Definition of a standard neutron field with the reaction $^7Li(p,n)^7Be$

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Introduction

The reaction $^7Li(p,n)^7Be$ represents an important neutron source in the keV and MeV energy range. For astrophysical applications it is of special interest: At a proton energy of 1912 keV the emitted neutron spectrum resembles a Maxwell-Boltzmann distribution with kT=25 keV (see fig. 1), which corresponds to the conditions of the astrophysical s-process. Hence, this reaction allows one to directly measure Maxwellian-averaged cross sections, which are the essential input for s-process calculations. The neutron capture cross section on ^{197}Au was measured for this spectrum with an uncertainty of 1.4% [1] and served as a reference cross section for numerous activation measurements.

These results rely on an accurate knowledge of the neutron spectrum itself. A new measurement was performed with improved resolution in neutron energy at PTB Braunschweig to check and solidify previous information.

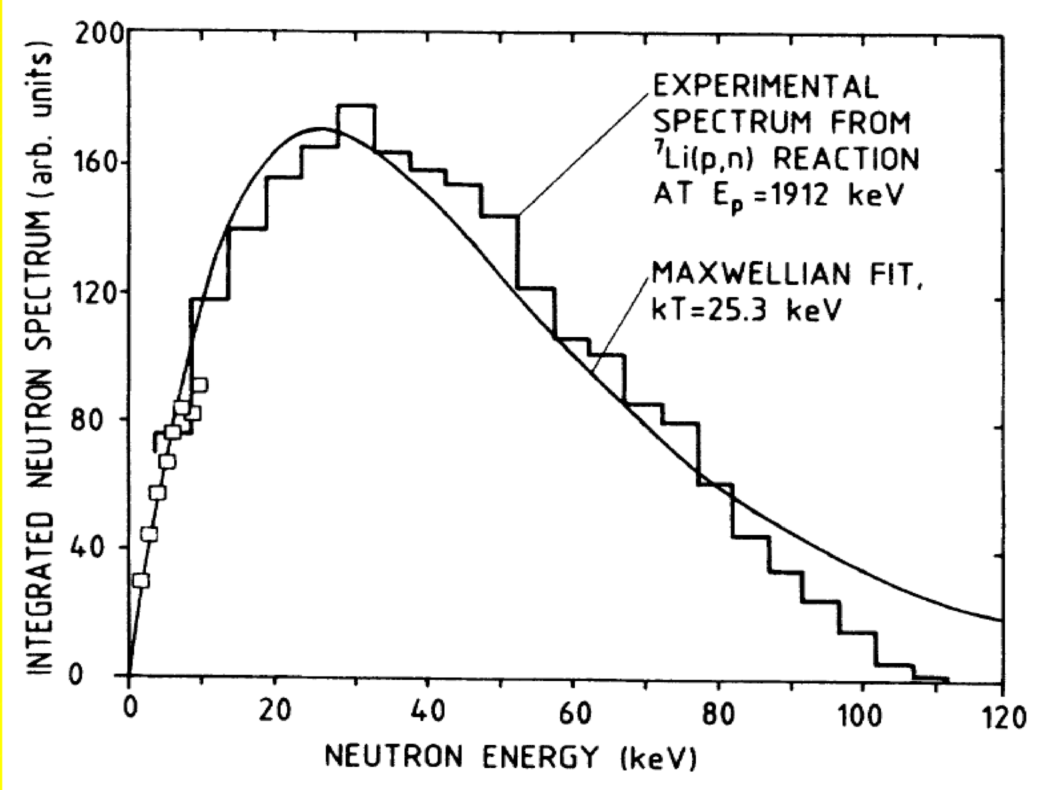

Fig. 1: $^7Li(p,n)^7Be$ spectrum of Ratynski and Käppeler (1988) compared to a Maxwellian distribution at kT=25.3 keV [1].

The PTB-Ion-Accelerator-Facility PIAF

Protons provided by the 3.75 MV Van-de-Graaff accelerator (see Fig. 2):
- E_p=1912 keV
- Pulse width: 1.5 ns
- Repetition rate: 625 kHz
- Beam current: 0.5-0.8 µA

Target:
- Metallic Li evaporated on Ta
- 10 µm thickness (565 µg/cm²)
- Target thickness chosen in a way, that all protons are slowed down below reaction threshold (E_{thr}=1881 keV)

Due to kinematics, neutrons are emitted in forward direction with an opening cone of 120 degree.

