nELBE - The Neutron Time-of-Flight Facility* at ELBE

* Part of the EFNUDAT (EU-FP6) consortium.

Proton-Recoil Detectors for Time-of-Flight Measurements of Neutrons with Kinetic Energies from some Tens of keV to a few MeV

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The Scintillation Detectors [1]

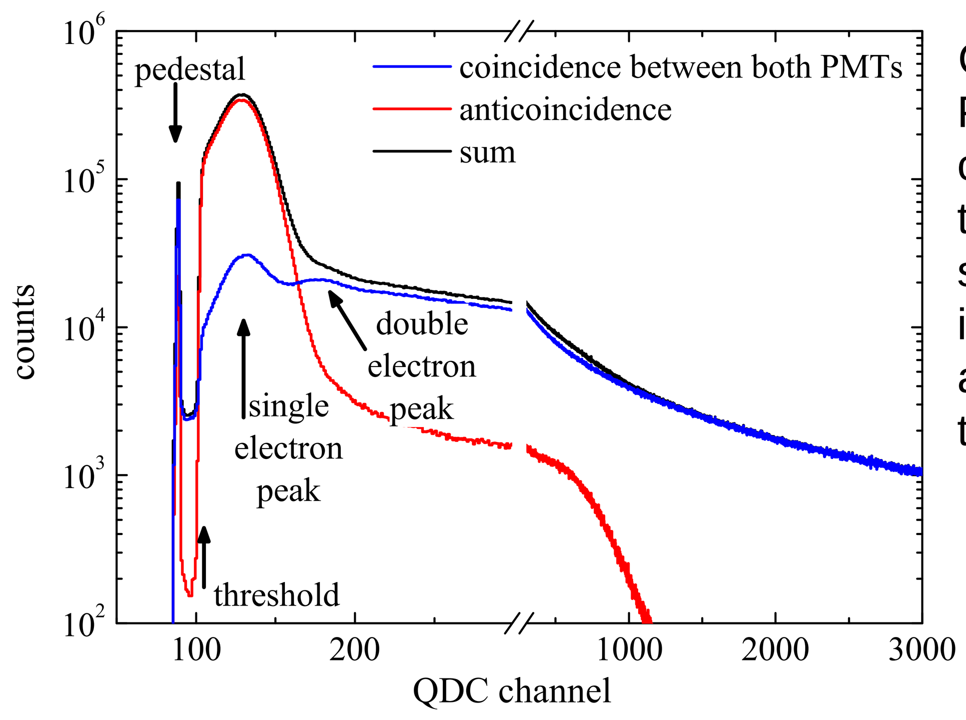
[1] R. Beyer, E. Grosse, et al., Nucl. Instr. Meth. A 575 (2007) 449-455, DOI:10.1016/j.nima.2007.02.096.

- material: plastic scintillator **EJ-200** (equivalent to BC-408 or Pilot F)
- dimensions: 1000 x 42 x 11 mm^3
- readout: two high gain photomultiplier tubes (PMT) Hamamatsu R2059-01
- electronics: - one multi hit, multi event TDC CAEN V1190A
  - two multi event QDCs CAEN V792
  - dedicated, inhouse developed CFDs

- trigger threshold: just below the single electron peak (SEP)

