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The Application of Super Heated Drop (Bubble Detectors) for the Characterization of Nano-Second-Pulsed Neutron fields

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Situation

- A neutron source with a pulse width of only a few nano-seconds.
- Want to determine ambient neutron fields in occupied locations.
- Want dose conversion factors for worker TLDs

Problem

- **Normal survey instruments cannot not be used**
  - **Cannot respond to neutron pulse quickly enough**
  - **EMP pulse affects equipment**

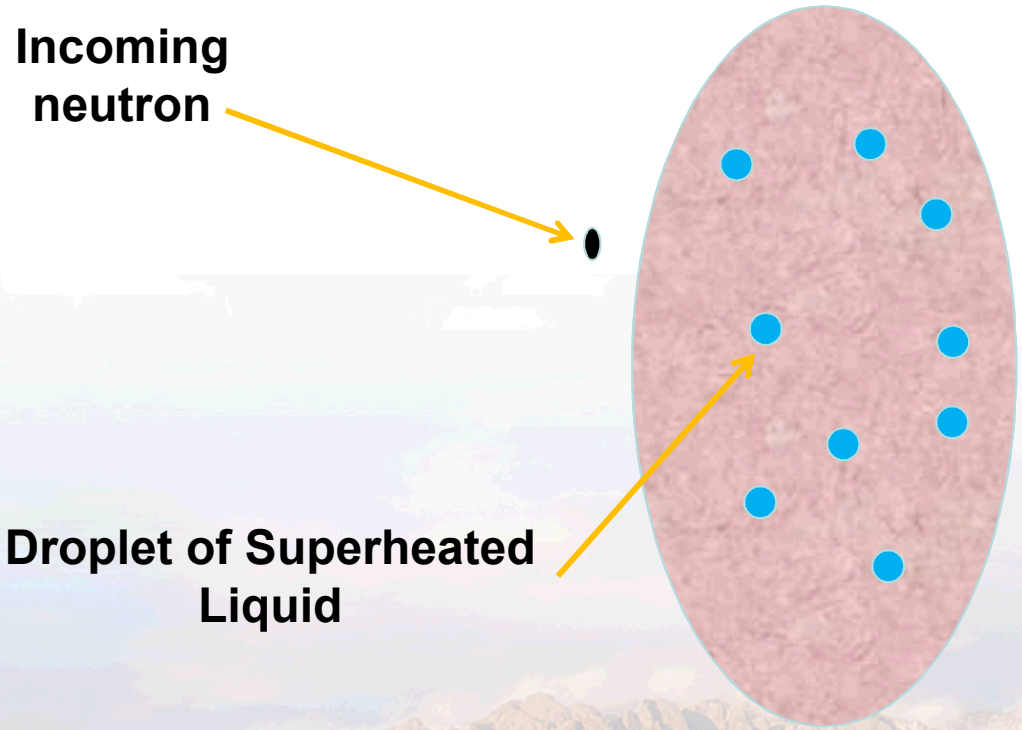
Challenge

- Needed a measurement technique that
  - can be used in pulsed fields,
  - has no gamma sensitivity
  - can give spectral information with absorbed doses in the range of a few hundred mrad.

