The Germanium detector array for P̄ANDA *

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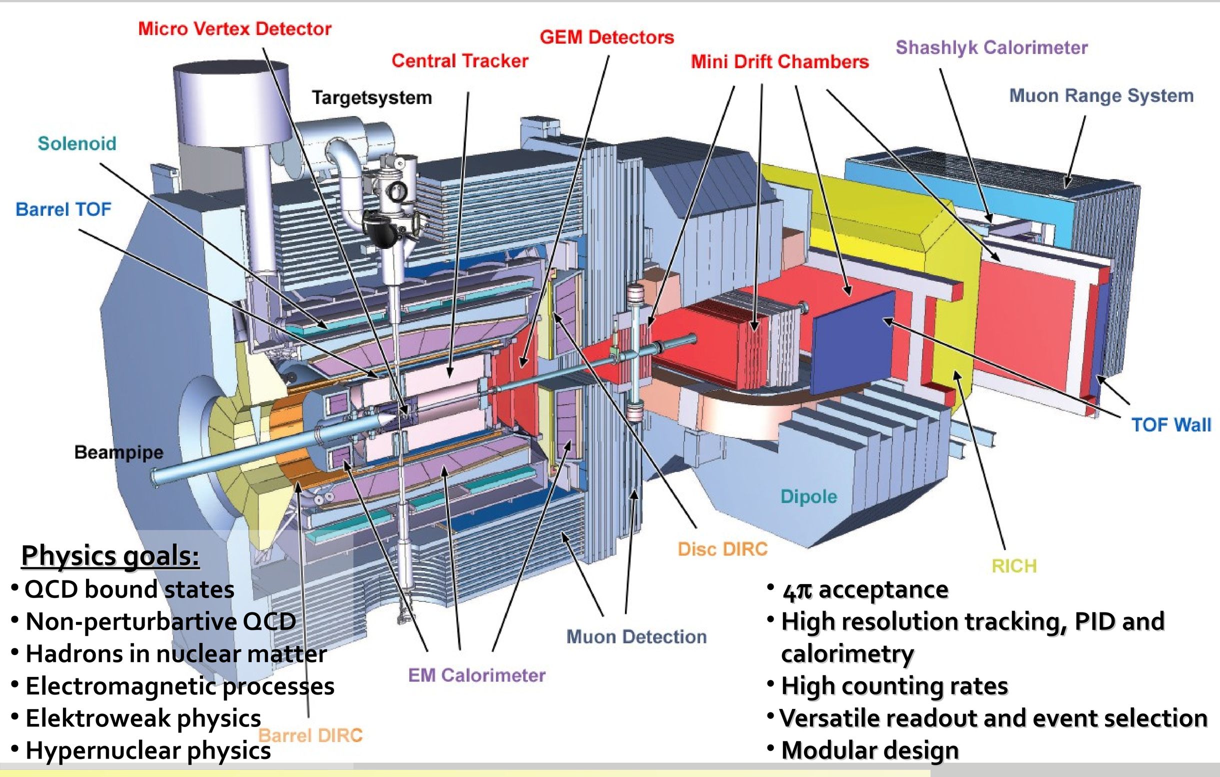
Production and detection of double Λ hypernuclei with the P̄ANDA experiment@FAIR

