Fission Total Kinetic Energy and Fission Product Yields

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CSWEG, Nov 4, 2014

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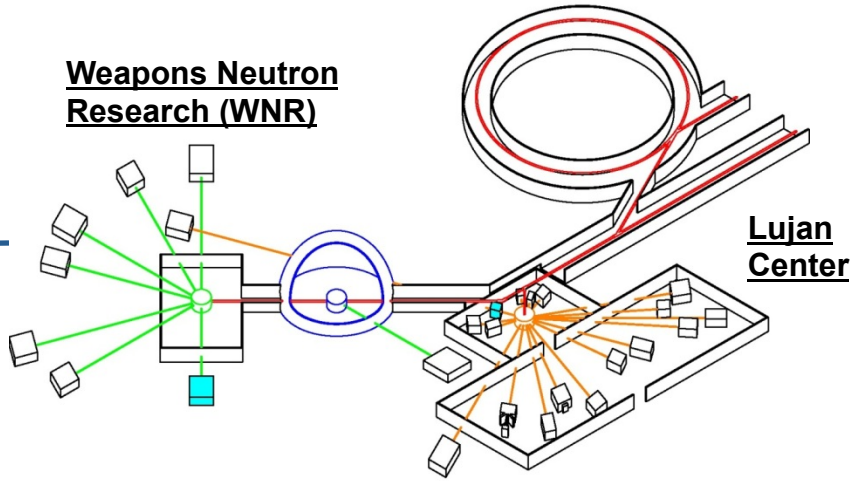
Outline

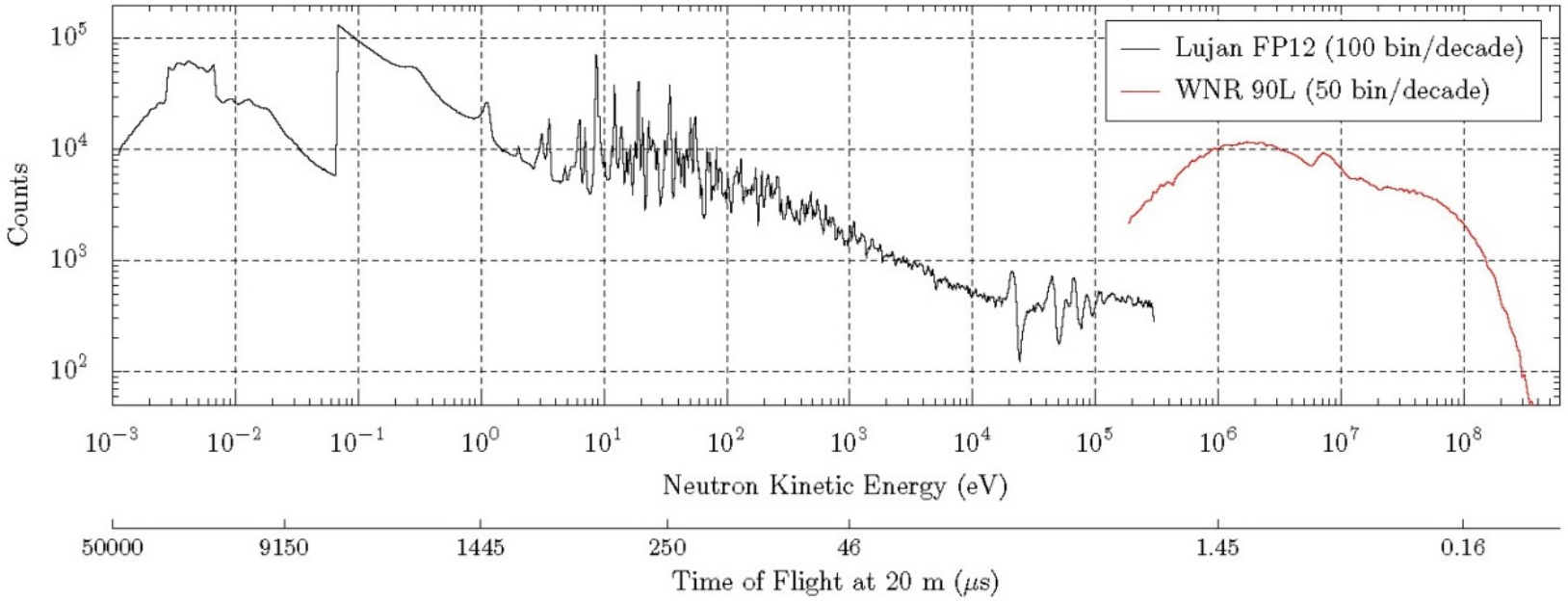
- Los Alamos Neutron Science Center
- Total Kinetic Energy (TKE)
  - Frisch-gridded ionization chambers
  - Experiments (U-238, U-235, Pu-239)
  - Results
- Fission Product Yields
  - Low-mass resolution yields with 2E-method
  - High-mass resolution yields with SPIDER
  - Commissioning of SPIDER with Cf-252(sf)
  - Plans for Pu-239 fission yields

