The nELBE setup for measurements of neutron-induced reactions

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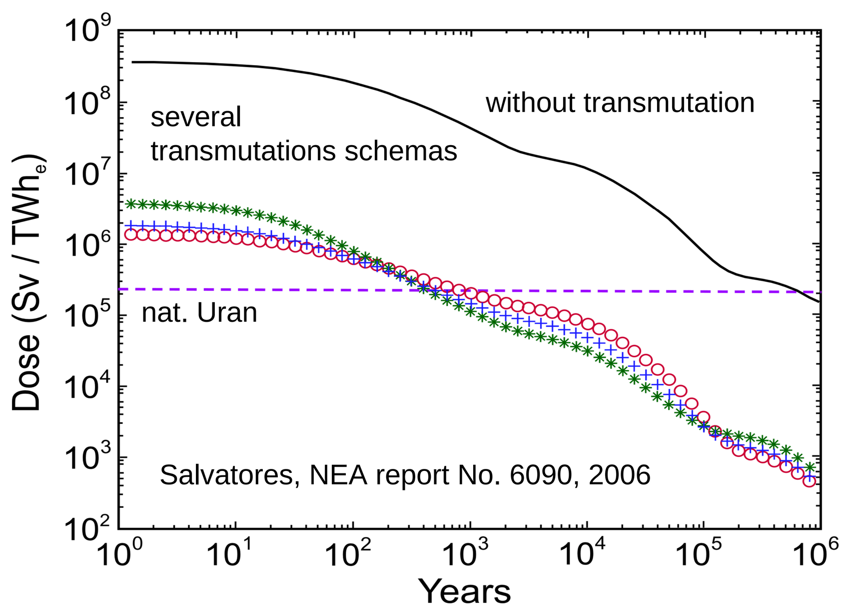
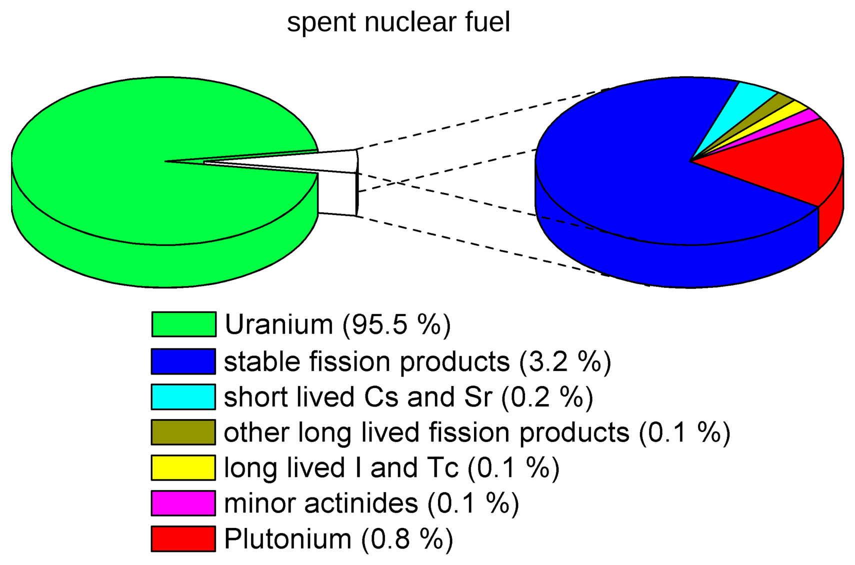
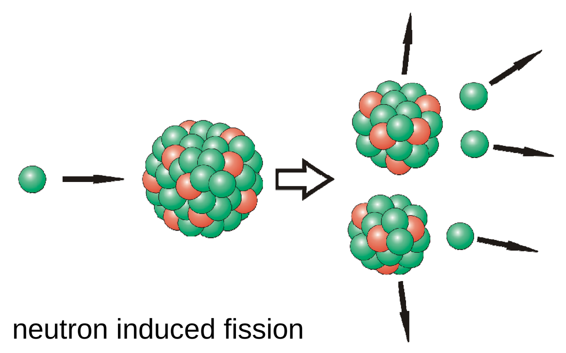
Transmutation of long-lived radio-nuclides

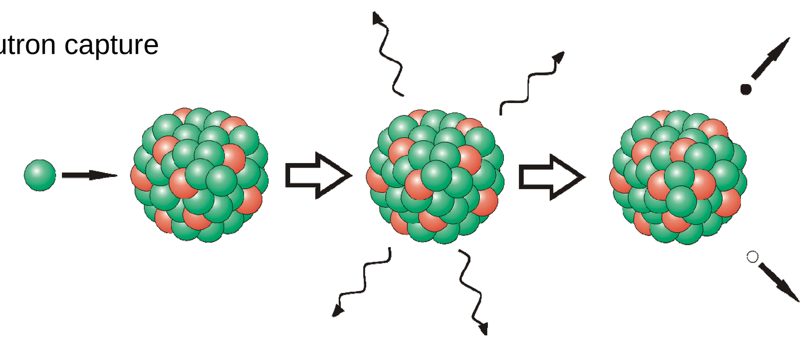
- **Transmutation** of radioactive waste **= convert long-lived radio-nuclides into short-lived ones** ➔ simplification of final disposal





