Progress in Explosives Detection using D-D Fusion at the University of Wisconsin-Madison

A.L. Wehmeyer

E.C. Alderson, R.P. Ashley, D.R. Boris, G.A. Emmert, R.C. Giar, G.L. Kulcinski, G.R. Piefer, R.F. Radel, T.E. Radel, and J.F. Santarius

Fusion Technology Institute
University of Wisconsin
Madison, WI

Outline

- Background
- Experimental Objective
- Theory of Explosives Detection
- Experimental Setup
- Modeling Experiment in MCNP5
- MCNP5 Calculational Results
- Experimental Results without Explosives
- Summary
- Future Work

Background Information

- Thermal neutron activation analysis (TNAA) can be used for detecting common explosives.

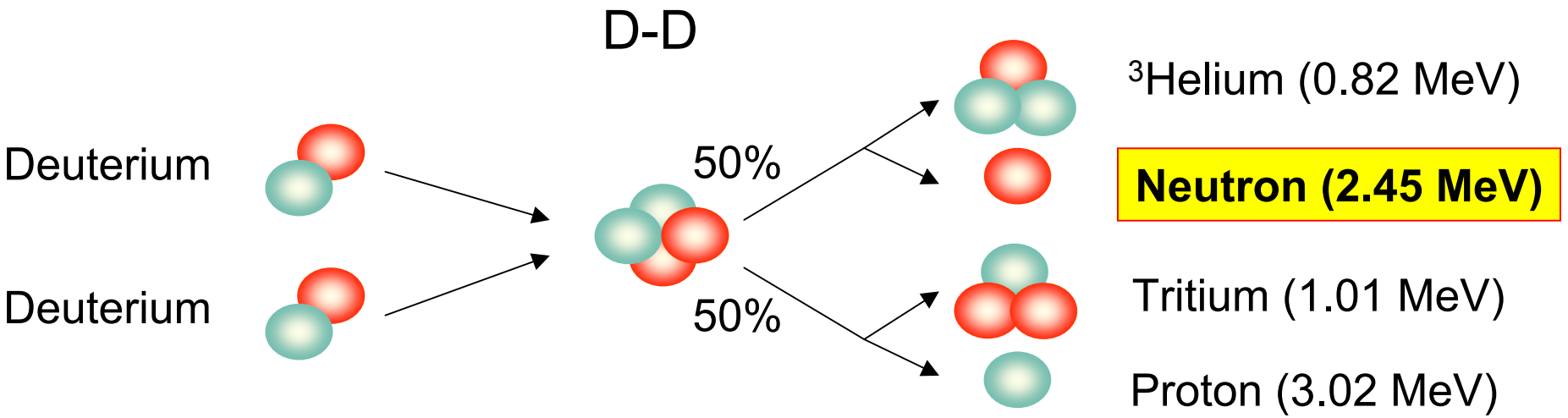
- Typical explosive compositions contain low Z material (C, H, N, O).

- Composition 4 (C-4), a military plastic explosive, is approximately 90% RDX by weight (RDX – $C_3H_6N_6O_6$).

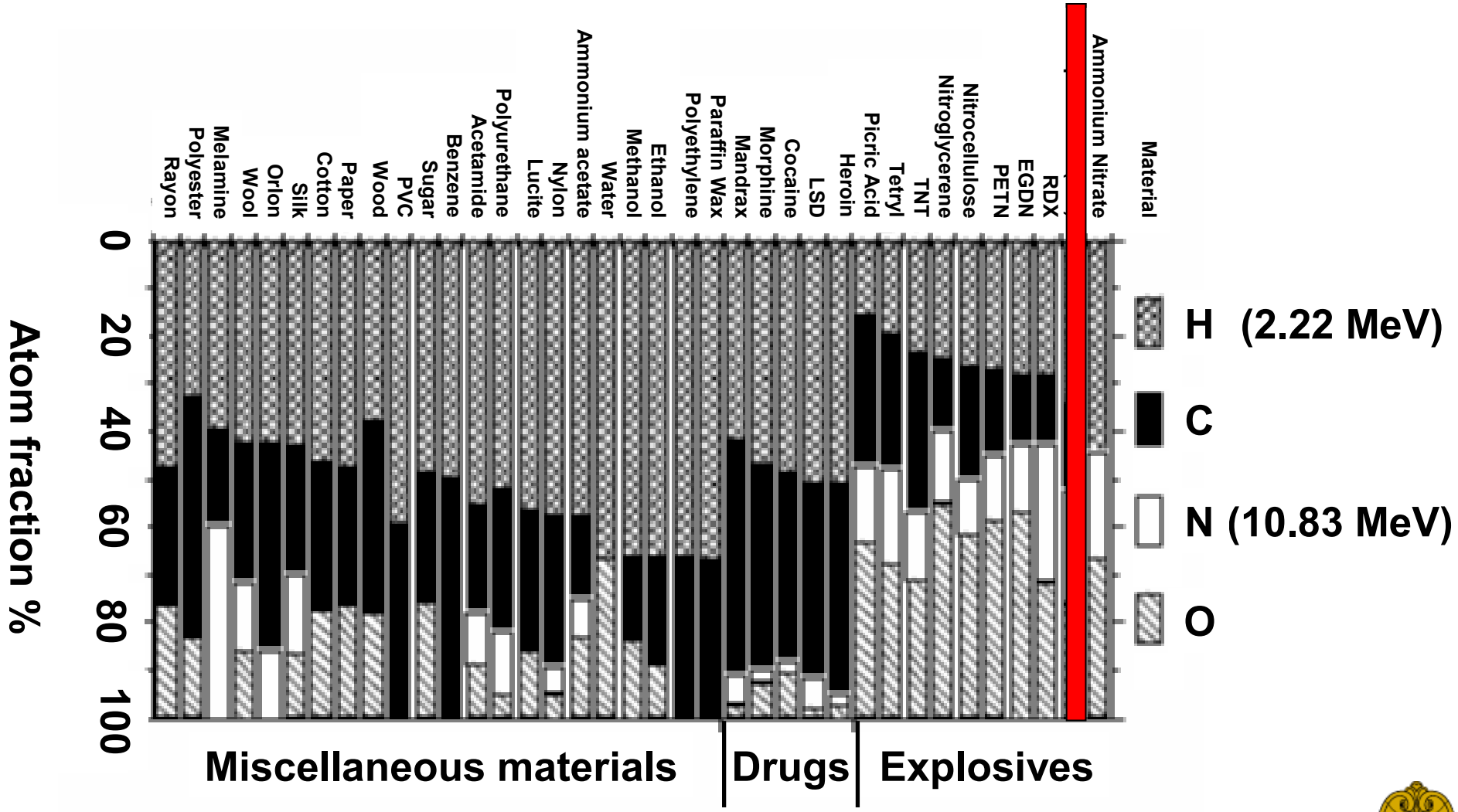
Package Containing 24 – 20g vials of Composition 4 (C-4)

