$^{10,11}B(\alpha,n)^{13,14}N$ CROSS SECTION MEASUREMENTS

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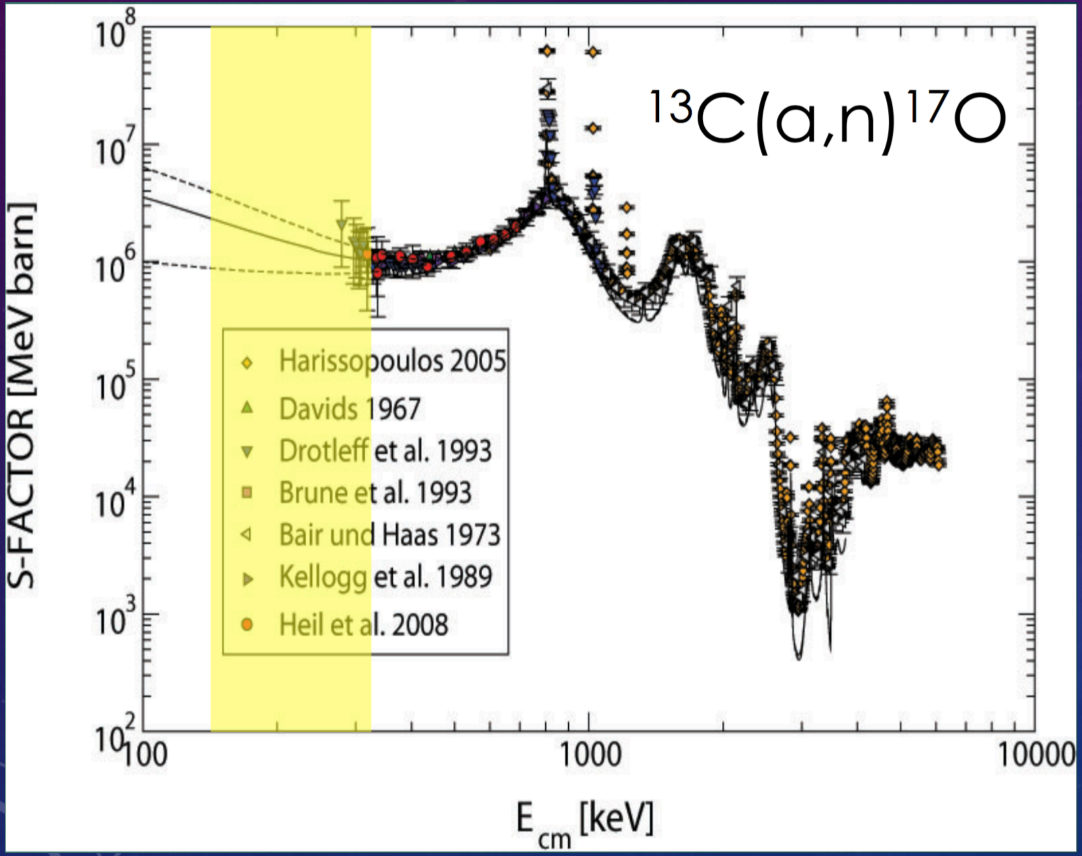
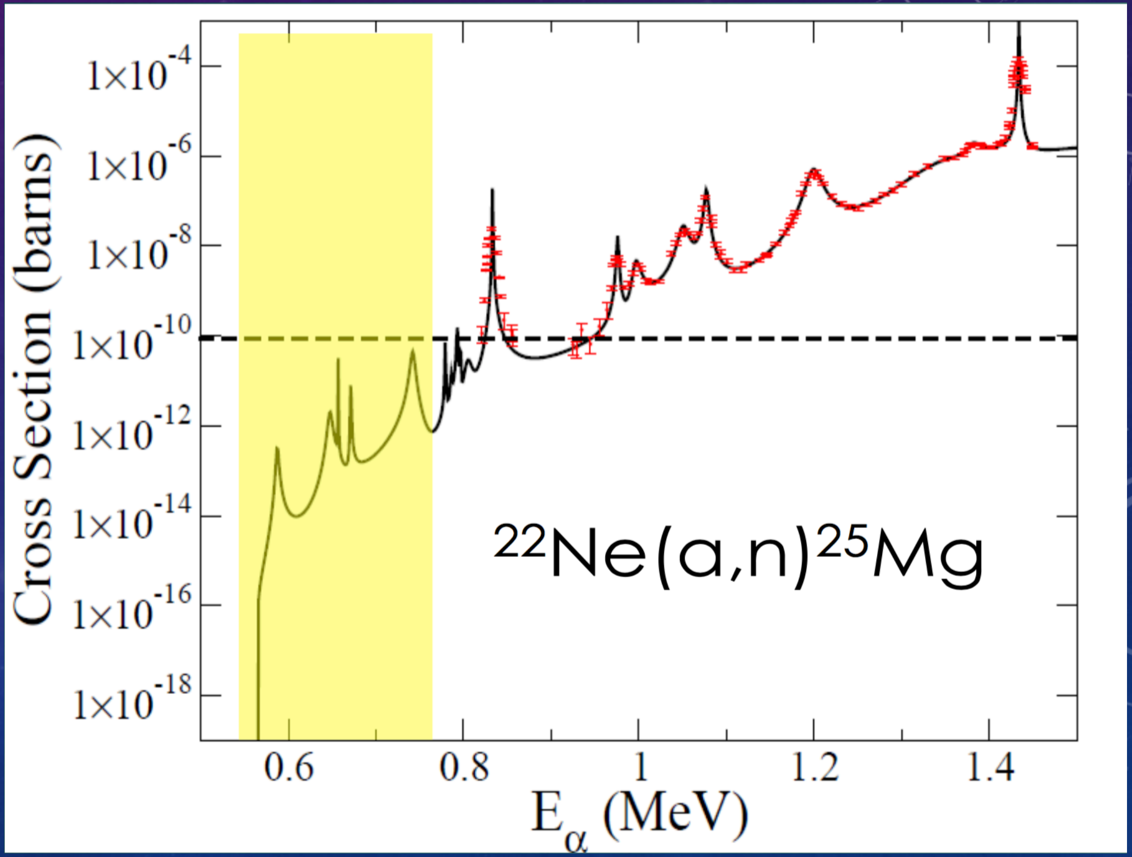
MOTIVATION

