
Nuclear astrophysics research in ATOMKI

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Research activities of the nuclear astrophysics group of

Experiments for the astrophysical p-process

Underground experiments: low cross section measurements (LUNA collaboration)

Study of the electron screening effect

- nucleosynthesis
- experiments in ATOMKI

- energy generation
- experiments in international collaboration

${}^7\text{Be}$

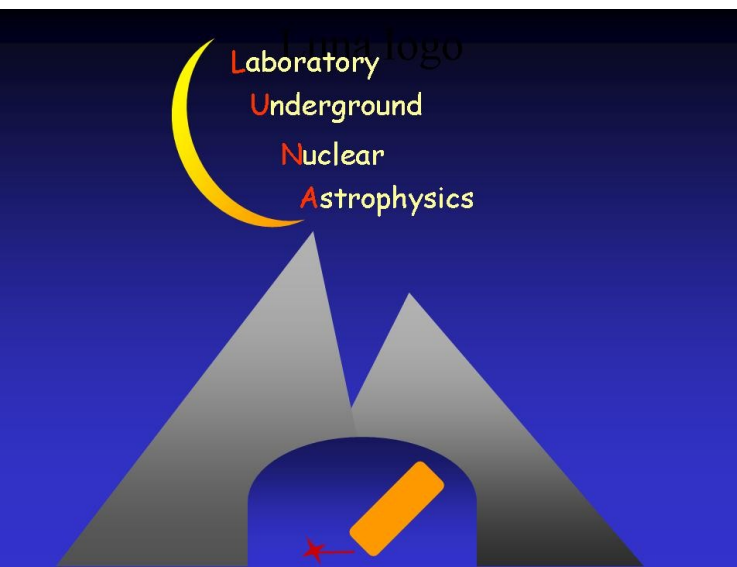
for nuclear astrophysics experiment

Application of the Trojan Horse indirect method

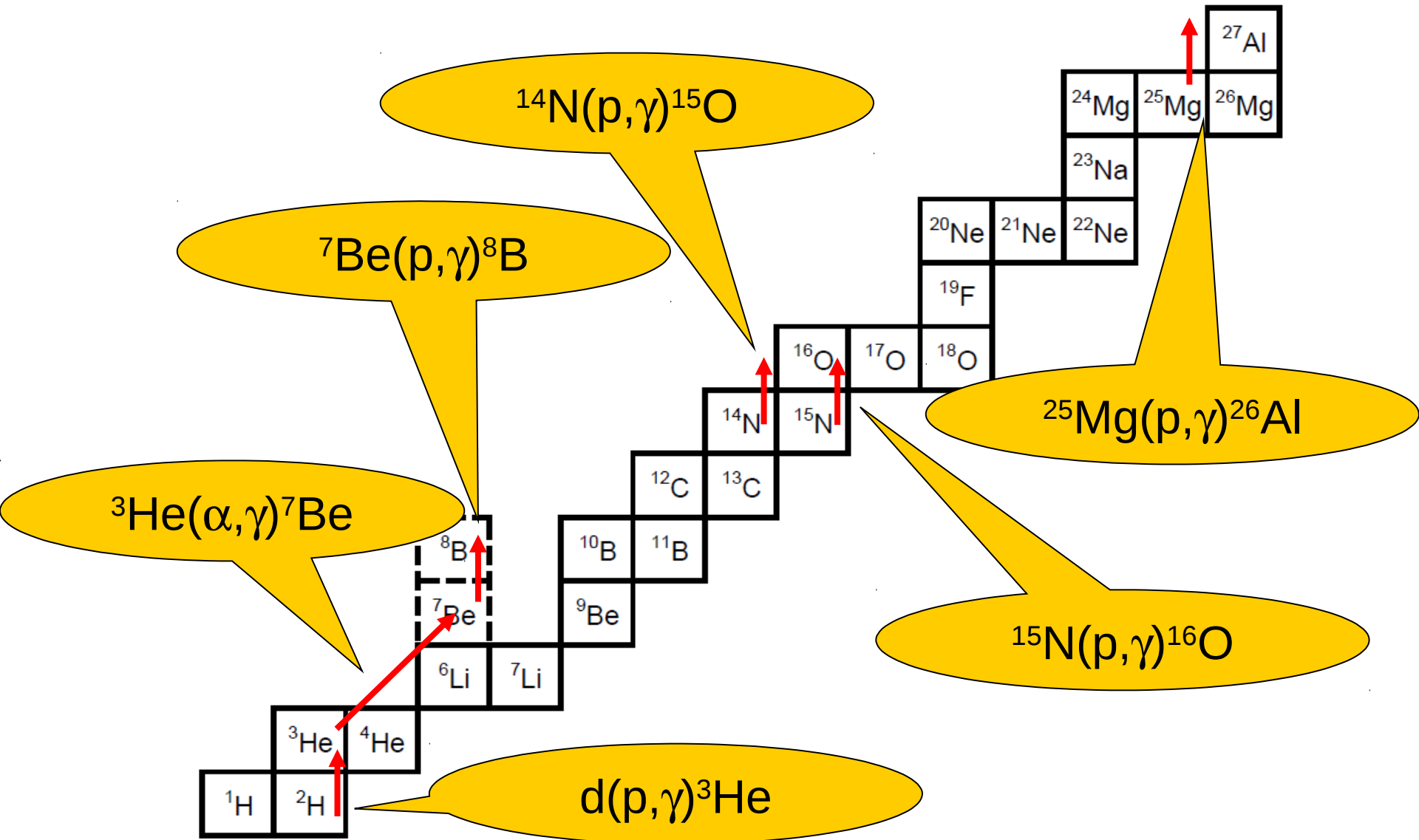
etc...

The LUNA collaboration

- Italian-German-British-Hungarian collaboration
- Operates the only underground accelerator of the world at LNGS, Gran Sasso, Italy
- Measurement of extremely low cross sections of astrophysical reactions

