Review Paper

Neutron Based Techniques for the Detection of Illicit Materials and Explosives

B. Sowerby[a], C. Franklyn[b], F. Mulhauser[c]

[a] CSIRO, Australia

[b] Necsa, South Africa

[c] IAEA, Austria

Abstract. The main focus of the Satellite Meeting was on the development and application of neutron techniques for the detection of illicit materials and explosives. Both new emerging applications and novel techniques in established fields were presented. In addition, methods and facilities for the production of fast neutrons were discussed.

1. Introduction

The Satellite Meeting comprised 31 papers, all of which were presented as posters and 19 of which were presented orally in six sessions held over three half-days. Each session had one 40 minute review paper followed by two or three 20 minute papers. A round table discussion was scheduled at the end of each half-day session. An overview paper by Dr Gozani entitled "Principles and Applications of Neutron Based Inspection Techniques" was presented on the first morning of the main conference (paper AP/INT-04).

The most commonly used methods for the detection of concealed contraband in cargo containers and passenger luggage are based on the use of X-rays, vapour and trace particle detection and sniffer dogs. Commercial X-ray systems using energies up to 9 MeV provide high resolution 2-D density images of the contents of containers and are ideally suited to the detection of metallic objects with readily identifiable shapes such as firearms and other weapons. Low energy dual-energy X-ray systems are widely used to provide density and composition images of luggage but they do not have sufficient penetration for scanning air and sea containers.

Neutron based techniques offer significant potential for the non-intrusive inspection of parcels and cargo. Neutron techniques are attractive for cargo screening as neutrons have the required penetration, they interact with matter in a manner complementary to X-rays and they can be used to determine elemental composition. However for neutron techniques to be successfully applied to cargo screening they must meet the needs of the industry and, as well, have significant advantages over the established and developing X-ray techniques. Some neutron based technologies may not represent the first level inspection, but rather a second level target-specific system which follows X-ray or other inspection.

The topic of the Satellite Meeting links with the current IAEA Coordinated Research Project (CRP) entitled "Neutron based techniques for the detection of illicit materials". Ten of the 31 papers presented at the Satellite Meeting were submitted by participants in this CRP. In reviewing the papers

presented at the Satellite Meeting it is convenient to divide the papers according to four distinct subject areas as follows:

2. Complete Scanning or Detection Systems

There were six papers that described various complete systems. Two systems for the scanning of cargo containers (described in papers by Sowerby (SM/EN-01) and Strellis (SM/EN-05)) have both been trialled at international airports. The Australian CSIRO Fast Neutron and X-Ray Radiography system (SM/EN-01) has recently been developed into a commercial product in collaboration with Nuctech Company Limited, China. The CSIRO/Nuctech system has the required speed to be used as a first level inspection system. The Pulsed Fast Neutron Analysis system trialled by Rapiscan, USA (SM/EN-05) is more suited to second level inspection.

A number of papers described systems that employ Associated Particle Imaging using tagged neutrons from sealed tube 14 MeV neutron generators. This is clearly an increasing trend. Complete systems were described by Vakhtin (SM/EN-11), Le Tourneur (SM/EN-17) and Belichenko (SM/EN-P11). These systems are primarily used for the detection of explosives and contraband in luggage and packets rather than cargo containers. In addition, there were two papers on specific applications of the Associated Particle Imaging technique, firstly to the detection of explosives behind or in front of dense organic goods (Sudac, SM/EN-04) and secondly to environmental security of the coastal sea floor (Valkovic, SM/EN-06).

A possible low-cost system was discussed by Megahid (SM/EN-P03) and applications to landmine detection were discussed by El-Bakkoush (SM/EN-P09).

3. Detection of Hidden Fissionable Materials

There is currently a high level of interest around the world in methods for the detection of hidden fissionable materials. This was reflected in the eight papers on this topic in this Satellite Meeting. In these eight papers, the techniques varied widely. One new method proposed by Lanza (SM/EN-08) and Goldberg (SM/EN-13) was high energy (4.43 and 15.11 MeV) dual gamma-ray radiography. In both papers the proposed source of high energy gamma-rays was the $^{11}B(d,n)^{12}C$ reaction. Goldberg proposed a novel dual purpose ion accelerator to also use gamma resonance absorption to detect nitrogen (SM/EN-13).

Other papers on the detection of hidden fissionable materials utilised 14 MeV neutrons (Chichester, SM/EN-02; Rosenstock, SM/EN-09; Belichenko, SM/EN-P11), thermal neutrons (Mayer, SM/EN-10), and direction sensitive imaging (Bom, SM/EN-20).

4. Neutron Generators

Various methods for generating neutrons were reported in the papers published in this Satellite Meeting. The choice of neutron generator was determined by the required features for the particular applications reported. These features included neutron output, neutron energy spectrum, portability,

pulsing ability, cost and reliability. The most commonly used neutron generators were 14 MeV D-T generators, either with or without alpha detectors to tag the neutrons. Larger accelerators were used to achieve faster pulsing or different energies.

A number of papers specifically on alternative neutron generators were presented in the Satellite Meeting. In particular, papers were presented on inertial confinement fusion devices (Sved, SM/EN-18 and SM/EN-P06), dense plasma focus (Gribkov, SM/EN-18 and SM/EN-P06), switchable radioisotope source (Meskhi, SM/EN-P04) and RFQ accelerator systems (Franklyn SM/EN-12).

5. Detectors

A number of interesting papers on detector systems and signal interpretation were presented. Radiographic detector imaging systems were presented by Vartsky (SM/EN-14 and SM/EN-15) and a new concept for direction sensitive imaging was presented by Bom (SM/EN-20).

A number of papers were presented on the interpretation and analysis of neutron-induced gamma ray spectra. Techniques included signatures for a portable analysis system (Perot, SM/EN-07), signatures for explosive detection systems as well as algorithmic classification (Kessler, SM/EN-P16). In addition a paper on understanding gamma-ray widths was presented by Womble (SM/EN-16).