Irradiation tests at HZDR

Anna Ferrari, Stefan Müller

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

pELBE and nELBE beamlines at ELBE
(Electron Linear accelerator with high Brilliance and low Emittance)

HZDR
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National Center for High-Power Radiation Sources:

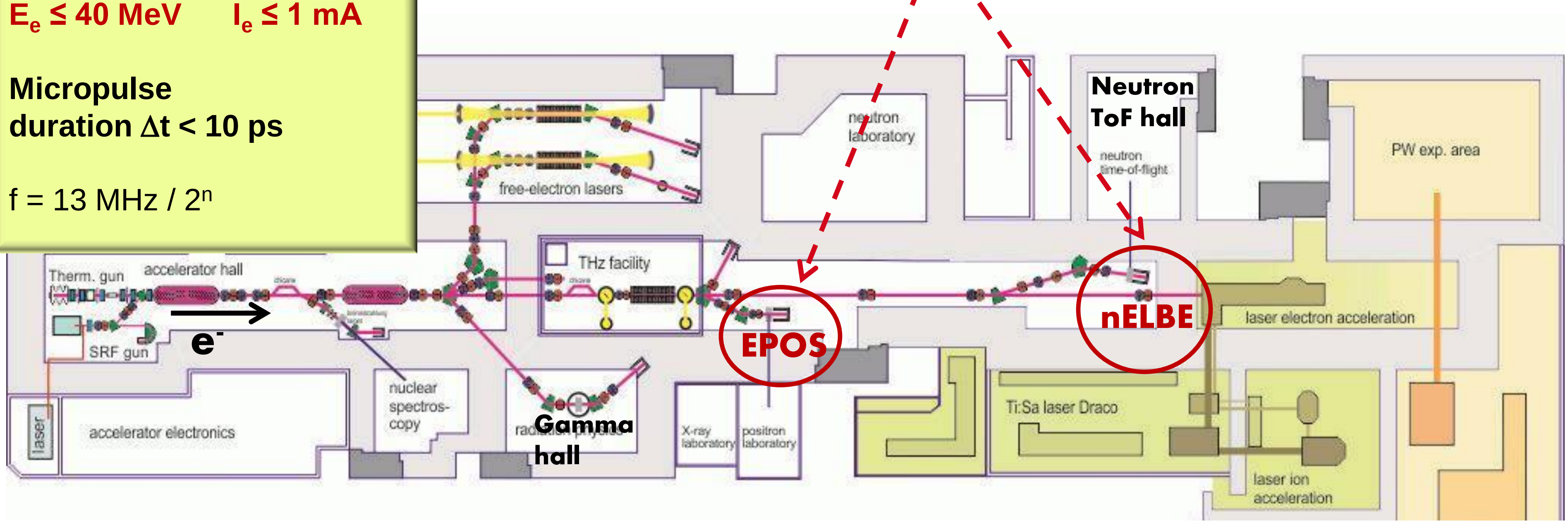
- Multiple secondary beams (neutrons, photons, positrons) & High-Power laser (PW) for electron/ion acceleration
- **nELBE**: Neutron Time-of-Light Facility for Transmutation Studies and Nuclear Physics measurements
- **pELBE** (EPOS)

