Nuclear Temperature and Moving Source Analysis

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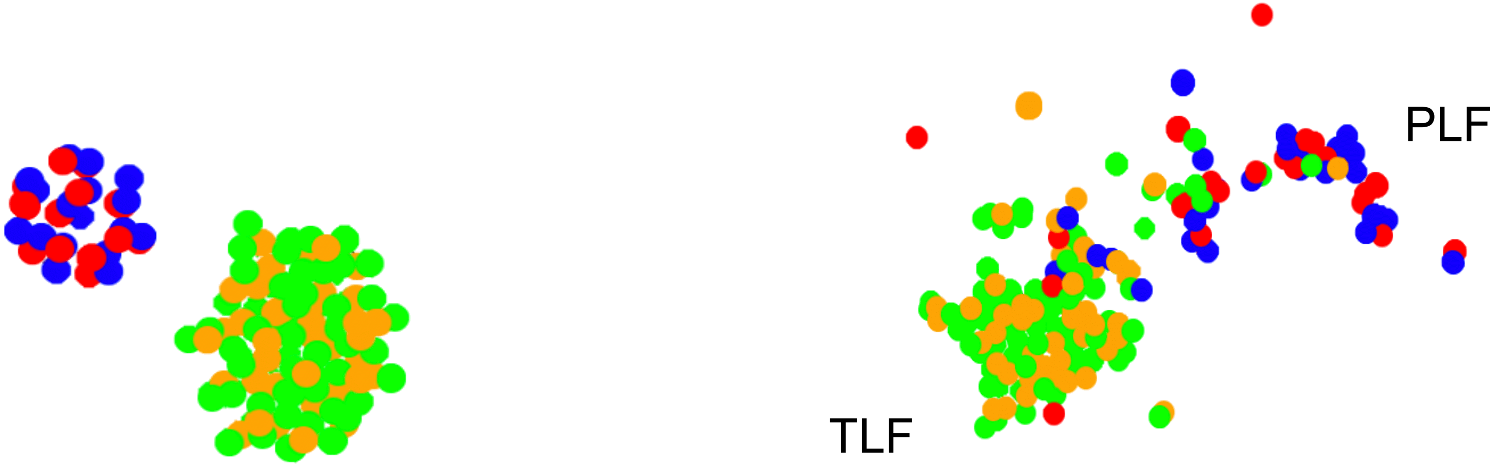
Overview

Analyze nuclear collision data collected from NIMROD, with a moving source fit, in order to obtain more information about the reaction that is occurring. Specifically we want to obtain information about the temperature of the reaction.

Peripheral Collision



PLF (Projectile Like Fragment)

TLF (Target Like Fragment)

NN (Nucleon-Nucleon Interaction)

Particle Emission

During the collision particles are emitted according to a Maxwell-Boltzmann distribution. This means the number of particles emitted with a given energy will be proportional to the reaction temperature and the energy of the source. The equations that describe this distribution follow:

