Neutron monitoring

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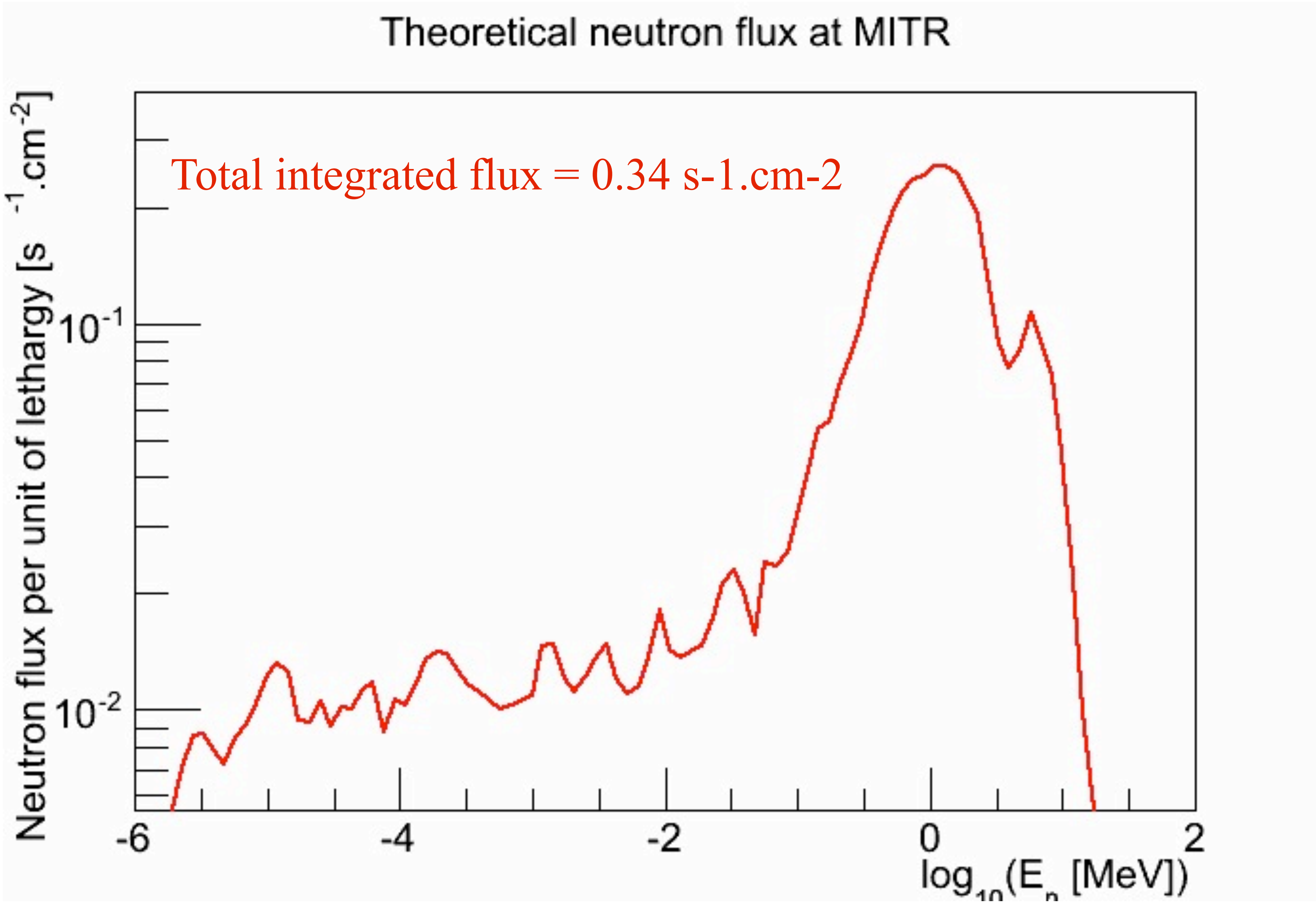
Neutron monitoring



