# $\alpha$ induced reaction cross section measurements on $^{162}$Er and the study of the $\alpha$ optical potential at low energies

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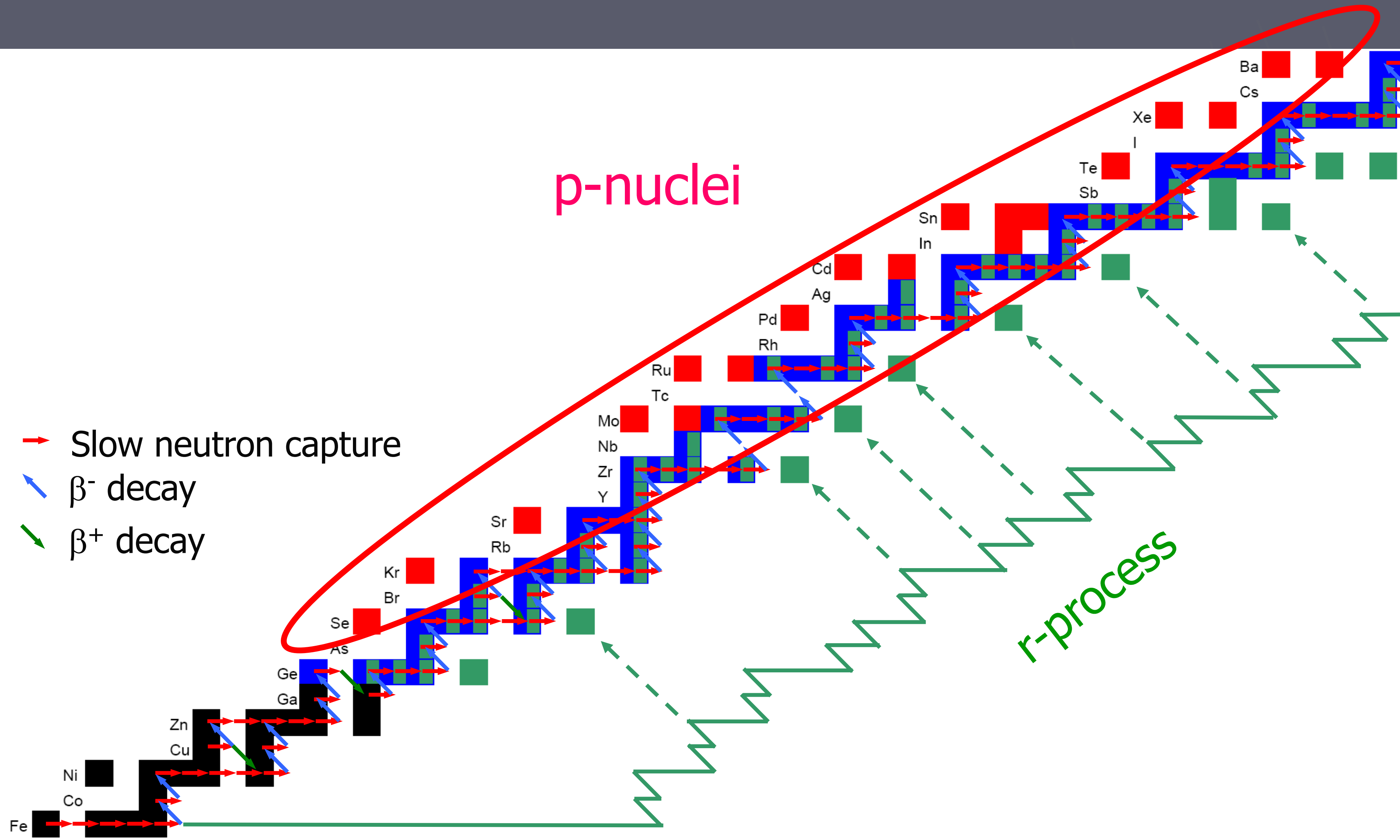
# Synthesis of the heavy nuclei

