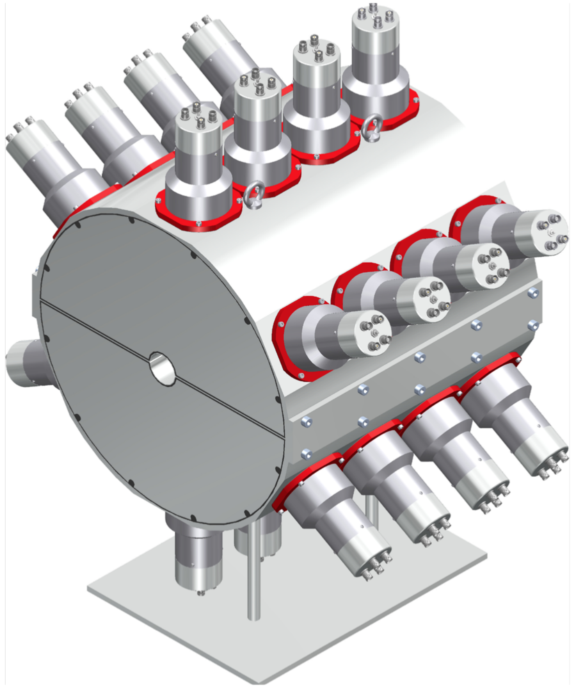
A Total Absorption Spectrometer for ISAC

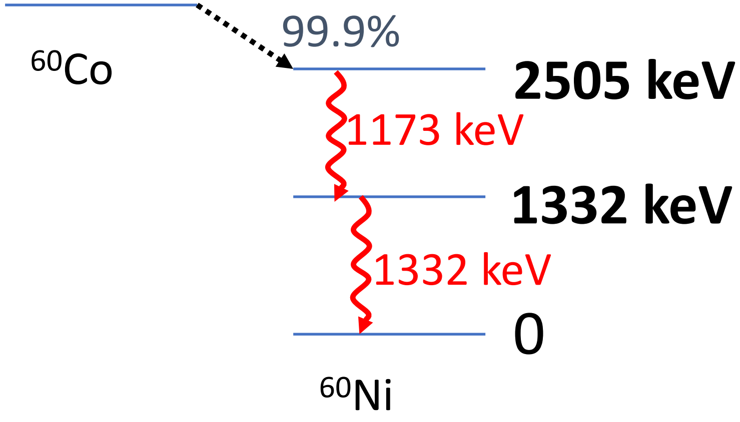
Dennis Muecher, University of Guelph & TRIUMF

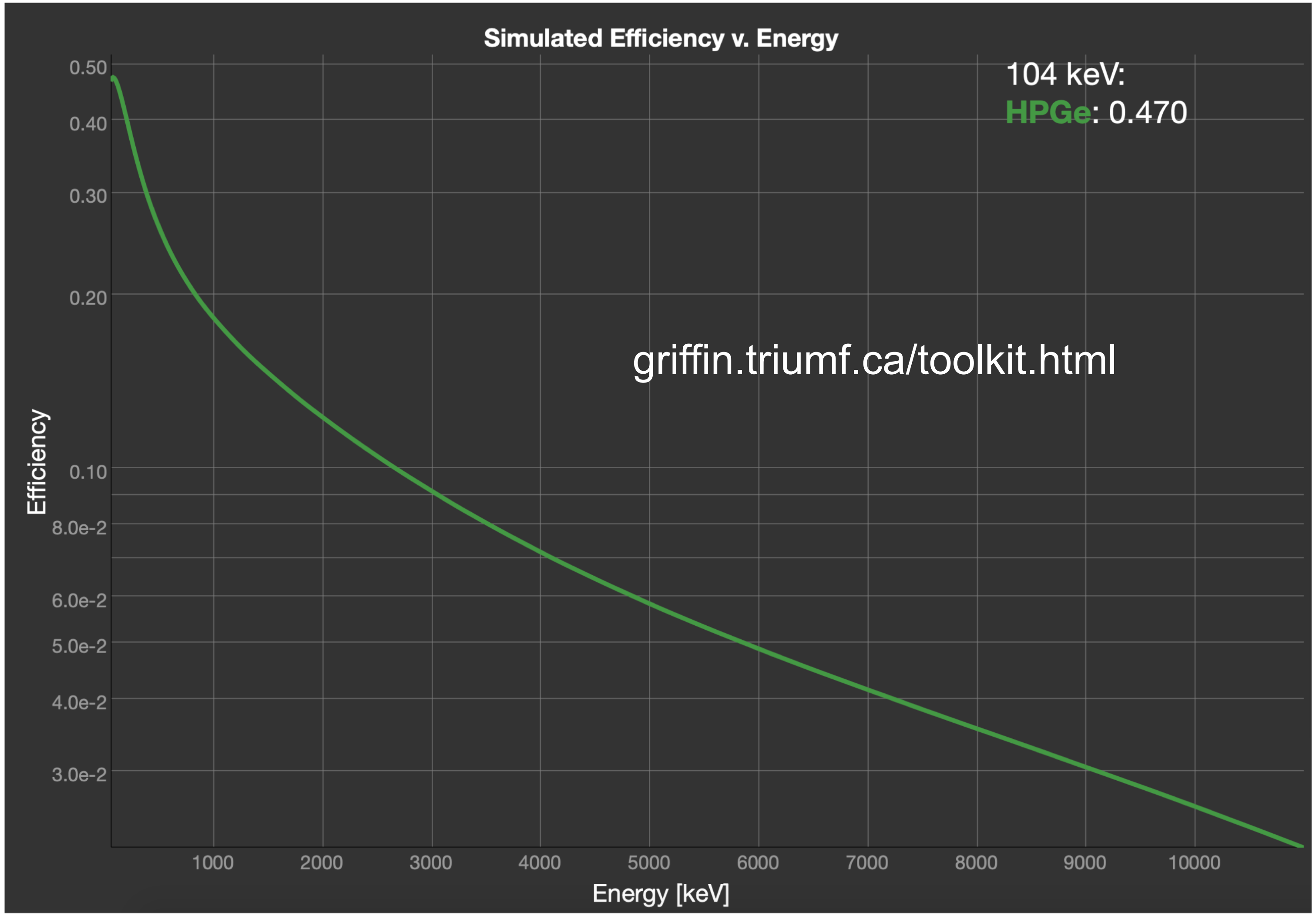
(collaboration with Artemis Spyrou, NSCL, Michigan State University)



