Alternatives To ^{3}He In Neutron Detection

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Outline

- Background
- Background dependencies
- Validation options
- Improvised data extraction

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In-Test Adaptation

- Creation of a near-real-time monitoring algorithm for plots
  - Allowed quick discovery of anomalies in test articles
  - Mitigated against repeating long data runs
- Quick-response modeling to support changes in test setup
  - MCNP for modeling moderator behavior for open-source dataset
- Quick-response data extraction from a reference detector
  - Needed to record neutron, gamma data
  - Employed detector in a manner unanticipated by vendor

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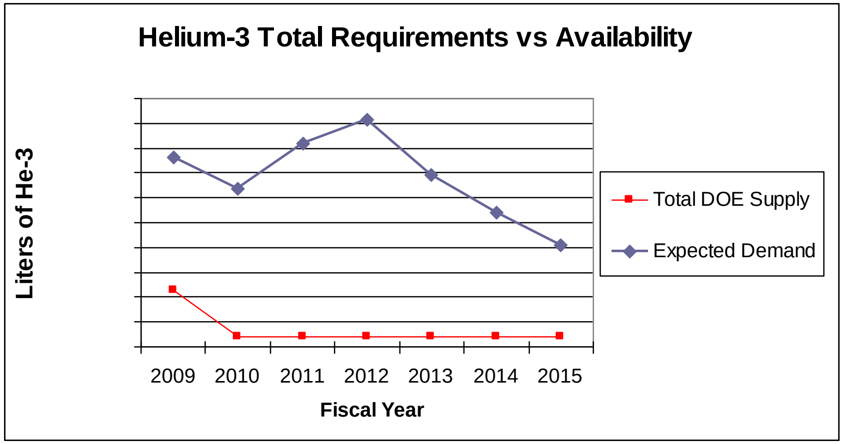
Background of The ^{3}He Issue

- **Supplies of ^{3}He are diminishing while demands – especially for neutron detection capabilities – are increasing**
- **^{3}He is a byproduct from the decay of tritium produced for the US nuclear weapons program**
  - **Tritium decays to ^{3}He with a 12.4 yr half life**
  - **A massive increase in tritium production will have little impact to offset the shortfall and comes at a very large expense**

- **The total expected Government and non-government demand requirements chart reflects the ^{3}He crises**



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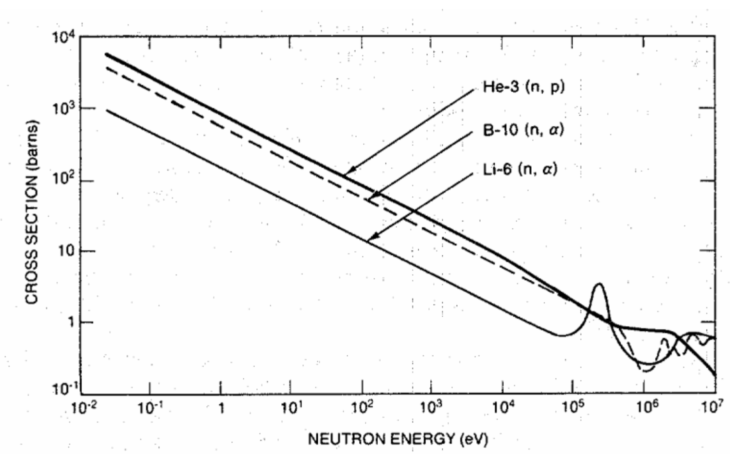
Background of The ^{3}He Issue

- ^{3}He Characteristics
  - Very efficient material for neutron detection
  - Inert and non-radioactive gas
  - Large cross section to absorb thermal neutrons
    - Absorption provides an energy signal that alerts the presence of neutrons, such as those for uranium and plutonium
    - Non-reactive/non-corrosive nature of the gas provides a long lasting, high intrinsic efficiency detector with few false positives (i.e. high gamma rejection)



^{10}B and ^{6}Li are good alternative candidates with reasonable thermal cross sections and Q-values

