NPL
National Physical Laboratory

A Simulated Neutron Workplace Field at NPL

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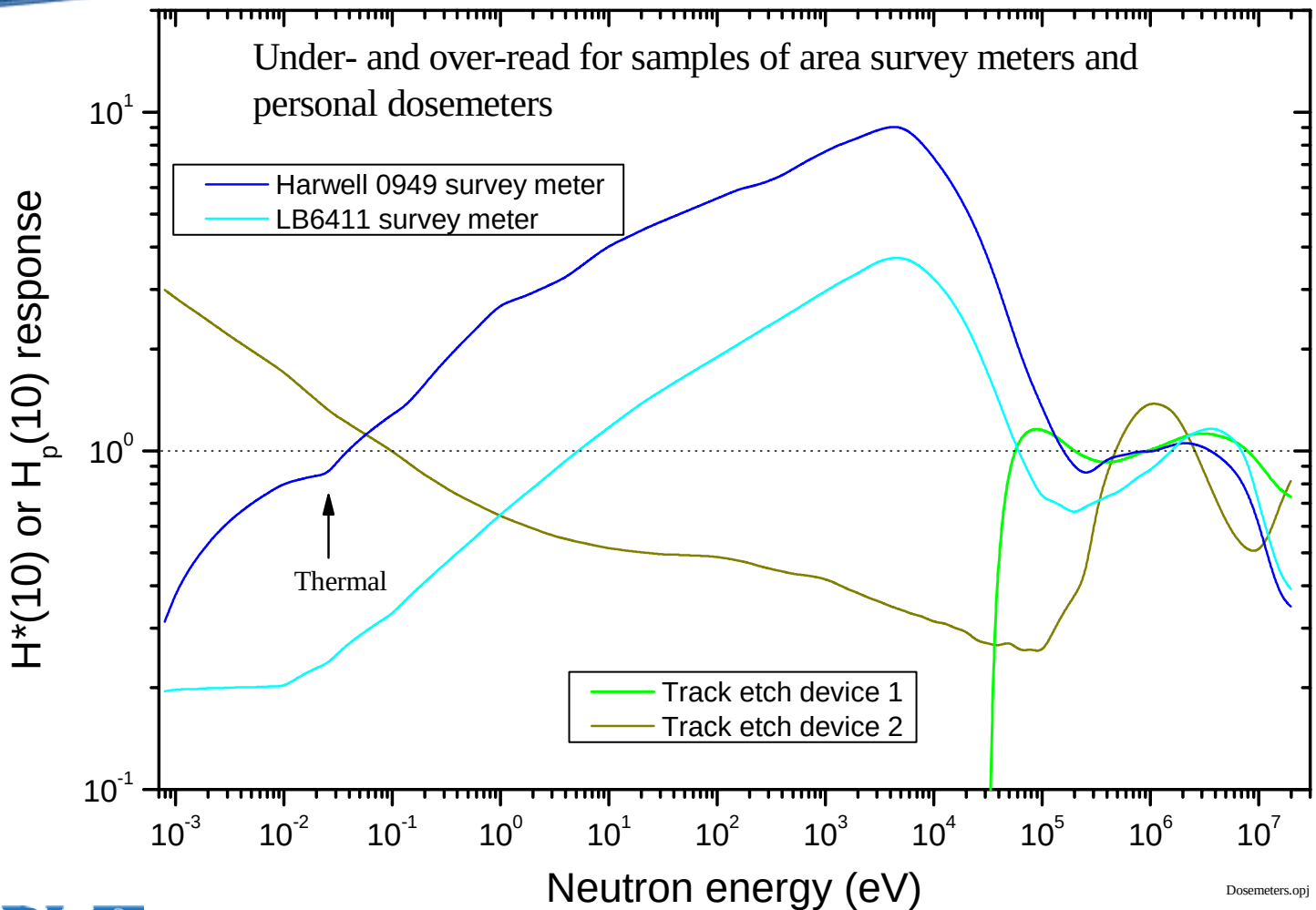
Introduction

1. Rationale – why establish simulated neutron workplace fields.

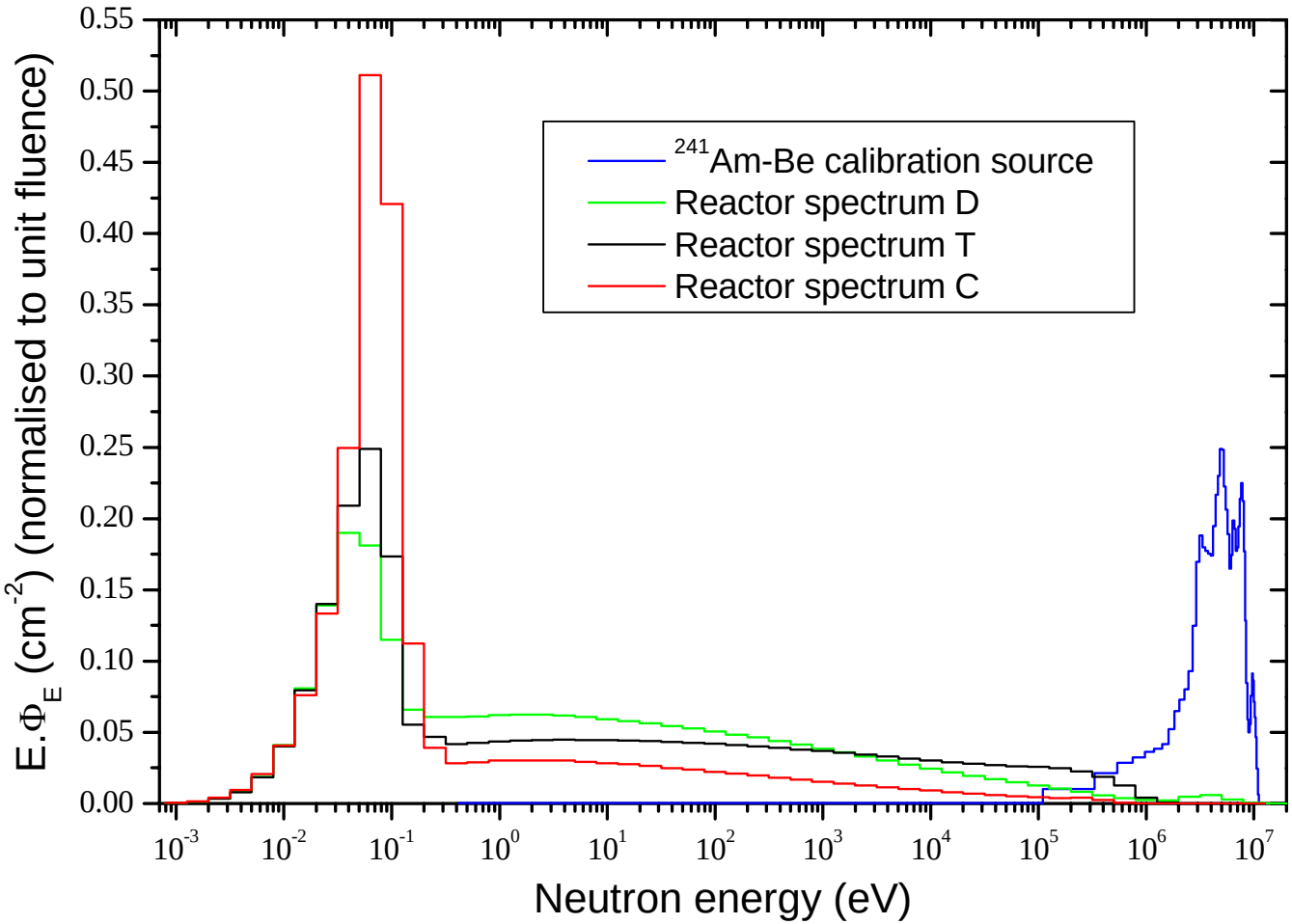
2. The approach to realising the NPL simulated workplace field.