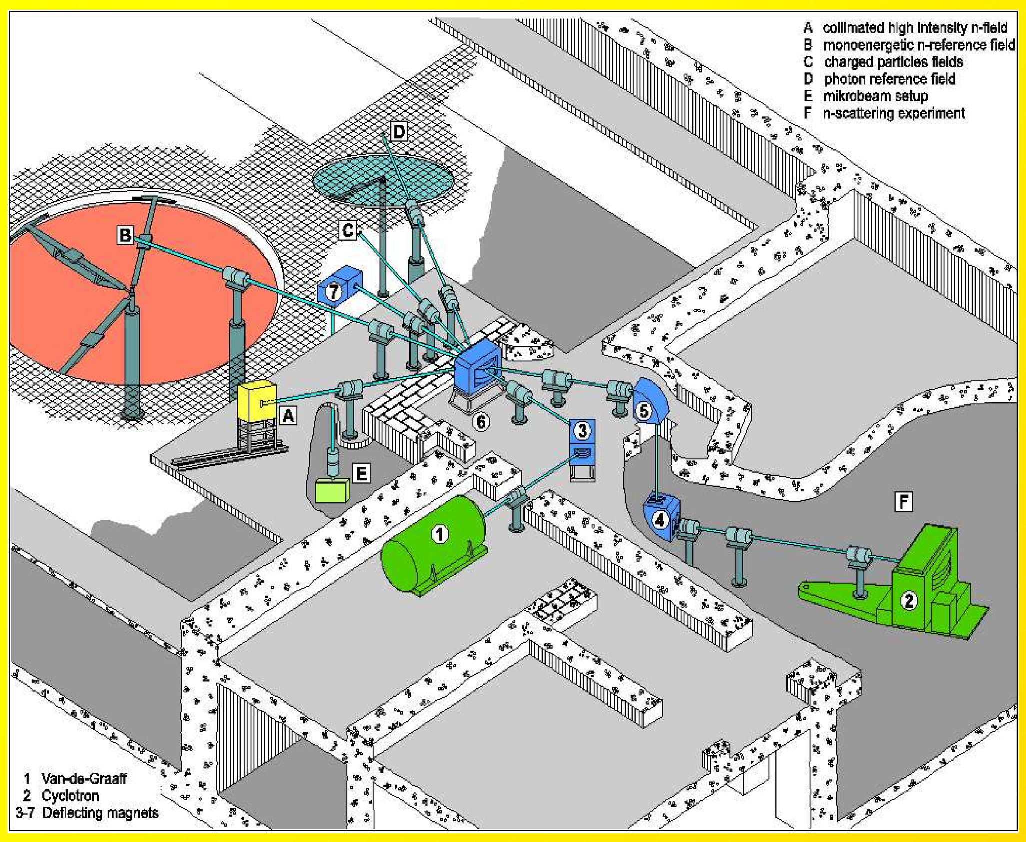

Fig. 2: Scheme of the Van-de-Graaff accelerator and related experiments. The measurement was performed in the open geometry of sector B indicated in red.

