

$^{141}\text{Pr}(\alpha, \text{n})^{144}\text{Pm}$ cross section measurement for the astrophysical p process using the $\gamma\gamma$ coincidence technique

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Workshop on Thermonuclear Reaction Rates for Astrophysics Applications

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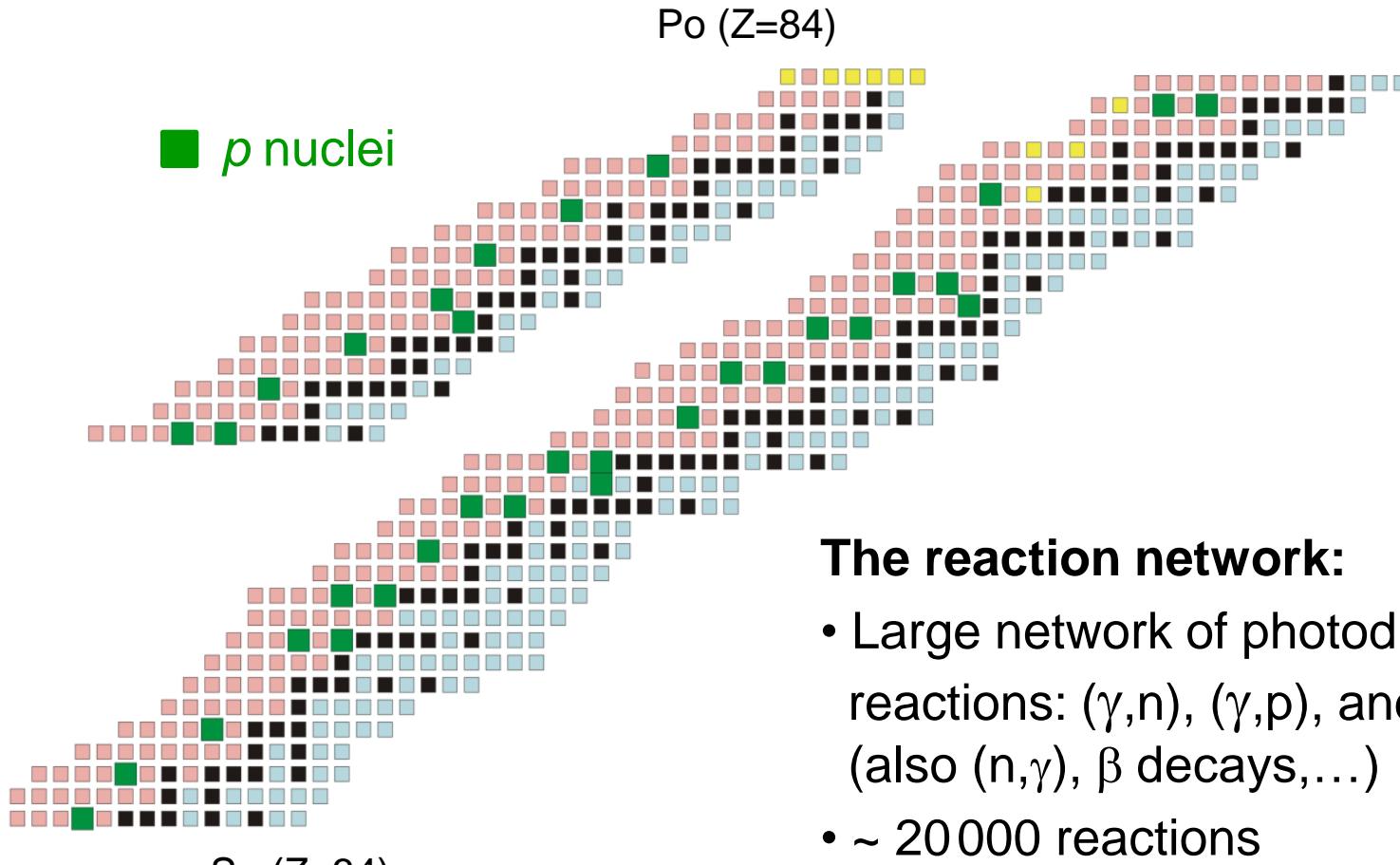
Bonn-Cologne Graduate School
of Physics and Astronomy

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p process

Nucleosynthesis process for the production of the *p* nuclei



The reaction network:

- Large network of photodisintegration reactions: (γ, n), (γ, p), and (γ, α) (also (n, γ), β decays,...)
- $\sim 20\,000$ reactions
- $\sim 2\,000$ nuclei (mainly unstable)

Nuclear physics data for the *p* process

Option 1:

Measure astrophysical reaction rates „directly“ in the relevant energy range

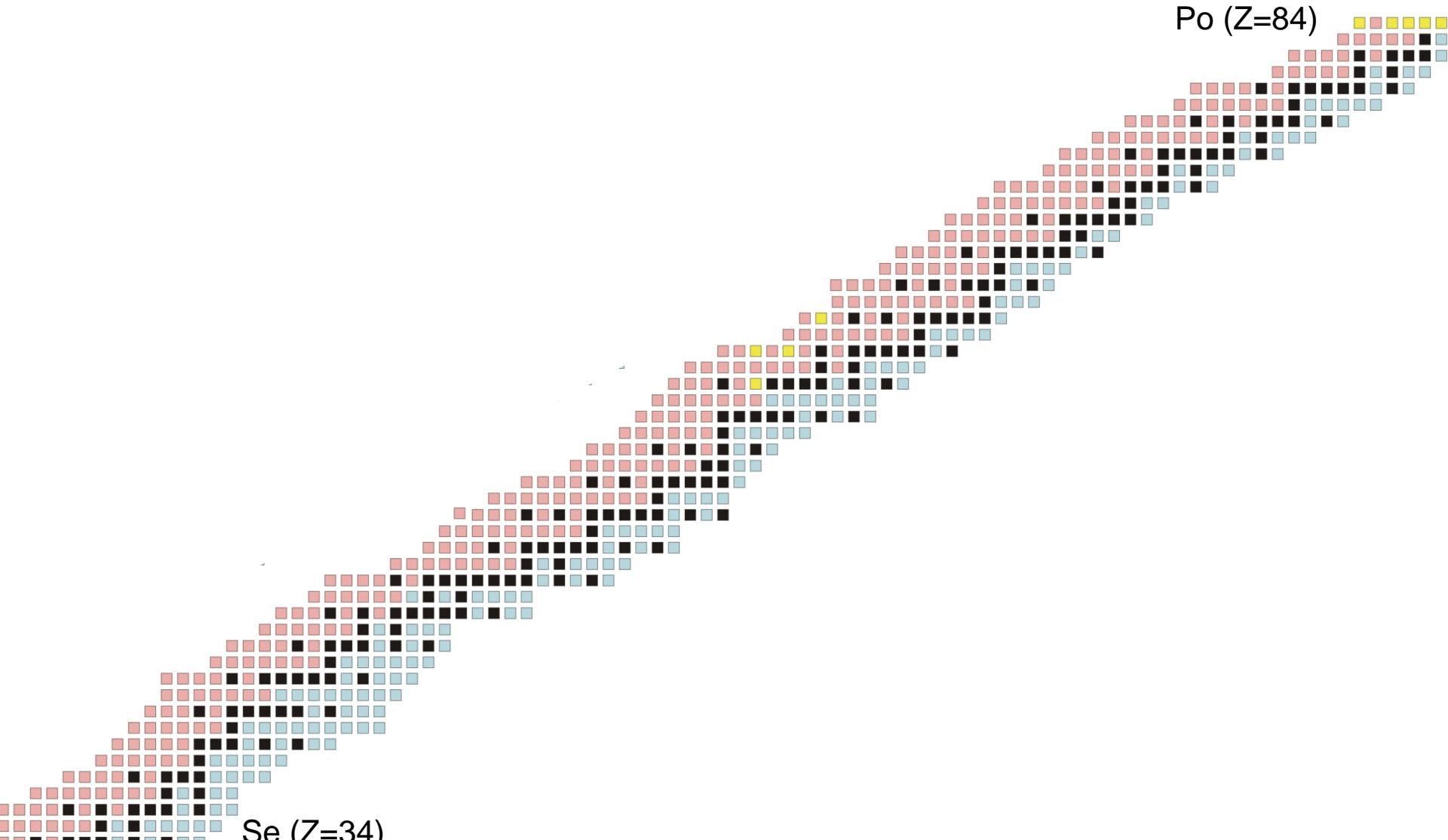
Only possible for a few reactions within the network

Option 2:

Improve nuclear models to calculate reaction rates

- Nuclear masses
- Properties of excited states
- Nuclear level densities
- γ -strength function
- Nucleon-nucleus OMP and α -nucleus OMP

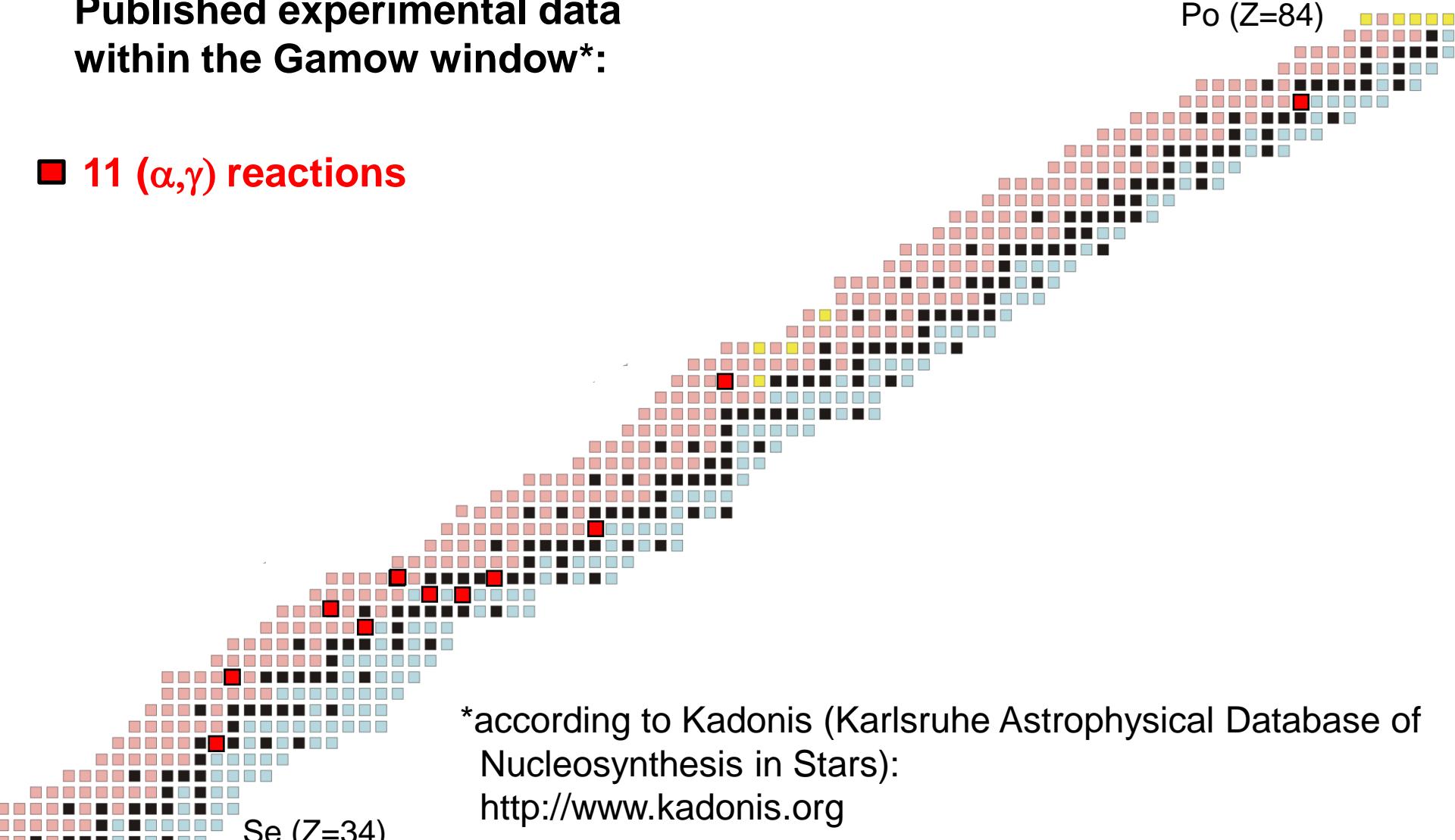
Experimental situation for α -induced reactions



