Simulation of Response Functions of the South Pole Neutron Monitors

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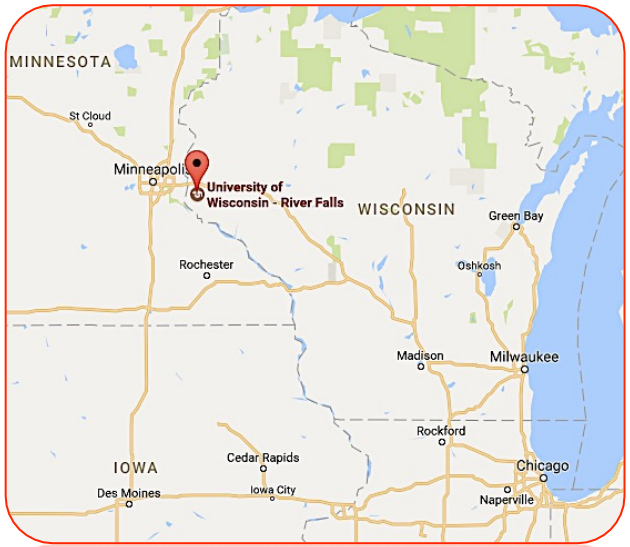

The University of Wisconsin–River Falls is a public liberal arts university located in River Falls, Wisconsin. ~6000 students, primarily undergraduates.

~ no grad students, no post-docs

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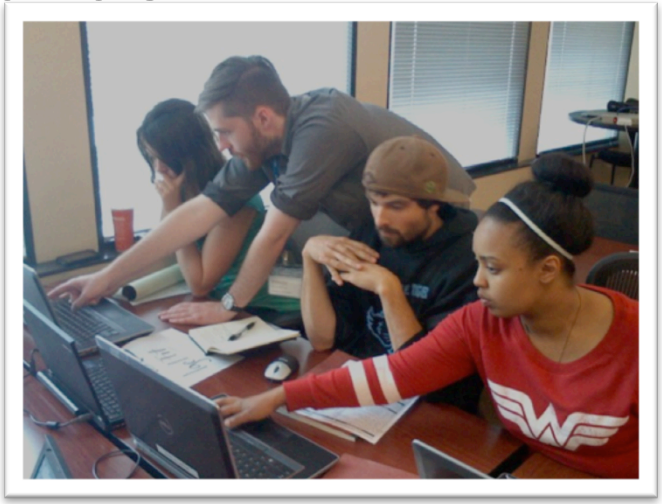
Engaging Undergraduates in Research Under 3 NSF Awards



- *Collaborative Research: Element Composition of High Energy Solar Particles*, Award Number:1341312; PI:Suruj Seunarine; Co-PI:James Madsen

- *REU Site: Research In Neutrino Astrophysics at the University of Wisconsin-River Falls*, Award Number:1460752; PI :Suruj Seunarine; Co-PI Investigator:James MadsenPI:Suruj Seunarine; Co-PI:James Madsen

- Collaborative Research: Neutron Monitor Observations of Cosmic Rays *from Jang Bogo and McMurdo,* Award Number: 1245914; PI:James Madsen

National Science Foundation
WHERE DISCOVERIES BEGIN

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Outline of Talk

- Neutron Monitors
- The UWRF Neutron Monitors
- Element composition project
- Simulation of South Pole Neutron Monitors

NM Components

- The **reflector** is made from polyethylene, which low energy neutrons in the environment that are not produced in cosmic ray interactions.
- When neutrons of ~ 100 MeV energy interact in lead **producer**, ~ 8-10 evaporation neutrons ~few Me are produced
- The **reflector** also helps to contain the neutrons inside the deetector.
- The polyethylene moderator slows down the neutrons before they reach the inner **proportional counter.**

Hatton and Carmichael (1964)

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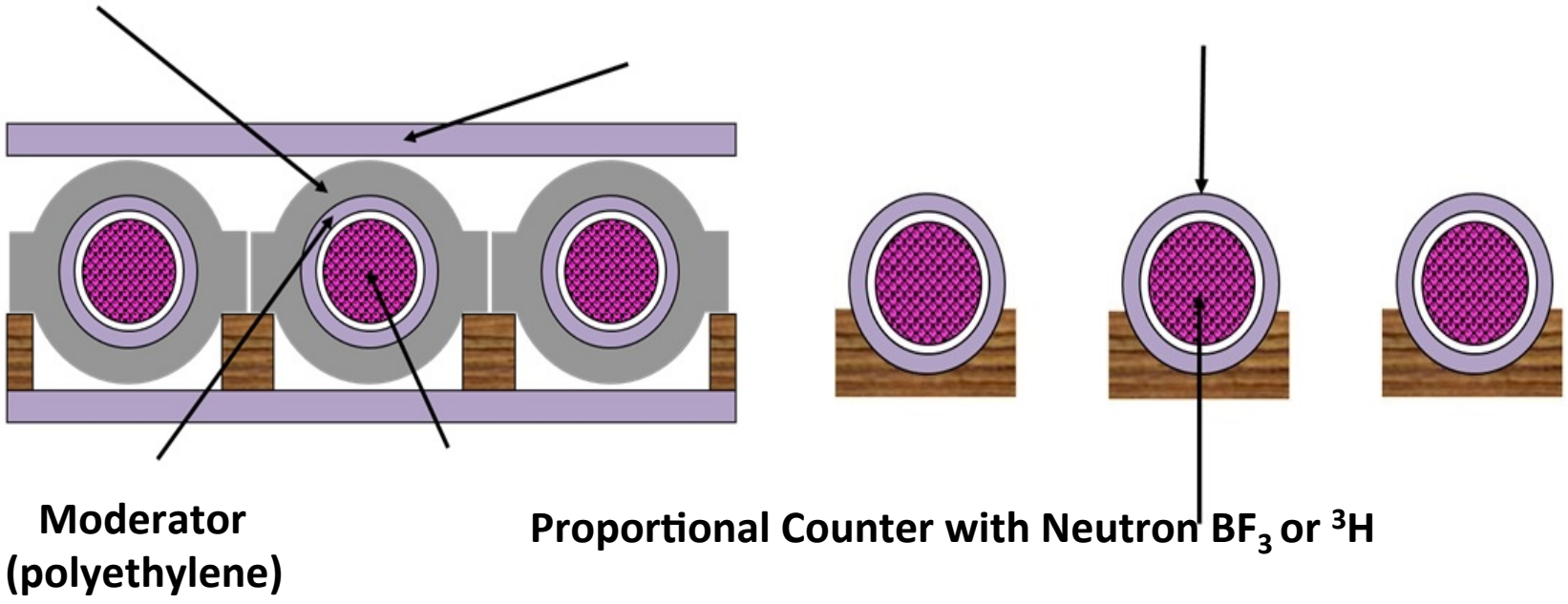
Neutron Monitor Configurations

Standard Neutron Monitor

Standard Bare Monitor



Figures courtesy Waraporn Nuntiyakul

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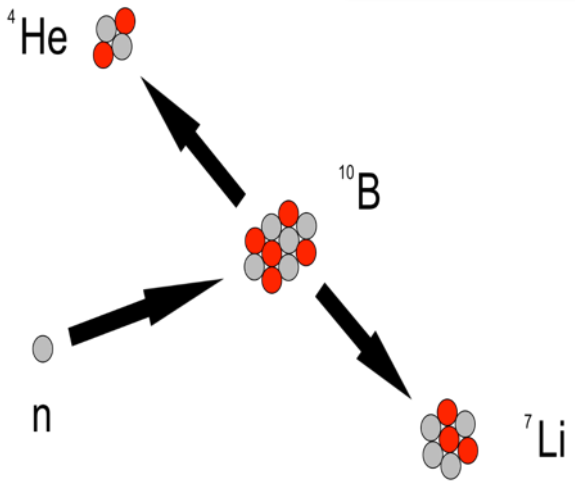
Boron or Helium Filled (NM64)

$n + {}^{10}B \rightarrow {}^{7}Li + {}^{4}He$



- Neutron gets captured by a ^{10}B nucleus and decays into Helium 4 and Lithium 7 ion.
- This ionizes the gas inside the counter.
- A large electric field accelerates the charged particles towards the wire.
- This creates a pulse in the wire that is recorded as a neutron detection.

or

$n + {}^{3}He \rightarrow p + {}^{3}H$

Diagram courtesy of UNIVERSITY OF WISCONSIN River Falls

Neutron Monitor Setup (at McMurdo)

- In lead about 8-10 evaporation neutrons are produced per incident nucleon. N=25$E^{0.4}$. Clem et al. (2004)
- The Li nucleus can be either in the ground state or first excited state.
- ~94% of the reactions lead to an excited with 1.47 MeV given to the α, ~6% produces the Li in the ground.
- The pulse heights in the data shows the two states.