$$\eta(E_{CM}) = E' \cdot e^{\frac{-E'}{T}}$$

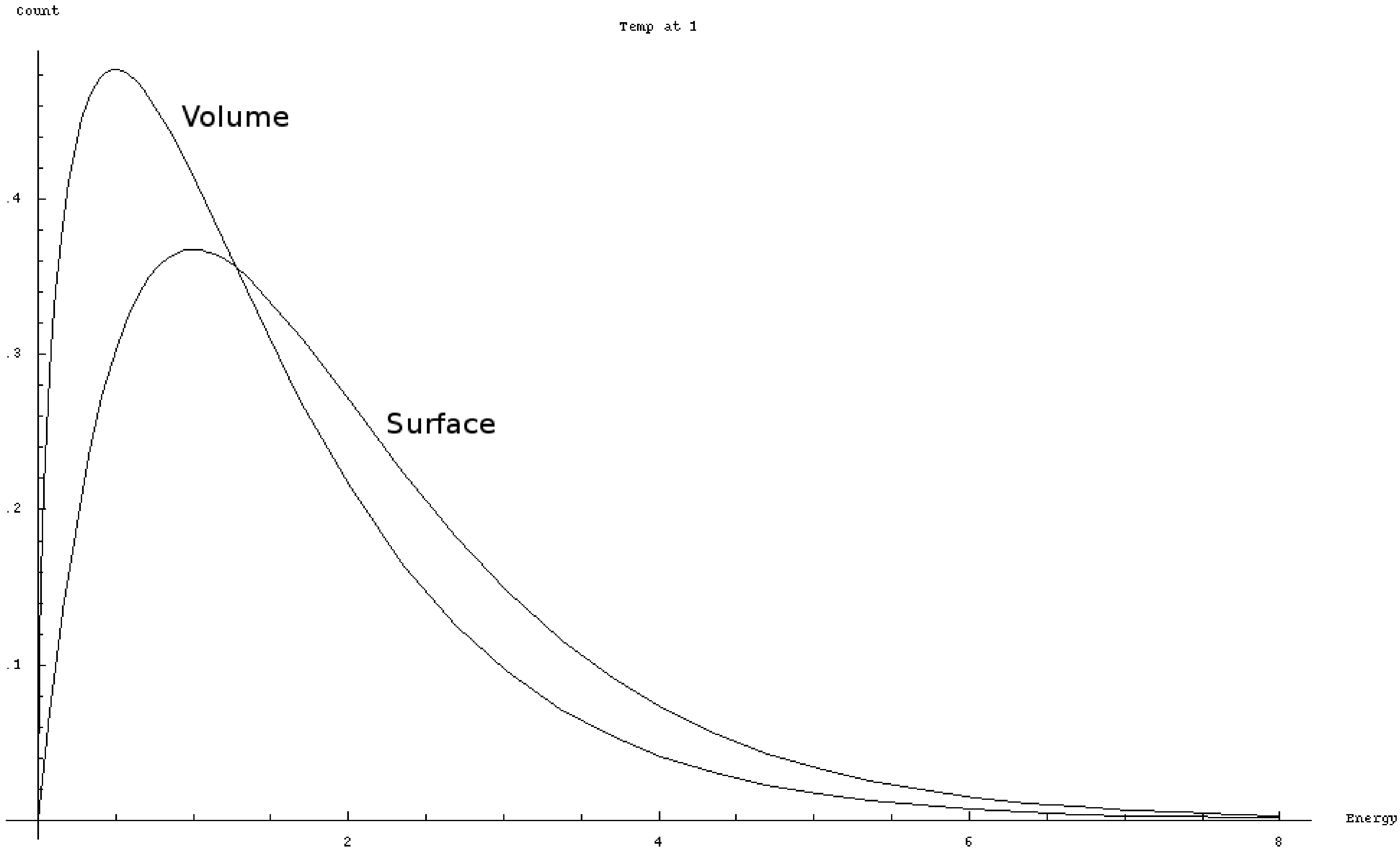
Surface Emission

$$\eta(E_{CM}) = \sqrt{E'} \cdot e^{\frac{-E'}{T}}$$

Volume Emission

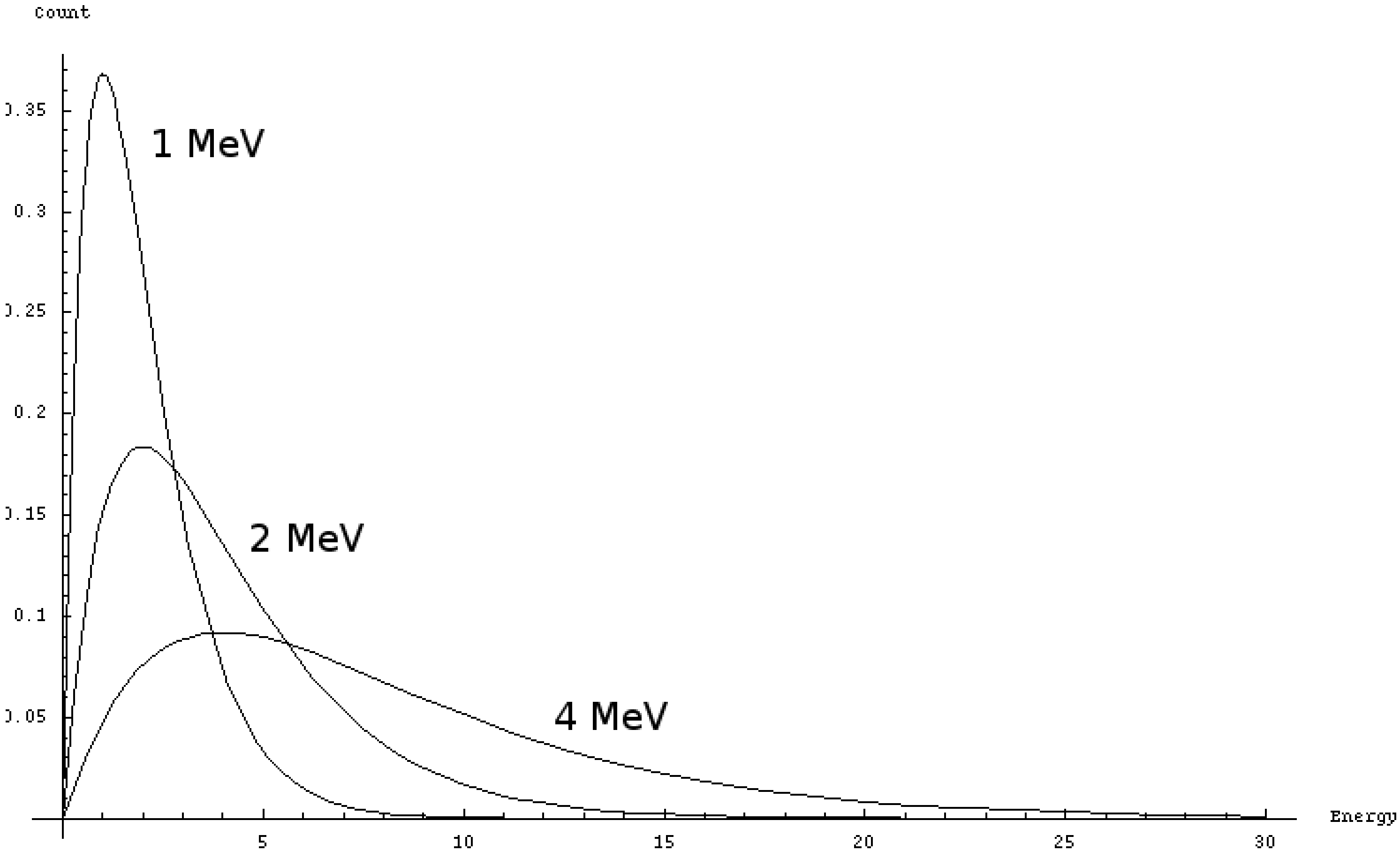
where

$$E' = E_{CM} - E_c$$



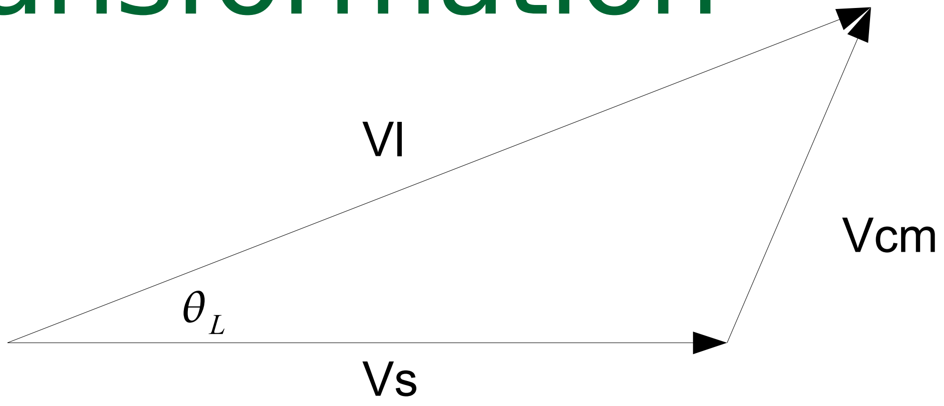
T = 1 MeV Ec = 0 MeV

Volume Type



Ec = 0 MeV

Lab Transformation



The law of cosines can be used to show that

$$E_{CM} = E_{LAB} + E_{SOURCE} - 2 \cdot \sqrt{E_{LAB} \cdot E_{SOURCE}} \cdot \cos(\theta_L)$$

A jacobian is also needed for the transformation

$$\eta(E_{LAB}) = \eta(E_{CM}) \cdot \sqrt{\frac{E_{LAB}}{E_{CM}}}$$

Transformed Equations

The energy spectra of the emitted particles, after conversion to the laboratory reference frame, are represented by the equations