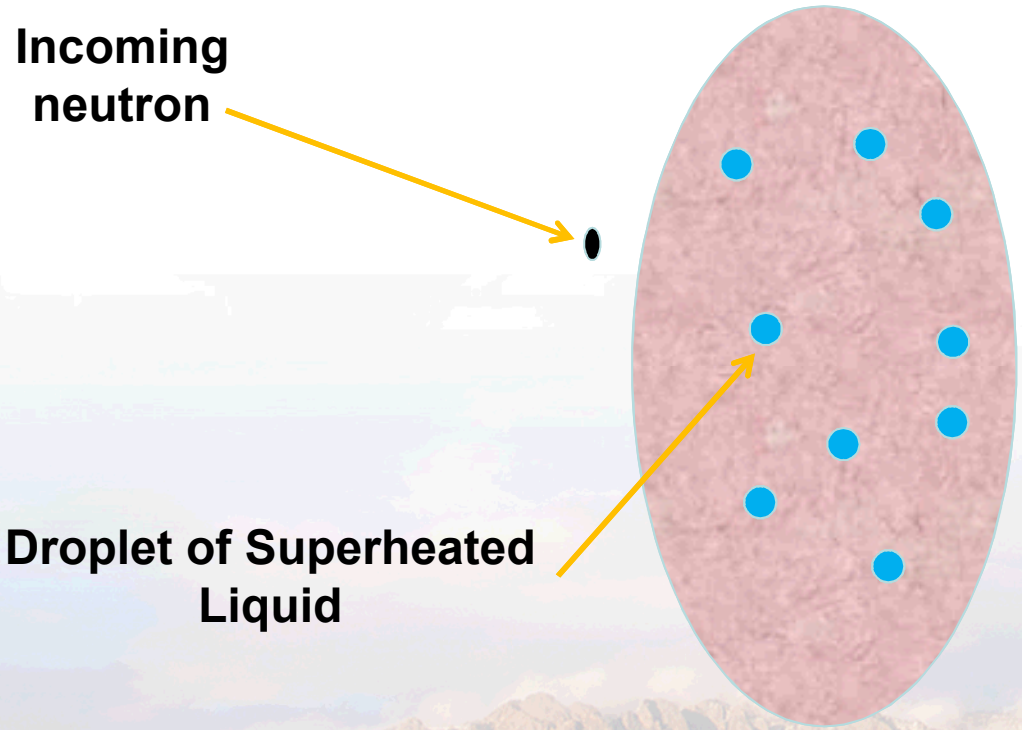
Approach

- Try and use Superheated Drop (Bubble) detectors to obtain neutron energy spectrum and an estimate of total fluence.
- Use this information to calculate a Dose Equivalent value.
- Not able to use Bonner Spheres

Super Heated Drop Detectors?

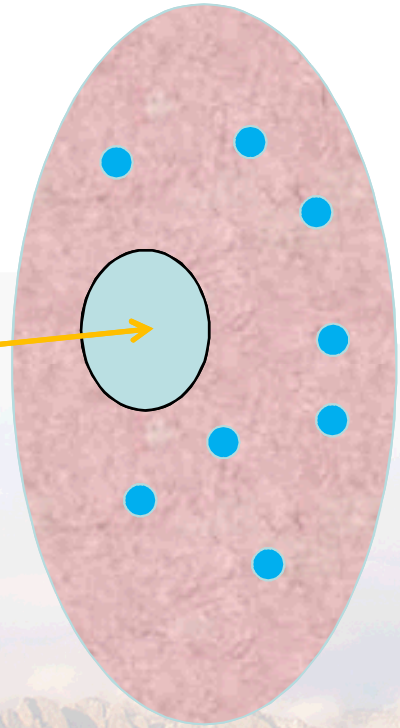


Super Heated Drop Detectors?

