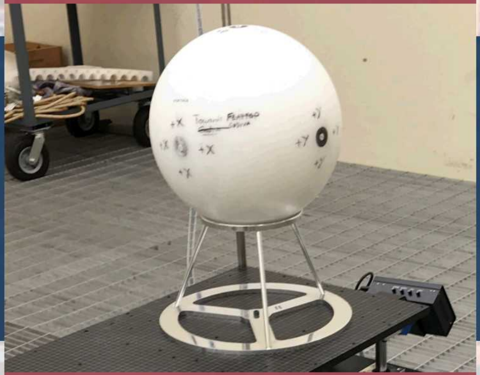
SAND2019-2498C

Characterization of Low Intensity Pulsed Neutron Fields Using a Passive Neutron Spectrometer Employing TLD 600/700 Pairs.



PRESENTED BY

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Introduction

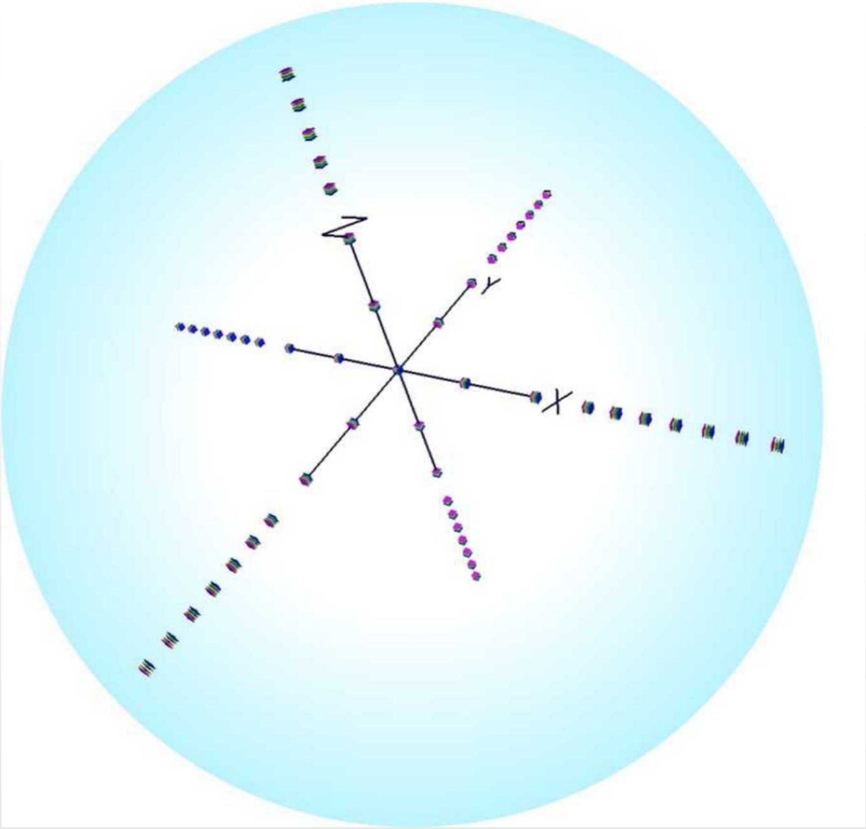
At SNL, there are some locations where occupational exposure to low intensity pulsed neutron fields occurs on a routine basis.

The accurate assessment of such exposures requires knowledge of both the intensity of the exposure (total neutron fluence) and the energy distribution of the neutrons (energy spectrum).

Conventional neutron spectrometry equipment such as Bonner Spheres, RoSpec, or liquid scintillation detectors, when employed in a pulsed environment, lack either the sensitivity or the ability to respond quickly enough to gather sufficient data for spectral analysis.

Introduction

In recent years another approach has been successful. This approach has been based upon work published by Gomez-Ros et al[1], which uses the principles of a multi-sphere spectrometer[2] combined into a single common moderator.