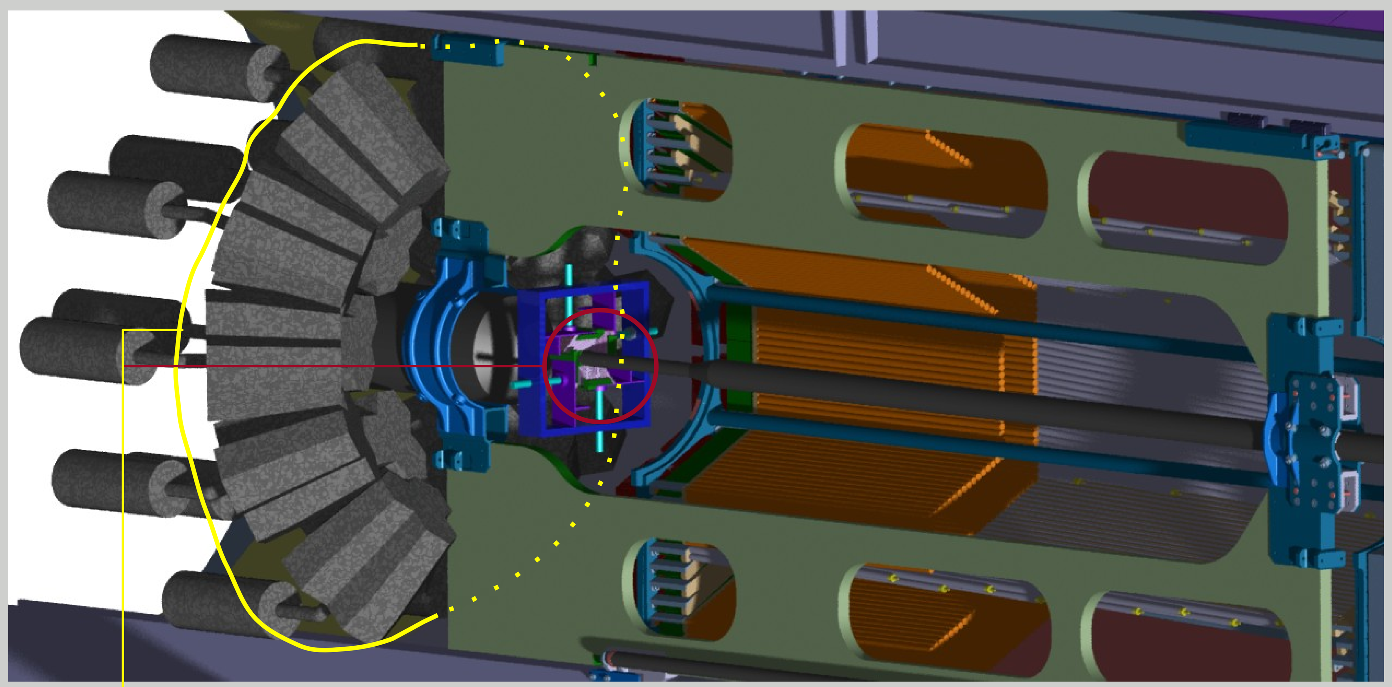


The P̄ANDA spectrometer in standard configuration

- $\theta_{lab} < 45°$, Ξ^+, K^+ trigger (P̄ANDA)
- $\theta_{lab} = 45°$-$90°$,
  - Primary target : $\bar{p} + {}^{12}C \rightarrow \bar{\Xi}^+ + \Xi^-$,
  - Secondary, active target: Ξ^- capture production of hypernuclei, detection of hyp. decay products

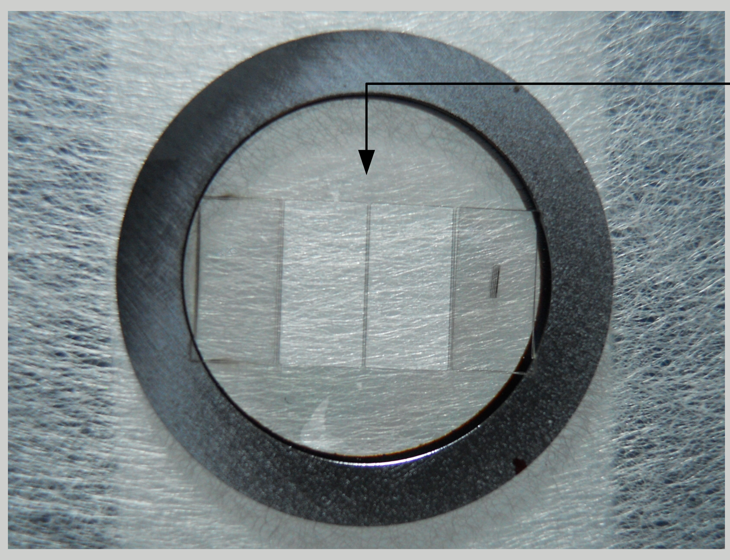
$\theta_{lab} > 90°$, γ-detection in backward direction