Experimental Objective

- Proof-of-principle experiment to detect explosives using the D-D fusion reaction in an IEC device.

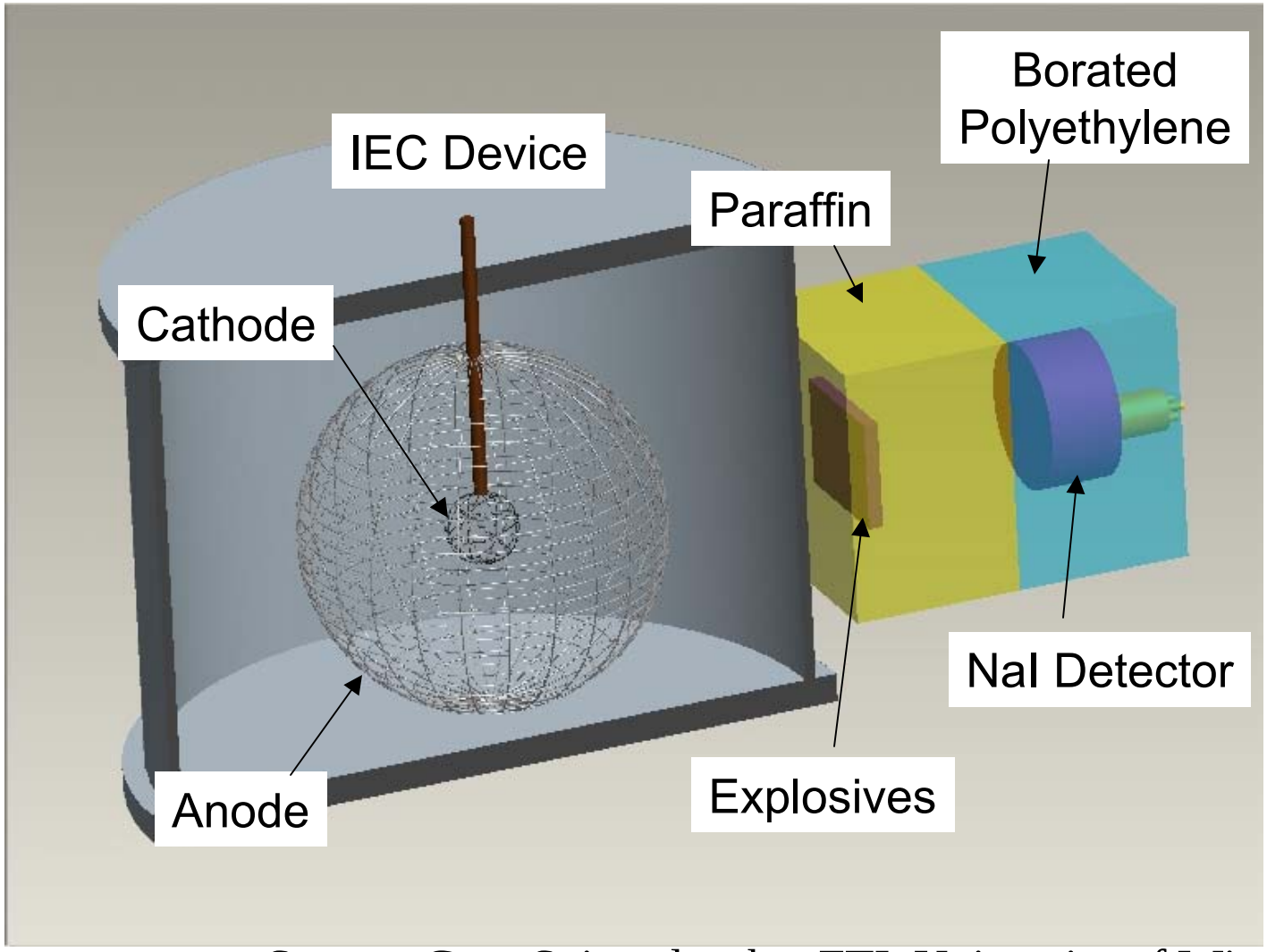


Characteristic gamma rays from hydrogen and nitrogen can be detected using TNAA



Source: A. Buffler, "Contraband Detection by Fast Neutron Scattering," presented at the 2nd National Nuclear Technology Conference, NAC, South Africa, May 14-15, 2001.

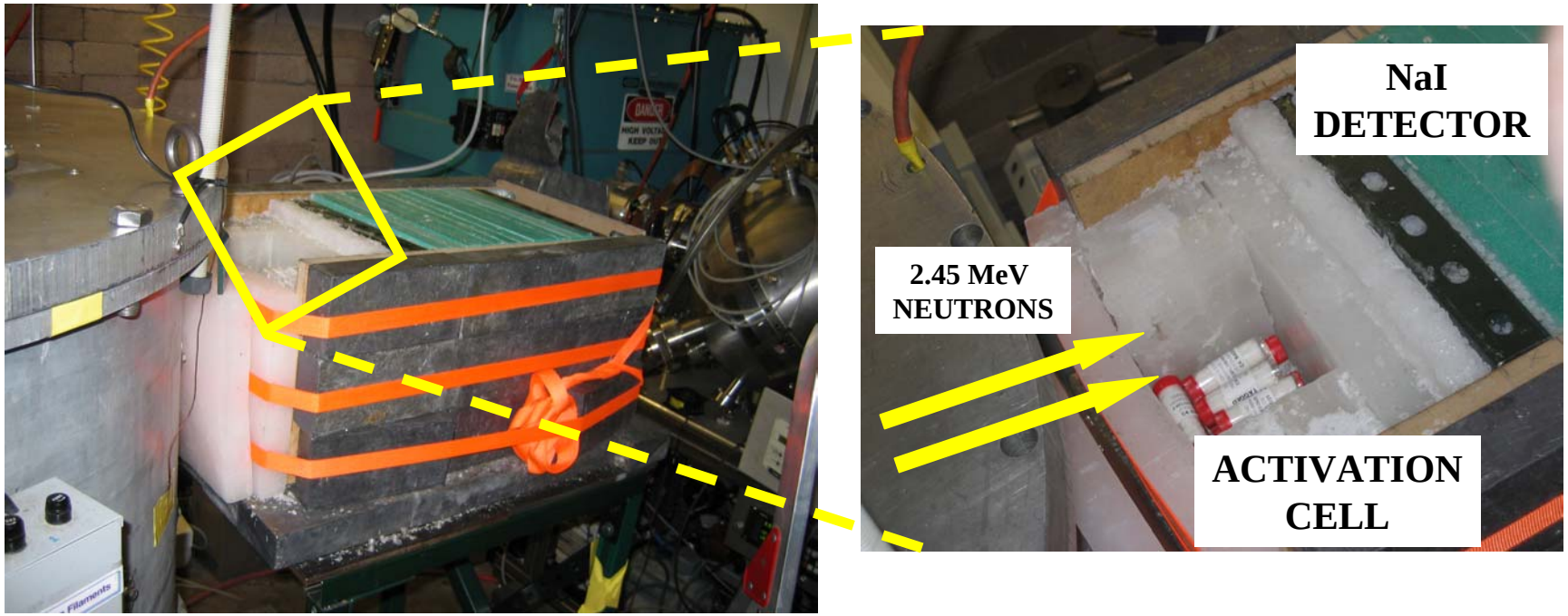
CAD Representation of UW Experimental Setup for Explosives Detection