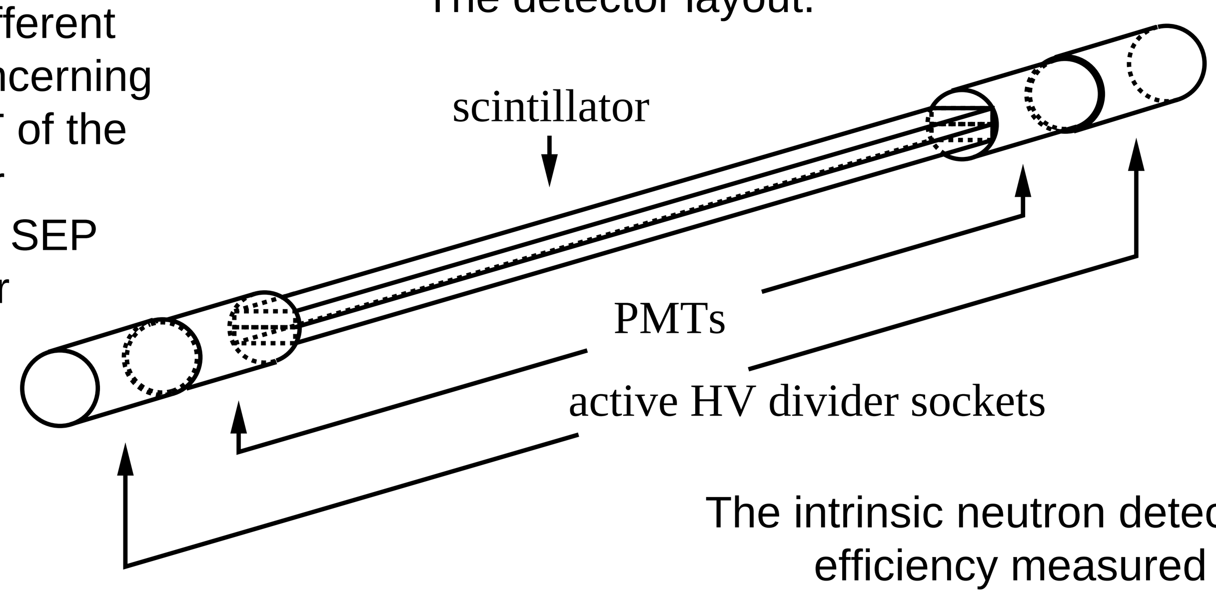
➔ results in:
- detection efficiency of **more than 10 % for 24 keV neutrons**
- detection efficiency of **20 % to 40 % at energies above 150 keV**
- well reproducable trigger threshold, because adjustment relative to the SEP

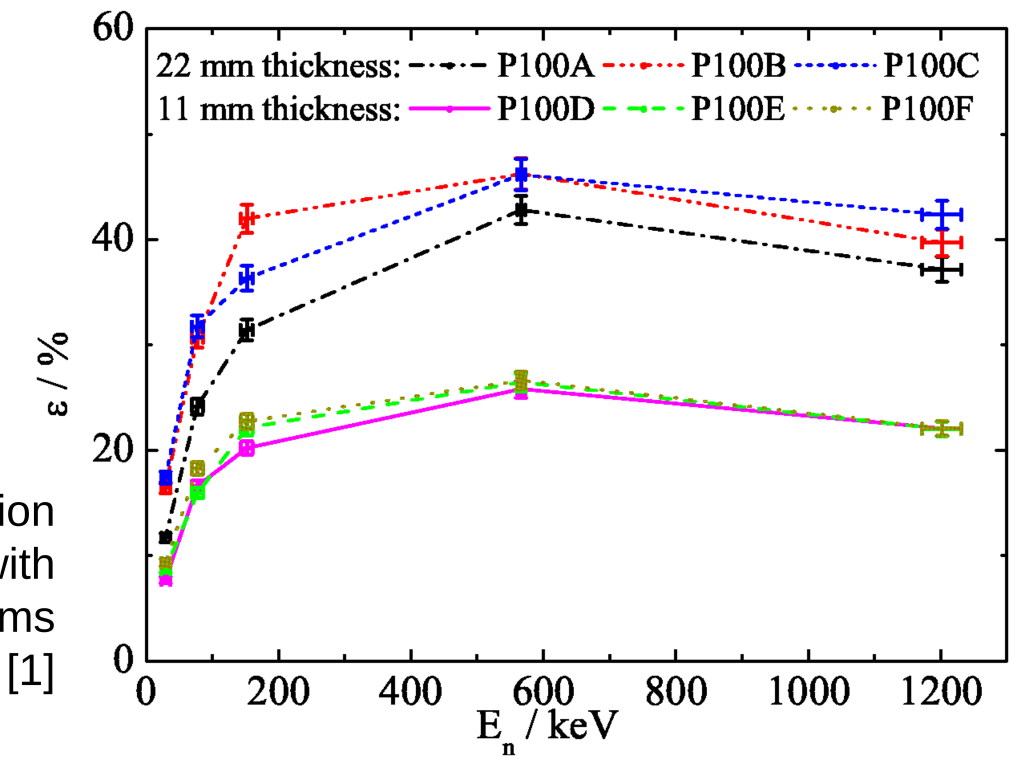
- time resolution: 700 ps (FWHM)



