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HPGe irradiation test and hyperatom experiment

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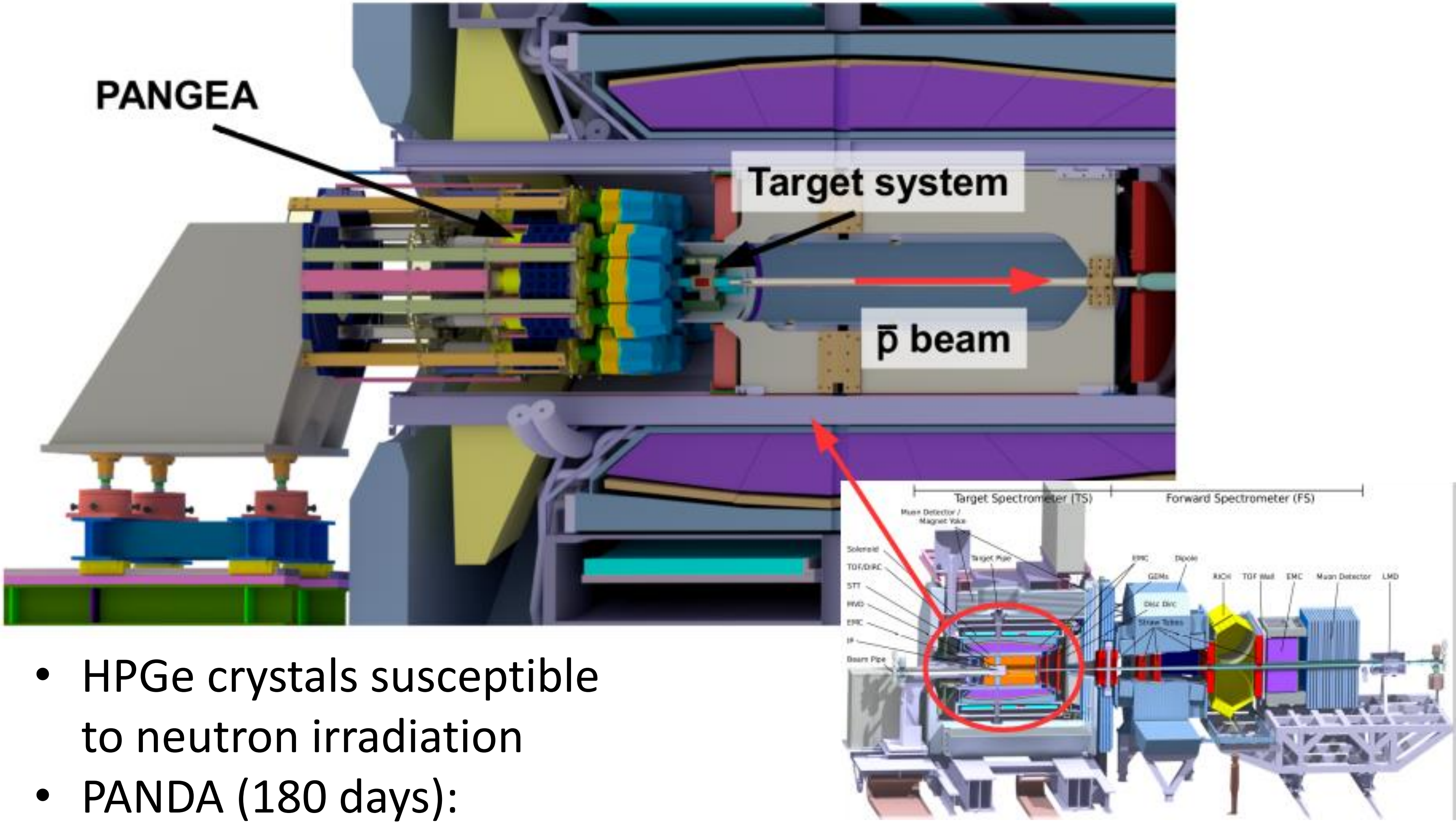
Outline

- HPGe Irradiation test at COSY
- Feasibility studies of the hyperatom experiment

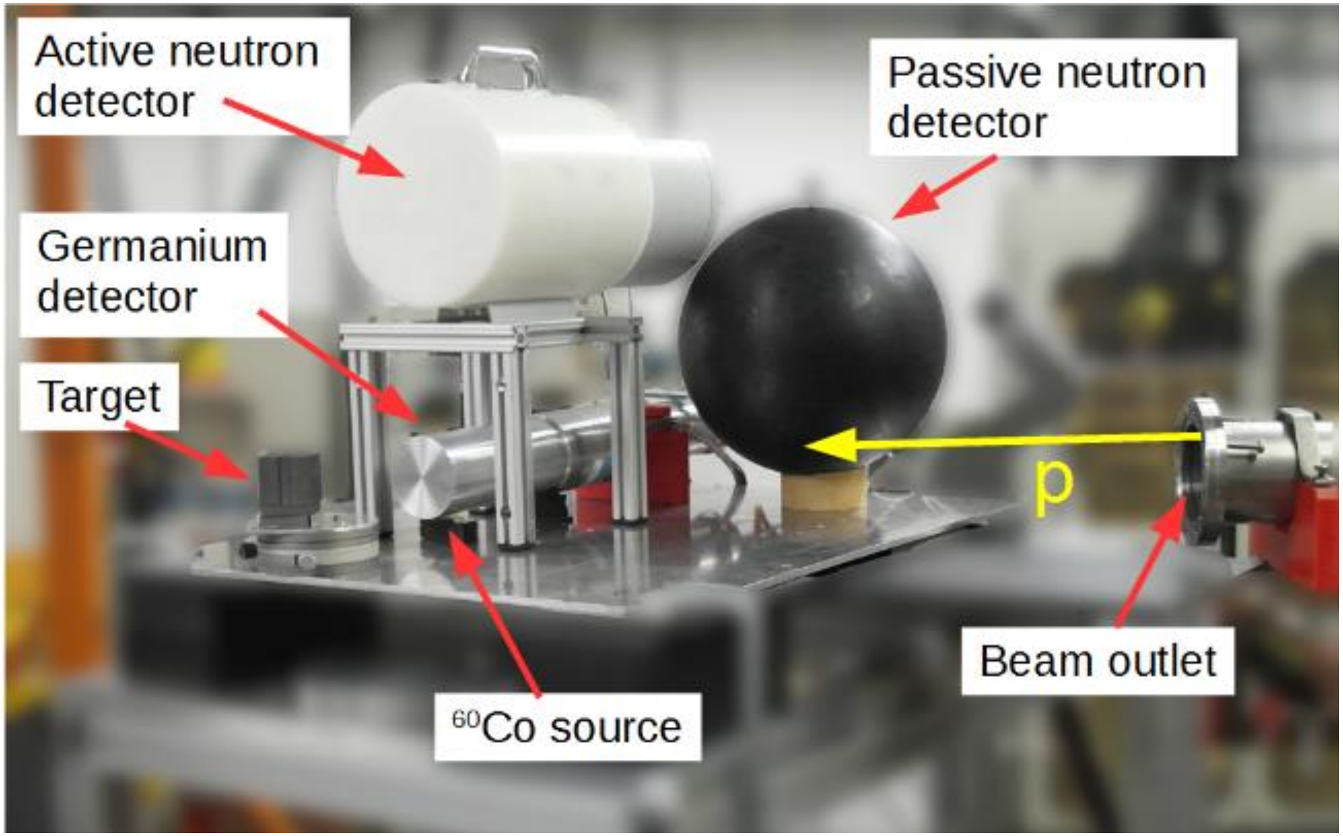
HPGe Irradiation test at COSY

PANGEA in PANDA



- HPGe crystals susceptible to neutron irradiation
- PANDA (180 days):
  n fluence ≈10^{10} n/cm^2

