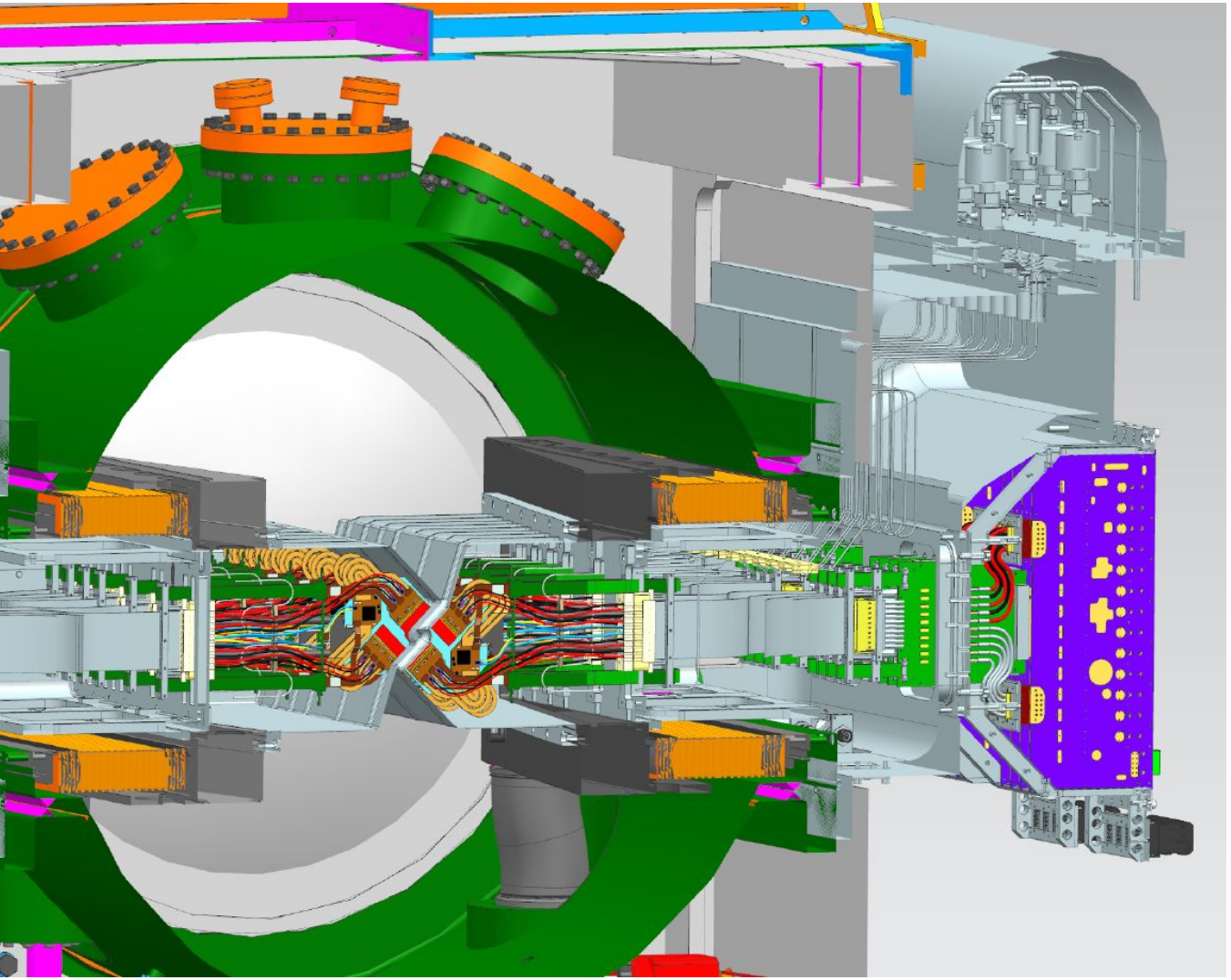
VeLo Commissioning Status and Plan

Victor Coco (CERN) for the Velo group

The LHCb Vertex Locator (VeLo)



- **The VeLo allows LHCb to reconstruct with high precision the trajectory of charged particles**
- **Located at the closest from the IP (foil @3.5mm, pixel @5.1mm)**
  - High-Radition
  - In (secondary) vacuum
  - Active cooling of the sensor (-30deg)
  - Movable to center around the beam

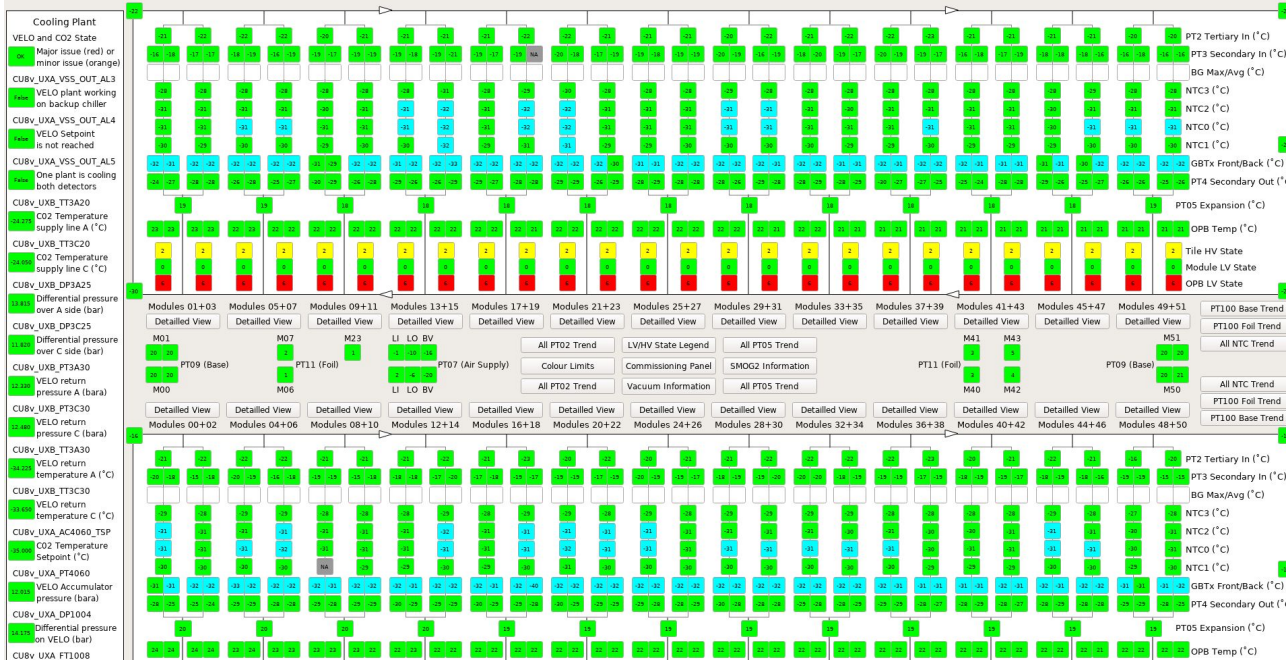
- **C-side installed in February 2022**
- **A-side installed in May 2022**
  - Thanks to a week given by the LHC during its re-commissioning (details in backup)

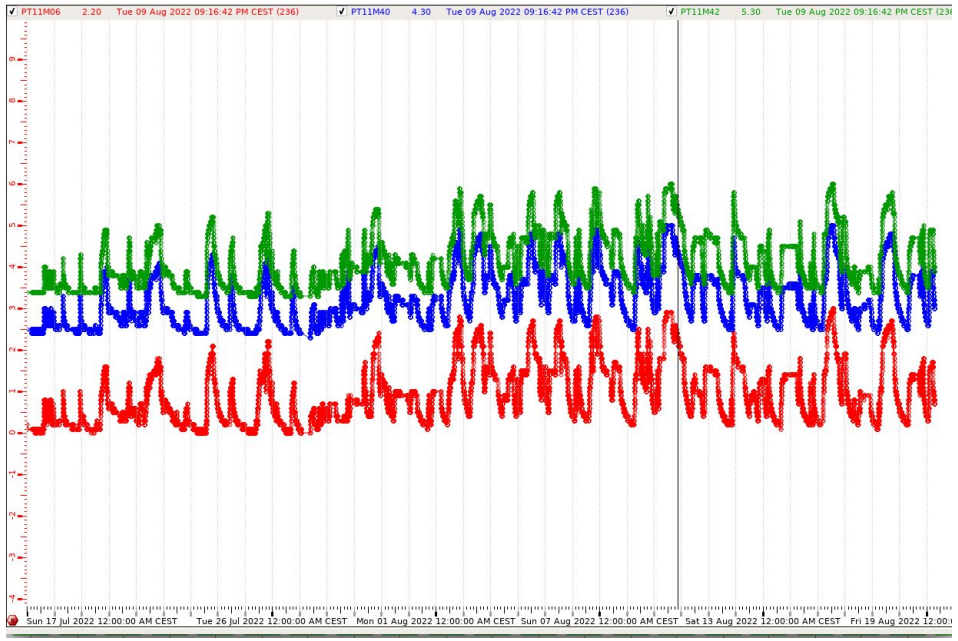
In Real Life

VeLo commissioning

Overall status

- CO_2 reliably circulating and boiling in microchannels in all 52 modules since start
- HV / LV all connected, tested, functionnal and control software ready. Used daily since installation
- Temperature monitoring includes more 700 temperature
- Safety system protects the detector from failure of the infrastructure or forbiden state
- FE and DAQ control in place, allowing to take data routinely in local

