STUK-A249 / AUGUST 2011

A

Research projects of STUK 2009–2011

S. Salomaa, N. Sulonen (Eds.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

STUK

STUK-A249/ AUGUST 2011

Research projects of STUK 2009–2011

S. Salomaa, N. Sulonen (Eds.)

STUK • **SÄTEILYTURVAKESKUS**
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Osoite / Address • Laippatie 4 , 00880 Helsinki
Postiosoite / Postal address • PL / P.O. Box 14, FI-00881 Helsinki, FINLAND
Puh. / Tel. +358 9 759 881 • Fax +358 9 759 88 500 • www.stuk.fi

The conclusions in the STUK report series are those of the authors and do not necessarily represent the official position of STUK.

ISBN 978-952-478-647-9 (print)
ISBN 978-952-478-648-5 (pdf)
ISSN 0781-1705

Electronic version published: http://www.stuk.fi

Kopio Niini Oy, Helsinki 2011

Sold by:
STUK – Radiation and Nuclear Safety Authority
P.O.Box 14, FI-00881 Helsinki, Finland
Tel. +358 9 759 881
Fax +358 9 759 88500

SALOMAA Sisko, SULONEN Nina (Eds.). Research projects of STUK 2009–2011. STUK-A249. Helsinki 2011, 167 pp.

Key words: radiation protection, ionising radiation, non-ionising radiation, health effects, radioecology, emergency preparedness

Foreword

The research conducted by the Radiation and Nuclear Safety Authority (STUK) serves the whole organisation's mission: to protect people, society, the environment and future generations from the harmful effects of radiation. The Radiation and Nuclear Safety Authority's strategy was revised in 2006 and the research agenda prepared on the basis of the strategy covers the years 2007–2011. This report summarises STUK's ongoing research projects during the latter half of the strategy period, from 2009–2011. More information on the research, researchers and publications of the Radiation and Nuclear Safety Authority is available at STUK's website: *www.stuk.fi*.

STUK's main research areas are the health effects of radiation, exposure to radon and its prevention, environmental research and preparedness for nuclear and radiation threats and accidents. Supervision in the medical use of radiation and non-ionising radiation is also supported by research, and more accurate and reliable methods of measurement are being developed. During 2009–2011, STUK has been actively developing strategic research agendas with European research organisations and funding bodies, with the aim of sustainable integration and long-term commitment to co-operation under a joint research programme. These multidisciplinary research agendas address priorities in low dose risk research as well as radioecology and emergency preparedness. Implementation of the integration process is supported by Networks of Excellence funded by the 7th Framework Program of Euratom. STUK is coordinating the Network of Excellence "Low Dose Research Towards Multidisciplinary Integration" (DoReMi) during 2010–2015. The development of novel technologies for nuclear security applications is another newly emerging field of research at STUK.

SALOMAA Sisko, SULONEN Nina (toim.). STUKin tutkimushankkeet 2009–2011. STUK-A249. Helsinki 2011, 167 s.

Avainsanat: säteilysuojelu, ionisoiva säteily, ionisoimaton säteily, terveyshaitat, radioekologia, onnettomuusvalmius

Alkusanat

Säteilyturvakeskuksen tutkimustoiminta palvelee koko keskuksen missiota: ihmisen, ympäristön, yhteiskunnan ja tulevien sukupolvien suojelua säteilyn haitallisilta vaikutuksilta. Säteilyturvakeskuksen strategia uusittiin vuonna 2006. Strategian pohjalta laadittu tutkimuksen toimintaohjelma kattaa vuodet 2007–2011. Tähän raporttiin on koottu strategiakauden jälkipuoliskolla 2009–2011 Säteilyturvakeskuksessa meneillään olevat tutkimushankkeet. Lisää tietoa Säteilyturvakeskuksen tutkimuksesta, tutkijoista ja julkaisutoiminnasta löytyy STUKin www-sivuilta *www.stuk.fi*.

Säteilyturvakeskuksen tutkimustoiminnan keskeisiä alueita ovat säteilyn terveyshaitat, radonin esiintyminen ja torjunta, ympäristötutkimus ja säteilyuhkiin ja onnettomuuksiin varautuminen. Tutkimuksella kehitetään myös säteilyn käytön valvontaa terveydenhuollossa ja ionisoimattoman säteilyn valvontaa sekä kehitetään entistä tarkempia ja luotettavampia mittausmenetelmiä. Vuosina 2009–2011 STUK osallistuu aktiivisesti strategisten tutkimusagendojen valmisteluun yhdessä eurooppalaisten tutkimuslaitosten ja tutkimuksen rahoittajien kanssa. Tavoitteena on tutkimuksen pysyvä integraatio ja pitkäjänteinen yhteistyö yhteisen tutkimusohjelman parissa. Tutkimusohjelmat koskevat pienten säteilyannoksien vaikutuksia sekä radioekologiaa ja onnettomuusvalmiutta. Euratomin 7. puiteohjelma tukee tutkimuksen integraation toteuttamista rahoittamalla huippuosaamisen verkostoja. STUK koordinoi vuosina 2010–2015 DoReMi-verkostoa (Low Dose Research Towards Multidisciplinary Integration). Myös turvallisuusviranomaisten tarpeeseen kehitettävät mittaus- ja analyysimenetelmät ovat viime aikoina nousseet vahvasti esille STUKin tutkimustoiminnassa.

Contents

1 Health effects of radiation

1.1 Integration of low dose risk

DoReMi: Low Dose Research towards Multidisciplinary Integration

Aim

The aim of the project DoReMi is to promote the sustainable integration of low dose risk research in Europe in order to more effectively resolve the key policy questions identified by the 'High Level Expert Group (HLEG) on Low Dose Risk Research' (*www.hleg.de*), namely the shape(s) of dose-response relationship(s), variation in risk between individuals, tissue sensitivity to cancer, radiation quality, risks from internal exposures and non-cancer effects.

Description of work

The DoReMi project is a Network of Excellence (NoE) funded by the 7th Framework Programme of the Euratom and it is the most extensive project in the radiation protection programme. The Finnish Radiation and Nuclear Safety Authority, STUK, is coordinating the project.

The research activities of DoReMi focus on those areas/directions identified by the HLEG as the most promising in terms of addressing/resolving the key policy questions. DoReMi provides an operational tool for the further development of the MELODI platform (Multidisciplinary European Low Dose Risk Research Initiative) consisting of major national bodies and research programmes that have long term commitments in low dose risk research in Europe.

The Joint Programme of Activities (JPA) of DoReMi includes:

1. a Joint Programme of Research (JPR) covering the issues outlined above and including the sharing and updating of existing infrastructures;
2. a Joint Programme of Integration (JPI) to realise a successful strategy for sustainable integration of the key players in Europe; and
3. a Joint Programme for the Spreading of Excellence (JPSE), covering in particular knowledge management, training & mobility and its implementation.

The Joint Programme of Research addresses three main topics: the shape of the dose-response curve for cancer, individual susceptibilities and non-cancer effects. Radiation quality, internal exposures and tissue sensitivities will be addressed as cross-cutting themes within the three main research areas. The proposal

describes a multi-disciplinary approach including interfaces with the broader (i.e. non-radiation) biological, toxicological and epidemiological communities. A substantial proportion of the JPA will be dedicated to the joint programme of research. DoReMi is expected to lead to the sustainable integration of low dose risk research in Europe which, in the longer term, would lead to an effective approach to resolution of the key remaining policy questions in radiation protection.

Strategic planning will be carried out in close collaboration with MELODI (*www.melodi-online.eu*). The long-term Strategic Research Agenda (SRA) will be developed by MELODI, whereas DoReMi research priorities are based on a shorter term Transitional Research Agenda (TRA), focusing on objectives that are feasible to achieve within the 6-year project and on areas where barriers need to be removed in order to proceed with the longer-term strategic objectives. The MELODI workshop in Stuttgart from 28–29 September 2009 provided a forum for the development of the first draft of the Strategic Research Agenda based on the HLEG Report. Since then, MELODI workshops have been organised annually (2010 in Paris, 2011 in Rome).

Dissemination and exploitation of results

The dissemination and promotion of networking activities will occur via the DoReMi website *www.doremi-noe.net*. Results will be announced via press releases and newsletters and scientific results will be published in peer-reviewed journals.

Collaborators

Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Commissariat à l'Energie Atomique (CEA), Institut Curie (IC) and Institut National de la Santé et de la Recherche Médicale (INSERM), France; Helmholtz Zentrum München (HMGU), Bundesamt für Strahlenschutz (BfS), Universitaetsklinikum Erlangen (UKER), Johann Wolfgang Goethe Universitaet, Frankfurt am Main (GUF) and Universitaet Rostock (UROS), Germany; Health Protection Agency (HPA), UK; University of Pavia (UNIPV); Istituto Superiore di Sanitá (ISS) and Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), Italy; Belgian Nuclear Research Centre (SCK-CEN), Belgium; University of Stockholm (SU), Sweden; Centre for Research in Environmental Epidemiology (CREAL), Spain; Dublin Institute of Technology (DIT), Ireland; Erasmus Universitair Medisch Centrum Rotterdam (Erasmus MC), the Netherlands; Norwegian University of Life Sciences (UMB), Norwegian Radiation Protection Authority (NRPA) and Nasjonalt Folkehelseinstitutt (NIPH), Norway; and Institute for Environmental Sciences (IES), Japan.

Schedule
2010–2015

Project leader
Sisko Salomaa

1.2 Environmental radiation and health

Lung cancer risk due to radon in Finland (RADONRISKI)

Aim

The aim is to assess the number of radon-induced lung cancer cases in Finland. Radon-reduction measures and smoking habits were included in the model. The results could be used in Finnish radon policy.

Description of work

The model is based on observed or predicted lung cancer cases. Smoking and the age distribution were included in the model. Lung cancers were classified as caused by 1) radon only, 2) radon and smoking, 3) smoking only and 4) other causes than radon or smoking. Avoidable lung cancer cases will be estimated for a decrease in smoking and increase in radon-safe buildings.

Dissemination and exploitation of results

The results have been published in Finnish and have been extensively utilised in risk communication.

Collaborators

Finnish Cancer Registry

Schedule

2006–2010

Project leader

Ilona Mäkeläinen

Indoor radon and lung cancer risk (RADON EPIDEMIOLOGY)

Aim

The project is aimed at obtaining a more precise and accurate estimate of the lung cancer risk from indoor radon by pooling studies conducted in various countries. Further applications include estimation of the proportion of lung cancer cases attributable to radon and assessment of the impact of various guideline values on this proportion.

Description of work

A pooled analysis of 13 European studies has been conducted. The large data set comprising some 7 000 lung cancer cases and 14 000 controls allowed a sharper distinction of the effects of radon and smoking than has been achieved previously. An evaluation of retrospective radon exposure assessment based on glass objects has been commenced.

Dissemination and exploitation of results

Two papers have been published from the European pooling project. Close collaboration occurred with the WHO Radon Project in 2004–2009. The results have been extensively utilised in risk communication in Finland.

Collaborators

Cancer Research UK, University of Oxford and National Radiological Protection Board, UK; Karolinska Institutet, Sweden; Finnish Cancer Registry, Finland; National Research Center for Environment and Health (GSF), Germany; Istituto Superiore dell Sanita and Associazione per la Ricerca di Epidemiologia, Italy; Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France; and National Radiological Protection Institute, Czech Republic.

Schedule

The data analysis for the pooled European studies is on-going. Little progress has been evident in the past couple of years, but the responsibility is not held by STUK.

Project leader

Anssi Auvinen

Cancer risk among reindeer herders (SAAMI)

Aim

People in the Arctic regions form one of the populations most heavily exposed to the global fallout from atmospheric atomic bomb testing in the 1950s and 1960s. This is due to their diet rich in reindeer meat in which radionuclides accumulate. We estimated the effect of the radioactive fallout and ethnicity on the cancer incidence in Northern Finland.

Description of work

A cohort of the Arctic population in Finland (n = 34 653) was identified through the Population Register Centre with grouping according to the reindeer herding status, ethnicity and radiation exposure. Annual average radiation doses, based on ^{137}Cs whole-body measurements, were assigned according to birth year, gender and reindeer herder status. Incident cancer cases of *a priori* selected cancer types in the study cohort during 1971–2005 were identified from the Finnish Cancer Registry.

Dissemination and exploitation of results

The results were published in a scientific article and presented at a European IRPA meeting. The results increase current knowledge of the health effects associated with internal radiation doses.

Collaborators

Finnish Cancer Registry

Schedule

1999–2010

Project leader

Päivi Kurttio

Chernobyl fallout and cancer incidence in Finland (CHEFIN)

Aim

The aims are to assess:

1. Whether an early increase in overall cancer incidence following the Chernobyl accident can be demonstrated in accordance with the hypothesised cancer-promoting effect with short latency (first 11 years following the accident).
2. Whether there has been a detectable increase in radiation-related cancer types after a 10-year latency since the Chernobyl accident in Finland (in accordance with the classical linear, no-threshold paradigm).

Description of work

Due to the relatively small radiation doses received from fallout, the predicted effect of the Chernobyl accident in Finland is small. Therefore, it is essential to have a large study population, obtain accurate exposure estimates and take into account the underlying cancer incidence rates. Finland provides a unique opportunity for such a study. The study cohort will thus include persons who lived in the same address from May 1986 until April 1987. Exposure assessment is based on measurements of dose rates from radioactive caesium, which is the most important source of exposure from the Chernobyl fallout. Measurements in 1 050 locations were performed during a mobile survey between May 1986 and August 1987. We will use aggregated cancer incidence data for small area units consisting of 250 × 250 m grids covering all of Finland, with numbers of person-years in relation to age, sex, house type and socio-economic status (SES) for each grid obtained from Statistics Finland. Background gamma radiation in different house types will be considered for the dose estimation or as a covariate. The effect of other sources of radiation exposure is assumed to have remained similar before and after the accident and is taken into account by adjustment for underlying cancer incidence rates and trends. 1) The endpoint in the analysis of the possible promotion effect includes all cancer types, excluding lung, breast and prostate cancers and basal cell carcinoma. 2) In the cancer site-specific analysis, specifically those cancer types strongly associated with radiation in previous studies will be analysed, as well as some 'control' sites not known to be associated with radiation.

Dissemination and exploitation of results

The results will be published in scientific papers on 1) promotion and 2) initiation effects. The research is motivated by a need for more information on the cancer

risk associated with low doses of radiation and with the Chernobyl accident. The results will be distributed to decision makers and citizens.

Collaborators
National Institute for Health and Welfare, Finnish Cancer Registry and University of Eastern Finland.

Schedule
2007–2012

Project leader
Päivi Kurttio

Risk of cancer among people living in the vicinity of nuclear power plants (YVY)

Aim

The aim was to determine whether the incidence of cancer, especially that of childhood leukaemia, was increased in the vicinity of the nuclear power plants (NPPs) in Finland.

Description of work

The study question was addressed with three different approaches. In the ecological approach, the incidence of leukaemia and total cancer in the neighbouring counties of the NPPs was compared to that of the rest of Finland. In the cohort approach, residential cohorts based on the censuses of 1980 and 1990 were used. The incidence of leukaemia and total cancer was compared between those living within a 15-km zone around NPPs and those living in the 15–50-km zone. The case-control approach was used for leukaemia alone and included information on individual residential histories. The case-control approach examined whether the residential distance from the closest NPP was associated with leukaemia, especially among children.

Dissemination and exploitation of results

The results were needed from a public health perspective. They were published in a scientific article and in a poster presentation at the IRPA conference in 2010. The incidence of cancer in the vicinity of the NPPs had not previously been studied in Finland.

Collaborators

National Institute for Health and Welfare, Finland

Schedule

2006–2010

Project leader

Sirpa Heinävaara

1.3 Occupational radiation and health

Lens opacities among physicians occupationally exposed to radiation (KAIHI)

Aim

The aim is to evaluate risk of lens opacities from occupational exposure to radiation.

Description of work

A pilot study of 57 physicians (mainly radiologists) monitored for occupational radiation exposure has been completed, with full ophthalmological examinations. Information on occupational history and risk factors for cataracts were obtained using a questionnaire survey. Of the participants, 26% (15 subjects) had lens changes fulfilling the LOCS-2 criteria. The prevalence of non-nuclear opacities was 12% (four subjects with cortical and three with posterior subcapsular opacities, excluding traces). Age, smoking and radiation were associated with lens changes in univariate analysis, but after mutual adjustment the radiation dose was no longer a significant predictor of opacities. The study will be extended by conducting similar examinations of both exposed and unexposed physicians. Similar inclusion criteria will be applied (cumulative dose >15 mSv, monitoring period >15 years, age 45–70 years).

Dissemination and exploitation of results

The results have been published in a scientific article and presented at various scientific meetings.

Collaborators

Department of Ophthalmology, Helsinki University Central Hospital; Finnish Work Environment Fund (funding).

Schedule

2006–2012

Project leader

Anssi Auvinen

Cancer risk among airline personnel (COSMIC)

Aim

The aim is to evaluate the possible effect of occupational radiation exposure on the cancer risk among airline personnel.

Description of work

Airline personnel are occupationally exposed to cosmic radiation with a substantial neutron component (10–15%). The aim is to evaluate the contribution of occupational exposures to the cancer risk, but the task is complicated by the strong correlation between age, work years and radiation dose. The subjects include 10 000 cabin attendants (85% women) who have been followed up for an average of 23 years. The start and end of employment have been obtained for all individuals and exposure to cosmic radiation assessed by means of a job-exposure matrix. The estimated median cumulative radiation dose was approximately 15 mSv. Cancer incidence data have been obtained from the national cancer registries and the analysis particularly focuses on breast and skin cancer as well as leukaemia.

Dissemination and exploitation of results

A Nordic collaborative analysis of the cancer incidence (in particular skin and breast cancer and leukaemia) among airline cabin crew has been carried out and a manuscript will be submitted for publication in 2011.

Collaborators

Finnish Cancer Registry, Finland; Karolinska Institute, Sweden; Cancer Registry of Norway; Danish Cancer Society, Denmark. Extension of the study include collaborators from University of Mainz, Germany, UK, the Netherlands, Italy and Greece. Contacts have also been established with researchers from the US, Canada and Japan for broader international collaboration.

Schedule

2009–2015

Project leader

Anssi Auvinen

1.4 Medical radiation and health

Biobank of samples collected from radiotherapy-treated prostate and breast cancer patients (TERBIOPANK)

Aim

The aim of the project is to form an inventory of histological samples collected within research projects on prostate cancer (PROSTATA 2000) and breast cancer (ESRI) from patients receiving radiotherapy. Samples from patients with clinical data available through the records of the department and researchers are included. The major goal is to assess the impact of radiation on cellular and organ levels.

Description of work

The patients have given informed consent for the collection of samples and the samples have been stored at –70 °C (freezer located in FFF/University of Turku). The samples include whole blood, serum and plasma from each patient. The clinical data available in patient records will be updated in 2011 for radiotherapy doses and targets and survival. Thereafter, the records and samples will be maintained for use as appropriate. For specific research needs that are identified, the approval of the ethical committee and VALVIRA (when appropriate) will be sought prior to initiating the analyses.

Dissemination and exploitation of results

Depending on the samples and in relation to projects utilising biobank materials, scientific papers are planned.

Collaborators

University Hospital and University of Turku, Finland.

Schedule

2011–2013

Project leader

Eeva Salminen

Cancer risk from computerised tomography (CHILD-MED-RAD)

Aim

The aim was to evaluate the cancer risk from radiation exposure received through CT examination in childhood.

Description of work

STUK participated in an EU-funded pilot study evaluating the feasibility of a cohort study and developing procedures for data collection. Information on the frequencies of paediatric CT scans estimated with the most common procedures and indications was collected from university hospitals. The radiology databases deal with examinations, not patients, and obtaining a computerised list of patient identifiers was not possible prior to the introduction of PACS databases (around 2000). Earlier examinations would have to be abstracted from the medical records, which is very laborious.

Dissemination and exploitation of results

Planning and preparation of the EPI-CT proposal.

Collaborators

International Agency for Research on Cancer (IARC); Center for Research in Environmental Epidemiology (CREAL), Spain; Danish Cancer Society, Denmark; Karolinska Institute, Sweden; Cancer Registry of Norway; and University of Mainz, Germany.

Schedule

2007–2009 (pilot); 2010 (planning of EPI-CT)

Project leader

Anssi Auvinen

Epidemiological study to quantify risks for paediatric computerised tomography and to optimise doses (EPI-CT)

Aim

The main aim is to establish a large multinational cohort of paediatric patients who received CT scans for evaluation of the radiation-related risk of cancer in this cohort and pilot testing of biological markers of CT irradiation effects

Description of work

The growing use of computerised tomography (CT) examinations is a topic of concern in radiological protection, especially for children and adolescents. Children are generally more sensitive to the carcinogenic effects of ionising radiation than adults. In addition, they have a longer life-span to express any effect and, because of their smaller mass, they may receive higher radiation doses from a CT examination than an adult.

The objective of a large-scale multinational collaborative study (EPI-CT) is to provide guidance on the optimisation of doses from paediatric CT scans with the specific aims to: 1) describe the pattern of use of CT in different countries and over time; 2) derive individual estimates of organ doses; 3) assess biological markers of CT irradiation effects; 4) directly evaluate the radiation-related risk of cancer following a CT examination; and 5) characterise the quality of CT images in relation to the estimated doses in order to better inform CT imaging practice. Scientists from nine European countries with expertise in epidemiology, clinical practice, radiology, dosimetry, biology and public health will contribute to the project.

Work to be conducted at STUK involves biological mechanisms. The aim is to assess from paediatric samples, in pilot tests, various biomarkers of exposure and sensitivity for potential use in risk assessment in future large-scale studies. The biomarkers include γ-H2AX, dicentric chromosomes and plasma cytokines.

Dissemination and exploitation of results

The results will be published in peer-reviewed international journals. Data will be used for future large-scale studies on paediatric CT patients.

Collaborators

Biological work package of the EPI-CT project; Belgian Nuclear Research Centre (SCK-CEN) and University of Ghent, Belgium; Bundesamt für Strahlenschutz (BfS), Germany; Institute Curie (IC), France; and Center for Research in Environmental Epidemiology (CREAL), Spain.

Schedule
2011–2016

Project leader
Carita Lindholm

1.5 Aetiology of brain tumours and health effects from the use of mobile phones

Aetiology of brain tumours

Aim

The aim is to examine whether the use of mobile phones and other factors are associated with the risk of brain tumours.

Description of work

As part of an international collaborative study, 184 cases with glioma, 239 with meningioma and 76 with acoustic neuroma (vertibular schwannoma) were recruited and interviewed in 2000–2002 (response rate 84–91% from among the cases), in addition to 562 population-based controls (56% participation). All diagnoses were independently confirmed by study neuropathologists. Tumour tissue microarrays were produced for histological analyses in molecular epidemiology studies. Detailed information on the anatomical location of the tumour was obtained for 100 glioma cases, with neuroradiologists indicating the centre point of the tumour on a 1 × 1 cm 3D grid. Blood samples were obtained for DNA extraction to analyse genetic risk determinants for a subset of the cases and controls. A validation study with 87 volunteers providing information from network operators on calling time was also carried out. Information on cancer incidence has been obtained from the Finnish Cancer Registry.