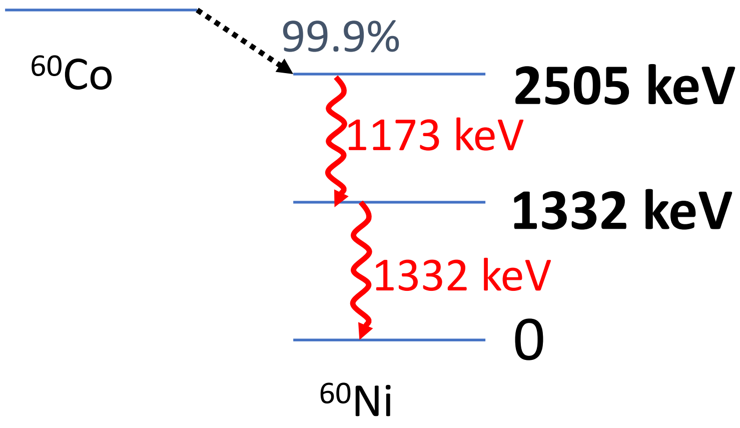
SuN, NSCL

GRIFFIN / TIGRESS gamma ray efficiency

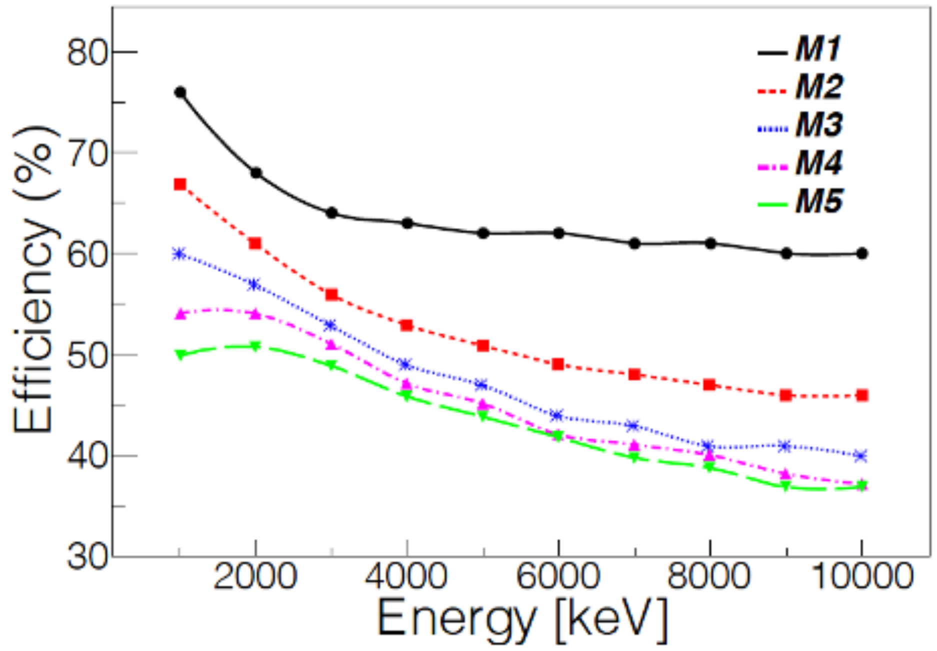


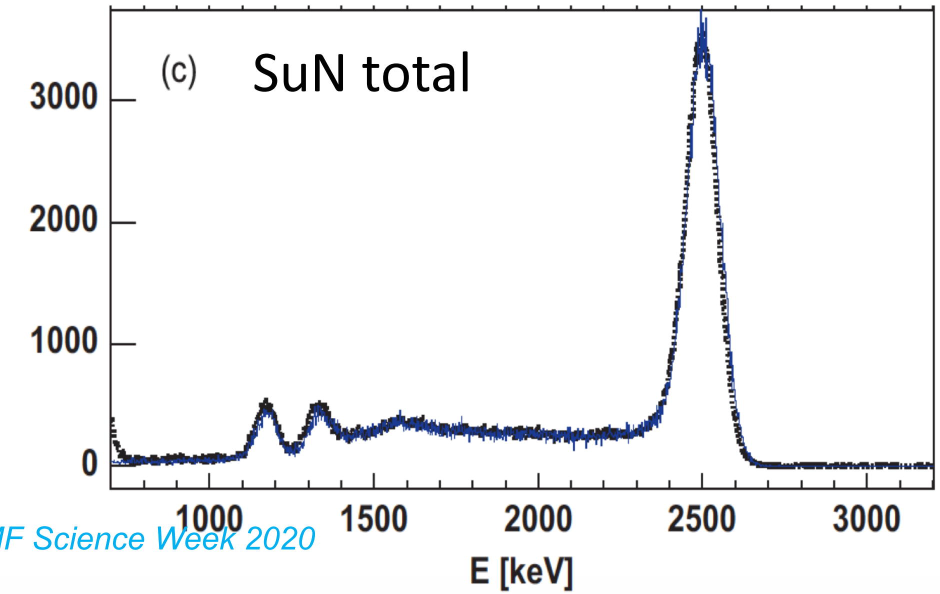


Total Absorption Spectrometry

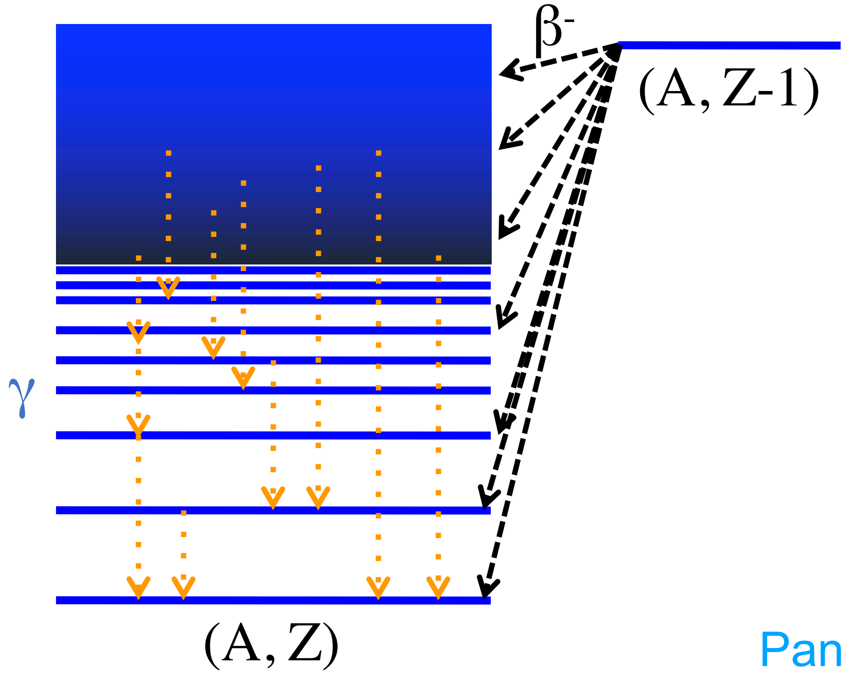


Chance to detect the sum energy: 60%

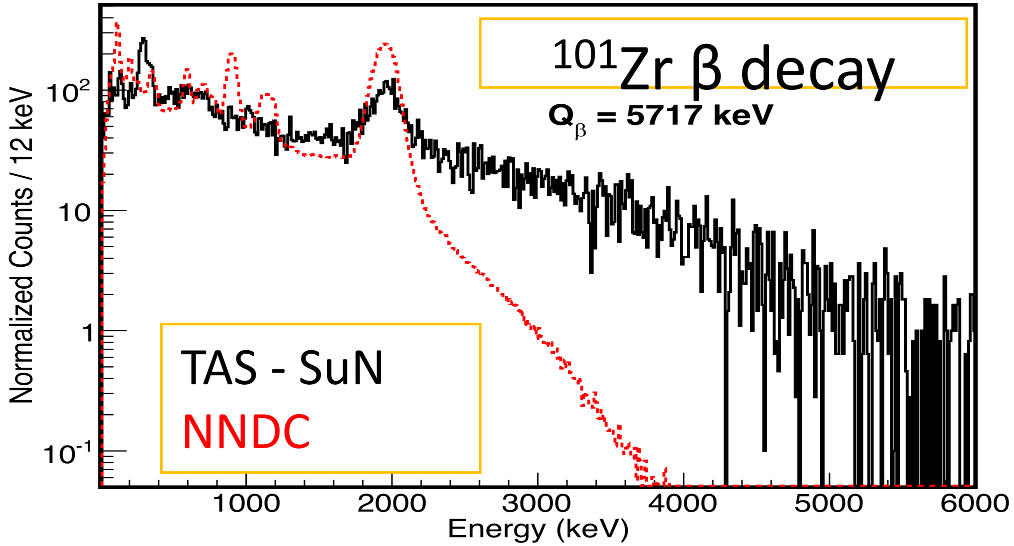


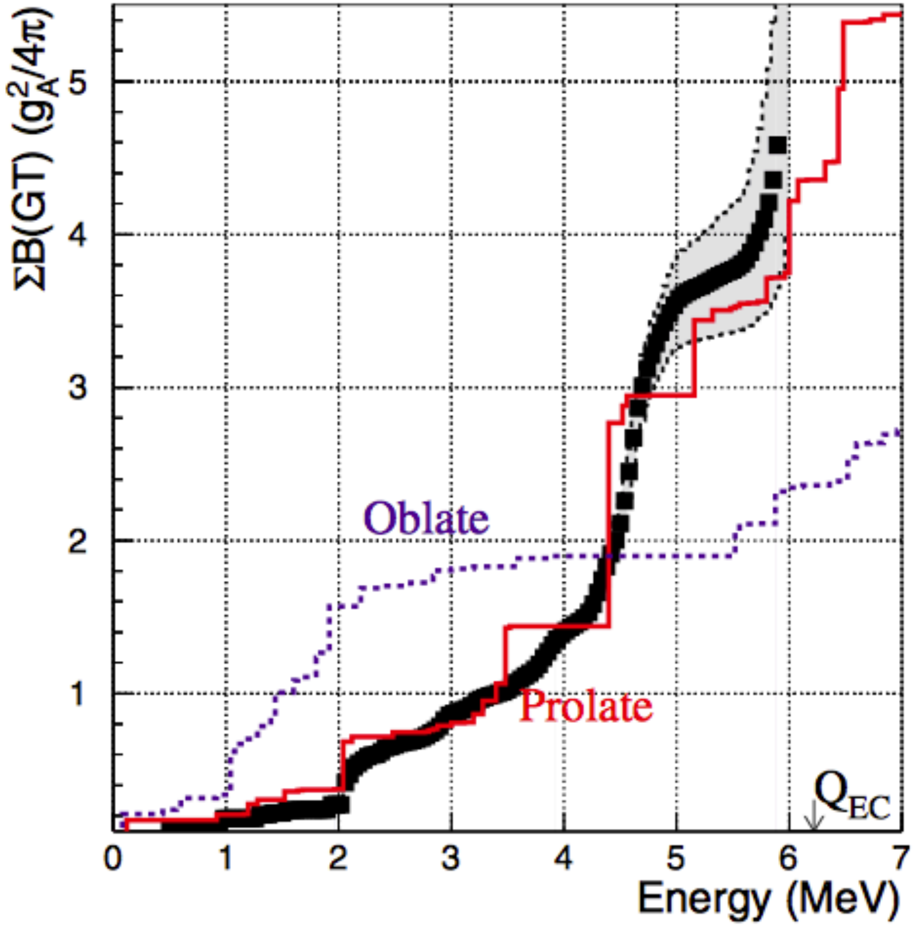


