Results of total cross-section measurements of the $^{87}Rb(p,\gamma)^{88}Sr$ reaction

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Motivation

Two different **neutron-capture processes** are accountable for the production of most of the elements heavier than iron, namely the slow (s) and the rapid (r) neutron-capture process. About 30 – 35 stable, neutron-deficient nuclei – the so called **p nuclei** [1] – are bypassed by these two processes.

These nuclei are predominantly produced in the **γ process**, which consists of different combinations of **photodisintegration reactions**, e.g. (γ,p) or (γ,α), on mainly unstable r- or s-process seed nuclei.

For **statistical model calculations**, nuclear physics input parameters – e.g. cross sections, nuclear level densities, and γ-ray strength functions – below the Coulomb barrier have to be known with high precision.

Therefore, measurements in the **Gamow window** are of utmost importance.

(p,γ) Reactions at N=50

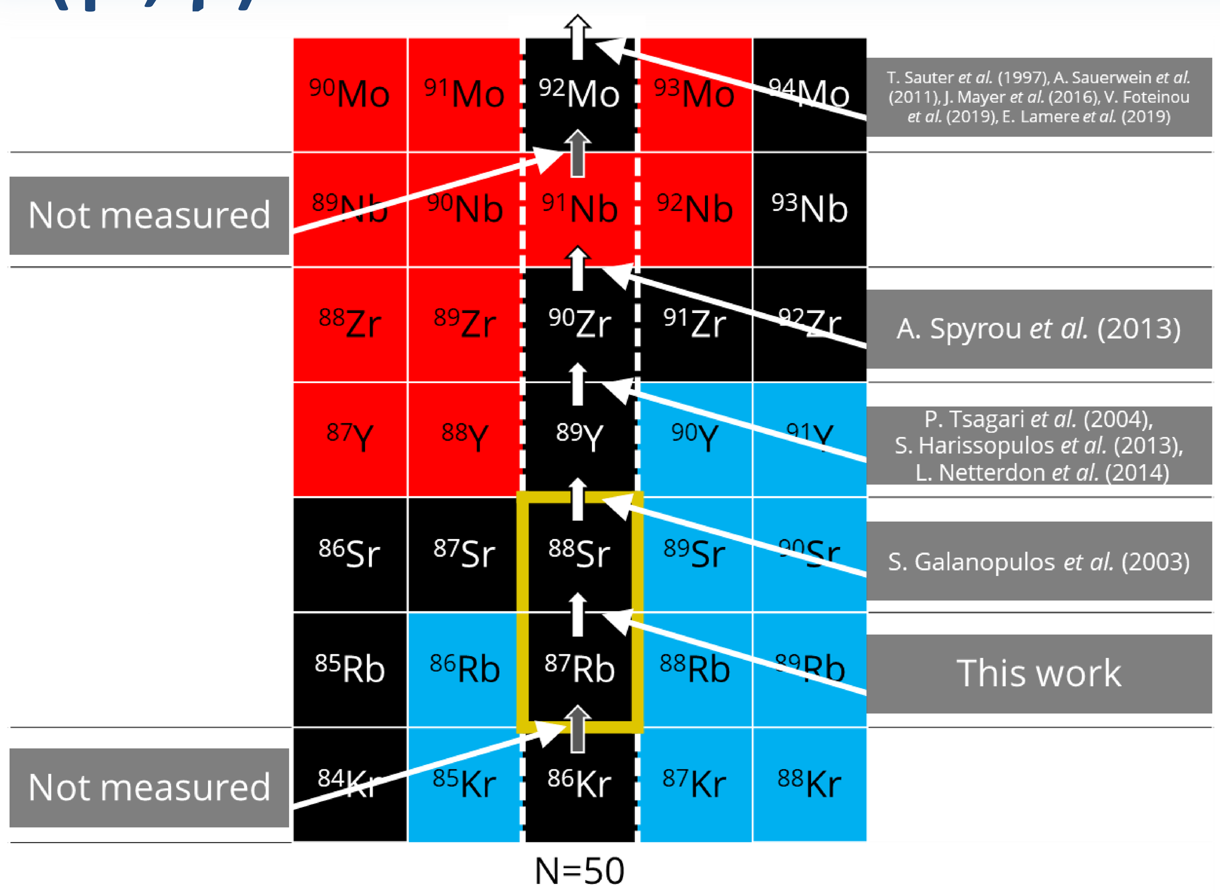

Fig. 1: Measured (p,γ) reactions – symbolized with the upward pointing arrows – in the A=90 mass region, where the reaction of interest is located in the N=50 isotonic chain.