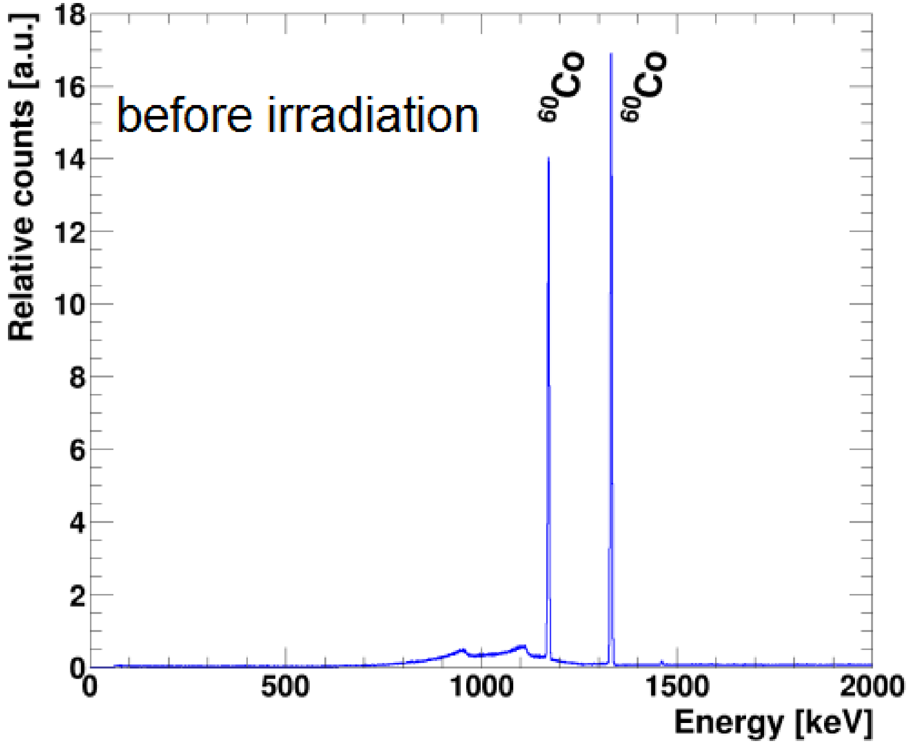
HPGe irradiation test

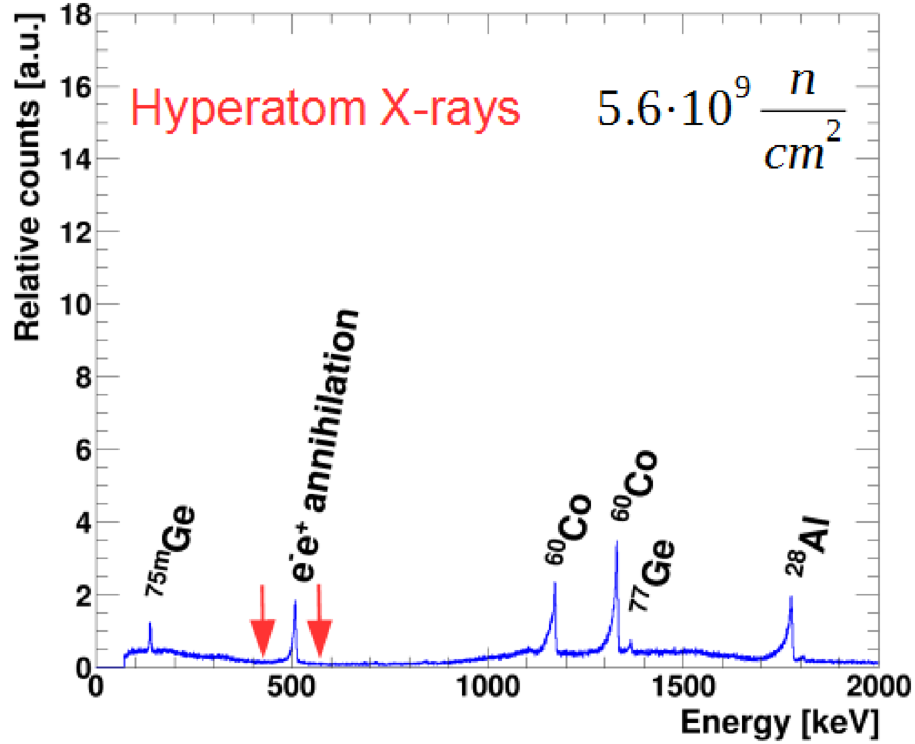


- Irradiation test at COSY with single crystal prototype
- 5.5 days COSY

  → 96 days PANDA

Influence on spectrum of ^{60}Co



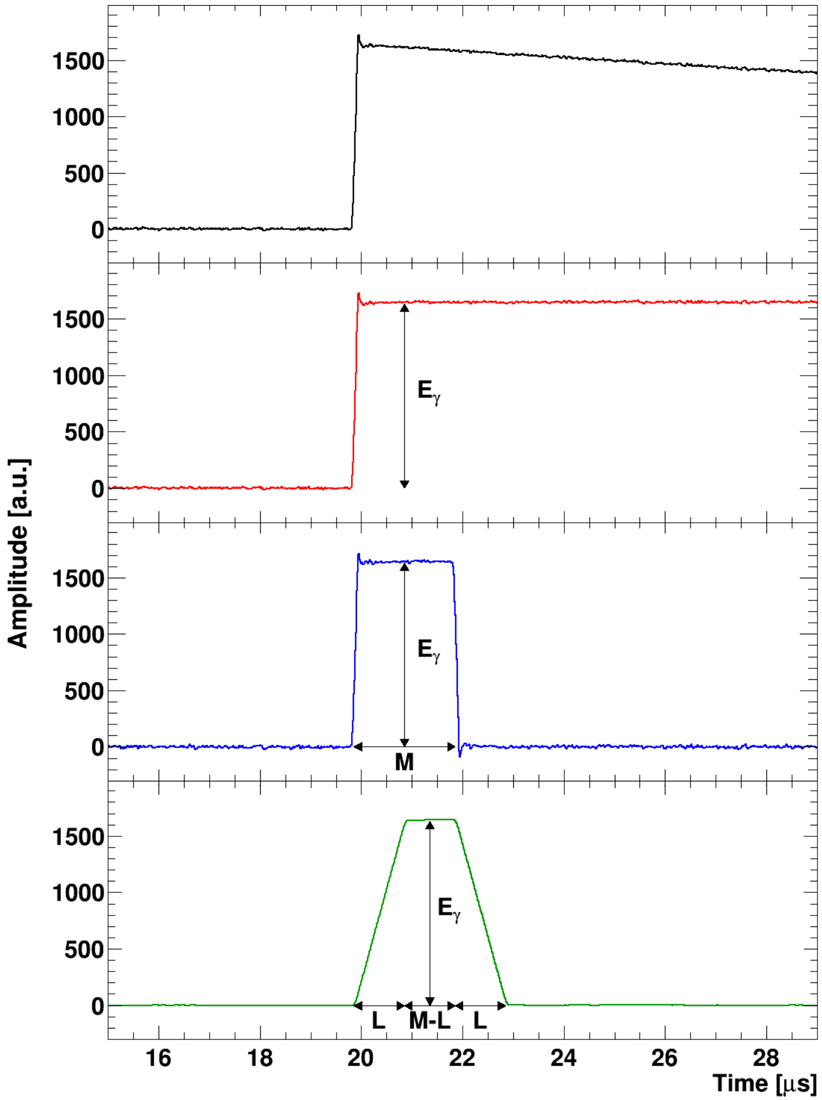


- Additional lines; enhanced compare to PANDA
- Line shape changes: Low energy tails, worse resolution
- Pulse shape analysis (PSA) allows partial recovery

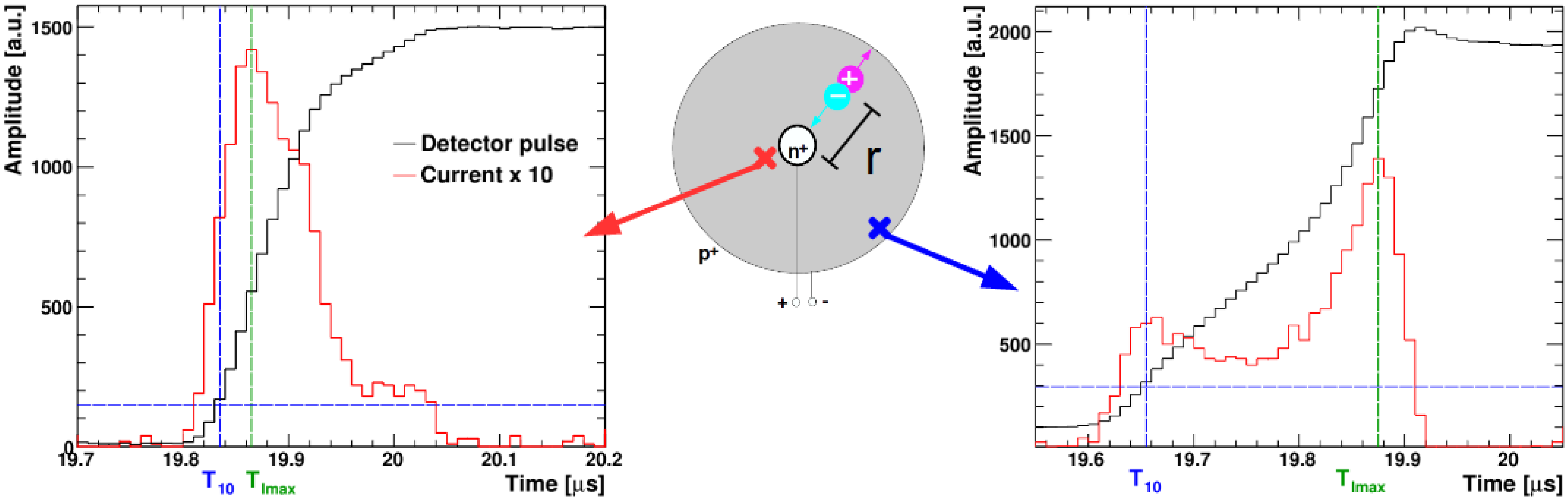
PSA: Moving window analysis

- Digital pulse processing via moving window deconvolution
  M. Lauer, http://doi.org/10.11588/heidok.00004991
  - Deconvolution
  - Numerical differentiation
  - Moving average (low pass)

