

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

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- ◆ 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  $\mu\text{m}$  Si) versus thick detector (40  $\mu\text{m}$  Si)
- ◆ Response for 100 MeV protons
- ◆ Further needs

# Electronic neutron dosemeters

**Thermo Electron EPD-N2**  
**3 silicon detectors (n,  $\gamma$ )**



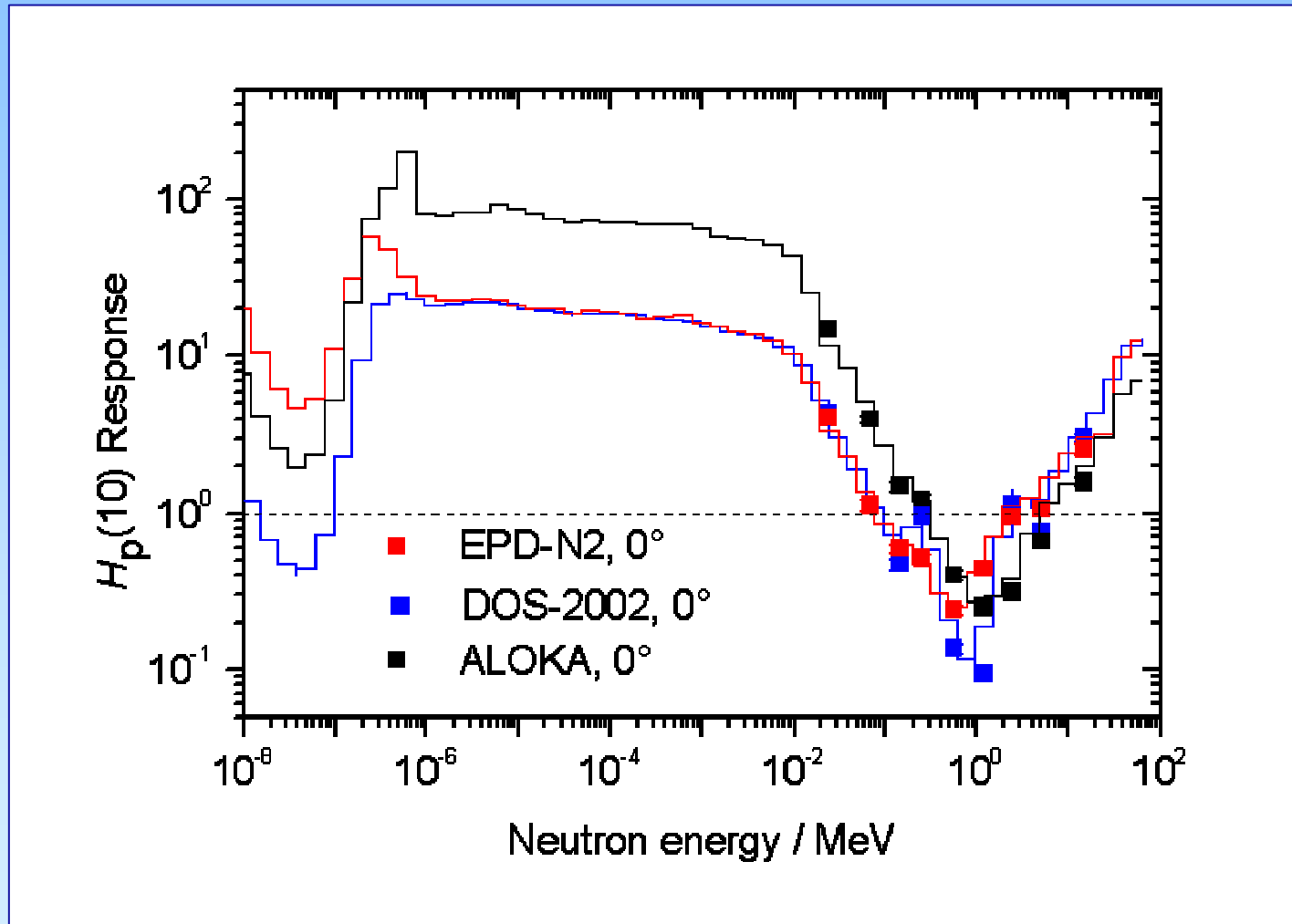
**ALoka PDM-313**  
**1 silicon detector (n)**



