LIBRA Partner Institution Universität zu Köln: Symmetries, Lifetimes and the Synthesis of Nuclei

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Institut für Kernphysik
Universität zu Köln

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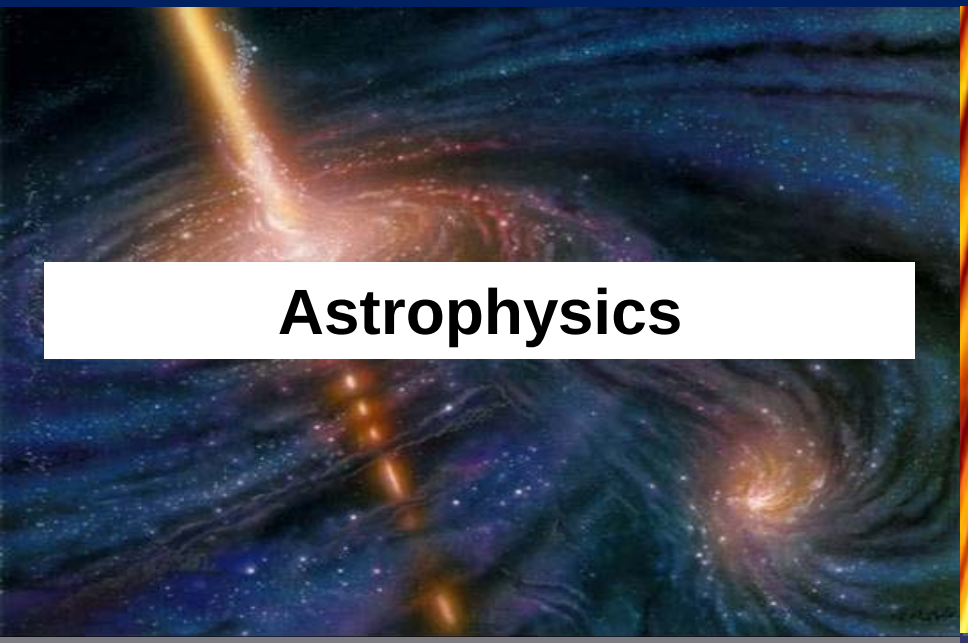
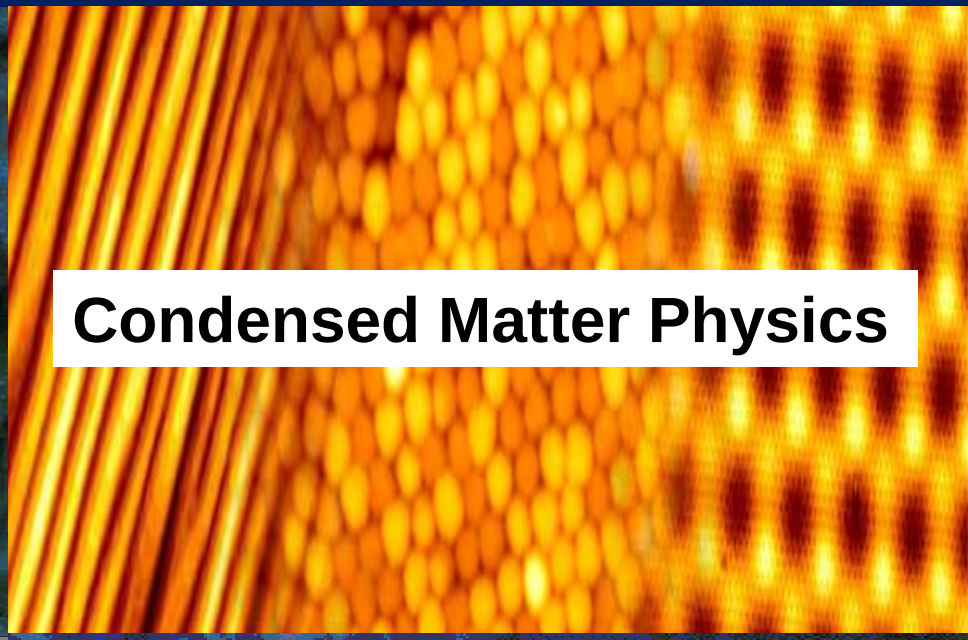
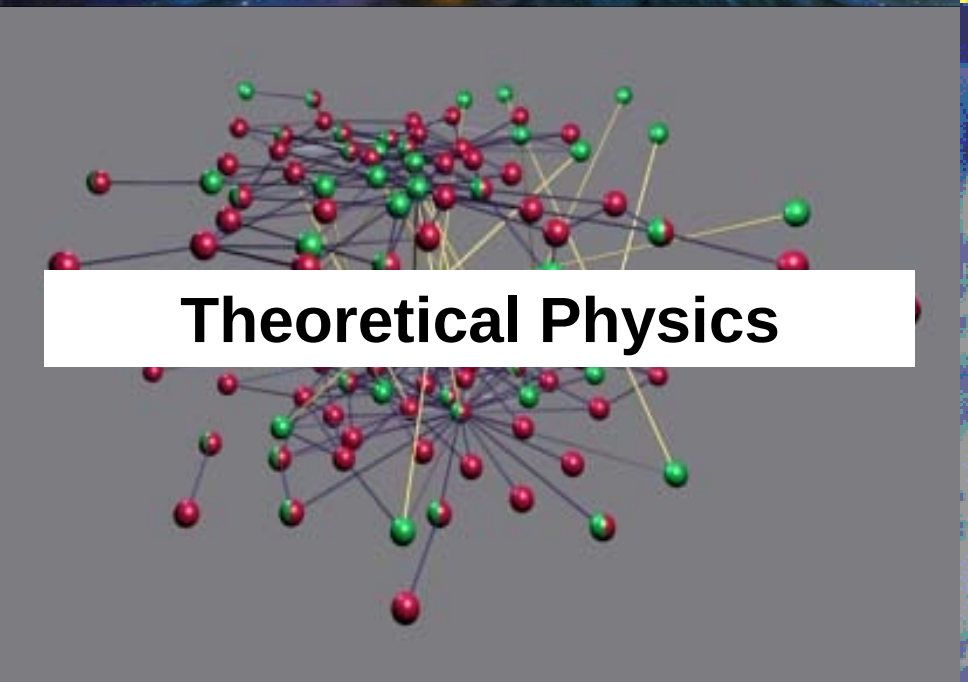
Department of Physics



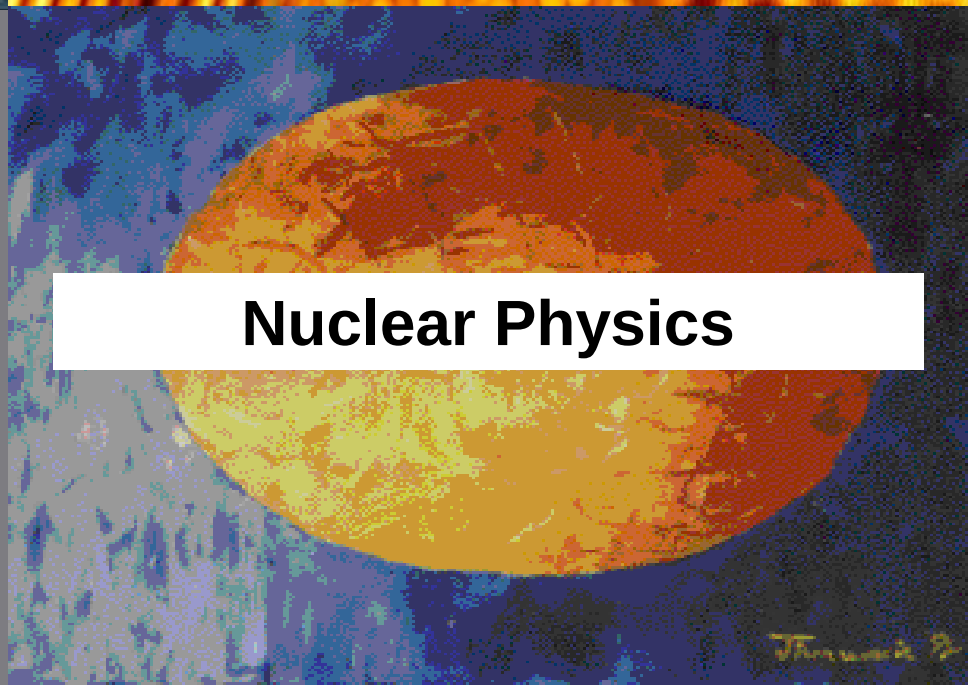
Astrophysics



Condensed Matter Physics



Theoretical Physics



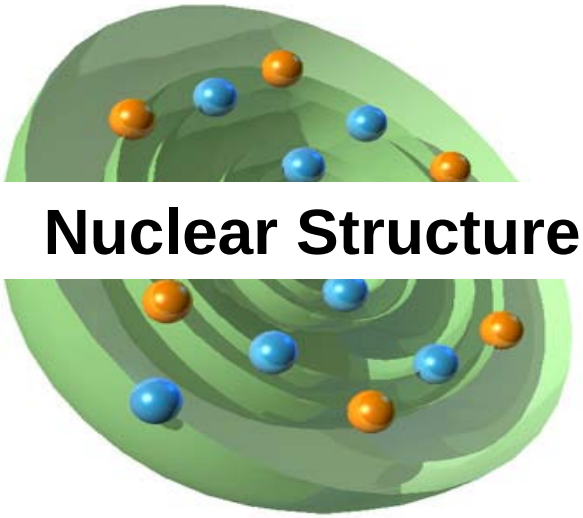
Nuclear Physics

Department of Physics

- **600 students**
- **25 faculty members**
- **3 Collaborative Research Centres (SFB)**
- **Research grants: 8.5 M€/a**

