Recent Results from the Low Energy Radioactive Ion Beam Spectroscopy Station (LeRIBSS)

M Madurga

University of Tennessee

People

ORNL (IRIS II and HRIBF)

C. Gross, K. Jost, A.J. Mendes II, D. Stracener

UTK

L. Cartegni, R. Grzywacz, A. Kuzniak, D. Miller, S. Padgett, S. Paulauskas

ORNL

K. Rykaczewski, K. Miernik

ORAU

J.C. Batchelder, M. Karny, S. Liu, M. Wolinska-Cichocka

Lousiana State

E. Zganjar

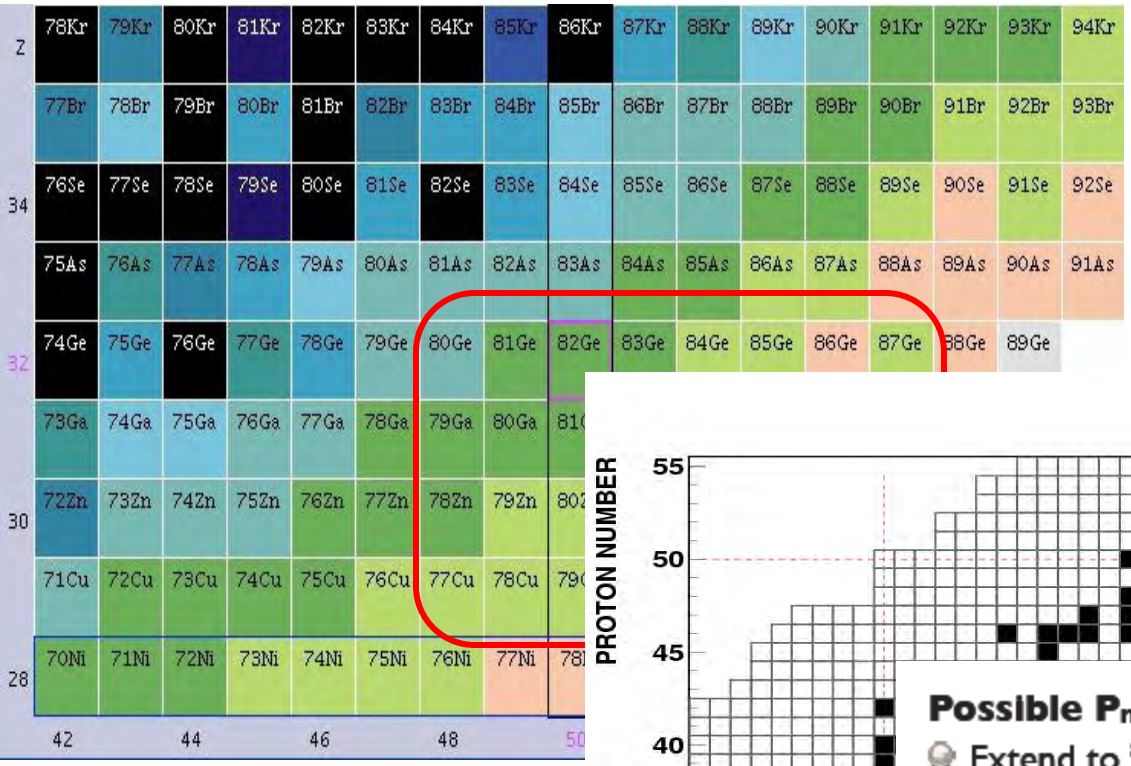
Mississippi State University

S. Ilyushkin, J. Winger

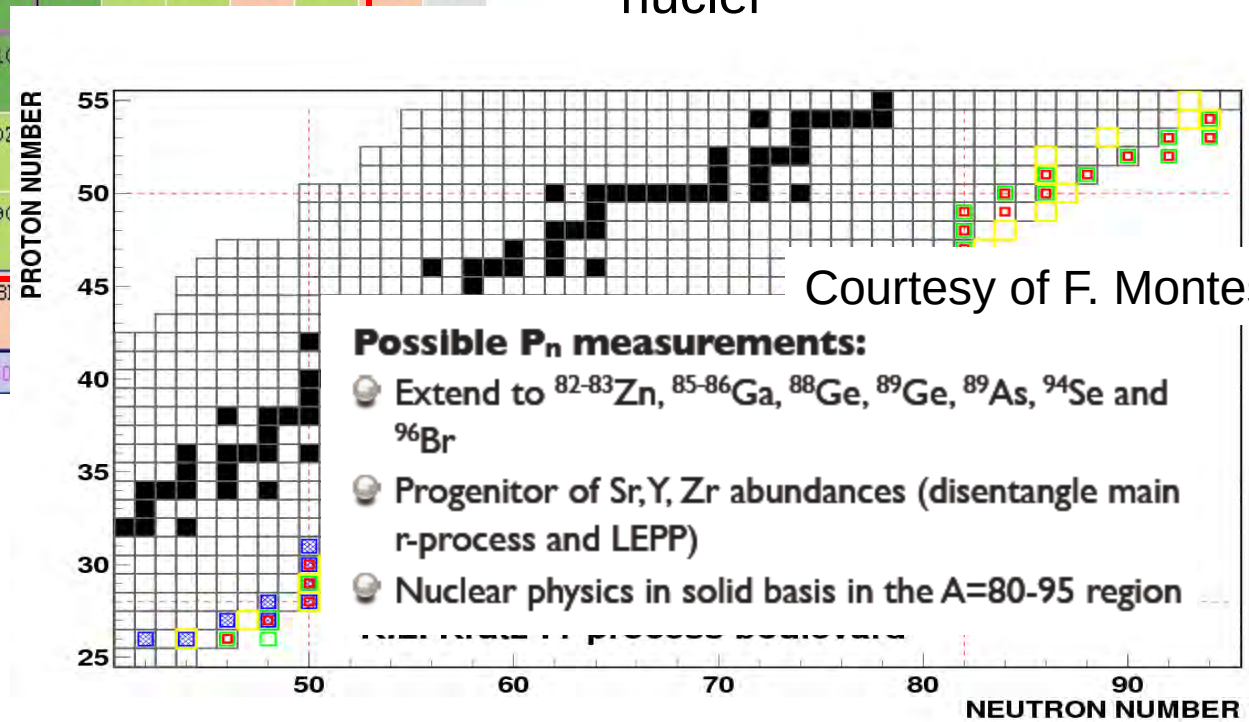
Vanderbilt

N. Brewster, A.V Ramaya, J.K. Hwang

The vicinity of ^{78}Ni

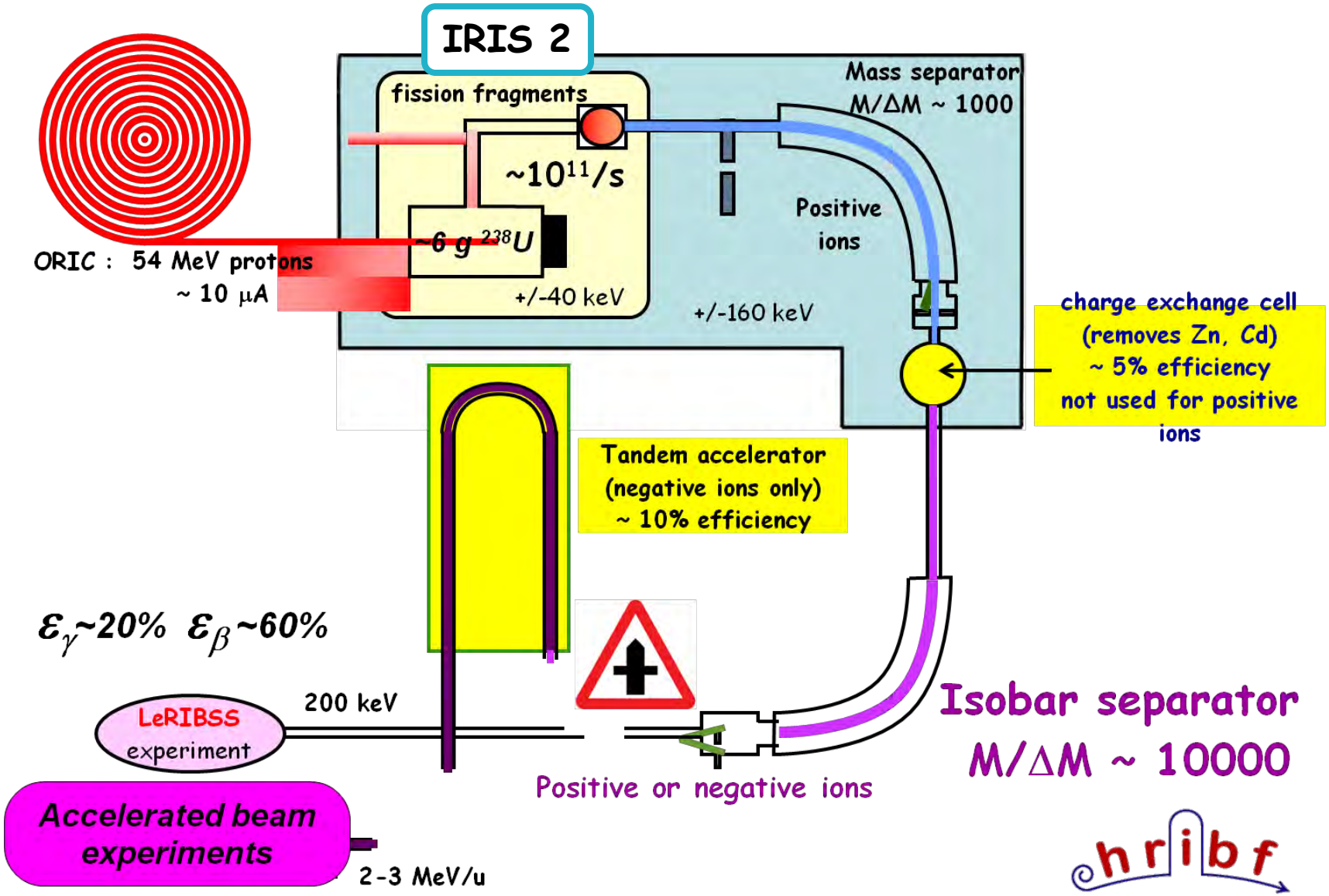


- Z=28 N=50 shell closures
- Observed shell evolution
- Progenitors of r-process nuclei