QDC spectrum of one PMT under different conditions concerning the other PMT of the same detector illustrating the SEP and the trigger threshold.

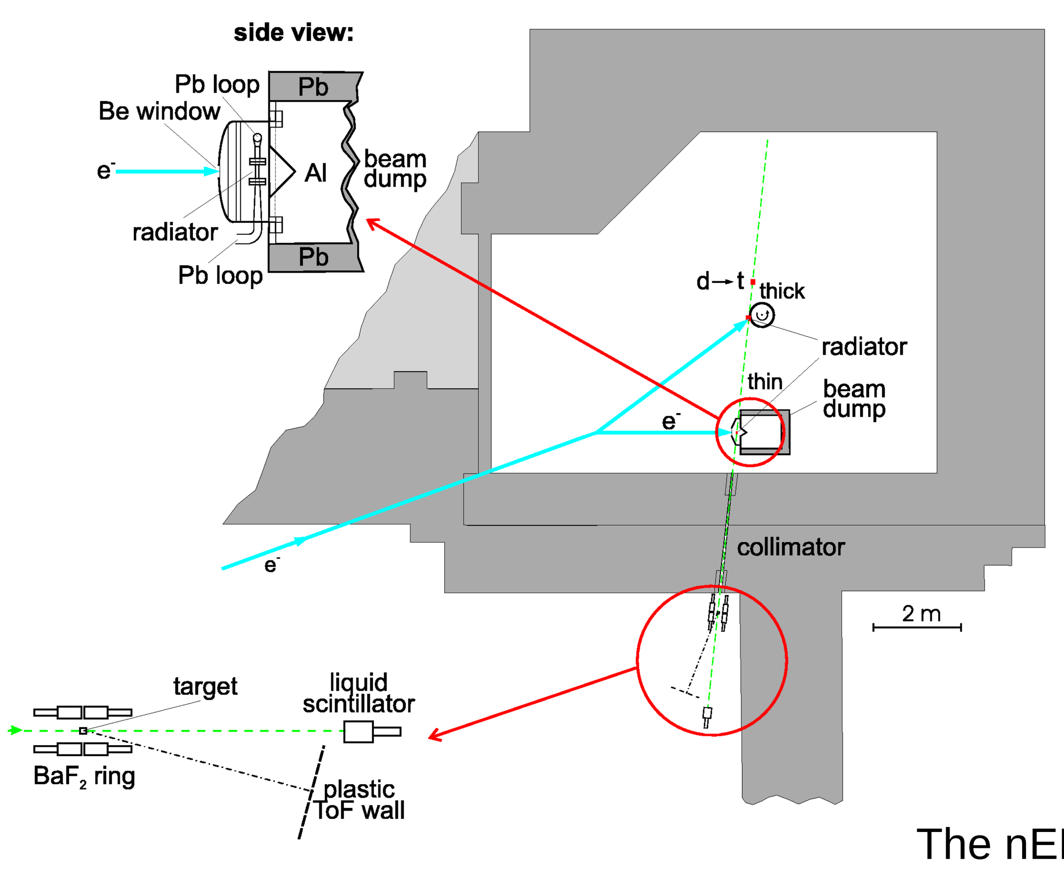
The detector layout.





