Status of the Target System for the hypernuclear Experiment

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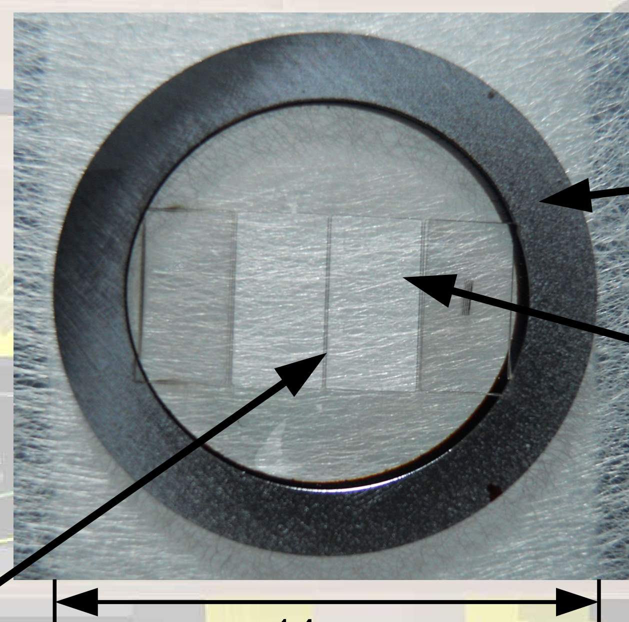
Filament target

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

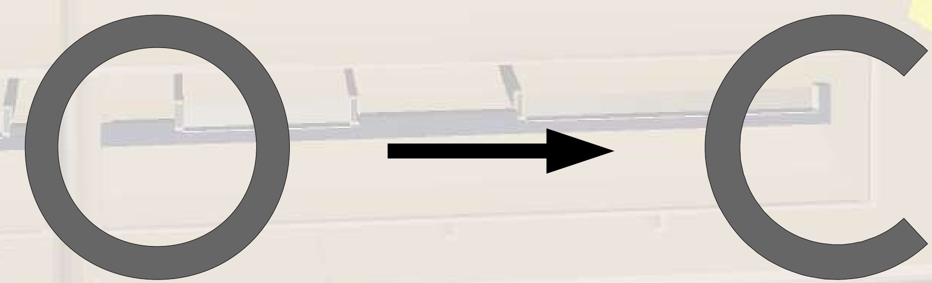
Requirements:

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

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



The closed silicon ring has to be cut to a C-shape that it has not to pass the $\bar{p}$ beam:

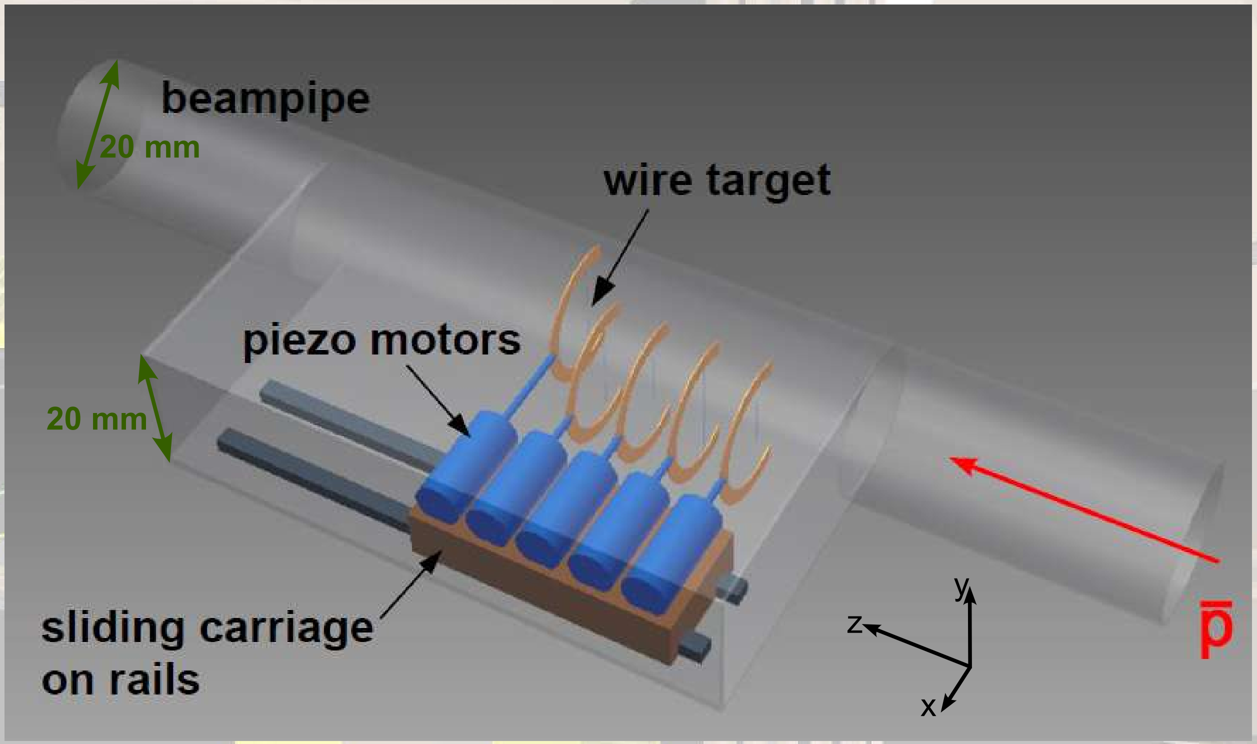


Insertion to the beam

Steps for primary reaction:

1. steering of $\bar{p}$ beam
2. moving target into beam halo at fixed position z = -550 mm in -x direction
3. only in case of a broken wire: movement in z direction to bring another target to position z = -550 mm for an easy replacement

⇒ motion in two dimensions



Requirements for positioning stage:

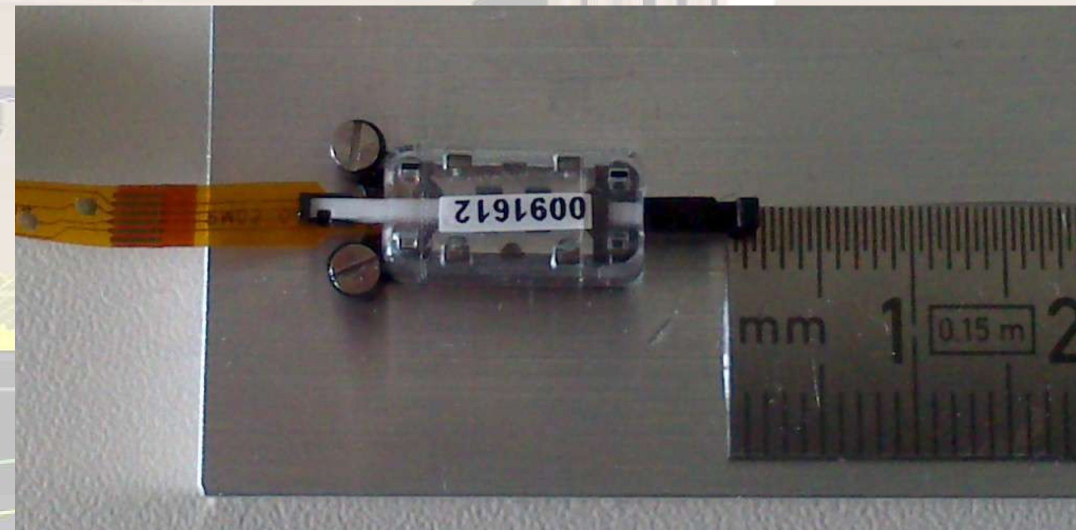
- functionality in a field of 2 T ⇒ nonmagnetic materials and operating mode
- working in an ultra high vacuum of 10^{-9} mbar and with negligible influence on that pressure
- radiation hardness
- total height limited to 20 mm minus 2x wall thickness

Piezo motor for x-direction

First piezo motor for tests:

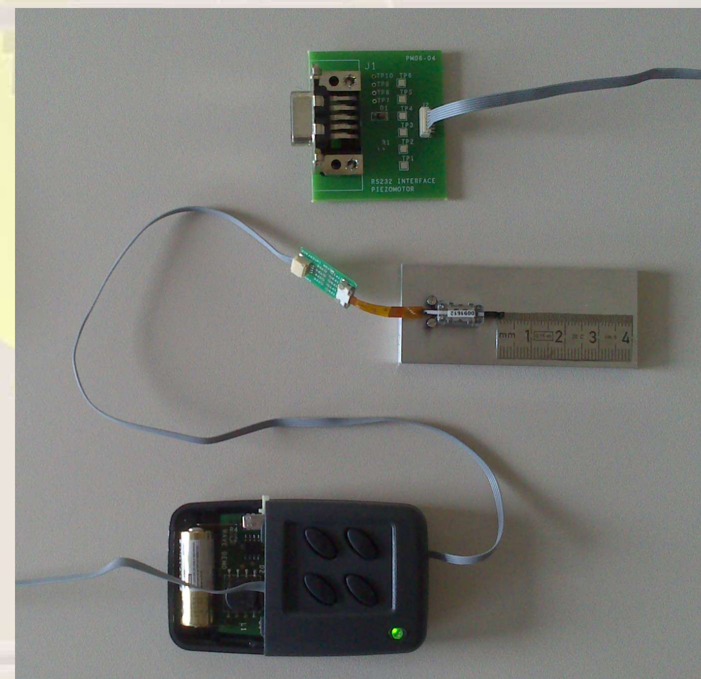
PiezoWave Linear 0.1 N
Manufacturer: PiezoMotor Uppsala AB

<u>Specifications:</u>
Stroke max: 8 mm
Maximum speed: 50 - 100 mm/s
Average step: 0.5 - 1.0 µm
Dynamic force: 0.1 N
Holding force: 0.3 N
Weight: 0.5 g
Size: 14.0 mm x 7.2 mm x 4.4 mm



Running the motor:

The PiezoWave is operated by the Starterkit Demo-Wave-10



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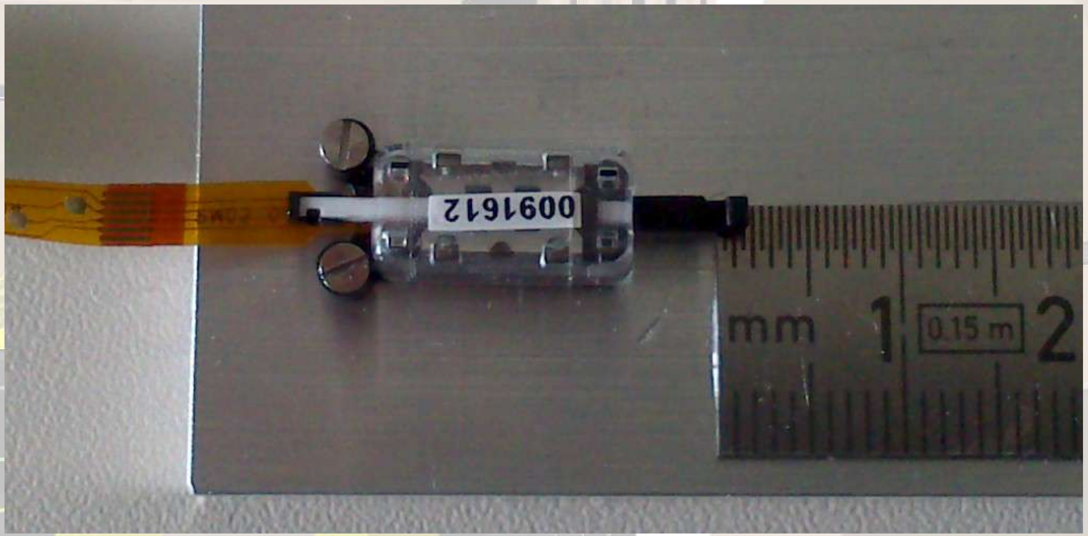

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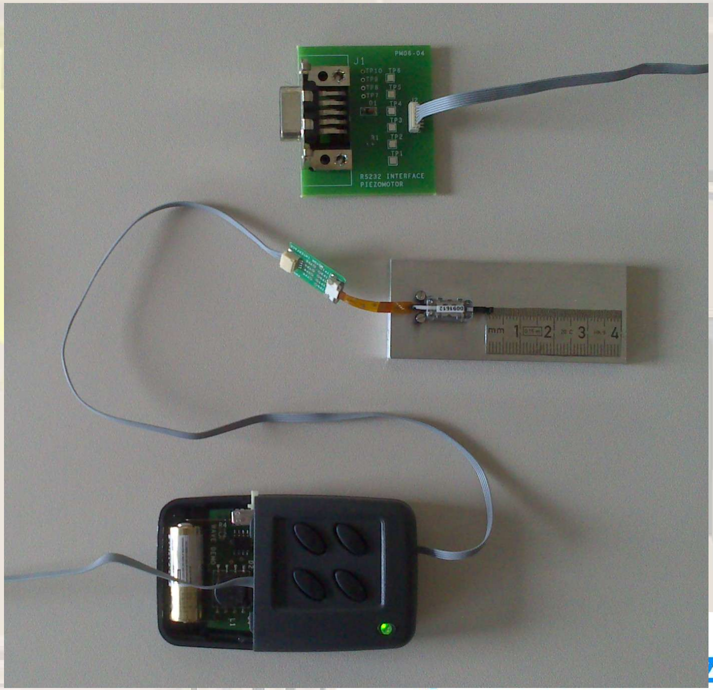