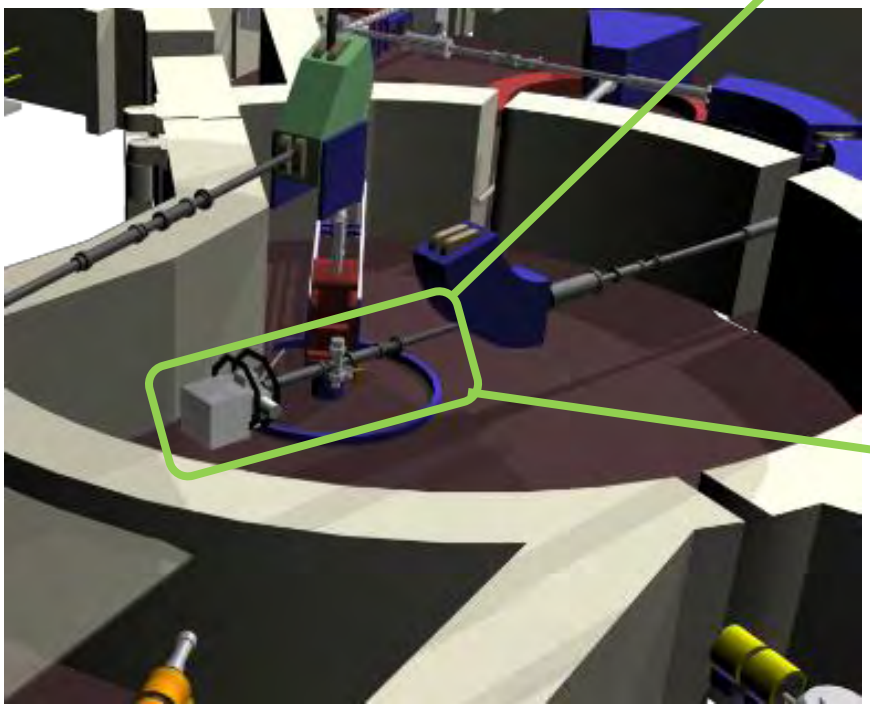


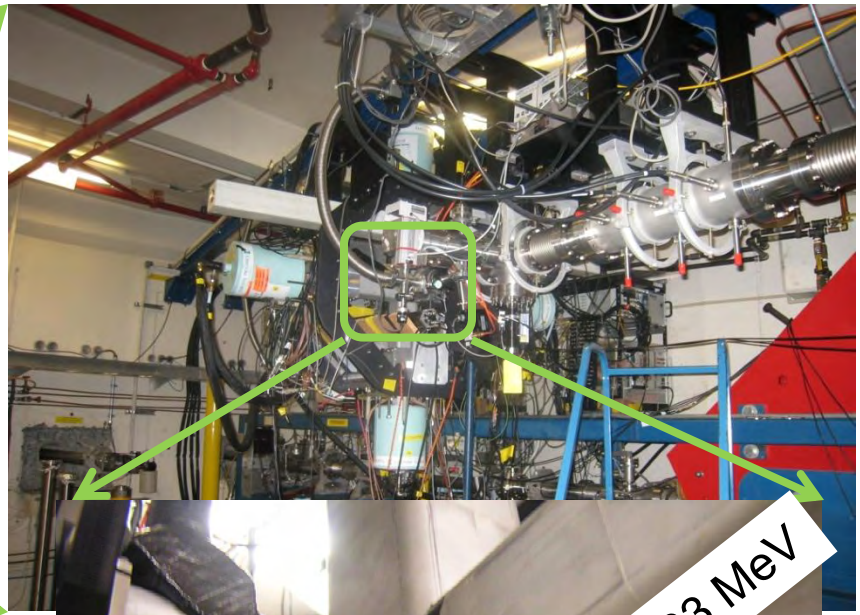
Courtesy of F. Montes

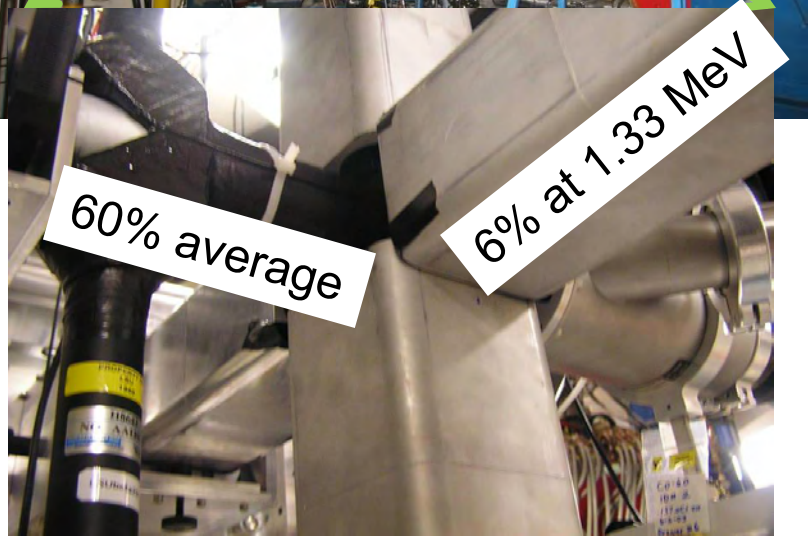
Isotope Separation OnLine



The Low energy Radioactive Ion Beam Spectroscopy Station







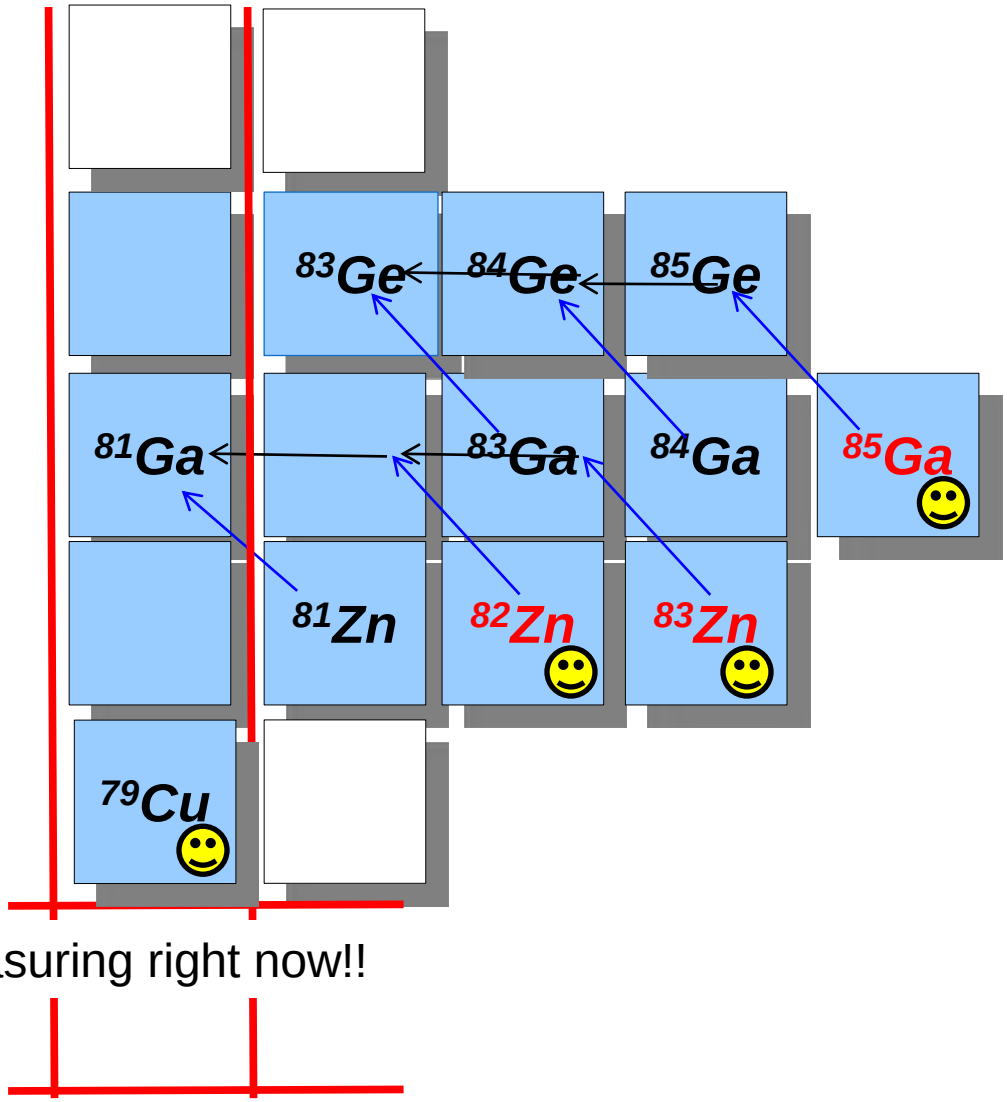
Disclaimer!

LeRIBSS campaign:
Feb. 5 → Feb. 26

6 weeks ago!!
(fresh out of the oven)

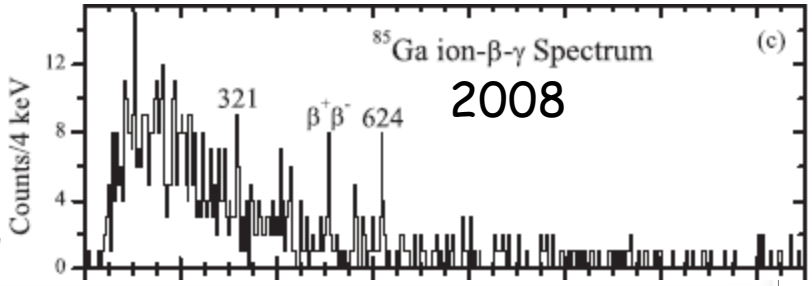
Very Preliminary!

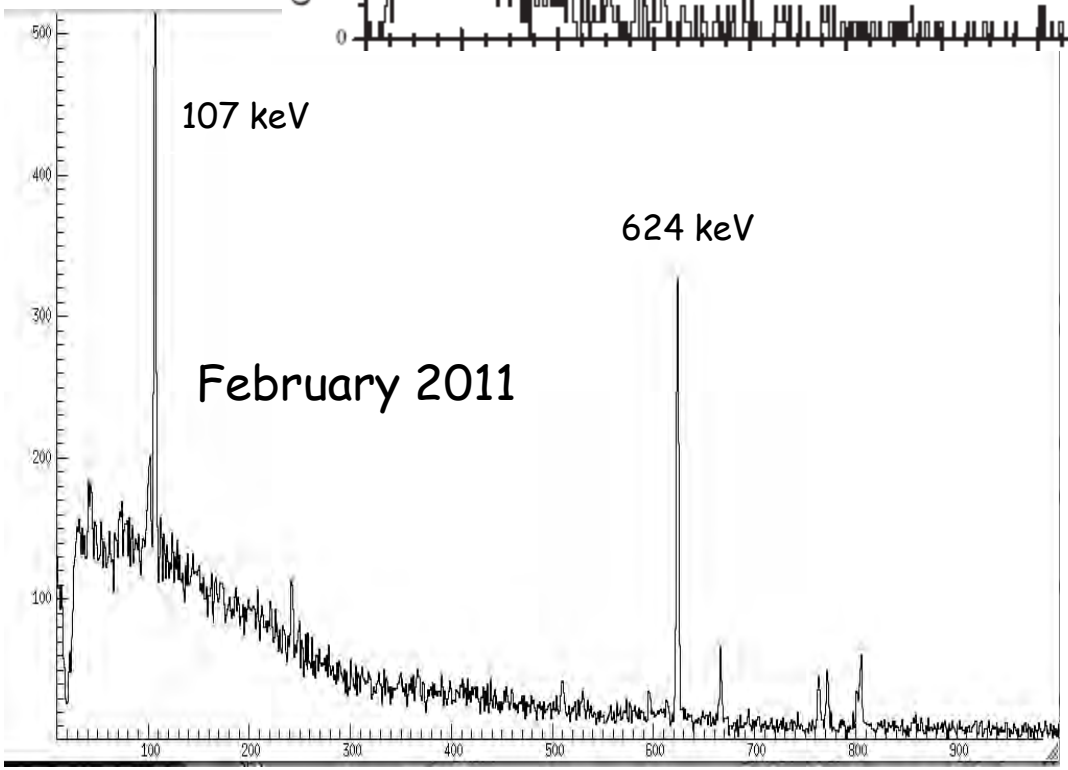
Recent measurements at a glance



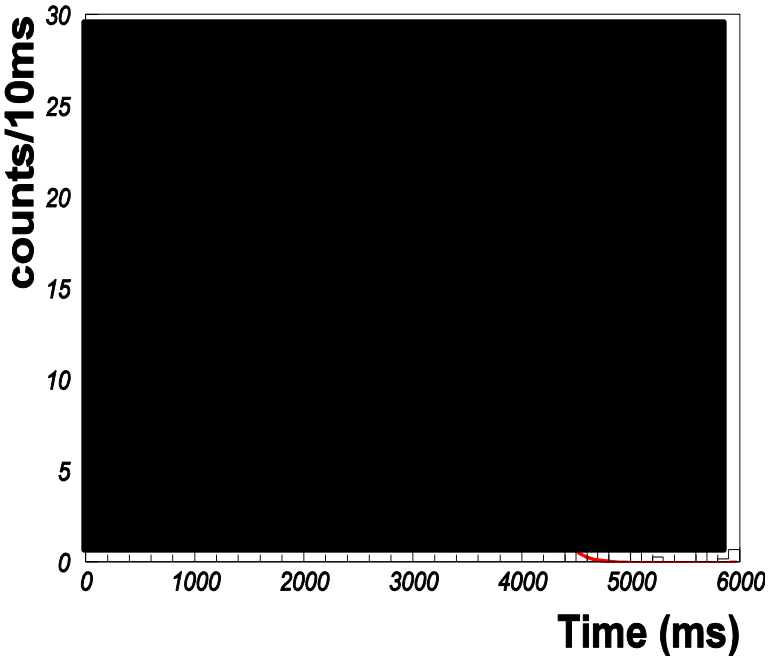
Measuring right now!!

