The time-of-flight setup for inelastic scattering measurements at nELBE

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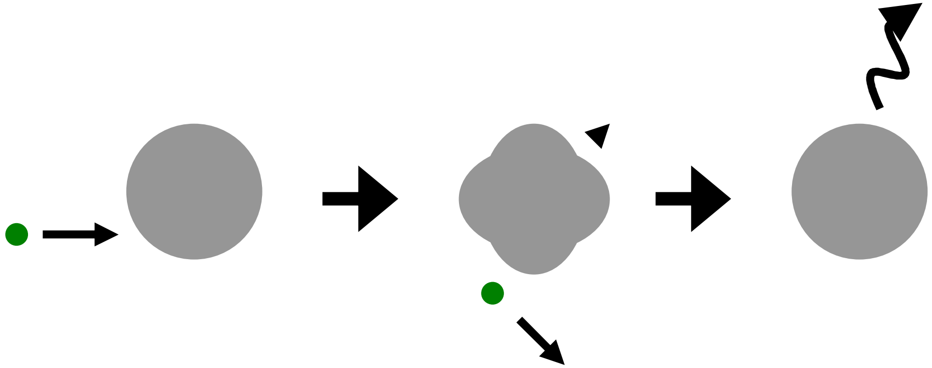
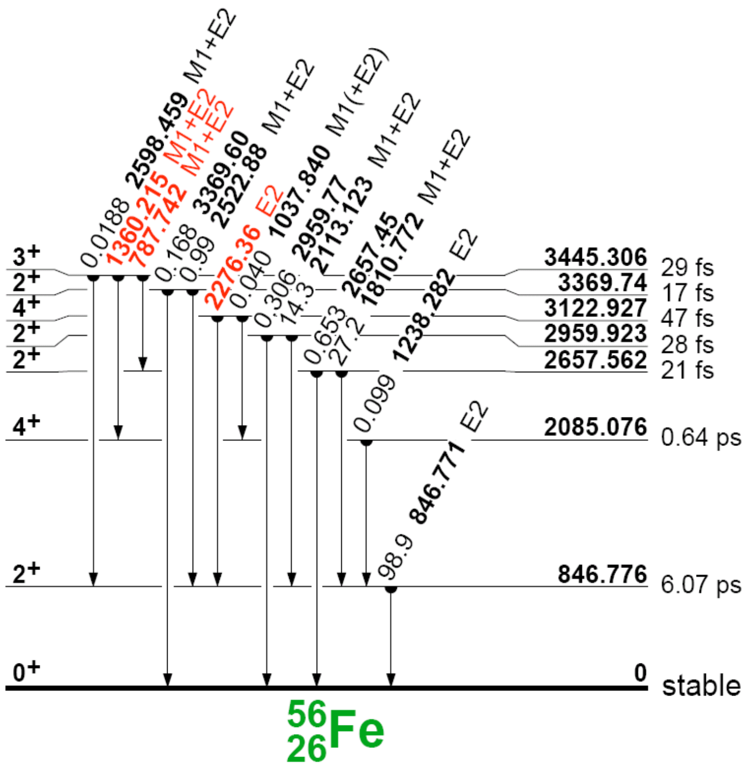
Inelastic neutron scattering





signature for inelastic scattering (on ^{56}Fe):

- coincident neutron in Plastic detectors and gamma in BaF_2 array
- kinematics has to match:
  - Energy of incoming and scattered neutron are measured with time-of-flight technique
  - form incoming neutron energy, scattering angle and excitation energy one calculate theoretical value for scattered neutron energy

Inelastic neutron scattering - kinematics

$$(E_{in}, \vec{p}_{in}) + (E_{Fe}, \vec{p}_{Fe}) = (E_{out}, \vec{p}_{out}) + (E_{Fe*}, \vec{p}_{Fe*})$$

$$E_{in} = E_{in,kin} + m_n \qquad m_{Fe*} = m_{Fe} + E_x$$

$E_{in,kin}$ … incoming neutron energy
m_n … neutron mass
m_{Fe} … target mass
E_x … excitation energy
θ … scattering angle