3. Preliminary results of an exercise to irradiate a range of survey instrument, personal dosemeters and spectrometers.

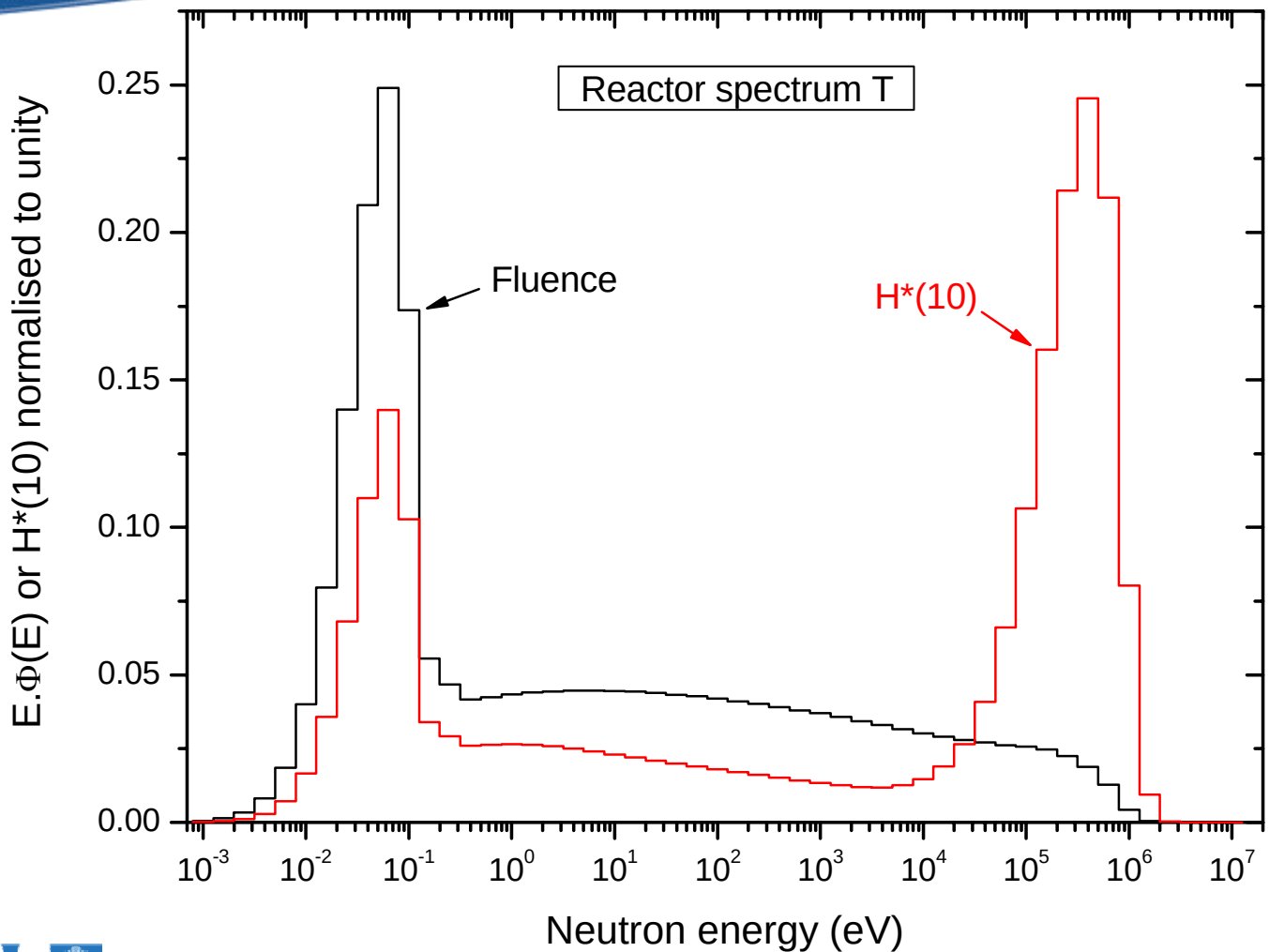
Rationale survey meter and dosemeter properties



