COORDINATED RESEARCH ACTIVITIES

ANNUAL REPORT AND STATISTICS FOR 2004

May 2005
Research Contracts Administration Section
Department of Nuclear Sciences and Applications
International Atomic Energy Agency

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1. Introduction

Article III of the IAEA Statute authorises the Agency to encourage and assist research on, and development and practical application of, atomic energy for peaceful purposes throughout the world and to foster the exchange of scientific and technical information, as well as the exchange of scientists in the field of peaceful uses of atomic energy. The Agency's Coordinated Research Activities stimulate and coordinate the undertaking of research in selected nuclear fields by scientists in IAEA Member States.

The research supported by the Agency is within the framework of the Agency's programmes, sub-programmes and projects that are listed in the approved Programme and Budget of the Agency. These Coordinated Research Activities are normally implemented through Coordinated Research Projects (CRPs) that bring together research institutes in both developing and developed Member States to collaborate on the research topic of interest. The Agency may also respond to proposals from institutes for participation in the research activities by awarding individual research contracts not related to a CRP. A small portion of available funds is used to finance individual projects, which deal with topics covered by the Agency's scientific programme.

The Agency also supports Doctoral CRPs, which are designed to strengthen promotion of research on nuclear technologies in developing Member States through pair building between agreement holders and contract holders. These CRPs include a PhD training programme at the contract holders' institutions. Three doctoral CRPs currently implemented by the Human Health programme address the management of liver cancer using radionuclide methods, improvement of radiotherapy outcomes in AIDS cancer patients and isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies.

Further information on the Agency's coordinated research activities, including current information on CRPs and programme areas supported, information on policies and procedures and the administration of the activities is contained in the Agency's Coordinated Research Activities website at:

http://www-crp.iaea.org

2. Coordinated Research Activities in Support of Agency Programmes and Subprogrammes

The Coordinated Research Activities reported in this document are conducted in support of the following Agency programmes/subprogrammes (Ref: GC(47)/3 of August 2003 and GC(48)/2 and 16 of August 2004).

Programme A: Nuclear Power
Programme B: Nuclear Fuel Cycle and Materials Technologies
Programme C: Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development
Programme D: Nuclear Science
Programme E: Food and Agriculture
Programme F: Human Health
Programme G: Water Resources
Programme H: Protection of the Marine and Terrestrial Environments
Programme I: Physical and Chemical Applications
Programme J: Safety of Nuclear Installations
Programme K: Radiation and Transport Safety
Programme L: Management of Radioactive Waste
Programme M: Nuclear Security

The Sub-programmes supported by the CRPs are listed in Appendix C.

Results of research are available to all Member States and are disseminated through, national, international and Agency scientific and technical publications. The Coordinated Research Activities are complementary to its Technical Cooperation Projects, with the knowledge gained via coordinated research used to enhance the quality of Technical Cooperation Projects. Some research results are directly relevant to Technical Cooperation Projects and lead to successful implementation of these projects, while some Technical Projects lead to participation in Coordinated Research Activities. In addition, CRPs and TC Projects may also be carried out simultaneously.

3. Coordinated Research Activities in 2004

In terms of benefits to Member States through their participating research institutions, number of awards and degree of funding, coordinated research activities constitute a significant component of the Agency's overall programme.

942 contracts and agreements were awarded from the 1244 contract and agreement proposals received by the Agency during 2004. Annex I lists by country the number of proposals received and awards made.

In 2004, $6 765 324 were awarded from the regular budget to institutes under contractual arrangements and to fund Research Coordination Meetings (RCMs). Additionally, $230 859 of extra-budgetary contributions were used to fund additional contracts and RCMs. Thus, total awards amounted to $6 996 183. Table 1 summarizes all awards by Programme in 2004. The average award per contract was $6 065, which represents a slight decrease over the 2003 average award level.

Table 1: Summary of All Awards by Programme in 2004

	Programme	Regular Budget				Extra-budgetary Funding				Total Expenses
		Contracts	CRP Purchases	RCMs Expenses	**Total**	Contracts	CRP Purchases	RCM Expenses	**Total**	
		$	$	$	**$**	$	$	$	**$**	**$**
A	Nuclear Power	88 500	0	136 947	**225 447**	0	0	0	**0**	**225 447**
B	Nuclear Fuel Cycle and Material Technologies	71 500	0	94 841	**166 341**	0	0	0	**0**	**166 341**
C	Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	76 200	0	39 580	**115 780**	0	0	0	**0**	**115 780**
D	Nuclear Science	423 950	716	257 412	**682 078**	0	0	0	**0**	**682 078**
	Major Programme 1	***660 150***	***716***	***528 780***	***1 189 646***	***0***	***0***	***0***	***0***	***1 189 646***
E	Food and Agriculture	2 089 093	1 208	561 781	**2 652 082**	0	0	0	**0**	**2 652 082**
F	Human Health	1 269 413	11 497	211 762	**1 492 672**	0	0	0	**0**	**1 492 672**
G	Water Resources	221 000	0	121 998	**342 998**	0	0	0	**0**	**342 998**
H	Protection of the Marine and Terrestrial Environment	38 500	0	43 216	**81 716**	0	0	0	**0**	**81 716**
I	Physical and Chemical Applications	325 000	13 368	216 846	**555 214**	0	0	0	**0**	**555 214**
	Major Programme 2	***3 943 006***	***26 073***	***1 155 603***	***5 124 682***	***0***	***0***	***0***	***0***	***5 124 682***
J	Safety of Nuclear Installations	82 800	0	71 114	**153 914**	4 000	0	0	**4 000**	**157 914**
K	Radiation and Transport Safety	75 000	0	30 315	**105 315**	0	0	0	**0**	**105 315**
L	Management of Radioactive Waste	94 000	0	97 767	**191 767**	0	0	45 100	**45 100**	**236 867**
M	Nuclear Security	0	0	0	**0**	107 900	0	73 859	**181 759**	**181 759**
	Major Programme 3	***251 800***	***0***	***199 196***	***450 996***	***111 900***	***0***	***118 959***	***230 859***	***681 855***
	Total:	**4 854 956**	**26 789**	**1 883 579**	**6 765 324**	**111 900**	**0**	**118 959**	**230 859**	**6 996 183**
	Total Contract/CRP Awards	4 993 645								
	Total RCM Expenses	2 002 538								
	Total Expenditures	6 996 183								

Figure 1 illustrates the proportion of regular budget and extra-budgetary funding in 2004

Figure 1: 2004 Resources

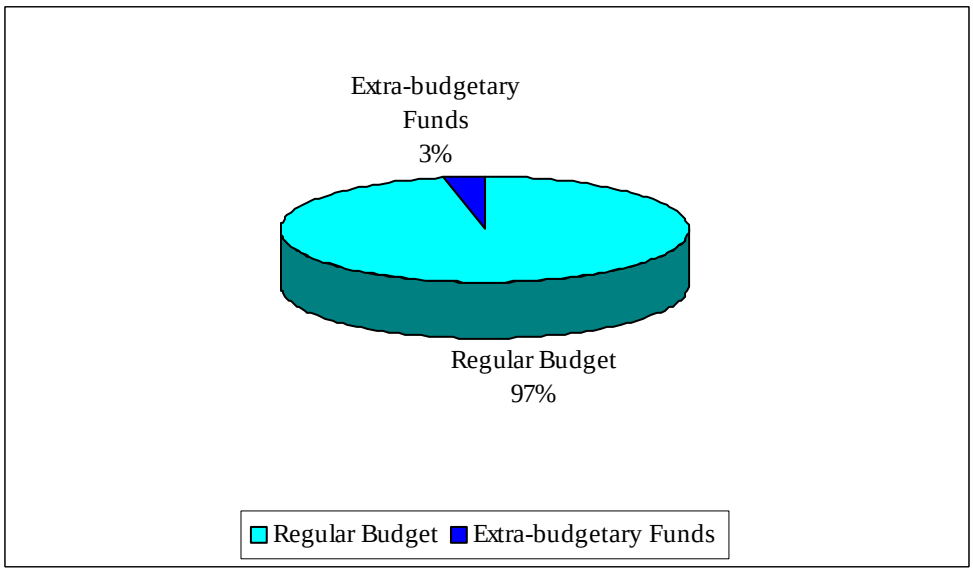
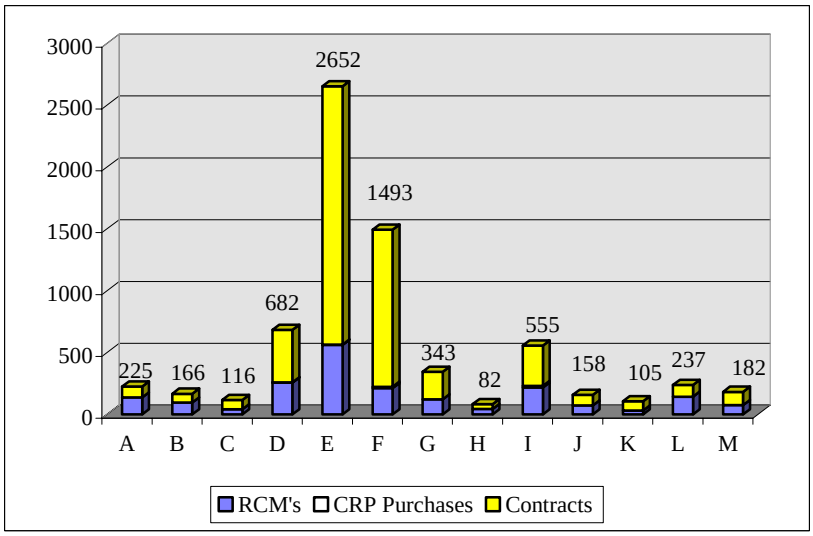


Figure 2 shows the types of awards made by programme.

Figure 2: Distribution of all 2004 Awards by Programme and Type of Activity



Details of resources for 2004 awards by programme and sub-programme and type of award are provided in Table 2. Annex II lists awards by country and programme.

Table 2: Distribution of 2004 Total Funds by Programme

Prog	Research Contracts		Technical Contracts		Doctoral Contracts		CRP Expenses	Total	RCMs		Overall Total
	#*	$	#*	$	#	$	$	$	#**	$	$
Regular Budget											
A102	4	16 000	0	0	0	0	0	16 000	0	0	16 000
A302	10	30 000	0	0	0	0	0	30 000	0	0	30 000
A401	6	13 000	0	0	0	0		13 000	1	31 483	44 483
A402	4	12 000	0	0	0	0		12 000	2	60 664	72 664
A403	0	0	0	0	0	0	0	0	2	44 800	44 800
A404	7	17 500	0	0	0	0	0	17 500	0	0	17 500
A	*31*	*88 500*	*0*	*0*	*0*	*0*	*0*	*88 500*	*5*	*136 947*	*225 447*
B102	1	2 500	0	0	0	0	0	2 500	0	0	2 500
B201	4	20 000	0	0	0	0	0	20 000	1	41 865	61 865
B202	4	20 000	1	5 000	0	0	0	25 000	1	40 426	65 426
B302	1	5 000	1	5 000	0	0	0	10 000	0	0	10 000
B401	3	14 000	0	0	0	0	0	14 000	1	12 550	26 550
B	*13*	*61 500*	*2*	*10 000*	*0*	*0*	*0*	*71 500*	*3*	*94 841*	*166 341*
C101	7	36 000	0	0	0	0	0	36 000	1	22 600	58 600
C202	7	35 000	0	0	0	0	0	35 000	1	16 980	51 980
C303	0	0	1	5 200	0	0	0	5 200	0	0	5 200
C	*14*	*71 000*	*1*	*5 200*	*0*	*0*	*0*	*76 200*	*2*	*39 580*	*115 780*
D102	8	37 500	0	0	0	0	0	37 500	2	38 893	76 393
D103	4	20 000	0	0	0	0		20 000	1	20 075	40 075
D104	15	70 000	0	0	0	0		70 000	3	54 126	124 126
D105	6	27 000	0	0	0	0		27 000	1	22 876	49 876
D201	14	59 000	0	0	0	0	0	59 000	2	30 075	89 075
D203	4	22 000	0	0	0	0	716	22 716	1	17 923	40 639
D301	10	49 500	0	0	0	0	0	49 500	1	14 017	63 517
D302	5	25 000	0	0	0	0	0	25 000	0	0	25 000
D303	1	5 000	0	0	0	0	0	5 000	0	0	5 000
D401	25	107 000	3	1 950	0	0	0	108 950	2	59 427	168 377
D	*92*	*422 000*	*3*	*1 950*	*0*	*0*	*716*	*424 666*	*13*	*257 412*	*682 078*
E101	11	79 000	1	10 000	0	0	0	89 000	0	0	89 000
E102	23	175 000	11	73 000	0	0	0	248 000	2	74 430	322 430
E103	13	117 500	1	10 000	0	0	0	127 500	1	51 557	179 057
E104	32	270 123	1	15 000	0	0	0	285 123	3	120 908	406 031
E105	23	207 000	2	20 000	0	0	0	227 000	1	30 160	257 160
E100	53	301 770	8	68 000	0	0	1 208	370 978	4	146 110	517 088
E201	10	80 000	1	5 000	0	0	0	85 000	1	17 842	102 842
E202	19	133 000	4	42 000	0	0	0	175 000	3	88 664	263 664
E203	13	136 700	2	25 000	0	0	0	161 700	0	0	161 700
E204	16	121 000	1	10 000	0	0	0	131 000	0	0	131 000
E301	20	109 000	1	10 000	0	0	0	119 000	1	32 110	151 110
E302	13	71 000	0	0	0	0	0	71 000	0	0	71 000
E	*246*	*1 801 093*	*33*	*288 000*	*0*	*0*	*1 208*	*2 090 301*	*16*	*561 781*	*2 652 082*
F101	38	223 213	4	22 000	0	0	0	245 213	2	47 388	292 601
F102	12	107 000	1	3 000	4	48 000	0	158 000	1	8 812	166 812
F103	17	95 000	1	10 000	0	0	0	105 000	2	45 036	150 036
F104	8	40 000	3	20 000	0	0	0	60 000	0	0	60 000
F201	5	27 000	1	10 000	0	0	0	37 000	0	0	37 000
F202	5	19 700	2	17 000	0	0	0	36 700	0	0	36 700
F203	15	76 000	3	30 000	1	8 000	9 997	123 997	1	19 147	143 144
F204	0	0	1	10 000	0	0	0	10 000	0	0	10 000
F303	5	20 000	1	9 000	0	0	0	29 000	0	0	29 000
F304	12	50 000	0	0	0	0	0	50 000	2	42 423	92 423
F401	34	241 500	3	30 000	6	75 000	1 500	348 000	2	48 956	396 956
F402	11	78 000	0	0	0	0	0	78 000	0	0	78 000
F	*162*	*977 413*	*20*	*161 000*	*11*	*131 000*	*11 497*	*1 280 910*	*10*	*211 762*	*1 492 672*

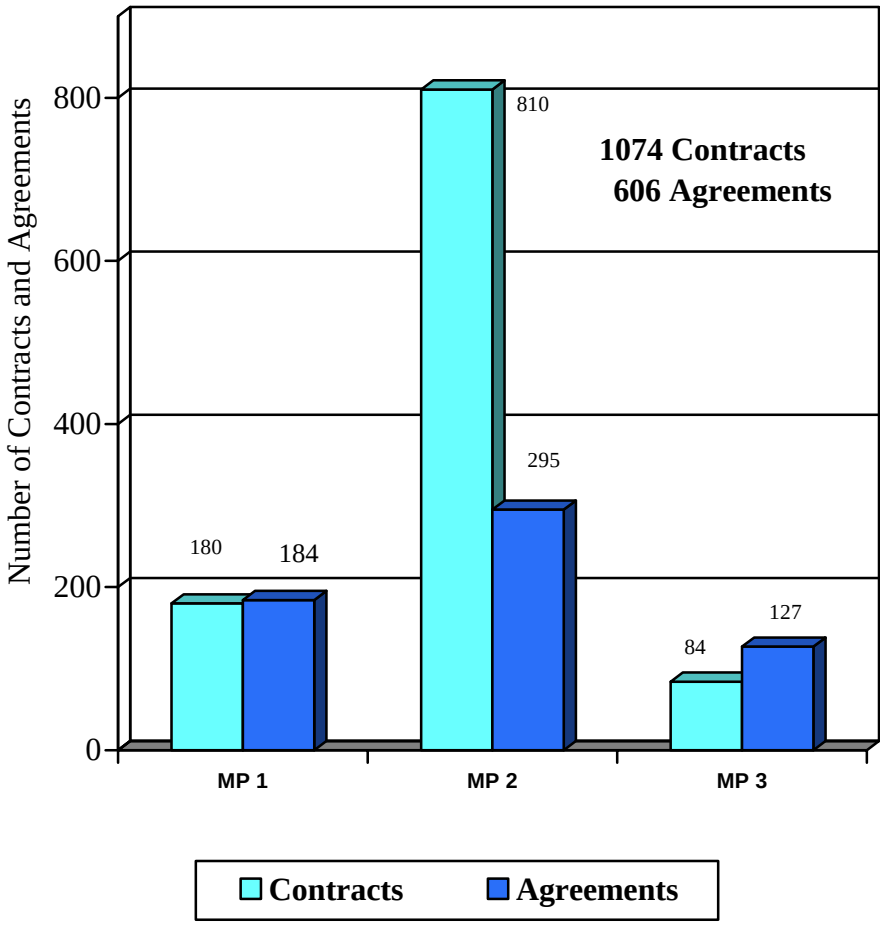
Prog		Research Contracts		Technical Contracts		Doctoral Contracts		CRP Expenses	Total	RCMs		Overall Total
		#*	$	#*	$	#	$	$	$	#**	$	$
	G101	9	44 000	0	0	0	0	0	44 000	1	8 176	52 176
	G103	1	4 000	0	0	0	0	0	4 000	1	4 610	8 610
	G105	14	57 500	1	40 000	0	0	0	97 500	1	35 468	132 968
	G201	11	52 500	0	0	0	0	0	52 500	2	73 744	126 244
	G203	1	5 000	4	18 000	0	0	0	23 000	0	0	23 000
G		*36*	*163 000*	*5*	*58 000*	*0*	*0*	*0*	*221 000*	*5*	*121 998*	*342 998*
	H102	0	0	0	0	0	0	0	0	1	8 176	8 176
	H103	4	20 000	0	0	0	0	0	20 000	1	25 040	45 040
	H203	3	15 000	0	0	0	0	0	15 000	0	0	15 000
	H204	1	3 500	0	0	0	0	0	3 500	0	0	3 500
	H403	0	0	0	0	0	0	0	0	1	10 000	10 000
H		*8*	*38 500*	*0*	*0*	*0*	*0*	*0*	*38 500*	*3*	*43 216*	*81 716*
	I101	15	60 000	0	0	0	0	0	60 000	1	28 464	88 464
	I102	12	36 000	0	0	0	0	0	36 000	2	38 460	74 460
	I103	14	56 000	0	0	0	0	12 210	68 210	2	61 090	129 300
	I104	1	4 000	0	0	0	0	0	4 000	0	0	4 000
	I201	13	52 000	0	0	0	0	0	52 000	1	25 785	77 785
	I202	18	72 000	1	4 000	0	0	0	76 000	2	43 109	119 109
	I203	9	36 000	0	0	0	0	1 158	37 158	1	19 938	57 096
	I204	1	5 000	0	0	0	0	0	5 000	0	0	5 000
I		*83*	*321 000*	*1*	*4 000*	*0*	*0*	*13 368*	*338 368*	*9*	*216 846*	*555 214*
	J301	6	29 800	0	0	0	0	0	29 800	1	19 179	48 979
	J503	12	33 000	0	0	0	0	0	33 000	1	9 200	42 200
	J701	5	20 000	0	0	0	0	0	20 000	2	42 735	62 735
J		*23*	*82 800*	*0*	*0*	*0*	*0*	*0*	*82 800*	*4*	*71 114*	*153 914*
	K104	0	0	2	40 000	0	0	0	40 000	0	0	40 000
	K501	3	7 000	5	10 500	0	0	0	17 500	1	14 080	31 580
	K502	6	13 000	2	4 500	0	0	0	17 500	2	16 235	33 735
K		*9*	*20 000*	*9*	*55 000*	*0*	*0*	*0*	*75 000*	*3*	*30 315*	*105 315*
	L401	5	25 000	0	0	0	0	0	25 000	1	39 312	64 312
	L402	6	24 000	0	0	0	0	0	24 000	2	28 800	52 800
	L403	6	30 000	0	0	0	0	0	30 000	1	29 655	59 655
	L701	3	15 000	0	0	0	0	0	15 000	0	0	15 000
L		*20*	*94 000*	*0*	*0*	*0*	*0*	*0*	*94 000*	*4*	*97 767*	*191 767*
		737	**4 140 806**	**74**	**583 150**	**11**	**131 000**	**26 789**	**4 881 745**	**77**	**1 883 579**	**6 765 324**
Extra-budgetary Funding												
J	J206	1	4 000	0	0	0	0	0	4 000	0	0	4 000
L	L303	0	0	0	0	0	0	0	0	1	45 100	45 100
M	M302	6	107 900	0	0	0	0	0	107 900	1	73 859	181 759
		7	**111 900**	**0**	**0**	**0**	**0**	**0**	**111 900**	**2**	**118 959**	**230 859**
		744	**4 252 706**	**74**	**583 150**	**11**	**131 000**	**26 789**	**4 993 645**	**79**	**2 002 538**	**6 996 183**

* Includes contracts with multiple funding

** Includes two meetings held jointly under different subprogrammes

At the end of 2004, there were 1,680 active research contracts and agreements supported by the Agency. 95% of these represented participation in the 133 active CRPs shown in Appendix A and 5% were individual projects. 77 RCMs (see Annex III) were held in support of these CRPs and an amount of $2 002 538 was spent in support of these meetings. Figure 3 shows the distribution by Major Programme of these contracts and agreements and Figure 4 shows the distribution by programme of the CRPs and RCMs held during the year.

Figure 3: Active Contracts and Agreements by Major Programme at End 2004

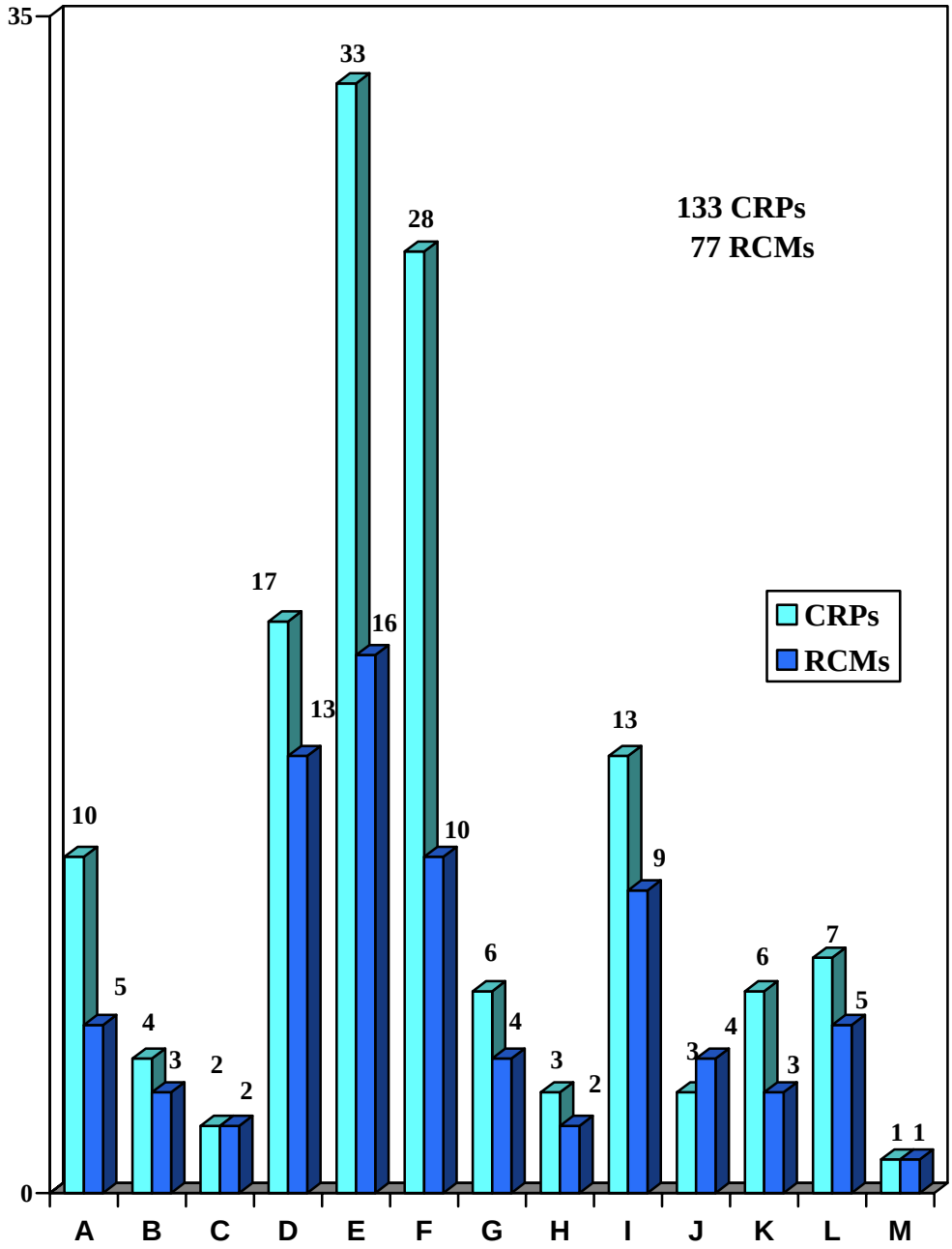


MP 1: A. Nuclear Power; B. Nuclear Fuel Cycle and Materials Technologies; C. Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development; D. Nuclear Science

MP 2: E. Food and Agriculture; F. Human Health; G. Water Resources; H. Protection of the Marine and Terrestrial Environment; I. Physical and Chemical Applications

MP 3: J. Safety of Nuclear Installations; K. Radiation and Transport Safety, L. Management of Radioactive Waste, M. Nuclear Security

Figure 4: CRPs Active at End 2004 and RCMs Held During the Year



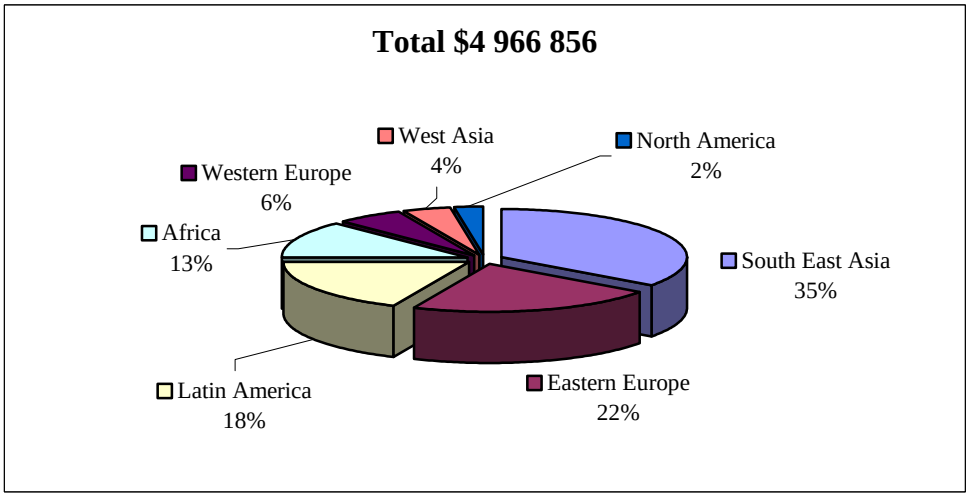
3.1 Member State Participation

The distribution of all contract awards in 2004 is shown by country in Annex IV. 88% of the funds awarded for contracts were made to institutes in developing countries. Table 3 and Figure 5 show the geographical distribution of all contract awards in 2004.

Table 3: Geographical Distribution of Research Contract Awards in 2004

	$	%
South East Asia	1 735 300	35
Eastern Europe	1 081 200	22
Latin America	902 586	18
Africa	623 200	13
Western Europe	298 300	6
West Asia	203 270	4
North America	123 000	2
Total	4 966 856	100

Figure 5: 2004 Total Contract Awards by Geographical Area



3.2 Extra-budgetary Funding

In 2004, extra-budgetary funds amounting to $230 859 were used for financing contracts and RCMs. The funds used were from the Nuclear Security Multi-donors Fund and Japan, as shown in Table 4.

Table 4: Summary of 2004 Extra-budgetary Funded Awards

Total Awards $230 859

Japan				
J7.10.10	Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools			
	1 contract	$4 000		
J9.10.06	Application of safety assessment methodologies for near surface waste disposal facilities (ASAM)			
			1 meeting	$45 100
Nuclear Security Multi-donors Fund				
M2.20.06	Improvement of technical measures to detect and respond to illicit trafficking of nuclear material and other radioactive materials			
	6 contracts	$107 900	1 meeting	$73 859
Total	**7 contracts**	**$111 900**	**2 meetings**	**$118 959**

3.3 Coordinated Research Projects Completed in 2004

17 CRPs were completed in 2004, with 10 of these CRPs concerning topics in Nuclear Techniques for Development and Environmental Protection, 4 in Nuclear Safety and Security, and 3 in Nuclear Power, Fuel Cycle and Nuclear Science. A list of these CRPs is included in Appendix B. Evaluations of these CRPs will be completed by the end of 2005 and their accomplishments will be included in the next annual report.

4. Accomplishments of Coordinated Research Projects Completed in 2003

Coordinated Research Projects are fully evaluated one year after their completion. During 2003, 30 CRPs were successfully completed: 16 of these related to Nuclear

Techniques for Development and Environmental Protection, 12 related to Nuclear Power, Fuel Cycle and Nuclear Science, and 2 to Nuclear Safety and Security.

Accomplishments of these CRPs are included in Appendix D. Detailed lists of publications and other outputs such as data bases, software packages, websites, presentations at conferences, etc. can also be seen in Appendix D.