- Interested in systematic studies of the N=50 isotonic chain since there is a shell closure
- First measurement of $^{87}Rb(p,\gamma)^{88}Sr$ reaction
- ^{91}Nb is a short-lived radionuclide which influences the production of ^{92}Nb that is produced in the p process [1].

Target details

- ^{87}Rb melting point of $T_m = 39.31°C$
- Rb_2CO_3 melting point of $T_m = 837°C$, evaporated on a gold backing, highly hygroscopic
- Areal density of the used target is $0.5 - 0.8\ \frac{mg}{cm^2}$

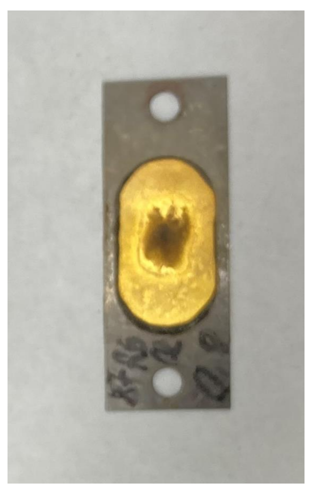

Fig. 2: Picture of the target with the prominent beam spot.

Experimental Details

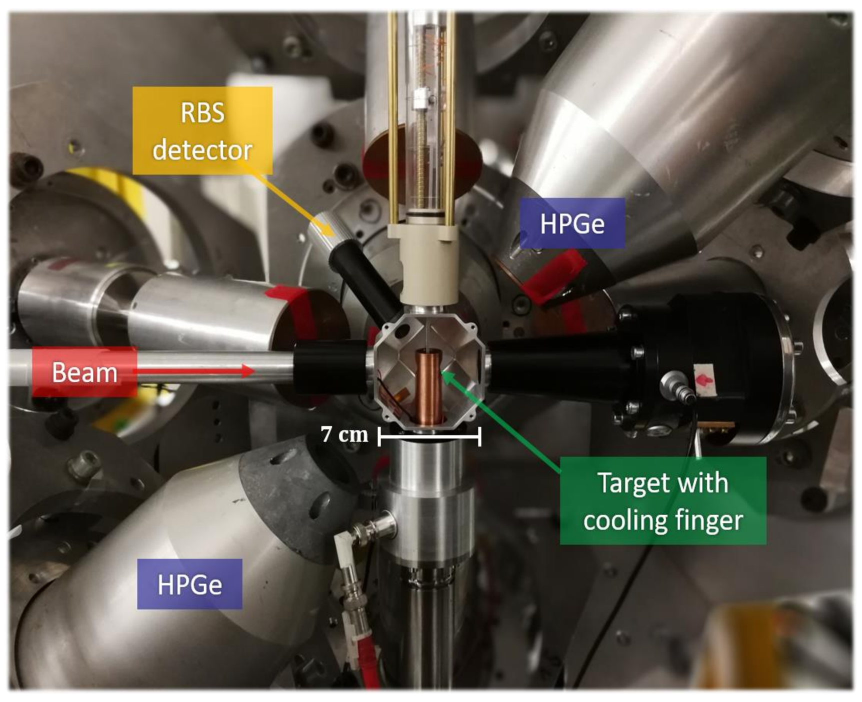

Fig. 3: Picture of the target chamber used for the in-beam method inside of HORUS in Cologne [2].

In-beam method

- Create highly excited compound nucleus
- Observation of transitions to the ground state to determine the total cross section
- Observation of de-excitation of the entry state to determine partial cross sections
- Information on the γ–ray strength function obtained by comparing the partial cross-sections to statistical model calculations [3,4]

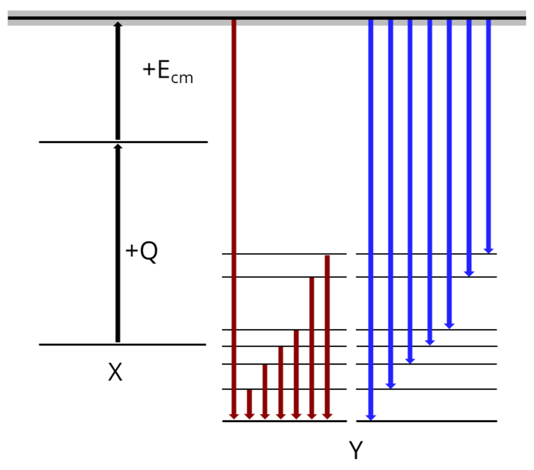

Fig. 4: Schematic figure of the in-beam method with transitions to the ground state and de-excitations of the entry state.

