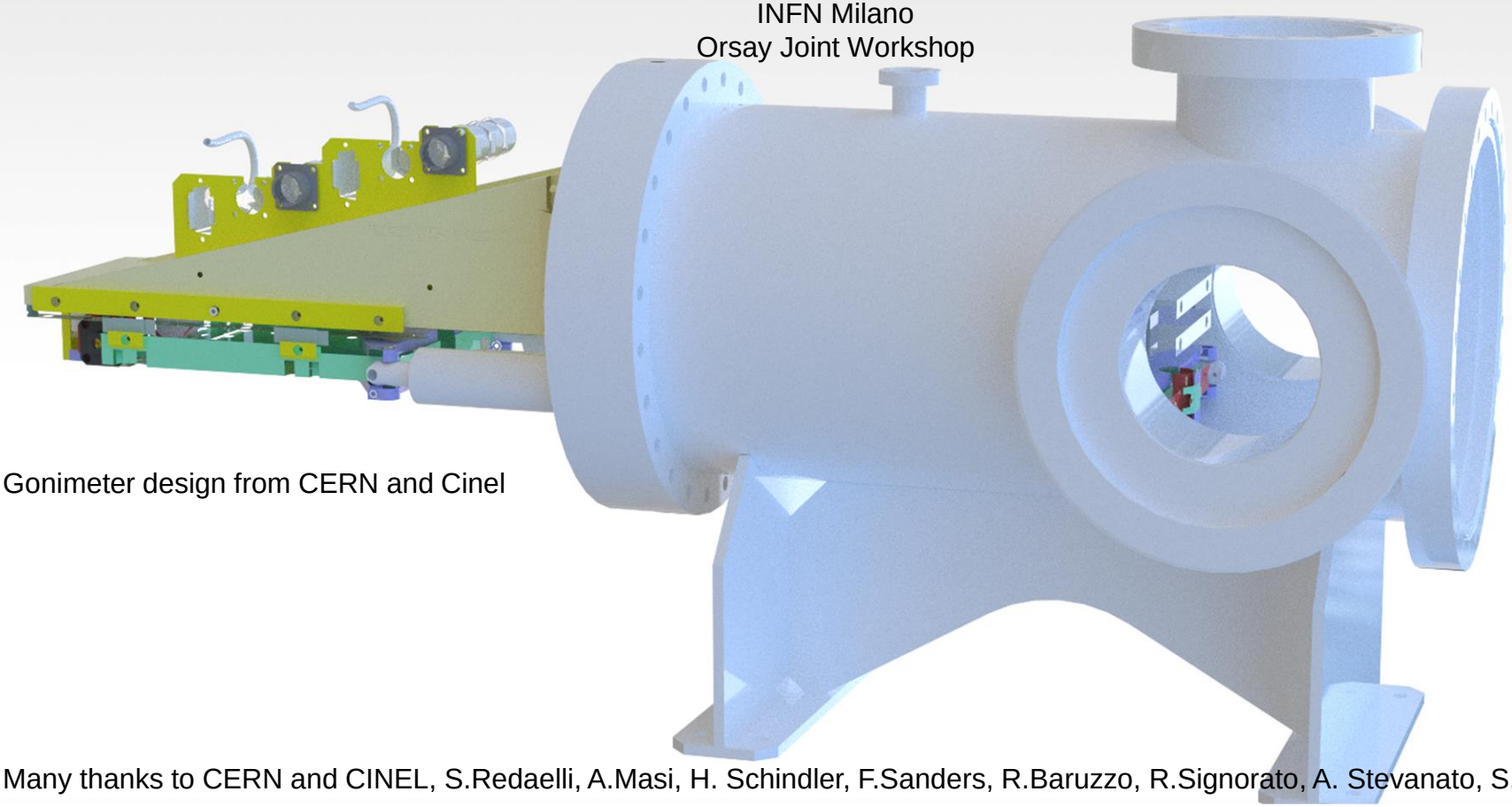
Goniometer For Long Bent Crystal For Charm Baryon Dipole Moments Experiment

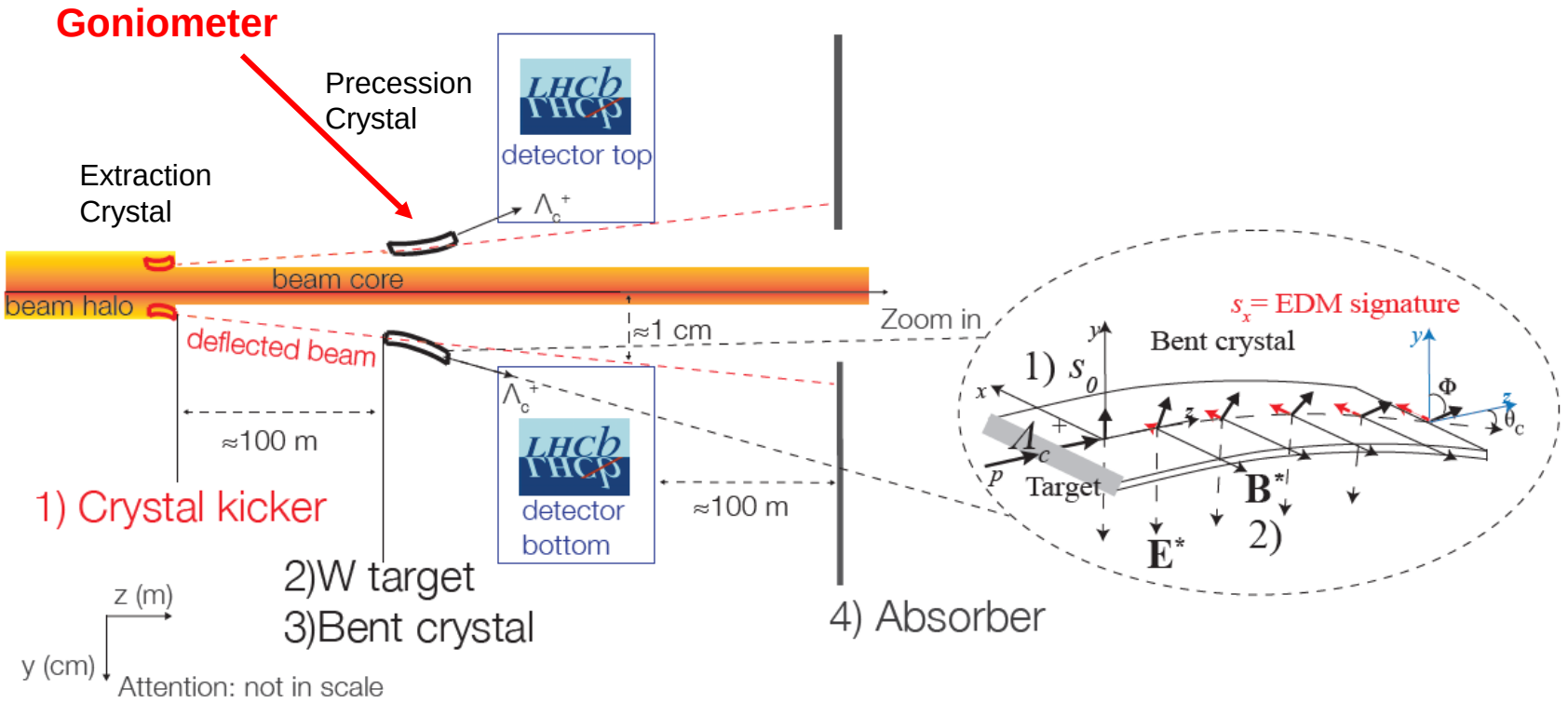
Federico De Benedetti
INFN Milano
Orsay Joint Workshop