- Increased rate capabilities
  → Pile-up handling

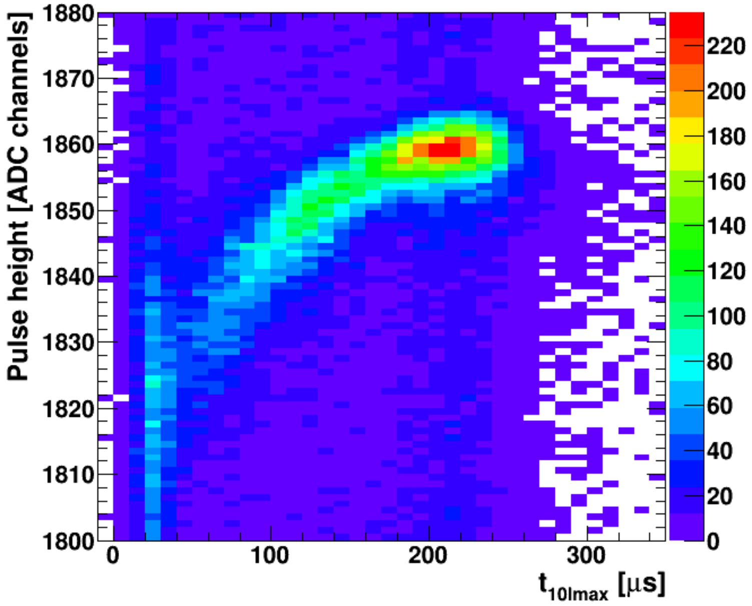


Radiation damage correction

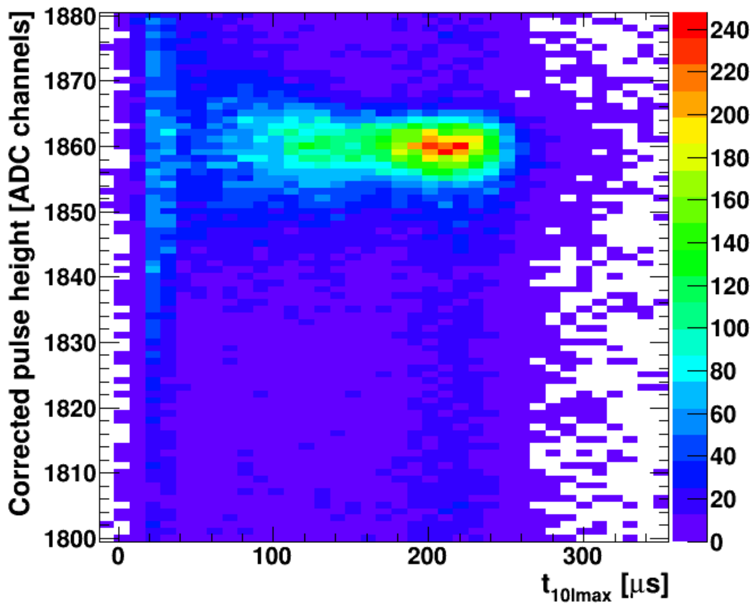


- Low energy tails cause by trapped holes
- Trapping prob. depends on path length of holes
- Analysis of rising edge of detector signal
  → Radial interaction point

Effect of Corrections

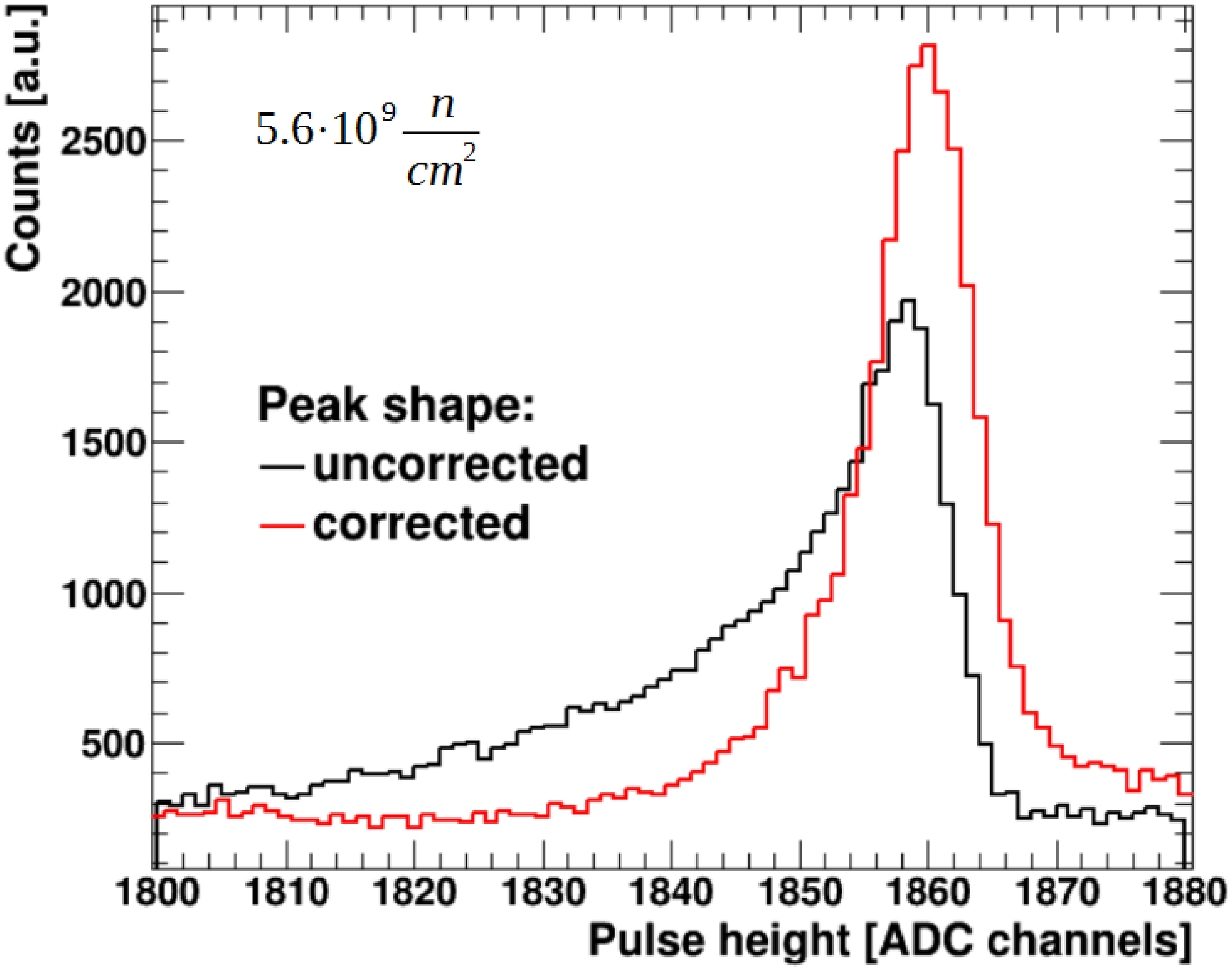


No correction



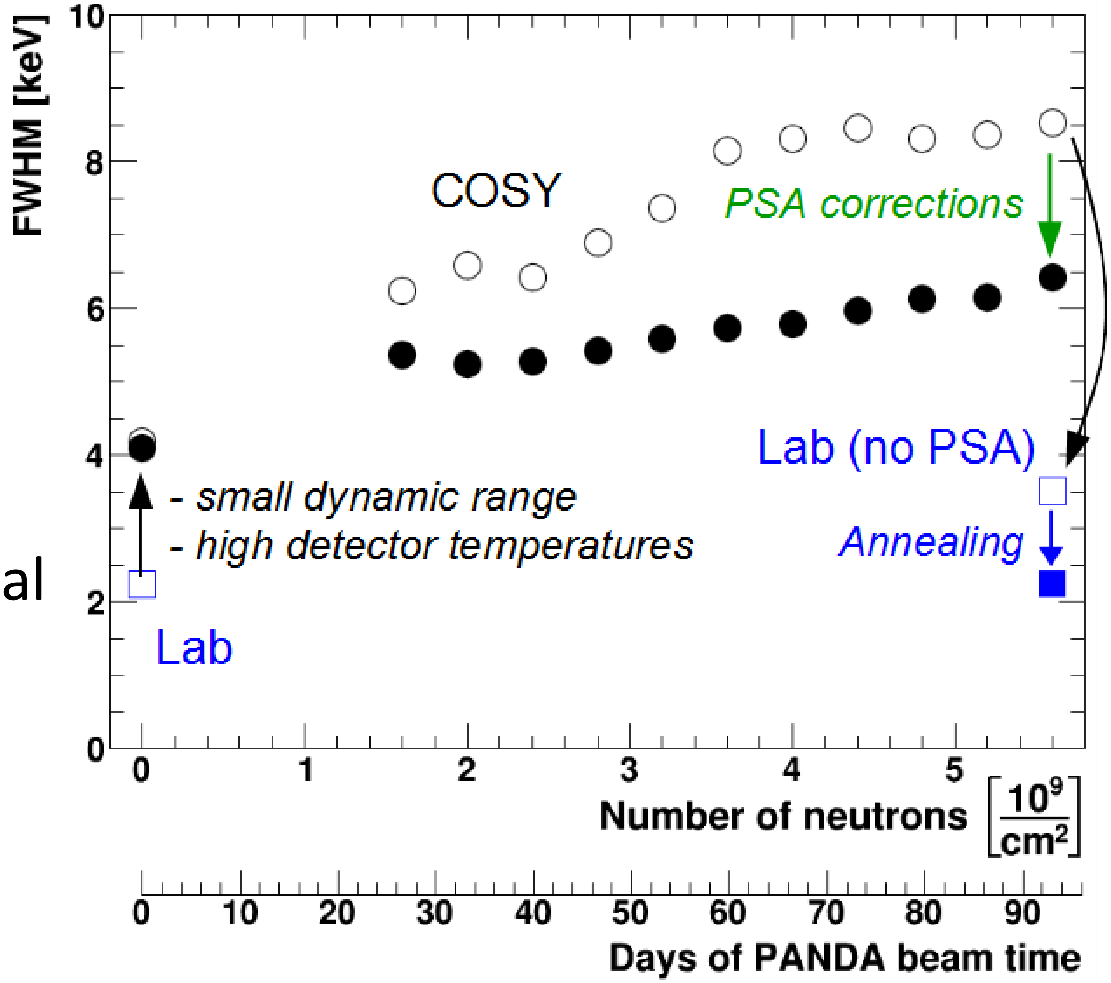
After correction

Gaussian shape recovery



Results

- DAQ and therm. issues decrease performance
- PSA allows partial resolution recovery
- Annealing recovers initial crystal performance
  → Detector withstands irradiation
- New systematic test: TRIGA reactor (2019/20)



