Radiochemical analysis of important radionuclides in Nordic nuclear industry

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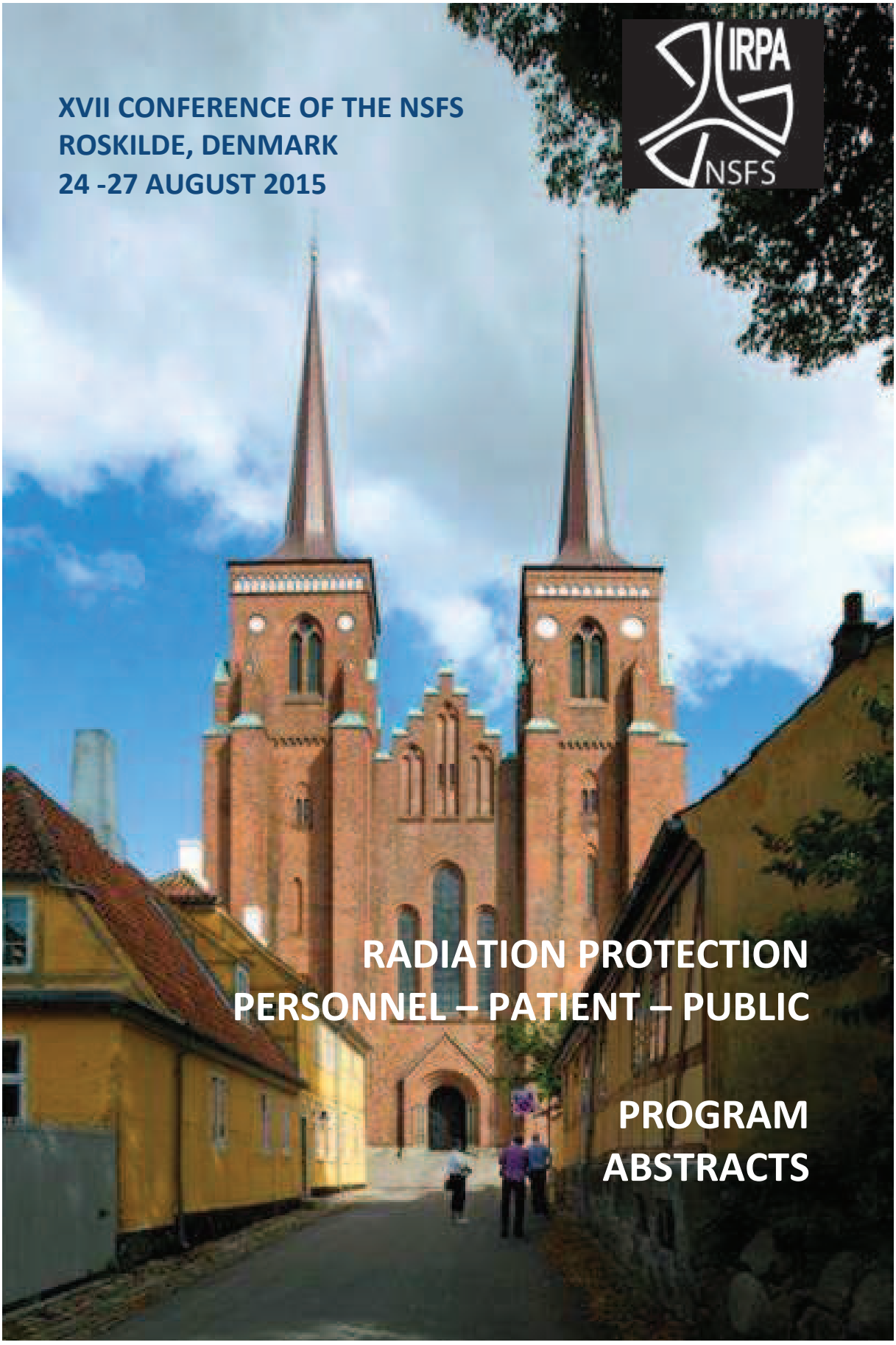

RADIATION PROTECTION PERSONNEL – PATIENT – PUBLIC

PROGRAM ABSTRACTS

PROGRAM AND ORGANIZING COMMITTEE:
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Hanne N. Waltenburg
Jens Søgaard-Hansen
Bent Lauritzen
Carsten Israelson
Søren Holm

CONTENTS

WELCOME

Dear colleagues

It is with great pleasure I welcome you all to Roskilde and to the XVII conference of the Nordic Society for Radiation Protection. The conference venue, Comwell Roskilde, provides a great venue for this conference. Roskilde is a famous Danish town founded more than 1000 years ago at the bay of Roskilde Fjord. In addition Roskilde is easy to reach from Copenhagen Airport and Central Station. The Danish NSFS Board is happy to welcome about 120 participants coming from the Nordic countries, six more European countries and even from countries overseas to this conference.

The theme for the conference is "Radiation Protection – Personnel, Patient and Public" which reflects the very broad spectrum of our professional field.

You will find this theme very well represented in the conference program. We have received many high quality papers from you - the conference participants - making it easy for the organizing committee to put together a very interesting program.

In addition, I am very pleased that the three invited speakers will introduce us to very hot radiation protection issues. On Monday, the latest international developments and cooperation in the field of emergency preparedness and response as well as the European Spallation Source in Lund in Sweden will be presented, and on Wednesday, developments and justification of applications using ionizing radiation in the medical field.

It is our hope that you in addition to all the professional activities will find time to relax and mingle among colleagues at the planned social activities including the Sunday evening reception at the Viking Ships Museum, the Conference Dinner on Tuesday and on Wednesday afternoon the guided visit in Roskilde Cathedral and the old city of Roskilde – hopefully in nice sunny weather.

We hope you will enjoy your stay in Roskilde.

Mette Øhlenschlæger

President of NSFS

PROGRAM

NSFS Conference 2015
24 – 27 August
Roskilde, Denmark

Venue	**Comwell Roskilde** **Vestre Kirkevej 12, 4000 Roskilde**
Theme	**Radiation Protection** **Personnel – Patient – Public**

Program highlights

Sunday 23 August, 19:00	**Welcome reception at the Viking Ship Museum** **Vindeboder 12, 4000 Roskilde** **Registration**
Monday 24 August, 8:00	**Registration**
Monday 24 August, 9:30	**Opening of conference**
Monday 24 August, 16:00	**NSFS General Assembly**
Tuesday 25 August, 19:00	**Conference dinner**
Wednesday 26 August, 15:30	**Visit to Roskilde Cathedral and the old city of Roskilde**
Thursday 27 August, 12:00	**End of conference**

MONDAY, 24 August

Session 1: Opening and Bo Lindell Award

9:30 - 11:00 Chair: Ole Harbitz, Norway

S1-O1 **Bo Lindell Lecture:**
Nordic co-operation in an international context
Sigurður M. Magnússon, Icelandic Radiation Safety Authority

S1-O2 **The Bo Lindell book translation project**
Jack Valentin, Former ICRP Secretary

11:00 - 11:30 Coffee and Posters

Session 2: International Perspectives

11:30 - 12:30 Chair: Ole Harbitz, Norway

S2-O1 **INVITED: New developments and growing international cooperation in the field of emergency preparedness and response**
Patrick Majerus, Ministry of Health, Department of Radiation Protection, Luxembourg

12:30 - 13:45 Lunch

Session 3: Nordic Perspectives

13:45 - 15:45 Chair: Kasper Andersson, Denmark

S3-O1 **INVITED: ESS status - focusing on the perspectives for international research, and the challenges related to radiation protection for the staff, the public and the environment**
Peter Jacobsson, European Spallation Source ESS AB, Environment, Safety & Health (ESH) Division

S3-O2 **Current and emerging challenges for Nordic nuclear safety: cooperation through the NKS-R programme**
Karin Andgren, NKS

Short presentations by exhibitors

Canberra
Doseco
Gammadata
Imec
Landauer
MetorX
NKS
NRG
RadPro

15:45 - 16:00 Coffee and Posters

16:00 NSFS General assembly

TUESDAY, 25 August

Session 4: Emergency, Preparedness and Response 1

8:30 - 10:30 Chair: Marie Solberg, Norway

S4-O1 **Current and emerging challenges for Nordic nuclear/radiological emergency preparedness: cooperation through the NKS-B programme**
Kasper Andersson, NKS / DTU

S4-O2 **Societal dimensions in post-accident recovery – return of experience from Fukushima and Chernobyl experience**
Inger Margrethe Eikelmann, Norwegian Radiation Protection Authority

S4-O3 **Uncertainties of Atmospheric Dispersion Calculations for Emergency Preparedness**
Jens Havskov Sørensen, Danish Meteorological Institute (DMI)

S4-O4 **Uncertainty in predictions of the ambient dose equivalent rates for 30 years following the Fukushima Daiichi nuclear power plant accident**
Sakae Kinase, Japan Atomic Energy Agency

S4-O5 **Dispersion model based dose-rate measurement simulation for exercises**
Tuomas Peltonen, Radiation and Nuclear Safety Authority (STUK)

S4-06 **DEMAs experiences with unmanned aerial vehicles for radiological measurements**
Carsten Israelson, Danish Emergency Management Agency (DEMA)

10:30 - 11:00 Coffee and Posters

Session 5: Emergency, Preparedness and Response 2

11:00 - 12:30 Chair: Marie Solberg, Norway

S5-O1 **Measurement requirements to maximise recovery phase dose reduction in large contaminated land areas**
Kasper Andersson, DTU

S5-O2 **An accidental exposure to I-131**
Wendla Paile, Radiation and Nuclear Safety Authority (STUK)

S5-O3 **Scenario Based Nuclear and Radiological Emergency Preparedness in a Non-Nuclear Country (Norway)**
Øyvind Gjølme Selnæs, Norwegian Radiation Protection Authority

S5-O4 **Online courses in radiation protection**
Mattias Jönsson, Lund University

Posters: Emergency, Preparedness and Response

S5-P1 **Elemental Composition and Structure of Commercial Available Personal Radiation Shielding Protective Clothing**
Radek Cerny, National Institute for Nuclear, Chemical and Biological Protection

S5-P2 **Probabilistic Off-site Consequences Analysis – development of a guiding document**
Karin Fritioff, Vattenfall AB

S5-P3 **Characterization of HPGe detectors using Computed Tomography**
Angelica Hedman, FOI

S5-P4 **Impact of atmosphere on the transport of Ruthenium in the primary circuit of nuclear power plant**
Ivan Kajan, Chalmers University of Technology

12:30 - 13:30 Lunch

Session 6: Radioecology

13:30 - 15:30 Chair: Sven P. Nielsen, Denmark

S6-O1 **Radiochemcial analysis of important radionuclides in Nordic nuclear industry**
Xiaolin Hou, Technical University of Denmark, Center for Nuclear Technologies

S6-O2 **Multivariate analysis of release data and environmental monitoring data from Swedish nuclear facilities**
Charlotte Lager, Swedish Radiation Safety Authority

S6-O3 **Application of Rapid and Automated Techniques in Radiochemical Analysis - Inspirations from NKS-B Rapid-Tech Project**
Jixin Qiao, DTU Nutech

S6-O4 **Canopy interception and accumulation of Fukushima Dai-ichi derived radiocaesium by forest trees.**
Stefan Bengtsson, Institute of Environmental Radioactivity, Fukushima University

S6-O5 **Concentrations and inventories of Cs-137 in dated sediments sampled in the Swedish Marine Environmental Monitoring Program**
Mats Eriksson, Swedish Radiation Safety Authority

S6-O6 **Effects of dynamic behaviour of Nordic marine environment to radioecological assessments (the EFMARE project)**
Mikhail Iosjpe, Norwegian Radiation Protection Authority

S6-O7 **Really long term radiological assessment of ecosystems**
Ulrik Kautsky, SKB

Posters: Radioecology

S6-P1 **Radioactivity in fertilizers**
Tuukka Turtiainen, Radiation and Nuclear Safety Authority (STUK)

15:30 - 16:00 Coffee and Posters

Session 7: Technologies and Safety

16:00 - 17:30 Chair: Karin Andgren, Sweden

S7-O1 **Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site - The regulators perspective**
Nils Addo, Swedish Radiation Safety Authority

S7-O2 **Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site - Particle Size, Morphology and Chemical Composition**
Edvin Hansson, Linköping University, Westinghouse Electric Sweden AB

S7-O3 **Performance of a new NIRP TL-dosemeter. Uncertainty and detection limit estimation**
Henrik Roed, National Institute of Radiation Protection

S7-O4 **The start of the decommissioning of the inner parts of the DR3 reactor**
Jens Søgaard-Hansen, Danish Decommissioning

S7-O5 **Radioactive Waste Management in Denmark**
Heidi Sjølin Thomsen, Dansk Dekommissionering

Posters: Technologies and Safety

S7-P1 **Establishing a method for a more accessible and reliable verification of medical radiation shielding**
Ibtisam Yusuf, Department of Radiation Physics and Department of Medicine and Health Sciences, Linköping University, Linköping, Sweden

19:00 Conference dinner

WEDNESDAY, 26 August

Session 8: Medical Applications 1

8:30 - 10:30 Chair: Ritva Bly, Finland

S8-O1 **INVITED: Developments and justification of applications using ionizing radiation in the medical field**
Steve Ebdon-Jackson, Public Health England, Medical Exposure Regulatory Infrastructure Team

S8-O2 **Radiation safety aspects of the Danish Center for Proton Therapy**
Lars Hjorth Praestegaard, Department of Medical Physics, Aarhus University Hospital

S8-O3 **New Danish research laboratory for medical dosimetry**
Claus E. Andersen, Technical University of Denmark

S8-O4 **The National System for the Introduction of New Health Technologies within the Specialist Health Service**
Eva Godske Friberg, Norwegian Radiation Protection Authority

10:30 - 11:00 Coffee and Posters

Session 9: Medical Applications 2

11:00 - 12:30 Chair: Eva Godske Friberg, Norway

S9-O1 **Computed paediatric tomography exposure and radiation-induced cancers: Results from a national cohort study in France**
Marie-Odile Bernier, IRSN

S9-O2 **Pediatric protocols and dose reduction devices in CT scanners where few examinations are performed**
Jonina Gudjonsdottir, Icelandic Radiation Safety Authority

S9-O3 **Population doses from x-ray and nuclear medicine procedures in Nordic countries**
Ritva Bly, Radiation and Nuclear Safety Authority (STUK)

S9-O4 **Sunbeds and sunburns in Iceland**
Þorgeir Sigurðsson, Icelandic Radiation Safety Authority

12:30 - 13:45 Lunch

Session 10: Medical Applications 3

13:45 - 15:15 Chair: Søren Holm, Denmark

S10-O1 **The importance of implementing radiation protection in the national eHealth-strategy**
Eva Godske Friberg, Norwegian Radiation Protection Authority

S10-O2 **Clinical audits for breast cancer radiotherapy in Norway**
Ingrid Espe Heikkilä, Norwegian Radiation Protection Authority

S10-O3 **Inspection of Cardiology departments in Norway: Are they making it great in radiation protection?**
Reidun D. Silkoset, Norwegian Radiation Protection Authority

S10-O4 **Measurement of eye lens radiation doses to staff during percutaneous coronary interventional procedures**
Ibtisam Yusuf, Department of Radiation Physics and Department of Medicine and Health Sciences, Linköping University, Linköping, Sweden

