LIMITED DISTRIBUTION

Working Material

Meeting Report of

the 1st Research Coordination Meeting related to the IAEA Coordinated Research Project Id 1575

on

Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams

International Atomic Energy Agency

Vienna, Austria

30 May - 4 June 2010

Vienna, Austria, July 2010

CONTENTS

1. LIST OF ACRONYMS

ANSTO	Australian Nuclear Science and Technology Organisation
BATAN	Badan Tenaga Nuklir Nasional-National Nuclear Energy Agency
CEA	Commissariat à l'Énergie Atomique
CIAE	China Institute of Atomic Energy
CNEA	Comisión Nacional de Energía Atómica
CRP	Coordinated Research Project
EC	European Commission
ENEA	Agenzia nazionale per le nuove tecnologie, l’energia e lo sviluppo economico sostenibile
IAEA	International Atomic Energy Agency
IE	Institute for Energy (JRC-EC)
ILL	Institut Laue-Langevin
IMR	Institute of Materials Research
INR	Nuclear Research Institute
IPEN	Instituto de Pesquisas Energéticas e Nucleares
JINR	Joint Institute for Nuclear Research
JPARC	Japan Proton Accelerator Research Complex
JRC	Joint Research Centre
KAERI	Korea Atomic Energy Research Institute
KFKI AEKI	Atomic Energy Research Institute of the Hungarian Academy of Sciences
KIT	Karlsruher Institut für Technologie
LANL	Los Alamos National Laboratory
LOCA	Loss Of Coolant Accident
NIFS	National Institute for Fusion Science
NPI	Nuclear Physics Institute
PDF	Pair Distribution Function
RCM	Research Coordination Meeting
RR	Research Reactor
SNS	Spallation Neutron Source
SZKFI	Szilárdtestfizikai és Optikai Kutatóintézet - Research Institute for Solid State Physics and Optics
TWA	Technical Working Area
VAMAS	Versailles Agreement on Advanced Materials and Standards
VVR	Light Water Reactor

2. BACKGROUND AND OBJECTIVES

2.1. Background

Nuclear technologies such as fission and fusion reactors including associated waste storage and disposal rely on the availability of not only nuclear fuels but also advanced structural materials. The objectives of this CRP are to address the use of neutron beams for characterization, testing and qualification of materials and components produced and/or under development for applications in the nuclear energy sector (fission and fusion). This CRP aims at bringing the stakeholders and end users of research reactors together for the enhanced use of available facilities and development of new infrastructures for applied material research in nuclear energy sector. Work envisioned under this CRP relates to the optimization and validation of research reactor based neutron techniques including facility and instrument modifications, improved process of data acquisition and analysis systems. Particular emphasis is placed on variable environment of materials to be characterized and tested as required by some applications such as intensive irradiation load, high temperature and high pressure conditions, presence of strong magnetic fields, etc. Targeted neutron beam techniques are material residual stress and texture measurements, advanced neutron radiography/tomography, and small angle neutron scattering. This CRP will expand the knowledge and understanding of materials behavior in terms of their characterization and qualification under extreme conditions for nuclear technologies. It will also contribute to the enhancement of utilization and applications of research reactors.

This CRP was approved by NACA in November 2009. As it is stated in the CRP proposal document the overall objective of this CRP is to employ advanced neutron beam techniques for solving problems of current interest of materials research in nuclear energy sector, to standardize and qualify relevant experimental techniques and modelling methods and to promote and establish collaboration among participants of the project and beyond. The specific objectives of this CRP are:

- To investigate and characterise materials using neutron beams at extreme conditions, relevant for the present and future nuclear technologies, e.g. intensive irradiation load, high temperature/pressure/corrosive environment, magnetic fields (fusion), etc.;
- To optimize and validate the advanced neutron beam experimental and modelling techniques, process of data acquisition and analysis, and to develop expertise in characterization and testing of materials in nuclear energy sector;
- To create an experimental data base to be used as a reference data to validate the models and calculation tools in nuclear material research;
- To bring the stakeholders and end users of RRs together for the enhancement of available facilities for applications of RRs in material research relevant to nuclear energy sector, including nuclear fission and fusion technologies.

2.2. Objectives of the 1st Research Coordinated Meeting (RCM)

The objectives of this first RCM were:

- To share information between participants regarding the proposed projects, employed neutron beam techniques and materials to be investigated.
- To identify the individual projects of common interest in order to establish closer collaboration of different teams during this CRP.
- To discuss the need for Round Robin experiment(s) related to the use of neutron beams in development, characterization and testing of materials.
- To discuss and agree on the modalities for sharing the information during this CRP, elaborate the creation of a dedicated experimental data base.
- To discuss and agree on the detailed work-plan for the 1st year and previsions for the 2nd and 3rd years.
- To prepare a draft meeting report.

3. MEETING ACHIEVEMENTS

The meeting was attended by 22 participants, from 16 Member States and one international organization, namely the EC-JRC. The meeting started with welcome, opening and introductory remarks by Mr. G. Mank, head of the Physics Section of the Division of Physical & Chemical Sciences within the IAEA Department of Nuclear Sciences & Applications. A welcome address was given by Mr. D. Ridikas, the IAEA Scientific Secretary of this RCM, which was followed by the self introduction of all meeting participants. Mr. M. Bourke (LANL, USA) was nominated as chair person and Mr. R. Martins (IE, EC-JRC) was appointed as *rapporteur* of this meeting. Right after followed a brief presentation by Mr. D. Ridikas (IAEA), on specific objectives of the meeting within the ongoing IAEA project D2.01 on Enhancement of Utilization and Applications of Research Reactors.

3.1. Summaries of individual presentations

The first two days were reserved for the presentation of the individual partners. The presentations covered the three neutron techniques, namely neutron radiography, neutron diffraction and SANS. The summaries of each individual contribution, including a detailed work plan for the 1st year of the CRP, are given in chronological order and can be found in **Annex I**. Copies of all presentations, papers and administrative information were distributed at the end of the meeting to all participants and may be obtained from the Scientific Secretary on request.

3.2. Content and results of discussions

3.2.1. Discussion groups on neutron techniques

The discussions following each of the presentations of the first two days allowed structuring the debates on synergies and potential cooperation. In a first step a tentative collaboration matrix was established to identify links between neutron techniques, partners, and materials/objects of interest to be studied (**see Annex II**). Three discussion groups then gathered in parallel on radiography, diffraction and SANS respectively to collect information among the participants on the available state of the art and needs for further development. Afterwards, the reporting-back to all partners took place. The following resumes the major findings and recommendations:

3.2.1.1. Neutron diffraction

Participants: A. Balagurov, M. Bourke, I. Ionita, R. Martins, P. Mikula, A. Nishimura, J. Santisteban

- The current state of the art for spatially resolved measurements on steady state as well as time of flight instruments is 1 mm^3 with improvements to be expected at new instruments at SNS (USA) and JPARC (Japan) pulsed neutron spallation sources. The instrumental resolutions are from 1 to 4 x 10^{-3}.

- Load frames are available at JINR (20kN), NPI (20 kN), ISIS (50 kN), and LANL (250 kN).

- Combined thermal and mechanical loading is available at JINR (up to 1000ºC) and LANL (77K to 2000K).

- For diffraction instruments the handling of highly textured materials or materials for which the grain size is large compared to the irradiation volume proves difficult. However, Partners at JINR have experience with successful measurements in strongly textured Zr-alloys with focus on microstress characterization.

- It was suggested to perform simultaneous diffraction and SANS studies, e.g. during in-situ experiments.

- It was suggested to apply PDF studies to ODS steels.

- Open question concerned the quantitative activity limits both for shipping and for acceptance at facilities. The perennial difficulty of shipping radioactive samples across national borders was acknowledged to be a major impediment to any potential collaboration.

3.2.1.2. Small Angle Neutron Scattering (SANS)

Participants: J. Teixeira, G. Török, Z. Wu, M. Law

- While there is still some room for the improvement of the instruments the role of the SANS data analysis was seen as an issue with higher priority. The first steps in the data analysis, such as data correction, are well established. However, a large variety of models exist for the further data analysis and interpretation, and the procedures are adapted case by case.

- SANS round robin measurements and data analyses with well defined q-range, specimens from the same family of material, and a common protocol were strongly recommended.

- The development of SANS simulation software is seen of high importance and therefore recommendable.

- SANS measurement with an applied magnetic field are seen as a major need for this CRP. A few such facilities are available at the CRP partners (e.g. a 36 m SANS spectrometer with 1 T external magnetic field is available in BATAN Indonesia)

3.2.1.3. Neutron Radiography

Participants: E. Lehmann, M. Grosse, J. Santisteban, R. Pugliesi, C. Sim, S. Sutiarso

- Five CCD based facilities are available among the partners (PSI, BATAN, KAERI, IPEN and soon CIAE)
- At PSI an energy selection, phase contrast measurements and measurements of radioactive materials are routinely made.
- It was recommended to create a template for a data base collecting information on radiography instrument description, its performance, detectors including sample environment available.
- In view of a possible collaboration with industrial partners the search of each partner on a local level was seen as more promising.
- Materials and phenomena of interest for radiography measurements are nuclear fuels, H-uptake in cladding and pressure tubes, structural materials, and determination of strain and texture. A particular interest exists for such specimens in irradiated conditions.
- The need for well defined calibration and round robin specimens was emphasized

3.2.2. Discussions on specimens and materials

The discussions following the different presentations showed that the interest in specific specimens could be grouped into two main groups:

- Firstly, investigation of well established round robin specimens or the creation of such specimens. Pre-defined measurement protocols should be used in these cases.
- Secondly, the investigation of exploratory specimens to some extent in a round robin fashion, meaning that ideally a specific aspect is investigated following a pre-defined protocol by more than one partner, to allow the comparison of experimental results.

3.2.2.1.Standard round robin specimens

Neutron Diffraction:

The well established VAMAS TWA 20 ring-and-plug strain round robin specimen shall be used by partners who whish to asses the performance of the neutron diffractometer for strain measurements. In addition, a bar, statically bent in an in-situ 4-point bending device, will be available as round robin specimen. This round robin specimen was developed within the IAEA CRP 12020, Development of the Techniques of Residual Stress Measurements in Materials. Details on how to obtain the specimens can be obtained from IE, EC-JRC.

Neutron Radiography:

At KAERI the development of phantoms for resolution, water artifact/contrast, and Gd-artifact are well advanced. In addition, a calibration specimen with known and unknown H_2-content is needed to qualify radiography instruments. On this basis, standard specimens will be developed in collaboration between the partners with an expertise in radiography. This activity ideally is the ground for the development of an ISO standard for neutron radiography phantoms. This activity is coordinated by KAERI.

