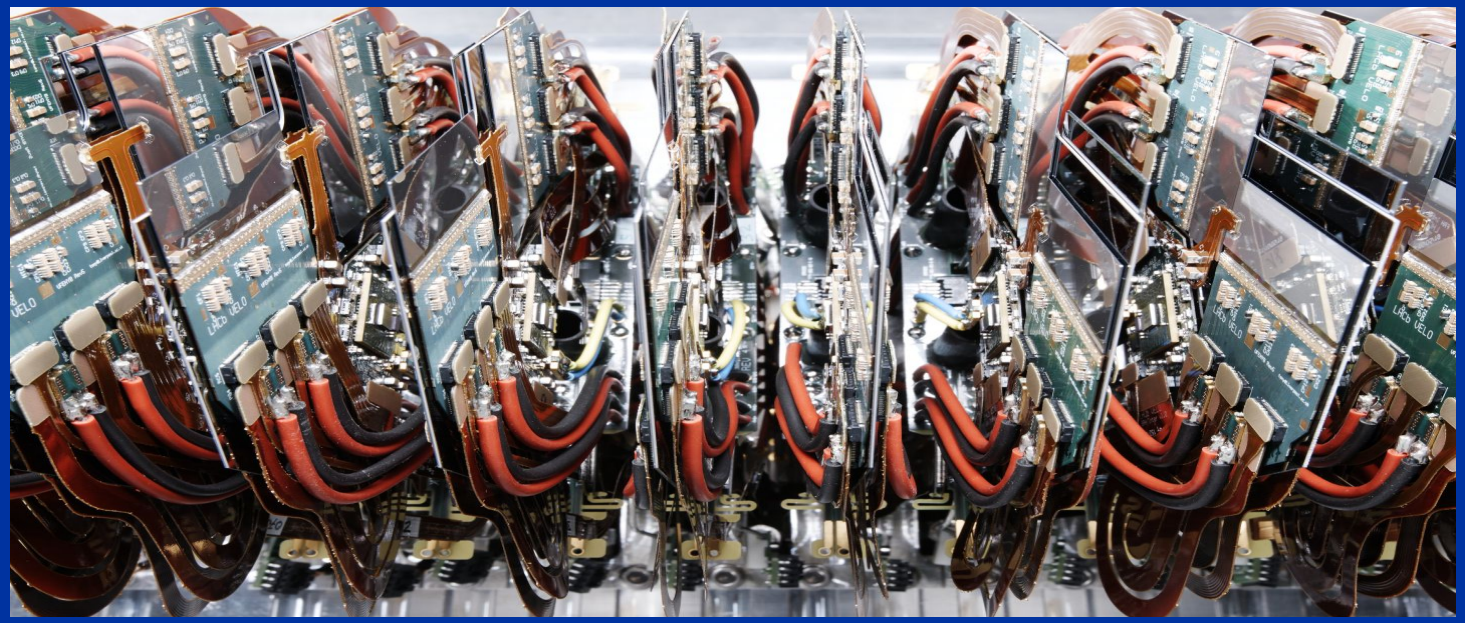
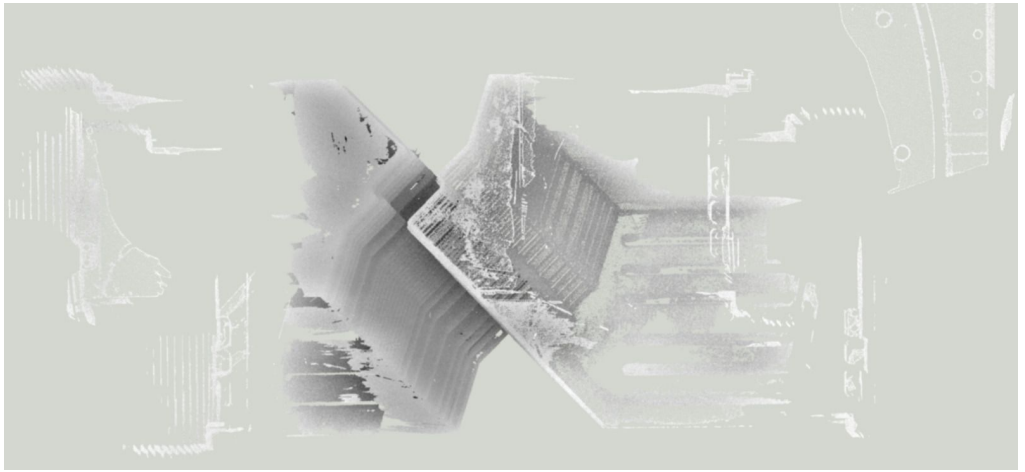


