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AN IAEA COORDINATED RESEARCH PROJECT ON IMPROVED PRODUCTION AND UTILIZATION OF SHORT PULSED, COLD NEUTRONS AT LOW-MEDIUM POWER SPALLATION NEUTRON SOURCES

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ABSTRACT

The International Atomic Energy Agency (IAEA) is coordinating a Coordinated Research Project (CRP) which is focused on enhancement of cold neutron flux for specific applications at spallation sources and research reactors. Coupled with new neutron techniques this project has the future prospect to expand neutron techniques and applications into new areas involving users in various disciplines of research. The objectives are to enhance the utilization possibilities of low and medium power spallation and reactor neutron sources for research and development in neutron science and applications, by increasing neutron supply at sources and by improving optimum use of neutron techniques in interested Member States.

The demands on neutron research are increasing and new coordinated research interfacing different branches of science will be necessary. Still research reactors are needed in developments in neutron beam research, new materials, and component integrity testing, and are expected to continue to do so in the coming decades. New techniques, besides using research reactors, require access to spallation neutron sources, where neutron intensity is increased by two orders of magnitude with high power sources. However, providing a worldwide access to these techniques cannot be accomplished by the few high power spallation neutron sources alone.

Eight institutions around the world have joint this project. Five projects are covering the source improvement, four projects are dealing with micro-focusing SANS, and two are in charge of enhanced evaluations..

1. Introduction

Accelerators and research reactors can provide some of the best analytical techniques and applications in a diverse range of fields such as materials science, environmental science, cultural heritage and the biosciences. The effective utilization of research reactors and accelerators is being promoted through participation in knowledge building activities, the development and application of innovative nuclear science, and the development of new generation nuclear energy systems. These areas offer a broad spectrum of activities for the development, and new applications of accelerators and accelerator based techniques.

The main emphasis of the work of the IAEA is on sharing and disseminating knowledge followed by training and education. In the field of education the IAEA is working together with the Abdus Salam International Centre of Theoretical Physics (ICTP), Trieste, Italy. The IAEA has coordinated research projects (CRP) on this topic, but would like to increase their efforts, on request by the Member States.

2. Background

For over 50 years research reactors have supported developments in neutron beam research, new materials, and component integrity testing, and are expected to continue to do so in the coming decades. Many of the benefits from research reactors have to be brought into today's technical, economic, and social realities. The demands on neutron research are increasing and new coordinated research interfacing different branches of science will be necessary. New techniques, besides using research reactors, require access to spallation neutron sources, where neutron intensity is increased by two orders of magnitude with high-power sources. However, providing a worldwide access to these techniques cannot be accomplished by the few high-energy spallation neutron sources alone. A broad network of low-medium energy facilities is needed to render accessibility, availability to a wider community, to allow the development of new techniques and application, and to train new users, operators designers and builders. Such a network will enhance the impact of the major facilities, for many emerging economies and the developing nations have a keen interest to expand opportunities in education, research, and industrial applications, using nuclear technology, but they do not always have sufficient resources, technology, or trained manpower to establish facilities suitable for these tasks. In order to foster the application of accelerator driven neutron sources (ADNS) in developing countries, a network of medium energy accelerator driven neutron source facilities and users is proposed to generate and strengthen international cooperation in this area.

3. Scope

The overall objective of the CRO is to enhance the utilization possibilities of low and medium energy spallation neutron sources for research and development in neutron science and applications, by increasing neutron supply at sources and by improving optimum use of neutron techniques in interested Member States.

The scope of the CRP should cover

- Improvement of spallation source by development of cryogenic moderators
- Increase of potential usage of beam lines by contributing to improve mini-focusing small angle neutron scattering
- Enhance capability for strain determination by improving data extraction and evaluation from high resolution energy-dispersive transmission measurements

These efforts will lead to source improvement as well as more effective source utilization. This CRP would be focused on improvement at spallation sources with a future prospect to expand neutron techniques and applications into new areas involving users in various disciplines of research.

4. Participation and Achievements

The CRP institutions are located in Argentina, Czech Republic, India, Indonesia, Japan, Malaysia, Russian Federation and USA. The distribution of work within the CRP is described below.

Table I: Small angle neutron scattering (SANS) development

Country	Chief Scientific Investigator	Project
Japan	FURUSAKA Michihiro	Development of mini focusing small angle neutron scattering instruments
Czech Republic	MIKULA Pavol	Development and optimization of a curved wide wavelength band monochromator based on strongly cylindrically bent perfect Si-slabs in a sandwich for mini-focusing small-angle neutron scattering (mfSANS) device
Malaysia	Bin MOHAMED Abdul Aziz	Development of mini-focus SANS
Indonesia	PUTRA Edy Giri R	SANS BATAN: Improvement in the Neutron Intensity by Focusing Optics

In the domain of Small angle neutron scattering (SANS) development, four participants are working toward the improvement of utilization of existing facitilites. Five groups are collaborating towards a better understanding of moderator for cold neutron sources, whereas two institutions are developing method and analysis for energy-dispersive transmission measurements. Table I to Table III are presenting the projects.

