The secondary target for the hypernuclear experiment at P̄ANDA

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HadronPhysics2 Study of Strongly Interacting Matter

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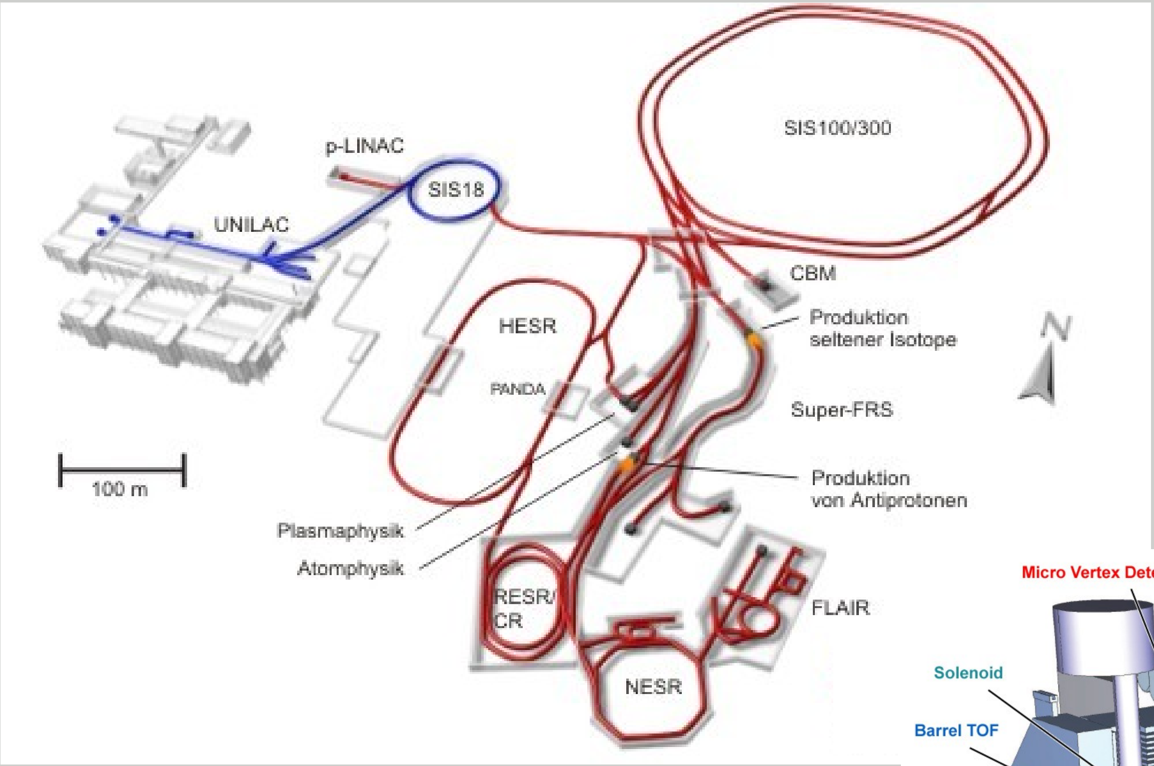
Motivation



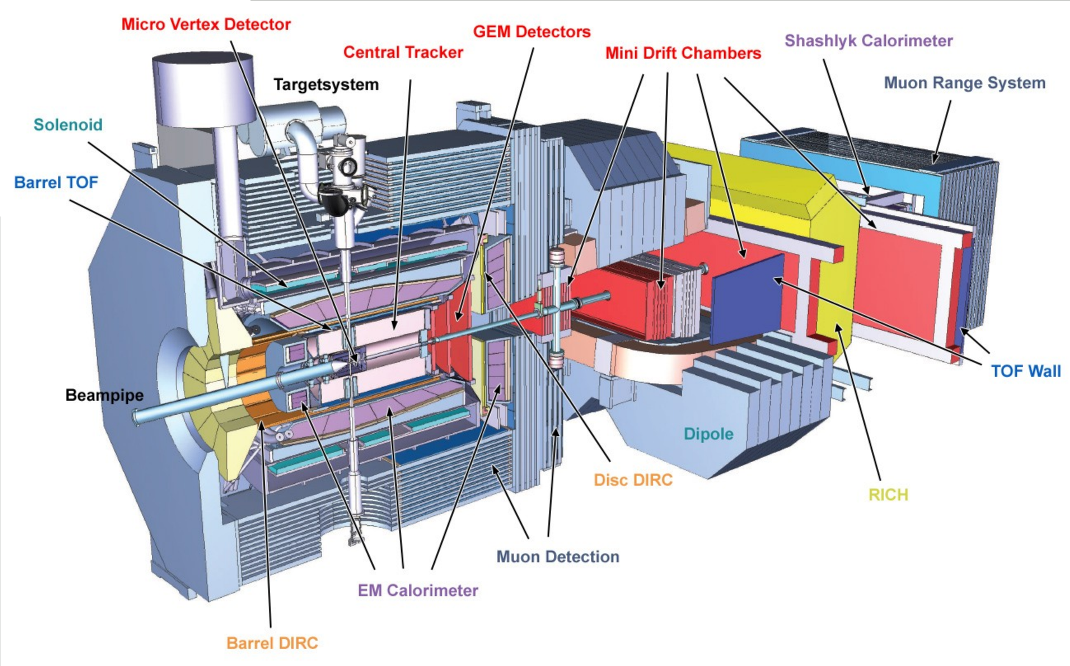
FAIR:
Facility for Antiproton and Ion Research