Neutron Capture Reactions

	Q-Value
^{3}He (n,p):	
$^{3}He + {}^{1}n \longrightarrow {}^{3}H + {}^{1}p$	0.764 MeV
$^{10}B(n,\alpha)$:	
$^{10}B + {}^{1}n \longrightarrow {}^{7}Li + {}^{4}\alpha$	2.792 MeV
$^{10}B + {}^{1}n \longrightarrow {}^{7}Li^{*} + {}^{4}\alpha$	2.310 MeV
$^{6}Li(n,\alpha)$:	
$^{6}Li + {}^{1}n \longrightarrow {}^{3}H + {}^{4}\alpha$	4.780 MeV

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Background

- MS0 18 May 2009
- Test Article Delivery 1 Oct 2010
- Test Execution 29 Oct – 20 Nov 2010
- Quick Look Report 3 Dec 2010

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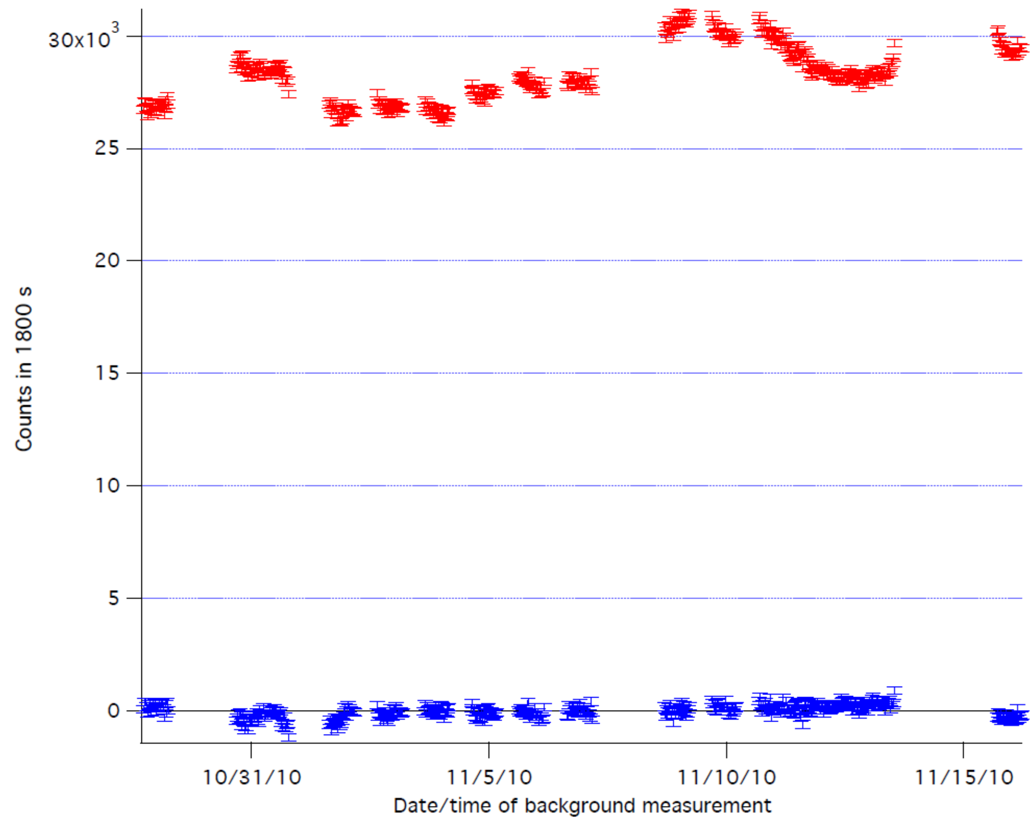
Background Data

- Analysis of the background runs found correlation of background counts to atmospheric pressure
  - Background from cosmics
  - Tighter controls on other neutron sources
  - Possible further correlation with other variables
- Increased frequency of background runs enabled greater understanding of detector behavior
  - Able to detect and recognize anomalous detector behavior more quickly