- ***Without transmutation**: Radio-toxicity of untreated nuclear waste from conventional nuclear reactors reaches level of original Uranium after several **100 000 years** (—)*
- ***With transmutation**: Within less than **1000 years** level of original Uranium is reached (- -)*



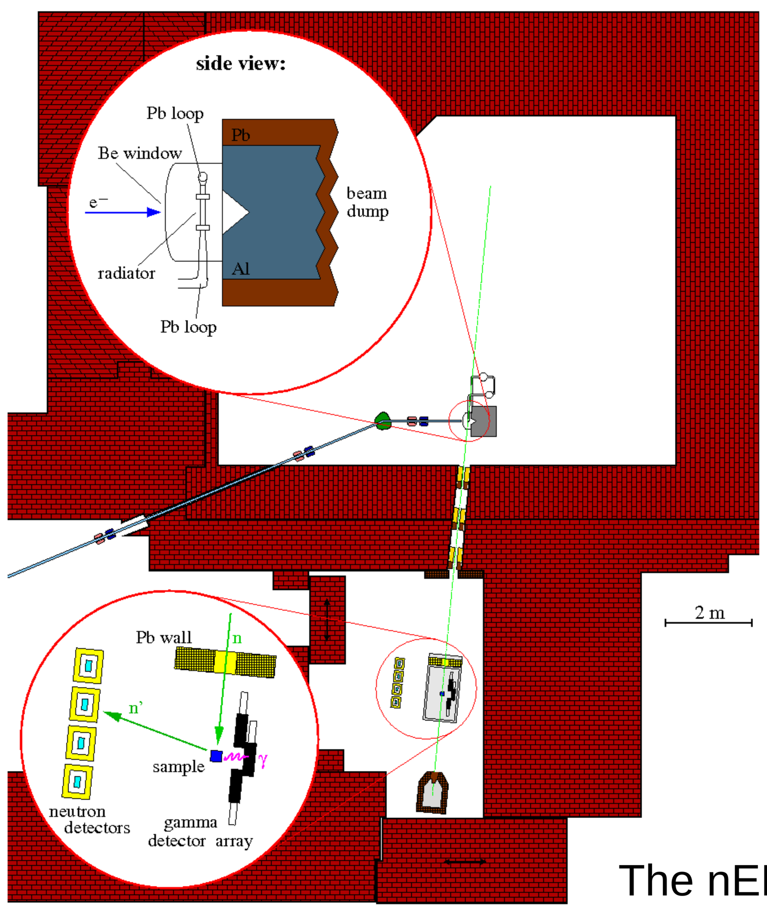


- **Fundamental processes** of inelastic neutron-scattering, neutron-capture and neutron induced fission **have to be well understood** to design transmutation facilities.

- **Fast**, non moderated **neutrons can both**:
  1. **transmute** long-live fission fragments
  2. **fission** transuranic elements: Plutonium (and other minor actinides) will be energetically used, too. Existing quantities can be burned up.