SANS:

For partners who wish to test and calibrate their new instruments the use of Ag-behenate samples was recommended. This activity is coordinated by SZFKI. For example, SANS BATAN has been calibrated using Ag-behenate and would need inter-laboratory comparison, especially on alloys samples.

3.2.2.2. Exploratory (round robin) specimens

It was agreed to concentrate the material research activities on **nine different topics**, three of which are dealing with ODS steel, two with Zr alloys, and the remaining four on radiography of fuels, residual stress in VVR 440 vessel material, Ni super alloys, and superconducting wires and bulk metallic glasses. With the aim to keep partners and potential partners updated, it was suggested that each coordinator of these nine topics writes a short status report on a quarterly basis, to be sent to the IAEA scientific secretary for further distribution.

The providers of specimens and material for this CRP are explicitly acknowledged for their willingness to share their material with the other participants.

1. Neutron diffraction measurements on thermo-mechanical loaded ODS steel rods:

    - Each of the four facilities equipped with load frames shall receive two specimens. In a first step investigations shall be performed at room temperature with elastic deformation only. In a further step specimens shall be subjected to cyclic load at elevated temperature (up to 1000ºC) up to plastic deformation. Aspects investigated are intergranular strains, residual stress, and peak broadening. A first draft of the protocol is expected for discussion before fall 2010. The measurements carried out are ideally to a large extent complementary. The deformed specimens are then available for SANS measurements to compare as-received and deformed microstructure.

    - The activity is coordinated by M. Bourke, LANL, and specimens will be provided by M.-H. Mathon, CEA. Participating partners are LANL, CEA, NPI, JINR, AEKI, ANSTO, IE.

2. SANS measurements on ODS steels:

    - A first round of measurements shall be performed on well characterized specimens which are already available from CEA and which have already been studied. CEA agreed to make its results available for comparison.

- SANS measurements as a function of distance from the weld line are projected for the ODS friction weld to be investigated by neutron diffraction in activity three below.

- The activity is coordinated and specimens will be provided by M.-H. Mathon/J.Teixeira, CEA. Participating partners are LANL, CEA, CIAE, AEKI, ANSTO, IE, ENEA.

3. Residual stress investigations by neutron diffraction in ODS friction weld:

- Ideally at least one friction weld specimen will be made available through CEA for residual stress investigations using neutron diffraction. The specimens are about 150 mm x 150 mm large with a weld width greater 10 mm. This activity will allow gaining expertise for diffraction measurements in this new class of materials. The specimen material shall be the same as for the thermo-mechanical load experiments in the first activity. A thin comb like specimen will be cut from the weld specimen as stress-free reference.

- The activity is coordinated by R. Martins, IE, and specimens are provided by M.-H. Mathon, CEA. Participating partners are LANL, AEKI, ANSTO, IE, ENEA, BATAN.

4. Investigation of nuclear Fuels by neutron radiography:

- U-Mo high density fuels for RRs, distribution of burnable poisons in fuel material, investigation of burn-up and isotopic vector (e.g. enrichment)

- The activity is coordinated by E. Lehmann, PSI, and specimens are provided by M. Bourke, LANL. Participating partners are PSI, LANL, IPEN, KAERI.

5. Texture in Zr-alloy tubes

- CNEA will provide well known texture specimen to be circulated among the partners. A detailed description of the experimental requirements will be prepared.

- It is expected to move irradiated specimens between partners under the patronage of the IAEA.

- The activity is coordinated and specimens will be provided by J. Santisteban, CNEA. Participating partners are CNEA, ANSTO, IPEN, CIAE, PSI, BATAN.

6. H-uptake in Zr cladding tubes

- Experiments on H-uptake in LOCA conditions are foreseen for June/July. M. Grosse will prepare well defined specimens made from ~20 mm long cladding tube sections for laboratory tests by partners. A protocol for the measurement campaigns will be prepared by M. Grosse.

- The impact of the texture of cladding tubes on the He diffusion will be measured by radiography.

- The activity is coordinated by M. Grosse, KIT, and specimens are provided by J. Santisteban, CNEA, and M. Grosse. Participating partners are KIT, CNEA, PSI, CIAE, LANL, IPEN, KAERI, ANSTO, CEA.

7. Residuals stress and SANS measurements on VVR 440 vessel material:

   - The specimens consist of 15KHMFA Russian type steel (8mm) + XHD18 cladding (2mm) with a size of 150 mm x 100 mm. The residual stress at the interface between wall and cladding shall be investigated. The results serve as validation of already ongoing modelling activities. Irradiated, and non-irradiated specimens will be available together with stress-free reference comb specimens. SZFKI will also perform standard destructive mechanical testing on this material. A measurement protocol will be formulated by SZFKI.

   - The activity is coordinated and specimens are provided by G. Török, SZFKI. Participating partners are AEKI, NPI, ANSTO.

8. SANS investigations of Ni base super alloy 800 NT

   - The activity is coordinated by G. Török, SZFKI and specimens will be provided by I. Ionita, NRI. Participating partners are NRI, AEKI.

9. Superconducting wires and bulk metallic glasses:

   - Bulk metallic glasses are seen as one of the relevant materials for the nuclear sector. The study of nucleation and recrystallization in irradiated and non-irradiated conditions is of main interest here. The activity is coordinated and specimens are provided by T. Shikama (Japan). Participating partners are Japan and USA.

   - Superconducting wires are important for potential applications in fusion reactors and in inspection systems for in-core structures in nuclear power plants. The wires are composed of several thousand filaments of different materials. The average residual stresses between filaments of different materials are of main interest here. Ideally, measurements are also carried out on irradiated wires. The activity is coordinated and specimens are provided by A. Nishimura (Japan). Participating partners are Japan and Romania.

4. SUMMARY OF THE MAIN RECOMMENDATIONS

The meeting was seen by all participants as successful and extremely valuable because of the broad spectrum and high level expertise gathered. The activities in this project will not only strengthen the collaboration between well established institutions but it will also allow partners with recently opened facilities to qualify their instruments and methods through several round robin measurements. The present lack of involvement from the nuclear industry was recognized and several actions are suggested to improve this situation. Possible synergies with the European Network on Neutron Techniques Standardization for Structural Integrity (NeT) were seen as beneficial in this context.

Based on the final discussions **the following specific recommendations were formulated:**

1. **Create a dedicated project web page for the dissemination of information within the CRP partners and also to potential future academic or industrial partners.**

2. **Create with the input from project partners an IAEA TECDOC** on **"Neutron beams for materials research in nuclear energy sector" (tentative title) with the nuclear industry as target group. The 1st draft shall be available until the 2nd RCM.**

3. **Organize a dedicated Consultancy Meeting on the "Role of research reactors for materials research relevant to nuclear fusion".**

4. **Identify potential representatives from the modelling field and industry to join the CRP and/or give advice on relevant experimental data to be stored in a data base for modelling input.**

5. **Assist and facilitate the share and transfer of irradiated specimens across international borders. Encourage at the same time experimenters to use as much as possible locally available samples.**

6. **Encourage participants with new facilities to validate and qualify their instruments through standard round robin measurements. Specimens for SANS instruments, neutron diffraction strain scanning instruments, and neutron radiography are/will be available from SZFKI (Hungary), IE (The Netherlands), and KAERI (Korea) respectively.**

7. **Encourage the establishment of standardized guidelines, reference specimens and phantoms in the field of neutron radiography-tomography.**

8. **Foster the efforts for the creation of standardized SANS techniques, in particular in the area of data analysis and interpretation of results.**

9. **Encourage and support experimental efforts on**

    a. **ODS-steel specimens: Neutron diffraction under thermo-mechanically load, SANS measurements of specimens subjected to various treatments, Residual Stress determination in friction welds.**

b. Radiography-tomography of fuel materials (e.g. UMo high density RR fuel pins).

c. Zr based alloys investigating texture, residual stress, irradiation, diffusion, LOCA, and H-uptake.

d. Residual stress and SANS investigations on cladded VVR 440 vessel materials.

e. SANS investigations of Ni based super alloys 800NT.

f. Residual stress in super conducting wires and nucleation and crystallization in bulk metallic glasses in irradiated and non-irradiated conditions.

10. Encourage and use, when necessary, the techniques complementary to neutron diffraction such as synchrotron X-ray diffraction.

11. Create a concise template based overview of SANS and neutron radiography instruments with instrument parameters and sample environment specifications. The implementation into existing data bases, e.g. http://pathfinder.neutron-eu.net/idb, should be considered.

12. Extend the existing IAEA data bases by including spallation neutron sources and the expected life-time of operational research reactors, both of high interest for neutron beam users.

13. Organize the 2nd RCM outside Vienna in September 2011. Indonesia, China and Hungary were identified as potential hosts.

ANNEX I. SUMMARIES OF INDIVIDUAL CONTRIBUTIONS

1. M.H. Mathon, CEA, France

The introduction was made on the experimental facilities available at the ORPHÉE research reactor of the Laboratoire Léon Brillouin. A large number of dedicated instruments for powder diffraction, single crystal diffraction, texture and strain measurements, SANS instruments, and other spectrometers and reflectometers are available to external users through a proposal system. Materials research relevant to the nuclear energy sector is concentrating on material's validation and optimization, modelling of ageing phenomena, and investigation of the mechanical behaviour, also after irradiation. The materials investigated are ODS materials, ZrNb alloys, and RAFM steels. The CEA has got its own production facilities for ODS alloys.

2. Á. Horváth, KFKI, Hungary and G. Török, SZFKI, Hungary

The safety and the feasibility of the future nuclear reactor concepts and their optimization will depend crucially on the capability of the chosen structural materials to withstand the expected operating conditions under specific thermal-hydraulics conditions. Oxide dispersion strengthened (ODS) ferritic steels are one of the promising materials with a potential to be used at elevated temperatures due to the addition of extremely thermally stable oxide particle dispersion into the ferrite/martensite matrix. The development of this type of steels started in the 80's, however the production of reproducible mechanical properties is still among the main issues.

The paper is summarizing our recent results on preparation, structural and mechanical investigation of oxide dispersed steel (ODS). Nano-yttria dispersed martensitic and austenitic steel compacts have been realized by powder metallurgical methods. An efficient dispersion of nano-oxides was achieved by employing high efficient attrition milling. A combined dry and wet (in ethanol) milling process of fine ceramic and steel particles is proposed. A novel sintering method, Spark Plasma Sintering (SPS) is applied to realize nanostructured steel compacts. Morphology and microstructure of the powder and sintered steels were studied by scanning electron microscope (SEM) and phase compositions were determined by X-ray diffractometer (XRD).