**PTB DOS-2002**  
**1 silicon detector (n,  $\gamma$ )**



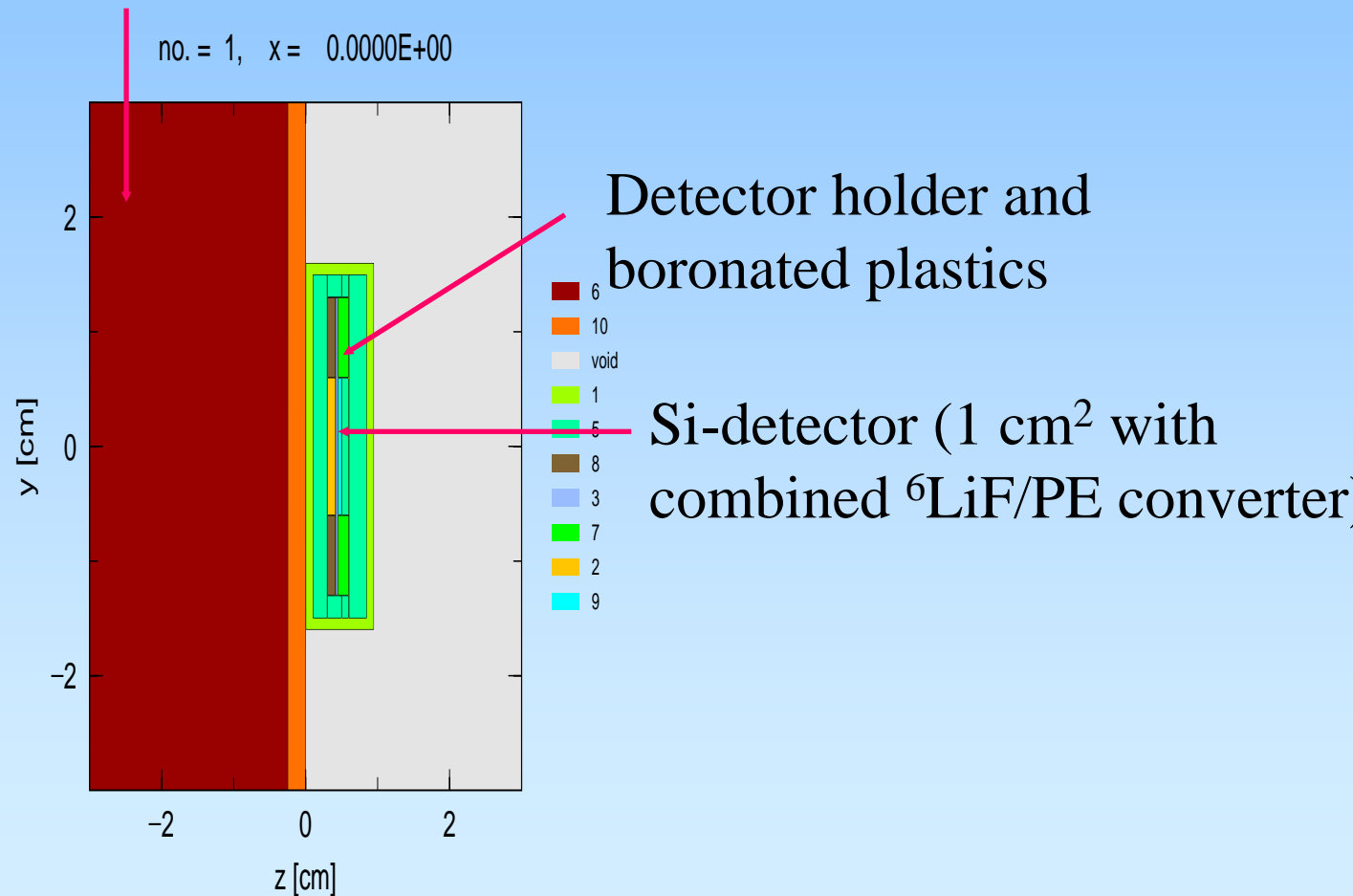
# Response obtained by unfolding



- 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