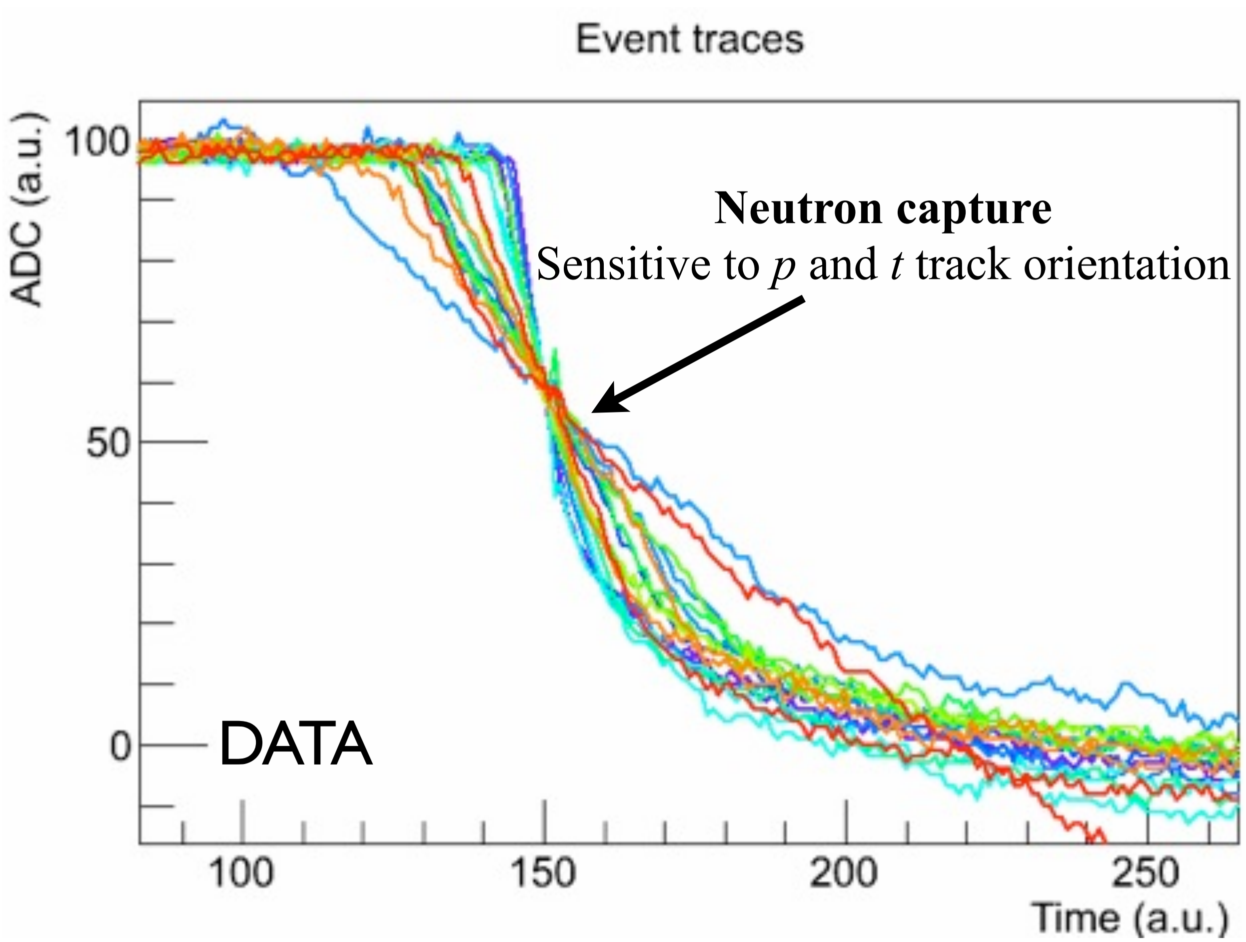
Need to measure neutron flux over 7 orders of magnitude with high precision