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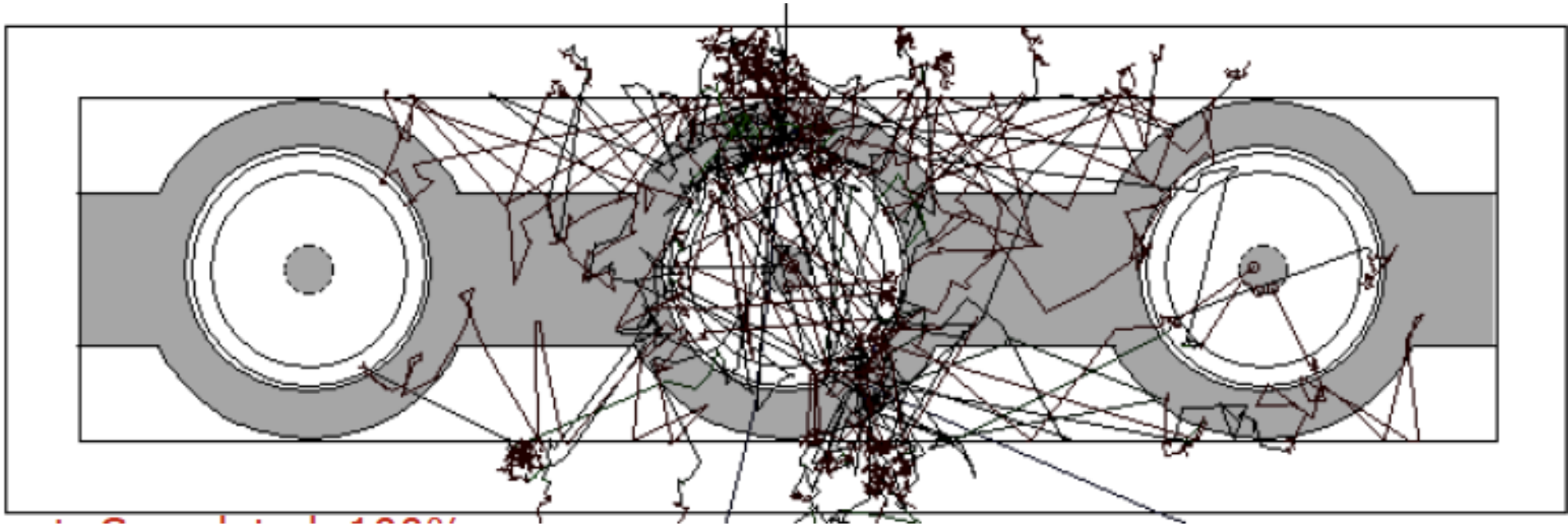
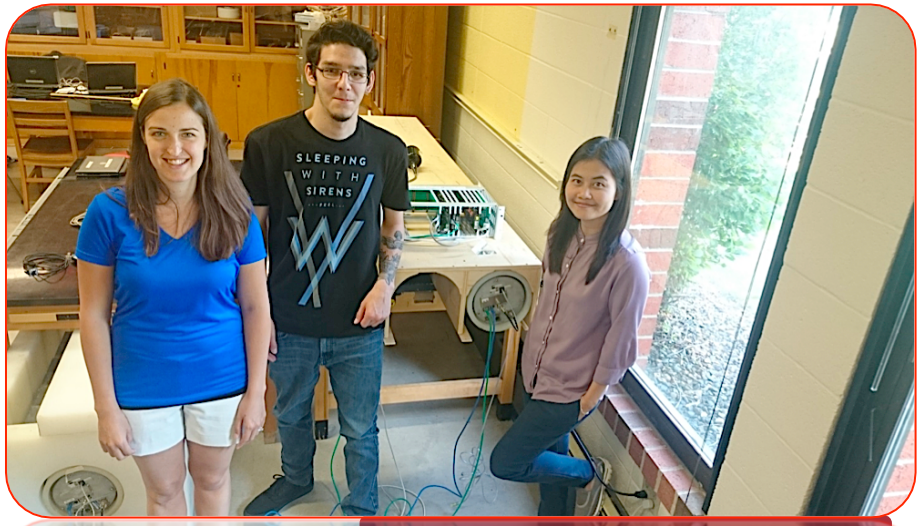
Cross Section of Monitor with simulated events



From J. Clem at
http://www.bartol.udel.edu/%7Eclem/nm/display/intro.html

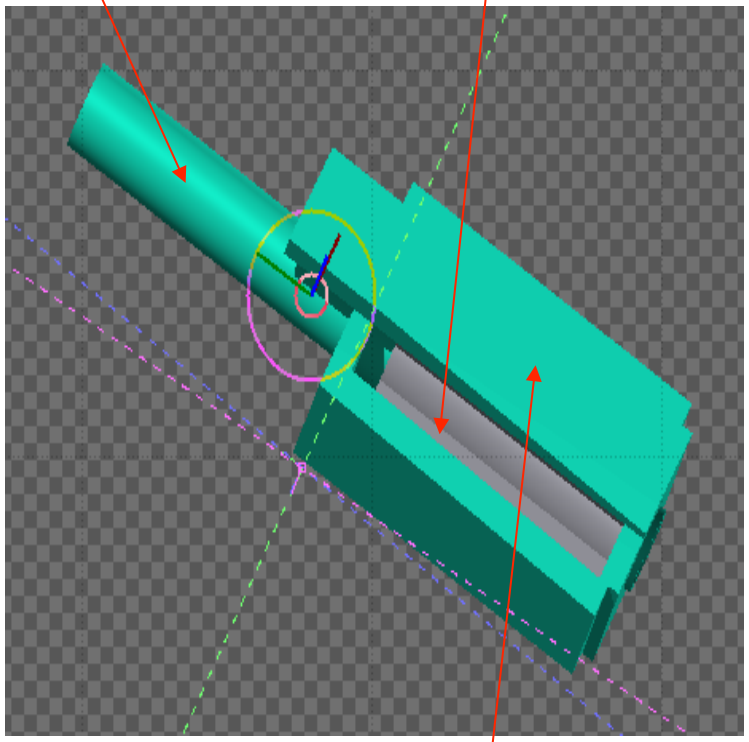
Summer 2015 newly acquired NMs are temporarily set up in lab



FLUKA Simulation of Neutron Monitors

Moderator (Polyethylene)

Producer (Pb)



Reflector (Polyethylene)

Single tube, partially enclosed

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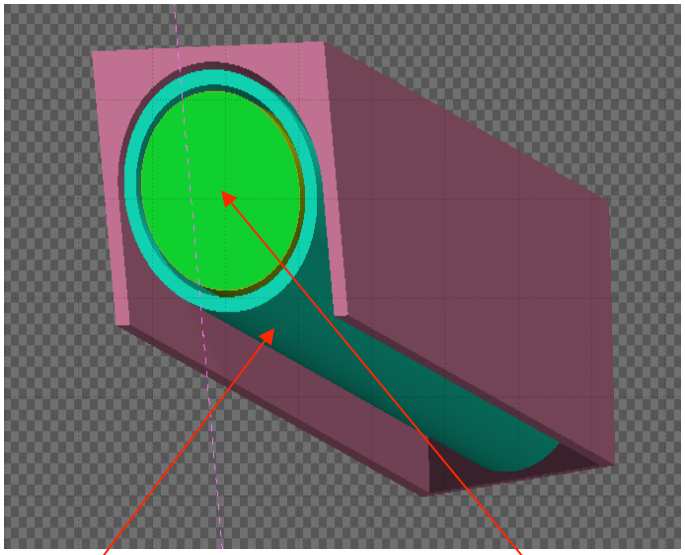
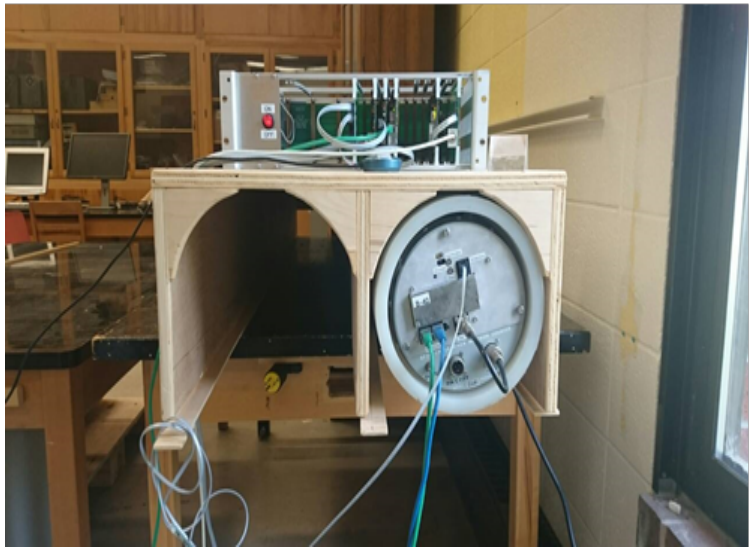
“Bare” Neutron Monitor





Moderator (Polyethylene)