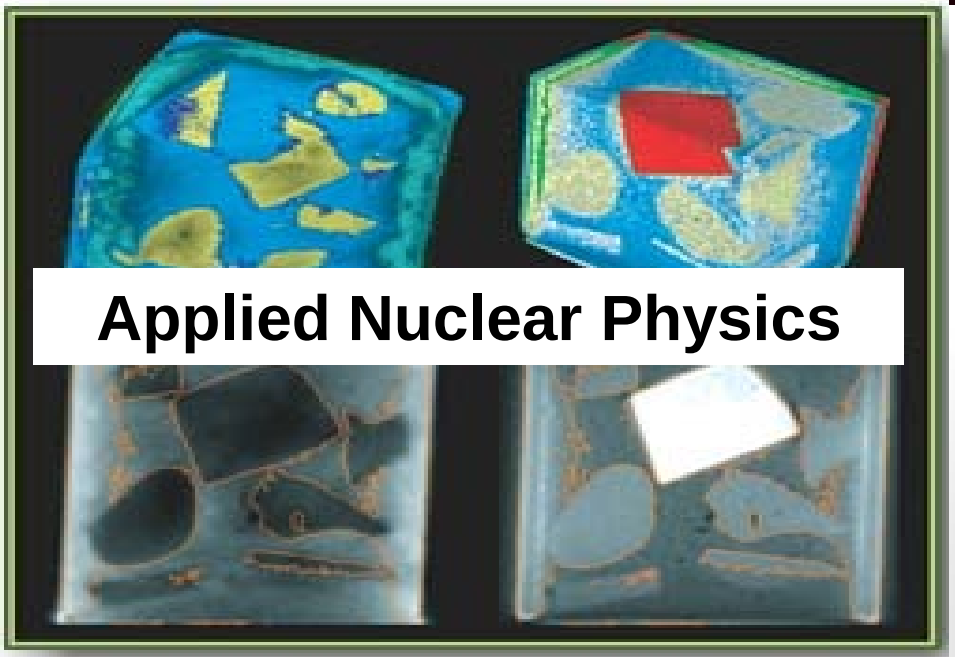
Bonn-Cologne Graduate School of Physics and Astronomy
(German Excellence Initiative 2007)

Institute of Nuclear Physics – Institut für Kernphysik

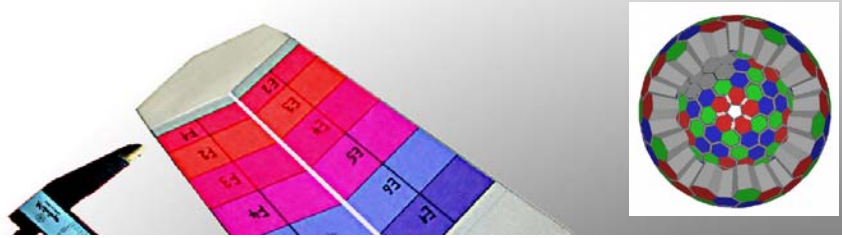


Nuclear Structure

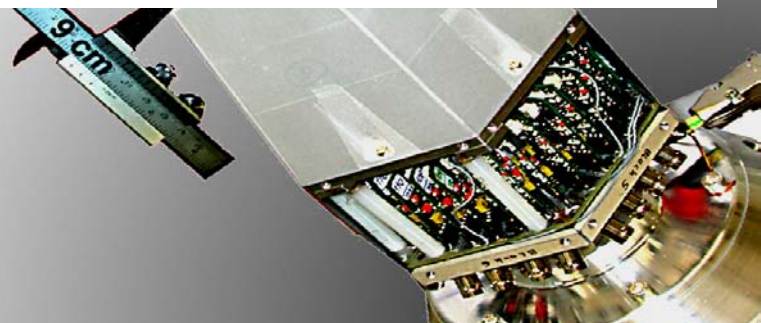
Nuclear Astrophysics



Applied Nuclear Physics



Detector development



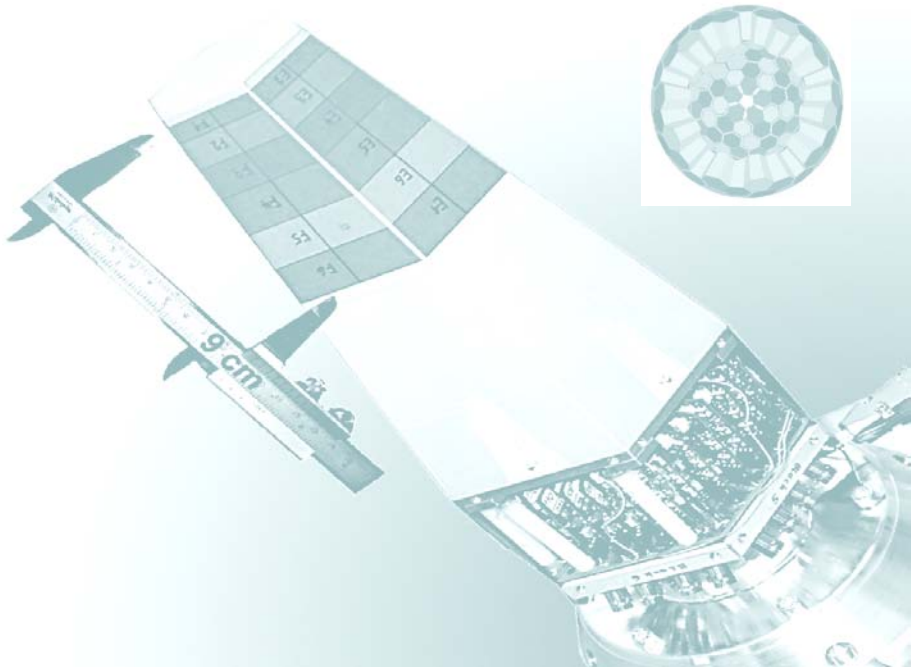
Institute of Nuclear Physics – Institut für Kernphysik

- Alfred Dewald
- Jan Jolie
- Peter Reiter
- Andreas Zilges

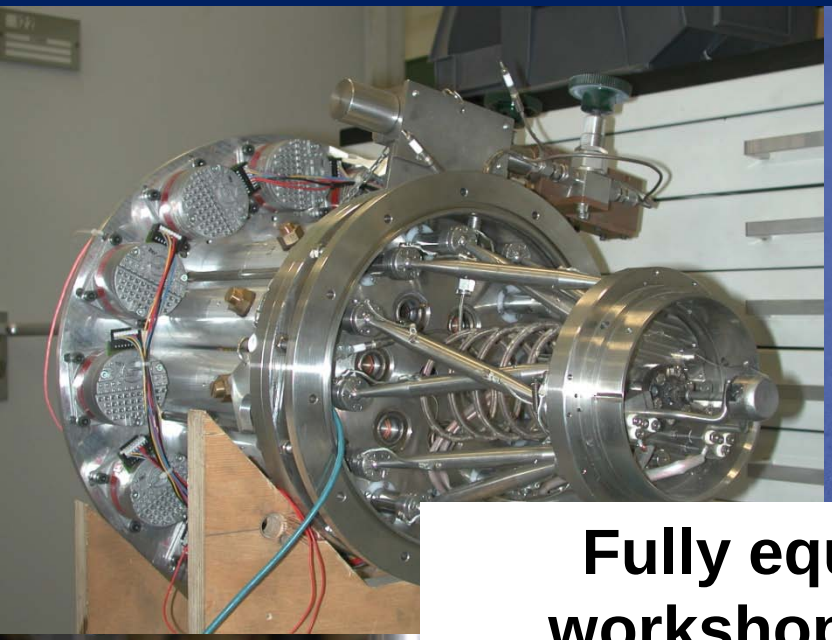
- Hans Ströher (FZ Jülich)

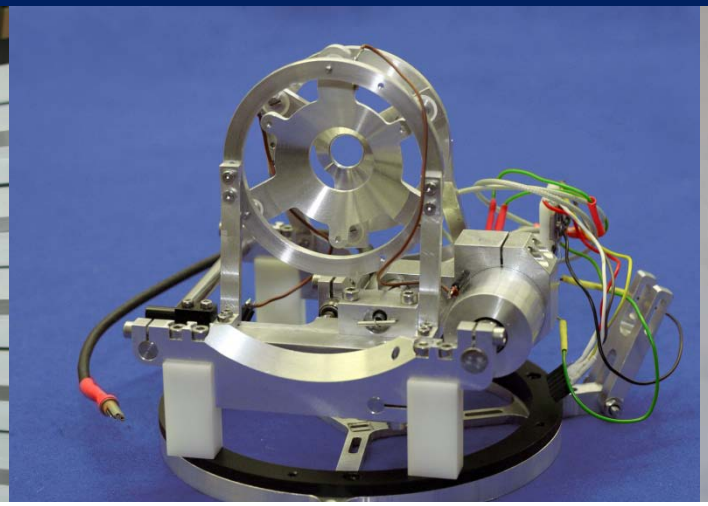
- Peter von Brentano (emer.)