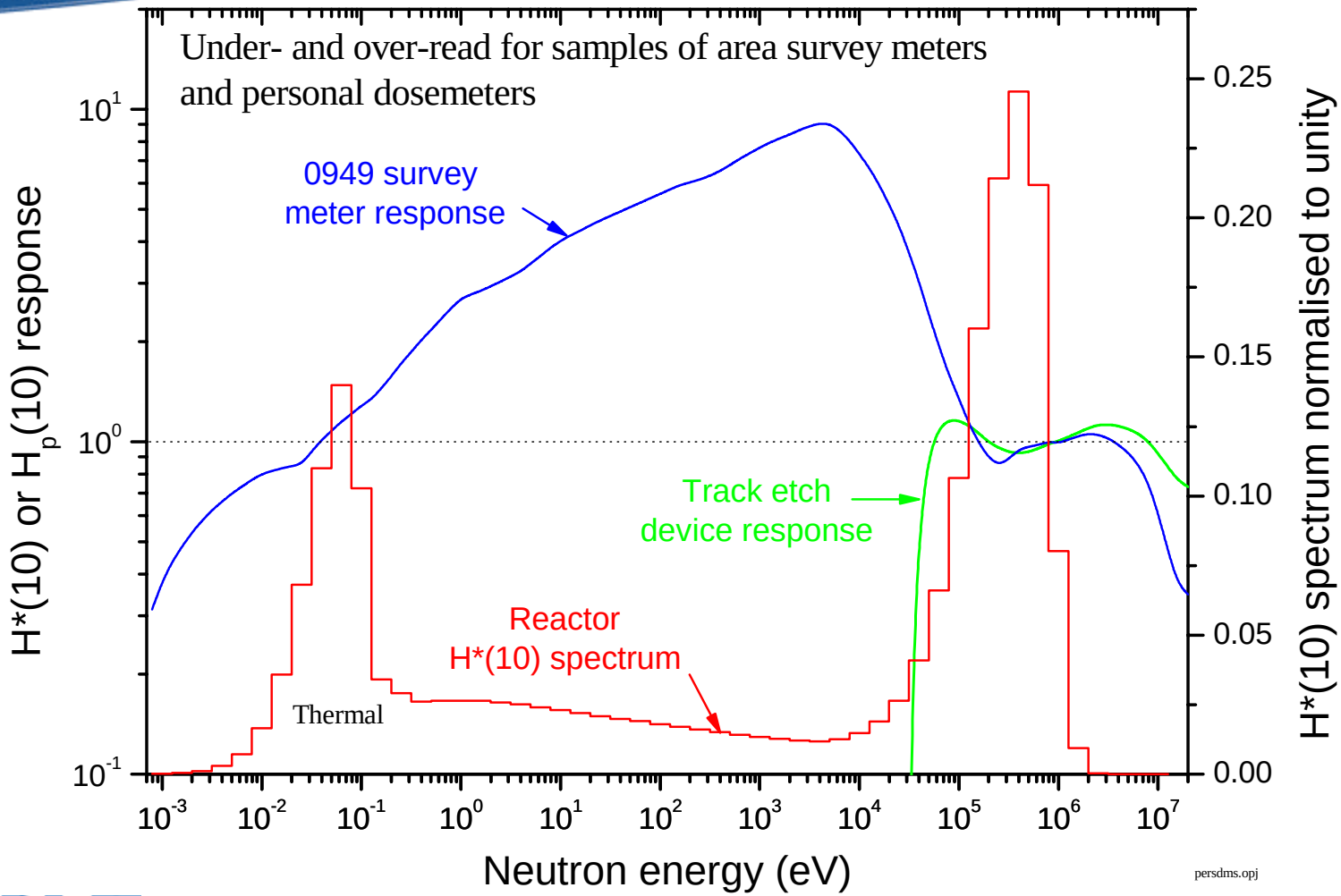
Workplace neutron spectra



Fluence and H*(10) spectra



Potential under- and over-response – hence need for simulated fields

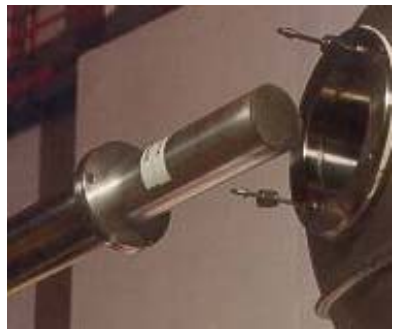


Approach to simulating a low-energy field

- Start with a low-energy source of neutrons.The $^{7}Li(p,n)^{7}Be$ reaction produces neutrons in the 30keV to 1.3MeV energy region for proton bombarding energies between 1.9 and 3 MeV.
- Use a thick lithium target to get a broad neutron energy distribution and a high fluence.
- Heavy water, D_2O, is an excellent moderator and was available so surround source with sphere of D_2O.
- Monte Carlo calculations showed that this approach can produce spectra with the required characteristics.