Astrochamber@HORUS

- Proton beam provided by 10 MV FN Tandem accelerator in Cologne
- Target chamber with a silicon detector installed in HORUS [2]
- Total of up to 14 HPGe
- The setup covers five different angles with respect to the beam axis which allows to measure angular correlations and to perform γγ-coincidence measurements.

Proton-beam properties

Energy [keV]	Current [nA]	Time [h]
2000	624	14.8
2800	615	20.3
3500	431	9.9
4000	356	11.8
4500	169	8.2
5000	137	15.6

Tab. 1: Properties of the impinging proton beam on the target with proton energy, proton current and irradiation time of the target.

Current regulated down for resonable count rates of about 10 kHz in detectors

Transitions to the ground state

Observed transitions in γ-ray spectra of the $^{87}Rb(p,\gamma)^{88}Sr$ reaction are shown in dark red. The transition in light red was not investigated directly but indirectly via the transition shown in blue.

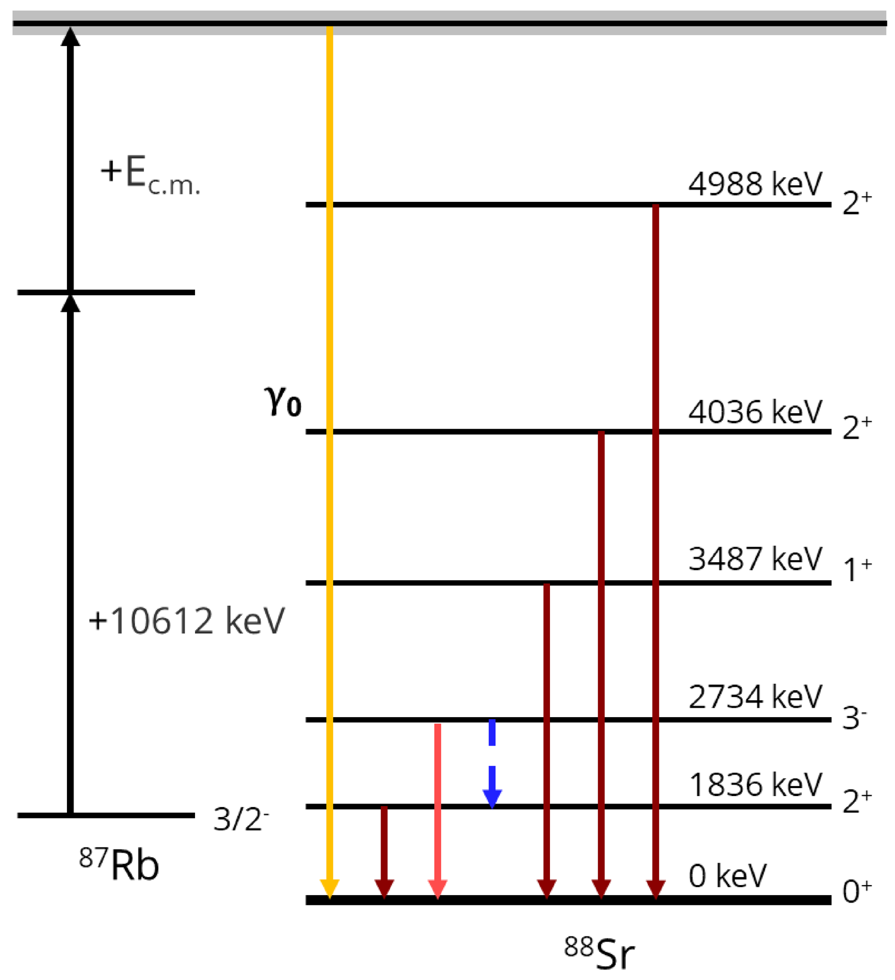

Fig. 5: Schematic level scheme of the $^{87}Rb(p,\gamma)$ reaction [5]. The observed γ-ray transitions to the ground state are shown in dark red.