The Los Alamos Neutron Science Center (LANSCE)



- Spallation neutron source
- Moderated & un-moderated flight paths
- Neutron time-of-flight

LANSCE provide neutrons from thermal to hundreds of MeV



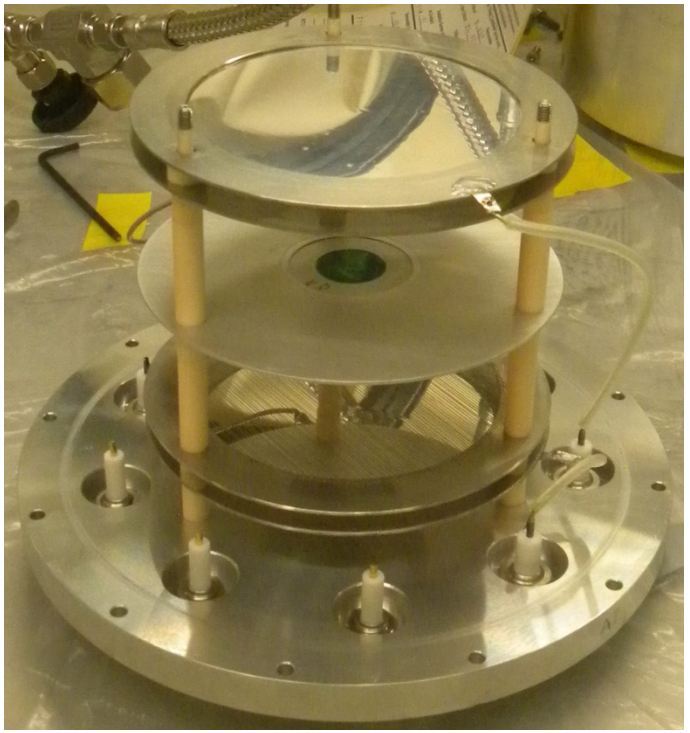
- High neutron flux over the full energy range
- Excellent resolution for fast neutrons, reasonable for slow neutrons

TKE experiments

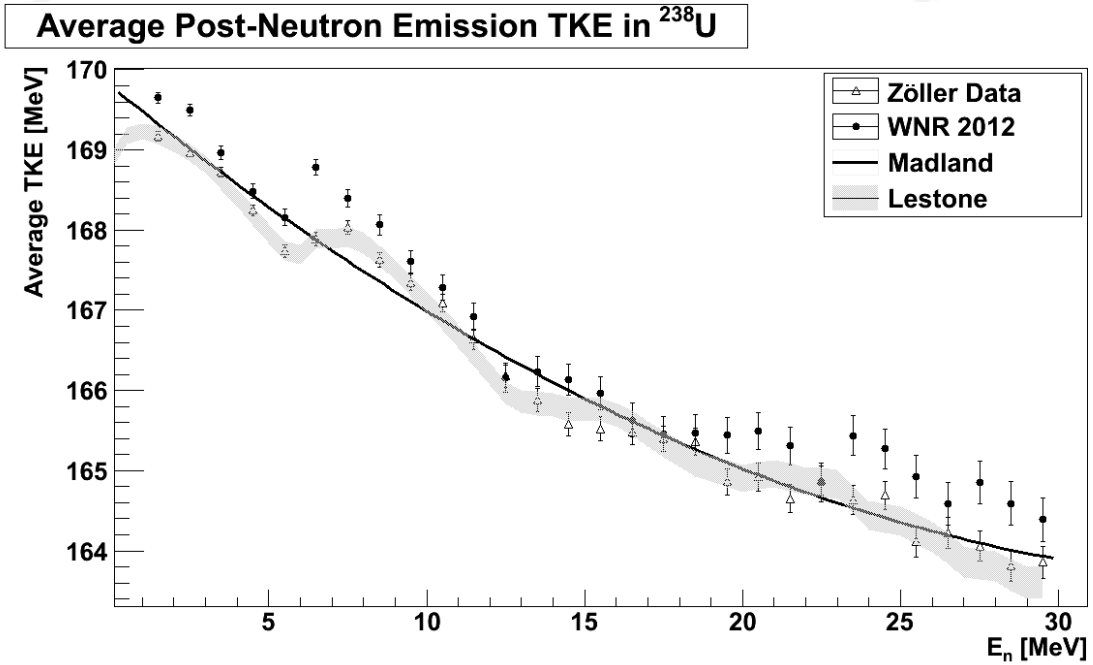
- Three targets: U-238, U-235 and Pu-239
- Experiments at two neutron facilities
  - Lujan Center: thermal spectrum
  - WNR: 1-30 MeV
- Fission detector: Frisch-gridded ionization chamber
  - Developed at IRMM (Hambsch et al.)
  - Measures kinetic energy of two coincident fragments
  - Measures fragment polar angle
  - Commonly used in fission experiments for low-resolution mass measurements with the 2E-method

