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Preliminary Report on $^{16}O(n,\alpha)$ cross section measurement at LANSCE

LENZ at LANSCE can provide high quality nuclear data for neutron-induced charged particle reactions

Hye Young Lee
P-27, Physics Division

LENZ collaborators:

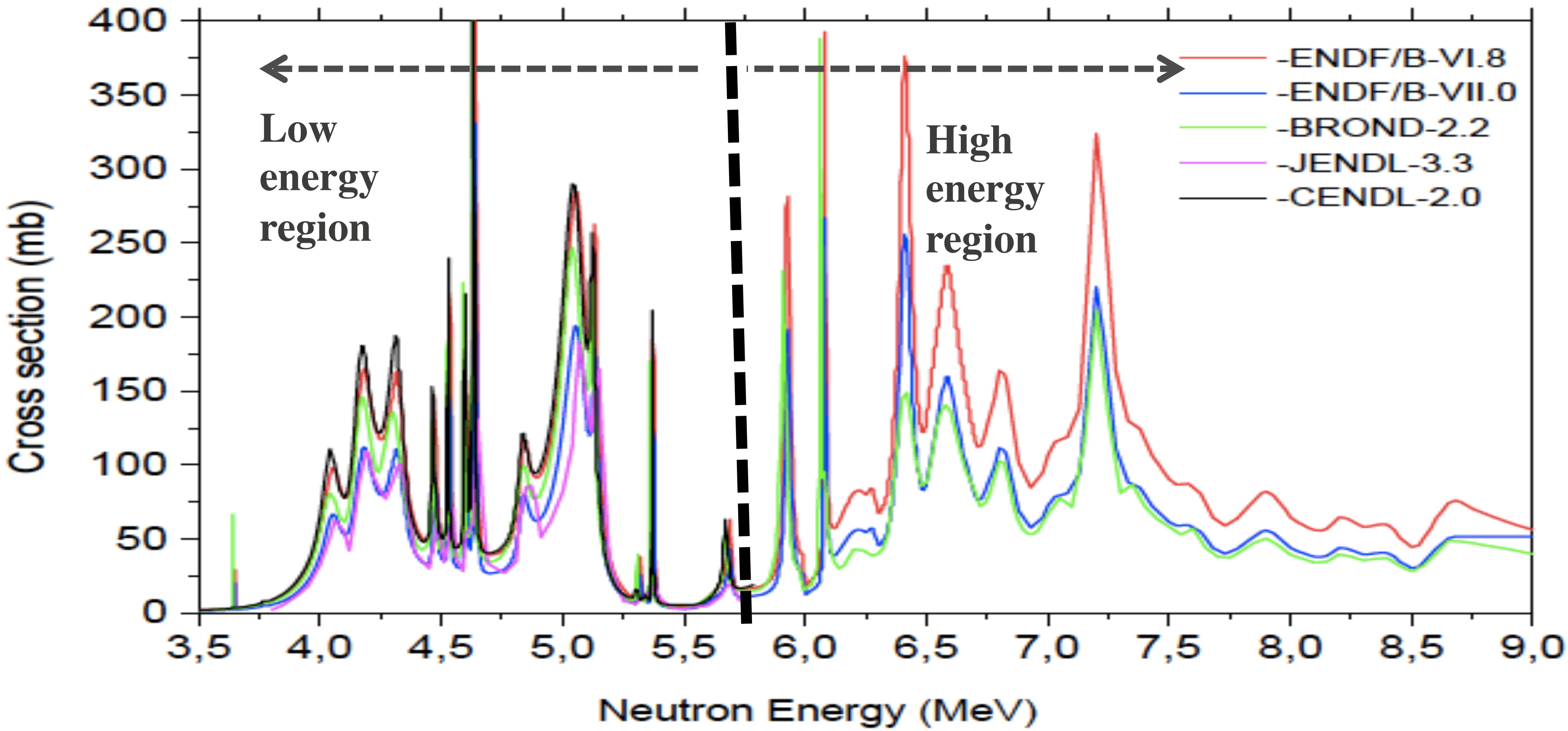
P-27 : H.Y. Lee, J. Davison*, Z. Purcell*, A. Long, C. Prokop

T-2 : G. Hale, M. Paris

* undergrad, red-postdocs

Evaluation of $^{16}O(n,\alpha)$ reaction : differ by up to 30-50 %

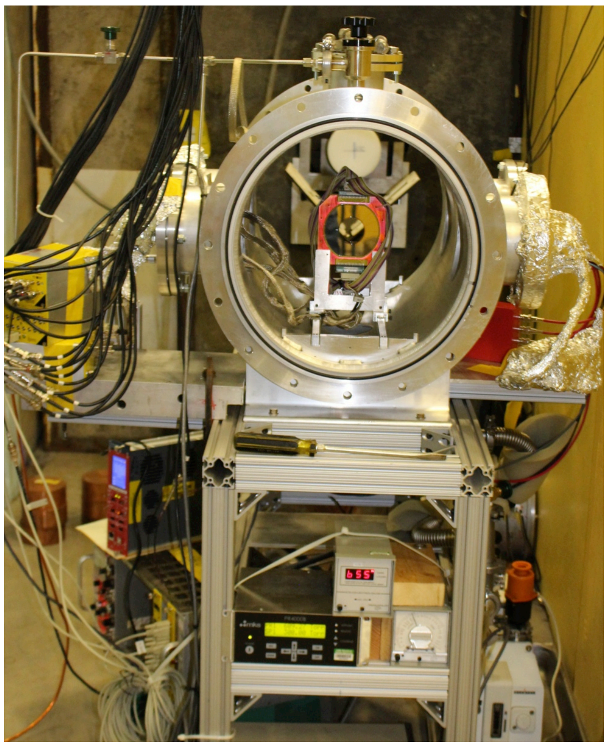
- **Knowing precise cross sections on oxygen is crucial in designing/ evaluating nuclear reactors, however the current evaluation effort (CIELO) requires better quality data.**

