Simulation studies of the hypernuclear experiment at $\bar{\text{P}}$ANDA to optimize the production and detection rates of ΛΛ hypernuclei

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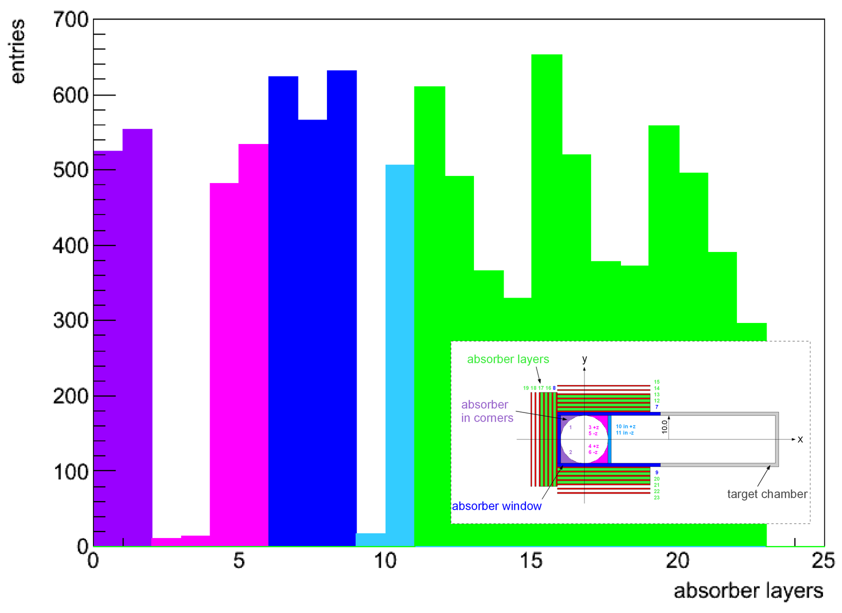
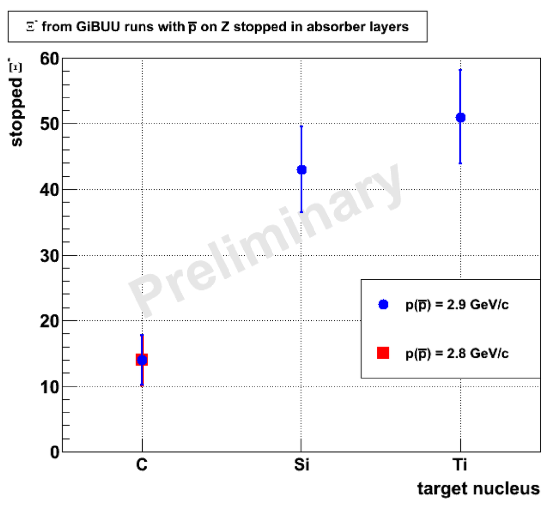
Optimization of the hypernuclei production

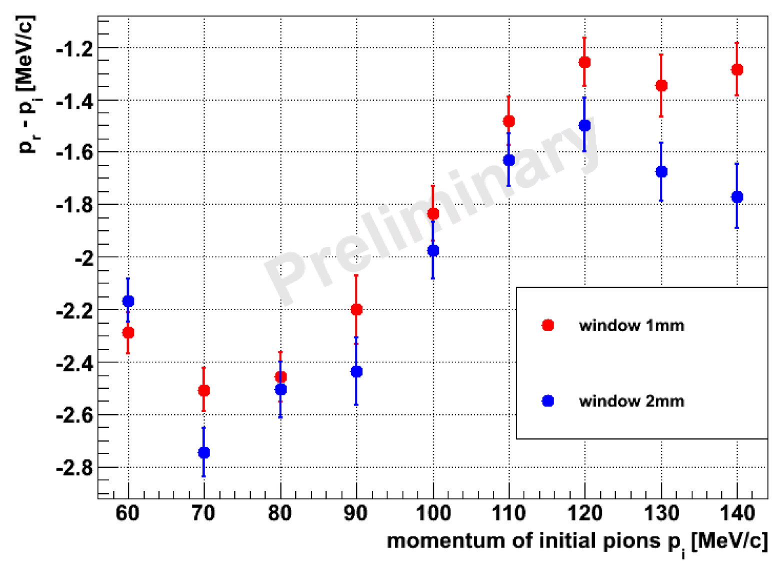
The primary reactions $\bar{p}$ on nuclei are simulated using GiBUU transport model to get a realistic momentum distribution of Ξ^-, essential for the production of the hypernuclei. The stopping of these Ξ^- in the absorber layers of the sec. target is simulated. A comparison of the number of stopped Ξ^- for several materials as prim. target is given below.