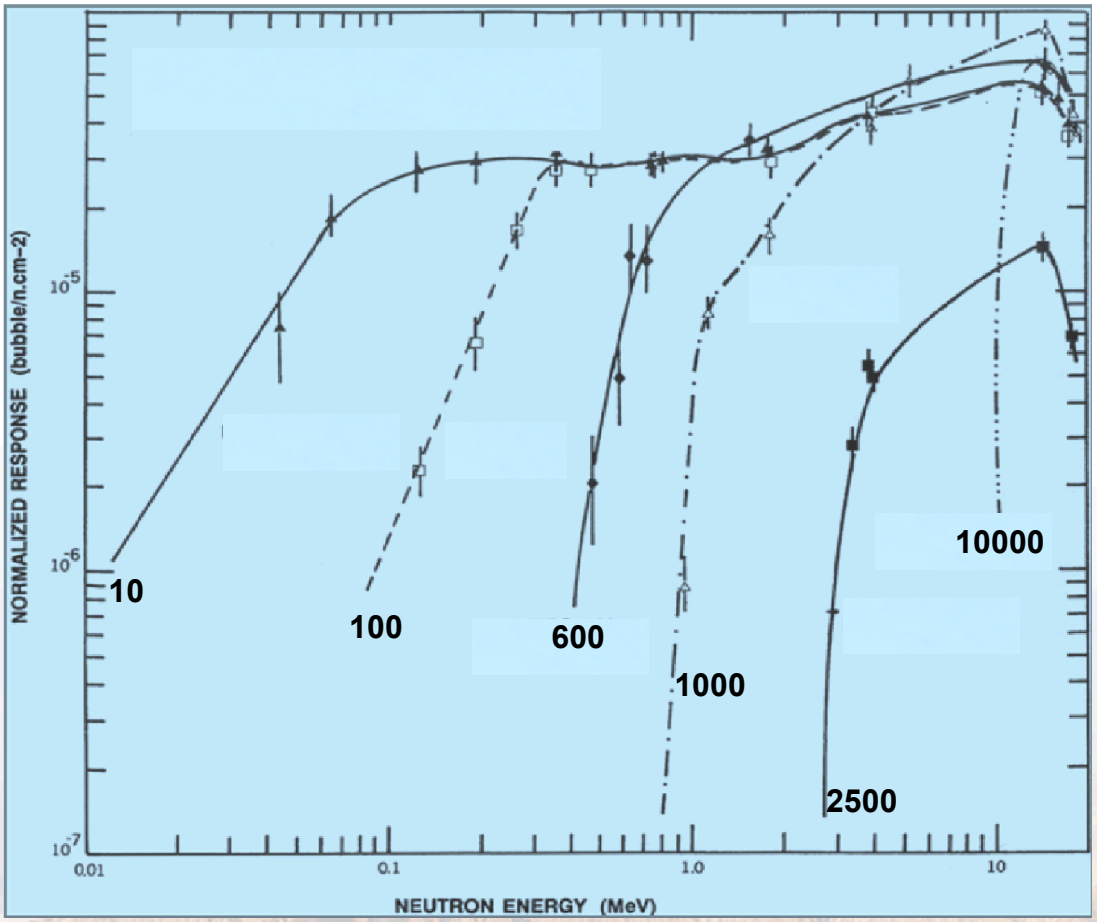


Super Heated Drop Detectors?