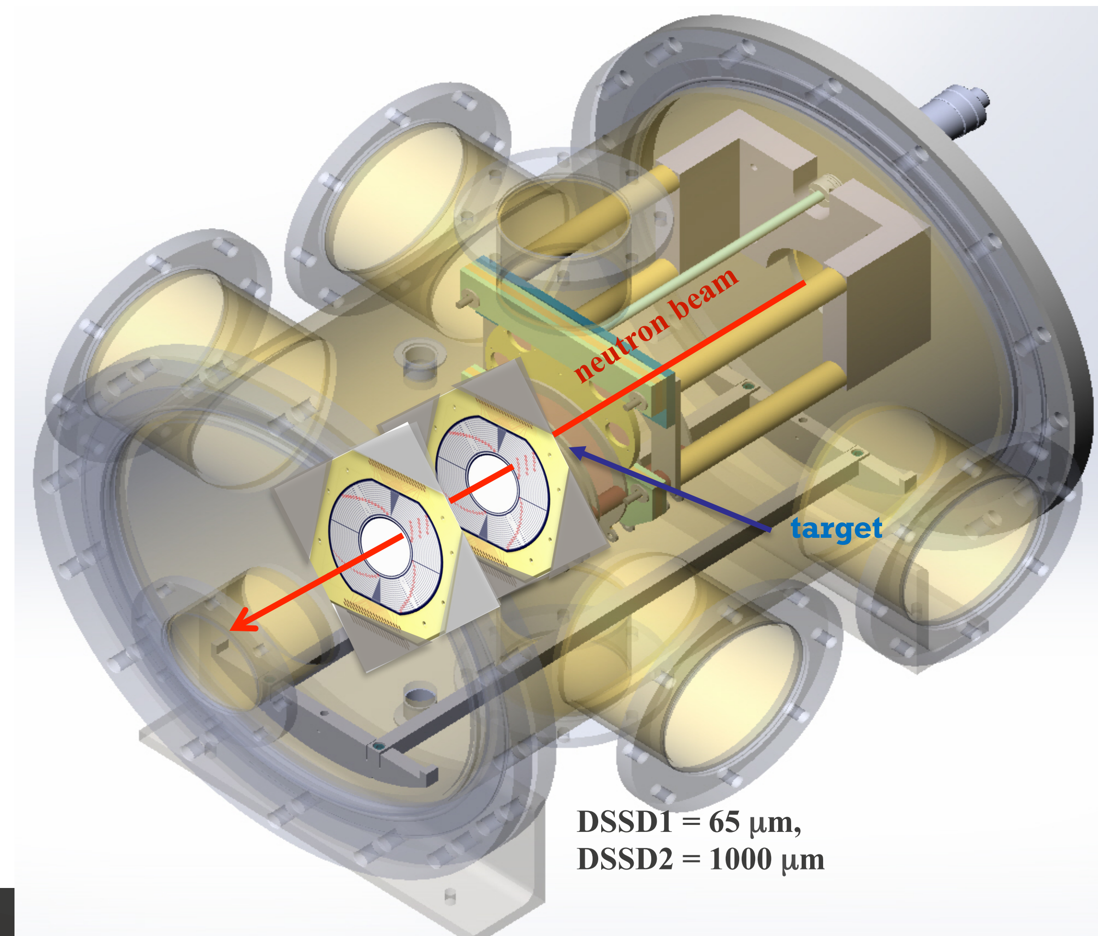


NEMEA-7, 5-8 November 2013, Geel, Belgium

LENZ : Low Energy NZ instrument at LANSCE

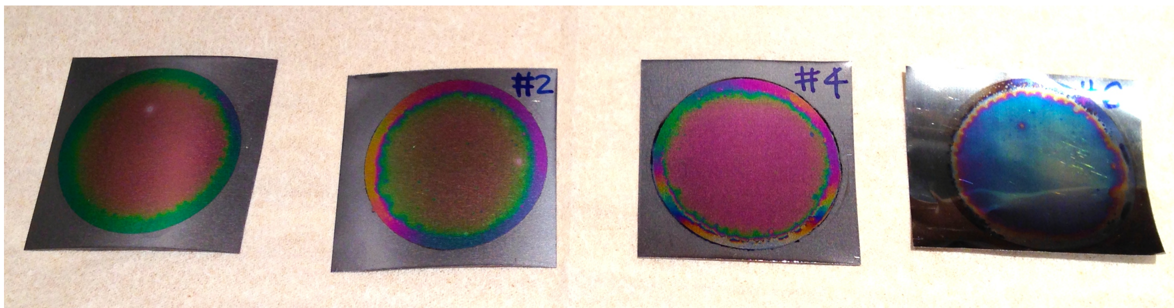
- Designed for measuring (n,z) reactions with a large solid angle and low detection threshold for various applications
- Last two years, there was a focused effort of measuring the $^{16}O(n,\alpha)$ reaction cross section at LANSCE, in order to provide an additional data set





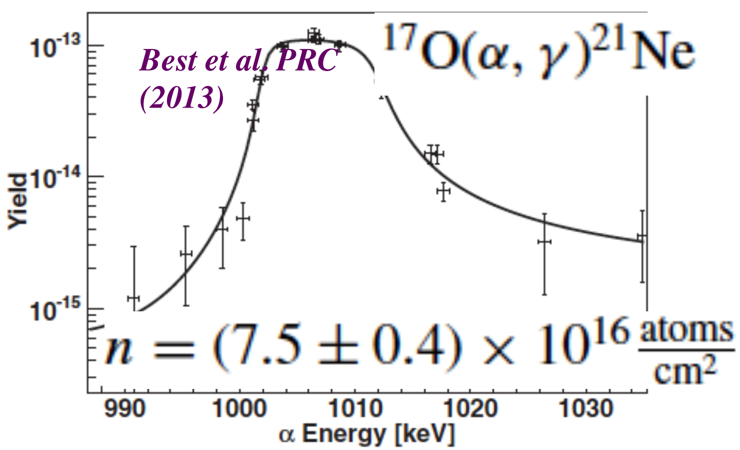
Solid ^{16}O target for LANSCE measurements

- For better control of the target amount and ease of manufacturing in house, we used a solid oxygen target
- Tantalum backing was anodized to produce Ta_2O_5 with ~ 4000 Å

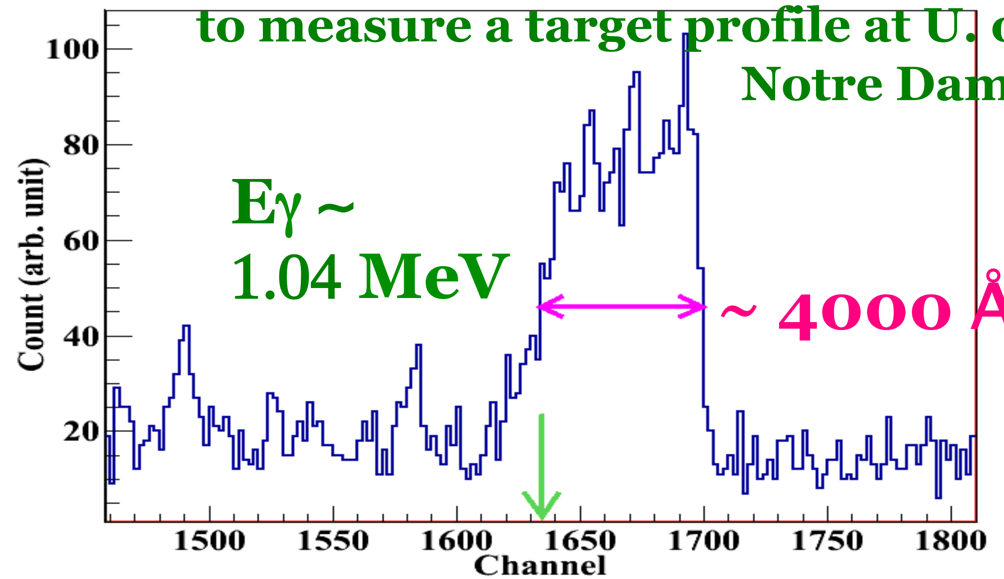


Vermilyea, Acta Metallurgica (1953)