Total Number of
Proposals Received and Awards Made in 2004

Country	Proposals Received			Awards*			
	Contracts	Agreements	Total	Regular Budget	Extra-budgetary	Agreements	Total
Albania	1	0	1	0	0	0	0
Algeria	8	0	8	6	0	0	6
Argentina	48	1	49	39	0	1	40
Armenia	2	0	2	2	0	0	2
Australia	7	9	16	5	0	8	13
Austria	3	4	7	3	0	2	5
Bangladesh	18	0	18	8	0	0	8
Barbados	1	0	1	1	0	0	1
Belarus	7	0	7	5	0	0	5
Belgium	3	1	4	3	0	3	6
Benin	3	0	3	1	0	0	1
Bolivia	4	0	4	0	0	0	0
Brazil	56	1	57	45	0	0	45
Bulgaria	20	0	20	15	0	0	15
Burkina Faso	5	0	5	3	0	0	3
Cameroon	4	0	4	2	0	0	2
Canada	6	3	9	5	0	4	9
Chile	12	0	12	8	0	0	8
China	66	2	68	57	0	1	58
Colombia	13	1	14	7	0	1	8
Costa Rica	7	0	7	5	0	0	5
Côte d'Ivoire	1	0	1	0	0	0	0
Croatia	11	0	11	10	0	0	10
Cuba	27	0	27	16	0	0	16
Cyprus	2	0	2	1	0	0	1
Czech Republic	16	2	18	19	0	2	21
Denmark	1	1	2	1	0	1	2
Ecuador	1	0	1	1	0	0	1
Egypt	13	0	13	6	0	0	6
Estonia	5	0	5	4	0	0	4
Ethiopia	2	0	2	2	0	0	2
Finland	0	1	1	0	0	0	0
France	1	8	9	1	0	8	9
Georgia	1	0	1	0	0	0	0
Germany	4	9	13	3	0	9	12
Ghana	9	0	9	6	0	0	6
Greece	17	4	21	8	0	2	10
Guatemala	0	0	0	1	0	0	1
Honduras	1	0	1	1	0	0	1
Hungary	15	1	16	16	0	0	16
India	69	2	71	61	0	2	63
Indonesia	22	1	23	13	1	0	14
Iran, Islamic Republic of	21	1	22	9	0	0	9
Israel	5	1	6	5	0	1	6
Italy	1	7	8	1	0	6	7
Japan	1	11	12	1	0	9	10
Jordan	6	0	6	2	0	0	2
Kazakhstan	5	0	5	4	0	0	4

* Also includes proposals received in previous years

Total Number of
Proposals Received and Awards Made in 2004

	Proposals Received			Awards*			
Country	**Contracts**	**Agreements**	**Total**	**Regular Budget**	**Extra-budgetary**	**Agreements**	**Total**
Kenya	16	6	22	8	0	2	10
Korea, Republic of	20	15	35	17	0	5	22
Kyrgyzstan	1	0	1	0	0	0	0
Latvia	1	0	1	0	1	0	1
Libyan Arab Jamahiriya	1	0	1	0	0	0	0
Lithuania	3	1	4	3	0	0	3
Malaysia	11	0	11	11	0	0	11
Mali	0	0	0	1	0	0	1
Malta	1	0	1	1	0	0	1
Mauritius	5	0	5	2	0	0	2
Mexico	17	0	17	14	0	0	14
Monaco	0	0	0	0	0	1	1
Mongolia	3	0	3	2	0	0	2
Morocco	10	0	10	10	0	0	10
Myanmar	2	0	2	1	0	0	1
Namibia	1	0	1	1	0	0	1
Nepal	1	0	1	1	0	0	1
Netherlands	0	3	3	0	0	3	3
New Zealand	0	0	0	0	0	2	2
Nicaragua	1	0	1	0	0	0	0
Niger	1	0	1	1	0	0	1
Nigeria	7	0	7	3	0	0	3
Norway	1	2	3	1	0	2	3
Pakistan	72	2	74	30	0	0	30
Paraguay	1	0	1	1	0	0	1
Peru	10	0	10	9	0	0	9
Philippines	15	1	16	14	0	1	15
Poland	22	1	23	18	1	1	20
Portugal	6	1	7	4	0	1	5
Romania	24	1	25	16	0	0	16
Russian Federation	46	3	49	38	4	3	45
Saudi Arabia	3	1	4	0	0	1	1
Senegal	1	0	1	1	0	0	1
Serbia and Montenegro	4	0	4	3	0	0	3
Singapore	5	0	5	5	0	0	5
Slovakia	15	2	17	12	0	1	13
Slovenia	9	0	9	8	0	0	8
South Africa	18	1	19	20	0	1	21
Spain	2	3	5	2	0	4	6
Sri Lanka	13	0	13	5	0	0	5
Sudan	5	0	5	4	0	0	4
Sweden	1	0	1	0	0	0	0
Switzerland	3	2	5	3	0	3	6
Syrian Arab Republic	17	0	17	10	0	0	10
Thailand	26	0	26	25	0	0	25
The Frmr.Yug.Rep. of Macedor	2	0	2	3	0	0	3
Togo	1	0	1	0	0	0	0
Tunisia	3	0	3	3	0	0	3
Turkey	36	1	37	19	0	0	19

* Also includes proposals received in previous years

Total Number of
Proposals Received and Awards Made in 2004

	Proposals Received			Awards*			
Country	**Contracts**	**Agreements**	**Total**	**Regular Budget**	**Extra-budgetary**	**Agreements**	**Total**
Uganda	3	0	3	4	0	0	4
Ukraine	7	1	8	4	0	1	5
United Kingdom	8	8	16	8	0	6	14
United Republic of Tanzania	5	0	5	5	0	0	5
United States of America	11	21	32	9	0	25	34
Uruguay	14	0	14	10	0	0	10
Uzbekistan	6	0	6	5	0	0	5
Venezuela	5	1	6	2	0	0	2
Vietnam	19	0	19	20	0	0	20
Yemen	2	0	2	1	0	0	1
Zambia	1	0	1	1	0	0	1
Zimbabwe	1	0	1	1	0	0	1
	1,096	**148**	**1,244**	**812**	**7**	**123**	**942**

* Also includes proposals received in previous years

Distribution of Total
2004 Contract Awards, by Country and Programme

Annex II.1

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	M	MP 3	Total $
Algeria	1	5	6	0	0	0	0	**0**	7 000	16 000	0	0	4 000	**27 000**	4 000	0	0	0	**4 000**	**31 000**
Argentina	13	26	39	4 500	0	6 000	30 000	**40 500**	109 000	21 000	9 000	0	8 000	**147 000**	4 000	0	10 000	0	**14 000**	**201 500**
Armenia	0	2	2	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	4 000	0	0	0	**4 000**	**14 000**
Australia	3	2	5	0	0	5 200	0	**5 200**	19 000	0	4 000	0	0	**23 000**	0	2 500	0	0	**2 500**	**30 700**
Austria	0	3	3	0	0	0	0	**0**	0	0	40 000	0	0	**40 000**	0	4 000	0	0	**4 000**	**44 000**
Bangladesh	3	5	8	0	0	0	5 000	**5 000**	32 000	24 000	0	0	0	**56 000**	0	0	0	0	**0**	**61 000**
Barbados	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	0	**0**	**6 000**
Belarus	2	3	5	0	0	0	10 000	**10 000**	0	0	0	0	8 000	**8 000**	0	0	5 000	0	**5 000**	**23 000**
Belgium	2	1	3	0	0	0	650	**650**	25 000	0	0	0	0	**25 000**	0	0	0	0	**0**	**25 650**
Benin	0	1	1	0	0	0	0	**0**	7 000	0	0	0	0	**7 000**	0	0	0	0	**0**	**7 000**
Brazil	21	25	46	6 000	2 500	5 000	28 150	**41 650**	96 000	47 313	10 000	5 000	27 000	**185 313**	4 000	0	5 000	0	**9 000**	**235 963**
Bulgaria	3	12	15	0	10 000	5 000	20 000	**35 000**	23 000	12 000	0	0	4 000	**39 000**	6 000	0	0	0	**6 000**	**80 000**
Burkina Faso	1	2	3	0	0	0	0	**0**	21 000	0	0	0	0	**21 000**	0	0	0	0	**0**	**21 000**
Cameroon	1	2	3	0	0	0	0	**0**	8 000	10 000	0	0	0	**18 000**	0	0	0	0	**0**	**18 000**
Canada	4	1	5	0	0	0	0	**0**	10 000	30 000	4 000	0	0	**44 000**	0	0	0	0	**0**	**44 000**
Chile	1	7	8	0	0	0	0	**0**	34 500	13 000	0	0	0	**47 500**	0	0	0	0	**0**	**47 500**
China	21	36	57	5 500	0	5 000	34 000	**44 500**	210 000	54 000	19 000	0	19 000	**302 000**	4 000	0	14 000	0	**18 000**	**364 500**
Colombia	1	6	7	0	0	0	0	**0**	15 000	34 000	5 000	0	0	**54 000**	0	0	0	0	**0**	**54 000**
Costa Rica	2	3	5	0	0	0	0	**0**	20 000	6 000	0	0	0	**26 000**	0	0	0	0	**0**	**26 000**
Croatia	7	3	10	7 000	0	0	12 000	**19 000**	11 000	13 500	0	0	3 000	**27 500**	0	0	0	0	**0**	**46 500**
Cuba	8	8	16	0	0	5 000	5 000	**10 000**	28 000	41 000	0	0	11 000	**80 000**	0	0	5 000	0	**5 000**	**95 000**
Cyprus	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	0	**0**	**6 000**
Czech Republic	4	15	19	8 000	16 000	0	13 000	**37 000**	23 000	23 000	0	0	8 000	**54 000**	5 000	0	9 000	0	**14 000**	**105 000**
Denmark	1	0	1	0	0	0	0	**0**	0	10 000	0	0	0	**10 000**	0	0	0	0	**0**	**10 000**
Ecuador	0	1	1	0	0	0	0	**0**	0	0	0	0	4 000	**4 000**	0	0	0	0	**0**	**4 000**
Egypt	3	3	6	2 500	0	0	3 000	**5 500**	15 000	10 000	4 000	0	0	**29 000**	0	0	0	0	**0**	**34 500**
Estonia	1	3	4	0	0	0	5 000	**5 000**	0	13 500	0	0	0	**13 500**	0	0	0	0	**0**	**18 500**
Ethiopia	1	1	2	0	0	0	0	**0**	16 000	0	0	0	0	**16 000**	0	0	0	0	**0**	**16 000**
France	1	0	1	0	0	0	0	**0**	0	10 000	0	0	0	**10 000**	0	0	0	0	**0**	**10 000**
Germany	0	3	3	0	0	0	0	**0**	30 000	0	0	0	0	**30 000**	0	0	0	0	**0**	**30 000**

* Includes contracts with multiple fundings

Distribution of Total
2004 Contract Awards, by Country and Programme

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	M	MP 3	Total $
Ghana	3	3	6	0	0	0	0	**0**	16 000	18 500	2 500	0	3 000	**40 000**	0	0	0	0	**0**	**40 000**
Greece	5	3	8	0	0	0	0	**0**	22 000	0	9 000	0	8 000	**39 000**	0	0	0	0	**0**	**39 000**
Guatemala	0	1	1	0	0	0	0	**0**	5 123	0		0	0	**5 123**	0	0	0	0	**0**	**5 123**
Honduras	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	0	**0**	**5 000**
Hungary	2	14	16	0	5 000	0	13 000	**18 000**	25 000	8 000	0	0	19 000	**52 000**	5 000	0	5 000	0	**10 000**	**80 000**
India	17	45	62	12 500	2 000	5 000	29 000	**48 500**	103 700	140 500	19 500	0	20 000	**283 700**	4 000	7 000	0	0	**11 000**	**343 200**
Indonesia	8	6	14	3 000	0	0	0	**3 000**	52 000	17 500	0	10 000	8 000	**87 500**	4 000	0	0	0	**4 000**	**94 500**
Iran, Islamic Republic of	5	4	9	0	0	0	0	**0**	36 000	14 000	0	0	8 000	**58 000**	0	0	0	0	**0**	**58 000**
Israel	4	2	6	0	0	0	0	**0**	24 770	0	0	5 000	0	**29 770**	0	0	0	0	**0**	**29 770**
Italy	0	1	1	0	0	0	0	**0**	0	0	0	0	0	**0**	0	2 000	0	0	**2 000**	**2 000**
Japan	1	0	1	0	0	0	0	**0**	0	8 000	0	0	0	**8 000**	0	0	0	0	**0**	**8 000**
Jordan	1	1	2	0	0	0	0	**0**	0	0	0	5 000	4 000	**9 000**	0	0	0	0	**0**	**9 000**
Kazakhstan	2	2	4	0	0	0	10 000	**10 000**	0	0	0	0	7 000	**7 000**	0	0	0	0	**0**	**17 000**
Kenya	2	6	8	0	0	0	0	**0**	57 000	7 000	0	0	0	**64 000**	0	0	0	0	**0**	**64 000**
Korea, Republic of	5	12	17	5 500	0	0	9 000	**14 500**	47 000	14 400	0	0	8 000	**69 400**	8 000	0	4 000	0	**12 000**	**95 900**
Latvia	1	0	1	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	0	15 000	**15 000**	**15 000**
Lithuania	1	2	3	3 000	0	5 000	0	**8 000**	0	0	0	0	0	**0**	0	0	5 000	0	**5 000**	**13 000**
Malaysia	2	9	11	0	0	0	3 000	**3 000**	33 000	0	0	0	11 000	**44 000**	0	4 000	0	0	**4 000**	**51 000**
Mali	1	0	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	0	**0**	**5 000**
Malta	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	0	**0**	**6 000**
Mauritius	2	0	2	0	0	0	0	**0**	11 000	0	0	0	0	**11 000**	0	0	0	0	**0**	**11 000**
Mexico	6	8	14	0	0	5 000	0	**5 000**	51 000	21 500	0	0	11 000	**83 500**	0	0	0	0	**0**	**88 500**
Mongolia	1	1	2	0	0	0	0	**0**	0	17 000	0	0	0	**17 000**	0	0	0	0	**0**	**17 000**
Morocco	4	7	11	0	0	0	0	**0**	22 000	36 000	10 000	0	0	**68 000**	0	0	0	0	**0**	**68 000**
Myanmar	0	1	1	0	0	0	0	**0**	0	5 000	0	0	0	**5 000**	0	0	0	0	**0**	**5 000**
Namibia	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	0	**0**	**6 000**
Nepal	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	0	**0**	**5 000**
Niger	0	1	1	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	0	0	0	0	**0**	**10 000**
Nigeria	0	3	3	0	0	0	0	**0**	11 500	8 000	0	0	0	**19 500**	0	0	0	0	**0**	**19 500**
Norway	0	1	1	0	5 000	0	0	**5 000**	0	0	0	0	0	**0**	0	0	0	0	**0**	**5 000**

* Includes contracts with multiple fundings

Annex II.3

Distribution of Total
2004 Contract Awards, by Country and Programme

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	M	MP 3	Total $
Pakistan	9	21	30	2 500	0	0	0	**2 500**	86 000	58 000	21 500	0	16 000	**181 500**	4 000	0	0	0	**4 000**	**188 000**
Paraguay	0	1	1	0	0	0	0	**0**	8 000	0	0	0	0	**8 000**	0	0	0	0	**0**	**8 000**
Peru	3	6	9	0	0	0	0	**0**	13 000	24 000	0	5 000	7 000	**49 000**	0	0	0	0	**0**	**49 000**
Philippines	7	8	15	0	0	0	0	**0**	62 000	42 000	0	0	4 000	**108 000**	0	0	0	0	**0**	**108 000**
Poland	5	14	19	0	0	5 000	15 000	**20 000**	35 000	13 000	0	0	24 000	**72 000**	0	2 500	0	19 000	**21 500**	**113 500**
Portugal	2	2	4	0	0	0	4 000	**4 000**	11 000	0	0	0	4 000	**15 000**	0	0	0	0	**0**	**19 000**
Romania	3	14	17	2 000	5 000	5 000	24 500	**36 500**	8 000	4 000	0	0	16 000	**28 000**	5 000	0	0	0	**5 000**	**69 500**
Russian Federation	9	33	42	20 000	16 000	10 000	77 500	**123 500**	8 000	7 000	0	0	8 000	**23 000**	13 800	0	14 000	73 900	**101 700**	**248 200**
Senegal	0	1	1	0	0	0	0	**0**	0	9 000	0	0	0	**9 000**	0	0	0	0	**0**	**9 000**
Serbia and Montenegro	1	2	3	0	0	0	6 000	**6 000**	0	5 000	5 000	0	0	**10 000**	0	0	0	0	**0**	**16 000**
Singapore	2	3	5	0	0	0	5 000	**5 000**	0	33 000	0	0	0	**33 000**	0	0	0	0	**0**	**38 000**
Slovakia	3	9	12	1 000	10 000	5 000	9 500	**25 500**	25 000	0	2 500	0	0	**27 500**	6 000	0	0	0	**6 000**	**59 000**
Slovenia	2	6	8	0	0	0	0	**0**	0	23 000	14 000	0	3 000	**40 000**	0	0	0	0	**0**	**40 000**
South Africa	7	15	22	0	0	0	12 500	**12 500**	51 000	52 200	10 000	0	5 000	**118 200**	0	0	4 000	0	**4 000**	**134 700**
Spain	0	2	2	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	2 000	0	0	**2 000**	**7 000**
Sri Lanka	2	3	5	0	0	0	0	**0**	26 000	19 500	0	0	0	**45 500**	0	0	0	0	**0**	**45 500**
Sudan	2	3	5	0	0	0	0	**0**	0	25 000	0	0	0	**25 000**	0	0	0	0	**0**	**25 000**
Switzerland	3	0	3	0	0	0	0	**0**	10 000	20 000	0	0	0	**30 000**	0	0	0	0	**0**	**30 000**
Syrian Arab Republ	4	6	10	2 500	0	0	0	**2 500**	25 000	5 000	9 000	0	3 000	**42 000**	4 000	0	0	0	**4 000**	**48 500**
Thailand	9	16	25	0	0	5 000	5 000	**10 000**	78 000	57 500	0	5 000	0	**140 500**	0	6 500	0	0	**6 500**	**157 000**
The Frmr.Yug.Rep. of Macedonia	2	1	3	0	0	0	5 000	**5 000**	10 000	6 000	0	0	0	**16 000**	0	0	0	0	**0**	**21 000**
Tunisia	2	1	3	0	0	0	0	**0**	28 000	0	0	0	0	**28 000**	0	0	0	0	**0**	**28 000**
Turkey	7	12	19	0	0	0	4 000	**4 000**	41 500	18 000	10 500	3 500	12 000	**85 500**	2 000	2 500	0	0	**4 500**	**94 000**
Uganda	2	2	4	0	0	0	0	**0**	25 000	5 000	0	0	0	**30 000**	0	0	0	0	**0**	**30 000**
Ukraine	1	3	4	0	0	0	5 000	**5 000**	0	0	0	0	0	**0**	0	0	14 000	0	**14 000**	**19 000**
United Kingdom	2	6	8	0	0	0	650	**650**	33 000	5 000	0	0	0	**38 000**	0	32 000	0	0	**32 000**	**70 650**
United Republic of Tanzania	2	3	5	0	0	0	0	**0**	21 000	12 500	0	0	0	**33 500**	0	0	0	0	**0**	**33 500**
United States of	3	6	9	0	0	0	0	**0**	35 000	29 000	5 000	0	0	**69 000**	0	10 000	0	0	**10 000**	**79 000**

* Includes contracts with multiple fundings

Distribution of Total
2004 Contract Awards, by Country and Programme

Country	Contracts* New	Renewal	Total	A	B	C	D	MP 1	E	F	G	H	I	MP 2	J	K	L	M	MP 3	Total $
America																				
Uruguay	4	6	10	0	0	0	0	**0**	15 000	42 000	0	0	8 000	**65 000**	0	0	0	0	**0**	**65 000**
Uzbekistan	2	3	5	0	0	0	9 000	**9 000**	16 000	8 000	0	0	0	**24 000**	0	0	0	0	**0**	**33 000**
Venezuela	0	2	2	0	0	0	4 000	**4 000**	8 000	0	0	0	0	**8 000**	0	0	0	0	**0**	**12 000**
Vietnam	9	11	20	3 000	0	0	7 500	**10 500**	55 000	38 000	7 500	0	12 000	**112 500**	0	0	0	0	**0**	**123 000**
Yemen	0	1	1	0	0	0	0	**0**	8 000	0	0	0	0	**8 000**	0	0	0	0	**0**	**8 000**
Zambia	0	1	1	0	0	0	0	**0**	7 000	0	0	0	0	**7 000**	0	0	0	0	**0**	**7 000**
Zimbabwe	1	0	1	0	0	0	0	**0**	0	5 000	0	0	0	**5 000**	0	0	0	0	**0**	**5 000**
Total	**288**	**541**	**829**	**88 500**	**71 500**	**76 200**	**423 950**	**660 150**	**2 089 093**	**1 269 413**	**221 000**	**38 500**	**325 000**	**3 943 006**	**86 800**	**75 000**	**94 000**	**107 900**	**363 700**	**4 966 856**

Annex II.4

* Includes contracts with multiple fundings

Research Coordination Meetings Held in 2004

A. NUCLEAR POWER

A.4. Technology Developments and Applications for Advanced Reactors

		$
I3.10.14	Natural circulation phenomena, modelling and reliability of passive systems that utilize natural circulation	31 483
I3.20.04	Studies of innovative reactor technology options for effective incineration of radioactive waste	35 904
I3.20.05	Updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects	24 760
I3.10.12	Evaluation of high temperature gas cooled reactor performance	24 410
I3.10.13	Conservation and application of HTGR technology: Advances in HTGR fuel technology	20 390

B. NUCLEAR FUEL CYCLE AND MATERIALS TECHNOLOGIES

B.2. Nuclear Fuel Performance and Technology

T1.20.14	Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)	41 865
T1.20.15	Improvement on the models used for fuel behaviour simulation (FUMEX II)	40 426

B.4. Topical Nuclear Fuel Cycle Issues and Information Systems

T1.30.11	Study of process-losses in separation processes in Partitioning and Transmutation (P&T) systems in view of minimizing long term environmental impacts	12 550

C. CAPACITY BUILDING AND NUCLEAR KNOWLEDGE MAINTENANCE FOR SUSTAINABLE ENERGY DEVELOPMENT

C.1. Energy Modelling, Databanks and Capacity Building

I1.40.04	Cost effectiveness of nuclear power compared to CO2 capture and sequestration from fossil fuel power plants	22 600

C.2. Energy Economics Environment (3E) Analysis

I1.10.04	Historical evolution of indicators of sustainable energy development (ISED) and the use of this information for designing guidelines for future energy strategies in conformity with the objectives of sustainable development	16 980

D. NUCLEAR SCIENCE

D.1. Atomic and Nuclear Data

F4.10.19	Improvement of the standard cross sections for light elements	22 050
F4.10.22	Parameters for calculation of nuclear reactions of relevance to non-energy nuclear applications	16 843

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

F4.10.21	Nuclear data for production of therapeutic radionuclides	20 075
F4.30.11	Atomic and molecular data for fusion plasma diagnostics	15 991
F4.30.12	Data for molecular processes in edge plasmas	17 200
F4.30.13	Tritium inventory in fusion reactors	20 935
F4.10.20	Evaluated nuclear data for the Thorium-Uranium fuel cycle	22 876

D.2. Research Reactors

F1.20.15	Development of improved sources and imaging systems for neutron radiography	18 615
F2.30.21	New applications of prompt gamma neutron activation analysis (PGNAA)	11 460
T1.30.10	Corrosion of research reactor aluminium-clad spent fuel in water (Phase II)	17 923

D.3. Utilization of Accelerators and Instrumentation

F1.20.16	Ion beam modification of insulators	14 017

D.4. Nuclear Fusion Research

F1.30.08	Elements of power plant design for inertial fusion energy	33 260
F1.30.10	Joint research using small tokamaks	26 167

E. FOOD AND AGRICULTURE

E.1. Sustainable Intensification of Crop Production Systems

D1.50.06	Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques	32 500
D1.50.08	Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides	41 930
D2.30.25	Pyramiding of mutated genes contributing to crop quality and resistance to stress affecting quality	51 557
D2.30.21	Molecular characterization of mutated genes controlling important traits for seed crop improvement	47 550
D2.30.23	Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology	37 108
D2.40.11	Effects of mutagenic agents on the DNA sequence in plants	36 250
D1.20.08	Selection for greater agronomic water-use efficiency in wheat and rice using carbon isotope discrimination	30 160
D4.10.16	Quality assurance of mass produced and released fruit flies for SIT programmes	43 050

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

D4.10.18	Improvement of codling moth SIT to facilitate expansion of field application	32 170
D4.10.19	Molecular technologies to improve the effectiveness of SIT	34 836
D4.10.20	Improving sterile male performance in fruit fly SIT programmes	36 054

E.2. Sustainable Intensification of Livestock Production Systems

D3.10.22	Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage	17 842
D2.30.22	Mutational analysis of root characters in annual food plants related to plant performance	29 505
D3.20.19	Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay-based technologies for increasing farmyard poultry production in Africa	40 609
D3.20.20	The use of non-structural protein of foot-and-mouth disease virus (FMDV) to differentiate between vaccinated and infected animals	18 550

E.3. Risk Analysis Methodologies and Capacity Building for Compliance with Food Safety Standards

D6.20.07	Irradiation to ensure the safety and quality of prepared meals	32 110

F. HUMAN HEALTH

F.1. Nuclear Medicine

E1.30.25	Nitrate augmented myocardial imaging for assessment of myocardial viability	20 161
E1.30.29	Evaluation of a single utilization of pulmonary perfusion scintigraphy in patients with suspected pulmonary embolism	27 227
E1.30.20	Intravascular radionuclide therapy (IVRNT) using liquid beta-emitting radiopharmaceuticals to prevent restenosis following percutaneous transluminal coronary angioplasty	8 812
E1.30.24	Improvement in the treatment of acute lymphoblastic leukemia (ALL) by the detection of minimal residual disease (MRD)	15 851
E1.30.28	Standardisation and quality control of in-house prepared radiopharmaceuticals for nuclear oncology	29 185

F.2. Applied Radiation Biology and Radiotherapy

E3.30.21	The role of teletherapy (TT) supplementary to intraluminal high dose rate (ILHDR) brachytherapy (BT) in the palliation of advanced oesophageal cancer	19 147

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

Research Coordination Meetings Held in 2004

F.3. Dosimetry and Medical Radiation Physics

E2.40.12	Development of TLD-based quality audits for radiotherapy dosimetry in non-reference conditions	21 158
E2.40.13	Development of procedures for quality assurance for dosimetry calculations in radiotherapy	21 265

F.4. Nutrition and Effects of Contaminants on Human Health

E4.30.13	Doctoral CRP on Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies	16 040
E4.30.16	Assessment of total energy expenditure and body composition for older adult subjects with different lifestyles	32 916

G. WATER RESOURCES

G.1. Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

F3.30.14	Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones	8 176
D1.50.08	Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides	4 610
F3.30.15	Isotopic age and composition of streamflow as indicators of groundwater sustainability	35 468

G.2. Reference Isotope Data and Analysis for Hydrological Applications

F3.10.02	Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate	29 880
F3.20.03	Design criteria for a network to monitor isotope compositions of runoff in large rivers	43 864

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENT

H.1. Measurement and Assessment of Radionuclides in the Marine Environment

F3.30.14	Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones	8 176
K4.10.09	Nuclear and isotopic studies of the El Niño phenomenon in the ocean	25 040

H.4. Measurement and Assessment of Radionuclides and Non-redoactive Pollutants in the Terrestrial Environment

G4.10.03	Radiochemical, chemical and physical characterisation of radioactive particles in the environment	10 000

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

Research Coordination Meetings Held in 2004

I. PHYSICAL AND CHEMICAL APPLICATIONS

I.1. Radiochemical Applications

F2.20.40	Development of generator technologies for therapeutic radionuclides	28 464
F2.20.35	Development of radioimmunometric assays and kits for non clinical applications	25 644
F2.30.18	Development and validation of speciation analysis using nuclear techniques	12 816
F2.20.37	Comparative laboratory evaluation of therapeutic radiopharmaceuticals	30 867
F2.20.38	Development of 99mTc based small bio molecules using novel 99mTc cores	30 223

I.2. Industrial Applications and Nuclear Techniques for Demining

F2.10.10	Validation of tracers and software for inter-well investigations	25 785
F2.20.34	Radiation synthesis of stimuli-responsive membranes, hydrogels and adsorbents for separation purposes	20 609
F2.30.22	Remediation of polluted waters and wastewater by radiation processing	22 500
F2.30.20	Corrosion and deposit determination in large diameter pipes, with and without insulation by radiography testing	19 938

J. SAFETY OF NUCLEAR INSTALLATIONS

J.3. Use of Advanced Tools for Safety Assessment

J4.20.04	Assessment of the interfaces between neutronic, thermal-hydraulic, structural and radiological aspects in accident analyses	19 179

J.5. Engineering Safety of Existing Nuclear Installations and Site Evaluations

J4.10.05	Safety significance of near field earthquakes	9 200

J.7. Research Reactor Safety

J7.10.09	To update and expand the IAEA reliability data for research reactor PSAs	20 055
J7.10.10	Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools	22 680

K. RADIATION AND TRANSPORT SAFETY

K.5. Radiological Protection of Patients

J1.70.08	Evaluate quantitatively and promote patient dose reduction approaches in interventional radiology	14 080
J1.70.07	Avoidance of unnecessary dose to patients while transitioning from analogue to digital radiology	5 516

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

J1.70.09	Dose reduction in computed tomography (CT) while maintaining diagnostic confidence	10 719

L. MANAGEMENT OF RADIOACTIVE WASTE

L.4. Technologies for Disposable Radioactive Waste Management

T2.10.21	Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions	39 312
T2.10.20	Anthropogenic analogues for geological disposal of high-level and long lived radioactive waste	10 280
T2.10.22	Characterization and performance studies and demonstration in underground research laboratories of swelling clays as engineered barriers of geological repositories	18 520
T2.40.06	Disposal aspects of low and intermediate level decommissioning waste	29 655
	Regular Budget	**$1 883 579**

L.3. Safety Policies and Approaches for Disposable Radioactive Waste Safety

J9.10.06	Application of safety assessment methodologies for near surface waste disposal facilities (ASAM)	45 100

M. NUCLEAR SECURITY

M.3. Detection of and Response to Malicious Activities Involving Nuclear and other Radioactive Materials

M2.20.06	Improvement of technical measures to detect and respond to illicit trafficking of nuclear material and other radioactive materials	73 859
	External Funds	**$118 959**
	Overall Total	**$2 002 538**

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

Research Coordination Meetings Held in 2004

Locations:

Argentina

Canada

China (4)

Czech Republic

Germany

Guatemala

India

Indonesia

Italy (2)

Kazakhstan

Mexico

Monaco (2)

Norway

Philippines

Poland (2)

Portugal (2)

Republic of Korea

Russian Federation

South Africa (3)

Thailand

Italy

Turkey (4)

UK

USA (2)

Headquarters (41)

* Two RCMs (D1.50.08 and F3.30.14) are shown under two subprogrammes.

