Optimization of the target system for the hypernuclear experiment at $\bar{P}$ANDA

●Sebastian Bleser[1], Felice Iazzi[2], Josef Pochodzalla[3], Kai Rittgen[3], Cihan Sahin[3], Alicia Sanchez Lorente[1] and Marcell Steinen[1]

[1]Helmholtz-Institut Mainz
[2]Politecnico di Torino and INFN, Sez. di Torino, Italy
[3]Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz

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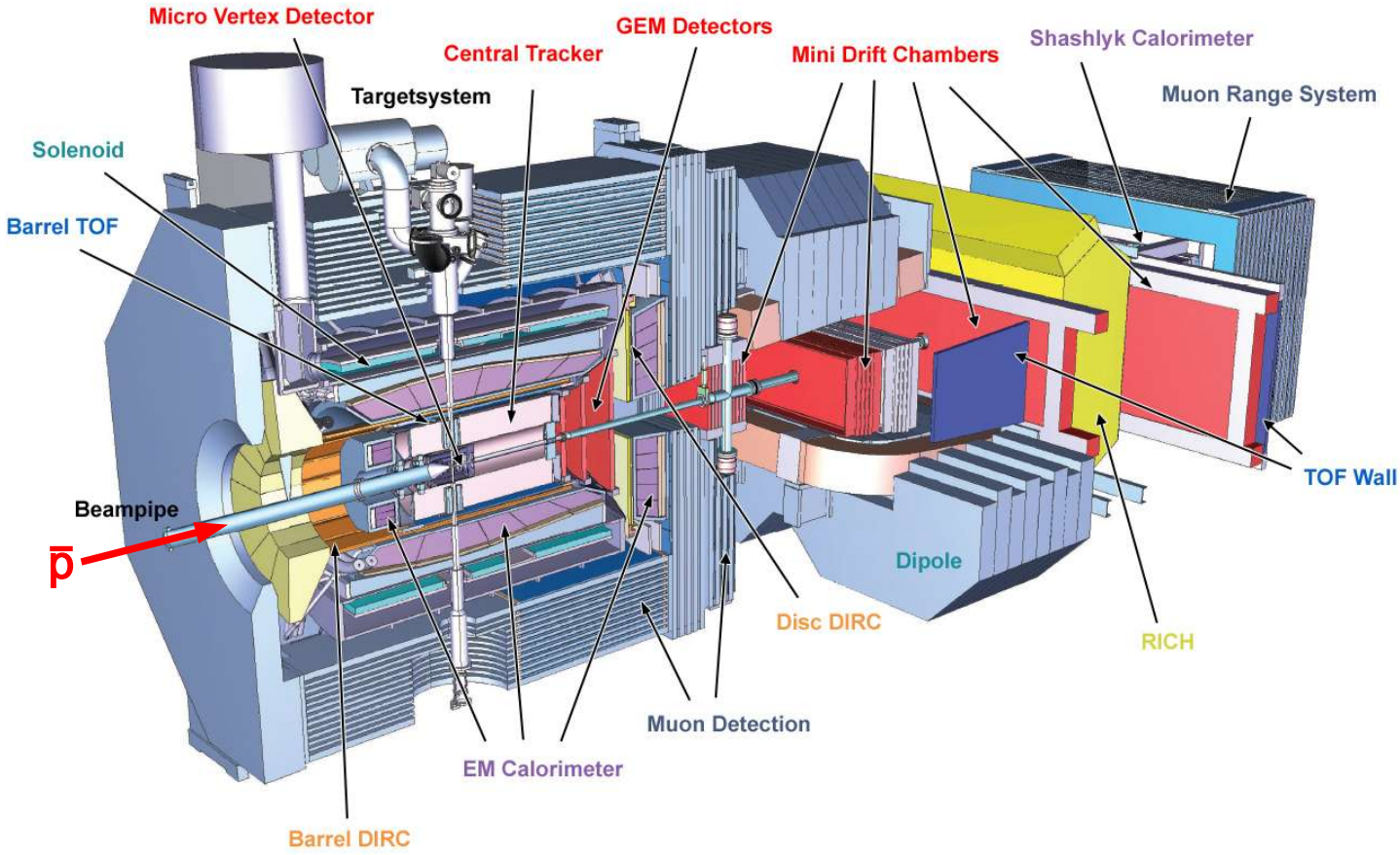
Outline

- Motivation
- The primary target
- The secondary target
- Outlook

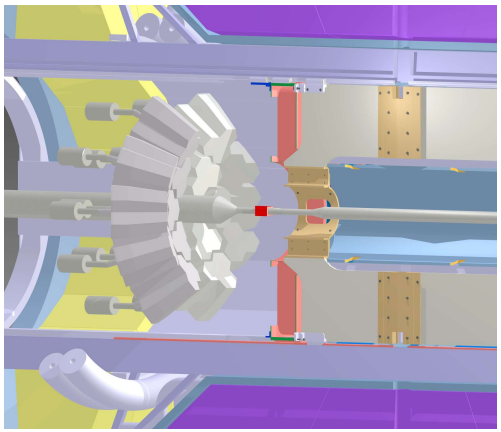
Motivation

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

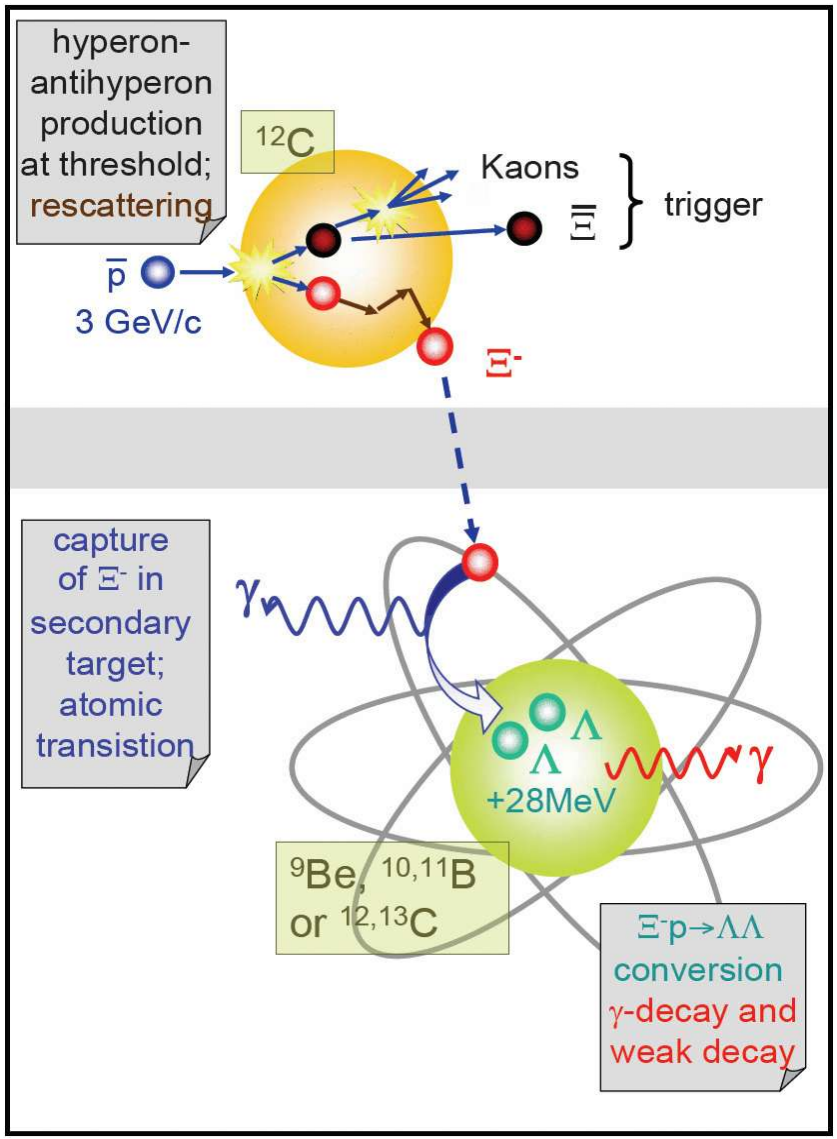
modular detector
in the HESR of FAIR



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

Germanium detector array:

- γ-spectroscopy of Λ-Λ-hypernuclei with Ge detectors
  → *Talk of Marcell Steinen HK 44.1*

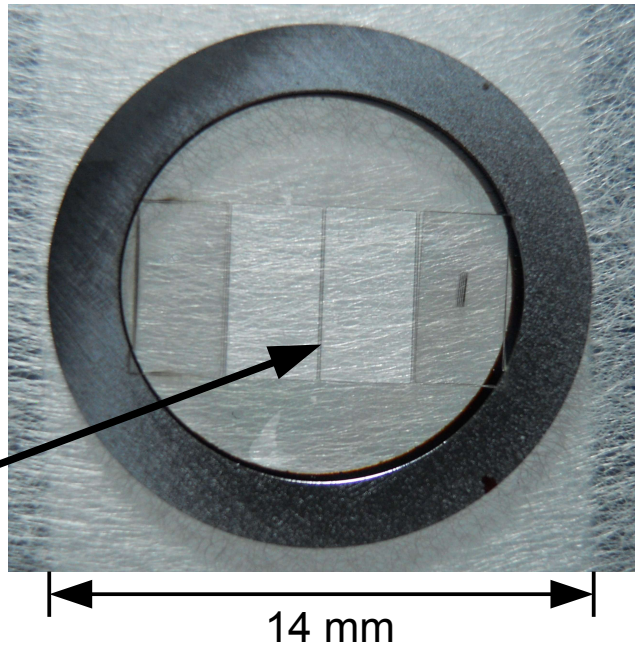
The primary target

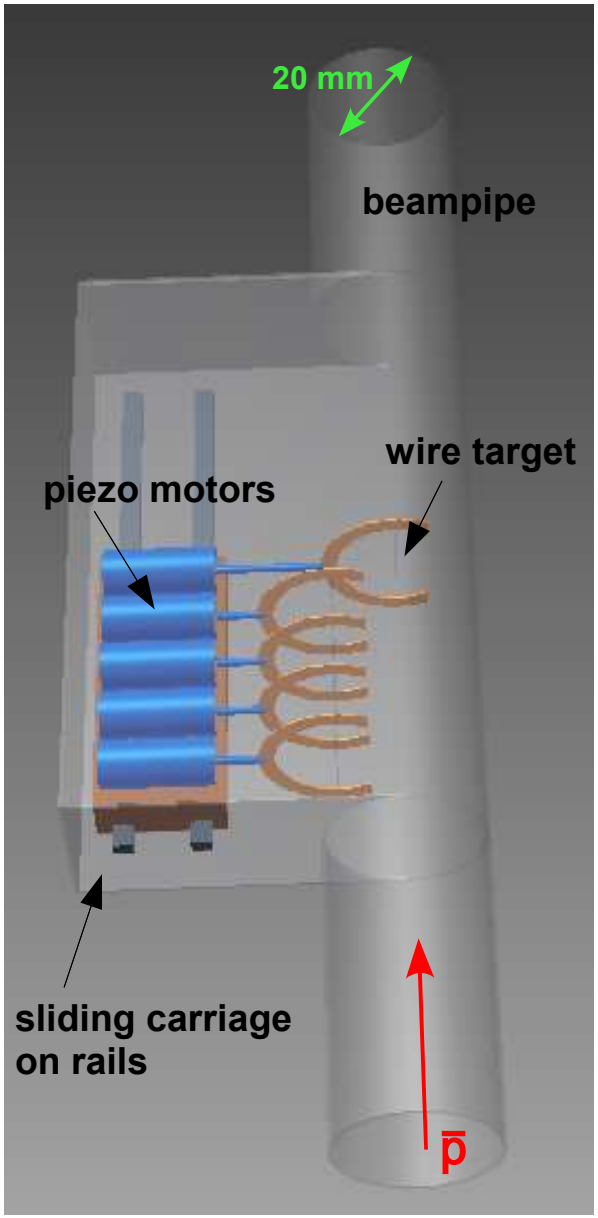
Task of the primary target:
production of slow Ξ^-

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

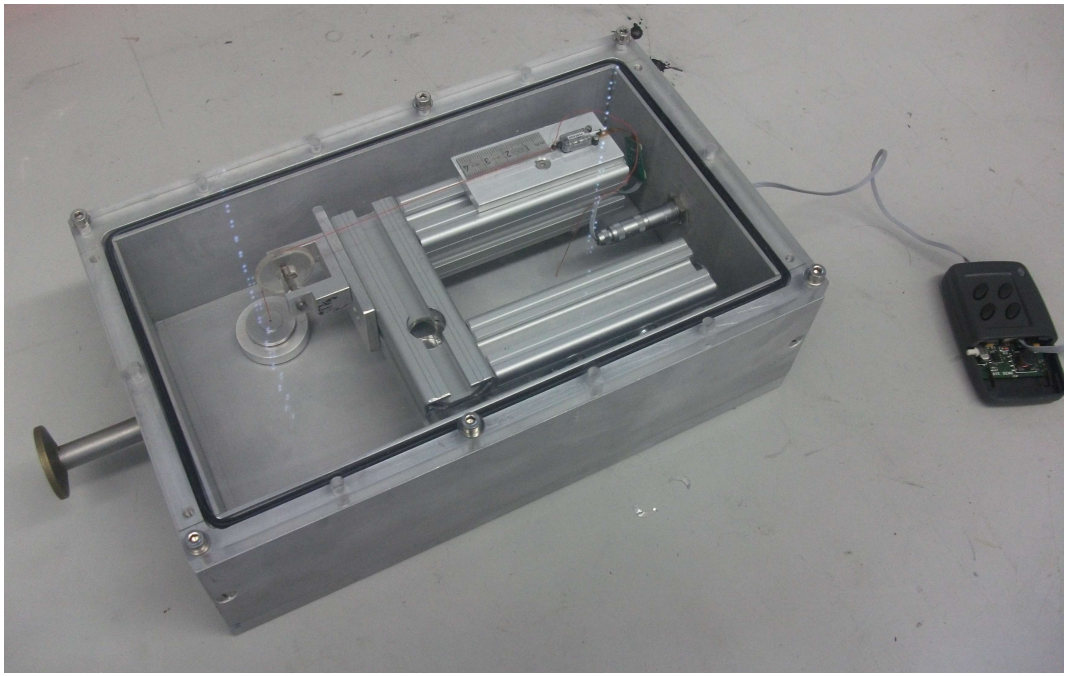
Specifications:

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

Nanomotion ST motor

Experimental tests:

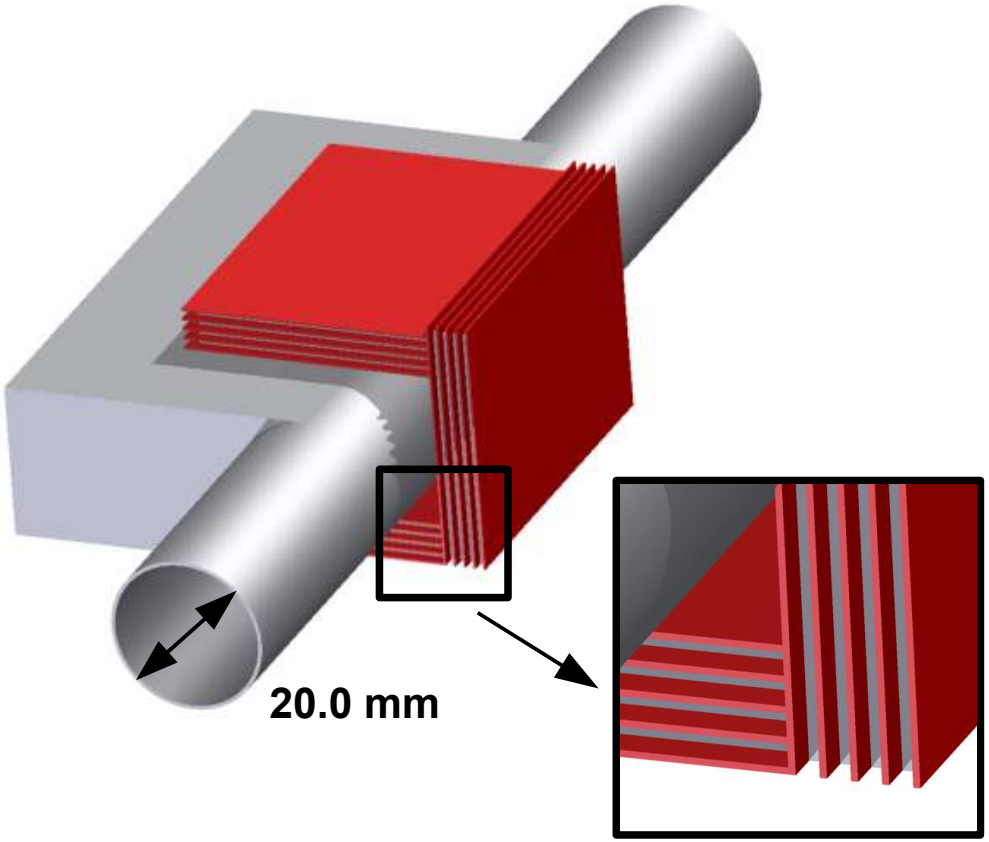
- average step size:
  0.96 µm → precise enough ✓
- Measurement of forces with weights:
  dynamic force = 0.14 N → sufficient ✓
  holding force = 0.88 N
- proper running in vacuum
  proved for some weeks ✓
- no influence in a magnetic field
  of 1.3 T discovered ✓
- no radiation damage discovered
  in beam test at COSY in Jülich



