Beam Gas Curtain (BGC) monitor : Implementation in LHC during LS3

Gerhard Schneider, Daniele Butti, Chiara Pasquino, Raymond Veness

HL-LHC Beam Halo Review 18.12.2024

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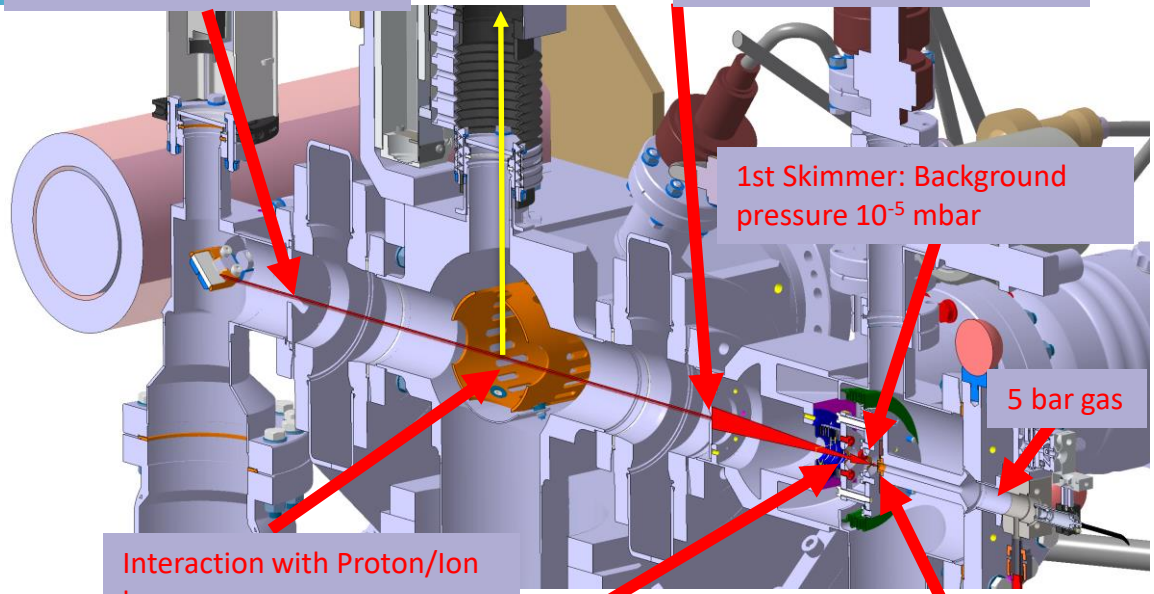
BGC Operation Principles as Halo Monitor as explained by Daniele with 2 operation options