Beta-decay strength measurements: Structure, Astrophysics…



Pandemonium effect

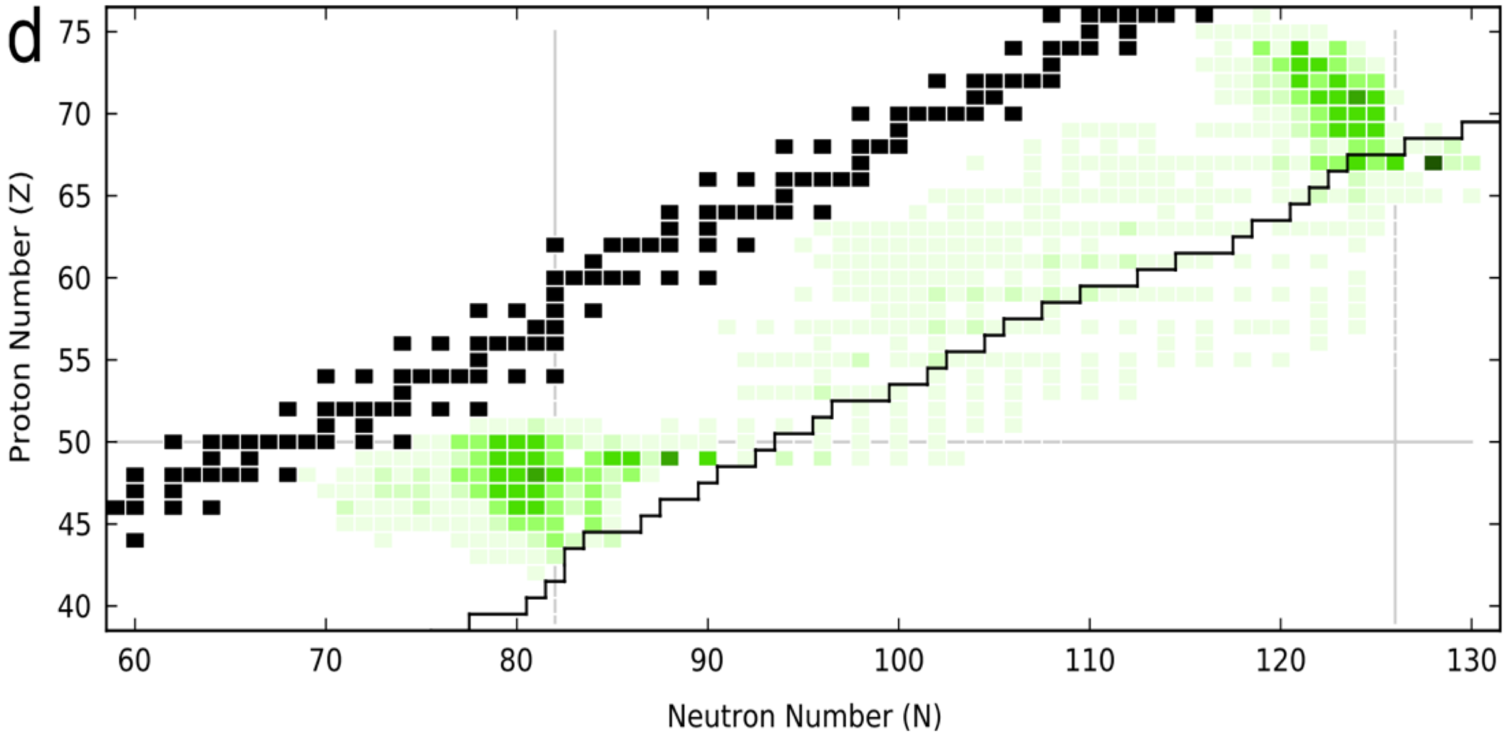




E. Nacher, *et al., Phys. Rev. Lett. 92 (2004) 232501.*

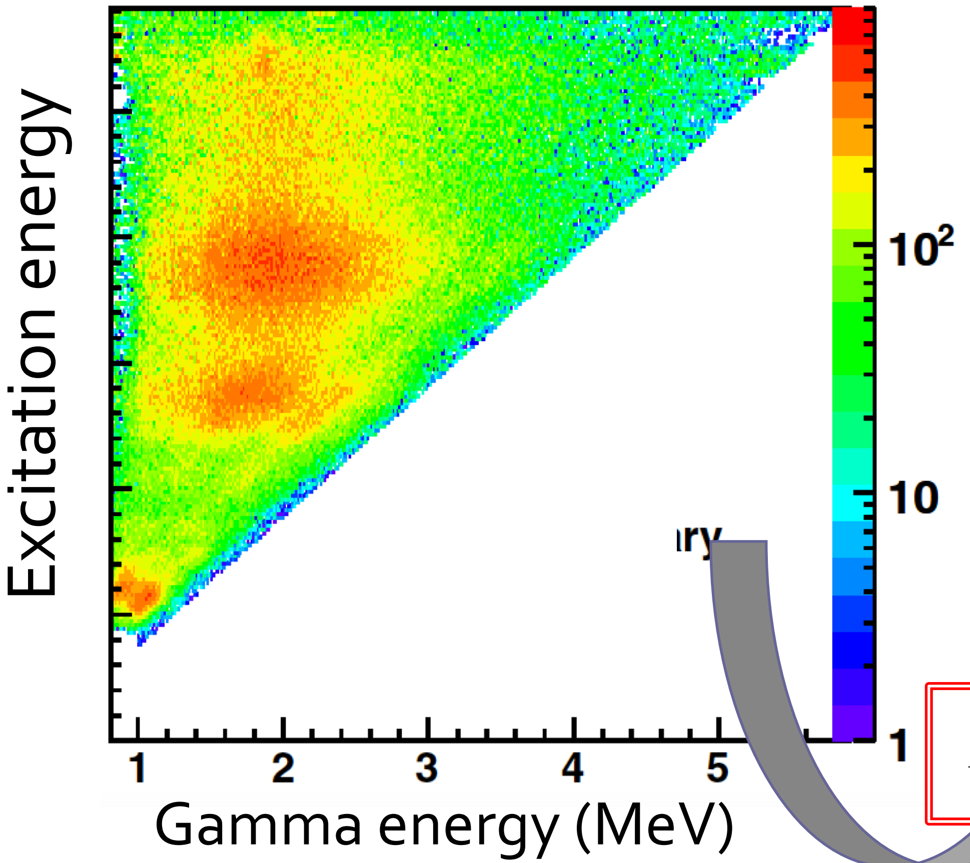
Neutron capture Rates

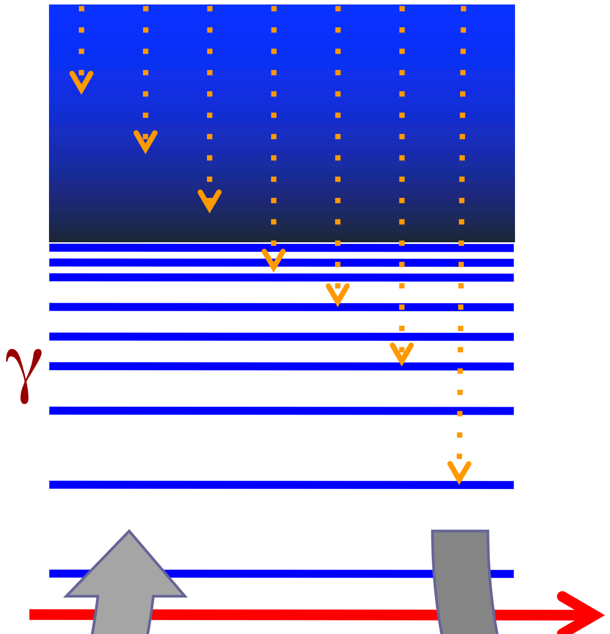
- GRIFFIN: $T_{1/2}$ and β-delayed neutrons
- TIGRESS: constraining neutron capture rates