Posters: Medical Applications

S10-P1 **Frequency of Medical X-ray Examinations in Iceland in 2013**
Nelly Petursdottir, Icelandic Radiation Safety Authority

S10-P2 **Ra-223 planar whole body scan and SPECT of surgically removed bone**
Robin de Nijs, Rigshospitalet, Nuclear Medicine and PET

S10-P3 **Whole body counting of radium-223 for monitoring of staff in radionuclide therapy.**
Søren Holm, Rigshospitalet, Nuclear Medicine and PET

S10-P4 **Developments in first choice from conventional X-rays to CT for selected studies**
Britta Højgaard, National Institute of Radiation Protection

15:30 Visit to Roskilde Cathedral and old city of Roskilde

THURSDAY, 27 August

Session 11: Policy, Regulations and Inspections

8:30 - 10:15 Chair: Gísli Jónsson, Iceland

S11-O1 **Swedish Radiation Safety Authority: Systematic monitoring and evaluation of work practices an important aspect of improving radiation safety for patients.**
Camilla Larsson, Swedish Radiation Safety Authority

S11-O2 **Inspections of x-ray equipment at Danish public hospitals**
Peter Kaidin Frederiksen, National Institute of Radiation Protection

S11-O3 **Electronic inspection of industrial radiography companies in Norway**
Bjørn Helge Knutsen, Norwegian Radiation Protection Authority

S11-O4 **Inspections in non-medical use of radiation in Finland in 2010-2014**
Siiri-Maria Aallos-Ståhl, Radiation and Nuclear Safety Authority (STUK)

S11-O5 **New procedures for disposal of ionisation chamber smoke detectors**
Jannie Kalør Svendsen, National Institute of Radiation Protection

Posters: Policy, Regulations and Inspections

S11-P1 **Regulatory Authority Records from the 2014-2015 Blood Irradiator Inspection Campaign**
Charlotte Nielsen, National Institute of Radiation Protection

S11-P2 **Norway has phased out gamma based blood irradiators**
Øivind Syversen, Norwegian Radiation Protection Authority

S11-P3 **Results from an All-inclusive IAEA-based Inspection Approach for Industrial Irradiation Facilities**
Charlotte Nielsen, National Institute of Radiation Protection

S11-P4 **NORGIR**
Þorgeir Sigurðsson, Icelandic Radiation Safety Authority

S11-P5 **Survey on needs for changes in the Finnish radiation legislation and on regulatory oversight – The perspectives of practitioners**
Ritva Bly, Radiation and Nuclear Safety Authority (STUK)

S11-P6 **Nordic Working Group on Medical Applications**
Hanne N Waltenburg, National Institute of Radiation Protection

10:15 - 10:45 Coffee and Posters

Session 12: Natural Radioactivity

10:45 - 11:45 Chair: Carsten Israelson, Denmark

S12-O1 **Indoor and outdoor radon levels in Iceland**
Gísli Jónsson, Icelandic Radiation Safety Authority

S12-O2 **NORM in Norwegian Mineral Industry**
Paula Nunez, Institute for Energy Technology

S12-O3 **TENORM in geothermal applications in Iceland**
Þorgeir Sigurðsson, Icelandic Radiation Safety Authority

Posters: Natural Radioactivity

S12-P1 **NKS: Developing Methods for Reliable and Efficient Radiological Characterization of NORM Contaminated Objects**
Charlotte Nielsen, National Institute of Radiation Protection

S12-P2 **The Swedish Radiation Safety Authority's Radioanalytical Laboratory: who are we and what do we do?**
Mats Eriksson, Swedish Radiation Safety Authority

S12-P3 **Gross alpha and beta radioactivity levels measurement in mining ponds in Jos Metropolis-Plateau State, Nigeria**
Daniel Jwanbot, University of Jos

Closing Session

11:45 - 12:00 Chair: Mette Øhlenschlæger, Denmark

12:00 Lunch

Bo Lindell Lecture: Nordic co-operation in an international context

Sigurður M. Magnússon

Icelandic Radiation Safety Authority

The Nordic countries have a long history of co-operation in nuclear and radiation issues. What began with sporadic contacts in the time after World War 2 evolved over the next 10 – 15 years into an extensive and formalized co-operation that is still important in spite of radical societal and technological changes taking place since then.

The Nordic co-operation has adapted well, to both external events and changing political climate in the Nordic countries. It has stood the test of time and severe nuclear accidents, is robust and fit for purpose. Through the wide ranging co-operation leading to important Nordic documents, such as the Flag books, a common Nordic view on nuclear and radiation safety issues has been established.

The Nordic nuclear and radiation co-operation is dual in its nature. On one hand there is the traditional co-operation between the authorities and on the other hand there is the research co-operation within the framework of NKS.

The lecture will give an overview of the Nordic co-operation in an international context, where we are and what the future may hold.

S1-O2

The Bo Lindell book translation project

Jack Valentin

Former ICRP secretary

Almost all NSFS members and most other IRPA members have heard of the admirable Bo Lindell (former ICRP Chair, former UNSCEAR Chair, former head of SSI, the Radiation Protection Authority in Sweden, etc etc). Many IRPA members around the world have met him over the years, and many are aware of his significant book series, 'Strålningens, radioaktivitetens och strålskyddets historia' (The history of radiation, radioactivity, and radiological protection), comprising 2637 pages of accurate, important, and exciting information with a Nordic perspective on developments world-wide. Unfortunately, fewer have been able to read the complete set of four books, since they are written in Swedish. Bo Lindell has met most of the significant contributors to the development of radiation science and radiological protection in the 20th century, he contributed personally to many of the crucial events, and he is well known world-wide both for his razor-sharp intellect and encyclopaedic knowledge and for his ever-lasting politeness, kindness, and patience. Because of this, and given that there are not that many other documents summarising the history of radiation and protection, there is a considerable demand for a translation into English, both within the Nordic countries and internationally. However, in spite of that demand, commercial translation and publishing of the books was not a viable proposition. Therefore, NSFS has launched a Translation Project, organising professional translation through a proper agency, Quality Assurance through an editorial committee of senior Nordic and Anglo-Saxon experts, and engaging additional sponsors to co-fund the costs. In addition to NSFS, the co-sponsors are NKS, IRPA, and the five Nordic licensing authorities. The project is now well under way, with the first volume (Pandora’s Box) completed. The second volume (The Sword of Damocles) is in the final stages of preparation, the third volume (The Labours of Hercules) is under Quality Assurance editing, and the translator is half-way through the raw translation of the final volume (The Pains of Sisyphus).The resulting English versions will be published in two ways: by making PDF files available for free downloading from the NKS and/or NSFS web sites, and by providing print-on-demand hard copies available at cost price.

New developments and growing international cooperation in the field of emergency preparedness and response

Patrick Majerus

Ministry of Health, Department of Radiation Protection, Luxembourg

Emergency preparedness and response (EP&R) has mostly been developed and implemented at national level without giving great importance to cross-border issues. In case of the nuclear accident in Fukushima Daiichi, this resulted in different advises given to the own citizens by European and other states. In the event of a nuclear emergency in Europe, immediate protective actions may have to be taken in more than one country. Exercises, such as the one of the Greater Region in 2012, involving France, Germany, Belgium and Luxembourg, clearly demonstrate the difficulties to coordinate the response between several countries.

Internationally, many efforts have been taken in recent years to improve the situation. HERCA has worked on recommendations for a better coordination during the response on accidents taking place in Europe or elsewhere. Together with WENRA, recommendations concerning fast kinetic severe accidents were also put forward. The European Commission has significantly improved its ECURIE information exchange platform and performed a review on EP&R in Europe. The IAEA, based on its action plan on nuclear safety, gave additional competences to its Incident and Emergency Centre (IEC), particularly with regard to assessment and prognosis. Other international initiatives, such as NERIS, MELODI and PREPARE, develop enhanced scientific and technical tools to support EP&R.

In the legal area, Directive 2013/71/EURATOM contains several new approaches. Member States may implement these provisions based on purely national considerations, with the risk that differences between the States will again increase. The following years will therefore be decisive in terms of promoting a coherent implementation of the various provisions and recommendations at all levels. In addition, a testing and verification mechanism will be needed to ensure the effectiveness of the new EP&R arrangements.

S3-O1

ESS status - focusing on the perspectives for international research, and the challenges related to radiation protection for the staff, the public and the environment

Peter Jacobsson

European Spallation Source ESS AB, Environment, Safety & Health (ESH) Division

The European Spallation Source (ESS) is a multi-disciplinary research center based on the world's most powerful neutron source. This new facility will be around 30 times brighter than today's leading neutron-scattering facilities, enabling new opportunities for researchers in the fields of life sciences, energy, environmental technology, cultural heritage and fundamental physics. ESS will be designed to the highest level of safety in order to meet both the expectations of the users, the personnel and the regulatory requirements. This applies to all aspects of safety but in particular radiation safety and radiation protection.

The presentation will describe the fundamental safety functions for the neutron source, the confinement barriers and the aspects of radiation shielding. It will discuss different aspects of possible radiation doses to the staff, users and the third person during normal operation and accidents. The presentation will also point out challenging areas, e.g. material behavior of the tungsten (the ESS target material) during spallation, where research is presently being done.

Current and emerging challenges for Nordic nuclear safety: cooperation through the NKS-R programme

Karin Andgren[1], Kasper G. Andersson[2] Finn Physant[3], Sigurdur M. Magnusson[3]

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[2] *NKS, DTU*
[3] *NKS*

Building on the foundation of a common cultural and historical heritage and a long tradition of collaboration, NKS aims to facilitate a common Nordic view on nuclear and radiation safety. A common understanding of rules, practice and measures, and national differences in this context, is an essential requirement. Through collaborative efforts problems may be tackled quicker, more efficiently, more consistently, and at a lower cost. NKS activities are divided into two programme areas, NKS-B and NKS-R. Recent results and on-going activities of the NKS-R (reactor safety) programme will be presented at the seminar. On-going activities include projects within the areas of severe accidents, risk analysis and organisational issues. For example, the research on core melt debris coolability and steam explosion represents the front edge research worldwide for Nordic boiling water reactors. Other activities financed by NKS in 2015 include guidelines on level 3 probabilistic safety analysis (consequences off-site) and a project aiming to enhance organisational learning from successful actions and decisions. A seminar is one of the best ways of disseminating information about the work NKS does and the results it achieves. We therefore invite all interested persons and organisations to participate in a seminar 12-13th of January 2016 in Stockholm. Focus will be on lessons learned from Fukushima and the way to proceed in both Nordic emergency management and nuclear risk assessment, which are strongly interrelated disciplines.

S4-O1

Current and emerging challenges for Nordic nuclear/radiological emergency preparedness: cooperation through the NKS-B programme

Kasper Andersson[1], Karin Andgren[2], Finn Physant[3], Sigurdur Magnusson[4]

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[2]*NKS / FRIT*
[3]*NKS / Vattenfall*
[4]*NKS / Icelandic Radiation Safety Authority*

The Nordic countries share a sociocultural heritage, which has historically facilitated cooperation on a wide range of societal themes. Specifically on nuclear and radiological preparedness topics, cooperation over many decades in what has evolved into the core of the NKS-B programme has provided a common understanding of important issues while maintaining close links between organisations with an interest in the field. Following up on a number of preparedness related learning points after the Fukushima accident in 2011 a suite of new dedicated NKS-B activities were launched already in January 2012. The scope and requirements in cooperative Nordic preparedness were illustrated and discussed at the NKS seminar in Stockholm in January 2013 on the Fukushima Accident and Perspectives for Nordic Reactor Safety and Emergency Preparedness, which had 140 participants. For instance the needs for well exercised monitoring strategies and the important role of detailed and operational information pathways and strategies were highlighted. The results of tens of activities have now been published on the NKS website, which are directly aimed at extending and upgrading Nordic capabilities to respond to an emergency in the light of the Fukushima experience. On this background NKS invites all interested persons and organisations to participate in a follow-up workshop on 12-13th of January 2016 on lessons learned and the way to proceed in both Nordic emergency management and nuclear risk assessment, which are strongly interrelated disciplines. Over the years, the NKS-B programme has also produced numerous valuable results in areas as diverse as improvement of routine measurement technologies for the nuclear industry and waste management relating to decommissioning and NORM generating processes.

Societal dimensions in post-accident recovery – return of experience from Fukushima and Chernobyl experience

Inger Margrethe Eikelmann

Norwegian Radiation Protection Authority, inger.eikelmann@nrpa.no

Emergency and post-accident situations are of a complex nature insofar as they involve a large number of actors and a large number of intrinsically interlinked dimensions and issues (heath, environmental, economic, social, cultural, ethical dimensions). People and organisations have to face this complexity in a context in which the usual social and institutional routines are particularly challenged and destabilised. Existing return of experience from post-Chernobyl situation in Norway and from post-Fukushima situation in Japan show that the societal dimension plays is of key importance in the recovery process following a nuclear accident. In effect, the capacity of local actors to build their response to the crisis, at a personal and community levels also depends on the capacity of local actors to build new forms of cooperation among themselves and with other actors (e.g. experts, actors providing resource). The societal dimension in post-accident recovery and the understanding of the interactions between the different recovery paths includes a reflection on how some central values (truth, justice, solidarity, dignity, democratic culture), are taken into account in the different paths. In effect this has an influence on the resilience capacities of the actors). The objectives for the study is an analysis of the societal dimension of local post-accident recovery processes, on the basis of the post-Chernobyl experience in Norway and on the post-Fukushima experience in Japan. The work is carried out by case studies in the Norwegian and Japanese context. The case studies cover the following fields: Food and farming, healthcare and local community management. The analysis of the cases identifies the different recovery paths (individuals and families, local authorities, regional and national authorities, experts and TSOs and their interactions. It also shows the role of values in the interaction between the different recovery paths and in the sustainability of recovery.

S4-O3

Uncertainties of Atmospheric Dispersion Calculations for Emergency Preparedness

Jens Havskov Sørensen[1], Henrik Feddersen[1], Carsten Israelson[2], Bent Lauritzen[3], Heiko Klein[4], Jonas Lindgren[5], Bjarne Amstrup[1], Steen Cordt Hoe[2], Jerzy Bartnicki[4]

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[2]*Danish Emergency Management Agency (DEMA)*
[3]*Technical University of Denmark (DTU)*
[4]*Norwegian Meteorological Institute (MET Norway)*
[5]*Swedish Radiation Safety Authority (SSM)*

Atmospheric dispersion model calculations of anticipated radionuclide releases from a nuclear accident provide information on possible contamination levels and radiation hazards; thereby facilitating decisions on protective actions. This is implemented in emergency management through Decision Support Systems (DSSs). Recent developments in numerical weather prediction models include probabilistic forecasting techniques to address the inherent uncertainties in numerical forecasting. This approach may readily be taken over by atmospheric dispersion modelling. Most current DSSs, however, do not accommodate uncertainties, but merely allow for presentation of the 'most likely' e.g. plume dispersion or deposition pattern. In the NKS-B project 'Meteorological Uncertainty of atmospheric Dispersion model results' (MUD) the uncertainties of atmospheric dispersion model calculations are investigated, as well as means for incorporating these into DSSs, allowing for the presentation of uncertainties to decision makers in a comprehensible manner. The MUD methodology has been implemented operationally in the Danish setup providing long-range atmospheric dispersion modelling for ARGOS. In the current NKS-B project 'Fukushima Accident: Uncertainty of Atmospheric dispersion modelling' (FAUNA), the MUD methodology is applied to the Fukushima Daiichi NPP accident, where the influence of meteorological uncertainties on real-time assessments of atmospheric dispersion and deposition is being investigated, imitating real-time emergency management. The objective of the project is to examine how uncertainty estimates can be presented to experts as well as decisions makers in a manner that meets both requirements: of the experts running the DSS and the decision makers relying on practical decision support. In the paper, the methodology developed in MUD will be described, and results of MUD and FAUNA presented.

