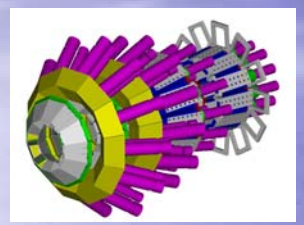
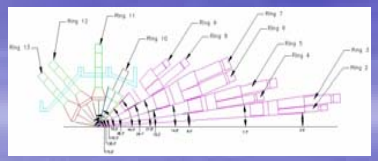
CsI Detectors of NIMROD

Kyunghee Cho, UCLA
REU 2004 – Texas A&M University – Cyclotron Institute
Mentor: Joseph Natowitz

NIMROD

- *N*eutron *I*on *M*ultidetector for *R*eaction *O*riented *D*ynamics
- Charged particle detectors composed of ionization chambers, silicon telescopes, and CsI(Tl) scintillators
- Used to study dynamics and thermodynamics of nuclear reactions – good energy and atomic number resolution required to obtain useful information



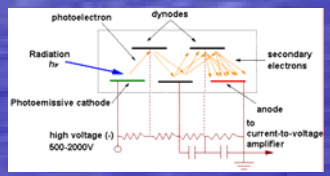


- **168 CsI(Tl)**
  - 6 rings of 12 detectors between 3 and 35 degrees.
  - 2 rings of 24 detectors between 30 and 45 degrees
  - 2 rings of 16 detectors between 45 and 100 degrees.
  - 2 rings of 8 detectors between 100 and 140 degrees.
- **Silicon Telescopes per ring:**
  - 2 (150 + 500 microns) (Super Telescopes)
  - 1 150 microns
  - 2 300 microns
- **96 Ionization chambers**

CsI Detectors

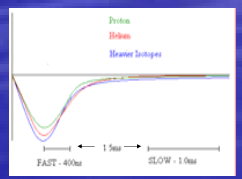
Charged Particle → CsI (Tl) → Photomultiplier tube

- Charged particle interacts with electrons in detector material – creates ion path
- Energy released by excited thallium atoms give off radiation of varied wavelengths
- Photon hits photocathode, which knocks out an electron which hits dynodes and knocks out linearly increasing number of electrons
- Amplified signal collected

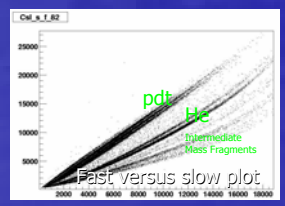


Photomultiplier Tube

Photomultiplier output – pulse shape discrimination



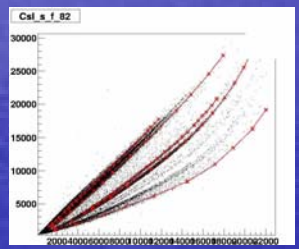
- Energy levels measured at two gates
- Differences in charge densities of different isotopes produce different amplitudes in the signal



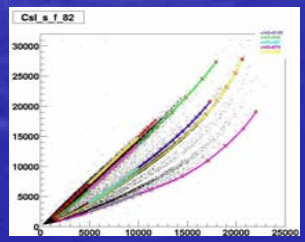
Fast versus slow plot

Determination of CsI Detector Resolution

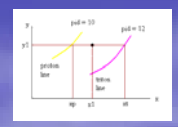
In order to determine resolution of CsI detectors (168 of them), a specified region of each detector's fast versus slow spectrum was linearized, using ROOT based programs.

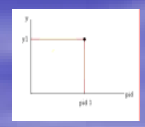


1. Manually clicked points on top of lines of proton, triton, $^3He^+$, and alpha particles

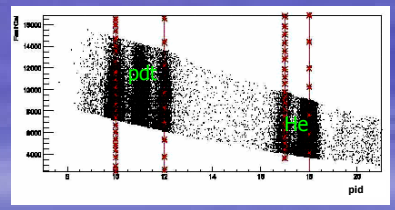


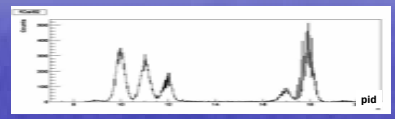
2. Program fitted smooth lines to selected points:
   - First set of lines: maximum 7th order polynomial
   - To a specified region of the spectra, added a second of set of lines: maximum 2nd order polynomial



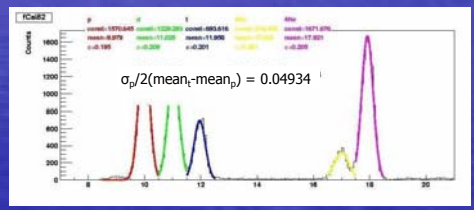


- d = xt - xp
- pid1 = 12 (x1 – xp)/d + 10 (xt – x1)/d





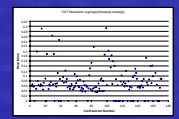
3. Linearized Cuts Projected to pid-axis

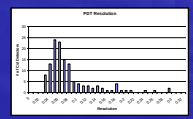


4. Gaussian Fit and Resolution Determination

Divided the width of the proton peak by twice the distance from the proton peak to the triton peak to obtain resolution

Results





- Most detectors have similar resolution (range ~0.04 - ~0.08)
- 49.4% have good or fair resolution (0.02 – 0.08)
- Some very poor detectors

Possible reasons for poor resolution

Impure crystals

Surface scattering – crystals require Mylar cover in addition to Teflon cover

Bad electronics – time jitter introduced by incorrect delay in discriminator

What now?

Correlate pdt resolution to resolution for curves of heavier isotopes

Match good CsI detectors with good Si detectors – optimize charged particle detection