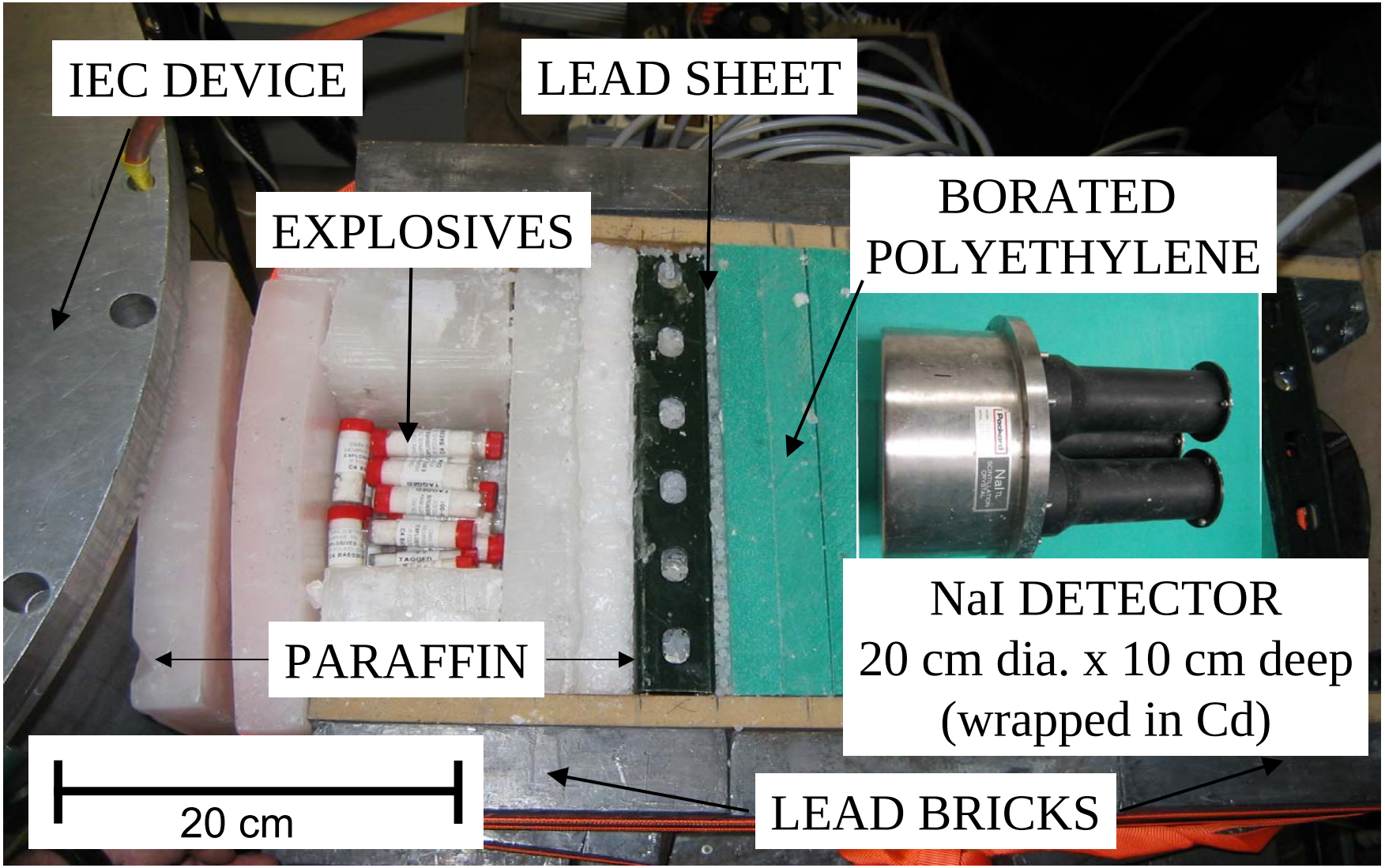
Source: Greg Sviatoslavsky, FTI, University of Wisconsin

UW Experimental Setup for Explosives Detection using IEC Fusion

UW Experimental Setup for Explosives Detection using IEC Fusion (cont.)

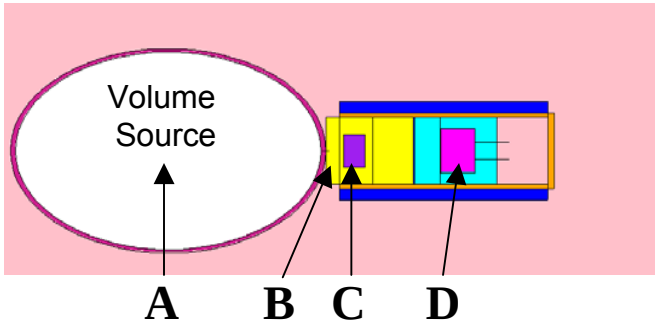


UW Experimental Setup for Explosives Detection using IEC Fusion (cont.)

