Detection of Nitrogen Based Explosives using the UW IEC Device

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Outline

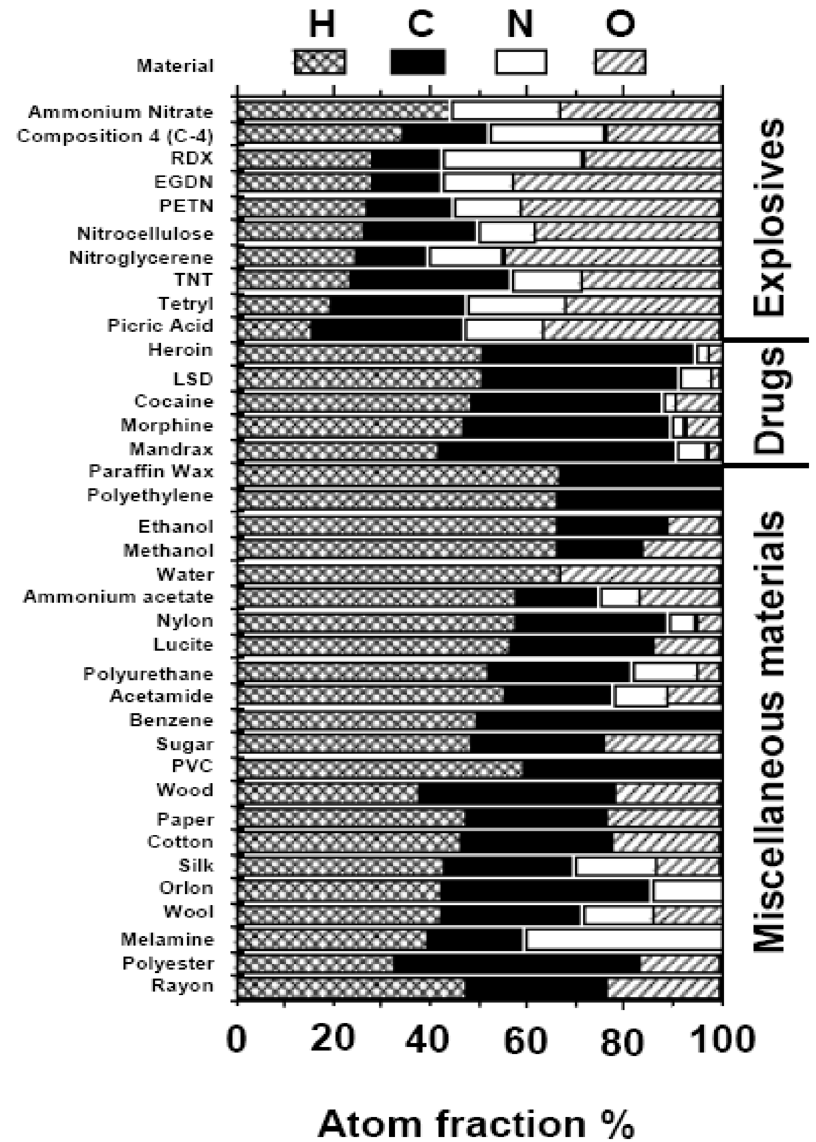
- Basic Theory
- Previous Research
- Current Methods
- Preliminary Results

The 2.45 MeV neutron created by the D-D fusion reaction is used for activation of nitrogen

- Using the IEC device to create D-D fusion, a steady rate of 2.45 MeV neutrons are produced
- The neutrons bombard the sample that is under investigation
- A neutron interaction with a nitrogen atom produces a 10.83 MeV gamma ray
- The gamma rays emitted from the sample are then detected using NaI detectors