Running the motor:

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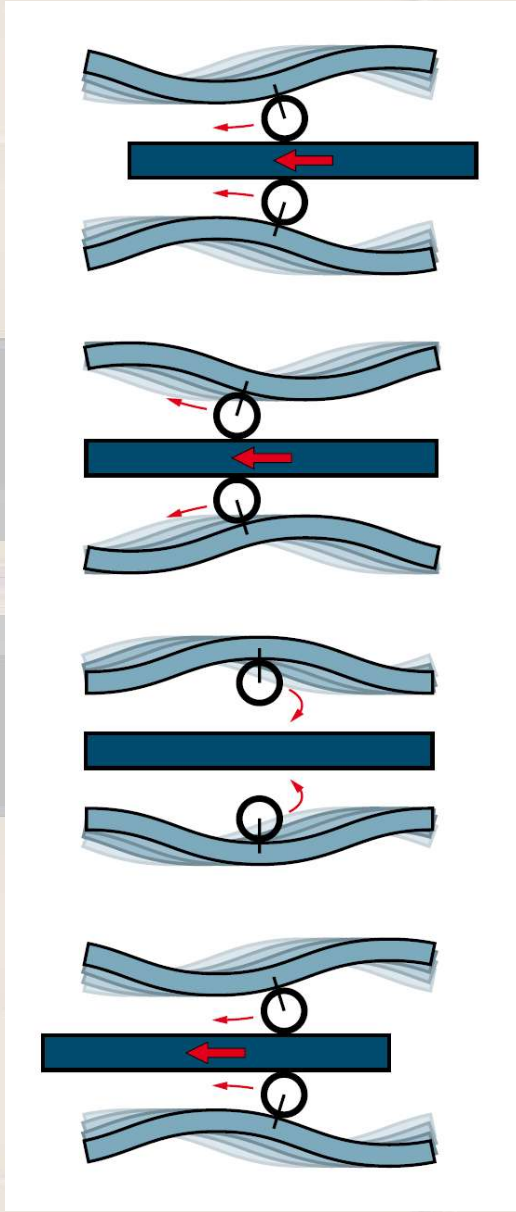
PiezoWave - principle

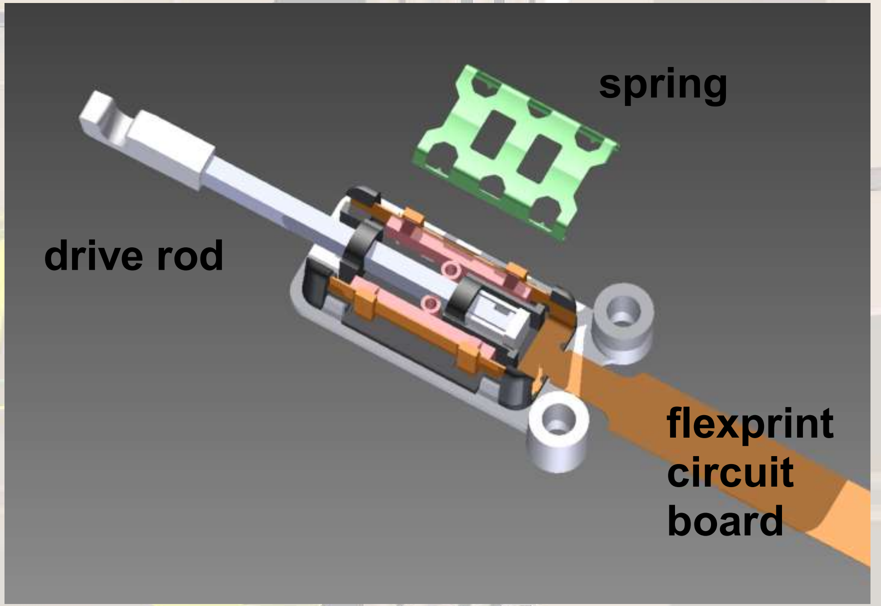


Two piezo ceramic elements with drive pads move when activated
⇒ drive rod moves

End of first motion cycle

Repositioning

Next step



Motion is transferred by contact friction

→ no power consumption in holding position
→ determines the holding force
→ drive rod slides at large impact force

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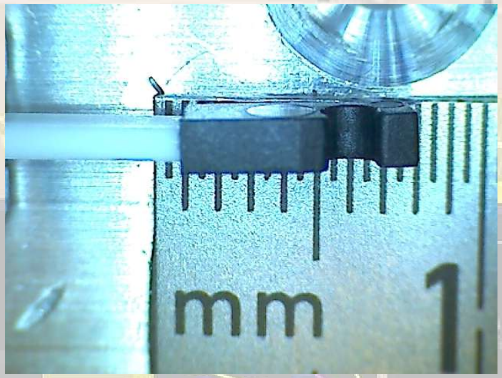
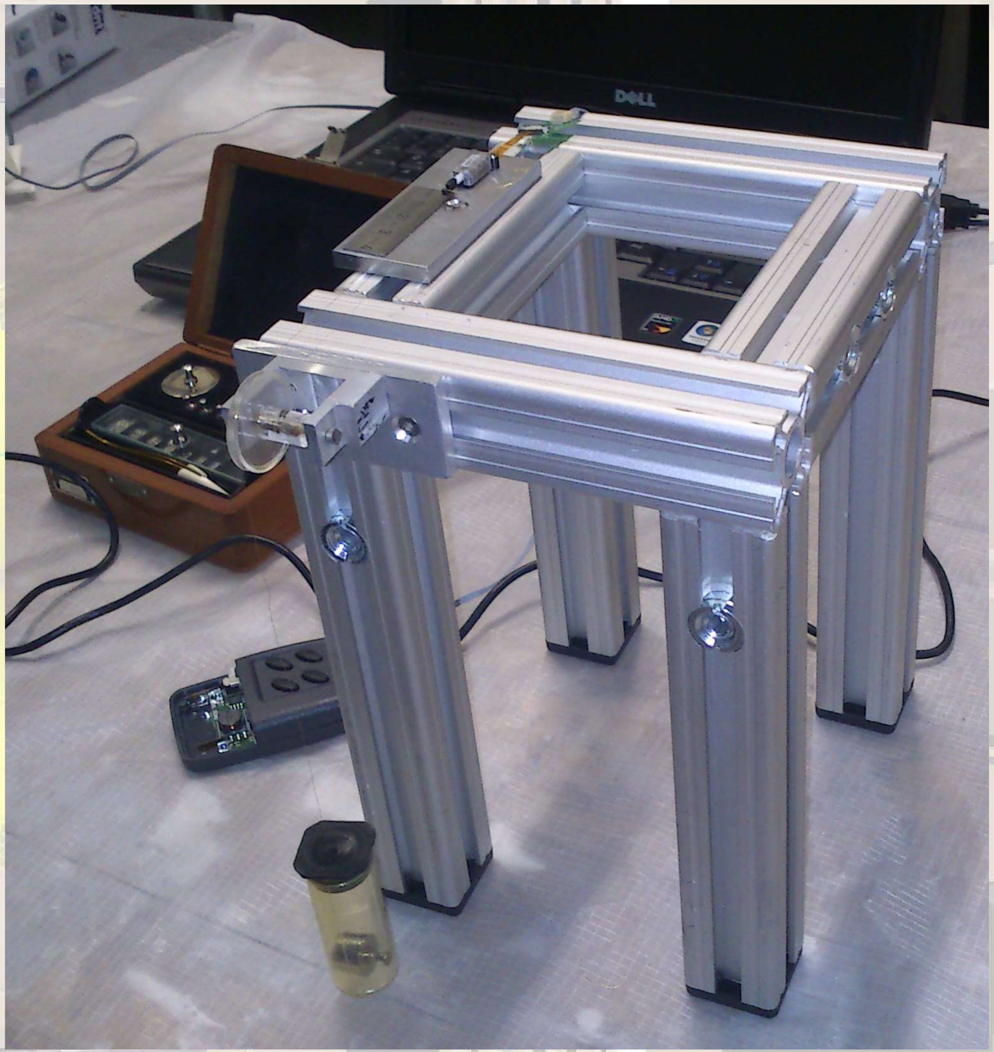
Experimental tests

- Measurement of the average step size with the help of a microscope:



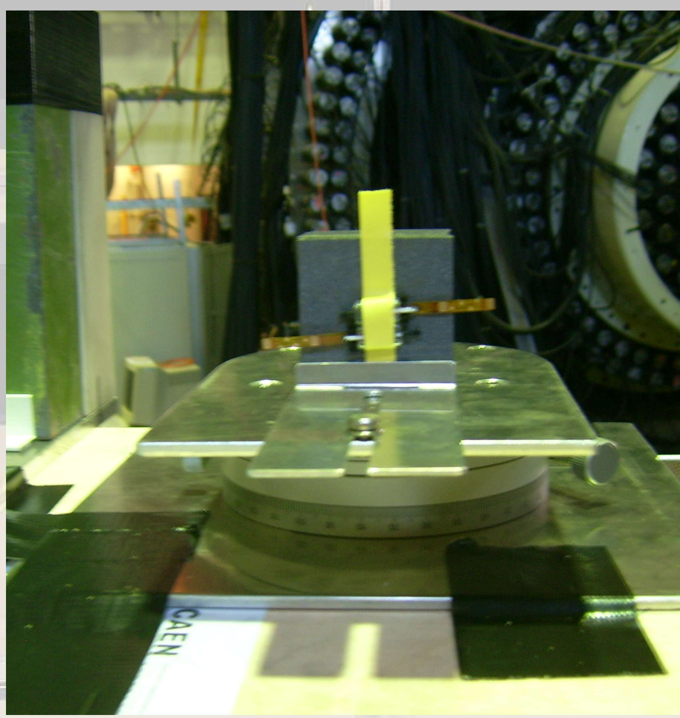
0.96 µm → precise enough but differs

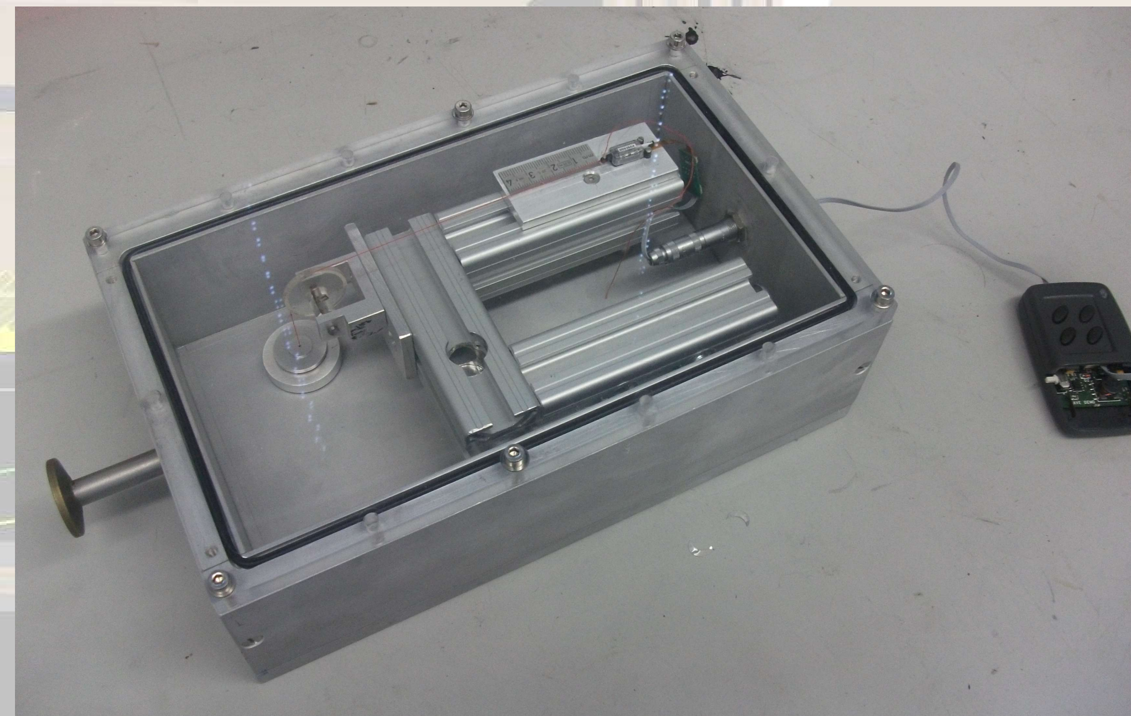
- Measurement of the forces with weights:
  dynamic force = 0.14 N → sufficient
  holding force = 0.88 N
- Test in vacuum:
  proper running proved for some weeks
- Test in a magnetic field of 1.3 T:
  no influence discovered



Experimental tests

- Combined measurement of the forces in vacuum with weights:
  dynamic force = 0.15 N
  holding force = 0.90 N
- Beam test at COSY in Jülich:
  no radiation damage discovered

