TC project RER4032

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Working Material

Strategic Planning for Sustainability in the Baltic region: Research Reactor Utilization

Report of a Workshop within regional TC project RER4032

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1. FOREWORD

Research Reactor (RR) Coalitions and Networks presently promoted and supported by the IAEA aim at consolidation of the international/regional RR sector by establishing grouped entities to serve as international/regional user centres. In this way, countries/regions that do not have RRs or are considering closing an old reactor can gain access to nearby facilities which have up to date technical capabilities including high levels of nuclear safety and security. It is expected that Member States (MSs) will increasingly need Agency assistance in strategic planning and institutional arrangements for possible national and regional RR coalitions, networks and shared-user facilities. The Agency support is ensured both through the regular budget and extra-budgetary contributions, including ongoing regional Technical Cooperation (TC) projects.

In 2007-2009, with the assistance of the IAEA a number of RR coalitions have been formed in Eastern Europe, Central Asia, Latin America and Caribbean regions and more are being discussed (e.g., the Baltic, the Mediterranean, Asia/Pacific, African regions,…). These cover different areas for collaboration, including radioisotope production, neutron activation analysis, fundamental research, education and training activities.

2. SPECIFIC REGION BACKGROUND

After the closure of RRs in Sweden and Denmark, and keeping in mind well defined plans of the three Baltic Sates with Poland to build a new NPP at the Ignalina NPP site in Lithuania, there is a potential need to revise the utilization of RRs in the region as schematically shown in Fig. 1. One has to add in this context a very recent announcement by Russia to build a new NPP in the Kaliningrad's region. Similar actions were made also by the neighboring Byelorussia.

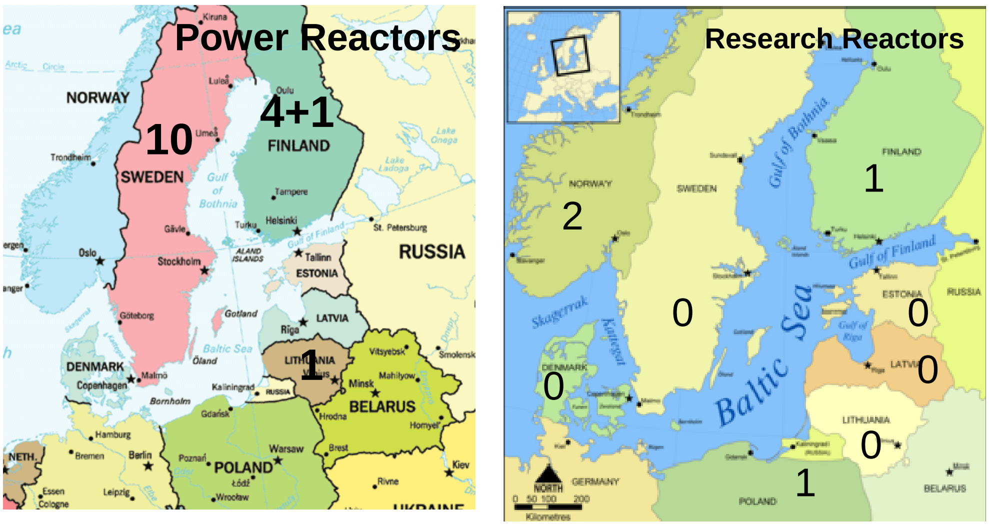

Figure 1: The Baltic Region countries with operational power reactors (on the left) and research reactors (on the right).

Tables 1 and 2 provide some of the relevant information. Indeed, the MSs in Baltic Region, in particular Nordic Countries and three Baltic States, might need more coordinated and collaborative actions related to the access and utilization of RRs in the region. The most urgent priority seems to be education and training in all nuclear technology areas including present and future NPP operators, users of nuclear facilities, radiation protection and regulatory personnel, nuclear science students and researchers. Other potential applications of the RRs might also be of interest for the MSs in the region and could be considered at the second stage.

Country/Number of operational RRs	**Nuclear Energy**	**Research Reactors**	**Role**	**Remarks**
Norway/2	Non	2 operational: 1) 20MW; heavy water 2) 2MW; heavy water	Host	Some recent interest in ADS & Th fuel cycle in particular
Sweden/0	Yes	3 shut down 1 decommissioned	User	Earlier: complete phase out of nuclear power. Very recent decision to continue with nuclear power.
Finland/1	Yes	1 operational: 250kW, TRIGA 1 decommissioned	Host	New EPR under construction
Russia/~50	Yes	~50 RRs operational; different types and power levels, various utilization purposes	Host	Ambitious plans in doubling of NPP capacity by 2020-2030; 2400MW_{el} NPPs in Kaliningrad's region
Estonia/0	No	0	User	Partner for a new NPP in Lithuania
Latvia/0	No	2 shut down	User	Partner for a new NPP in Lithuania
Lithuania/0	Yes	0	User	Last RBMK to be shut down in 2009; host for a new 3400MW_{el} NPPs to be built in Lithuania
Poland/1	No	1 operational: 30MW; H2O 2 shut down 2 decommissioned	Host	Partner for a new NPP in Lithuania; plans to build a new NPP also individually
Germany/12	Yes	12 RRs operational	Host	Phase out of nuclear power in the future
Denmark/0	No	2 shut down 1 decommissioned	User	No plans for nuclear energy

Table 1: Some relevant facts of the Baltic Region: User – potential client of RRs; Host – potential service provider.

COUNTRY	RR NAME	POWER, kW	TYPE	STATUS	CRITICALITY
Finland	FIR-1	250	TRIGA MARK II	OPER	1962-03-27
Germany	BER-II	10,000	POOL	OPER	1973-12-09
Germany	FRG-1	5,000	POOL	OPER	1958-10-23
Norway	HBWR	20,000	HEAVY WATER	OPER	1959-06-29
Norway	JEEP II	2,000	TANK	OPER	1966-12-01
Poland	MARIA	30,000	POOL	OPER	1974-12-18
Russia	WWR-M	18,000	TANK WWR	OPER	1959-12-29
Russia	PIK PHYSICAL MODEL	0.0	CRIT ASSEMBLY	OPER	1983-12-24
Russia	PIK	100,000	TANK	CONS	Physical start in 2009, operational in 2012

Table 2: List of operational/planned RRs represented during the workshop (the internet link in blue gives more detail information about individual facility. Source: IAEA Research Reactor Data Base http://www.iaea.org/worldatom/rrdb/).

3. OBJECTIVES OF THE MEETING

The main objectives of this workshop were:

- → Identify and characterize the needs and requests to access the research reactors (RRs) in the region from the MSs without their own RRs
- → Evaluate availability and potential of the RRs in the region to provide products-services for neighbouring countries, in particular in the area of education and training
- → Discuss other potential applications of RRs, where cooperative efforts might lead to regional coalitions/networks (e.g., isotope production, neutron activation analysis, decommissioning related issues, materials research, etc.)
- → Define possible mode of operation and steps to be taken for initiating collaborations, creation of RR network or coalition in the Baltic region
- → Create a network/coalition of users/operators of RRs in the Baltic Region in order to:
    - open up facilities for regional users, develop dedicated users programs, develop common utility plans
    - publicize the capabilities of the facilities, encourage R&D for new products and services

- develop common undergraduate and postgraduate curricula in nuclear science and technology
- ensure the transfer and preservation of knowledge, exchange of students and scientists.

4. EXECUTIVE SUMMARY

The exploratory workshop was organized under the IAEA regional Technical Cooperation project RER4032 "Enhancing the Sustainability of Research Reactors and Their Safe Operation through Regional Cooperation, Networking and Coalitions". The meeting was attended by 17 participants from 10 Member States in the Baltic Sea region, including two representatives from the IAEA, namely Mr I. Videnovic (IAEA) and Mr D. Ridikas (IAEA).