Introduction

This variant of the PNS utilizes TLD600 chipstrates

The use of TLD600 dosimeters allows for

- Greater sensitivity in low dose-rate neutron fields
- Dosimeters are integrating type dosimeters suitable for use in pulsed fields

TLD600/700 Material

TLD Material	Thermo Part #	Type	Chip Dimensions	%^{6}Li	%^{7}Li
700	EXTRAD-26977	Chipstrate	1/8" x 1/8" x 0.015"	0.07	99.93
600	EXTRAD-26976	Chipstrate	1/8" x 1/8" x 0.015"	95.6	4.4

Chipstrates are read using a Harshaw 6600 automatic reader

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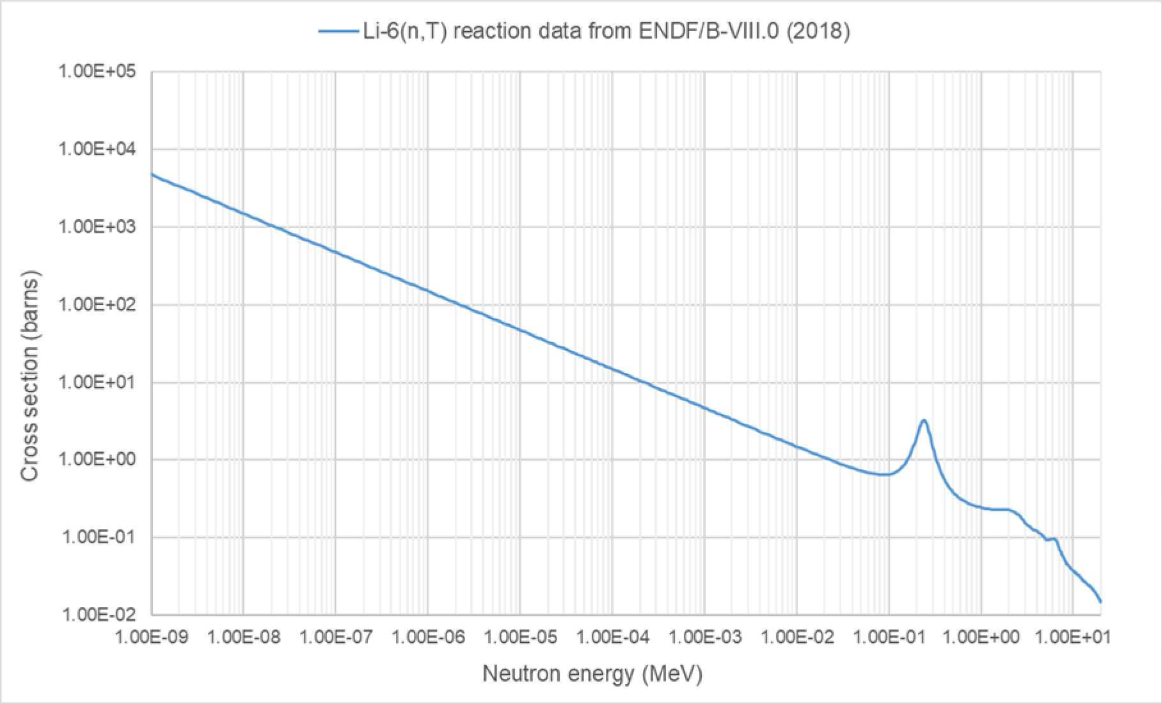
TLD600/700 Material

Response of each TLD chip assumed proportional to the number of 6Li(n,t)4He reactions per source neutron

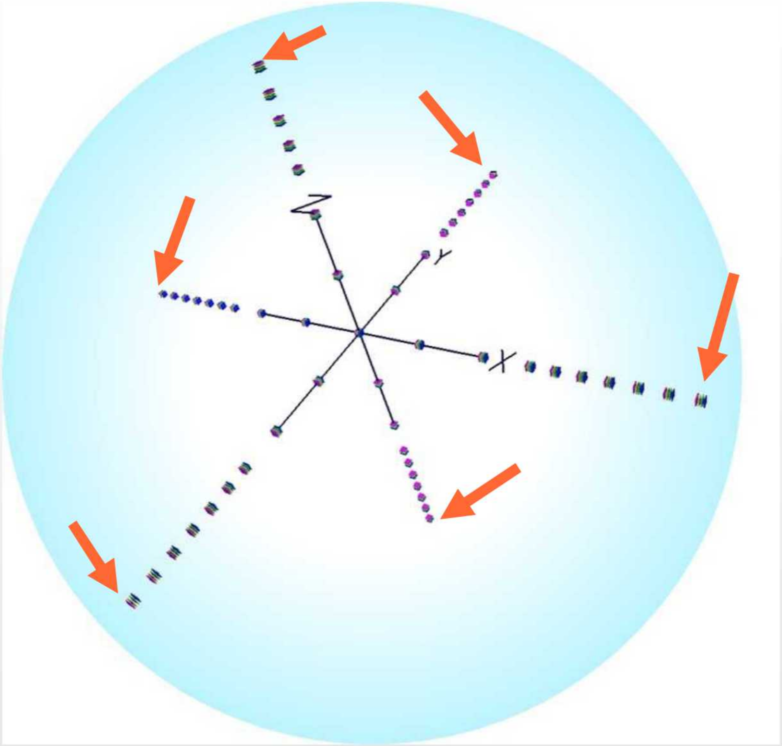
–Q = 4.79 MeV



Modeling

Interested in energy deposition per gram of TLD material per unit fluence.

