CO-ORDINATED RESEARCH ACTIVITIES

ANNUAL REPORT AND STATISTICS FOR 2003

July 2004
Research Contracts Administration Section
Department of Nuclear Sciences and Applications
International Atomic Energy Agency

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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 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 co-ordinated research activities are normally implemented through Co-ordinated 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 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 several Doctoral CRPs. This new, optional type of CRP has been 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 are currently being carried out by the Human Health programme.

Further information on the Agency's co-ordinated 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 website at:-

http://www-crp.iaea.org

2. Co-ordinated Research Activities in Support of Agency Programmes and Subprogrammes

The co-ordinated research activities reported in this document are conducted in support of the following Agency programmes/subprogrammes (Ref: GC(45)/8 of August 2001 and GOV/2002/1 of March 2002).

Programme A: Nuclear Power
Programme B: Nuclear Fuel Cycle and Material Technologies
Programme C: Analysis 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 Safety (including Transport Safety)
Programme L: Management of Radioactive Waste
Programme M: Safeguards
Programme N: Security of Material

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 (TECDOCs). In certain cases the research results are directly relevant to implementation of projects in the Agency's Technical Co-operation Programme.

3. Co-ordinated Research Activities in 2003

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

883 contracts and agreements were awarded from the 1242 contract and agreement proposals received by the Agency during 2003. Annex I lists by country the number of proposals received and awards made.

In 2003, $6 675 465 were awarded from the regular budget to institutes under contractual arrangements and to fund Research Co-ordination Meetings (RCMs). Additionally, $325 546 of extra-budgetary contributions were used to fund additional contracts and RCMs. Thus, total awards amounted to $7 001 011. Table 1 summarizes all awards by Programme in 2003. The average award per contract rose to $6 400, which represents a 12% increase over the 2002 average award level.

Table 1: Summary of All Awards by Programme in 2003

	Programme	Regular Budget				Extra-budgetary Funding				Total Expenses
		Contracts	CRP Purchases	RCM Expenses	**Total**	Contracts	CRP Purchases	RCM Expenses	**Total**	
		$	$	$	**$**	$	$	$	**$**	**$**
A	Nuclear Power	105 000	14 000	115 819	**234 819**	0	0	0	**0**	**234 819**
B	Nuclear Fuel Cycle and Material Technologies	79 800	0	19 820	**99 620**	0	0	0	**0**	**99 620**
C	Analysis for Sustainable Energy Development	70 000	0	35 887	**105 887**	0	0	0	**0**	**105 887**
D	Nuclear Science	362 357	0	301 853	**664 210**	0	0	0	**0**	**664 210**
	Major Programme 1	**617 157**	**14 000**	**473 379**	**1 104 536**	**0**	**0**	**0**	**0**	**1 104 536**
E	Food and Agriculture	1 958 548	4 004	566 223	**2 528 775**	53 150	0	0	**53 150**	**2 581 925**
F	Human Health	1 253 350	39 899	412 523	**1 705 772**	0	0	8 604	**8 604**	**1 714 376**
G	Water Resources	245 950	0	63 974	**309 924**	0	0	0	**0**	**309 924**
H	Protection of the Marine and Terrestrial Environments	48 000	0	22 301	**70 301**	0	0	0	**0**	**70 301**
I	Physical and Chemical Applications	314 400	7 034	221 353	**542 787**	0	0	0	**0**	**542 787**
	Major Programme 2	**3 820 248**	**50 937**	**1 286 374**	**5 157 559**	**53 150**	**0**	**8 604**	**61 754**	**5 219 313**
J	Safety of Nuclear Installations	44 000	0	70 409	**114 409**	17 250	0	0	**17 250**	**131 659**
K	Radiation Safety (including Transport Safety)	57 000	16 703	58 683	**132 386**	0	0	0	**0**	**132 386**
L	Management of Radioactive Waste	85 000	0	81 400	**166 400**	0	0	0	**0**	**166 400**
	Major Programme 3	**186 000**	**16 703**	**210 492**	**413 195**	**17 250**	**0**	**0**	**17 250**	**430 445**
M	Safeguards	175	0	0	**175**	0	0	0	**0**	**175**
N	Security of Material	0	0	0	**0**	199 844	0	46 698	**246 542**	**246 542**
	Major Programme 4	**175**	**0**	**0**	**175**	**199 844**	**0**	**46 698**	**246 542**	**246 717**
	Total:	**4 623 580**	**81 640**	**1 970 245**	**6 675 465**	**270 244**	**0**	**55 302**	**325 546**	**7 001 011**
	Total Contract/CRP Awards	4 975 464								
	Total RCM Expenditures	2 025 547								
	Total Expenditures	7 001 011								

Figure 1 illustrates the proportion of regular budget and extra-budgetary funding in 2003.

Figure 1: 2003 Resources

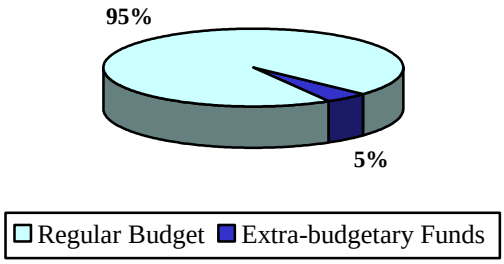
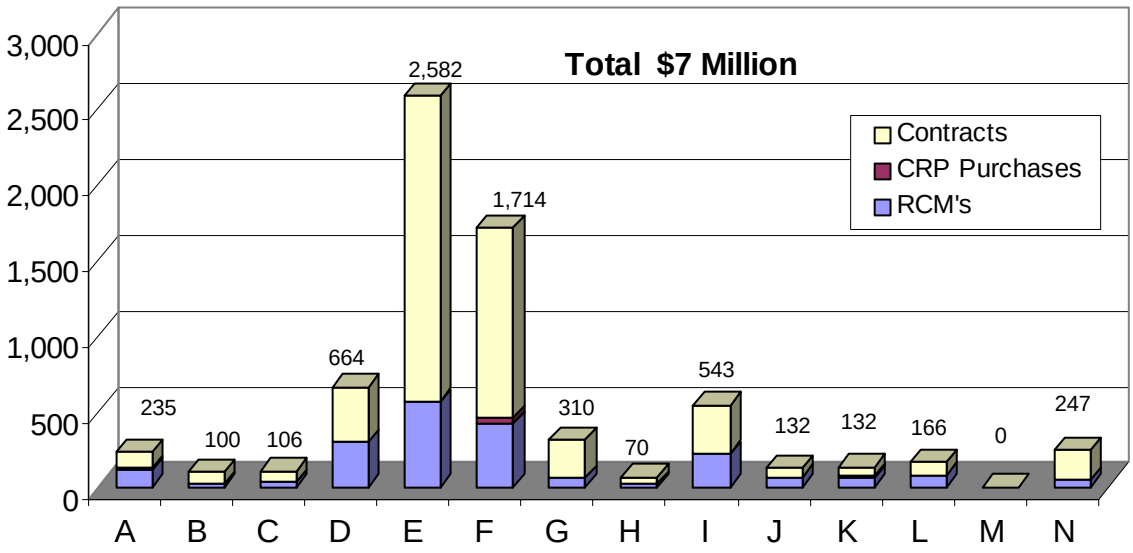


Figure 2 shows the types of awards made by programme.

Figure 2: Distribution of all 2003 Awards by Programme and Type of Activity



Details of resources for 2003 awards by programme and sub-programme and type of award are provided in Table 2. Annex II lists awards by country and programme.

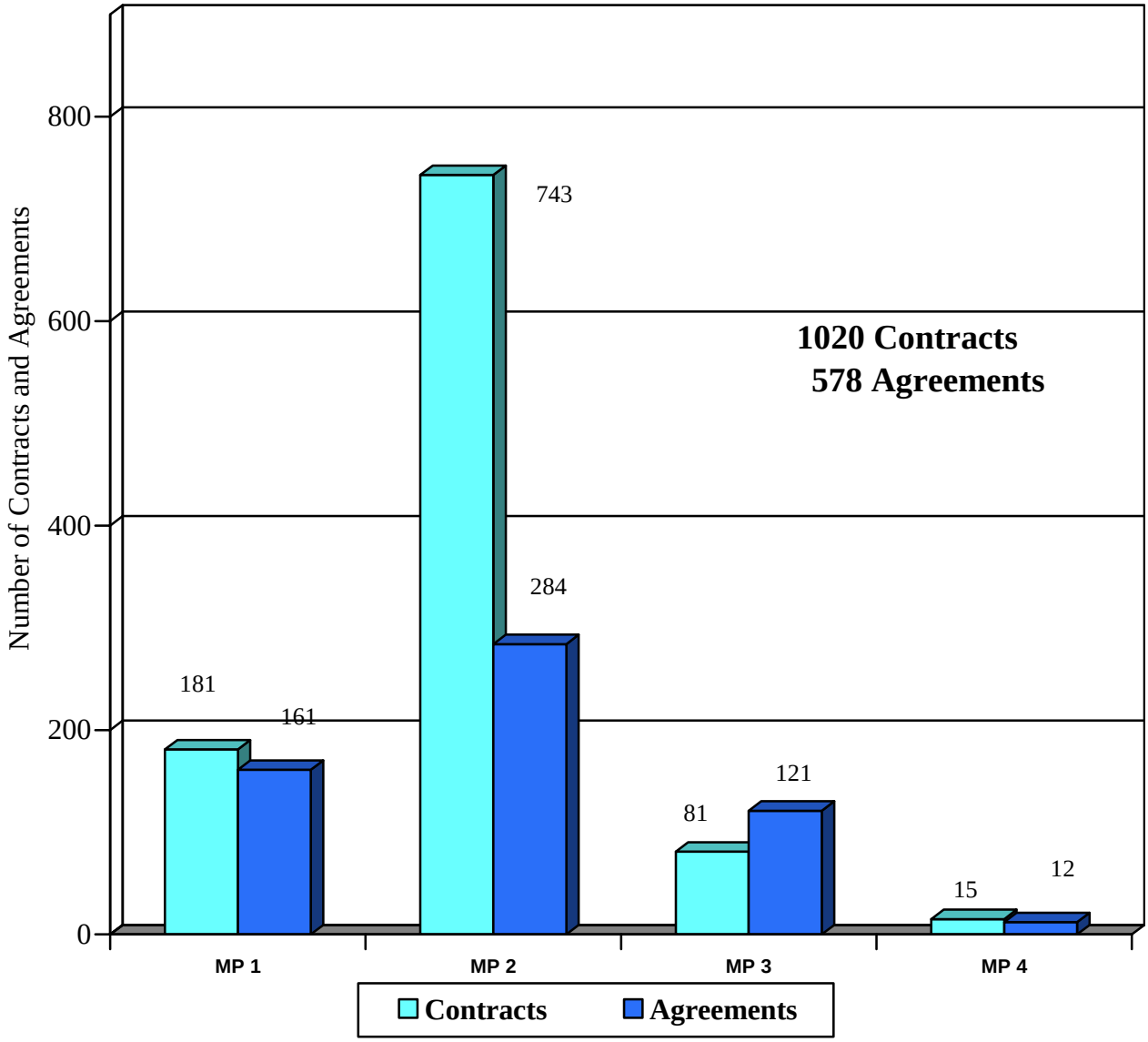
Table 2: Distribution of 2003 Total Funds by Programme

Prog.	Research Contracts		Technical Contracts		Doctoral Contracts		CRP Expenses	Total	RCM's		Overall Total
	#	$	#	$	#	$		$	#*	$	$
A1	10	41 000	0	0	0	0	14 000	55 000	2	45 300	100 300
A2	23	64 000	0	0	0	0	0	64 000	4	70 519	134 519
A	33	105 000	0	0	0	0	14 000	**119 000**	6	115 819	**234 819**
B2	8	40 000	1	5 000	0	0	0	45 000	0	0	45 000
B4	4	18 000	1	16 800	0	0	0	34 800	1	19 820	54 620
B	12	58 000	2	21 800	0	0	0	**79 800**	1	19 820	**99 620**
C1	7	35 000	0	0	0	0	0	35 000	1	14 130	49 130
C2	7	35 000	0	0	0	0	0	35 000	1	21 757	56 757
C	14	70 000	0	0	0	0	0	**70 000**	2	35 887	**105 887**
D1	33	155 000	0	0	0	0	0	155 000	6	94 299	249 299
D2	19	91 000	0	0	0	0	0	91 000	4	68 665	159 665
D3	22	105 357	2	11 000	0	0	0	116 357	7	138 889	255 246
D	74	351 357	2	11 000	0	0	0	**362 357**	17	301 853	**664 210**
E1	45	328 500	9	79 000	0	0	0	407 500	4	120 219	527 719
E2	54	471 555	2	30 000	0	0	1 924	503 479	2	72 861	576 340
E3	50	334 812	3	30 500	0	0	0	365 312	4	126 716	492 028
E4	64	418 300	13	129 000	0	0	0	547 300	5	133 543	680 843
E5	36	190 030	0	0	0	0	2 081	192 111	3	112 884	304 995
E	249	1 743 197	27	268 500	0	0	4 005	**2 015 702**	18	566 223	**2 581 925**
F1	76	525 500	5	43 000	5	59 000	0	627 500	8	189 264	816 764
F2	30	139 850	5	46 000	1	8 000	36 816	230 666	4	86 449	317 115
F3	8	40 000	1	9 000	0	0	0	49 000	2	18 701	67 701
F4	38	310 500	1	10 000	5	62 500	3 083	386 083	6	126 713	512 796
F	152	1 015 850	12	108 000	11	129 500	39 899	**1 293 249**	20	421 127	**1 714 376**
G1	13	65 000	0	0	0	0	0	65 000	4	63 974	128 974
G2	16	77 000	4	103 950	0	0	0	180 950	0	0	180 950
G	29	142 000	4	103 950	0	0	0	**245 950**	4	63 974	**309 924**
H1	2	15 000	0	0	0	0	0	15 000	0	0	15 000
H2	6	28 000	0	0	0	0	0	28 000	1	22 301	50 301
H3	1	5 000	0	0	0	0	0	5 000	0	0	5 000
H	9	48 000	0	0	0	0	0	**48 000**	1	22 301	**70 301**
I1	35	141 000	0	0	0	0	7 034	148 034	5	110 385	258 419
I2	42	169 400	1	4 000	0	0	0	173 400	5	110 968	284 368
I	77	310 400	1	4 000	0	0	7 034	**321 434**	10	221 353	**542 787**
J1	4	17 250	0	0	0	0	0	17 250	0	0	17 250
J2	0	0	0	0	0	0	0	0	2	25 656	25 656
J4	5	8 000	0	0	0	0	0	8 000	0	0	8 000
J6	8	36 000	0	0	0	0	0	36 000	2	44 753	80 753
J	17	61 250	0	0	0	0	0	**61 250**	4	70 409	**131 659**
K1	0	0	1	30 000	0	0	0	30 000	0	0	30 000
K3	0	0	1	10 000	0	0	0	10 000	0	0	10 000
K4	4	11 000	2	6 000	0	0	16 703	33 703	4	49 709	83 412
K5	0	0	0	0	0	0	0	0	1	8 974	8 974
K	4	11 000	4	46 000	0	0	16 703	**73 703**	5	58 683	**132 386**
L3	16	80 000	0	0	0	0	0	80 000	2	67 440	147 440
L6	1	5 000	0	0	0	0	0	5 000	1	13 960	18 960
L	17	85 000	0	0	0	0	0	**85 000**	3	81 400	**166 400**
M2	1	175	0	0	0	0	0	175	0	0	175
M	1	175	0	0	0	0	0	**175**	0	0	**175**
N2	15	199 844	0	0	0	0	0	199 844	1	46 698	246 542
N	15	199 844	0	0	0	0	0	**199 844**	1	46 698	**246 542**
	703	**4 201 073**	**52**	**563 250**	**11**	**129 500**	**81 641**	**4 975 464**	**92**	**2 025 547**	**7 001 011**

*Includes three meetings held jointly under different subprogrammes.

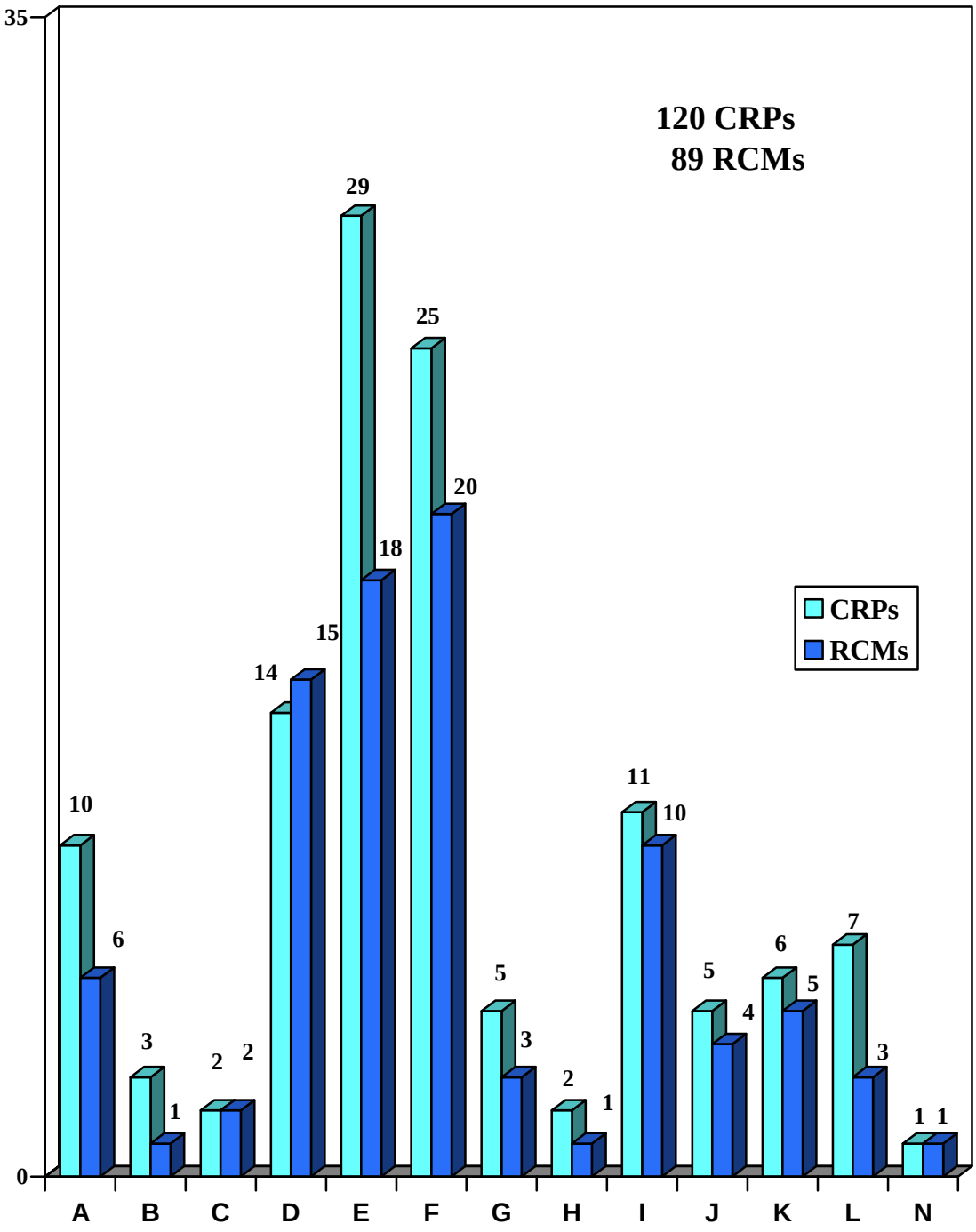
At the end of 2003, there were 1,598 active research contracts and agreements supported by the Agency. 94% of these represented participation in the 120 active CRPs shown in Appendix A and 6% were individual projects. 89 RCMs (see Annex III) were held in support of these CRPs and an amount of $2 025 547 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 2003



MP 1: Nuclear Power; Nuclear Fuel Cycle and Material Technologies; Analysis for Sustainable Energy Development; Nuclear Science
MP 2: Food and Agriculture; Human Health; Water Resources; Protection of the Marine and Terrestrial Environments; Physical and Chemical Applications
MP 3: Safety of Nuclear Installations; Radiation Safety; Management of Radioactive Waste
MP 4: Safeguards; Security of Material

Figure 4: CRPs Active at End 2003 and RCMs Held During the Year



3.1 Member State Participation

The distribution of all contract awards in 2003 is shown by country in Annex IV. 85% of the funds awarded for contracts were made to institutes in developing countries. Table 3 shows the geographical distribution of all contract awards in 2003.