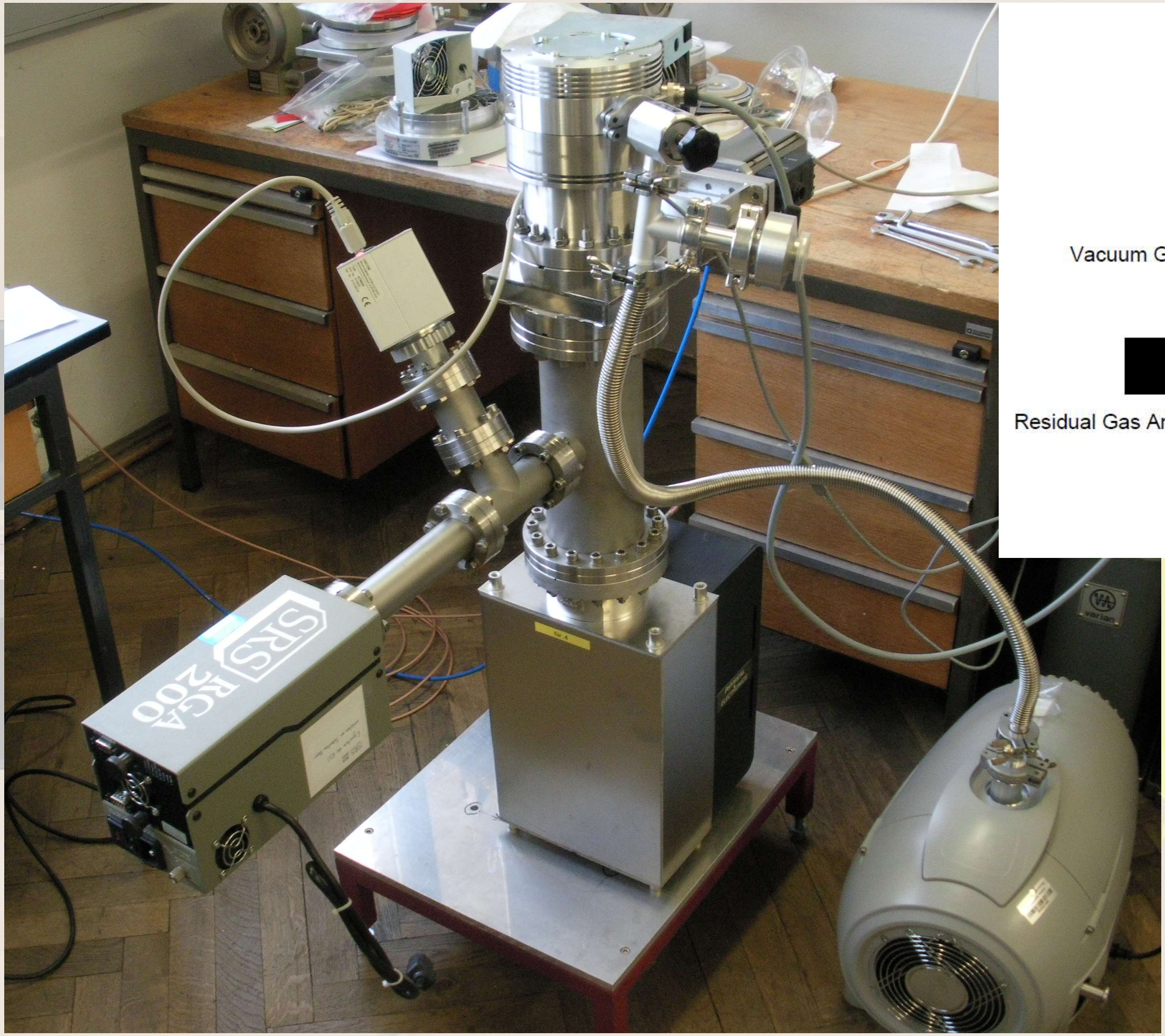


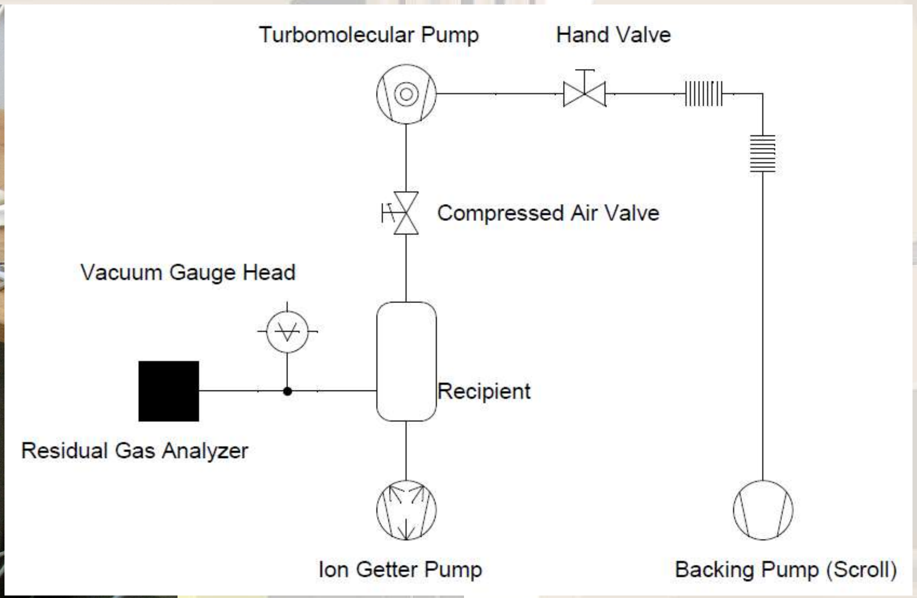


Conclusion:

- Specifications of PiezoWave confirmed or better than declared
- Demands for the hypernuclear experiment fulfilled

Influence on UHV





Setup of pumps to reach a vacuum better than 10^{-9} mbar

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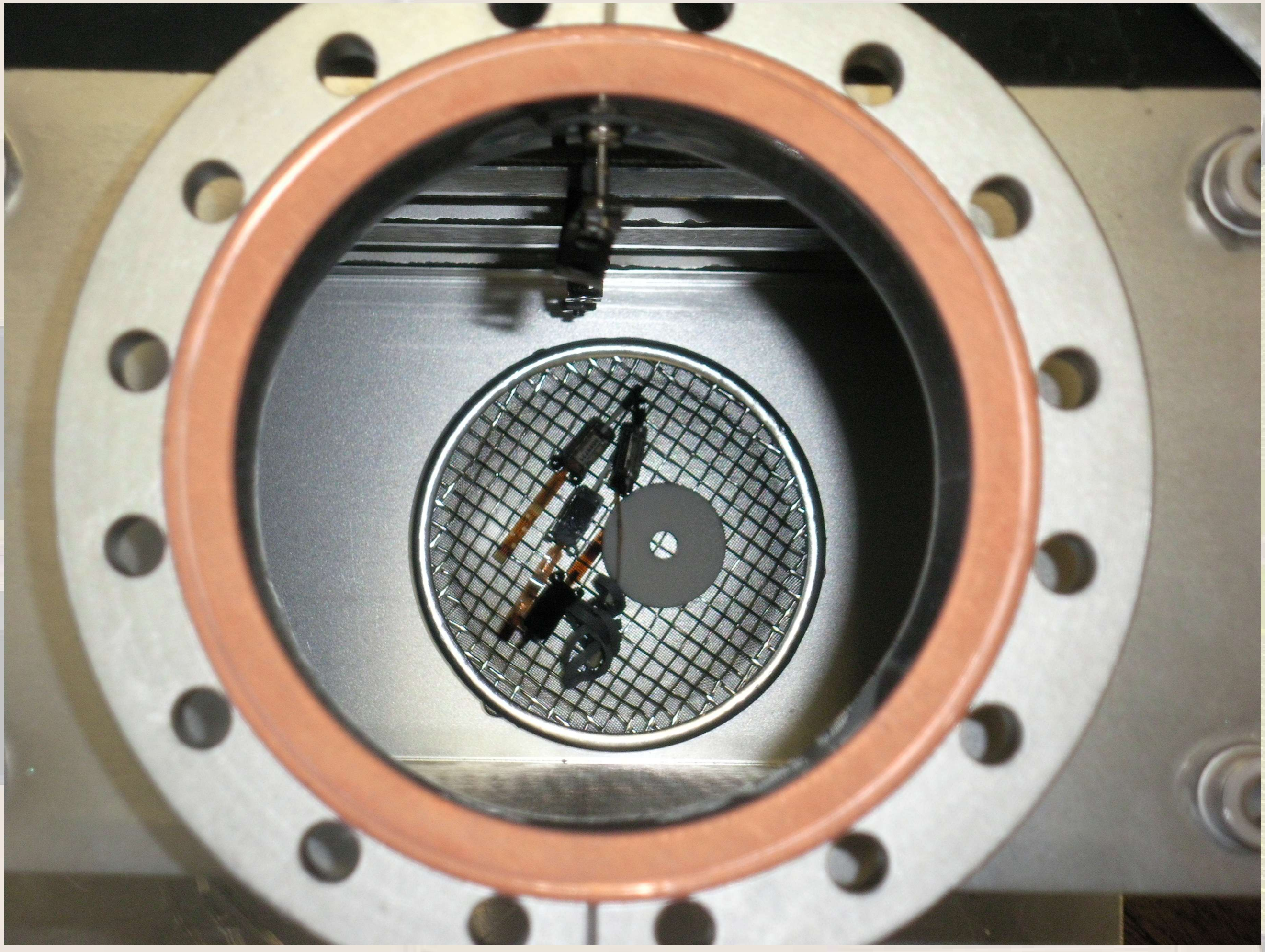
Influence on UHV



First measurement with

- 4 PiezoWave motors
- 1 motor interface card
- 1 cable
- 1 piece of teflon

in the ion getter pump:

→ 5.60×10^{-8} mbar

Then comparison with
the empty ion getter pump:

→ 5.50×10^{-8} mbar

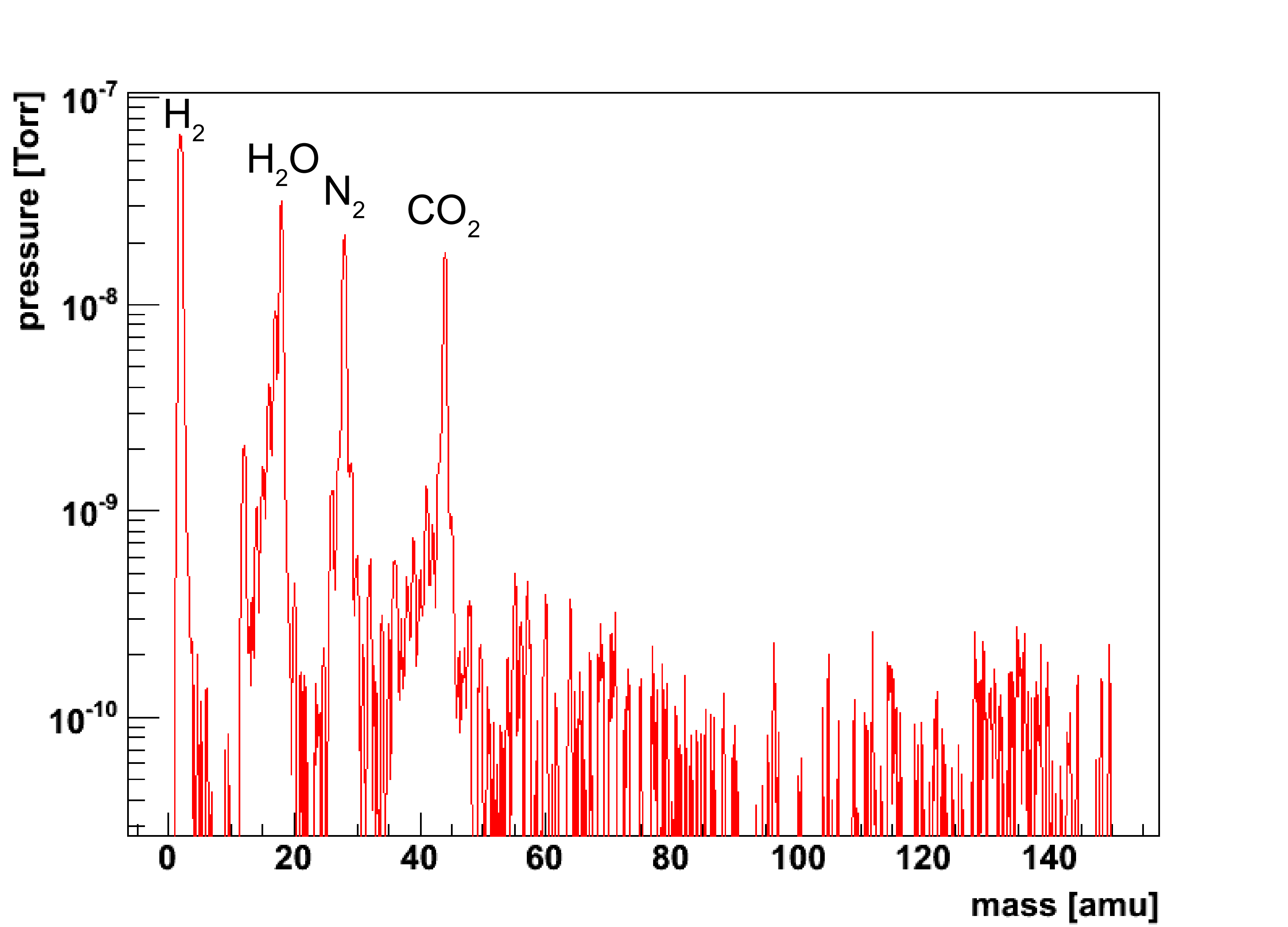
The given system of pumps should reach a much lower pressure ⇒ heating of the setup