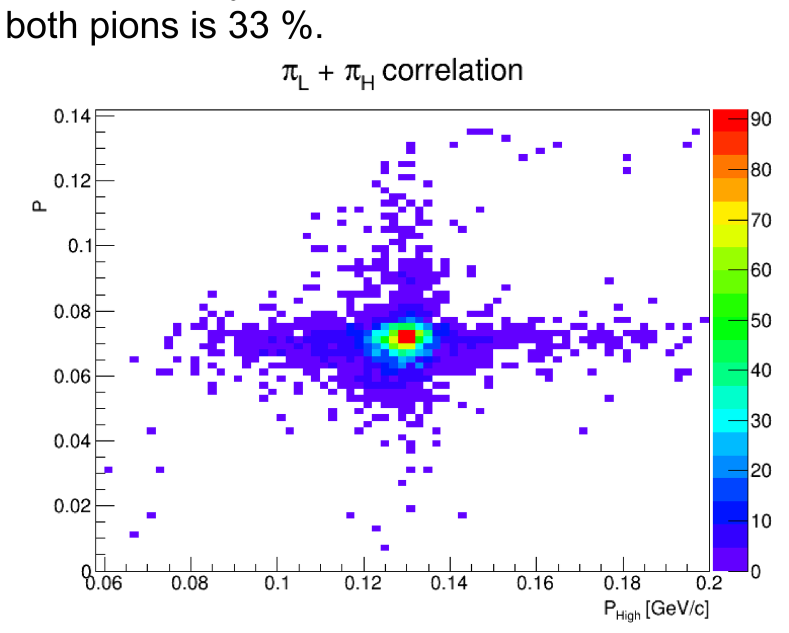


The stopping of Ξ^- in boron absorbers is shown above. A generator using parametrized GiBUU events is used for this simulation. Most of the Ξ^- are stopped in the closest absorber volumes and in backward direction for momenta of Ξ^- below 0.5 GeV/c. Ξ^- with a higher momentum are not stopped.

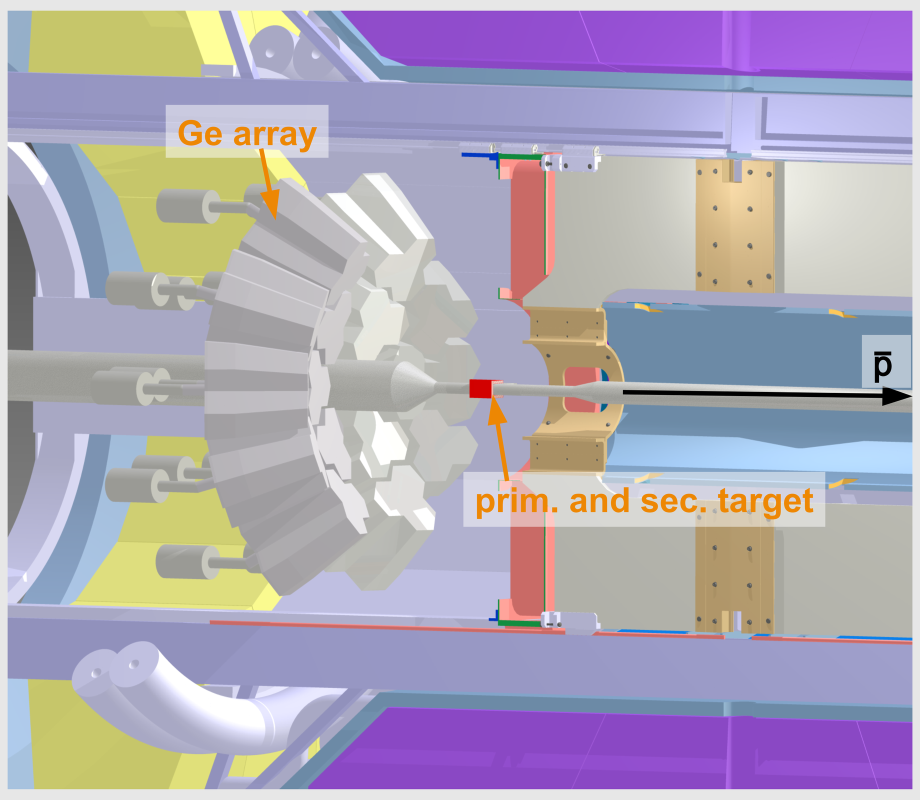
Optimization of the hypernuclei identification