Total 2004 Contract Awards, by Country

Country	Total $
China	364 500
India	343 200
Russian Federation	248 200
Brazil	235 963
Argentina	201 500
Pakistan	188 000
Thailand	157 000
South Africa	134 700
Vietnam	123 000
Poland	113 500
Philippines	108 000
Czech Republic	105 000
Korea, Republic of	95 900
Cuba	95 000
Indonesia	94 500
Turkey	94 000
Mexico	88 500
Bulgaria	80 000
Hungary	80 000
United States of America	79 000
United Kingdom	70 650
Romania	69 500
Morocco	68 000
Uruguay	65 000
Kenya	64 000
Bangladesh	61 000
Slovakia	59 000
Iran, Islamic Republic of	58 000
Colombia	54 000
Malaysia	51 000
Peru	49 000
Syrian Arab Republic	48 500
Chile	47 500
Croatia	46 500
Sri Lanka	45 500
Canada	44 000
Austria	44 000
Ghana	40 000
Slovenia	40 000
Greece	39 000
Singapore	38 000
Egypt	34 500
United Republic of Tanzania	33 500
Uzbekistan	33 000
Algeria	31 000
Australia	30 700
Germany	30 000
Uganda	30 000
Switzerland	30 000
Israel	29 770
Tunisia	28 000
Costa Rica	26 000

Total 2004 Contract Awards, by Country

Country	Total $
Belgium	25 650
Sudan	25 000
Belarus	23 000
The Frmr.Yug.Rep. of Macedonia	21 000
Burkina Faso	21 000
Nigeria	19 500
Ukraine	19 000
Portugal	19 000
Estonia	18 500
Cameroon	18 000
Mongolia	17 000
Kazakhstan	17 000
Serbia and Montenegro	16 000
Ethiopia	16 000
Latvia	15 000
Armenia	14 000
Lithuania	13 000
Venezuela	12 000
Mauritius	11 000
Niger	10 000
Denmark	10 000
France	10 000
Jordan	9 000
Senegal	9 000
Yemen	8 000
Japan	8 000
Paraguay	8 000
Spain	7 000
Benin	7 000
Zambia	7 000
Malta	6 000
Cyprus	6 000
Barbados	6 000
Namibia	6 000
Guatemala	5 123
Honduras	5 000
Myanmar	5 000
Mali	5 000
Norway	5 000
Zimbabwe	5 000
Nepal	5 000
Ecuador	4 000
Italy	2 000
Total $	**4 966 856**

Active Coordinated Research Projects
at end 2004

A. NUCLEAR POWER

A.1. Nuclear Power Plant Operating Performance and Life Cycle Managment

I2.10.14 Verification of WWER steam generator tube integrity

5 Contracts 6 Agreements 01/3/1 04/12/31

Croatia(C)[1], Czech Republic(C), Finland(A)[2], France(A), Germany(A), Hungary(A) Hungary(C), Russian Federation(C), Spain(A), Ukraine(C), United States of America(A)

I2.10.16 Evaluation of radiation damage of WWER reactor pressure vessels using the IAEA database on reactor pressure vessel materials

4 Contracts 2 Agreements 01/9/15 05/9/14

Czech Republic(C), Finland(A) (2), Hungary(C), Russian Federation(C), Ukraine(C)

A.3. Coordination of International Collaboration for the Development of Innovative Nuclear Technologies

I2.50.01 Small reactors without on-site refueling

10 Contracts 5 Agreements 04/12/1 08/12/31

Brazil(C) (2), Croatia(C), India(C), Indonesia(C), Italy(A), Japan(A), Lithuania(C), Russian Federation(C) (3), United States of America(A) (3), Vietnam(C)

A.4. Technology Developments and Applications for Advanced Reactors

I3.10.12 Evaluation of high temperature gas cooled reactor performance

2 Contracts 8 Agreements 97/11/1 06/12/31

China(C), France(A), Germany(A), Indonesia(C), Japan(A), Netherlands(A), Russian Federation(A), South Africa(A), Turkey(A), United States of America(A)

I3.10.13 Conservation and application of HTGR technology: Advances in HTGR fuel technology

11 Agreements 00/11/1 05/12/31

China(A), France(A), Germany(A), Japan(A) (2), Korea, Republic of(A) (2), Netherlands(A), Russian Federation(A), South Africa(A), United States of America(A)

I3.10.14 Natural circulation phenomena, modelling and reliability of passive systems that utilize natural circulation

4 Contracts 13 Agreements 04/3/1 08/2/29

Argentina(C), Czech Republic(C), France(A), Germany(A), India(C), Italy(A) (2), Japan(A), Korea, Republic of(A), Netherlands(A), Russian Federation(A), Slovakia(C), Spain(A), Switzerland(A), United States of America(A) (3)

I3.20.04 Studies of innovative reactor technology options for effective incineration of radioactive waste

4 Contracts 18 Agreements 01/12/15 05/12/14

Belgium(A) (2), China(A) China(C), Czech Republic(C), France(A) (2), Germany(A) (2), Hungary(A) (2), India(C), Italy(A), Japan(A), Korea, Republic of(A), Netherlands(A) (2), Poland(A), Russian Federation(A) (2) Russian Federation(C), United States of America(A)

I3.20.05 Updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects

2 Contracts 7 Agreements 99/10/1 05/11/30

China(C), France(A), Germany(A), India(A), Japan(A), Korea, Republic of(A), Russian Federation(C), United Kingdom(A), United States of America(A)

I3.30.10 Intercomparison of techniques for pressure tube inspection and diagnostics

6 Contracts 1 Agreement 98/12/15 05/12/31

Argentina(C), Canada(A), India(C), Korea, Republic of(C) (2), Romania(C) (2)

[1] (C) Research Contract
[2] (A) Research Agreement

I3.50.02 Economic research on, and assessment of, selected nuclear desalination projects and case studies

8 Contracts 3 Agreements 01/12/15 06/12/31

Argentina(C), Canada(A), China(C), Egypt(C), France(A), India(C), Korea, Republic of(C), Pakistan(C), Russian Federation(C), Syrian Arab Republic(C), United States of America(A)

B. NUCLEAR FUEL CYCLE AND MATERIALS TECHNOLOGIES

B.2. Nuclear Fuel Performance and Technology

T1.20.14 Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)

4 Contracts 13 Agreements 01/3/1 06/3/31

Bulgaria(A), Canada(A), China(A), Czech Republic(C), Finland(A), France(A), Germany(A), Hungary(A), India(A), Japan(A), Romania(C), Russian Federation(C), Slovakia(C), Sweden(A), Ukraine(A), United States of America(A) (2)

T1.20.15 Improvement on the models used for fuel behaviour simulation (FUMEX II)

5 Contracts 11 Agreements 02/9/1 07/8/31

Argentina(A), Belgium(A), Bulgaria(C) (2), Canada(A), China(A), Czech Republic(C), Finland(A), Germany(A) (2), India(A), Japan(A), Korea, Republic of(A), Norway(C), Romania(A), Russian Federation(C)

B.3. Management of Spent Fuel from Power Reactors

T1.30.12 Spent fuel performance assessment and research (SPAR II)

2 Contracts 7 Agreements 04/12/1 09/12/31

Germany(A), Hungary(C), Japan(A) (2), Korea, Republic of(A), Slovakia(C), Spain(A), United Kingdom(A), United States of America(A)

B.4. Topical Nuclear Fuel Cycle Issues and Information Systems

T1.30.11 Study of process-losses in separation processes in Partitioning and Transmutation (P&T) systems in view of minimizing long term environmental impacts

3 Contracts 5 Agreements 03/9/1 08/8/31

China(A), Czech Republic(C), Germany(A), India(C), Japan(A), Korea, Republic of(A), Russian Federation(C), United States of America(A)

C. CAPACITY BUILDING AND NUCLEAR KNOWLEDGE MAINTENANCE FOR SUSTAINABLE ENERGY DEVELOPEMENT

C.1. Energy Modelling, Databanks and Capacity Building

I1.40.04 Cost effectiveness of nuclear power compared to CO2 capture and sequestration from fossil fuel power plants

9 Contracts 3 Agreements 02/5/15 06/5/31

Argentina(C), Australia(A), Bulgaria(C), China(C), India(C) (2), Korea, Republic of(A), Pakistan(C), Poland(C), Romania(C), Russian Federation(A) Russian Federation(C)

C.2. Energy Economics Environment (3E) Analysis

I1.10.04 Historical evolution of indicators of sustainable energy development (ISED) and the use of this information for designing guidelines for future energy strategies in conformity with the objectives of sustainable development

7 Contracts 02/4/1 06/3/31

Brazil(C), Cuba(C), Lithuania(C), Mexico(C), Russian Federation(C), Slovakia(C), Thailand(C)

D. NUCLEAR SCIENCE

D.1. Atomic and Nuclear Data

F4.10.19 Improvement of the standard cross sections for light elements

3 Contracts 5 Agreements 02/4/1 06/3/31

Austria(A), China(C), Germany(A), Korea, Republic of(C), Russian Federation(C), United States of America(A) (3)

F4.10.20 Evaluated nuclear data for the Thorium-Uranium fuel cycle
6 Contracts 4 Agreements 02/11/1 05/12/31
Austria(A), Belarus(C), Bulgaria(C), China(C), India(C), Japan(A), Romania(C), Russian Federation(C), United States of America(A) (2)

F4.10.21 Nuclear data for production of therapeutic radionuclides
4 Contracts 5 Agreements 02/12/1 06/12/31
Brazil(C), France(A), Germany(A), Hungary(C), Korea, Republic of(A), Russian Federation(C), Slovakia(C), United States of America(A) (2)

F4.10.22 Parameters for calculation of nuclear reactions of relevance to non-energy nuclear applications
5 Contracts 5 Agreements 03/3/15 06/12/31
Belarus(C), Belgium(A), China(C), Cuba(C), France(A), Netherlands(A), Romania(C), Ukraine(C), United States of America(A) (2)

F4.30.11 Atomic and molecular data for fusion plasma diagnostics
3 Contracts 9 Agreements 01/7/15 05/9/30
Austria(A), China(C), Germany(A) (2), Netherlands(A), Russian Federation(C), Spain(A), The Frmr.Yug.Rep. of Macedonia(C), United Kingdom(A) (2), United States of America(A) (2)

F4.30.12 Data for molecular processes in edge plasmas
3 Contracts 8 Agreements 01/8/1 05/7/31
Austria(A), Belgium(A), Czech Republic(C), France(A), Germany(A), Italy(A), Japan(A), Russian Federation(C), Slovakia(C), Sweden(A), United States of America(A)

F4.30.13 Tritium inventory in fusion reactors
3 Contracts 8 Agreements 02/8/1 06/7/31
Canada(A), Germany(A) (2), Japan(A), Russian Federation(C) (2), United Kingdom(A), United States of America(A) (3), Uzbekistan(C)

D.2. Research Reactors

F1.20.15 Development of improved sources and imaging systems for neutron radiography
7 Contracts 3 Agreements 03/3/15 06/3/14
Bangladesh(C), Brazil(C), Germany(A), India(C), Malaysia(C), Romania(C), Russian Federation(C), South Africa(C), Switzerland(A), United States of America(A)

F2.30.21 New applications of prompt gamma neutron activation analysis (PGNAA)
6 Contracts 3 Agreements 02/9/1 05/12/31
Argentina(C), China(C), Hungary(C), India(C), Korea, Republic of(A), Turkey(C), United States of America(A) (2), Venezuela(C)

T1.30.10 Corrosion of research reactor aluminium-clad spent fuel in water (Phase II)
4 Contracts 4 Agreements 02/3/15 06/3/14
Argentina(C), Brazil(A), Czech Republic(A), Kazakhstan(C), Poland(A), Romania(C), Serbia and Montenegro(C), Thailand(A)

D.3. Utilization of Accelerators and Instrumentation

F1.10.10 Development of distance learning (DL) modules on troubleshooting of nuclear instruments
5 Contracts 1 Agreement 01/11/1 05/2/14
Argentina(C), Brazil(C), Cuba(C), India(C), Israel(A), Vietnam(C)

F1.20.16 Ion beam modification of insulators
4 Contracts 2 Agreements 04/8/1 08/7/31
Bulgaria(C), Croatia(C), Germany(A), South Africa(C), Thailand(C), United Kingdom(A)

F1.20.17 Development of new techniques and applications of accelerator mass spectrometry
5 Contracts 04/12/15 08/12/14
Argentina(C) (2), China(C), Croatia(C), Kazakhstan(C)

D.4. Nuclear Fusion Research

F1.30.08 Elements of power plant design for inertial fusion energy
8 Contracts 8 Agreements 00/12/15 05/5/31
Czech Republic(C), Germany(A), Hungary(C), India(C), Japan(A) (2), Korea, Republic of(C), Poland(C), Russian Federation(C) (2), Spain(A), United States of America(A) (4), Uzbekistan(C)

F1.30.09 Dense magnetized plasmas
8 Contracts 2 Agreements 01/12/15 05/12/31
China(C), Estonia(C), Italy(A), Korea, Republic of(A), Poland(C) (2), Romania(C), Russian Federation(C) (2), Singapore(C)

F1.30.10 Joint research using small tokamaks
11 Contracts 1 Agreement 04/9/1 08/8/31
Belgium(C), Brazil(C) (3), Canada(A), China(C), Czech Republic(C), Egypt(C), Portugal(C), Russian Federation(C) (2), United Kingdom(C)

E. FOOD AND AGRICULTURE

E.1. Sustainable Intensification of Crop Production Systems

D1.20.07 Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry systems
9 Contracts 5 Agreements 98/12/1 05/12/31
Australia(A) (2), Benin(C), Chile(C), China(C), Costa Rica(C), France(A), Kenya(A) (2)Kenya(C), Malaysia(C), Sri Lanka(C), Uganda(C), Zambia(C)

D1.20.08 Selection for greater agronomic water-use efficiency in wheat and rice using carbon isotope discrimination
13 Contracts 1 Agreement 03/11/1 08/10/31
Algeria(C), Australia(C), Bangladesh(C), China(C) (2), India(C) (2), Mexico(C), Morocco(C), Pakistan(C), Philippines(C), Syrian Arab Republic(C), United States of America(A), Yemen(C)

D1.50.06 Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques
10 Contracts 3 Agreements 99/10/15 04/12/31
Benin(C), Brazil(C) (2), Burkina Faso(C), Cuba(C), Germany(C), Kenya(A), Mexico(C), Nigeria(A), United States of America(A) United States of America(C) (2), Venezuela(C)

D1.50.07 Integrated soil, water and nutrient management for sustainable rice-wheat cropping systems in Asia
9 Contracts 2 Agreements 01/10/1 06/9/30
Australia(A) Australia(C), Bangladesh(C), China(C) (2), India(A) India(C) (2), Nepal(C), Pakistan(C), Philippines(C)

D1.50.08[*] Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides
14 Contracts 6 Agreements 02/11/1 07/12/31
Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(A), Chile(C), China(C) (2), India(C), Japan(A), Morocco(C), Pakistan(C), Poland(C), Romania(C), Russian Federation(C), Switzerland(A), Turkey(C), United Kingdom(C), United States of America(A), Vietnam(C)

D1.50.09 Integrated soil, water and nutrient management in conservation agriculture
9 Contracts 2 Agreements 04/12/1 09/11/30
Argentina(C), Australia(A), Brazil(C), Chile(C), India(C), Kenya(A), Morocco(C), Pakistan(C), Turkey(C), Uganda(C), Uzbekistan(C)

D2.30.21 Molecular characterization of mutated genes controlling important traits for seed crop improvement
12 Contracts 6 Agreements 99/7/7 05/7/6
Brazil(C) (2), Bulgaria(C), Canada(A), China(C) (3), India(A), Korea, Republic of(C) (2), Philippines(C), Poland(C), Portugal(C), Turkey(C), United Kingdom(A) (2), United States of America(A) (2)

[*] Jointly with Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources (G.1.)

D2.30.23 Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology

11 Contracts 3 Agreements 00/8/1 05/11/30

China(C), Cuba(C), India(C), Indonesia(C), Iran, Islamic Republic of(C), Israel(A), Malaysia(C) (2), Pakistan(C), Philippines(C), South Africa(C), Thailand(C), United Kingdom(A), United States of America(A)

D2.30.24 Physical mapping technologies for the identification and characterization of mutated genes contributing to crop quality

10 Contracts 4 Agreements 02/9/2 07/8/31

Argentina(C), Bulgaria(C), China(C) (2), Czech Republic(C), Germany(A), Iceland(A), Pakistan(C) (2), Poland(C), Ukraine(C), United Kingdom(A), United States of America(A), Vietnam(C)

D2.30.25 Pyramiding of mutated genes contributing to crop quality and resistance to stress affecting quality

12 Contracts 5 Agreements 04/7/1 09/6/30

Australia(A), Bulgaria(C), China(C) (2), Colombia(A), Cuba(C), France(A), India(C), Indonesia(C), Iran, Islamic Republic of(C), Japan(A), Korea, Republic of(C), Pakistan(C), Poland(C), Thailand(C), The Frmr.Yug.Rep. of Macedonia(C), United Kingdom(A)

D2.30.26 Identification and pyramiding of mutated genes: novel approaches for improving crop tolerance to salinity and drought

14 Contracts 5 Agreements 04/12/1 09/11/30

China(C) (2), Cuba(C), Egypt(C), Ghana(C), India(C) (2), Indonesia(C), Israel(A), Italy(A), Pakistan(C), Thailand(C), Tunisia(C) (2), Turkey(C), United States of America(A) (3), Vietnam(C)

D2.40.11 Effects of mutagenic agents on the DNA sequence in plants

10 Contracts 3 Agreements 03/9/15 08/9/14

Bulgaria(C), China(C) (2), Colombia(C), India(C), Korea, Republic of(C) (2), Philippines(C), Poland(C), South Africa(C), United Kingdom(A), United States of America(A) (2)

D4.10.16 Quality assurance of mass produced and released fruit flies for SIT programmes

11 Contracts 6 Agreements 99/10/1 04/12/31

Argentina(A)Argentina(C) (2), Australia(A), Chile(C), Costa Rica(C), France(A), Israel(C) (2), Japan(A), Mexico(C) (2), Peru(C), Philippines(C), Portugal(C), South Africa(A), United States of America(A)

D4.10.17 Development of improved attractants and their integration into fruit fly SIT management programmes

14 Contracts 6 Agreements 00/4/1 05/8/31

Argentina(C), Brazil(C), Colombia(C), Costa Rica(C), France(A) (2), Greece(C), Honduras(C), Israel(C), Italy(A), Kenya(C), Mauritius(C), Mexico(C), Pakistan(C), Portugal(A), Spain(A) Spain(C), United Kingdom(A), United States of America(C) (2)

D4.10.18 Improvement of codling moth SIT to facilitate expansion of field application

11 Contracts 4 Agreements 02/5/1 07/4/30

Argentina(C) (2), Armenia(C), Brazil(C), Canada(A) Canada(C), Chile(C), Czech Republic(C), Russian Federation(C), South Africa(A), Switzerland(A), Syrian Arab Republic(C) (2), United States of America(A) United States of America(C)

D4.10.19 Molecular technologies to improve the effectiveness of SIT

3 Contracts 12 Agreements 03/6/12 08/6/11

Australia(A), China(C), Germany(A), Greece(A) (3), India(C), Italy(A) (2), New Zealand(A), Thailand(C), United Kingdom(A) (2), United States of America(A) (2)

D4.10.20 Improving sterile male performance in fruit fly SIT programmes

10 Contracts 6 Agreements 04/7/1 09/6/30

Argentina(C), Australia(A) (2), Croatia(C), France(A), Greece(C), Israel(C), Mauritius(C), Mexico(C) (2), Philippines(C), Portugal(C), Spain(A), Thailand(C), United States of America(A) (2)

D4.10.21 Development of mass rearing for New World (Anastrepha) and Asian (Bactrocera) fruit fly pest in support of SIT

15 Contracts 2 Agreements 04/11/15 09/11/14

Argentina(C) (2), Australia(A), Bangladesh(C), Brazil(C) (2), Costa Rica(C), Greece(C), Israel(C), Italy(A), Kenya(C), Mauritius(C), Mexico(C) (2), Philippines(C), Thailand(C), Vietnam(C)

D4.30.02 Evaluating the use of nuclear techniques for the colonization and production of natural enemies of agricultural insect pests

14 Contracts 3 Agreements 99/8/1 05/5/31

Argentina(C), Austria(A) (2), Bangladesh(C), Bulgaria(C), China(C), India(C), Indonesia(C), Mexico(C), Pakistan(C), Poland(C), Slovakia(C), Syrian Arab Republic(C), Turkey(C) (2), United States of America(A) United States of America(C)

E.2. Sustainable Intensification of Livestock Production Systems

D3.10.22 Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage

5 Contracts 3 Agreements 98/7/1 04/12/31

Australia(A), Bangladesh(C), Brazil(C), Canada(A), Indonesia(C), Tunisia(C), Turkey(C), United Kingdom(A)

D3.10.23 Integrated approach for improving small scale market oriented dairy systems

11 Contracts 4 Agreements 01/11/1 06/12/31

Bangladesh(C), Cameroon(C), Malaysia(A), Pakistan(C), Paraguay(C), Peru(C) (2), South Africa(C), Sri Lanka(C), Tunisia(C), United Kingdom(A), United Republic of Tanzania(C), United States of America(A), Uruguay(A), Venezuela(C)

D3.10.24 Development and use of rumen molecular techniques for predicting and enhancing livestock productivity

10 Contracts 4 Agreements 03/11/15 09/11/14

Brazil(C), China(C) (2), Colombia(C), Cuba(C), Ethiopia(C), India(C), Japan(A), New Zealand(A), Switzerland(C), Thailand(C), Turkey(C), United Kingdom(A), United States of America(A)

D3.10.25 Gene-based technologies in livestock breeding: Characterization of small ruminant genetic resources in Asia

9 Contracts 04/12/1 09/11/30

Bangladesh(C), China(C) (2), Indonesia(C), Iran, Islamic Republic of(C), Kenya(C), Pakistan(C), Sri Lanka(C), Vietnam(C)

D3.20.20 The use of non-structural protein of foot-and-mouth disease virus (FMDV) to differentiate between vaccinated and infected animals

15 Contracts 5 Agreements 99/1/15 04/12/31

Argentina(C) (2), Australia(C), Austria(C), Brazil(A)Brazil(C), China(C) (2), Colombia(C), Denmark(A), Italy(A), Lao P.d.r.(C), Malaysia(C), Myanmar(C), Peru(C), Philippines(C), South Africa(C), Thailand(C), United Kingdom(A), United States of America(A)

D3.20.21 Developing, validating and standardising methodologies for the use of PCR and PCR-ELISA in the diagnosis and monitoring of control and eradication programmes for trypanosomosis

11 Contracts 5 Agreements 00/11/15 05/11/14

Belgium(A)Belgium(C), Bolivia(C), Brazil(C), Burkina Faso(C), Chile(C), Côte d'Ivoire(C), Germany(A), Kenya(C), Netherlands(A) (2), South Africa(C), Thailand(C), Uganda(C), United Kingdom(A), Vietnam(C)

D3.20.22 The development of strategies for the effective monitoring of veterinary drug residues in livestock and livestock products in developing countries

15 Contracts 3 Agreements 02/1/1 06/12/31

Argentina(C), Barbados(C), Brazil(C), Cyprus(C), Germany(A)Germany(C), Indonesia(C), Kenya(C), Korea, Republic of(C), Malta(C), Namibia(C), South Africa(C), Sri Lanka(C), Sweden(A), Thailand(C), Turkey(C), United Kingdom(A)United Kingdom(C)

D4.20.09 Enabling technologies for the expansion of SIT for old and new world screwworm

7 Contracts 4 Agreements 01/8/1 05/7/31

Brazil(C), Indonesia(C), Iran, Islamic Republic of(C), Sweden(A), United Kingdom(A) United Kingdom(C) (2), United States of America(A) (2), Uruguay(C), Venezuela(C)

D4.20.10 Improved and harmonized quality control for expanded tsetse production, sterilization and field application

12 Contracts 2 Agreements 03/6/12 08/6/11

Austria(A) (2), Belgium(C), Burkina Faso(C), Costa Rica(C), Ethiopia(C), Kenya(C) (2), Mali(C), Slovakia(C) (2), South Africa(C), Uganda(C), United Republic of Tanzania(C)

E.3. Risk Analysis Methodologies and Capacity Building for Compliance with Food Safety Standards

D6.10.22 Use of irradiation to ensure hygienic quality of fresh, pre-cut fruits and vegetables and other minimally processed food of plant origin

11 Contracts 4 Agreements 01/4/1 05/8/31

Argentina(C), Brazil(C), Canada(A), Chile(C), China(C), Egypt(C), Hungary(C), India(C), Malaysia(C), Pakistan(C), Portugal(C), Turkey(C), United Kingdom(A), United States of America(A) (2)

D6.10.23 Testing the efficiency and uncertainty of sample processing for analysis of food contaminants

12 Contracts 4 Agreements 02/4/1 07/3/31

Argentina(C), Australia(A), Belarus(C), China(C), Colombia(C), Costa Rica(C), Croatia(C), Hungary(C), India(A) India(C) (2), Netherlands(A), Serbia And Montenegro(C), Slovenia(C), Thailand(C), United Kingdom(A)

D6.20.07 Irradiation to ensure the safety and quality of prepared meals

11 Contracts 3 Agreements 02/1/1 06/2/28

Argentina(C), China(C), Ghana(C), Greece(C), Hungary(C), India(C), Indonesia(C), Israel(A), Korea, Republic of(C), South Africa(C), Syrian Arab Republic(C), Thailand(C), United Kingdom(A), United States of America(A)

D5.40.03 Quality control of pesticide products

12 Contracts 3 Agreements 00/12/1 05/11/30

China(C), Cuba(C), Greece(A), Hungary(C), India(C), Korea, Republic of(C), Myanmar(C), Nigeria(C), Philippines(C), Thailand(C), Turkey(C), United States of America(A) (2), Uruguay(C), Vietnam(C)

F. HUMAN HEALTH

F.1. Nuclear Medicine

E1.10.13 Development and validation of an Internet based clinical and technical study communication system for nuclear medicine

3 Contracts 1 Agreement 98/12/15 04/12/31

Argentina(C), China(C) (2), United States of America(A)

E1.30.19 Doctoral CRP on Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radioconjugate therapy and internal dosimetry

9 Contracts 7 Agreements 00/9/1 05/8/31

Australia(A), Austria(A), China(C), Colombia(C), France(A), India(A) India(C), Mongolia(C), Philippines(C), Singapore(C), Slovenia(C), Thailand(C), United Kingdom(A), United States of America(A) (2), Vietnam(C)

E1.30.20 Intravascular radionuclide therapy (IVRNT) using liquid beta-emitting radiopharmaceuticals to prevent restenosis following percutaneous transluminal coronary angioplasty

7 Contracts 4 Agreements 00/11/15 04/12/31

Colombia(C), Cuba(C), Germany(A), Hungary(C), India(C), Iran, Islamic Republic of(C), Korea, Republic of(A), Poland(C), Turkey(C), United States of America(A) (2)

E1.30.22 Harmonization of radionuclide procedures and protocols in the management of neonatal hydronephrosis

14 Contracts 2 Agreements 01/8/1 05/7/31

Algeria(C), Chile(A)Chile(C), China(C), Colombia(C), Cuba(C), Czech Republic(C), Estonia(C), Greece(C), India(C), Iran, Islamic Republic of(C), Pakistan(C), Peru(C), Serbia and Montenegro(C), Slovakia(C), Spain(A)

E1.30.23 Radiopharmaceutical imaging to predict and evaluate the response of breast cancer to neoadjuvant chemotherapy

7 Contracts 1 Agreement 01/8/1 05/11/30

Argentina(C), Chile(C), Colombia(C), Cuba(C), India(C), Italy(A), Poland(C), Thailand(C)

E1.30.24 Improvement in the treatment of acute lymphoblastic leukemia (ALL) by the detection of minimal residual disease (MRD)

7 Contracts 1 Agreement 02/10/24 05/12/31

Chile(C), France(C), India(C), Myanmar(C), Pakistan(C), Sudan(C), United Kingdom(A), Uruguay(C)

E1.30.25 Nitrate augmented myocardial imaging for assessment of myocardial viability

8 Contracts 3 Agreements 02/9/1 05/12/31

Australia(A), Bulgaria(C), China(A), Cuba(C), India(A)India(C), Lithuania(C), Pakistan(C), Philippines(C), Singapore(C), Uruguay(C)

E1.30.26 Comparative evaluation of radiopharmaceuticals for radiosynovectomy

12 Contracts 3 Agreements 02/10/15 05/12/31

Argentina(C), Chile(C), Colombia(C), Germany(A), India(C), Korea, Republic of(C), Philippines(C), Poland(C), Serbia and Montenegro(C), Slovakia(C), Thailand(C), United States of America(A), Uruguay(C), Venezuela(A), Vietnam(C)

E1.30.27 Role of radionuclide techniques in the diagnosis of early dementia

9 Contracts 4 Agreements 03/7/1 08/6/30

Bangladesh(C), China(C), Cuba(C), Czech Republic(C), Hungary(C), India(A) India(C), Italy(A), Japan(A) Japan(C), Korea, Republic of(C), Norway(A), Singapore(C)

E1.30.28 Standardisation and quality control of in-house prepared radiopharmaceuticals for nuclear oncology

10 Contracts 1 Agreement 04/6/1 08/5/31

Algeria(C), China(C), Costa Rica(C), Cuba(C), India(C), Mongolia(C), Singapore(C), The Frmr.Yug.Rep. of Macedonia(C), Turkey(C), United States of America(A), Uruguay(C)

E1.30.29 Evaluation of a single utilization of pulmonary perfusion scintigraphy in patients with suspected pulmonary embolism

11 Contracts 1 Agreement 04/9/1 07/8/31

Croatia(C), Czech Republic(C), India(C) (2), Japan(A), Pakistan(C), Philippines(C), Poland(C), Slovenia(C), Thailand(C), Turkey(C), Uruguay(C)

E1.30.30 Development and quality control of hospital prepared radiopharmaceuticals for infection imaging for use in HIV/AIDS positive patients

8 Contracts 1 Agreement 04/11/15 07/11/14

Argentina(C), India(C), Indonesia(C), Iran, Islamic Republic of(C), Netherlands(A), South Africa(C), Syrian Arab Republic(C), Uruguay(C), Vietnam(C)

F.2. Applied Radiation Biology and Radiotherapy

E3.30.18 Aspects of radiobiology applicable in clinical radiotherapy - Increase of the number of fractions per week

7 Contracts 1 Agreement 98/9/15 06/3/31

Chile(C), Denmark(A) Denmark(C), Estonia(C), India(C) (2), Pakistan(C) (2)

E3.30.21 The role of teletherapy (TT) supplementary to intraluminal high dose rate (ILHDR) brachytherapy (BT) in the palliation of advanced oesophageal cancer

7 Contracts 1 Agreement 02/9/1 06/8/31

Brazil(C), Canada(C), China(C), Croatia(C), India(C), South Africa(C), Sudan(C), United States of America(A)

E3.30.22 Doctoral CRP on clinical and experimental studies to improve radiotherapy outcome in AIDS cancer patients

7 Contracts 2 Agreements 03/6/15 09/6/14

Canada(C), China(C), India(C), South Africa(C), Uganda(C), United Kingdom(A), United Republic of Tanzania(C), United States of America(A), Zimbabwe(C)

E3.30.23 Resource sparing treatment of head and neck cancer

9 Contracts 03/9/15 09/9/15

Algeria(C), Egypt(C), Indonesia(C), Malaysia(C), Morocco(C), Pakistan(C), Philippines(C), Thailand(C), Tunisia(C)

E3.30.24 Radiobiological and clinical study on viral-induced cancers response to radiotherapy

7 Contracts 1 Agreement 04/8/1 10/7/31

Brazil(C), Canada(C), India(C), Korea, Republic of(C), Morocco(C), Peru(C), South Africa(C), United Kingdom(A)

F.3. Dosimetry and Medical Radiation Physics

E2.10.05 Harmonization of quality practices for nuclear medicine radioactivity measurements

5 Contracts 3 Agreements 04/12/15 08/12/14

Brazil(C), Cuba(C), Czech Republic(A), India(A), Iran, Islamic Republic of(C), Korea, Republic of(A), Romania(C), Turkey(C)

E2.40.12 Development of TLD-based quality audits for radiotherapy dosimetry in non-reference conditions

7 Contracts 2 Agreements 01/12/15 07/2/28

Algeria(C), Argentina(C), Austria(A), Belgium(A), Bulgaria(C), China(C), Cuba(C), India(C), Poland(C)

E2.40.13 Development of procedures for quality assurance for dosimetry calculations in radiotherapy

5 Contracts 2 Agreements 04/4/1 08/3/31

Argentina(C), Cuba(C), Estonia(C), Germany(A), South Africa(C), Thailand(C), United States of America(A)

E2.40.14 Development of procedures for in vivo dosimetry in radiotherapy

5 Contracts 2 Agreements 04/12/15 07/12/14

Brazil(C), Canada(A), China(C), Croatia(C), Pakistan(C), Poland(C), United Kingdom(A)

F.4. Nutrition and Effects of Contaminants on Human Health

E4.10.13 Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities

11 Contracts 3 Agreements 01/12/15 05/12/31

Brazil(C), Canada(A), China(C), Czech Republic(C), Ghana(C), India(C), Nigeria(C), Peru(C), Russian Federation(C), Slovenia(C), South Africa(A), Sweden(A), Uzbekistan(C), Vietnam(C)

E4.30.13 Doctoral CRP on Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies

11 Contracts 6 Agreements 01/12/15 05/12/31

Ghana(C), India(A) India(C), Indonesia(C), Mexico(C), Pakistan(C), Sri Lanka(C), Switzerland(A) (2) Switzerland(C) (2), Thailand(C), United Kingdom(A), United States of America(A) (2) United States of America(C) (2)

E4.30.14 Application of isotopic and nuclear techniques in the study of nutrition-pollution interactions and their impact on the nutritional status of human subjects in developing country populations

8 Contracts 3 Agreements 01/12/15 05/12/31

Bangladesh(C), Brazil(A), Chile(C), China(C), India(C), Kenya(C), Korea, Republic of(A), Morocco(C), Peru(C), Sweden(A), Vietnam(C)

E4.30.15 The application of isotopic and nuclear techniques in studies related to intrauterine growth restriction (IUGR) issues in populations from developing countries

9 Contracts 1 Agreement 03/9/15 07/9/14

Bangladesh(C), Brazil(C), Cameroon(C), India(C), Morocco(C), Pakistan(C), South Africa(C), Sudan(C), United Republic of Tanzania(C), United States of America(A)

E4.30.16 Assessment of total energy expenditure and body composition for older adult subjects with different lifestyles

9 Contracts 3 Agreements 03/11/1 07/10/31

Brazil(C), China(C), Guatemala(C), India(C), Mexico(C), Morocco(C), New Zealand(A), Philippines(C), Senegal(C), South Africa(C), United States of America(A) (2)

G. WATER RESOURCES

G.1. Iosotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

F3.30.12 Origins of salinity and impacts on fresh groundwater resources: Optimization of isotopic techniques

3 Contracts 5 Agreements 00/8/1 05/7/31

Australia(A), France(A), Italy(A), Jordan(C), Korea, Republic of(C), Morocco(C), Sweden(A), United Kingdom(A)

F3.30.13 Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection

8 Contracts 2 Agreements 00/12/15 05/12/14

Austria(A), China(C), Germany(C), India(C), Israel(C), Pakistan(C), Slovenia(C), South Africa(C), Syrian Arab Republic(C), United Kingdom(A)

F3.30.14[*] Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones

5 Contracts 4 Agreements 02/8/1 06/7/31

Brazil(C), India(A), Italy(C), Japan(A), Russian Federation(C), Slovenia(C), Turkey(C), United States of America(A) (2)

F3.30.15 Isotopic age and composition of streamflow as indicators of groundwater sustainability

13 Contracts 3 Agreements 04/7/1 10/6/30

Argentina(C), Austria(A), Brazil(C), China(C), Colombia(C), Germany(A), Ghana(C), Greece(C), India(C), Morocco(C), Pakistan(C), Portugal(A), Serbia and Montenegro(C), Slovakia(C), Turkey(C), Vietnam(C)

G.2. Reference Isotope Data and Analysis for Hydrological Applications

F3.20.03 Design criteria for a network to monitor isotope compositions of runoff in large rivers

11 Contracts 8 Agreements 02/3/22 06/3/31

Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(C), China(C), France(A), Germany(A), India(C), Israel(A), Japan(A), Pakistan(C), Slovenia(C), South Africa(C), Syrian Arab Republic(C), Turkey(C), United States of America(A) (2), Vietnam(C)

F3.40.10 Isotope methods for the study of water and carbon cycle dynamics in the atmosphere and biosphere

5 Contracts 2 Agreements 04/11/15 08/11/14

Australia(C), Canada(C), China(C), Pakistan(C), Switzerland(A), United States of America(A) United States of America(C)

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENT

H.1. Measurement and Assessment of Radionuclides in the Marine Environment

K4.10.09 Nuclear and isotopic studies of the El Niño phenomenon in the ocean

4 Contracts 7 Agreements 04/3/1 09/2/28

Australia(A) (2), France(A), Indonesia(C), Israel(C), Jordan(C), Monaco(A), New Zealand(A), Peru(C), United States of America(A) (2)

H.2. Radioecological Approaches to Coastal Contaminant Problems

K4.10.08 Nuclear applications to determine bioaccumulation parameters and processes used for establishing coastal zone monitoring and management criteria

6 Contracts 3 Agreements 02/12/15 05/12/14

Australia(A), Brazil(C), Cuba(C), Indonesia(C), Korea, Republic of(A), Pakistan(C), Philippines(C), Thailand(C), United States of America(A)

H.4. Measurement and Assessment of Radionuclides and Non-redoactive Pollutants in the Terrestrial Environment

G4.10.03 Radiochemical, chemical and physical characterisation of radioactive particles in the environment

4 Contracts 4 Agreements 00/12/1 05/11/30

Denmark(A), Finland(A), Hungary(C), Kazakhstan(C), Norway(A), Russian Federation(C), Ukraine(C), United States of America(A)

I. PHYSICAL AND CHEMICAL APPLICATIONS

I.1. Radiochemical Applications

F2.20.35 Development of radioimmunometric assays and kits for non clinical applications

8 Contracts 3 Agreements 01/8/1 06/7/31

China(C), Cuba(C), Greece(C), Hungary(A), India(A), Indonesia(C), Iran, Islamic Republic of(C), Poland(C), Thailand(C), United Kingdom(A), Uruguay(C)

[*] Jointly with Measurement and Assessment of Radionuclides in the Marine Environment (H.1.)

