Investigation of ^{238}U Fission Properties at LANSCE

Dana Duke

FIESTA 2014

Santa Fe, NM

LA-UR-14-26967

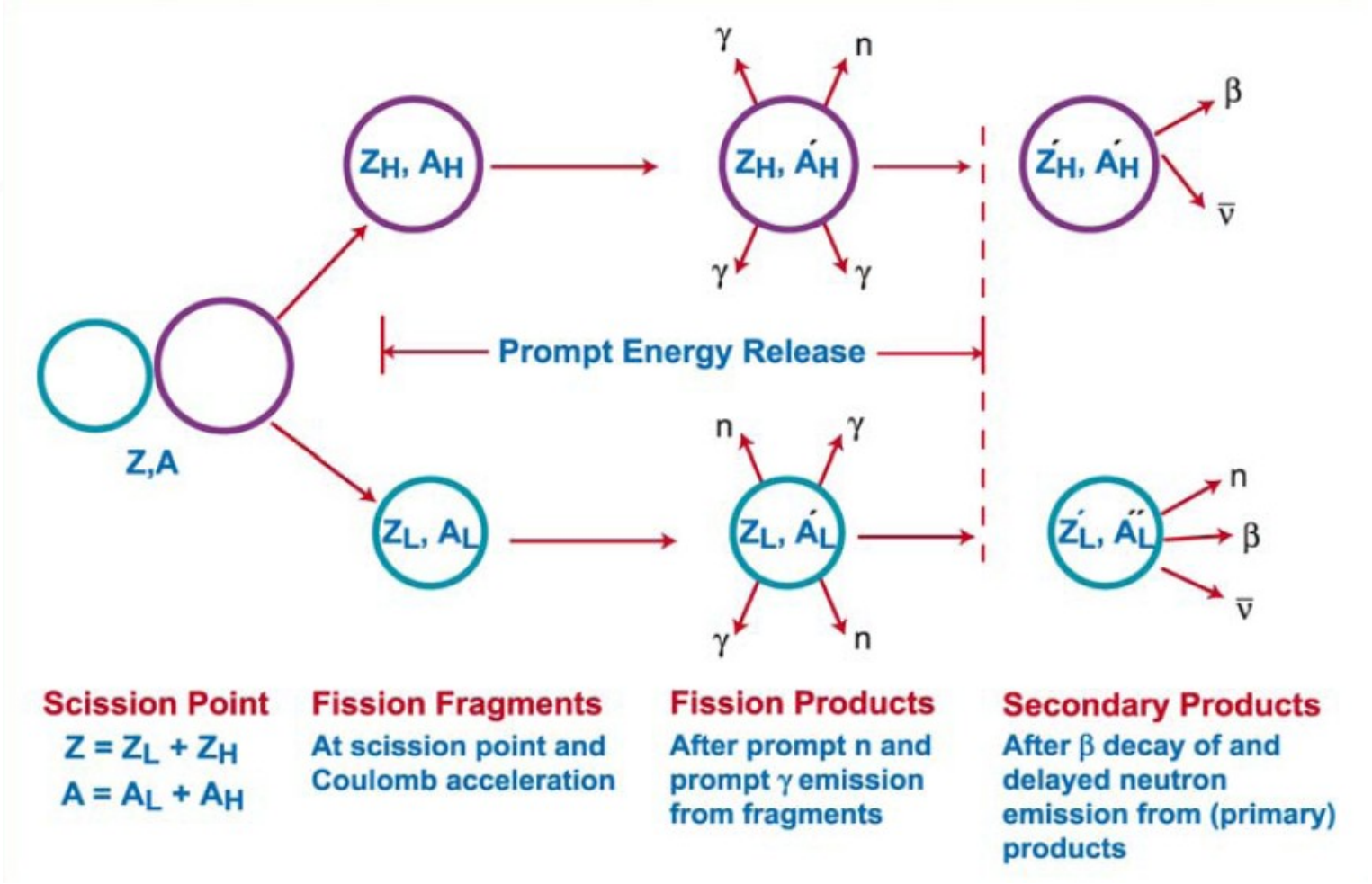
- Open questions in fission regarding energy dependency of average TKE and mass yield distribution remain.

- The energy release and mass distributions of ^{238}U are important for applications, theory, and evaluations.

- We seek to measure the evolution of fission properties with increasing incident neutron energy for ^{238}U using a Frisch-gridded ionization chamber.

- This is the first step in developing a technique to measure fission properties of the major actinides, ^{235}U and ^{239}Pu.

