Gamma-strength functions and the proton capture reaction on ^{92}Mo

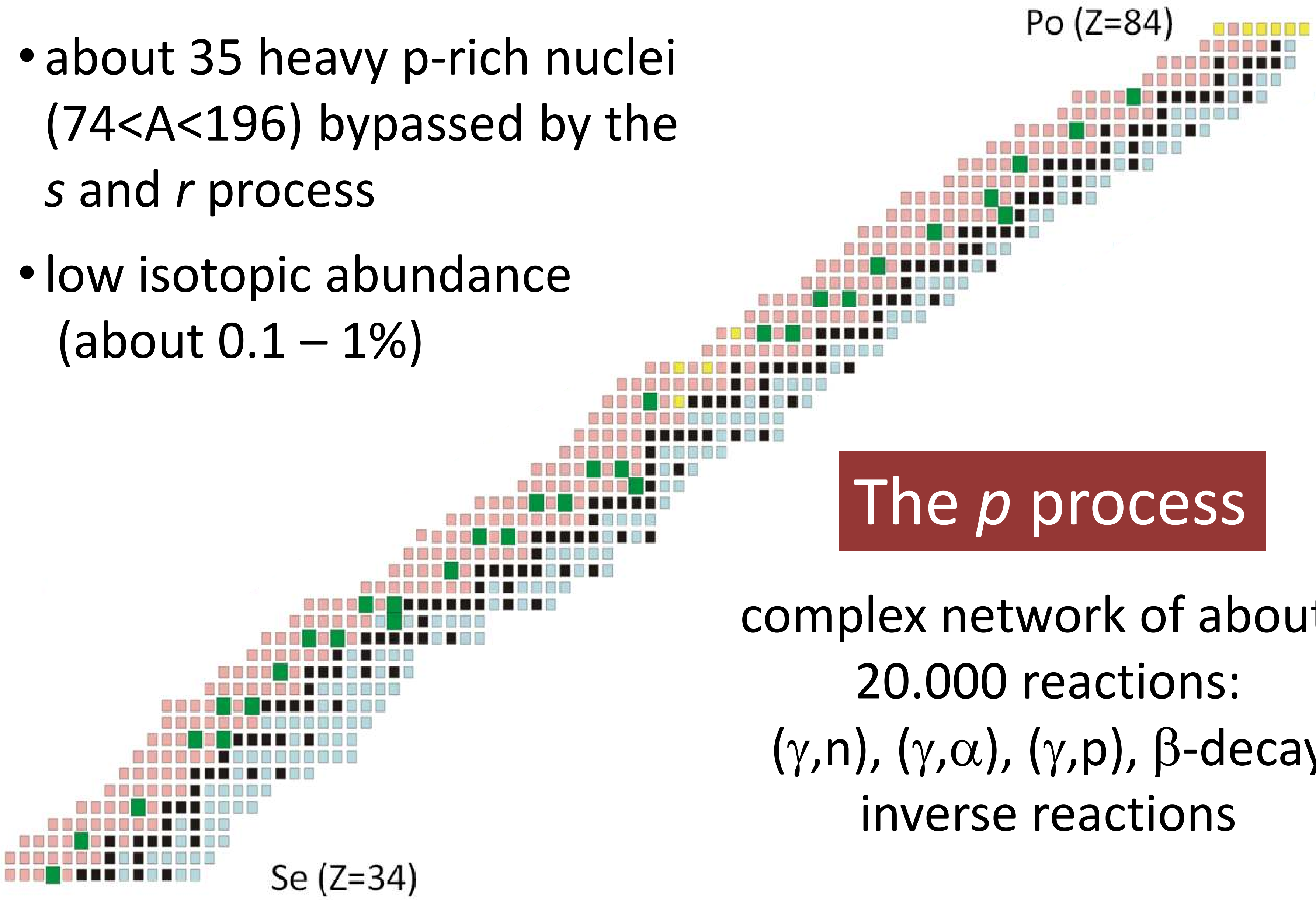
A. Hennig, A. Sauerwein, L. Netterdon, J. Endres, J. Hasper, and A. Zilges

Institut für Kernphysik, Universität zu Köln

supported by DFG **(ZI 510/5-1 and INST 216/544-1)**

A bit of Nuclear Astrophysics: The *p* nuclei

- about 35 heavy p-rich nuclei (74<A<196) bypassed by the *s* and *r* process
- low isotopic abundance (about 0.1 – 1%)