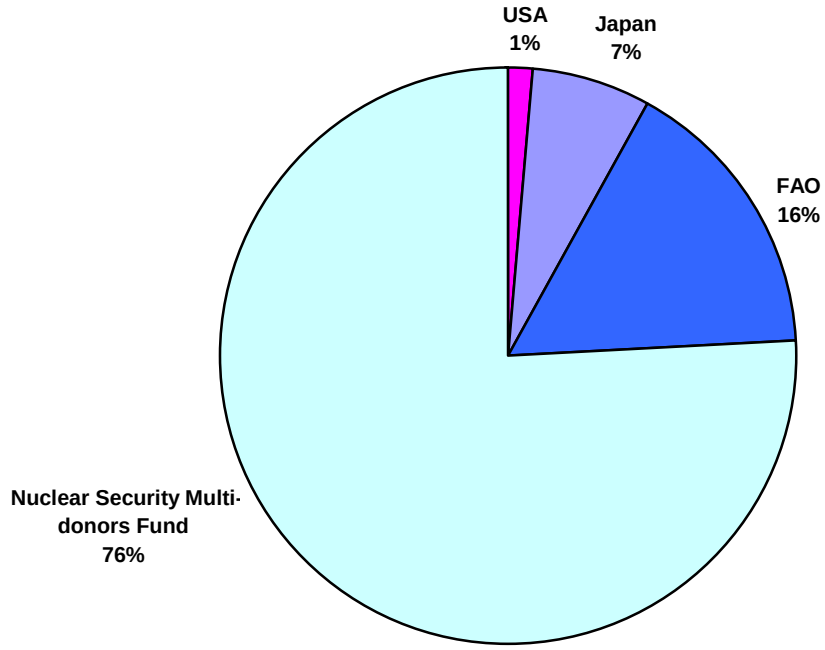
Table 3: Geographical Distribution of Research Contract Awards in 2003

	$	%
South East Asia	1 491 950	31
Eastern Europe	1 085 732	22
Latin America	954 280	20
Africa	536 312	11
Western Europe	438 800	9
North America	217 750	4
West Asia	169 000	3
Total	4 893 824	100

3.2 Extra-budgetary Funding

In 2003, extra-budgetary funds amounting to $325 546 were used for financing contracts and RCMs. The funds used were from the Nuclear Security Multi-donors Fund, FAO, Japan and the United States of America, as shown in Figure 5 and Table 4.

Figure 5: Extra-budgetary Funds, Approved in 2003, by Donor



Total Awards $325 546

Table 4: Summary of 2003 Extra-budgetary Funded Awards

Food and Agriculture Organization of the United Nations

D1.00.00	Food and agriculture: Soil fertility, irrigation and crop production			
	1 contract	10 000		
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			
	8 contracts	43 150		

Japan

E4.30.10	Isotopic evaluations in infant growth monitoring - a collaboration with WHO (partly RCA)			
			1 meeting	4 225
J7.10.09	To update and expand the IAEA reliability data for research reactor PSAs			
	2 contracts	9 250		
J7.10.10	Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools			
	2 contracts	8 000		

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			
	15 contracts	199 844	1 meeting	46 698

United States of America

E4.30.10	Isotopic evaluations in infant growth monitoring - a collaboration with WHO (partly RCA)			
			1 meeting	4 379

Total	28 Contracts	**$270 244**	**Total**	2 Meetings	**$55 302**

3.3 Co-ordinated Research Projects Completed in 2003

29 CRPs were completed in 2003, with 15 of these CRPs concerning topics in Nuclear Techniques for Development and Environmental Protection, 12 in Nuclear Science and Technology, and 2 in Nuclear Safety and Protection against Radiation. A list of these CRPs is included in Appendix B. Evaluations of these CRPs will be completed by the end of 2004 and their accomplishments will be included in the next annual report.

4. Accomplishments of Co-ordinated Research Projects Completed in 2002

Co-ordinated Research Projects are fully evaluated one year after their completion. During 2002, 21 CRPs were successfully completed: 14 of these related to Nuclear Techniques for Development and Environmental Protection, 5 related to Nuclear Science and Technology, and 2 to Nuclear Safety and Protection against Radiation.

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 2003

	Proposals Received			Awards*			
Country	**Contracts**	**Agreements**	**Total**	**Regular Budget**	**Extra-budgetary**	**Agreements**	**Total**
Albania	0	0	0	1	0	0	1
Algeria	8	0	8	8	0	0	8
Argentina	43	0	43	32	0	1	33
Armenia	1	0	1	1	0	0	1
Australia	4	5	9	5	0	3	8
Austria	4	5	9	3	0	6	9
Bangladesh	16	0	16	8	0	0	8
Barbados	0	0	0	1	0	0	1
Belarus	10	0	10	4	1	0	5
Belgium	2	2	4	2	0	2	4
Benin	1	0	1	1	0	0	1
Bolivia	1	0	1	1	0	0	1
Bosnia and Herzegovina	2	0	2	0	0	0	0
Botswana	1	0	1	1	0	0	1
Brazil	38	0	38	33	0	0	33
Bulgaria	18	1	19	12	0	1	13
Burkina Faso	5	0	5	3	0	0	3
Cameroon	5	0	5	2	0	0	2
Canada	3	2	5	3	0	1	4
Chile	17	0	17	14	0	0	14
China	80	2	82	52	1	1	54
Colombia	19	0	19	9	0	0	9
Costa Rica	4	0	4	6	0	0	6
Croatia	6	1	7	5	1	1	7
Cuba	23	0	23	16	0	0	16
Cyprus	3	0	3	2	0	0	2
Czech Republic	20	1	21	16	0	2	18
Ecuador	1	0	1	1	0	0	1
Egypt	12	1	13	3	1	1	5
Estonia	3	0	3	3	0	0	3
Ethiopia	3	0	3	1	0	0	1
Finland	0	2	2	0	0	2	2
France	0	5	5	0	0	4	4
Georgia	1	0	1	0	1	1	2
Germany	4	10	14	4	0	9	13
Ghana	9	0	9	5	1	0	6
Greece	11	2	13	9	0	2	11
Guatemala	2	0	2	2	0	0	2
Honduras	1	0	1	1	0	0	1
Hungary	23	2	25	20	0	2	22
India	69	2	71	58	0	2	60
Indonesia	24	1	25	8	3	0	11
Iran, Islamic Republic of	16	0	16	5	0	0	5
Israel	7	1	8	5	0	0	5
Italy	0	8	8	0	0	8	8
Jamaica	1	0	1	0	0	0	0
Japan	0	6	6	0	0	6	6
Jordan	8	0	8	1	0	0	1

* Also includes proposals received in previous years.

Total Number of
Proposals Received and Awards Made in 2003

	Proposals Received			Awards*			
Country	**Contracts**	**Agreements**	**Total**	**Regular Budget**	**Extra-budgetary**	**Agreements**	**Total**
Kazakhstan	4	2	6	4	0	0	4
Kenya	8	0	8	9	1	0	10
Korea, Republic of	23	24	47	19	0	9	28
Lao P.D.R.	1	0	1	1	0	0	1
Latvia	0	0	0	1	0	0	1
Lebanon	2	0	2	1	0	0	1
Lithuania	4	1	5	3	0	0	3
Madagascar	1	0	1	0	1	0	1
Malawi	2	0	2	0	0	0	0
Malaysia	13	0	13	10	0	0	10
Mali	1	0	1	0	0	0	0
Malta	1	0	1	1	0	0	1
Mauritius	1	0	1	1	1	0	2
Mexico	13	0	13	11	0	0	11
Monaco	0	1	1	0	0	0	0
Mongolia	1	0	1	1	0	0	1
Morocco	11	0	11	7	0	0	7
Myanmar	3	0	3	2	0	0	2
Namibia	1	0	1	1	0	0	1
Nepal	1	0	1	1	0	0	1
Netherlands	1	1	2	1	0	1	2
New Zealand	1	5	6	0	0	2	2
Niger	2	0	2	2	0	0	2
Nigeria	3	0	3	1	0	0	1
Norway	1	1	2	1	0	2	3
Pakistan	55	0	55	26	0	0	26
Paraguay	2	0	2	2	0	0	2
Peru	10	0	10	7	0	0	7
Philippines	14	0	14	11	0	1	12
Poland	29	1	30	22	1	1	24
Portugal	5	1	6	5	0	1	6
Romania	17	0	17	16	0	0	16
Russian Federation	40	3	43	34	6	3	43
Saudi Arabia	1	0	1	0	0	0	0
Senegal	1	0	1	1	0	0	1
Serbia and Montenegro	13	0	13	5	0	0	5
Singapore	4	0	4	3	0	0	3
Slovakia	25	1	26	13	0	1	14
Slovenia	9	1	10	8	0	0	8
South Africa	19	1	20	17	0	1	18
Spain	1	3	4	1	0	2	3
Sri Lanka	10	0	10	4	0	0	4
Sudan	7	0	7	3	1	0	4
Switzerland	0	5	5	0	0	5	5
Syrian Arab Republic	16	0	16	9	0	0	9
Thailand	23	0	23	17	0	0	17
The Frmr.Yug.Rep. of Macedonia	4	0	4	1	0	0	1
Tunisia	4	2	6	2	0	0	2
Turkey	46	3	49	22	1	0	23

* Also includes proposals received in previous years.

Total Number of
Proposals Received and Awards Made in 2003

	Proposals Received			Awards*			
Country	**Contracts**	**Agreements**	**Total**	**Regular Budget**	**Extra-budgetary**	**Agreements**	**Total**
Uganda	6	0	6	4	1	0	5
Ukraine	11	7	18	8	1	2	11
United Arab Emirates	2	0	2	0	0	0	0
United Kingdom	5	10	15	5	0	9	14
United Republic of Tanzania	12	1	13	4	1	0	5
United States of America	14	28	42	14	1	22	37
Uruguay	11	0	11	11	0	0	11
Uzbekistan	5	0	5	3	1	0	4
Venezuela	8	0	8	4	0	0	4
Vietnam	21	0	21	9	2	0	11
Yemen	1	0	1	1	0	0	1
Zambia	2	0	2	1	0	0	1
	1 081	161	1 242	738	28	117	883

* Also includes proposals received in previous years.

Annex II.1

Distribution of Total
2003 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	MP3	M	N	MP4	Total
Albania	0	1	1	0	0	0	607	**607**	0	0	0	0	0	**0**	0	0	0	**0**	0	0	**0**	**607**
Algeria	2	6	8	0	0	0	5 000	**5 000**	6 000	19 000	3 500	0	4 000	**32 500**	0	0	0	**0**	0	0	**0**	**37 500**
Argentina	4	28	32	5 500	0	5 000	16 000	**26 500**	85 030	30 000	3 000	0	8 000	**126 030**	9 000	0	10 000	**19 000**	0	0	**0**	**171 530**
Armenia	0	1	1	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	0	0	0	**0**	0	0	**0**	**10 000**
Australia	5	0	5	0	0	0	0	**0**	29 000	0	0	0	0	**29 000**	0	3 000	0	**3 000**	0	0	**0**	**32 000**
Austria	3	0	3	0	0	0	0	**0**	15 500	0	50 000	0	0	**65 500**	0	3 000	0	**3 000**	0	0	**0**	**68 500**
Bangladesh	4	4	8	0	0	0	5 000	**5 000**	23 000	24 000	0	0	0	**47 000**	0	0	0	**0**	0	0	**0**	**52 000**
Barbados	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Belarus	2	3	5	0	0	0	5 000	**5 000**	5 000	0	0	0	4 000	**9 000**	0	0	5 000	**5 000**	0	5 000	**5 000**	**24 000**
Belgium	2	0	2	0	0	0	0	**0**	8 800	5 000	0	0	0	**13 800**	0	0	0	**0**	0	0	**0**	**13 800**
Benin	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Bolivia	0	1	1	0	0	0	0	**0**	10 000	0	0	0	0	**10 000**	0	0	0	**0**	0	0	**0**	**10 000**
Botswana	0	1	1	0	0	0	0	**0**	600	0	0	0	0	**600**	0	0	0	**0**	0	0	**0**	**600**
Brazil	10	24	34	0	5 000	5 000	18 000	**28 000**	111 000	30 000	4 500	15 000	24 000	**184 500**	5 000	0	0	**5 000**	0	0	**0**	**217 500**
Bulgaria	3	9	12	4 000	10 000	5 000	10 000	**29 000**	33 000	7 000	0	0	0	**40 000**	1 000	0	0	**1 000**	0	0	**0**	**70 000**
Burkina Faso	2	1	3	0	0	0	0	**0**	24 000	0	0	0	0	**24 000**	0	0	0	**0**	0	0	**0**	**24 000**
Cameroon	1	1	2	0	0	0	0	**0**	8 000	9 000	0	0	0	**17 000**	0	0	0	**0**	0	0	**0**	**17 000**
Canada	1	2	3	0	0	0	0	**0**	10 000	16 000	0	0	0	**26 000**	0	0	0	**0**	0	0	**0**	**26 000**
Chile	0	14	14	0	0	0	0	**0**	44 000	36 000	0	0	0	**80 000**	0	2 000	0	**2 000**	0	0	**0**	**82 000**
China	12	41	53	8 500	0	5 000	23 000	**36 500**	173 000	82 000	14 000	0	12 000	**281 000**	0	0	15 000	**15 000**	0	6 000	**6 000**	**338 500**
Colombia	3	6	9	0	0	0	0	**0**	35 000	33 000	0	0	0	**68 000**	0	0	0	**0**	0	0	**0**	**68 000**
Costa Rica	1	5	6	0	0	0	0	**0**	38 000	0	0	0	0	**38 000**	0	0	0	**0**	0	0	**0**	**38 000**
Croatia	1	5	6	0	0	0	0	**0**	5 000	3 000	5 000	0	5 000	**18 000**	0	0	5 000	**5 000**	0	10 000	**10 000**	**33 000**
Cuba	4	13	17	0	0	5 000	10 750	**15 750**	39 500	37 000	0	5 000	12 000	**93 500**	0	0	0	**0**	0	0	**0**	**109 250**
Cyprus	1	1	2	0	0	0	0	**0**	6 000	10 000	0	0	0	**16 000**	0	0	0	**0**	0	0	**0**	**16 000**
Czech Republic	5	11	16	7 000	14 000	0	5 000	**26 000**	23 000	21 000	0	0	8 000	**52 000**	5 000	0	10 000	**15 000**	0	0	**0**	**93 000**
Ecuador	0	1	1	0	0	0	0	**0**	0	0	0	0	4 000	**4 000**	0	0	0	**0**	0	0	**0**	**4 000**
Egypt	1	3	4	2 500	0	0	0	**2 500**	6 000	5 000	0	0	4 000	**15 000**	0	0	0	**0**	0	0	**0**	**17 500**
Estonia	0	3	3	0	0	0	5 000	**5 000**	0	9 000	0	0	0	**9 000**	0	0	0	**0**	0	0	**0**	**14 000**
Ethiopia	1	0	1	0	0	0	0	**0**	8 000	0	0	0	0	**8 000**	0	0	0	**0**	0	0	**0**	**8 000**
Georgia	1	0	1	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	0	**0**	0	20 400	**20 400**	**20 400**
Germany	3	1	4	0	0	0	0	**0**	25 000	10 000	5 000	0	0	**40 000**	0	0	0	**0**	0	0	**0**	**40 000**
Ghana	0	6	6	0	0	0	5 000	**5 000**	12 600	18 500	0	0	0	**31 100**	0	0	0	**0**	0	0	**0**	**36 100**
Greece	2	7	9	0	0	0	5 000	**5 000**	16 000	13 000	0	0	12 000	**41 000**	0	0	0	**0**	0	0	**0**	**46 000**
Guatemala	1	1	2	0	0	0	0	**0**	8 000	9 000	0	0	0	**17 000**	0	0	0	**0**	0	0	**0**	**17 000**
Honduras	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	0	0	**0**	**5 000**
Hungary	3	17	20	8 000	0	0	24 000	**32 000**	24 000	19 000	0	0	26 000	**69 000**	0	0	5 000	**5 000**	0	0	**0**	**106 000**
India	18	40	58	10 500	4 000	0	39 000	**53 500**	95 000	150 000	9 000	0	22 400	**276 400**	4 000	3 000	0	**7 000**	0	0	**0**	**336 900**
Indonesia	2	9	11	0	0	0	0	**0**	23 000	17 500	0	0	8 000	**48 500**	8 250	0	0	**8 250**	0	7 450	**7 450**	**64 200**
Iran, Islamic Republic of	1	4	5	0	0	0	0	**0**	14 000	3 000	0	0	8 000	**25 000**	0	0	0	**0**	0	0	**0**	**25 000**
Israel	2	3	5	0	0	0	0	**0**	15 000	0	15 000	0	0	**30 000**	0	0	0	**0**	0	0	**0**	**30 000**
Jordan	0	1	1	0	0	0	0	**0**	0	0	0	0	4 000	**4 000**	0	0	0	**0**	0	0	**0**	**4 000**
Kazakhstan	0	4	4	0	0	0	5 000	**5 000**	0	0	0	0	12 000	**12 000**	0	0	0	**0**	0	0	**0**	**17 000**
Kenya	4	6	10	0	0	0	0	**0**	53 500	12 000	0	0	0	**65 500**	0	0	0	**0**	0	0	**0**	**65 500**
Korea, Republic of	4	15	19	11 500	0	0	10 000	**21 500**	50 000	20 000	4 000	0	8 000	**82 000**	4 000	0	5 000	**9 000**	0	0	**0**	**112 500**

* Includes contracts with multiple fundings

Annex II.2

Distribution of Total
2003 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	MP3	M	N	MP4	Total
Lao P.D.R.	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	0	0	**0**	**5 000**
Latvia	0	1	1	0	0	0	0	**0**	0	0	0	0	0	**0**	0	0	0	**0**	175	0	**175**	**175**
Lebanon	0	1	1	0	0	0	0	**0**	0	0	4 000	0	0	**4 000**	0	0	0	**0**	0	0	**0**	**4 000**
Lithuania	0	3	3	0	0	5 000	0	**5 000**	0	8 000	0	0	0	**8 000**	0	0	5 000	**5 000**	0	0	**0**	**18 000**
Madagascar	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Malaysia	5	5	10	0	0	0	5 000	**5 000**	28 000	13 000	0	0	8 000	**49 000**	0	4 000	0	**4 000**	0	0	**0**	**58 000**
Malta	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Mauritius	0	2	2	0	0	0	0	**0**	3 650	0	0	0	0	**3 650**	0	0	0	**0**	0	0	**0**	**3 650**
Mexico	3	8	11	0	0	5 000	0	**5 000**	62 000	9 000	0	0	4 000	**75 000**	0	0	0	**0**	0	0	**0**	**80 000**
Mongolia	0	1	1	0	0	0	0	**0**	0	11 000	0	0	0	**11 000**	0	0	0	**0**	0	0	**0**	**11 000**
Morocco	4	3	7	0	0	0	0	**0**	12 000	30 000	4 000	0	0	**46 000**	0	0	0	**0**	0	0	**0**	**46 000**
Myanmar	0	2	2	0	0	0	0	**0**	5 000	5 000	0	0	0	**10 000**	0	0	0	**0**	0	0	**0**	**10 000**
Namibia	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Nepal	0	1	1	0	0	0	0	**0**	6 000	0	0	0	0	**6 000**	0	0	0	**0**	0	0	**0**	**6 000**
Netherlands	1	0	1	0	0	0	0	**0**	0	10 000	0	0	0	**10 000**	0	0	0	**0**	0	0	**0**	**10 000**
Niger	2	0	2	0	0	0	0	**0**	10 000	9 000	0	0	0	**19 000**	0	0	0	**0**	0	0	**0**	**19 000**
Nigeria	0	1	1	0	0	0	0	**0**	0	8 000	0	0	0	**8 000**	0	0	0	**0**	0	0	**0**	**8 000**
Norway	0	1	1	0	5 000	0	0	**5 000**	0	0	0	0	0	**0**	0	0	0	**0**	0	0	**0**	**5 000**
Pakistan	5	21	26	2 500	0	5 000	0	**7 500**	56 000	54 850	15 500	5 000	12 000	**143 350**	0	0	0	**0**	0	0	**0**	**150 850**
Paraguay	1	1	2	0	0	0	0	**0**	8 000	5 000	0	0	0	**13 000**	0	0	0	**0**	0	0	**0**	**13 000**
Peru	0	7	7	0	0	0	0	**0**	16 000	17 000	0	0	4 000	**37 000**	0	0	0	**0**	0	0	**0**	**37 000**
Philippines	5	6	11	0	0	0	0	**0**	50 000	31 000	0	5 000	0	**86 000**	0	0	0	**0**	0	0	**0**	**86 000**
Poland	3	20	23	0	0	5 000	15 000	**20 000**	50 000	27 000	0	0	33 000	**110 000**	0	0	0	**0**	0	18 500	**18 500**	**148 500**
Portugal	0	5	5	0	0	0	0	**0**	20 000	0	5 000	0	4 000	**29 000**	0	0	0	**0**	0	0	**0**	**29 000**
Romania	3	13	16	6 000	5 000	5 000	21 000	**37 000**	8 000	5 000	0	0	12 000	**25 000**	9 000	0	0	**9 000**	0	0	**0**	**71 000**
Russian Federation	9	31	40	24 500	15 000	10 000	70 500	**120 000**	13 000	7 000	0	5 000	4 000	**29 000**	0	0	10 000	**10 000**	0	100 994	**100 994**	**259 994**
Senegal	1	0	1	0	0	0	0	**0**	0	9 000	0	0	0	**9 000**	0	0	0	**0**	0	0	**0**	**9 000**
Serbia and Montenegro	4	1	5	0	0	0	6 000	**6 000**	6 000	23 000	0	0	0	**29 000**	0	0	0	**0**	0	0	**0**	**35 000**
Singapore	1	2	3	0	0	0	5 000	**5 000**	0	19 000	0	0	0	**19 000**	0	0	0	**0**	0	0	**0**	**24 000**
Slovakia	2	11	13	4 000	5 000	5 000	9 500	**23 500**	38 556	18 000	0	0	0	**56 556**	1 000	0	0	**1 000**	0	0	**0**	**81 056**
Slovenia	3	5	8	0	0	0	0	**0**	0	27 000	19 000	0	4 000	**50 000**	0	0	0	**0**	0	0	**0**	**50 000**
South Africa	7	10	17	0	0	0	10 000	**10 000**	64 000	33 500	10 000	0	0	**107 500**	0	0	0	**0**	0	0	**0**	**117 500**
Spain	0	1	1	0	0	0	0	**0**	5 000	0	0	0	0	**5 000**	0	0	0	**0**	0	0	**0**	**5 000**
Sri Lanka	1	3	4	0	0	0	0	**0**	13 000	17 500	0	0	0	**30 500**	0	0	0	**0**	0	0	**0**	**30 500**
Sudan	1	3	4	0	0	0	0	**0**	9 000	18 000	0	0	0	**27 000**	0	0	0	**0**	0	0	**0**	**27 000**
Syrian Arab Republic	1	8	9	2 500	0	0	0	**2 500**	24 000	0	10 000	0	4 000	**38 000**	4 000	0	0	**4 000**	0	0	**0**	**44 500**
Thailand	3	14	17	0	0	5 000	0	**5 000**	42 000	49 500	0	5 000	4 000	**100 500**	0	0	0	**0**	0	0	**0**	**105 500**
The Frmr.Yug.Rep. of Macedonia	0	1	1	0	0	0	5 000	**5 000**	0	0	0	0	0	**0**	0	0	0	**0**	0	0	**0**	**5 000**
Tunisia	1	1	2	0	0	0	0	**0**	8 000	5 000	0	0	0	**13 000**	0	0	0	**0**	0	0	**0**	**13 000**
Turkey	7	16	23	0	0	0	0	**0**	64 000	24 000	11 500	3 000	16 000	**118 500**	2 000	0	0	**2 000**	0	6 000	**6 000**	**126 500**
Uganda	1	4	5	0	0	0	0	**0**	31 500	0	0	0	0	**31 500**	0	0	0	**0**	0	0	**0**	**31 500**
Ukraine	3	6	9	8 000	0	0	5 000	**13 000**	13 000	0	0	0	0	**13 000**	0	0	15 000	**15 000**	0	5 000	**5 000**	**46 000**
United Kingdom	1	4	5	0	0	0	0	**0**	43 000	0	0	0	0	**43 000**	0	30 000	0	**30 000**	0	0	**0**	**73 000**
United Republic of Tanzania	2	3	5	0	0	0	0	**0**	23 462	7 000	0	0	0	**30 462**	0	0	0	**0**	0	0	**0**	**30 462**
United States of America	6	9	15	0	16 800	0	0	**16 800**	87 000	29 000	48 950	0	0	**164 950**	0	10 000	0	**10 000**	0	0	**0**	**191 750**