The Interphone study provided some suggestions of increased risks in relation to mobile phone use. In analyses according to cumulative call-time, an increased risk was observed in the highest decile of use, but without any monotonic increase across other exposure strata. Some increase was also related ipsilateral use (use mainly on the side where the tumour occurred), but this was most strongly related to short-term use. In addition, elevated ORs were found for temporal lobe tumours. However, there were serious concerns about possible selection bias (mainly due to low participation among controls with non-users under-represented) and information bias (recall bias with some cases probably overestimating their amount of use). To evaluate the effect of such biases, several validation studies have been conducted. Furthermore, approaches avoiding such biases have been conducted, for instance case-case analysis of tumour location. Analyses of incidence trends in the Nordic countries and their comparison with expected scenarios assuming certain effect sizes and latency periods have been conducted. Information on mobile phone use has been obtained from the INTERPHONE control subjects and national telecommunications statistics. Further work on regression calibration to adjust for non-differential exposure

misclassification (tendency of light users to underestimate and heavy users to overestimate their amount of use) is planned. Exploration of the dose-response relation allowing for information bias is also planned. A systematic review of both epidemiological and laboratory studies of RF fields and cancer risk has been conducted under the coordination of Michael Repacholi.

Dissemination and exploitation of results

A total of 35 publications have appeared with authors from STUK from the INTERPHONE project. So far, the results of the full INTERPHONE data set regarding the glioma and meningioma risk in relation to mobile phone use have been published, but a manuscript on acoustic neuroma will also soon be submitted. In addition, several validation studies have been published besides the design paper. Incidence trends of brain tumours in the Nordic countries have been analysed in smaller scale collaboration. The possible effect of mobile phone use was also assessed in analyses of the data from the Nordic countries and the UK. Other related publications include two validation studies, two meta-analyses and three papers on the location of gliomas. In addition, several studies on genetic factors and other risk factors for brain tumours have been published.

Collaborators

Finnish Cancer Registry, Finland; Karolinska Institute, Sweden; Cancer Society of Denmark; Cancer Registry of Norway; Cancer Research Institute UK; University of Mainz, Germany; International Agency for Research on Cancer (IARC, part of the World Health Organization, WHO).

Schedule

1999–2011

Project leader

Anssi Auvinen

Cohort Study of Mobile phone users (COSMOS)

Aim

The rationale of the international collaborative COSMOS study (Denmark, Finland, Sweden, the Netherlands, the UK) is to assess possible long-term health risks from RF exposure from mobile phone use. Earlier studies on mobile phone users and health have concentrated on brain tumours and mobile phone use has been estimated retrospectively. Retrospective exposure assessment is prone to biases and other possible health effects should also be considered and studied. The aim is to first establish a prospective cohort of mobile phone users and then to examine the association between mobile phone use and health.

Description of work

Information on mobile telephone use has been collected prospectively via both questionnaires (details of usage such as laterality, use of hands-free devices, use in urban/rural areas, indoors/outdoors etc.) and objective traffic data on the amount of use from network operators on an annual basis. Outcome information will be collected by record linkage to disease registries, while changes in symptoms such as headache, sleep and mood disorders, tinnitus and health-related well-being are being assessed by baseline and follow-up questionnaires. A prospective cohort study with a sufficient sample size overcomes many of the shortcomings of previous studies such as selection bias among controls, recall bias and non-differential misclassification due to retrospective reporting of exposure. Its major advantages are exposure assessment prior to the diagnosis of disease by the prospective collection of objective call data, the long-term follow-up of multiple health outcomes and the flexibility to investigate future changes in technologies or new research questions. The end-points studies will include cerebrovascular disease, Alzheimer's disease, Parkinson's disease as well as head and neck tumours. Validated instruments are being used to assess various symptoms.

The feasibility of the prospective cohort study COSMOS was evaluated in a pilot study in Finland. The impact of different recruitment strategies on participation was evaluated. Furthermore, the pilot study was also used for the validation of exposure assessment. The pilot study demonstrated that a cohort of mobile phone users can be recruited from network operators' customer databases using stratified sampling to obtain a balanced distribution of age, sex and amount of mobile phone use. Mobile phone data were successfully obtained from operators for those who agreed to participate in the study. The main risk concern was a low response rate (< 20%), which increases the recruitment cost and prolongs the recruitment period. The agreement between self-reported and

operator-derived estimates of call time was moderate and overestimation of the call time common.

In Finland, more than 100 000 customers of the two major network operators have been approached and about 12% have consented with slightly above 10% providing both consent and completing the baseline questionnaire. The size of the Finnish cohort is approximately 12 000 persons. The recruitment will be completed by the final round of mailings in November 2011. The anticipated final size is 16 000 people.

The anticipated overall cohort size is at least 200 000 persons. Recruitment has been completed in Denmark, Sweden and the UK (with about 150 000 subjects participating). The cohort will be followed for a minimum of 10 years.

Dissemination and exploitation of results

Several international peer-reviewed articles and press releases.

Collaborators

Karolinska Institutet, Sweden; Imperial College, UK; Kreftens Bekampelse, Denmark;, Institute for Risk Assessment Sciences, the Netherlands; network operators Elisa, TeliaSonera and DNA.

Schedule

2006–2011 and follow-up

Project leader

Anssi Auvinen

STUK perspective on electromagnetic hypersensitivity, IEI-EHS (SÄH)

Aim

The aim is to respond to the public concern raised on IEI-EHS and to support the development of scientifically validated evidence-based information and guidelines.

Description of work

Modern health concerns such as electromagnetic hypersensitivity are globally relevant and have an impact on authorities and the medical community, creating pressures to respond to public demands and concerns.

Idiopathic environmental intolerance attributed to electromagnetic hypersensitivity (IEI-EHS) is the current concept for concerns on the effects of electromagnetic radiation. In European surveys, 1.5% of respondents report suffering from related problems. In Finland, as in other countries, there have been concerns among the general population and complaints about the response received in health care.

Working with other stakeholders, STUK is participating in a knowledge update, reviews and recommendations related to this issue.

Dissemination and exploitation of results

Evidence-based guidelines, seminars, publications, participation in knowledge platform discussions as appropriate.

Collaborators

The Ministry of Social Welfare and Health in Finland; non-government organisations as appropriate.

Schedule

2011–2013

Project leader

Eeva Salminen

1.6 Biological effects of low-dose ionising radiation

The effect of repair-gene polymorphisms on DNA damage in a population exposed to ionising radiation (CA of cleanup workers)

Aim

The aim of the study is to investigate the effect of individual susceptibility factors on the yield of chromosomal aberrations from the blood samples obtained from Estonian Chernobyl cleanup workers.

Description of work

The yield of chromosomal aberrations will be evaluated in the Estonian males who participated in the cleaning operations after the Chernobyl accident. The work involves aberration analysis applying FISH chromosome painting of about 300 exposed males and 100 controls whose lymphocyte samples are available. Analysis of more than half of the samples has been performed. Translocation frequencies can be used as a retrospective dosimeter. Other factors may also influence the frequency of translocations in which substantial individual variation has been observed. Individual differences in DNA may be one of the sources of the variation. The samples will be genotyped with respect to polymorphisms occurring in DNA repair and cell cycle control genes, and the association between polymorphisms, other confounders and the yield of translocations will be assessed.

Dissemination and exploitation of results

The research results will be published in peer-reviewed journals and form part of a doctoral thesis. The different genotypes may help in explaining the large individual differences in translocation yields and indirectly the results may also help in understanding low-dose risks.

Collaborators

National Institute of Health Development, Estonia

Schedule

2004–2010

Project leader

Carita Lindholm

Methods for detecting radiation sensitivity – ATM mutations as a model for characterising individual susceptibility (ATModelDirect)

Aim

The aim of this study is to investigate individual sensitivity to ionising radiation using at least three different methods: cell viability assay, the Comet assay and chromosomal aberration (CA) assay.

Description of work

The study model (the ATM model) will include lymphoblastoid cell lines from breast cancer patients carrying previously characterised ATM mutations. ATM is known to be a major activator of cellular responses to DNA double-strand breaks and is involved in several signalling pathways, including cell cycle control and mitotic recombination. At the cellular level, AT heterozygotes have been shown to be intermediate in radiation sensitivity between normal and AT-deficient cells. In the present study, individual sensitivity to ionising radiation will be studied using a cell viability assay, the Comet assay and the chromosomal aberration (CA) assay. The experiments will be conducted by using low-LET X-ray doses (100 mGy, 1 Gy and 2 Gy).

Dissemination and exploitation of results

The results will be published in peer-reviewed international journals. Methods for detecting radiation sensitivity at low doses will be used in future projects.

Collaborators

Oulu University Hospital and University of Oulu, Finland.

Schedule

2009–2010

Project leader

Virpi Launonen

Studies on non-targeted effects in 3D EpiAirway artificial human tracheal/bronchial tissue systems (NOTE/Task 2.4)

Aim

The aim of this project is to study non-targeted effects in 3D artificial human tracheal/bronchial tissue systems after low dose microbeam irradiation.

Description of work

EpiAirway (MatTek, USA) artificial human tracheal/bronchial tissue systems will be used as a model to study the non-targeted tissue effects of ionising radiation. A tissue bank of EpiAirway artificial lung tissues will be established after microbeam exposures ($^{3}He^{2+}$ particle and proton irradiation). The microbeam exposures will be performed at the Gray Cancer Institute and the University of Leipzig. Non-targeted effects of ionising radiation will be assessed using apoptosis and differentiation as endpoints.

Dissemination and exploitation of results

The results are part of the NOTE project.

Collaborators

Gray Cancer Institute, UK and University of Leipzig, Germany.

Schedule

2006–2010

Project leaders

Virpi Launonen and Sisko Salomaa

Clastogenic factors in subjects exposed to ionising radiation (NOTE / CLASTO)

Aim

To assess clastogenic, i.e. chromosome damaging, factors in blood plasma from individuals exposed to ionising radiation with biochemical and cytogenetic techniques.

Description of work

The project was part of the NOTE programme and aimed at investigating clastogenic factors, molecules that are found in the plasma of individuals exposed to ionising radiation and shown to induce chromosomal aberrations when added to normal blood cultures. The plasma samples investigated in this project were obtained from German patients treated locally with ionising radiation for basal cell carcinoma, arthritis of the knee or tendinitis of the heel or elbow. The effects of plasma extracted from the blood samples on normal cells were investigated using chromosomal aberration, micronucleus and DNA double-strand break (γ-H2AX foci) assays. The plasma from patient groups investigated in the current study was demonstrated not to contain CFs induced by ionising radiation. Plasma obtained from two radiation accident victims showed increased induction of chromosomal aberration in reporter cells. Proteomics analysis of the plasma fractions is ongoing.

Dissemination and exploitation of results

The results will be published in peer-reviewed international journals.

Collaborators

University of Leipzig, Germany

Schedule

2008–2010

Project leader

Carita Lindholm

Individual sensitivity in non-targeted effects of radiation – ATM as a model for characterising individual susceptibility

(NOTE / ATModel)

Aim

The main aim of this study is to investigate the role of genetic heterogeneity with respect to individual variation in the non-targeted response to ionising radiation. This study will also address the issue of low dose effects using X-ray.

Description of work

The study model (the ATM model) will include lymphoblastoid cell lines from breast cancer patients carrying previously characterised ATM mutations. ATM is known to be a major activator of cellular responses to DNA double-strand breaks and is involved in several signalling pathways, including cell cycle control and mitotic recombination. At the cellular level, AT heterozygotes have been shown to be intermediate in radiation sensitivity between normal and AT-deficient cells. The experimental system used in this study, will be based on a co-culture system where irradiated cells can communicate with unirradiated cells immediately post-irradiation. Induction of the bystander effect will be measured using A cell viability assay and the response to radiation manifested as cytogenetic damage will be quantified using a chromosomal aberration (CA) assay. The experiments will be conducted by using low-LET X-ray doses (100 mGy, 1 Gy and 2 Gy).

Dissemination and exploitation of results

The project will provide information on the non-targeted effects of ionising radiation. The results will be published in peer-reviewed international journals.

Collaborators

Oulu University Hospital and University of Oulu, Finland; Oxford Brookes University, UK.

Schedule

2009–2010

Project leader

Virpi Launonen

The mechanisms of cardiovascular risk after low radiation doses (CARDIORISK)

Aim

Epidemiological studies have demonstrated that women who have received radiation therapy for breast cancer have a higher risk of developing heart and blood vessel atherosclerosis. A similar increase in risk was observed among the survivors of the atomic bombing of Hiroshima and Nagasaki. CARDIORISK is examining the cellular mechanisms that are activated by low doses of ionising radiation and that lead to the development of heart and blood vessel atherosclerosis.

Description of work

STUK's part of the project will be executed in collaboration with the Helmholz Center in Munich, Germany and will analyse the effects of low doses of radiation on the cell proteome (HC) and phospho-proteome (STUK). The analysis of phospho-proteome responses to low dose ionising radiation in human endothelial cell line EA.hy926 and mouse primary heart endothelial cells (HUVEC) will be performed at STUK.

Dissemination and exploitation of results

The project will provide information on the possible biochemical mechanisms of the development of radiation-induced atherosclerosis. This information will be of used in the development of clinical treatments and in the prevention of this disease. Results will be published in a peer-reviewed journal and presented at an international conference. The results will also be included as a part of the final report of the CARDIORISK project.

Collaborators

Technische Universität München – Klinikum Rechts Der Isar, Technische Universität Dresden, Helmholtz Zentrum München and Universität Leipzig, Germany; Vereinigte Het Nederlands Kanker Instituut and Universiteit Maastricht, the Netherlands; Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France; Queen's University Belfast and University of Sheffield, UK; and Maria Sklodowska-Curie Memorial Cancer Center, Poland.

Schedule

2008–2010

Project leader

Dariusz Leszczynski

Combining epidemiology and radiobiology to assess cancer risks in the breast, lung, thyroid and digestive tract after exposures to ionising radiation with total doses in the order of 100 mSv or below (EpiRadBio)

Aim

The main aim of the project is to combine epidemiology and radiobiology to assess cancer risks in the breast, lung, thyroid and digestive tract after exposures to ionising radiation with total doses in the order of 100 mSv or below.

Description of work

The EpiRadBio project consists of three sub-projects:

1. Genomic instability and individual susceptibility: Key factors of radiation-induced carcinogenesis such as genomic instability will be measured in cancer tissues and blood samples from members of the different radio-epidemiological cohorts.
2. Radiation-induced perturbation and activation of processes involved in carcinogenesis: Inter-cellular communication after exposure to low-dose radiation exposure and its influence on apoptosis, cell proliferation, differentiation and genomic instability will be explored.
3. Epidemiology, carcinogenesis and risk: The results of the radiobiological studies will be integrated in the development of models of carcinogenesis for the evaluation of epidemiological cohorts. Cancer risk will be determined for the breast, lung, thyroid and the digestive tract after low-dose-rate exposure to low-LET radiation and high-LET radiation. Lifetime cancer risks including individual risk factors will be calculated to establish a new basis for deriving dose limits and estimating cancer risks, including those from medical diagnostic exposures.

STUK is mainly participating in Sub-project 2 and focusing on lung carcinogenesis. The role of the tissue micro-environment response and inter-cellular communication will be investigated using different lung cell and tissue models exposed to low dose irradiation. A highly differentiated full-thickness 3-D Epiairway tissue model (MatTek, USA) composed of a fibroblast-containing collagen matrix and epithelial cell layers will be used as an *in vivo*-like model to study epithelial-stromal interactions. Radiation-induced epithelial to mesenchymal transition and the involvement of the TGFβ signalling pathway in this process will also been investigated. In addition, the identification of biomarkers following low dose irradiation is one of our goals.

Dissemination and exploitation of results

This project will yield new information on the health effects of low dose radiation. The results will be published in peer-reviewed international journals.

Collaborators

Helmholtz Zentrum München, University of Rostock and Eberhard Karls University of Tübingen, Germany; French Atomic Energy Commission and Institut National de la Sante et la Recherche Medical, France; Chancellor, Masters and Scholars of the University of Oxford, Queen's University Belfast, Health Protection Agency and Imperial College of Science, Technology and Medicine, UK; University of Pavia, Italy; University of Stockholm, University of Gothenburg and Karolinska Institute, Sweden; Federal State Unitary Enterprise Southern Urals Biophysics Institute of Federal Medicobiological Agency, Russian Federation; Institute of Endocrinology and Metabolism of the National Ukrainian Academy of Sciences, Ukraine; and VU University Medical Center, the Netherlands.

Schedule

2011–2014

Project leader

Virpi Launonen

Validation of biodosimetry assays using blood samples from a radiotherapy patient with cancer (RT case study)

Aim

To evaluate the sensitivity of biological dosimetry techniques using lymphocytes obtained from a cancer patient exposed to high-dose partial-body irradiation.

Description of work

A patient diagnosed with prostate cancer will receive a total dose of 75 Gy photon irradiation administered to a small tissue volume (30 cm^3) with 2 Gy fractions per day. Blood sampling will be conducted before and during the radiotherapy regime. Biodosimetry assays, the dicentric method and the γ-H2AX technique will be applied to lymphocytes isolated from whole blood. The sensitivity of the assays will be determined with respect to the cumulative dose received.

Dissemination and exploitation of results

The results will be exploited in other studies aiming at the development of biodosimetry assays.

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Carita Lindholm

1.7 Biological effects of non-ionising radiation

Review of studies examining the effects of electromagnetic fields on living cells using high-throughput screening techniques (TG-HTST)

Aim

To determine whether the studies published to date provide any consistent information on the possible effects of electromagnetic fields on gene or protein expression.

Description of work

The work is part of the EU COST Action. Scientific tasks of the TG-HTST:

- In-depth analysis of relevant scientific publications (studies where HTST were used to examine EMF effects)
- Preparation of a set of guidelines for scientists using HTST in EMF research in order to improve quality of the studies
- Development of ideas for a HTST-EMF-related database (possible host: WHO).

Dissemination and exploitation of results

It has been preliminarily agreed with the Editor-in-Chief of Proteomics that the review will be published in this journal.

Collaborators

University of Nottingham, UK; University of Rostock, University of Münster and University of Tübingen, Germany; and National Centre for Biotechnology, Spain.

Schedule

2009–2011

Project leader

Dariusz Leszczynski

Inter-comparison of two exposure chambers and effects on cells obtained with their use

Aim

To compare the responses of EA.hy926 cells to 900 and 1 800 MHz GSM radiation in simultaneously conducted experiments.

Description of work

Previous studies have detected changes in protein expression in human endothelial cells (EA.hy926) exposed to 900 MHz GSM radiation at SAR 2.4 W/kg. When the same cell line has been exposed to 1 800 MHz radiation at SAR 2.0 W/kg, either no changes have been observed or the changes have been very small. These differences may be due to: 1) the difference in exposure conditions (SAR value, field distribution), 2) methodological differences in the proteomics technique used, or 3) the difference in radiation frequency (900 or 1 800 MHz).

The chamber comparison will be performed by simultaneously exposing the same cell batch of EA.hy926 cells at two similar exposure levels, 2 and 5 W/kg. Changes in protein expression in cells exposed in both chambers will be examined using 2DE-DIGE technology. Any proteins that are shown to change their expression in response to irradiation will be identified with mass spectrometry and confirmed with Western blotting.

Dissemination and exploitation of results

The results will be published in a peer-reviewed international journal.

Collaborators

IT'IS Foundation, Zürich, Switzerland

Schedule

2010–2011

Project leader

Dariusz Leszczynski

Live imaging of mobile phone radiation-induced morphological and molecular-level changes in human endothelial cells

Aim

To determine the time kinetics of changes in cell size, shape and cytoskeleton protein distribution in human endothelium exposed to mobile phone radiation.

Description of work

The purpose of this research project application is to obtain funds that would allow Research Professor Dariusz Leszczynski from STUK, the Radiation and Nuclear Safety Authority in Helsinki, Finland, to execute a series of experiments at the Swinburne University of Technology, Hawthorne, Victoria, Australia. Swinburne University of Technology is the only institute with equipment that allows the observation of living cells during their exposure to mobile phone radiation. Cells labelled with fluorescent probes are observed using a confocal fluorescence microscope. This unique exposure equipment has been made available to Prof. Leszczynski by its constructor, Prof. Vitas Anderson, and its current user, Prof. Andrew Wood, both of Swinburne University of Technology.

Dissemination and exploitation of results

The results will be published in a peer-reviewed international journal.

Collaborators

Brain Sciences Institute at the Swinburne University of Technology, Hawthorn, Melbourne, Australia.

Schedule

2011–2012

Project leader

Dariusz Leszczynski

Effect of UV radiation on the metastatic capacity of melanoma cells

Aim

We have previously investigated the effect of solarium-derived UV irradiation on the metastasis of melanoma. Our results indicate that UV irradiation of mice *in vivo* dramatically increases haematogeneous pulmonary metastasis and colony formation in the lungs. However, the fate of the melanoma cells in the mouse body during the first hours and days after melanoma cell injection remains obscure. Thus, the experiments in this project were designed to investigate the metastatic process in real time using different *in vivo* molecular imaging technologies.

Description of the work

The project focused on melanoma cell detection in the mouse blood circulation and the host organs after solarium UV exposure. The first aim was to determine how UV exposure affects the clearance of the melanoma cells from the circulation to the lungs. This was investigated using *in vivo* confocal flow cytometry (IVFC), by which the migration of the cell population of interest can be observed in the blood circulation. As a second aim, the localisation and proliferation of mouse melanoma cells after UV irradiation was assessed by *in vivo* biochemiluminescense system that allows whole body imaging.

Dissemination and exploitation of results

This study could offer new insights into the possible role of UV exposure on the spread of cancer and provide new information on the physiological effects of UV radiation on photobiology. The results may be used in the prevention of the long-term detrimental health hazards derived from UV-induced reactions. Results of the experiments will be published in peer-review journals and presented at scientific conferences.

Collaborators

Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, US. The project has received funding from the Academy of Finland.

Schedule

2009–2011

Project leader

Riikka Pastila

2 Use of radiation

European Metrology Research Programme (EMPR) / External Beam Cancer Therapy (EBCT): Development of a method for the verification of dose distributions for IMRT treatments of the prostate

Aim

The central objective is to provide a reliable metrology for all radiation-based forms of cancer therapy. For IMRT the aim is to ensure accurate and reliable dosimetry in modern therapy techniques for small and shaped radiation fields, with the following specific targets:

- Development of a simple and a more complex phantom
- Establishment of metrological traceability of radiochrome film measurements to the water calorimeter (Spatial detection uncertainty < 2 mm, uncertainty in dose < 2.5%)
- Production of CT-scan of phantoms, 3D-electronic voxel phantoms
- Determination of dose values and location of gradients inside the phantom by means of radiochrome film

Within the targets for IMRT in the project, the aim for STUK was to develop a suitable method (dosimeter and measurement phantom) for the verification of dose distributions in prostate treatments using IMRT.

Description of work

In the Health topic of the European Metrology Research Programme (EMPR) within the Seventh European Framework Research Programme, a project on external beam cancer therapy was launched in 2009. The project includes working areas for modern forms of ionising radiation therapy, such as Hadron therapy and intensity modulated radiation therapy (IMRT), and emerging therapy techniques such as high intensity therapeutic ultrasound (HITU). STUK was a leader of the work package for the verification of treatment planning systems in IMRT.

The use of radiochromic film in the measurements and the materials and construction of an applicable phantom were tested practical IMRT radiotherapy beams. Evaluation of the suitability of the methods was based on estimation of the uncertainties and the general feasibility of the methods, determined both in laboratory testing and from measurements in clinical IMRT beams. A film scanner was also developed at STUK. Parallel to the investigation of the characteristics of the film, a multipurpose water-filled phantom applicable for both external beam dosimetry in IMRT and for brachytherapy dosimetry

was developed. The dosimetry methods and the phantom were tested in the laboratory and under clinical conditions.