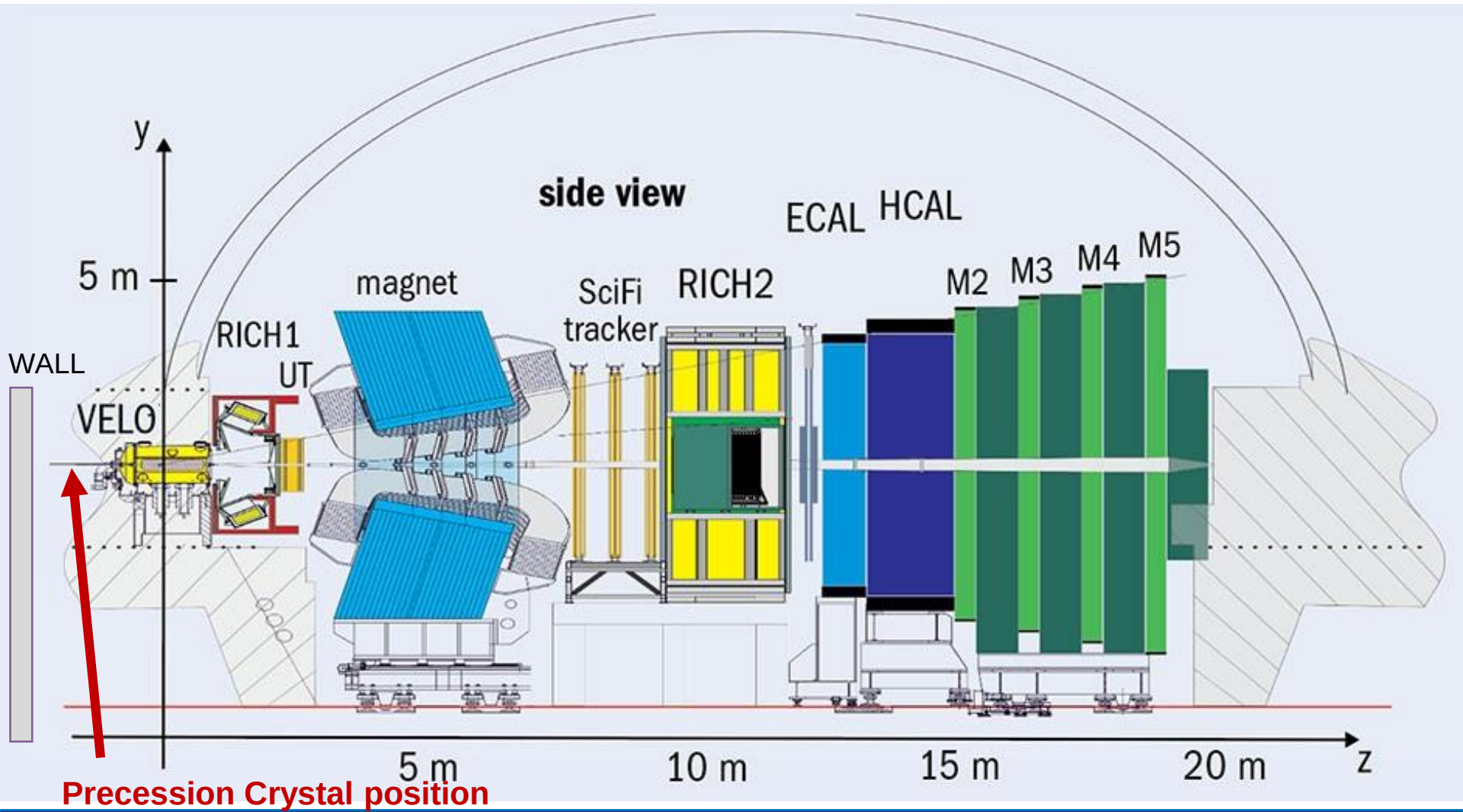
Gonimeter design from CERN and Cinel

Many thanks to CERN and CINEL, S.Redaelli, A.Masi, H. Schindler, F.Sanders, R.Baruzzo, R.Signorato, A. Stevanato, S.Bongiovanni

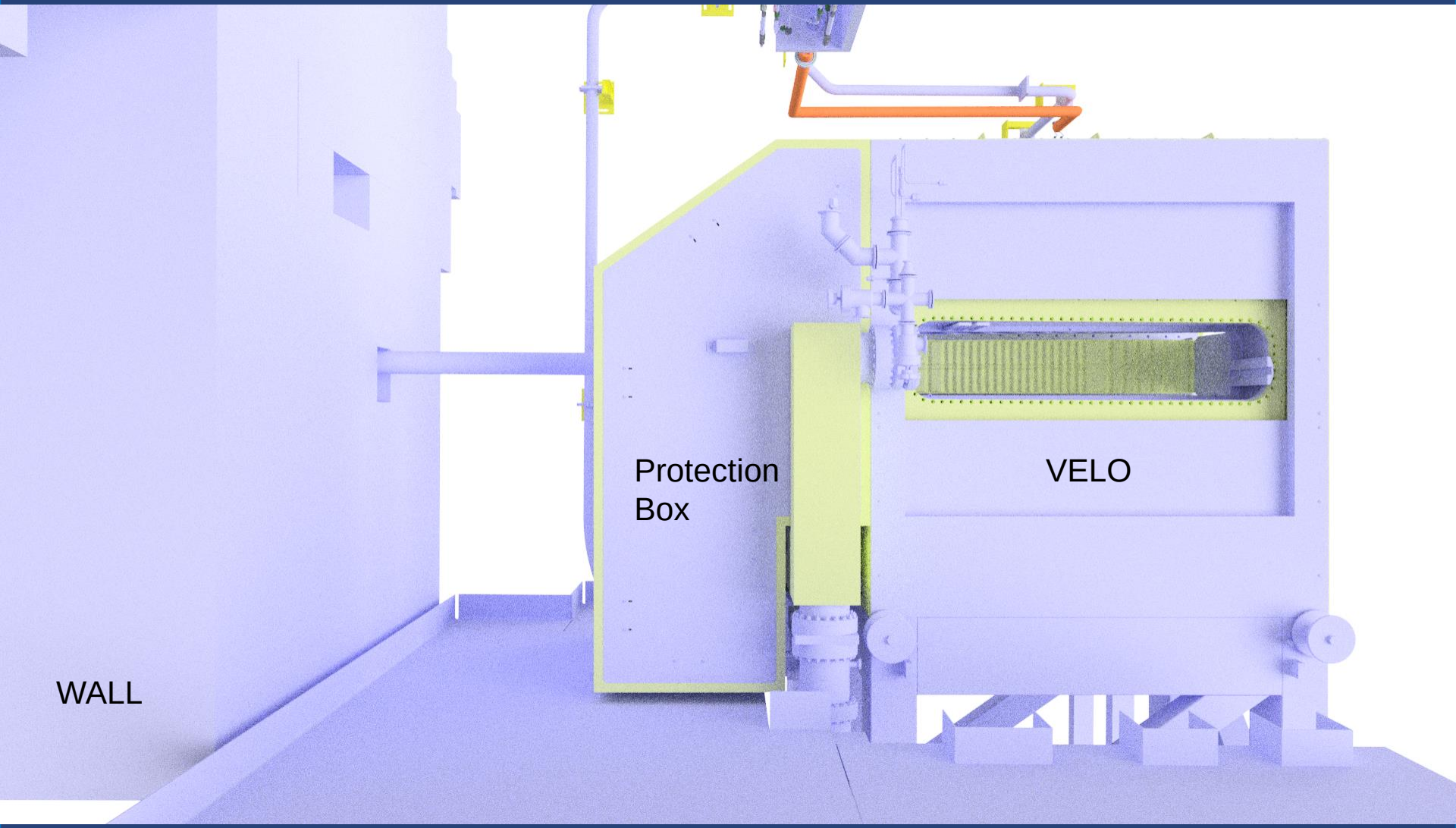
Fixed Target Setup



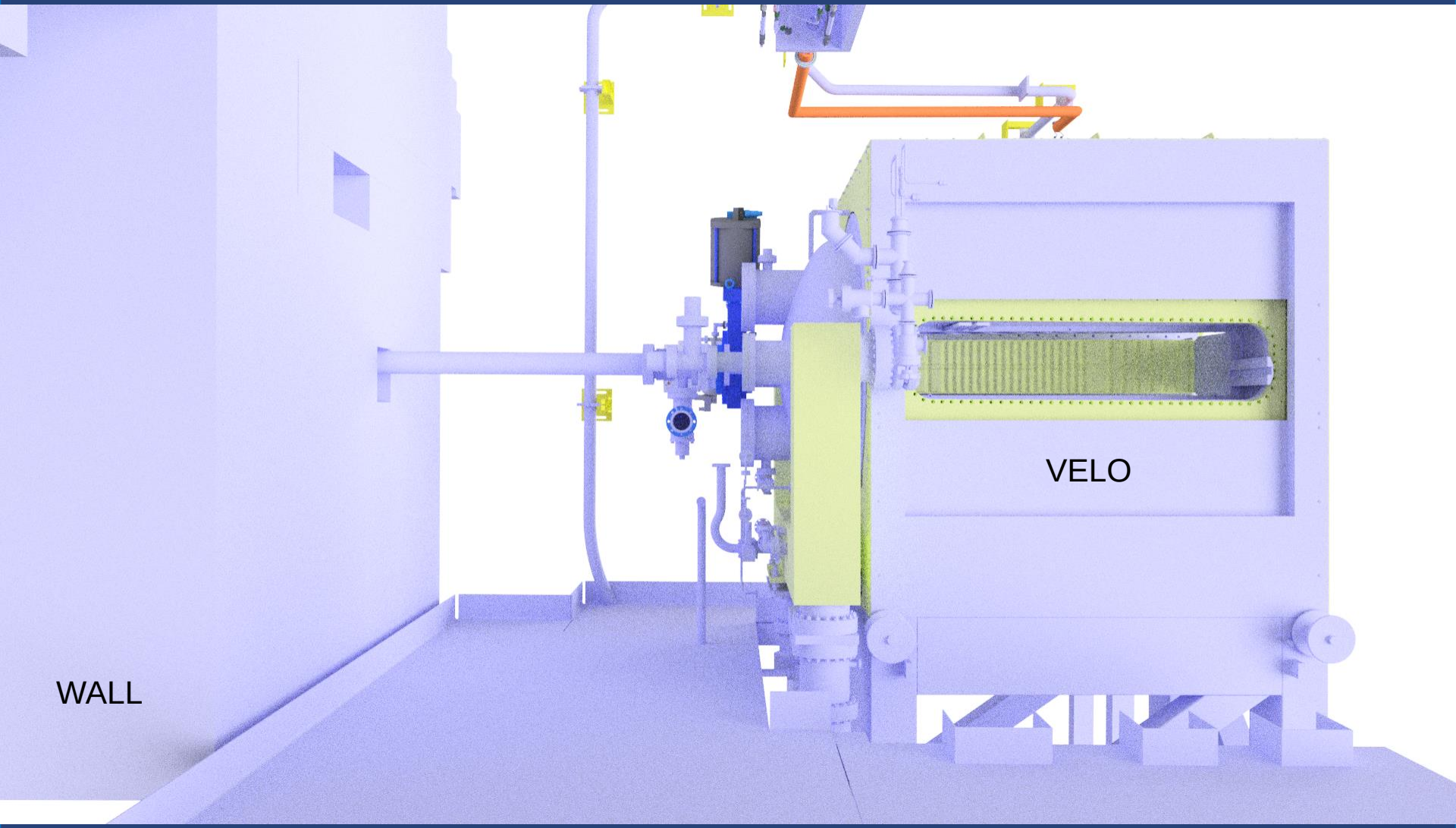
- V. G. Baryshevsky, Phys.Lett.B 757 (2016) 426
- L. Burmistrov et al, CERN-SPSC-2016-030, SPSC-EOI-012 (2016)
- F. J. Botella et al, Eur.Phys.J.C 77 (2017) 181
- A.S. Fomin et al, JHEP 1708 (2017) 120
- E. Bagli et al, Eur.Phys.J.C 77 (2017) 828
- A.S. Fomin et al, Eur.Phys.J.C 80(2020) 358
- S. Aiola et al. Phys.Rev.D 103 (2021) 072003