The *p* process

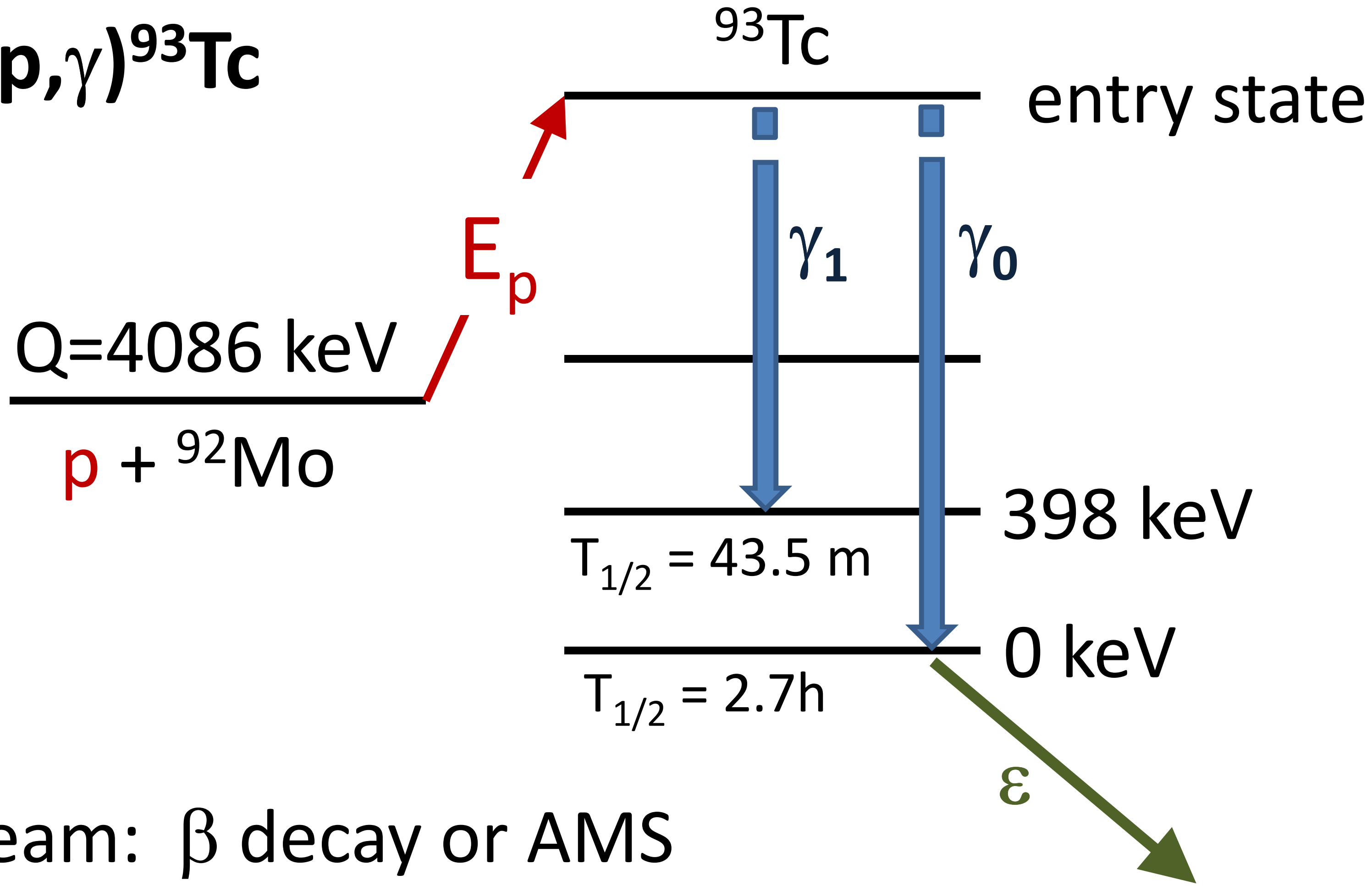
complex network of about 20.000 reactions: (γ,n), (γ,α), (γ,p), β-decay, inverse reactions

Nuclear Physics input for the p process

- Ground state masses
- Properties of excited states
- Level densities
- Optical potentials (p,n,α – nucleus)
- Gamma strength functions

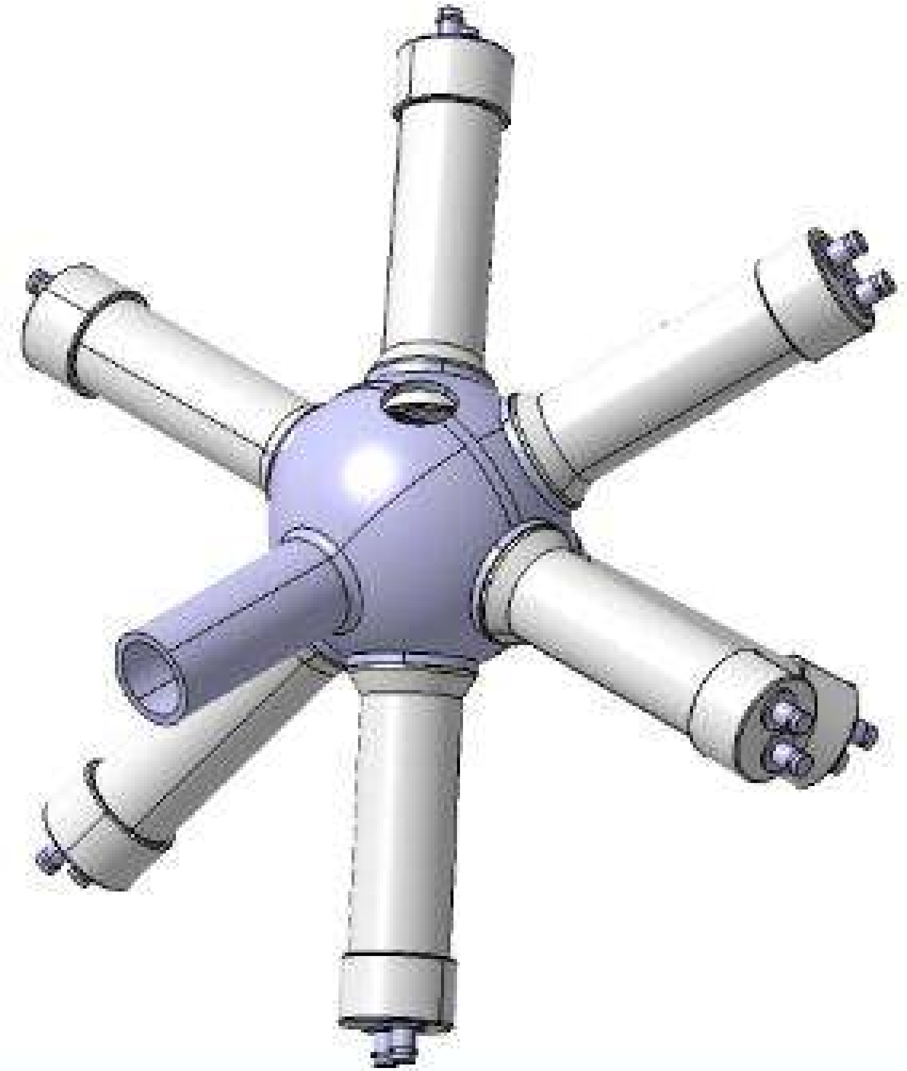
A radiative capture experiment

$^{92}Mo(p,\gamma)^{93}Tc$



- off-beam: β decay or AMS
- in-beam: - summing crystal → σ_{total}
  - HPGe spectroscopy → $\sigma_{partial}$