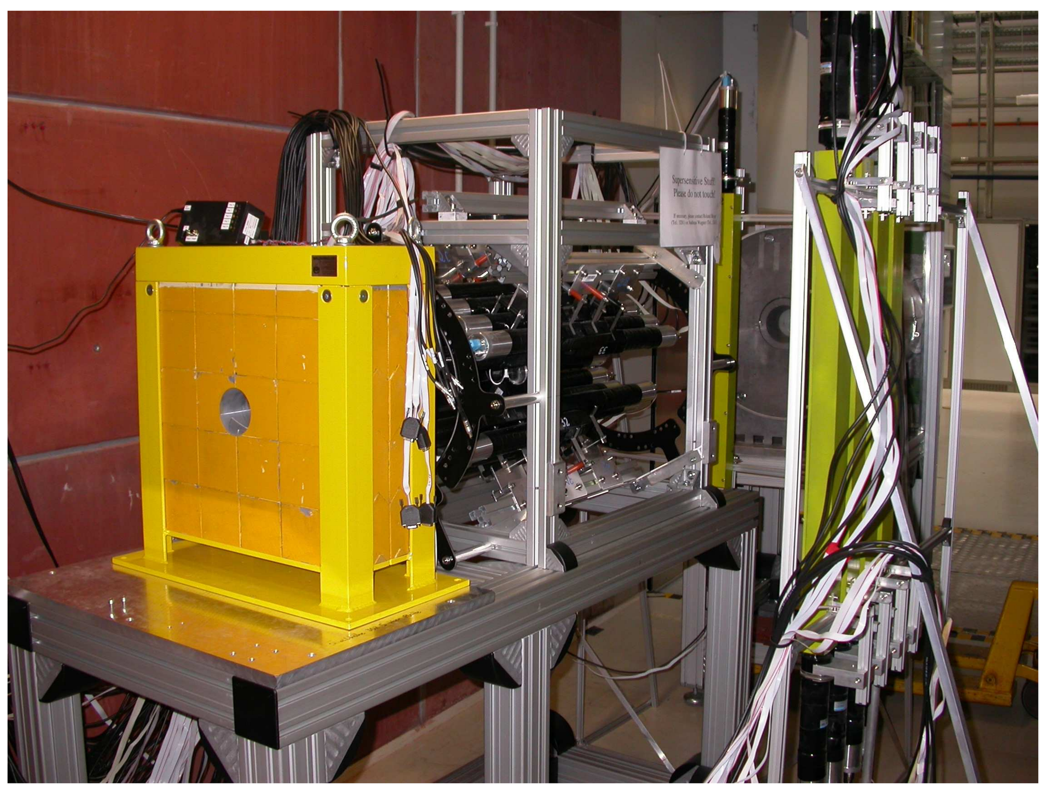
- **At nELBE reaction cross sections of neutron-induced processes will be measured to high precision.**

The nELBE neutron time-of-flight facility



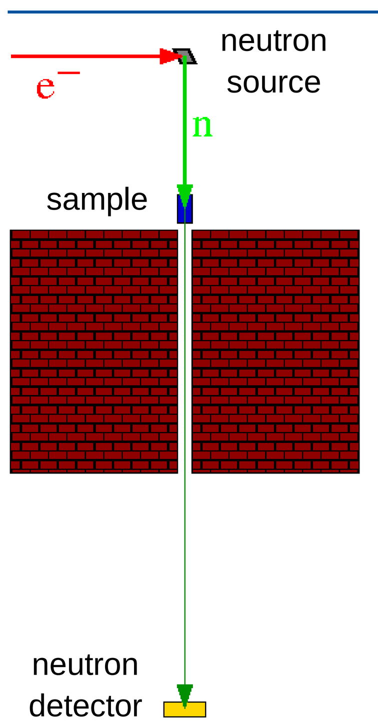
The nELBE neutron time-of-flight facility

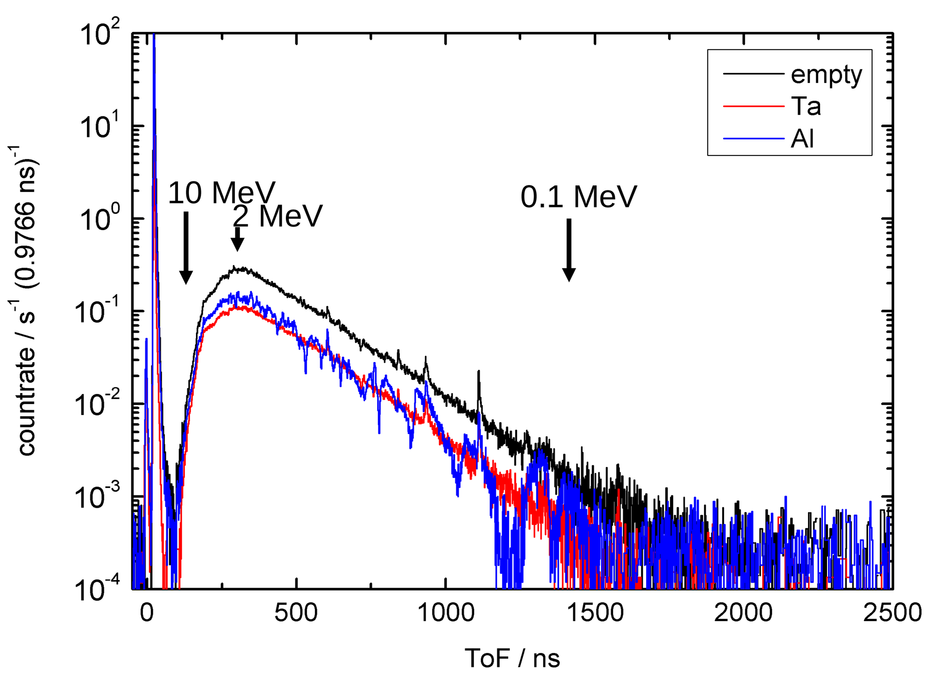
- Neutrons are produced by the ELBE electron beam impinging on a liquid lead target
- Repetition rate: 101-202 kHz
- Flight path: 5-7 m
- Neutron intensity: 1.5·10^7 cm^{-2} s^{-1}
- Neutron energy range: 100 keV < E_n < 10 MeV (energy range compare-able with fast reactors)
- Neutron energy resolution: ΔE/E < 1 %