After the official host opening remarks by Mr K. Wieteska, Director of Institute of Atomic Energy (Poland), some introductory remarks were given by Mr I. Videnovic, the Project Management Officer (IAEA). Mr J. P. Rambaek (IFE, Norway) was nominated as a chair person and Mr S.R. Ghias (KTH, Sweden) was appointed as a *rapporteur* of the meeting. Right after followed a brief presentation by Mr D. Ridikas, the Project Technical Officer and Scientific Secretary of the Workshop (IAEA), on specific region background and main objectives of the meeting.

The 1st day of the workshop was exclusively dedicated to evaluate availability and potential of the RRs in the region to provide products and services for neighbouring countries. Therefore, individual country presentations from RR host countries (Norway, Germany, Poland, Finland and Russia) were given (see Annex I). At the end of the day a summary **supply-service** table was prepared (see Annex II).

The 2nd day aimed to identify and characterize the needs and requests to access the RRs in the region from the Member States without their own RRs. The individual country presentations were given by the corresponding MSs, namely Estonia, Latvia, Lithuania, Denmark and Sweden (see Annex I). A summary table quantifying **demand-needs** was prepared afterwards (see Annex II). On the same day Mr J. Jaroszewicz (Poland) gave a dedicated presentation on existing RR coalition, namely "East European RR Initiative (EERRI): share of experience, lessons learned, present and future activities". Finally a technical visit to the Maria Research Reactor and its experimental facilities was organized by the host institution.

During the 3rd day a number of round table discussions took place in order to

- Prepare a summary demand-supply matrix and quantify common MSs' interests as a result of work output during days 1 and 2
- Define actions, work-plan and responsibilities for the future cooperation
- Discuss the formation of the regional RR Network or Coalition
- Draft the summary report and recommendations.

As a result, **representatives of all 10 Member States agreed on creation of the Baltic Research Reactor Network (BRRN).** Mr J. P. Rambaek (IFE, Norway) was proposed and agreed to be a Chair Person of the Network until the next meeting. The below four topics of common interest have been clearly identified to start the BRRN activities. For each topic a coordinator was designated to lead and organize the work in collaboration with other partners within the Network.

Nuclear Education and Training (Mr S.R. Ghias, KTH, Sweden). The Baltic RR training course to be designed/initiated and will use the RR capabilities in the region. Experimental work (practical) at the RR facility, as part of MSc and/or engineering course curricula, was suggested and could be ensured (at different levels) by most of the RRs in the region. Detailed course/program curricula will be collected in order to develop a common experimental/practical/theoretical training program. Equally, RR capabilities should be specified and listed in order to guarantee that these desired experimental/practical parts of the courses are properly covered. Exchange of students/lecturers with the Network was recommended.

Irradiation services, isotope production, NAA, etc. (Mr L. Martiny, Risoe, Denmark) Isotope production is of interest for a number of partners, both RR host states and countries without RRs. Need for cooperation on this particular topic was clearly expressed and detailed list of isotopes (demand/supply) will be generated. Particular emphasis was put on non-standard radio isotopes, what would facilitate entry to the market without additional difficulties.

Applied neutron scattering, neutron radiography (Mr H. Krohn, HZB, Germany). It was agreed that promotion of applied research using neutron beams was of great importance in non-destructive testing of different objects/devices, material research and qualification. Inclusion of representative examples of applied neutron scattering in general education and training programmes was also desired. Participation in already existing neutron scattering schools within the network was recommended.

RR operation, decommissioning and rad-wastes (Mr A. Abramenkovs, BAPA, Latvia). A need to share the operational and/or ongoing decommissioning and dismantling experience and lessons learned at different facilities was noted. The decommissioning expertise developed at RRs in certain cases could be transmitted/adopted for the decommissioning of other nuclear facilities, including NPPs. However, already existing networks/efforts should be taken into account in order not to duplicate the activities.

In addition to the above topical activities, the following specific actions have been suggested:

- → design and maintain a dedicated web page for BRRN,
- → promote and assist in exchange of young researchers/engineers/academia among RR facilities in the region,
- → support students from the Baltic region to attend the Berlin neutron scattering school,
- → organize the 2nd BRRN meeting in Sweden in Q4 2009, so the date is within the period of the EU presidency by Sweden.

5. CONCLUSIONS

The participants concluded that the organized workshop was a very successful and well organized event. Mr D. Ridikas (IAEA) thanked Polish representatives for hosting this meeting and also the representatives of all 10 Member States in the Baltic region for their active participation and contribution. He also congratulated the formal creation of the Baltic Research Reactor Network (BRRN) with the following topical activities relevant to RRs: 1) Nuclear education and training, 2) Irradiation services and products, 3) Basic and applied use of neutron beams, 4) RR operation and decommissioning issues. The next BRRN coordination meeting was scheduled to be held in Sweden in Q4 2009.

ANNEX I. INDIVIDUAL COUNTRY SUMMARIES

1.1 Norway: Research Reactor JEEP II, Mr. Jon Per Rambaek, IFE

Main parameters

- Heavy water (D_2O) cooled and moderated
- Core
  - Hexagonal
  - 19 elements
  - 90 cm height
- Fuel
  - 254 kg UO2
  - 3,5 % enriched
- Flux $3 \cdot 10^{13}$ n $\cdot$ cm^{-2} $\cdot$ s^{-1}
- Thermal output 2 MW

Utilization - Irradiation thimbles

- Neutron transmutation doping of silicon
- Isotope production
  - Tracers
  - Radiopharmaceuticals
  - Industrial control sources
- Neutron activation analysis

Utilization – Beam channels

- Neutron radiography
- Neutron diffraction
  - One diffractometer in operation
  - Two more in operation at the end of this year
  - One more in operation next year
- Neutron reflectometer in operation 2011

What can we offer?

Education / training

→ Neutron diffraction (Presently for students from University of Oslo)
→ Reactor physics (probably from next year a new course should start)

Irradiation

- Isotope production
- Neutron activation analysis
- Irradiation of different materials
- Gamma irradiation facility

Neutron diffraction

- Participation in projects

Discussions, comments and concerns

During the discussion following Mr. Rambaeck's presentation, he explained that JEEP II has over 50 % utilization rate. JEEP II is used routinely for education in the field of material science and also training of Norwegian research reactor operators. IFE is fully responsible for handling the waste and accident management. Norway has ongoing collaboration with Denmark, Poland and Sweden.

1.2 <u>Germany (1):</u> Research Reactor FRG-1, Mr. Peter Schreiner, GKSS

Neutrons are an excellent method to study the structure and dynamics of condensed matter. The knowledge of these properties down to the atomic scale is necessary for the understanding of the macroscopic properties of condensed matter in applied as well in basic research.

The GKSS research centre Geesthacht GmbH has been operating the MTR-type pool research reactor FRG-1 (5MW) as a neutron source for more than 50 years. The FRG-1 was originally designed and constructed in 1957/1958 (criticality on October 23, 1958). During its lifetime the focus of the research at the FRG-1 was continuously adapted to changing scientific needs. The various upgrades and modernizations of the neutron source as well as of the scientific instrumentation over the decades will be briefly reviewed. These include:

- ⇨ Installation of a new focussing cold neutron source
- ⇨ Two core compactions from 49 to 26 and finally to 12 fuel elements
- ⇨ Digital reactor protection system
- ⇨ Emergency power facility
- ⇨ New primary and secondary coolant systems
- ⇨ Emergency ventilation
- ⇨ Physical protection system
- ⇨ New grid plate with supporting frame
- ⇨ Fire protection system
- ⇨ New experimental hall with novel instrumentation and numerous instrument upgrades

Besides a safe reactor operation with a reliable schedule, a high availability of more than 200 full power days per year is the basis of the success of the FRG-1 as a middle flux neutron source for national and international users. With a unique focus on engineering materials research, the instrumentation of the FRG-1 offers a number of attractive possibilities. For more information please visit www.gkss.de

Discussions, comments and concerns

Mr. Schreiner also enlightened the group about the concern raised by the political decision of the German government to shut down the reactor in 2010. After shut down some of the instrumentation might be shipped to Russia and all radioisotope production including Co-60 will stop. There is no plan at this stage for starting a new training program at the reactor, although previously such training programs were running.