Photo-neutron sources:
neutron production via photo-nuclear reactions

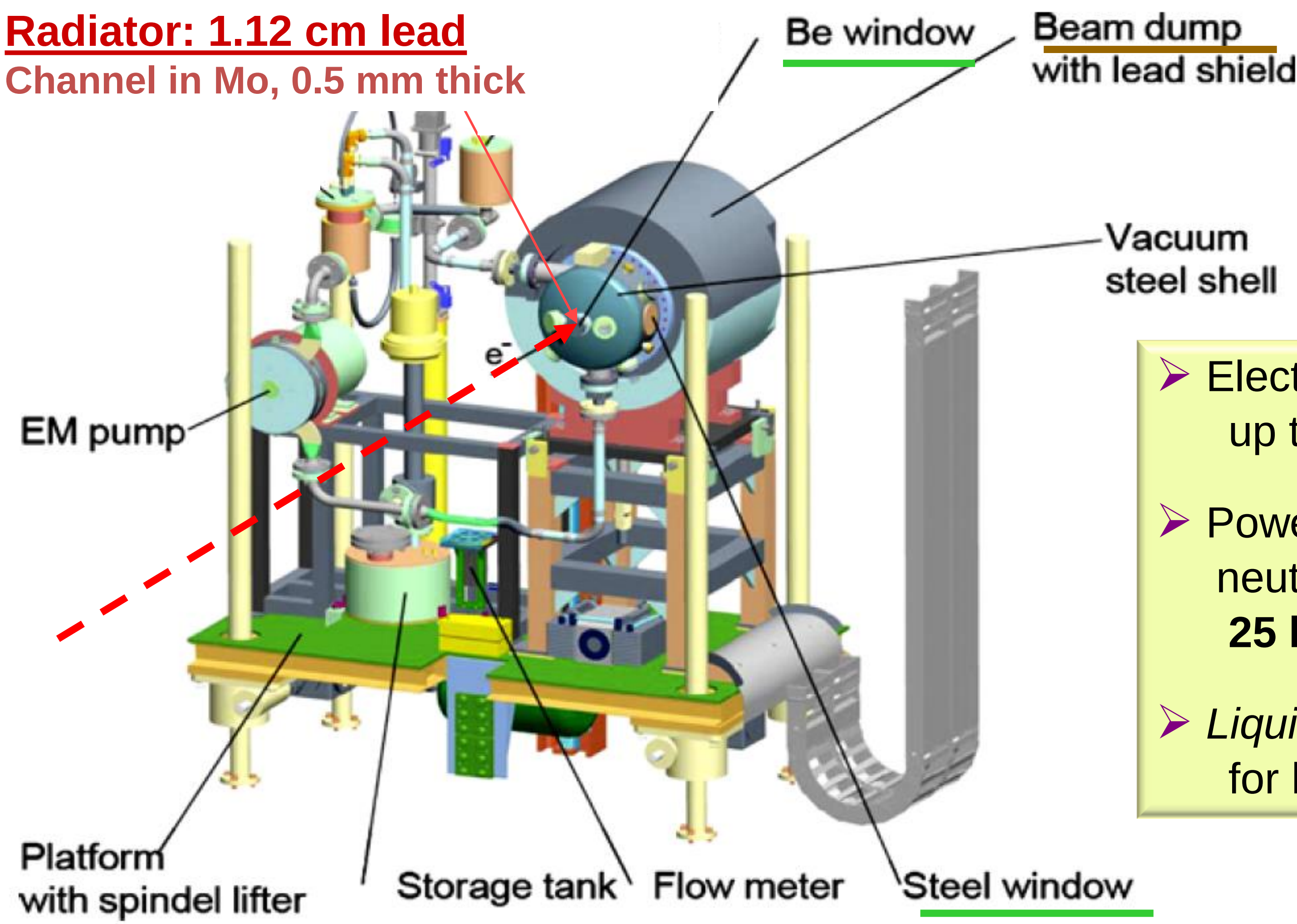
$E_e \leq 40$ MeV $I_e \leq 1$ mA

Micropulse duration $\Delta t < 10$ ps

$f = 13$ MHz / 2^n

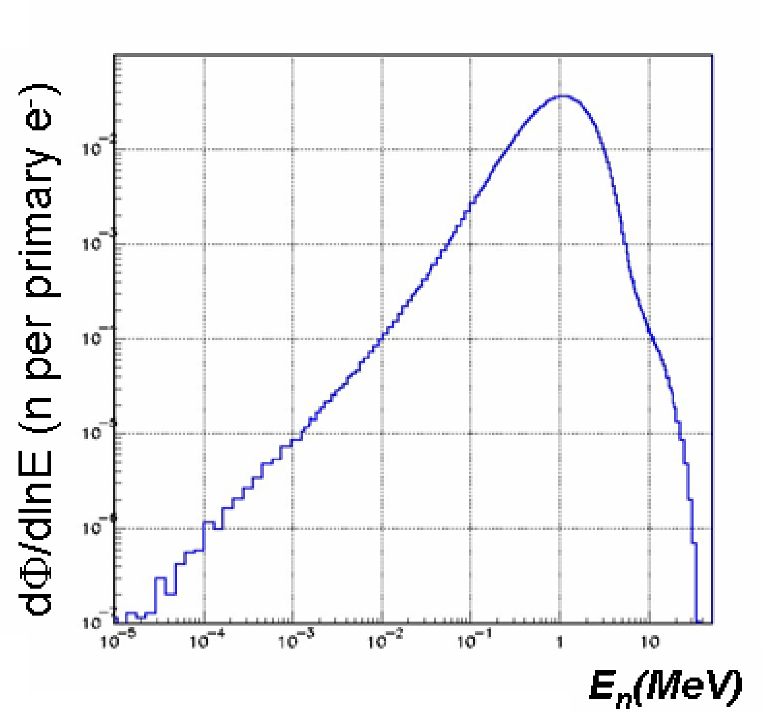


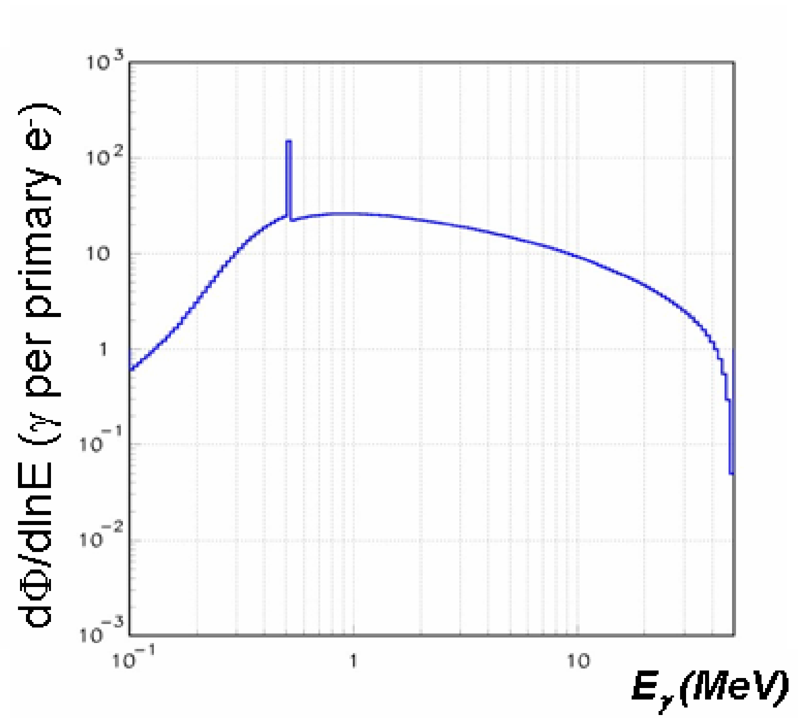
nELBE: the photo-neutron source



- Electron beam power up to **40 kW**
- Power density in the neutron radiator up to **25 kW/cm^3**
- *Liquid lead circuit* for heat transport

Source strength and photon/neutron yield ratio





Electron Energy (MeV)	Neutron Yield [n/e$^-$] (FLUKA sim.)	Source Strength [n/s] @1 mA (FLUKA sim.)	Photon Yield [γ/e-] (FLUKA sim.)
30	3.108 10^{-3}	1.94 10^{13}	4.14

Problem: γ/n yield ~ 10^3 !