TKE detector: Frisch-gridded ionization chamber

- Kinetic energy of both fragments are measured in coincidence
- Energy resolution for fission fragments is 0.5-1.0%
- High efficiency: ~95%
- Mass resolution: 4-5 amu resolution
- Provides emission angle information

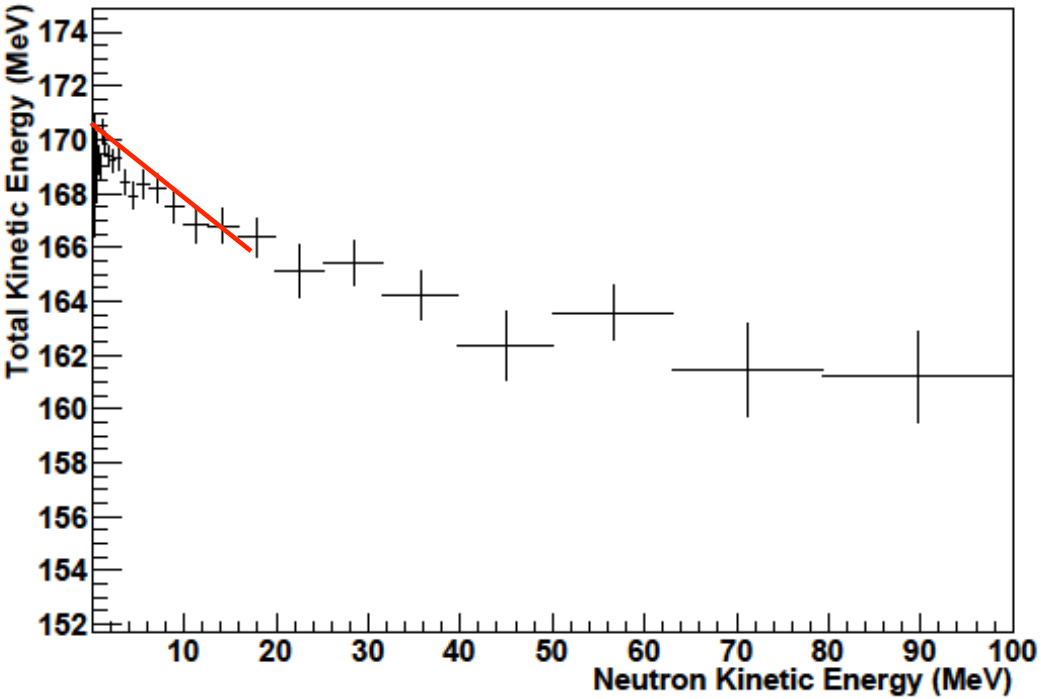


Total Kinetic Energy: U-238



- First experiment with IC at LANSCE-WNR, collaboration with Hambsch et al. PhD work of Dana Duke.
- General good agreement with Zoller et al., slight normalization difference (0.25%)
- Manuscript in preparation

