NUCLEAR POWER

Nuclear Power Technology Development and Applications

Studies of advanced reactor technology options for effective incineration of radioactive waste

Member States pursuing R&D activities in the area of partitioning and transmutation (P&T) have recognised the need for comparative assessments between different incinerating/transmuting nuclear systems. The goal of these studies is ultimately to provide objective ground for answering the question as to whether it is worthwhile to embark into the management of high-level radioactive wastes via P&T and face higher costs and potentially higher risks in order to decrease the long-term radio-toxicity in the geological disposal, or whether innovative nuclear systems (e.g., hybrid systems) presently under discussion have a distinctive edge over "classical" systems (e.g., advanced fast reactors). In this CRP R&D tasks contributing towards the proof of practicality for long-lived waste transmutation will be performed. For a sound assessment of the transient and accident behaviour, the neutron kinetics and dynamics have to be qualified, especially as the margins of the safety relevant neutronics parameters are becoming small. The CRP will pursue benchmarking of transient/accident simulation codes focusing on the phenomena and effects relevant to various sub-critical systems under severe neutron flux changes and rearrangements. The final goal is to deepen the understanding of the dynamics of the accelerator driven system, especially systems with deteriorated safety parameters, qualify the available methods, specify the range of validity of methods, and formulate requirements for future theoretical developments. The potential need for transient experiments will be formulated if deemed necessary

Benchmark analyses on data and calculational methods for accelerator driven system (ADS) source related neutronic phenomenology with experimental validation

Most Member States with nuclear programmes are considering ADS systems as a means to implement nuclear waste transmutation in the scope of their nuclear waste management strategies. The objective of the CRP is to improve the present understanding of the coupling of ADS spallation sources with multiplicative sub-critical nuclear systems. The proposed CRP will advance the Member States efforts towards designing a demonstration facility by providing the information exchange and collaborative research framework needed to ensure that the tools to perform detailed ADS calculations, namely from the high energy proton beam down to thermal neutron energies, are available. The proposed CRP will address all major physics phenomena of the spallation source and its coupling to the sub-critical system. The participants will use integrated calculation schemes to perform computational and experimental benchmark analyses.

Conservation and application of high-temperature gas cooled reactor (HTGR) fuel technology: advances in HTGR fuel technology development

This CRP will identify research needs and exchange information on advances in technology for a limited number of topical areas of primary interest to HTR development, and establish, within these topical areas, a centralised co-ordination function for the conservation of HTGR know-how and for international collaboration, utilising electronic information exchange, data acquisition and archiving methods.

NUCLEAR FUEL CYCLE AND MATERIAL TECHNOLOGIES

Coated Particle Fuel Technology for Advanced Nuclear Fuel Cycle

High Temperature Gas-cooled Reactors (HTGR) offer an answer to the three basic doctrines of nuclear energy namely environmental friendliness, resource utilization efficiency and cost-effectiveness. These reactors facilitate various advanced functions such as high temperature gas applications, transuranic-burning capacity, thorium utilization, fission product retention for ultimate disposal and hydrogen production. These achievements of the HTGR concept are due to its unique coated particle fuel design, which has all these inherent rewards and potentials. Coated particle fuel has a micro spherical fuel particle coated by four layers e.g. carbon and silicon carbide or zirconium carbide. Recognizing these potential benefits of HTGR, many of Member States are seriously pursuing the development of coated particle fuel. The objectives of the CRP are: a) new requirements and developments in coated particle fuel technology to deal with modern safety criteria, high burnup for Pu as well as transuranics burning, incorporating nano-technology for coating, developing Inert Matrix Fuel and thorium based coated particle fuel issues; b) data analysis and documentation; c) fuel fabrication; d) fuel irradiation; e) fuel accident condition testing; f) fuel performance and fission product transport modelling; g) generic fuel issues; h) fuel performance in operating HTGRs. The CRP will complement the R&D efforts currently underway in several Member States in establishing high operational limits and realizing the advanced potential of HTGRs.

System Study on Process Optimization and Minimization of Environmental Impacts associated with Partitioning and Transmutation

Despite innovations in nuclear power plant technology, nuclear energy is unable to gain complete public acceptance due to long-term radiological toxicity of nuclear waste arising out of the back-end of the fuel cycle. Many Member States are contemplating the use of advanced Partitioning and Transmutation (P&T) techniques in the nuclear fuel cycle to destroy long-lived radiotoxic elements, such as minor actinides and other pertinent fission products, to diminish this radiological toxicity. As any nuclear procedure involves a radiation burden to the operators, it is appropriate to arrive at optimum conditions for P&T which would result in minimized environmental impacts apart from other technical considerations. A pyrochemical partition method for recovering long-lived actinides decides the effectiveness of P&T. The objectives of the CRP are: a) to conduct an evaluation of recent advances in pyrochemical processing of various types of advanced fast reactor fuels in the form of oxide, nitride, alloys or cermets; b) to select pyrochemical processing methods of various ADS targets from the knowledge of fast reactor processing, and c) to identify areas of collaborative research as well as scaling-up of pyrochemical methods. The results of this CRP will provide the Member States the information necessary to deal with the back-end of nuclear fuel with minimum environmental impacts by effective use of pyrochemical partition methods in P&T.