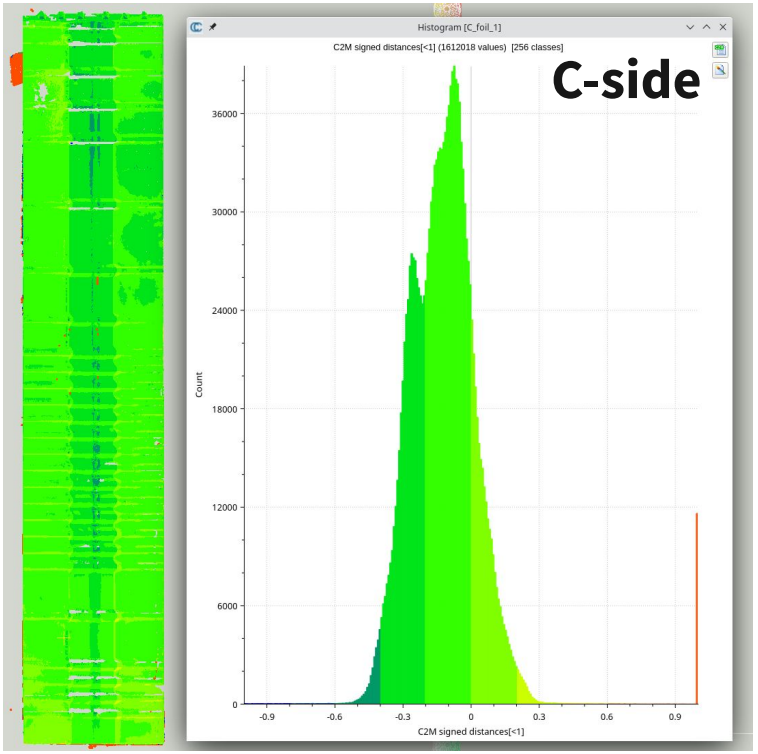
VELO revalidation and intensity ramp-up

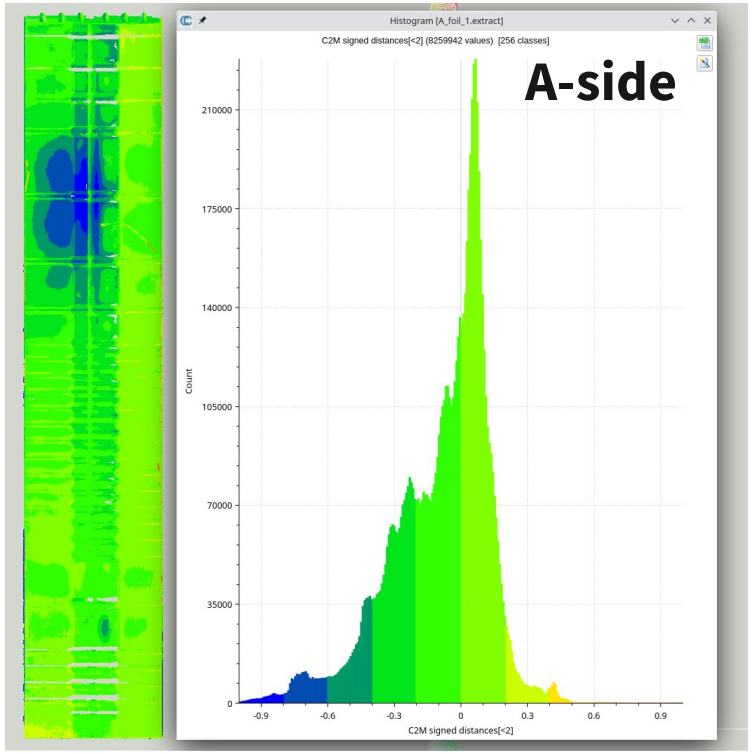
Victor Coco (CERN) for the LHCb Velo group

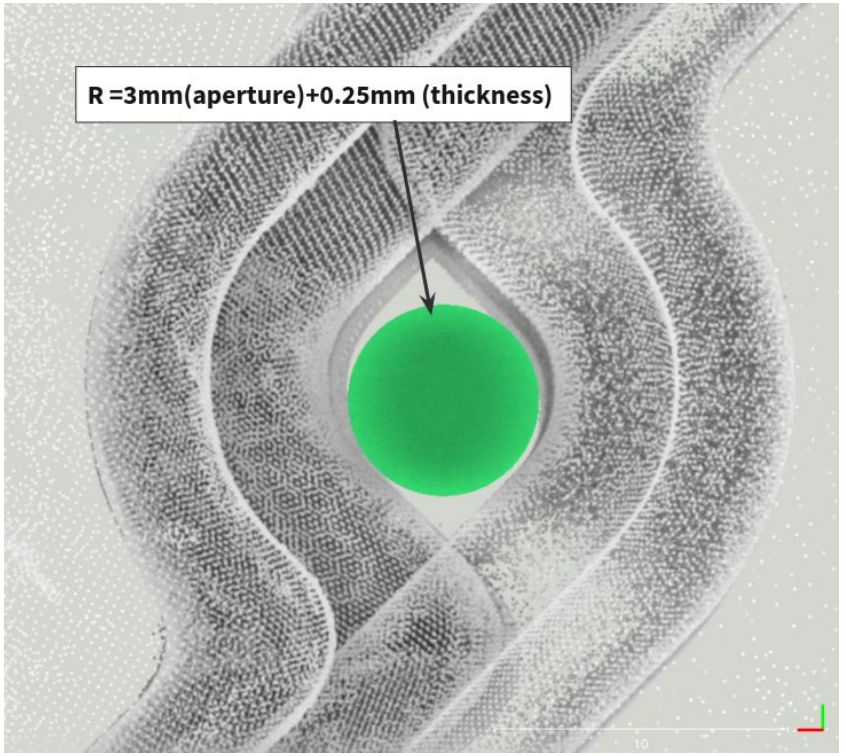
Validation of the aperture

- **Metrology performed in situ**
  - Provide a good expectation for the aperture
  - Same features than in 2022: slight deformation wrt. CAD + rotation along horizontal of one half wrt. The other will likely provide a 3mm aperture in nominal position



