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National Nuclear Security Administration

Fission Product Yield Measurements at TUNL

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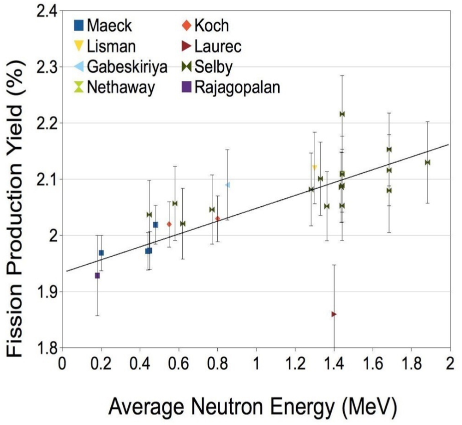
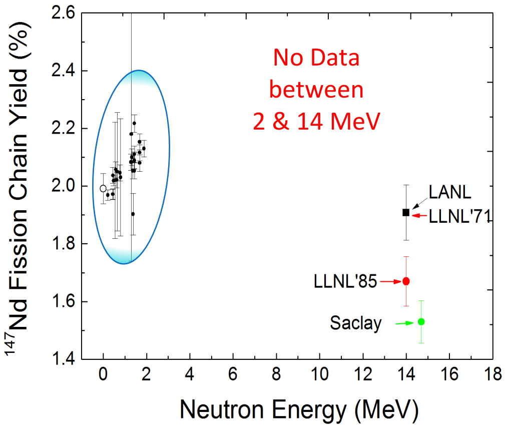
OUTLINE

- MOTIVATION
- ‘LONG’-LIVED YIELDS
- ‘SHORT’-LIVED YIELDS
- RABITTS

MOTIVATION

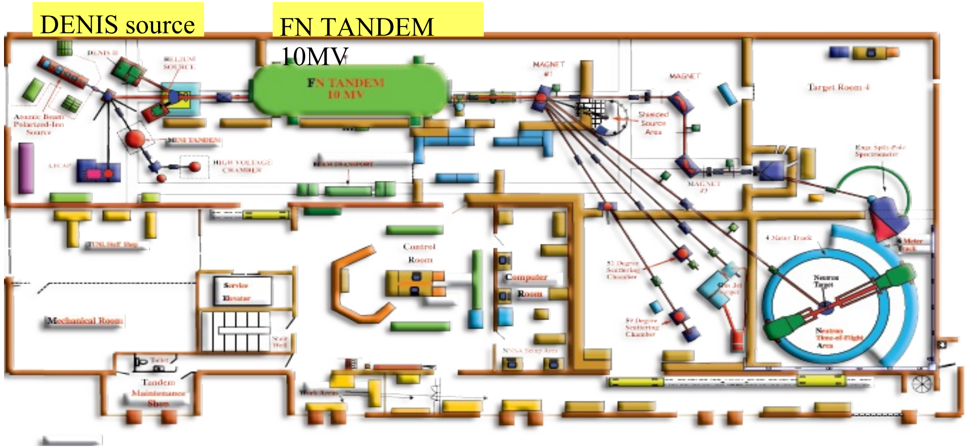




- If we consider the fission product ^{147}Nd from ^{239}Pu(n,f) what do we see?
  - An energy dependent trend with increasing neutron energy
  - But .. Is this an artifact or real physics?

- Majority of fission yield measurements have been performed with reactors (thermal) and with critical assemblies (fission)
- 14 MeV neutron sources from DT fusion are also common and numerous measurements exist for this energy