$$\eta(E_{LAB}) = E' \cdot e^{\frac{-E'}{T}} \cdot \sqrt{\frac{E_{LAB}}{E''}}$$

for surface emission and

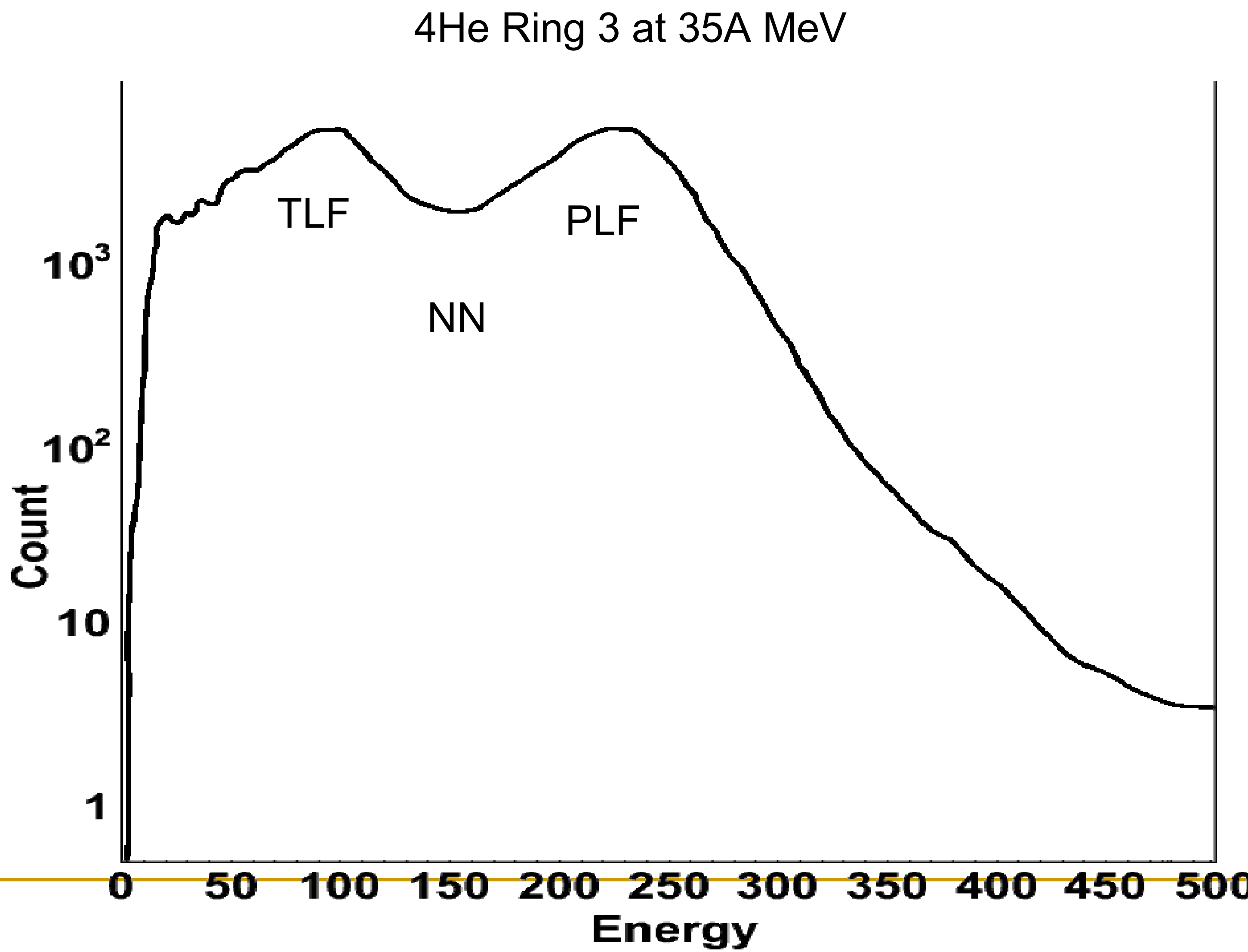
$$\eta(E_{LAB}) = \sqrt{E'} \cdot e^{\frac{-E'}{T}} \cdot \sqrt{\frac{E_{LAB}}{E''}}$$

for volume emission where

$$E'' = E_{LAB} + E_{SOURCE} - 2 \cdot \sqrt{E_{LAB} \cdot E_{SOURCE}} \cdot \cos(\theta)$$

$$E' = E'' - E_c$$

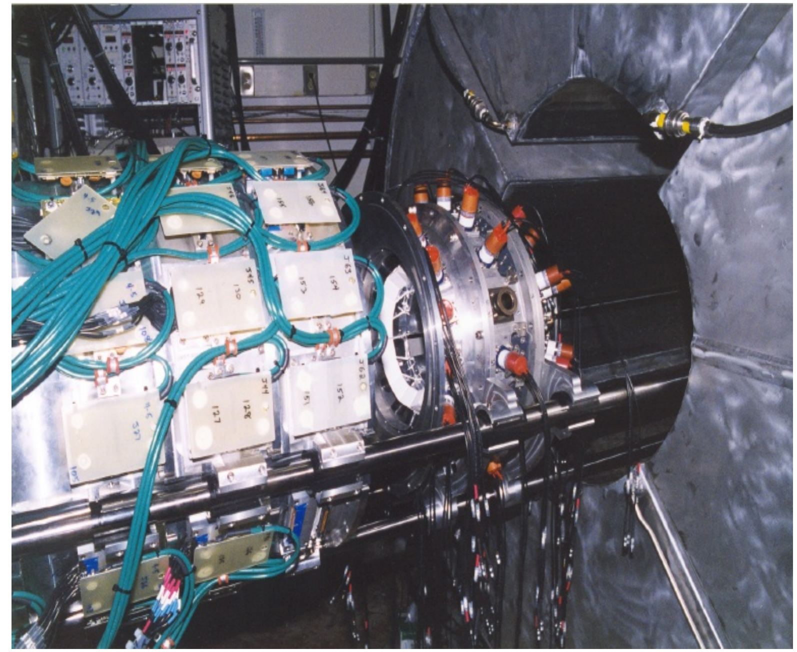
Collected Data



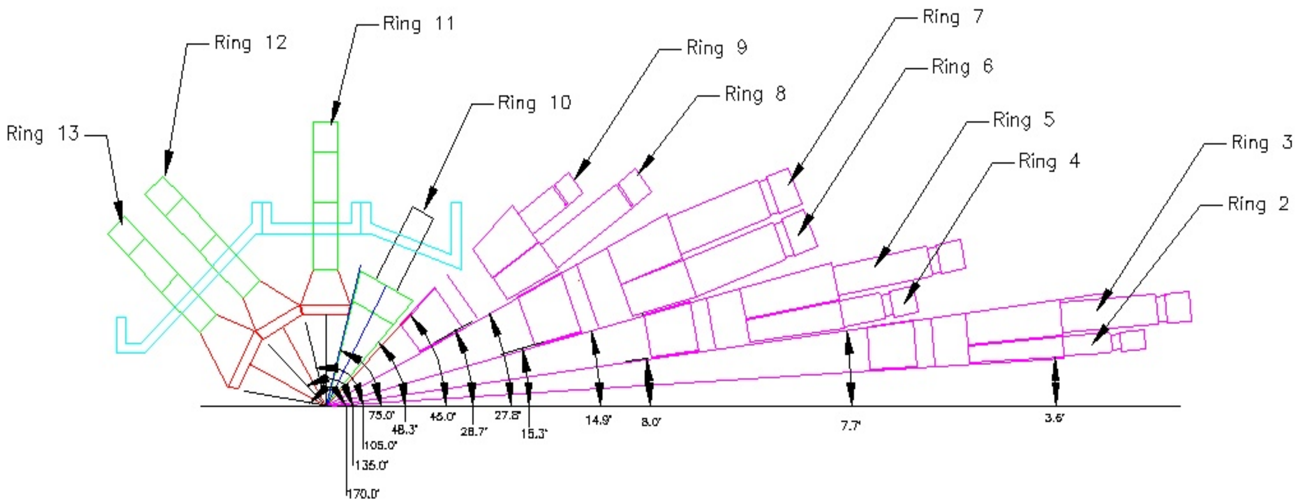
NIMROD

NIMROD, Neutron Ion Multidetector for Reaction Oriented Dynamics, is a 4 pi neutron and charged particle detection system. It is able to select collisions according to their impact parameter. Charged particles are detected using 96 charged particle detection modules which consist of a gas ionization chamber, one or two silicon detectors and one or two CsI detectors.