* Includes contracts with multiple fundings

Annex II.3

Distribution of Total
2003 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	MP3	M	N	MP4	Total
Uruguay	3	8	11	0	0	0	0	**0**	6 000	43 000	0	0	16 000	**65 000**	0	2 000	0	**2 000**	0	0	**0**	**67 000**
Uzbekistan	1	3	4	0	0	0	10 000	**10 000**	0	7 000	0	0	0	**7 000**	0	0	0	**0**	0	20 500	**20 500**	**37 500**
Venezuela	0	4	4	0	0	0	4 000	**4 000**	25 000	0	0	0	0	**25 000**	0	0	0	**0**	0	0	**0**	**29 000**
Vietnam	2	9	11	0	0	0	5 000	**5 000**	15 000	26 000	5 000	5 000	4 000	**55 000**	9 000	0	0	**9 000**	0	0	**0**	**69 000**
Yemen	1	0	1	0	0	0	0	**0**	7 000	0	0	0	0	**7 000**	0	0	0	**0**	0	0	**0**	**7 000**
Zambia	0	1	1	0	0	0	0	**0**	7 000	0	0	0	0	**7 000**	0	0	0	**0**	0	0	**0**	**7 000**
Total	**202**	**566**	**768**	**105 000**	**79 800**	**70 000**	**362 357**	**617 157**	**2 011 698**	**1 253 350**	**245 950**	**48 000**	**314 400**	**3 873 398**	**61 250**	**57 000**	**85 000**	**203 250**	**175**	**199 844**	**200 019**	**4 893 824**

* Includes contracts with multiple fundings

Research Co-ordination Meetings Held in 2003

A. NUCLEAR POWER

Engineering and Management Support for Competitive Nuclear Power

A1	I2.10.13	Surveillance programmes results application to reactor pressure vessel integrity assessment
	I2.10.16	Evaluation of radiation damage of WWER reactor pressure vessels using the IAEA database on reactor pressure vessel materials

Nuclear Power Technology Development and Applications

A2	I3.20.05	Updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects
	I3.30.11	Establishment of a thermophysical properties data base for LWRs and HWRs
	I3.50.01	Optimization of the coupling of nuclear reactors and desalination systems
	I3.50.02	Economic research on, and assessment of, selected nuclear desalination projects and case studies

B. NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

Nuclear Fuel Cycle Issues and Information Cycles

B4	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

C. ANALYSIS FOR SUSTAINABLE ENERGY DEVELOPMENT

Energy Modelling, Databanks and Capacity Building

C1	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

Energy-Economy-Environment (3E) Analysis

C2	I1.40.04	Cost effectiveness of nuclear power compared to CO2 capture and sequestration from fossil fuel power plants

D. NUCLEAR SCIENCE

Nuclear and Atomic Data

D1	F4.10.18	Development of a database for prompt gamma-ray neutron activation analysis
	F4.10.19	Improvement of the standard cross sections for light elements
	F4.10.20	Evaluated nuclear data for the Thorium-Uranium fuel cycle
	F4.10.21	Nuclear data for production of therapeutic radionuclides
	F4.30.11	Atomic and molecular data for fusion plasma diagnostics
	F4.30.12	Data for molecular processes in edge plasmas

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

Research Reactors

D2	F1.10.08*	Development and applications of alpha particle spectrometry
	F1.20.13	Development and practical utilization of small angle neutron scattering (SANS) applications
	F1.20.15	Development of improved sources and imaging systems for neutron radiography
	T1.30.08	Ageing of materials in spent fuel storage facilities

Nuclear Research Facilities and Instrumentation

D3	F1.10.07*	Application of nuclear techniques to anti-personnel landmines identification
	F1.10.08*	Development and applications of alpha particle spectrometry
	F1.10.09	In-situ applications of X-ray fluorescence (XRF) techniques
	F1.10.10	Development of distance learning (DL) modules on troubleshooting of nuclear instruments
	F1.20.14	The use of ion beam techniques for analysis of light elements in thin films, including depth profiling
	F1.30.08	Elements of power plant design for inertial fusion energy
	F1.30.09	Dense magnetized plasmas

E. FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

E1	D1.20.07	Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry 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
	D1.50.07	Integrated soil, water and nutrient management for sustainable rice-wheat cropping systems in Asia
	D1.50.08*	Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides

Plant Breeding and Genetics

E2	D2.30.20	Genetic improvement of underutilized and neglected crops in low income food deficit countries (LIFDCs) through irradiation and related techniques
	D2.30.24	Physical mapping technologies for the identification and characterization of mutated genes contributing to crop quality

Animal Production and Health

E3	D3.10.23	Integrated approach for improving small scale market oriented dairy systems
	D3.20.18	The monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

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

Insect and Pest Control

E4	D4.10.16	Quality assurance of mass produced and released fruit flies for SIT programmes
	D4.20.05	Genetics application to improve the SIT for tsetse control/eradication
	D4.20.09	Enabling technologies for the expansion of SIT for old and new world screwworm
	D4.20.10	Improved and harmonized quality control for expanded tsetse production, sterilization and field application
	D4.30.02	Evaluating the use of nuclear techniques for the colonization and production of natural enemies of agricultural insect pests

Food Quality and Safety

E5	D5.40.03	Quality control of pesticide products
	D5.50.01	The classification of soil systems on the basis of transfer factors of radionuclides from soil to reference plants
	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

F. HUMAN HEALTH

Nuclear Medicine

F1	E1.30.18	Study of the relationship between recurrent lower respiratory tract infection, gastroesophageal reflux and bronchial asthma in children
	E1.30.19	Doctoral CRP on Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radioconjugate therapy and internal dosimetry
	E1.30.20	Intravascular radionuclide therapy (IVRNT) using liquid beta-emitting radiopharmaceuticals to prevent restenosis following percutaneous transluminal coronary angioplasty
	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
	E1.30.22	Harmonization of radionuclide procedures and protocols in the management of neonatal hydronephrosis
	E1.30.23	Radiopharmaceutical imaging to predict and evaluate the response of breast cancer to neoadjuvant chemotherapy
	E1.30.26	Comparative evaluation of radiopharmaceuticals for radiosynovectomy
	E1.30.27	Role of radionuclide techniques in the diagnosis of early dementia

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

Applied Radiation Biology and Radiotherapy

F2	E3.30.18	Aspects of radiobiology applicable in clinical radiotherapy - Increase of the number of fractions per week
	E3.30.22	Doctoral CRP on clinical and experimental studies to improve radiotherapy outcome in AIDS cancer patients
	E3.30.23	Resource sparing treatment of head and neck cancer
	E3.50.07	Comparative assessment of teletherapy modalities

Dosimetry and Medical Radiation Physics

F3	E2.10.03	Dosimetry in X-ray diagnostic radiology. An international Code of Practice
	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

F4	E4.10.12	Health impacts of mercury cycling in contaminated environments studied by nuclear techniques
	E4.10.13	Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities
	E4.30.10	Isotopic evaluations in infant growth monitoring - a collaboration with WHO (partly RCA)
	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
	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
	E4.30.15	The application of isotopic and nuclear techniques in studies related to intrauterine growth restriction (IUGR) issues in populations from developing countries

G. WATER RESOURCES

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

G1	D1.50.08*	Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides
	F3.30.11	Isotope response to dynamic changes in groundwater systems due to long term exploitation
	F3.30.12	Origins of salinity and impacts on fresh groundwater resources: Optimization of isotopic techniques
	F3.30.13	Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENTS

Transfer of Radionuclides in the Marine Environment

H2	K4.10.08	Nuclear applications to determine bioaccumulation parameters and processes used for establishing coastal zone monitoring and management criteria

I. PHYSICAL AND CHEMICAL SCIENCES

Radiochemical Applications

I1	F2.20.32	Development of kits for Tc99m radiopharmaceuticals for infection imaging
	F2.20.33	Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides
	F2.20.35	Development of radioimmunometric assays and kits for non clinical applications
	F2.20.36	Development of radioactive sources for emerging therapeutic and industrial applications
	F2.20.38	Development of 99mTc based small bio molecules using novel 99mTc cores

Radiation Processing, Radiography and Radiotracer Applications

I2	F1.10.07*	Application of nuclear techniques to anti-personnel landmines identification
	F2.10.09	Industrial process gamma tomography
	F2.20.34	Radiation synthesis of stimuli-responsive membranes, hydrogels and adsorbents for separation purposes
	F2.20.39	Controlling of degradation effects in radiation processing of polymers
	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

Development of Safety Assessment Methods and Tools

J2	J4.20.04	Assessment of the interfaces between neutronic, thermal-hydraulic, structural and radiological aspects in accident analyses
	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

J6	J7.10.09	To update and expand the IAEA reliability data for research reactor PSAs
	J7.10.10	Safety significance of postulated initiating events for different research reactor types and assessment of analytical tools

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

K. RADIATION SAFETY (INCLUDING TRANSPORT SAFETY)

Radiological Protection of Patients

K4	J1.70.06	Exploring the possibility of establishing guidance levels for interventional radiology
	J1.70.07	Avoidance of unnecessary dose to patients while transitioning from analogue to digital radiology
	J1.70.08	Evaluate quantitatively and promote patient dose reduction approaches in interventional radiology
	J1.70.09	Dose reduction in computed tomography (CT) while maintaining diagnostic confidence

Safety of Radiation Sources

K5	J1.70.05	To investigate appropriate methods and procedures to apply probabilistic safety assessment (PSA) techniques of large radiation sources

L. MANAGEMENT OF RADIOACTIVE WASTE

Safety of Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal

Technologies for Disposable Radioactive Waste Management

L3	T2.10.23	New development and improvements in processing of "problematic" radioactive waste streams
	T2.40.06	Disposal aspects of low and intermediate level decommissioning waste

Technologies for the Decommissioning of Installations and Restoration of Sites

L6	T2.30.14	Technologies and methods for long term stabilization and isolation of uranium mill tailings

N. SECURITY OF MATERIAL

Addressing Illegal Activities Involving Nuclear and Other Radioactive Materials

N2	M2.20.06	Improvement of technical measures to detect and respond to illicit trafficking of nuclear material and other radioactive materials

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Research Co-ordination Meetings Held in 2003

Locations:

Argentina
Australia
Brazil
Bulgaria
Burkino Faso
Canada
Chile
China
Colombia (2)
Czech Republic (2)
Estonia
France
Germany
Greece (2)
Hungary
India
Italy (2)
Luxemburg
Malaysia
Mali
Mexico
Monaco
Norway
Paraguay
Phillippines
Poland (2)
Russia
Slovenia (2)
South Africa (2)
Spain
Sri Lanka
Sweden
United Kingdom (2)
USA

Headquarters (47)

*Three RCMs (D1.50.08, F1.10.07 and F1.10.08) are shown under two subprogrammes.

Total 2003 Contract Awards, by Country

Country	Total US $
China	338 500
India	336 900
Russian Federation	259 994
Brazil	217 500
United States of America	191 750
Argentina	171 530
Pakistan	150 850
Poland	148 500
Turkey	126 500
South Africa	117 500
Korea, Republic of	112 500
Cuba	109 250
Hungary	106 000
Thailand	105 500
Czech Republic	93 000
Philippines	86 000
Chile	82 000
Slovakia	81 056
Mexico	80 000
United Kingdom	73 000
Romania	71 000
Bulgaria	70 000
Vietnam	69 000
Austria	68 500
Colombia	68 000
Uruguay	67 000
Kenya	65 500
Indonesia	64 200
Malaysia	58 000
Bangladesh	52 000
Slovenia	50 000
Greece	46 000
Morocco	46 000
Ukraine	46 000
Syrian Arab Republic	44 500
Germany	40 000
Costa Rica	38 000
Algeria	37 500
Uzbekistan	37 500
Peru	37 000
Ghana	36 100
Serbia and Montenegro	35 000
Croatia	33 000
Australia	32 000
Uganda	31 500
Sri Lanka	30 500
United Republic of Tanzania	30 462
Israel	30 000
Portugal	29 000
Venezuela	29 000
Sudan	27 000

Total 2003 Contract Awards, by Country

Country	Total US $
Canada	26 000
Iran, Islamic Republic of	25 000
Belarus	24 000
Burkina Faso	24 000
Singapore	24 000
Georgia	20 400
Niger	19 000
Lithuania	18 000
Egypt	17 500
Cameroon	17 000
Guatemala	17 000
Kazakhstan	17 000
Cyprus	16 000
Estonia	14 000
Belgium	13 800
Paraguay	13 000
Tunisia	13 000
Mongolia	11 000
Armenia	10 000
Bolivia	10 000
Myanmar	10 000
Netherlands	10 000
Senegal	9 000
Ethiopia	8 000
Nigeria	8 000
Yemen	7 000
Zambia	7 000
Barbados	6 000
Benin	6 000
Madagascar	6 000
Malta	6 000
Namibia	6 000
Nepal	6 000
Honduras	5 000
Lao P.D.R.	5 000
Norway	5 000
Spain	5 000
The Frmr.Yug.Rep. of Macedonia	5 000
Ecuador	4 000
Jordan	4 000
Lebanon	4 000
Mauritius	3 650
Albania	607
Botswana	600
Latvia	175
Total	**4 893 824**

Active Co-ordinated Research Projects
at end 2003

A. NUCLEAR POWER

Engineering and Management Support for Competitive Nuclear Power

I2.10.14 Verification of WWER steam generator tube integrity

7 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) (2), Slovakia(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

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

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

Nuclear Power Technology Development and Applications

I3.10.12 Evaluation of high temperature gas cooled reactor performance

2 Contracts 8 Agreements 97/11/1 05/2/28

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

10 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), United States of America(A)

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

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

Belgium(A), China(A)China(C), Czech Republic(C), France(A), Germany(A), Hungary(A) (2), India(C), Italy(A), Japan(A), Korea, Republic of(A), Netherlands(A) (2), Poland(A), Russian Federation(A)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 04/9/30

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

7 Contracts 1 Agreement 98/12/15 04/11/30

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

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

4 Contracts 2 Agreements 98/10/22 03/12/31

Canada(A), China(C), France(A), India(C), Korea, Republic of(C) (2)

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

4 Contracts 98/5/15 03/12/14

Egypt(C), India(C), Russian Federation(C), Tunisia(C)

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)

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

B. NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

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)

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. ANALYSIS FOR SUSTAINABLE ENERGY DEVELOPMENT

Energy Modelling, Databanks and Capacity Building

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)

Energy-Economy-Environment (3E) Analysis

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)

D. NUCLEAR SCIENCE

Nuclear and Atomic 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
3 Contracts 1 Agreement 03/3/15 06/12/31
Belgium(A), Cuba(C), Romania(C), Ukraine(C)

F4.30.11 Atomic and molecular data for fusion plasma diagnostics
3 Contracts 9 Agreements 01/7/15 04/6/30
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)

Research Reactors

F1.20.13 Development and practical utilization of small angle neutron scattering (SANS) applications
8 Contracts 4 Agreements 00/8/25 03/12/31
Austria(A), Brazil(C), France(A) (2), Germany(A), Greece(C), Hungary(C), India(C), Korea, Republic of(C), Portugal(C), Russian Federation(C), South Africa(C)

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 4 Agreements 02/9/1 05/12/31
Argentina(C), China(C), Germany(A), Hungary(C), India(C), Korea, Republic of(A), United States of America(A) (2), Venezuela(C), Vietnam(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)

Nuclear Research Facilities and Instrumentation

F1.10.10 Development of distance learning (DL) modules on troubleshooting of nuclear instruments
5 Contracts 1 Agreement 01/11/1 04/12/31
Argentina(C), Brazil(C), Cuba(C), India(C), Israel(A), Vietnam(C)

F1.30.08 Elements of power plant design for inertial fusion energy
8 Contracts 8 Agreements 00/12/15 05/12/14
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)

E. FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

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)Kenya(C), Malaysia(C), Nigeria(A), 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

9 Contracts 2 Agreements 03/11/1 08/10/31

Algeria(C), Australia(C), China(C), India(C) (2), Mexico(C), Morocco(C), Pakistan(C), Philippines(A), 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

12 Contracts 4 Agreements 99/10/15 04/12/31

Australia(C), Benin(C), Brazil(C) (2), Burkina Faso(C), Cuba(C), Germany(A)Germany(C), Kenya(A), Mexico(C), Nigeria(A)Nigeria(C), 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 8 Agreements 02/11/1 07/12/31

Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(A) (2), 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) (2), Vietnam(C)

Plant Breeding and Genetics

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)

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

9 Contracts 9 Agreements 99/9/1 04/8/31

Argentina(C), Australia(A) (2), Belgium(A), Brazil(C), China(C) (2), Cuba(C), Germany(A), India(C), Israel(A), Poland(C), South Africa(C), Switzerland(A), Turkey(C), United Kingdom(A), United States Of America(A) (2)

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

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

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)

D2.40.11 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)

Animal Production and Health

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

6 Contracts 3 Agreements 98/7/1 04/6/30

Australia(A)Australia(C), 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)

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

8 Contracts 4 Agreements 97/1/1 04/2/29

Cameroon(C), Côte D'ivoire(C), Ethiopia(C), France(A), Kenya(C), Korea, Republic of(C), Mali(C), Pakistan(C), South Africa(A), Sweden(A), United Kingdom(A), United Republic of Tanzania(C)