Dissemination and exploitation of results

The following publications/presentations for STUK have been prepared: 1. Computer controlled densitometer for Gaf-Chromic EBT2 film, P. Sipilä et al., STRO, 2010. 2. P. Sipilä et al. A multipurpose, semi-anatomical water phantom for TPS verification. IAEA/IDOS Symposium, Vienna, November 2010. The results of the project have also been presented in the annual national meetings of radiotherapy physicists in Finland in 2008 and 2011. The results will be presented in a symposium for the project in November 2011.

Collaborators

Laboratoire National Henry Becqurel (LNHB), France; Physikalisch-Technische Bundesanstalt (PTB), Germany (overall project coordinator); Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA), Italy; Instituto Nazionale de Ricerca Metrologica (INRIM), Italy; NMi Van Swindon Laboratorium (NMi), The Netherlands; Instituto Tecnológico e Nuclear (ITN), Portugal; Slovak Institute of Metrology (SMU), Slovak Republic; Ulusal Metroloji Enstitüsü (UME), Turkey; and National Physical Laboratory (NPL), UK.

Schedule

2008–2011

Project leader

At STUK: Antti Kosunen

European Metrology Research Programme (EMPR) / Increasing cancer treatment efficacy using 3D brachytherapy: Development of methods for brachytherapy dosimetry

Aim

The aim was to develop a suitable method (dosimeter and measurement phantom) for the verification of dose distributions in gynaecological treatments with ^{192}Ir and ophthalmic treatments with ^{125}I.

Description of work

Small scintillation dosimeters (OPTIDOS scintillator (type T10013)) and Gafchromic film (Gaf-chromic® EBT and EBT-2) were applied in the measurements, and for ^{125}I ophthalmic applicators, semiconductor detectors (Scanditronix diode (type DEB050)) were also used. In the first step, the energy and dose response of the selected detectors were determined for the energy region and dose rates of interest (up to 20 Gy/min): X-ray qualities (HV 100–250 kV, HVL 0.15–2.4 mmCu) and a ^{60}Co gamma beam were used. In the second step, the 2D and 3D dose distributions of ^{192}Ir and ^{125}I sources in a phantom for gynaecologic radiotherapy were determined. Experimental measurements were compared with Monte Carlo simulations for selected cases.

For the measurements of dose distributions of the ^{191}Ir source, a water-filled, semi-anatomical phantom was constructed. A wide range of detectors and anatomical structures corresponding to organs can be installed in this measurement phantom. Parallel to the development of the phantom, read-out systems for Gafchromic® EBT and EBT-2 radiochromic films were constructed. For the measurements of dose distributions of ^{125}I ophthalmic applicators, a simple rectangular water phantom with appropriate detector and source holders and a moving mechanism were constructed and used for the measurements of single ^{125}I seed sources and four different concave ophthalmic applicators.

Dissemination and exploitation of results

The results of the energy response testing have been presented at the IAEA IDOS conference (IAEA-CN-182). A conference presentation and a scientific paper will be prepared to publish the results of measurements and calculations of brachytherapy sources under clinical conditions. The results of the project have also been presented at the annual national meetings of radiotherapy physicists in Finland in 2008 and 2011. Results will be presented in a symposium for the project in November 2011.

Collaborators
Physikalisch-Technische Bundesanstalt (PTB), Germany (overall project coordinator); National Physical Laboratory (NPL), UK; Ente per le Nuove tecnologie, l'Energia e l'Ambiente (INMRI-ENEA), Italy; Laboratoire National Henry Becqurel (LNE-LNHB), France; Bundesamtfur Eich-und Vermessungswesen (BEV), Austria; Swedish Radiation Safety Authority (SSM), Sweden; Instituto Tecnológico e Nuclear (LMRI-ITN), Portugal; and Czech Metrology Institute – Inspectorate for Ionising Radiation (CMI), Czech Republic.

Schedule
2008–2011

Project leader
At STUK: Hannu Järvinen

Determination of effective doses to the population from X-ray and nuclear medicine examinations in Finland

Aim

The aim was to determine the collective effective doses to the population from X-ray and nuclear medicine examinations in Finland in 2008 and 2009, respectively.

Description of work

The collective effective doses to the population from X-ray procedures were determined both by using the TOP 20 method (EC radiation protection 154) and a more accurate calculation based on all examination types. The collective effective dose from conventional plain radiography was estimated both by using the new (ICRP 103) tissue weighting factors and the old (ICRP 60) tissue weighting factors. For the number of procedures in the calculations, the results of a questionnaire survey carried out by STUK were used, for X-ray procedures in 2008 and for NM in 2009. For the calculation of dose, both patient dose surveys and calculations by MC programmes (PCXMC) and data from the literature were used.

Dissemination and exploitation of results

The results were presented at the International Congress of Radiation Protection in Medicine, Varna 2010, and have been submitted for publication in Radiation Protection Dosimetry. A preliminary study based on 2005 data on examination frequencies was published earlier in 2008 in the IRPA 12 Congress Proceedings.

Collaborators

No collaborators outside STUK

Schedule

2009–2010

Project leader

Hannu Järvinen

Patient doses in paediatric CT examinations and the feasibility of setting diagnostic reference levels

Aim

The aim was to collect and compare patient dose data in paediatric CT examinations in order to conclude on the feasibility of setting diagnostic reference levels (DRLs) for these examinations.

Description of work

Collection of patient dose data was carried out by using a special form distributed to the paediatric clinics. The study was focused on selected most common and important paediatric CT examinations, i.e. paediatric chest and head CT. It was launched in collaboration with five university hospitals in Finland and with some hospitals from Estonia and Lithuania.

Dissemination and exploitation of results

The results were presented at the International Congress of Radiation Protection in Medicine, Varna 2010, and submitted for publication in Radiation Protection Dosimetry. The results will be used as a basis for a further study to improve the statistics and enable more reliable setting of DRLs.

Collaborators

Helsinki University Hospital, Kuopio University Hospital, Oulu University Hospital, Tampere University Hospital and Turku University Hospital, Finland; Radiation Protection Centre, Lithuania; and Tartu University Hospital, Estonia.

Schedule

2009 – 2010

Project leader

Hannu Järvinen

Population dose caused by the use of unsealed radioactive sources

Aim

The aim is to determine the population dose caused by radioactive waste and releases of radioactivity from the use of unsealed sources in a few Finnish towns, and to establish a calculation method to determine the population dose caused by a given radioactive release.

Description of work

The population dose caused by releases from all users of unsealed sources in 3–5 example cities in Finland will be investigated. All possible disposal methods (e.g. release to the sewage system or air, incineration, placing at a disposal site) and related exposure pathways shall be investigated. The example cities will be chosen so that they represent different types of practices and disposal routes in Finland. Doses to a representative person will be estimated based on the current maximum permitted releases. The most significant exposure pathways shall be identified.

Dissemination and exploitation of results

The results will be published as a STUK-A report and in some international conference or journal. The results will be used as background information for updating the regulatory guide ST 6.2 Radioactive Wastes and Discharges.

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Santtu Hellsten

Study on European Population Doses from Medical Exposure
(Dose Datamed 2)

Aim
The aim is to collect available data on the doses from radiodiagnostic procedures (both X-ray procedures and NM) in the European Union and to facilitate the further implementation of *Radiation Protection 154. European Guidance on Estimating Population Doses from Medical X-Ray Procedures,* published by the European Commission in 2008.

Description of work
To achieve the above objectives, the study aims at

- Providing advice and collecting feedback from the application of the guidance RP 154;
- Providing estimates of population doses in EU Member States and the population dose in the European Union as a whole;
- Providing a database for population dose information that will enable continuous collection and follow-up of European population doses.

The study is divided into six separate Work Packages (WP):

- WP 1: Management and coordination
- WP 2: General questionnaire and database
- WP 3: Population dose for countries with national surveys
- WP 4: Population dose for countries without national surveys
- WP 5: Population dose in the European Union as the whole
- WP 6: European Workshop.

STUK is acting as a coordinator of the project and as a leader of WPs 1 and 5.

Dissemination and exploitation of results
The results will be presented at the European Workshop organised by the project. The results will also be presented in the project reports to the European Commission and a few scientific papers. In addition, the results may result in improved guidance on population dose estimations (revision of, or supplement to RP 154).

Collaborators
Public Research Centre Henri Tudor (CRP-HT), Luxembourg; Norwegian Radiation Protection Authority (NRPA), Norway; National Centre of Radiobiology and Radiation Protection (NCRRP), Bulgaria; Greek Atomic Energy Commission

(GAEC), Greece; World Health Organization (WHO); and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Schedule
2010–2013

Project leader
At STUK: Ritva Bly

Cost-benefit modelling in medical radiation (TIEKKU)

Aim

The population dose from medical radiation has increased rapidly due to the availability of computed tomography (CT) imaging. In some countries, this forms the largest contribution to medical radiation exposure. CT imaging has contributed to accuracy in cancer diagnostics and treatment planning. On the other hand, it has been estimated that a significant number of new cancer cases are caused by excess exposure to radiation due to CT imaging. Testicular cancer is common among young men of 20 to 34 years of age at diagnosis. Most patients are cured with a relatively long life expectancy. However, their care includes frequent CT imaging, with up to 10–20 abdominal CT scans in 10 years. Among testicular cancer survivors, an increased risk of second malignancies and death due to circulatory and infectious diseases has been reported. The role of frequent CT imaging in later health effects remains to be studied. The 1997 EU directive requires "all concerned to reduce unnecessary exposure of patients to radiation." The aim in TIEKKU is to assess the cost–benefit of frequent CT imaging using testicular cancer treatment and follow-up as a model.

Description of work

In Finland, abdominal CT and chest X-rays are frequently taken during the treatment and follow-up of testicular cancer patients. The radiation dose (effective dose) from a single abdominal CT is 10 to 12 mSv. This study describes a 10-year survey of testicular cancer patients treated at the Department of Oncology and Radiotherapy, Turku University Hospital (TUH), from 1995 onwards and with 5 to 15 years of follow up. The gains from CT intervention in terms of the detection of recurrence and the cost and potential harmful effects of radiation from frequent CT imaging will be assessed and estimated. The aim is to reduce unnecessary CT usage if the gain and beneficial interventions following CT imaging could be achieved using protocols with less exposure to radiation. The follow-up assessment includes assessment of the value of CT as a first indicator of relapse and the incidence of second malignant cancers (data for second cancers will be obtained in collaboration with the Finnish Cancer Registry). Following the approval at TUH for using patient records, the patients have been identified and their clinical data are currently being collected. Pilot assessment of the CT dose using the NRPB-SR250 programme has been commenced with the employment of another physicist at TUH by the project.

Dissemination and exploitation of results

The results will be published in the form of two high-quality peer-reviewed journal articles. The physicists/participating students will use the data in their scientific reports. Conference presentations in radiation oncology and radiology are encouraged during the study period.

Collaborators

University Hospital and University of Turku, Finnish Cancer Registry, Finland. It is foreseen that at later stage, other university hospitals, e.g. Oulu and Tampere, will join the project.

Schedule

2011–2013

Project leader

Eeva Salminen

Radiation safety in the use of accelerators

Aim

Several new accelerators for isotope production and research activities have recently been taken into use in Finland. The aim of the study is to evaluate whether there is a need to establish practice-specific regulations or guidance for these practices.

Description of work

The work will include a review of international recommendations, standards, guides and manufacturers' criteria, as well as existing national requirements related to radiation safety in the use of accelerators. This will be followed by site visits to different types of accelerator facilities to assess current safety arrangements and to discuss with the licensees to seek any possible further background information.

Dissemination and exploitation of results

The results will be published as a STUK-A or STUK-B report, and will be used as background information for a possible new regulatory guide.

Collaborators

No collaborators outside STUK

Schedule

2011–2012

Project leader

Jyri Lehto

Ionising radiation metrology for the metallurgical industry (MetroMetal)

Aim

Foundries annually produce millions tons of steel that can be potentially contaminated by the smelting of radioactive sources hidden in scraps. Undesirable consequences include the contamination of cast metal, furnaces, slags, the environment and also the accidental irradiation of the population with expensive costs and a strong international impact. Current radioassay controls do not guarantee appropriate traceability. Therefore, the project will address the need for European-harmonised action to configure appropriate instruments, develop reference materials and issue measurement procedures and technical standards for SI-traceable radioactivity monitoring of scrap, slag, fumes, dust and cast steel, in order to prevent contamination effects, population hazards and trade disputes, leading to uniform application and technical acknowledgment across Europe and worldwide.

Description of work

The project has the following scientific and technical objectives:

1. Design of overall standardised traceable measurement methods, optimised for the control/measurement of scrap loads, metal products, slag, fumes and dust according to the EC and national regulations and to NEA and IAEA recommendations.
2. Development of standard reference sources for cast steel and slags at the contamination threshold levels for:
    a. potential contaminant radionuclides (^{60}Co, ^{137}Cs, ^{192}Ir, ^{226}Ra, …);
    b. different steel compositions, black and grey slags, fume filters;
    c. different sample geometries, matching the cast steel probes currently used for on-line measurements and the slag cartridges needed for the calibration of detectors;
3. Characterisation of reference sources by combined measurement-simulation methods and inter-laboratory comparisons.
4. Optimised setup of reference measurement system(s), based on spectrometric systems with NaI, HPGe, plastic scintillation detectors or other appropriate sensitive devices.
5. Development of technical procedures for scrap controls, calibration of measurement systems and on-line radioassay controls.
6. Development of measurement, evaluation, calibration and control software.
7. Demonstration, testing and user training actions at selected foundries in Europe.

8. Dissemination of results and knowledge to stakeholders, end-users and to the scientific community.
9. Development of recommendations leading to technical standardisation of the calibration of measurement systems, on-line monitoring of production and final certification of cast steel batches with technical acknowledgment all around Europe and in third countries.

Dissemination and exploitation of results

Journal and conference papers will be written; a workshop will be organised; inclusion of specific project results in standards and application guides is foreseen.

Collaborators

Research Centre in Energy, Environment and Technology, CIEMAT, Spain (overall project coordinator); Physikalisch-Technischer Pruefdienstdes, Bundesamt Fuer Eich- Und Vermessungswesen (BEV/PTP), Austria; Commissariat à l'Energie Atomique (CEA), France; Cesky Metrologicky Institut (CMI), Czech Republic; Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA), Italy; Institute of Physics and Nuclear Engineering (IFIN-HH), Romania; Institut Jožef Stefan Institute (IJS), Slovenia; Instituto Tecnológico e Nuclear (ITN), Portugal; Joint Research Centre (JRC), European Commission, Italy; Hungarian Trade Licensing Office (MKEH), Hungary; Institute of Atomic Energy POLATOM, Poland; Physikalisch-Technische Bundesanstalt (PTB), Germany; and Slovensky Metrologicky Ustav (SMU), Slovakia.

Schedule

2011–2014

Project leader

At STUK: Teemu Siiskonen

3 Occurrence and mitigation of natural radiation

3.1 Occurrence of radon

Radon emanation rate determined by liquid scintillation counting

Aim of study

The objective of the project was to develop a simple and reliable method for determining the radon emanation rate in soil samples.

Description of work

In the developed method, a soil sample and an open liquid scintillation vial filled with a scintillation cocktail are sealed with a rubber stopper inside a glass bottle. The radon concentration inside the bottle begins to rise and is partly absorbed by the cocktail. The cocktail is taken out after 1–3 weeks and the concentration of radon absorbed by the cocktail is determined with a liquid scintillation counter. Based on the calibrations carried out, the radon emanation rate can be calculated.

The liquid scintillation method is generally more rapid than any of the previously applied methods that require three weeks to attain results. The method can detect lower emanation rates than the previous methods.

Dissemination and exploitation of results

The results have been published in a peer reviewed journal.

Collaborators

No collaborators outside STUK

Schedule

2003–2009

Project leader

Tuukka Turtiainen

Uranium and radon in the geosphere (URNGEO)

Aim

The aim of the project is to strengthen the scientific basis of the mobilisation, migration and immobilisation of natural radionuclides in the geosphere (rock / sediments / soil / ground water / surface waters), especially of the porosity and transport properties of rocks and sediments.

Description of work

The main work package of this project is the completion of a doctoral thesis (Daniel Breitner) together with the collaborators. In this work, samples from Palmottu, Olkiluoto, Askjola and Hollola have been analysed. The occurrences of uranium minerals, weathering processes and the effect on radon emissions have been investigated. As a part of this project, the methods have been developed and the results will be published for the EU-POSINAM project (Karl-Heinz Hellmuth in the service of the POSINAM project in 2011) together with the University of Helsinki. POSINAM (Pore Space Investigation in Natural and Artificial Materials) aims at improving knowledge of the petrography of rock, cements, soils and other materials in relation to porosity, and at characterisation of the heterogeneous spatial porosities of these materials using a saturation technique with a ^{14}C or ^{3}H polymethylmethacrylate (PMMA) resin.

Dissemination and exploitation of results

Publication of a doctoral thesis (Daniel Breitner) in 2011: Geochemical and mineralogical investigation of overburden profiles in glaciated terrain, Finland – implication for the assessment of radon emission, and in related scientific publications. Publication of POSINAM results in cooperation with HYRL.

Collaborators

University of Helsinki, Laboratory of Radiochemistry (HYRL), Finland (doctoral thesis and POSINAM studies); Lithosphere Fluid Research Group, Department of Petrology and Geochemistry, Eötvös University (LRG), Budapest, Hungary (doctoral thesis); and Geological Survey of Finland (GTK), Finland (mineralogical studies of the doctoral thesis).

Schedule

2005 – 2011

Project leader

Hannu Arvela

Seasonal variation in radon concentration and ventilation strategies

Aim

This project aims at quantifying the seasonal variation in indoor radon concentrations. Radon concentrations in summer are generally only 50% or less compared with those in winter.

Description of work

The research will utilise a modified model originally developed at STUK in 1995. The model takes into account air exchange in dwellings and the basic physics of radon entry. The results will be compared with winter and summer measurements of the two previous nationwide sample surveys, including more than measurements in low-rise residential buildings. Similarly, previous measurements in 300 dwellings with a one-month measurement period will be utilised, as well as the calculation published in 2005 (Arvela H. Review of seasonal variation in residential indoor radon concentration. Radioactivity in the Environment 2005; 7: 612–617). This study will explore the effect of the climate on radon concentrations. These results will be expanded for an evaluation of the effect of global warming. In the work package for ventilation strategies, the results from previous studies (Indoor radon mitigation, STUK-A229, Ventilation studies in the Tuusula housing fair area, HTKK and STUK 2002) concerning the underpressure and ventilation will be published in a refereed journal. The overall effect on radon concentrations will be assessed.

Dissemination and exploitation of results

The results will be exploited in the evaluation and authority decision making concerning seasonal variation and adjustments needed for heating period measurements in order to determine the annual average radon exposure. The results will also be utilised in international work, in ICRU (International Commission on Radiation measurements and Units) Report Committee 27 on Measurements and Reporting of Radon Exposures.

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Hannu Arvela

Nationwide indoor radon sample survey (VARO)

Aim

The aim is to obtain an overview of the exposure to indoor radon in dwellings in Finland. The particular interest is in characterising the changes in building practices that have taken place since the previous nationwide sampling survey in 1990 – 1991.

Description of work

A total of 2 882 randomly selected dwellings were measured (6 000 were invited) using STUK's alpha track detectors. The first measurement took place from April to November 2006 and the second one from November 2006 to April 2007. The residents completed a 2-page questionnaire concerning the building characteristics of the house. The national and regional statistical radon parameters were calculated. The effects of construction year, foundation type, ventilation type and other house-specific factors on indoor radon were determined. The seasonal variation in indoor radon was also reported.

The nationwide annual average concentration was 121 Bq/m^3 in houses and 49 Bq/m^3 in flats. The overall annual average is 96 Bq/m^3. The percentages of dwellings exceeding 200 Bq/m^3 for houses and flats were 15.1% and 1.5%, respectively, and 10.4% for all dwellings.

Dissemination and exploitation of results

Results have been reported in a STUK-A series and have been presented in a European IRPA meeting and in a national seminar concerning indoor air. In 2011 a scientific article will be prepared for a refereed journal. The results provide the basic data needed in risk communication and when planning the development of the national radon policy.

Collaborators

No collaborators outside STUK

Schedule

2006 – 2012

Project leader

Tuomas Valmari

Radon at workplaces

Aim

The aim is to establish a database of radon measurements made at workplaces for utilisation in radon prevention studies.

Description of work

The database consists of the results of radon measurements at workplaces beginning in 2001 and information from questionnaires. Information will be gathered in the database from a total of 10 000 radon measurements. The project will provide various kinds of statistics concerning radon measurements at workplaces, e.g. the number of workers and working hours spent in specific work spaces. It is possible to classify radon measurements according to the type of workplace (office, industrial spaces) and the type of measurement place. A special review of underground workplaces will be written, because these are subject to special control. The analysis will yield the regional average and median of radon concentrations and also the number of measurements that exceeded the action level of 400 Bq/m^3.

Dissemination and exploitation of results

A scientific article will be published in 2011–2012.

Collaborators

No collaborators outside STUK

Schedule

2010–2012

Project leader

Heikki Reisbacka

Mapping of radon in houses

Aim

The project is aimed at maintaining up-to-date radon maps and statistics on the radon measurement situation in Finland. The project will also provide radon measurement data for other projects that are examining the effect of various building practices on indoor radon concentrations.

Description of work

The results of approximately 10 000 alpha-track radon measurements carried out by STUK in dwellings each year are stored in a national measurement database, together with the data from the 2-page questionnaire completed by the residents of the measured houses. The questionnaire concerns building characteristics of the measured house (foundation type, ventilation strategy, radon prevention etc.). Radon maps and measurement statistics are regularly produced.

Dissemination and exploitation of results

The Radon Atlas of Finland 2010 was published in a STUK-A series. Radon maps and measurement statistics are published on the STUK website. The information is exploited in public communication and regional radon campaigns. The measurement data are also utilised in various research projects.

Collaborators

No collaborators outside STUK

Schedule

Continuous project

Project leader

Tuomas Valmari

Factors affecting indoor radon concentrations in Finland (SIRA)

Aim

This project aims at quantifying the factors (other than radon prevention and mitigation) that affect the indoor radon concentration in Finnish houses and flats and following up the radon situation in Finland. A key task is to develop methods to obtain representative results from the extensive but unrepresentative data in the national radon measurement database.

Description of work

The database, currently containing over 100 000 measurements, is being analysed in this project. The geographical distribution of the measurements is uneven due to the higher measurement activity in the radon-prone areas. A method based on weighting of the data according to the local housing density was developed to obtain representative values for regional radon parameters. The method has also been used to produce a follow-up of the radon situation in Finnish low-rise residential buildings (mean radon concentration vs. construction year). In addition, the method has been tentatively applied in studying the effect of foundation type and ventilation strategy on the radon concentration. Work is ongoing to compensate for the unrepresentativeness in the database material concerning house-specific factors. The methods so far used only for low-residential buildings will also be applied to flats.

Dissemination and exploitation of results

Understanding of the key factors affecting indoor radon is used in risk communication and in guidance concerning radon measurements, radon prevention and mitigation. So far, the method based on weighting the data according to the local housing density has been published in a scientific article and has been presented in scientific conferences.

Collaborators

No collaborators outside STUK

Schedule

Continuous project

Project leader

Tuomas Valmari

3.2 Mitigation of radon and other naturally occurring radionuclides

Radon campaigns

Aim

The aim of radon campaigns is to increase radon awareness among the general public, to increase radon measurement activity and activate home owners to perform indoor radon mitigation, and to increase general radon communication. Through the extensive database maintained by STUK, the results will be exploited in research aiming at the development of Finnish radon policy.

