The Versatile Array of Neutron Detectors at Low Energy

S. V. Paulauskas

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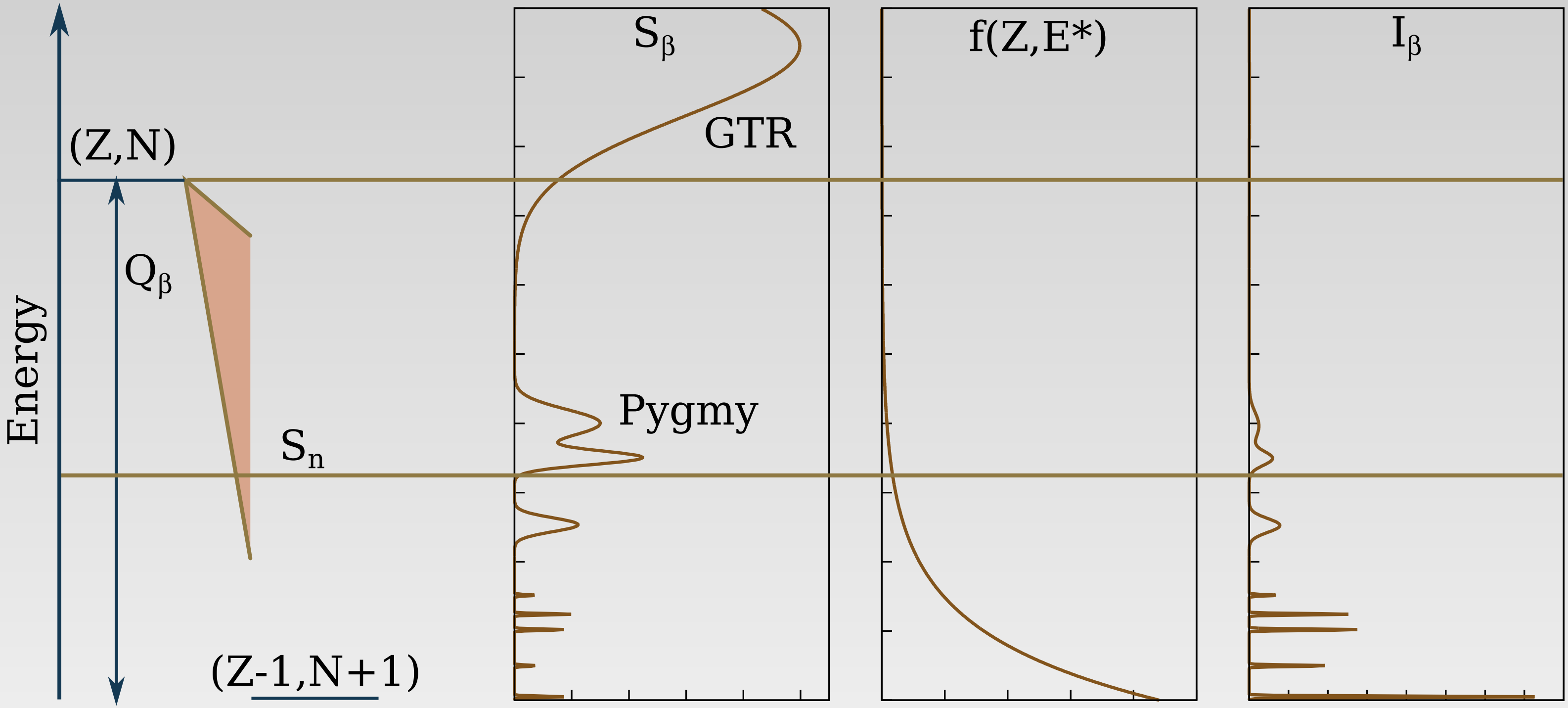
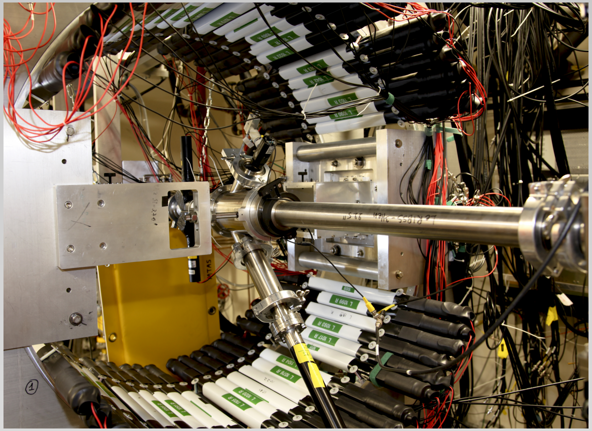
Beta Strength, Nuclear Lifetimes, and Branching Ratios

$$\frac{1}{T_{1/2}} = \sum_{E_i \geq 0}^{E_i \leq Q_\beta} S_\beta(E_i) \times f(Z, Q_\beta - E_i) \qquad S_\beta(E_i) = \langle \psi_f | \hat{O} | \psi_i \rangle$$