Decay spectroscopy of ^{85}Ga

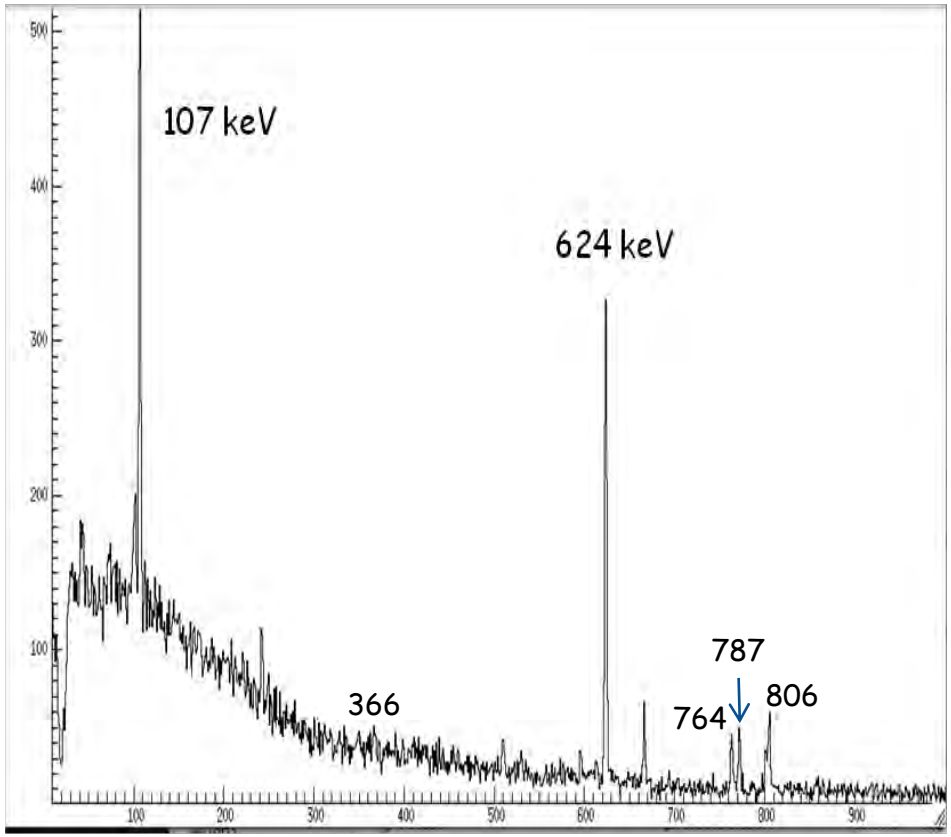


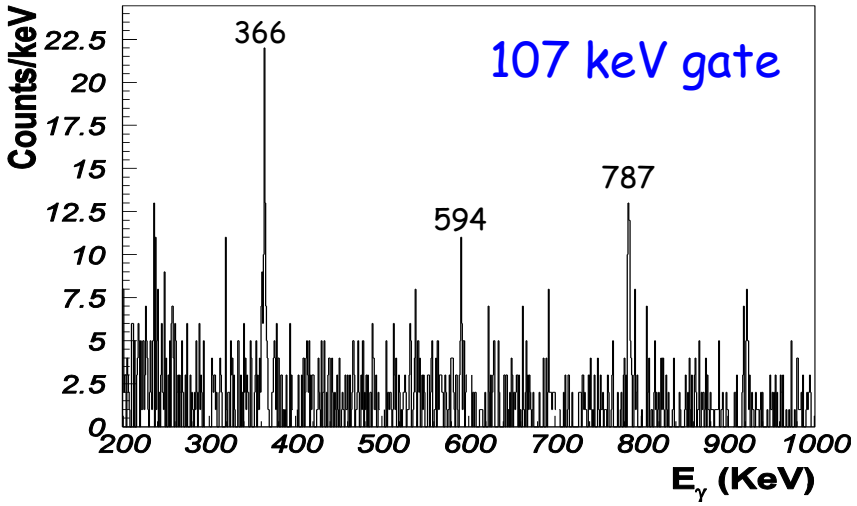


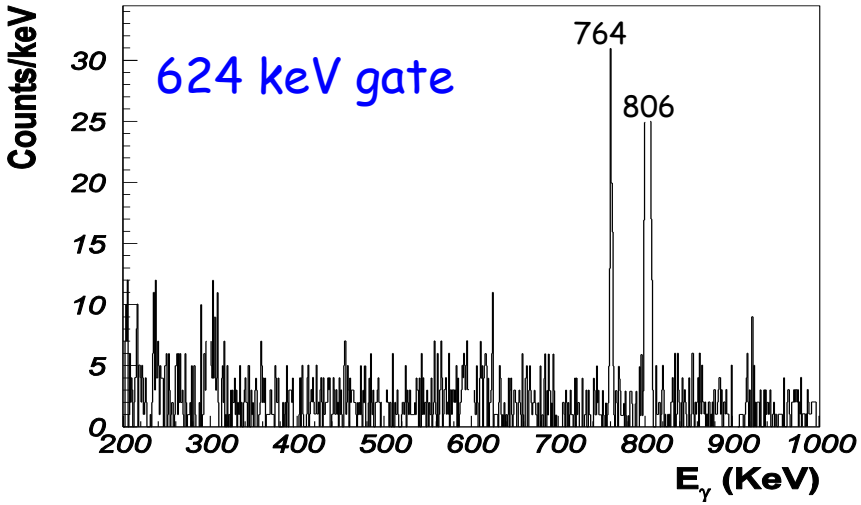
- Rate(2011) = 400 x rate(2008)
- Confirm 624 keV transition
- No 321 keV transition →107 keV



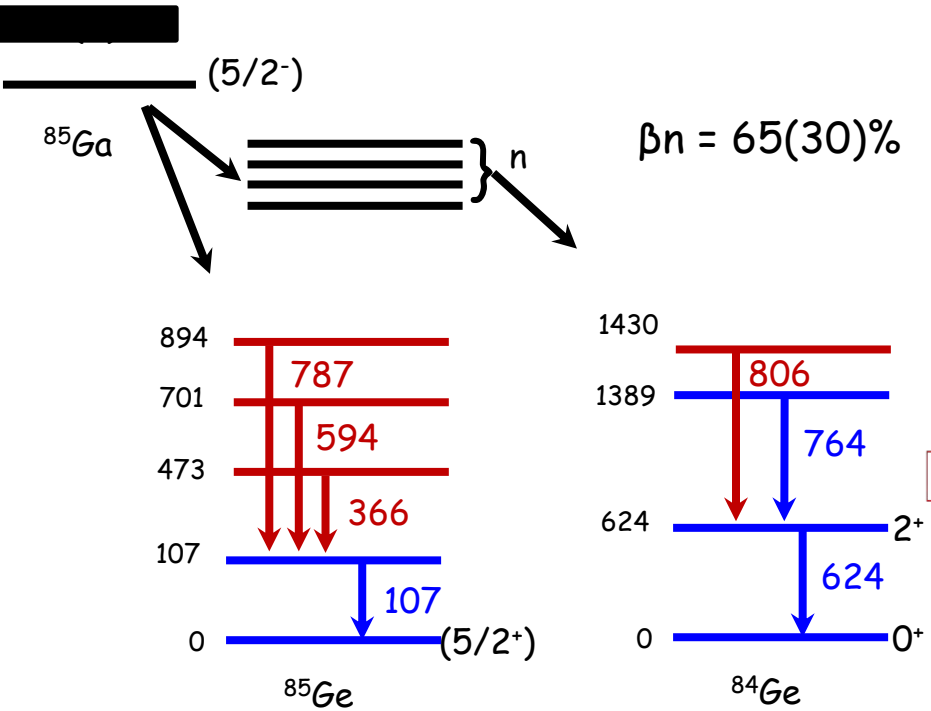
Gamma-gamma coincidences and level scheme



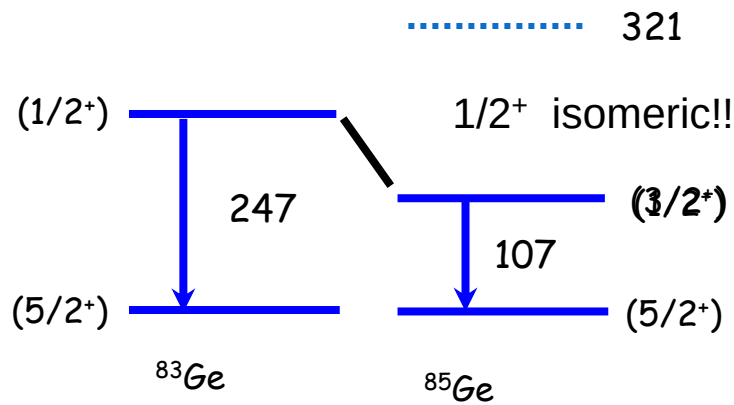


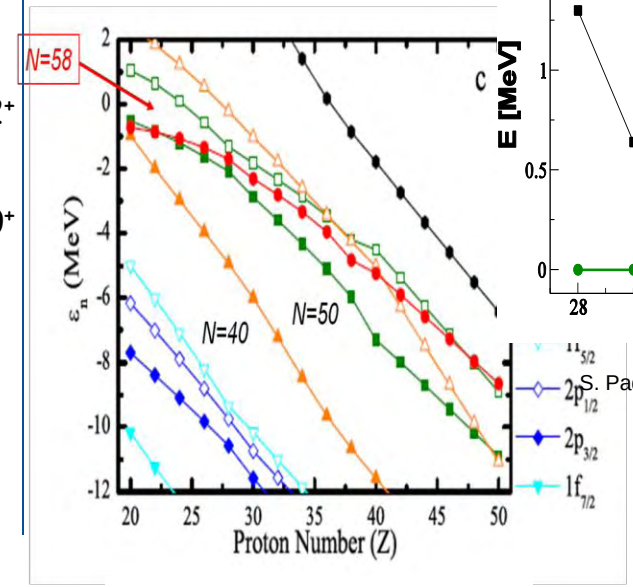


^{85}Ga level scheme

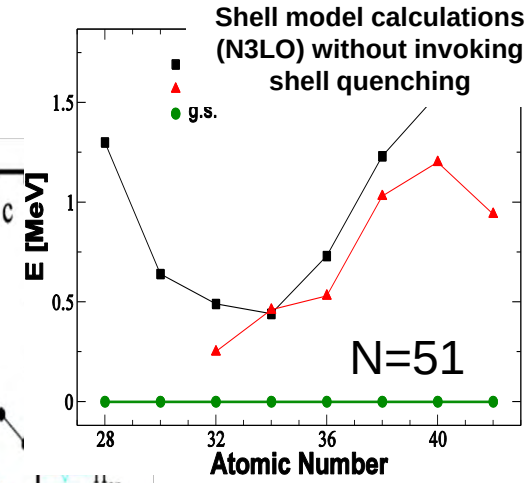


Potential N=58 $d_{5/2}$-$s_{1/2}$ subshell?



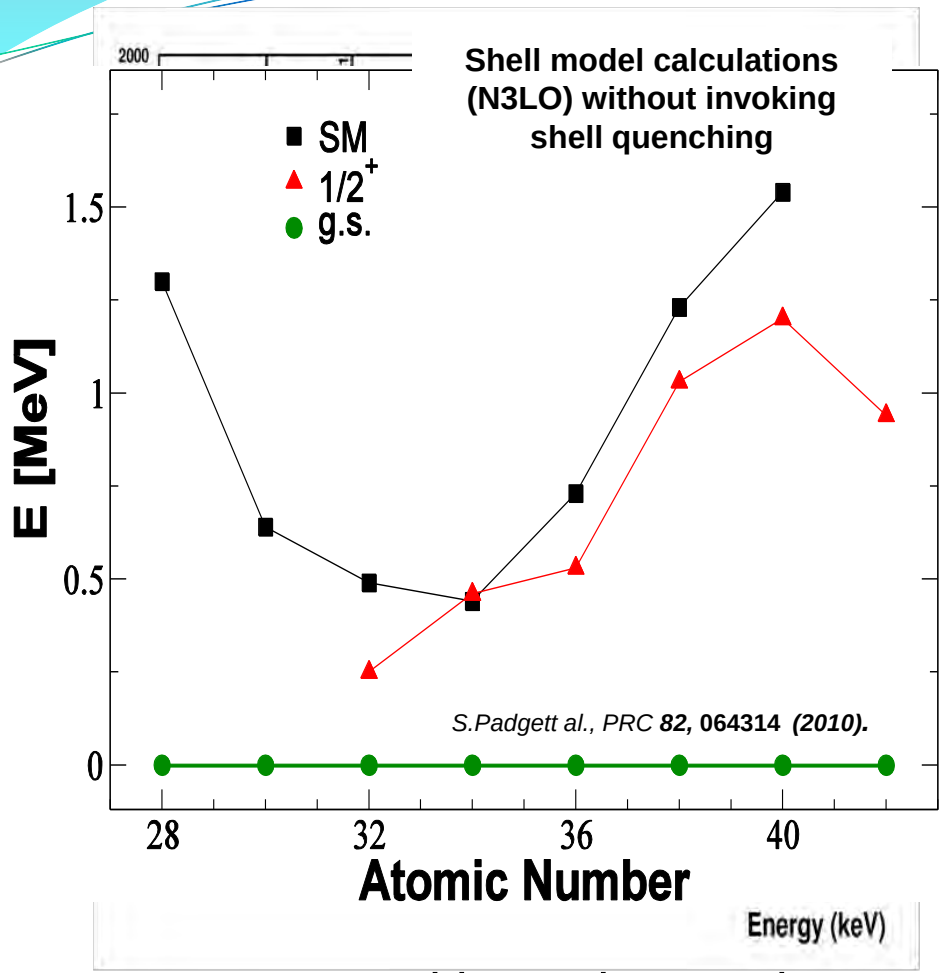


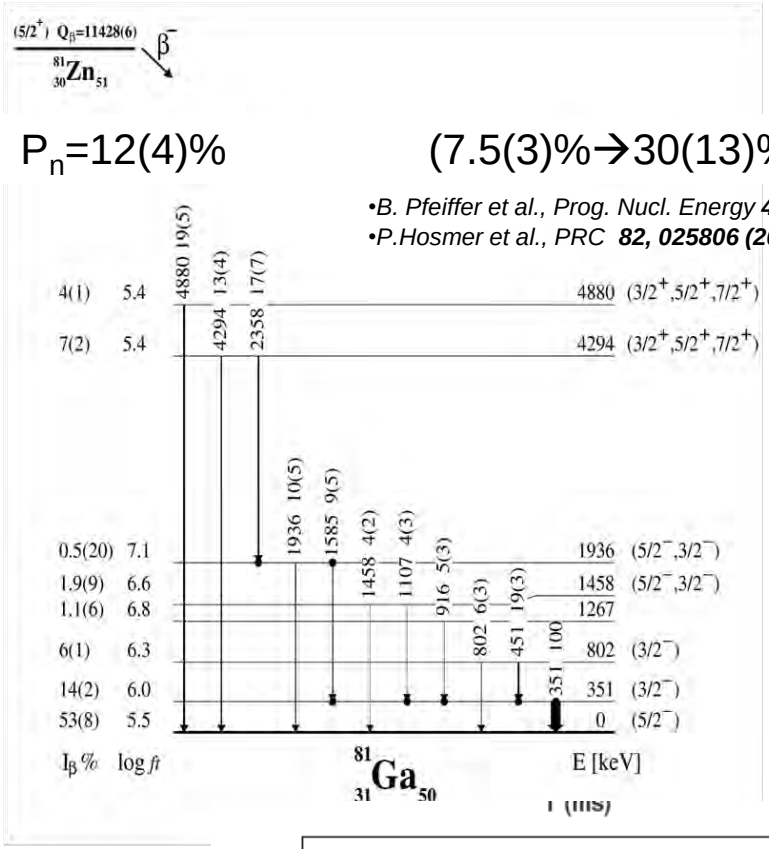
J. Dobaczewski published in
J. Winger et al., PRC ***81, 044303 (2010)***



