



Beam Gas Curtain (BGC) Design and Plans

Gerhard Schneider for BGC Collaboration Team

Beam Gas Curtain (BGC):
baseline instrument for on-line monitoring of the overlap between proton and electron beams in the hollow e-lens and as a general non-invasive profile measurement diagnostic

12th HL-LHC collaboration meeting 20 09 2022 Uppsala



Science and
Technology
Facilities Council



UNIVERSITY OF
LIVERPOOL

Content

- BGC Collaborations
- BGC v3 Tunnel installation Phase 1
- BGC v3 on Electron Beam Test Stand (EBTS)
- BGC v3 Tunnel installation Phase 2
- BGC v4 final instrument

Notes:

BGC v3: Demonstrator instrument

BGC v4: Final instrument for Hollow Electron Lens

Presentation Share

My presentation: Hardware, Installations and Planning

Presentation Ondrej Sedlacek: Tests and Physics

BGC Collaborations



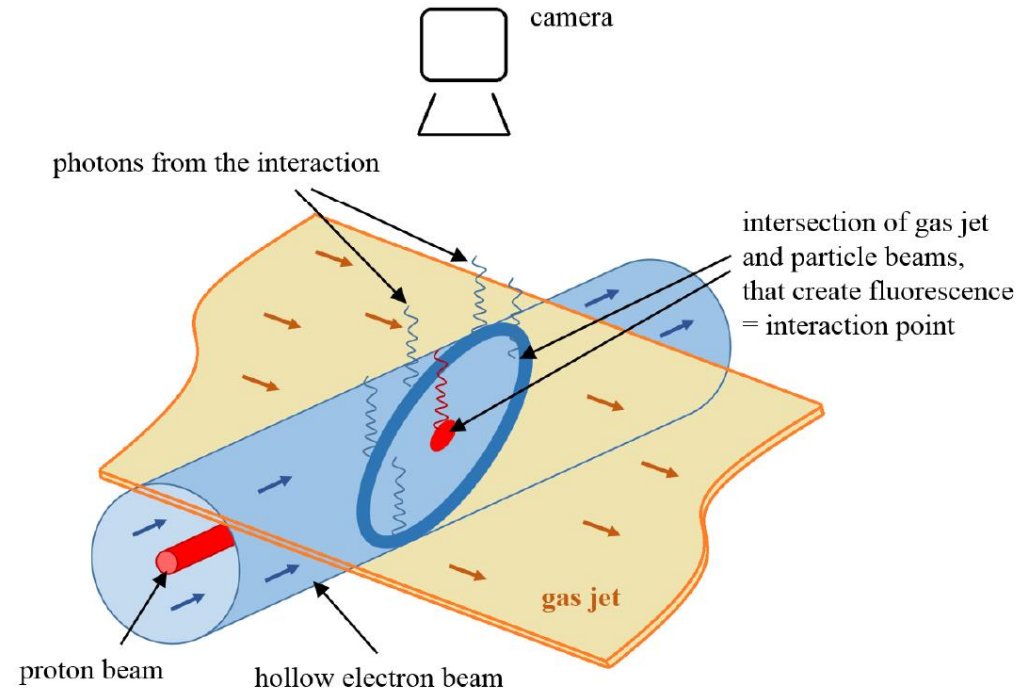
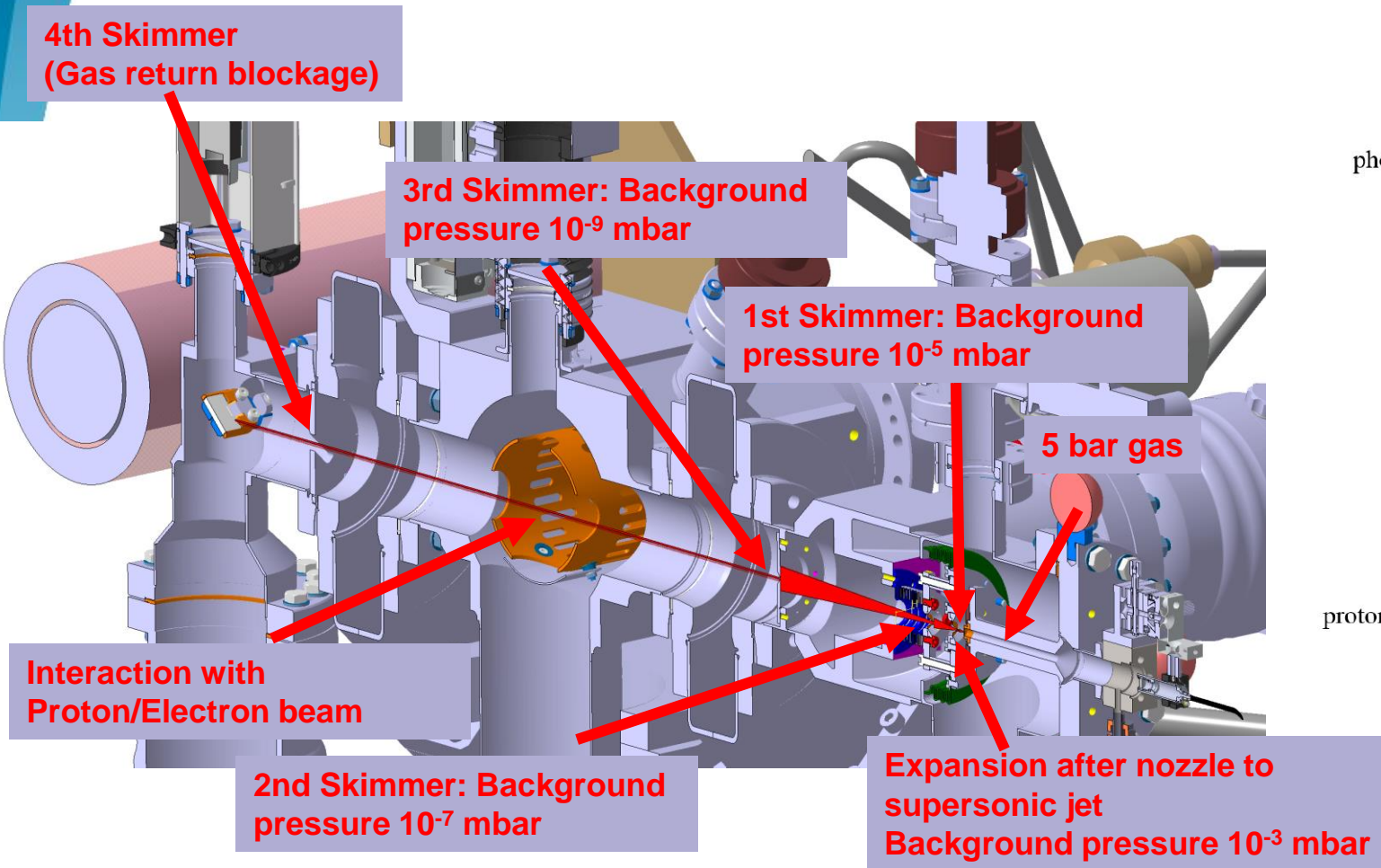
- BGC Collaboration with deliverable v3
 - Liverpool University/Cockcroft Institute: KE3298/BE/HL-LHC Addendum Nr. 3
 - GSI: KE3036/BE Addendum Nr. 10



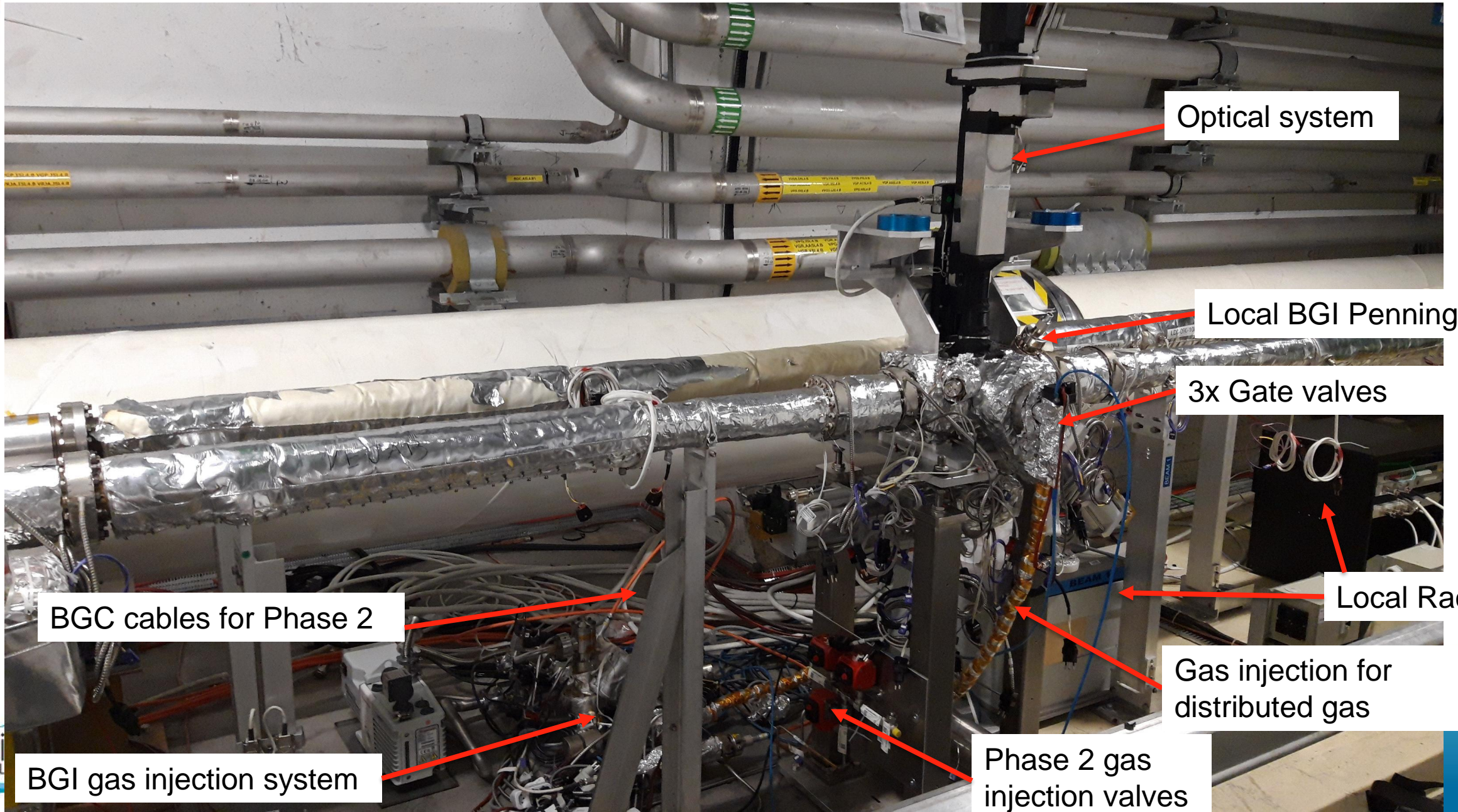
- BGC v4 final instrument
 - In-kind contribution Liverpool University/Cockcroft Institute (UK2), CERN EDMS 2369616
 - CERN supply: HL-LHC infrastructure for LHC operation



Beam Gas Curtain principle



BGC tunnel installation today (Phase 1)