1.3 Germany (2): Research Reactor BERII, Mr. Herbert Krohn, HZB

The BERII is located in Berlin, Germany and belongs to the Helmholtz-Zentrum-Berlin. It is a pool – type reactor with a thermal power of 10MW. The BERII went first in operation in December 1973 with a thermal power of 5MW. It was upgraded in the years from 1985 to 1990. The goal of the upgrade was to increase the neutron flux in the beam tubes to make the BERII more fit for neutron scattering experiments. This was done by:

- increase the thermal power from 5 to 10 MW
- decrease the core size
- installing a beryllium reflector
- installing a cold neutron source

According to German law beside of these improvements a complete safety analysis of the reactor had to be done. As a result, all components and systems which are related to the reactor safety had to be renewed. Therefore, when the reactor was restarted in 1991 it was up to date in all aspects. After the restart in 1991 the BERII was operated with high enriched uranium but from 1997 and 2007 its core was converted to low enriched uranium.

There are two irradiation devices in the BERII. One is located in the reflector and another one - in the core. However, the BERII is mainly used for neutron scattering elements. For each of the experiments there are two scientists responsible. All experiments are open for external users, from Germany or abroad. For the users it is free of charge but before they get so called beam time they have to submit an experimental proposal which has to be approved by an international scientific committee.

To improve the experiment opportunities a 30Tesla magnet will be installed in a new experimental hall. It is planned to operate the BERII at least until 2025 parallel to the more powerful research reactor in Germany, the FRMII in Munich.

Discussions, comments and concerns

BERII operates ~210 days per year, i.e. utilization rate is > 50 %, and serves domestic and foreign researchers. 30 % of the reactor beam is consumed by local researchers and the rest is allocated to external scientists. The beam time at the reactor is free of charge for accepted experimental proposals and in part supported by the European Union.

1.4 Poland: Research Reactor MARIA, Mr. Grzegorz Krzysztoszek and Mr. Janusz Waldemar Jaroszewicz, IAE

The high flux research reactor MARIA is water and beryllium moderated reactor of a pool type with graphite reflector and pressurised channels containing concentric six-tube assemblies of fuel elements. It has been designed to provide high degree of flexibility.

The fuel channels are situated in a matrix containing beryllium blocks and enclosed by lateral reflector made of graphite blocks in aluminium cans. The MARIA reactor is equipped with vertical channels for irradiation of target materials, a rabbit system for short irradiations and six horizontal neutron beam channels.

The main characteristics and data of MARIA reactor:

- nominal power 30 MW(thermal)
- material UO_2-Al alloy
- moderator H_2O, beryllium
- cooling system channel type
- output thermal neutron flux
- at horizontal channels $3 \div 5 \times 10^9$ n/cm^{2}s.

The main areas of reactor application:

- production of radioisotopes,
- testing of fuel and structural materials for nuclear power engineering,
- neutron radiography,
- neutron activation analysis,
- neutron transmutation doping,
- research in neutron physics.

The IAE is ready to offer for junior scientists or students from countries that do not have any research reactor in operation the co-operation in thermal neutron scattering using neutron beam from MARIA RR horizontal channels:

- neutron radiography in studies of migration of hydrogenous liquids in uniform and stratified beds of granular porous materials;
- the micro dynamics of structural and magnetic phase transitions in metallic alloys with invar, elinvar and shape memory properties.

Discussions, comments and concerns

Mr. Jaroszewicz presented the collaboration formed by the initiative of IAEA between the Eastern European research reactors (EERRI). The presentation made at the second day of the meeting was received with high attention of the participants. Estonian and Lithuanian representative expressed interest in the 6 weeks training program within EERRI available and supported by IAEA.

1.5 Russia: research reactors WWR-M and PIK, Mr. Maxim V. Voronov, PNPI

In Gatchina, a picturesque and rich with historical sites suburb of St.-Petersburg, one of the largest institutes of the Russian Academy of Sciences - the Petersburg institute of nuclear physics is located. It has been founded in 1956.

Fundamental scientific researches in the area of physics of elementary particles and high energies, the nuclear physics, condensed-matter physics, molecular and radiation biophysics are carried out at the institute. Besides, researches in applied areas where application of the most advanced scientific decisions leads to essentially new workings out in the field of instrumentation, medicine and ecology are conducted. Scientists of institute take part in the international researches in the largest science centers of Europe and America.

Mainly, the prospects for the development of the institute are connected with building of a new research reactor PIK. After start-up it will make a competition for the unique high-flux research reactor of the ILL. The reactor will have hot, cold and ultra cold neutrons sources, eight neutron guide systems that allow transportation of neutrons to experimental installations, and all about fifty positions on neutron beams. With its characteristics the reactor meets the most strict safety requirements.

Nowadays two base experimental installations operate at the institute - the WWR-M reactor and the high energy proton accelerator. This combination of two basic nuclear installations on one platform, each of which could be a kernel of a standalone institute, allows carrying out unique scientific research and promoted the creation of erudite experts collective.

WWR-M REACTOR

In spite of the fact that the WWR-M reactor has been commissioned in the end of 1959, it still remains a stably working nuclear research reactor and a unique reactor of the Russian Academy of Sciences. Researches in the area of physics of the condensed condition, radiating materials technology, radio biology, and also the nuclear physics and in other consecutive areas are carried out on the reactor.

Characteristics of WWR-M

- Type – thermal, heterogeneous, research
- Rated power, MW – 18
- Fuel elements – concentric pipes of uranium (enriched to 90%) and aluminum alloy, aluminum enveloped
- ^{235}U quantity in reactor core, kg – 8-10
- Moderator and coolant – light water
- Reflector – metallic beryllium
- Peak thermal neutron flux (in light water trap), n/cm^2 s – up to $4x10^{14}$
- Number of horizontal neutron extraction channels – 17
- Neutron flux at channel inlet, n/cm^2 s – up to $1.5x10^{14}$
- Number of vertical channels for sample irradiation in flux up to $1.5x10^{14}$, n/cm^2 s – 18

The reactor is equipped with twenty specialized installations, fifteen of which are intended for carrying out the researches of nano-systems and materials.

Experimental installations at the reactor:

All the installations with characteristics are performed in the table.

Instruments	Ch No	I(sample), n/cm^2s	Purpose
UCN – ultra-cold neutron		$6 \cdot 10^3$	Fundamental physics
PCN – polarized cold neutrons		$6 \cdot 10^8$	Fundamental physics
PD - Powder diffractometer	1	10^6	Structure study
MRPN – Monochromator of resonance Polarized neutrons	1	$5 \cdot 10^4$	P,T-parity, fission physics
BSGS GSK–2M – Bend crystal γ-spectrometer (Cauchois-type)	2	$6 \cdot 10^{13}$	Precise g-spectroscopy
IN NEUTRON-3 - Three-axis spectrometer	3	10^6	Inelastic scattering
SAPNS-VECTOR - SANS instrument of Polarized neutrons	4	$1.7 \cdot 10^4$	Spin correlations
SANS-MEMBRANA - small angle diffractometer	5	10^5	Supra structure
CSPN – correlation spectrometer of polarized neutrons	6	10^5	Magnetic diffraction
MRN – Monochromator of resonance neutrons	7	$5 \cdot 10^6$ eV	Physics of fission

RCN – radiation neutron capture instrument	8		
RTOF Mini-SFINKS –Time of flight powder diffractometer	9	$2\cdot10^7$	Atomic structure
CD UCNS – Solid deuterium UCN source	10	$5\cdot10^2$	Fundamental physics
MSES - Modified spin-echo spectrometer	11	10^2	L-f - dynamics
RPN - Reflectometer of polarized neutrons (under construction)	12		Surface of liquids
TOFRPN – Time of flight reflectometer of polarized neutrons	13	10^3	Neutron optics
SCD – Single crystal diffractometer	13A	$2\cdot10^5$	Single crystals
3DAPN – 3-d analyzer of polarized neutrons	14	$3\cdot10^3$	Magnetic texture
LTHeL - Low-temperature He-loop		$7\cdot10^{13}$(t) $1\cdot10^{13}$(f)	Radiation physics
GD – Gamma-diffractometer		200 Cu	Perfect crystals

In addition to fundamental research, the production of radionuclides is carried out in the WWR-M. So PNPI can suggest the Baltic coalition its possibilities of irradiation services by neutrons of wide spectrum. Unfortunately, PNPI has no license for exporting and selling of isotopes right now. It is carried out by means of scientific-production association «Radium institute», Saint-Petersburg.