# DOS-2002 on ISO water phantom

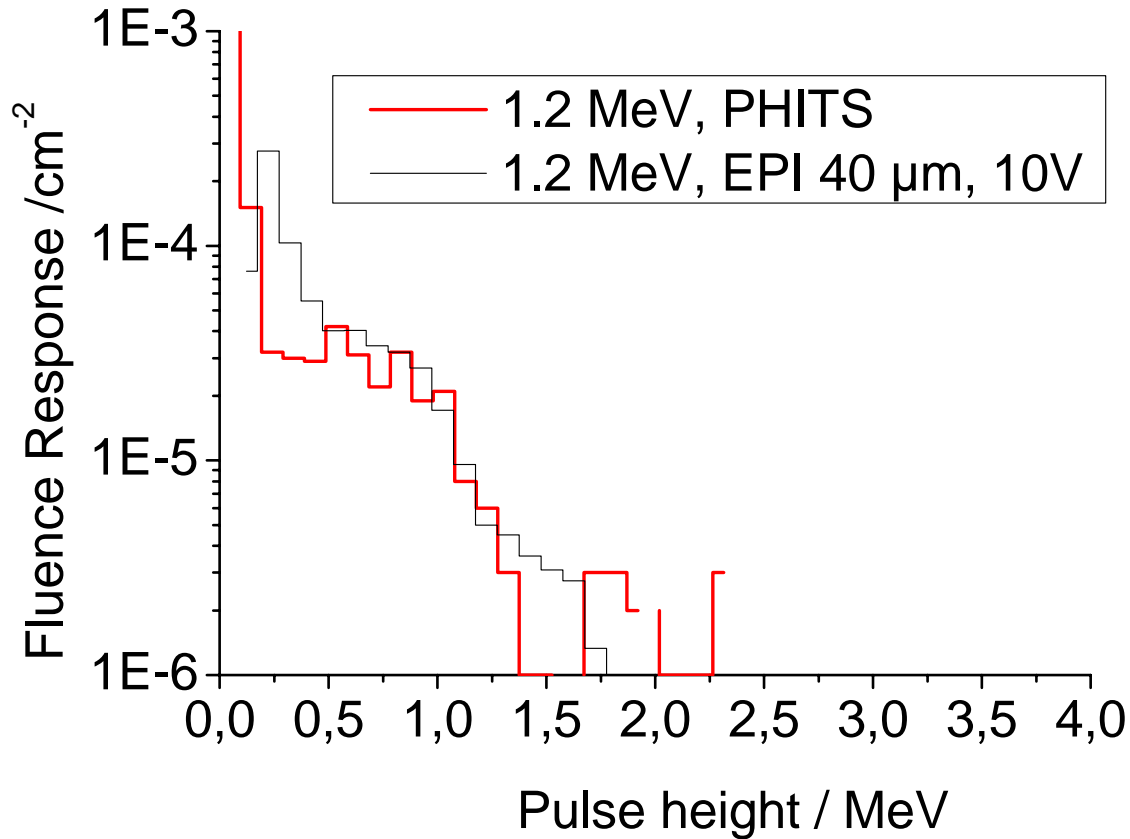
## ISO water phantom



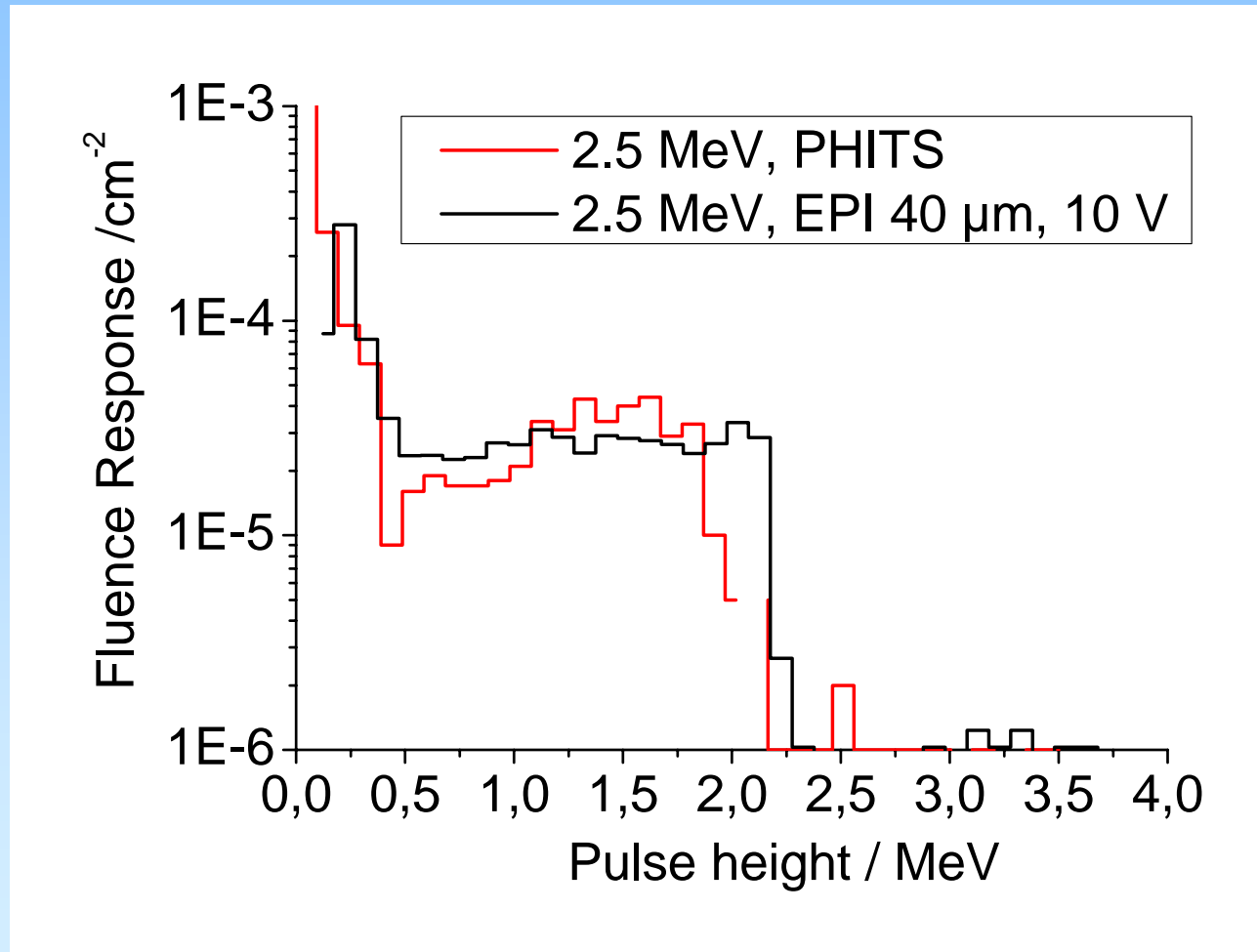
# Special Parameters

- **Planar circular source, diam. 10 to 100 cm<sup>2</sup>, normal incidence**
- **Low values of  $e_{min}$  to allow transport of all particles**
- **Cross section libraries from MCNPX**
- **In most cases 1.0e6/ cm<sup>2</sup> incident particles used**