Total Kinetic Energy: U-235

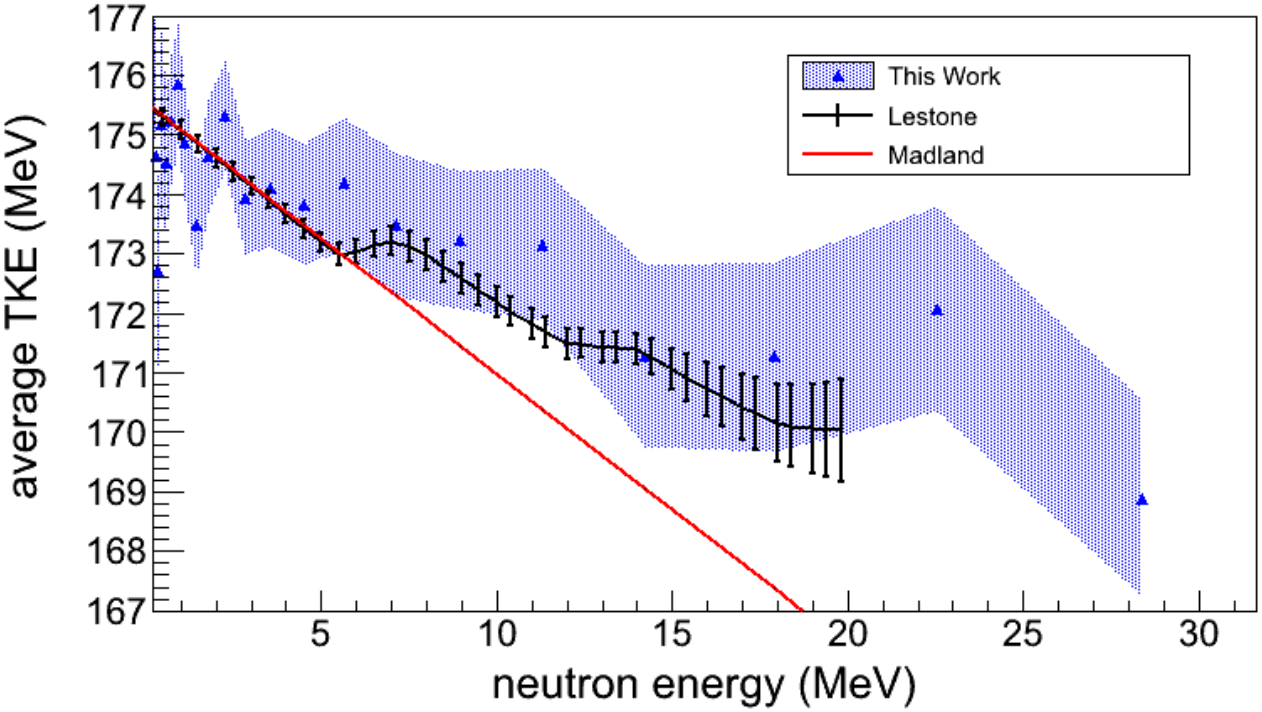


+ This work

— Madland

- Developed new digital DAQ for this experiment that better suited LANSCE-WNR
- Analysis in progress, procedure is developed with U-238
- Decrease in average TKE observed below 1 MeV
- Overall normalization agrees with previous experiments