$$\boxed{E_{out} = \frac{1}{2A}\left(-B \pm \sqrt{B^2 - 4AC}\right)}$$

$$E_{out,kin} = E_{out} - m_n$$

$$A = (m_{Fe} + E_{in})^2 - (E_{in}^2 - m_n^2)\cos^2\theta$$

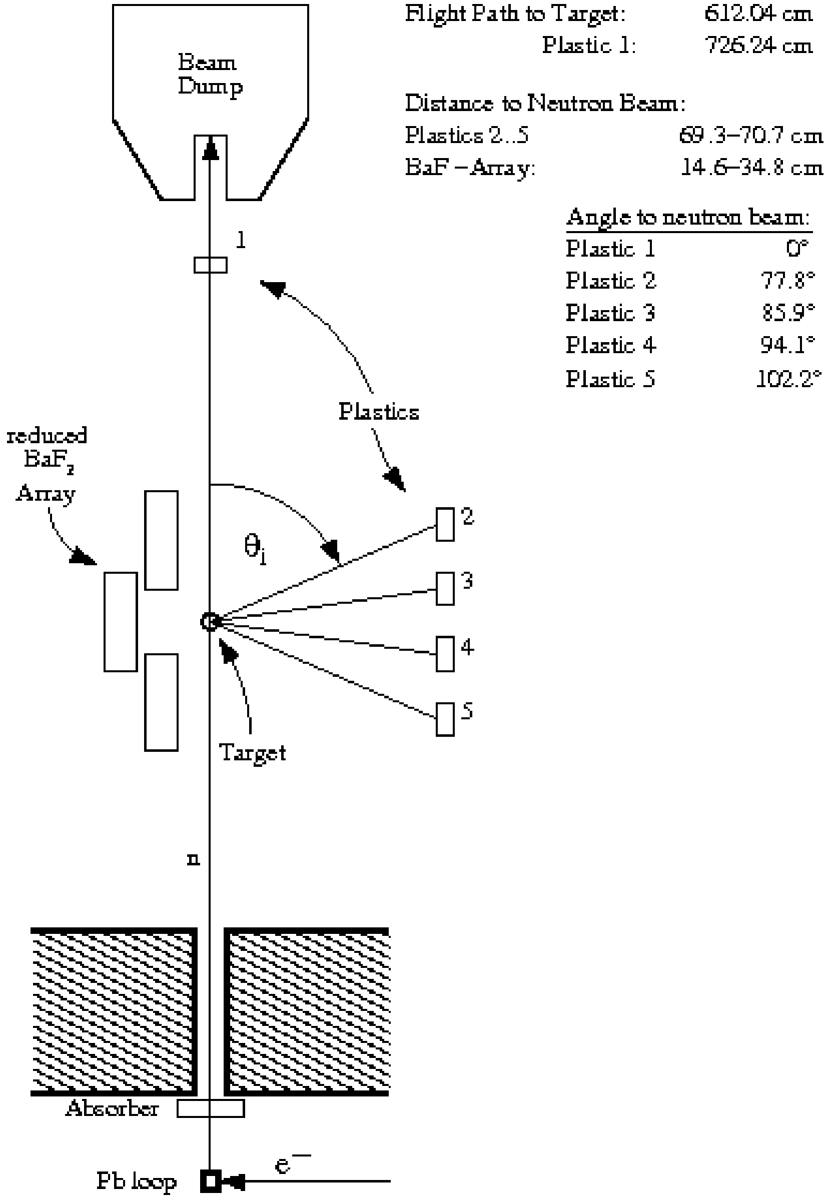
$$B = -2(M + E_{in} m_{Fe})(m_{Fe} + E_{in})$$

$$C = (M + E_{in} m_{Fe})^2 + m_n^2 (E_{in}^2 - m_n^2)\cos^2\theta$$

$$M = \frac{m_{Fe}^2 + 2m_n^2 - m_{Fe*}^2}{2}$$

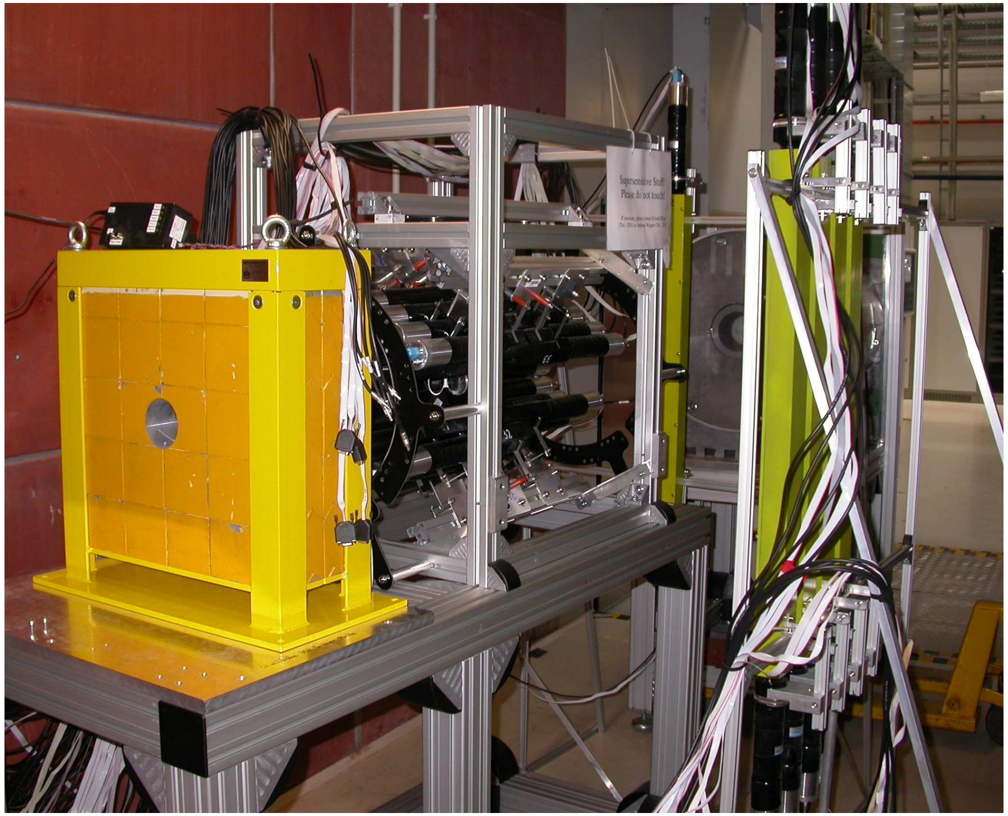
The detector setup

- Target:
  - ^{nat}Fe: 52 mm diam., 41 g → 20 g in beam
- Absorber:
  - Pb: 60 mm diam., 10 mm length
- ELBE beam:
  - 32.8 MeV
  - 1.7 – 2.3 µA
  - 101 kHz