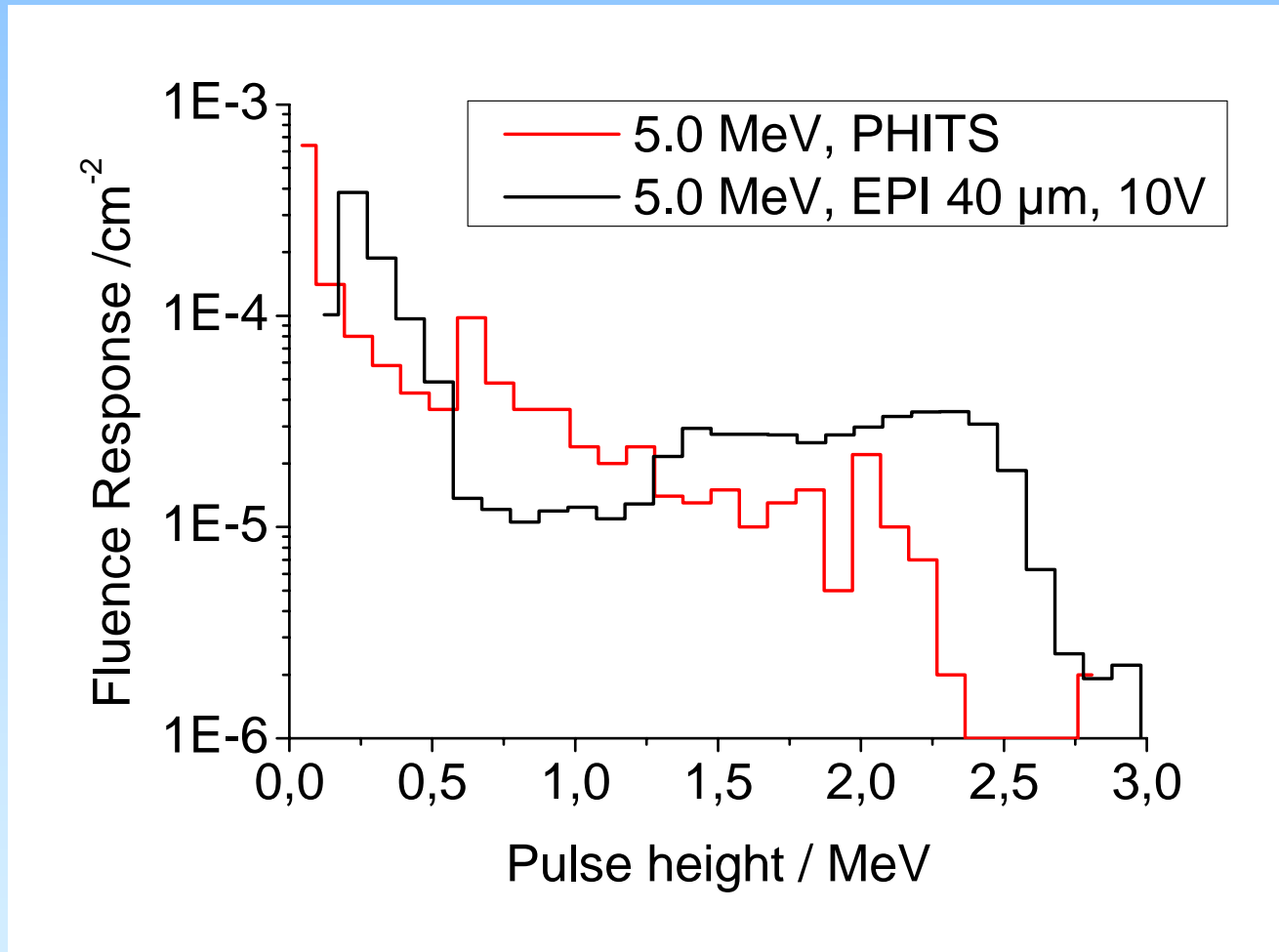
# Comparison of measured and calculated pulse height spectra