Proportional Counter

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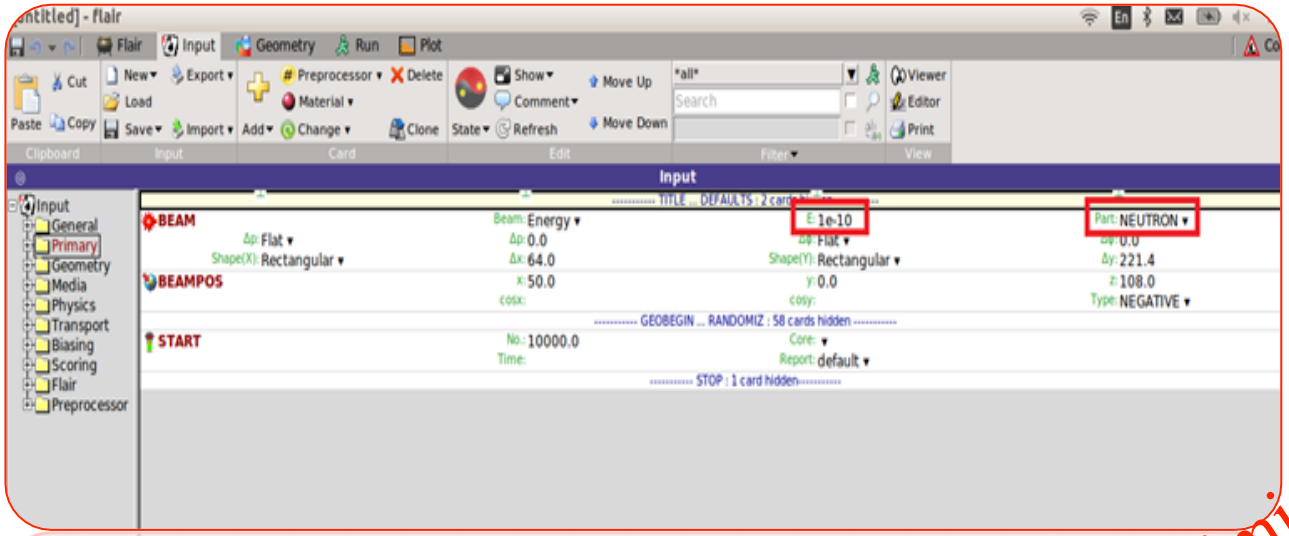
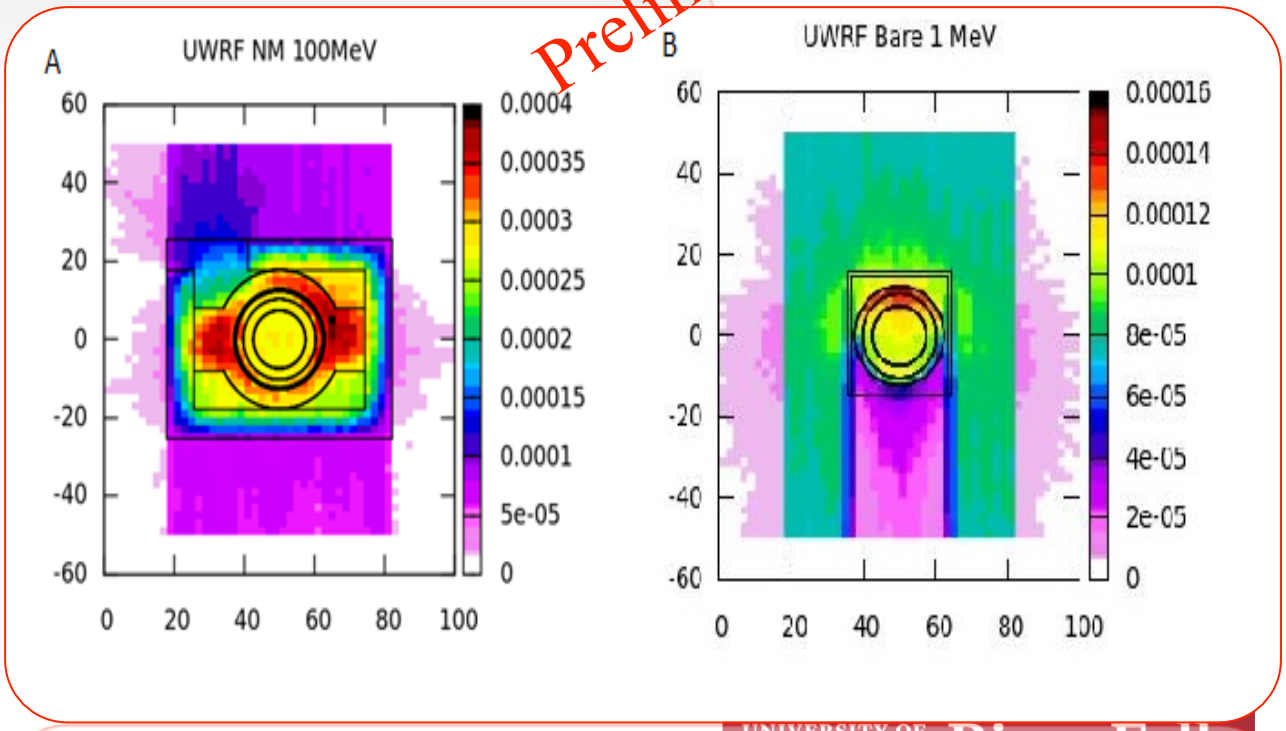


Preliminary

- UWRF Neutron Monitors: Neutron “density” maps



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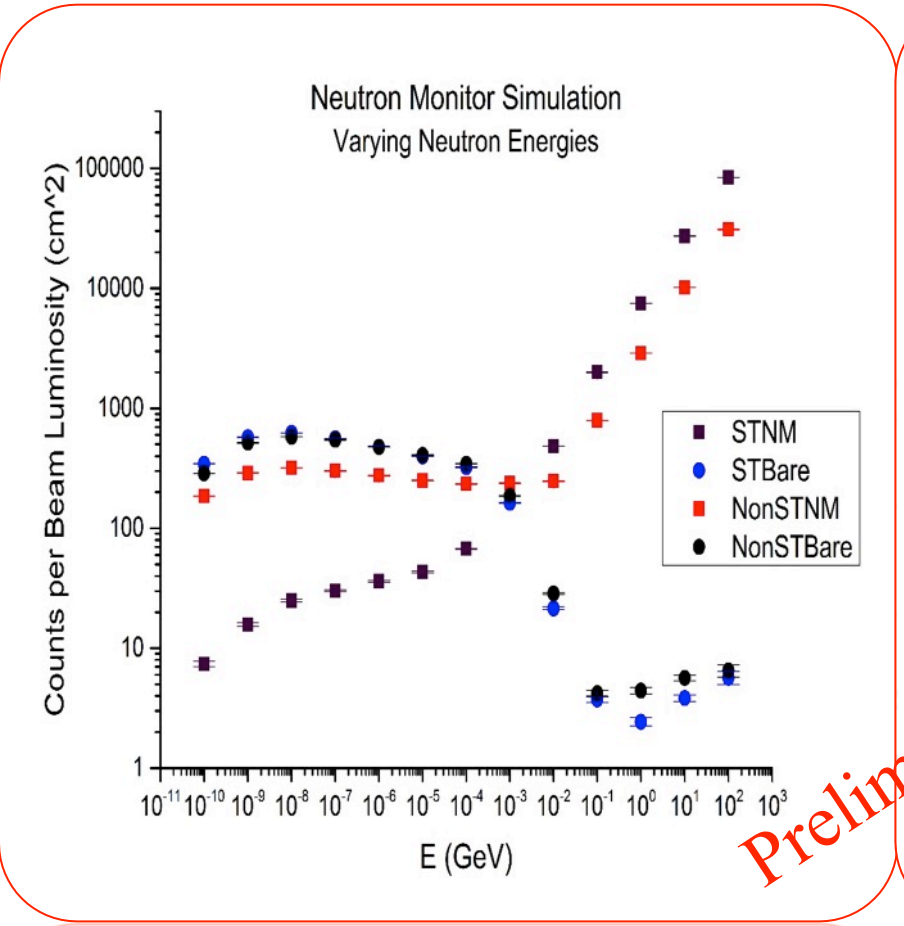
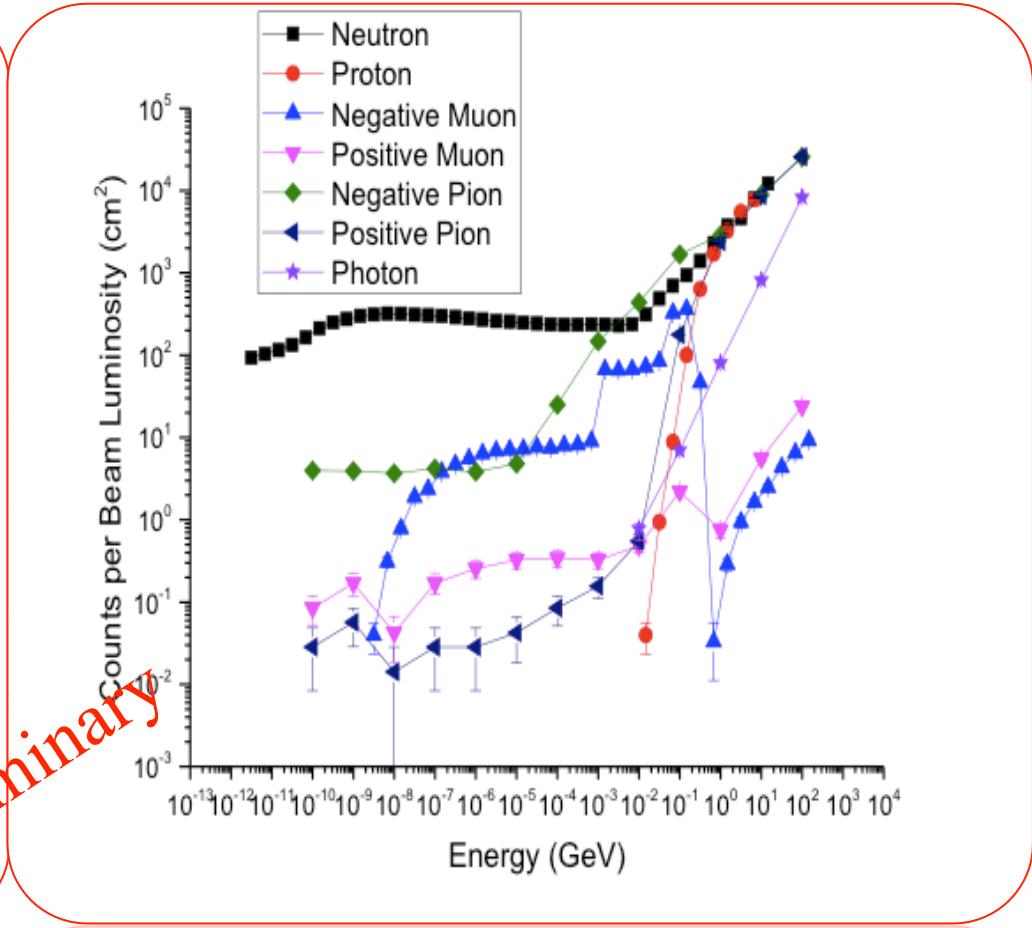
Response Function