at GSI in Darmstadt

momenta of antiprotons in HESR
1.5 – 15 GeV/c

$\overline{\text{P}}$ANDA:
Anti-Proton Annihilations at Darmstadt

modular detector in the HESR



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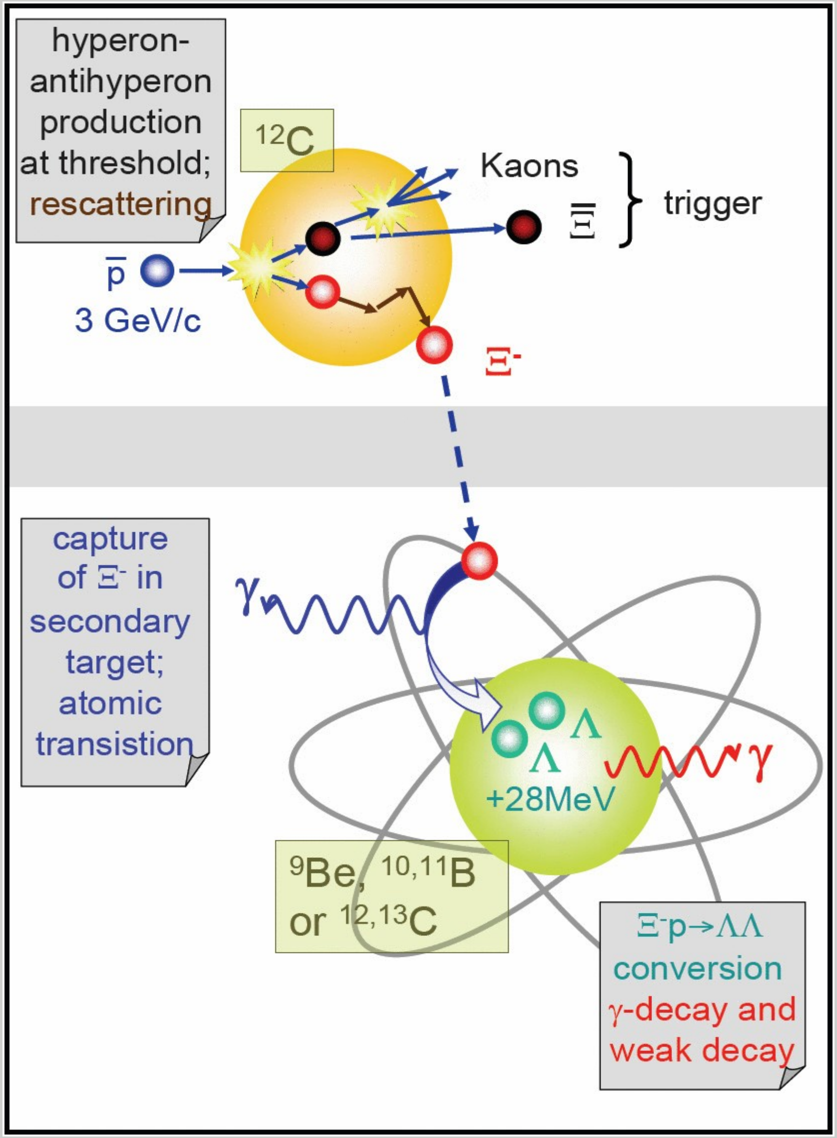


Production and detection of Λ-Λ-hypernuclei at $\overline{\text{P}}$ANDA

Primary Target (C-12):

- formation of Ξ^--particles in $\bar{p}$ + ^{12}C – reactions

Secondary Target (Be, B, C):