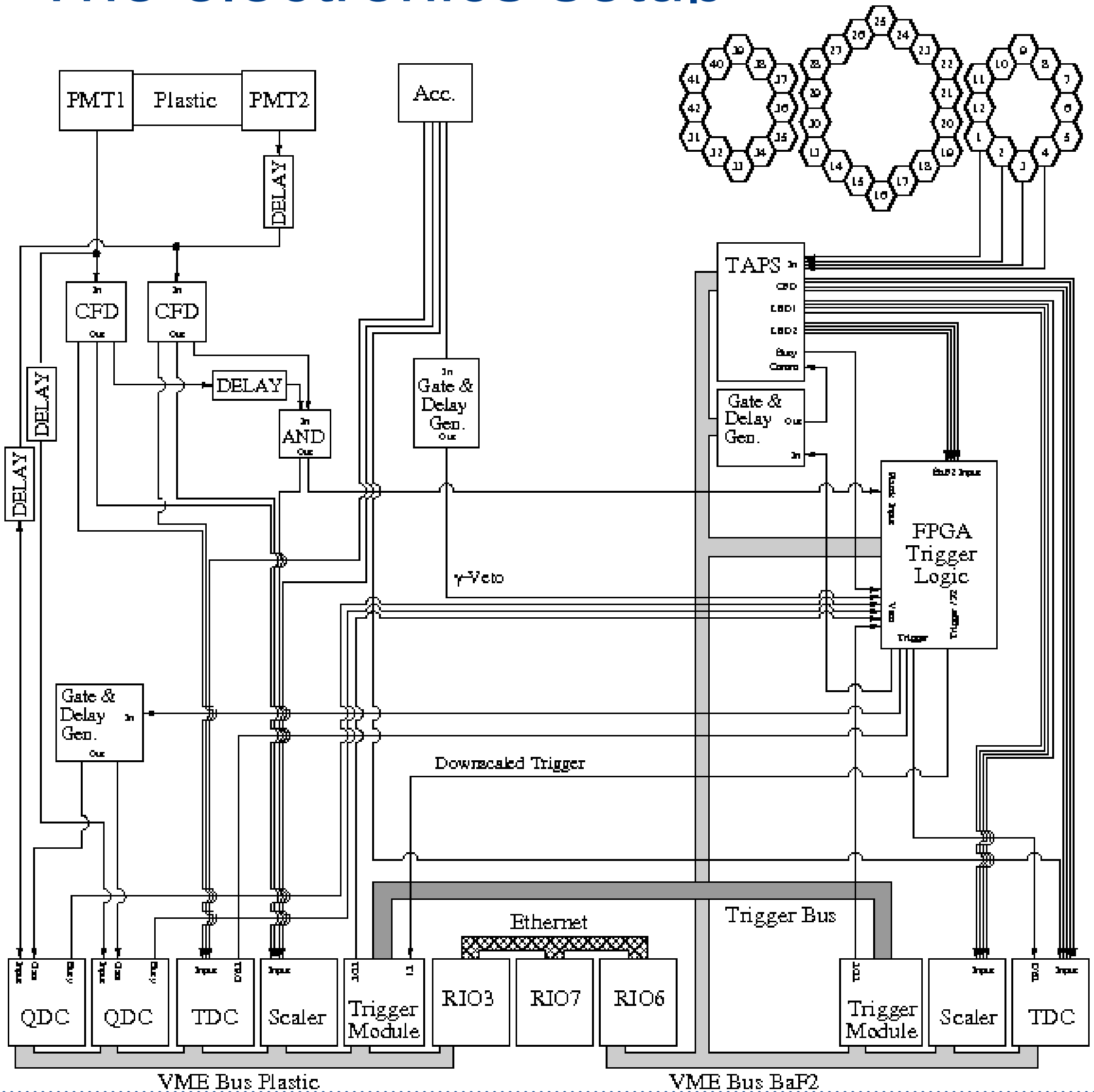


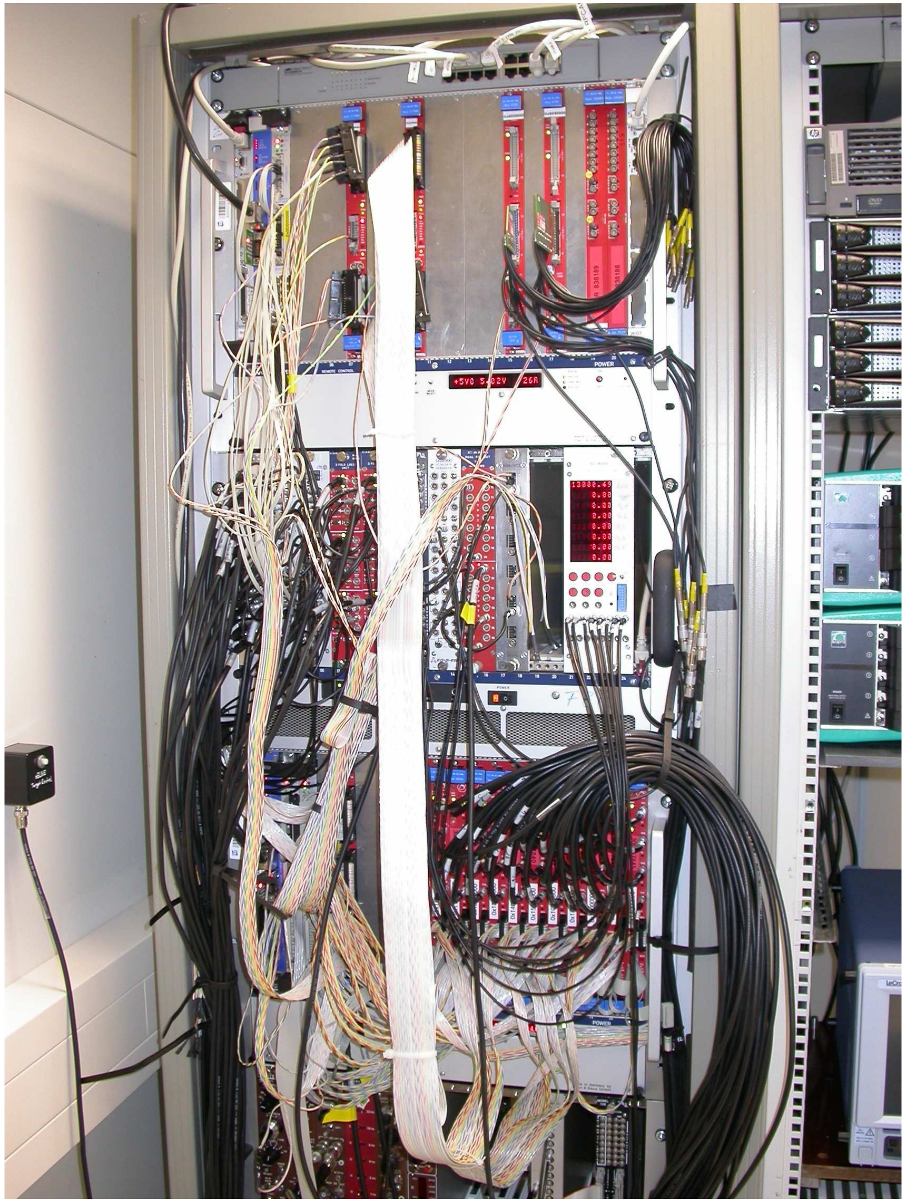
- time of signal from BaF2 gives the energy of the incoming neutron (ΔE/E ca. 1 %)
- time difference between BaF2 and plastic signals gives the energy of the outgoing neutron (ΔE/E ca. 10 %)