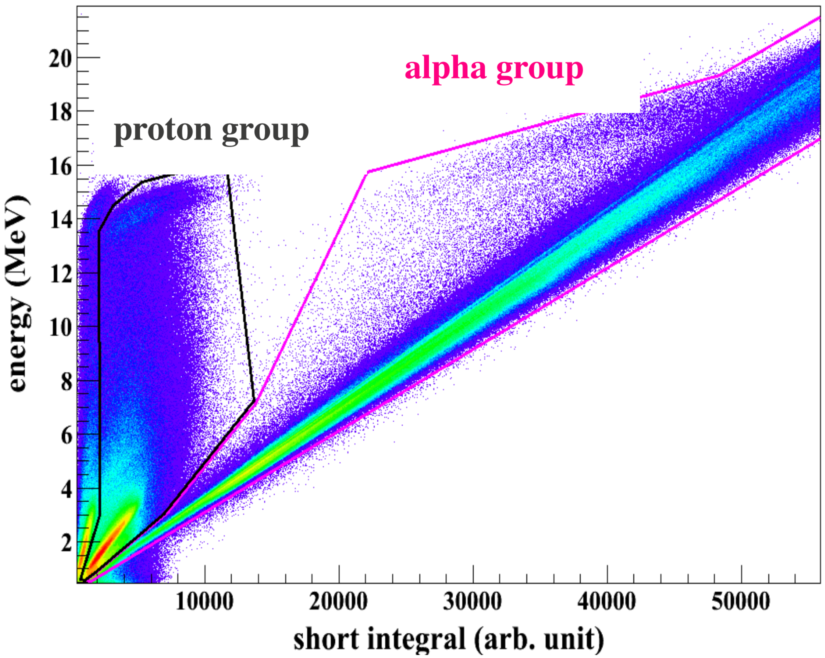
Thickness (Å)	Error (Å)
200-500	1
500-2500	5
2500-5000	8



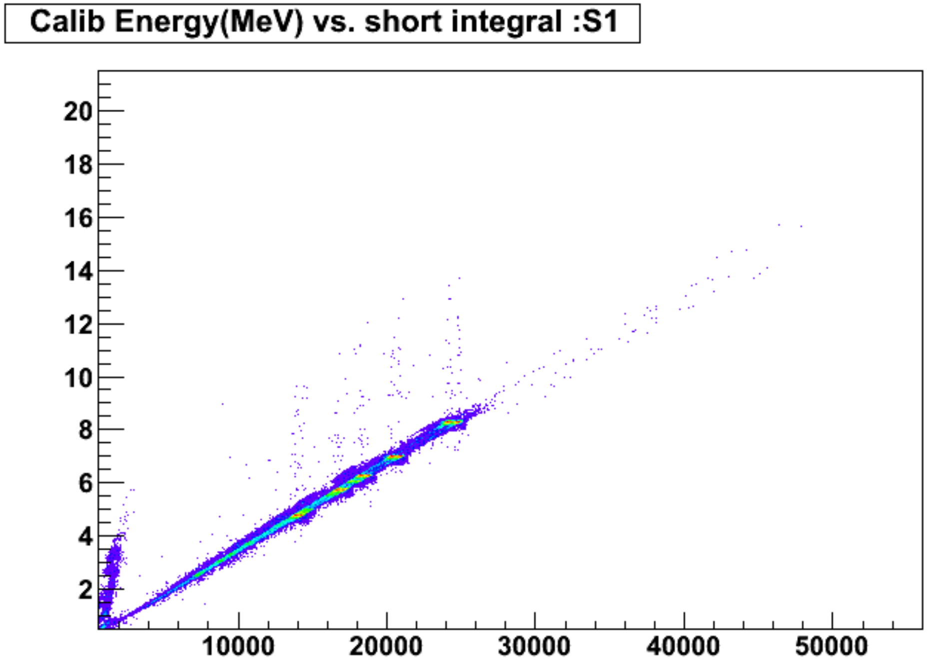
$^{16}O(p,\gamma)$ Direct Capture to measure a target profile at U. of Notre Dame



Double Sided Silicon Strip Detector: pulse shape discrimination for identifying different charged particles



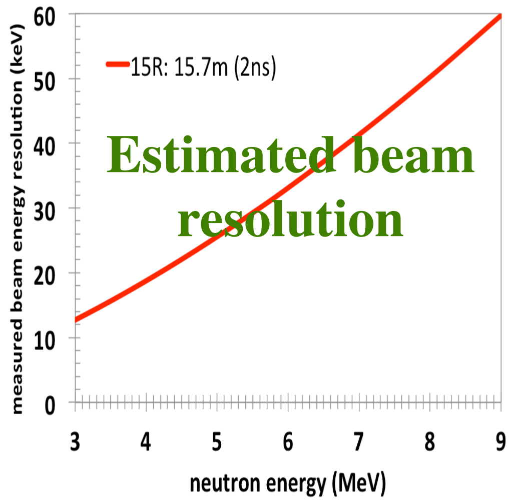
By applying a short integral vs. a long integral method, it is possible to have particle identifications

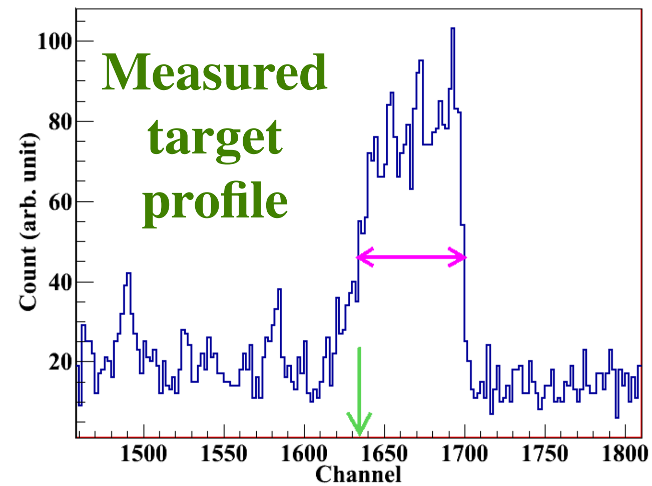


Th-229 alpha source measurement on the same condition as the left, neutron beam on Ta_2O_5 target

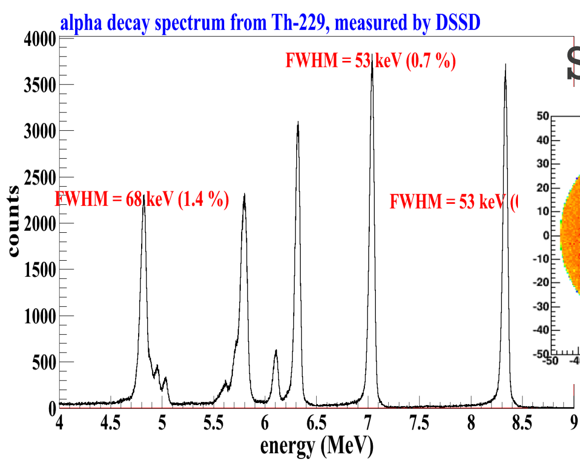
$^{16}O(n,\alpha)$ data : Forward Propagation Analysis

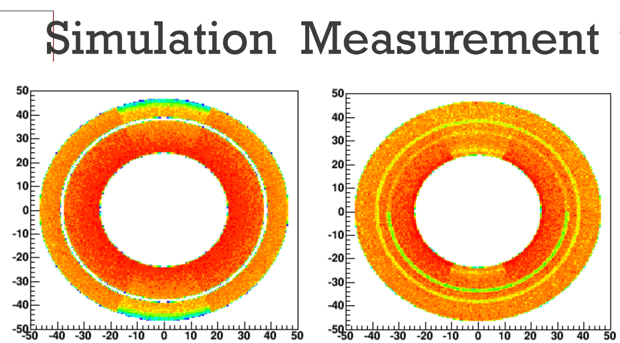
With well characterized experimental response functions and systematically varying input cross sections, we plan to analyze data "inclusively" by fitting yields in Monte Carlo framework