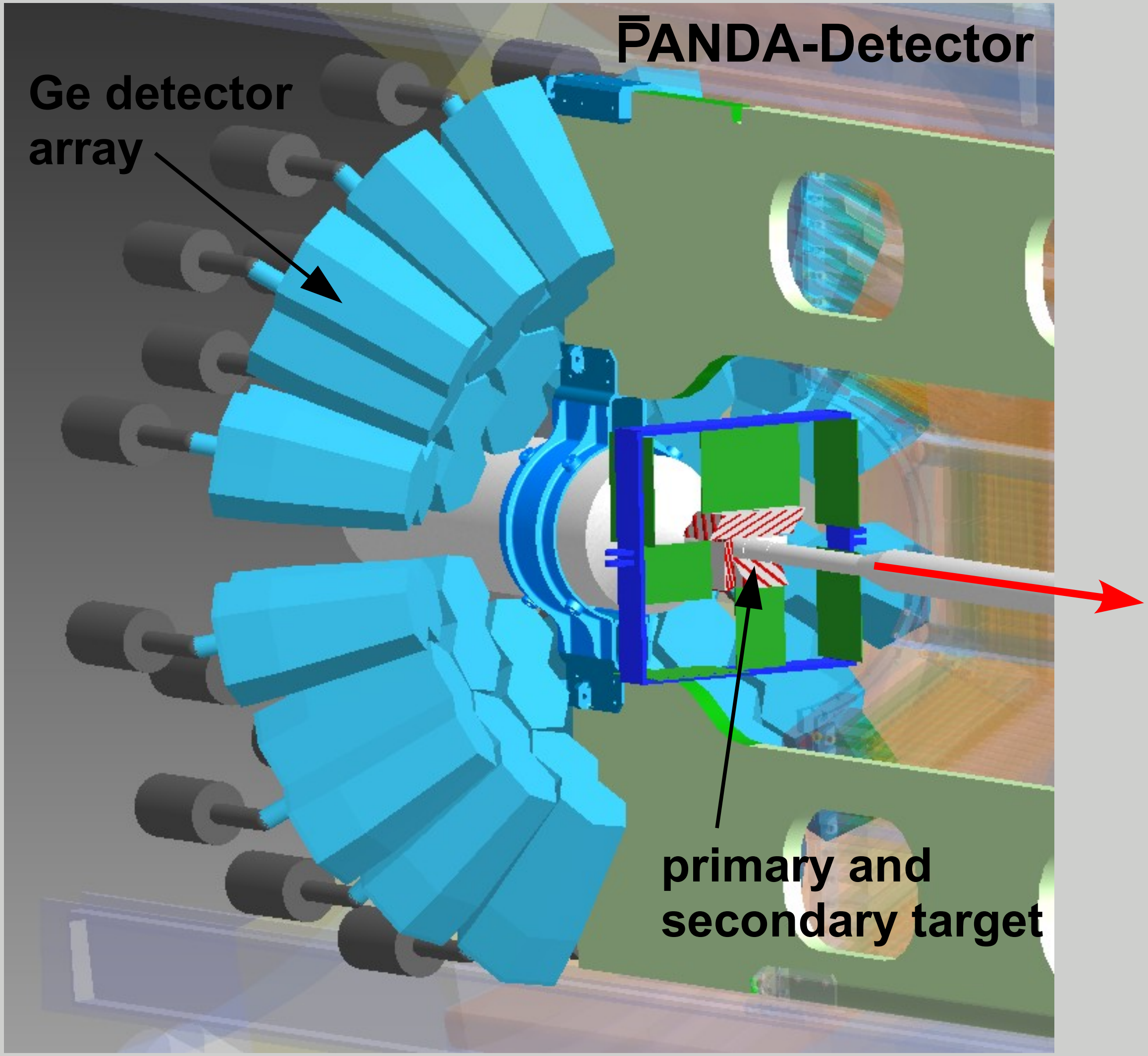
- deceleration of Ξ^--particles
- integration in the atomic shell of absorber atoms
- capture of Ξ^- by nucleus
- formation of Λ-Λ-hypernuclei by conversion: $\Xi^- p \rightarrow \Lambda\Lambda$
- detection of weak decay products

Ge detector array:

- γ-spectroscopy of Λ-Λ-hypernuclei with Ge detectors

→ *Poster of Marcell Steinen*

Hypernuclear setup



photons from excited double hypernuclei emitted isotropically

high particle flux in forward direction

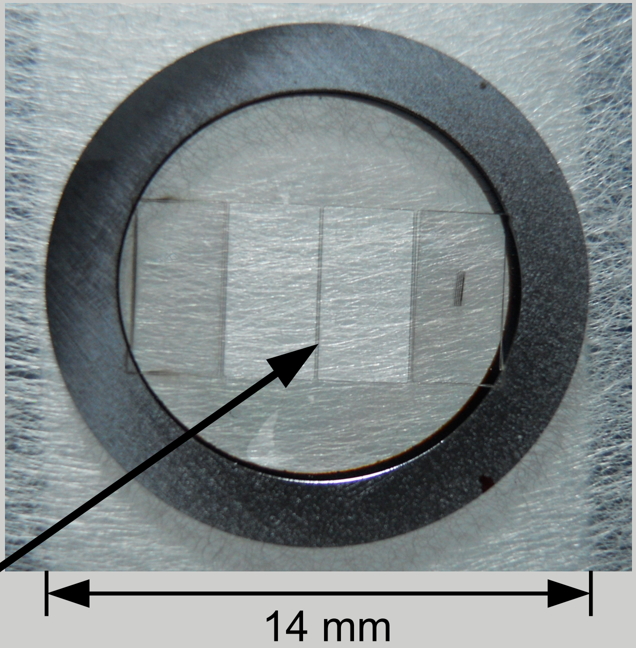
⇒ arrangement of Germanium detector array in backward direction