9 Postdocs
21 PhD students
16 Master/Diploma students

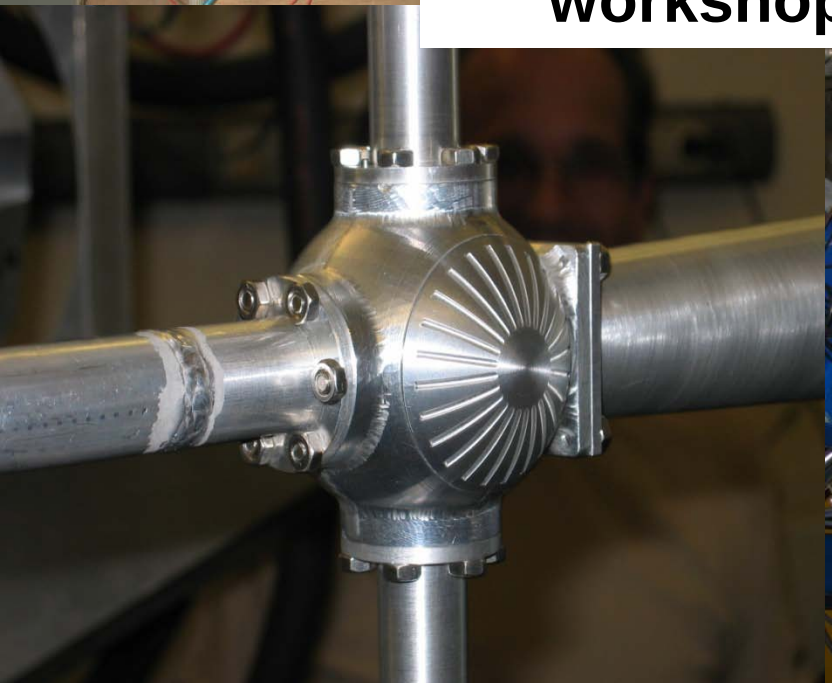


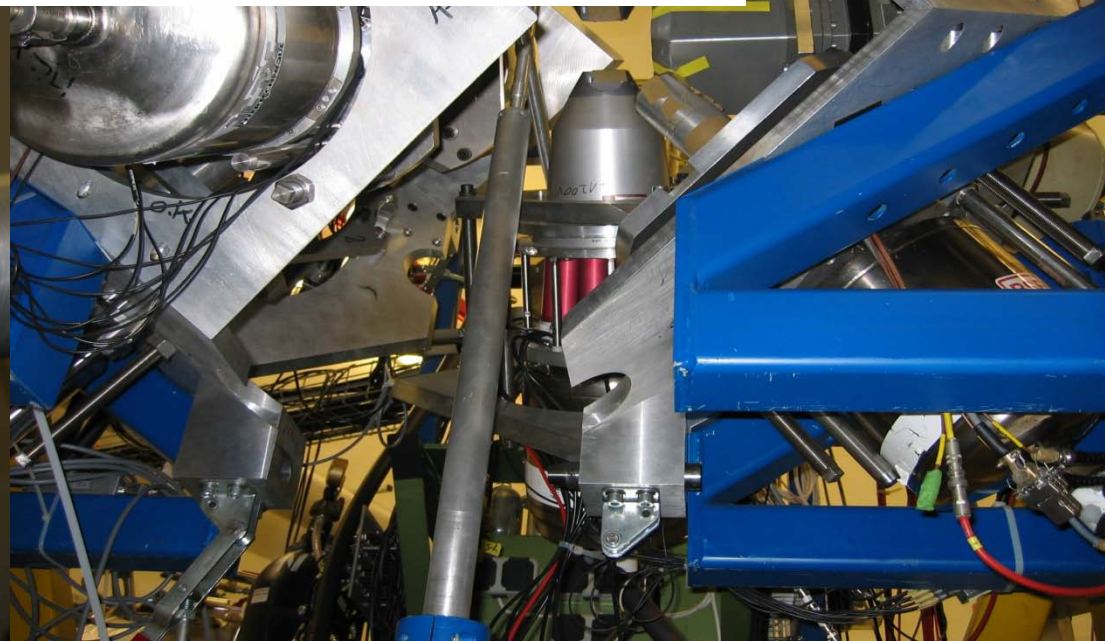
Mechanical Workshop - Institute of Nuclear Physics