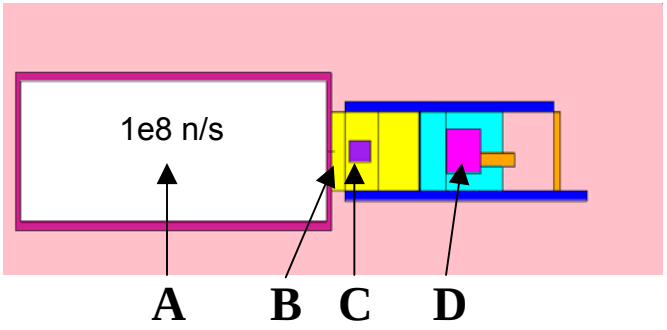


MCNP Model of UW Experimental Setup for Explosives Detection and MCNP Results

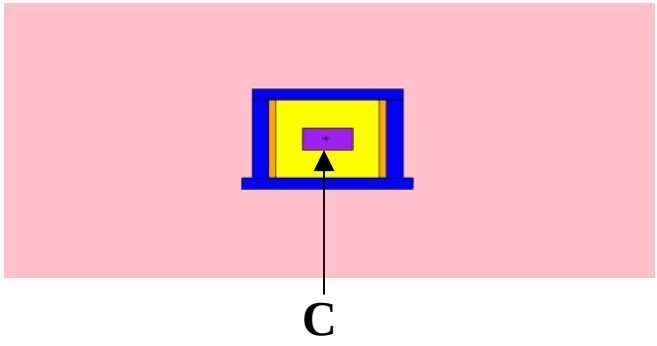
TOP VIEW

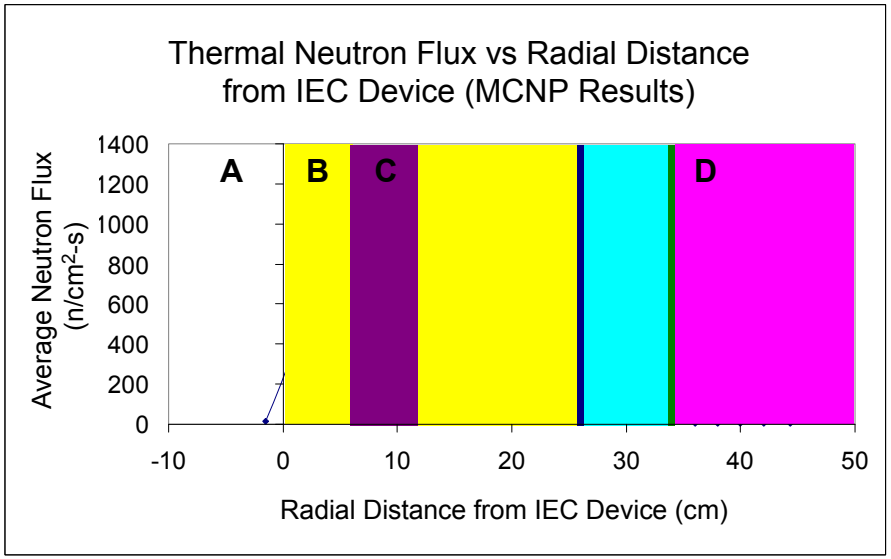


SIDE VIEW