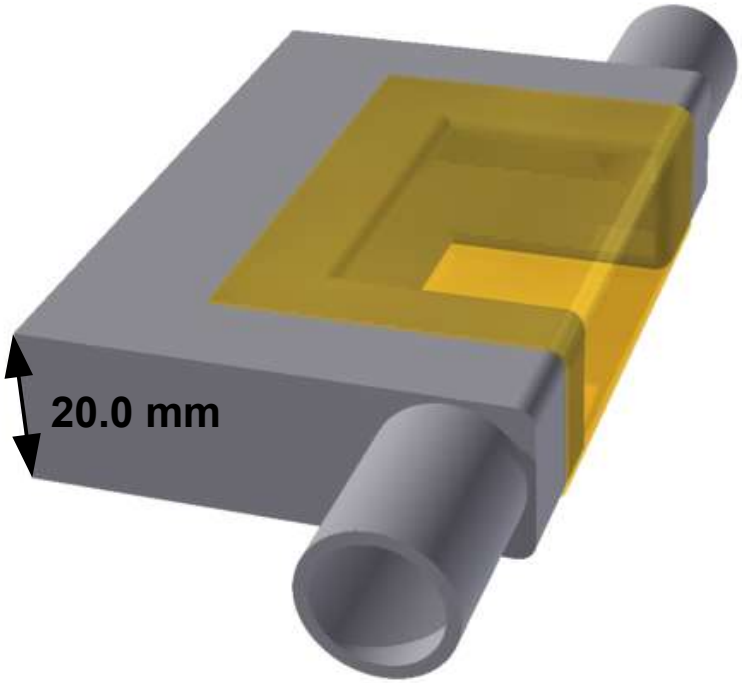
Design of the target system

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

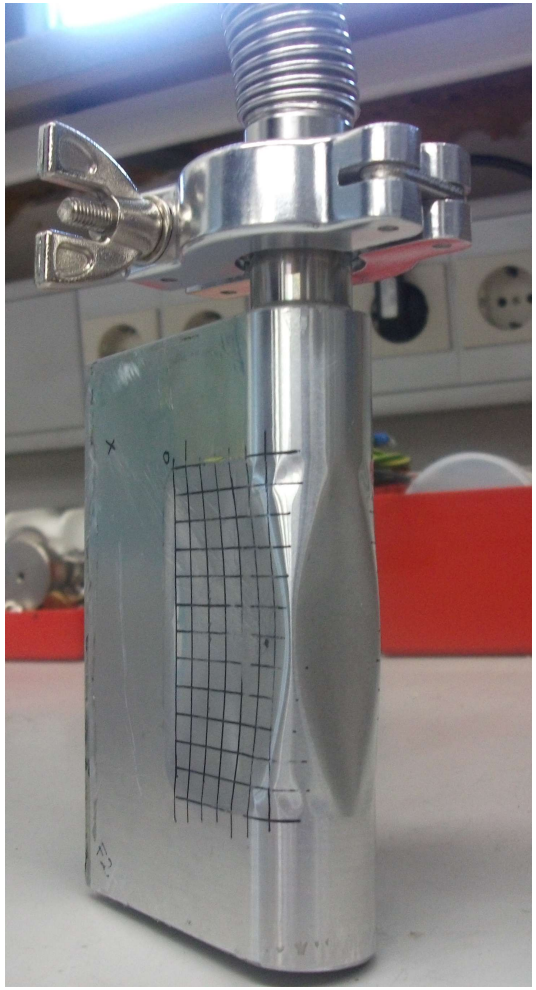


minimization of material budget
→ reduction of thickness

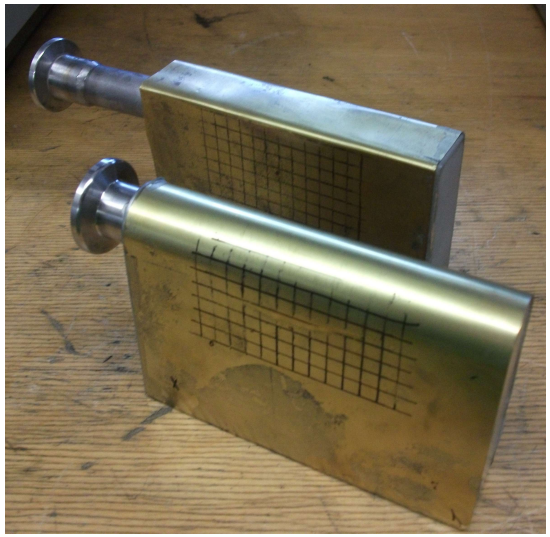


Target chamber studies

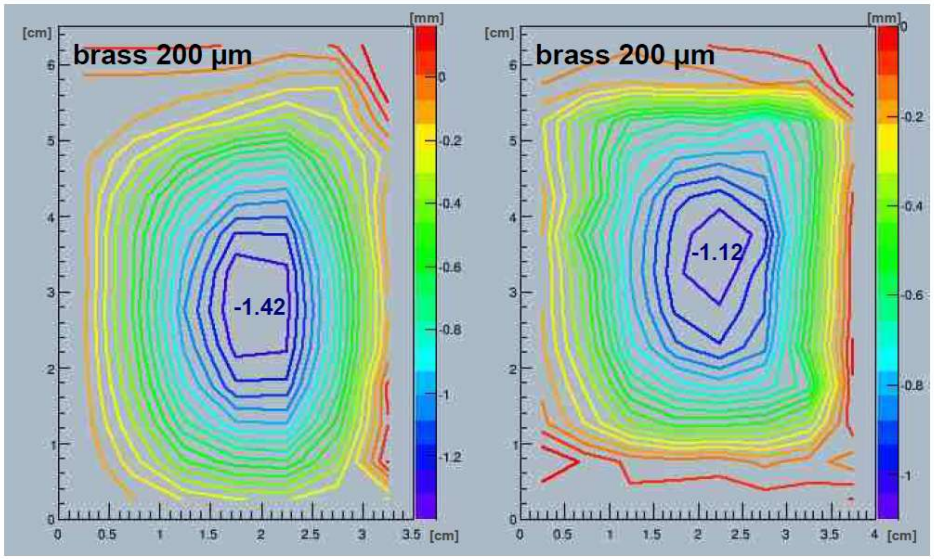
Stability tests in vacuum:



alloy AlMg3, 100 µm



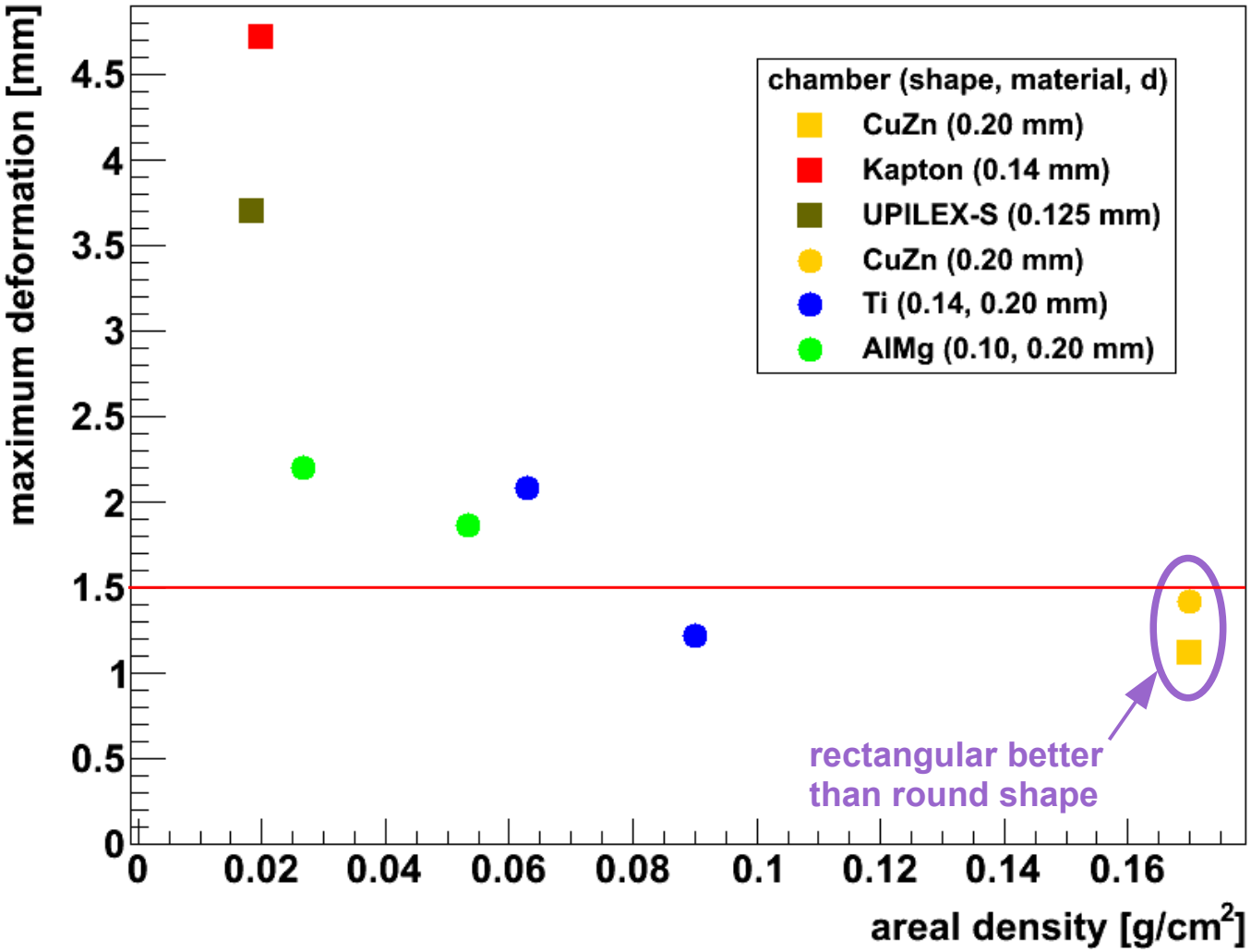
Brass, 200 µm



round shape

rectangular shape

Target chamber measurements

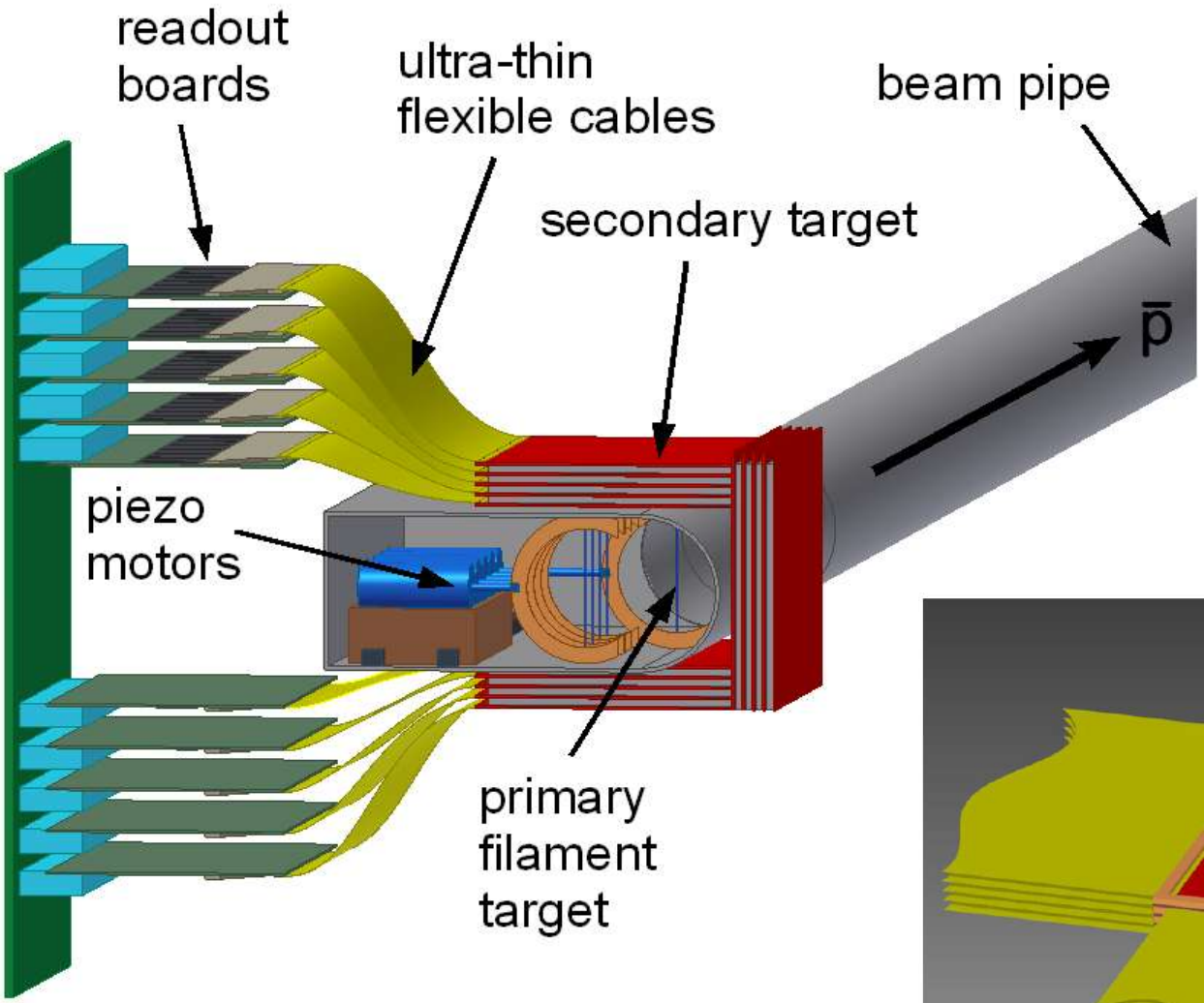


Final tests:

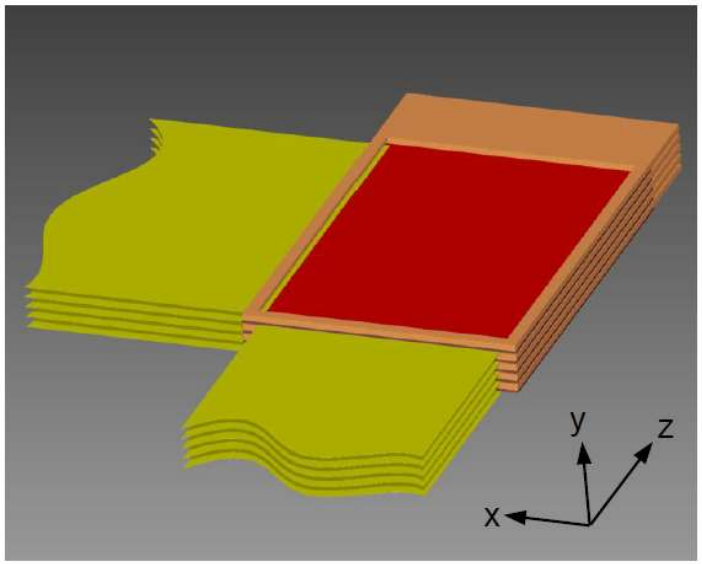
- Titanium 200 µm
- AlMg 300 µm

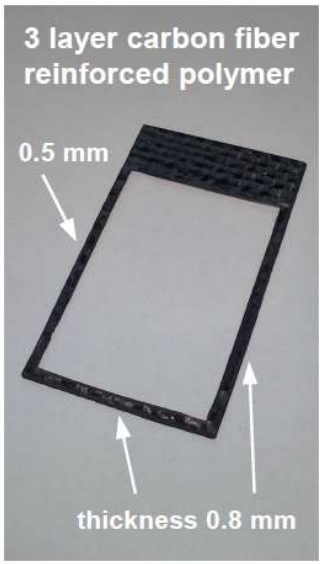
on rectangular frame

Design of the secondary target



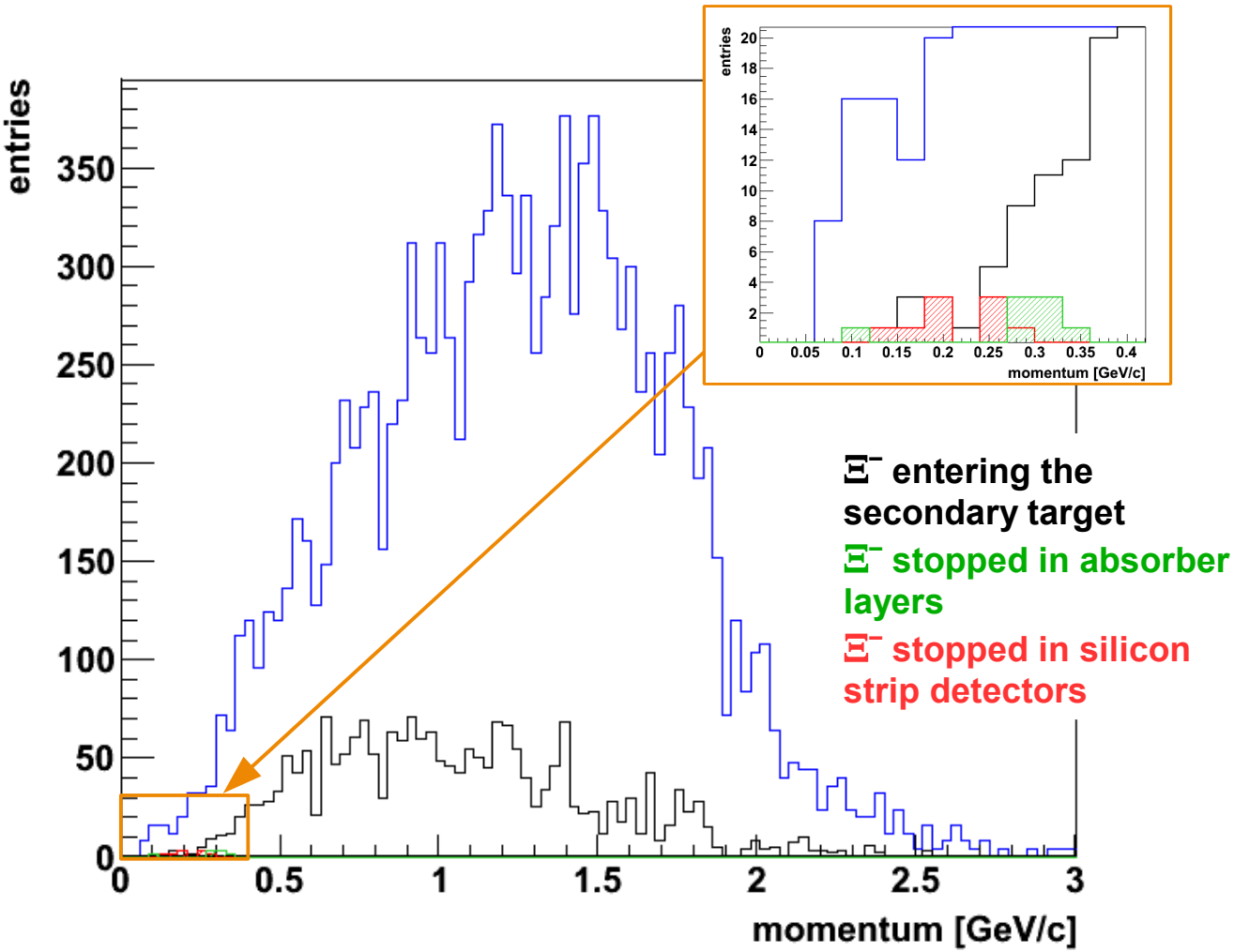
cabling and support structures





Stopping of Ξ^-

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

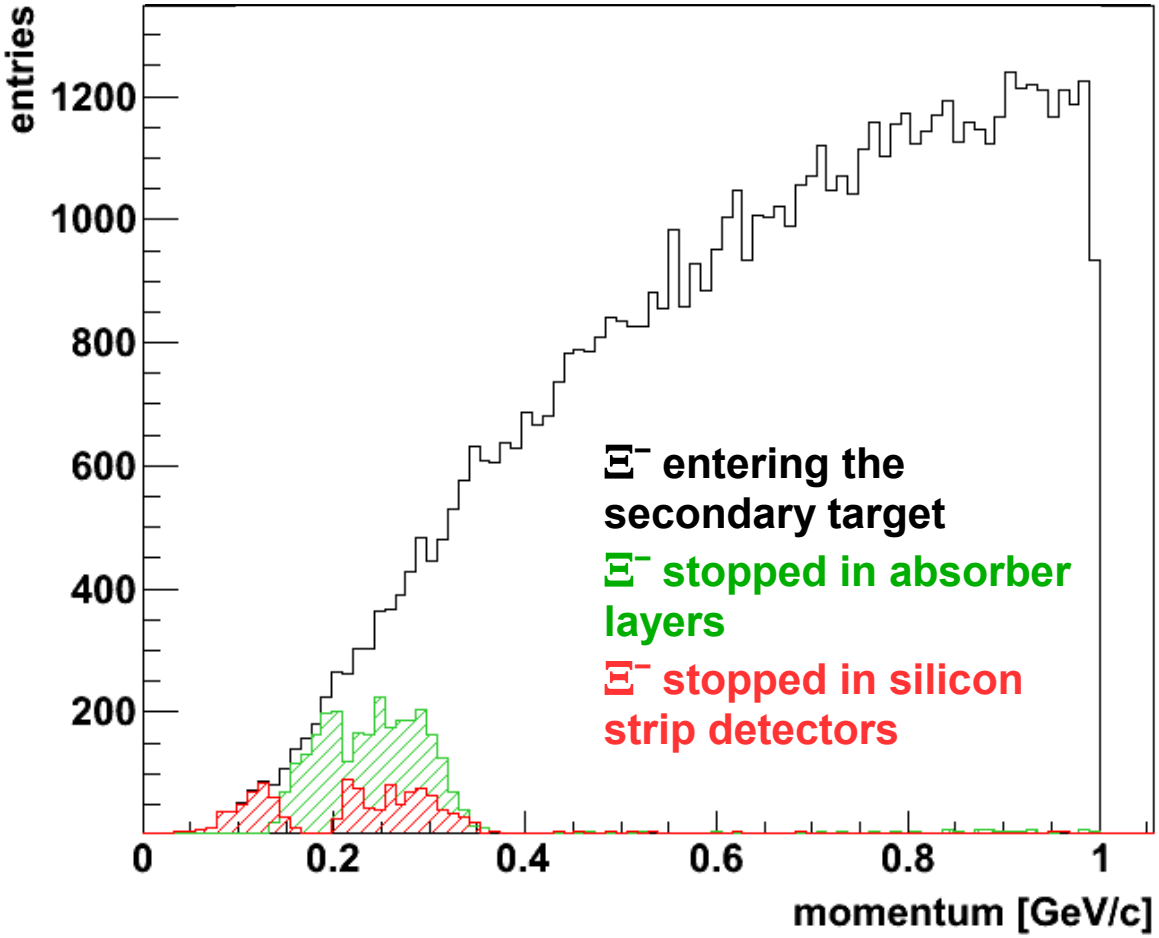


momentum distribution of Ξ^- and results after stopping in the secondary target

→ 0.07% of the generated Ξ^- are stopped in beryllium

Stopping of Ξ⁻

Simulation of Ξ⁻ in the uniform momentum range from 0.1 to 1.0 GeV/c by the box generator