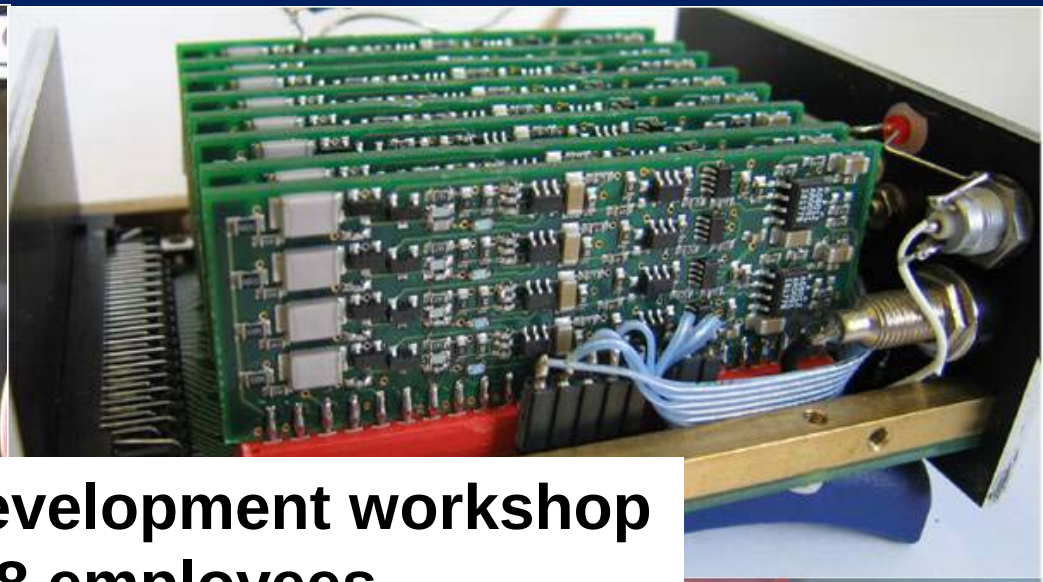


Fully equipped mechanical workshop with 15 employees

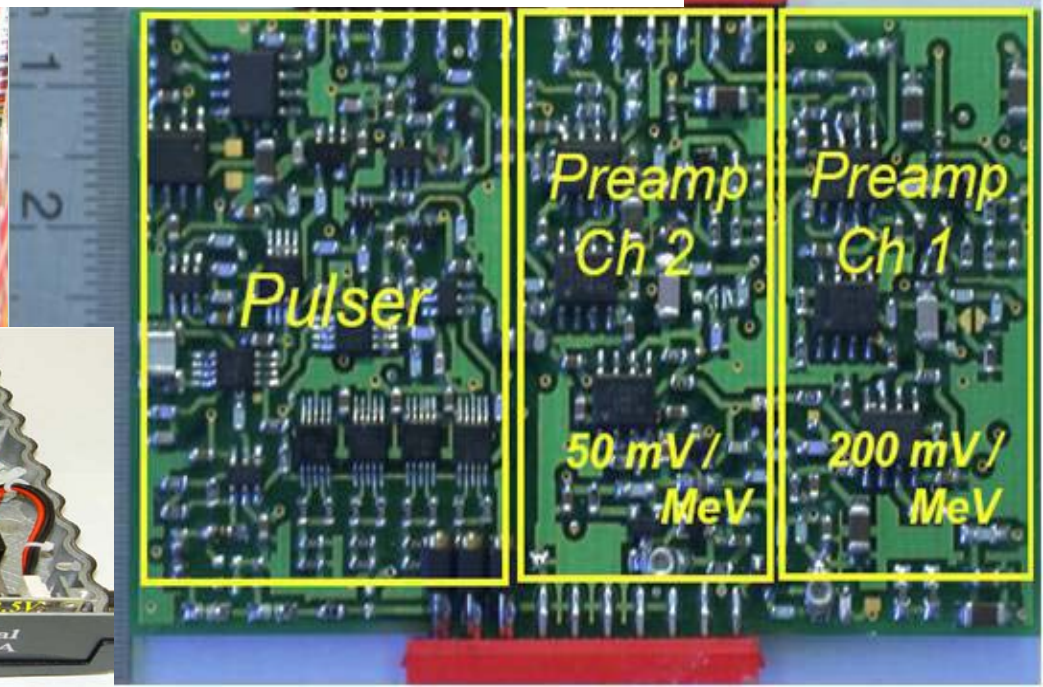




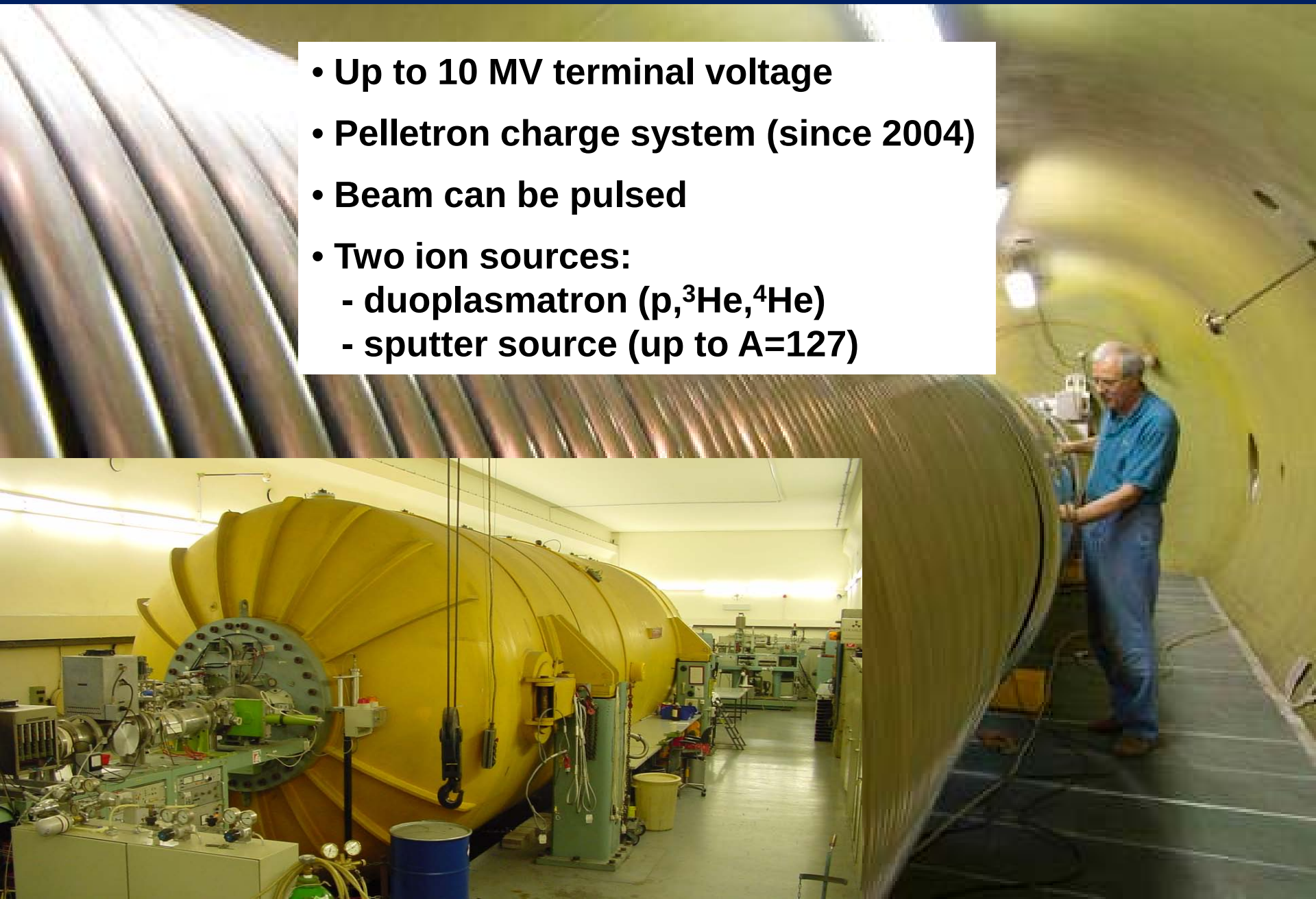
Electronics workshop - Institute of Nuclear Physics



Electronics development workshop with 8 employees



FN Tandem Accelerator at IKP



- Up to 10 MV terminal voltage
- Pelletron charge system (since 2004)
- Beam can be pulsed
- Two ion sources:
  - duoplasmatron (p,^{3}He,^{4}He)
  - sputter source (up to A=127)

Accelerator Mass Spectrometry at IKP (under construction)

Geosciences, Prehistory, Protohistory, Nuclear Physics

- 6 MV terminal voltage
- standard isotopes: ^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl, ^{129}I
- ample beam time for development

CologneAMS (Start: 2010)

A. Dewald, J. Jolie, and A. Zilges, Nuclear Physics News 18 (2008) 26

DFG

Universität zu Köln

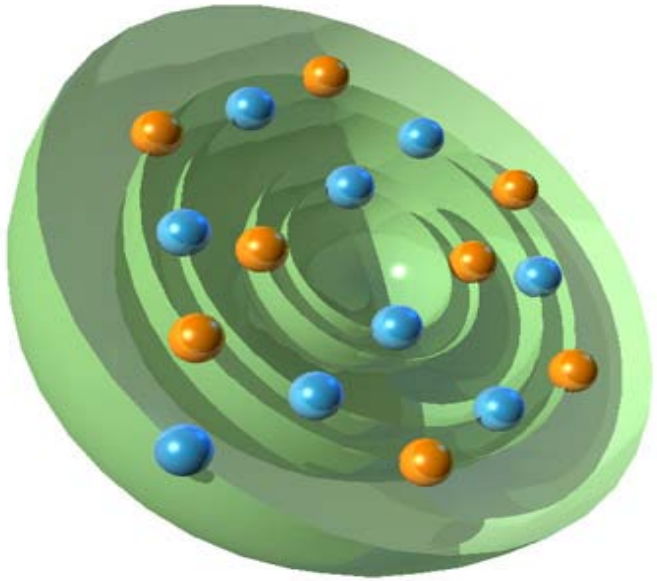
GFZ Helmholtz-Zentrum Potsdam

Nuclear Structure

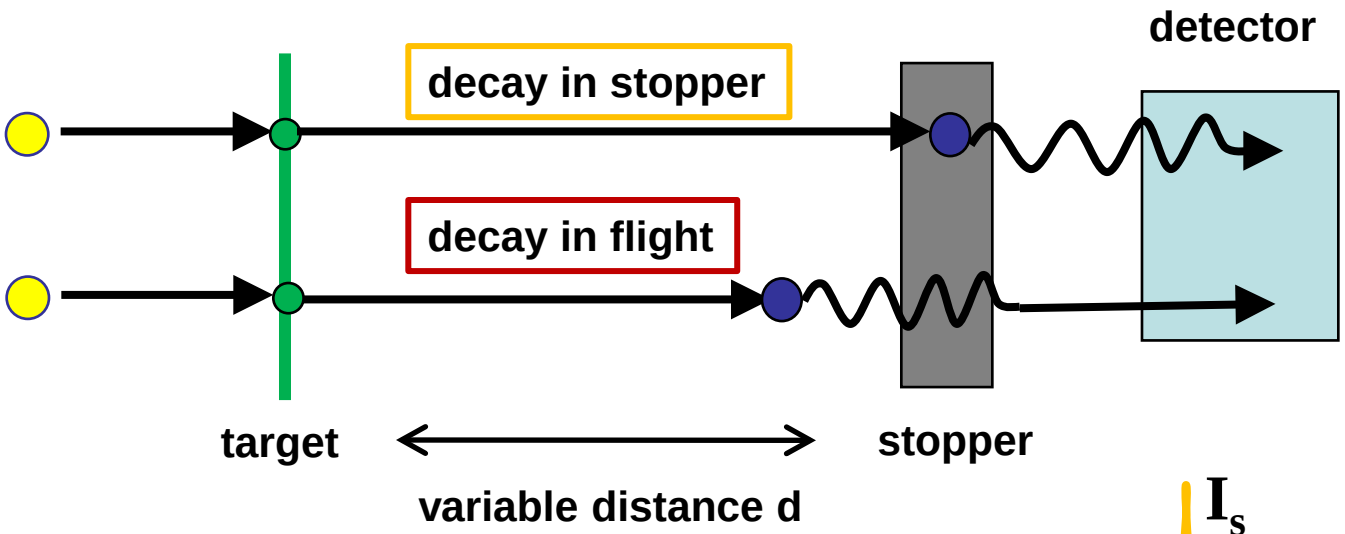
- The nucleus is a mesoscopic quantum system
- Ab initio descriptions are in many cases not feasible
- Symmetry properties reduce the degrees of freedom considerably