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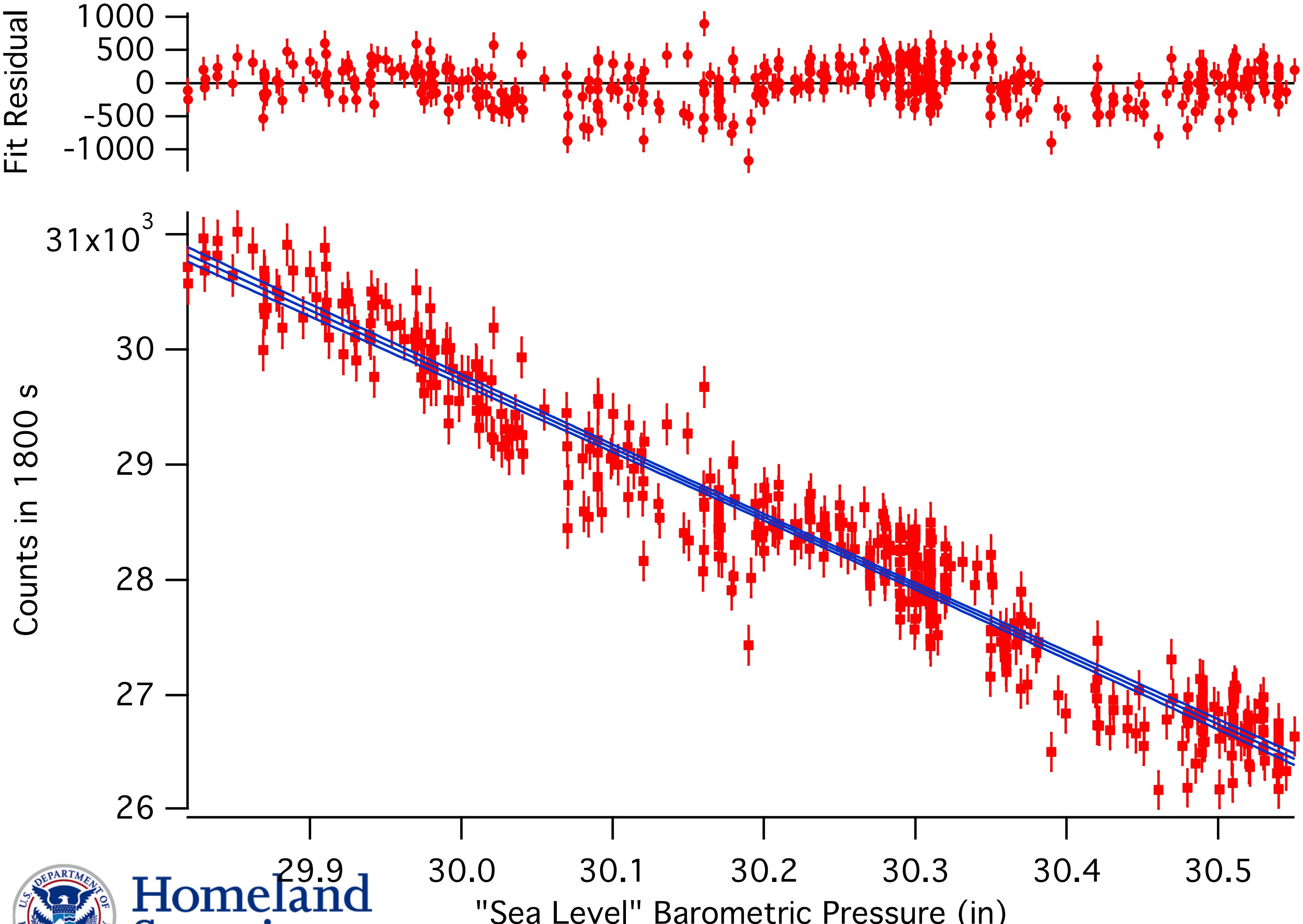
Background Calculations