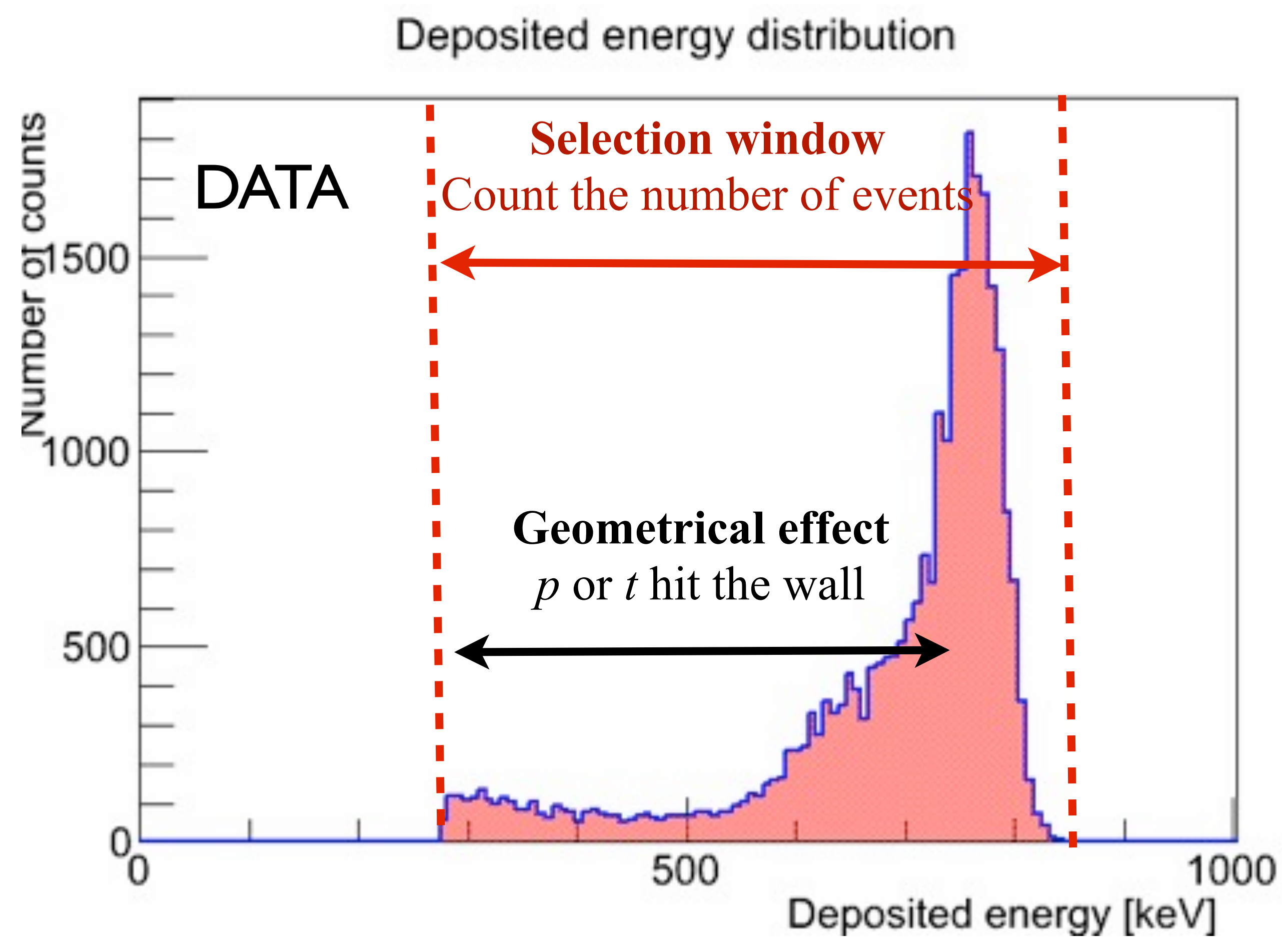
Neutron monitoring

Use of He3 Neutron Capture Detector (NCD) based on the following process:

$$n +^3 \mathrm{He} \rightarrow p + t \quad (Q = 764 \text{ keV})$$

- **Cylinder shape:** 200 cm long, 5.08 cm diameter => active volume ~ 4000 cm3
- **Gaseous TPC:** 85% 3He + 15% CF4 @ 2.53 bar
- **Charge readout:** charge preamplifier Canberra 2001A
- **Optimal HV:** 1.95 kV
- **Energy resolution @ 764 keV**: 3.3%