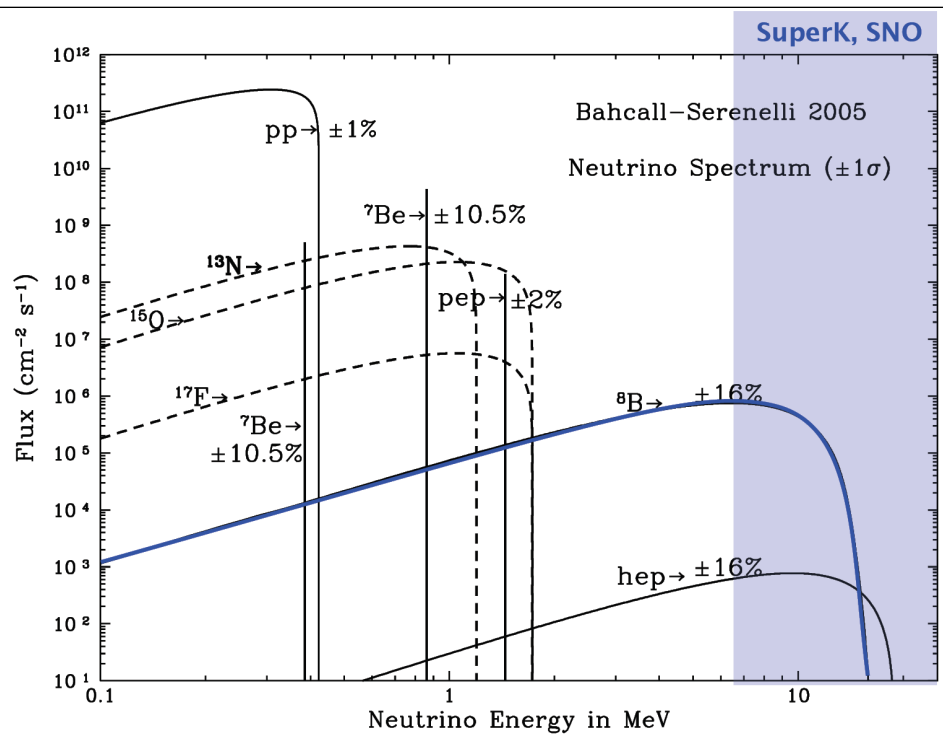


Reactions studied at LUNA

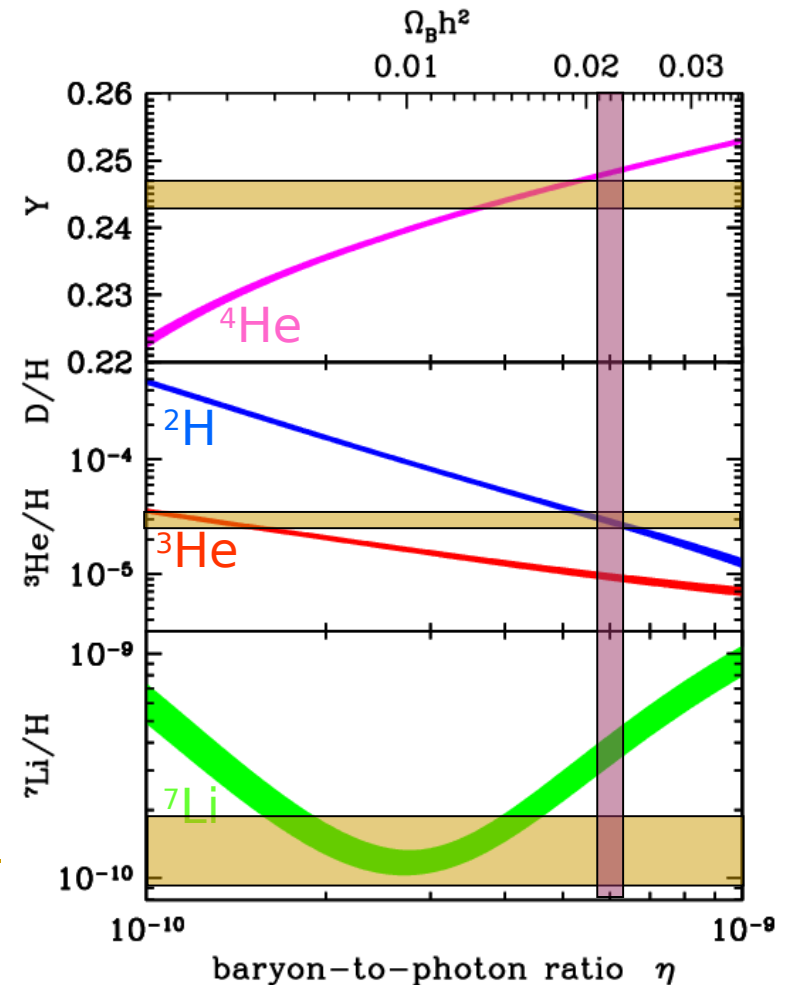


The importance of ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$

pp-chain of Hydrogen burning,
solar neutrinos



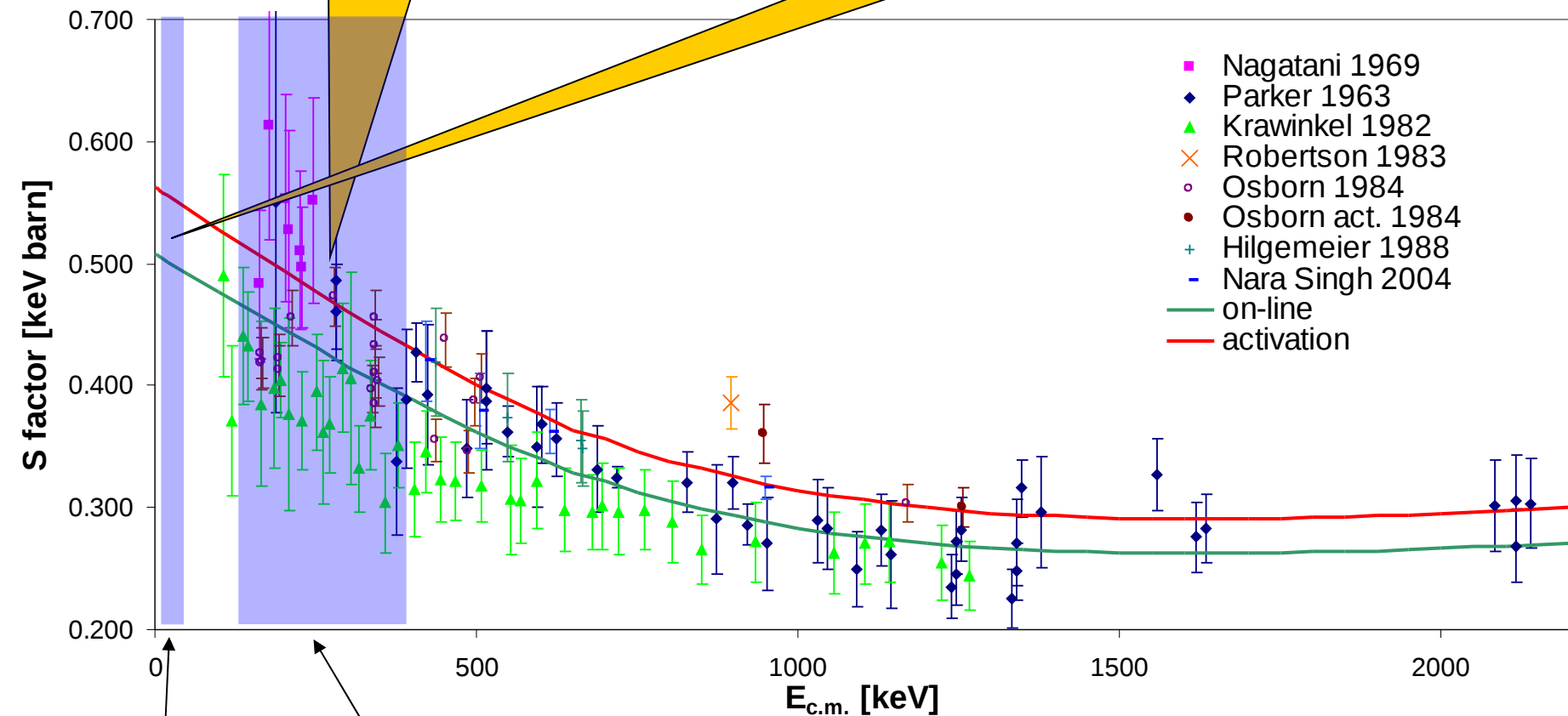
big-bang nucleosynthesis,
 ${}^7\text{Li}$ problem