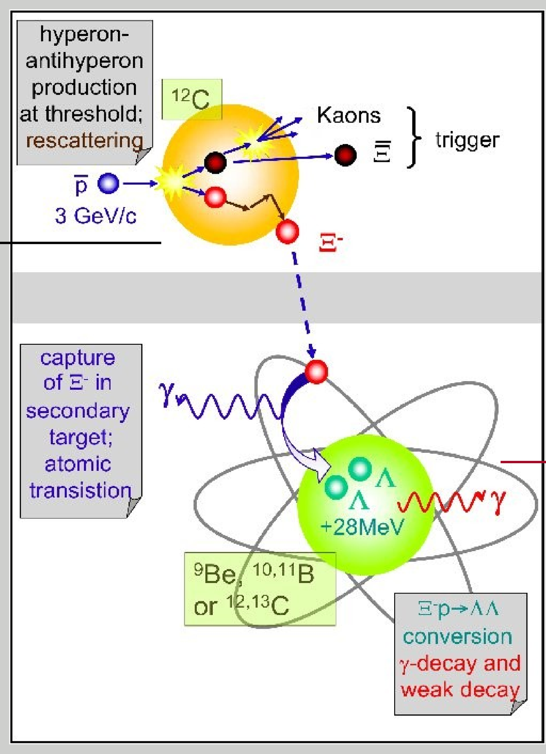
High neutron background (16 000 s^{-1} per crystal)



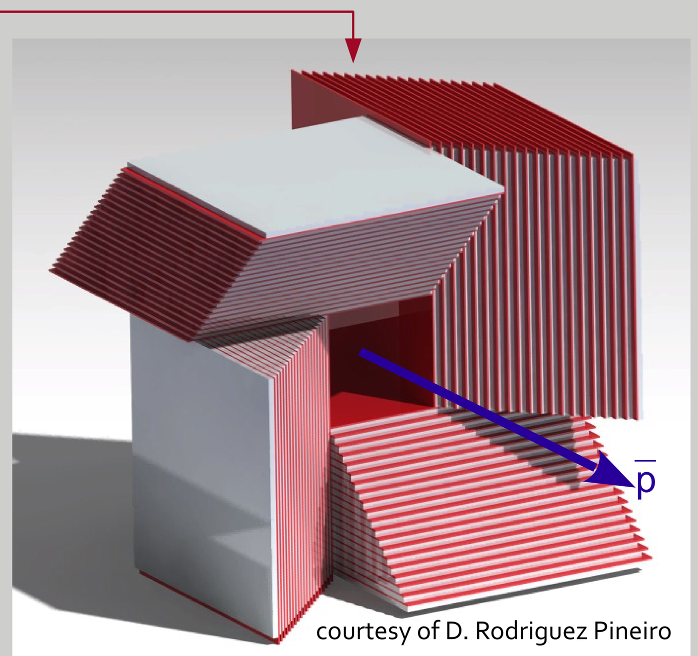
In order to perform hypernuclear physics, the P̄ANDA spectrometer has to be accordingly modified:
- Micro vertex detector, backward EMC and target pipe will be removed
- Modified central tracker frame and beam pipe will be inserted
- Primary (wire) target,
- Secondary, active target and
- Germanium (HPGe) detector array will be installed

The task of the **primary target** is the production of slow Ξ^- particles. For this issue light nuclear targets will be preferred in order to avoid a high hadronic background into the backward direction. Additionally it is required that the luminosity of the p̄-beam remains as constant as possible. Therefore, beam losses, mainly due to coulomb scattering, must be kept low. The best candidate will be a ^{12}C micro-wire target. High Interaction rates will be avoided by steering an appropriate fraction of the beam onto the target.