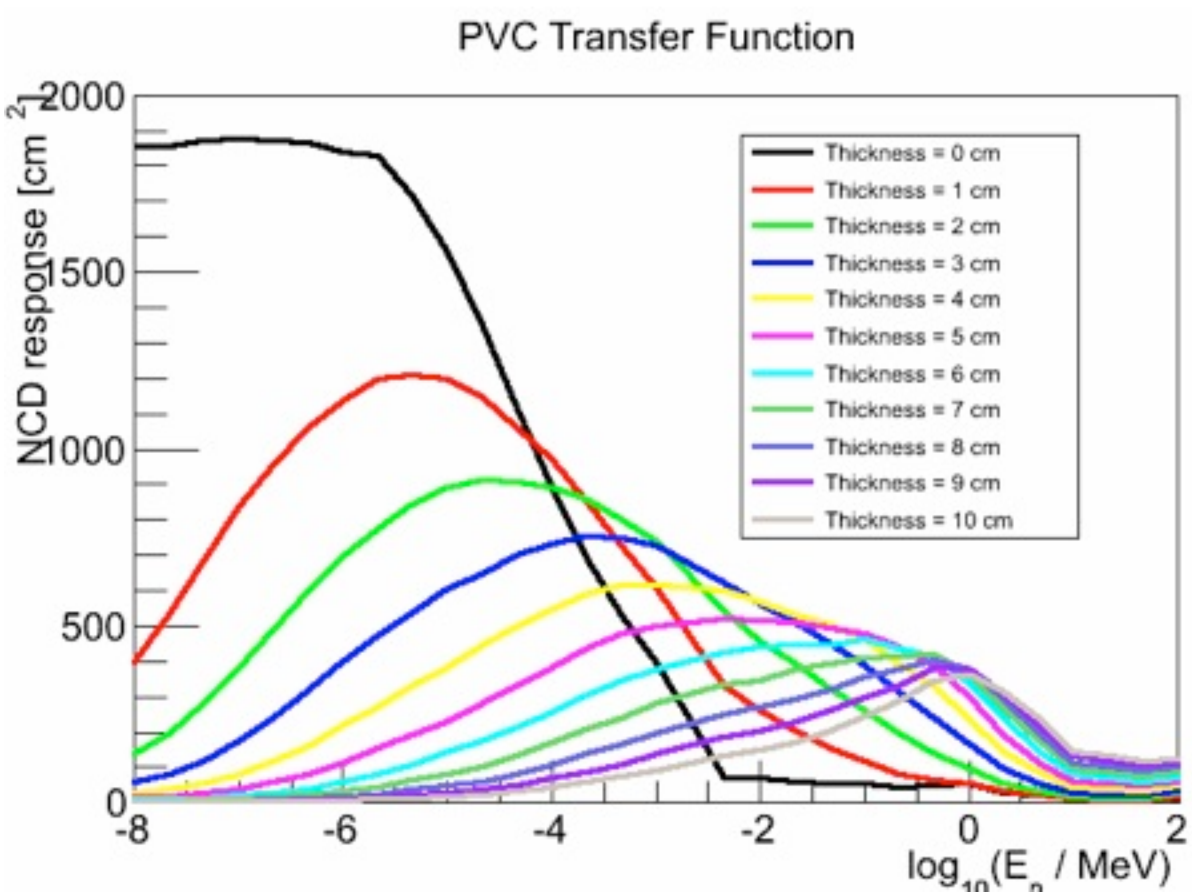
Neutron monitoring

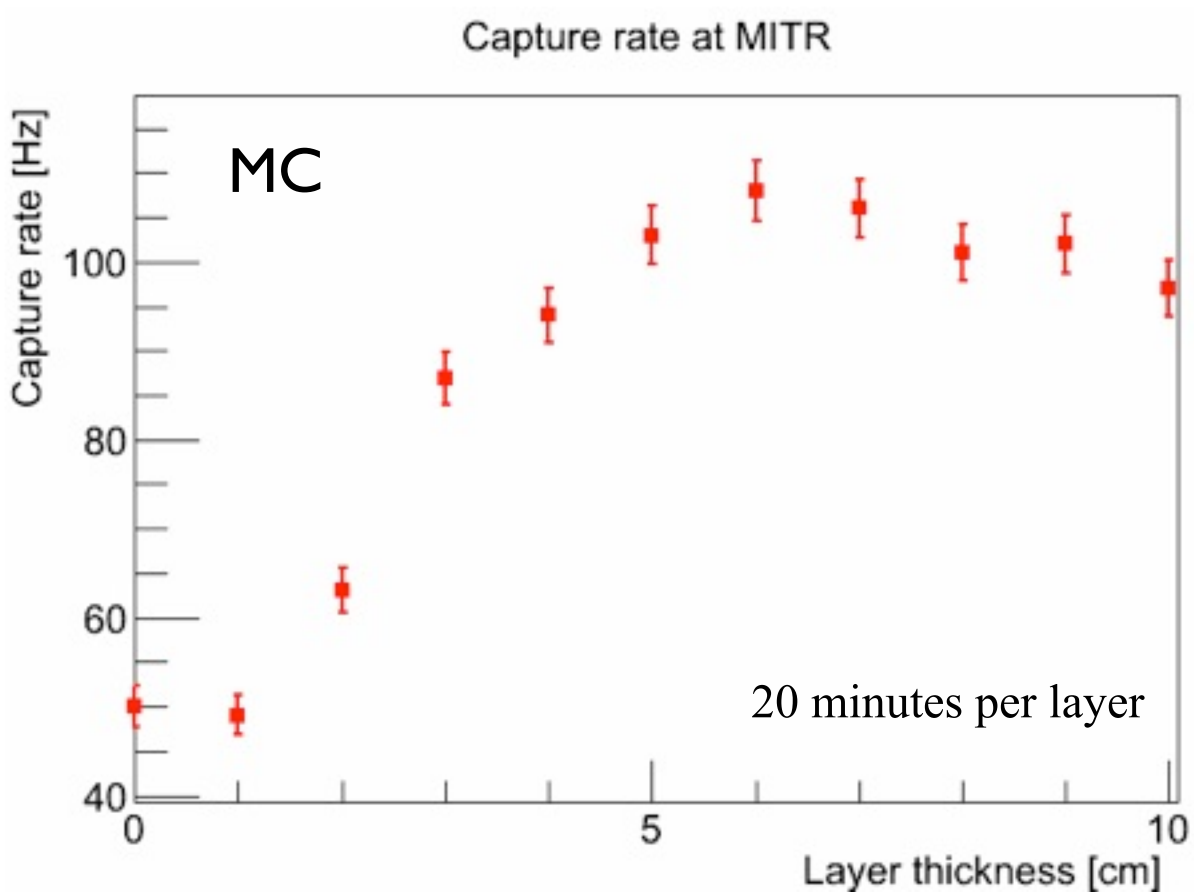
A bonner sphere approach

NCD are mostly sensitive to thermal neutrons (cross section ~ 10^4 barns)

Use layers of PVC to slow down neutrons due to multiple collisions with hydrogen (mostly)

With PVC thicknesses up to 10 cm, we are sensitive to MeV neutrons!





