

Electronic personal neutron dosemeters for high energies: calculation of pulse height spectra using the PHITS code

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WRMISS 11, Oxford, 6 – 8. Sept. 2006

- ◆ The dosimeters DOS-2002, EPD-N2, ALOKA
- ◆ Mono-energetic neutron response up to 60 MeV
- ◆ Estimation of DOS-2002 response using PHITS
- ◆ Measured and calculated pulse height spectra
- ◆ Thin (6 μm Si) versus thick detector (40 μm Si)
- ◆ Response for 100 MeV protons
- ◆ Further needs

Electronic neutron dosemeters

Thermo Electron EPD-N2
3 silicon detectors (n, γ)



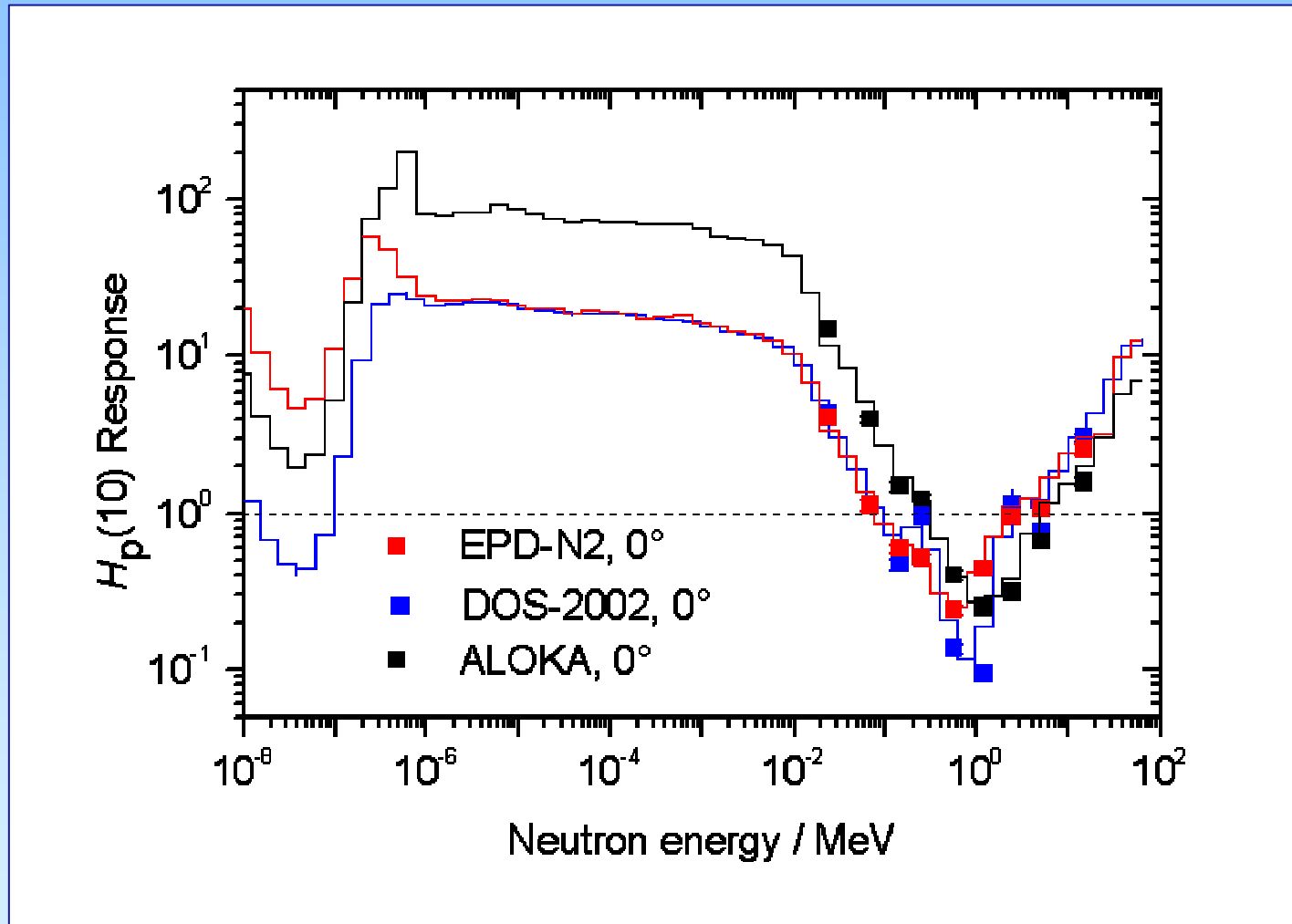
ALoka PDM-313
1 silicon detector (n)