Feasibility studies of the hyperatom experiment

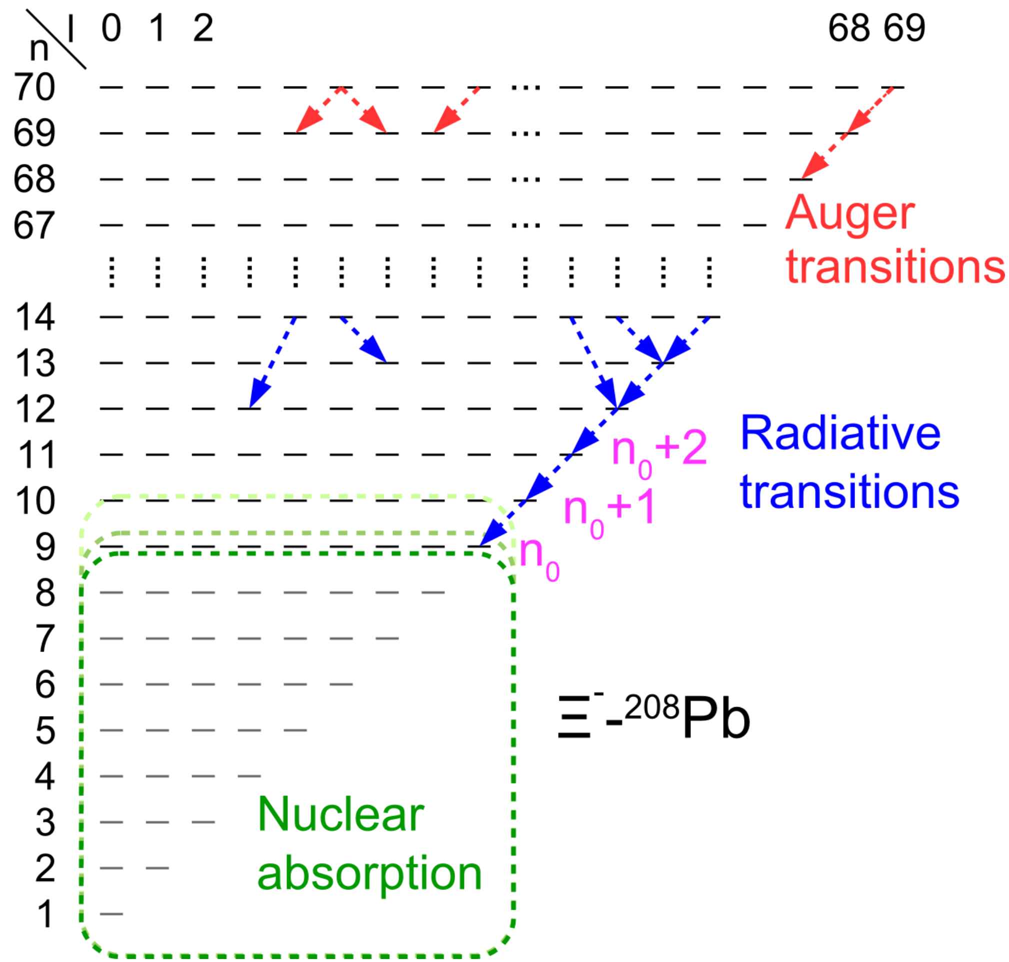
Hyperatoms

- Hyperon puzzle in neutron stars
- $m_{red,\Xi} \approx 2570\ m_{red,e}$
- High initial (n,l) states
- X-ray energy to keV-MeV

  → Germanium detectors
- Radius of states: $r \propto \frac{n^2}{m_{red}}$

  → Nuclear interaction in neutron rich periphery

  → Measurement of V_Ξ



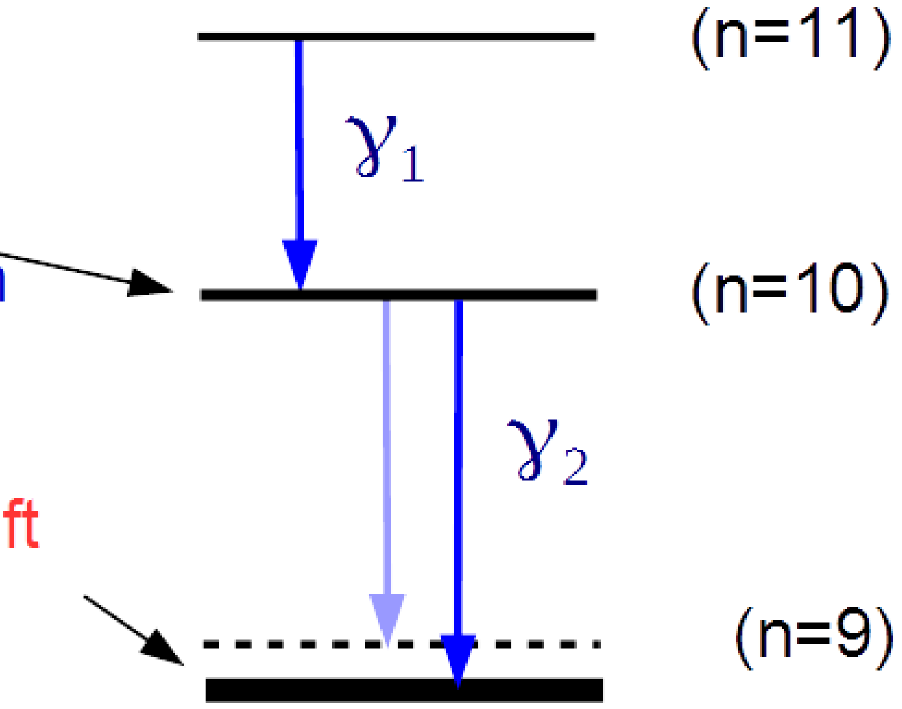
Adaptation from T. Aramaki et al Astroparticle Physics 49 (2013), pp. 52-62

Observables

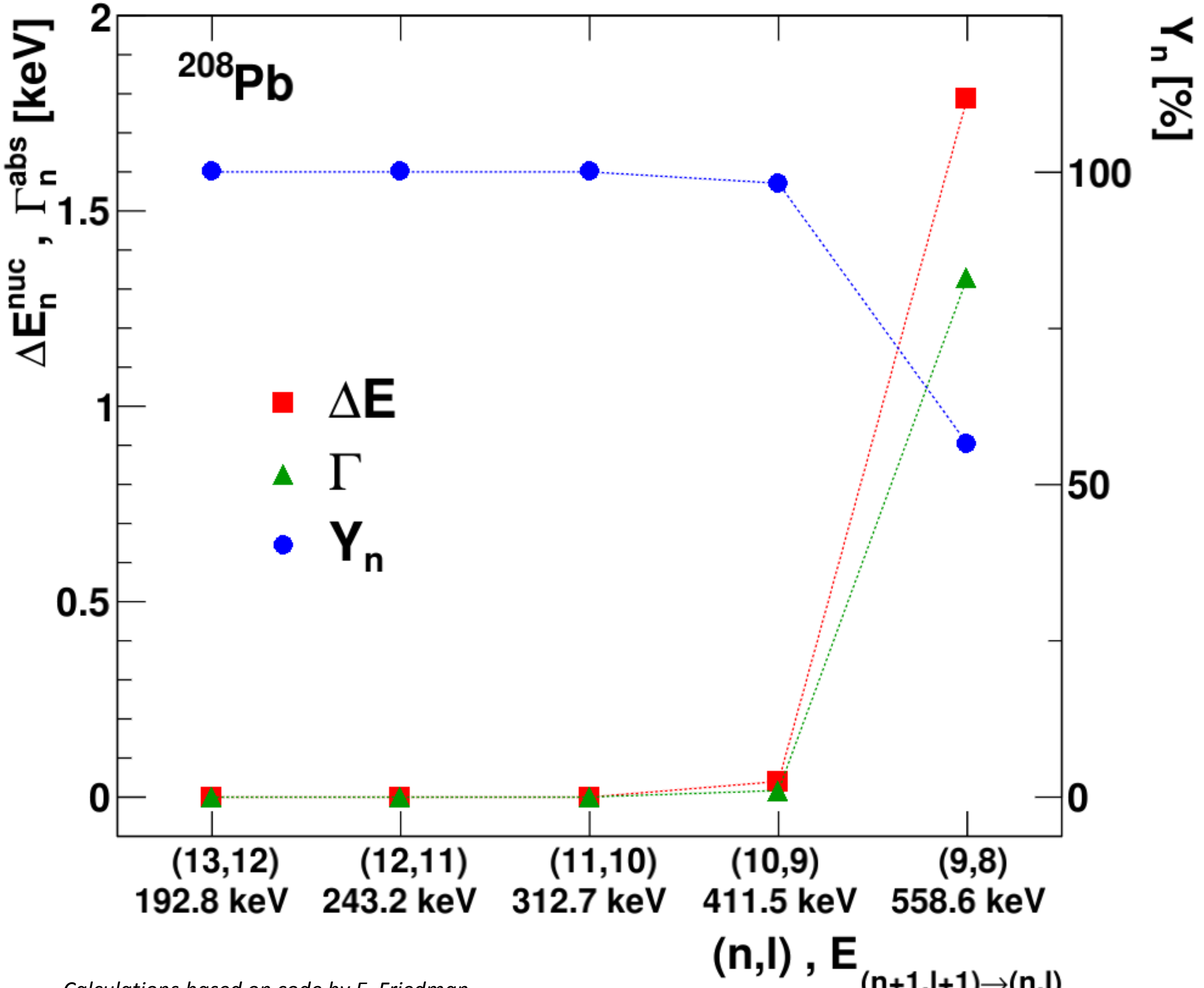
$\Gamma^{abs}_{n_0+1} \rightarrow Y_{\gamma_2}$ Nuclear absorption