Very few materials have high concentrations of nitrogen

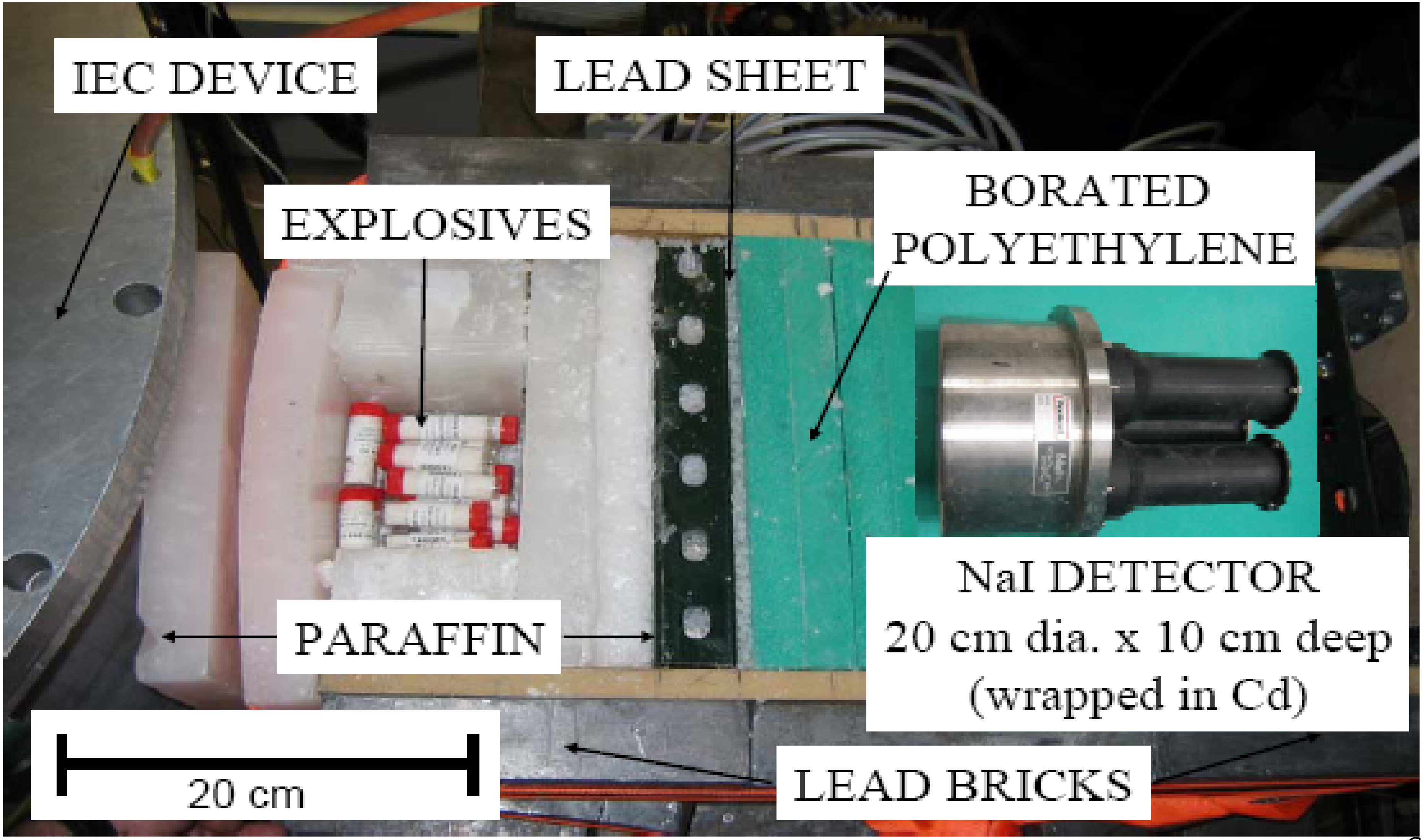
- Most commercial products do not contain a high concentration of nitrogen
- Typically only explosive materials and fertilizers have an atomic fraction of nitrogen higher than 10%
- A nitrogen signature in a sample would most likely indicate a suspicious object



Previous experiments conducted at UW have successfully detected C-4

- Previous experiments conducted within the UW IEC group have shown success in detecting a 480 g sample of Composition-4 (C-4) at a steady state neutron rate of 6.3×10^7 n/s
- The configuration used involved lining up the moderator, the sample of C-4, and the NaI detector along the path of the neutrons streaming out of the chamber
- A single 3”x3” NaI(T1) Detector was used in these experiments