@ **1 m** , **100µA** e^- current and 30 MeV e^- energy:

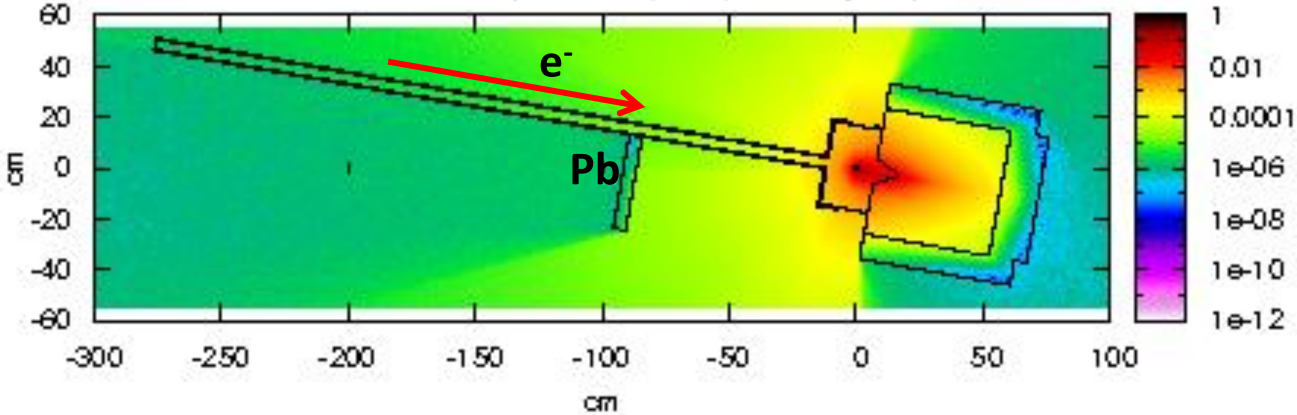
1.54 10^7 n cm^-2 s^-1 — $\mathbf{1.54\ 10^{7}\ \ n\ cm^{-2}\ s^{-1}}$

To accumulate $3{\cdot}10^{11}$ n/cm2 only **~5.4 h** are needed

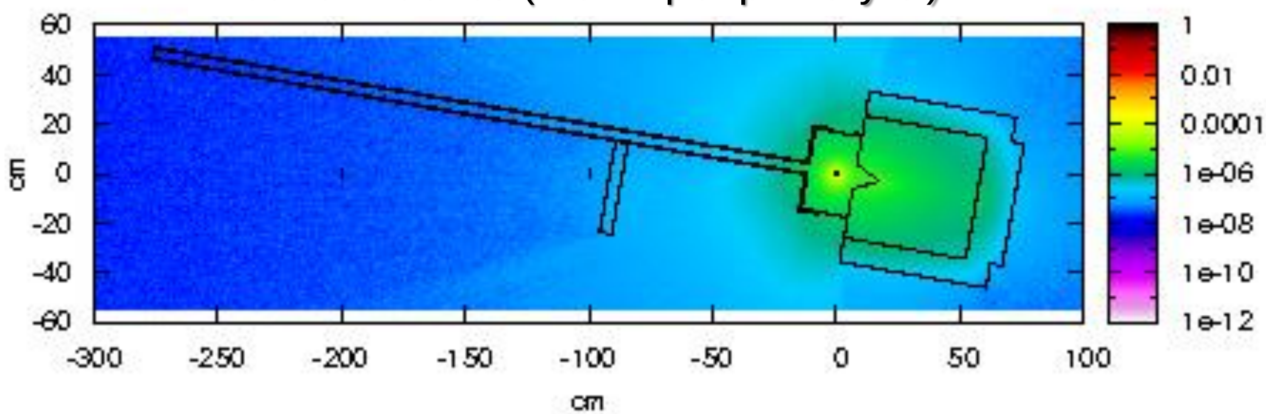
→ To suppress the gamma radiation
a local Pb shielding can be used, without
problematically losing neutron flux

Use Pb shielding to lower the γ/n ratio

Photon fluence (n cm^{-2} per primary e^{-})

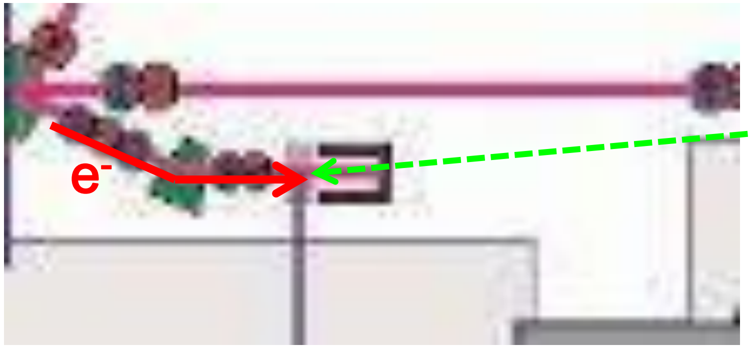


Neutron fluence (n cm^{-2} per primary e^{-})