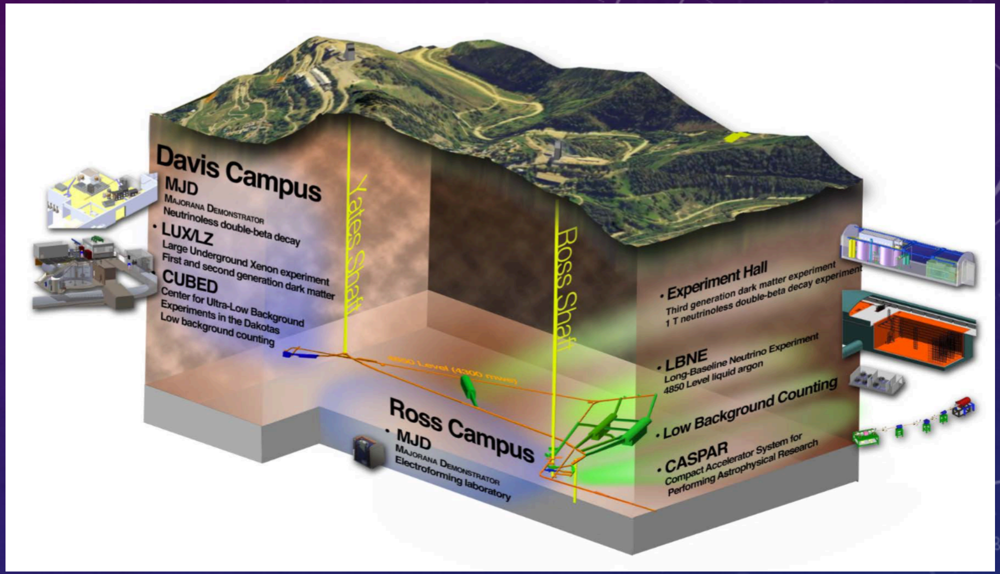
$^{13}C(\alpha,n)^{17}O$ and $^{22}Ne(\alpha,n)^{25}Mg$ are neutron sources for the s-process





MOTIVATION

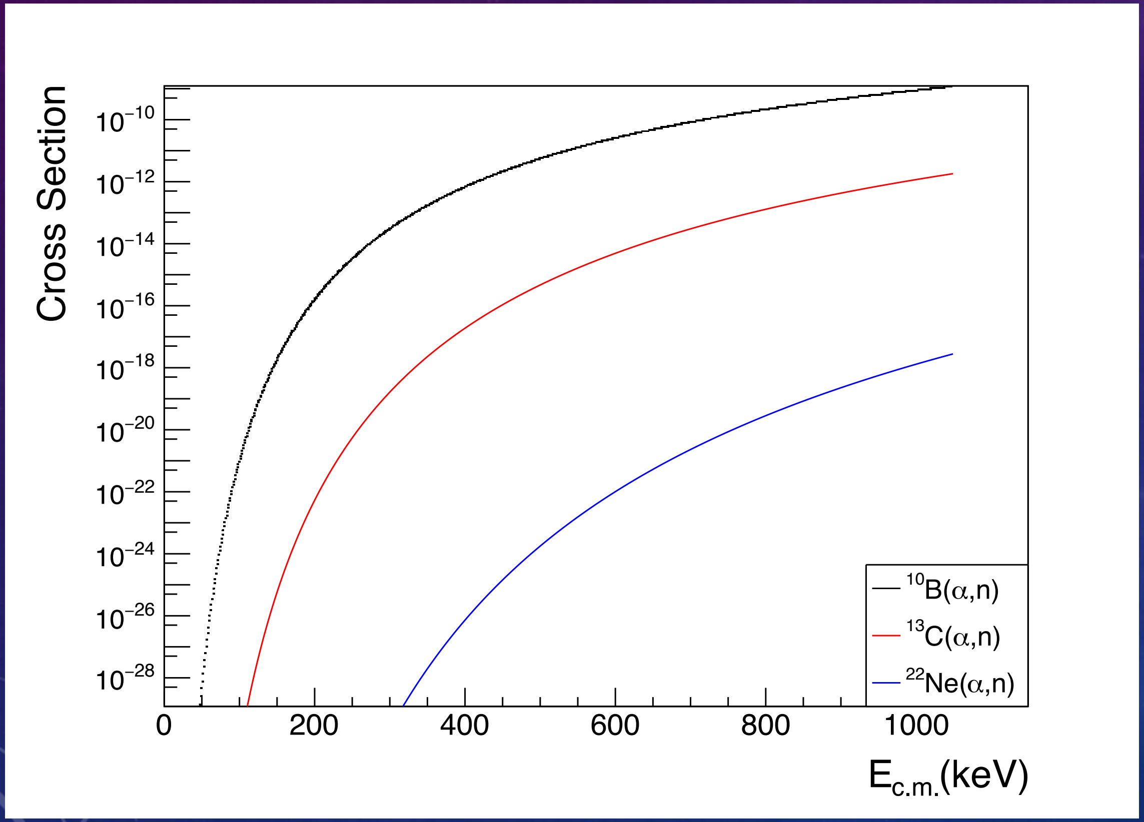
- $^{10,11}B(\alpha,n)^{13,14}N$ are possible neutron background sources for underground measurements.
- Previously the differential cross section data has only been available at energies above E_{α}= 1.0 MeV by Van der Zwan and Geiger in 1973.
- The objective is to extend previous studies to lower energy.



SURF FACILITY LAYOUT (4850L)

WHY CHOOSE BORON?

Coulomb barrier dominates cross section at low energy



$$\sigma(E) = \frac{1}{E}\exp(-2\pi\eta)\,S(E)$$

$$2\pi\eta = 31.29 Z_1 Z_2 \left(\frac{\mu}{E}\right)^{1/2}$$

Important to characterize light-Z nuclei (α,n) background

WHY CHOOSE BORON?