$\Delta E^{nuc}_{n_0}$ Strong shift

$\Gamma^{abs}_{n_0}$ and width



Ξ^- - ^{208}Pb observables



Calculations based on code by E. Friedman

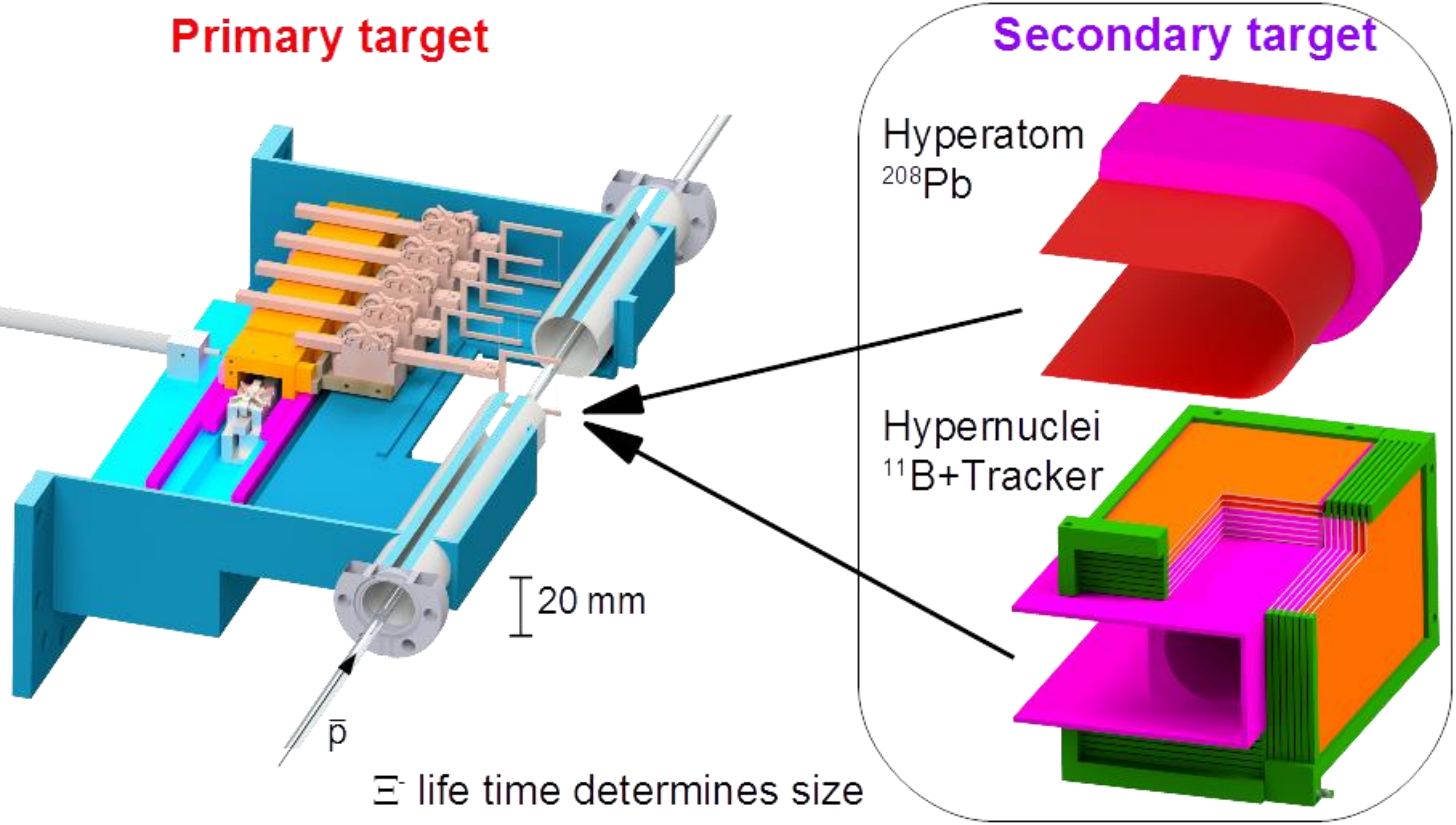
(9,8):

1.83 keV

1.33 keV

56.5 %

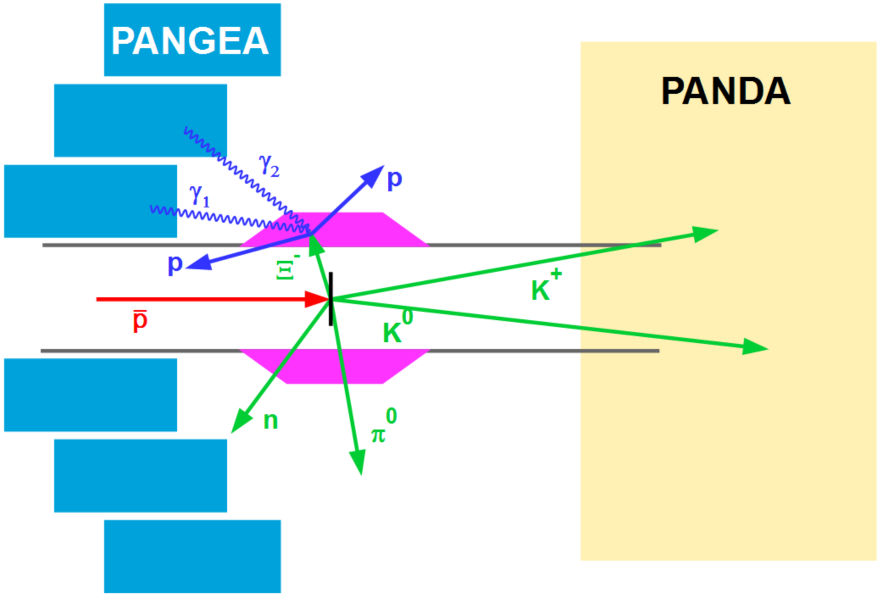
Production: Target system

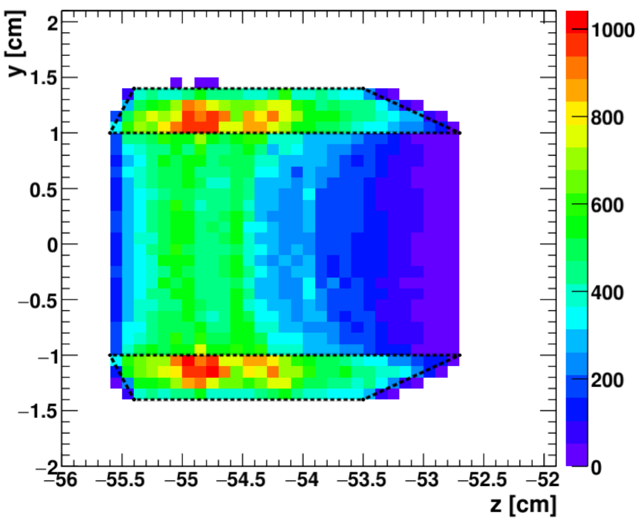


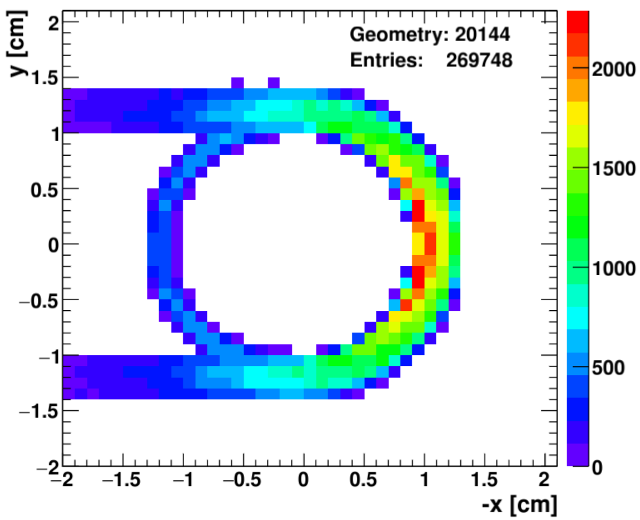
Secondary target

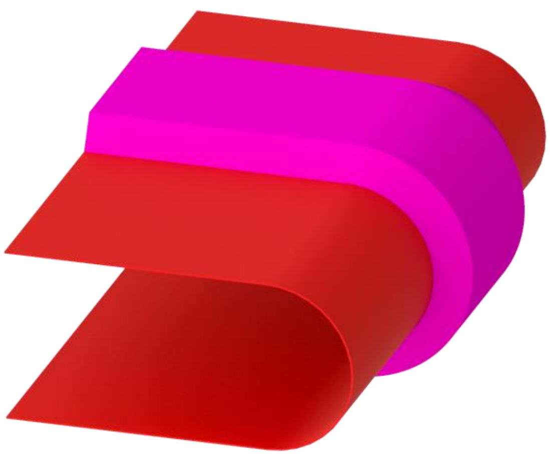
- Split target system unique
  -> heavy targets possible