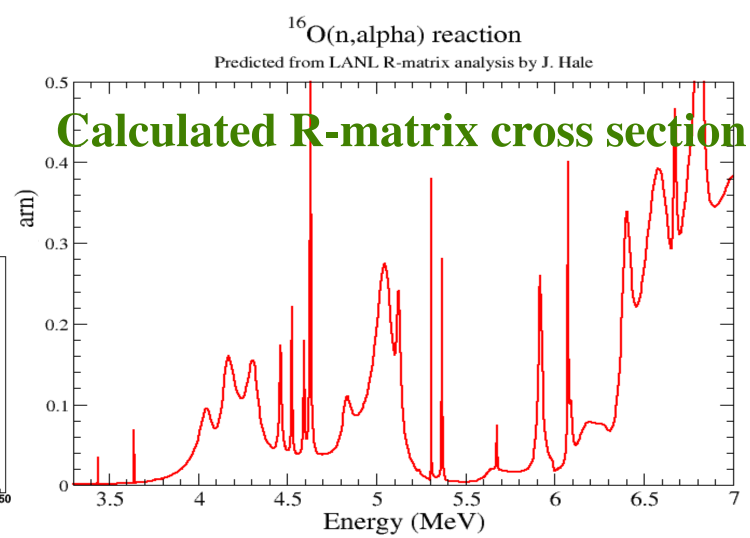




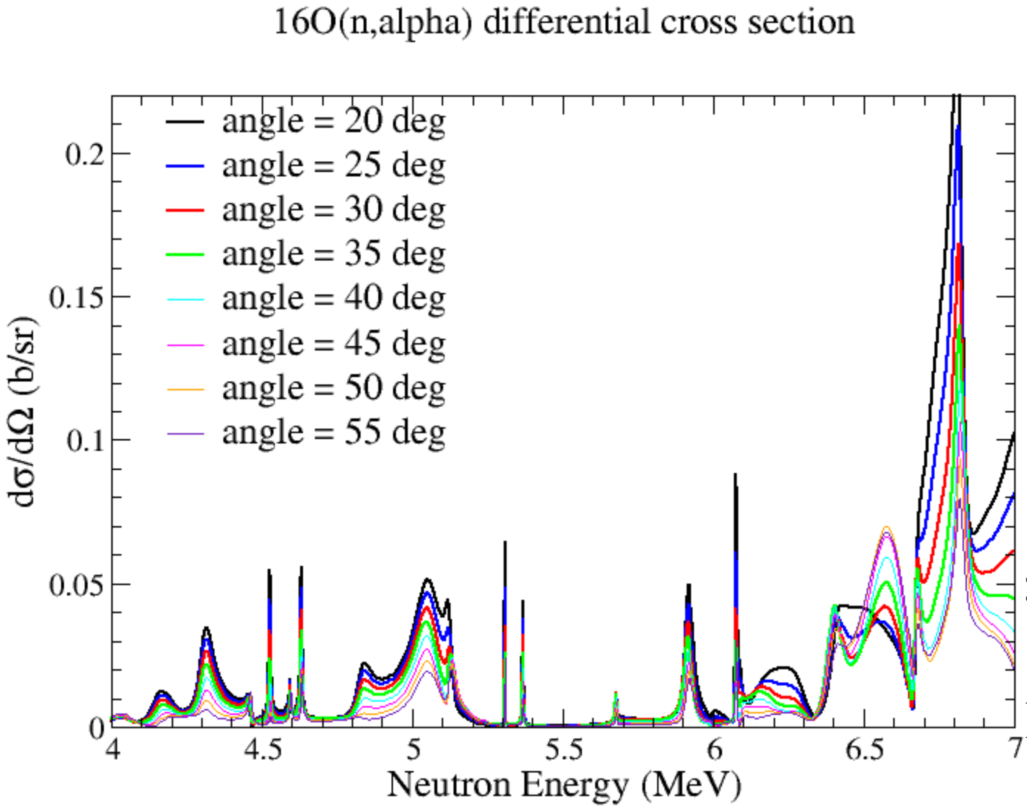
Measured detector resolution & efficiency

