New measurements of $^{63}Cu(\alpha,\gamma)^{67}Ga$ reaction compared with improved calculations

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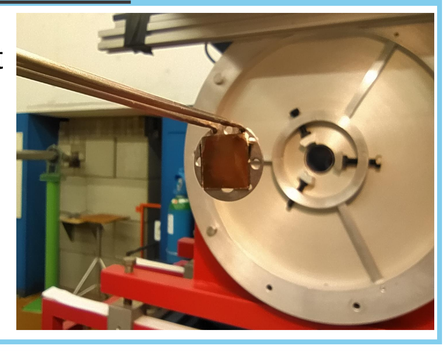
Introduction

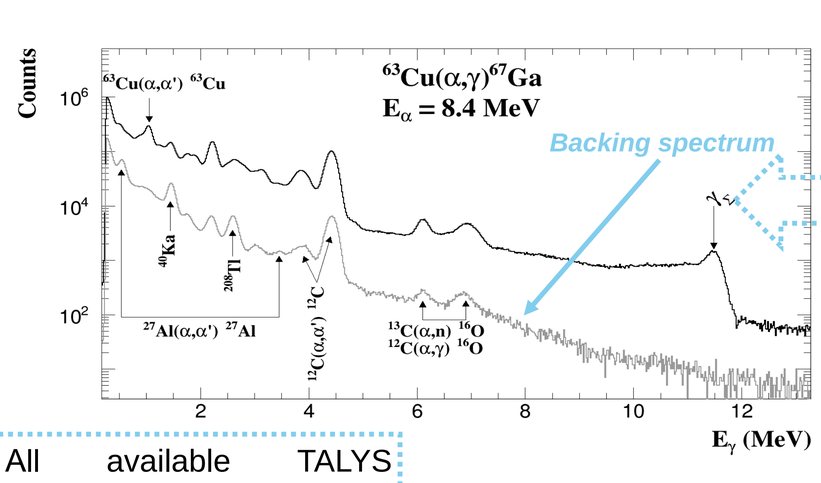
Two nucleosynthetic processes, the s-process and r-process, are responsible for producing most elements heavier than iron. However, these mechanisms cannot account for the creation of 35 proton-rich nuclei, known as p-nuclei. Consequently, a third mechanism, the p-process, is proposed for their formation. Despite their small number, p-nuclei are of interest in nuclear astrophysics due to the discrepancy between theoretically predicted and observed abundances. Abundance calculations in astrophysical models require cross-section input from a vast nuclear reaction network. Measuring every cross-section is practically impossible, thus, predictions often rely on the Hauser-Feshbach theory. In this work, experimental data from the $^{63}Cu(\alpha,\gamma)^{67}Ga$ reaction were compared with refined theoretical calculations aiming to improve the parametrization of the calculations.

Experimental details

- Central Unit for Ionbeams and Radionuclides, Ruhr Universitat Bochum, Germany
- 12 x 12'' single-crystal scintillator
- 4π γ-summing method
- 349 μg/cm^2 foil of ^{63}Cu (determined via XRF)
- E_{lab} ~ 5.3 - 8.6 MeV