The equipment with a source of cold and ultracold neutrons, and neutron guide hall of the WWR-M reactor is under construction. It will allow to essentially expand the possibilities for experimental researches because of the expansion of a spectrum of used neutrons and providing low-background conditions. Specialised cryogenic hall is created for realisation of this project on the WWR-M reactor and the equipment with powerful cryogenic installations is under development.

The WWR-M has operated without an accident for 50 years. The level of the discharges is far below the permissible values. During the existence of the reactor, there has been no case of a staff member suffering from radiation disease or excessive irradiation. However, the WWR-M has become out of date for the most interesting neutron research, and the future hopes of the Institute are attached to the PIK reactor.

PIK High-Flux Reactor

By the early 1960s, it had already become clear that future progress in neutron research after 20 years required higher neutron fluxes. A scheme was drafted for a high-power high-flux research reactor denoted by PIK. The core had a volume of 50 liters and was cooled by light water under pressure, and had a light-water central trap surrounded by a heavy-water reflector with thickness of 1 m and height of 2 m. The parameters of the trap, core, and reflector were optimized in accordance with the principle for minimizing reactor costs. Calculations for cores with volumes of some tens of liters showed that heavy water rather than beryllium provided for the best ratio of thermal neutron flux density to power. The interchangeable bodies enabled one to vary the core parameters widely. The coolant and moderator (light water) has a short neutron moderation length, so the core is compact. The intermediate cooling circuits protect the third circuits in contact with the atmosphere from the leakage of radionuclides. The PIK has also a full-scale physical model (zero power critical assembly), on which all the neutron-physics parameters were checked by experiment.

Basic parameters for the PIK:

- Power, MW - 100
- Thermal neutron flux, 10^{15} n s^{-1} cm^{-2};
  - in trap – 4.5
  - in reflector – 1.3
- Moderator and coolant – Water
- Reflector – Deuterium oxide
- Load of ^{235}U, kg – 27.5
- Enrichment, % - 90
- Coolant pressure, MPa – 5
- Number of channels:
  - horizontal - 13
  - inclined and vertical - 14
  - Number of neutron guides - 8
- Flux density at exit, 10^{10} s^{-1} cm^{-2};

It is planned to set up 20-25 installations for research on elementary particle physics, nuclear physics, and applications based on nuclear physics methods; these will be located in the main hall of the reactor and in the inclined-beam hall, and partially also in the neutron guide hall. Much space will be given to fundamental research in physics of elementary particles and nuclear physics. To extend these researches, it is planned to set up a universal source of cold and ultra-cold neutrons in the Horizontal experimental channel 4. That source should greatly improve the experimental facilities compared to the analogues ones in the WWR-M reactor. It is planned to conduct a very important experiment on the neutron electric dipole moment, as well as experiments involving precision measurements on the β-decay of the neutron: lifetime and correlation constants. The purpose of the precision measurements on the neutron β-decay is to check the standard model at a new level of accuracy and thus detect possible deviations. Much space will also be given to researches on weak nucleon-nucleon interactions using the intense beam of polarized cold neutrons. Preparations are also being made for neutron-optical and neutron-interferometry methods.

About 25 installations are planned on the PIK for research in condensed-state physics. They will be located partially in the main hall on the horizontal thermal and hot neutron beams, but mostly they will be in the neutron-guide hall, which has four thermal-spectrum neutron guides and four guides from the cold neutron source. The solid-state instruments include powder and single-crystal diffractometers, three-axis inelastic-scattering spectrometers, time-of-flight spectrometers, and instruments having no analogous on other reactors in Russia or abroad.

These instruments include a back-scattering spectrometer, a Sphinx diffractometer (d/d ~10^{-3} - $5\cdot10^{-4}$), a modified spin-echo spectrometer involving modulation of the neutron spin phase precession spectrum in a magnetic field, a high-luminosity diffractometer for researching magnetic correlation tensors and involving the analysis of polarization in the region of small scattering angles, which involves simultaneous measurement of diffraction at large angles, a diffractometer employing high-intensity γ-ray sources and with angular resolution better than one second of arc, a neutron interferometer based on diffraction gratings for the long-wave region of the neutron spectrum, and so on. All these installations are equipped with the latest readout and control facilities for the angular and linear displacements, along with reliable computer support, and equipment for small-angle scattering: two-coordinate position-sensitive neutron detectors.

PNPI welcomes foreign participation/collaboration for neutron research and to use PIK's unique possibilities.

Annual «Winter School»

The PNPI annually holds the Winter School in various directions of scientific work of institute since 1966. Within this educational event the Institute holds Schools on the physics and the techniques of reactors which subjects are basically connected with the operation of research reactor, its modernization and with a construction of the PIK reactor. Also the schedule of the School includes summarizing lectures on the physical experiments carried out on reactors. For performances leading experts of PNPI and other nuclear centers are invited.

The Winter Schools contribute greatly to improvement of professional skill and a scientific outlook of employees and especially young experts of the institute. The Schools also provide an exchange of the scientific information and experience of scientific research that is especially relevant for the forthcoming start-up of high-flux research reactor PIK. After the Winter Schools all materials of the most interesting lectures are published.

PNPI is glad to offer the Baltic coalition its knowledge, possibilities and experience. We invite employees, trainees and students under auspices of IAEA to take part in PNPI Winter Schools. It is believed that the IAEA's sponsorship would allow expanding institute's possibilities to attract leading foreign experts as lecturers and senior students of universities as participants at Winter Schools.

Discussions, comments and concerns

The winter school held at PNPI consists of different courses including reactor physics and operator training programs. Courses are available in Russian and will soon be also available in English. The PNPI looks forward to having deeper collaboration with foreign scientists and welcomes English speaking lecturers to the winter school. The fee for international participants is not finalised yet. It was suggested by the panel that a reduced fee could be offered to the MSs that provide lecturer to the winter school.

1.6 Finland: Research Reactor FiR 1, Mr. Iiro Auterinen, VTT

The Finnish TRIGA reactor, FiR 1, has been in operation since March 1962. It belonged first to the Department of Technical Physics at the Helsinki University of Technology. The activities of the reactor were defined as training in nuclear technology, research and production of radioactive isotopes. In 1972 the reactor was transferred under the administration of the Technical Research Centre of Finland (VTT).

From its early days the reactor created versatile research to support the national nuclear program as well as generally the industry and health care sector. The volume of neutron activation analysis was impressive in the 70’s and 80’s the reactor operating close to daily only for activation analysis. For uranium prospecting yearly some 30 000 mineral samples were counted for delayed neutrons with an automated system. Now other analysis methods have nearly totally replaced neutron activation analysis. In isotope production a small research reactor is competitive only in producing short lived isotopes for local markets.