Table II: Moderator Development

Country	Chief Scientific Investigator	Project
USA	BAXTER David	Development of very cold moderator materials at the low energy neutron source
Argentina	GRANADA Rolando	Modelling and measurement of neutronic properties of new cryogenic neutron moderators
Japan	KIYANAGI Yoshiaki	Development of pulsed cryogenic moderators
Russian	SHABALIN	R&D of productive pelletized cold neutron

Federation	Evgeny	moderators
India	BASU Saibal	Developing H2O ice based cold moderator and multilayer based neutron optical elements for enhancing cold neutron flux in reactors and accelerator based sources

The first coordination meeting took place in Sapporo, Japan, in July 2007, where participants presented their projects [1]. The collaboration were initiated or strengthened towards reaching common goals by the end of the CRP. The workplan for the full project duration were updated to take into account the potential aspect of collaborative work.

The second coordination meeting took place in Kuala Lumpur, Malaysia [2], in July 2009, following an international conference of neutron and x-ray scattering, where all the participants were presents. First results and updated workplan were presented.

Table III: Energy-dispersive transmission measurements

Country	**Chief Scientific Investigator**	**Project**
Japan	KIYANAGI Yoshiaki	Development of transmission method at a pulsed source
Argentina	SANTISTEBAN Javier	Bragg edge transmission analysis at a medium intensity pulsed neutron source

The demonstration of a working “mini-focusing SANS” instrument provides an opportunity to have a qualitative impact on this technique in terms of both its general availability world-wide and the ease with which the SANS technique may be introduced to a new facility. Energy-dispersive transmission measurements can provide a wealth of important data on a wide variety of materials and it is possible to perform these measurements at relatively weak sources. Development of these techniques therefore offers an opportunity for national-scale neutron sources to have significant impact on local industry, but realizing this potential will require significant development of the technique. Two groups (Argentina and Japan) have made significant progress in this arena. Parallel development of analysis software will facilitate the eventual validation of both.

The neutron moderator lies at the heart of all neutrons scattering experiments, but the development of new moderator concepts has been inhibited by the lack of available computer models and corresponding data libraries of candidate materials at the desired temperatures, and a significant part of the CRP activity is devoted to the development of new models. This will include the collection of appropriate data for validating the models as well as the computational work itself. Strong collaboration lead by Argentina is taking place between Japan, India, USA, and Russian Federation groups. New moderators will be developed for the facilities of at least three of the participating groups thereby providing a significant boost to the capabilities of those facilities. The optimization of designs for

Target/Moderator/Reflector assemblies at small scale accelerator driven neutron sources (ADNS) is expected to be different from those for larger scale spallation sources or research reactors. One of the activities in the CRP will directly address this issue. Simulations of the performance of a low-energy Li-target based system being completed with significant detail. Experimental verification of the predicted performance of the re-entrant hole mesitylene moderator should be completed. A list identifying those materials for which we have both reasonable kernels and adequate spectral data should be produced as a first step toward providing a catalogue of evaluated neutron kernels. This will require communication among the groups from Argentina, Japan, Russia, and USA.

5. Conclusions

It is important to emphasise that the above activities are not independent, but that there exist valuable synergies among the various activities. For example, the improved models for the dynamics of hydrogenous materials needed for research on neutron moderators can also contribute to more accurate handling of inelastic scattering corrections for SANS, transmission measurements on this class of materials provide valuable data for model development, the development of bent crystal optics will enhance both SANS and transmission measurements, and enhancements of moderator performance will directly increase instrument performance for these and many other techniques.

Several examples of these synergies have been evident over the initial 18 months of the CRP. These include the exchange of personnel between Malaysia and Japan, and the use of kernels developed in Argentina in the design of moderators in Russia and India. Many of the action items identified above for the remaining period of the CRP call for specific interactions among the participants in order to encourage additional synergistic collaborations over the remainder of the CRP. As a result of the second meeting a plan has been developed to aid the Malaysian group with the installation of a new data acquisition system for the SANS instrument in order to facilitate the transfer of data to a computer suitable for later analysis.

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7. References

[1] 1st Meeting: http://www-naweb.iaea.org/napc/physics/meetings/RCM-Sapporo2007/datasets/forewordJULY.html
[2] 2nd Meeting: http://www-naweb.iaea.org/napc/physics/meetings/RC-1056/datasets/foreword.html