F2.20.36 Development of radioactive sources for emerging therapeutic and industrial applications

8 Contracts 3 Agreements 02/4/1 05/6/30

Belarus(C), China(C), Hungary(A), India(C), Iran, Islamic Republic of(C), Kazakhstan(C), Korea, Republic of(A), Peru(C), Poland(C), Russian Federation(C), United States of America(A)

F2.20.37 Comparative laboratory evaluation of therapeutic radiopharmaceuticals

9 Contracts 6 Agreements 02/8/1 05/10/31

Brazil(A), Cuba(C), Czech Republic(A), Greece(C), Hungary(C), India(C), Italy(A), Korea, Republic of(A), Mexico(C), Pakistan(C), Poland(C), Romania(C), United Kingdom(A), United States of America(A), Uruguay(C)

F2.20.38 Development of 99mTc based small bio molecules using novel 99mTc cores

6 Contracts 7 Agreements 03/3/15 06/3/14

Austria(A), Brazil(C), China(C), Germany(A), Greece(C), Hungary(C), India(C), Italy(A), Portugal(A), Russian Federation(A), Switzerland(A), United States of America(A), Uruguay(C)

F2.20.40 Development of generator technologies for therapeutic radionuclides

8 Contracts 5 Agreements 04/7/1 08/6/30

Brazil(C), China(C), Cuba(C), Germany(A), India(C), Indonesia(C), Italy(A), Korea, Republic of(A), Mexico(C), Poland(C), Russian Federation(A), United States of America(A), Vietnam(C)

F2.30.23 Applications of nuclear analytical techniques to investigate the authenticity of art objects

11 Contracts 4 Agreements 04/11/15 08/11/14

Brazil(C), China(C), Croatia(C), Cuba(C), France(A), Germany(A), Ghana(C), Greece(A), Hungary(C), Kazakhstan(C), Malaysia(C), Mexico(C), Peru(C), Poland(A), Syrian Arab Republic(C)

I.2. Industrial Applications and Nuclear Techniques for Demining

F2.10.09 Industrial process gamma tomography

6 Contracts 4 Agreements 03/3/15 06/3/14

Argentina(C), Brazil(C), Czech Republic(C), France(A), Korea, Republic of(C), Malaysia(C), Norway(A), Poland(C), United Kingdom(A), United States of America(A)

F2.10.10 Validation of tracers and software for inter-well investigations

7 Contracts 3 Agreements 04/7/1 08/6/30

Argentina(C), Australia(A), Brazil(C), China(C), France(A), Indonesia(C), Norway(A), Pakistan(C), Philippines(C), Vietnam(C)

F2.20.34 Radiation synthesis of stimuli-responsive membranes, hydrogels and adsorbents for separation purposes

6 Contracts 4 Agreements 00/12/15 04/12/31

Egypt(C), France(A), Germany(A), Hungary(C), India(C), Japan(A), Kazakhstan(C), Korea, Republic of(A), Poland(C), Turkey(C)

F2.20.39 Controlling of degradation effects in radiation processing of polymers

5 Contracts 7 Agreements 03/11/15 06/11/30

Brazil(C), Bulgaria(A), Czech Republic(A), Egypt(A), Korea, Republic of(A), Pakistan(C), Poland(A), Romania(C), Spain(A), Turkey(C), United States of America(A), Vietnam(C)

F2.30.20 Corrosion and deposit determination in large diameter pipes, with and without insulation by radiography testing

10 Contracts 2 Agreements 02/6/1 05/10/31

Algeria(C), Canada(A), Germany(A), Hungary(C), India(C), Iran, Islamic Republic of(C), Malaysia(C), Pakistan(C), Romania(C), Syrian Arab Republic(C), Turkey(C), Uruguay(C)

F2.30.22 Remediation of polluted waters and wastewater by radiation processing

7 Contracts 3 Agreements 02/5/1 06/4/30

Austria(A), Brazil(C), Ecuador(C), Hungary(C), Jordan(C), Korea, Republic of(A), Poland(C), Portugal(C), Turkey(C), United States of America(A)

F2.30.24 Electron beam treatment of organic pollutants contained in gaseous streams

6 Contracts 4 Agreements 04/12/15 08/12/14

Belarus(C), Bulgaria(C), Japan(A), Korea, Republic of(C), Poland(C), Romania(C), Russian Federation(C), Saudi Arabia(A), Spain(A), United States of America(A)

J. SAFETY OF NUCLEAR INSTALLATIONS

J.3. Use of Advanced Tools for Safety Assessment

J4.20.04 Assessment of the interfaces between neutronic, thermal-hydraulic, structural and radiological aspects in accident analyses

6 Contracts 7 Agreements 02/12/1 05/11/30

Bulgaria(C), Croatia(A), Czech Republic(C), Finland(A), Hungary(A)Hungary(C), Italy(A), Russian Federation(C) (2), Slovakia(A) (2)Slovakia(C), United States of America(A)

J.5. Engineering Safety of Existing Nuclear Installations and Site Evaluation

J4.10.05 Safety significance of near field earthquakes

11 Contracts 10 Agreements 02/7/1 05/12/31

Armenia(C), Bulgaria(C), Canada(A), China(C), Finland(A), France(A) (3), India(C), Italy(A), Japan(A), Korea, Republic of(C) (2), Romania(C), Russian Federation(C), Slovakia(C), Spain(A), Turkey(C) (2), United Kingdom(A), United States of America(A)

J.7. Research Reactor Safety

J7.10.10 Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools

8 Contracts 4 Agreements 02/9/1 06/8/31

Algeria(C), Argentina(A)Argentina(C), Brazil(C), Czech Republic(C), Germany(A), Indonesia(C), Italy(A), Korea, Republic of(A), Romania(C), Syrian Arab Republic(C), Vietnam(C)

K. RADIATION AND TRANSPORT SAFETY

K.5. Radiological Protection of Patients

J1.70.06 Exploring the possibility of establishing guidance levels for interventional radiology

6 Contracts 02/5/21 06/5/31

Austria(C), Chile(C), Italy(C), Spain(C), United Kingdom(C), Uruguay(C)

J1.70.07 Avoidance of unnecessary dose to patients while transitioning from analogue to digital radiology

5 Contracts 1 Agreement 02/11/15 06/12/31

Australia(C), Austria(C), India(C), Malaysia(C), Thailand(C), United Kingdom(A)

J1.70.08 Evaluate quantitatively and promote patient dose reduction approaches in interventional radiology

4 Contracts 2 Agreements 02/11/15 06/2/28

India(C), Italy(A), Japan(A), Malaysia(C), Thailand(C), Turkey(C)

J1.70.09 Dose reduction in computed tomography (CT) while maintaining diagnostic confidence

3 Contracts 3 Agreements 02/11/15 06/2/28

Germany(A), Greece(A), India(C), Poland(C), Thailand(C), United Kingdom(A)

K.7. Safety of the Transport of Radioactive Material

J1.30.09 Accident severity during air transport of radioactive material

7 Agreements 98/6/1 05/7/31

Canada(A) (2), France(A), Germany(A), Sweden(A), United Kingdom(A), United States of America(A)

L. MANAGEMENT OF RADIOACTIVE WASTE

L.3. Safety Policies and Approaches for Disposable Radioactive Waste Safety

J9.10.05 The use of selected safety indicators (concentrations; fluxes) in the assessment of radioactive waste disposal

9 Agreements 00/2/15 05/2/14

Argentina(A), Brazil(A), China(A), Cuba(A), Czech Republic(A), Finland(A), Japan(A), Sweden(A), United Kingdom(A)

J9.10.06 Application of safety assessment methodologies for near surface waste disposal facilities (ASAM)

24 Agreements 02/8/27 05/12/31

Belarus(A), Belgium(A) (3), Brazil(A), Bulgaria(A), China(A), Cuba(A), France(A), Hungary(A), Kazakhstan(A), Korea, Republic of(A), Lithuania(A) (2), Peru(A), Romania(A) (2), Russian Federation(A) (3), South Africa(A), Spain(A), Ukraine(A), Vietnam(A)

L.4. Technologies for Disposable Radioactive Waste Management

T2.10.21 Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions

3 Contracts 9 Agreements 98/12/15 04/12/31

Argentina(A), Australia(A), Belgium(A), Croatia(C), Czech Republic(A), France(A), India(A), Japan(A), Korea, Republic of(C), Russian Federation(A) Russian Federation(C), United Kingdom(A)

T2.10.22 Characterization and performance studies and demonstration in underground research laboratories of swelling clays as engineered barriers of geological repositories

6 Contracts 3 Agreements 04/2/19 08/2/29

Canada(A), China(C), Czech Republic(C), India(A), Japan(A), Korea, Republic of(C), Russian Federation(C), South Africa(C), Ukraine(C)

T2.10.23 New development and improvements in processing of "problematic" radioactive waste streams

5 Contracts 11 Agreements 03/3/15 07/3/14

Argentina(C), Australia(A), Belarus(C), Belgium(A), China(C), Czech Republic(A) Czech Republic(C), Finland(A), India(A), Korea, Republic of(A) (2), Russian Federation(A) (2), South Africa(A), Ukraine(C), United States of America(A)

T2.40.06 Disposal aspects of low and intermediate level decommissioning waste

6 Contracts 7 Agreements 02/9/1 06/8/31

Argentina(C), Canada(A), China(C), Germany(A), Hungary(C), India(A), Korea, Republic of(A), Lithuania(C), Russian Federation(C), Slovakia(A), Sweden(A), Ukraine(C), United States of America(A)

L.7. Technologies for the Decommissioning of Installations and Restoration of Sites

T2.40.07 Innovative and adaptive technologies in decommissioning of nuclear facilities

3 Contracts 10 Agreements 04/5/1 09/4/30

Argentina(A), Austria(A), Belgium(A), Brazil(C), Cuba(C), Czech Republic(A), Denmark(A), Korea, Republic of(A), Norway(A), Russian Federation(C), Slovakia(A), Ukraine(A), United Kingdom(A)

M. NUCLEAR SECURITY

M.3. Detection of and Response to Malicious Activities Involving Nuclear and other Radioactive Materials

M2.20.06 Improvement of technical measures to detect and respond to illicit trafficking of nuclear material and other radioactive materials

16 Contracts 13 Agreements 03/3/15 06/3/14

Australia(A), Austria(A) (2), Belarus(C), China(C), Croatia(C), France(A), Georgia(C), Germany(A) (3), Indonesia(C), Italy(A) (2), Korea, Republic of(A), Latvia(C), Poland(C), Russian Federation(C) (6), Slovakia(A), Turkey(C), Ukraine(C), United States of America(A) (2), Uzbekistan(C)

CRPs Approved, but not yet initiated

A. NUCLEAR POWER

A.1. Nuclear Power Plant Operating Performance and Life Cycle Managment

I2.10.17	Influence of synergism of nickel and other alloying elements on RPV materials irradiation embrittlement
I2.10.18	Master curve approach to monitor the fracture toughness of reactor pressure vessel in nuclear power plants

A.4. Technology Developments and Applications for Advanced Reactors

I3.20.06	Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS)
I3.20.07	Analyses of and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems

D. NUCLEAR SCIENCE

D.1. Atomic and Nuclear Data

F4.10.23	Development of a reference database for ion beam analysis
F4.20.05	Reference database for neutron activation analysis
F4.20.06	Updated decay data library for actinides
F4.30.14	Atomic and molecular data for plasma modelling

D.3. Utilization of Accelerators and Instrumentation

F1.20.18	Development of harmonized QA/AC procedures for maintenance and repair of nuclear instruments

E. FOOD AND AGRICULTURE

E.1. Sustainable Intensification of Crop Production Systems

D2.30.27	Molecular tools for quality improvement in vegetatively propagated crops including banana and cassava

F. HUMAN HEALTH

F.1. Nuclear Medicine

D4.20.11	Development of standardised mass rearing systems for male anopheles arabiensis mosquitoes
E1.50.19	Improved accuracy of molecular and immunological markers for prediction of efficacy of antimalarial drugs

F.4. Nutrition and Effects of Contaminants on Human Health

E4.30.17	Assessment of nutrients uptake from biofortified crops in populations from developing countries

J. SAFETY OF NUCLEAR INSTALLATIONS

J.3. Use of Advanced Tools for Safety Assessment

J7.20.04	Probabilistic safety assessment of nuclear facilities in relation to external events

K. RADIATION AND TRANSPORT SAFETY

K.7. Safety of the Transport of Radioactive Material

J1.30.11 The appropriate level of regulatory control for the safe transport of naturally-occurring radioactive material (NORM)

CRP's Completed in 2004

A. NUCLEAR POWER

Technology Developments and Applications for Advanced Reactors

I3.30.11 Establishment of a thermophysical properties database for LWRs and HWRs

I3.50.01 Optimization of the coupling of nuclear reactors and desalination systems

D. NUCLEAR SCIENCE

Research Reactors

F1.20.13 Development and practical utilization of small angle neutron scattering (SANS) applications

E. FOOD AND AGRICULTURE

Sustainable Intensification of Crop Production Systems

D2.30.22 Mutational analysis of root characters in annual food plants related to plant performance

Sustainable Intensification of Livestock Production Systems

D3.20.17 To develop and validate standardised methods for using polymerase chain reaction (PCR) and related molecular technologies for rapid and improved animal disease diagnosis

D3.20.19 Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay-based technologies for increasing farmyard poultry production in Africa

F. HUMAN HEALTH

Nuclear Medicine

E1.10.14 To compare clinical application software between nuclear medicine laboratories by software phantoms developed by the Agency and COST B2 project

E1.30.18 Study of the relationship between recurrent lower respiratory tract infection, gastroesophageal reflux and bronchial asthma in children

Dosimetry and Medical Radiation Physics

E2.10.04 Development of techniques at SSDLs for the dissemination of absorbed dose to water standards

Nutrition and Effects of Contaminants on Human Health

E4.10.12 Health impacts of mercury cycling in contaminated environments studied by nuclear techniques

G. WATER RESOURCES

Reference Isotope Data and Analysis for Hydrological Applications

F3.10.02 Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate

I. PHYSICAL AND CHEMICAL APPLICATIONS

Radiochemical Applications

F2.30.18 Development and validation of speciation analysis using nuclear techniques

Industrial Applications and Nuclear Techniques for Demining

F2.30.19 Integration of residence time distribution (RTD) tracing with computational fluid dynamics (CFD) simulation for industrial process visualization and optimization

J. SAFETY OF NUCLEAR INSTALLATIONS

Information and Communication Networks and Global Infrastructure for Nuclear Installation Safety

J4.60.01 Round-robin exercise on WWER (water-cooled and -moderated reactor pressure vessel)-440 RPV weld metal irradiation embrittlement and annealing

Research Reactor Safety

J7.10.09 To update and expand the IAEA reliability data for research reactor PSAs

L. MANAGEMENT OF RADIOACTIVE WASTE

Technologies for Disposable Radioactive Waste Management

T2.10.20 Anthropogenic analogues for geological disposal of high-level and long lived radioactive waste

Technologies for the Decommissioning of Installations and Restoration of Sites

T2.30.14 Technologies and methods for long term stabilization and isolation of uranium mill tailings

IAEA 2004 Programme/Sub-programme and CRP Codes

MAJOR PROGRAMME 1: NUCLEAR POWER, FUEL CYCLE AND NUCLEAR SCIENCE

		CRP Code
Programme A:	**Nuclear Power**	
A1	Nuclear Power Plant Operating Performance and Life Cycle Management	I2
A3	Coordination of International Collaboration for the Development of Innovative Nuclear Technologies	I2
A4	Technology Developments and Applications for Advanced Reactors	I3
Programme B:	**Nuclear Fuel Cycle and Materials Technologies**	
B1	Uranium Production Cycle and Environment	T1
B2	Nuclear Fuel Performance and Technology	T1
B3	Management of Spent Fuel from Power Reactors	T1
B4	Topical Nuclear Fuel Cycle Issues and Information Systems	T1
Programme C:	**Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development**	
C1	Energy Modelling, Databanks and Capacity Building	I1
C2	Energy Economics Environment (3E) Analysis	I1
C3	Nuclear Knowledge Management	I1
Programme D:	**Nuclear Science**	
D1	Atomic and Nuclear Data	F4
D2	Research Reactors	F1, F2, T1
D3	Utilization of Accelerators and Instrumentation	F1
D4	Nuclear Fusion Research	F1

MAJOR PROGRAMME 2: NUCLEAR TECHNIQUES FOR DEVELOPMENT AND ENVIRONMENTAL PROTECTION

Programme E:	**Food and Agriculture**	
E1	Sustainable Intensification of Crop Production Systems	D1, D2, D4
E2	Sustainable Intensification of Livestock Production Systems	D3, D4
E3	Risk Analysis Methodologies and Capacity Building for Compliance with Food Safety Standards	D5, D6
Programme F:	**Human Health**	
F1	Nuclear Medicine	E1
F2	Applied Radiation Biology and Radiotherapy	E3
F3	Dosimetry and Medical Radiation Physics	E2
F4	Nutrition and Effects of Contaminants on Human Health	E4
Programme G:	**Water Resources**	
G1	Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources	F3
G2	Reference Isotope Data and Analysis for Hydrologic Applications	F3
Programme H:	**Protection of the Marine and Terrestrial Environments**	
H1	Measurement and Assessment of Radionuclides in the Marine Environment	K4
H2	Radioecological Approaches to Coastal Contaminant Problems	K4
H4	Measurement and Assessment of Radionuclides and Non-redoactive Pollutants in the Terrestrial Environment	G4

IAEA 2004 Programme/Sub-programme and CRP Codes

		CRP Code
Programme I:	**Physical and Chemical Applications**	
I1	Radiochemical Applications	F2
I2	Industrial Applications and Nuclear Techniques for Demining	F1, F2
MAJOR PROGRAMME 3:	**NUCLEAR SAFETY AND SECURITY**	
Programme J:	**Safety of Nuclear Installations**	
J2	Information and Communication Networks and Global Infrastructure for Nuclear Installation Safety	J7
J3	Use of Advanced Tools for Safety Assessment	J4
J5	Engineering Safety of Existing Nuclear Installations and Site Evaluation	J4
J7	Research Reactor Safety	J7
Programme K:	**Radiation and Transport Safety**	
K1	National and Global Infrastructure Enhancement for Radiation and Transport Safety	J1
K5	Radiological Protection of Patients	J1
Programme L:	**Management of Radioactive Waste**	
L3	Safety Policies and Approaches for Disposable Radioactive Waste Safety	J9, T2
L7	Technologies for the Decommissioning of Installations and Restoration of Sites	T2
Programme M:	**Nuclear Security**	
M3	Detection of and Response to Malicious Activities Involving Nuclear and other Radioactive Materials	M2

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **D2.30.20 Genetic improvement of underutilized and neglected crops in low income food deficit countries (LIFDCs) through irradiation and related techniques**

Participating Countries: Bolivia(C), Costa Rica(C), Costa Rica(C), Ecuador(C), France(A), France(A), Germany(A), Ghana(C), Ghana(C), India(C), India(C), Indonesia(C), Mexico(C), Slovakia(C), South Africa(C), South Africa(C), Syrian Arab Republic(A), Thailand(C)

Total Cost: **$440 344**

Duration: 1998-12-01 — 2003-12-16

CRP Overall Objectives

To improve food security, enhance nutritional balance, and promote sustainable agriculture in LIFDCs.

CRP Specific Objectives

To overcome major constraints to the productivity of neglected and underutilised crops by genetic improvement, in order to enhance economic viability and sustain crop species diversity, ensuring future benefits to small farmers.

Research Outputs

- Identifying and prioritising major constraints for the development of locally adapted and neglected crops
- Establishing a network of research cooperation and germplasm conservation and use
- Overcoming the constraints of neglected and under-utilised species using genetic improvement techniques including selection and cross breeding, mutation techniques and appropriate biotechnological approaches
- Developing germplasm for a number of selected neglected and under-utilised crops
- Developing protocols for genetic improvement techniques of individual under-utilised crops.

CRP Outcome (Effectiveness; Impact; Relevance)

1. Fifteen drought tolerant leafy mutants of Amaranthus tricolor were selected in the field for their comparatively higher performance in artificially created drought conditions.
2. Forty-eight Amaranthus cruentus selected mutants and eighteen mutants of K-433 hybrid were obtained, that bore various useful traits, i.e. determinate growth, uniformity in flowering and seed maturity, leaf-less inflorescences and an increased seed size.
3. Twenty-two okra mutant lines were selected showing tolerance to yellow vein mosaic virus. Twelve of them gave satisfactory yield but fruits had an undesirable shape, and the remaining ten mutants produced fruits of desirable shape and yield is yet to be determined.
4. Bambara groundnut mutants resistant to Cercospora leaf spot with desirable agronomic traits were identified. A newly developed technique shortened its generation cycle using in vitro and in vivo methods.
5. Three selected mutants of taro (B43, B63, and B 133) had the desired characters: high tolerance to leaf blight disease, early maturing, heavy corms and good taste.
6. A novel strategy for shortening generation cycles in vitro gave 7 and >4 generation cycles/year for pea and grass pea, respectively. Gene transfer with Agrobacterium tumefaciens containing reporter GUS marker gene was successful as regenerated transgenic plants expressed GUS activity inherited in the progeny.
7. Seventeen putative root rot disease tolerant mutants of cocoyam were obtained after irradiation and screening. The genetic relationship amongst 70 accessions has also been established by DNA fingerprinting.
8. A genetic diversity bank of bitter potato was established. A total of fourteen potentially useful mutants were kept for further field tests.
9. A reliable strategy for plant regeneration from in vitro cultured nodal explants was developed in Dioscorea spp. Plants were multiplied to the M1V6 generation. Dwarf plants were selected and currently are being micropropagated for large-scale plant multiplication.

A new technique has been developed for shortening generation cycle in bamabara groundnut. Moreover, it takes long time to develop a mutant variety, and further work is being carried out for developing mutant varieties and distribute to the farmers.

The CRP results will encourage paying more attention to neglected and under-utilised crops in plant breeding programs and that will allow to produce raw material for the food industry, improve nutrition in human diet, and hopefully improve food security and socio-economic status of the growers.

One group will use okra mutants in a new CRP entitled "Pyramiding of mutated genes contributing to crop quality and resistance to stress affecting quality". This group will do genetic mapping of the okra mutant resistant to yellow vein mosiac virus (YVMV), and identify and isolate resistant YVMV gene.

Only a limited number of crops produce the bulk of food consumed in the world. Many neglected and under-utilised species are extremely important for food production in low-income food deficit countries. They are locally well adapted to marginal lands and constitute an important part of the local diet, relevant to medicine, source of useful germplasm etc. The CRP is relevant in promoting the use of neglected and under-utilised crops regularly in plant breeding programmes for sustainable food production, nutrition, food security, and raw material for agro-based industries. The neglected crops would be of great help in gene identification and isolation for useful traits.

Recommended Future Action by Agency

The continuation of the research projects in this CRP should be facilitated, as they have generated useful results, to ensure continuity and realization of the goals of the projects.

Research on the evaluation of the mutants generated from this CRP for nutritional quality and acceptability by consumers is of the utmost importance. Mechanisms for the release of the improved varieties that might result from these efforts should also be established to allow farmers to benefit quickly from them.

This will require the improvement of facilities in participating countries and the training of personnel in the use of mutagenesis, tissue culture and other biotechnologies to improve neglected and under-utilised crops.

Human resources development activities are highly recommended to allow the dissemination of know-how from this CRP, to benefit researchers from various LIFDCs. If supported, short-term workshops/training programmes in developing countries for technology transfer should accomplish this.

A greater cooperation with other existing projects addressing neglected and under-utilised species, e.g. the IPGRI-IFAD Project on Andean grains, Bamnet, Tarogen, International Centre for Under-utilized Crops, Global Facilitation Unit of Global Forum for Agricultural Research, and FAO, will be essential to create important synergies and experience sharing among partners.

Sharing of germplasm among participating countries is also highly desirable. The assistance of IPGRI in developing Material Transfer Agreements would be appreciated. The recently approved FAO International Treaty for PGRFA offers opportunities in this respect.

More new CRPs on various aspects should be developed on under-utilised and neglected crops.

Resulting Publications

ADU-DAPAAH, H.K., ASIBUO, J.Y. Genetic variation in agronomic traits of bambara groundnuts induced by irradiation and ethyl methane sulphate (EMS) treatment, Submitted (Acta Agronomica).

ADU-DAPAAH, H.K., SANGWAN, R.S. (2003) Agronomic and biotechnological approaches to bambara groundnut improvement. Submitted to the Bambara groundnut Workshop in Botswana, October 2003.

DANQUAH, E.Y., BLAY, E.T., OFFEI, S.K., FOSU-NYARKO, J., AMITEYE, S. (2001) Genetic diversity in cocoyam as revealed by random amplified polymorphic DNA. African Journal of Root & Tuber Crops 4 (2) (in press).

DANQUAH, E.Y., OFFEI, S.K., ASANTE, I.K. (2003) Genetic structure of 70 cocoyam (Xanthosoma sagittifolium, Linn, Schott) accessions in Ghana based on RAPD. Submitted, Hereditas.

DANQUAH, E.Y., OFFEI, S.K. BLAY, E.T. ASANTE, I.K. (2003) Genetic polymorphism in cocoyam (Xanthosoma sagittifolium L. Schott). Ghana Journal of Horticulture (Accepted).

DURIEU, P., OCHATT, S. (2000) Efficient intergeneric fusion of pea (Pisum sativum L.) and grass pea (Lathyrus sativus L.) protoplasts. Journal Experimental Botany 51: 1237-1242.

LACROIX, B., ASSOUMOU, Y., SANGWAN, R.S. (2003) Efficient in vitro direct shoot organogenesis and regeneration of fertile plants from embryo explants of bambara groundnuts (Vigna subterranea L. Verdc.). Plant Cell Reports 21: 1153-1158.

GAJDOSOVA A., LIBIAKOVA G. (2002). Breeding programme for cultural species of amaranth. Proc. from IXth scientific seminar "New knowledge from genetics and breeding of agricultural crops", Piestany, p. 123-124 (in Slovak).

GAJDOSOVA A. (2002). Improvement of selected Amaranthus cultivars by means of mutation techniques and biotechnological approaches. In: Report of the second research Co-ordination Meeting of FAO/IAEA CRP "Genetic improvement of under-utilised and neglected crops in LIFDCs through irradiation and related techniques", San Jose, Costa Rica, p. 27-28.

GAJDOSOVA A., LIBIAKOVA G., KORMUTAK A., FEJÉR J. (2003). Application of radiation mutagenesis and biotechnological approaches in improvement of selected Amaranthus cultivars. Proceedings International Symposium "Recent Advances in Plant Biotechnology", Stara Lesna, Sept. 7-13, Slovak Republic, in press.

JUREKOVA Z., PULLMAN J., STEFCIKOVA M., GAJDOSOVA A. (1997b). In vitro cultivation of Amaranthus L. genus plants. In: Proceedings Conference "Adaptability of growing and use of amaranth (Amaranthus L.) in Slovakia", Nitra, p. 20-25 (in Slovak).

MENDOZA, V.H. (1998) Experiencias Preliminares con Irradiación (Rayos Gamma) en Papa. (Solanum tuberosum). Instituto Boliviano de Ciencia y Tecnología Nuclear. La Paz - Bolivia. 3p.

MURILLO, R. (1998) Optimización de medios de Cultivo para la Micropropagación en Papa Amarga Variedades Bola Lucky y Kheto Lucky .(Solanum juzepczukii). Instituto Boliviano de Ciencia y Tecnología Nuclear (IBTEN). BOL 104/15 OIEA La Paz - Bolivia. 7p.

MURILLO, R. (1999) Medios de Cultivo para Producción de Semilla Pre-básica de Papa en Cultivares Waycha Paceña y Sani Negra. Instituto Boliviano de Ciencia y Tecnología Nuclear (IBTEN). La Paz - Bolivia. 6p.

MURILLO, R. (2002) Mejoramiento por mutaciones inducidas mediante el uso de técnicas nucleares en papa amarga (Solanum juzepczukii). III Reunion Nacional de Biotecnología Vegetal REDBIO-FAO. Oruro, Bolivia.

OCHATT, S.J., DURIEU, P., JACAS, L., PONTECAILLE, C. (2001) Protoplast, cell and tissue cultures for the biotechnological breeding of grass pea. (Lathyrus sativus L.). Lathyrus Neurolathyrism Newsletter 2: 35-38.

OCHATT, S.J., MUNNEAUX, E., MACHADO, C., JACAS, L., PONTECAILLE, C. (2002a) The hyperhydricity of in vitro regenerants of grass pea (Lathyrus sativus L.) is linked with an abnormal DNA content. Journal Plant Physiology 159: 1021-1028.

OCHATT, S., SANGWAN, R.S., MARGET, P., ASSOUMOU NDONG, Y., RANCILLAC, M., PERNEY, P. (2002b) New approaches towards the shortening of generation cycles for faster breeding of protein legumes. Plant Breeding 121: 436-440.

OCHATT, S.J., BENABDELMOUNA, A., MARGET, P., AUBERT, G., MOUSSY, F., PONTECAILLE, C., JACAS, L. (2003a) Overcoming hybridization barriers between pea and some of its wild relatives. Submitted.

OCHATT, S.J., GUINCHARD, A., RIBALTA, F., SANGWAN, R.S. (2003b) Early prediction of somatic embryogenesis competence from cell suspensions of grain legumes. Vth European Conference on Grain Legumes, in press.

OFFEI, S.K., DANQUAH, E.Y., BLAY, E.T., ABOAGYE-NUAMAH, F. (2002). Isozyme and total protein polymorphisms among 52 accessions of cocoyam (Xanthosoma sagittifolium). Ghana Journal of Horticulture 1: 1-8.

PHADVIBULYA, V. et al. (2001) Induced mutation for resistance to yellow vein mosaic virus in okra. 8th Science and Nuclear Technology Conference. OAEP, Bangkok, Thailand (in Thai).

SABORÍO, F., SOLANO, W. (2002) Evaluación de la diversidad genética del tiquisque blanco (Xanthosoma sagittifolium) utilizando RAPDs. Simposio Subregional de Biodiversidad, Biotecnología y Bioseguridad. CATIE, Turrialba, Costa Rica, July 3-5, 2002.

STEFCIKOVA M., PULLMAN J., JUREKOVA Z., GAJDOSOVA A. (1997).The first knowledge on cultivation of some Amaranthus species. In: Proc. from Conference "Utilizing biological sciences in plant production VII", Nitra, p.81-88 (in Slovak).

IAEA-TECDOC-1426 [2004]. Genetic improvement of under-utilised and neglected crops in low income food deficit countries through irradiation and related techniques, pp 219.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **D3.20.18 The monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays**

Participating Countries: Botswana(C), Côte d'Ivoire(C), Ethiopia(C), France(A), Ghana(C), Kenya(C), Mali(C), Namibia(C), Nigeria(C), Sweden(A), Uganda(C), United Kingdom(A), United Kingdom(C), United Republic of Tanzania(C), United States of America(A), Zambia(C)

Total Cost: **$345 995**

Duration: 1997-11-15 — 2003-12-15

CRP Overall Objectives

To assist national veterinary laboratories in the diagnosis of CBPP and in the monitoring of national and regional control and eradication campaigns.

CRP Specific Objectives

To establish the monoclonal antibody based ELISA test (c-ELISA) for the detection of antibodies to CBPP to monitor national and regional CBPP control programs in 11 countries.

Research Outputs

The capability to diagnose CBPP by ELISA was established in the 11 participating laboratories.

CRP Outcome (Effectiveness; Impact; Relevance)

The ELISA technology for CBPP diagnosis is fully established in 11 African laboratories and contributes to the national control programs. The c-ELISA was evaluated with respect to diagnostic sensitivity and specificity. The number of CBPP outbreaks was reduced during the course of this project according to OIE animal health data.