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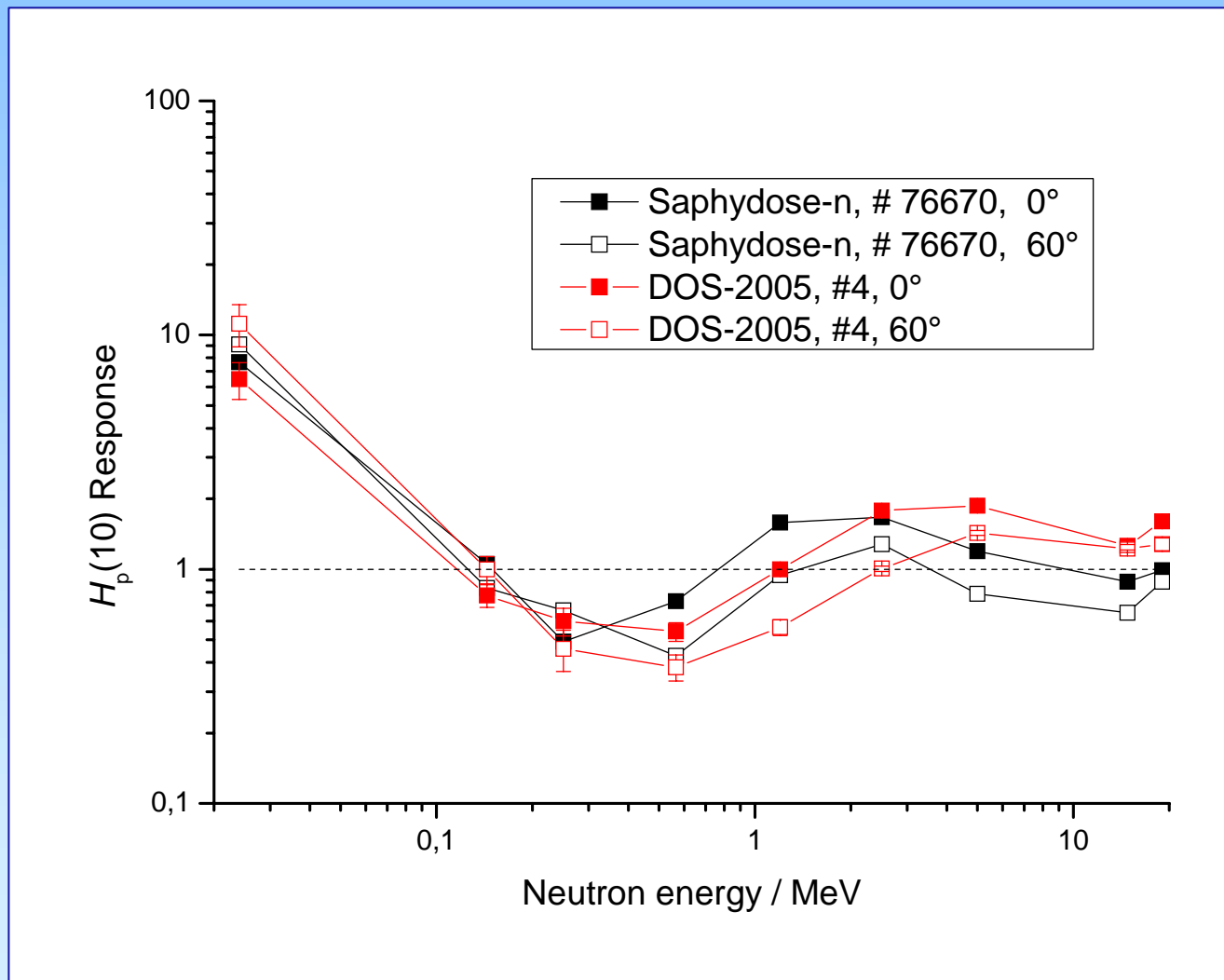