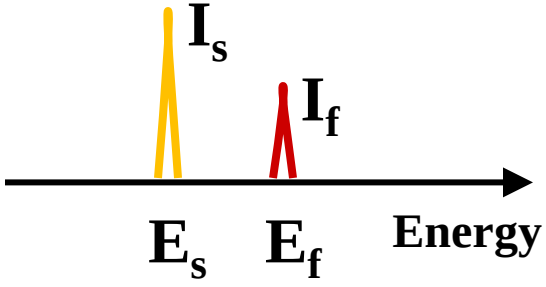
Important observables of excited states:

- Energies
- Spins
- Parities
- Decay patterns
- Lifetimes



Lifetimes: Recoil Distance Doppler Shift Method





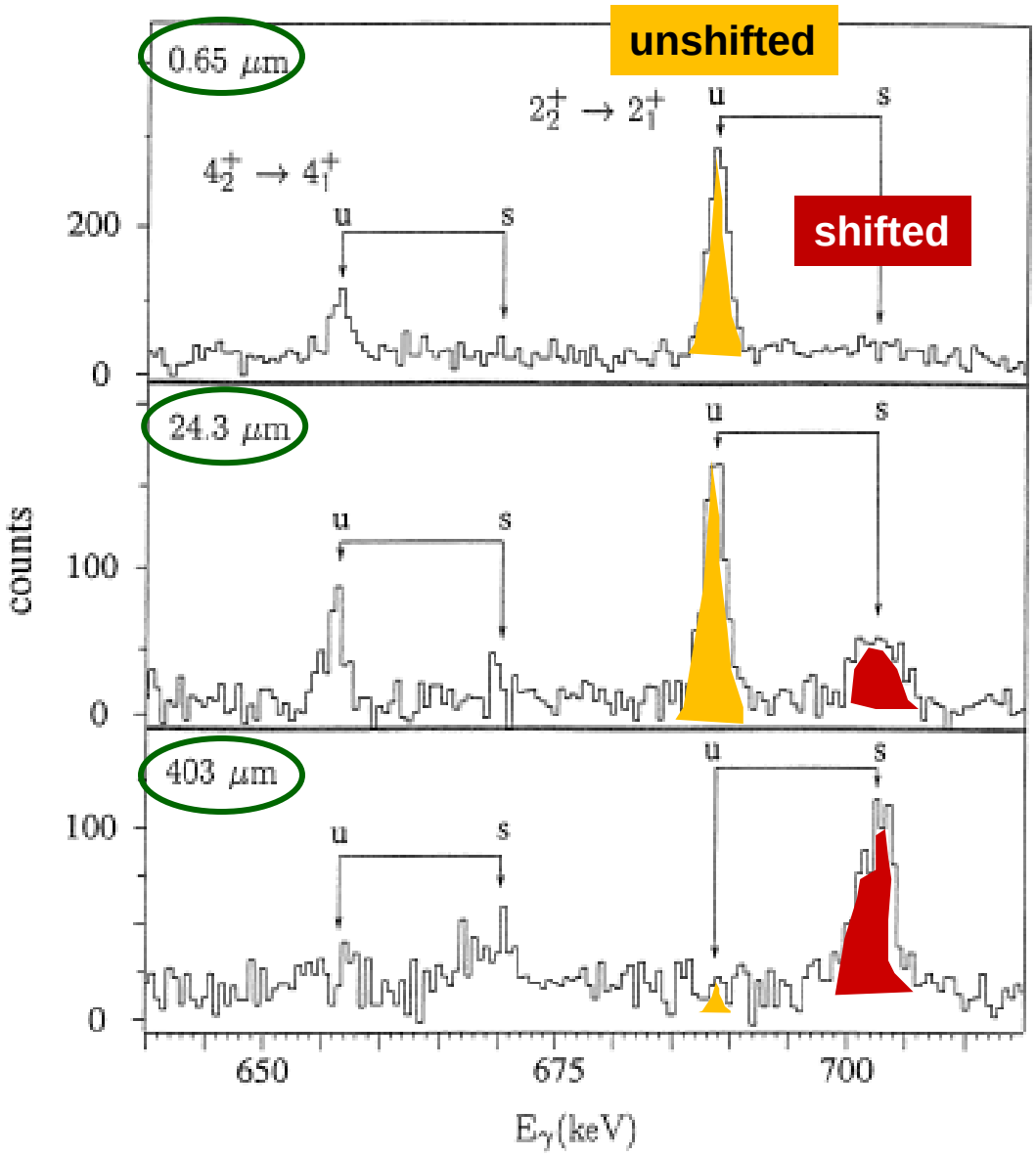
The ratio between decays in stopper and decays in flight depends:
on the distance d,
the lifetime of the excited state τ,
and the recoil velocity v.

Lifetimes: The Cologne Plunger

Lifetime range:
~ ps to ns

Lifetimes: The Cologne Plunger

$^{152}Sm(^{32}S,^{32}S)^{152}Sm$



T. Klug, A. Dewald et al.

Cologne Plunger worldwide

- INFN Legnaro, Italy
- Jyväskylä, Finland
- NSCL/MSU, USA
- Argonne National Laboratory, USA
- GANIL, Caen, France
- Yale University, USA
- IFIN-HH Bukarest, Romania (under construction)
- Demokritos, Greece (planned)

Lifetimes: The Cologne Plunger

PRL 102, 242502 (2009) PHYSICAL REVIEW LETTERS week ending 19 JUNE 2009

Lifetime Measurements of the Neutron-Rich $N = 30$ Isotones ^{50}Ca and ^{51}Sc: Orbital Dependence of Effective Charges in the fp Shell

PHYSICAL REVIEW C 80, 044331 (2009)

First measurement of lifetimes in the yrast band of ^{100}Pd

PHYSICAL REVIEW C 80, 014324 (2009)

Evolution of collectivity in ^{180}Hg and ^{182}Hg

More than 50 publications since 2004

PRL 102, 202502 (2009) PHYSICAL REVIEW LETTERS week ending 22 MAY 2009

Low-Lying Neutron Intruder State in ^{13}B and the Fading of the $N = 8$ Shell Closure

Eur. Phys. J. A 39, 291–294 (2009)
DOI 10.1140/epja/i2008-10724-1

THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Experimental Physics

Lifetime measurement in ^{195}Po

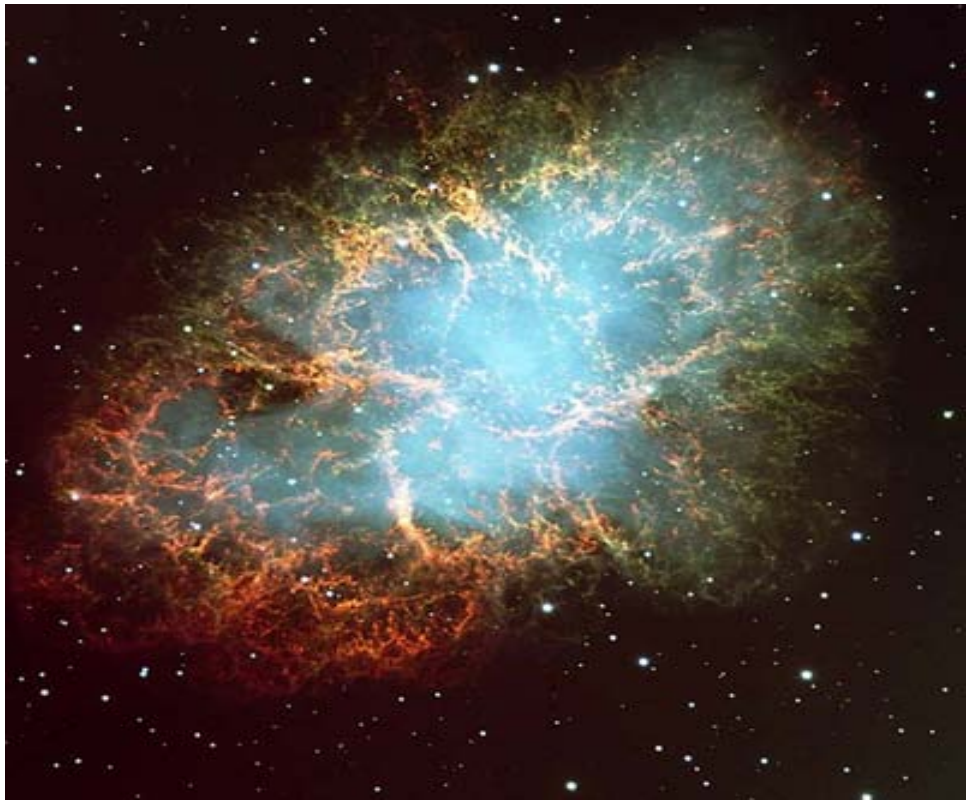
Nuclear Astrophysics

What is the origin of energy and radiation in our universe?