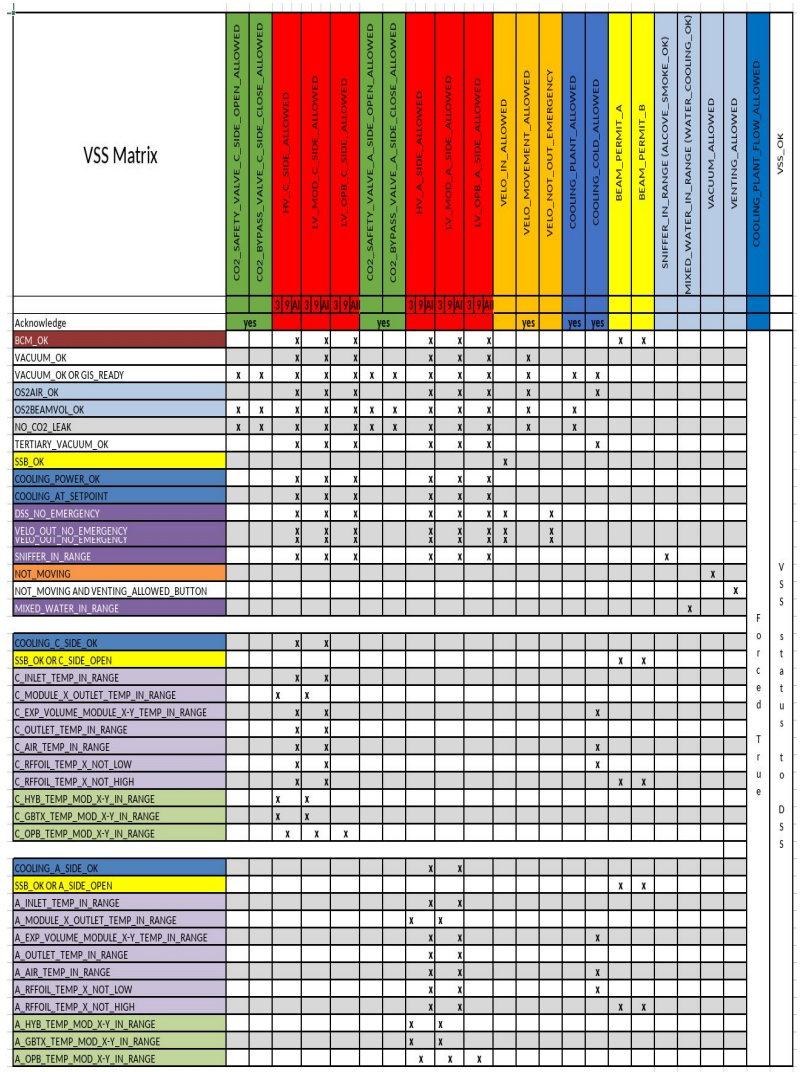




VeLo commissioning

Velo Safety System

- **Interlock system reacting to the detector temperatures (sensor, cooling pipes etc…), the vacuum state, the LHC state, motion system state, the infrastructure state to insure the detector safety (Implementation S. Ravat, X. Pons, EP-DT)**
- **Mapping during installation and functional test of the lines**
- **Some decision relevant to the VELO safety during closing:**
  - Activity in the BCM ⇒ beam dump (protect VELO from beam excursion)
  - Temperature of the RFFoil above a certain value (+80C) ⇒ beam dump (protect from pick-up)
  - VELO inward movement passed open position is inhibited if SSB is False
  - If VELO is not in open position while SSB is False beam permit is lifted (ie. in case LHC operator want to keep the beam but remove SSB flag- old UNSTABLE beam flag - , we should open not to cause a dump)



Message ID: **340**	Entry time: **05-Jul-2022 12:57**
Author:	Victor Coco
System:	VSS
Subject:	Test of VSS / CIBU / CCC communication and lines

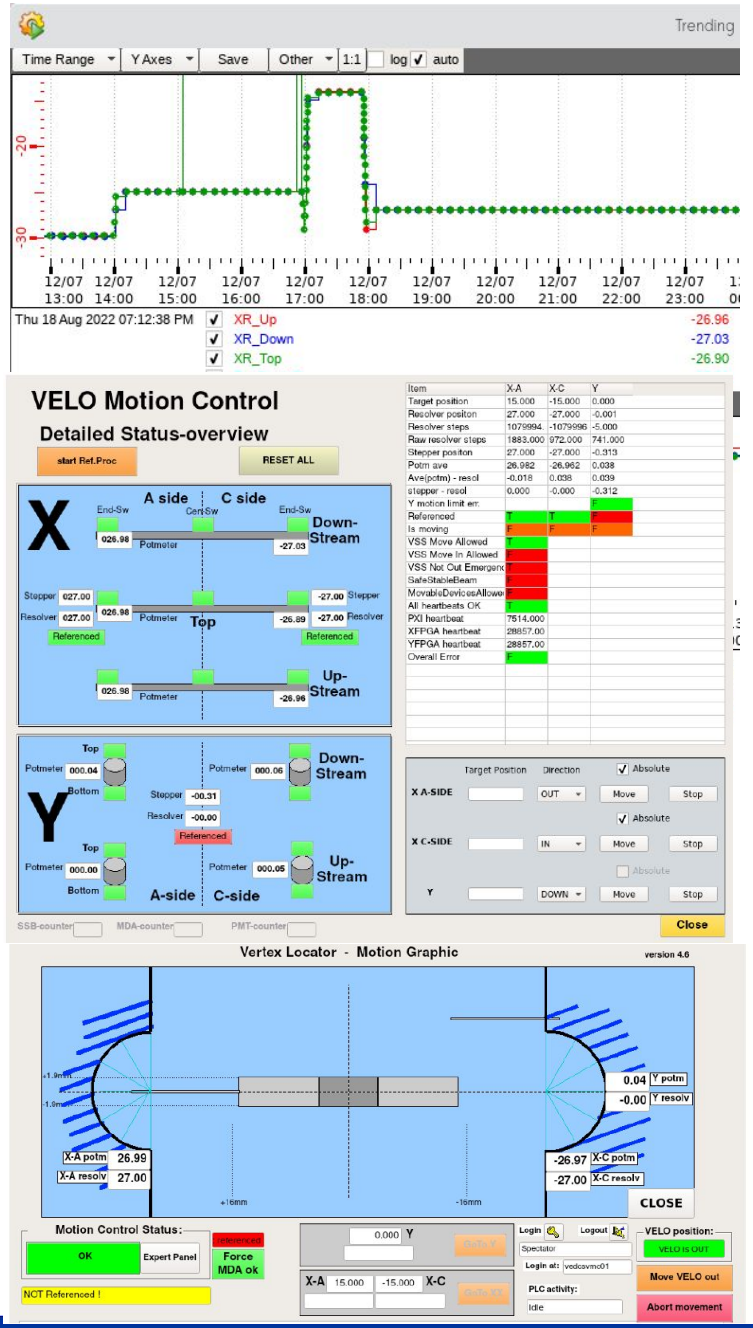
This morning with Sylvain and the LHC operators we tested the VSS lines leading to interlock of the USER_PERMIT_A and USER_PERMIT_B from the LHCb_MOV CIBU (CCIBUS___-ID000220) which goes to the CCC through the BIS which is located in UA87.

VeLo commissioning

Motion System

- **Motion system hardware (S. Ravat, X. Pons, EP-DT)**
  - **PXIe real-time controler + FPGA (same setup than for Roman Pots)**
    - position calculation
    - signal of the motor drive
    - limit control
    - interlock
  - **Motion control and calibration tested during LS2**
  - **Position from potentiometer/ resolver / stepper**
    - motion only possible if :
      - pot. and res.within 500um
      - pot and res step within 50um
      - if de-referenced only expert an operate

- **Local mode control (PXIe) tested**
- **OPCUa mode and Emergency mode to be tested**
- **WinCC control tested (comm. with OPCUa, reduced limits, dereferenced mode etc..)**
- **Residual x-talk in the system to be adressed next TS, does not affect commissioning at that stage**



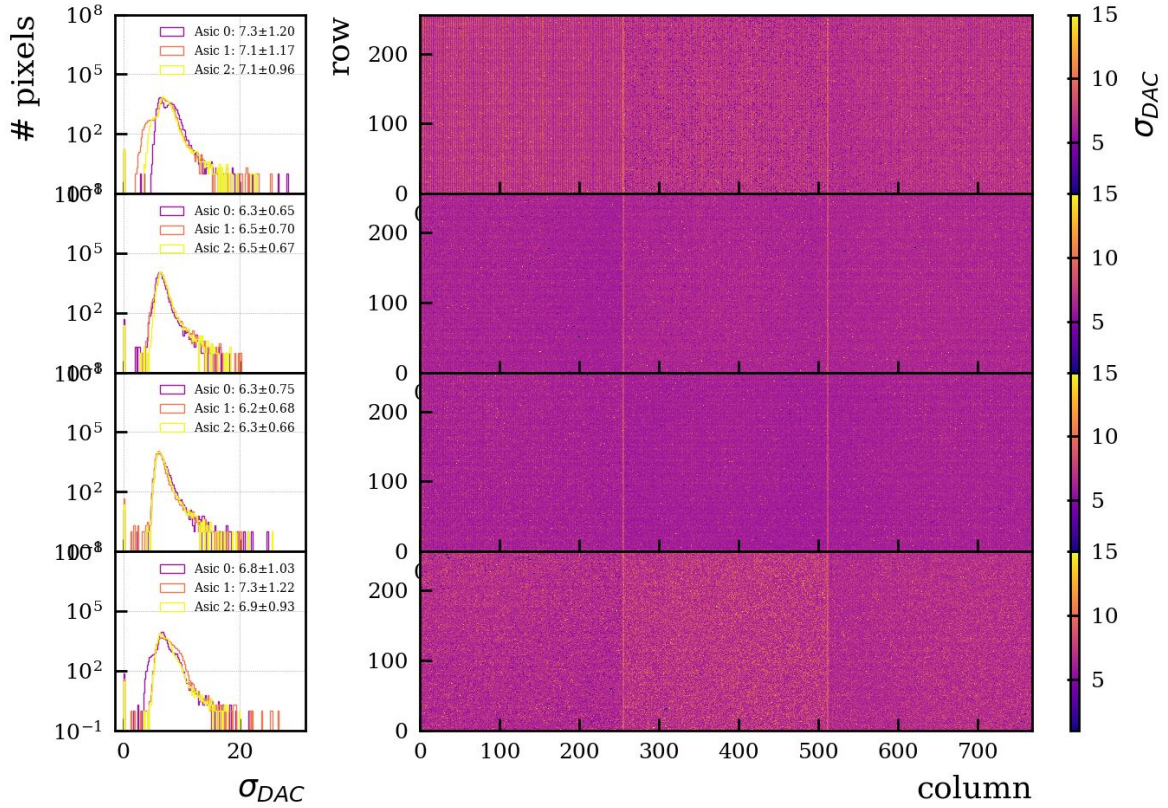
VeLo commissioning
Readout and reconstruction

