The nELBE time of flight facility

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ELBE accelerator

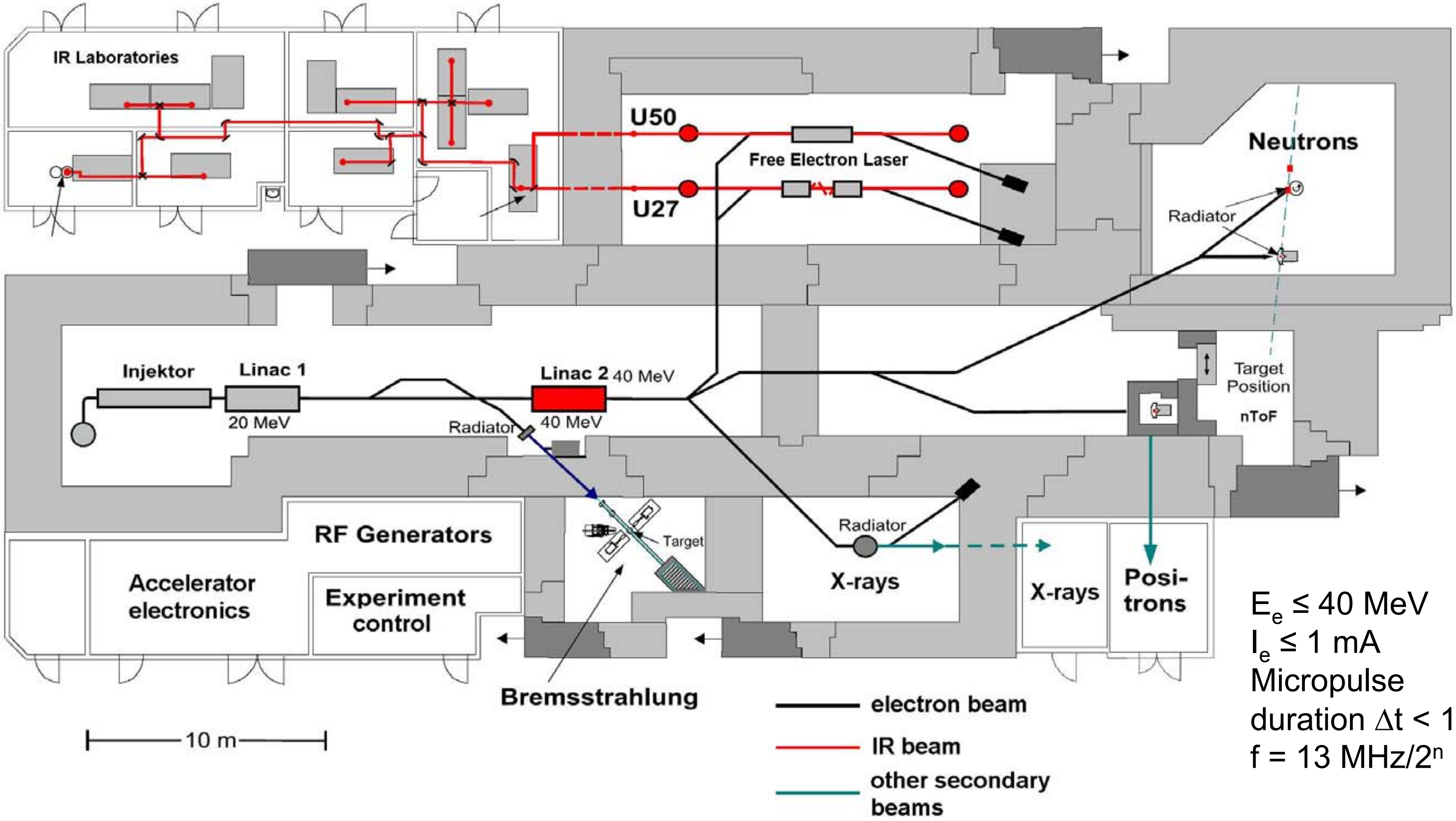
nELBE photo neutron source

Detection setup

Commissioning results

Outlook

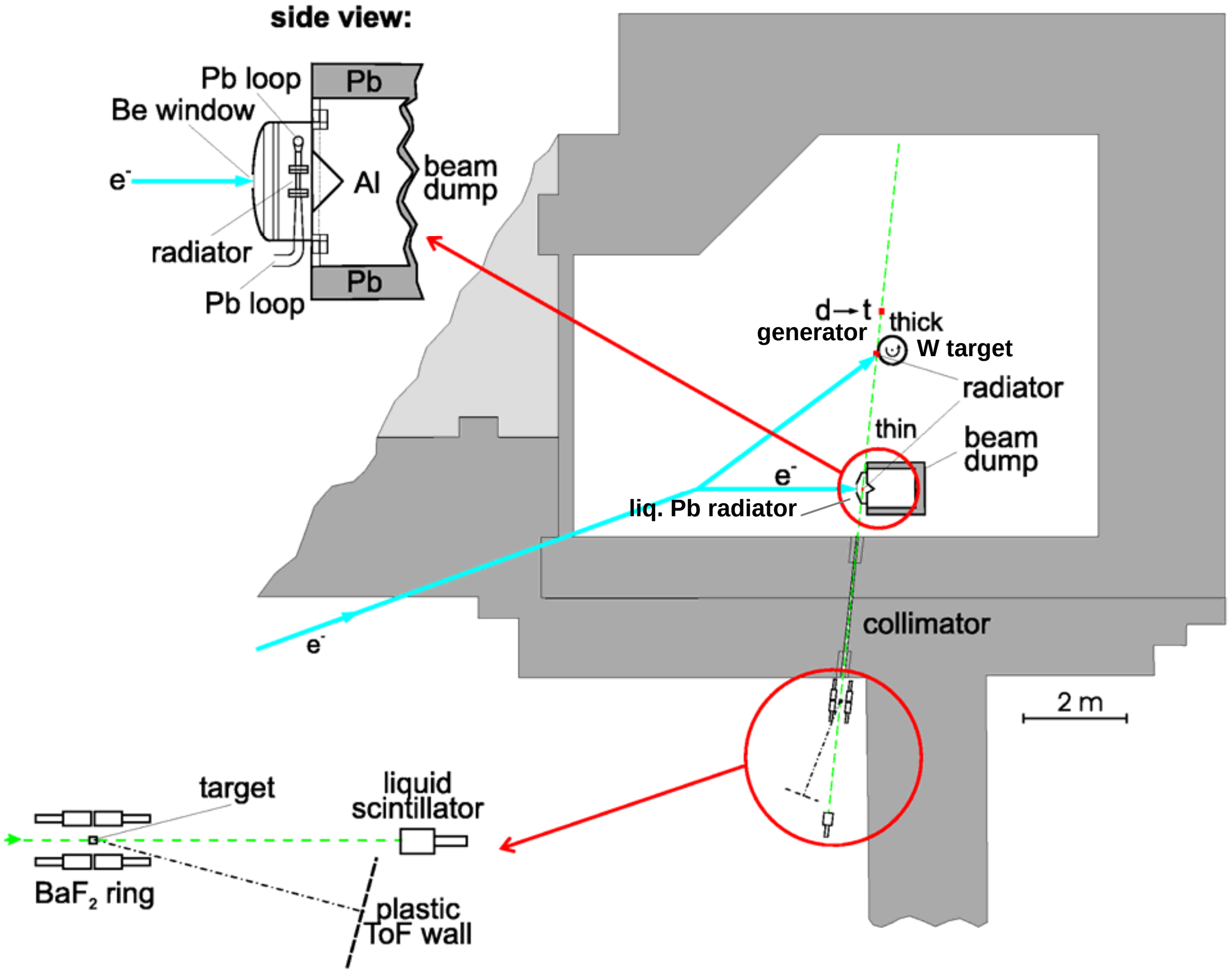
ELBE: Electron Linear accelerator with high Brilliance and low Emittance



$E_e \leq 40$ MeV
$I_e \leq 1$ mA