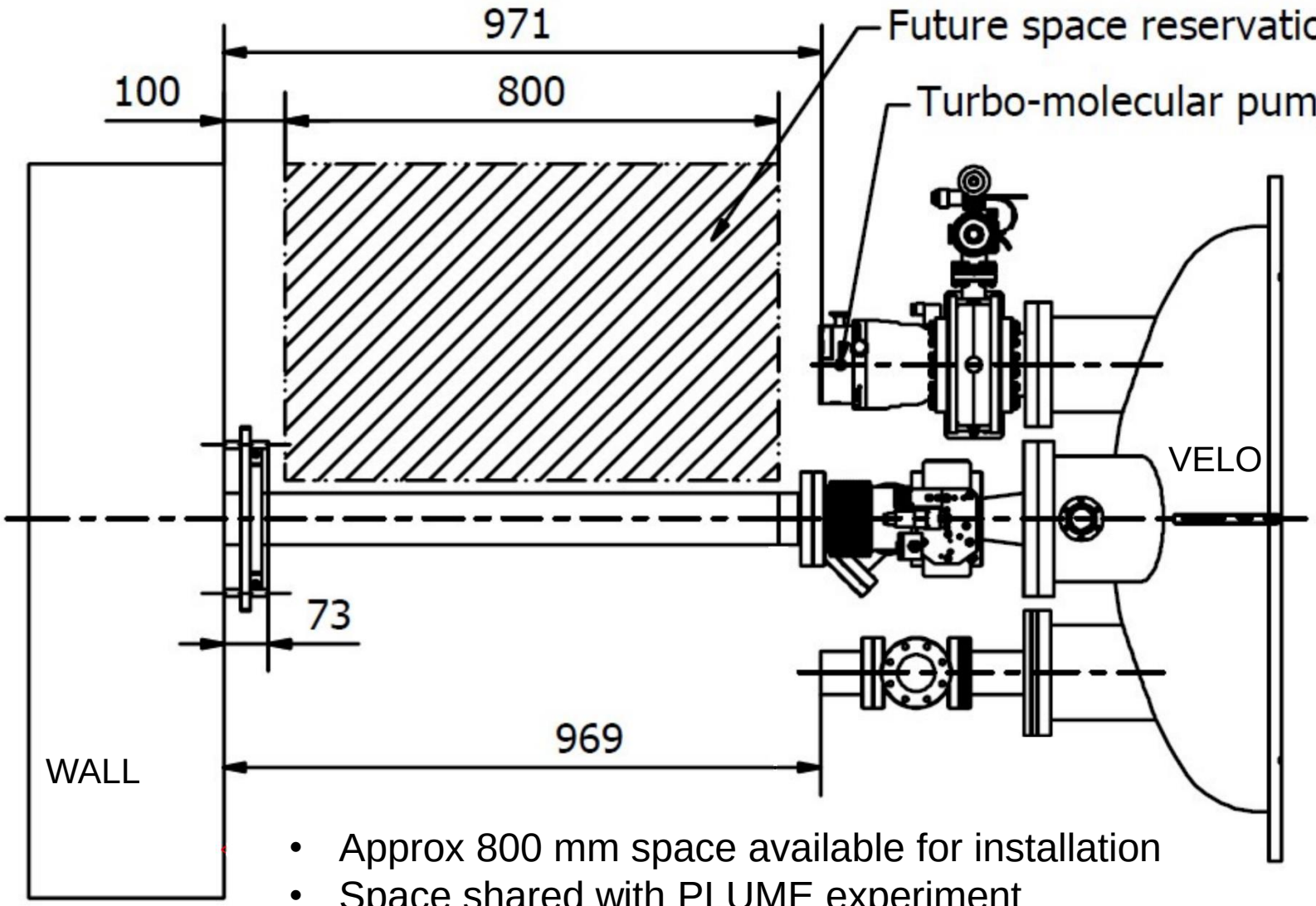

side view
y
5 m
WALL
VELO
RICH1
UT
magnet
SciFi
tracker
RICH2
ECAL
HCAL
M2
M3
M4
M5
5 m
10 m
15 m
20 m
z
Precession Crystal position