Summary LHC tunnel installations (Phase 1) resulting from approved ECRs

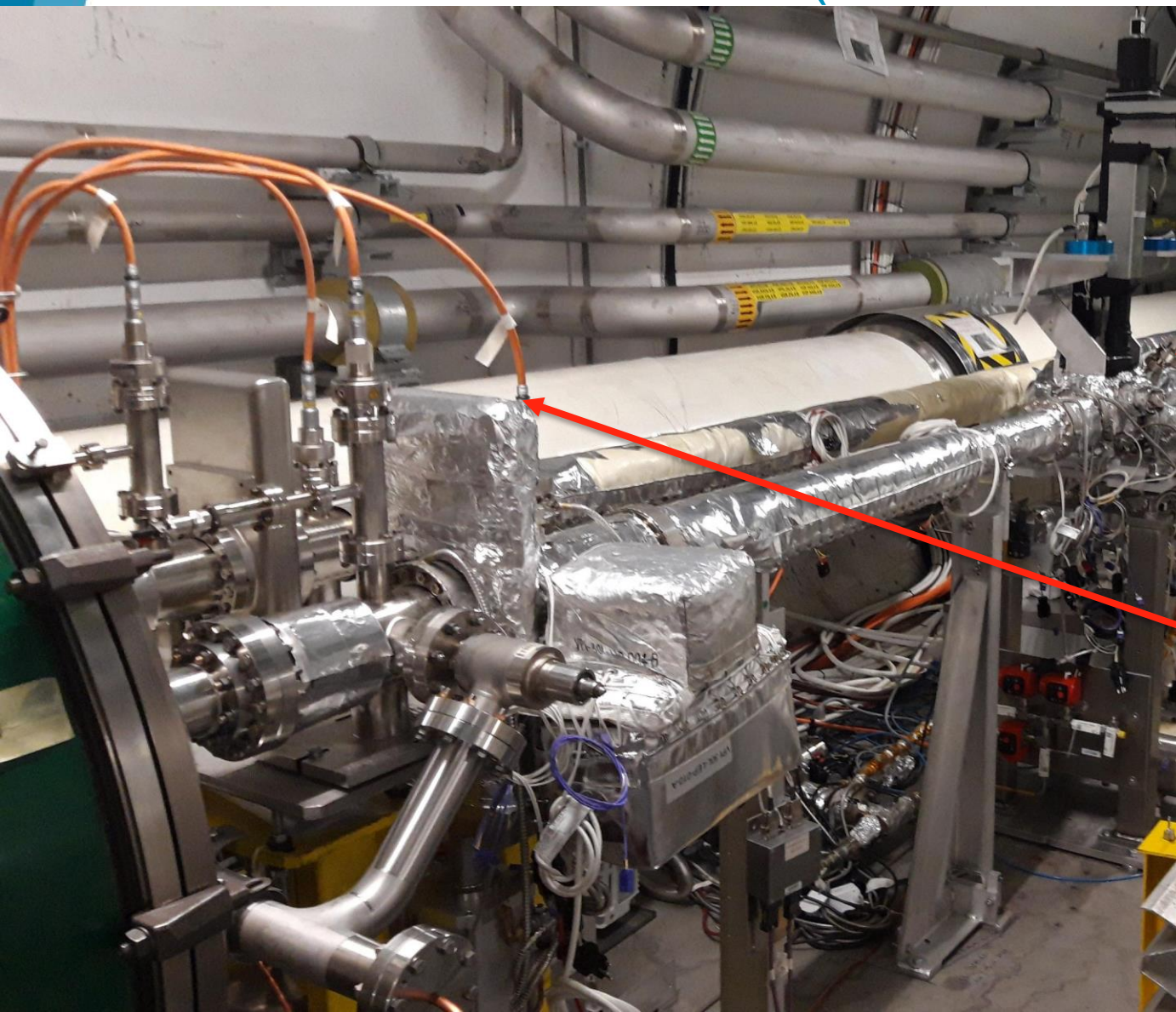
Done in LS2 and YETS 21/22

- BGC Installed in the LHC
- Gas line is pulled from the gas bottle to the BGC (for Phase 2)
- Gas line valves installed
- Compressed air for the valves pulled
- Power cables pulled
- Fibre optics cable pulled and rack installed
- BGI gas system and control rack now operational on BGC, Injection made
- Optical system installed and operational

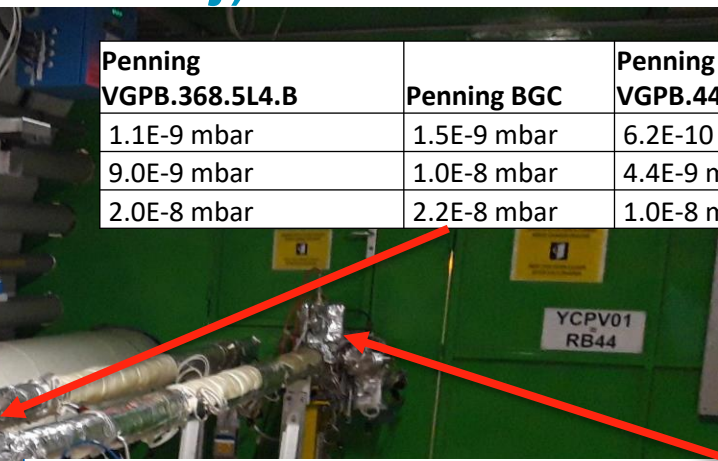
ECR 2025553 + ECR 2363497 = LS2 + YETS 21/22



V3 Phase 1: Operational for distributed gas injection (more see Ondrej)



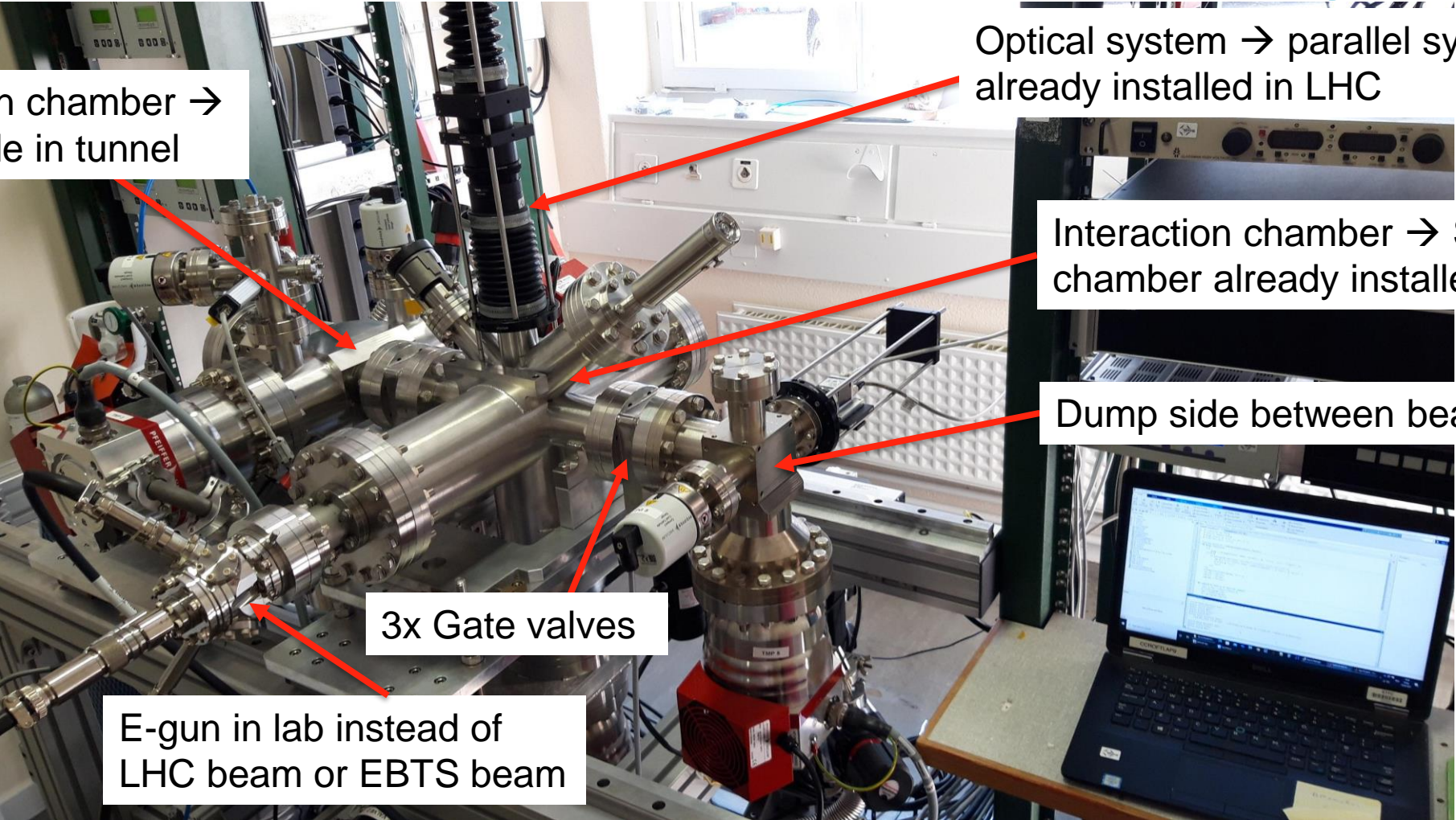
Penning VGPB.368.5L4.B	Penning BGC	Penning VGPB.443.5L4.B
1.1E-9 mbar	1.5E-9 mbar	6.2E-10 mbar
9.0E-9 mbar	1.0E-8 mbar	4.4E-9 mbar
2.0E-8 mbar	2.2E-8 mbar	1.0E-8 mbar



**A big thanks to all of you helped that we now
can take data with the LHC beam and with
distributed gas in the 2022 Run!!**

**First Neon gas injections with LHC beam were
done with the BGC via the BGI gas injection
system, looking forward for more data!**

Phase 2 instrument with Gas Curtain delivered from Cockcroft Institute/Liverpool University to CERN in March 2022 → This is the real thing...