Influence on UHV

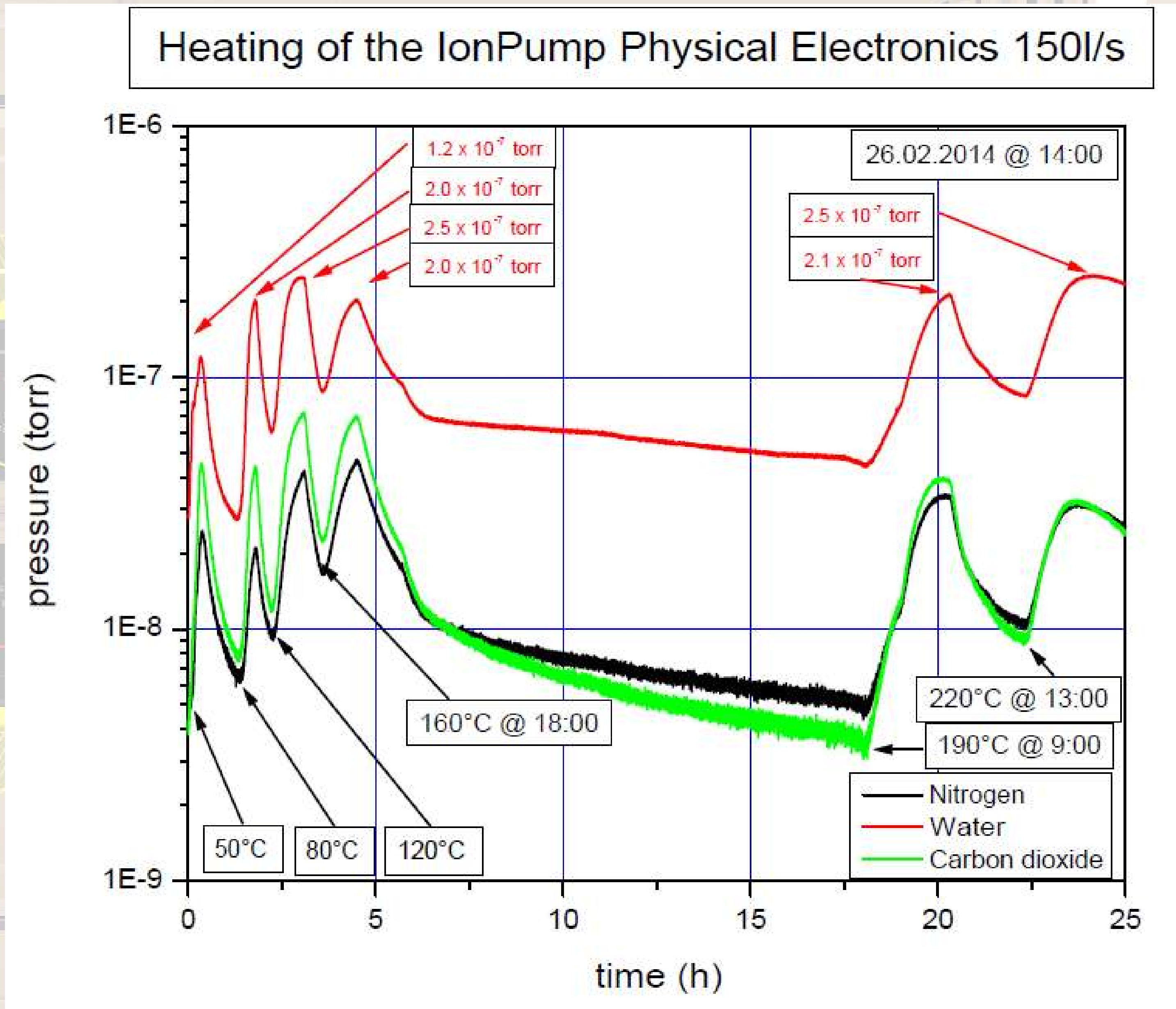
Bake-out by heating resistors
around the ion getter pump
and the recipient,
isolation with aluminium foil

Influence on UHV

Measurement with the residual gas analyzer



Influence on UHV



Influence on UHV

Measurements after heating:

- best measured pressure im empty ion getter pump : 4.60 x 10^{-10} mbar
- measurements with different pieces finished
- measurement of PiezoWave with removed plastic parts
  → operating temperature of PiezoWave -10 to +50°C

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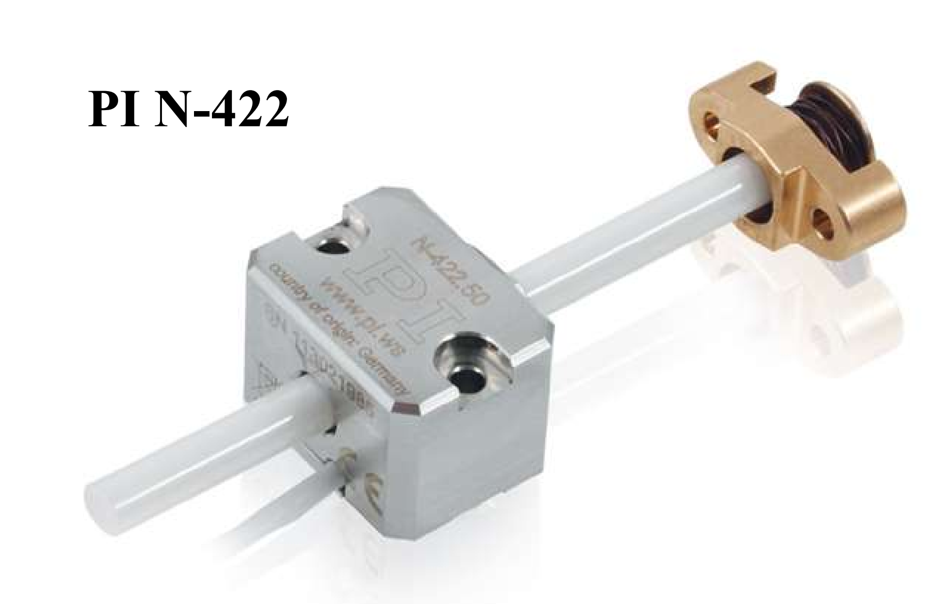
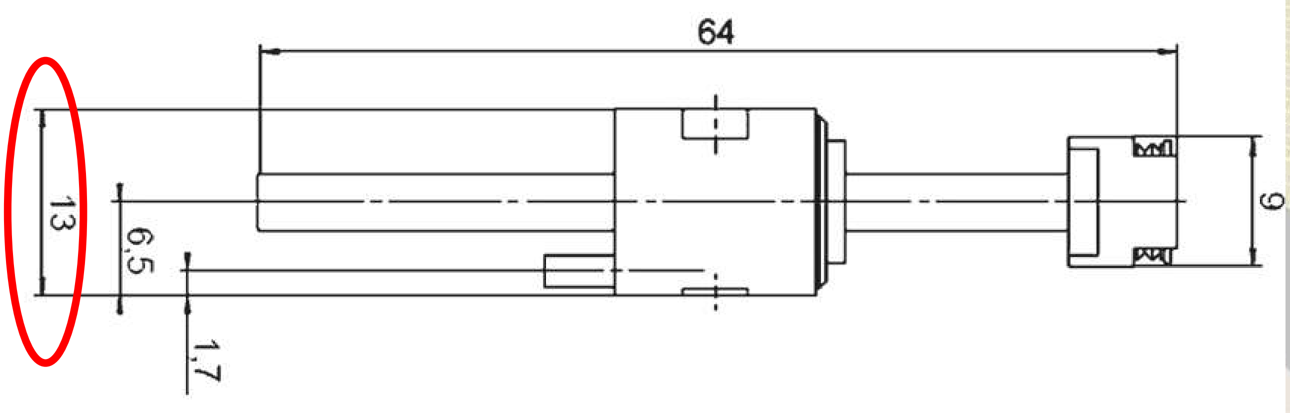
Piezo motor for z-direction

With five assembled PiezoWave next to each other one needs a traveling distance of 28.8 mm
→ drive rod based piezo motors with a preferred direction have too short traveling distances

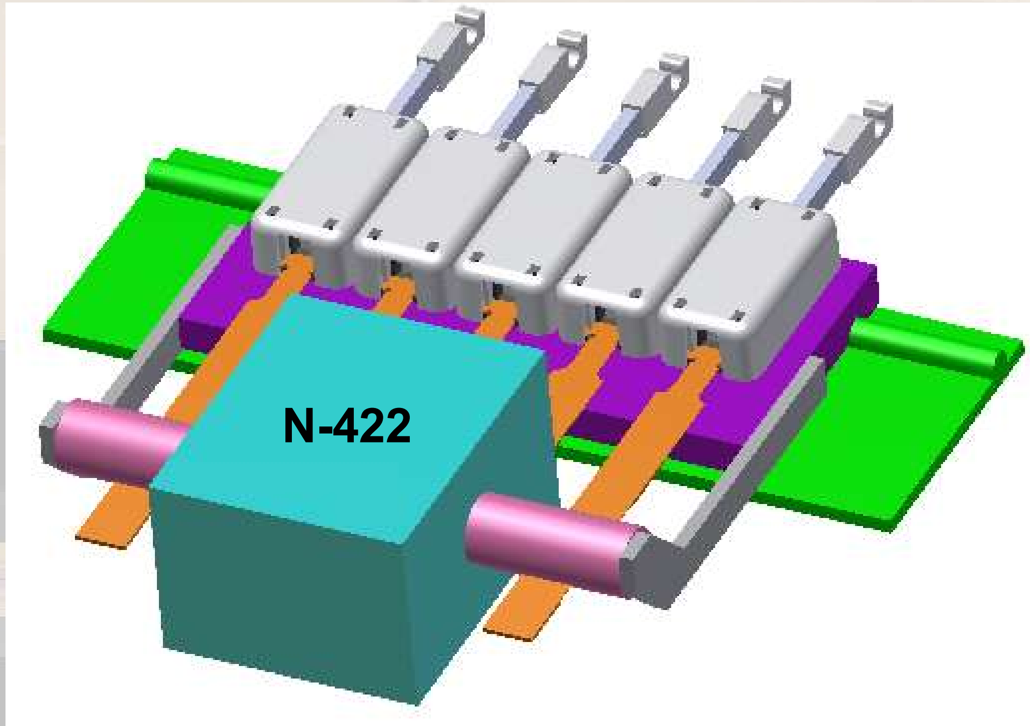


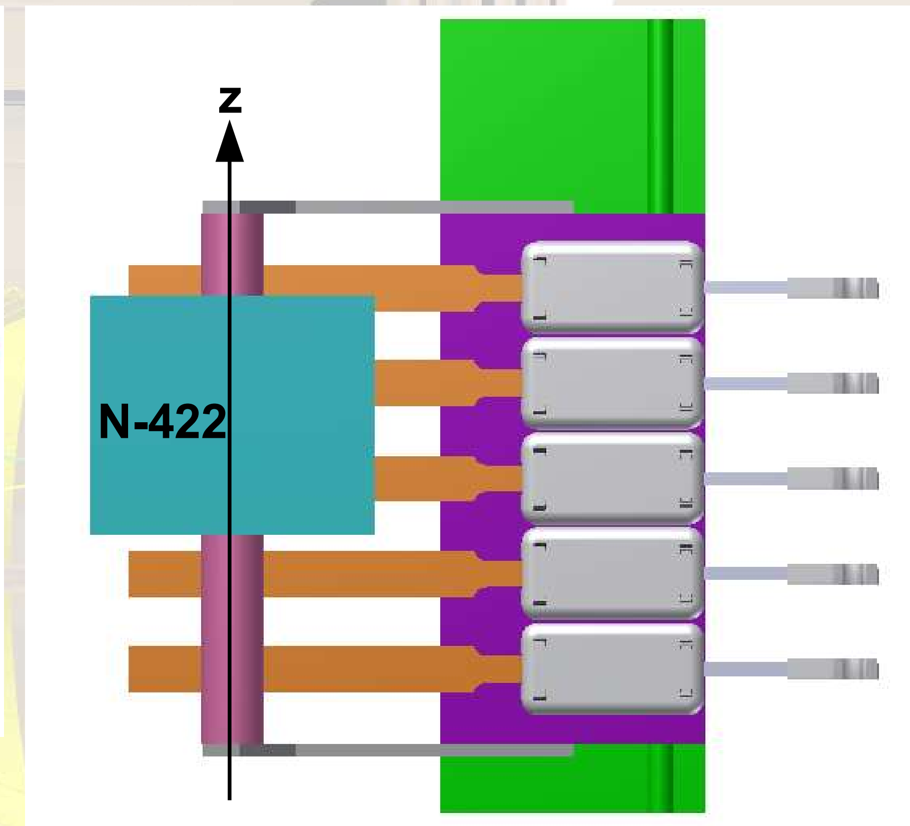
Similar alternative: N-422 from PI

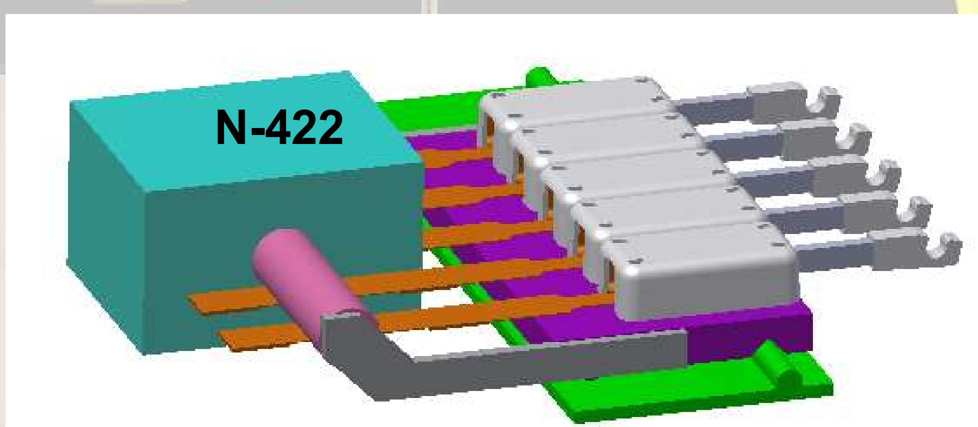
would fit inside the target chamber
but is still rather high
Displacement: 35 mm
(can be extended → loss of precision)