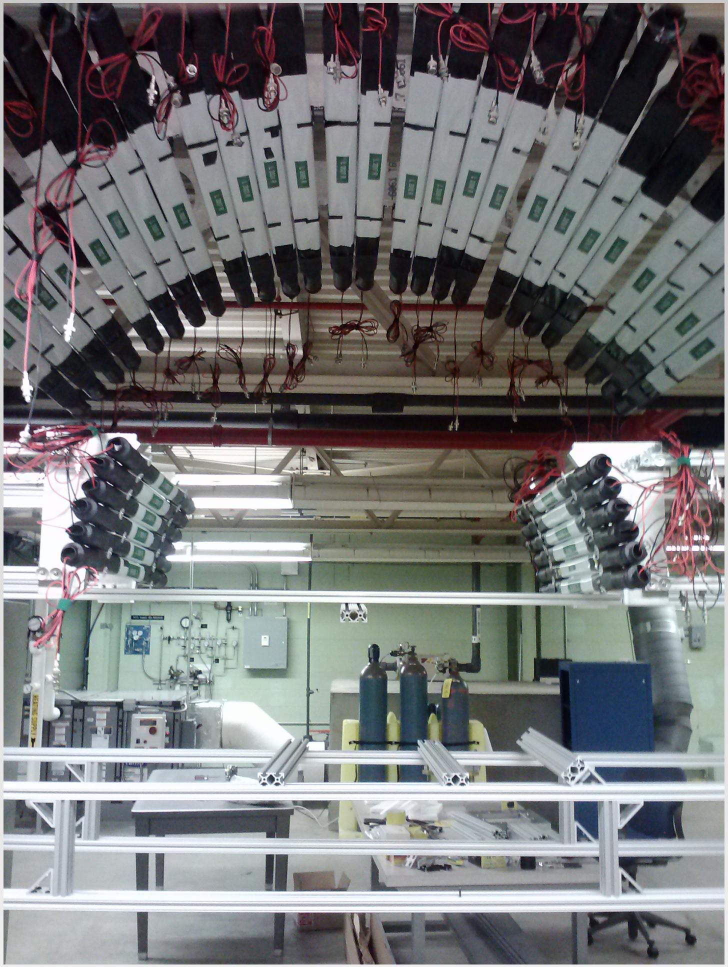


VANDLE

- A highly modular array of plastic scintillators
- Can be used to measure β-delayed neutrons and for reaction studies.
- Bar Sizes:
  - Small : 3x3x60 cm^3
  - Medium : 3x6x120 cm^3
  - Large : 5x5x200 cm^3
- Neutron Energies Covered:
  - Small/Med. : 0.1 - 6 MeV
  - Large : 1 - 20 MeV