Triangle Universities Nuclear Lab

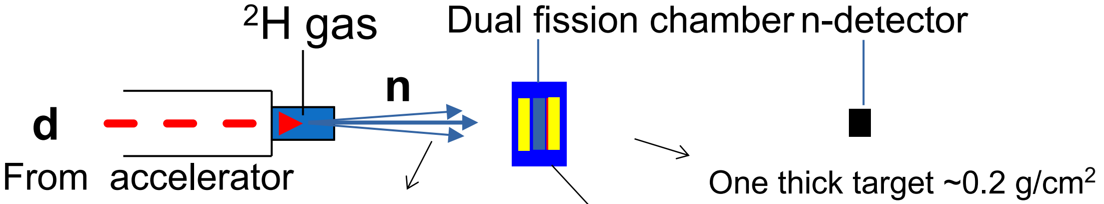


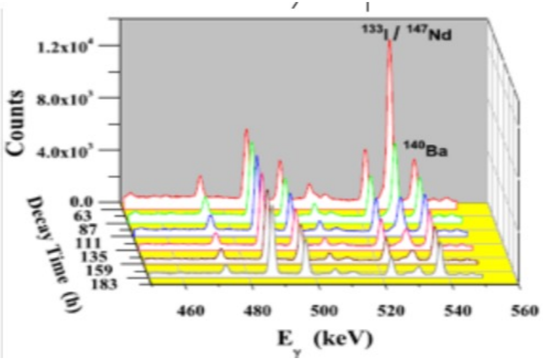
$^{7}Li(p,n)^{7}Be$; Monoenergetic neutrons: 0.1 – 0.65 MeV

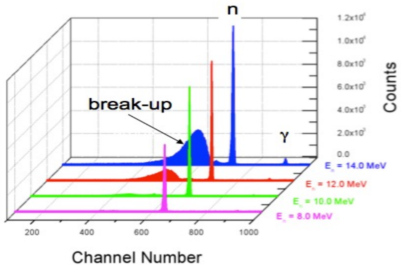
$^{3}H(p,n)^{3}He$; Monoenergetic neutrons: 0.5 – 7.7 MeV

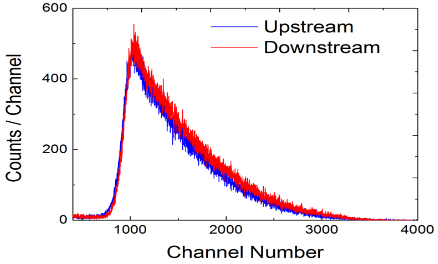
$^{2}H(d,n)^{3}He$; Monoenergetic neutrons: 4.0 – 7.7 MeV

$^{3}H(d,n)^{4}He$; Monoenergetic neutrons: 14.8 – 20.5 MeV

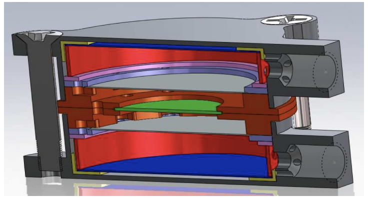


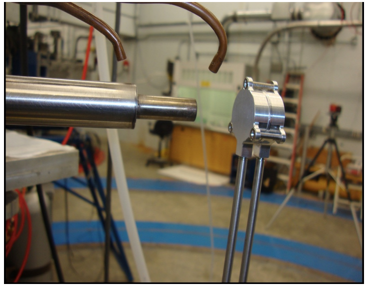


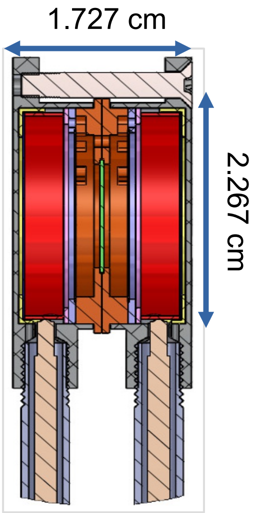


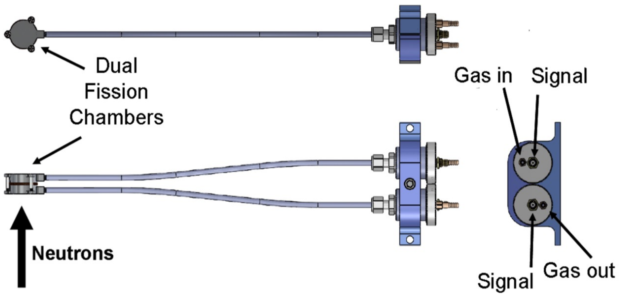


Fission Chambers









- To measure the fission yield, we need to know how many fissions happened ⟶ *Fission Chambers*

- 3 Chambers were constructed: 1 for each target isotope
  - ^{235}U: ~ 100 μg/cm^2 ref. / 200 mg/cm^2 target
  - ^{238}U: ~ 100 μg/cm^2 ref. / 400 mg/cm^2 target
  - ^{239}Pu: ~ 10 μg/cm^2 ref. / 200 mg/cm^2 target

- The number of fissions in the target is determined by scaling

Total Fissions = Counts * M_T/M_R

- No fission cross section needed!

