Results of total and partial cross-section measurements of the ^{87}Rb(p,γ)^{88}Sr reaction

Svenja Wilden, Felix Heim, Benedikt Machliner, Martin Müller, and Andreas Zilges

Institute for Nuclear Physics, University of Cologne, Germany

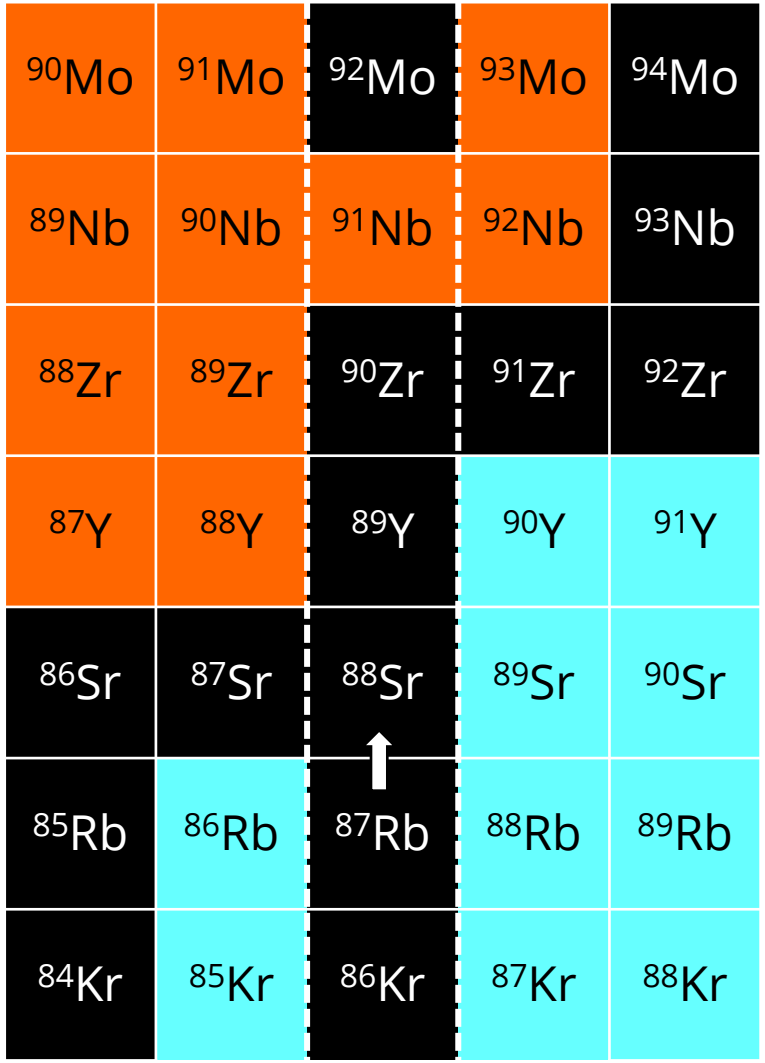
19th Russbach School on Nuclear Astrophysics

03. – 09.03.2024

Supported by the DFG (ZI 510/8-2), ChETEC-INFRA (101009324), and Hans-Böckler-Stiftung

