The illicit trafficking of explosives through conventional commercial networks (air, maritime and terrestrial) represents a real challenge to civil security. The inspection of containers is largely based on X-ray or gamma ray systems, but it provides limited information about contained objects such as their shape and density. It is not always possible to distinguish between materials that are harmless or harmful using X-rays alone and there is a need for additional information about the chemical composition of the suspect items, in order to detect illicit materials such as explosives, drugs or dirty (radioactive) bombs. Neutron interrogation, therefore, offers the possibility of measuring the elemental density of most elements in materials. Neutrons, in particular fast neutrons, are well suited to explore large volume samples because of their high penetration range in bulk materials.

Exploring the methods and devices for practical application of neutron-based techniques for such applications, was the theme of a recently conducted second Research Co-ordination Meeting of the IAEA, on “Neutron-based Techniques for the Detection of Illicit materials and explosives,” held at Hotel Citizen, Juhu, Mumbai from 12 to 16th Nov. 2007. The meeting was hosted by BARC. Eighteen participants from

At the inauguration from left to right : Dr. Ms. Francoise Mulhauser, IAEA representative, Dr. S. Kailas, Associate Director, Physics Group, BARC and Dr. Amar Sinha, LNPS, BARC
different countries and some invited delegates from BARC attended this CRP meeting. The meeting was inaugurated by Dr. S. Kailas, Associate Director, Physics Group. Dr. Amar Sinha of LNPS, BARC was the local convener of this meeting and was ably assisted by his colleagues in organizing this meeting.

**Technical Sessions**

Dr. Ms. Francoise Mulhauser, IAEA representative reported on the activities of IAEA in the field of neutron-based techniques and also outlined the scope of the meeting.

There were six sessions each with several presentations on topics such as Neutron sources, Nanosecond neutron pulses, Neutron backscattering, Associated Particle Imaging, Neutron radiography, Systems, simulation and modelling.

Dr. A. Kuznetsov from the Radium Institute, Russia presented his work which was done in collaboration with five international organizations including NATO and an industry partner. He discussed the systems for detection of explosives and fissile materials based on Associated Particle Imaging (API) technique in which associated alpha particles in the binary reaction $^2$H + $^3$H in coincidence with the emitted neutron are used, for tagging the emitted neutron, with respect to its time of emission and direction. Such a technique, allows the inspection of a chosen element of volume (voxel), out of a large investigated object such as a maritime container, using time-of-flight methodology for tagged neutrons. A brief introduction on a similar technique for explosive and fissile material detection in maritime cargo, based on EURITRAC project, which is under advanced stage of development and testing, by a Consortium of 16 European partners, was also presented.

Dr. Brian D. Sowerby from CSIRO, Australia, presented a new scanner used at Brisbane airport to inspect containers for airfreight cargo. The concept is based on combined transmission radiography through the container, using fast neutrons produced with a D-T neutron source and gamma rays produced by a Co-60 source along with a novel detector design. The relative transmissions are sensitive to small differences in the compositions of organic materials. Prof. Leopoldo Soto, from Comisión Chilena de Energía Nuclear (CCHEN) spoken about his work on the development of portable neutron sources, based on pinch and plasma focus discharges. Work on design of several portable neutron devices based on plasma focus of (a) several hundred Joules (b) 30-100 Joules and (c) only about 0.1 Joule (the Nanofocus device), were presented by him, during the meeting. Dr. Leri Meskhi from Georgian Technical University presented his work on a portable neutron device, which indicates the presence of hidden organic materials such as illicit materials or explosives, within spaces just below the external cladding of cargo, containers or vehicles. The method is based on detecting the higher concentrations of thermalized neutrons, produced, when concentrations of organic materials are located nearby. Prof. Richard Lanza from MIT, USA made a presentation on a device, based on fast neutron resonance radiography, for the detection of explosives. Prof. Vladimir Gribkov from ITEP, Moscow, discussed a technique of explosive detection in cargo, using single intense neutron pulse 10-20 ns long, produced using a plasma focus device based on D-D reaction. Dr. Colin Murray Battle from New Zealand, presented the use of small, low cost portable neutron probes, to detect harmful materials, enhanced through comparative techniques such as detecting radiation at different viewing angles. Prof. Victor Bom from Netherlands, displayed the neutron backscatter technique, which has been configured into a light hand-held device, as well as a platform-mounted wide-area imaging system, that has undergone through advanced laboratory tests and is ready for field applications. Prof. Riad Mostafa Megahid from Egypt, presented the use of isotopic sources for explosive detection.
Mr. Roberto E. Mayer from Argentina, discussed about his work on pulsed electron Linac-based neutron generation and time-of-flight method for thermal and epithermal neutrons for explosive detection, whereas, Dr. Christopher Franklyn from NECSA, South Africa, showcased his work on Intense pulsed neutron generation, based on the principle of plasma immersion ion implantation technique, to detect illicit materials. Dr. Tsuyoshi Misawa from Japan presented his work on the development of compact, discharge-driven D-D fusion neutron source and it’s application for landmine detection. A report on simulation and modeling for optimization of associated particle based imaging devices and utilization of photoneutron sources for inspection and status of experiments with neutron generators, was presented by Dr. Amar Sinha from BARC and Mr. Surendra Sharma, IPR, India.

It was recognized, that neutron-based technologies may not represent the first level inspection, but rather a second level target-specific system, which follows x-ray inspection. Detection of Special Nuclear Materials (SNM) remains a potential exception and neutrons would play a special role in such applications.

As part of this meeting, a visit to BARC was also organized.

A group photograph of the participants