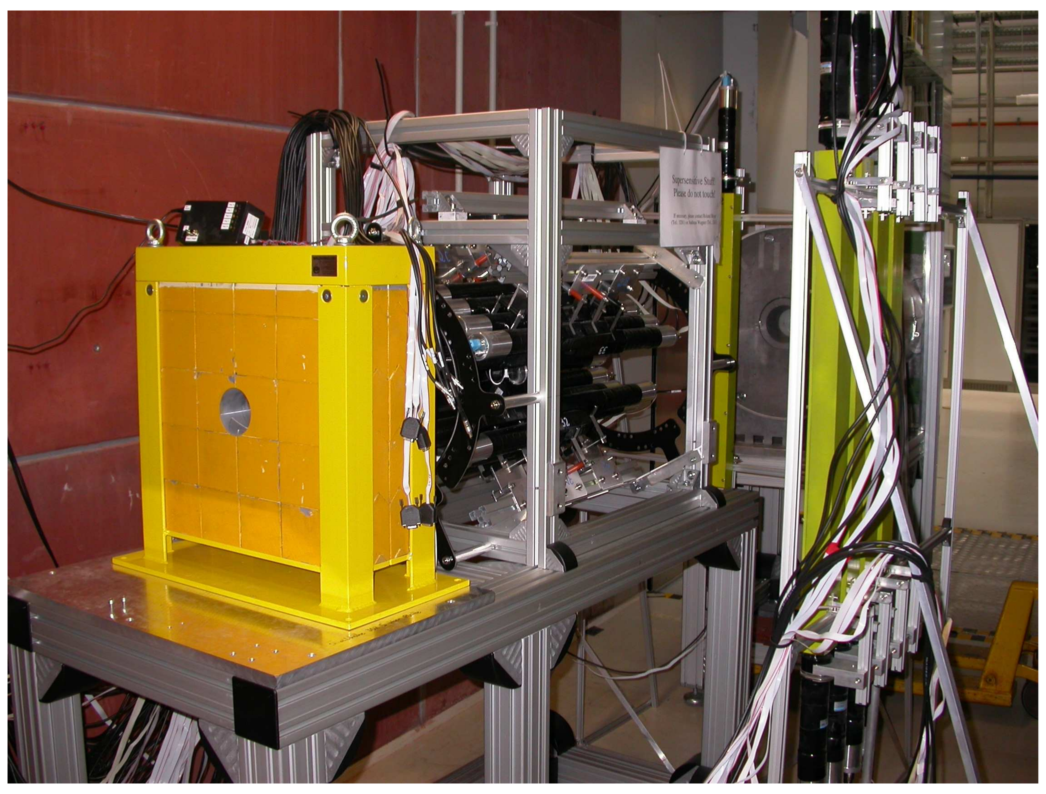
The intrinsic neutron detection efficiency measured with monoenergetic neutron beams at PTB Braunschweig [1]

