A high resolution germanium detector array for hypernuclear studies at $\bar{P}$ANDA

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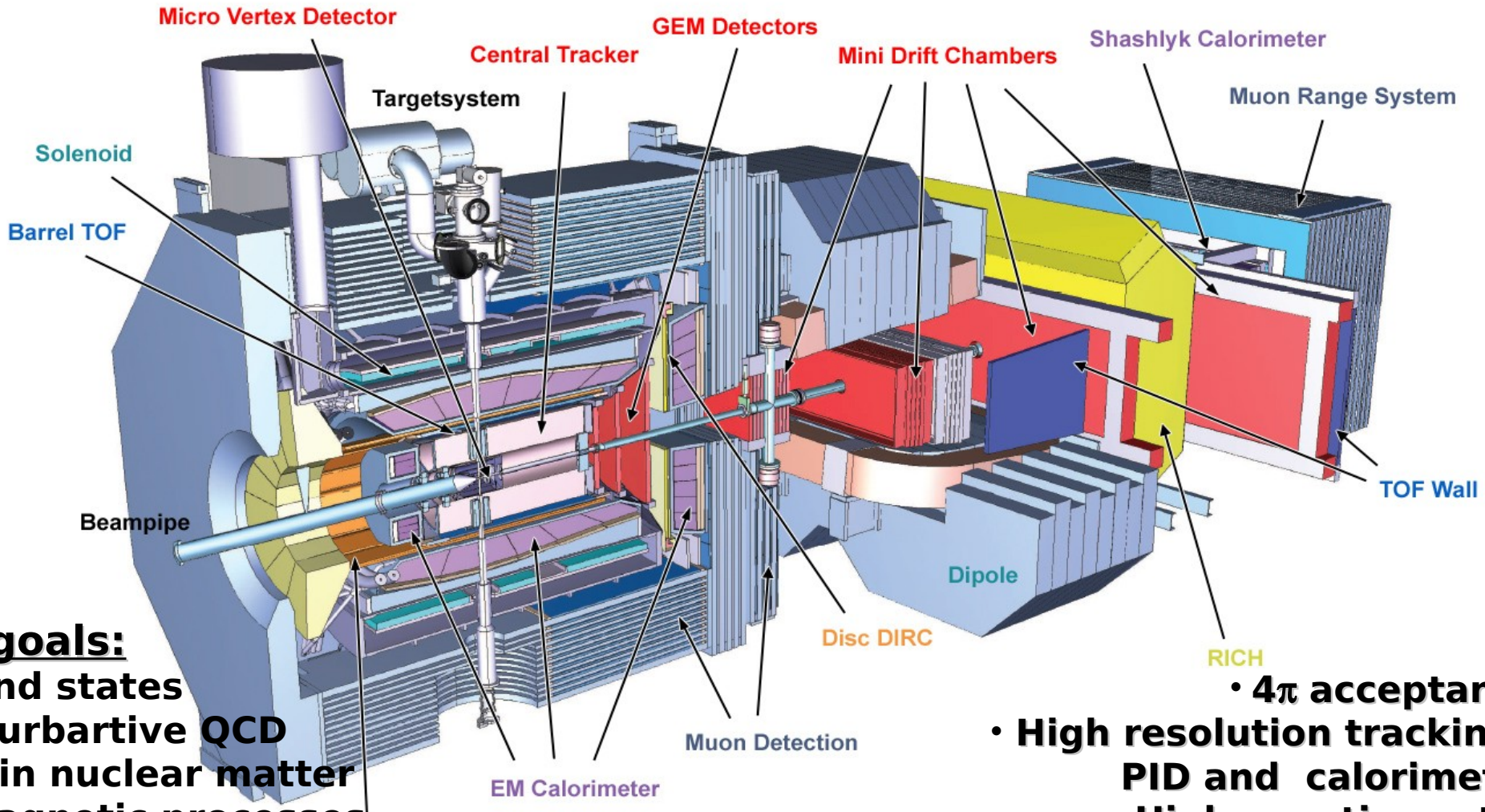
Outline

- $\bar{P}$ANDA
- Hypernuclear experiment of $\bar{P}$ANDA
- Germanium detector array
- Tests at COSY

PANDA

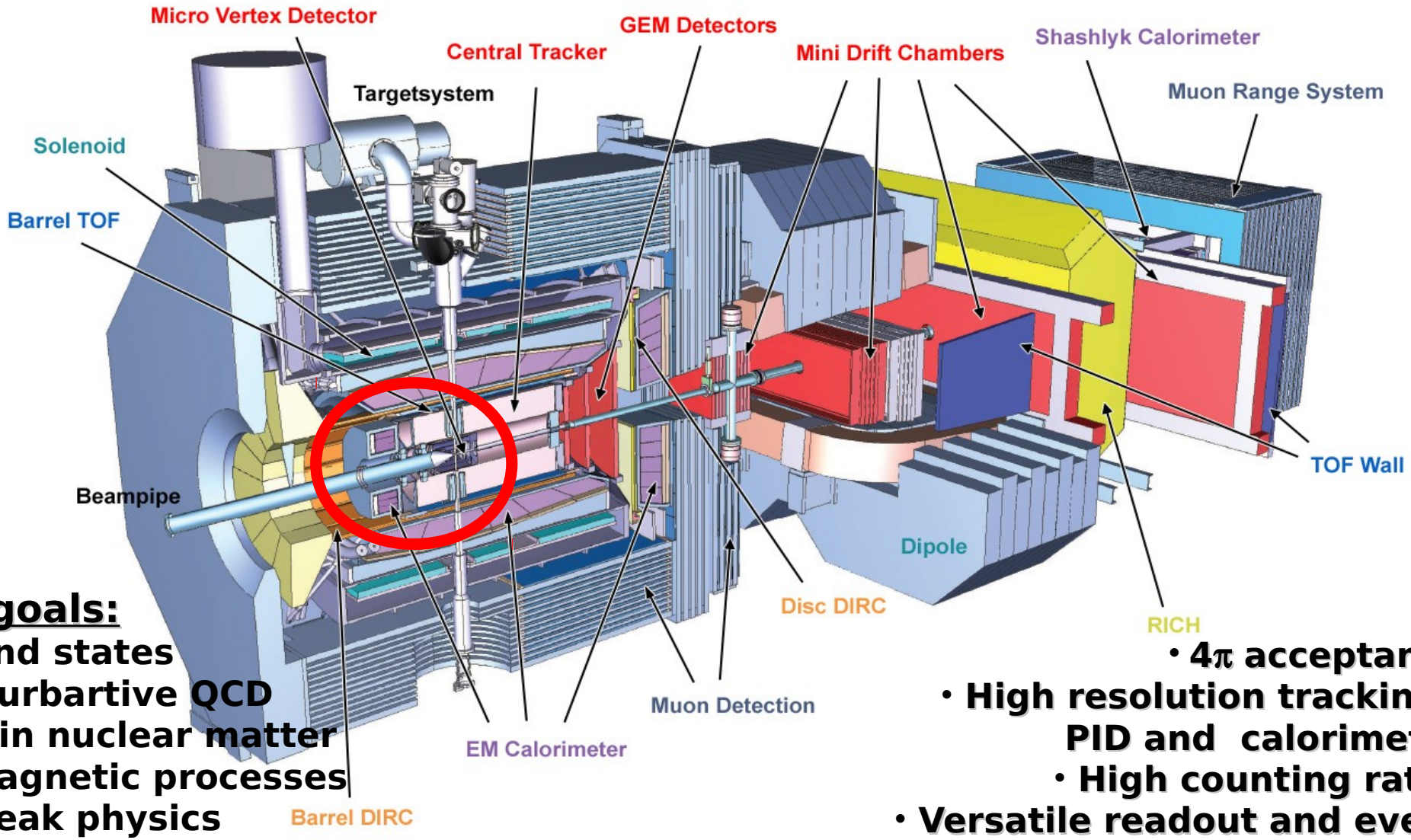


Physics goals:

- QCD bound states
- Non-perturbartive QCD
- Hadrons in nuclear matter
- Electromagnetic processes
- Elektroweak physics
- **Hypernuclear physics**

- 4π acceptance
- High resolution tracking, PID and calorimetry
- High counting rates
- Versatile readout and event selection
- **Modular design**

PANDA



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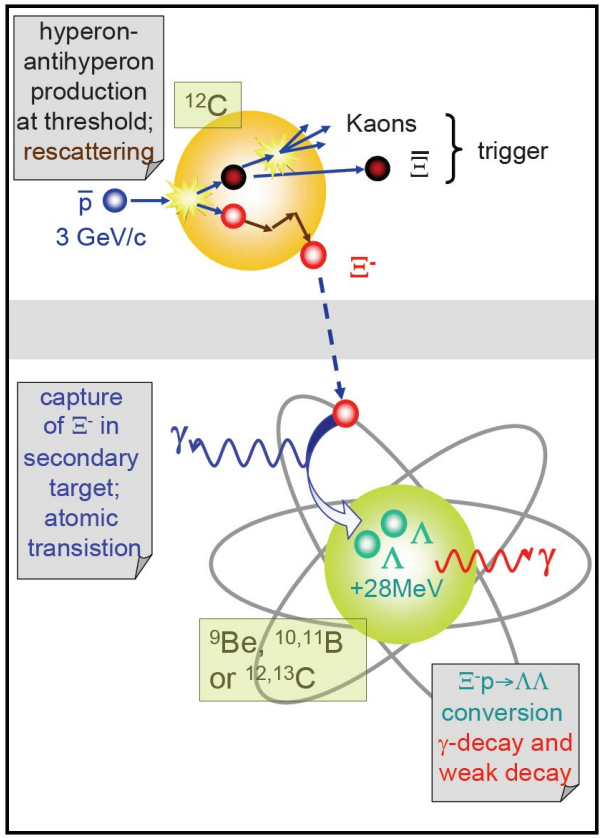
Hypernuclear experiment of $\bar{P}$ANDA



<u>prim. target</u>

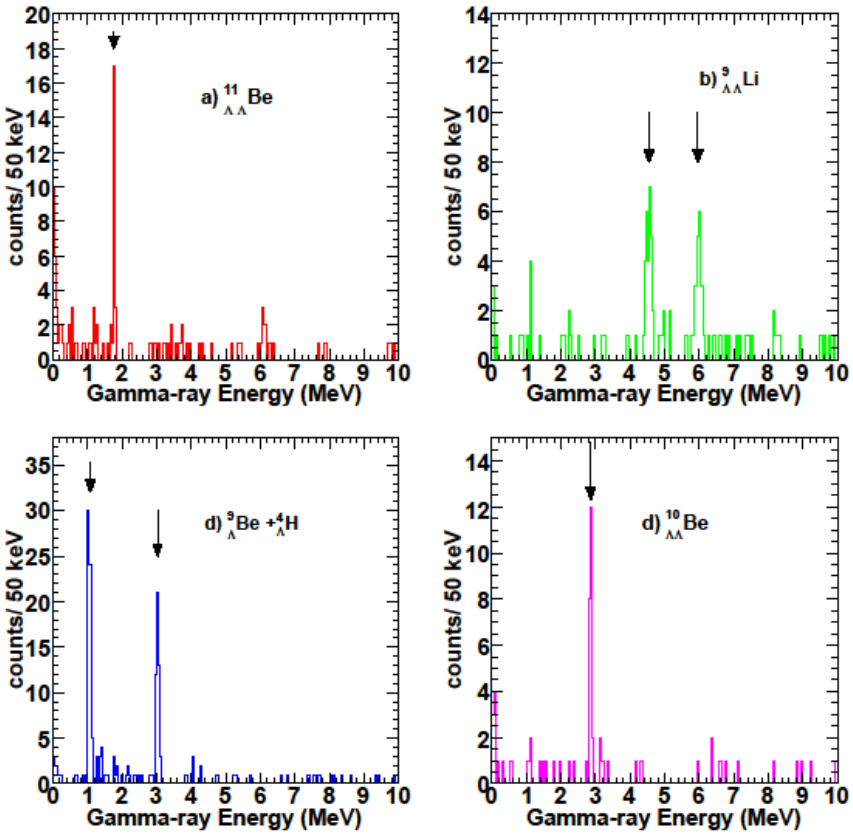
$\bar{p}\ N \rightarrow \Xi^-\ \Xi^{0/+}$

<u>sec. target</u>

$\Xi^-\ p \rightarrow \Lambda\Lambda$

γ isotropic

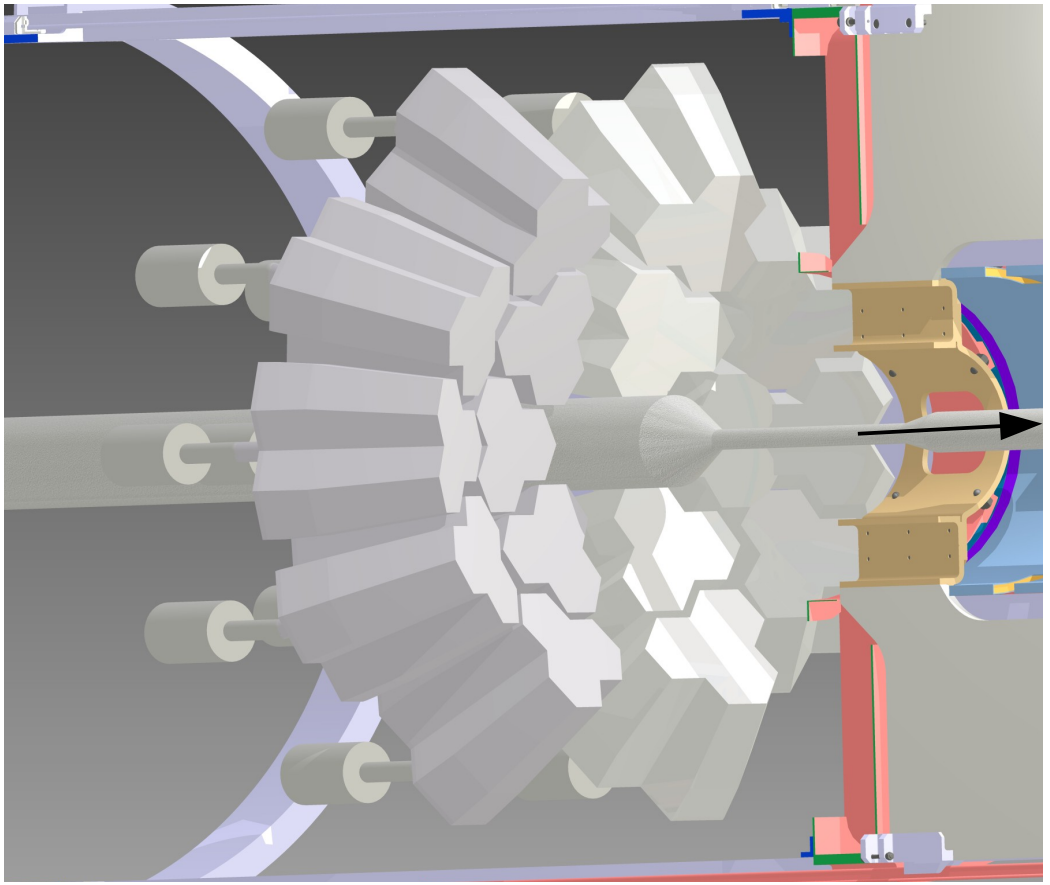
Physical process of the hypernuclear experiment