Description of work

During the campaign, house owners can carry out indoor radon measurements for a reduced price. The target of STUK is at least 5 000 radon campaign measurements per year. Regional radon data and trends in radon concentrations have been published in radon campaign reports (STUK-A233, Radon campaigns – Status report 2008) and on the STUK website. Analysis of the results and publication on the website will be continued. The project also includes follow-up of the indoor radon mitigation measures needed in the campaign areas. The results will be utilised in the development of mitigation policy. Training of local companies in radon mitigation is also a part of the programme. Mitigation training has been offered in nine one-day seminars.

Dissemination and exploitation of results

The campaign and Finnish radon policy will be developed on the basis of the results achieved. Publications will be issued, among others, as press releases and articles, research reports and scientific articles and on the STUK website.

Collaborators

Local health authorities of Finland. The Ministry of Social Affairs and Health supports the campaign.

Schedule

2003 – 2012

Project leader

Heikki Reisbacka

RADPAR: Radon prevention and remediation

Aim

The general objective of this project is to assist in reducing the significant public health burden of radon related lung cancers in EU Member States (MS). The effectiveness of the various existing radon prevention and remediation technologies in the MS will be assessed with the objective of improving them. Existing radon control strategies in EU Member States will be critically reviewed. Radon risk communication strategies targeted at policy and decision makers, the general public and high risk groups such as people in high-radon areas and smokers will also be developed. Altogether, 13 countries are participating in this EU DG SANCO project.

Description of work

The main work packages are:

- Coordination WP1
- Dissemination of the results WP2
- Evaluation of the project WP3
- Development of policies and strategies to promote effective radon prevention and remediation WP4
- Establishment of an EU radon risk communication network WP5
- Assessment and harmonisation of radon control technologies in Member States, WP6
- Analysis of the cost-effectiveness and health benefits of radon control strategies WP7

The key task of STUK has been to carry out a questionnaire study on the techniques used and their efficiencies in radon remediation in existing dwellings and radon prevention in new construction. The effect of the measures on energy consumption will be also estimated. In addition, STUK is participating in an evaluation of the effect of new energy saving passive constructions on indoor radon concentrations and in the development of a common framework for radon remediation training.

Dissemination and exploitation of results

The report "Assessment of current techniques used for reduction of the indoor radon concentration in existing and new houses – RADPAR questionnaire study" will be published in a STUK-A-series report in 2011. An international publication on these results is in preparation. The Finnish results are published in RADSPAR Newsletters and on the website *http://web.jrc.ec.europa.eu/radpar/index.cfm.*

Collaborators

Associated partners: University of Western Macedonia (UOWM), Greece; Bundesamt fur Strahlenschutz (BfS), Bremen Institute for Prevention Research and Social Medicine (BIPS), Germany; The Chancellor, Masters and Scholars of the University of Oxford, UK; Centre Scientifique et Technique du Batiment (CSTB), France; Institute Superiore di Sanita (ISS), Italy; Austrian Agency for Health and Food Safety (AGES), Austria; Norwegian Radiation Protection Authority (NRPA), Norway; International Bureau for Environmental Studies (IBES), Belgium; Joint Research Centre (JRC), European Commission, Italy; and National Radiation Protection Institute (SURO), Czech Republic. Collaborative partners from: World Health Organisation (WHO); Federal Office of Public Health, Switzerland; Health Protection Agency (HPA), UK; Technical University of Helsinki, Finland; University of Cantabria, Spain; University of Porto, Portugal; and Radiological Protection Institute of Ireland.

Schedule

2009–2012

Project leader

Hannu Arvela

Radon mitigation measures in dwellings and work places

Aim

Aim of the project is to develop the mitigation techniques and to maintain national top expert knowledge on the radon mitigation measures carried out in Finland and to utilise this knowledge in the preparation of national guidance and in training material.

Description of work

The number and efficiency of mitigation measures carried out will be estimated using STUK's radon measurement database, and if needed using an additional questionnaire addressed to households where radon remediation has been implemented.

Work plan for 2010–2011: The Finnish indoor radon mitigation guide, STUK-A229, was published in 2008. Based on comments received and additional material collected during 2010 and 2011, the guide is being revised in 2011 and a new edition is being published. Detailed mitigation examples are being added, in particular examples of sub-slab depressurisation systems.

Utilisation of a normal drainage piping system in radon mitigation is being studied in field experiments in low-rise residential buildings. The drainage piping system is located in the house foundation, outside the base wall and below the lowest point of the footing. In this method, an exhaust fan is connected to the inspection well of the drainage piping. The effect of the fan on the indoor radon level is being studied using a continuous radon monitor. According to the first trials, this method provides an economical and efficient way to reduce the indoor radon concentration.

A guide on radon mitigation measures at work places and in large buildings is being prepared based on the results of several commissioned studies carried out in last 10 years.

Dissemination and exploitation of results

An international article on the efficiency of radon mitigation measures will be published in a peer-reviewed journal. The radon mitigation guide is being revised and a new edition is to be published. Examples of the depressurisation of a drainage piping system have been added to the mitigation guide.

Collaborators

No collaborators outside STUK

Schedule
Continuous project

Project leader
Olli Holmgren

Radon prevention in new construction

Aim

The aim of the project is carry out research and to provide the results for use by building inspection authorities and the construction industry in such a way that they have the best possible influence on radon prevention in new construction in Finland. Radon prevention work aims at the widespread use of efficient prevention techniques in all new Finnish construction work.

Description of work

In 2009, STUK carried out random sample survey in 1 500 new low-rise residential building on the radon prevention practices and indoor radon concentrations. The results have been published in a national report (STUK-A244) and also in an international publication. The results were very promising, showing a marked reduction in the radon concentrations. Preventive measures have been carried out in 50% of new construction, and in areas with the highest radon concentrations these measures have reduced the radon concentration by 50%. These results will form the basis for future work.

The work will be continued by estimating the prevalence and efficiency of preventive measures in Finland through case studies, using the STUK radon measurement database and through new national sample surveys.

The practical guidelines (RT building file, RT 81-10791) will be revised in cooperation with the Ministry of Environment and Building Information Ltd. This work will take place in 2011–2012. The research results of STUK and the complementing guidelines issued via the STUK website will be utilised. Experiences from US guidelines will also be utilised in this work.

The survey and case studies carried out in 2009 showed that radon piping with passive ventilation (no electrical fan coupled) typically reduces radon concentrations by 20–60%. In order to obtain further physical confirmation, case studies will be continued in 2011.

Dissemination and exploitation of results

Development of national guides in co-operation with Building Information Ltd; A STUK-A-series report, STUK-A244, Radon prevention in new construction – Sample survey 2009, 2010; a refereed publication in Radiation Protection Dosimetry 2011; national journal articles; scientific article on the effect of passive radon piping; direct communication with the Ministry of the Environment; the STUK website.

Collaborators
The Ministry of the Environment and Building Information Ltd, Finland

Schedule
Continuous project

Project leader
Hannu Arvela

Mitigation of radiation exposure to radon by household water treatment

Aim

The objective of the project is to 1) review research on household water treatment to remove radon carried out at STUK since 1997, 2) disseminate previously unpublished data and 3) prepare a doctoral thesis.

Description of work

A doctoral thesis will be compiled from the following publications:

- Turtiainen T, Salonen L. and Myllymäki P. Radon removal from different types of ground water applying granular activated carbon (GAC) filtration. Journal of Radioanalytical and Nuclear Chemistry 2000; 243 (2): 423–432.
- Turtiainen T. Radon removal by aeration – observations on testing, installation and maintenance of domestic treatment units. Water Science and Technology: Water Supply 2009; 9 (4): 469–475.
- Turtiainen T and Salonen L. Prevention measures against radiation exposure to radon in well waters: Analysis of the present situation in Finland. Journal of Water and Health 2010; 8 (3): 500–512.
- Vesterbacka P, Turtiainen T, Heinävaara S, Arvela H. Activity concentrations of ^{226}Ra and ^{228}Ra in drilled well water in Finland. Radiation Protection Dosimetry 2006; 121 (4): 406–412.
- Turtiainen T. Measurement of radon emanation of drainage layer media by liquid scintillation counting. Journal of Radioanalytical and Nuclear Chemistry 2009; 279 (1): 325–331.

Dissemination and exploitation of results

Several articles have been published in peer-review journals (see above). The thesis in now being prepared and it will be published as a STUK-A series report.

Collaborators

No collaborators outside STUK

Schedule

2009–2011

Project leader

Tuukka Turtiainen

4 Environmental research

4.1 Integration of environmental research

STAR: Strategic Network for Integrating Radioecology

Aim

The goal is to efficiently integrate important organisations, infrastructures and research efforts into a sustainable network that contributes to a European Research Area in radioecology.

Description of work

To achieve the goal, a Joint Programme of Activities (JPA) will be implemented covering the integration and sharing of infrastructures; training, education and mobility; knowledge management and dissemination. STAR has three key research themes: integrating human and non-human radiological risk assessments; radiation protection in a multi-contaminant context and ecologically relevant low-dose effects. To help address the challenges of STAR research, Observatories for Radioecological Research will be included in JPA. The Network will interact with other European and international research institutes in radioecology, radiobiology and ecology to produce the best research for addressing the key scientific challenges in radioecology. STAR will promote integration, networking and scientific excellence to benefit human and environmental radiation protection. A vital role of STAR is to develop a transition plan to sustainability that invokes a permanent management structure (the European Radioecology Alliance) and long-term funding for radioecological research, infrastructure, training and education.

The STAR Network of Excellence is funded by the European Commission in the Seventh Framework Programme.

Dissemination and exploitation of results

The dissemination and promotion of networking activities will occur via a web portal, presentations at conferences, the development of STAR's role in a long-term, international conference series and at focused workshops. STAR's innovative web portal will form the basis for an accessible radioecological knowledge management system that will contain, for instance, searchable databases, e-learning packages and training material. Scientific achievements will be published in peer-reviewed journals and they could also form parts of doctoral theses.

Collaborators

Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France (overall project coordinator); Belgian Nuclear Research Center (SCK-CEN), Belgium; Natural Environment Research Council – Centre for Ecology and Hydrology (NERC), UK; Research Centre in Energy, Environment and Technology (CIEMAT), Spain; Stockholm University (SU), Sweden; Bundesamt für Strahlenschutz (BfS), Germany; Norwegian Radiation Protection Authority (NRPA); and Norwegian University of Life Sciences (UMB), Norway.

Schedule

2011–2015

Project leader

At STUK: Tarja K. Ikäheimonen

4.2 Transfer of radioactive substances in the environment

Long-term effects of ^{137}Cs fallout on trees

Aim

^{137}Cs activity concentrations in trees are being examined in commercial forest stands to provide information for the assessment of radioactivity in timber and wood fuels. The project aims to determine: 1) how ^{137}Cs activity concentrations in trees vary between forest stands of different ages, 2) how ^{137}Cs activity concentrations in trees change in the course of time (in the long term), and 3) how the forest site type affects the ^{137}Cs concentrations in trees.

Description of work

The project was started in 1997 in co-operation with Finnish forest industries. The study sites are located in Central Finland, which is a part of the area that was contaminated with ^{137}Cs from the Chernobyl fallout in 1986. The studied forests are spruce or pine-dominated coniferous forests growing on dryish or moist sites on mineral soil. The study sites represent common forest types in Southern and Central Finland. The tree stands represent three different development classes.

Sampling of trunk wood and other parts of trees was carried out in 1999 and 2005 at six sites. The ^{137}Cs activity concentrations in samples have been determined using gamma-ray spectrometry. Samples of soil and ground vegetation have also been collected and analysed. The ^{137}Cs distributions in trees and soil have been obtained from these sample measurements. The existing data are being analysed and a summary of results prepared.

Dissemination and exploitation of results

The results will be published in scientific journals or in the STUK-A report series and they will be communicated to the Finnish forest industries involved in the project. The results could be used for the evaluation of radioactivity in domestic wood products and in models developed for exposure assessment.

Collaborators

Finnish forest industries

Schedule

Continuous project. The project was, however, discontinued in 2001–2003 due to the execution of other projects. Sampling and ^{137}Cs determinations will be planned annually. The project will continue for the present.

Project leader

Virve Vetikko

Guide for sampling forest vegetation and soil (NKS-FOREST)

Aim

The main objective of the Nordic FOREST project 2005–2008 was to prepare guidance for the sampling of forest vegetation and soil. The motivation for the guide originated in the need to improve the comparability and credibility of forest radioactivity data published internationally. Secondly, a Nordic forest seminar for the presentation of new results from radioecological studies related to forests was arranged. The seminar supported the third objective of the project, activating a network for scientists and experts involved in studies of forest radioecology or having an interest in preparedness to manage contaminated forests.

Description of work

As a result of the work of four partner organisations from Norway, Sweden and Finland under the FOREST project of the Nordic Nuclear Safety (NKS) Research Programme, three outputs were delivered in 2008–2009.

A guide for sampling forest vegetation and soil for radioecological studies, planned and compiled in 2005–2008, was published as an NKS report in 2009. The Nordic FOREST seminar was organised at STUK for scientists in the field of forest radioecology and representatives of the forest industry in 2008, and the proceedings were published as an electronic version of an NKS report in 2009. Thirdly, the Nordic network for forest radioecology was activated in 2008.

Dissemination and exploitation of results

The publications and the new network were presented on the web page of NKS and information was sent using the distribution list of the NKS radioecology programme.

Collaborators

Swedish Defence Research Agency (FOI), Sweden; Institute for Energy Technology (IFE), Norway (overall project coordinator); Forest Research Institute, Parkano Research Unit, Finland.

Schedule

2005–2009

Project leader

At STUK: Aino Rantavaara

Fertilisation effect on the radionuclide distribution in forests

Aim

Mineral fertilisation (NPK, PK) was foreseen and has hitherto been shown to reduce the radionuclide contamination of forest vegetation, particularly trees, and to reduce Sr in selected tree compartments. The aim of the collaborative fertilisation studies is to systematically quantify the effect of fertilisation, applying scientifically based field experiments and sampling and analysis methods. The ultimate goal is to provide scientific information on the usefulness of sustainable forest management methods as countermeasures that can contribute to the production of acceptable timber and other forest products after radionuclide contamination of forests.

Description of work

The field experiments chosen for analysis of the effect of forest management methods on radionuclide uptake and distribution in the forest ecosystem were established to test forest growth. The stands and sites differ in fertility, soil type and development stage of the stands, as well as the species of dominant and undergrowth trees. The experimental forests are located on mineral soils (4 sites) and peatlands (3 sites) with different vegetation types. Scots pines are mostly the dominant trees; Norway spruce and silver birch are also included. From a mature spruce stand, harvest losses were also sampled. The obtained data were used to assess the development of the activity content in wood ash after recycling of biofuel ash. In most of the field studies, the division of trees into compartments for radionuclide analysis has also allowed estimation of the activity concentration in various tree fractions used for bioenergy and the effect of fertilisation on them.

In addition to mineral fertilisation (NPK, PK), the effects of liming, prescribed burning, wood ash fertilisation and soil preparation on radionuclide uptake by forest vegetation have also been examined. Analysis of the liming experiment included both radioactive caesium and strontium.

The most comprehensive sampling and analysis was carried out for measurement of the fertilisation effect on radiocaesium budgets of a forest on mineral soil and another on peatland in 1997. Scots pine was the dominant tree species on both sites, while the undergrowth trees consisted of Norway spruce and silver birch. Ten years later, the sampling and analysis of needles was duplicated to determine whether there was a continued fertilisation effect on radionuclide uptake from soil to trees. Tree sampling and the pre-treatment of samples was also repeated at one site in the same year.

The experimental studies confirmed the long-term effect of mineral and wood ash fertilisation. The nutrient status before fertilisation and the application dose were significant factors reducing the ^{137}Cs concentrations in the trees. Reduction to a half of the initial activity concentration in stem wood grown on unfertilised soil is a realistic goal for the delayed effect measured several years after the treatment. The main sources of variation can often be identified, when data from different sites corresponding to varying application doses of K are compared. There is evidence for a continued fertilisation effect approximately twenty years after treatment, with a gradually declining effect for even longer.

Dissemination and exploitation of results

Conferences on environmental radioactivity (several articles in Radioprotection), the most recent in Hamilton, Canada (June 2011) and Bergen, Norway 2008. Articles in technical reports, information bulletins, and the Nordic forest seminar Helsinki 2008. Communication with the forest industry. A plan for the networked preparation of guidance for the management of contaminated forests (2009).

Collaborators

Forest Research Institute, Finland

Schedule

2007–2011

Project leader

At STUK: Aino Rantavaara

Needles from permanent monitoring plots as indicators of ^{137}Cs uptake by trees

Aim

Through analysis of time series of the concentrations of ^{137}Cs in needles, variability in its uptake by trees can be analysed. Site and stand conditions, including the surface density of ^{137}Cs, explain the distribution of concentrations and are aimed to be used in the interpretation of the data. The data could be used to evaluate the usability of needles as indicators of ^{137}Cs uptake by trees.

Description of work

Several forest sites in the Chernobyl-contaminated area in Southern Finland are included in regular annual sampling of pine and spruce needles. Current (c) and one-year-old needles (c+1) have been collected. The time series of activity concentrations of ^{137}Cs started in 1987 and has been completed to cover most of the years up to the early 2000s. The analysis of data is continuing in 2011.

Dissemination and exploitation of results

To be published in as a scientific article.

Collaborators

Forest Research Institute, Parkano Research Unit, Finland

Schedule

2009–2012

Project leader

Aino Rantavaara

Summary of studies carried out in the aquatic environments of Finnish nuclear power plants

Aim

The objective of the project was to prepare an extensive summary of the ecological and radioecological studies carried out in the sea areas off the Loviisa and Olkiluoto nuclear power plants during 40 years, to compare the results obtained from these two areas and the suitability of the areas for receiving cooling water discharges, and to assess the impact of environmental factors on the obtained results in both areas.

Description of work

The ecological effects of both thermal discharges and radioactive discharges on the aquatic environment were considered. The sea areas off Loviisa and Olkiluoto differ substantially from each other with regard to topographic characteristics (open coastal area/sheltered archipelago area), salinity of the water, the level of eutrophication (Gulf of Finland/Bothnian Sea), and other parameters. The goal was to distinguish on the grounds of the results, which part of the eutrophication trend in the sea areas has been caused by local thermal discharges and which part is due to the general eutrophication trends of the larger sea areas, the Gulf of Finland and the Bothnian Sea, during the study period.

Dissemination and exploitation of the results

The studies carried out in Loviisa and Olkiluoto over 40 years have generated a very extensive and valuable set of results. For many variables, the long time series of the results is unique. The extensive study material collected during the 40-year period was summarised and published in a PhD thesis. The results of the study could be exploited in public relations and the planning of further studies.

Collaborators

No collaborators outside STUK

Schedule

2006–2009

Project leader

Erkki Ilus

The Arctic Monitoring and Assessment Programme (AMAP)

Aim

The Arctic Monitoring and Assessment Programme was established in 1991 to monitor identified pollution risks and their impacts on Arctic ecosystems. The AMAP is a group working under the Arctic Council. One of the key pollutants in the AMAP programme is radioactivity.

Description of work

STUK is responsible for the radioactivity data in the Finnish National Implementation Plan.

Dissemination and exploitation of results

A 3rd AMAP Radioactivity Report was published in 2010. The data are stored in an AMAP database.

Collaborators

Nordic Radiation Protection Agency (NRPA), Norway; Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) and Centre for Environmental Chemistry, SPA "Typhoon", Russian Federation; Risø DTU National Laboratory for Sustainable Energy, Denmark; Department of Energy (DOE), Canada; International Atomic Energy Agency (IAEA); Icelandic Radiation Safety Authority (GR), Iceland; University of the Faroe Islands, Denmark; and Finnish Meteorological Institute (FMI), Finland.

Schedule

Continuous project

Project leader

Dina Solatie

Behaviour of ^{210}Po and ^{210}Pb in the environment

Aim

The general goal of the project was to obtain an overview of the behaviour and mobility of ^{210}Po and ^{210}Pb in the environment. In most cases, the dominant contribution to radiation doses derives from natural ^{210}Po and ^{210}Pb in food, while the contribution from anthropogenic ^{137}Cs is negligible. In this study, the binding and mobility of ^{210}Po and ^{210}Pb in soil were studied, as well as the transfer of polonium and lead from soil to plants and the contribution of surface fallout in plants. The activity concentrations of fallout-derived ^{137}Cs were analysed as a point of comparison.

Description of work

The radioactivity concentrations of ^{210}Po and ^{210}Pb in forest soil and in vegetation were determined. The soil samples were collected from Scots pine forests from seven locations in Finland. Two of these were main study areas, one in Southern Finland and the other in Northern Finland. At the northern Finland site, the radioactive concentration due to the Chernobyl fallout was low, while at the site in southern Finland the ^{137}Cs concentration from the fallout was ten times higher. In northern Finland, wild berries were also collected from Downy birch and Norway spruce forests.

Soil profiles were separated into various horizons: litter, organic and mineral soil layers. Vegetation was also collected at the sampling sites. Samples of wild berry plants, blueberry and lingonberry and also mushrooms of different kinds were collected from both sites. The activity concentrations of ^{210}Po, ^{210}Pb and ^{137}Cs were analysed from rhizomes of the berry samples and separately from berries, leaves and stems.

Dissemination and exploitation of results

The results have been published in scientific publications.

Collaborators

Finnish Academy and Finnish Forest Research Institute (METLA)

Schedule

2006–2009

Project leader

At STUK: Dina Solatie

^{90}Sr and ^{137}Cs in deposition, grass and milk in Northern Finland

Aim

STUK's Regional Laboratory in Northern Finland has regularly analysed ^{90}Sr and ^{137}Cs in deposition, grass and milk samples from different sites in Northern Finland. The aim of this study was to investigate the changes in ^{90}Sr and ^{137}Cs concentrations since the atmospheric nuclear weapon tests and following the Chernobyl accident, and to estimate and compare the ecological half-lives in milk and deposition.

Description of work

Milk was sampled at different sites in Finnish Lapland and in the Province of Oulu beginning in 1960. Some grass and AIV silage were also taken from the farms. The deposition was sampled in Apukka from October 1972 onwards. Sr was separated from samples using two different methods: the traditional fuming nitric acid method and extraction chromatography using an Sr resin (Eichrom). The strontium was measured through its yttrium daughter with a proportional counter. ^{137}Cs was measured by gamma spectrometry.

Dissemination and exploitation of results

The results were published in a scientific publication.

Collaborators

No collaborators outside STUK

Schedule

2008

Project leader

Dina Solatie

Cesium-137, Polonium-210 and Lead-210 concentrations in seal from Arctic seas, the Baltic Sea and Lake Saimaa in 1995–2009

Aim

The aim of this study was to provide baseline data on radionuclide concentrations and their distribution in seals (*Phocida*) in three environments: marine, brackish and freshwater ecosystems.

Description of work

Seal samples from Arctic seas were delivered to STUK by Murmansk Marine Biological Institute (MMBI) and Akvaplan Niva, and seals from the Gulf of Bothnia and Lake Saimaa were provided by the Natural Heritage Services of the National Board of Forestry, Finland. The carcasses were dissected and both gamma and alpha emitting nuclides were analysed by STUK.

Dissemination and exploitation of results

The results will provide a contribution to assessment of the recent radioactivity situation in the northern hemisphere and how the activity concentration has changed over time. Public knowledge and awareness of the vulnerability of the Arctic will be raised. The results will be published in an international scientific journal.