Activities within the project also involve microstructure studies with SANS on the newly developed high strength steels and the investigation of residual stresses in welded structures by neutron diffraction method. Also has been showed the development achieved in last years of residual stress measurements on the Round Robin sample and the bending device test and furnace measurement. We displayed also a SANS and residual stress measurement on the reactor control rod (activated and non activated ones).

In order to follow up the microstructure changes, due to radiation and high temperature the small-angle neutron scattering (SANS) is important to determine precipitate size distributions and volume fractions. Moreover the SANS measurement usually carries a non destructive character, so need not such sample preparation which changes the original form and layout of investigated details.

The advantage of SANS is that information about the size and volume fraction of nanometer-sized precipitates can easily be achieved with statistical significance. In addition, the ratio of magnetic to nuclear scattering intensity from non-magnetic precipitates in a ferromagnetic matrix also provides information about the composition of the precipitates.

3. R. Coppola, ENEA, Italy

The proposed research consists of the microstructural characterization of Oxide Dispersion Strengthened (ODS) Eurofer steel for nuclear applications by means of small-angle neutron scattering (SANS) and neutron diffraction,. SANS results (1) obtained on polycrystalline 9 Cr Eurofer ODS have provided an accurate characterization of the Y_2O_3 particle distribution, in good agreement with transmission electron microscopy (TEM) results. Mechanically alloyed powders of this same material, submitted to annealing up to 1100°C, have also been studied successfully by SANS (2, 3) but in this case additional microstructural information is needed to check the occurrence of other phases such as carbide precipitates: therefore, high resolution neutron diffraction measurements are carried out to investigate the crystallographic phases present in the material (by Rietveld refinement) and to compared the line broadening of the high-angle diffraction with the SANS results. Additional information is expected from the analysis of polarized SANS measurements, which have already been successfully carried out on similar steels (4, 5).

In the first year of the project the experimental activities will concentrate on a selected number of un-irradiated mechanically alloyed Eurofer ODS, optimizing the SANS measurements both experimentally (availability of Q-range, reference sample) and concerning the data analysis yielding the size distributions; the same samples will be investigated by neutron diffraction to clarify the presence of the different metallurgical phases and correlate the line-width with the SANS distributions. The data analysis will be carried out in close interaction with the other partners involved in similar activities, in order to contribute in standardizing the adopted methods. Un-irradiated samples from other partners will possibly be included in the experimental program and the investigated samples will be made available for tests at other facilities. Based on the outcome of this first phase of the research program, the following will be defined in order to apply the same experimental procedure to a systematic microstructural investigation of thermal evolution in Eurofer-ODS, including hopefully the case of some irradiated samples.

References

1) R. Coppola, M. Klimiankou, R. Lindau, R. P. May, M. Valli, Physica B 350 (2004) 545
2) R. Coppola, R. Lindau, R. P. May, A. Möslang, M. Valli, P. Vladimirov, A. Wiedenmann, in print. J. Phys. C (2010)
3) R. Coppola, R. Lindau, A. Möslang, M. Valli, A. Wiedenmann pres. at IAEA-EC Workshop Barcelona, October 2009 and Sub. J. Nucl. Mat.
4) R. Coppola, H. Glättli, M. Valli, Appl. Phys. A 74 (2002) S1055-1057
5) R. Coppola, C. Dewhurst, R. Lindau, R.P. May, A. Möslang, M. Valli, Physica, B 345 (2004) 225

4. A. Balagurov, JINR, Russian Federation

Information about neutron scattering possibilities at the IBR-2 pulsed reactor in Dubna has been presented. The reactor is being refurbished now after more than 25 years successful operation and should be operational again in the beginning of 2011. The main parameters of modernized (practically new) reactor IBR-2M are not changed much in comparison with the IBR-2. This reactor is an original branch of the family of research neutron sources, and its main parameters – total average neutron flux (~10^{13} n/cm^2/s at average power of 2 MW) and pulse width (350 μs) – correspond to parameters of the third generation pulsed neutron sources such as SNS (USA), J-SNS (Japan) and future ESS (Europe).

In FLNP JINR four neutron scattering techniques of condensed matter investigations are successfully employed and developed: diffraction, reflectometry, small-angle and inelastic scattering. A group of diffractometers includes: HRFD – high-resolution Fourier diffractometer, FSD – Fourier stress diffractometer, DN-2 – multi-purpose diffractometer, DN-12 – diffractometer for microsamples, SKAT – spectrometer for quantitative texture analysis, EPSILON – diffractometer for analysis of internal stresses in rocks. The parameters of HRFD, DN-2, DN-12, SKAT and EPSILON can be significantly improved with cold moderators on the IBR-2M. The new reflectometer GRAINS is now under construction at the IBR-2M reactor. The key features of the reflectometer are a vertical scattering plane and simultaneous measurement of specular and off-specular reflection. Small-angle neutron scattering (SANS) investigations at the YuMO spectrometer are among the most successful research activities on the IBR-2 reactor. The construction of an alternative SANS spectrometer for experiments at rather large momentum transfers is under consideration. The parameters of both inelastic scattering spectrometers – NERA and DIN-2 – meet modern standards, but serious modernization is needed to preserve their competitiveness in future.

Extremely good possibilities there exist at the IBR-2 for high-intensity and high-resolution neutron diffraction. In high-intensity mode real-time *in-situ* studies of irreversible processes like solid-phase chemical reactions or structural phase transitions can be performed with temporal resolution at a level of 1 minute or sometimes several seconds. High-intensity, low-background mode is used also for microsamples studies especially at high pressure up to 7 GPa. For high-pressure experiments the sapphire anvil cells, which can be cooled down to 10 K, are used.

For high-resolution diffraction the Fourier reverse TOF correlation technique has been developed at the IBR-2. Two RTOF diffractometers are constructed at the IBR-2: HRFD – High Resolution Fourier Diffractometer and FSD – Fourier Stress Diffractometer. The first is mainly used for structural studies; the second is dedicated to stress analysis in bulk samples.

A. Balagurov explained the main features of the Fourier method: the extremely high resolution in large *d*-spacing range at relatively short flight path, the dependence of TOF-resolution on maximum frequency of intensity modulation, special peak shape, etc. The resolutions of HRFD and HRPD at ISIS are comparable ($\Delta d/d \approx 0.001$), despite only 20 m flight path between chopper and sample at HRFD, instead of 100 m flight pass for HRPD. With so high resolution analysis of macro- and microstresses is possible with high precision, and diffraction peaks width anisotropy can be easily measured.

The new FSD instrument is still under development and has been partially supported in the frame of IAEA Research Contract during 2006-09. At this diffractometer combined geometrical and electronic focusing is used for the detector system. The radial collimators provide spatial resolution (gauge volume) ~2 mm in scattering plane. The completion of detector system is continued, currently already 3x3 detector modules are installed, building up to 2x7. The measured $\Delta d/d$ resolution is equal to 0.002 for backscattering detector and 0.004 for 90 deg. At the FSD instrument 5-axes Huber Goniometer, furnace up to 2000°C, loading machine LM-20 up to 20 kN are available.

FLNP team participates in the IAEA CRP on Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams with IAEA Research Contract "Ferrite-Martensite Steels Dispersion Hardening studied by TOF Neutron Diffraction". The main idea of the project is measuring of microstresses in hardened steels and revealing relation between dispersion-hardening particle size and microstress level. The subject of studies in the frame of this contract is high-strength dual-phase ferrite - martensite steel (soft ferrite matrix containing islands of martensite) with dispersion-hardened phases. As an experimental technique the high-resolution TOF neutron diffraction with high-temperature *in situ* loading will be used.

The work plan for the first year includes selection of steels with various type of disperse particles, sample preparation, calibration of tensile testing machine LM-20, and determination of type and size of dispersion particles using electron microscopy. Preliminary experiments were performed already with three types of steels Fe-12%Cr matrix + V/Mo/Nb carbides (EP-450), V/W/Nb nitrides (EP-900), and EP-450 ODS (oxide dispersion strengthened by Y_2O_3). They showed clearly that high-resolution neutron diffraction can provide high-quality data, which are needed for solution of the problem.

5. T. Shikama, IMR, Japan and A. Nishimura, NIFS, Japan

We propose two materials, metallic glasses (MG), having a homogeneous structure, and superconducting materials (SM), having a composite structure, for the present CRP. The metallic Glasses (MG) have a high potential for their application in nuclear systems due to their excellent properties such as high strength, super plasticity, and high corrosion resistance. The superconducting materials (SM) are composing critical components in the nuclear fusion systems and have a potential application in other nuclear systems, such as non-destructive defects probes in structural steels. Essential properties of the both materials are seriously affected by radiation effects and the neutron beam analyses will be the determinant tools for analyzing radiation induced nano-to-micron structural evolutions and generated localized stresses, which are responsible for the concerned properties changes. Specifically, the study will focus on the radiation induced in-homogeneity in chemical compositions and resultant nucleation and growth of nano-to-micro crystallites in the uniform matrix of MG, and on the nucleation and growth of the small defect clusters in the SM which will have strong interaction with vortex. Also, the generated internal stress along the interfaces between composite components in the SM will be analyzed by the neutron beam analyses.

For a moment, the proposed project will start as a stand-alone initiative with interactive knowledge exchanges with other projects, but in the course of the progress, we are looking forward to establish much stronger collaboration with other groups. In the meantime, we are ready to supply specimens, non-irradiated and irradiated, of the MG and the SM to the groups who have interests in these two materials.

<u>Year 1 work plan</u>:

Developed glassy metals being candidates for the nuclear structural materials will be irradiated in JRR-3 and in JMTR. Stability of glassy structures will be in-situ studied during irradiation by monitoring their electrical conductivity under collaboration with Tohoku University and the JAEA.

Development and selection of superconductive candidate materials lead by NIFS under collaboration with IMR, Tohoku University and industries. Irradiation of superconductive materials in controlled irradiation rig at low temperatures in JMTR. (at present, below 100C. when low temperature irradiation facility is developed, below -190K .) will be carried out.