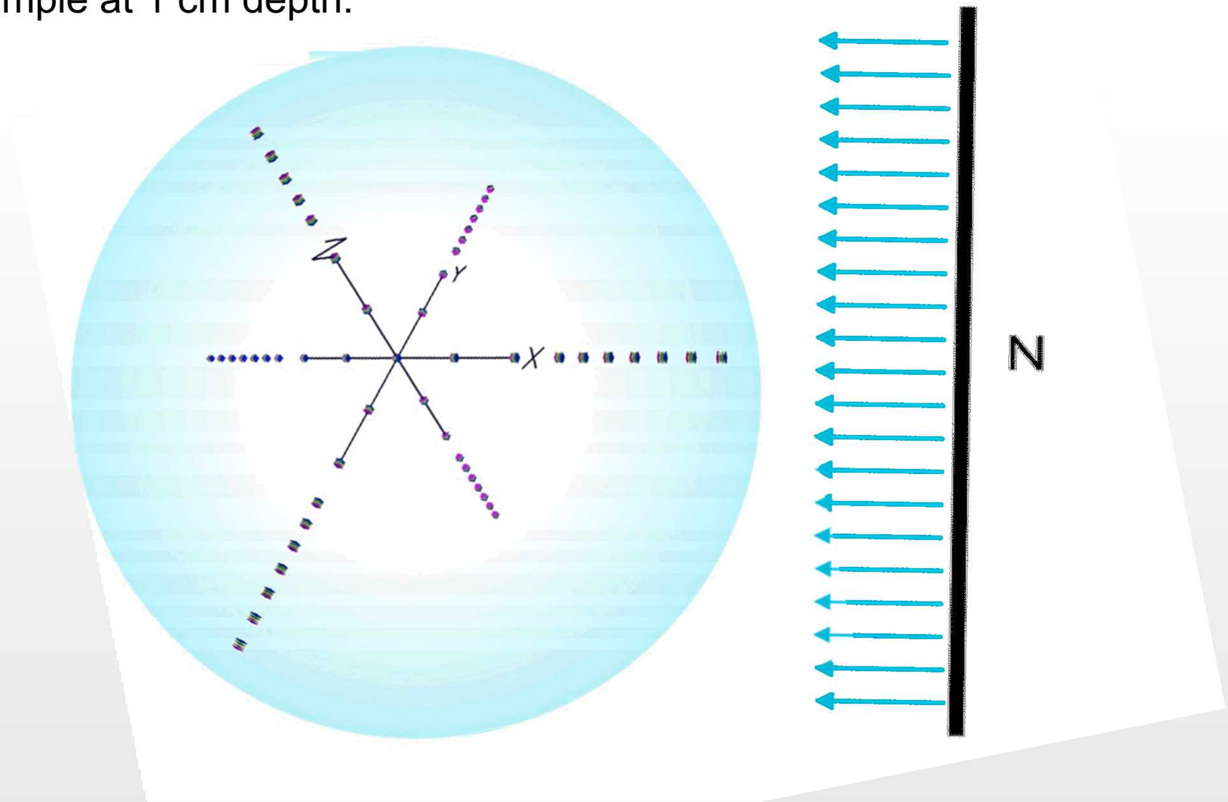
Looking at the sum of the energy deposition per gram at different shell depths