PTB DOS-2002
1 silicon detector (n, γ)

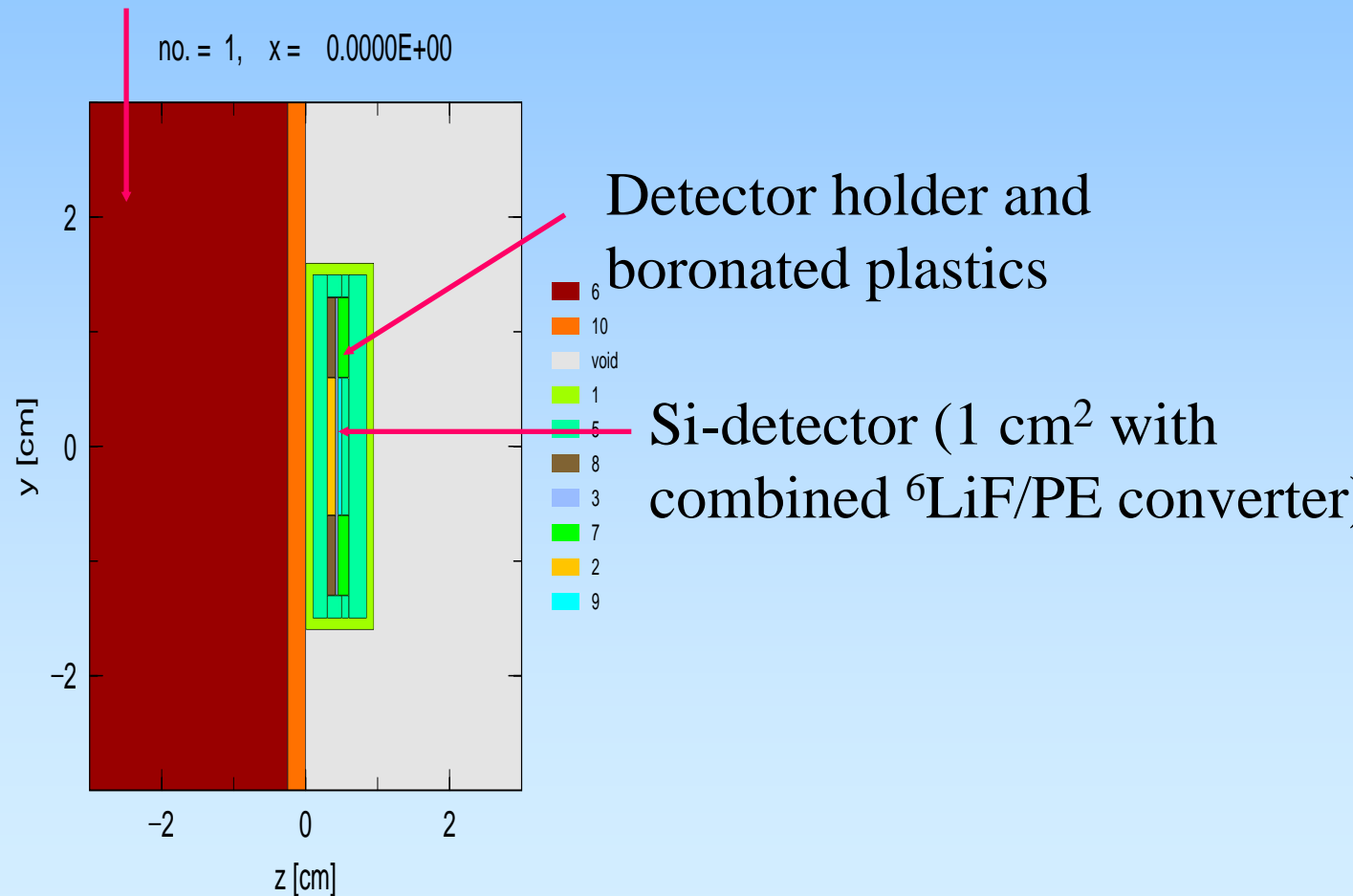


Response obtained by unfolding



- 3D MonteCarlo code
- Transport and collision of all particles
- Neutron, Proton, Meson, Baryon, Electron, Photon, Nucleus
- With wide energy range (up to 200 GeV)
- Developed in Japan (Niita et al.)
- Used for calculations in space and at high-energy accelerators
- For neutrons similar to MCNPX