Old data of ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$ S-

High uncertainty

Ambiguous results



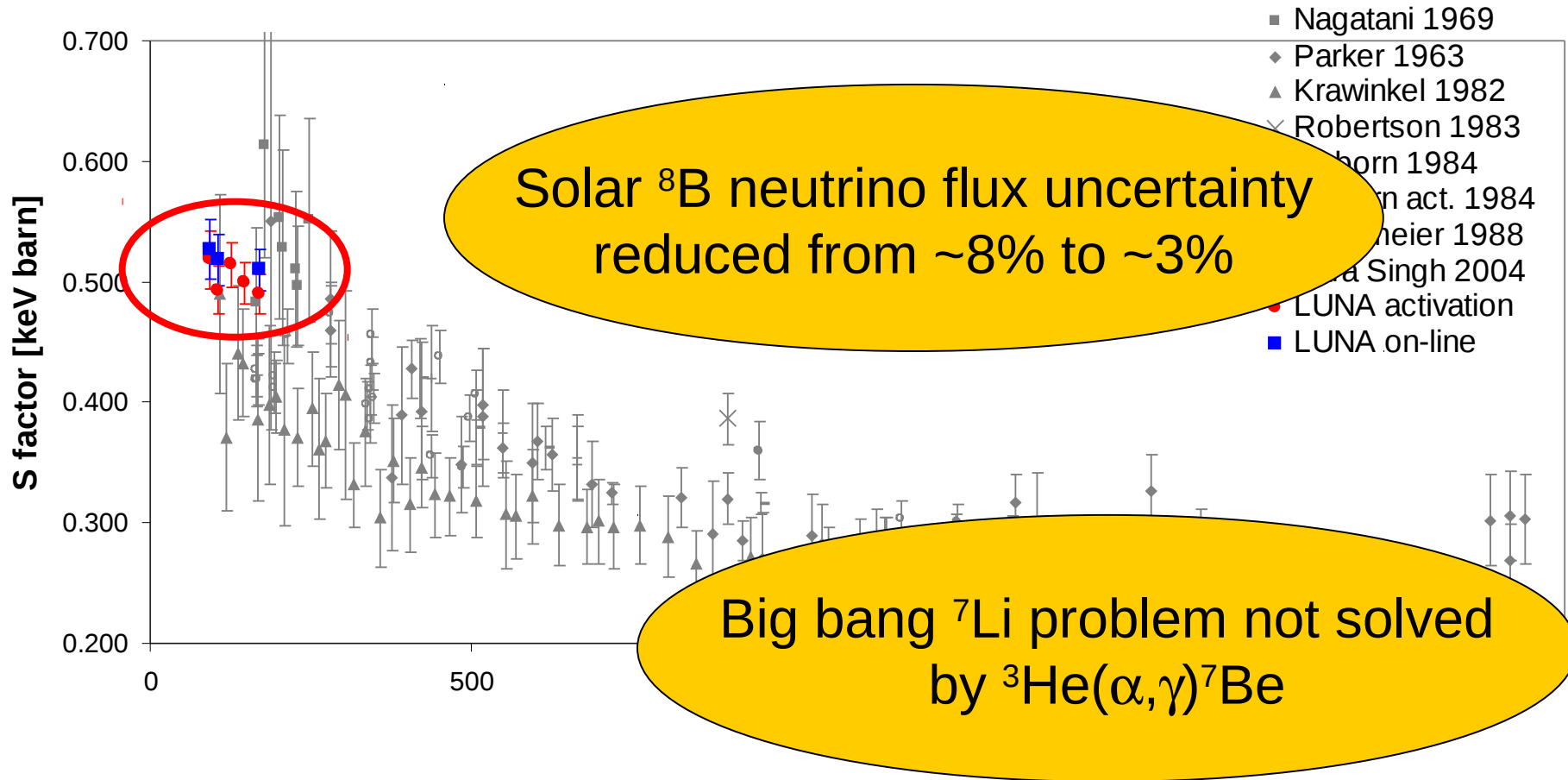
pp-chain

big bang

The LUNA of ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$ measurements

- ✓ Low energies never reached before ($E_{\text{c.m.}} = 92 - 170 \text{ keV}$)
- ✓ With both activation and in-beam methods (good agreement found)
- ✓ With high precision ($<5\%$)

The LUNA results



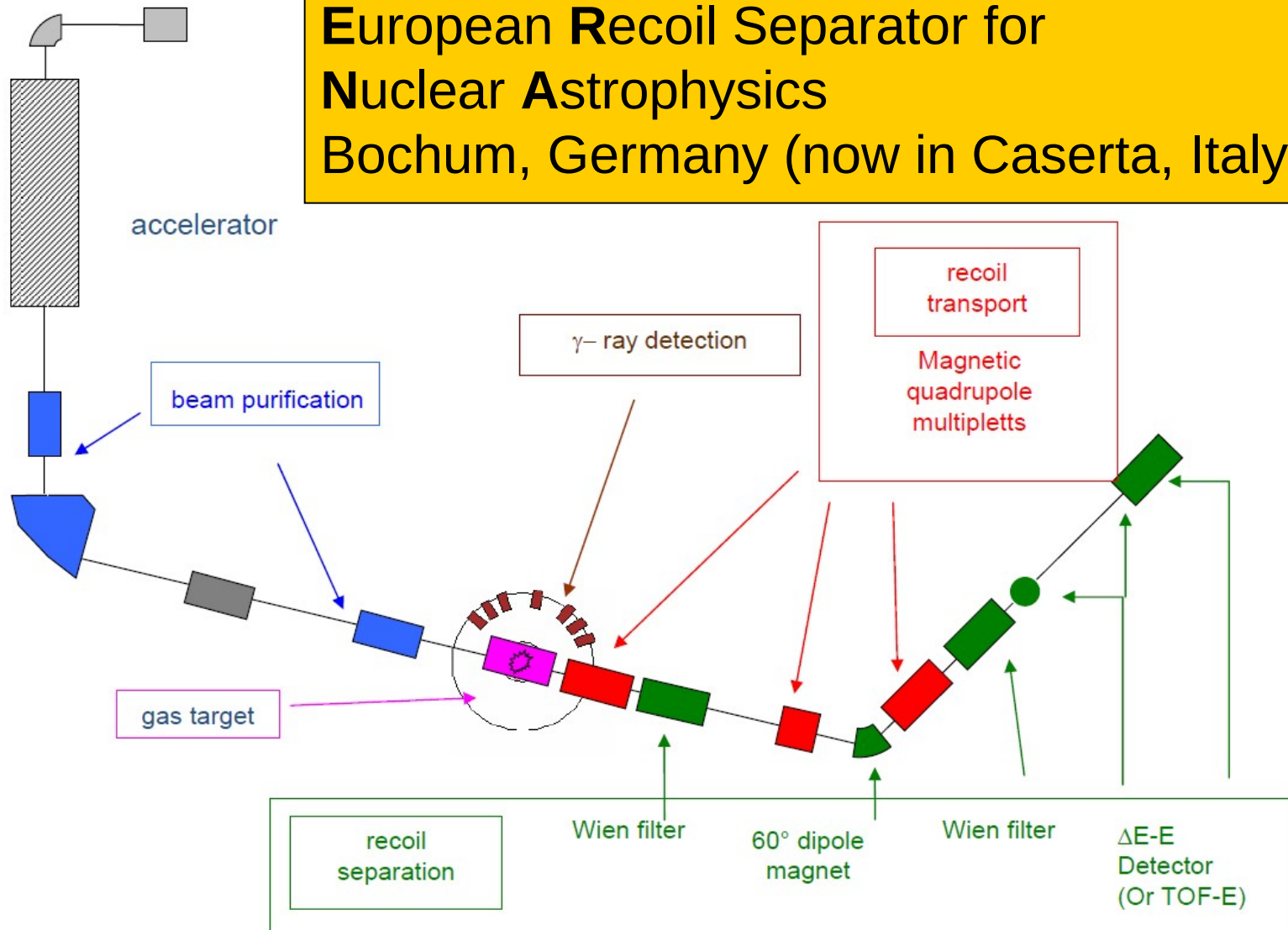
D. Bemmerer *et al.*, Phys. Rev. Lett. **97** (2006) 122502

Gy. Gyürky *et al.*, Phys. Rev. C **75** (2007) 035805

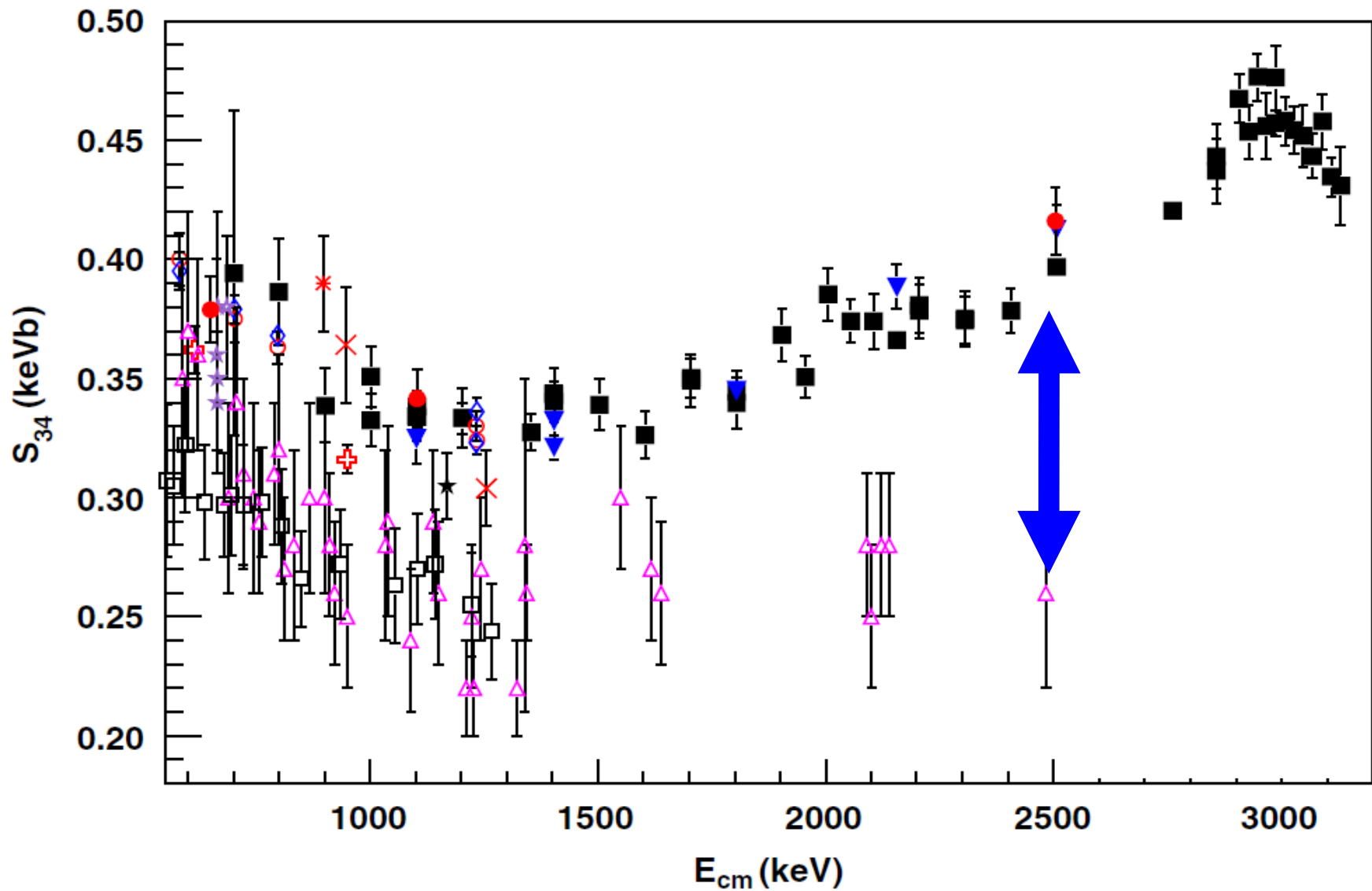
F. Confortola *et al.*, Phys. Rev. C **75** (2007) 065803