NIMROD



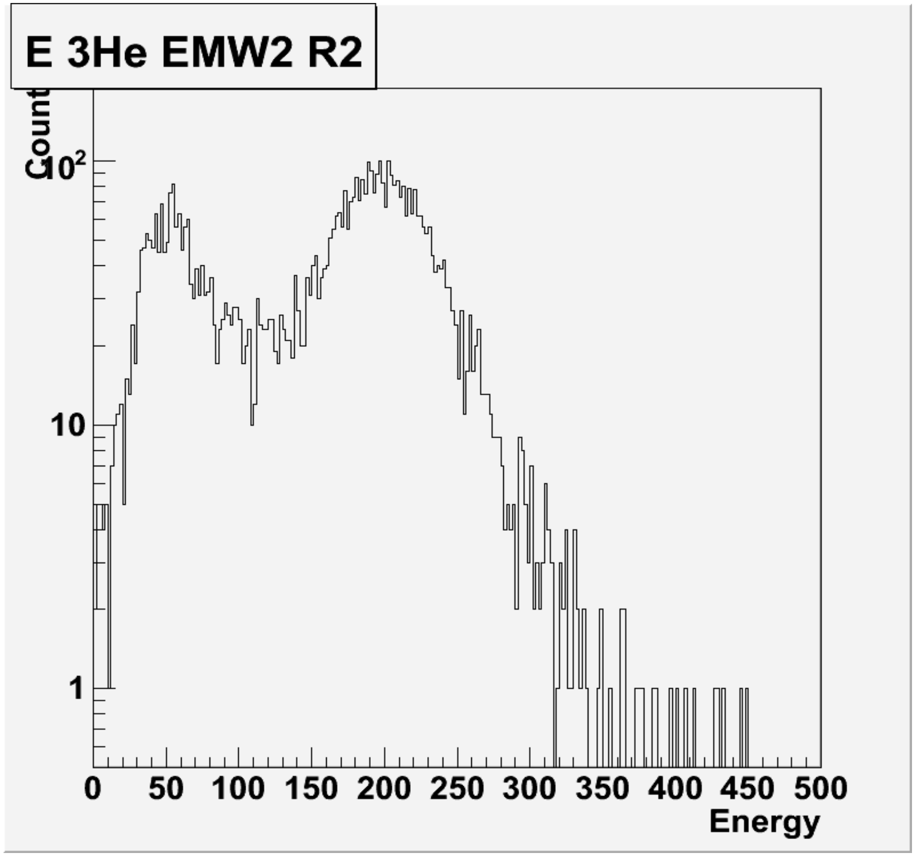
NIMROD RING NUMBERING
ANGULAR COVERAGE

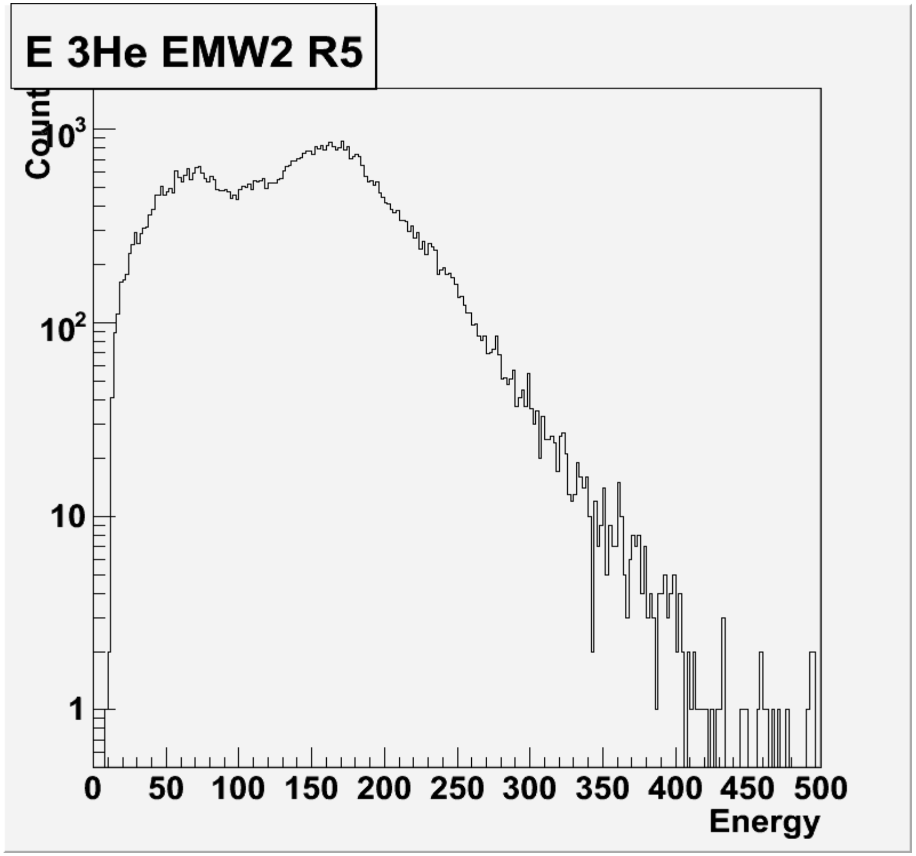


Data Collection

- T data are collected from NIMROD, a 4 pi detector that can select collisions according to their violence.
- Collected from two different runs with ^{64}Zn on ^{92}Mo. One at 47A MeV and one at 35A MeV.
- The data are from four rings of detectors at 4.5, 6.4, 9.43, and 12.93 degrees, relative to the particle beam.
- The observed angles only go through 8.5 degrees, so all data are from very forward angles.