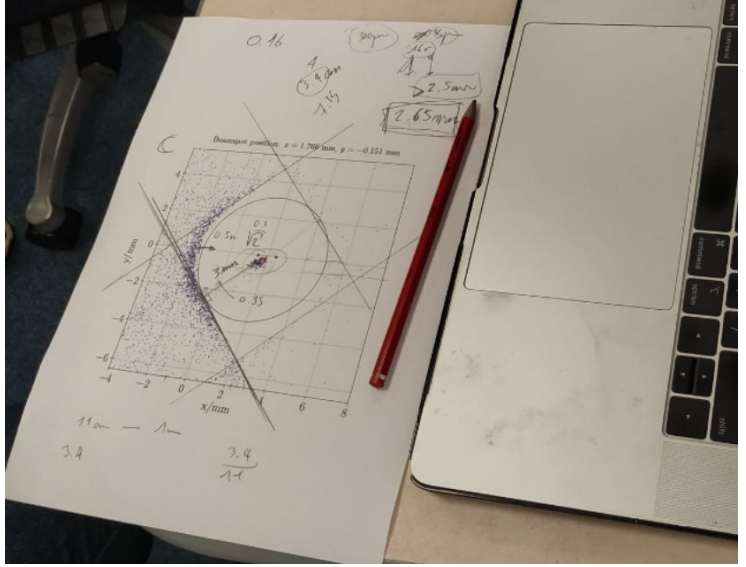


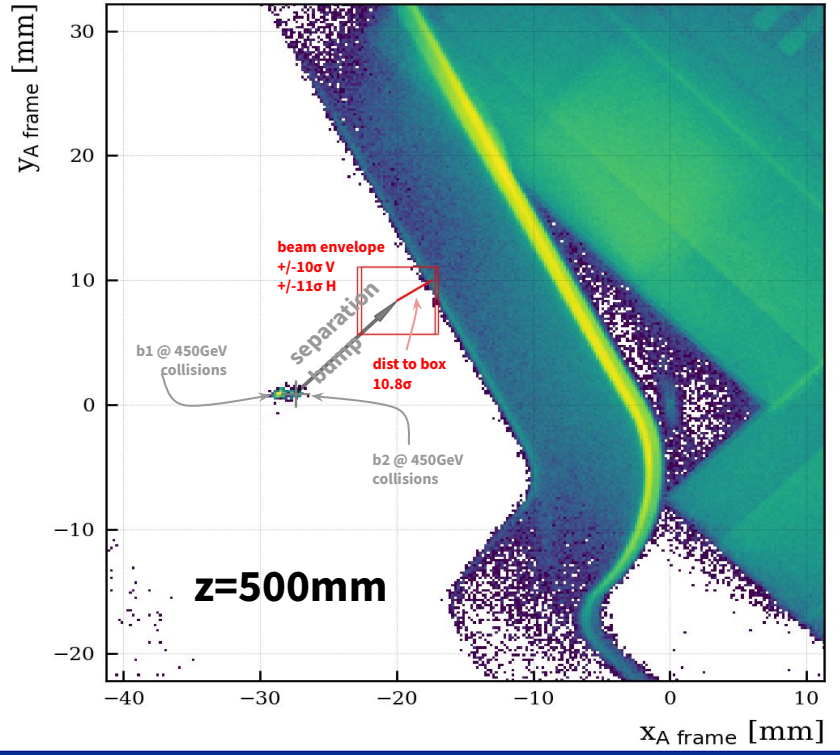




Validation of the aperture

- **Tomography as a proxy for aperture measurement**
  - Used in 2022 for our internal tests
  - Compared in 2023 with aperture measurement from the collimation team wrt. the deformed foil ⇒ good agreement
  - Not really possible to perform aperture measurement with the beam when VELO is closed.
  - Will do a “quick” tomography at 2mm gap during the first closure as in 2022:
    - About 30min datataking + about 30min data analysis
    - Obtain the relative distance between the two halves + value for the final aperture
  - Quick check at fully closed position
- **Full tomography around 400b**





Intensity ramp-up checks

- **Vacuum**
  - Expected to behave linearly with beam intensity
  - Will compare with reference runs
  - All datapoint on TIMBER
- **Motion system**
  - Check for movement on the potentiometer when the beam is present (none expected)
- **VELO temperatures**
  - RF foil, SMOG and tank, sensitive to the beam instensity, all datapoint on TIMBER