Expected spectra of most frequently produced double Hypernuclei

Germanium detector array

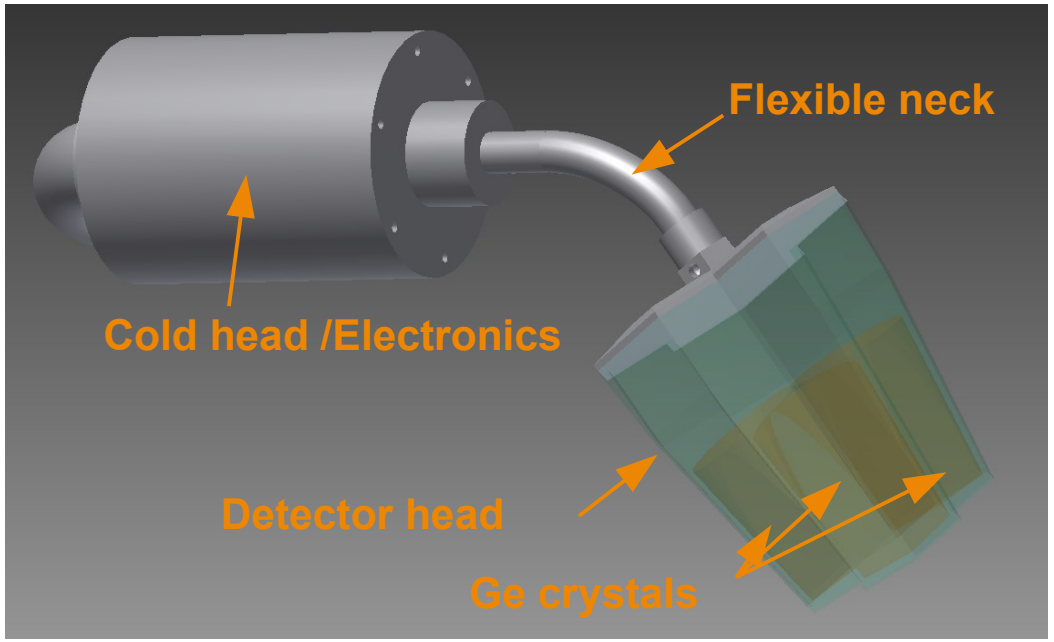
- Space highly limited inside the $\bar{P}$ANDA barrel
  - Complete rearrangement of existing detectors needed
  - No LN2 cooling possible
- High Magnetic Field
  - Effects on energy resolution [1]
- Particle background
  - Backward angles for reduction
  - Effects on energy resolution
  - Some radiation damage on the crystals expected



[1] *A. Sanchez Lorente et al.*, Nucl. Instr. and Meth. A 573 (2007) 410–417

New detector design

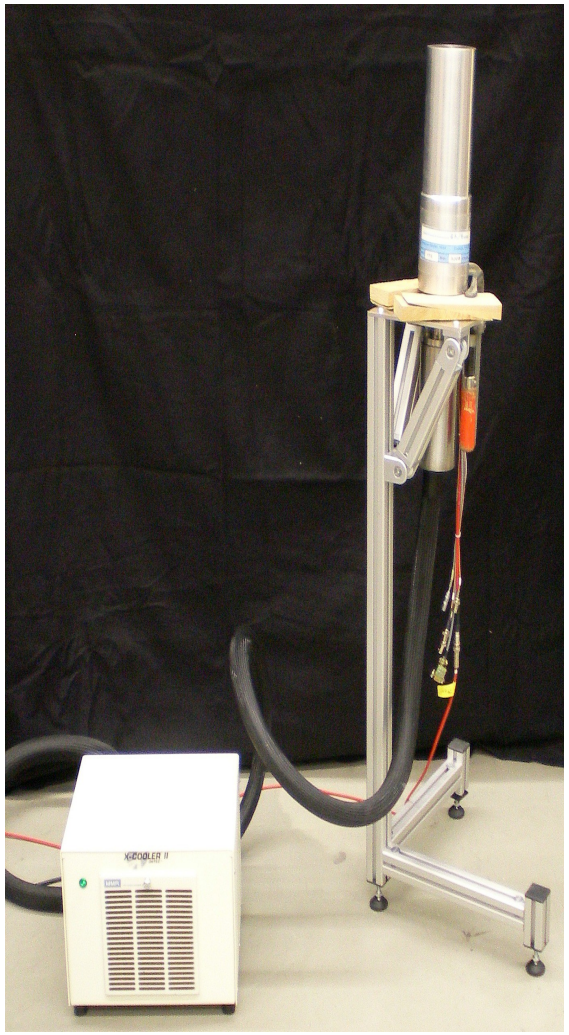
- Triple crystal detector
- Electro.-mech. cooler
- HV and readout “onboard”
- Flexible neck



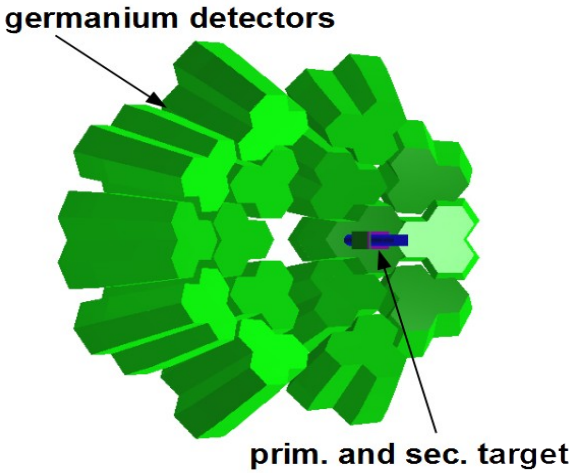
- Prototype is planned to be finished until end of 2014 / begin of 2015