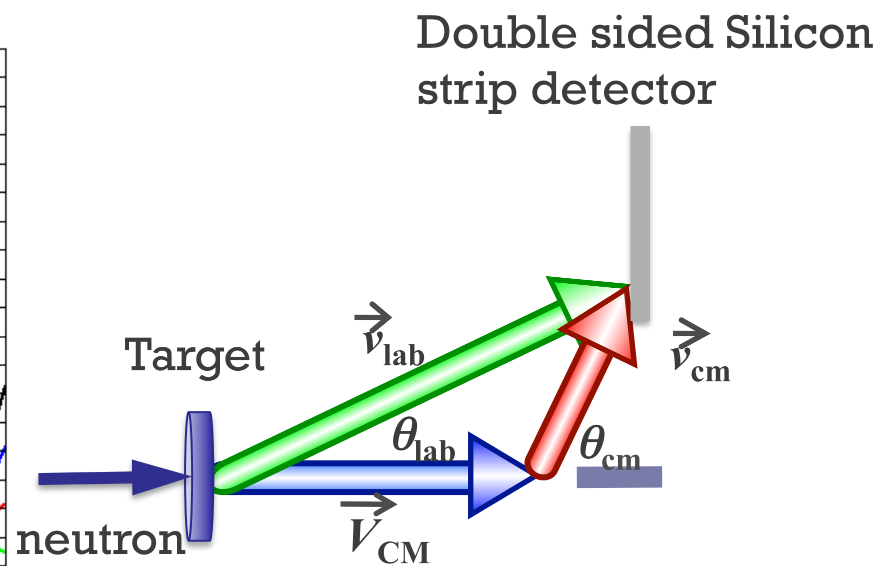






Differential cross sections and 2-body kinematics relative to LENZ observables



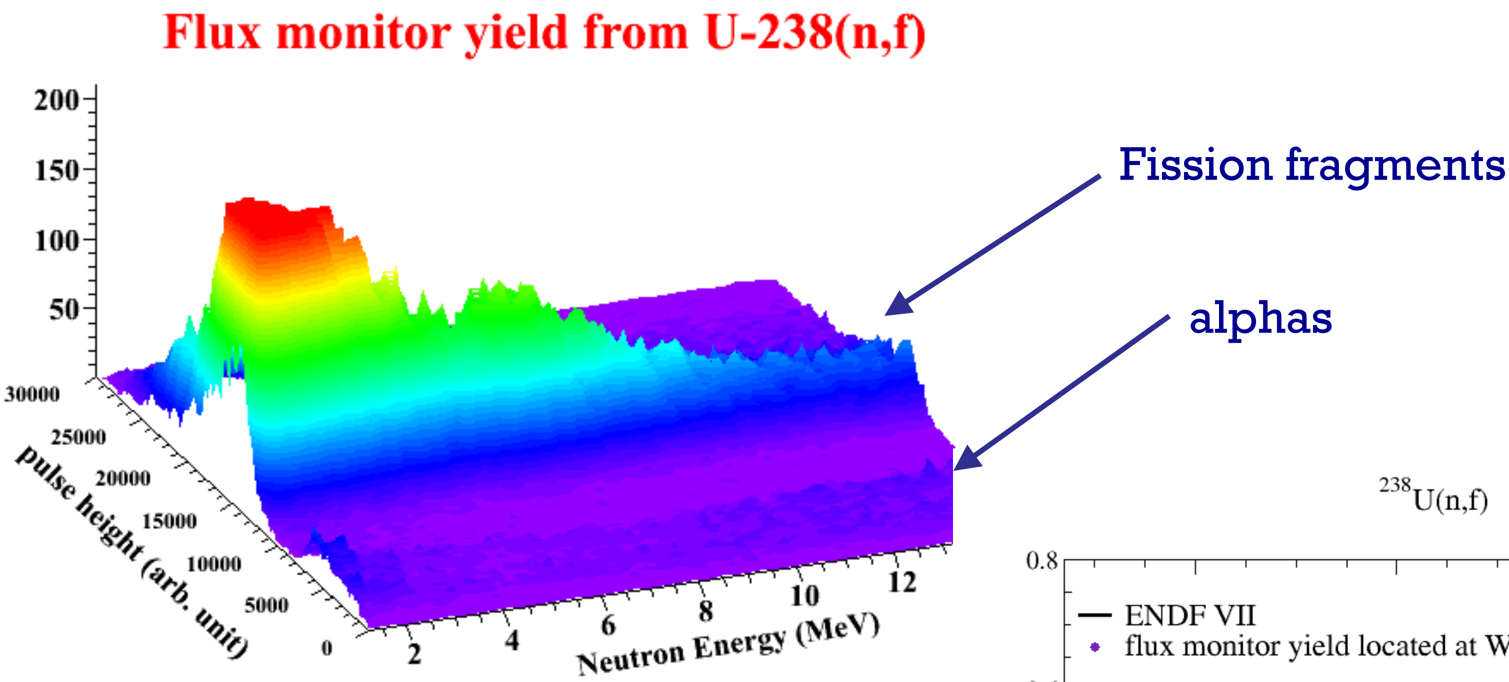


Particles are detected at fixed θ_{lab} :

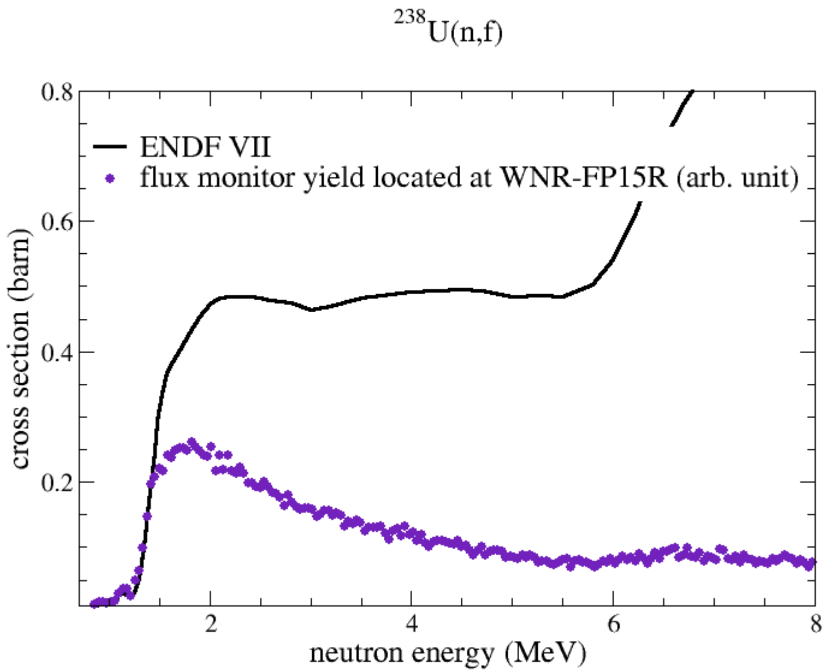
$$v_{lab}^2 = v_{cm}^2 - V_{CM}^2 + 2 v_{lab} V_{CM} \cos\theta_{lab}$$

$$\therefore \Delta E_{lab} = \Delta E_{cm} + \sqrt{2m} V_{CM} \cos\theta_{lab} \left(\sqrt{E_{2lab}} - \sqrt{E_{1lab}}\right)$$

Neutron flux normalization at the FP15R LANSCE

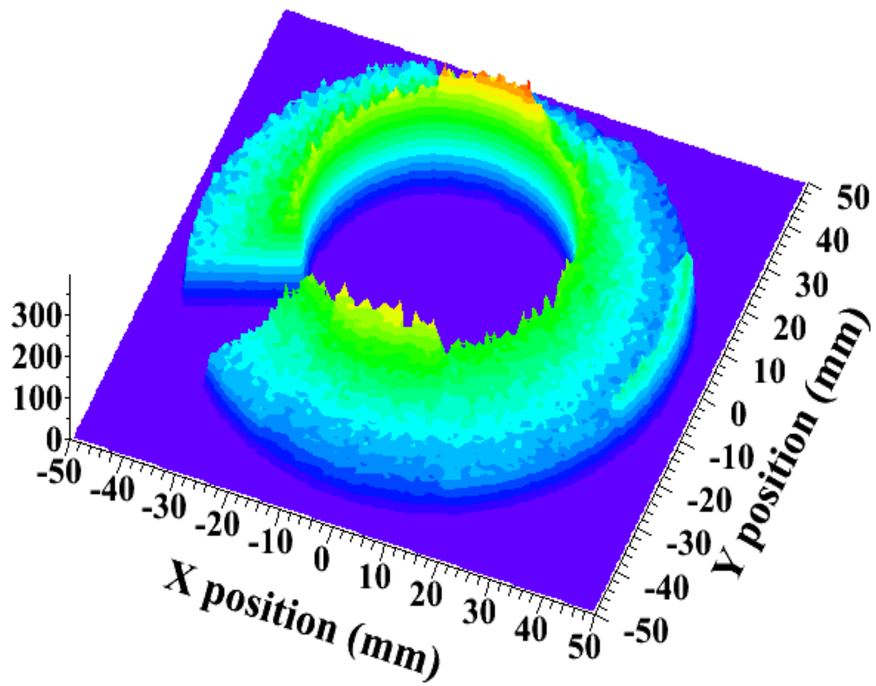


The ratio of the yield from the ^{238}U fission ionization chamber to the evaluated cross section provides the neutron flux at flight path.

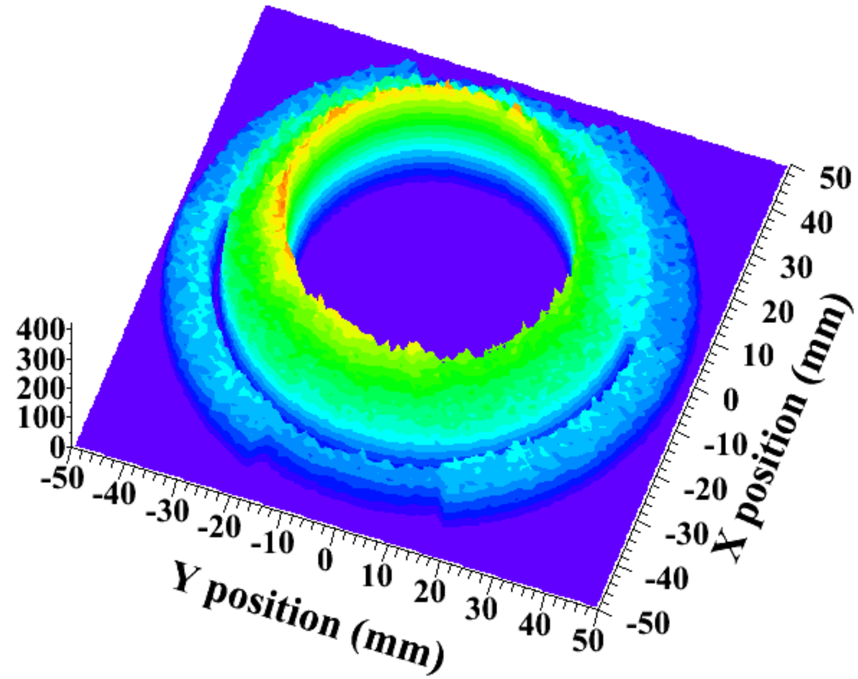


Measured detector hit patterns from double sided silicon strip detectors, gated at the neutron and alpha energies