The detector setup



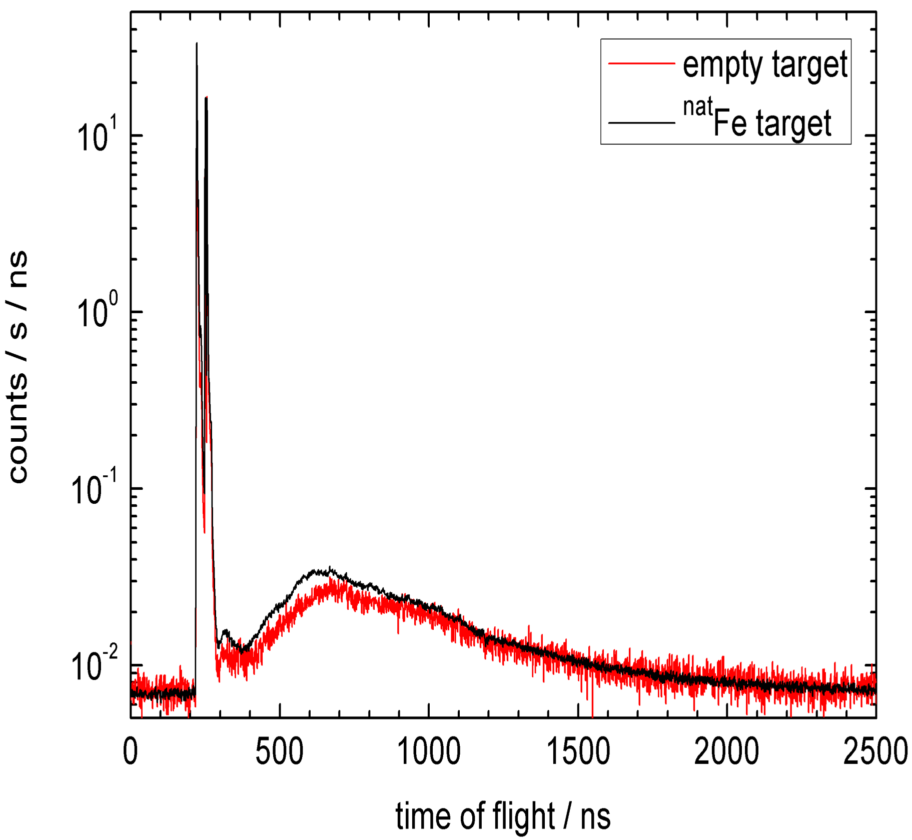
The electronics setup



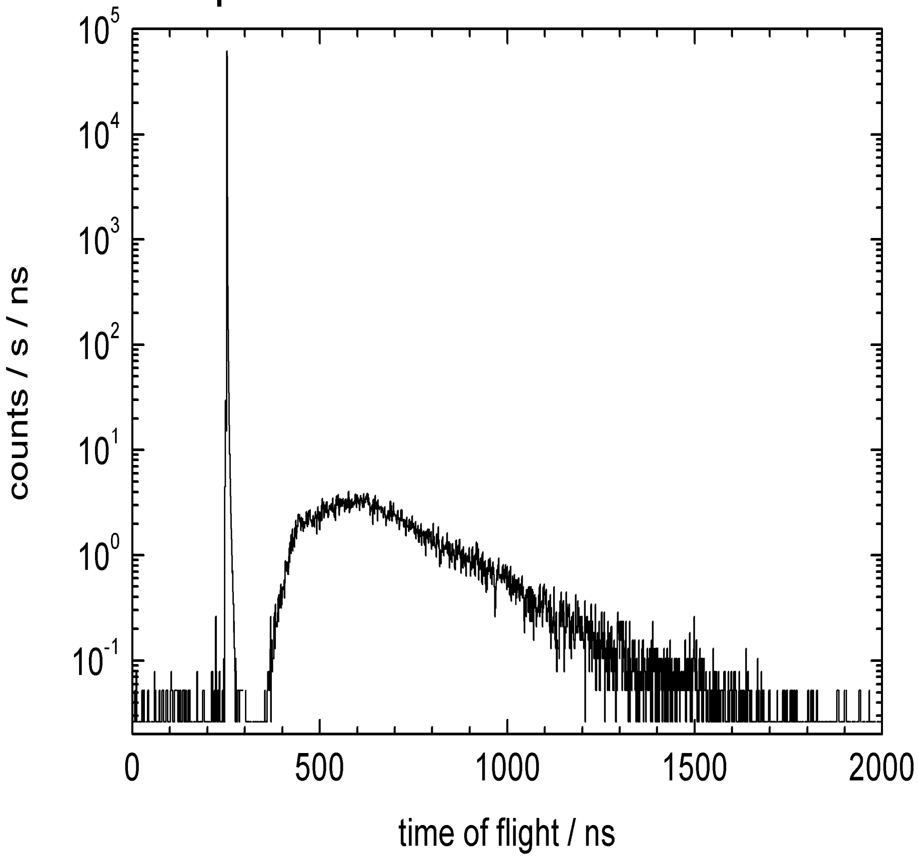


Time of flight spectra

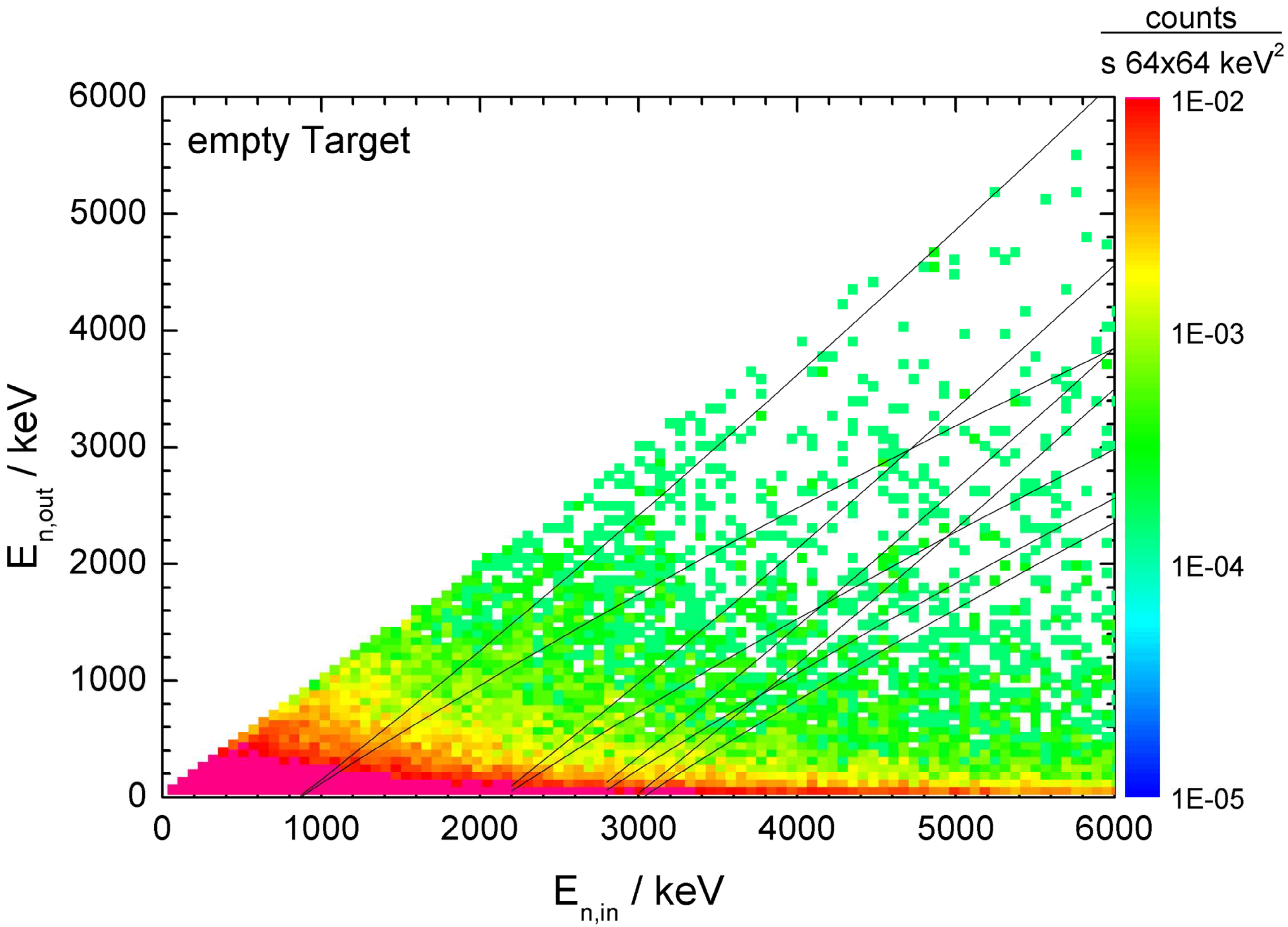
Spectrum measured under 77.8°