Preliminary

Consistent with what we expected compared with standard NM

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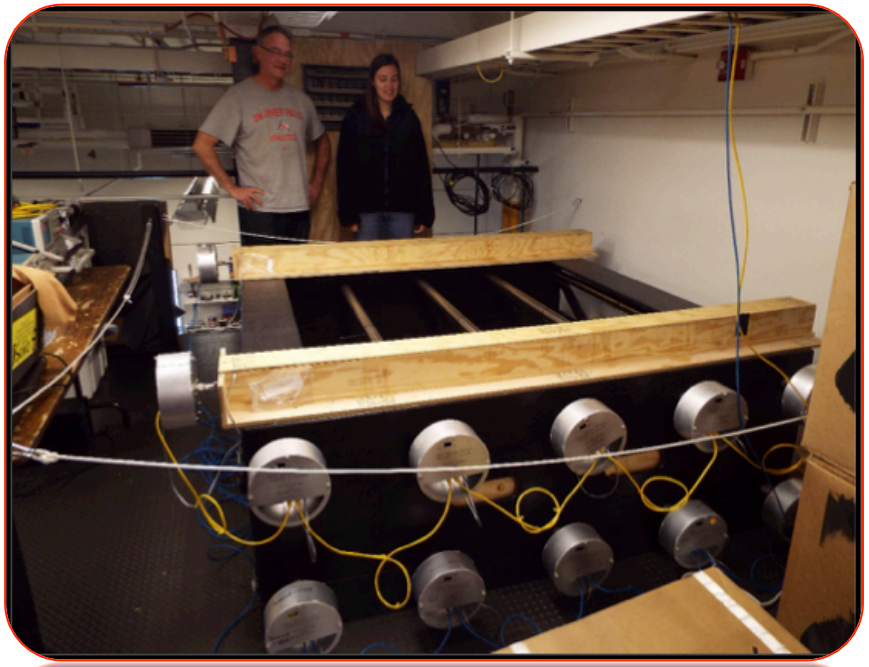
South Pole Neutron Monitors

Three NM63 On Platform

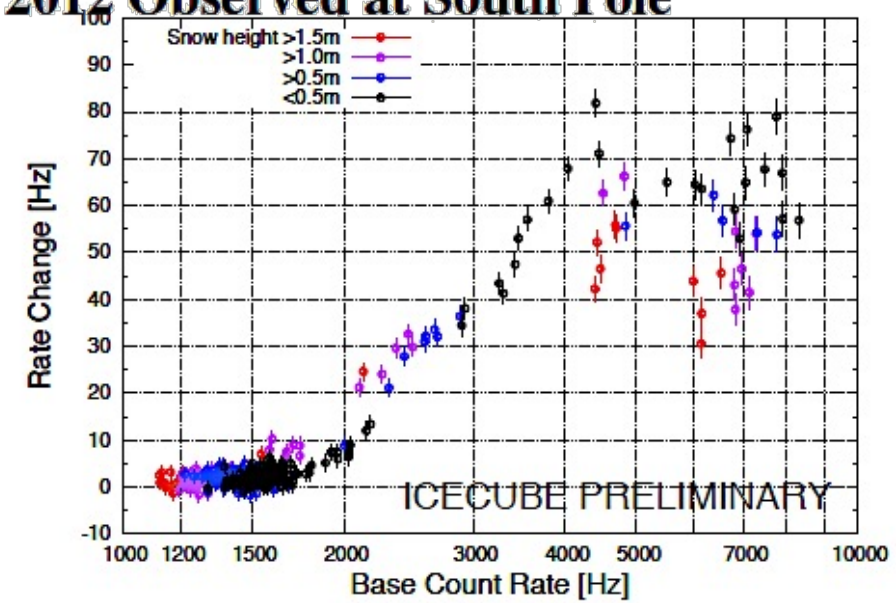
Bare NMs (Polar Bares) in Lab

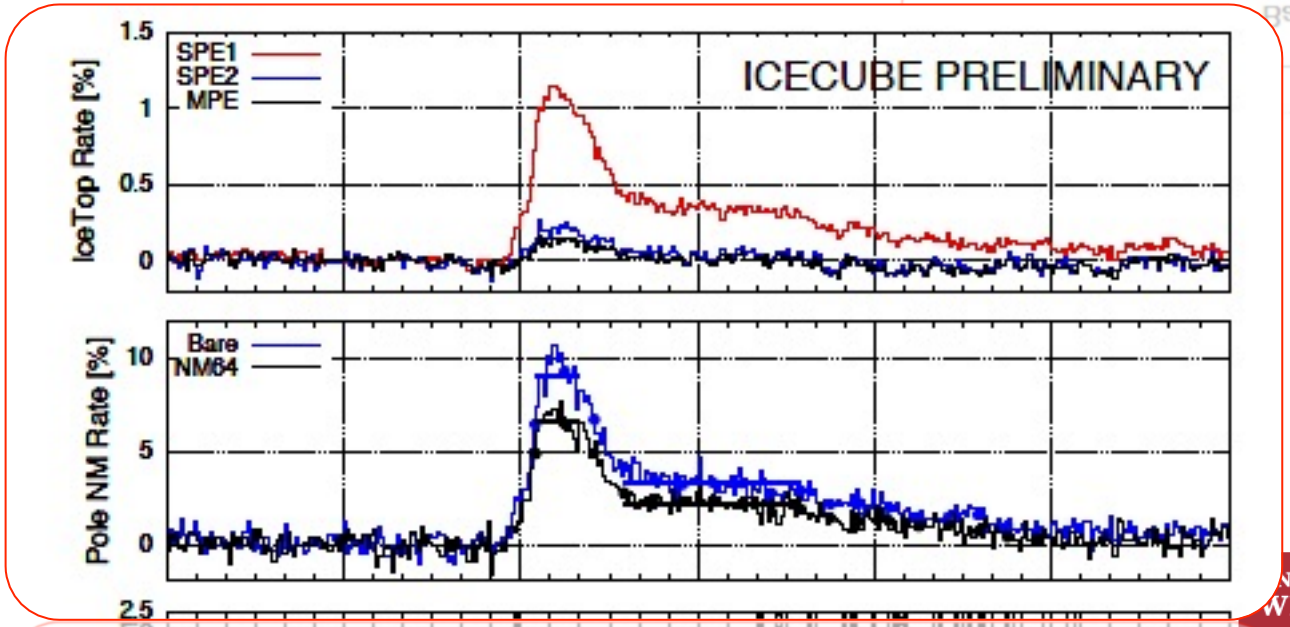


Ground Level Enhancement of May 17, 2012 Observed at South Pole

THE ICECUBE COLLABORATION[1]

- Larger goal is complementary analysis with IceTop air shower data for spectral determination.
- Currently working on IceTop Simulations with different now cover to get yield functions for individual tanks.
- New FLUKA simulations of the neutron monitors.





ICRC 2013

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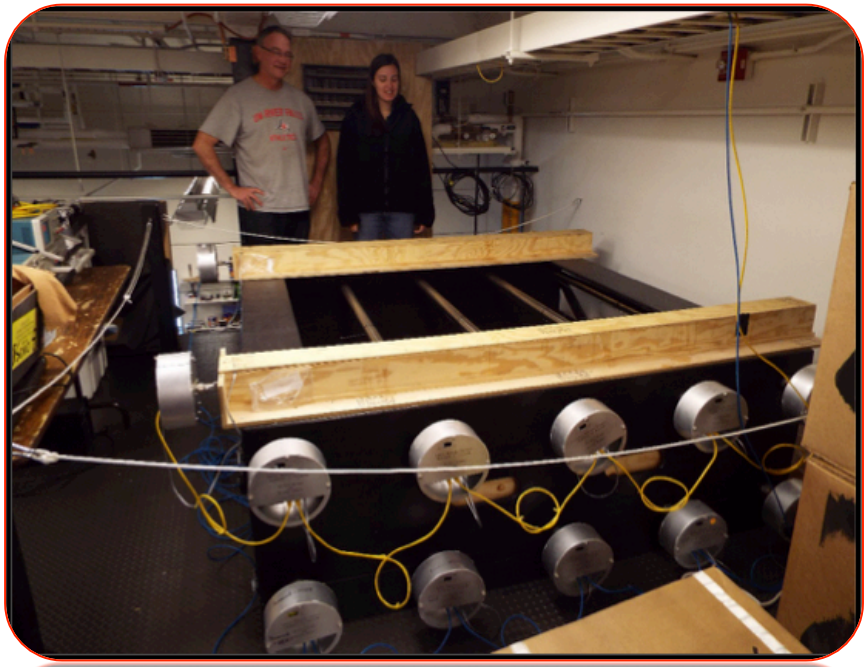
Polar Bares

- The rack" is a plywood structure that houses two rows of five bares, Polar Bares, spaced 16 inches apart.
- Two "Oden-bares" placed on top.
- They are located on the mezzanine of the science area inside the B2 wing of the Amundsen-Scott South Pole Station.