Energy of recoil charged particle causes droplet to vaporize and create a bubble



Detector Response Functions

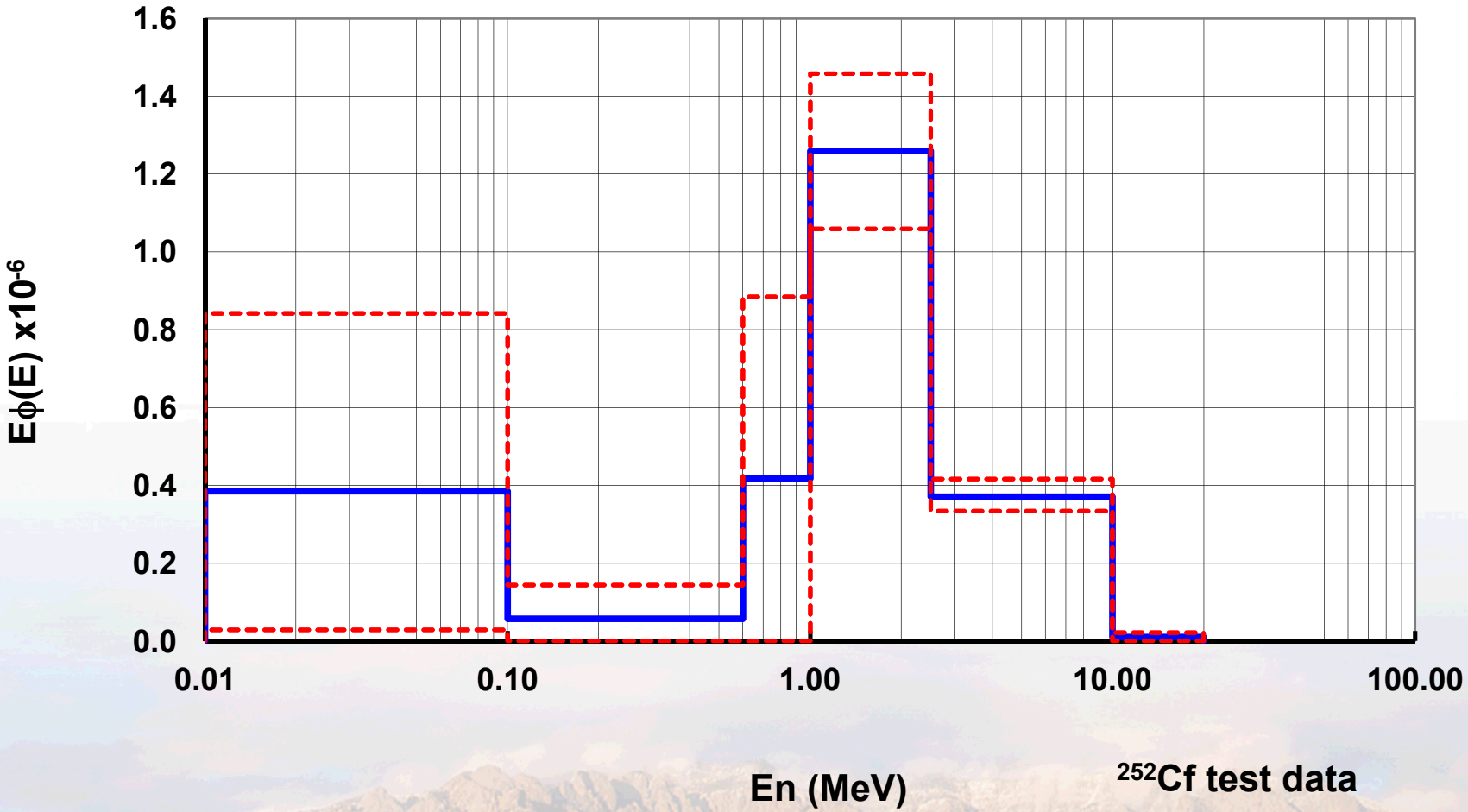


Energy Bin thresholds: (keV)