- Optimization
  – Max. Ξ⁻ stopping
  – Min. X-ray absorption



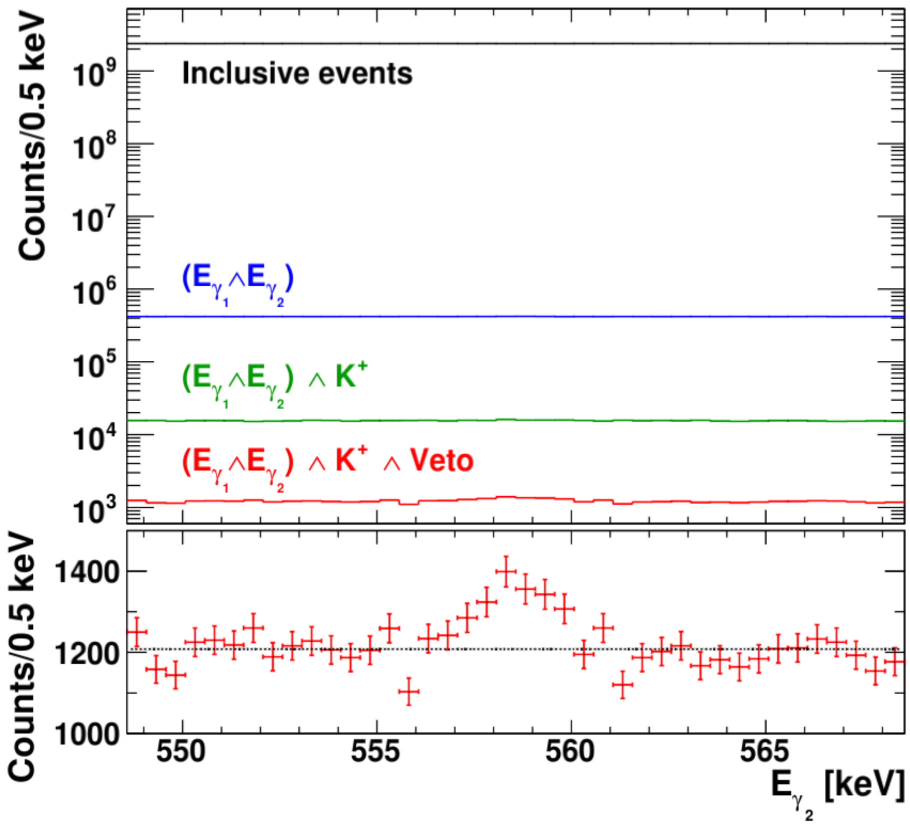


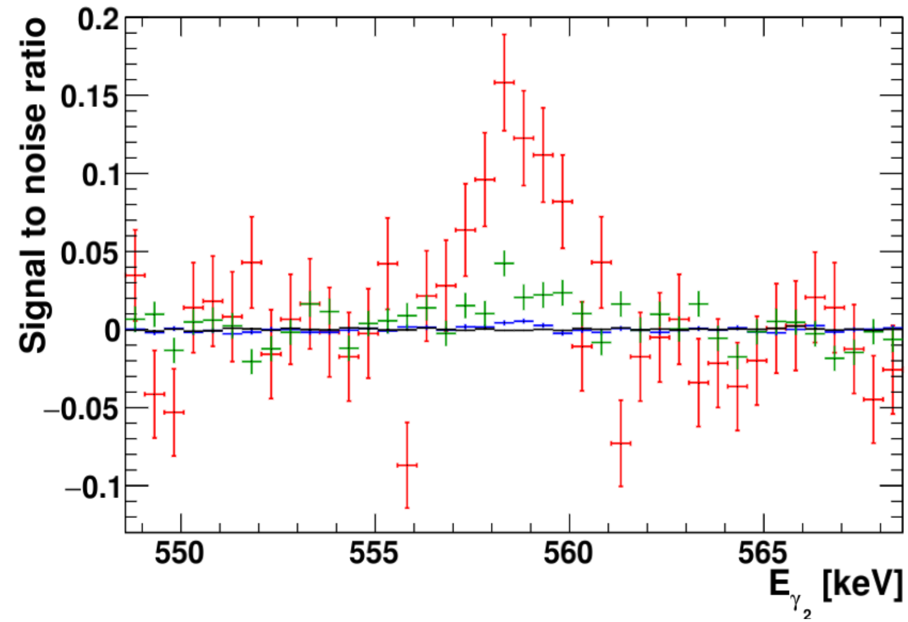


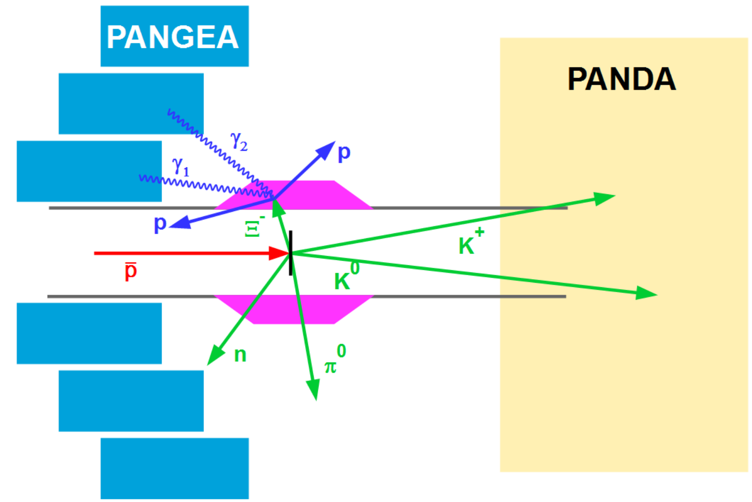


Based on events generated in GiBUU

Event selection

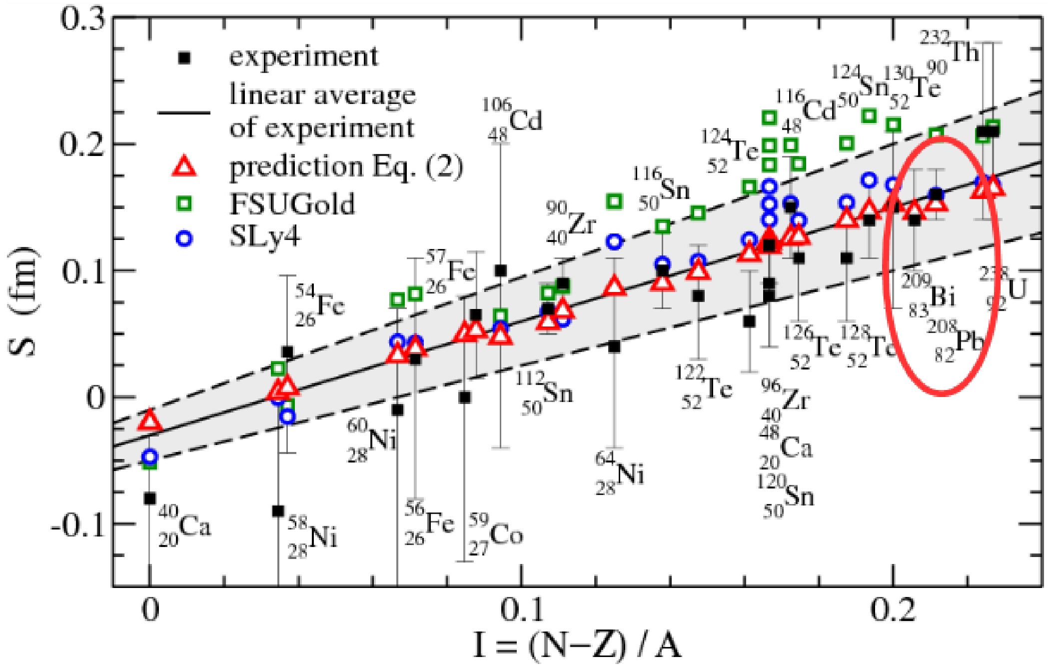




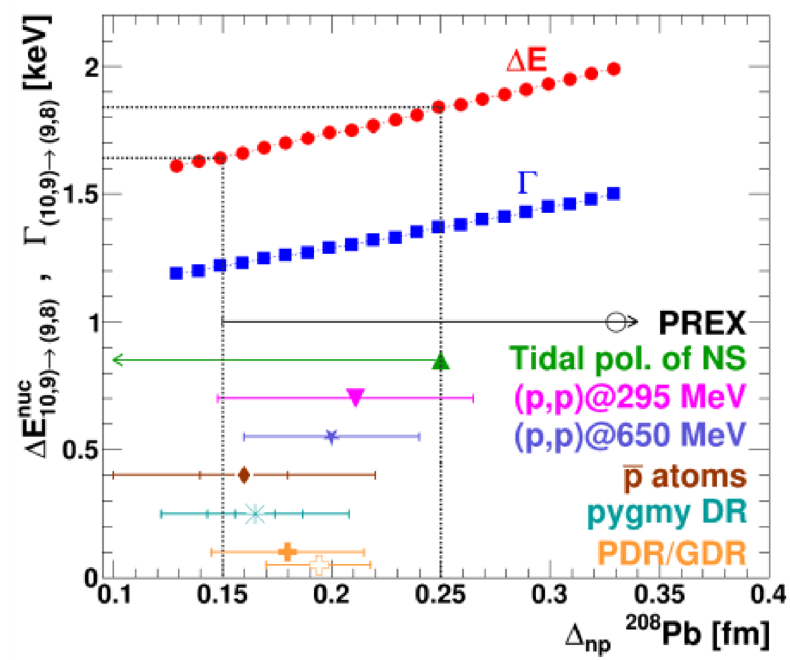


- Signals after cuts (180 days): 1237
- Signal efficiency: 0.9 %
- Background suppression : $2 \cdot 10^6$