Micropulse duration $\Delta t < 10$ ps
$f = 13$ MHz/2^n

FZ Dresden-Rossendorf invites external groups for experiments at ELBE

Neutron time of flight experiment: nELBE



The nELBE setup: design aspects

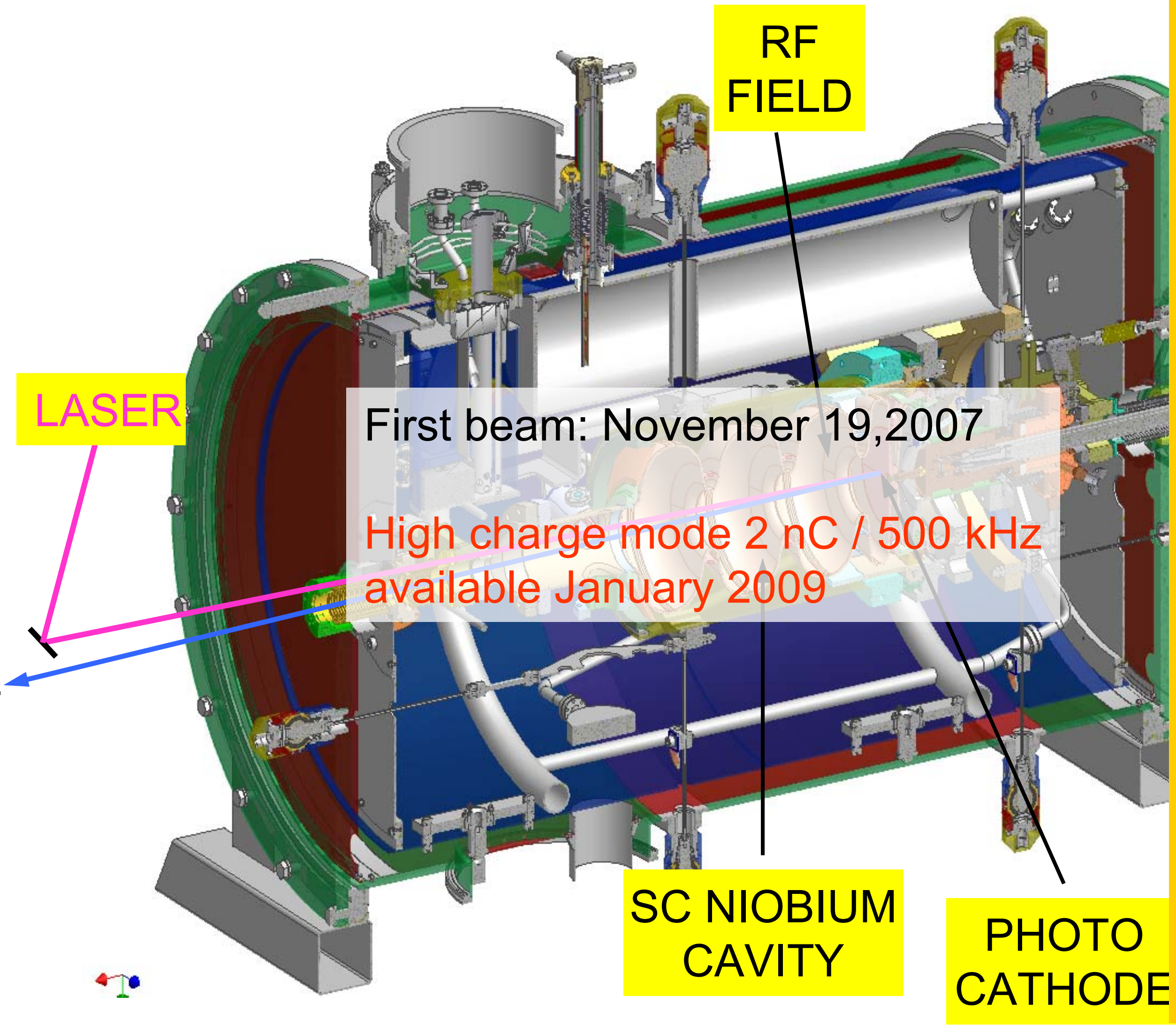
- ELBE Electron beam up to 40 MeV
  - bunch charge 80 pC (thermionic injector)
  - pulse length $\Delta t < 10$ ps
  - micropulse repetition rate 13 MHz/2^n