Uncertainty in predictions of the ambient dose equivalent rates for 30 years following the Fukushima Daiichi nuclear power plant accident

Sakae Kinase[1], Tomoyuki Takahashi[2], Hideaki Yamamoto[1], Kimiaki Saito[1], Satoshi Sato[1]

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[2]*Kyoto University*

It is essential to develop long-term prediction models allowing follow-up of the radiological situation and the sustainability of the rehabilitation programme after the Fukushima Daiichi nuclear power plant accident. At the Japan Atomic Energy Agency (JAEA), long-term prediction models have been developed to assess how ambient dose equivalent rates might change in the future and to analyze radiological situations within the 80 km radius of the Fukushima Daiichi nuclear power plant. The long-term prediction models described using a double exponential form with ecological half-lives -the time for half the radioactive caesium to disappear from the local environment due to natural removal phenomena and human activites- for land use, enable affected population to receive information on the level of ambient dose equivalent rates and its space and time distribution for the next 30 years after the accident. In the present study, uncertainties concerning future ambient dose equivalent rates within the 80 km radius of the Fukushima Daiichi nuclear power plant were assessed using Monte Carlo simulations of model parameter variability in conjunction with the long-term prediction models. The model parameters were the ecological half-life for the fast/slow elimination components and the fractional distribution of fast elimination component. It was found that ambient dose equivalent rates for the next 5-30 years after the accident would have a 90% confidence interval of a factor of approximately 2 for the maximum variability. In addition, the model parameter to which the log-term prediction models were consistently most sensitive was found to be the fractional distribution of fast elimination component. The long-term prediction models would be useful for a better understanding of the radiological situation since they provide information on the space and time variation of the ambient dose equivalent rates in inhabited areas.

S4-O5

Dispersion model based dose-rate measurement simulation for exercises

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The external dose rate monitoring network ULJAS covers over 250 stations located all over Finland. The dose rate results are collected and presented by the USVA system. It is used to produce the real-time overview of radiological situation in the country. The USVA system also alerts the expert on duty when dose rate exceeds station specific alarm limit. During radiological exercises the Radiation and Nuclear Safety Authority STUK can simulate dose-rate measurements for these ULJAS stations. The background dose-rate value is read from real measurements and the increment is read from dispersion model output. Currently the simulator supports long-range dispersion model SILAM provided by Finnish Meteorological Institute (FMI) and short/medium range dispersion models included in JRODOS Decision Support System. The simulations are not geographically limited to Finland. The simulator can simulate dose rate results to all monitoring stations in Europe. The simulation software is Web-based and it is very easy to use. Before the beginning of the exercise the simulator starts the dispersion calculation using predefined source term and the newest numerical weather prediction (NWP). Before the simulation the meteorologist can make an assumption of the best NWP model for current weather conditions. From the model output doses and dose-rates are calculated and further interpolated to measurement points. As the exercise progresses the simulated measurements incremented by background values are inserted into database with 10 minutes interval. Users can view the results via Web browser. The Web interface has a similar layout compared to normal dose-rate monitoring network view except for the large "exercise" text appearing on the site. The results are accessible for all the players in the exercise including the rescue officers. Compared to traditional simulation methods for exercises STUK's system has many advanced features. It can use the most sophisticated dispersion models available and it is not limited to one dispersion model or one weather prediction model. NWP based real weather conditions including historical data are supported but with JRODOS the weather input by hand can also be used. The real-time availability of results online for large number of players is unique feature and following of results online makes it possible to have more realistic feeling of an exercise.

DEMAs experiences with unmanned aerial vehicles for radiological measurements

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Unmanned radiological measurement can be useful for a wide range of scenarios including mapping of plume passage and ground contamination during and after an accident with a nuclear power plant.

The Nuclear Division at DEMA has completed tests with an unmanned X8 helicopter from Danish Aviation Systems ApS carrying an off-the-shelf Canberra Colibri dose rate monitor with a CsI detector. The X8 has a pay load of 1.5 kg and can fly programmed patterns with a fly time of approximately 20 minutes. The Colibri dose rate monitor has a build-in GPS and a logging function that can store dose rates and coordinates every 1 s.

Preliminary tests show that the system readily locates radioactive sources on the ground and the obtained data combined with GIS software can be used to create maps with dose rates and terrain.

In the future, DEMA will among other things work on reducing the weight of the dose rate monitor and possible installing it in a fix wing unmanned aerial vehicle. This will increase the range and the operational functionality of unmanned radiological measurements considerably.

S5-O1

Measurement requirements to maximise recovery phase dose reduction in large contaminated land areas

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Numerous European and Nordic guidance handbooks have been produced over the years for optimisation of recovery countermeasure strategies following a widespread terrestrial radioactive contamination. Here the experience from particularly clean-up efforts made in areas contaminated by the Chernobyl accident has been summarised to provide decision makers in future contamination scenarios with an overview of how to construct optimised strategies for intervention in contamination scenarios with different characteristics. However, all along the way, the focus has been on enabling selection of the most suitable countermeasure options, and not on how to best ensure that they are implemented in the best possible way in practice. Operational optimisation of countermeasure implementation requires dedicated measurement strategies to assess the local contaminant distribution as well as parameters that will enable proper estimation of residual dose. It has previously been demonstrated experimentally in Chernobyl-contaminated areas that where military standard operations failed in reducing contamination levels significantly, essentially the same countermeasure strategy, when carried out in accordance with simple but specific contamination measurements in the area, could reduce dose greatly and highly cost-effectively. Yet there is still a profound gap in the literature on how to carry out measurement-based countermeasure implementation. For example ICRU and IAEA guides for sampling and measurement entirely fail to take into account the purpose of sampling. In connection with the Fukushima accident huge numbers of soil samples were taken with the stated purpose of 'evaluating Fukushima derived radionuclides', but the lack in specificity is reflected in generally rather low dose reductive effects in the contaminated areas. The presentation pinpoints the current problems in this context and proposes a way to improve operational effectiveness through measurement recommendations.

An accidental exposure to I-131

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In a company manufacturing radiopharmaceuticals, a laboratory technician was contaminated with I-131 while preparing I-131 capsules for treatment of thyroid carcinoma. She was wearing two pairs of protective gloves and, when changing gloves, noticed a rupture in the right inner glove but did not notice any rupture in the outer glove. Only 3-4 h later, routine monitoring revealed heavy contamination of the back of her right hand. Immediate actions to decontaminate the hand were taken on-site. On the next day, besides persisting heavy contamination of the hand, I-131 was also detected in the thyroid gland.

Based on the measurements on-site and later follow-up at STUK, including surface contamination measurements and whole body counting, the original I-131 activity on the hand was estimated at 12 MBq and the superficial skin dose at 33 Gy, affecting a skin area of about 10 cm^2. The thyroid dose was estimated at 430 mGy. Stable iodine would have reduced the thyroid dose substantially but was not administered.

Eleven days after the incident the skin was dry and slightly desquamated but no severe skin damage developed. Four days later the skin was intact with no desquamation left. No further signs of skin damage had occurred when the person was seen after three months, and none have come to our knowledge later on. Cytogenetic analysis of circulating lymphocytes was performed and a slight elevation of chromosomal aberrations was observed, pointing to a small, partial exposure, which is in line with the incident. Health Phys. 107(4):351–355; 2014

S5-O3

Scenario Based Nuclear and Radiological Emergency Preparedness in a Non-Nuclear Country (Norway)

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Severe nuclear or radiological events may have significant consequences, with a large and immediate need for information, considerable challenges related to implementation of protective measures, advice to the general public and affected stakeholders, and decisions on other mitigating actions. A number of authorities will be involved, and the management of the event will most likely involve many Professional and governmental environments and fields. Recovery and long-term rehabilitation in the aftermath of the event may be demanding. Management of severe events will also require international coordination. In emergency planning, the aim is to form a preparedness that provides the best protection based on the resources available. In May 2010, the Norwegian government established six scenarios in order to priority needs and to plan an as good as possible nuclear and radiological emergency preparedness in Norway. The scenarios are based on experiences from previous events and evaluations of existing and future activities. They form a comprehensive list and qualitatively describe possible events with different consequences, and each represents distinct aspects towards crisis management. The six scenarios are:

1. Large airborne release from a facility in another country
2. Airborne release from a facility in Norway
3. Local event from a mobile source
4. Local event evolving over time
5. Marine release, and/or fear of marine or terrestrial contamination
6. Severe event abroad without direct consequences for Norwegian territory.

The primary users of the scenarios are all authorities with responsibilities in nuclear and radiological emergency preparedness and response. The scenarios id in reviewing crisis management plans, developing specific scenario based communication plans, raise general consciousness on different needs in emergency response, and provide a comprehensive approach towards emergency preparedness planning.

Online courses in radiation protection

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The new master programme in radiation safety at the University of Gothenburg has attracted the interest of many students. To give students a good start, we prepare online courses including recorded lectures, quizzes, calculation exercises, and recommendations to further reading. The aim of the courses is to effectively teach the basics of radiation physics, detectors of ionizing radiation and gamma spectrometry.

Massive Open Online Courses (MOOC) is offered by several Universities. The courses often consists of short recorded lessons (3-15 min) directly followed by a quiz or a calculation exercise. For many students, short bursts of information followed by a quiz are an effective method for learning. With support from the Swedish Radiation Safety Authorities (SSM), some of the courses given at the master programme are also available to medical physicists, PhD-students and professionals working in the nuclear power industry as continuous professional development courses (CPD). The online material will be available to CPD participants as well. In the future, online courses may be an interesting alternative to the intense CPD courses given today. The first online course: Radiation detectors and measurement in radiation protection and preparedness and will be launched in the fall of 2015. The first versions will be given in Swedish; however, material is continuously translated into English.

S5-P1

Elemental Composition and Structure of Commercial Available Personal Radiation Shielding Protective Clothing

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Recently, the demand for personal protective equipment for radiation protection is increasing. The laboratory of Nuclear Protection Department at National Institute for NBC Protection (SUJCHBO v.v.i.), Czech Republic deals with a study of selected personal protection equipment properties. This Research is supported by the project called "Prevention, Preparedness and Mitigation of Severe Accidents at Czech Nuclear Power Plants in Connection with New Findings of Stress Tests after the Fukushima Accident" (project No. VG 20132015105, founded by the Ministry of the Interior of the Czech Republic). As a part of this research a collection of commercially available personal radiation shielding protective clothing (RSPC) was gathered at National Institute for NBC Protection. This protective clothing is a kind of protective garments used not only against radioactive contamination, but due to a special shielding layer RSPC protect against penetrating ionizing radiation as well. RSPC are possible to be used by special emergency response technical workers during accidents in nuclear facilities or by first responders and firemen in emergency situations such as accidents during radioactive material transportation, terrorist incidents involving radioactive dispersal devices or nuclear weapons. As a first part of the study there was determined X and gamma radiation attenuation in the materials of individual RSPC. During further research, it is intended to determine the effective dose to man using this protective garments and staying in a radiation field. This determination will be realized by Monte Carlo simulations using MCNPX code. For this purpose it is necessary to know the elemental composition of RSPC, especially the composition of the shielding layer. The elemental composition was determined by X-ray fluorescence analysis. The results were then refined using chemical analysis. In addition the material structure of RSPC was studied using electron microscopy. During the structure study, the elemental composition of shielding layers of selected shielding materials was determined using Energy-dispersive X-ray spectroscopy as well. In the contribution, the collection of commercially available RSPC will be presented with regard to their shielding material. There will also be presented methods for determining the elemental composition of RSPC and their results. Finally, the shielding materials of RSPC will be compared with respect to their structure.

Probabilistic Off-site Consequences Analysis – development of a guiding document

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Probabilistic Off-site Consequences Analysis, commonly referred to as Level 3 Probabilistic Safety Assessment (Level 3 PSA), is infrequently performed and generally regarded as a less developed analysis when compared to Level 1 and Level 2 PSA. Due to new nuclear construction plans there is a renewed interest in objective and risk-based siting analysis in order to better understand off-site consequences, especially in the wake of the multi-unit disaster at the Fukushima Daiichi site. Based on an inquiry from the Nordic PSA Group and the Nordic Nuclear Safety Research group (NKS), a consortium of Swedish nuclear risk consultancies (Lloyd's Register Consulting, ÅF Industry and Risk Pilot) and the Finnish research institute VTT has begun a multi-year study of Probabilistic Off-site Consequences Analysis (Level 3 PSA). This last year of the project, Vattenfall joined the consortium to provide radiation protection expertise in the pilot studies performed and in the development of a Nordic guiding document on Level 3 PSA. The objective of the project is to further develop understanding within the Nordic countries in the field of Level 3 PSA; the scope of its application, its limitations, the appropriate risk metrics, and the overall need and requirements for performing a Level 3 PSA. The project activities include:

- Performing an industrial survey about expectations on a Level 3 PSA, which included several workshops and meetings with Nordic utilities, regulators, and safety experts
- Investigate the use and benefit of L3 PSA risk metrics
  - Health Effects: Individual and Collective Dose, Early/Late Effects
  - Environmental Effects: Ground contamination, “loss” of land
  - Economic: Food bans, relocation, land decontamination, business impacts, etc.
- Investigate the use and benefit of countermeasures (evacuation, sheltering etc.)
- Investigate the interfacing to L2 PSA: Additional requirements to existing L2 PSA Two pilot studies with the aim to
  - illuminate possibilities and identify key uncertainties and limitations in Level 3 PSA analysis
  - Establish resource requirements for production of a Level 3 PSA

The final activity will be the development of a guiding document for Level 3 PSA. This presentation will focus on radiation protection aspects in performing a Level 3 PSA, especially in the development of this guide.

S5-P3

Characterization of HPGe detectors using Computed Tomography

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Computed Tomography (CT) high-resolution imaging have been used to investigate if there is a significant change in the crystal-to-window distance, i.e. the air gap thickness, in a small n-type detector cooled to 77 K, and in a medium sized p-type HPGe detector when cooled to 100 K. The findings were compared to detector dimension data made available by the manufacturer. The air gap thickness increased by (0.38±0.07) mm for the n-type detector and by (0.40±0.15) mm for the p-type detector when the detectors were cooled to 77 resp. 100 K compared to at room temperature. Monte Carlo calculations indicate that these differences have a significant impact on the efficiency in close geometries (< 5 cm). In the energy range of 40-700 keV with a source placed directly on endcap, the change in detector efficiency with temperature is 1.9-2.9% for the n-type detector and 0.3-2.1% for the p-type detector. The measured air gap thickness when cooling the detector was 1.1 mm thicker than manufacturer data for the n-type detector and 0.2 mm thicker for the p-type detector. In the energy range of 40-700 keV and with a source on endcap, this result in a change in detector efficiency of 5.2-7.1 % for the n-type detector and 0.2-1.0 % for the p-type detector, i.e. the detector efficiency is overestimated using data available by the manufacturer.