Ageing of Irradiated Reactor Core Materials

The decommissioning of research reactors presents an excellent opportunity to assess the ageing of core materials by examining samples of core structural materials for the assessment of important properties, such as embrittlement and other degradations of the mechanical and physical properties of highly irradiated materials. Most of the reactors currently being decommissioned operated for periods of 30 to 40 years and the accumulated fluences are very high. Hot cell evaluation of samples of such materials can reveal the extent of ageing degradation and estimates of their remaining life under operating conditions. The expected results of the CRP should serve two very important purposes: 1) provide information for those seeking to license life extension of similar reactors; and 2) provide very useful information on core materials selection for the designers of new reactors. In addition, the results should provide further insights into the mechanisms of radiation damage, especially at high fluences.

NUCLEAR SCIENCE

Nuclear and Atomic Data

Evaluated nuclear data for the Thorium-Uranium fuel cycle
Member States have expressed interest in the development of proliferation-resistant advanced nuclear fuel cycles, especially the Th-U fuel cycle. Current predictions of fuel cycle parameters are not precise because of uncertainty in the nuclear data employed. The objective of the CRP is to identify the particular deficiencies in nuclear data that are responsible for observed discrepancies in predictions of Th-U fuel cycle parameters, and to make corresponding improvements in the nuclear database.

Nuclear Research Facilities and Instrumentation

Development of distance learning (DL) modules on troubleshooting of nuclear instruments
The objective of this CRP is to help Member States train engineers and technicians more efficiently. The distance learning modules will also help the students understand the fundamentals of electronic circuits and instruments before they come to Agency training courses. This will ensure that the students have a common level of knowledge at the beginning of the course, avoiding the need to spend time teaching fundamentals. The training courses will thus be able to provide more hands-on experience using the instruments. The result of the CRP will be DL modules consisting of CD-ROM disks that contain training information about specific topics. The DL modules will work on a common computer platform and have a common format. The topics will include electronic circuits, power supplies, preamplifiers, spectroscopy amplifiers, analog to digital converters, and multichannel analyzers. Such instruments are essential for liquid scintillation counters and radio-immunoassay (for nuclear medicine), and for nuclear spectrometers (environmental monitoring).

Development of improved sources and imaging systems for neutron radiography
Neutron Radiography has been used at many reactors centres in R & D and for non-destructive testing. However, there is a need for optimisation of the neutron beams and the detection technique. The facilities in some of the institutions in developing Member States are not fully utilized due to various problems like: optimisation of resolution and intensity; right type of detecting / imaging technique; lack of expertise; and need of trained manpower for operation, utilization & maintenance. The objective of the CRP is to promote the building of bilateral collaboration between developing and developed laboratories. It will also help to train young workers in developing and designing new instruments and using them effectively, solving some of the problems of developing institutions. Activities in the CRP will assist in the understanding and development of new imaging and beam optimisation techniques to improve the utilisation of neutron radiography, attracting more users for long term programme sustainability.

Applications of dense magnetized plasma
Dense magnetized plasma (DMP) sources are of high interest in nuclear fusion energy research as a potential means for fusion power reactors and also as intense neutron/proton sources for plasma research related to non-power applications. Dense magnetized plasmas can be generated by various types of devices, including pinches, focuses, plasma accelerators, open switches, sparks, hollow cathode discharges, etc. They are expected to be compact, less expensive and technologically demanding than machines pursued in today's mainline fusion programmes, and good sources of ionizing radiation. Based on recent advances in individual laboratories, dense magnetized plasma research has now reached a stage where large benefits

can be obtained from a Coordinated Research Project (CRP) on "Dense Magnetized Plasmas". Specifically the CRP will focus on new technologies for DMP drivers for use in fusion research and industrial applications that require high efficiency neutron and X-ray generation , development of driver/chamber interfaces, target chamber design considerations including target positioning, as well as selective and combined target irradiation by various types of ionising radiation.

FOOD AND AGRICULTURE

Soil and Water Management and Crop Nutrition

Selection for greater agronomic water-use efficiency in wheat and rice using carbon isotope discrimination

Drought and soil salinity are major constraints to sustainable agricultural productivity in many parts of the world. Around 1500 million ha worldwide of dry land or rain fed agriculture are already affected by salinity, and the problem is increasing annually. An integrated approach to the management of water, nutrients and crops is required if the full potential of dry land cropping systems is to be realised in a sustainable manner. Plant genotypes characteristically differ in their tolerance to abiotic stress factors such as drought, salinity and limited nutrient supply. These genotypic differences can be exploited to mitigate the effects of stress, particularly in situations where external inputs of resources such as water and fertilizer are restricted due to economic or other factors. Genotypes with superior resources-use efficiency are required, especially in harsh environments. Carbon-13 isotope discrimination can assist in identifying crop cultivars with high agronomic water use efficiency. This method provides an integrated measure of the response of photosynthetic gas exchange to environmental variable such as water availability and salinity. The main objective of this CRP will be to evaluate different strategies for using carbon-13 isotope discrimination as a selection tool for higher yielding rice and wheat genotypes under drought and saline conditions. The project will be implemented in 2003 and preference will be given to scientists and institutions in both developing and developed countries with experience in the use of the carbon-13 isotope discrimination technique, so that the CRP can be integrated with on-going experiments and available resources. Multi-location testing sites will be selected in consultation with CIMMYT for wheat and IRRI for rice for development of effective selection strategies for improvement of crop production under drought and saline conditions.