Systematics

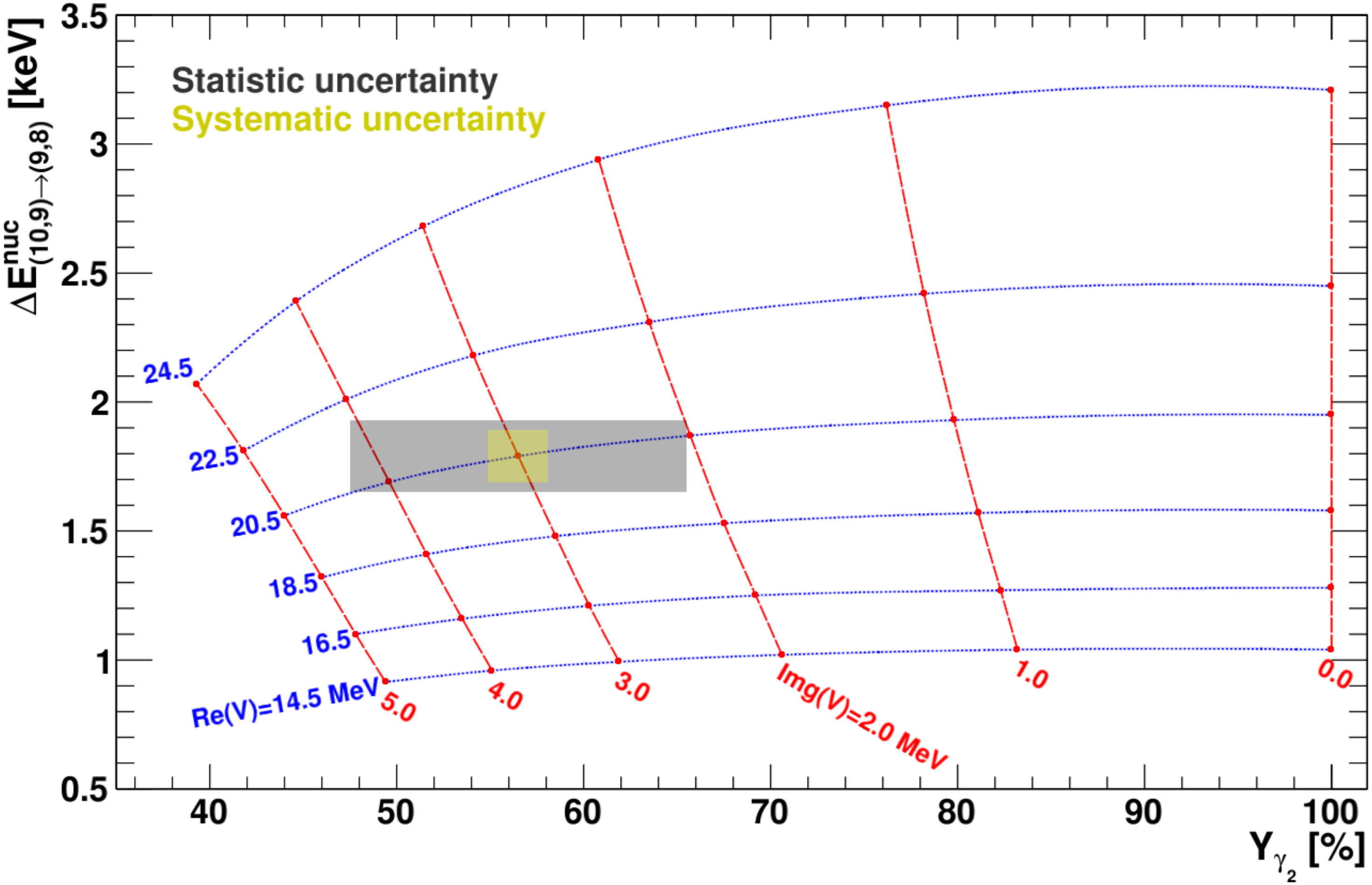


Centelles et al., Phys.Rev.Lett. 102 (2009) 122502



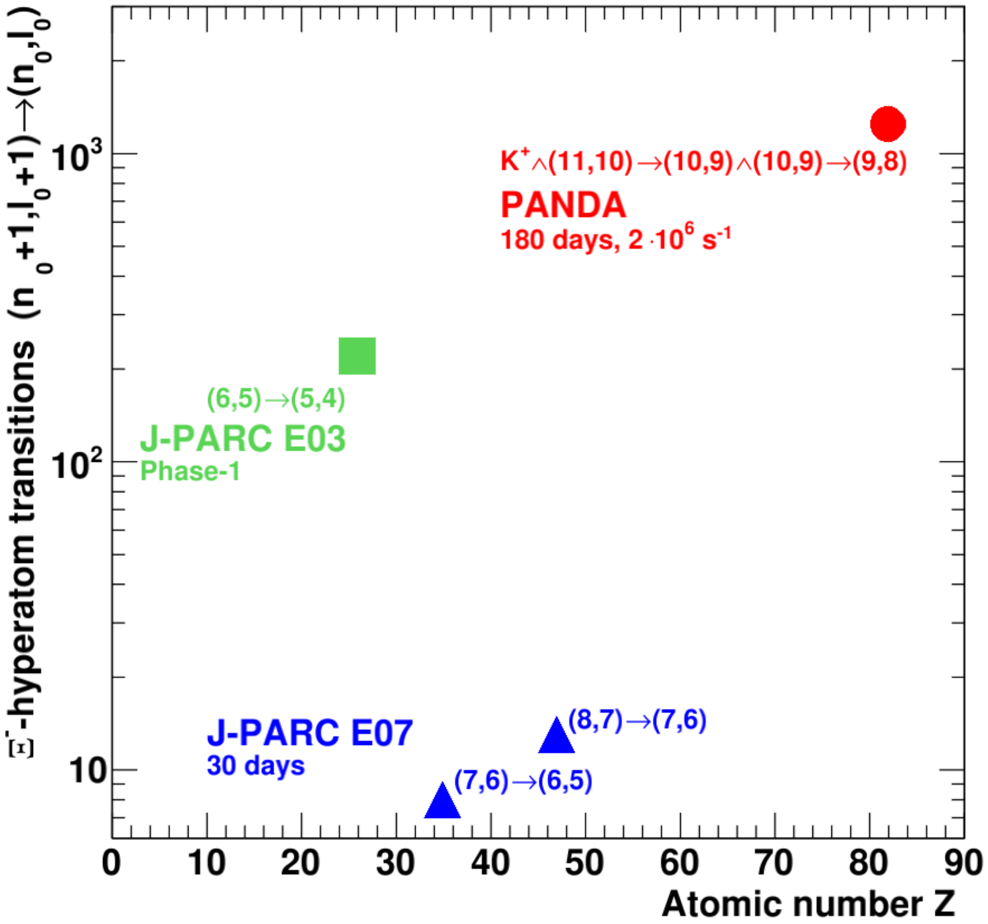
- Dominated by uncertainty of nuclear shape
- High precision calibration via ^{152}Eu

Predictions



$$\delta(\mathrm{Re}(V_{\Xi})_{stat} \approx \delta(\mathrm{Im}(V_{\Xi})_{stat} \approx 1\ \mathrm{MeV}$$

Experimental Landscape



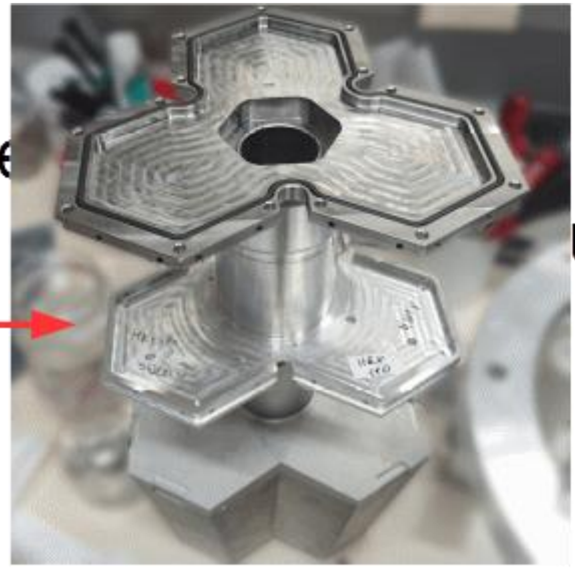
Summary

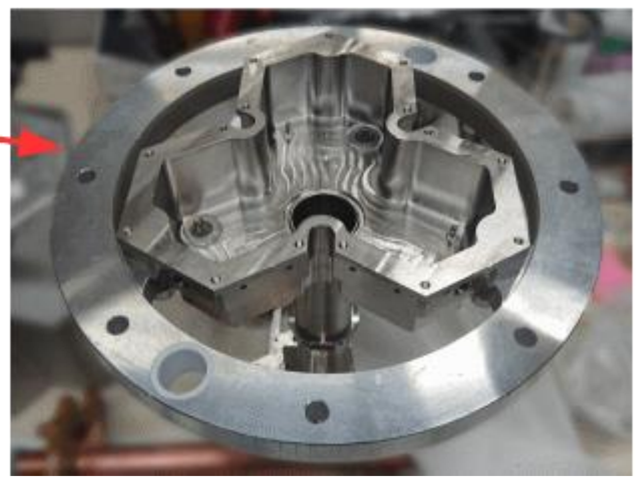
- Promising irradiation test at COSY
  - PSA allows partial recovery of radiation damage
  - Improvements at TRIGA in 2019/2020
- ^{208}Pb hyperatoms allow to study Ξ^- optical potential in neutron rich matter
  - Heavy hyperatoms unique at PANDA
  - Higher rates than experiments at J-PARC
  - $\delta(\mathrm{Re}(V_\Xi)_{stat} \approx \delta(\mathrm{Im}(V_\Xi)_{stat} \approx 1\ \mathrm{MeV}$
  - Further improvement possible by more sophisticated cuts

