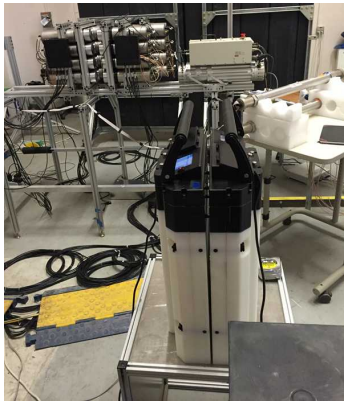
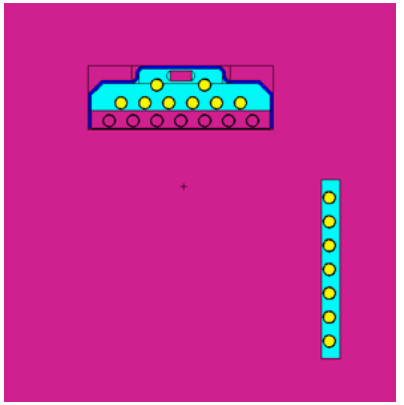
SAND2017-13524PE





MCNP study of MC-15 response

Scott Kiff, Sandia National Laboratories
Gabriel Sandler, University of Florida

December 2017 meeting at AWE

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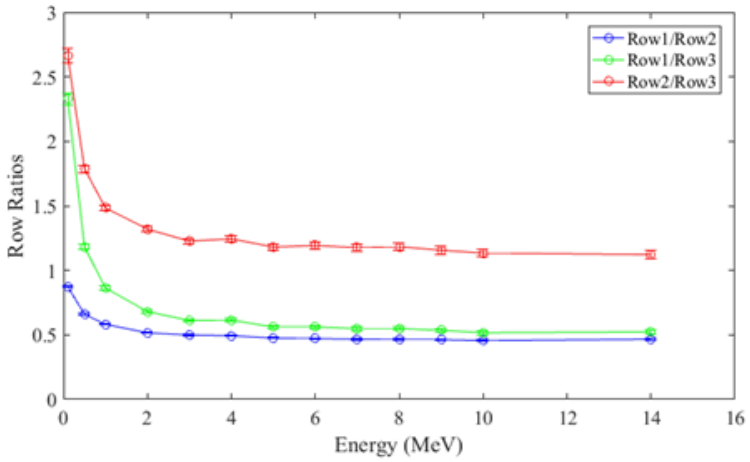
Study goals

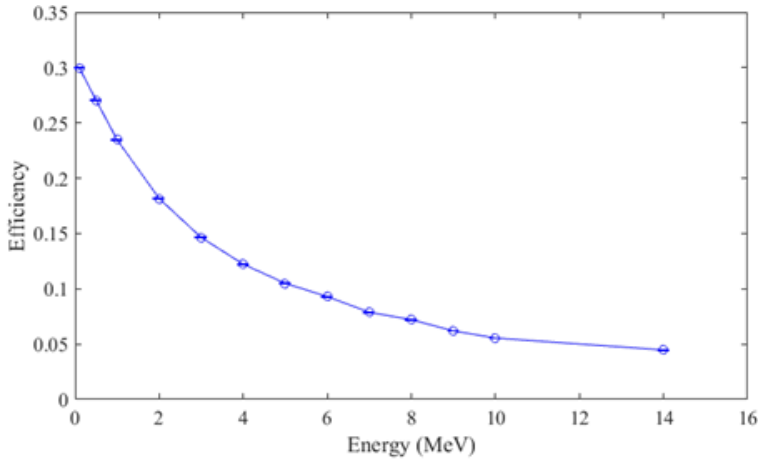
- Characterizing detector differential response function vs. neutron energy is the “purest” response
  - If response is known as a function of particle energy, the response to any source can be constructed
  - Characterization using fission-spectrum sources and moderators is informative, but this integral method is time consuming and provides less information
- In a perfect world, this response function would characterize detector
  - Total efficiency
  - Count distribution among ^{3}He tubes
  - Timing response
- Simulations addressing efficiency and tube distribution will be presented (timing response required more effort)