Piezo motor for z-direction







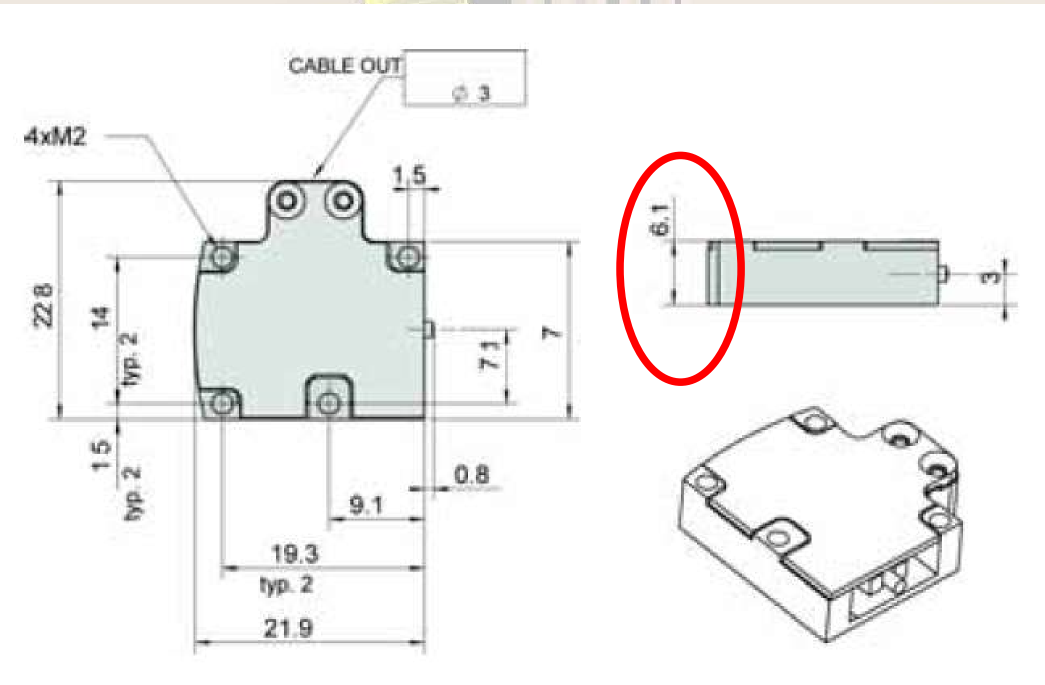
CAD study of a positioning table assembled with five PiezoWave motors driven by the PI N-422
→ traveling distance too short

Piezo motor for z-direction

Different principle: elliptic motion of the ceramic finger tip
by pressing against a ceramic strip a driving force is exerted

Advantage: providing unlimited linear motion (given by length of ceramic strip)

Nanomotion ST motor

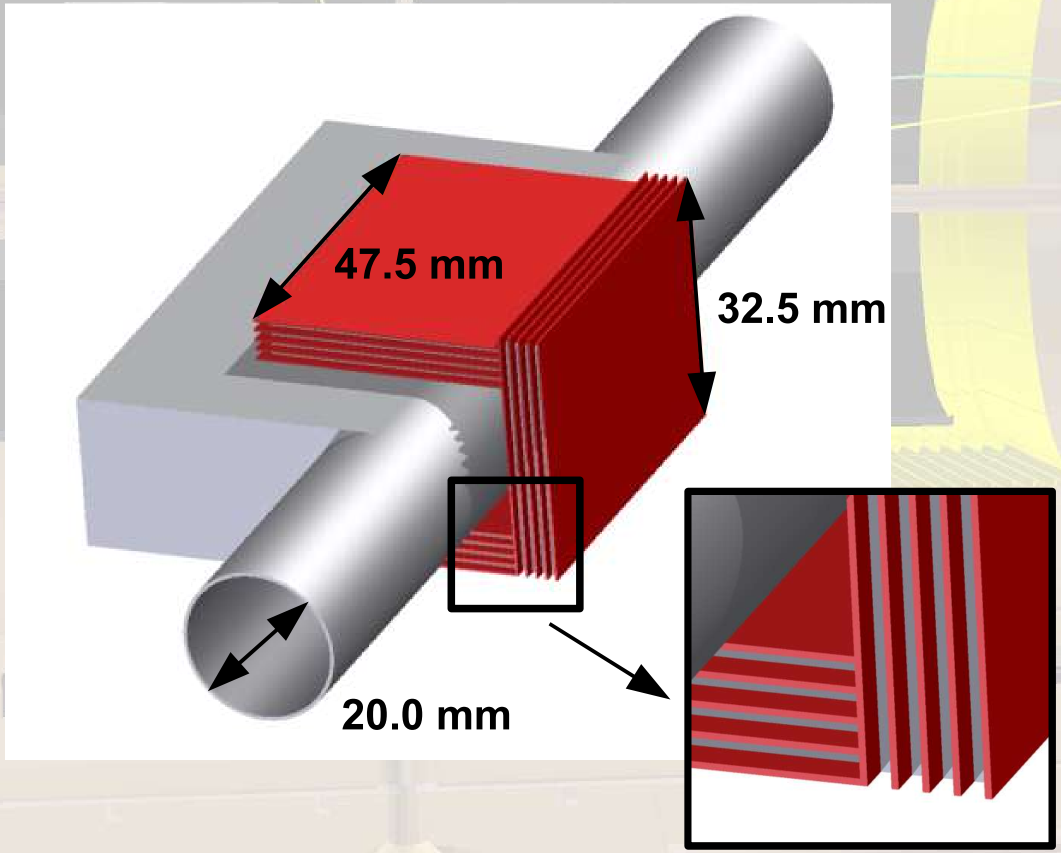


„These motors have no magnetic materials and no intrinsic magnetic field
→ no external magnetic field sensitivity“
Versions for vacuum up to 10^{-10} Torr available

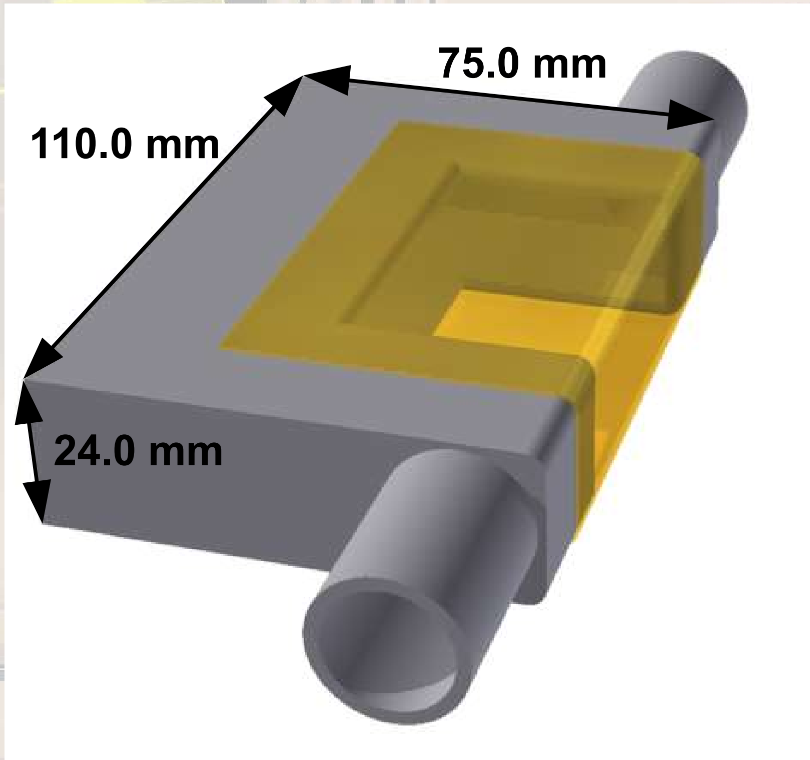
Design of the target system

Very short life time of Ξ^-: τ = 0.164 ns ⇒ compact structure essential

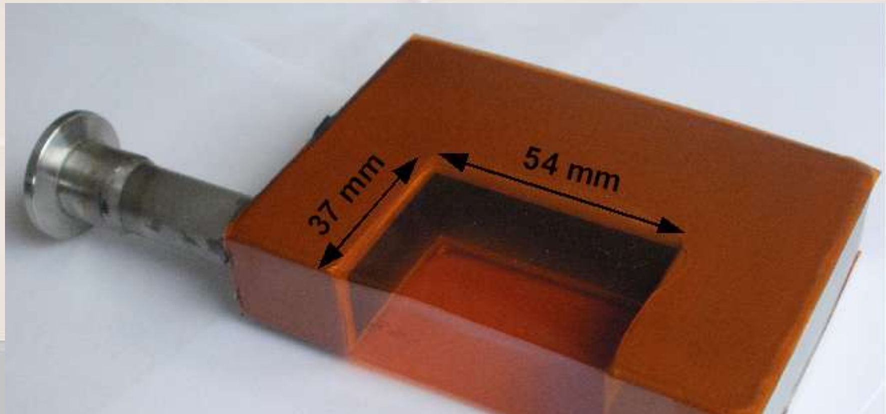
Arrangement of DSSD-absorber-assemblies directly around the target chamber and beampipe
→ minimization of beampipe diameter



Minimization of material budget
→ reduction of thickness

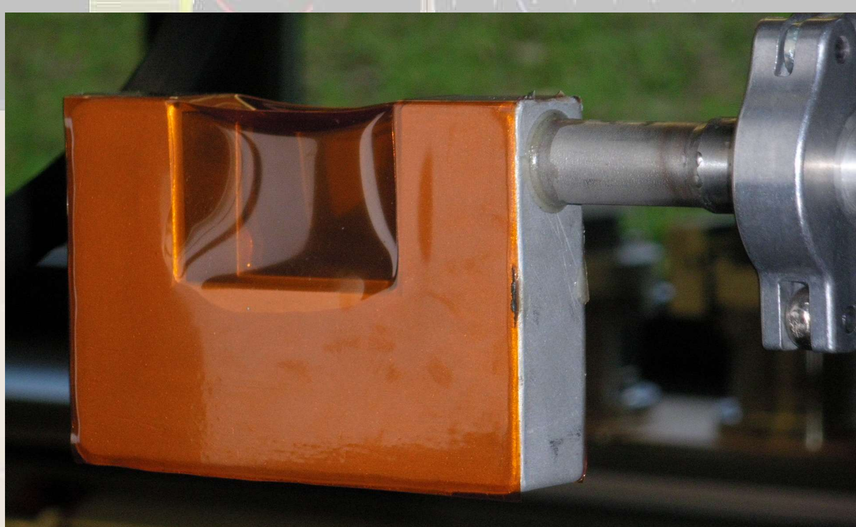


Target chamber studies



Foil, 1st try:
Kapton, thickness 75 µm

Stability tests in vacuum:



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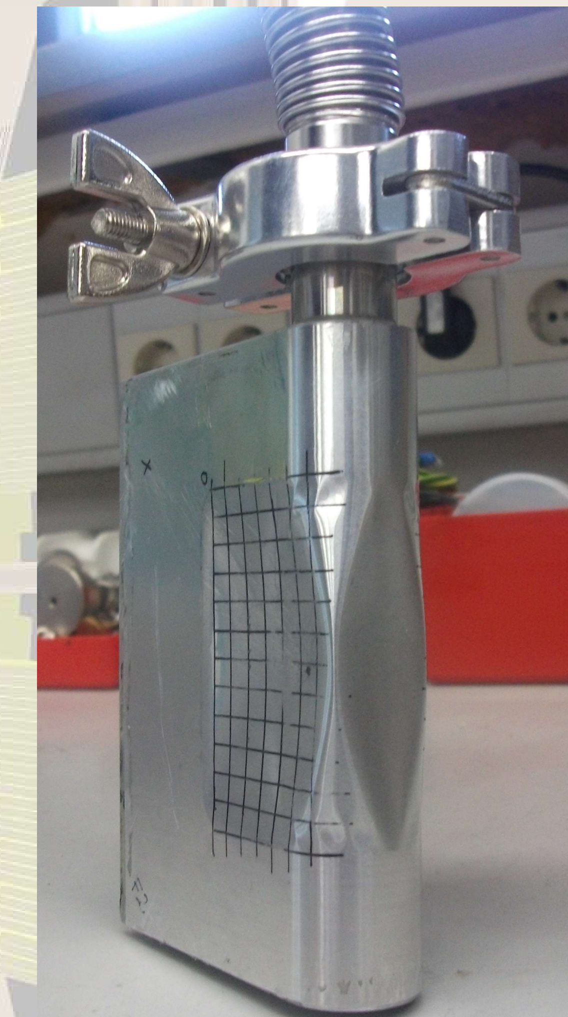
Target chamber studies