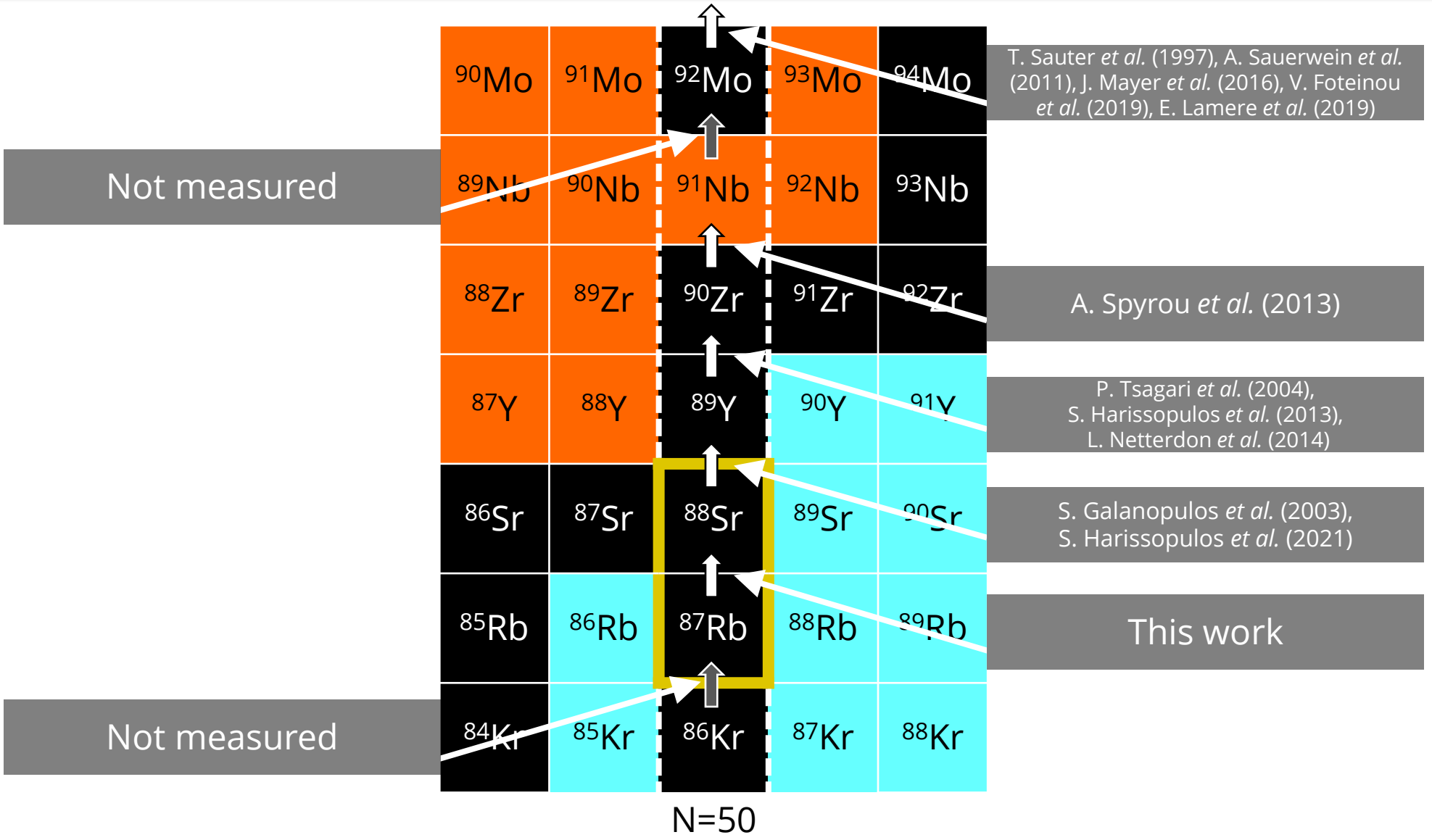
swilden@ikp.uni-koeln.de

Measured (p,γ) reactions at N=50



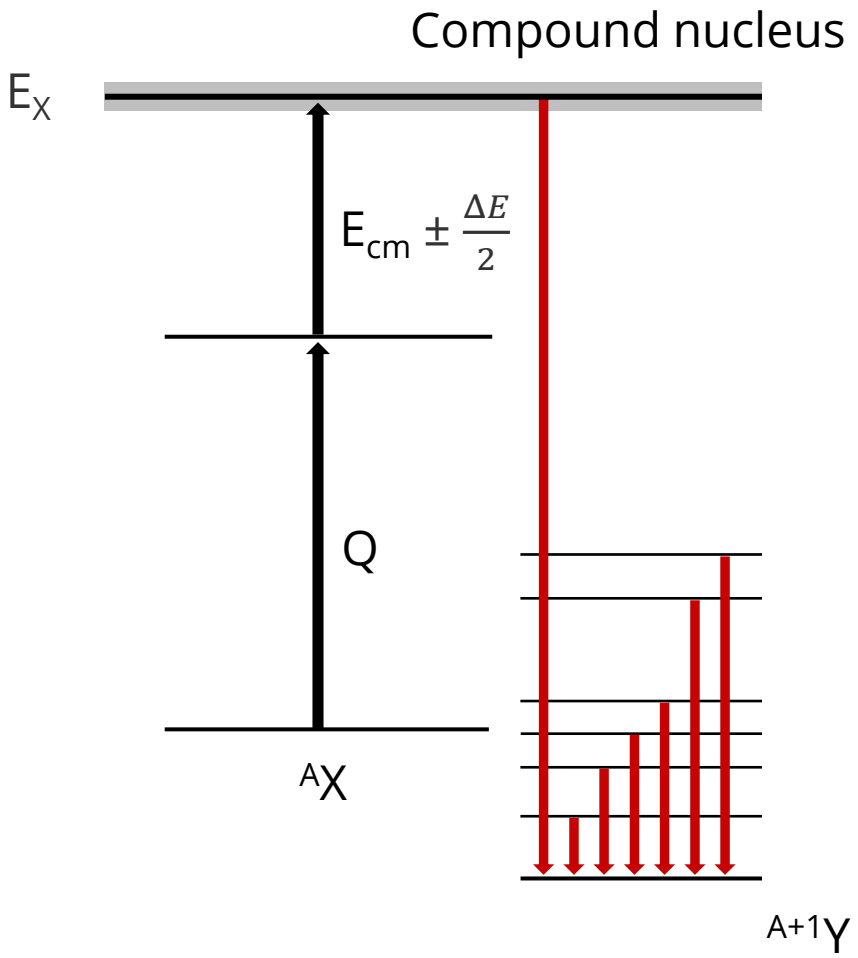
N=50

Measured (p,γ) reactions at N=50



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



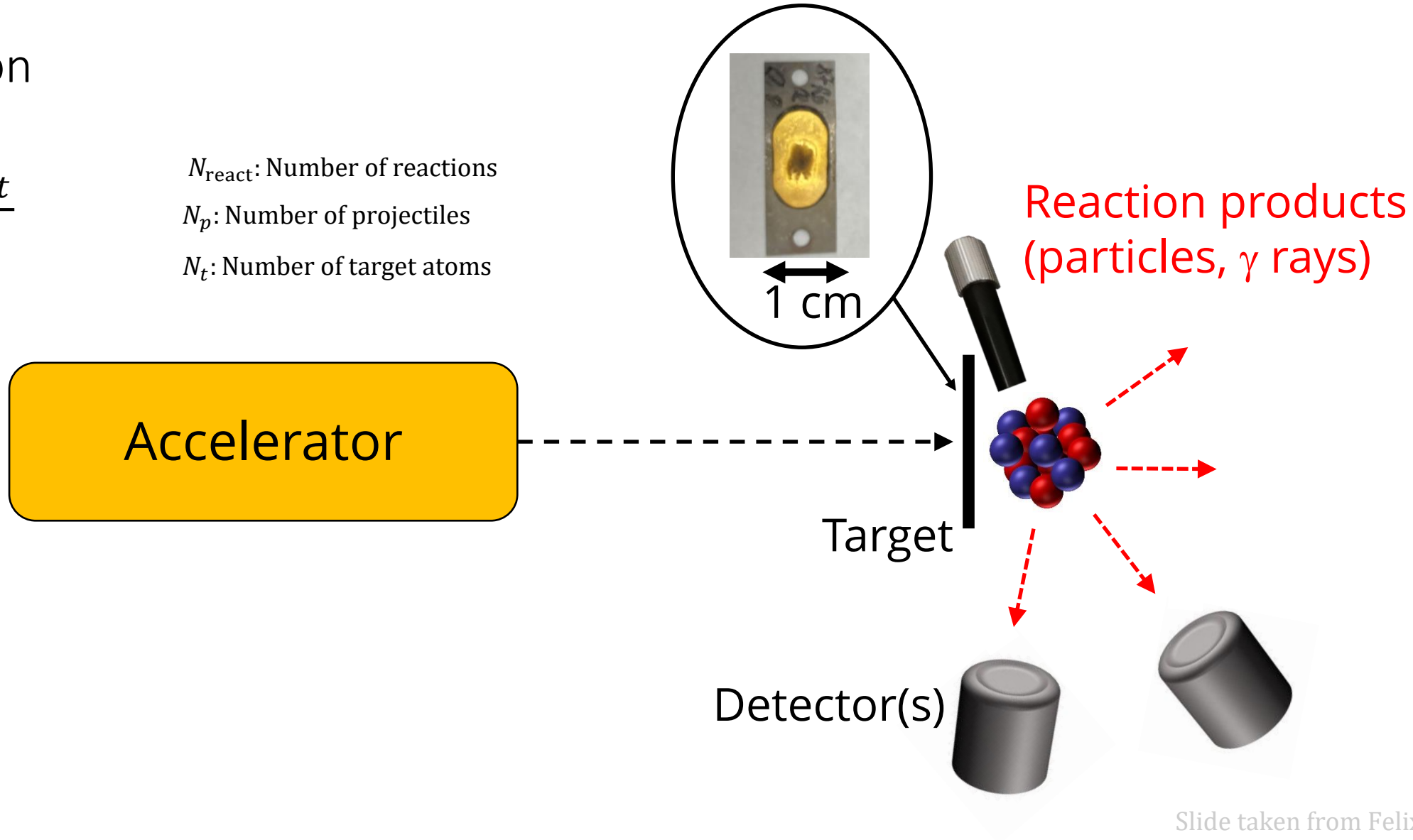
Cross section

$$\sigma = \frac{N_{react}}{N_t\, N_p}$$

N_{react}: Number of reactions

N_p: Number of projectiles