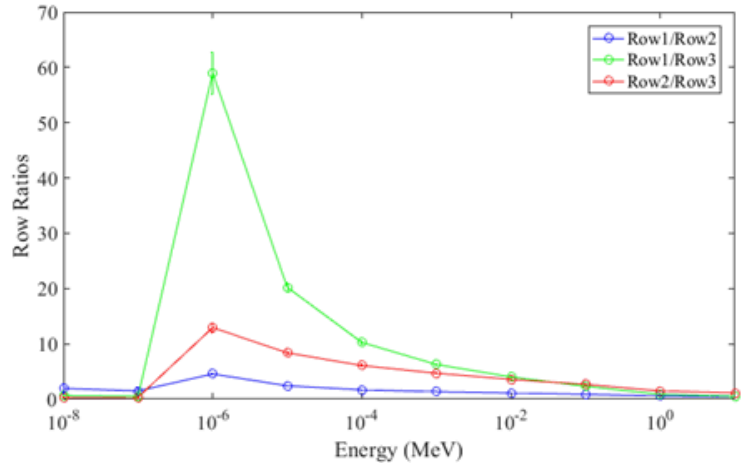
Some details of this work

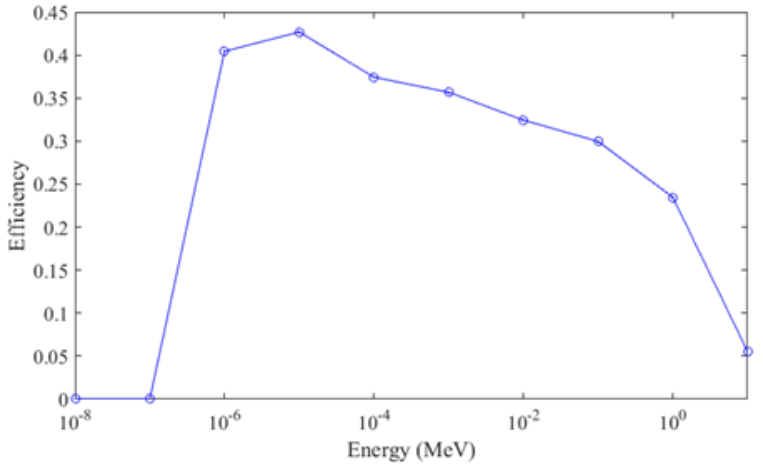
- Performed mostly by a student funded by the DNN R&D (NA-22) Consortium for Verification Technology in 2016
- MCNP6 simulations used an MC-15 model constructed by Jeff Favorite (LANL)
  - Cd/no Cd options considered
  - Removable front panel considered
- Some attempts at lab validation using monoenergetic neutron sources (D-D and D-T neutrons)
  - Pulse pileup is a problem!
  - Evidence that Cd can be useful when MC-15 is at a significant standoff (1.5 meters)