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

13 Contracts 6 Agreements 98/4/1 04/3/31

Cameroon(C), Côte D'ivoire(C), Denmark(A), Egypt(C), Ghana(C), Kenya(C), Madagascar(C), Mauritius(C), Morocco(A)Morocco(C), Mozambique(C), Netherlands(A), Nigeria(A), Sudan(C), Uganda(C), United Republic of Tanzania(A)United Republic of Tanzania(C), United States (A), Zimbabwe(C)

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

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

Argentina(C) (2), 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

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

Belgium(A), 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

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

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)

Insect and Pest Control

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

11 Contracts 6 Agreements 99/10/1 04/12/30

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

15 Contracts 6 Agreements 00/4/1 05/3/31

Argentina(C), Brazil(C) (2), 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

10 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), United States Of America(A)United States of America(C)

D4.10.19 Molecular technologies to improve the effectiveness of SIT

2 Contracts 13 Agreements 03/6/12 08/6/11

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

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

11 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), Slovakia(C) (2), South Africa(C), Uganda(C), United Republic of Tanzania(C)

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

15 Contracts 3 Agreements 99/8/1 04/7/31

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

Food Quality and Safety

D5.40.03 Quality control of pesticide products

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

China(C) (2), Cuba(C), Greece(A), Hungary(C) (2), 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)

D5.50.01 The classification of soil systems on the basis of transfer factors of radionuclides from soil to reference plants

10 Contracts 3 Agreements 98/11/1 04/6/30

Australia(A), Bangladesh(C), Brazil(C), Chile(C), China(C), India(C), Japan(A), Russian Federation(C), Syrian Arab Republic(C), Turkey(C), Ukraine(C), United States of America(A), Vietnam(C)

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 05/12/31

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

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

Argentina(C), China(C), Ghana(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)

F. HUMAN HEALTH

Nuclear Medicine

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

5 Contracts 1 Agreement 98/12/15 03/12/31

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

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

8 Contracts 2 Agreements 99/12/15 03/12/31

Argentina(C), Austria(A), Chile(C), China(C), Cuba(C), Hungary(C), India(C), South Africa(C), Thailand(C), United Kingdom(A)

E1.20.16 Radioimmunoassay of advanced glycation end products (AGEs) in the long term management of diabetes mellitus

3 Contracts 2 Agreements 00/9/1 04/8/31

Greece(C), India(C), Thailand(C), United Kingdom(A), United States of America(A)

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

9 Contracts 1 Agreement 99/12/15 03/12/31

Chile(C), China(C), Colombia(C), India(A), Pakistan(C), Philippines(C), Poland(C) (2), Thailand(C), Turkey(C)

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

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

Australia(A), Austria(A), China(C), Colombia(C), France(A), India(A)India(C), Korea, Republic of(C), Mongolia(C), Singapore(C), Slovenia(A), 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

13 Contracts 4 Agreements 00/11/15 04/11/14

China(C), Colombia(C), Cuba(C), Cyprus(C), Germany(A), Hungary(C), India(C), Iran, Islamic Republic Of(C), Korea, Republic of(A)Korea, Republic of(C), Poland(C), Singapore(C), Thailand(C), Turkey(C), United States of America(A) (2), Uruguay(C)

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

8 Contracts 3 Agreements 00/12/1 03/12/31

Argentina(C), Belgium(A)Belgium(C), China(C) (2), India(C), Italy(A), Korea, Republic of(A), South Africa(C), Thailand(C), Turkey(C)

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

13 Contracts 3 Agreements 01/8/1 04/7/31

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(A), 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

8 Contracts 1 Agreement 01/8/1 04/7/31

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

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

6 Contracts 2 Agreements 02/10/24 05/12/31

Chile(C), India(C), Myanmar(C), Pakistan(C), Sudan(C), United Kingdom(A) (2), Uruguay(C)

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

8 Contracts 4 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(A), Thailand(C), Uruguay(C)

E1.30.26 Comparative evaluation of radiopharmaceuticals for radiosynovectomy

12 Contracts 3 Agreements 02/10/15 06/12/31

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), Malaysia(C), Norway(A), Serbia And Montenegro(C), Singapore(C)

Applied Radiation Biology and Radiotherapy

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

6 Contracts 2 Agreements 98/9/15 06/3/31

Chile(C), Denmark(A) (2), 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) (2), India(C), Iran, Islamic Republic of(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

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

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

E3.30.23 Resource sparing treatment of head and neck cancer

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

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

Dosimetry and Medical Radiation Physics

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

2 Contracts 2 Agreements 01/4/1 04/3/31

Algeria(C), France(A), Norway(A), Thailand(C)

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

7 Contracts 2 Agreements 01/12/15 06/12/31

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

Nutrition and Effects of Contaminants on Human Health

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

7 Contracts 4 Agreements 99/10/1 04/9/30

Brazil(C), Canada(A), China(C), Germany(A), India(C), Japan(A), Philippines(C), Slovenia(C), Sweden(A), United Republic of Tanzania(C), Venezuela(C)

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 06/12/31

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

8 Contracts 8 Agreements 01/12/15 07/12/31

Ghana(C), India(A)India(C), Indonesia(C), Mexico(C), Netherlands(A), Pakistan(C), Sri Lanka(C), Switzerland(A) (2), Thailand(C), United Kingdom(A), United States of America(A) (3)United States Of America(C)

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 05/3/31

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), Niger(C), Pakistan(C), South Africa(C), Sudan(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 03/11/1 07/10/31

Brazil(C), China(C), Guatemala(C), India(C), Mexico(C), Morocco(C), Philippines(C), Senegal(C), South Africa(C)

G. WATER RESOURCES

Isotope 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

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

Australia(A), China(C), France(A), Israel(C), Italy(A), Jordan(C), Korea, Republic of(C), Morocco(C), Pakistan(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)

Reference Isotope Data and Analysis for Hydrologic Applications

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

9 Contracts 5 Agreements 00/6/15 04/12/14

Algeria(C), Austria(A), Croatia(C), Egypt(C), France(A), Israel(A), Italy(A), Lebanon(C), Morocco(C), Portugal(C) (2), Slovenia(C), Spain(A), Turkey(C)

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

11 Contracts 9 Agreements 02/3/22 06/3/31

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

H. PROTECTION OF THE MARINE AND TERRESTRIAL ENVIRONMENTS

Transfer of Radionuclides in the Marine Environment

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)

Measurement and Assessment of Radionuclides and Non-radioactive pollutants in the Terrestrial Environment

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

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

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

I. PHYSICAL AND CHEMICAL APPLICATIONS

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)

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

9 Contracts 3 Agreements 02/4/1 05/3/31

Belarus(C), China(C), Hungary(A), India(C), Indonesia(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 05/7/31

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)

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

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

Argentina(C), Austria(A), Belgium(A), Brazil(C), China(C), Ghana(C), India(A), Slovenia(C)

Radiation Processing, Radiography and Radiotracer Applications

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)

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

6 Contracts 4 Agreements 00/12/15 04/12/14

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)

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

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

Australia(A), Brazil(C), Cuba(C), Czech Republic(C), France(A), Germany(A), India(C), Korea, Republic of(C), Norway(A), Poland(C), United States of America(A)

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 05/5/31

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)

J. SAFETY OF NUCLEAR INSTALLATIONS

Development of Safety Assessment Methods and Tools

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)

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

5 Contracts 4 Agreements 96/10/1 03/12/31

Belgium(A), Finland(A), France(A), Hungary(C), Norway(A), Russian Federation(C) (3), Slovakia(C)

Engineering Safety of Existing Nuclear Installations

J4.10.05 Safety significance of near field earthquakes

12 Contracts 10 Agreements 02/7/1 05/6/30

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

Research Reactor Safety

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

7 Contracts 4 Agreements 01/3/15 04/3/14

Argentina(C), Australia(A), Austria(A), Brazil(C), Canada(A), Czech Republic(C), India(C), Indonesia(C), Korea, Republic of(A), Romania(C), Vietnam(C)

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 SAFETY (INCLUDING TRANSPORT SAFETY)

Safety of Transport of Radioactive Material

J1.30.09 Accident severity during air transport of radioactive material

8 Agreements 98/6/1 04/6/30

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

J1.30.10 Radiological aspects of package and conveyance non-fixed radioactive contamination

7 Agreements 01/9/1 04/8/31

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

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 05/11/14

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 05/11/30

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

L. MANAGEMENT OF RADIOACTIVE WASTE

Safety of Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal

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)

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

Belarus(A), Belgium(A) (3), Brazil(A), Bulgaria(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)

Technologies for Disposable Radioactive Waste Management

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

3 Contracts 2 Agreements 99/7/15 04/3/14

China(C), Czech Republic(C), Korea, Republic of(A), Ukraine(C), United States of America(A)

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

4 Contracts 10 Agreements 98/12/15 04/5/1

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

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)

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

4 Contracts 8 Agreements 00/2/15 04/2/14

Brazil(A), Canada(A), China(C), Czech Republic(A), France(A), Germany(A), Kazakhstan(C), Korea, Republic of(A), Poland(A) (2), Russian Federation(C), Ukraine(C)

N. SECURITY OF MATERIAL

Addressing Illegal 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

15 Contracts 12 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), Poland(C), Russian Federation(C) (6), Slovakia(A), Turkey(C), Ukraine(C), United States of America(A), Uzbekistan(C)

CRP's Completed in 2003

A. NUCLEAR POWER

Engineering and Management Support for Competitive Nuclear Power

I2.10.11 Scientific basis and engineering solutions for cost-effective assessments of software-based I&C systems

I.2.10.12 Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials

I.2.10.13 Surveillance programmes results application to reactor pressure vessel integrity assessment

I.2.10.15 National approaches to correlate nuclear power plant performance targets and O&M costs

I.2.70.01 Information management solutions for SAT applications (SAT-IM)

C. ANALYSIS FOR SUSTAINABLE ENERGY DEVELOPMENT

Energy Modelling, Databanks and Capacity Building

I1.10.02 The impact of infrastructural requirements on the competitiveness of nuclear power

D. NUCLEAR SCIENCE

Nuclear and Atomic Data

F4.10.16 Fission product yield data required for transmutation of minor actinide nuclear waste

F4.10.18 Development of a database for prompt gamma-ray neutron activation analysis

Research Reactors

T1.30.08 Ageing of materials in spent fuel storage facilities

Nuclear Research Facilities and Instrumentation

F1.10.08 Development and applications of alpha particle spectrometry

F1.10.09 In-situ applications of X-ray fluorescence (XRF) techniques

F1.20.14 The use of ion beam techniques for analysis of light elements in thin films, including depth profiling

E. FOOD AND AGRICULTURE

Plant Breeding and Genetics

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

Animal Production and Health

D3.20.18 The monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays

Insect and Pest Control

D4.20.05 Genetics application to improve the SIT for tsetse control/eradication

Food Quality and Safety

D6.10.21 Evaluation of methods of analysis for determining mycotoxin contamination of food and feed

F. HUMAN HEALTH

Nuclear Medicine

E1.50.18 The significance of viral load and virus type in Hepatitis B and C for Pathogenesis and treatment efficacy

Applied Radiation Biology and Radiotherapy

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

E3.50.07 Comparative assessment of teletherapy modalities

Dosimetry and Medical Radiation Physics

E2.10.03 Dosimetry in X-ray diagnostic radiology. An international Code of Practice

Nutrition and Effects of Contaminants on Human Health

E4.30.10 Isotopic evaluations in infant growth monitoring - a collaboration with WHO (partly RCA)

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

E.4.30.12 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

G. WATER RESOURCES

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

F3.30.11 Isotope response to dynamic changes in groundwater systems due to long term exploitation

I. PHYSICAL AND CHEMICAL APPLICATIONS

Radiochemical Applications

F2.20.32 Development of kits for Tc99m radiopharmaceuticals for infection imaging

F2.20.33 Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides

Radiation Processing, Radiography and Radiotracer Applications

F1.10.07 Application of nuclear techniques to anti-personnel landmines identification

J. SAFETY OF NUCLEAR INSTALLATIONS

Development of Safety Assessment Methods and Tools

J4.50.02 Development and application of indicators to monitor NPP operational safety performance

K. RADIATION SAFETY (INCLUDING TRANSPORT SAFETY)

Safety of Radiation Sources

J1.70.05 To investigate appropriate methods and procedures to apply probabilistic safety assessment (PSA) techniques of large radiation sources

IAEA 2003 Programme/Sub-programme and CRP Codes

MAJOR PROGRAMME 1: NUCLEAR SCIENCE AND TECHNOLOGY

		CRP Code
Programme A:	**Nuclear Power**	
A1	Engineering and Management Support for Competitive Nuclear Power	I2
A2	Nuclear Power Technology Development and Applications	I3
Programme B:	**Nuclear Fuel Cycle and Material Technologies**	
B2	Nuclear Fuel Performance and Technology	T1
B4	Nuclear Fuel Cycle Issues and Information Systems	T1
Programme C:	**Analysis for Sustainable Energy Development**	
C1	Energy Modelling, Databanks and Capacity Building	I1
C2	Energy-Economy-Environment (3E) Analysis	I1
Programme D:	**Nuclear Science**	
D1	Nuclear and Atomic Data	F4
D2	Research Reactors	F1, F2, T1
D3	Nuclear Research Facilities and Instrumentation	F1

MAJOR PROGRAMME 2: NUCLEAR TECHNIQUES FOR DEVELOPMENT AND ENVIRONMENTAL PROTECTION

Programme E:	**Food and Agriculture**	
E1	Soil and Water Management and Crop Nutrition	D1
E2	Plant Breeding and Genetics	D2
E3	Animal Production and Health	D3
E4	Insect and Pest Control	D4
E5	Food Quality and Safety	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	D1, 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	F3
H2	Transfer of Radionuclides in the Marine Environment	K4
H4	Measurement and Assessment of Radionuclides and Non-radioactive Pollutants in the Terrestrial Environment	G4

IAEA 2003 Programme/Sub-programme and CRP Codes

Programme I: Physical and Chemical Applications

I1	Radiochemical Applications	F2
I2	Radiation Processing, Radiography and Radiotracer Applications	F1, F2

MAJOR PROGRAMME 3: NUCLEAR SAFETY AND PROTECTION AGAINST RADIATION

Programme J: Safety of Nuclear Installations

J2	Development of Safety Assessment Methods and Tools	J4
J6	Research Reactor Safety	J7

Programme K: Radiation Safety (including Transport Safety)

K4	Radiological Protection of Patients	J1
K5	Safety of Radiation Sources	J1

Programme L: Management of Radioactive Waste

L2	Safety of Disposable Radioactive Waste: Managing Non-Reusable Radioactive Materials and Arranging for their Disposal	J9
L3	Technologies for Disposable Radioactive Waste Management	T2
L6	Technologies for the Decommissioning of Installations and Restoration of Sites	T2

MAJOR PROGRAMME 4: NUCLEAR VERIFICATION AND SECURITY OF MATERIAL

Programme N: Security of Material

N2	Addressing Illegal Activities Involving Nuclear and Other Radioactive Materials	M2

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D12006 Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production**

Participating Countries: Argentina(C), Australia(A), China(C), France(A), India(A), India(C), India(C), Jordan(C), Kenya(A), Kenya(C), Mexico(A), Mexico(C), Morocco(C), Niger(A), Niger(C), Pakistan(C), Senegal(C), Syrian Arab Republic(A), Syrian Arab Republic(C), Tunisia(C), Zimbabwe(C)

Total Cost: **$500 922**

Duration: 1997-12-15 – 2002-12-15

CRP Overall Objectives

To increase crop production through improved management of nutrients and water in rain fed arid and semi-arid areas.

CRP Specific Objectives

(i) To investigate management strategies that optimize and sustain the productivity of rain fed farming systems by increasing the efficiency of water and nutrient utilization.
(ii) To define appropriate technologies to enhance crop water use and nutrient uptake, and to ensure their applicability at the farm level.
(iii) To test crop responses to water and nutrients in relation to crop sequence and surface management in field experiments using nuclear techniques.
(iv) To promote collection of minimum sets of data in all experiments, storing the data in a common data base, testing and applying simulation models and using the data and models in training national staff.

Research Outputs

The results of this CRP provided valuable information on the management of nutrient and water under rain fed conditions for a wide range of cropping systems in different agro-ecological regions. There is an increasing demand for cost-effective management practices for improving soil fertility and crop production in these less favoured regions, since irrigated land can only meet a rather small proportion of the entire food requirements of the increasing population. The results of this CRP showed the importance of investigating fertilizer use efficiency under different moisture regimes. Nitrogen response studies conducted under rain fed conditions demonstrated that substantial amounts of N inputs can be saved by determining the optimum rate of nitrogen required for a given crop under local conditions. Incorporation of grain legumes into cereal cropping systems showed promising results in improving soil fertility and increasing crop yields. Application of locally available resources, such as phosphogypsum and phosphate rocks in Senegal, significantly increased crop yields. The effects of adding crop residues and manure on crop yields were variable depending mainly on soil and climatic parameters. In general, bio-physical properties of soil improved when residues were incorporated. The results demonstrated that long-term experiments are needed to evaluate the effects of these parameters on soil fertility and crop production. The 15N studies showed that approximately two-thirds of fertilizer nitrogen is lost irrespective of the form applied, and water and residue management practices adopted. Most of the losses occurred during the first season suggesting that more work needs to be done on nitrogen fertilizer management to minimize losses. The residual effect of nitrogen fertilizers for subsequent crops was less than 5%. Some of the contract holders will be continuing the field-work initiated through this CRP from local funds to obtain long-term information for identifying promising fertilizer and water management practices.

CRP Outcome (Effectiveness; Impact; Relevance)

This CRP provided valuable information on (i) use efficiency of nitrogen fertilizers and water under different cropping systems in arid and semi-arid areas (ii) technologies tailored to local conditions to enhance crop water and nutrient uptake (iii) use of nuclear techniques to test crop responses to water and nutrients in relation to crop rotations and different fertilizer, water and residue management practices (iv) collection of minimum data needed for applying simulation models for obtaining meaningful information for identifying promising management practices for sustaining soil fertility and increasing crop production under rain fed conditions.

Increasing crop productivity in arid and semi-arid areas is widely recognized as difficult. These areas have not benefited from the green revolution as much as regions well endowed with water resources. High input agriculture is

not a viable option for most farmers in these regions due to economic constraints. Nevertheless, there is some evidence that crop yields in these regions can be profitably increased and the yield variation decreased with a combination of careful management and low inputs of nutrients. The key is to combine nutrient inputs with crop management practices that increase the supply of water to crops.

The participants of this CRP gained valuable experience in the use of 15N techniques and neutron moisture probes for investigating the efficiency of N fertilizers and water in different crop rotations over several seasons. The acquired skills such as 15N and water balance studies under field conditions will be certainly useful for planning future research activities at their local institutes aimed at restoring and sustaining soil fertility for increased crop production. The results of this CRP will be disseminated to the scientific community through research publications and to Member States through a TECDOC.

Recommended Future Action by Agency

The use of nuclear techniques such as carbon isotope discrimination for identifying higher yielding crop genotypes under drought conditions would be a logical follow up of this CRP.

CRP Published Results

Internal: One TECDOC in preparation.
External: Journal and conference papers published by the participants

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D31021** **Use of nuclear and colorimatric techniques for measuring microbial protein supply from local feed resources in ruminant animals**

Participating Countries: Australia(A), Chile(C), China(A), China(C), China(C), Indonesia(C), Italy(A), Italy(C), Malaysia(C), Morocco(C), Spain(A), Sri Lanka(A), Sri Lanka(C), Turkey(C), United Kingdom(A), United Kingdom(C), Venezuela(C), Vietnam(C), Zimbabwe(C)

Total Cost: **$348 215**

Duration: 1996-04-15 – 2002-12-15

CRP Overall Objectives

To estimate microbial protein supply in ruminant livestock.

CRP Specific Objectives

(i) To refine and standardize the purine derivative (PD) excretion technique for measuring microbial protein supply in ruminant livestock.
(ii) To validate the PD excretion technique for indigenous cattle in developing country and their crosses with exotic breeds, and for buffalo, sheep, goat and camel.
(iii) To use the PD excretion technique as a robust and inexpensive method for estimating rumen microbial protein supply for developing feeding strategies and as a diagnostic tool for assessing nutritional status of animals in the field and for grazing animals where the quantitative collection of urine output is much more difficult.

Research Outputs

The models describing recovery of PD in urine have been developed for different breeds of cattle, and for sheep, buffalo and camel. The digestible organic matter intake (DOMI) is significantly positively related to daily PD excretion, and more specifically to the PD: creatinine index (the PDC index) in different species of cattle. For Bos indicus (e.g.Yerli Kara, Kedah-Kelantan, Ongole), B. taurus (Friesian) and B sondaicus (Bali) the relationship is similar. The data, therefore, can be combined to give a single prediction equation as follows: DOMI (kg/d) = 0.0597* PDC index + 0.6776 (n=44, R2=0.97).