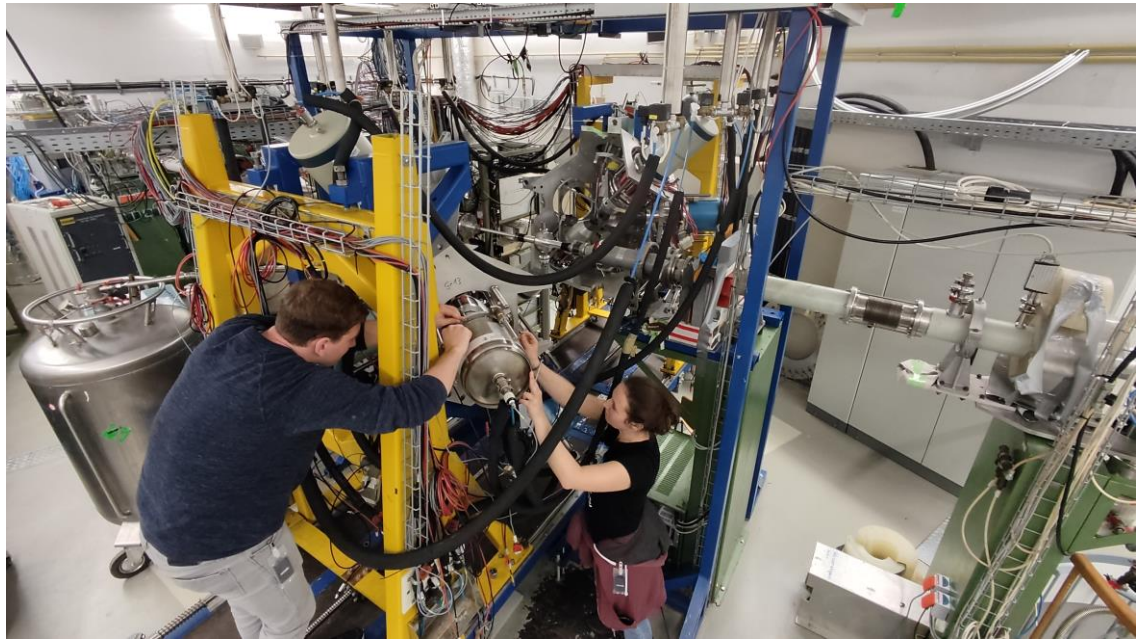
N_t: Number of target atoms

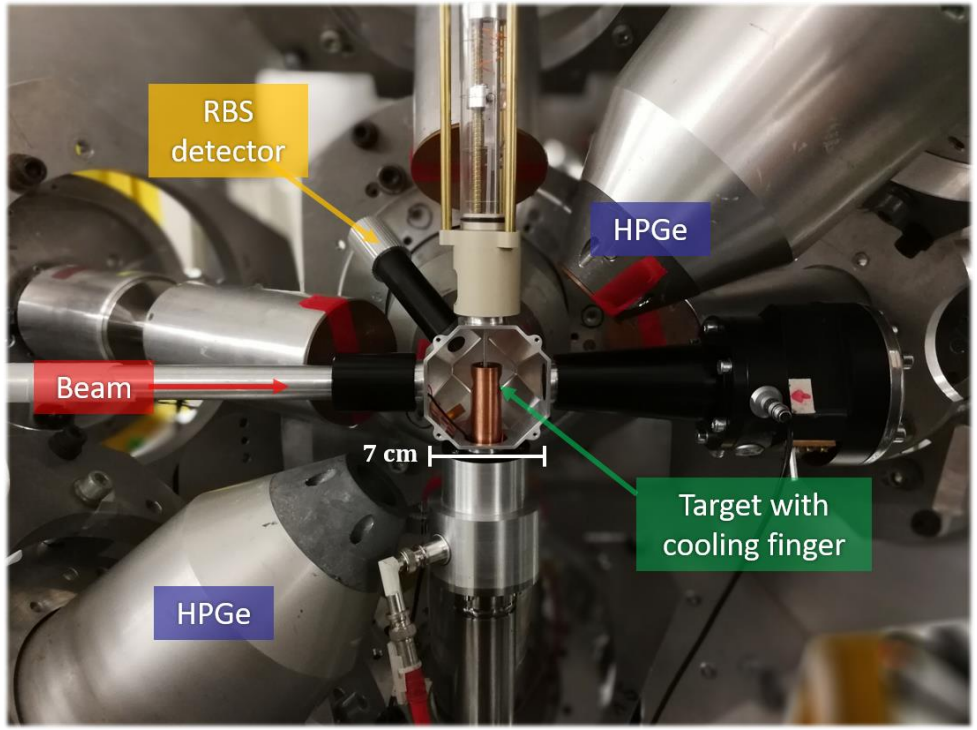


Slide taken from Felix Heim

Astrochamber@HORUS

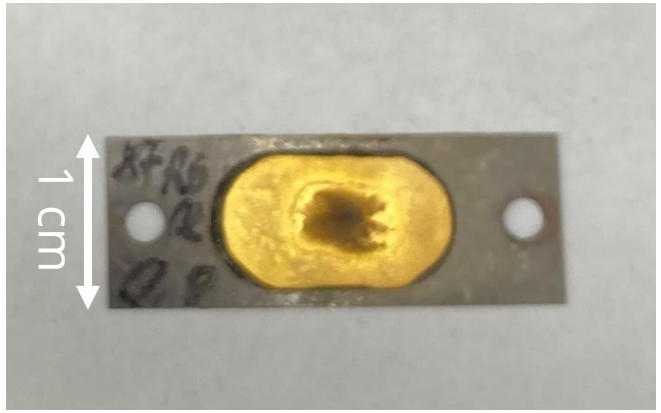
- 10 MV FN-Tandem accelerator providing proton beam
- HORUS consists of 14 HPGe with total efficiency of 3-4 % @ 1.3 MeV
- Coverage of five different angles with respect to the beam axis
- γγ-coincidence possible





