The target system for the hypernuclear experiment at P̄ANDA

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Outline

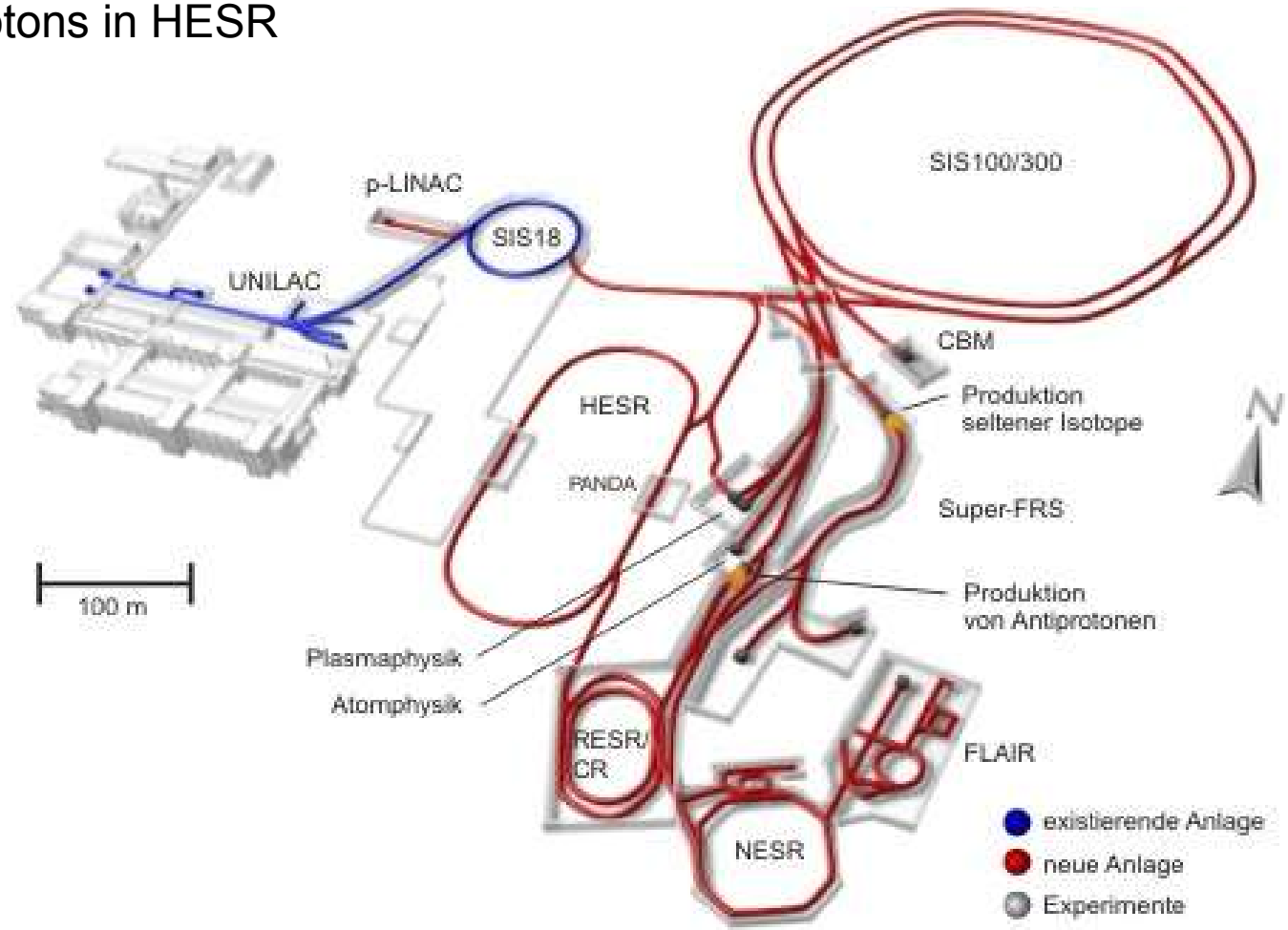
- The $\overline{\text{P}}$ANDA experiment
- The primary target
- The secondary target
- Outlook

Motivation

FAIR (Facility for Antiproton and Ion Research)

at GSI in Darmstadt

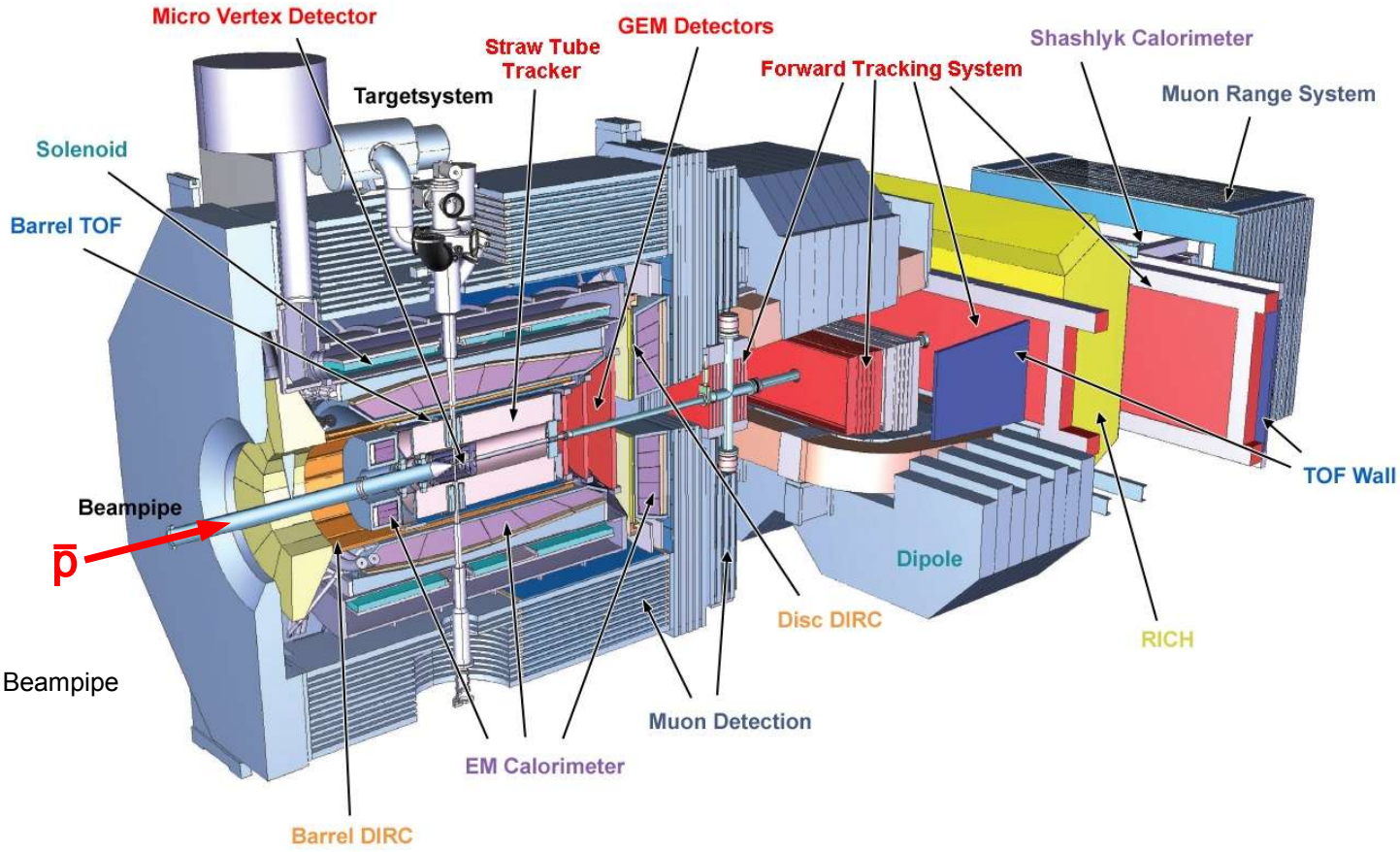
momenta of antiprotons in HESR
1.5 – 15 GeV/c