γ-ray Spectra

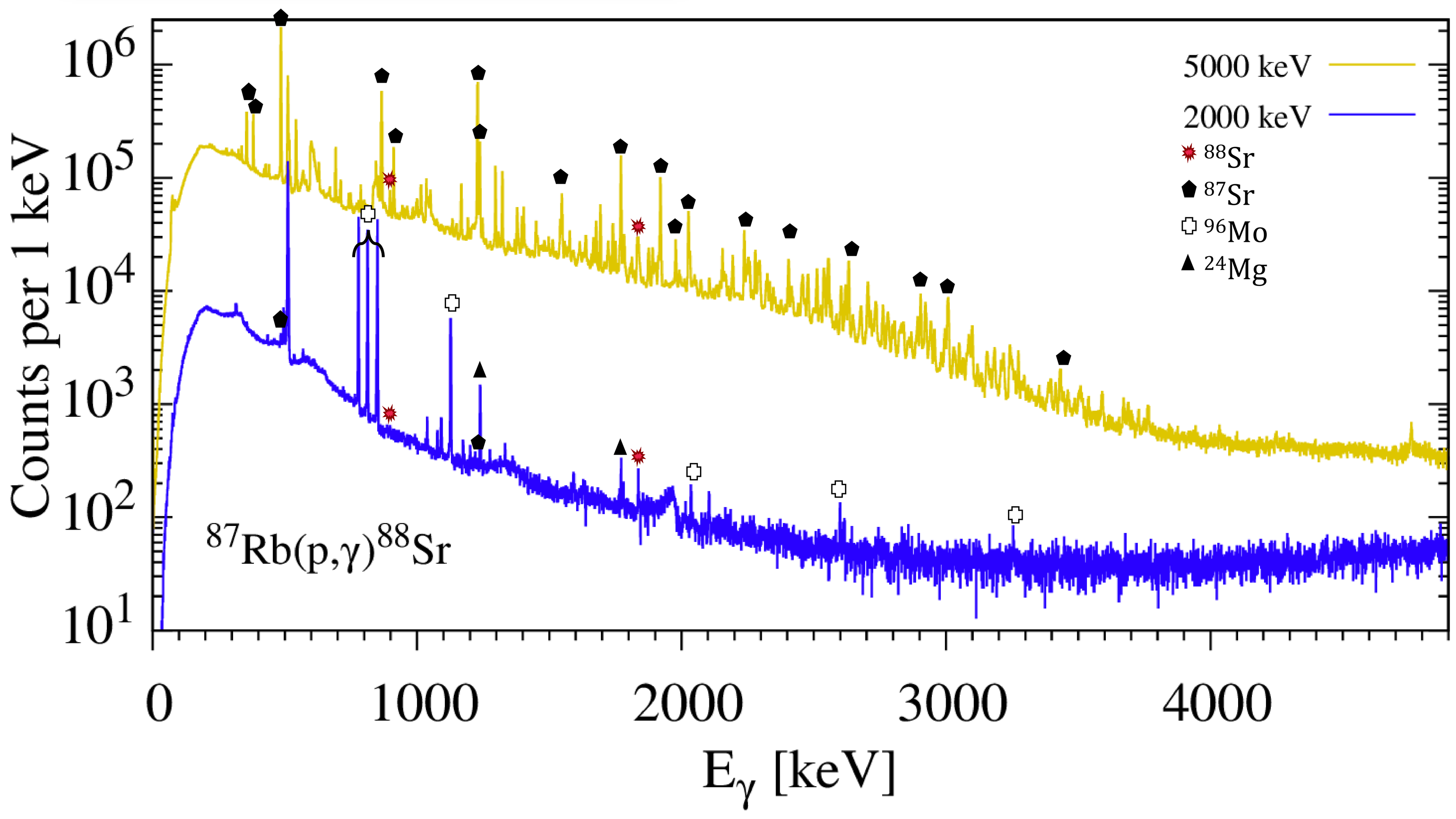

Fig. 6: Comparison of γ-ray spectra obtained at beam energies of E_p = 2000 keV and 5000 keV.

- Higher beam-induced background and more transitions of the (p,n)-product are visible for E_p = 5000 keV for similar irradiation time.
- At E_p = 2000 keV small contributions of contaminations in the target material are visible due the low beam-induced background.
- At higher beam energies the γ-ray spectra become increasingly complicated and a precise reconstruction of the peak origin is necessary.