Gas injection chamber → Passage side in tunnel

Optical system → parallel system already installed in LHC

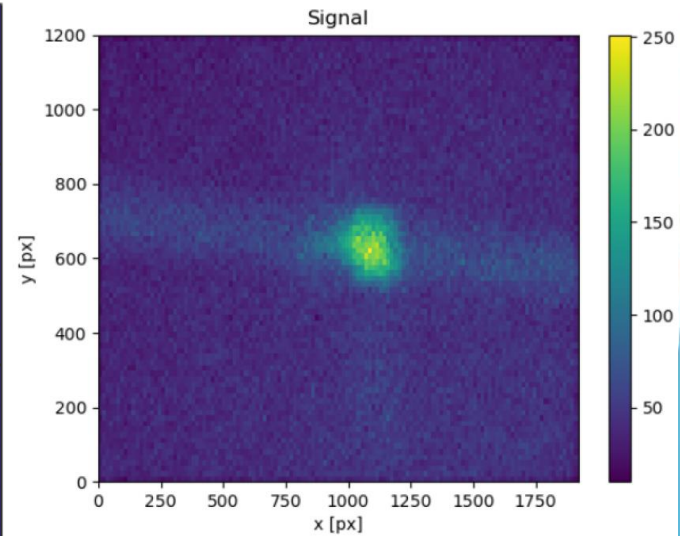
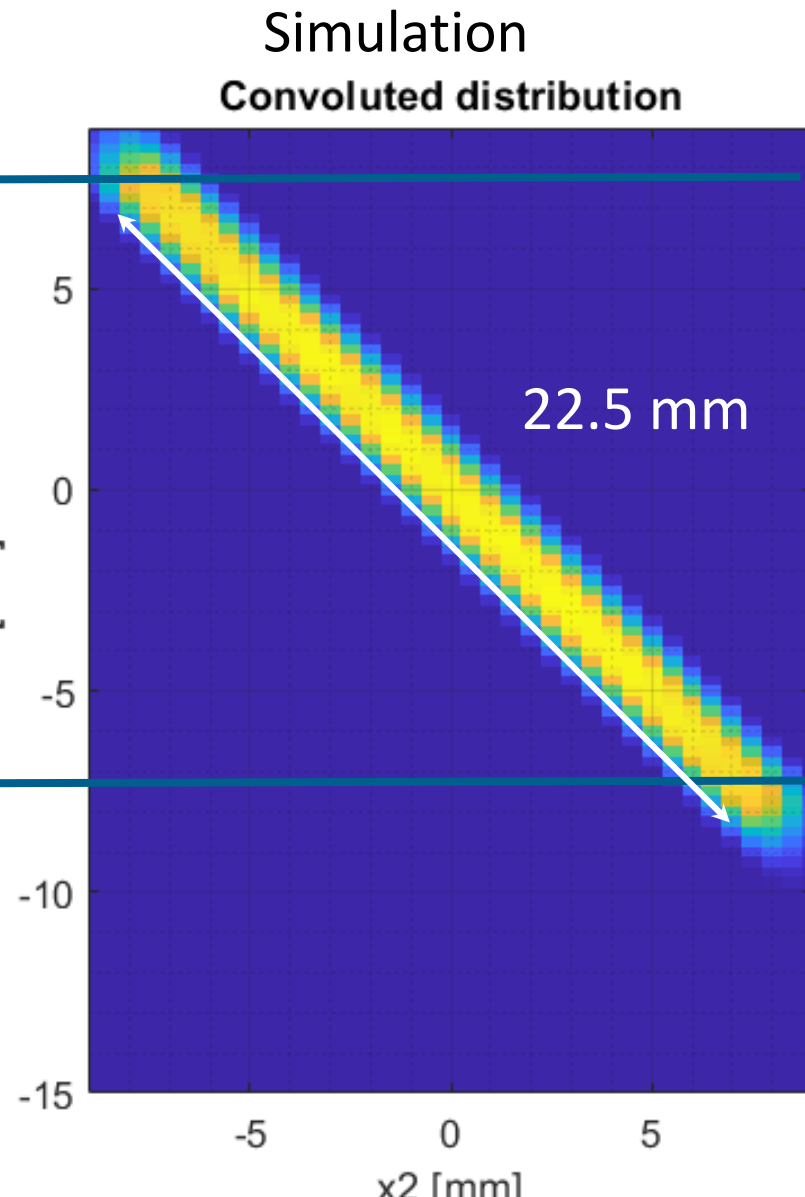
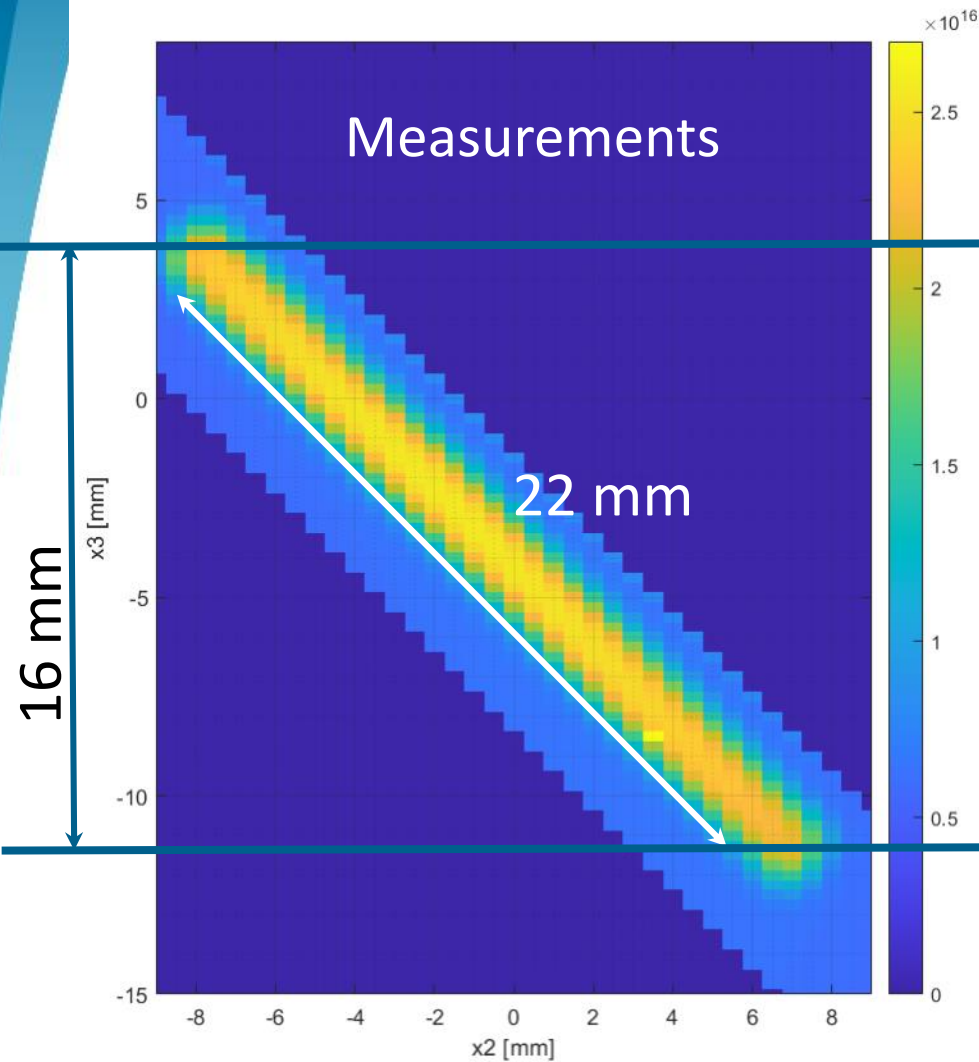
Interaction chamber → Sister/Brother chamber already installed in the LHC

Dump side between beam pipes

3x Gate valves

E-gun in lab instead of LHC beam or EBTS beam

... and it works



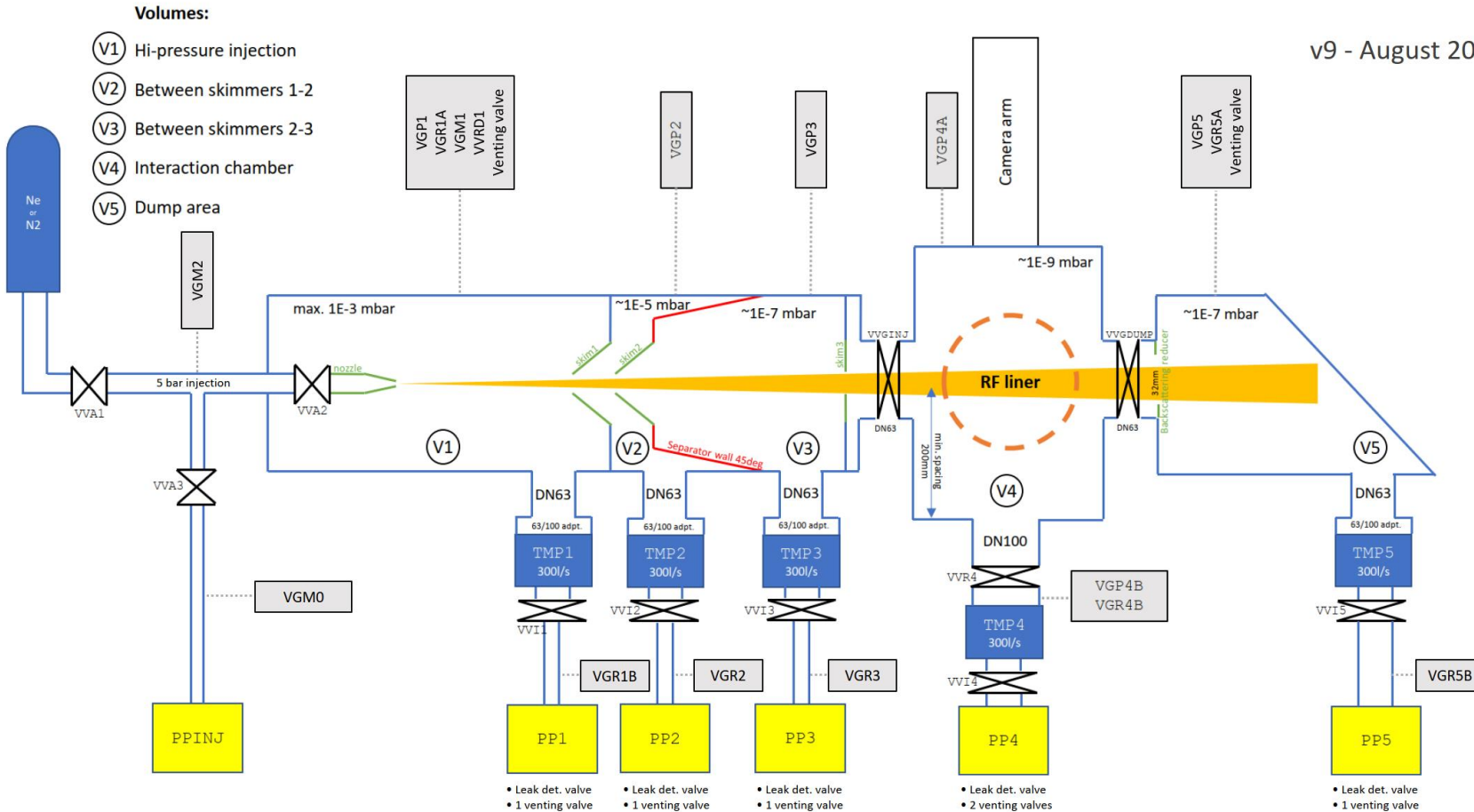
Observed E-beam
v3 at CERN

Phase 2: Go from Laboratory Vacuum system to LHC compatible Vacuum System

TE-VSC and EN-CV colleagues actively working on:

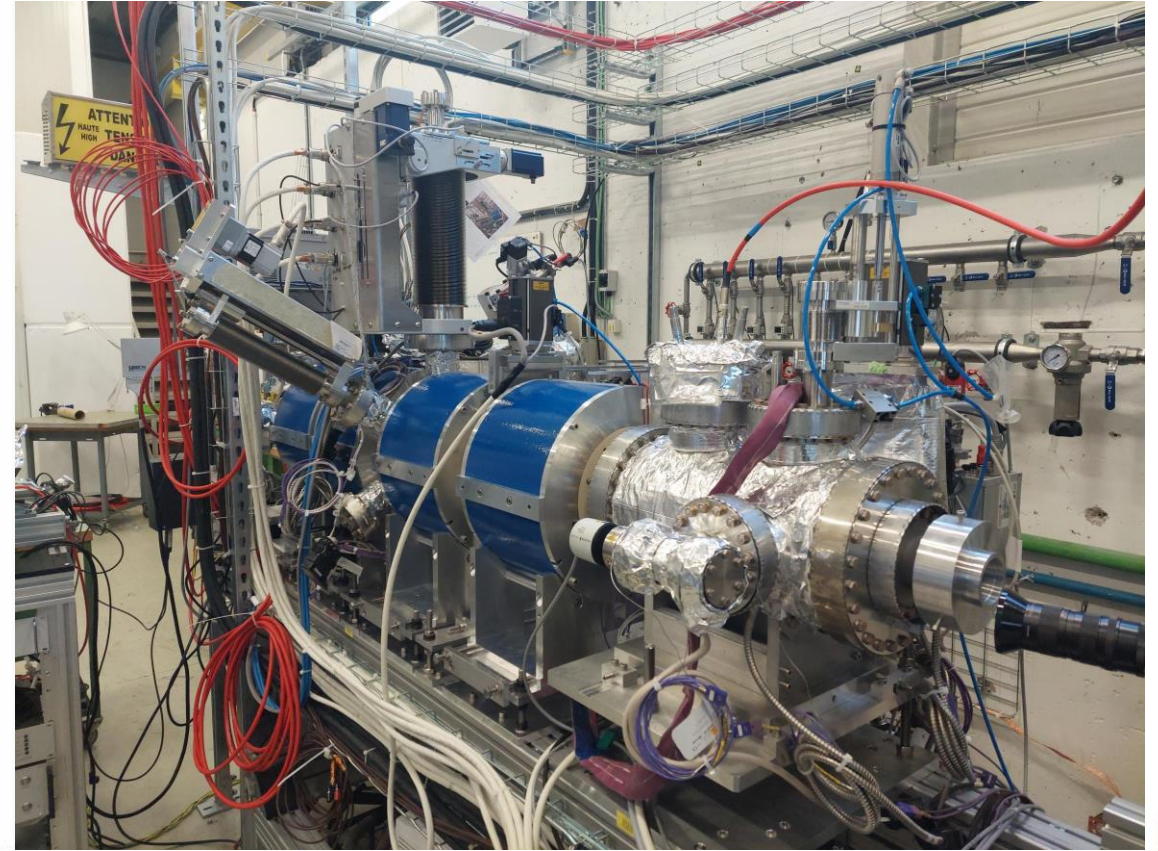
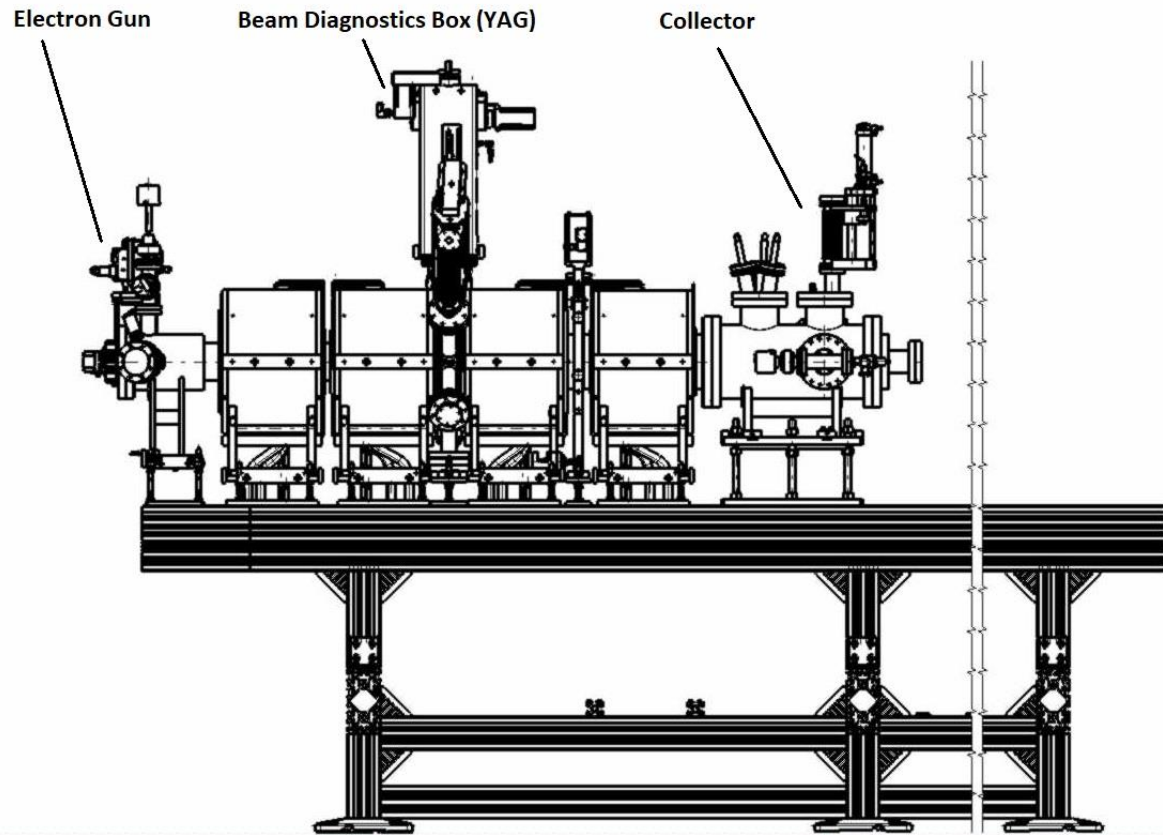
v9 - August 2022

- BGC vacuum aspects relevant for LHC operation (Gas loads, pump-down times...)
- LHC compatible operation (Start, operation and stop...)
- Implementation in the LHC (last cables requested)
- Ordering PLC and other control equipment ongoing
- Assure safe operation (separate compressed air arrival for BGC valves, local solution without depressurisation the compressed air mains)

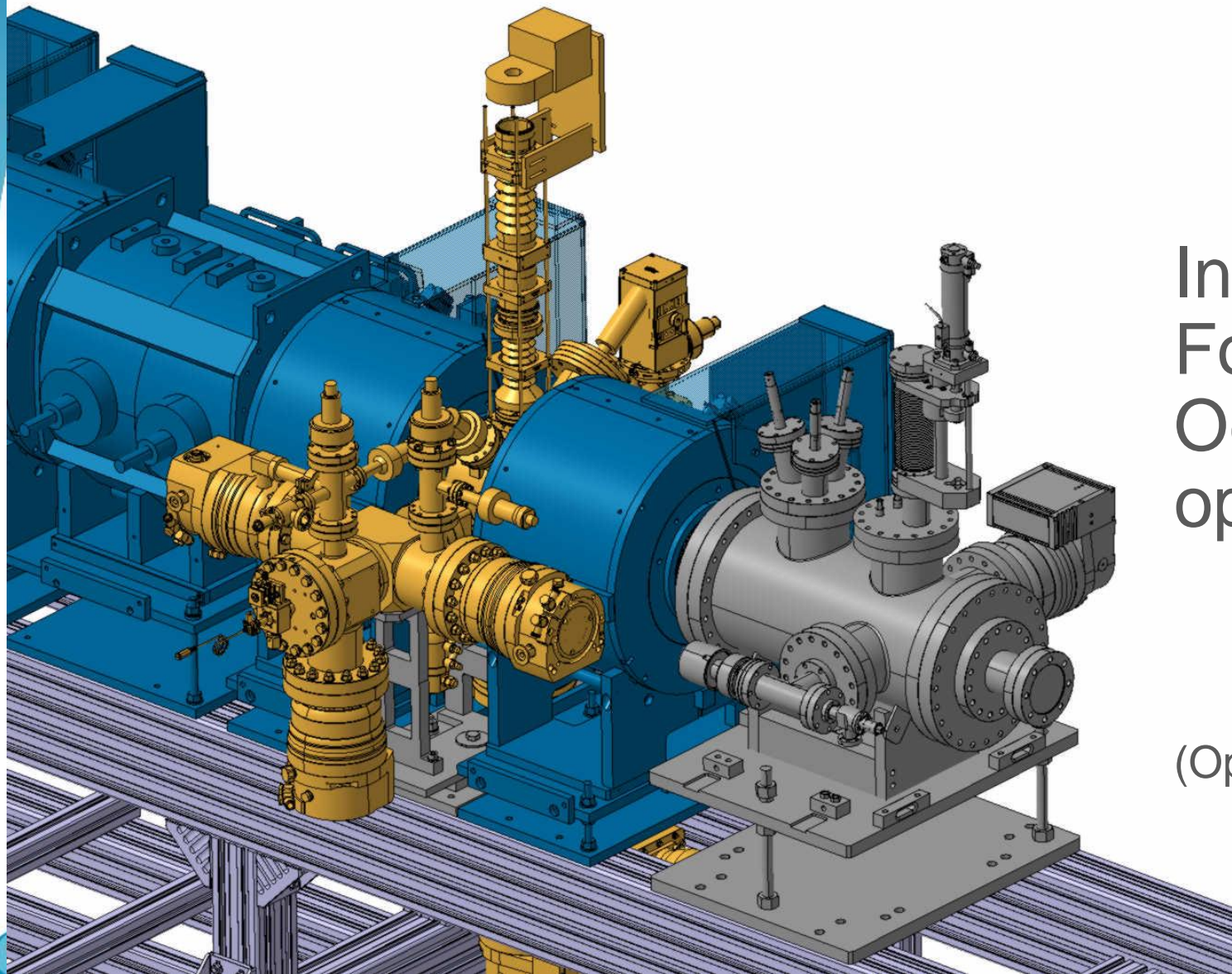


Before installation in the LHC: Test on Electron Beam Test Stand (EBTS)

Current situation; Electron Gun & Collector Current



BGC on Electron Beam Test Stand (EBTS)



Install BGC on EBTS.
Foreseen installation:
October 2022 followed by
operation

(Operational Programme → see Ondrej)

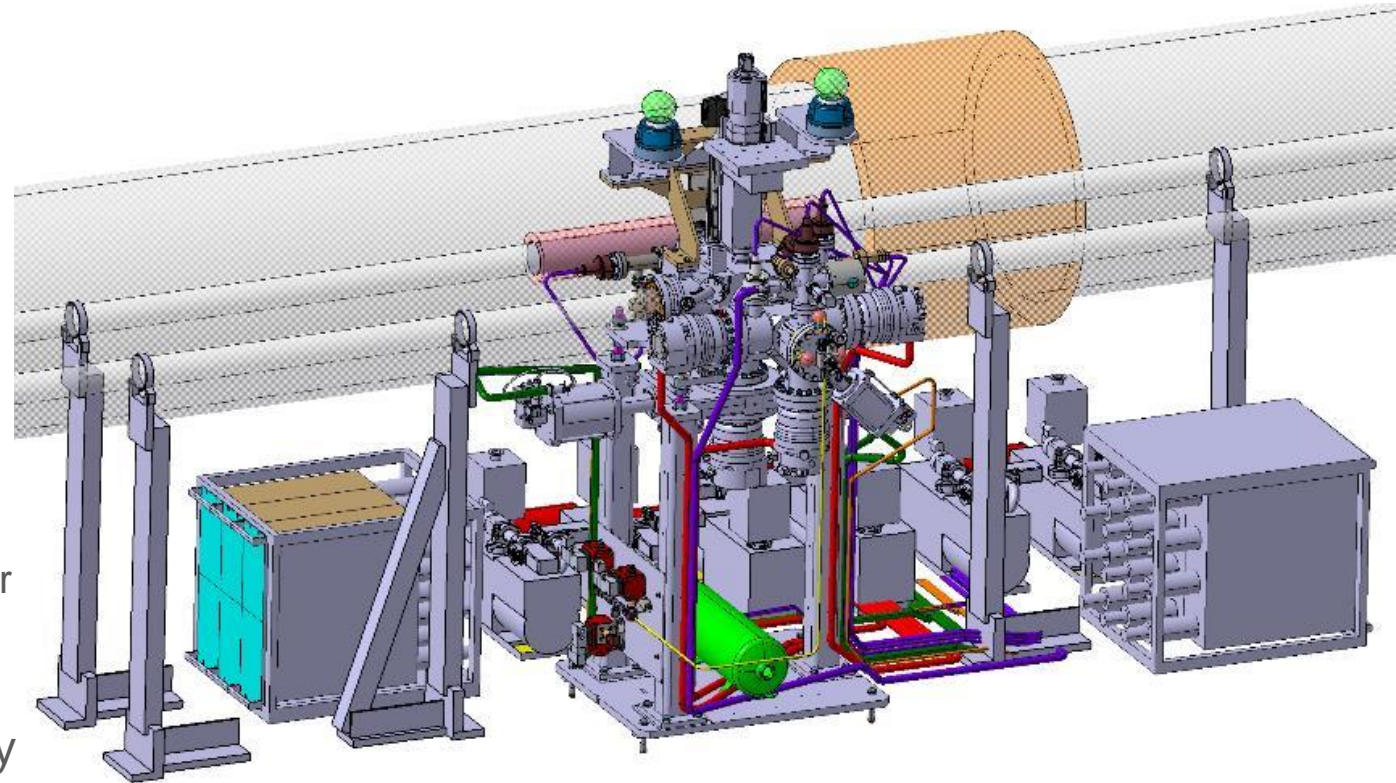
Phase 2 Installation in LHC

Remove:

- BGI gas system
- BGI control rack

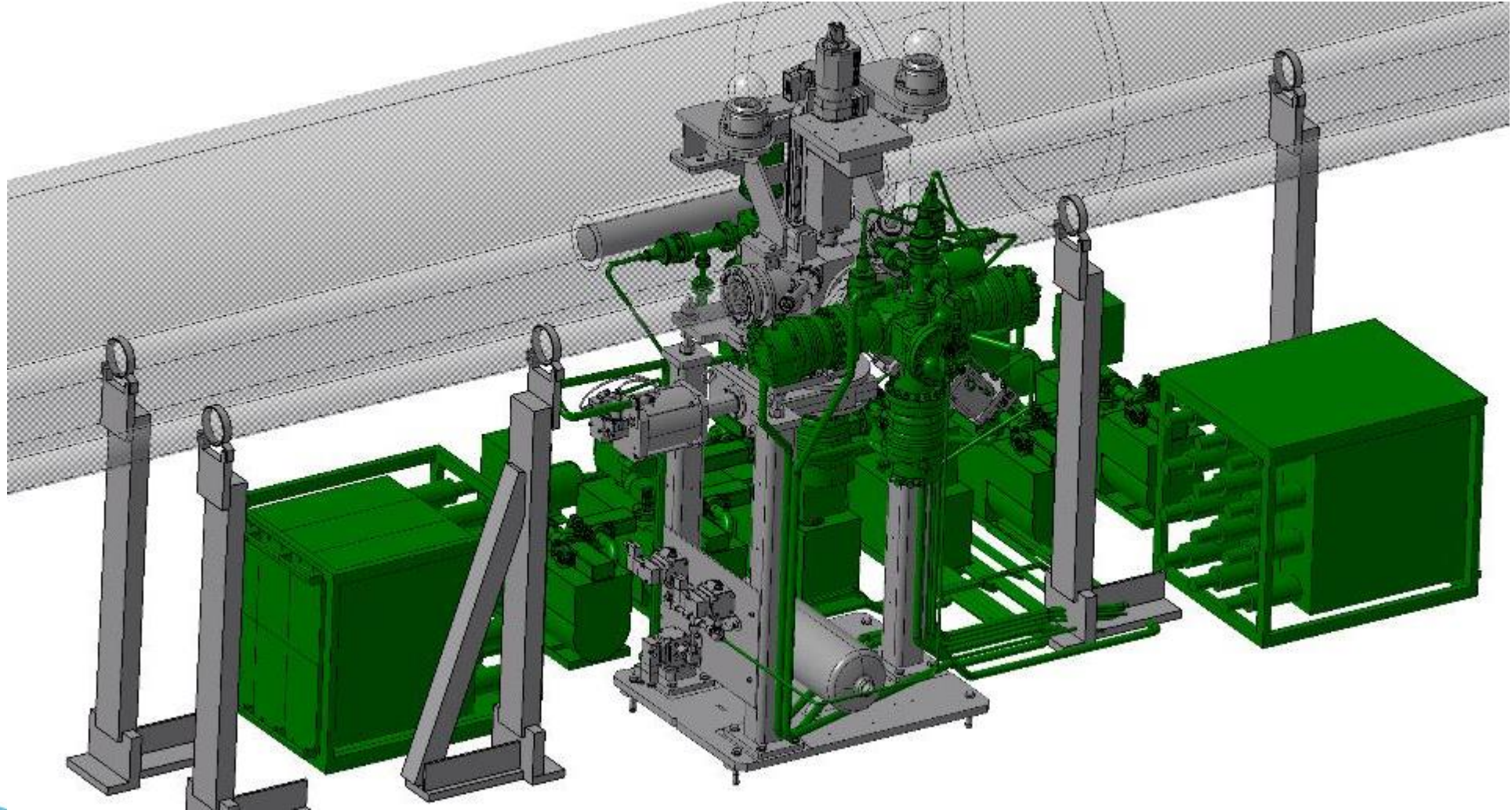
Install:

- 6 primary pumping units
- Gas injection system
- Gas dump chamber
- 5 TMPs:
 - Gas injection system with 3 TMPs
 - Gas dump chamber with 1 TMP
 - 1 TMP directly on the interaction chamber
- Compressed air line to the valves
- 3 solenoids for the gas injection valves
- Add independent compressed air supply for BGC vacuum pumping system



Connect everything to power and controls

Phase 2 to be installed in green



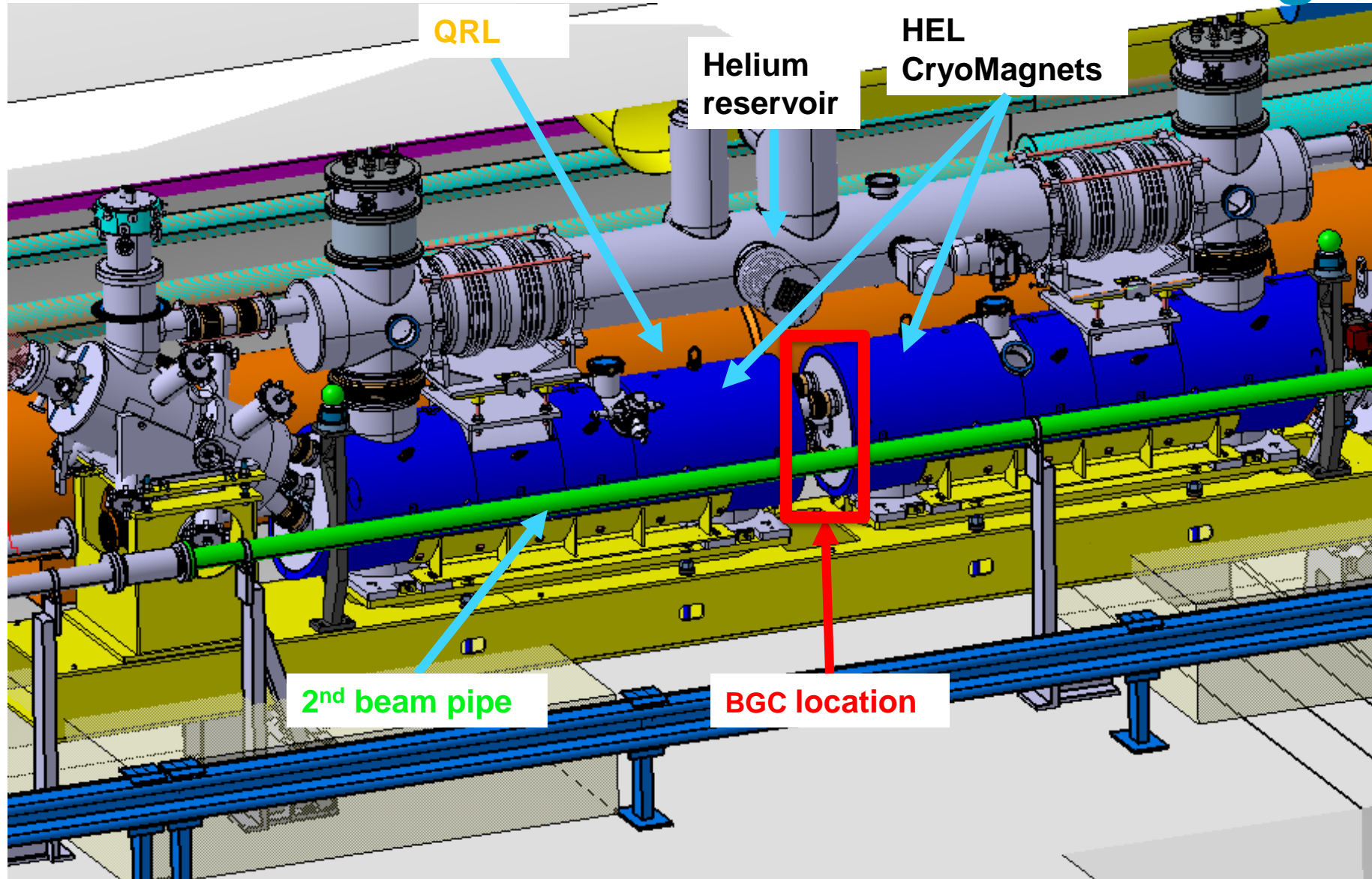
Timeline v3

- Phase 2 BGC validation operation ongoing
- Change from laboratory vacuum system to LHC compatible system ongoing. Objective: Finish by Q4 2022. Challenging controls supply due to global events.
- Validation on EBTS as from October 2022. Foreseen operation about 2 month
- Very challenging but not impossible objective for YETS 2022/23 tunnel installation, not all cards in our hands. Alternative installation in YETS 23/24, which is the more likely scenario