How were and are the chemical elements synthesized?

Ingredients:

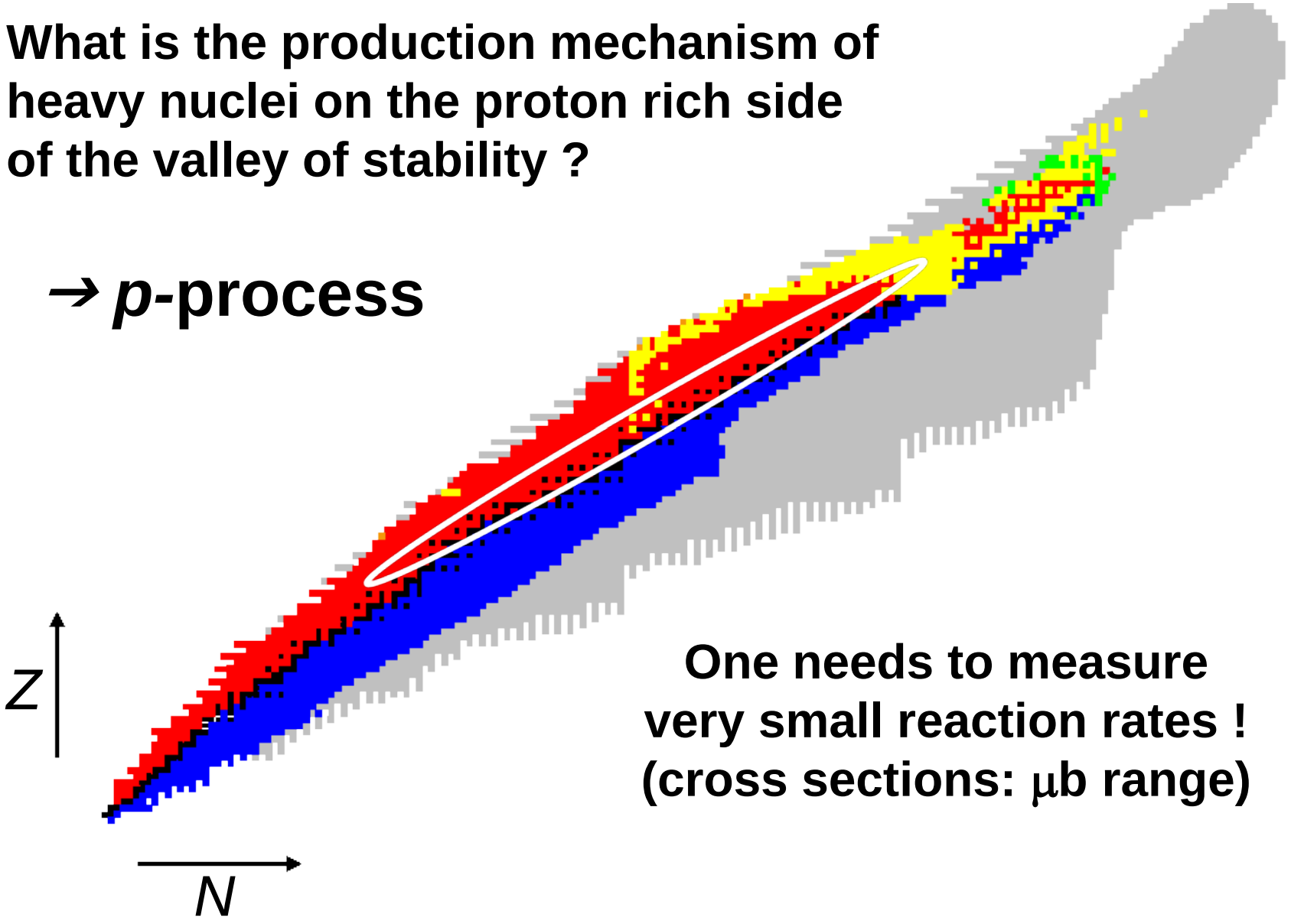
- **Astrophysics**
- **Nuclear Physics**



Synthesis of Nuclei

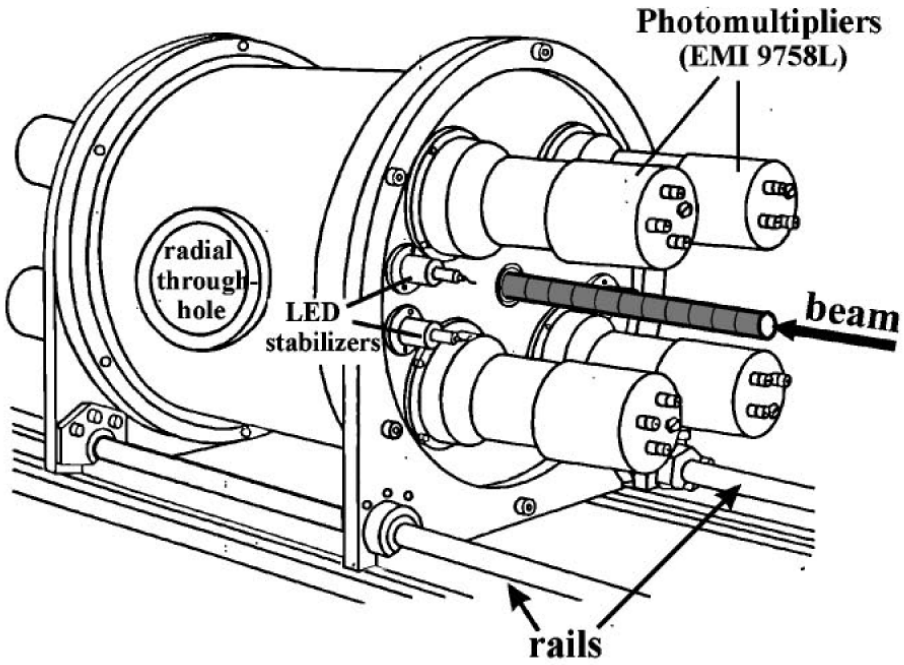
What is the production mechanism of heavy nuclei on the proton rich side of the valley of stability ?

→ *p*-process



One needs to measure very small reaction rates ! (cross sections: μb range)

In beam experiments using a NaI crystal



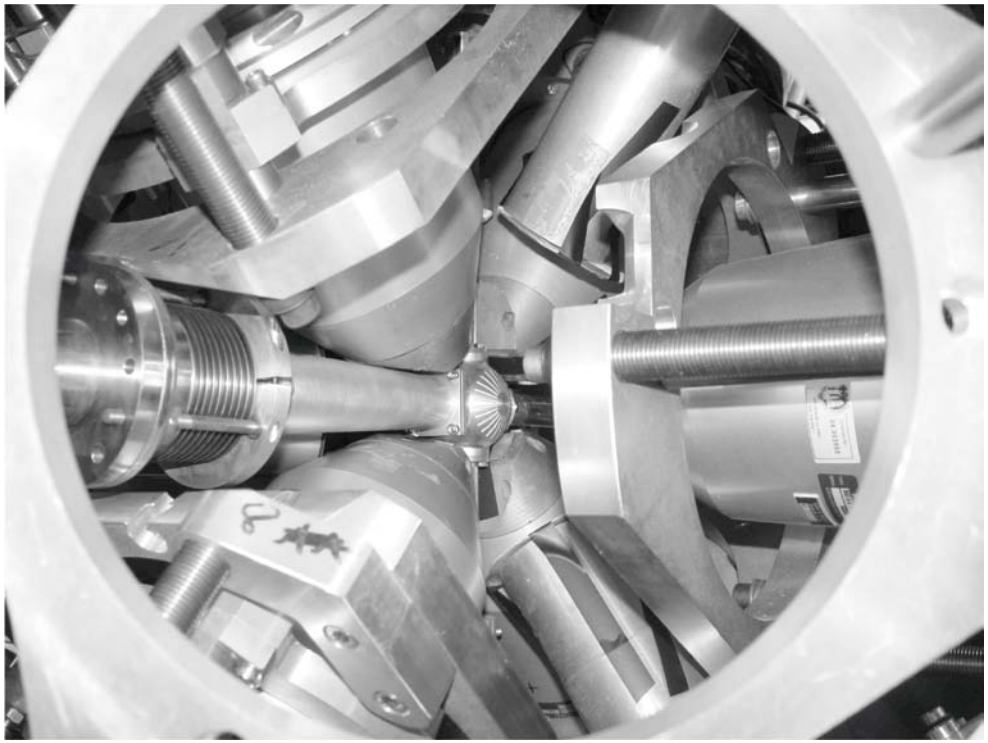
e.g.: P. Tsagari et al., PRC 70 (2004) 015802