In the 1980´s FiR 1 had a major role in the Finnish radiopharmaceutical research and development. Till mid 1990’s samarium-153 was produced for bone cancer treatment and dysprosium-165 for treatment of arthritis. The spin-off company established at the reactor at that time, MAP Medical Technologies, has been successful but relies now on other sources for its radioisotopes, the accelerator at the Jyväskylä University in central Finland and traditional international radioisotope producers.

In the 1990´s an epithermal neutron irradiation facility was constructed for boron neutron capture therapy (BNCT) of cancer patients. FiR 1 has made already now a major contribution in the research and development of BNCT. Internationally important breakthroughs have been achieved in the application of BNCT for cancer treatment. BNCT treatments dominate the current utilization of the reactor: two days per week are for BNCT purposes and the rest for other purposes such as radioisotope production, neutron activation analysis and education/training.

Boron Neutron Capture Therapy and Medical Physics

Boron neutron capture therapy is an experimental radiotherapy used in clinical trials in Europe, Japan and the Americas. In BNCT the highly lethal radiation (α, $^{7}Li^{*}$) released in thermal neutron capture of boron-10 atoms is used. The dose is targeted to the tumour using a boron carrier substance that is selectively taken up by the cancerous tissue. In epithermal BNCT epithermal neutrons penetrate deep into the tissue thermalizing at the same time. The epithermal neutrons (0.5 eV – 10 keV) are produced from the fission neutrons by a moderator block consisting of $Al+AlF_3$ (Fluental™) developed and produced by VTT. The material gives excellent beam values both in intensity and quality and enables the use of a small research reactor as a neutron source for BNCT purposes.

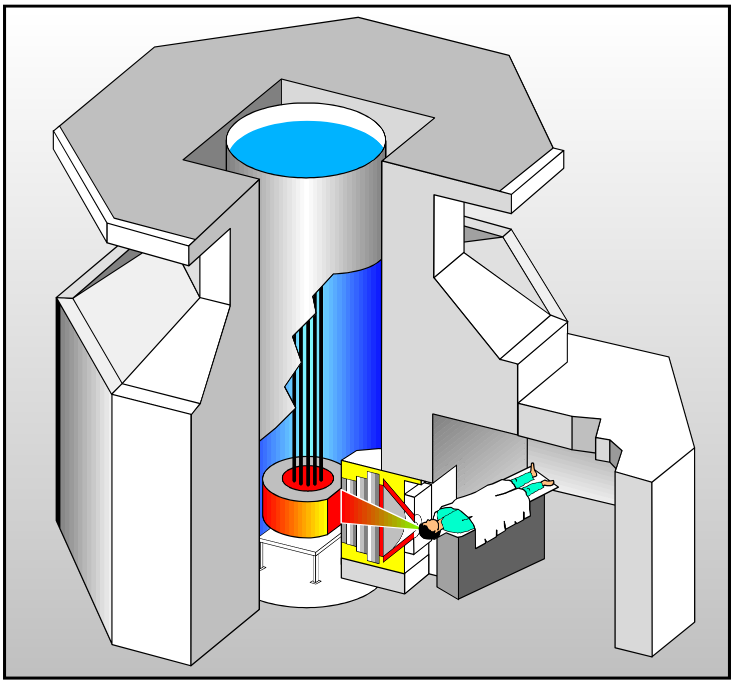

Fig 1. The BNCT facility at FiR 1.

Clinical trials

Three clinical trials sponsored by the Boneca Corporation have been running at the FiR 1 BNCT-facility. Since May 1999 over 200 patient irradiations have been performed (table 1). The patients have been with glioblastoma, an until now incurable brain tumour, with recurring or progressing glioblastoma or with recurrent inoperable head and neck carcinoma. The irradiation procedure typically lasts for about one hour.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
BNCT-irradiations	7	5	9	0	8	17	38	26	44	49

Table 1. Number of BNCT patient irradiations yearly at FiR 1.

Recently the Finnish group working at FiR 1 was able to report that most head-and-neck cancers that recur locally after prior full-dose conventional radiation therapy respond to BNCT. The scientific director of the research program Heikki Joensuu, professor of radiotherapy and oncology at the University of Helsinki, considers the results clinically significant. The successes in the BNCT development have now created a demand for these treatments, although they are given on an experimental basis. The Helsinki and Uusimaa hospital district decided to purchase in 2008 about 50 BNCT treatments annually to Finnish patients. Additionally foreign patients are treated.

Medical physics research and education

Due to the BNCT project FiR 1 has become an important research and education unit for medical physics. Since the early 1990's several graduate and postgraduate students from the medical physics program of the University of Helsinki have been working at the FiR 1 BNCT facility and are credited up to one year of required hands-on experience for the hospital physicist exam. In research projects dosimetry, radiation transport modelling, treatment planning, prompt-gamma imaging and other medical physics aspects of the BNCT have been studied and developed. Over 10 academic theses and dissertations have been produced in these projects, along with over hundred scientific publications.

Radioisotope production

Typical radioisotopes produced at FiR 1 for tracer studies in industry are Br-82, Na-24 and La-140. The applications are calibrations of liquid or gas flow meters and analysis of disturbances in chemical or other processes. The most popular carriers for Br-82 are either KBr or ethylene bromide. Typical activity of one irradiated Br-sample is 20 - 80 GBq.

	2004	2005	2006	2007	2008
Number of deliveries					
- all	196	156	213	159	225
- for outside customers	61	87	92	91	82
- science	4	6	10	5	1
- industry	57	81	82	86	81
Total activity produced (TBq)					
- all	1,6	2,8	3,1	4,6	3,0
- for outside customers	1,6	2,8	2,9	4,5	2,9

Table 2. Yearly radioisotope production figures at FiR 1.

Nuclear engineering education and training

Helsinki University of Technology has yearly at least two courses for technical physics and energy technology students in reactor and neutron physics that utilize the reactor. Reactor physics demonstrations are also organized for the students of the Lappeenranta Technical University. The KTH (Stockholm) uses FiR 1 as the site for student reactor exercises. FiR 1 is utilized also in the continuing education and training of the personnel at nuclear power companies, both in Finland and in Sweden, and other organisations connected to nuclear power. These are typically one day intensive courses with hands on exercises, or demonstrations and excursions in connection to longer lecture courses. On the average there are yearly over 20 days dedicated for education and training.

Cost of operation

The basic cost for maintenance and operation of the reactor is about 400 000 euros per year, including licensing administration. The operational costs of the reactor are moderate as one operation shift includes only the reactor operator and the shift supervisor and they are not fully occupied by the reactor operation. The radiation protection has one duty officer.

The aim is to cover a substantial part of the reactor costs with the income from the services. Currently two thirds of the turnover comes from the services. Still financial support from VTT-basic funding or other government sources is required. New funding possibilities from the administrative sector of the Ministry of Education and from different science funds are looked for. Together with the increasing income from the BNCT treatments this would balance the economy of the reactor.

Long term strategy

A long term strategy is being worked out for FiR 1 by VTT and its proprietor the Ministry of Employment and the Economy supported by an independent survey of an outside consultant. According to the survey most actors in state administration, education and research consider the continuation of the development of BNCT nationally important and even ethically necessary. Developments of linear accelerators to substitute reactors as a neutron source for BNCT have started. The prospect is that in the future such a facility will be constructed at the Helsinki University Central Hospital. Meanwhile development of BNCT to an established treatment for several cancers requires FiR 1 as a demonstration and reference facility at least till year 2016. As part of the consultant survey a SWOT analysis for the future of the FiR 1 was performed. An adaptation of that analysis is presented in table 3.