Modeling

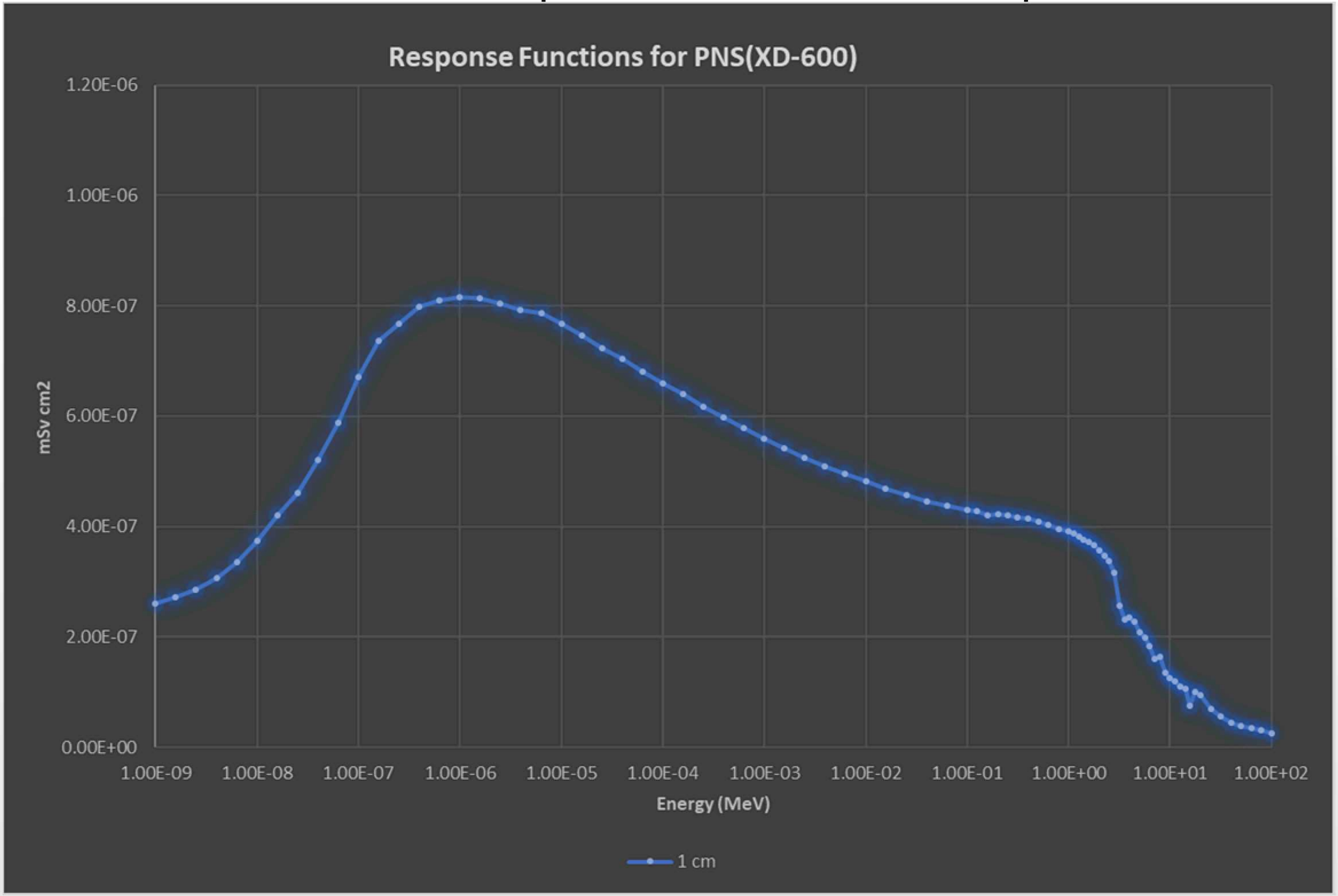
Now, let us look at how energy deposition at a particular depth varies with neutron energy (MeV).

For example at 1 cm depth:



Modeling

Calculated Response function for 1 cm Depth



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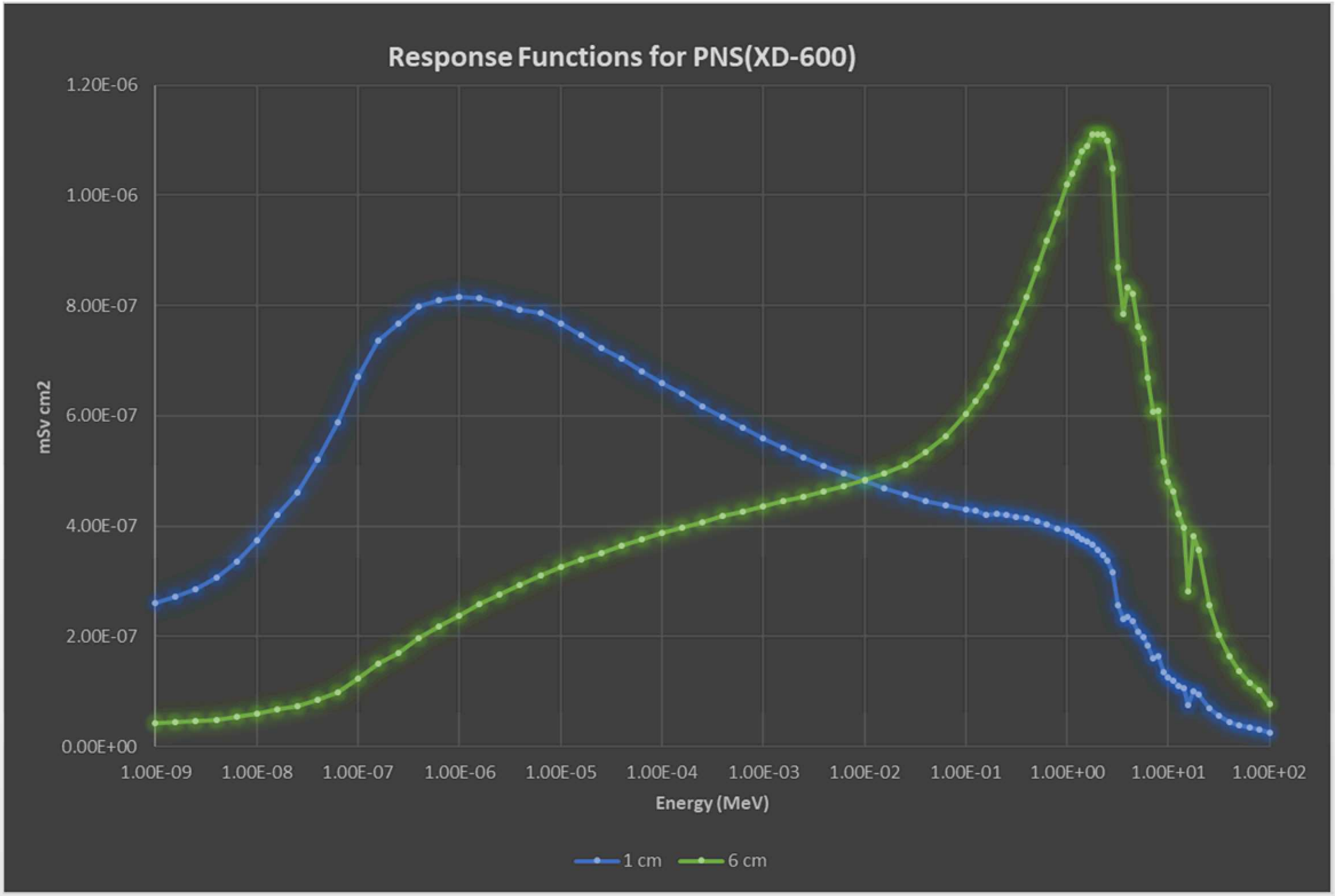
Modeling