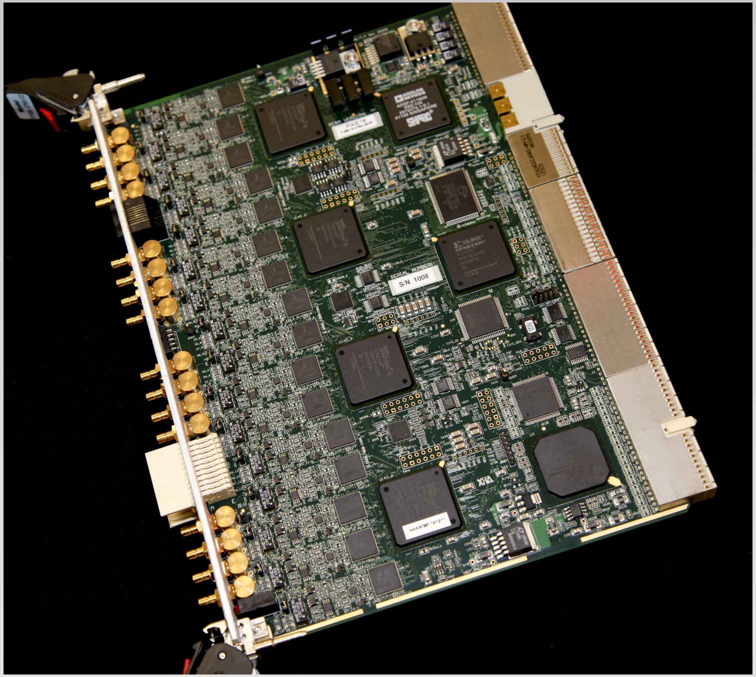
VANDLE at CARIBU - Setup



- Designed by N. T. Brewer
- Clovers mount to the bottom of the frame and do not mask any of the VANDLE modules.
- Using new medium bars - Improves energy res.
- Specially designed frame.
- Footprint : 81 x 61 in^2

Electronics

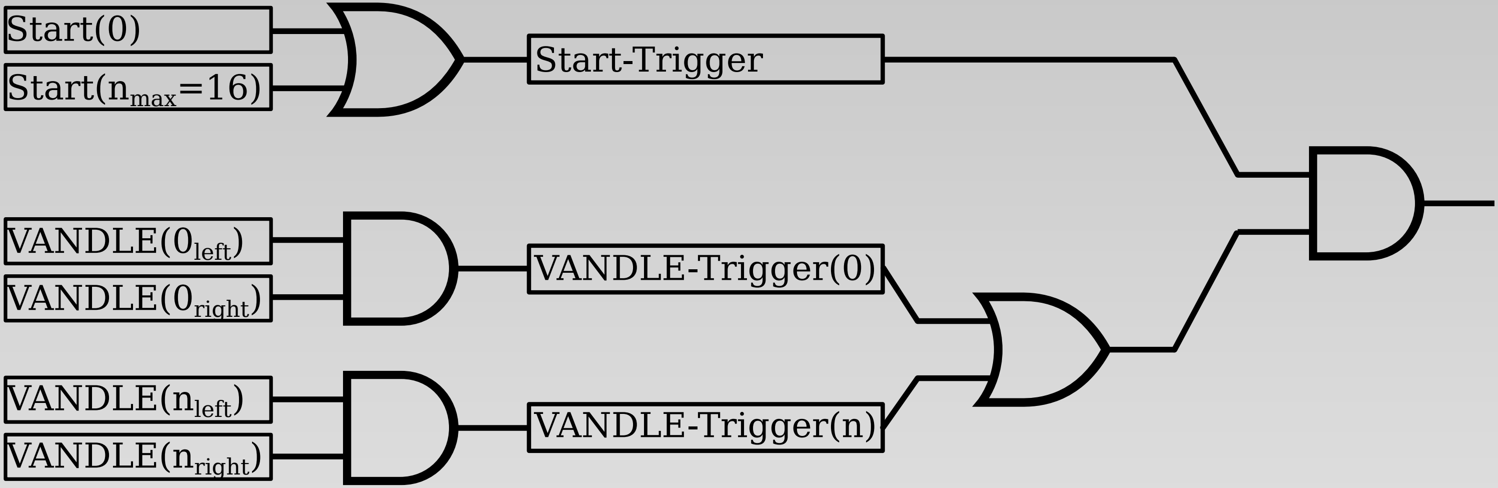
- XIAs Pixie-16-250 digitizers; Designed for VANDLE
- Time stamps each event
- Records digitized signals
- Low trigger threshold
- Custom Trigger Scheme



Coupled with VANDLE yields a **unique** system, using "slow" digitizers with fast scintillators