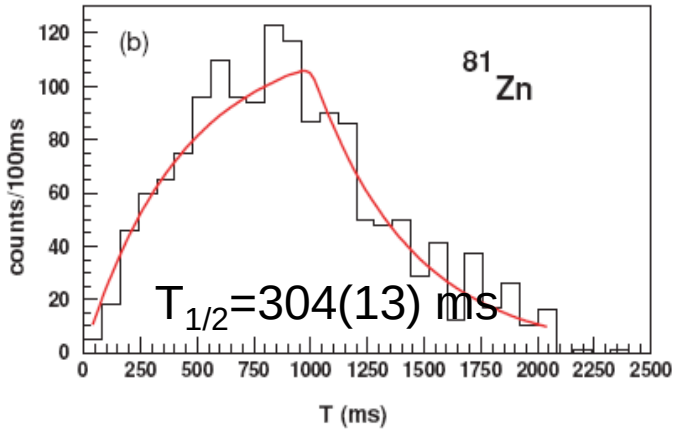
S. Padgett et al. PRC 82, 064314 (2010)

Summary of ^{81}Zn results

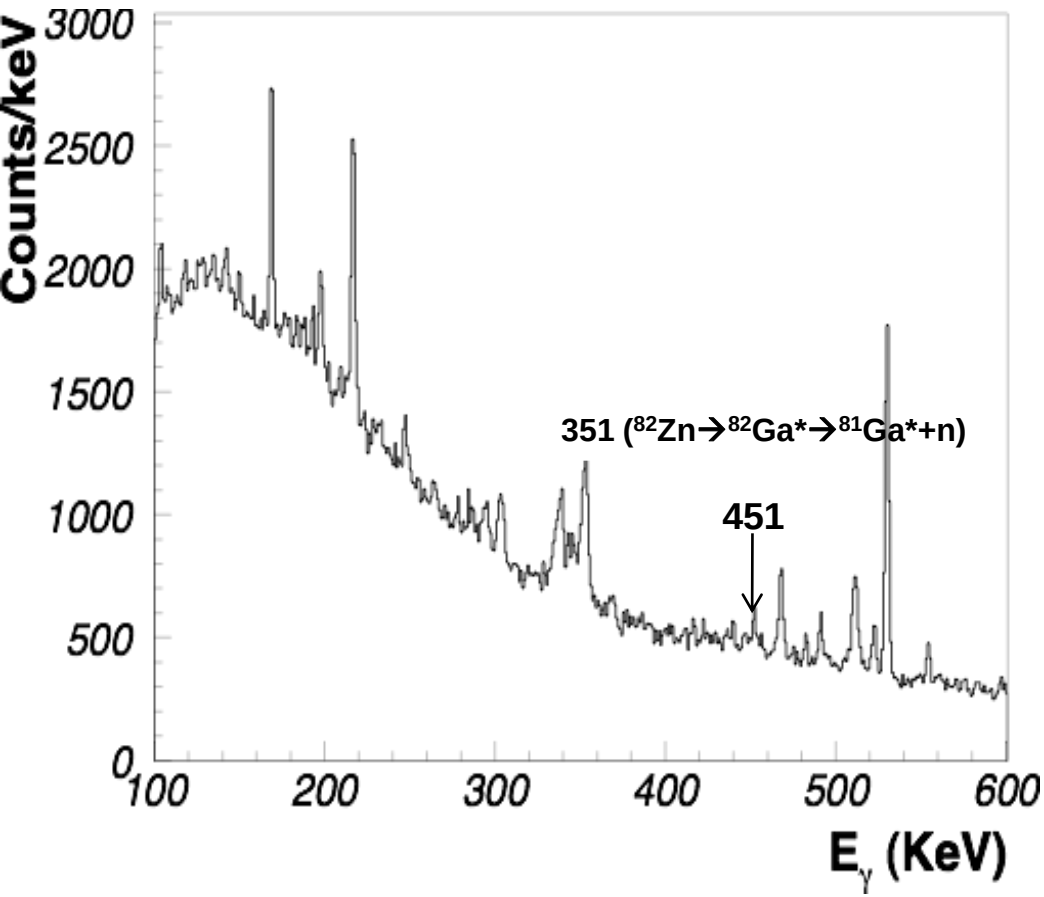


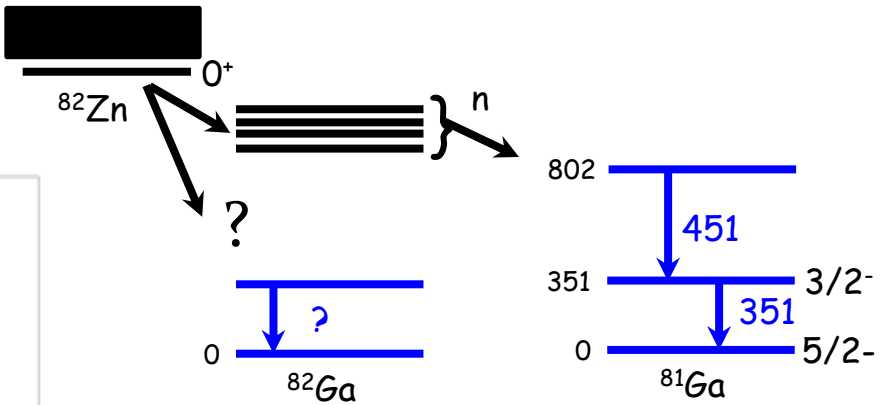


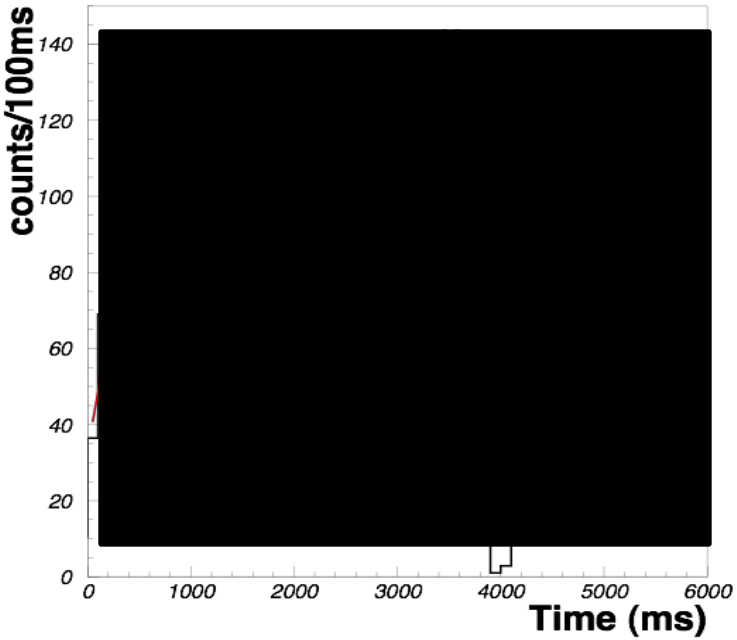
- 11 gamma transitions observed, 9 new ones.
- All placed in level scheme → 5 new states
- Pure ^{81}Zn beam