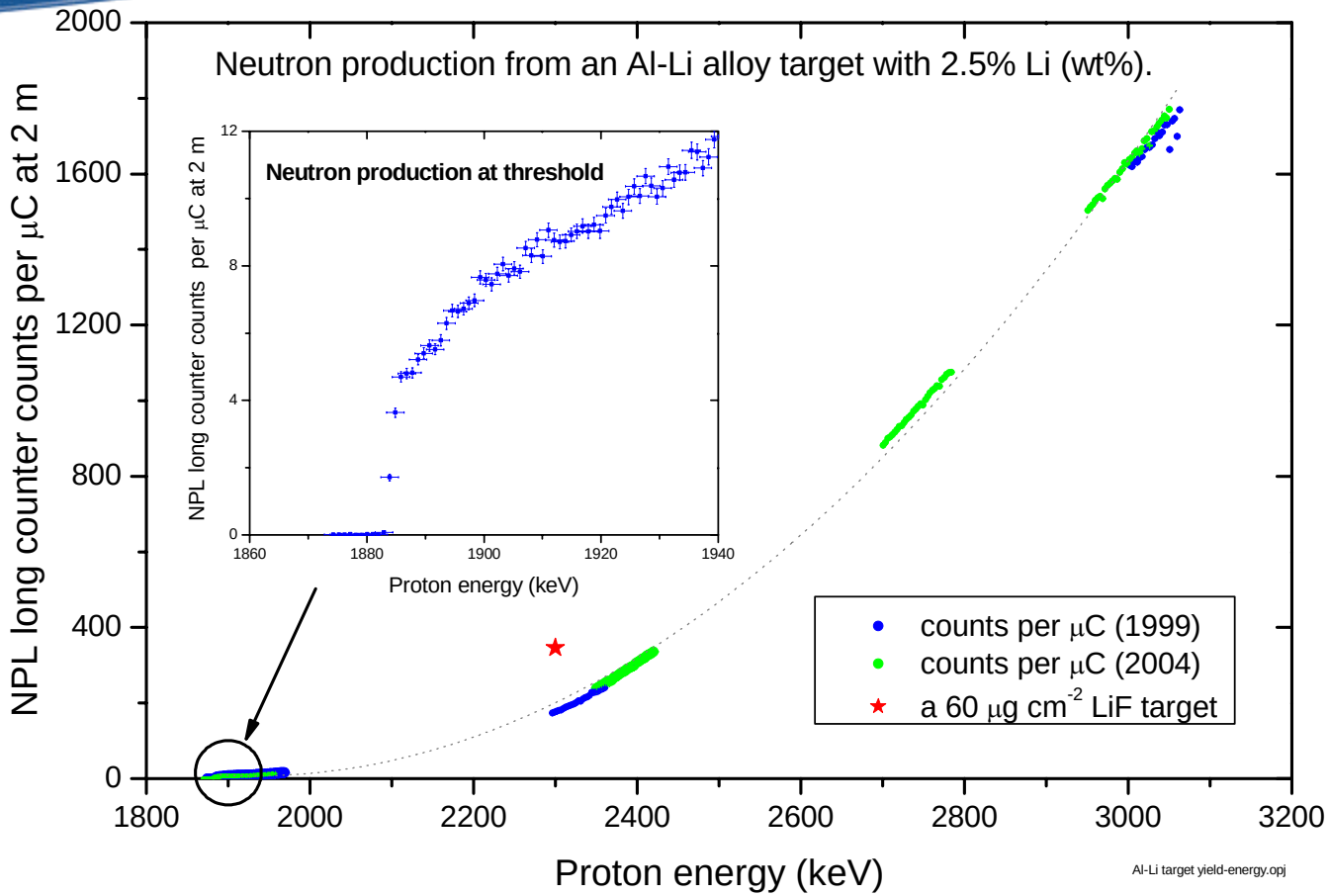
NPL simulated field facility

How do we make a thick lithium target?



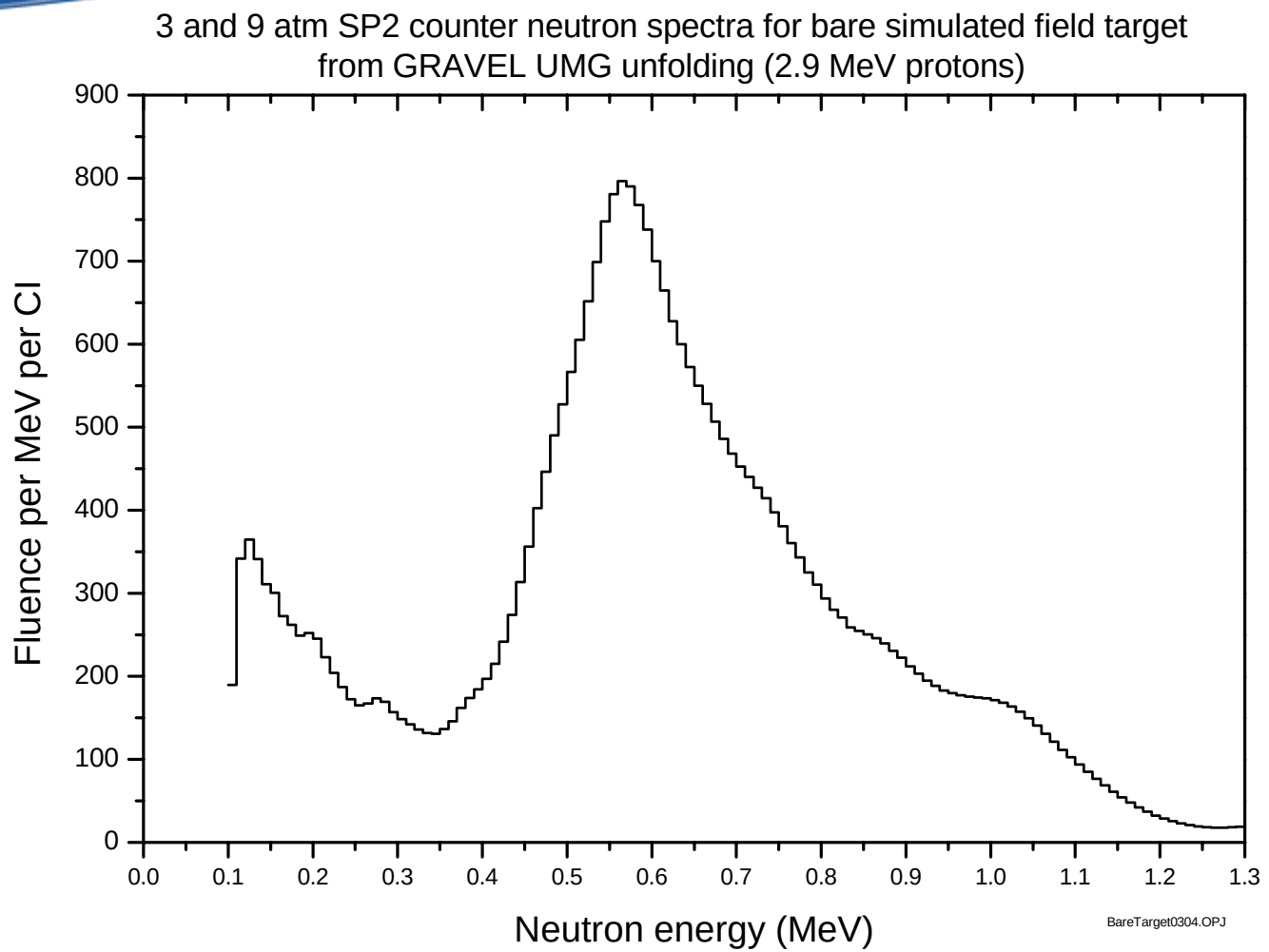
- **One major problem was finding a suitable lithium target :–**
  - **Metal is out of question because of its chemical properties**
  - **Not possible to make thick and stable LiF layers**
  - **Solution was a piece of Al-Li alloy (2.5% Li by wt) which acts as a good ‘thick’ target**