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**Published experimental data
within the Gamow window*:**

■ 11 (α,γ) reactions

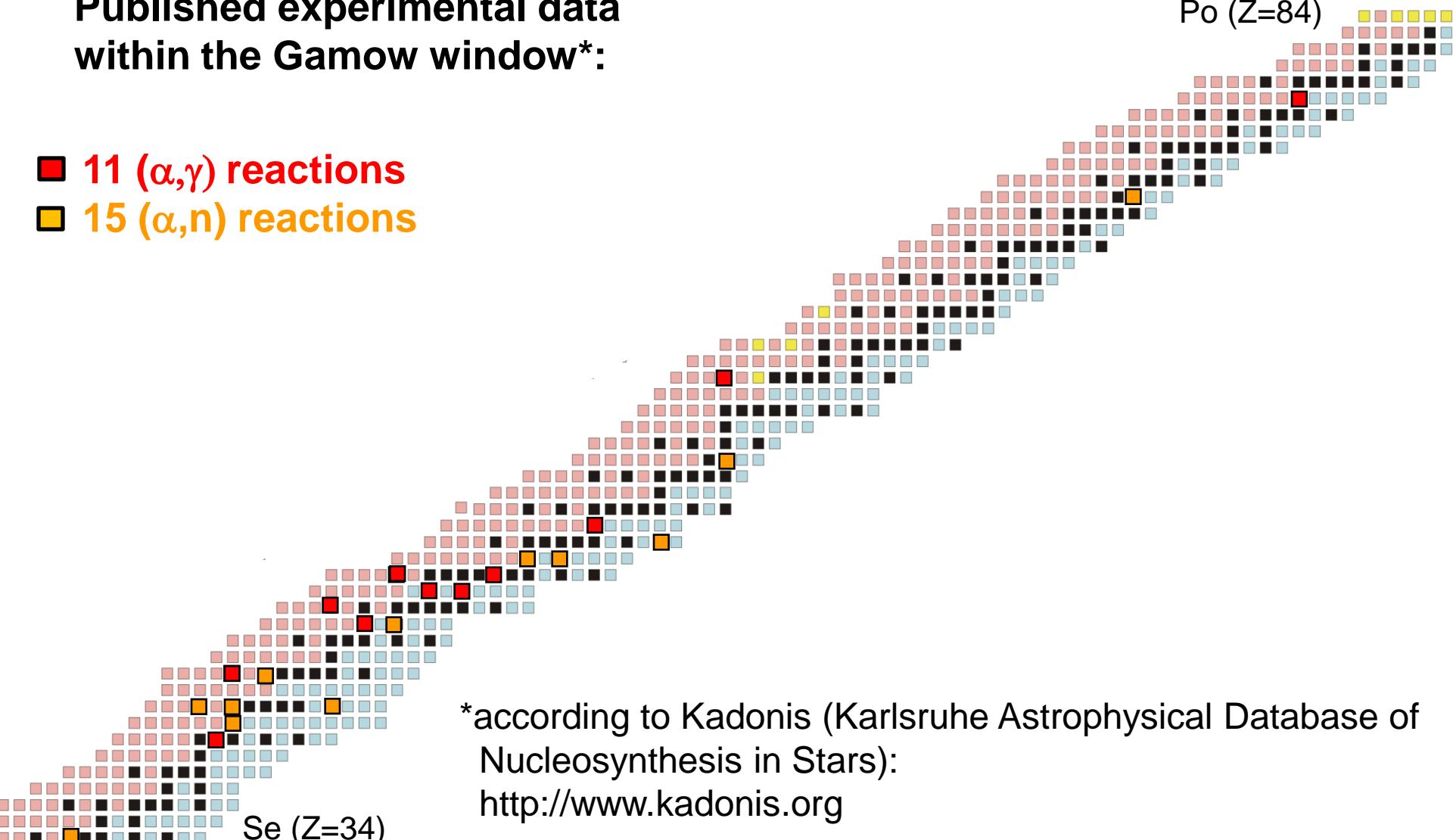


*according to Kadonis (Karlsruhe Astrophysical Database of Nucleosynthesis in Stars):
<http://www.kadonis.org>

Experimental situation for α -induced reactions

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- **11 (α,γ) reactions**
- **15 (α,n) reactions**

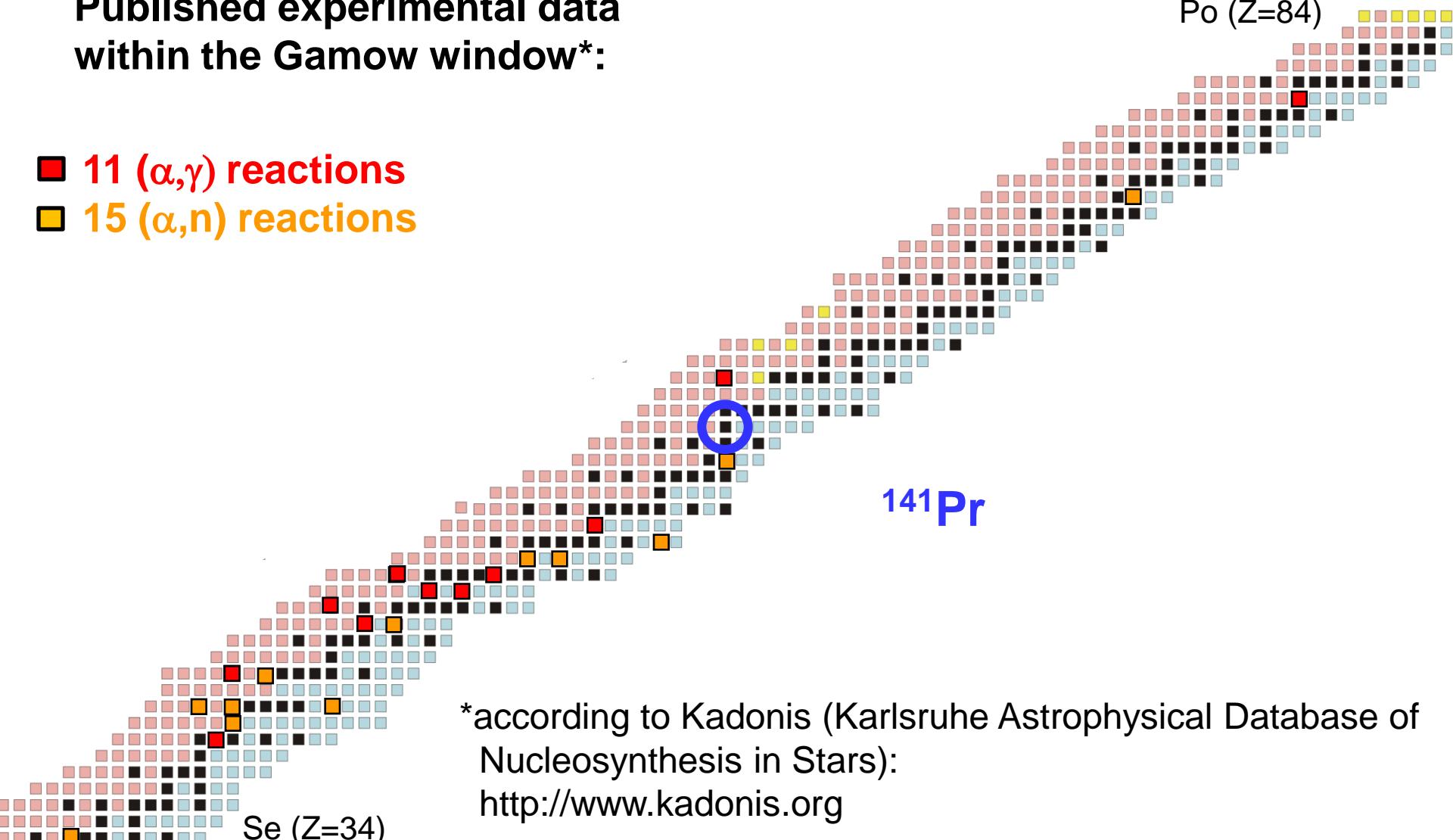


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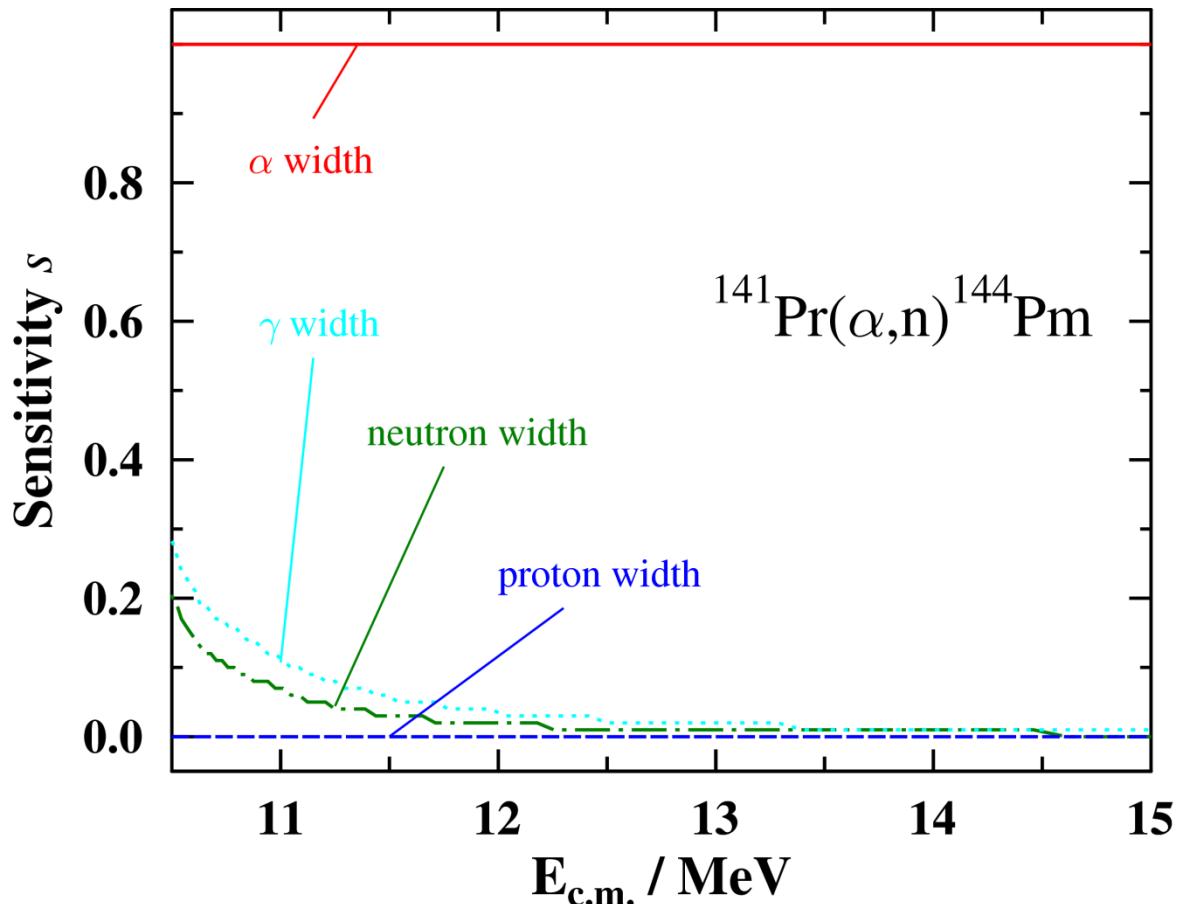
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Relevance of nuclear physics input of different reaction channels