Example Data

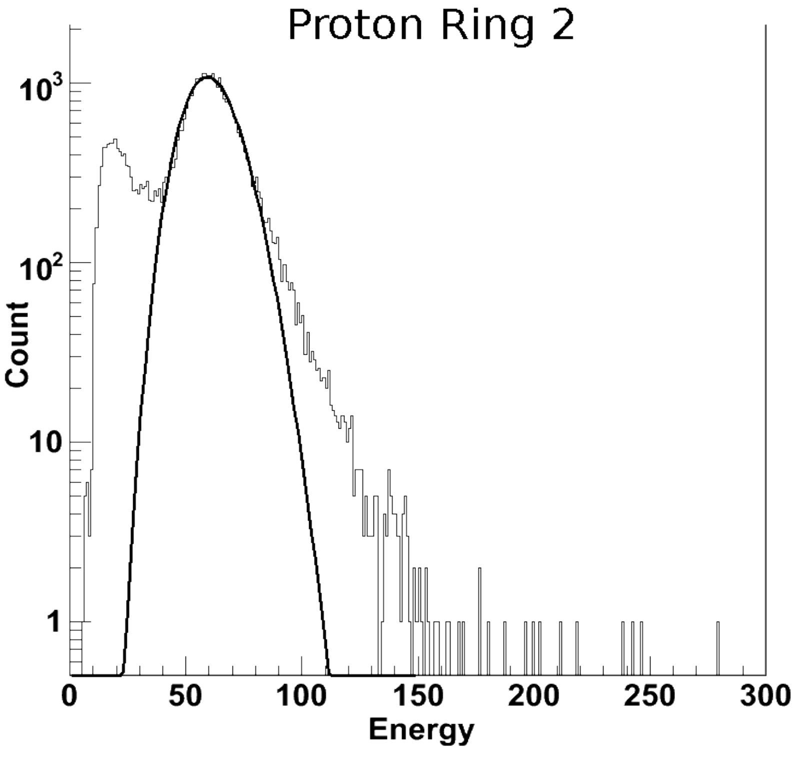


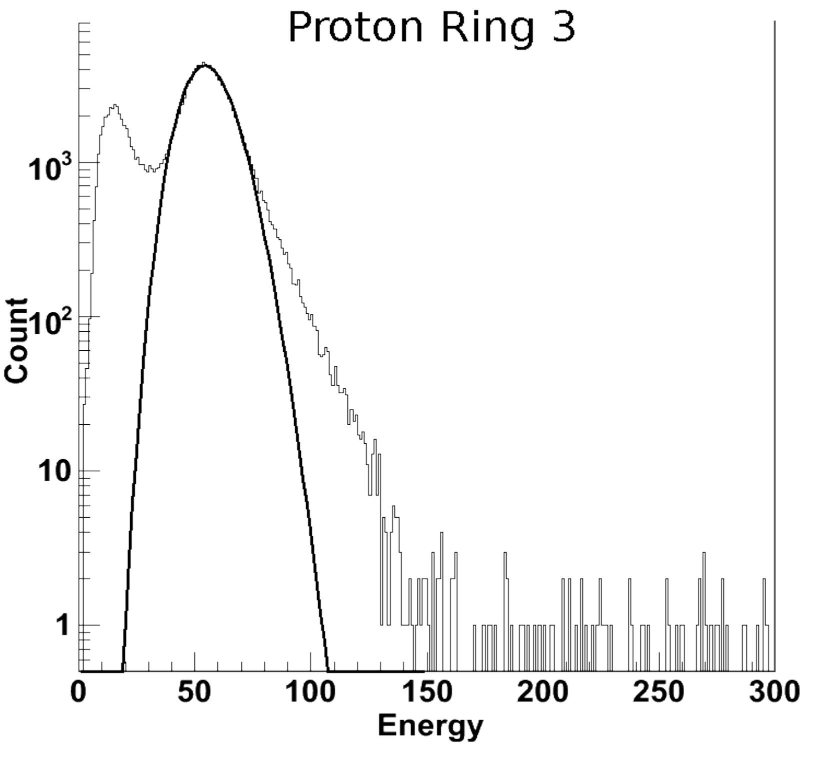


Data Analysis

- All analysis was done using a program I wrote using ROOT. ROOT is an object oriented data analysis framework developed by CERN.
- The fits were done for the PLF, ring 3, using the volume formula.
- The values for that fit were then applied to the other rings to check for accuracy and consistency