Calculated Response functions for 2 Depths



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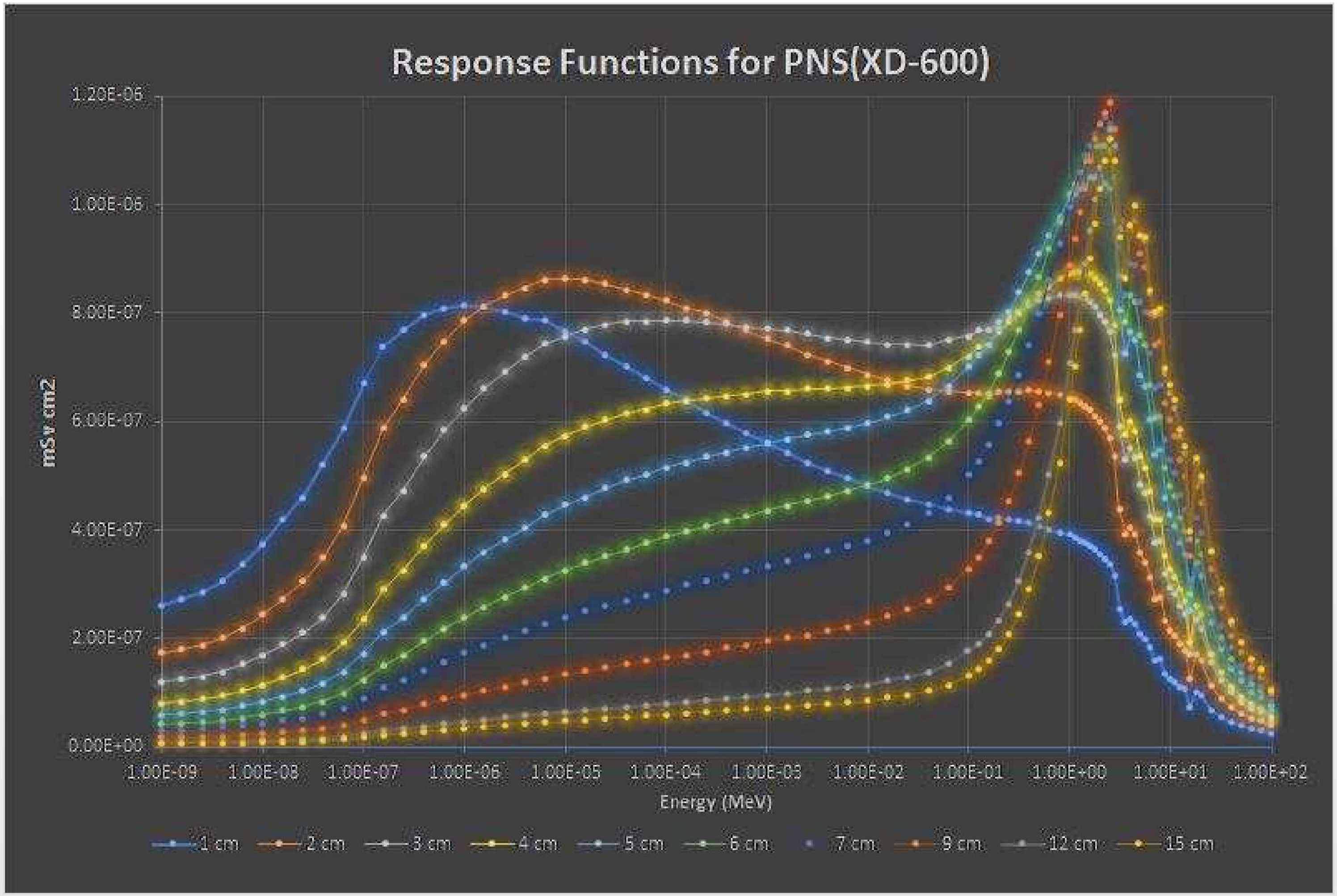
Modeling

A full set of Response functions



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Results

Taken from AWE Report No. 445/18; Validation of a High Sensitivity Passive Neutron Spectrometer; by Chris Wilson, dated 20 December 2018[5]

Exposed to Cf-252 source at the National Physical Laboratory (NPL). This is a reference field for neutron instrument calibration.

Table 1: Details of calibration irradiations. The distance given is to the point on the surface of the sphere nearest the source.

Exposure type	Distance	Start Time	Stop Time	Fluence
	cm	BST	BST	cm^2
Total	185.2	27/07/2018 16:47	30/07/2018 09:15	3.05E+07
Scattered	185.2	10/08/2018 16:05	13/08/2018 09:35	3.07E+07

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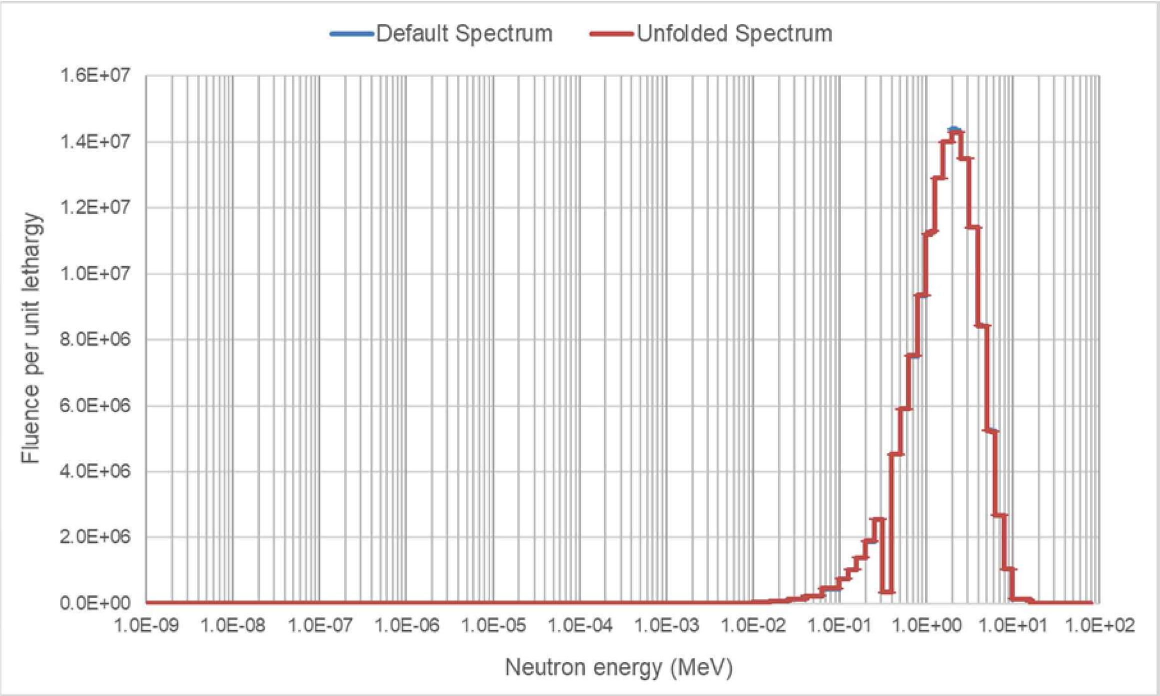
Results