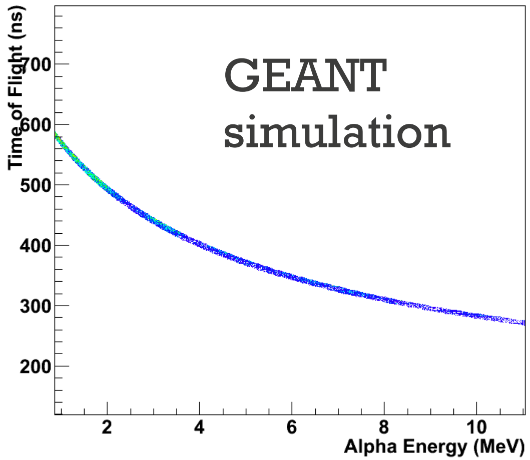
Double sided silicon detector hit pattern (R1)

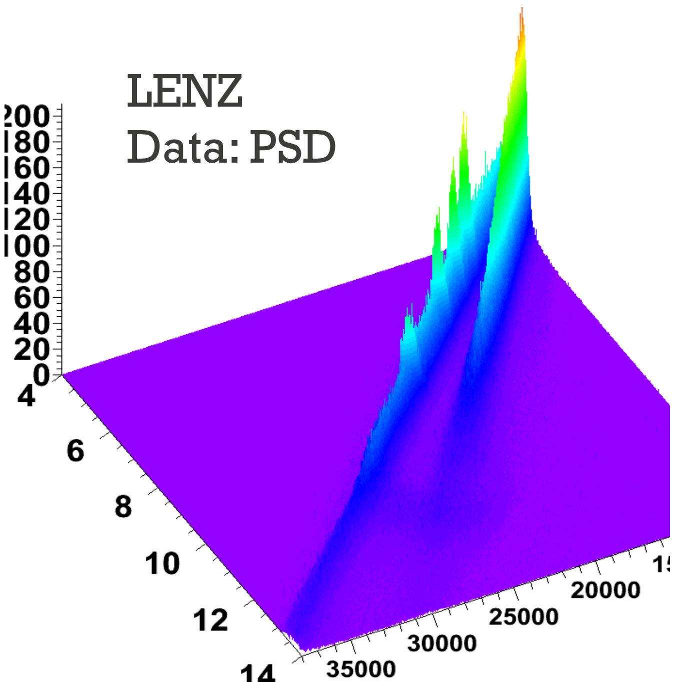


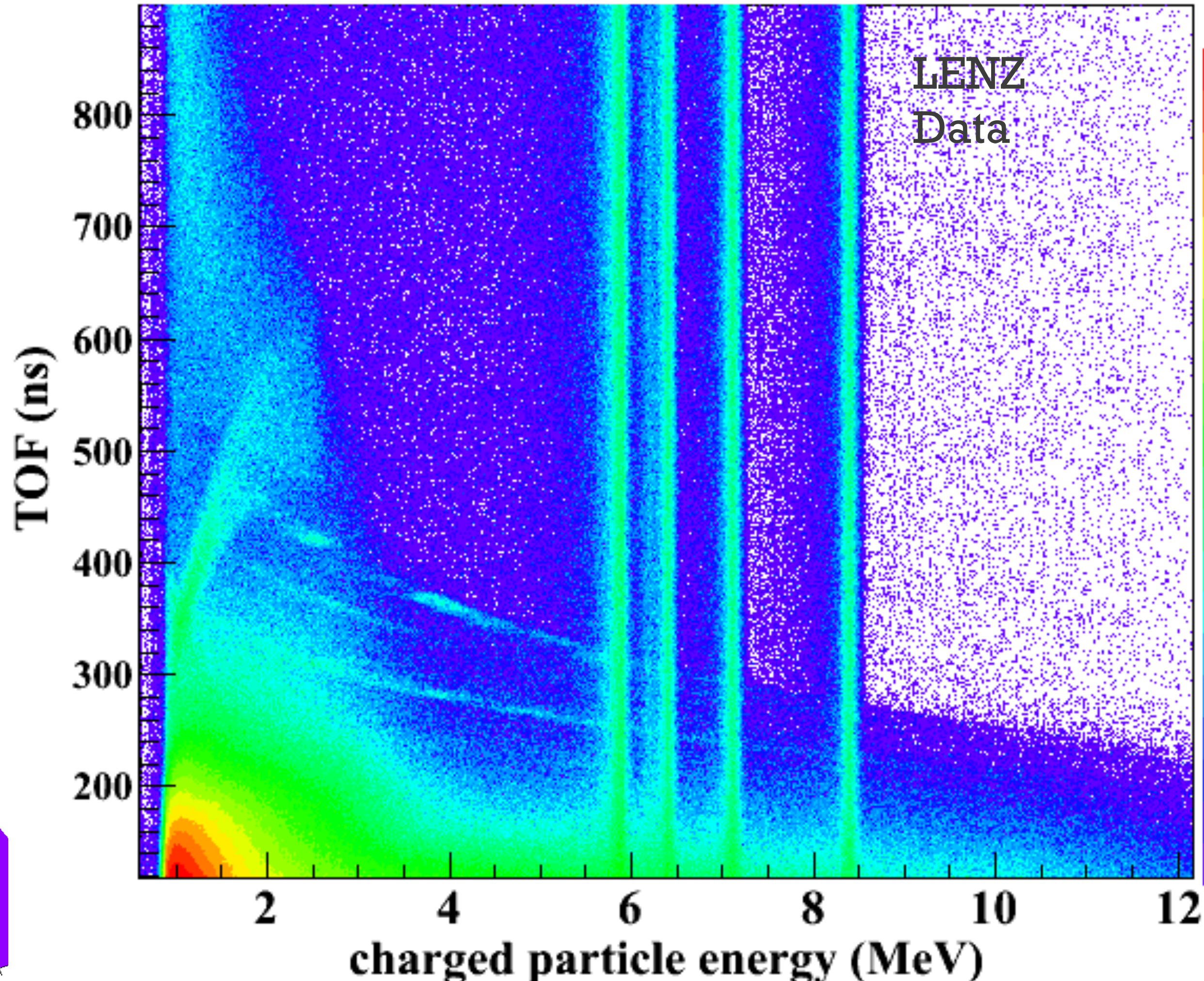
Double sided silicon detector hit pattern (R2)