# Comparison of measured and calculated fluence response

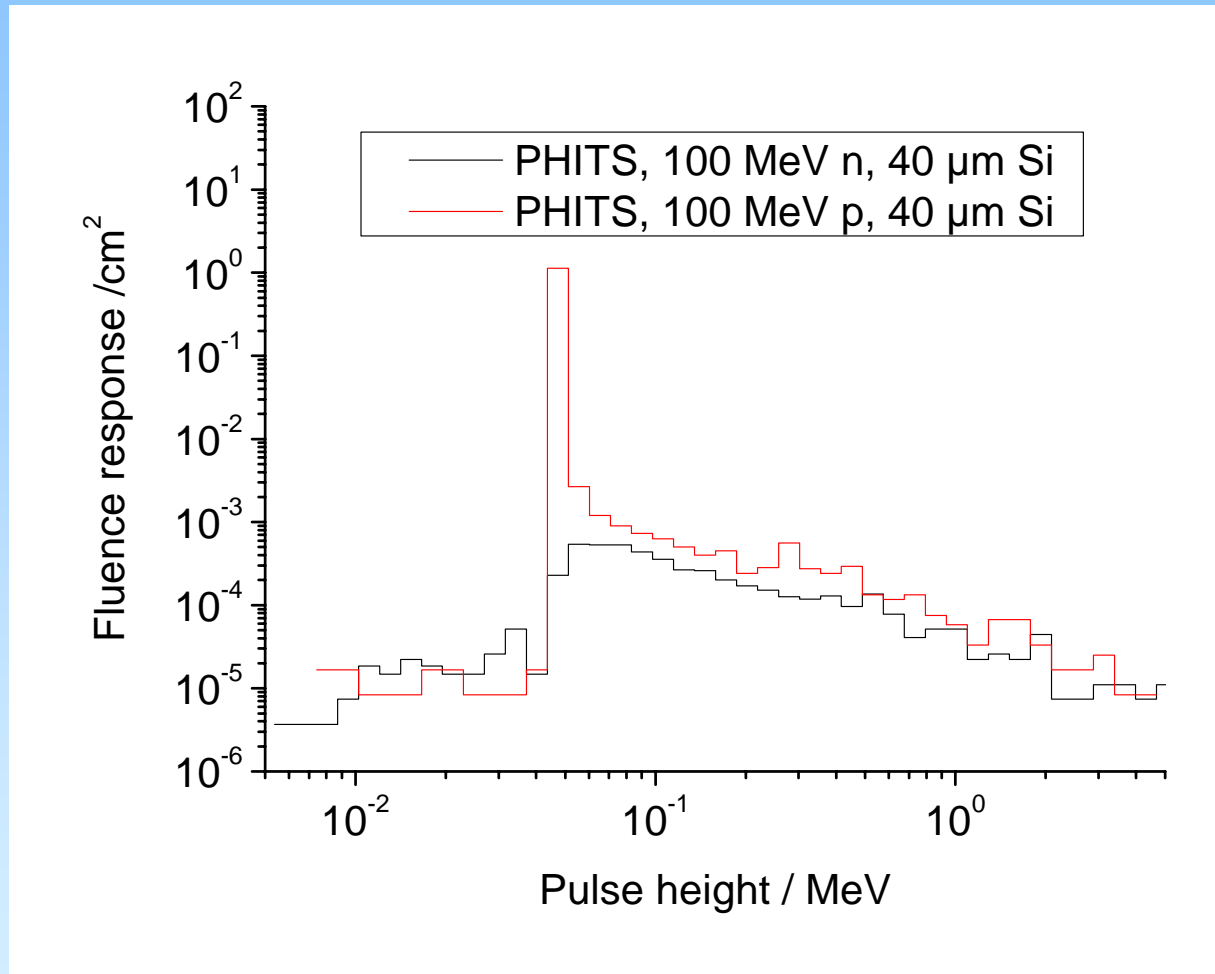
$E_n$ / MeV	DOS-2002, 40 $\mu\text{m}$ Si, 1.13 -1.83 MeV PHITS calculation	DOS-2002, 40 $\mu\text{m}$ Si, 1.13 -1.83 MeV Measurement	$R_{\text{calc}}/R_{\text{meas.}}$
0,144	2,40E-05	3,72E-05	0,65
1,2	1,60E-05	3,00E-05	0,53
2,5	2,61E-04	1,97E-04	1,32
5	1,10E-04	1,59E-04	0,69