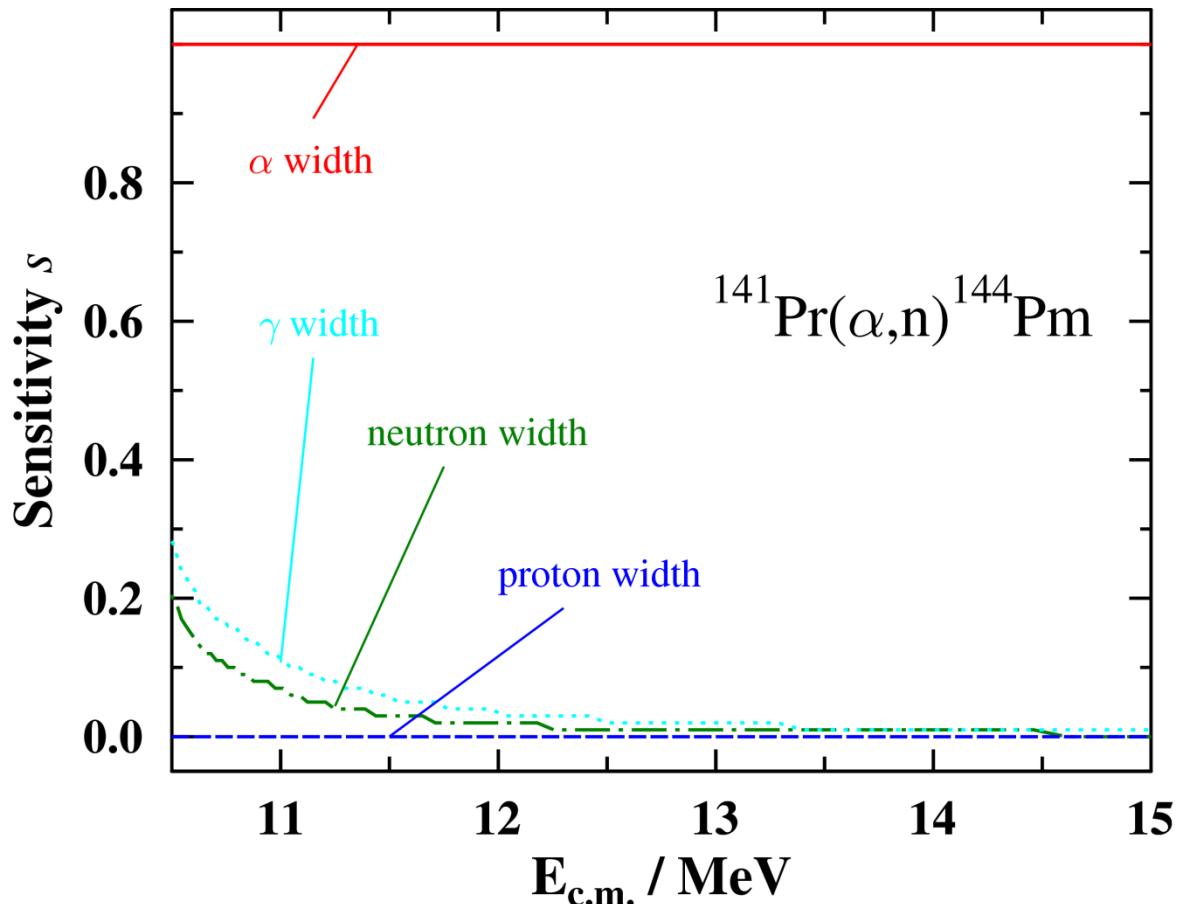


A. Sauerwein *et al.*,
Phys. Rev. C **84** (2011) 045808

Calculated with SMARAGD Code version 0.8.3s (T. Rauscher)

Relevance of nuclear physics input of different reaction channels

Except close to the (α, n) threshold the $^{141}\text{Pr}(\alpha, n)$ -rate is sensitive to the α -nucleus OMP



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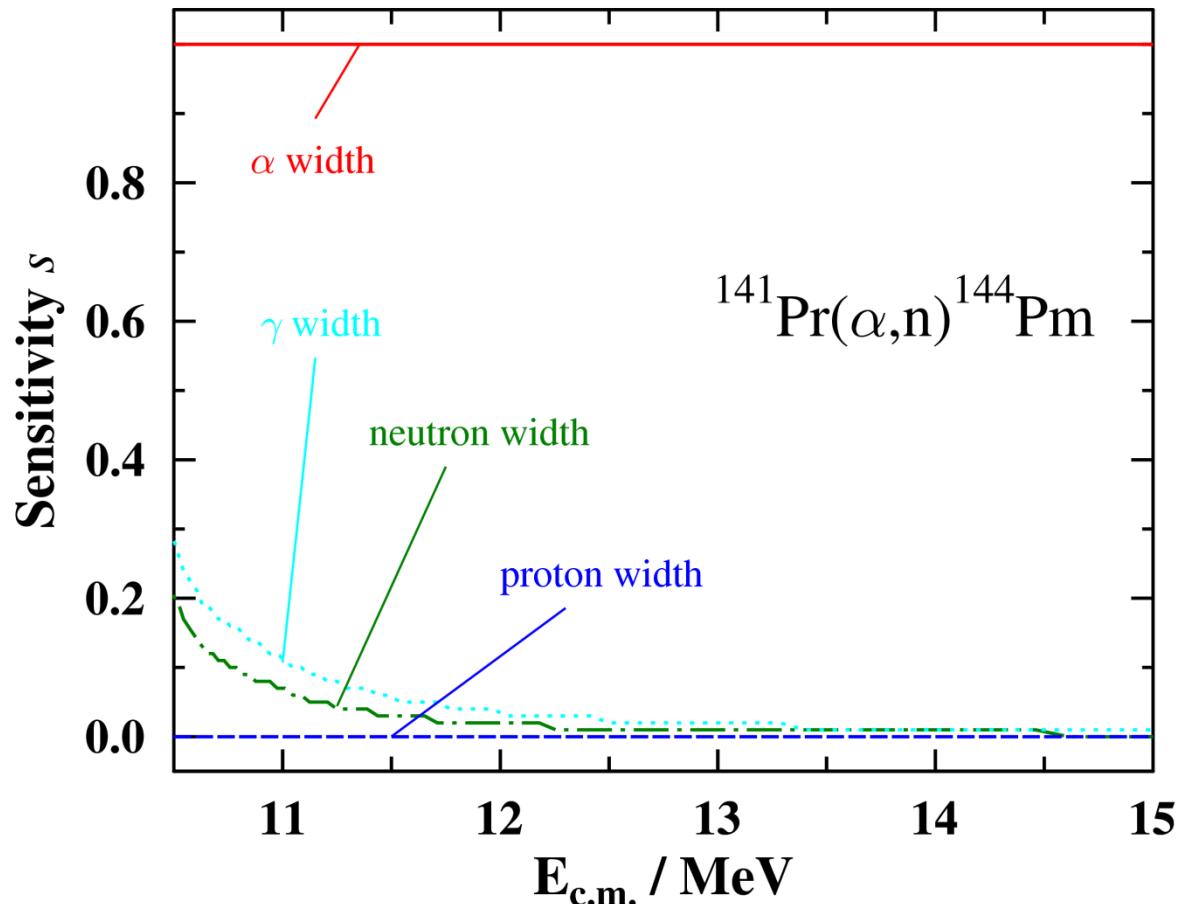
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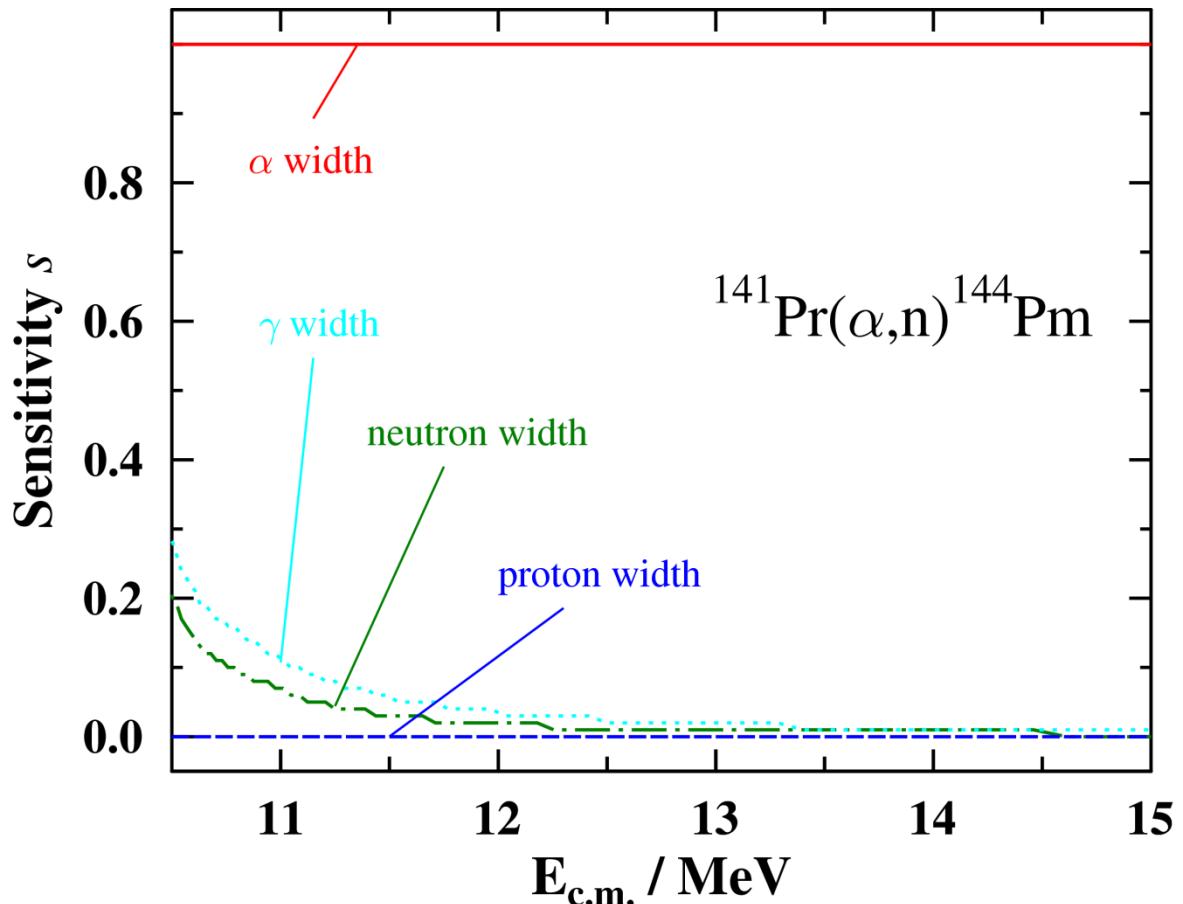
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Improvement of predictions of stellar $^{145}\text{Pm}(\gamma, \alpha)^{141}\text{Pr}$ -rate