Bare NMs (Polar Bares) in Lab



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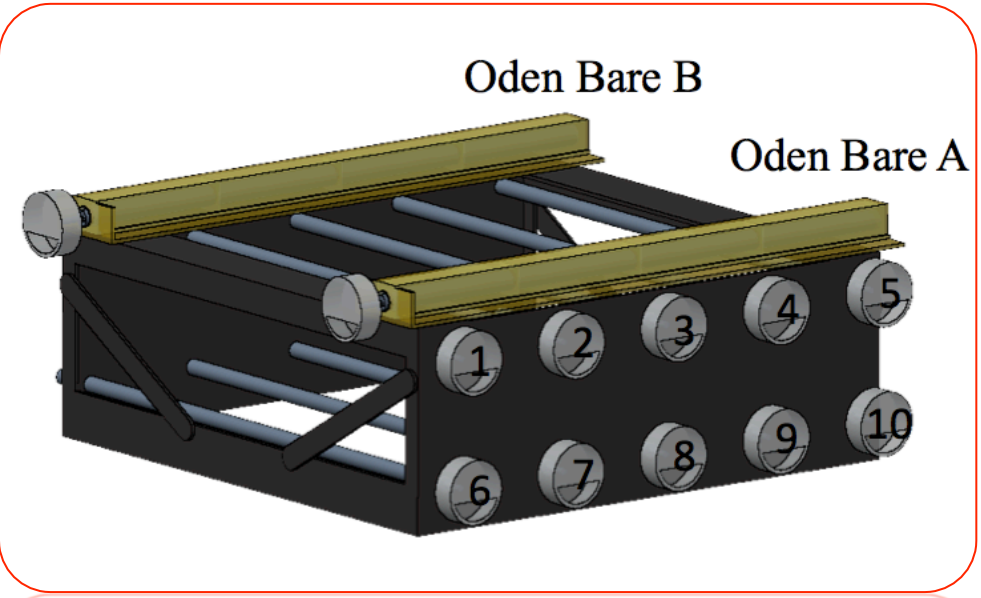
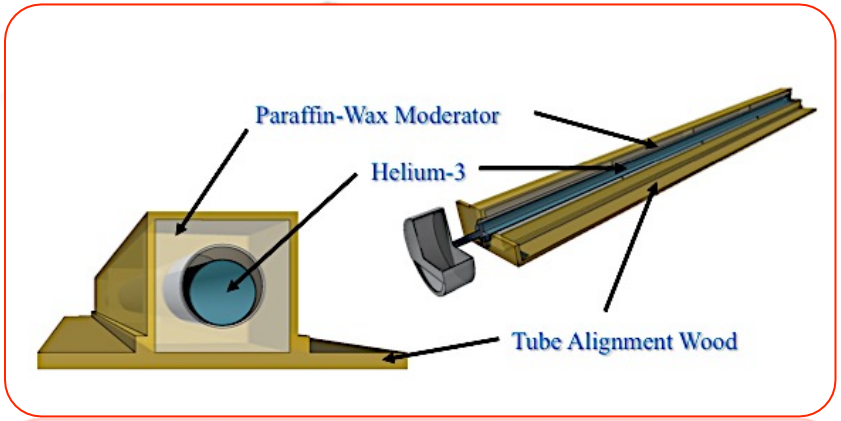
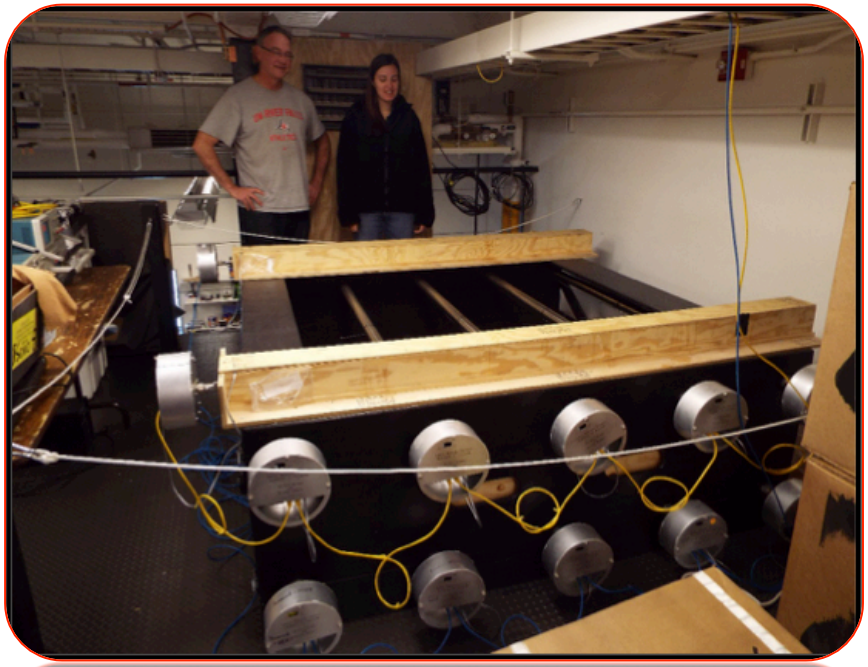
South Pole Neutron Monitors

FLUKA Simulation





Bare NMs (Polar Bares) in Lab



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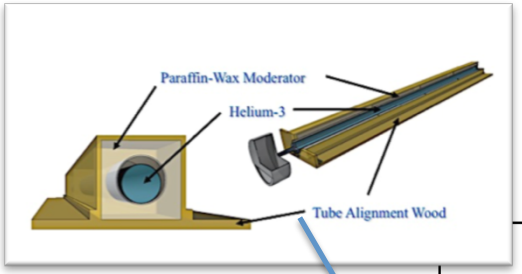
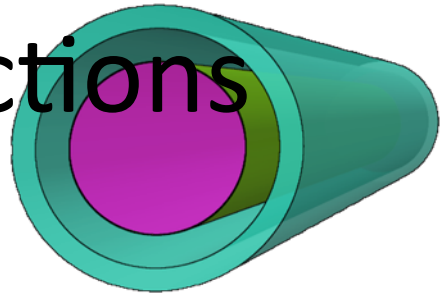
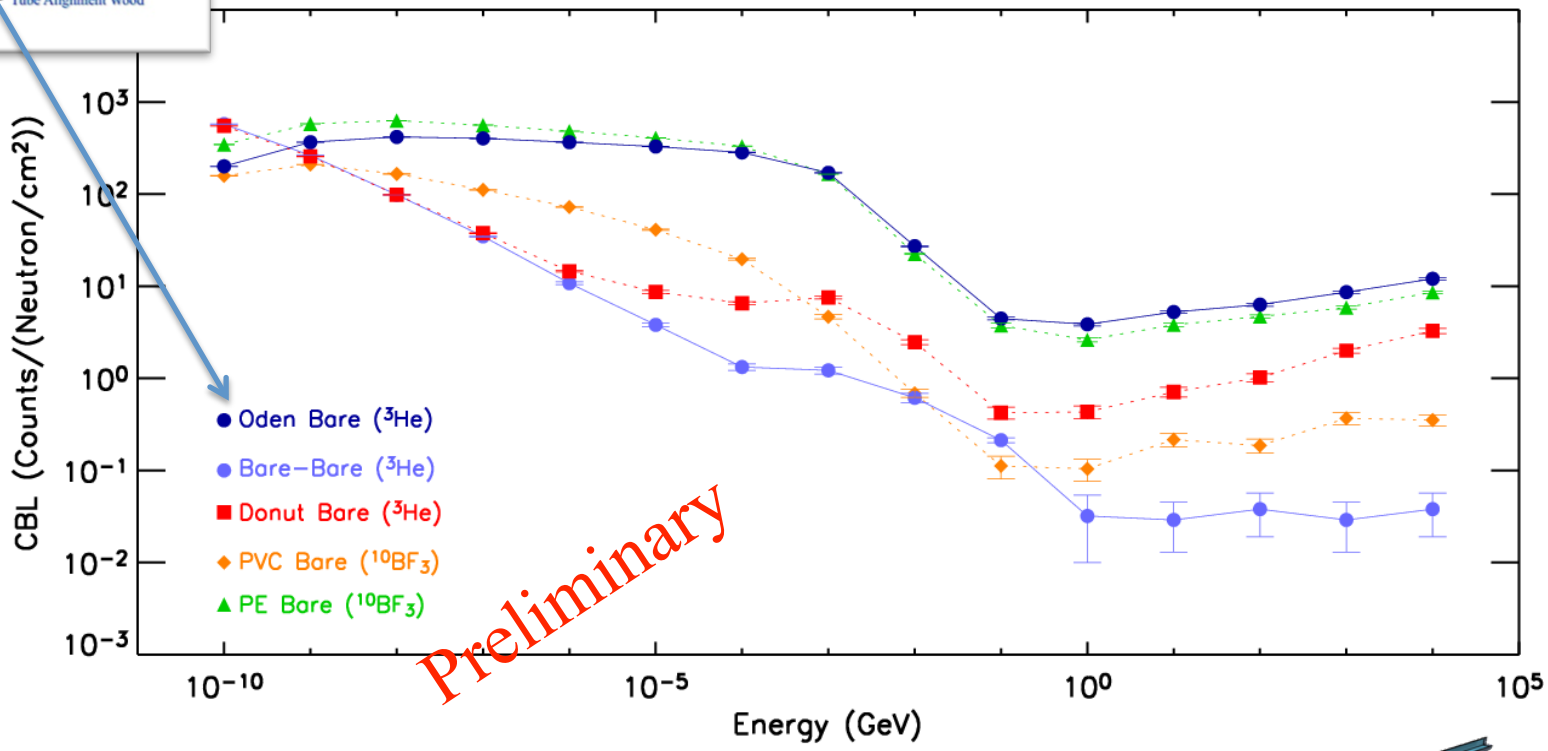
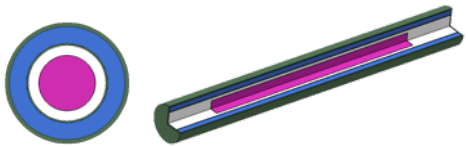
Bare NM Response Functions