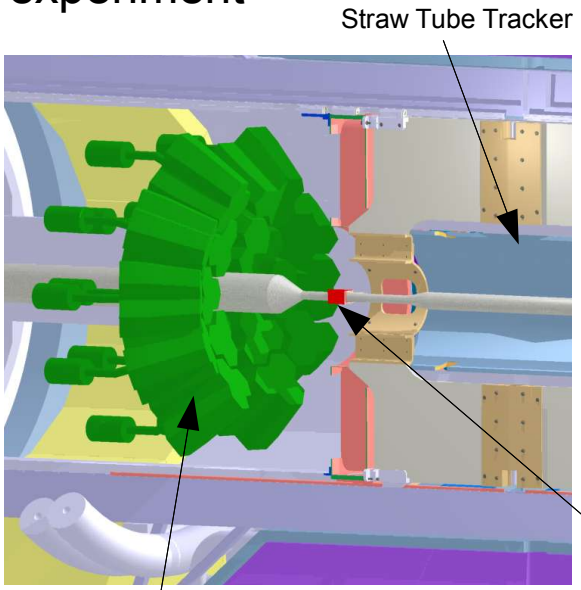
Motivation

$\bar{\text{P}}$ANDA (Anti-Proton Annihilations at Darmstadt)

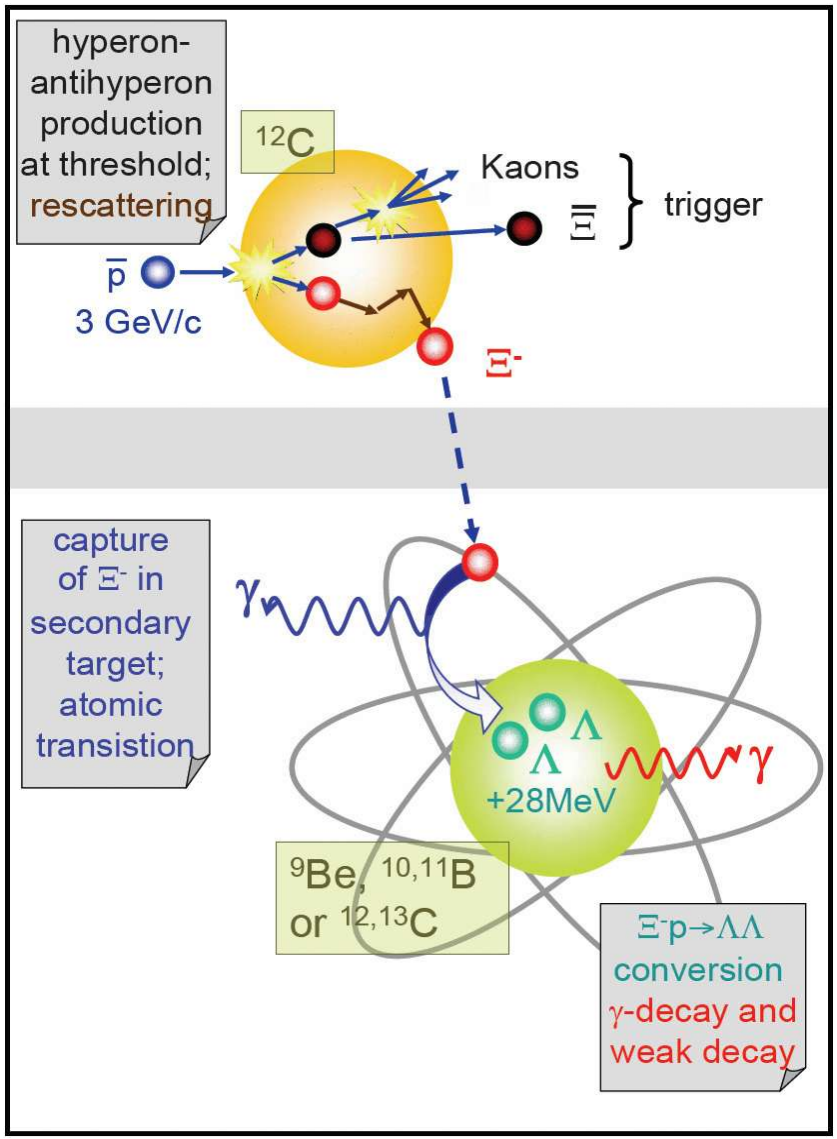
modular detector
in the HESR of FAIR



setup for hypernuclear experiment



Motivation



Production and detection of Λ-Λ-hypernuclei at $\bar{\text{P}}$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 (pions)

Germanium detector array:

- γ-spectroscopy of Λ-Λ-hypernuclei with Ge detectors
  → *next talk by Marcell Steinen*

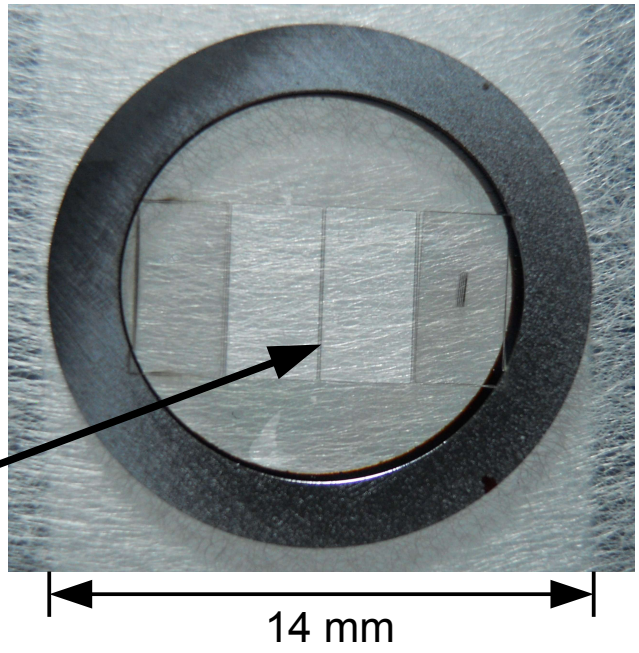
The primary target

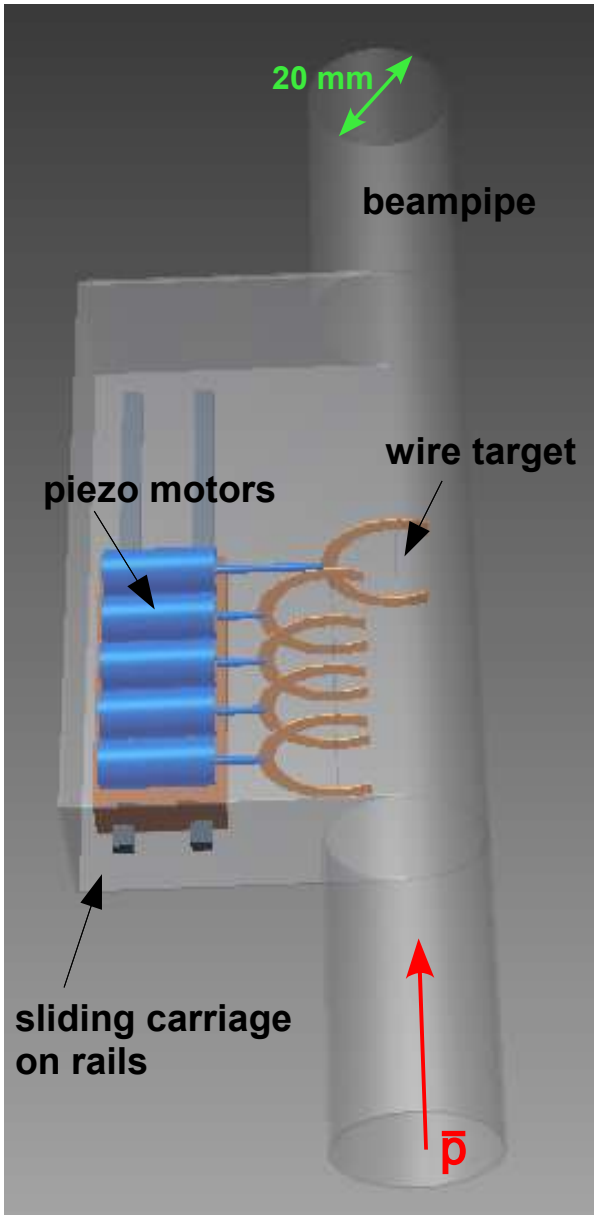
Task of the primary target:
production of slow Ξ^-