1 MC-15, front irradiation, Cd

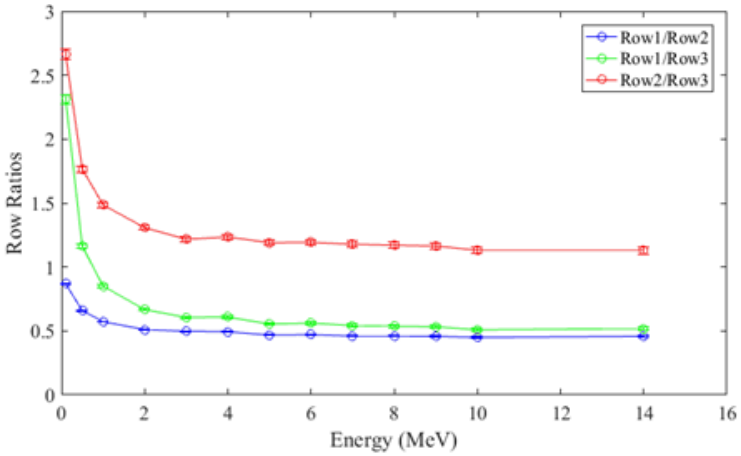


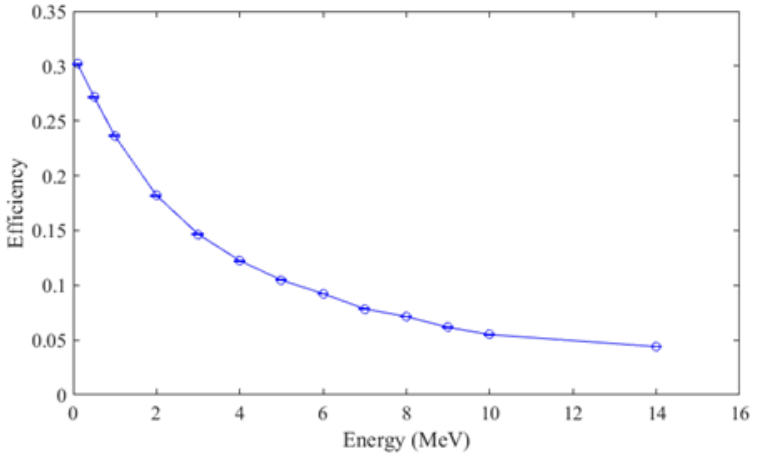


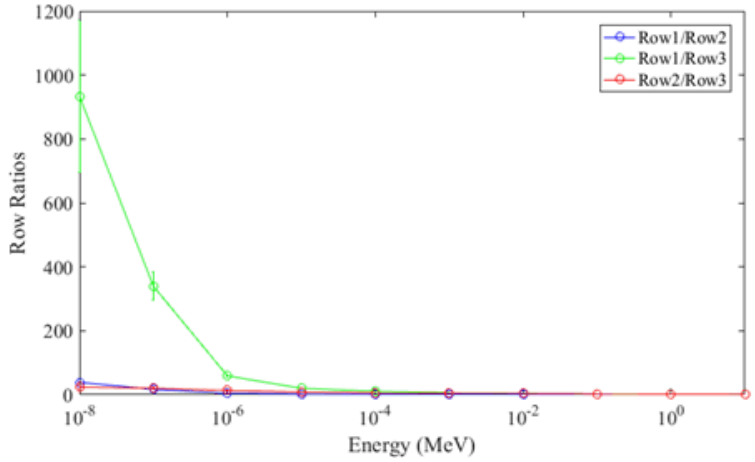


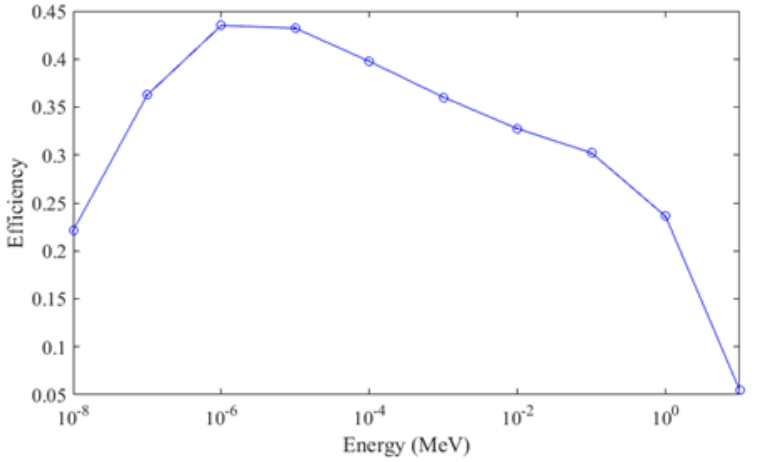


1 MC-15, front irradiation, no Cd

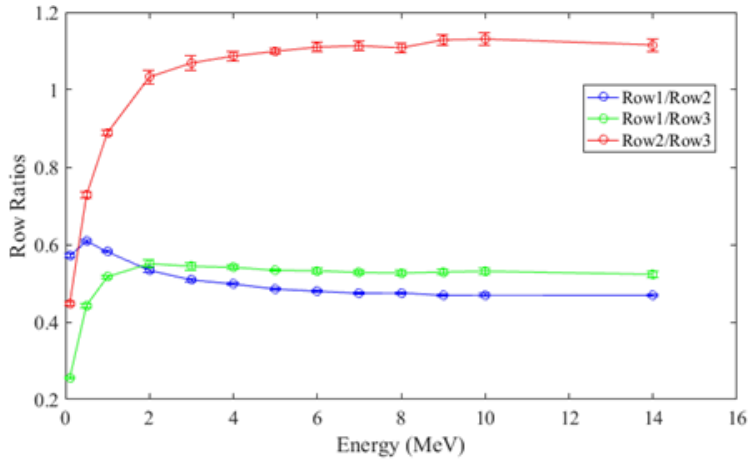


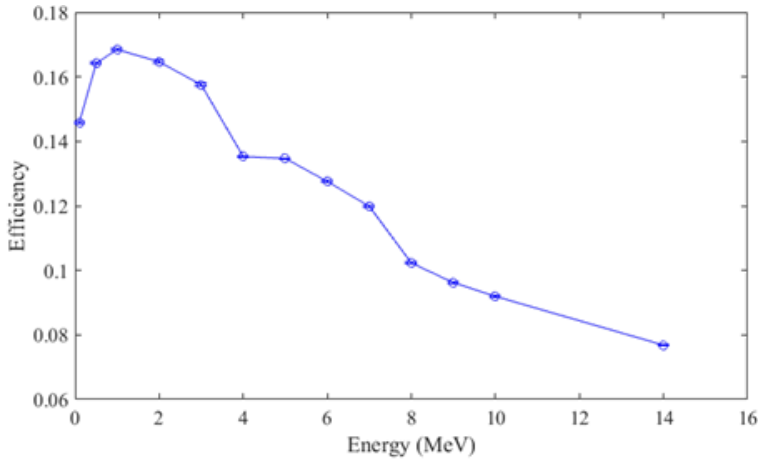


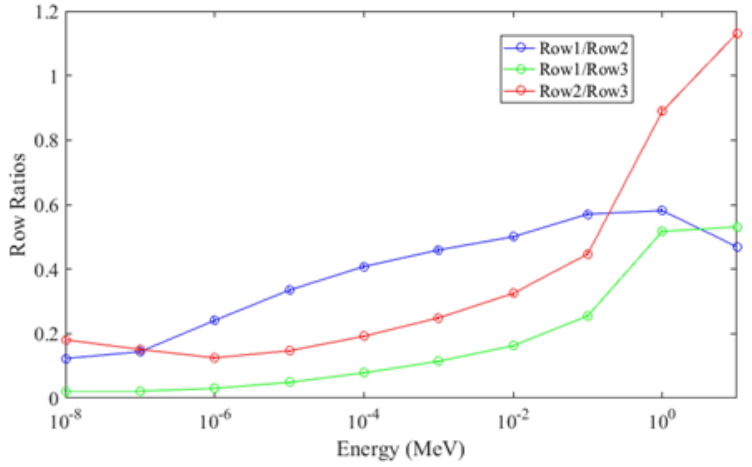


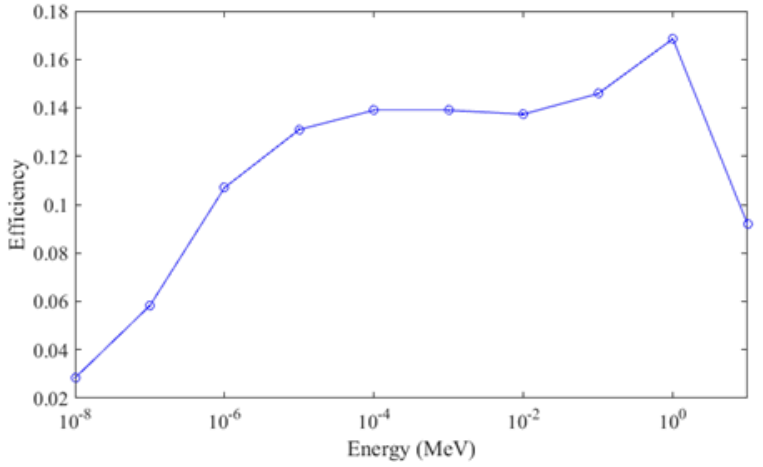


Irradiation from side, no Cd (Cd case identical)