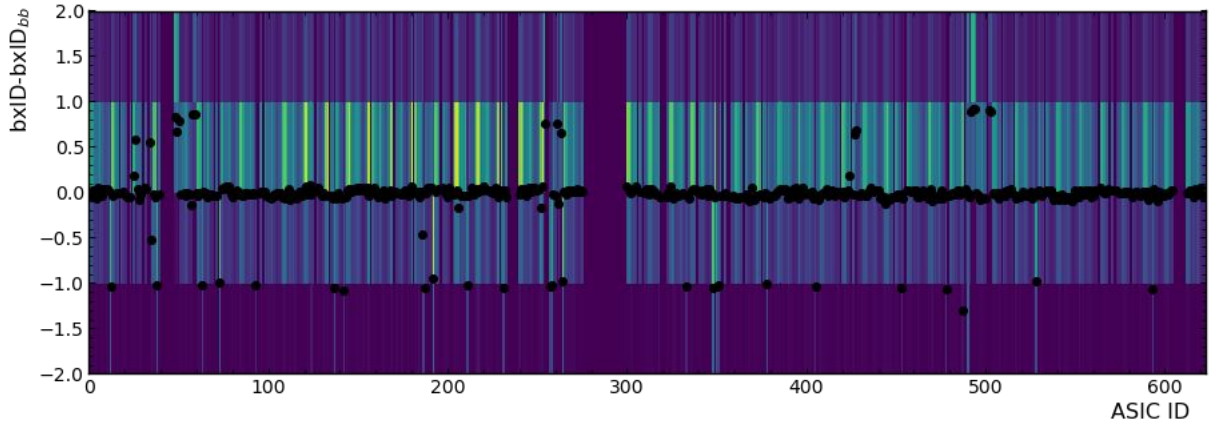
- **Front end and Readout commissioning advancing:**
  - 98% of the data links are up and running
  - FE ASICs calibration
    - equalisation of the pixel thresholds
    - ASIC time alignement almost finalised
    - some work to be done on the spread within ASIC but not holding us at that point (lower efficiency)

  ⇒ Good enough to reconstruct tracks and vertices, not yet at physics production level

- **First part of the commissioning needed lot of "no beam" time, now more dependent on beam time and still very "expert" operations**

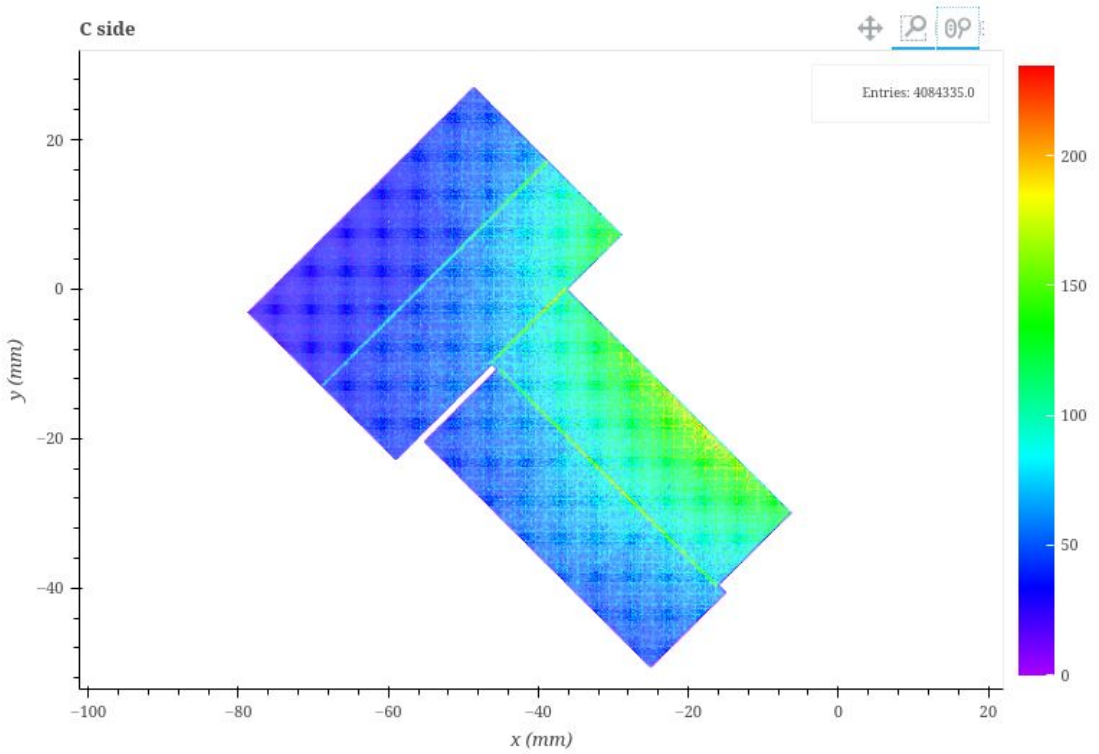
  ⇒ Improved fraction of stable beam during day time was and continues to be crucial for us.



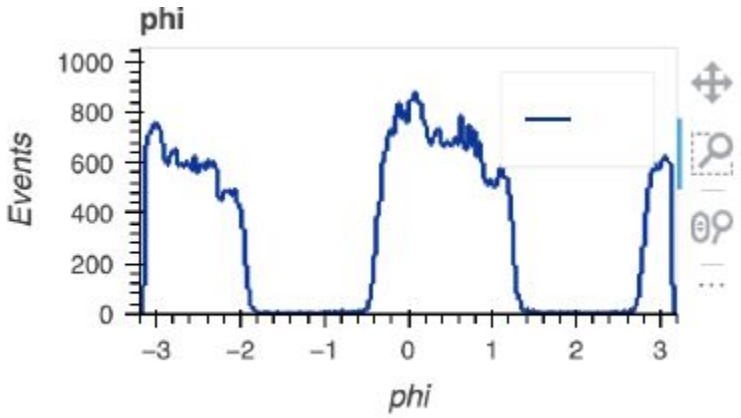


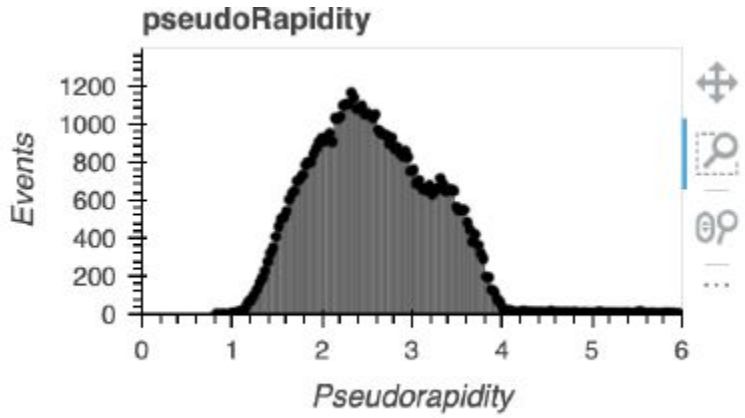
VeLo commissioning
Readout and reconstruction

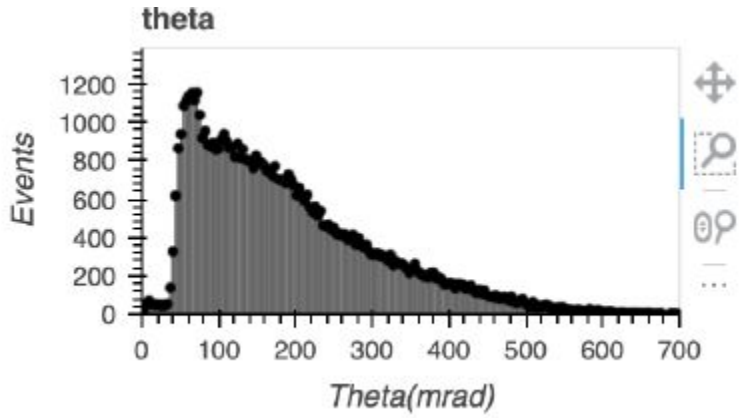
- **Before any movement we need to be able to reconstruct the relative position of the beam wrt. to the VELO**
  ⇒ ie. VELO readout, reconstruction and online monitoring



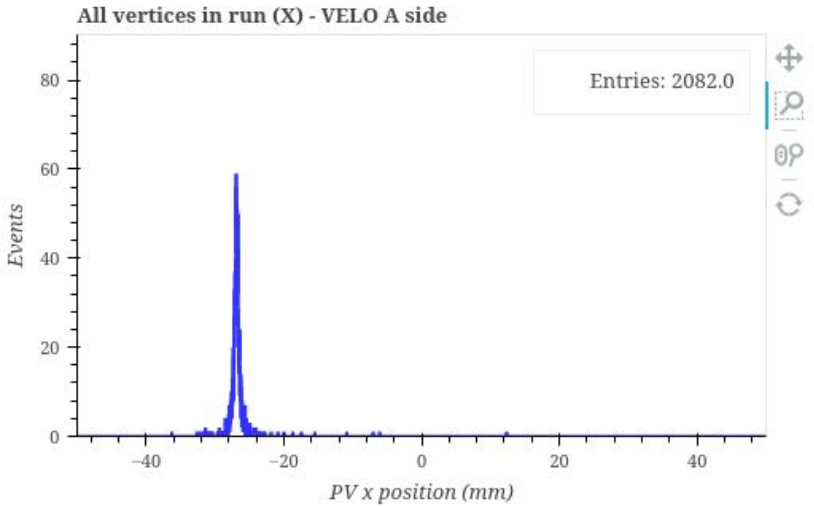
- **2% of the data recorded is routed to the online monitoring:**
  - **allow to visualise the data quality “online”**
  - **reconstruct the tracks and the primary vertices**