Energy Release in Fission

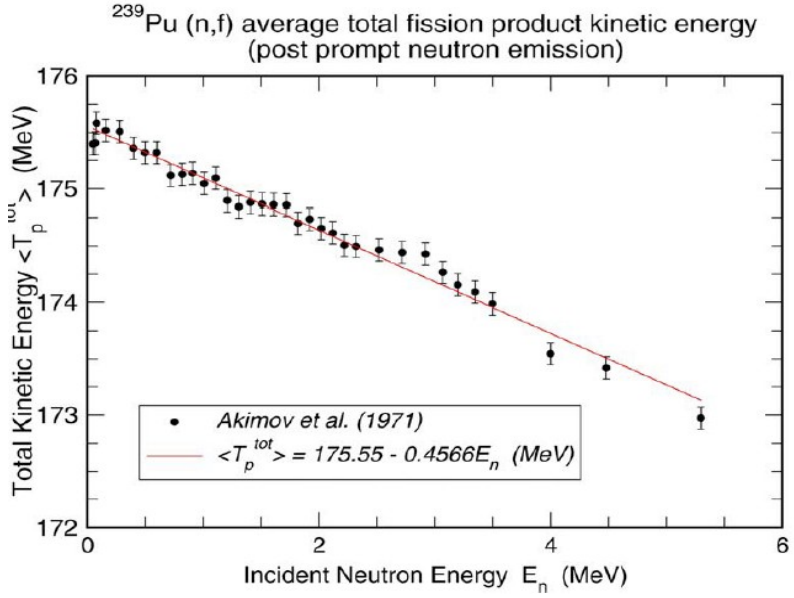


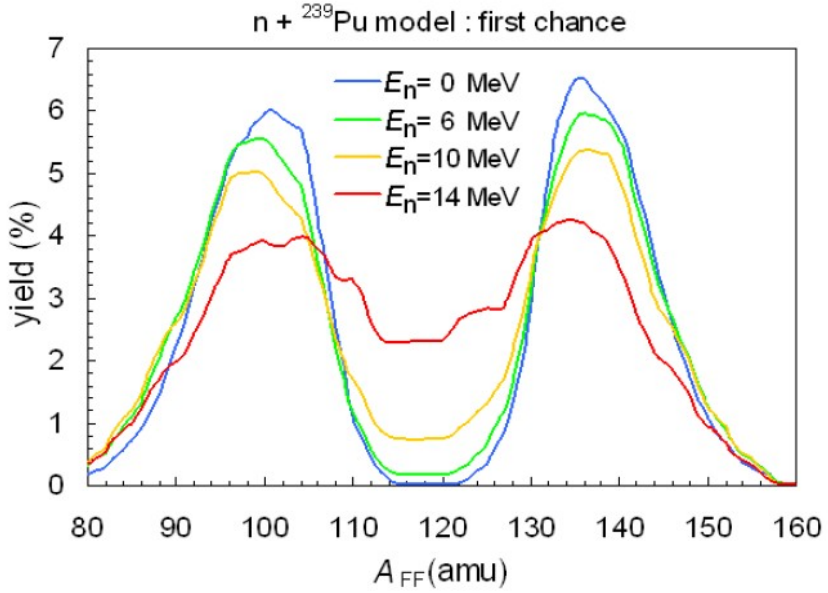
[**Madland, D.** *Nuclear Physics A*, 2006, 772, 113 - 137]

Motivation and Goals

- Improving understanding of energy release in fission requires experimental data. This data is used to test theories and to develop fission models that have both defense- and energy-related applications.

- Existing data at a wide range of incident energies is lacking





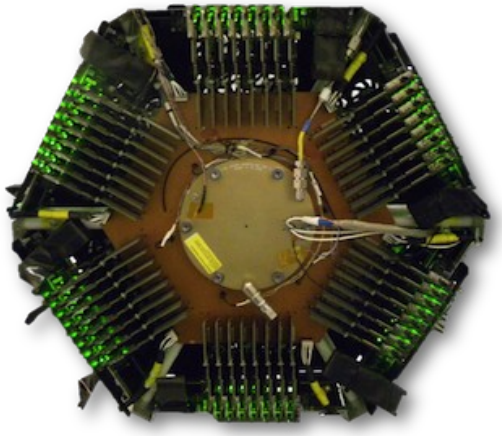
[**D.G. Madland**, Nuclear Physics A 772 (2006) 113-137] [**Lestone, J.** Nuclear Data Sheets , 2011, 112, 3120 - 3134]

Support Fission Experiments at LANCE

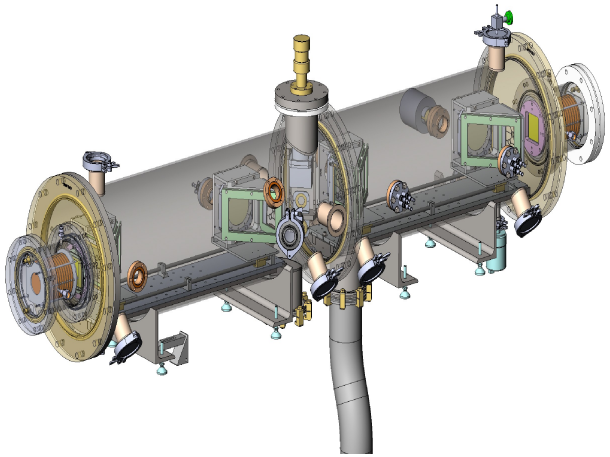
- Many fission experiments run at LANSCE using new kinds of detector technology

- Tested technology and methods applied to a new problem (high incident E_n) will provide a global understanding of how fission properties change with neutron energies.

- This work adds weight to the forthcoming results of the novel detectors.

