Experiments with fast neutrons at *m*ELBE

ZENTRUM DRESDEN

HELMHOLTZ

ROSSENDORF

R. Beyer¹, A. R. Junghans¹, T. Kögler², R. Schwengner¹, S. Urlaß¹, A. Wagner¹

¹Institute of Radiation Physics - Nuclear Physics ²Institute of Radiooncology – OncoRay - Medical Radiation Physics

Overview

Accurate data for neutron induced nuclear reactions







Nuclear Astrophysics:

All elements heavier than iron have been produced by neutron induced reactions

Radio therapy:

Secondary neutrons in proton or ion therapy

Particle transport:

Precise data over a wide energy range for computer simulations

New neutron time-of-flight facility: superconducting accelerator based ~ELBE



R. Beyer et al., Nucl. Instr. Meth. A 723 (2013) 151. ; A.R. Junghans et al., Nucl. Data Sheets 119 (2014) 349. ; A.R. Junghans et al., EPJ Web of Conf. 93, 02015 (2015).

Nuclear data measurements at *~*ELBE



Inelastic neutron scattering: Double time-of-flight setup to detect scattered neutron and de-excitation photon





Cross section for 1st excited state of ⁵⁶Fe:





 γ -detectors

Photon-production: determine inelastic scattering cross section from photon-production cross section

Angular distribution measurement

- Correlation of time-of-flight of incoming neutron ToF_{in} and of scattered neutron ToF_{out} identifies excited state
- Correlation of time-of-flight of incoming neutron ToF and energy of the emitted photon E_{γ}



- good agreement with evaluated data and other facilities
- double ToF results indicate angular correlation effects

R. Beyer, R. Schwengner et al., Nucl. Phys. A 927 (2014) 41.; R. Beyer et al., EPJ Web of Conf. 149 02017 (2017).; R. Beyer, M. Dietz et al., Eur. Phys. J. A 54(2018), 58.

neutron detector \leftrightarrow sample neutron source

sample

e⁻

reference chambers

Neutron total cross section:

- **Transmission measurement**
- Automatic sample changes every 15 minutes to minimize influence of beam fluctuations
- Measurement of three different samples in one beam time



- Resulting cross sections show excellent agreement with other facilities
- Complete range covered from 100 keV to 10 MeV
- **Uncertainties 1-3 % Energy resolution 1-2 %**



R. Hannaske et al., Eur. Phys. J. A 49 (2013) 137. ; R. Beyer et al., Eur. Phys. J. A 54 (2018), 81.



Neutron induced fission:

Fission chamber containing deposits



Fast signals and electronics enable

fission

neutron

- of fissionable material to be investigated (e.g. ²⁴²Pu)
- Fission cross section measurement relative to ²³⁵U
- Production of thin, homogeneous, isotopic enriched deposits (100 μ g/cm²)

time resolution of approx. 2 ns and energy resolution below 2 %

- Pulse height discrimination of high α -activity
- good agreement with other facilities

T. Kögler et al., Nucl. Data Sheets 119 (2014) 404. ; T. Kögler et al., Phys. Proc. 64 (2015) 150.; T. Kögler et al., Phys. Rev. C 99 (2019) 024604