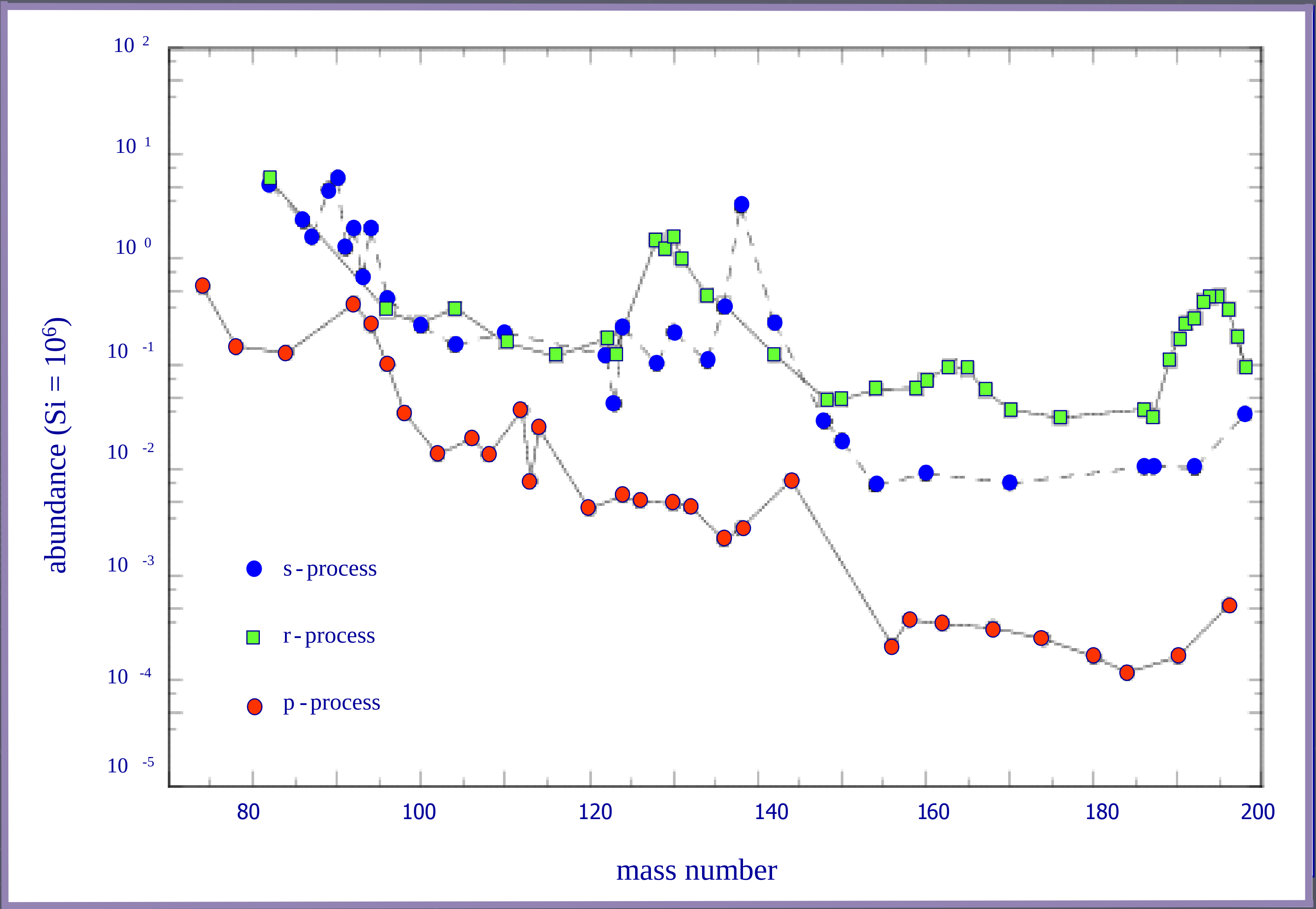


# The p-nuclei

- $^{74}$Se
- $^{78}$Kr
- $^{84}$Sr
- $^{92}$Nb
- $^{92,94}$Mo
- $^{96,98}$Ru
- $^{102}$Pd
- $^{106,108}$Cd
- $^{113}$In
- $^{112,114}$Sn
- $^{120}$Te
- $^{124,126}$Xe
- $^{130,132}$Ba
- $^{138}$La
- $^{136,138}$Ce
- $^{144,146}$Sm
- $^{156,158}$Dy
- $^{162}$Er
- $^{168}$Yb
- $^{174}$Hf
- $^{180}$Ta
- $^{180}$W
- $^{184}$Os
- $^{190}$Pt
- $^{196}$Hg

Mostly even-even

Low relative abundance (0.1-1%) except $^{92,94}$Mo, $^{96,98}$Ru



# The p-process

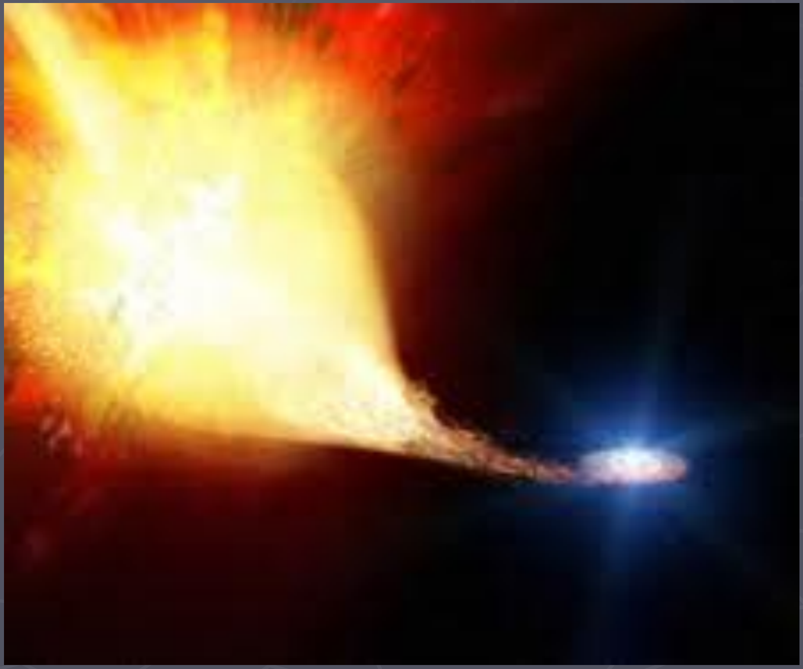
# The astrophysical site

- High energy photons (necessary for the photodisintegrations) - high temperatures: T = 2-3 GK
- Short timescale (~1s)