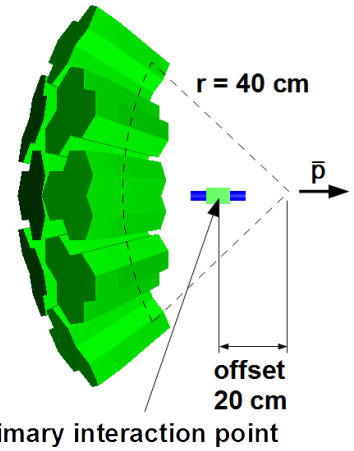
Electro mechanical cooler

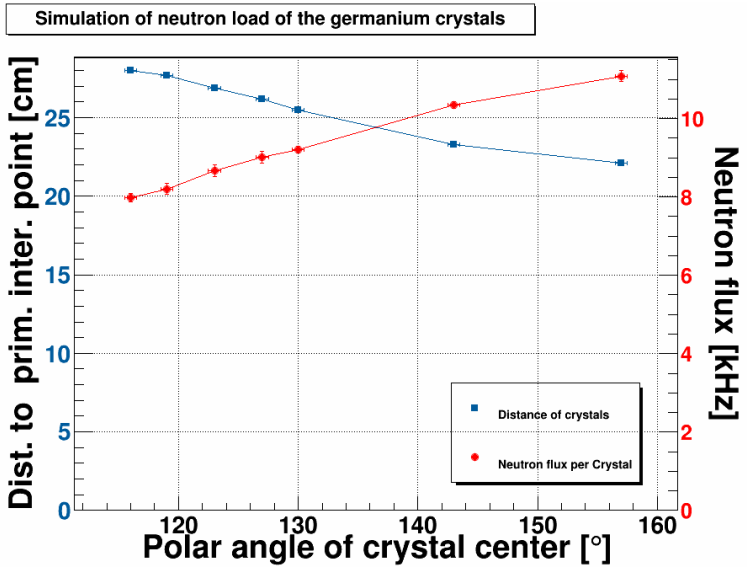
- Ortec X Cooler II
- Placed outside of the $\bar{P}$ANDA barrel (space, magnetic field)
- Limited but sufficient cooling power for three crystals
- Resolution of prototype detector deteriorates slighty due to higher temperature of 95 K (2.25 keV @ 1.332 MeV)

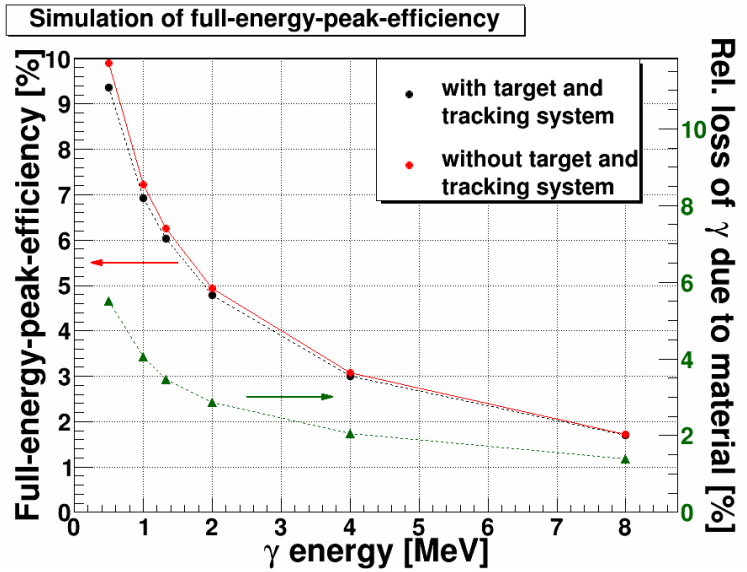


Simulation of the detector









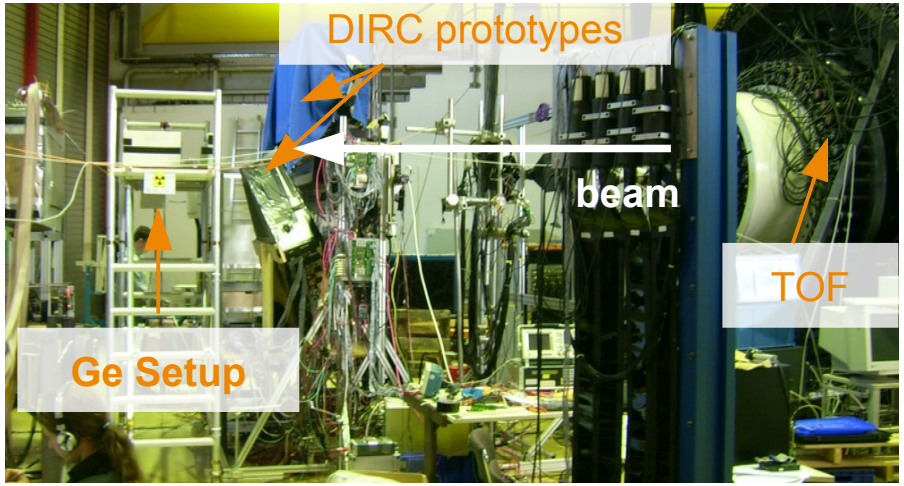
- Efficiency and background simulations
- PandaRoot framework (ROOT, Geant4)
- 2.9*10^9 n/cm^2 accumulated over