Impact of atmosphere on the transport of Ruthenium in the primary circuit of nuclear power plant

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Ruthenium is a semi-volatile element originating as a fission product in nuclear reactors that can be released in case of a severe nuclear accident. This release is promoted by air ingress, high humidity, high temperature and oxidative conditions in the reactor containment when the consistency of primary circuit is lost. In this work impact of atmosphere composition on transport of ruthenium through the primary circuit was examined. In experiments silver nanoparticles were used as a representative aerosol in the primary circuit. Additionally impact of NO2 gas as product of air radiolysis was examined. Quantification of ruthenium transported both as a gas (RuO4) and aerosol was performed, to determine amounts of transported ruthenium. Chemical composition of ruthenium species was evaluated by XPS, XRD and Raman spectroscopy techniques. Significantly increased transport of gaseous ruthenium through the facility was detected while NO2 gas was in the atmosphere. In experiments conducted with both silver aerosols and NO2 in atmosphere transport of ruthenium in both gaseous and aerosol form was promoted. Conclusion was made that modification of the atmosphere composition in the primary circuit will have unneglectable effect on the amount of ruthenium transported to the containment during a severe accident.

S6-O1

Radiochemical analysis of important radionuclides in Nordic nuclear industry

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In the Nordic countries, there are 5 nuclear power plants in operation: Forsmark, OKG and Ringhals NPPs in Sweden and Loviisa and Olkiluoto in Finland. In addition, there are 3 research reactors JEEP II and HBWR in Norway and FiR-1 in Finland. Environmental safety of the nuclear installations is a sensitive and critical issue for the public and authorities. In the past years, an increased and more restrict environmental assessment program has been required by the authorities and initiated in the nuclear power plants and host institutions. For this purpose, some radionuclides difficult to measure, such as 14C, 63Ni, and 55Fe, have been added to the list of routine monitoring programme for discharges and circulation water. In the past years, some radiochemical analytical methods have been developed and applied in Nordic industry and research institutions for waste analysis, environmental monitoring and decommissioning.

However, because no suitable reference material is available, it is not easy to validate these methods. There is a high demand for a good approach for quality control and a great need for standard analytical methods for routine analysis of some important radionuclides. A joint NKS project on standardization of radio analytical methods for important radionuclides in Nordic nuclear industry (STANDMETHOD) has been launched by collaboration of 8 Nordic labs, the activities and achievement of this collaboration project are presented.

Multivariate analysis of release data and environmental monitoring data from Swedish nuclear facilities

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On behalf of the Swedish Radiation Safety Authority a multivariate analysis of release and environmental data from some of the Swedish nuclear facilities has been performed. For the facilities in Oskarshamn (three BWR:s and an interim storage for nuclear fuel), Forsmark (three BWR:s) and Studsvik (a waste treatment facility and a closed down research reactor) an analysis for both water and air variables was performed. Earlier a similar study for the facilities in Ringhals (one BWR and three PWR:s) for water variables was performed on behalf of the Swedish University of Agricultural Sciences. For the nuclear power plants in Oskarshamn, Forsmark and Ringhals the radionuclides Co-58, Co-60, Cs-137, Zn-65, Mn-54 and Fe-59 were investigated and for the waste treatment facility in Studsvik Co-60, Cs-134, Cs-137, Eu-152, Eu 154 and Mn-54 were considered. The aim of this project was to investigate if there are correlations between the measured released activity and the measured concentrations of radionuclides in the environment. Multivariate analysis is a statistical tool which can analyse many variables at a time. It is here used to find correlations between samples in the environment and the releases of radionuclides to air and water. Quantifiable correlations between measured releases and measured radioactivity in the environment were identified. Several of the investigated environmental samples showed significant correlations with the releases and mathematical models describing the relationship between releases and concentrations in the environment were identified. The results from the multivariate analysis enables the identification of the most reliable sample types in the monitoring programs in order to reflect releases from the nuclear facilities. A proper selection of sample types allows the estimation of expected environmental concentrations from the release, in addition to estimation of historic releases based on environmental concentrations.

S6-O3

Application of Rapid and Automated Techniques in Radiochemical Analysis – Inspirations from NKS-B Rapid-Tech Project

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Rapid sample processing techniques are desirable in radionuclide determination for emergency preparedness, environmental monitoring, nuclear decommissioning and waste management to achieve fast analysis, and high sample throughput with low labor intensity and cost. Within the Nordic countries, a few laboratories working with radiochemistry have initiated R&D in developing rapid radiochemical methods using different rapid and effective sample treatment techniques. However, the exploration of rapid techniques is still a fresh area, and very little has been done to share experiences and knowledge on this topic among the Nordic countries. In 2014, within NKS-B Rapid-Tech project [AFT/B(14)7], Nordic scientists gathered together and screened the current analytical methods for common radionuclides (e.g., Sr, actinides). Problems and needs in developing rapid radiochemical methods were identified and applications of distinct rapid sample processing techniques to improve the simplicity and analytical efficiency in radio assays for determination of the most common radioisotopes were assessed. Based on the screening, several consensuses through the screening have been reached:

1) Current application of novel automated techniques in Nordic countries is very limited, many of them have only been exploited for research purpose while most routine analysis are still operated in batch-wised manual fashion.
2) Analytical techniques used for Sr determination vary significantly from lab to lab. Especially for low-level environmental samples, several Nordic labs are still using very traditional methods developed in 1960-70s. These methods are not only problematically slow and labor intensive but also based on the use of harmful chemicals (e.g., fuming nitric acid) wherein laboratory safety issues are worth of concern.
3) There is a need for end users to become more aware of the advantages of improved techniques for radiochemical assays, so that they can become more active in driving the long-term development. Identification of concrete analytical benefits and experience sharing are necessary for selecting purpose-fit novel techniques.

To better improve the application of rapid and automated techniques in radiochemical analysis thus to prompt the development of effective radio-analytical methods, insights and perspectives obtained from the NKS-B Rapid-Tech 2014 project are discussed in this paper in combination of specific analytical protocols (e.g., for 90Sr and Pu isotopes).

Canopy interception and accumulation of Fukushima Dai-ichi derived radiocaesium by forest trees

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Radioactive particles, such as Cs-134 and Cs-137, where released to the atmosphere from the nuclear power plant (NPP) accident in Fukushima Dai-ichi in March 2011. These released radioactive particles were deposited both as dry and wet deposition onto forest trees. Some of the intercepted and post-deposited retained radioactive particles were be taken up directly by the forest vegetation through e.g. leaves and/or bark. The aim of this study was to investigate the canopy interception of radiocaesium and the effects of species characteristics on the canopy interception. Moreover, to analyse the accumulation within different plant parts of forest trees. The investigation was based on 4 different monitoring surveys obtained by the efforts of Fukushima Prefecture. The surveys has been carried out from year 2011 in the radioactivity contaminated forest areas of Fukushima Prefecture in Japan, after the release of radiocaesium (Cs-134 and Cs-137) from the Fukushima Dai-ichi NPP accident in March 2011. Totally approximately 250 measurement points in 7 different forest stands was studied. The different tree species were divided into 2 groups, evergreen species (coniferous) and deciduous species (broad leaves).The average interception of radiocaesium (both Cs-134 and Cs-137) was largest for Oak tree mixtures (282 ± 467 Bq m^{-2}) and lowest for Japanese cedar tree (58 ± 104 Bq m^{-2}). The average f-values of radiocaesium (both Cs-134 and Cs-137) were highest for Beech trees (0.58±0.17). The bark part had in generally the highest activity concentration of radiocaesium whereas the lowest activity concentration was in the wood part (both softwood and heartwood). Moreover, there was found that pre-leaves had a higher activity concentration of radiocaesium then in post leaves. The deciduous trees had in general higher activity concentration in the bark part and in the litter layer then for coniferous trees. This can be explained by that the deposition of radiocaesium occurred before the deciduous trees had started leafing.

S6-O5

Concentrations and inventories of Cs-137 in dated sediments sampled in the Swedish Marine Environmental Monitoring Program

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The Swedish Radiation Safety Authority (SSM) collects, jointly with other Swedish authorities (e.g. Swedish Environmental Protection Agency and Geological Survey of Sweden), samples from the marine environment surrounding Sweden. This activity is a part of the Swedish Marine Environmental Monitoring Program. In a subprogram focusing on metals and organic pollutants in sediment, SSM takes part to monitor radioactivity. Sampling stations in this subproject have been monitored since the 1970s, but monitoring in its present form, comprising 16 stations in open sea which are revisited every 5-6 years, started in 2003. The idea is to study trends in pollutions (including 68 elements and 66 organic compounds) at these stations which are carefully selected to be in deep bottom areas with undisturbed sediments that form excellent archives that can be dated. SSMs role has been to study radioactivity in the sediments and to produce sediment dating results for the other collaborators monitoring metals and organic pollutants. We will present the Cs-137 results from 16 sediment cores collected during the 2008 sampling campaign and compare the results with the 2003 data that are already published in the HELCOM database. The sediments collected during the 2014 sampling campaign have just arrived to the SSM, and hopefully some preliminary results on selected cores will be given at the conference.

Effects of dynamic behaviour of Nordic marine environment to radio ecological assessments (the EFMARE project)

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Within the scope of the EFMARE project, the consequences of severe radioactive releases to the Nordic marine environment were analysed with special attention to the effects of dynamic behaviour, namely kinetic bioaccumulation processes and their modelling and the temporal variability of pollutant dispersal. The hypothetical NPP and a submarine reactor accident in the coastal Nordic marine environment (The Baltic Sea regions; Icelandic and Faroese coastal areas) were under consideration. Our results for estimating the concentration of radionuclides in marine organisms and for dose assessment regarding the implementation of the kinetic bioaccumulation model into the NRPA box model and the DETRA computer code clearly demonstrate that there is a significant quantitative difference between the kinetic modelling approach and the approach based on the assumption of constant concentration ratios. Model results were compared with experimental data on the basis of an improved version of the NRPA box model for the Baltic Sea. This clearly demonstrates that dynamic modelling of bioaccumulation processes can provide a more precise description of the concentration of radionuclides in biota and can be very useful for radio ecological assessment. With a numerical case study the temporal variability of pollutant dispersal in Icelandic waters is demonstrated. The simulations, which contain a pollution source in Denmark Strait northwest of Iceland, are based on flow and turbulence fields provided by the CODE operational ocean model. The results show a spreading directed mainly eastwards over the north Icelandic shelf with the North Icelandic Irminger Current. Another path leads into the southward directed East Greenland Current. The dispersal into both branches shows a high inter-seasonal variability whereas the role of the seasonal signal is, at least in certain areas, only of minor importance. These results emphasize that operational hydrodynamic ocean modelling can provide important additional information for radio ecological assessment.

S6-O7

Really long term radiological assessment of ecosystems

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A major challenge for the assessment of nuclear waste repositories is to make estimates for the long time scales of 1000 to 100 000 of years. The Swedish Nuclear Fuel and Waste Management Co. (SKB) has recently handed in two applications for repositories. One high level repository for spent fuel and one low level waste repository for operational nuclear waste. In both assessments the knowledge of the past history of the sites, the last glaciation period to now, and the deduction from the ongoing processes are combined to produce an illustration of future landscapes. This includes variations in the natural ecosystem as well as potential land use of the surface ecosystems and the potential exposure to humans and the environment. The results from these applications give that humans can be exposed to a variation of several orders of magnitude depending at when and how long releases might occur to the surface. A brief overview of the methods applied will presented, and some examples of results. Finally the balance for a complex “realistic” biosphere assessment versus a “simplistic” assessment will be discussed.

Radioactivity in fertilizers

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Fertilizers are produced from organic materials or minerals deposits. Varying concentrations of radionuclides are found in these raw materials. During industrial processes, radionuclides may concentrate in the product, side product or waste. Therefore, fertilizers in the Finnish market were investigated as a part of the environmental radioactivity surveillance. Radioactivity in fertilizers may transfer from soil to agricultural produce either directly to edible crops or via feed cultivation to livestock and hence cause exposure internally to consumers. Fertilizers may also cause exposure externally to those who handle them professionally. The previous survey into radioactivity in fertilizers had been carried out in 1982–1983. The sample consisted of 45 fertilizers: 32 inorganic, 7 organic, 4 soil amendments and 2 substrates. The samples were the same that Finnish Food Safety Authority – Evira selected for their fertilizer's control analyses. The fertilizers originated from Finland, Russia, Germany, Estonia, Israel, Sweden and Belgium, and were collected in 2012. In all investigated fertilizers, radioactivity content was so small that they do not significantly increase the natural radioactivity content of agricultural soils. The radioactivity content of soil amendments and substrates were in the same range as or smaller than agricultural soils in general. Among those who handle these fertilizers at work, excess effective dose from external exposure does not exceed 1 mSv/year.

S7-O1

Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site – The regulators perspective

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This presentation is based on the research project “Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site - Particle Size, Morphology and Chemical Composition”. This study has been conducted by Linköping University for the Swedish Radiation Safety Authority, SSM. The conclusions and viewpoints presented in the report (2015:18) are those of the author/authors and do not necessarily coincide with those of the SSM. From SSM’s point of view it is interesting to present how this research project will support regulatory supervision at nuclear facilities with airborne radioactive particles present. The authority has a challenge at nuclear facilities to understand and follow up how the uncertainties in the different parameters are handled concerning data collection for calculating the committed effective dose. In operating of nuclear facilities, in the process of controlling the radiation working places, many parameters in the collecting data are crucial for following calculations of committed effective dose. Three such parameters concerning uranium aerosols are the particle size, the morphology and the chemical form. It is in our regulations (SSMFS 2008:51) pointed out basic provisions for the protection of workers and the general public. The operator has to control the amount of intake of radioactivity via respiration, ingestion or through the skin (including wound). For this control the air and surface contamination are monitored in “controlled areas”. Results of calculated committed effective dose are related to the regulating dose limits including equivalent dose to the foetus not getting more than 1 mSv. Results of monitoring people shall also be recorded.

Radiation protection of individuals exposed to ionizing radiation at nuclear facilities is based on regulations (SSMFS 2008:26) where the operator is pointed out to have continuous calibrations and checks of instruments and equipment. Personal contamination checks before leaving controlled area has to be installed. Whole body counting including urine analysis and lung measurements if needed is required. If committed effective dose of 0.25 mSv or more is found, the whole working team shall be measured. Single event of intake which is calculated to give a committed effective dose of 5 mSv or more shall be reported in writing to the Swedish Radiation Safety Authority. Such a report has to declare type of intake and circumstances, committed effective dose and the basis for these calculations.

Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site – Particle Size, Morphology and Chemical Composition

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Characteristics are crucial in order to carry out accurate internal dosimetry calculations following the International Commission on Radiological Protection methodology. Examples of such parameters are Activity Median Aerodynamic Diameter and solubility. Understanding of such parameters requires knowledge of aerosol characteristics such as size distribution, morphology and chemical form. In this pre-study, these parameters have been studied at two process steps (fluidizing bed furnace and burnable absorber grinder) at the Westinghouse Electric Sweden AB nuclear fuel factory in Västerås, Sweden. Aerosols were collected using a cascade impactor and 45nalysed with Scanning Electron Microscopy coupled with Energy Dispersive X-ray analysis. The results show a significant variation in uranium aerosol shape (spherical, near-cylindrical, irregular with sharp edges, conglomerates of small particles, etc.), with particle size distributions to some extent deviating from the expected lognormal distribution, possibly indicating two 'families' of particles. The vast majority of the radioactive aerosols, unsurprisingly, consisted of uranium and oxygen, but at the bed furnace, 1-6% of the uranium aerosols contained fluorine. Other uranium aerosols were shown to be attached to elements such as nitrogen, aluminium, gadolinium and silicon. This is believed to affect the aerosols' physicochemical properties.

S7-O3

Performance of a new NIRP TL-dosimeter – Uncertainty and detection limit estimation

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In July 2012 the Danish Health and Medicines Authority/National Institute of Radiation Protection introduced a new dosimetry system based on thermoluminescent dosimeters (TLD). The system consist of a HarshawTM TL-card with LiF:Mg,Cu,P material and automated '8800' TL-readers from Thermo Fisher Scientific. The TL-card is worn in a designated plastic holder to measure the operational quantities for individual monitoring. The performance of the dosimeters is being tested according to the international standard IEC 62387-1 and irradiations with photon and beta-particle fields are performed according to the standards ISO 4037 and ISO 6980. Results from this test will be presented and uncertainties and detection limit will be presented and discussed in accordance with internal standards.

The start of the decommissioning of the inner parts of the DR3 reactor

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The decommissioning of the former DR3 research reactor at the Risø site has now reached a state, where the first of the reactors inner parts have been removed. These parts were the top shield plug (TSP) and the top shield ring (TSR) which constituted the shielding at the top of the reactor tank. Both the TSP and the TSR were heavy components with very active bottom parts. Therefore careful planning and monitoring was needed prior to and during the removal of the two components. A characterization of the reactor components was used to estimate the distribution of activity in the components. The radiation levels around the TSP and TSR were calculated both unshielded as well as when placed in their shielding casks, based on the estimated activity contents. The components were handled remotely during the removal until they had been shielded to an extent that enabled human handling. Also the dose rate was monitored remotely. Good agreement was obtained between measured and calculated dose rates. A dose constraint of 1mSv was set for individual effective dose for the workers participating in the operations. Both Danish Decommissioning personnel and external workers did participate in the removal of the TSP and TSR. Effective doses to the workers were all well below the dose constraint.

S7-O5

Radioactive Waste Management in Denmark

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Danish Decommissioning (DD) receives and manages all the radioactive waste produced in Denmark. The waste originates from a variety of users and activities including the industry, the health sector, research institutions, schools, and the decommissioning of the nuclear facilities at the Risø area. The waste management is subject to a number of requirements concerning the protection of humans and environment. These requirements concern all stages of the waste management and –treatment from production of the waste over short- or long term storage till the final disposal. During the early stages of waste production and –storage humans and environment must be protected from ingestion of and exposure to direct radiation from radionuclides. At the final stage of the waste management, the disposal, the effort will concentrate on isolating the waste from humans and environment, and to inhibit, reduce and delay the migration of radionuclides at any times from the waste to the biosphere. In order to consider and prepare for all stages of the waste life cycle a number of requirements have been set up for the waste management. The requirements include:

- Volume reduction of the waste;
- Sorting of the waste according to material and origin
- Waste characterization including weight, size, material composition, and identification of radionuclides involved
- Maintaining data about the waste for future generations.

The detailed description of the waste is important as waste properties can be deciding factors when selecting a final design for a long term solution for the waste. We present the Danish Waste management which is based on the requirements above. Furthermore we present the possibilities for a long term solution for the Danish radioactive waste that have been decided politically, and we outline the considerations and models that will be a part of a safety case for a long term solution for the Danish Radioactive waste.

Establishing a method for a more accessible and reliable verification of medical radiation shielding

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Background: In the planning of any medical X-ray facility one of the main priorities is to ensure that persons in the vicinity of the x-ray facility are not exposed to levels of radiations that exceed regulatory exposure limits. Verification in the form of measurements and calculations of the radiation shielding are mandatory when it is not entirely unlikely that the exposure limits could be exceed, due to increased workload, new equipment or renovation.

Aim: The aim of this project is to evaluate current methods in use for assessment of medical radiation shielding. Furthermore, we aim to establish a practical and reliable method for verification of radiation shielding.

Methods: Measurements of wall shielding in medical x-ray facilities will be carried out using a portable high-purity germanium detector. Initial measurements will focus on determining a suitable radionuclide, taking into regard factors such as measurement time, half-life, availability etc. The sources to be considered are medical radionuclides such as I-131 and Tc-99m, and other available nuclides such as Am-241 and Cs-137. Measurements will also be carried out using mobile x-ray equipment, also here factor such as availability, practicality and reliable results will be taken into regard. Additional comparative measurements will be performed using available methods in use today.

S8-O1

INVITED: Developments and justification of applications using ionizing radiation in the medical field

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In recent years, those professionals of the radiation protection community who work within the field of medical exposures have embraced and promoted the importance of appropriate justification and optimisation. The focus however has been on individual exposures and the applications of these principles to classes or types of exposure has been largely forgotten. Such exposures can be considered as being at Level II of the ICRP justification hierarchy.

The publication of the Basic Safety Standards Directive 2013/59/Euratom is a timely reminder that Member States need to ensure that new classes or types of exposure must be justified before being adopted. In addition, justification of existing classes or types of exposure must be reviewed in the light of new and important evidence regarding their use and efficacy.

A new requirement of the Directive requires occupational and public exposure must be taken into account when considering medical exposures.

The rate of development in diagnostic and therapeutic medicine is rapid and this applies equally to those areas where ionising radiation is used. This presents specific challenges to those organisations tasked with undertaking the required justification processes.

This presentation considers different approaches to Level II justification, including two examples in the clinical field to illustrate the problems faced by Member States seeking to comply with Directive requirements.

Radiation safety aspects of the Danish Center for Proton Therapy

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The Danish Center for Proton Therapy will be located at Aarhus University Hospital in Skejby 5 km outside Aarhus. The facility will have 3 treatment rooms with gantries and a research room with a fixed beam line. The present status is that Varian Medical Systems has been selected as the supplier of the proton therapy equipment and that the building construction soon will begin. Patient treatment will start in 2018.Secondary neutrons produced by the loss of protons is the main prompt radiation hazard of the facility during operation of the proton therapy equipment, whereas the contribution from other types of radiation normally can be neglected owing to shorter attenuation lengths in matter. Besides the prompt radiation from the therapy equipment, proton and neutron interactions also produce radionuclides in the proton therapy equipment and in surrounding building structures. The facility will be shielded by concrete because concrete has good neutron attenuation properties, is relatively cheap, and has excellent structural properties. The method for determination of the thickness of the concrete shielding will be presented. Long-lived radionuclides in the concrete shielding could be a significant expense for the decommissioning of the building at its end-of-life. Accordingly, the amount of radionuclides in concrete has been estimated and the use of other materials with more favorable activation properties has been investigated. The secondary neutrons also produce radionuclides in air, in the cooling water, and in the groundwater. The radiation safety aspects of these radionuclides will also be presented.

S8-O3

New Danish research laboratory for medical dosimetry

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In 2014, DTU's Center for Nuclear Technologies inaugurated a new laboratory for medical dosimetry at Risø Campus near Roskilde. Key elements in the laboratory are a medical linear accelerator (Truebeam, Varian Medical Systems), a cobalt-60 irradiator (Terabalt 100, UJP Praha), and an advanced instrumentation for dosimetry research. The laboratory has been made possible through a large donation from the John and Birthe Meyer Foundation. An important aim for the work at the laboratory is to develop new improved methods for measurement of the absorbed dose to water, for example, in MV photon beams from linear accelerators. This work comprises both (i) clinically oriented projects carried out in close collaboration with Danish hospitals, (ii) detector oriented projects based on in-house developments and DTU technology, and (iii) metrology projects on new standards and calibration procedures. The objective of this presentation is to outline the design of the new laboratory, and to highlight work related to radiation-protection dosimetry, such as characterizing personal electronic dosimeters for Hp10-measurements in pulsed beams.

The National System for the Introduction of New Health Technologies within the Specialist Health Service

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The National System for the Introduction of New Health Technologies within the Specialist Health Service was introduces in 2013. The main purpose with the system is to ensure that patients get access to new methods showing a safe and evidence based clinical effect and avoid unsafe and non-effective methods. The Norwegian Radiation Protection Authority (NRPA) became a full-part member in August 2014. The motivation for this implementation is the national radiation protection regulations requirement for a generic justification evaluation of new methods and practices in medical exposure before they are introduced in general clinical practice. This national system coordinates all steps and authorities involved in the process of evaluating new methods before they are put into general practice. The system covers alerts of new methods, evaluation of new methods, prioritizing, decisions and finally implementation. Evaluation of methods follows international principles of health technology assessment (HTA) and is performed at three levels: mini-HTA, fast-HTA and complete-HTA. Mini-HTA is performed locally at the Hospital Trust, while fast and complete HTA are performed at a national level. The Norwegian Medicines Agency (NMA) is responsible for the fast-HTA of pharmaceuticals and the Norwegian Knowledge Centre for the Health Services (NKCHS) is responsible for fast-HTA of medical equipment. A complete-HTA is always performed by NKCHS. NRPA is assisting both NMA and NKCHS in fast and complete-HTA of new radiopharmaceuticals and new equipment and procedures for use in medical exposure. NRPAs role in the national system is to ensure that radiation protection issues are evaluated and taken into account in the total risk-benefit evaluation of the method in all three levels of evaluation. As a part of the system, NRPA get properly involved in all processes related to the introduction of new methods and a national overview of local mini-HTA performed on the different hospital trusts for equipment and procedures within medical exposure.

S9-O1

Computed pediatric tomography exposure and radiation-induced cancers: Results from a national cohort study in France

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Context: The increasing use of computed tomography (CT) scans for the pediatric population raises the question of the possible impact of such ionising radiation (IR) exposure on the occurrence of radio-induced cancers. Recent epidemiological studies have suggested an increased risk of cancer among children receiving CT scans. In France, a nationwide study has been launched to assess cancer risks, especially leukemia and cerebral tumors, associated with the use of CT scans in pediatrics. This study is part of the Epi-CT collaborative European project.

Material and methods: The cohort includes children less than 10 years old, subjected to at least one CT scan between 2000 and 2011 in 23 French University hospitals. Cumulative organ doses were estimated according to the protocols retrieved from the radiology departments, using specifically designed simulation software. Clinical information recorded during hospitalization was used to determine whether the children had medical predisposing factors (PFs) likely to increase their risk of cancer. Cancer incidence and mortality data were retrieved through national registries.

Results: At all, 67 274 children were included, 30% of whom were exposed to a first CT scan before the age of 1 year. Examinations of the head represent 57% of the CT scans. PFs to cancer were observed in 2.3% of the children. During the follow-up from 2000 to 2011, 27 children were diagnosed with cerebral tumors, 25 with leukemia. Hazard ratios (HRs) of 1.06 (95% CI 1.02–1.10) for cerebral tumors and of 1.08 (95% CI 0.80–1.44) for leukemia (17 cases) were estimated for each increment of 10 mGy in CT X-rays organ dose. In children without PFs, hazard ratios were similar to those which were estimated for the whole cohort while HRs decreased in children with PFs. This decrease of risk was possibly due to a concomitant increase in non-cancer mortality risk among children with PFs.

Conclusion: These first results indicate that patients with PFs should have a very different risk of radiation-induced cancer than patients without PFs. Then, in terms of public health, the most relevant risk estimates should be analyzed separately for each group. Confounding bias by indication could nevertheless not be excluded and should be investigated by extending the follow-up of the cohort and by other ongoing studies.

Pediatric protocols and dose reduction devices in CT scanners where few examinations are performed

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The increase in number of computed tomography (CT) examinations in the last decades has inspired important technical improvements in the area of dose reduction. Among the emerging techniques in the last decade are iterative reconstruction (first image based and then model based), dose optimized selection of kV, organ dose modulation and pediatric optimized protocols. These new technologies are generally not all available in all scanners, especially not in the older ones. In Iceland, a substantial amount (19,5%) of all CT examinations are done in CT scanners in which less than 5000 examinations are done per year and those scanners might not be equipped with optional technical features. The aim of our study was to evaluate factors related to scanner design and setup that might result in considerable differences in radiation dose between geographic areas. All scanners outside the Reykjavik-capital area were included because it is known that relatively few CT examinations are performed with each scanner in contrast to CT scanners in the more densely populated capital area. The scanners were systematically examined with regard to the existence and use of pediatric protocols and the aforementioned dose reduction technologies. The results show that numbers of examinations performed are from a few hundred examinations/year up to a few thousand. Pediatric protocols are generally present but not well developed and even not used at all. Special guidelines for pediatric examinations are generally not available. Dose reduction techniques that have been introduced in the last decade are generally not available. Our results show that an effort is needed to increase awareness of the importance and necessity of pediatric protocols, especially where pediatric examinations are rare. Many CT examinations are still performed with scanners where few or none of the new dose reduction tools are available.

S9-O3

Population doses from x-ray and nuclear medicine procedures in Nordic countries

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Population doses from radiodiagnostic (x-ray and nuclear medicine) procedures in Nordic countries were estimated based on data collected from 36 European countries in Dose Datamed 2 (DDM2) project. In Nordic countries the mean effective dose per caput from all diagnostic x-ray and nuclear medicine procedures was 0,87 mSv which is lower than the corresponding dose 1,12 mSv in the EU and EFTA countries (except Lichtenstein).

For x-ray procedures in Nordic countries a mean effective dose was 0,83 mSv per caput, being lowest in Finland (0,45 mSv) and highest in Iceland (1,70 mSv). Compared to the average of EU and EFTA (except Lichtenstein) countries included in the survey in which a mean effective dose was 1,05 mSv per caput, only Iceland and Norway had higher per caput doses and also their frequencies of CT procedures were higher than in other Nordic countries.

For nuclear medicine procedures in Nordic countries a mean effective dose was 0,04 mSv per caput, being lowest in Finland (0,02 mSv) and highest in Denmark (0,07 mSv). Compared to the EU and EFTA (except Lichtenstein) countries in which a mean effective dose was 0,06 mSv per caput, only Denmark had higher per caput dose, and the frequency of positron emission tomography (PET) studies was higher than in other Nordic countries.

Recent increases in medical imaging, particularly with respect to computed tomography (CT) and other high dose procedures, have led to significant increase of individual patient doses and of the collective dose to the population as a whole. The overall per caput effective doses from radiodiagnostic procedures in Nordic countries are about half the recent value of per caput effective doses estimated in Australia (Wallace 2012) and about one-third of the corresponding value in the USA (NCRP 2009). Comparing the results with an earlier estimation of population dose in Europe, in the DDM1 countries, there seems to be a trend upwards, in Denmark 92 % and both in Norway and in Sweden 14 %. In Finland the overall per caput effective dose has not changed.