+ Very high efficiency

+ „simple“ data evaluation

- No detailed information

In beam experiments using HPGe detectors

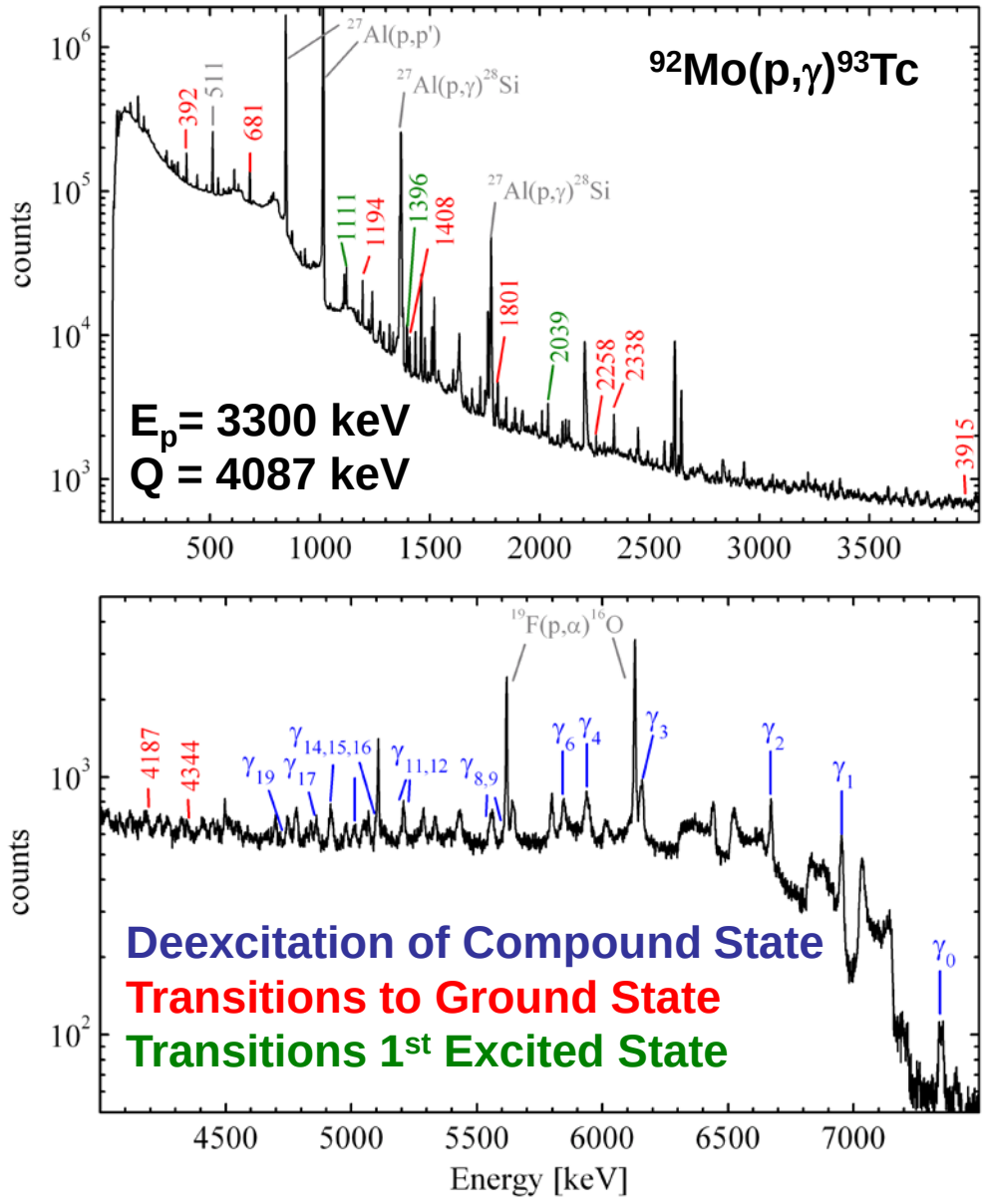


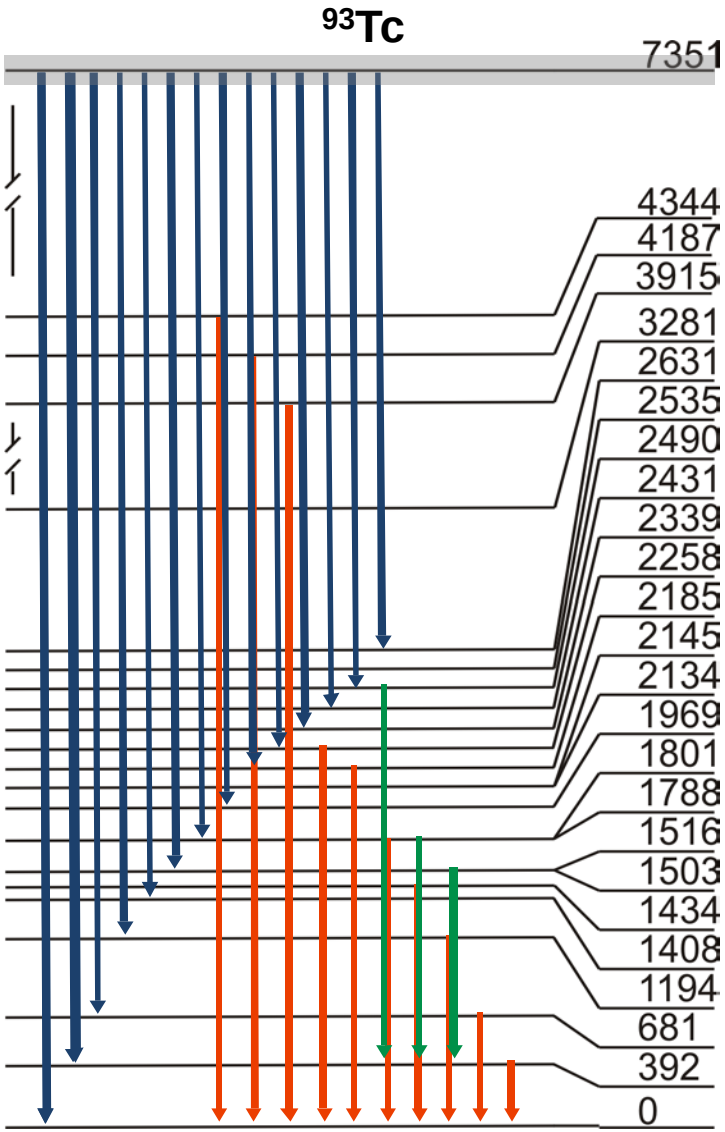
HORUS @ IKP Köln:

- **14 HPGe detectors in close geometry**
- **Photopeak efficiency at 1332 keV: up to 5%**

- **High energy resolution to observe single transitions**
- **Adequate efficiency to study low cross sections**
- **Determination of angular distributions possible**
- **Coincidence technique to suppress background**

