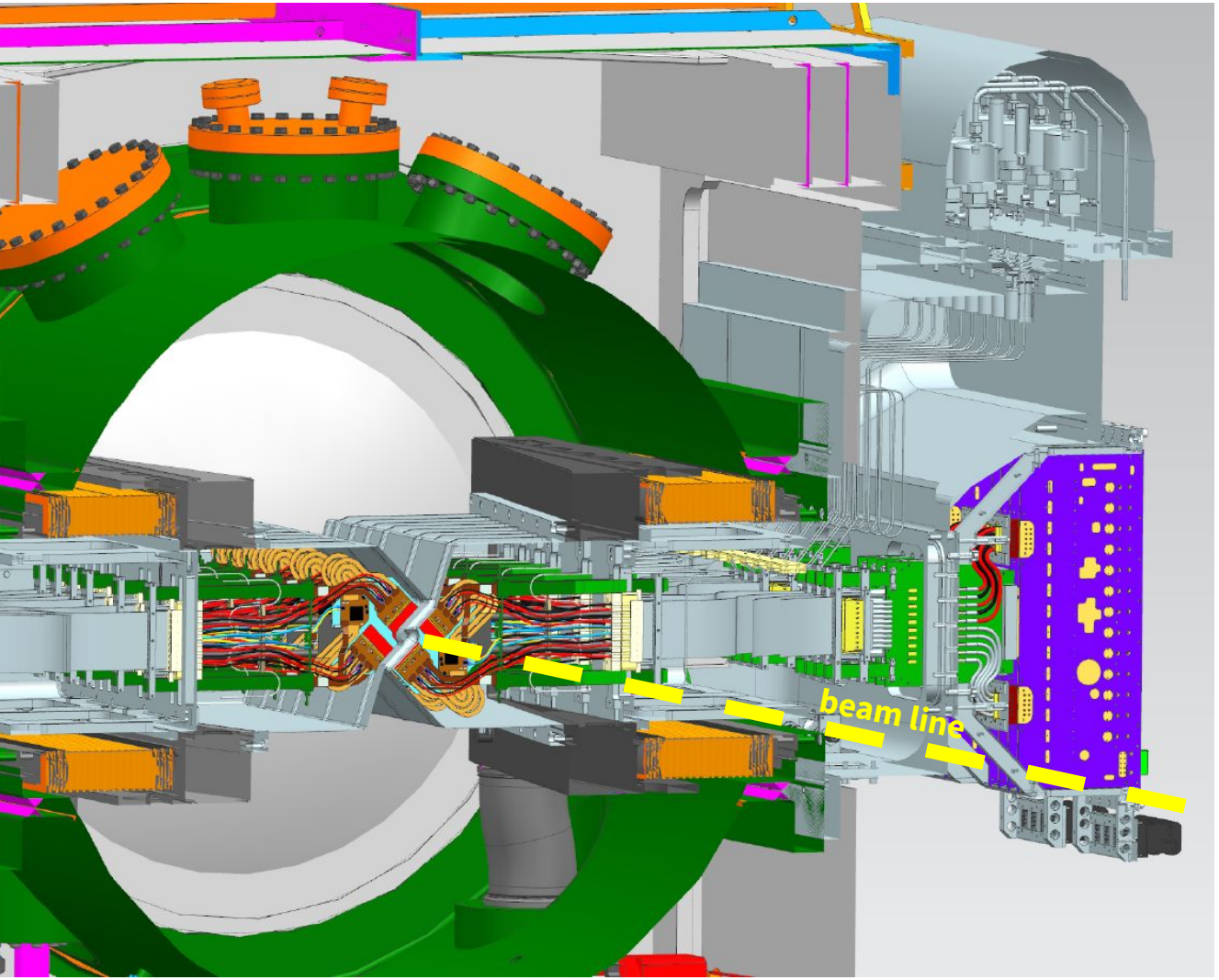
VeLo Tomography and plans for closing

Victor Coco (CERN) for the Velo group

PRELIMINARY, for discussion with MPP & Collimation

The LHCb Vertex Locator (VeLo)



- The VELO allows LHCb to **reconstruct with high precision the trajectory** of charged particles and their **origin vertices**

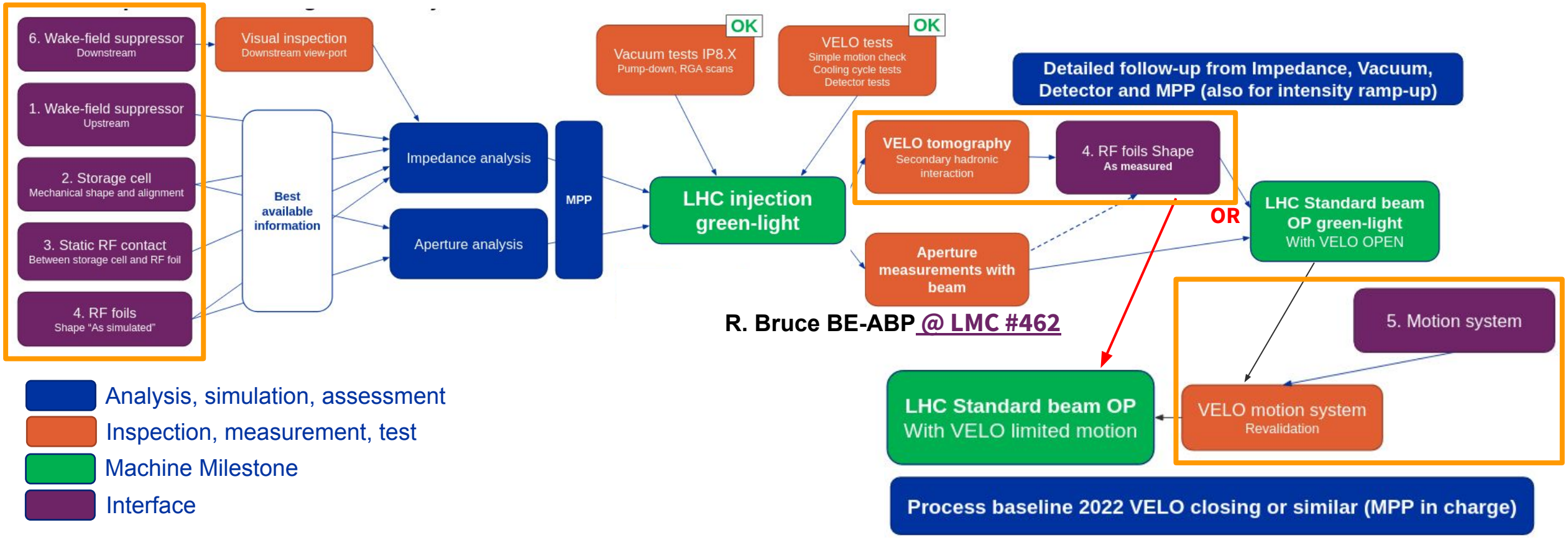
- **Silicon hybrid detector:**
  - Upgraded from strip to pixels (~41M)
  - Requires active cooling (CO_2 in Si-microchannel)
- **Very close to the interaction region:**
  - Closest measurement: 8mm ⇒ 5.1mm
  - RF-foil clearance: 5mm ⇒ 3.5mm
- **In secondary vacuum:**
  - Separated from the primary vacuum by RF-foil
  - Secondary vacuum @ 10^{-6} - 10^{-7} mbar
- **Movable (~30mm in open position)**
  - protect the detector at injection
  - allows larger aperture at injection energy
  - allows the VELO center around beam fill by fill