Plant Breeding and Genetics

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

The improvement of quality traits in food and industrial crops is one of the most important goals in plant breeding and is gaining more and more attention. Improved crop quality is considered to be of great economical value for both developed and developing countries and in the case of nutritional quality it will have a significant positive effect on human health. This applies in particular to regions, which suffer malnourishment. A constraint to improving quality in agricultural crops is a lack of understanding of the basis of trait gene manipulation. This CRP will address the problems associated with physical placement of a gene or gene complex in a chromosome. The work plan will apply the technology involved in accessing the genetic and physical position of quality genes in various crop genomes. It will build towards accelerating crop breeding programs through the application of physical mapping and complementary genomic approaches, and the characterization and utilization of induced mutants for improvement of crop quality with the objective of increasing agricultural

sustainability, food security, economic stability, and alleviating local quality-related food problems.

Effects of mutagenic agents on the DNA sequence in plants

Modern breeders and farmers can tap into a widely broadened diversity through mutation induction techniques to improve their crops. The impact of induced mutations on crop improvement programs is reflected in more than 2200 entries in the IAEA's database on officially registered mutant varieties (MVD), whereof about 3 quarters are direct mutant varieties mainly derived from treatment with gamma rays. In contrast to data on the potential of mutation techniques very little is known about the effects of the different mutagenic agents on the DNA sequence in plants. In particular detailed knowledge is missing on the category of changes a certain mutagen is causing (point mutations, size of deletions, translocations, inversions) as well as on the frequency of these changes. Data on the effect of mutagens, however, will substantially facilitate mutational analysis of plant traits, which is regarded as one of the most efficient approaches for identification and isolation of agronomically important genes. Additionally this information will be extremely helpful to the plant breeder to identify a successful dose for treatment of his material. This CRP will utilize mutation techniques principles, genetic and cytogenetic methods of mutation frequency evaluation and genomics high-throughput techniques to address these questions of paramount importance to mutation oriented breeding programs.

Insect and Pest Control

Improvement of Codling Moth SIT to facilitate expansion of field application

Codling moth (*Cydia pomonella*) is a key pest of pome (e.g. apples, pears, etc.) fruits in more than 70 countries, and its control currently requires the use of large quantities of insecticide. However the development of resistance to insecticides, including several of the new generation of insect growth regulators, and ever lower insecticide residue limits to protect consumers are making codling moth control increasingly difficult. The objectives of this CRP are to improve the application of the sterile insect technique (SIT) and inherited sterility (IS) for codling moth control and its integration with other environmentally friendly control methods to expand its use in field control applications and reduce insecticide use. The expected outputs of this CRP are:- a) the improvement of the cost-effectiveness of rearing, release and distribution of moths; b.) the development of standards for quality of moths and mating competitiveness; c) the improvement of the understanding of codling moth genetics for developing genetic strains; d) the improvement of the knowledge of populations and release strategies; e) the improvement of the currently available monitoring techniques and f) the improvement of the understanding of combinations of SIT with other techniques.

Improved and Harmonized Quality Control for Expanded Tsetse Production, Sterilization and Field Application

The recent Pan-African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) provides a mechanism within which SIT will be one of the major components of an integrated area-wide approach to the establishment of tsetse fly-free areas. Currently worldwide tsetse production is 1/40 of the projected requirement in 2006. To achieve this objective it is essential that quality control (QC) measures suitable for the expanded production be in place. Therefore, improved QC methodology has become a top priority. Improvements in QC methodology will help to ensure the attainment of these production goals and improve quality of rearing, minimize production costs and generate trained QC and production staff required to successfully produce flies and monitor their quality and suitability for release. The proposed CRP is designed to address these issues.

Molecular Technologies to Improve the Effectiveness of SIT

The application of the SIT in integrated pest management programmes continues to increase. However, efficiency can still be considerably enhanced when certain components of the technology are improved, such as the development of genetic sexing strains. Recent major advances in the ability to create transgenic strains of pest insects open the possibility to utilize molecular approaches for SIT strain improvement. This CRP will develop and evaluate these new strains to a level where a decision can be made as to their suitability for use in large scale SIT programmes. The CRP is not restricted to these developments in a particular pest species but it will instead focus on the application of the technology in a variety of key insect pests.