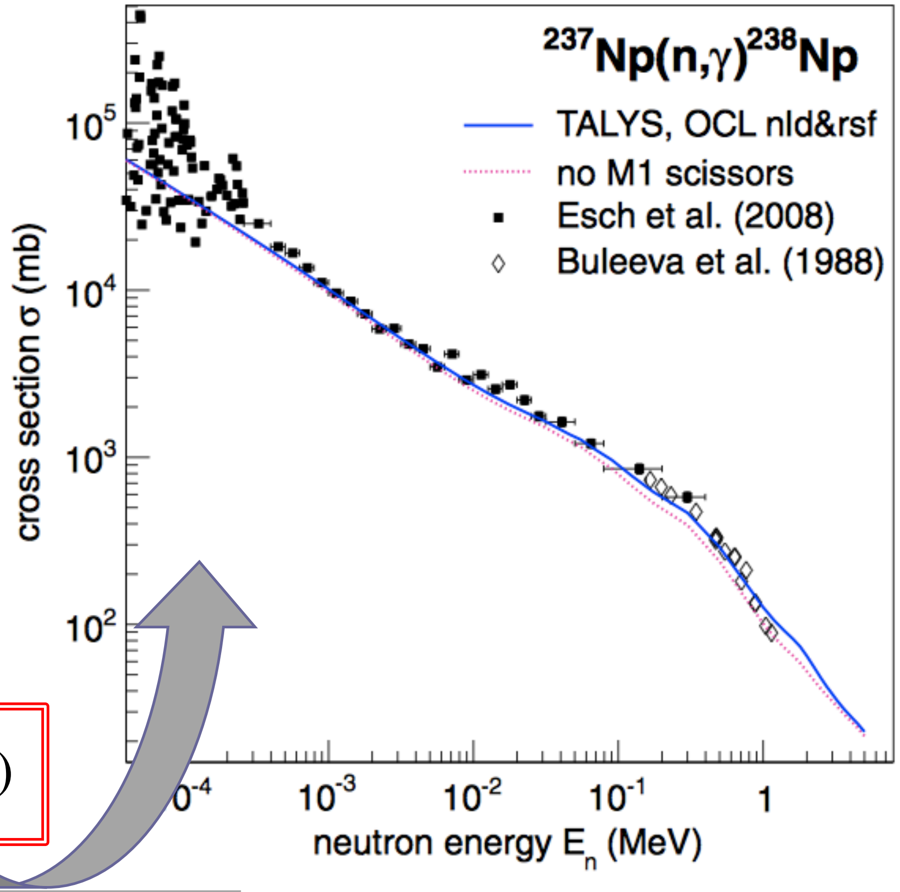
Mumpower et al., Progress in Particle and Nuclear Physics 86 (2016) 86–126