Total Kinetic Energy : Pu-239

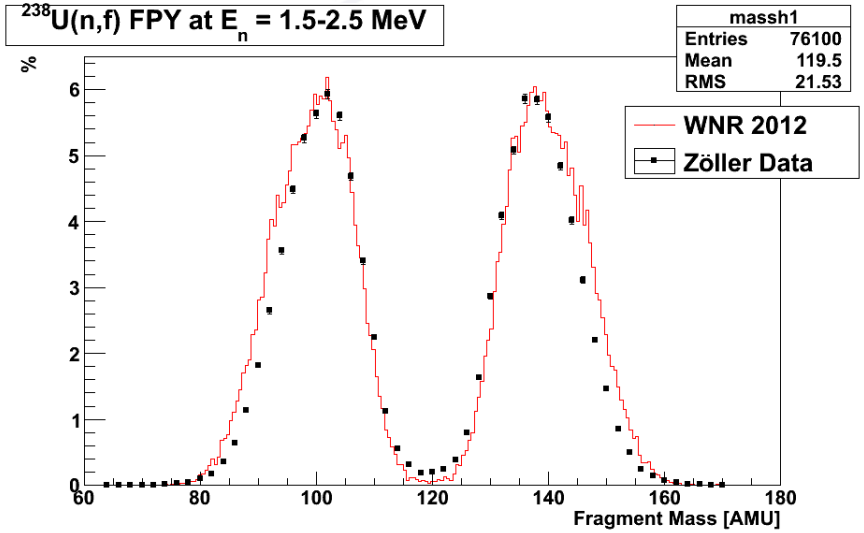


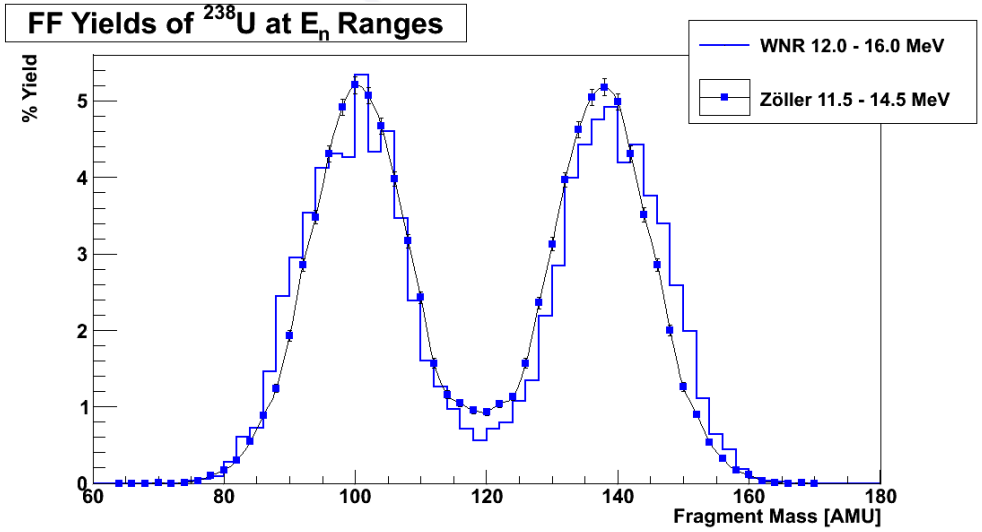
- 2013 data: sample quality was poor, hence large uncertainties
- New experiment planned in the next few months
- First results support Lestone prediction

Fission Product yields

- Three targets: U-238, U-235, Pu-239
- Two types of measurements
  - 2E method
    - Low mass resolution, high efficiency
    - Gross trends as function of excitation energy
  - SPIDER spectrometer
    - High mass resolution, low efficiency
    - Precise measurements of FPY at select excitation energies

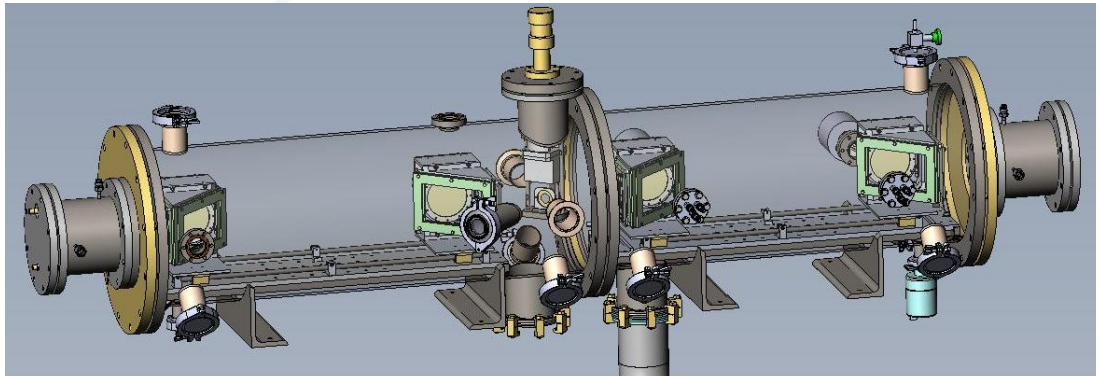
Mass yields for U-238 with 4-5 amu resolution