Experiment Summary:

- The experiments have been broken down into *3 time scales* and *11 Energies*:
- Energies: 0.5, 1.4, 2.4, 3.6, 4.6, 5.5, 6.5, 7.5, 9, 11 and 14 MeV
  - **Long**: cumulative yields of long lived (days-months) fission products; i.e. near stability
    - Requires irradiations of a few days to a week+

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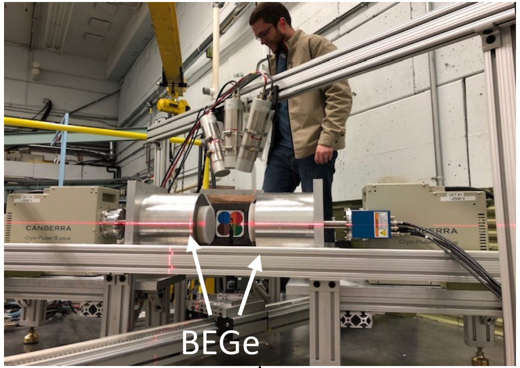
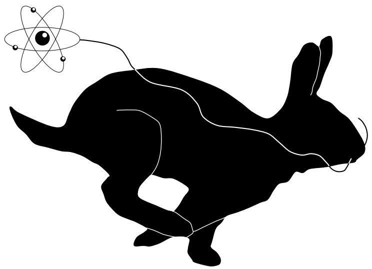
  - **Short**: cumulative yields of short(er) lived fission products (10's of minutes to hours)
    - Irradiations for 1-2 hours
    - Analog sample transfer system -> LLNL Colleague runs sample to counters
      - So called *Jack Rabbit* measurements

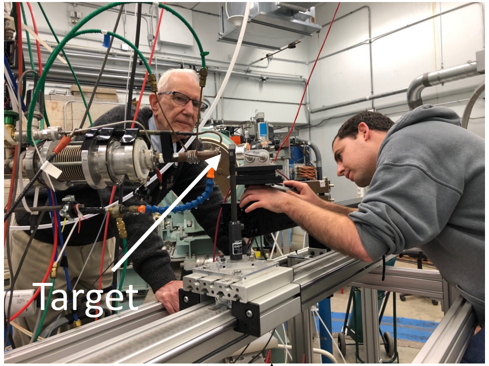
Experiment Summary:

RABITTS: RApid Belt-driven Irradiated Target Transfer System



RABITTS





10 m

Irradiation & Counting Cycles

4 s | 20 s x 5000 times

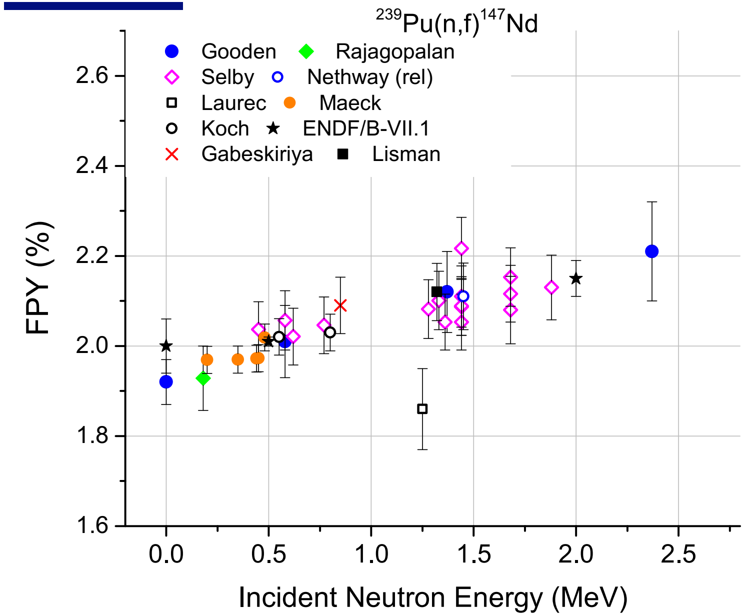
10 s | 60 s x 2000 times

60 s | 300 s x 400 times

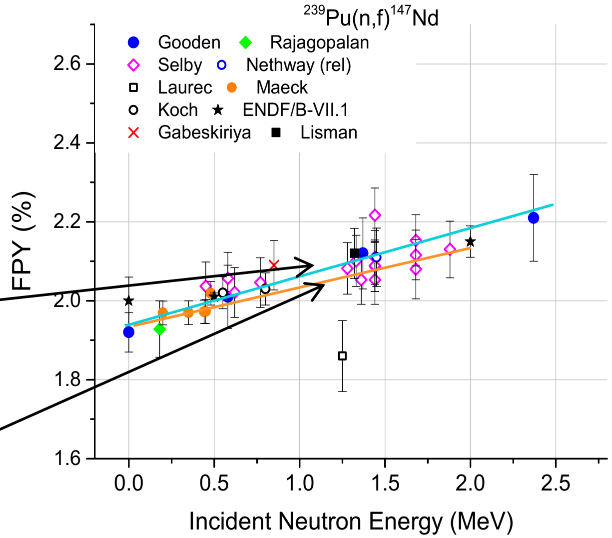
Target Position Reproducibility	42 μm
Transit Time	1 s

RESULTS

^{147}Nd:



- For ^{147}Nd, we have demonstrated a positive energy dependence to its cumulative fission yield, in agreement with data from other sources



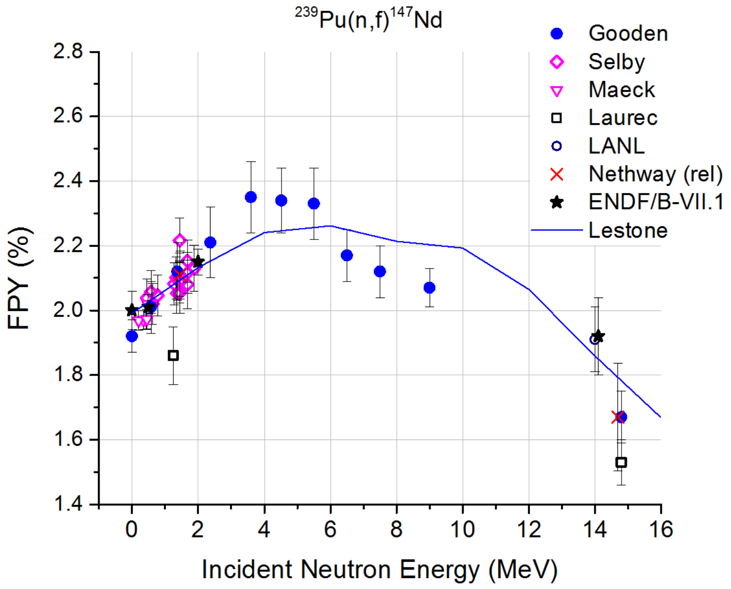
- **TUNL : 5.8 %/MeV**

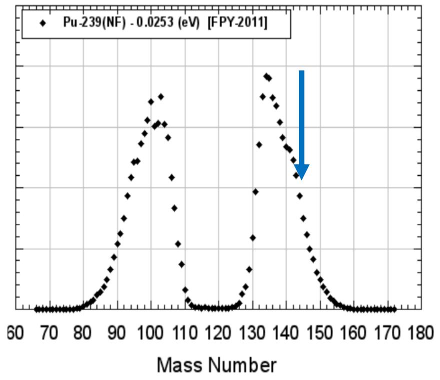
  1.950 + 0.113∗E

- **Chadwick: 4.7 %/MeV**

  1.950 + 0.091*E

^{147}Nd:

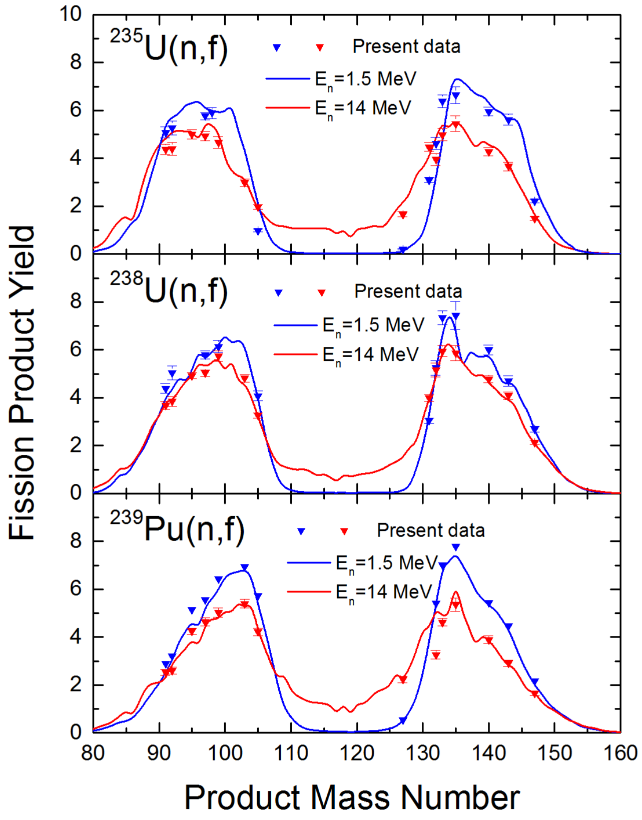




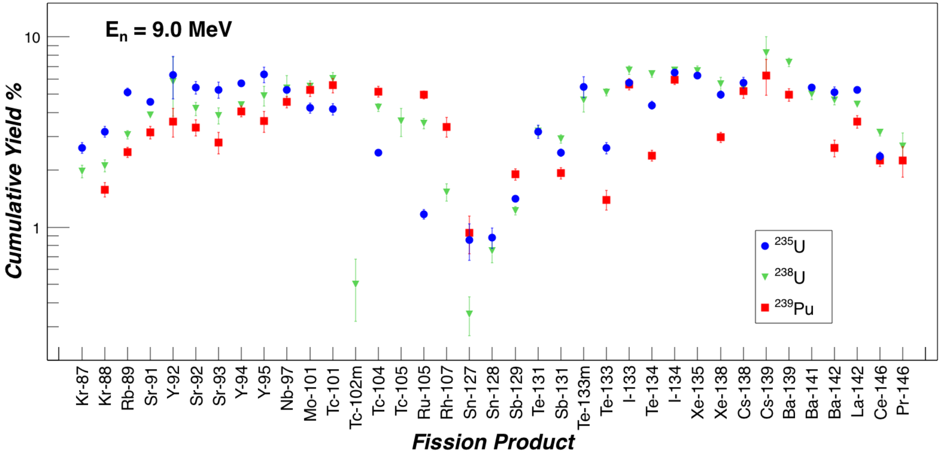
We have addressed the question of energy dependence in the low-energy region, added data between 2-14 MeV and have helped address the discrepant data near 14 MeV.

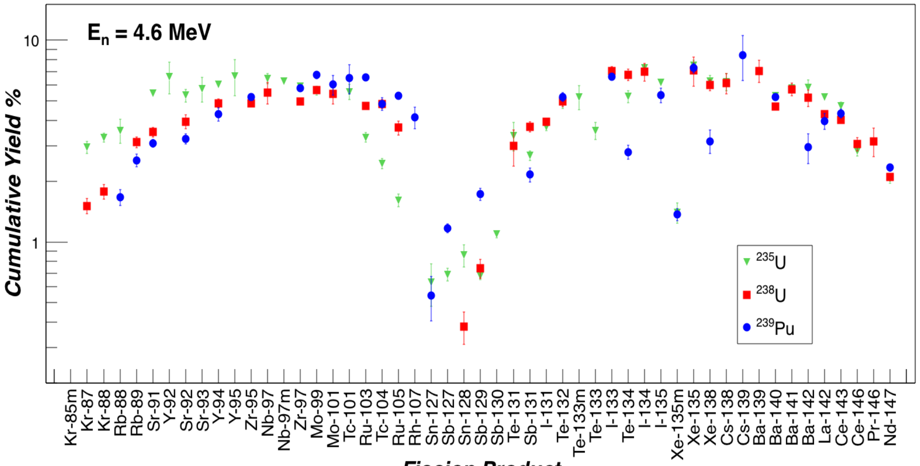
Comparison to England & Rider:

- From whole foil gamma counting we have found yields for ~15 fission products
    - Small sample of all yields
- No valley products
- Reasonably good agreement with England & Rider
    - E&R for some yields can have very large uncertainty: >50%
    - New data will help to reduce this

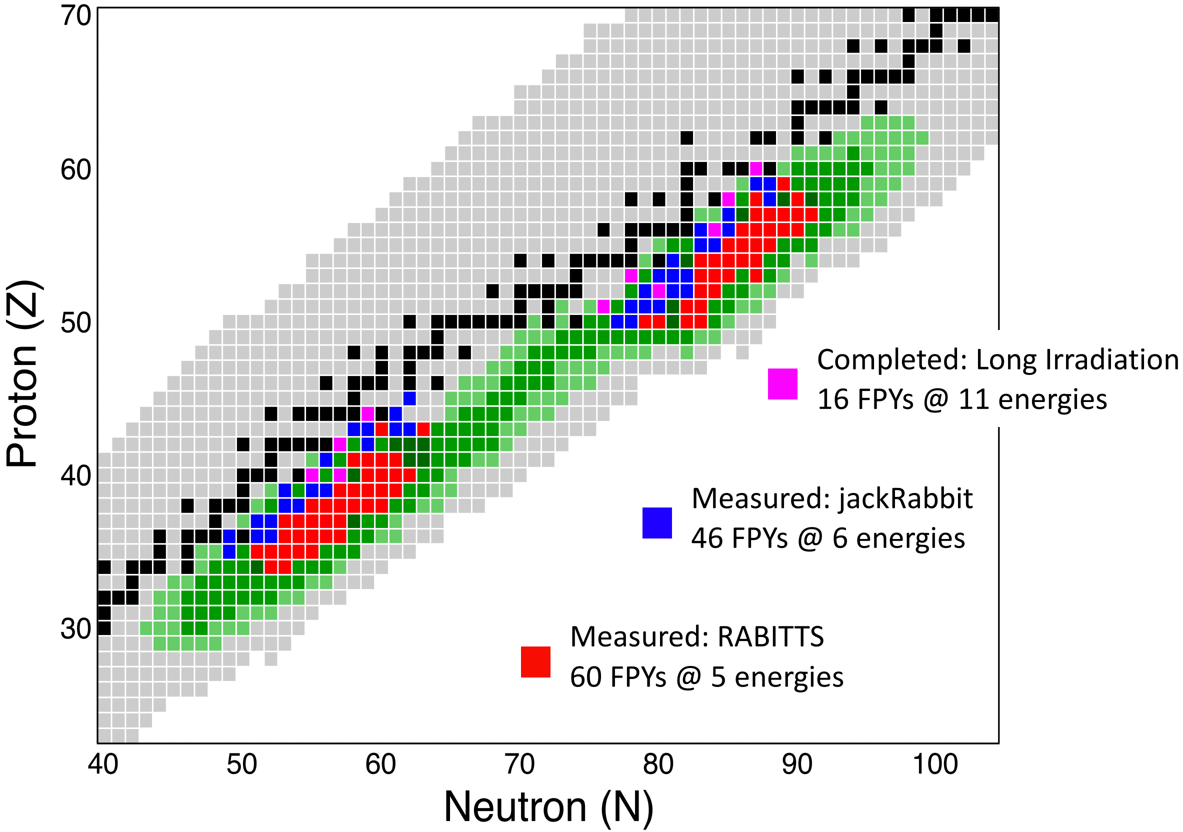


Short Activations (JR):





Summary: Our Coverage on the Nuclear Chart



Collaboration

Joint collaboration between LANL, LLNL and TUNL:

LANL

Matthew E. Gooden
Todd A. Bredeweg
Evelyn Bond
David Vieira
Jerry Wilhelmy
Vanessa Linero

LLNL

Ron Malone
Anthony Ramirez
Jack Silano
Mark Stoyer
Anton Tonchev

TUNL

Sean Finch
Calvin Howell
Werner Tornow

THANK YOU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