    ⇒ check for stabilisation of the temperatures after 1h being closed
  - In 2023 introduced modules temperatures, propose to drop them (More than 400 sensors completly dominated by the temperature of the cooling system, even at maximum intensity the presence of the beam is not visible)
- **Can check “online” tomography:**
  - No detailed analysis possible per fill but can check that the distribution of interaction with material are similar between intensity ramp-up fills (to be checked w or w/o SMOG)

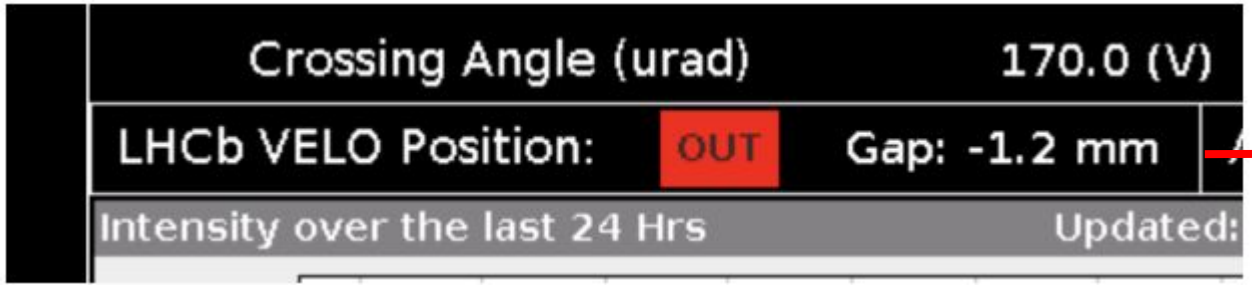
LHCb Vacuum
LSS8L
VGISC.73.1L8.X.PR
VGPB.33.1L8.X.PR
VELO
VGPC.PE411.IP8.VE.PR
VGPC.PE412.IP8.VE.PR
LSS8R
VGI.193.1R8.X.PR

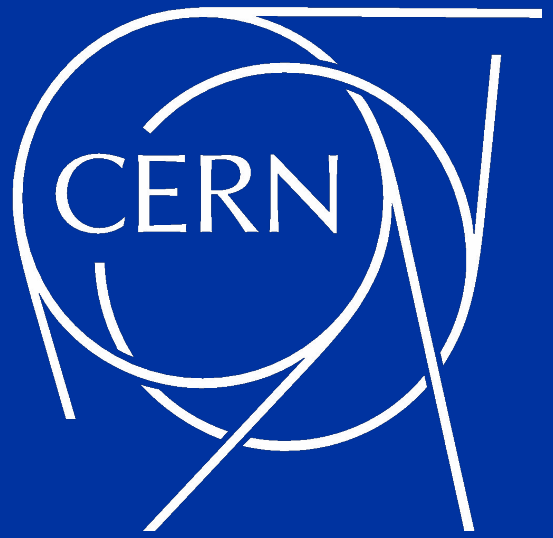
LHCb motion system
XA, XC and Y potientiometers

SMOG & RFBox temperatures
DIP.LHCB.SMOG.SMOG_T1_A_upstream:ACQUISITION
DIP.LHCB.SMOG.SMOG_T2_A_upstream:ACQUISITION
DIP.LHCB.SMOG.SMOG_T3_A_upstream:ACQUISITION
DIP.LHCB.SMOG.SMOG_T4_A_upstream:ACQUISITION
DIP.LHCB.SMOG.SMOG_T5_A_upstream:ACQUISITION
DIP.LHCB.SMOG.VELO_BottomVessel_1:ACQUISITION
DIP.LHCB.SMOG.VELO_BottomVessel_2:ACQUISITION
DIP.LHCB.SMOG.VELO_Sphere_1:ACQUISITION
DIP.LHCB.SMOG.VELO_Sphere_2:ACQUISITION
DIP.LHCB.SMOG.VELO_TopVessel_1:ACQUISITION
DIP.LHCB.SMOG.VELO_TopVessel_2:ACQUISITION
DIP.LHCB.COOLING.VELO.VELOA_VSS_TEMP_HALF_P11M07:Acquisition
DIP.LHCB.COOLING.VELO.VELOA_VSS_TEMP_HALF_P11M23:Acquisition
DIP.LHCB.COOLING.VELO.VELOA_VSS_TEMP_HALF_P11M41:Acquisition
DIP.LHCB.COOLING.VELO.VELOA_VSS_TEMP_HALF_P11M43:Acquisition
DIP.LHCB.COOLING.VELO.VELOC_VSS_TEMP_HALF_P11M06:Acquisition
DIP.LHCB.COOLING.VELO.VELOC_VSS_TEMP_HALF_P11M40:Acquisition
DIP.LHCB.COOLING.VELO.VELOC_VSS_TEMP_HALF_P11M42:Acquisition