Li target yield *v* energy

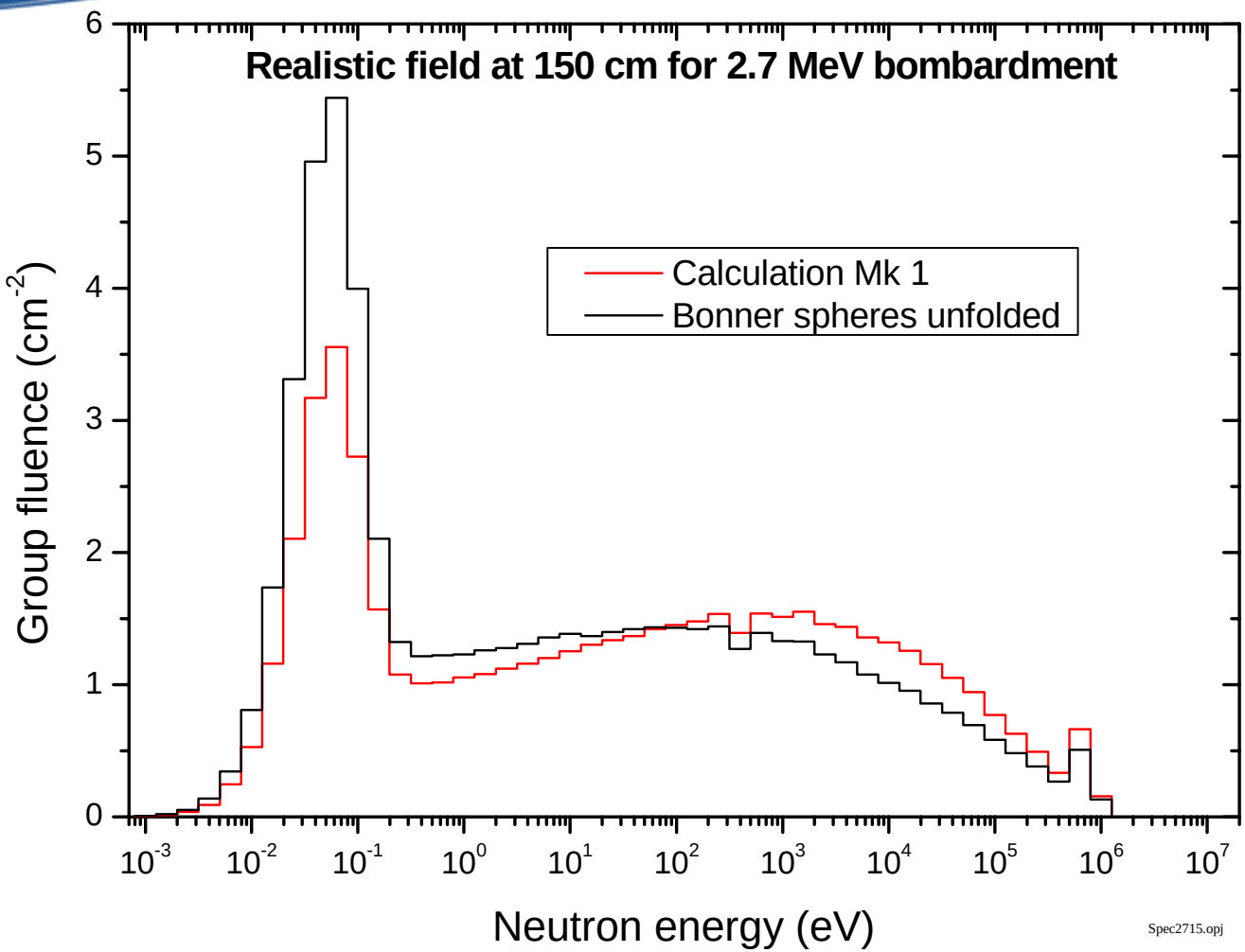


Note: a 60 μg cm^{-2} thick LiF target bombarded with 2.3 MeV protons to produce 565 keV neutrons gives a fluence of about 25 cm^{-2} per μC at 200 cm.

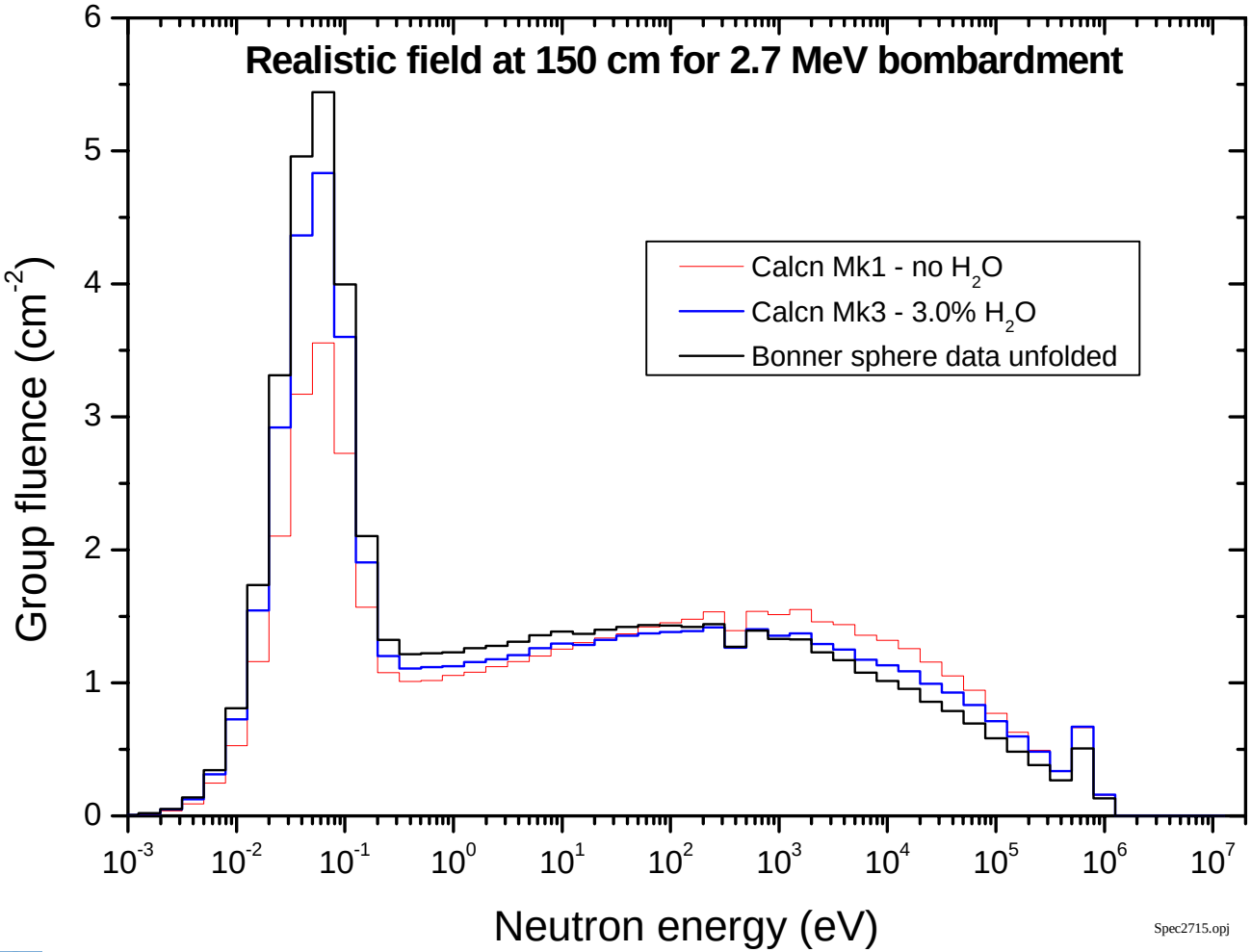
Primary neutron spectrum from bare lithium target