ERNA ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$ experiment

European Recoil Separator for Nuclear Astrophysics
Bochum, Germany (now in Caserta, Italy)

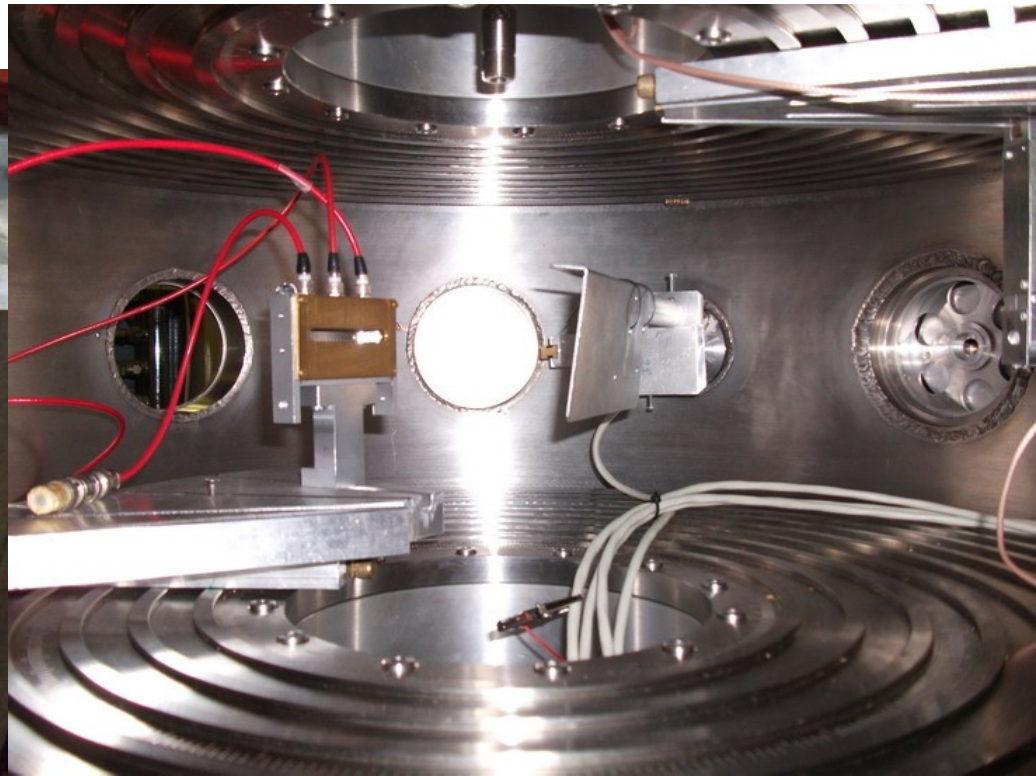
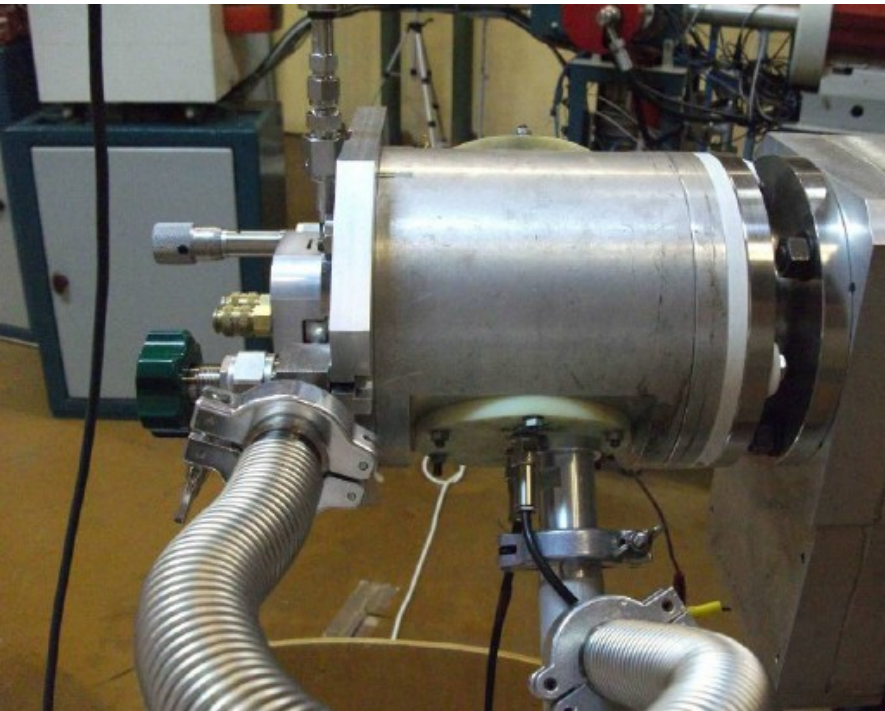


ERNA Results

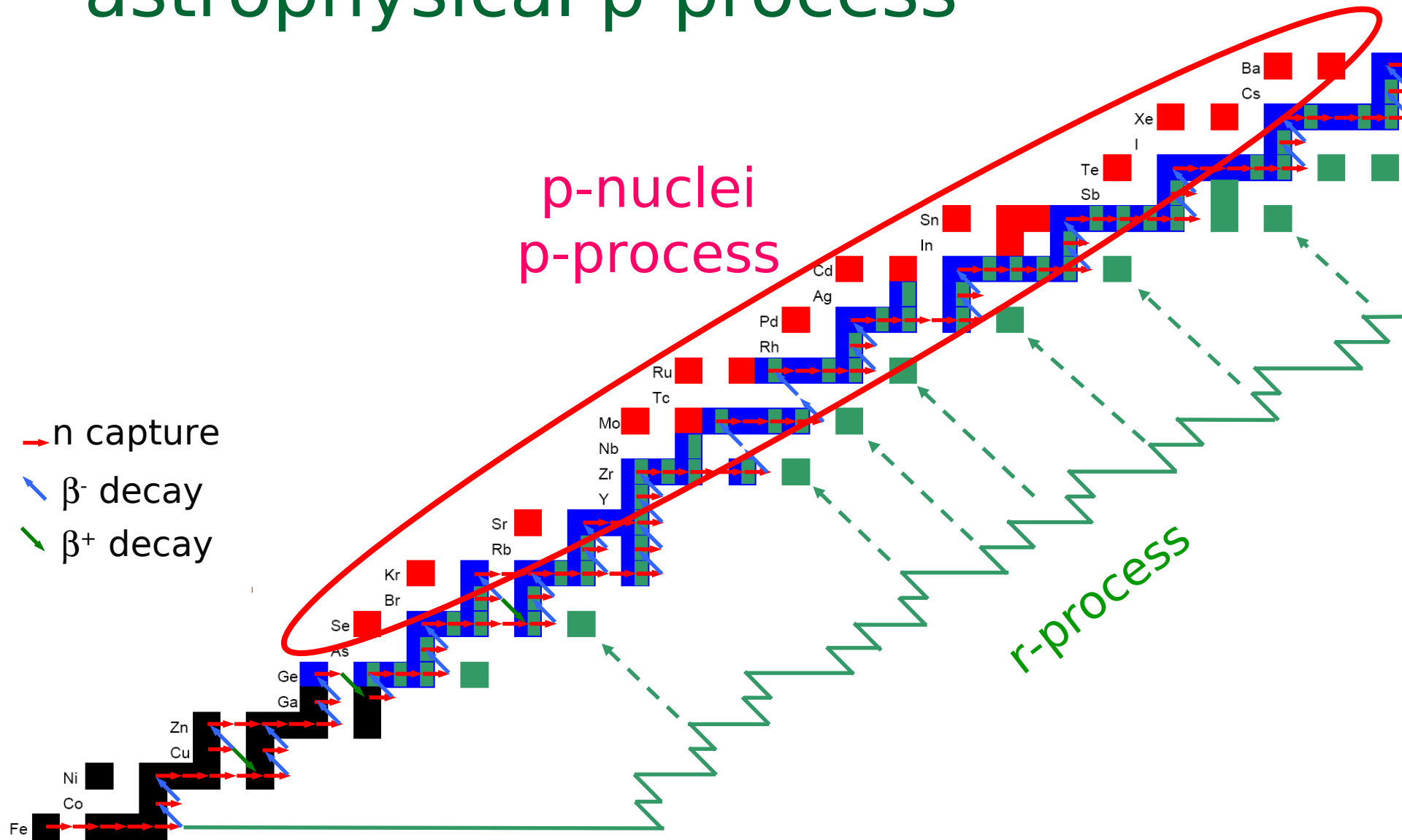


${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$: outlook

- new measurements in ATOMKI
- high energy activation and indirect measurements (ANC)