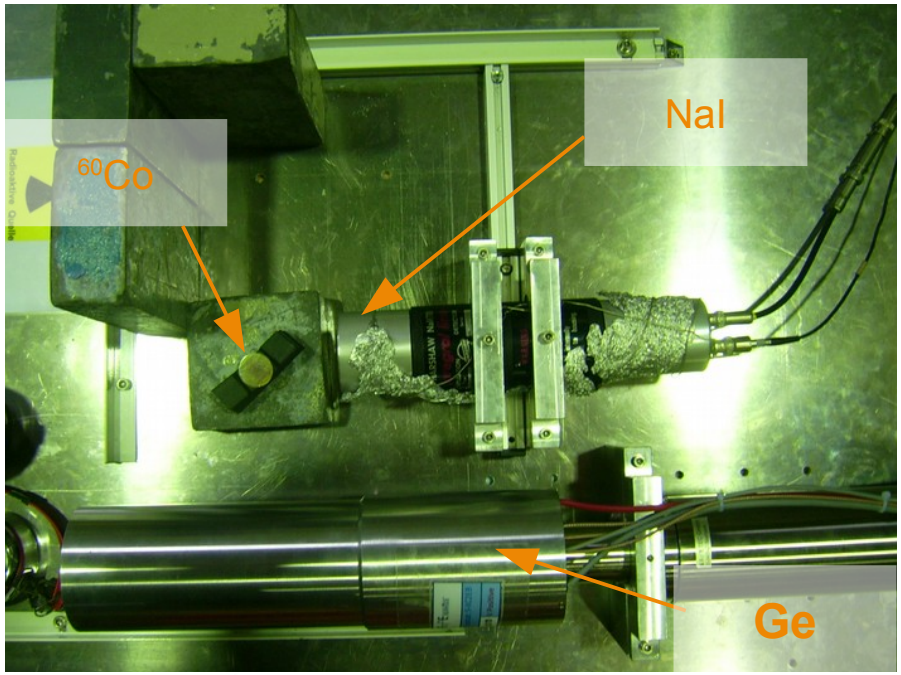
  100 days of $\bar{P}$ANDA conditions

  @ 10^6 interactions/$_s$

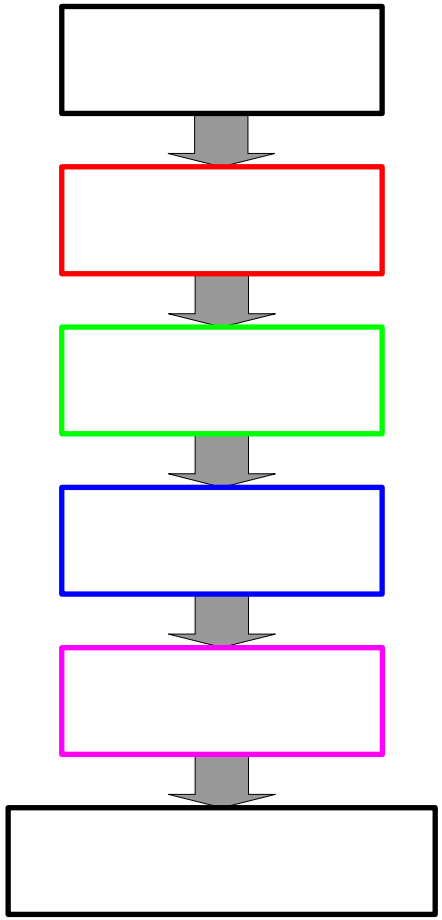
First beam test @ COSY in Jülich

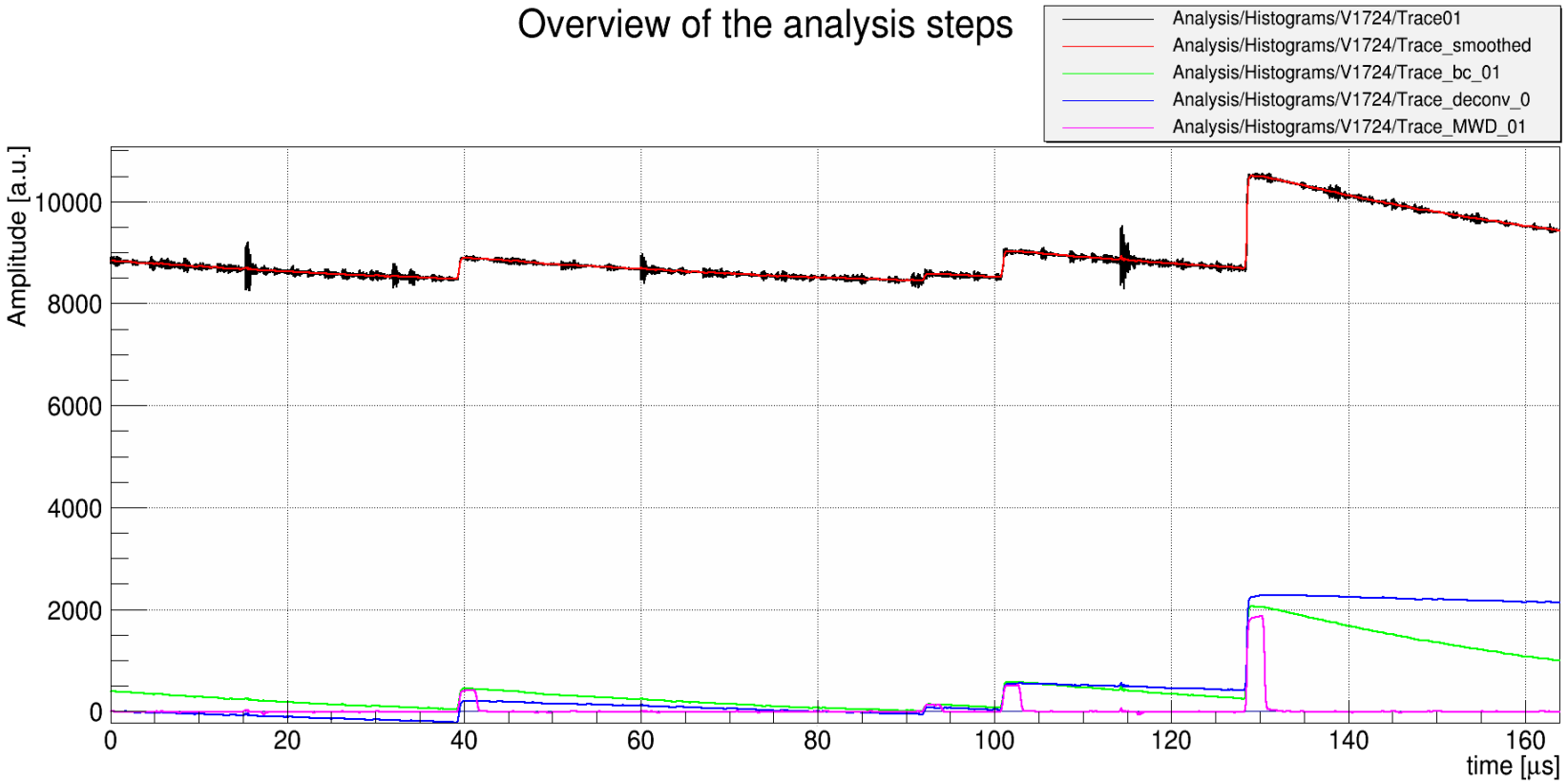
- Beam test in oct./nov. 2013
- Parasitic, TOF area
- 5 cm carbon target in beam (2.95 GeV/c p, 10^7/s) to produce particle background similar to $\bar{P}$ANDA
- Detector @ 90°, r = 90 cm
- Measurement during beam spill
- Coincidence (Ge + NaI)for triggering on ^{60}Co source