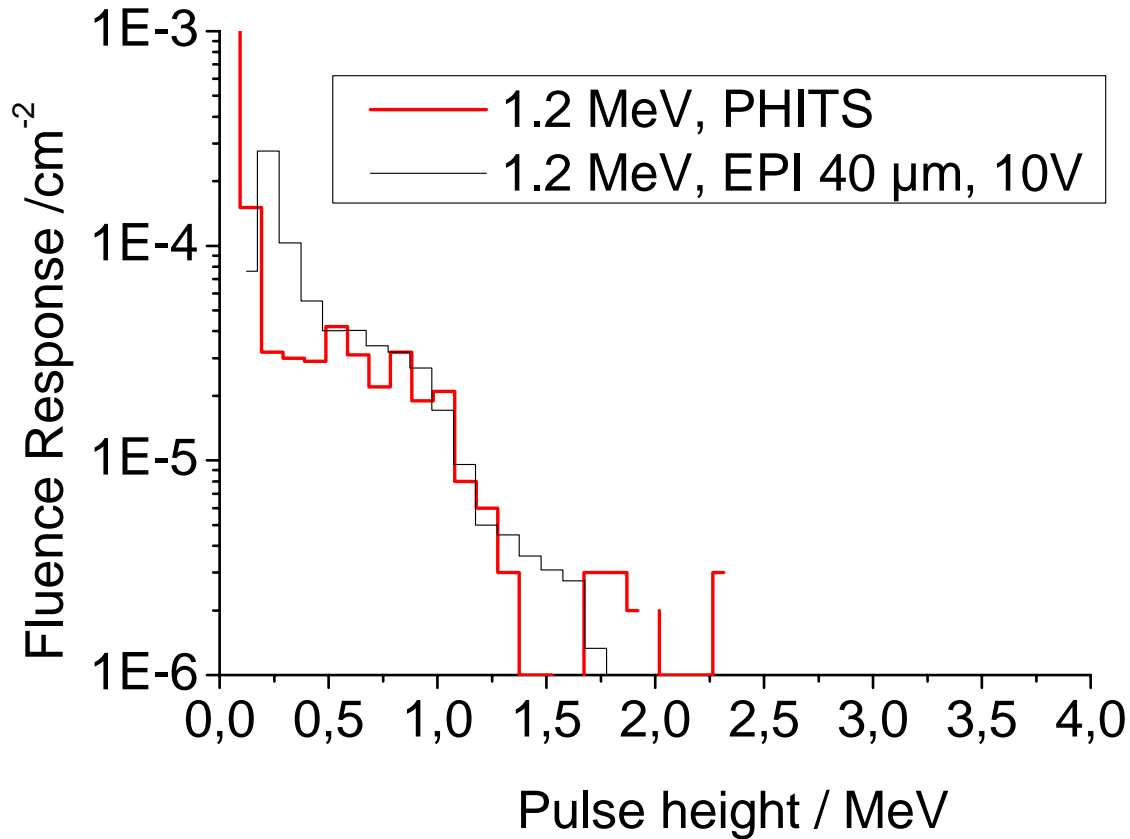
ISO water phantom



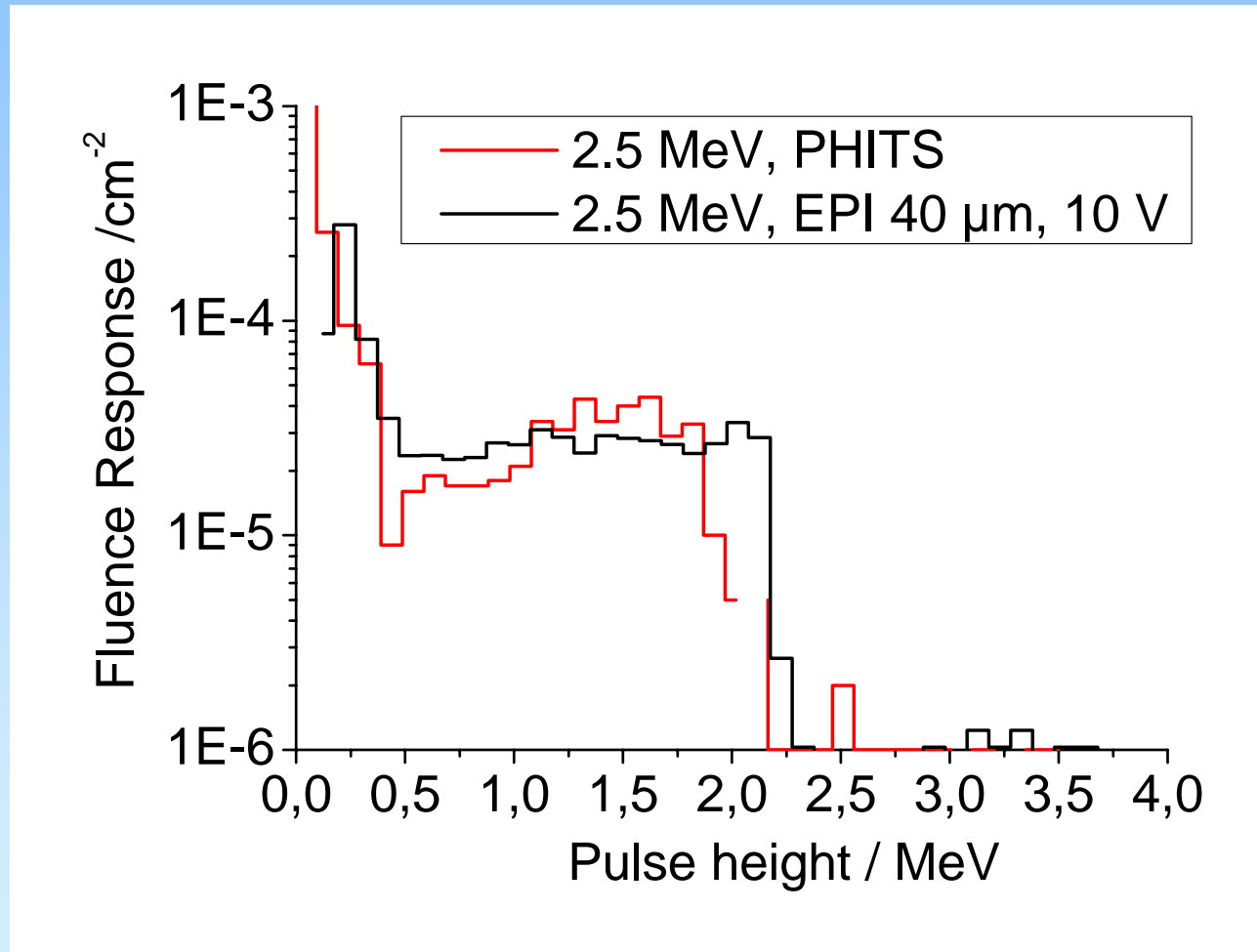
Special Parameters

- **Planar circular source, diam. 10 to 100 cm², normal incidence**
- **Low values of e_{min} to allow transport of all particles**