- For time of flight measurements:
  micropulse repetition rate 100 kHz – 500 kHz
  average current 8 – 39 μA (beam power 250 – 1300 W)

- Future: SRF photo injector (high charge mode 2 nC)
  ➔ 500 kHz / 1mA or smaller rate with reduced beam current

- Flight path 4.0 - 8.0 m
- Neutron intensity $1.5 \cdot 10^7$ cm^{-2} s^{-1}
- Neutron energy range 100 keV < E_n < 10 MeV
  (energy range similar to a fast reactor)
- Neutron energy resolution $\Delta E/E < 1$ % at 6.0 m flight path

Generation of high brightness electron beams



1. **direct production of short pulses:**

   laser & photo cathode

2. **high acceleration field at cathode:**

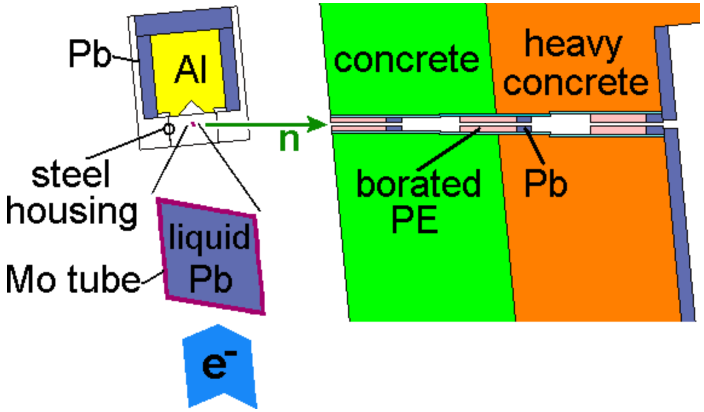
   radio frequency field

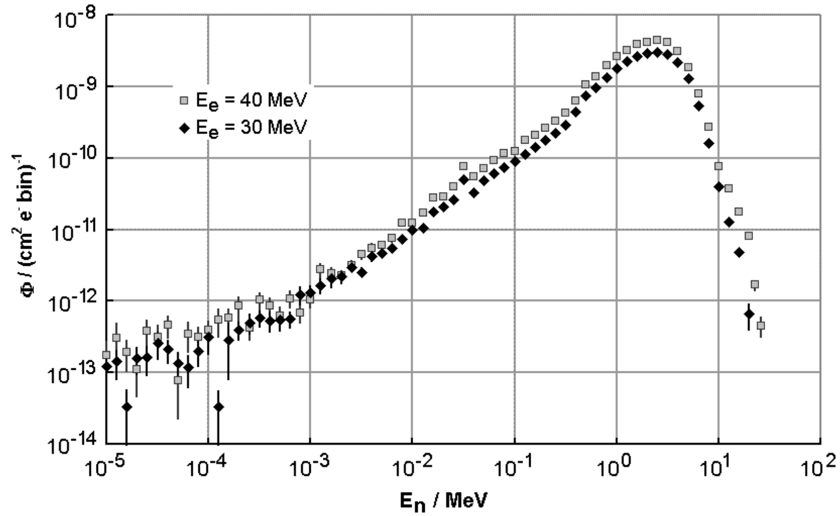
3. **CW operation for high average current:**