10,
100,
600,
1000,
2500,
10000

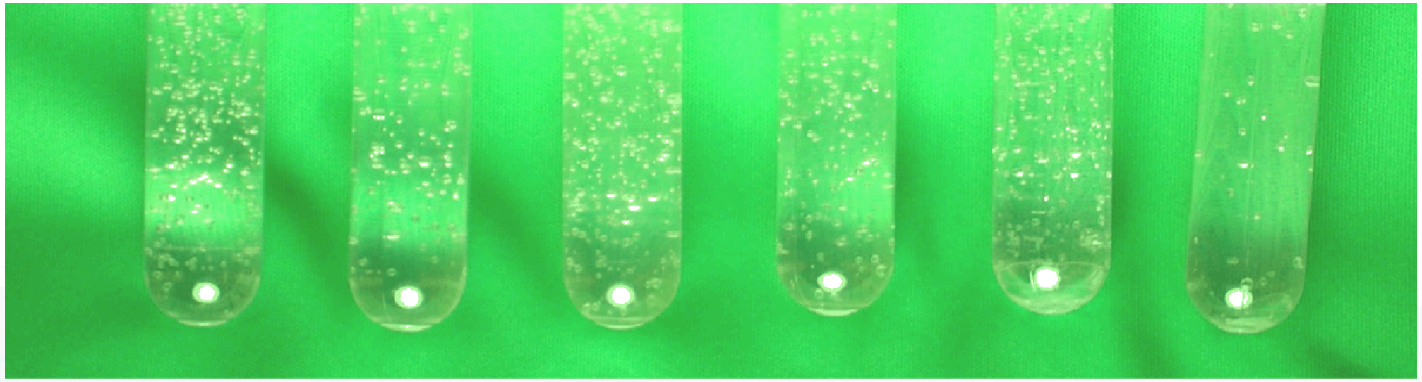
Positive Unfolded Data

Unfolded Spectrum



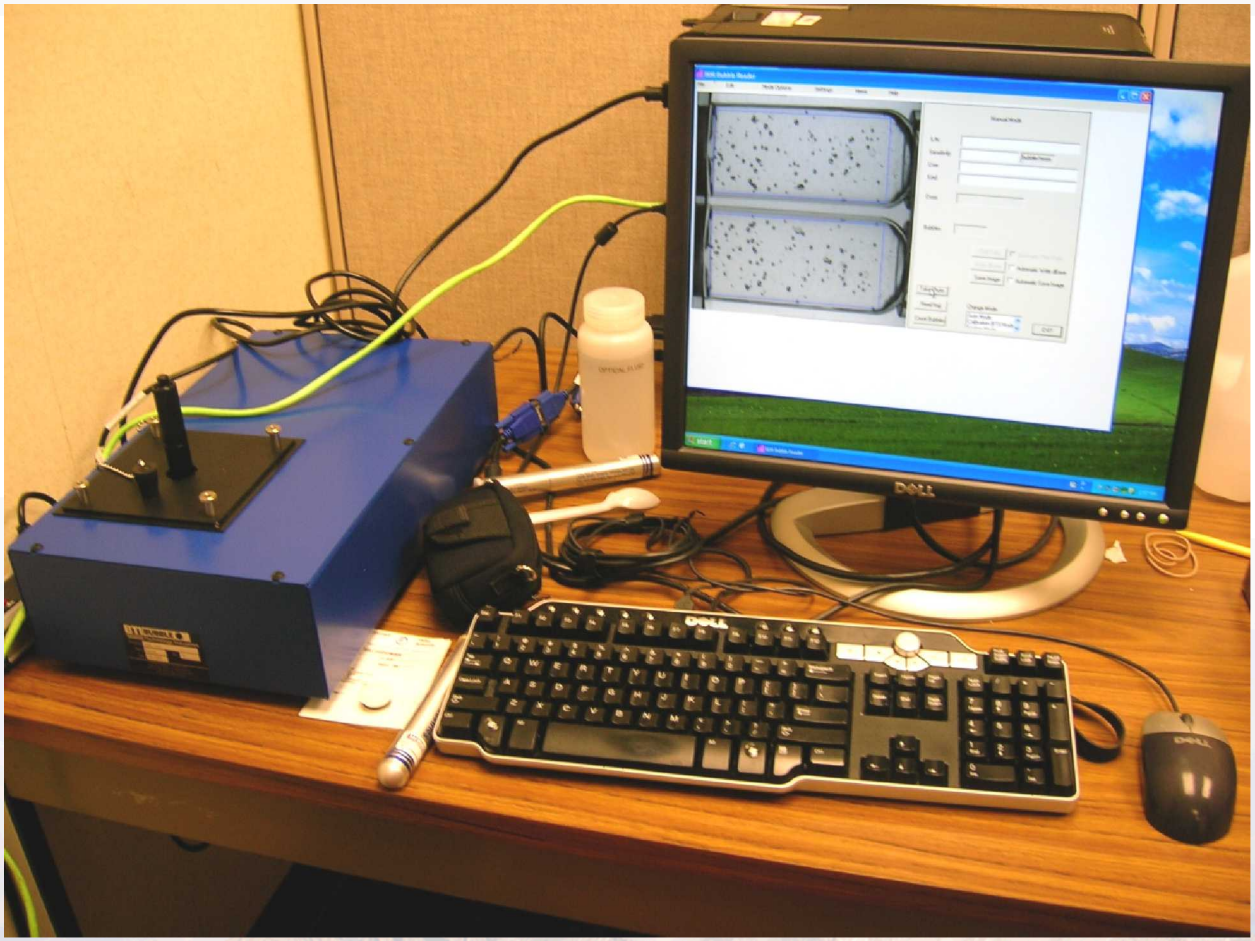
Exposed Detectors

0.01 – 0.1 MeV	0.1 – 0.6 MeV	0.6 – 1 MeV	1 – 2.5 MeV	2.5 – 10 MeV	≥10 MeV

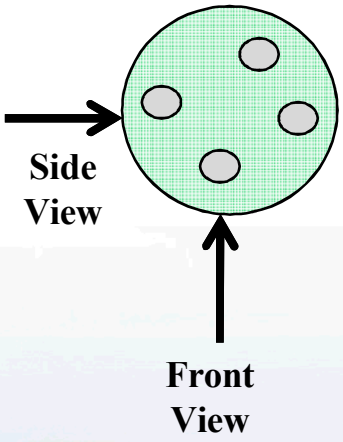


Set exposed to a PuBe Source
in the SNL Neutron Calibration Facility, Bldg 818.

Automated Counting



Screen Shot of Counting Process



Must Compress Tubes to Re-Zero

Tubes are uncapped and placed in the black holders.

Holders are stacked and inserted into the re-compression chamber.