Neutron monitoring

Detector

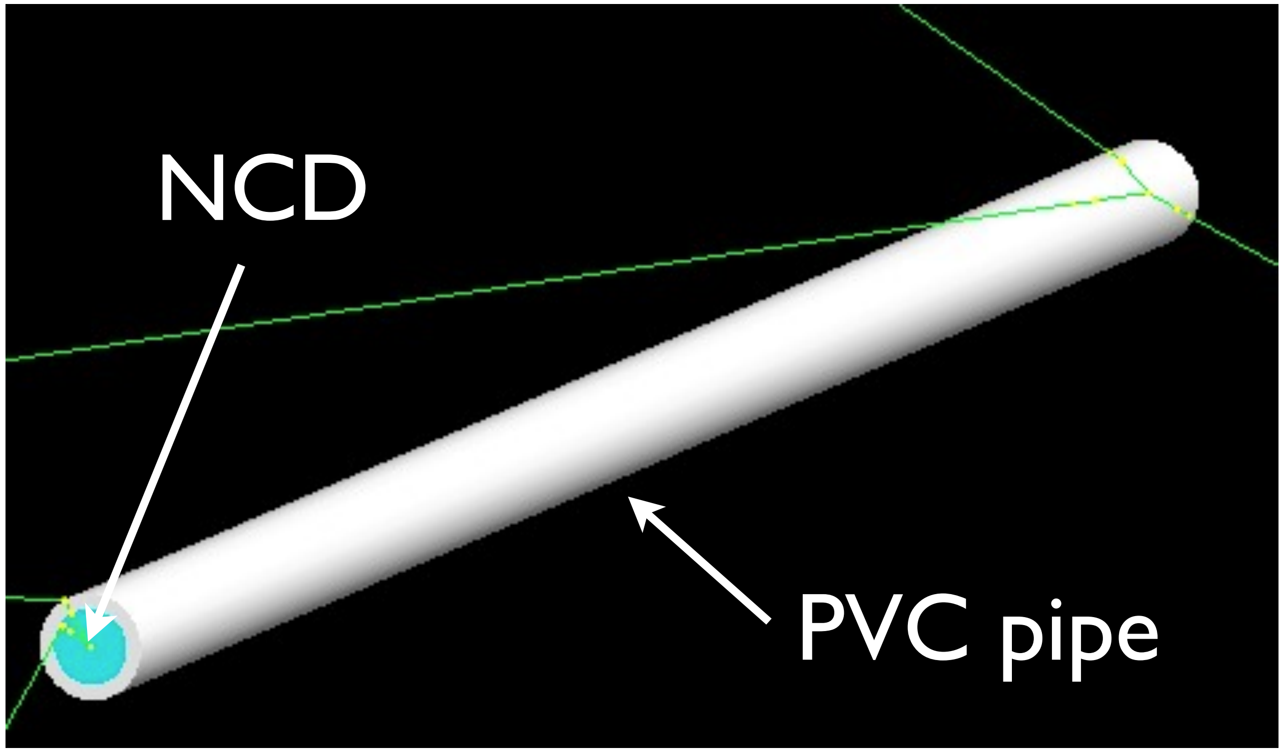
Neutron monitoring

Geant4 simulation of detector

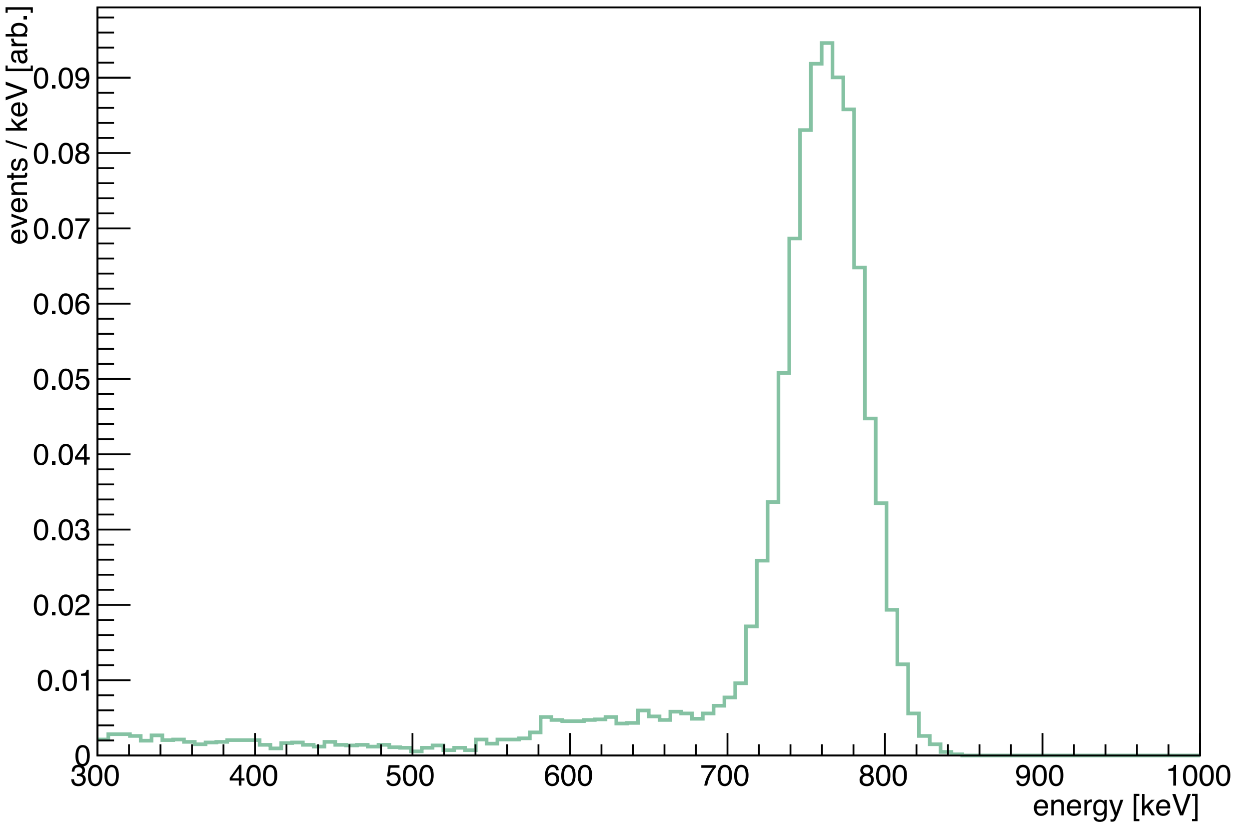
Transfer functions used in the deconvolution of the energy spectrum are estimated using a geant4 simulation of the detectors for each thickness of shielding

Current simulation qualitatively reproduces observed energy spectrum from cosmic neutrons

Quantitative validation of simulation with AmBe source underway



NCD spectrum from cosmic neutrons (δE/E ~ 3%)