The LHC-VELO Vacuum incident

Add a slide to explain summarise what happened

Recovery plan

updated information



R. Bruce BE-ABP @ LMC #462

Analysis, simulation, assessment

Inspection, measurement, test

Machine Milestone

Interface

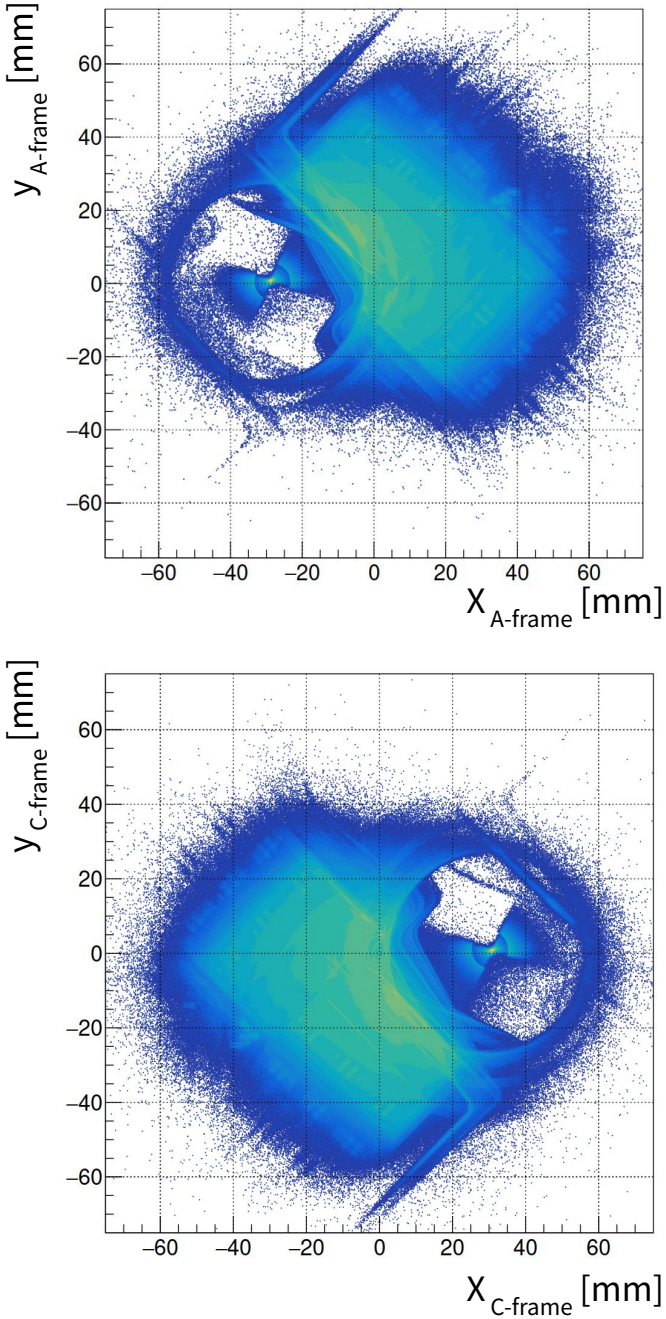
Summary from J.Sestak TE-VSC @ LMC #457

Tomography

- **450GeV data taken over the easter week-end**

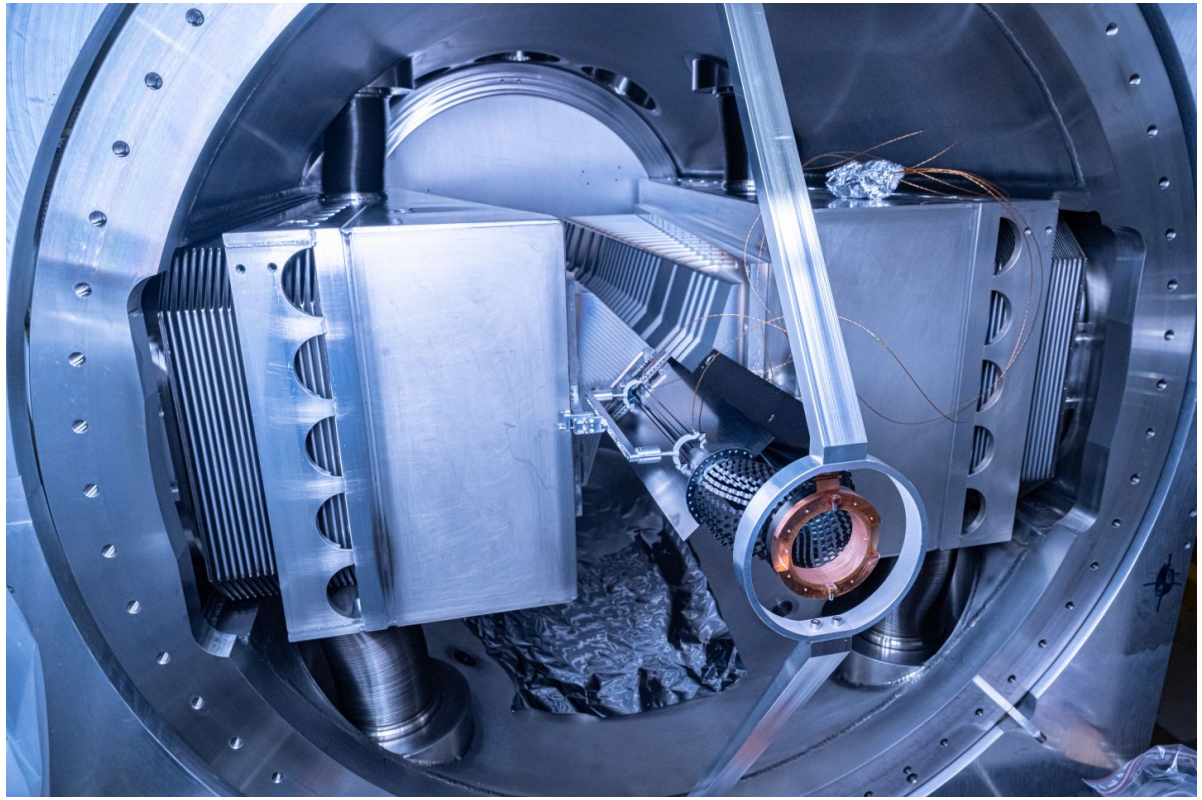
- **6.8TeV data taken during the 400b fills**
  - SMOG injection to enhance the production of particles outside the interaction region
  - Every events with at least 3 tracks very displaced from interaction region are selected (~17kHz)
  - Vertex reconstruction makes “good” vertices with at least 3 tracks (241M A side /312M C side)
    - primary (ie see the beams)
    - interaction with material
    - but also B,D-decay and various reconstruction noises

Output of the tomography reconstruction



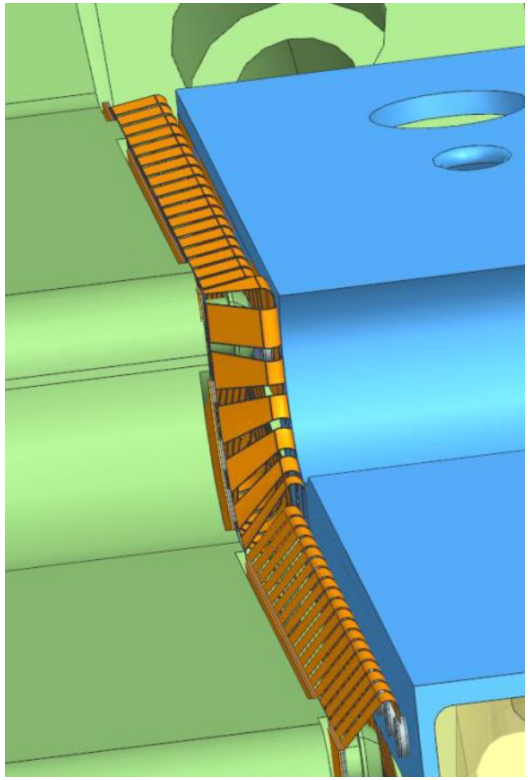
Topological inspection
(1.) and (2.)

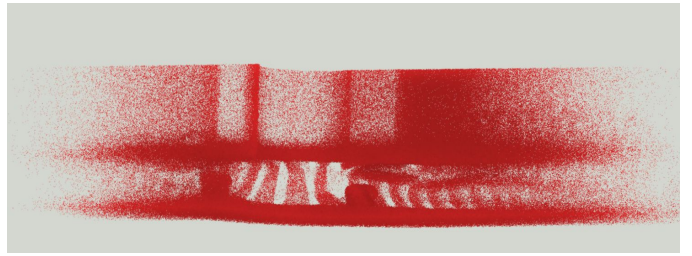
- No visible broken finger on the upstream wakefield suppressor (1.)
- No damage to the SMOG cell (2.)
- Transverse position of the cell wrt. foil identical to last year



Topological inspection
(3.)

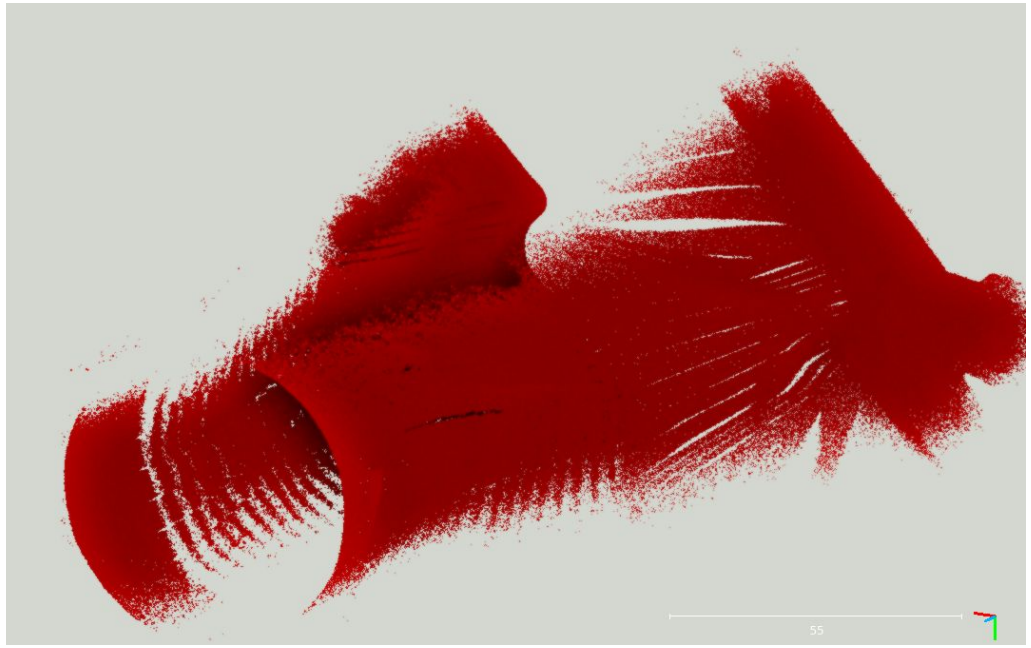
- No visible broken finger at the contact between foil and SMOG cell (3.)
- Shape of the finger as expected
- Mushroom not touching the SMOG cell