The HORUS array at IKP Köln

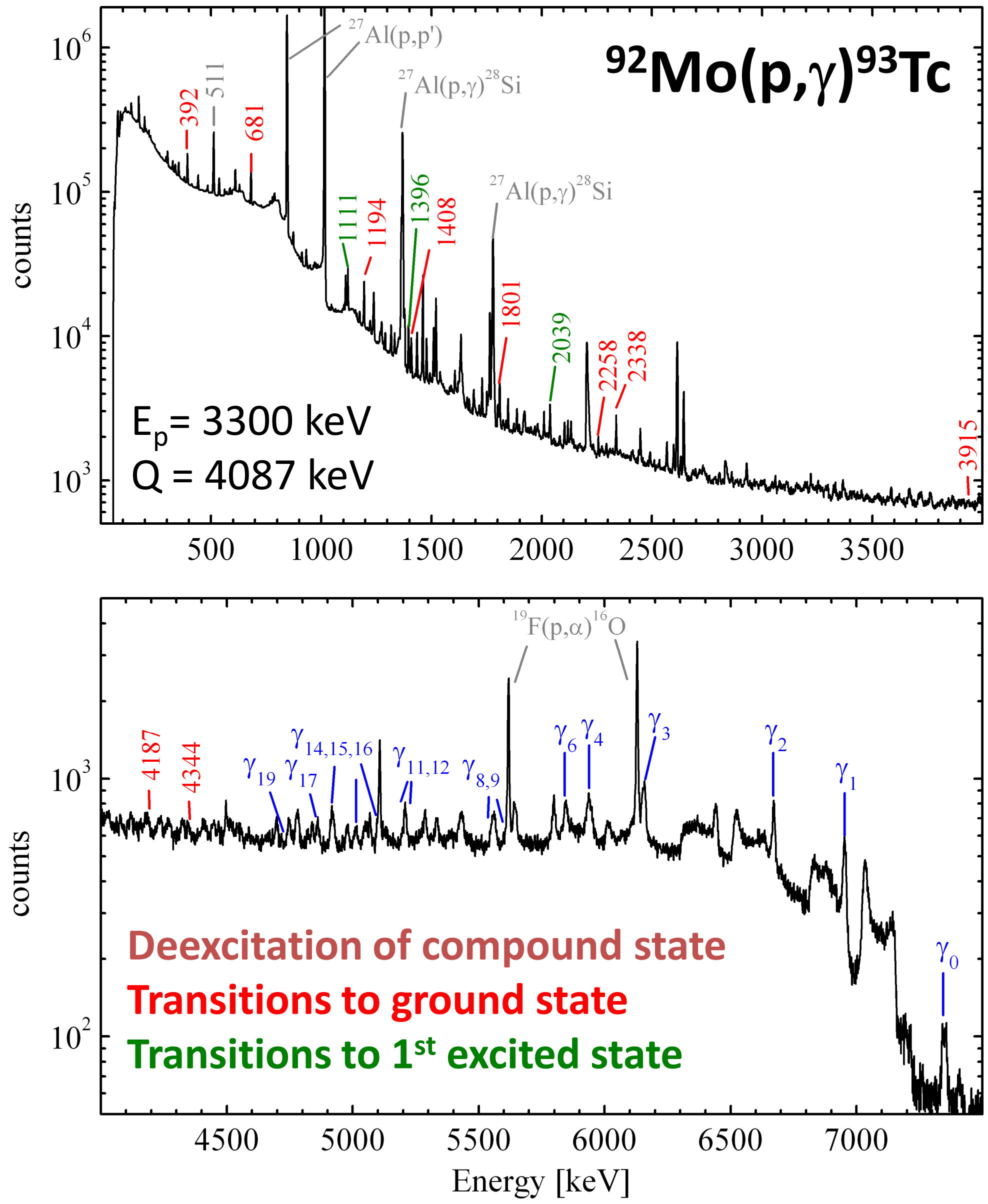


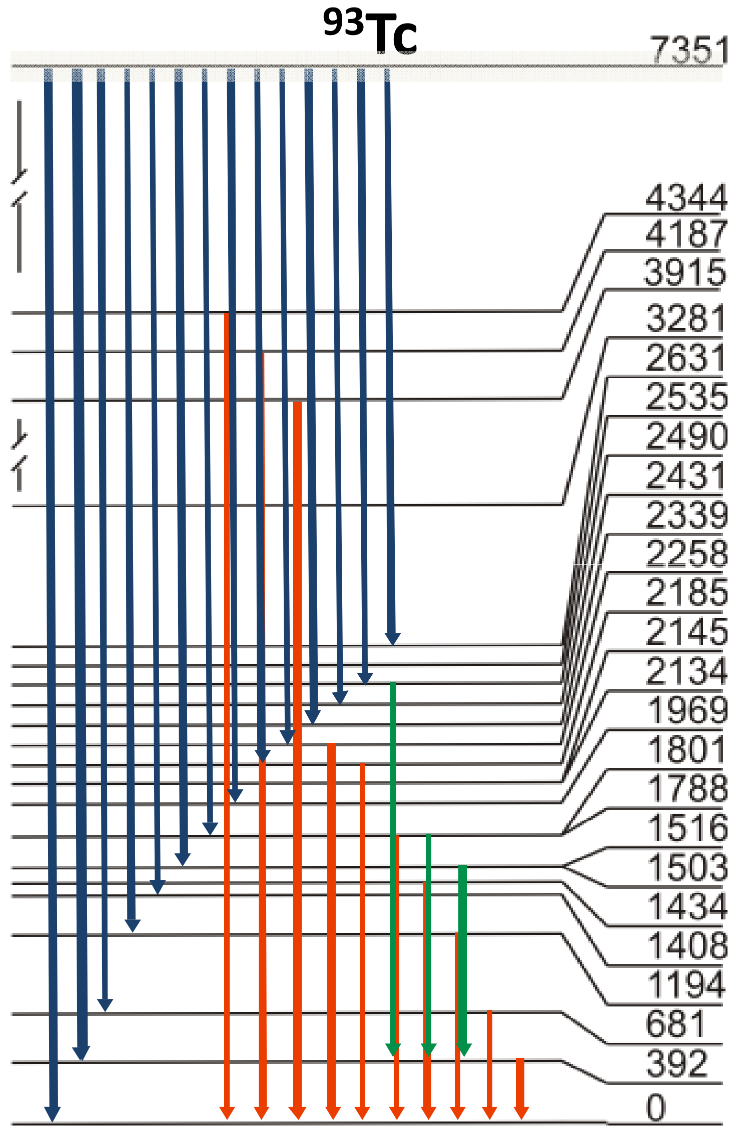
- **14 HPGe γ detectors** in close geometry, partly segmented
- Photopeak efficiency at 1332 keV: up to 5%
- Ancillary: Si particle detector array with 8 ΔE-E detectors