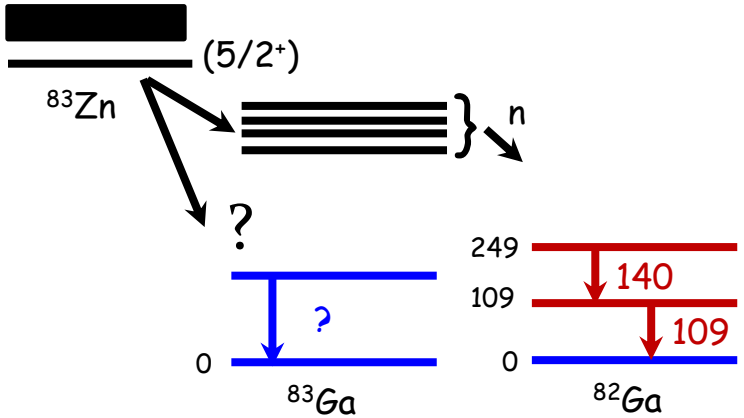
Decay spectroscopy of ^{82}Zn

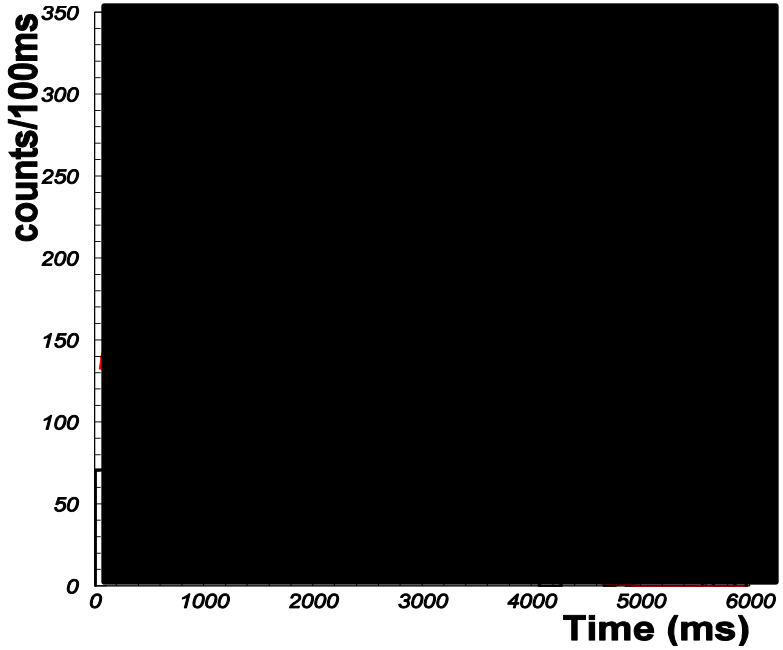


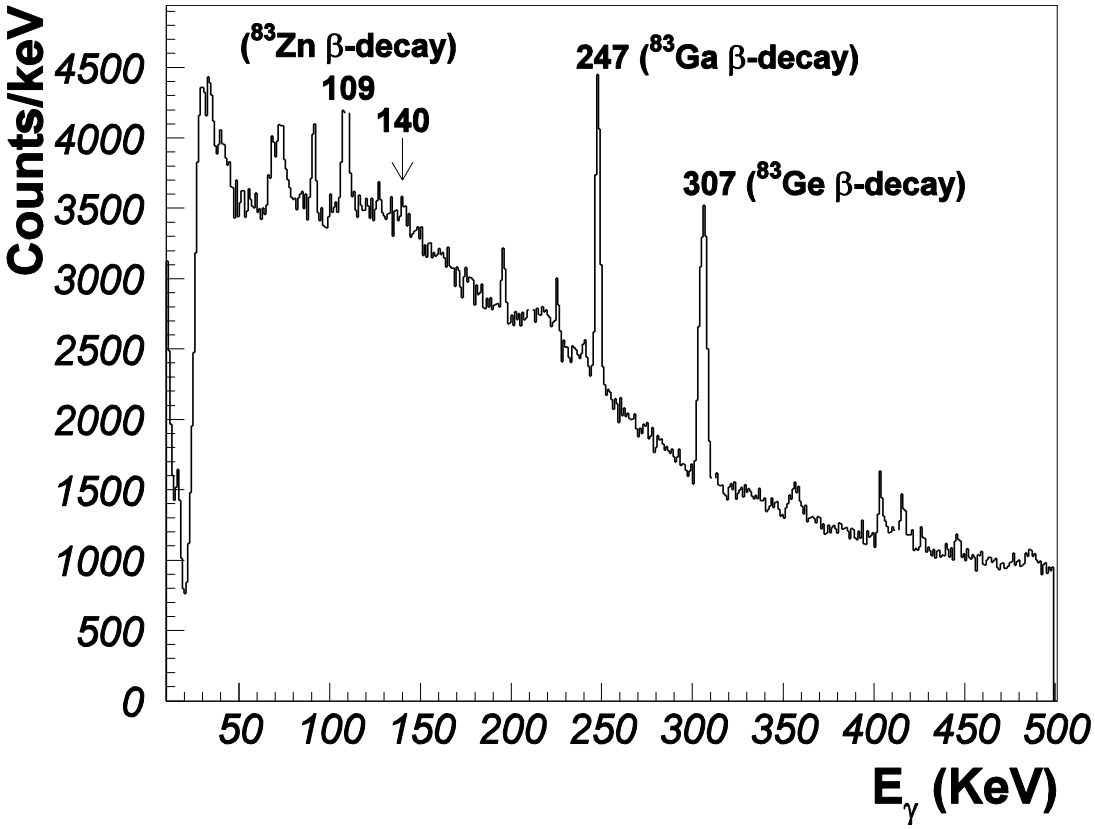




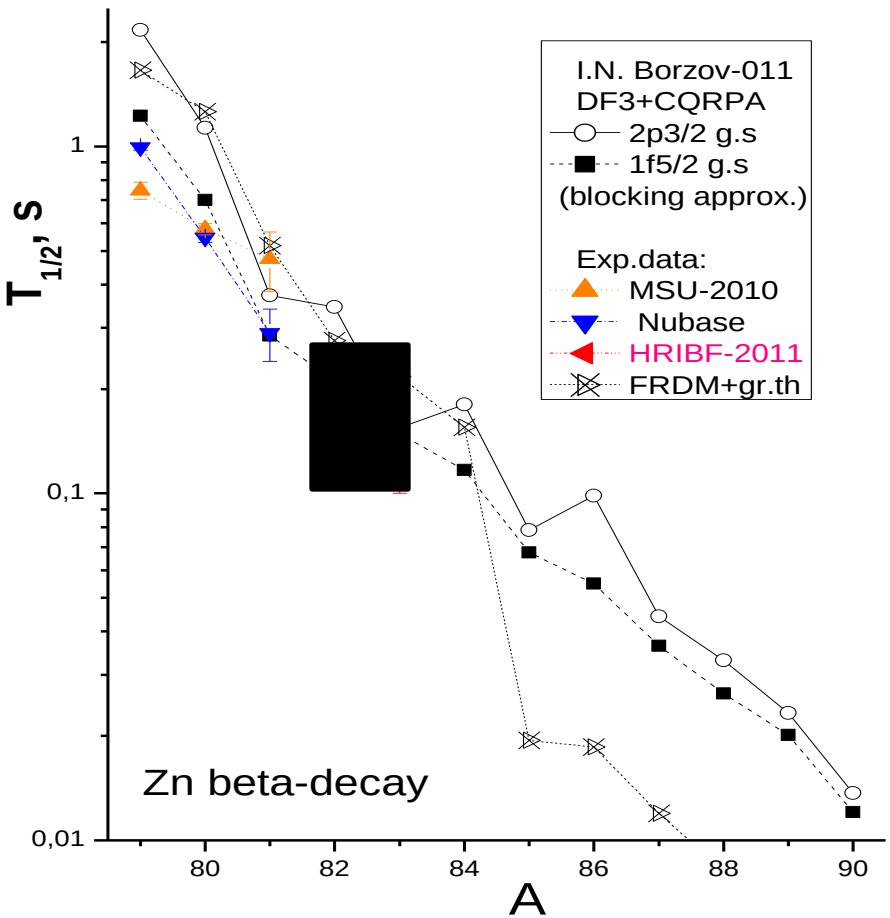
Decay spectroscopy of ^{83}Zn



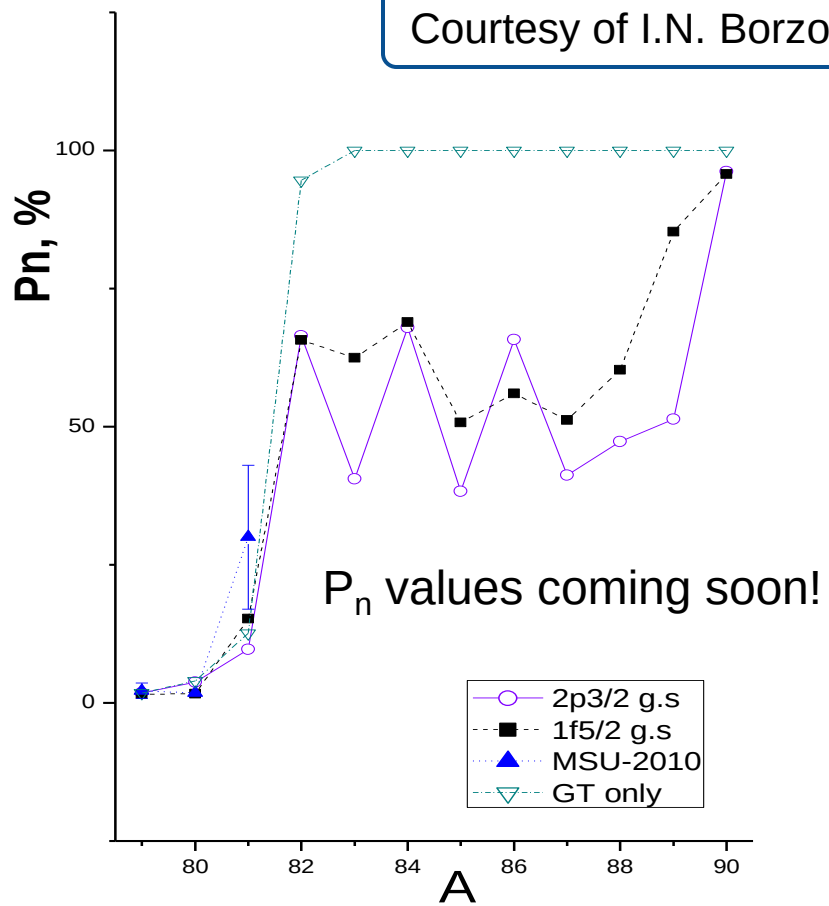




Calculation of Zn half-lives



Courtesy of I.N. Borzov

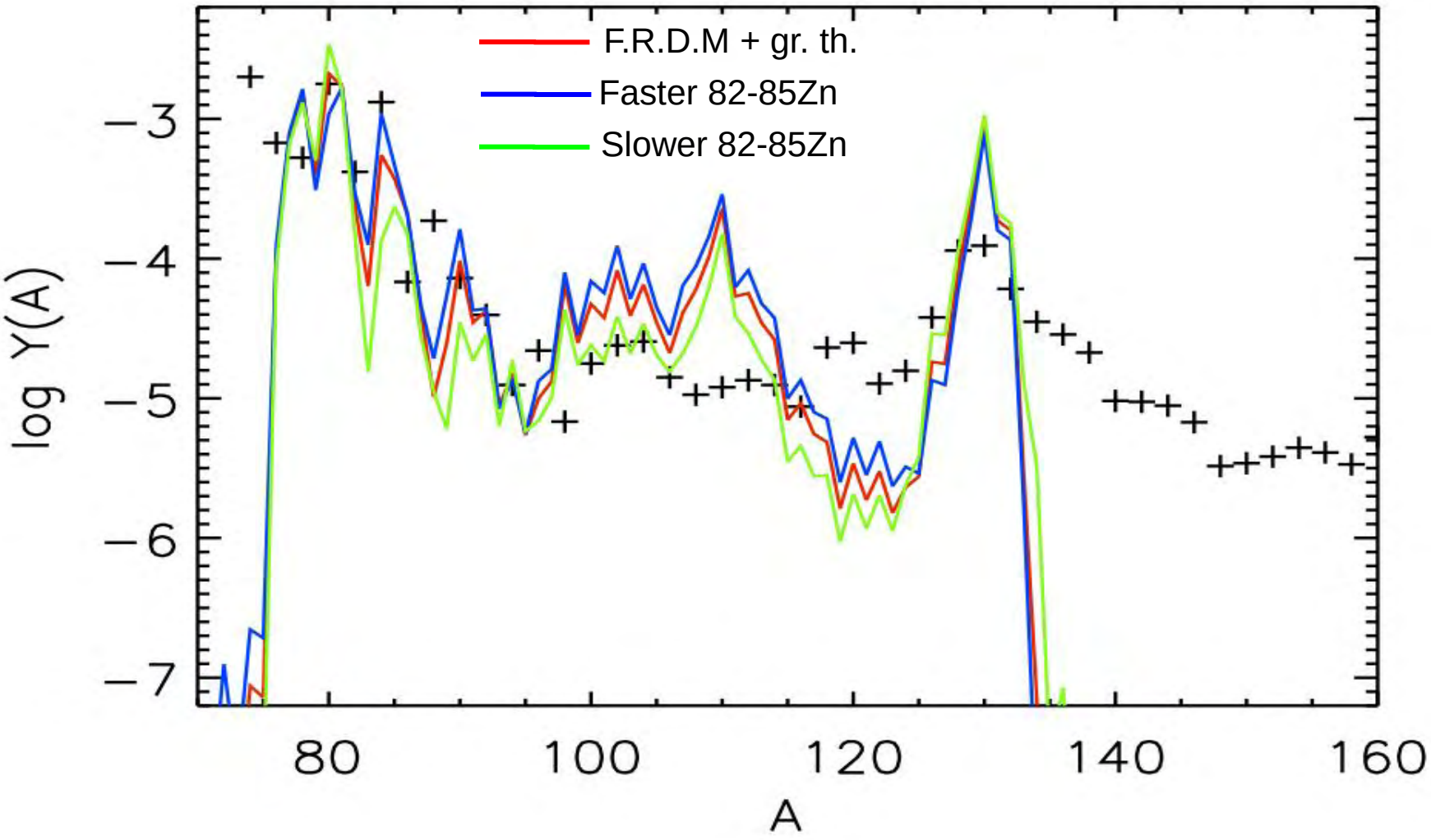


P_n values coming soon!

- New LeRIBSS half-lives validate g.s($\pi f_{5/2}$) calculations
- Half-lives systematically faster than FRDM calculations

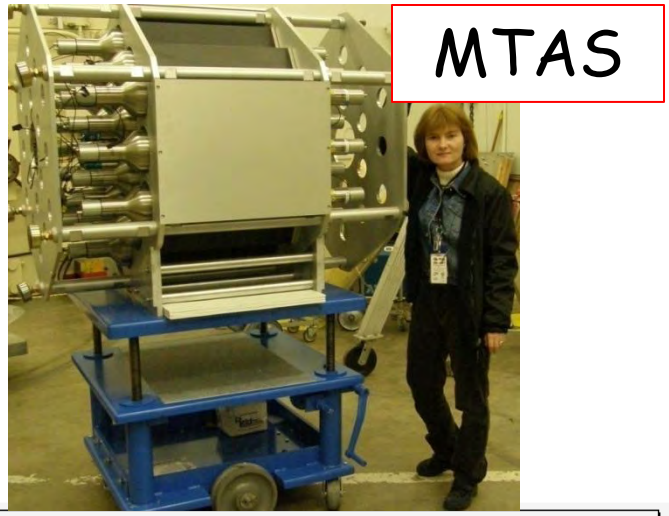
Zn isotopes half-lives and r-process abundances