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Able to Calculate Backgrounds from Pressure

- High correlation between background rate and barometric pressure, as shown on previous graph.
- Blue lines on graph are 95 % confidence interval for fit.
- Measurement of barometric pressure during all runs means that we can interpolate the background rate (with uncertainties) at any point for a given detector.
- Still some non-statistical uncertainty, perhaps correlated with temperature, humidity, or space weather.
- At this point just adding remaining non-Poisson fluctuations as additional uncertainty

Subtlety in Background Uncertainty

- Because of long (overnight+) background runs, know the background *rate* very well (better than 1 % often)
- In a short run, counting statistics may dominate uncertainty
  - Example: 1 s^{-1} background rate, 400 s run has ~5 % uncertainty in number of background counts
  - Naïve calculation (and essentially zero uncertainty on time from resolution of LMM) would give 1 % uncertainty on background counts

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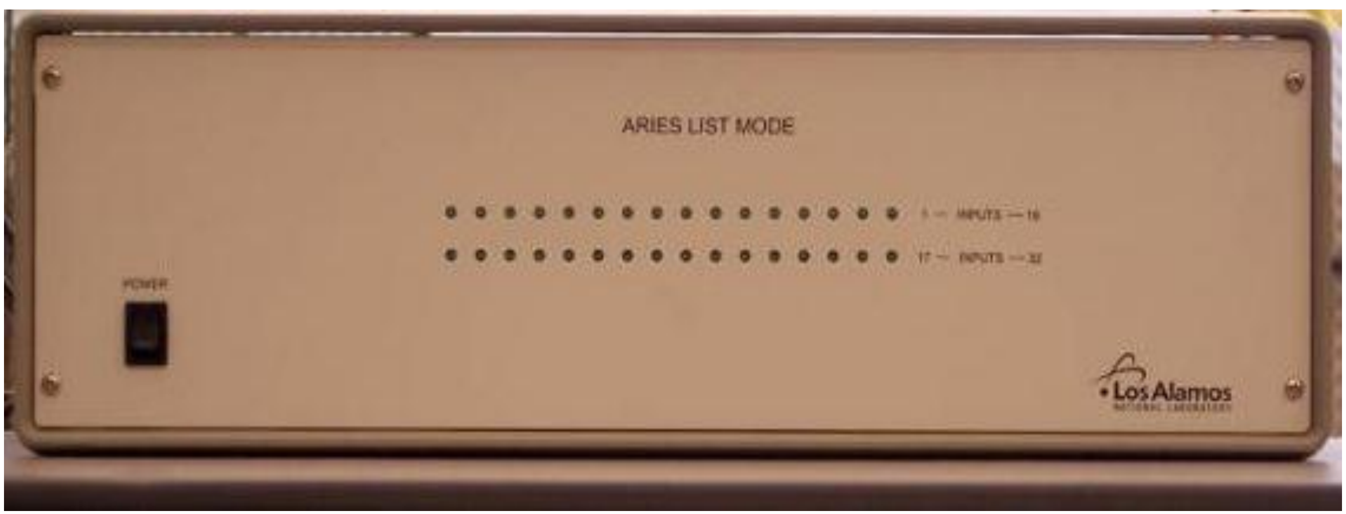
LANL List Mode Module

- 16 channels
- TTL input
- Records pulse arrival time with ~100 ns precision for all channels



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List Mode Data Advantages

- Consistent Time Structure
  - Same time structure and length of collection
  - Able to tag with external parameters
- Data Management
  - Single file format
  - Single file per configuration or measurement
  - All detectors in single file
- Recovery of measurement data