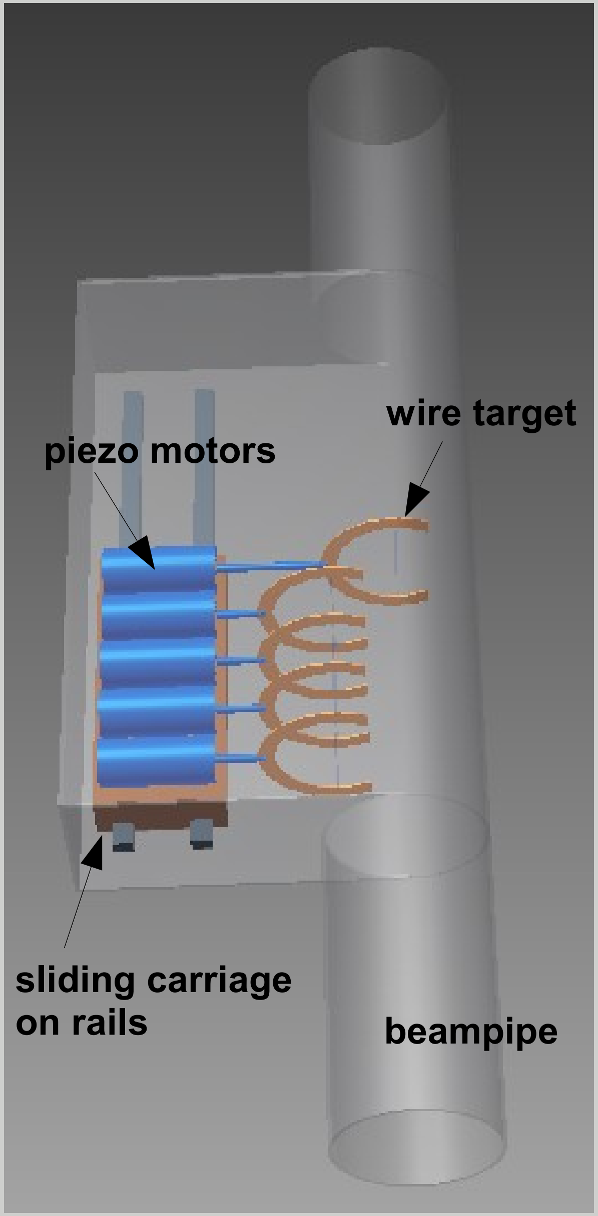
Primary target

Task of the primary target:
production of slow Ξ^-

Requirements:
- minimal hadronic background in backward direction
- constant luminosity of $\bar{p}$-beam
  $\Rightarrow$ beam losses, mainly due to coulomb scattering, must be kept low

$\Rightarrow$ ^{12}C micro-wire target with thickness 0.02 – 0.04 µm





Insertion to the beam:
- controlling interaction rates by moving target into beam halo
- easy replacement

Design of the secondary target

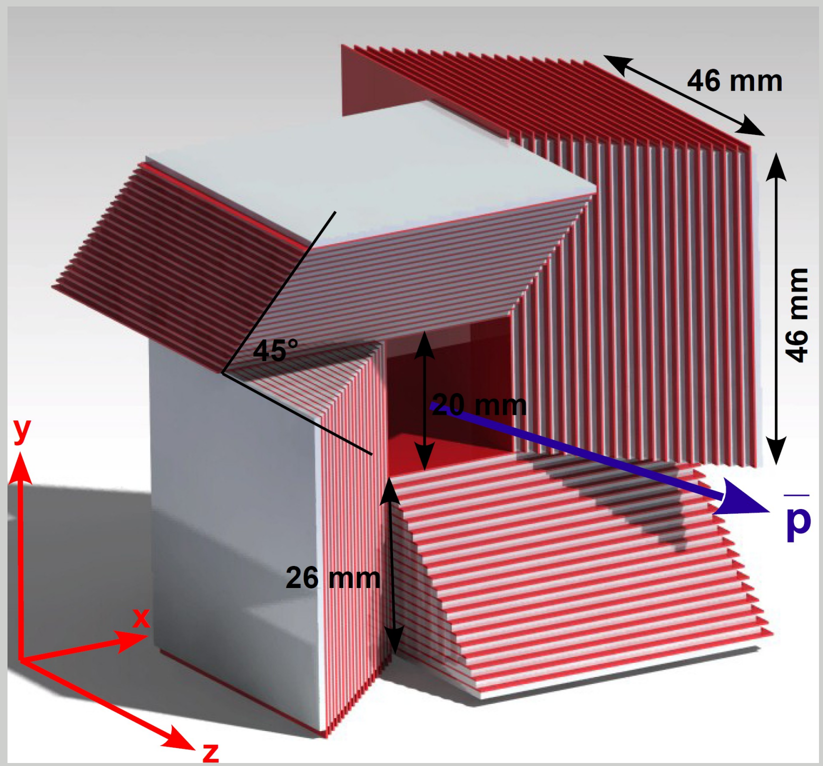
Requirements for the secondary target

- adjusted to stop time and life time of Ξ^- (τ = 0.164 ns) as well as geometry

  ⇒ compact structure without gaps (t_{stop} ≈ 0.06 ns)

- tracking of Ξ^- and the decay products of Λ-Λ-hypernuclei

  ⇒ alternating layers of Si strip detectors and absorber material



red:

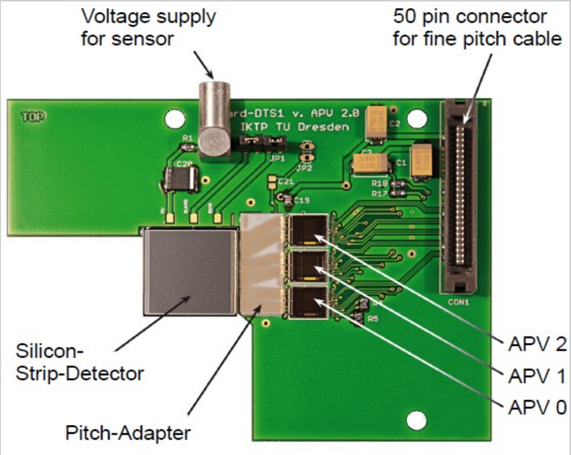
20 layers of double sided silicon strip detectors (thickness 300 µm) in each block

gray:

20 layers of absorbers (thickness 1 mm) different for each block (^{9}Be, ^{10,11}B or ^{12,13}C)

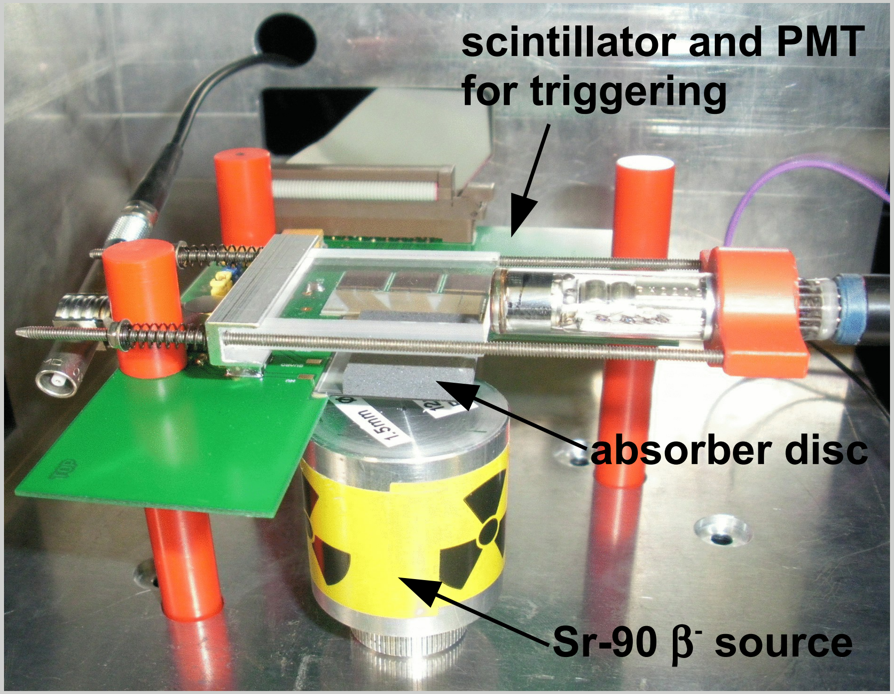
Experimental tests

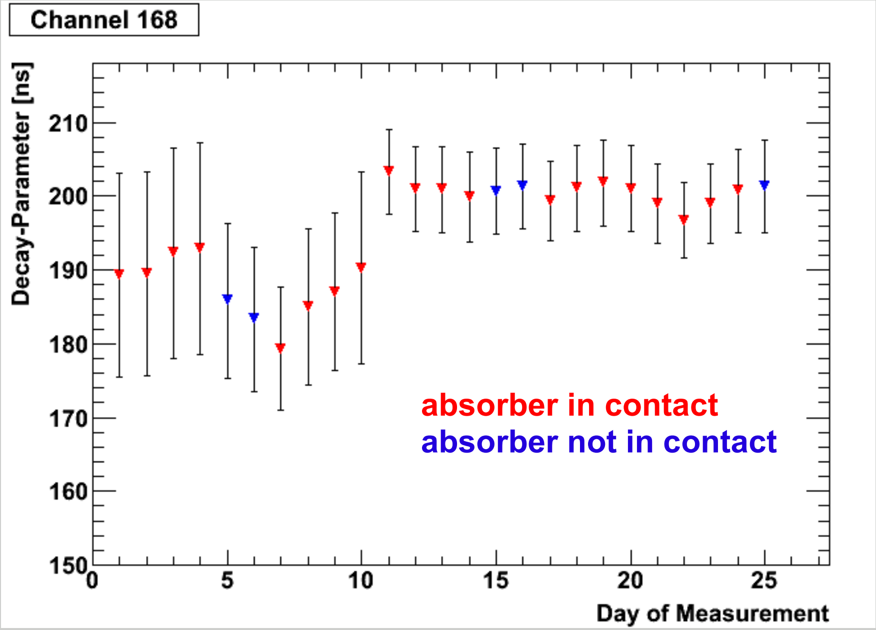
Compact structure ⇒ test of absorber contact



Si strip detector:

- 20 x 20 mm^2
- thickness 300 µm
- 384 strips
- pitch 50 µm
- readout of the p-side with 3 APV25-S1 Chips





Experimental result for boron

comparison of decay constant of the pulseshape in measurements with direct contact and with a gap between sensor and absorber