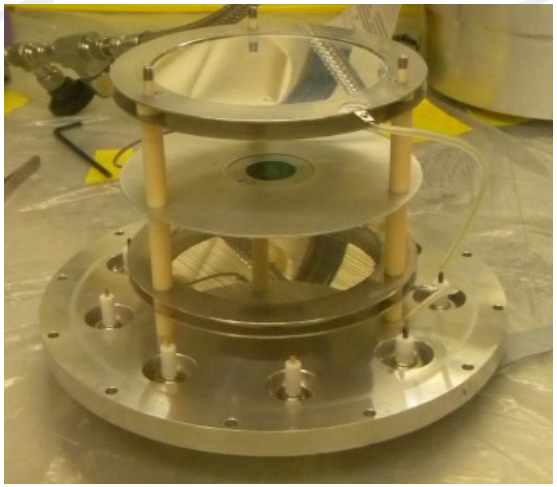


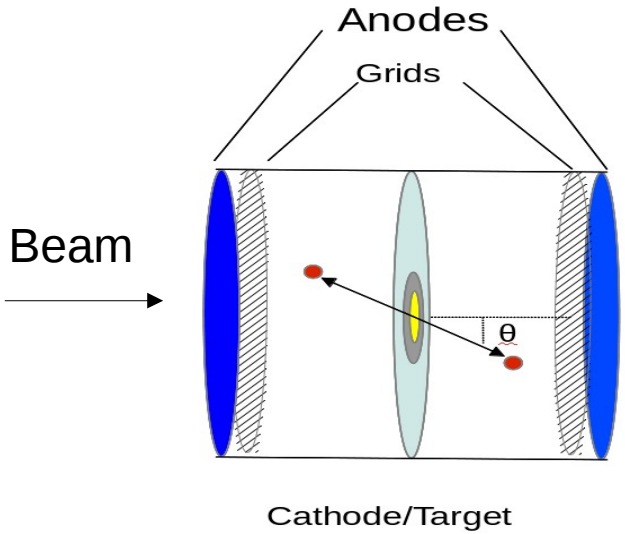
[**Heffner, M.; et al.** *NIMA* , 2014, 759, 50-64]



[**Arnold, C.; et al.** *NIMA*, 2014]