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Activation experiments

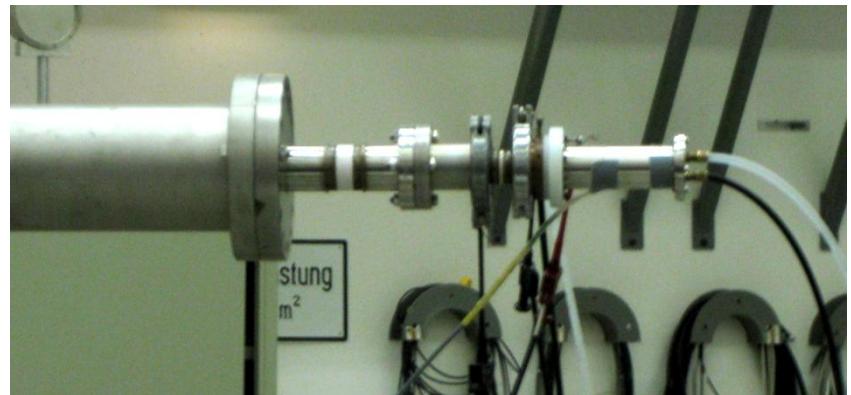
I. Activation

Cyclotron @ Physikalisch-Technische Bundesanstalt, Braunschweig

Beam intensities up to $3.5 \mu\text{A}$

α energies: 11, 11.4, 12, 12.6, 13.2,
13.8, 14.4, and 15 MeV

t_{act} : 1 - 17 h



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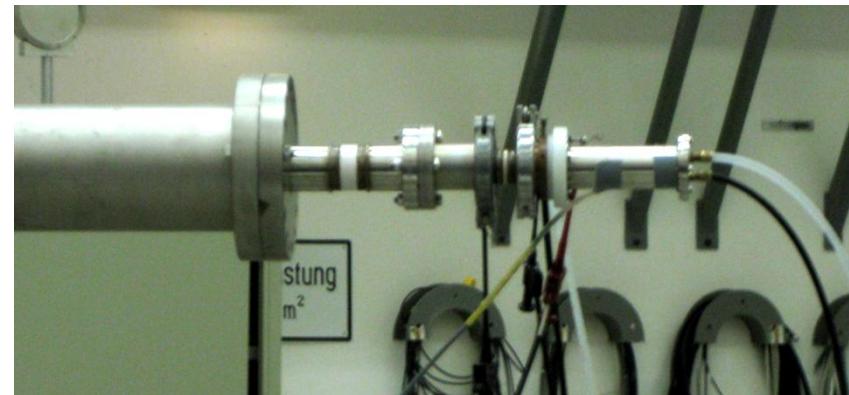
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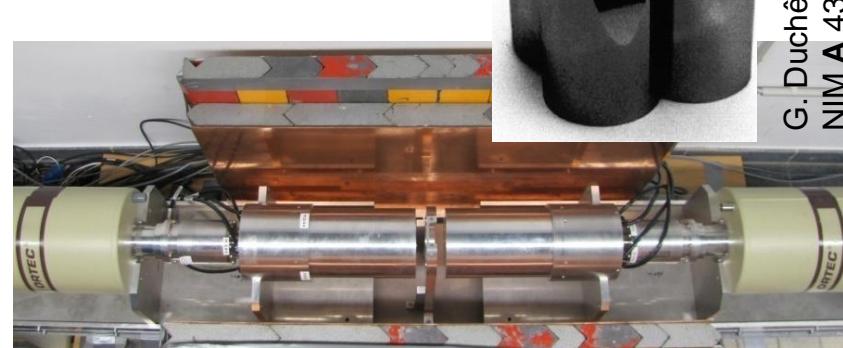
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II. Counting

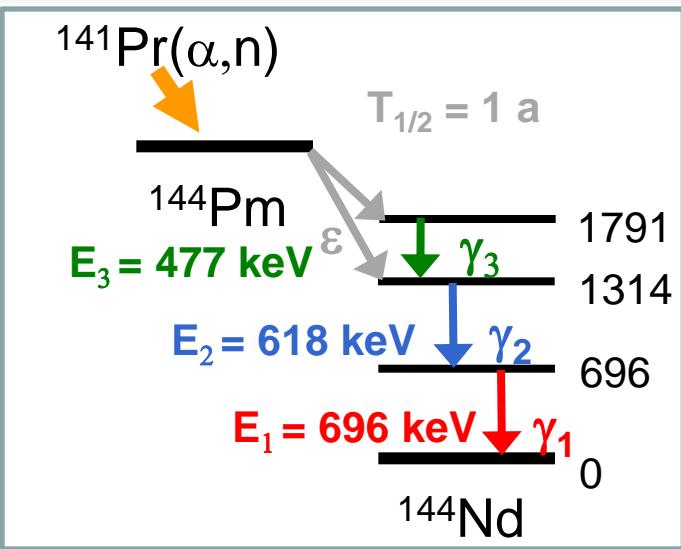
@ Institut für Kernphysik, Cologne

t_{count} : 15 h - 40 d



G. Duchêne et al.
NIM A 432 (1999) 90

Experimental parameters and spectra



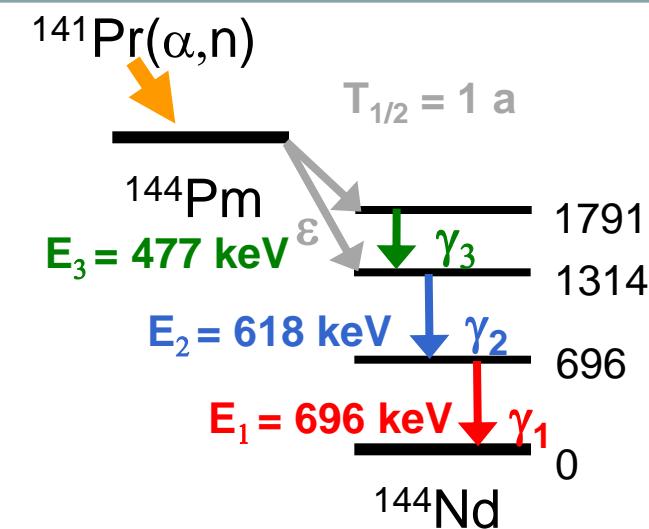
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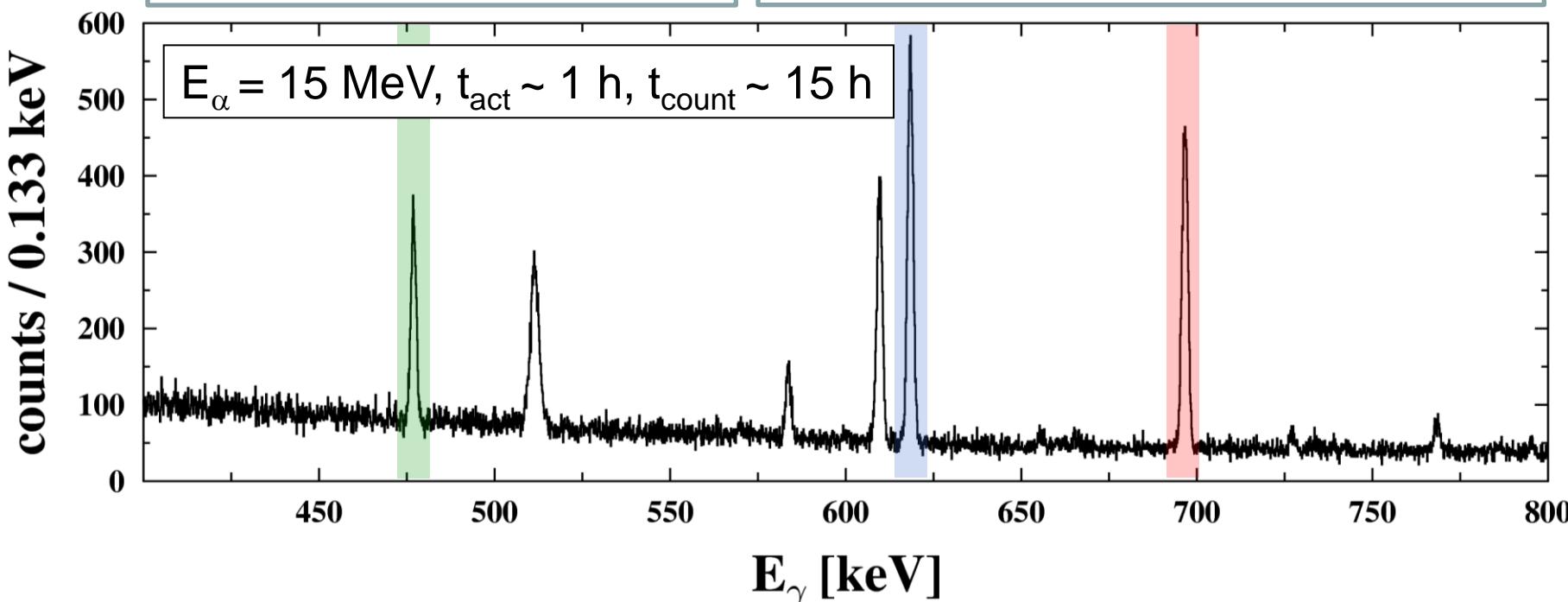