Food Quality and Safety

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

The objective of the CRP is to strengthen the capability of national food control laboratories for testing pesticide residues and food contaminants by determining the efficiency of various sample processing equipments and estimating the uncertainty of sample processing. The reliability and accuracy of an analytical result is mainly influenced by the random errors of sampling, sample processing and analysis. Laboratories wishing to be accredited according to ISO 17025 have to estimate the uncertainty of their measurements and estimate the uncertainty budget for the whole process, which should include sample processing. Insufficient information is available on the stability of the analytes during the homogenisation of the sample. Presently there is no internationally agreed procedure for testing the efficiency of sample processing. The results of this CRP should lead to simple and practical internal quality control procedure to determine the efficiency of sample processing, validation of sample processing methods and equipment, typical uncertainty values for sample processing of representative commodities, and information on the stability of pesticides under processing conditions. It will facilitate the compliance of laboratories with the new requirements of ISO 17025 and thereby promote testing compliance with Codex Limits according to current international requirements.

Irradiation to ensure the safety and quality of prepared meals

There is an increasing demand for prepared meals, often marketed under frozen condition, to meet the requirements of developing countries. This CRP will address the use of irradiation to ensure microbiological safety and shelf-life extension of prepared meals to be marketed either at refrigeration or ambient condition instead of frozen, without compromising the microbiological safety and with sufficient shelf life to meet market requirements. Validated methods for microbiological determination of food and validated procedures for irradiation, process control, sensory evaluation to ensure the safety and quality of food will be employed throughout. While there are ample data on the effectiveness of irradiation as a sanitary and phytosanitary treatment for individual food commodities, there is little information available on the effectiveness of irradiation on a complex mixture of food such as prepared meals. This CRP should lead to a broader database on the effectiveness of irradiation on a more complex mixture of food and to widen the horizon of the application of food irradiation. Such data will be important for governments in developing countries to re-evaluate the current methods of marketing prepared meals under conditions prevailing in most developing countries.

HUMAN HEALTH

Nuclear Medicine

Comparative evaluation of therapeutic radiopharmaceuticals for radiosynovectomy

Radiosynovectomy, particularly of the knee joint using beta-emitting radiopharmaceuticals offers significant and long-lasting relief from pain and other symptoms in patients with rheumatoid arthritis and haemo-arthrosis by ablating the synovial lining of the knee joint by radiation. The procedure is simple and extremely cost-effective in patients suffering from this chronic disease and requiring long-term treatment with costly analgesics and other supplementary medications. A number of beta-emitting radiopharmaceuticals like ^{166}Ho, ^{153}Sm, ^{186}Re, ^{165}Dy and ^{90}Y are currently being used in this procedure. The objective of the proposed CRP is to evaluate and compare the efficacy and toxicity of these radiopharmaceuticals and identify the most suitable and cost effective agent for radiosynovectomy, especially for use in the developing countries.

Role of Diamox Cerebral Perfusion SPECT in the differential diagnosis of Dementia

Dementia is a major clinical problem. There are two major causes of dementia, e.g., neuro-degenerative and of vascular. While there is no valid therapeutic method for neuro-degenerative dementia, correct and early diagnosis of vascular dementia may help in the institution of appropriate therapeutic measures leading to slowing or arresting the progress of the disease. Clinically and with morphological techniques, such as MRI, it is often difficult to distinguish between the two entities. It is well known that agents such as acetazolamide can be used to determine the "perfusion reserve" of the brain. Stress Cerebral perfusion studies following pharmacological interventions with drugs such as acetazolamide, adenosine or dypiridamol may be able to differentiate patients of dementia of vascular origin from those of neuro-degenerative origin. The test may also help in the monitoring and evaluation of such patients following therapy. Although the concept of stress cerebral perfusion SPECT appears highly attractive and logical in the management of patients with dementia, currently the available clinical data in medical literature is scanty. A multi-centre study to accumulate a large volume of data is therefore indicated in order to verify this hypothesis and establish its role in routine clinical practice.

Applied Radiation Biology and Radiotherapy

Comparative cost assessment of teletherapy modalities

Institutions using both cobalt and linear accelerator teletherapy machines will be requested to analyze their acquisition, maintenance and repair costs data for some years, according to an agreed standardized formula, related to patient throughput and "down-time". Factors such as available budget, national infrastructure for support of these technologies will be related to the patient treatment costs. The results of the CRP will provide guidance on the necessary budget provision to ensure sustainability of these two competitive technologies for teletherapy.

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

A previous IAEA study on 232 patients has demonstrated the efficacy of fractionated ILHDR BT in the palliative management of dysphagia. A pilot study has shown no additional morbidity on 30 patients treated with ILHDR BT plus teletherapy against that seen in 30 patients treated by ILHDR BT alone. It is anticipated that in excess of 180 patients will be needed to refute or demonstrate an advantage for the addition of teletherapy. This CRP is open to radiotherapy institutions where ILHDR BT using microsource Ir-192 and teletherapy

(cobalt and/or linac) and simulation (or CT planning) are available. The centres will need to agree to provide in excess of 20 patients with advanced M_o or M_+ oesophageal squamous carcinoma per year to the study. Only raw data will be required; all analysis will be performed at a selected Technical Contract centre.