Type II „core-collapse” supernovae

O/Ne layer

Typa Ia supernovae

C. Travaglio *et al.*, APJ 739 (2011) 93.

S. E. Woosley and W. M. Howard, APJ. Suppl 36 (1978) 285.
M. Arnould and S. Goriely, Phys. Rep. 384 2003 1.

# $\gamma$-process simulations

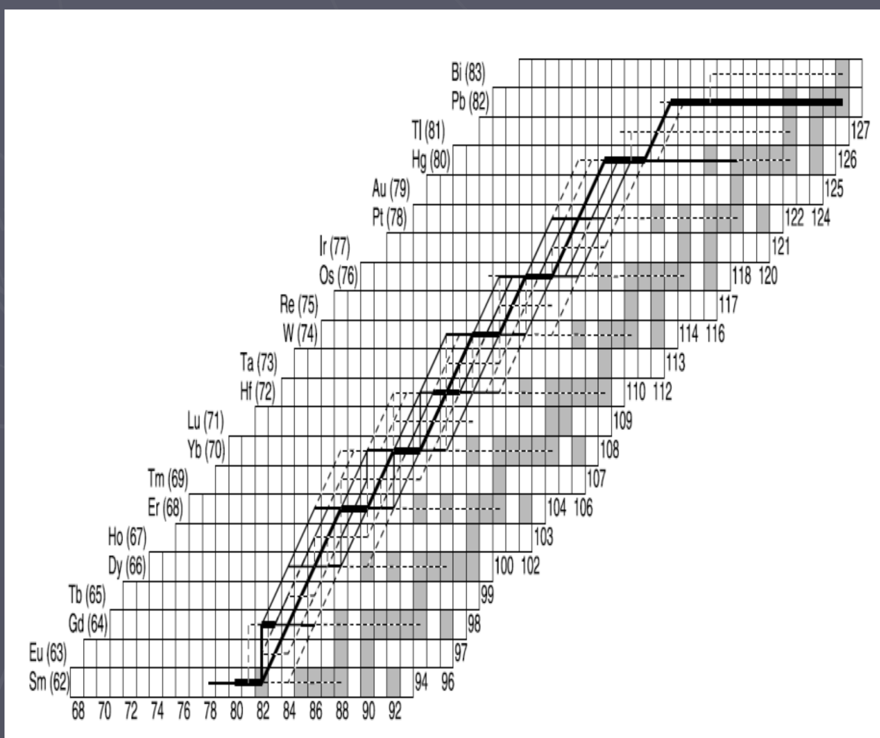
Nuclear network of

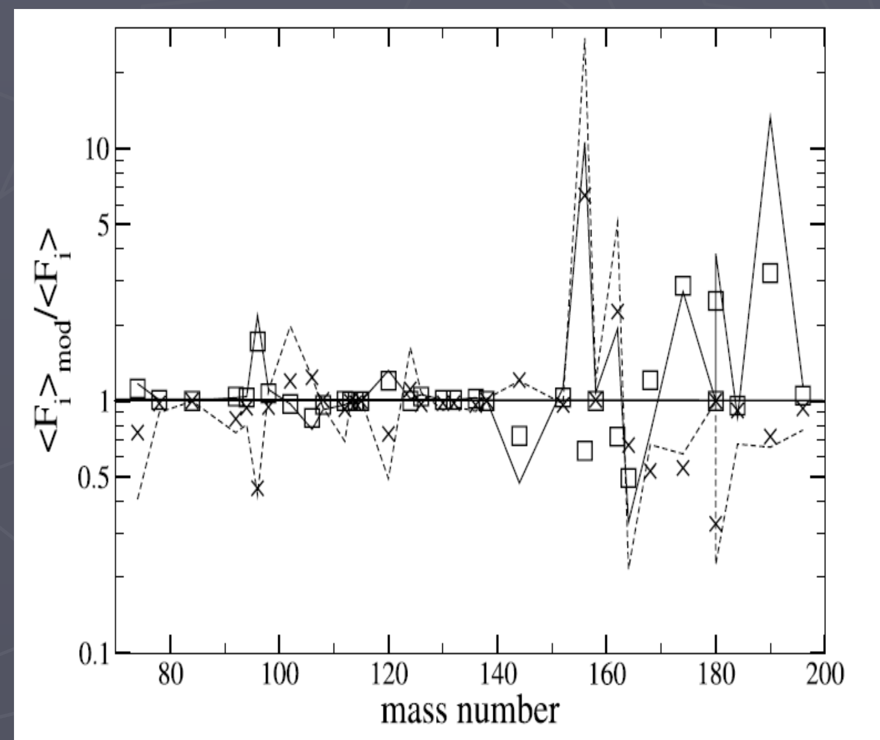
~2000 (mostly unstable) nuclei;