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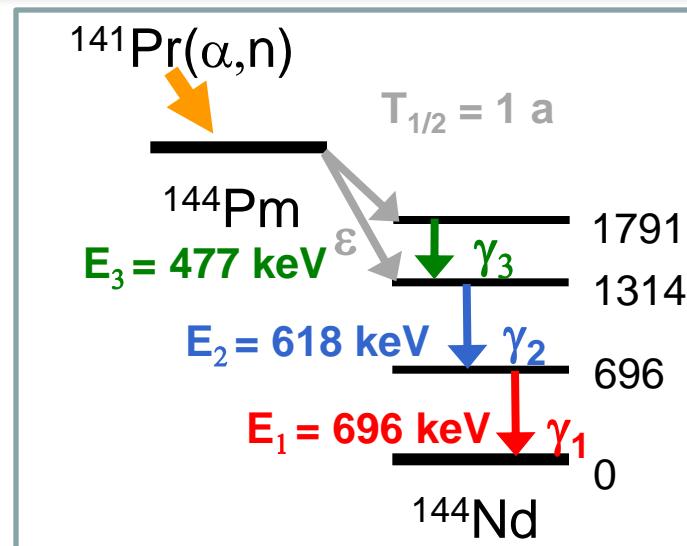
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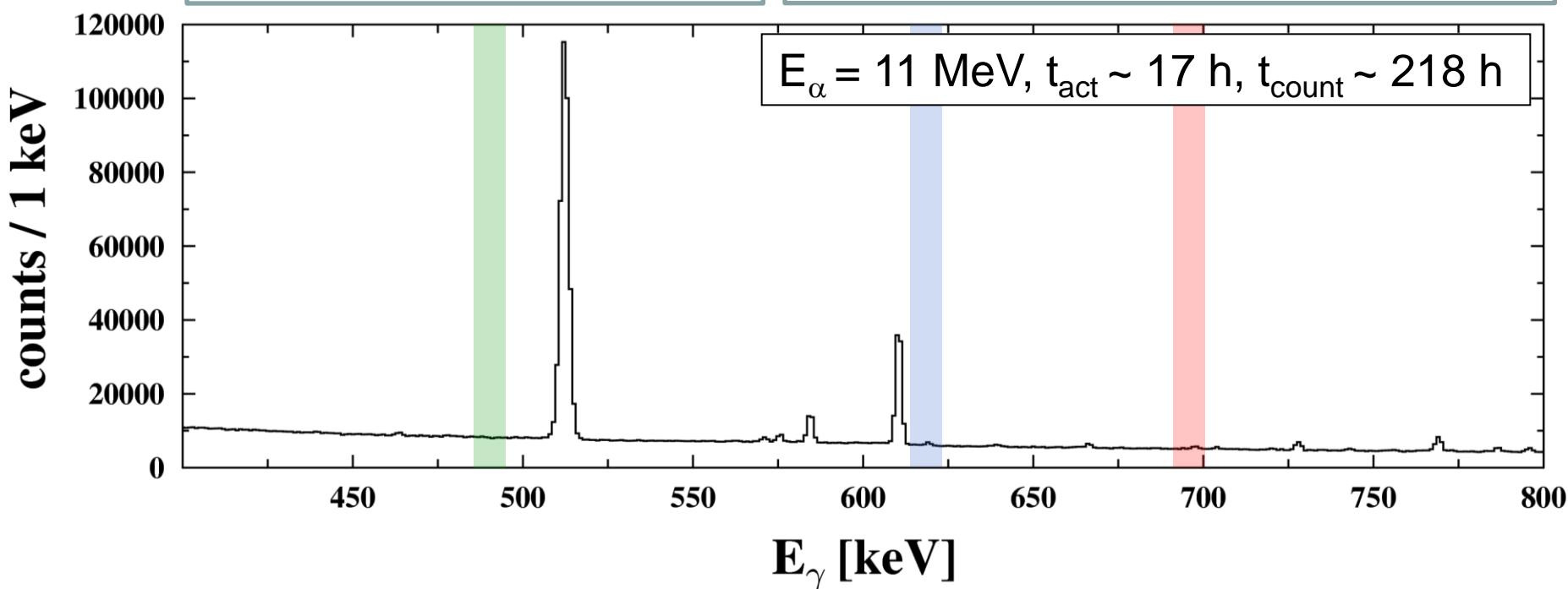


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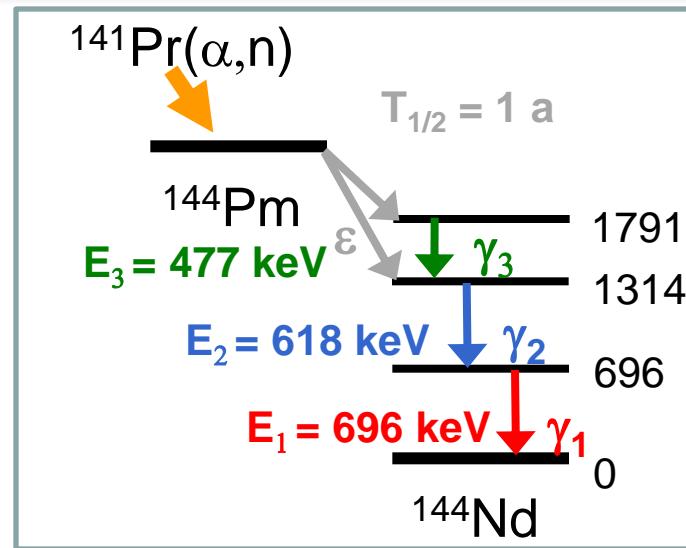
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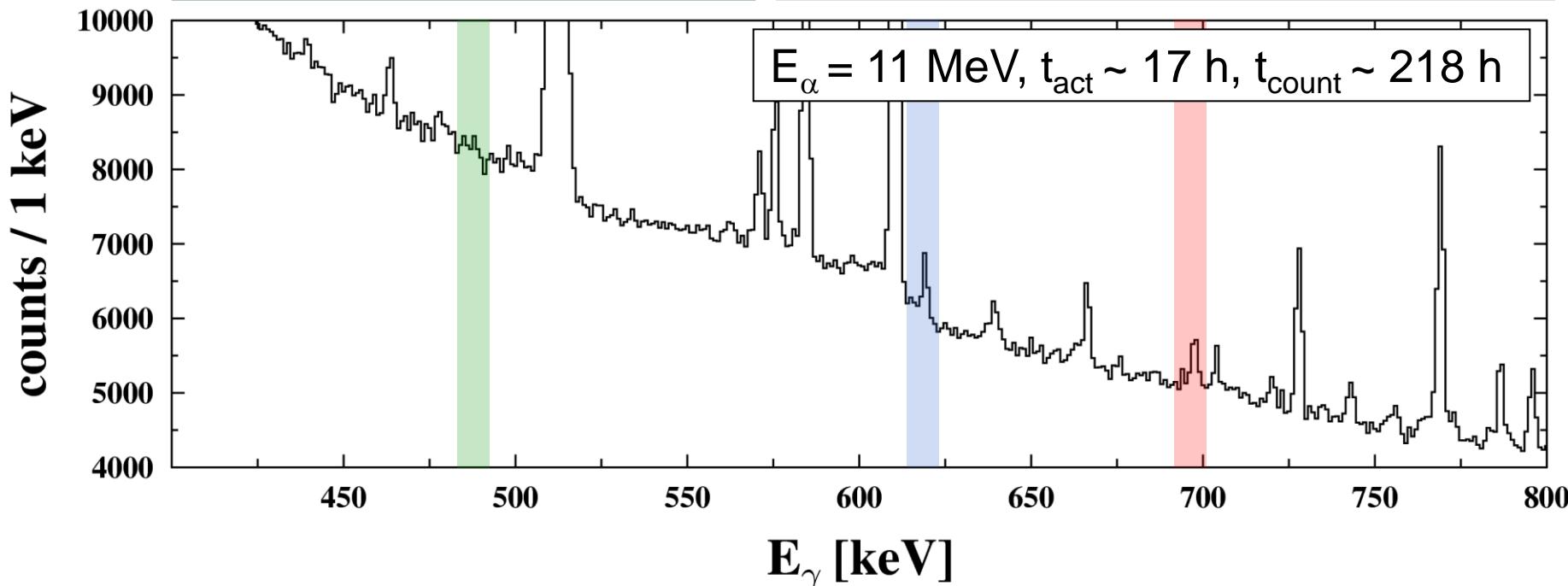