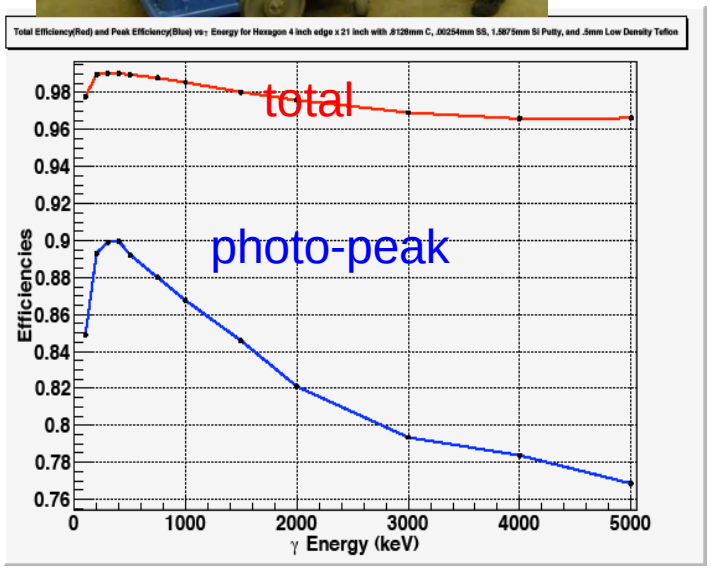
Courtesy of R. Surman



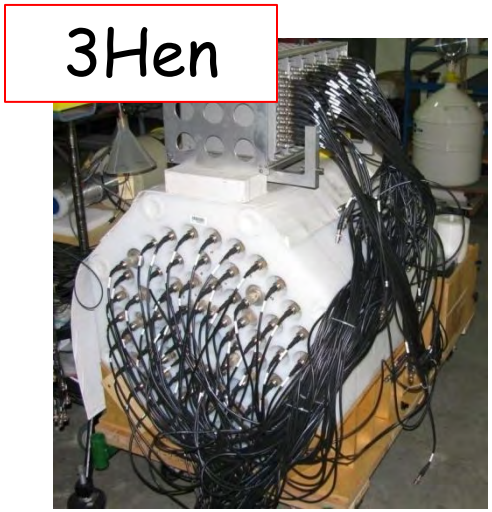
New detectors @ LeRIBSS

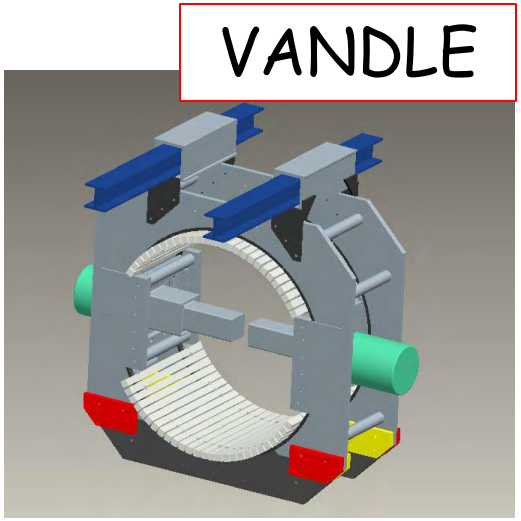
Gamma calorimetry

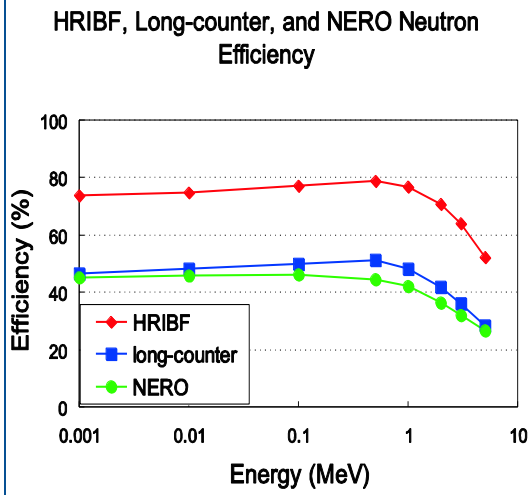




Neutron Detection

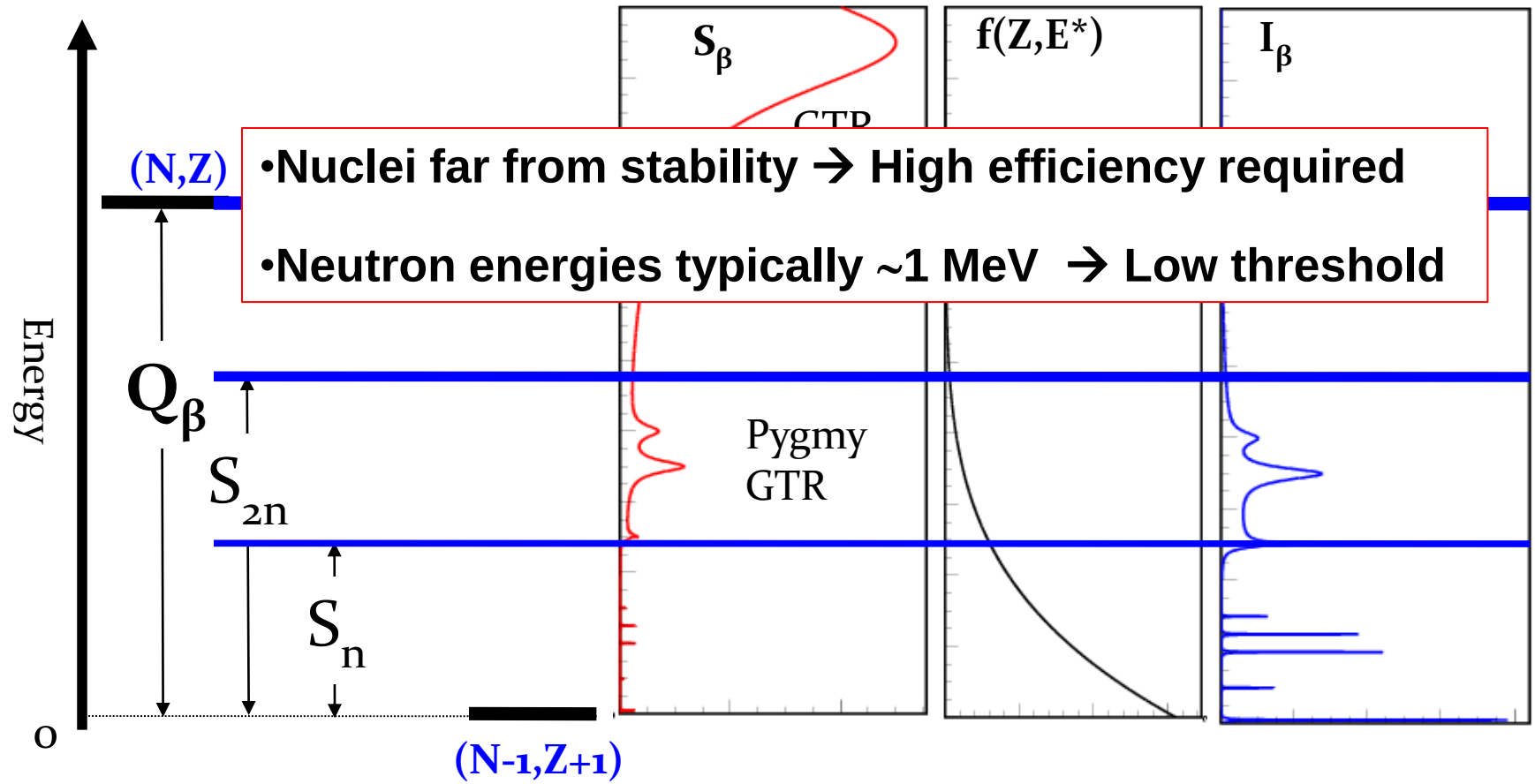






Gamow-Teller decay of neutron rich nuclei

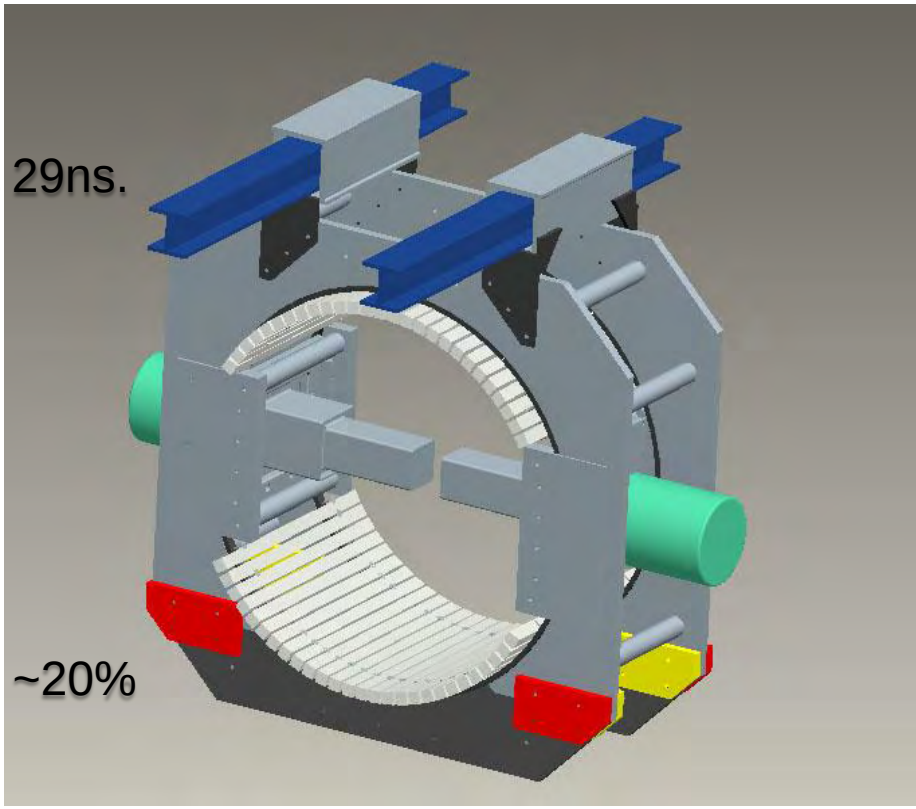
$$\frac{1}{T_{1/2}} = \sum_{E_i \geq 0}^{E_i \leq Q_\beta} S(E_i) \times f(Z, Q_\beta - E_i)$$



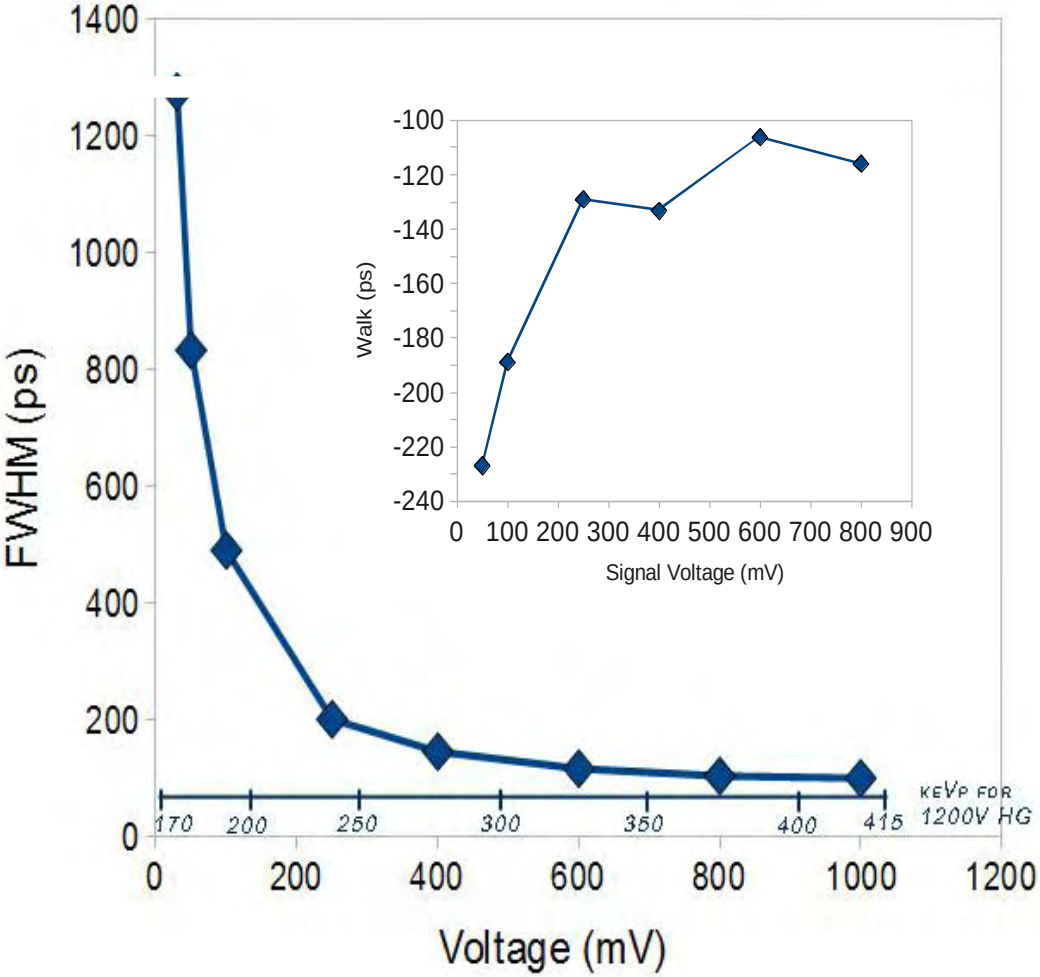
- Nuclei far from stability → High efficiency required
- Neutron energies typically ~1 MeV → Low threshold

VANDLE: Beta-n Configuration

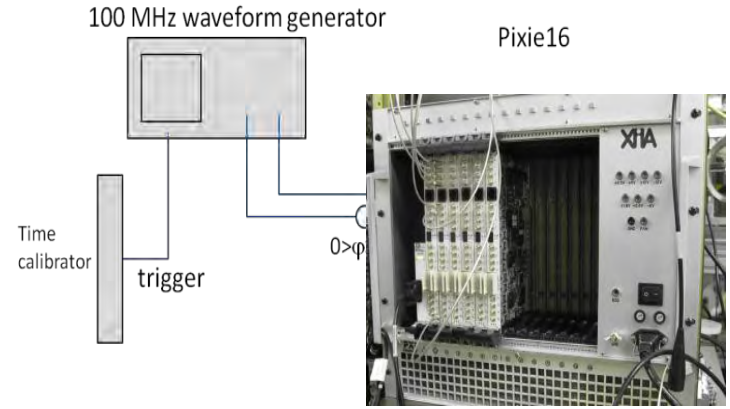
- Details
  - Full cylinder: r = 40cm
    - TOF for 1MeV neutron at 40cm is 29ns.
  - 80 bars: $(3cm)^2$ x 60cm
- Properties
  - Geometrical coverage: ~60%
  - Energy Range: 100keV – 2MeV
  - Low neutron threshold
  - Estimated neutron detection efficiency: ~20%