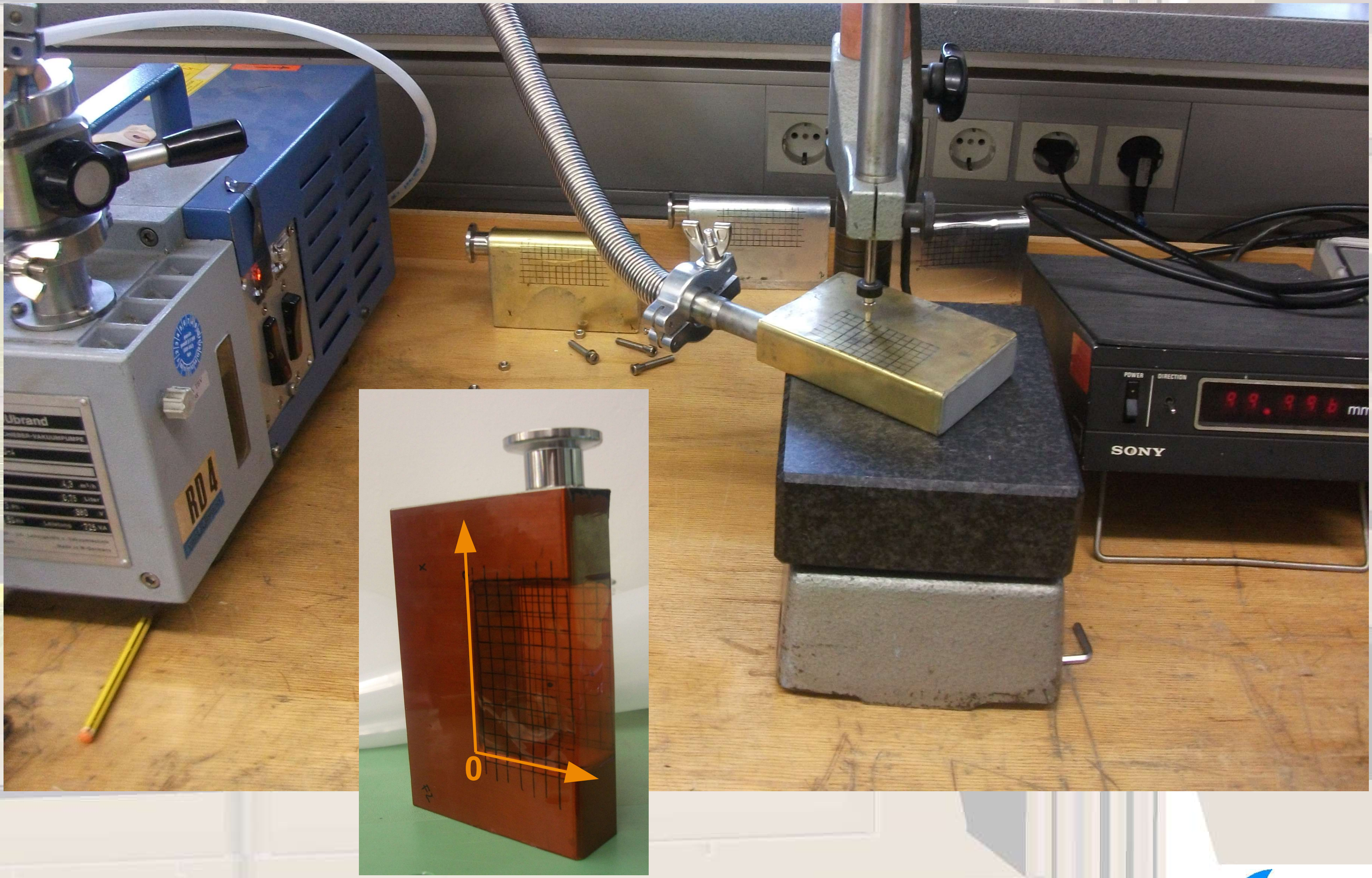
Brass, 200 µm

Titanium, 200 µm



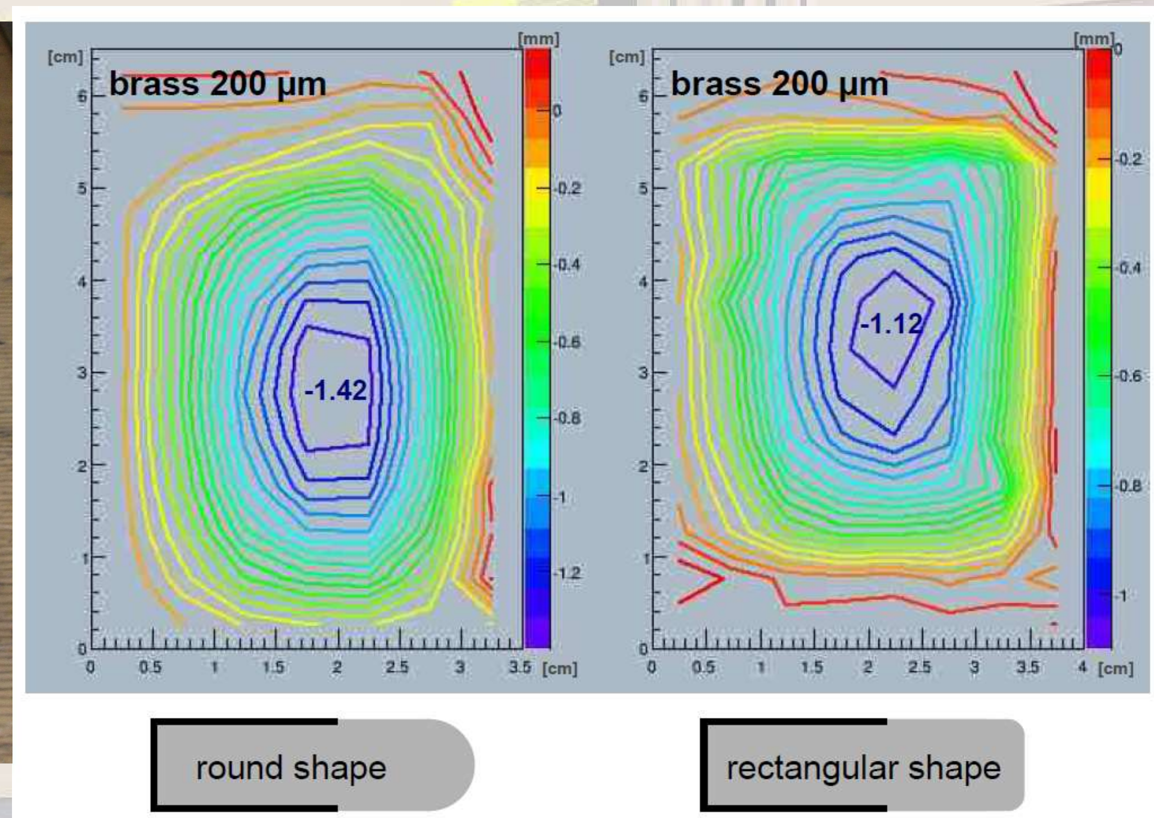
Alloy AlMg3, 100 µm

Setup for measurements



Target chamber measurements

Two shapes in comparison → bending smaller for rectangular shape



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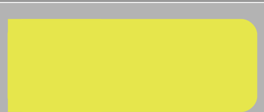
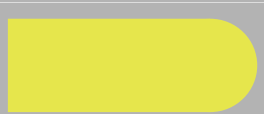
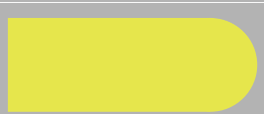
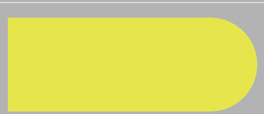
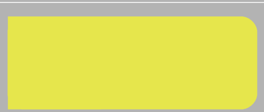
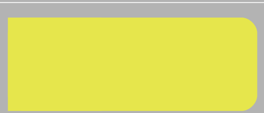
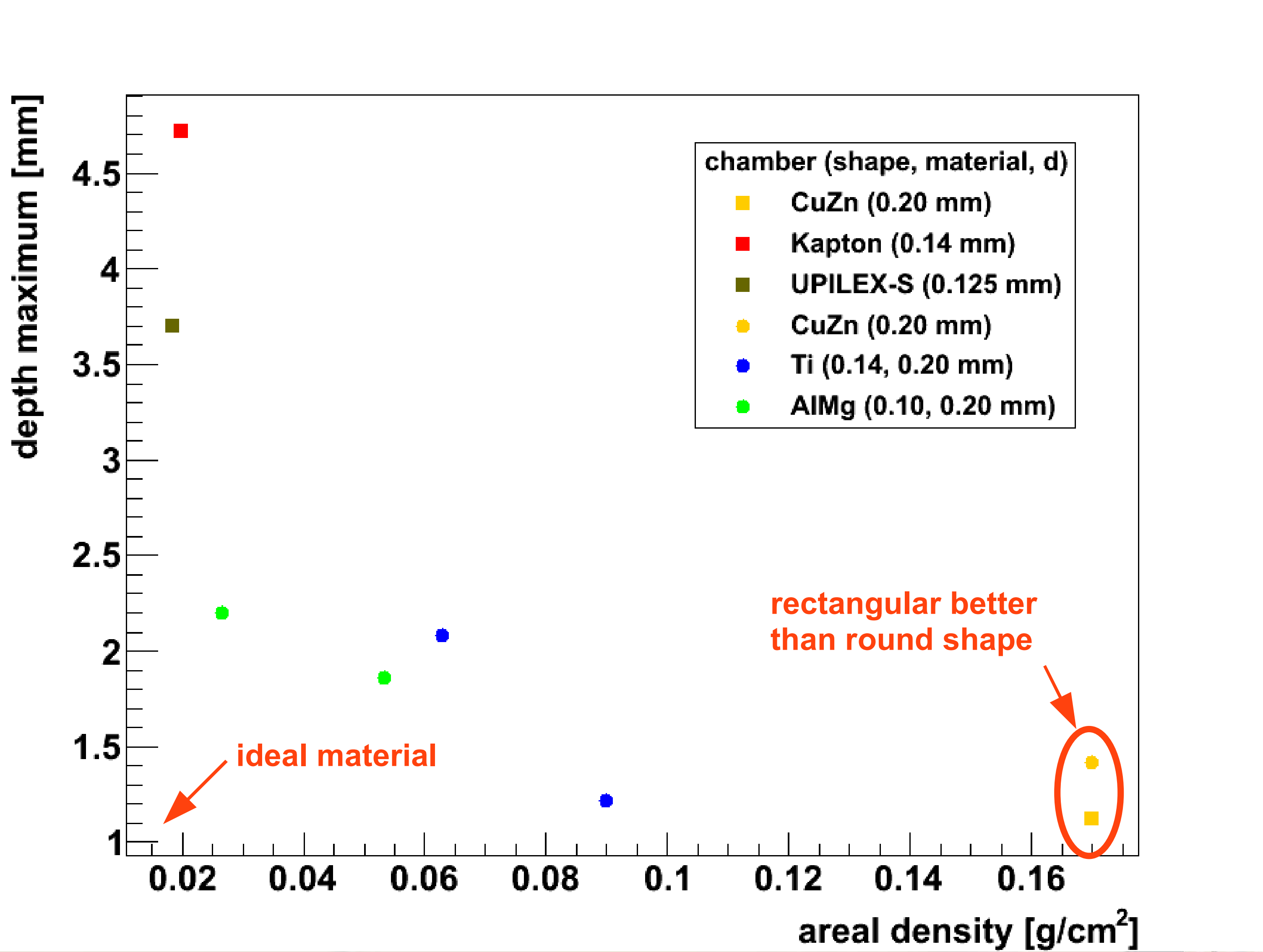
Target chamber measurements

material	density [g/cm3]	chamber shape	thickness [µm]	depth max [mm]
brass	8.50		200	1.12
brass	8.50		200	1.42
titanium	4.54		200	1.22
titanium	4.54		140	2.08
AlMg	2.66		200	1.86
AlMg	2.66		100	2.20
Kapton	1.42		140	4.72
UPILEX-S	1.47		125	3,70