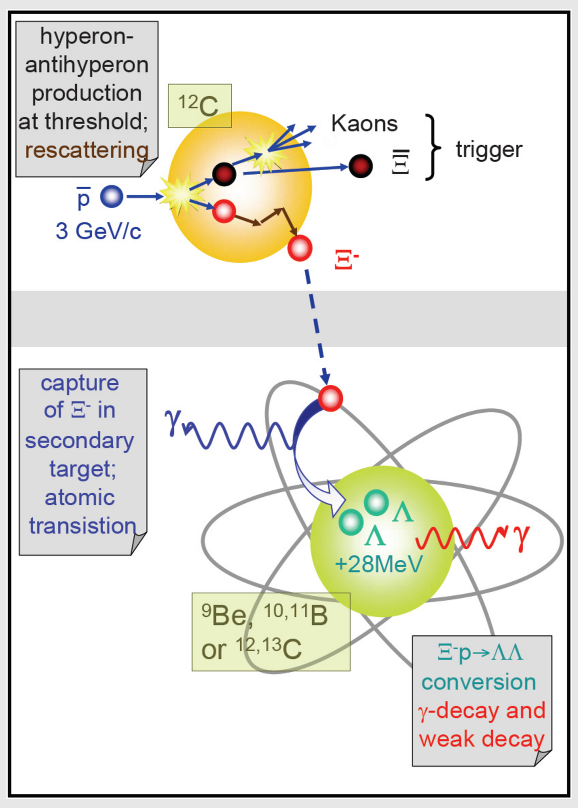
In addition to the production of hypernuclei, the active part of the secondary target is used for the tracking of low momentum pions. The figure below shows the correlation of the two pions that are produced in the decay
$^{11}_{\Lambda\Lambda}\text{Be} \rightarrow {}^{11}_{\Lambda}\text{Be} + \pi^-_H \rightarrow {}^{11}\text{C} + \pi^-_L + \pi^-_H$.
The efficiency for a correlated detection of both pions is 33 %.



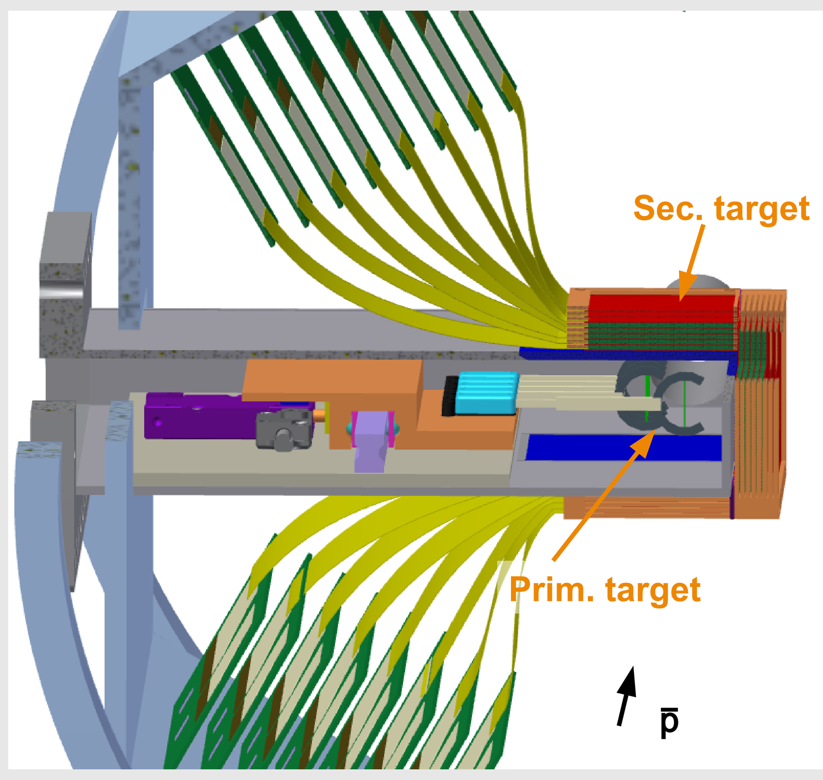
The precision in the reconstruction of the momentum of these pions, tracked by the secondary target, is studied in simulations for typical momenta in the range of 60 to 140 MeV/c, shown above. The FWHM resolution is about 4 MeV/c, sufficient for a unique identification.