Flickering BEAM_PERMIT episode

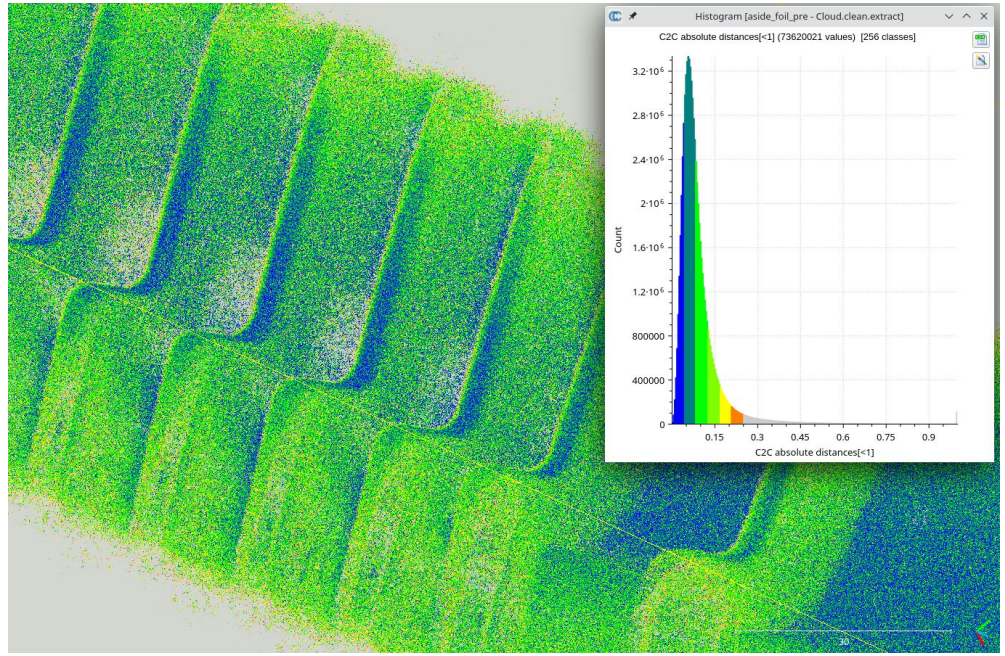
- **Wed morning during access uploaded new motion firmware**
  - New calib for resolver (40000 step/mm → 40170 step/mm measured during metrology campain)
  - New calib for potentiometer (scan taken wrt. Resolver position to produce calibration curves)
- **Potentiometer ADC fluctuation shortly brought it out of range producing the flickering**
  - Was not seen during the test on the morning because the events were too short to display. Could be traced back from the VELO safety system input.
- **Took ~30min to trace it and fix temporarily**
  - Could not fix the calibration curve on the spot so had to revert to previous firmware.
  - Once new calibration Will need to use next access to upload and retest (access >= 2h)
  - **No VELO movement before this is done**
- **Bad published gap value for about 24h**
  - While reverting to previous firmware, we introduced a sign error in the resolver calibration constant, leading the C side to appear at a positive position instead of a negative one ⇒ gap computed from the resolver was close to 0 instead of 58mm.
  - Took the occasion yesterday to (re-)publish the potentiometer estimated gap which is what is relevant to LHC