Buffaloes have much lower (and more variable) urinary excretion of PD per unit DOMI than cattle. The urinary PD excretion in buffalo is neither due to lower supply of microbial cells from the rumen nor to lower absorption of purines from the small intestine, but to differences in tissue metabolism for which mechanisms are not fully understood. For these reasons, at present, the use of the PD prediction method in buffaloes is not recommended.

The urinary PD excretion is also positively related to DOMI for camel, and the PD technique can also be used for estimation of rumen microbial outflow in this species. The slope of the curve - - urinary PD excretion to DOMI (10-12 mmol/kg DOMI) for camel is lower than that for cattle. Xanthine oxidase activity is not detectable in camel plasma and activity of this enzyme in its intestine and liver is lower than respective tissues in other ruminants. Creatinine excretion from camel is about one-third of that from other large ruminants examined. The recovery of purine base infused into the duodenum was about 64 % that of other ruminants.

The rate of excretion of allantoin in sheep is affected by its movement through multiple fluid compartments in the body and its recovery in the urine (mean 84%) may be more variable (range 65 - 95%) than previously thought.

The spot urine sample approach for estimation of microbial protein supply has been validated: The PDC index, a new index put forward in this project, in general appears to respond positively, as expected, to changes in DOMI. The creatinine excretion has proved to be a robust means of predicting quantitative recovery of PD in urine. The time of collection of samples does not appear to affect the PDC index. The PDC index has potential as a research tool to optimise feed resources. The PDC index from urine samples collected from groups of animals on a farm allows these animals to be categorised into 'bands' corresponding to their nutritional status. This will assist researchers and extension workers to diagnose nutritional problems.

The spot urine approach has been shown to work for the following types of animals: 1) Friesian and crosses, 2) Chinese yellow cattle, 3) Vietnamese yellow cattle, 4) Malaysian Kedah-Kelantan cattle, 5) Sri Lankan indigenous cross-bred cattle, 6) Yerli Kara cattle of Turkey and their crosses, 7) Zebu and Ongole cattle of Indonesia, 8) Camels and 9) Sheep.

Accomplishments of CRPs Completed in 2002

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been successful in achieving the specific objectives. The models describing excretion of PD in urine have been developed for a number of livestock species. Using these models, the PD technique for estimation of microbial protein production and supply has been standardised and validated. A spot urine sample approach has also been validated which allows estimation of microbial protein supply from a spot urine sample, without the need to quantitatively collect urine output. These methods have the advantage of being non-invasive, simple to use, and inexpensive.

The PD technique has proved to be a powerful technique that is being increasingly used in a variety of research programmes. Since the completion of this CRP, this technique has been integrated into R & D activities in the area of animal nutrition in 20 developing countries. It has enabled the development of feeding startegies based on efficient utilization of locally available feed resources, leading to higher animal productivity. The use of these approaches is also likely to decrease both methane emission and nitrogen excretion into the environment.

In developing countries, livestock are fed mainly on agro-industrial by-products containing a large proportion of ligno-cellulosic feeds like cereal straws, stovers, sugarcane by-products and other similar feeds. These feeds are poor in protein, energy, minerals and vitamins. Microbial cells formed as a result of rumen digestion of carbohydrates and assimilation of nitrogen under anaerobic conditions are a major source of protein for ruminants. They provide the majority of the amino acids that the host animal requires for maintenance, growth and production. Therefore, knowledge of the microbial contribution to the nutrition of the host animal is imperative for developing feed supplementation strategies for improving ruminant production. While this factor has been recognized for many years, estimation of the rumen microbial production and supply to the lower intestine has always been a difficult problem for ruminant nutritionists. This constraint of estimating microbial protein supply to ruminant livetsock has been overcome through development, standardisation and validation of a non-invasive technique based on determination of PD in urine samples. This technique will play an important role in enhancing production and availability of animal and animal products in developing countries.

Recommended Future Action by Agency

The methodologies, protocols and guidelines developed in this project should be transferred to Member States through training workshops. The work to develop more rapid tests for PD for diagnostic use, particularly in field, e.g. dipstick (paper-litmus type) tests, biosensor, easy-to-use kits, etc. should be undertaken. Further research to elucidate mechanisms that cause buffaloes and camels to be different from cattle and sheep with respect to PD excretion should be supported. Aspects that need attention are the quantitation of renal vs. non-renal losses of allantoin in buffaloes, and analysis of the absorption and metabolism of the PD in intestinal mucosa and liver of buffaloes.

CRP Published Results

Internal

[1] Estimation of rumen microbial protein production from purine derivates in urine. A laboratory manual IAEA-TECDOC-945, IAEA, Vienna (1997).
[2] Nuclear based technologies for estimating microbial protein supply in ruminant livestock IAEA-TECDOC-1093, IAEA, Vienna (1999).
[3] Development, standardization and validation of nuclear based technologies for estimating microbial protein supply in ruminant livestock for improving productivity (editing in progress)
[4] A CD-ROM: Protocols and templates for laboratory assays and quality control for purine derivatives in ruminant urine (development in progress)

External

[1] BALCELLS, J., GANUZA, J.M., PEREZ, J.F., MARTÍN-ORÚE, S.M., Urinary excretion of purine derivatives as an index of microbial-N intake in growing rabbits. Brit. J. Nutr. 79 (1998) 373-380.
[2] BARRIOS URDANETA, A., FONDEVILA, M., BALCELLS, J., DAPOZA, C., CASTRILLO, C., In Vitro microbial digestion of straw cell wall polysacchrides in response to supplementation with different sources of carbohydrates. J. Agric. Res. 51 (2000) 393-399.
[3] BELENGUER, A,. BALCELLS, J., FONDEVILA, M., TORRE, C., Caecotrophes intake in growing rabbits estimated other from urinary excretion of purine derivatives or from direct measurement using animals provided with neck collar: effect of type and level of dietary carbohydrate. Anim. Sci. 74 (2002) 135-144.
[4] ÇETINKAYA, N., YAMAN, S., GÜCÜS, A.I., ÖZCAN, H., ULUTÜRK, S., Urinary excretion of purine derivatives in Yerli Kara cattle. Turkish J. Nucl. Sci. Vol. 27, No.1 : 13-28 (2000).

[5] CHEN, X.B., CALDER, A.G., PRASITKUSOL, P., KYLE, D.J., JAYASURIYA, M.C.N., Determination of 15N Isotopic enrichment and concentrations of Allantoin and Uric Acid in Urine by Gas Chromatography/Mass Spectrometry. J. Mass Spectrometry 33 (1997) 130-137.
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[7] CHEN, X.B., MATUSZEWSKI, W., KOWALCZYK, J., Determination of allantoin in biological cosmetic and pharmaceutical samples. J. AOAC International 79 (1996) 628-635.
[8] KAHN, L.P., NOLAN J.V., Kinetics of allantoin metabolism in sheep. Brit. J. Nutr. 84 (2000) 629-634.
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[10] Sensitivity to plasma loading with unlabelled allantoin. Brit. J. Nutr. 86 (2001) 691 - 696.
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(In addition 15 conference papers/abstracts were published by the group).

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D41012 Enhancement of the SIT through genetic transformation of arthropods using nuclear techniques**

Participating Countries: Australia(A), Greece(C), Italy(A), Italy(A), Italy(A), New Zealand(C), United Kingdom(A), United States of America(A), United States of America(A), United States of America(A), United States of America(A)

Total Cost: **$136 757**

Duration: 1994-12-15 – 2002-12-31

CRP Overall Objectives

To identify, analyze and engineer mobile elements so that they can be used as transformation vectors in insect pests of economic importance.

CRP Specific Objectives

To clone and analyze genes and promoters which have relevance for the improvement of SIT strains.

Research Outputs

a) Development of genetic transformation for pest insect species of agricultural and the functional analysis of transposable element gene vectors used for pest insect transgenesis.

Good progress has been made in this field since 1996. Four transposable element gene vectors have been developed that transform pest insect species. Counting only initial published reports, to date there are 14 examples of genetic transformation of pest insect species covering three orders of insects and, of the 21 referenced examples, 20 have been published during the time period covered by the CRP and 10 are from the laboratories of CRP participants/consultants or observers. Of special note is that at least six of them, Ceratitis capitata, Bactrocera dorsalis, Anastrepha suspensa, Lucilia cuprina, Anopheles stephensi and Pectinophora gossypiella, are, or have been, the focus of vigorous genetic control programmes using the SIT or, in case of Lucilia cuprina, a related technology. Based on these results it is reasonably safe to assume that most, if not all insect pest species can be genetically transformed with one or more of the four available vector systems and, based on the current knowledge, all four systems are in principle useful as transformation vectors.

b) Testing and validation of promoters for use in pest insect species.

The ability to place genes into pest insect species, has led to the rapid testing of a number of promoters in these species in order to determine if they are effective in driving the expression of strategic genes of genetic markers in these species. These have included two male specific promoters from C. capitata, the hsp70 promoters from both Drosophila melanogaster and C. capitata, the synthetic 3xP3 promoter, the polyubiquitin promoter from D. melanogaster, the apyrase, maltase, carboxypeptidase and vitellogenin promoters from Ae. aegypti, the actin5C promoter from D. melanogaster, the actin promoter from Bombyx mori, and the Minos and piggyBac transposase promoters. Once again, published reports of the testing and use of these promoters have all occurred during the tenure of this CRP and CRP participants/consultants and observers have played significant roles in these studies. It is concluded that although most of the promoters can also be used outside of the original species, their ability to drive high levels of expression in a controllable fashion may be restricted. This is compounded by severe position effects, i.e. either the level of transgene expression is modulated by the nature of the surrounding chromatin or the transgene is expressed in a variety of different patters probably due to the influence of neighboring control elements.

c) Development of new genetic markers for the identification of transgenic insects.

Initial reports of the genetic transformation of pest insect species utilized eye pigmentation genes as the genetic markers used to efficiently identify transgenic individuals. However, it was clear from the beginning that this would probably not be a practical approach, e.g. the eye color mutation is usually not rescued completely leaving the vision of the insect impaired. Since 1999, the use of fluorescent protein genetic markers such as GFP, enhanced GFP, CFP, YFP and dsRed has greatly facilitated the generation of transgenic pest insect strains through both the ease of their identification and the elimination of the requirement to have recessive, mutant strains as the recipient. Indeed 15 of the first published examples of insect transformation listed in Table 1 have utilized these fluorescent protein marker genes. In conclusion, fluorescent protein markers can be applied universally across many or even all species and, in addition

it was shown that the fluorescence can be detected several weeks after the death of the insect, which is of course an essential prerequisite for a marker to be useful to distinguish released and wild flies in the field.

d) Identification, isolation and testing of strategic genes for use in transgenic pest insect species.

Strategic genes that have, or are being tested, for specific use in the development of transgenic genetic sexing strains of C. capitata are the transformer, transformer 2, doublesex, alcohol dehydrogenase, and inaZ ice nucleation genes. Research into using the Sex lethal, transformer and doublesex genes of C. capitata has indicated that genes located downstream (referring to the Drosphila pathway) from the Sex lethal gene are suitable candidates for the engineering of genetic sexing strains in C. capitata. Research into these sex determination genes continues to be intense with the now added possibility that RNA inhibition technology might be useful in silencing the activity of these important genes.

e) Development of strategies for the development, using transgenesis, of new genetic sexing strains.

New genetic sexing strategies using the tetracycline repressible system have been developed for insects and, as proof of principle, have been demonstrated to lead to the efficient elimination of females in transgenic strains of D. melanogaster containing this system. These systems have yet to be extended into pest insect species, however it is clear, based on the D. melanogaster research, that, provided sex specific promoters and appropriate cell death genes can be efficiently utilized in these species, and provided the repressor molecule can be delivered to the developing embryo or early larvae, these approaches to genetic engineered genetic sexing are valid and offer a glimpse into how future genetic sexing strains may be constructed.

f) Initiation of searches for new genes and gene vectors for use in genetic sexing strategies.

The rapid success of genetic engineering technology for pest insect species, using the transposable element vectors, promoters and genes described above has fueled interest in the search for more genes and promoters that can be used for genetic sexing strategies in pest insect species. These include C. capitata and B. dorsalis genes that are the key regulatory switch in the initial determination of gender and promoters that are differentially expressed between male and female early embryos. Similarly, cell death genes that function efficiently in these pest insect species are being actively sought.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has played an important role in facilitating the research and exchange of ideas and reagents that has, in part, led to the good progress witnessed over the past six years. This increased knowledge will provide the scientific basis that is essential for the successful development of improved strains for the practical application in SIT programmes. The relevance of this progress is directly proportional to the increased need for technologies that ensure an increasing global food supply while decreasing our dependence on chemical insecticides. The technologies developed here offer a targeted, yet areawide approach to pest insect control that will only become more important as global warming increases the range of many of these species.

Recommended Future Action by Agency

The use of genetic engineering technologies for the improvement of the SIT should be further facilitated with the objective now being to push it toward field application. Research is needed for:

Optimization, improvement and refinement of gene vectors, genes, genetic markers and promoters for use in genetic sexing strategies with particular attention devoted to their effects on the mass rearing and strain stability. This includes the development of insulator sequences and sequences that can stabilize transgenes.

Assessment of the genetic fitness and stability of transgenic strains under the necessary containment guidelines.

The establishment of clear guidelines for the laboratory testing of genetically engineered pest insect strains before they are moved from the laboratory to field cage or field trials. Such guidelines would best be developed through the convening of a meeting of experts. Directly related to this is the need for the Agency to become involved with the formulation of international guidelines for determining calculations of risk associated with the applications of these technologies and with working towards increasing public acceptance of the use of transgenic technologies for the betterment of human welfare.

CRP Published Results

Accomplishments of CRPs Completed in 2002

A publication with the final results of the CRP, together with a few selected invited papers, will be appear in 2003 in the journal "Insect Biochemistry and Molecular Biology". The publication will be a special issue of the journal highlighting the involvement of the FAO/IAEA in the field of applied molecular biology to improve the SIT. In addition, the following articles were published by CRP participants during the CRP:

RESEARCH RESULTS PUBLISHED BY THE PARTICIPANTS (1996-2002):

[1] ALLEN, M.L., LEVESQUE, C.S., O'BROCHTA, D.A., ATKINSON, P.W., Stable germ-line transformation of Culex quinquefasciatus (Diptera: Culicidae). J. Med. Entomol. 38 (2001) 701-710.
[2] ATKINSON, P.W., Genetic engineering in insects of agricultural importance. Accepted by Insect Biochem. Mol. Biol. (March 2002) 5 ms pp.
[3] ATKINSON, P.W., JAMES, A.A., Germline transformants spreading out to many insect species. Advances in Genetics 47 (2002) 49-86.
[4] ATKINSON, P.W., MICHEL, K., Drosophila melanogaster germ-line transformation. In Encyclopaedia of Life Sciences, Accepted by Nature Publishing Group, Macmillan Press (February 2002) 10 ms pp.
[5] ATKINSON, P.W., MICHEL, K., What's buzzing? Mosquito genomics and transgenic mosquitoes. Genesis 32 (2002) 42-48.
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Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D42008** **Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barrier systems used in tsetse control/eradication campaigns**

Participating Countries: Burkina Faso(C), Hungary(C), Kenya(C), Mali(C), Switzerland(A), Uganda(C), United Kingdom(A), United Republic of Tanzania(C), United States of America(A), United States of America(A)

Total Cost: **$216 851**

Duration: 1994-12-15 – 2002-12-31

CRP Overall Objectives

To improve the planning and efficient implementation and assessment of integrated areawide tsetse and trypanosomosis intervention campaigns with emphasis on the tsetse SIT component.

CRP Specific Objectives

The specific research objectives under this CRP were to identify, test and refine, particularly for "difficult" tsetse species, for which no or inefficient attractants are available:

traps or targets that may be used for population monitoring, pre-release fly population reduction and in (temporary) barrier systems for preventing re-infestation of tsetse into tsetse-free areas;

appropriate technology for tsetse population monitoring using attractants from previous work or new candidate chemicals for use in integrated areawide SIT schemes;

locally available inexpensive sources of chemical and visual attractants and alternative, less expensive methods for synthesizing conventional attractants; and

other attractant or odour-based mechanisms that may be used for, or are relevant to, tsetse SIT operations. This includes the assessment of known or suspected sex pheromone components of conspecific tsetse of different populations in order to better understand these pheromone systems and also to ensure that proper biological interaction between different populations is likely to occur when SIT is contemplated or used, i.e. laboratory colony versus wild flies.

Research Outputs

The main research outputs under this CRP were:

The screening of new structurally related compounds, including specific stereoisomers, of known tsetse attractants resulted in the identification of several new candidate odour attractants with promising potential.

An efficient two-step synthetic method was developed for the pilot plant scale production of 3-n-propyphenol, synergistic tsetse kairomone component.

Electrophysiological experiments complemented with wind tunnel studies provided an efficient basis for the laboratory screening of candidate attractants prior to the initiation of laborious field tests.

New traps were identified and modifications of existing traps were tested for some species that previously were difficult to monitor.

The combination of some plant volatiles with new and standard host odours constitute attractant odour blends for several tsetse species for which previously no odour attractants were known.

The novel hydrocarbons identified and characterized from several tsetse species specifically influence (stimulate or inhibit) the sexual behaviour of tsetse males and offer useful tools in rearing / control operations.

Accomplishments of CRPs Completed in 2002

CRP Outcome (Effectiveness; Impact; Relevance)

The co-ordinated research project (CRP) on "Improved Attractants for Enhancing the Efficiency of Tsetse Fly Suppression Operations and Barrier Systems used in Tsetse Control/Eradication Campaigns" involved a) the identification, synthesis and provision of candidate kairomones, their analogues and of dispensers; b) laboratory screening of synthesised candidate kairomones through electrophysiological studies and wind tunnel experiments; c) field tests of candidate kairomones alone or as part of odour blends, in combination with available and or new trap designs; and d) analysis of hydrocarbons that influence tsetse sexual behaviour.

Particularly the combination of laboratory screening of synthesised candidate kairomones through electrophysiological studies and wind tunnel experiments with field testing of promising components and odour blends proved to be an efficient and effective way to reach the specific research objectives.

At the initiation of this CRP, the available visually attractant devices and odours for entomological monitoring and for suppression of tsetse fly populations were not equally effective against all economically important tsetse fly species. For species like G. austeni, G. brevipalpis, G. swynnertoni and some species of the PALPALIS-group of tsetse flies no sufficiently effective combinations of visual or odour attractants were available for efficient suppression and standardized monitoring as part of an operational integrated intervention campaign against the tsetse and trypanosomosis (T&T) problem.

The development and field use of improved odour baited traps and insecticide impregnated targets against several tsetse fly species in different parts of Africa facilitates entomological monitoring and, to a certain extent, generates the basis for expanded community-based tsetse suppression efforts. Improved artificial baits also provide new options for the (temporary) use of such devices in support of natural barriers in larger-scale tsetse intervention operations, involving the SIT.

The research outputs of the CRP provide options for field projects to increase the effectiveness of previously rather ineffective entomological monitoring and of pre-SIT tsetse suppression operations. This has implications on the planning/design and efficient implementation of integrated areawide tsetse and trypanosomosis intervention operations.

The work done and research findings obtained and reported as part of this CRP are directly relevant to the Agency's efforts to support the objectives of the AU-PATTEC initiative (see resolutions 12D of IAEA GCs 45 and 46) and were included in the DG's report to the 47th IAEA-GC on work done by the Agency in support of PATTEC.

Recommended Future Action by Agency

Earlier efforts by other tsetse researchers mainly focussed on identifying odour attractants for tsetse fly species that were derived from known host animals. The approach adopted under this CRP involved - besides tsetse field researchers from T&T affected Member States - specialists from other relevant fields, i.e. an insect pheromone / kairomone expert with specialization on synthesizing artificial candidate molecules that are stereo-isomerically related to known attractant molecules, and an expert specialised on laboratory physiological work with attractants for haematophagous insects and arthropods. As such an approach appears to generate short-cuts towards relevant research findings, the Agency's technical staff should consider (also for future CRPs) involving specialists with different, complementary/synergistic background and skills.

CRP Published Results

Internal:

[1] IAEA-TECDOC-1373

External:

[1] CARLSON, D.A.; F. MRAMBA, K. KAPPMEIER-GREEN & K. MORI (in preparation). Sex pheromone of the tsetse fly Glossina austeni: isolation, identification and synthesis.J. Chemical Ecology.
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[3] RAYAISSE, J.B., KABORE, I., SYED, Z, GUERIN, P. UJVARY, I. FELDMANN, U. (in preparation). Developing tsetse attractants: from lab to field.
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Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D52034** **Alternative methods to gas and high performance liquid chromatography for pesticide residue analysis in grain**

Participating Countries: Argentina(C), Bangladesh(C), China(C), Croatia(C), Cyprus(C), Hungary(C), India(C), Niger(C), Pakistan(C), Panama(C), Philippines(C), South Africa(A), Tunisia(C), Turkey(C)

Total Cost: **$314 491**

Duration: 1997-12-01 – 2002-12-15

CRP Overall Objectives

To improve the capability of pesticide residue laboratories in performing the determination of pesticide residues by elaboration of alternative techniques to GC and HPLC detection.