- Agreement of absolute responses (no normalization used) satisfactory

# Response of Saphydose-n and DOS-2005 (6 $\mu\text{m}$ Si, 200 keV- 1.2 MeV)

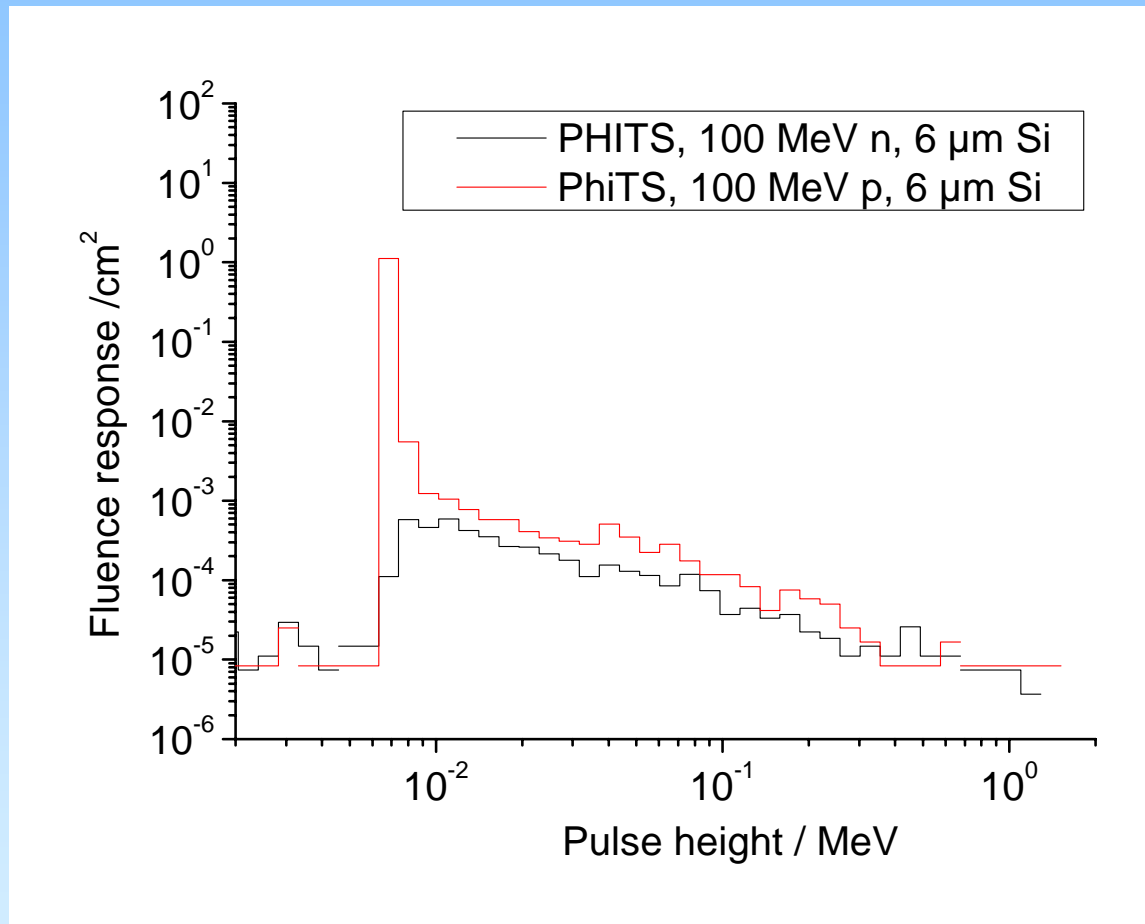


# Calculated pulse height spectra for 100 MeV neutrons and protons



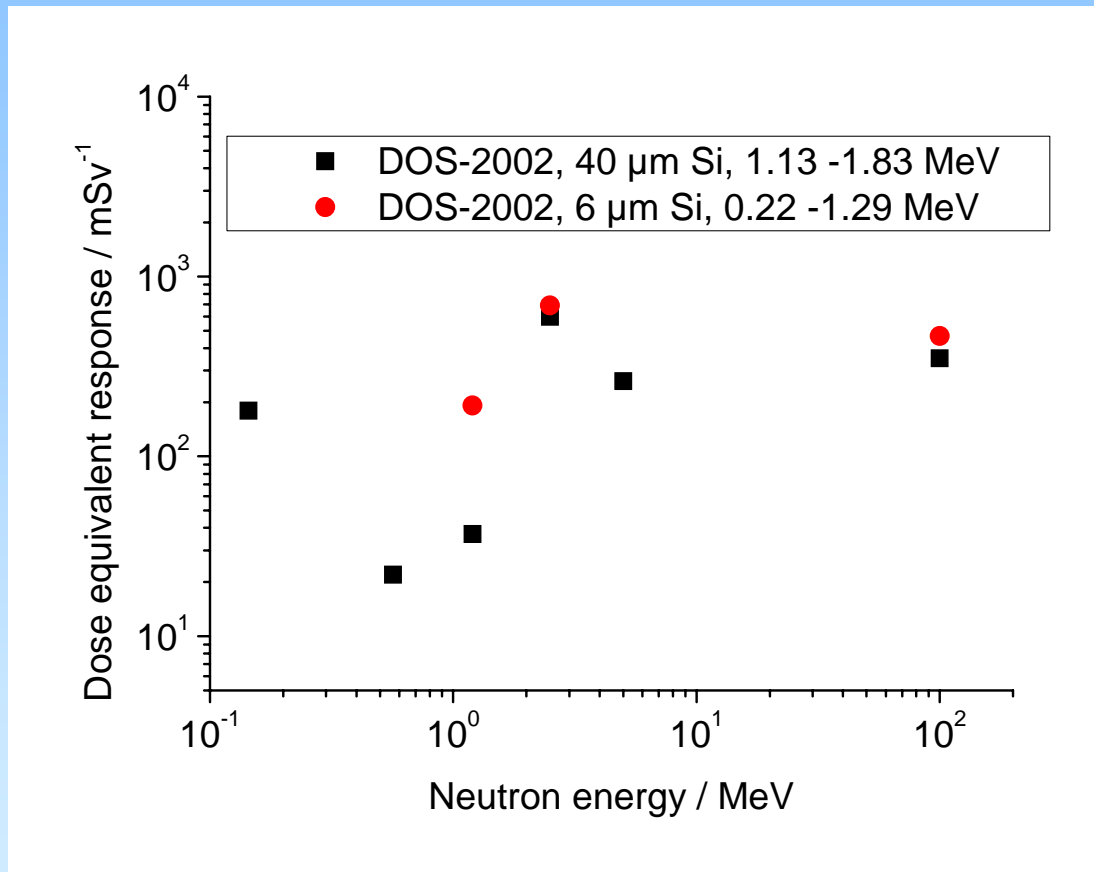
Similar response for neutrons and protons in the interval 1 to 2 MeV

# 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  $\mu\text{m}$  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**