6. P. Mikula, NPI, Czech Republic

P.Mikula presented instrumentation and know-how capabilities of Nuclear Physics Institute ASCR in Rez how to contribute to fulfill the tasks of CRP project and also suggested the fields where the participation of NPI could be very efficient.

a) Participation on TECDOC in the field of neutron diffraction and high resolution SANS
b) Ex-situ and in-situ structure change studies by powder diffraction
c) Microstructure measurements and studies of precipitates and porosity by high-resolution SANS
d) Ex-situ and in-situ strain/stress measurements of metallic polycrystalline samples around the welds as well as under the thermo-mechanical load.
e) Development of instrumentation and software

Intended collaborative activities:
All: contribution to TECDOC
Italy, Germany, Japan, Argentina: Ex-situ and in-situ structure change studies by powder diffraction
Germany, Italy, France: Microstructure measurements and studies of precipitates and porosity by high-resolution SANS
Italy, Germany, France, Japan: Ex-situ and in-situ strain/stress measurements of metallic polycrystalline samples around the welds as well as under the thermo-mechanical load
Italy, Australia, Indonesia, China: Instrumentation development, software

Action	May–December 2010	January-May 2011	May- 2011
TECDOC	Preparation	Finalization	
Ex-situ and in-situ structure studies Ex-situ and in-situ strain/stress measurements of metallic polycrystalline samples and SANS R&D, software	Discussions with the partners on the samples Discussions with the partners on the samples Design, know how	Test measurements on chosen samples Test measurements on chosen samples Design, know how	Evaluation of the results and dis-cussions on fur-ther steps Evaluation of the results and dis-cussions on fur--ther steps Design, know how

7. R. Martins, IE, EC-JRC, The Netherlands

The Institute for Energy (IE) is organized in seven different units covering a wide range of aspects concerning energy production, storage, and safety. Among these the unit for the "Safety of Future Nuclear Reactors" (SFNR) has an action on "MATerials performance assessmenT for Innovative reactOr systems" (MATTINO). Among the classes of materials of interest are ferritic/martensitic steels, ODS alloys and iron or Ni-based superalloys. The work in MATTINO is organized in topics which are cross cutting in nature such as modelling, prenormative R&D, Materials Data Management, and advanced microstructural characterization methods. The other topics are system specific materials testing activities for three selected Generation IV reactor candidates. The IE has equipment for slow strain rate tensile testing and stress corrosion crack testing in super critical water. For advanced materials analyses IE has a Positron Annihilation Spectroscopy Laboratory, Barkhausen Noise and Seebeck-Thompson Effect measurement equipment and a laboratory X-ray source. At the High Flux Reactor (HFR) the IE is operating two neutron diffraction (ND) instruments for residual stress (RS) analyses and one Small Angle Neutron Scattering (SANS) instrument. With the SANS instrument, operated at a wavelength of 0.475 nm, a q-range from 0.05 to 4 nm^{-1} is accessible. One of the ND instruments is designed for a specimen weight up to 200 kg, with a fixed wavelength of 0.257 nm. The second one has an adjustable wavelength between 0.18 and 0.6 nm and is dedicated for large components with a weight up to 1 t. In addition IE uses high-energy synchrotron radiation diffraction for RS analyses via the usual proposal systems. IE has a strong expertise in spatially resolved RS analyses.

IE proposes to investigate the ferritic ODS alloys MA 956, ODM 751 and PM 2000. IE has enough of this material for its own in house destructive testing, but can only provide small quantities to partners for microstructural analyses.

IE proposes to perform SANS, RS investigations and ND peak width analyses to observe phase separations, precipitation forming, pore evolution due to thermal ageing or thermo-mechanical load. Furthermore, the investigation of RS in welds made from ODS are in the focus of interest. However, IE is not able to provide such welds.

In the first year IE will:

Find suitable collaborators, elaborate a test and materials matrix in collaboration with the partners and perform first SANS measurements, provided that the HFR is starting up again in August, as planned, after the major repair that started in February.

8. I. Ionita, INR, Romania

The main goal of this research project is the study of the aging behavior for the Incoloy 800HT and 304-L alloy standing a heat treatment trial at high temperatures. The second goal of this project is to put in operation the Q-focusing neutron diffractometer installed at the TRIGA INR PITESTI reactor and to develop the computing instruments allowing the design and optimization of a certain configuration and the experimental data processing in the case of Q-space focusing configurations. More precise it is aiming:

- to realize a Rietveld program taking account for the significant peculiarities of the focusing geometry to allow a correct processing of the diffraction diagrams
- to develop computational instruments to evaluate the instrumental properties and to optimize the instruments configurations

Incoloy 800 HT is a nickel based alloy with excellent corrosion resistance in water at high temperatures. The good mechanical properties of Incoloy 800 combined with its resistance to high temperature corrosion make this alloy exceptionally useful for many applications involving long term exposure to elevated temperature and corrosive atmosphere.
This alloy is widely used in various types of heat treating furnaces, in power generation for steam generators tubing and high temperature heat exchangers in gas cooled nuclear reactors. Recently, this alloy starts to be studied as candidate material for fuel cladding in GEN IV reactors like supercritical water reactors (SCWR).
304 L alloy is an austenitic stainless steel with high ductility, low yield stress and relatively high ultimate tensile strength. This material has good corrosion resistance and is widely used in nuclear power plants.

These alloys were tested in water at different temperatures above thermodynamic supercritical water point (374^{0}C). Our concern is intent to establish the aging behavior of these alloys tested at high temperatures.

During the last years many attempts were done to improve the neutron crystal diffractometers performances by using bent crystals, flexible configurations or detectors with larger vertical coverage. The flexible configurations, the bent focusing monochromators or the special designed detecting systems are quite common in present.

A new approach has been developed in our institute aiming to use the focusing in the phase space rather than the spatial focusing at sample, detector or anywhere else. Such a configuration has been realized in our institute and this configuration proves to be a really high-resolution one.
Two decades ago a comprehensive program was started aiming to use new techniques to get better performances in crystal neutron diffractometry. This program was partially supported by IAEA Vienna through the contracts 4941, 4941RB, 3496 R1, 3496 R1/RB. A new concept of high resolution focusing configuration, aiming to use the focusing effects in the phase-space rather than the spatial focusing at sample or anywhere else, was developed offering very promising opportunities in the research centers where only medium flux neutron sources are available.

The main characteristics of these focusing configurations are the use of the bent perfect crystals in asymmetric reflection as monochromators, the absence of the Soller collimators, a take-off angle either under 90^0 or greater than 120^0 and the rotation of the plate-like sample during the diffraction pattern raise in order to fulfill the focusing conditions. The perfect crystal is bent pneumatically but it could be promising to have different horizontal and vertical radii of curvature and therefore to use an alternative way of bending, as happens in the case of Missouri group.

Further improvements have been obtained through a program partially supported by IAEA Vienna, contract 10516/RO, involving a complete theoretical description of the line shifts appearing in focusing configurations, a proper description of the reflectivity properties and of the surface shape for pneumatically bent crystals. First applications using this configuration were performed including first attempts in realizing stress determinations.

During the last three years, with partial support of IAEA Vienna through the contract (13579/RBF) this Q-space focusing instrument was modified to be suited for stress determinations.

Unfortunately due to the prolonged period of reactor upgrading stress determinations could not be realized. In present the reactor is in final testing and will be again operational in the first part of 2010. Therefore the existing two instrument using the TRIGA radial channel neutron beam, the Q-space focusing neutron diffractometer and the SANS instrument will be again operational.

A SANS facility with a rather simple configuration is installed at the radial channel of the TRIGA PITESTI steady state reactor. This instrument was realized under the assistance of JINR DUBNA. We are planning to realize both diffraction measurements at our Q-space focusing neutron diffractometer and SANS determinations on the Incoloy 800HT and 304 L alloy samples.; the SANS measurements are planned to be repeated at the instrument existing at JINR DUBNA.

A special department devoted with material properties investigations exist in our institute. Among other kind of materials, of particular interest in nuclear field, are 800 HT and 304 L alloys.

For the first year we intend to:

- to prepare the Incoloy 800 HT and 304 L alloy samples to be measured at neutron diffractometer and SANS instrument
- to put in operation the Q-focusing neutron diffractometer and the SANS instrument both installed at the TRIGA INR PITESTI reactor
- to evaluate, theoretically and experimentally, the scatering angle value range, for which the sample orientated properly for a certain scattering angle value, still gives good resolution
- to evaluate experimentally the instrumental performances of the neutron diffractometer

9. M. Bourke, LANL, USA and **D. Brown, LANL, USA**

Small angle neutron scattering (SANS), high resolution and high intensity neutron diffraction (ND) studies of a range of nuclear materials are being used to perform fundamental studies and to validate numerical results. The neutron scattering measurements are closely complemented by conventional materials characterization in glove boxes and hot cells and are also complemented by measurements using high energy synchrotron X-rays.

The SANS studies are intended to provide fundamental insights into the radiation stability of oxide dispersion strengthened steels.

The ND phase stability studies will inform engineers about appropriate HIPPING conditions for prototype fuel types.

The residual stress measurements on the repair welds are part of a concerted effort relating to life extension programmes.

The in situ loading measurements are part of a modeling effort that will inform and calibrate lifetime and operation margin predictions for CANDU reactors.

All activity here is subject to peer review and neutron beam time is allocated as a result of competitive proposals.

Year 1 workplan

1 Perform neutron diffraction residual stress measurements on a dissimilar material (stainless steel – nickel V groove weld 15mm thick. Sectioning will be performed to determine d-0 variations and contour measurements will also be performed. Sample is provided by NRC

2 Perform neutron diffraction measurements on a repair weld removed from the St Lucie reactor. This is also a dissimilar metal weld – but the component thickness is in excess of 30mm and will require slotting to allow neutron beam access to the weld area.

3 SANS and diffraction measurements on a nanostructured alloy 14YWT. The study will assess microstructural stability following HIPPING and or hot extrusion. A comprehensive range of mechanical property measurements will also be performed

4 Round robin collaboration on ODS steels provided by CEA - TBD

Year 2 workplan

1 Perform neutron tomography measurements on a surrogate fuel urania fuel pellet at PSI

2 TBD

10. J. Santisteban, CNEA, Argentina

Argentina (CNEA) is developing a new rolling process for Zr2.5%Nb pressure tubes, aimed to be used in the refurbishment of its CANDU nuclear power station at Embalse. As part of this development, we will study the spatial distribution and evolution of residual stresses and texture for tubes subjected to different levels of rolling reduction and annealing times (autoclaving).

The tasks proposed for the first year are:

- Production of tubes with different levels of cold rolling.
- Machining and microscopic characterization of small specimens: extruded, cold rolled 27%, cold rolled 37%.
- Exploration of imaging texture variations by energy resolved neutron radiography to be performed at PSI (Switzerland).
- Development of a prototype time-focussed neutron detection bank, aimed at studying intergranular stresses in Argentina.

Predicted activities for the second year include:

- Neutron diffraction experiments to characterize texture of α-Zr and β-Zr phases (abroad).
- In-situ neutron diffraction experiments at 400^{o}C over ~36 hrs, in order to study the thermal evolution of those phases (abroad).