Neutron monitoring

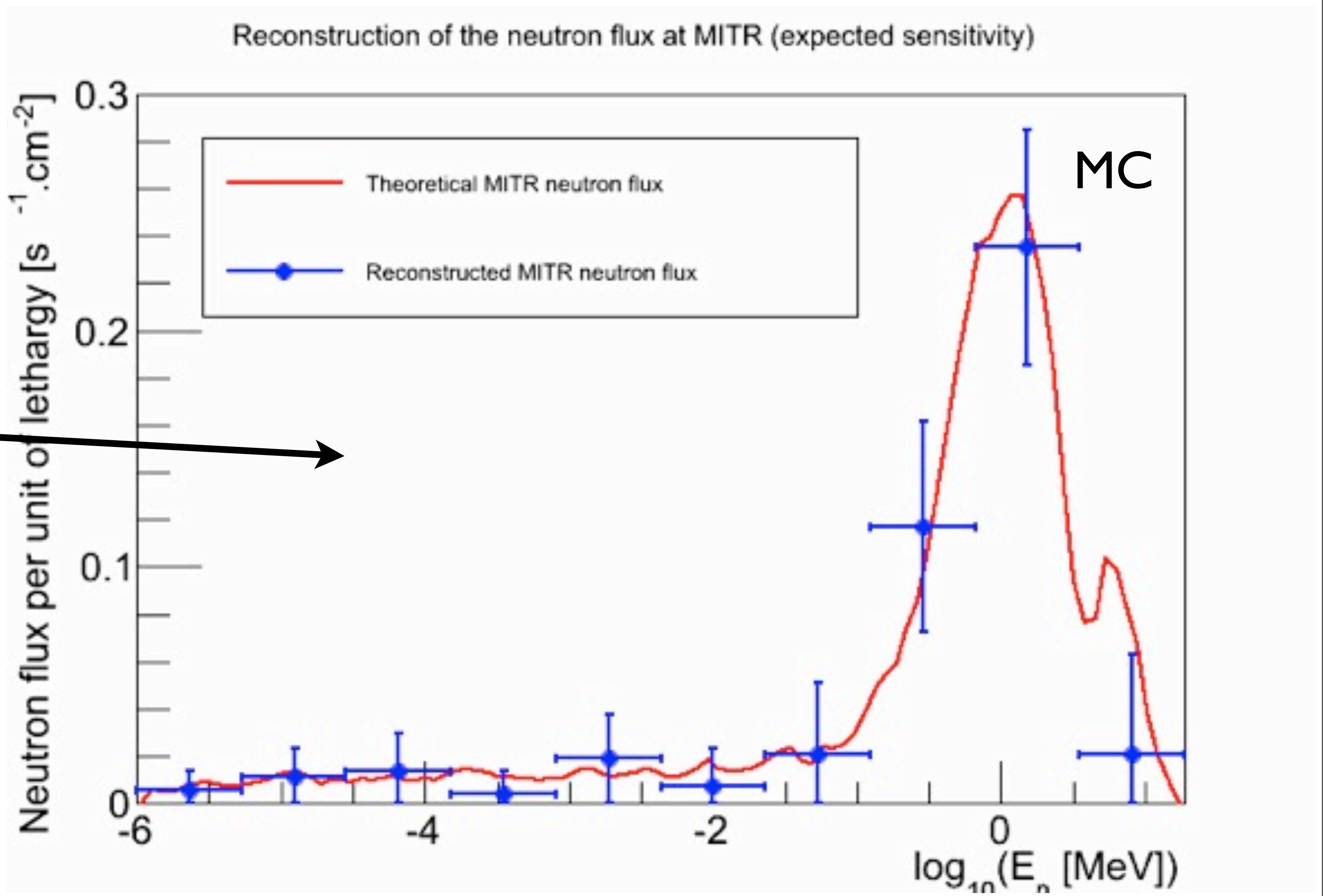
Recovering the neutron flux from NCD rate measurements
Likelihood approach

Definition of the likelihood function:

$$\mathscr{L}(\vec{F}) = \prod_{i=1}^{l} \exp\left[-\frac{(N_i^{th} - N_i^{obs})^2}{N_i^{obs}}\right]$$

Expected neutron flux reconstruction sensitivity using maximum likelihood distribution

This example considers:
- MITR theoretical neutron flux
- 10 neutron energy bins
- 11 PVC layers
- An acquisition time of **20 minutes** per layer



Reconstructed total flux = 0.348 ± 0.021 neutron /s/cm2 (~5% uncertainty)

Validation of the method using a monoenergetic deuteron neutron source is ongoing...

Neutron monitoring

Next things to do:

- Build transfer functions from incident neutron energy to NR probability

- Optimization of the PVC layer design

- Construction of the PVC layers

- Measure the atmospheric neutron flux and compare it to CRY simulation

- Start taking data for the characterization of the MIT Reactor