The nELBE Neutron Time-of-Flight Setup



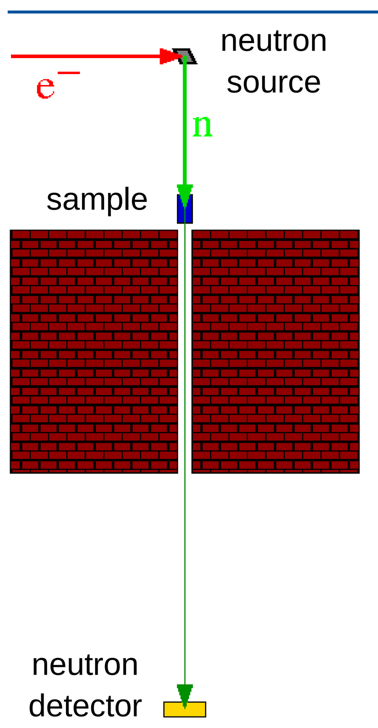
The nELBE neutron source

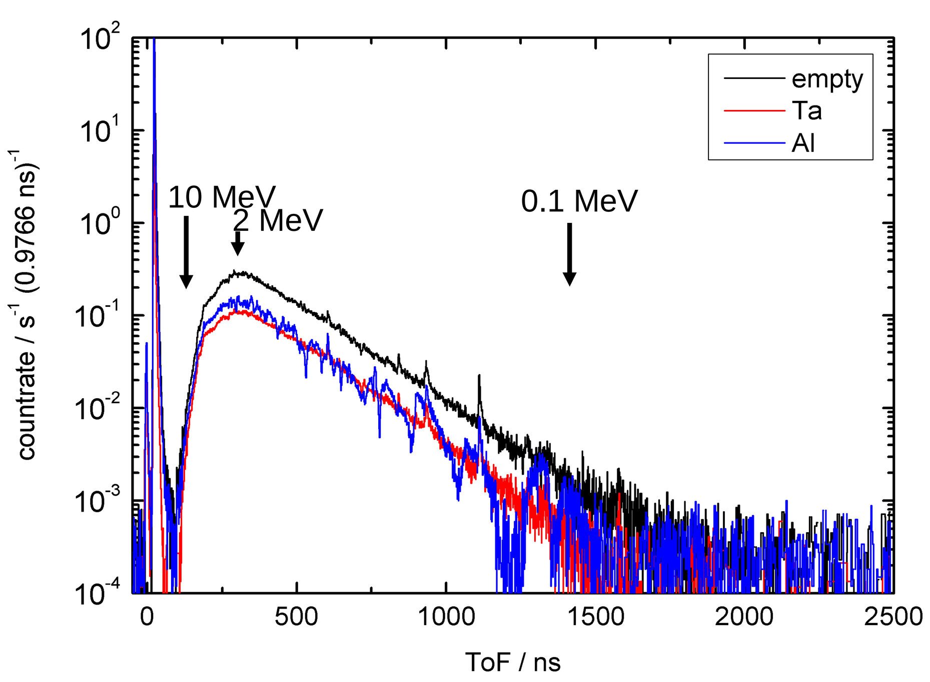
- neutrons are produced by the ELBE electron beam (40 MeV) impinging on a liquid lead target
- repetition rate: 101 kHz
- flight path: 6.0 m
- neutron intensity: $1.5 \cdot 10^7$ cm^{-2} s^{-1}
- neutron energy range: 100 keV < E_n < 10 MeV (energy range similar to a fast reactor)
- neutron energy resolution: ΔE/E < 1 %



The nELBE detector setup:
- 5 plastic scintillation detectors for neutron detection
- an array of 42 BaF_2 crystals for photon detection

Transmission (n,tot)





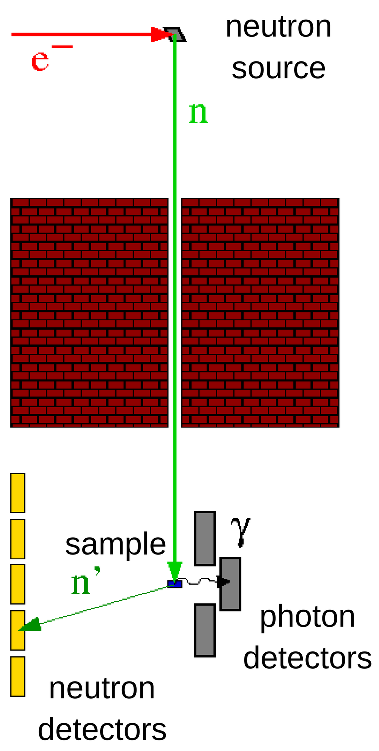
Measured neutron time-of-flight spectra with different absorbers

➔ total neutron cross section is determined by:

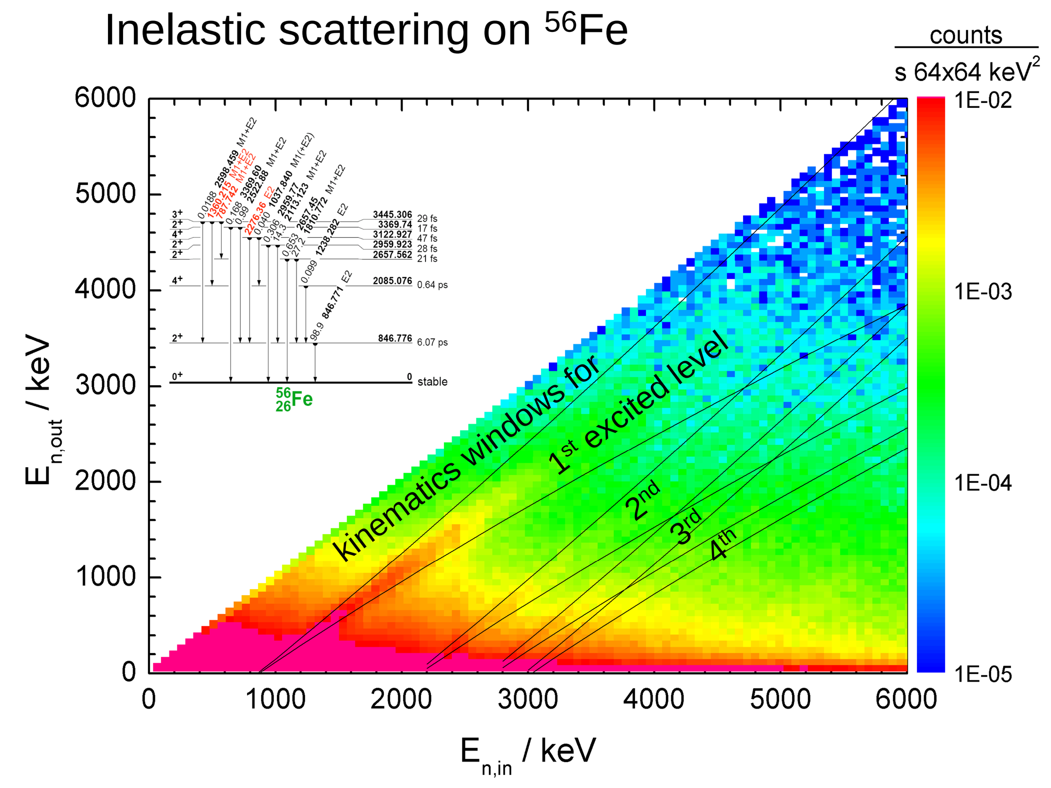
$$\sigma_{tot} = \frac{\ln \dot{N}_{empty} - \ln \dot{N}_{sample}}{\rho / M_{mol} \cdot N_A \cdot d}$$

ρ … sample density
M_{mol} … molar mass
d … sample thickness

Inelastic Scattering (n,n'γ)



Inelastic scattering on ^{56}Fe



kinematics windows = possible range of $E_{n,out}$ for given $E_{n,in}$, calculated by relativistic kinematics including scattering angle, excitation energy and experimental uncertainties

$E_{n,in}$ … energy of the incoming neutron, determined by time of detection of the photon (ΔE/E ca. 1 %)
$E_{n,out}$ … energy of the scattered neutron, determined by time difference between detection of the photon and detection of the neutron (ΔE/E ca. 10 %)

➔ inelastic neutron scattering cross section is determined by:

$$\sigma_{tot} = \frac{\dot{N} / \varepsilon_{BaF2} / \varepsilon_{Pl}}{\Phi \cdot N_{Targ}}$$

$\dot{N}$ … detected reaction rate determined from kinematics windows (see graph)
Φ … incoming neutron flux
N_{Targ} … number of target nuclei

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