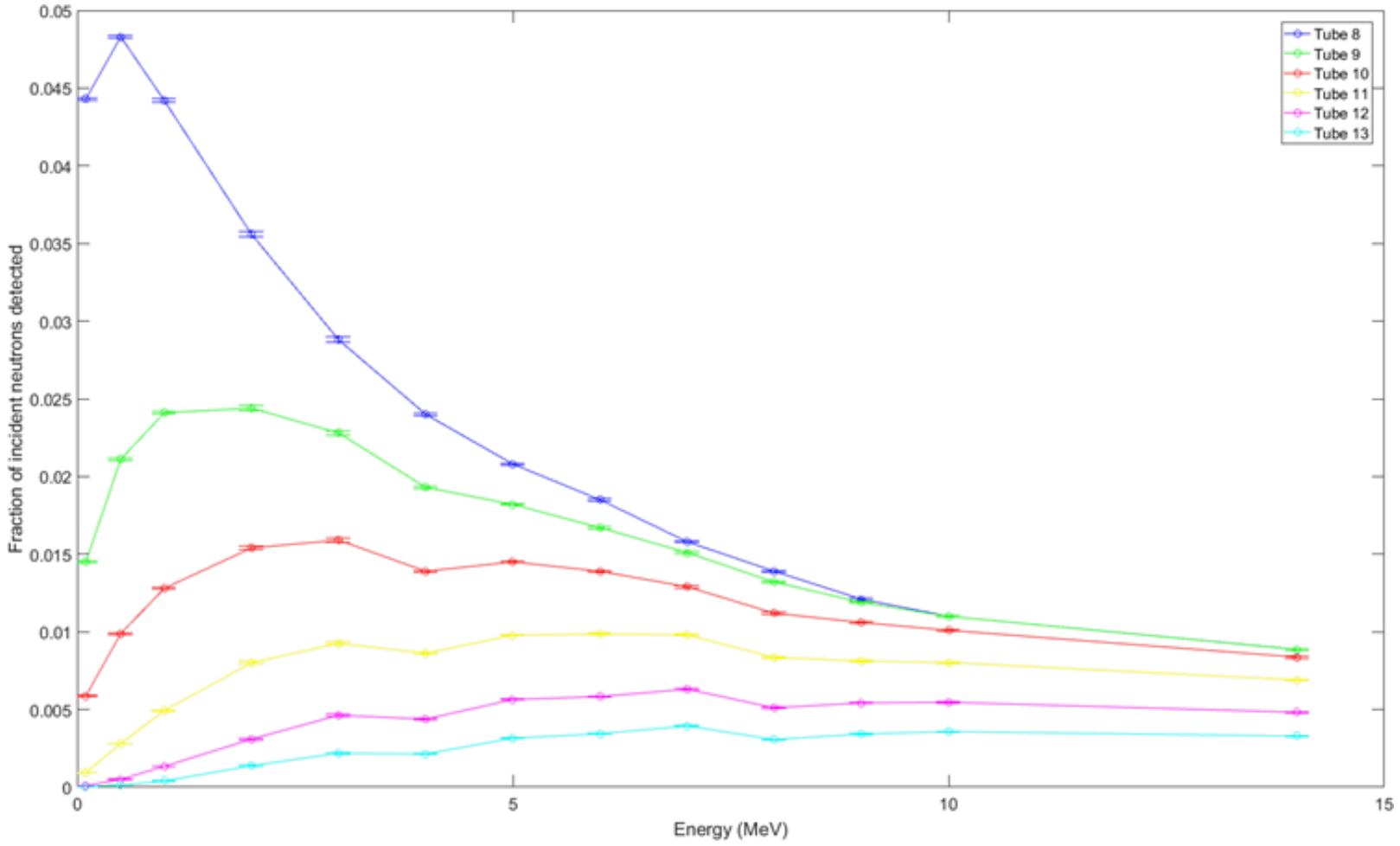




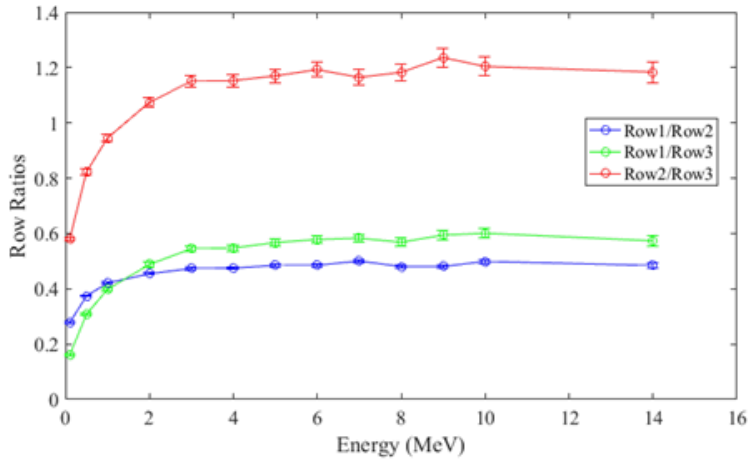


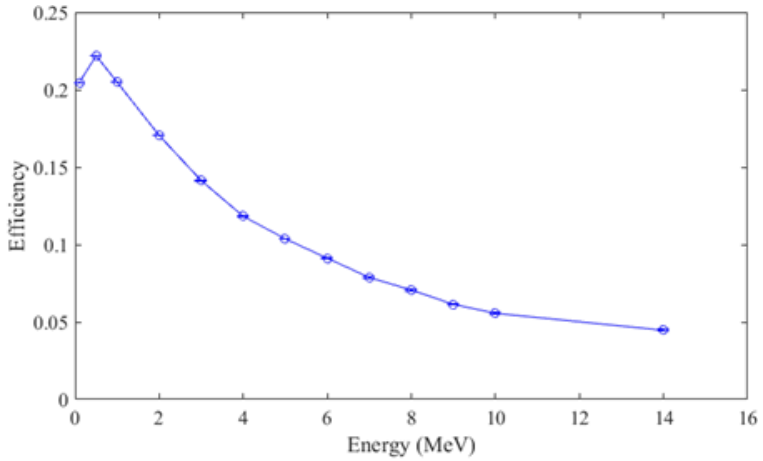


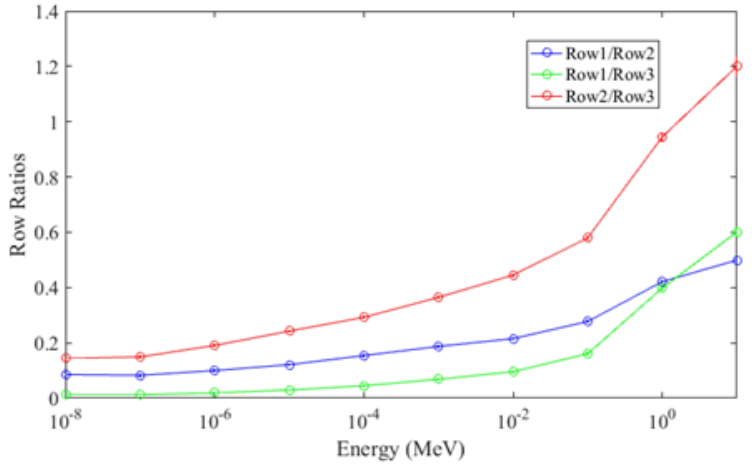
Side irradiation: tube response

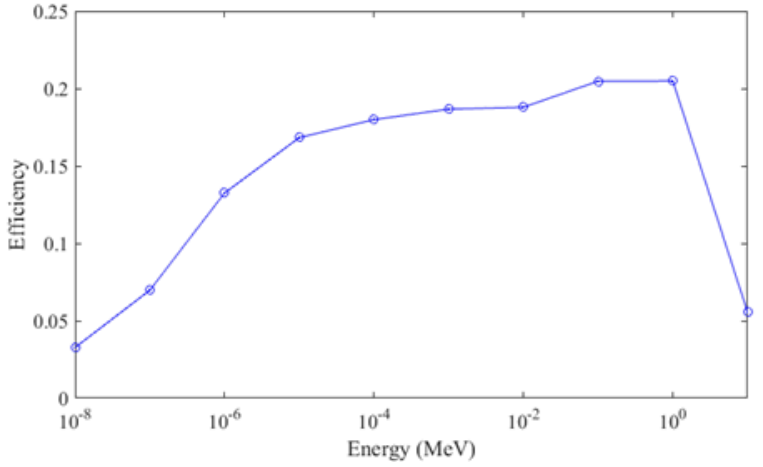