See S. V. Paulauskas et al. NIM A Volume 737 (2014), Pages 22–28

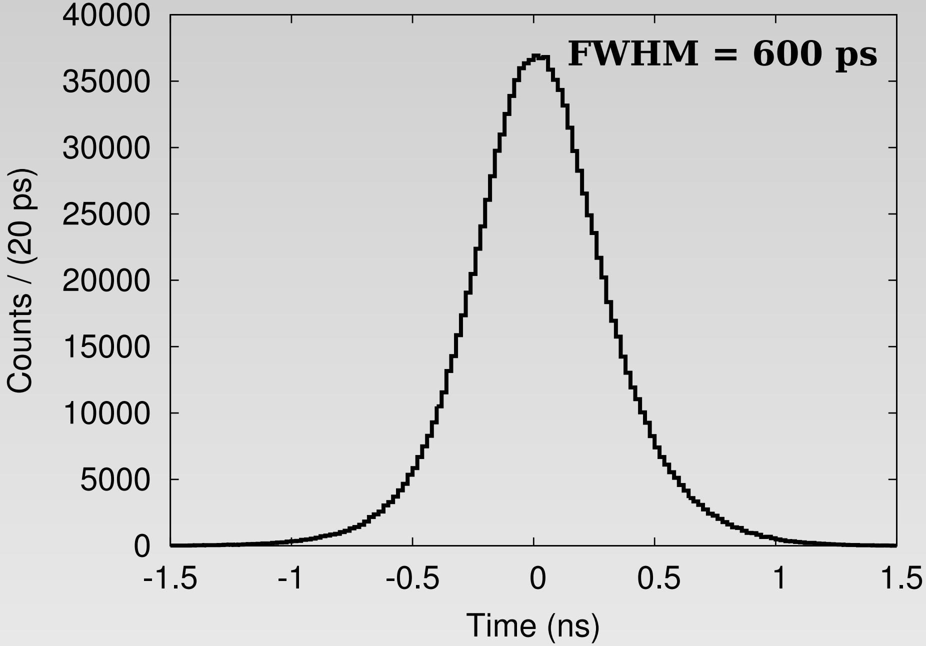
Custom Triggering



- Handles upto 16 starts and n VANDLE modules
- Reduces count rates
- Allows for acquisition in PMT noise
- System allows for 99.9% live time.

Timing with PMTs

- A small 1x1x0.5 in^3 EJ-200 chip between 2 PMTs
- ^{60}Co provides gammas



The resolution is consistent with PMT specifications.
Resolution contribution of electronics negligible