Requirements:

- minimal hadronic background in backward direction
- constant luminosity of $\bar{p}$-beam

$\Rightarrow$ ^{12}C micro-wire target with thickness 3 µm, width 100 µm





Requirements for positioning stage:

- functionality in a field of 2 T
- working in an ultra high vacuum of 10^{-9} mbar
- radiation hardness
- total height limited to 20 mm

Piezo motor tests

PiezoWave Linear 0.1 N

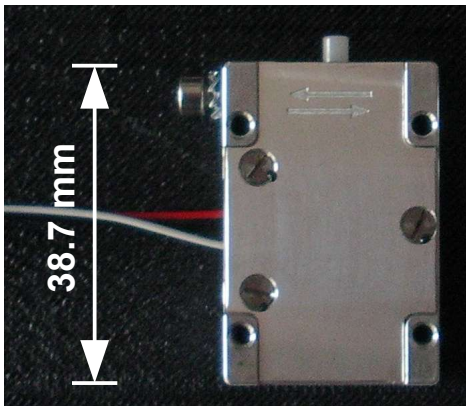
Specifications:

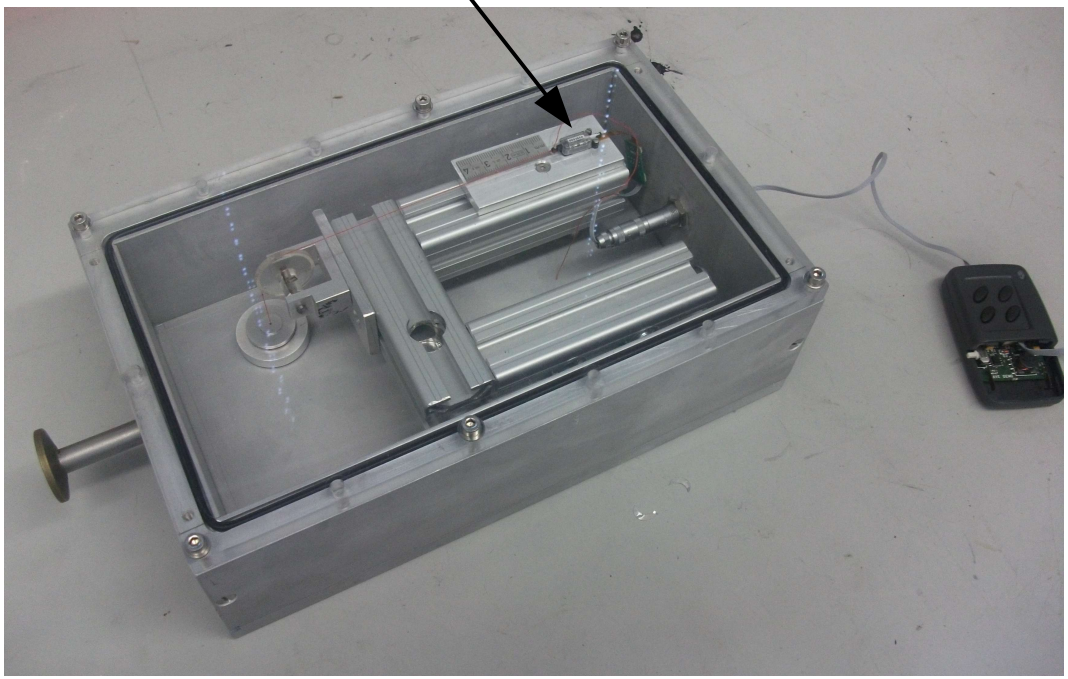
- stroke max: 8 mm
- size: 14.0 mm x 7.2 mm x 4.4 mm

Experimental tests:

- average step size:
  0.96 µm → precise enough ✓
- Measurement of forces with weights:
  dynamic force = 0.14 N → sufficient ✓
  holding force = 0.88 N
- proper running in vacuum
  proved for some weeks ✓
- not influenced by a
  magnetic field of 1.3 T ✓
- no radiation damage discovered
  in beam test at COSY in Jülich ✓

Nanomotion HR1-1-U-0

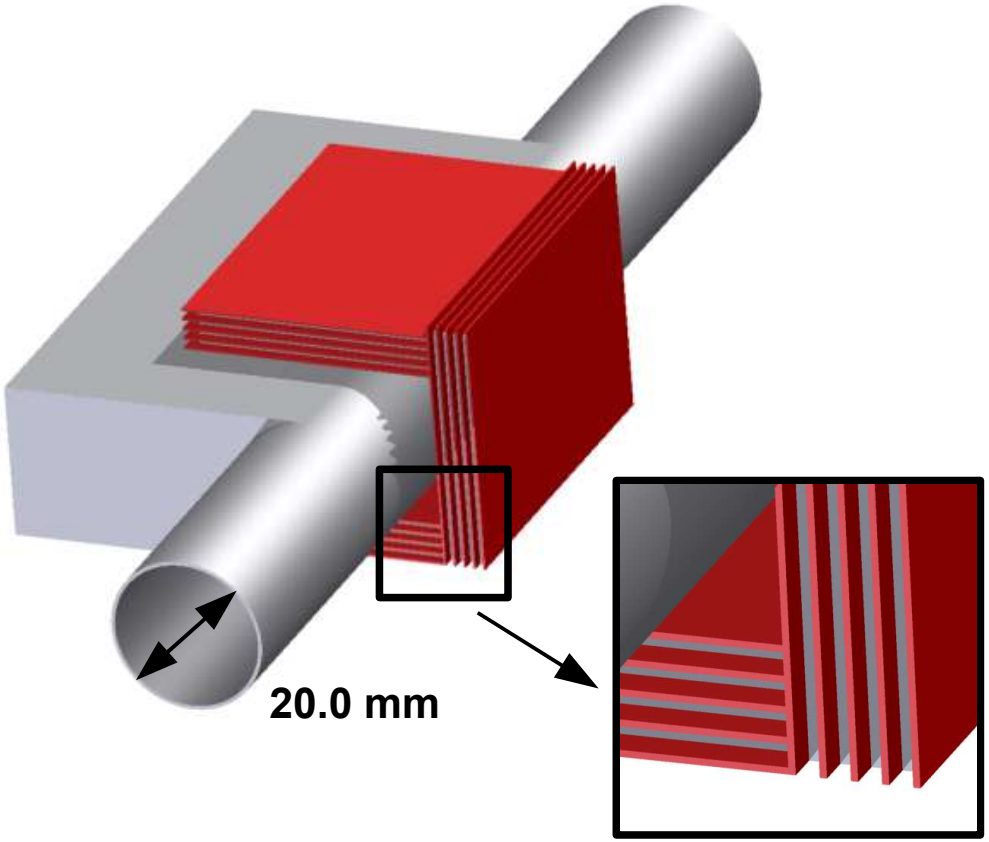




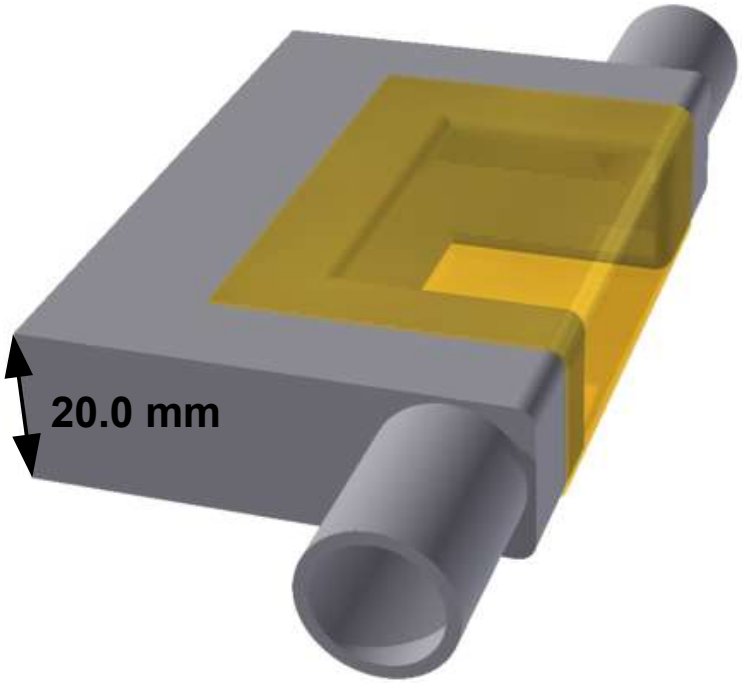
Design of the target system

very short range of Ξ^-: $c\tau$ = 4.914 cm ⇒ compact structure essential

arrangement of DSSD-absorber-assemblies
directly around the target chamber and beampipe
→ minimization of beampipe diameter