Irradiation from back, no Cd (Cd case identical)









Considering the detachable front panel

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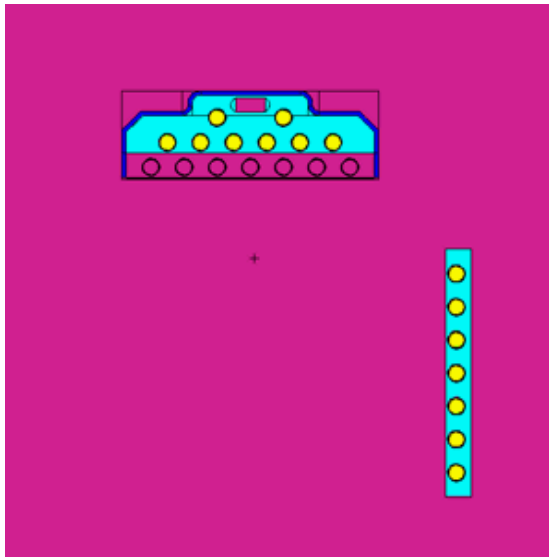
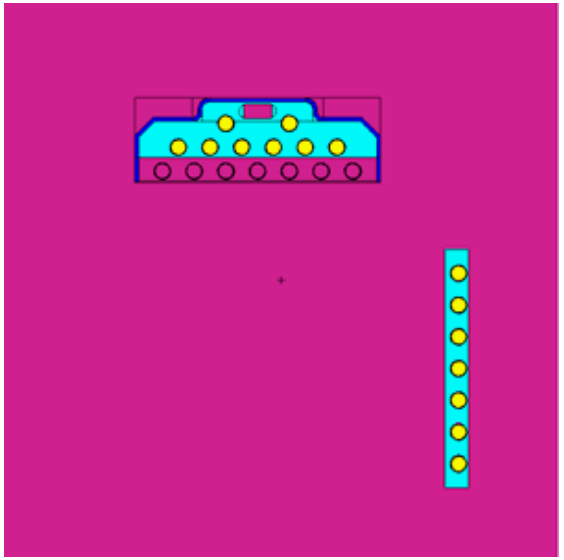
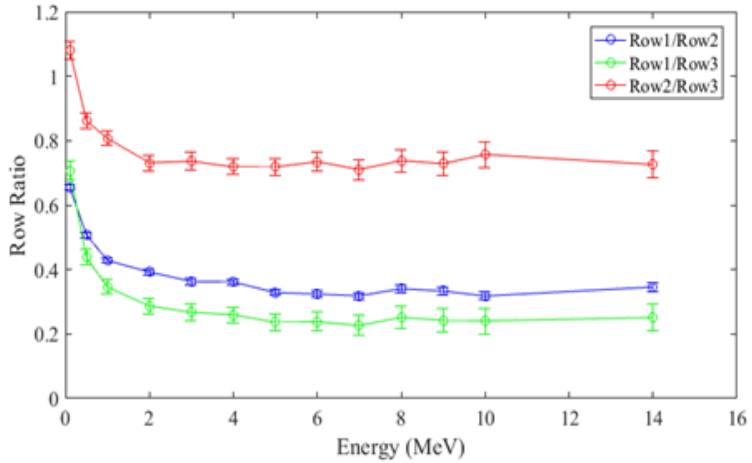
Correct orientation