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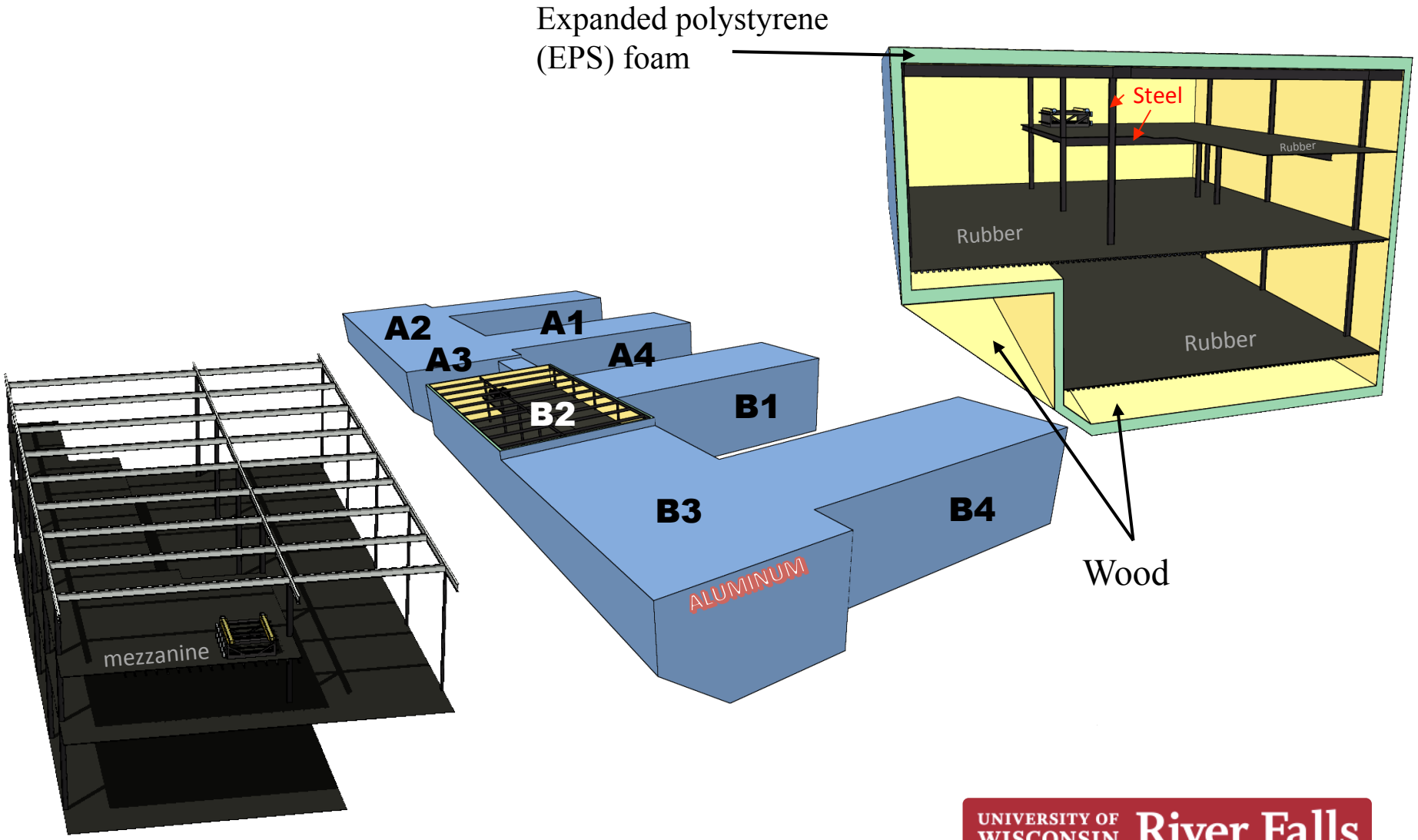
South Pole Station Simulation



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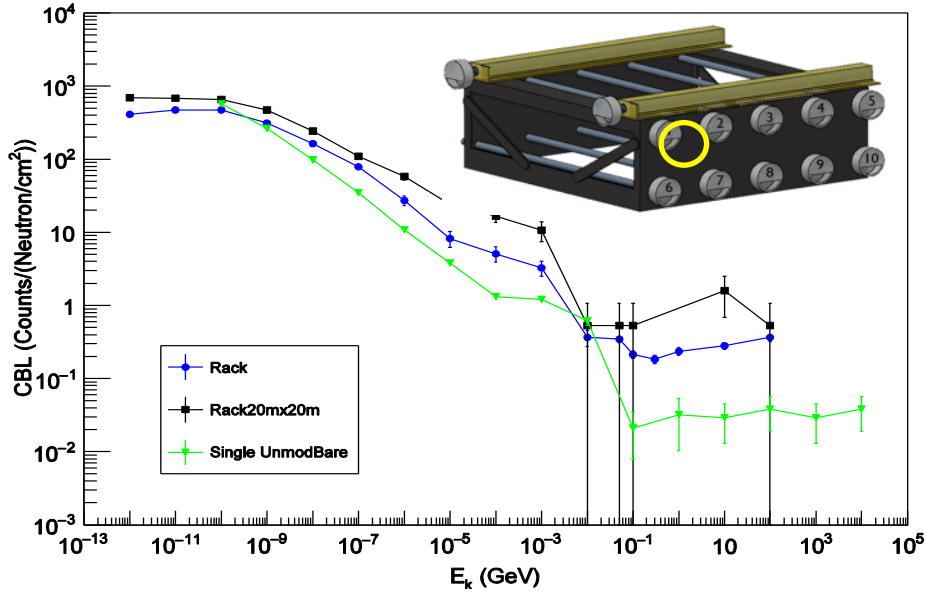
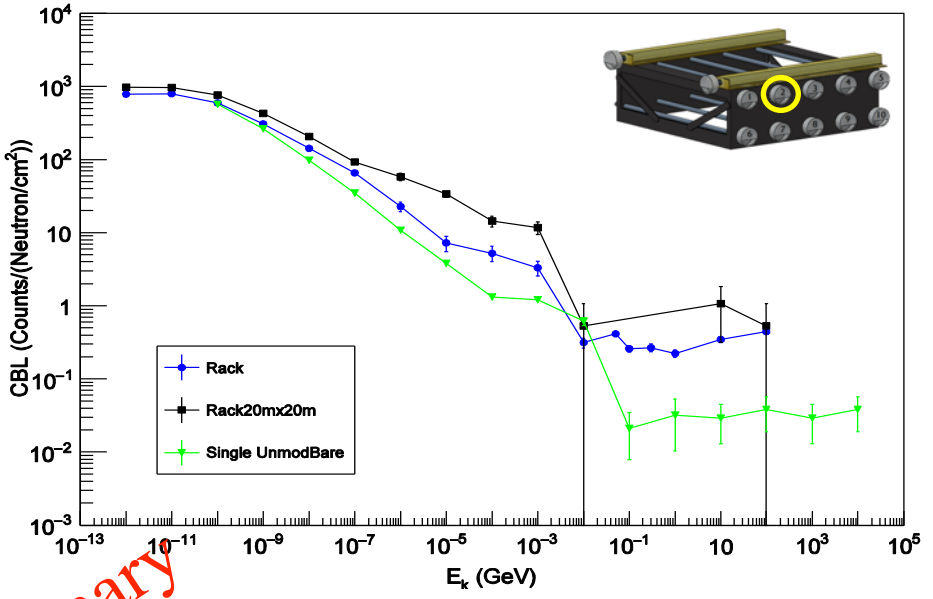
Response Functions: Neutron ZEN=0 AZI=0 [UnmodBare #1]

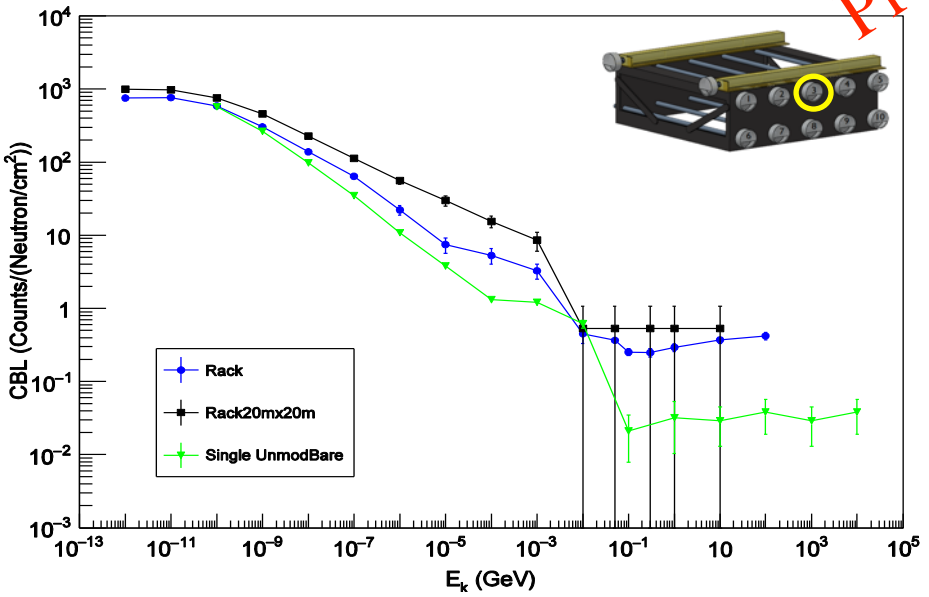


Response Functions: Neutron ZEN=0 AZI=0 [UnmodBare #2]