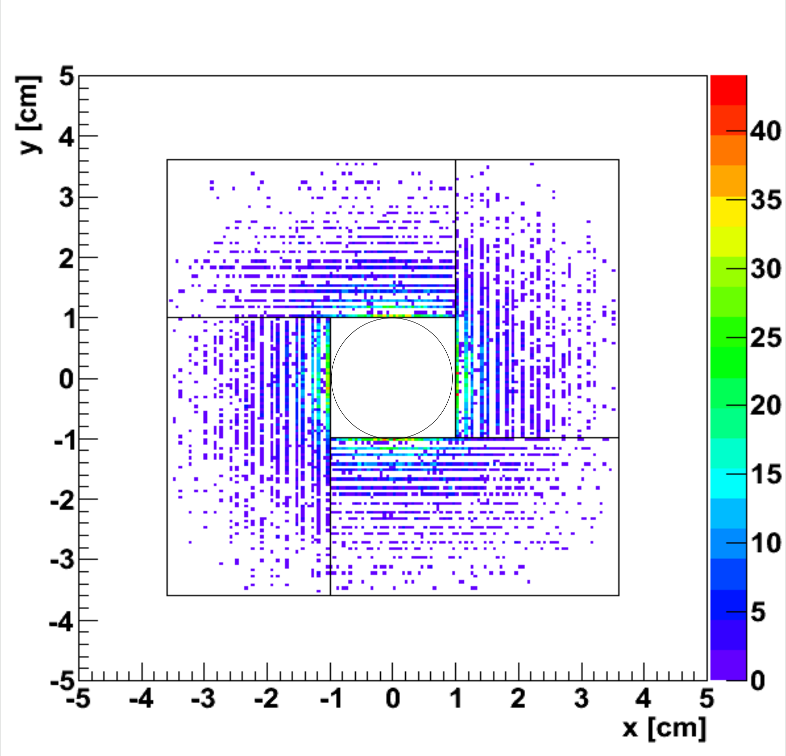
⇒ no significant change, other effects predominant

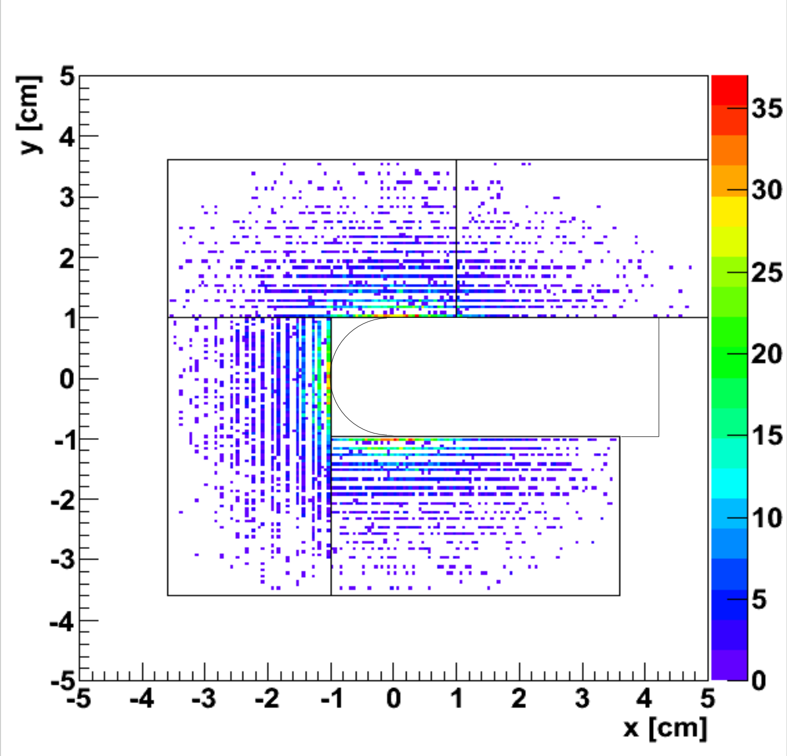
similar results for Be and C
⇒ direct contact possible

Simulations

Simulation results after generation of 200,000 Ξ^- -particles
with momentum range 100 MeV/c to 500 MeV/c