The nELBE detector setup:
- 5 plastic scintillation detectors to detect the neutrons
- an array of up to 42 BaF_2 crystals for photon detection

Transmission (n,tot)





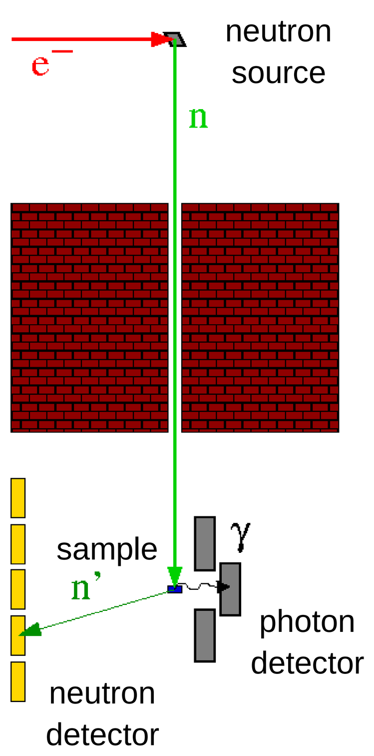
measured neutron time-of-flight spectra for different samples

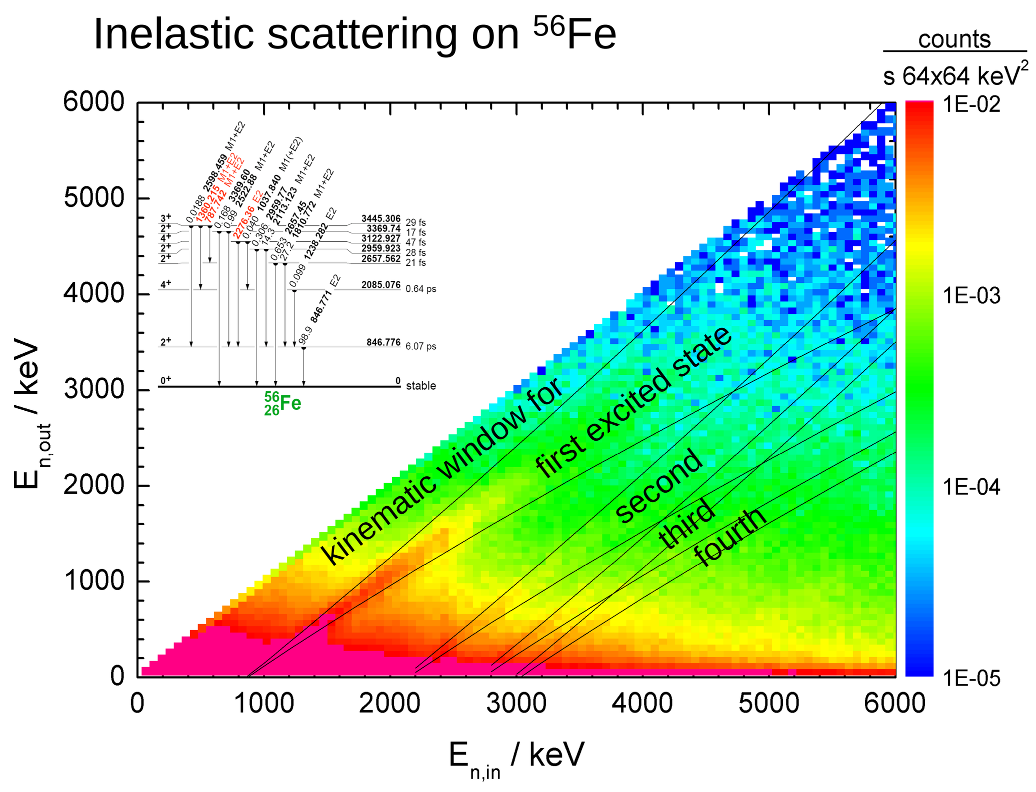
➔ total neutron cross section determined by:

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

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

Inelastic scattering (n,n'γ)





kinematic window = allowed range of $E_{n,out}$ for given $E_{n,in}$, calculated in relativistic kinematics considering scattering angle, excitation energy and experimental uncertainties

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

➔ Inelastic neutron scattering cross section determined by:

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

$\dot{N}$ … reaction detection rate
Φ … incoming neutron flux
N_{Targ} … number of nuclei in the sample