The introduction of the c-ELISA and the generation of relevant data from samples gathered by the surveillance programs supported the control strategies against CBPP in the co-operating countries. This reduced the number of outbreaks of CBPP in these countries and helped the veterinary authorities in the control of the disease and improved livestock productivity. The new diagnostic capacities of the counterpart laboratories will help them to follow the OIE path way towards declaration of freedom of CBPP.

The CRP was instrumental in introducing a critical diagnostic capacity and the research data generated during the CRP resulted in the acceptance of the c-ELISA by OIE as recommended test. This facilitates the control of the disease and supports the declaration of freedom leading to increased productivity and reduced trade restrictions.

Recommended Future Action by Agency

As vaccination is still a problematic part of the CBPP control strategy a diagnostic test differentiating vaccinated animals from infected would be of high value in the final stages of eradication. Similarly molecular methods as PCR and PCR sequencing would help in early detection and epidemiology. These in combination with an integrated surveillance and disease reporting system introduced in all affected African countries will be vital for the eradication form the continent.

Resulting Publications

Bruderer U, Regalla J, Abdo el-M, Huebschle OJ, Frey J. Serodiagnosis and monitoring of contagious bovine pleuropneumonia (CBPP) with an indirect ELISA based on the specific lipoprotein LppQ of Mycoplasma mycoides subsp. mycoides SC. Vet Microbiol. 2002 Jan 23;84(3):195-205.

March JB, Kerr K, Lema B. Rapid detection of contagious bovine pleuropneumonia by a Mycoplasma mycoides subsp. mycoides SC capsular polysaccharide-specific antigen detection latex agglutination test. Clin Diagn Lab Immunol. 2003 Mar;10(2):233-40.

A TECDOC is in the final review process and will be published early 2005.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **D4.20.05 Genetics application to improve the SIT for tsetse control/eradication**

Participating Countries: Belgium(A), Burkina Faso(C), Canada(A), Côte d'Ivoire(C), Greece(C), Italy(A), Kenya(C), United States of America(A), United States of America(A), United States of America(A), United States of America(A)

Total Cost: **$137 254**

Duration: 1997-01-01 — 2003-08-31

CRP Overall Objectives

To improve the planning, implementation and evaluation of tsetse SIT programmes by the development of appropriate genetic tools.

CRP Specific Objectives

(i) To develop and apply genetic tools for studying tsetse fly populations and their possible isolation.
(ii) To investige tsetse fly refractoriness to trypanosome infections.
(iii) To develope genetic / physiological maps for further relevant studies with tsetse.

Research Outputs

The participants developed a suite of molecular genetic markers, including allozyme, mitochondrial and microsatellite loci. The markers were used for basic genetic studies and for assessing tsetse gene-flow and isolation as part of applied tsetse population genetic investigations in the field. The breeding structure of some PALPALIS group and MORSITANS group tsetse fly populations have been characterized, and the findings indicate a surprisingly restricted gene flow among tsetse populations in the field. This suggests that a possible return of tsetse populations to areas from which they have been eliminated may be a slow process, if compared with many other insect pests.

Further studies identified genes that code for anti-parasitic substances, which may eventually be expressed by tsetse symbionts. The participants also identified and characterized, at the molecular level, tsetse fly symbionts and parasites, which may in future be instrumental to "drive" desired traits, for example refractoriness to acquiring mature trypanosome infections, into mass-reared tsetse fly strains used in SIT campaigns. Monoclonal antibodies developed against major tsetse gut proteins provide an additional basis for understanding tsetse-trypanosome interactions and for identifying putative targets for disrupting these interactions.

Polytene chromosome maps have been developed for the MORSITANS tsetse fly group and for Glossina austeni. Such maps are considered as the basis for various relevant cytogenetic analyses, including the precise location of cloned genes, the mapping of insertions and other genetic changes, and for various other studies of, for example, evolutionary relationships and tsetse population genetic differences.

Hybridization studies conducted with selected tsetse fly species and subspecies confirmed the major cause of hybrid male sterility to be the incompatibility of sex chromosomes from different taxa, and that hybridisation asymmetry (different success in reciprocal crosses) is due chromosomal rather than maternally inherited factors.

CRP Outcome (Effectiveness; Impact; Relevance)

Studies on morsitans group and palpalis group tsetse flies show unanticipated levels of genetic differentiation. Genetic drift is the likely operating mechanism, but adaptation cannot be ruled out. Current and planned research is investigating the likelihood of local adaptations in maintaining the high levels of genetic differentiation.

Much basic research has been accomplished and promising results have been obtained in engineering the secondary symbiont Sodalis to express anti-trypanosomal substances thus making released flies inherently refractory. An additional number of antibiotic candidate substances have been identified. We must plan for field evaluation of these promising developments.

State of the art cytogenetic [i.e. physical] maps have been constructed for G. m. submorsitans, G. m. morsitans, G. pallidipes, and G. austeni. Genetic maps have been developed for G. m. submorsitans, G. m. morsitans, and G. p. palpalis. New biochemical and molecular markers have been incorporated into these linkage maps and additional work is anticipated.

Genetic diversities of colonized tsetse indicate conservation of genetic variation, testifying to the careful husbandry required to maintain thriving tsetse cultures. The question of genetic compatibility of released, sterile mass reared flies and their wild conspecifics has not been investigated directly, but genetic studies of natural populations show high levels of population structure. Although there is no a priori reason why genetically differentiated populations should predict a degree of mating incompatibility between released and wild flies, the possibility should be investigated thoroughly. Cryptic species may occur within the palpalis group. Evidence for this comes from population genetics of natural G. p. gambiensis populations and from breeding experiments on G. p. palpalis cultures that originated from different regions. The development of new microsatellite genetic markers for morsitans and palpalis group tsetse allow, for the first time, the unambiguous genotyping of natural populations, in addition to monitoring genetic drift [i.e., random changes] in cultured breeding stocks. Techniques necessary to engineer refractory tsetse flies have been developed via genetic engineering of the secondary symbiont, Sodalis glossinidius.

Three major impacts can be identified: (a) The development of genetic tools for studying tsetse flies; (b) the development of tsetse as a model system for studies on insect immunity, and (c) the finding that tsetse populations show an unexpectedly high degree of genetic differentiation. All impacts are noteworthy from a purely scientific point of view, and each has profound consequences for the successful application of the SIT.

The CRP succeeded in focusing attention of investigators on the practicalities of instituting an operational SIT programme. The CRP fortuitously corresponded with the PATTEC initiative.

Recommended Future Action by Agency

The Agency should closely harmonize its future activities (through the RB and the TC mechanisms) with the work of other partners in the field, particularly with activities funded by a) WHO-TDR; b) US-National Institute of Health; and c) Leverhulme Trust Tsetse Research Network.

Doing so, the Agency should focus on a) continuing relevant in-house research, both at Seibersdorf and, when necessary, through the CRP mechanism, that is driven by the needs of field projects in Member States; b) enhancing capacity building through training, organization of workshops, support to relevant regional centres, etc.; c) identifying, promoting and supporting scientific opportunities, making use of new or improved, acceptable technologies at hand; d) facilitating the communication of relevant developments and findings among specialists, particularly in developing Member States; and e) assisting in the movement / shipment of biological materials along internationally accepted regulations and guidelines.

Resulting Publications

The results of the CRP will be published as full papers in the journal GENOME.

Genetic and molecular biology contributions to tsetse sterile insect technique programmes. A.S. Robinson
Mapping experiments suggest occurrence of hybrid breakdown or cryptic species in G. p. palpalis (Diptera: Glossinidae). R.H. Gooding, P. Solano and S. Ravel
Hybridisation, sperm preference and remating in the morsitans group of tsetse flies. P. Olet, A.S. Robinson
Molecular markers for Glossina population structure. L. Gomulski, Bonizzoni M. Compagnoni L. Gasperi G. Robinson A. Malacrida A.
Genetic diversity and gene flow in Glossina pallidipes populations in East and southern Africa: An assessment using microsatellites and mitochondrial DNA variation. J.O. Ouma, J.G. Marquez, M.A. Cummings, and E.S. Krafsur
Genetic differentiation in natural populations of Glossina palpalis s.l. using microsatellite DNA polymorphism: artifacts, demes, or cryptic species? P. Solano, S. Ravel, t. De Meeus, S. De la Rocque, B. Sane, D. Zeze, L. Ndri, D. Kaba, V. Jamonneau and G. Cuny
AFLP and microsatellite analysis of Glossina pallidipes Austen in Kenya. Kinyua, J.K., Kiragu, J and Ndungu, J.M.
Application of molecular genetics for the control of trypanosome transmission by the tsetse vector. Y. Hu, I. Kasumba, B. Weiss and S. Aksoy
Analysis of 18S and 5S ribosomal from 5 species of Glossina. O. P. Perera & A.S. Robinson
Polytene chromosome maps in four tsetse (Glossina) species: A comparative analysis. A. Gariou-Papalexiou, G. Yannopoulos, A.S.Robinson, A. Zacharopoulou RNA genes and internal transcribed spacer 1 (ITS-1)

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **D6.10.21 Evaluation of methods of analysis for determining mycotoxin contamination of food and feed**

Participating Countries: Argentina(C), Australia(C), Austria(A), Brazil(C), Canada(A), Canada(C), China(C), Cuba(C), Egypt(C), France(A), Ghana(C), India(C), Indonesia(C), Italy(A), Malaysia(C), Philippines(C), South Africa(C), United Kingdom(A), United Kingdom(A), United Kingdom(C), United States of America(A), Uruguay(C)

Total Cost: **$376 382**

Duration: 1998-11-01 — 2003-11-06

CRP Overall Objectives

To assist national food control authorities and institutions to improve food safety and stimulate international trade by providing appropriate methods to effectively monitor the mycotoxins content of agricultural import and exports.

CRP Specific Objectives

To identify, improve and validate time and cost efficient methods through inter-laboratory studies and comparison of analytical procedures for detection and quantification of mycotoxins in food in order to effectively monitor the mycotoxins content of agricultural import and exports.

Research Outputs

Validation operations were performed for TLC methods for:
- Fumonisins B1 in maize,
- Aflatoxins in maize and peanuts butter, and
- Ochratoxin M1 in Milk.

The participants participated in proficiency testing programme sponsored by the Agency to help improve the performance of the analysts involved n the CRP.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP achieved the main objectives and established core expertise on analytical methods for mycotoxins.

The CRP succeeded in raising (1) awareness of the worldwide phenomenon of mycotoxin contamination of agricultural commodities (2) limitations of mycotoxin detection and quantification methods, (3) showing advantages of cost effective rapid and robust CRP developed and validate methods, and establishing networking activities among CRP participants.

The participation in FAPAS Proficiency testing programme funded by the Agency increased the quality of the results obtained form the collaborative studies.

The TLC methods used generated good results for the detection and analysis of Fumonisin B1 in Maize, and Ochratoxin M1 in milk.

Most of the CRP selected methods were found applicable, and reproducible, and cost-efficient. The reuse of IAC had reduced the cost of the method.

However, while the CRP was unsuccessful in resolving all the constraints related to mycotoxin reference standard/analytical reagents acquisition, the CRP has generated positive networking between analyst throughout workgroup activities and information exchange.

Recommended Future Action by Agency

The selected CRP methods should be used for FAPAS proficiency tests and monitoring; if possible, use a second method.
To have 14C-materials available for method validation studies and industrial food processing studies.
To make ELISA kits available under the prevision of IAEA legal division recommendations.
The CRP participants should make available routine methods used in their laboratories to others.
To organize regional backstopping for assisting with methodology implementation.
To prepare and present a paper on CRP results at IUPAC symposium of May, 2004, and have informal RCM.
Establish an e-mail network or information exchange on the CRP work.
Disseminate information on the CRP work using IAEA and FAO web sites and Newsletters.

The FAO/IAEA Division to implement training workshops on:

Quality Assurance Principles,
Method Validation,
Standard preparation, proficiency testing studies,
Troubleshooting and remedial action at IAEA Seibersdorf Laboratory

The CRP developed Methods, i.e. the methods for Aflatoxin M1 (S. Dragacci), Fumonisin B1 (Gordon Shephard), Total Aflatoxins (B1; B2; G1 and G2), DON and NIV (J. Cea).

Regional Workshop on Prevention of Mycotoxin Contamination Applying the FAO/IAEA HACCP Manual in Africa (Ghana, or Cape Town), in Asia (China), and in Latin America (Cuba) coinciding with SLAM.

National/Regional training on the CRP selected Methods, jointly with FDA Phase II workshop, e.g. the first in Argentina.

To produce Video and CD-ROM of the CRP selected methods for training purposes.

To participate in FAPAS tests and send results in time; should any problem occur, please inform both IAEA and FAPAS. Send letter to CDC and Sigma on the relevance of making standard available for least developing countries for scientific purposes.

Resulting Publications

1) Avantaggiato, G., De La Campa, R., Miller, J.D., Visconti, A., Effects of Muffin Processing on Fumonisins from 14C-Labeled Toxins Produced in Cultured Corn Kernels, Journal of Food Protection: Vol. 66, No. 10, pp. 1873-1878.

2) De La Campa, R., Miller, J.D., Hendricks, K.A., Fumonisin in tortillas produced in small-scale facilities and the effect of traditional masa production methods on this toxin, submitted to the Journal of Agricultural and Food Chemistry, October 2003.

3) Shephard, G.S., Sewram, V., "Determination of the mycotoxin fumonisin B1 in corn by reversed-phase thin layer chromatography" (2003).

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E1.30.21 Comparative evaluation of ictal brain SPECT, magnetic resonance Imaging (MRI) and X-ray computerized tomography (CT) of brain in the management of patients with refractory seizures**

Participating Countries: Argentina(C), Belgium(A), Belgium(C), China(C), China(C), Colombia(C), India(C), Italy(A), Korea, Republic of(A), Korea, Republic of(C), South Africa(C), Thailand(C), Turkey(C)

Total Cost: **$212 184**

Duration: 2000-12-01 — 2003-12-31

CRP Overall Objectives

To improve the health care and quality of life of patients suffering from refractory seizures by standardizing the diagnostic procedure and determining the possible surgical strategy and outcome.

CRP Specific Objectives

(i) To evaluate the role of Brain SPECT in patients with refractory seizures, determining the most suitable tracer, acquisition and analysis protocol.
(ii) To determine the best diagnostic protocol for patients with refractory seizures.
(iii) To identify patients that could benefit from surgical intervention and determining the cost/benefit of the procedure.
(iv) To provide recommendations for a management strategy of patients with refractory seizures.

Research Outputs

227 patients with refractory epilepsy, ninety-two of which underwent surgery, matched inclusion criteria and underwent interictal and ictal brain SPECT, MRI and interictal and ictal EEG. SPECT scans were performed using multiple headed gamma cameras with high resolution or ultra high resolution collimators. Scanning was performed at least 45 minutes after the injection of using 99mTc-ECD, either performed ictally or interictally. Images were acquired over 360 degrees using step and shoot mode with a step angle of 3 degrees. An acquisition matrix of 128 x 128 pixels was used. At least 5 million counts were acquired for each study. Reconstruction was performed using filtered backprojection or iterative algorithms. Images were reorientated to transaxial, coronal and sagittal 1 pixel slices, using the orbito-meatal line, and, additionally, parallel to the temporal lobe axis. After coregistration using SPM2, ictal/interictal SPECT images were both visually interpreted and analyzed by SISCOS (Subtraction Ictal SPECT Co-registered to interictal SPECT).

Results: With surgical site and clinical outcome as gold standard, sensitivities of various diagnostic modalities for lateralization and localization, respectively were: ictal SPECT, 82.2% (76/92) and 81.5% (75/92); ictal EEG, 72.5% (66/91) and 58.2% (53/91); MRI, 80% (73/92) and 75% (69/92); interictal SPECT, 61.5% (48/78) and 58.9% (46/78); and interictal EEG, 51.8% (42/81) and 43.5% (34/78). Ictal SPECT could accurately lateralize and localize 84% (21/25) and 77% (30/39) of the seizure foci missed by ictal EEG; and 73.6% (14/19) and 69.5% (16/23) of the seizure foci missed by MRI. Taken together, ictal SPECT, ictal EEG, and MRI could accurately lateralize and localize the seizure focus in 96.7% and 95.7% of operated cases, respectively.

Conclusions: Ictal SPECT plays a vital role in the presurgical diagnostic evaluation of refractory epilepsy patients. Ictal EEG, MRI and ictal/interictal SPECT have a complementary role to each other and should be sequentially used in the diagnostic work-up of epileptic patients candidate to surgery.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP allowed investigators to collect data on more than 150 patients, which is the most extensive population studied so far with this technique. The best study protocol was identified, including best tracer and acquisition technique. More than 90 patients were submitted to surgical intervention and brain SPECT diagnostic power and accuracy was tested against clinical outcome following surgery.

All patients whose diagnostic workup included brain SPECT for surgery eligibility, experienced a dramatic improvement of quality of life following surgery. Results of this CRP have been partly presented to International Conferences: EANM 2004; SNM 2005. In addition, full papers will be prepared and submitted to peer reviewed scientific journals in 2005.
In the majority of patients with epilepsy, seizures can be well controlled with appropriate medication. At the present time there are several different molecules, which are able to keep the seizures under control. However, 20-30% of patients are estimated to be refractory to all forms of medical therapy. On the other hand those who respond well to the medical therapy may also benefit from surgery and obtain a permanent cure from the disease. Such surgical therapy is normally recommended in young patients who have a long life expectancy. It is extremely important in patients with refractory seizures to identify one or more abnormal areas of cortex from which the seizures originate, before considering the surgical option. The single most important determinant of a successful surgical outcome is patient selection. This requires detailed presurgical evaluation to characterize the seizure type,
frequency, site of onset, psycho-social functioning and degree of disability in order to select the most appropriate treatment from a variety of surgical options. The evaluation of epileptic patients includes a detailed clinical history, physical examination, advanced neuro-imaging, video-EEG monitoring, neuropsychological testing and the assessment of psycho-social functioning. Although modern neuro-imaging is crucial for surgical decision making, the preoperative evaluation of patients with medically refractory epilepsy remains controversial: interictal and ictal EEG, MRI, PET and interictal and ictal SPECT have been used in various combinations towards this objective. There is therefore a need to develop an optimum algorithm of diagnostic modalities for accurately identifying the seizure focus. Single Photon Emission Computed Tomography (SPECT) imaging of the brain done in the ictal and interictal state, and Subtraction analysis, provide complementary functional information that adds additional information in some cases. In our study, Technetium-99m ethylemne cysteine dimmer (99mTc-ECD) was used for all SPECT scans. Due to the well described in-vitro stability of the radiopharmaceutical, it is ideally suited for the performance of ictal SPECT scans.

This study was performed as a three-year prospective study, starting in March 2001. Patients with refractory epilepsy having at least one seizure per month, despite an optimal anti-epileptic drug regimen, were enrolled from seven participating centres. All patients were possible candidates for resective surgery. They underwent full neurological, neuropsychological and psychiatric examinations, as well as 24 hour Video-EEG recording. For the purpose of the ictal studies, Anti-epileptic medication was withdrawn under the supervision of the local neurologist/epileptologist.

Patients who underwent resective surgery according to accepted standard practice are being followed up clinically for a period of at least 12 months. In these patients, the outcome of resective surgery was compared with the results of each imaging technique. Compared to MRI and ictal EEG, the additional information obtained from SPECT imaging and particularly subtraction analysis was determined.

Thus, considering the above findings it can be concluded that ictal SPECT plays a vital role in the presurgical diagnostic evaluation of refractory epilepsy patients. Moreover, for presurgical evaluation of patients with refractory epilepsy, ictal SPECT, MRI and ictal EEG have a complimentary role to each other and must be used in tandem.

Recommended Future Action by Agency

Organizational needs, which are quite demanding, remain a major problem in applying this specific diagnostic application. Only highly specialized centers will be able to follow this procedure. However, it should be borne in mind that epilepsy surgery can be carried out only at high level medical centers.

The recommendations for future directions include continue support to "centers of excellence", where usually also nuclear medicine expertise is high and able to meet with high level clinical expectations.

Resulting Publications

Internal: Final report

External:

S.Tepmongkol, C.Locharemkul, S.Lerdlum. Factors determine interictal brain SPECT perfusion change in unilateral hippocampal sclerosis. Eur J Nucl Med Mol Imaging, 2004; 31:S364 (Abs).

S.Tepmongkol, C.Locharemkul, S.Lerdlum.. Intratemporal and extratemporal perfusion changes in unilateral hippocampal sclerosis with ictal injection lesser than 60 seconds, Eur J Nucl Med Mol Imaging, 2004; 31:S364 (Abs).

2005 (Submitted)

Ictal/Interictal Brain SPECT in refractory epilepsy: Correlation with MRI and EEG for presurgical evaluation of patients candidate to surgery. Results from an IAEA Coordinated Research Project.

Dynamical ictal brain perfusion patterns in patients with mesial temporal lobe epilepsy associated with hippocampal sclerosis: results from a multicenter IAEA sponsored study.

Article in preparation:
Dynamical ictal brain perfusion patterns in patients with mesial temporal lobe epilepsy associated with hippocampal sclerosis.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E1.50.18 The significance of viral load and virus type in Hepatitis B and C for Pathogenesis and treatment efficacy**

Participating Countries: Argentina(C), China(C), China(C), India(C), Korea, Republic of(C), Malaysia(C), Russian Federation(C), United Kingdom(A), Uruguay(C)

Total Cost: **$125 083**

Duration: 1999-10-01 — 2003-08-15

CRP Overall Objectives

To improve the diagnostic and therapeutic management of patients with Hepatitis B or C (HBV and HCV).

CRP Specific Objectives

(i) To study the relationship (correlation) between viral load, viral genotype disease progression and susceptibility to treatment in HBV and HCV.
(ii) To develop novel viral quantitation and genotyping methods for HCV and HBV.

Research Outputs

The technology of PCR, RFLP and sequencing was customized for genotyping of HCV and HBV. Viral load for HCV was determined and correlated with disease pathogenicity. The significance of demonstrating the pre-core mutations was shown in pathogenesis of HBV infection and for timing of IFN therapy as detailed in impact of the CRP.

CRP Outcome (Effectiveness; Impact; Relevance)

By establishing and using radionuclide based molecular methods for determining viral load and virus type, the CRP achieved overall Agency project objectives to enhance the capabilities of Member States to employ in vitro nuclear medicine technology efficiently for managing their important health problems, and for undertaking related basic and clinical research. Isotopes used in the CRP were 32P and 33P for sequencing, ^{3}H for in vitro translation system and 53Cr for immunoassay and functional cell assays.

Genotyping, determination of viral load and analysis of phylogenetic tree was successfully carried out for HCV. Higher prevalence of genotype 1b was shown in studies from Argentina and India, followed by genotype 2a/2c. In Malaysia, predominant genotype was 3a, followed by 1 (1b-63.5%). In Russia, subtype 3a was predominant in younger individuals (IV drug addicts), suggesting recent introduction of this genotype to the community. The emergence of genotype 3a and its association with IV-drug use is a proof of emerging situation of public health concern in Russia. In non-addicts, subtype 1b was found to be predominant. Genotype 1b was associated with higher viral load and more severe disease and therefore was shown to be a bad prognostic factor. Results of phylogenetic analysis on HCV isolates from haemodialysis patients demonstrated association of clustering of sequences with use of same haemodialysis machine. In South America, 12 out of 245 patients with chronic HCV infection were found to be co-infected with more than one genotype. The median viral load for the co-infected patient was not significantly different from patients infected by a single genotype, which in turn did not vary significantly amonth different genotypes.

Studies on precore variant of HBV in Korea demonstrated a mixture of wild type with precore variants as predominant. In Malaysia, 39% of HBeAg+ve and 67% of HBeAg-ve patients were shown to have precore mutations. Pre-S1/Pre-S2 region RFLP for HBV genotyping was demonstrated to be reliable in differentiating between different genotypes. RFLP for genotyping of HBV worked very well in Russia. In northwestern part of Russia, genotype D was predominant. Further, the population of HBV genotype D was heterogeneous. The precore HBV mutant (mutation resulting in stop codon at residue 28) was the commonest for HBV strains. The utility of pre-core variant of HBV to trace common source of outbreaks was demonstrated. The significance of demonstrating the precore mutations was shown in pathogenesis of HBV infection, increased risk for development of hepatocellular carcinoma and cirrhosis and for timing of IFN therapy for better patient management. Follow up of chronic HBV infected patients showed that during acute exacerbation followed by quiescent disease, there was a change in the major quasispecies in the former but not in the latter phase. This knowledge can be used to time therapy with IFN. As quasispecies change occur during IFN therapy, sequential use of IFN and lamivudine can be tested for better resolution of the clinical picture.

Accomplishments of CRPs Completed in 2003

Radionuclide-based molecular methods were successfully employed for determination of viral load and virus types in HBV and HCV, thus achieving Agency's overall objectives. By establishing and using radionuclide based molecular methods for determining viral load and virus type, the CRP achieved overall objectives to enhance the capabilities of Member States to employ in vitro nuclear medicine technology efficiently for managing their important health problems, and for undertaking related basic and clinical research. Isotopes used in the CRP were 32P and 33P for sequencing, ^{3}H for in vitro translation system and 53Cr for immunoassay and functional cell assays.

Recommended Future Action by Agency

A new CRP on co-infection of HIV and viral hepatitis with the objective of defining whether co-infection influences the course or severity of liver diseases, with use of established methodology, recommended.

Resulting Publications

The results of the CRP have been published in four individual and one joint papers. Two additional joint manuscripts have been submitted for publication.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E2.10.03 Dosimetry in X-ray diagnostic radiology. An international Code of Practice**

Participating Countries: Germany(A), Malaysia(A), Sweden(A), United Kingdom(A), United States of America(A)

Total Cost: **$20 320**

Duration: 2000-12-01 — 2003-12-31

CRP Overall Objectives

To assist Secondary Standards Dosimetry Laboratories (SSDLs) and hospitals in Member States in providing calibrations of equipment and conducting dosimetry measurements in the field of x-ray diagnostic radiology.

CRP Specific Objectives

To develop a Code of Practice for dosimetry in x-ray diagnostic radiology to cover both the calibration of instruments at the SSDLs and the measurement of doses in hospitals. To achieve this goal, various parallel research activities were conducted within the CRP to (i) analyse all relevant international and national standards and protocols, (ii) identify the dosimetry requirements for various x-ray diagnostic procedures, (iii) to verify of the results of analysis (when needed) and preparation of necessary dosimetry data, (iv) to extend the IAEA dosimetry laboratory's beam qualities to cover the whole range of x-ray diagnostics.

Research Outputs

Recommendations to SSDLs on selection of instrumentation and establishment of a facility for calibration of diagnostic dosimeters and kVp meters were prepared. This includes calibrations of instruments used for measurements in general and dental radiography, fluoroscopy including interventional procedures, mammography and computed tomography.

Recommendations to clinical users on the choice of dosimeters and/or phantoms for a particular application was prepared together with measurement methodology, quality control and interpretation of results.

Guidance on the uncertainty treatment was prepared that can be used by both, the SSDLs as well as the end-users in hospitals.

CRP Outcome (Effectiveness; Impact; Relevance)

The various national and international documents related to the topic of the CoP were analysed and discussed. A consensus has been achieved on the equipment and procedures to be used in SSDLs and clinics. The results of the research together with a practical experience of consultants were used for preparing a draft of the Code of Practice.

When implemented, the Code of Practice will help to achieve traceability of measurements in diagnostic radiology in Member States to the international standards. This will result in improving the quality of measurements and make comparison of measured data among countries more reliable.

The CRP will have a direct impact on members of the IAEA/WHO Network of Standard Dosimetry Laboratories and users in hospitals. It will help to develop calibration facilities and clinical dosimetry in Member States. It will improve implementation of the technical co-operation projects in the field of x-ray dosimetry.

X-ray diagnostic radiology is the largest contributor to exposures from man-made sources. Radiologists constantly face the dilemma of trying to minimize patients' exposure whenever possible, while still using exposures that are high enough to produce images of good quality to be able to provide proper diagnosis. It is important that the measurements in hospital are accurate. This requires a continued support of x-ray diagnostic radiology dosimetry activities from the Agency. The completed CRP is the first step in harmonization of calibration and measurement procedures in this field.

Recommended Future Action by Agency

The proposal of this CRP included the testing of the Code of Practice and the identification of problems related to its implementation in developing countries. It is suggested that the new CRP on testing the Code of Practice is approved. It is also suggested that activities in x-ray diagnostic radiology dosimetry are further supported.

Resulting Publications

Accomplishments of CRPs Completed in 2003

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1) Pernicka, F., Alm Carlsson, G., Dance, D. R., DeWerd, L. A., Kramer, H.-M., Ng, K.-H., Development of an international code of practice for dosimetry in x-ray diagnostic radiology, in Contributed papers to the International Conference on Radiological Protection of Patients in Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy, Malaga, March (2001) 93

2) Pernicka, F., Danes, J., Giczi, F., Staniszewska, M. A., Nikodemova, D., Milu, C., Oresegun, M., Maccia, C., Padovani, R., Vano, E., Comparison of TLD Air Kerma Measurements in Mammography, In Proc. of the International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, Vienna, November (2002) in print

3) F. Pernicka, G. Alm Carlsson, D. R. Dance, L. A. DeWerd, H.-M. Kramer, K.-H. Ng, P. Ortiz Lopez, In Proc. of the World Congress on Medical Physics and Biomedical Engineering, August 24-29, Sydney, Australia (2003)

4) J. Zoetelief, F. Pernicka, G. Alm Carlsson, D. R. Dance, L. A. DeWerd, G. Drexler, H. Järvinen, H. M. Kramer, K.-H. Ng, Dosimetry in diagnostic and interventional radiology - ICRU and IAEA activities, In Proc. of the International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, Vienna, November (2002) in print

5) J. Witzani, H. Bjerke, F. Bochud, I. Csete, M. Denoziere, W. de Vries, K. Ennow, J. E. Grindborg, C. Hourdakis, A. Kosunen, H. M. Kramer, F. Pernicka, T. Sande, Calibration of dosemeters used in mammography with different X-ray qualities EUROMET project no. 526, Radiat. Prot. Dosimetry (2004), v. 108, No.1, 33-45

6) F. Pernicka, G. Alm Carlsson, D. R. Dance, L. A. DeWerd, H.-M. Kramer, K.-H. Ng, P. Ortiz Lopez, Code of practice for dosimetry in diagnostic and interventional radiology, European Congress of Radiology, Vienna , March 5-9 (2004), accepted for an oral presentation

6) International Atomic Energy Agency, Dosimetry in Diagnostic Radiology: An International Code of Practice, draft of TRS publication prepared for an external review

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E3.30.13 Randomised clinical trial of radiotherapy combined with Mitomycin C in the treatment of advanced head and neck tumours**

Participating Countries: Bulgaria(C), Denmark(A), Denmark(A), Denmark(C), Denmark(C), Denmark(C), India(C), India(C), Italy(A), Japan(A), Japan(A), Malaysia(C), Pakistan(C), Pakistan(C), Sri Lanka(C), Thailand(C), Turkey(C), United States of America(A)

Total Cost: **$328 620**

Duration: 1995-04-15 — 2003-04-30

CRP Overall Objectives

To study the clinical applications of bioreductive agents in radiotherapy.

CRP Specific Objectives

To conduct an international multicenter randomized clinical trial of mitomycin-C (MMC) in the treatment of head and neck cancer.

Research Outputs

From 1995 to 1999, 558 patients were randomised and treated by either radical radiotherapy (RT) or RT with the addition of MMC. The number evaluable was 478. The overwhelming majority of the patients entered were from India, Pakistan or Sri Lanka. MMC did not enhance the acute or late side effects of RT. The rates of locoregional control and survival were not significantly different between the two arms. Among the 161 patients with N0 stage, the addition of MMC appeared to improve the local-regional control (p=0.01).

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been successfully concluded and demonstrated convincingly that MMC delivered in this manner is not indicated in the management of this population of patients, with the possible exception of those with N0 stage.

This CRP is a very important contribution to the knowledge base about the clinical usefulness of the prototypical bioreductive agent, viz. MMC.

This is the largest and most definitive study of MMC and radiotherapy in cancers of the head and neck. Furthermore, it establishes an important benchmark regarding the effectiveness of radiotherapy in such patients from developing countries (particularly the Indian sub-continent). The study has been accepted for publication by a most prestigious peer-reviewed journal in the field of radiotherapy and oncology, accompanied by an editorial.

Cancers of the head and neck are very common in many developing countries. By clarifying the role of MMC this study ensures that the treatment resources can be more rationally expended.

Recommended Future Action by Agency

1. Support future studies in the field of head and neck cancer in developing countries.
2. Ensure that central quality review is a part and parcel of future studies.

Resulting Publications

Internal: Reports of the RCMs.

External: Peer-reviewed article (in press) in the journal "Radiotherapy & Oncology".