Results

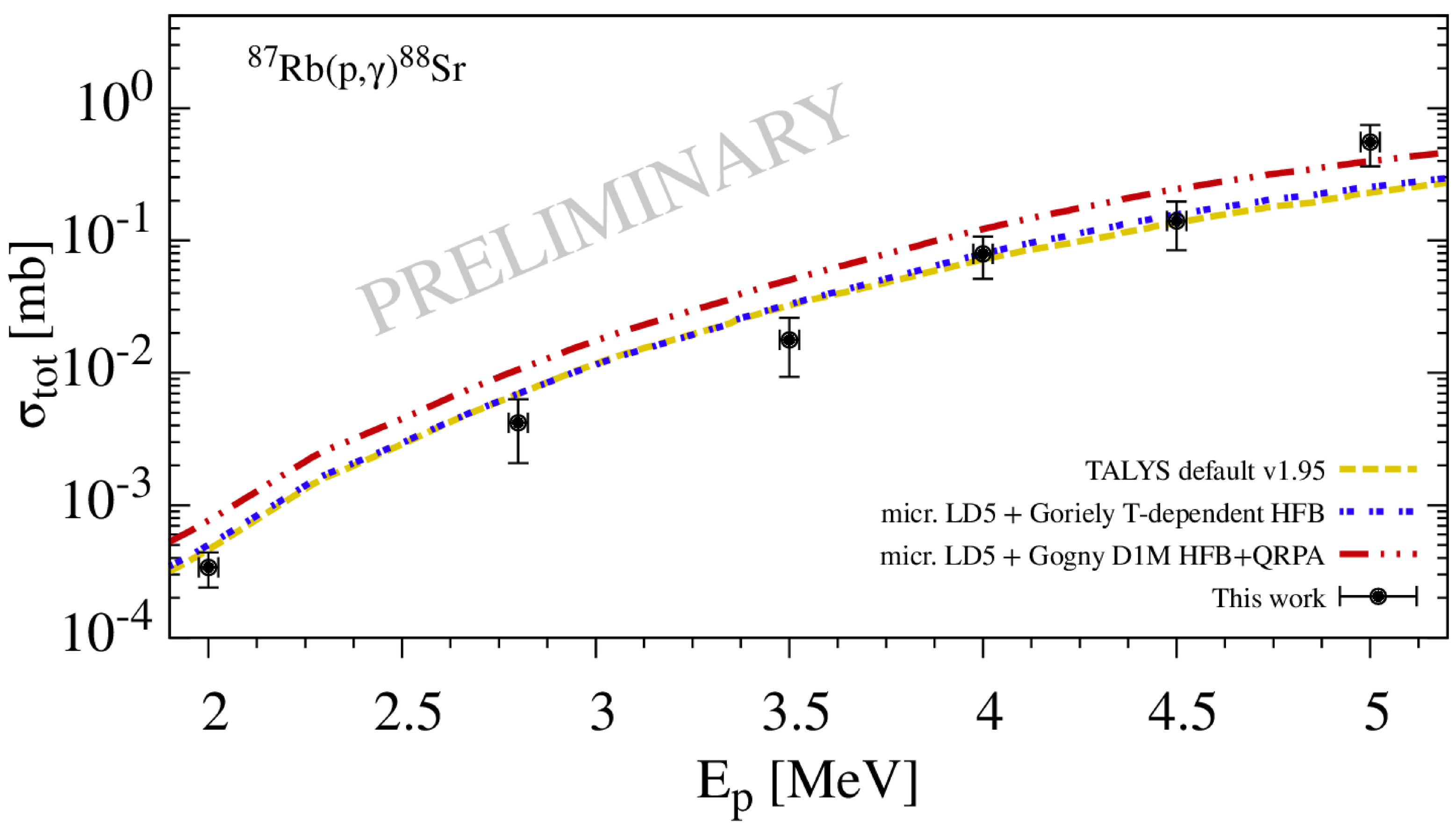

Fig. 7: Results of the cross-section measurement of the $^{87}Rb(p,\gamma)^{88}Sr$ reaction in comparison to theoretical Talys [4] model calculations.

- Determination of target thickness is ongoing, uncertainties not finalized
- The microscopic level densities (Skyrme force) from Hilaire's combinatorial tables (micr. LD5) [7] proved their predictive power [3,4]
- Good agreement between experiment and theory
- Further analysis of partial cross-sections is still pending

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