Oslo Method





$$P(E_\gamma, E_x) \sim \rho(E_x - E_\gamma)\mathcal{T}(E_\gamma)$$

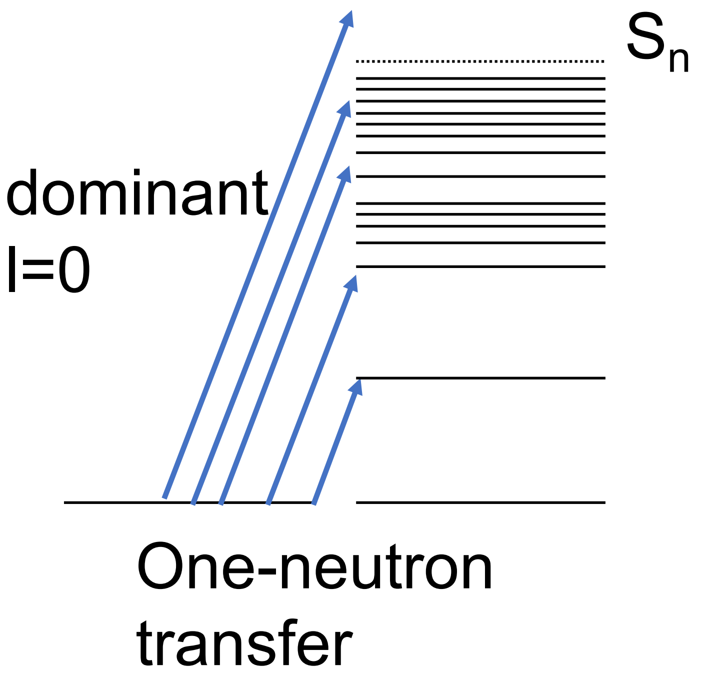


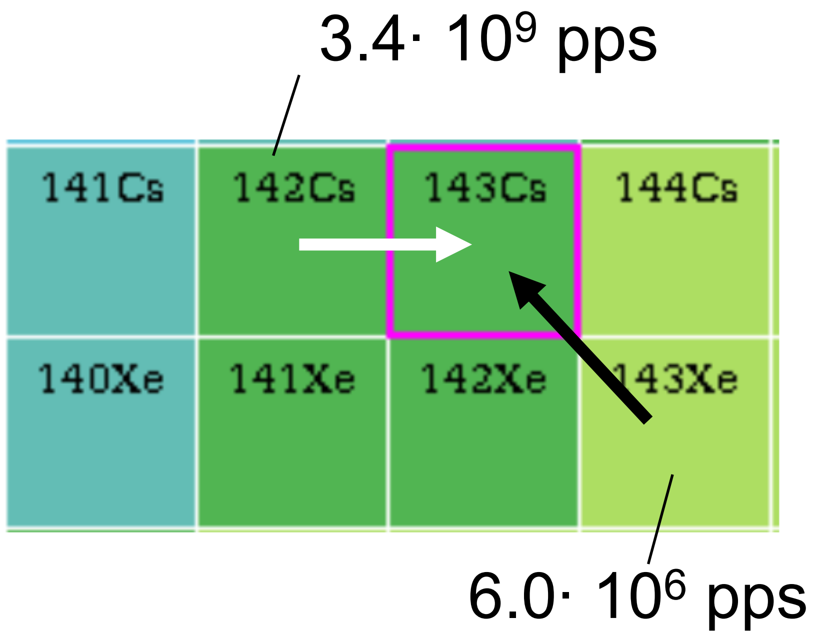
Unfolding
Iterative subtraction

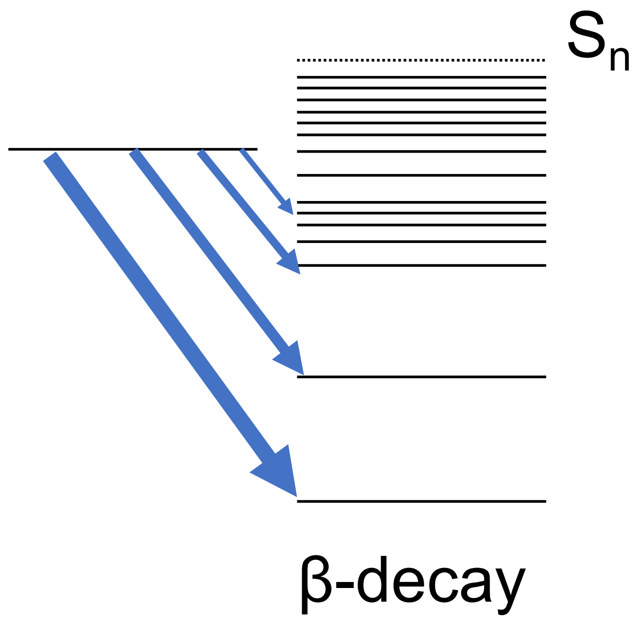
Normalization

T.G. Tornyi, M. Guttormsen,et al., PRC2014

Oslo vs. β-Oslo

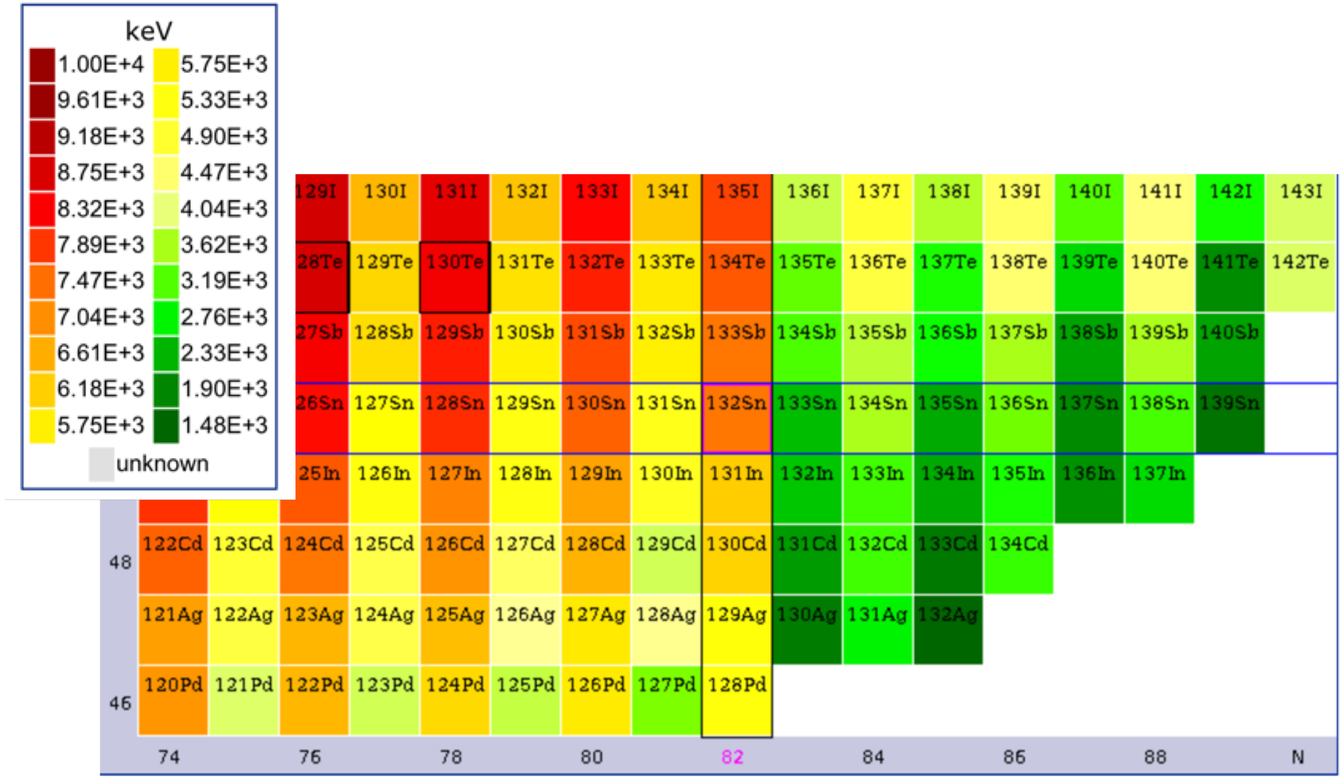


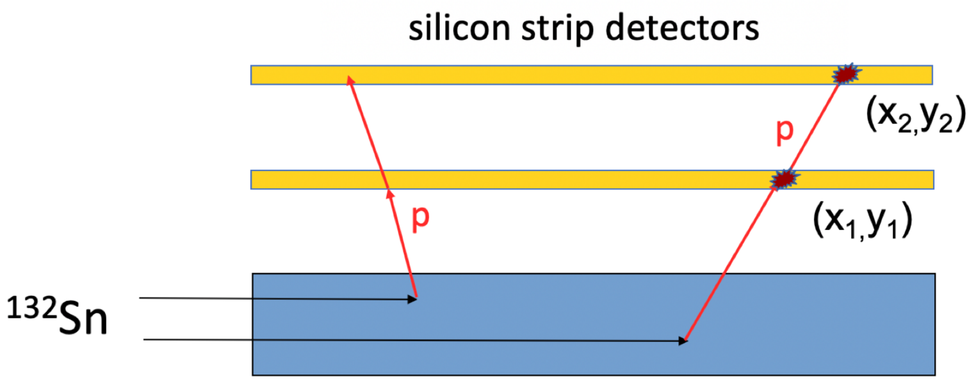




- In general, β-Oslo is the more sensitive method in terms of how exotic we can go
- Neutron transfer populates mostly l=0, similar to neutron capture
- In certain cases, β-Oslo cannot be applied because of Q-value and/or spin restrictions

Non-Statistical cases around ^{132}Sn: transfer reactions





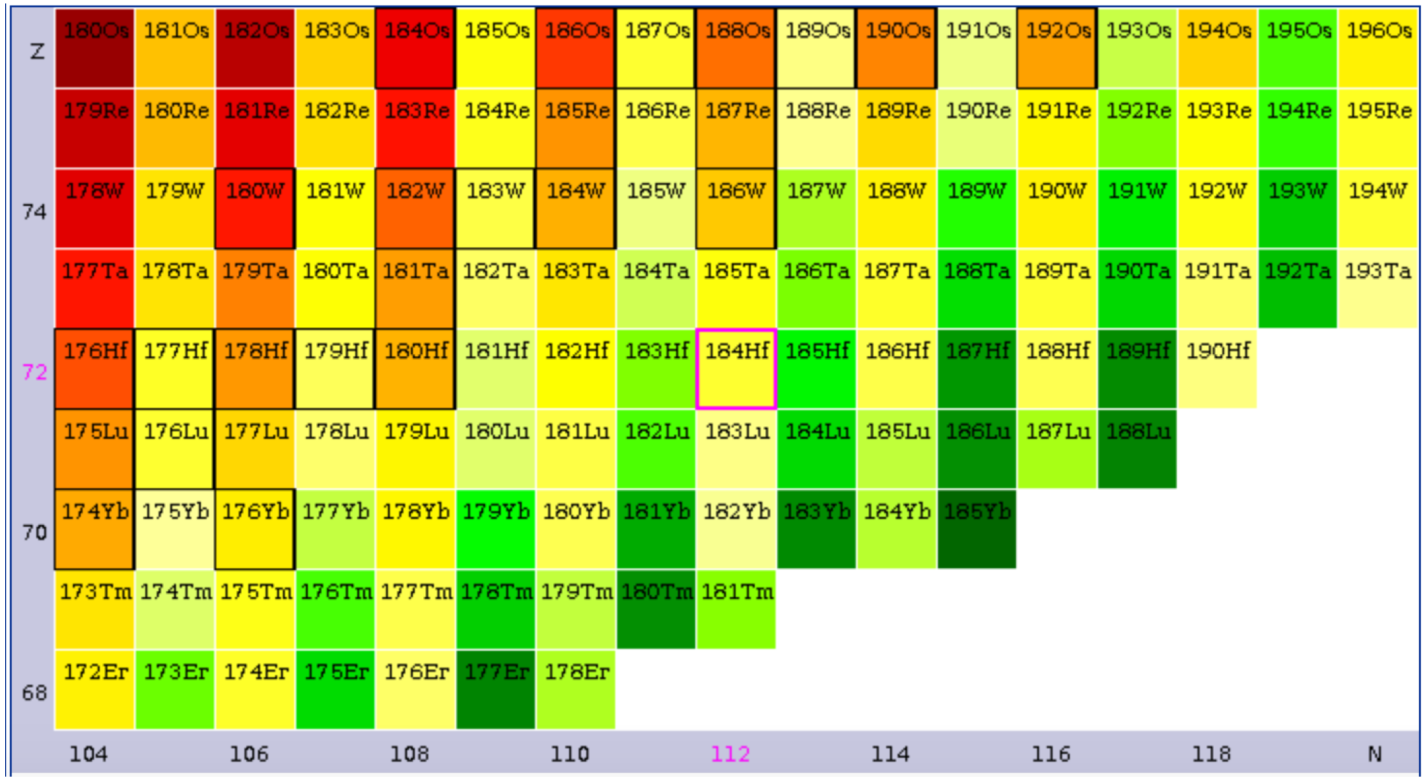
Required beam intensity on target:
10^3-10^4 pps