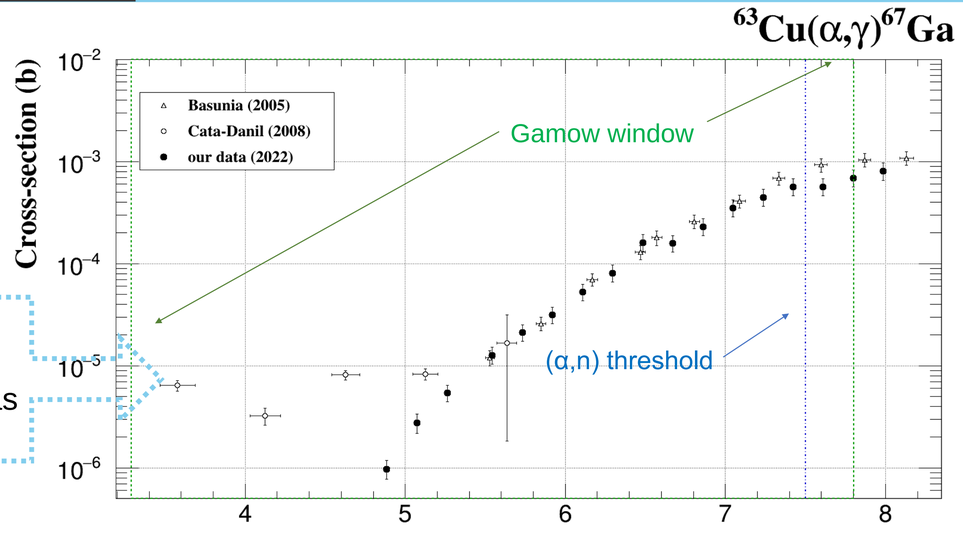


Experimental results and theoretical calculations



results

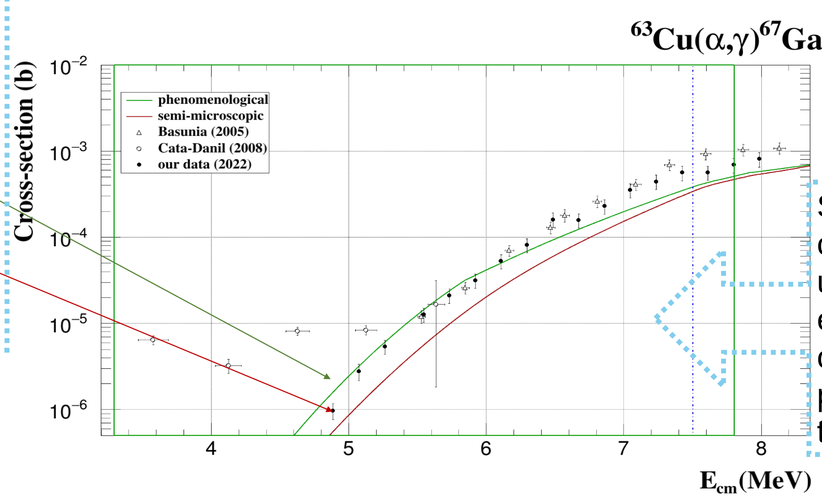
Typical experimental & backing spectrum
γ_Σ → sum-peak of the reaction under study



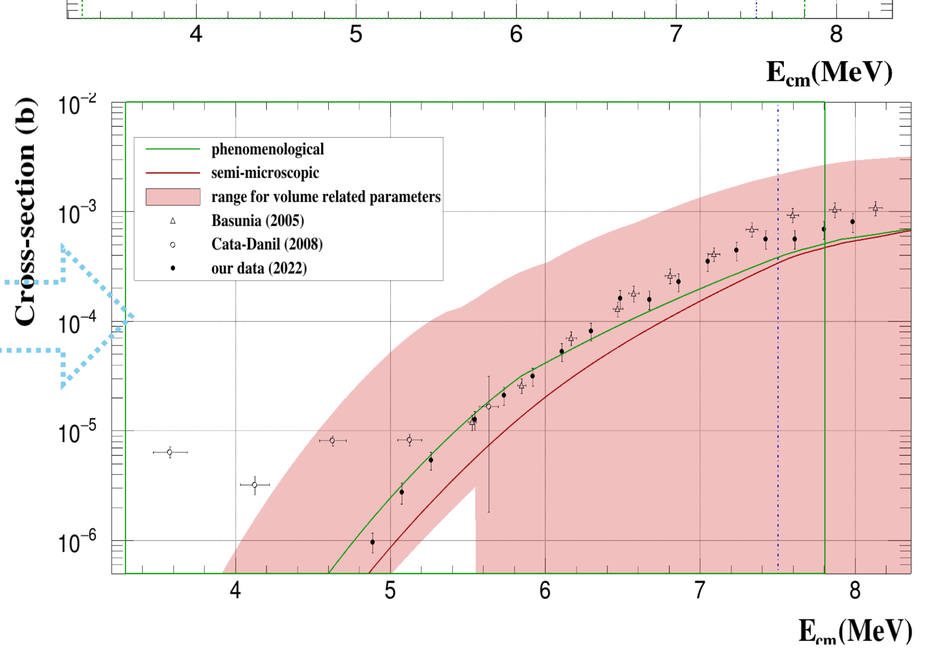
In agreement with previous activation measurements!!!

All available TALYS (version 1.96) pOMP, αOMP, NLD and γSF E1 & M1 models → focused on two model combinations:

- Phenomenological: KD + AV + CTFG + SMLO
- Semi-microscopic: JLM + αOMP-III + HFB + D1M/HFB/QRPA



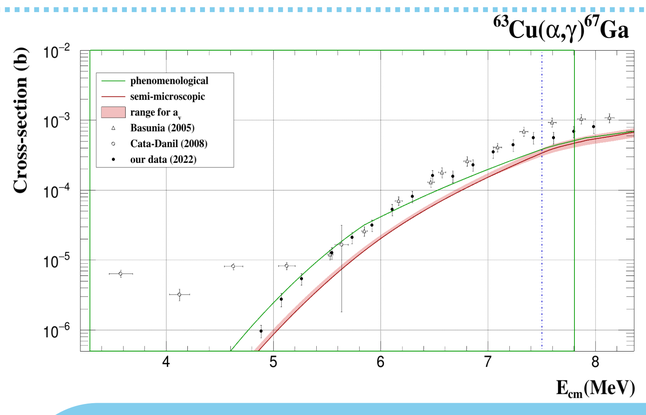
Semi-microscopic comb. underestimates the exp. data → optimize the parametrization of the αOMP