Integration of dedicated detectors inside the $\bar{\text{P}}$ANDA barrel spectrometer to study ΛΛ hypernuclei



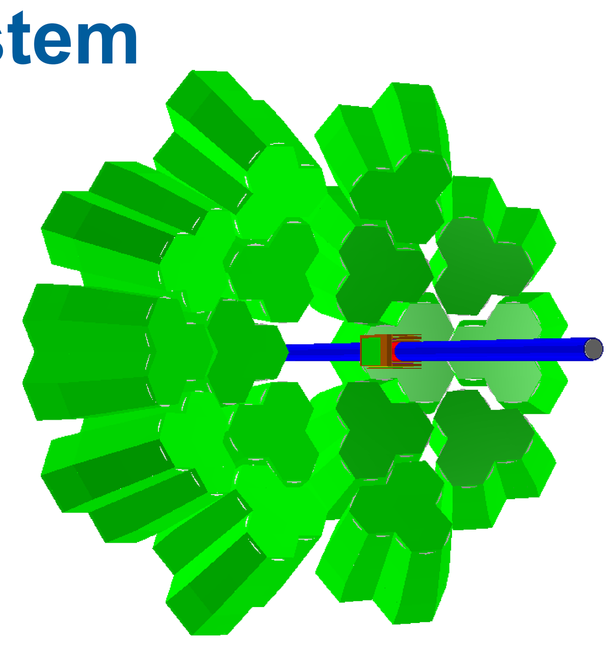
Production process and decay of ΛΛ hypernuclei at $\bar{\text{P}}$ANDA

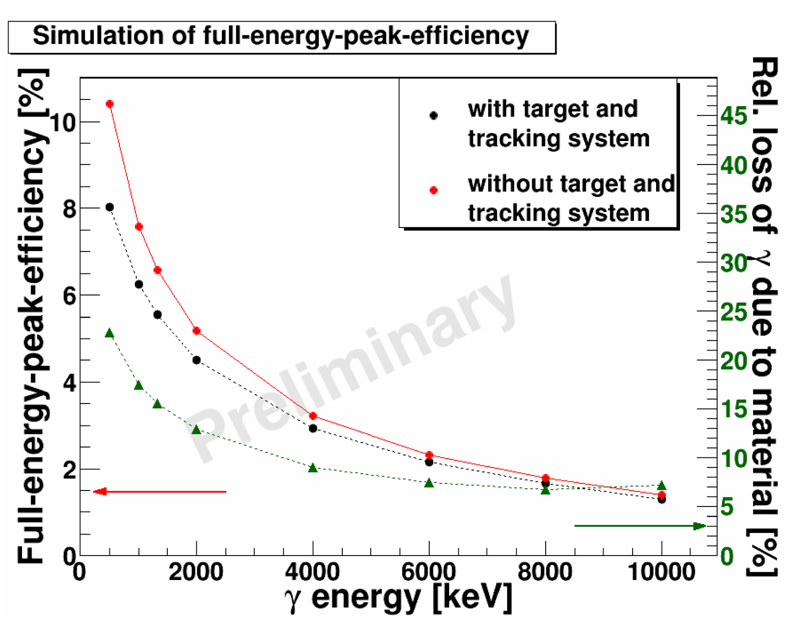


Look inside the target chamber with the magazine of spare primary targets and the sandwich structure of absorbers and Si detectors of the sec. target