Strengths	**Weaknesses**
The reactor is in good condition and is for the moment the best facility in the world suited for BNCT treatments. Skilled personnel. Operational license now valid till end of 2011 and can be easily extended till 2016. Enough fuel to operate 50 years more. Funds exist for nuclear waste management and decommissioning of the reactor.	The Finnish nuclear power utilities do not directly use the research reactor. The future of the reactor depends strongly on the developments in BNCT. Lack of international collaboration especially in the field of BNCT. Part of personnel retiring in the coming years. Operation and maintaining of the reactor are loss-making requiring financial support

The efficacy of BNCT has been demonstrated in the treatment of head and neck tumours (published in 2007).	from the VTT infrastructure funds and/or elsewhere.
Opportunities Development of BNCT to an established treatment for several cancers requires FiR 1 as a demonstration and reference facility. The likely closing of the BNCT activities by the European commission at Petten gives new possibilities for FiR 1. Increasing interest of venture capitalist in BNCT. Development of linear accelerators to substitute reactors as a neutron source for BNCT has started internationally. New funding possibilities from the national research infrastructure program and from the new Health and Welfare Strategic Centre for Science, Technology and Innovation.	**Threats** The goals set for the contribution margin at VTT are not met in the next 2 to 3 years. Slow progress in receiving international recognition and significantly increasing international collaboration in BNCT. Risks involved in the financing and in the schedule of the development of the accelerator based BNCT concept.

Table 3. SWOT-analysis for the future of the FiR 1, adapted from.

The current operating license expires at the end of the year 2011. An application for a new operating licence will be submitted to the authorities by the end of 2010. In 2009 the main parameters of the application for a new operating license will be decided. Due to the age structure of the personnel most of the reactor key persons have changed and will change during the years 2008 to 2010 due to retirements.

FiR 1 has an important regional role in producing short lived isotopes as well as in education and training as there are only a few research reactors in the Baltic region suitable for these tasks. FiR 1 is participating in the IAEA Baltic Research Reactor Initiative where the main objective is to evaluate availability and potential of the research reactors in the region to provide services for neighbouring countries, in particular in the area of education and training.

Discussions, comments and concerns

The education and training program for students at higher academic level is available at FiR1. Master of Science students are trained at FiR1 for 1-2 days.

FiR1 is also used for BNCT treating patients from different hospitals in Finland. In addition to domestic patients, FiR1 has also been used for treating patients from Italy, Japan and Sweden.

Suitability of patients for BNCT treatment are decided by the medical staff it is however limited by patients possibility to maintain basic life functions, such as breathing without help.

Although Poland is in the R&D stage for using MARIA rector for BNCT, there has not been any collaboration between Poland and Finland up until now.

1.7 <u>Estonia:</u> Research Reactor Needs and Collaboration, Mr. Alan Henry Tkaczyk, University of Tartu

With projected increases in Estonian electricity usage and the uncertain future for oil shale, many options are being considered for the energy portfolio of Estonia. Plans for an Estonian nuclear power plant are being actively considered. Increased knowledge of nuclear science and engineering will be valuable for the Estonian public sector and electric utility. To meet these needs, the University of Tartu and Tallinn University of Technology have applied for a joint master's degree program in "Nuclear Energy and Safety." As Estonia has no research reactor, practical training abroad is critical. A Baltic research reactor network would be an ideal choice for practical education and training of Estonian students, also serving the purpose of increased regional cooperation and nuclear networking.

Estonia has a need for comprehensively trained individuals in the full spectrum of nuclear engineering to optimally work with the government, oversight bodies, and electric utility. In addition to reactor physics, thorough training in safety and environmental aspects of nuclear power are essential.

The master's program will be conducted in English, allowing the participation of international students and instructors. Participation of experienced international educators and scientists with high-level expertise or hands-on practical skills is strongly encouraged, and applications have been made to support and attract foreign instructors. We would welcome the members of the Baltic research reactor network to participate in the master's program, in both experimental and theoretical context. Specific activities could include support of student practical training, training of faculty members, updating or sharing educational equipment, establishing course sequences, international guest lectures.

In addition to education and training, we are interested in nuclear research collaboration such as neutron scattering, radiography, neutron activation analysis, and radioactive waste issues.

Discussions, comments and concerns

1.8 Latvia: Utilization of Salaspils research reactor's site, Mr. Andris Abramenkovs, State Agency for Management of Hazardous Waste

The research reactor facility IRT is located in Salaspils site near the capital Riga was put into operation in September 1961. The research reactor was originally built according to former USSR design as a pool type light water-water reactor with nominal thermal power 2 MW. Since 1975, after physical reconstruction of the reactor, the nominal thermal power of reactor was increased up to 5 MW. In May 16 of 1995, the Cabinet of Ministers had made the decision to shut down the Salaspils Research Reactor (SRR) after last 2 years of operation (the decision prohibited obtaining fresh nuclear fuel) and requested the Nuclear Research Centre of the Latvian Academy of Sciences to start the preparation of Concept for decommissioning. In this case the essential stakeholders – the Government of Latvia, local municipality and different state institutions were involved in decision taking process for decommissioning. Decommissioning of Salaspils Research Reactor was a large challenge for the Latvia, since the country in this moment had no decommissioning experience and necessary technologies for the implementation of the defined goals by the Government. In this case for facilitation of the decommissioning of Salaspils Research Reactor (SRR), the significant role was expected for the local and international stakeholders.

The presentation describes the different stages of decommissioning of SRR. It was shown, that technical and economical support from DOE, USA provides the possibility to solve the fuel problem during decommissioning of SRR, as well as, to increase the physical safety of SRR and repository "Radons". The role of governmental institutions in the decommissioning of Salaspils research reactor is discussed in the presentation. It was shown, that the support from International Atomic Energy Agency significantly promotes the decommissioning of SRR. The main issues were expert support for solution of different technical problems in radioactive wastes management, area monitoring, and verification of decommissioning plans, training of staff and technical expertise during whole process of decommissioning. The different possibility to reuse the SRR site is analyzed. It was shown, that the best option for reuse of territory is connected with the development of new innovative radiation technologies for health care and radioactive wastes management on the site. The role of further cooperation in the range of the Baltic Region cooperation is discussed in the presentation, in particular in the area of education and training, decommissioning of nuclear facilities, nuclear waste issues.

Discussions, comments and concerns

Latvian research reactor has been decommissioned. Some of the equipments are to be shipped to Munich and/or Grenoble. The site is to be used for a small nuclear power plant or a new research facility such as cyclotron used for education.

1.9 Lithuania: Expression of needs and requests, Mr. Laurynas Juodis, Institute of Physics and Mr. Eugenijus Uspuras, Lithuanian Energy Institute

In Lithuania there are no research reactors (RR) in operation, under decommissioning nor in near future plans to be built. However, Lithuania is a nuclear power state producing up to 80 % of its electricity in RBMK-1500 type nuclear reactors in Ignalina NPP (INPP). Unit I of INPP was shut down in 2004-12-31, Unit II is planned to be shut down at the end of 2009. Lithuania has decided to immediate dismantle of shut down reactors in order to profit from available INPP personnel in decommissioning activities. The decommissioning of INPP is planed to be finished at about 2030.

After shut down of INPP Unit II the needed electricity will be produced in thermal power plant AB "Lietuvos elektrinė" (by burning of imported fossil fuel: gas, oil products), other small thermal or sustainable energy power plants, or imported from neighbouring countries (Latvia, Belorussia). To reduce dependence on imported fossil fuel, reduce greenhouse gas emissions and improve safety of energy sector it is planned to build the new nuclear power plant (Visagino atominė elektrinė, VAE). First activities have been performed: selection of VAE site, Environment Impact Assessment Report issued, etc.

Current activities in nuclear energy sector of Lithuania indicate the needs of activities to be planned and performed, some of them could be linked with RR utilization:

- Building of new NPP requires increasing human resources of Lithuanian nuclear energy sector for:
  - Regulating organizations (VATESI, Radiation protection centre, Ministry of Energy, Ministry of Environment);
  - Operating organizations: VAE, re-qualification of INPP staff to be able to work in VAE, Radioactive Waste Management Agency (RATA);
  - Education and scientific institutions.
- Decommissioning of INPP needs implementing modern requirements and best practice in order to minimize the exposure doses, arising radioactive waste, and cost. Adequate competence is one of the basic components for safe INPP decommissioning.