Stopped Ξ^- in beryllium absorbers of 20 x 1.0 mm thickness



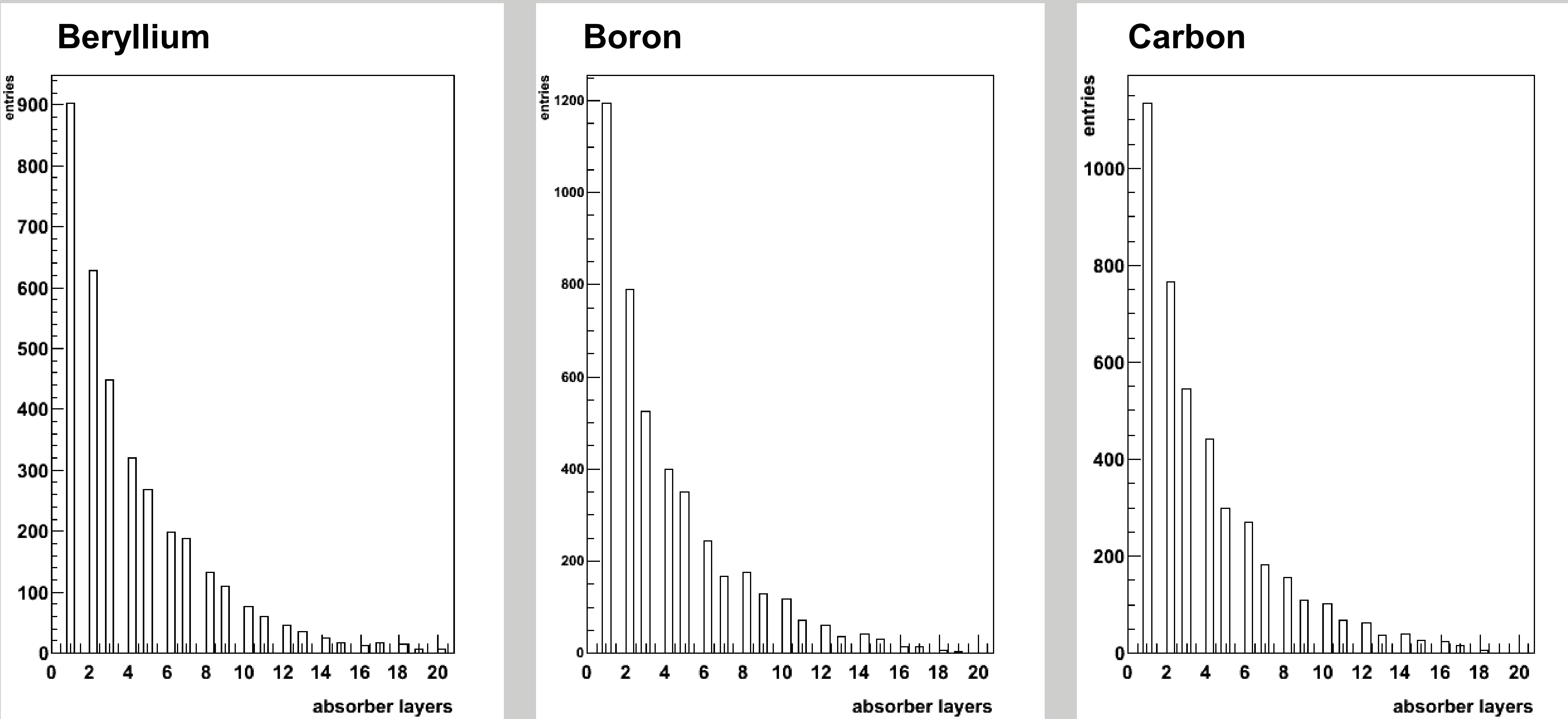


Full coverage around beampipe
⟶ not practical

Loss of ≈ 19% stopped Ξ^-

Simulations

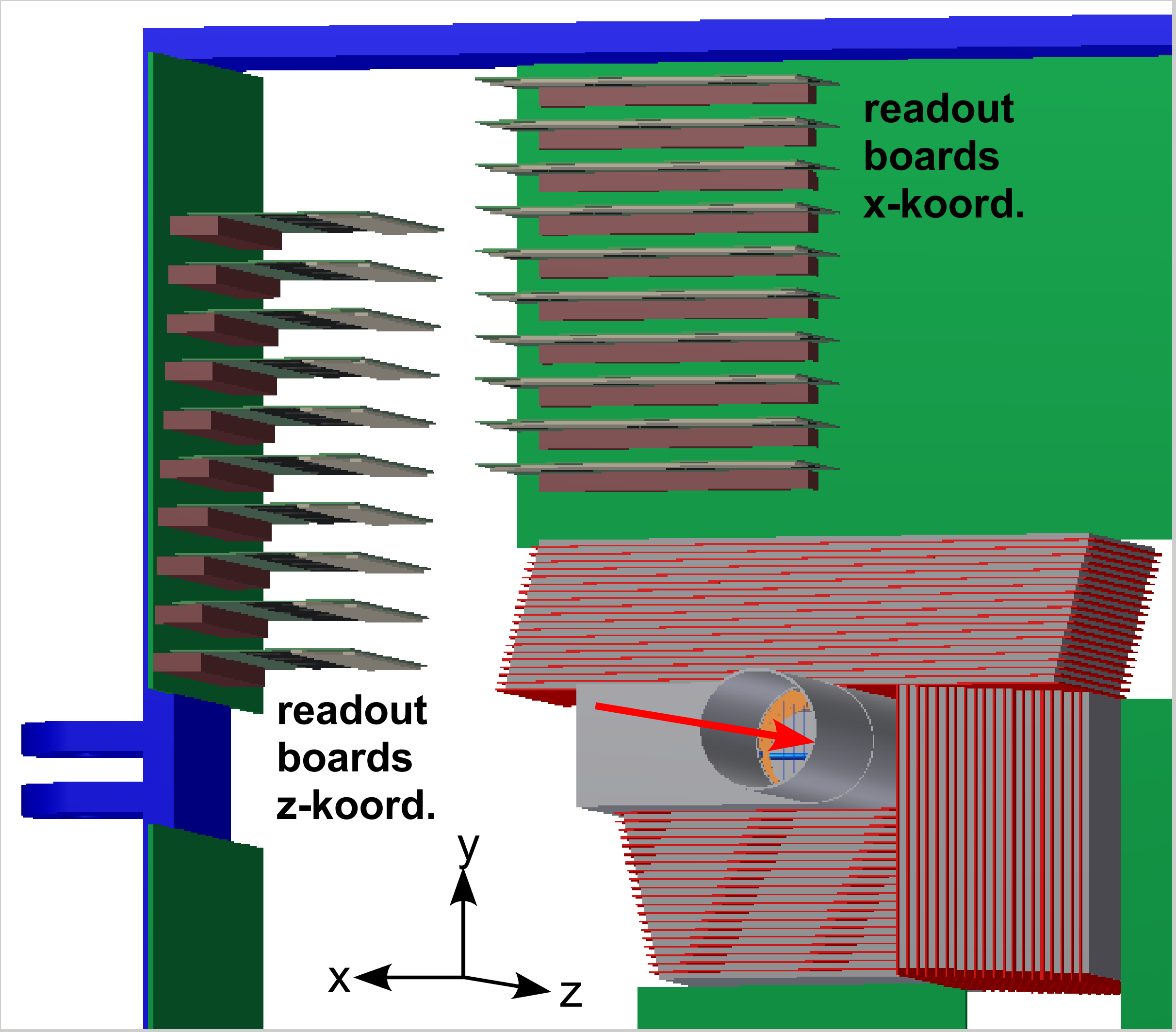
Number of stopped Ξ^- in the absorber layers of 1.0 mm thickness