~20000 reactions, $\sigma$ from Hauser-Feshbach theory

no key photodisintegration reaction,

systematic investigation is needed



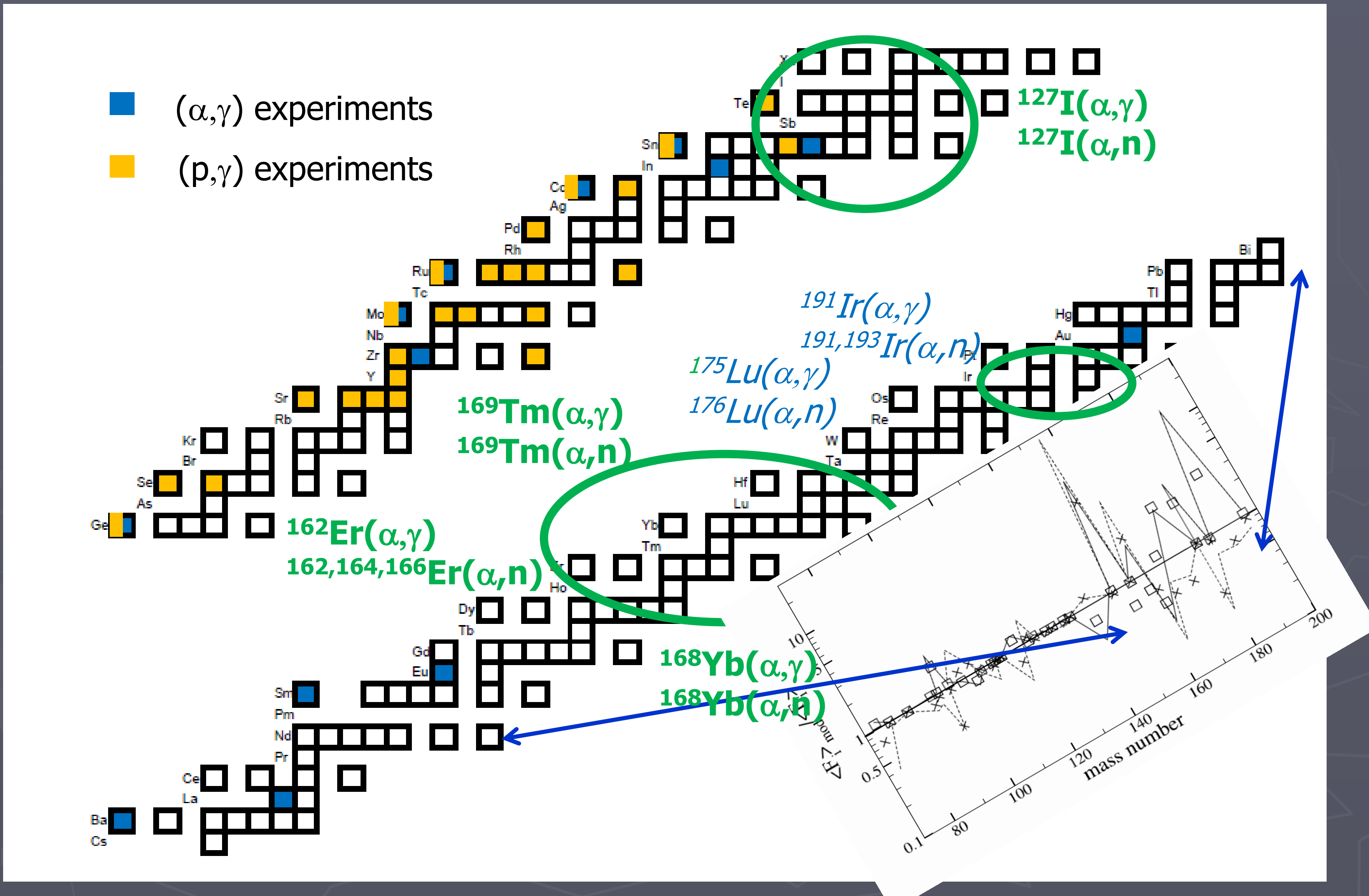




W. Rapp *et al.*, APJ 653 (2006) 474.

# Experimental verification

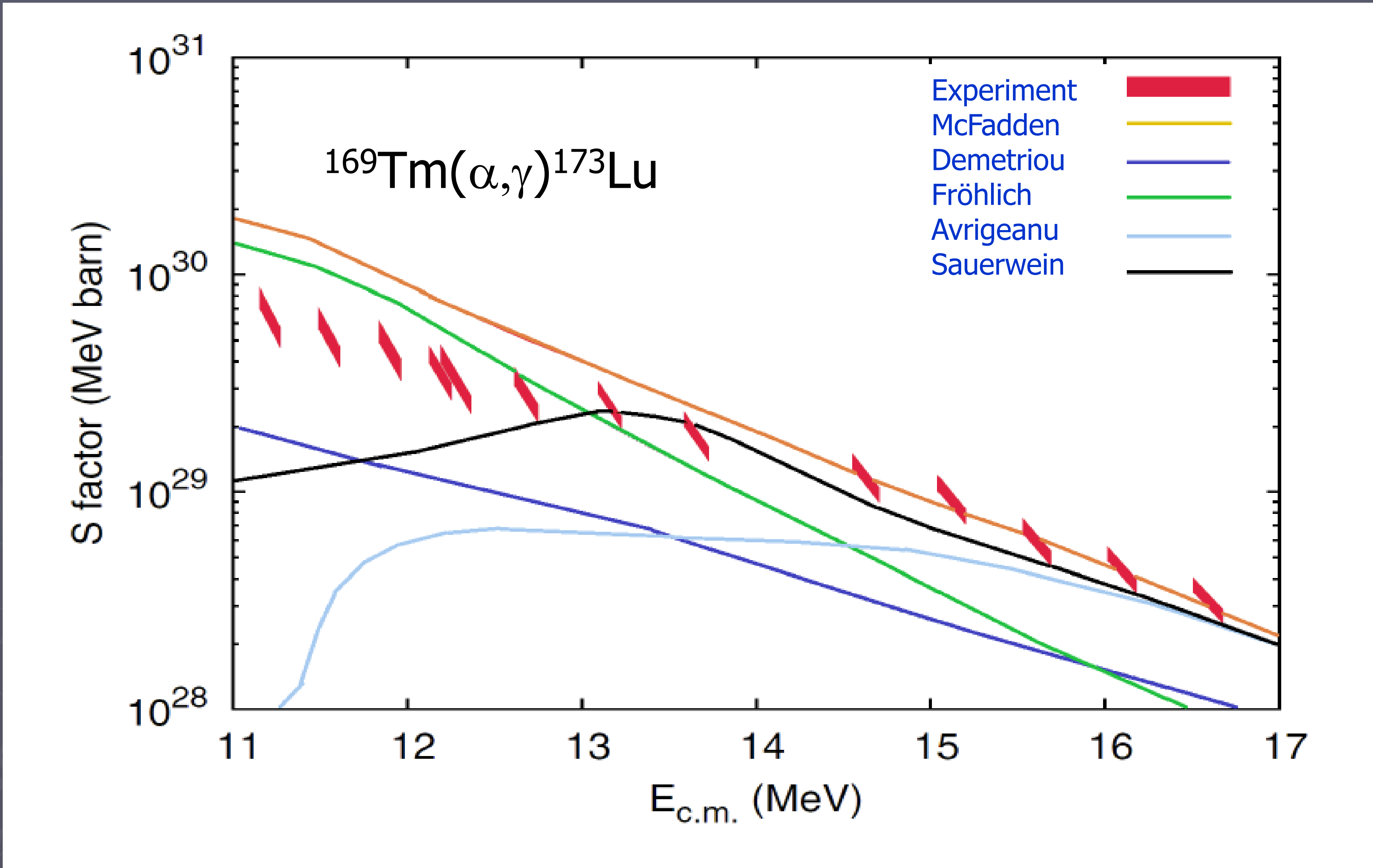
- Both the Hauser-Feshback (H-F) predictions and their inputs need experimental verification
- $\gamma$-induced reactions are hard to study (e.g. Mohr *et al.*, EPJ **32**)
- The inverse, capture reaction provides important and more relevant (G. G. Kiss et al., PRL **101**) information to check the H-F prediction