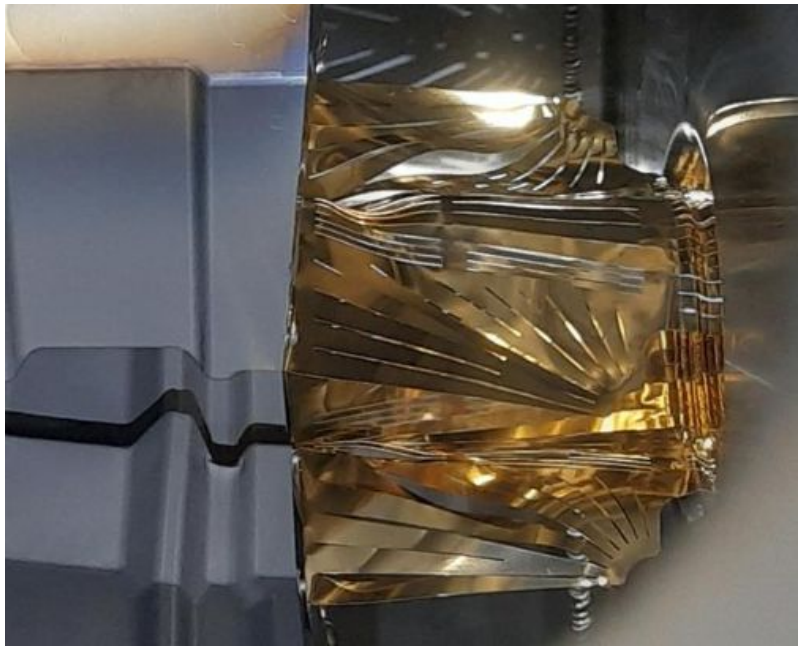


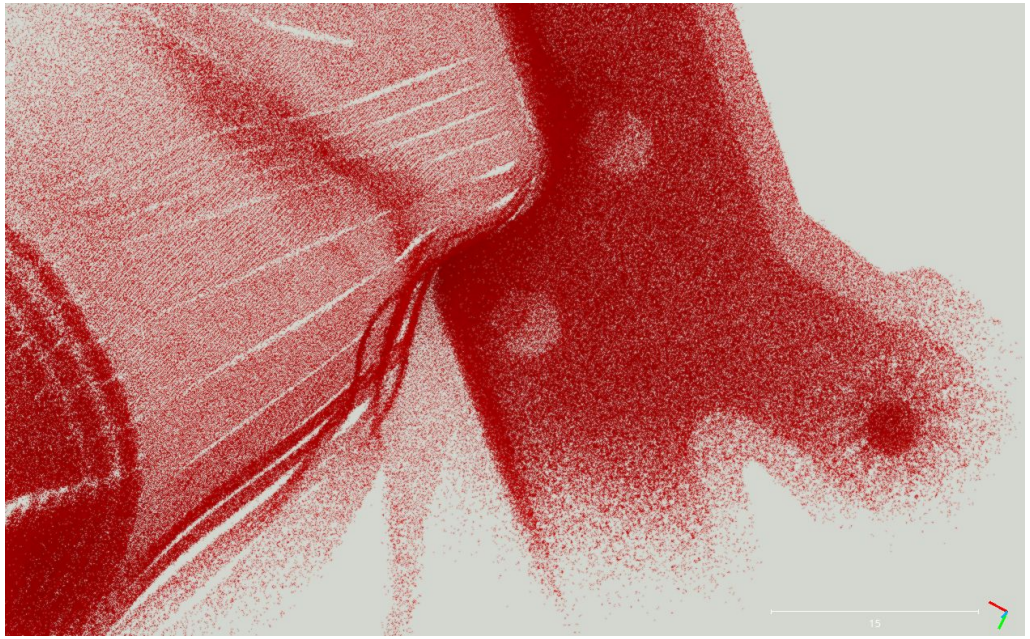


Topological inspection (6.)

- No broken downstream wakefield supressor fingers (6.)
- Detailed view of the exact shape of the fingers (was difficult to get from viewport)
- Can be monitored at different position of the RFBox when there is beam

