

VeLo Commissioning Status and Plan

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What is still needed to close the VELO?



- Check temperature and vacuum behaviour during closing
 - checking SMOG / RFFoil temperatures and vacuum evolution
 - time spent in closed position to see temperature evolution
 - ⇒ Intensity ramp-up
- Cross-checked of detector alignment and metrology with particles
 - The RFfoil is closest element to the beam
 - Metrology performed on-site to be confirmed by tomography from reconstructed hadronic interaction with the material
 - \Rightarrow Partial closure at 2mm before going to full closure



Partial Closure

- Sept 30th, rehearsal behind closed position @1200b
 - moved between 29.7mm and 25mm
- Tuesday Oct 4th:
 - power cut in data center at FLAT TOP
 - \circ could not get back 40% of the VELO ⇒ asked to postpone
- Thursday Oct 6th:
 - Fill 8232, 12b
 - Fill 8233, 300b \Rightarrow 218b (injector issue)
- Used the final closing manage (with manual handshake)
 - check DAQ states, HV current, vertex reconstruction, compatibility with BPM, ...
 - check in parallel the monitoring (position of vertices, currents) to verify validity of inputs
- No Y movement:
 - Offset in vertex reconstruction understood from metrology but prefered to check with data at various x to validate.

Inch	System	State	Thu 22-Sep-2022	10:09:28
гнср	VELO_Position		root	٩
– VELO Closing Manag	er		1	
Motion		DAQ HV BCM BPM VTX		
ALLOWED				
PARTIALLY IN/OUT		Motion Criteria		
Beam Position	Motion S	System Position		
X 0.00 mm	XA 10.00 mm	XC -10.00 mm		
Y 0.05 mm	Y	0.05 mm		
FLOG				
Status:		v8.6		
Do you want to mov	e the VELO to:			
XA = 5.000mm, 2	XC = -5.000mm and Y = 0	0.050mm ?		
BeCheck		Ok Cancel		