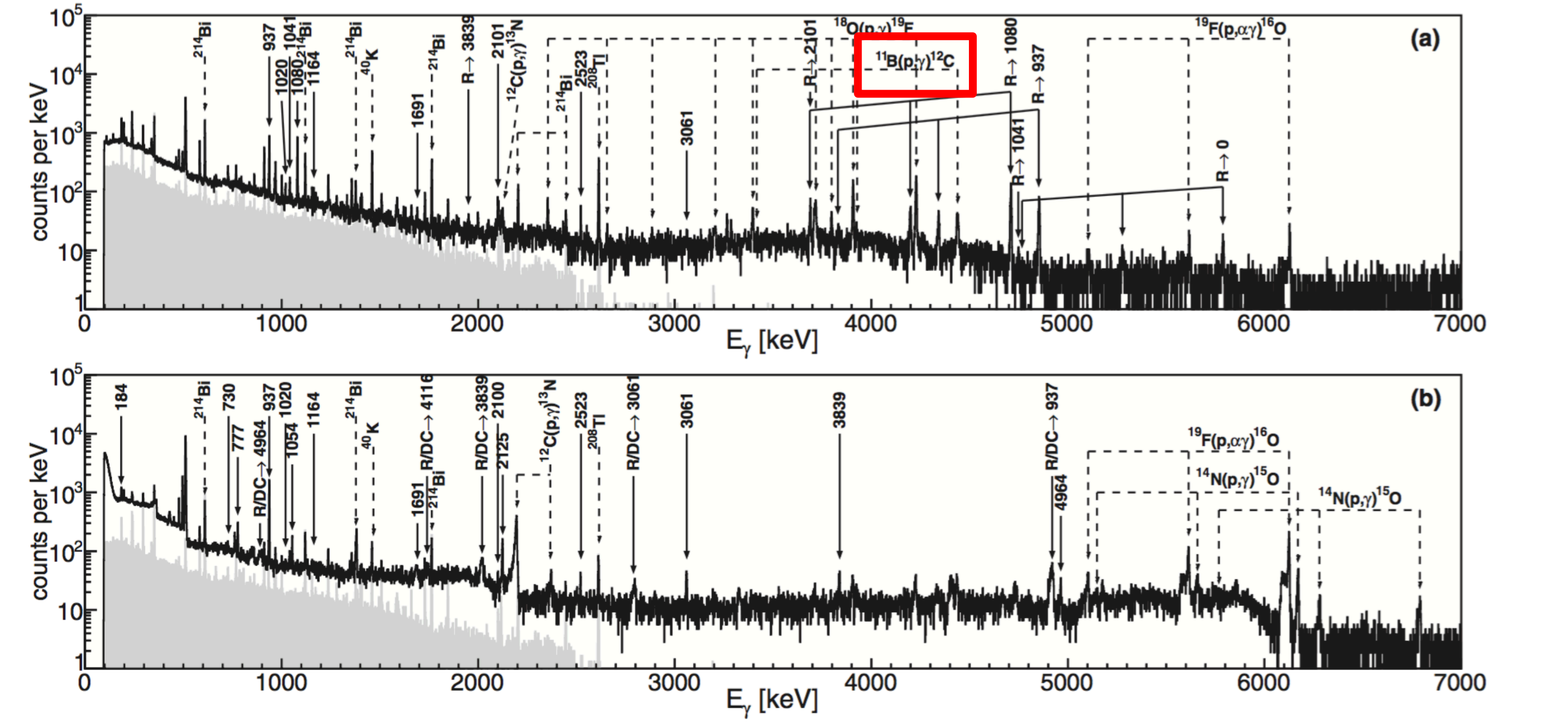


FIG. 5. (a) Sample spectrum of an on-resonance measurement at energy $E_{c.m.} = 183$ keV. (b) Sample spectrum for an off-resonance measurement at $E_{c.m.} = 250$ keV. In gray is the time-normalized room background with 10 cm of lead surrounding the detector.