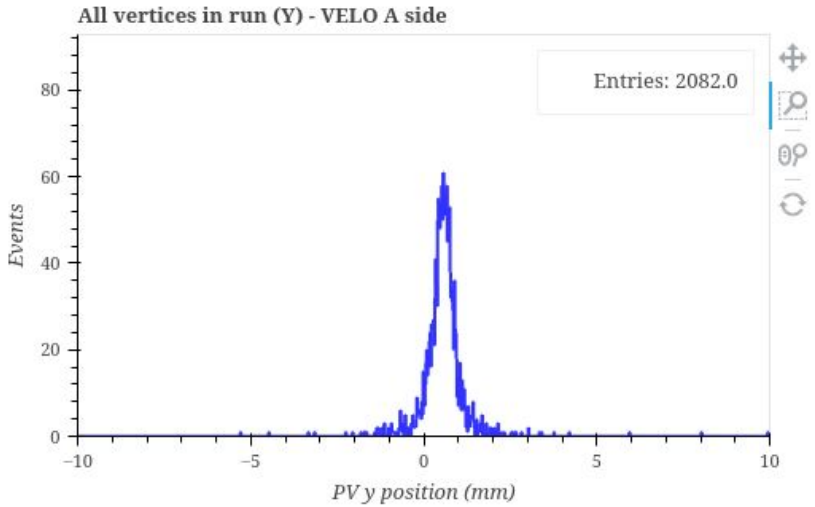


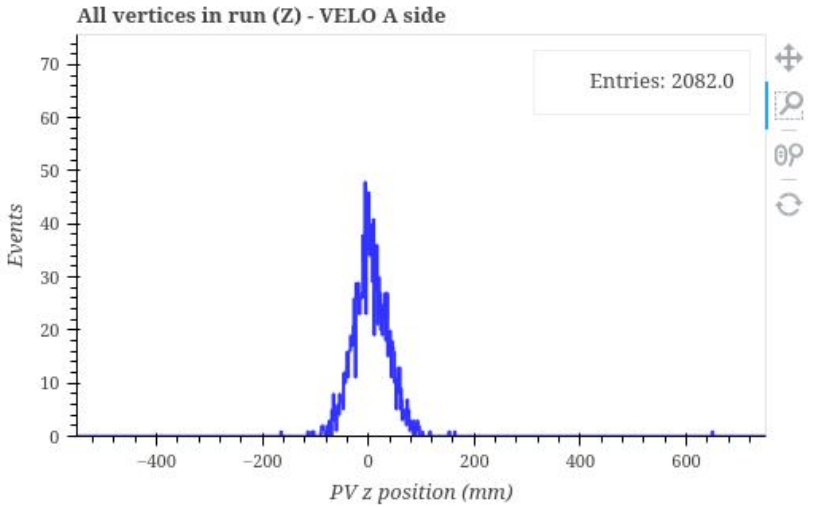


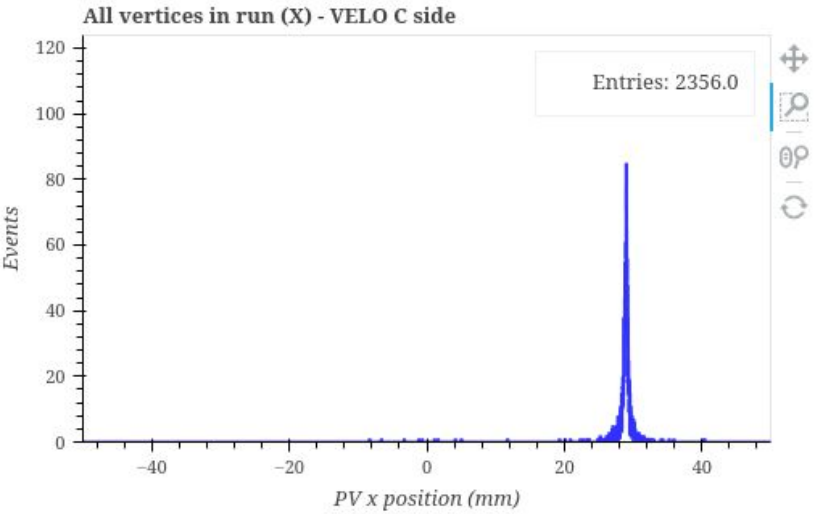


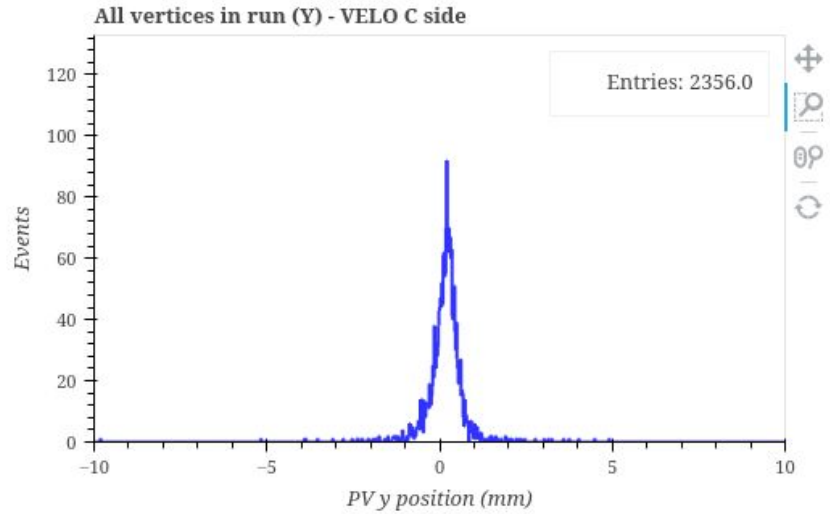
VeLo commissioning
Readout and reconstruction