Simulated field spectrum Calculation Mk1



Simulated field spectrum calculation with 3% H_2O



Monitoring

- **Monitoring:-**
  - **Current on target**
  - **‘Slab’ detector**
  - **NPL long counter**
- **Good to the order of 1-2%**

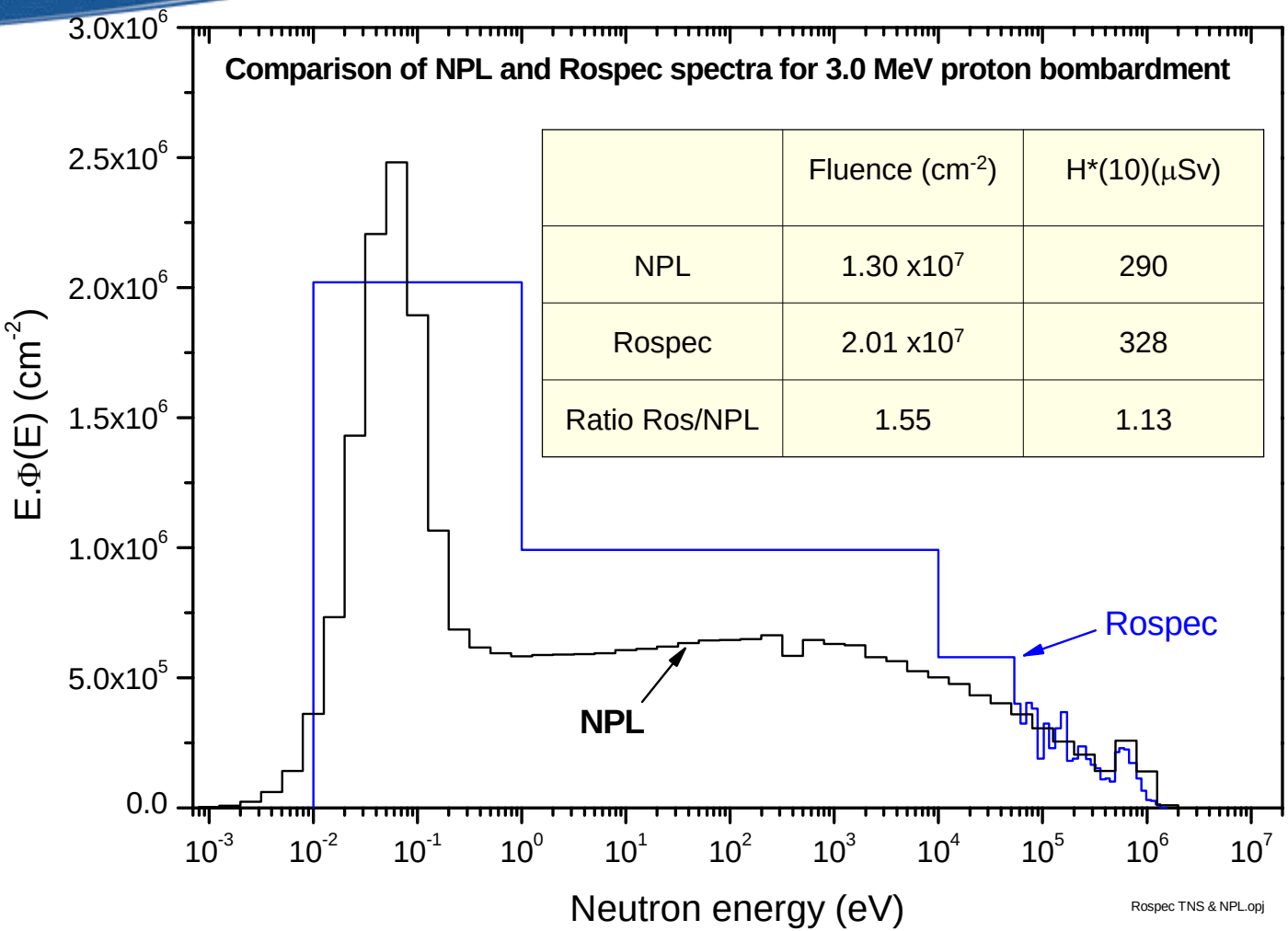
Fluence and dose equivalent rates

Proton energy (MeV)	Distance from target (cm)	Fluence rate ($cm^{-2}\ s^{-1}\ \mu A^{-1}$)	H*(10) rate ($\mu Sv\ h^{-1}\ \mu A^{-1}$)	H*(10)/Φ (pSv cm)
2.7	150	59.9	4.33	20.1
2.7	300	19.2	1.23	17.9
3.0	150	113	9.06	22.3
3.0	300	36.4	2.72	20.8