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E3.50.07 Comparative assessment of teletherapy modalities**

Participating Countries: Brazil(C), China(C), Croatia(C), Cuba(C), Greece(C), India(C), Indonesia(C), Netherlands(C), Pakistan(C), Peru(C), South Africa(C)

Total Cost: **$133 445**

Duration: 2001-08-01 — 2003-07-31

CRP Overall Objectives

To provide valid data to evaluate the costs of competing nuclear technologies used in the practice of radiation oncology, reflecting the reality of developed and developing countries.

CRP Specific Objectives

To determine the costs of establishing teletherapy treatment using cobalt or linear accelerators and the cost implications for continued support of this equipment to maintain quality control at optimal levels.

Research Outputs

Eleven countries with 16 institutions participated in this economic study. A total of 75 machines were reviewed. For 50 machines in current use, all costs related solely to the delivery of over a half million fractions (representing over one million radiotherapy fields) were documented in 2002. Full details are recorded in the 'Scientific Report' (Draft peer-review article) of the CRP with the TO. Because of the variability of the length of the workday inter-institutionally, the statistics quoted in this study were reduced to fractions per operating hour.

Productivity measured in fractions per hour was a mean of 4.5 on Co-60 and 5.5 on the linacs. The fields per fraction averaged 2.42 (R 1.05 - 3.49) over all machines. Cobalt averaged 2.28 (R 1.5 - 2.76) while linear accelerators averaged 2.51 (R 1.05 - 3.49) fields per fraction.

While the time spent on linac QA and maintenance was typically twice that of cobalt, the inter country variability was most pronounced. Three components of the costs were considered: costs, if any, of contracts; other third party costs and costs of Hospital personnel involved in maintenance and/or QC. The median total annual cost for QA and maintenance was US$3 177 for cobalt and US$43 774 for linacs.

The factors influencing variation of the initial capital cost of the linac teletherapy machines were discussed to explain why the price of the linear accelerators varied from US$129 532 [purchased December 1986] to US$1.8 mi [purchased January 2001]. Similarly, models of cobalt teletherapy machines have risen in price from under US$100 000 (mid 1980s) to about US$400 000. Factors impacting on costs of cobalt machines, additional to those of relevance to linacs, were also identified. The current cost per curie of cobalt sources varies widely between countries. Sources may be obtained from the original equipment supplier, or a re-processor. The price range from the participants was from US$3.51 to 33.33 per curie. The average replacement period was 7.4 y over 21 sources identified from all cobalt units.

Power consumption of the various linac models was obtained from the manufacturers. Utilising local rates for electricity in kWh and individual machine usage, a median cost of US$2 500 was obtained for linacs (Range 1470 - 8078) per year while cobalt machine costs for power averaged only US$250 per year. Water costs were also identified for participating countries, but, as virtually all linacs used recirculating systems, this factor was irrelevant in cost assessment.

The life-expectancy of the machines was determined from an additional group of 25 machines decommissioned before this study. This was found to be an average age of 18.3 years for cobalt and 15.9 years for linacs. The median age of both groups of machines was almost identical, 17.3 and 17.7 years respectively. The 50 functioning machines in the study were on average 14.3 years old for cobalt and 6.6 years for linacs as at 1 July 2002.

An analysis of the costs per fraction delivered showed a range from US$1.13 to 37.08 for cobalt and 3.17 to 46.81 for linacs. As the countries were used as their own controls, the ratio of linac to cobalt costs has more relevance. Three countries had less than 10% difference between linac and cobalt; in one country linac costs were 25% less than cobalt; the remaining countries showed linac costs to exceed cobalt costs by factors of 1.2 to 4.9 - the highest two being in countries which supply their own cobalt sources.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has proven highly effective in assisting the Agency in the determination of costs of establishing (cobalt or linac) teletherapy in a wide spectrum of Member States differing in economic resources.

The data generated will be incorporated into 'Produce document on econmics of teletherapy [Modeling of costs of teletherapy]'. This will be a valuable tool for the Agency to determine both the current natinal commitment to this nuclear technology and in improved advice on the capital and ongoing costs of such a service in Member States, especially those initiating radiation oncology.

Recommended Future Action by Agency

1. The data from this CRP should be incorporated as far as possible into the ABC modeling of radiotherapy costs by June 2004.

2. The validity of the finalized ABC model for countries of different economic status should be tested.

3. An advisory group should be convened (by ARBR and DMRP) following validation of the ABC model to determine how the IAEA should proceed.

4. The data and analysis of this CRP should be formatted as a scientific paper and submitted to a peer reviewed Journal.

5. All economic radiotherapy models developed by the Agency should be reviewed 5-years hence. Models should be expanded to incorporate new technologies.

Resulting Publications

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E4.30.10 Isotopic evaluations in infant growth monitoring - a collaboration with WHO**

Participating Countries: Bangladesh(C), Brazil(C), Chile(C), Pakistan(C), United Kingdom(A), United States of America(A)

Total Cost: **$103 006**

Duration: 1999-11-01 — 2003-11-18

CRP Overall Objectives

To extend the use of stable isotopes as tools for evaluating and monitoring infant growth.

CRP Specific Objectives

To measure breast milk intake, using stable isotopes in a sub-group of breast-fed infants growing normally, and to assess their nutrient intakes. The studies included the following major components:
(i) growth measurements (anthropometrics)
(ii) total energy expenditure measurements by doubly labelled water
(iii) resting energy expenditure by indirect calorimetry
(iv) breast milk composition
(v) child development

Research Outputs

A total of 405 breast milk intake measurements in 232 infants have been done in diverse settings (Brazil, Chile, Pakistan, United Kingdom); 705 growth measurements were in 332 infants; total energy expenditure using doubly labeled water was measured in 67 infants (Brazil); resting energy expenditure using indirect calorimetry in 112 infants (Pakistan); 90 measurements of breast milk composition (Chile); child development was measured in 189 infants (Pakistan and Brazil)

CRP Outcome (Effectiveness; Impact; Relevance)

The method was successfully set up in all participating countries. Important information was obtained on breast milk intake in relation to growth of breast-fed infants in representative cohorts. The available global scientific database on isotopic breast milk intake measurements have been more than doubled as a result of the CRP.

Although the increased awareness of stable isotopes use for evaluating and monitoring infant growth has resulted relevant development of WHO recommendations for energy intake in developing countries, expand this studies to other countries might be of fundamental importance. The use of stable isotopes technology on this CRP in selected countries has shown needed data to decisions makers aimed at improving childhood health.

This CRP has demonstrated the capacity for nutritionists to obtain data on breast-milk intake in community-based studies of free-living mother-infant pairs in a wide variety of developing country settings. This experience shows that the method can now be used extensively to investigate the relationships between early feeding and health during infancy, childhood and adulthood.

Data collected during this CRP has demonstrated that the introduction of non breast-milk foods and fluids can have significant effects on infant milk intake, energy utilisation and body composition.

The data also have significance for the development of WHO recommendations for energy intake in developing countries. First, energy requirements may differ according to socio-economic status, due to differences in energy utilisation; currently, recommendations are based on the intakes of infants of high socio-economic status second, who are unrepresentative. Second, data from predominantly and exclusively breast-fed infants do not differ significantly and may be pooled in the analysis of the WHO multi-centre growth reference study.

Recent research has increasingly emphasised the importance of early growth patterns for the profile of disease during childhood and adulthood. Fetal and infant growth patterns, and the nutritional factors that underlie variability in these parameters, have been linked in many studies to the risk of subsequent diseases including obesity, type 2 diabetes, cardiovascular disease, hypertension and stroke. Understanding the relationships between early nutritional intakes and early

growth is therefore a priority for the development of public health programmes aimed at improving childhood and adult health.

Until recently, objective data on breast-milk intake were almost impossible to obtain. Comparability between studies was severely hindered by methodological variability in test-weighing protocols, while the method is also intrusive and difficult to apply in field settings. The dose-to-the-mother deuterium oxide turnover method has transformed research in this area, enabling the collection of objective data using standardised protocols in diverse settings. The work achieved during the CRP has established a strong basis for further applications of the dose-to-the-mother method in this area of research.

Recommended Future Action by Agency

In view of the successful achievements of this CRP, the investigators feel further work in this area is of importance. Specific recommendations are as follows:

1. Following initial investment in these unique cohorts of infants, follow-up studies are advocated in order to examine the relationship between early breast-milk intake and later growth and body composition.
2. The present studies addressed cohorts where maternal nutritional status was within the normal range; the application of this technique to (1) malnourished mothers and (2) low birth weight infants is now a priority.
3. Stable isotope measurements of body composition represent a high-quality approach for epidemiological studies of the relationship between early nutrition and later growth and body fatness.
4. The Agency should facilitate access to the isotopes required as isotope procurement is a problem for some participating countries.

Resulting Publications

Brazil:
Breast milk and energy intake in exclusively, predominantly, and partially breast-fed infants. Haisma, H., Coward, W.A., Albernaz, E., Visser, G.H., Wells, J.C.K., Wright, A., Victora, C.G. Eur J Clin Nutr, in press.

The dose-to-the-mother deuterium-oxide turnover method as a means to detect bias in intake of complementary feeding of breast-fed infants. Haisma, H., Coward, W.A., Barros, A., Visser, G.H., Wright, A., Victora, C.G., submitted.

Effects of complementary feeding with cows' milk on sleeping metabolic rate of breast-fed infants. Haisma, H., Wells, J.C.K., Coward, W.A., Wright, A., Visser, G.H., submitted.

Influence of socio-economic status on total energy requirements of breast-fed infants in Brazil. Haisma, H., Coward, W.A., Visser, G.H., Wells, J.C.K., Wright, A., Victora, C.G., submitted.

Energy utilisation of breast-fed infants. The influence of breast-feeding pattern and socio-economic status. Haisma, H. PhD thesis.

Chile:
Breast-feeding and growth in a group of selected 0 to 24 months old infants. Alvear J., Salazar, G., Berlanga, R., Anciani, A., Pizarro, F., in preparation.

Maternal nutrient intake and growth in exclusively breast-fed infants. Berlanga, R., Anciani, A., Salazar, G., Alvear J., in preparation.

Pakistan:
Exclusive breast-feeding, milk intake and infant growth in Pakistan. Bhutta, Z.A., Abbass, S., Wright, A., Coward, W.A., in preparation.

Growth, body composition and energy metabolism in exclusively breast-fed infants in Pakistan. Bhutta, Z.A., Abbass, S., Khan, I., Wright, A., Coward, W.A., in preparation.

Growth, morbidity, and developmental outcomes in exclusively breast-fed infants in Pakistan. Bhutta, Z.A., Abbass, S., Jamali, T., Ibrahim, S., in preparation.
United Kingdom:
Simultaneous measurement of breast milk intake and energy expenditure in partially breast-fed infants by dual dosing of mother and infant. Wells, J.C.K., Haisma, H., Wright, A., Coward, W.A., submitted.

Overall:
Two NAHRES reports have resulted from this CRP. The first one with the initial proposals and the final one under preparation will contain the final reports from all participants.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E4.30.11 Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependant diabetes) in ageing**

Participating Countries: Brazil(C), Chile(C), Chile(C), China(C), Cuba(C), India(C), India(C), Jamaica(C), Mexico(C), New Zealand(A), Nigeria(C), United Kingdom(A), United States of America(A), United States of America(A)

Total Cost: **$353 065**

Duration: 1998-12-15 — 2003-05-02

CRP Overall Objectives

To provide information for developing strategies or interventions to reduce obesity and NIDDM prevalence in identifiable high risk populations or groups: to further define the magnitude of the NIDDM/obesity problem in developing countries; to identify vulnerable groups; to describe the physiological and biochemical mechanisms involved.

CRP Specific Objectives

(i) To apply of nuclear and isotopic techniques to improve knowledge of the biology of obesity and non-insulin dependent diabetes, especially as it relates to the developing countries in transition.
(ii) To enhance North-South collaboration and transfer of know-how and technology.

Research Outputs

This CRP offered an opportunity to study body composition , body fat distribution and physical activity in relation to obesity and insulin resistance in seven countries including countries in nutrition transition.

Deuterium dilution, double labeled water (DLW), and Dual X-Ray Absorptiometry (DEXA) techniques were used to assess body composition, energy expenditure and body fat distribution. Radioimmunoassay methods were used to measure hormones status i.e. insulin.

During this CRP conventional methods for body composition assessment such as bioelectrical impedance and anthropometry were validated using isotope dilution method as reference technique. Standardized protocols for body composition were developed and applied in different age groups, different populations and in different geographical locations.

The results of this CRP showed that the increasing risk of obesity and related diseases such as Non Insulin Dependant Diabetes Mellitus (NIDDM) are correlated with changes in diet and physical activity patterns in countries in transition. The results suggest that fat distribution and its topography are perhaps the most important predictors of the evolution of insulin resistance syndrome.

In addition, preliminary results of a three years study in Brazil showed that stunted children have higher body fat gain, higher central fat and higher insulin sensitivity compared to children with normal height for age. Thus, stunted children have higher risk of developing obesity and insulin resistance later in life.

The CRP activities have demonstrated, in addition, that both North - South and South-South collaborations can be very successful and productive.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP showed that isotopic techniques, especially the deuterium dilution and double labeled water method (DLW) are suitable for field applications in a diverse group of settings, to provide information on biological mechanisms involved in the development of obesity and non-insulin dependent diabetes in countries in transition.

The CRP has contributed to the Agency's mandate to promote safe, secure and effective use of nuclear technologies in the human health area.

Lack of financial resources: A more target population groups and larger sample sizes could have been studied to strengthen the database, if resources were available.

The results of this CRP are relevant and if applied on larger populations they could be used to develop and evaluate strategies/interventions aimed at reducing obesity and related diseases.

The successful completion of this CRP has come at a crucial time as the WHO is seeking guidance on measurements related to obesity aspects in context of WHO's global strategy on diet, physical activity and health. This WHO initiative was launched in 2003.

Recommended Future Action by Agency

Technology transfer: strongly extend technical support to the new TC-projects, especially regional projects addressing obesity, in particular childhood obesity.

Resulting Publications

The results of this CRP were presented by the principal investigators in several national meetings, and collectively at the Latin American Society's year 200 meeting in Buenos Aires, Argentina. Several peer reviewed publications have just started to appear in open literature or being submitted for publication. Please see the enclosed list:

1. Macías N, Calderón de la Barca AM, Bolaños A, Alemán H, Esparza J and Valencia ME. Body Composition in Mexican Adults by Air DisplacementPletismography (ADP) with the Bod-Pod and Deuterium Oxide Dilution Using Infrared Spectroscopy (IRS-DOD). Food and Nutrition Bulletin. 2002, 23(3 Suppl): 99-102.

2. Shetty P, Iyengar V, Sawaya A, Diaz E, Guansheng Hernandez M, Yajnik C, Forrester T, Valencia ME, Rush E, Adeyemo, Jahoor F, Roberts S. Application of Stable isotopic techniques in the prevention of degenerative diseases. Food and Nutrition Bulletin, 2002, 23(3 Suppl):174-179.

3. Mauro E. Valencia, Heliodoro Alemán-Mateo, Gabriela Salazar, and Manuel Hernández Triana. Body Composition by Hydrometry (deuterium oxide dilution) and bioelectrical impedance in subjects aged >60 y from a rural regions of Cuba, Chile and Mexico. International Journal of Obesity: 2003, 27(7) 848-55.

4. Sawaya Al, Martins PA, Grillo LP, Florencio TT. Long -term effects of early malnutrition on body weight regulation. Nutr Rev. 2004; 62 (7): S127 -33

5. Rush EC, Plank LD, Mitchelson E, Laulu MS. Central obesity and risk for type 2 diabetes in Maori, Pacific, and European young men in New Zealand. Food Nutr Bull. 2002; 23 (3 Suppl): 82-6.

6. Manuel Hernández-Triana,, C Porrata.Energy Requirements and Physical Activity Levels of Elderly People in Cuba. SCN News No. 19, December 1999:44-6.

7. S González, H Alemán, Manuel Hernández-Triana, G Salazar, V Sánchez, B Basabe, M Valencia. Total energy expenditure in elderly subjects from a rural mountain community in Cuba, by questionnaire and resting metabolic rate (factorial meted), compared with the doubly labelled water meted as gold standard. Annals of Nutrition and Metabolism 2001; 45 (Suppl I):354.

8. A. Kurpad, P. Shetty, V. Iyengar, A. Sawaya, E. Diaz, G. Ma, M. Hernandez-Triana, C. Yajnik, T. Forrester, M. Valencia, E. Rush and A. Adeyemo. The application of stable isotopic techniques in the prevention of degenerative diseases like obesity and NIDDM in developing countries. In press Proceedings of the Asian Congress of Nutrition (ACN), Delhi, India 2003.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **E4.30.12 Use of isotopic techniques to examine the significance of infection and other insults in early childhood to diarrhoea morbidity, mal-assimilation and failure to thrive**

Participating Countries: Argentina(C), Bangladesh(C), Belgium(A), Benin(C), Chile(C), Cuba(C), Democratic Rep. of the Congo(C), India(C), Indonesia(C), Mexico(C), Mexico(C), Pakistan(C), Senegal(C), United Kingdom(C)

Total Cost: **$240 104**

Duration: 1999-12-15 — 2003-06-30

CRP Overall Objectives

To assist national laboratories to use the 13C Urea Breath Test (13C-UBT) and mass spectrometry to examine the causes of diarrhoeal diseases and to study its impact on nutritional status and growth of children in developing countries.

CRP Specific Objectives

(i) To identify children or individuals who harboured Helicobactor pylori in their stomach, by means of the 13C-urea breath test.
(ii) To evaluate the effectiveness of the use of prebiotics and/or probiotics in children who were infected with H. pylori.
(iii) To evaluate the possibility that individuals colonized by H. pylori also had associated bacterial overgrowth in the upper gastro-intestinal tract by H2 quantification in breath samples.
(iv) To assess the possibility of associations between H. pylori infection and deterioration of nutritional status and nutritional indexes of children.

Research Outputs

1. High prevalence of H. pylori colonization / infection was observed especially in young infants and children living in poor socio-economic conditions and those with malnutrition.
2. A positive correlation was demonstrated between H. pylori colonization/ infection and growth retardation and stunting in children between 6 months - 10 years of age.
3. Eradication of H. pylori associated with nutritional intervention and its improvement was demonstrated in the Indonesian study.
4. Some probiotics used in this study were effective in eradicating of H. pylori infection in children; the classical triple therapy failed in the eradication of H. pylori infection in a high proportion of the children.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has addressed a public health problem that concerns especially developing countries because of the risk factors identified as associated with H. pylori colonization/infection.

Recommended Future Action by Agency

Although this CRP resulted in important information, it has raised questions that require future studies. These should focus on the use of isotopic techniques for identification of risk factors, the functioning of the transmission chain, the effect on probiotic dosage and strain on infection, natural resistance to colonization/infection as related to H. pylori.

Resulting Publications

The participants are in the process of writing the papers related to this CRP. The manuscripts of the same will be forwarded to the IAEA as soon as they are completed.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F1.10.07 Application of nuclear techniques to anti-personnel landmines identification**

Participating Countries: Australia(A), Canada(A), Croatia(C), Egypt(A), France(A), Hungary(C), Italy(A), Netherlands(A), Russian Federation(C), Slovakia(C), Slovenia(C), Sweden(A), United States of America(A), United States of America(A), Vietnam(C)

Total Cost: **$147 560**

Duration: 1999-10-01 — 2003-12-31

CRP Overall Objectives

To develop nuclear techniques for the identification of anti-personnel landmines.

CRP Specific Objectives

At present well known and mature nuclear techniques including Neutron Activation Analysis (NAA), Nuclear Quadrupole Resonance (NQR) and X-ray Imaging are used for applications such as Bulk Hydrogen Analysis, Bore Hole Logging and explosives detection in airport luggage. The specific objectives of this CRP were to apply this knowledge to Humanitarian Demining and to make already existing prototype instruments ready for field deployment, including

- Adaptation of neutron sources for humanitarian demining
- Development of novel nuclear based techniques for identification of anti-personnel landmines
- Adaptation of X-ray sources for humanitarian demining
- Adaptation of detectors
- Optimisation of source and detector configurations
- Development of software for signal treatment and identification
- Tests of devices using dummy mines, and
- Proposal for field tests.

Research Outputs

The participating groups published their research results in international journals and at conferences. The final report of the CRP was published as a special edition of the journal "Applied Research and Isotopes, Vol. 61, Issue 1, July 2004. In addition, several ongoing research collaboration projects, between countries/groups, were established (e.g. The Netherlands-Egypt, Croatia-Italy, USA-Croatia). Although promising results with neutron based devices were obtained a general conclusion of the CRP is that no single device can solve the "landmine problem". A combination of different complementing sensors on a multisensor platform is urgently needed.

CRP Outcome (Effectiveness; Impact; Relevance)

Several prototype instruments have been developed and tested under laboratory conditions and the CRP has lead to increased awareness of the unique possibilities of nuclear based methods for identifying/detecting explosive materials in Agency Member States.

The most important achievements, as recognized by the participants of the final RCM, are:

- Advancement of AP landmine detection, which resulted in the development of a number of devices and publications by the participants. Especially can be mentioned the hand held Neutron Backscatter devices developed by the South African and the Dutch group.

- The CRP has resulted in the establishment of a test laboratory in Croatia. The laboratory at the Rudjer Boskovic Institute in Zagreb is used by international groups to evaluate the performance of devices for detection of explosives (landmines) and illicit materials.

- The CRP has provided opportunities for information exchange and training of young scientists.

- Useful connections between participants from landmine contaminated countries, and those from other countries through this CRP. Recently a group from University of Delft (the Netherlands) has tested a Neutron Backscatter device, developed within the CRP, in Egypt.

- A dummy landmine (DLM2) was developed by the South African group, and made available for testing by the CRP participants.

The CRP has lead to an increased understanding/recognition of the possibilities of nuclear based methods for the detection/identification of explosives and other threat materials among Agency Member States.

Recommended Future Action by Agency

The CRP participants recognized that the technology developed by this CRP is not only suitable for use in humanitarian demining, but is also suitable for the detection of other threat materials. IAEA should explore further promotion of all these efforts. In view of this a technical meeting is planned for 2005 in order to explore these possibilities. Furthermore the CRP realised that no single device can solve the "landmine problem". A combination of different, complementing sensors, on a multisensor platform is needed. Further research on this topic is urgently needed in order to find the optimal combination of sensors. A draft CRP proposal addressing these problems is under preparation for 2006.

Resulting Publications

The results of the CRP were published as a special edition of the Journal Applied Radiation and Isotopes (Vol. 61, Issue 1, July 2004). In addition numerous articles and reports were published in international journals and conference proceedings by the individual research groups. The meeting reports from three RCMs have been published as IAEA working material.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F1.10.08 Development and applications of alpha particle spectrometry**

Participating Countries: Algeria(C), China(C), Cuba(C), Finland(A), India(C), Kazakhstan(C), Korea, Republic of(A), Mexico(C), Norway(A), Russian Federation(A), Slovenia(C), Spain(A), Sweden(A)

Total Cost: **$154 147**

Duration: 2000-07-01 — 2003-11-12

CRP Overall Objectives

To enhance the Member States utilisation of Alpha Particle Spectrometry in different fields of applications such as geological, biological and archaeological dating, studies of geochemical and oceanographic processes, assessment of radiological contamination in the environment and safeguarding of nuclear materials. The initiation of a Co-ordinated Research Project in this field was recommended by four external consultants' during a meeting in July 1999.

CRP Specific Objectives

(i) To develop and characterise reference and intercomparison materials.
(ii) To develop software for alpha particle spectrum analysis.
(iii) To investigate the availability and expense of tracers.

Research Outputs

A software package (WinAlpha) was developed, reference material based on uranium mine tailings was produced and analysed, and a gridded ionisation chamber for large samples and prototype solid state detectors were produced.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has increased the utilisation of alpha spectrometry in by making reference materials and computer software for spectrum analysis available to laboratories in IAEA Member States.

The ability to measure extremely low levels of radioactivity in a wide variety of sample matrices is of is of high importance in a number of scientific areas. This CRP has increased the capacity of laboratories in IAEA Member States to perform low level alpha particle spectrometry.

This CRP addressed relevant questions, in the field of alpha particle spectrometry, such as availability of reference materials, sample preparation, low level spectrum analysis and detector development.

Recommended Future Action by Agency

To distribute the WinAlpha software and the uranium reference material on request.

Resulting Publications

Thirty scientific publications and conference reports related to the CRP were published by project members.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F1.10.09 In-situ applications of X-ray fluorescence (XRF) techniques**

Participating Countries: Albania(C), Argentina(C), Belgium(A), China(C), Ghana(C), Hungary(C), Italy(A), Mongolia(C), Pakistan(C), Poland(C), Romania(C), Slovenia(C), United Kingdom(A)

Total Cost: **$172 727**

Duration: 2000-07-10 — 2003-12-01

CRP Overall Objectives

To assist laboratories in Member States in such areas as environmental pollution monitoring, mineral exploration, preservation of cultural heritage, control of industrial processes and optimisation of analytical methodologies for these applications using Field Portable XRF (FPXRF) instruments.

CRP Specific Objectives

(i) To develop and optimise sampling methodologies for in situ XRF measurements.
(ii) To improve analytical performance of FPXRF based on the study of mineralogical effects, surface irregularity effects, heterogeneity and the influence of moisture content.
(iii) To develop and validate quantitative and/or semi-quantitative procedures to be applied for in situ XRF analysis.
(iv) To develop complete operating procedures for selected in situ applications, including relevant quality assurance.

Research Outputs

Several methods for quantitative analysis have been developed, adapted and improved. The proposed methods and procedures led to improved precision and accuracy of in situ element determination by XRF technique. The following improved correction algorithms and/or improvements in quantification procedures resulted from the CRP:

1. Extension of the range of standard reference materials used for calibration;
2. The use of site specific and matrix matched calibration samples;
3. Improved quantification procedures for analysis of painting's pigments and other objects of works of art;
4. Correction procedures for moisture/light matrix content, dilution effect and surface irregularity effects;
5. Method for estimating effective atomic number of analyzed samples in support of quantification;
6. Estimation of low-Z matrix composition by applying emission-transmission method in support of quality control;
7. Corrections for surface roughness, mineralogy and preliminary work on weathering effects in the analysis of rock outcrops;
8. Development of partial least squares (PLS) procedures to improve quantification;
9. Modification of a fundamental parameters correction procedure for dual excitation of samples by using 55Fe and 109Cd sources.

Moreover, sampling strategies and procedures as well as methods for in situ sample preparation and analysis have been elaborated. Based on the reports presented by the participants the following three harmonized guidelines/protocols for in situ XRF analysis were compiled:
1. Guidelines for in situ sampling and analysis of soils, sediments and rocks
2. Guidelines for using portable XRF equipment for non-destructive analysis of works of art
3. Sample preparation protocol for alloy characterization and scrap metal sorting by FPXRF spectrometry

CRP Outcome (Effectiveness; Impact; Relevance)

The outputs of the CRP contributed to establishing complete analytical methodologies (including development of instruments and procedures) for in-situ applications of XRF techniques. The methodologies were successfully tested and implemented in the participating laboratories for the analysis of contaminated soils, sorting scrap metal alloys, geochemical mapping and archaeological studies.

Following development of the analytical methodologies based on FPXRF instruments, new applications of the XRF technique were successfully demonstrated. Inherent features of FPXRF such as non-destructive analysis, on-site immediate availability of analytical results, multielement capability, speed of operation and access to valuable/unique samples guarantee that FPXRF will be widely used for in-situ characterisation of materials.

The CRP created opportunities for new applications of XRF technique where no alternative solution is available. Moreover, analytical capabilities of XRF laboratories were considerably improved and new end-users of FPXRF were identified.

The CRP was useful for the Agency and the target groups in the Member States, as it responded to the growing needs and interest of Member States to apply (in a cost effective way) nuclear analytical techniques where no alternative solution is available.

Recommended Future Action by Agency

The CRP identified a few areas in which further research is still needed. The outstanding problems include possible further improvements in methodology and instrumentation.

Resulting Publications

Internal: TECDOC in preparation.

External: Papers published by the participants in peer-reviewed journals and presented at conferences.

Other outputs:
Final reports submitted to the Agency by the RC/RA holders are available from the Instrumentation Unit, NAAL.
Summary of the results obtained under the CRP distributed via the Agency's XRF Newsletter to around 150 XRF laboratories worldwide.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F1.20.14 The use of ion beam techniques for analysis of light elements in thin films, including depth profiling**

Participating Countries: Brazil(C), China(C), Croatia(C), Finland(A), France(A), Hungary(C), Mexico(C), New Zealand(A), Portugal(C), Slovenia(C)

Total Cost: **$143 520**

Duration: 2000-08-01 — 2003-11-12

CRP Overall Objectives

To promote a co-ordinated research effort between accelerator laboratories and materials science research groups in the IAEA Member States.

CRP Specific Objectives

To assist and promote the development of quality assurance methods, to evaluate databases of parameters needed for quantitative analysis and to develop and apply accelerator-based nuclear techniques of analysis to selected problems concerning the surface modification of materials and production of thin films.

Research Outputs

Over 30 papers published in internationally refereed journals. New and enhanced research facilities established in Member States. TECDOC-1409 published.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP demonstrated the effectiveness of accelerator-based, nuclear techniques for analysis to provide valuable data and knowledge not readily accessible using other non-nuclear methods and facilitated the development of synergies between accelerator laboratories and materials research groups in Member States.

The outcomes of this CRP successfully demonstrated to Member States that accelerator based, nuclear techniques of analysis can provide reliable, quantitative information on a wide range of emerging materials of technological importance; information that is difficult to obtain by non-nuclear methods. Quality assurance protocols were strengthened, and suitable reference standards provided, enabling Member States to provide higher quality, and more comparable information. The CRP identified the need and importance to harmonize databases, and to supplement it with reliable information in areas where there are identified deficiencies.

Through this CRP, Member States have a strengthened capacity to develop and apply accelerator-based nuclear techniques of analysis to problems concerning the characterization and modification of advanced materials.

Recommended Future Action by Agency

It is recommended that activities to assist and promote the development of quality assurance methods, and the evaluation and upgrading of nuclear data is undertaken.

Resulting Publications

IAEA-TECDOC-1409, Ion beam techniques for the analysis of light elements, including depth profiling, October 2004.

ANDRADE E., CHROMIK S., JERGEL MI, JERGEL MA, FALCONY C., STRIBK V., ZAVALA E.P., ROCHA M.F., Study of the Superconducting MgB2 Films by Ion Beam Analysis Methods, Thin Solid films, 433 (2003) 103.

ARAUJO, L.L., GRANDE, P.L., BEHAR, M., DIAS, J.F., DOS SANTOS, J.H.R., SCHIEWITZ, G., Channelling loss of O ions in Si: the Barkas effect, Nucl. Instr. Meth. B193 (2002) 172.

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BATTISTIG, G., GARCIA LOPEZ, J., MORILLA, Y., KHANH, N.Q., LOHNER, T., PETRIK, P., RAMOS, A.R., Effect of ion current density on damage in Al ion implanted SiC, submitted to Nucl. Inst. Meth. B (July 2003).

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BOGDANOVIC RADOVIC, I., JAKSIC, M., BENKA, O., GURBICH, A.F., Helium elastic scattering from carbon for 30º to 150º in the energy region from 2 to 4.8 MeV, Nucl. Instr. Meth. B190 (2002) 100.

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FLORES, M., MUHL S., ANDRADE, E., The relation between the plasma characteristic and the corrosion properties of TiN/Ti multilayers deposited by unbalanced magnetron sputtering, Thin Solid Films 433 (2003) 217.

GRACIN, D., JAKSIC, M., DUBCEK, P., MEDUNIC, Z., Investigation of the nano-structural properties of amorphous SiC alloys by IBA technique, optical spectroscopy and GISAXS, Vacuum 71 (2003) 47.

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Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F2.20.32 Development of kits for Tc99m radiopharmaceuticals for infection imaging**

Participating Countries: Argentina(C), China(C), Hungary(A), India(C), Indonesia(C), Mexico(C), Netherlands(A), Pakistan(C), Poland(C), Thailand(C), United States of America(A), Uruguay(C)

Total Cost: **$206 561**

Duration: 2000-06-15 — 2003-06-14

CRP Overall Objectives

To create a technical base for production, quality assurance and distribution in sufficient quantity, of kits for Tc99m labelled infection imaging agents for better management of such patients, particularly in developing Member States.

CRP Specific Objectives

To investigate Tc99m labelling of selected molecules with a view to develop a 'specific' infection-imaging agent and evaluate them by laboratory investigations and animal biodistribution studies.

Research Outputs

Among the objectives of this CRP was the development of labeling strategies in participating laboratories that would be useful in the preparation of radiolabeled infection imaging agents. In addition, techniques were to be developed for the testing in vitro and in vivo of label stability. Finally, it was hoped that one or more of the identified agents would prove to localize in infection by what appears to be a specific mechanism. The selection of agents to be investigated under the CRP was dictated by two considerations: 1) that if a truly "infection specific" imaging agent is presently in existence, then that agent is likely to be one of the antimicrobial peptides; and 2) of the agents known to be "nonspecific" (i.e. infection/inflammation agents) only those showing faster pharmacokinetics and less normal tissue radioactivity uptake than that displayed by radiolabeled cells or HIgG are of interest. Accordingly, in the first category ubiquicidin (UBI) was selected while in the second category, the participants selected ethylenediaminetetraacetic acid biotin monomer (EB1) and human neutrophil elastase inhibitor (HNE2). Available published information also indicated that these are promising agents that can be labeled with Tc99m.