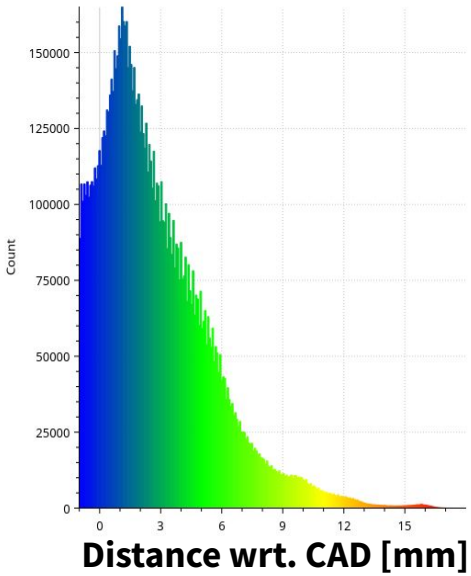


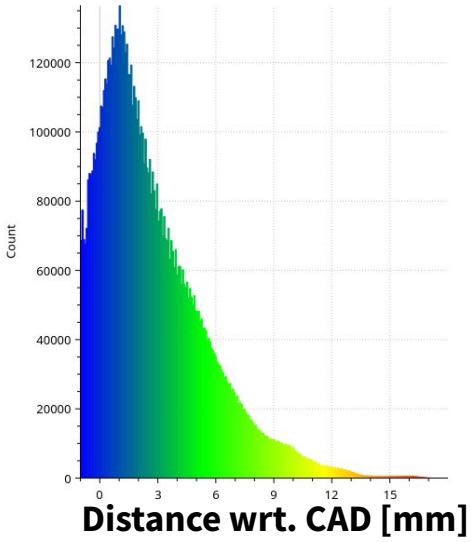


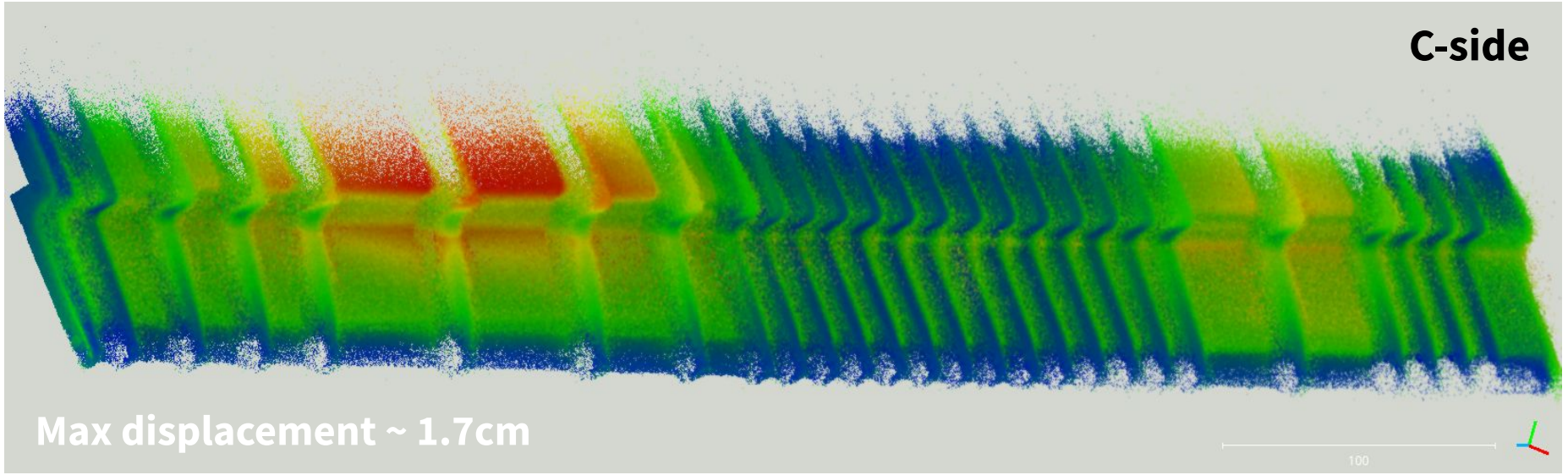


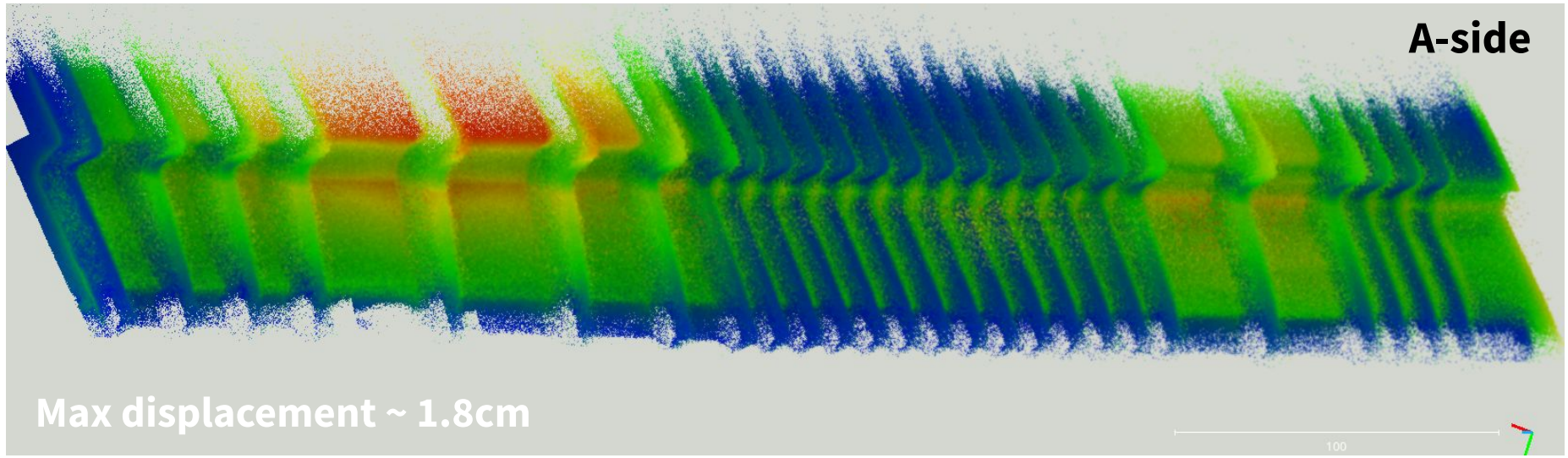
RF-foil deformation

and comparison with nominal foil





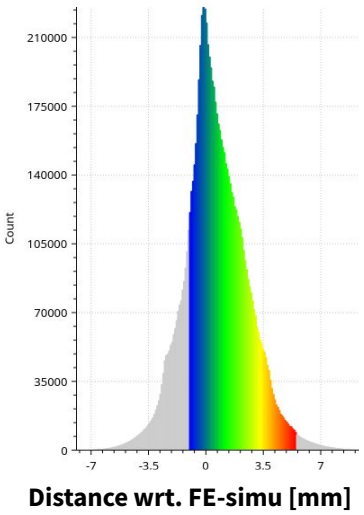




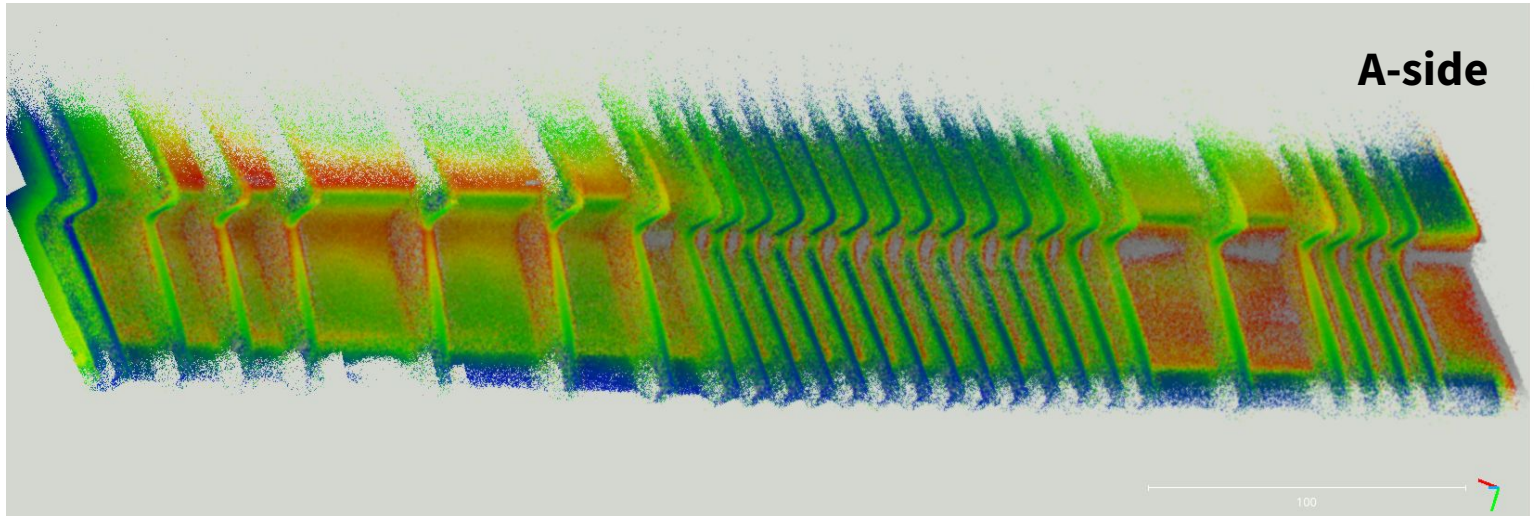
RF-foil deformation

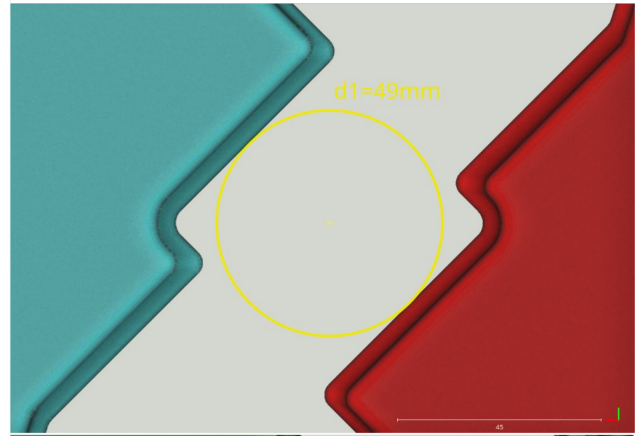
and comparison with finite-element-simulation

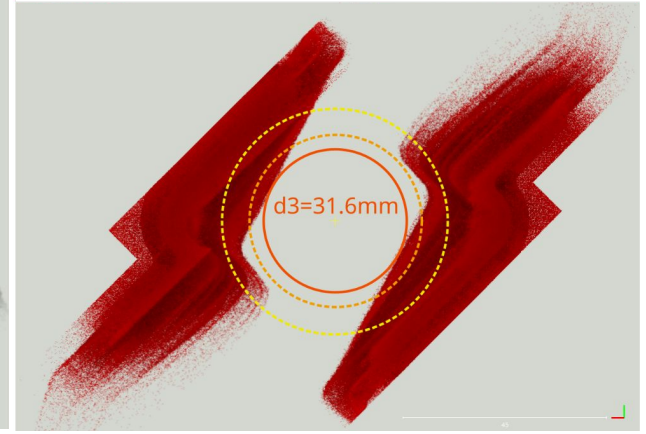
- **Elasto-plastic simulation of A-side foil by M. Morrone and C. Garion (TE-VSC), used to assess the risk damage of the sensor when going back to pressure balance.**
- **Provided estimation of the aperture in open position in absence of direct observation**
- **Tomography data show 18% reduced aperture compared to simulation**
  - slightly different shape
  - in some part up to 30% more displacement



Distance wrt. FE-simu [mm]



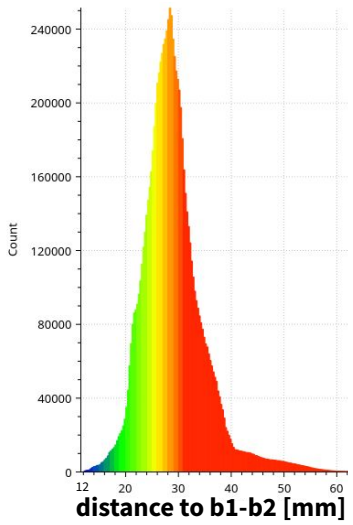


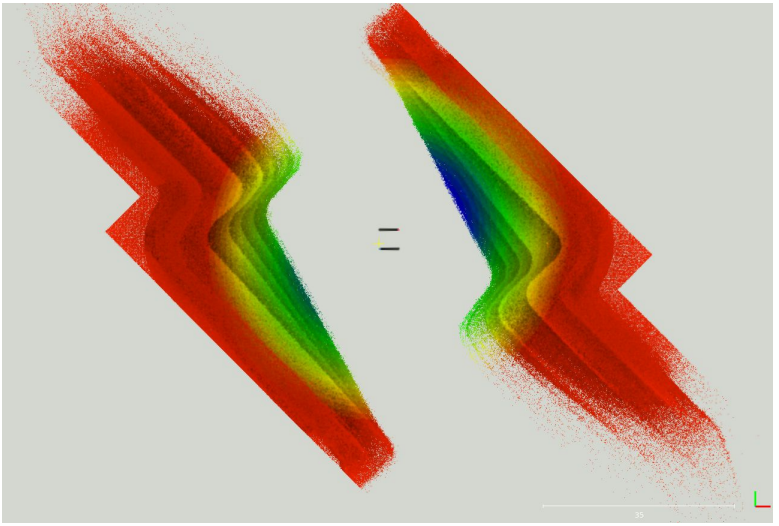


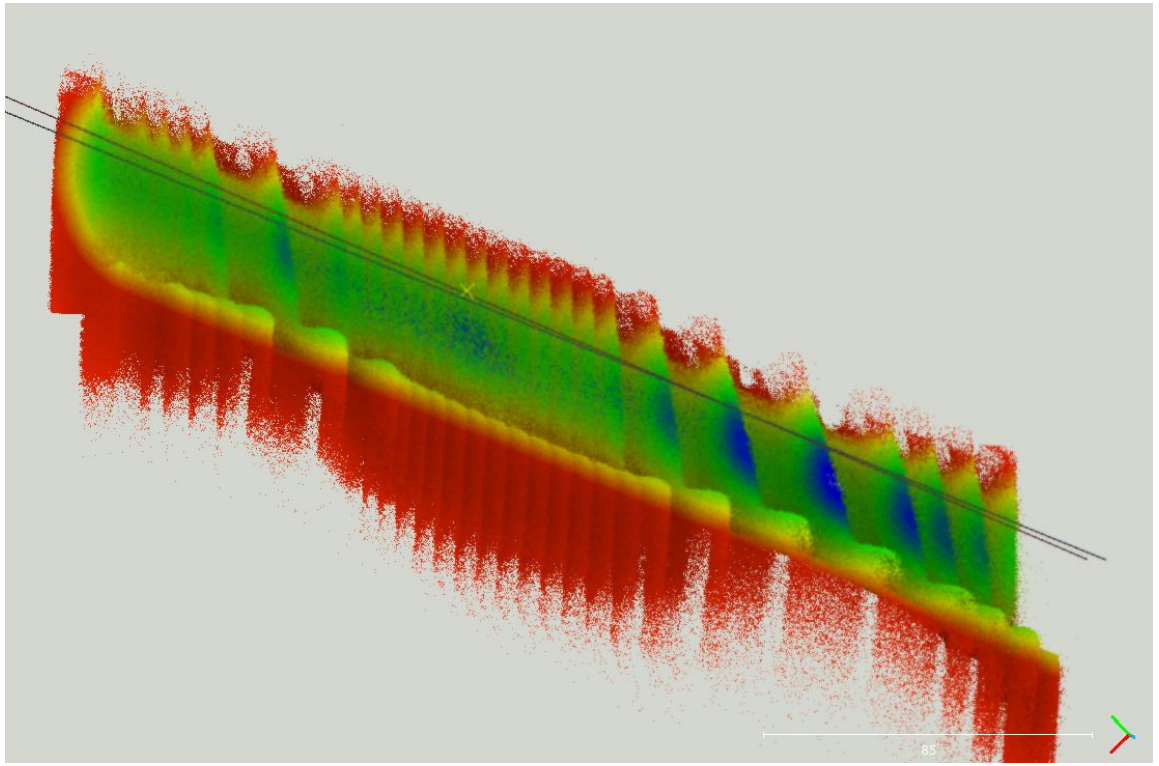
Aperture

- **Report by R. Bruce @ LMC #462**
  - Local aperture measurement performed by collimation group
  - …