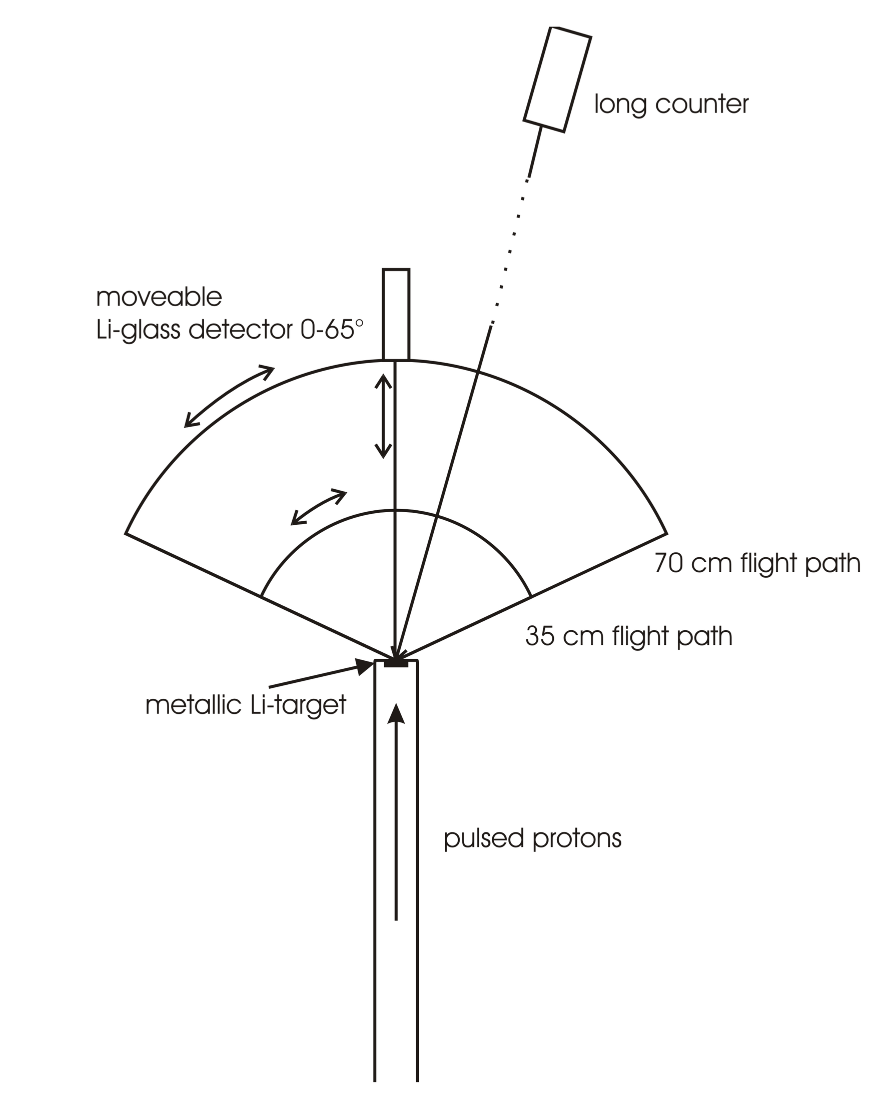

Fig. 3: Sketch of the experimental setup: Detector position at angles between 0 to 65° in steps of 5° for flight paths of 35 and 70 cm.

Measurement

The time-of-flight (TOF) spectra were recorded in steps of 5° with a movable Li-glass detector at angular positions from 0°-65° with respect to the proton beam. In total, two runs were performed using flight paths of 35 and 70 cm as sketched in fig. 4. The shorter flight path provided a more detailed investigation of the low energy end of the spectra due to the higher signal/noise ratio. Comparison of the spectra at the two flight paths could be used to check the background for possible structures, e.g. due to scattered neutrons. The neutron fluence was monitored during the entire experiment by a stationary long-counter at an angle of -16° and at a distance of about 6 m from the target. Measurement times varied between 1.5 and 3 h to compensate the decrease in intensity with angle. The stability of the setup was checked by regular reference runs at 70 cm and 0°. The small differences at high energies, which can be attributed to the gradual build-up of a surface layer on the metallic Li target, was considerably reduced in runs with LiF targets (fig. 5).