CRP Specific Objectives

To test the applicability of TLC detection methods for qualitative and quantitative determination of pesticide residues.
To elaborate extraction and cleanup procedures for determining pesticide residues in cereal grains with TLC detection.
To validate the methods.

Research Outputs

The detectability and elution characteristics of 234 pesticide compounds were tested with 8 elution systems and 6 detection methods.
The within and between laboratories reproducibility has been tested and typical values established.
Internal quality control procedures were elaborated and applied to demonstrate the reliability of the methods.
The methods were validated in corn, rice and wheat matrices as representative commodities for cereal grains with representative compounds selected from 6 chemical classes of pesticides.
The results will be published in a Technical document and in a peer-reviewed journal.

CRP Outcome (Effectiveness; Impact; Relevance)

The specific objectives were achieved. The applicability of the method had been characterised and demonstrated. The methods elaborated proved to be suitable for inexpensive screening for specified compounds and for qualitative confirmation of the identity of a large number of organophosphorus, carbamate insecticides, triazine and urea type of herbicides, benzimidazole, dicarboximide fungicides and several pesticides of various chemical classes.

The methods cover a wide range of currently used pesticides and with proper experience they can provide valid results. Applying TLC detection methods for confirmation the capacity of the laboratories is increased, and their capability to perform residue analysis in a quality controlled environment is improved. Therefore the overall objective have been met.

The participating laboratories started to apply the methods in their routine work. The impact of the results can be realistically measured a few years after the dissemination of the technical document and publishing the results.

The confirmation of the identity of the analytes detected is a basic requirement in trace organic analysis. The methods elaborated makes also possible the confirmation of compounds which cannot be determined with GC, thus their confirmation would require very expensive LC/MS systems (200000-300000 US$). The TLC confirmation of GC amenable compounds is also very important as it eliminates the need of changing columns and time consuming stabilisation of the system, by this improves the capacity of the laboratory without increasing the number of GCs and HPLC instruments.

Recommended Future Action by Agency

With CRPs D5 20 33 and 34 the applicability of TLC detection techniques have been properly explored and demonstrated. The reliable application of the elaborated methods require practice and experience, therefore their practical demonstration should be continued in the future training workshops.

Accomplishments of CRPs Completed in 2002

CRP Published Results

The preparation of the Technical Document is in its final stage. The preparation of a number of papers is in the final stage for publication in peer-reviewed journal.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D61019 Determination of profiles of human bacterial pathogens in foods for export by introduction of quality-assured microbiological assays**

Participating Countries: Australia(A), Austria(A), Brazil(C), Chile(C), China(C), France(A), Ghana(C), India(C), Indonesia(C), Korea, Republic of(C), Mexico(C), Nigeria(C), Paraguay(C), Philippines(C), South Africa(C), Thailand(C), United Kingdom(C)

Total Cost: **$281 142**

Duration: 1997-12-15 – 2002-10-31

CRP Overall Objectives

The overall objectives of this CRP were to assist national food control authorities and institutions to improve food safety and stimulate international trade, by determining profiles of selected human bacterial pathogens of concern to importing countries, on raw foods and on food products.

CRP Specific Objectives

To support the activities of the FAO/IAEA Training and Reference Center for Food and Pesticide Control of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture under its mandate to assist Member States and their institutions to fulfill requirements to support the implementation of international standards/agreements relevant to food safety.

Research Outputs

The results of this CRP provided valuable information on the contamination of a wide variety of foods which are of a great importance in the international trade. Meat (chicken, beef and pork), seafood (shellfish, such as shrimp, scampi, lobster and different types of fish such as salmon), spices (pepper, paprika), vegetables (asparagus, peas and corn) as well as other products such as coconut were studied. In terms of bacterial contamination, Salmonella spp. remains the main concern. This pathogenic bacteria was found in almost all the foods studied. The ubiquity of Salmonella spp. in the natural environment may contribute significantly to the continued prominence of Salmonella in many foods, especially in meat and derivate products.

CRP Outcome (Effectiveness; Impact; Relevance)

Profiles of selected human bacterial pathogens in some foods, raw materials and products were established.

The scientific information generated as a result of this CRP will be useful for national food control authorities and institutions to improve the microbiological safety of some of the foods produced for external market or imported for internal consumption

International trade in agricultural products and commodities has been expanding greatly during the last decade with a value estimated at US$ 583 billion which represents 42,5% of the world export of primary products. The increase in the international market has also enlarged the possibility of introducing new food borne pathogens into the importing countries (e.g. novel Salmonella strains), or of spreading pathogens across boundaries from endemic of low incidence areas (e.g. Vibrio cholerae). As a result of this, some countries have imposed food safety technical barriers to trade, including, for instance, restrictions due to scientifically insupportable low tolerance levels for Salmonella, Listeria or other pathogens. Such barriers can effectively limit or block international trade in food and can result in substantial economic loss to the exporting country. This CRP has generated valuable information that could help to avoid practices of economic impact in the international market without a scientific support.

Recommended Future Action by Agency

In recognition that laboratory analysis is only one part of the quality control of the total food chain, it is recommended that attention be directed by national authorities also to the improvement of the microbiological safety of the environment, agricultural practices, processing, storage, transport and distribution of foods as well as the implementation of GMP and HACCP. Efforts to harmonize international standards and testing methodology undertaken by Codex and ISO should also be encouraged and supported by national food control authorities.

Accomplishments of CRPs Completed in 2002

CRP Published Results

Internal : One TECDOC in preparation.
External : Journal and conference papers published by the participants.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **D61020 Irradiation as a phytosanitary treatment of food and agricultural commodities**

Participating Countries: Australia(A), Brazil(C), Chile(C), China(C), China(C), India(C), Iran, Islamic Republic of(C), Japan(A), Malaysia(C), Philippines(C), Poland(C), Syrian Arab Republic(C), Thailand(C), Turkey(C), United States of America(A), United States of America(A), United States of America(A)

Total Cost: **$291 477**

Duration: 1998-12-01 – 2002-12-15

CRP Overall Objectives

To study the feasibility of using irradiation as a phytosanitary measure for different foods and agricultural commodities.

CRP Specific Objectives

To identify commodity/pest systems amenable to efficient use of irradiation technology.
To identify efficacy requirements and data needs acceptable to regulatory agencies.
To develop efficacy data for pest/commodities systems.
To develop data on commodity tolerance to irradiation.
To evaluate whether systems/combinations are amenable to irradiation technology.

Research Outputs

The CRP provided relevant information about the radiosensibility of different pests as well as the tolerance of different foods and agricultural commodities to the irradiation treatment or irradiation in combination with other quarantine treatments. Efficacy requirements were identified and efficacy data were developed for some pest/commodities systems.

CRP Outcome (Effectiveness; Impact; Relevance)

This CRP provided valuable information about the feasibility of using irradiation alone or in combination with other treatments as a quarantine in a wide variety of pest/commodities. The results obtained under this CRP will be of a great value to establish in the future a generic dose as a quarantine treatment, and contributed to the improvement of the knowledge about the use of irradiation as a quarantine treatment and to establish a solid scientific base to determine a generic dose in a near future.

The international trade in agricultural products and commodities has been expanding greatly during the last decade with a value estimated at US$ 583 billion which represents 42,5% of the world exports of primary products. Accompanying increased trade in agricultural products is the increased risk for inadvertently transporting quarantine pests to countries or regions where they do not already occur. Quarantined pests can seriously disrupt marketing of fresh agricultural products not only between countries, but also between geographical areas within countries unless accepted postharvest quarantine treatments are available. Quarantine or phytosanitary treatments such as fumigation, heat, cold, or irradiation disinfest host commodities of insect pests before they are moved through market channels to areas where the pests do not occur. Some physical methods suchs as vapor heat treatment, hot water dip and low temperature treatment have either technical limitations, high costs or are applicable only to specific products. Chemical treatments also have limitations, for instance, methyl bromide is being phased out globally because of environmental concerns. Irradiation is recognized as a versatile treatment with broad-spectrum activity against arthropod pests at dose levels that have minimal adverse effects on the quality of most commodities. This CRP has generated valuable information that could help solve quarantine problems of food and agricultural commodities at national and international levels using low doses of irradiation as a quarantine treatment.

Recommended Future Action by Agency

The participants of the CRP believed that the pursuit of generic doses for specific taxonomic groups of insects and mites would be a worthy objective for future research. The approval of generic doses would facilitate more rapid

adoption of irradiation as a phytosanitary measure. It was recommended that IAEA supports future research activities in connection to this matter.

CRP Published Results

Internal : TECDOC in final revision before publication.
External : Journal and conference papers published by the participants.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E15015 Molecular typing of mycobacteria strains in multi-drug resistant tuberculosis**

Participating Countries: Brazil(C), India(C), India(C), India(C), Korea, Republic of(C), Malaysia(C), Morocco(C), Netherlands(A), Russian Federation(C), South Africa(C), Vietnam(C)

Total Cost: **$240 252**

Duration: 1997-12-01 – 2002-12-02

CRP 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.

CRP Specific Objectives

i. To apply novel molecular-based techniques to type the drug resistant strains of M.tuberculosis in order to improve therapy and limit their transmission
ii. To develop and validate novel techniques
iii. To evaluate the use of these techniques for typing of M.tuberculosis and resistance genotyping of MDR strains
iv. To use these techniques to type M.tuberculosis isolates in respective geographical locales in order to determine the extent of ongoing transmission of MDR strains in the community
v. To apply the technology for rapid detection of drug resistance in patients' samples to facilitate appropriate and timely therapy
vi. Application of the date for planning or modification of control programmes

Research Outputs

Novel molecular techniques of spoligotyping, RFLP analysis (for typing of mycobacterial strains), reverse line blot assay, dot blot hybridization, RFLP and PCR-SSCP (for resistance genotyping), were validated, evaluated and used to determine the extent of ongoing transmission of MDR strains in the communities as well as to facilitate appropriate and timely therapy to the patients as detailed under impact of CRP

CRP Outcome (Effectiveness; Impact; Relevance)

All of the specific objectives were achieved except the application of the date for planning or modification of control programmes.

Novel radionuclide-based molecular techniques for typing of M.tuberculosis and resistance genotyping of MDR strains were developed, validated, evaluated and applied to determine the extent of ongoing transmission and to rapidly facilitate appropriate therapy. The technique of genotyping was used to demonstrate active transmission of tuberculosis in a Russian prison and nosocomial transmission in a Korean hospital.

Strain typing and resistance genotyping were carried out for M.tuberculosis. A total of 2150 samples, including 610 resistant strains were typed. Of these, about 900 were spoligotyped and about 2000 were analyses by RFLP. Spoligotyping was used for strain typing by al participating laboratories except South Korea, where this method was found non-discriminatory in about 95% of the samples. Several families of spoligotypes were identified. Beijing type spoligopattern was seen in <5% to >95% in different centres, expcept in Brazil, were it was not seen. Type 18 spoligopattern was identified by India. Other clusters of identical isolates were reported by the laboratories in South Africa (4), India (4), Malaysia (12) and Brazil (12). RFLP analysis based on IS6110 was also carried out by all. Families of isolates with similar RFLP patterns were identified in South Africa, South Korea and India. Resistance genotyping using reverse line blot assay (RLB) was performed on a total of 640 isolates for rpoB gene, 306 for streptomycin gene, 585 for KatG gene and 297 for ethambutol gene. The results of reverse line blot assay were satisfactory only with rpoB genotyping. The assay was not found useful for detection of gene mutations associates with INH and was of limited use for streptomycin resistance. RLB was evaluated for detection of mutation for resistance to all 4 drugs. Its sensitivity ranged from 70-80% and specificity from 70-83% in Russia. The sensitivity and specificity for rpoB was found to be 100% and 90% respectively in India. The performance for other targets was sub-optimal. 531TTG mutation for rifampicin gene was the most frequently detected mutation in Russian isolates. 82% of Beijing isolates in north-western Russia had the 531TTG mutation, while only 20% of the non-Beijing isolates

had this mutation. The most frequently encountered mutations for rifampicin gene were 531TTG, 516GTC and 526GAC from other regions.

Extensive analysis of resistance genes was also carried out, using alternative approaches, such as dot blot hybridization, RFLP and PCR-SSCP. In South Korea PCR-SSCP was evaluated for detection of rpoB mutation for rifampicin resistance and its results were compared with those of sequence analysis. Radioisotope PCR-SSCP showed an excellent correlation with sequence analysis of 157bp region of rpoB gene for rapid detection of rifampicin resistance in M.tuberculosis. In a separate study from South Korea and South Africa, the detection power of PCR-SSCP using radioisotopic nuclides was estimated to be about 33 times higher than that of PCR-SSCP using non-radioisotope nuclides. Performance of mutation analysis by dot blot hybridization was compared with phenotypic drug resistance tests. Three selected codons, rpoB 531, rpoBB 526 and katG 318 allowed identification of 90% of MDR-TB. 90% of rifampicin, streptomycin and ethambutol resistance and 75% of INH were detected by screening for six codons: rpoB531, rpoB526, rrs513, rpsL43, embB306 and katG315. The performance of genotypic method was found superior to the routine phenotypic method, with the exception of sensitivity for INH resistance. Molecular detection of early appearance of drug resistance in a mixed population of resistant and sensitive bacteria was evaluated using dot blot and ARMS. These molecular methods were able to detect up to 20% of the minority strain. These methods were 10 times more sensitive than the commercial kit INNO-LIPA, which was able to detect up to 2% of the minority strain.

The direct use of microscopy stained slides and sputum samples was evaluated for its suitability in molecular analysis. The success ratio for amplification of targets using stained slides and sputum was 50-60%, with the exception of Russia (85%) and 90-98%, respectively. The use of sputum was demonstrated to be more promising in India and South Africa. Molecular analysis of spoligotyping was also performed directly on these biological materials.

In conclusion, the results demonstrated that spoligotyping has less resolution than RFLP, but is simpler than RFLP for typing of M.tuberculosis. For detection of drug resistance, dot blot hybridization was better than SSCP, which in turn was better than RLB assay. For direct molecular analysis, success with sputum as a biological sample was much higher than with microscopy stained slides.

Radionuclide based novel molecular methods were successfully developed and used for determination of ongoing transmission of MDR tuberculosis and facilitated the appropriate, timely therapy to patients. Isotopes used in the CRP were 32P for dot blot/Southern hybridization, 14C in BACTEC and 35S for sequencing.

Recommended Future Action by Agency

As there has been a substantial progress in this CRP, the work should be continued. Molecular techniques, especially for detection of drug resistance of rifampicin and ethambutol should be considered as gold standard for future work. Another project on host-pathogen interaction, involving techniques like in situ PCR and radioimmunoscintigraphy is also recommended.

CRP Published Results

JOINT PUBLICATIONS:

[1] LEE H, VICTOR TC, SUFFYS PN, SINGH U, BANG HE, JORDAN A, GOMES HM, SURESH VN, KIM SC, KHAN BK, CHO SN. Evaluation of PCR-SSCP analysis for the detection of the rpoB mutations associated with resistance to rifampicin in Mycobacterium tuberculosis. World Journal on Nuclear Medicine 2(1):45-51, 2003

JOINT PUBLICATIONS UNDER PREPARATION:

[2] MOKROUSOV I, BHANU N. VIJAYA, SUFFYS PN, KADIVAL GV, YAP SF, CHO SN, JORDAN AM, NARVSKAYA O, SINGH UB, GOMES HM, LEE H, KULKARNI SP, LIM KC, KHAN BK, SOOLINGEN DV, VICTOR TC, VAN EMBDEN JDA. Multicenter evaluation of Reverse Line Blot Assay to predict drug resistance in M. tuberculosis isolates. Submitted to the Journal of Clinical Microbiology.
[3] HYEYOUNG L et al. Comparison between radioisotopic and non-radioisotopic PCR-SSCP for the detection of mutations at rpoB gene associated with rifampin resistance of Mycobacterium tuberculosis.
[4] Direct molecular analysis of microscopy stained slides and sputum samples for M. tuberculosis by spoligotyping.

INDIVIDUAL PUBLICATIONS

[5] CHO, S.N, et.al. A simple and rapid molecular typing of M.tuberculosis by polymerase chain reaction. J. Microbiol.,36:124-129, 1998
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Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E15016 Genotype/phenotype correlation in thalassemia and muscular dystrophy**

Participating Countries: Australia(A), Brazil(C), Cyprus(C), India(C), Mauritius(C), Netherlands(C), Pakistan(C), South Africa(C), Thailand(C), Tunisia(C), Turkey(C), United Kingdom(C)

Total Cost: **$221 079**

Duration: 1998-11-01 – 2002-12-15

CRP 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.

CRP Specific Objectives

To characterize thalassemia mutations prevalent in each population, if not already known.
To determine genetic factors stimulating HbF synthesis.
To study the interaction of the above factors in thalassemia and thalassemia/HbE patients.
To determine the incidence of Duchenne/Becker muscular dystrophy, limb girdle muscular dystrophies, fascio-scapulohumoral dystrophy and their underlying molecular genetic defects in the participating countries.

Research Outputs

Radioisotopic molecular techniques like southern blot, dot blot hybridization and sequencing were used to detect deletions in alpha thalassemia and the dystrophin gene (DMD), identifying carriers (DMD), linkage analysis (DMD and LGDM), mutations detections (LGMD, beta thalassemia) and identifying variable repeats in upstream gene expression promoters (beta globin gene). These results were used to define molecular basis of thalassemia in different ethnic groups in order to have a better diagnostic strategy and clinical management of patients in these countries. These techniques were also used to make prenatal diagnosis of thalassemia in India and Cyprus. Genotype-phenotype correlation was also established in Duchenne/Becker muscular dystrophies and limb girdle dystrophy as detailed under "impact of CRP"

CRP Outcome (Effectiveness; Impact; Relevance)

Radionuclide based molecular techniques were used to study and characterize molecular basis of thalassemia, Duchenne/Becker muscular dystrophy and limb girdle muscular dystrophy in participating countries. The correlation of the genetic factors was made with phenotype and severity of these diseases. These techniques were used to make prenatal diagnosis of thalassemia in India and Cyprus and for formulating better diagnostic strategy and clinical management of patients. New loci were identified in Tunisia and Turkey.

Thalassemia mutations were characterized by participating countries. Mutations in beta globin gene thalassemia (18/17/4 mutations), XmnI polymorphism and in gamma alpha thalassemia gene were studied in 1142 patients from India, Cyprus, Iran, Mauritius, Pakistan and Thailand. The beta thalassemia disease exhibited a milder phenotype if the mutation was one of the known mild mutations, if XmnI mutation was present or if alpha thalassemia mutation was co-inherited. The ameliorating factor varied in different ethnic groups. In Cyprus and Thailand, it was co-inheritance of alpha thalassemia. In Iran, it was XmnI polymorphism. In India and Pakistan, both of the above factors were present. Mild beta thalassemia mutations, e.g. IVSI-6 (Cyprus) and CAP+I and -88 (Pakistan) were also seen to a varying extent. These results not only allow formulation of accurate and better diagnostic strategy for each country for families at risk, but can also be used for better clinical management of patients with mild form of beta thalassemia. In India, prenatal diagnosis was established in 16 women, 3 of whom were carriers. Genetic preventive programmes and awareness raising activities were also carried out in India.

Analysis of genes such as from dystrophin and sacroglycons was carried out for muscular dystrophies. More than 1992 patients with Duchenne/Becker muscular dystrophy (DMD/BMD) were studied. Deletions accounted for the disease in 58% (India), 60% (Netherlands) and 36% (South Africa). Point mutations were detected in up to 9% (Netherlands) and 8% (South Africa) of the DMD/BMD patients.

A total of 352 patients were studied for limb girdle muscular dystrophy (LGMD). LGMD2C was more common in Tunisia, compared to DMD/BMD. A large set of families with LGMD2C were shown to carry the same single point

mutation, but exhibited a wide range of clinical phenotypes, which can be used to identify additional genes involved in the disease. Results from Turkey also demonstrated that lesions in muscle proteins like gamma sarcoglycan lead to more severe phenotype. New loci were identified in Tunisia and Turkey.

Radionuclide based molecular methods were successfully used for detection of thalassemia mutations and their correlation with the phenotype in order to formulate better diagnostic and therapeutic strategies for patients in each country as well as for making prenatal diagnosis. Detection of deletions and point mutations (DMD/BMD) and point mutation (LGMC) accounted for the molecular basis for these muscular dystrophies. Isotopes used in the CRP were 32P, 35S and 33P for southern/dot blot hybridization and sequencing.

Recommended Future Action by Agency

As commendable progress in genotype/phenotype correlation was made in this CRP, work should be continued to investigate genotypic basis of still unexplained phenotypes. A project for studying abnormal haemoglobin was proposed to study such patients and the project could be expanded to include the sickle cell variants as well. Multiple gene disorders like fascio-scapalohumeral muscular dystrophy (FSHD) and cerebral ataxias were also identified as subjects for future projects.