A relatively low value of population dose can be a good sign for the successful implementation of the justification and optimization principles in radiation protection. The Nordic countries are considered to be very similar to each other; however there seems to be variation in use of different imaging modalities.

Sunbeds and sunburns in Iceland

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The incidence rate of melanoma rose rapidly in Iceland in the 1990s. In the Nordic countries and among young women (less than 50 years of age) it stood out in Iceland. The incidence rate did however start to decline around year 2000 and it is currently below the Nordic average. It has been suggested that the increase was due to the introduction of the modern type of sunbeds in the 1980s. Currently the number of sunbeds per 1000 inhabitants of Reykjavik is 0.3 but in 1988, this number was more than fourfold (1.5) [1]. In this work, the frequency of sunburns will be presented and discussed. Currently, Icelanders have a relatively low frequency of sunburns. A survey from 2014 showed that 72% of 18 years and older received no sunburn and there was no gender difference. In the age group 12-17, 66% of males had no burns and 47% of the females. This can be attributed to a frequent cloud cover and a low solar-radiation (low UV-index) due to a northern latitude. Consequently it can be assumed that a higher proportion of sunburns are received in sunbeds in Iceland than in other countries. This further supports a causal link in Iceland between the number of sunbeds and the incidence rate of melanoma.

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S10-O1

The importance of implementing radiation protection in the national eHealth-strategy

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The technological development in medical exposure is fast and new equipment and methods are continuously introduced and implemented in clinical use. As a consequence, medical exposure is now the largest man-made source of radiation to the population. To ensure for proper medical exposure it is crucial that justification, optimization and dose limitation is properly implemented at health care facilities. International and European organizations have lately increased their focus on the necessity of implementing these radiation protection principles in the health care facilities IT-systems. Norway has now initiated a national eHealth strategy. One of the objectives is to make data available for quality assurance, health surveillance, management and research. The Norwegian Radiation Protection Authority (NRPA) has now been included in the national eHealth strategy. Two major projects are under development at NRPA to strengthen the implementation of justification and optimization in medical exposure. Unjustified radiological examinations are an increased challenge both from a health economical and radiation protection perspective. Evidence based referral criteria and their implementation in clinical decision support systems (CDS) is identified as an important tool to reduce unjustified examinations. NRPA is part of a national working group with the mandate to look into the possibilities for adapting and adopting already available referral criteria, to implement them in CDS systems and connect it to general practitioners electronic referral systems. Local and national overview of patient doses is essential for optimization of radiological examinations and to be able to communicate radiation risks to patients. NRPA strongly recommend that dose parameters from radiological examinations automatically are transmitted from the modality to a local database that support statistics and reporting to national records. NRPA have initiated cooperation with the National Patient Register (NPR) to automatically collect activity and dose data from the health care facilities. These data will further give input to a national surveillance system for medical exposure. This system will provide NRPA with important information of national dose distributions and frequencies of typical radiological examinations and allow for establishing national diagnostic reference levels (DRLs) and frequent estimates of the population dose from medical exposure.

Clinical audits for breast cancer radiotherapy in Norway

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Background: During 2009-2011, external peer review clinical audits for breast cancer radiotherapy were carried out at nine radiotherapy centres in Norway. The purpose was to assess compliance with the national radiotherapy guidelines regarding treatment planning for post-operative left sided breast cancer. All radiotherapy departments volunteered to take part in the audits. The audits were a joint project between the Norwegian Breast Cancer Group (NBCG) and the quality assurance group in radiotherapy (KVIST) at the Norwegian Radiation Protection Authority.

Material and methods: The audit topic was post-operative left sided breast cancer radiotherapy, focusing on indication and radiotherapy treatment planning. The audit standard was the national guidelines for breast cancer treatment (developed by NBCG). The auditors had a list of items for evaluating clinical practice against the audit criteria. A total of 180 treatment files were audited. The findings were grouped to analyse the degree of guideline compliance for indication, treatment technique, delineation of treatment volumes and organs at risk, and dose related parameters.

Results: The treatment was in accordance with the guidelines for indication, treatment technique and lung delineation in 98% of the cases, with minor deviations in 2%. For delineation of the clinical target volume (CTV) and the heart, minor deviations were found in 44% of the cases, major deviations in 6%. The dose distribution to the CTV was in accordance with the guidelines in 89% of cases, with minor deviations in 11%. A minimum dose to CTVbreast/breast wall of at least 95% of prescribed dose (D98% ≥95%) was attained in 39%, whereas D98% ≥90% was attained in 93% of the cases. According to the auditors, the guideline principles were attained without or with minor deviance in 87% of the cases. Conclusion: For a large majority of audited cases, the radiotherapy was planned in accordance to the guideline principles. Delineation of target volumes and optimal dose distribution are challenging tasks, for which improvements are still desirable.

S10-O3

Inspection of Cardiology departments in Norway: Are they making it great in radiation protection?

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Purpose: Cardiology departments are one of the largest users of medical radiation, and interventional cardiology procedures are increasing, both in frequency and complexity. The procedures have great clinical benefits for patients, but they have the potential to induce radiation injuries. Staff involved in interventional cardiology receives the highest occupational doses in Norway, and skin burns of patients have been reported. Focus and awareness on radiation protection (RP) in cardiology is therefore crucial to reduce the associated radiation risks. To identify the level of implementation of RP for patients and staff, and compliance with the RP regulation, the Norwegian Radiation Protection Authority carried out inspections with all cardiology departments in Norway.

Method: The inspections were conducted (2013–14) as quality system reviews, based on document reviews, interviews, on-site inspections and observations of interventional procedures. Focus topics were organisation of RP, role and involvement of RP officer and medical physicists, education and training in RP, justification and optimisation, protection of staff and patients, personal dosimetry, local standard dose, monitoring and follow-up of patient doses and performance of quality control of X-ray equipment. Cardiology interventions are centralised in eight hospitals in Norway, seven public and one private.

Results: The inspections revealed that most of the hospitals had non-compliances according to the RP regulation. Most deviations were associated with education in RP and follow-up of patients who had received high radiation doses. Lack of systematic optimisation of procedures and estimation of the eye lens doses to evaluate the risk of exceeding the new proposed dose limit for cardiologists with high personal dosimetry readings (worn over the apron) was common. Other common non- compliances dealt with establishment of local diagnostic reference levels and their systematic use in optimization of cardiology practice. Notification of unintended incidences, especially patient doses much higher than intended, was not systematically reported in the hospitals quality system. The inspections revealed a need for increased awareness of RP in cardiology practice.

Conclusion: Level of compliance with some of the requirements given in the RP regulation was poor. Inspections turned out to increase the awareness of RP in cardiology and are identified as an effective tool for improving RP and safety.

Measurement of eye lens radiation doses to staff during percutaneous coronary interventional procedures

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Interventional cardiology staff has a high exposure to radiation. In light of the recently lowered recommended occupational eye lens dose limit by ICRP, it is now even more justified to monitor staff radiation dose. However, measuring eye lens doses is challenging because the dose at any measurement point differs from the dose to the eye lens, depending on variations in staff position relative to the patient, projection angle, radiation quality, patient size and the presence of radiation protection shields and/or personal lead glasses. The main aim of this study was to investigate the relationship between the absorbed dose at different measurement positions near the eye and the absorbed dose to the lens during cardiac interventional x-ray procedures. Furthermore, we aimed to assess the effect of projection angle, patient size, lead shields and protective eyewear on this relationship. Phantom measurements were carried out using two anthropomorphic phantoms representing patient and operator, respectively. Dosimeters calibrated in terms of Hp(0,07) were used to measure the equivalent dose, one dosimeter inserted at the anatomical eye lens position and the other at one of three chosen measurement positions. Exposures were made with automatic exposure parameters, projection angles (lateral and craniocaudal) ranging from -90 to 90 degrees, two patient sizes (standard phantom and additional 5 cm PMMA), and for two types of common lead glass models. The results indicated that for a wide range of projection angles, the lowest deviation from the eye lens dose was received for a dosimeter placed on the left temple, with a mean (SD) deviation of 2.7 (5.1) %. The other two positions, above left eyebrow and mid forehead, deviated with -15 (7.5) % and -30.5 (4.1) % respectively. The same tendencies were seen for a larger patient size. The mean (SD) dose reduction ability of lead glasses was 7.1 (1.6) % and 6.8 (2.2) % for the two models, while a ceiling-mounted lead shield, in proper position completely blocked stray radiation to the eye lens. Eye lens dosimetry is challenging in a clinical environment because dosimeters have to be positioned at a remote position from the eye lens. For cardiac interventional x-ray procedures, a dosimeter placed at the left temple provides the most accurate measurement of eye lens dose. Protective lead eyewear has limited dose reduction ability of less than 10 %, while a ceiling-mounted lead effectively reduces the dose to the eye lens.

S10-P1

Frequency of Medical X-ray Examinations in Iceland in 2013

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Introduction: The frequency of medical X-ray examinations has been investigated with a collection of national data every 5 years for the past two decades. The most recent collection of data was done in 2014 for the year 2013. In this report the results of this collection will be presented.

Materials and methods: Medical X-ray and Nuclear Medicine (NM) examinations are performed at 38 different locations in Iceland: hospitals, health care facilities, private clinics and research facilities. These examinations are stored (saved) in 6 different RIS/PACS systems. Information was collected about examination types according to RES codes, imaging modalities, department or the location where the examinations were performed and patient identification information (sex, date of birth and national id). Along with information about X-ray and NM examinations, information about other medical imaging examinations were collected (Ultrasound (US) and Magnetic Resonance Imaging (MRI)).

Results and discussion: The number of all medical diagnostic imaging examinations in Iceland in 2013 is presented. This number has decreased by a small fraction from 2008 when this information was collected last. Conventional X-ray examinations have decreased considerably, while there is a steady increase in CT, Interventional, MRI and US examinations. The number of NM examinations has continued to decrease from 2008 as it did in the period from 2003. A collection of patient dose data from the major contributing X-ray and NM-departments is ongoing and should be concluded by the end of this year or early 2016.

Ra-223 planar whole body scan and SPECT of surgically removed bone

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Introduction: Radionuclide therapy with Ra-223 dichloride has been initiated for prostate cancer patients with symptomatic bone metastases. Typical prescribed activity is 50 kBq/kg bodyweight, 6 times at 4 weeks interval. Ra-223 is an alpha-emitter, but it also emits gamma radiation, that can be utilized for imaging purposes.

Methods and materials: The possibility of imaging Ra-223 treated patients and bone was investigated. We acquired a SPECT scan 27 days after the last treatment of ex-vivo bone, which was removed during hip surgery. The hip bone was stored in a plastic container in a formaldehyde solution. A planar whole body scan of a patient (in-vivo), who was administered 4.4 MBq Ra-223 one hour before scanning, was also acquired. Half-life of Ra-223 is 11.43 d. The decay chain of Ra-223 to stable Pb-207 involves 6 stages, all with shorter half-lives (ms to min) than Ra-223. Four stages are by alpha, two by beta emission. Total emitted energy in the decay is 28 MeV; X-ray and gamma lines (1% of total energy) in the interval 80-400 keV allow external detection. A dual head Philips Precedence SPECT-CT with MEGP collimators was used. A one hour planar whole body scan was acquired with 40 mm/min scan speed and 2.78 mm pixel size. SPECT acquisition was performed in step and shoot mode with a 128x128 matrix size, 4.66 mm pixels and 128 angles. Data was acquired 600 s per angle resulting in a total acquisition time of almost 11 hours. Reconstruction was performed with a resolution recovery OSEM method (Astonish) with 3 iterations and 8 subsets. Attenuation Correction was performed with a 140 kVp low dose CT.We compared a set-up with two 20% width energy windows. One at 269 keV corresponding to the most intense gamma-line (14% yield) and another one at 84 keV overlapping the two most intense X-ray emissions at 84 and 81 keV (25% and 15% yield).

Results: The lower energy window resulted in visually better images than the higher energy window in both cases. The SPECT of the bone revealed that spatial allocation of the counts is best in the 84 keV window. The 269 keV SPECT showed a significant amount of counts in areas without bone indicating a bigger influence of scatter.

Discussion and Conclusion: LEGP collimators might improve the quality for the 84 keV SPECT, as long as downscatter from higher energy photons does not become a problem. We have showed that it is possible to image patients treated with Ra-223 and that it is best done with the 84 keV window.

S10-P3

Whole body counting of radium-223 for monitoring of staff in radionuclide therapy

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Aim: Radionuclide therapy with Ra-223 dichloride has been initiated in many countries for prostate cancer patients with bone metastases (Xofigo, Bayer). Prescribed activity is 50 kBq/kg, 6 times at 4 weeks interval. To license use of Ra-223, Danish authorities requested proof of ability to document compliance with dose limits. We used our low-background whole body counter (WBC).

Materials and Methods: Half-life of Ra-223 is 11.43 d; it decays to stable Pb-207 through 6 stages, with half-lives ms to minutes. Four stages are by alfa, two by beta emission. Total emitted energy per decay is 28 MeV; X- and gamma lines at 80-400 keV (1% of total energy) allow external detection. ICRP dose coefficient for Ra-223 inhalation is 6.9 mSv/kBq, hence dose limit for workers (20 mSv) may be received by a single inhalation of 3 kBq, or by a weekly uptake of ~60 Bq. The WBC is underground and shielded with 15 cm of steel lined with Pb and Cd. The 4 detectors are 6*4" NaI-cylinders. A WB phantom with human levels of K-40 in water was configured from 1L and 2L bottles corresponding to different person weights. A sample of 40 kBq Ra-223 was moved around to simulate uniform distribution or focal lung uptake. Various detector configurations were tested using 20-445 keV window and T= 1800 s for background (BG, "cold" phantom) and test. We compared sensitivity S (cps/Bq) to BG to determine minimal detectable activity (MDA) and minimal quantifiable activity (MQA). Optimized settings have been used on 10 treatment days.

Results: With std configuration for WB measurement, S =0.026 cps/Bq and BG=30 cps in the 77 kg phantom. From 55 kg to 88 kg, MDA was 20-24 Bq and MQA (10%) 60-74 Bq. In a configuration optimized for lung uptake, S increased to 0.14 cps/Bq with BG=37 cps. Resultant MDA (T reduced to 1200 s) was improved to 5-6 Bq, and MQA (10%) to 15-18 Bq. In consideration of Tc-99m contaminations (Bq-amounts), the window was reduced to 210-445 keV, with an increase of MDA to 8-10 Bq and MQA (10%) to 26-31 Bq. To date, no internal contamination of staff with Ra-223 has been detected.

Conclusion: MDA and MQA limits with WBC are sufficient to document compliance with dose limits. Knowledge of true BG is essential, and must be individually determined on each treatment day for quoted figures to be obtained. If low-level "continuous" uptake can be excluded, standard (personal) BG may still be sufficient to detect any dose significant uptake in case of a contamination incident.

Developments in first choice from conventional X-rays to CT for selected studies

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In the past 15 years extensive development within the field of CT has taken place. As a result, for some indications the first choice of examination method has changed from the conventional x-ray examination to CT examination. One example is the practice changes within kidney and colon examination over the past 10 years.