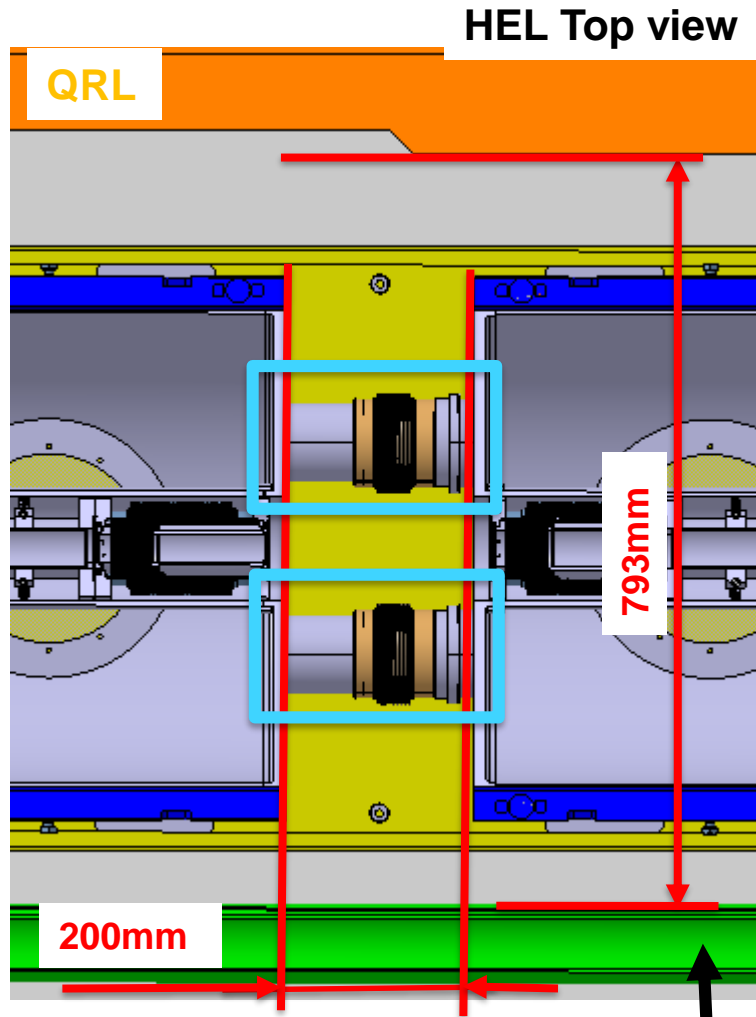
BGC V4: Design constraints

- Space

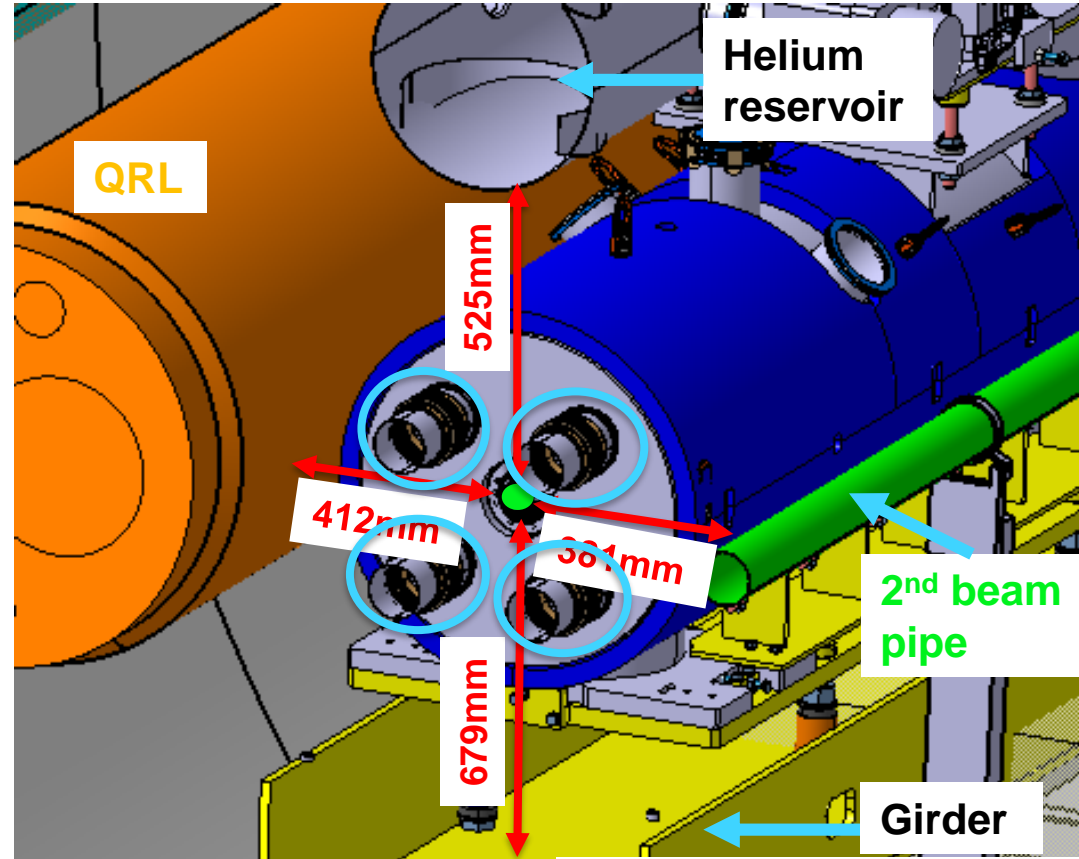
BGC V4 Installation environment P4 right



BGC V4 Space constraints Point 4 Right



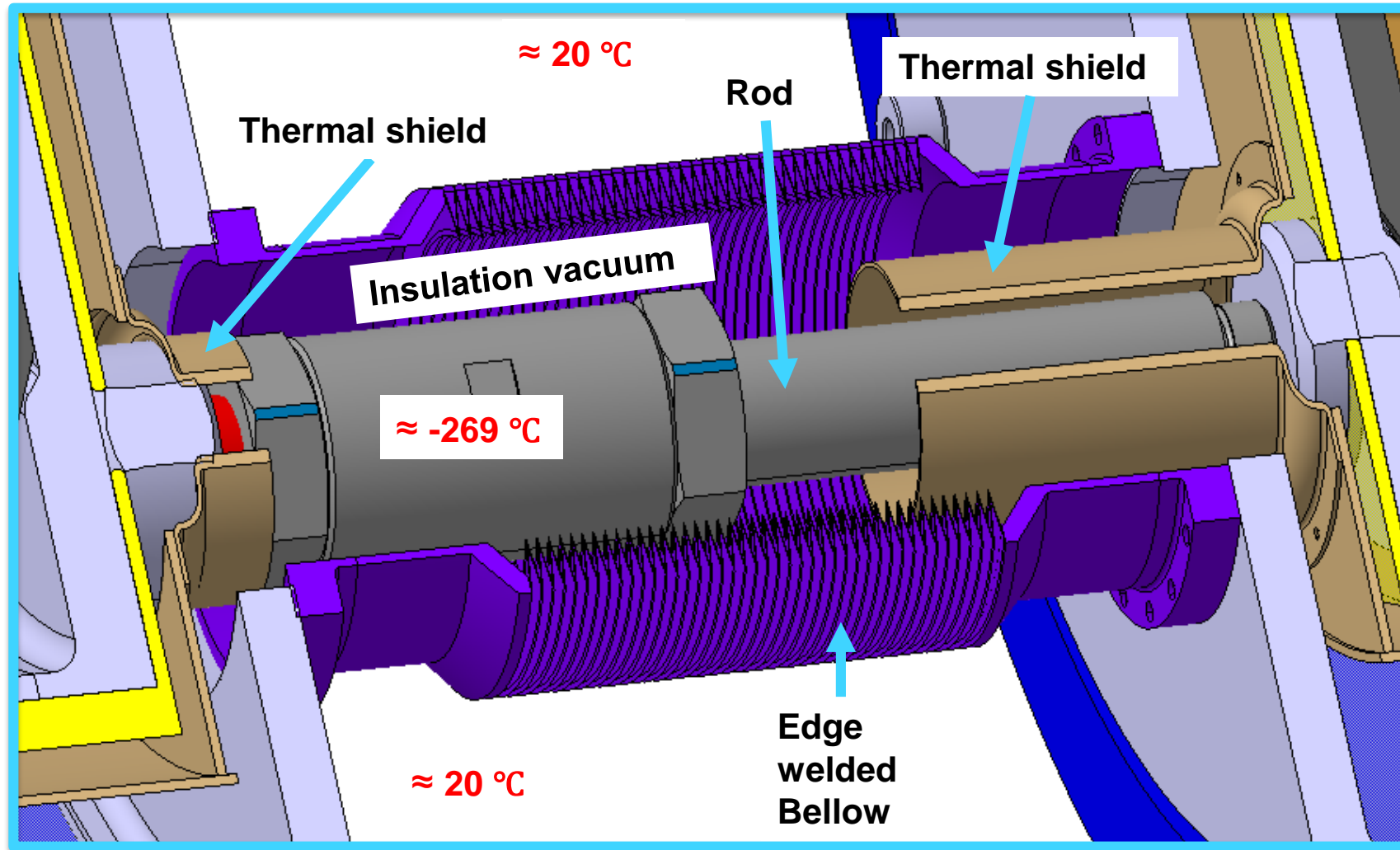
4x Rods in Bellows to compensate for magnets force