Upstream Sector



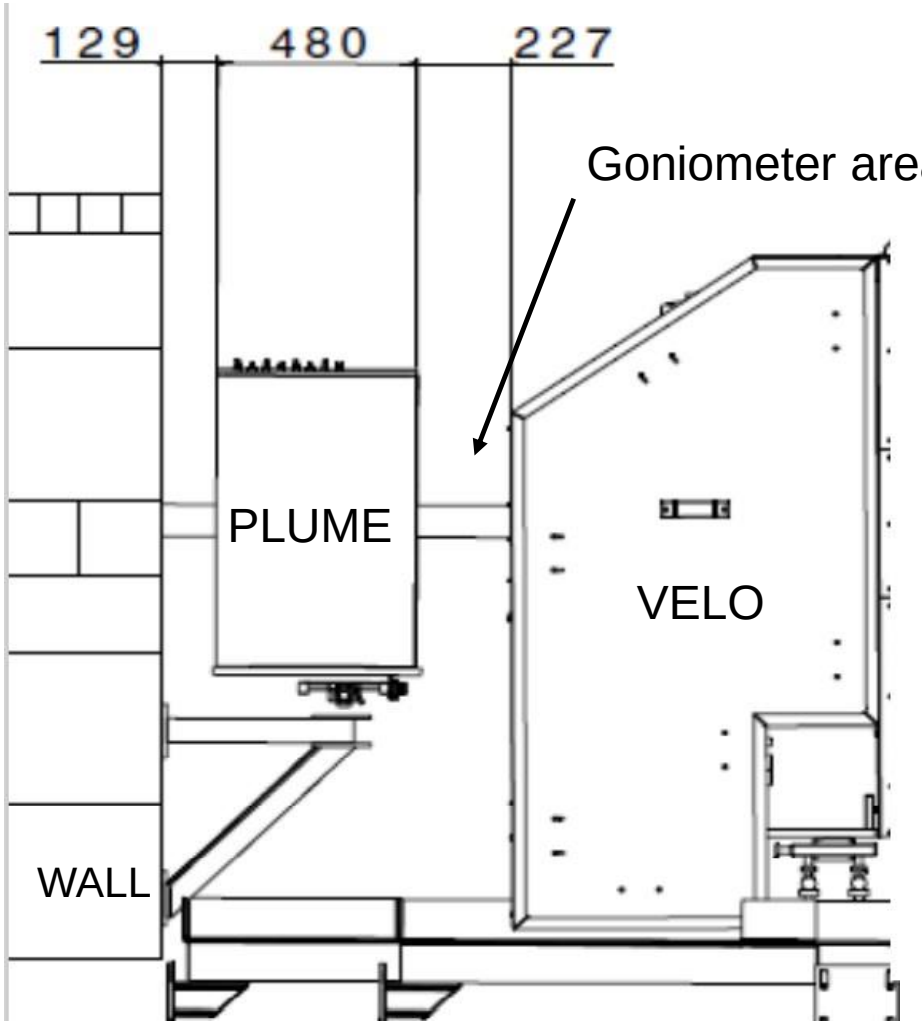
Upstream Sector



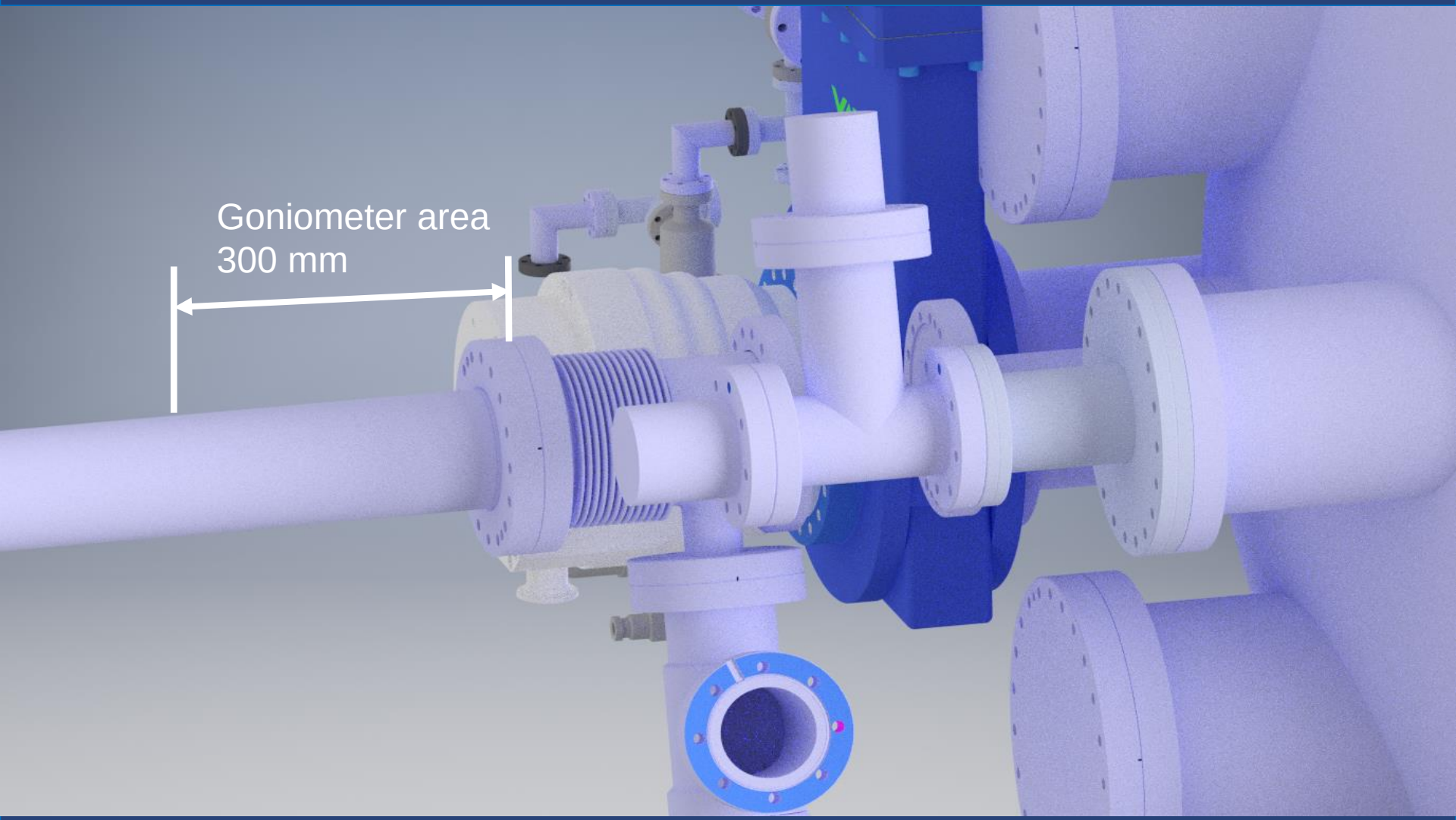


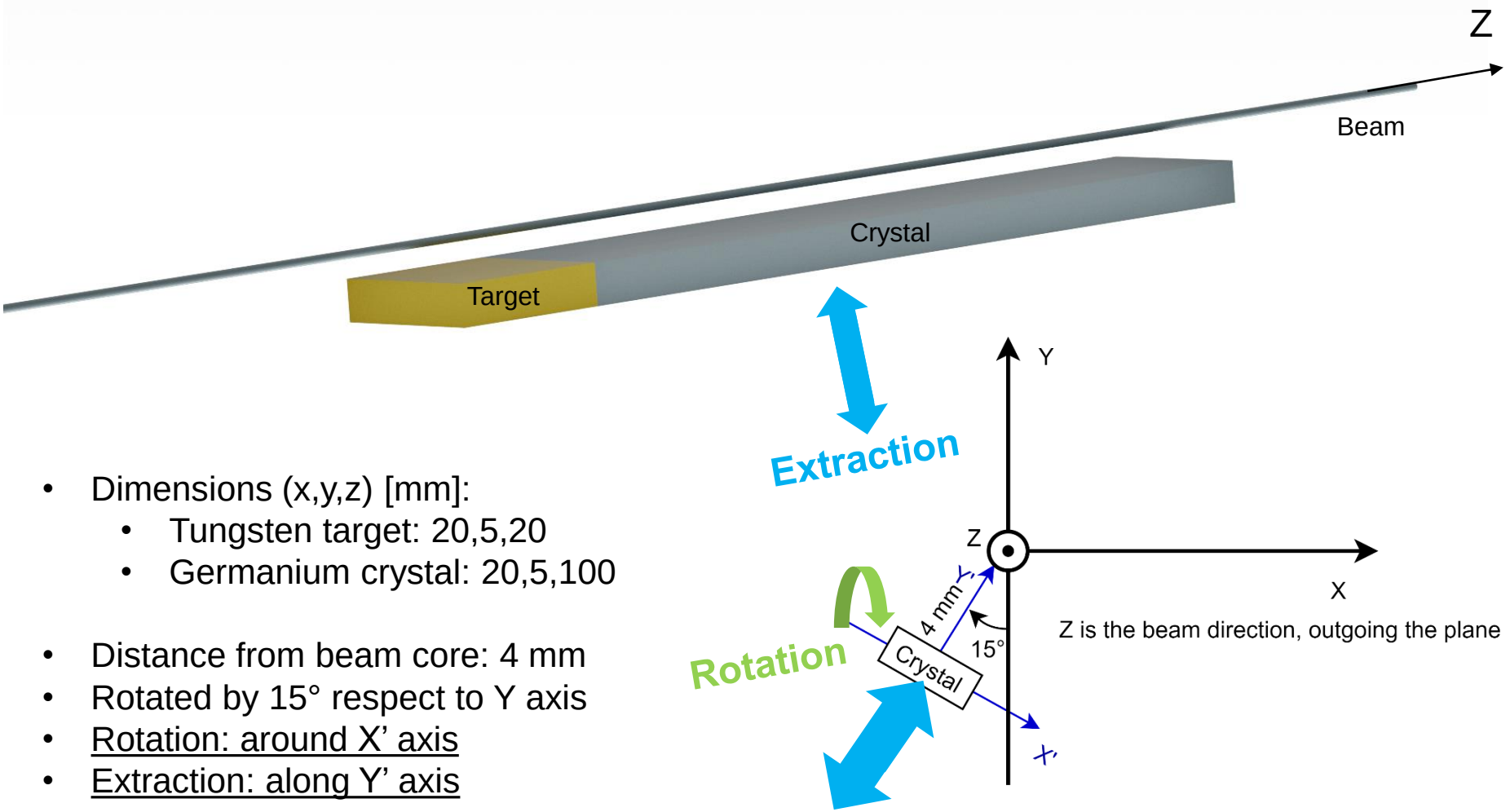
- Approx 800 mm space available for installation
- Space shared with PLUME experiment

Goniometer Space Constraints



- The goniometer will be installed between PLUME and VELO
- Available space: 320 mm
- Goniometer lenght: 300 mm
- The VELO protection box has to be modified in order to fill the entire available space.
- The beampipe and the flange on the VELO side (bellow) have to be modified