11. S. Sutiarso, BATAN, Indonesia

The Multi Purpose Reactor (RSG) G.A.Siwabessy is the 30 MW research reactor. It is sited at Serpong Nuclear Technique Research Center, 30 km soutwest of Jakarta. The reactor and its facilities are owned and operated by the National Nuclear Energy Agency - Indonesia (BATAN). The neutron scattering laboratory is equipped with residual stress measurement (RSM) diffractometer, four circle diffractometer/texture diffractometer (FCD/TD), triple axis spectrometer (TAS), neutron radiography facility (NRF), small angle neutron scattering (SANS) spectrometer, high resolution small angle neutron scattering (HRSANS) spectrometer and high resolution powder diffractometer (HRPD). The first four instruments were installed in the reactor experimental hall (XHR) while the last three are located in neutron guide hall (NGH). Those two halls are connected by a tunnel accommodating two neutron guides.

The instruments associated with the CRP project are NRF, RSM diffractometer and FCD.TD. Some activities have been carried out using neutron radiografi such as estimation of nugget size of spot welding on two different type of steel using gadolinium oxide solution and preliminary neutron tomography setup using the NRF. Meanwhile the on going experiment is a measurement of water transport and root growth in rice plants using imaging technique in collaboration with biology department of Bogor Agriculture university. The activities related with the residual stress measurements were measurement of welded railway and SUS304 steel and some on going experiments is residual stress evaluation on plastically deformed low carbon steel and residual stress evaluation on Cu bicrystal in collaboration with Prof. Hanabusha from Tokushima University of Japan. The on going activities using texture diffractometer is measurement of texture on aluminium alloys (3104, 6060, 7075) and zircalloy.

The proposed 1st year project is mainly on the optimization of characterization techniques using these three instruments which include the Round Robin experiments on residual stress measurement using VAMAS sample, texture standard samples and neutron radiography. In addition, some assistance from the group is requested on the design and construction of radial collimator for RSM diffractometer, design and construction of vertical focusing monochromator and the use of gadolinium oxide for improving contrast in neutron radiography image of welding samples. The 2nd and 3rd years we propose of using the three instruments to measure weld samples of the steel and zirconium alloys.

12. Z. Wu, CIAE, China

Neutron Scattering Laboratory of China Institute of Atomic Energy will focus it work at the first year of the CRP mainly on the instrumentation owing to the expected low reactor (CARR) power and unready neutron instruments. There are small angle neutron spectrometer (SANS), neutron residual stress diffractometer and neutron texture diffractometer already existing besides CARR and the neutron radiography under design. All the instruments will take the time from the critical to steady running of CARR to align the beam line, do the trouble shooting and change or upgrading instrument components to reach better situation for CRP study. And the potential neutron users in nuclear energy sector in China will be held on together or the neutron instrument responsible will go to the nuclear energy sector materials producers to discuss the opportunity to get neutrons involved in the materials research.

For the residual stress diffractometer, the first stage is to get it running with present components. And then during the reactor pause period, one dimensional position sensitive detector will be implemented to get better instrument efficiency. Meanwhile double focusing silicon monochromator system will be developed for the residual stress diffractometer.

The neutron texture diffractometer will be changed or upgraded from the just relocated four circle diffractometer relocated from Forschungzemtrun Juelich, Germany. The main task is to implement new controlling software to achieve texture measurement and form suitable data format to agree with the analysis software.

Efforts on SANS will be alignment of optical system, combined test for the mechanical, electronical system, controlling and data acquiring system, increasing signal to noise ratio and the intensity at sample position. Special sample table with good shielding and remote controlling system will be designed for the measurement for activated materials.

The instrument design will start and neutron optics will be modified to manipulate intensity and resolution for specific application. And instrument shielding will be calculated to get reliable shielding and better signal to noise ratio. Advanced In-IP or Dy-IP neutron image plate will be developed for the activated materials research.

Discussion between CARR neutron instrument responsible and nuclear energy sector materials producers will start to better understand features of materials and supply more information for the modification of materials fabrication.

Note:

CARR will announce the accessible of every neutron instrument to the CRP members and welcome every partner to be CARR user. In this respect CARR would be happy to join your research on non-irradiated samples (ODS, Zr-alloy, etc).

Round Robin experiments are also very welcomed to evaluate instrument features, improve instrumentation and standardization of neutron analysis methods.

13. E. Lehmann, PSI, Switzerland

PSI will make available its neutron imaging facilities for non-invasive inspection of nuclear materials (fuel, cladding, steel from structures, irradiated test samples). The inactive option has a flexible setup, where objects can be scanned with a field of view (FOV) from 3 cm to 40 cm, where the spatial resolution can be varied over the range between 10 to 300 micro-meters accordingly.

In the case of activated samples, where the handling has to be done in a shielded environment, a special imaging procedure is needed with an inherent resolution of 50 micro-meters.

The PSI in-house research activities are focused onto the study of highly activated samples from the targets of the spallation source SINQ, mainly lead rods in Zr cladding. Furthermore, hydrated samples of cladding materials are under investigation (in collaboration with the FZ Karlsruhe). Recently, a new method was found to characterize the cooling characteristics of steel welds from pressure vessels by means of energy selective neutron imaging.

The methods at PSI and its facilities can be used within collaborations between the partners contributing to the CRP – F12023

PSI’s neutron spallation neutron source is operated by the bombardment of high energy protons onto a lead target. Because this neutron source is in the 1 MW class and world-leading therefore, the applied proton and neutron dose onto the target material is extremely high and will induce material modification or even damages. After the initial use of Zircaloy as target material the present material combination is a cladding (tubes with 10.8 mm outer diameter) with Zircaloy surrounding the lead rods. These rods (about 500 in total) are arranged perpendicular to the proton beam direction in a hexagonal grid structure where the coolant (heavy water) can flow thru.

It is an important task for neutron imaging to inspect the target rods after its exposure over about two years, where a proton current of up to 10 Ah is accumulated by the target material. The outcome of such inspection is a guideline in respect to the material limits and the operation time of the targets. As the target is an investment in the order of 100.000 $ each, a prolongation of the target life time is highly relevant.

In detail, the amount of absorbed and accumulated hydrogen in the rod cladding is of interest. It is well known that hydrogen in the Zircaloy structure leads to higher amounts of embrittlement with the risk of cracking. Because the lead filling of the rods is melting during high-flux conditions, a broken cladding might have the leak of active inventory as the consequence. This has to be avoided in any case during SINQ operation.

Another aspect is the search for the spallation product accumulation in the lead matrix in a quantitative way. The amount of spallation products like Hg, Ag, Au and others will initiate a higher attenuation contrast in the transmission images. The local distribution and the amount (in comparison to an initial pure lead sample) of absorbing material will give a feedback about the exposure history of the target.

For these investigations we will use a special setup (NEURAP) within the NEUTRA facility at SINQ, enabling the handling of the highly activated samples within the neutron beam. Due to the high gamma dose level of the samples it is impossible to use standard imaging devices like film, scintillators or semi-conductors. The only possible solution has been found in a transfer technique, where the neutron induced activation of Dy is used to stimulate signals within a special imaging plate. This technique can also be used to derive 3-dimensional information about the samples, when several projections in different directions are taken and the volume data are reconstructed with suitable software tools.

The results of this study will be made available for a broad community, interested in irradiation damage studies. These data can certainly inter- or extrapolated to other irradiation tests for comparison.

The proposed research project is of high importance not only for the spallation neutron sources but also for the Accelerator Driven Systems, dedicated both for energy generation as well as for nuclear waste incineration.

14. M. Grosse, KIT, Germany

Neutron radiography is a powerful tool to determine hydrogen concentrations in zirconium base alloys on a quantitative, non-destructive and fast manner with a spatial resolution up to about 25 µm. The fast and non-destructive character of the method provides the possibility of in-situ investigations of processes like hydrogen uptake during steam oxidation or diffusion of hydrogen into zirconium specimens. For these in-situ investigations the INRRO facility was constructed which has two windows transparent for neutrons. The atmosphere in this furnace system is well defined by Bronkhorst gas and mass flow controllers, gas mixer and evaporator.

The ex-situ measurements were calibrated by means of cladding tube segments loaded with a certain amount of hydrogen determined by measurement of the mass gain. On a comparable manner also the effect of oxide scale was determined. Because hydrogen is very volatile at high temperatures, the calibration of the in-situ measurements is not possible in this way. The calibration was done by using chemical equilibrium conditions between gas phase and zirconium alloys. The calibration of the effect of the oxygen uptake under in-situ conditions is not yet finished.

In the presentation examples of ex-situ investigations (post-test examinations at specimens withdrawn from large scale QUENCH tests and specimens from laboratory scale separate-effect tests) and first in-situ measurements (diffusion of hydrogen into Zry-4, hydrogen uptake during steam oxidation) were given.

KIT plans to contribute to the CRP by:

- Offering access to the INRRO facility by cooperation
- Post-test examinations of the hydrogen distribution in zirconium claddings after LOCA tests (ex-situ)
- Influence of mechanical deformation on the hydrogen uptake of zirconium alloys (ex-situ and in-situ)

15. C.M. Sim, KAERI, Republic of Korea

1. Neutron Tomography standardisation document: -Source type, -Detection system, -Manipulation system, Computer system, Image Reconstruction Software, Image display: LUT, Operator Interface and so on.

-1st year: Propose the agenda of Neutron Tomography standardisation on ISNR board meeting (3, OCT. 2010, South Africa) and organize international members

-2nd year: Outline on Neutron tomography document

-3rd year: Draft (version_0) on Guidelines for Neutron Tomography Standardisation

2. Round Robin, provision of samples/phantoms

a) Phantom for Digital Neutron Image Beam Quality

In order to measure the scattered neutron and low gamma energy and high energy, the test phantom of ASTM E-545-91 are redesigned for digital neutron image.

b) Phantom for Performance Measurements on NCT

NCT examination system performance parameters must be determined and monitored regularly to ensure consistent results. NCT performance measurement on NCT system terms of flaw detection is considered in terms of resolution, contrast sensitivity and artifacts.