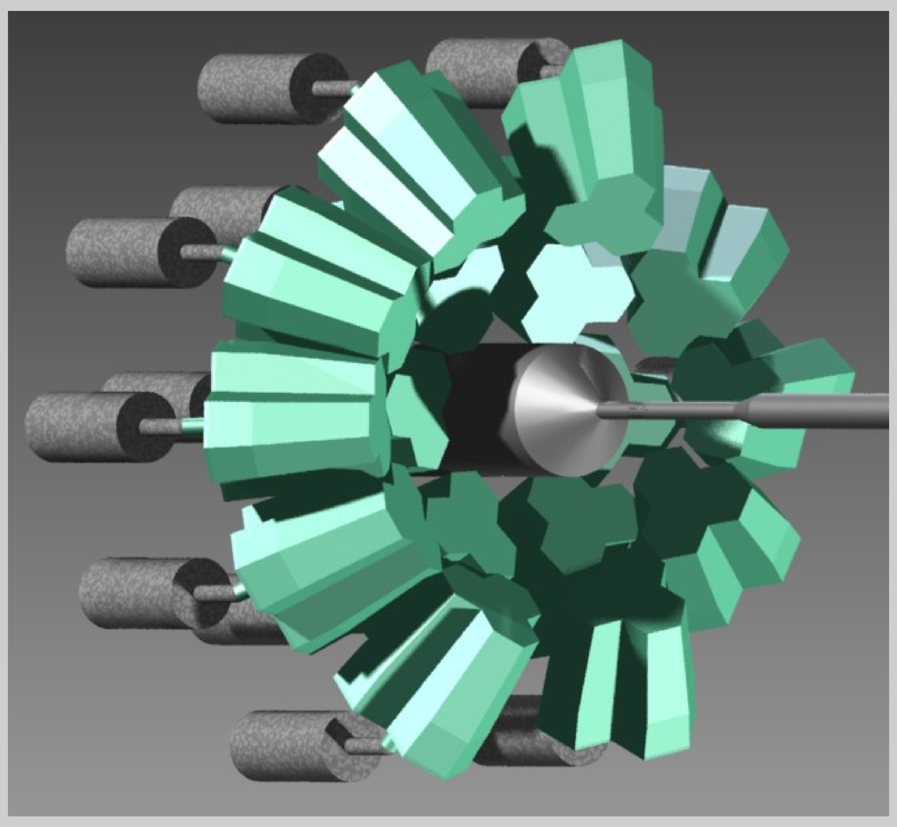
Simulations show that Ξ^- with a momentum below 500 MeV/c will be emitted in an angular region of 40° to 90° and stopped within a radius of 20 mm before decaying.
Kaons produced by annihilation of primary $\bar{\Xi}^+$ are boosted into forward angles (0° - 40°). These kaons can be tracked by the standard P̄ANDA spectrometer and used as a signature for the production of a $\bar{\Xi}^+$ Ξ^- pair.