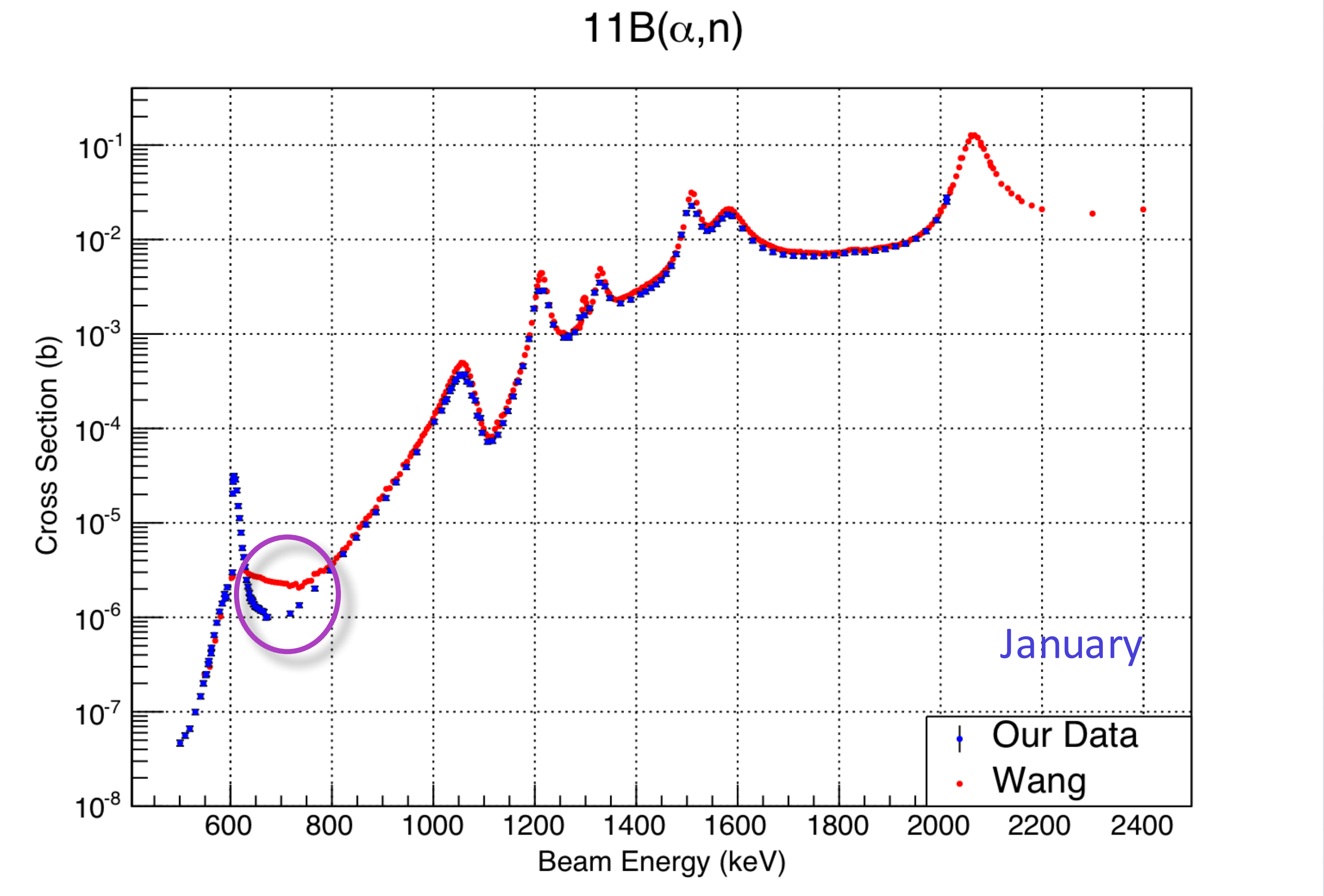
Target Impurities: $^{10,11}B$

A.Di Leva et al. PRC(2014)

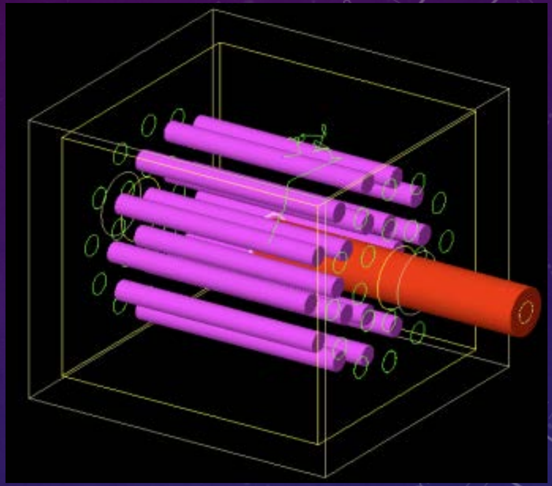
$^{17}O(p,\gamma)^{18}F$ -- Target: 31% ^{16}O, 65% ^{17}O, 4% ^{18}O

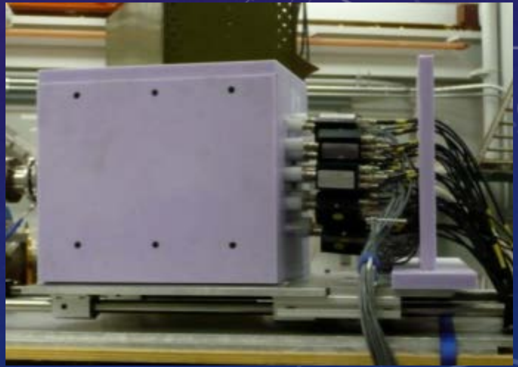
LUNA

$^{11}B(\alpha,n)^{14}N$ EXCITATION CURVE



Wang, Vogelaar and Kavanagh (1991)