Previous setup had the C-4, moderator, detector in line with incoming neutrons

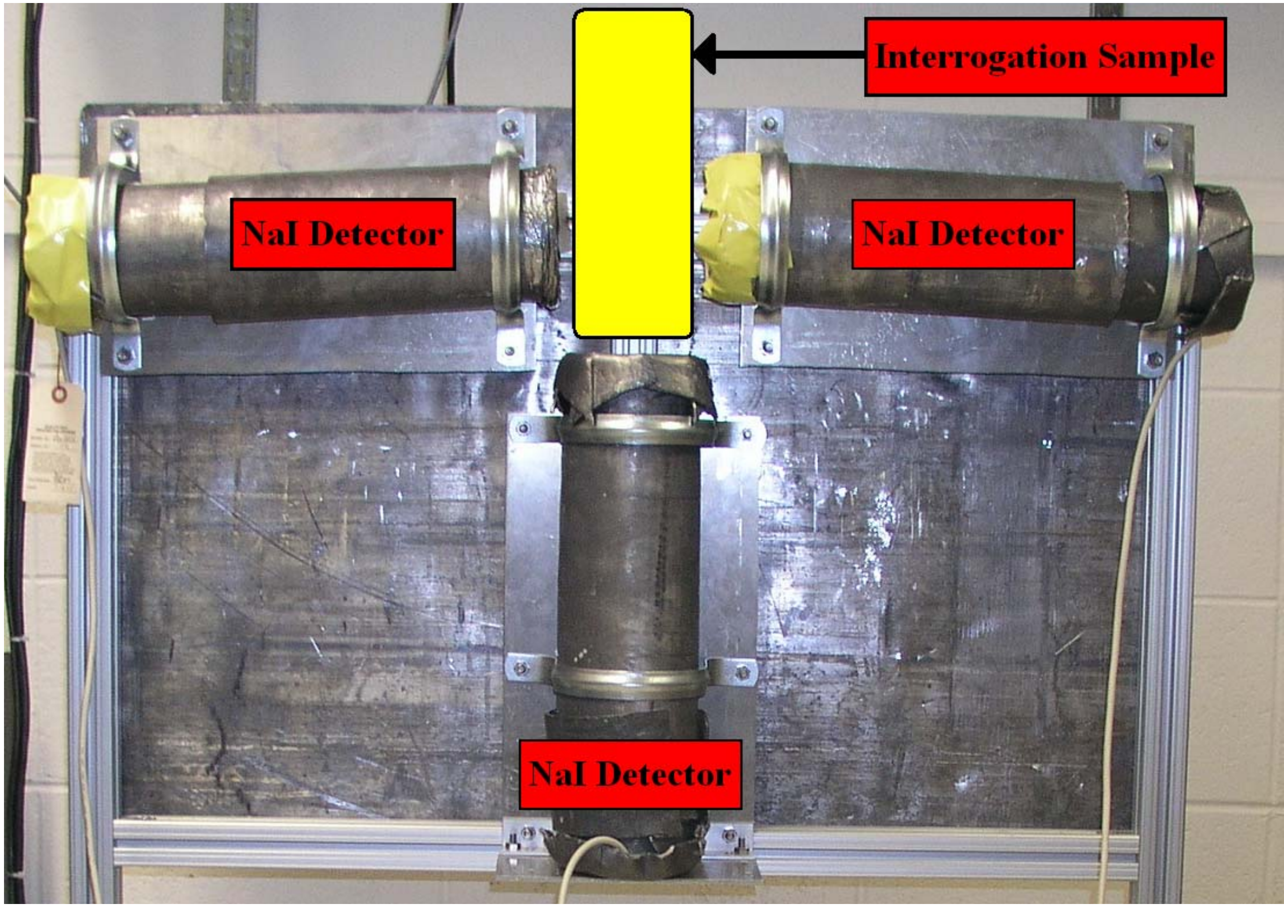


Previous methods were successful but had some areas that could be improved upon

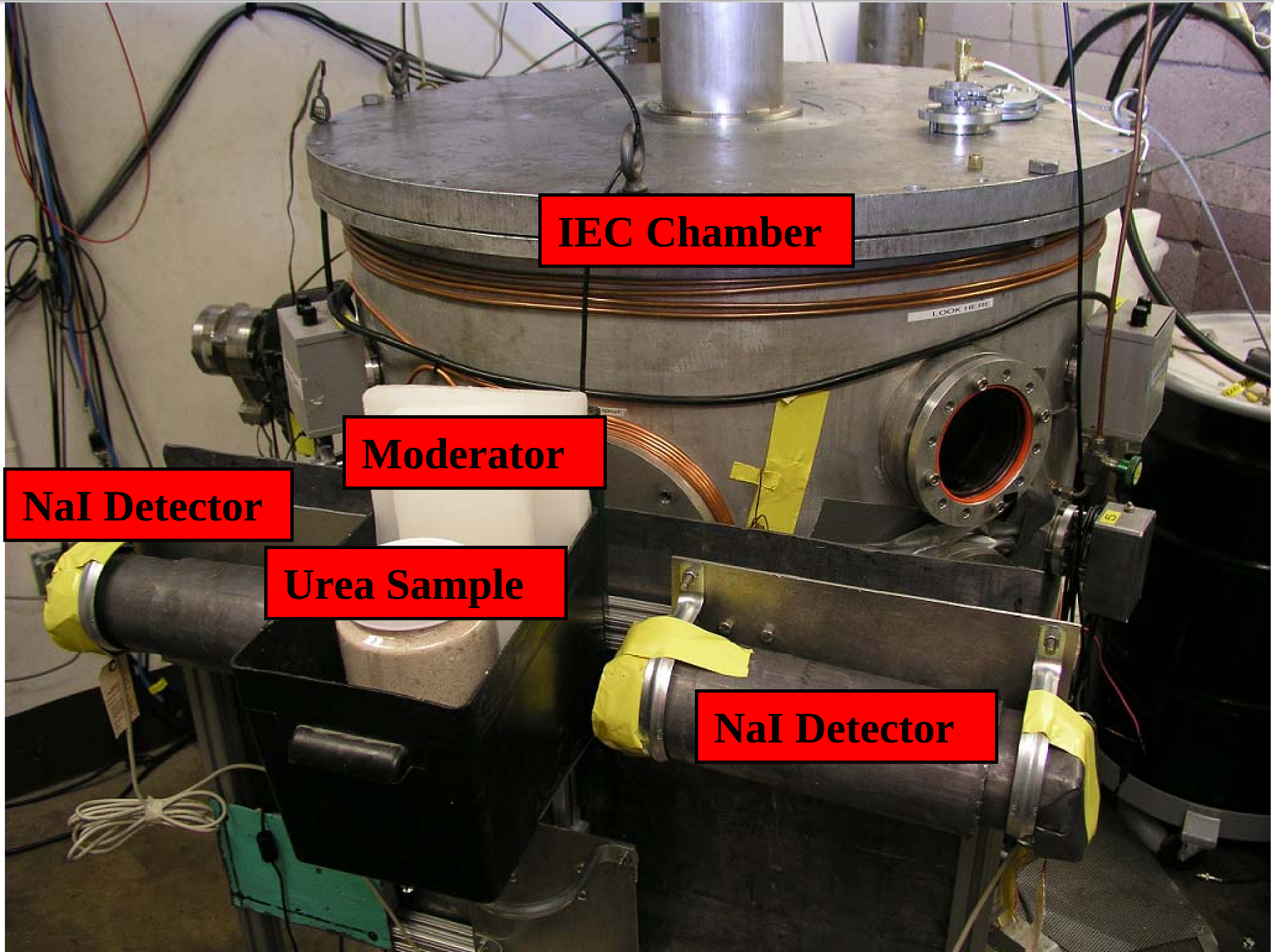
- Shielding of detector setup was provided by lead bricks, which allowed x-rays to penetrate in through cracks between the bricks
- Moderator between the IEC chamber and the detector caused excessive activation of the Iodine in the NaI crystals
- Only one detector was used, minimizing the amount of the solid angle surrounding the sample that could be detected

The detector setup was changed to address some issues with the previous research

- Three NaI(T1) detectors are now in use
- All three are oriented on the same plane in a three-sided cross with the sample in the center
- The plane on which the detectors lie is parallel to the surface of the chamber
- 8 cm of paraffin wax is used as moderator between the sample and the chamber