The HORUS array at IKP Köln

- High **energy resolution** to observe single transitions of decay cascade
- Adequate **efficiency** to study low cross sections
- Determination of **angular distributions** possible
- **Coincidence** technique to identify cascades and to suppress background
- Completely **digital data acquisition**

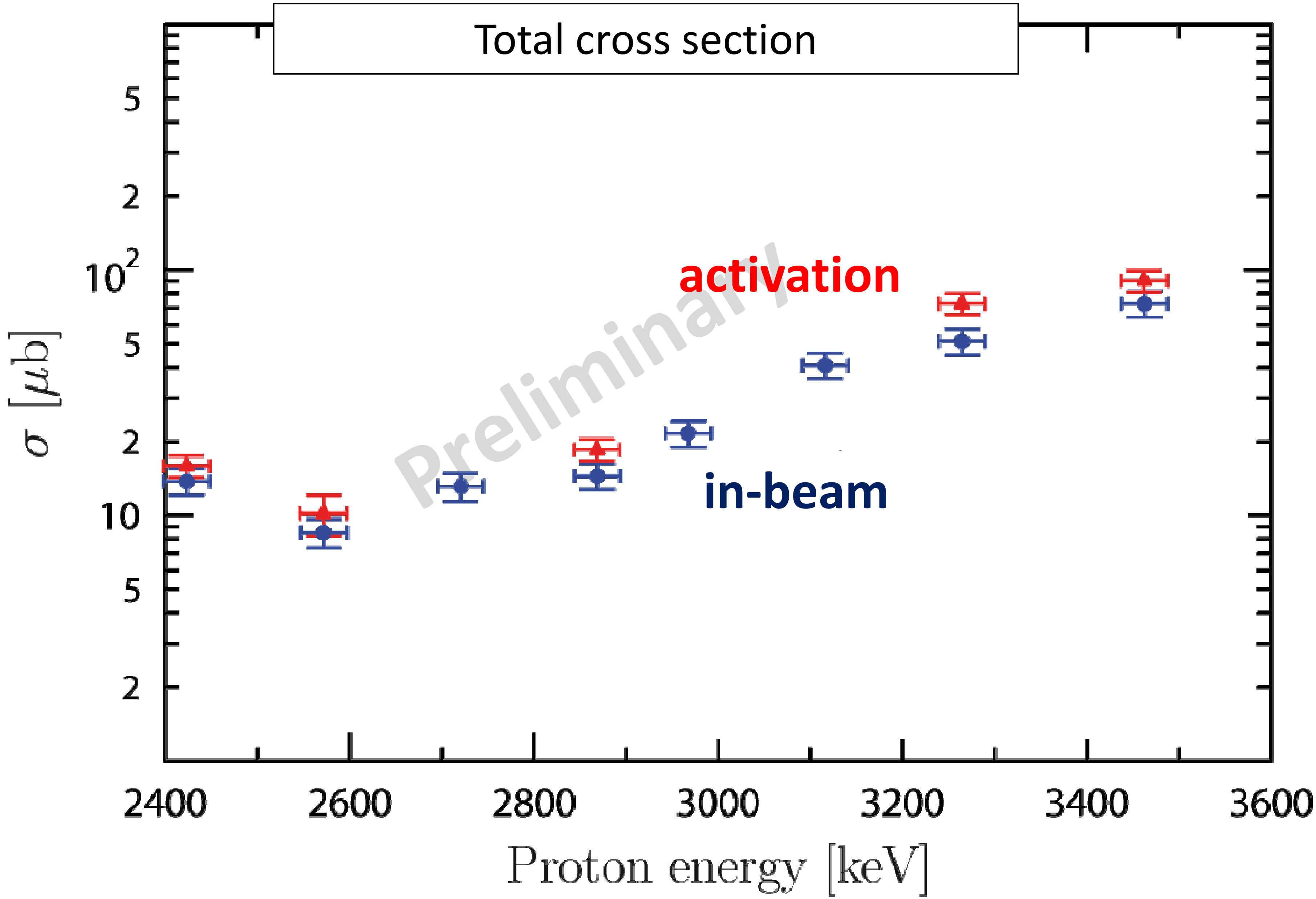
Radiative proton capture on ^{92}Mo