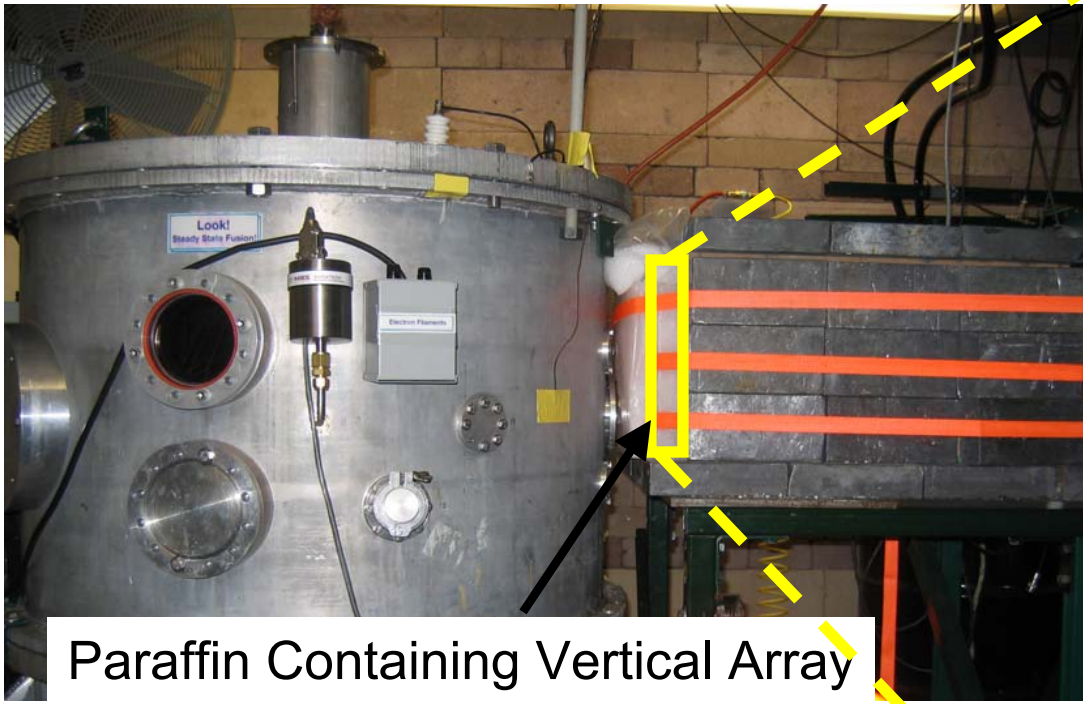


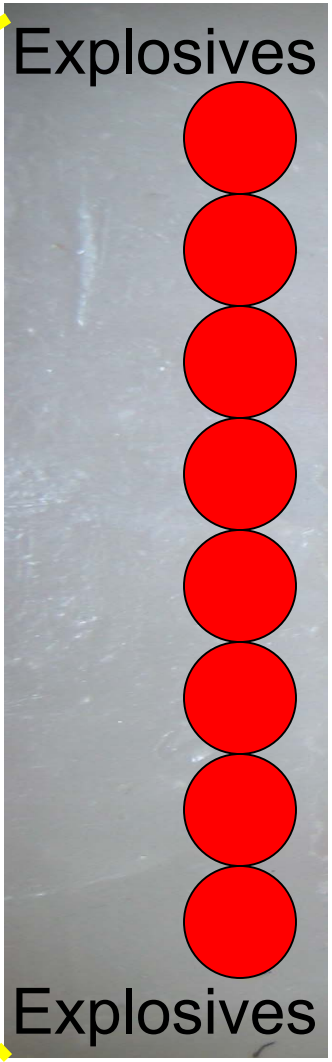
FROM CENTER OF EXPLOSIVES





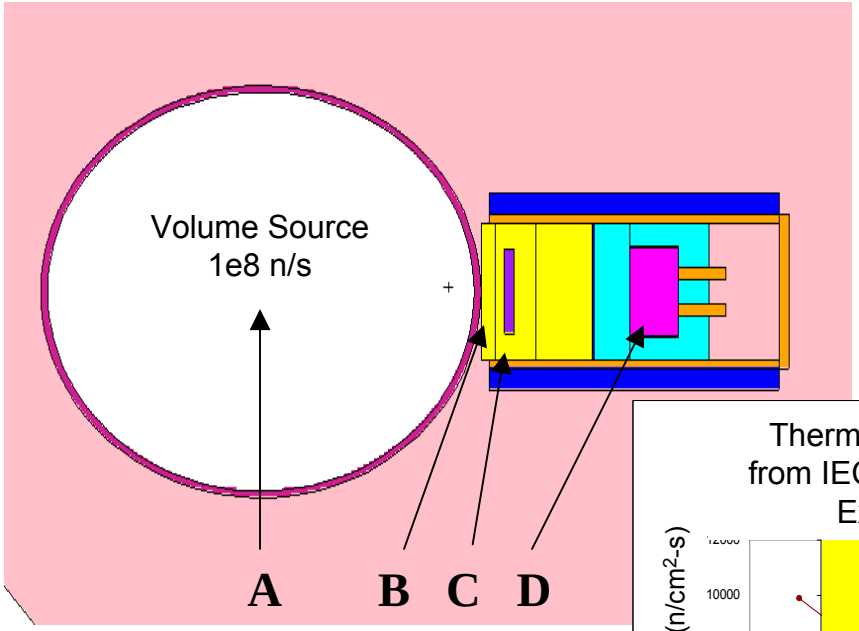
Changed to Vertical Explosives Array Configuration based on MCNP Results