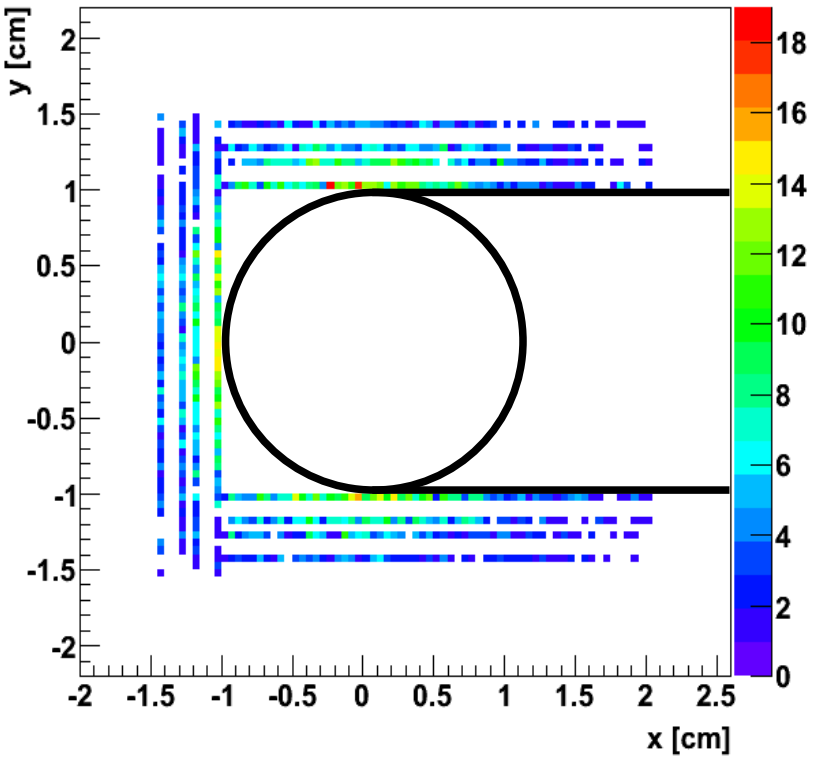


momentum distribution of stopped Ξ⁻ at the entrance of the secondary target

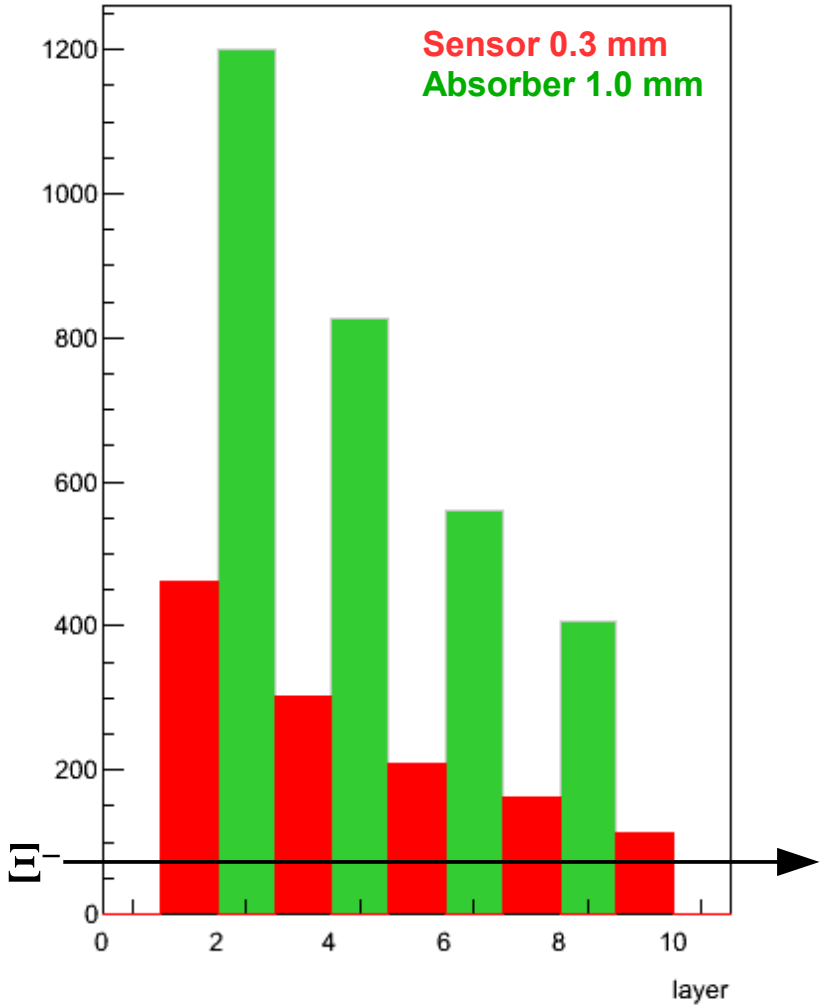
→ only Ξ⁻ in the momentum range from 0.1 to 0.5 GeV/c can be stopped

Stopping of Ξ⁻

Simulation of Ξ⁻ in the uniform momentum range from 0.1 to 1.0 GeV/c by the box generator



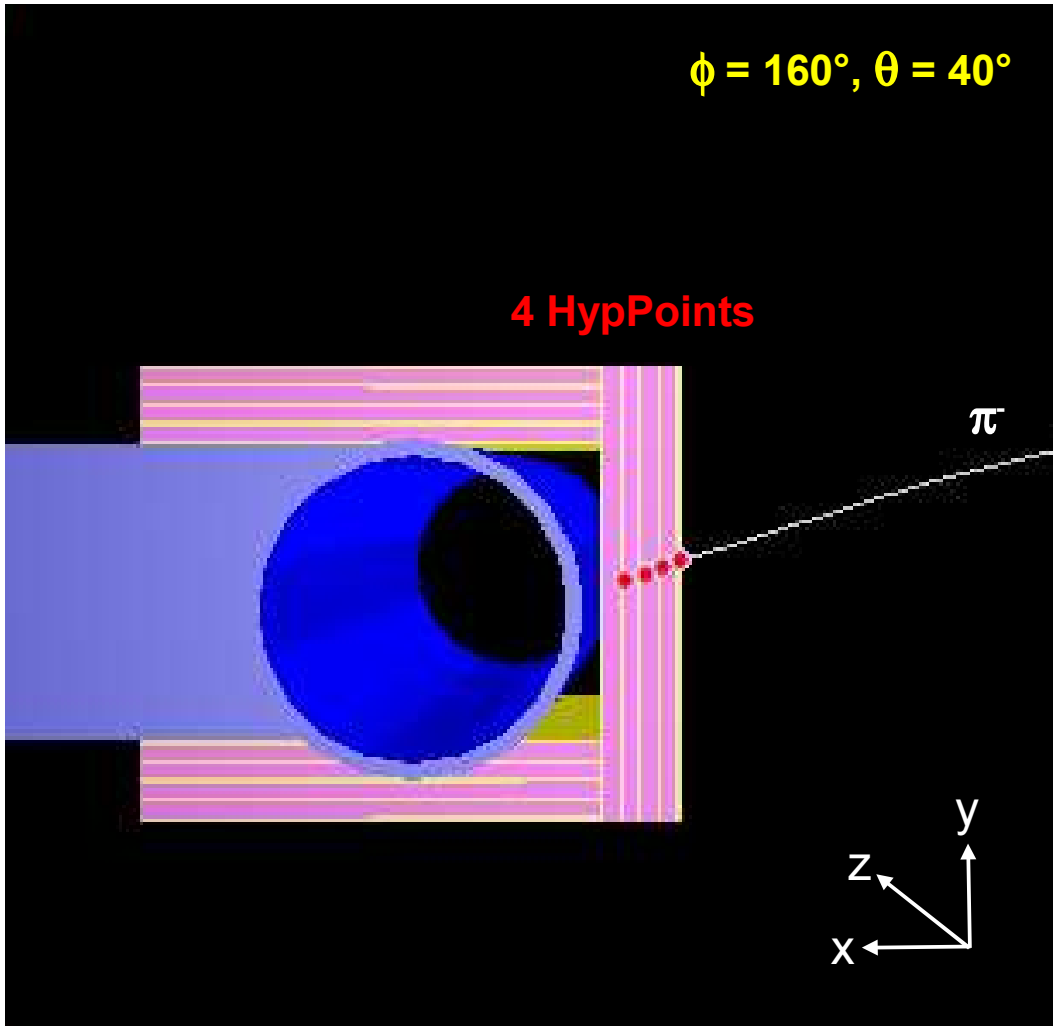
stopped Ξ⁻ in the four absorber layers of the three blocks