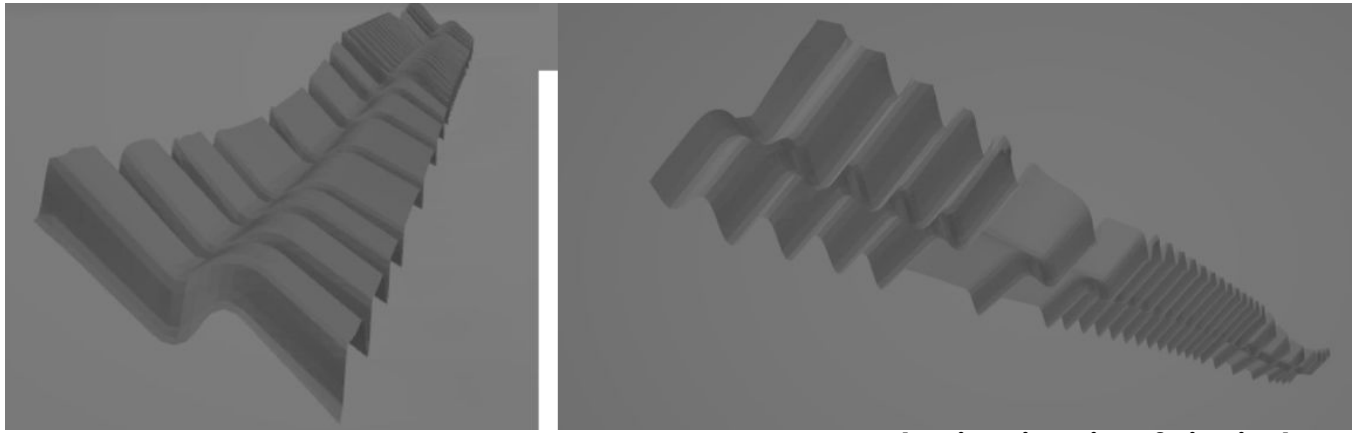

CERN

More detailed studies

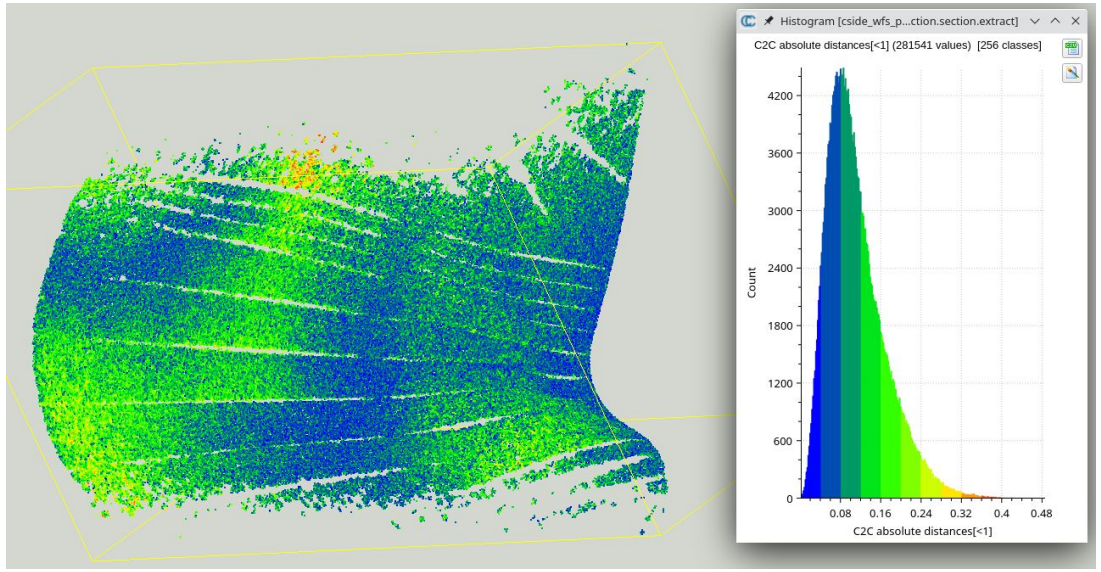
- **After 2021 LS1 took tomography data during intensity ramp-up**
- **Studied difference between 400b and 2400b**
- **Temperature increase with intensity seen on SMOG cell and RFFoil**
- **SMOG2 and Foil position wrt. VELO not affected**
- **Variation of the shape of the downstream WFS observed**
  - <100um for most of the surface (~resolution)
  - 200-350um in some region
- **No significant difference in RFBox shape**
  - difference well within the resolution
  - can refine by using the surface fit tool developed to feedback shape in simulation studies