Experiment Setup

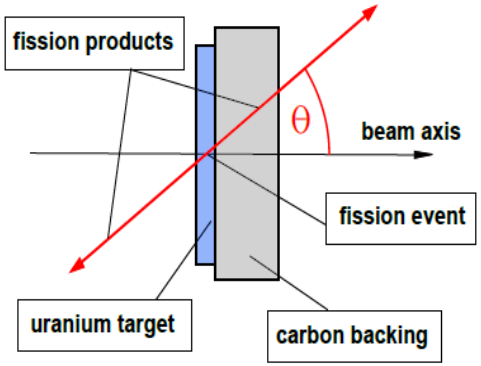


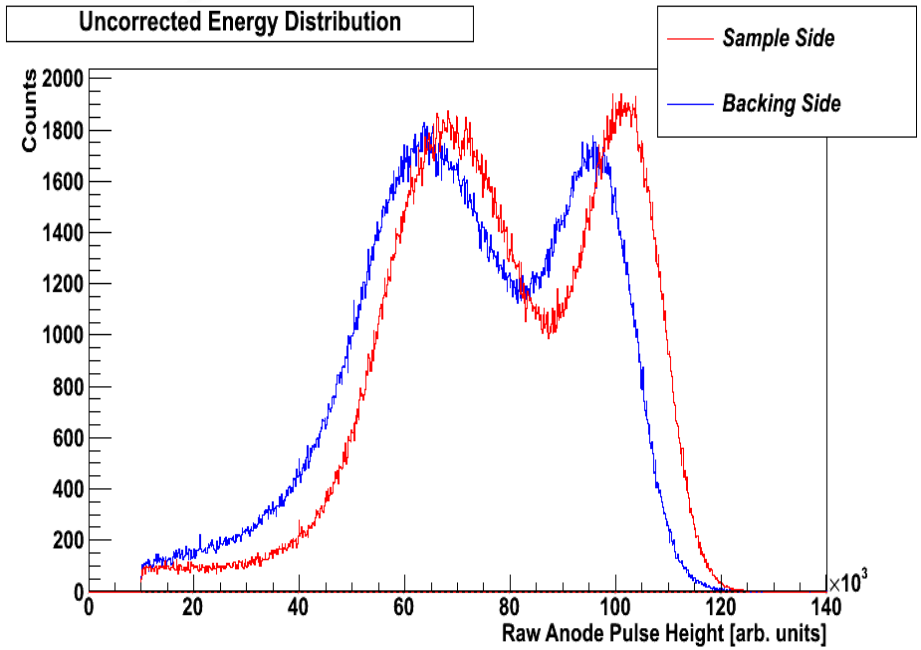


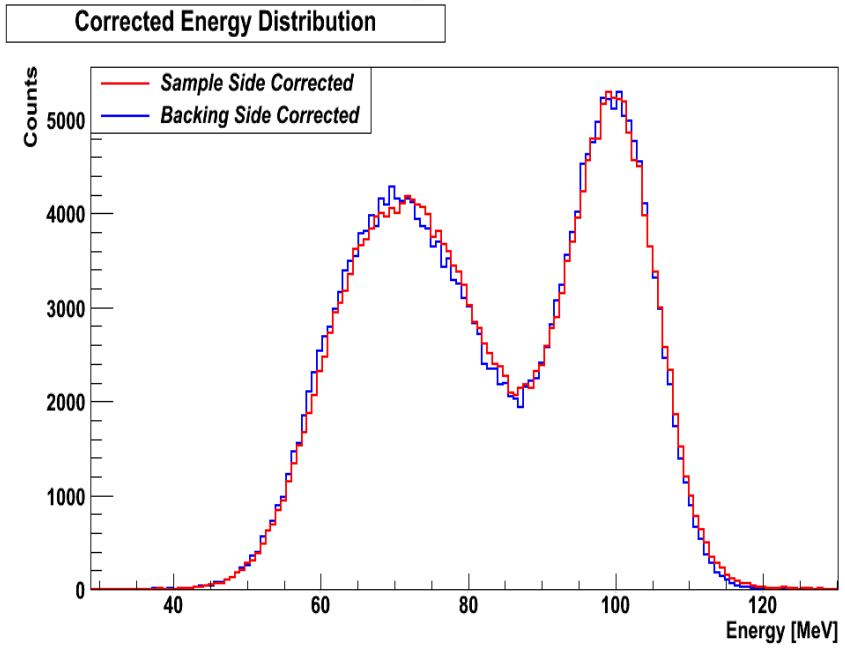
- Frisch-gridded ionization chamber
  - High efficiency detector
  - High energy resolution ~1%
  - Uses P10-Drift gas
- Thin ^{238}U target
- WNR neutron beam: 100's keV to 100's MeV
- Capable of measuring:
  - Energies of the two fission fragments
  - Emission angles
  - Measure average TKE and mass yield distributions with 4-5 AMU resolution.

[**Mosby, S.; et al.** *NIMA*, 2014, 757, 75 - 81]

Analysis – Energy Spectrum

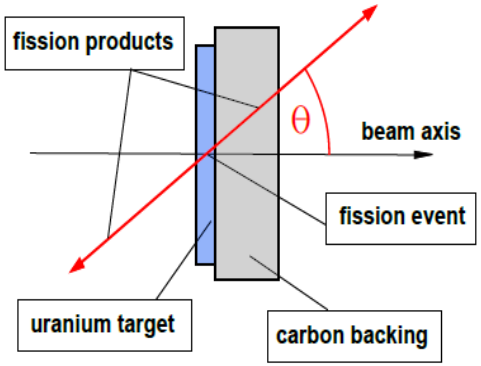


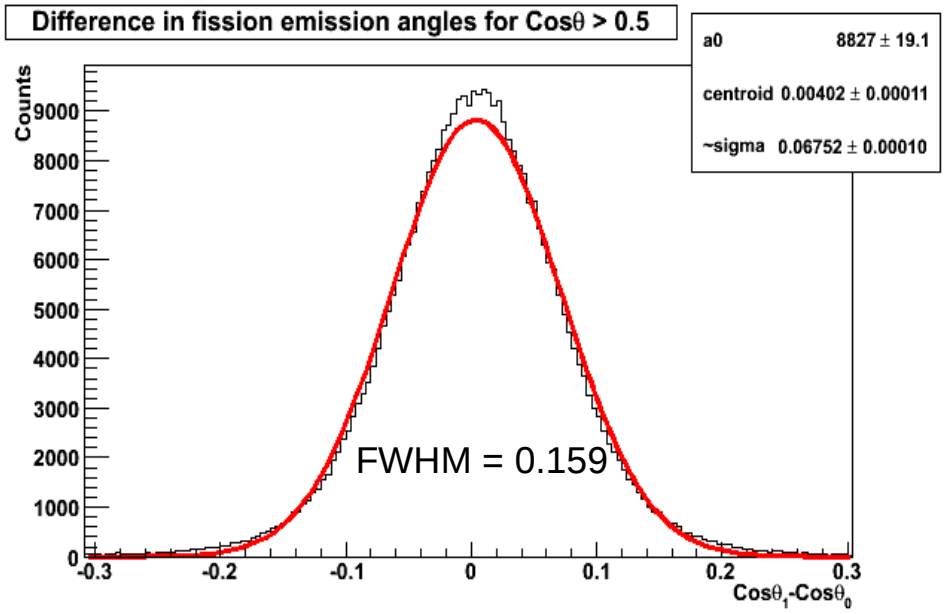


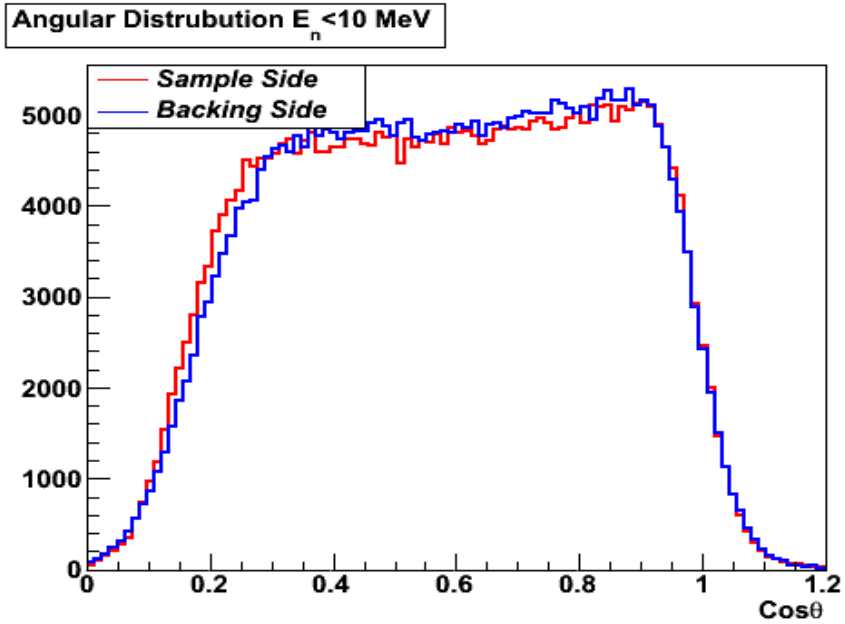


- Apply corrections and convert the anode pulse heights to fission product energies.
- Combine this information with the incident neutron energy to get average TKE.