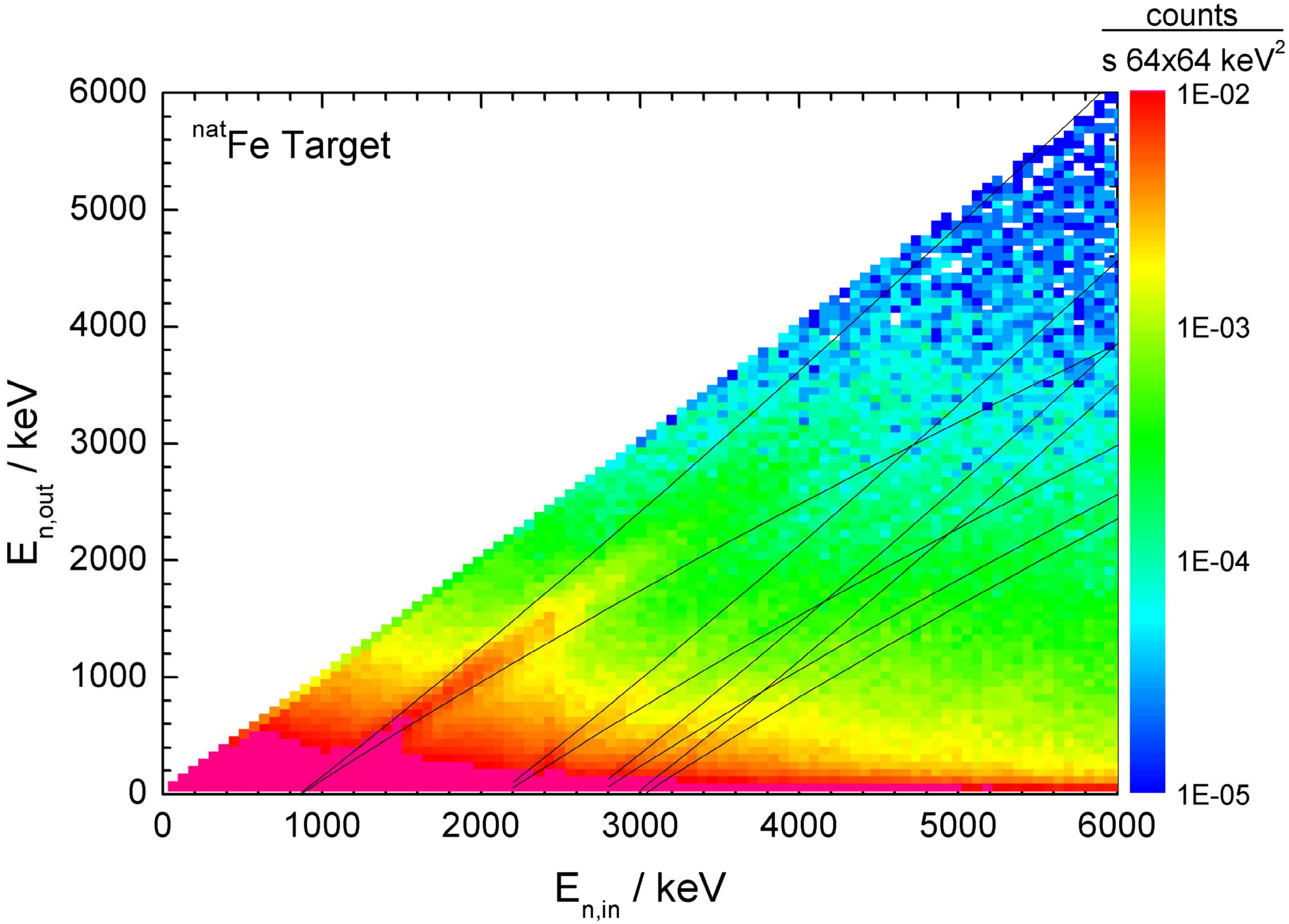
Spectrum measured unde r 0°



2D – energy spectrum without target

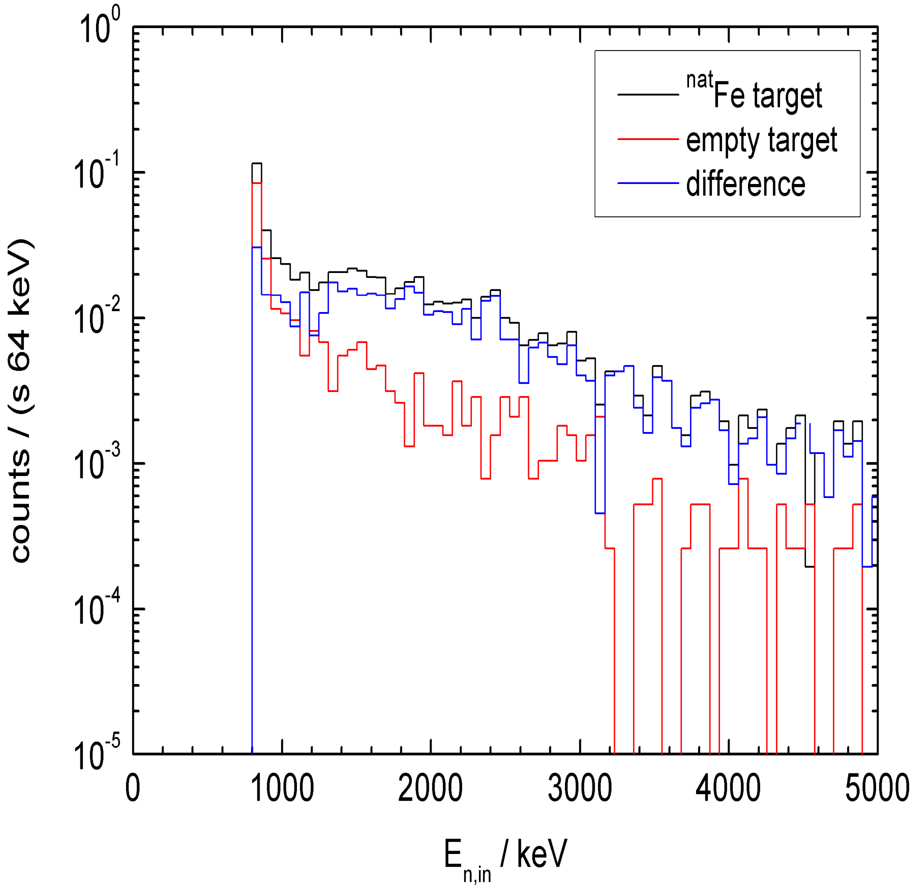


2D – energy spectrum with target

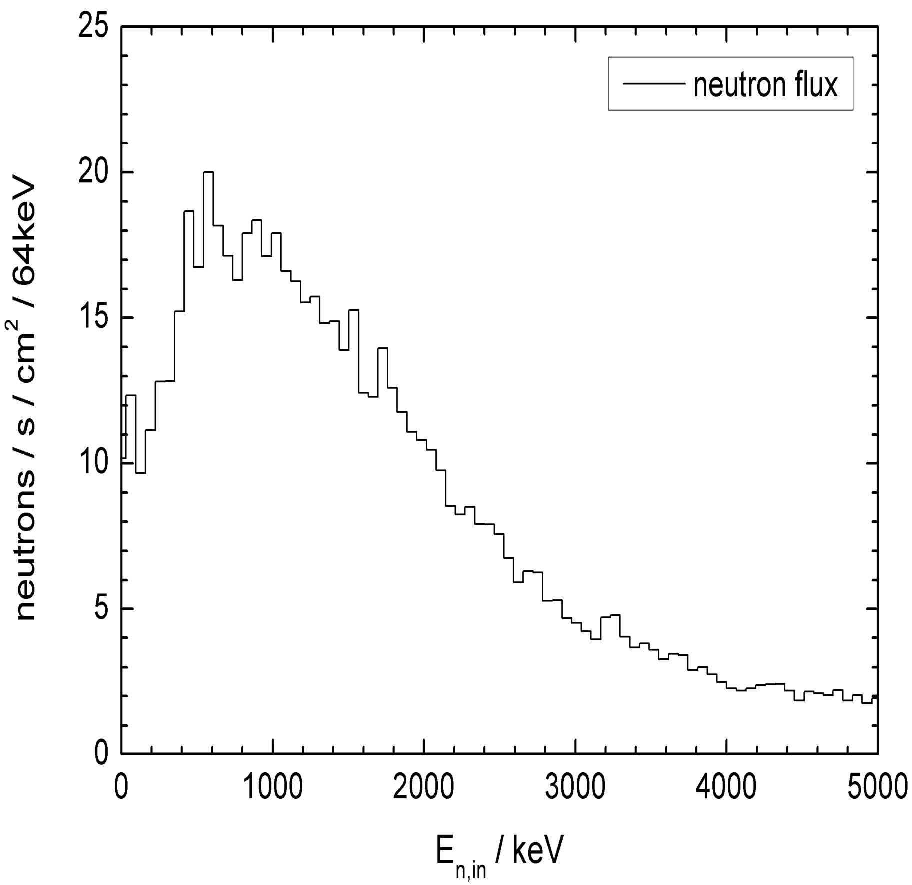