- BGC as Halo Instrument with beam imaging using fluorescence

- BGC as Halo Instrument with beam profiler using beam losses

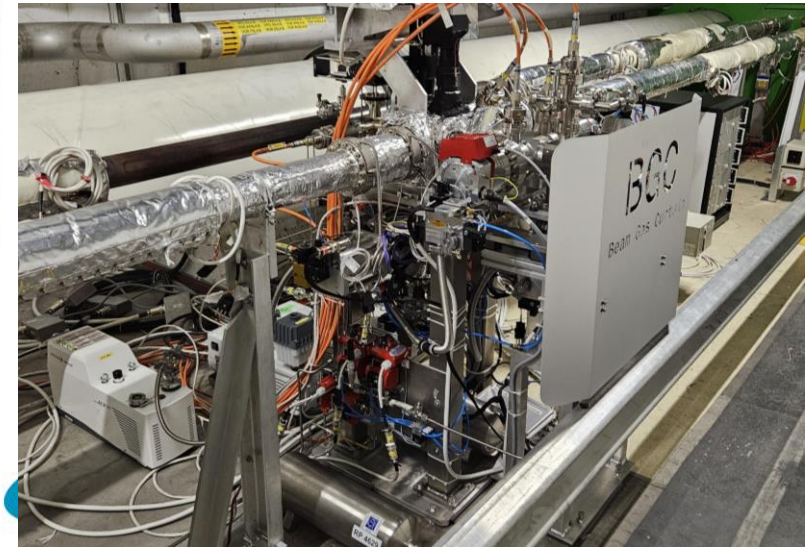
Design Elements of the Beam Gas Curtain

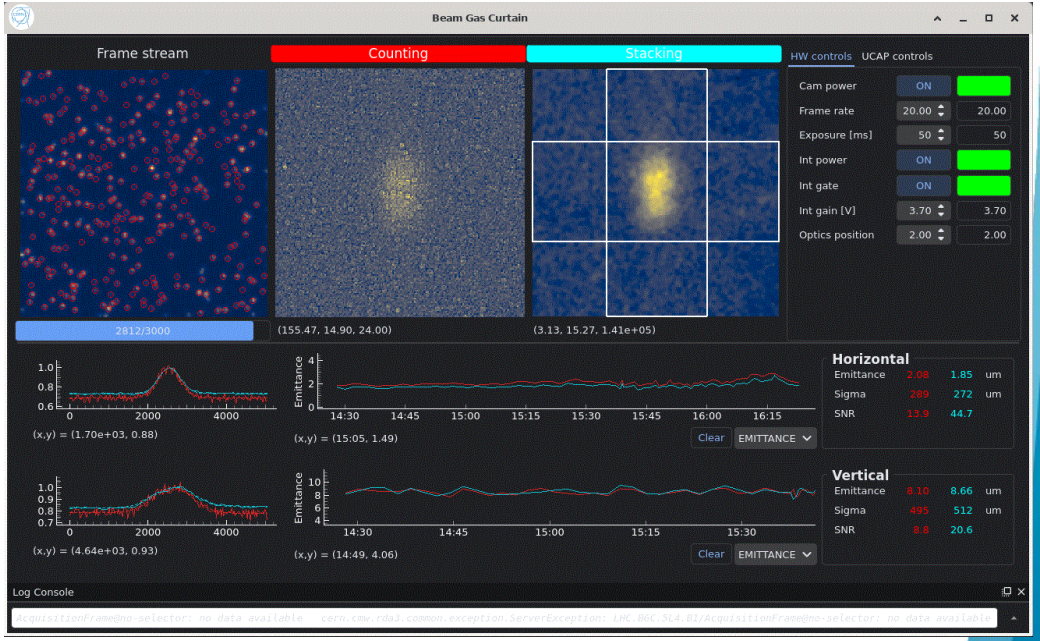


- Pressurised gas arrival
- Vacuum system including gauges and Turbo Molecular Pumps backed primary pumps
- Optical System including lenses, optical filters and camera
- Blackened elements to reduce the synchrotron light arriving at the camera
- Cables, racks and infrastructure

Present Status

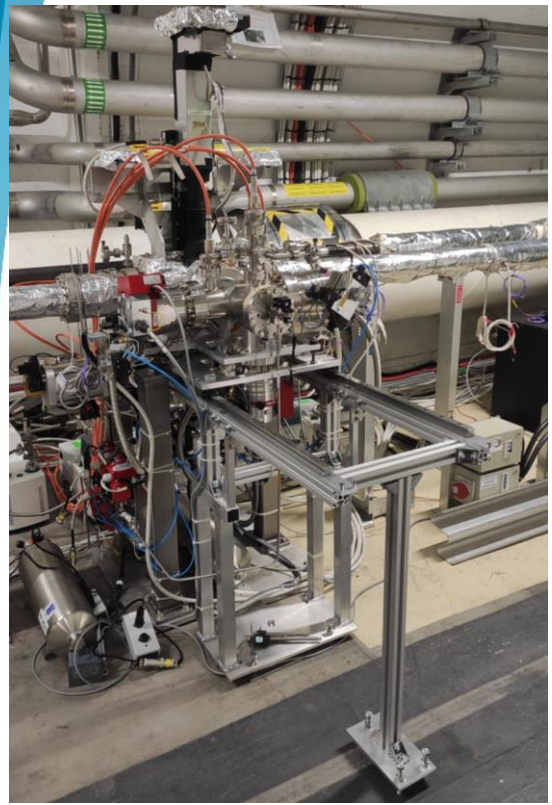
- BGC Instrument installed on Beam 1 in LHC P4 left on B1 between “green doors” and D3 magnet
- In full operation in LHC since March 2023
- Real time measurements were provided for the 2024 ion run in the CCC