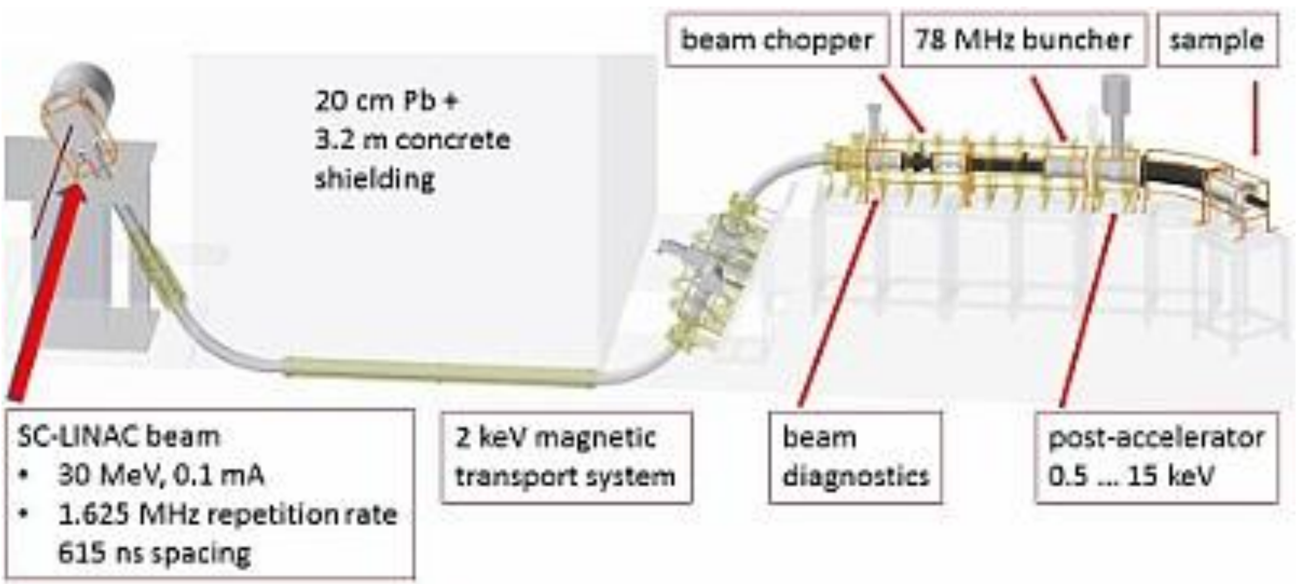
With 5 cm lead shielding the γ/n ratio goes down to ~ 10 beyond the lead block