- Neutron separation energies as low as 2-3 MeV
- Level densities: 1-10 states / MeV

→ Highly non-statistical behavior, dominated by individual resonances

- TI-STAR under development, optimized for such measurements

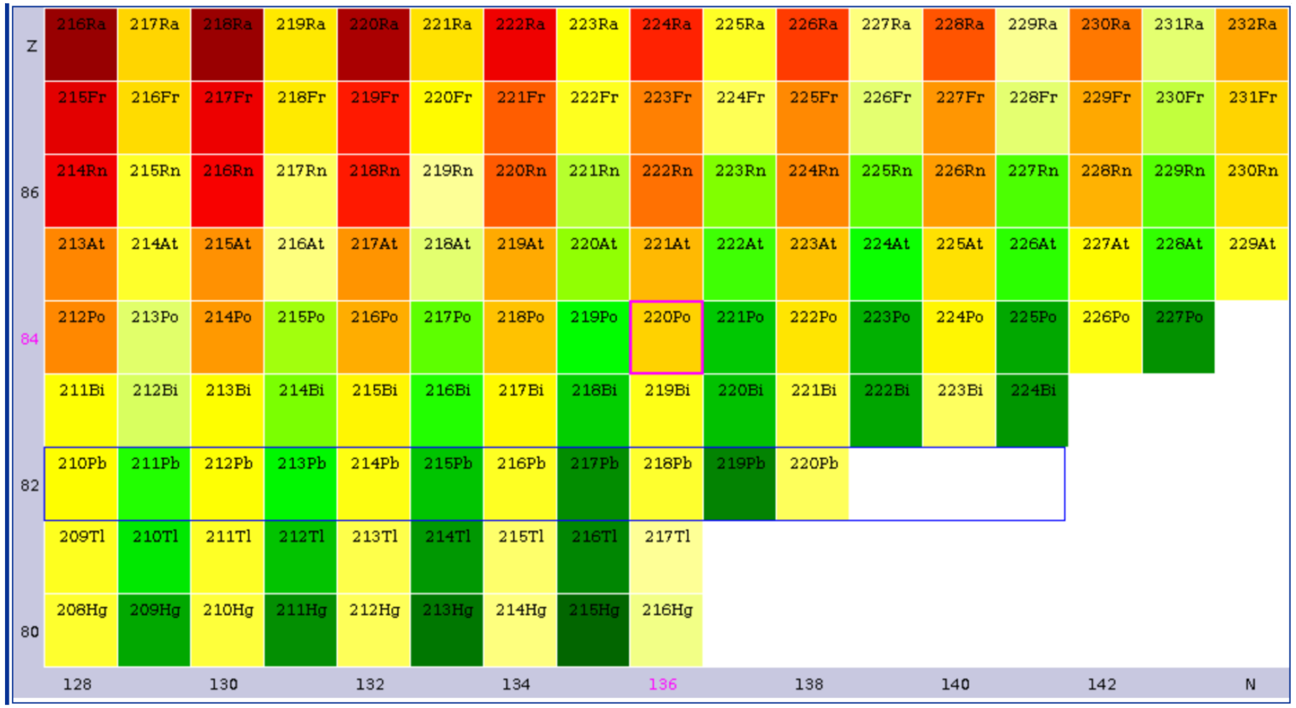
Statistical cases approaching N=126



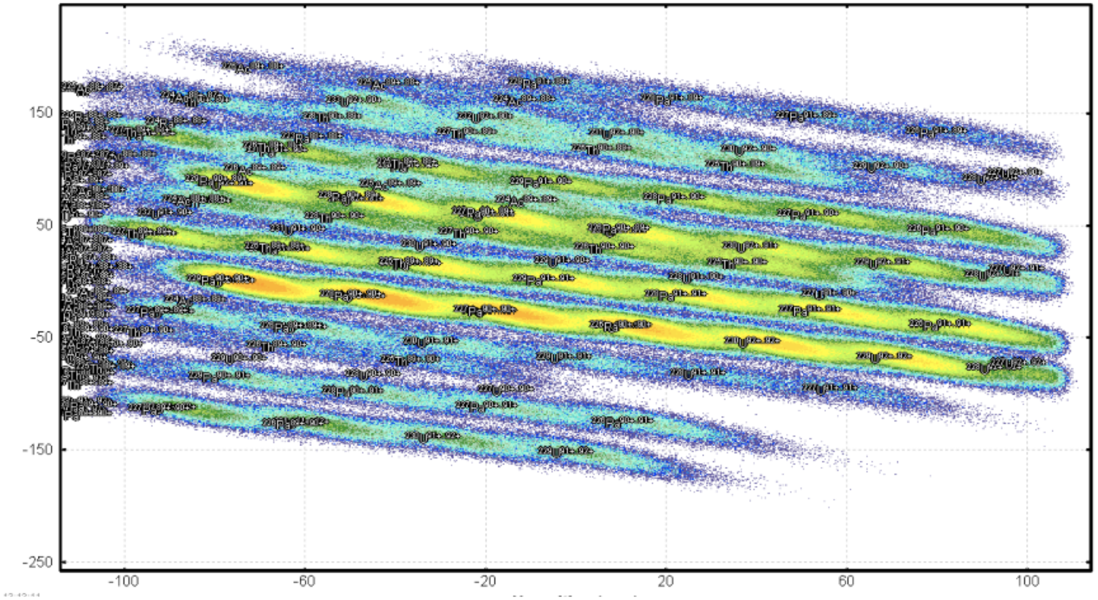
- Neutron separation energies as low as 4-5 MeV
- Level densities at S_n: 10^4 -10^5 / MeV
- statistical behavior, but beam intensities will be low if we want to be relevant

→ ideal for beta-Oslo technique: down to 1pps beam intensity required, only!

Statistical cases beyond N=126: Actinides



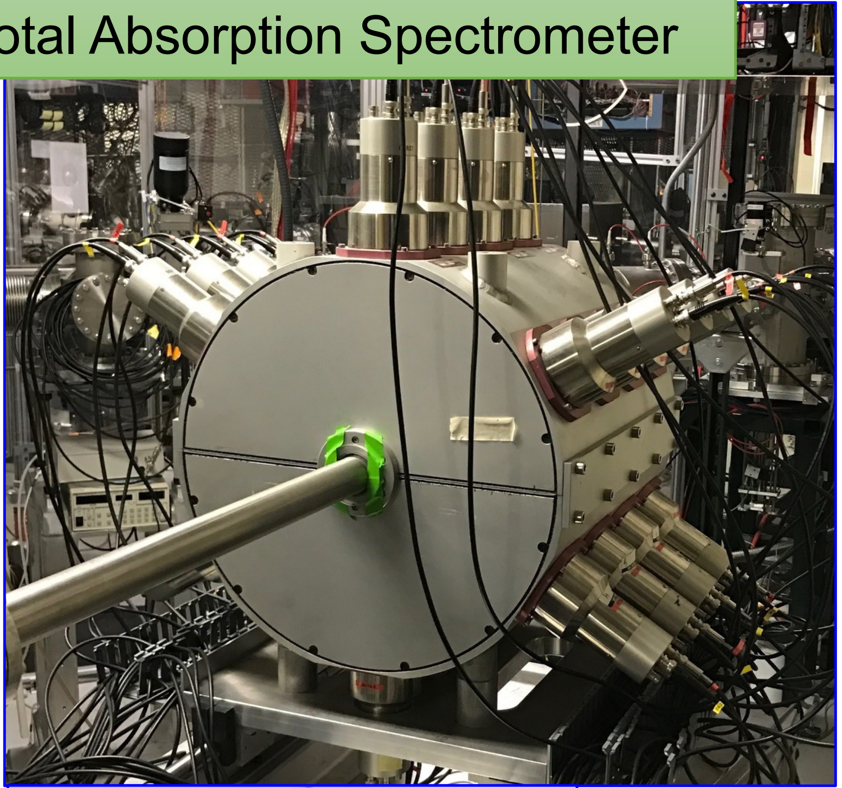
LISE++ SUPER-FRS simulation of PID Setting for ^{220}Po