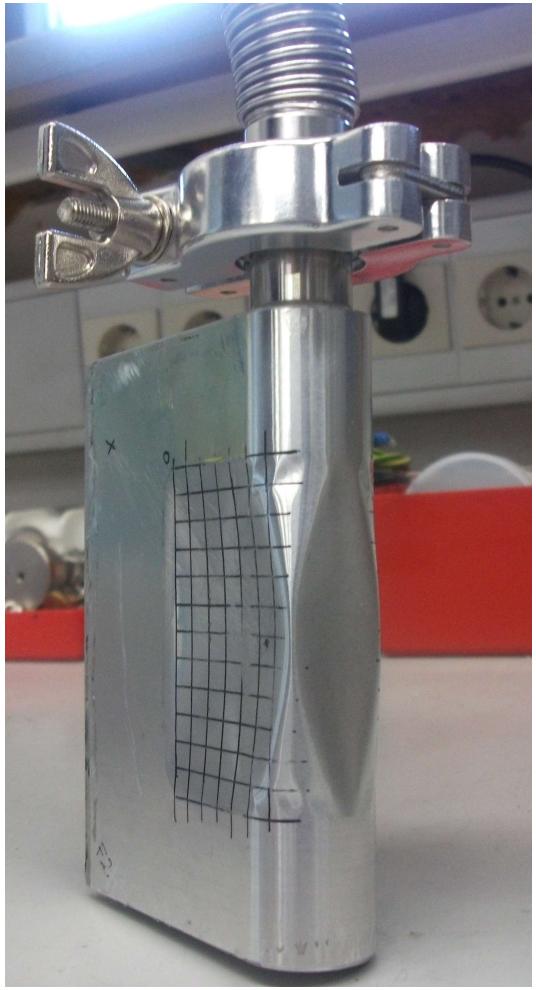


minimization of material budget
→ reduction of thickness

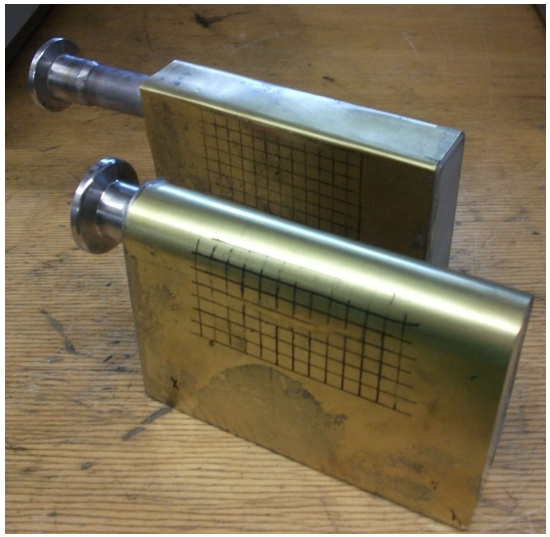


Target chamber studies

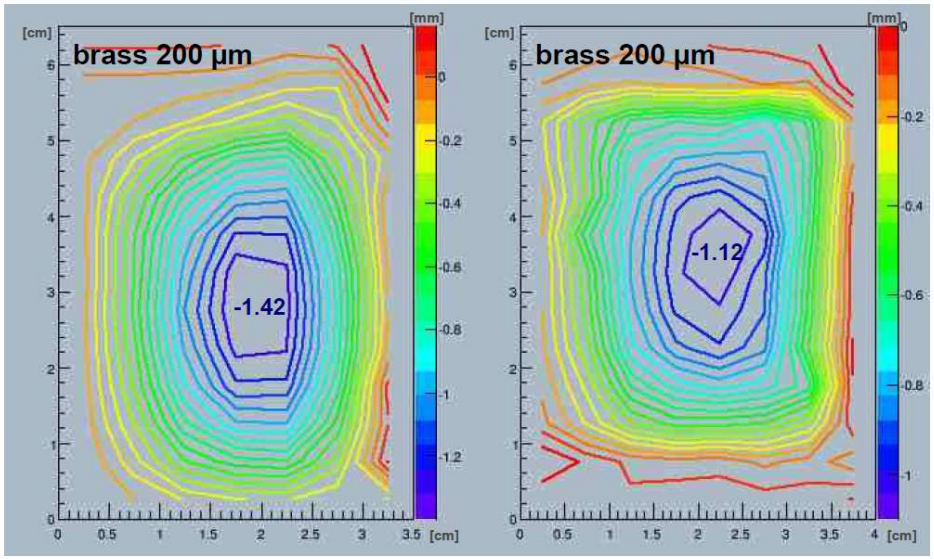
Stability tests in vacuum:



alloy AlMg3, 100 µm



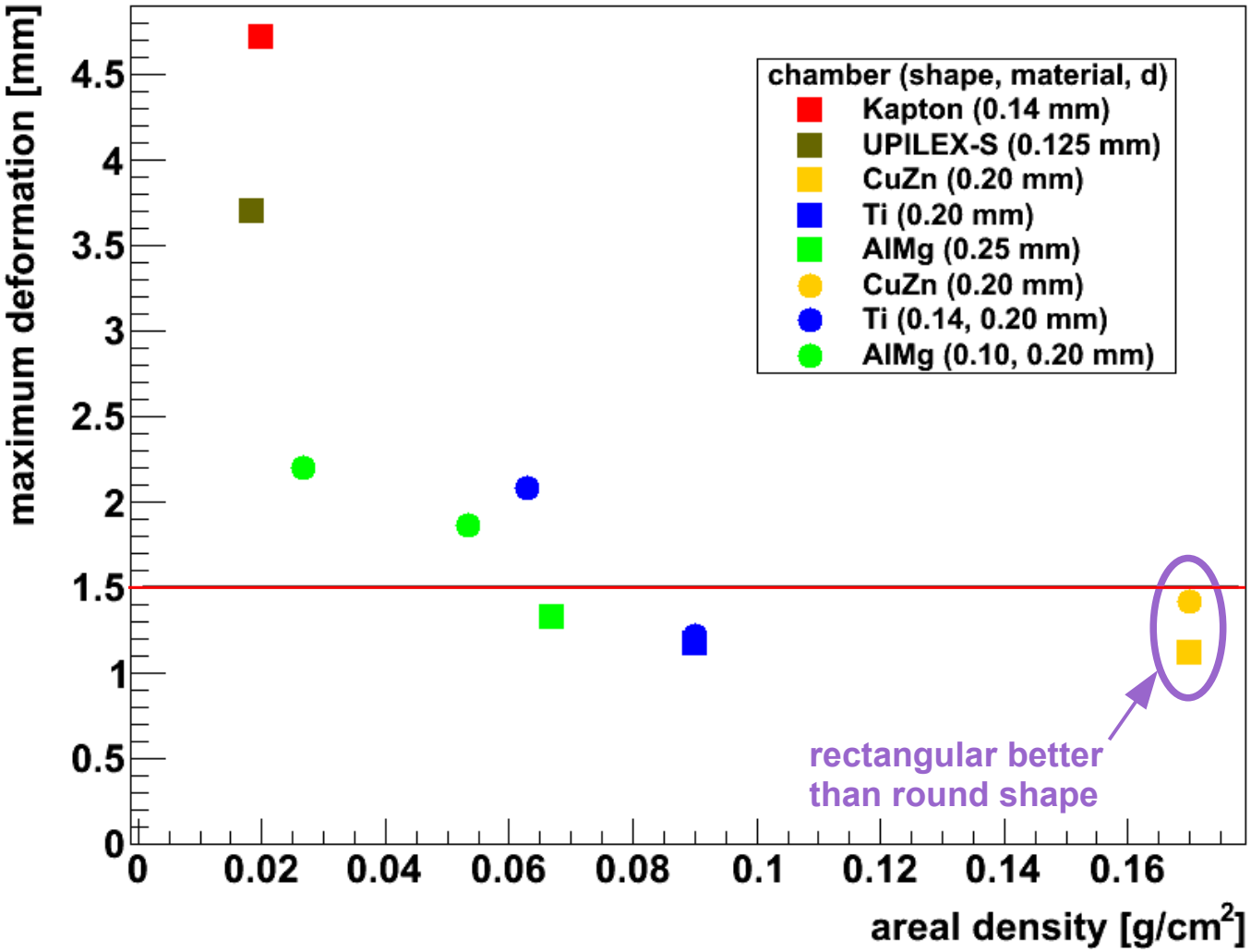
Brass, 200 µm



round shape

rectangular shape

Target chamber measurements



Conclusion:

possible materials:

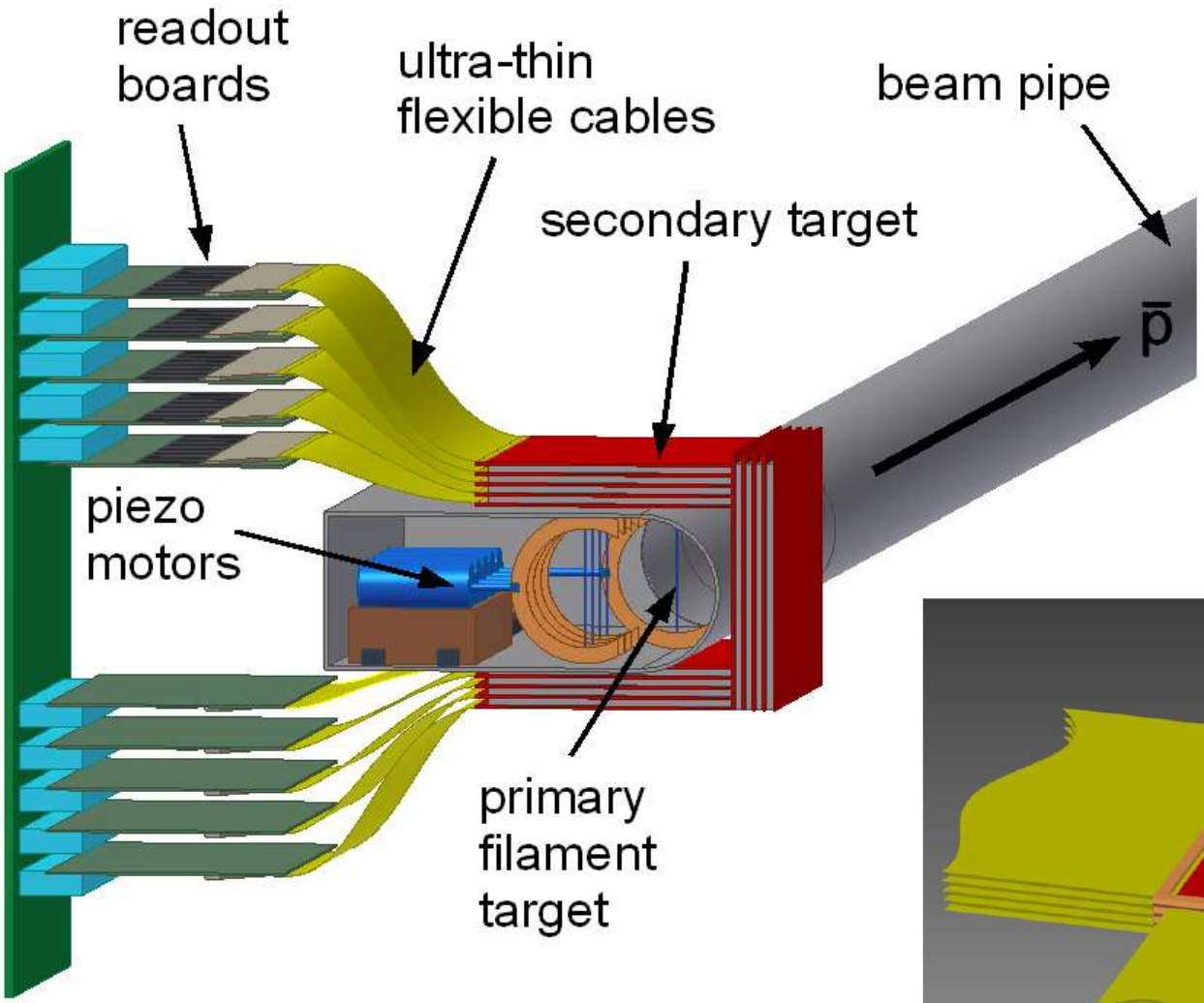
- Titanium 200 µm
- AlMg 250 µm

shape:

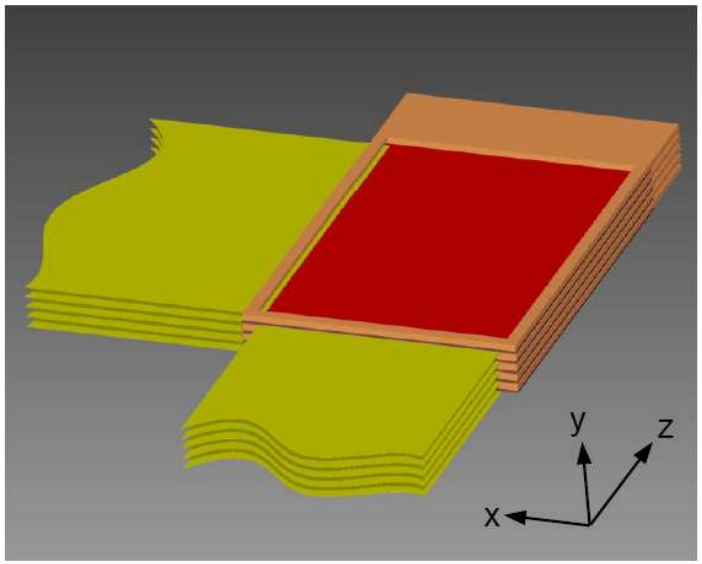
lower deformation with rectangular frame

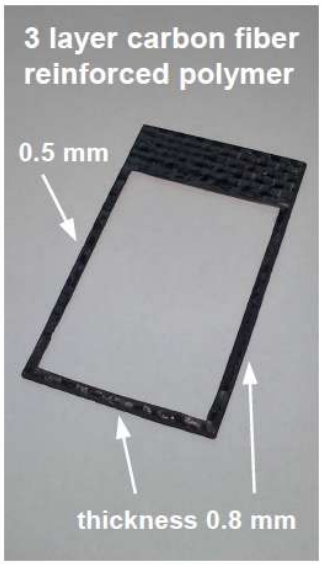
but AlMg teared at one edge after 1600 cycles