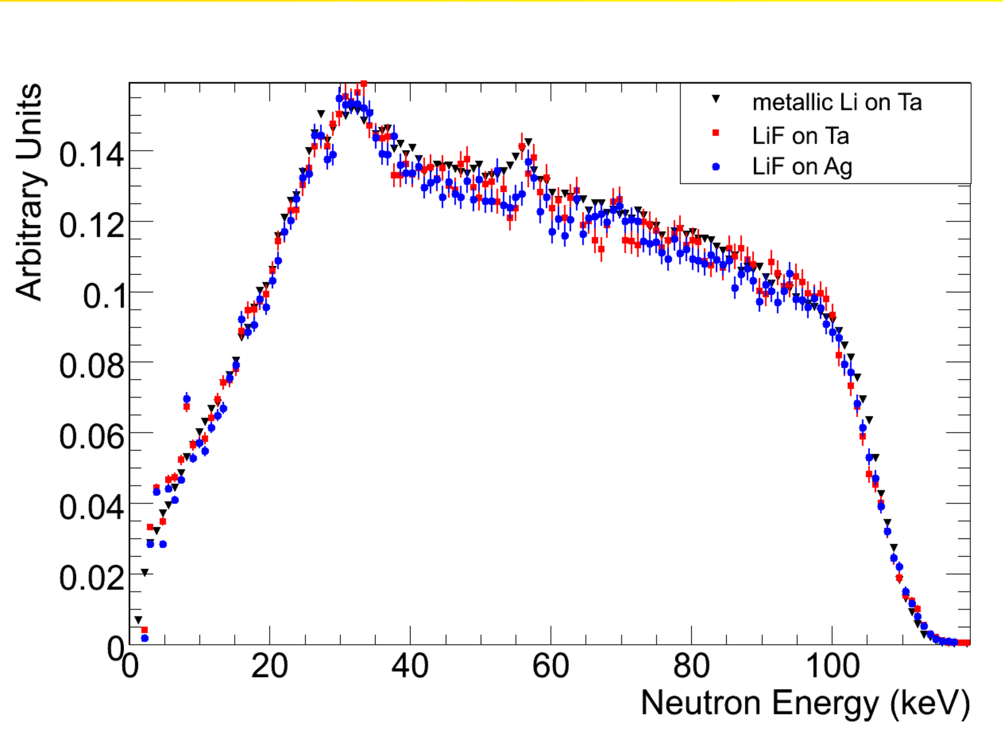

Fig. 4: Spectra recorded with LiF evaporated on Ta and Ag are compared to metallic Li on Ta.

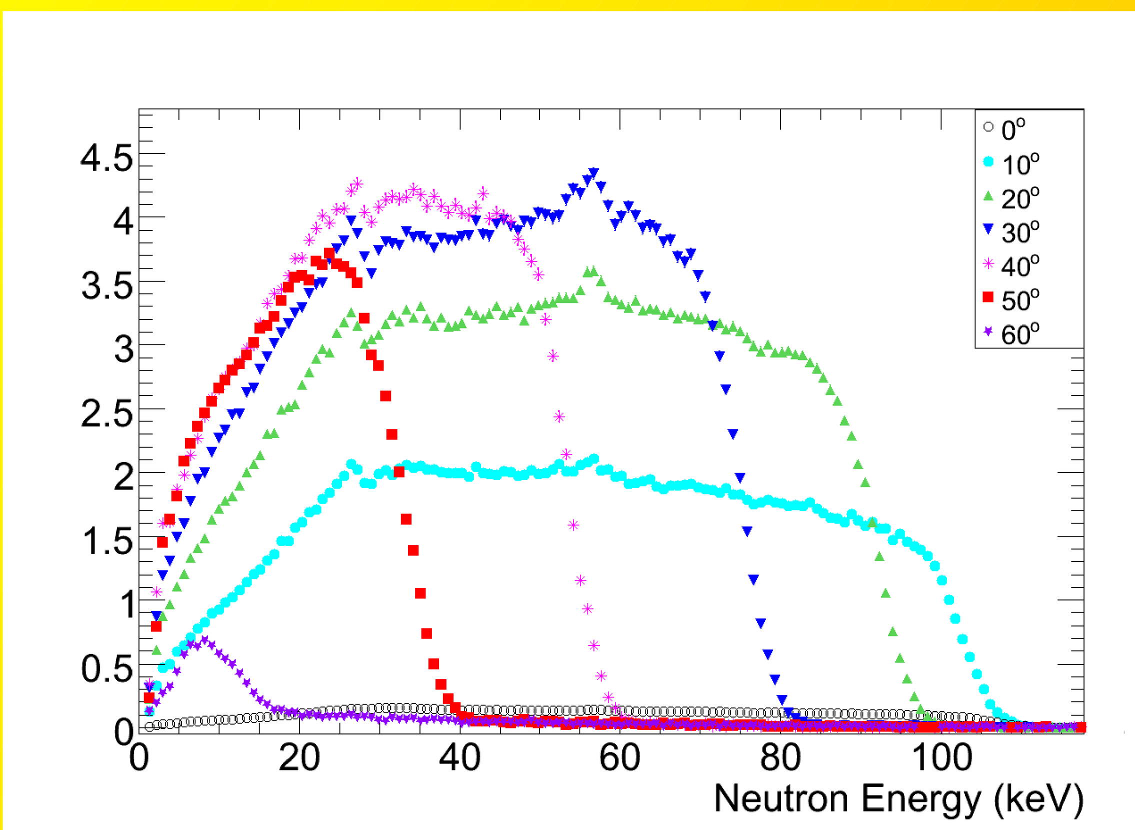

Fig. 5: Selected spectra for different angular positions and a flight path of 70 cm: The background subtracted spectra are corrected for dead-time, neutron fluence, detection efficiency and solid angle.