-First half year of 1st year: Designed by KAERI, reviewed by PSI and Brazil, redesigned/ fabricated by KAERI

-Second half year of 1st year: Round robin test at PSI, Brazil, Indonesia

3. Tomography on Zr with Hydrogen content and Gd(4%-6%) on UMo fuels: Gd(1%)

-1st year: Tomography measurement on Calibration samples Zr + H, Gd(4%-6%) in Al matrix and discussion on the possible way of neutron image experiment on Hydrogen uptake during LOCA and detection of DHC (Delayed hydride cracking) with KAERI colleague

16. R. Pugliesi, IPEN, Brazil

Neutron imaging Since the theme of the present project is on Neutron Tomography, I firstly talked about Neutron imaging, emphasizing the importance to use neutrons as penetrating radiation and, describing the typical parts of a neutron imaging facility. Furthermore and since the most traditional neutron imaging technique is the neutron radiography a description of how to obtain a neutron radiography was also given. A brief description of the Neutron Imaging activities at IPEN-CNEN/SP (1992 - 2007), highlighting the imaging techniques developed as well as examples of some images obtained were also presented.

Neutron tomography. The neutron tomography facility of IPEN is being installed in the beam-hole 08 of the 5 MW IEA-R1 nuclear research reactor(project FAPESP 09 50261-0). Basically it consists of a neutron divergent collimator having bismuth filters to minimize gamma radiation in the image formation. The neutron flux at the irradiation position is $1x10^6 ns^{-1}cm^{-2}$. The facility posses an external shielding manufactured by a boron - paraffin mixture. The sample to be irradiated is positioned in an automated rotating table and the neutron transmitted intensity impinges a LiF (18cm x 24cm) scintillator generating an image or tomo, which is captured by a cooled CCD video camera and, stored in a computer. In order to minimize damages in the CCD a mirror reflects the light to the camera, which is positioned 45° with respect to the neutron beam and is installed inside a (30cm x 15cm x 15cm) borated poly box. The scintillator the mirror and the camera are installed inside an aluminum (100cm x 20cm x 20cm) light tight box to prevent external light contribution to the image formation. An electronic – mechanical interface rotates the sample a small angular step, typically 0.9^o and, a new tomo is captured. A set of 400 tomos is stored in the computer which, besides control the rotating table, camera and image capture, also performs through the softwares Octopus and VG Studio the image reconstruction and the visualization in 3D of the internal parts of the sample respectively. The figures 1 and 2 show the schematic diagram and some details of the tomography facility: rotating table, scintillator and the light tight box positioned in the irradiation position.

Among the activities of the working group, presently we are learning about Octopus and VG Studio, conducting tests regarding the automated system for sample positioning as well as manufacturing standard samples to verify the characteristics of the facility. As potential future developments, applications of neutron tomography to inspect samples from several scientific fields such as archeology, medicine, nuclear engineering, aerospace technology, Indian Brazilian culture are the most promising.

The proposed project intends to design and install in the neutron tomography facility of IPEN-CNEN/SP a new neutron collimator and improve its external shielding. The main objectives of such propositions are to improve image quality, reduce the overall time to obtain a 3-D as well as to make easier and safer the sample irradiation and sample changing respectively.

The work plan for the first year of the project includes the designing, construction and installing of the new collimator to provide a parallel neutron beam. It consists of an external aluminum tube inside which another aluminum tube is fixed in a concentric position. The volume between the tubes will be filled with concrete or borated paraffin or borated poly and the external wall of the inner tube will be coated with cadmium probably. The dimensions of the collimator will be length 150cm, external diameter 15cm and it will provide a neutron beam with 10cm in diameter. The neutron beam-stopper will be a water column, inside the inner aluminum tube, and will operate according the following procedure: for non irradiation condition the tube will be filled with water and for the irradiation condition emptied. According to the previous experiments, 150cm of water are enough to assure a negligible neutron dose rate and hence a safe sample manipulation inside the shielding. As mentioned above, the images will be reconstructed by using the software Octopus. Because of the mathematics involved in the image reconstruction, if the neutron collimator provides a divergent beam (the present one) it is necessary to obtain images between 0 and 360^o to reconstruct the image. But if the collimator provides a parallel beam (the proposed one), only images between 0 and 180^o are required (see figure 3). This will reduce the capture time, in principle, from 4000 to 2000s. The plan also includes an improvement of the external shielding of the facility by using borated poly sheets in replacement of the boron + paraffin mixture of walls and roof (see figure 4).

Finally, in the case of the mentioned plan be performed the measurements to be carried out are: evaluation of the neutron flux at the sample irradiation position provided by the new collimator, comparison of 3D images of standard samples obtained by using the two types of collimators.
With respect to collaboration with other partners we believe that the modeling of this new collimator to test some types of materials in its wall, as well as a comparison of neutron tomography results between partners will be very useful for both. Although the project´s main theme be tomography, it is worth mentioning that the track-etch foil imaging technique is available in IPEN and it is very useful to inspect radioactive materials since it is insensitive to gamma radiation.

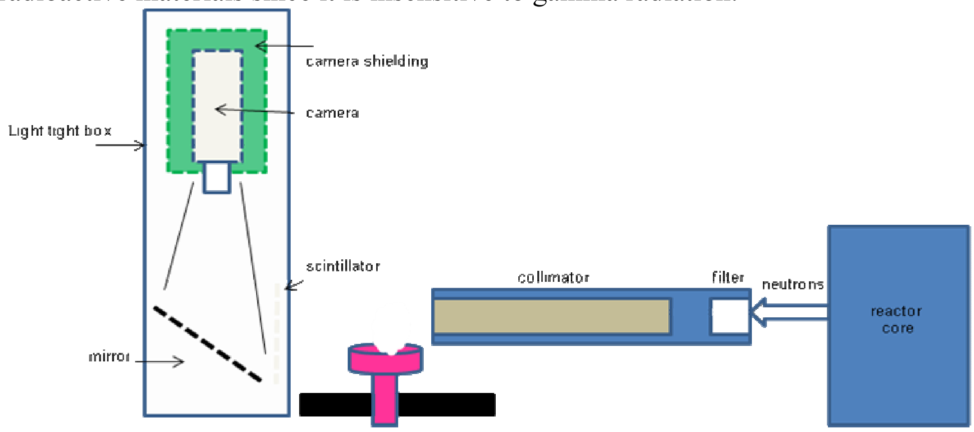

Fig.1. Schematic diagram of the tomography facility

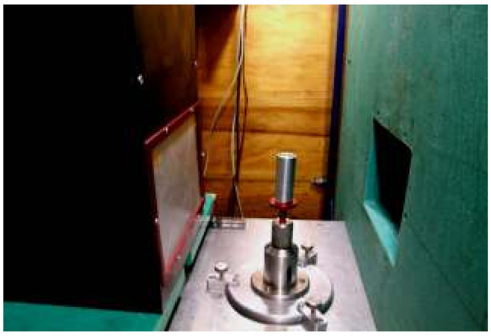
Fig.2. Some details of the of the tomography facility

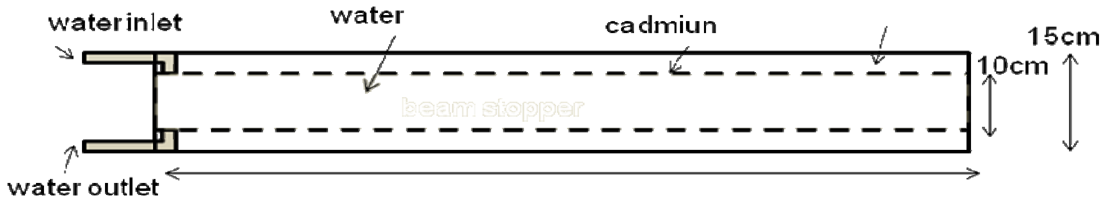

Fig.3. Schematic diagram of the proposed collimator

Fig.4. Improvements in the shielding

Collaboration/Participation with other countries. The technical discussions among the participants of the meeting have resulted in some important topics regarding the collaboration between countries to the development of the neutron imaging techniques. Among the suggested topics those ones very important to the development of our CRP and our tomography facility include: round robin measurements by using standard samples to compare the performance of tomography facilities as well as performing measurements according to established protocols. The main provider of these standard samples and of the design of simple standard samples will be Korea. The other countries involved in such matter, including Brazil, are Indonesia, Australia and Switzerland. Other very important aspects regarding the development of neutron imaging systems will be the creation of a data base for consulting in which each researcher will provide information about its facility, irradiation protocol, obtained results by imaging standard samples for example, contrast, spatial resolution, modulation transfer function-MTF, etc.

In terms of collaboration of Brazil to other countries, in the present, my institute, the IPEN-CNEN/SP, can offer two neutron imaging techniques for sample investigation. The first one makes use of solid state nuclear track detectors – SSNTD. Its main characteristic is the ability to provide images of high radioactive samples. The second technique is the Neutron Induced Radiation Radiography – NIRR which is especially adequate to inspect very thin samples on the order of tens of microns.

17. M. Law, ANSTO, Australia

Reactor: 20 MW research reactor OPAL.

Instrument	Experience level	Validation/round robin	R & D	Planned experiments (and number)
Kowari - strain scanner	Medium-2 years residual stress and texture measurements. Deeveloped methods of calculating effect of cuttting samples on measured stressb	Have participated in VAMAS, NeT, NRC round robins	Investigate measurement of radioactive samples	1 ODS HT sample 3 ODS FRS weld 7 Clad reactor sample 5 ZR RS texture
Quokka - SANS	Medium-2 years non-metallic measurements	Planned round robin on SANS samples (CAE)	Measurement and analysis of metallic samples	2 ODS round robin (CAE, Hungary) 3 ODS FRS weld 1 ODS HT samples
Dingo – radiography	Low-planning, construction in 3 years		Input from other facilities	ZR hydrides (ANSTO sample)

<u>Year 1</u>:

- Investigate the experience of other facilities in the examination of active materials.
- Design flasks for moving samples and for measurement on neutron instruments
- Design neutron radiography facility (Dingo) for OPAL
- Round robin ODS samples on Quokka (SANS)
- D-zero estimation, comparison of measured sample and d-zero samples
- D-zero estimation, comparison of slab and coupon d-zero samples
- Dissimilar metal welds