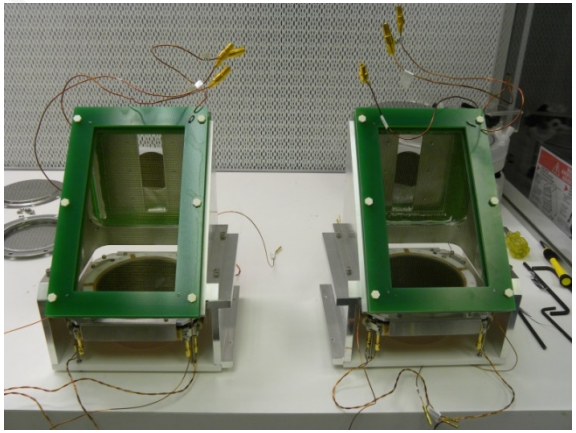




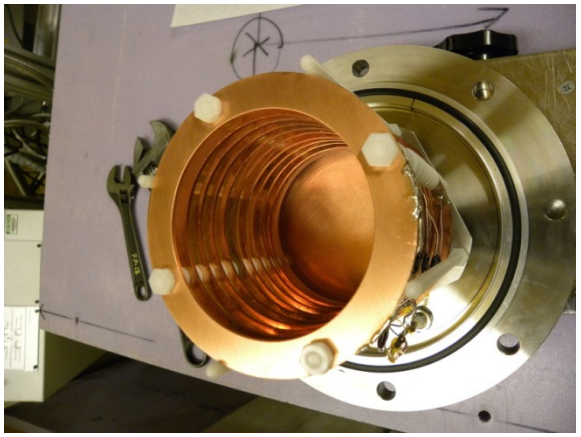
- Zoller previously measured mass yields at WNR up to 100 MeV for U-238, no other isotopes
- Good agreement between Zoller and current data at 2 and 14 MeV
- Data collected for U-235, Pu-239 will be measured this year