A better solution: the EPOS source at positron extraction beamline pELBE

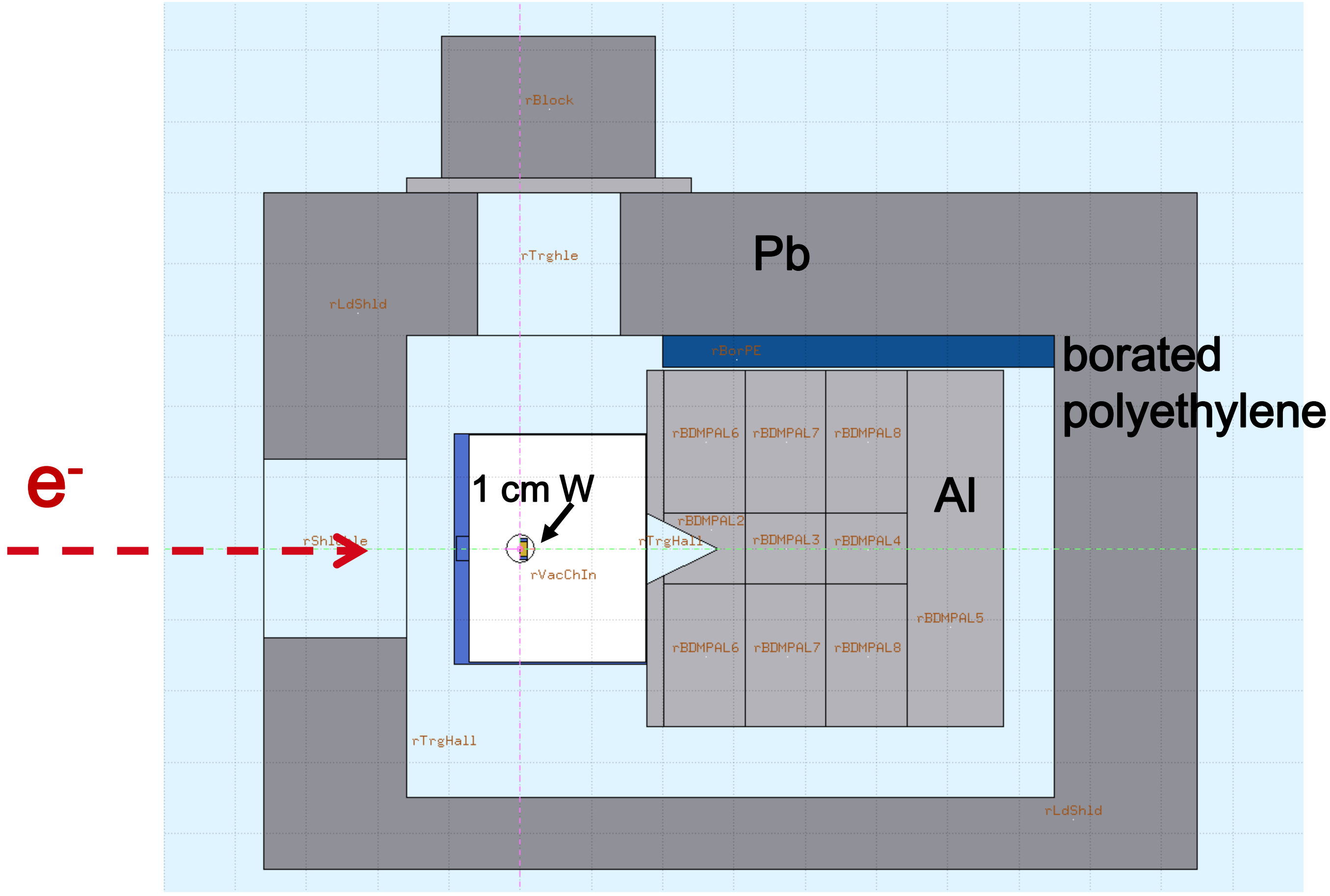


Bremsstrahlung/photoneutron target: 1 cm W

<u>positron extraction beamline</u>



Geometry around the target

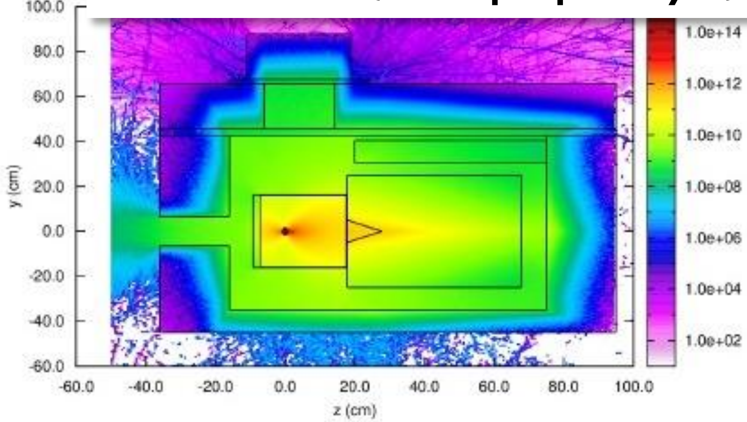


Radiation fields around the target: fluence rates

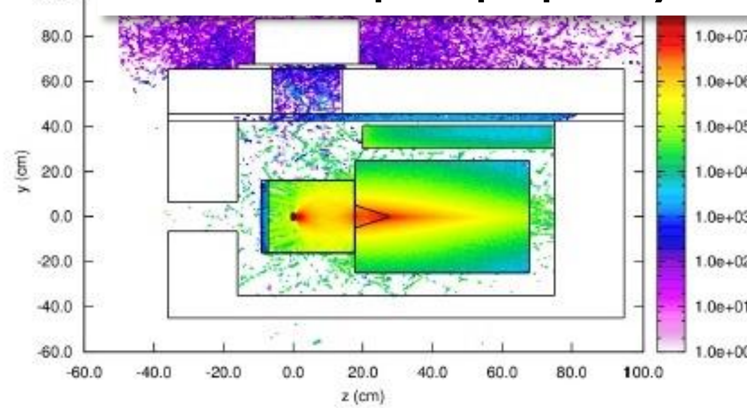
EPOS simulations: Prompt radiation@30 MeV pencil beam ($\sigma_{x,y}$=0.3cm) with 100µA

Total neutron yield coming from target: (2.83e-03 ±8.17e-07) neutrons/primary =(1.767e+12 ±3.979e+08) n/s @100µA

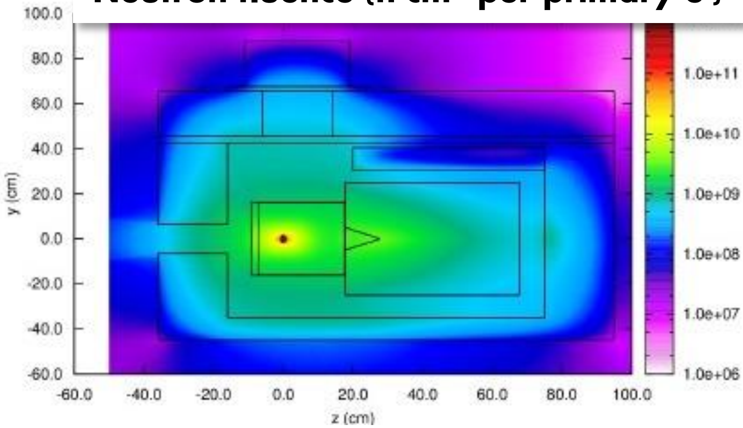
Electron fluence (e^- cm^{-2} per primary e^-)



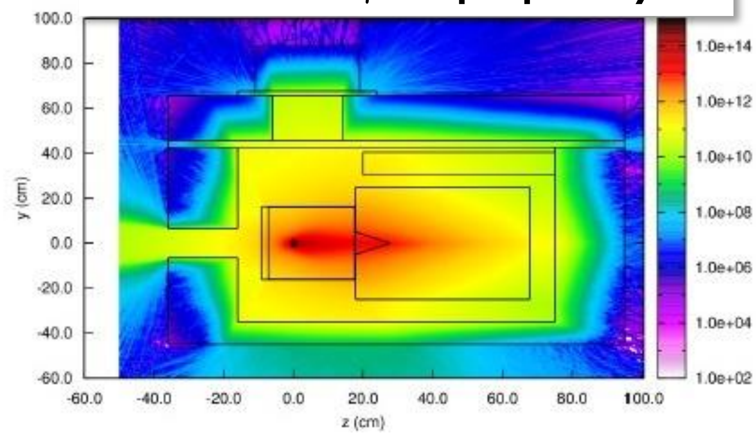
Proton fluence (p cm^{-2} per primary e^-)



Neutron fluence (n cm^{-2} per primary e^-)



Photon fluence (γ cm^{-2} per primary e^-)