Resource sparing treatment of head and neck cancer

Cancer of the nasopharynx is relatively common in N. Africa and S.E. Asia. Clinical protocols advocated are based on radiation therapy. The classical radiotherapy protocol of daily fractionation to the primary region and involved nodes requires good imaging, immobilisation, and treatment planning and delivery. Even with this, these protocols have seen a large number of innovative modifications using altered fractionation schemes [accelerated or split-course or hyper-fractionation], local primary boosts [High dose rate (mHDR) brachytherapy or conformal 3-D radiotherapy (CRT) or stereotactic radiotherapy (SRT)] and concomitant chemotherapy (using different agents, dosages, schedules and duration. No standard protocol has yet been devised for homogeneous groups of patients with similar stage, histology and grade. Evidence-based analyses of the current modifications of practice have not been performed. Resource-sparing protocols are of value in the endemic regions. The CRP will explore clinical protocols utilising well planned and executed conventional teletherapy with or without a local boost using mHDR, CRT or SRT in the management of nasopharyngeal cancer. The patient selection will be advanced T3/4, N_all, M0 patients. Therapy dose and concomitant chemotherapy administered will be decided at the first research co-ordination meeting to achieve the consensus. Suitable participants should have available computer tomography imaging, immobilisation, treatment planning, block-shaping or multileaf collimation, and a means of achieving a discrete volume boost. Each advanced country applicant institution will be paired with one or more developing country with the ability to execute the protocol. These will undertake guidance for clinical and physics quality control of treatment as well as supervising higher degree theses.

Dosimetry and Medical Radiation Physics

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

The Agency has published a new Code of Practice (Technical Reports Series No. TRS-398 (Dec. 2000), based on the quantity of absorbed dose to water with the objective of achieving uniformity, consistency and better accuracy in radiotherapy dosimetry. A key stage in this process is the standardization of procedures for the calibration of ionisation chambers at Secondary Standards Dosimetry Laboratories (SSDLs) in terms of absorbed dose to water. The objective of the CRP is to assist SSDLs develop the necessary techniques needed for the realization and dissemination of the new quantity to end users in hospitals, thereby providing calibrations that yield the most accurate results available to meet modern standards. Methods for calibrating ionisation chambers wil be designed and further developed through the CRP.

Development of procedures for in vivo dosimetry

Treatment verification plays an important role in Quality Assurance (QA) programmes for radiotherapy. It is a powerful tool for the ultimate check of the dose delivered to patients at a radiotherapy department. Three complementary systems exist; these include record and verify systems (R&V), portal imaging and in vivo dosimetry. R&V and portal imaging are linked to the selection of the treatment parameters at the irradiation machine and verify patient positioning during treatment, radiotherapy field placement and the use of beam modifying accessories. However, in vivo dosimetry verifies the overall process of dose delivery to the patient. Small dosimeters are placed on the patient in the treatment field to measure the

entrance and/or exit doses from which a dose to tumour is derived. In vivo dosimetry is useful to detect systematic errors at treatment centres as well as errors for individual patients or treatment sessions. The Agency encourages the use of in vivo dosimetry as a QA tool in radiotherapy departments. This CRP aims at optimising the methodology for setting-up in vivo dosimetry systems in developing Member States.

Nutritional and Effects of Contaminants on Human Health

Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies

This CRP on nutrition addresses the need to develop effective strategies to combat micro-nutrient malnutrition in developing countries using isotopic and nuclear methods. The major objectives of the CRP are to extend the use of nuclear and isotopic tracer methods to measure micronutrient (Fe, Zn, Vitamin A, I, Se, Cu) status and evaluate micro-nutrient interactions in chronically undernourished populations and to train at least one nutrition professional or biomedical scientist from each participating centre leading to the award of PhD degrees by the local universities. This project will also help evaluate interventions done to improve micronutrient status in developing country populations.

The causes and consequences of intrauterine growth retardation (IUGR)

There is evidence that size at birth is related to various neurodevelopmental outcome and physical growth in childhood. The major determinants of IUGR are nutritional (as reflected by low gestational weight gain, low pre-pregnancy body mass index (BMI) and short maternal statue. The consequences of IUGR are associated with impaired immunocompetence, increased morbidity and mortality in infancy and growth deficits, persisting into adulthood. The problems to be addressed are: nutritional and other factors contributing to "small-for-gestational-age" birth weights; morbidity and mortality of fetuses that have suffered from growth retardation in populations from different cultural backgrounds studied under a harmonized protocol; impact of socio-economic disparities on pregnancy outcome and social habits (smoking, alcohol) among others, which have major implications for public health.
The objective of this CRP is to study IUGR, which is highly prevalent in most developing countries and is considered as a major public health problem. The CRP will utilise nuclear and complementary techniques for body composition and nutritional status monitoring.