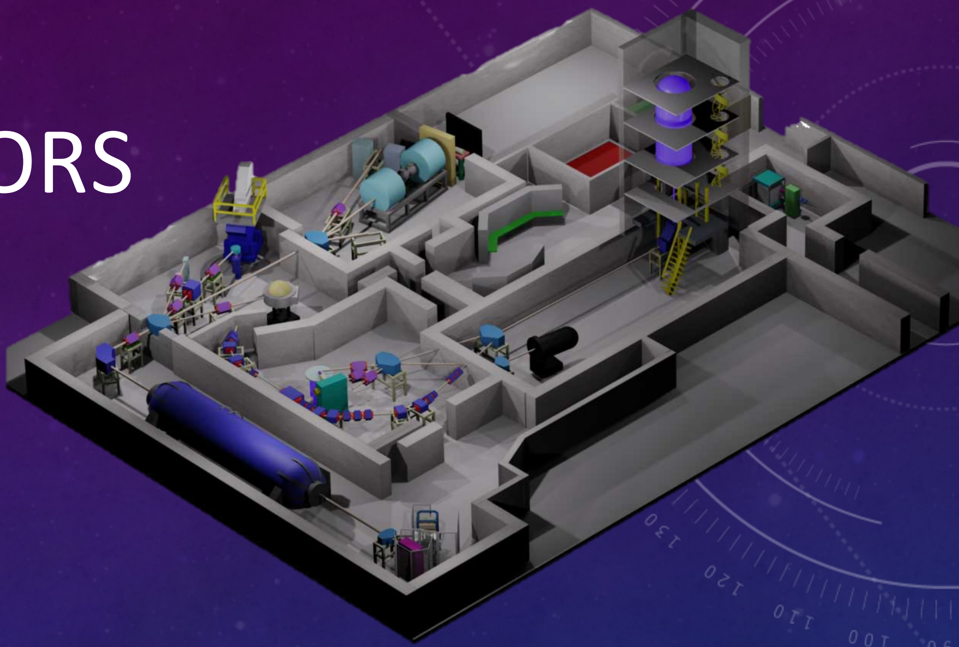




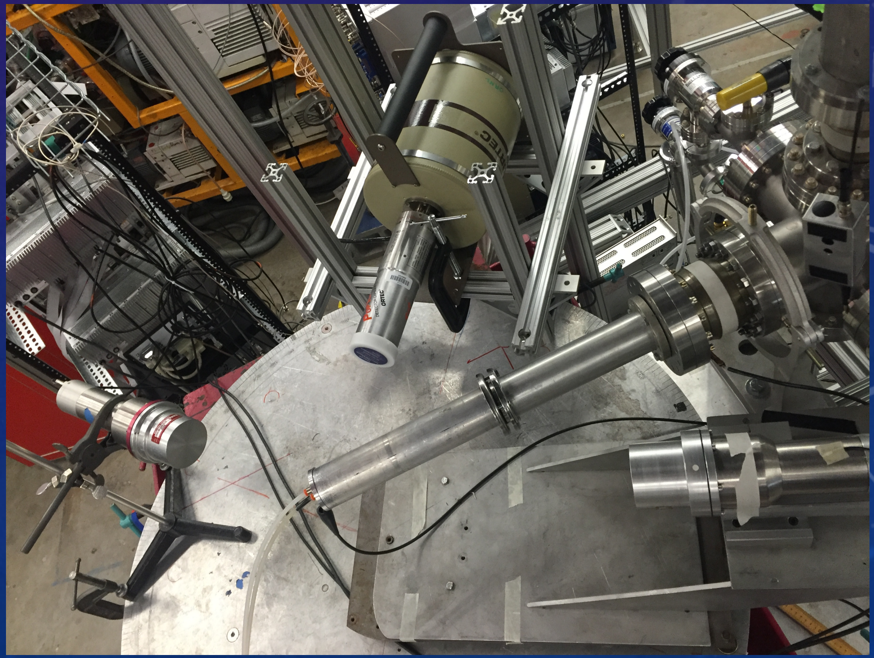
^{3}He Counter:

- Pros:
  - High Efficiency
- Cons:
  - No neutron energy info

SETUP USING LIQUID SCINTILLATORS



- $^{10}B(\alpha,n)^{13}N$, $\sigma_{11B+\alpha} \gg \sigma_{10B+\alpha}$
- 5U accelerator
  - No TOF
- Deuterated Liquid Scintillator
  - Reference neutron detector EJ315 fixed at 45°
  - EJ301D mounted on a swing arm which covered a wide range of angles: 0°, 30°, 60°, 90°, 120°, 130°, 155°
  - Use Unfolding Technique
- HPGe γ detector fixed at 130°



NEUTRON UNFOLDING

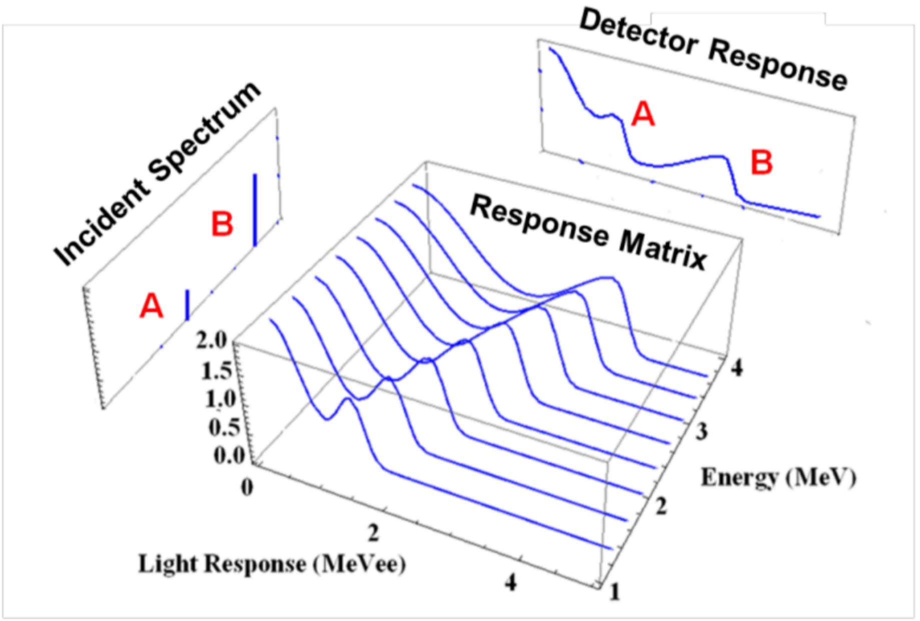


Figure 3.9 - Graphical interpretation of Equation 3.15.

Michael Febbraro, PhD Thesis, University of Michigan(2014)

