HFNG Flux Calculation

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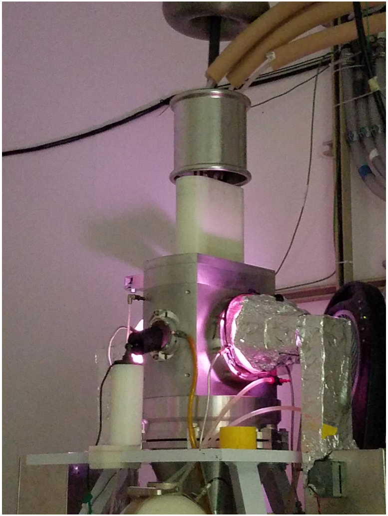
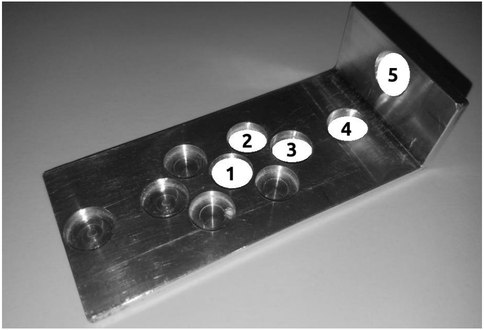
Overview

- Experiment summary
- DD fusion spectrum
- Solution method
- Implementation
- Results



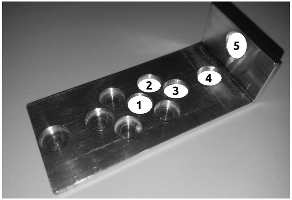
Experiment Summary



- Goal to measure $^{35}Cl(n,p)^{35}S$ cross section
- 5x 11 mm OD NaCl pellets
- Monitor fluence using $^{58}Ni(n,p)^{58}Co$
- Need to determine energy spectrum for each sample

Experiment Summary

Sample	Δx [mm]	Δy [mm]	Δz [mm]	$\Delta\theta$ [°]
1	0.0	0.0	8.0	0
2	9.0	8.0	8.0	0
3	18.0	0.0	8.0	0
4	36.0	0.0	8.0	0
5	46.0	0.0	-7.0	90



- Δx, Δy, Δz relative to beam center
- Additional 1.5 mm Δz due to thickness of sample holder
- 14 mm beam diameter

DD Fusion Spectrum

A_n	100 keV	200 keV
A_0	2.4674	2.47685
A_1	0.30083	0.39111
A_2	0.01368	0.04098
A_3	0.0	0.02957

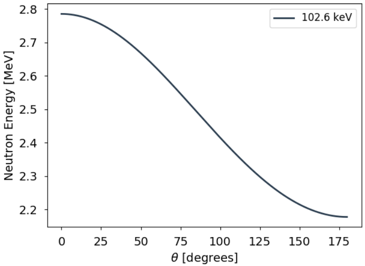
$$E_n(\theta) = A_0 + \sum_{n=1}^{3} A_n cos^n(\theta)$$

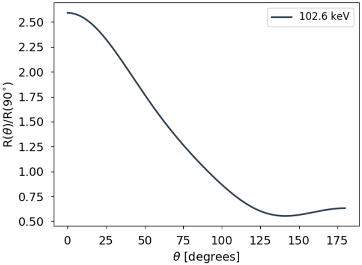
A_n	100 keV	200 keV
A_1	0.01741	-0.03149
A_2	0.88746	1.11225
A_3	0.22497	0.38659
A_4	0.08183	0.26676
A_5	0.37225	0.11518

$$\frac{R(\theta)}{R(90^\circ)} = 1 + \sum_{n=1}^{5} A_n cos^n(\theta)$$

- Use neutron energy and intensity correlations as input to source definition

DD Fusion Spectrum





$$E_n(\theta) = A_0 + \sum_{n=1}^{3} A_n cos^n(\theta) \qquad \frac{R(\theta)}{R(90^\circ)} = 1 + \sum_{n=1}^{5} A_n cos^n(\theta)$$