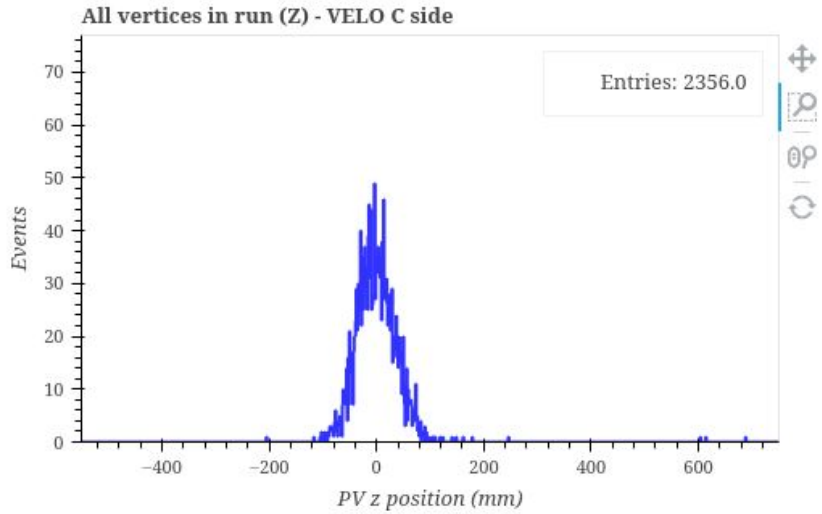






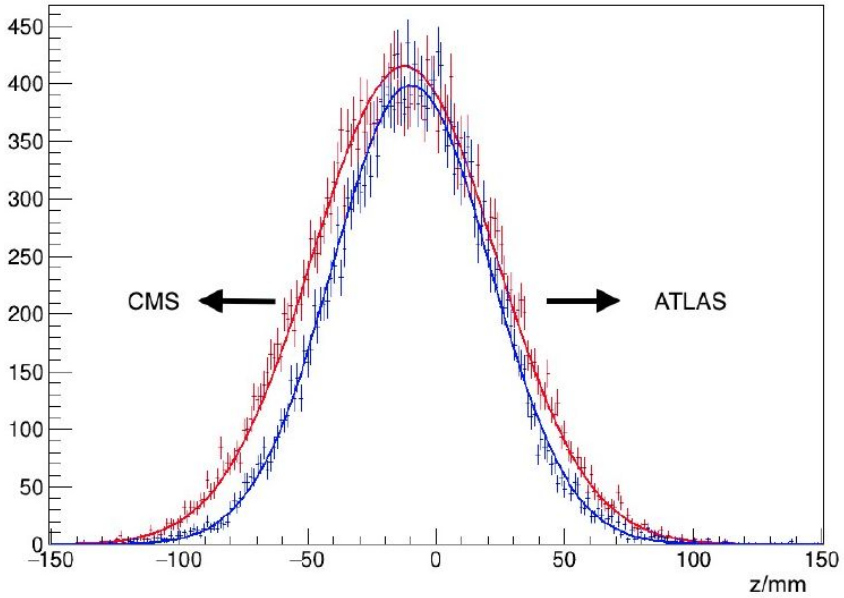


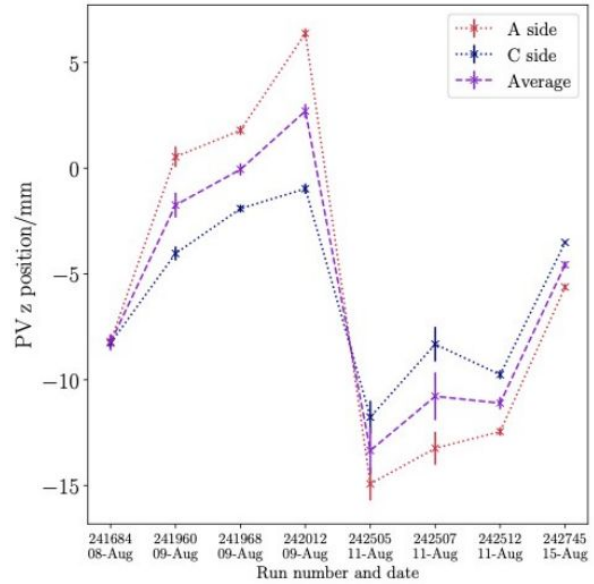


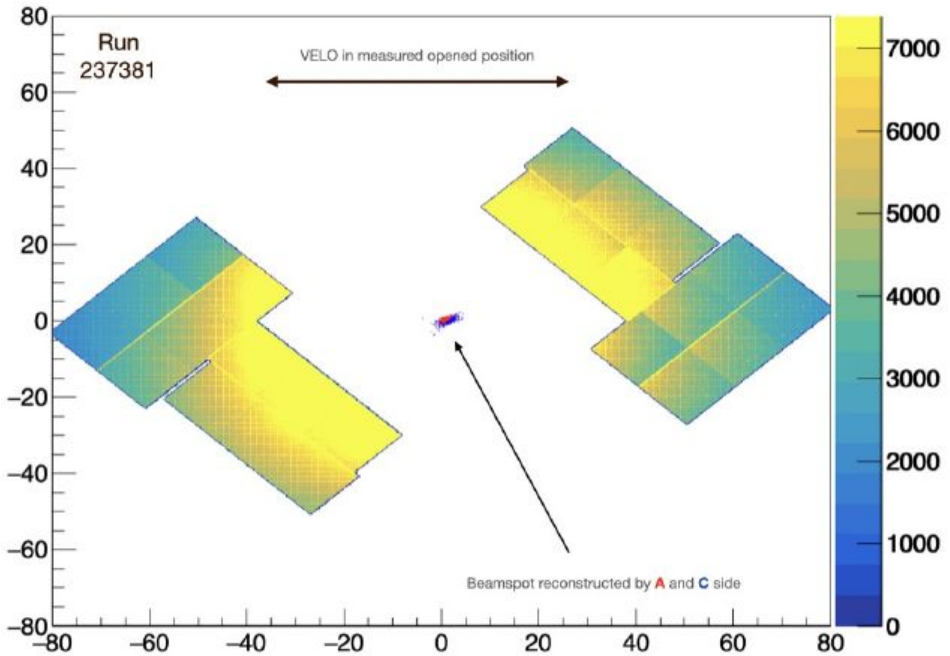


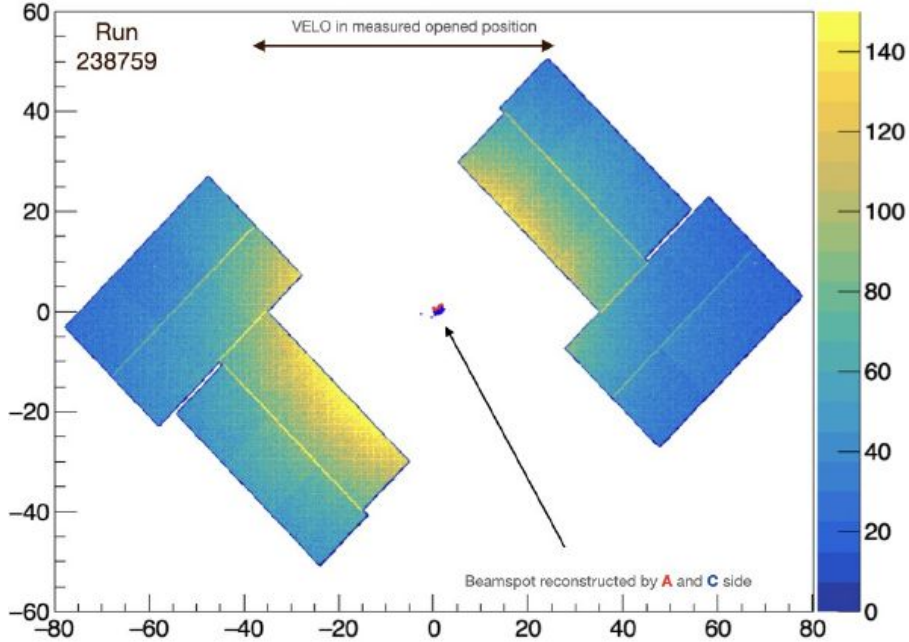
VeLo commissioning
Vertex Reconstruction

- Could see the z-offset of the IP
- Took data at referencing position (29.8mm) and garage position (27mm), proper distance seen
- 0.6 mm offset in Y observed, 0.4mm seems to be seen in metrology, values at different x will be precious to undertsand the source

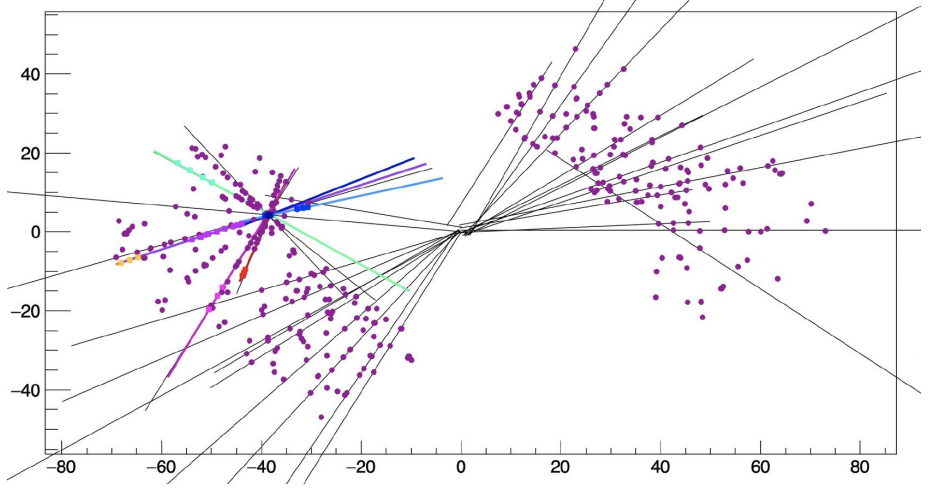








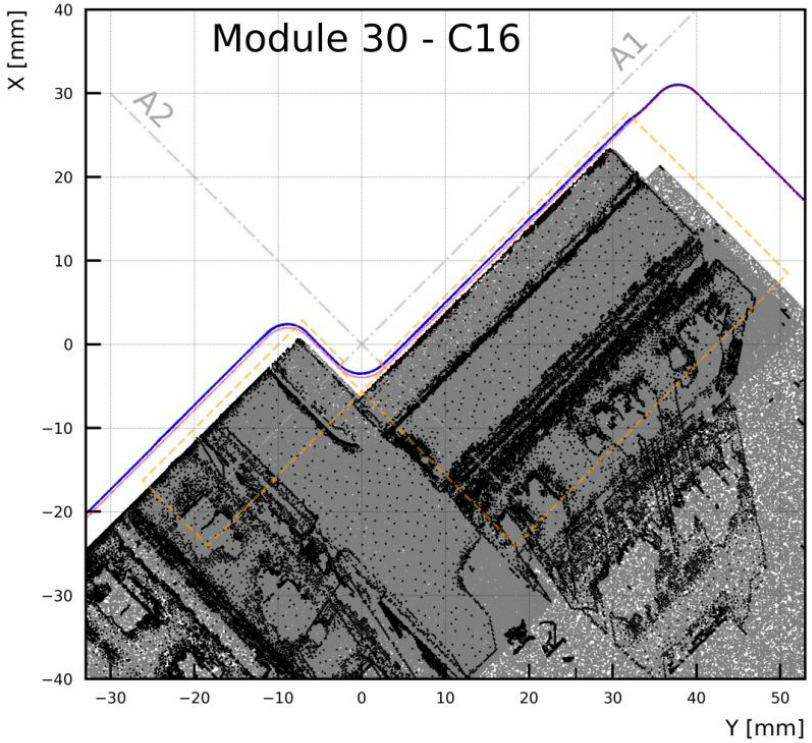
VeLo commissioning
First closure(s)



- **Won't close beyond 10mm minimal aperture radius before TS1:**
  - need to validate fully the alignment and the metrology data
  - need to cross check RF-Foil shape
    - compare tomography done with hadronic interaction with the 3D laser metrology

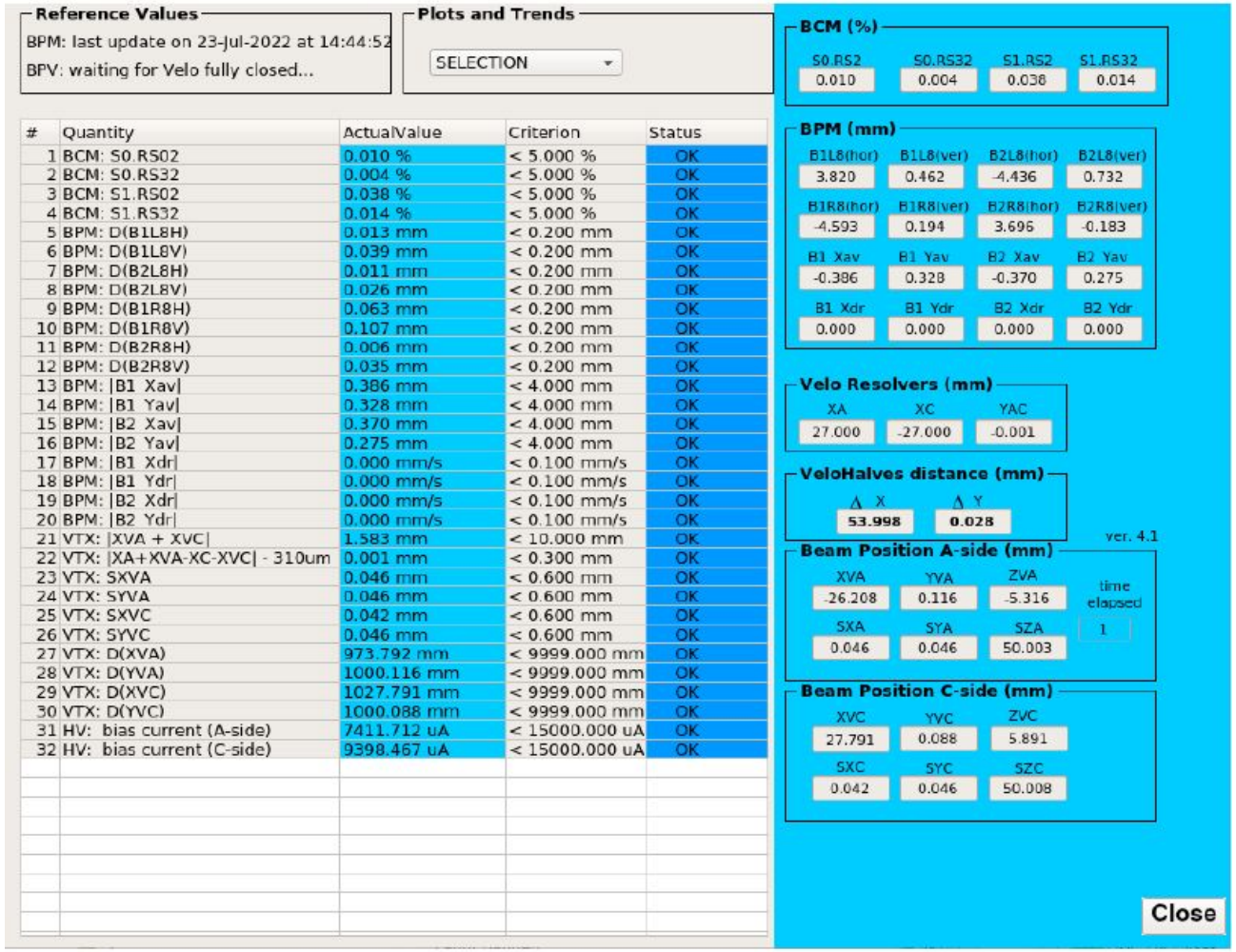
- **Move 1mm by 1mm at each step check:**
  - Velo position wrt beam, its compatibility wrt. pot. res. step and with the previous position (to spot alignment issue)
  - HV current
  - Temperatures (foil / SMOG / tank / detector)
  - Rates (should go in 1/r^2)