Analysis – Angular Corrections

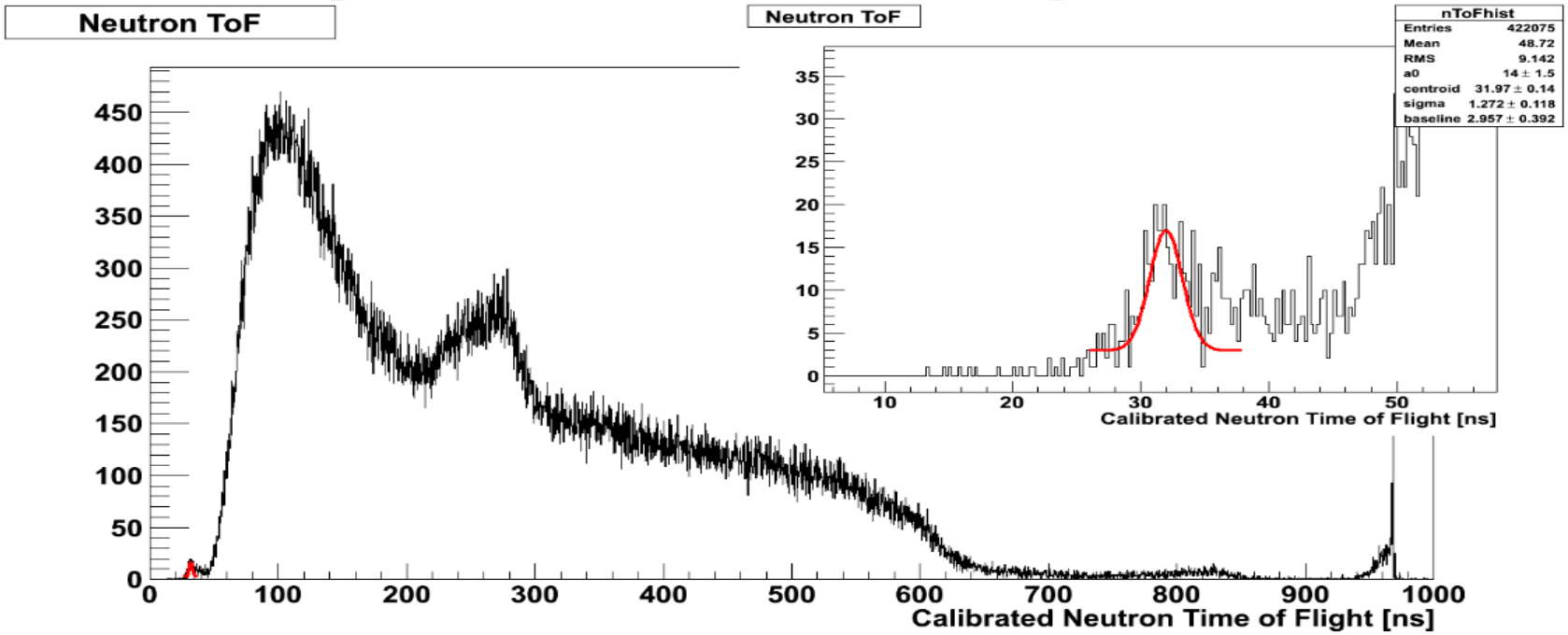






- The angles overlay, indicating back to back fission fragment emission, as expected.
- The FWHM of the Gaussian is on par with the accepted value for these detectors.
- Angular information can be improved by including neutron momentum transfer.