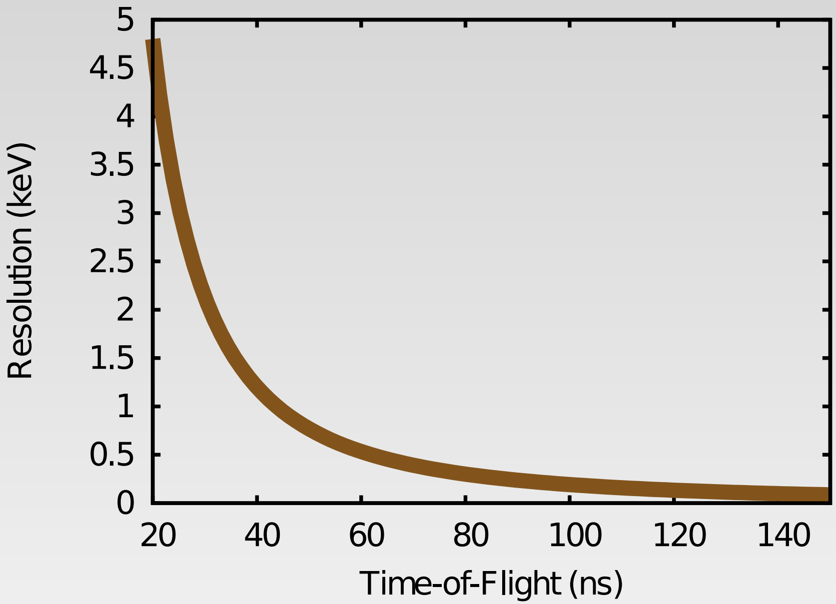
Energy Resolution

- Resolution given by

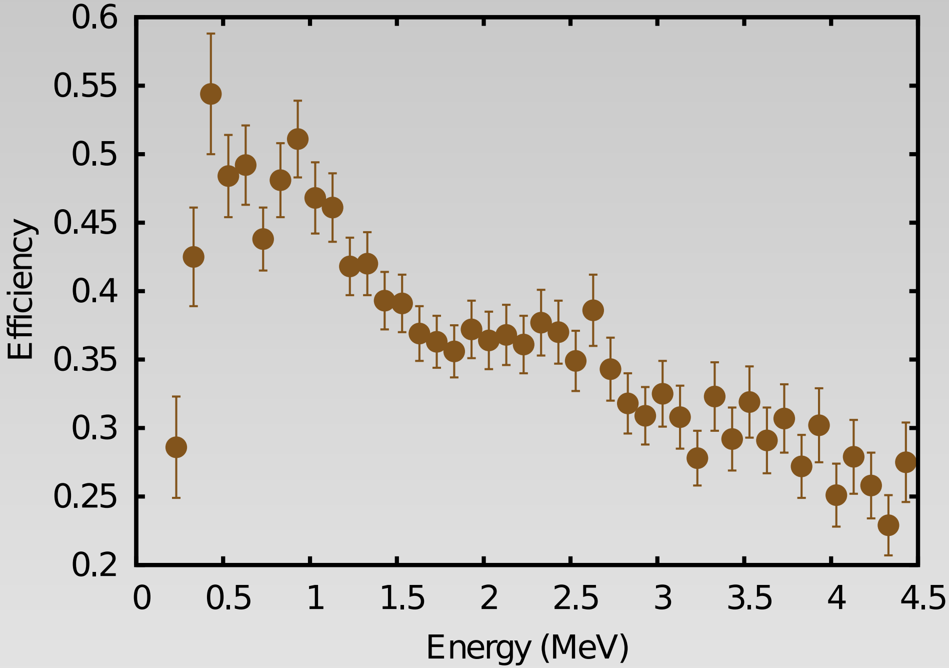
$$\left(\frac{dE}{E}\right)^2 = \left(\frac{2dt}{t}\right)^2 + \left(\frac{2dL}{L}\right)^2$$

Kornilov et al. NIMA, 599 (2009) 226-233

- dL = 3 cm, L = 60 cm, dt = 700 ns
- Energy Resolution critically dependent on time resolution!