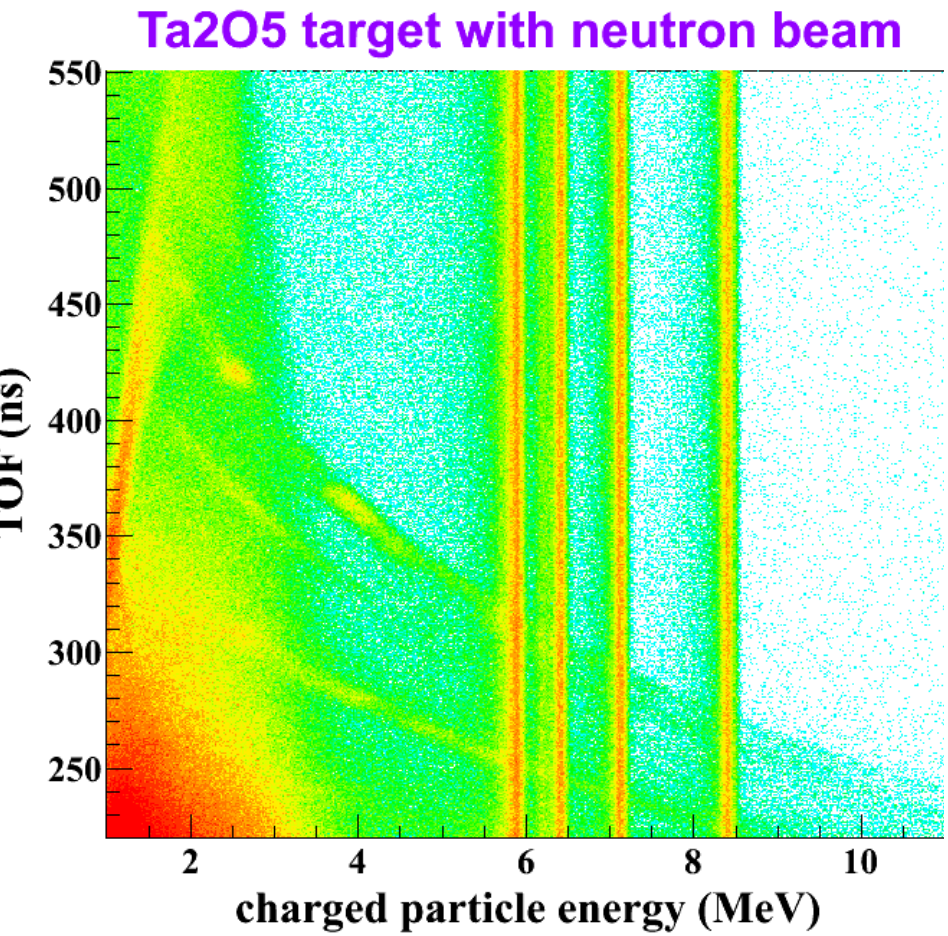
Comparison of LENZ data with the GEANT simulation

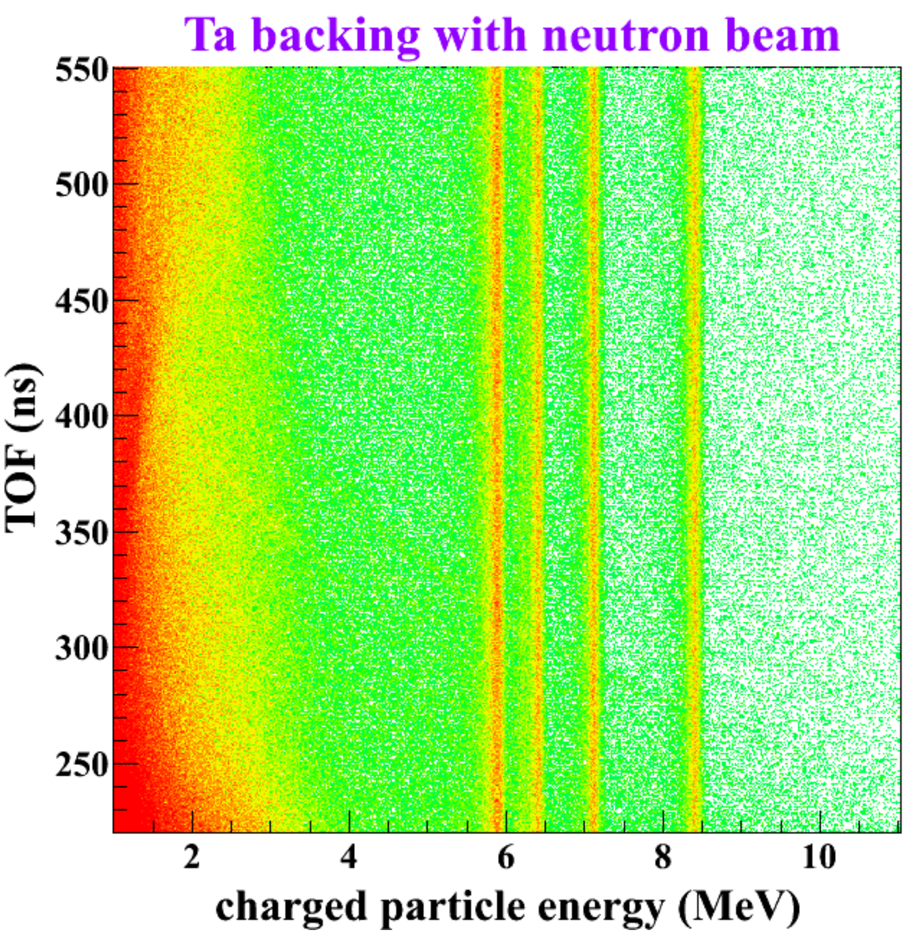






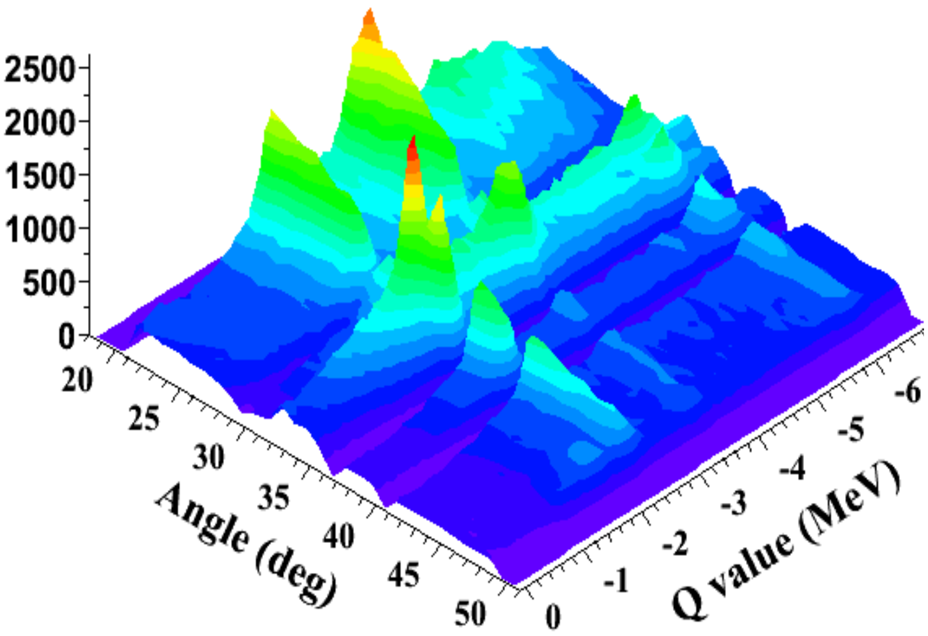
Neutron-beam induced background investigation, by comparing the foreground (left) and the background (right)