We have compared the development in the numbers of examinations, performed in hospitals and clinics in Denmark, for the following examinations:

- Intravenous urography (IVU) vs. CT urography
- Colon fluoroscopy vs. CT colography

Patient doses for selected x-ray examinations are collected from hospitals and clinics by the National Institute of Radiation Protection with the aim of setting national diagnostic reference levels (DRLs). DRLs have existed for many years for IVU and colon fluoroscopy, while a DRL for CT colography has been set in Denmark primo 2015, and a DRL for CT urography Is still preliminary due to lack of sufficient data.

For both urography and colon examinations, a CT examination has become the first choice. By switching from the conventional X-ray examination to CT scanning, the dose to the patient is increased significantly. However, the CT scanning will provide more information, which may result in a faster diagnosis by avoiding the supplementary examinations. It is important that the CT examinations are justified and optimized.

We will continue to follow the CT doses for these and other examinations, as a lot of work within dose optimization is being carried out both at the producer and locally at the hospitals.

S11-O1

Swedish Radiation Safety Authority: Systematic monitoring and evaluation of work practices an important aspect of improving radiation safety for patients

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Background: Inspections performed by the Swedish Radiation Safety Authority have shown that radiographers do not follow basic radiation protection guidelines to reduce the radiation dose to patients. In addition, hospital management insufficiently monitors compliance with these guidelines.

Performance: In 2012, 199 radiology departments in Sweden were requested to report on existing guidelines regarding identity checks, X-ray examinations of women of childbearing age, when to use lead shielding of gonads for male patients and when to use compression. Over the course of 2013 and 2014, the Swedish Radiation Safety Authority conducted a follow-up to the survey of basic radiation protection guidelines. Heads of staff at 94 radiology departments were requested to evaluate their compliance with existing guidelines for reducing radiation doses to patients.

Results: When comparing the 2013 and 2014 outcomes, the Swedish Radiation Safety Authority could conclude that the radiology departments have improved their capability to evaluate compliance with their own guidelines. In 2013, only 30 per cent of the participating radiology departments were able to evaluate compliance with their own guidelines. In 2014, the percentage had increased to 93 per cent. Despite improvements in the radiology departments' capability to evaluate compliance with their own guidelines, the departments' compliance is still low. With an average of about 50 per cent in compliance with their own guidelines, there is great potential for improvement. Several radiology departments in both public and private healthcare show 100 per cent adherence.

Inspections of x-ray equipment at Danish public hospitals

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During the last 3 years NIRP has been inspecting every single x-ray equipment at Danish public hospitals. This has been done by following one responsible medical physicist at a time. At the inspections, we have been looking at different aspects of radiation protection as well as controls of the equipment. This talk will summarise the general findings as well as some more peculiar observations.

S11-O3

Electronic inspection of industrial radiography companies in Norway

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In Norway, there are at any given time 70-80 companies with a license to perform industrial radiography. Given the companies' geographical spread and the limited staff of the Norwegian Radiation Protection Authority (NRPA), conducting on-site inspections with desired frequency is a formidable task. Therefore, the NRPA is currently testing "electronic inspections" as an addition to on-site inspections. The aim is to increase inspection frequency greatly, with only a modest increase in workload, hopefully raising awareness of radiation protection in the radiography community. The method relies on the radiography companies self-reporting on a number of subjects, put to them in a web-based questionnaire (Easyresearch by Questback). Questions pertain to the companies having written radiation protection procedures, operators having accredited radiation protection certificates, radiation sources being registered in the NRPA source database, etc. In accordance with the goal of keeping workload low, we do not ask to see the actual documents. For the same reason, the questions are predominantly multiple-choice, thus limiting the number of possible answers. This allows for automated analysis of the replies, as we can decide beforehand the answers that are not in compliance with regulations. Seeing as the questionnaire is just now closed for entries, only rudimentary results are available at the time of writing. However, the response rate alone qualifies the electronic inspections as a success. 67 out of 70 companies (96 %) completed the questionnaire. The high response rate can probably be attributed to the fact that we made it clear that the questionnaire had the same regulatory status as an on-site inspection, meaning the companies were obliged to answer under the radiation protection regulation. Further data analysis and follow-up of companies remain, but as a teaser we can reveal that the initial analysis revealed 37 cases of non-compliance with the Norwegian radiation protection regulation, reported from 21 companies. From an NRPA point of view, the method of electronic inspection is so far deemed a success. Putting in a moderate amount of work, we have received a large amount of data. Judging from response rate and informal feedback, the new inspection format also seems to be well received in the radiography community, many citing it as an incitement to review their own practices and procedures.

Inspections in non-medical use of radiation in Finland in 2010-2014

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This study analyzes inspections conducted in 2010 – 2014 by the Finnish Radiation and Nuclear Safety Authority (STUK) in the use of radiation in industry, research, education and servicing, repair and installation in Finland. The total number of inspections made was 1020. In 800 cases STUK issued orders to correct observed non-compliance. This means that only 22 % of the inspections were done without any orders issued. The total number of issued orders was 3345. The most common reason was lack of warning signs for radiation or insufficient additional protective devices in the radiation source. It was also noticed that local rules regarding the preparedness for abnormal events were missing in many places where radiation is used. Also quite many orders concerned the organization itself, such as unspecified duties of the radiation safety officer or insufficient supplementary training of the radiation safety officer. The data collected in 2010-2014 will be used in the future to target more inspections to areas were most of the non-compliance were observed. During the years 2010-2014 STUK has emphasized the preparedness for abnormal events which can now be observed as the number of organizations inspected lacking local rules for abnormal events incidents decreased from 100 in 2010 to 56 in 2014.

S11-O5

New procedures for disposal of ionisation chamber smoke detectors

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Recycling is a hot topic today. Many consumers are aware that waste containing electrical and electronic equipment (WEEE) should be disposed for recycling.

Hence recycling sites receive disposed ionisation chamber smoke detectors (ICSDs). Some of the recycling sites treat the ICSDs as WEEE. In the recycling industry shredding is commonly used, hence there is a risk of the ICSDs being shredded together with WEEE. This could lead to contamination of the shredded material, and in the worst case internal exposure to americium-241 for workers dealing with shredded material. To prevent this, NIRP, in cooperation with DPA-system (Dansk Producent Ansvar/Danish Producer Responsibility) and the Environmental Protection Agency, is presently introducing new procedures for the recycling industry in order to ensure full separation of ICSDs from WEEE. The focus is on guiding the recycling sites and the recycling industry in correct handling, separation from WEEE; especially optical smoke detectors, and disposal of ICSDs. In continuation of the new procedures NIRP will carry out inspections of the relevant sites at the recycling industry.

Regulatory Authority Records from the 2014-2015 Blood Irradiator Inspection Campaign

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Denmark hosts 17 Cs-137 based blood irradiation facilities with a maximum permitted inventory ranging up to 105 TBq. In addition to blood irradiation activities, the facilities are used in research projects. The use of these facilities is regulated through the National Board of Health order no. 985 of 11 July 2007 on the use of sealed radioactive sources. Blood irradiator facilities are mostly associated to hospital blood banks in close proximity to many workplaces and patient treatment areas. The operation of blood irradiators thus requires a high level of safety and security. In 2014/15, inspections at 7 blood irradiation facilities were carried out, resulting in several regulatory required actions and remarks regarding safety and security, including:

- Closure of facilities where practice is considered no longer justified.
- Removal of flammable materials from blood irradiation room.
- Reconstruction of blood irradiation room.
- Update of alarm and warning systems.
- Stressing of procedure for control of access to blood irradiation room.
- Enhanced registration and control of staff access to blood irradiation room.

S11-P2

Norway has phased out gamma based blood irradiators

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The 13 Norwegian gamma based blood irradiators have been phased out or replaced by almost risk-free blood irradiators based on X- ray technology. Acquisition and use of new gamma based blood irradiators is no longer considered justified by the NRPA. The Norwegian phase–out policy was carried out for security reasons and concerns related to possible consequences of a malevolent act. The phase - out process was initiated by the NRPA and strongly supported and further enhanced by the Ministry of Health and Care Services, the owner of the hospitals and the blood banks. Consensus among relevant national authorities and suitable regulations made the phase-out process possible and time efficient. The Breivik 22.7.2011 attack on governmental buildings and the following security report have been an implicit fundamental driving force in this security process.

Results from an All-inclusive IAEA-based Inspection Approach for Industrial Irradiation Facilities

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Denmark hosts three Co-60 based industrial irradiation facilities with a maximum permitted inventory ranging from 7.000 to 69.000 TBq. The use of these facilities is regulated through the National Board of Health order no. 985 of 11 July 2007 on the use of sealed radioactive sources. These facilities host the largest inventory of sealed sources in Denmark, and as such, undergo continuous efforts to maintain and improve safety and security. Annual inspections are conducted on each of the facilities. Since 2011, inspections have been carried out in accordance with IAEA recommendations (IAEA-TECDOC-1526), making use of the Inspection Record template: “Irradiator”. In the early years, focus for the inspections was centered on regulatory approval of contingency plans regarding accidents and incidents. In recent years, the focus of regulatory oversight has shifted to aspects of safety related to normal operations and foreseeable operational occurrences such as: ”shallow source pond water levels” or ”source rack does not descend”. In addition to the annual inspections, specific topical sessions are organized for the industrial irradiator facilities. Such sessions have included meetings between facility staff, regulators and local emergency response units regarding the special requirements for first response operations at industrial irradiator facilities. A separate session on safety and security during source change operations has also been conducted.

S11-P4

NORGIR

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NORGIR is an acronym for Nordic group in industrial radiation and research. The group has radiation experts from all of the five Nordic radiation protection (RP) authorities. Meetings and workshops are held annually or biannually and reports are given to annual meetings of Nordic RP directors. In this poster, some of the agenda items that have been discussed in the previous meetings are listed together with some recommendation to the RP directors.

Survey on needs for changes in the Finnish radiation legislation and on regulatory oversight – The perspectives of practitioners

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This study surveyed needs for changes in the Finnish radiation legislation, and evaluated the regulatory oversight. The total renewal of the Finnish radiation legislation will be done simultaneously with the transposition of the Council directive (2013/59/Euratom) into national legislation before 6th February, 2018. The survey was performed on behalf of the Finnish Radiation and Nuclear Safety Authority (STUK), and it was conducted in collaboration with the School of Management in University of Tampere. The online survey was open in February and March 2015. STUK informed on the survey nationwide on web pages and by sending e-mails and an e-news letter to radiation safety officers, dosimetry services, education and training organizations of radiation safety officers and other interest groups. The survey included also questions concerning the use of non-ionizing radiation (NIR), such as ultrasound and MRI, in healthcare. The data was analyzed by both quantitative and qualitative methods. The total number of answers to the survey was 182. The majority of those (101) represented the use of radiation in healthcare. The second largest group (46) was industry including the use of radiation in industry, research, education and training, product and security control, trade, import and export of radiation equipments and sources, production of radioactive isotopes, installation, manufacture and service of radiation equipment and sources. Most of the answerers were satisfied with the current Finnish radiation legislation. However, many proposals were given, such as improving the definition of an undertaking and regulating qualifications of both radiation protection officers and experts. About one third of the answerers in the use of radiation in industry and one fourth in health care did not find needs for changes in radiation legislation. Most of the answerers both in health care and in industry were as well satisfied with the STUK's regulatory oversight, figures being 65 % and 67 % correspondingly. However, a few proposals to enhance came up e.g. concerning co-operation between different authorities and needs to simplify practical guidance on the safety of radiation. In conclusion, the results provide valuable feedback from users of radiation and other professionals for the radiation legislation renewal in Finland.

S11-P6

Nordic Working Group on Medical Applications

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The 'Nordic Working Group on X-ray Diagnostics' was founded in 1978 as a cooperation between the radiation protection authorities in all of the five Nordic countries. In the last couple of years, the scope of the working group has been broadened to include also nuclear medicine and radiotherapy. As a consequence, the name of the working was changed in 2014 to 'Nordic Working Group on Medical Applications'.

The working group meets annually where the focus is national reports on recent activities and discussions on subjects of common interest. Between meetings the group forms a valuable forum for discussions through email, and a few telephone conferences has also been held.

The activities of the group during the last four year in the form of common statements and workshops will be presented as well as the current focus areas.

At the moment, the main focus areas of the group are:

- National implementation of EU-BSS
- Level 2 justification (level of implementation in Nordic countries)
- Referral guidelines
- Regulatory management of proton therapy units
- Recommendations on shielding of thyroid and gonads
- Automatic dose monitoring in x-ray examinations

Indoor and outdoor radon levels in Iceland

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We report on the first nation-wide survey of indoor radon in Icelandic homes. This was carried out using alpha track detectors with a detection limit around 7-15 Bq/m^3, depending on the sampling time. The annual mean radon concentration was measured on the ground floors or basements of 250 homes around the island. Volunteers were sought so the measurement locations were not randomly assigned. Additionally, measurements were made in 32 kindergartens and 19 public swimming pools. The results indicate that the radon concentration in Iceland is very low. The mean is 13 Bq/m^3, and the median 9 Bq/m^3. Most of the results (around 85%) were below minimum detection activity and 95% of the results below 40 Bq/m^3 and the highest value is 79 Bq/m^3. No appreciable differences were found between the different regions of Iceland except that in the North of the country, slightly higher values were found. Measurements in kindergartens and swimming pools gave even lower values. These results, which match expectations given what is known about the Icelandic basaltic bedrock (which has a low uranium concentration) and from previous spot measurements, imply a mean dose to the population from radon inhalation around 0.2 mSv/year. This value is almost certainly an overestimate, since only ground floors and basements are included in the study. Continuous measurements of radon in outdoor air in Reykjavík, in collaboration with the University of Iceland‘s Science Institute are ongoing. These are performed using a lead shielded liquid scintillator counting system (with a background of 0.2 counts per hour) developed and made by the Science Institute. Preliminary results from a few months of measuring indicate that outdoor air in Reykjavík has a radon concentration of about 1-3 Bq/m^3. Continuous measurements of radon indoor in a university building are done at the same time showing little or no variation in daily or weekly radon concentration.

S12-O2

NORM in Norwegian Mineral Industry

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Due to new waste and discharge regulations in Norway (from 2011) many companies using minerals in their production process are now bound to apply for discharge permits for radioactive substances. The discharge permits require both that discharges be quantified and that environmental surveys be conducted. This is a new and unknown issue for most mineral companies and there are little Norwegian comparable data available for mainland discharges or background specific activities in for example fjords. This paper will present a case study from a mineral company in western Norway, with discharges to a fjord and to air. Results from discharge analysis and the environmental survey will be presented and discussed. Also other aspects of the consequences of the process, such as doses to personnel, the public and the environment will be looked into.

TENORM in geothermal applications in Iceland

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The amount of sulphide scaling in geothermal pipes in Iceland is limited and confined to sites in the Reykjanes, geothermal area, SW-Iceland. The Reykjanes geothermal area is considered to be an analogue to black smokers on the ocean floor found for example along the Atlantic ridge. The black smokers are associated with rich mineral deposits and an unusual and varied biological habitat. In this work, alpha radiation activity at over 20 Bq/g is reported in scales from the geothermal power plant in this region. No instances of technically enhanced natural radioactivity above 1 Bq/g of have been reported in Iceland before. The Icelandic volcanic bedrock is poor in uranium and other natural radioactive elements. The origin of the radioactive scaling is thus likely to be in the earth crust below it. Of interest is that the isotope with the longest half-life in the scaling is lead (Pb-210) with a half-life of 22 years and thus a decay of 3% per year (producing the shorter lived alpha emitter Po-210). The first estimate of the yearly amount of scaling produced is only a few tons. Assuming that at most 3 tons, containing an average of 20 Bq/g, are released from the geothermal pipes per year through their cleaning (i.e. 0.06 GBq per year), at most 2 GBq of alpha emitting material can possibly accumulate.