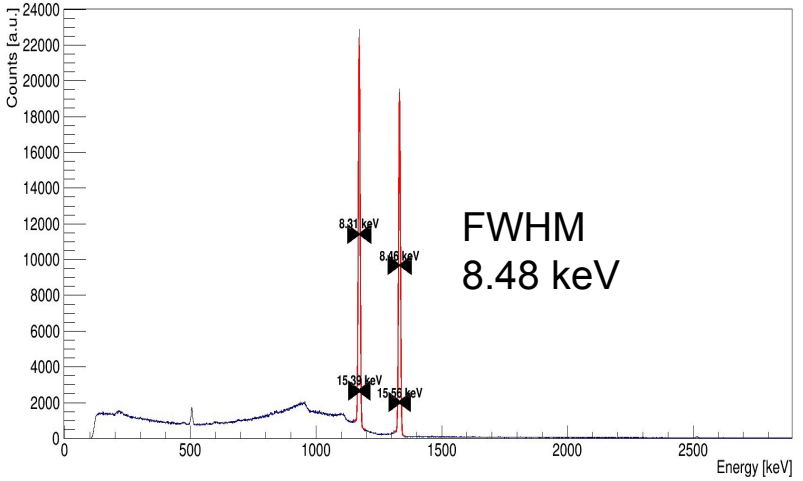
Analysis procedure

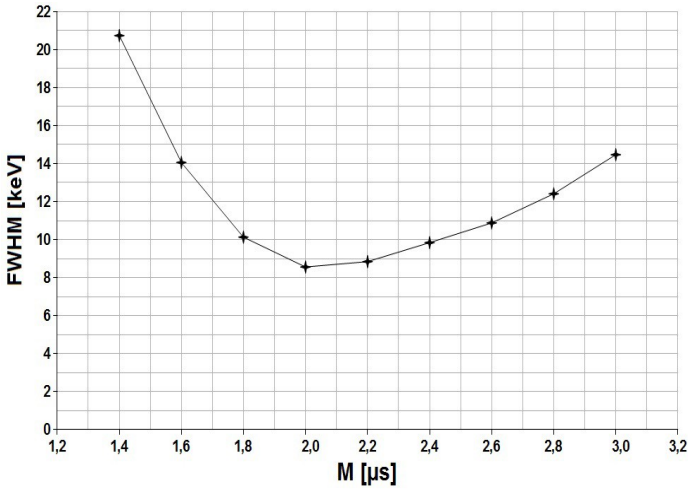




Results of first beam test

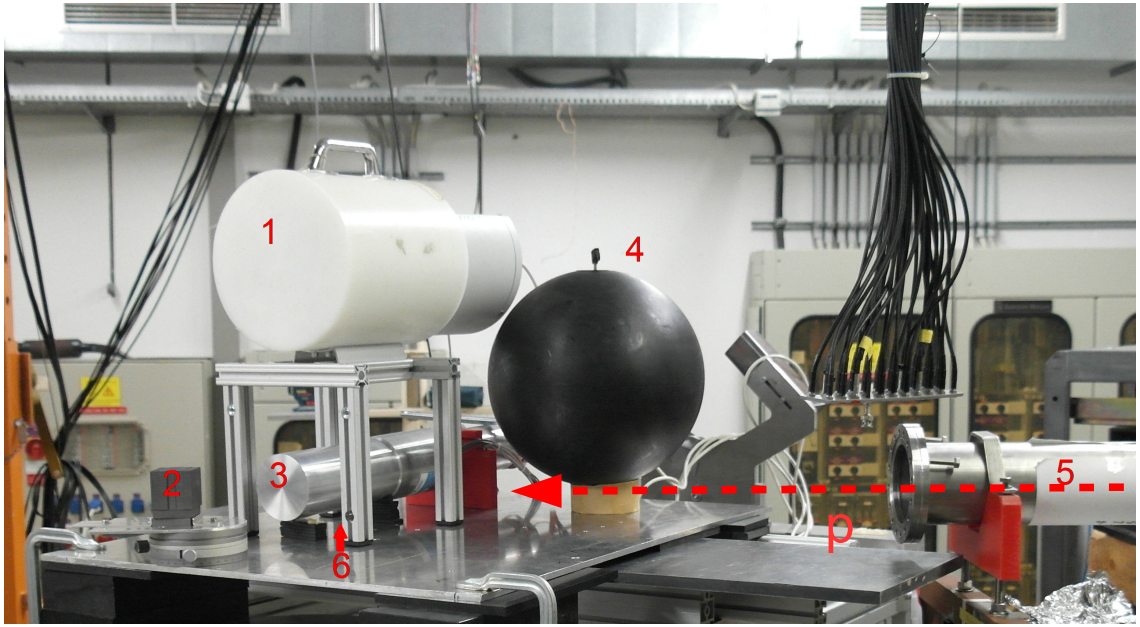
- Resolution limited by pick up noise in this test!
- Beam intensity too low to cause detectable radiation damage ($6*10^6$ n/cm^2)
- Further measurements with beam require actively resetting preamplifier





Irradiation test @ COSY in Jülich

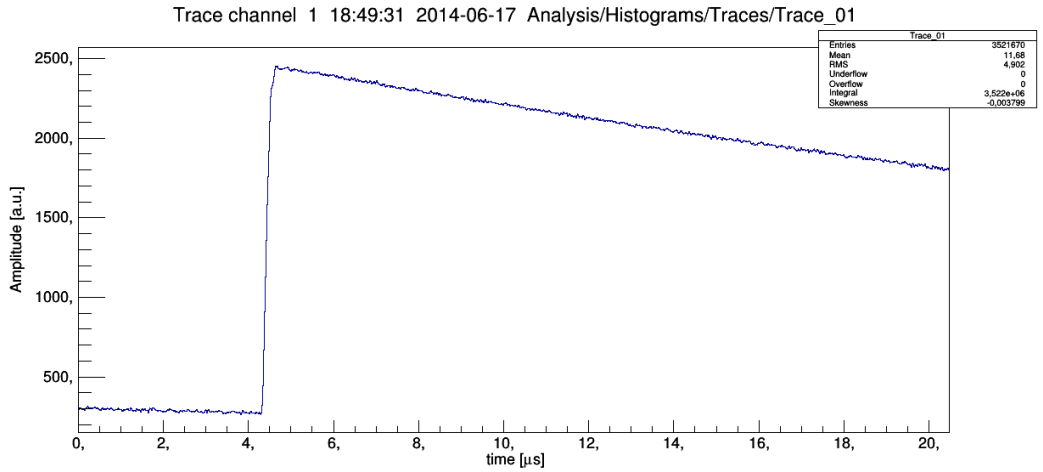
- Beam time in june and july 2014
- Jessica area
- Beam: $8*10^8$ p, 6 s beam,
  17 s cycle, 2.78 GeV/c
- 5 cm carbon target
- Measurements in 11s spill pause
- Detector @ 120°, 15 cm distance
- Additional neutron detectors



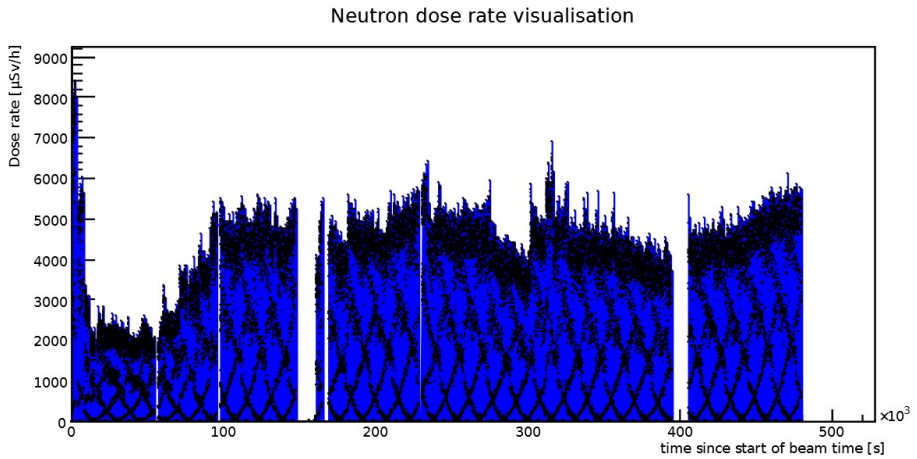
1 act. n detector	4 pas. n detector
2 target	5 beam pipe
3 Germanium	6 ^{60}Co source