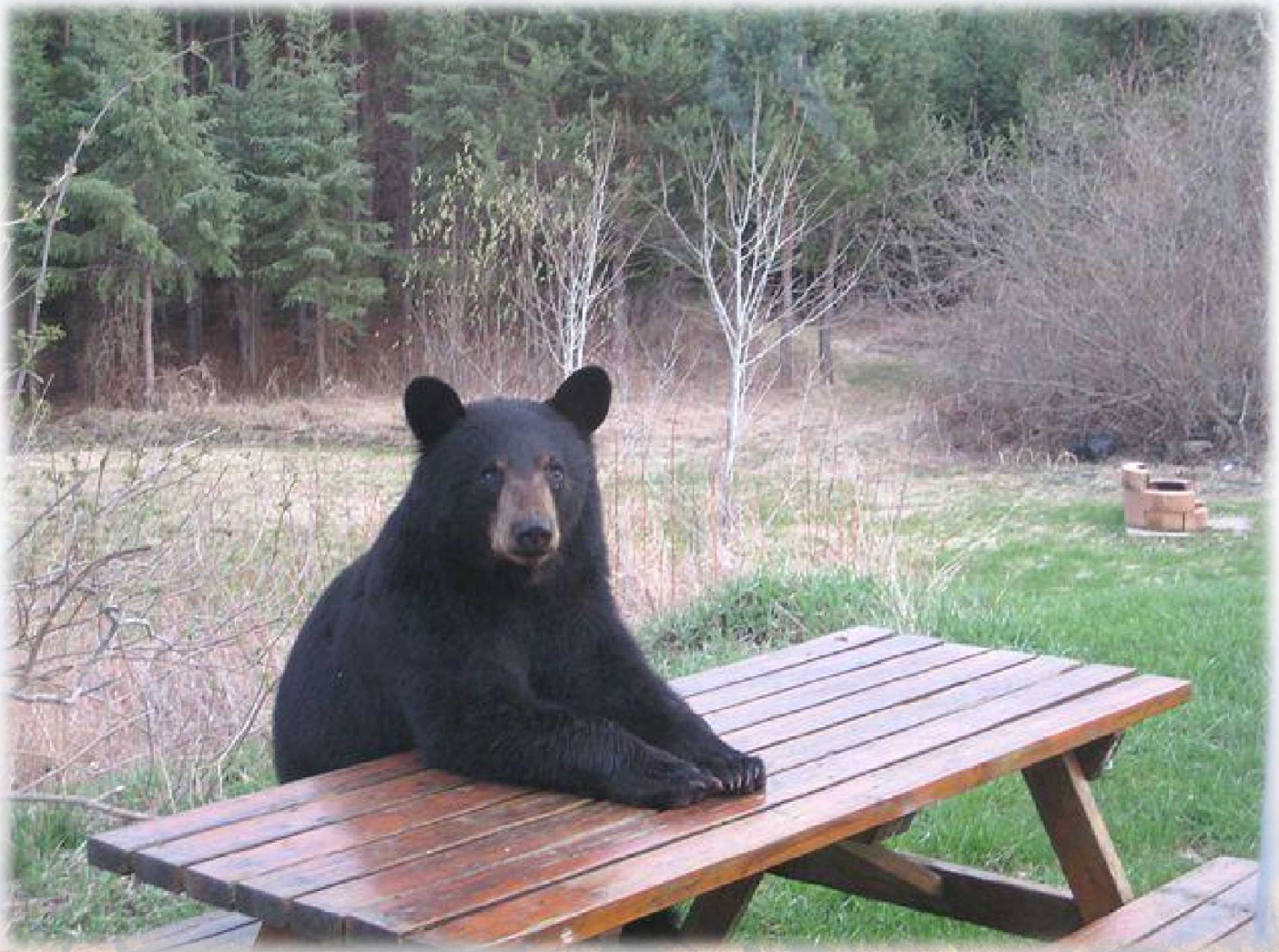
The chamber is filled with distilled water and sealed.

The handle is screwed down until there is a pressure of 400 psi on the gauge.

Operational Issues

- Temperature Sensitivity: 20^{o} C ± 0.5
- Must recompress periodically: Weekly
- Detector Lifetime: Few months after activation
- Data Processing: Within a few hours of exposure