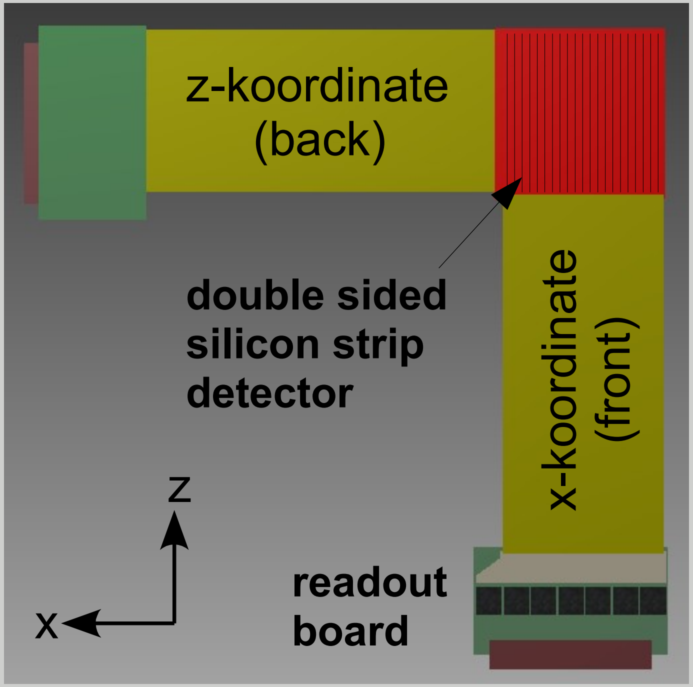


> 90% stopped Ξ^- in inner 10 layers $\Rightarrow$ number of absorbers must be optimized

Assembly of the secondary target

tiny compact structure and high irradiation
⇒ fan out the readout electronics



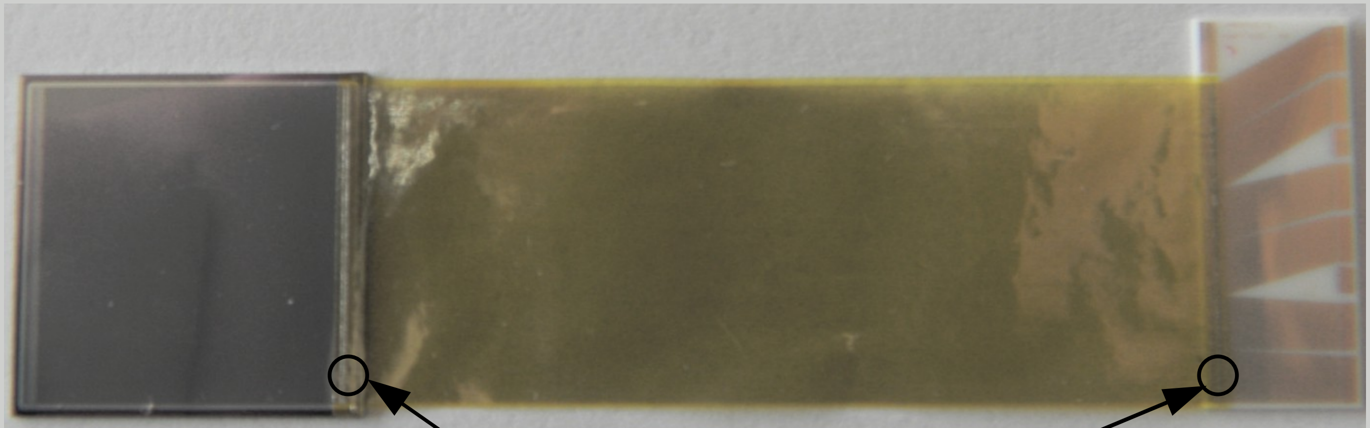


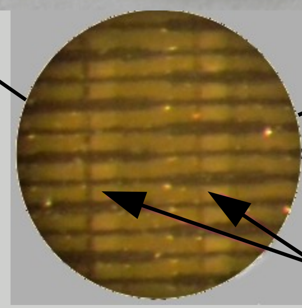
Readout of double sided silicon strip detectors:

Sensor and readout boards connected by ultra thin microcables via TAB bonding (Tape Automated Bonding)

Readout boards hosting pitch adapter, frontend chips and connector

Ultra-thin flexible cables





holes in polyimid layer for ultra-sonic TAB bonding

Manufacturer of cables:

State Enterprise Scientific Research Technological Institute of Instrument Engineering (Ukraine)

material: “foiled dielectric“ FDI-A-20

- 10µm aluminium layer
- 10µm polyimide layer

⇒ very low material budget: ≈ 99.75% of 1 MeV photons pass 10 cables

Outlook

- Simulations on pion tracking
  $\Rightarrow$ Optimization of absorber thickness and number
- Test of the produced cables
  and development of further prototypes
- Design and test of piezo motors:
  in vacuum, radiation hardness, reliability, ...

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Thank you for the attention!