- Use neutron energy and intensity correlations as input to source definition

Solution Method

Solve for average flux over sample (in vacuum) for given source definition and sample geometry using Monte Carlo

$$\bar{\phi}(E) = \int\int S(\vec{r}, E, \hat{\Omega}) d^3 r d\hat{\Omega}$$

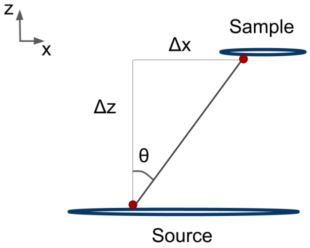
$$= \int\int \phi_0 \frac{n(\vec{r})\delta(\hat{\Omega} - \Omega_{sample})R(\theta(E))}{|\vec{r} - r|^2} d^3 r d\hat{\Omega}$$

$$= \frac{1}{N}\sum_{n=1}^{N} \phi_0 \frac{R(\theta(E_n))\delta_{r\theta}}{(\Delta r_n)^2} = \phi_0 \sum_{n=1}^{N} \frac{R(\theta(E_n))\delta_{r\theta}}{(\Delta r_n)^2}$$

where $n(\vec{r})$ is PDF for source (e.g. Gaussian) and $\delta_{r\theta}$ constrains neutron rays to source-sample paths.

Solution Method

Generate ray coordinates by randomly generating source point from (radial) Gaussian distribution, and sample point from (radial) uniform distribution.



In general:

$\theta = arccos(\frac{\vec{r_1} \cdot \vec{r_2}}{|\vec{r_1}||\vec{r_2}|})$

In 2D Cartesian:

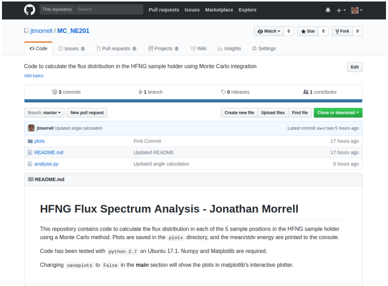
$\theta = arccos(\frac{\Delta z}{\sqrt{\Delta x^2 + \Delta z^2}})$

In 3D Cartesian:

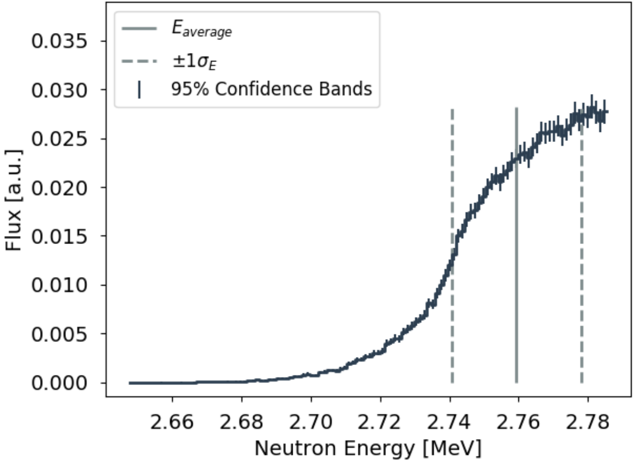
$\theta = arccos(\frac{\Delta z}{\sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}})$

Implementation

- Implemented in python 2.7
- Source on github:
- `https://github.com/jtmorrell/MC_NE201`
- Generates plots of flux spectrum for each sample and prints $E_{average} \pm 1\sigma_E$

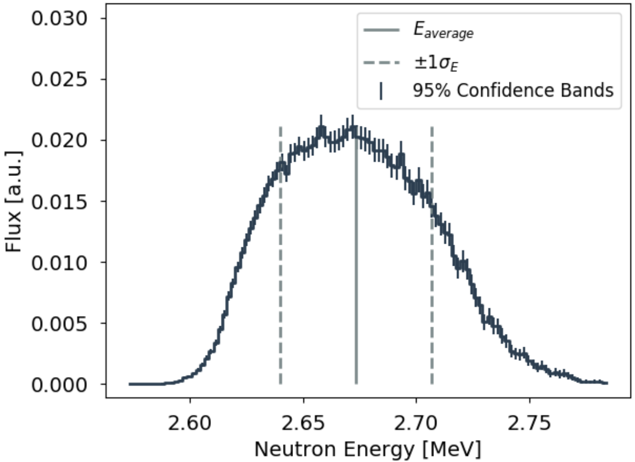


Results (Sample 1)