The CRP was successful in all three measures. In general, each participating laboratory became proficient in labeling with 99mTc using a variety of techniques . Furthermore, the importance of quality assurance measurements became universally recognized and applied such that in the end of the CRP, the radiolabeled agents were viewed as reliably labeled. Finally, with the identification of UBI 29-41 as a radiolabeled agent with potential clinical utility, this CRP has obviously made a major contribution to the armamentarium of the nuclear medicine physician by providing the first trustworthy specific infection imaging agent. The details of experimental results related to all three agents are summarized below:

HNE2:

Source: The only source of HNE2 was Dyax in Cambridge, MA and then only in first year of the CRP. Bovine Pancreatic Trypsin Inhibitor (BPTI) in sufficient quantities was provided from USA to be used as a model for the radiolabeling of the much less available HNE2.
Labeling: HNE2 and BPTI were both radiolabeled using HYNIC/tricine MAG3 and DTPA. Purification after labeling was necessary and was accomplished either on P4 columns or using a Sep-pak as above. Adequate quantities of trypsin were also supplied from USA to use in a shift assay with BPTI. Shift assays performed in Argentina and India with open column G75-100 chromatography showed the expected shift and, therefore, provided evidence that the BPTI was properly labeled.
Quality assurance: As mentioned above, the shift assay was positive
Stability studies: Argentina showed by cysteine challenge of DTPA-BPTI and HYNIC-BPTI, that both were very stable.
Both were also stable in PBS but both also showed binding to serum proteins, especially in the case of HYNIC/tricine.
Serum stability studies in India of MAG3-HNE2 also showed stability.
Animal studies: In Argentina at 2 h in mice, labeled BPTI showed high uptake in kidneys. In India, MAG3-BPTI provided high kidney uptake in normal mice. Monkey studies in Hungary with DTPA-HNE2 showed high kidney uptake, low liver and a somewhat disappointing T/NT ratio between 1.2-1.7 for heat-killed inflammation vs. bacterial infection.
Summary: While the labeling of HNE2 or BPTI proceeded without difficulty, the former peptide became unavailable after the first year of the CRP. Therefore, this peptide was no longer a contender for infection or inflammation imaging and efforts on this peptide by participants was accordingly ended.

EB1

Source: The EB1 was first provided from USA initially while later in the CRP, solid EB1 was synthesized and distributed from Pakistan and India. Kits containing tin were prepared in Pakistan, India and Poland. The kit preparation from Poland was freeze dried using manitol. There was general agreement that the tin content was not critical in these kits.
Labeling: No difficulties were experienced in the labeling and specific activities as high as 1 GBq/25 ug could be achieved.
Quality Assurance: ITLC/acetone was used to determine pertechnetate while Sep-pak could be used to measure pertechnetate, EDTA in the first wash with 0.001 M HCl and labeled EB1 in the second wash with 50% ethanol/saline.
Colloids remain on the column. Typical labeling efficiencies were greater than 95%. The shift assay using open column G25 sephadex or HPLC were both used but the molar ratio of avidin was shown to be critical to achieve a complete shift. Stability studies: C-18 Sep-pak analysis after 24 hr incubation in neat human serum at 37degree C showed no evidence of instabilities.
Animal studies: Radiolabeled EB1 clears rapidly through the kidneys showing some accumulation in this organ but otherwise very low backgrounds everywhere. The infection/inflammation ratio in mice was 1.4 and T/NT was about 2-3. But uniform numbers of bacteria were not used to prepare the infection sites making comparison difficult. For example, an excellent T/NT ratio of 5 was achieved in Thailand using high concentrations of bacteria.
Summary: EB1, regardless of its source or whether labeled from a kit, is easily radiolabeled at high specific activity and the radiolabel is stable in vitro and in vivo. The participants agreed that EB1 probably provides superior T/NT ratios in relation to UBI 29-41 but unlike UBI 29-41 is nonspecific.

UBI 29-41

Source: UBI 29-41 was synthesized and distributed to participants by Leiden University Medical Center with funds from the Agency. In addition, the university provided the scrambled peptide as control. The peptide was found to be stable to transport. In addition, the peptide was also synthesized in Poland for HYNIC conjugation and for kit preparations in that country.
Labeling: Labeling of this agent was both by direct and indirect methods.
Direct: As demonstrated in several participant laboratories, UBI 29-41 could be radiolabeled directly without the need for an exogenous chelator. The mechanism of direct labeling was investigated by molecular mechanics and quantum mechanical calculations by Mexico with the results that the arginine and lysines appear to provide a cage for the reduced technetium. While the initial method developed in The Netherlands involved potassium borohydride and pyrophosphate, investigators in Mexico showed that both were unnecessary (and may have functioned only to raise pH above 8). Thus, the final method does not include these reagents and therefore avoids concerns regarding the toxicity of borohydride. Kits for the direct labeling of UBI 29-41 have been developed in Poland, India and Pakistan. The composition of the three different formulations are listed in the relevant research reports and all appear to work well.
Indirect: MAG3, DTPA and HYNIC were considered for the indirect labeling of UBI 29-41, in part, to determine the influence of these methods on the pharmacokinetic properties of the labeled agent. While DTPA was shown in Poland to provide a useful method of labeling UBI 29-41 with 111In, this chelator gave too low a specific activity with 99mTc. In Argentina, MAG3-UBI 29-41 was found to provide stability no different from that of HYNIC/tricine UBI 29-41 but lower binding to S. aureus. However, the difference in pharmacokinetics was dramatic in that kidney accumulations were much higher with HYNIC. When compared between tricine and EDDA, labeling efficiencies at room temperature were better (>90%) with tricine and lower with EDDA unless heated to boiling water temperatures. Concern was expressed about the effect of this temperature on the peptide. As shown in Poland, combined EDDA/tricine provides a poor label compared to tricine alone but the label is more stable in serum and is expected to show improved pharmacokinetics. UBI 29-41 was synthesized in Poland with the HYNIC attached but the properties appear to be exactly the same with the conjugated UBI 29-41. In all cases, the coupling ratio was 3:1 but groups attached per molecule were not measured. Two UBI 29-41 labeling kits were made in Poland, one with tricine and another with tricine/EDDA and kits were made in Thailand and Pakistan differing in the amount of tricine. However there appears to be no significant differences in pharmacokinetics, labeling yield (approx. 95%), stability of either the kit or the free product. The in vitro binding to S. aureus varied between 25-40%.
Quality assurance: Label quality was established using RP HPLC, C18-Sep-pak, ITLC and paper chromatography. It was agreed that Sep-pak was the approach of choice for the analysis of labeled UBI 29-41. Acidic methanol will wash off the peptide, pertechnetate elutes with 0.001 M HCl and colloids remain on the column. Nevertheless, it was agreed that HPLC analysis is essential to look for nonradioactive impurities such as tricine. Serum stabilities under physiological conditions were measured along with cysteine challenge as a further measure of quality with what appears to be satisfactory results. The only quality assurance procedure of integrity of the peptide is bacterial binding.
Animal Studies: Biodistribution in normal mice showed that the label is predominantly excreted by the kidneys and that HYNIC/tricine provides much more liver radioactivity than direct labeling while direct provides much higher kidney activity than HYNIC/tricine. Stability in vivo was shown in The Netherlands in that intact UBI 29-41 was identified in urine. The T/NT ratio was approximately 1.5- 1.8 for indirect compared to 2.5-3.5 for direct, both after 2 h.
Patients: Even though patient studies were not a primary objective of the CRP, one laboratory performed preliminary clinical trials. Seven patients in Mexico with suspected bone infections were studied with direct labeled UBI 29-41, with the approval of the appropriate institutional and national regulatory committees. The T/NT ratio was about 2.2 + 0.7. Radioactivity levels were found at 4 h to be decreasing and at 24 hr no activity remained at the site of infection. Overall, the biodistributions look similar to that seen in mice. It was suspected that the best imaging time is 1-2 h. Clinicians evaluated the images as "good"

and "useful" and concluded that chronic infection showed slight uptake but acute showed intense accumulation. Several infections were confirmed by biopsy and there were no evidence of false positive results.
Summary: There seems to be no outstanding advantages to indirect labeling so that the members agreed that direct labeling was preferred. There was also agreement that UBI 29-41 appears to show specific binding to infection.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP was a success in the development of useful labeling strategies and, in particular, in the establishment of 99mTc-labeled UBI 29-41 as an imaging agent with potential for specific infection imaging. A number of publications by participants have already appeared describing work done in connection with this CRP.

The overall objective was accomplished since the procedures for preparing Tc99m infection specific agent and its quality assurance were established in all participating labs, many of them from developing Member states. The information has also been published in the open literature.

There is need for a Tc99m labelled agent for specific infection imaging. This CRP helped to establish the antimicrobial peptide labelled with Tc99m as an infection imaging agent which will introduce this new agent for diagnosis of a variety of infections difficult to diagnose otherwise. In patient management this will have a very good impact.

Recommended Future Action by Agency

To support dissemination of this expertise through other means such as TC projects and encourage cooperation among participants by other means.

Resulting Publications

The results of the work done under the CRP have been published in journals and national and international symposia by the participants. A TECDOC is under preparation compiling the results obtained by participating laboratories.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F2.20.33 Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides**

Participating Countries: Argentina(C), Belgium(A), China(C), Hungary(A), Indonesia(C), Iran, Islamic Republic of(C), Kazakhstan(C), Romania(C), Russian Federation(A), Saudi Arabia(C), United States of America(A)

Total Cost: **$134 835**

Duration: 2000-09-01 — 2003-12-31

CRP Overall Objectives

To optimise and standardise the solid phase cyclotron target technology for the production of I-123, I-124, Tl-201 and Pd-103.

CRP Specific Objectives

(i) To investigate the possibility of using electrodeposited tellurium and melted tellurium oxide as target material for the production of I-123 and I-124.
(ii) To prepare a target for the production of Thallium-201 which will withstand high beam currents in the range of 100 μA or more. This will be accomplished through the transfer of the technology available on the electrodeposition of Thallium onto copper plates to produce a smooth, stable surface.
(iii) To prepare a target for the production of Pd-103 from Rhodium by electrodeposition of Rh onto metal plates.

Research Outputs

The major technical and scientific developments achieved by the participants can be summarized, for each radionuclide, as follows:

Thallium-201
- The current density has been set at 2-3 mA/cm2 allowing time controlled production of 4 targets in less than 6 hours.
- Plating performed from cyanide free solutions has proven to give an excellent product with proper adjustment of the metal contents of the plating bath.
- Tl-203 layers have been demonstrated to withstand 270 microamper for 9 hours with no apparent loss of material.
- An improved water cooling geometry for the target carrier has been determined to allow the target to be operated at higher beam currents.
- A new procedure has been implemented in Argentina that utilizes the information from the CRP, which has resulted in a product of high purity and ease of operation completely automated. An exchange chromatography method for the separation of Tl+ from Pb2+ has been developed and implemented.
- The transfer of the technology from the CRP made it possible for Kazakhstan to develop Tl-201 as a new product.
- The thallium recovery rate in Kazakhstan has been improved to 99.5%.
- A program has been developed in Hungary which allows the prediction of the levels of impurity based on the isotopic composition of the target material and using the best values for the nuclear reaction cross-sections for the relevant reactions.

Iodine-123 and Iodine-124
- A remote controlled system has been designed and built based on the information transferred in this CPR. Such a system for production of I-123 from the TeO2 target has been installed in Russia.
- A more efficient helium cooling system has been used on the TeO2 target in Russia to aid in heat transfer.
- Quality control test have been developed by Russia for the TeO2. There should be a visual inspection of the target plate to check for color and uniformity of layer thickness.
- A beam scanner has been used to evaluate the effect of beam wobbling and beam optics on yield in Russia.
- The technology for plating of the tellurium on a nickel surface electrodeposited onto the copper surface has been used in China. Loss of tellurium in the beam was reduced with this technology.
- The recovery of the expensive enriched tellurium has been increased to better than 99% in China after transfer of the technology.
- After changing the thickness of the target carrier plate to 0.5 mm, the maximum beam current was increased from 30 microamper to 80 microamper in China.
- A new method for the preparation of I-123 from tellurium metals target has been used in Saudi Arabia utilizing the technology developed in this CRP. The new method has increased yield by more than 30% with the same level of quality of the final product.

Accomplishments of CRPs Completed in 2003

Palladium-103

- In Iran a cylindrical graphite centrifugal electro dissolution mini-reactor was developed which allow the dissolution of small pieces of rhodium effectively.
- The chemistry for the recovery of the rhodium was evaluated and results indicated that Rh2O3 works the best.
- The technique of thermal diffusion of Pd-103 from a rhodium foil has been further evaluated. Such a process would allow one to minimize target preparation and recovery.
- Methods for the preparation of seeds on an experimental scale have been tried in both Argentina and China.

CRP Outcome (Effectiveness; Impact; Relevance)

Improved cyclotron solid target technology has been developed under the auspices of the CRP which in turn has allowed an increased in both, quality and reliability of the production of Pd-103, I-123 and Tl-201. By having at hand improved and more reliable technologies, the practical radionuclide production yields have been increased up to 30% in some instances, contributing to improve the efficiency and economic of radionuclide production programmes.

The radionuclide production programmes in Member Sates based on the operation of cyclotrons will be significantly strenghtened by having improved and tested technologies. The technology developed under the current CRP can be easily applied to the production of radioonuclides other than the ones included in the current investigations.

The CRP has stimulated collaborative research in a high-tech area, and it has produced important technical and original data for the fabrication of cyclotron solid targets capable of withstanding high beam currents. This development will increase the reliability of radionuclide production programmes in Member States as well as to improve the economics of radionuclide production programmes. Furthermore, the results of the CRP have clearly demonstrated that compact, medium current cyclotrons can produce interesting amounts of contemporary radionuclides such as Pd-103 for brachytherapy applications.

Radionuclides continue to play an important role in diagnostic and therapeutic applications in modern nuclear medicine. Many of these radionuclides are produced by cyclotrons and the corresponding laboratory production methodologies and technologies are subject to constant improvements. In particular, Thallium-201, Iodine-123, Iodine-124 and Palladium-103 are important radioisotopes for use in medical diagnosis and therapy and are expected that their use will increase in the foreseeable future. Thus, Tl-201 is already being regularly produced and utilized in several countries including a number of developing countries, I-123 is widely used for imaging by Single Photon Emission Computed Tomography (SPECT) where Tc-99m analogues are not yet available for example brain receptor imaging, whereas Pd-103 has been recently introduced successfully for brachytherapy of prostate cancer and other solid tumors. I-124 is a potentially useful radionuclide for targeted therapy as well as for molecular imaging by Positron Emission Tomography (PET) . Interest in the later two isotopes is growing amongst many developing countries operating cyclotrons.

Recommended Future Action by Agency

Further development of solid target technology to withstand higher beam current is expected to continue in the future. The CRP participants have identified areas for future research which the Agency may consider promoting. In particular:

1. Gas or liquid targets - This is related to fabricating targets which will withstand higher beam currents (>100 microamper) for the production of several radioisotopes with an emphasis on the PET isotopes in particular fluorine-18. One example for the production would be the liquid water target using oxygen-18 enriched water with improved cooling and perhaps a new medium. Another would be the oxygen-18 enriched oxygen gas target which can be run at high beam currents and the fluorine-18 extracted efficiently from the walls of the target. The technology for irradiation of gas targets at high beam currents could be applied to additional gas targets for the production of other radioisotopes.

2. Solid targets for new radioisotopes - The technology which has been developed in this CRP can be applied to a wide variety of other metals which in turn expands the number of useful radioisotopes which can be produced at high beam current with solid targets. The products of these targets could be metals, liquids or gases as has been shown in the current research. The radioisotopes which might fall into this category are Zn-62, Cu-62, Cu-64, Cu-67, Ge-68, Br-76, Br-77 and I-124. High beam current targets would allow efficient production of these isotopes in reasonable irradiation times.

3. Extension of current research - The current research has shown that the target cooling parameters and beam optics play a very important role in determining the maximum current which may be applied to a target. There is significant research which may be done in different methods of cooling, different methods of construction and measurement of beam optics at the high beam currents possible with these targets. Irradiation of other physical forms of the target materials such as foils and wires needs to be explored as they may simplify the processing of the target if the extraction of the product can be made to be efficient.

Resulting Publications

- The results of the work done under the CRP have been published in journals and national and international conferences by the participants.
- A TECDOC and a scientific paper are under preparation compiling the results obtained by participating laboratories.

PUBLICATIONS RESULTING FROM THE CRP

IN JOURNALS

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VAN DEN WINKEL P.N., DE VIS L., DE BACKER G., "A new industrial high-quality Tl-203 plating/recovery technology", 4th Conference and Workshop on Cyclotrons and Applications, CCW'01, Cairo, Egypt, February 17-21, 2001.

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Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F3.30.11 Isotope response to dynamic changes in groundwater systems due to long term exploitation**

Participating Countries: Australia(A), Denmark(A), Germany(A), Germany(A), India(C), Israel(C), Jordan(C), Malaysia(C), Philippines(C), South Africa(C), Switzerland(A), Tunisia(C), Turkey(C), United States of America(A)

Total Cost: **$191 018**

Duration: 1999-06-01 — 2003-05-31

CRP Overall Objectives

To make an assessment of potential utilization of long-term isotope responses of hydrological systems, particularly aquifers in arid and semi-arid regions, in the quantitative understanding of hydrodynamic changes induced by exploitation, and to investigate their impact on the resource both in terms of quantity and quality of water. Applied field research in selected bench-mark systems with different hydrogeological settings and spatial scales will enable predictions to be made of future behaviour of the systems under different exploitation scenarios.

CRP Specific Objectives

To use environmental isotopes and hydrochemistry to: a) obtain long-term isotope response of groundwater systems under transient exploitation patterns; b) assess the applicability of these isotope responses in studying the hydrodynamic changes in the system behaviour (flow dynamics and pathways, mixing patterns, hydraulic interrelationships, mass transport characteristics); and c) develop dynamic simulation models based on the isotope data to be used for predictive purposes.

Research Outputs

This CRP demonstrated how environmental isotopic and geochemical tracers can be used to evaluate the hydrological consequences of long-term utilization of water resources. The different case studies demonstrate that long-term exploitation of aquifer systems modifies the recharge regimes, flow directions in the aquifer, and causes inflow of external water sources that enter the aquifer and modify its water quality. In all of the study cases, it is demonstrated that the isotopic tools are essential in evaluating the recharge patterns, flow dynamics, and mixing with external water resources. The studies showed that isotopic tools should be integrated in hydrological evaluation, model predictions, and management plans. The isotopic tools provide a clear validation for numerical modeling and prediction for future safe yield of exploited aquifer.

In Germany it was shown that variations in selected radioactive and stable isotope ratios are important tools for construction and calibration of groundwater flow models. Such models can be further used to develop adequate management strategies to protect water resources against pollution and over-exploitation. The isotopes help to establish an early warning system for recharge of contaminated water; for shallow aquifers, mainly stable isotopes and tritium, for deep aquifers radioactive (e.g., 39Ar) isotopes are suitable. Similarly, qualitative comparison of multiple tracers (3H/3He, 85Kr, CFC-12, SF6) and age distribution simulations in a shallow aquifer in Denmark showed that numerical models could be validated by using the isotopic data. The isotopic snapshot investigation combined with tritium time-series highlights the importance of using transient simulation models when dealing with transport in shallow multi-aquifer systems. The use of tritium also enables reconstruction of the history of exploitation and flow patterns, as demonstrated in the Singen aquifer, Germany. Over-exploitation during early 1970's is reflected by the tritium content, which explains the accelerate dynamics of flow in the aquifer. The isotopic data explains the present contamination situation, which is different from what would expect from hydrodynamic data alone.

Similarly, isotopic data obtained from the carbonate Principal aquifer of the Roswell basin, USA, confirm the results of a numerical finite models that were preformed for the basin. The isotopic data enabled estimation of the recharge rate and showed rapid groundwater movement in the aquifer.

Natural recharge in the Jwaneng well field, Botswana, was investigated using long-term isotopic data. The environmental isotope data provides not only unequivocal evidence of ongoing recharge to the Jwaneng well field, Botswana, but allowed it to be quantified and clarify important aspects of its hydrology not incorporated into operational modeling. Similarly, radioisotope sampling in the Amadeus Basin aquifer in central Australia indicates no changes in groundwater age despite 35 years of intensive extraction that has resulted in a decrease of the standing water levels by over 50 meters. Modern recharge is occurring in the area of the proposed new well field, which would mitigate over-use of the current well field thus ensuring the sustainability of Alice Springs' water supply. The recharge patterns were evaluated also in Afyon basin in central Turkey. Stable isotopes were used in studying to delineate the source of recharge water, which is derived from high elevation recharge. This conceptual model contradicts previous hydrological models for water recharge and thus the water budget estimations for

the basin are not correct. Numerical modeling was performed based on the new isotopic constraints. Any future evaluation of the water budget and exploitation should be based on isotopic and hydrochemical data.
In contrast, artificial recharge modifies the oxygen and deuterium isotopic composition of the natural groundwater. The long-term impact of artificial recharge of imported water from the Sea of Galilee was evaluated in the Mediterranean coastal aquifer of Israel. It was shown that the distinctive isotopic and chemical signals of the recharged water could be used to delineate and to quantify the mixing relationships with regional groundwater. The isotopic tool is an essential tool to monitor the regional distribution of artificial recharge.
In arid basins, long-term exploitation also changes the water quality of the groundwater. Over-exploitation of Azraq basin, Jordan, for 20 years resulted in decrease of water level, which led to elimination of spring discharge and consequently completely destroyed the unique Azraq oasis. This was accompanied by salinization due to upflow of deep mineralized formation water, as evidenced by the isotope data. Reducing abstraction rates showed consequent rising of water tables and improving water quality, which indicates that remediation of the basin is still possible. A similar situation is observed in the Complex-Terminal aquifer in the south of Tunisia and particularly in Nefzaoua area.
Long-term exploitation for 30 years resulted draw-down of water level, elimination of spring discharge, and salinization. The isotope data indicated that the salinity is derived from deep saline water. Further reduction of water level might lead to further contamination from hypersaline shallow Chott (sabkha) aquifer. Thus, in
arid basins, the isotopic signature can be used as alarm signal and a monitoring tool for the potential sources of salinity, particularly the distinction between up-flow of deep saline groundwater and down-flow of hypersaline shallow brines formed in sabkhas. A similar case study was demonstrated in western Rajasthan, India. The combined use of isotope, hydrochemical, and numerical modeling techniques helped in understanding the dynamics and changing water quality of deep fresh water lens in view of long-term exploitation. The isotope data indicates that the fresh water is old and no modern recharge occurs. Moreover, the salinization phenomena is due to mixing with deep brackish groundwater, which is very old. In addition, the isotope data enabled the delineation of potential zones for safe groundwater abstraction in a ephemeral river-recharged phreatic aquifer. By using the isotopic data it was possible to indicate that the river is recharging the aquifer and improving its water quality.
In the geothermal system of Negros, Philippines, long-term isotope and geochemistry data provided valuable information in determining the proper and sustainable reservoir management strategy. The degradation of the reservoir thermal quality was associated with an isotopic change, reflecting the influence of meteoric water. In the overlying shallow groundwater basin, the spatial distribution and migration of outflow mineralized thermal waters under transient conditions were determined through the use of environmental isotopes and geochemistry. In thermal waters of western Turkey, extensive exploitation shows strong effects on chemical and isotopic composition of thermal water, especially in CO2 dominated thermal systems. In such systems the decrease of the artesian overpressure is accompanied by a drop of the CO2 partial pressure and therefore also of the CO2 concentration in the water itself.

CRP Outcome (Effectiveness; Impact; Relevance)

The impact of the CRP has mainly been that isotopes are recognized as effective indicators to be used in a long term monitoring programme to record unexpected changes in the system. Specific questions have been elucidated, such as aquifer changes by time, by the integration of isotopes as tracers in the monitoring of water resources which have been under long term exploitation.
The CRP has lead to the establishment of a monitoring programme for several aquifers. This will further help to understand the cause of changes in aquifer systems of both renewable and non-renewable character which are under long term exploitation.
The studies performed in the CRP has a direct relevance to the planning and management of groundwater resources. It is especially shown to be valuable to apply a multiple isotope long-term monitoring programme for non-renewable water resources. In this respect the overall result of the CRP has shown that the isotopes are effective early warning indicators for irreversible processes. Also the collected time series through monitoring of aquifers over time help to understand the dynamics of the system as well as the rate of observed changes.

Recommended Future Action by Agency

If a similar CRP is designed it is strongly recommended that one or possibly two sites are selected for the field study. In the current CRP each participating group or contract holder concentrated the on their own site. There has been advantages with this, however, some of the questions to be elucidated in the CRP could have been more focused if the study was performed at one site.

Resulting Publications

Final reports have been collected and a TecDoc is being compiled and planned to be produced for a publication.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F4.10.16 Fission product yield data required for transmutation of minor actinide nuclear waste**

Participating Countries: Belarus(C), China(C), Germany(A), Japan(A), Kazakhstan(C), Netherlands(A), Russian Federation(A), Russian Federation(C), Ukraine(C), United Kingdom(A), United States of America(A), United States of America(A)

Total Cost: **$155 178**

Duration: 1997-10-01 — 2003-06-17

CRP Overall Objectives

To provide reasonable quality fission yield data for the more obscure (yet important) actinides to as to improve predictions and design features of proposed transmutation nuclear waste plant and procedures - feasibility studies for different nuclear waste concepts and scenarios require nuclear data, including fission yields up to 150 MeV incident neutron energy.

CRP Specific Objectives

To develop fission yield systematics and nuclear models as tools for an evaluation of energy-dependent fission yields up to 150 MeV.

Research Outputs

- Descriptions of the partitioning of actinide fission cross sections into non-emissive and emissive fission contributions are presented as tools for the calculation of the contributions of different fissioning nuclides to the total fission yield distributions of given target nuclides.
- Six different model codes have been developed from systematics and nuclear models for the calculation of energy-dependent fission yields . The results of these various calculations have been compared in a benchmark exercise.

CRP Outcome (Effectiveness; Impact; Relevance)

The specific research objectives of the CRP have been achieved and the results of the CRP are necessary tools for future evaluations of fission yields over energies up to 150 MeV, as required for nuclear waste transmutation studies.

Contributions of individual fissioning nuclides and resulting fission product yield distributions have been studied quantitatively for the first time at energies up to 150 MeV. The results of this CRP will serve as a basis for future studies and developments.

The detailed studies, developments of systematics and models should lead to a better understanding of fission mechanisms at energies up to 200 MeV. The computer codes developed during the CRP can be used for the calculation of fission yields for any desired target and incident particle energy, and are suitable for adoption in future evaluations of fission yields.

Recommended Future Action by Agency

The results of benchmark calculations showed discrepancies, particularly at energies above about 30 MeV, which have not been fully understood. The Agency should support a detailed analysis of the models, codes and calculational results as a first step towards a better understanding and necessary improvements of the models, codes and/or underlying nuclear data.

Resulting Publications

A suitable technical document is in preparation.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **F4.10.18 Development of a database for prompt gamma-ray neutron activation analysis**

Participating Countries: China(C), Hungary(C), India(C), Korea, Republic of(A), United States of America(A), United States of America(A), United States of America(A), Vietnam(C)

Total Cost: **$101 102**

Duration: 1999-04-01 — 2003-04-30

CRP Overall Objectives

To improve the accuracy and completeness of the data needed in PGAA in order to make possible the reliable application of this technique in such fields as materials science, chemistry, geology, mining, archaeology, environment, food analysis and medicine.

CRP Specific Objectives

To compile measurements, and evaluations or improvement of the data below:

(i) Capture gamma-ray energies and absolute intensities for the dominant neutron capture isotope of each chemical element.
(ii) Thermal and sub-thermal neutron-capture cross sections for dominant isotopes.
(iii) Correction factors to account for cross section deviations from the 1/v law.
(iv) k0-factors for all elements.

Research Outputs

The CRP resulted in databases providing a variety of tables for all natural elements (from H to U) including the following data: isotopic composition, thermal radiative cross section (total and partial), Westcott g-factors, energy of the gamma rays (prompt and delayed), decay mode, half life and branching ratios.

CRP Outcome (Effectiveness; Impact; Relevance)

Prompt gamma-ray analysis developed slowly after the first reports of gamma radiation from neutron capture by Lea and the Fermi group (1934). The first published tabulation of gamma-ray energies and intensities (Groshev, 1961) and plots of spectra (Greenwood and Reed, 1965) led to a number of significant applications during the era of NaI scintillation counters, from borehole logging to planetary exploration. A major advance was the comprehensive Chalk River compilation of Lone (1981), which remain indispensable at the desk of every PGAA researcher for twenty years, despite some inadequacies inherent in these early measurements. The result of this CRP (2004) incorporates results generated during a gap of more than 20 years, and adds recently measured energies and intensities of capture gamma rays of the elements from the PGAA facility at the Budapest Research Reactor, and recent data from other CRP participants. These data are combined and compared with nuclear levels and other information from the Evaluated Nuclear Structure Data File (ENSDF) to produce a comprehensive, self-consistent set of capture gamma data. Prompt-gamma neutron activation analysis has become a well-established analytical method with applications in many areas. The new data compilation resulted from this CRP represents a major break through and will encourage the further and more extensive use of PGAA in the future.

The increasing importance of Prompt Gamma-ray Activation Analysis (PGAA) in a broad range of applications is evident, and has been emphasized at many meetings related to this topic. PGAA is a non-destructive radioanalytical method capable of rapid or simultaneous "in-situ" multi-element analyses across the entire Periodic Table, from hydrogen to uranium. However, inaccurate and incomplete data have been significant hindrances in the qualitative and quantitative analysis of complicated capture-gamma spectra by means of PGAA. Therefore, the main goal of the CRP was to improve the quality and quantity of these data in order to make possible the reliable application of PGAA in fields such as materials science, chemistry, geology, mining, archaeology, environment, food analysis and medicine. This aim has been fully achieved and is documented in the TECDOC. An associated CD-ROM contains the complete databases, the retrieval system, and important electronic documents related to the project.

Recommended Future Action by Agency

To organize a new CRP or a Data Development Project that would focus on the total radiative cross sections that can be derived from the capture gamma database.

Resulting Publications

A TECDOC and a CD-ROM are in preparation.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I1.10.02 The impact of infrastructural requirements on the competitiveness of nuclear power**

Participating Countries: Bulgaria(C), China(C), India(C), Kazakhstan(C), Pakistan(C), Russian Federation(C), Turkey(A), Turkey(C)

Total Cost: **$152 269**

Duration: 1999-10-01 — 2003-10-10

CRP Overall Objectives

To obtain, by means of energy sector modelling and consideration of selected representative countries, new knowledge concerning the impact of the need to develop and support power sector infrastructure on the competitiveness of nuclear power with other energy sources.

CRP Specific Objectives

The specific objectives were:
(i) to assist the participating Member States in refining their studies in support of energy and nuclear power planning programmes with the use of comprehensive, state-of-the-art models;
(ii) to determine, on a country-by-country basis, competitive advantages of nuclear power related to the type and amount of infrastructural investments in the nuclear sector and its competitors;
(iii) to generalise, to the extent possible, these findings and their impact on the development of nuclear power world-wide;
(iv) to derive and formulate, on the basis of country-specific studies, general methodological guidelines for assessing the impact of the infrastructural factor on comparative assessment of energy sources;
(v) to support and enrich the existing capability of energy system analysis in the participating Member States.

Research Outputs

Participating national teams prepared a country report presenting the methodology used and the main results obtained.

CRP Outcome (Effectiveness; Impact; Relevance)

The modelling efforts in participating countries varied in approach. The competitive aspects were mostly studied inversely, by estimating the incremental costs of infrastructure requirements in competing energy sectors. Some general methodological guidelines were devised by Agency staff for participants to use in assessing infrastructure requirements, but these were not further developed by participants, nor were findings generalised.

Despite certain analytical shortcomings, the overall-objective of capacity building in the field of energy modelling was met by the project.

This CRP proved to be a good vehicle for capacity building in two specific areas: energy sector modelling and comparative assessment in a competitive context. Participating teams gained new insights and new tools for performing such evaluations.

The Agency is producing a series of studies on different cost aspects of nuclear energy. This CRP provided a first step in looking at infrastructural questions, and provided the impetus for future work looking at the infrastructural benefits of nuclear technologies.