# Available database for (α,γ) reactions



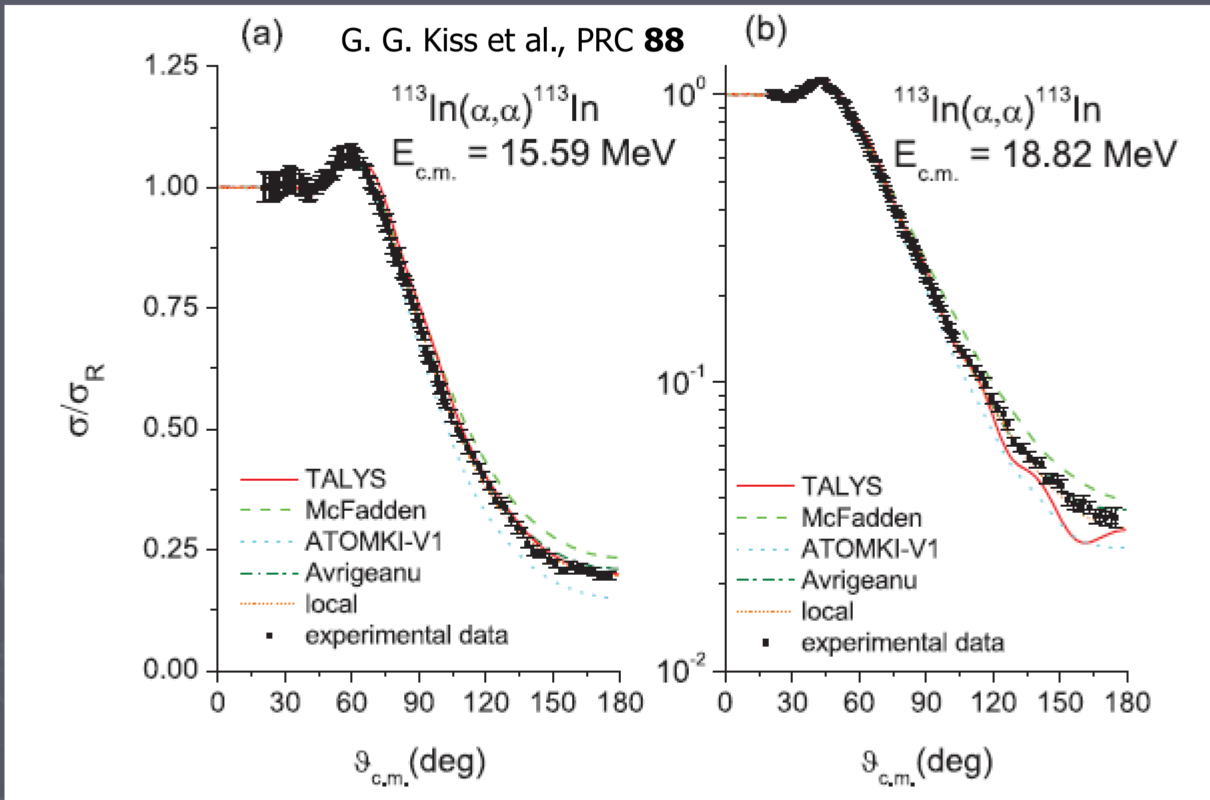

G. G. Kiss *et al.*, PLB **695,** G. G. Kiss *et al.*, Nucl. Phys. A **867,** T. Rauscher *et al.*, PRC **86,** G. G. Kiss *et al.*, PRC **86,** L. Netterdon *et al.*, Nucl. Phys. A **916**, G.G. Kiss *et al.*, PLB **735**