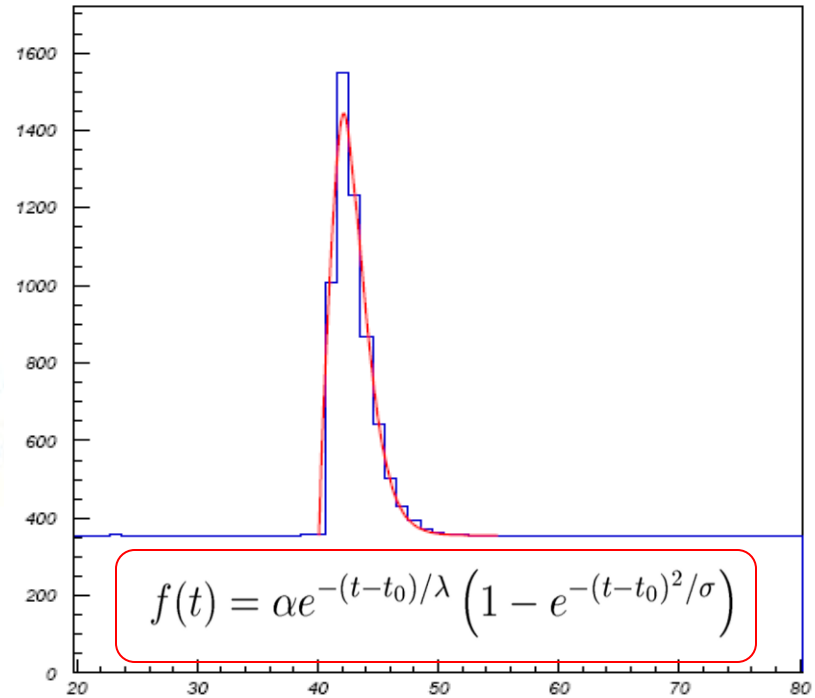


Digital electronics for VANDLE



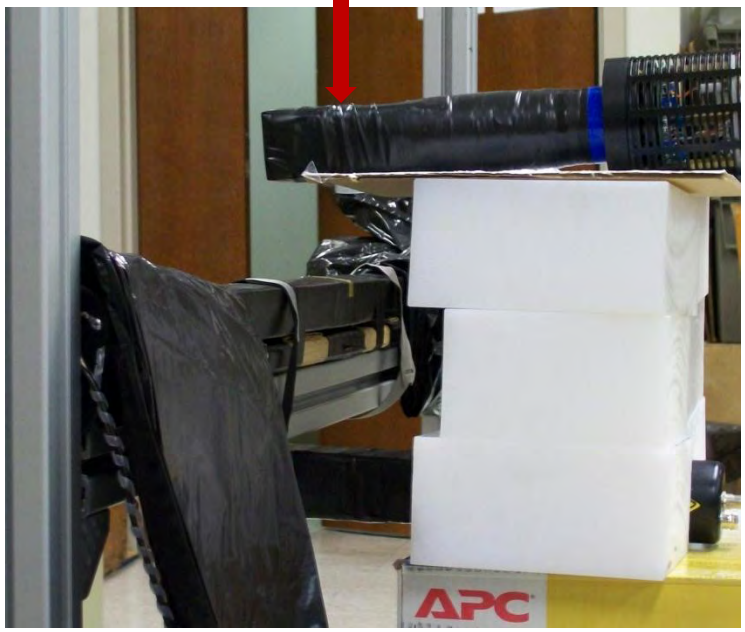
Energy calibration courtesy of I. Spassova & W.A. Peters

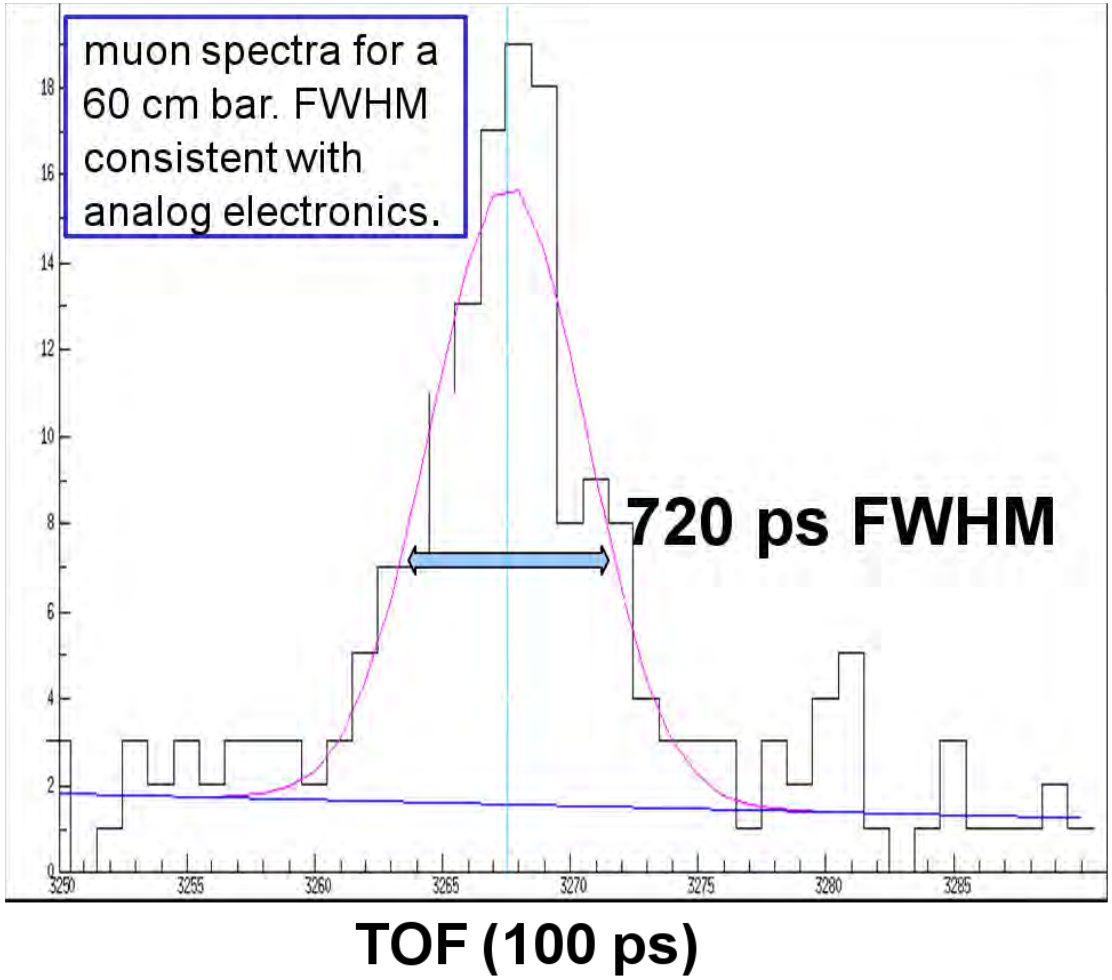




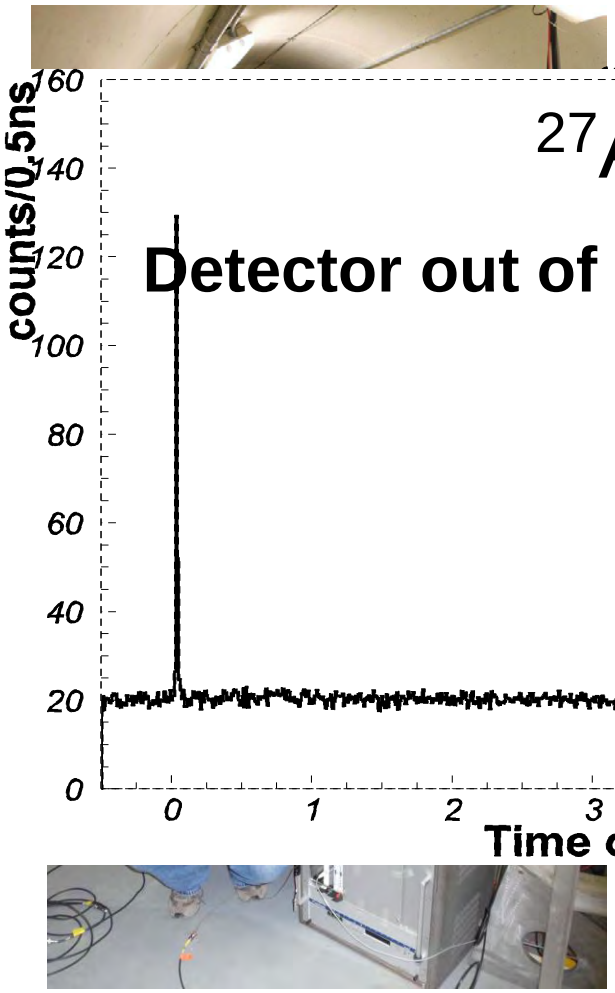
Measuring the time resolution of VANDLE detectors

4-coincidences, only accepts muons in this region

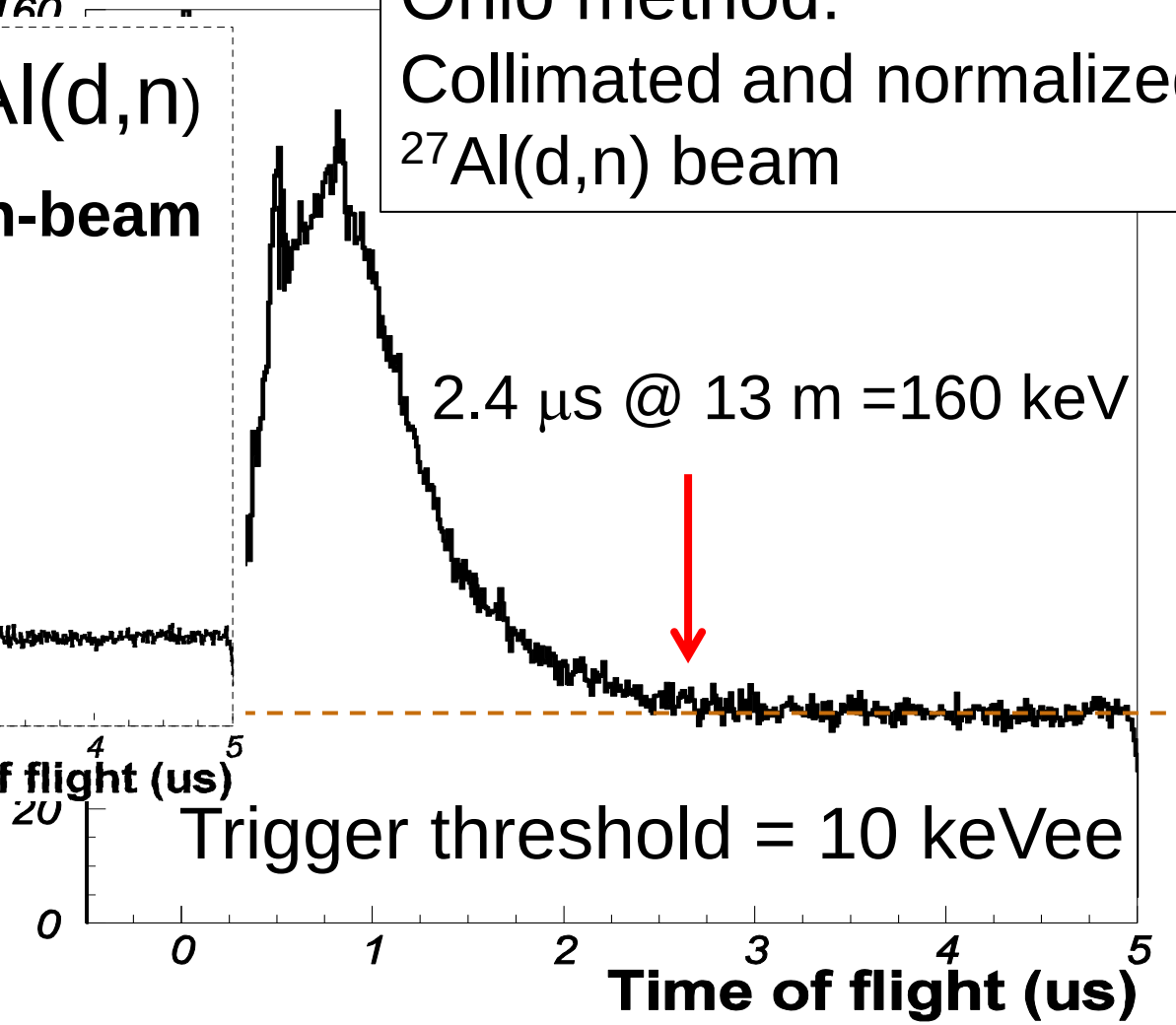




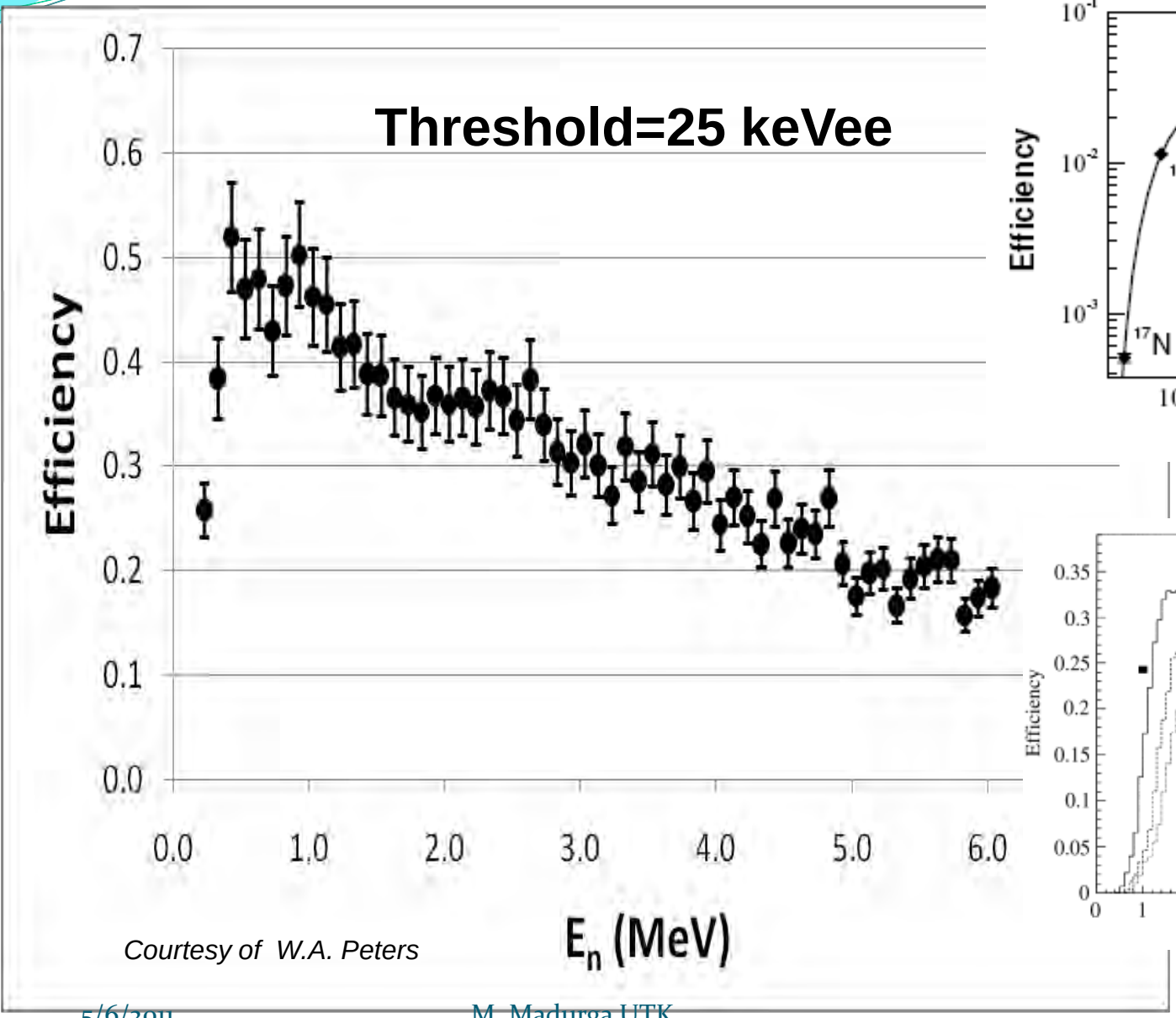
VANDLE efficiency measurement at Ohio University