- **Cross section libraries from MCNPX**
- **In most cases 1.0e6/ cm² incident particles used**

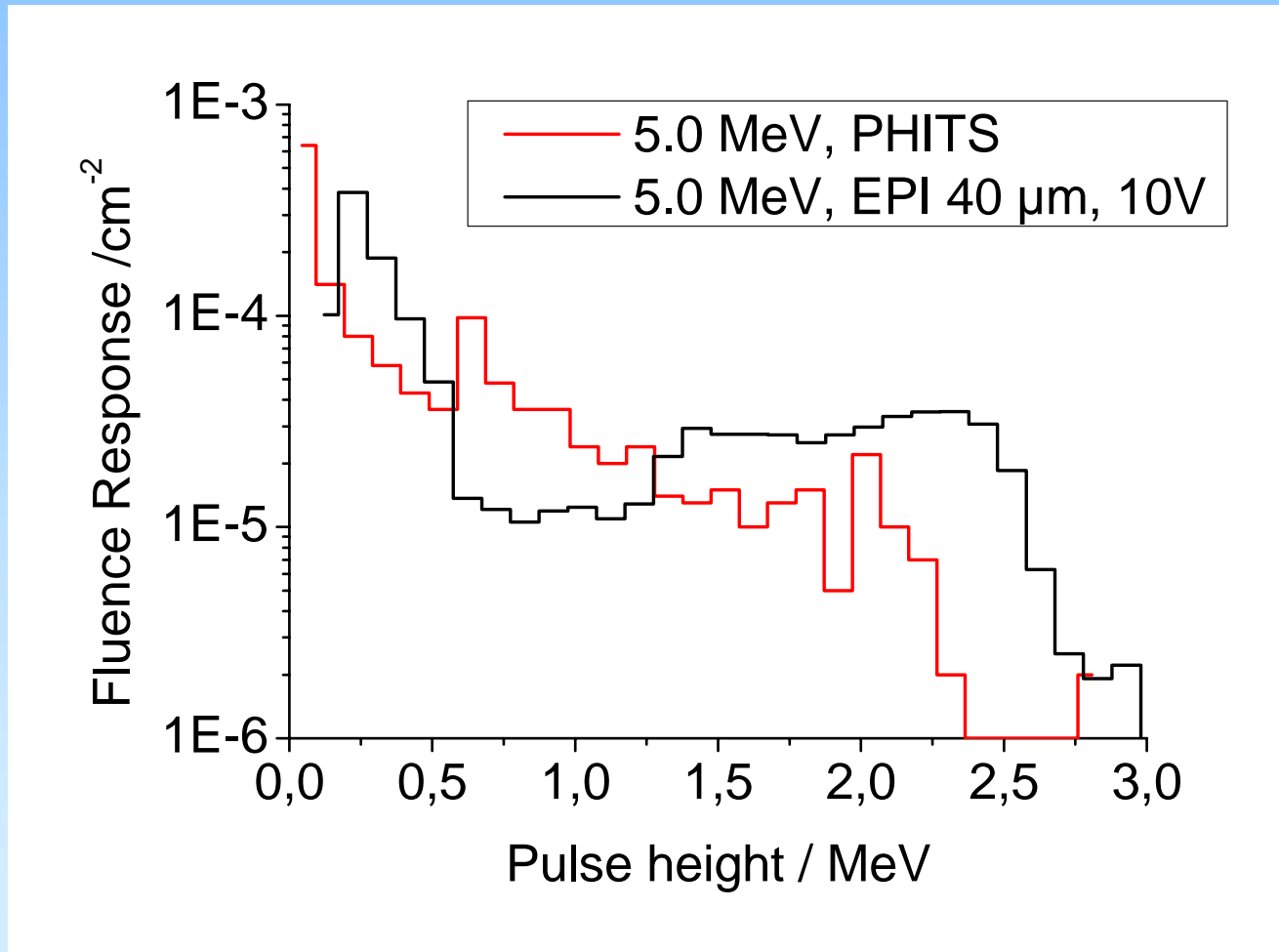
Comparison of measured and calculated pulse height spectra