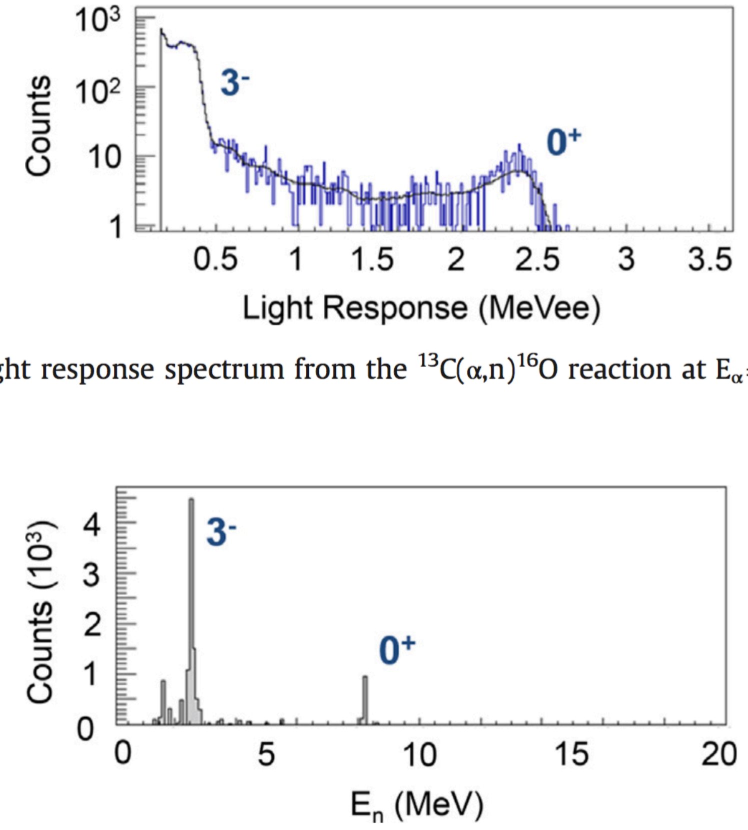


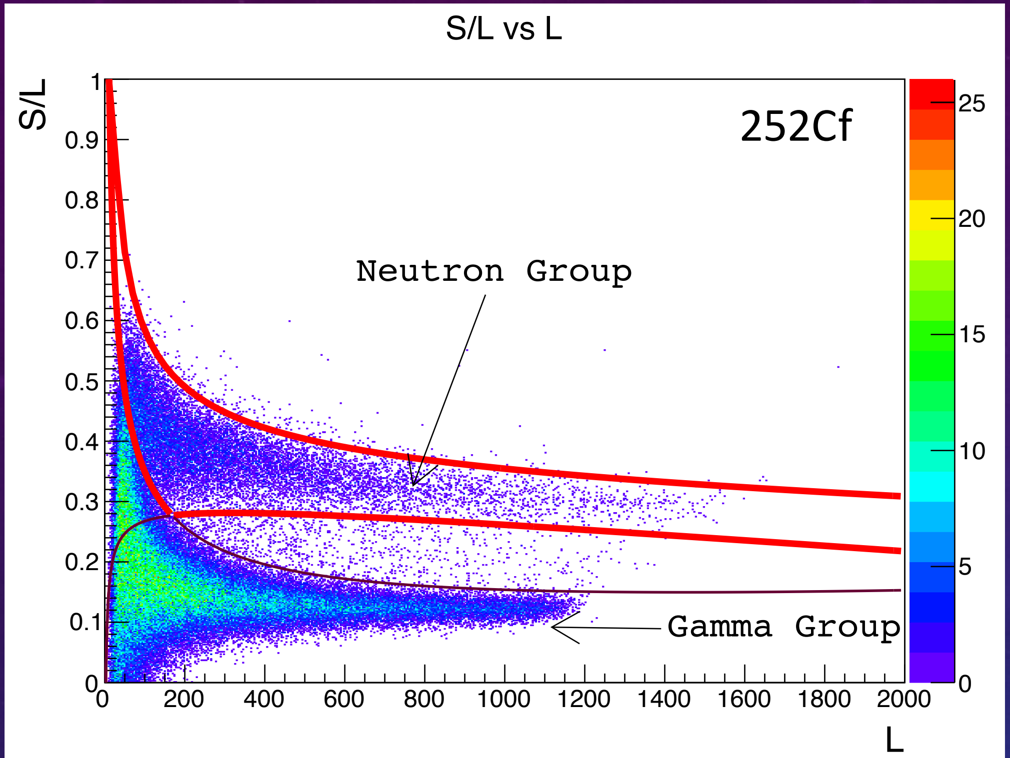
Fig. 7. Light response spectrum from the $^{13}C(\alpha,n)^{16}O$ reaction at $E_\alpha = 7.5$ MeV.

Fig. 8. Unfolded neutron spectrum from the $^{13}C(\alpha,n)^{16}O$ reaction at $E_\alpha = 7.5$ MeV.

Maximum-Likelihood Expectation-Maximization (MLEM)

M.Febbraro et al. (2015)

PRELIMINARY RESULTS



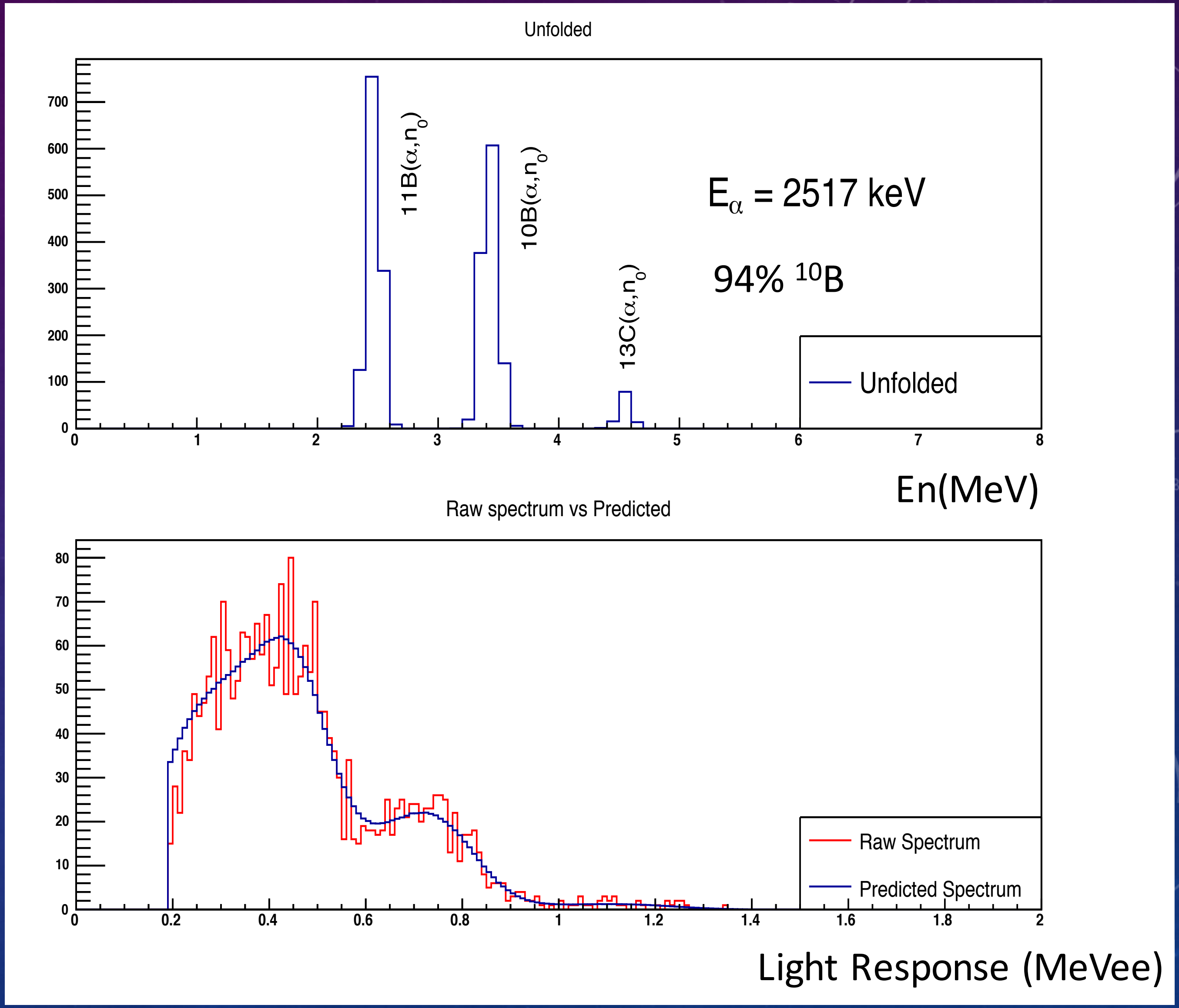
Neutron Gate defined by $\frac{a}{\sqrt{x}} + b + c * x$