High resolution mass yields are measured with SPIDER

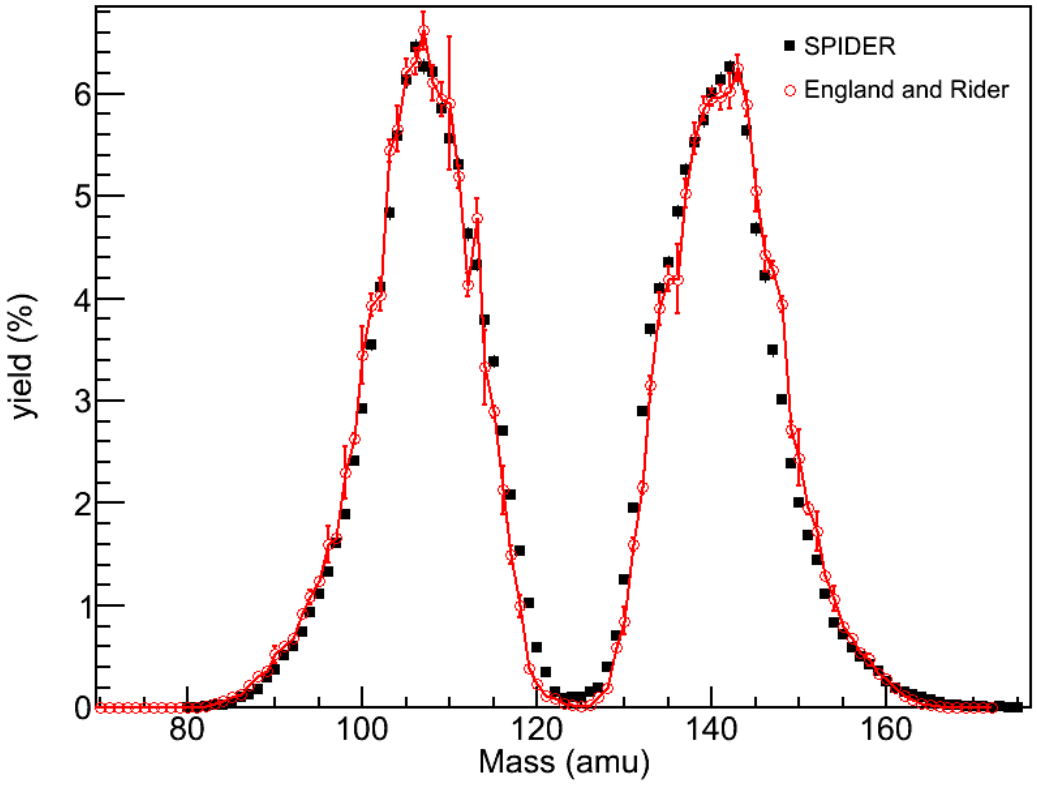




- The 2E-2v method can provide 1 amu resolution for light fragments
  - Demonstrated with Cosi-fan-Tutti at ILL
- SPIDER uses ionization chambers for energy measurement
  - 1% energy resolution for α-particles, 0.5% for fission fragments
  - Thin entrance window (mylar or SiN)
- Fast, position sensitive TOF detectors
  - Carbon conversion foils
  - Electrostatic mirror
  - Micro-channel plates
  - Delay-line anode

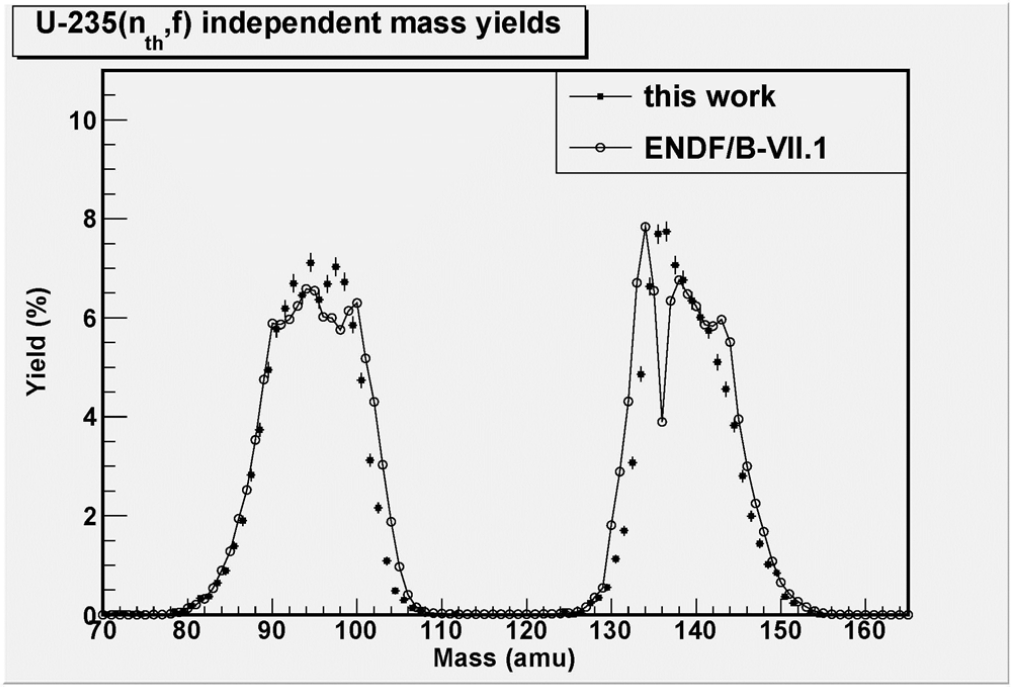


Cf-252(sf) Fission Product Yields



- SPIDER was commissioned with Cf-252 source
- Current data with one-sided source
- Next step is to measure fragment coincidences thin-backing source
- Mass resolution is close to 1 amu

U-235(n,f) Fission Product Yields



- First neutron-induced fission data collected in 2013
- Mylar windows caused large energy loss, lower (3 amu) resolution
- SiN windows have since been implemented, significantly lower energy loss
- New experiment currently in progress

Status and outlook

- Total Kinetic Energy
  - U-238: analysis completed, manuscript in progress
  - U-235: analysis in progress, completion in early 2015
  - Pu-239: new experiment in 2014 (thermal and fast), if successful new result out mid-2015
- Fission Product Yields
  - U-235 and Pu-239 thermal yields are being measured over the next few months
  - First fast measurement of U-235 by Feb. 2015
  - Pu-239 fast yields planned for fall 2015

Collaborators

- Los Alamos National Laboratory
  - Dana Duke, GRA
  - Rhiannon Meharchand (now at IDA)
  - Krista Meierbachtol
  - Shea Mosby
  - Dan Shields, GRA
  - Morgan White
- Oregon State University
  - Walt Loveland
- University of New Mexico
  - Adam Hecht
  - Rick Blakeley