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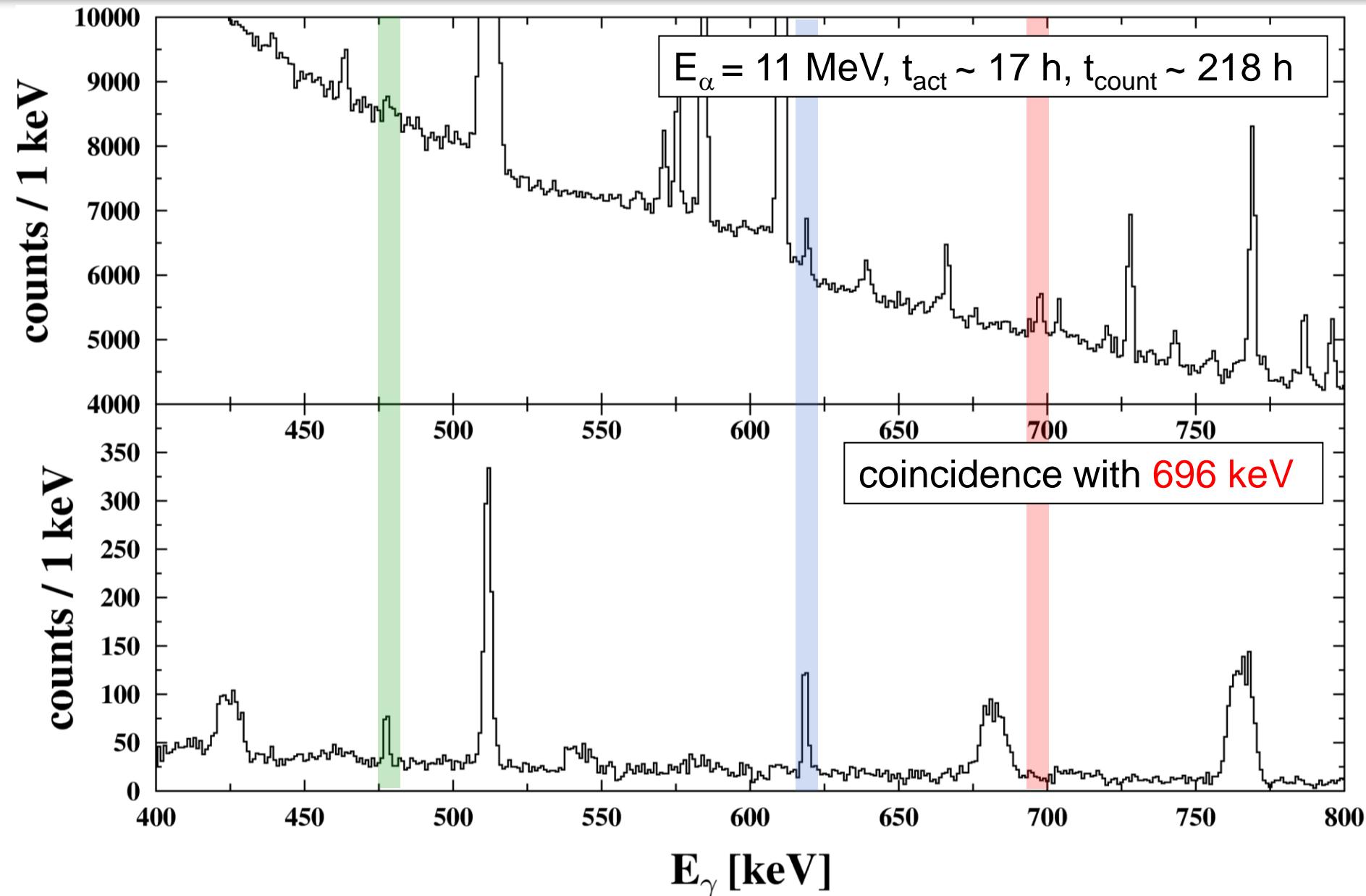
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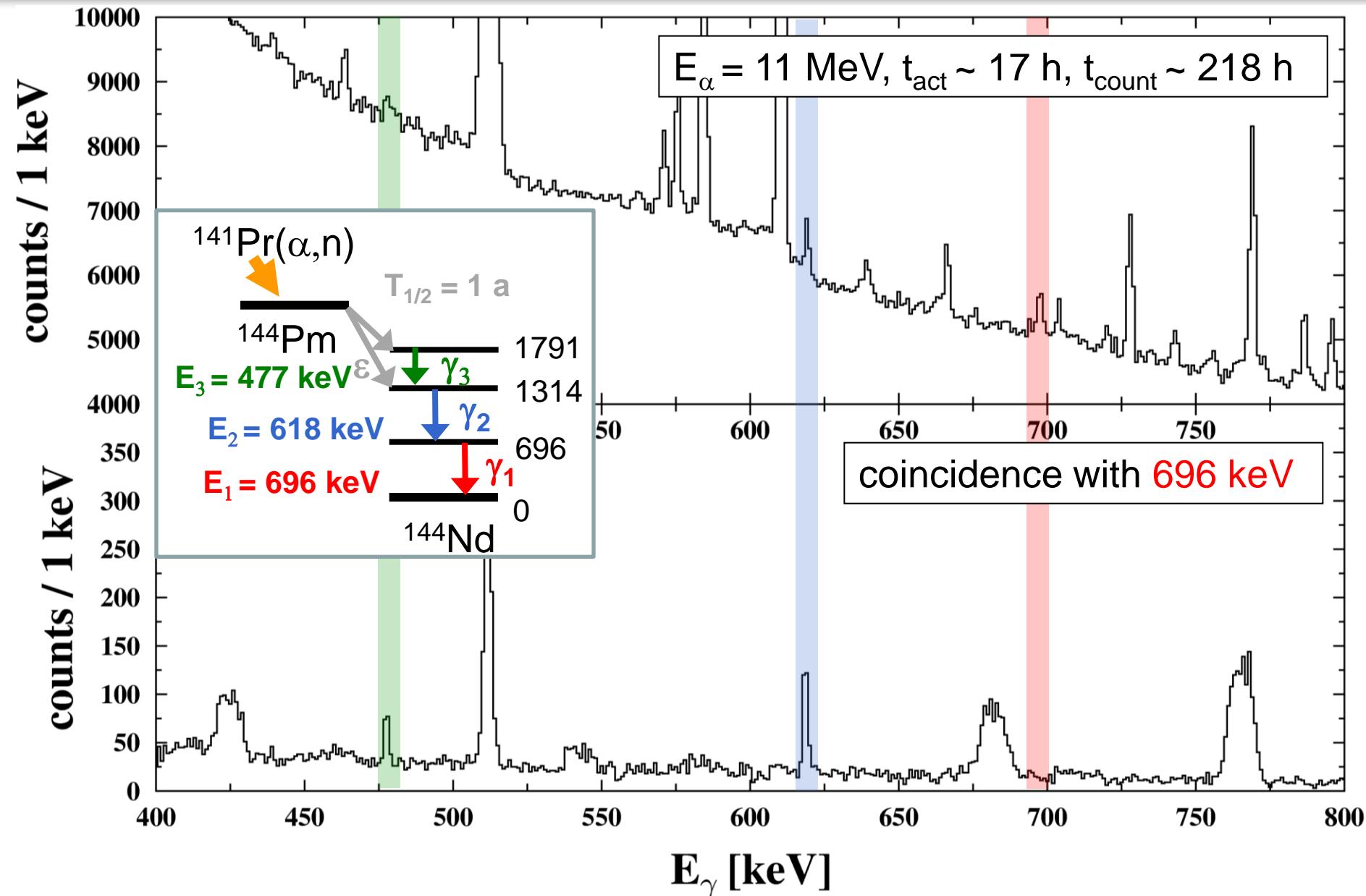
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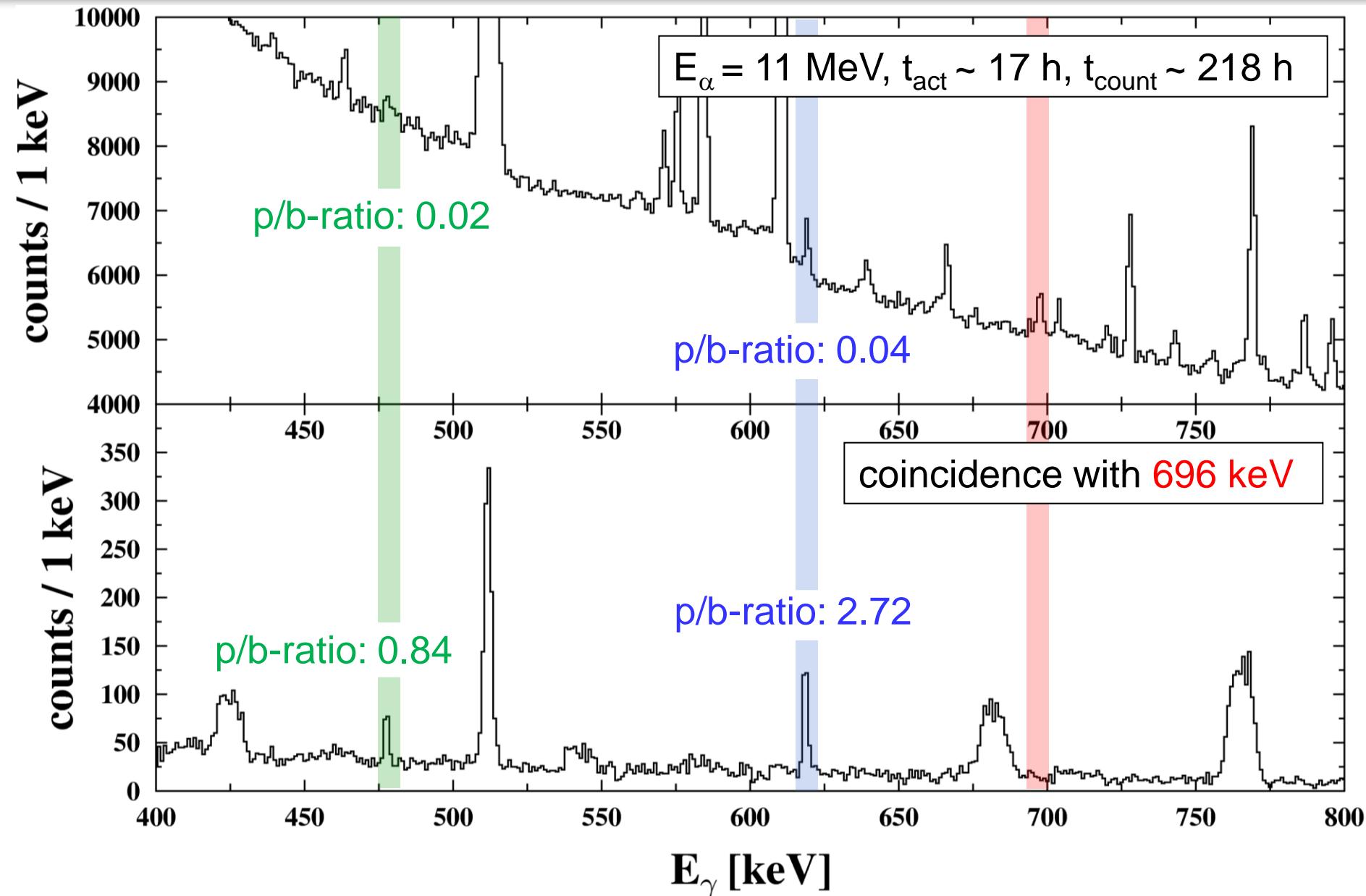
Comparison of single spectra and coincidence spectra



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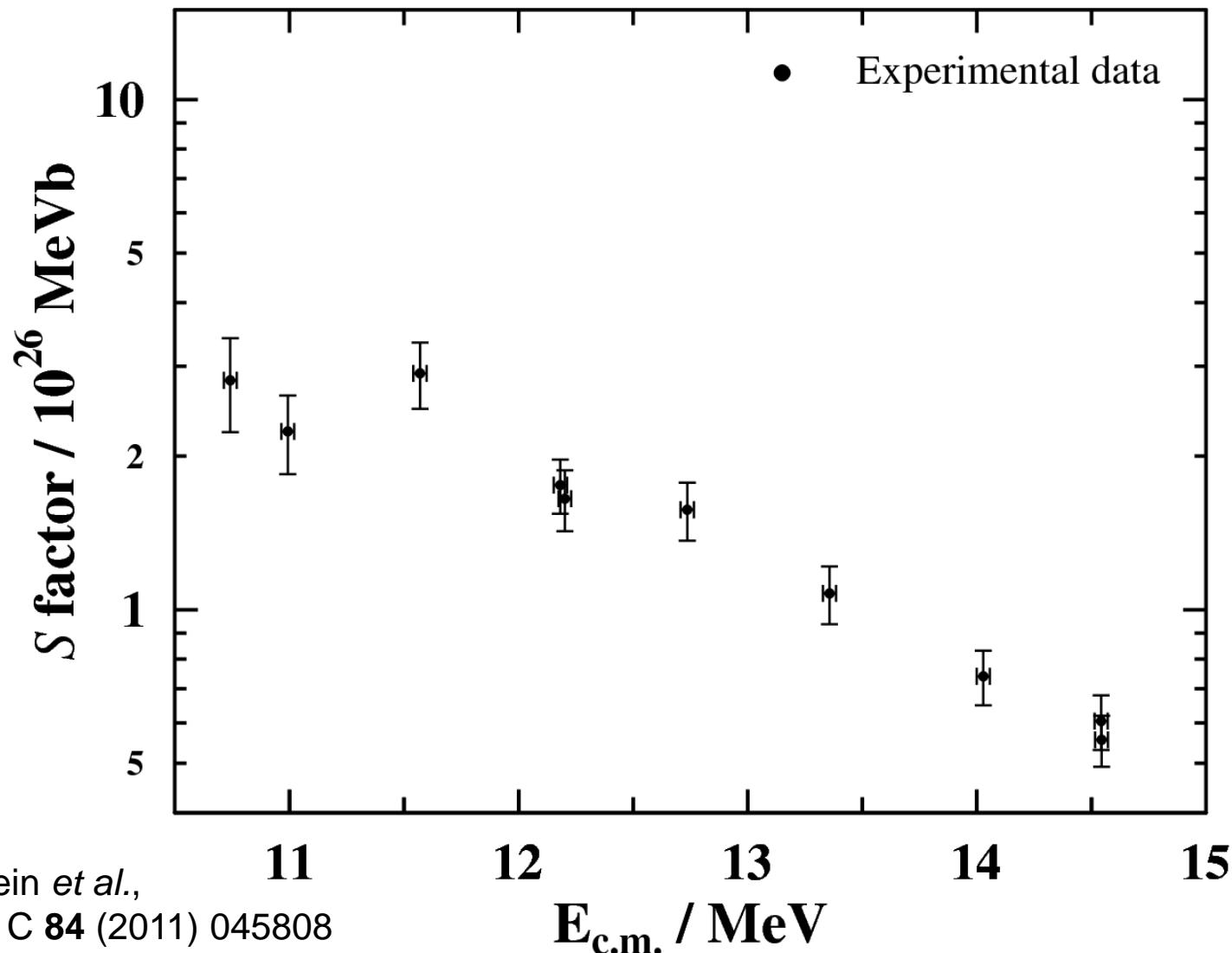


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Results $^{141}\text{Pr}(\alpha, \text{n})^{144}\text{Pm}$