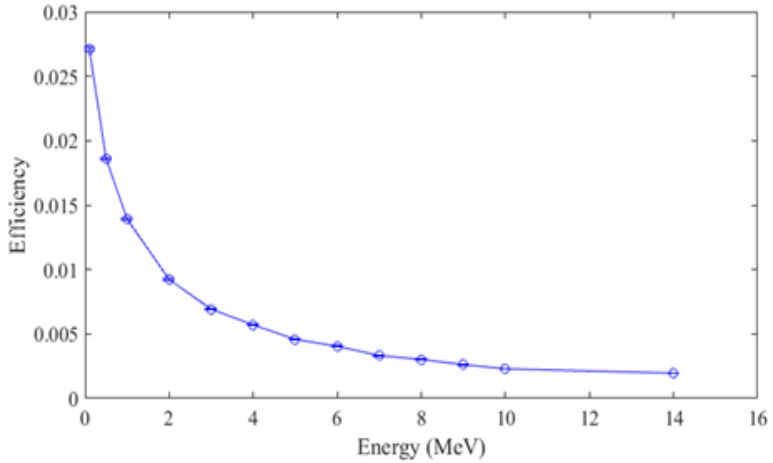


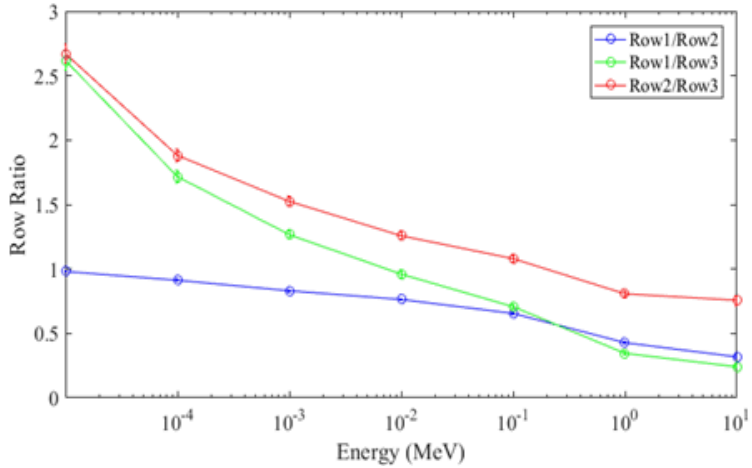
Detached panel reversed

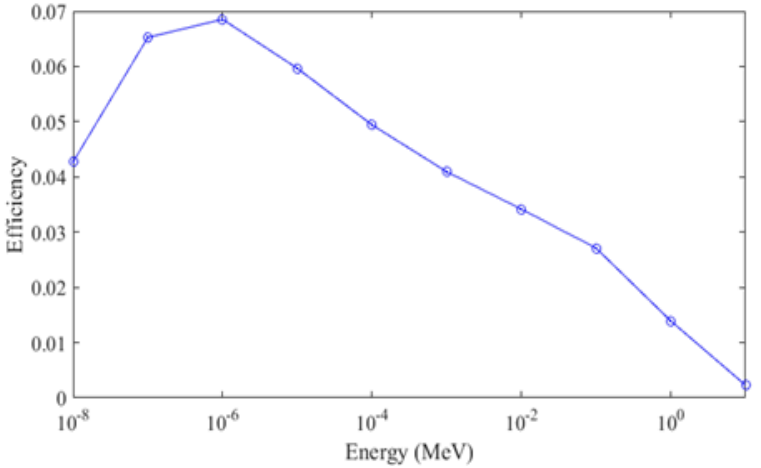


Detached front panel, correct orientation

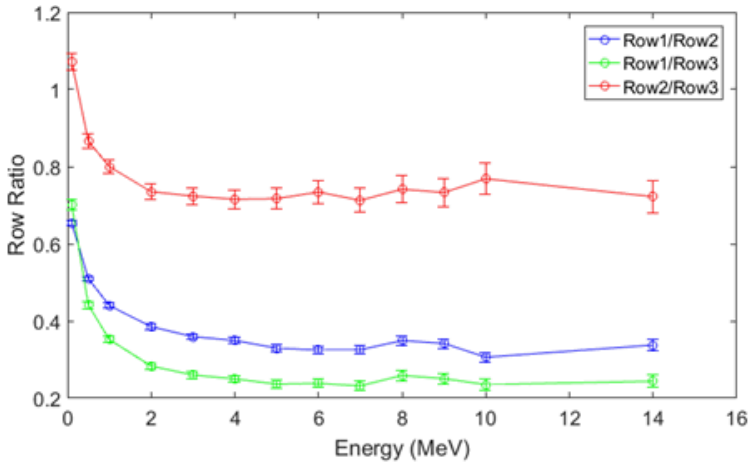


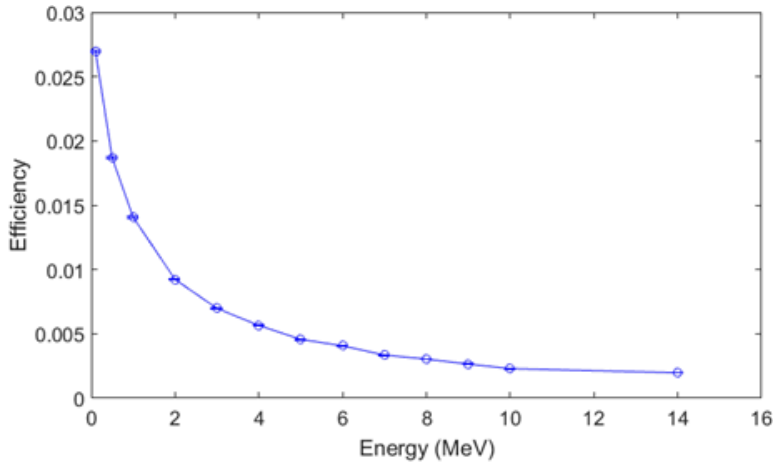


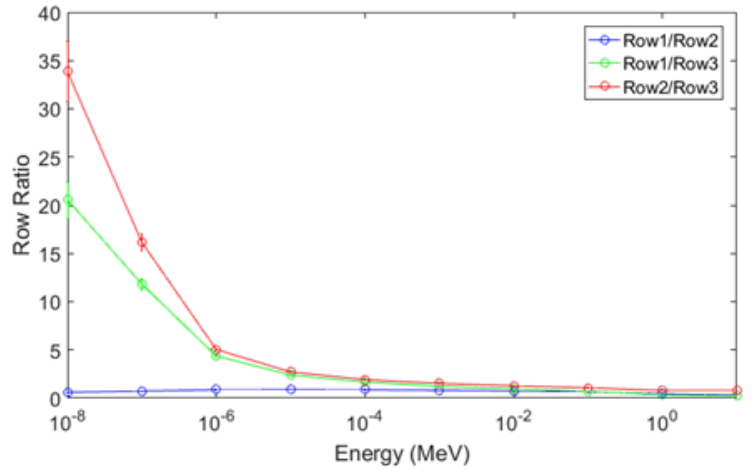


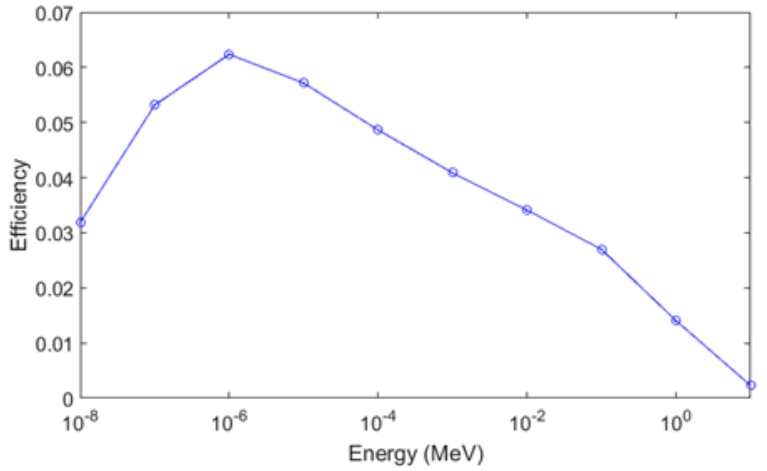


Detached front panel, reversed orientation





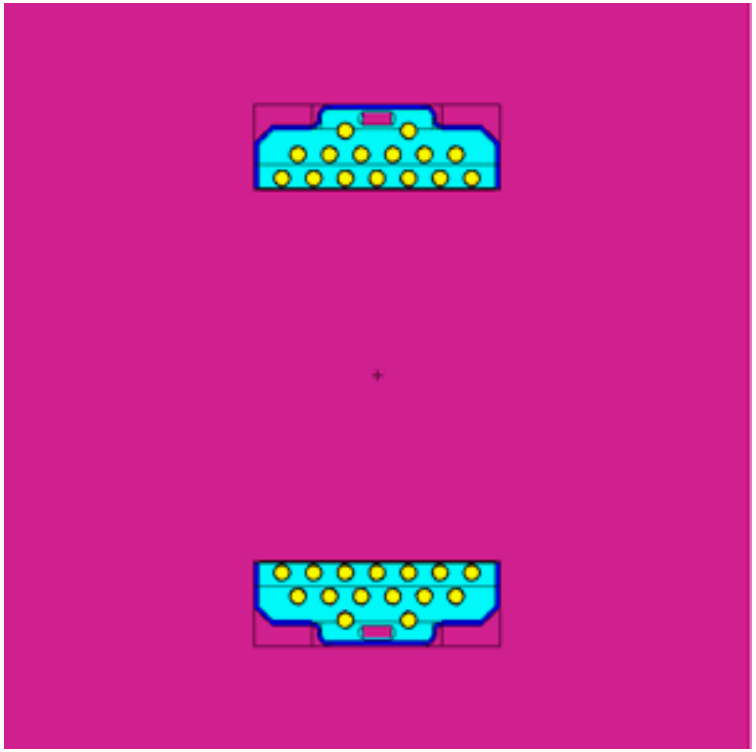




Tabulated results

Energy (MeV)	ε (correct)	ε (reversed)	$\frac{\varepsilon(\text{correct})}{\varepsilon(\text{reversed})}$
1E-08	4.273%	3.188%	134.03%
1E-07	6.525%	5.321%	122.64%
1E-06	6.854%	6.237%	109.89%
0.00001	5.967%	5.716%	104.38%
0.0001	4.943%	4.865%	101.60%
0.001	4.094%	4.087%	100.15%
0.01	3.416%	3.412%	100.10%
0.1	2.711%	2.697%	100.49%
0.5	1.858%	1.867%	99.53%
1	1.392%	1.406%	98.95%
2	0.923%	0.923%	99.98%
3	0.692%	0.698%	99.19%
4	0.570%	0.565%	100.99%
5	0.458%	0.457%	100.30%
6	0.405%	0.407%	99.56%
7	0.332%	0.335%	99.20%
8	0.302%	0.304%	99.51%
9	0.263%	0.265%	99.14%
10	0.229%	0.229%	99.93%
14	0.196%	0.197%	99.30%