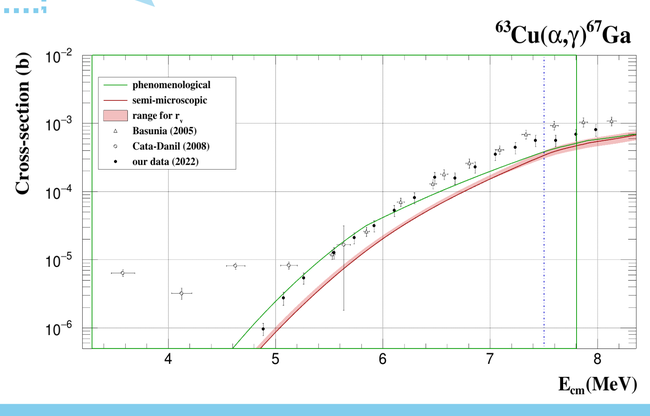


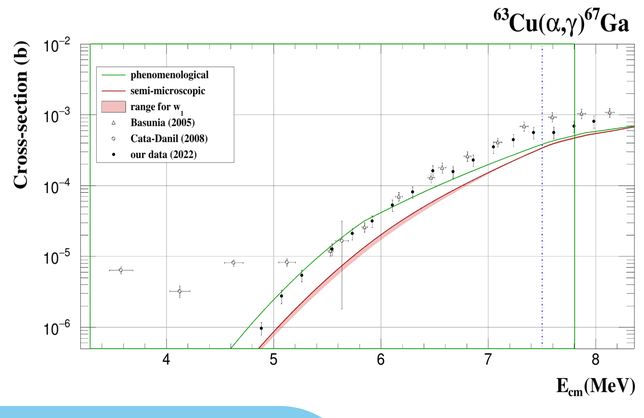
optimization → 6 αOMP parameters

- 3 volume imaginary potential parameters (geometry →a_v & r_v & depth → w_1)
- 3 surface imaginary potential parameters(geometry → a_w & r_w & depth → d_1)⋆

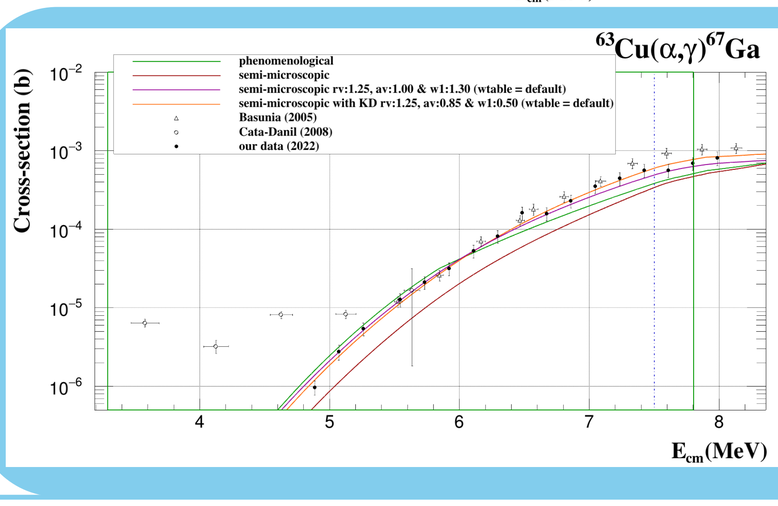
⋆*The surface related parameters did not affect the calculations*

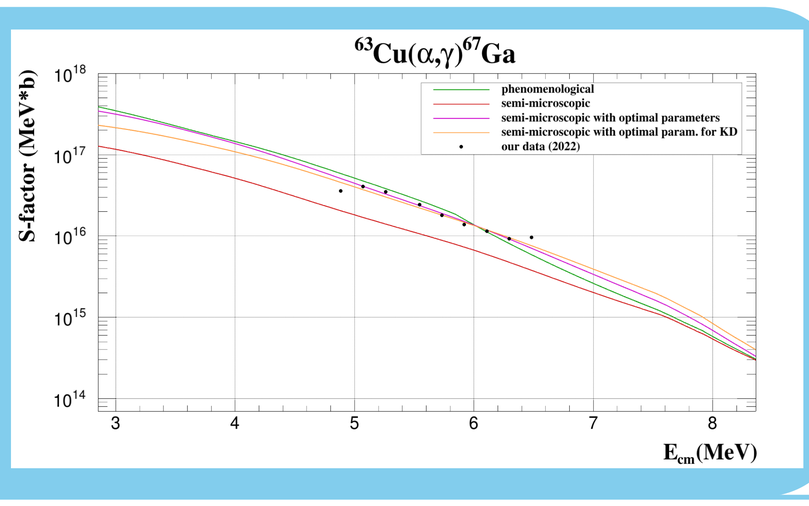






Optimal αOMP parameter values determined via χ^2 calculations using only the experimental points below the (α,n) channel threshold





Optimal values determined also for the semi-microscopic combination using KD for the pOMP

Conclusions

The cross-section of the reaction $^{63}Cu(\alpha,\gamma)^{67}Ga$ was measured at the RUBION Institute, using the 4π γ-summing method, in seventeen energies relevant to nuclear astrophysics. The results are consistent with previous activation measurements. Cross-section calculations were performed using TALYS 1.96 with the goal of optimizing the parametrization of the αOMP model. Optimal parameter values were determined through χ^2 calculations, using only the experimental points below the (α,n) channel threshold. The optimized model accurately describes both the reaction cross-section as well as the S-factor.

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