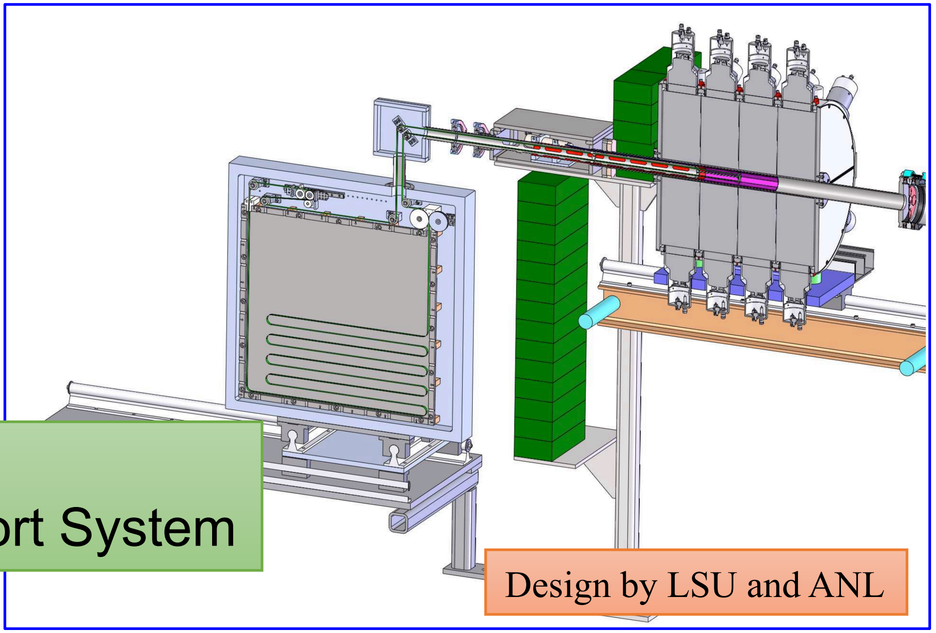
- Neutron separation energies as low as 4-5 MeV
- Level densities at S_n: 10^4 -10^5 / MeV
- statistical behavior, but beam intensities will be low
- advantage for TRIUMF: FRIB, GSI, RIKEN will only deliver highly mixed (in isotopes and charge states) ions, difficult to deal with for beta-Oslo

Beta-Oslo setup at NSCL (Slide from Artemis Spyrou)