Comparison of measured and calculated pulse height spectra



Comparison of measured and calculated pulse height spectra

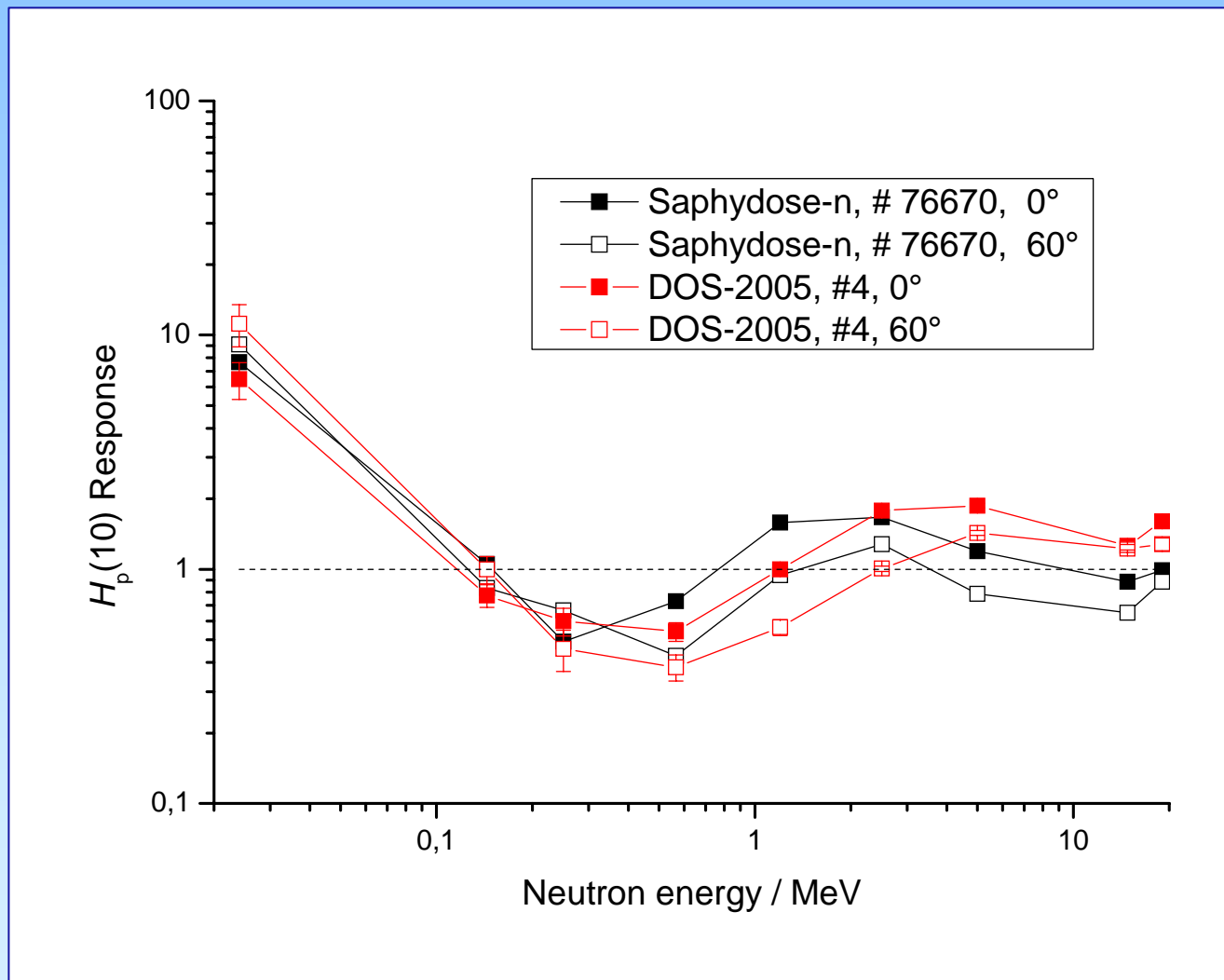


Comparison of measured and calculated fluence response

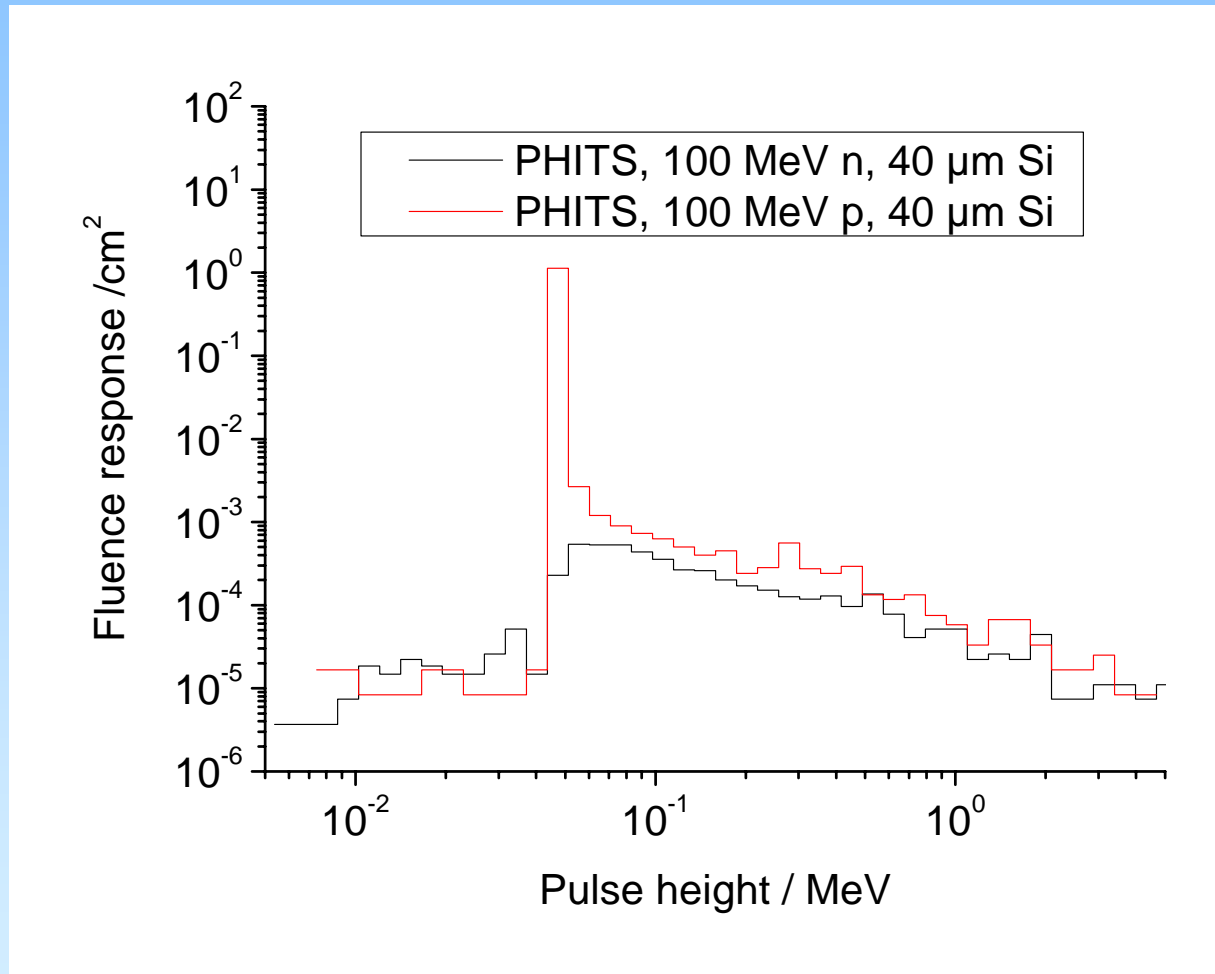
E_n / MeV	DOS-2002, 40 μm Si, 1.13 -1.83 MeV PHITS calculation	DOS-2002, 40 μm Si, 1.13 -1.83 MeV Measurement	$R_{\text{calc}}/R_{\text{meas.}}$
0,144	2,40E-05	3,72E-05	0,65
1,2	1,60E-05	3,00E-05	0,53
2,5	2,61E-04	1,97E-04	1,32
5	1,10E-04	1,59E-04	0,69