⇒ Precise monitoring tool available



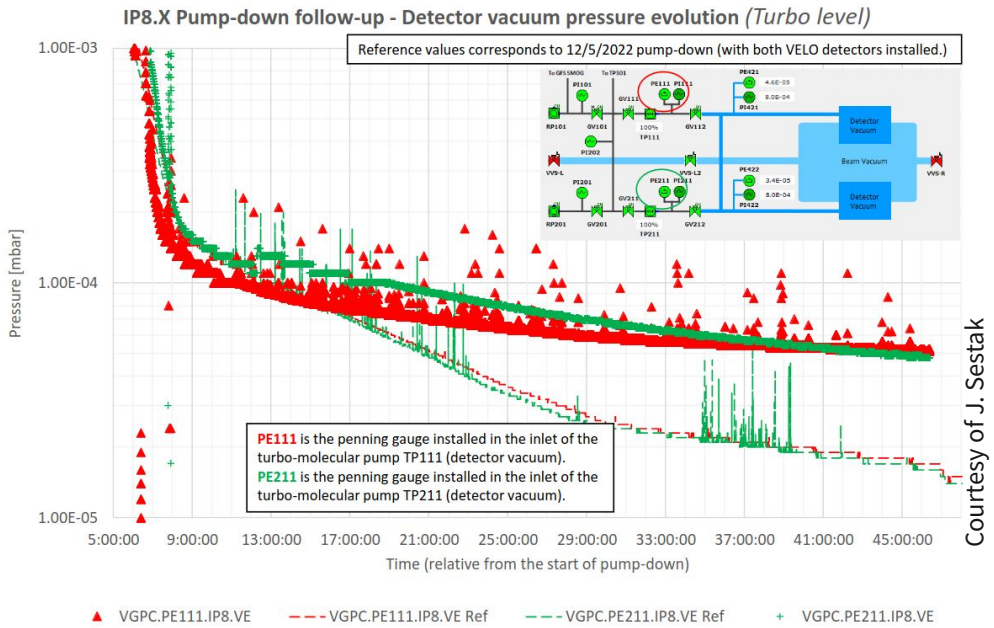
M. Madurai, University of Birmingham

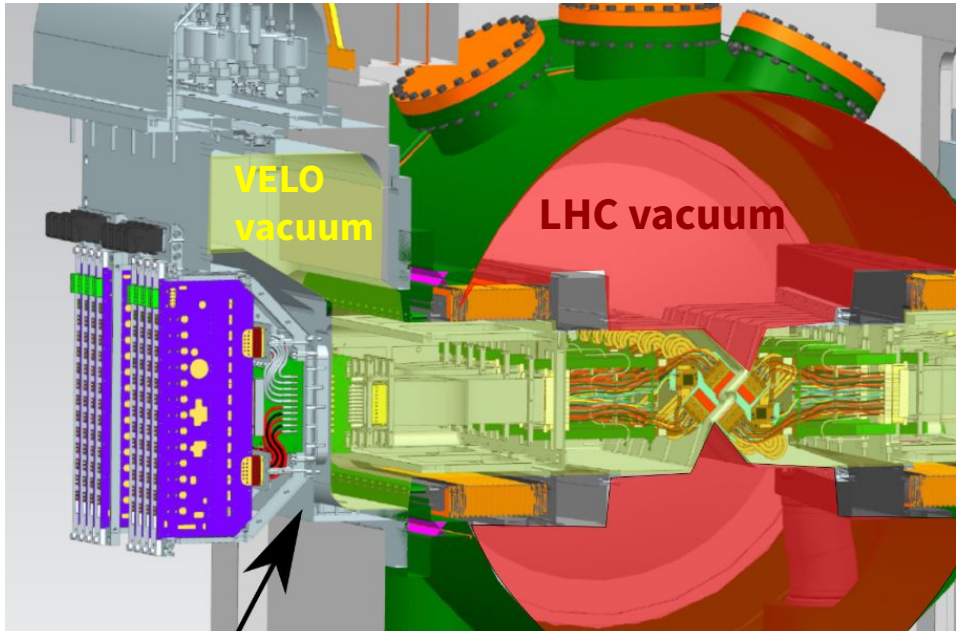


VELO detector vacuum leak finding

- **Pump down on Feb 14th**
  - pushed after recabling work to have time to perform other YETS works that were delayed because of VELO activities
- **Pressure evolution within the detector vacuum volume was different from the 2022:**
  - DSO test on 15th, retightenned flange on 16th, checked impact of tertiary vacuum on 19th followed by He-leak test.
  - Stabilised around 3-4.10^{-5}mbar
- **He leak check by TE-VSC**
  - Identified the possible region at the top corner of A-side detector flange.
  - Measurement at 10^{-5} mbar.l/s but likely an underestimation because of the complex mechanical interface.
  - Max leak rate from pressure readout and pump speed is **10^{-2}mbar.l/s**
- **Intervention to fix requires O(10 days)**
  - Discussion with TE-VSC, LHCb TC and VELO groups to evaluate the options on Feb. 23th , could have started on 26th Feb.
  - No time left to recommission the detector (access and time without beam needed to test cabling, cooling, communication, optical fibers, detector calibration)

    ⇒ would have required either delay of machine check-out or recommissioning during accesses (ie high likelihood VELO would not be ready for closing during intensity ramp-up)