Radiation fields around the target: dose [H*(10)] rates

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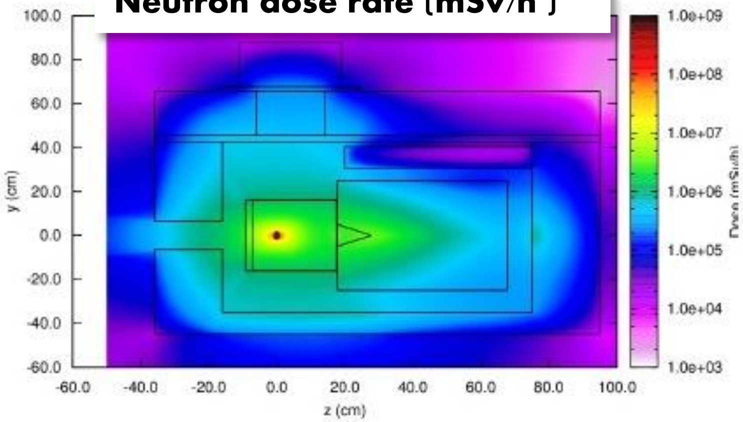
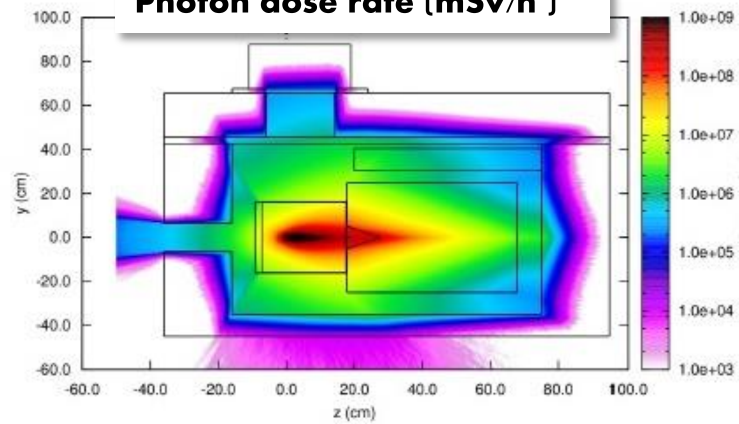
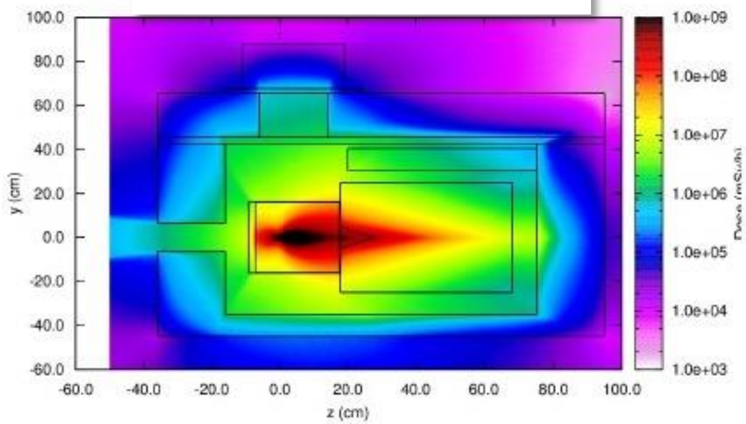
Neutron dose rate (mSv/h)



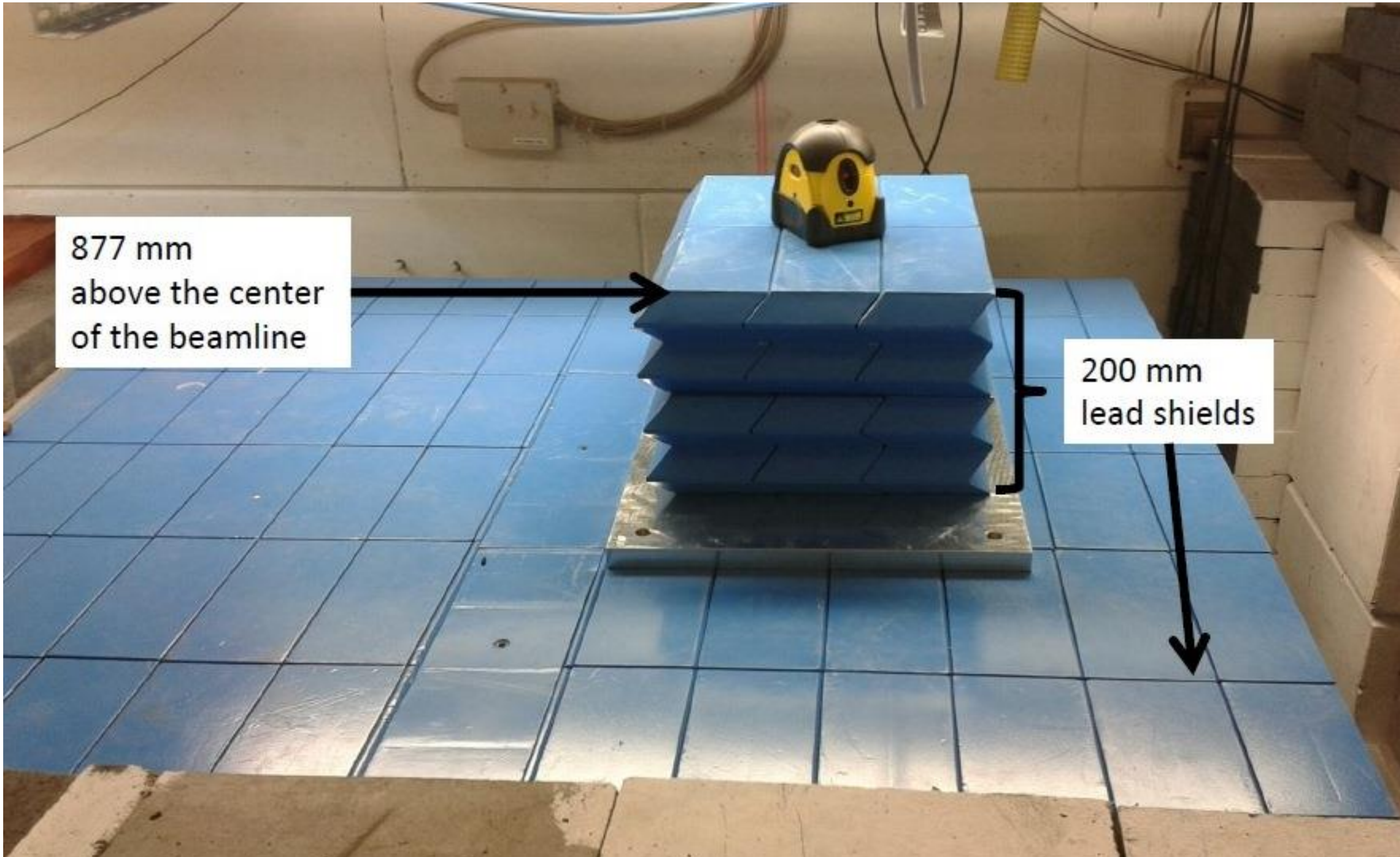
Photon dose rate (mSv/h)