Collaborators

Finnish Food Safety Authority Evira and Natural Heritage Services of the National Board of Forestry, Finland; and Akvaplan-Niva AS and Polar Environmental Centre, Norway.

Schedule

2009–2011

Project leader

Jarkko Ylipieti

Natural radionuclides in meadow and pasture land in the Nordic countries (RADPAST)

Aim

The aim of the project is to determine the status of natural radionuclides in meadow and pasture land and in grassland plants in the Nordic countries and on the transfer of these radionuclides in the food chain soil–pasture–milk/meat. Limited data are currently available on the transfer of natural radionuclides in food chains and on the concentrations of these radionuclides in milk and meat in the Nordic countries.

Description of work

The participants in each country will select four sampling sites/farms, including different soil types and some areas with high natural background radiation. Samples of soil, water, grass and milk/meat are to be taken at each site. The same sampling procedure is to be used in all of the participating countries. The soil characteristics (pH, %OM, CEC, sand and clay content in mineral fraction) will be determined in order to enable comparison with the data published in IAEA-TECDOC-1616. Naturally occurring radionuclides (^{238}U, ^{235}U, ^{232}Th, ^{228}Th, ^{228}Ra, ^{226}Ra, ^{210}Pb, ^{210}Po and ^{40}K) and ^{137}Cs will be determined from the samples. Intercomparison between the participating laboratories to determine the natural radionuclides in a reference soil sample by gamma spectrometry will be carried out to ensure the quality of the results. Transfer factors from soil to grass and milk will be calculated and the doses from milk consumption will be assessed.

Dissemination and exploitation of the results

The results of the project are to be published annually in NKS reports and in an international peer-review journal. The results will provide valuable new data for assessing the effective radiation doses from natural radionuclides. In addition, the transfer data could be used when estimating the influence of possible mining activities.

Collaborators

Swedish University of Agricultural Sciences (SLU), Sweden (overall project coordinator); Norwegian Radiation Protection Authority (NRPA) and Norwegian University of Life Sciences (UMB), Norway; Risø DTU National Laboratory for Sustainable Energy, Denmark; and Icelandic Radiation Safety Authority (GR), Iceland.

Schedule
2009–2011

Project leader
Eila Kostiainen

Effect of liming on the transfer of ^{90}Sr into fish

Aim

The project aims at assessing the effect of liming on the transfer of ^{90}Sr into fish and evaluating the usability of liming as a countermeasure in case of a radiological accident.

Description of work

In 1991 the Finnish Game and Fisheries Research Institute conducted experimental liming in a small acidified lake. The lake was divided into two parts and calcium carbonate was added to one half. Both fish and water samples were collected from this lake during 1986–2006 and now analysed for ^{90}Sr. The data will be evaluated to determine whether liming reduces ^{90}Sr accumulation in fish. The results will provide new information on the usability of countermeasures in case of a radiological accident. Additionally, the effect of water chemistry, such as pH, on the accumulation of ^{90}Sr in fish will be evaluated.

Dissemination and exploitation of the results

The results will be published as an article in an international publication series. The results could also be utilised in improving the models describing the transfer of radionuclides in the environment and in assessing different countermeasures in case of a radiological accident.

Collaborators

Finnish Game and Fisheries Research Institute

Schedule

2009–2010

Project leader

Iisa Outola

Assessment of weathering and leaching rates of Thule hot particles (HOTRATE)

Aim

The project aimed at assessing the weathering and leaching rates of terrestrial Thule Pu/U particles through laboratory experiments. The suitability of sequential extraction method to assess leaching and health aspects of hot particles were evaluated.

Description of work

The dissolution of plutonium and americium from the hot particles was studied in the laboratory using a sequential extraction protocol that had previously been developed and used for soil and sediment samples, but not for single particles. Experiments were carried out separately with two hot particles. Existing procedures were converted to the micro-scale. Information obtained from the study could also be used to assess the environmental migration of plutonium and americium.

Dissemination and exploitation of the results

Results have been reported according to the NKS (Nordic Nuclear Safety Research) project plan (Roos P et al. Assessment of weathering and leaching rates of Thule hot particles. NKS-215). They have also been published in an international publication series (Outola I et al. Leaching of ^{239,240}Pu and ^{241}Am from Thule nuclear bomb particles investigated by sequential extraction. In: Warwick P (Ed.). Environmental Radiochemical Analysis IV. Cambridge: The Royal Society of Chemistry; 2011. p. 155–164). The methods developed in the project could be utilised when assessing the health hazards from hot particles in case of a radiological accident.

Collaborators

Risø DTU National Laboratory for Sustainable Energy, Denmark; Swedish Defence Research Agency (FOI), Sweden; and Institute for Energy Technology (IFE), Norway.

Schedule

2009

Project leader

Iisa Outola

Cosmogenic ^{7}Be and ^{22}Na isotopes as atmospheric tracers (COSMO)

Aim

The aim of the project is to examine the behaviour of cosmogenic isotopes in surface air in Finland and draw conclusions on the possibility to use them as atmospheric tracers.

Description of work

There are eight airborne radioactivity monitoring stations in Finland. These stations were established after the Chernobyl accident. In nominal operation they collect data on a weekly basis. Data on cosmogenic isotopes have been collected since the beginning of sampling from four stations: Kotka, Kajaani, Rovaniemi and Ivalo. The time-series were analysed using novel time series analysis tools to identify periodicities. The observed periodicities could be linked to large-scale climatic phenomena such as the North Atlantic Oscillation, Arctic Oscillation and Southern Oscillation. Since in many of the climatic proxies the data are collected on an annual basis, these observations could provide information on short-term climatic events and contribute to understanding of the past climate. Another area of interest is the ratio of ^{7}Be/^{22}Na, which could be used as a radiochronometer for atmospheric dynamics. Since both isotopes are formed in the upper atmosphere, the ^{7}Be/^{22}Na ratio could be an excellent tracer for vertical atmospheric transport.

Dissemination and exploitation of results

The results will provide updated information on the transport, production and behaviour of cosmogenic isotopes in the atmosphere. The results have been or will be published in peer-reviewed journals where the information is available to all interested scientists. The results will be utilised by atmospheric scientists and modellers when developing atmospheric transport and dispersion models.

Collaborators

Sodankylä Geophysical Observatory, Oulu University, Finland

Schedule

2006–2013

Project leader

Ari-Pekka Leppänen

Mobilisation of radionuclides and heavy metals from mining mill tailings

Aim

The main objective is to study the solubility of natural radionuclides from uranium mill tailings waste and to determine the chemical forms of dissolved radionuclides to evaluate their transfer properties in the surrounding soil. Secondary targets are mill tailings waste from apatite mining and the solubility of heavy metals. New data and understanding will be gained from the northern boreal environment. The results will also form an important part in estimating radiation doses to humans and to the environment resulting from the disposal of mill tailings waste. In the study, the following questions will be addressed:

- In which mineral phases do the radionuclides occur in the ores and in the mill tailings?
- What are the residual fractions of radionuclides in the mill tailings compared to the original ores?
- What are the solubilities of radionuclides and heavy metals from the ores and from the mill tailings, and what factors affect these solubilities?
- What are the chemical forms of radionuclides in solutions with contact to mill tailings?

Description of work

A literature survey will be carried out. Samples from the Sokli apatite deposit in Savukoski, the Talvivaara nickel mine and the former Paukkajanvaara uranium mine in Eno will be taken. The samples will be characterised using XRD and ICP-MS, and will be measured by gamma and alpha spectrometry and ICP-MS. The radionuclide-bearing mineral phases will be identified using SEM/EDAX, LA (laser ablation)-ICP-MS and an FIB microscope. Leaching of radionuclides and heavy metals from ore minerals and mill tailings will be investigated by batch and column leaching of ore and tailings grains with a rainwater stimulant. The oxidation state of uranium in minerals will be determined. For the speciation of the chemical forms of radionuclides dissolved from mill tailings, computational, direct and indirect methods will be used.

Dissemination and exploitation of results

The main project results will comprise basic scientific knowledge for estimation of the solubility and aqueous speciation of radionuclides and heavy metals from mill tailings waste. The results could be used in evaluating the transfer of radionuclides and heavy metals from waste disposal sites to the surrounding soil and aquatic systems. The results of the project will be presented in 5–6 scientific papers to be published in international peer-reviewed journals.

A doctoral thesis based on these papers and two to three Master's theses will also be published. In addition, the project results will be presented at several international conferences during the project duration. Since STUK also has a regulatory authority profile, the project results will be directly available to authorities in the evaluation of mining and mill tailings waste disposal activities. At the end of the project period, the research consortium will organise an open one-day seminar in Rovaniemi for the public and media.

Collaborators
Laboratory of Radiochemistry, University of Helsinki, Finland (overall coordinator of the research programme) and Enterprise Ltd, UK.

Schedule
2010–2014

Project leader
At STUK: Dina Solatie

4.3 Foodstuffs

Cesium-137 in mushrooms after the Chernobyl deposition

Aim

The project aims to assess the ^{137}Cs concentrations of commercial mushrooms in Finland.

Description of work

Variation in the ^{137}Cs concentrations of different mushroom species and in different areas has been studied using the data collected following the Chernobyl accident. The changes in the concentrations since 1986 have been assessed. The aggregated transfer factors of the mushroom species have been calculated for different time periods and areas (sites) in order to determine the areal (site-specific) variation in transfer factors or in the course of time. The aggregated transfer factors have been calculated by using the information on the areal (municipal) deposition and also by using the available data on soil samples. The influence of the Arctic environment on the caesium uptake of mushrooms has been studied by comparing the data from Northern Finland with that from other parts of the country. In 2008 and 2009 the data were supplemented by taking mushroom and soil samples when necessary.

Dissemination and exploitation of the results

The results provide information on the concentration of ^{137}Cs in commercial mushrooms in different deposition areas of Finland. The results will be exploited by providing information and advice to the general public as well as the dealers on the mushroom market. The radiation doses received via ingestion will be assessed using the results. The results of the project have been published in the report STUK-A240 (2010) and will also be published in a scientific journal.

Collaborators

No collaborators outside STUK

Schedule

2008–2009

Project leader

Eila Kostiainen

Radioactivity in cereal crops – survey

Aim

The objective of the project was to gain general information on the activity concentrations of naturally occurring radionuclides in cereal crops and to complement the previously gathered results on artificial radionuclides.

Description of work

The project was carried out in cooperation with Finnish Food Safety Authority (Evira). Evira organised sampling for the project "Fusarium mould toxins, pesticides and ^{137}Cs in cereal crops for human consumption" at 35 flour mills and provided STUK with 68 samples for radioactivity analysis. ^{238}U, ^{232}Th, ^{228}Ra, ^{226}Ra and ^{210}Pb concentrations were determined in 30 samples. From these determinations, concentrations of ^{235}U, ^{234}U and ^{210}Po were estimated. ^{137}Cs was determined in all samples and ^{90}Sr in 20 samples.

The mean effective doses resulting from the radionuclides in cereal products were 31.6 and 24.0 μSv a^{-1} among men and women, respectively. The highest effective doses were caused by ^{210}Po and ^{210}Pb, which accounted for 70% of the total effective dose. Most of the remaining dose was attributed to radium isotopes. The effective dose from artificial radionuclides, ^{137}Cs and ^{90}Sr, was about 1.5% and the dose from U and Th about 0.1% of the total effective dose.

Dissemination and exploitation of results

The results have been published in a peer-reviewed journal.

Collaborators

Finnish Food Safety Authority Evira

Schedule

2008–2010

Project leader

Tuukka Turtiainen

Statistical analysis of ^{137}Cs in freshwater fish

Aim

The projects aimed at assessing the activity concentrations of ^{137}Cs in lake waters and in fish in four small forest lakes at Lammi, Finland, determined after the Chernobyl accident at STUK. Using statistical methods, we sought to determine whether the behaviour of ^{137}Cs in lake waters and in fish or the transfer of ^{137}Cs into fishes differs between two types of lakes: lakes that are part of water courses, meaning that water exchange is relatively rapid, and lakes without any input or output rivers, meaning that the water exchange of these lakes is mainly determined by precipitation and evaporation.

Description of work

Long-term results on the activity concentrations of ^{137}Cs in lake water and in fish from these lakes were analysed with suitable statistical methods. Besides various species of fish, various size groups of the fish were taken into account. In addition to activity concentrations of ^{137}Cs in water and in fish, variation in the transfer coefficients between water and fish in these lake types was statistically tested. Water chemical and hydrological factors of the lakes were taken into account in the statistical analyses. Differences in the recovery of the lakes from the deposited ^{137}Cs were also examined.

Dissemination and exploitation of the results

The study provided information on long-term changes in and recovery from radioactivity in various types of lakes. The results were published in 2010 (Saxén R et al. Transfer of ^{137}Cs into fish in small forest lakes analysed with linear models. Journal of Environmental Radioactivity 2010; 101: 647–653). The results could be utilised in assessments needed in case of some new deposition event.

Collaborators

No collaborators outside STUK

Schedule

2008–2010

Project leaders

Ritva Saxén and Sirpa Heinävaara

Long-term behaviour of ^{137}Cs in lakes and transfer into fish

Aim

This project aims at assessing the long-term behaviour of ^{137}Cs in lakes. The relationship between water parameters and the uptake of ^{137}Cs by fish will also be evaluated.

Description of work

Fish will be sampled from several lakes to identify those lakes where high concentrations of ^{137}Cs remain. Water samples will be analysed from the selected lakes for which information on the water chemistry also exists. The transfer of ^{137}Cs from water into fish will be evaluated, taking consideration the lake characteristics and water chemistry. Dose assessment based on the consumption of fish will also be evaluated.

Dissemination and exploitation of the results

The results will be published as an article in an international publication series. They will be also used to inform the public of the dose associated with the consumption of fish. In addition, the results could be utilised in improving models describing the transfer of radionuclides in the environment.

Collaborators

No collaborators outside STUK

Schedule

2010–2014

Project leader

Iisa Outola

^{137}Cs concentrations in Finnish reindeer meat

Aim

The objective of the project is to analyse reindeer meat ^{137}Cs concentrations as a function of time over a long time period to determine the effective half-life.

Description of work

The measurements of reindeer meat ^{137}Cs concentrations in Finland already began in the early 1960s. The measurements have been carried out ever since. Systematic measurements began after the Chernobyl accident. STUK has 3 reindeer cooperatives that send meat samples regularly every year. The time series of ^{137}Cs concentrations in reindeer meat was analysed, and an effective half-life of 5 – 7 years was determined.

Dissemination and exploitation of results

The results show how ^{137}Cs concentrations vary in reindeer meat. The effective half-life varies regionally and is affected by feeding habits. The results will help in planning countermeasures after a nuclear accident and could serve as an input for decision support systems used in Finland.

Collaborators

Reindeer herder's association, Kemin-Sompio, Paistunturi, Ivalo reindeer herding cooperatives.

Schedule

2007 – 2010

Project leader

Ari-Pekka Leppänen

Determination of the ^{137}Cs content of reindeer summer fodder in the Finnish reindeer management area

Aim

The objective of the project was to investigate the summer fodder plants of reindeers and analyse their ^{137}Cs content and spatial distribution. The results demonstrated the effects of summer fodder on ^{137}Cs concentrations in reindeer meat.

Description of work

In 1997–1998 the reindeer research station of the Finnish Game and Fisheries Research Institute (RKTL) together with the University of Oulu Department of Geography mapped the quality and quantity of vegetation in the Finnish reindeer management area. In conjunction with this, numerous samples of reindeer summer pasture plants were collected for analysis of ^{137}Cs. The samples were quantified by site type and geographical region. Statistical analyses were performed on samples to determine the relationships between site types and geographical locations. *Tricophorum* was also suggested as a new indicator species for reindeer summer pasture plants.

Dissemination and exploitation of results

The results will be used to estimate how possible radioactive fallout would affect the different parts of a reindeer management area. Overgrazing has been seen for many years in the lichen fields and thus the ^{137}Cs levels in the summer fodder have become increasingly important. The study identified possible indicator species along with the lichen that would be sensitive to nuclear fallout. Regional differences in the ^{137}Cs content in different species can be viewed from thematic maps. The ^{137}Cs content will also be compared between the different site types.

Collaborators

Reindeer Research Station of the Game and Fisheries Research (RKTL), Alfred Colbaert and University of Oulu, Finland.

Schedule

2007–2010

Project leader

Ari-Pekka Leppänen

Radioactivity in vegetables – survey

Aim

The objective of the project is to gain general information on the activity concentrations of naturally occurring radionuclides in vegetables produced in Finland and to complement the previously gathered results on artificial radionuclides.

Description of work

The project is being carried out in cooperation with Finnish Food Safety Authority Evira. Evira has organised sampling for the pesticide monitoring programme and provided STUK with samples for radionuclide analysis. The samples are being taken from vegetables produced in the main production areas of Finland. Sampling encompasses the most widely consumed vegetables: potato, carrot, cabbage, onion, tomato, cucumber, lettuce and zucchini. Organic production and greenhouse vegetables are included in sampling. Naturally occurring radionuclides (^{238}U, ^{232}Th, ^{228}Th, ^{228}Ra, ^{226}Ra, ^{210}Pb and ^{210}Po) and ^{137}Cs and ^{90}Sr will be analysed from individual or pooled samples. The average radiation doses from natural and artificial radionuclides due to the consumption of vegetables will be assessed.

Dissemination and exploitation of the results

An article based on the project's outcomes will be prepared and published in an international peer-reviewed journal and in a domestic trade publication. A press release will be prepared at the end of the project. The results will introduce new valuable data to be employed in assessing effective doses from food intake among Finns. Moreover, the results will be utilised in radiation monitoring of the environment.

Collaborators

Finnish Food Safety Authority Evira

Schedule

2009–2011

Project leader

Eila Kostiainen

Caesium-137 in forest food

Aim

The aim is to provide information on the variation of ^{137}Cs concentrations in wild foodstuffs (mushrooms, berries, game meat) in Finland. Changes in the ^{137}Cs levels in the course of time and variation between different areas are being studied, as well as the variation in internal radiation doses due to the consumption of wild food in different areas. The results will provide information for assessing the situation in Finland regarding the maximum permitted level, 600 Bq/kg, recommended to be respected when placing wild game, wild berries and mushrooms on the market (Commission recommendation 2003/274/ Euratom). The results are to be exploited in testing and developing food dose models (RODOS).

Description of work

Sampling of forest products (mushrooms, berries, game meat) has continually been carried out at the monitored sampling sites since 1986 to assess the temporal changes in ^{137}Cs concentrations. The variation between the ^{137}Cs concentrations of different species is being statistically tested using the existing data. Long-term changes in ^{137}Cs levels of different species are being studied. The transfer of ^{137}Cs from soil to mushrooms is being studied by taking soil samples at some sampling sites. Sampling is being directed to areas with the highest ^{137}Cs deposition to obtain information on the highest ^{137}Cs levels in forest food.

Dissemination and exploitation of the results

The results provide information on long-term changes in radioactivity in wild foodstuffs. The results are being exploited in assessing the internal radiation dose due to the consumption of wild foodstuffs, the variation in doses between different areas and in people with different consumption habits. Information on the results is provided on STUK's web pages.

Collaborators

No collaborators outside STUK

Schedule

A continuous programme

Project leader

Eila Kostiainen

4.4 Protection of biota

Application of the ERICA Assessment Tool to freshwater biota in Finland

Aim

In recent years there has been growing international interest in the assessment of doses and risks from ionising contaminants to biota. Several models are now available that enable the assessment of radiological risk to biota. The objective of this project was to perform dose assessments for biota in selected lake ecosystems in Finland affected by the Chernobyl accident.

Description of work

Dose rates to biota were estimated using the ERICA Assessment Tool, a software programme developed within the ERICA project under the 6th EC Framework Programme. The ERICA Tool allows the estimation of dose rates to biota for terrestrial, freshwater and marine ecosystems for a set of default reference organisms or user-defined organisms. The Tool includes databases on radionuclide transfer and dose conversion coefficients enabling dose calculation to be performed from input data on radionuclide concentrations in biota and/or media such as soil or water. STUK's data on the measured activity concentrations of ^{137}Cs, ^{134}Cs and ^{90}Sr in fish, aquatic plants, lake sediment and water were used as input information in the ERICA model. Data sets for three lakes (Lake Päijänne, Lake Siikajärvi and Lake Vehkajärvi) located in a region with high ^{137}Cs deposition were applied in the assessment. The three selected lakes are among those having the highest activity concentrations found in Finland and therefore they represent the highest exposure to biota in freshwater ecosystems affected by the Chernobyl fallout. Measured and predicted ^{137}Cs activity concentrations in sediments were also compared. In addition, the annual dose from ^{137}Cs to perch of Lake Päijänne estimated using the ERICA Tool was compared with the respective dose estimated by a programme earlier developed at STUK for calculating doses to biota.

Dissemination and exploitation of results

The project is related to the ongoing international development in radiation protection of the environment. It builds a basis for applying the framework for the radiation protection of biota to Finnish conditions. The results of the project have been reported in an article (Vetikko V, Saxén R. Application of the ERICA Assessment Tool to freshwater biota in Finland. Journal of Environmental Radioactivity 2010; 101: 82–87).

Collaborators
No collaborators outside STUK

Schedule
2008 – 2009

Project leader
Virve Vetikko

5 Preparedness for nuclear and radiological threats and emergencies

5.1 Emergency management

Nordic Workshop for DSS Experts (NordDSS)

Aim

The main aim of the project was to share information between Nordic countries about procedures and software used to manage nuclear emergencies and exchange experiences.

Description of work

ARGOS and RODOS are decision support systems (DSS) used by nuclear emergency management authorities in Denmark, Sweden, Norway and Finland, together with several other countries. Both DSS feature models and functionalities to simulate the dispersion of an accidental release from a nuclear reactor or another radiological source, visualise measurements, analyse the consequences of the radioactive contamination and evaluate countermeasures. A workshop was arranged in order to share national practice and experience on the use of ARGOS and RODOS during a crisis with the focus on operational implementation and use, the interpretation and verification of results and production of a decision basis. The aim was to establish a common ground to better understand how these DSS are used in the different countries, identify differences and exchange knowledge in order to increase competence. In the long term the outcome could be used to focus future development on improving the operational use of ARGOS and RODOS and harmonise their results.

Dissemination and exploitation of results

The findings of the workshop have been published in an NKS report.

Collaborators

Norwegian Radiation Protection Authority, Norway; Swedish Radiation Safety Authority, Sweden; and Danish Emergency Management Agency, Denmark.

Schedule

2009

Project leader

At STUK: Michael Ammann

Operationalisation of risk assessment for marine reactors (MareNuc)

Aim

The aim of the project is to create a reference Nordic framework (and expert network) for assessing the threats caused by marine reactors (e.g. vessel reactors, floating NPPs).

Description of work

MareNuc is an NKS project co-ordinated by the NRPA. The work includes defining nuclide inventories, source terms and possible accident scenarios. In addition, past accidents will be reviewed and a few accident consequence calculations performed using the existing models. STUK's main task in the project is to present the analogy of the consequence assessment methodologies in marine reactor accidents and NPP accidents.

Dissemination and exploitation of results

A couple of workshops/seminars will be arranged. There will be workshop reports and a final report that will be published as an NKS report. The data collected and the main findings will be taken into account in preparing various Nordic consequence assessment systems and procedures.

Collaborators

Norwegian Radiation Protection Authority (NRPA), Norway; Danish Emergency Management Agency (DEMA), Denmark; and Icelandic Radiation Safety Authority (GR), Iceland. A couple of experts from Russia may also participate in the work.