Production of 1st excited state

Total cross section for proton capture on ^{92}Mo



Gamma-ray strength functions used in TALYS code

Brink-Axel standard Lorentzian

Generalized Lorentzian Kopecky-Uhl for E1 radiation

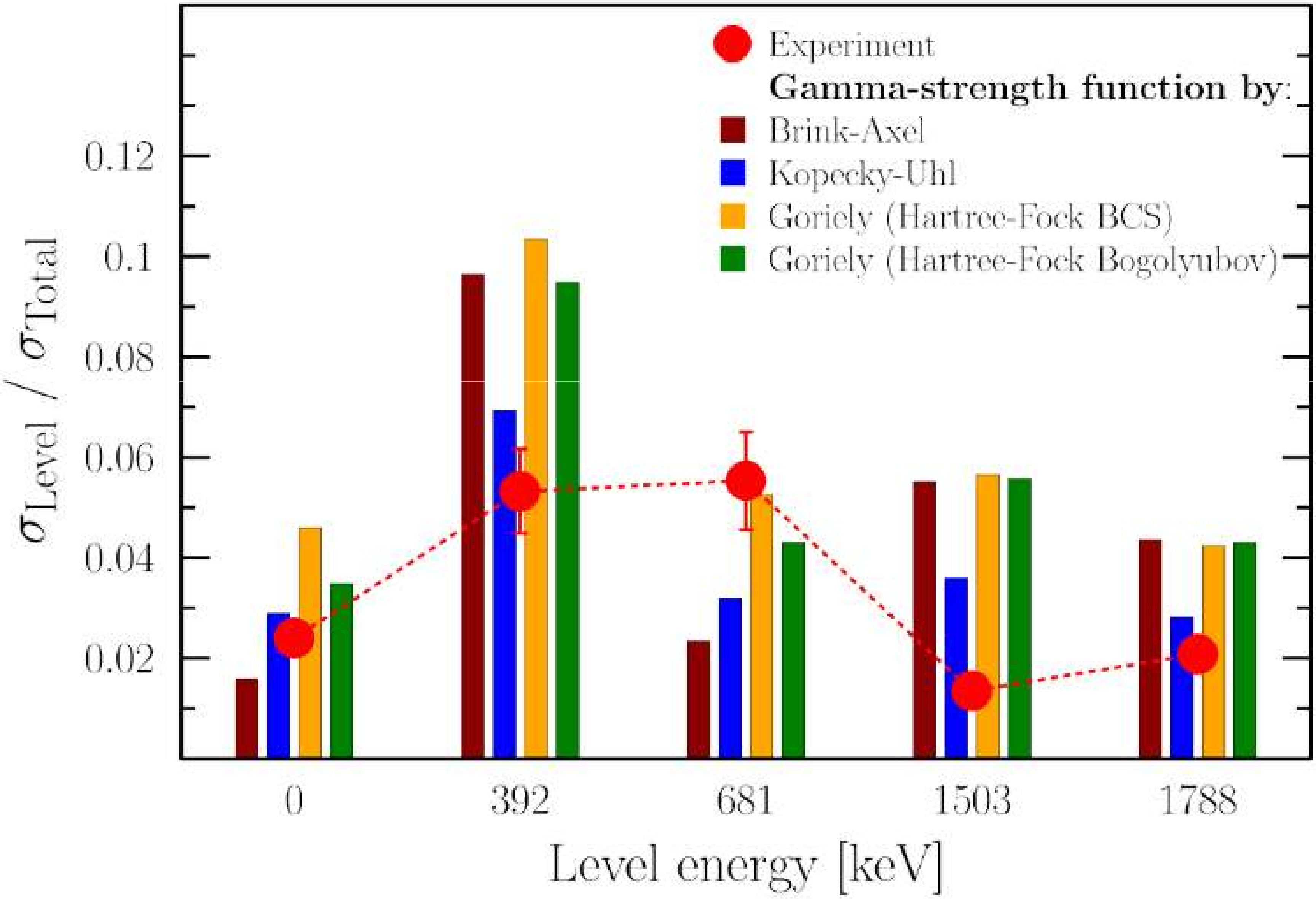
Microscopic Hartree-Fock BCS tables for E1 radiation

Microscopic Hartree-Fock-Bogolyubov tables for E1 radiation

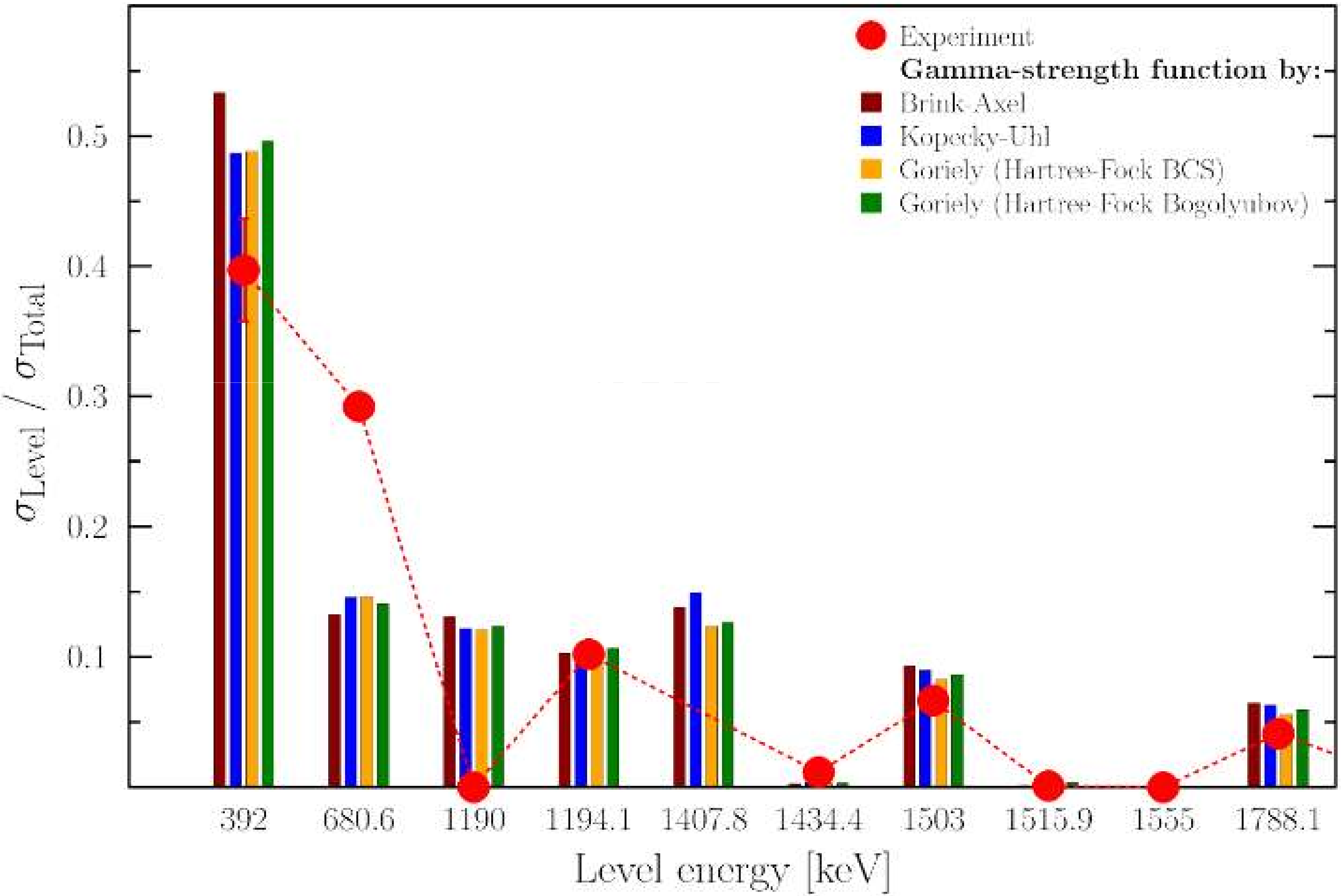
TALYS 1.2:

A. Koning, S. Hilaire, M. Duijvestijn

Partial cross sections for $^{92}Mo(p,\gamma)$



Feeding of levels in $^{92}Mo(p,\gamma)$

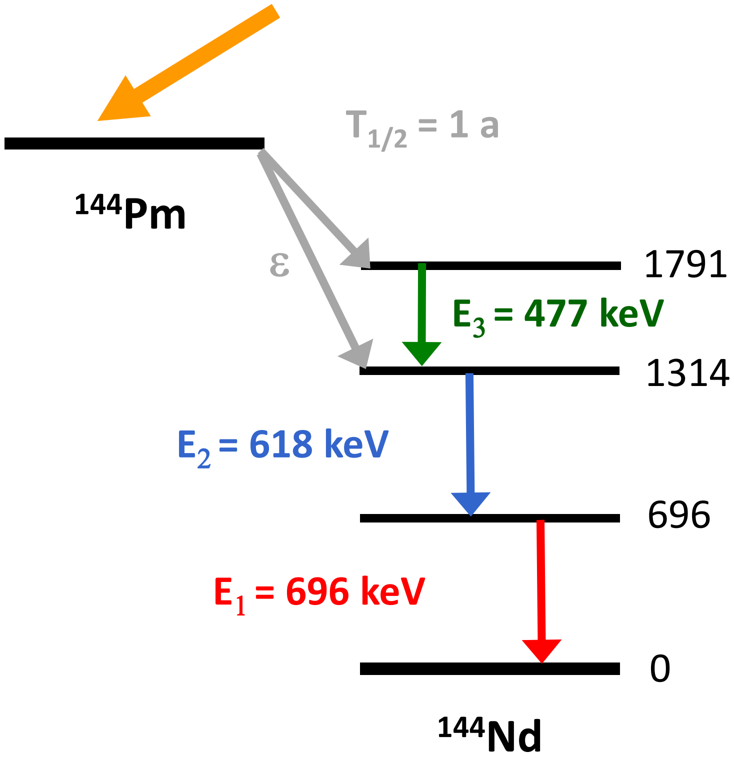


Gamma-strength functions and the proton capture reaction on ^{92}Mo

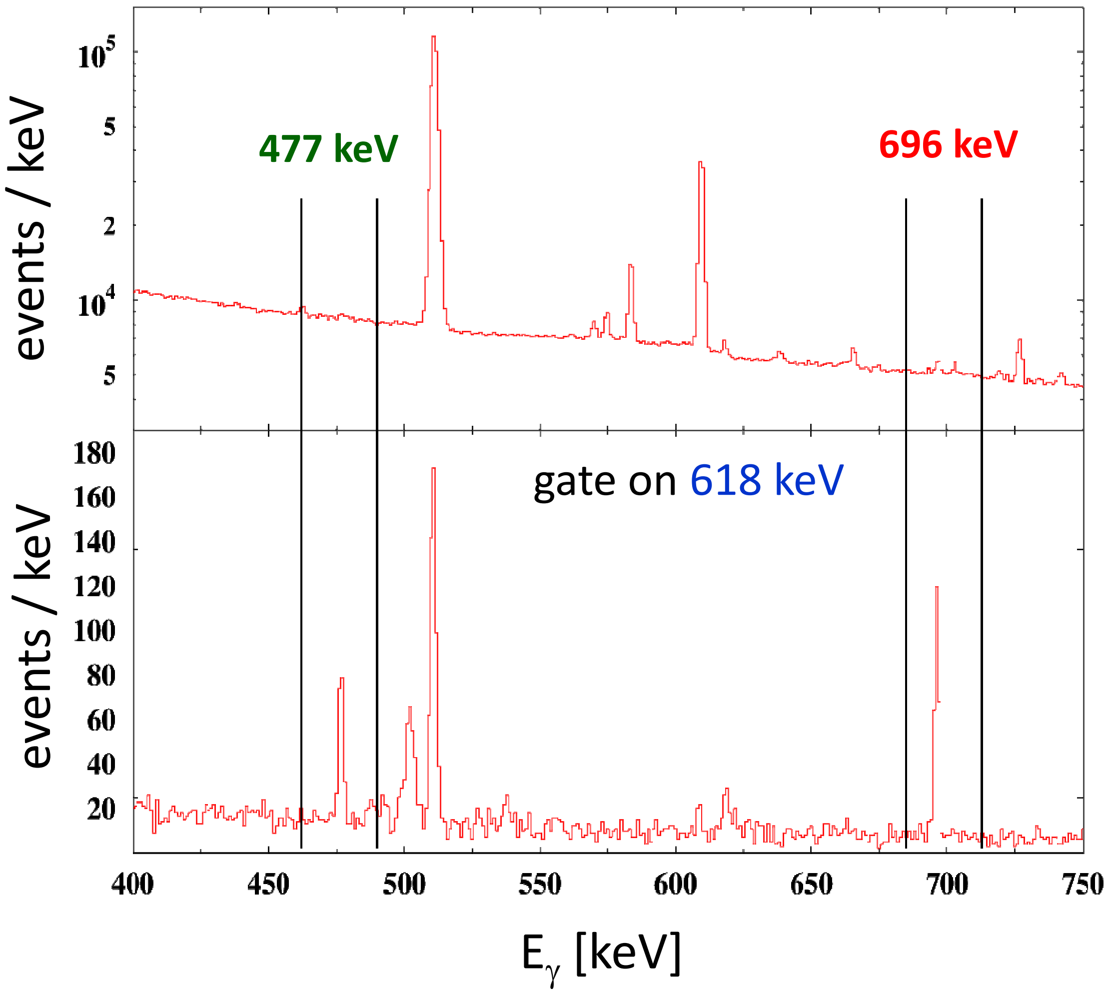
- A wealth of data can be extracted from radiative capture experiments using HPGe arrays
- Partical cross sections and level feedings can be compared to values derived from different γ strength functions