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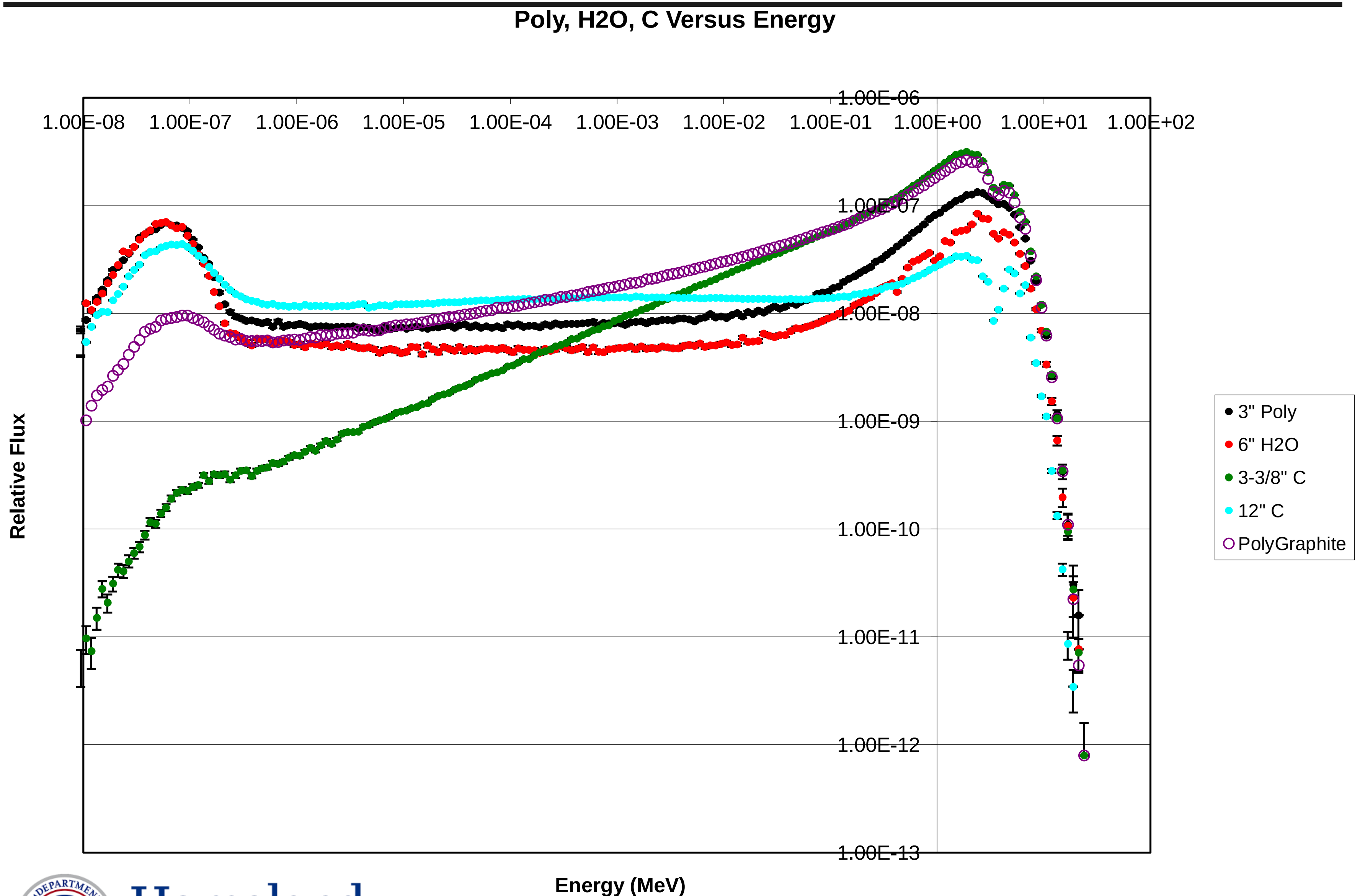
MCNP for modeling moderator



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Lessons Learned

- Sensitivity of measurements to any external neutrons
    - More pronounced in low-flux sources
- Extra pre-test preparation time on-site paid large dividends during the testing period
- Better monitoring of conditions in immediate surrounding area helps mitigate against unexpected results.