# The role of the α nucleus optical potential



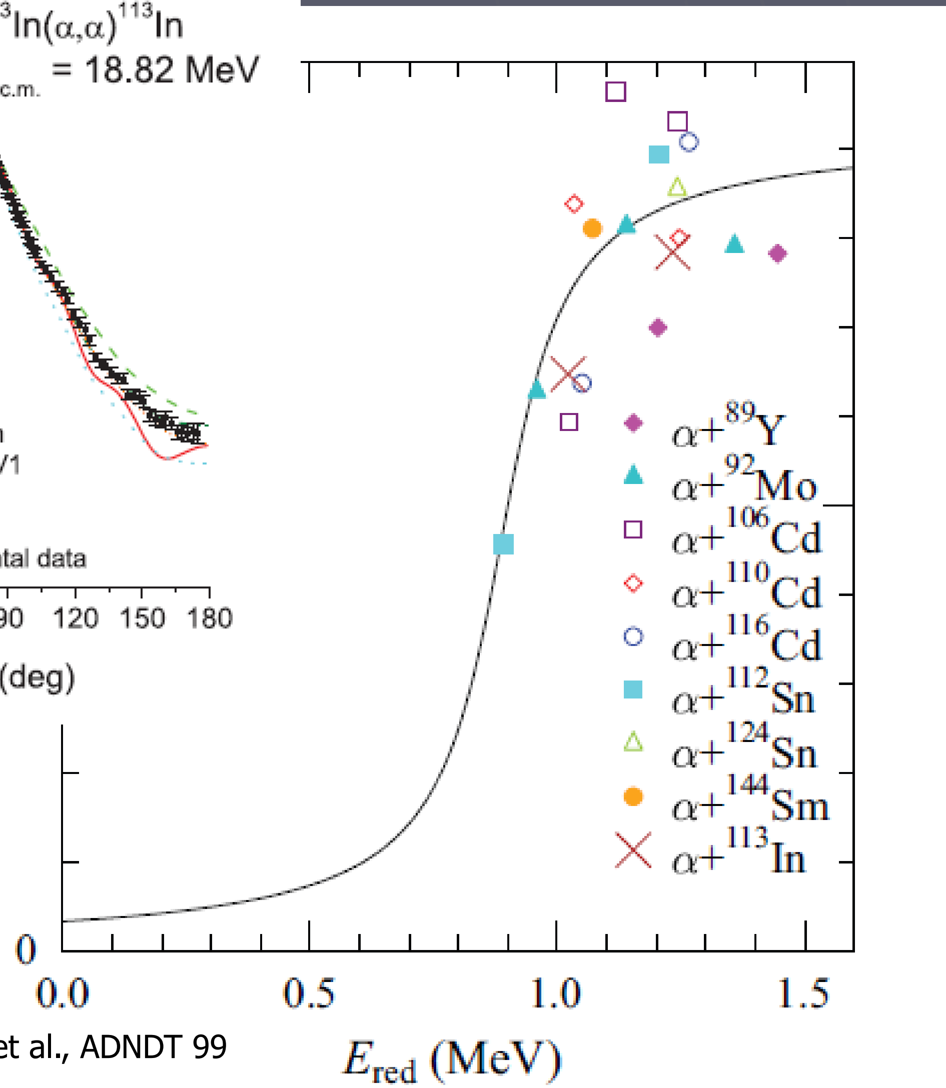

G. G. Kiss *et al.*, PLB **695** (2011), T. Rauscher *et al.*, PRC **86** (2012)

# The role of the α nucleus optical potential



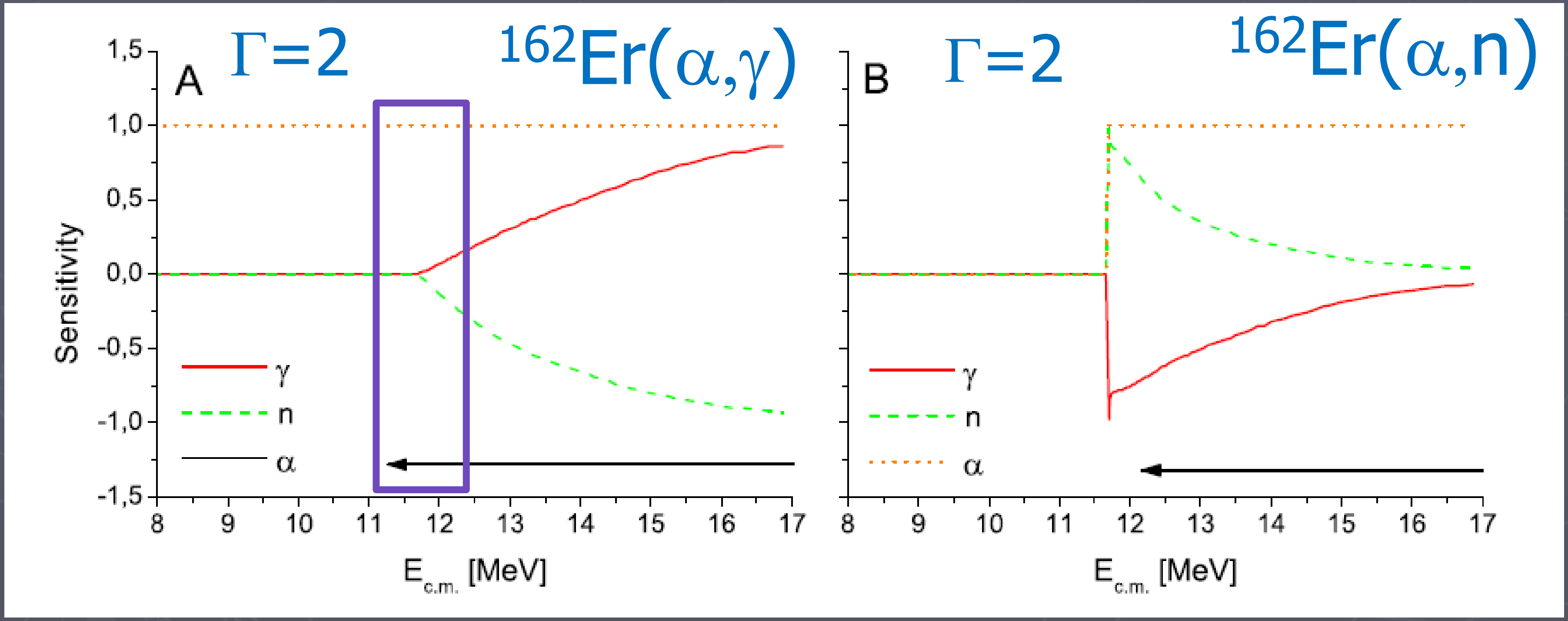
G. G. Kiss et al., PRC **88**

- We used alpha induced ...
  the a nucleus optical po...



P. Mohr et al., ADNDT 99

# Sensitivity of the cross section calculations on different nuclear inputs



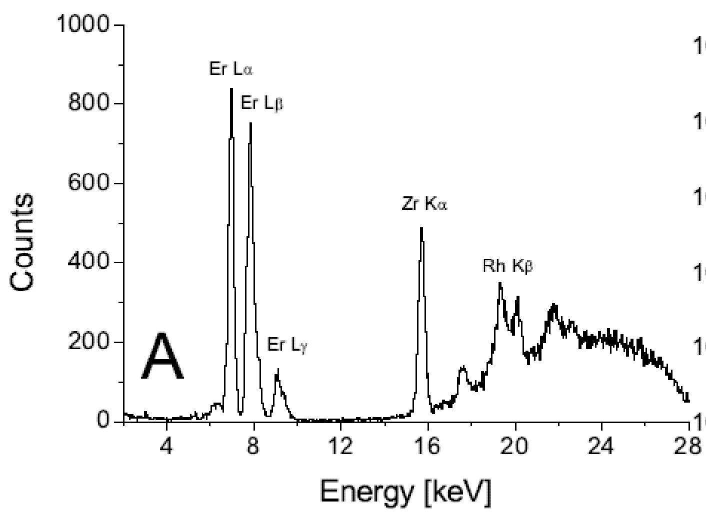
# $^{162}$Er target preparation

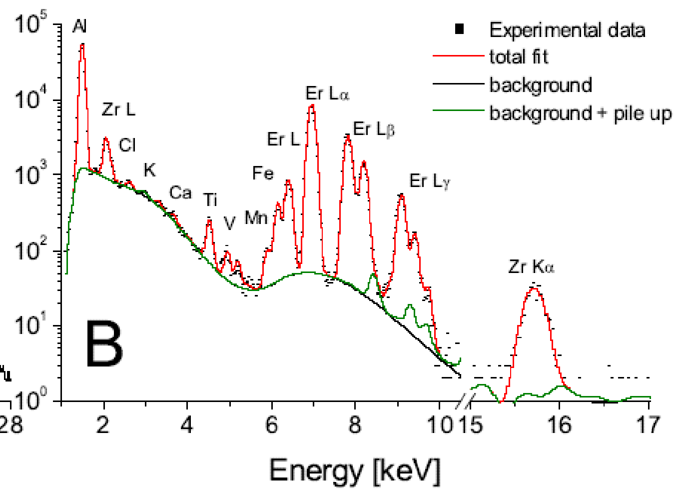
vacuum evaporation onto 2μm Al / 20 μg/cm$^2$ C foils

typical target thicknesses: 0.1-8 x $10^{18}$ atom/cm$^2$

Target thickness/quality determination:

- PIXE (proton-induced X-ray emission)
- RBS (Rutherford Backscattering spectroscopy)
- XRF spectroscopy (X-ray fluorescence spectrometry)

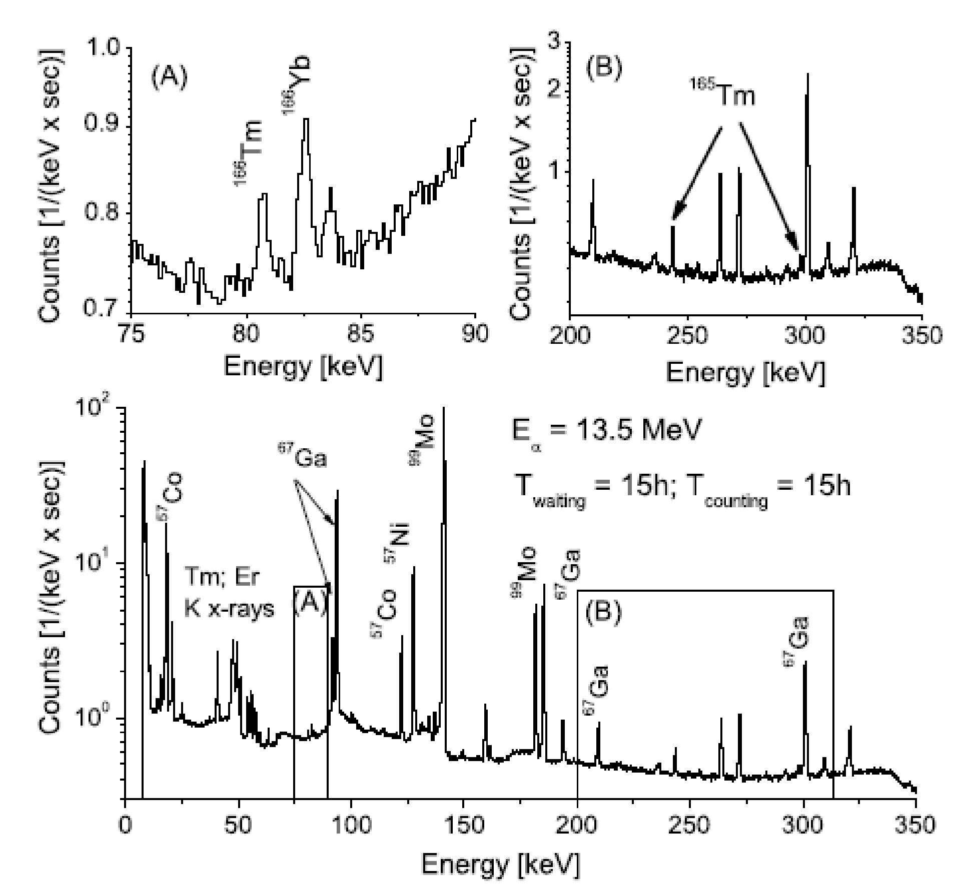


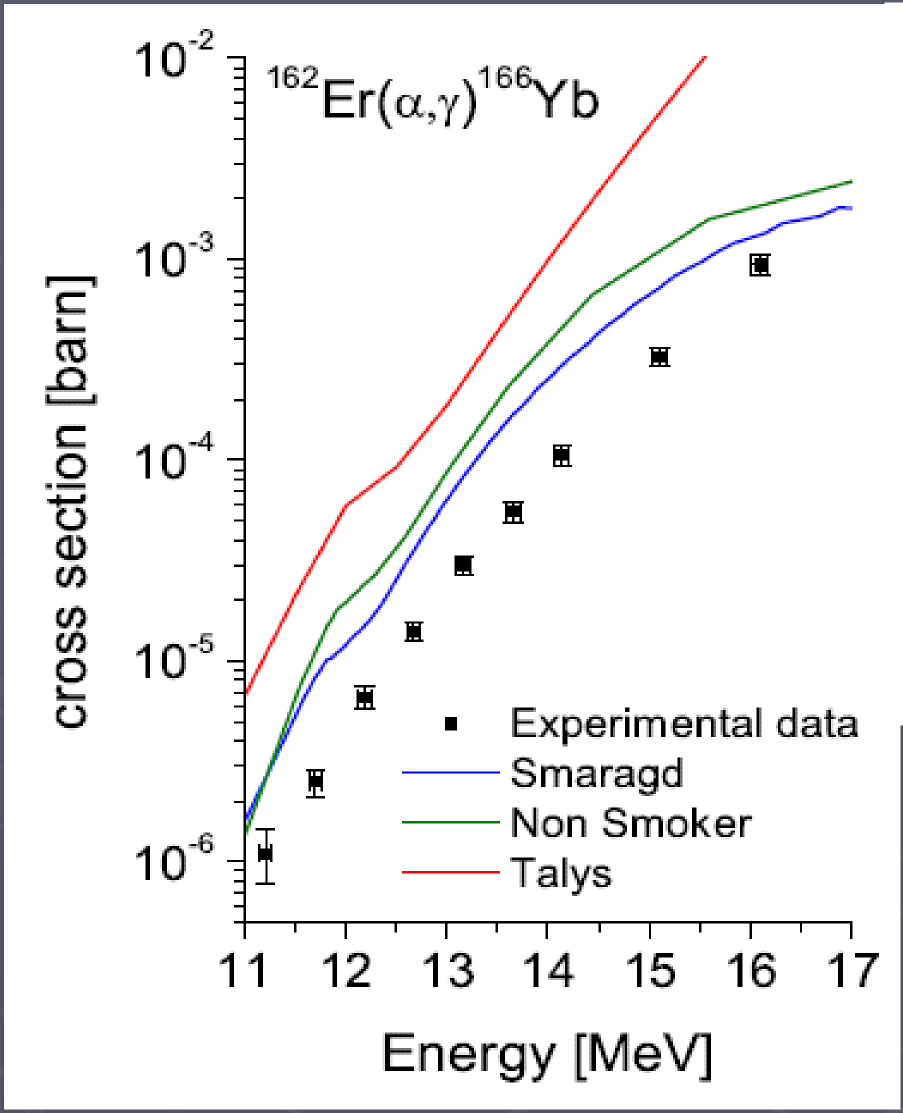

# Irradiation and $\gamma$ counting

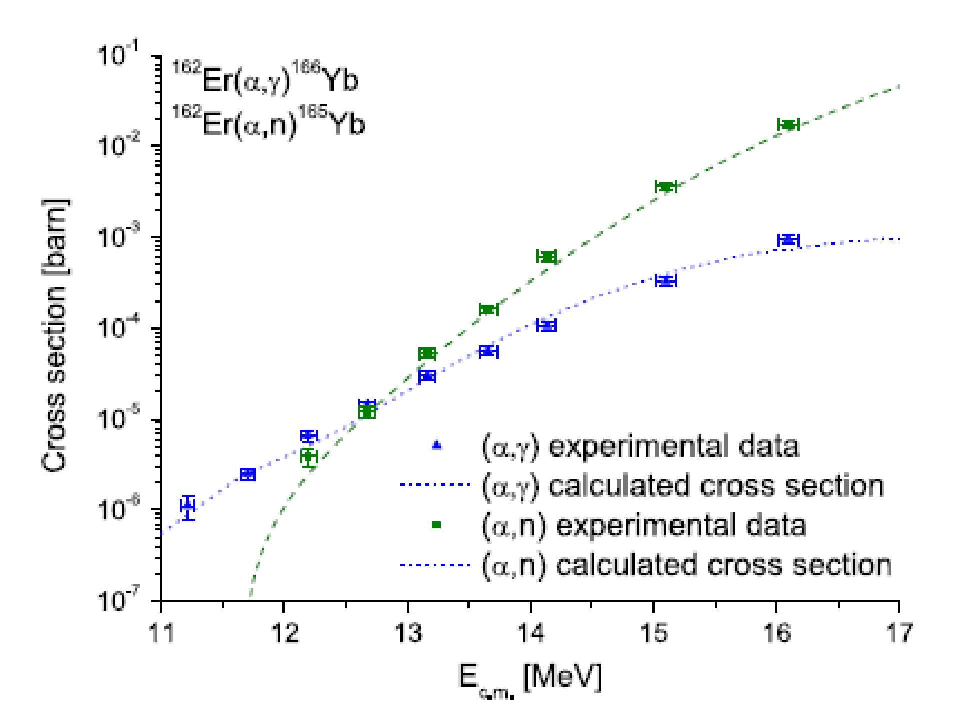
- K=20 Cyclotron of ATOMKI
  11.2 MeV < $E_{\alpha}$ < 16.1 MeV
  (0.5-1 MeV steps)
- several irradiations repeated using different targets
- 0.8-2.3 $\mu$A beam current, length: 8-24 hours
- Number of incident particles:
  Faraday cup, secondary electron suppression
  Current integrator
  multichannel scaling mode
- Target stability monitoring

► Low Energy Photon Spectrometer