- Cologne FN Tandem and HORUS resume operation in September 2011 after 6 M€ renovation of accelerator area

supported by DFG (ZI 510/5-1 and INST 216/544-1) and PB 03-11

Coincidence between two Clover segments

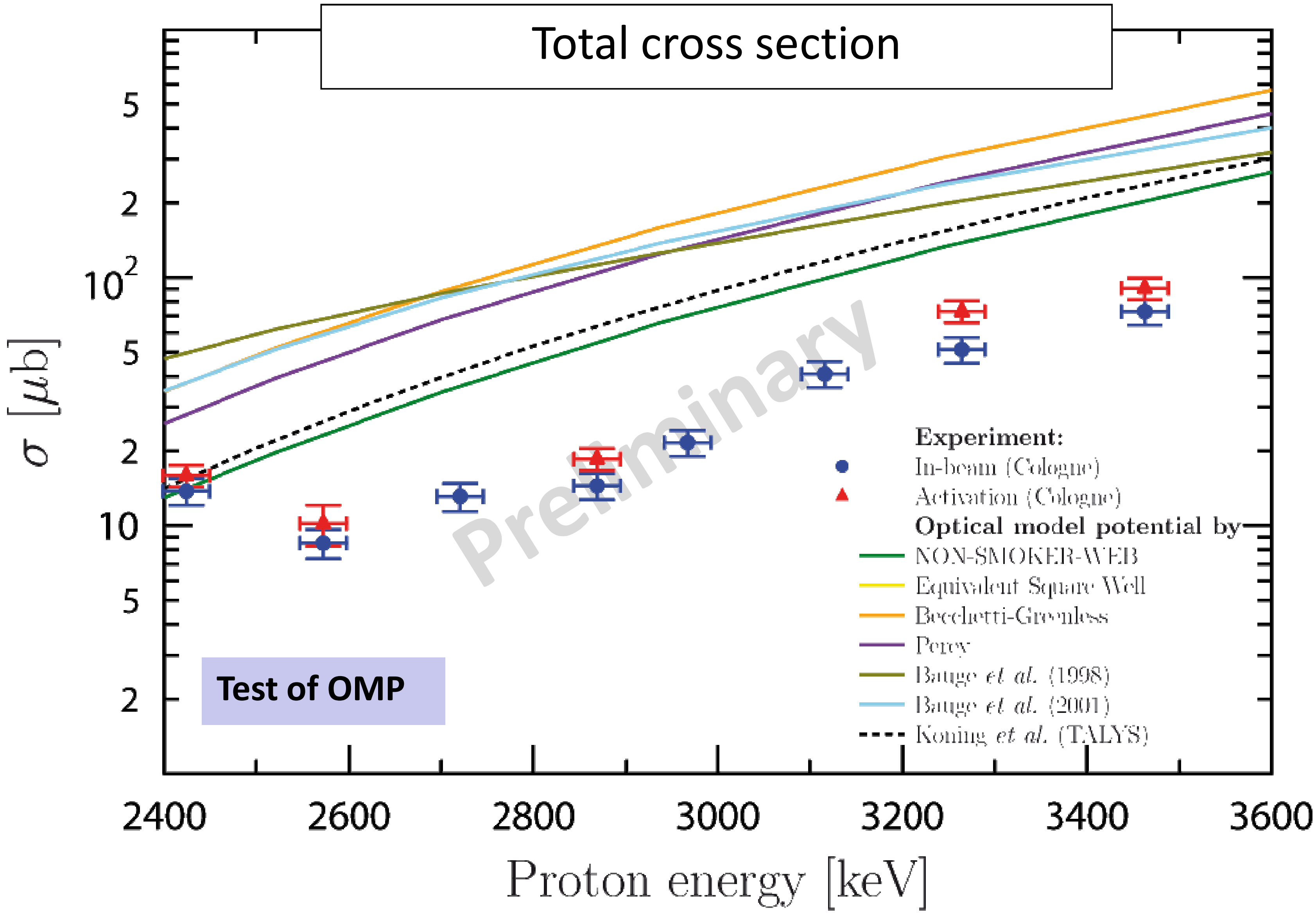


E_α=11.0 MeV



A. Sauerwein, A. Hennig et al.

Radiative proton capture on ^{92}Mo



Gamma-ray strength functions used in TALYS code

Brink-Axel standard Lorentzian

$$f_{X\ell}(E_\gamma) = K_{X\ell} \frac{\sigma_{X\ell} E_\gamma \Gamma_{X\ell}^2}{(E_\gamma^2 - E_{X\ell}^2)^2 + E_\gamma^2 \Gamma_{X\ell}^2}$$