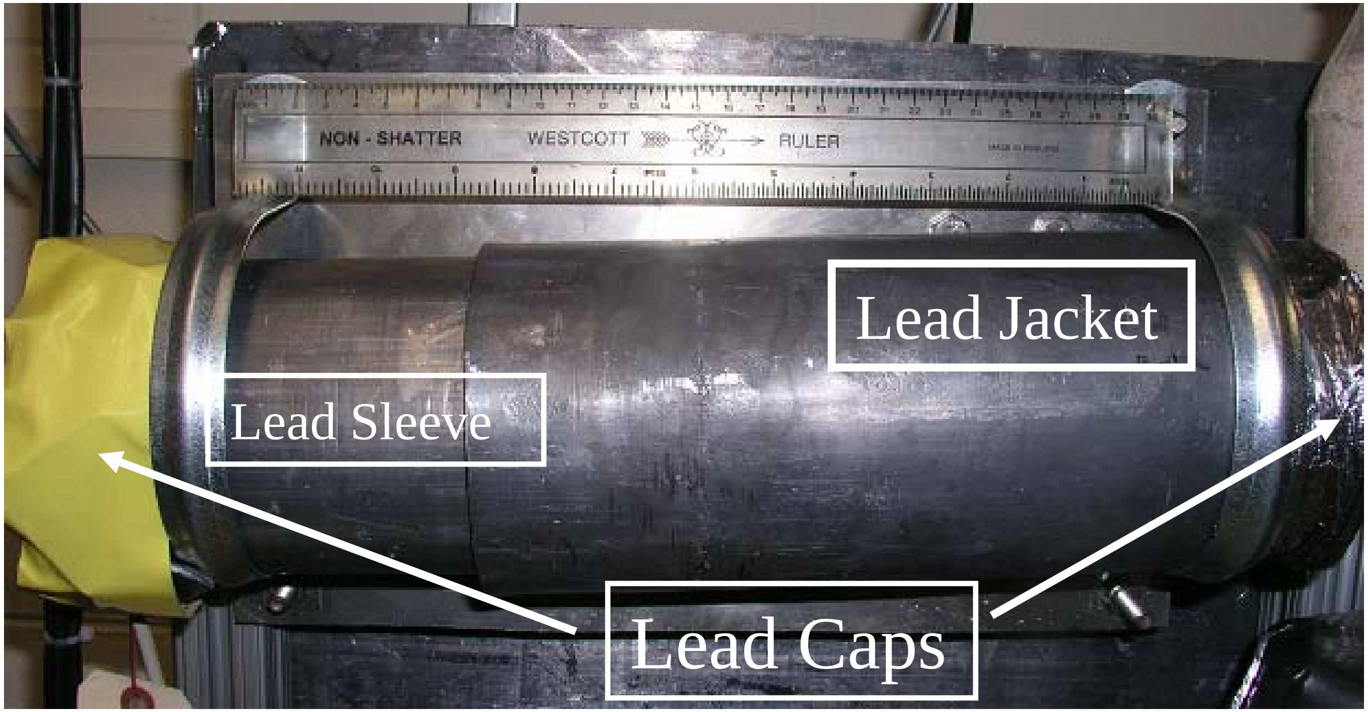


Experimental Configuration



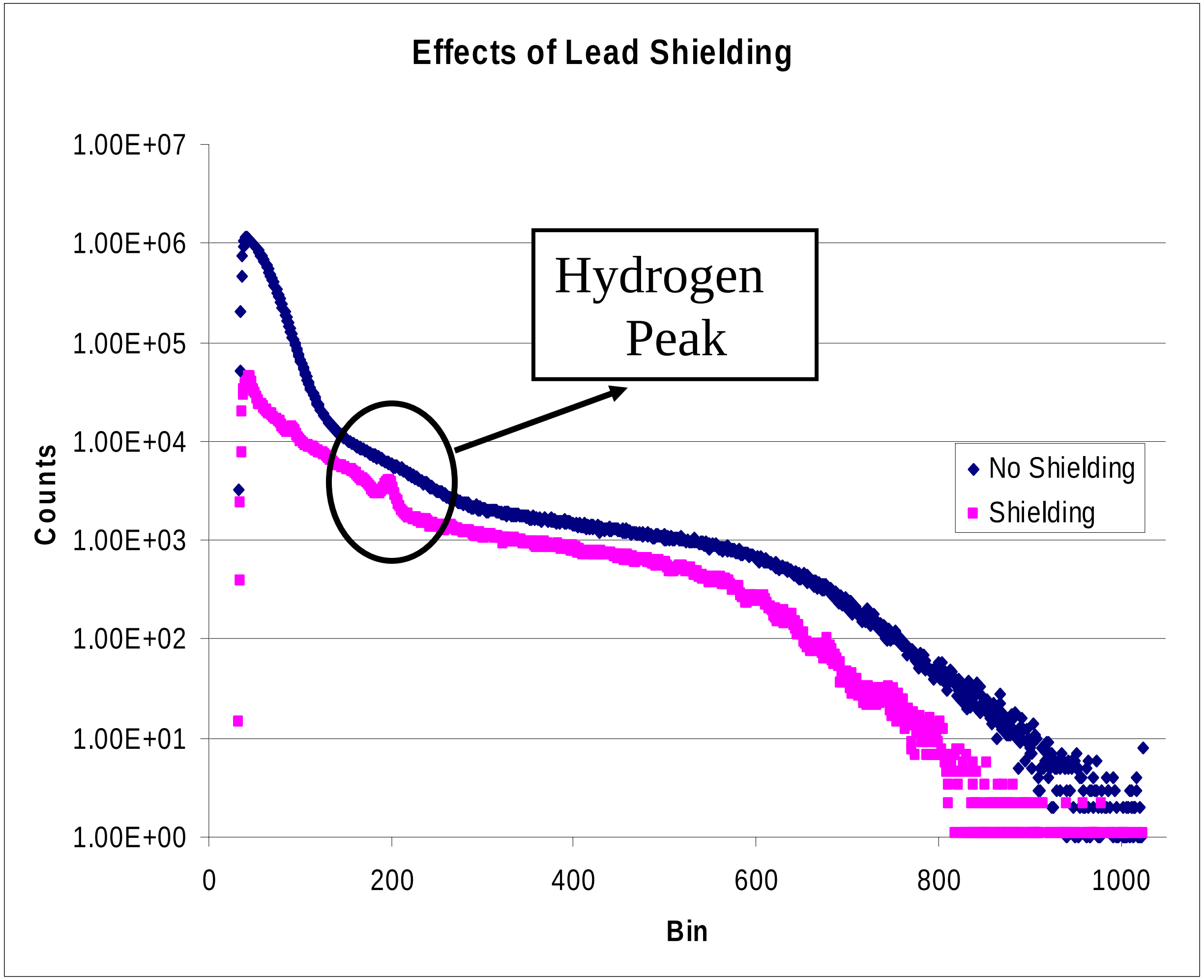
Shielding issues with the NaI detector were addressed to minimize background noise

- To address shielding concerns, each detector was shielded individually
- All detectors are now shielded on all sides by minimum 0.32 cm of lead with maximum of 1 cm of lead shielding between IEC source and NaI crystals



Current NaI detector shielding has proven successful at screening out noise

- Shielding configuration has been quite effective at screening out low energy x-rays and allow for more clearly defined peaks



Urea has been chosen as the sample for preliminary interrogation experiments

- Urea is an organic compound with chemical formula $(NH_2)_2CO$
- Urea is primarily used as fertilizer
- At around 45% nitrogen by mass, it has the highest nitrogen content of any solid nitrogeneous fertilizer in common use
- This high nitrogen content is why it was chosen for testing interrogation methods