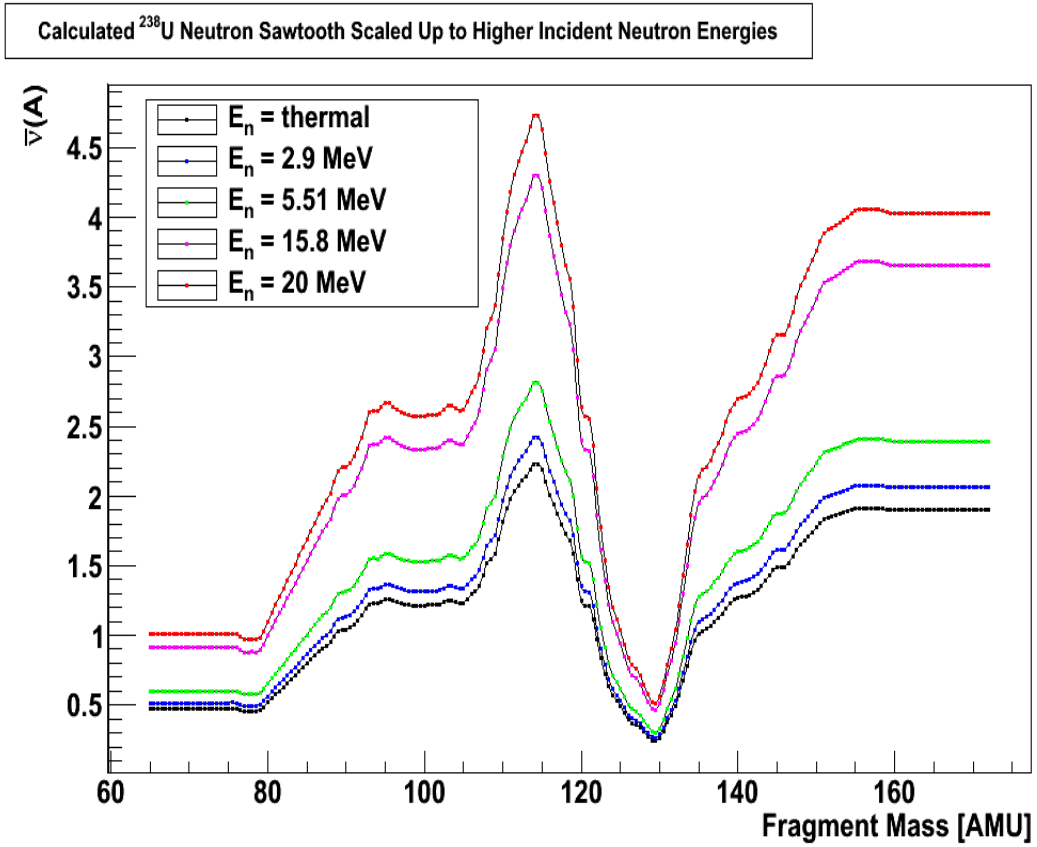
Analysis – Neutron Energies

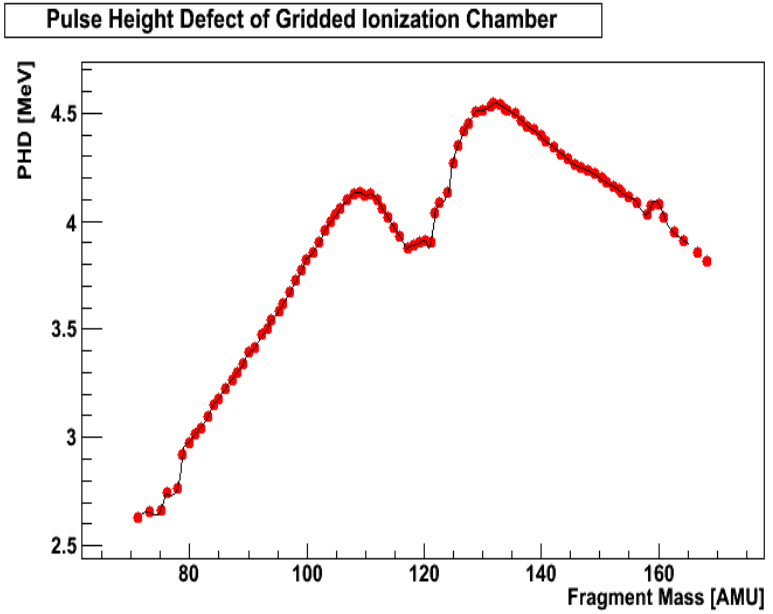


- A neutron time-of-flight (nToF) method is employed to deduce the incident neutron energies.
- Neutron ToF = pulsed accelerator T_0 - detector cathode signal
- High energy neutrons have a short ToF, lower energies have longer ToF.