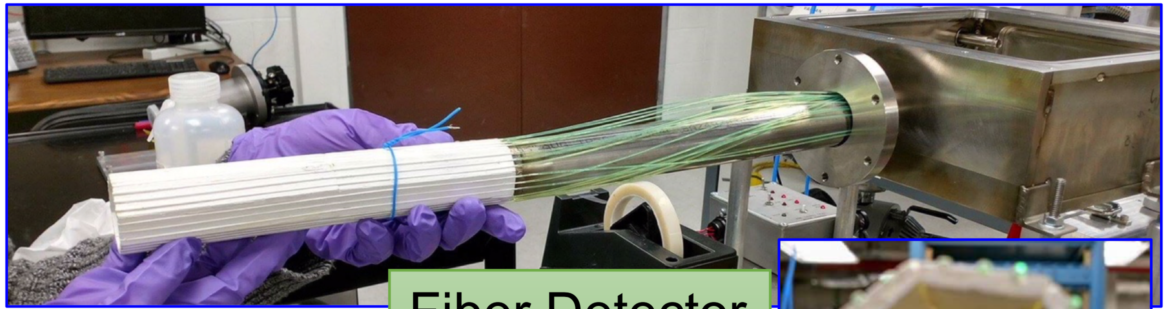
SuN
γ-Total Absorption Spectrometer



SuNTAN
Tape Transport System

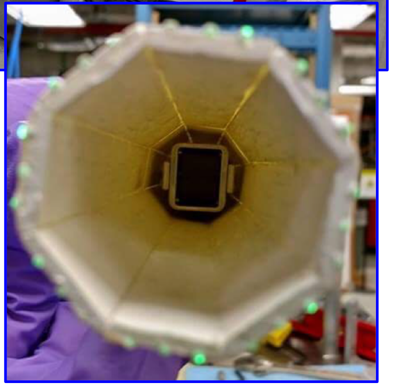


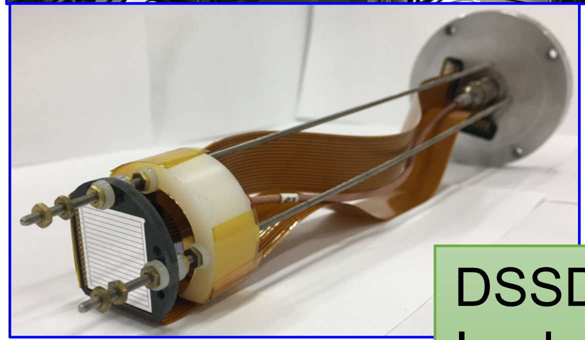
Design by LSU and ANL



Fiber Detector
β-detection

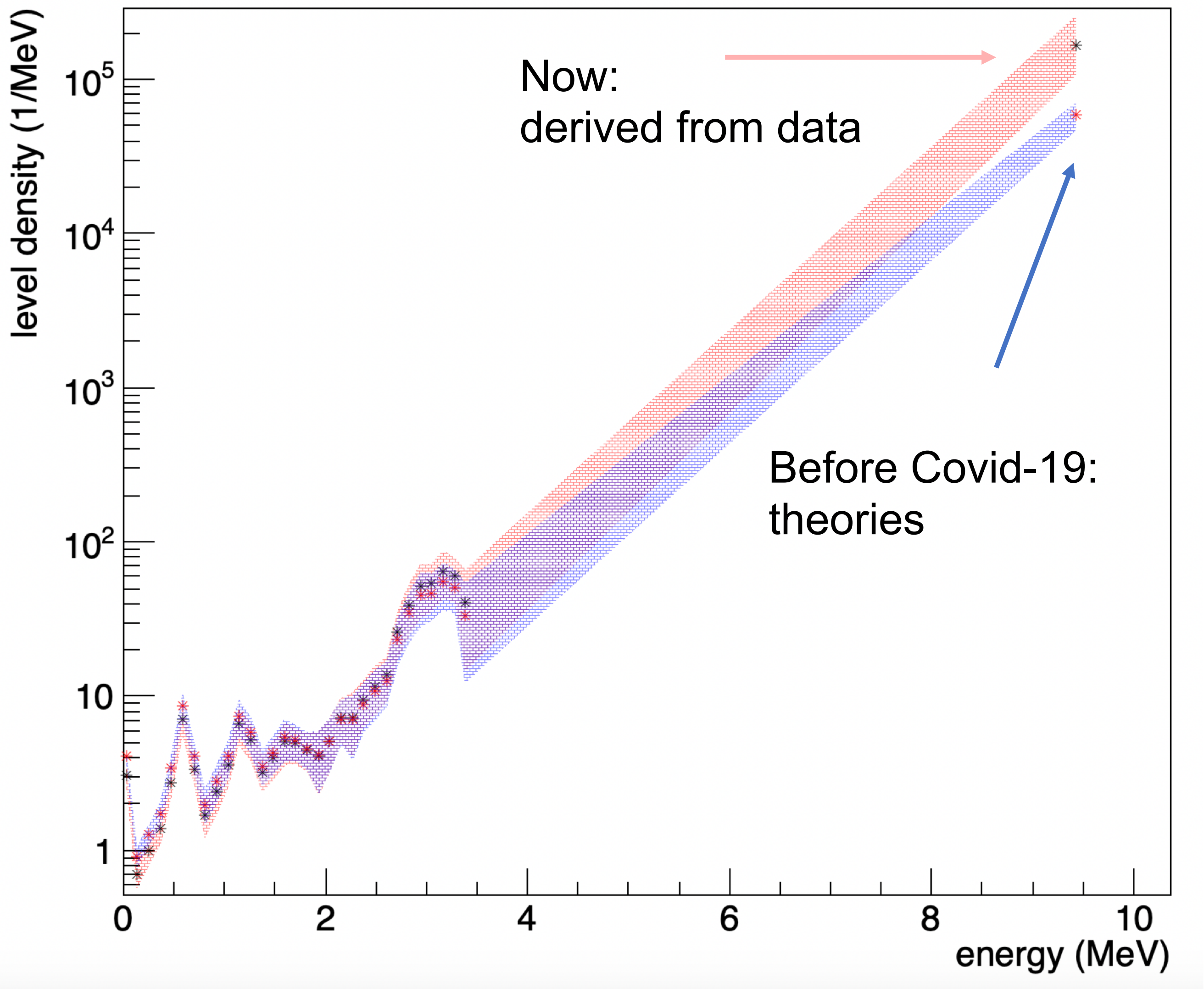
Hope College





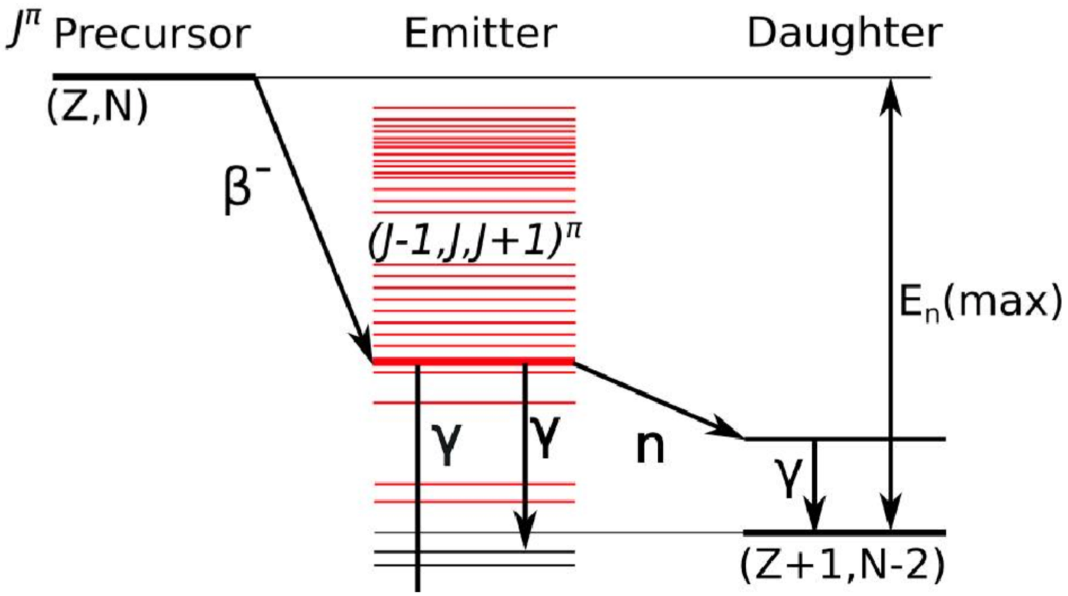
DSSD
Implantation-decay correlation

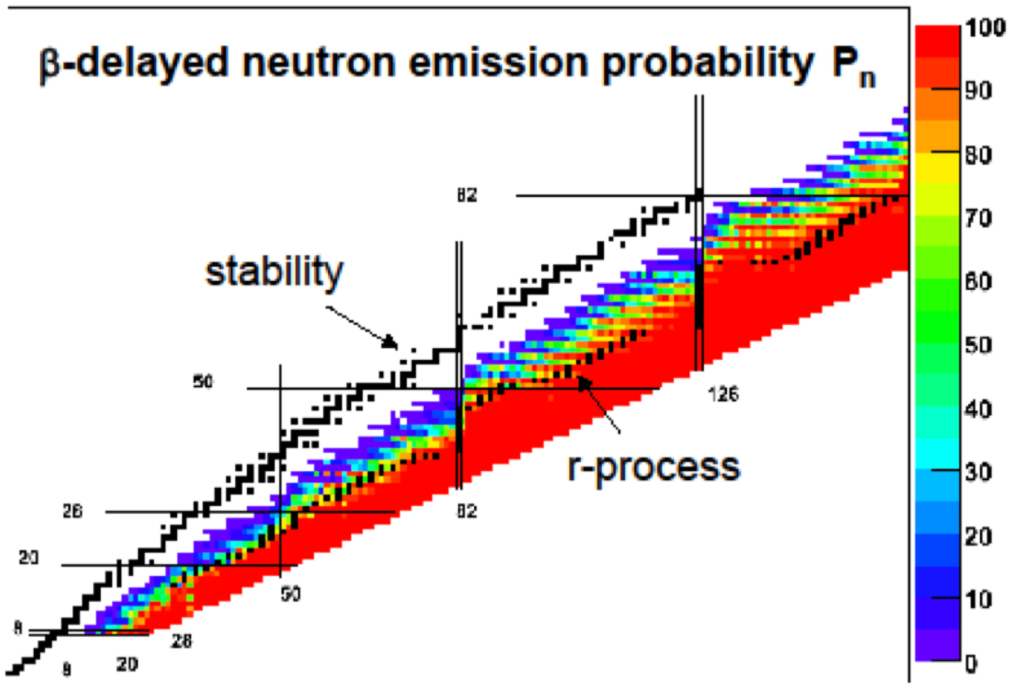
Challenges far away from stability: Normalizations for the Oslo method



- Before: level density at neutron separation energy had to be derived from theory and/or systematics
- Now: able to constrain the level density at high energies from the data
- Addition: in selected cases, low-lying spin quantum numbers can be deduced → potentially huge impact for structure physics far away from stability
- Collaboration: A. Spyrou, A. C. Larsen, M. Guttormsen, F. Zeiser M. Wiedeking, S. Lidick, DM et al: in preparation

Challenges far away from stability: beta-delayed neutron emission





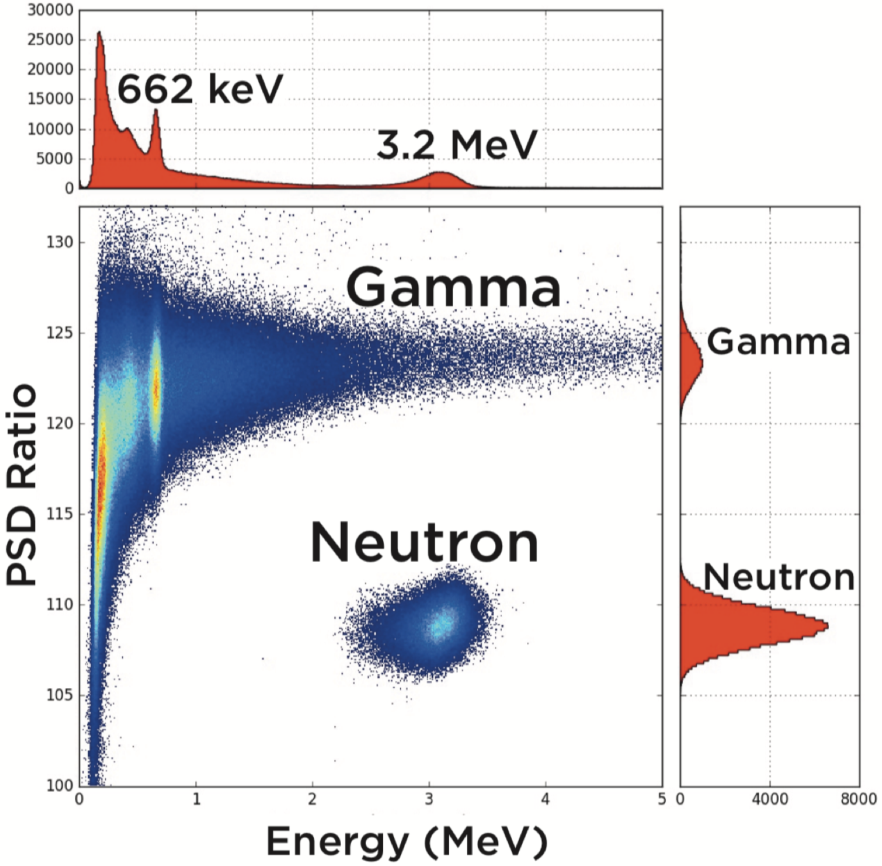
- Values for P_n presumably very large for almost all relevant r-process cases
- Current TAS instruments do not allow for event-by-event neutron-gamma discrimination
- MTAS (ORNL) can identify the presence of neutrons and are working on improvements towards better discrimination

A Total Absorption Spectrometer for ISAC

SAINT-GOBAIN

Wishlist for a dedicated ISAC-TAS:

- Basic design similar to existing TAS devices (SuN, MTAS)
- Tape system critical (we have experience with this at TRIUMF)
- new: neutron identification, e.g. NaI(Tl+Li) crystals
- new: suppression of β-decay electrons:
  - Permanent magnetic inside the bore?
  - External magnetic field?
  - Extra, inner, detector layer?
- new: Phototubes → SiPMs



Next steps:

- Input from ISAC community: other potential uses for such a device?
- Level-0 design study, cost estimate ($2.5M?)
- Gate-0 review
- …