Design of the secondary target



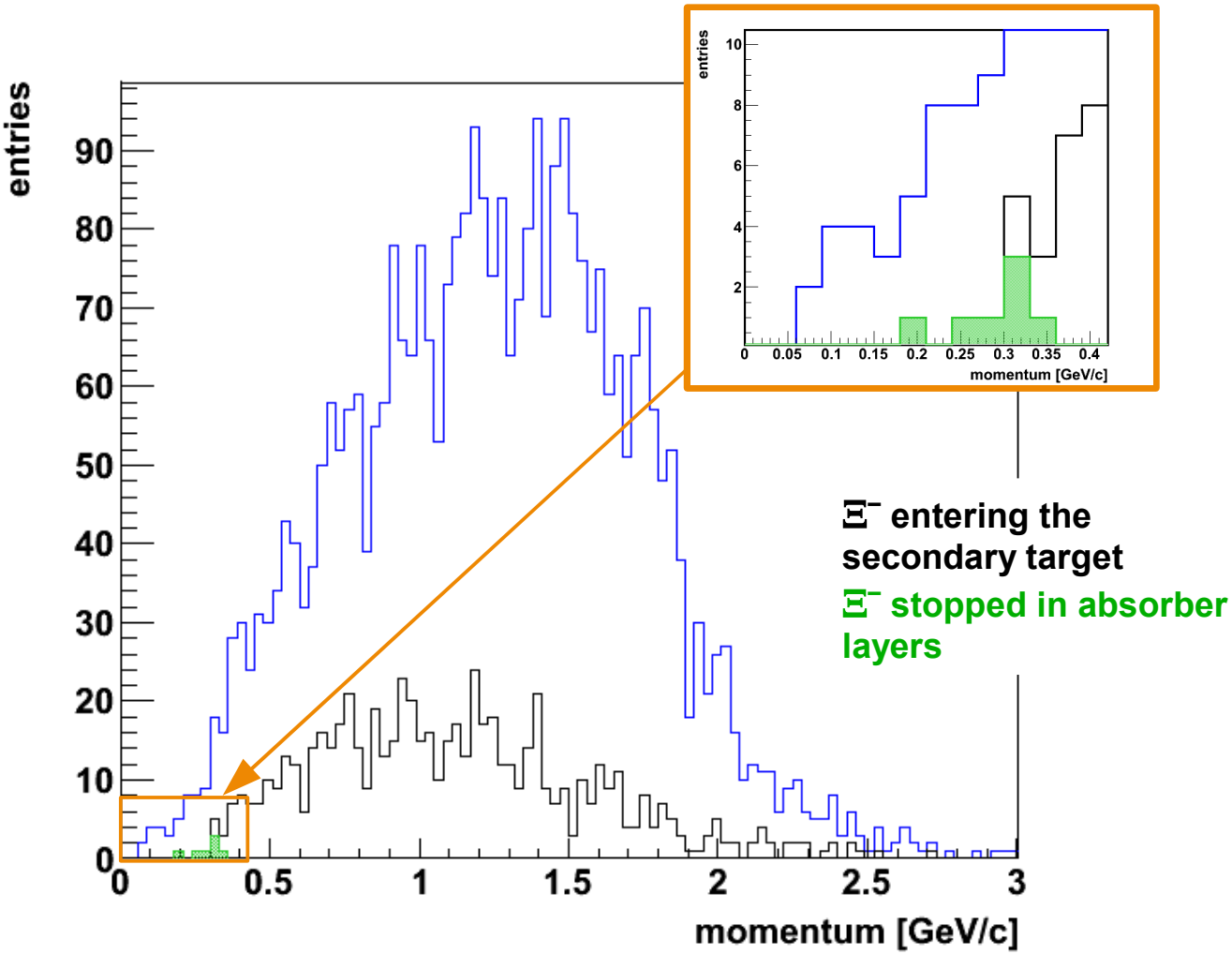
cabling and support structures





Stopping of Ξ^-

Ξ^- out of GiBUU simulations with $\bar{p}$ on ^{12}C at 2.9 GeV/c

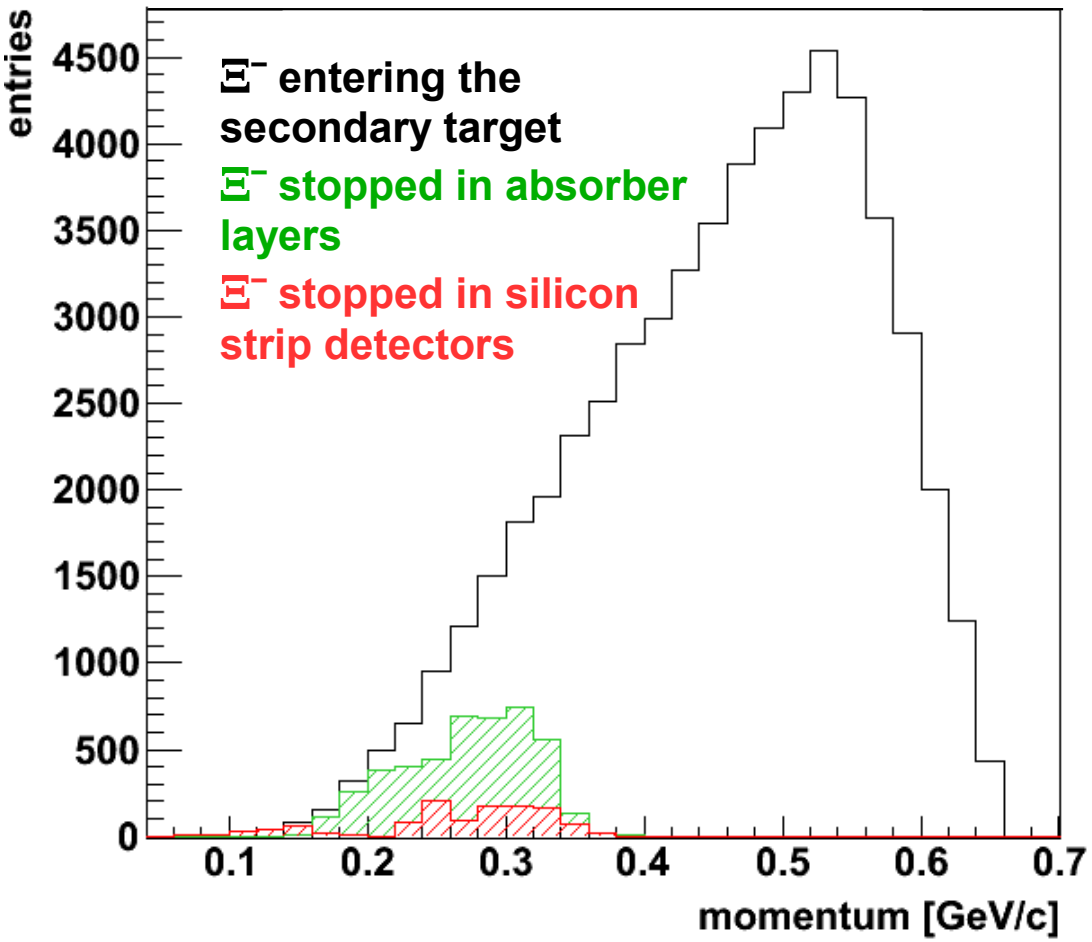


momentum distribution of Ξ^- and results after stopping in the secondary target

→ 0.204% of the generated Ξ^- (≈ 1 minute of $\bar{P}$ANDA) are stopped in beryllium

Stopping of Ξ^-

Simulation of Ξ^- with a created generator of parametrized GiBUU events



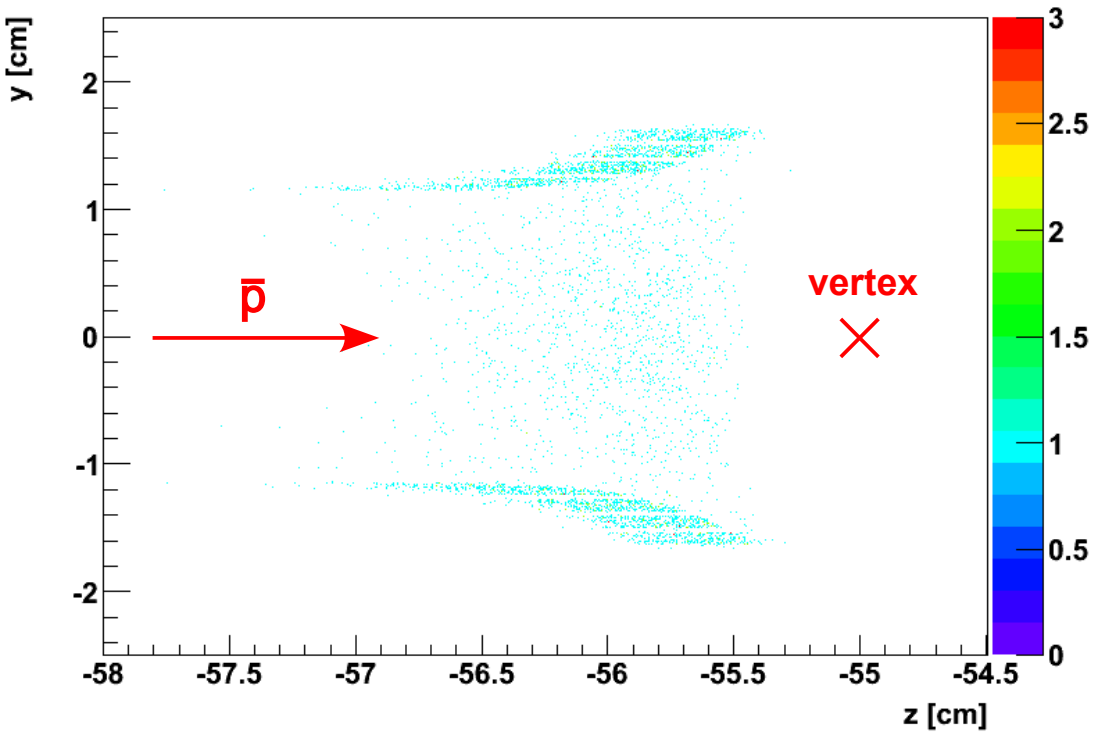
momentum distribution of stopped Ξ^- at the entrance of the secondary target