Slide to be finalised for LMC



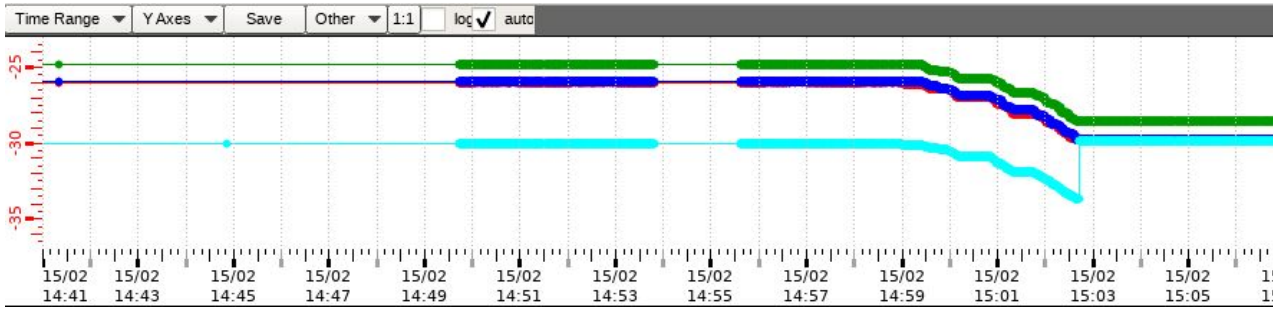


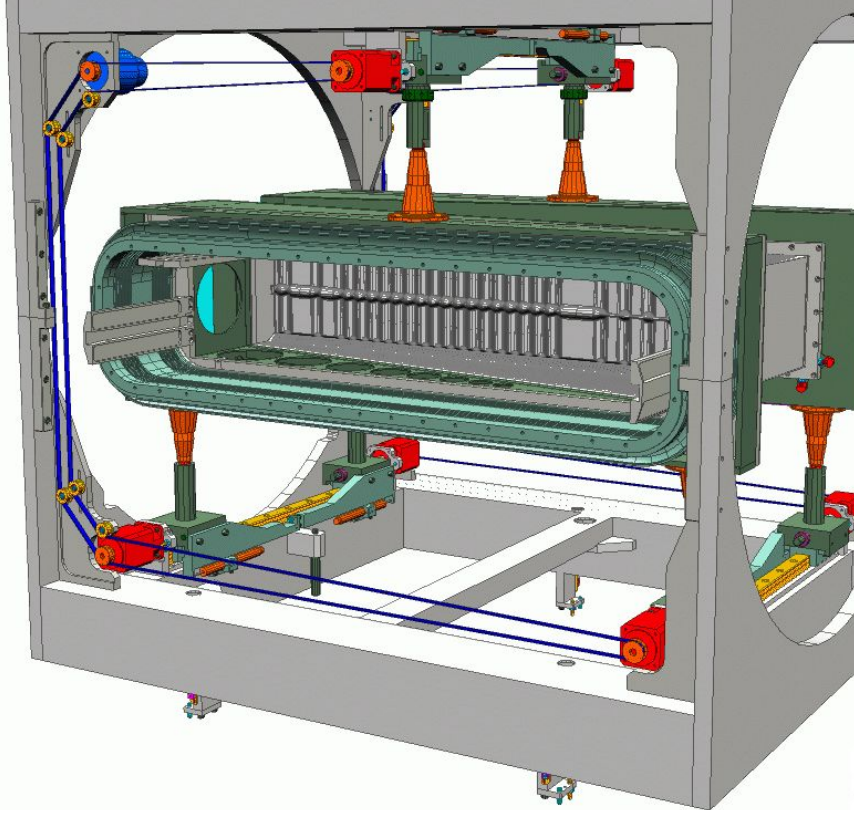


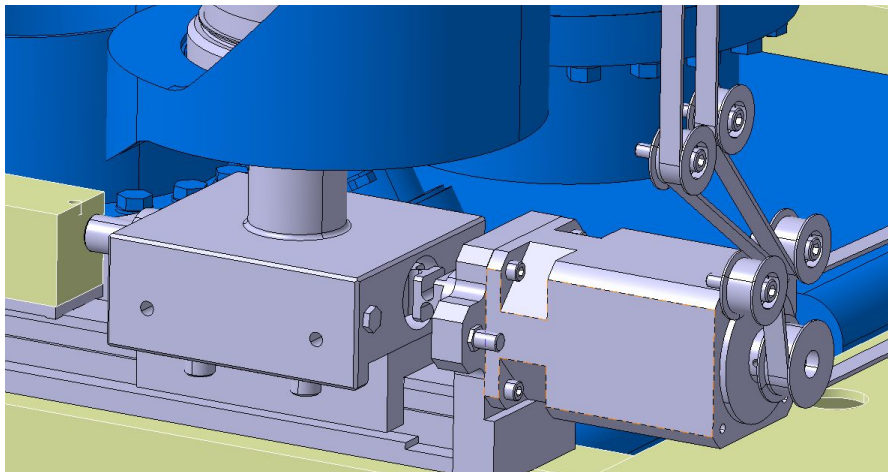
Motion system recovery

- **Movement seen on the motion system during the event.**
  - due to force applied to the RFBox
  - mainly recovered during re-balancing
  - residual displacement of the top support by 1.25(0.9)mm on C(A)-side
  - could indicate elongation/damage to the coupling between the detector support and the gear box.

- **Good response of the system during first tests**
  - small movement between -26/28mm and -29.8/29.8mm



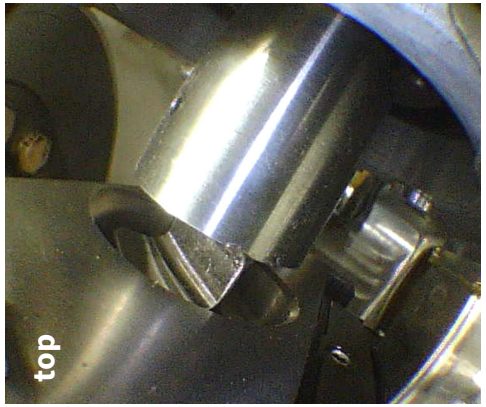




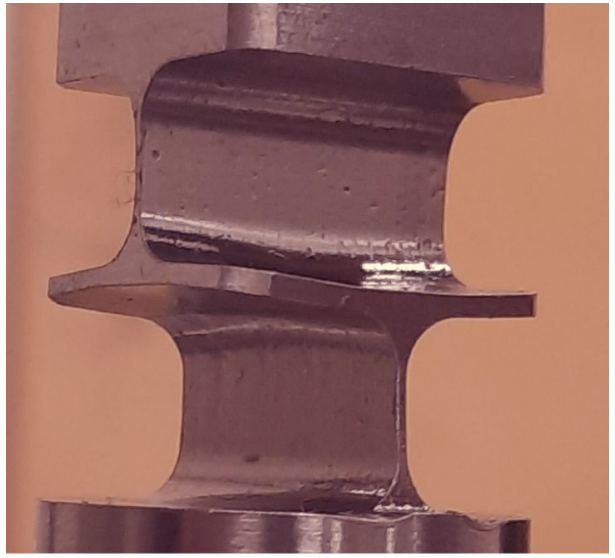
⇒ HW and SW limits on the motion system for now

Motion system recovery

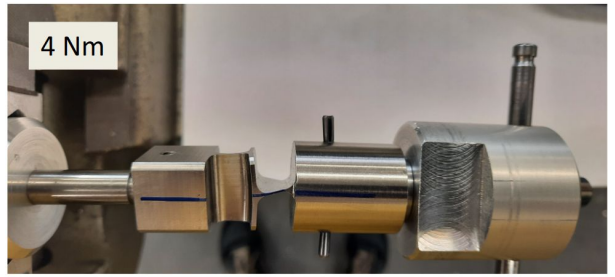
- In the lab we observe deformations compatible with the residual movement of the halves (expected to be between 4 and 5kN)
- May 4th, closed one half at the time to inspect those piece
- Good response of the system, could move with no problem between 30mm and 10mm
- No rotation deformations
- Hard to give a definite answer for traction deformation (full piece not visible), indication of deformations from the light reflexions and looking at the rotating piece in video
- Will reduce the closing speed to be able to more easily spot deviation between resolver and potentiometer position

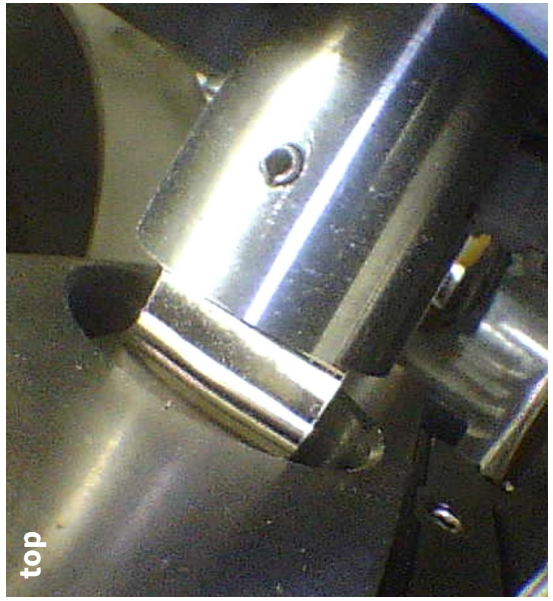


Deformation under 6000N traction
Total 3.1mm (2.1mm plastic)