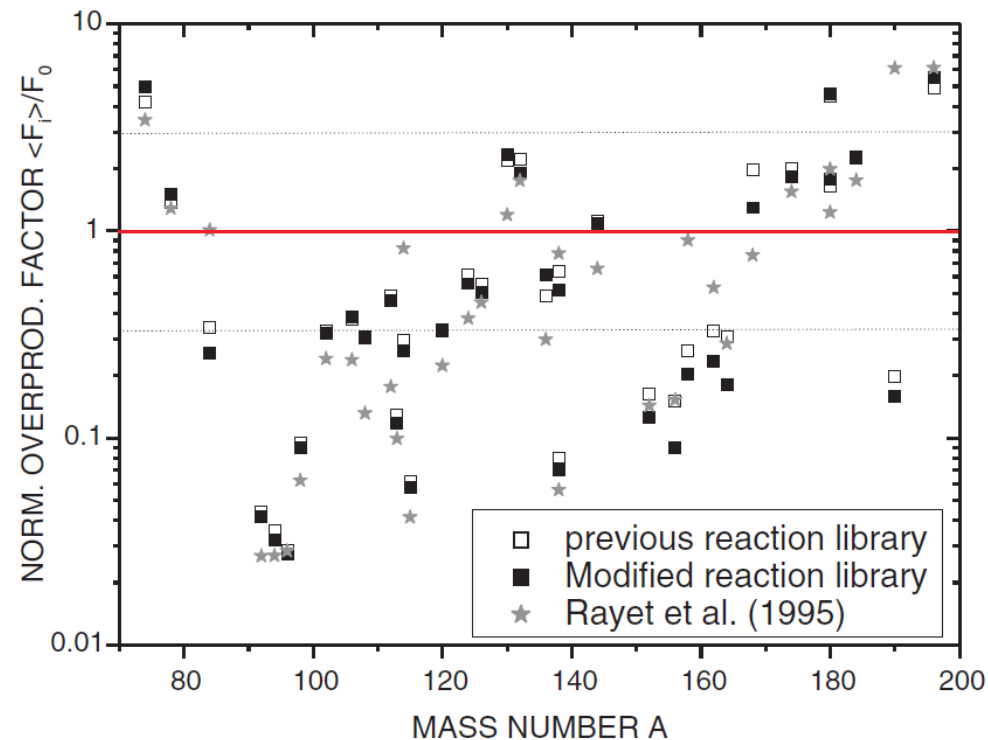


Experimental study of the astrophysical p-process



The p-process nucleosynthesis

- Secondary process initiated on s- and r-seeds
- Several sub-processes involved
- Most important: γ -process (γ -induced reactions)
- Models are not able to reproduce the observed p-isotope abundances



Data needs for the p-process

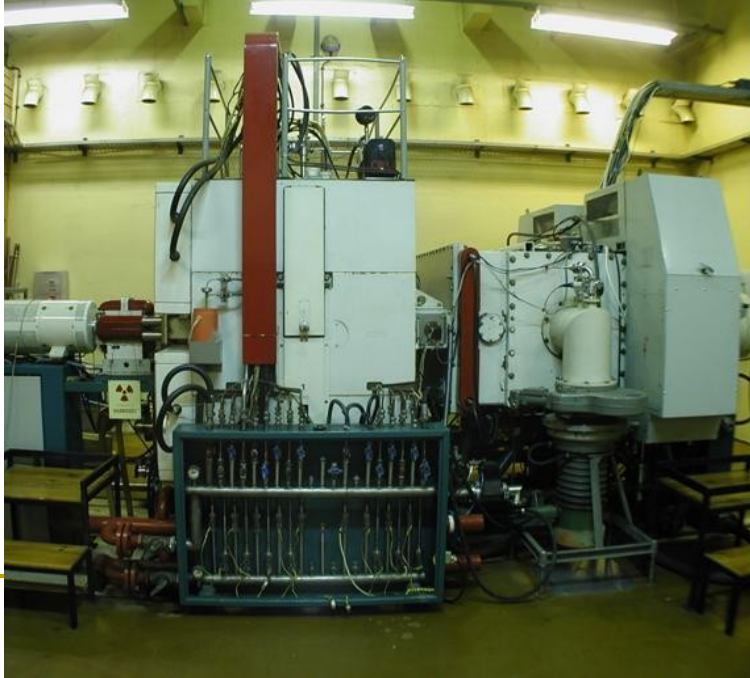
- Astrophysics: stellar environment
 - temperature
 - density
 - seed abundances
 - time scale
 - etc...
- Nuclear physics
 - masses
 - decay properties
 - **reaction rates!!!**

Reaction rates:

- based on theory
- very few experimental data
- high uncertainty
- experiments highly needed

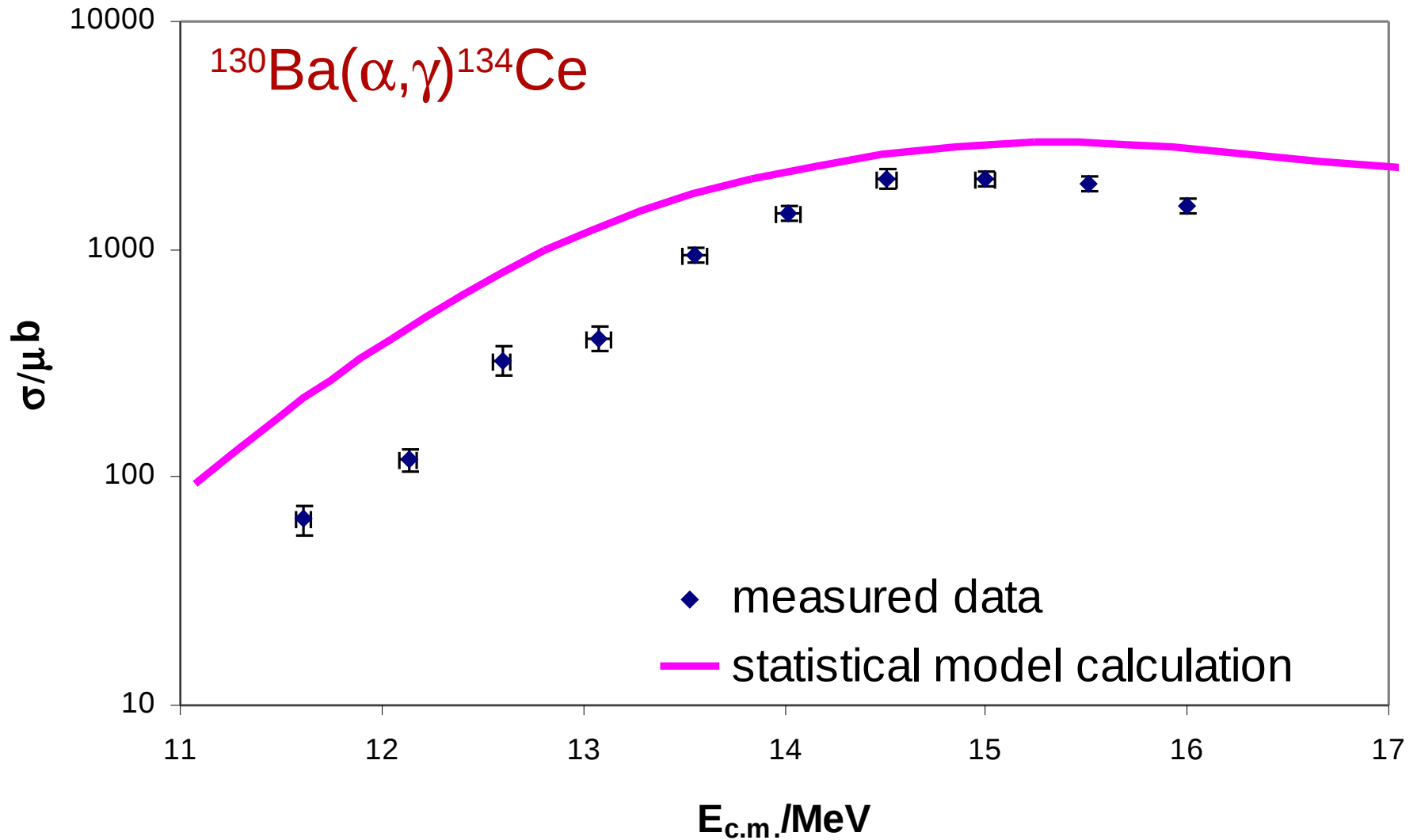
Experiments

- Alpha-induced reactions:
8-15 MeV
⇒ Cyclotron
- Proton-induced reactions: 1-4 MeV
⇒ Van de Graaff