Impact of ageing on human energy and macro- and micronutrient metabolism and requirements

Small increases in physical activity and/or small weight losses can have considerable metabolic effects (e.g. lowering the incidence of glucose intolerance and diabetes). In older individuals, energy requirements are very variable and tend to be more activity – than age-related. The problems to be addressed are: the influence of physiological and pathological factors in older subjects on the demand for dietary protein, amino acids and energy; use of body mass index (BMI) and energy turnover as indicators of chronic energy deficiency anticipated in poor population segments in developing countries. The objective of this CRP is to study the impact of weight losses or gains on the overall health of the elderly in relation to the incidence of morbidity and mortality.

Correlation of toxic element atmospheric deposition data with diseases

Airborne emission of toxic elements due to various anthropogenic activities causes pulmonary and other element-related diseases. It is important, therefore, to identify the sources and evaluate the fate of these contaminants with the objective of improving populations' health. The objective of the CRP is to study the effects of airborne toxic elements on human health by investigating relationships between metal atmospheric deposition data and epidemiological

data. The CRP will link epidemiological knowledge with the data on atmospheric toxic metal deposition. The metal deposition data will reflect industrial activities, the local circumstances, and also long-range transported pollutants. The CRP will focus on health-related information (mortality, pulmonary disease, cancer incidence, causes of death, etc,) and help explain the observed data. The obtained relationships between atmospheric deposition and epidemiological data will give basis for health risk evaluation.

WATER RESOURCES

Isotope Methodologies for the Protection and Management of Surface water, Groundwater and geothermal Resources

Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones

The estimation of submarine groundwater discharge is increasingly being recognised as an important factor in the understanding and sustainable management of coastal aquifers in many highly populated areas of the world. In addition, in those areas where groundwater contamination (e.g., organics, metals, radionuclides) has occurred, SGD is being recognised as a significant pathway for these elements to enter the near shore marine environment. Estimation of groundwater fluxes into the marine environment is complicated because direct measurement is not possible by conventional means. Measurement of a range of isotopic tracers at the aquifer-marine interface provides the possibility to produce integrated flux estimates of discharge not possible by other non-nuclear methods. A focus of the CRP will be on SGD in the Mediterranean Sea, which is a particularly vulnerable marine environment to fluxes of contaminated groundwater. The outcomes from this CRP will be of direct relevance to the management of coastal aquifers and coastal zones.

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

Practical applications of isotope techniques in the water sector and related environmental studies require a global scale reference data for isotope concentrations in precipitation and other components of the hydrological cycle. The Agency has collected and managed a global network for isotopes in precipitation and provided these data to all Member States. In addition to applications in hydrology, this data set is increasingly being used in climate and climate change modelling that are issues of concern to all Member States. As rivers contain a significant proportion of water in the hydrologic cycle that is continually renewed, large-scale river systems effectively integrate climate and hydrological processes at an annual time scale. Isotope composition of runoff in large rivers, in relation to other hydrological components, provides information on basin-integrated hydrological processes such as water origin and residence times, snowmelt processes, surface-groundwater exchange, evaporation-transpiration partitioning, precipitation variability, and climate/land use changes. These data are also a powerful diagnostic tool for constraining global circulation and basin or continental-scale hydrological models. An operational global network of isotope monitoring of large river systems can provide reference data for climate change studies, basin scale analysis of rainfall-runoff relationships, and, together with isotope data from precipitation, can enhance the use of isotopes for water resources management. The objective of the CRP is to develop the design criteria for long-term monitoring of isotopes in river flow. These criteria are likely to include the locations and density of monitoring stations, sampling procedures, frequency of sampling and isotope species to be analysed

PROTECTION OF THE MARINE AND TERRESTIAL ENVIRONMENTS

Measurement and Assessment of radionuclides in the Marine Environment

Nuclear and isotopic studies of the El Niño phenomenon in the ocean

The objective of the CRP is to investigate the El Niño phenomenon in the marine environment using nuclear and isotopic techniques, to contribute to better understanding its past behaviour and to predict possible scenarios in the future. One of the most important parameters in determining the climate on Earth is the temperature record of the surrounding ocean. It is believed, therefore, that surface seawater temperature and its coupling with atmospheric processes is the most important phenomenon in the long-term climate record. Recently El Niño has been the most important environmental problem affecting the climate of the Pacific region and has significant local effects lasting up to several years with important consequences on fish populations and rainfall, including the formation of cyclones. The CRP will co-ordinate efforts in the use of nuclear techniques for studying isotope records in corals and seawater with the aim of deriving past temperature records in the Pacific Ocean. For this purpose, analysis of natural (^{210}Pb, ^{226}Ra, ^{228}Ra, Th and U isotopes) and anthropogenic (^{14}C) radionuclides will be carried out in coral and seawater samples collected in the Pacific region using radiometrics and mass spectrometry techniques (ICPMS, Accelerator Mass Spectrometry). These analyses will enable to develop absolute chronology for corals going back several hundreds of years, so the temperature records obtained by analysis of δ^{13}C and δ^{18}C in corals can be developed for the same time period. Such isotopic records will enable to look for El Niño effects in the past, to better understand its characteristics and predict ocean-atmosphere coupling in the future.