F. Heim *et al.*, Nucl. Instr. Meth. A **966**, 163854 (2020)

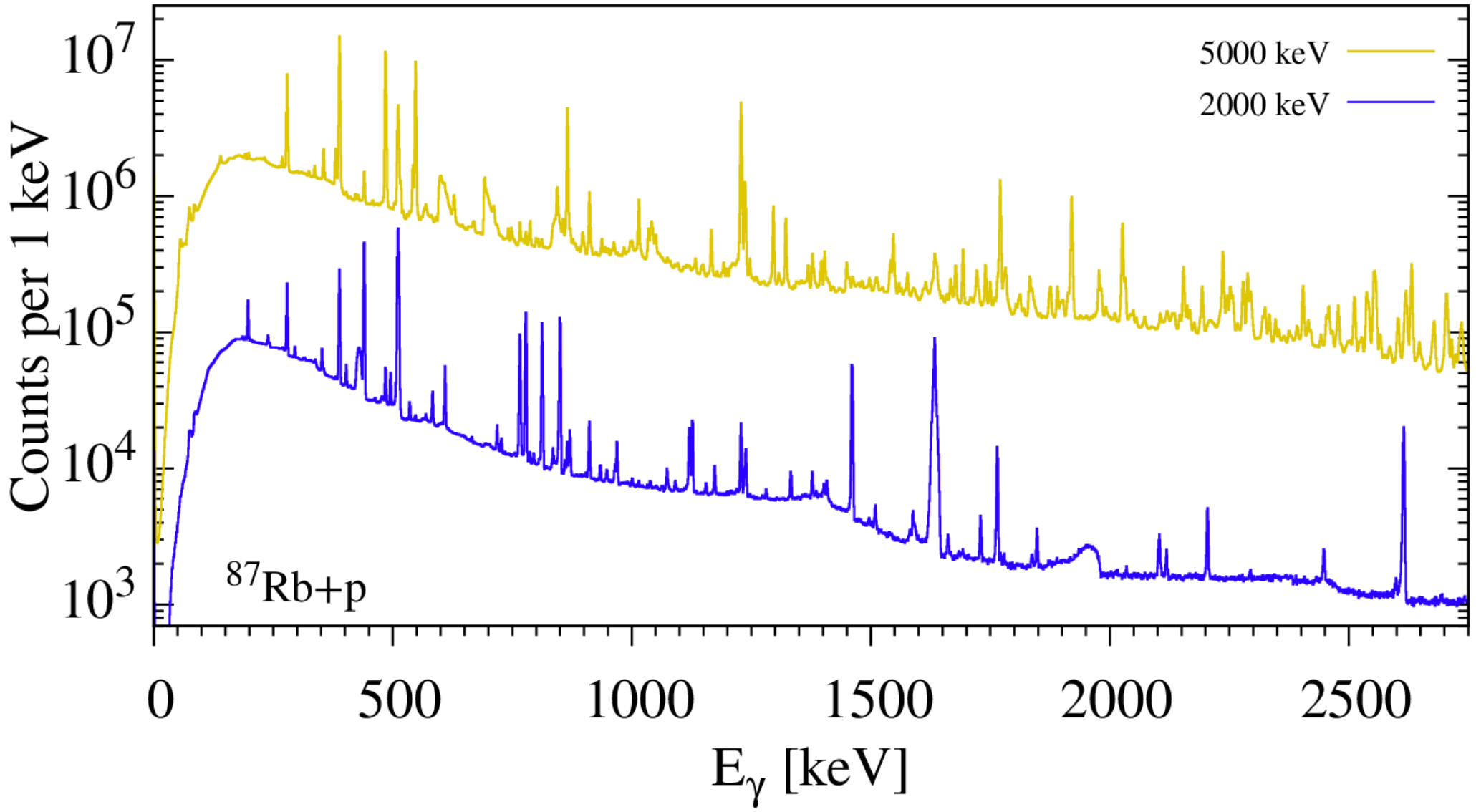
Experimental details



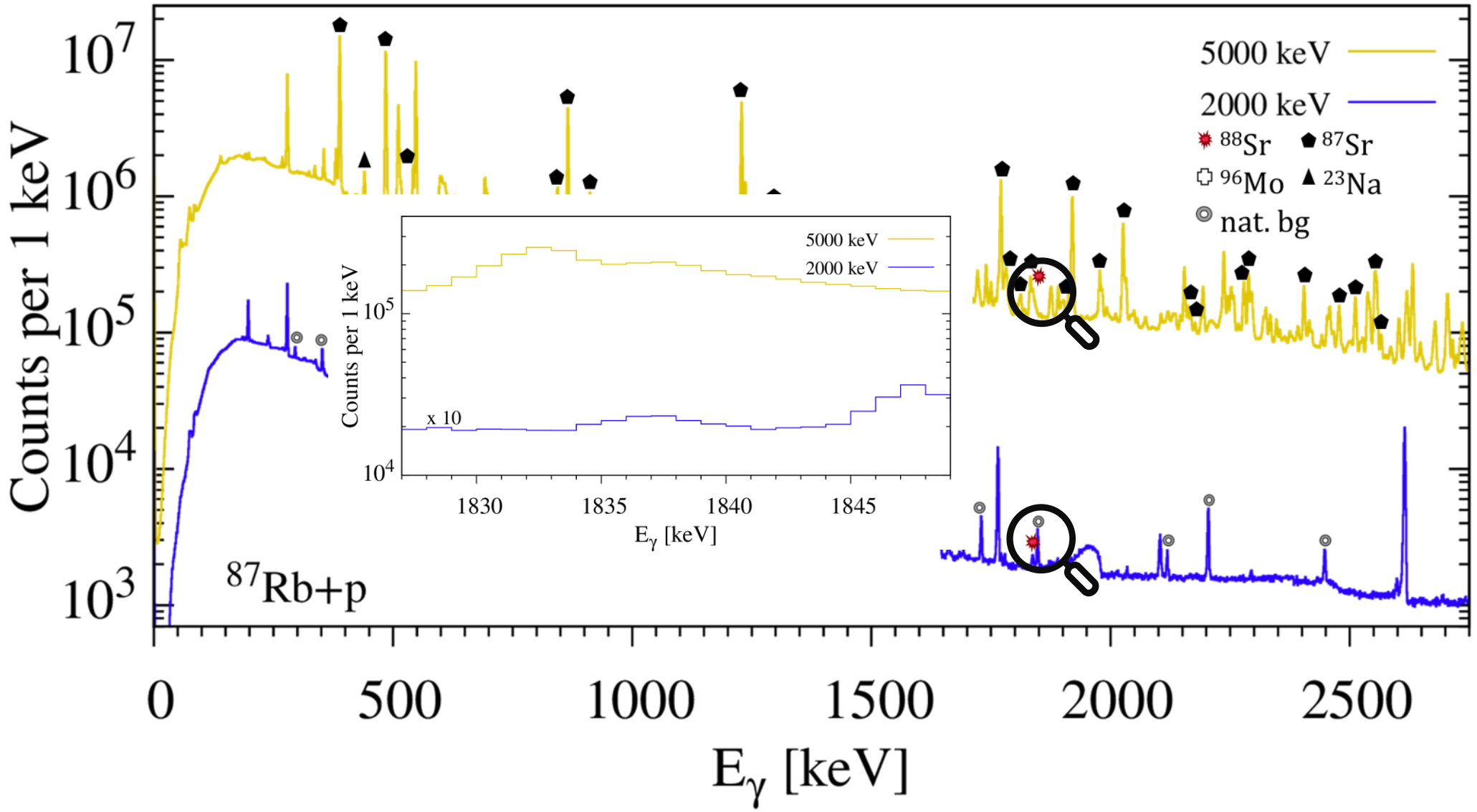
- Rb melting point: $T_m \approx 40°C$
- Rb_2CO_3 melting point: $T_m \approx 800°C$
- Rb_2CO_3 very hygroscopic
- Areal density $d = 0.52(6)\ \frac{mg}{cm^2}$

Energy [keV]	Current [nA]	Time [h]
2000	620	14.8
2800	610	20.3
3500	430	9.9
4000	360	11.8
4500	170	8.2
5000	140	15.6