ANNEX II. COLLABORATION MATRIX OF COMMON INTERESTS

R&D/Materials/Objects	Neutron Imaging	Neutron Diffraction	SANS
Contribution to the IAEA TECDOC on "Neutron beams for materials research in nuclear energy sector"	Switzerland, Korea, Japan, Germany	USA, Netherlands, Italy, Czech, Argentina, Hungary, China, Japan, France, Russia, Romania, Indonesia	Italy, Czech, Hungary, China, Japan, France
R&D on instrumentation, hardware and software	China, Brazil, Indonesia, Australia, Switzerland, Korea	China, Romania, Indonesia, Italy, France, Hungary, Czech, Argentina,	China, Indonesia, Italy, France, Hungary, Czech, Australia
Round Robin measurements: done in 2 stages a) facility performance/qualification b) more exploratory (e.g. ODS welded sample)	Korea, Brazil, Indonesia, Australia	Netherlands, Russia, Hungary, Romania, China, Indonesia, Czech, USA, Italy, France	Hungary, China, Romania, USA, Netherlands, Italy, Australia, France
ODS steels	Switzerland	France, Hungary, Italy, Russia, Netherlands, USA, Czech	France, Hungary, Italy, Russia, Netherlands, USA, Czech
Ferritic-martensitic steels **Fe-12%Cr matrix +** **V/Mo/Nb carbides (EP-450), Fe14%Cr1W Alloy, Fe-12% Cr matrix +V/W/Nb nitrides (EP-900)**		France, Russia, Germany, Netherlands, Hungary, Czech	France, Germany, Italy, Netherlands, Hungary
ZrNb, other Zr Alloys, Zr-2.5Nb pressure tubes	Germany, Argentina, Australia, Switzerland,	France, Germany, Argentina, Australia, Russia, USA, Czech	France, Germany
Metallic glasses (Zr55Ni5Al10Cu30)		Japan, USA	Italy

Superconductive materials **(NbTi, Nb3Sn, Nb3Al)**		Japan, Romania	
Reactor Pressure Vessel/Material		Czech, Hungary, Russia	Czech, Hungary
ZrO2 coatings (turbines)			Czech
304-L alloy		Romania	Romania
Ni base superalloy, 800 HT		Czech, Romania, Germany	Czech, Romania, Germany
Irradiated materials	Switzerland, Brazil, Australia	France, Hungary, Japan, USA, Australia, Czech, Argentina	France, Hungary, Japan, USA, Australia, Italy
Fuel pins	USA, Switzerland	USA	
Fuel cladding & pressure tubes	Germany, Switzerland, Argentina	Argentina	
UMo fuels	Korea	USA, France, Argentina	USA, France
Welds	Switzerland, Indonesia, Argentina	Czech, USA, Indonesia, Australia, Netherlands, Hungary	USA, Australia, Nerherlands, Hungary
Spallation target materials	Switzerland	Hungary	Hungary, Italy

ANNEX III. EXPRESS OF MAJOR INTERESTS PER PARTICIPANT

USA:

- TECDOC
- Fuels and related materials

Netherlands:

- TECDOC
- Round Robin
- ODS as materials and other techniques for characterization

Italy:

- TECDOC
- Combination of diffraction and SANS
- Interest/support of imaging

Indonesia:

- Round Robin (VAMAS + texture sample + radiography)
- Assistance in collimator design/optimization for diffraction beam line
- Assistance in design/optimization of vertical focussing monochromator

Russia:

- Steels, study of microstructure
- Provision of high resolution diffraction

Hungary:

- ODS Steels, exchange of samples
- SANS and diffraction, qualification/conventional complimentary measurements
- Irradiated materials

Switzerland:

- TECDOC
- New materials to be tried with imaging (e.g. ODS), linkage to diffraction through energy selected imaging
- Training in neutron imaging

Japan:

- TECDOC
- Irradiated materials: superconducting materials and metallic glasses, provision of samples
- Extend measurements to all 3 neutron techniques

Korea:

- Tomography standardisation document
- Round Robin, provision of samples/phantoms
- UMo fuels

Brazil:

- Tomography standardisation, Round Robin, protocols
- Imaging of thin samples
- Imaging samples with relevance to the nuclear energy sector

Australia:

- Imaging development and standardisation
- SANS Round Robin
- Irradiated sample analysis
- Waste storage matrix forms/rock samples

Germany:

- Reactor Core materials, Zr Alloys
- Hydrogen uptake studies during the accidents, 2nd phase precipitation during the process
- All 3 techniques needed/suggested

Czech Republic:

- TECDOC
- Steels, microstructure and strain studies
- SANS, porosity and precipitation studies
- Collaboration on other samples/phenomena, offer of beam time

Argentina:

- Studies of Zr Alloy tubes through texture and strain analysis
- Request for beam time at other facilities
- All 3 techniques needed/suggested, energy selecting imaging in particular

Romania:

- Round Robin for diffraction and SANS
- Diffraction on other samples (superconducting materials) to qualify the instrument
- Share of experience in Q-space focusing neutron diffraction

China:

- Residual stress and texture, qualification, diffraction Round Robin protocols
- SANS qualification only without cold neutron source at the moment
- Experience in imaging and instrumentation, assistance from the partners

ALL were interested in exchange of:

- Know-how
- Samples
- Results
- Scientists

ANNEX IV. LIST OF PARTICIPANTS

1st Research Coordinated Meeting (RCM) related to
the IAEA CRP on Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams
31 May - 4 June 2010
VIC F0811, IAEA, Vienna, Austria
IAEA CRP F1.20.23, Id 1575

Country	RC	Title of project	Contact information of Chief Scientific Investigator	Contact information of the Meeting Participants
Argentina	RC1	Evolution of Phases, Inter-granular Stresses and Texture in Cold Rolled Zr-2.5Nb Pressure Tubes	**SANTISTEBAN Javier (M)** Comisión Nacional de Energía Atómica (CNEA); Centro Atómico Bariloche Avenida Exequiel Bustillo 9500 Casilla de Correo 138 R8402AGP BARILOCHE, Pcia. de Río Negro ARGENTINA Tel. +54-2944-44 5154/5165 j.r.santisteban@cab.cnea.gov.ar	**SANTISTEBAN Javier (M)** Comisión Nacional de Energía Atómica (CNEA); Centro Atómico Bariloche Avenida Exequiel Bustillo 9500 Casilla de Correo 138 R8402AGP BARILOCHE, Pcia. de Río Negro ARGENTINA Tel. +54-2944-44 5154/5165 j.r.santisteban@cab.cnea.gov.ar
Brazil	RC2	Improvement of a Neutron Tomography System	**PUGLIESI Reynaldo (M)** Comissão Nacional de Energia Nuclear (CNEN); Instituto de Pesquisas Energeticas e Nucleares (IPEN); Centro d Reator de Pesquisas Travessa R 400, Caixa Postal 11.049 05422-970 SÃO PAULO, S.P., BRAZIL pugliesi@ipen.br	**PUGLIESI Reynaldo (M)** Comissão Nacional de Energia Nuclear (CNEN); Instituto de Pesquisas Energeticas e Nucleares (IPEN); Centro d Reator de Pesquisas Travessa R 400, Caixa Postal 11.049 05422-970 SÃO PAULO, S.P., BRAZIL pugliesi@ipen.br
China	RC3	Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams in China	**LIU Yuntao (M)** Neutron Scattering Laboratory China Institute of Atomic Energy (CIAE) P.O. Box 275(30) 102413 BEIJING, CHINA ytliu@ciae.ac.cn & zhanhua@ciae.ac.cn	**WU Zhanhua (M)** Neutron Scattering Laboratory China Institute of Atomic Energy (CIAE) P. O. Box 275(30) 102413 Beijing, China Tel: +86-10-69358771, Cell: +86-13811290909 zhanhua@ciae.ac.cn
Czech Rep.	RC4	Development and optimization of high-resolution neutron scattering instruments dedicated to characterization and testing of materials of relevance to nuclear energy sector and related experiments in SANS, residual strain/stress and texture studies	**VRANA Miroslav (M)** Academy of Sciences of the Czech Republic (ASCR); Nuclear Physics Institute (NPI); Department of Neutron Physics Husinec-Rez, cp.130 250 68 REZ, CZECH REPUBLIC vrana@ujf.cas.cz & mikula@ujf.cas.cz	**MIKULA Pavol (M)** Academy of Sciences of the Czech Republic (ASCR); Nuclear Physics Institute (NPI); Department of Neutron Physics Husinec-Rez, cp.130 250 68 REZ, CZECH REPUBLIC mikula@ujf.cas.cz

Hungary	RC5	Microstructural Investigation of ODS Ferritic Steels	**HORVATH Akos (M)** Hungarian Academy of Sciences; Central Research Institute for Physics; KFKI Atomic Energy Research Institute (AEKI) Konkoly Thege Miklós út 29-33 P.O. Box 49, 1525 BUDAPEST, HUNGARY Tel.: +36 1 392 2296 Akos.Horvath@aeki.kfki.hu & torok@szfki.hu	**TOROK Gyula** (M) Research Institute for Solid, State Physics and Optics P.O. Box 49, 1525 Budapest HUNGARY Tel.: +36 13922501 torok@szfki.hu **HORVATH Akos (M)** Hungarian Academy of Sciences; Central Research Institute for Physics; KFKI Atomic Energy Research Institute (AEKI) Konkoly Thege Miklós út 29-33 P.O. Box 49, 1525 BUDAPEST, HUNGARY Tel.: +36 1 392 2296 Akos.Horvath@aeki.kfki.hu
Indonesia	RC6	Optimization of Neutron Beam Techniques for Characterization of Structural Materials	**SUTIARSO Sutiarso (M)** National Nuclear Energy Agency (BATAN); R & D Centre for Materials and Science and Technology Jl. K. H. Abdul Rochim Mampang Prapatan JAKARTA SELATAN 12710, INDONESIA sasok@batan.go.id	**SUTIARSO Sutiarso (M)** National Nuclear Energy Agency (BATAN); R & D Centre for Materials and Science and Technology Jl. K. H. Abdul Rochim Mampang Prapatan JAKARTA SELATAN 12710, INDONESIA sasok@batan.go.id
Romania	RC7	Study of the Ageing Behavior for the Incoloy 800HT and 304 L Alloy Standing a Heat Treatment Trial at High Temperatures Using the TRIGA INR-PITESTI Q-Space Focusing Neutron Diffractometer and the SANS Instrument	**IONITA Ion (M)** Institute for Nuclear Research (NRI) P.O. Box 78 0300 Pitesti, ROMANIA ionionita@lycos.com	**IONITA Ion (M)** Institute for Nuclear Research (NRI) P.O. Box 78 0300 Pitesti, ROMANIA ionionita@lycos.com
Russia	RC8	Ferrite-Martensite Steels Dispersion Hardening studied by TOF Neutron Diffraction	**BALAGUROV Anatoly** (M), Joint Institute for Nuclear Research (JINR) ul. Joliot-Curie, 6 141980 DUBNA, Moskovskaya Oblast RUSSIAN FEDERATION Tel.: +7 4962165803 bala@nf.jinr.ru	**BALAGUROV Anatoly** (M) Joint Institute for Nuclear Research (JINR) ul. Joliot-Curie, 6 141980 DUBNA, Moskovskaya Oblast RUSSIAN FEDERATION Tel.: +7 4962165803 bala@nf.jinr.ru
Country	RC	Title of project	**Contact information of Chief Scientific Investigator**	**Contact information of the Meeting Participants**