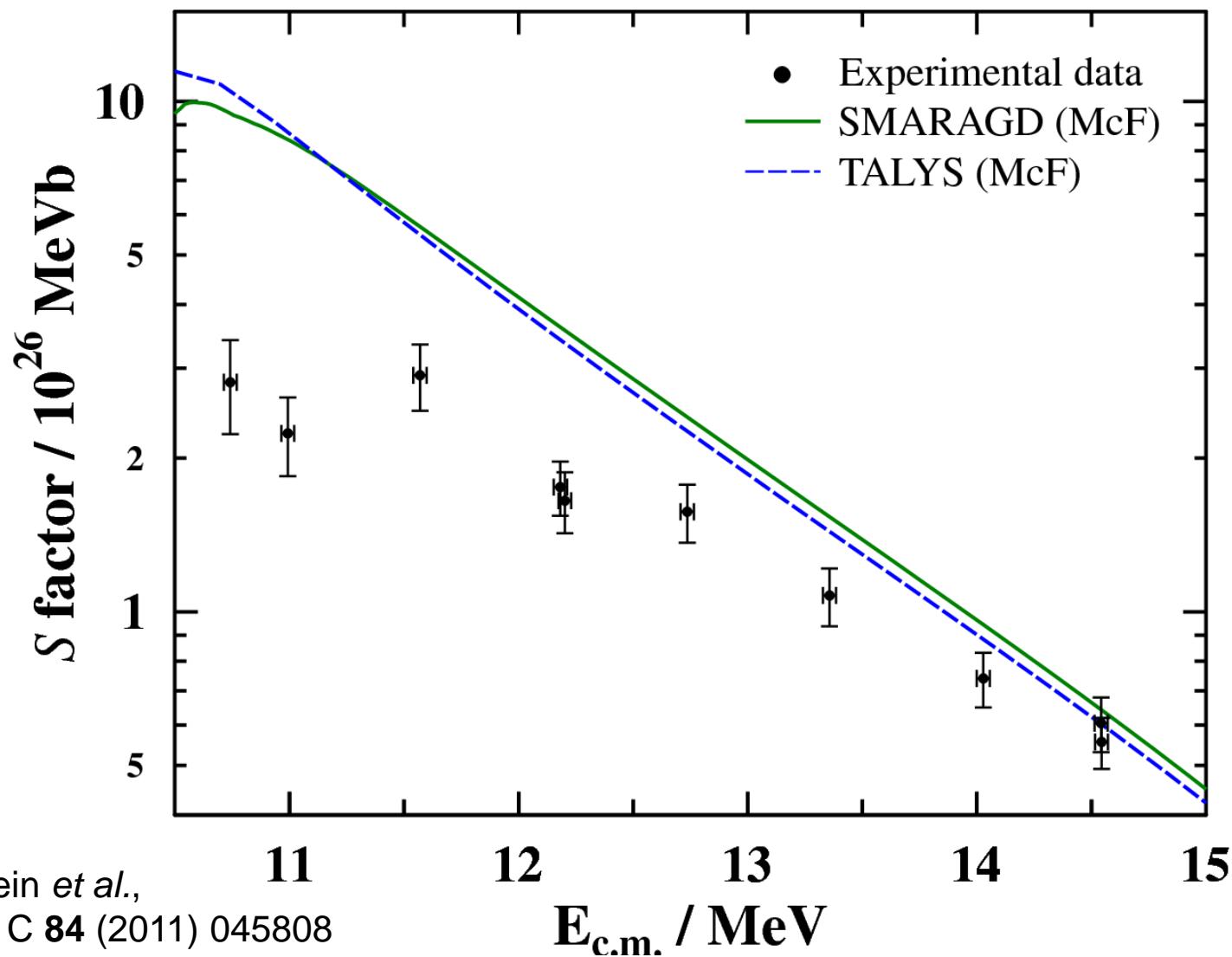
Astrophysical S factor: $S(E) = \sigma(E) \cdot E \cdot e^{2\pi\eta}$



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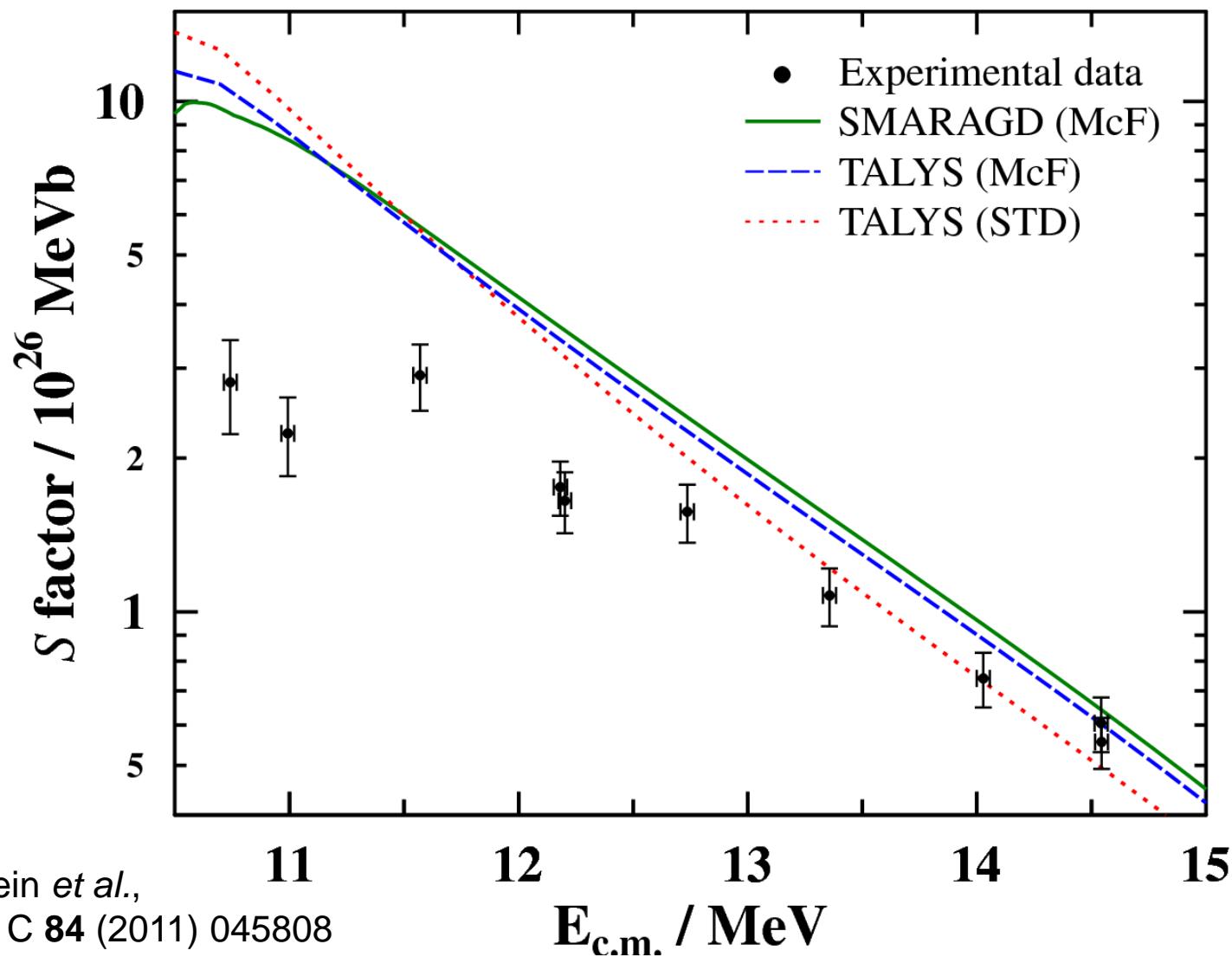
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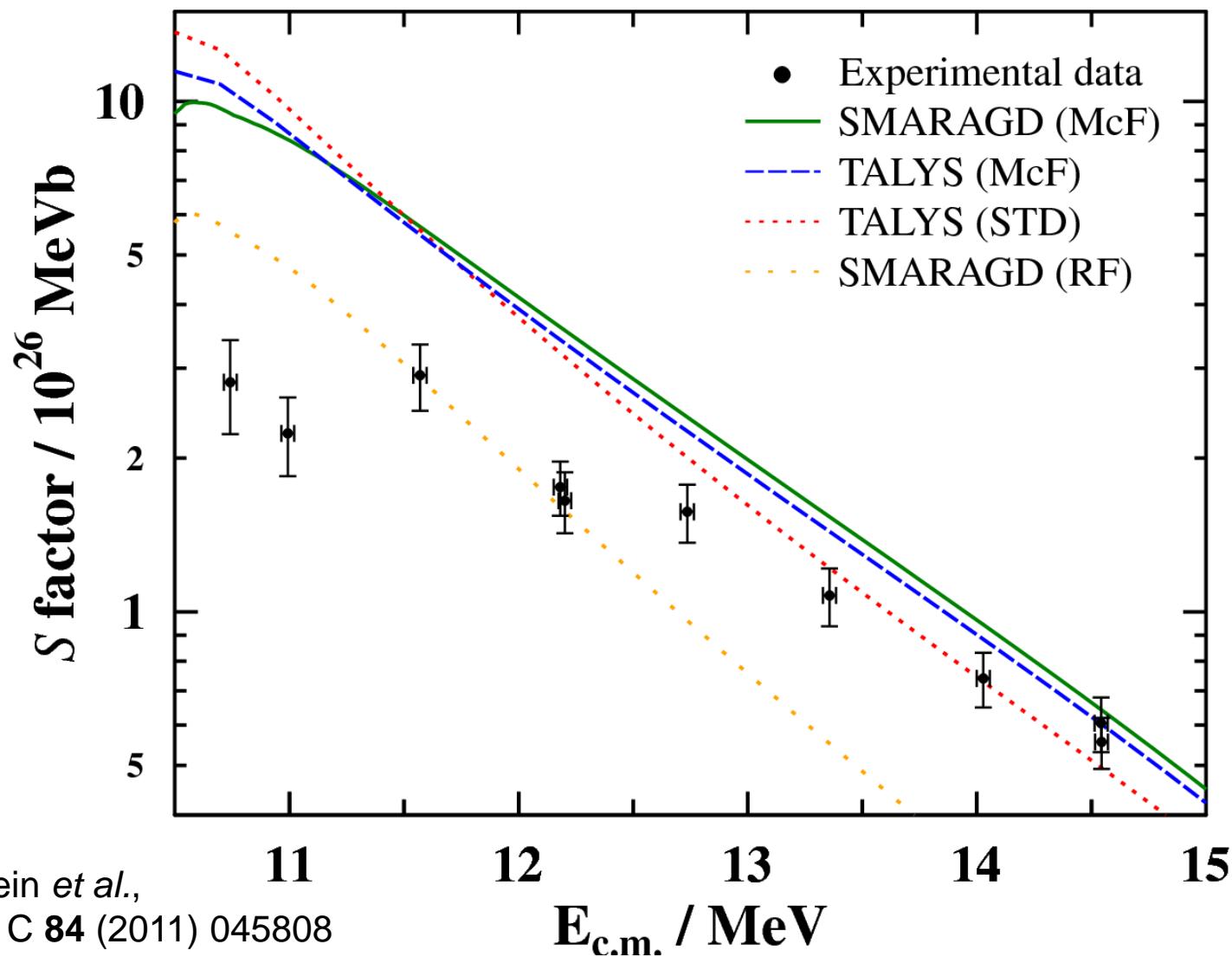
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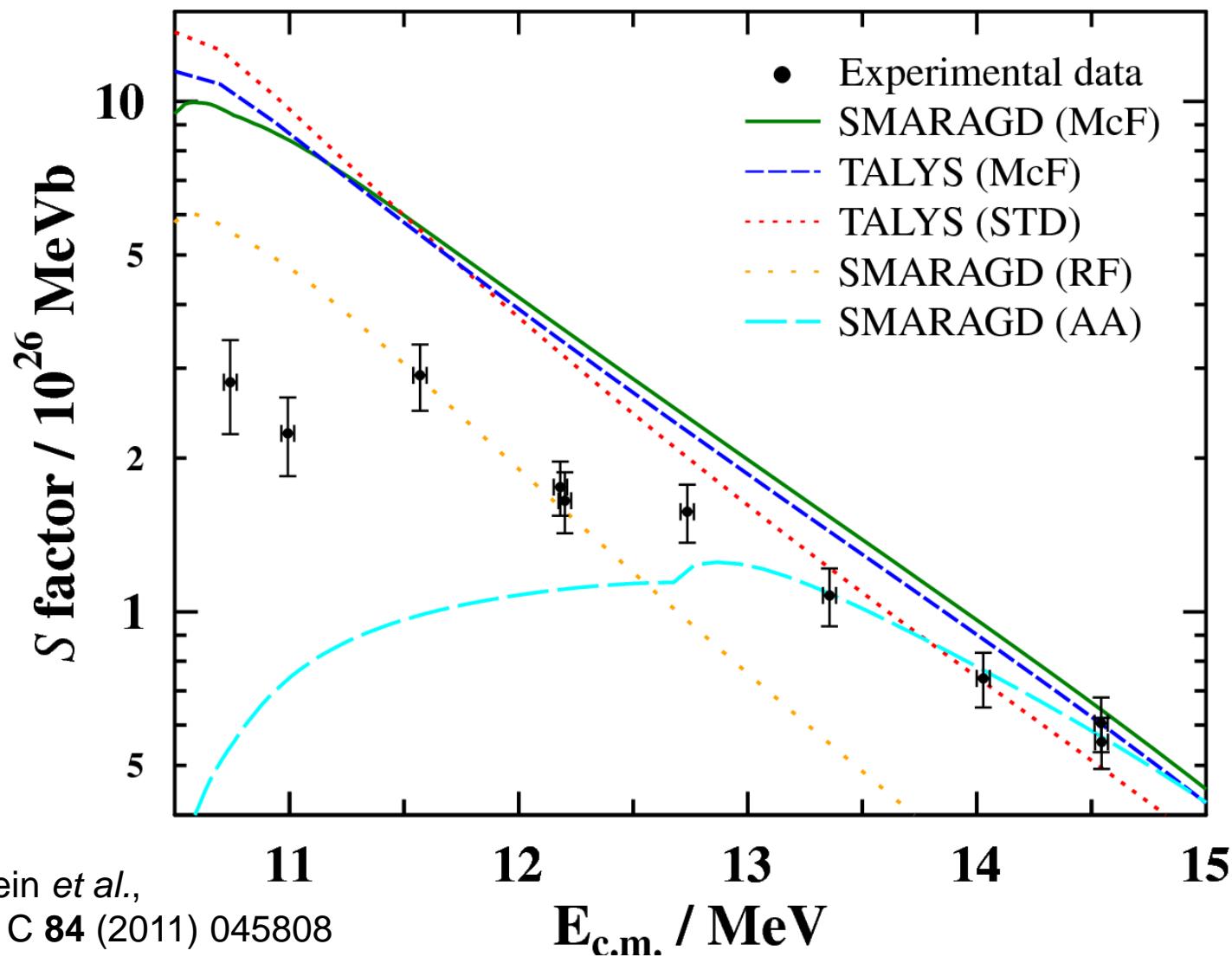