Goniometer area
300 mm



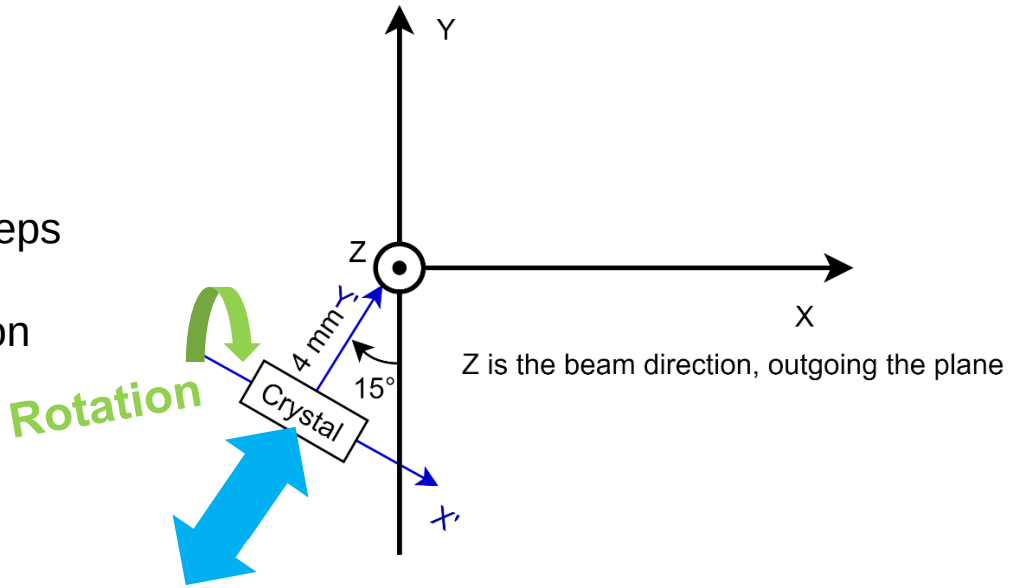
- Dimensions (x,y,z) [mm]:
  - Tungsten target: 20,5,20
  - Germanium crystal: 20,5,100

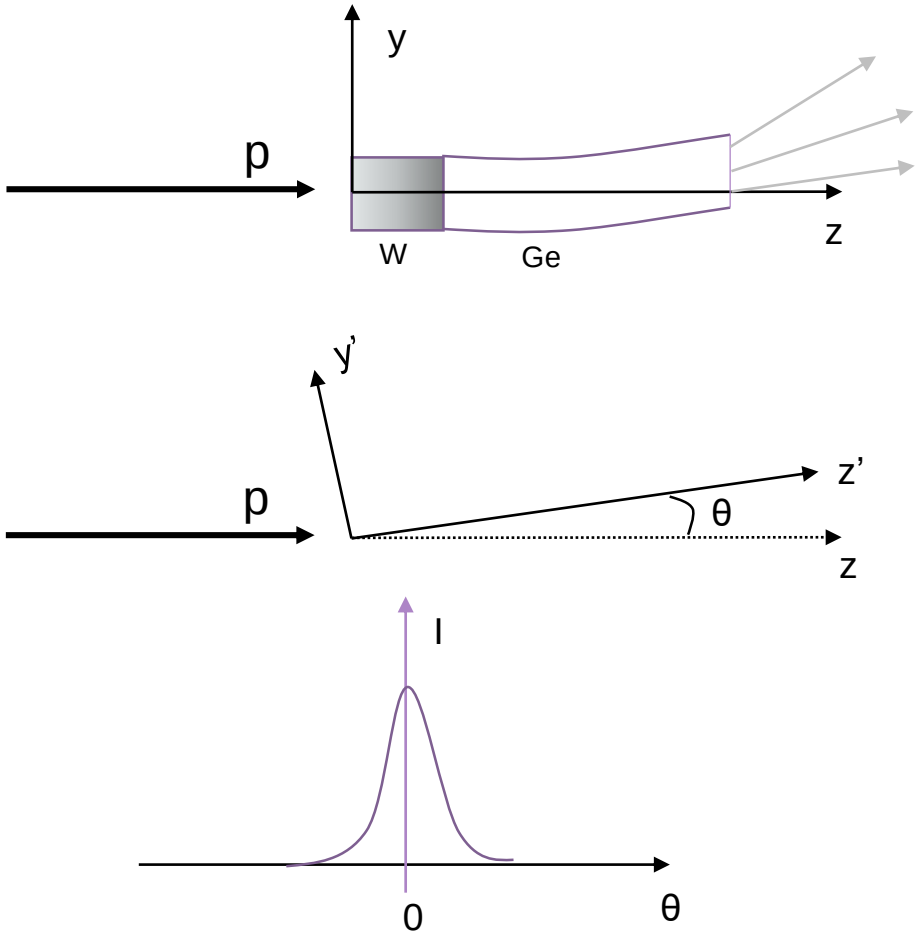
- Distance from beam core: 4 mm
- Rotated by 15° respect to Y axis
- Rotation: around X' axis
- Extraction: along Y' axis

- Y' is the direction of crystal insertion
  - Mechanical stroke: 60 mm
  - Precision: 10 um
  - Accuracy: 20-50 um

- X' is the rotation axis
  - Mechanical stroke = ±1°
  - Precision = 10 urad
  - Accuracy = 20-50 urad

- Open loop system:
  - No feedback inside the goniometer. Internal resolver for counting motor steps
  - Possibility of closed-loop system with feedback from LHCb detector based on channeled particle reconstruction