Q Values:

$^{11}B(\alpha,n)^{14}N$: 0.16 MeV

$^{10}B(\alpha,n)^{13}N$: 1.06 MeV

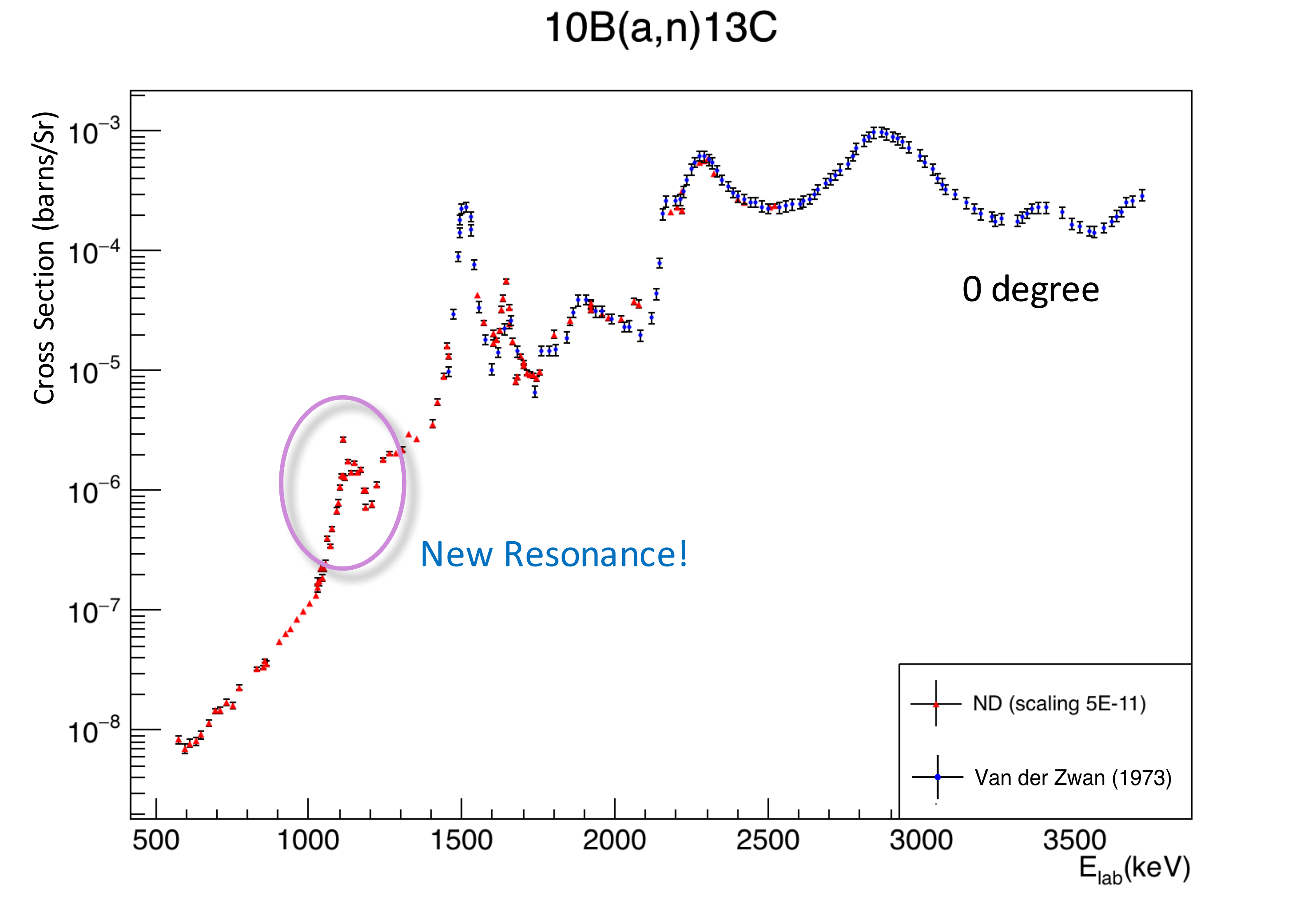
$^{13}C(\alpha,n)^{16}O$: 2.22 MeV



MLEM Unfolding

$^{10}B(\alpha,n)^{13}N$ EXCITATION CURVE

L. Van Der Zwan and K.W. Geiger (1973)



FUTURE PLAN

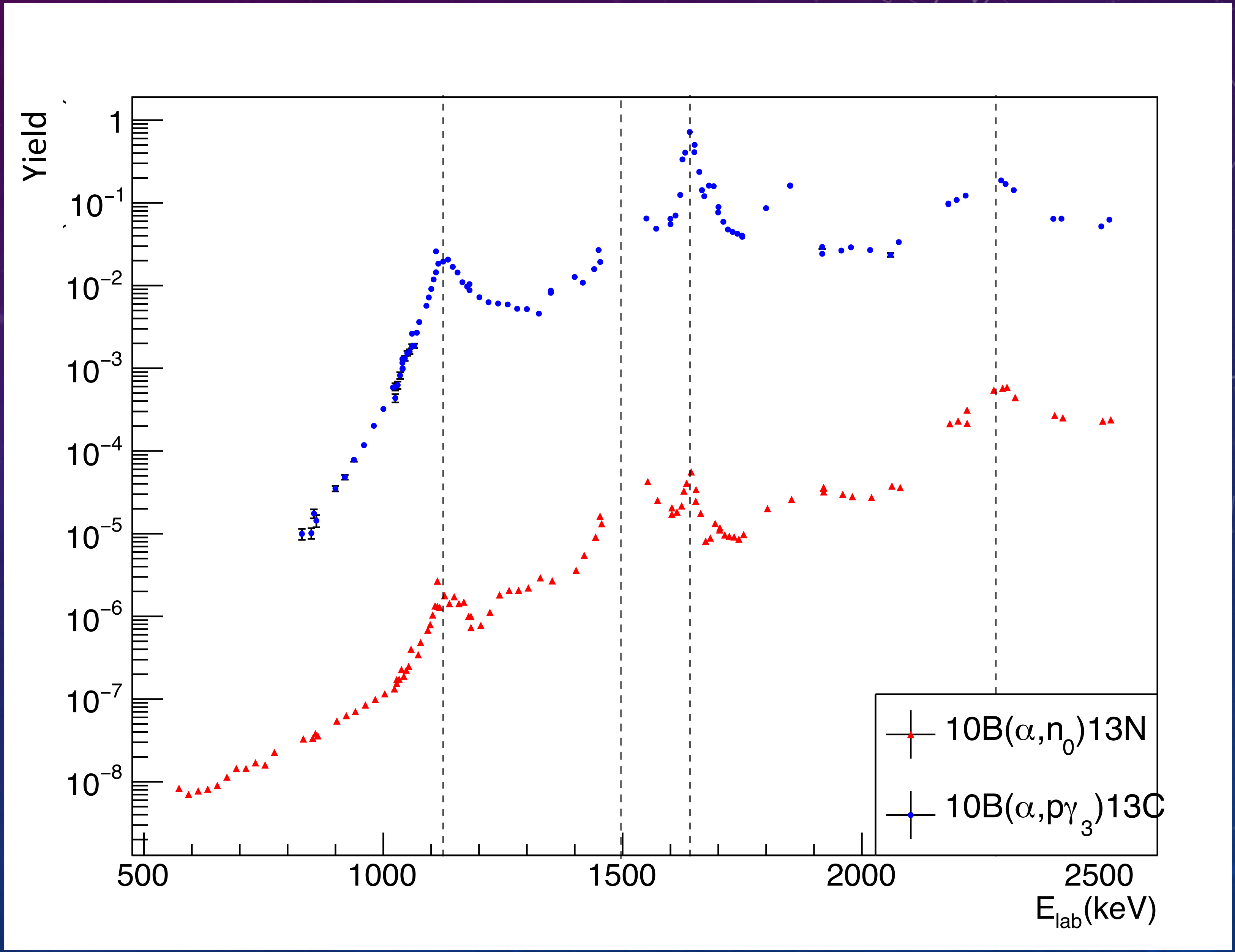
Angular Distribution Analysis

R-Matrix Fit