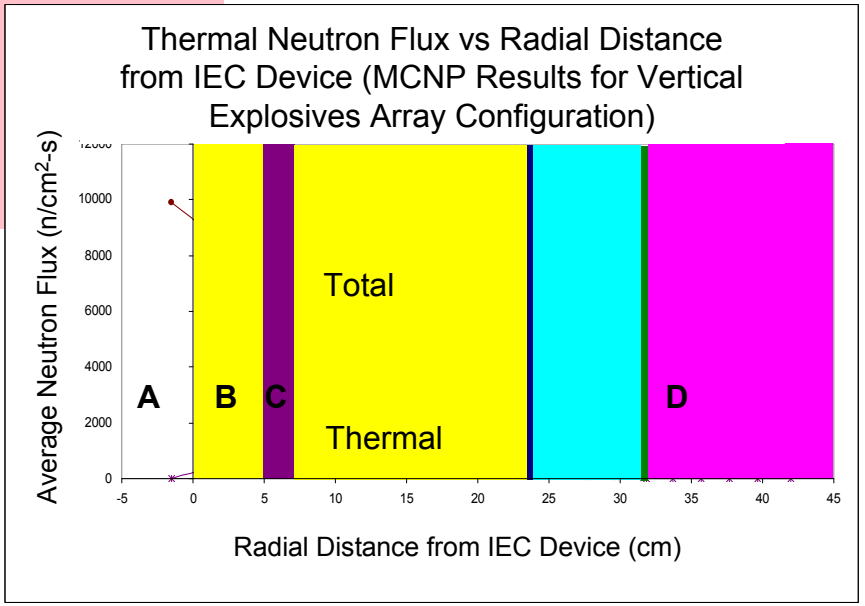


MCNP Model and Results from Vertical Explosives Array Configuration

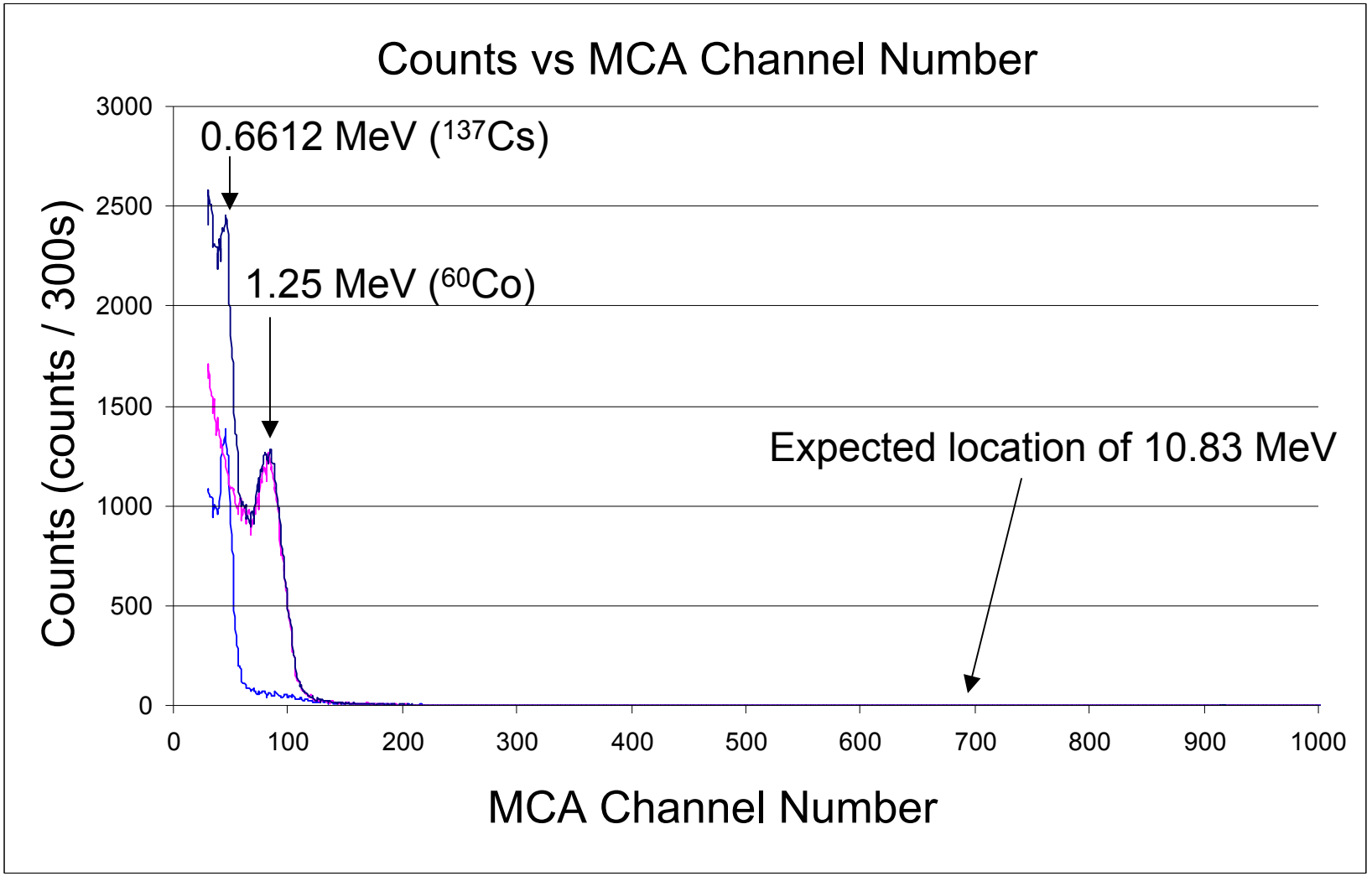