Influence of the target system on the γ detection

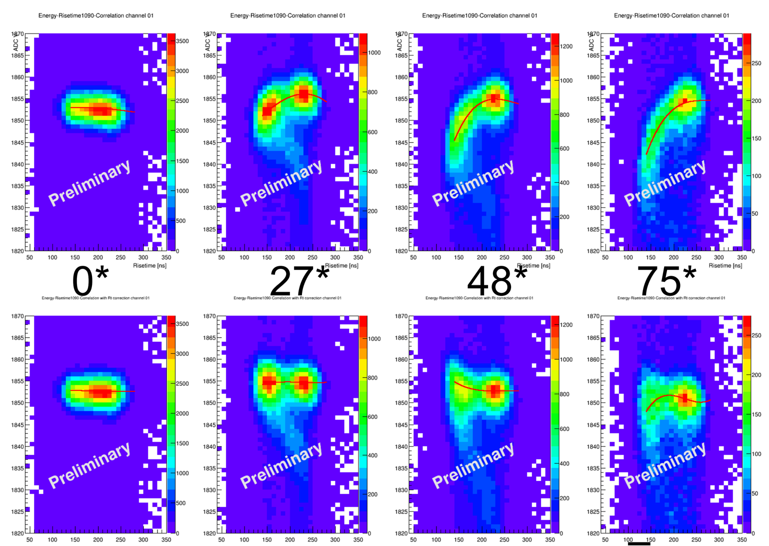
Besides the production and tracking efficiency of the target, it is important that its influence on the detection of the γ is minimized. Studies of this are done using the $\bar{\text{P}}$ANDAroot framework. The used, simplified, geometry is shown on the right.





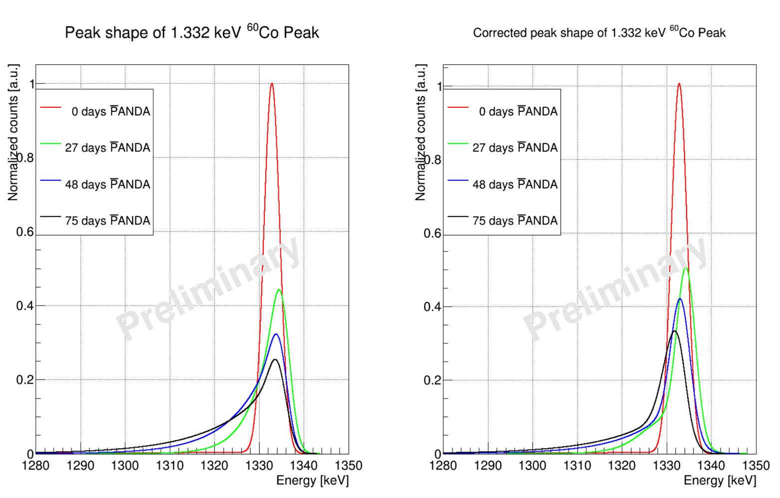
These studies show a significant absorption by the target system. The simulation results for the expected energy range of photons is shown on the left. Especially low energy γ are strongly absorbed and still 7 % of 10 MeV photons are affected by the target material. Therefore further studies and optimizations of the target geometry are necessary.

Irradiation damage studies



The high hadronic background inside the $\bar{\text{P}}$ANDA spectrometer damages the germanium crystals. Therefore irradiation tests at COSY have been performed. The digitization of pulse shapes allows the appliance of digital filters offline. The picture on the left shows the correlation of risetime and energy for varying periods of irradiation without and with a correction on the risetime.

This correction offers a simple way to improve the energy resolution of a damaged detector. Its result on the line shape of the 1332 keV ^{60}Co peak is shown on the right. The low energy tailing is strongly reduced and the resolution is improved. This is important for the identification of low signal rates as expected in the $\bar{\text{P}}$ANDA experiment.



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