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$E_{\text{c.m.}} / \text{MeV}$

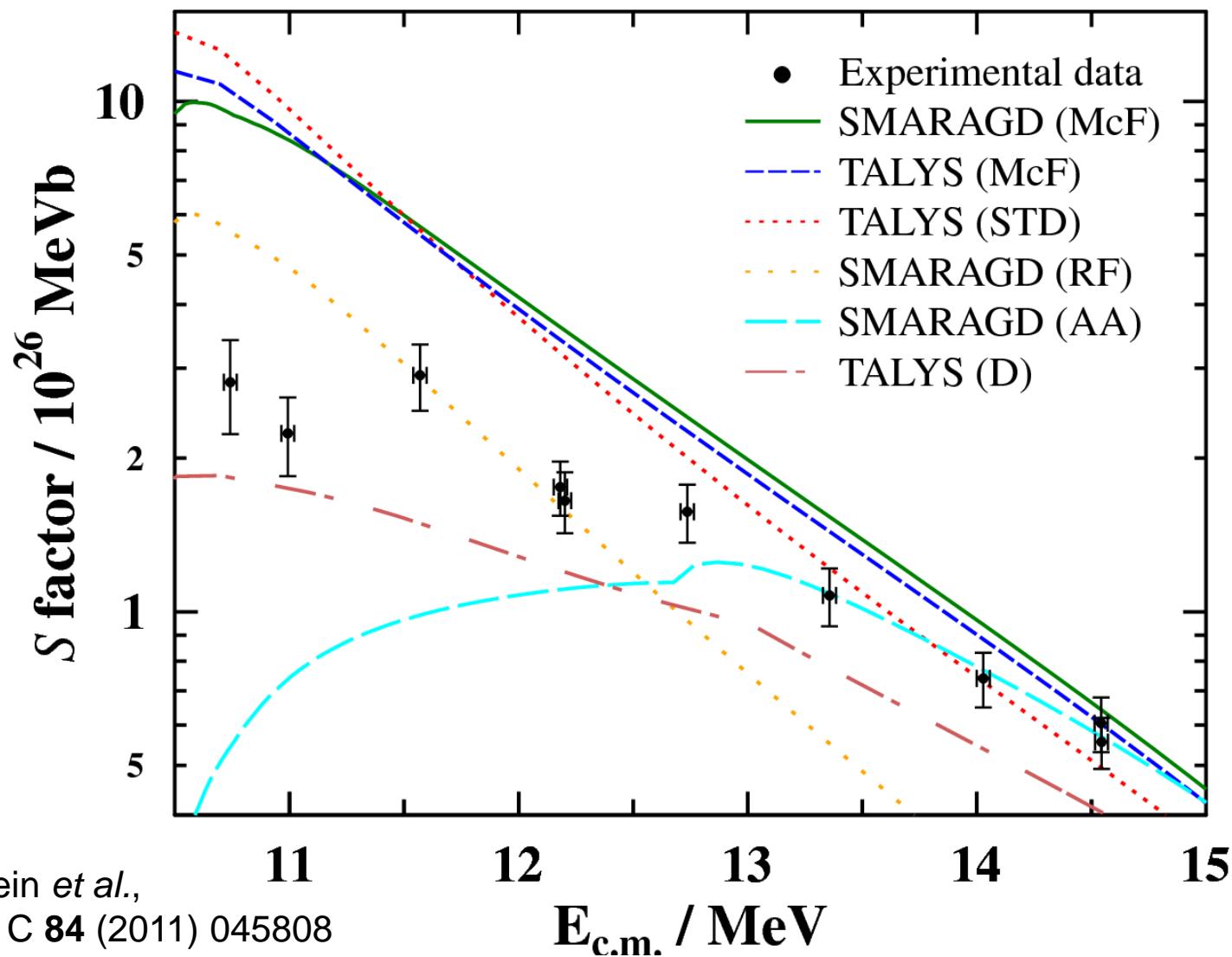
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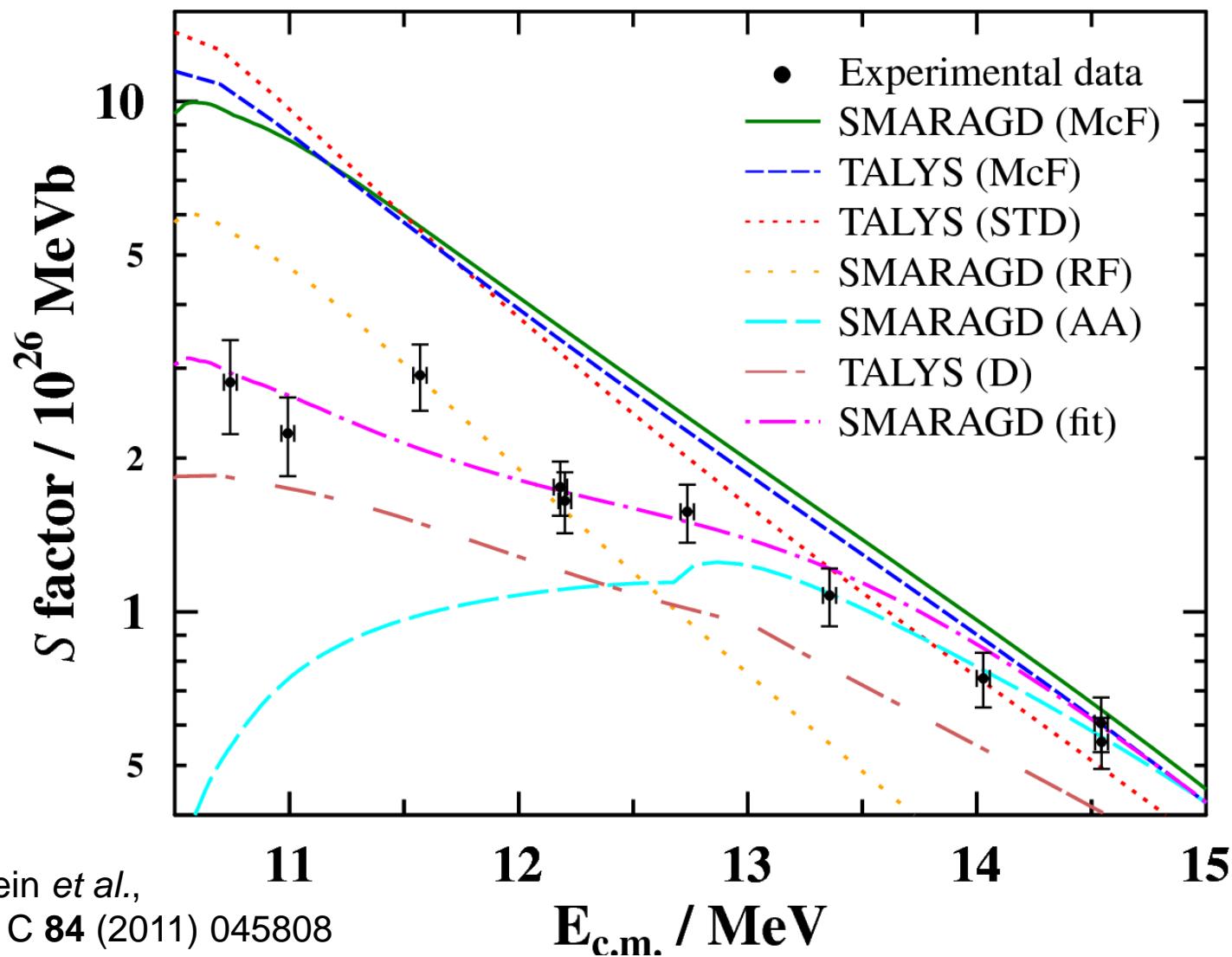
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V. Derya, M. Elvers, **J. Endres**, **A. Hennig**, J. Mayer,
L. Netterdon, S. Pascu, S. Pickstone, F. Schlüter,
P. Scholz, M. Spieker, K.-O. Zell, and A. Zilges

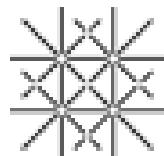
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Ruhruniversität Bochum



T. Rauscher
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