- **Will repeat "manual" procedure when fully closing**
- **VSS will catch temperature increase in the RF-Foil and dump the beam ⇒ for VELO safety no need for lower intensity beams**

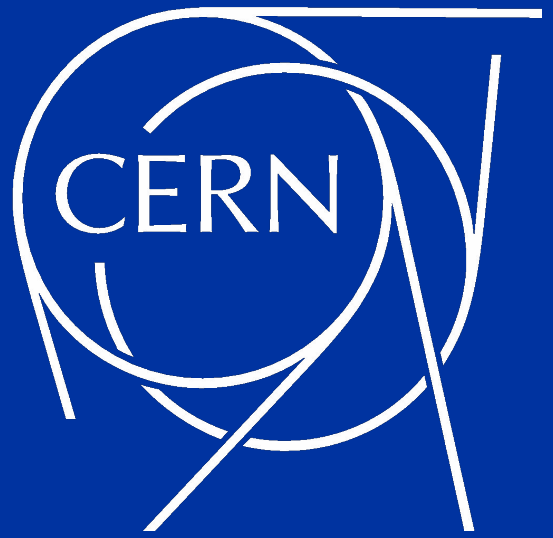


VeLo commissioning
Towards automatic closure

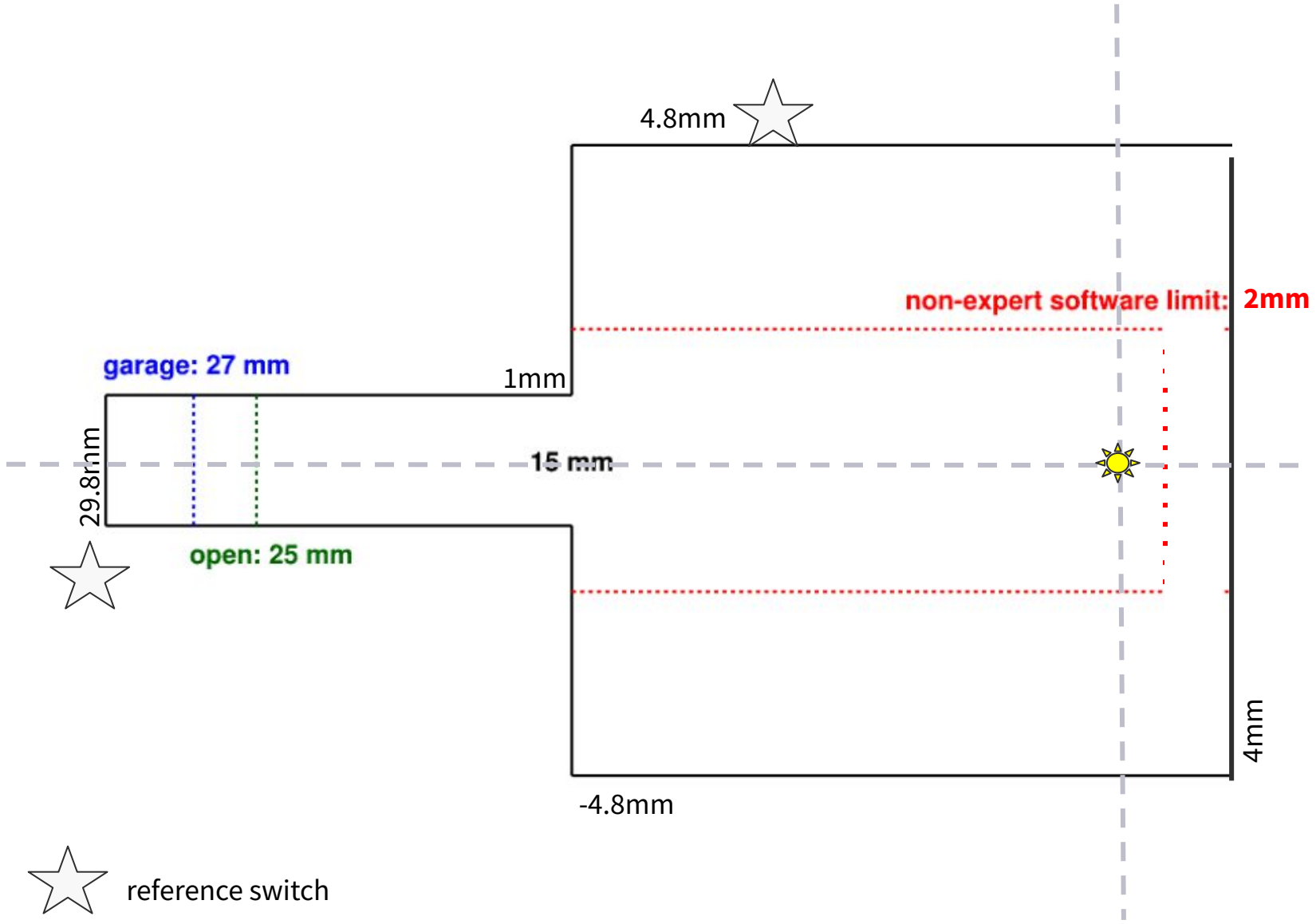
- Repeat the sequence with automatic closure procedure but manual handshake between steps for a few times
- Need for the detector to be in global mode… probably not routinely before TS1
- Move from online monitoring to dedicated task out of Hlt1 selected events.
- Software side of the procedure tested with MC injection
  - communication computing farm → winCC → motion system



#	Quantity	ActualValue	Criterion	Status
1	BCM: S0.RS02	0.010 %	< 5.000 %	OK
2	BCM: S0.RS32	0.004 %	< 5.000 %	OK
3	BCM: S1.RS02	0.038 %	< 5.000 %	OK
4	BCM: S1.RS32	0.014 %	< 5.000 %	OK
5	BPM: D(B1L8H)	0.013 mm	< 0.200 mm	OK
6	BPM: D(B1L8V)	0.039 mm	< 0.200 mm	OK
7	BPM: D(B2L8H)	0.011 mm	< 0.200 mm	OK
8	BPM: D(B2L8V)	0.026 mm	< 0.200 mm	OK
9	BPM: D(B1R8H)	0.063 mm	< 0.200 mm	OK
10	BPM: D(B1R8V)	0.107 mm	< 0.200 mm	OK
11	BPM: D(B2R8H)	0.006 mm	< 0.200 mm	OK
12	BPM: D(B2R8V)	0.035 mm	< 0.200 mm	OK
13	BPM: |B1 Xav|	0.386 mm	< 4.000 mm	OK
14	BPM: |B1 Yav|	0.328 mm	< 4.000 mm	OK
15	BPM: |B2 Xav|	0.370 mm	< 4.000 mm	OK
16	BPM: |B2 Yav|	0.275 mm	< 4.000 mm	OK
17	BPM: |B1 Xdr|	0.000 mm/s	< 0.100 mm/s	OK
18	BPM: |B1 Ydr|	0.000 mm/s	< 0.100 mm/s	OK
19	BPM: |B2 Xdr|	0.000 mm/s	< 0.100 mm/s	OK
20	BPM: |B2 Ydr|	0.000 mm/s	< 0.100 mm/s	OK
21	VTX: |XVA + XVC|	1.583 mm	< 10.000 mm	OK
22	VTX: |XA+XVA-XC-XVC| - 310um	0.001 mm	< 0.300 mm	OK
23	VTX: SXVA	0.046 mm	< 0.600 mm	OK
24	VTX: SYVA	0.046 mm	< 0.600 mm	OK
25	VTX: SXVC	0.042 mm	< 0.600 mm	OK
26	VTX: SYVC	0.046 mm	< 0.600 mm	OK
27	VTX: D(XVA)	973.792 mm	< 9999.000 mm	OK
28	VTX: D(YVA)	1000.116 mm	< 9999.000 mm	OK
29	VTX: D(XVC)	1027.791 mm	< 9999.000 mm	OK
30	VTX: D(YVC)	1000.088 mm	< 9999.000 mm	OK
31	HV: bias current (A-side)	7411.712 uA	< 15000.000 uA	OK
32	HV: bias current (C-side)	9398.467 uA	< 15000.000 uA	OK