Building of new NPP – VAE requires providing qualified specialists to cover the needs of operating and regulating organizations. From 1978 specialists of nuclear engineering (bachelor study program) are educated at Kaunas University of Technology (KTU). From 2008 new bachelor study program has been started at Vilnius University (VU). Masters degree programs are planned to be started at VU and KTU (depends on further development of education basis).

The above indicated activities have to be adequately supported:

- Qualification of teaching staff has to be improved:
  - Setting up of qualification improvement program;
  - Participation in seminars, workshops, training courses, on reactor training – **case for RR utilisation**;
- Laboratories and experimental equipment for laboratory exercises for students have to be renewed.

Some training of the students has to be very specific (training at research reactor – approach to criticality, start up, temperature effects, poisoning, power doubling time, rod calibration, safety issues,… – **case for RR utilisation**) and is evaluated to be needed in about 2-3 years.

Institute of Physics (Fizikos institutas, FI) in Vilnius is involved in INPP decommissioning projects, related to the radioactive waste characterization. FI is the leading institution in Lithuania in theoretical and experimental determination of nuclide composition of environmental and technogenic samples, as well as engaged in application of advanced analysis methods of detection of micro-impurities in the environment (e.g. migration of ^{129}I). Radioactive waste (RW) arising at INPP has to be managed according to the new RW management rules requiring thorough characterization of nuclide composition of waste.

Two basic methods are used at FI to predict the RW nuclide composition:

- Theoretical modelling of RW composition applying fuel evolution codes SCALE, MCNP(X), and analysis of nuclide migration in reactor and NPP technological media.
- Measurements of RW samples (are required by the normative documents to be performed in order to verify the theoretical assessment results).

Arising problems of RW characterization are:

- Content of some nuclides in specific media is difficult to predict by analytical techniques or to measure by experimental spectrometric techniques (e.g., ^{129}I in very low level activity waste (VLLW), low and intermediate level waste (LILW) or transuranium elements in graphite).
- It is necessary to know the amount of impurities in order to evaluate the activation of LILW, high level waste (HLW) (graphite, stainless steel, zirconium alloy E110 – all specific to RBMK type reactors).

This indicates that neutron activation analysis (**case for RR utilization**) could be very useful technique to solve the problems of RW nuclide composition determination or to improve assessment accuracy.

Discussions, comments and concerns

Treatment of graphite waste is undergoing in Lithuania. Different options such as combustion are studied for the moment, however the increase of CO2 release to the atmosphere must also be considered. Lithuanian law does not allowed treat of any radioactive waste from other countries.

1.10 <u>Denmark:</u> Radiation Research Division at Risø National laboratory, Mr Lars Martiny and Mr Dennis Ringkjobing Elema, Risø

Risø was inaugurated in 1958 and has been operating three research reactors (RR) aiming at research in the peaceful application of nuclear energy. As public opinion turned against nuclear power in Denmark in the late 70s, it was in 1985 decided by the Danish parliament, that Denmark was not to build nuclear power plants. Research at Risø was therefore turned towards other energy technologies including wind power. The RR was employed in a large range of neutron scattering experiments as well as irradiation services and isotope production. After a safety issue in the late 1990'ies with a tritium leak, it was although decided to shut down the reactors. In 2001 the last operating RR was shut down. The employees that was primarily involved in the operation of the reactor as well as the nuclear safety was split out in Danish Decommissioning (DD) and was charged with the decommissioning of the reactors. The researchers at the reactor remained at Risø in the Radiation Research Division.

The Division for Radiation Research at Risø DTU is today the national research based centre of competence on ionizing radiation, radioisotopes, nuclear technologies and the manufacture of radiopharmaceuticals. The Division is involved in the Danish Nuclear Emergency Preparedness program as well as the surveillance programmes for compliance with the Euratom treaty and Helsinki convention.

The division has approximately 60 employees including 7 PhD students and an academic staff of 23. The Division is organised in three programmes: a) The programme for radiation physics, b) the programme for radioecology studies, and c) the Hevesy Laboratory for radiopharmaceuticals. In 2008, a total of 80 publications originated from the division.

The programme for radioecology (RAS) carries out studies on environmental radioactivity including monitoring activities in Denmark, the Faroe Islands and Greenland. Research projects focus on the transfer of radioactivity in the environment and through food chains, and the monitoring activities test if radioactivity levels in the environment and food are below national and international limits. The analytical work in RAS is specialised in detecting very low levels of radioactivity requiring significant pre-treatment of samples prior to radionuclide analysis.

The Radiation Physics Programme (STR) carries out research in radiation dosimetry, optically stimulated luminescence (OSL), reactor physics and nuclear emergency preparedness. Radiation dosimetry covers medical and industrial dosimetry applications aiming at improving methods for dosimetry in relation to radiation therapy and diagnostics, nuclear medicine and radiation sterilization. Fundamental OSL research aims at developing methods and instruments for retrospective dosimetry including dosimetry for geological age determination.

The Hevesy Laboratory (HEV) is a radiochemical and radiopharmaceutical research program. The laboratory has a 16.5 MeV proton biomedical cyclotron equipped with a beam-line for in house production of many radioisotopes, most important presently F-18 for PET scanning. With its main competences in isotope production, radiochemistry, radio-labelling and radio-pharmacy, The Hevesy Laboratory participates at many levels in the development of new diagnostic and therapeutic radiopharmaceuticals. The present large scale growth of PET and PET/CT imaging capability throughout the world is a key driver for this research and it opens important opportunities for the development and clinical dissemination of new diagnostic PET tracers, supplementing the already very successful cancer tracer FDG.

In addition, the Hevesy Laboratory still develop and supply reactor produced isotopes. Targets are then prepared at Risø, irradiated at collaborating RR's and finally reprocessed at Risø in the hot-cell facility. The laboratory therefore works with a wide range of isotopes:

Cyclotron produced	18F, 64Cu and others
Reactor produced	82Br, 203Hg, 24Na, 75Se, 111Ag, 47Ca, 198Au and others
From commercial sources:	133Xe, 177Lu, 3H, 14C, 125I

Perspectives to a potential Baltic RR coalition

As a RR *user*, we wish to collaborate on:

- Reactor physics and neutronics – Training and collaboration
  - The division is involved in the national nuclear emergency preparedness programme, therefore needs to safeguard knowledge on reactors physics (despite pension, funding and recruitment).
- Access to thermal neutrons for isotope production
  - Access to medium and high flux thermal neutrons for specialised irradiations.
- Collaborations on decommissioning.
  - Knowledge within Risø and DD on decommissioning of research reactors.
- (Access to RR's for neutron activation studies)
  - Has been used extensively in the past, but is today replaced with alternative methods due to absence of activation facility.

Discussions, comments and concerns

Although the research reactor at Risø has been decommissioned, the laboratory continues to deliver products to the customer by preparing samples to be irradiated RR abroad (e.g. JRC-Petten, MURR-US).

Risø researchers also are involved in neutron scattering experiments abroad. R&D in neutron therapy, using accelerator-based neutron sources, might be considered in the future.

1.11 <u>Sweden:</u> SURE, Swedish education and training reactor, Mr. Sean Roshan, Royal Institute of Technology

Nuclear power production constitutes close to half the supply of electricity in Sweden, and will continue to do so in the foreseeable future. Presently, nuclear power industry needs to employ hundreds of engineers every year. While general skill engineers may be available in such numbers, engineers having deep functional knowledge in nuclear power science and technology are rather scarce. Hence, MSc programmes in nuclear energy engineering have started at KTH in 2007 and at Chalmers University of Technology in 2009, with support from the nuclear industry. An essential part of such training programmes is laboratory exercises in training reactors. There, students obtain functional knowledge in the operation of reactors by means of learning activities such as criticality approach, control rod calibration, determination of neutron flux and delayed neutron precursor half-life. Until 2005, similar exercises were made in the R2-0 reactor of Studsvik. After the shut-down of the reactors in Studsvik, Swedish students have had to go abroad to obtain this training, e.g. in SCK Mol (Belgium), Helsinki (Finland), Budapest (Hungary), Prague (Czech Republic) and Kyoto (Japna). While this solution provides an added value in terms of exposing students to international environments, it is a costly and time-consuming process, especially when the number of students exceeds the size of a suitable laboratory group (~ 10).