HEL cut in BGC location

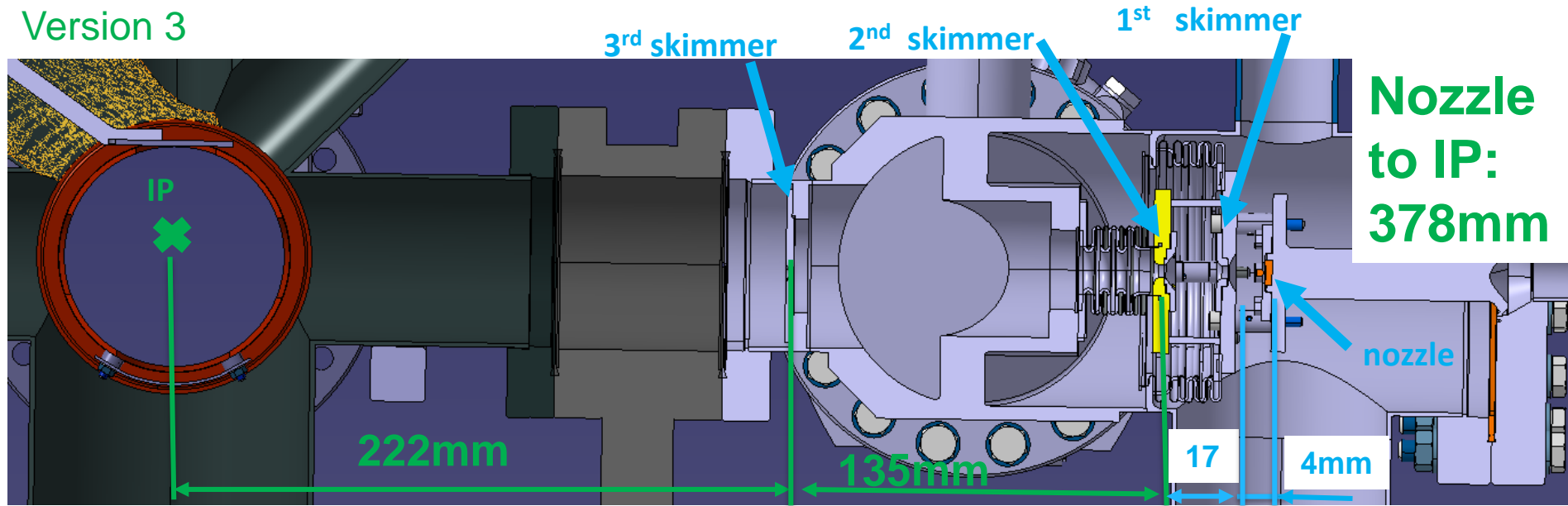
2nd beam pipe

BGC V4 Space constraints Point 4 Right

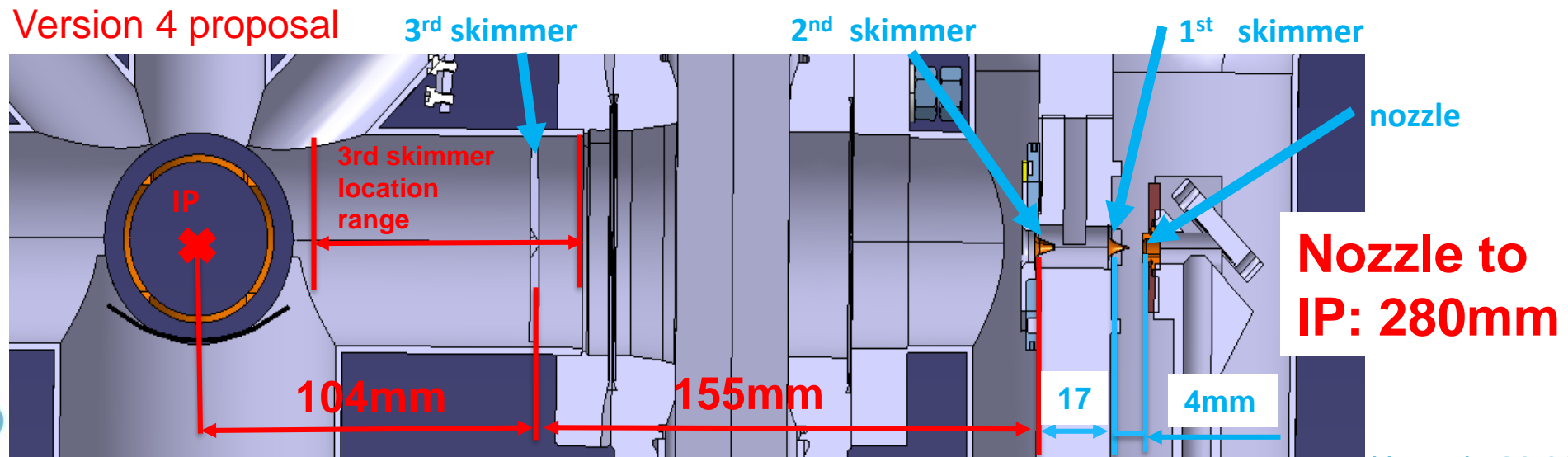


BGC V3/V4 Space comparison

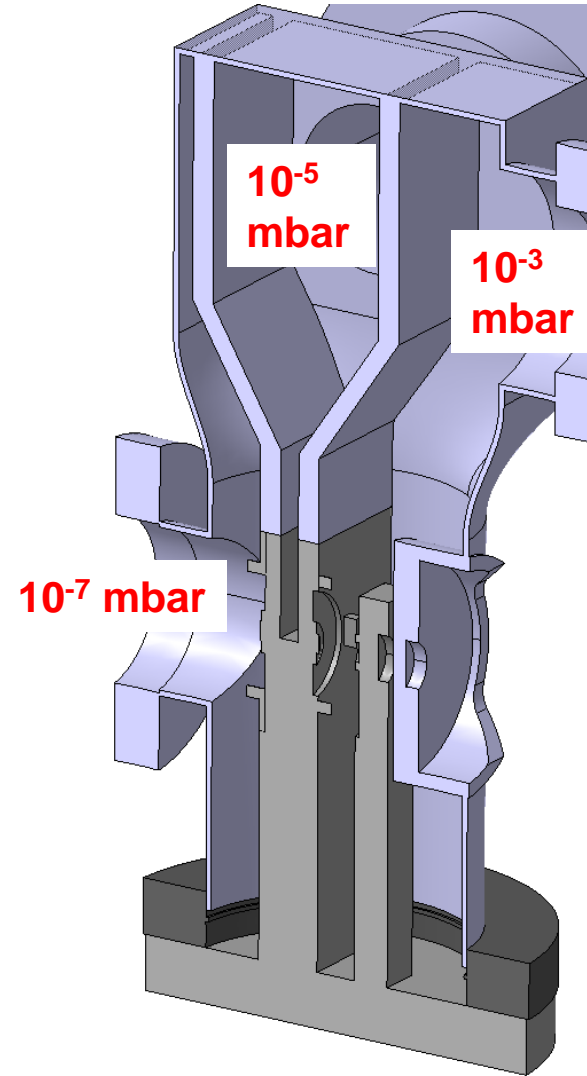
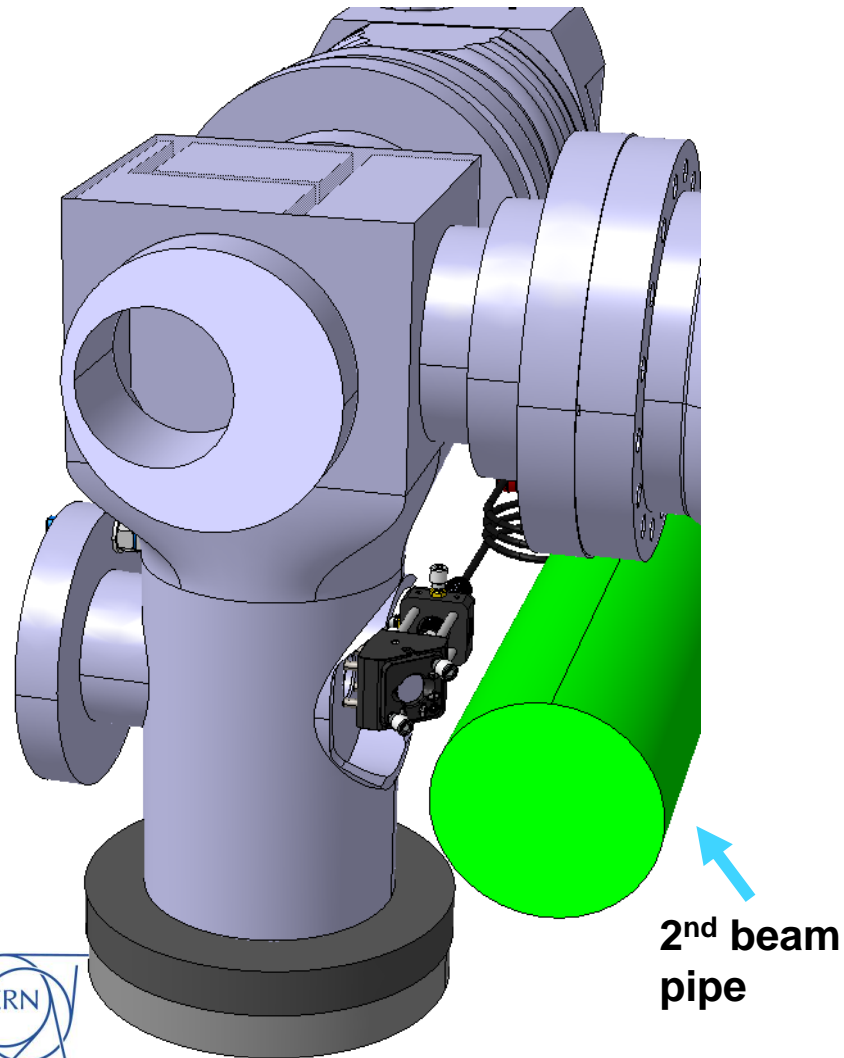
Version 3



Version 4 proposal



V4 related to Space: Optimise conductances to remove injected gas



BGC V4 in HEL

Optical System
(possibly with mirror)

QRL

Gate Valve

Dump Chamber

TMP

Central Chamber

TMP

Helium reservoir

4x Rod

Gate Valve

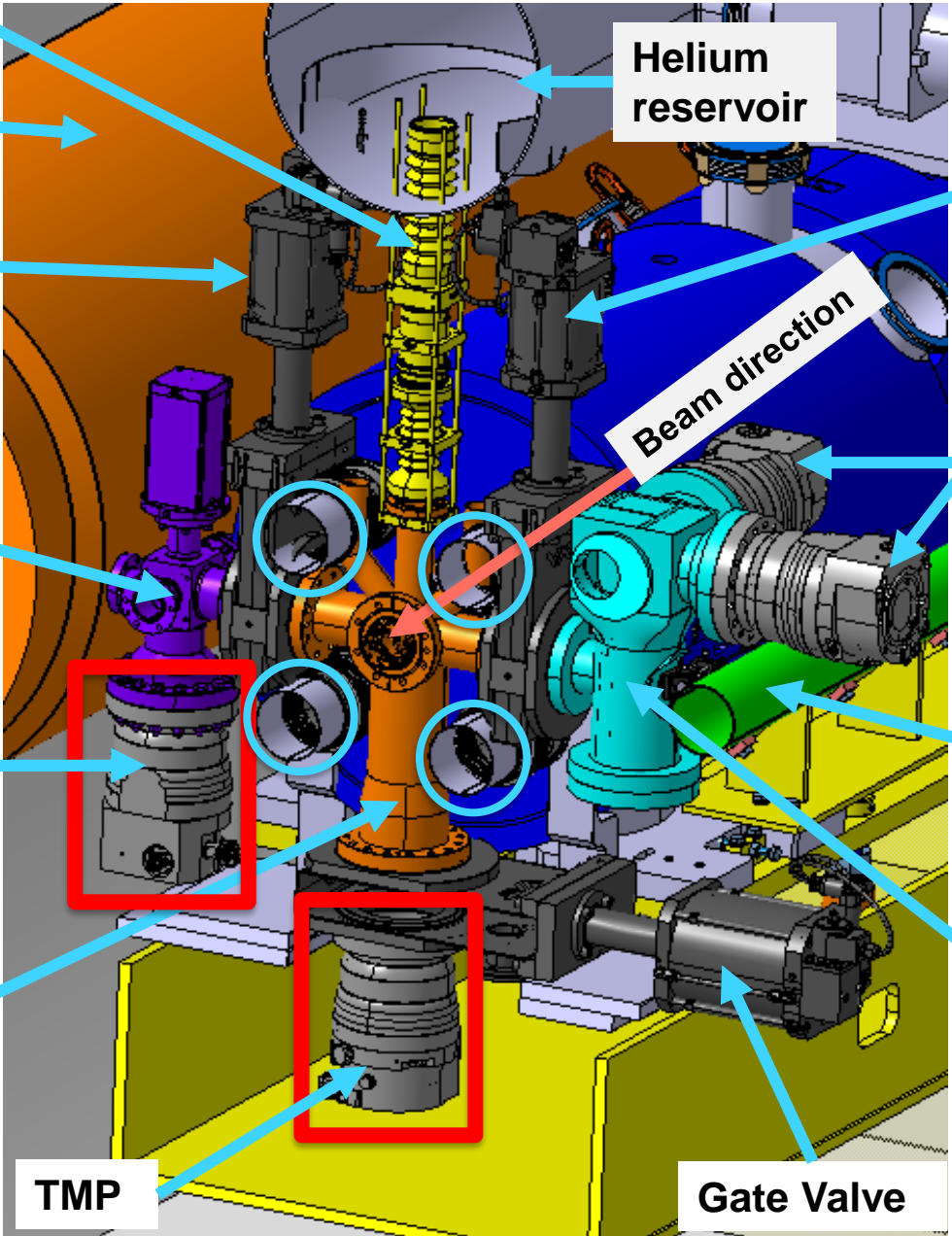
Beam direction

3x Turbo Molecular Pump (TMP) (3rd not shown)