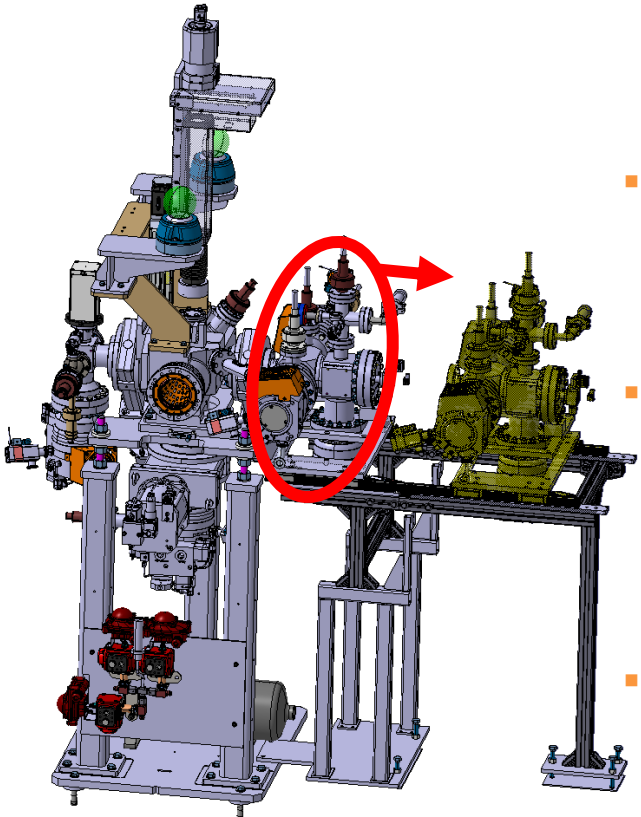




Courtesy R. Veness and D. Butti

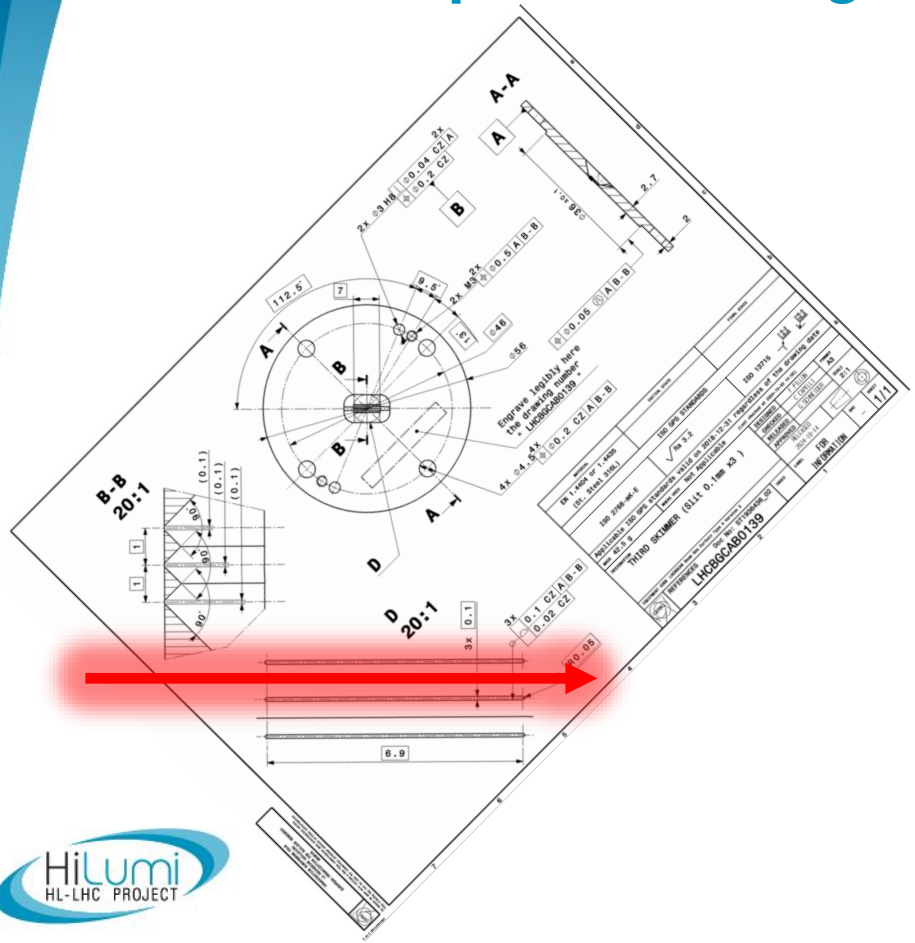
Changes foreseen in EYETS 24/25





- Optimise for hadron operation by reducing curtain size by changing skimmer 3, ECR 3190406.
- Skimmer changes does not require opening of LHC beam vacuum system → no bakeout required.
- Adding 2 BLMs specifically optimized for BGC-induced losses also beneficial for monitoring the radiation levels generated by the instrument, ECR 3162252.
- Further automisation of gas injections by TE-VSC.