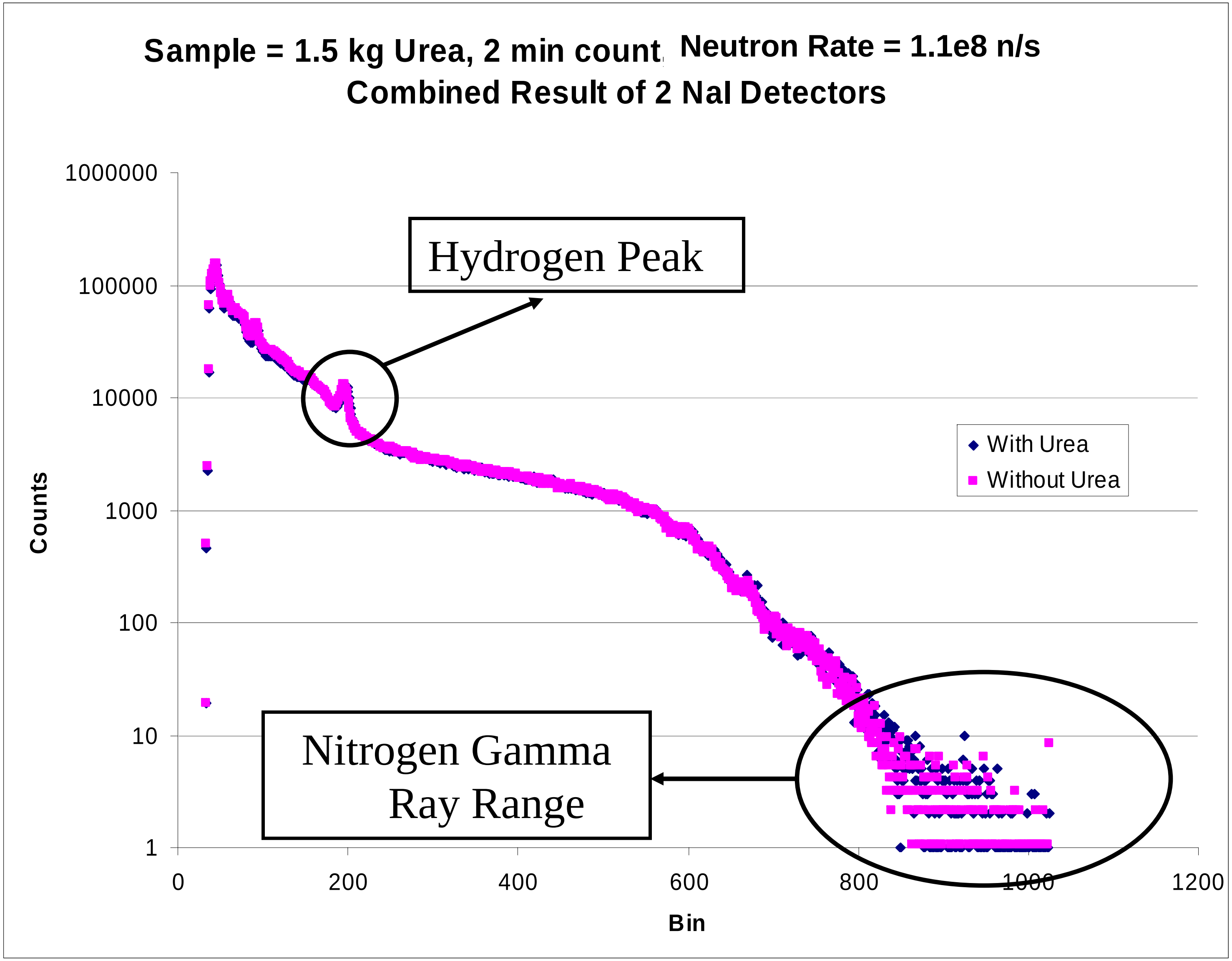
Experimental Procedure

- Experiments are typically performed with neutron rates of at least $1x10^8$ neutrons/second
- Runs are performed for 15 to 30 minutes
- A series of scans of photon energy from the NaI detectors are recorded ranging in length from 2 to 5 minutes
- The scans are performed first with the sample of Urea in place
- The machine is then shut down and the sample is removed
- Operation is then reinitialized and another series of photon energy scans are performed with no sample