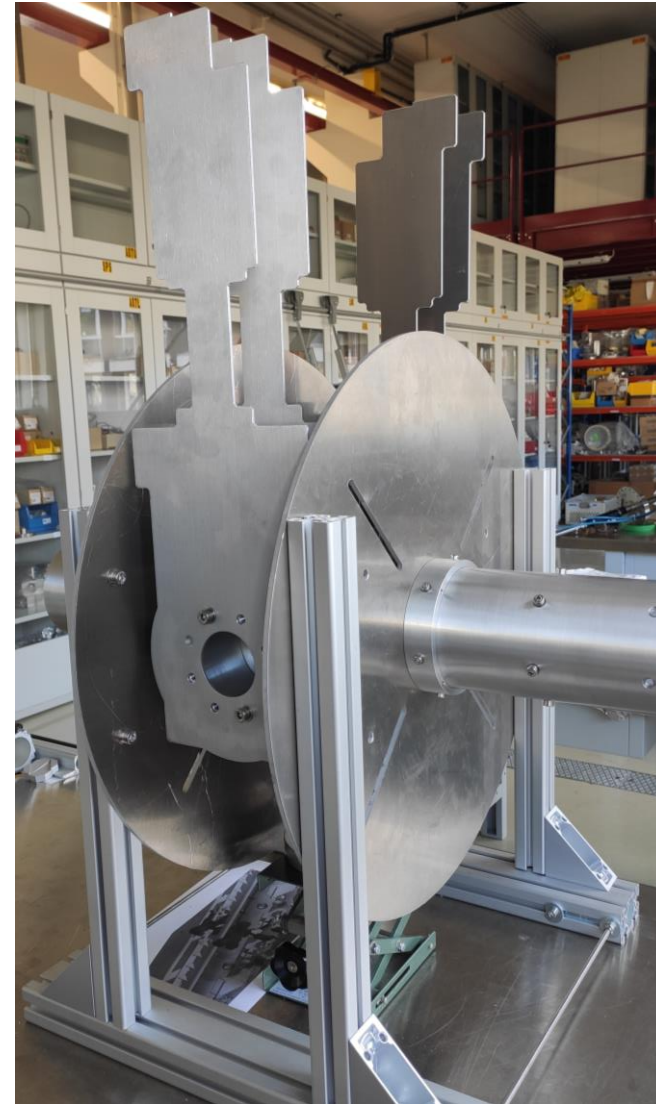
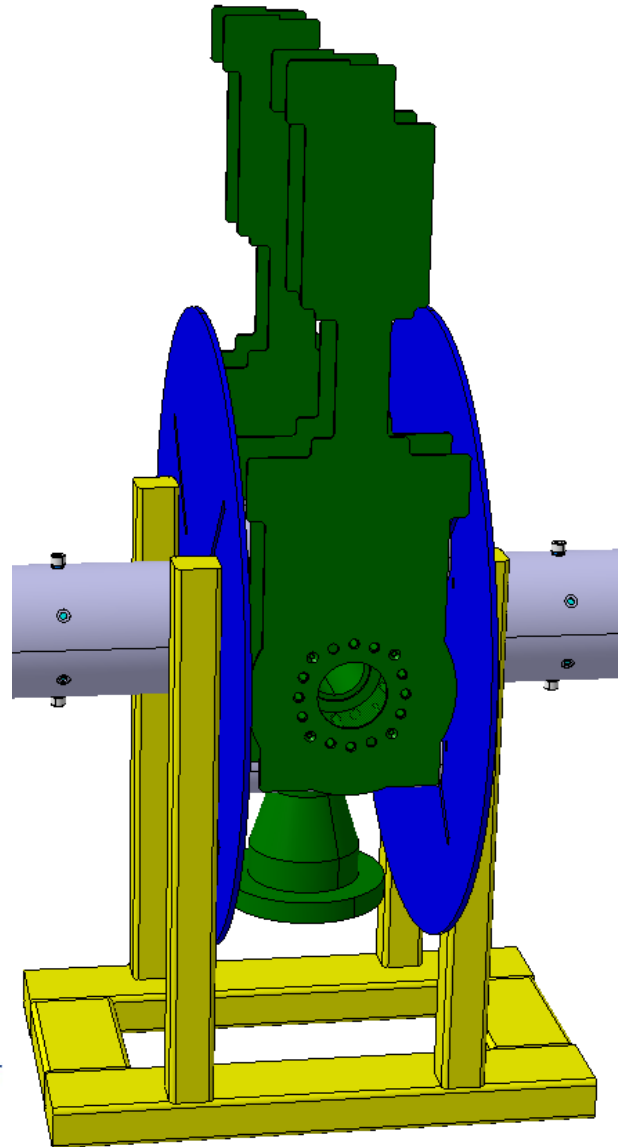
2nd beam pipe

Gas Injection Chamber

Gate Valve



BGC V4 Installation Mock-up: Procedure checked



Summary v3

- Phase 1 BGC installation objectives for distributed gas fully achieved, operation with Neon injected with LHC beam has started.
- Phase 2 BGC installation underway
 - BGC v3 Phase 2 instrument delivered to CERN and fully operational for laboratory use
 - EBTS test required prior to installation
 - Change to LHC compatible vacuum system under way
 - Approval by LHC management after proof of vacuum compatibility
 - Additional cable request by VSC for YETS 22/23 done, minor activity
 - Additional compressed air connection in tunnel addressed
 - Objective for full installation in YETS 22/23, very challenging. Alternative YETS 23/24

Summary v4

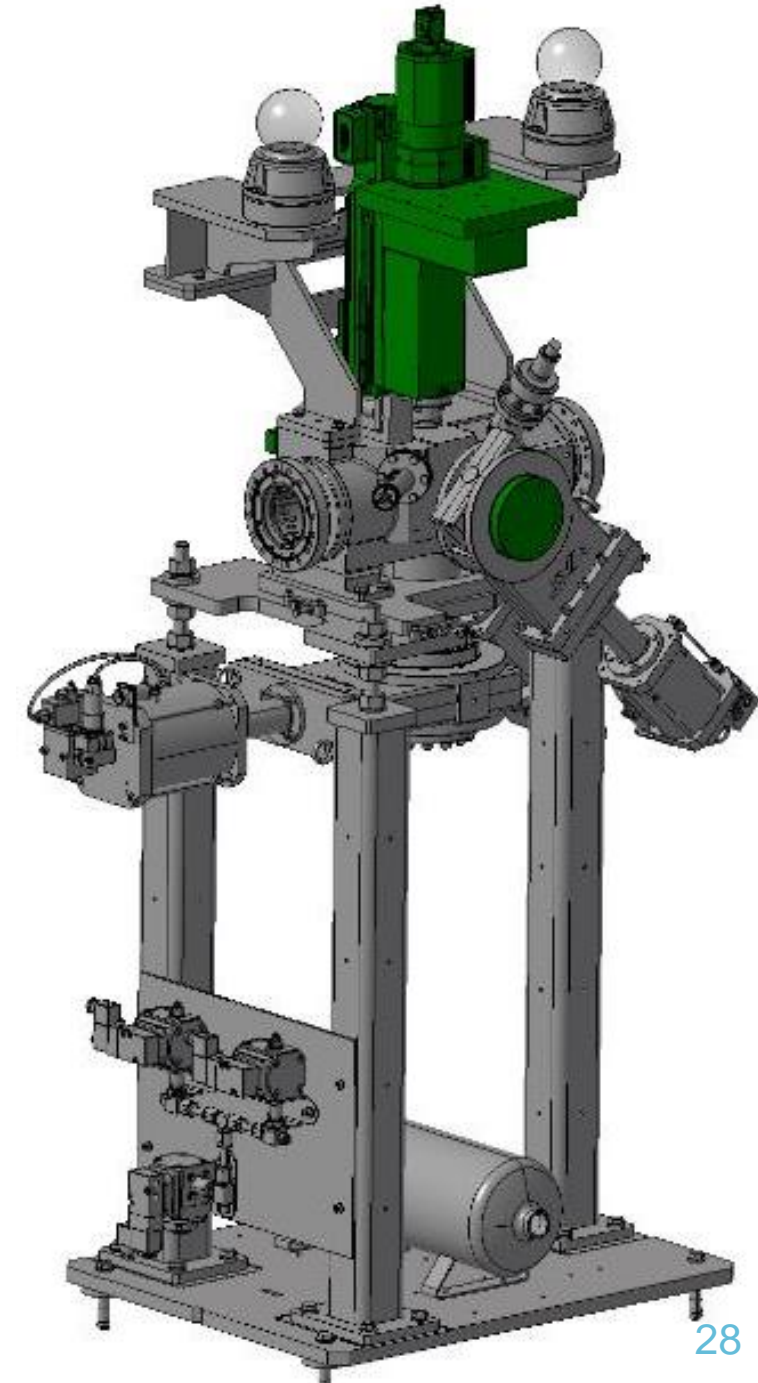
- In-kind contribution from Liverpool/Cockcroft institute (UK2)
- Engineering well advanced
- Further challenges to optimise conductance on gas injection side



Questions?



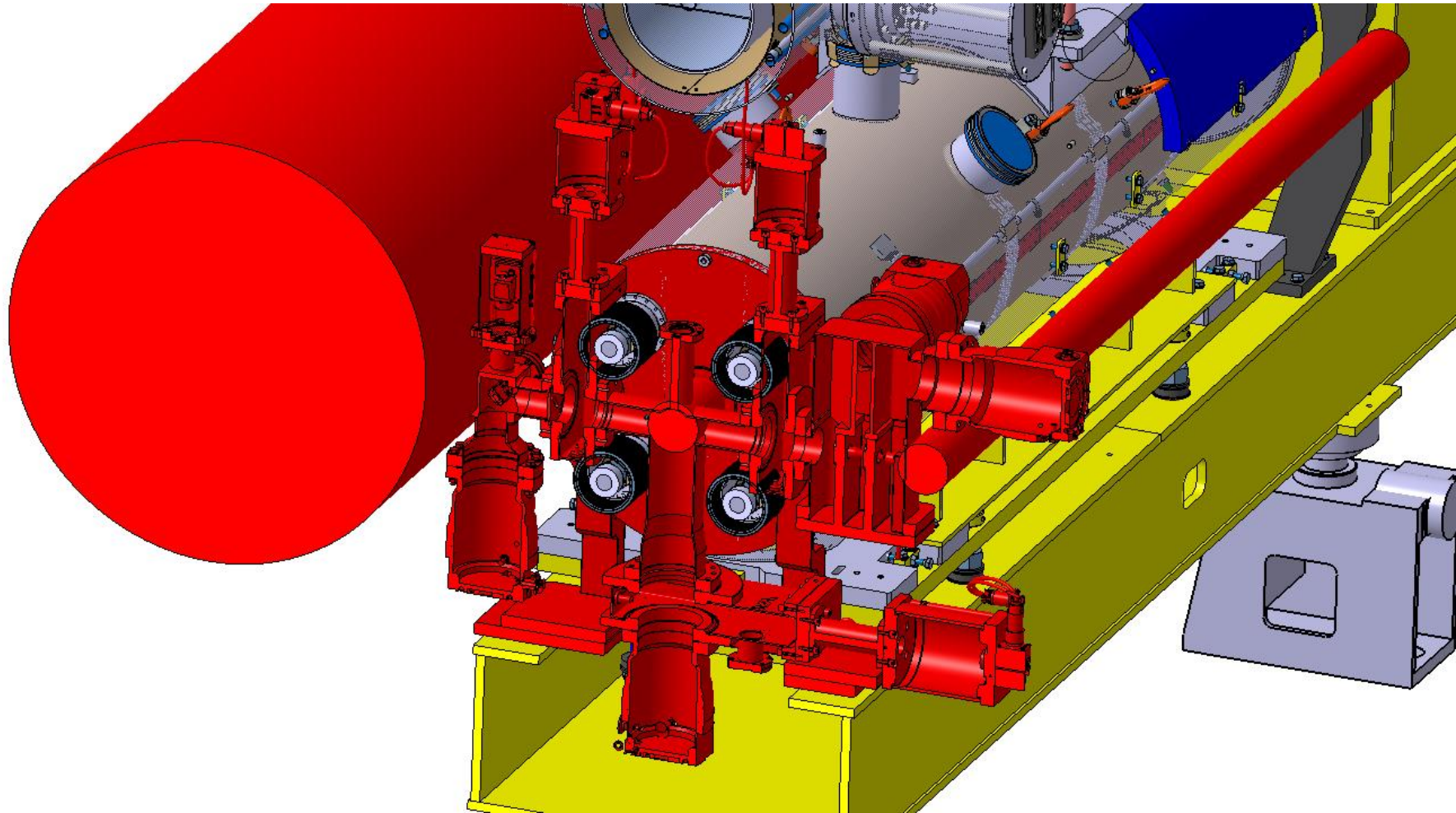
BGC Phase 1



BGI Gas injection system next to BGC



Final BGC version (V4) in HEL, here 4R



Design of final instrument (V4) for HEL well in Progress

Challenge: Space