Deformation when applying torque

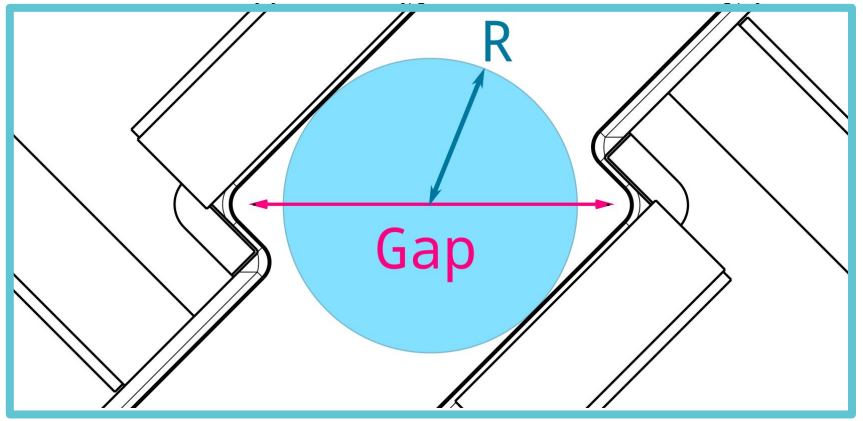


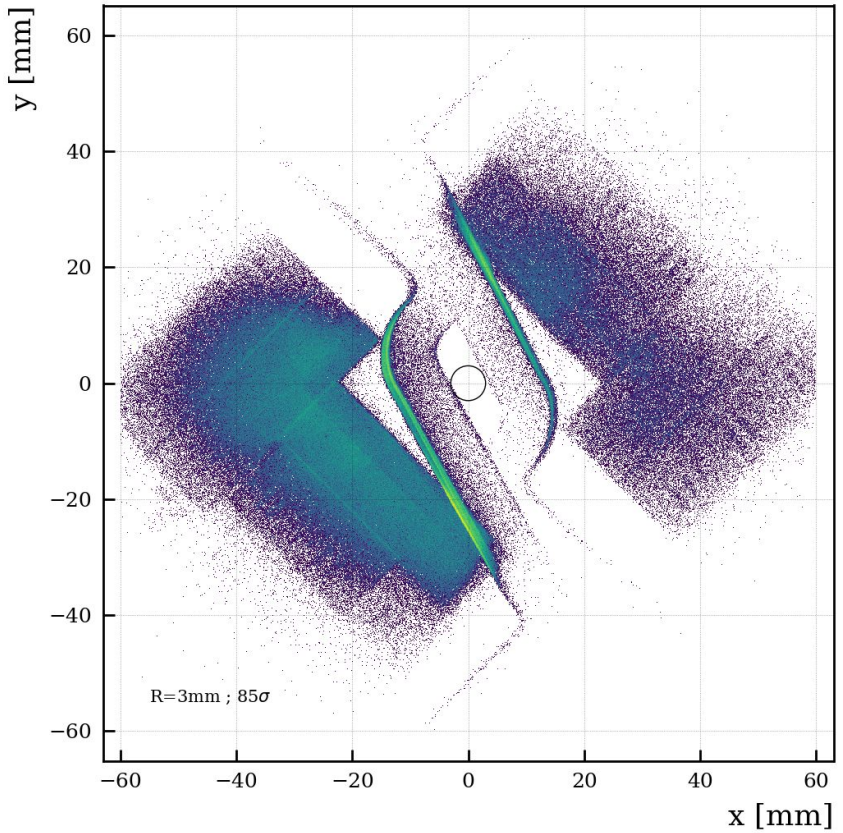


Maximal position for closing

- **Estimate maximal possible closing from the foil perspective**
  - still finalising the estimation, but somewhere between Gap of 34 and 36 mm
- **Estimate aperture at this maximum “mechanical” closing**
- **If Rmech closing < 3mm, increase the gap to reach 3mm**
- **Before reaching the last step will do a quick tomography to confirm the aperture (~30min, did it last year too)**

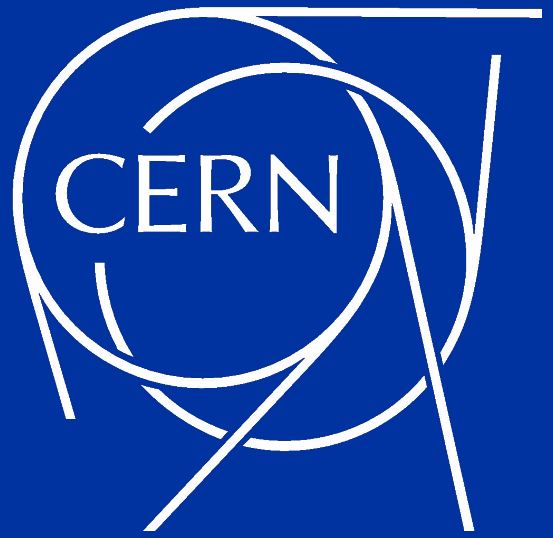
Slide to be finalised for LMC





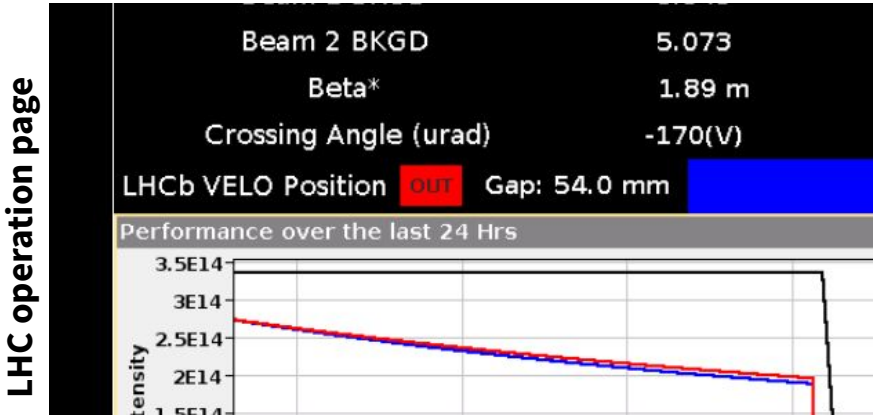
Conclusion

- **In agreement with MPP would like to proceed with the following steps:**
  - 400b / 900b / 1200b / 1800b fills
  - Closed position kept for 1h at each intensity
  - On the 400b will fill stop 2mm before reaching the expected final position to cross check the position with a fast tomography