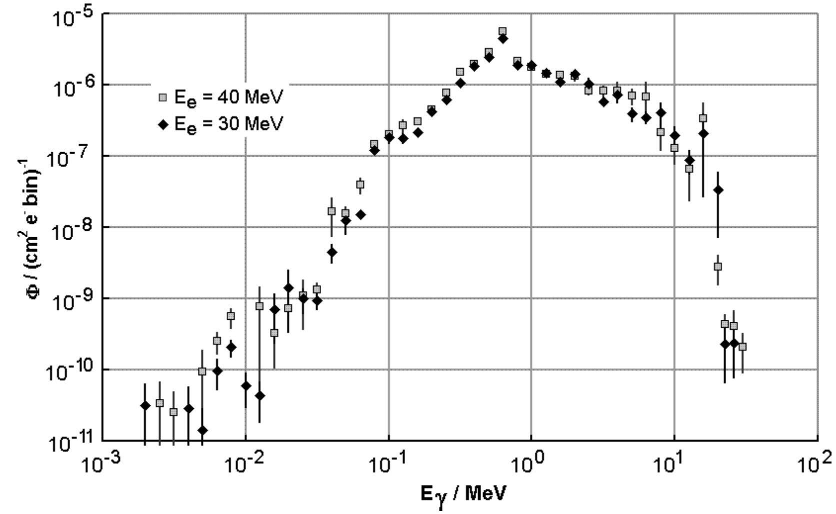
   superconducting cavity

ELBE SRF PHOTO INJECTOR

MCNP: Neutron and photon source spectra







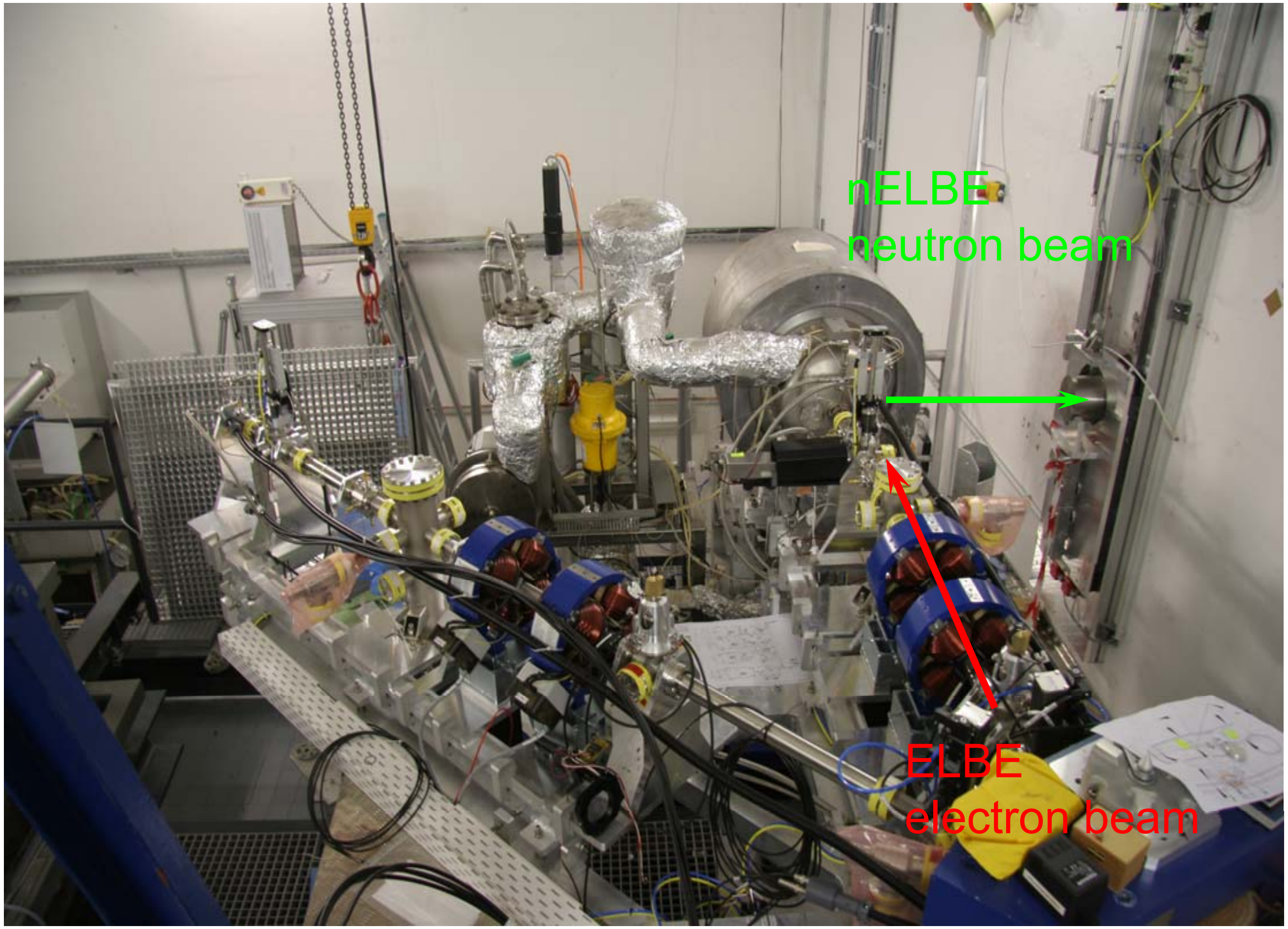
- *Mode e p n* calculation with photonuclear physics turned on
- Photonuclear cross sections for Pb and Mo adopted
- Electrons started uniformly outside Mo channel from circular disc, $\varnothing = \varnothing_{beam}$ = 8 mm
- Neutron and photon source distributions detected in collimator direction
- Distributions used as source spectra in later simulations – n & γ started uniformly from a cylindric volume (= intersection between e^- beam and Mo/Pb radiator)

➔ J. Klug et al. NIM A 577 (2007) 641

Neutron beam intensity comparison

Facility	CERN n-ToF	CERN n-ToF Phase-2	LANL NSC	ORNL SNS	FZK VdG	ORNL ORELA	IRMM GELINA	nELBE	nELBE with SRF-gun
Pulse charge / nC	ca. 10^3	ca. 10^3	$4 \cdot 10^3$	$3 \cdot 10^4$	0.01	ca. 100	ca. 100	0.08	1.8
Power / kW	10	10	60	1000	0.4	8	7	5	40
Pulse rate / s^{-1}	0.4	0.4	20	60	$2.5 \cdot 10^5$	500	800	$1.6 \cdot 10^6$	$5 \cdot 10^5$
Flight Path / m	183	Ca. 20	60	84	0.8	40	20	4	4
n-pulse length / ns	>7	>7	125	100-700	ca. 1	>4	>1	< 0.4	< 0.4
E_{min} / eV	0.1	0.1	1	0.1	10^3	10	10	$2 \cdot 10^5$	$2 \cdot 10^4$
E_{max} / eV	$3 \cdot 10^8$	$3 \cdot 10^8$	ca. 10^8	ca. 10^8	$2 \cdot 10^5$	$5 \cdot 10^6$	$4 \cdot 10^6$	$7 \cdot 10^6$	$7 \cdot 10^6$
resolution at 1 MeV / %	0.5%	5%	> 10 %	> 20 %	ca. 5 %	< 1 %	< 2 %	ca. 1 %	ca. 1 %
n flux density / $s^{-1}cm^{-2}$ (E decade)$^{-1}$	10^5	ca.10^7	ca. 10^6	10^6 -10^7	ca. 10^4	10^4	$4 \cdot 10^4$	$4 \cdot 10^5$	$3 \cdot 10^6$