Considering a second MC-15



2 MC-15s, no Cd: counts on a second detector, 35 cm separation

Energy (MeV)	ε
1E-08	3.865% ± 0.012%
1E-07	3.239% ± 0.011%
1E-06	2.480% ± 0.010%
0.00001	2.360% ± 0.009%
0.0001	2.573% ± 0.010%
0.001	2.863% ± 0.010%
0.01	3.069% ± 0.011%
0.1	2.984% ± 0.010%
0.5	2.356% ± 0.009%
1	1.948% ± 0.009%
2	1.480% ± 0.007%
3	1.155% ± 0.007%
4	1.237% ± 0.007%
5	0.870% ± 0.006%
6	0.800% ± 0.005%
7	0.665% ± 0.005%
8	0.738% ± 0.005%
9	0.564% ± 0.005%
10	0.479% ± 0.004%
14	0.434% ± 0.004%

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EXPERIMENTAL VALIDATION

Simple experiments with ^{252}Cf

Measurement configuration	Row 1:2	Row 1:3	Row 2:3
Front irradiation w/ Cd (Experiment)	0.642	0.995	1.549
Front irradiation w/ Cd (MCNP)	0.633	0.944	1.491
Back irradiation (Experiment)	0.411	0.354	0.861
Back irradiation (MCNP)	0.387	0.339	0.875
Detached Panel, Reversed (Experiment)	0.399	0.325	0.816
Detached Panel, Reversed (MCNP)	0.415	0.338	0.815

D-T experiments with a Thermo Scientific MP 320

D-T experimental analysis

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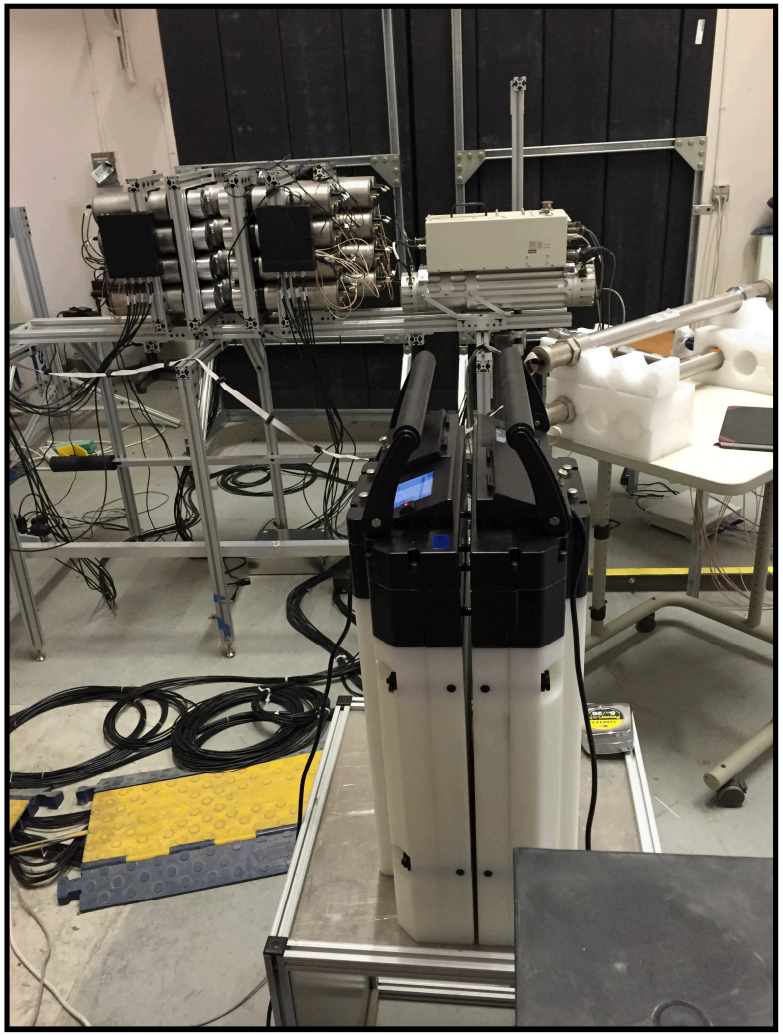
Experiment/ MCNP	Detector	Cadmium	Row 1:2	Row 1:3	Row 2:3	Count rate (cps)
Experiment	Off Floor	Yes	0.672	0.818	1.217	6839
Experiment	On Floor	Yes	0.691	0.830	1.202	6673
MCNP	Off Floor	Yes	0.5040	0.5540	1.0991	
Experiment	Off Floor	No	0.789	0.961	1.218	7416
Experiment	On Floor	No	0.833	1.006	1.208	7248
MCNP	Off Floor	No	0.5048	0.5620	1.1133	

Another measurement geometry



^{252}Cf +HDPE measurements in this side-irradiation geometry

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HDPE Thickness (cm)	Experiment / MCNP	Tube 8	Tube 9	Tube 10	Tube 11	Tube 12	Tube 13
0	Experiment	42.860%	24.451%	13.999%	8.256%	5.573%	4.861%
0	MCNP	42.900%	24.257%	14.061%	8.365%	5.642%	4.777%
2	Experiment	45.651%	23.268%	12.888%	7.892%	5.280%	5.021%
2	MCNP	45.865%	22.907%	13.133%	7.910%	5.350%	4.835%
4	Experiment	47.079%	22.455%	12.429%	7.542%	5.281%	5.213%
4	MCNP	47.488%	22.209%	12.497%	7.583%	5.321%	4.903%
8	Experiment	48.595%	21.703%	11.719%	7.287%	5.241%	5.456%
8	MCNP	48.373%	21.377%	12.583%	7.389%	5.239%	5.039%