44:52 SELEC	Criterion < 5.000 %	Status OK	S0.852 0.010 BPM (mm	50.RS32 0.004	\$1.R52 0.038	S1.RS32 0.014
ActualValue 0.010 % 0.004 % 0.038 %	Criterion < 5.000 %	Status	0.010	0.004	0.038	0.014
ActualValue 0.010 % 0.004 % 0.038 %	Criterion < 5.000 % < 5.000 %	Status	BPM (mm	()	0.030	0.014
ActualValue 0.010 % 0.004 % 0.038 %	Criterion < 5.000 % < 5.000 %	Status OK	BPM (mm)		
0.010 % 0.004 % 0.038 %	< 5.000 % < 5.000 %	OK	B118(bor)			
0.004 % 0.038 %	< 5.000 %		OTLO(IIOI)	B1LB(ver)	B2L8(hor)	B2L8(ver)
0.038 %		OK	3.820	0.462	-4.436	0,732
0.014.0/	< 5.000 %	OK				
0.014 %	< 5.000 %	OK	BIR8(hor)	B1R8(ver)	B2R8(hor)	B2R8(ver)
0.013 mm	< 0.200 mm	OK	-4.593	0.194	3.696	-0.183
0.039 mm	< 0.200 mm	OK	B1 Xay	B1 Vav	B2 Xav	B2 Yay
0.011 mm	< 0.200 mm	OK	0.386	0.328	0 370	0.275
0.026 mm	< 0.200 mm	OK	-0.386	0.328	-0.570	0.273
0.063 mm	< 0.200 mm	OK	B1 Xdr	B1 Ydr	B2 Xdr	B2 Ydr
0.107 mm	< 0.200 mm	OK	0.000	0.000	0.000	0.000
0.006 mm	< 0.200 mm	OK				
0.035 mm	< 0.200 mm	OK				
0.386 mm	< 4.000 mm	OK	-Velo Rese	olvers (mr	n) ———	10
0.328 mm	< 4.000 mm	OK	XA	YC	YAC	
0.370 mm	< 4.000 mm	OK	77.000	77.000	2.001	
0.275 mm	< 4.000 mm	OK	27.000	-27.000	-0.001	
0.000 mm/s	< 0.100 mm/s	OK				ř.
0.000 mm/s	< 0.100 mm/s	OK	VeloHalve	es distanc	e (mm)-	
0.000 mm/s	< 0.100 mm/s	OK	A X	A 1	Y	
0.000 mm/s	< 0.100 mm/s	OK	53.9	0.0	28	
1.583 mm	< 10.000 mm	OK				ver. 4.
0.001 mm	< 0.300 mm	OK	Beam Pos	sition A-si	de (mm)-	
0.046 mm	< 0.600 mm	OK	XVA	YVA	ZVA	
0.046 mm	< 0.600 mm	OK	-26,208	0.116	-5.316	time
0.042 mm	< 0.600 mm	OK	20.200	0.110	5.510	etapsed
0.046 mm	< 0.600 mm	OK	SXA	SYA	SZA	1
973.792 mm	< 9999.000 mm	OK	0.046	0.046	50.003	
1000.115 mm	< 9999.000 mm	OK				
1027.791 mm	< 9999.000 mm	OK	-Beam Por	sition C-si	de (mm) -	
1000.088 mm	< 9999.000 mm	OK	N/C	1010	7//0	
7411.712 UA	< 15000.000 uA	OK	XVC	TVC	200	10
9398.467 UA	< 15000.000 uA	OK	27.791	0.088	5.891	1
	222.501000 011		SXC	SYC	SZC	
			0.042	0.046	50.008	
			01042	1.040	111000	12 C
	0.026 mm 0.063 mm 0.005 mm 0.035 mm 0.035 mm 0.328 mm 0.328 mm 0.328 mm 0.328 mm 0.328 mm 0.328 mm 0.000 mm/s 0.000 mm/s 0.000 mm/s 0.000 mm/s 0.000 mm/s 0.000 mm/s 0.000 mm/s 0.001 mm 0.046 mm 0.048 mm 0.042 mm 0.042 mm 0.042 mm 0.042 mm	0.256 mm < 0.200 mm <	0.26 mm < 0.200 mm	0.26 mm < 0.200 mm OK 0.66 mm < 0.200 mm OK 0.107 mm < 0.200 mm OK 0.357 mm < 0.200 mm OK 0.358 mm < 0.200 mm OK 0.358 mm < 4.000 mm OK 0.378 mm < 4.000 mm OK 0.275 mm < 4.000 mm OK 0.275 mm < 4.000 mm/S OK 0.000 mm/S < 0.100 mm/S OK 0.000 mm/S < 0.000 mm OK 0.000 mm/S < 0.000 mm OK 0.000 mm/S < 0.000 mm OK 0.000 mm < 0.600 mm OK 0.046 mm < 0.600 mm OK 0.047 mm < 9999.000 mm OK 0.047 mm < 9999.000 mm OK 0.047 mm < 9999.000 mm OK 0.047 mm < 0.5000 mm OK 0.046 mm < 0.600 mm OK 0.047 mm < 0.600 mm OK 0.046 mm < 0.600 mm OK 0.047 mm < 0.600 mM OK 0.040 MM < 0.600 MM OK 0	0.026 mm < 0.200 mm < 0K 0.065 mm < 0.200 mm < 0K 0.055 mm < 0.200 mm < 0K 0.055 mm < 0.200 mm < 0K 0.358 mm < 0.200 mm < 0K 0.358 mm < 4.000 mm < 0K 0.328 mm < 4.000 mm < 0K 0.275 mm < 4.000 mm / 0K 0.000 mm/s < 0.100 mm/s < 0K 0.000 mm/s < 0.000 mm < 0K 0.000 mm/s < 0.000 mm < 0K 0.000 mm/s < 0.000 mm < 0K 0.046 mm < 0.600 mm < 0K 0.046 mm < 0.600 mm < 0K 0.046 mm < 0.9999.000 mm < 0K 0.046 0.046 0.046 0.046 0.046 0.046 0.046 0.046 0.042 0.048	0.26 mm < 0.200 mm



Partial Closure

- Several steps
 - 27mm jaw position ⇒ 25mm centered on beam (check mechanism works)
 - ⇒ 20mm ⇒15mm ⇒ 10mm ⇒ 8mm ⇒ 6mm ⇒ 5mm [only @218b] ⇒ 4mm [stayed ~15min] ⇒ 3mm
 ⇒ 2mm [stay 1h] ⇒ 4mm [only @ 12b] ⇒ 27mm





Temperature and vacuum evolution



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

RFfoil temperature decrease by



Temperature and vacuum evolution



• **Temperature increase still @4mm** • ~1K, not scaling with intensity

• Vacuum increase when moving

- \circ 3e-9 to 6e-9 mbar
- scaling with intensity?
- Probing some temperature increase elsewhere?
- Decrease when movement is idle (linked to movement itself?)
- Sharp decrease when moving out.



Foil (and SMOG) opening



- Foil temperature drops while closing
 - cooling of the foil by the foil



Hadronic interaction

- Using interaction with material to check the position of the foil
 - reconstruct tracks
 - reconstruct vertex from the tracks
 - \Rightarrow pp interaction and interaction with material

• Analysis on going

- interplay with alignement (rotation/translation of modules wrt. foil can be seen as rotation/translation of the foil wrt. the global frame)
- local (from halves) vs. global (wrt. beam position) studies
- A-side foil seen from C-side modules and opposite give as little bias information as possible





Hadronic interaction

- Bulging compatible with metrology results
- Should still understand the positioning of the halves
- Effective aperture radius may be reduced by ~0.5-0.7mm (really still preliminary, to be confirmed)







Conclusion

What are the next steps?