Country	RC/RA	Title of project	Contact information of Chief Scientific Investigator	Contact information of the Meeting Participants
Australia	RA	Development of the Capability of Evaluating Residual Stresses and Internal Defects in Radioactive Materials Using Neutron Scattering Instruments	**LAW Michael (M)** Australian Nuclear Science and Technology Organisation (ANSTO) Locked Bag 2001 KIRRAWEE, DC, NSW 2232 AUSTRALIA Tel.: 61 (0) 2 97179102 mlx@ansto.gov.au	**LAW Michael (M)** Australian Nuclear Science and Technology Organisation (ANSTO) Locked Bag 2001 KIRRAWEE, DC, NSW 2232 AUSTRALIA Tel.: 61 (0) 2 97179102 mlx@ansto.gov.au
France	RA1	Study of ODS martensitic/ferritic materials	**MATHON Marie-Helene (F)** Commissariat à l'énergie atomique (CEA); Centre de Saclay; Laboratoire Léon Brillouin (LLB) 91191 GIF SUR YVETTE CEDEX FRANCE mhmathon@cea.fr & jose.teixeira@cea.fr	**MATHON Marie-Helene (F)** Commissariat à l'énergie atomique (CEA); Centre de Saclay; Laboratoire Léon Brillouin (LLB) 91191 GIF SUR YVETTE CEDEX France, mhmathon@cea.fr **TEIXEIRA Jose (M)** Commissariat à l'énergie atomique (CEA); Centre de Saclay; Laboratoire Léon Brillouin (LLB) 91191 GIF SUR YVETTE CEDEX France, jose.teixeira@cea.fr
Germany	RA2	Neutron radiography Investigations of the Hydrogen Uptake of Fuel Cladding Tubes during LOCA and Severe Accidents	**GROSSE Mirco (M)** Forschungszentrum Karlsruhe GmbH (FZK); Institut für Materialforschung Postfach 3640 76021 KARLSRUHE, GERMANY mirco.grosse@kit.edu	**GROSSE Mirco (M)** Forschungszentrum Karlsruhe GmbH (FZK); Institut für Materialforschung Postfach 3640 76021 KARLSRUHE, GERMANY mirco.grosse@kit.edu
Italy	RA3	Characterization of Y2O3 particle distribution in oxide dispersion strengthened eurofer steel for nuclear applications by means of small-angle neutron scattering (SANS) and of neutron diffraction	**VALLI Monica (Ms)** ENEA-Faenza Via Ravegnana 186 48018 Faenza (RA) Italy phone 00390546678566, monica.valli@enea.it & roberto.coppola@enea.it	**COPPOLA Roberto (M)** Ente per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA) Via Anguillarese 301 00123 ROMA, ITALY roberto.coppola@enea.it
Japan	RA4	Radiation Effects on Correlation between Nuclear Materials and Their Radiation Induced Nano-Micro Structures	**SHIKAMA Tatsuo (M)** Institute of Materials Research Tohoku University 2-1-1 Katahira, Aoba-ku SENDAI 980-8577, JAPAN shikama@imr.tohoku.ac.jp & nishi-a@nifs.ac.jp	**NISHIMURA Arata (M)** National Institute for Fusion Science 322-6 Oroshi, Toki, Gifu 509-5292 Japan Phone: +81-572-58-2118 Fax: +81-572-58-2676 nishi-a@nifs.ac.jp

				SHIKAMA Tatsuo (M) Institute of Materials Research Tohoku University, 2-1-1 Katahira, Aoba-ku SENDAI 980-8577, JAPAN shikama@imr.tohoku.ac.jp
Korea, Republic of	RA5	Application of neutron tomography for the measurement Gd distribution in Al and the evaluation of hydride content in zirconium	**SIM Cheul Muu (M)** KAERI (Korea Atomic Energy Research Institute) (150-1 Deokjin-Dong), 1045 Daedeokdaero, Yuseong, Daejeon, Korea Telephone: 82+42+868+8612 cmsim@kaeri.re.kr	**SIM Cheul Muu (M)** KAERI (Korea Atomic Energy Research Institute) (150-1 Deokjin-Dong), 1045 Daedeokdaero, Yuseong, Daejeon, Korea Telephone: 82+42+868+8612 cmsim@kaeri.re.kr **WOO Wan Chuck (M)** KAERI (Korea Atomic Energy Research Institute) (150-1 Deokjin-Dong), 1045 Daedeokdaero, Yuseong, Daejeon, Korea chuckwoo@kaeri.re.kr
The Netherlands	RA6	Combined Small Angle Neutron Scattering and Diffraction Studies to Investigate the Structure Property Relationship of Generation IV Reactor Candidate Materials and of Structural Components	**MARTINS René (M)** European Commission Directorate General - Joint Research Centre; Institute for Energy Westerduinweg 3 1755 LE PETTEN, NETHERLANDS rene.martins@ec.europa.eu & carsten.ohms@ec.europa.eu	**MARTINS René (M)** European Commission Directorate General - Joint Research Centre; Institute for Energy Westerduinweg 3 1755 LE PETTEN, NETHERLANDS rene.martins@ec.europa.eu
Switzerland	RA7	Study of Material Property Changes After Long Term Irradiation by Means of Neutron Imaging Methods	**LEHMANN Eberhard (M)** Paul Scherrer Institut 5232 VILLIGEN PSI SWITZERLAND eberhard.lehmann@psi.ch	**LEHMANN Eberhard (M)** Paul Scherrer Institut 5232 VILLIGEN PSI SWITZERLAND eberhard.lehmann@psi.ch
USA	RA8	Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams	**BOURKE Mark (M)** University of California, Los Alamos; Los Alamos National Laboratory (LANL) P.O. Box 1663 LOS ALAMOS, NM 87545 UNITED STATES OF AMERICA bourke@lanl.gov	**BOURKE Mark (M)** University of California, Los Alamos; Los Alamos National Laboratory (LANL) P.O. Box 1663, LOS ALAMOS, NM 87545 UNITED STATES OF AMERICA bourke@lanl.gov **BROWN, Don (M)** University of California, Los Alamos; Los Alamos National Laboratory (LANL) P.O. Box 1663, LOS ALAMOS, NM 87545 UNITED STATES OF AMERICA dbrown@lanl.gov
Country	RC	Title of project	**Contact information of Chief Scientific Investigator**	**Contact information of the Meeting Participants**

IAEA contacts	Technical Officer 1	**RIDIKAS Danas** (M), d.ridikas@iaea.org IAEA, NAPC, Tel. : +41 1 2600 21751
	Technical Officer 2	**INOZEMTSEV Victor** (M), v.inozemtsev@iaea.org IAEA, NEFW, Tel. : +43 1 2600 22760
	Secretariat	**DEVIA TORRES Cecilia** (Ms) International Atomic Energy Agency Physics Section Wagramer strasse 5, PO Box 100 A-1400 Vienna, Austria Tel: (+43 1) 2600 – 26393, Fax: (+43 1) 26007 E-mail: c.devia-torres@iaea.org

ANNEX V. MEETING AGENDA

1st Research Coordinated Meeting (RCM) related to the IAEA CRP on Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams

31 May - 4 June 2010

VIC F0811, IAEA, Vienna, Austria

Monday, 31 May 2010

08:30-09:30	**Registration, Gate 1**
09:30-10:10	**Welcome & Opening Remarks** **Mr G. Mank** (Head, NAPC / Physics Section) **Mr D. Ridikas** (Scientific Secretary, NAPC / Physics Section) Self introduction of the participants Selection of the Chairperson, Rapporteur, Facilitator Approval of the Agenda Discussion & administrative arrangements
10:10-10:40	**Mr D. Ridikas**, IAEA: Introduction and Objectives of the Meeting
10:40-11:00	*Coffee break*
11:00-13:00	**Mr M.H. Mathon**, CEA, France **Mr A. Horvath,** KFKI, Hungary, Mr G. Torok, **Mr R. Coppola**, ENEA, Italy
13:00-14:00	*Lunch break*
14:00-16:00	**Mr A. Balagurov**, JINR, Russia **Mr T. Shikama,** Tohoku University, **Mr A. Nishimura**, National Institute for Fusion Science , Japan **Mr P. Mikula**, NPI, Czech Republic
16:00-16:20	*Coffee break*
16:20-17:00	**Mr R. Martins,** JRC, The Netherlands
17:00-**17:15**	**Discussion, end of the 1st day**

Tuesday, 1 June 2010

09:00-10:20	**Mr I. Ionita**, INR, Romania **Mr M. Bourke**, LANL, USA
10:20-10:50	*Coffee break*
10:50-12:50	**Mr J. Santisteban**, CNEA, Argentina **Mr S. Sutiarso**, BATAN, Indonesia **Mr Z. Wu**, CIAE, China
13:00-14:00	*Lunch break*
14:00-16:00	**Mr E. Lehmann,** PSI, Switzerland **Mr M. Grosse,** KIT, Germany **Mr C.M. Sim**, KAERI, Korea
16:00-16:20	*Coffee break*
16:20-18:00	**Mr R. Pugliesi,** IPEN, Brazil **Mr M. Law**, ANSTO, Australia
18:30 -	***Hospitality event***

Wednesday, 2 June 2010

09:00-10:30	**Discussion** on synergies among different projects and subjects for cooperation
10:30-11:00	*Coffee break*
11:00-12:30	**Discussion** on subjects of common interests and formation of groups
12:30-14:00	*Lunch break*
14:30-17:30	Technical/social tour to "Kunsthistorisches Museum" under the topic "Application of neutron beam techniques to cultural heritage studies", host contact person Dr. Martina Griesser
18:00	**End of the 3rd day**

Thursday, 3 June 2010

09:00-10:30	**Discussion on** the need for the Round Robin experiment(s) related to the use of neutron beams in development, characterization and testing of materials
10:30-11:00	*Coffee break*
11:00-12:30	**Discussion on** the need for the dedicated data base related to the use of neutron beams and modeling in development, characterization and testing of materials
12:30-14:00	*Lunch break*
14:00-15:30	**Discussion & Finalization of** detailed work plan for the 1st year and provisions for the 2nd and 3rd years
15:30-16:00	*Coffee break*
16:00-17:30	**Drafting of** meeting summary, conclusions and recommendations
17:30	**End of the 4th day**

Friday, 4 June 2010

09:00-10:30	**Finalization** of meeting summary, conclusions and recommendations
10:30-11:00	*Coffee break*
11:00-12:00	**Final discussion, wrap-up**
12:00	**End of the meeting**