Recommended Future Action by Agency

None

Resulting Publications

"Infrastructure Development and Nuclear Competitiveness: Initial Results of an IAEA Research Project" by S. Kononov, A. McDonald and H.-H. Rogner, presented at and published by "Workshop on New Energy Infrastructures in Eurasia and the Environment, IIASA, Laxenburg, Austria, 19-20 October 2000.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I2.10.11 Scientific basis and engineering solutions for cost-effective assessments of software-based I&C systems**

Participating Countries: Argentina(A), China(A), China(C), Czech Republic(A), Finland(A), Germany(A), Korea, Republic of(A), Norway(A), Russian Federation(A), Russian Federation(C), Ukraine(A), Ukraine(C), United States of America(A)

Total Cost: **$69 530**

Duration: 1999-10-01 — 2003-04-28

CRP Overall Objectives

To facilitate the cost-effective implementation of software-based instrumentation and control (I&C) systems in nuclear power plants.

CRP Specific Objectives

To assess engineering solutions which will cost-effectively produce the information required to facilitate evaluations and acceptance of software-based I&C systems. This is being done to assure that the software-based I&C systems are of acceptable quality for use in safety and safety-related applications in nuclear power plants, but is also relevant for non safety systems that still need to have high reliability and availability for economic reasons.

Coordinated research carried out in the following areas:

- Project management;
- Requirement specification;
- Custom designed systems;
- Use of commercially available or commercial-off-the-shelf (COTS) systems;
- Generic pre-qualification of platforms, devices, applications, and tools;
- Safety and reliability enhancements;
- Evaluation methods;
- Verification and validation;
- Licensing issues.

Research Outputs

To successfully implement software-based I&C systems, it is necessary that the safe operation of such software based systems in nuclear power plants is proven during the licensing process in order to gain the acceptance of regulatory authorities, as well as acceptance in the plant itself. Suitable assessment methods in order to demonstrate safe and reliable functionality of the system, in particular for software related functionality, have to be applied. Efficient methods to meet the required high quality of the assessment within acceptable costs are needed. The engineering solutions of such assessment methods evaluated and developed in this CRP were designed to contribute to this overall objective.

The results of this CRP facilitated the cost effective assessment of software based I&C systems in nuclear power plants which was necessary in addressing obsolescence issues, introduce new beneficial functionality, improved overall performance.

CRP Outcome (Effectiveness; Impact; Relevance)

The large CRP group consisted of 13 laboratories representing 13 Member countries. This CRP has approached the challenge of finding cost effective assessment of software based I&C systems in nuclear power plants. Cost effectiveness was found in two ways:

(1) Solutions that improve the assessment methods or assessment process to enhance the quality of the assessment and/or to reduce the cost of the assessment;
(2) Solutions that can be done in earlier phases of the project, or in earlier projects, to reduce the amount of assessment required and/or to reduce the costs of the assessment, such as generic pre-qualification of a platform for an application or taking advantage of assessment activities done by others.

There continues to be uncertainty with both suppliers and utilities as to the regulatory requirements to be met when licensing software based I&C systems. Even when regulatory requirements are available, there remains uncertainty and inconsistency in their interpretation. Although not part of the CRP, since regulations are country dependent, stabilization of the licensing environment in each country is necessary for widespread implementation of software-based systems. The engineering solutions to improve the evaluation process, when generally accepted, will help the realization of this stabilization.

This CRP final report (IAEA-TECDOC -1328) described the approaches for the use of cost effective solutions to achieve high quality assessment of software based I&C system. These systems include safety applications, safety related applications, and not important to safety applications. It is obvious that assessment is required for safety and safety related systems to obtain the high quality required by safety regulations. However, from operation and economic points of view, high reliability is needed for many not important to safety systems as well, which leads to additional assessment activities. The utility may decide to do more assessment work than what is required by safety regulations for safety and safety related systems due to other requirements, such as economic ones requiring very high reliability and availability.

Recommended Future Action by Agency

This CRP provided the scientific bases for engineering solutions to use the software based I&C system. Based on the CRP results, the proposed CRP focuses on the successful integration of software-based and analogue systems and human system interfaces from the human cognitive perspective. The successful integration of software-based and existing I&C systems and interfaces from a human cognitive perspective during I&C modernization programs is a key factor in reducing the likelihood of human error and in improving performance. However, the technical basis and methodology/guidance of human factors engineering and assessment for successful integration were not developed for the modernized I&C system.

Resulting Publications

IAEA-TECDOC-1328: Solutions for cost effective assessment of software based instrumentation and control in nuclear power plants.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I2.10.12 Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials**

Participating Countries: Bulgaria(C), Czech Republic(C), France(A), Hungary(A), India(C), Netherlands(A), Russian Federation(C), Russian Federation(C), Russian Federation(C), Slovakia(C), Ukraine(C), United Kingdom(A), United States of America(A), United States of America(A)

Total Cost: **$188 970**

Duration: 1999-12-01 — 2003-11-18

CRP Overall Objectives

To determine the mechanism for and quantify the nickel content on the deteriorating effect in radiation embrittlement of reactor pressure vessel steels of Ni-Cr-Mo-V or Mn-Ni-Cr-Mo types.

CRP Specific Objectives

(i) To analyse of mechanical properties and microstructure of materials in the as received state;
(ii) Investigate irradiation conditions for the participants' irradiation experiments;
(iii) To analyse mechanical properties and microstructural examination of materials in the post irradiation condition;
(iv) To analyse the combined results in the as-received and irradiated conditions;
(v) To derive the relationship between the transition temperature shift dependence on neutron fluence taking into account nickel content;
(vi) To analyse results of tests with national steels;
(vii) To make recommendations for further research on the effects of nickel on irradiation-induced embrittlement mechanisms in RPV steels.

Research Outputs

Eleven institutes from eight different countries and the European Union participated in this CRP and six institutes conducted the irradiation experiments of the CRP materials. In addition to the irradiation and testing of those materials, irradiation experiments of various national steels were also conducted. Moreover, some institutes performed microstructural investigations of both the CRP materials and national steels. The research results were presented, discussed and analysed under the CRP. The results analysed are clear in showing the significantly higher radiation sensitivity of high nickel weld metal (1.7 wt%) compared with the lower nickel base metal (1.2 wt%). These results are supported by other similar results in the literature for both WWER-1000 RPV materials, pressurized water reactor (PWR) type materials, and model alloys.

CRP Outcome (Effectiveness; Impact; Relevance)

Irradiation experiments of the CRP WWER-1000 RPV materials were conducted by six of the eleven institutes participating in the CRP. In addition to the irradiation and testing of those materials, irradiation experiments of various national steels were also conducted. Moreover, some institutes performed microstructural investigations of both the CRP materials and national steels.

It is generally accepted that the presence of nickel in RPV steels increases its sensitivity to neutron-induced embrittlement even at low phosphorus and copper concentrations. Additionally, it was stated that there is only a limited quantity of data on neutron embrittlement of WWER-1000 steels (Ni-Cr-Mo-V) with high nickel content (>1.5 wt%). As a result, the IAEA organized this CRP with the stated goal: "to provide information based on the results obtained that will allow for improved understanding of the effects of nickel on light-water RPV embrittlement that will lead to the development of improved predictive techniques".

It is clear from the various studies that nickel associates with copper in the irradiation-induced copper-enriched precipitates, and that manganese (and possibly silicon) is similarly associated. At least for the very high nickel steels examined (A508 grade 4N), an important observation is that when there is very little manganese, even for very high nickel content, very little irradiation-induced embrittlement occurs.

Thus, at least for that steel, it appears that high nickel content, when not combined with copper and moderate manganese, is not a serious embrittling agent. For WWER-1000 steels with very low copper contents and irradiated to relatively low fluence, atom probe tomography has shown ultra-fine manganese-nickel-silicon enriched precipitates. Atom probe tomography of such steels at relatively high fluences has not been performed, but the results at low fluence compel the need for such examination.

Recommended Future Action by Agency

(i) It is desirable to study the synergistic effect of nickel with manganese, respectively silicon to explain/understand the embrittlement mechanism of high/low nickel RPV steels/welds.
(ii) Detailed studies of changes in mechanical properties should be accompanied by microstructural investigations to be able to explain potential damage mechanisms and synergisms (qualitatively and even semi-quantitatively).
(iii) Regarding the potential synergistic effect of manganese and nickel to radiation embrittlement of WWER-1000 RPV materials and the fact that the predictive formula in the Russian Guide was evaluated on the basis of moderate nickel content (up to 1.5 wt.%), an activity for the revision of this formula is recommended.

Resulting Publications

IAEA-TECDOC Series: Effects of Nickel on Irradiation Embrittlement of Light Water Reactor Pressure Vessel Steels (PC/4656): approved by PC on 9 February 2005.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I2.10.13 Surveillance programmes results application to reactor pressure vessel integrity assessment**

Participating Countries: Argentina(A), Brazil(A), Bulgaria(A), Czech Republic(A), Czech Republic(A), Finland(A), Germany(A), Germany(A), Hungary(A), India(A), Japan(A), Korea, Republic of(A), Mexico(C), Netherlands(A), Romania(A), Russian Federation(A), Russian Federation(A), Russian Federation(C), Russian Federation(C), Slovakia(A), Spain(A), United States of America(A), United States of America(A), United States of America(A)

Total Cost: **$141 470**

Duration: 1999-11-10 — 2003-11-09

CRP Overall Objectives

To use the Master Curve approach for assessing structural integrity of RPVs using small surveillance size specimens, such as the pre-cracked Charpy loaded in three-point bending. In order to assess the use of this small specimen, a plan to test a single material by all of the participating laboratories was established, as well as additional testing of national steels and other related characterizations. The material selected for the quasi round robin testing was the IAEA standard reference material JRQ.

CRP Specific Objectives

- To develop a large database of fracture toughness data using the Master Curve methodology for both pre-cracked Charpy size and one-inch thick (25.4 mm) compact tension (1T-CT) specimens to assess possible specimen bias effects and any effects of the range of temperatures used to determine T0, either using the single temperature or multi-temperature assessment methods.
- To develop international guidelines for measuring and applying Master Curve fracture toughness results for RPV integrity assessment.

Research Outputs

Fracture toughness test results show clear evidence that lower values of unirradiated T0 are obtained using pre-cracked Charpy specimens as compared to results from 1T-CT specimens. This bias in test results is very important when considering use of pre-cracked Charpy specimens in evaluating RPV integrity. The results from this CRP were influential in changing the ASTM Test Method to include consideration of this effect.

The overall outputs from this CRP provide data, which are applicable for both material characterization purposes and test and analysis method development and verification. In general, the results for the JRQ plates and the national materials are consistent with previous data analyzed using ASTM E 1921-02 or its preceding versions or the SINTAP Master Curve procedures. The following conclusions can be made derived from the JRQ and national material fracture toughness test data analyzed in this CRP:

- The mean fracture toughness of the 6JRQ plate material generally can be described satisfactorily with the standard Master Curve method from ASTM E 1921-02. For conservative estimates, the SINTAP procedure is recommended to be used for materials showing marked inhomogeneity.
- The SINTAP analyses confirm that the 6JRQ plate material can show some weak inhomogeneity; this inhomogeneity can be taken into account by applying the SINTAP procedure for a conservative Master Curve estimate of T0.
- The overall mean T0 values show, in accordance with previous investigations, that a bias of around 10oC exists between the T0 values of CT and SE (B) specimen types with the CT specimens giving higher values of T0.
- The analyses of both the JRQ and the national materials confirm that the procedures specified in ASTM E 1921-02 as well as the SINTAP procedure are generally valid and applicable for characterizing JRQ type steels and even steels showing distributed inhomogeneity.

CRP Outcome (Effectiveness; Impact; Relevance)

The large CRP group consisted of 20 testing laboratories representing 15 Member countries. The designation code for each participating organization is also indicated along with the type of specimen(s) and material(s) tested. Further details on the actual test matrices for the JRQ steel and the analysis of the test results are contained in Sections 5 and 7, TECDOC-1435, respectively. Results from the additional testing of the national steels are presented in Sections 5 and 8, TECDOC-1435. Other characterization testing for JRQ and national steels also is covered in Section 9 TECDOC-1435.

Accomplishments of CRPs Completed in 2003

A short summary of the RPV material section of the IAEA International Database on Reactor Pressure Vessel Materials (IDRPVM) was developed as results of CRP. One of the main goals of the database is to assist researchers in understanding underlying trends, identifying potential mechanisms, and storing valuable data for future studies.

Scientists and engineers from Argentina, Brazil, Bulgaria, the Czech Republic (two laboratories), the European Commission (JRC), Finland, France, Germany (two laboratories), Hungary, Japan, Republic of Korea, Romania, the Russian Federation (two laboratories), Spain, and the United States (three laboratories) contributed to the development of these guidelines. Through benchmark analysis, the comparisons of results with the same type of specimen(s) and material(s) have been done.

Recommended Future Action by Agency

As a general recommendation for further research, the Master Curve based approach, which is mostly applicable in the basic, standard form, should be expanded further to a more generic form which includes procedures for testing the quality of data and special tools for analyzing abnormal cases. These cases may be applicable to materials showing bimodal type fracture behaviour, materials requiring a lower-shelf adjustment, or situations where specific constraint consideration is needed.

Resulting Publications

- IAEA-TECDOC-1435: Application of Surveillance programme results to reactor pressure vessel Integrity assessment
- IAEA-TRS-***: Guidelines for Application of the Master Curve Approach to Reactor Pressure Vessel Integrity in Nuclear Power Plants (PC/4569): approved by PC on 17 March. 2004.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I2.10.15 National approaches to correlate nuclear power plant performance targets and O&M costs**

Participating Countries: Argentina(A), Brazil(C), Czech Republic(C), Hungary(C), India(C), Korea, Republic of(C), Mexico(C), Slovakia(C), Ukraine(C), United States of America(A), United States of America(A)

Total Cost: **$90 247**

Duration: 1999-11-15 — 2003-10-08

CRP Overall Objectives

To discuss and analyse national approaches to correlated performance targets and O&M costs with the objective to identify major economic performance indicators, on the assumption that the development of economic performance indicators would allow the management to identify more clearly where and how costs are being incurred and sharpen its judgement to determine whether adjustments would improve plant competitiveness.

CRP Specific Objectives

(i) To develop economic performance indicators to get a better understanding of the financial management system in each country. These indicators could be used for basic comparison with industrial values as well as among the plants.
(ii) To develop a standard benchmarking process to correlate performance targets and O&M costs. Cost benchmarking would assist members to achieve the optimum level of performance and enable economic performance data to be analysed at an international level. This process could focus among others on: methods for optimising operations and maintenance costs; identifying high and low costs areas in O&M activities; establishing cost impact of extended outage, e.g. due to regulatory requirements, backfitting, etc.; identifying refuelling costs. These standard benchmarking processes would enable to choose a simple function/process and identify trends and areas to improve.

Research Outputs

(i) Identification of major economic performance indicators and development of international set of definitions for these indicators;
(ii) Development of standard benchmarking process to correlate performance targets and O&M costs and enabling simple functions.
(iii) Publication of research results (TRS Nuclear Power Plant Economic Performance).

CRP Outcome (Effectiveness; Impact; Relevance)

All project objectives were met. National methodologies and approaches to establish performance targets were discussed and shared. A set of international performance indicators were identified and validated during the project. Benchmarking analysis were conducted by the individual participants and results shared in the meetings.

The project enabled sharing national approaches to evaluate performance targets and O&M costs what was the starting point to identify indicators for international use.
Some participants have already implemented new techniques and methodologies identified during the project in their organizations. A set of economic indicators for international use was identified and documented. It's well proven that an integrated approach to economic and performance analysis of nuclear power plant can lead to overall improvements on plant performance and contribute to plant safe, reliable and cost effective operation.

The outcome of this project also contributed to and benefited from the results of other projects being implemented by the Agency under Project A1.01- "Nuclear Power Planning, Implementation and Performance" and A1.06.- "Management of Nuclear Power Plant Operations in a Competitive Environment".

The project contributed to the identification of high and low costs areas in O&M activities, means to optimize outages and the cost impact of extended outage.
The development of a set of indicators and its association with the IAEA Nuclear Economic International System (NEPIS) provided the means to look at overall performance of NPP thus improving plant performance.

Recommended Future Action by Agency

A natural continuation of this CRP would be the identification of O&M "best practices" plants and encourage the spread of O&M best practices quickly and efficiently to all plants.

Resulting Publications

Technical Report Series - Nuclear Power Plant Economic Indicators.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **I2.70.01 Information management solutions for SAT applications (SAT-IM)**

Participating Countries: Bulgaria(C), Canada(A), Hungary(A), India(C), Russian Federation(A), Russian Federation(C), Slovakia(A), Spain(A), Ukraine(A), United States of America(A)

Total Cost: **$59 240**

Duration: 2000-06-01 — 2003-02-24

CRP Overall Objectives

To facilitate cost-effective implementation of information technology for nuclear plant personnel training programmes to address national/utilities' experience issues, to introduce new training approaches, and to improve the overall effectiveness of SAT-based training.

CRP Specific Objectives

To assist in the development of information technology solutions that will cost-effectively produce and manage information required to ensure competent NPP personnel via systematically developed, implemented and maintained training programs.

Research Outputs

CRP Outcome (Effectiveness; Impact; Relevance)

The objective of the CRP was reached through co-ordinated research and collected experience in the areas of needs analysis for SAT-IM and benefits expected, scope of the SAT-IM, project management; specification requirements, use of software and hardware platforms, use of commercial off the shelf products, user and system interfaces, and engineering solutions for SAT database management.

This project provided the opportunity to investigate a practical solutions of an implementation of information technology for nuclear plant personnel training programs and impact of these solutions on achieving better performance, increase safety, and reduce workload and lower costs.

The project has produced several documents and technology transfer meetings. During each year a research co-ordinated meeting was held to discuss the progress of each organization on the tasks in this project. Three meetings were organized during the period of 200-2002 in Paks NPP, Hungary (September 2000), in Madrid, Spain (October 2001) and in Trnava, Slovak Republic (October 2002). The reports from each of these meetings, along with this final report, describe all of the activities carried by the co-operating organizations under this project. The final report gives guidance for information management solutions for SAT applications. The information in this report consists of shared knowledge and experience of organizations in several countries: Kozloduy NPP, Bulgaria, Paks NPP, Hungary, Nuclear Power Corporation of India Ltd, India, VNIIAES and Research Institute of Atomic Reactors, Russian Federation, VUJE Trnava, a.s., Slovak Republic, Tecnatom S.A., Spain, and Exitech Corporation, USA. The results of these efforts benefit all countries in their development and implementation of effective training programmes for NPP personnel.

The CRP was relevant to the needs of Member States and the Agency programme as it realistically addressed the pressing need for Member States to compile lessons-learned and develop guidance for Member States in the area of maintaining and upgrading the management information contained in their SAT (Systematic Approach to Training) programs. The focus of the project was to take advantage of the capabilities available in computer based information management systems in order to improve operational efficiency and increase safety performance.

Recommended Future Action by Agency

The CRP recommendations have been taking into consideration in development of the IAEA programmes for 2004-2005 and 2006-2007.

Resulting Publications

The results of the CRP and national reports have been published on CD-ROM.

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **J1.70.05 To investigate appropriate methods and procedures to apply probabilistic safety assessment (PSA) techniques of large radiation sources**

Participating Countries: Argentina(C), Canada(A), China(C), Cuba(C), Japan(C), Mexico(C), United States of America(A)

Total Cost: **$64 337**

Duration: 2000-06-27 — 2003-11-17

CRP Overall Objectives

To apply probabilistic safety assessment to the use of radiation sources in a selected sample of irradiation facilities (medical, industrial and research) in order to identify safety weaknesses, and areas where additional efforts to improve safety should be focused.

CRP Specific Objectives

(i) To provide all participating in the CRP with the tools and instructions for performing risk analysis (Probabilistic Safety Assessment (PSA)) of medical and industrial sources.
(ii) To apply the tools and techniques (event trees, fault trees) by participants to their current procedures and processes (this includes procedures and equipment, which in turn includes hardware and software).
(iii) To use the results from objective 2 to qualitatively assess the strengths and vulnerabilities of the current procedures and processes with respect to safety.
(iv) To determine the frequency of accidents and the probability of contributing events (quantification of the fault and event tree models) using the best available reliability data to obtain a quantitative assessment of current procedures and processes with respect to safety.
(v) To evaluate the benefits of performing PSA to improve the safety of current procedures and processes in the practices under investigation.
(vi) To make available to Member States the results of the work performed under this CRP and guidance for performance of this type (PSA) of analysis. (TECDOC).

Research Outputs

Five research teams applied PSA techniques to several large radiation sources including an industrial irradiator, teletherapy machines and brachytherapy sources. PSA techniques have been applied to nuclear power plants for many years. However, prior to this CRP, PSA techniques had not been applied extensively to radiation sources. The research performed under this CRP demonstrated that probabilistic safety assessment techniques could be successfully utilized to address safety concerns related to the use of radiation sources. The studies completed have identified the areas where so-called "classical" PSA techniques can be applied directly as well as those areas where significant adaptation is required.

CRP Outcome (Effectiveness; Impact; Relevance)

1. All research teams were able to apply PSA techniques that were beneficial in the assessment of safety.
2. All research teams were able to apply PSA techniques to large radiation sources.
3. The results from Objective 2 were used to qualitatively assess those factors associated with the use of radiation sources that may cause undesired endstates.
4. In some cases, the research teams were able to determine the probability of an undesired endstate. However, in other cases, the lack of human reliability data and failure rates for equipment did not allow for a quantitative assessment.
5. The CRP found that PSA techniques can be used as a powerful tool to:
   i) identify and delineate the events or combinations of events that may lead to any of the analysed undesirable end states;
   ii) assess, when data is available, the expected probability of occurrences of such combinations;
   iii) identify changes or alternations in design and operational procedures that might lead to improved safety.

The CRP reached the conclusion that PSA techniques may effectively and reasonably be used to identify the relative risks associated with various initiating events associated with the operation or radiation sources.

Participation in the CRP caused research teams to think in new ways about the application of PSA techniques to radiation sources. Prior to this CRP, PSA techniques had not been extensively applied to radiation sources. This CRP studied the application of PSA techniques to radiation sources, and in doing so, new information concerning the benefits and limitations of this approach was developed.

The results of this CRP will be considered by the Agency as it develops guidance related to the safety of radiation sources. It is possible that PSA techniques may be used more extensively as part of the safety assessment process. Also, attention may be focused on various factors that affected safety that were identified by the systematic approach to assessing safety that the PSA methodology provides.

Recommended Future Action by Agency

The Agency should consider the results of this CRP as it develops future radiation safety standards. The results of the individual studies that were performed point toward specific weaknesses in safety that should be considered as new safety standards are developed. Also, the Agency should consider whether PSA techniques should be applied to the use of large radiation sources as part of the safety assessment process.

One issue that should be considered for future research sponsored by the Agency is human reliability analysis. Human reliability analysis has been a relatively small component of PSA as it has been applied to power plants. However, with regard to radiation sources, especially medical applications, the human contribution to errors is much more dominant than that from equipment failure. Therefore, better understanding of human reliability analysis is needed, especially as it is applied to radiation sources. Also, if PSA is to be applied in a significant way to radiation sources, specific data on human reliability is necessary.

Resulting Publications

A TECDOC, tentatively titled, "Application of Probabilistic Safety Assessment Techniques to Radiation Sources", is being prepared that will present the results of the CRP.

Thomadsen, B., Lin, S.-W., Laemmrich, P, Waller, T., Cheng, A., Caldwell, B., Rankin, R., and Stitt, J., "Analysis of treatment delivery errors in brachytherapy using formal risk analysis techniques", International Journal of Radiation Oncology, Biology, Physics. Vol. 57, Issue 5, 1492 - 1508 (2003).

Thomadsen, B. (in press) "Medical Failure Taxonomies" in Handbook of Human Factors and Ergonomics in Healthcare and Patient Safety. Pascale Carayon(ed) Lawrence Erlbaum Associates: Mahwah, NJ.

Thomadsen, B. (in press) "Taxonomic Guidance For Remedial Actions" in Advances in Patient Safety: From Research to Implementation, Agency for Healthcare Research and Quality (ed) U.S. Government Printing Office: Washington DC.

Núñez Mc Leod, J., Barón, J., Rivera, S, "Human Reliability Analysis in Cobalt-therapy Process using and Adapted ATHEANA Prospective Approach", SESREL 2004 - PSAM 7 International Association for Probabilistic Safety Assessment and Management / European Safety and Reliability Association, Springer-Verlag, London, ISBN 1-85233-827-X (2004).

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **J4.50.02 Development and application of indicators to monitor NPP operational safety performance**

Participating Countries: Bulgaria(C), China(A), Czech Republic(C), India(C), Lithuania(A), Netherlands(A), Pakistan(C), Slovakia(A), Slovakia(A), Slovakia(C), Spain(A), Spain(A), Sweden(A), Ukraine(C), United Kingdom(A)

Total Cost: **$114 384**

Duration: 1999-10-01 — 2003-08-14

CRP Overall Objectives

The objective of the CRP was to foster the exchange of information and develop guidance on application of the IAEA framework for development and implementation of plant-specific operational safety performance indicator programmes, which would include general instructions on the individual steps needed to develop a particular system of safety performance indicators.

CRP Specific Objectives

1) To discuss the safety performance indicator framework proposed in IAEA-TECDOC-1141, analyse its applicability to the participating NPPs and support them in defining their own plant-specific indicators, including calculation formulas, data collection requirements and procedures for indicator monitoring and use. Based on the gained experience, the participating plants were to provide proposals for framework improvements and additions.
2) To propose methods for specific indicator selection, evaluation and aggregation.
3) To develop the software necessary for administration of the system of indicators, data collection, display and analysis of results.

Research Outputs

1) An improved SPI framework based on the feedback from experience containing a representative set of operational safety performance indicators which covers all relevant areas of safety performance.
2) Guidance on the selection and definition of plant specific indicators.
3) Guidance for the definition of performance bands and definition of thresholds and goals.
4) Development of methods and guidance for trending and aggregation of Safety Performance Indicators (SPIs).
5) Development of general principles on how to efficiently use an SPI system.
6) Development of computerised support systems. Development or implementation of software tools for data collection and indicator analyses, result presentation and interpretation.

CRP Outcome (Effectiveness; Impact; Relevance)

Within the CRP work, each participating group reviewed the framework proposed in IAEA-TECDOC-1141 and analysed its applicability to its own plant. Following this step, the participating organizations defined their own specific indicator systems based upon the framework. They developed or revised a set of their plant specific indicators including all the indicator specifications. For this purpose, appropriate indicator selection methods were proposed.

Within the specific research projects, the methods of indicator transformation and aggregation for evaluating the higher level indicators, as well as computer aided indicator administration and display systems were developed. The participants discussed these methods during the second RCM.

Final progress made by each participant in developing and implementing SPIs in their NPPs was presented at the last RCM. Assembled information on SPIs implementation by selected non-participant countries was considered. Advise on development of specific indicators at the Department/Section level as well as recommended criteria for prioritization of indicators was also given. Finally, some thoughts were brought up about an optimum small set of key SPIs for public information and the possibility of extracting a subset of the IAEA recommended SPIs to be proposed for Regulatory Body use.

At the final stage of the CRP, all the plant specific sets of indicators were reviewed, and an sample set of specific indicator to be used by other plants was proposed. Based on the research done, the CRP participants presented suggestions for modifications or additions to the framework proposed in IAEA-TECDOC-1141.

Accomplishments of CRPs Completed in 2003

After each RCM, the work results were summarized in progress reports prepared by the individual research groups. These reports were compiled and issued in the form of Working Materials.

The methods developed for assisting the implementation and use of a plant specific systems of SPIs as well as the revised framework and the experiences have been documented in a technical document, which will be submitted soon for publication, and so distributed to other potentially interested organizations in the Member States.

The CRP has promoted the cooperation and exchange of experiences at international level. The participating plants have obtained support in the development of their own systems of SPIs. The application of the methodologies developed and software tools has led to the development of plant specific systems of indicators used as a tool for own plant self assessment. The methods developed have been used in some plant for developing detailed performance indicators at section and departmental level.

Recommended Future Action by Agency

NPPs need to establish safety and quality management systems, which make use of indicators of plant safety performance. Some of these indicators are being also monitored by many Regulators for sharpening the focus of their oversight activities. There are further research and development needs for including risk-based indicators and indicators that capture the influences safety culture and organizational aspects in the plants, as it is increasingly being demanded in several international meetings. For this reason a new CRP for the period of 2006-2008 has been proposed.

Resulting Publications

Draft TECDOC

Accomplishments of CRPs Completed in 2003

CRP Number and Title: **T1.30.08 Ageing of materials in spent fuel storage facilities**

Participating Countries: Argentina(C), Australia(A), China(C), Germany(A), Kazakhstan(C), Romania(C), Russian Federation(A), United Kingdom(A), United States of America(A)

Total Cost: **$124 143**

Duration: 1999-10-01 — 2003-12-23

CRP Overall Objectives

To focus on the materials science aspects of the ageing of spent fuel (mainly from research and test reactors) and spent fuel facilities for both power and research reactors with a view to improving ageing management.

CRP Specific Objectives

(i) To focus on the ageing management of materials at CRP participants' facilities, to identify the most problematic materials and to initiate research on effective control and monitoring techniques to evaluate their ageing.
(ii) To build up a body of knowledge that can be used to support any case presented to a regulatory authority to support life extension of the facility.
(iii) To transfer know-how on ageing management between the participating Institutes.
(iv) To develop a Report on "Understanding and managing ageing of materials at spent fuel storage facilities" that in taking the best of practices from each of the participating countries and Institutes essentially provides a very useful guidelines document for managing the ageing of materials at all spent fuel storage facilities.

Research Outputs

From the results of a survey carried out during the CRP circulated to all of the facilities in the participating countries, not just the participating Institutes themselves, materials that should be monitored over the lifetime of any spent fuel facility, wet or dry, and for power or research reactors, have been identified along with the stressors that provoke their ageing degradation. Together the experts involved in the CRP have developed an overall strategy to address the management of ageing degradation of materials in spent fuel storage. Research on monitoring of materials initiated during the CRP, which ranges from simple but effective visual monitoring and underwater video photography of the surfaces of critical components and non-destructive testing techniques such as ultrasonic testing, to the use of corrosion coupons and their subsequent destructive testing and microstructural evaluation, have demonstrated usefulness of programmes of materials surveillance.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been effective in achieving specific goals. For example, in the area of the sensitization of stainless steel, an expert from one Institute has essentially become the scientific mentor of the whole programme on the topic at another Institute, helping plan the programme and the analysis of its results. Other pairings of Institutes in the CRP plan to work together long after the CRP has been terminated.

With the final publication of the Report "Understanding and managing ageing of materials at spent fuel storage facilities", which is in the final draft stage, the CRP will have gone a long way to accomplishing its main goal.

The CRP has already had a significant impact. Research programmes in at least two of the participating Institutes have been very much improved. The main impact will come from the Final Report, which being the first of its kind in this area is much needed and is destined to have a very long shelf life.

The back end of the fuel cycle for both power and research reactors is one of the biggest problems faced by the nuclear industry and topics in this area are a high priority in the Agency's programmes. The ageing degradation of materials in spent fuel storage facilities has been a somewhat neglected topic, because the materials have so far performed very well. However, nobody expected spent fuel storage to be extended for as long as it has been already and this will be extended further into the foreseeable future for most countries. For this reason ageing degradation of materials has become a serious concern, if not yet a serious problem.

Recommended Future Action by Agency

The Agency should keep a watching brief on the ageing degradation of materials in all areas of the nuclear fuel cycle. Any future CRP in this area should however be limited to one particular material, class of material or group of alloys so the research can be better co-coordinated. The final report of this CRP will need to be revisited in five to ten years and updated to include any improved approaches to ageing management that come along. But this could be more effectively carried out by a couple of expert meetings.

Resulting Publications in PC

1) N.S. Yanovskaya, T.F. Makarchuk, N.V. Arhangelsky, V.N. Ershov, Prospects for safe management of spent fuel of research reactor (IAEA-CN-82/42). International conference on topical issues in nuclear safety, Vienna, Austria, 3-6 September 2001.

2) O.P. Maksimkin, F.A. Garner, A.B. Johnson, Microstructural and Mechanical studies of the stainless steel/aluminium alloy control rod of the WWR-K research reactor. 10th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, 5-9 August 2001, Lake Tahoe, Nevada, USA. (published in the proceedings)

3) O.P. Maksimkin, Radiation effects in structural materials of nuclear reactor WWR-K and BN-350 3rd International Conference "Nuclear and Radiation Physics, July 2001, Almaty, Kazakhstan. (published in the proceedings).

4) O.P. Maksimkin, M.N. Gusev, Effect of neutron irradiation and long ageing on the mechanical and energetic characteristics of stainless steel. The Physics of Metals and Metallography 2001, v. 92, Number 5, pp 496-499.

5) Final CRP Report "Understanding and Managing the Ageing of Materials in Spent Fuel Storage Facilities" in final preparation for submission to Publications Committee in March 2005.

This list will be extended as soon as the input from the participants has been collected by the scientific secretary.