Schedule

2010–2012

Project leader

At STUK: Juhani Lahtinen

DETECT: Design of optimised systems for the monitoring of radiation and radioactivity in the case of a nuclear or radiological emergency in Europe, Euratom FP7, 2010 – 2013

Aim

The objective of the project is to improve decision making by developing a methodology and planning tool for optimising monitoring systems in Europe. STUK is not directly involved in the development of the methodology, but is an end-user of the final products.

Description of work

The objective will be achieved via:

- Elicitation of the most important criteria for decision making in the early phase of an emergency
- Evaluation of existing information on monitoring strategies
- Analysis of the equipment available at present
- Assessment of recent developments in monitoring equipment for use in a future strategy
- Analysis of the most important release scenarios and definition of the most effective monitoring strategy for this
- Provision of simulated "measurements" for testing
- Development of compendia for the collection of all relevant information related to a monitoring strategy for a given event/scenario combination
- Development of a handbook for assistance in defining monitoring strategies
- Development of an easy-to-use tool for defining the best strategy, including other factors such as monetary, social and political constraints
- Demonstration of the applicability of the methodology on a regional, national and European scale

Dissemination and exploitation of results

Dissemination of the results will on one hand be achieved by creating a user group that actively contributes to the development of the tools, and on the other hand through the demonstration project, which will clearly show the added value of the products developed within DETECT. In particular, the demonstration project will prove to the operational community that the end products can be used for the purpose they have been designed for. Based on the experience gained within the EURANOS project, organisations from other countries could be attracted to contribute to the demonstration project – even if not as a partner – without financial contribution. The user group is also an open forum where

organisations not involved in DETECT can contribute, attend meetings and become involved in contributing to the objectives of DETECT.

The dissemination of the DETECT software will be performed by the Karlsruhe Institute of Technology (KIT), free of charge, for use in emergency centres in the EU and elsewhere (where this is in the interest of the DETECT Consortium), subject to the signing of a software agreement. All cost arising through the installation and customisation phases must be covered by the institution responsible for the future operation of DETECT products.

Collaborators

Belgian Nuclear Research Center (SCK-CEN), Belgium (overall project coordinator); Karlsruhe Institute of Technology (KIT), Westfälische Wilhems-Universität Münster (UOM) and Helmholtz Zentrum München (HMGU), Germany; Risø DTU National Laboratory for Sustainable Energy, Denmark; and Norwegian Radiation Protection Agency (NRPA), Norway.

Schedule

2010–2013

Project leader

At STUK: Raimo Mustonen

NERIS-TP: Towards a self-sustaining European Technology Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery, Euratom FP7, 2010–2013

Aim

The first objective is the establishment and operation of the European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery. The second objective is the realisation of the ICRP 103 recommendations in the simulation models of the European decision support systems ARGOS and RODOS. The third objective is to strengthen the preparedness at the local level, but also strengthen the cooperation between the national and local levels through the establishment or consolidation of local-national fora in five European countries: Slovakia, Spain, France, Belarus and Norway. The fourth objective deals with the development of a toolbox that allows the coupling of an emergency information system such as ECURIE to a decision support system (DSS). Training and dissemination is the fifth objective, aiming at widespread usage of the new products.

Description of work

The first work package 1 (WP1) deals with the establishment of the earlier-created European-wide NERIS Platform and also includes the user groups of the two decision support systems, ARGOS and RODOS. At the end of the project, the NERIS platform will be self-sustainable. WP2 will improve the existing simulation models of DSSs and integrate the new ICRP approach of a residual dose that should not be exceeded in a given period. WP3 deals with tools such as the Governance Framework for preparedness, the European Handbooks, the RODOS and ARGOS systems, the MOIRA DSS and information and communication strategies that could be locally applied to explore where they can improve the local preparedness and to foster cooperation between local, national and international stakeholders. WP4 intends to develop an atmospheric toolbox that allows the use of freely available data at the global level to locally prepare all the meteorological input fields necessary to run the DSS with the source term provided by an emergency information system.

Dissemination and exploitation of results

Training and dissemination will be realised in WP5 in close cooperation with WP1, in which the European platform and all relevant working groups are established. Besides training courses, technical exercises will also be used to test and attract organisations for these new tools.

Collaborators

Karlsruhe Institute of Technology (overall project coordinator) and Bundesamt für Strahlenschutz (BfS), Germany; Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire and MUTADIS, France; Norwegian Radiation Protection Authority (NRPA) and Norwegian University of Life Sciences, Norway; VUJE Inc., Slovakia; Universidad Politécnica de Madrid and Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain; "Horia Hulubei" National Institute of R&D for Physics and Nuclear Engineering, Romania; National Centre for Scientific Research "Demokritos" and University of Western Macedonia, Greece; Risø DTU National Laboratory for Sustainable Energy, Danish Emergency Management Agency (DEMA) and Prolog Development Centre, Denmark; Health Protection Agency (HPA), UK; Ukrainian Center of Environmental and Water Projects, Ukraine; and Belgian Nuclear Research Centre (SCK-CEN), Belgium.

Schedule

2010–2013

Project leader

At STUK: Raimo Mustonen

5.2 Decision support systems

KETALE: A centralised data system for the management of dispersion and dose calculation results

Aim

The objective has been to design and build a data system for the management of various dispersion and dose calculation results and for the rapid preparation of situational analyses and other reports in an emergency.

Description of work

The project started in 2005 with preliminary planning (then not yet as a formal project) and the first operational system was released in May 2008. KETALE is based on web server and database technologies and on open source software. KETALE provides basic tools for data acquisition, data management, data analysis, data visualisation and the preparation of reports. Its data acquisition component allows the making of requests to start calculations or retrieve various meteorology-related data from other systems.

In 2011 the emphasis has been, for instance, on enhancing the possibilities to incorporate the results of the FMI's local-range models in KETALE, on the comparison of calculation data from different models and on creating a source term database. New radiological threats such as RDD explosions will also be taken into account and the overall quality control arrangements will be improved.

KETALE has been tested in many exercises and also during the Fukushima case. It has markedly facilitated STUK's activities during an accident and streamlined the data exchange and general collaboration between the FMI and STUK.

Dissemination and exploitation of results

The project has produced and still produces different working reports, conference presentations and probably also papers published in scientific literature. When KETALE version 1.0 was released, a seminar for national emergency authorities and certain other parties was arranged in 2008.

Collaborators

Finnish Meteorological Institute (FMI)

Schedule
2005–

Project leader
Juhani Lahtinen 2005–2008, Kaj Vesterbacka 2008–2009, Michael Ammann 2009–2011

RODOS: maintenance, adaptation, use, exercises and user group

Aim

The main aim of the project is to maintain and operate the RODOS system as part of STUK's emergency preparedness effort and to participate in the information sharing and networking of the RODOS user group. An additional goal is to extend the potential user basis by making a JRODOS service available to all KETALE users.

Description of work

The project has allocated resources for normal maintenance and operation of the RODOS system in STUK. It covers training, exercises and resources that are needed to participate in the RODOS user group. In addition to the normal resource allocation, the project has also covered additional resources that were needed to test and migrate to the new JRODOS system during 2010. These resources were needed to investigate different deployment scenarios, to integrate geographic and demographic data, to integrate numerical weather prediction data and measurement data, to test the system for compliance with intended use cases, and for other purposes. The project has additionally covered a pilot study to link JRODOS to the KETALE system. The goal is to support the request of JRODOS calculations directly from the KETALE web page, which considerably extends the potential user basis in STUK and allows a better integration of JRODOS results into the decision basis during exercises and emergencies. Another focal point will be to operate JRODOS in the emergency centre on a 24/7 basis for the two domestic NPP sites. The goal is to display constantly updated information on the dispersion situation around these sites and secondly to have constant quality control of the system availability.

Dissemination and exploitation of results

Technical system documentation and standard operating procedures.

Collaborators

RODOS User Group

Schedule

Continuous project

Project leader

Michael Ammann

Development of RODOS forest models

Aim

RODOS forest models were aimed to ensure reliable and sufficient assessments of radionuclide contamination of forests and human doses to different population groups. To protect the users of forests, the significant human dose pathways have been identified and modelled.

Description of work

STUK has been responsible for the development of the two forest models currently integrated in the RODOS system since 1997. During the 4th to 6th Framework programmes of the European Union, the models were built and gradually improved. In 1999, the first operational version of the Food chain and Dose Model for Forests (FDMF) was delivered as a result of collaboration with IRSN (France) and subcontractors at IRH (St. Petersburg, Russia). Outputs of the model were the external dose to people during their stay in forests and ingestion doses from wild foods. The dynamic module provided the time-dependent distribution of radionuclides in the forest and activity concentrations in wild foods. In 2004, the Late Countermeasure Model for Forests (LCMforest) was delivered by STUK. The management options covered the reduction of the ingestion dose and contamination of timber. The concurrent version of FDMF was extended to also consider radionuclide contamination of timber.

During the 6th Framework Programme of the European Union, RODOS models were further developed under the EURANOS project. Modelling efforts were preceded by the compilation of countermeasure descriptions in a fact sheet format that facilitates evaluation of the practicability of management options. In 2007–2009 the model LCMforest was revised and extended to contain the new descriptions of forest countermeasures. A new measure of the type 'social countermeasures' was advice for restriction of the dose from residential wood ash distributed to kitchen gardens. The model calculates long-term doses from continuous ash fertilisation. By adjusting the ash utilisation details, the doses can be reduced. The model reveals where and when the ash application of soil needs to be adjusted. The model results facilitate identification of the facts needed so that the authorities can provide directions to the users of local firewood. The revised measures for the reduction of radioactive caesium in timber were modelled under selective harvesting and potassium fertilisation of forests. New outputs are doses to operators who are carrying out the measures in forests and handling and transporting ash. The new model content necessitated additional data on tree biomass, the harvesting of trees, timber, types of firewood and

intervention criteria. The database of forest models was supplemented and revised.

In 2010 the model description of FDMforest was restructured and completed to correspond to the changes in LCMforest. The database was partly revised; revisions are also needed in the future after new data relevant for the models becomes available. STUK remains responsible for communication with the models' users.

In 2011 the RODOS forest models are at stage of being used by those responsible for early phase recommendations to be given to the forestry sector after radionuclide contamination of large rural areas. In the first half of 2011 an internal model demonstration and training were arranged at STUK, based on a new user interface of JRODOS. As earlier, RODOS provides models for air dispersion, general databases and graphics.

Dissemination and exploitation of results

Model descriptions to the RODOS consortium, the latest in 2009 (LCMforest) and 2010 (FDMforest). Presentation of model development at the final meetings of the projects, the latest in Madrid 2009. Use of the models in the analysis of forest dose pathways, as for the IRPA Conference, Helsinki 2010, and an NKS Forest seminar in Helsinki in 2008.

Collaborators

Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France (In 4th Framework Programme)

Schedule

1997–2011

Project leader

Aino Rantavaara

Utilisation of GIS for in-field measurements

Aim

The aim of the project was to develop software that enables representation of the results of mobile measurements in real time on a digital map. The application was based on queries to the measurement database.

Description of the work

Mobile measurements are needed to search for nuclear material out of regulatory control. Of particular importance are major public events and political meetings. Mobile teams perform measurements continuously. The spectra and analysis results together with the team locations are transmitted to the command and control centre for further analysis. Real-time measurement and positioning information are crucial for planning and managing the mobile measurements and for reporting the findings.

In the first phase of the project, new software was developed for representing mobile measurements in real time. The results of the measurements are displayed on screen, including the movement of the teams on the online digital map. If radioactive material is found, an alarm is generated, and the mapping system indicates the location on the map. The command and control centre uses the information for planning the measurements and providing instructions to the field teams. In the second phase of the project, different indoor positioning techniques were tested. Traditionally, a global satellite navigation system is used for positioning. It works well outdoors, but positioning inside a building is challenging. The goal of the indoor positioning techniques is to have a comprehensive system where the measurements can be carried out both indoors and outdoors; the users need not know how the positioning is performed.

Dissemination and exploitation of the results

The results of the project can be used as a tool in radiation emergencies and other situations where collaboration with other authorities is of vital importance. Initial results on indoor positioning were published in IRPA in June 2010.

Collaborators

Laurea University of Applied Sciences and VTI Technologies, Finland

Schedule

2008–2010

Project leader

Tarja Ilander

Important nuclides that could be used for illegal or malicious purposes (IKÄ)

Aim

The objective is to gather available data on a few tens of radionuclides that could be used for malicious purposes and to build a data system for managing the collected nuclide data and information.

Description of work

The first phase of the project (IKÄ, 2009) consisted of gathering various important data (e.g. physical and radiological properties, dose conversion factors, detection, health effects…) on about 40 radionuclides, such as ^{241}Am, ^{252}Cf, ^{244}Cm, ^{137}Cs, ^{60}Co, ^{192}Ir, ^{210}Po, ^{238}Pu, ^{226}Ra, ^{75}Se, ^{90}Sr, ^{170}Tm and ^{169}Yb, and preparing an aggregate document (a collection of fact sheets).

The second phase (IKÄ2, 2010) included the creation of a data system (database) that stores and manages the nuclide data and the addition of some new nuclides to the system.

The deliverables of the project support STUK's emergency preparedness activities.

Dissemination and exploitation of results

Internal seminars. Fact sheet document and database. Some parts of the data may also be given to other authorities.

Collaborators

No collaborators outside STUK

Schedule

2009–2011

Project leader

Juhani Lahtinen

BALTRAD: An advanced weather radar network for the Baltic Sea Region

Aim

The objective is to create a state-of-the-art real-time weather radar network for the Baltic Sea Region that facilitates the harmonised production, exchange and use of radar data.

Description of work

The BALTRAD project, headed by SMHI, is partially funded by the European Union's Baltic Sea Region Programme 2007–2013. An integral part of the project includes so-called pilots that will demonstrate the value of BALTRAD for end-users in fields such as hydrology, aviation and radiation safety. The concept being followed has already been proven once before in the NORDRAD network (involving the radars from Norway, Finland and Sweden), but the original NORDRAD technology is becoming obsolete and needs major updating. The project consists of seven work packages (and a separate preparation work-package). STUK is a full partner in the following work-packages: WP1 (Project Management and Administration), WP5 (Production Framework), WP6 (Deployment) and WP7 (Pilots). STUK's principal role is to disclose the point of view of an end-user, to carry out tests and to develop 1–2 pilot applications related to its field of expertise (radiation protection and nuclear safety).

Dissemination and exploitation of results

The project will produce various working reports, conference presentations and probably also papers published in the scientific literature. Furthermore, a couple of seminars with possible end-users will be arranged. The project will also have external (public) and internal web pages. The radar data will be applied by various end users in their emergency management (and other) systems.

Collaborators

Swedish Meteorological and Hydrological Institute (SMHI), Sweden; Finnish Meteorological Institute (FMI), Finland; Institute of Meteorology and Water Management, Poland; Latvian Environment, Geology and Meteorology Agency, Latvia; Danish Meteorological Institute, Denmark; Hydrometeorological Center, Belarus; and Estonian Meteorological and Hydrological Institute, Estonia.

Schedule

2009–2012

Project leader

At STUK: Juhani Lahtinen

Geovisualisation of radiation monitoring results – case Olkiluoto

Aim

The aim of the project is to fulfil requirements for the visualisation of radiation monitoring results at the Olkiluoto Nuclear Power Plant.

Description of work

The project will examine how radiation experts use a GIS interface in their work, and in detail how they first notice something on the map service, then select objects based on some criteria and finally analyse radiation monitoring results with a particular method. Users will operate with the GIS interface in the demonstration phase and after that they will be asked to complete questionnaires and take part in an interview concerning the expediency and efficiency of and satisfaction with the interface. Radiation monitoring results from Olkiluoto will be uploaded to the server, where sample results will be divided into two sections: terrestrial and marine ecosystem. The analysed nuclides will be ^{137}Cs and ^{3}H in the terrestrial and ^{137}Cs, ^{90}Sr and ^{60}Co in the marine ecosystem. Techniques used in the visualisation will include thematic or time-aware maps and charts.

Dissemination and exploitation of results

The results will provide information to construct a web-based information system for operative use not only by the Radiation and Nuclear Safety Authority but also in industrial and emergency preparedness in the municipalities of the nuclear sites. The results will be published in a Master's thesis and an international scientific journal.

Collaborators

University of Oulu, Department of Information Processing Science and Teollisuuden Voima Oy (TVO), Finland

Schedule

2010–2012

Project leader

Jarkko Ylipieti

Source-term database

Aim

The aim of the project is to create a source-term database for nuclear accidents and software to share source-term information and exchange it between different systems. Formalised procedures to exchange source-term information are important, as source-term information has to cross the boundaries between different groups in the emergency preparedness and response process.

Description of work

The goal of the project is to create a source term database for the KETALE and JRODOS systems. The database should allow the users to search for a representative source term, to modify it appropriately, share it with other users and feed it into different atmospheric transport and dispersion models. Initially, the database is intended to support more traditional emergency preparedness and response involving nuclear accidents. With time, however, we intend to extend the database to new threats, such as dirty bomb scenarios and accidents involving nuclear marine vessels.

STUK is operating the JRODOS system on a 24/7 basis for the two domestic NPP sites in order to display constantly updated information on the dispersion situation around these sites. Currently, an arbitrary source term is used in the dispersion calculations. Within this project, a more realistic source term with an emphasis on likelihood and containment bypass will be defined in order to make the current setup more meaningful.

Dissemination and exploitation of results

The outcome of the project will be a database and associated software to exchange and share source-term information. A technical specification document will be made available as part to the system documentation.

Collaborators

No collaborators outside STUK

Schedule

2011

Project leader

Michael Ammann

5.3 Radiation protection countermeasures

TMT Handbook: Triage, monitoring and treatment – a handbook for management of the public in the event of malevolent use of radiation

Aim

The main objective of the Euratom 6th Framework Programme project on the TMT Handbook was to produce a practicable handbook for the effective and timely triage, monitoring and treatment of people exposed to radiation following a malevolent act. The TMT handbook contains both general information and detailed recommended actions to be taken at the scene of the incident and in hospitals by specialised response teams in radiation protection, monitoring, dosimetry and medical management. It gives advice on how to plan the response for such incidents and how to handle the situation, starting at the scene of the incident and going through the response at the hospital level and further to public health interventions, including criteria for long-term follow-up. It also provides guidance on public information and communication strategies. In addition, the TMT Handbook is a useful tool for training purposes.

Description of work

Project activities were organised into five work packages (WP):

- WP1 (Scenario descriptions – overview of threats and scenarios) gathered information on scenarios in which radiation or radioactive material could be used malevolently.
- WP2 (National Strategic Response) collected and analysed available information on national response plans, monitoring strategies, monitoring resources and recommendations on medical management.
- WP3 (Guidelines for Triage and Monitoring) developed a handbook module giving guidelines on the triage and monitoring of potentially exposed people. STUK was responsible for work package 3 of the project.
- WP4 (Guidelines for Treatment, Management and Long-term Follow-up) developed a handbook module giving guidelines on the medical management, treatment and long-term follow-up of affected people.
- WP5 (Dissemination and Training) promoted the dissemination and implementation of the Handbook.

Dissemination and exploitation of the results

At the start of the TMT Handbook project, an information leaflet was sent to all European emergency response organisations with specific functions to plan, coordinate and execute mitigating actions in response to malevolent

acts involving ionising radiation. The leaflet informed about the project and encouraged organisations to join as end users. End users from 16 countries participated in the project and gave valuable input to the draft, both through correspondence and through participation at a feedback workshop arranged in Norway after a consultation period of about 6 months. A training course based on the TMT Handbook was held in February 2009. The training was directed primarily at representatives of national emergency response organisations with responsibility for first response in emergency situations, hospitals and wider health-care infrastructure, such as public health authorities. The aim of this course was to enable participants to better understand the principles of management of malevolent events involving exposure to radiation, to strengthen national capabilities for planning and response to such events and to encourage participants to promote the incorporation of the TMT Handbook into exercise and training programmes in their countries.

The TMT Handbook was published in April 2009. The electronic version is available on the project's web page: *www.tmthandbook.org* upon registration.

Collaborators

Belgian Nuclear Research Center (SCK-CEN), Belgium; Norwegian Radiation Protection Authority (NRPA), Norway; ENVIROS, and Health Protection Agency (HPA), UK; Central Laboratory for Radiological Protection (CLOR), Poland; and World Health Organization (WHO).

Schedule

2006–2009

Project leader

Tua Rahola

Security and decontamination of drinking water distribution systems following a deliberate contamination (SecurEau)

Aim

The project is carried out under the EU's the Seventh Framework Programme for Research and Technological Development. The main objective of the project is to limit the impact of safe water privation on the population because of contaminated networks and to launch an appropriate response for rapidly restoring the use of the drinking water network after deliberate contamination by CBRN (chemical, biological, radiological and nuclear) substances.

Description of work

The vulnerability of drinking water distribution systems to deliberate attacks is one of the main issues of concern to regulatory agencies and water utilities. SecurEau will serve as a demonstration project for designing and implementing an effective and timely response to a CBRN attack. STUK will participate in work packages concerning 1) rapid off-line detection methods for water and biofilms, 2) modelling the accumulation of radionuclides on pipe surfaces, 3) decontamination procedures of distribution systems and 4) organisation of dissemination and exploitation of the results by stake holders.

An investigation into adsorption/desorption of radionuclides carried out by STUK has given more insight into the behaviour of radionuclides inside a distribution network. The chemical cleaning experiments carried out on laboratory scale have been encouraging: we have been able to efficiently decontaminate water pipe materials exposed to radionuclides with inexpensive and non-toxic agents. A rapid screening method for detecting alpha-active radionuclides in water and biofilms has been validated.

Dissemination and exploitation of the results

Some of the results from the project are classified as EU restricted due to the sensitiveness of the topic. Nevertheless, clear and effective dissemination, exploitation and transfer of the results and their applicability to the international scientific community, water agencies, local governments, industry and the general public will be carried out, for instance through the project web pages. Several reports have already been prepared.

Collaborators

Université Henri Poincaré – Nancy 1 (NanCIE) (overall project coordinator), Centre National de la Recherche Scientifique (CNRS); Veolia Environnement Recherche et Innovation; Centre national du Machinisme Agricole, du Génie

Rural, des Eaux et des Forêts (CEMAGREF) and Commissariat à l'Energie Atomique (CEA), France; Rheinisch-Westfälisches Institut für Wasserforschung gemeinnützige GmbH (IWW), Germany; University of Southampton, Monitoring Systems Ltd, Veolia Water Central and Yorkshire Water Services Ltd, UK; National Institute for Health and Welfare (THL), Finland; Faculdade de Engenharia da Universidade do Porto, Portugal; and Riga Technical University, Latvia.

Schedule
2009–2013

Project leader
Maarit Muikku (Tuukka Turtiainen in 2010)

PARameters for ingestion Dose models for NORdic areas (NKS-PARDNOR)

Aim

The objective of the PARDNOR project was to enable the Nordic end users to make trustworthy ingestion dose estimates for decision support. The work was targeted at application in the ECOSYS model, which is the ingestion dose model applied in the ARGOS and RODOS decision support systems.

Description of work

Recent investigations have identified a number of reasons why estimates made with the ECOSYS model of ingestion doses in the Nordic areas may be incorrect by orders of magnitude. In general, the problem is a severe lack of up-to-date parameter data that also adequately reflect the variation between various types of locations/regions.