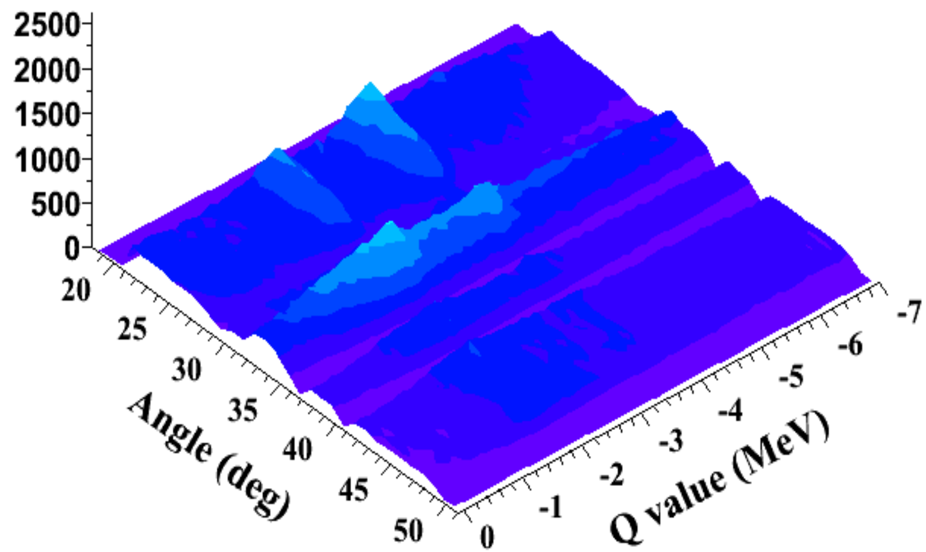


Q-value vs. angle plots measured with Ta_2O_5 target and Ta blank target, to investigate the beam-induced background yields

(n,a) yield on Ta2O5 target

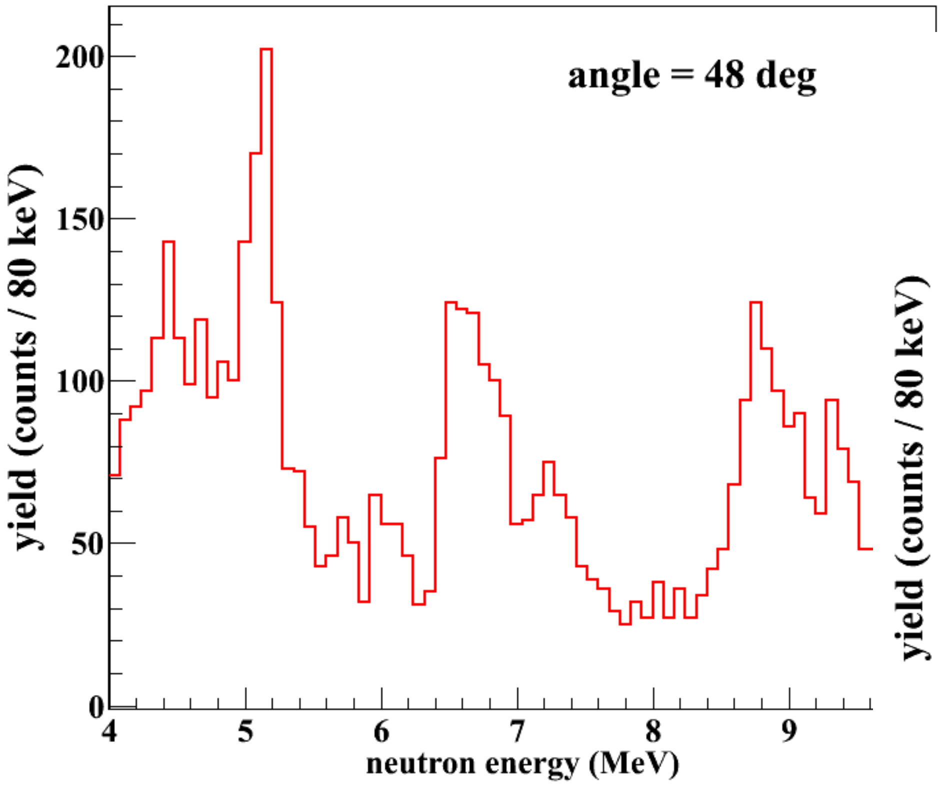


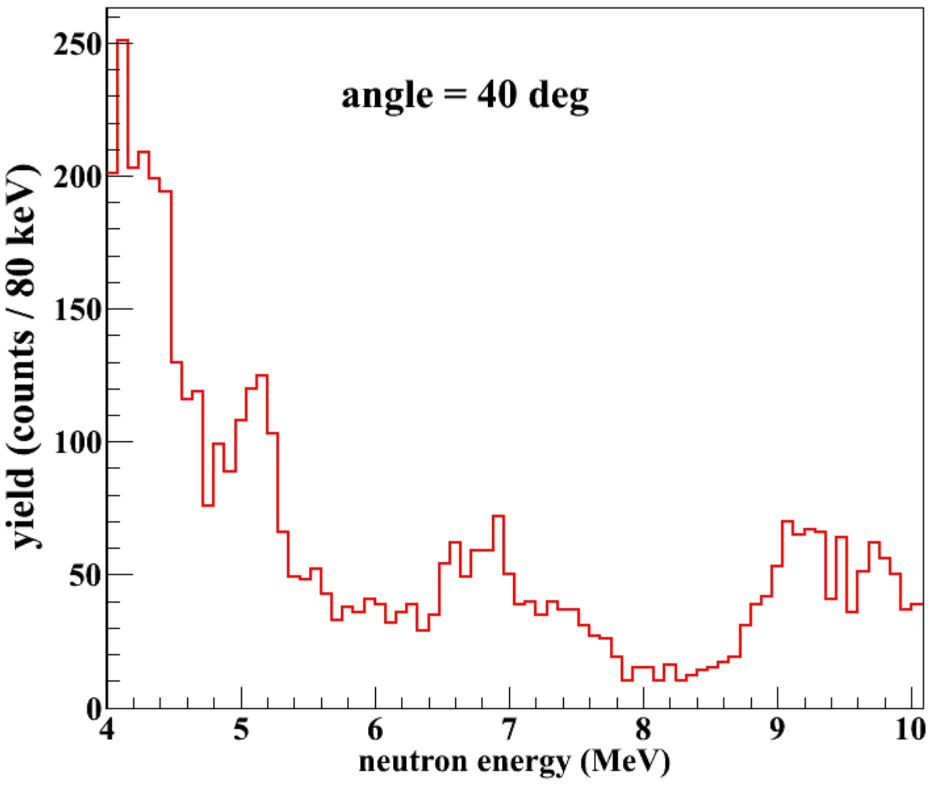
(n,a) yield on Ta backing target



Measured angular distributions

The yields are not corrected for background events, in order to perform the Forward Propagation Analysis for the purpose of reduced systematic uncertainty.





Uncertainty budget perspectives *(Still changing and under serious investigation)*

target thickness	5	%
stoichiometry	<1	%
neutron flux	10	%
timing resolution	1	%
alpha energy resolution	1	%
total sys unc.	11.3	%
statistical unc./bin	5-10	%
total unc.	12.4-15.1	%

Outlook on LANSCE $^{16}O(n,\alpha)$ cross section data

1. For the Forward Propagation Analysis, complete the backing material reaction cross sections and sensitivity study
2. Use the finer angular differential cross sections for input cross sections and cross sections at En > 7 MeV
3. Improve the statistics from the Nov 2017 measurement

4. Three ways to determine the normalization
   a. Conventional experimental normalization
   b. Forward Propagation Analysis normalization
   c. EDA 6 by fitting experimental yields through unitary constraint

5. Can plan on measuring the Li/O measurement for improving the systematic uncertainty
   a. first trial target was very unstable with neutron beams, so needs to invest on making stable targets
   b. knowing Li cross section En > 4 MeV is necessary for improved final uncertainty