Comparison exercise

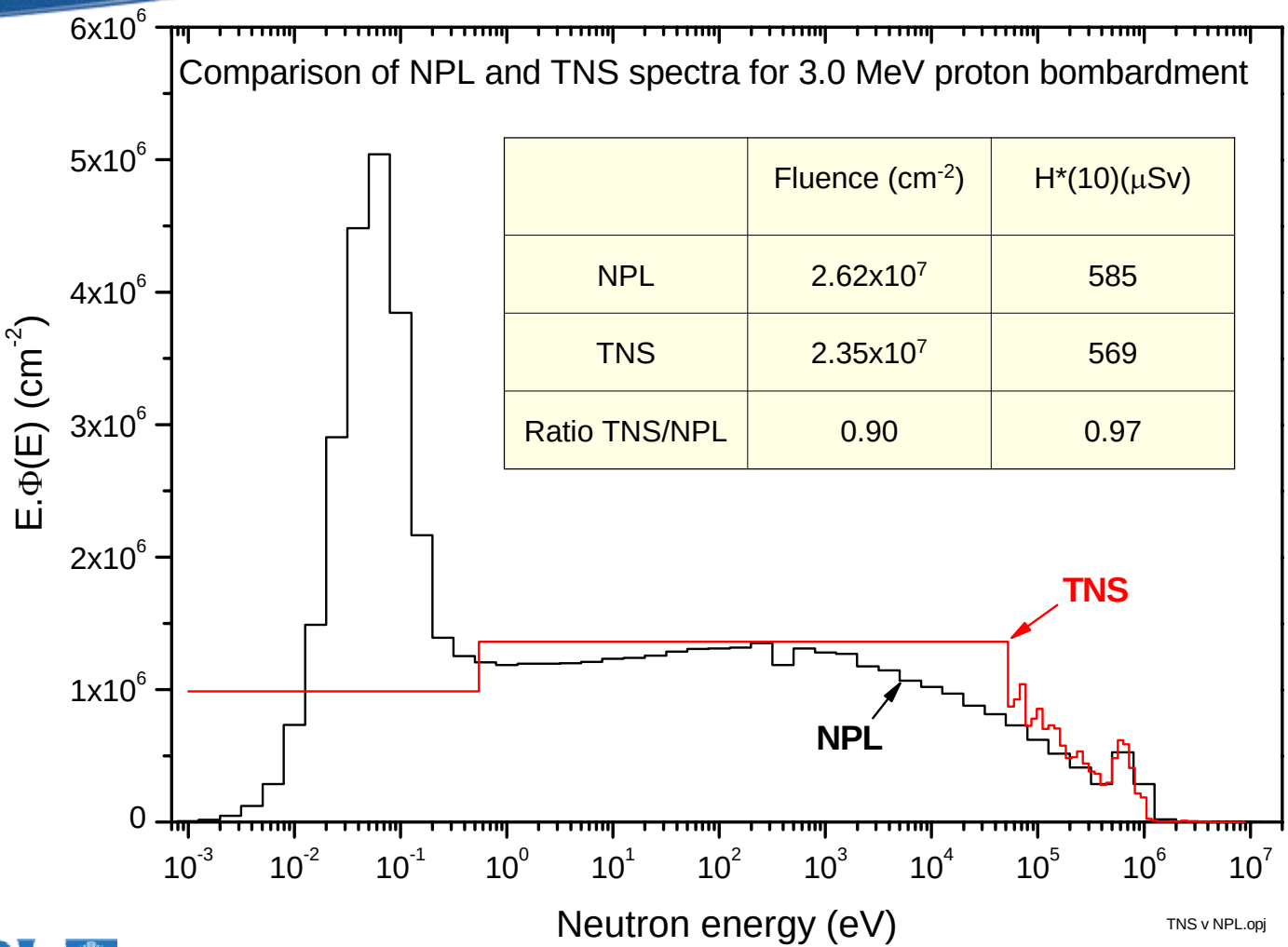
Dates	Participant	Instrument(s)
4-6 May 04	Los Alamos/Sultan	ROSPEC
6-7 July 04	BAE systems	TNS, Duo spheres, NMS017
8 July 04	Lancaster Univ.	EPD-N2, Hybrid survey meter
8-13 July 04	NPL	0949, NM2, Hawk, Bubble dets
14-16 July 04	DSTL	Passive dosemeters
20-21 July 04	NRPB	Passive dosemeters

Rospec spectrum



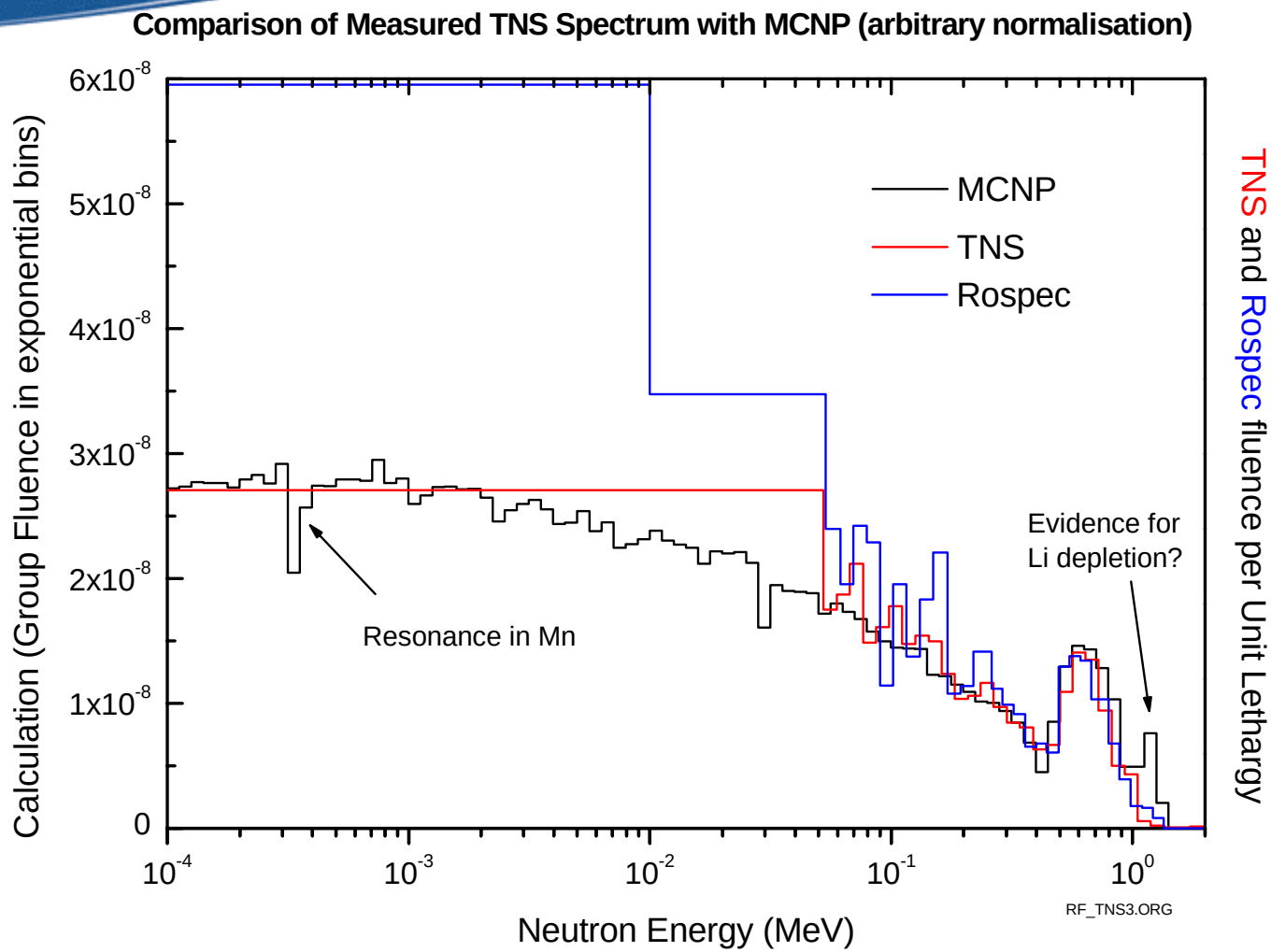
	Fluence (cm^{-2})	H*(10)(μSv)
NPL	1.30 x10^7	290
Rospec	2.01 x10^7	328
Ratio Ros/NPL	1.55	1.13