Irradiation test @ COSY in Jülich

- Better noise conditions due to improved grounding of the setup



- 4 *10^{13} protons accumulated
  ~50 days $\bar{P}$ANDA
- Limitation by radiation protection and beam time

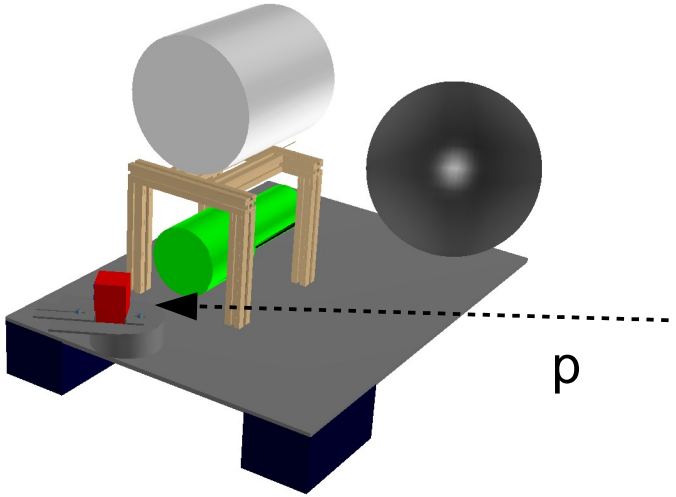


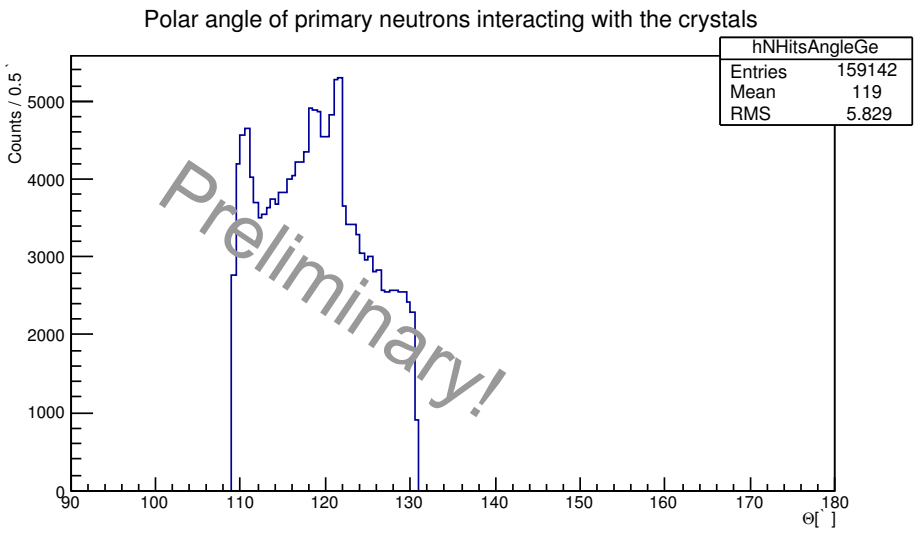
Irradiation test: Simulation

- Geometry of test setup build in PandaRoot
- 10^8 events, 1.6 *10^5 n

  → 2.1*10^9 n/cm^2 total

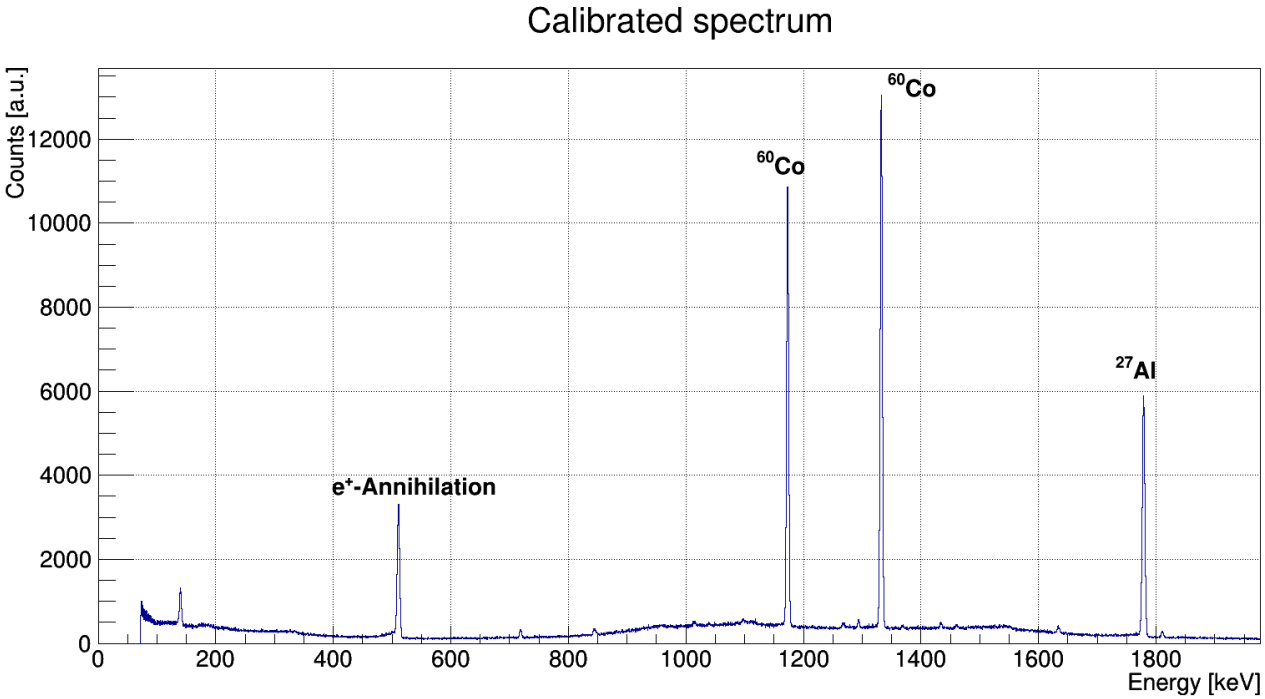
  (~75 days of $\bar{P}$ANDA)
- More detail in geometry and analysis in progress
- Confirmation via neutron detector measurements foreseen





