Design of Neutron sources and investigation of neutron based techniques for the detection of explosive materials
Outline

- Activities in the institute
- Scope of the project under the CRP
- Work related to project carried out
- Results obtained till now
- future work and plan
Activities in the institute
Design and development of 3.6 kJ plasma focus

System description
- Anode length 200 mm
- Diameter 50 mm
- Cathode length 200 mm
- Diameter 100 mm
- Insulator sleeve 40 mm
- Electrode material SS
- Operating gas Deuterium
1. $dI/dt$ signal from Rogowski coil.

2. Neutron detection by bubble detector (BD-PND, sensitivity 24 bubbles/mrem)

3. Hard X-ray and neutron study from Time of flight detector (Plastic Scintillator)

4. Neutron detection by silver activation counter (GM counter, ECIL-I1010)
The neutron generator uses D(T,n)He nuclear fusion reaction for the generation of monoenergetic 14.1 MeV neutrons.
**Design parameter of neutron generator**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron flux</td>
<td>$10^{11}$ n/s</td>
</tr>
<tr>
<td>Maximum Beam energy</td>
<td>320 KeV</td>
</tr>
<tr>
<td>Beam current at the target</td>
<td>1 mA</td>
</tr>
<tr>
<td>Beam spot at target (mm)</td>
<td>10 mm</td>
</tr>
<tr>
<td>Ion source</td>
<td>ECR type</td>
</tr>
<tr>
<td>Extraction voltage</td>
<td>20 kV</td>
</tr>
<tr>
<td>High Voltage power supply</td>
<td>300kV/10mA</td>
</tr>
<tr>
<td>D.C Isolation transformer</td>
<td>350kV/5kVA</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>400lps</td>
</tr>
<tr>
<td>Tritium target</td>
<td>10 Curie</td>
</tr>
</tbody>
</table>

The system is in commissioning stage
Setting up of pulsed neutron generator facility

Specification of pulsed NG
Neutron Flux $10^{10}$ n/s
Neutron Energy 14 MeV
Neutron pulse width less than microsecond
Neutron output per pulse $10^5$ - $10^8$ n/s

Activation of ammonium nitrate has been done with the pulsed NG facility
Neutron diagnostics

- Fast neutron diagnostics NE213 liquid scintillation detector
- Neutron emission study by bubble detector
- Activation foils
- Fast digitizer system
Gamma ray diagnostics

- NaI detector with PMT and accessories
- BGO detector with PMT and its accessories
- HPGe detector for high resolution gamma spectroscopy
A new neutron lab is made for experiments, adequate shielding is provided by high density polyethylene, concrete blocks and borated rubber sheets.
Scope of project under CRP
Design and development of low cost neutron source

Detection system and investigation of neutron based techniques for the explosive detection
Design of compact and low cost neutron source

Plasma focus system

Specification of plasma focus

Energy 800 J

Inductance of system 25nH

Undamped peak current 282 kA

Diameter of inner electrode 1.2 cm

Outer electrode 2.4 cm

The system is ready and vacuum of $10^{-4}$ mbar is achieved inside the plasma chamber. Capacitor bank and its power supply is also ready. Soon we will operate it with deuterium gas.
Detection system and investigation of neutron based techniques for the detection of explosive materials
Detection system for explosive detection experiment

- 3” x 3” Bismuth Germanium orthosilicate (BGO) with PMT and its accessories
- Spectroscopy amplifier
- High speed digitizer system (2 Channel, 2 GS/second)
- Signal optically transfer to PC in ASCII format using optical fiber
- Signal is converted from ASCII to DAT format using software
- Pulse height analysis of signal using MATLAB programming
Schematics diagram of explosive detection experiment
Experimental set up for explosive detection experiment
Pulse height spectrum of Cs-137 source
Pulse height spectrum of Co 60
Pulse height spectrum of Ammonium nitrate sample
Analysis of the PH spectrum of Ammonium nitrate

The gamma spectrum of ammonium nitrate sample is measured with BGO. The main line observed are 6.13 MeV for O, 2.22 MeV for H and 5.11,1.64 MeV for N.

- The observed peak confirms the presence of O, H and N in the sample

- The intensity of 2.22 MeV peak is much greater than other peak because of hydrogenous material in the surrounding of the detector. The peak is also overlapped with 2.31 MeV gamma ray from N

- 10.8 MeV gamma from nitrogen could not be observed due to saturation of BGO that results in the pile up of the gamma rays
Future work plan
- We have done the qualitative measurement for the identification of Nitrogen (N), Hydrogen (H) and Oxygen (O). Quantitative measurement will be done to identify the fractional elemental concentration in the sample.

- We could not see the prompt gamma signal due to saturation effect. An attempt will be done to see the prompt gamma signal.

- Increasing the gamma photon count by using two BGO detector. Use of one more BGO will improve the detection probability of prompt gamma.

- This technique will be improved further to observe the 10.8 MeV gamma ray photon from N by reducing the neutron flux on the sample and shielding of BGO against 14 MeV neutrons.
- Irradiation study of other sample will be carried out.

- Experiments will be carried out by hiding the explosive in a large container
Thank you