Target chamber measurements

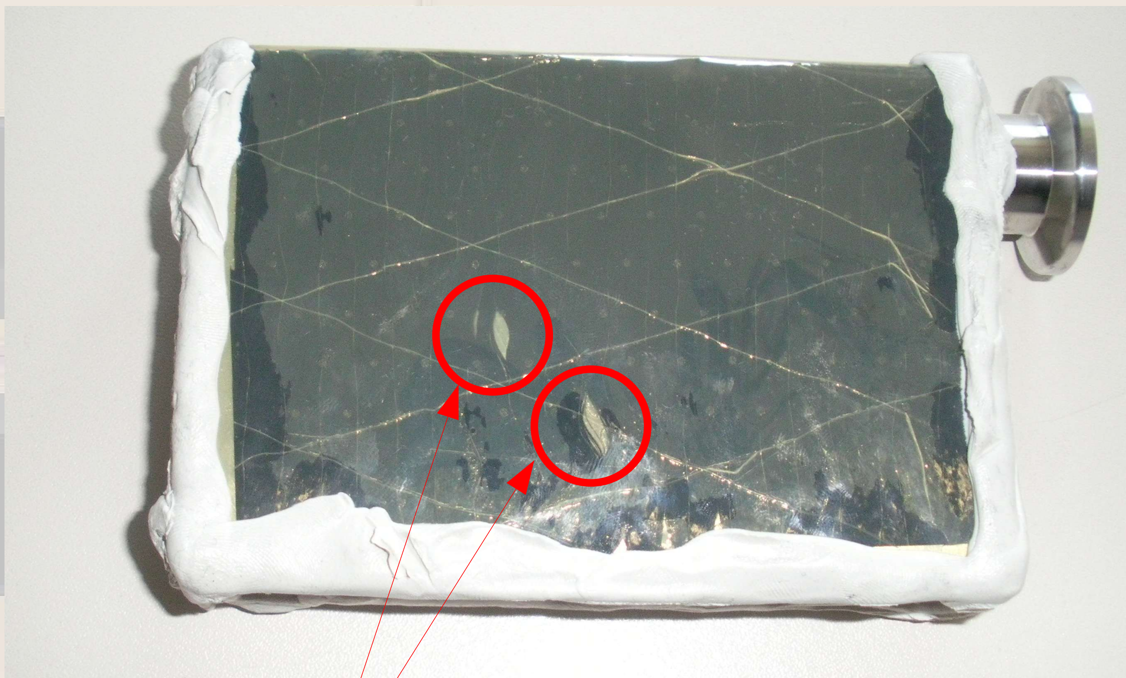


some possible combinations still remain for experimental tests but possible foils shall be evaluated by simulations first

Target chamber measurements

fiber reinforced polymer fabricated on a mold

fibers oriented only in x-direction impregnated with resin (thickness about 250 µm, 0.038 g/cm^2)



no closed composite material
⇒ not capable for vacuum
⇒ thin Kapton foil for sealing

evacuation of the chamber

composite material highly bent to the inside with clicking noise (fractures)

Design of the secondary target

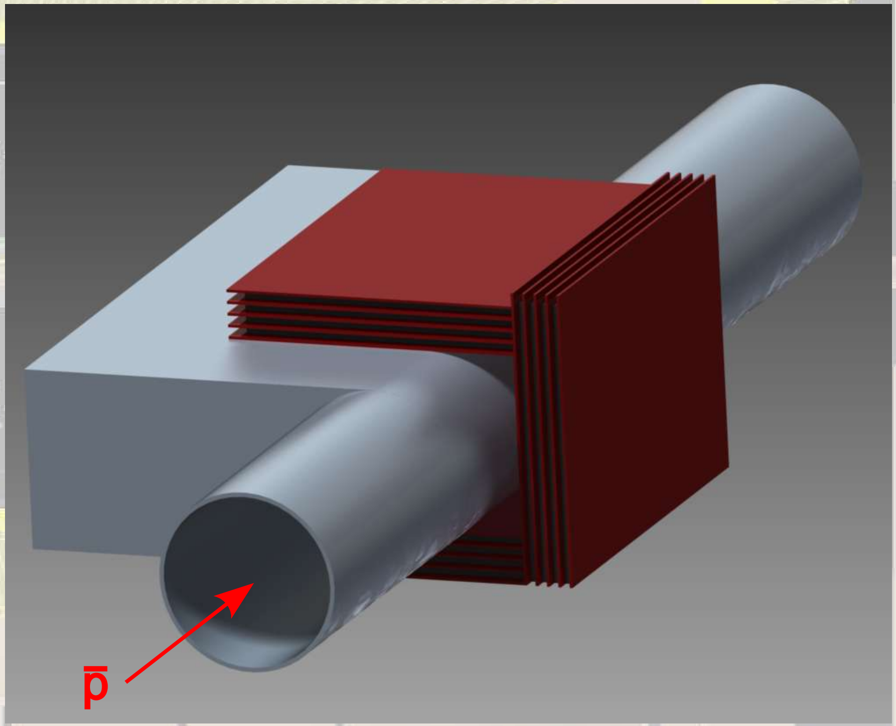
Requirements for the secondary target

- 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:

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

gray:

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

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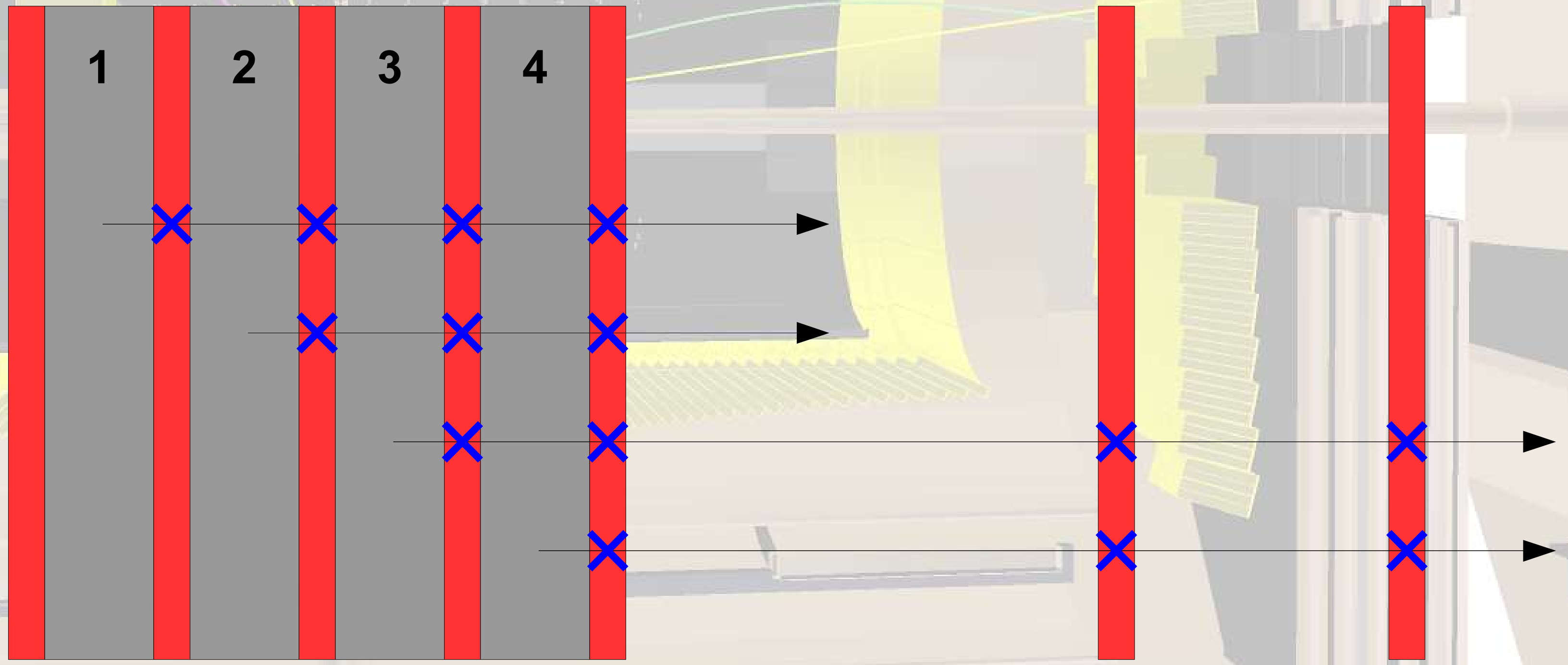
Pion tracking

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



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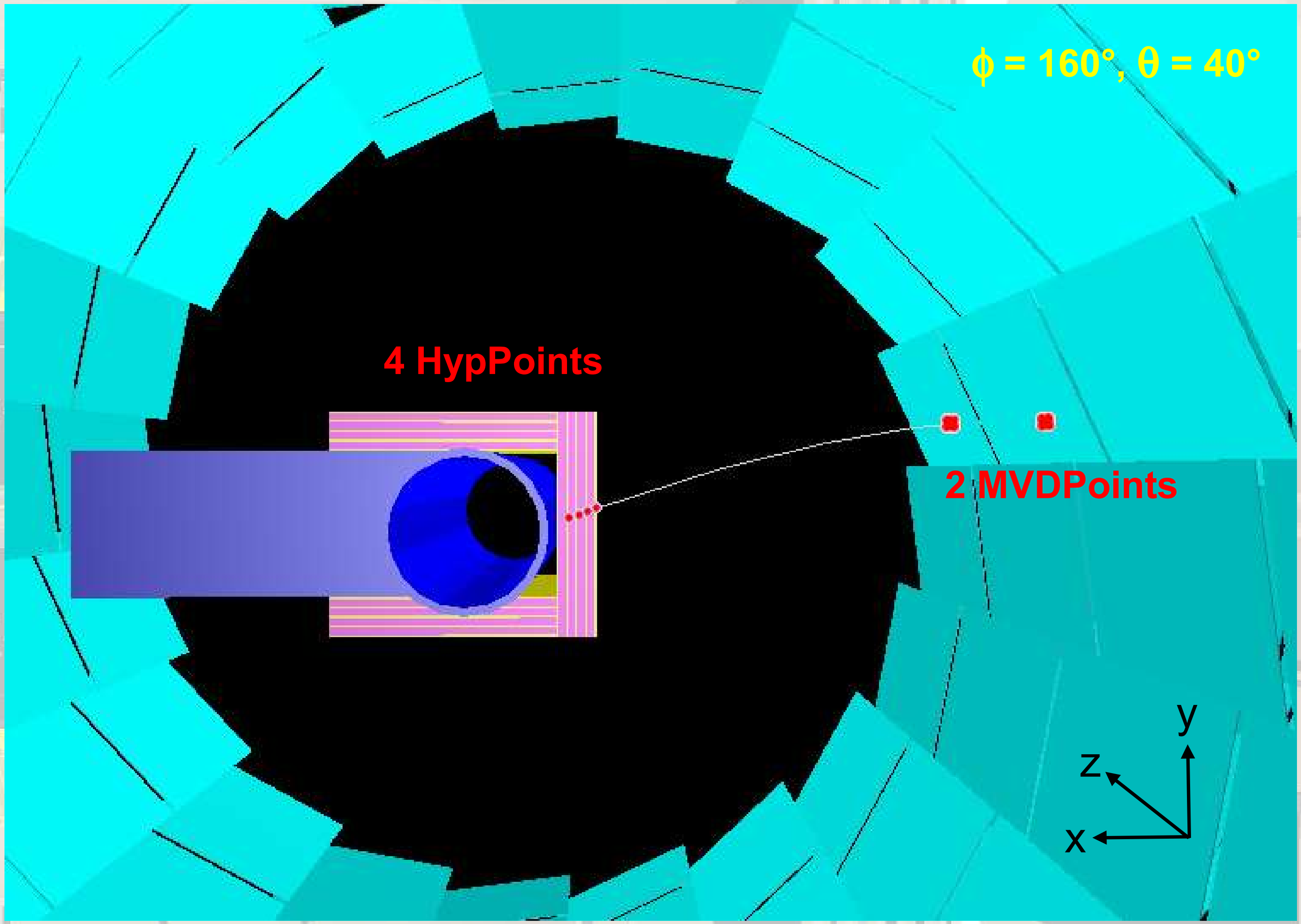
Pion tracking

MC Simulation:

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

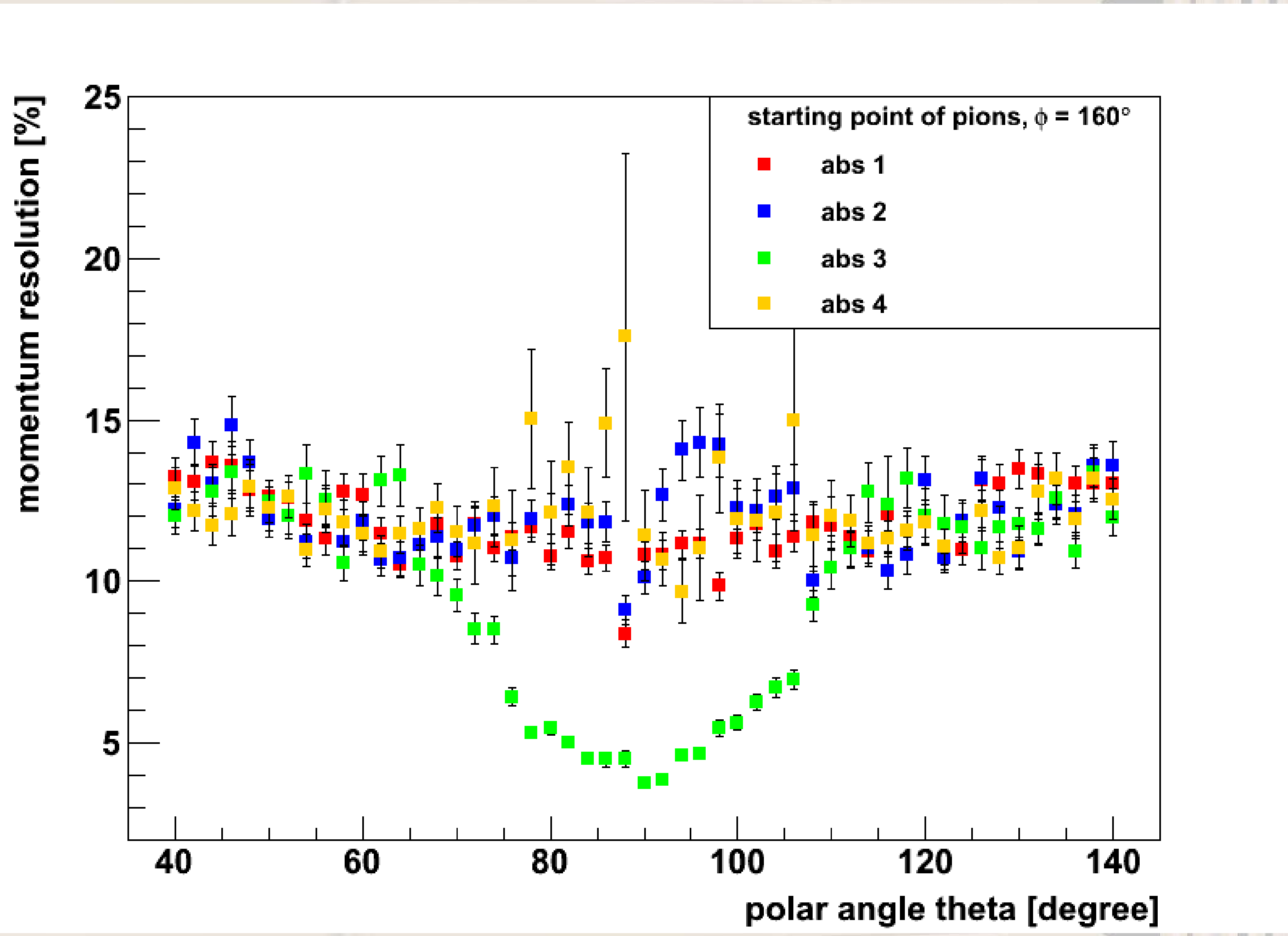
ϕ = 160° and
B = 0.5 T fixed

BoxGenerator modified
→ absorber layers define the origin



Event display of a pion from the first absorber layer in a magnetic field of 0.5 T