→ only Ξ^- in the momentum range from about 0.1 to 0.5 GeV/c that means θ from 100° to 180° can be stopped

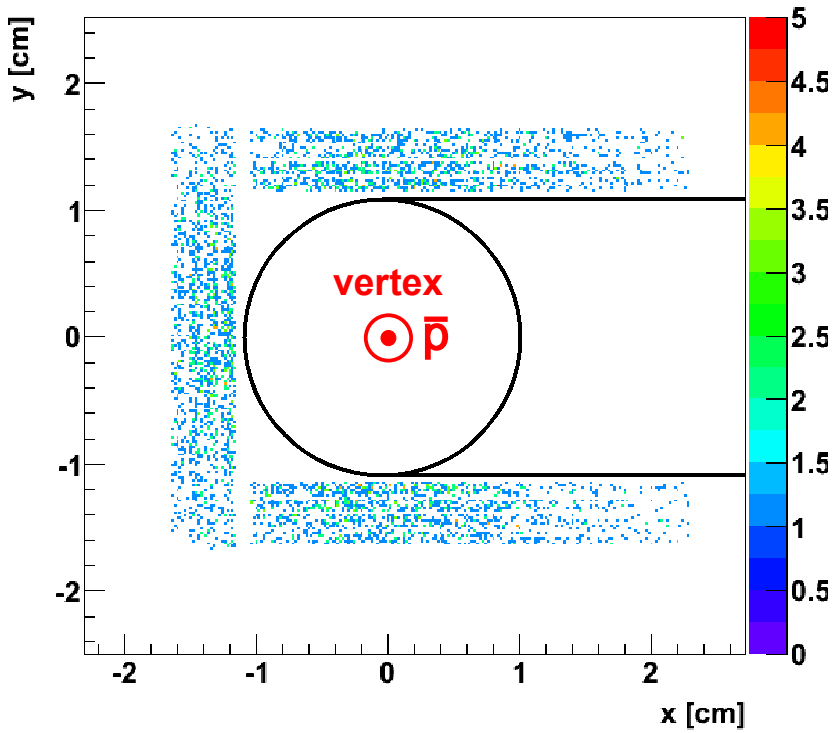
Stopping of Ξ^-

Simulation of Ξ^- with a created generator of parametrized GiBUU events in a theta range from 70° to 180°

Stopping points in zy view:



Stopping points in xy view:

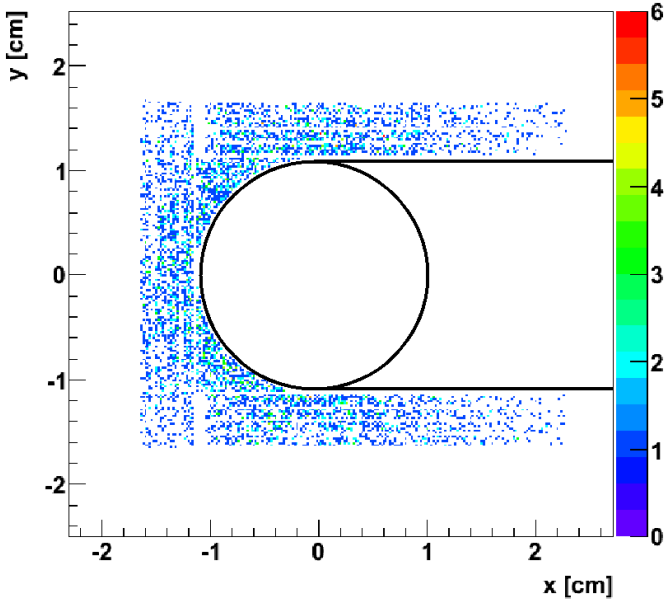


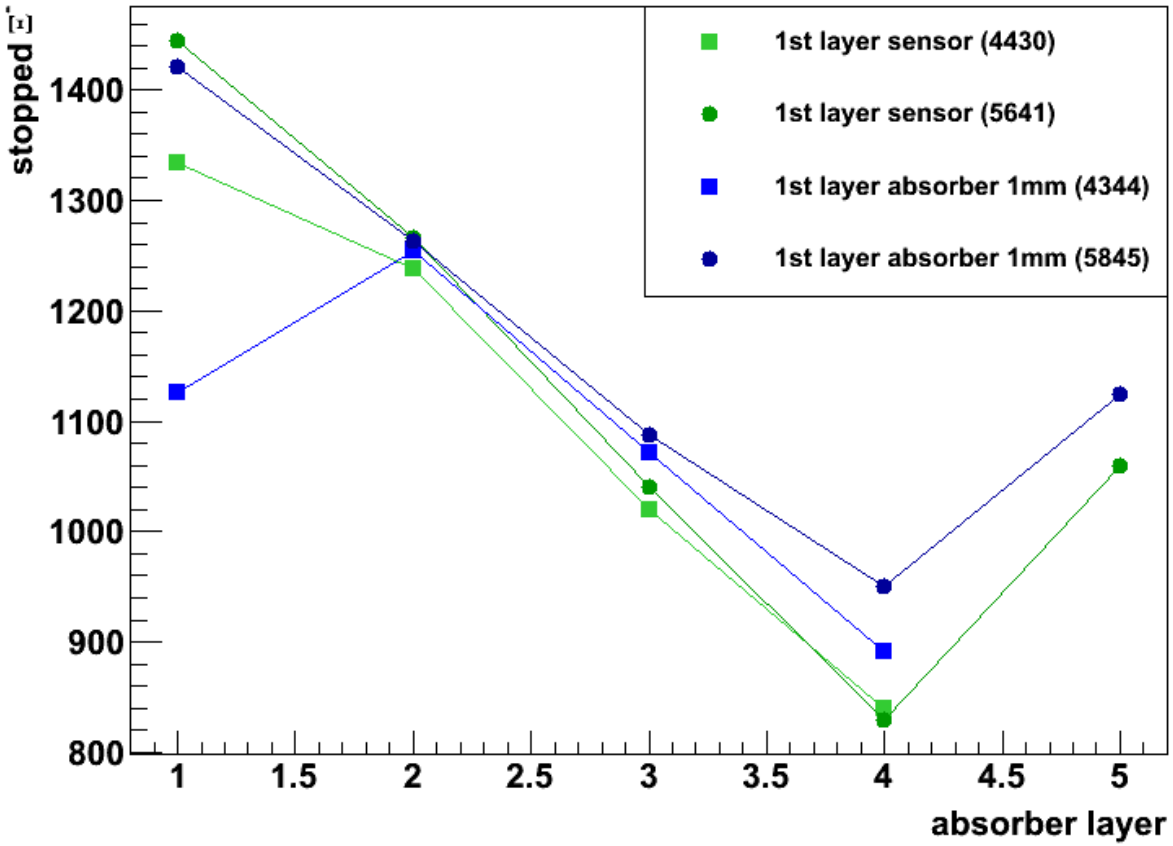
Stopping of Ξ^-

Simulation of Ξ^- with a created generator of parametrized GiBUU events in a theta range from 70° to 180°

optimization studies:

- corners filled with absorber material
- exchange of the starting layer
- increased absorber thickness