Input and output spectra from the Gravel unfolding algorithm.

Discussion

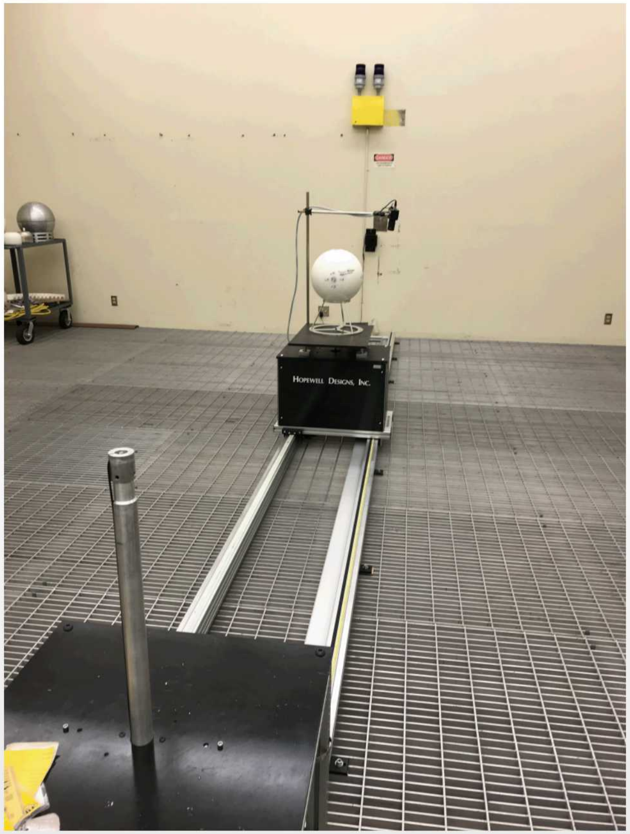
Typically, under controlled conditions TLDs have a detection limit around 30 – 50 μSv (3–5 mrem) therefore it should be possible to accurately measure ambient neutron dose of the order of 0.1 mSv (10 mrem). [the exact figure would depend on the neutron energy spectrum].

Hand held neutron survey instruments are more sensitive, but their response is strongly dependent on the neutron energy spectrum, which in most operational cases is unknown.

Given the spectrometric capability the PNS(XD-600) could be used to make accurate neutron dose surveys in relatively short time scales;