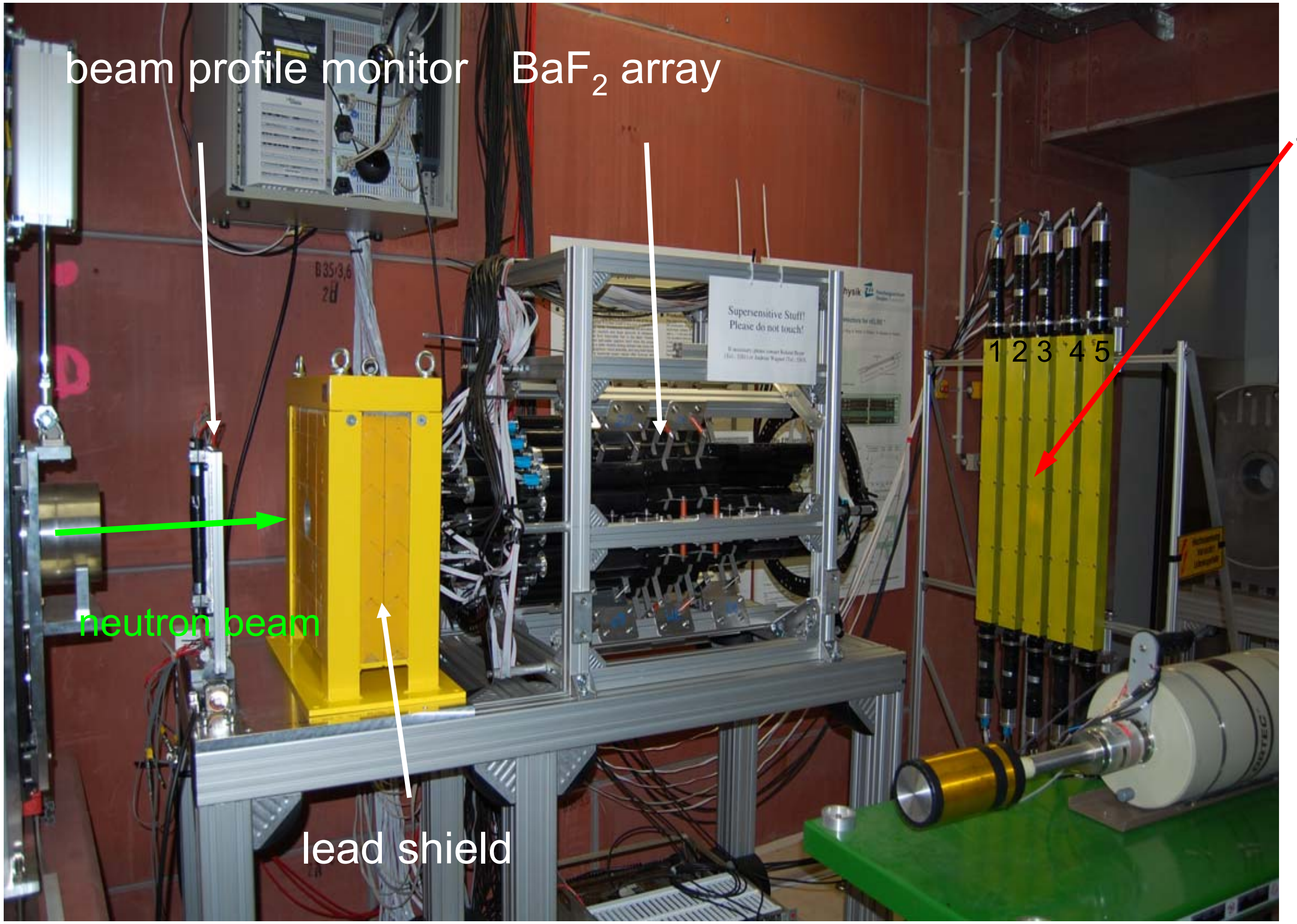
nELBE Photo-neutron source



operational with ELBE electron beam

liquid Pb loop as neutron radiator,
➔talk by V. Galindo, wednesday 14:50

nELBE experimental setup



5 plastic scintillators for neutron time of flight measurement

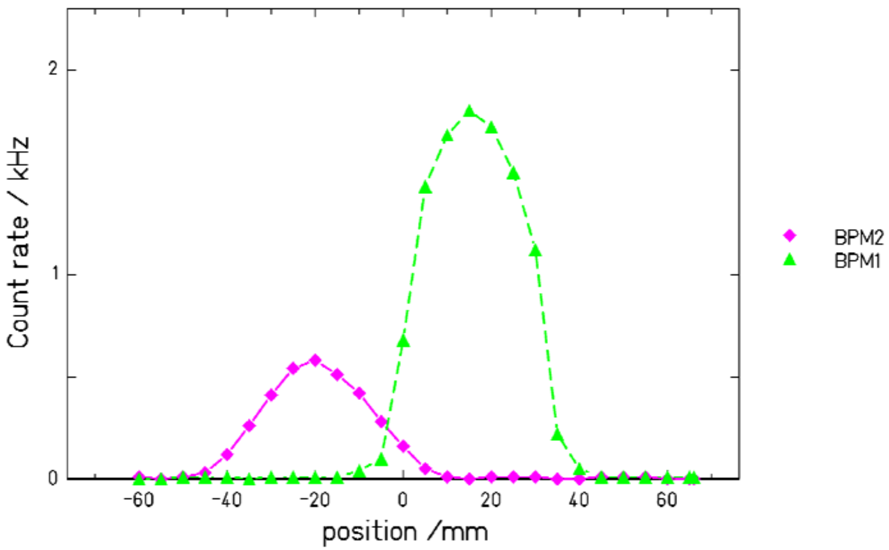