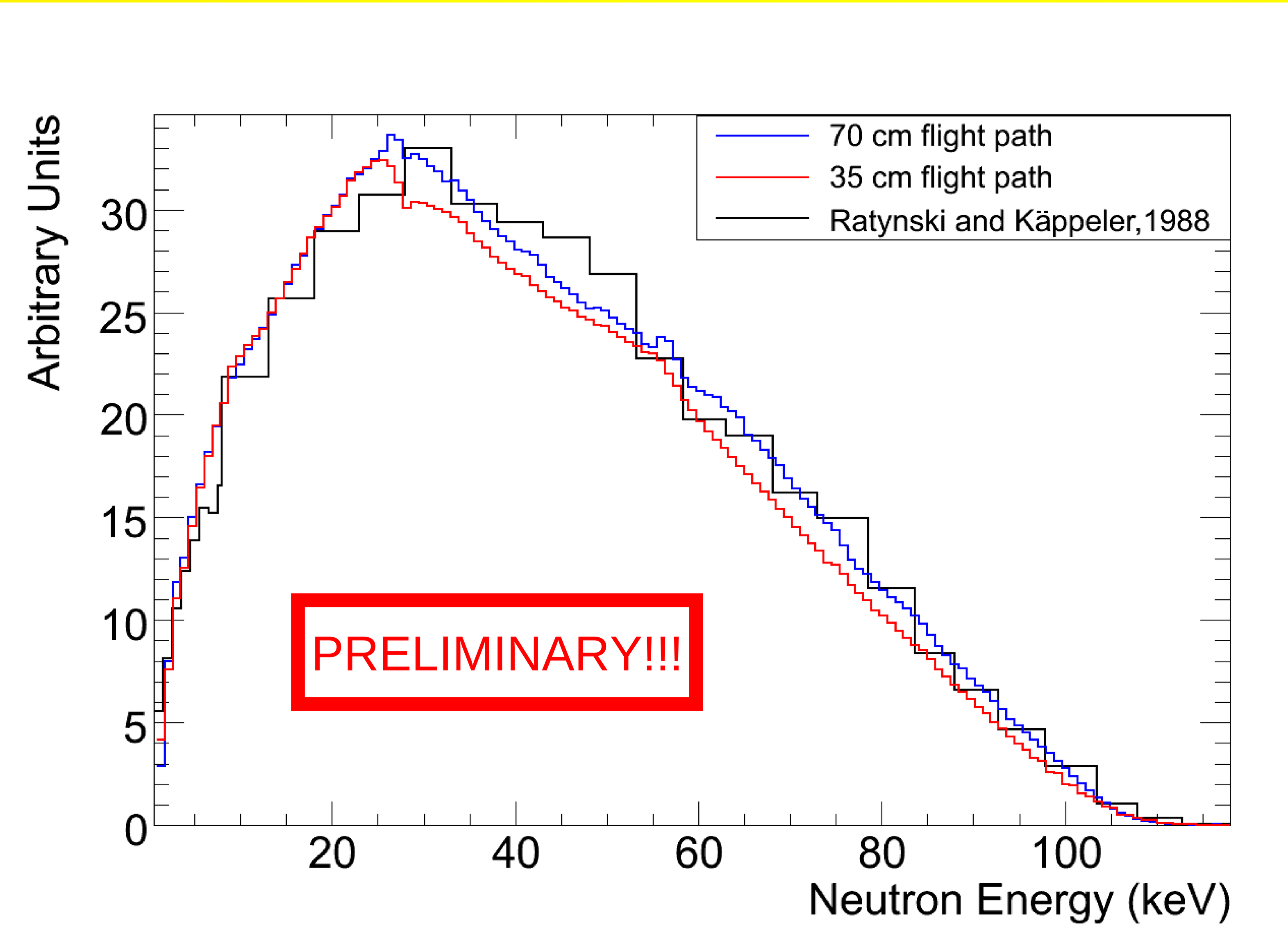

Fig. 6: Sum spectra for 35 and 70 cm runs are compared to the measurement of Ratynski and Käppeler (1988). The differences between the two present spectra can be explained by the build-up of an impuritiy layer on the Li target during the measurement.

Data analysis and first results

The background and dead-time corrected TOF spectra were transformed to an energy grid and normalized to the neutron fluence recorded by the long-counter. Further corrections were applied for detection efficiency, solid angle, and flux attenuation in 35 and 70 cm of air (fig. 6). A comparison of the preliminary sum spectrum with the measurement of Ratynski and Käppeler [1] in fig. 7 shows good agreement between the data obtained at 35 and 70 cm in the low energy part. The differences above 30 keV may be caused by the build-up of an impurity layer on the metallic Li target, because the 35 cm measurement was performed after the 70 cm runs.

References:

[1] W. Ratynski and F. Käppeler, Phys. Rev. C **37**, 595 (1988)

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