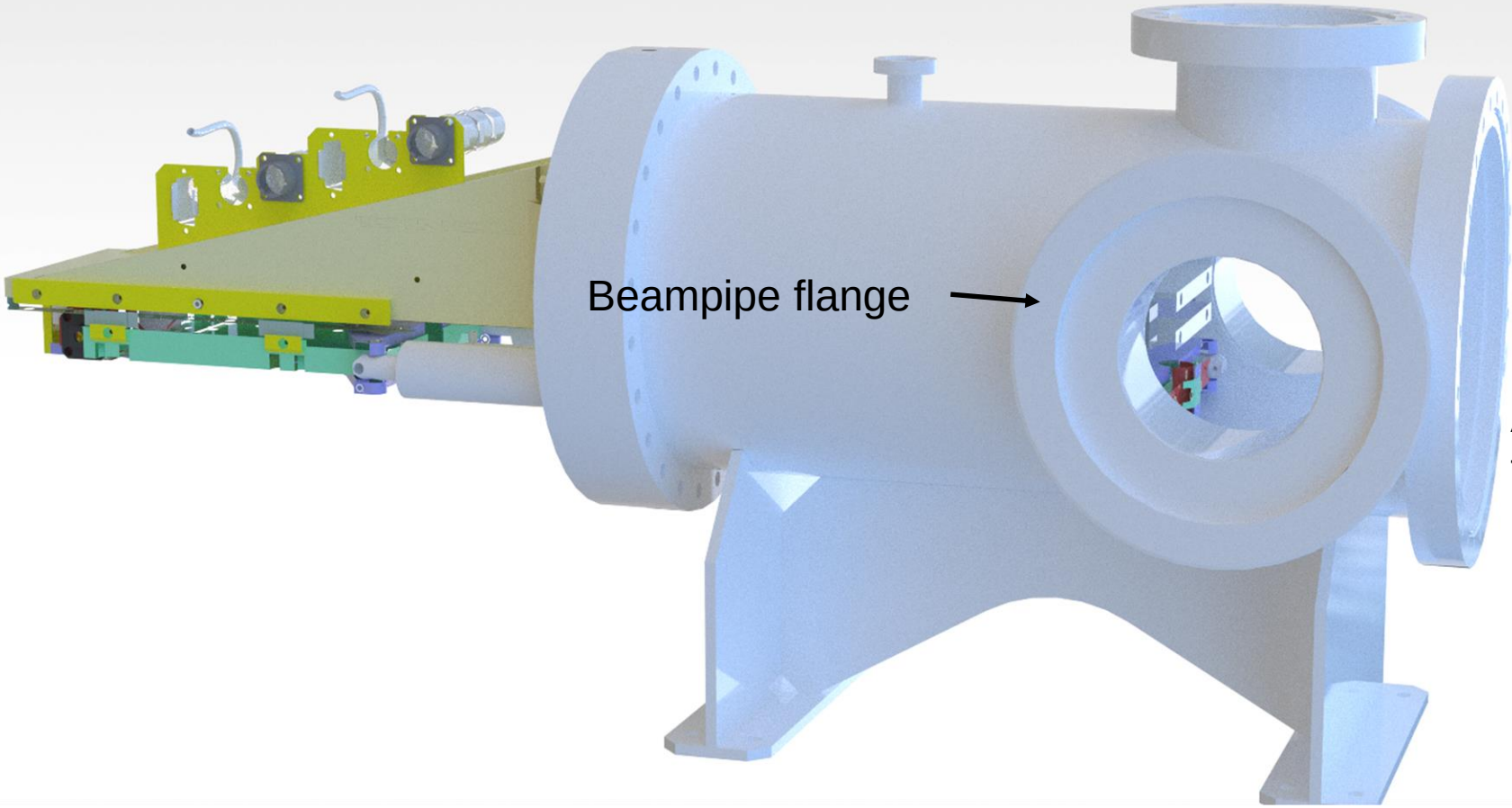


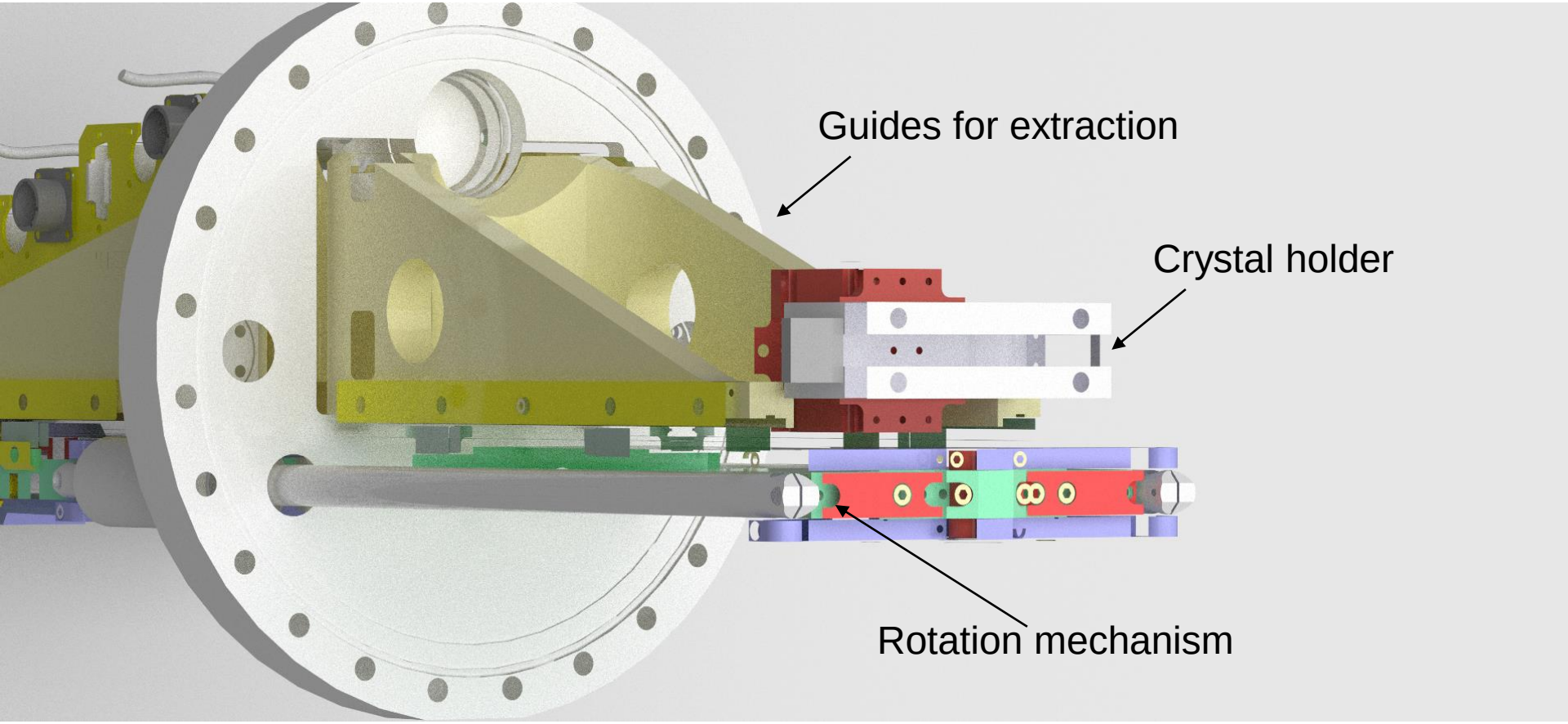


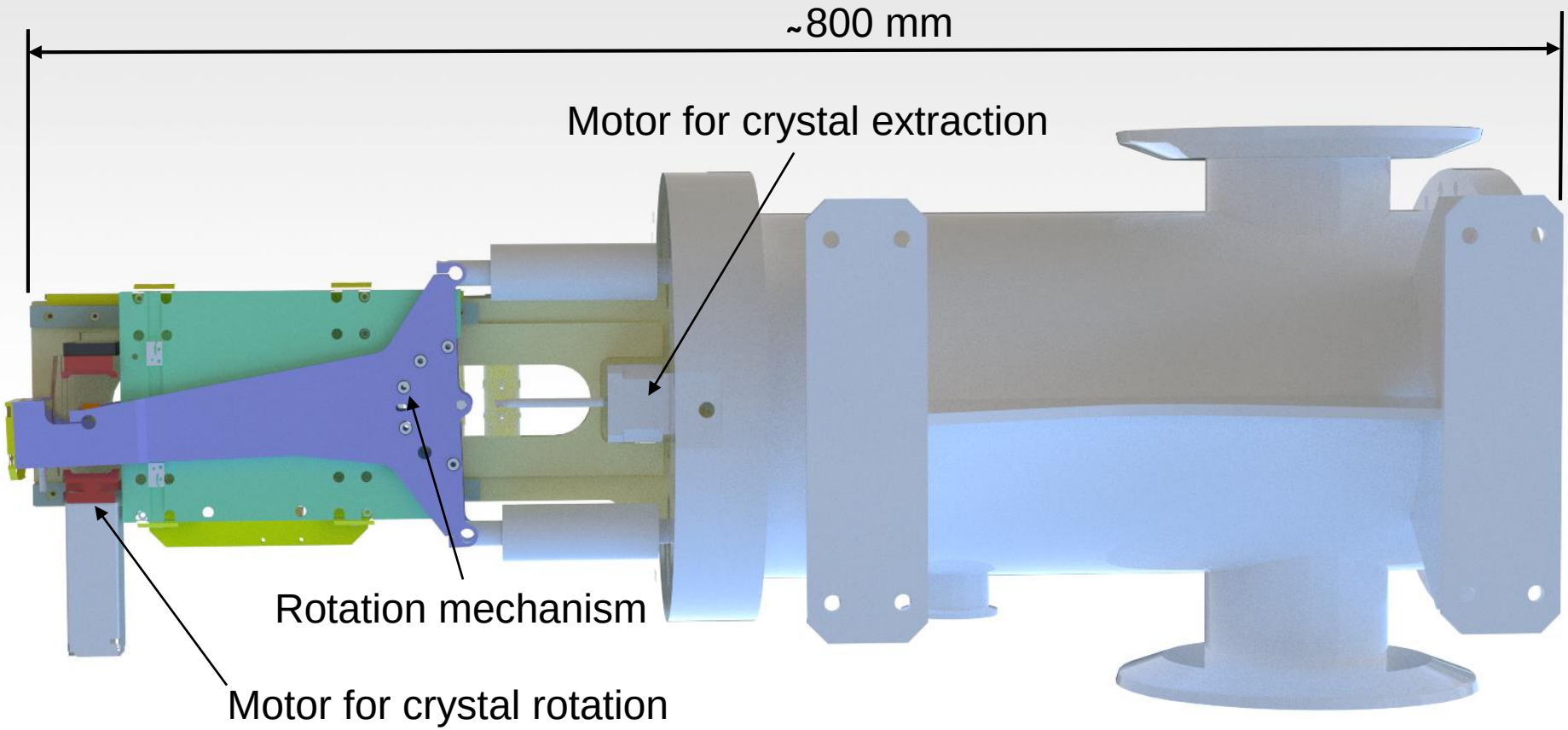
- Crystal alignment performed through an angle scan and event recontruction
- Scan between -1 mrad and +1 mrad
- The optimal angle is found where the intensity is maximum