- Agreement of absolute responses (no normalization used) satisfactory

Response of Saphydose-n and DOS-2005 (6 μm Si, 200 keV- 1.2 MeV)

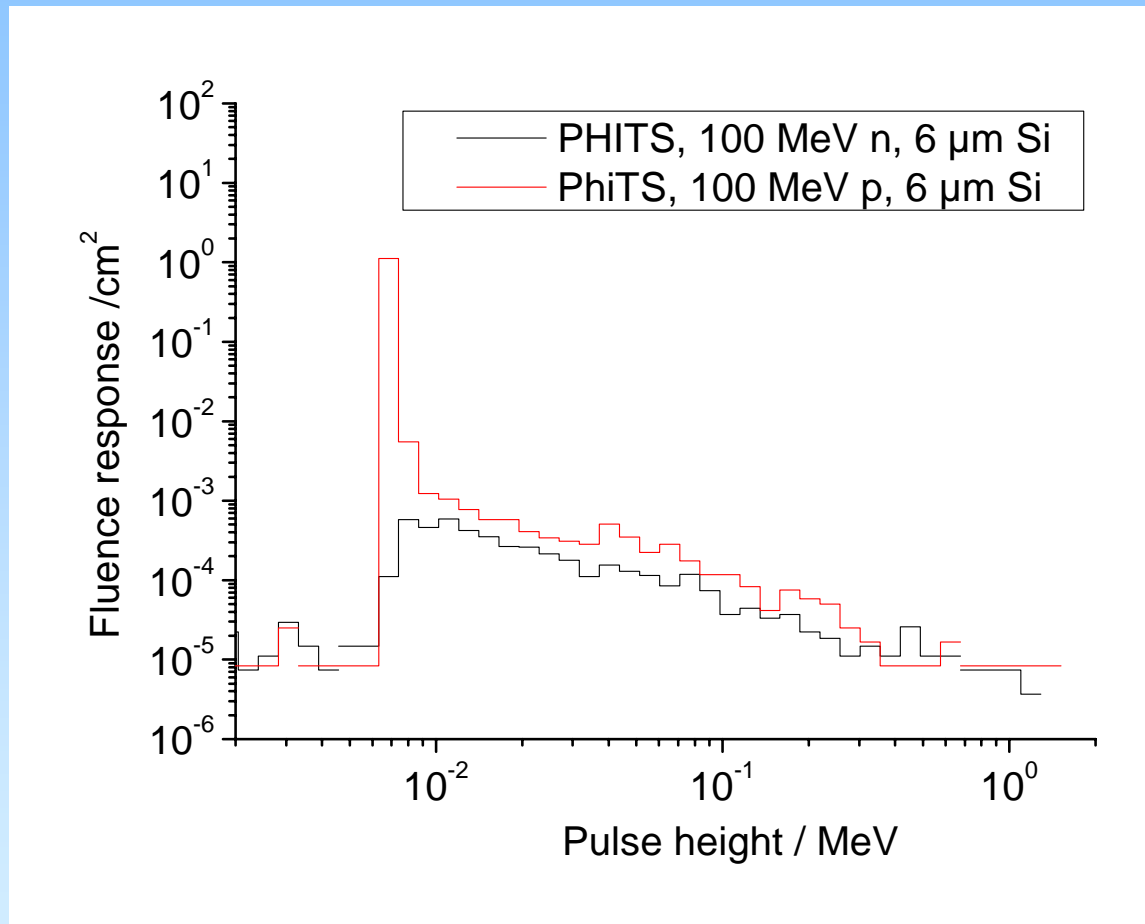


Calculated pulse height spectra for 100 MeV neutrons and protons



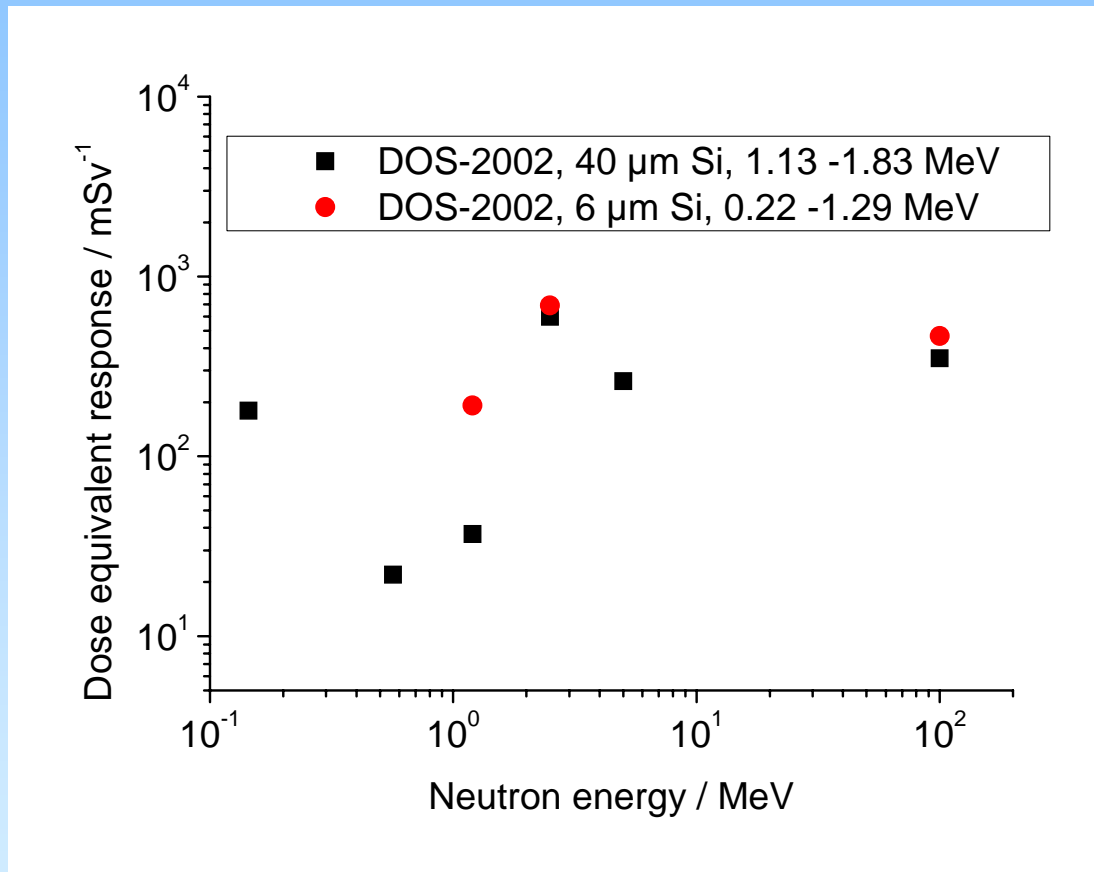
Similar response for neutrons and protons in the interval 1 to 2 MeV

Calculated pulse height spectra for 100 MeV neutrons and protons



Similar response for neutrons and protons in the interval 0.2 to 1 MeV

Dose equivalent response for neutrons PHITS calculation



- improved for thin detector at 1.2 MeV
- no drastic increase of response at 100 MeV

- Measured and calculated (PHITS) pulse height spectra agree well for neutrons of 1.2 MeV, 2.5 MeV and 5.0 MeV
- The calculations indicate that the neutron dose equivalent response at 100 MeV is similar to that of 2.5 MeV
- The detector with 6 μm effective layer shows an improved response at 1.2 MeV and otherwise no big changes
- The proton response is comparable to the neutron response for 100 MeV for normally incident particles and the thresholds used for the DOS-2002 and the DOS-2005

Further needs

Further measurements with high-energy neutrons up to 200 MeV (iThemba)

Some measurements with protons with energies up to a few hundred MeV

Agreement on conversion factors for high energy neutrons and protons

Response measurements and calculations at angles (also backward directions)

Folding energy and direction dependent responses with spectra in space

Based upon these results decision whether the proton response disturbs the neutron dose indication

Estimated dosemeter responses

Radiation field	$H_{p,estim.}(10)/ H_{p,c}(10)$		
	DOS-2002	ALOKA	EPD-N2
CERF (Concrete)	6.6	4.0	6.2
CERF (Iron)	1.8	2.1	1.7
GSI (OC-11)	6.3	4.1	5.8
GSI (EM-21)	2.0	6.0	3.2

Assumptions

Dosemeter response flat at energies above 60 MeV

Neutrons incident normally to the dosemeter surface