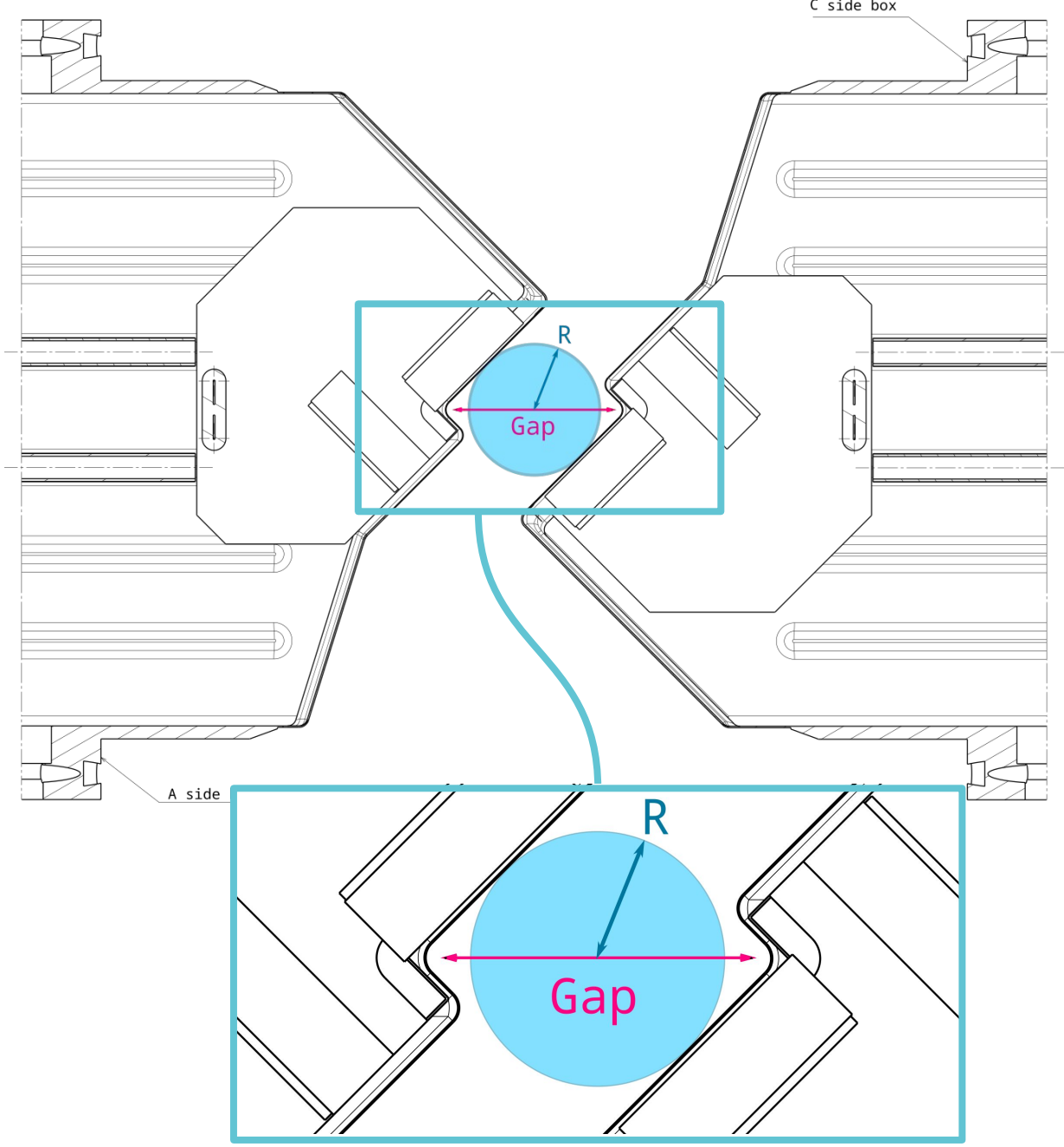

CERN

Closing vocabulary

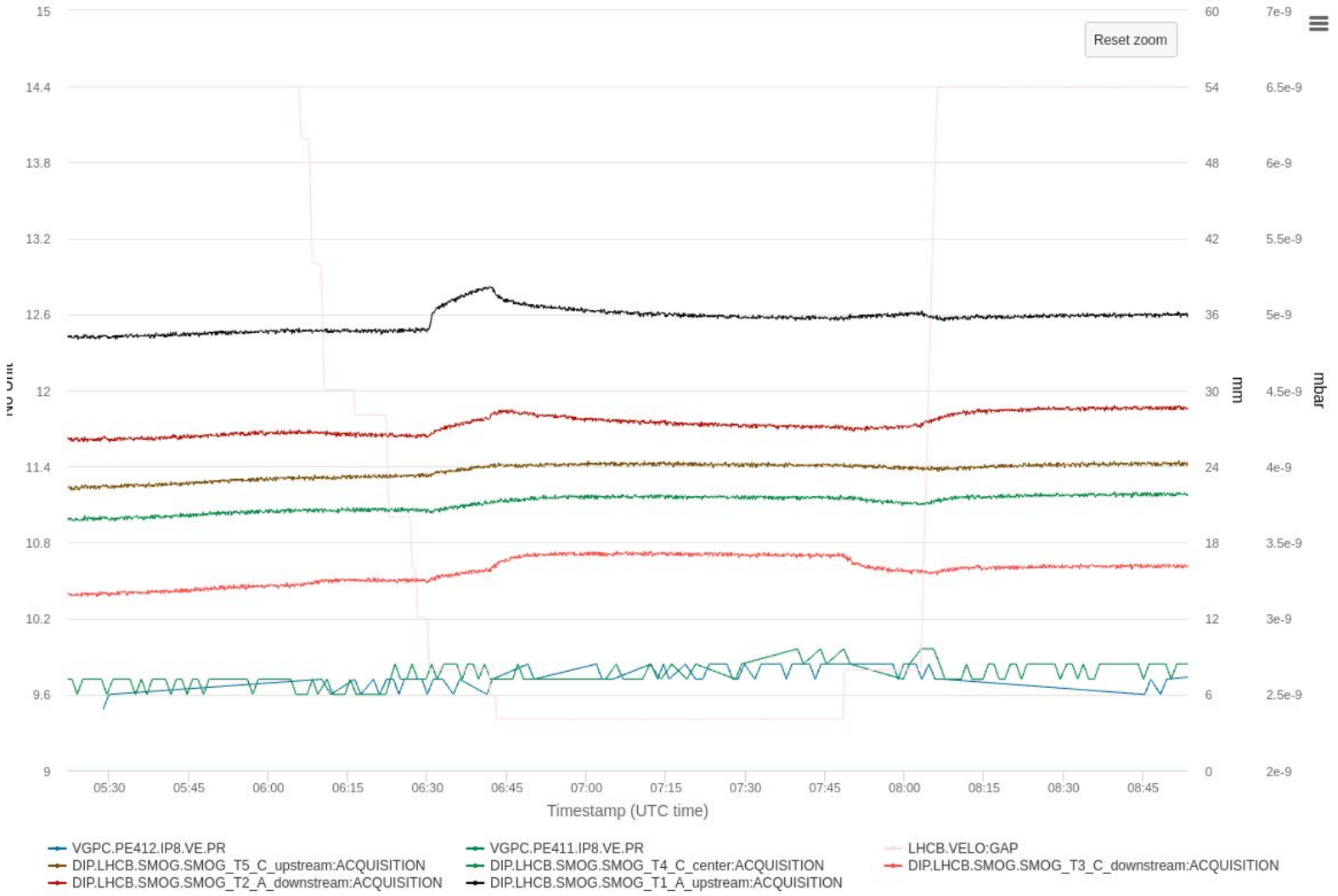
- **Half position is the distance of the half wrt. the beam position**
  - in garage position centered over reference orbit
  - while moving centered on reconstructed beam
- **The Gap is the sum of A and C side positions**



- **The minimal radial aperture R, is the minimal aperture seen by the beam when the VELO is centered on the interaction point**

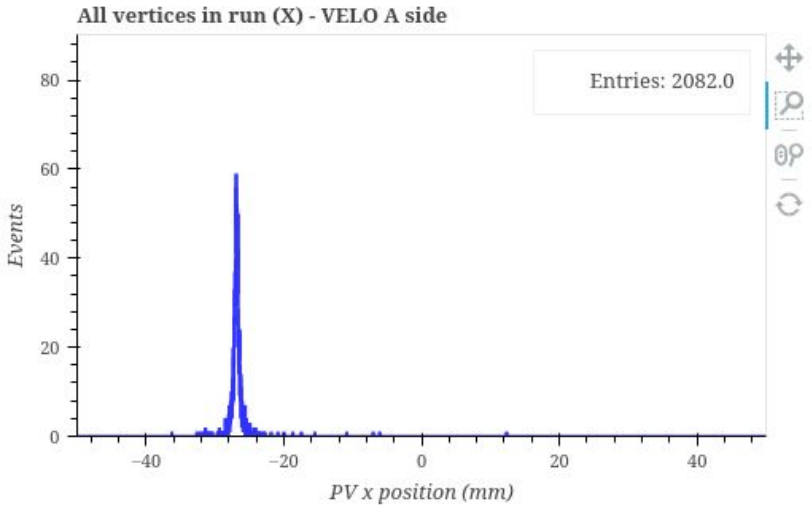


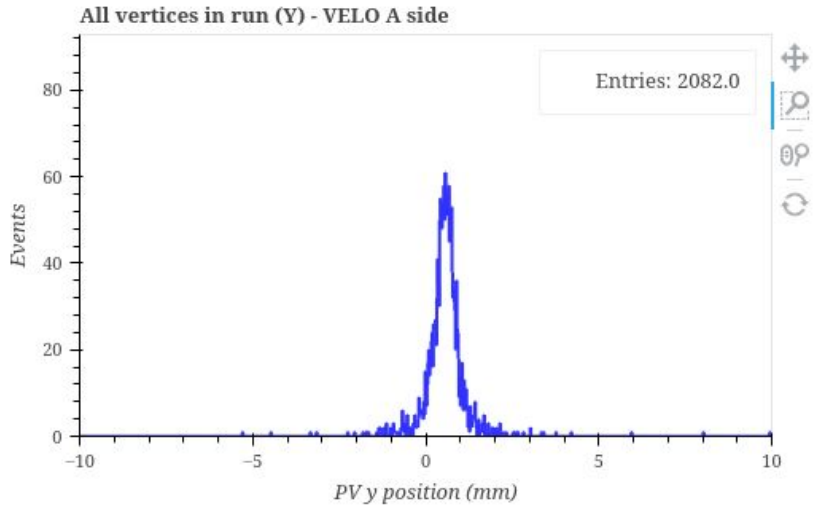
Temperature and vacuum evolution 12b

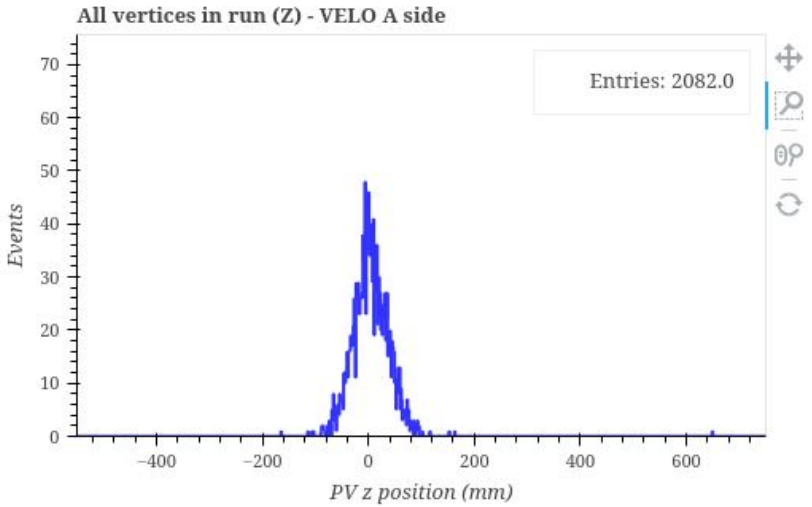


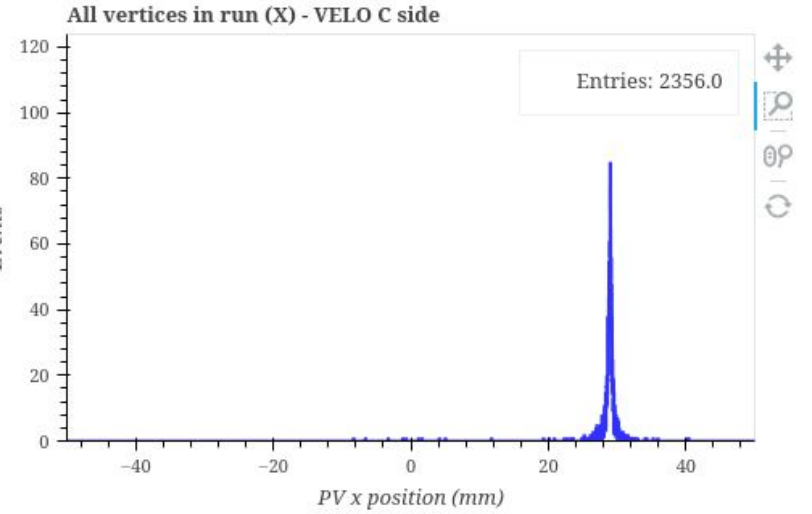
- **Temperature increase @4mm**
  - ~0.3K
  - Fast then slower and quickly less when moving to 3mm
- **Small vacuum increase at some point during closure**
  - ~1e-10 mbar