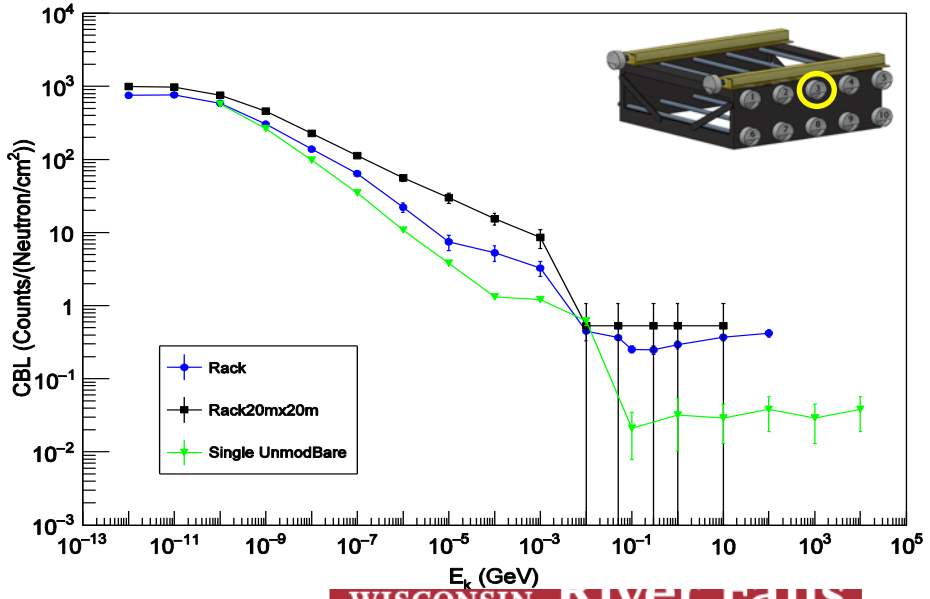


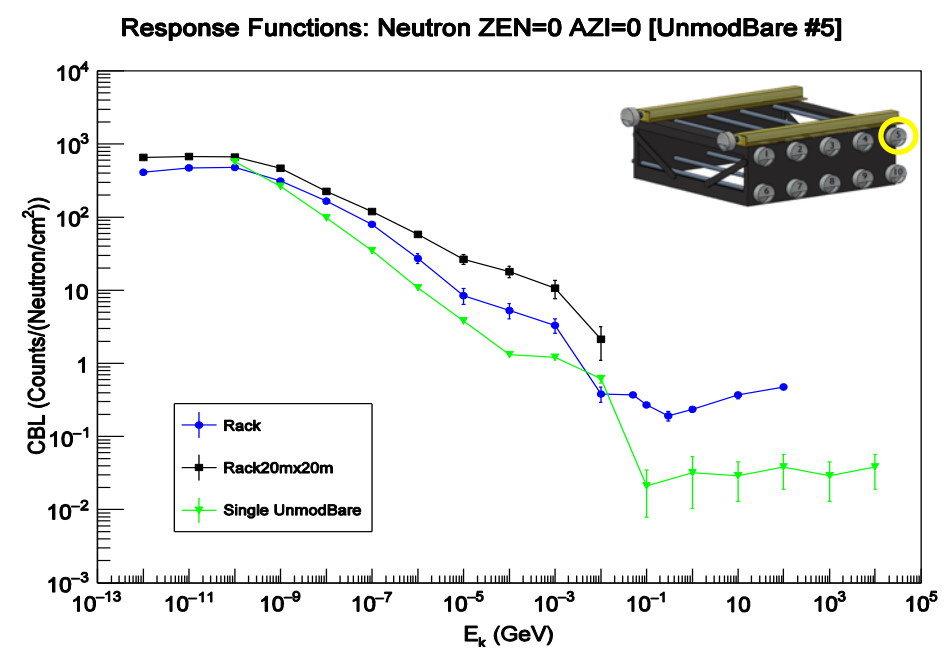
Preliminary

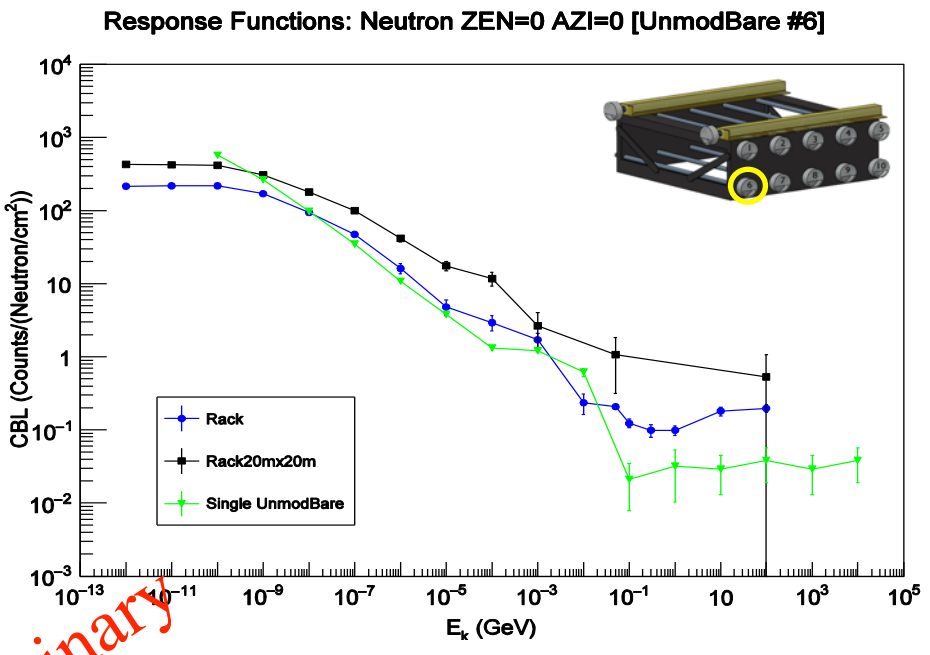
Response Functions: Neutron ZEN=0 AZI=0 [UnmodBare #3]

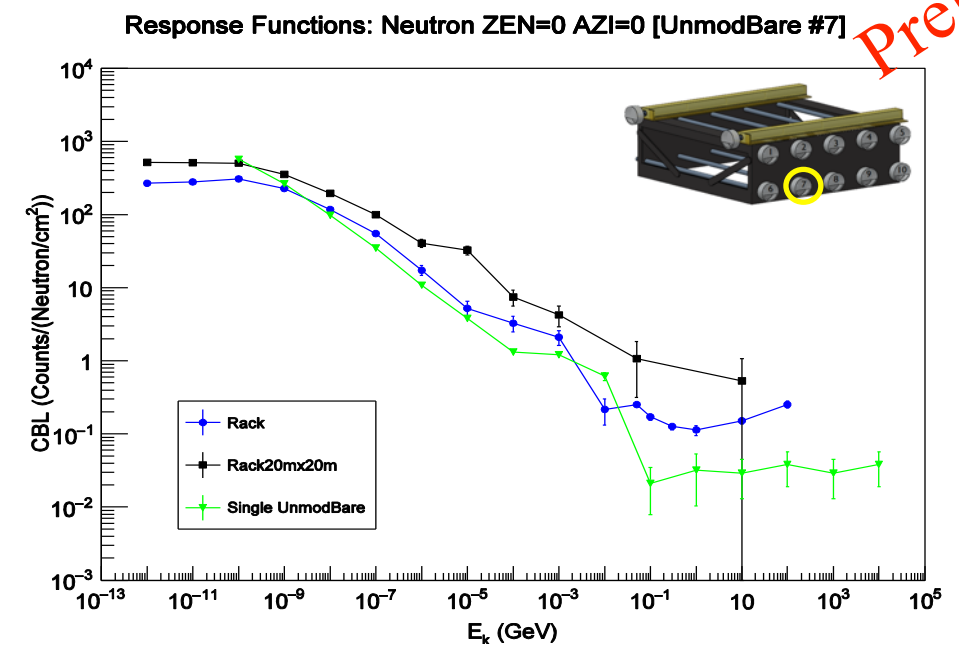


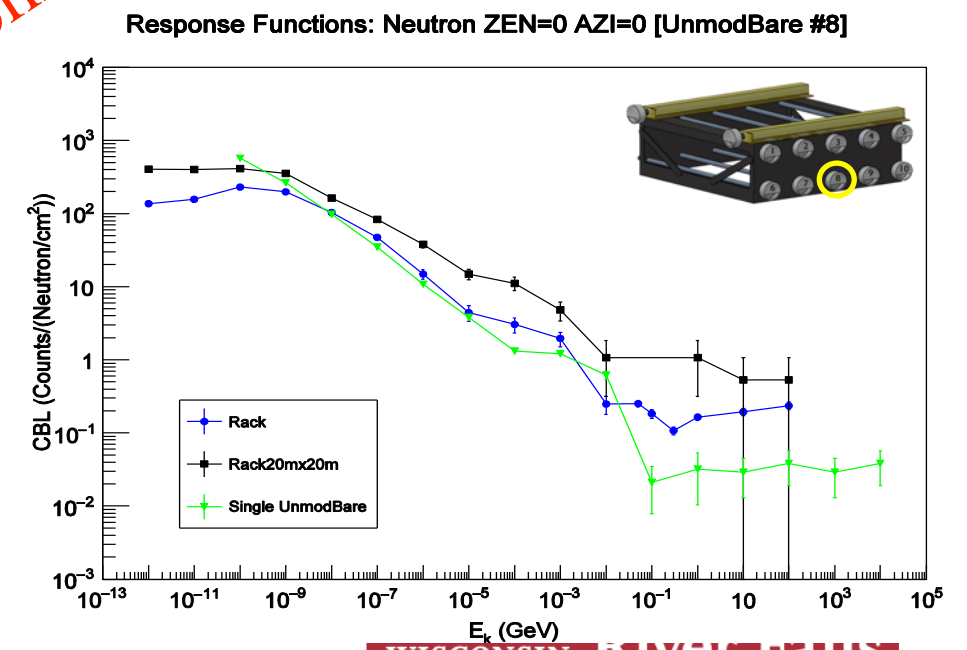
Response Functions: Neutron ZEN=0 AZI=0 [UnmodBare #3]