Irradiation test: results

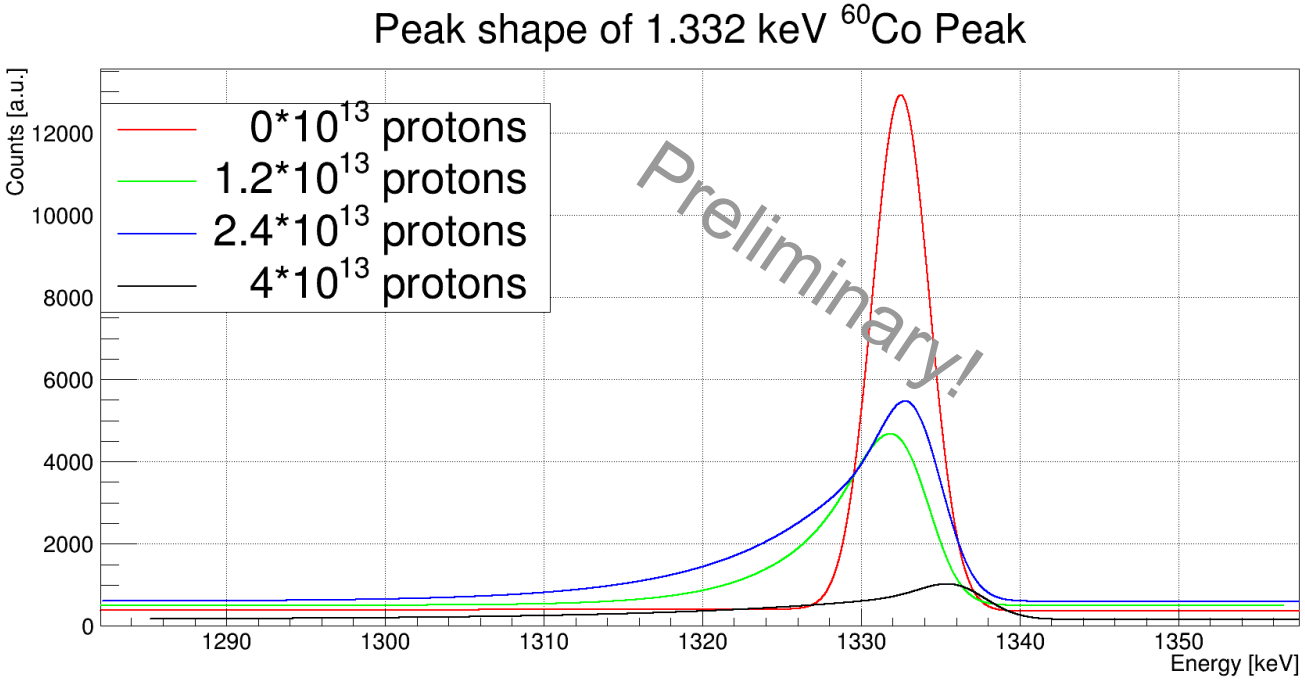
- Spectrum in spill pause
- Activation of surrounding material gives additional lines
- Useful for calibration, but additional background



Irradiation test: results

Evolution of line shape:

- Broadening
- Low energy tail
- Position shift due to calibration issues in the analysis



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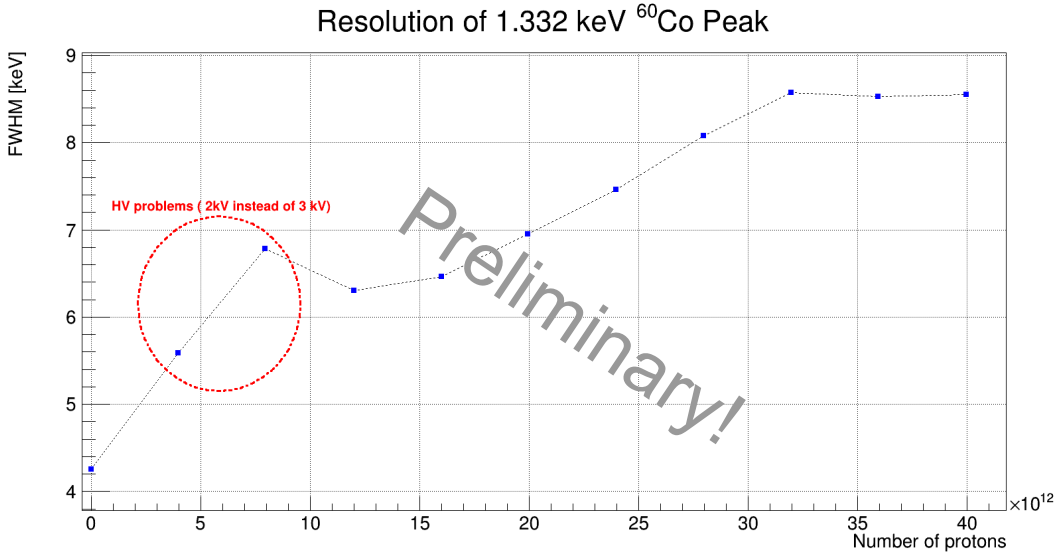
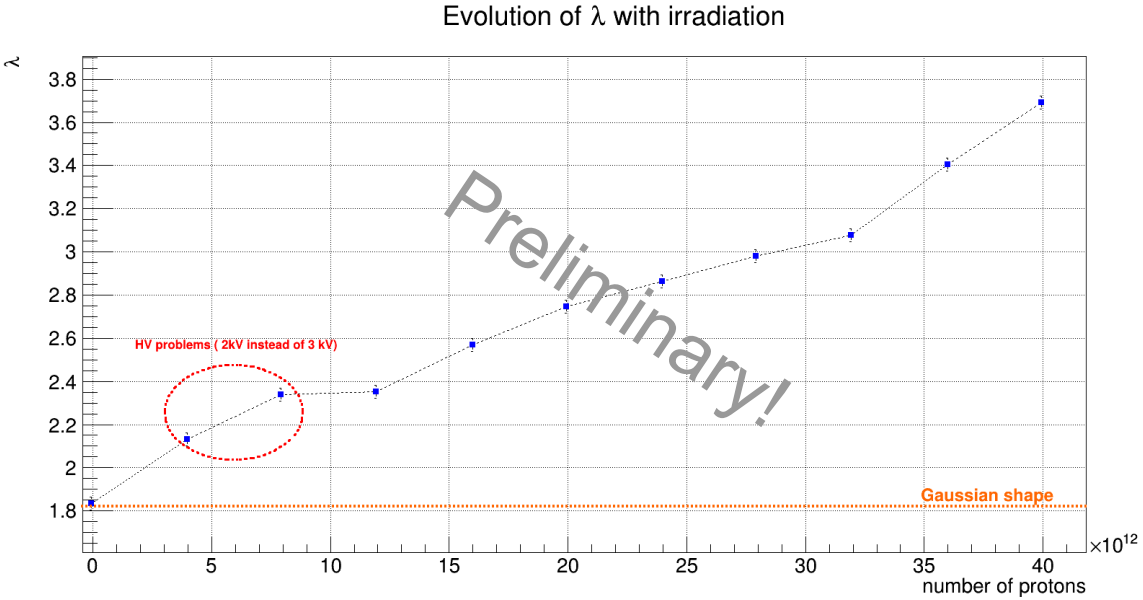


$$\lambda = \frac{Full\ width\ at\ tenth\ maximum}{Full\ width\ at\ half\ maximum}$$

- Gaussian: λ = 1.82
- Ratio is steadily growing

- Degradation of resolution
- FWHM seems to flatten

  at 8.5 keV
- FWHM still much better than shown in simulation!
- No corrections (risetime, variation of window size) applied yet!



Summary / Outlook

- Some challenges for the germanium array, but a working solution for all of them!
- Good performing single crystal prototype
- Full size triple crystal prototype is ordered and foreseen for the end of 2014 / beginning of 2015
- Actively resetting preamplifier will be implemented
- Irradiation test done to show the feasibility of the Germaniums for $\bar{P}$ANDA, analysis of beam times in progress
- Next beam test with active resetting preamplifier and $\bar{P}$ANDA background rate at the end of this year

Thanks for your attention