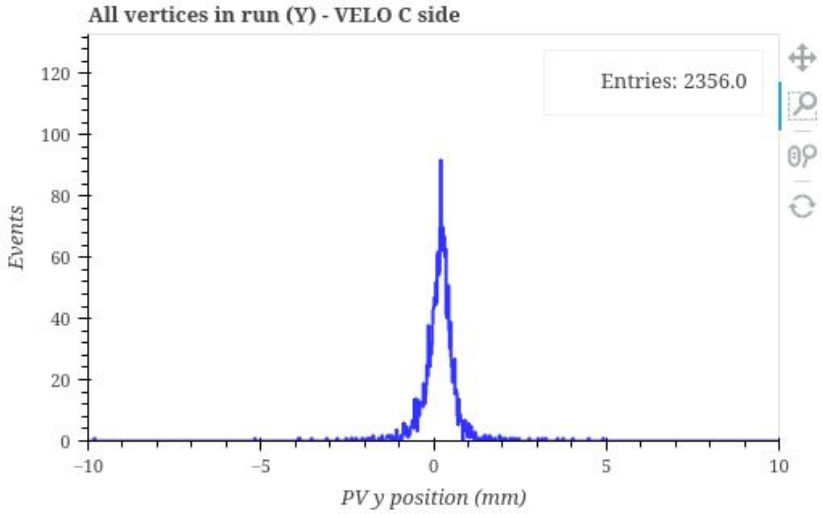
VeLo commissioning
Readout and reconstruction

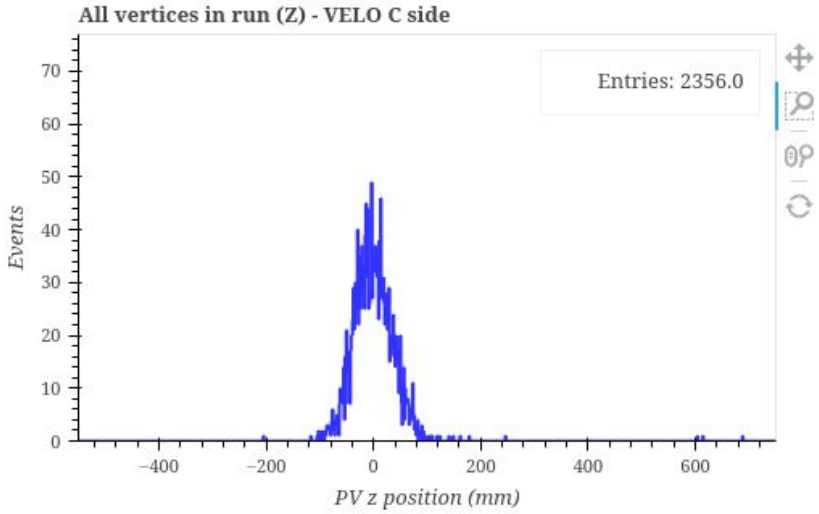




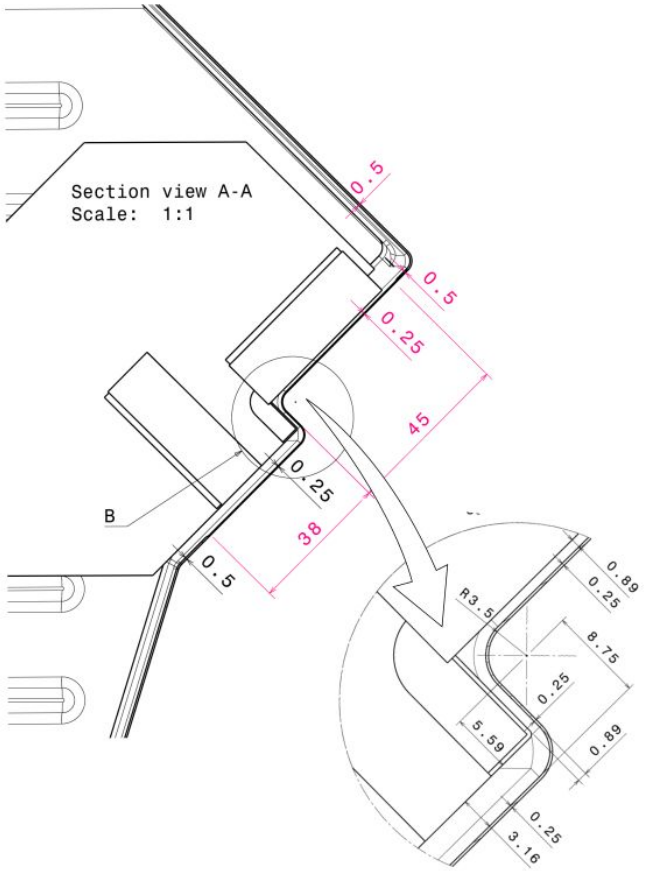






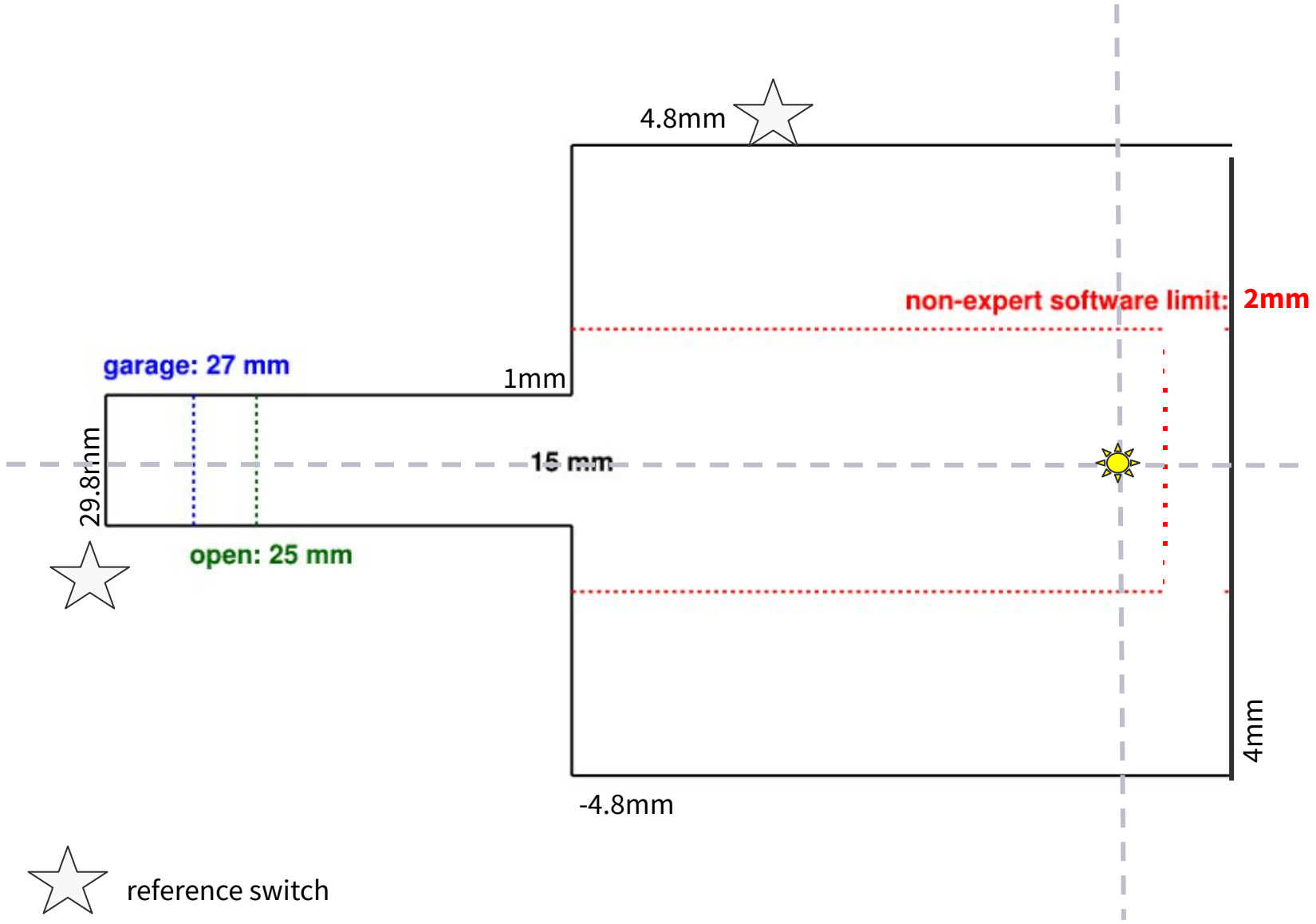


RF-foil



- New foil shape wrt. Run1&2
- Same mechanical system for the motion (motors,position measurement, …)but new control HW

Motion system limits



reference switch

A-side surface test

April 30th to May 9th

- **Mechanical preparation**
  - installation of removable shims
  - base plate removal
  - test of balancing

- **Metrology**
  - 3D laser scan in horizontal position
    ⇒ absolute position at room temperature
  - check for collision with RFFoil 3D laser scan
  - with Liv. metrology data provides reference for alignment