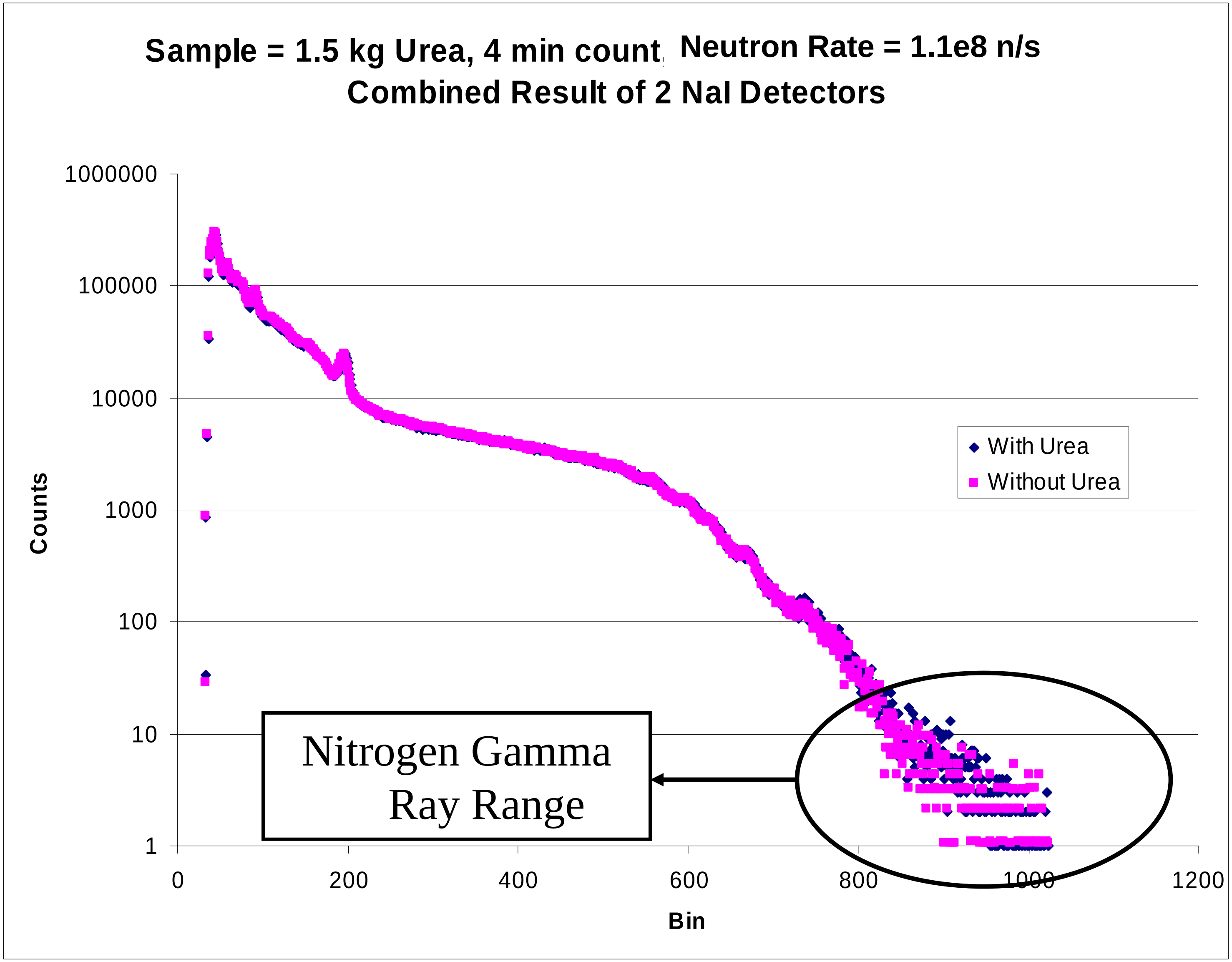
Analysis of Results

- The scans recorded with and without the sample of Urea are compared
- The hydrogen peak is typically clearly identifiable and is useful for:
  - Calibration of the energy spectrum
  - Compensating for slight differences in neutron rates by lining up the height of the hydrogen peak

Preliminary Results: 2 min count, $1.1x10^8$ n/s



Preliminary Results: **4 min count**, 1.1x10^8 n/s



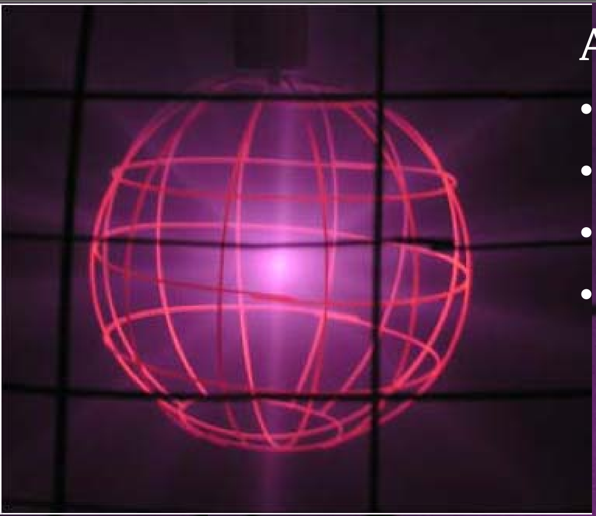
Preliminary Results

- Shielding efforts appear to be successful at screening out excess noise
- Hydrogen peak is reliably identifiable
- Preliminary results indicate a higher number of counts in the nitrogen gamma ray energy region when sample is present
- These results demonstrate initial progress and mandate further work to improve the nitrogen signal

Future Plans

- Place neutron reflecting material, most likely H_20, behind the sample to increase neutron flux into the sample from all directions
- Use MCNP analysis to determine moderator thickness that optimizes the number of thermal neutrons reaching the sample
- Experiment with using D_20 as a moderator as opposed to Paraffin Wax
- Look into alternative forms of gamma ray detection
  - BGO Crystals as opposed to NaI Crystals
  - High Purity Germanium Detectors

Questions?



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