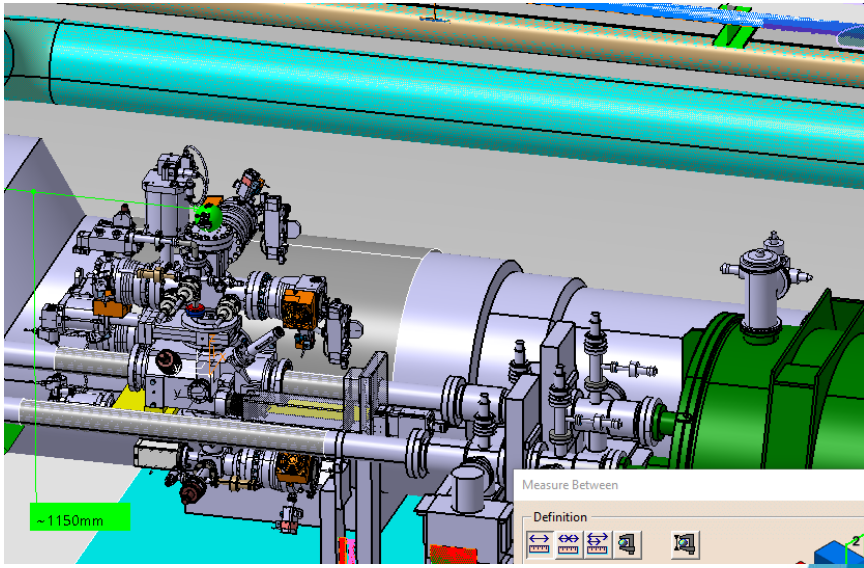
Optional change in YETS 25/26



- Optimise for beam loss operation by changing skimmer 3 to have one or more horizonal gas jets
- Possible beam movement to check efficiency on BLMs installed in YETS 24/25

Pre-LS3 Development Phase for BGC for Beam 2

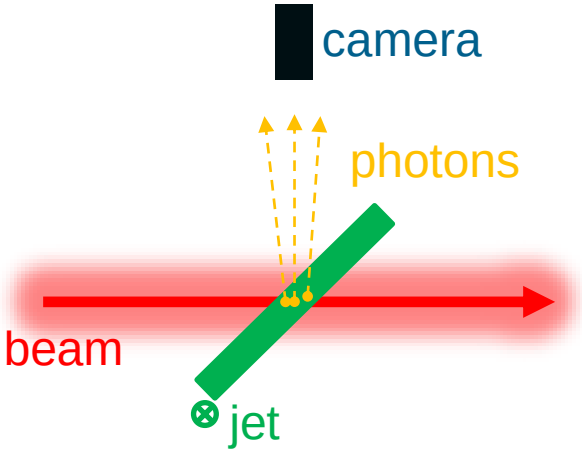
- Location for next BGC on Beam 2 identified in P4
- Vertical Gas Jet
- Design for optimised beam profile and/or beam halo measurements
  → Result of this review on priorities



Pre-LS3 Fluorescence Development of BGC

- Objective:
  View better the beam tails = beam halo

  → Optimise Optical system to get more light from the interaction
  → Optimise the skimmer system to reduce the background pressure
  → Optimise background pressure and signal by studying alternative gases as N_2
  → Shielding of the camera system in order to reduce noise
  → Decrease the pressure in the beam vacuum chamber by optimising the pumping system for profile measurements