- A dedicated remote control system has to be designed

Designed by Cinel

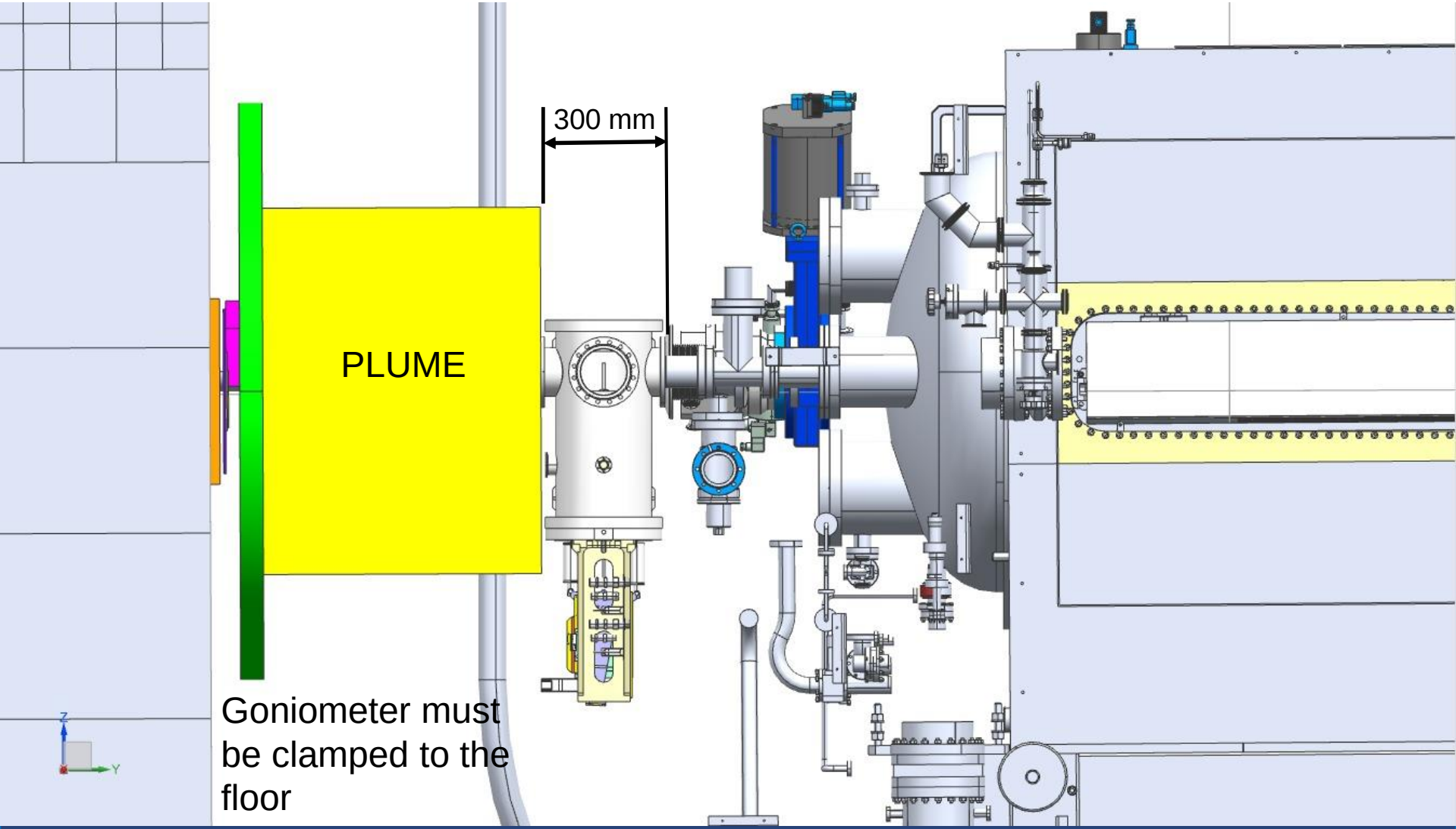



Guides for extraction
Crystal holder
Rotation mechanism

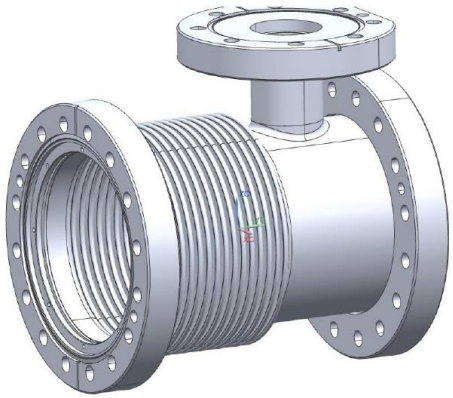


- Motors will be changed with a LHC compliant rad-hard model
- New motors lead to an increased lenght of approx 200-250 mm

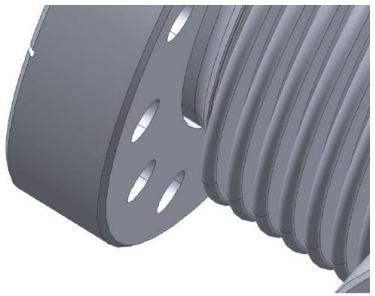
Goniometer Space Constraints

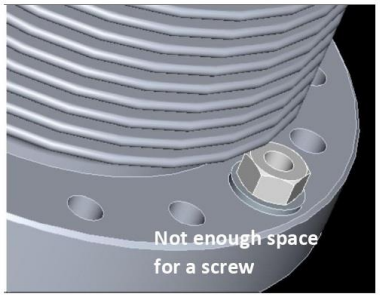


- To keep the occupancy around 300 mm on the Z-axis we need to change the flanges on both sides (VELO bellow and Beampipe), **avoiding the use of the screws.**
- One solution can be the EVAC ISO CeFiX with chain clamp (in the figure)



- Upstream mechanics modification, needed for the goniometer installation:
  - Beampipe length and flange connection to the goniometer
  - Vacuum bellow on the VELO side

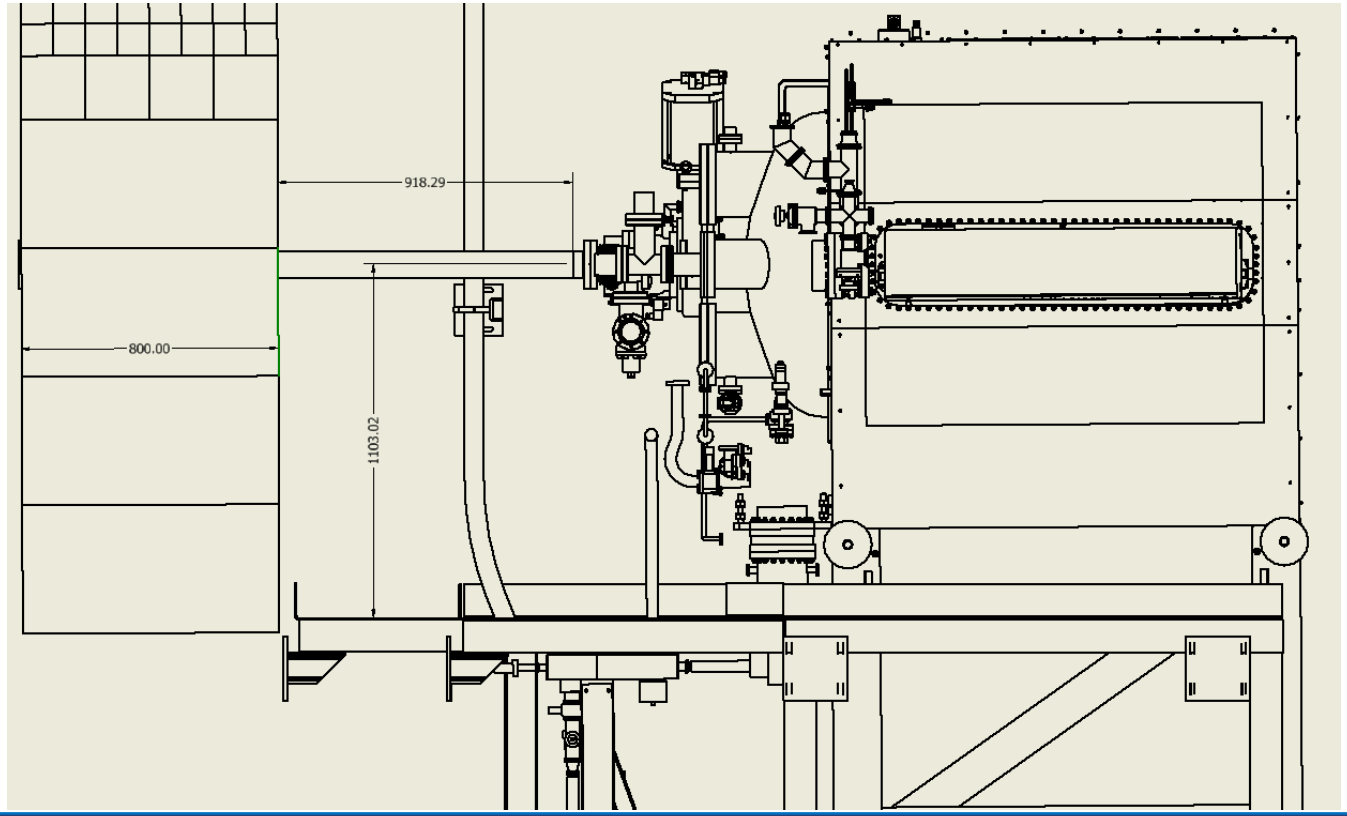




- To keep the occupancy around 300 mm on the Z-axis we need to change the flanges on both sides (VELO bellow and Beampipe), **avoiding the use of the screws.**
- One solution can be the EVAC ISO CeFiX with chain clamp (in the figure)

- Upstream mechanics modification, needed for the goniometer installation:
  - Beampipe length and flange connection to the goniometer
  - Vacuum bellow on the VELO side

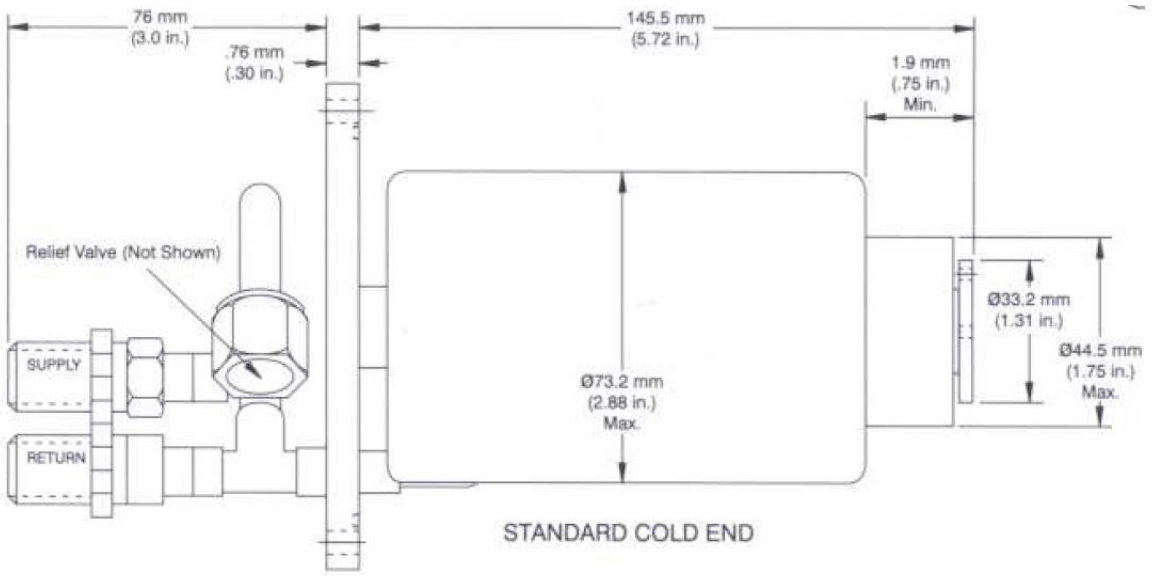
The estimated weight of the goniometer is 80-100 kg. It has to be fixed to the floor. We need to understand the floor stability and where to connect the object to achieve the requested specifications