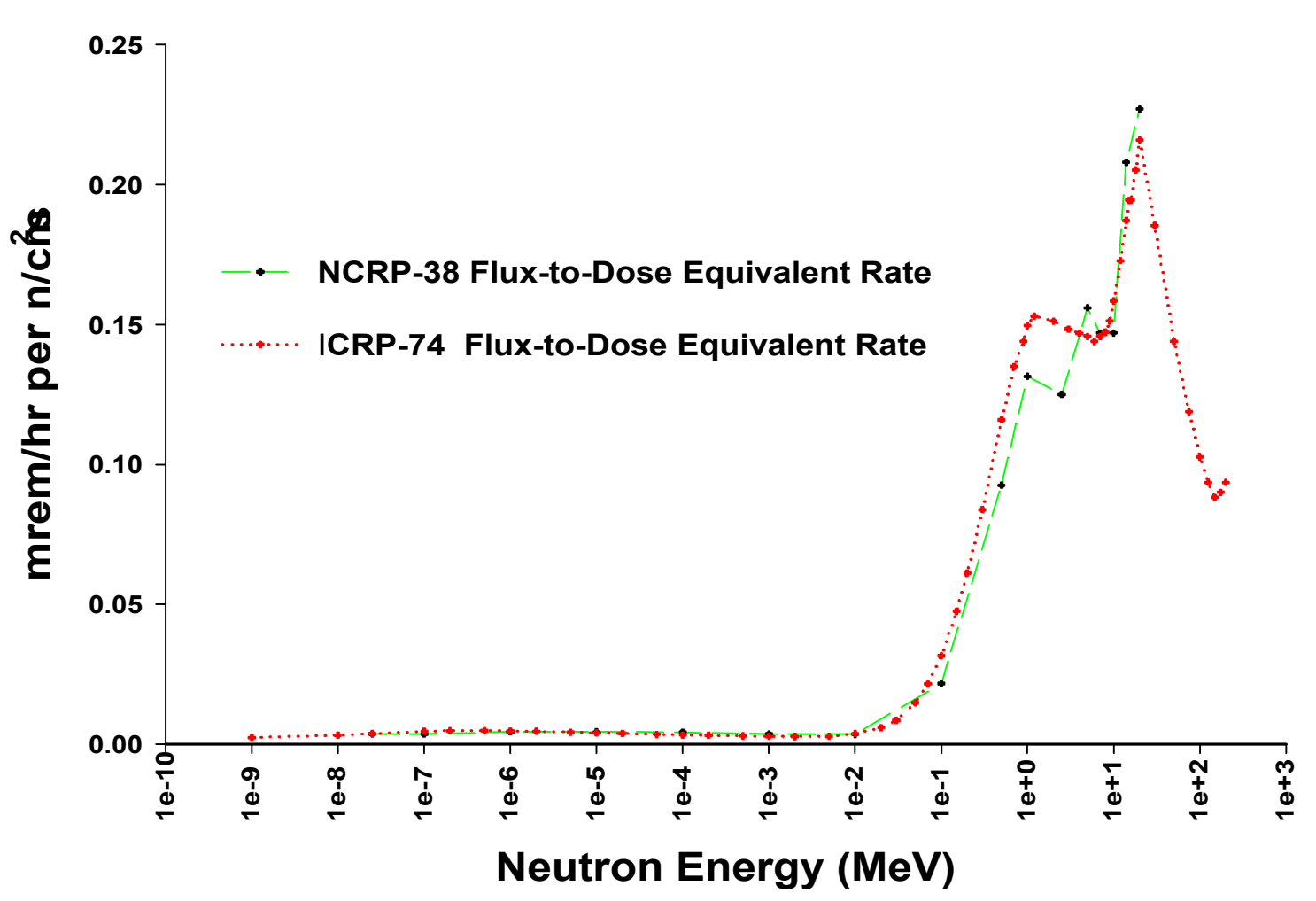
Questions?



Example Dose Calculation

$$\frac{\textit{Ambient Dose Equivalent}}{\textit{per unit neutron fluence}} * \textit{fluence} = \textit{Dose Equivalent}$$

REGION (MEV)	FLUENCE (N CM-2)	pSv/ncm-2	μSv/ncm-2	μSv	% of total
0.01-.1	8.84E+05	4.58E+01	4.58E-05	40.50	5%
.1-.6	1.02E+05	3.10E+02	3.10E-04	31.52	4%
.6-1.0	2.13E+05	3.90E+02	3.90E-04	83.01	10%
1.0-2.5	1.15E+06	4.20E+02	4.20E-04	484.43	57%
2.5-10	5.13E+05	4.01E+02	4.01E-04	205.57	24%
10-20	7.27E+03	5.40E+02	5.40E-04	3.93	0%
				848.95	100%


0.25
0.20
0.15
0.10
0.05
0.00
mrem/hr per n/cm2s
NCRP-38 Flux-to-Dose Equivalent Rate
ICRP-74 Flux-to-Dose Equivalent Rate
1e-10
1e-9
1e-8
1e-7
1e-6
1e-5
1e-4
1e-3
1e-2
1e-1
1e+0
1e+1
1e+2
1e+3
Neutron Energy (MeV)