35A MeV Proton Emission

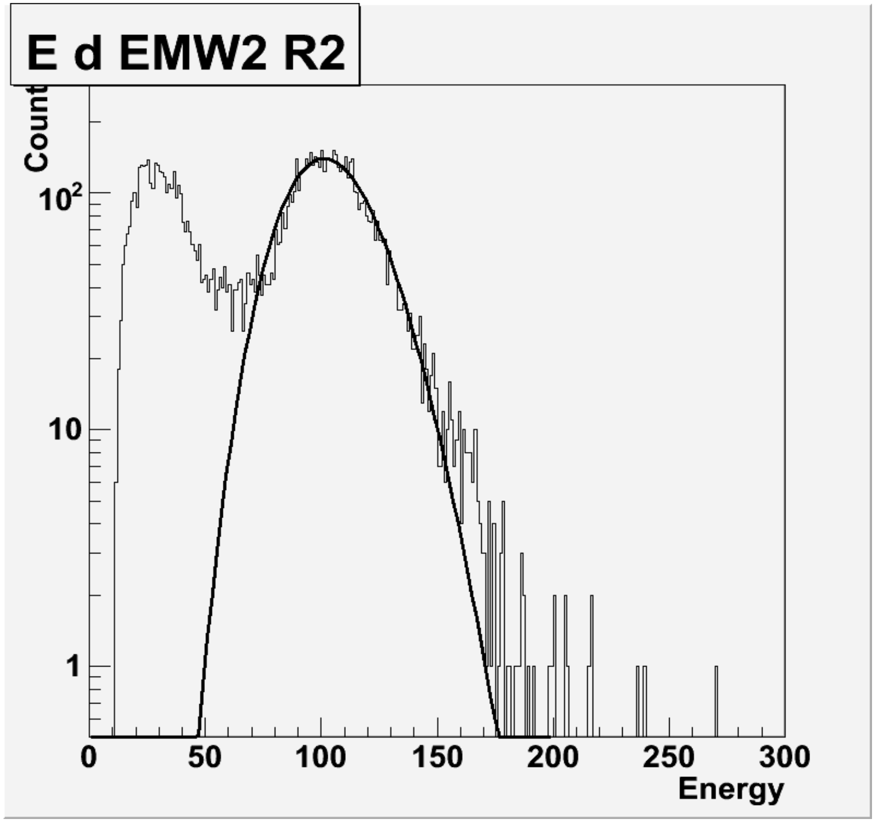


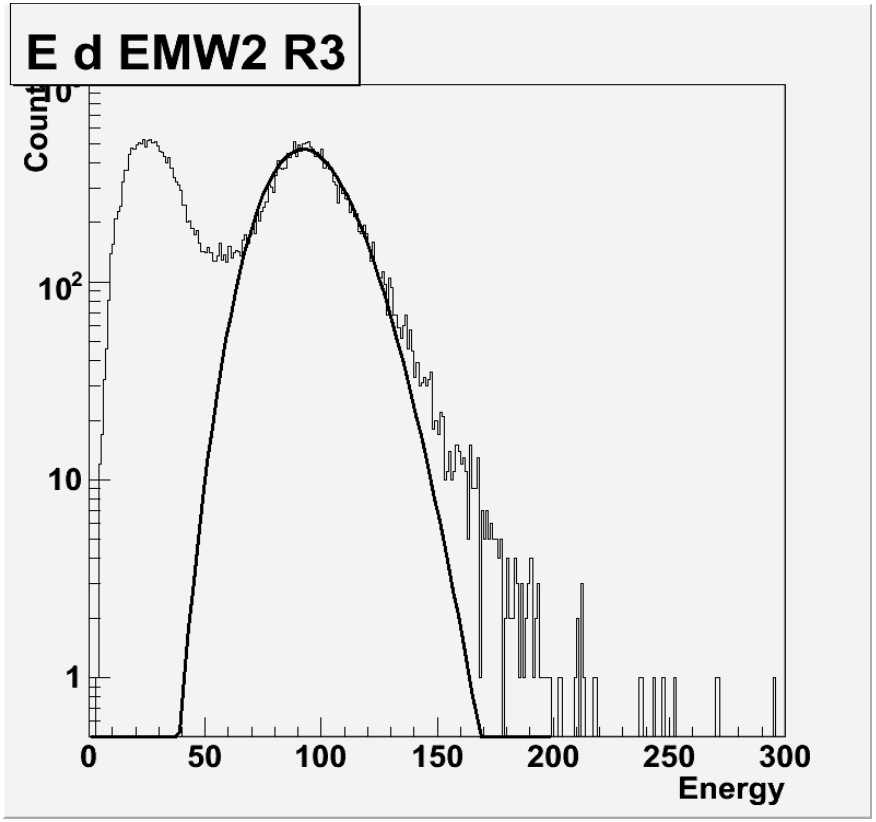


T=1.0 MeV

V=10.11 cm/ns

35A MeV Deuteron Emission

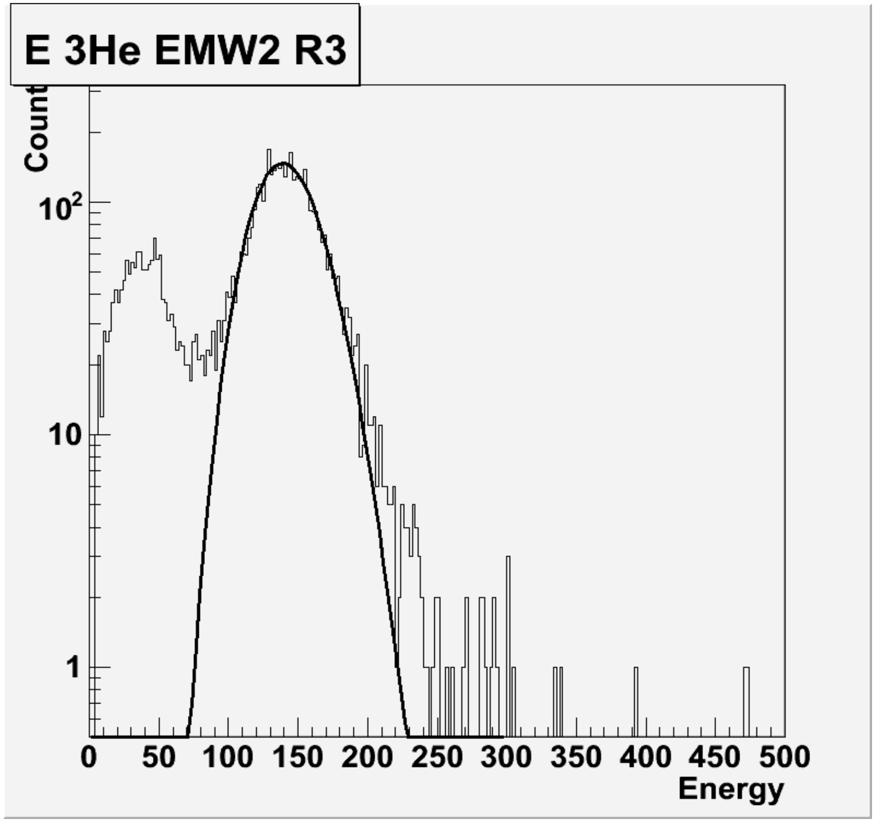


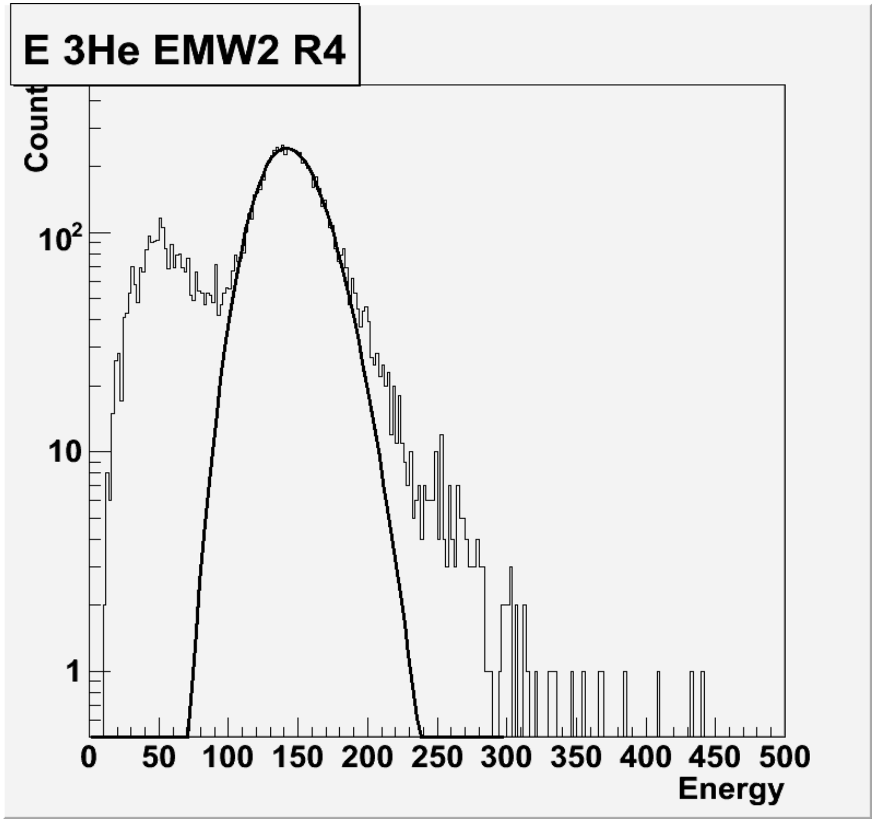


T=1.68 MeV

V=9.35 cm/ns

35A MeV 3He Emission

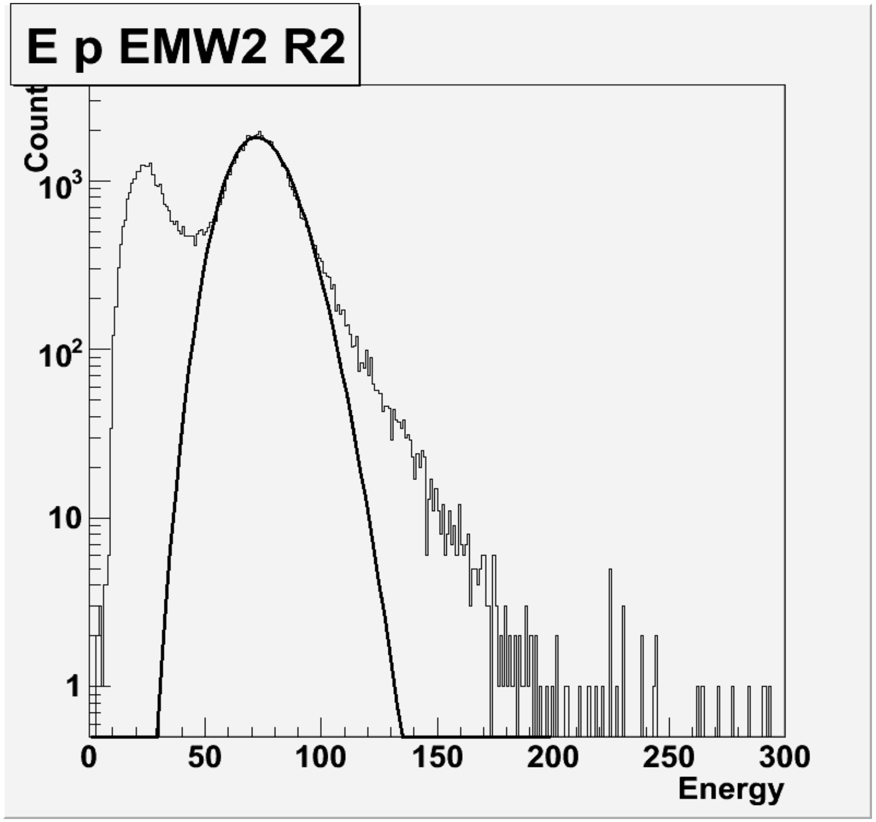


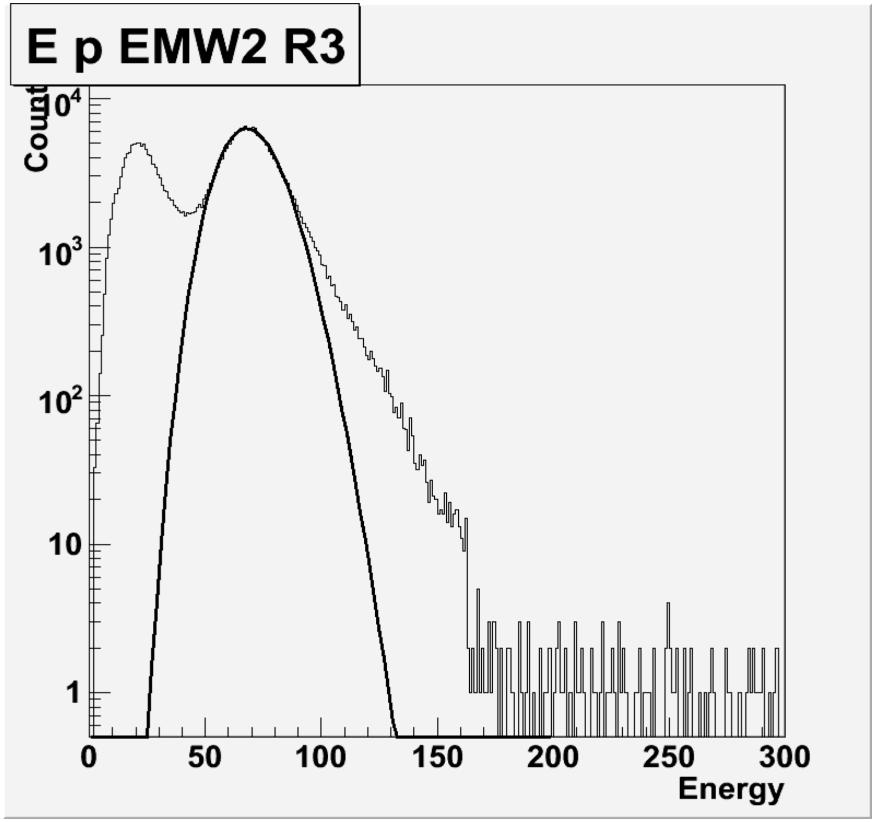


T=1.94 MeV

V=9.39 cm/ns

47A MeV Proton Emission

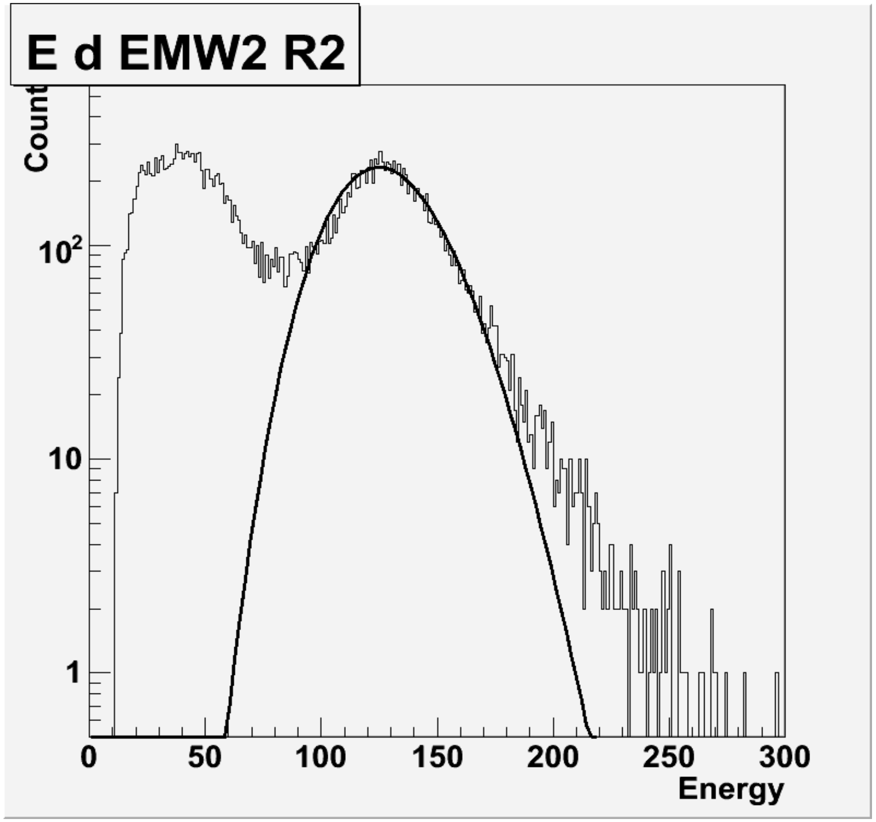


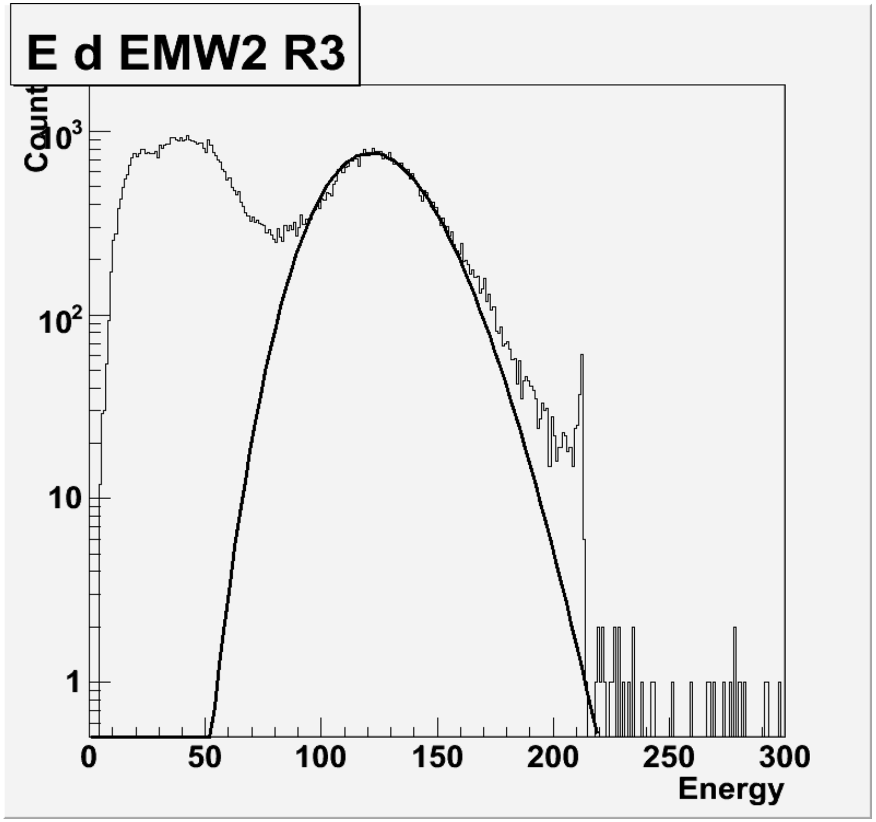


T=1.13 MeV

V=11.3 cm/ns

47A MeV Deuteron Emission