The PARDNOR project addressed these deficiencies and improved the model accordingly. Customising the model for local use in each of the Nordic countries required identification of local parameters such as typical consumption rates of dietary constituents, animal feeding regimes and seasonal crop development. It was demonstrated that the variations in these parameters between the Nordic countries and in relation to the German ECOSYS default data can have a considerable impact on dose estimates. In 2008, ingestion dose sensitivity analysis was performed for the variation of each of these parameters. In addition, a description of the leaf area index (LAI) was carried out, which is linked to parameters such as sowing time, soil type and temperature and is targeted at the Nordic areas. This is important, as the LAI governs direct crop deposition. Furthermore, a study has been carried out on soil leaching rates, fixation rates, desorption rates and resuspension enrichment factors, which are all parameters that may prove to be important in the ECOSYS model. These will all be described according to soil groups relevant to the Nordic areas.

Dissemination and exploitation of the results

The results have been published in annual reports NKS-174, NKS-185, NKS-210, NKS-232 and in international publications (Hansen H et al. Effect of Nordic diets on ECOSYS model predictions of ingestion doses. Radiation Protection Dosimetry 2010; 140 (2): 182–190; and Andersson KG et al. Improving ingestion dose modelling for the ARGOS and RODOS decision support systems: A Nordic initiative. In: Proceedings – Third European IRPA Congress, 14–18 June 2010, Helsinki, Finland. Helsinki: Nordic Society for Radiation Protection; 2011. S04-05. p. 691–698). The results have been exploited in the RODOS system.

Collaborators
Risø DTU National Laboratory for Sustainable Energy, Denmark (overall project coordinator); Göteborg University, Sweden; Norwegian Radiation Protection Authority (NRPA), Norway; Icelandic Radiation Safety Authority (GR), Iceland; Frodskaparsetur Føroya, Faroe Islands; and VTT Technical Research Centre of Finland.

Schedule
2007–2010

Project leader
Eila Kostiainen

Strontium and caesium deviation in snow after radioactive fallout (LUMI)

Aim

The vertical mobility of strontium and caesium in snow was studied in order to obtain information on the possible fallout situation resulting from a nuclear accident during winter.

Description of work

The experiment was performed in two parts. The first part was carried out indoors in a freezer at –18 °C, as well as in a cold room with an adjustable temperature. The second part was carried out outdoors with naturally varying temperature and snow layers. The samples were taken 7, 14, 21 and 70 days after spraying the tracer solution onto the snow.

Dissemination and exploitation of results

International publication.

Collaborators

No collaborators outside STUK

Schedule

2008–2010

Project leader

Dina Solatie

EU Kolarctic ENPI: Collaboration Network on EuroArctic Environmental Radiation Protection and Research (CEEPRA)

Aim

The aim of the project is the establishment of a cooperation network in the EuroArctic region, cross-border exchange of knowledge and skills, improvement of emergency preparedness capabilities and risk assessments in the case of nuclear accidents in the region, as well as raising awareness and knowledge among the general public and stakeholders with respect to the nature, common challenges and associated risks in the area of nuclear safety, emergency preparedness and radioactivity in the environment.

Description of work

The project will assess the current state of radioactive contamination in terrestrial and marine ecosystems in the EuroArctic region by examining environmental samples collected from Finnish Lapland, Finnmark and Troms in Norway, the Kola Peninsula and the Barents Sea. Special attention will be given to the collection and analysis of natural products widely used by the populations in Finland, Russia and Norway, such as berries, mushrooms, fish and reindeer meat.

The region-specific risk assessments will be carried out through modelling and investigation of the long-term effects of potential nuclear accidents in the EuroArctic region and possible impacts on the region's indigenous population, terrestrial and marine environments, reindeer husbandry, the natural product sector, tourism and industries.

Dissemination and exploitation of results

The results will provide updated information on the present levels, occurrence and fate of radioactive substances in the Arctic environments and food chains. It will also be possible to estimate where the radioactive substances originate from and the risks they may present in the case of a possible accident. The results will be published in international scientific journals.

Open seminars for the general public and target groups will be arranged during the project implementation period to provide relevant information on radioactivity-related issues and the status in the region.

Collaborators

Murmansk Marine Biological Institute (MMBI), Russia; Norwegian Radiation Protection Authority (NRPA), Norway; Finnish Meteorological Institute (FMI) and Pöyry Finland Oy, Finland.

Schedule
2011–2013

Project leader
Dina Solatie

5.4 Security technology

Spectral Nuclide Identification Technology for Counterterrorist and Hazmat Units (SNITCH)

Aim

SNITCH is intended to support the detection of criminal use of radionuclides. SNITCH is a national demonstration project funded by the EU through the Fight Against Crime Programme.

Description of work

An important element of the integrated radionuclide detection capability is mobile monitoring. SNITCH provides efficient data communication and management, including automated data exchange from database to database via the Internet. SNITCH transfers the alarms and the key analysis results immediately to Command and Control for alarm handling. This gives a timely response capability for law enforcement against unauthorised or criminal actions related to nuclear or other radioactive materials. SNITCH also provides a means for reachback functionality to expert organisations. Measurement results can be sent manually or automatically to an expert organisation for detailed analysis and the analysis results can be sent back to the field team.

The major deliverables of the project are:

- a concept for mobile monitoring;
- demonstration of a functional prototype that will be used by Finnish law enforcement in their field missions;
- proposal on formats and protocols (XML) for the exchange of radionuclide data and analysis results between European law enforcement agencies;
- software for data exchange (database and I/O tools); and
- a training package, including a pilot course, for law enforcement on mobile radionuclide search and survey.

Dissemination and exploitation of results

Reports are to be written for the EU and the concept will be demonstrated to the IAEA and other international organisations. SNITCH will be used, inter alia, to give reachback support to the Finnish Customs for border control.

Collaborators

Police counterterrorist unit in the Helsinki area

Schedule
2008–2010

Project leader
Petri Smolander

Direct Alpha Analysis of Forensic Samples (DAAFS)

Aim

To develop an in-field sampling system and data analysis software, including data management through databases, and to deliver a deployable direct alpha sample spectrometry system to the Canadian authorities for use at the Vancouver Olympics in 2010.

Description of work

The DAAFS project was designed to rectify current gaps in the detection of pure alpha- and beta-emitting material (also effective in gamma detection). The system comprises, firstly, an innovative method for rapid on-site sample collection of difficult-to-detect RN contamination (e.g., pure alpha and beta emitters). Secondly, the incorporation of an experimental alpha spectrometry analysis software suite, "ADAM", is provided for performing the required on-site deconvolution of the complex alpha spectra arising from direct sample measurement. Thirdly, a Concept of Operations (ConOps) for the implementation of the system in RN field teams is included.

The combination of the swipe methodology, advanced swipe treatment equipment, mobile field laboratories and the state-of-the-art analysis software suite will provide RN response teams with the capability to identify and rapidly (hours, not days) quantify low activity and difficult-to-detect alpha emitters.

The proposed system provides the solution to this identified gap through a deployable real-time alpha detection capability. This capability includes: a non-destructive particle sampler, a self-contained field alpha spectrometry system and an integrated data management/communications tool allowing for real-time raw-data tracking and data sharing. This system also provides responders the type/quantity of RN material, thereby improving mitigation and forensics.

The objectives of this project are to:

- Develop an alpha spectrometry system, for use by deployable RN survey and detection teams, which provides a capability for real-time alpha and difficult-to-detect RN contamination analysis in a field environment.
- Develop an alpha spectrometry capability that could be used in ports, borders and airports to detect the presence of nuclear material being illicitly transported.
- Improve criminal investigations by providing rapid and secure evidence collection.

- Allow for RN material attribution according to the source or location of origin for the investigative process.
- Provide rapid and accurate bounding of the crime scene and security of evidence.

Dissemination and exploitation of results
Progress reports have been written at three-month intervals, scientific presentations have been prepared following the Olympics in 2010.

Collaborators
Health Canada, and Atomic Weapons Establishment (AWE), UK.

Schedule
2008–2010

Project leader
Harri Toivonen

The use of a $LaBr_3$ spectrometer at a dose rate monitoring station (LASKU)

Aim

The main aim of the project is to integrate an $LaBr_3$ spectrometer into an external dose rate monitoring station, to lower the alarm threshold and to add nuclide identification capability at dose rate monitoring stations.

The project includes a feasibility study for outdoor use, software development and development of a fully automated analysis pipeline.

Description of work

The project is divided into four stages. The first stage includes integration into the dose rate monitoring station and a feasibility study for outdoor use. The second phase includes an automated analysis pipeline to the LINSSI 2.0 database. The third phase comprises installation at the selected dose rate monitoring stations.

The fourth phase is to connect the alarms from spectrometers to STUK's 24/7 officer on duty service. This is to be carried out after proper test period.

Dissemination and exploitation of results

Spectra and analyses from monitoring stations are stored in the LINSSI database. They can viewed from a USVA user interface.

Collaborators

No collaborators outside STUK

Schedule

2008–2009

Project leader

Kaj Vesterbacka

Non-destructive analysis

Aim

The NDA project is intended to improve the collection and analysis of samples. Novel analytical techniques have been developed, including the localisation and characterisation of individual particles. End users of the results include environmental analytical laboratories and nuclear forensics laboratories. The potential of the new techniques for safeguard applications are being tested using samples provided by the EC/ITU and IAEA. The aim is to bring the developed techniques into routine use.

Description of work

The project has examined non-destructive analysis techniques and developed measuring equipment and software. The time-stamped event-mode data storage format and different coincidence techniques have been the main focus of the project. Considerable effort has been allocated to the development of data management and analysis software. With respect to safety and security applications, all primary radiation types including conversion electrons, X-rays, gamma rays, alpha and beta particles will be studied.

Successful completion of the detection part of the project required the development and construction of an experimental platform called PANDA (PArticles and Non-Destructive Analysis). PANDA has also been partly used in the studies related to the development of sampling.

The major deliverables of the project are:

- The PANDA device – event-mode data acquisition
- The MiniPANDA device – $\alpha\beta\gamma$ coincidence techniques
- $\beta\gamma$ setup for the SONNI vehicle
- Swipe kit for in-field sampling (ASKO)
- Sampling device using an impactor for on-site measurements (SIMO)
- Construction of an alpha and conversion electron spectrometry system using a silicon-drift detector
- Analysis software for the processing and interpretation of the generated data

Dissemination and exploitation of results

Several conference proceedings and original articles have been written. Additionally, the project will result in several doctoral theses. Some articles have been written for the general public.

Collaborators
University of Jyväskylä, Senya Inc. and Oxford Instruments Inc., Finland.

Schedule
2008–2011

Project leader
Harri Toivonen

Experimental nuclear physics for security research

Aim

This project aims at transferring technology from basic nuclear research to applied sciences for supporting disarmament and non-proliferation. The project is a combination of tasks employing the nuclear physics infrastructure at the Accelerator Laboratory of the University of Jyväskylä (JYU), Finland. Due to the broad field covered by the project, its end users are STUK and other similar actors worldwide, including the CTBTO and the IAEA. Facilities providing heavy-ion therapy will also benefit from the work. The project is continuous in nature and is based on the Memorandum of Understanding between STUK and JYU.

Description of work

The project is developing methods for the production of desired radioactive sources that are otherwise commercially unavailable. As an example, a production method for ^{133m}Xe sources was recently developed. Since this is a very important isomer for the CTBTO noble gas monitoring network, our achievement was also acknowledged by New Scientist magazine in April 2010. The second task of the project is to provide missing data for the radiation safety and security communities. As an example, independent and cumulative neutron induced fission yields for xenon and other species are desired by the CTBTO. On the other hand, the heavy ion therapy community is interested in having experimental data on the stopping power of heavy ions in liquid water.

The major deliverables of the project are:

- Production methods for ^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe sources
- Production methods for the gaseous calibration sources
- Production methods for other interesting samples such as ^{235}U
- Independent and cumulative fission yields
- Stopping powers of protons in liquid water
- Stopping powers of ^{12}C in liquid water

Dissemination and exploitation of results

Results produced by the project have been presented at several conferences. Therefore, a large number of conference proceedings and also original articles have been written. In addition, several newspaper and other articles have been written for the general public.

Collaborators
University of Jyväskylä, Finland. The project has received some funding from the CTBTO and Department of Energy (DOE), US; and Commissariat à l'Energie Atomique (CEA), France.

Schedule
2009–2012

Project leader
Kari Peräjärvi

Rapid Identification of Alpha Emitters

Aim

The project aims at improving STUK's expertise and preparedness to rapidly identify and detect alpha-particle emitting radionuclides in case of the malevolent use of alpha emitters. A specific aim is to develop a cost-effective alpha spectrometer that can even be used at ambient air pressure.

Description of work

The project is divided into five main tasks: 1) Development of rapid alpha spectrometry from liquid samples. The results were compared with those obtained by STUK's certified laboratory for radiation measurements. 2) Prototype equipment for *in-situ* alpha spectrometry operating at ambient air pressure. The goal is to perform measurements of good quality without a vacuum. 3) Development of software for measurements performed in a laboratory and in the field. 4) Implementation, testing and documentation of spectrum analysis software (ADAM and AASIFIT programs). 5) Preparation of a training package for direct alpha spectrometry.

Dissemination and exploitation of the results

The output of the project consists of new methods for radionuclide measurement, including prototype equipment, validated software and a training package for alpha spectrometry. The results obtained so far have been published in the IRPA 2010 congress; other scientific reporting is in progress.

Research and technical development performed during recent years and during the present project will be combined to ensure rapid operations in a nuclear or radiation incident. In addition, radiation monitoring, services and research will also benefit.

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Roy Pöllänen

Remote monitoring of alpha emitters in real time

Aim

This research programme aims at finding new ways to detect ^{241}Am and other alpha emitters in scrap yards. Alpha-induced ultraviolet (UV) light is the basis of the research towards developing a practical solution for the scrap metal industry.

Description of work

Alpha emitting radiation sources are typically difficult to detect due to the short range of alpha particles in air. Remote detection of alpha radiation in air is possible by measuring the ionisation-induced fluorescence of air molecules. Alpha-induced ultraviolet (UV) light is mainly emitted by molecular nitrogen and its fluorescence properties are well known. The benefit of this method is the long range of UV photons in air. The main challenge of the optical method is to discriminate the weak fluorescence signal from background lighting. The issue is addressed by means of spectral filtering of the UV light and coincidences related to the generation of the UV. Feasibility studies indicate that using specially selected room lighting, a device can be built to detect a 1 kBq alpha emitter from a distance of 40 cm with a one-second integration time.

The research is focusing on the practical problems in industry, and demonstration devices will finally be built according to the specification given by the Executive Board of the Research Consortium.

Dissemination and exploitation of results

Several scientific papers will be written. The project is providing data for two doctoral theses at STUK and the Technical University of Tampere. The results will create a scientific basis for product development for various applications in radiation safety and security.

Collaborators

Tampere University of Technology, Tekes – the Finnish Funding Agency for Technology and Innovation; from industry: Outokumpu, Ovako Wire Koverhar, Ruukki, Senya, Mirion, and Environics Oy.

Schedule

2011–2012

Project leader

Harri Toivonen

Detection and identification of neutron emitters

Aim

This project aims at finding new methods to detect neutrons. This is of vital importance for nuclear security due to the global shortage of ^{3}He.

Description of work

Conventional neutron detectors are difficult to purchase. The reason is the global lack of ^{3}He, which mainly goes to portal monitors in the United States. Therefore, new detection methods need to be developed. The NEUTRO project aims at detecting neutrons indirectly through high-energy gamma radiation that has its origin in fission or neutron activation reactions, either near the source or in a special converter around the detector. The result of the project will be information on how to modify existing NaI detectors for an additional task, i.e., neutron detection above 3 MeV photon energies.

A spectrometer and a data acquisition system around a database (LINSSI) will be built and various converters will be designed by Monte Carlo simulation (GEANT 4). The performance of the system will be compared with a large state-of-the-art neutron counter filled with ^{3}He (pressure 3 bars). In addition, theoretical studies will be conducted to design a neutron spectrometer.

Dissemination and exploitation of results

Reports to MATINE will be written and a diploma thesis will be prepared. The results may have a large economic impact because the need to buy new hardware for border control may disappear.

Collaborators

No collaborators outside STUK. This work is financially supported by the Finnish Scientific Advisory Board for Defence (MATINE).

Schedule

2008–2010

Project leader

Harri Toivonen

5.5 Biological dosimetry

Biological dosimetry following exposure to neutrons in a criticality accident (BIONCA)

Aim

To further implement cytogenetic techniques for biodosimetry purposes in the Nordic countries with neutron exposures.

Description of work

Experiments were conducted to establish both PCC ring and dicentric dose calibration curves. Neutron irradiation of human whole blood was conducted in the Netherlands at the Petten reactor. Cell cultures and analysis of whole blood exposed to eight doses between 0 and 10 Gy were performed for both techniques. For the dicentric assay, excellent uniformity in dose calibration for data from both SU and STUK was observed. For PCC rings, the SU and STUK curves were not equally congruent, probably due to the less uniform scoring criteria. However, both curves displayed strong linearity throughout the dose range. In addition, an exercise was conducted to simulate a criticality accident and to test the validity of the established dose calibration curves. For accident simulation, 16 blood samples were irradiated in Norway at the Kjeller reactor and analysed for dose estimation with both assays. The results showed that, despite the different composition of the radiation beams in Petten and Kjeller, good dose estimates were obtained. The activity has provided good experience in collaboration required in radiation emergency situations where the biodosimetry capacity and resources of one laboratory may be inadequate.

Dissemination and exploitation of results

The results will be published in a peer-reviewed international journal and reported to NKS. They could be exploited in Nordic biodosimetry collaboration in the event of a mass casualty radiation accident.

Collaborators

Norwegian Radiation Protection Agency (NRPA), Norway; and Stockholm University (SU), Sweden.

Schedule

2009–2010

Project leader

Carita Lindholm

Improvement of the dose calibration curve for dicentric chromosomes in low-dose Co-60 gamma-rays (Dicentric calibration curve)

Aim

To re-evaluate dicentric frequencies at low doses for the purpose of improving dose assessment.

Description of work

During evaluation of the accredited method 'Biological assessment of a radiation dose', inadequate accuracy of dose estimates at low doses was observed. To improve the dose calibration for dicentrics in the low dose range, new chromosomal aberration analyses will be performed for cells irradiated *in vitro* with doses from 50/100 mGy up to 1 Gy. The analysed data will be combined with the old data and new calibration coefficients will be established.

Dissemination and exploitation of results

The precision of dose estimates will be improved.

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Carita Lindholm

Multi-disciplinary biodosimetric tools to manage high-scale radiological casualties (MULTIBIODOSE)

Aim

The aim of this multi-disciplinary collaborative project is to analyse a variety of biodosimetric tools and adapt them to different mass casualty scenarios.

Description of work

In the event of a large scale radiological emergency, biological dosimetry is an essential tool that can provide timely assessment of radiation exposure to the general population and enable the identification of those exposed people who should receive medical treatment. A number of biodosimetric tools are potentially available, but they must be adapted and tested for a large-scale emergency scenario. These methods differ in their specificity and sensitivity to radiation, the stability of signal and speed of performance. A large-scale radiological emergency can take different forms. Based on the emergency scenario, different biodosimetric tools should be applied so that the dosimetric information can be made available with optimal speed and precision. The following biodosimetric tools will be validated and established: the dicentric assay, the micronucleus assay, the gamma-H2AX assay, the skin speckle assay, the blood serum protein expression assay and EPR/OSL dosimetry in components of pocket electronic devices. The assays were chosen because they complement each other with respect to sensitivity, specificity to radiation and the exposure scenario, as well as speed of performance. The final deliverable of this project will be the establishment of a biodosimetric network that is fully functional and ready to respond in case of a mass casualty situation.

Dissemination and exploitation of results

The results will be published in peer-reviewed international journals.

Collaborators

Stockholm University (SU), Sweden; Bundesamt für Strahlenschutz (BfS), Helmholtz Zentrum München (HMGU) and Bundeswehr Institut für Strahlenbiologie (BIS), Germany; Universiteit Gent (UGent), Belgium; Health Protection Agency (HPA), UK; Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France; Istituto Superiore di Sanità (ISS), Italy; Norwegian Radiation Protection Authority (NRPA), Norway; Universitat Autonoma de Barcelona (UAB), Spain; and Institute of Nuclear Chemistry and Technology (INCT), Poland.

Schedule
2010–2013

Project leader
Carita Lindholm

Long-term cytogenetic follow-up of radiological accident victims (CA follow-up)

Aim

To determine the temporal changes in radiation-induced chromosomal aberrations *in vivo*.

Description of work

Victims of the 1994 radiological accident in Estonia have previously been studied with respect to chromosomal aberrations from blood samples taken during 1994–2001. Lymphocytes isolated from blood samples taken during 2002–2008 from four of the victims who were exposed to the highest doses will be analysed with FISH chromosome painting. Cell cultures from samples stored in liquid nitrogen will be established and chromosome aberrations scored. The persistence of translocations will be of special interest, since these can be exploited in retrospective dosimetry, and the series of samples will give unique information on the stability of translocations up to 14 years post-exposure.

Dissemination and exploitation of results

The results will be published in a peer-reviewed international journal.

Collaborators

National Institute of Health Development, Estonia

Schedule

2010–2011

Project leader

Carita Lindholm

6 Dosimetry and metrology

6.1 Dosimetry of medical radiation

Accurate low-dose rate measurements by photon spectrometry

Aim

To study the suitability and accuracy of an HPGe detector for low-dose rate measurements. To develop an unfolding method to obtain the energy spectrum of the radiation impinging on the detector and to determine the corresponding air kerma rate.

Description of work

The detector response for photons (1–300 keV) was modelled with EGSnrc and MCNPX Monte Carlo codes. For this purpose, a detailed model of the detector was constructed for the Monte Carlo codes and the sensitivity of the response was studied as a function of the level of detail in the response simulations. Software was developed to unfold the detector response, to compare the measured spectra and to calculate the air kerma rate in the measured beam. The calculated air kerma values have been verified to correspond accurately to the values measured by ionisation chambers. Further validation of the measured spectra was obtained by comparing half-value layers calculated from the spectra with those measured using ionisation chambers.

Dissemination and exploitation of results

The method is a routine quality control tool in the Radiation Metrology Laboratory of STUK. Two STUK-TR reports have been published.

Collaborators

No collaborators outside STUK

Schedule

2005–2009

Project leader

At STUK: Markku Tapiovaara

Accelerator beam modelling with BEAMnrc MC-code and comparison of calculated beam data with measured data

Aim

The aim of the project was to develop a tool for dose verification of conventional and state-of-the-art radiotherapy techniques in complex geometries.

Description of work

In this project, EGSnrc Monte Carlo simulation and BEAM user code were used. The work has been completed with an accurate model of a linear accelerator with 6 MV and 15 MV photon beams. The research project is continuing with processing of the simulation results using IMRT techniques.

Dissemination and exploitation of results

The findings will be applied in the regulatory control of radiotherapy to verify dose distributions produced in treatment planning and the final implementation of radiotherapy treatment.

Collaborators

No collaborators outside STUK

Schedule

2009

Project leader

Jarkko Ojala

Measurement of dose rate components below the background

Aim

To examine and test methods and instruments for very low dose rate measurements in cases where the dose rate caused by the source is below the ambient dose rate.

Description of work

The present dose constraint for the population poses stringent demands for dose rate measurements. The measurement of dose rates, for instance, from radioactive sources at levels well below 0.1 microSv/h is not possible with ionisation chambers or other spectrally integrating detectors. In this project, different spectrometers will be tested and calibrated for such measurements.

Dissemination and exploitation of results

Internal report

Collaborators

No collaborators outside STUK

Schedule

2010

Project leader

Teemu Siiskonen

Energy loss of protons and heavy ions in water

Aim

To determine the stopping power of liquid water for protons (and for heavy ions such as ^{12}C); improvement of the accuracy of dosimetry in proton beam radiotherapy; and provide general data for proton, heavy ion and neutron dosimetry.