courtesy of D. Rodriguez Pineiro

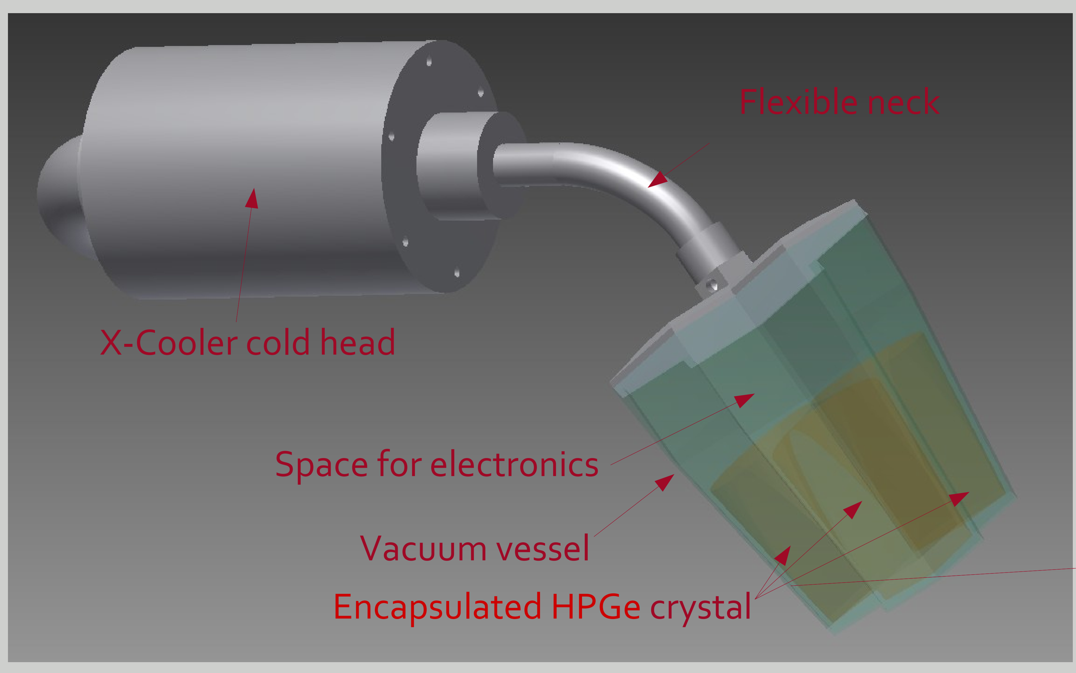
The **secondary, active target** consists of alternating layers of silicon strip detector and absorber material. Double Λ hypernuclei will be produced in the absorber material ($\Xi^- p \rightarrow \Lambda\Lambda + 28$ MeV). The active layers (silicon) are used to track the incoming Ξ^- and the charged decay products of the produced hypernuclei.
The size and the shape of the secondary target is determined by the Ξ^- lifetime and the angle of emitted kaons.

Development of the detector array



The space available for the 16 triple cluster of the germanium array inside the barrel part of P̄ANDA is very limited. It is determined by the outer diameter of the beam pipe (15 cm) and the inner diameter of the DIRC (90 cm). Because of that no bulky, common LN2 cooling system is possible. Instead, an electromechanical cooler (ORTEC X-COOLER II) for each triple cluster will be used to cool the crystals to LN2 temperatures.

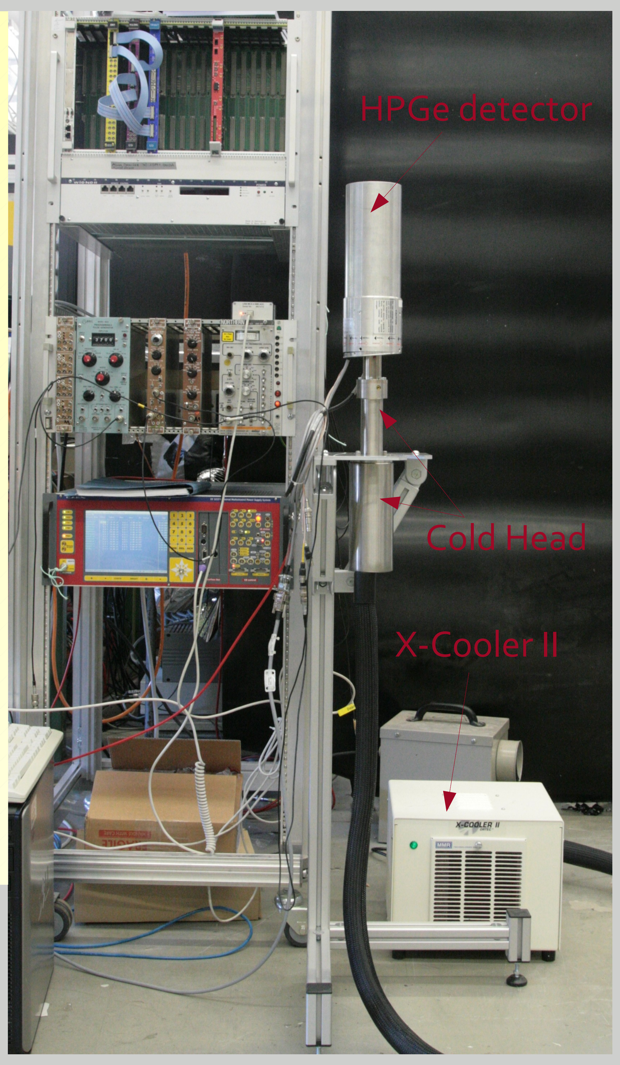
The encapsulated n-type coaxial HPGe crystals (EUROBALL) have a tapered hexagonal shape. The crystals of each cluster are arranged in a triangular form. The free space behind the crystals is foreseen for electronics. The connection from the crystal vessel to the cold head of the cooler is flexible so that the detector can be adapted to fit into the limited space.