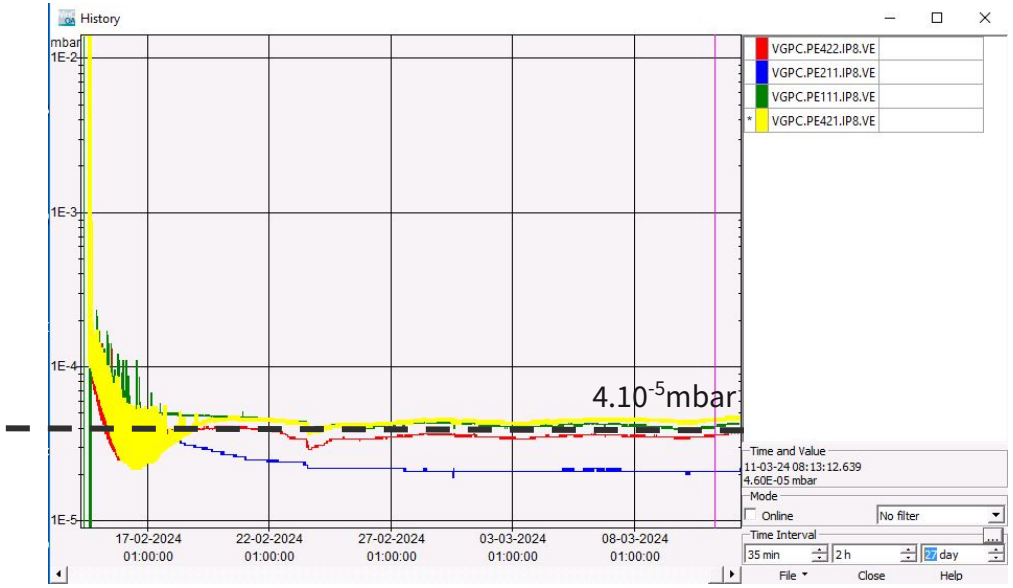
Impact on LHCb / LHC operation

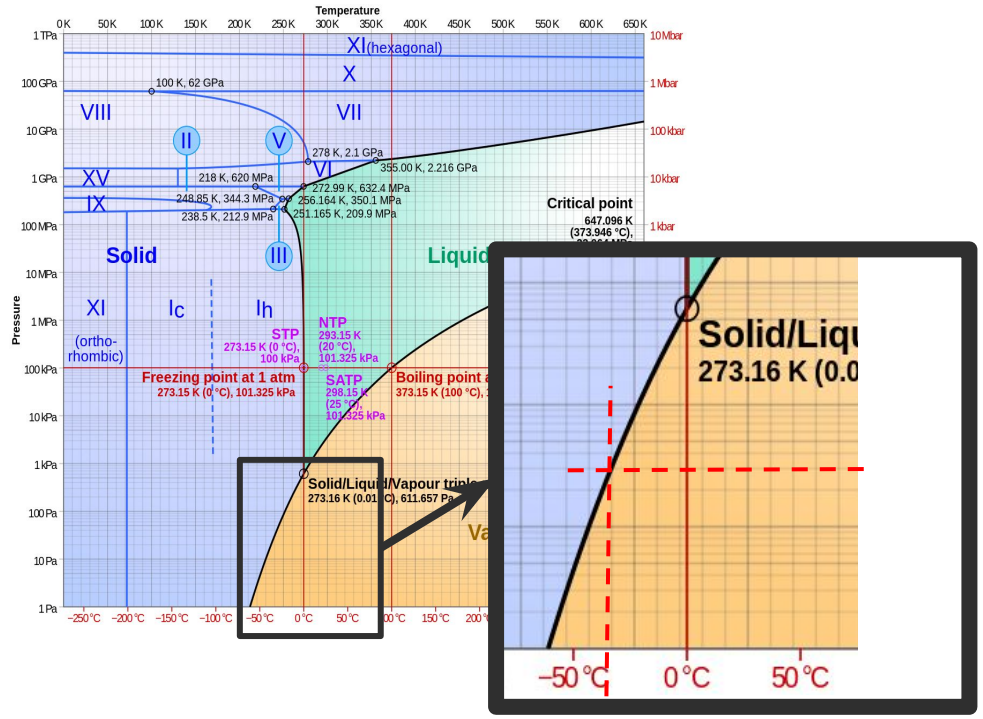
- **Pressure evolution stabilised**
  - 3-4.10^{-5}mbar instead of 10^{-6}-10^{-7} mbar
  - Expected not to degrades under steady load
- **Potential issue for the detector**
  - presence of water from air humidity in the detector
  - when the pump are running:
    - saturated water vapor at -35°C is at 0.22mbar
    - Partial pressure of water in air 0.028, ie needs to reach about 7.8mbar to form ice
  - If pumps stops:
    - Would take about 5 days to reach
    - But at 10^{-3}mbar (about 1 min): hw safety system triggers turning OFF HV and LV, warming up the detector (~1h), and close the CO_2 safety valve.

⇒ No risk for detector operation

- **Potential issue for LHC**
  - reaching the 10 mbar limit of the vacuum safety system (ie connecting LHC and detector vacuum) if the pump stops
    - about 7 days to reach 10 mbar
    - leave enough time to fix the source of the stop

⇒ No risk for LHC operation

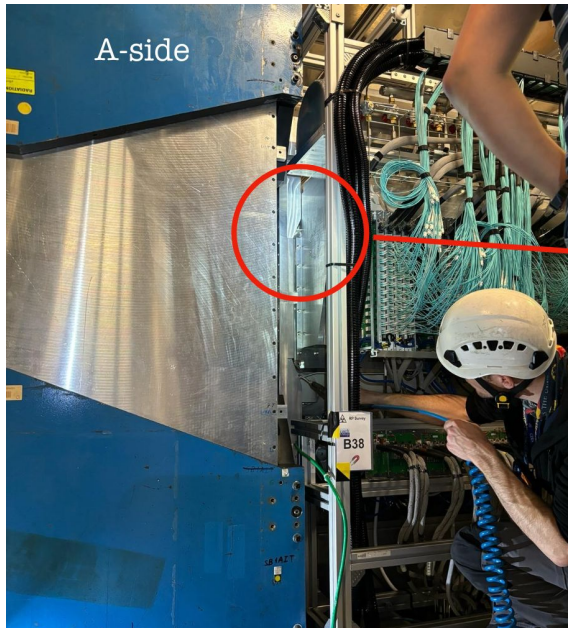




Mitigation and fixes

- **Source of the leak is not completely identified**
  - Could be parts of the heat mat stuck, or dust on the O-ring.
- **J. Sestak (TE-VSC) kindly providing an design for isolation vacuum around the leak**
  - If 1 mbar can be reached, better detector vacuum could be reached
  - To be produced and tested in the coming days
- **Fixing the leak**
  - Intervention itself should take about 10 days and requires:
    - Uncabling (2-4 days depending how much we uncable)
    - Venting (2 days)
    - Opening detector, de-engaging from RF box, cleaning interface / changing O-ring, re-engaging and closing (1-2 days)
    - Pump down (2 days)
    - Recabling (2-4 days depending how much we uncable)
    - Recommissioning without beam (2-3 days)
  - Come with some risk for the detector equipment

⇒ probably not before YETS 2024/2025



Region spotted by He leak check