γ-ray energy spectra

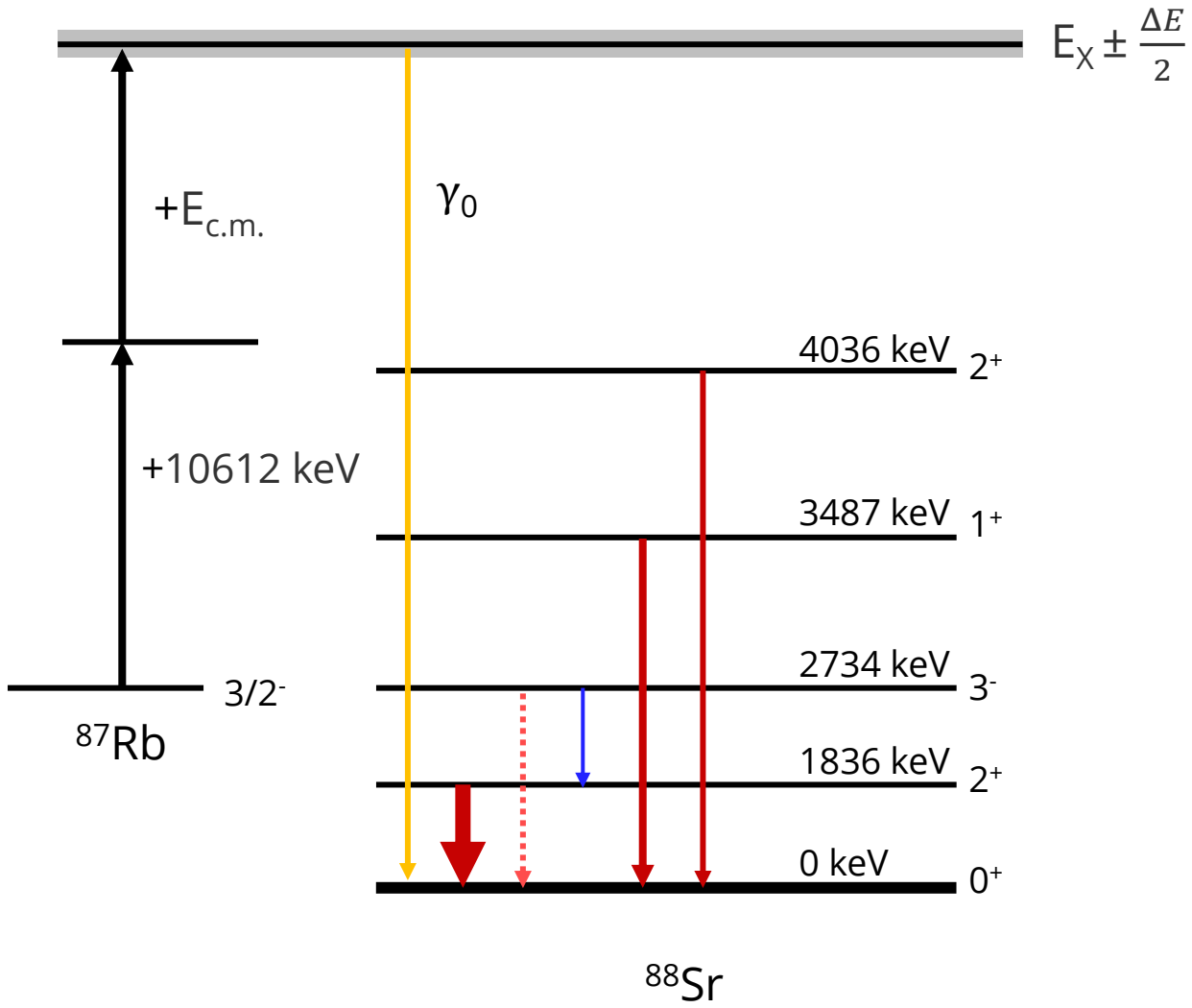


γ-ray energy spectra



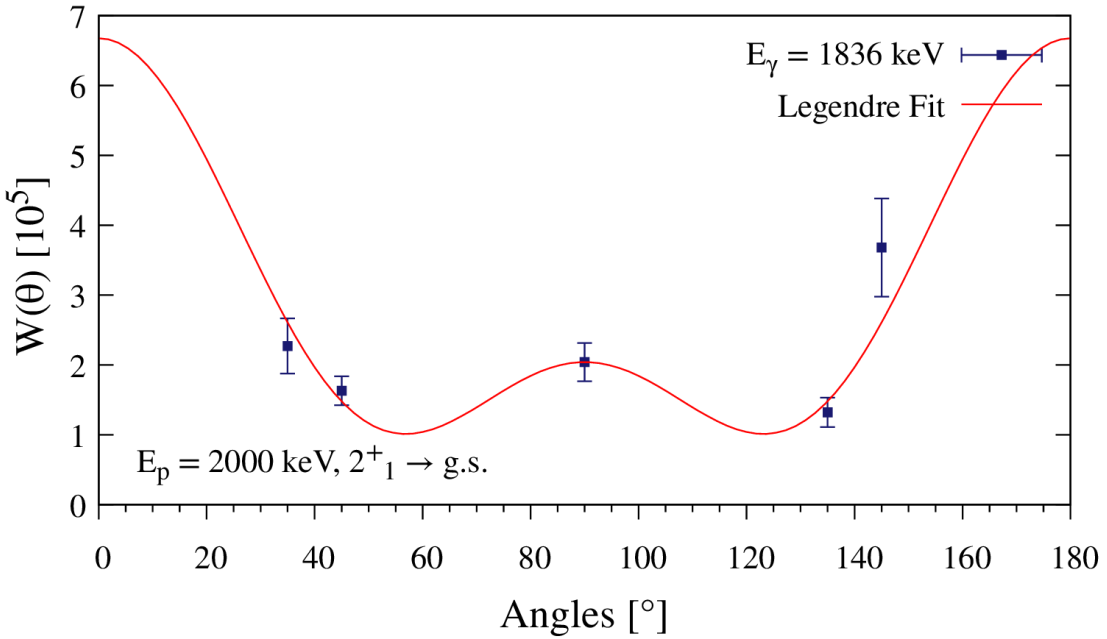
Ground-state transitions

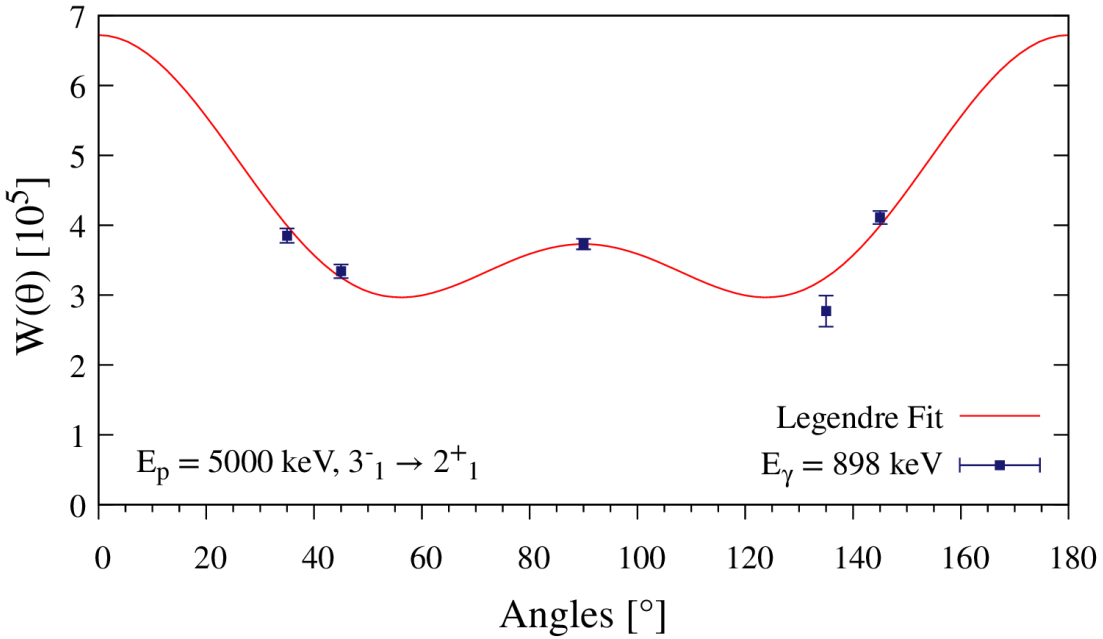
E_x in keV	E_γ in keV
γ_0	γ_0
4036	4036
3487	3487
2734	898
1836	1836



E.A. Mccutchan and A.A. Sonzogni, Nucl. Data Sheets **115** (2014)

Angular distributions





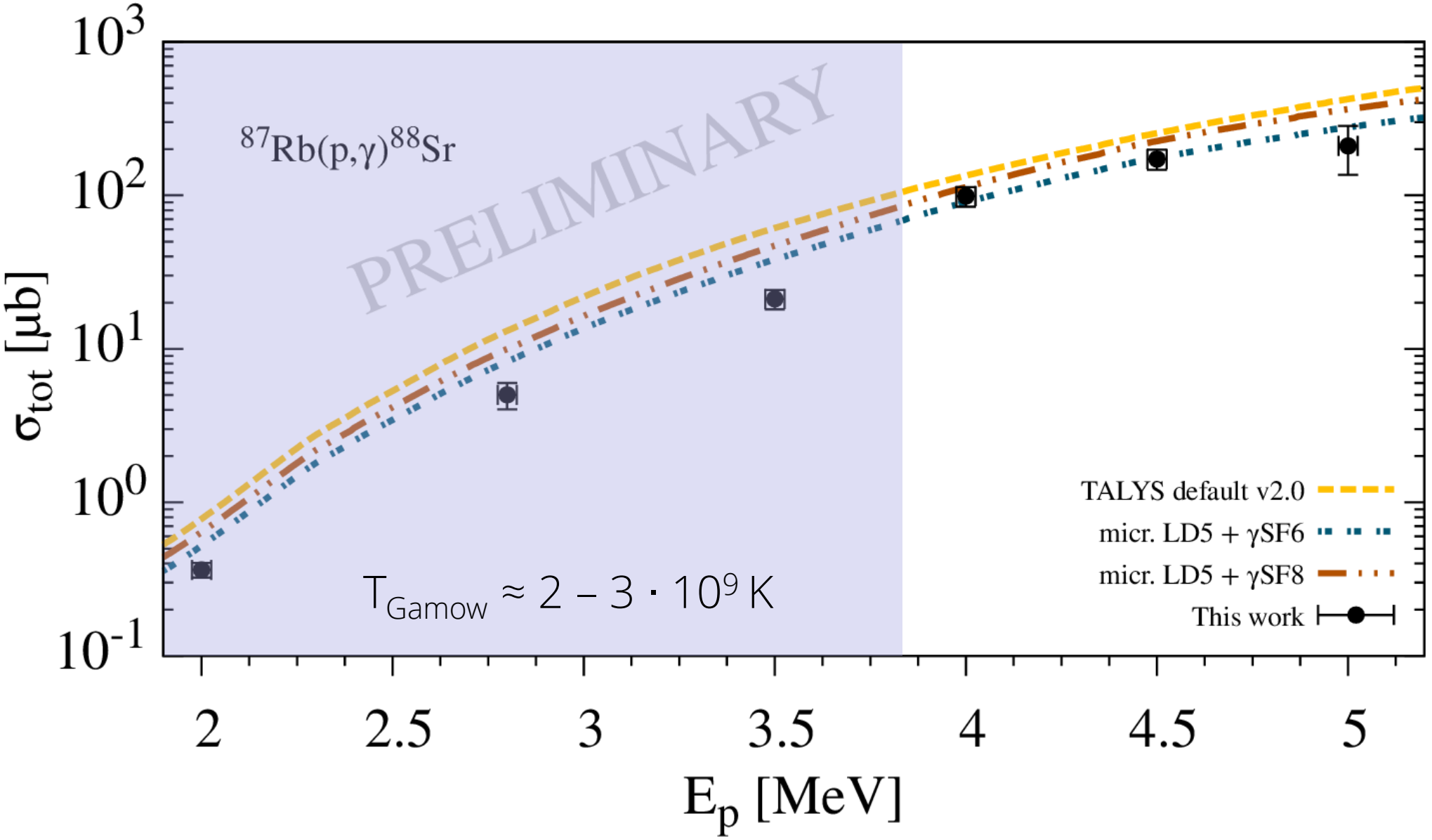
- Experimental yield measured at 5 different angles
- Fitting Legendre polynomials to data

$$W(\theta) = A_0 \cdot (1 + \alpha_2 P_2(\cos\theta) + \alpha_4 P_4(\cos\theta))$$