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

Within coastal pollutant monitoring programmes at both the national and regional level, many Member State institutions use bioindicator organisms as a tool for monitoring changes in water quality. While these pollution sentinel species have proven extremely useful in serving as an early warning system for the presence of many contaminants such as heavy metals, radionuclides and pesticides, accurate interpretation of the biomonitoring data they produce is often difficult to achieve because of the lack of adequate understanding of the biological and environmental parameters which control bioaccumulation of the contaminant in the organism. Parameters such as contaminant uptake and excretion rates, and the many variables which affect them, i.e., temperature, salinity, season, sexual state are often unknown and are difficult to measure in the field. However, the use of radiolabelled contaminants under controlled laboratory conditions offers a rapid and cost-effective method for making the required measurements. The CRP aims to co-ordinate efforts in using state-of-the-art experimental radiotracer techniques to assess the bioaccumulation parameters in potential bioindicator species in order that biomonitoring data on contaminant levels and their variability over time are properly interpreted. Such information is vital for establishing proper coastal zone monitoring and management criteria.

PHYSICAL AND CHEMICAL APPLICATIONS

Radiochemical Applications

Development and evaluation of Tc99m labelled small molecules using Tc99m nitrido and carbonyl moieties.

Tc-99m radiopharmaceuticals account for nearly 80% of diagnostic nuclear medicine procedures worldwide. Tc-99m agents are available for imaging almost all of the important organs of the body. Until now, much of the chemistry of Tc-99m radiopharmaceuticals development has focused primarily upon the $[Tc(O)]^{3+}$ core. Based on this moiety, several bifunctional chelating ligands (i.e., N_3S or N_2S_2) have been synthesized and used for labeling molecules of biological interest. The advent of the new, low-valent, $[Tc(CO)_3]^{+}$ metal core and of the $[Tc(N)PXP]^{2+}$ (X = N, S, or O) metal fragment have introduced a new avenue for the Tc99m labelling of biologically active compounds. The versatility and inherent *in vitro*/*in vivo* stability of the $[Tc(CO)_3]^{+}$ and $[Tc(N)PXP]^{2+}$ metallic moieties warrant further research efforts into the design and development of radiopharmaceuticals of this type. Radiolabeling with these new fragments has achieved the level of a well-established technique, thus the appropriate choice of biologically active molecules and new ligand frameworks for efficient preparation of labeled conjugates remains to be an area largely unexplored with vast potential. The complementary nature of these novel techniques allows for the radiolabeling of biomolecules that have not been considered thus far, to be labeled with Tc-99m. For example, molecules such as m-IBG, fluoro-uracil, ubiquidine, nitroimidazoles or even glucose might be of interest. The new CRP intends to develop Tc99m labelled small molecules of biological interest using these novel strategies and evaluate their potential usefulness

Radiation Processing, Radiography and Radiotracer Applications

Controlling of degradation effects in radiation processing of polymers.

Ionizing radiations (gamma rays, electron and ion beams) are known to be very efficient in modifying the molecular weight, surface and bulk properties of polymers through its degradative effect. A number of experimental factors are known to affect the occurrence and yield of radiation induced degradation chemistry of polymers. Further work into understanding of how these factors can be manipulated in order to control degradation and to achieve degradation under lower radiation doses is warranted. The treatment by irradiation of natural polymers from agricultural, forest and fishing industries provides important possibilities for industrial development, particularly for many developing countries. Radiation induced oxidation together and simultaneous chain scission can be used beneficially in the reclamation of waste consumer plastics. The CRP is being launched with the objectives of developing methodologies for better controlling and enhancing radiation induced bond-breaking process in both natural and synthetic polymers. It is anticipated that through collaborative and cooperative research efforts of the participants, materials with new or enhanced properties will be produced and processability of the polymers will be improved. It will eventually provide better utilization of radiation processing as a clean and energy efficient alternative to conventional methodologies.

Gamma industrial process tomography.

Gamma process tomography as part of real time imaging techniques for flow pattern visualization inside vessels is important for troubleshooting and optimising multiphase industrial processes. Gamma process tomography is complementary to radiotracer and gamma

sealed source techniques used for diagnosing industrial process units. In process engineering, gamma transmission and emission tomographic applications consist mainly of the inspection of packed columns, bubble-columns, multiphase flows, fluidised beds and porous media.
The objective of the CRP is to test and validate gamma process tomography for diagnosing industrial multiphase complex processes. Gamma and X-rays transmission and emission tomography will be developed further under this CRP. The CRP will help developing Member States in introducing advanced radioisotope technology for optimising their industrial processes.