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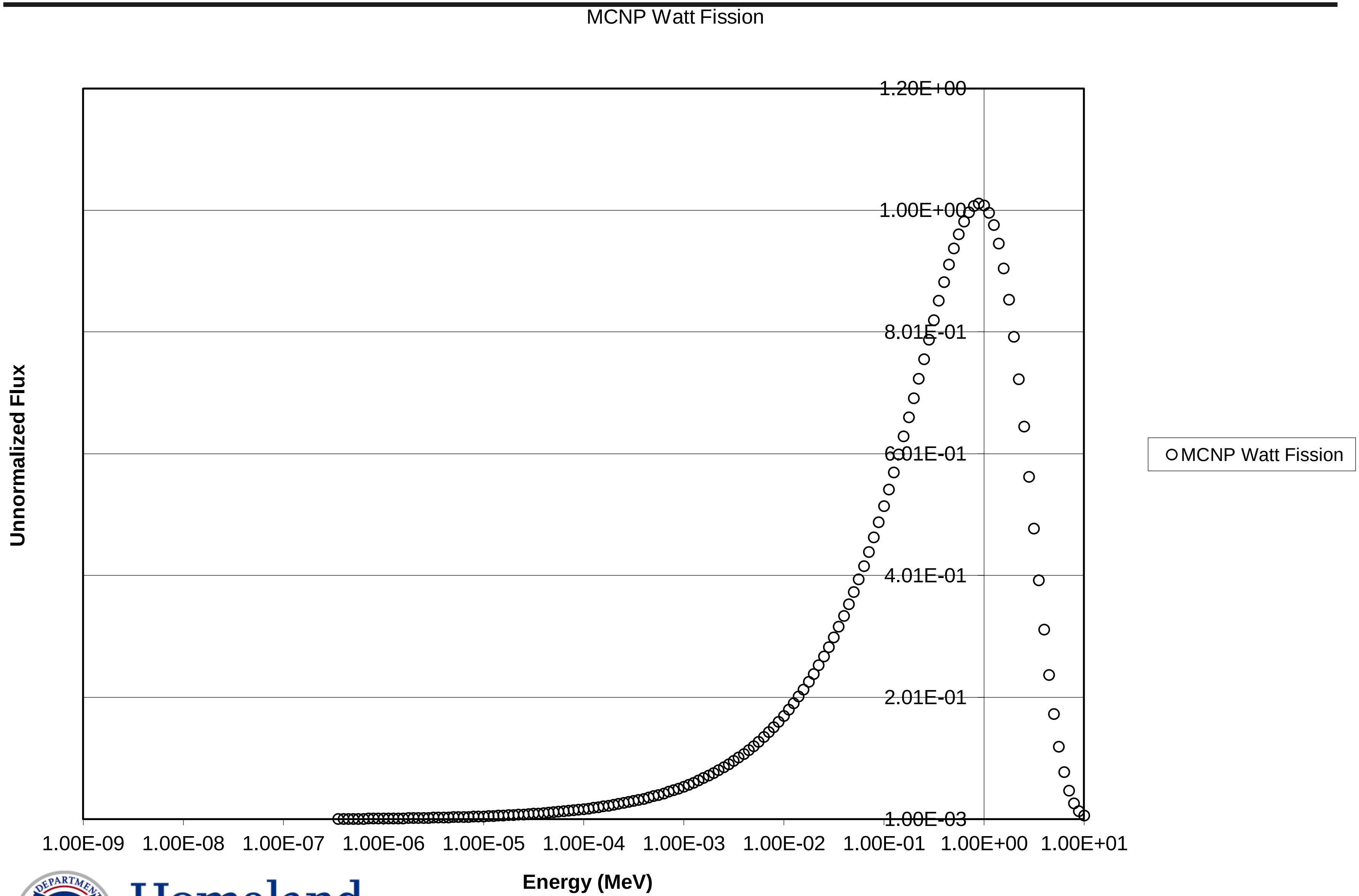
MCNP for modeling moderator—input spectrum



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