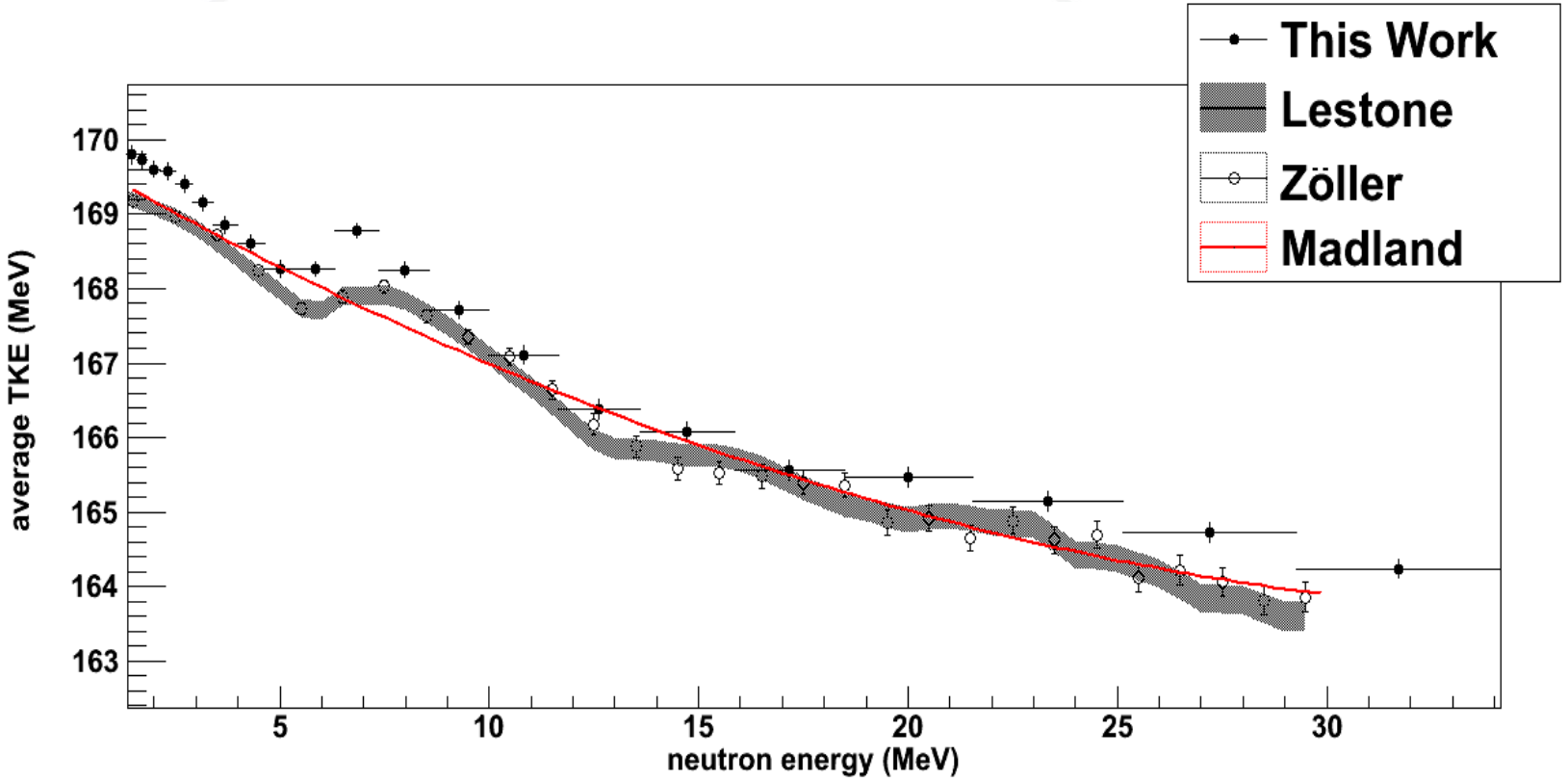
The 2E Method

- The 2E method is an iterative procedure used to calculate mass yield distributions.
- It corrects for prompt neutron emission and pulse height defect.