RADIATION SAFETY

Radiological Protection of Patients

Dose reduction in computed tomography (CT) while maintaining diagnostic confidence
Computed tomography (CT) is a high dose radiological procedure. The frequency of CT is rapidly increasing in both the developed and developing countries. Patient doses, both collective and individual, have shown an increasing trend not only because of increased frequency but as a result of the changing pattern of use of CT and choice of excessive exposure factors by the users. Image quality is related to patient dose. There is a growing realization that image quality in CT often exceeds the level needed for confident diagnosis and that patient doses are higher than necessary. This is due to the fact that increasing exposure factors do not result in blackening of images; rather better quality images are obtained. At present the choice of exposure factors is seldom related to the diagnostic question. There is a need to study image quality variation with body size, establish the level of image quality where diagnostic confidence can be met, explore body parameters which can help in adjusting exposure factors. The CRP has the objective of identifying ways of reducing patient dose while maintaining diagnostic confidence, involving the development and verification of methodologies by which CT exposure technique can be optimised for individual patients.

Evaluate quantitatively and promote patient dose reduction approaches in interventional radiology
Radiation doses delivered to the skin of patients from complex fluoroscopically guided interventional procedures can be very high and some have resulted in severe injuries to patients. Dose monitoring equipment for such procedures is seldom available and physicians are unaware of the doses and harm that can be delivered. The CRP has the objective of identifying ways of reducing patient dose by evaluating quantitatively the contribution of various parameters to patient dose, and by raising the level of awareness about the doses delivered to patients from procedures performed using different types of equipment in individual centres. This will involve developing and verifying methodologies to estimate doses at individual centres and to provide tools that will provide information necessary to understand and implement dose reduction techniques.

Avoidance of unnecessary dose to patients while transitioning from analogue to digital radiology
Increasing numbers of X-rays are being taken digitally to improve patient care. Digital radiography started as an expensive technology, and thus there has been a delay in its adoption in many countries. Now, with costs decreasing, there is greater momentum towards switching over to digital radiological systems, in particular the computed radiography. Recent experience has shown that there is a need to consider many factors in order to avoid unnecessary radiation doses to the patient. Those who have only worked with analogue radiological system do not, in many cases, understand all factors that need to be taken into account. There is a need to work out the details of those factors which result in unnecessary

patient doses. The CRP has the objective of achieving patient dose reduction while maintaining image quality.

MANAGEMENT OF RADIOACTIVE WASTE

Technologies for Disposable Radioactive Waste Management

New Developments and Improvements in Processing of Problematic Radioactive Waste Streams

Many specific and some routine waste streams exist which can be considered as "problematic" for treatment and conditioning by conventional techniques. These include waste containing different organic components, toxic or chemically aggressive constituents, radionuclides with specific properties (high mobility, high chemical activity, volatile elements, etc.), other waste not appropriate for direct immobilization (e.g. spent organic ion exchange resins), etc. For such waste application of conventional treatment and conditioning options may not be efficient and appropriate in terms of economy, safety and performance characteristics. In many cases such wastes are stored awaiting appropriate treatment and a conditioning solution. The objectives of the CRP are to encourage and to co-ordinate R&D work on characterization and management of such problematic waste types, to facilitate exchange of information and technological experiences on new developments in the area, to identify particular specific waste types which require special approaches and innovative technologies to be applied for conformity with modern safety and economic requirements, both for operation and for final waste products.

Characterization and Performance Studies and Demonstration in Underground Research Laboratories of Swelling Clays as Engineered Barriers of Geological Repositories

The objective of this CRP is to help developing Member States learn how to characterize and evaluate swelling clays for use in engineered barrier systems of geologic repositories. Swelling clays placed between the excavated rock and the waste containers in a repository can mechanically fill the open volume, buffer the chemistry around the container, and retard radionuclide migration. This project will assist developing Member States in selecting, within their territory, suitable swelling clays to be used as engineered barriers; developing skill and learning material characterization techniques; and developing their own concept to integrate the characterized clay in a national repository project. Resources and competence provided by the Network of Centres of Excellence will facilitate the transfer of knowledge and technology to developing Member States, by allowing training and development of competence and – in some cases – helping them to develop laboratories equipped for swelling clay characterization studies. At the end of the CRP, participating Member States should be able to identify and characterize swelling clay that is suitable for use in a geologic repository.

NUCLEAR SECURITY

Addressing Illegal Activities Involving Nuclear and Other Radioactive Materials

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

The detection of and responding to illicit trafficking of nuclear and other radioactive materials include screening vehicles and individuals at borders to: a) detect smuggling of these materials; b) locate, measure and characterize the source of radiation, and c) fully characterize any confiscated material. Currently available instruments used for the field measurements are not optimised for this purpose and may not detect shielded plutonium and highly enriched uranium. In addition, confiscated radioactive materials need to be characterized by non/destructive and destructive analysis. To accomplish this, the analytical methods available need improvement and international collaboration is needed to enhance the use of presently available data on nuclear material processes and uses. The CRP should provide research and development results that will: - a) improve the detection capability and performance of hand held and portable isotope measurement devices, including the technical and functional specifications for such devices: b) standardise procedures to examine suspicious packages and to assess the hazard of confiscated material, and c) develop recommendations and guidelines for and the establishing of a network of analytical laboratories to be available for Member States to obtain the required nuclear forensics analysis.