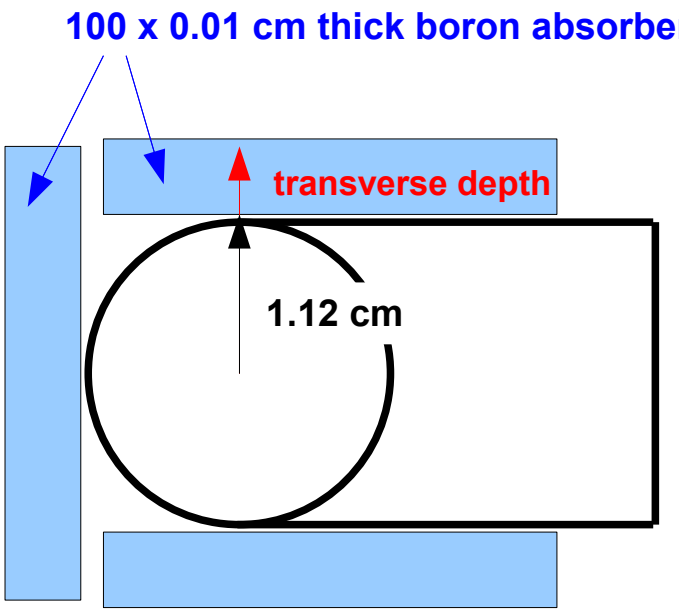




⇒ **absorber material in the corners**

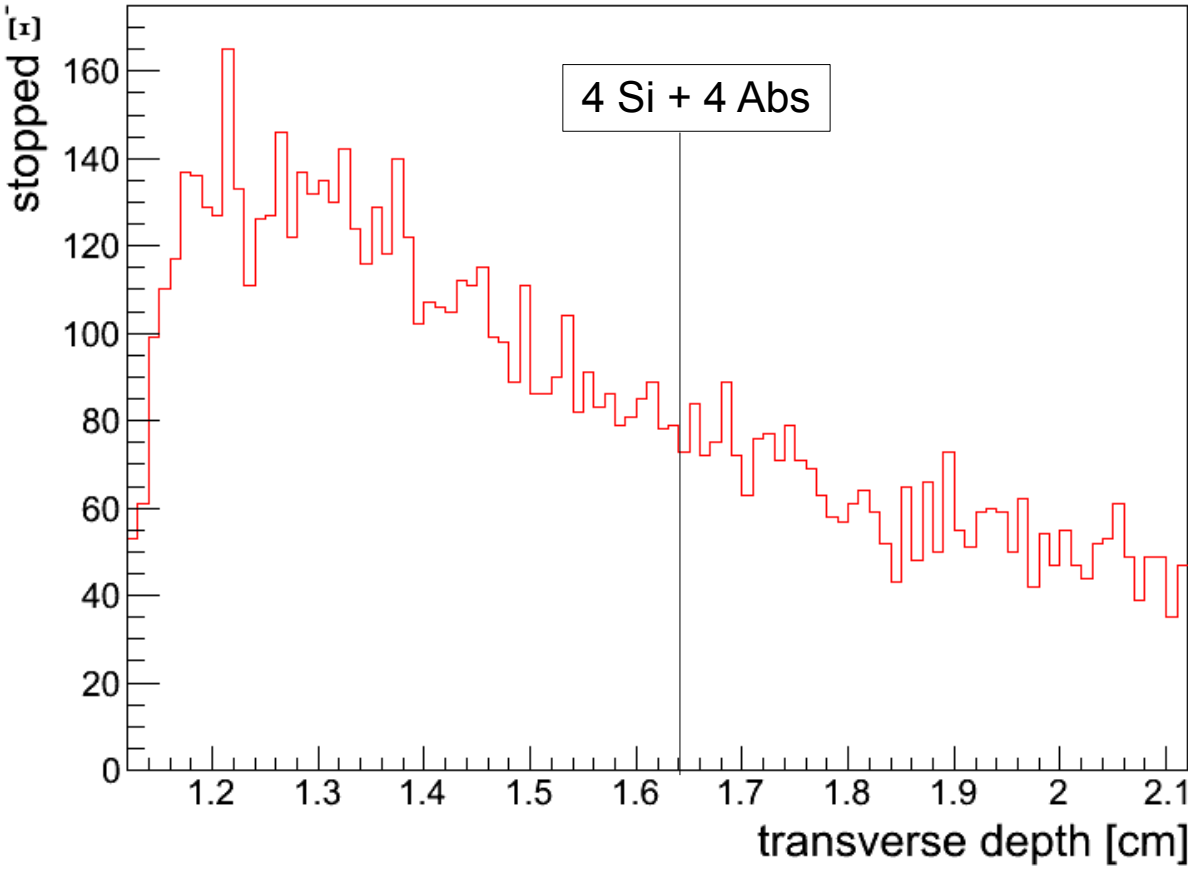
Stopping of Ξ^-

Simulation of Ξ^- with a created generator of parametrized GiBUU events in a theta range from 70° to 180°



density (B) = 2.460 g/cm^3

≈ 2.336 g/cm^3 = density (Si)



⇒ **more layers**

Pion tracking

Concept of the pion tracking:

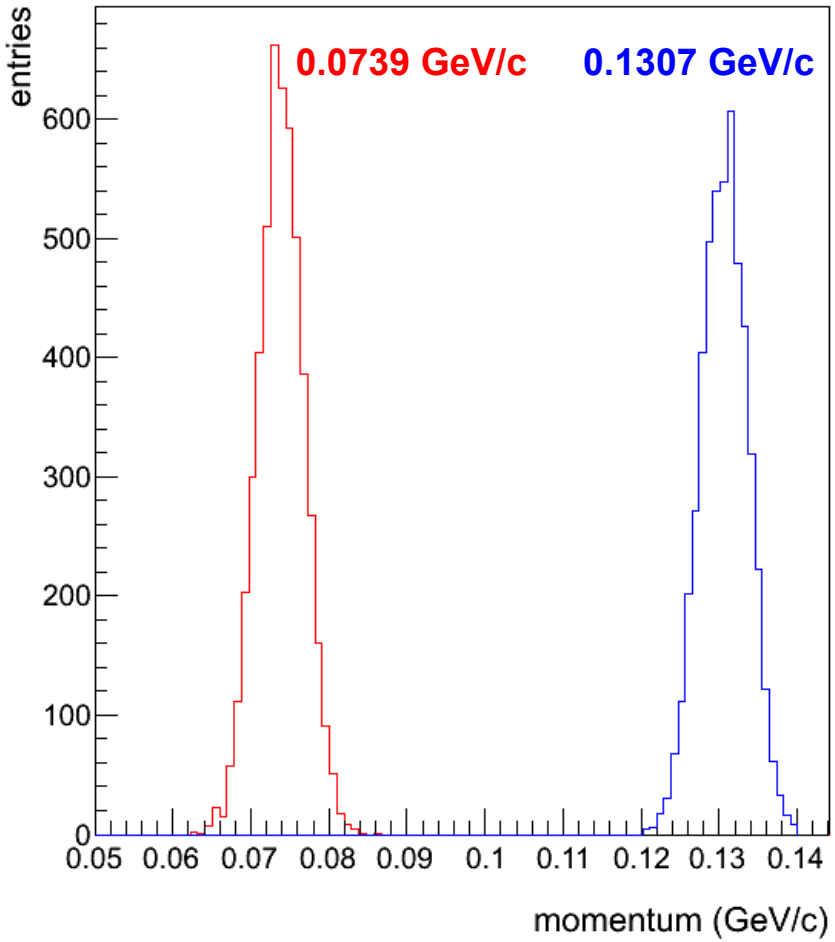
- extract the coordinates of the Ξ^- stopping points
- placing ${}^{11}_{\Lambda\Lambda}$Be double hypernuclei
- phase space decay by Geant4

$$ {}^{11}_{\Lambda\Lambda}\mathrm{Be} \rightarrow {}^{11}_{\Lambda}\mathrm{B} + \pi^-_1 $$

$$ {}^{11}_{\Lambda}\mathrm{B} \rightarrow {}^{11}\mathrm{C} + \pi^-_2 $$

- tracking of π^-_1 and π^-_2

expected momentum distribution:



Outlook

- beamtest of the filament target
- construction of a positioning stage
- tests of a target chamber with B_4C window
- study of the arrangement and thickness of the layers in case of the stopping of Ξ^- and the pion tracking
- ongoing GiBUU simulations