CRP Published Results

One joint paper has been published and one additional paper is under preparation. 24 individual papers have been published.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E15017 Development of an improved serological kit for Chagas diagnosis using radionuclide methods**

Participating Countries: Argentina(C), Argentina(C), Bolivia(C), Brazil(A), Brazil(C), Brazil(C), Brazil(C), Honduras(C), Mexico(C), Panama(C), Venezuela(C)

Total Cost: **$146 607**

Duration: 1999-03-01 – 2002-12-15

CRP Overall Objectives

To develop a serological kit for the diagnosis and strain typing of Chagas disease in endemic and non-endemic areas.

CRP Specific Objectives

To establish a panel of sera that include well characterized Chagasic and non-Chagasic sera from different Chagas disease endemic areas and countries of Latin America.

To clone and express candidate recombinant antigens.

To test individually and in various combinations the recombinant antigens by ELISA and RIA to improve the diagnosis and typing of Chagas diseases.

To construct chimeric recombinant proteins or multiepitope polyantigens and test their diagnostic potential.

Research Outputs

Radionuclide based molecular methods were used for cloning, expression and identification of recombinant antigens. A total of 15 antigens were studied in this CRP. They were tested individually and in combinations with reference to their large scale production as well as their suitability for inclusion in the diagnostic kit. The best suitable antigen MAP and JL8 were tested by ELISA against panels of well characterized Chagasic and non-Chagasic sera from different endemic areas and countries of Latin America, and their sensitivity and specificity determined for their potential use as a diagnostic kit. Details shown under "impact of CRP".

CRP Outcome (Effectiveness; Impact; Relevance)

It was not possible to achieve the specific objective "construct chimeric recombinant proteins or multiepitope polyantigens and test their diagnostic potential" due to time constraints.

Radionuclide based molecular methods were used for cloning, expression and identification of recombinant antigens, which were then tested individually and in combination against panels of characterized sera for their diagnostic performance and suitability for development of improved serological kit. Two recombinant proteins MAP and JL8 in combination were demonstrated to be very useful for immunodiagnosis of acute and chronic Chagas disease.

A total of 15 recombinant antigens were evaluated for their large scale production, suitability as diagnostic agents in diagnostic assays and their performance in the assay. Three best suitable antigens, namely JL8, MAP and TcPO were further evaluated for their diagnostic performance in ELISA by testing them against panels of well characterized Chagasic and non-Chagasic sera. A combination of JL8 and MAP was demonstrated to have a sensitivity of 99.4% and specificity of 99.3% when tested with 150 sera from Chagasic and 142 sera from non-Chagasic individuals from Bolivia, Brazil, Honduras, Mexico and Panama. Moreover, this combination was able to diagnose 84.2% of acute phase patients of T.cruzi infection, thus demonstrating its utility for the diagnostic kit.

Radionuclide-based methods were successfully employed using recombinant DNA technology for cloning, expression and identification of recombinant antigens. The combination of JL8 and MAP was further used to demonstrate its suitability, performance and utility for an improved serological kit for diagnosis of Chagas disease, thus achieving overall Agency's 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 basic and clinical research. The isotopes used in this CRP were 32P and 125I.

Recommended Future Action by Agency

Keeping in view the substantial progress of this CRP, two new CRPs are recommended:

1. Serological and molecular diagnosis of Chagas disease using recombinant antigens and PCR.

2. Correlation between T.cruzi variability and course of infection in different geographical areas.

It is also emphasized that projects on molecular diagnosis of re-emerging disease are of extreme importance for the Latin American region.

CRP Published Results

One joint paper and 19 individual papers.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E24009 Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water**

Participating Countries: Belgium(A), Brazil(C), France(A), France(A), Germany(A), Germany(A), India(C), Italy(A), Japan(A), New Zealand(A), Slovenia(C), United States of America(A)

Total Cost: **$66 636**

Duration: 1997-09-01 – 2002-12-15

CRP Overall Objectives

To replace the present IAEA Codes of Practice TRS-277/381, based on the quantity kerma in air, by a Code of Practice based on the new standards and to transfer the resultant procedures to the SSDLs and hospitals in Member States.

CRP Specific Objectives

To develop a Code of Practice based on the standards of absorbed dose to water.
To test practical implementation of the Code of Practice by users in hospitals in Member States by analysing and quantifying possible differences with the existing protocols for different types of radiation beams and ionization chambers, and to publish the results as an IAEA TECDOC.

Research Outputs

As an output of CRP the following results were obtained:
- publication of the Code of Practice as the IAEA TRS 398
- implementation of the IAEA TRS 398 by users in hospitals in Member States
- publication of results of the IAEA TRS 398 verification for clinical beams

CRP Outcome (Effectiveness; Impact; Relevance)

The IAEA Code of Practice TRS 398 based on absorbed dose to water standards meets the highest scientific standards and yields the most accurate results for absorbed dose determination in external beam radiotherapy.

The use of TRS 398 will improve practical dosimetry in photon, electron, proton and ion beams used for the radiotherapy in Member States.

The IAEA TRS 398 provides recommmendations for the dosimetry procedures for external radiotherapy beams and will decrease the uncertainty of the dose delivered to the patient as the number of steps involved and conversion factors is reduced. For Member States it will yield a unified and consistent framework, which does not exists today.

The use of the IAEA TRS 398 will provide users in Member States with improved dosimetry practice. The verification results and comparisons with the existing protocols produced by the participants of the CRP will allow to evaluate possible impact on patient dosimetry.

Recommended Future Action by Agency

IAEA should review the data in TRS 398 and prepare the second edition of the Code of Practice in about five years after its publication.

CRP Published Results

About 15 papers reporting results of testing IAEA TRS 398 for different clinical beams and ionization chambers will be published in 2003 in the Proceedings of the International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry organized by the IAEA in 2002. The other major publications are listed below.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed dose determination in external beam radiotherapy: An International Code of Practice for dosimetry based on standards of absorbed dose to water. IAEA Technical Reports Series no. 398, IAEA, Vienna (2000).
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Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E33012 Clinical application of radiosensitizers in cancer radiotherapy**

Participating Countries: Austria(C), Austria(C), China(C), India(C), Japan(A), Japan(A), Japan(C), Nigeria(C), Pakistan(C), Peru(C), Sri Lanka(C), Turkey(C), United Kingdom(C)

Total Cost: **$273 614**

Duration: 1994-09-15 – 2002-12-31

CRP Overall Objectives

To study the Clinical Application of Radiosensitizers in Cancer Radiotherapy.

CRP Specific Objectives

To conduct an international multicentre randomized clinical trial. of a hypoxic cell radiosensitiser, AK-2123 in the treatment of cervix cancer.

Research Outputs

From 19 May 1995 to 16 December 1998, 333 patients were randomised and treated either by radical radiotherapy (RT) or radiotherapy with the addition of a hypoxic cell radiosensitiser, AK-2123. Six patients were excluded as they were never treated and were lost to follow up. Local toxicity did not differ significantly in the two treatment groups. There were 20 patients in the RT+AK-2123 arm who experienced peripheral neuropathy. In most cases, this normalized within 6 months. In one patient a mild, permanent peripheral neuropathy has been recorded. The rate of local tumour control was 62% after RT+AK-2123 and 46% after RT (p=0.006), which is significant. The actuarial survival at 60 months was 57% after RT+AK-2123, compared to 41% after RT (Log Rank p= 0.007).

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been concluded and the preliminary results are encouraging.

This clinical trial has advanced the study of Clinical Application of Radiosensitizers in Cancer Radiotherapy

The low toxicity and improved tumor control are encouraging but the short follow-up of the patients would need to extended for critical acceptance.

Recommended Future Action by Agency

1. The Agency needs to provide for sophisticated support by statisticians in such studies.
2. After the independent expert peer-reviewers' comments/criticisms are received from the International Journal of Radiation Oncology Biology and Physics, additional funding may be necessary to address those comments/criticisms.

CRP Published Results

The manuscript was submitted in Oct 2002 to the International Journal of Radiation Oncology Biology and Physics.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E33017 Regional hyperthermia combined with radiotherapy for locally advanced cancers**

Participating Countries: China(C), China(C), India(C), Japan(A), Japan(A), Japan(C), Japan(C), Japan(C), Japan(C), Korea, Republic of(C), Korea, Republic of(C), Pakistan(C), Ukraine(C), Ukraine(C), United States of America(A)

Total Cost: **$174 490**

Duration: 1997-12-15 – 2002-12-15

CRP Overall Objectives

To study the clinical applications of hyperthermia in radiotherapy.

CRP Specific Objectives

To conduct an international multi-centre randomized clinical trial of hyperthermia in cancers of the cervix, lung and rectum.

Research Outputs

From 1998 to 2002, 110 patients with cervix cancer, 80 patients with lung cancer, and 69 patients with rectal cancer were randomized and treated by either radical radiotherapy (RT) or RT plus regional hyperthermia. Only the results for the patients with cervix cancer (the largest group) have so far been systematically analyzed by the technical contract holder. 110 patients with biopsy-proven, locally advanced carcinoma of the uterine cervix were randomized to treatment by radiotherapy with or without hyperthermia. The patients were stratified by institution, stage and histological type. Each patient received external beam radiation therapy and brachytherapy. For the patients randomized to receive hyperthermia, a minimum of five sessions (60 minutes each, once per week) were administered, employing RF capacitive heating. Intratumoral temperature was measured at the first hyperthermic treatment, and at least once more during the course of treatment. The equipment and the policies and procedures at each participating institution except one were personally inspected at least once by the technical contract holder, to ensure that quality assurance procedures were in place and were followed for treatment according to the protocol guidelines. The median follow-up period was 46.6 months for all the patients and 51.2 months for the surviving patients. The two arms were well balanced with regard to the patient factors, tumor factors, and treatment factors. The overall survival rate at 3 years was 73.2% and the local control rate was 68.5%. There were no significant differences between the patients treated with or without hyperthermia, either with regard to the survival ($p=0.1893$) or the rate of local control ($p=0.58$). The survival was significantly worse among the patients with stage IIb disease that received hyperthermia ($p=0.0162$) although there was no difference in their rate of local control ($p=0.7988$). Further analysis is necessary to determine if the difference in survival is due to a greater incidence of distant metastases or some other cause. Acute grade 2-3 toxicity was seen in 10/55 patients (18%) treated by hyperthermia and in 2/55 of the patients (4%) treated without hyperthermia ($p=0.01$). There was no significant difference in the late toxicity observed in the two arms. This prospective randomized study failed to show any benefit from the addition of hyperthermia to radiotherapy in the treatment of locally advanced carcinoma of the uterine cervix. The acute toxicity was significantly greater among the patients receiving hyperthermia, and the survival was significantly worse among the stage IIb patients receiving hyperthermia even though there was no difference in the local control rate.

CRP Outcome (Effectiveness; Impact; Relevance)

1. Some participants gained valuable experience in conducting clinical research and were able to improve the follow-up of their patients as a result of participation in this CRP.
2. An important benchmark has been established with regard to the worth of regional hyperthermia in treating cancer, showing that it is ineffective in improving the outcome.

This CRP demonstrated convincingly that hyperthermia delivered in this manner is not indicated in the management of this population of patients.

This is one of the largest and most definitive studies of hyperthermia and radiotherapy ever undertaken. It showed that it is not worthwhile to expend scarce resources on this technology for the treatment of cancers in developing countries.

Cancers of the cervix, lung and rectum are common in many developing countries. By clarifying the role of hyperthermia 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 emerging technologies adjuvant to radiotherapy in developing countries.

CRP Published Results

Internal: Reports of the RCMs.
External: Three peer-reviewed manuscripts (in preparation) to be submitted to prestigious journals in the field.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **E41011 Validation and application of plants as biomonitors of trace element atmospheric pollution, analyzed by nuclear and related techniques**

Participating Countries: Argentina(C), Brazil(A), Chile(A), China(C), Germany(A), Ghana(C), India(C), Israel(A), Israel(C), Jamaica(C), Netherlands(A), Norway(A), Portugal(C), Romania(C), Russian Federation(C)

Total Cost: **$327 712**

Duration: 1997-12-15 – 2002-12-15

CRP Overall Objectives

To study environmental contaminants affecting human health by nuclear and related analytical techniques.

CRP Specific Objectives

To Identifiy and validate of suitable biomonitors for the monitoring of air pollution in different (local/regional) areas, including:

(i) Identification of suitable biomonitors (e.g. moss and lichen) of air pollution having potential for their regional applications;
(ii) Selection of relevant sites and appropriate techniques for sampling;
(iii) Establishment of protocols for the preparation and analysis of samples for the relevant elements (toxic and others) by NAA and complementary techniques (ICP-MS, ICP-AES, XRF, etc.);
(iv) Quality assurance/validation of the data through participation in interlaboratory exercises; and
(v) Processing and evaluation of the data including quantification of the possible correlation between the elemental concentrations in the biomonitors and the air polluting activities, survey studies for the assessment of geographical differences and/or time trends in deposition and/or atmospheric concentrations by the determination of elemental content of the sampled biomonitors, mapping of the biomonitoring results, etc.

Research Outputs

A country specific summary covering the major activities, the bioindicators involved and the analysis techniques followed is as follows:

Argentina-Quantification, geographical resolution, survey, mapping and impact involving Lichens and Tillandsia species and INAA, TXRF, AAS techniques.
Brazil-Quantification, geographical resolution, and survey involving Lichens , Tradescantia, tree bark species, and INAA technique.
Chile-Quantification, geographical resolution, survey, and mapping involving Lichens species and INAA technique.
China-Quantification, time resolution, geographical resolution, and survey, involving tree leaves and INAA technique.
Germany-Quantification, time resolution, geographical resolution, survey, and mapping involving moss species and ICP-MS technique.
Ghana-Geographical resolution, and survey involving Lichens species and INAA, XRF techniques.
India- Quantification, geographical resolution, and survey, involving moss, lichens weeds, shrubs species, and PIGE, ICP-MS techniques.
Israel- Time resolution, geographical resolution, survey, and impact involving Lichens species and ICP-AES technique.
Jamaica-Quantification, time resolution, geographical resolution, survey, and mapping involving Lichens, mosses, Tillandsia species, and INAA, XRF, techniques.
The Netherlands-Quantification, time resolution, geographical resolution, survey, and mapping involving tree bark, mosses species and INAA technique.
Norway- Quantification, time resolution, geographical resolution, survey, and mapping involving mosses species and INAA, ICP-MS techniques.
Portugal-Quantification, time resolution, geographical resolution, survey, and mapping involving Lichens species and INAA, PIXE techniques.
Romania-Geographical resolution, survey, and mapping involving moss species and INAA, AAS techniques.
Russian Federation - Time resolution, geographical resolution, survey, and mapping involving moss species and INAA, AAS techniques.

The details of the research carried out are:

In the initial phase of the project, the participating scientists selected appropriate bioindicators. They focused on lichens and mosses as they obtain most of their nutrient supply directly from precipitation and dry deposition of airborne particles The final selection of the bioindicators was made on the basis of their suitability for the local/regional applications. In several cases lower plants were not available at selected areas of investigation, so either active biomonitoring or higher plants as bioindicators were selected.

All the participants also developed written protocols for sample collection and preparation.

Two interlaboratory comparison exercises were carried out within the project: the first one, denoted as NAT - 5 in 1998 on two lichen samples, and the second one (NAT - 6) on two moss samples in the year 2000. The initial selection comprised 23 elements. However, due to variety of problems tackled and analytical methods used in individual countries, each participant decided the suite of elements considered. The first exercise revealed systematic discrepancies found for some elements between non-destructive methods (e.g. INAA, PIXE, XRF) and some analytical methods, where sample dissolution is needed before the final measurement. The discrepancies were attributed to different sample digestion procedures and after their harmonization they were not observed in the second exercise. Overall, only about 5 % of all submitted results were rejected as outliers after thorough statistical evaluation. The participants showed their ability in providing analytical results at up to about 20 % uncertainty level for most trace elements, which was found to be adequate for biomonitoring purpose.

Quantification studies were carried out under very different climatic conditions ranging from prevailing wet to prevailing dry deposition patterns. These include the significant positive correlations between biomonitor content and precipitation data for two different moss species found in Norway for As, Cd, Co, Fe, Mo, Pb, Sb, Tl, V, and Y, and the extensive quantification experiments on lichens and airborne particulate matter carried out in Portugal in places with prevailing dry deposition.

All participants tested several bioindicators from the same area thus allowing for interspecies calibration, which is of great help in the selection of suitable biomonitor available in an area, and and its application in other not having these biomoitors.

Studies carried out in Argentina and Israel also included determination of several other parameters (cell membrane integrity, chlorophyll, etc.) aimed at evaluating vitality and degree of stress induced in lichens and Tillandsia species due to environmental conditions. Measurement results could be presented in form of pollution index, foliar damage index, or parameters of lichen vitality, and included as separate parameters in subsequent data evaluation by multivariate statistics.

The surveys carried out comprised areas within the participating countries from Africa, Asia, the Caribbean, Europe and Latin America. In some countries biomonitoring for assessing trace element deposition data was used for the first time, whilst in other countries, mainly the developed ones, it has been already a long-year practice. The case studies included: (1) single emission sources such as coal-fired power plant (Israel), thermometer factory (India), various industrial complexes (China, Portugal), mining areas (Ghana), (2) urban areas (Argentina, Brazil, Chile, China, India, and (3) large-scale surveys (Argentina, Germany, Israel, Jamaica, The Netherlands, Norway, Romania, Russian Federation). The areas studied ranged from about 1,000 sq. km up to about 300,000 sq. km, proving that biomonitoring could be used at a regional scale. In many cases soil samples were assayed simultaneously to add value to the surveys by accounting for possible soil re-suspension contribution.

Participants from India, Jamaica and Russian Federation included in their survey scanning electron microscopy analysis of individual particles trapped on the biomonitor surface, thus obtaining additional information regarding discrimination of local pollution sources from long-range transport. German and Dutch participants were able to compare deposition data with human health indices showing future application of the accumulated deposition data linked with epidemiological evidence.

The mapping (presentations) varied from simple lines connecting points with equal element content found in bioindicators, to much more sophisticated colored plots based on geographical information systems and advanced graphical tools. The distribution maps were found to be a very useful way of presenting the monitoring results.

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP has been effective in providing a better understanding of the role and usefulness of biomonitors for the monitoring of air pollution. The involvement of wide spectrum of the experts, the variation in the availability of biomonitors, monitoring needs from region to region and use of nuclear and related techniques have provided excellent opportunity to address the specific objectives of the CRP.The results which got disseminated through various means including publications will be of great help to all concerned directly or indirectly with the assessment, monitoring and control of air pollution, including the monitoring and control of toxic elements such as lead and mercury.

The approach of the CRP covering biomonitors has not only added to an easy adoption of the use of these natural resources for air pollution monitoring in different areas but also in an increased understanding the effectiveness of the nuclear and related techniques for this purpose. The results of these studies will also provide a very useful information base in deciding strategies for the monitoring and control of air pollution in the concerned areas.

The CRP enabled :

1. Introduction of programmes for the monitoring of air pollution using biomonitors.
2. Providing of base line information data concerning the air pollution situation of the regions involved in the studies,
3. Better understanding of the interaction of plants especially lichens and moss with respect to the elements existing in their surrounding air, and
4. Better understanding of the effectiveness of nuclear and related techniques in the study of air pollution through use of biomonitors,
5. Availability of the increased knowledge and expertise through publications in journals.

The experience and expertise obtained through the CRP has a great relevance for all those concerned with studies, monitoring and control of air pollution.

Recommended Future Action by Agency

1. A multinational network of different researchers of Asia should be created on the basis of the results obtained in India and China.

2. Studies involving additional pollutants (Ozone, Oxides of sulfur and nitrogen, etc.) and trace elements in human tissues keeping in view the ultimate goal of addressing human health issues through use of biomonitoring techniques.

CRP Published Results

The participants published their studies/results concerning this CRP in over 50 papers/articles and made presentations at more than 35 conferences/workshops.The results therefore reached a large community resulting into very high recognition of the CRP.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **F13007 Comparison of compact toroid configurations**

Participating Countries: Argentina(C), Brazil(C), China(C), India(C), Israel(C), Italy(A), Japan(A), Japan(A), Japan(A), Japan(A), Japan(A), Russian Federation(C), Russian Federation(C), Ukraine(C), United Kingdom(A), United States of America(A), United States of America(A), United States of America(A), United States of America(A)

Total Cost: **$223 705**

Duration: 1998-11-01 – 2002-12-15

CRP Overall Objectives

To provide coordination for world research efforts on compact toroids
To promote the comparison of various compact toroidal configurations, in order to judge which is most promising for the economical production of fusion energy
To foster research collaboration
To encourage participation in the world effort by developing Member States

CRP Specific Objectives

To define the relative advantages of the various compact toroid configurations and to ascertain which concepts appear to be more promising for a fusion power plant.
To compare plasma stability in various compact toroid configurations
To compare the effectiveness of plasma sustainment by various means.