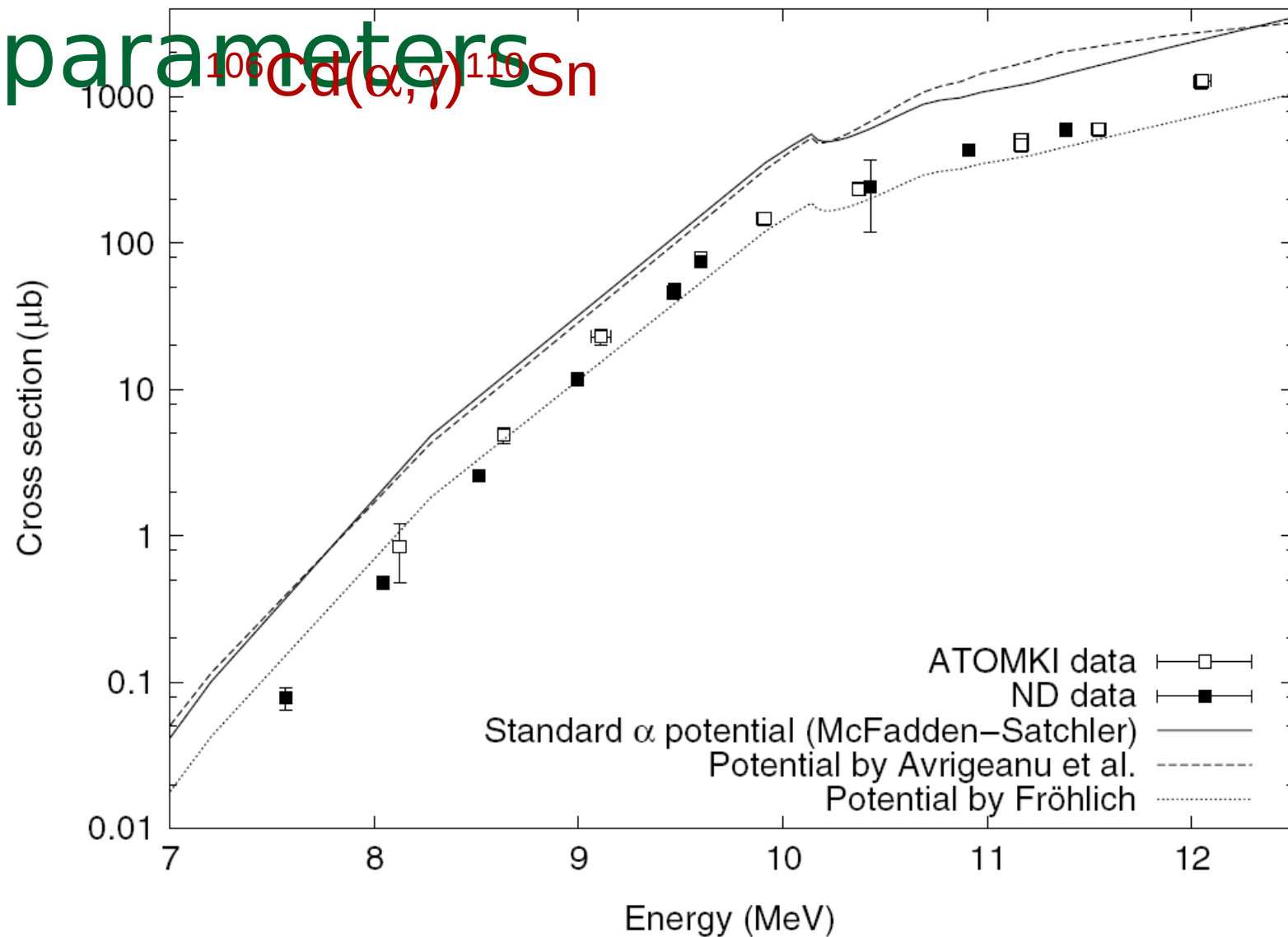


Capture reaction cross section measurements

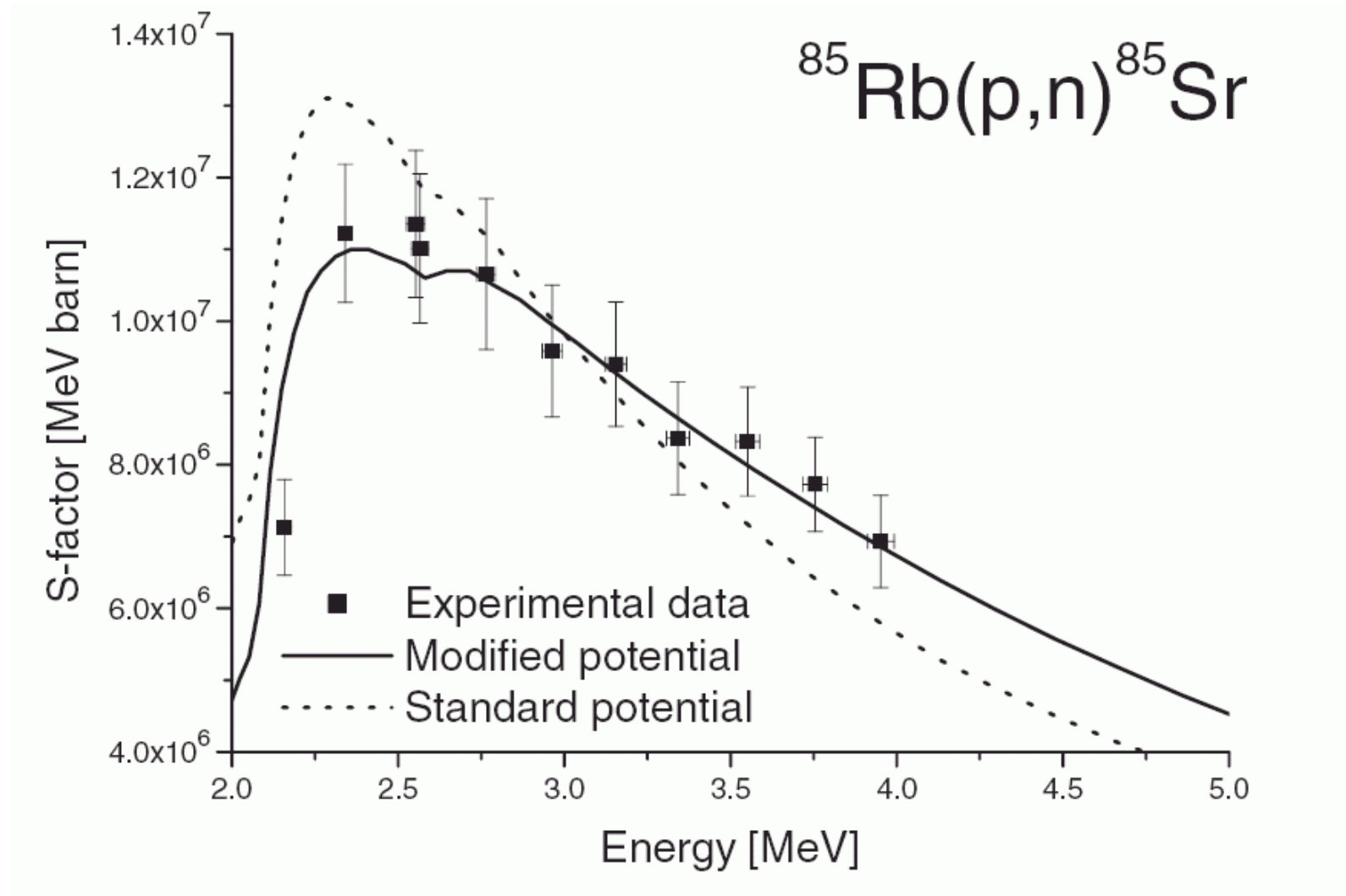
Comparison with theory



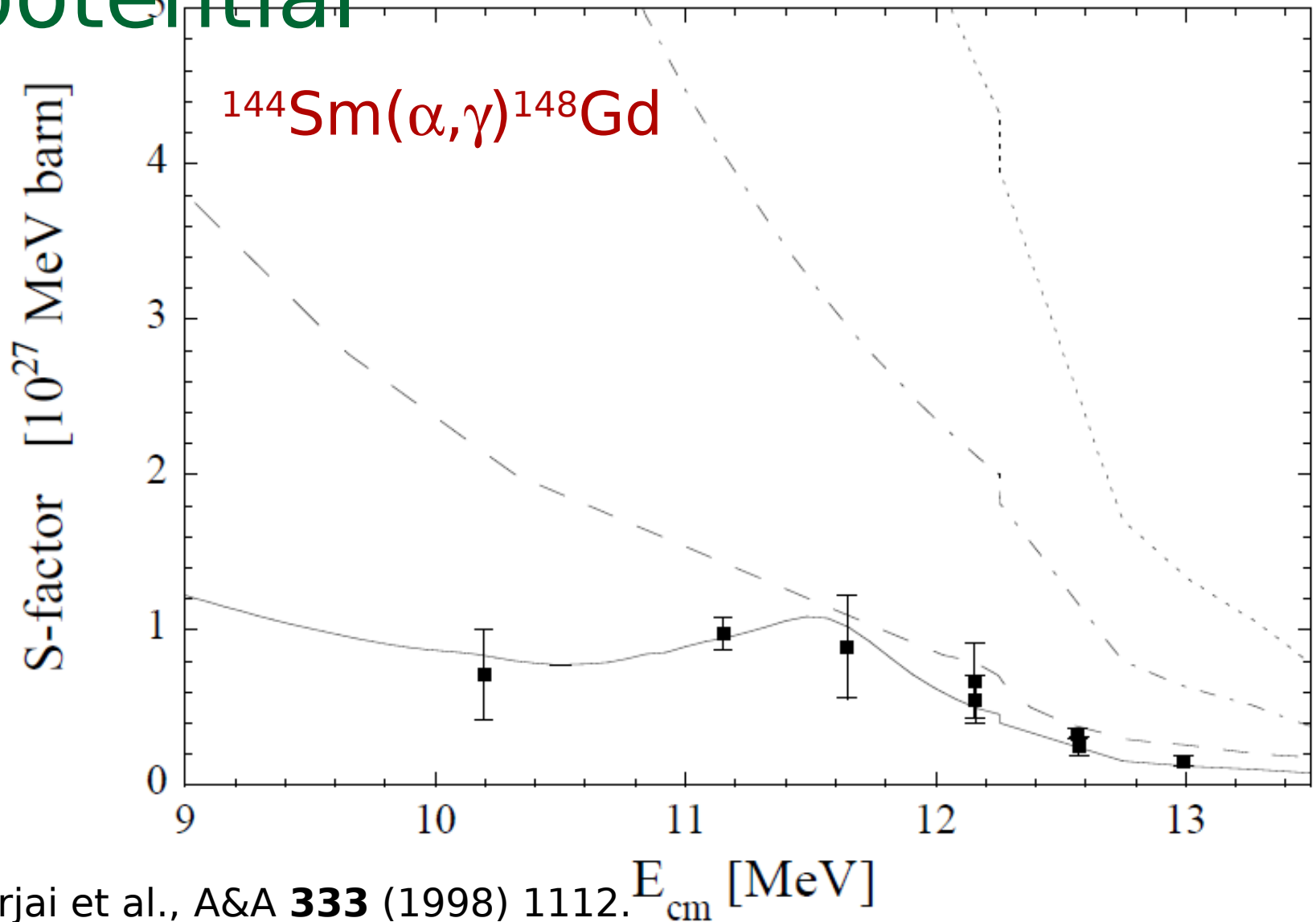
Dependence on input parameters



Fine tuning of parameters



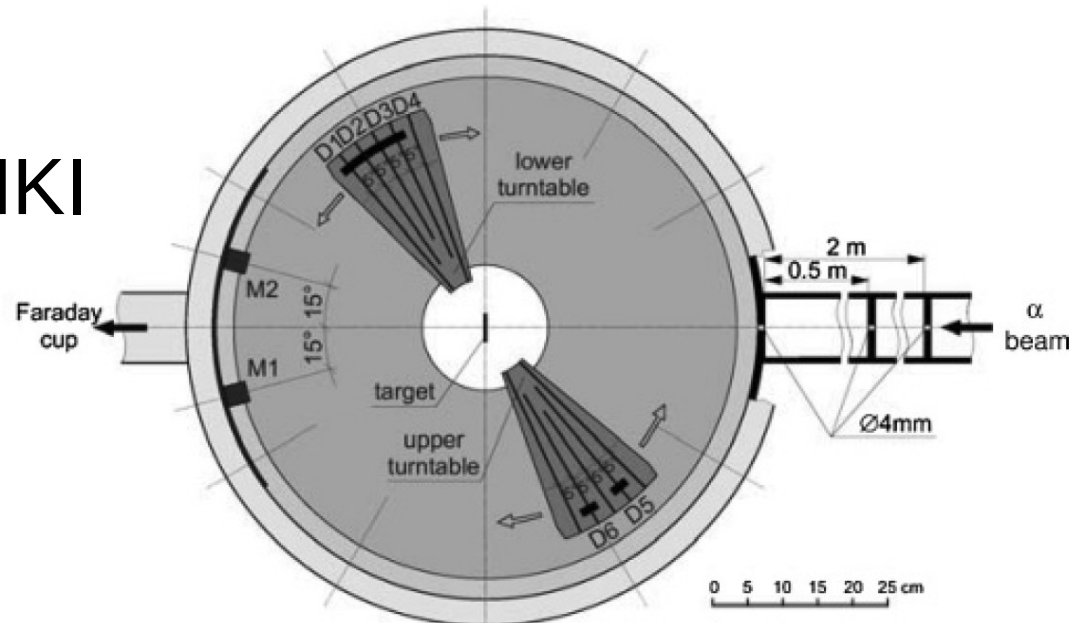
Alpha-nucleus optical potential




Somorjai et al., A&A **333** (1998) 1112.


Direct determination of alpha-nucleus optical potential


- High precision elastic scattering experiments
- Low energies (around Coulomb-barrier)
- Comparison with global optical potentials
- Construction of local potentials
- Experiments:
cyclotron of ATOMKI