TOP VIEW



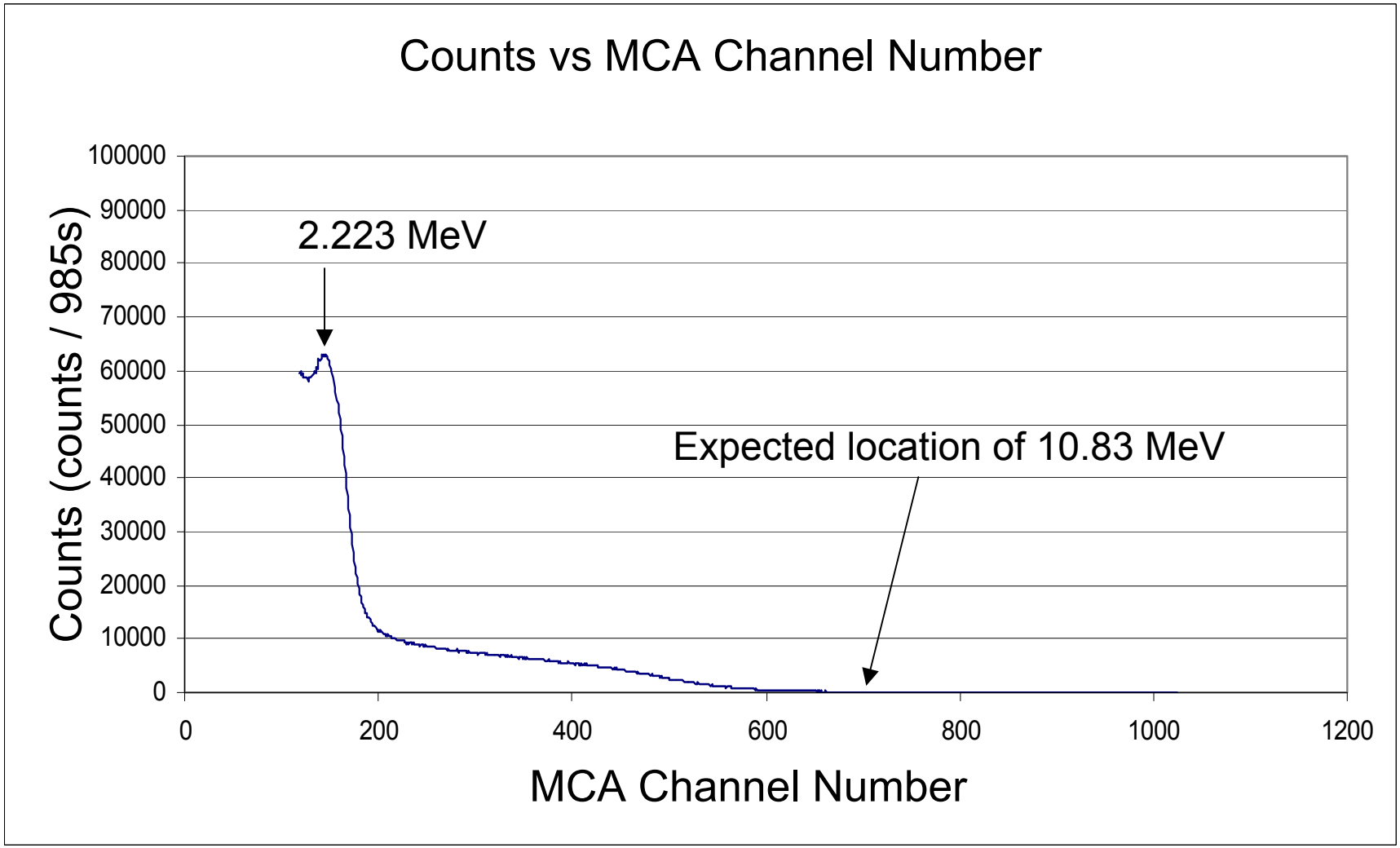
Avg thermal neutron flux increased from 856 n/cm^2-s to 1220 n/cm^2-s within the C-4