- Crystal efficiency depends on temperature
  - Very good efficiency at cryogenic temperatures (77K) for Ge crystal
- We are exploring a solution with a cold finger (from CryoTiger), connected to the crystal holder. Pdiss max = 3W at 77K
- Very compact system. Compressor can be placed up to 15m away from the goniometer

- Crystal efficiency depends on temperature
  - Very good efficiency at cryogenic temperatures (77K) for Ge crystal
- We are exploring a solution with a cold finger (from CryoTiger), connected to the crystal holder. Pdiss max = 3W at 77K
- Very compact system. Compressor can be placed up to 15m away from the goniometer

COMPRESSOR FRONT



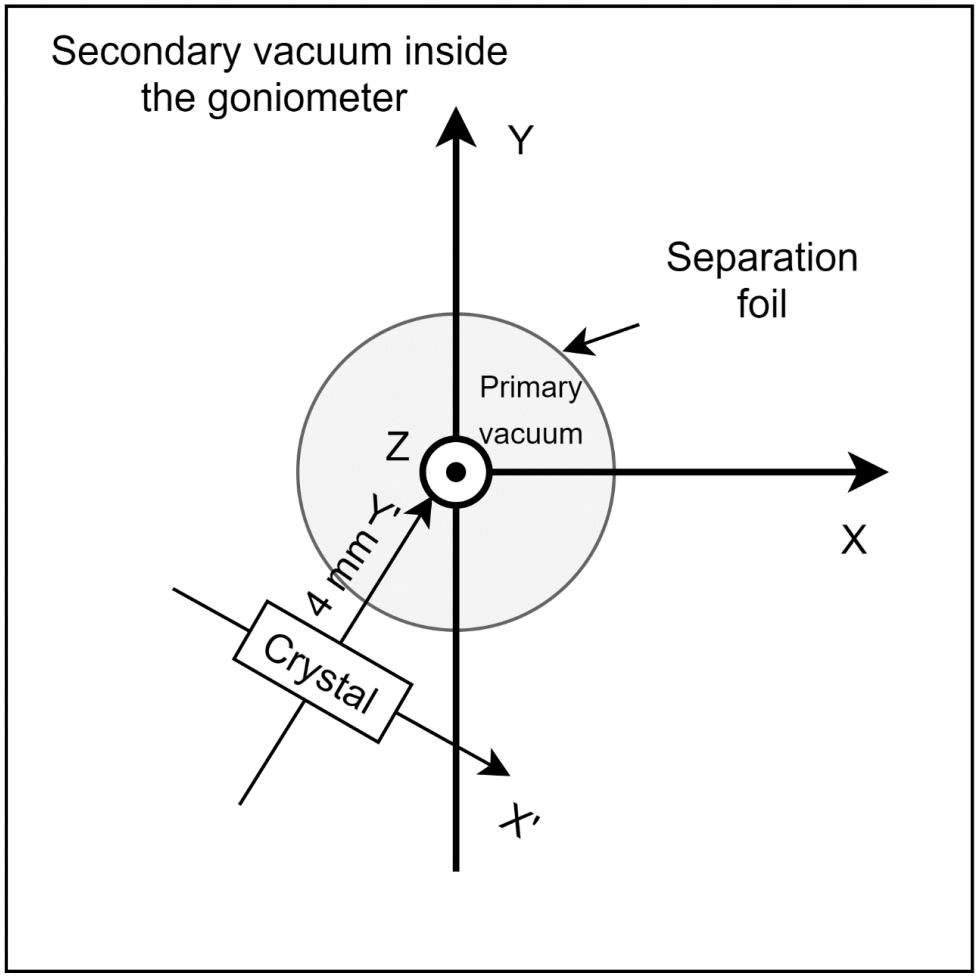
STANDARD COLD END

- **LHC requested bakeout temperature: 250°C (external)**

- CryoTiger max bakeout temperature: 100°C
- Goniometer max temperature: 150-200°C
- Bakeout procedure has to be evaluated to assess if the internal temperature is higher than the above mentioned limits

Possible solutions:

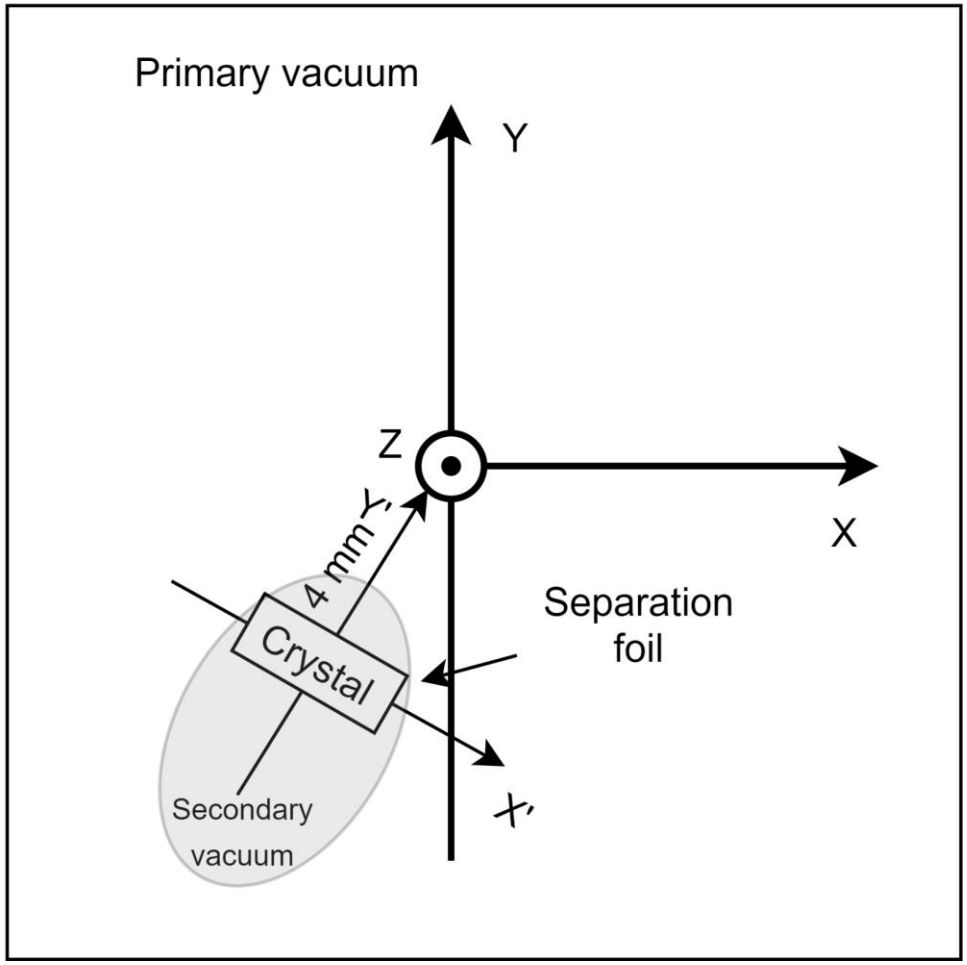
- Bakeout al lower temperature?
  - We will contact CryoTiger to check the alternatives or change the model/company
- Use of secondary vacuum, following the VELO approach?



- Primary and secondary vacuum separated with a foil

PROS:
- No bakeout needed
- Improved impedance

CONS:
- Increased system complexity
- Increased cost



- Primary and secondary vacuum separated with a foil

PROS:
- No bakeout needed
- Improved impedance

CONS:
- Increased system complexity
- Increased cost

Summary

- Goniometer mechanical specifications assessed
- Found a company interested in the goniometer development (Cinel)
- First mechanical draft ready
- Some open questions:
  - Mechanical alignment to the LHC beampipe
  - Floor stability and goniometer holding system

Next Steps

- Clarify the issue with the bakeout and find a working solution
- Design of a dedicated electronic remote control system
- FEM analysis for crystal cooling
- Goniometer and crystal alignment procedures
- Angle scan simulations of the reconstructed tracks in function to the crystal angle
- Design and build a goniometer prototype in collaboration with CERN and Cinel
- Goniometer performance measurements at room and cryogenic temperature in the lab
- Machine test foreseen at IR3 during RUN3