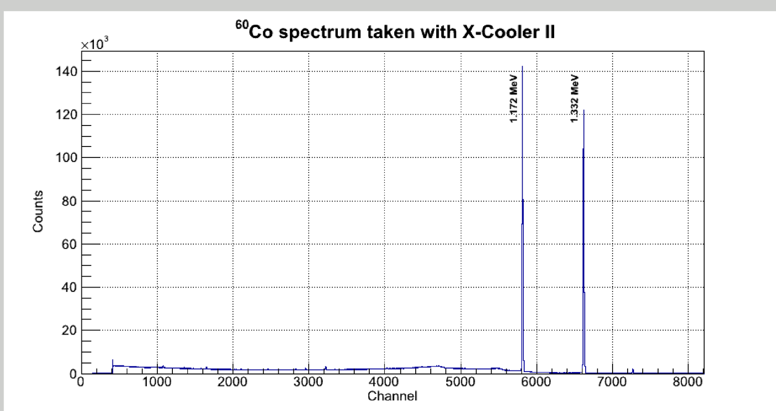


Experimental results

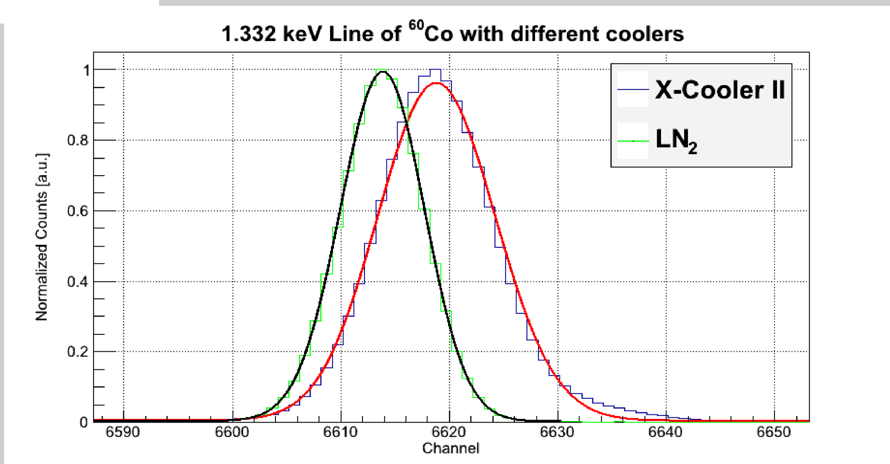
The influence of a X-Cooler system on the **energy resolution** of germanium detectors has been studied by using an Ortec GEM-75205P device and analog readout electronics.
Energy resolution of 1.332 MeV line of ^{60}Co:
- Ref. (given by Ortec): at least 2.05 keV
- Measured with LN2 cooling: 1.83 keV
  → good resolution
- Measured with X-Cooler: 2.54 keV
  → cooling power was not sufficient (only 110 K, LN2: 77 K):
  - Crystal is bigger than EUROBALL crystal
  - Crystal is not encapsulated (lower thermal transfer)
  - Cooling power of X-Cooler II limited

Future activities:
- Test with encapsulated crystal
- Improvement of heat transfer
- Improve cooling power (cold head needs optimization)





Measured spectrum of ^{60}Co with electromechanically cooled detector.



Comparison of 1.332 MeV line with both cooling options. Peak width of LN2 cooled detector is better due to lower noise current (lower temperature).
For the sake of clarity, spectra have been shifted.

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