- Total cross section: $\sigma_{(p,\gamma)} = \frac{\sum_i A_{0,i}}{N_t\, N_p}$

N_t: number of target nuclei
N_p: number of impinging protons

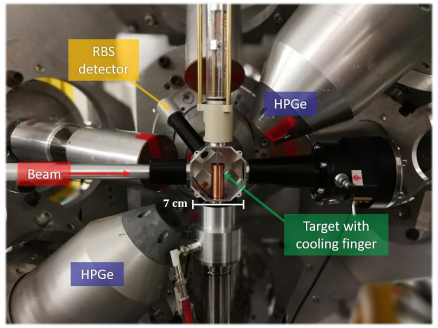
(p,γ) total cross-section measurement

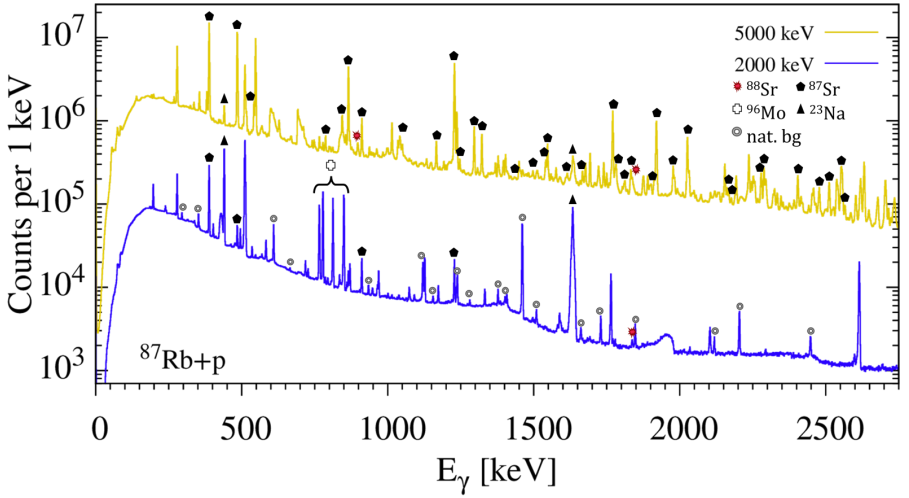


Summary and Outlook

Successful analysis of $^{87}Rb(p,\gamma)^{88}Sr$ experiment

- Analysis of partial cross sections
- $^{87}Rb(p,n)^{87}Sr$
- N=50 isotonic chain: ^{86}Kr and ^{91}Nb measurement
- Analysis $^{85}Rb(p,\gamma)^{86}Sr$