Pion tracking



it seems that there is a problem in the tracking software

Pion tracking

MC Simulation:

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

ϕ = 160° and
B = 0.5 T fixed

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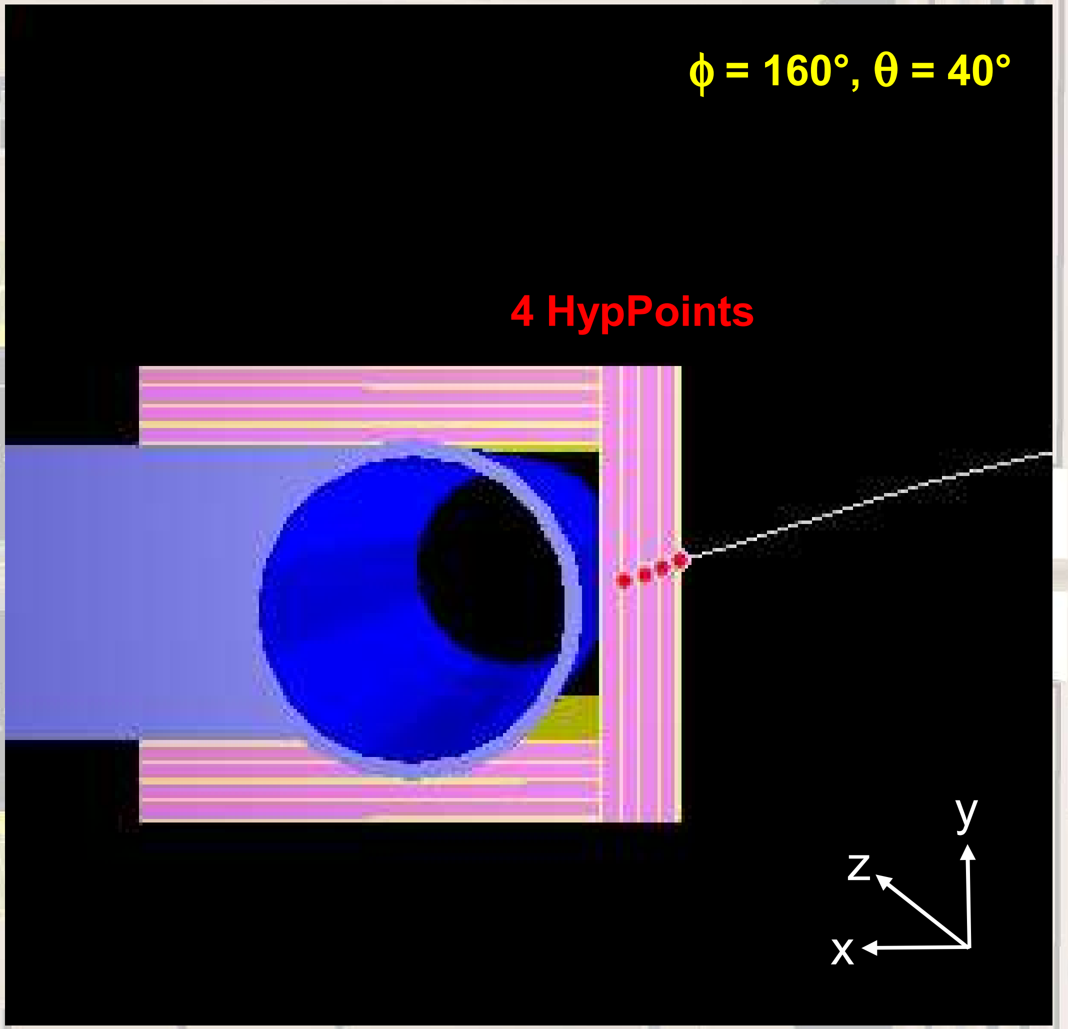
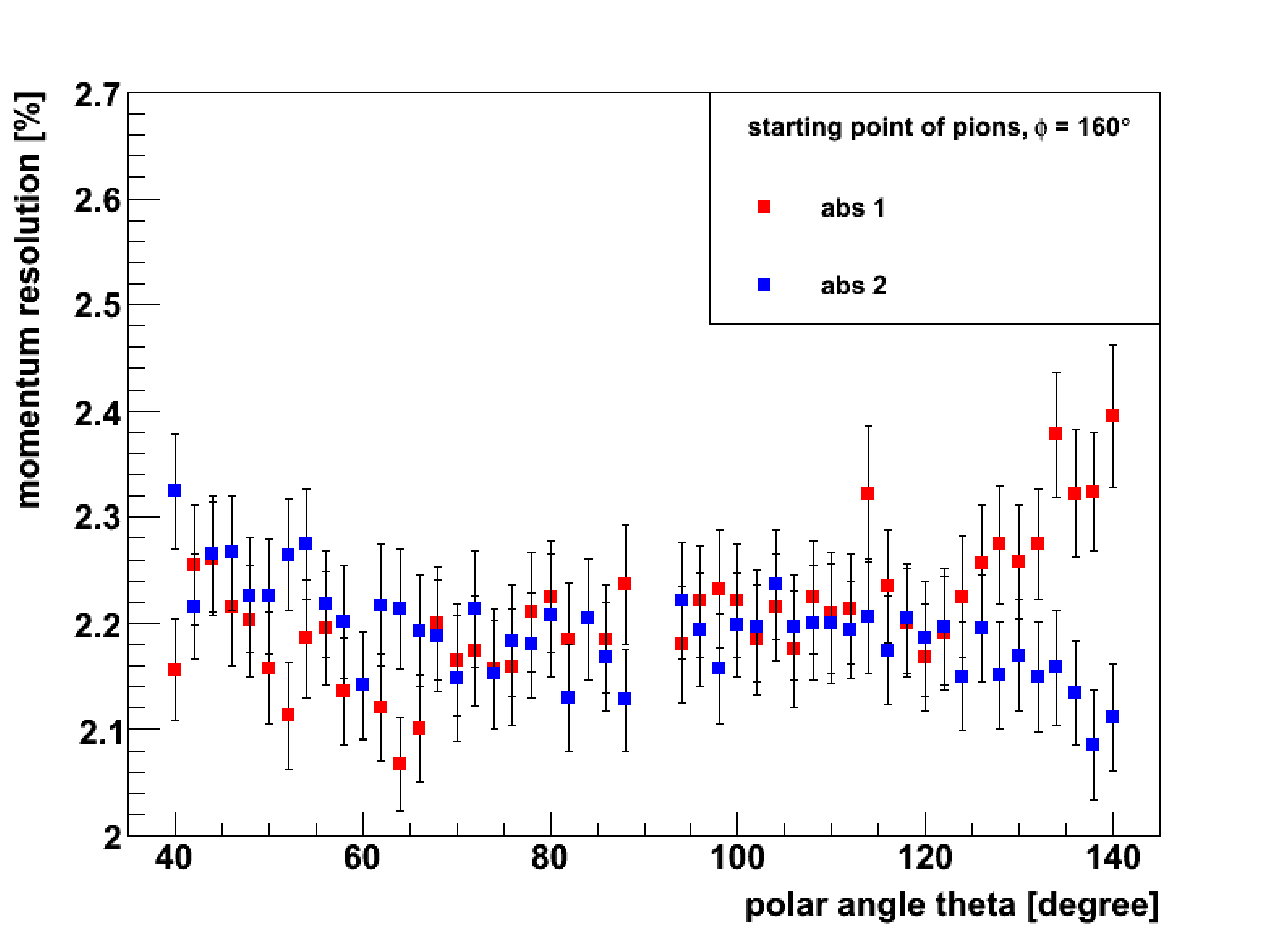


Same situation but only sensors of the secondary target used for the tracking

Event display of a pion from the first absorber layer in a magnetic field of 0.5 T

Pion tracking



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

but two additional sensor layers needed!

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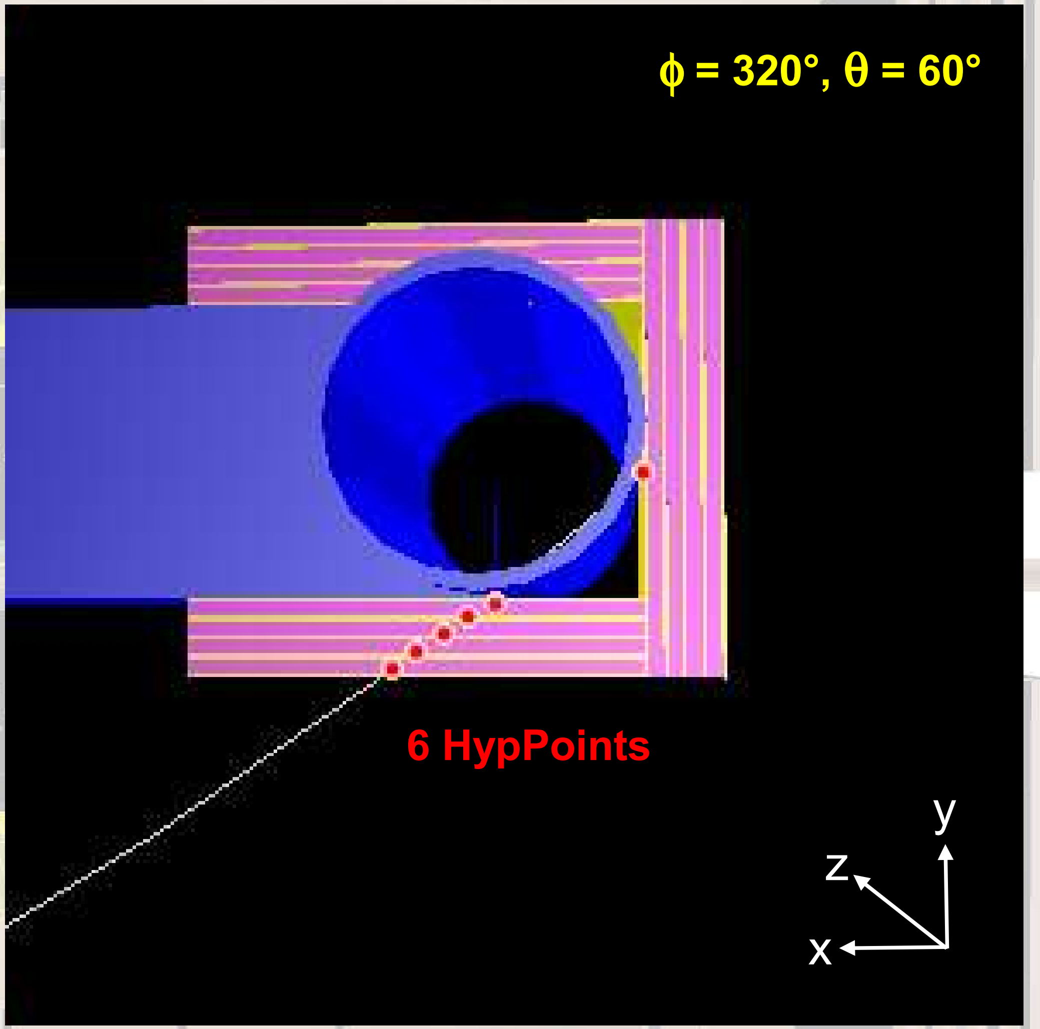
Pion tracking

MC Simulation:

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

ϕ = 320° and
B = 0.5 T fixed

BoxGenerator modified
→ absorber layers define the origin



Event display of a pion from the first absorber layer in a magnetic field of 0.5 T

problems in track fitting not yet solved

Outlook

- construction of a positioning stage
- simulations and final tests of target chamber materials
- ongoing GiBUU simulations
- look at events with Ξ^-
- study the arrangement and thickness of the layers in case of the stopping of Ξ^- and the pion tracking (use the stopping points of Ξ^- as starting point for pions)