S12-P1

NKS: Developing Methods for Reliable and Efficient Radiological Characterization of NORM Contaminated Objects

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As a bi-product of the extraction process and pipe transport of oil and gas in the North Sea, NORM materials accumulate as scale deposits on the inside of piping. During maintenance operations and decommissioning of oil and gas production facilities, piping and other equipment with potential NORM contamination is routinely characterized, in order to ensure allocation to the proper waste stream. However, routine inspections by RPOs on North Sea platforms or radiation portal monitor alarms in scrapyards show that a review and update of the present monitoring program is warranted. Erroneous characterization of NORM contaminated components represents a potential health hazard and a financial liability risk. Consequently, consensus has developed between radiation protection authorities and industry to optimize existing procedures or develop new procedures for reliable characterization of potentially NORM contaminated equipment. Swedish, Norwegian and Danish radiation protection authorities have entered collaboration with DTU NUTECH and two major Danish oil and gas operators to define the project CONCORE (Characterisation of NORM Contaminated Objects: Reliable & Efficient). NKS committed 400.000 DKK in 2014 and 363.000 DKK in 2015 for the realization of this project. The characterization procedure to be developed during this project may potentially find use in other industries such as paper production or nuclear facilities, where non-standard methods for radiological characterization may be required.

The Swedish Radiation Safety Authority's Radio-analytical Laboratory: who are we and what do we do?

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The radio analytical laboratory (RAL) at the Swedish Radiation Safety Authority (SSM) consists of four scientists and engineers with a broad competence in the field of radio analytics and radio physics. RAL's instrument park consists of five HPGe detectors, two low-background LSCs, two alpha spectrometry systems with a total of 18 chambers, and a whole-body counting facility with a thyroid measuring station. In addition to the instrument park, there are two radiochemical laboratories for sample preparation, radiochemical separation, and source preparation. While none of RAL's methods has ISO 17025 accreditation, the ambition is that all work is carried out according to this standard. RAL provides support to several units within SSM that work with supervision. For example, the laboratory analyzes samples gathered from clearance inspections of buildings and lands, from evaluations of radioactive ashes and their need to be deposited, and also samples from general investigations of industries with the possible enrichment of NORM. RAL also analyzes samples for the national environmental monitoring program, a program that was created because of requirements set up by national and international organs, such as the EU. Furthermore, RAL performs intercomparison tests with the Swedish nuclear power plants' laboratories, both on environmental samples from their monitoring programs and on discharged water samples from the power plants. The average yearly throughput in the laboratory is 600 samples and about 35 people are measured with the whole-body counter every year. RAL is part of the national network of laboratories responding to nuclear and radiological emergencies. The laboratory has a coordinating role in many of the activities of this network and regularly arranges intercomparison exercises for the other laboratories. RAL is also an active member of the IAEA network ALMERA, which is a cooperative effort of IAEA to establish a network that can provide reliable analyses of environmental samples in the event of an accidental or intentional release of radioactivity. RAL's research activities comprise the areas of radiometric measurement development, radio analytical methods, marine radioecology, retrospective dosimetry, internal dosimetry, and in vivo measurements techniques. Additionally, the laboratory takes an active part in the supervision of PhD and Master Students. Our research partners are Linköping University, IAEA, NRPA, EURADOS, ANKA, and CNA.

S12-P3

Gross alpha and beta radioactivity levels measurement in mining ponds in Jos Metropolis-Plateau State, Nigeria

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Twenty (20) water samples from the mining ponds were collected from Jos in which all the samples were drawn in two litres plastic containers. Few drops of nitric acid were added for preservation and after the total dissolved solids had been estimated, the samples were evaporated then transferred into planchet for counting. The counting were done using MPC-2000 Dual Phosphor detector. The gross alpha activity from this mining pond ranged from (0.006±0.002 – 0.144 ± 0.003) Bq/L with a mean value of 0.0382±0.007 Bq/L. The gross beta activity concentration ranged from (0.006±0.330 – 11.319±0.519) Bq/L with a mean value of 1.72±0.356 Bq/L. When these values are compared with the International Standard, all the values obtained for gross alpha were within the acceptable limit while for the gross beta, nine of these values were above the acceptable limit.

The committed effective dose for gross alpha ranged from (0.002 – 0.030) mSv/yr for adults while the values for children ranged from 0.18 – 3.55) mSv/yr. In comparison with WHO Standard of 0.1 mSv/yr for the general public some the ponds may be highly radioactive to children than adults. This suggests that these sources of water are radioactive to human health and therefore care must be taken when using the water from these nine sources.

KEYWORDS: Gross Alpha, Gross Beta, Radioactivity, Effective Dose and Activity Concentration

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Imec supplies and services measurement equipment and systems for detecting and measuring all kinds of radiation, our supplier is Ludlum Measurements Inc. TX, USA
Imec also develops and manufacture custom made radiation shielding solutions for hospitals and clinics.
Imec is dedicated to render a prompt, precise and reliable solution and service to satisfy our customers in the market area we represent.
This market area is the Nordic Countries, Germany, Poland and the Baltic states.

Imec supplies also 2 ranges of high quality analytical instruments on the Danish market only. Handheld instruments based on fluorescent XRF technology and stationary instruments based on OES technology.
Imec ApS is located app. 40 km from Copenhagen and holds a complete technical center with a hot source for calibration purposes.

Our German sales company, Imec GmbH, is located in Hamburg. Imec was founded in 1997 and appointed representative for Ludlum Measurements Inc., Sweetwater, TX, USA in 1998. In 2012 Imec was appointed European Repair and Calibration Center for Ludlum Measurements Inc. TX, USA, who keeps yearly audits at Imec.

In 2010 Imec and Bruker signed a representative agreement for Bruker's range of hand held XRF instruments. In 2012, this agreement was expanded to contain Bruker OES systems, too.

MetorX B.V. are a specialized science and technology partner in the field of nuclear instrumentation. We are strongly focused to innovate “Measuring Tools for Radiation”.
In corporation with our customers and partners, we create and deliver user friendly, clever and dedicated tools who can do the job effectively.

Our “Tools” find their way to customers in nuclear reactors, biotech companies, environmental, academic and governmental research centers and nuclear medicine and PET departments.

We are an active player in the field of liquid scintillation counting, gamma counting, area and stack monitoring, gamma-ray spectrometry, contamination monitoring, radionuclide specific surveys, dose rate measurments, waste monitors, digital air sampling and radioactive sources.

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NKS - a forum for Nordic cooperation and competence maintenance in nuclear and radiological safety

NKS (Nordic Nuclear Safety Research) builds on a long Nordic tradition of cooperation. Today, for instance exchange of Nordic operational expertise and new ideas can be valuable to tackle common challenges at nuclear installations. The Fukushima accident has highlighted the need for maintaining an effective operational emergency preparedness.

NKS runs joint activities producing seminars, exercises, scientific articles, technical reports and other types of reference material. The activities are divided into two programme areas: NKS-R (thermal hydraulics, severe accidents, reactor physics, risk analysis and probabilistic methods, organisational issues and safety culture, decommissioning, and plant life management and extension) and NKS-B (radiological and nuclear emergency preparedness, measurement strategies, technology and quality assurance, radioecology and environmental assessments, and management of radioactive waste and discharges). Recent detailed descriptions of the programmes, including ongoing activities, were published in four papers in the RPD journal Radiation Regulator in 2013-15 (www.radiationregulator.net).

NKS warmly welcomes proposals for new activities (deadline this year: 15th October; total budget near 1 M€; for further information:
www.nks.org/en/nksr/call_for_proposals;
www.nks.org/en/nksb/call_for_proposals).

A joint NKS-R and NKS-B seminar entitled 'Nordic perspectives of Fukushima: Where are we now and where do we go?' will be held in Stockholm on 12-13 January 2016. The aim is to outline the current state of development in Nordic nuclear risk assessment and preparedness and examine implications and needs for the future. The seminar will follow up on the progress since the NKS Fukushima seminar in 2013, and feature the newest results of Nordic research and development. International speakers include Ted Lazo (OECD/NEA) and Chris Clement (ICRP). Also IAEA will participate, presenting the forthcoming comprehensive IAEA report on the Fukushima accident. More detailed information, including possibilities for registration, will follow in September.

For free subscription to NKS NewsFlashes and NewsLetters, please refer to www.nks.org.

nks
Nordic nuclear safety research

NRG's business unit Consultancy & Services delivers products, projects, and high end solutions in the areas of nuclear safety, decommissioning and waste, and integrated radiation protection.

With circa 150 highly qualified staff , we are a mid-size organization operating independently from governments and industries. Most of our employees have a degree in radiation protection. One of our missions is to support organizations to operate as safely and responsibly as possible with the risks of radiation. Besides our commercial activities we participate in international co-operation programs of the EU and the IAEA.

We are a one-stop-shop for radiation protection. Hence, we provide a wide range of services and products. NRG offers different products and services, varying from consultancy for permits, risk calculations and shielding calculations to decontamination services. Our integrated service package furthermore consists of personal and environmental dosimetry, education and training, maintenance and calibration of measuring equipment, and control measurements.

We support our clients by supplying an intelligent compliance information system named ReGuard, which manages radiation protection data simply and efficiently, and proactively monitors and controls the status of licenses. In ReGuard the Plan – Do – Check - Act cycle is modelled, which enables you to keep the radiation risks under control. And, with an up-to-date overview of the complete radiation protection organization, ReGuard keeps clients in 24/7 control.

In ReGuard also radioactive waste can be registered. Especially for decommissioning projects NRG developed a tailor made system called ReWind. This application offers full traceability of waste generated during the decommissioning, and also presents the inventory of (intermediate) storages inside or outside facilities.

More information? Visit us at the NSFS conference, or our website www.nrg.eu on the topic Radiation Protection

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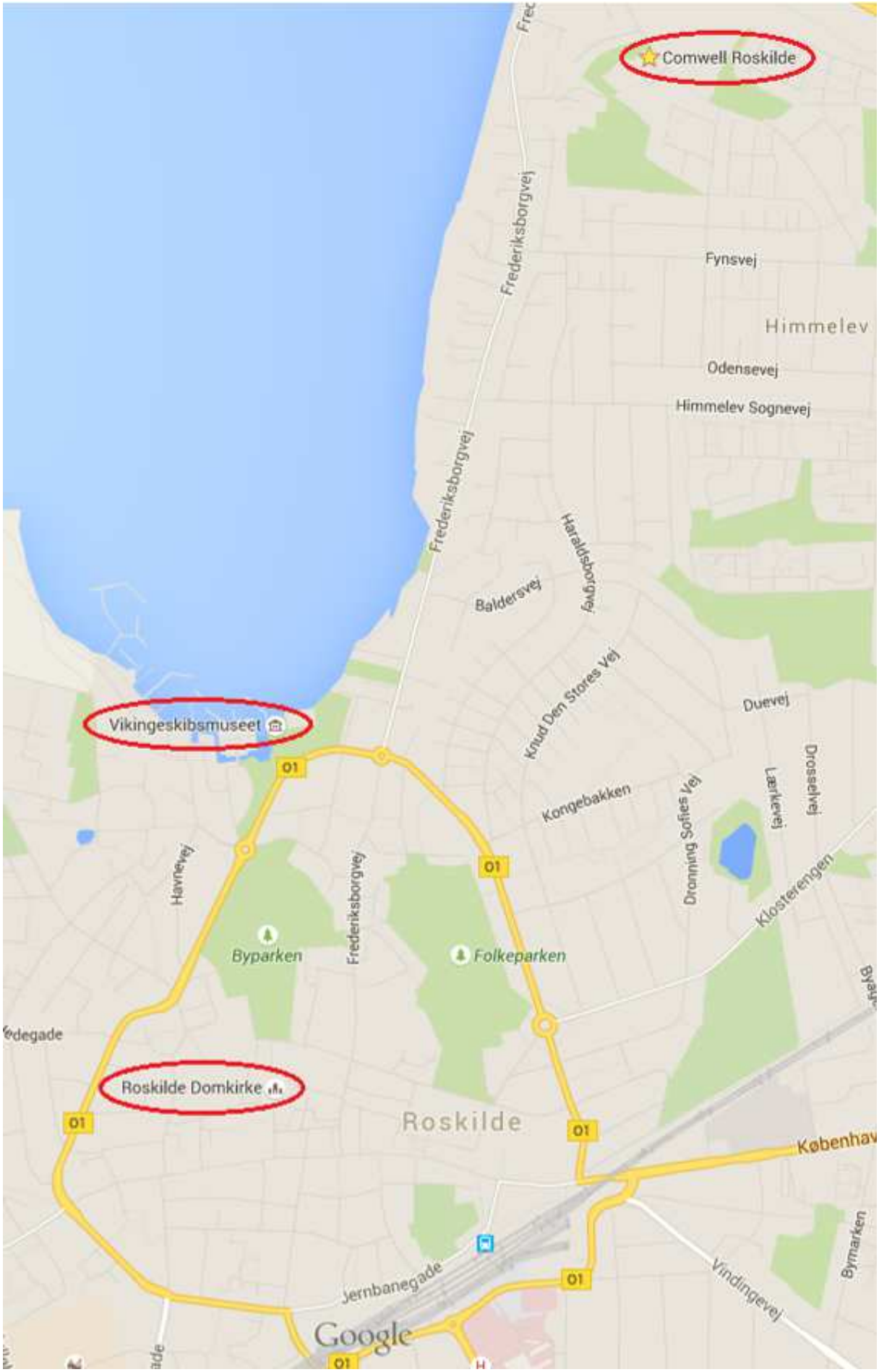
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Program Overview

	Sunday, 23 August	Monday, 24 August	Tuesday, 25 August	Wednesday, 26 August	Thursday, 27 August
08:00		Registration Coffee			
08:30			**Session 4** Emergency , Preparedness and Response 1	**Session 8 *** Medical Applications 1	**Session 11** Policy, Regulations and Inspections
09:00					
09:30		**Session 1 *** Opening and Bo Lindell award			
10:00					
10:30			Coffee and posters	Coffee and posters	Coffee and posters
11:00		Coffee and posters	**Session 5** Emergency , Preparedness and Response 2	**Session 9** Medical Applications 2	**Session 12** Natural Radioactivity
11:30		**Session 2 *** International Perspectives			**Closing Session**
12:00					Lunch
12:30		Lunch	Lunch	Lunch	
13:00					
13:30			**Session 6** Radioecology		
14:00		**Session 3 *** Nordic Perspectives		**Session 10** Medical Applications 3	
14:30					
15:00		Exhibitor presentations			
15:30		Coffee and posters	Coffee and posters	Visit to Roskilde Cathedral and city of Roskilde	
16:00		**NSFS General Assembly**	**Session 7** Technologies and Safety		
16:30					
17:00					
17:30					
18:00					
18:30					
19:00	Welcome reception at the Wiking Ship Museum Registration		Conference Dinner		

* Sessions marked with an asterisk contain invited lectures