A possible aim of the Swedish universities providing education in nuclear energy engineering (KTH, Chalmers and Uppsala University) is to train of the order of magnitude 100 students per year in reactor physics. This could provide a sufficient basis for building and operating a dedicated reactor for training and education in Sweden. The present document describes the major objectives of such a reactor, under the acronym STURE (Svensk Tränings- och Utbildnings REaktor), a pre-conceptual design and a preliminary dose rate assessment.

As the present document shows, it would be possible to construct a pool type training reactor based on standard LWR fuel pin design, using 3.4% enriched uranium dioxide fuel and light water moderator. At a tentative power of the reactor equal to 10 kW, the core could have an operational life time of 30 years without changing the fuel.

Presently, a safety analysis of the here suggested core design is performed at the division of Nuclear Power Safety at KTH. The resulting safety report could be used as a basis for applying for permission to build the reactor at a suitable location in Sweden.

Discussions, comments and concerns

The question of necessity of a Swedish training and education reactor was raised by different members of the panel, while several research and educational reactors are available within the network in the Baltic region, and the use of regional approach was encouraged.

ANNEX II. DEMAND-SUPPLY TABLES

Capabilities Table (supply) by Research Reactor host Member States

	Education & Training Reactor physics Topic schools	Isotope production	Neutron Scattering, Radiography, other use of neutron beams	Irradiation services and products	bnct	Maintenance, refurbishment, operation, decommissioning
FIR-1 Finland	YES	YES	Possible on request	YES: NAA, samples	YES	YES
BER-II Germany	Possible on request		OK RU, POL	YES: NAA		YES
FRG-1 Germany	Possible on request	YES	YES	YES: sample irradiation both n & g		YES
JEEP II Norway	YES: n-scattering Future courses at UiO	YES	YES	YES: NAA, NTD, g-source		YES
MARIA Poland	YES	YES	YES	YES: NAA, NTD, Gem coloration Sample irradiation	YES: R&D	YES
WWR-M Russia	YES	YES	YES	YES: NAA, NTD, Sample irradiationGem coloration p-accel.		YES
PIK Russia	2012	2012	2012	2012		YES
RISO Denmark		p,d-accel.		p,d-accel. g-source		YES
Studsvik-KTH Sweden						YES: containment
BAPA Latvia		p-accel.		g-source, p-accel. n-source		
Dresden AKR-II	YES					

Demand Table (needs): non-RR MS

	Education & Training (reactor physics)	Isotope production	Neutron Scattering, Radiography	Irradiation services	Nuclear waste issues, decommissioning, emergency readiness
BAPA Latvia	YES	YES	YES	YES	YES
LEI Lithuania	YES	YES		YES	YES
PI Lithuania	YES: MSc VU & KTU, MSc, engineers, operators		YES	YES NAA, samples	YES
Riso Denmark	YES	YES	YES	YES NAA, samples	YES
UoT Estonia	YES: MSc, UoT with TTU, EU funds, ENEN		YES		YES
KTH Sweden	YES: MSc at KTH, Chalmers, Uppsala	YES	YES		YES

ANNEX III. WORKPLAN UNTIL NEXT MEETING

	E&T	**Irradiation services**	**Decommissioning/ waste**	**Operation experience**	**Applied neutron scattering**
Coordinator	Sweden	Denmark	Latvia	Norway	Germany
Action/Date (supply)	Collect information on possible training capabilities at RRs	Collect information on isotope production capabilities at RRs	Collect publicly available information and documents on decommissioning and radioactive waste management of nuclear facilities in the region	Exchange of information and operation staff visits	Collect the information on applied use of neutron beams and potential capabilities in the RRs of the region
Action/Data (demand)	Collect information on needed training programs using RRs	Collect information on needed non-standard isotopes	Collect requests on lack/need of expertise on decommissioning and radioactive waste management	Exchange of information and operation staff visits	Promote and share the information on applied use of neutron beams with potential end users

ANNEX IV. LIST OF PARTICIPANTS

RER4032/9002/01
Workshop on Strategic Planning for Sustainability in the Baltic Region: Research Reactor Utilization, held in Poland, Otwock Swierk
from 2009-06-03 to 2009-06-05

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ANNEX V. WORKSHOP AGENDA

RER4032/9002/01
Workshop on Strategic Planning for Sustainability in the Baltic Region: Research Reactor Utilization
Maria RR, Otwock Swierk, Poland
3-5 June 2009

Tuesday, 2 June 2009

2000-2130	Welcome reception “Polonia” Hotel

Wednesday, 3 June 2009

0900-0930	Registration
0930-1030	Welcome & Opening Remarks
	Prof. K. Wieteska, Director of Institute of Atomic Energy
	Mr I. Videnovic, IAEA/TC Europe
	Mr D. Ridikas, IAEA/NAPC
	Introduction of participants
	Selection of the Chairperson, Rapporteur, Facilitator
	Approval of the Agenda
	Goals of the Meeting, Mr D. Ridikas, IAEA
1030-1100	Break

Session #1:

Availability, access, and services by Member States with RRs, 30 min each

1100-1130	Mr Jon Per Rambaek, IFE, Norway
1130-1200	Mr Peter Schreiner, GKSS, Germany
1200-1230	Mr Herbert Krohn, HMI, Germany
1230-1400	Lunch break

Session #1 (continued):

1400-1430	Mr G. Krzysztoszek and Mr J.J Milczarek, IAE, Poland

1430-1530	Visit of Maria RR and associated facilities
Break	
1600-1630	Mr Maxim V. Voronov, PNPI, Russia
1630-1700	Mr Iiro Auterinen, VTT, Finland
1700-1800	All: discussion, needs for cooperation among RRs, draft of supply/service table, summary
2000 -	Hospitality event - “Chianti” Restaurant, Foxal 17 street

Thursday, 4 June 2009

Session #2:

Example of the RR coalition - East European RR Initiative (EERRI): share of experience, lessons learned, present and future activities

0900-1000	Mr J. Jaroszewicz, IAE, Poland

Session #3:

Expression of needs and requests by Member States without RRs, 30 min each

1000-1030	Mr A.H. Tkaczyk, University of Tartu, Estonia
1030-1100	Break
1100-1130	Mr A. Abramenkovs, BAPA, Latvia
1130-1200	Mr E. Uspuras, LEI, Lithuania
1200-1230	Mr L. Juodis, Institute of Physics, Lithuania
1230-1400	Lunch break

Session #3 (continued):

1400-1430	Mr L. Martiny, Risoe, Denmark
1430-1500	Mr Sean S. Roshan, KTH, Sweden
1500-1530	Break

1530-1700	All: discussion, common requests and needs, draft of demand table, summary

Friday, 5 June 2009

Session #4:

Preparation of demand-supply matrix, identification and quantification of common interests

0900-1030	All, 5-10 min each
1030-1100	Break

Session #5:

Definition of actions, work-plan and responsibilities for future cooperation

Discussion on formation of the regional RR Users' Network or RR Coalition

Draft of summary report and recommendations

1100-1230	All, 5-10 min each
1230-1400	Lunch Break

Session #5 (continued):

Finalization of work-plan, summary report and recommendations

1400-1530	All, Discussion and Editing
1530-1600	Concluding remarks and wrap up
1600	End of the workshop