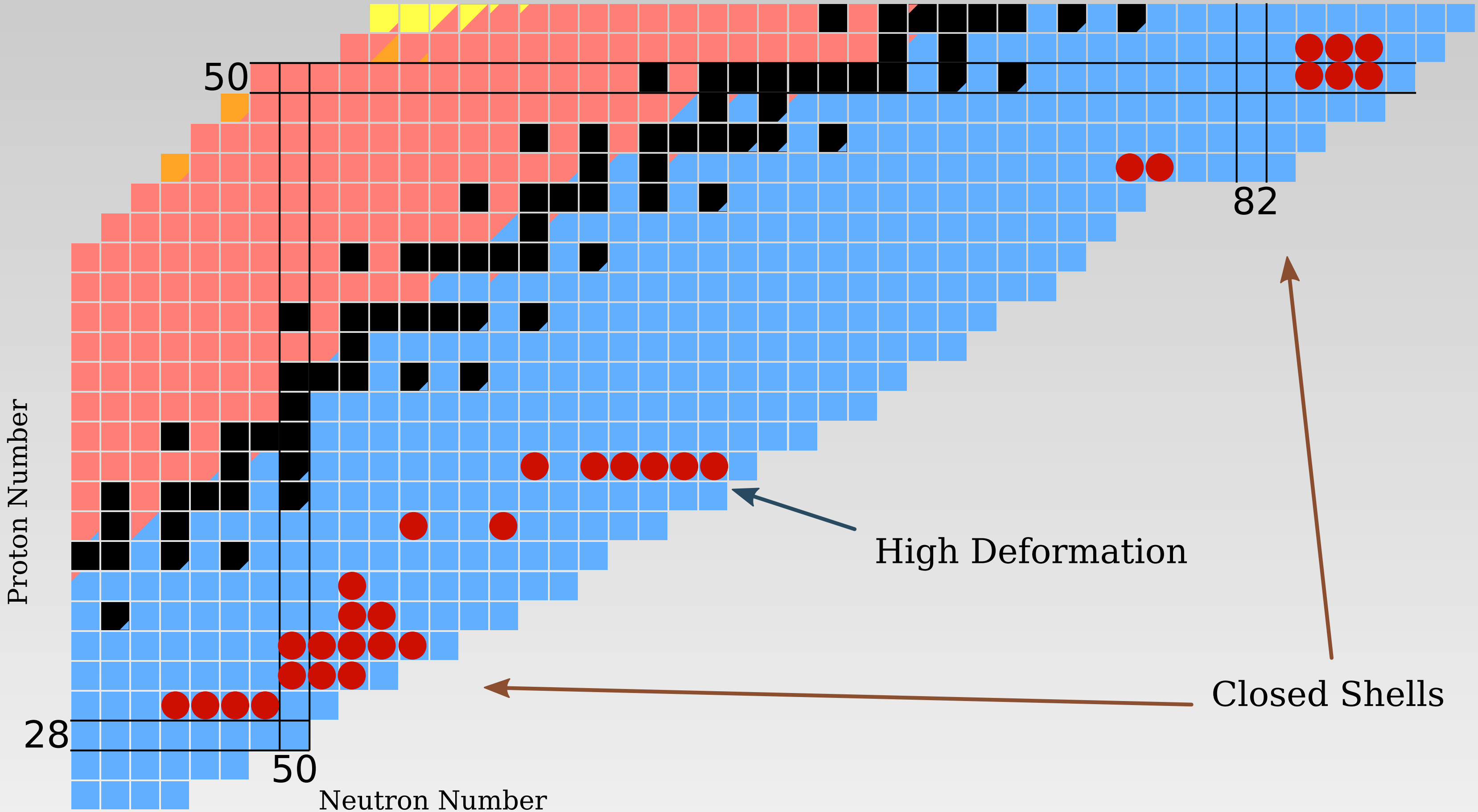
Intrinsic Module Efficiency



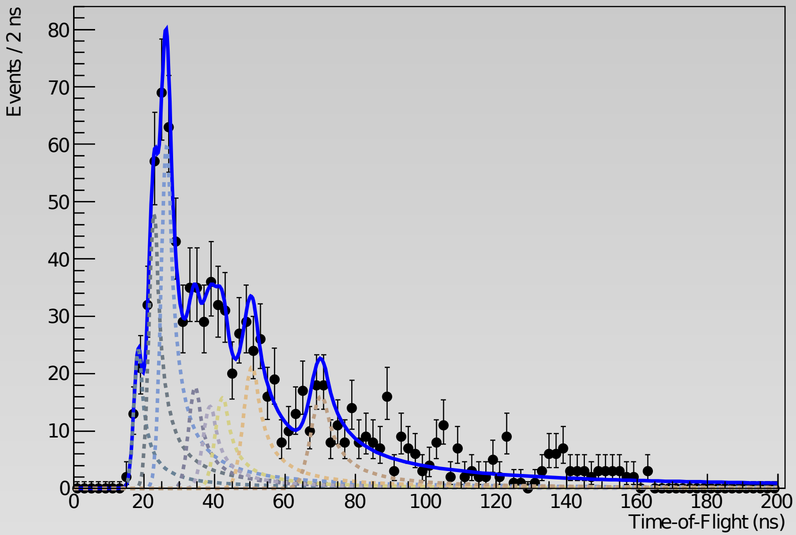
- Measurement performed at Ohio University using neutrons from the $^{27}Al(d,n)$ reaction
- High efficiency due to combination of electronics and PMTs.

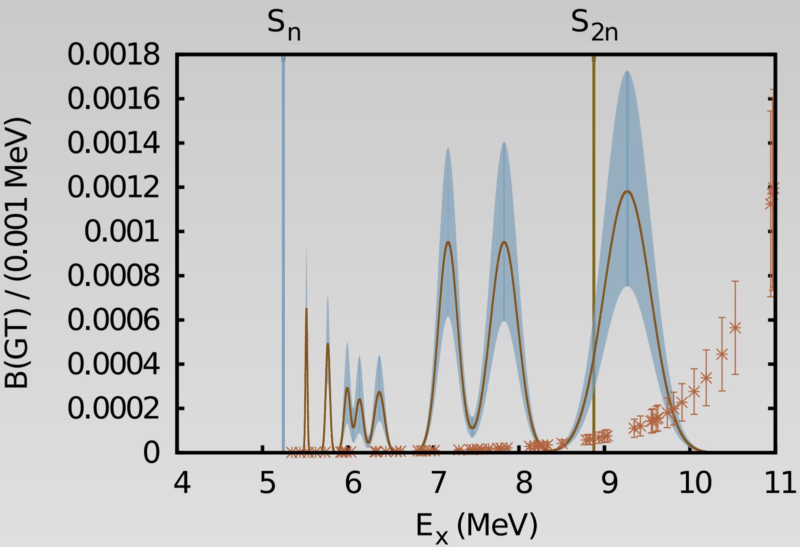
Measurement at HRIBF

These are regions accessable with CARIBU



Resonant Behavior of ^{84}Ga





- Above the N = 50 shell gap
- Large P_n (74%) and large Q-value (13.9 MeV)
- Strong resonant behavior for high energy neutrons.
- Still working to interpret these data

Summary

- VANDLE is a highly efficient array
- Modular design and several detector sizes provide an adaptable detection system
- Fully digital data acquisition system provides high resolution timing and coincidence triggering.
- Has been successfully used for both reaction and decay studies.