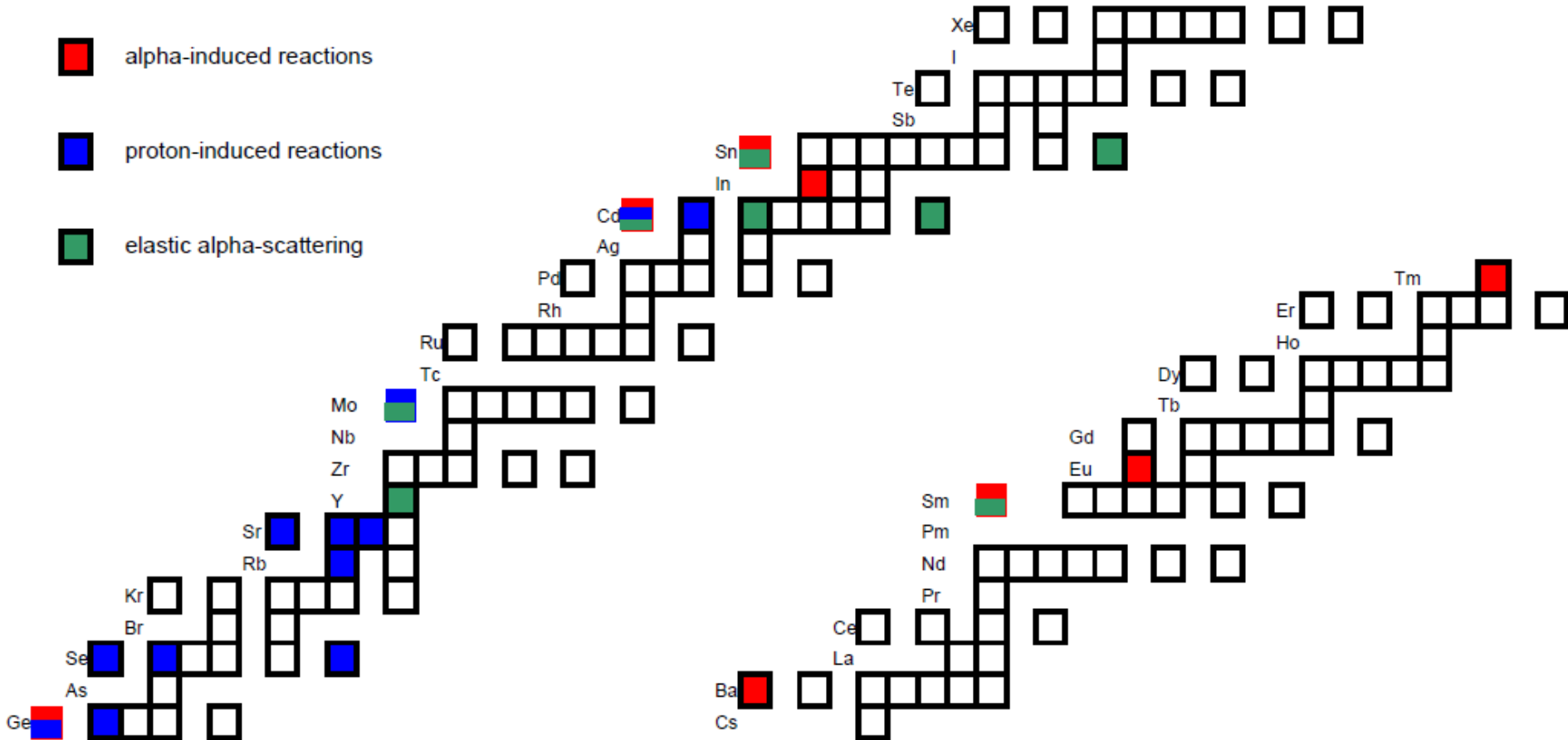


Capture and scattering experiments

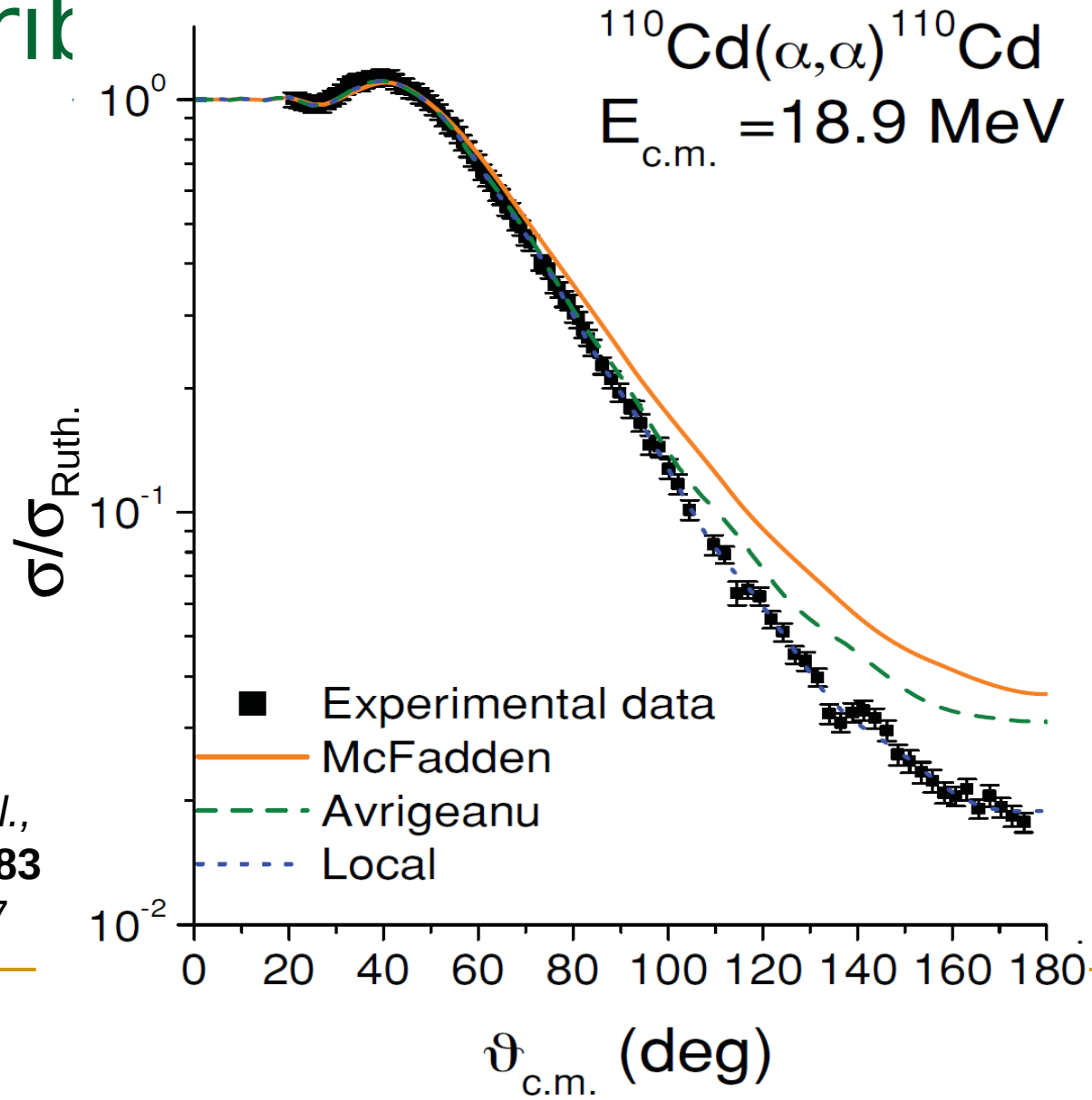
 alpha-induced reactions

 proton-induced reactions

 elastic alpha-scattering



Measured complete angular distribution



G.G. Kiss *et al.*,
Phys. Rev. C **83**
(2011) 065807

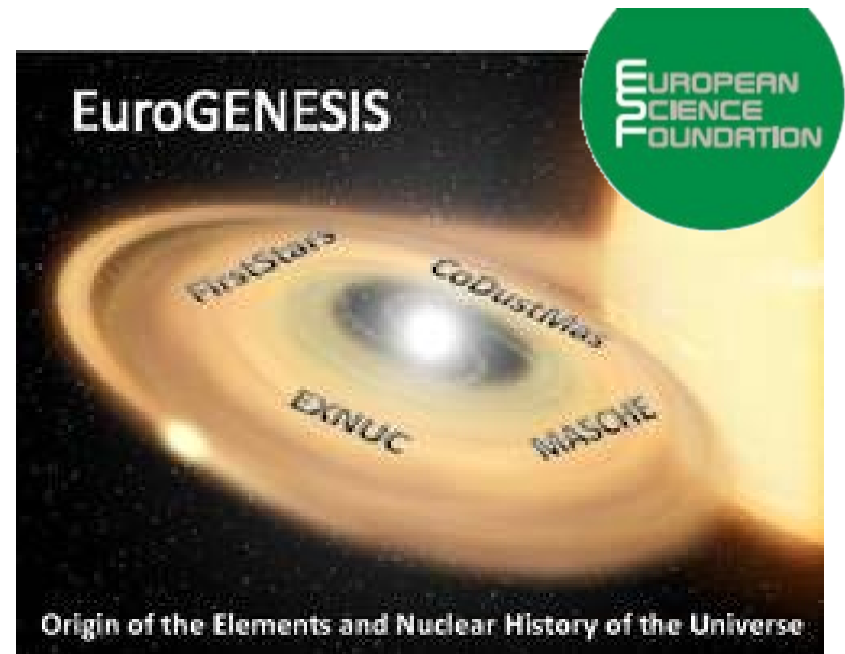
P-process: Outlook

- further needs for experimental data
- recognized by the scientific community



European Research Council

-Supporting top researchers
from anywhere in the world



For further information...



Institute of Nuclear Research of the Hungarian Academy of Sciences

http://www.atomki.hu/atomki/IonBeam/nag/index_en.html

Magyar verzió 

Home

Staff/Contacts

Research activity

Facilities

Photo gallery

Collaborations

ERC grant

Welcome to the Website of the Nuclear Astrophysics Group

Welcome to the homepage of the Nuclear Astrophysics Group of **ATOMKI**. Our group has been founded by Prof. Endre Somorjai and became one of the two research groups of the **Section of Ion Beam Physics**. Since its foundation, NAG represents experimental nuclear astrophysics among the walls of ATOMKI. In these pages you will find detailed information about our past and present activities, collaborations and group members. Have a nice browsing!