2D – energy spectrum with target

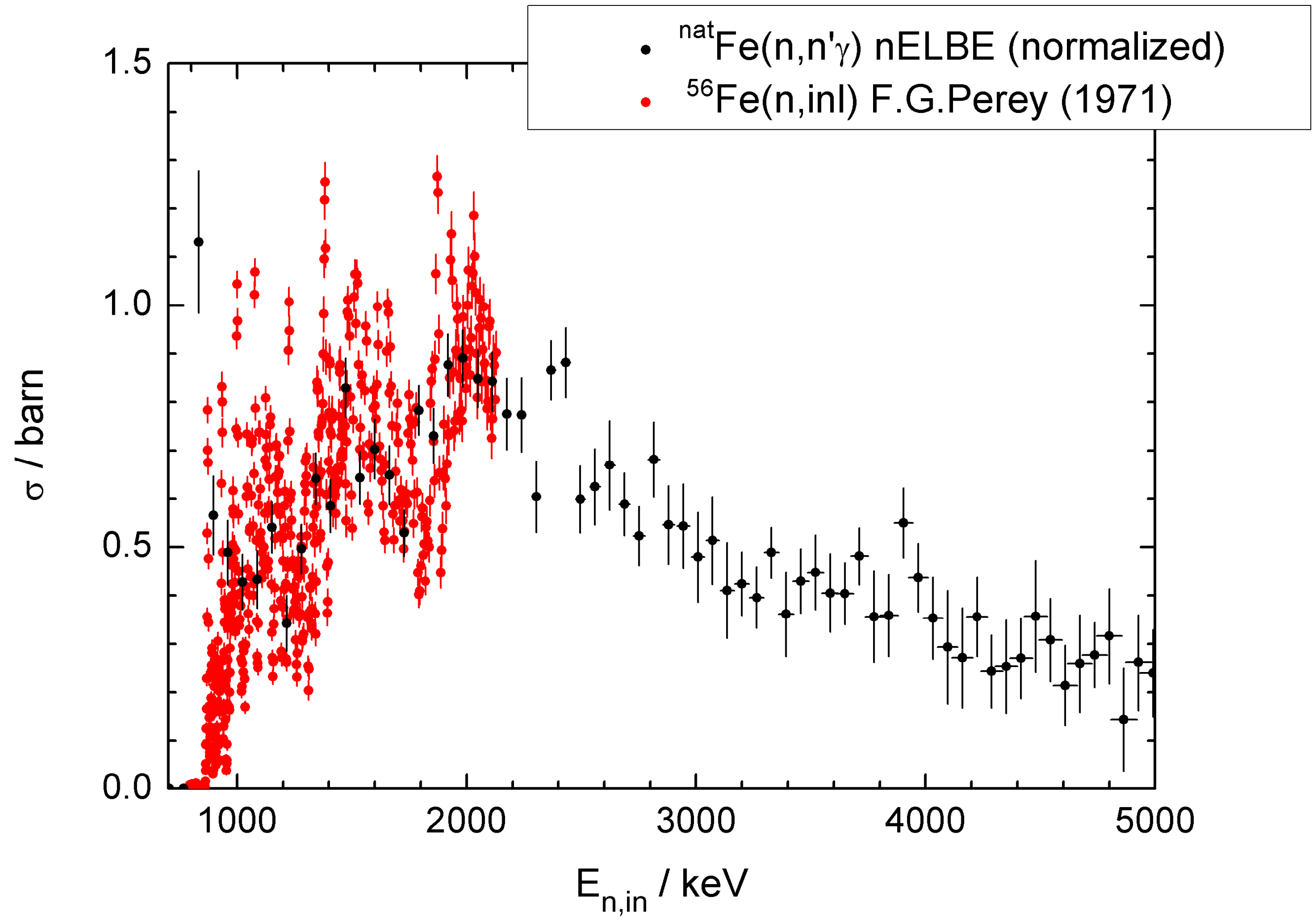
Projected spectrum for E_x = 847 keV



Incoming neutron flux



2D – energy spectrum with target



Conclusion

- Setup for measurement of inelastic scattering cross sections was build at nELBE
- Cross section is determined from double-time-of-flight measurement

Outlook

- Experimental background has to be identified and reduced
- Absolute neutron flux has to be measured
- More statistics is needed