Ohio method:
Collimated and normalized ^{27}Al(d,n) beam

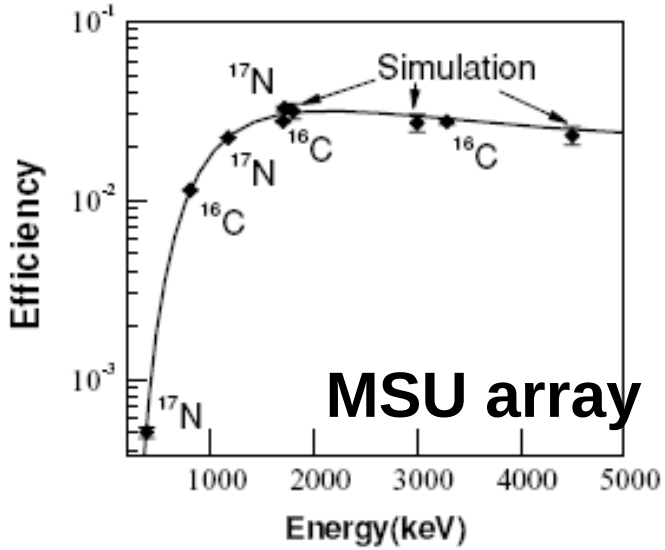


VANDLE efficiency

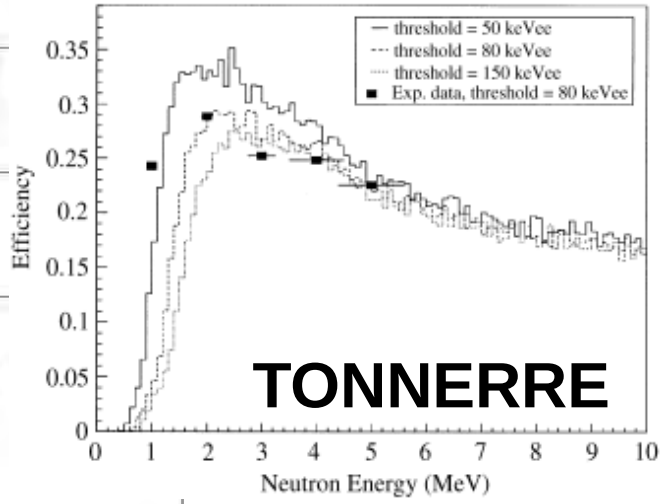


Courtesy of W.A. Peters

C. Sumithrarachchi et al., PRC 74, 024322(2006)

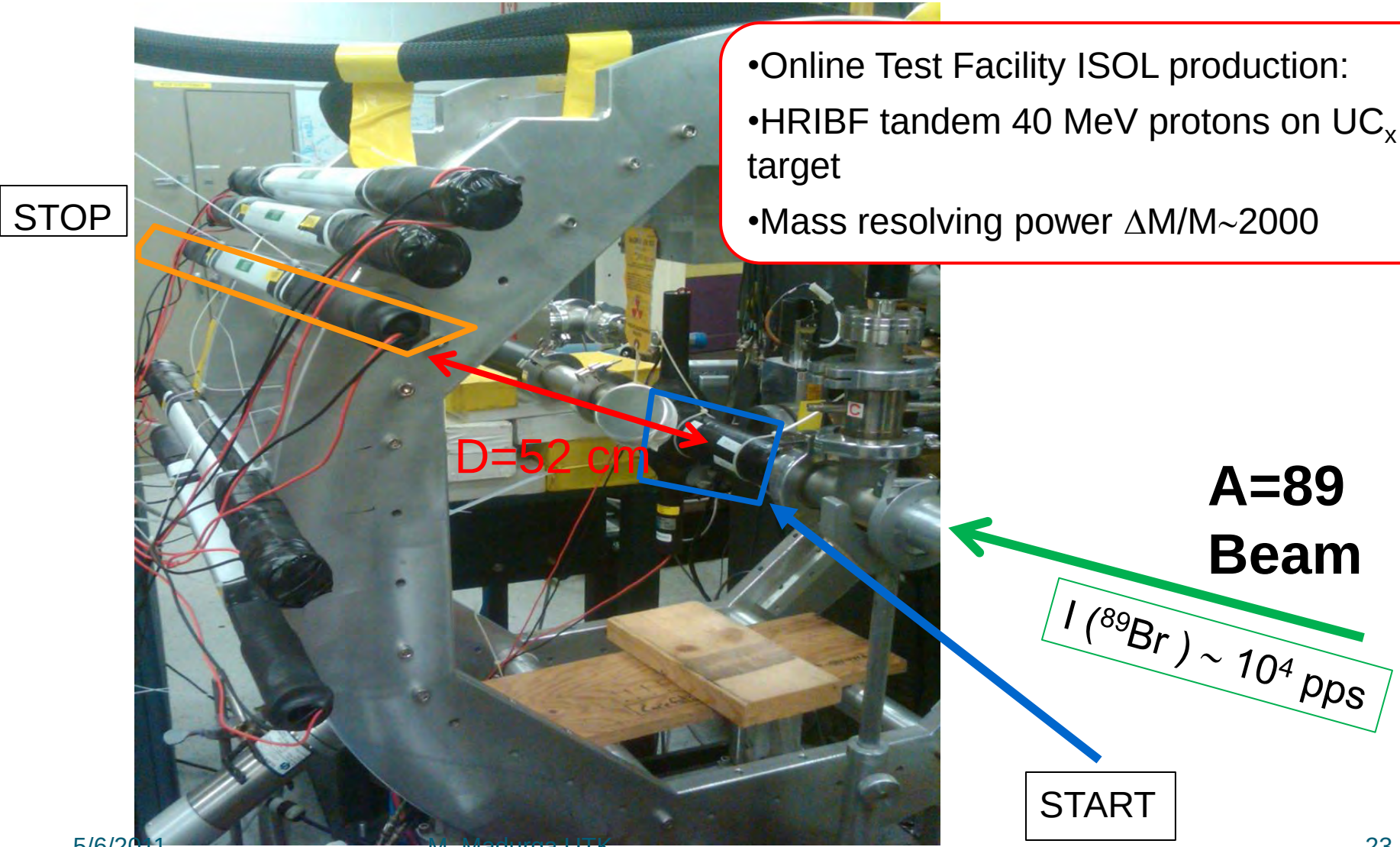


A. Buta et al.., NIM A 455 (2000) 412



Proof-of-principle measurement of ^{89}Br delayed neutron emission @ OLTF

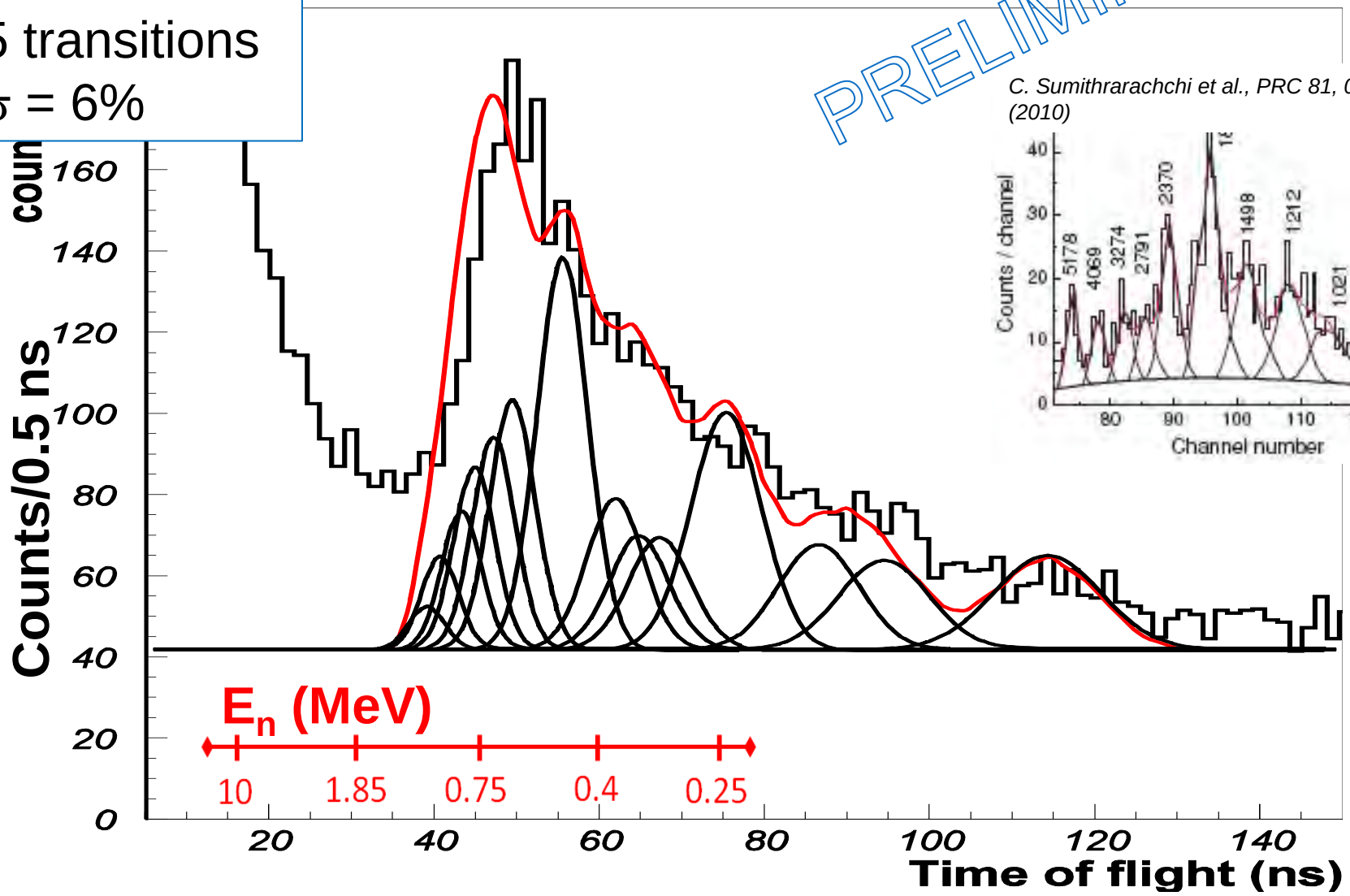
- Online Test Facility ISOL production:
- HRIBF tandem 40 MeV protons on UC_x target
- Mass resolving power $\Delta M/M \sim 2000$



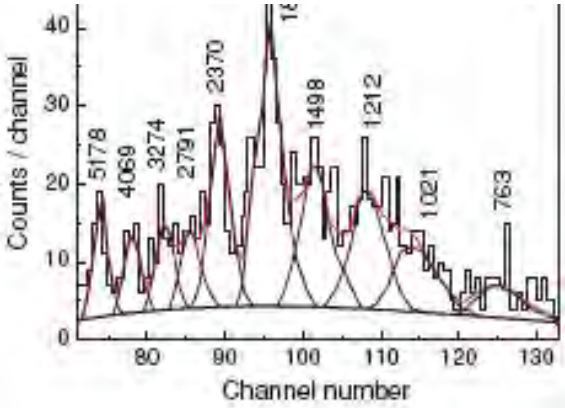
Peak identification

5 transitions
σ = 6%

PRELIMINARY



C. Sumithrarachchi et al., PRC 81, 014302 (2010)



Summary and outlook

- IRIS 2 commission great success! Clean, high quality data.
- 3 new half-lives of r-process relevant nuclei.
- Continue exploring beta-decay of n-rich Ga, Ge, Sb Ag isotopes. CARIBU role.
- VANDLE's high efficiency and low threshold makes it ideal for beta delayed neutron spectroscopy.