Description of work

The interest in cancer therapy in using either proton or heavy ion beams has significantly increased during the last decade with nearly 40 treatment centres operational at the moment and several tens being planned or under construction. Obviously, for successful treatments, knowledge of the absorbed dose to the tumour and to the surrounding tissues is of paramount importance. A small change in the absorbed dose to the tumour could lead to a significant change in the probability of cure. In radiotherapy, dosimetry is often carried out relative to a ^{60}Co beam, in terms of dose to water. The conversion from the dose to water from a ^{60}Co beam to that from a proton or heavy ion beam is usually carried out via the beam quality correction factor, which depends on the ratio of stopping powers of air and water. According to the IAEA, this ratio is the main source of uncertainty in proton or heavy ion beam dosimetry. However, the experimental data on water stopping powers are practically non-existent. The proton stopping powers are also needed to determine the dose distribution inside the patient. A small error in the stopping powers may result in a significant error in the dose, especially at the distal edge of the treatment region.

The widely-used stopping power tabulations for water are based on refined Bethe's theory – no experimental data have been available above 2 MeV in proton energy. In this project we have measured, for the first time, the stopping power of liquid water for protons.

Dissemination and exploitation of results

Three presentations have been given at international conferences and the main publication from the experiment has been published in 2011 in Physics in Medicine and Biology (vol. 56). The journal raised the article in the Featured Article category so that it received more visibility. Medicalphysicsweb.org released news concerning our experiment.

Collaborators

University of Jyväskylä, Department of Physics, Finland

Schedule
2008–2010 (continuation 2011–2012)

Project leader
Teemu Siiskonen

EGSnrc CAVRZ simulations of the dosimeter response in terms of the CT air kerma index in cylindrical PMMA phantoms

Aim

The aim is to study the perturbation correction in the ionisation camber for the measurements of $C_{K,PMMA,100}$.

Description of work

Simulations are being used to determine $C_{K,PMMA,100}$ for different detectors at the centre of the CT head and body phantoms. A k_q correction factor between dose measurements in the phantom and free in air will be determined for the model detectors and for the real detectors using measured $C_{K,PMMA,100}$ data. The k_q is being modelled as the perturbation correction induced by the IC walls and the centre electrode, the materials of which differ from a reference air-filled cavity (in PMMA) of a similar active volume. Simulations are being performed using EGSnrc CAVRZ code.

Dissemination and exploitation of results

The results will form part of a scientific paper (Physica Medica: European Journal of Medical Physics).

Collaborators

No collaborators outside STUK

Schedule

2010–2011

Project leader

Arvi Hakanen

The improvement of dosimetry methods for diagnostic and interventional radiology in Finland

This project is part of the IAEA-coordinated research projects CRP E2.10.06: Implementation of the International Code of Practice on Dosimetry in Diagnostic Radiology and CRP E210008: The development of advanced dosimetry techniques for diagnostic and interventional radiology.

Aim

The aim of this project is to improve the reliability and feasibility of the whole chain of dose measurements beginning from the calibration of dosimeters at SSDL, continuing to the dose measurements in a hospital and subsequently, to the calculation of patient organ doses based on the measured dosimetric quantities.

Description of work

IAEA publication TRS 457 (2007) gives general guidelines for dosimetry in X-ray imaging. In the first CRP the implementation of TRS 547 was examined. It was conducted during 2005 to 2008 and the main part of writing the final documents was performed during 2009–2010. In the second CRP research project the usefulness of CoP methods for challenging dosimetric situations is being tested and evaluated. This project started in autumn 2010 and will continue until 2013.

This project is a joint effort between the secondary standard dosimetry laboratory (SSDL) of STUK and Finnish university hospitals. The whole dosimetric chain from the calibration of dosimeters to the determination of organ doses will be studied, and improved calibration and measurement methods will be developed. Calibration techniques are being investigated at the SSDL and the clinical dosimetry methods are being investigated at hospitals. Methods for the calibration of dosimeters for X-ray imaging methods will be improved to better cover the challenging dosimetric situations. The proposed project will help in implementing methods for advanced dosimetry measurements in hospitals.

Dissemination and exploitation of results

Results of the first project were published in a Health series document (IAEA 2011). In addition, scientific papers have been published on the calibration of kerma-area product (KAP) meters in Physics in Medicine and Biology 2008 (vol. 53) and 2009 (vol. 54). These were also part of a PhD thesis (STUK-A239).

The expected result of the second CRP is to have generally more reliable dose measurements and computational methods as a basis for reliable surveys

on patient doses. A conclusion on the feasible methods for advanced dosimetry in hospitals will be drawn, and based on the study, guidance to Finnish hospitals will be provided. The calibration methods of the STUK dosimetry laboratory are being evaluated and improved. The results of this project will be published in the IAEA Health series. In addition, some scientific articles will be published.

Collaborators

This research group includes experts from STUK in X-ray dosimetry and X-ray imaging. In addition, in the second CRP the group has included experts in clinical radiology physics from three Finnish university hospitals in Kuopio, Helsinki and Oulu. The international group includes IAEA and experts from different countries. Eleven countries participated in the first CRP and 12 countries in the second CRP.

Schedule

2010–2013

Project leader

At STUK: Paula Toroi

6.2 Internal dosimetry

The mean concentrations of natural uranium in urine and hair of the Finnish population (VIHURA)

Aim

The aim of the study was to determine the mean concentrations of natural uranium in the urine and hair of the occupationally unexposed Finnish population. The interpretation of uranium contents in bioassay samples of radiation workers requires knowledge of the natural uranium excretion rates and their dependence on intake via foodstuffs and drinking water, especially in case of increased intakes.

Description of work

The Finnish Population Register Centre carried out a random sampling of the Finnish working population (aged from 18 to 65 years). About one thousand persons volunteered to participate in the study. The uranium concentrations in the household water, urine and hair of the occupationally unexposed Finnish working population have been determined using inductively coupled plasma mass spectrometry (ICP-MS) at Ramboll Analytics Ltd.

Dissemination and exploitation of the results

The results have been used to assess the exposure of the occupationally unexposed Finnish population to natural uranium. The results have been published in a peer-reviewed journal.

Collaborators

No collaborators outside STUK

Schedule

2005–2009

Project leader

Maarit Muikku

Mathematical calibration of *in vivo* spectrometers

Aim

The purpose of this intent is to begin using numerical human phantoms, also known as voxel phantoms, in the calibration of whole body spectrometers.

Implementation

Initially, a literature survey to obtain information on the voxel phantoms used in different countries and simulation programs for the purpose was carried out. In addition, a visit to IRSN, France, was made to become familiar with the use of phantoms, the necessary computer codes and the numerical specifications of the detectors. The method will be applied to the spectrometers used at STUK.

Dissemination and exploitation of the results

The simulation of the whole body counter with a numerical phantom will be used to guide the design of the new geometry for the whole body spectrometers at STUK. Concerning the present spectrometers, the numerical phantoms provide the necessary corrections to the measurement results due to height and weight differences between the measured people. Enhanced accuracy will be obtained in relation to the absorption of the different radiation types by different tissue types, which can be taken into account. In addition, the uneven distribution of contamination in the body can be taken into account in the measurement results. A scientific report will be produced during 2011.

Collaborators

Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France

Schedule

2007 – 2011

Project leader

Jussi Huikari

Excretion of ^{210}Po in urine

Aim

The aim of the study was to determine the excretion rates of ^{210}Po and ^{210}Pb in urine of special population groups receiving more ^{210}Po and ^{210}Pb from the diet than the Finnish population in general. The diets of these special population groups include freshwater fish, reindeer meat or drinking water with high concentrations of ^{210}Po. The urine concentrations were used to assess internal doses from the intake of ^{210}Po via foodstuffs.

Description of work

Urine and household water samples were collected from Finnish adult volunteers who were divided into four groups according their diet. The first group comprised recreational fishermen, the second group represented people consuming more reindeer meat than an average Finn, while people using drinking water with very high activity concentrations of ^{210}Po and ^{210}Pb were selected for the third group. The fourth group was a control group. In addition to urine and household water samples, ^{210}Po and ^{210}Pb concentrations were determined in freshwater fish and reindeer meat samples provided by the study participants. A questionnaire was used to collect information on the usage of household water, the consumption of freshwater fish, seafood, reindeer meat and game, as well as smoking habits.

Dissemination and exploitation of the results

The results were used to assess the exposure of the special dietary groups to ^{210}Po and ^{210}Pb. The results will be published in a peer-reviewed journal.

Collaborators

No collaborators outside STUK

Schedule

2007 – 2010

Project leader

Maarit Muikku

^{90}Sr and ^{226}Ra in human bones (LUUT)

Aim

The aim is to examine and describe the time series of the human bone ^{90}Sr and ^{226}Ra concentrations and their dependence on the dietary intake.

Description of work

Activity concentrations were measured in the bones of diseased persons during 1960–1966 (about 600 samples) and during 1969–1972 and 1980–1982 (about 200 samples). The radioactive fallout from nuclear weapons testing in the 1950s and 1960s can be seen in these bones. The intake of radionuclides in relation to the year of death, age, sex and region will be included in the analysis. The data could be used in the evaluation of existing biokinetic models.

Dissemination and exploitation of results

Results will be published as a scientific article. The database is an important source of time series of internal exposure to ^{90}Sr and ^{226}Ra and provides an opportunity to validate biokinetic models.

Collaborators

Department of Forensic Medicine, University of Helsinki, Finland

Schedule

2008–2011

Project leader

Päivi Kurttio

The enhancement of the whole body counters (IMU)

Aim of the study

The motivation for this enterprise is to renew the whole body counters of STUK (a mobile unit and an indoor laboratory) to enhance internal dose assessment.

Description of work

Mobile unit on a truck: To begin with, a prototype of the new measurement setup was built in parallel to the present one. The aim of the improvements was to enhance the safety of the system as the vast cold (liquid nitrogen) masses above the monitored person will be removed. The ergonomics will also be much better and the detection efficiency for lung contamination will increase. Based on the results, a completely new unit was planned. The data acquisition software will be harmonised with the Radionuclide Analytics Laboratory. The testing and calibration phase will exploit both traditional and mathematical (voxel) phantoms.

Laboratory: The old rails and detector support ring will be removed from the iron room to make way for a new lung counter. The present whole body counter will be modified in order to optimise the use of semiconductor detectors and possibly some NaI(Tl) crystals. The data acquisition software will be harmonised with the Radionuclide Analytics Laboratory and with the mobile unit. The testing and calibration phase will exploit both traditional and mathematical (voxel) phantoms. In addition, the lung phantoms that have been ordered from Russia will be used for the lung counter calibration. Voxel models will be created from these new phantoms once they arrive.

Dissemination and exploitation of the results

New measurement units will be used in research, service and preparedness tasks. Scientific reports will be published in both national and international forums.

Collaborators

Measurement instrument dealers and commercial metal workshops

Schedule

2010–2012

Project leader

Sauli Pusa

Phantom-based Intercomparison Among NOrdic whole body counting facilities and the development of a Nordic phantom LIBrary website (PIANOLIB)

Aim

The project will establish a web-based calibration phantom library and an intercomparison exercise will be performed among Nordic whole body counting laboratories.

Implementation

The Phantom library is intended for Nordic countries and will contain a list of available phantoms, source specs, the location of the phantom, reservation status and contact information. The intercomparison round will be organised during 2010–2011.

Dissemination and exploitation of the results

Intercomparison exercises are a necessity for accredited laboratories. The results will be used to maintain and enhance the high quality of the measurement results. The project was started in 2010 and will last 2 years. The phantom library was opened in early 2011 and can be found via the NKS web pages. The final report will be written and a workshop to discuss the results will take place during the final quarter of 2011.

Collaborators

Swedish Radiation Safety Authority (SSM), Sweden (overall project coordinator); Norwegian Radiation Protection Authority (NRPA), Norway; and Icelandic Radiation Safety Authority (GR), Iceland.

Schedule

2010–2011

Project leader

At STUK: Jussi Huikari

^{137}Cs content and internal radiation doses of special population groups

Aim

Changes in internal radiation doses affecting the population and special population groups receiving more ^{137}Cs from the diet than the population in general have been studied using *in vivo* measurements performed annually or at longer time intervals. The diet of these special population groups includes freshwater fish, wild mushrooms and wild berries from areas with high ^{137}Cs deposition. In reindeer herding areas, the diet includes reindeer meat as well as other natural products. Long-term follow-up studies are necessary in order to obtain representative dose estimates. In addition to the annual committed effective doses, the results also provide information on the sources from which Finns receive the highest radiation doses.

Description of work

The studies of the special diet groups have been carried out using the mobile whole-body counter. The members of the group from Central Finland were measured annually until 2009, after which measurements have been conducted every second year. They represent a population consuming forest berries and mushrooms and especially a lot of freshwater fish caught in small lakes in a region with high Chernobyl fallout. The group of reindeer herders from Northern Lapland has been measured at five-year intervals. Reindeer meat is the primary source of ^{137}Cs for this group. The concentrations of ^{137}Cs in the food products from nature consumed by the study populations have also been determined. In addition, a reference group representing people living in the Helsinki area has been regularly measured.

Dissemination and exploitation of the results

The results are being used to assess the internal doses for the Finnish population and they will be published in peer-reviewed journals. The article "Effective half-lives of ^{134}Cs and ^{137}Cs in reindeer meat and in reindeer herders in Finland after the Chernobyl accident and the ensuing effective radiation doses to humans" by Leppänen et al. was published in May 2011.

Collaborators

Laboratory of Radiochemistry, University of Helsinki, Finland

Schedule

Continuous follow-up project

Project leader

Maarit Muikku

6.3 Activity measurements

Validation of a ^{226}Ra and ^{228}Ra determination method from environmental samples

Aim

The objective of the research is to validate a radiochemical determination method for the simultaneous determination of radium isotopes, ^{226}Ra and ^{228}Ra, from environmental samples. The method in use for ^{228}Ra is based on gamma spectrometry and is suitable for high activity levels. A new method is needed for low-level measurements. For ^{226}Ra, the activity concentration calculated from gross alpha measurement is mainly suitable for drinking water samples, not for samples containing, for instance, iron.

Description of work

According to the literature, the most common techniques used for radium activity concentration measurements are high resolution gamma spectrometry, alpha spectrometry techniques, liquid scintillation counting and emanometry. Preliminary testing is being carried out for the simultaneous determination of radium isotopes ^{226}Ra and ^{228}Ra from water samples. MnO_2 is being used to preconcentrate radium from water samples and extraction chromatography to separate ^{226}Ra and ^{228}Ra from interfering radionuclides. The method is first being tested using water samples and certified reference materials (e.g. soil reference materials). Alpha spectrometry in ^{226}Ra determination is being tested. Liquid scintillation counting or gas-flow proportional counting is being used for the determination of ^{228}Ra via the measurement of ^{228}Ac. In addition, the possibility to use gamma spectrometry with sample preconcentration methods is being taken into account. Validation will be performed after selecting a suitable method.

Dissemination and exploitation of results

The results are being utilised in the measurement services offered especially for waterworks and in research projects carried out at STUK.

Collaborators

No collaborators outside STUK

Schedule

2010 – 2012

Project leader

Kaisa Vaaramaa

6.4 Irradiation facilities

Development of STUK's alpha-particle irradiation system (NOTE / Task 6.1)

Aim

The main aim of the project is to construct a narrow-beam system specially designed for non-targeted effects experiments based on the existing 238Pu isotope broad-beam irradiation facility.

Description of work

STUK's alpha particle irradiator will be upgraded for narrow-beam irradiations (the beam width of 0.1 mm). Three different types of narrow-beam collimator system will be evaluated and Monte Carlo simulations of the dose distributions behind the narrow beam collimator will be performed.

Dissemination and exploitation of results

The results form part of the NOTE project. An alpha particle irradiator will be used for biological studies in the Radiation Biology Laboratory.

Collaborators

No collaborators outside STUK

Schedule

2010

Project leader

Teemu Siiskonen

7 Non-ionising radiation

Traceable measurement of field strength and SAR for the Physical Agents Directive (EMF and SAR)

Aim

This was a joint research project (JRP) that was implemented as a collaboration between all the European national metrology institutes active in this area. The JRP belonged to the European Metrology Research Programme, which is partly supported by the European Commission and EURAMET (European Association of National Metrology Institutes). The objectives of the JRP were to provide traceable metrology for electromagnetic (EM) field strength and SAR measurements at all frequencies in general use and to develop expertise in exposure assessment associated with EM fields. The special objectives of STUK's work were to develop calibration methods for SAR probes below 400 MHz and for instruments measuring currents induced in limbs in the frequency range from 10 MHz to 50 MHz.

Description of the work

SAR probes were calibrated in a vertically mounted transverse electromagnetic (TEM) transmission cell with the upper section filled with a tissue-simulating liquid. The SAR at the calibration point was determined with temperature rise measurements by using a small non-perturbing thermistor sensor. The RF current transformers were calibrated by using a centre conductor in a partly open box. The conductor was much shorter than the wavelength in the frequency range from 10 MHz to 50 MHz and its RF current could then be determined by measuring the output RF power of the box with an RF power meter and by assuming that the line impedance was 50 ohms. The results obtained from the calibrations of SAR probes and RF current transformers carried out at STUK were compared with the corresponding calibrations carried out at the National Physical Laboratory, UK. The work will continue after the end of the project with analyses of the comparisons and possibly with further comparisons.

Dissemination and exploitation of results

The project has provided calibration equipment and methods for SAR probes below 400 MHz as well as RF current measuring instruments in the frequency range from 10 MHz to 50 MHz. This will improve the traceability of the SAR and limb current measurements at these frequencies.

The results of the study will be published in project reports and in scientific journals.

Collaborators

Physikalisch-Technische Bundesanstalt (PTB), Germany (overall project coordinator); National Physical Laboratory (NPL), UK; Laboratoire National de Métrologie et d'Essais (LNE), France; National Institute of Metrological Research (INRIM), Italy; National Metrology Institute van Swinden Laboratorium (NMi-VsL), the Netherlands; and Tübitak Ulusal Metroloji Enstitüsü (UME), Turkey.

Schedule

2008–2011

Project leader

Lauri Puranen

RF dosimetry for biological studies (WIRECOM-RFDOS)

Aim

This project belonged to WIRECOM (Wireless Communication Devices and Human Health), which is a national research programme into the possible health effects of mobile phones. The project was partly funded by TEKES, the Finnish Funding Agency for Technology and Innovation. The objectives of the project were to provide reliable and accurate exposure assessment for human experiments studying the effect of mobile phone fields on the metabolism of brain and for an epidemiological cohort study.

Description of the work

The exposure systems were designed in co-operation of the researchers of the other participating institutes of the WIRECOM programme. The heads of human volunteers were exposed to GSM mobile phone fields. The SAR induced in the head and the SAR distribution was determined in each exposure scenario by FDTD computations using realistic numerical models of a human head and a GSM mobile phone. The computations with the numerical phone model were validated with SAR measurements carried out in a homogeneous liquid phantom. The uncertainty of the local SAR induced in the head of human volunteers was estimated to be ± 20%. The epidemiological cohort study carried out by STUK was supported by providing information on the exposure to mobile phone fields when the phone is used in different environments. This improves the exposure assessment and helps in dividing the phone users into different exposure groups.

Dissemination and exploitation of results

The exposure set-ups developed in the project were used for human studies carried out by the Finnish Institute of Occupational Health and University of Turku. The dosimetric information supporting the epidemiological study will be used to classify phone users into different exposure groups. The results will be published in project reports and in scientific journals.

Collaborators

Finnish Institute of Occupational Health and University of Turku, Finland

Schedule

2009 – 2010

Project leader

Lauri Puranen

Actions promoting the well-being of MRI workers

Aim

This project will be carried out in collaboration with the Finnish Institute of Occupational Health (FIOH). The objective is to improve occupational safety (magnetic fields, noise) in order to promote the well-being of persons working in the vicinity of magnetic resonance imaging (MRI) scanners. A part of the funding for this project has been applied for from the Finnish Work Environment Fund.

Description of the work

STUK's tasks are to develop exposure assessment methods for static magnetic fields, rapidly varying low-frequency magnetic fields (gradient fields) and radiofrequency magnetic fields. In addition, methods will be developed and tested for limiting the exposure to electric fields induced in the head by movement in a strong static magnetic field. A guide for safe working in the vicinity of MRI scanners will be prepared together with the FIOH.

Dissemination and exploitation of results

The results will be utilised in the preparation of a guide for safe working with MRI scanners. The guide will be distributed to all work places where MRI scanners are used and especially to nursing staff. Information on the results will be disseminated to all occupational groups working with MRI scanners via technical journals and organisational papers. The main results will also be presented at international conferences and meetings.

Collaborators

Finnish Institute of Occupational Health

Schedule

2011–2013

Project leader

Tim Toivo

STUK-A-reports

STUK-A249 Salomaa S, Sulonen N (Eds.). Research projects of STUK 2009–2011. Helsinki 2011.

STUK-A248 Salomaa S, Sulonen N (Eds.). Research activities of STUK 2005–2010. Helsinki 2011.

STUK-A247 Larjavaara S. Occurrence studies of intracranial tumours. Doctoral thesis. Helsinki 2011.

STUK-A246 Lahkola A. Mobile phone use and risk of brain tumours. Doctoral thesis. Helsinki 2010.

STUK-A245 Valmari T, Mäkeläinen I, Reisbacka H, Arvela H. Suomen radonkartasto 2010 – Radonatlas över Finland 2010 – Radon Atlas of Finland 2010. Helsinki 2010.

STUK-A244 Arvela H, Mäkeläinen I, Holmgren O, Reisbacka H. Radon uudisrakentamisessa – Otantatutkimus 2009. Helsinki 2010.

STUK-A243 Toivonen T. Microwave dosimetry in biological exposure studies and in practical safety evaluations. Doctoral thesis. Helsinki 2010.

STUK-A242 Mäkeläinen I, Kinnunen T, Reisbacka H, Valmari T, Arvela H. Radon suomalaisissa asunnoissa – Otantatutkimus 2006. Helsinki 2009.

STUK-A241 Saxén R, Outola I. Vesistöjen ja juomaveden ^{137}Cs, ^{90}Sr ja ^{3}H sekä pitoisuuksien arviointi valmiustilanteessa. Helsinki 2009.

STUK-A240 Kostiainen E, Ylipieti J. Radioaktiivinen cesium Suomen ruokasienissä. Helsinki 2009.

STUK-A239 Toroi P. Patient exposure monitoring and radiation qualities in two-dimensional digital x-ray imaging. Doctoral thesis. Helsinki 2009.

STUK-A238 Ilus E. Environmental effects of thermal and radioactive discharges from nuclear power plants in the boreal brackish-water conditions of the northern Baltic Sea. Doctoral thesis. Helsinki 2009.

STUK-A237 Arvela H, Reisbacka H. Radonsanering av bostäder. Helsinki 2009.

STUK-A236 Saxén R, Rask M, Ruuhijärvi J, Vuorinen P, Rantavaara A, Koskelainen U. ^{137}Cs in small forest lakes of Finland after the Chernobyl accident. Helsinki 2009.

STUK-A-reports on STUK's home pages:
http://www.stuk.fi/julkaisut_maaraykset/en_GB/tutkimusjulkaisut

A

Laippatie 4, 00880 Helsinki
Puh. (09) 759 881, fax (09) 759 88 500
www.stuk.fi

ISBN 978-952-478-648-5 (pdf)
ISSN 0781-1705
Kopio Niini Oy, Helsinki 2011