Thanks for your attention

Backup Slides

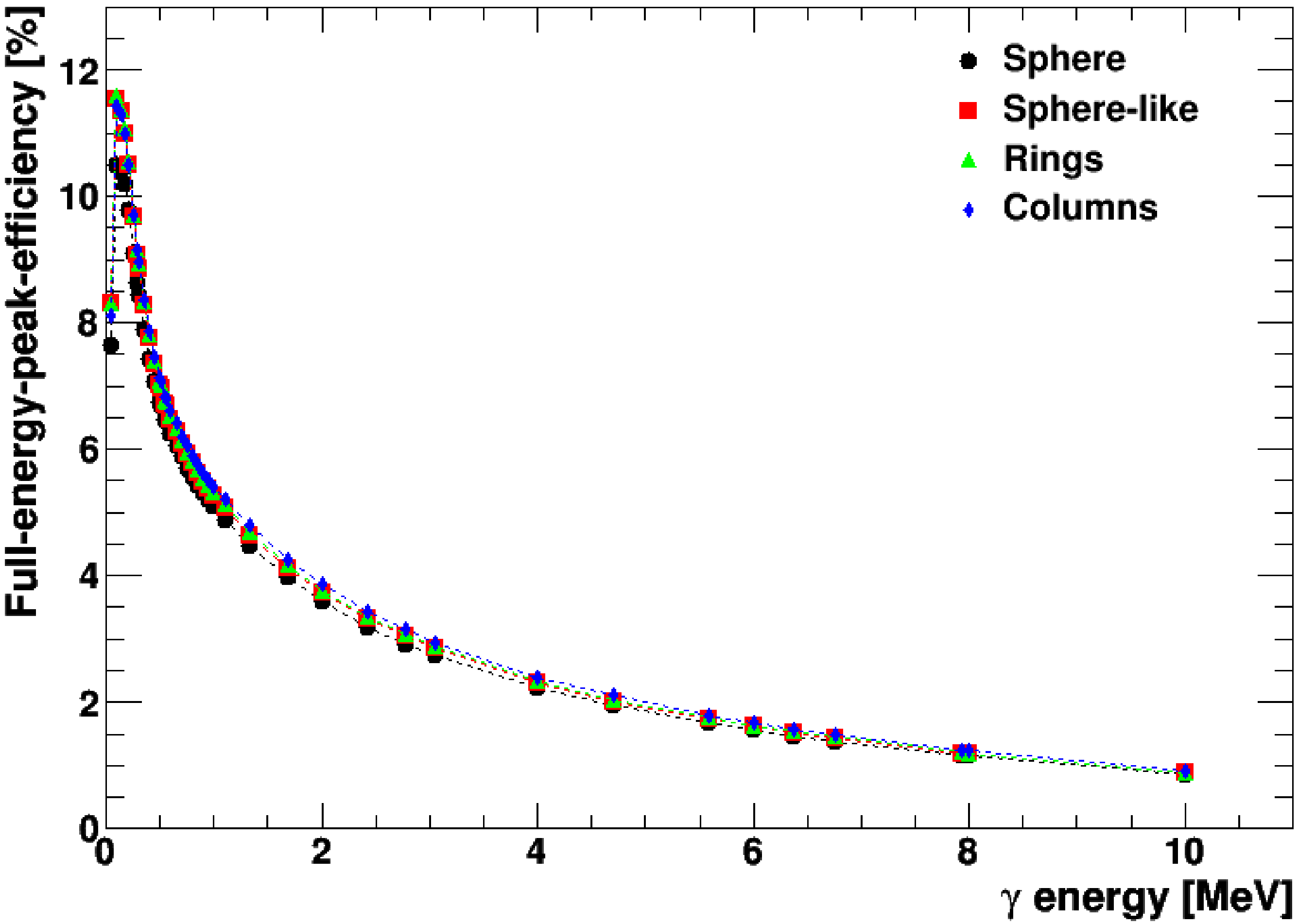
- Klicke … durch Klicken



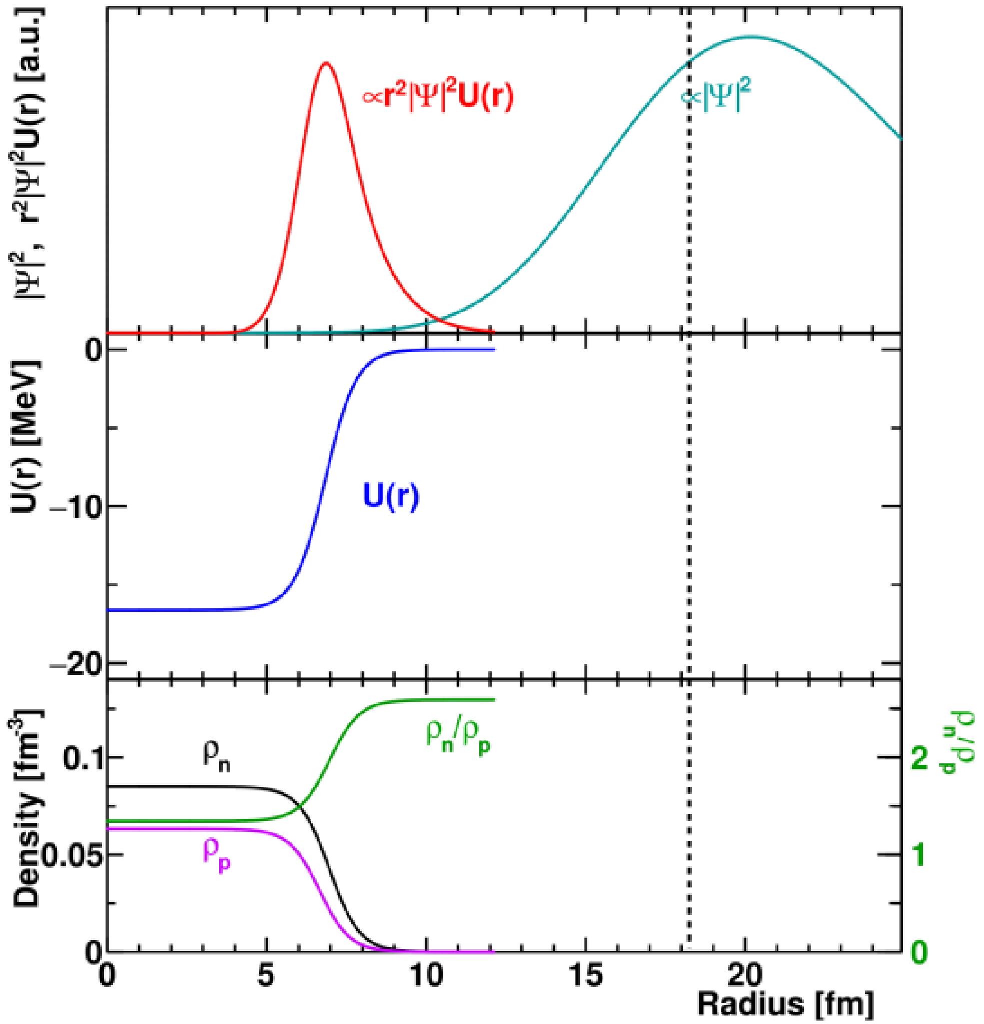


Courtesy of I. Kojouharov

FEP-efficiency PANGEA

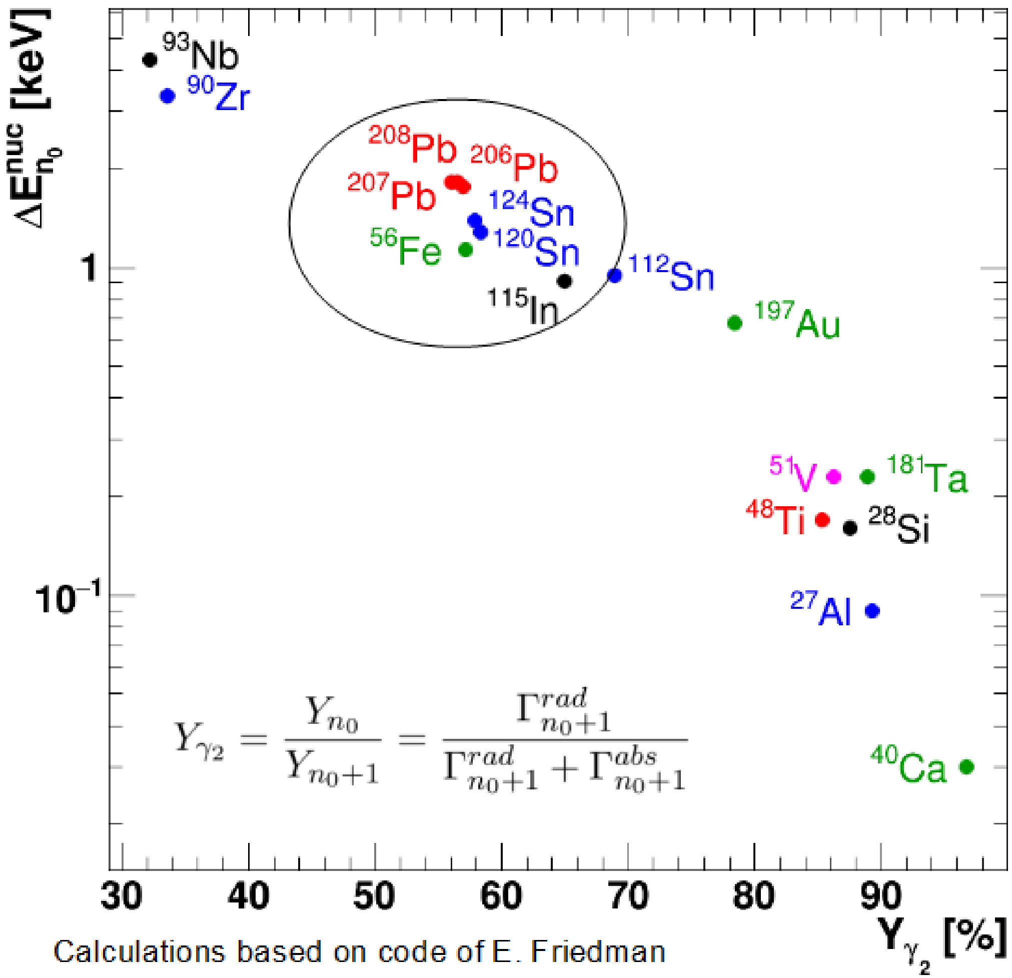


Ξ⁻ - ²⁰⁸Pb



|Ψ|², r²|Ψ|²U(r) [a.u.]
∝r²|Ψ|²U(r)
∝|Ψ|²
U(r) [MeV]
0
−10
−20
U(r)
Density [fm⁻³]
0.1
0.05
0
ρn
ρp
ρn/ρp
2
1
0
0
5
10
15
20
Radius [fm]

Absorber materials - observables



Calculations based on code of E. Friedman