Research Outputs

16 papers published in international journals, 7 preprints and 16 presentations during international conferences and meetings.

CRP Outcome (Effectiveness; Impact; Relevance)

Detailed comparison of the three compact tori concepts (Field Reverse Configuration, Spheromak and Spherical Tokamak) has been done and presented in the final report.

Significant progress has been made in laboratories involved in the project in different plasma formation and sustainment methods, equilibrium and stability enhancement etc. Several technology and reactor issues have been also discussed in view of a future energy source based on CTC. The coordinated nature of the research asserted the extension and unification of methodologies used in different laboratories.

Recommended Future Action by Agency

As the overall objectives of the CRP as well as specific ones has been achieved, the "compact tori community" can continue research efforts in the field in close collaboration with the IAEA but using their own financial resources.

CRP Published Results

Peer-reviewed papers:

[1] YA.I.KOLESNICHENKO, V.V.LUTSENKO, V.S.MARCHENKO; "Fishbone mode in spherical tokamaks", Phys.Rev. Lett, 82, (1999), 3260.
[2] Ya.I.KOLESNICHENKO, V.V.LUTSENKO, R.B.WHITE, Yu.V.YAKOVENKO, "Effect of sawtooth oscillations on energetic ions", Nucl. Fusion, 40 (2000), 1325-1341.
[3] Ya.I.KOLESNICHENKO, V.V.LUTSENKO, V.S.MARCHENKO, R.B. WHITE, "Effect of trapped energetic ions on MHD activity in spherical tori", Phys.Lett. A305 (2002), 245.
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[12] A.LIFSCHITZ, R.FARENGO, N.ARISTA, "Monte Carlo simulation of neutral beam injection into a field reverse configuration", Nuclear Fusion, 42 (2002), 863.
[13] R.FARENGO, A.F.LIFSCHITZ, I.CAPUTI, N.R.ARISTA, R.A.CLEMENTE, "Theoretical studies of non inductive current drive in compact toroids", Brazilian Journal of Physics, 32 (2002), 65-75.
[14] R.FARENGO, K.I.CAPUTI, "Relaxed, minimum dissipation states of a flux core spheromac sustained by helicity injection", Plasma Phys. and Controlled Fusion, 44 (2002), 1707-1722.
[15] A.F.LIFSCHITZ, R.FARENGO, N.R.ARISTA, "Numerical calculations of neutral beam injection in Spheromaks", Plasma Phys. and Contr. Fusion, 44 (2002), 1979-1997.
[16] A.F.LIFSCHITZ, R.FARENGO, R.A.CLEMENTE "The effect of ion motion on rotating magnetic field current drive", Plasma Phys. and Controlled Fusion (2002).

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **F41017** **Nuclear model parameter testing for nuclear data evaluation (Reference input parameter library: Phase II)**

Participating Countries: Belgium(A), China(C), Cuba(C), France(A), Hungary(C), India(C), Japan(A), Netherlands(A), Russian Federation(A), Ukraine(C), Ukraine(C), United States of America(A)

Total Cost: **$121 060**

Duration: 1998-07-01 – 2002-12-14

CRP Overall Objectives

To preserve the accumulated knowledge on the required numerical input for nuclear model codes and make it easily and generally available.

CRP Specific Objectives

To test and improve nuclear model parameters for theoretical calculations of nuclear reaction cross sections at incident energies below 100 MeV.
To produce a well-tested Reference Input Parameter Library for calculations of nuclear reactions using nuclear reaction codes.
To develop user-oriented retrieval tools and interfaces to established codes for nuclear reaction calculations.
To publish support documentation and make the library and tools available on-line and on CD-ROM.

Research Outputs

This IAEA CRP resulted in the RIPL-2 library of recommended input parameters for nuclear model calculations of reaction cross-sections at low and intermediate energies. Incident and outgoing particles include neutrons, protons, deuterons, tritons, 3He and 4He, with energies up to approximately 100 MeV.

CRP Outcome (Effectiveness; Impact; Relevance)

RIPL-2 database is available on the IAEA-NDS web server and on CD-ROM. A number of state-of-the-art nuclear model codes (e.g. TALYS, EMPIRE-II, GNASH) use the RIPL-II library to define the default input parameters. Ease of accessibility and reliability has made RIPL-II a reference starting point for many other projects.

The practical use of nuclear model codes requires a considerable amount of numerical input that describes the properties of the nuclei and the interactions involved. Experts have used a variety of different input sets, often developed over many years in their own laboratories. These partial input databases were often poorly documented, or not documented at all, and not always available to other users. To preserve the accumulated knowledge and make it easily and generally available, the IAEA has undertaken an extensive co-ordinated effort to develop a library of evaluated and tested nuclear-model input parameters.

Recommended Future Action by Agency

The RIPL-II library is becomming an established product offered by the IAEA, but to preserve the leading edge, it requires maintenance and upgrades, based on contributions from external users. Activities should continue that will focus on: (i) tools for checking and ease of maintenance, (ii) updating the information with external contributions that will improve the predictive capability and extend the applicability of the library, (iii) further improvement of display and retrieval utilities.

CRP Published Results

The IAEA-TECDOC describing the methods and the contents of the RIPL-II library is in the editorial stage of preparation.
References to other publications can be found in INIS. Selected papers in international publications directly referring to RIPL are listed below:
[1] SU ZONGDI et al: Chinese evaluated nuclear parameter library and reference input parameter library of IAEA, Nuclear Physics Review (2002)

[2] HERMAN, M. et al: Recent development and validation of the nuclear reaction code EMPIRE, ND 2001: International conference on nuclear data for science and technology Tsukuba, Ibaraki (Japan) 7-12 Oct 2001 (2002)
[3] A.TRKOV: IAEA Activities Related to Nuclear Data for P&T and ADS, InWor for P&T and ADS'2003, 6-8 October 2003, Mol, Belgium.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **F42004 Update of X- and gamma-ray decay data standards for detector calibration**

Participating Countries: Australia(C), Belgium(A), Brazil(C), France(A), Germany(A), Hungary(C), Poland(C), Russian Federation(C), Slovakia(C), Slovakia(C), Spain(A), United Kingdom(A), United States of America(A)

Total Cost: **$136 287**

Duration: 1998-04-01 – 2002-12-15

CRP Overall Objectives

To update and extend the database of decay data standards (half-lives, and x- and gamma-ray emission probabilities) appropriate for detector efficiency calibration and other applications.

CRP Specific Objectives

To collect and compile all relevant data and define their sources.
To undertake comprehensive decay-scheme and half-life evaluations, and produce recommended sets of these data.
To include data recommendations to cover high-energy gamma rays, gamma-gamma correlations and consideration of covariance analyses.
To prepare and publish support documents, and make the library available on CD-ROM and through the Internet.

Research Outputs

The CRP resulted in the x- and gamma-ray library of recommended half-lives, and x-ray and gamma-ray emission probabilities covering all radionuclides of agreed relevance to detector efficiency calibration, and other specific applications (dosimetry, safeguards, waste management and nuclear medicine).

CRP Outcome (Effectiveness; Impact; Relevance)

The database will be made available on the IAEA-NDS web server and as CD-ROMs. A first preparation and issue of this library in 1991 resulted in significant improvements in nuclear decay-data measurements, and became an acknowledged standards library in the development of gamma-ray spectroscopy - similar impact is envisaged as a consequence of this improved and extended library.

The use of highly-reliable half-lives and x- and gamma-ray emission probabilities impacts directly on the accuracy of all such measurements throughout the user community. Historically, experimentalists have used a variety of different data sets, causing difficulties in the consistency and comparison of such data. Therefore, at the demand of MS users the IAEA has undertaken an extensive co-ordinated effort to develop a library of evaluated decay-data standards to ensure the consistency and quality of these measured data for other radianuclides.

Recommended Future Action by Agency

The library will become an established product offered by the IAEA. Relevant studies will continue in the scientific community to improve the recommended decay data further - those data should be re-visited and possibly modified in about 15-20 years.

CRP Published Results

The IAEA-TECDOC describing the methods and the contents of the decay-data library is in the completion and editorial stages of preparation. Selected papers in international publications directly referring to these new data include:
[1] A.L. NICHOLS, IAEA Co-ordinated Research Project: Update of X-ray and Gamma-ray Decay Data Standards for Detector Calibration and Other Applications, ICRM2003 Conference, 2-6 June 2003, Dublin, Ireland; to be published in Appl. Radiat. Isot. (2004).

[2] A.L. NICHOLS and O. SCHWERER, IAEA Nuclear Data Activities: Services and Emerging Databases, paper presented at V. Latinamerican Symposium on Nuclear Physics, XXVI Reuniao de Trabalho Sobre Fisica Nuclear no Brasil, 1-5 September 2003, Santos, Brazil; to be published in Brazilian Journal of Physics.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **J17004** **Image quality and patient dose optimisation in mammography in Eastern European Countries**

Participating Countries: Czech Republic(C), France(A), France(C), Hungary(C), Italy(A), Italy(C), Poland(C), Romania(C), Slovakia(C), Spain(A), Spain(C)

Total Cost: **$62 831**

Duration: 1999-10-01 – 2002-12-15

CRP Overall Objectives

To optimise radiological protection of patients undergoing mammography.

CRP Specific Objectives

To reduce patient dose while maintaining image quality.

Research Outputs

Data on performance status of mammography equipment in participating countries, data on film reject rates, awareness on QC, improvement achieved after QC actions.

CRP Outcome (Effectiveness; Impact; Relevance)

The radiological protection is achieved with patient dose reduction and also reduction in poor quality and reject quality films. A large number of steps in QA program help to create quality conciousness and culture. In this respect the project was effective.

In five countries of the Eastern Europe, considerable reduction in patient doses (31% reduction in the mean entrance skin dose, from 6.1 mGy to 4.2 mGy on average), was documented, without compromising on image quality. Compliance of image quality criteris was 81% and 88% respectively before and after QA actions. The variations in image quality observed in different countries before the QA actions showed improvement. The results of the CRP shall prove valuable to many other countries in instituting the optimisation program in mammography.

Mammography is an extremly valuable technique for early detection of breast cancer. High degree of accuracy is required as one is dealing with low contrast situation in breast having soft tissues and fat. Tumors in breast have very little difference in X ray attenuation. Optimisation in mammography has therefore great importance. The project was aimed at image quality optimisation and patient dose reduction.

Recommended Future Action by Agency

The TECDOC shall be of great use to Member States and should be circulated as soon as it is published. National projects dealing with optimisation of image quality and reduction in patient dose may be encouraged. Pro-active approach shall be desirable in this respect.

CRP Published Results

TECDOC has already been finalised and is undergoing editorial review. An oral paper was accepted for presentation and was presented recently in the World Congress on Medical Physics held at Sydney in August 2003.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **J71008 Safety of RBMK type Nuclear Power Plant in relation to external events**

Participating Countries: Bulgaria(C), Finland(A), Germany(A), Italy(A), Lithuania(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Russian Federation(C), Ukraine(C), United States of America(A), United States of America(A)

Total Cost: **$217 944**

Duration: 1997-12-15 – 2002-12-15

CRP Overall Objectives

To develop methodologies to deal with external events (such as earthquakes, airplane crashes, extreme winds and floods) for NPPs that have rectangular frame structures as their reactor buildings.

CRP Specific Objectives

To apply the developed methodologies on a specific prototype plant (Leningrad NPP) in order to assist in the assessment of safety margins.

Research Outputs

15 articles published in the Proceedings of International Conferences.

CRP Outcome (Effectiveness; Impact; Relevance)

The specific objective of applying the methodologies to the Leningrad NPP was accomplished for all types of external events considered. The Plant has pursued these studies to make their safety case in relation to the sesimic hazard issue.

Simplified and sophisticated analytical methods were developed and discussed. There was a very good degree of consensus amongst the participating institutions.

The results of the CRP were important to the design and operating organizations of both WWER 440 and RBMK type NPPs. Structurally these plants have a similar reactor building, i.e. a frame type structure as opposed to a more usual shell.

The type of external events considered included airplane crash, extreme winds, external floods and earthquakes. The new regulations for seismic design in the Russian Federation (issued by the Regulatory Authority Gosatomnadzor) imply the need for a re-evalution for these plants. The methods used during this CRP will be very beneficial in this process of re-evaluation and upgrading.

The well balanced mix of participating institutions from design, operation and research areas contributed to enhancing the relevance of the results to existing facilities.

Although the results of the CRP are sepcific to one typr of NPP design, the methods used are universally applicable.

Recommended Future Action by Agency

Some of the methods of analysis, especially related to airplane crash problem have a field of application in the nuclear security area. It is recommended that the IAEA adopts the methods used in the CRP to better suit the problem of external events of malevolent origin.

CRP Published Results

The CRP participants published a total of some 15 papers in the two biennial "Structural Mechanics in Reactor Technology" conferences held in 2001 Seoul and 2003 Prague.

Accomplishments of CRPs Completed in 2002

CRP Number and Title: **T12013 Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys**

Participating Countries: Argentina(A), Canada(A), China(C), India(A), Korea, Republic of(A), Lithuania(C), Pakistan(C), Romania(C), Russian Federation(A), Sweden(A)

Total Cost: **$127 185**

Duration: 1998-11-01 – 2002-12-15

CRP Overall Objectives

To assist in the evaluation and reduction of core and primary circuit materials degradation in nuclear power plants by transferring know-how in the area of hydride degradation of zirconium alloys from the leading laboratory in the field to the participating laboratories in the CRP.

CRP Specific Objectives

Phase 1 was designed to establish the method for a constant load cracking test on unirradiated Zr-2.5 Nb and to make a detailed comparison of results between laboratories so that the delayed hydride cracking (DHC) properties of zirconium alloys and components can be properly evaluated. Also, using "round robin" testing with standard samples, to ensure that all of the participants can accurately dope samples with predetermined amounts of hydrogen and accurately measure the concentrations of hydrogen in solution.

Building on the experience from Phase 1, pressure tube materials with different microstructures were examined to compare their DHC velocities at different constant loads and temperatures. For example, there are three versions of RBMK pressure tubes - cold-worked and annealed, TMT-1 and TMT-2 - while heat-treated Zr-2.5Nb is used in Kanupp in Pakistan. The strength and microstructure of each material was evaluated, hydrogen concentrations from "as-received" to 75ppm were attained and the DHC velocity was measured on six specimens at 250 C and 15 to 20 MPa root metre. The results were interpreted for the contributions to scatter and the contributions from the properties of the material to DHC velocity.

Research Outputs

Demonstration with appropriate experimental results that all of the participants could:· Successfully measure DHC velocities in the standard samples provided;· Hydride samples of zirconium alloys to pre-determined levels of hydrogen;·Prepare compact tension (CT) samples with notch and fatigue crack;· Characterize the microstructure of the alloys tested and correctly interpret the fractographs;· Analyze samples of the alloys for hydrogen content, even at low levels.

CRP Outcome (Effectiveness; Impact; Relevance)

The major goals of the CRP have been achieved. The considerable work put into the preparation of this CRP by the host laboratory, the Chalk River Laboratory of AECL, in preparing standard samples for the participants, and by the supervisory group in the meticulous preparation of detailed experimental protocols and in designing the experimental matrices to be carried out, has paid enormous dividends. The protocols themselves will be of use to scientists in the nuclear industry worldwide, not just those in the CRP. The results of the CRP show that the protocols work even better than expected and have been instrumental in the transfer of know-how in this experimental area of notorious difficulty.

The participants that come from almost all of the countries in the world with CANDU or RBMK reactors can now successfully monitor hydride degradation in the core materials of their NPPs. This will improve the safety of these reactors.

This CRP has already had a very significant impact. Owners and operators of CANDU and RBMK NPPs around the world are more aware of the safety implications of hydride degradation and national programmes to monitor hydrogen pick up have been set up where none existed previously.

The CRP was set up at a time when there was clear evidence in the literature, from widely scattered DHC velocity measurements, that many laboratories were having difficulties. This is no longer the case, which underlines the relevance and timeliness of this CRP.

Recommended Future Action by Agency

One of the last remaining concerns about NPP fuel is the possibility of axial slitting of zirconium alloy fuel cladding. This starts with debris fretting and leads to penetration of the cladding followed by rapid secondary hydriding and axial slitting. This in turn exposes the fuel meat to the coolant and releases huge quantities of fission products. DHC is thought to contribute to this phenomenon. However, testing for DHC in sections of fuel cladding is very difficult. A test has been developed by the Studsvik laboratory in Sweden that has offered to be the host laboratory for a follow up CRP on this topic of axial slitting.

CRP Published Results

Internal: All of the materials from the third RCM were Published as Working Material IAEA-NEFW September 2002 so that the participants would have access to all of the raw data while the final TECDOC or TRS is in preparation. The Final Report has been sent to the Publications Committee November 2003.

External Publications:

[1] KIDD K. V., Preparation of Material and Specimens for the IAEA Co-ordinated Research Programme on Delayed Hydride Cracking. FC-IAEA-001, T1.20.13-CAN-273.63-01, November 1998.
[2] LEPAGE, A. D., FERRIS, W. A. and LEDOUX, G. A., Procedure for adding Hydrogen to small sections of Zirconium alloys, FC-IAEA-03, T1.20.13-CAN-27363-03, November 1998.
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[13] KIM, S.S., KWON, S.C., KIM, Y.S., The effect of texture variation on delayed hydride cracking behavior of Zr-2.5%Nb plate, J. Nucl. Mater., 273, (1999), 52-59.
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[15] A. GRYBENAS, V. MAKAREVICIUS, A. BALTUSNIKAS, R. LEVINSKAS. Investigation of delayed hydride cracking velocity in Zr-2,5%Nb tube// Proceed of sixth Intern. Conf. "Materials in design, manufacture and operation of nuclear power plants equipment", 19-23 June 2000. St. Petersburg, 2000. -Vol. 1. -P. 136 -143.
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Accomplishments of CRPs Completed in 2002

CRP Number and Title: **T13007 Spent fuel performance assessment and research (SPAR)**

Participating Countries: Canada(A), Canada(A), France(A), Germany(A), Hungary(C), Japan(A), Korea, Republic of(A), Russian Federation(A), Russian Federation(A), Spain(A), United Kingdom(A), United States of America(A)

Total Cost: **$70 725**

Duration: 1997-07-01 – 2002-12-15

CRP Overall Objectives

1. To carry out research work to evaluate the technical basis for storing spent fuel for extended periods of time, i.e. more than 50 years.
2. To evaluate and exchange data on spent fuel storage research and experience among the participating countries to build a comprehensive, international database supporting the licensing of present and future technologies.
3. To assist in defining how the requirements for spent fuel storage and the whole fuel cycle back-end are connected.
4. To exchange operating experience in spent fuel storage.

CRP Specific Objectives

To identify materials issues in long term storage facilities.

Research Outputs

Evaluation of data for wet and dry storage for all major fuel types of power reactors, with emphasis on material issues. The results are documented in TECDOC-1343.
(Examples of topics:
· Analysis of 100 year fuel assembly behaviour;
· Structural material, ageing, pool materials, concrete behaviour;
· Fuel assembly degradation mechanisms.)

CRP Outcome (Effectiveness; Impact; Relevance)

The CRP assisted in identifying material issues possibly occurring during long term storage of all current types of spent fuel (LWR, AGR, Magnox, CANDU, RBMK and WWER fuel). These issues relate to materials of fuel assemblies and to those used in storage facilities. For fuel assemblies under storage conditions, degradation mechanisms were addressed, specifically:
1. significant physical and chemical processes affecting the integrity of the spent fuel structure;
2. important degradation mechanisms affecting the spent fuel cladding;
3. possible mechanisms arising from transition fuel from wet to dry (or vice versa) storage.
For storage facilities, the behaviour of two basic materials were addressed:
1. metallic components:
2. reinforced concrete.

The CRP assisted in defining the needs and important aspects to be considered in the design of long term spent fuel storage facilities. Additional data related to material behaviour will be needed for extended storage times. When storing spent fuel for extended periods of time, the registration and documentation of spent fuel information (composition, history in reactor core, data obtained from post reactor measurements, history of post reactor handling, etc.), becomes a very important activity.
The CRP provided information (e.g., published material noted below as well as real-time collaboration and data-sharing during the course of the CRP) to assist participating countries in licensing, construction and operation of spent fuel storage facilities.

Recommended Future Action by Agency

To initiate a new CRP (SPAR-II) to study the impact of advances in fuels and materials designs and evolving storage technologies on spent fuel storage performance and related activities (e.g. licensing, disposal), and to review results of surveillance and monitoring programmes as spent fuel storage durations extend.

CRP Published Results

Progress reports and RCM reports.
Technical papers presented at conferences and meetings (e.g., CN 102/60, 61).
TECDOC-1343, "Spent fuel performance assessment and research (SPAR)", Vienna (2003).