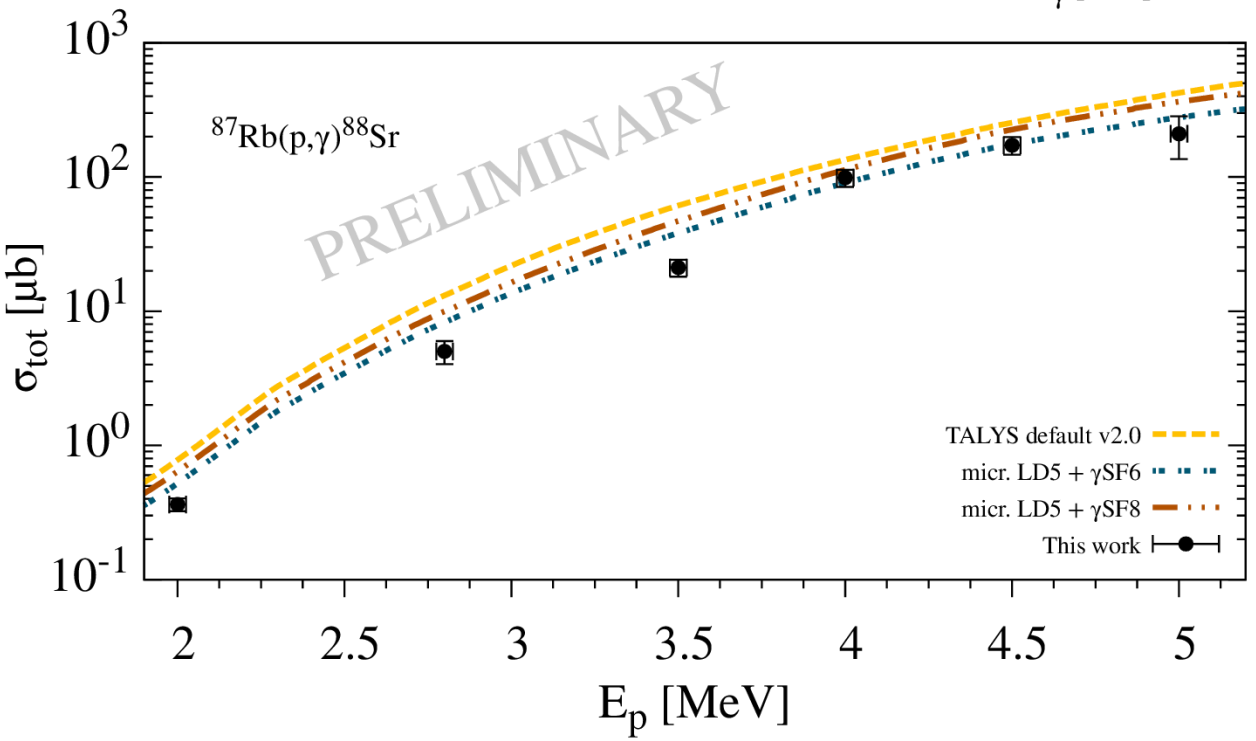


10 MV FN- Tandem

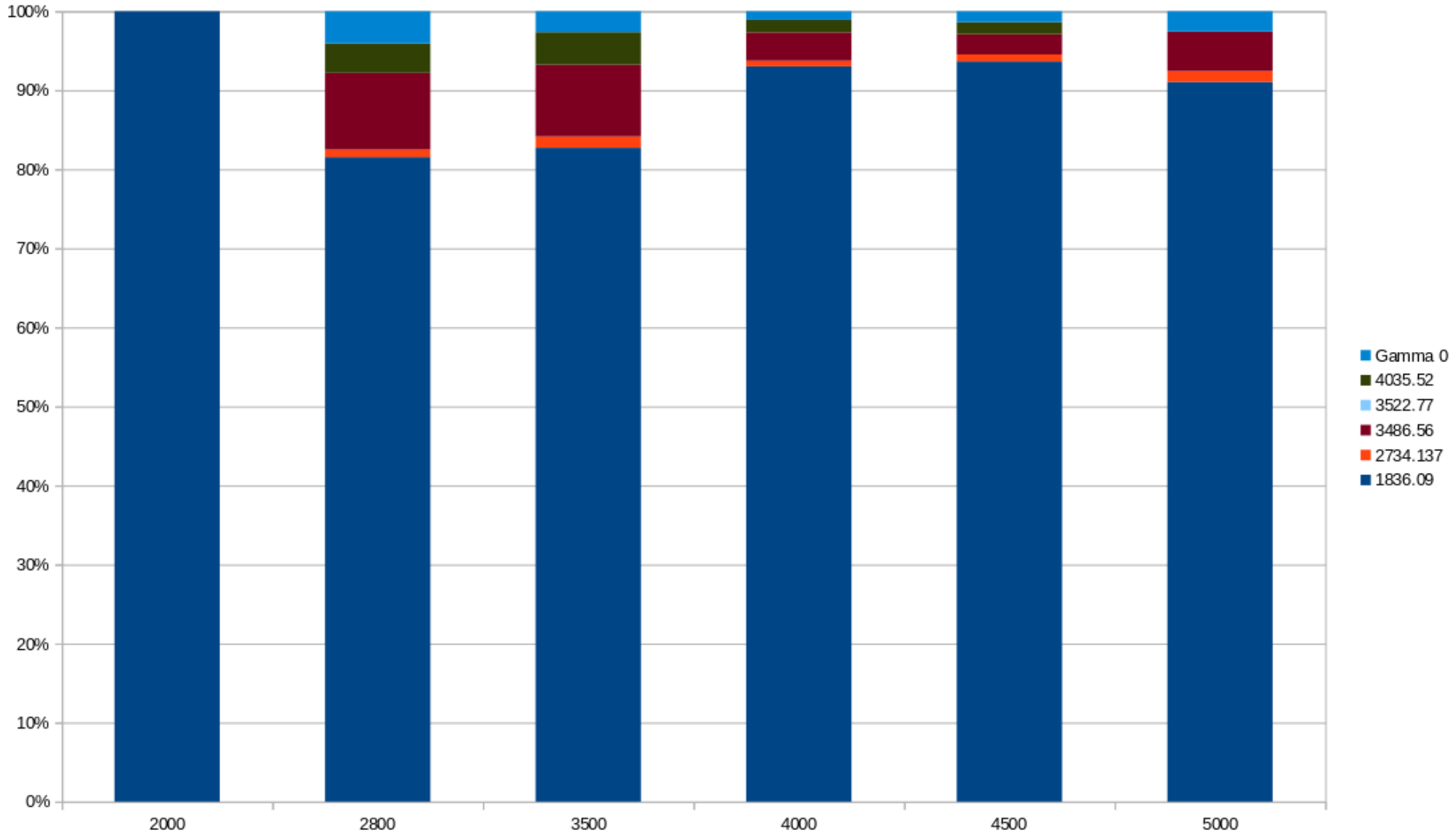
CologneAMS

^{90}Mo	^{91}Mo	^{92}Mo	^{93}Mo	^{94}Mo
^{89}Nb	^{90}Nb	^{91}Nb	^{91}Nb	^{92}Nb
^{88}Zr	^{89}Zr	^{90}Zr	^{91}Zr	^{92}Zr
^{87}Y	^{88}Y	^{89}Y	^{90}Y	^{91}Y
^{86}Sr	^{87}Sr	^{88}Sr	^{89}Sr	^{90}Sr
^{85}Rb	^{86}Rb	^{87}Rb	^{88}Rb	^{89}Rb
^{84}Kr	^{85}Kr	^{86}Kr	^{87}Kr	^{88}Kr