NaI Detector Calibration with two known sources (^{137}Cs and ^{60}Co)



Experimental Results from D-D Fusion Neutrons without Explosives



Summary

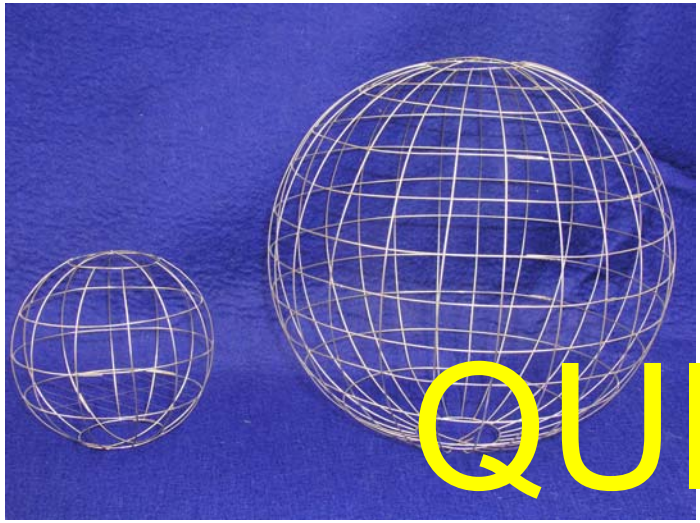
- Completed preliminary UW experimental setup for explosives detection.
- Completed preliminary MCNP5 model of UW experimental setup for explosives detection.
- Optimized placement of explosives within activation cell based on MCNP5 calculations.
- Successfully calibrated NaI detector and performed initial experiments without explosives

Future Work

- Conduct experiments with explosives (C-4, TNT, Urea fertilizer)
- Further refinement of MCNP5 model to include tally for (n,γ) reactions for ^{14}N and tally for pulse height detector output
- Increase shielding on backside of experimental setup and move detector closer to explosives
- Increase neutron production rates
  - Increase cathode voltage and current
  - Vary cathode size
  - Vary cathode to anode distance

Preliminary work has begun on studying different factors which might affect neutron production rates

Cathode Size

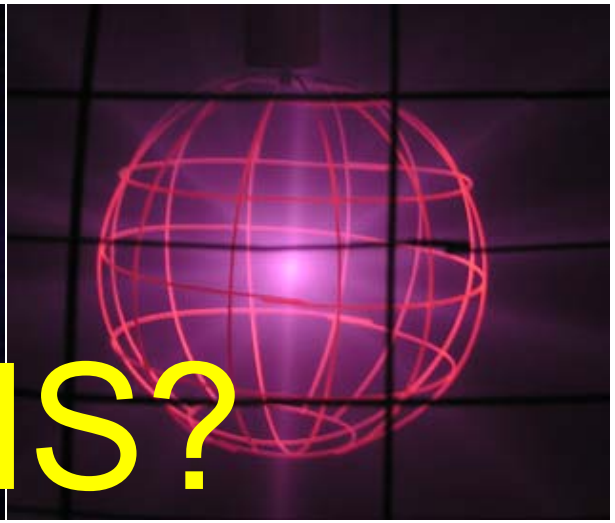


10 cm Inner Cathode Grid Diameter

20 cm Inner Cathode Grid Diameter

Cathode Geometry

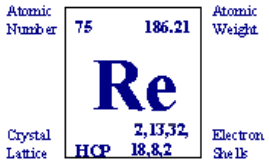
10 cm Symmetric Inner Cathode Grid



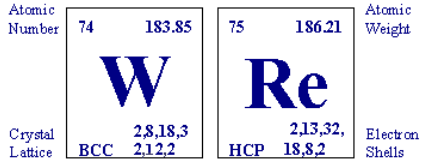
10 cm Lat/Long Inner Cathode Grid

QUESTIONS?

Cathode Material



10 cm Inner Cathode Grid (Re)



10 cm Inner Cathode Grid (WRe)