CERN

Motion system limits



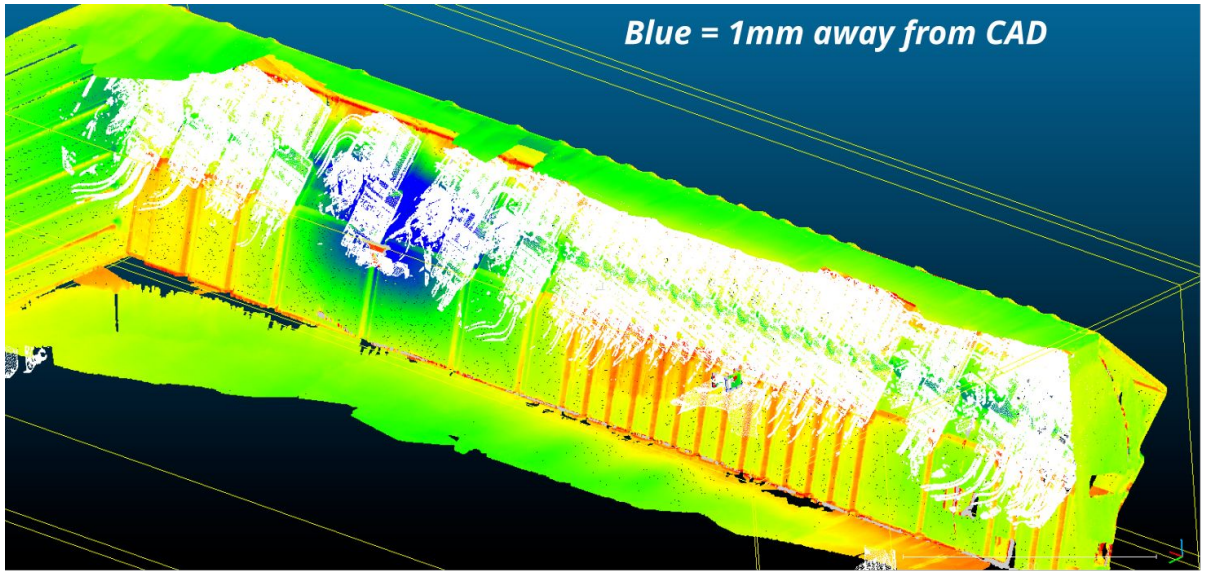
reference switch

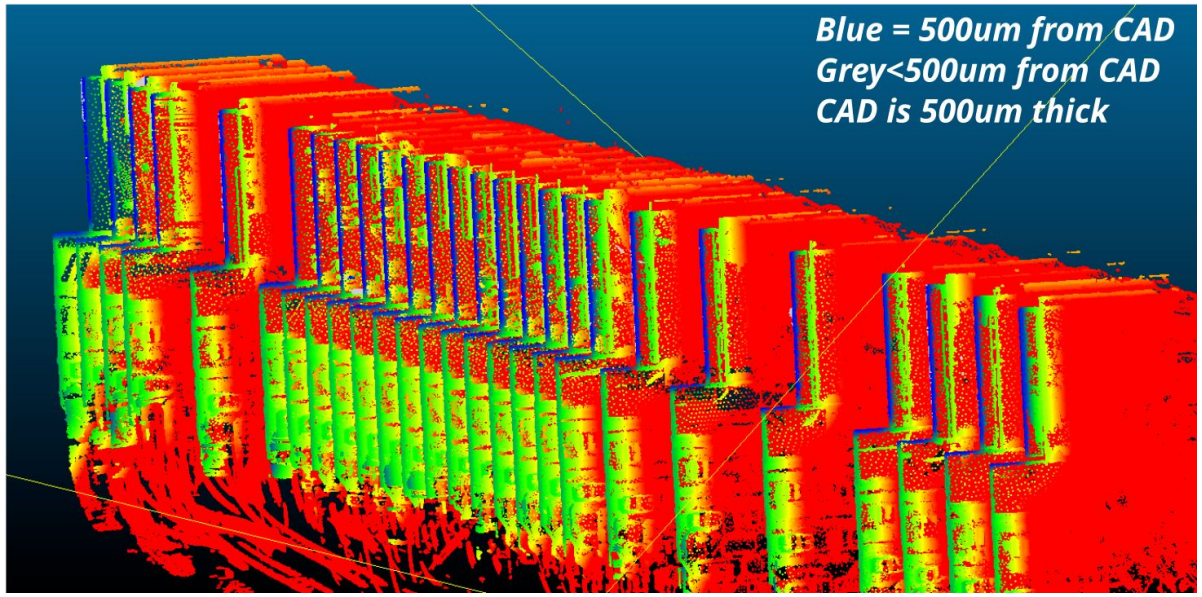
A-side surface test

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

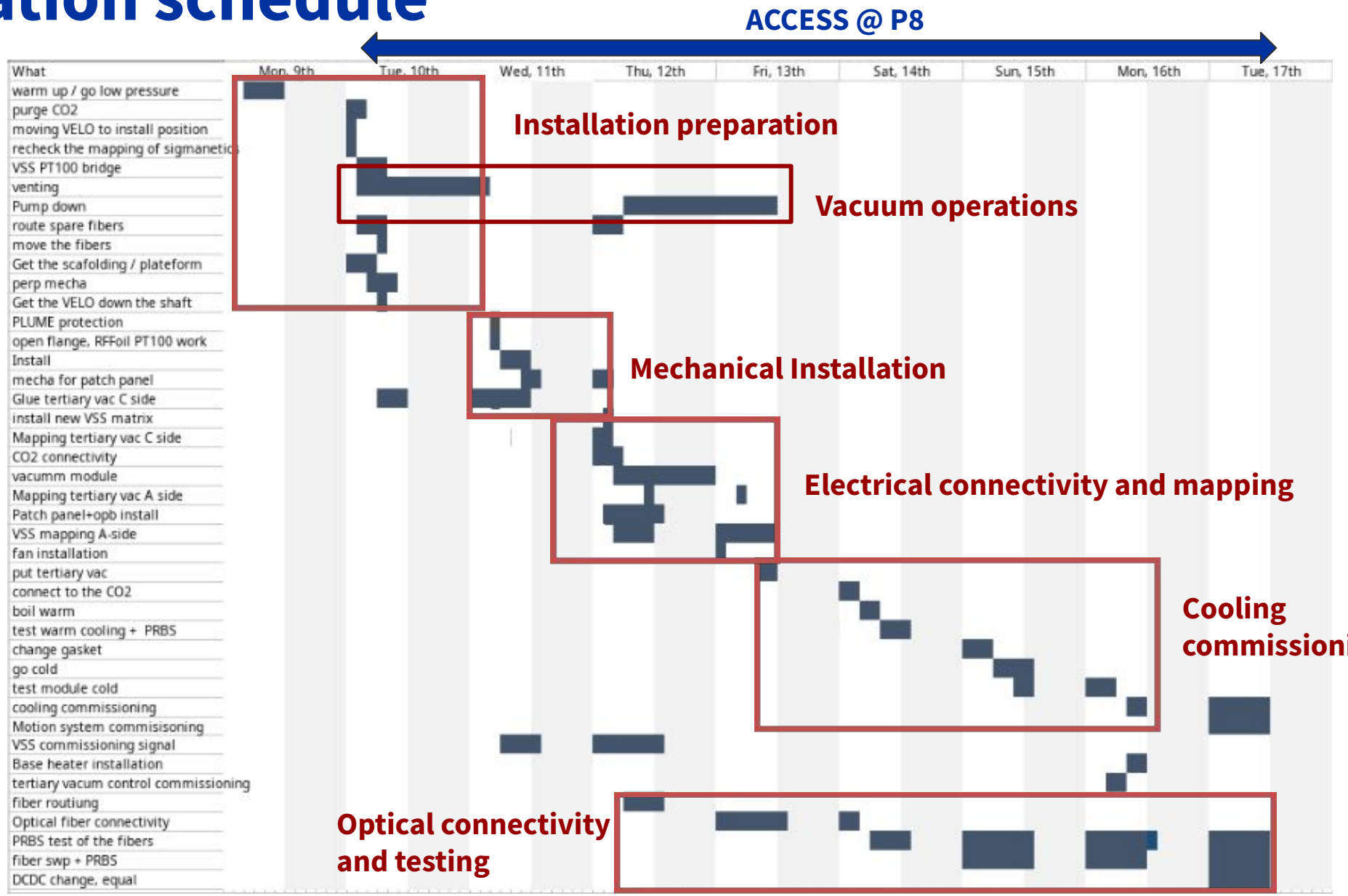




A-side installation schedule

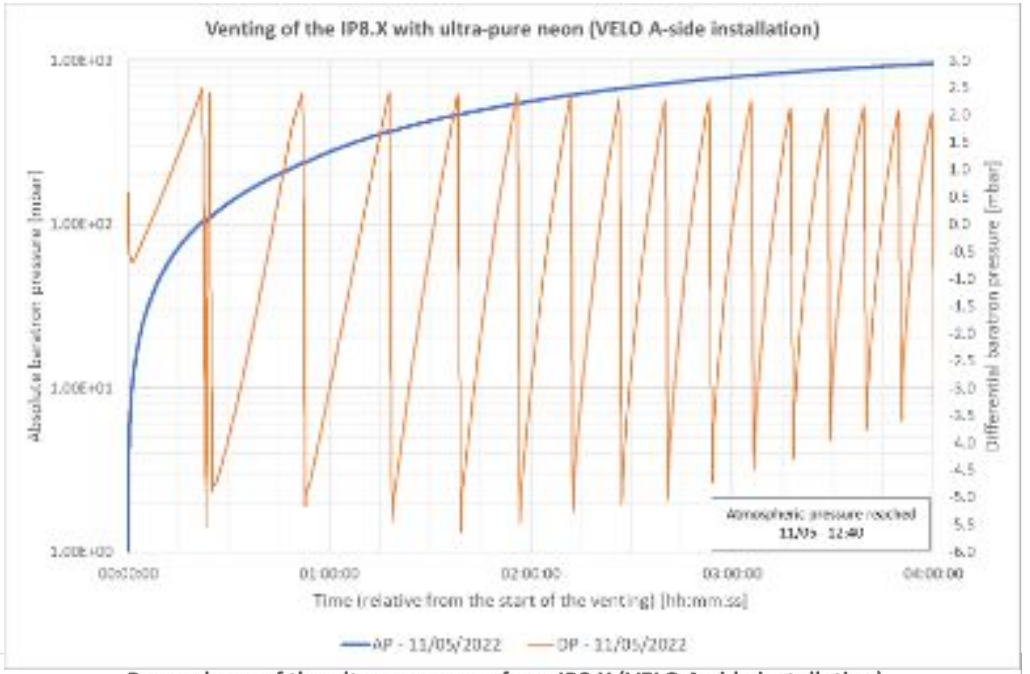
May 10th to 17th

- Team from Nikhef, Manchester, Santiago, Liverpool, Warwick, Oxford at CERN to help with installation
- Support from the pit infrastructure team
- Huge thanks to the LHC team to have organised a week of access to allow for installation!