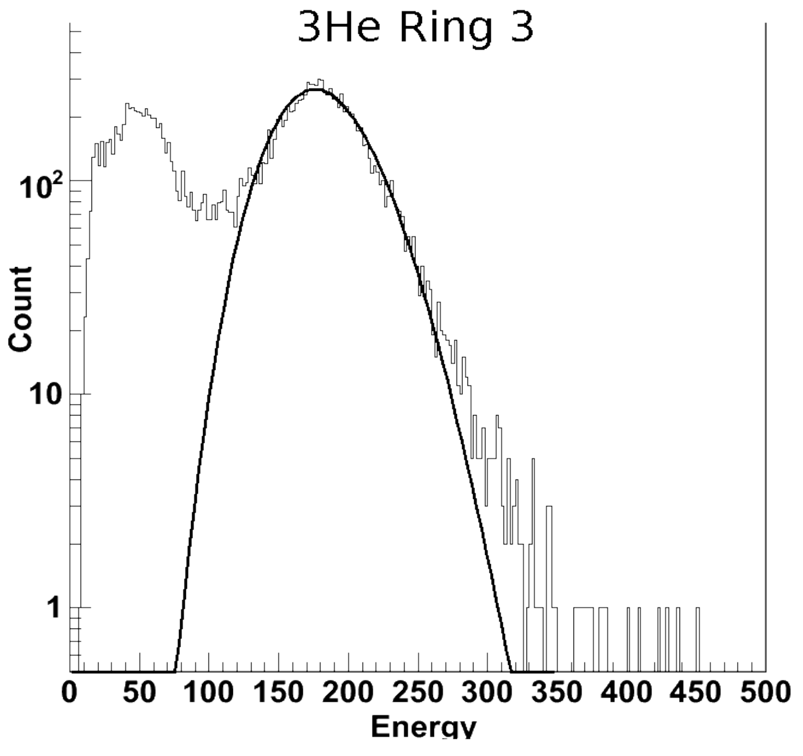


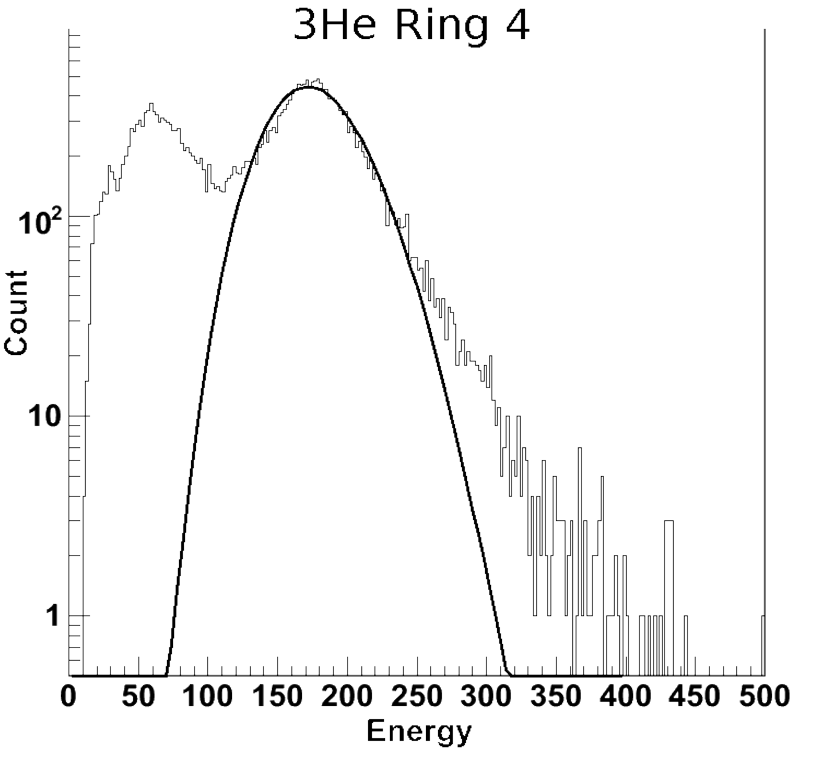


T=1.98 MeV

V=10.78 cm/ns

47A MeV 3He Emission





T=3.31 MeV

V=10.45 cm/ns

Results

By adjusting the parameters of the energy spectra equations, and trying to achieve the most accurate fit, we were able to uncover information about the system. The temperature of the reaction and the velocity of the source beam were the two main parameters we were looking for. The results of the fits were comparable to the expected values. The 47A run had higher velocity and temperature parameters than the 35A run. Also the emission temperatures of particles increased with the complexity of the particle.

Whats Next?

The next step is to perform a multi source analysis. This will allow for a fit that will take all three sources of particles (PLF, NN, TLF) into consideration, and will result in a much more accurate fit. From this fit we could get much more accurate results then the solitary PLF analysis done here.

Acknowledgments

- Dr. Roy Wada
- Dr. Joseph Natowitz
- Texas A&M Cyclotron
- REU Administrator – Dr. Sherry Yennello
- National Science Foundation