detectors 2 and 4 are 22 mm thick

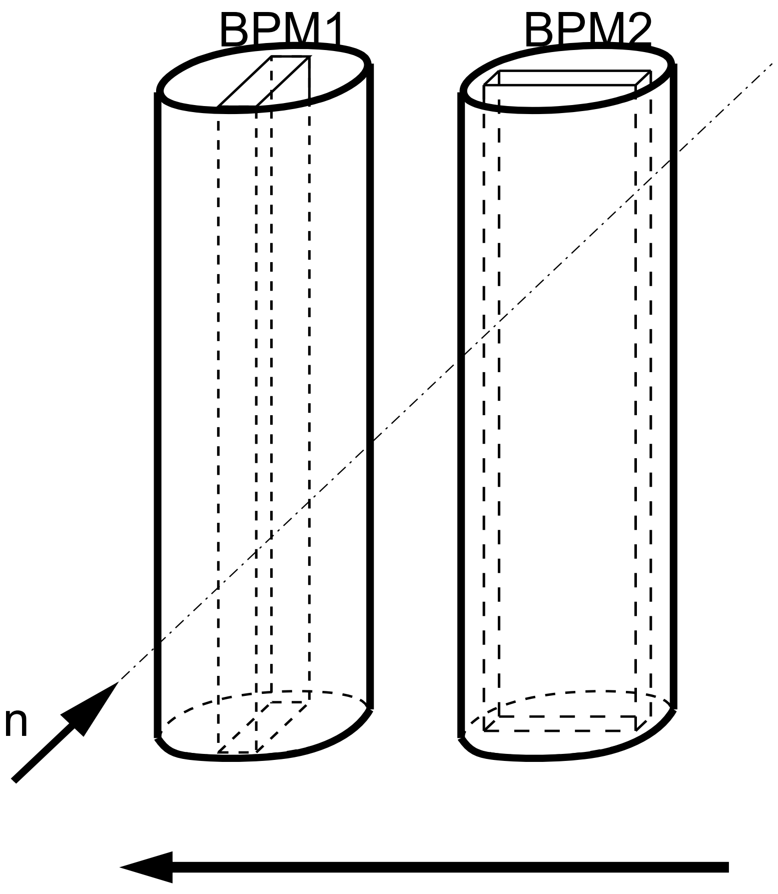
detectors 1,3,5 are 11 mm thick

Pb shield (d=1 cm) to suppress background.

R. Beyer et al.,
NIM A 575 (2007) 449

Beam profile measurements

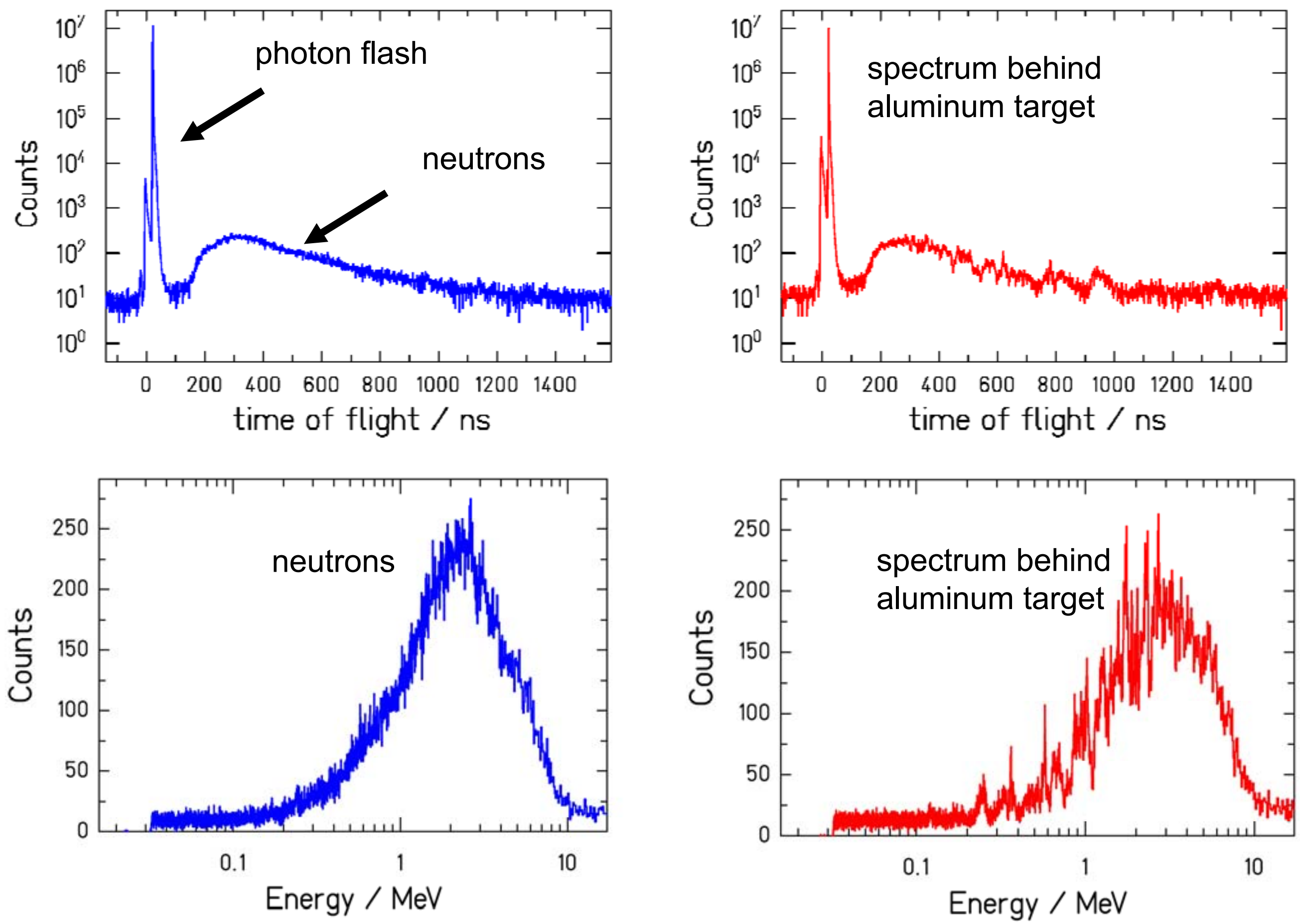




measurements with two plastic scintillators mounted on a translation stage:

beam diameter: 32 mm

First nELBE neutron spectra: 05-Nov-2007

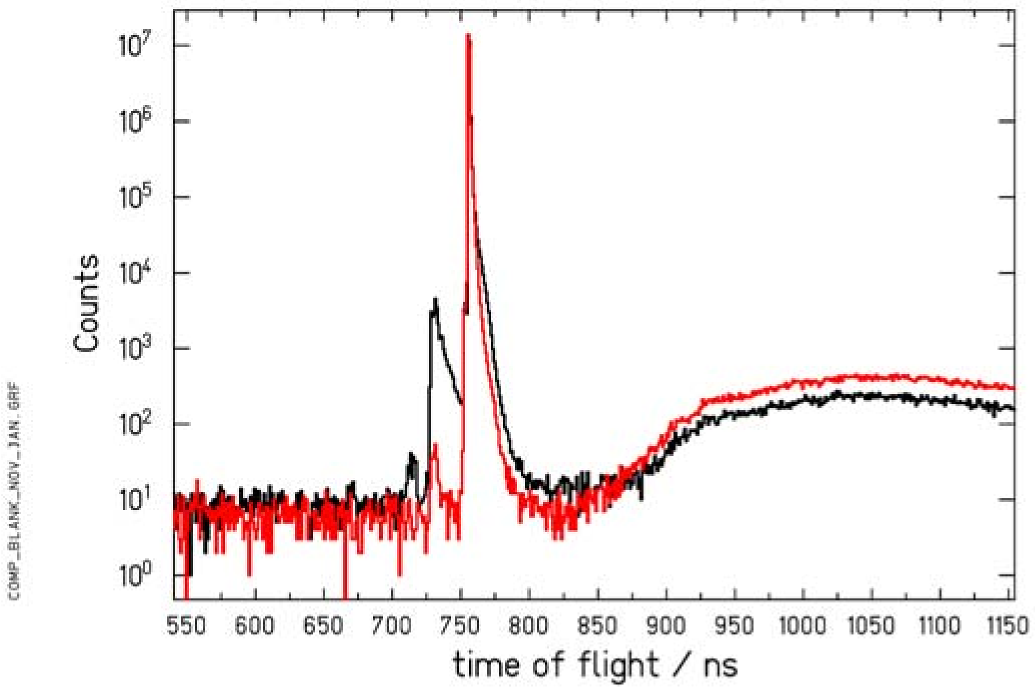


Flight path 6.5 m
micropulse repetition rate 100 kHz
average current 1 – 4 μA

Plastic scintillator:
time resolution 750 ps (FWHM)

beam intensity in Feb 08
average current < 1 μA
neutrons: 500 n/s

Photon background reduction

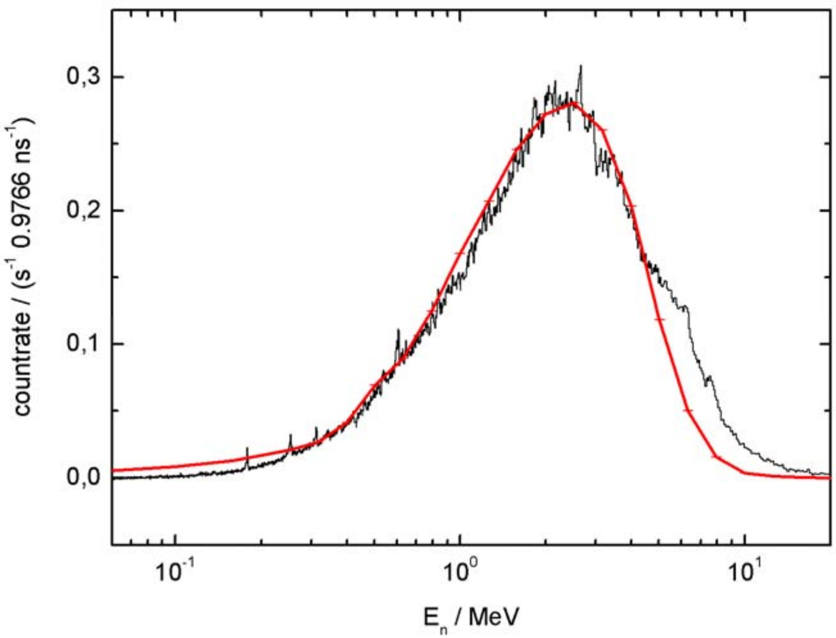


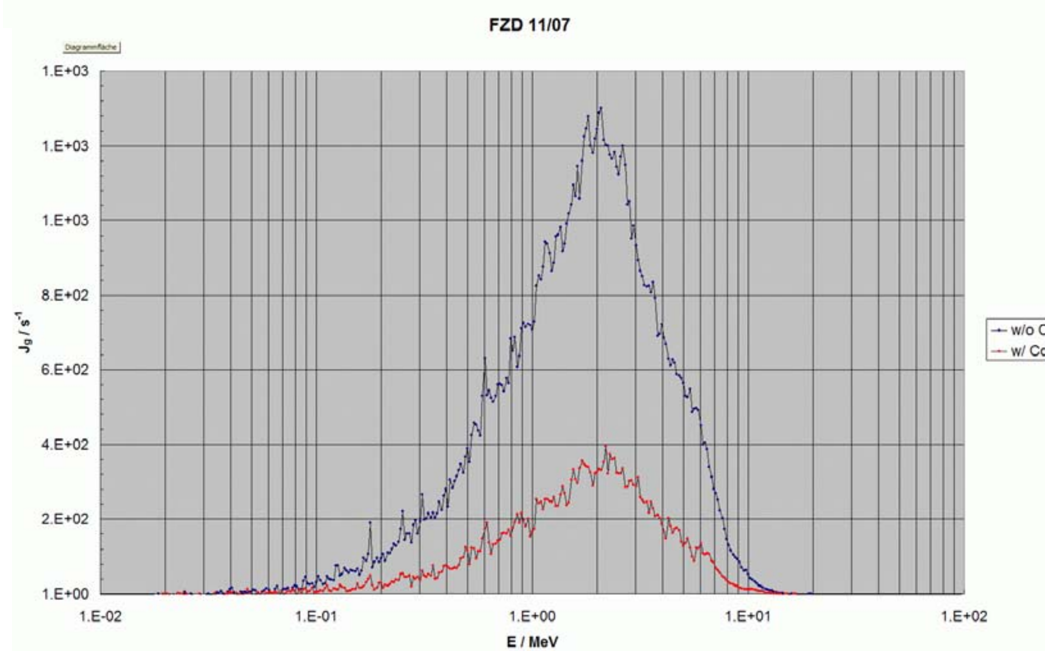
Additional photon flash arrives before photons from Pb-radiator (Nov. 2007).