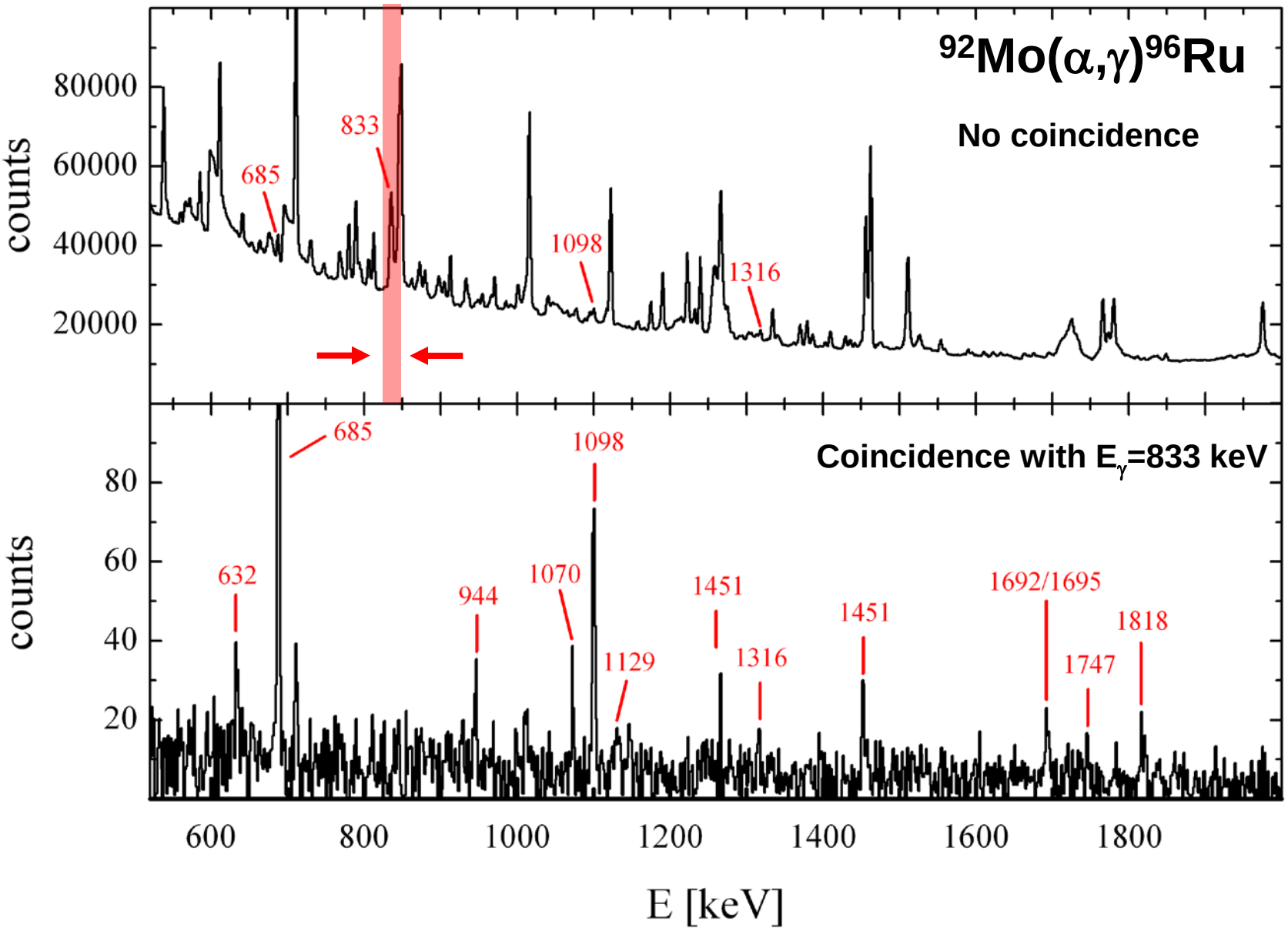
Radiative proton capture on ^{92}Mo





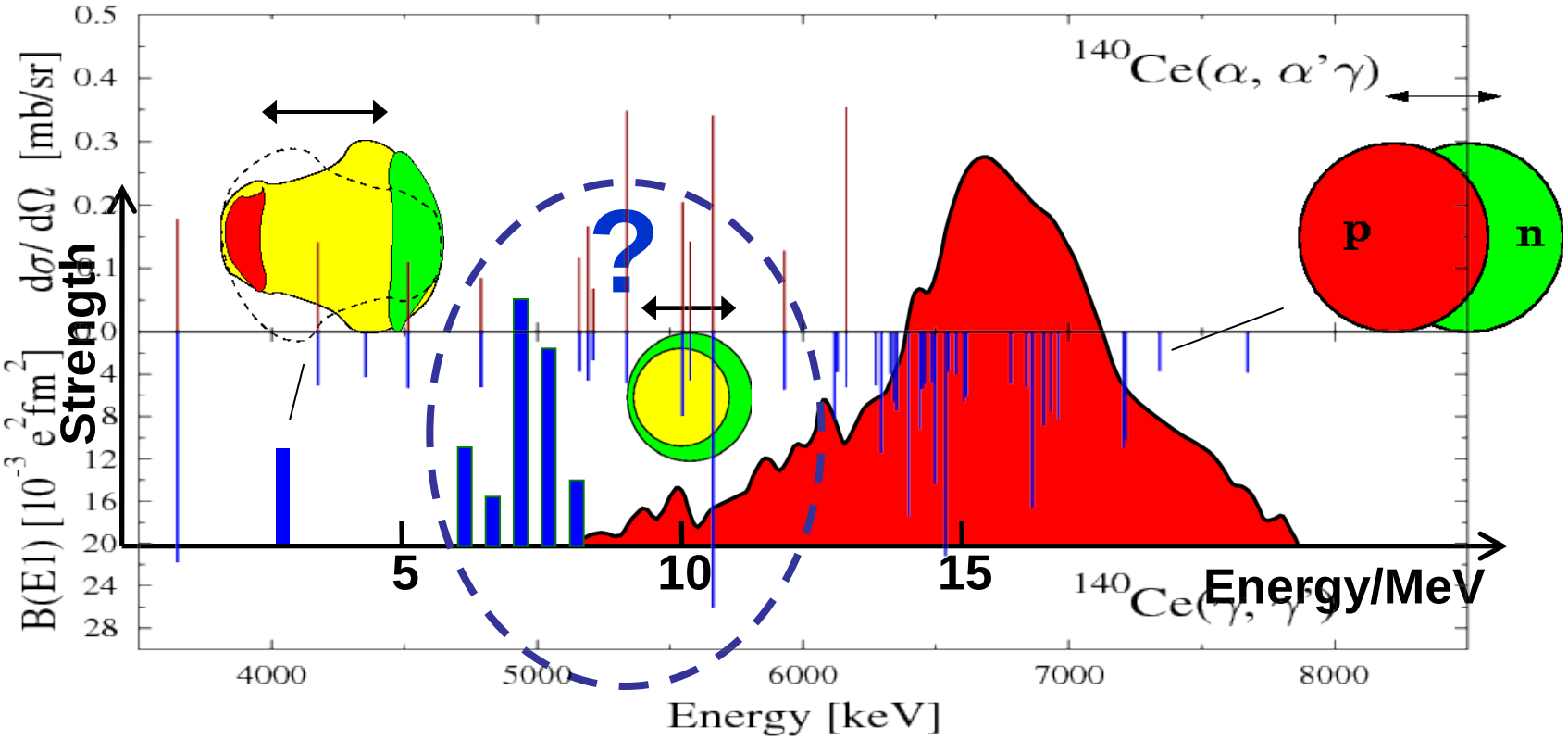
Production of 1st excited state

Background suppression with coincidence techniques



Collaboration LIBRA – IKP Köln

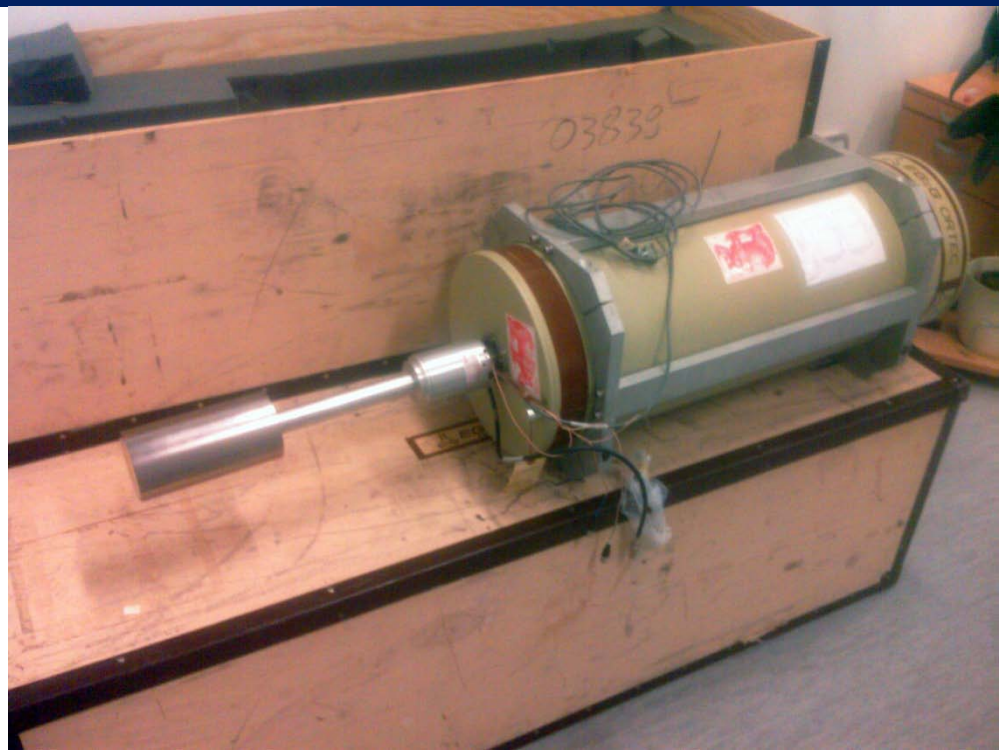
Study of the Pygmy Dipole Resonance in (α,α'γ) and (γ,γ') experiments



Collaboration LIBRA – IKP Köln

„Stuttgart“
HPGe detector pool

- 3 x 100% HPGe detectors
- 1 x 80% HPGe detector
- BGO shields
- Electronic modules



TECHNISCHE UNIVERSITÄT MÜNCHEN

TECHNISCHE UNIVERSITÄT DARMSTADT

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