Total dose rate (mSv/h)



Irradiation position



Fluence profiles at the irradiation position

EPOS simulations: Prompt radiation@30 MeV pencil beam ($\sigma_{x,y}$=0.3cm) with 100μA

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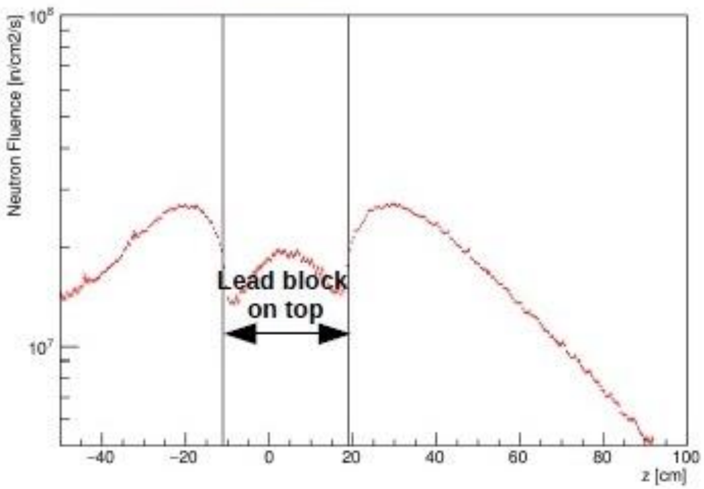
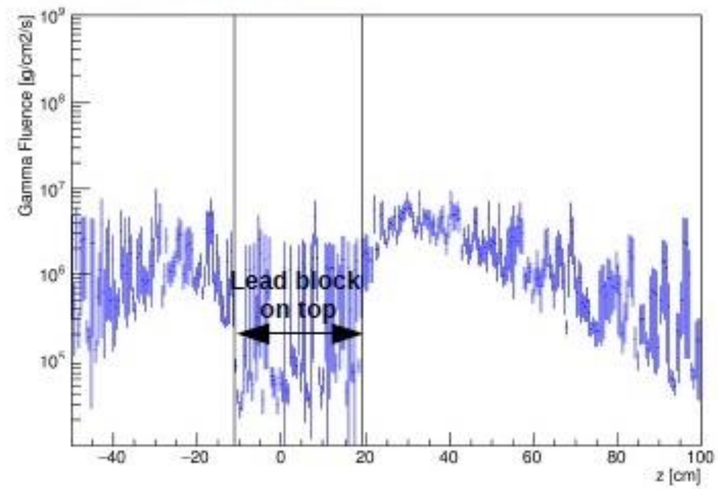
Slices between 88. < y < 88.5 cm (above lead block):

Neutron fluence:



Gamma Fluence:



Dose profiles at the irradiation position

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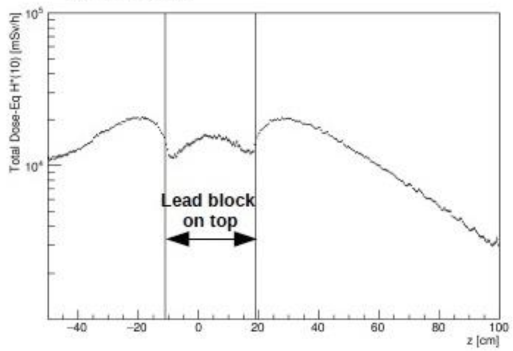
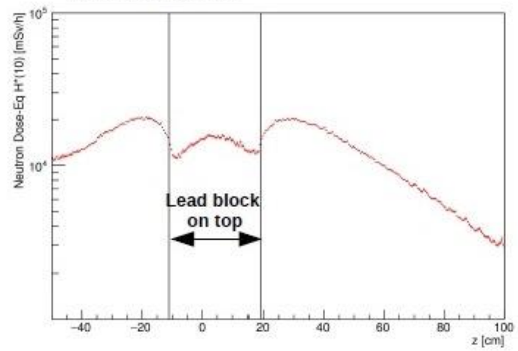
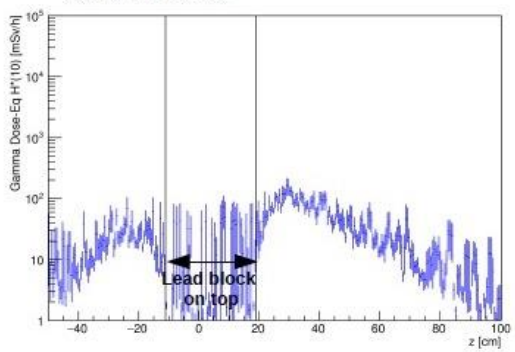
Total Dose:



Neutron Dose:



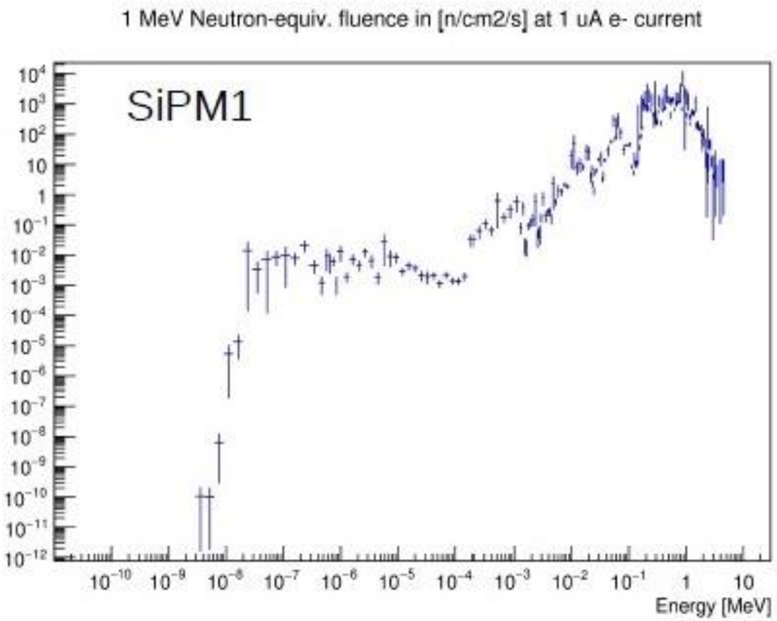
Gamma Dose:

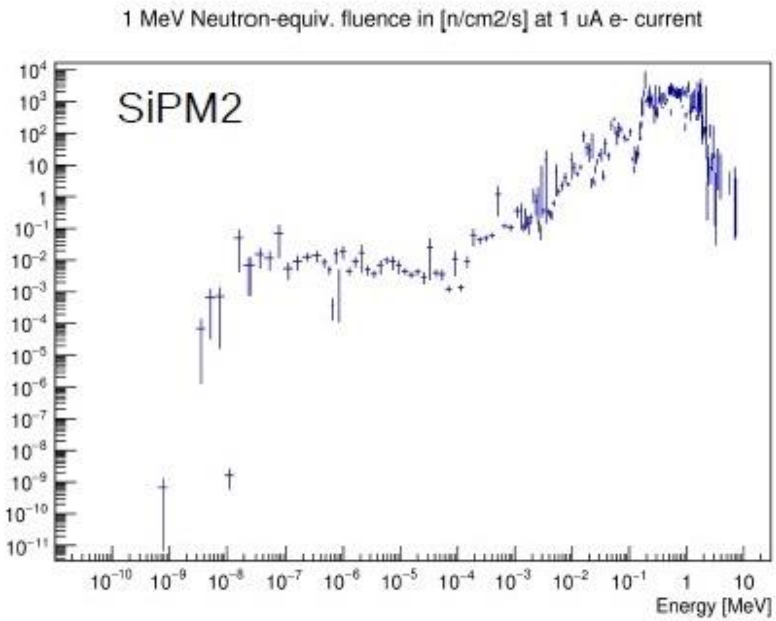


EPOS is an optimal neutron source for radiation damage studies

1 MeV-equivalent neutron spectra

The 2 plots refer to different irradiation positions of the SiPMs





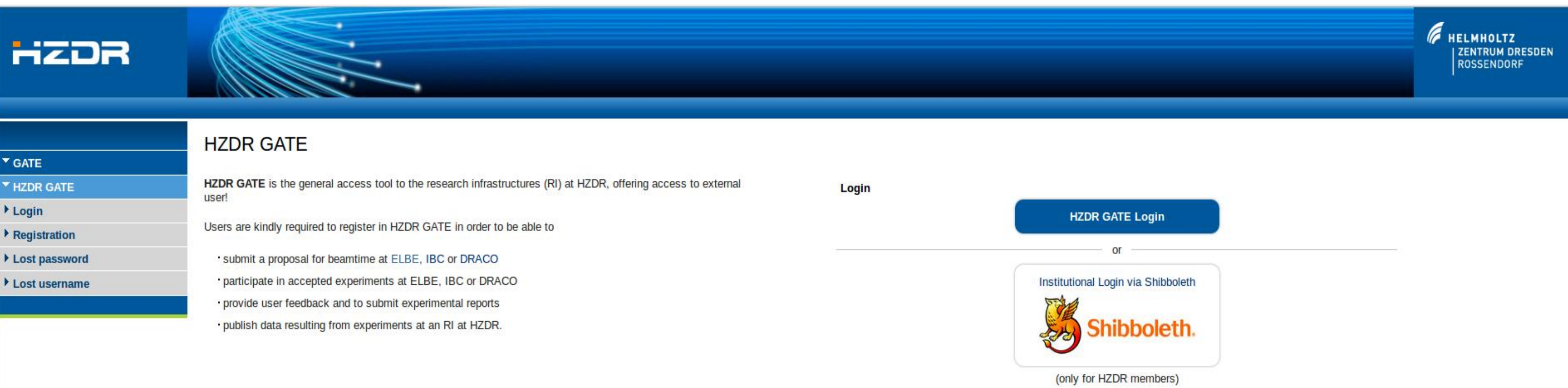
Total 1MeV-equiv. fluence at 1microAmp e- beam:(69438.5+-6990.84) n/cm^2/s (SiPM1)

Total 1MeV-equiv. fluence at 1microAmp e- beam: (90229.8+-6682.47) n/cm^2/s (SiPM2)

Planning the irradiation tests

2 options:

- **Running in parasitic way** **->** we completely depend on the main user needs
- **Asking for dedicated beamtime**



Next deadline: November 1, 2016
for the beamtime 1 Jan 2017 – 30 Jun 2017