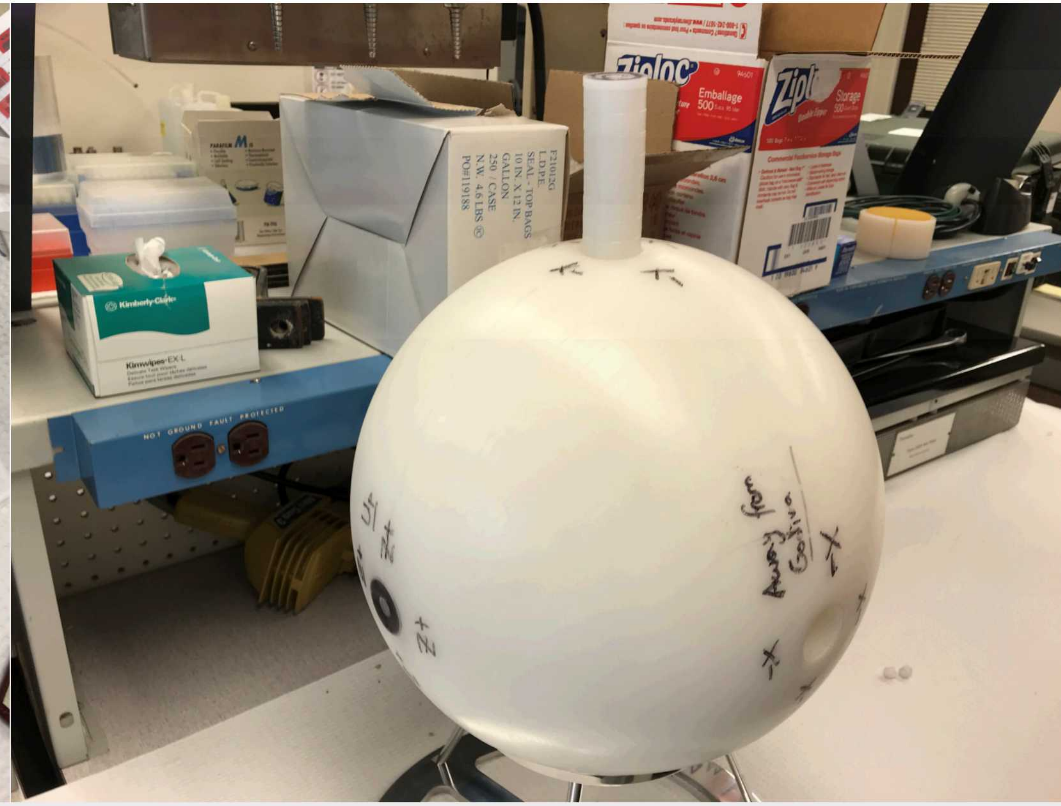
Additional Information

Deployment

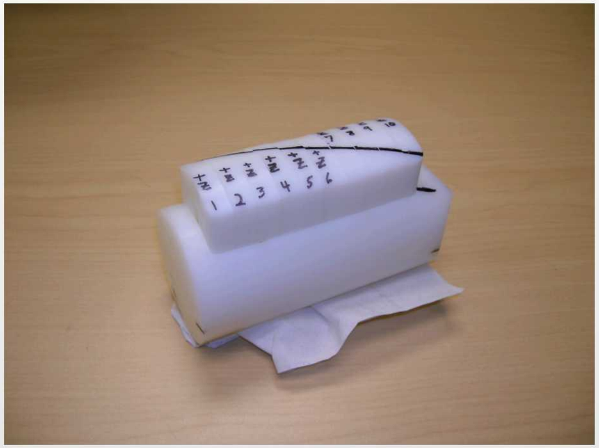


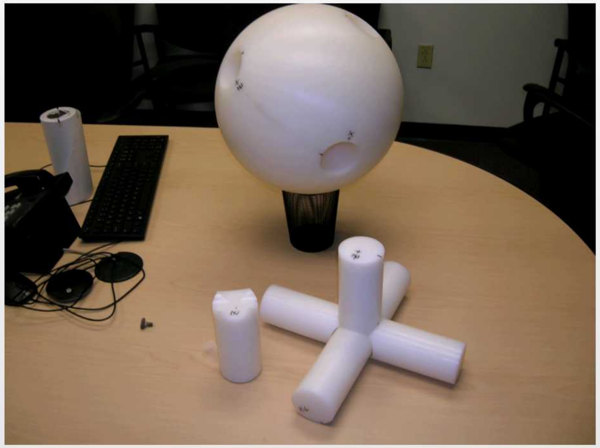
Assembly of PNS(XD-600)

Assembly of PNS(XD-600)



Newer Design





References

[1] Gomez-Ros, J. M. et al., "*A multi-detector neutron spectrometer with nearly isotropic response for environmental and workplace monitoring*", Nucl. Inst. Meth. Phys. Res. A 613, pp. 127-133 (2010)

[2] Bramblett, R. L.; Ewing, R. I.; Bonner, T. W., "*A new type of neutron spectrometer*", Nucl. Inst. Meth. 9, pp. 1-12 (1960)

[3] McElroy, W. N., et al., "*A computer-automated iterative method for neutron flux spectra determination by foil activation*", AFWL-TR-67-41, Air Force Weapons Laboratory, Kirtland Air Force Base, U.S.A (1967)

[4] Reginatto, M. and Goldhagen, P., "*MAXED, a computer code for maximum entropy deconvolution of multisphere neutron spectrometer data*", Health Physics 77, pp. 579-583 (1999)

[5] Wilson, C. L., "Validation of a High Sensitivity Passive Neutron Spectrometer", AWE Report No. 445/18, London, England (2018)