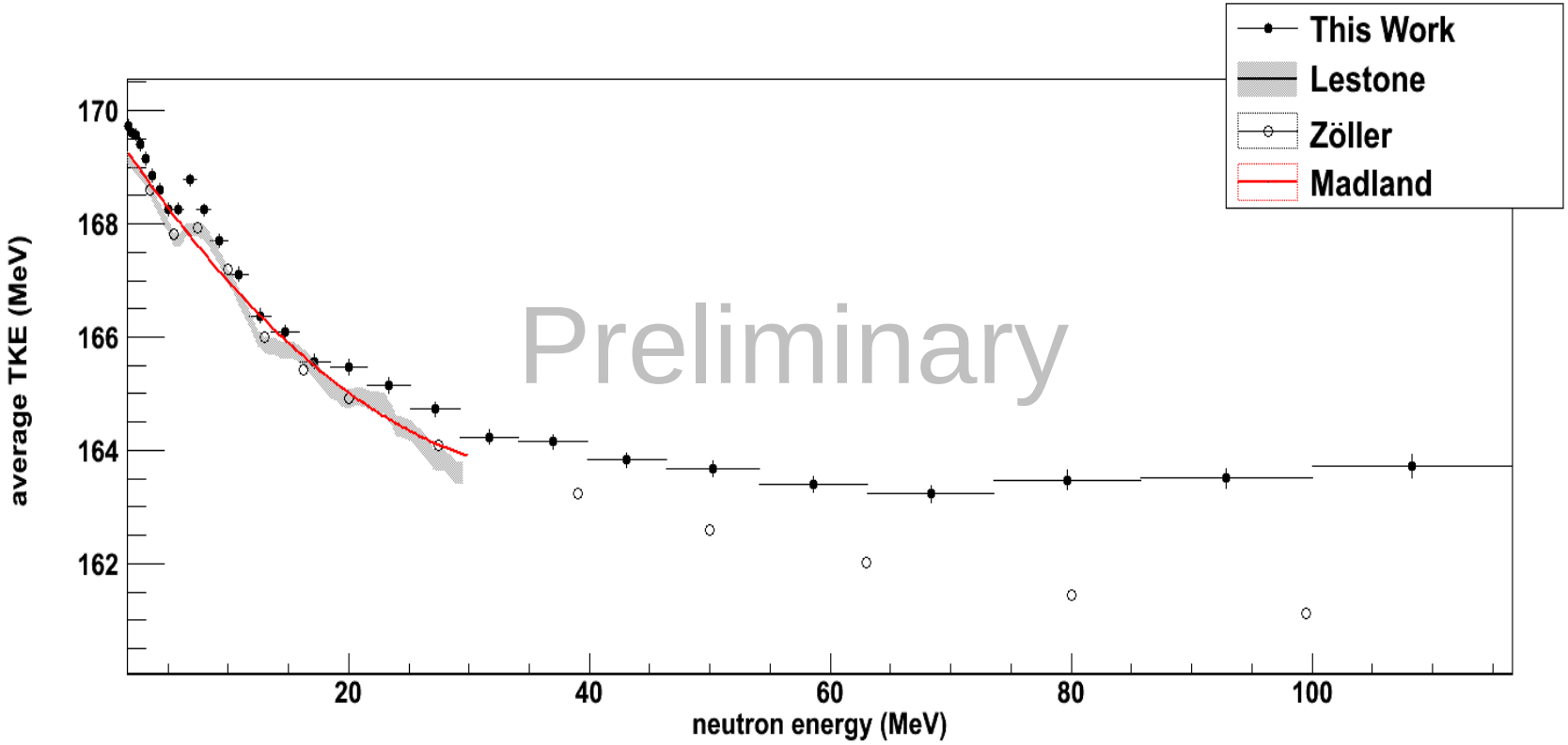


Results – ^{238}U average TKE post-neutron emission



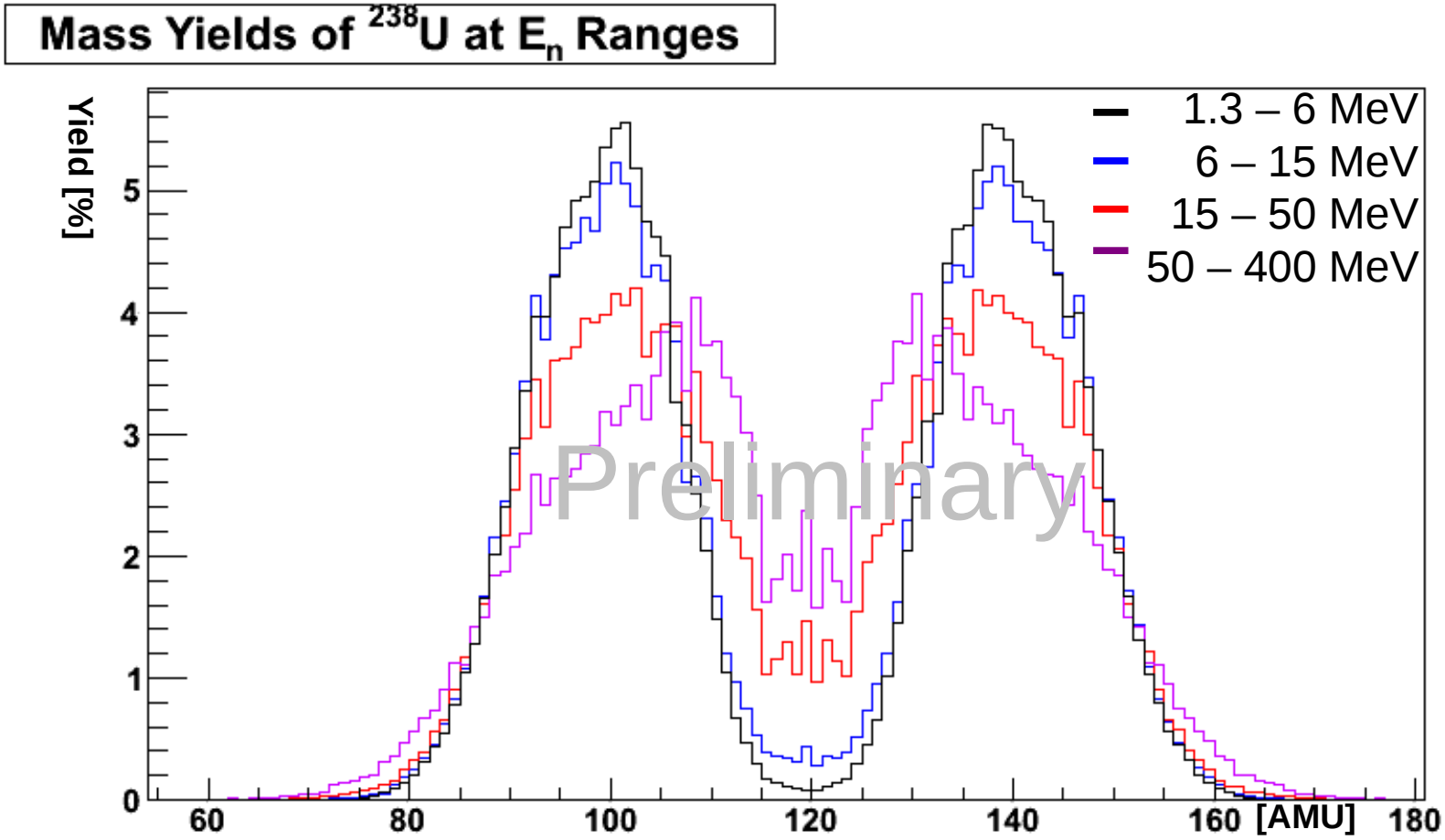
[**Zöller, C.** PhD Thesis. Technische Hochschule Darmstadt, 1995]

Results – ^{238}U average TKE post neutron emission



[**Zöller, C.** PhD Thesis. Technische Hochschule Darmstadt, 1995]

Results – 238U Mass Distributions pre neutron emission



Future plans: Extend to more isotopes

- The first measurement of ^{238}U average TKE and mass yield distributions with an ionization chamber over a wide range of neutron energies was completed.

- This investigation is important for applications, theory, evaluations, and supports the existing fission program at LANSCE.

- Results for ^{238}U soon to be finalized and prepared for publication.

- Work in progress:
  - ^{235}U data was collected and is undergoing analysis.
  - Data collection on high statistics ^{239}Pu slated for this fall.

Thanks to my LANL collaborators, Josch Hambsch who lent us the ionization chamber,
and to Walt Loveland for making the targets.
Funded by U.S. Department of Energy by Los Alamos National Security, LLC under contract DE-AC52-06NA25396.