# Experimental results



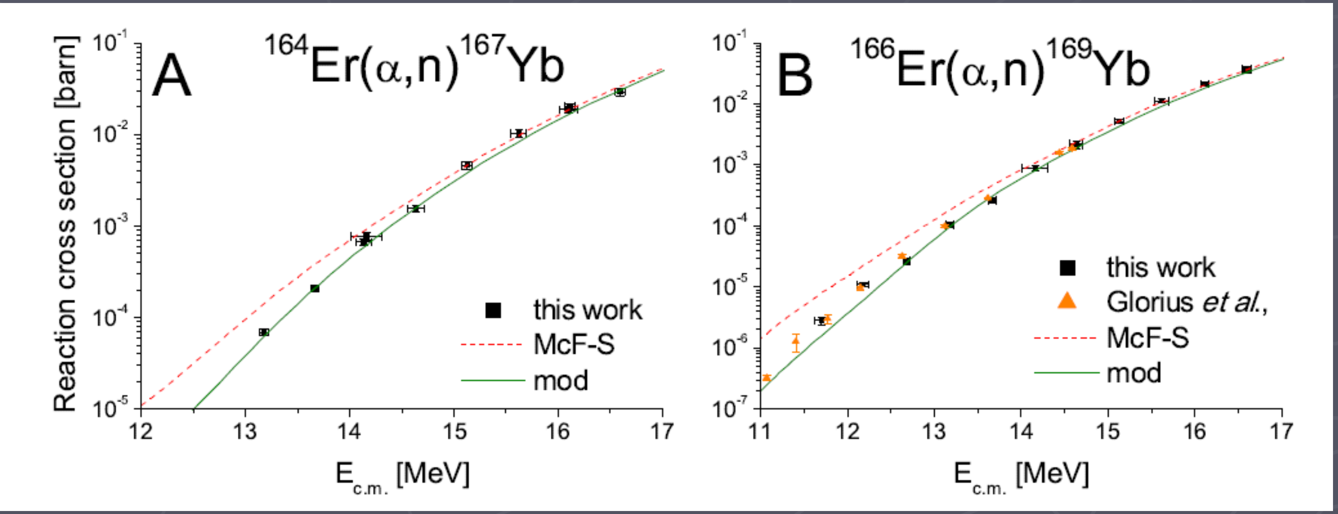




$$W\left(C, E^{\alpha}_{c.m.}\right) = \frac{25}{1 + e^{(0.9E_C - E^{\alpha}_{c.m.})/a_E}} \text{ MeV},$$

Used for $^{141}Pr(a,n)$, $^{165}Ho(a,n)$, $^{166}Er(a,n)$, too.
A. Sauerwein et al., PRC **84**, J. Glorius et al., PRC **89**

# Conclusions

- The cross section measurement of capture reactions is an important test for $\gamma$-process calculations
- Lack of data for $(\alpha,\gamma)$ cross sections, especially in the $A > 120$ region
- Theoretical models need to be fine-tuned, further high precision experimental data are needed

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# Thanks for your attention!


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