Investigate $^{10}B(\alpha,\alpha)$, $^{10}B(\alpha,p)$

$^{25}Mg(\alpha,n)$, $^{13}C(\alpha,n)$ with new array of 10 detectors

Continued measurement at CASPAR



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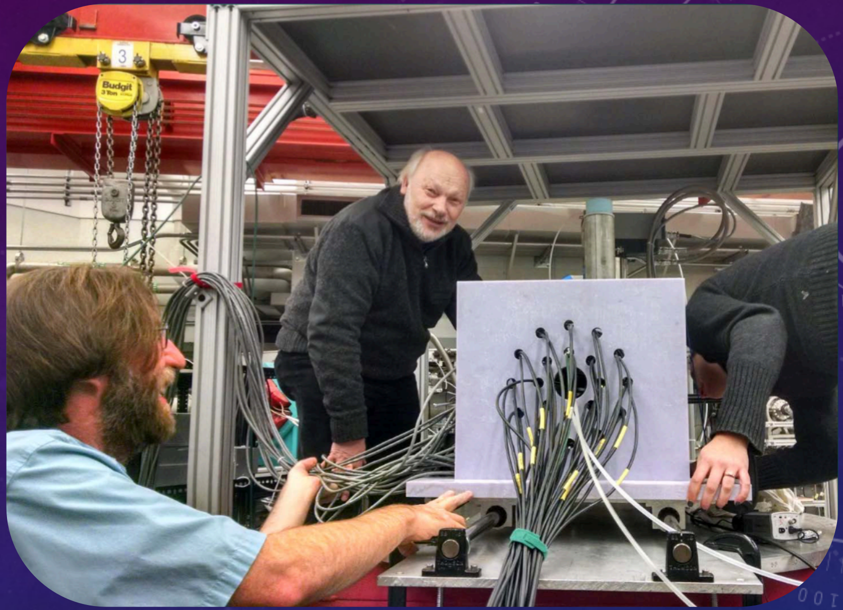

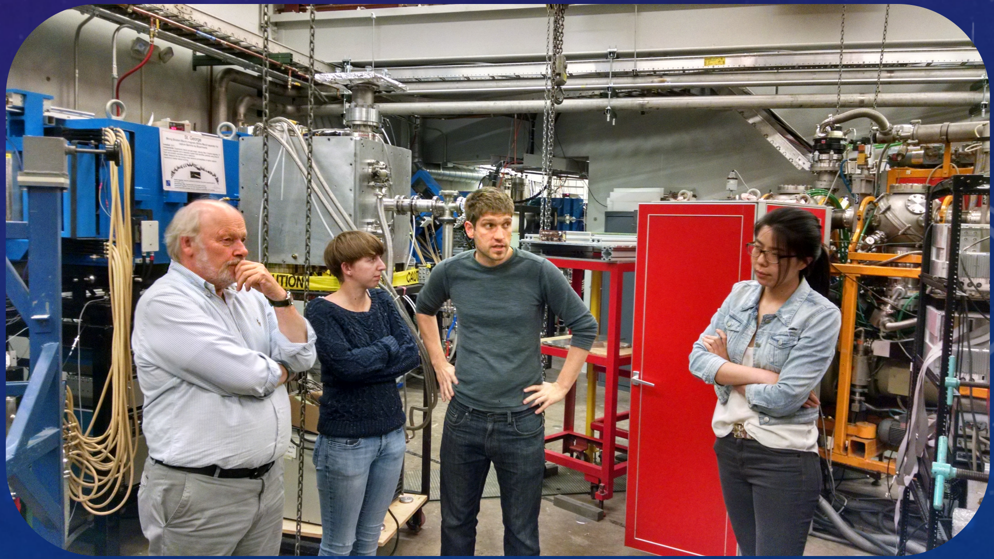

National Science Foundation
WHERE DISCOVERIES BEGIN