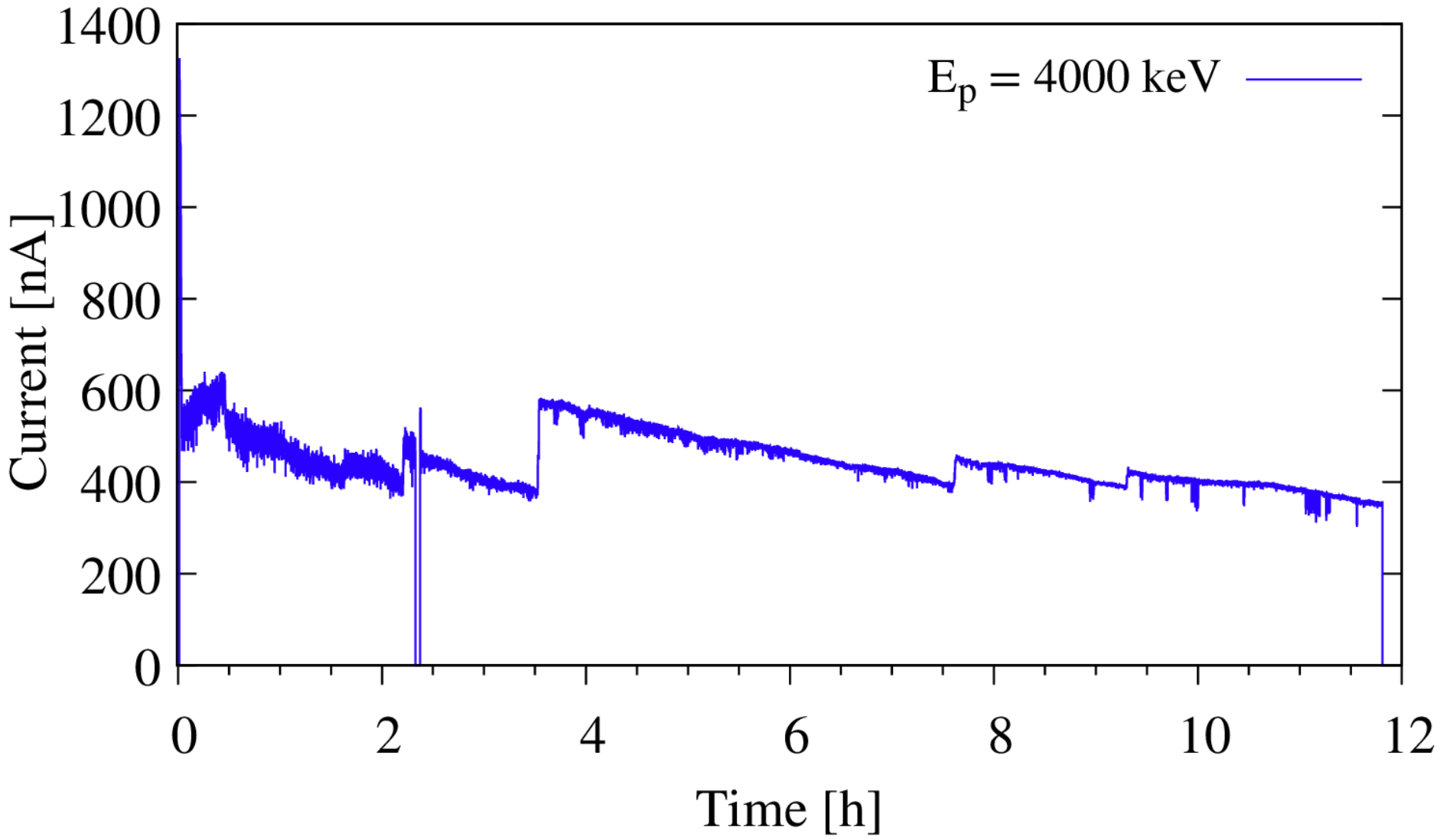
N=50



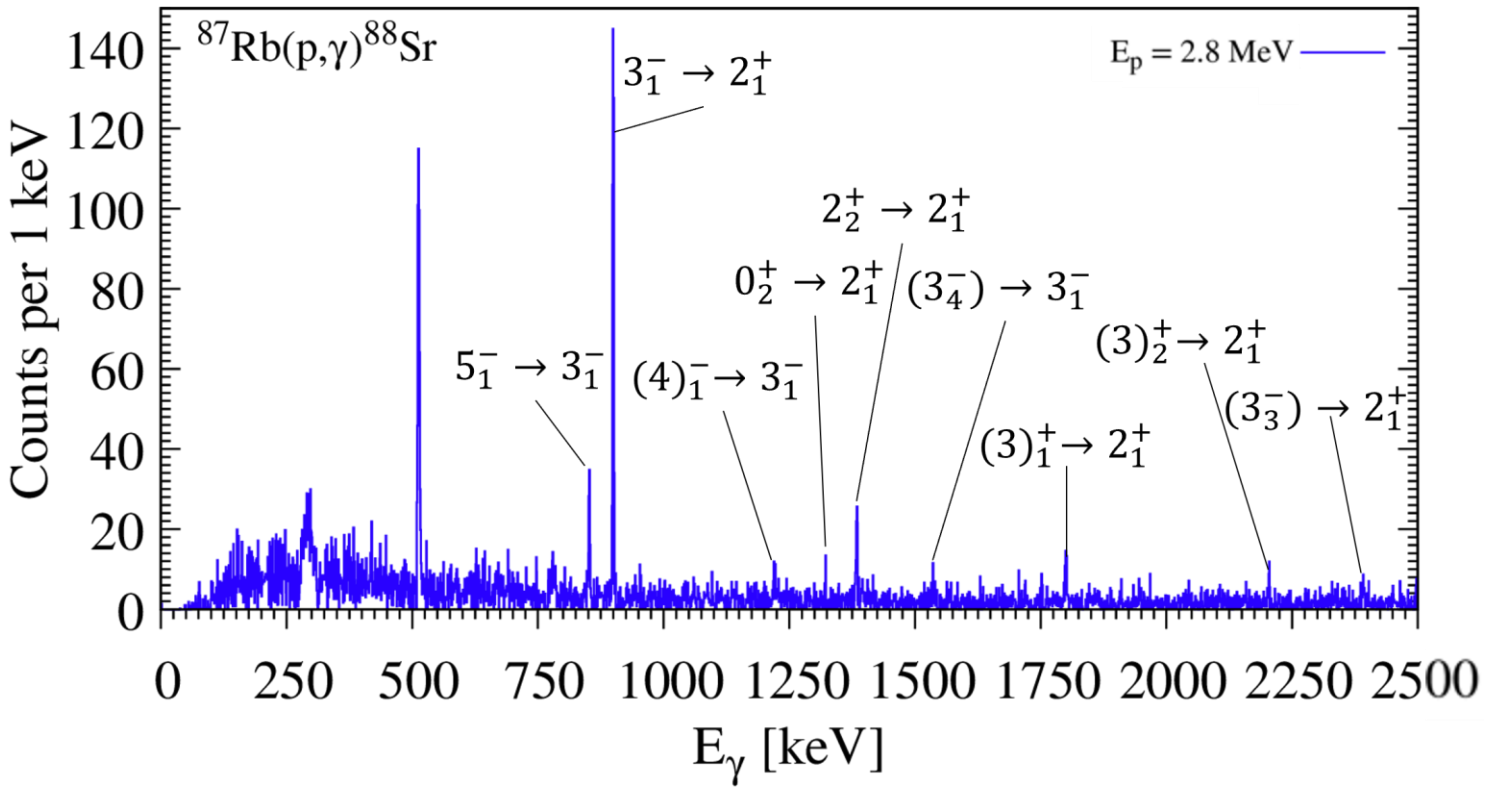
Ratios of different g.s. transitions

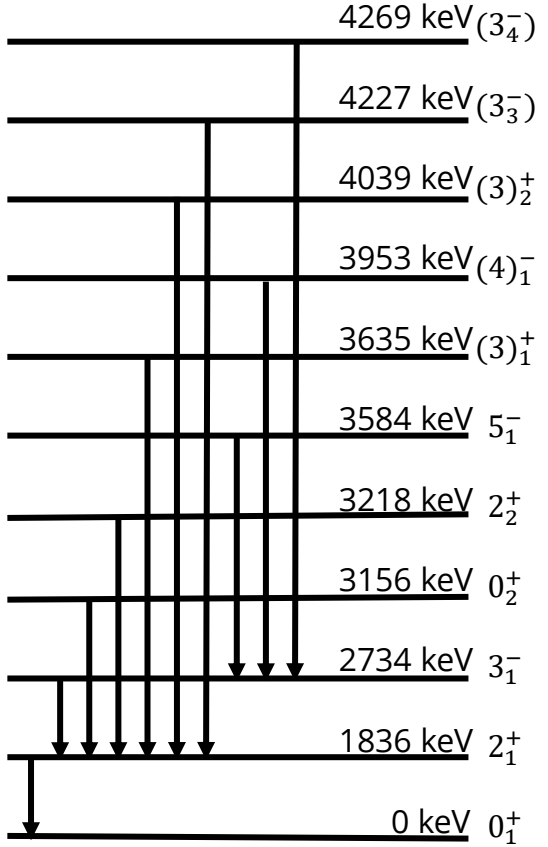


Proton beam current at E_p = 4000 keV

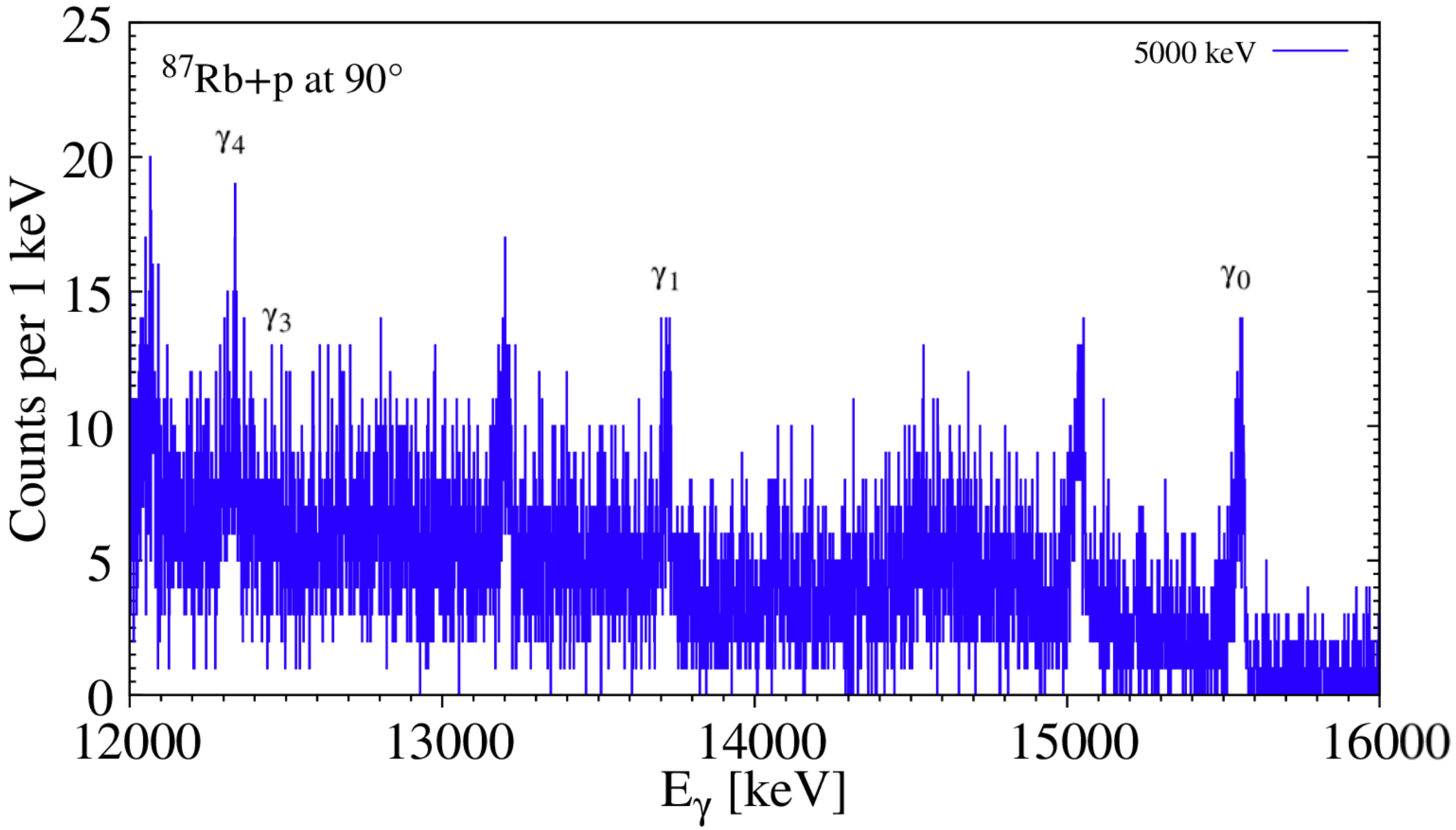


Gate on the $2_1^+ \rightarrow 0_1^+$ transition





Nucl. Data Sheets 115 (2014) 135.


^{87}Rb+p at 90°
5000 keV
γ_4
γ_3
γ_1
γ_0
Counts per 1 keV
E_γ [keV]
0
5
10
15
20
25
12000
13000
14000
15000
16000

partial cross-section measurement