$$K_{X\ell} = \frac{1}{(2\ell + 1)\pi^2 \hbar^2 c^2}$$

Gamma-ray strength functions used in TALYS code

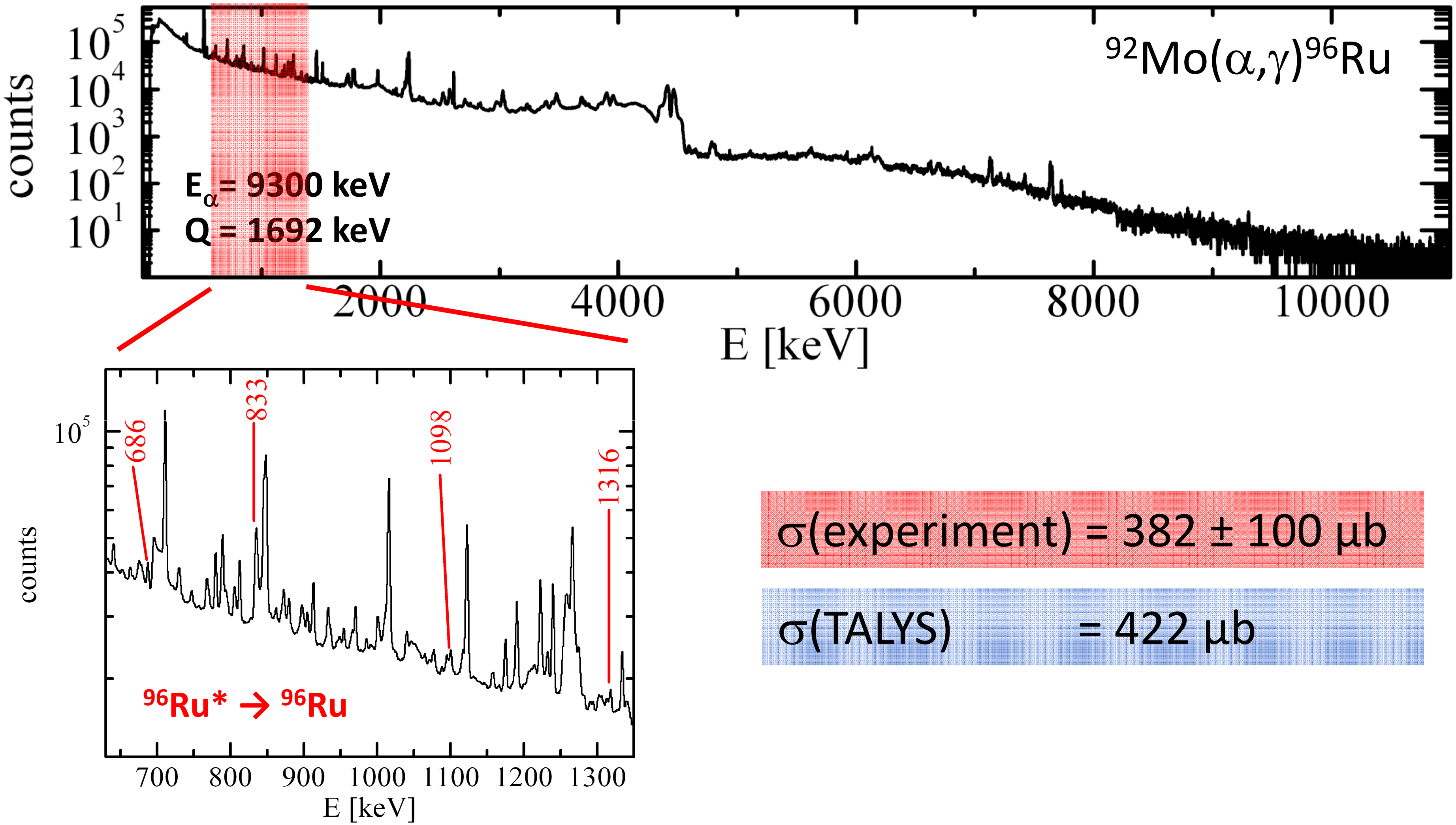
Generalized Lorentzian Kopecky-Uhl for E1 radiation

$$f_{E1}(E_\gamma, T) = K_{E1}\left[\frac{E_\gamma \tilde{\Gamma}_{E1}(E_\gamma)}{(E_\gamma^2 - E_{E1}^2)^2 + E_\gamma^2 \tilde{\Gamma}_{E1}(E_\gamma)^2} + \frac{0.7\Gamma_{E1} 4\pi^2 T^2}{E_{E1}^3}\right]\sigma_{E1}\Gamma_{E1}$$

$$\tilde{\Gamma}_{E1}(E_\gamma) = \Gamma_{E1}\frac{E_\gamma^2 + 4\pi^2 T^2}{E_{E1}^2}$$

$$T = \sqrt{\frac{E_n + S_n - \Delta - E_\gamma}{a(S_n)}}$$

Radiative α capture: $^{92}Mo(\alpha,\gamma)$



σ(experiment) = 382 ± 100 μb

σ(TALYS) = 422 μb

Background reduction necessary for smaller cross sections!

Background reduction using γ-γ coincidence techniques