Pion tracking

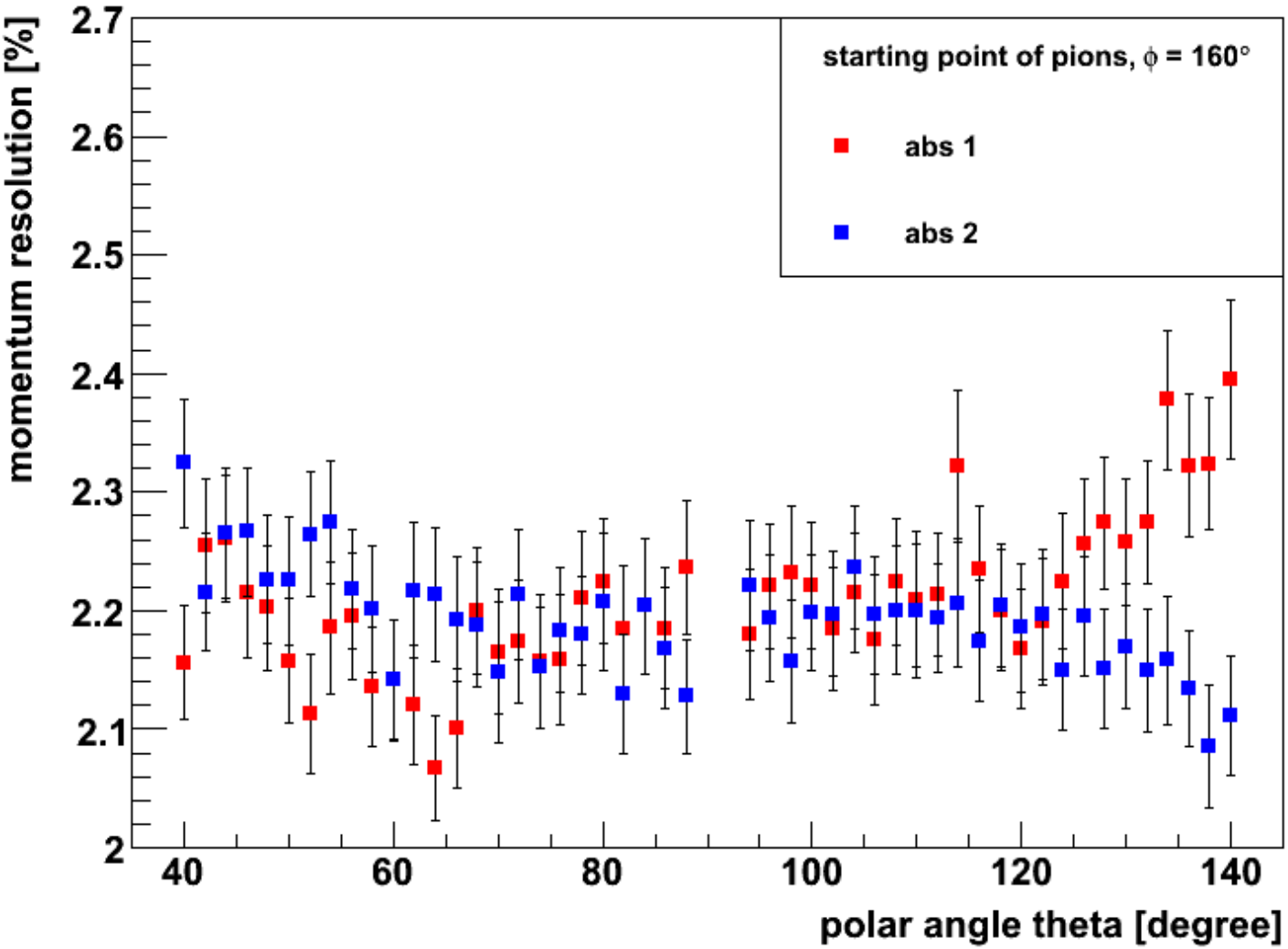
MC Simulation:

- 100 MeV/c pions
- polar angle varied from θ = 40° - 140°
- starting point of pions in absorber layers
- B = 0.5 T fixed



Event display of a pion from the first absorber layer

Pion tracking



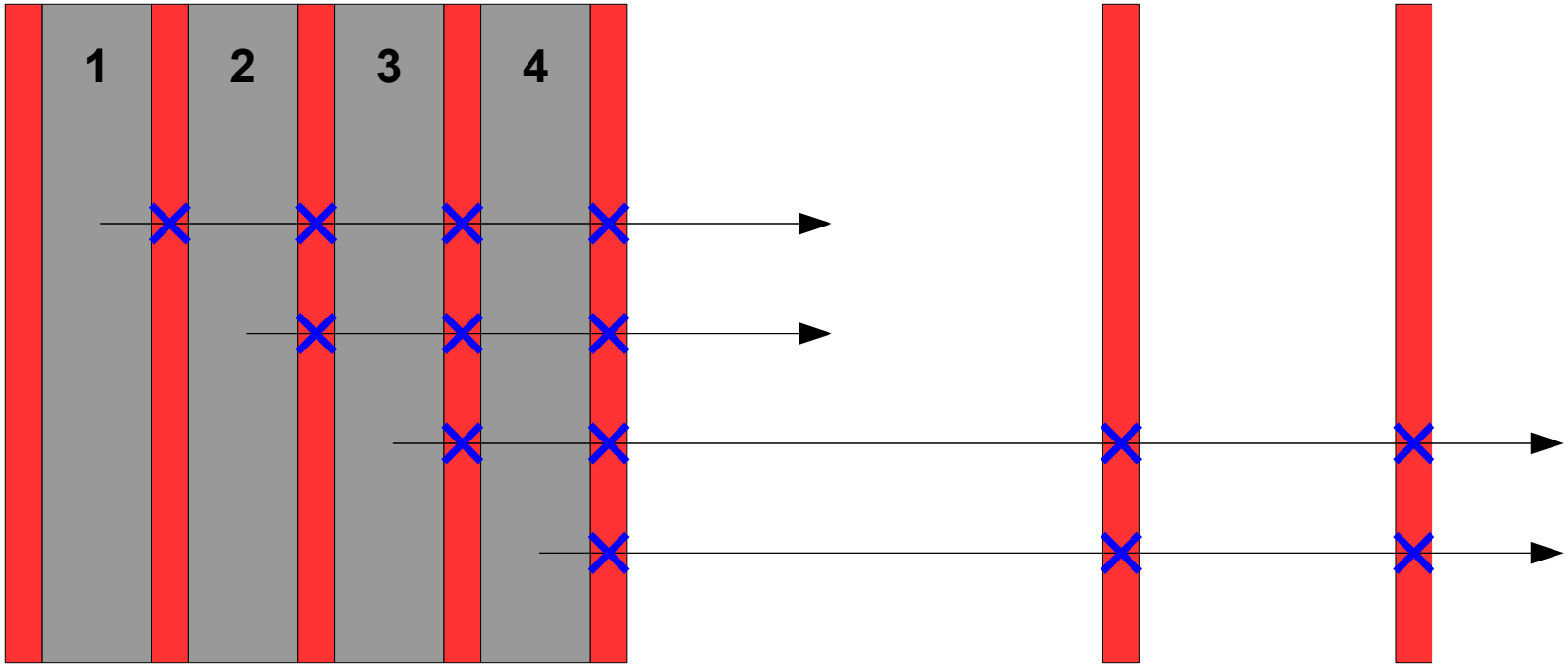
momentum resolution sufficient to separate π-π pairs from the different dominant double Λ hypernuclei

but two additional sensor layers needed!

Pion tracking

1. Monte-Carlo simulation
2. smearing of the points with spatial resolution
3. track finding and track fitting (minimum for the track fitting are 3 points)
4. momentum reconstruction

two additional outer sensor layers needed



Outlook

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