TNS spectrum



	Fluence (cm^{-2})	H*(10)(μSv)
NPL	2.62×10^7	585
TNS	2.35×10^7	569
Ratio TNS/NPL	0.90	0.97

TNS, Rospec, and calculated spectrum - high energy detail

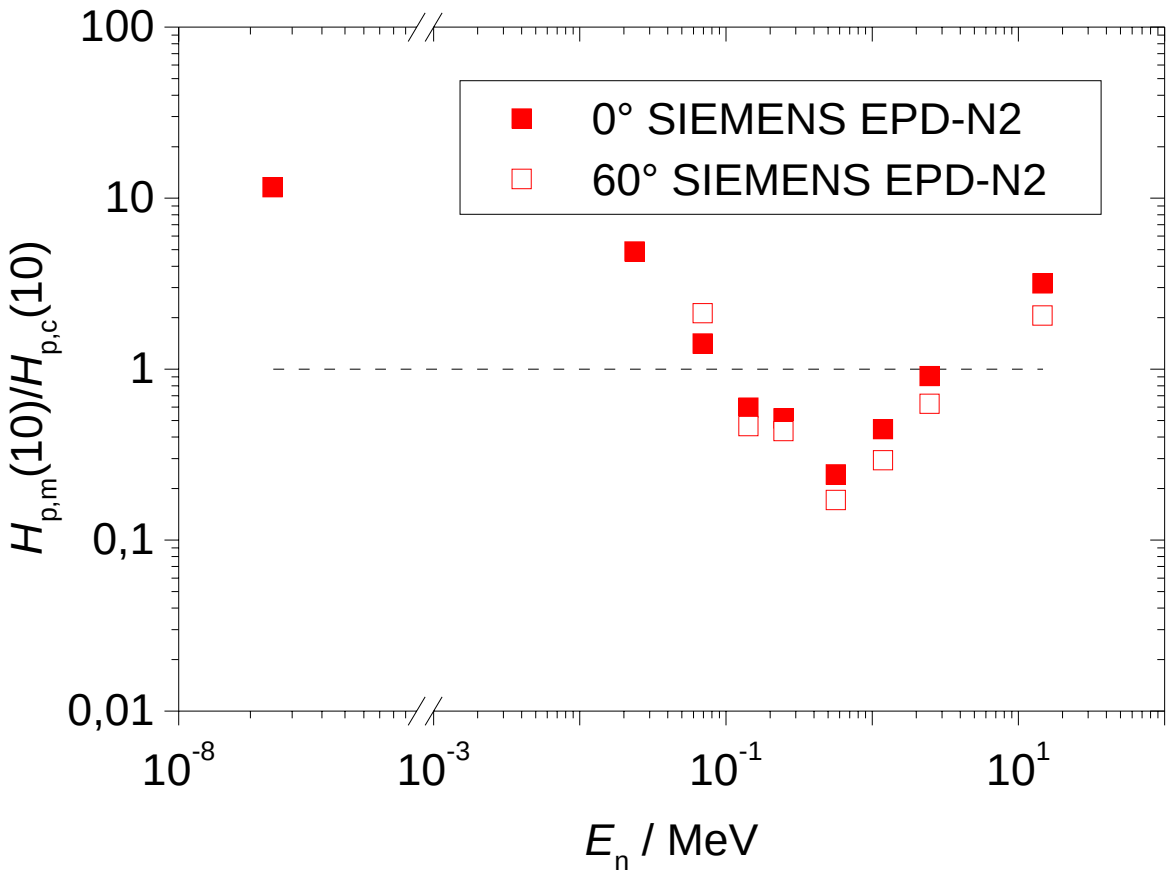


Duo-sphere results

	Measurement 1	Measurement 2
NPL H*(10)	13.4 μSv	14.1 μSv
Duo-sphere H*(10)	14.1 μSv	14.4 μSv
Ratio: Duo/NPL	1.05	1.02

EPD-N2 Results (Lancaster)

EPD-N2/NPL	
EPD1	**6.30**
EPD2	**6.35**
EPD3	**5.02**
EPD4	**5.75**
EPD5	**5.74**
EPD6	**5.41**
Mean =	**5.76**
Stdev =	**8.9%**
seom =	**3.6%**



Harwell 0949 Results

Results for two examples of the Harwell 0949 survey meter								
		Counts per CI pulse				H*(10) (nSv per CI pulse)		
Instrument		Measured	Predicted	Ratio M/P		Measured	Conv. true	Ratio M/'True'
'Research'		4.23	3.36	1.26		4.89	2.52	1.94
H32		3.13	3.36	0.93		3.62	2.52	1.44
		(Predicted using response function						
		from NRPB Report PB/5/2004)						
			Instrumant variation Research/H32					
			From these measurements =			1.35		
			From measurements with jig =			1.27		

Conclusions

- **Simulated field set up and operational:-**
  - **Dose rates are reasonable**
  - **Field is ‘appropriate’ for investigating instrument performance around reactors**
  - **First trial is showing some very interesting results.**
- **End**