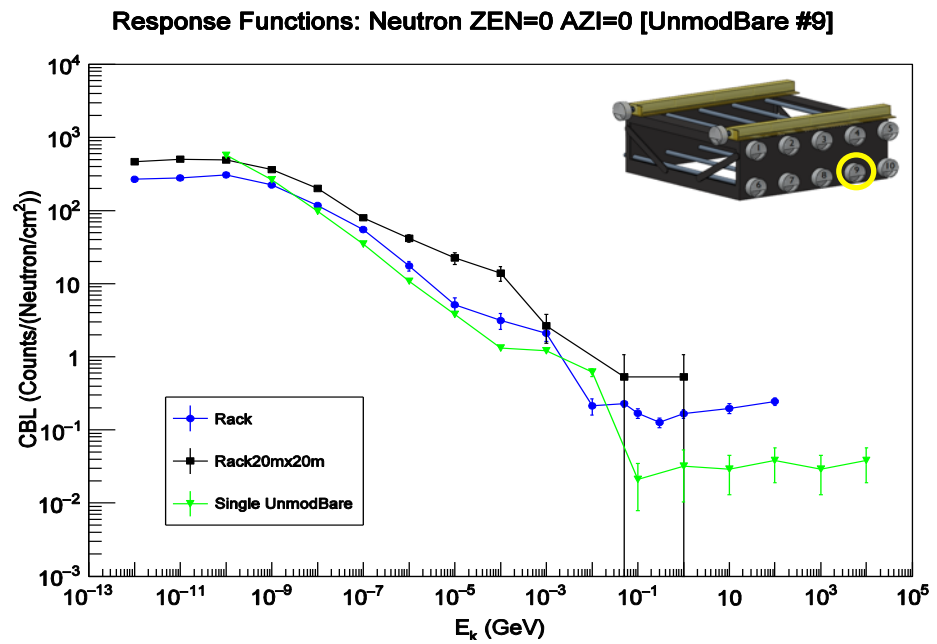


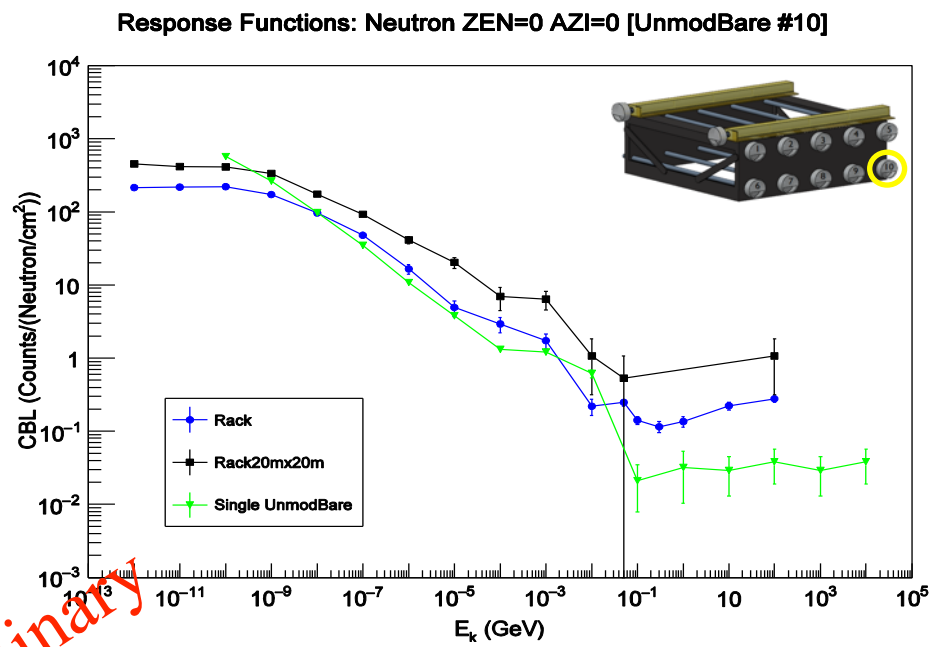


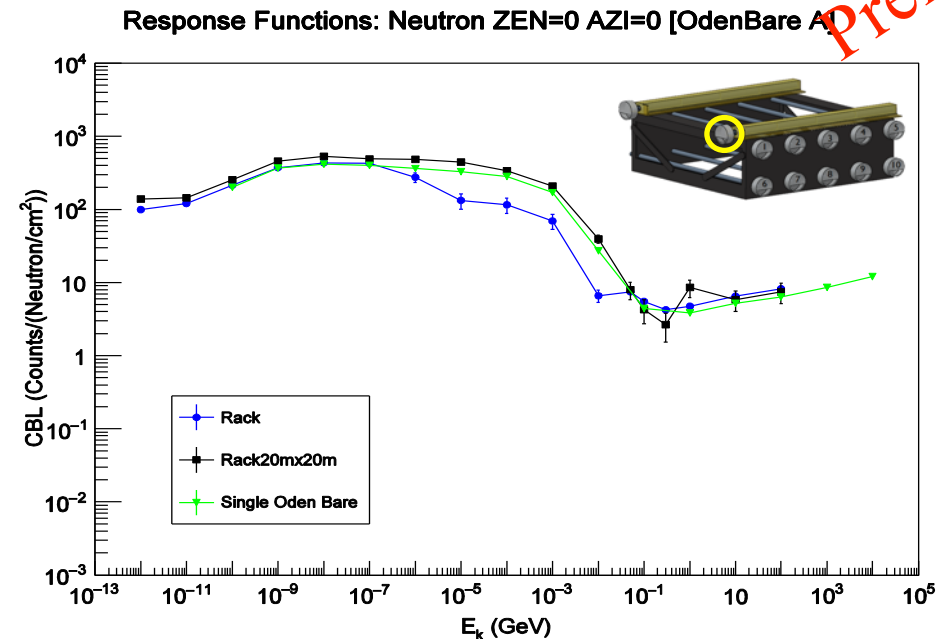


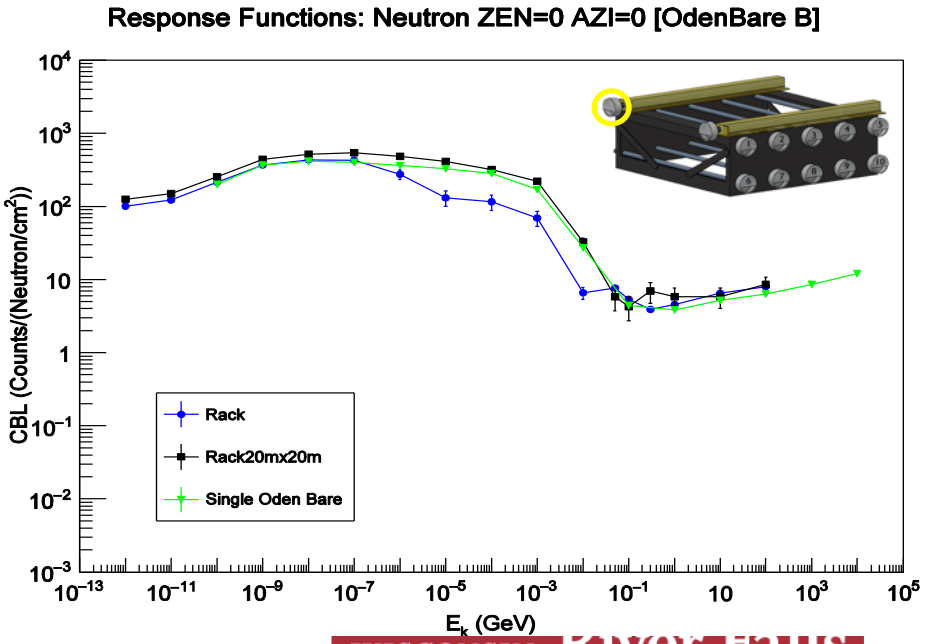












Next we'll simulate these

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SOUTH POLE! NOWHERE FROM HERE BUT NORTH

FEBRUARY 27, 2017 LEAVE A COMMENT

By Dylan Frikken – UWRF Undergraduate in physics

Summary and Future Work

- We have started a program of neutron monitor activity at UW-River Falls.
- Focus in on the South Pole Neutron Monitor and complementary analyses with IceTop.
- Heavy participation of undergraduates, with design and coding (both UWRF students and others through REU Site).
- Preliminary response functions for Polar Bars with new simulation, will work on standard NM64s next.
- Encourage your astrophysics undergrads to apply to our REU site.