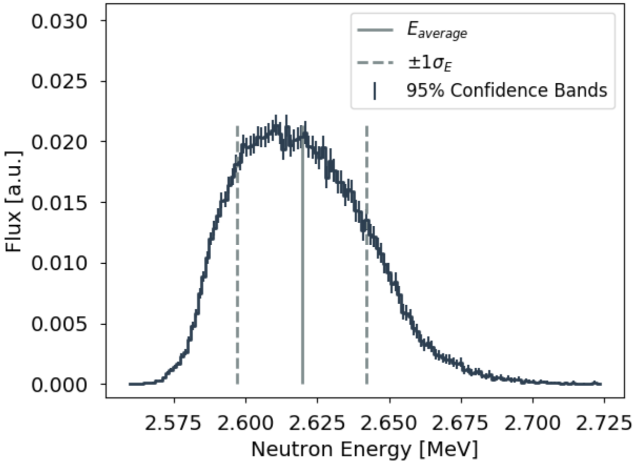
$$E_n = 2.76 \pm 0.019 \text{ [MeV]}$$

Results (Sample 2)



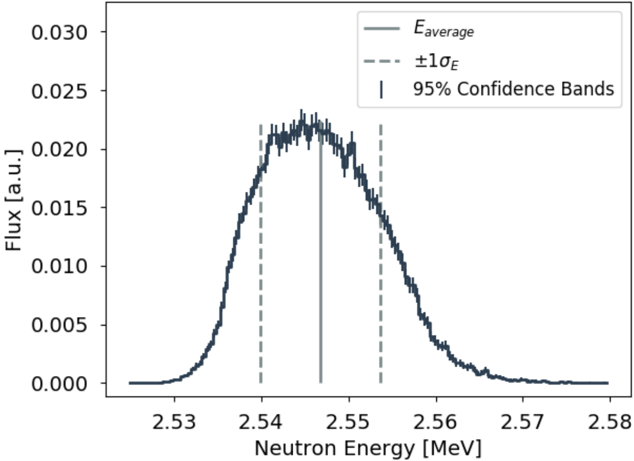
$$E_n = 2.67 \pm 0.033 \text{ [MeV]}$$

Results (Sample 3)



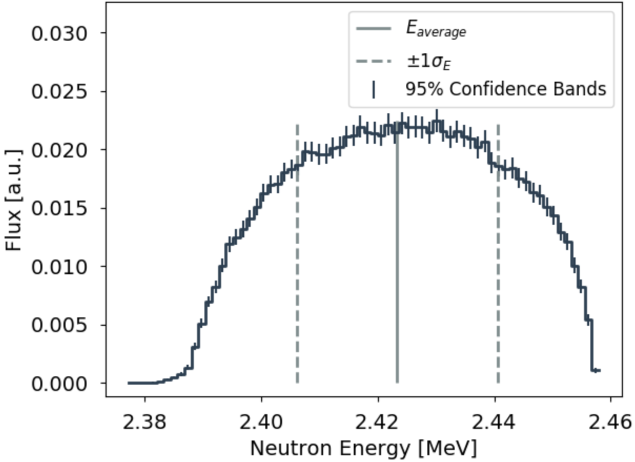
$$E_n = 2.62 \pm 0.023 \text{ [MeV]}$$

Results (Sample 4)



$$E_n = 2.55 \pm 0.007 \text{ [MeV]}$$

Results (Sample 5)



$$E_n = 2.47 \pm 0.018 \text{ [MeV]}$$

Summary of Results

Sample	$E_{average}$ [MeV]	$1\sigma_E$ [MeV]	Relative Flux [a.u.]
1	2.76	0.019	46.78
2	2.67	0.033	16.61
3	2.62	0.023	8.21
4	2.55	0.007	1.98
5	2.47	0.018	1