The LHCb Vertex Locator (VeLo)

- LHCb and the VELO were upgraded during LS2
 - Instantaneous luminosity $4.10^{32} \rightarrow 2.10^{33} \text{s}^{-1} \text{cm}^{-2}$
 - Increase in luminosity needed 40MHz readout with full software trigger
 - ➡ Full upgrade of the DAQ and readout electronics as well as of the tracking detectors and RICH
- The VELO allows LHCb to reconstruct with high precision the trajectory of charged particles and their origin vertices
 - ⇒ key instrument for **B,D hadron reconstruction**



With respect to Run 1&2 LHCb: to be upgrade/ to be kept





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	BPM (mm	ı) — — — — — — — — — — — — — — — — — — —		
1 BCM: 50 B502	0.010 %	< 5.000 %	OK	B118(hor)	B1L8(ver)	B218(hor)	B218(ver
2 BCM: 50 BS32	0.004 %	< 5.000 %	OK	3 820	0.462	4 436	0.732
3 BCM: \$1 BS02	0.038 %	< 5.000 %	OK	5.020	0.402	1.150	0.752
4 BCM: 51 B532	0.014 %	< 5.000 %	OK	B1R8(hor)	B1R8(ver)	B2R8(hor)	B2R8[ver
5 BPM: D(B1L8H)	0.013 mm	< 0.200 mm	OK	-4.593	0.194	3.696	-0.183
6 BPM: D(B1L8V)	0.039 mm	< 0.200 mm	OK	P1 You	D1 Vet	82 You	DO New
7 BPM: D(B2L8H)	0.011 mm	< 0.200 mm	OK	DI Xav	0 220	62 X4V	DZ TAV
8 BPM: D(B2L8V)	0.026 mm	< 0.200 mm	OK	-0.386	0.328	-0.370	0.275
9 BPM: D(B1R8H)	0.063 mm	< 0.200 mm	OK	B1 Xdr	B1 Ydr	B2 Xdr	82 Ydr
10 BPM: D(B1R8V)	0.107 mm	< 0.200 mm	OK	0.000	0.000	0.000	0.000
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	Velo Resolvers (mm)		1	
14 BPM: B1 Yav	0.328 mm	< 4.000 mm	OK	XA	xc	YAC	
15 BPM: [B2 Xav]	0.370 mm	< 4.000 mm	OK	27.000	27.000	0.001	
16 BPM: B2 Yav	0.275 mm	< 4.000 mm	OK	27.000	-27.000	-0.001	
17 BPM: B1 Xdr	0.000 mm/s	< 0.100 mm/s	OK	Marketter ber			
18 BPM: B1 Ydr	0.000 mm/s	< 0.100 mm/s	OK	velomaiv	es distano	:e (mm)-	1
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	53.9	98 0.0	28	
21 VTX: XVA + XVC	1.583 mm	< 10.000 mm	OK	Deam Dea	itian A al	de (mm)	yer.
22 VTX: XA+XVA-XC-XVC - 310ur	n 0.001 mm	< 0.300 mm	OK	Beam Po	sition A-si	de (mm)	
23 VTX: SXVA	0.046 mm	< 0.600 mm	OK	XVA	YVA	ZVA	time
24 VTX: SYVA	0.046 mm	< 0.600 mm	OK	-26.208	0.116	-5.316	elapsed
25 VTX: SXVC	0.042 mm	< 0.600 mm	OK	SYA	CYA	676	Pert
26 VTX: SYVC	0.046 mm	< 0.600 mm	OK	0.046	0.046	E0 002	
27 VTX: D(XVA)	973.792 mm	< 9999.000 mm	D OK	0.046	0.046	50.003	
28 VTX: D(YVA)	1000.116 mm	< 9999.000 mm	n OK			<u></u>	
29 VTX: D(XVC) 1027.791 n		< 9999.000 mm	n OK	Beam Po	sition C-si	de (mm)	
30 VTX: D(YVC)	1000.088 mm	< 9999.000 mm		XVC	YVC	ZVC	
31 HV: bias current (A-side)	7411.712 UA	< 15000.000 uA	A OK	27,791	0.088	5.891	
32 HV: bias current (C-side)	9398.467 uA	< 15000.000 uA	A OK	6140			
	A COMPANY OF A COMPANY OF			SXC	SYC	SZC	1
				0.042	0.046	50.008	



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





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
- \circ check for collision with RFFoil 3D laser scan
- with Liv. metrology data provides reference for alignment









A-side installation schedule May 10th to 17th

ACCESS @ P8

- 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





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 CO₂ 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

- CO₂ 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!







Alignement from metrology preliminary

Black: Design Yellow: Actual