➔New magnetic steerer improves transmission of beam line (Feb. 2008)

➔low photon background in plastic scintillators.
Random rate in tof spectra constant for beam on/off.

Neutron spectra: plastic scintillator - ^{235}U fission chamber

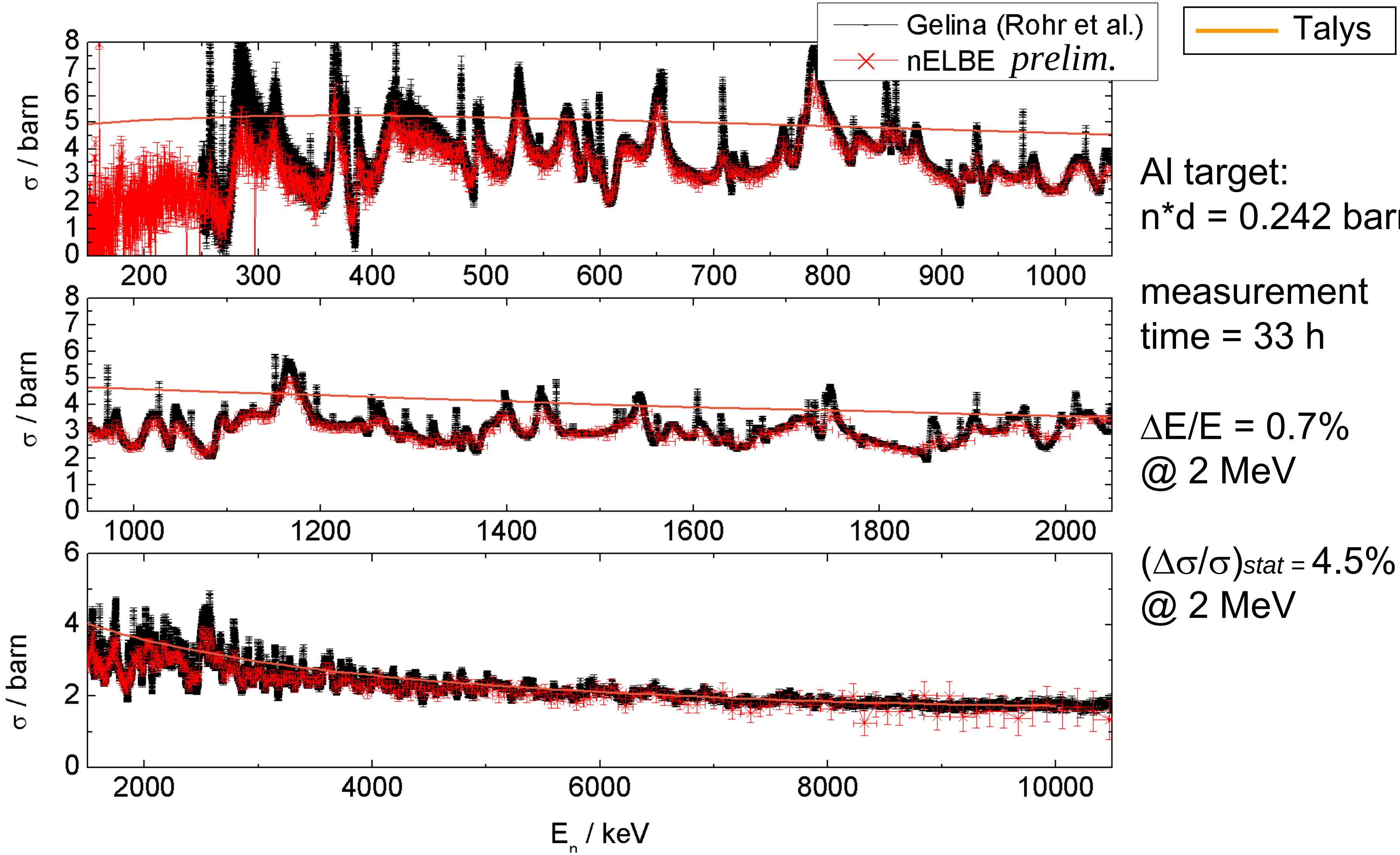




Feb 08 plastic scintillator
➔ talk of R. Beyer
•Electron energy 33 MeV
fine structure in photo neutron spectra from ^{nat}Pb
• MCNP simulation underestimates high energy part (PTB)

Nov 07 PTB fission chamber
➔ S. Röttger, progress report
•Electron energy 25 MeV (photon background)
same fine structure in photo neutron spectra
• very low thermal neutron background from comparison with/without Cd absorber

Al-Transmission measurements



Al target:
n*d = 0.242 barn^{-1}

measurement time = 33 h

$\Delta E/E$ = 0.7% @ 2 MeV

$(\Delta\sigma/\sigma)_{stat}$ = 4.5% @ 2 MeV

Outlook

- nELBE photo neutron source operational
  first measurements ongoing
- (n,n´γ) and σ_{tot} measurements planned
- Higher neutron intensity: Thermionic injector to be replaced by SRF photo injector (1 mA at 500 kHz repetition rate in Jan 2009)