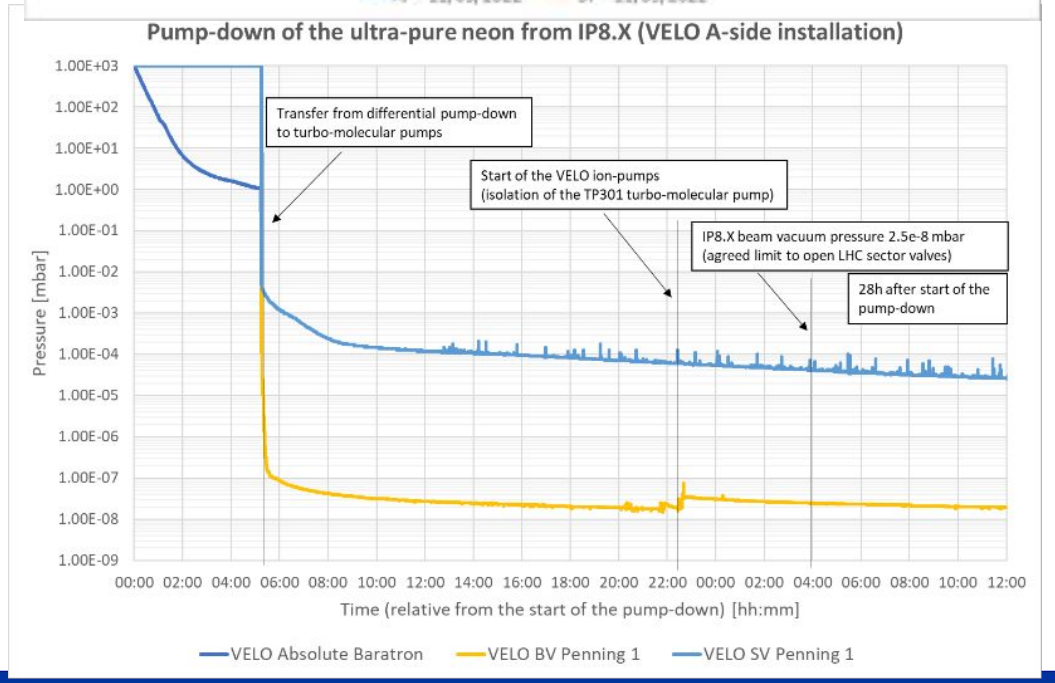


Vacuum operations
May 10th to 12th and May 25th

- **Venting to allow for VELO insertion**
- **Pump down on Thursday morning, 2.3x10^{-8} mbar in primary and 6.5x10^{-5} mbar in sec. achieved after 24h**
- **Last week first part of SMOG injection commissioning**
  - test with **open VELO** no beam
  - useful to provide particles out of stable beam interaction
  - next test withopen VELO and beam during a period of “quiet” beam
- **Many thanks to TE-VSC group for the support during installation and in getting SMOG system commissioned**



From Josef Sestak



A-side electrical connectivity

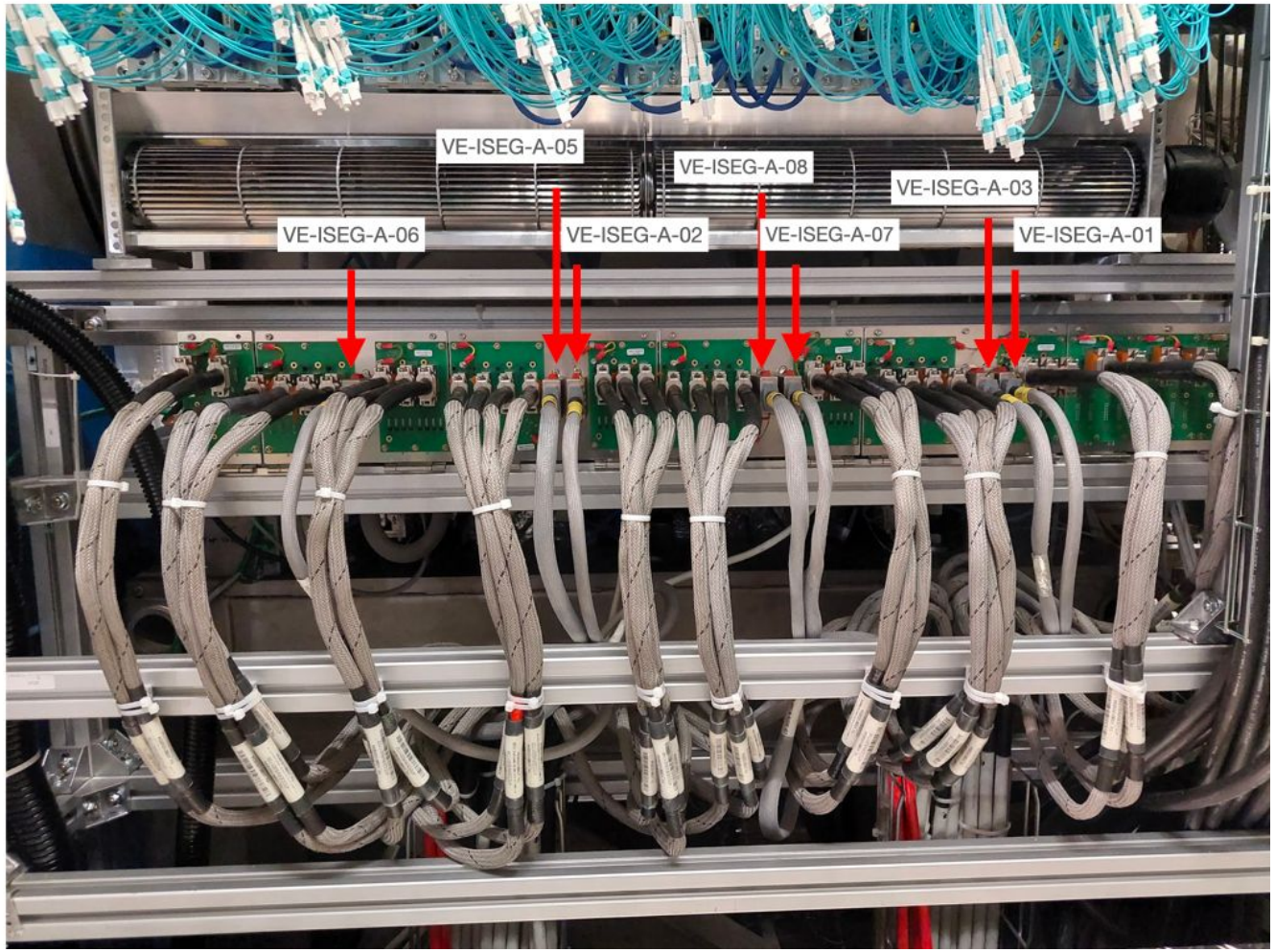
May 12-13th

- **Cabling following mechanical installation**
  - Installation of the optoelectronic boards
  - Routing of the LV and temperature sensor cables
  - Connection to the detector patch panel

- **Checked mapping of ~350 temperature measurements**
  - 4 not working ⇒ 3 fixed, one redundant sensor not recoverable

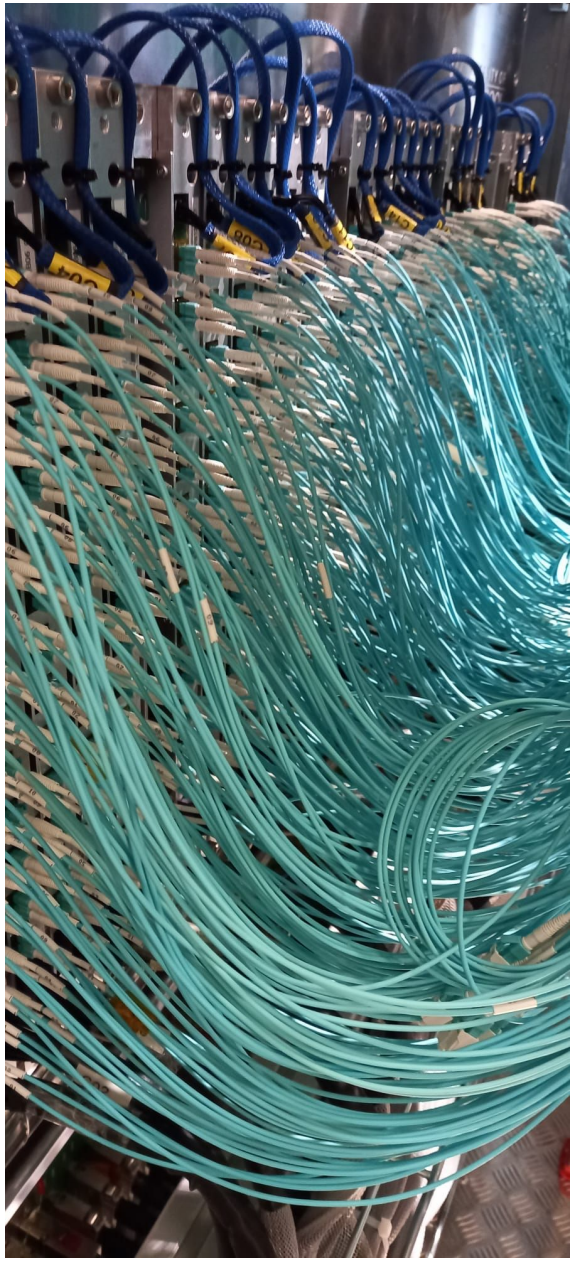
- **Validation of the safety system mapping**
  - full VSS system installed
  - As for C-side checked that each temperature sensor above limit trigger the proper LV/HV interlock
    ⇒ ready to put CO_2 and power-up

- **Gluing of C-side tertiary vacuum PT100**



A-side fiber connectivity
May 13th

- **Connection of the fibers to the patch panel done in April.**
- **A and C-side spares routed during installation**
- **676 LC connections on the A-side**
  - Two teams of 2 persons for 10h
  - Checked cleanness with microscope and connect
- **Optical link quality test**
  - run PRBS test to quantify the quality of the link and check presence of light
  - a few MPO swap to fix in the data center
  - a few swap of LC on the detector
  - a few LC needed to be recleaned
  - for several modules DCDC convertor replaced to higher values
    - not an optical link issue but some GBTx recieves too low voltage and link can't be tested



A-side cooling commissioning
May 12-16th

- **CO_2 connection to local box completed on Thursday**
- **Module under vacuum for 24h**
  - while finalising the safety system testing
- **Connection to the plant on Saturday**
  - boiling at warm setpoint
  - tested powering modules and quality of optical links
  - going cold prevented by dry-out in one module
- **Intervention to replace gasket of module 47**
  - Sunday vented tertiary vacuum and removed hood
  - replaced gasket
    - gasket itself obstructed by a flake (composition to be determined)
  - Cold on Monday
  - ***All module could be powered!***