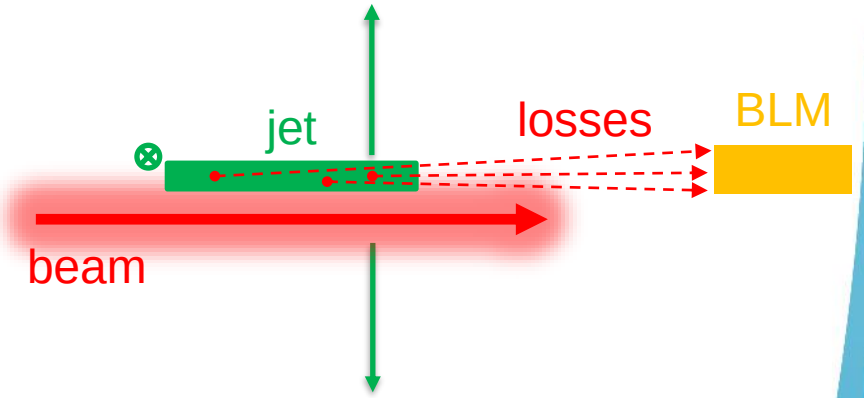


Courtesy D. Butti

Pre-LS3 Development using BGC interaction Beam Debris for BLMs signal

- Objective:
  Move the gas jet across the hadron beam
  = observe beam halo

  → Estimated movement +/- 5 mm
  → Option 1: Move the full BGC, for example using a Full Remote Alignment System (FRAS) already used in HL-LHC
    - Advantage: System can be fully calibrated between the skimmer system, no moving parts on the BGC itself
    - Consider connections to either side of the BGC
  → Option 2: Move only the skimmer system
    - Advantage: Potentially lower cost
    - Consider precise alignment of whole skimmer system during the movement



Courtesy D. Butti

LS3 Implementation Phase

- Confirmed installation plans:
  - BGC for Beam 2 in PLAN tool
- Non confirmed plan and open items requiring resolution/decision:
  - Technical challenges: Assure the BGC fits in the restricted space
  - Optimise to beam profile and/or halo instrument
  - Additional personal for simulation and integration design work missing

Budget

- BGC Instrument for beam 2 in-kind contribution of HL-LHC UK2
- Identified budget lines for CERN infrastructure
- Woman- and/or Man-Power required for BGC operation as Halo Monitor
  - → Simulations
  - → Mechanical design
  - → Integration

Key Milestones

Phase	Timeline	Deliverables	Dependencies	Budget Status
Pre-LS3	Baseline Instrument Q1 2025	Designs, Technical Specification, Cabling Requests, Test with BLMs	Optical Systems Collaborations	Manpower required
During LS3	Installation in Phased approach	BGC for beam 2	Geometers, Vacuum, Beam Loss Monitor System	Instrument from HL-LHC UK2 contribution CERN infrastructure budget identified
Post-LS3	Operation as of start of run 4	Optimise signal/noise ratio in fluorescence mode. Operation beam debris and BLMs	Beam Operation, Vacuum	

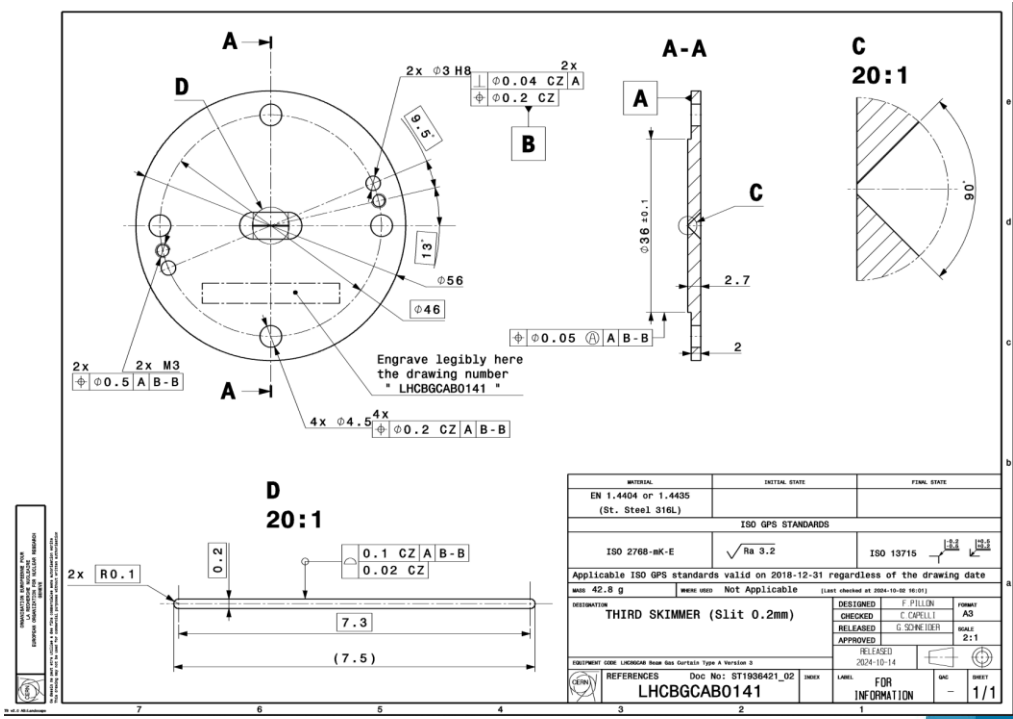
Summary

- Beam Gas Curtain instrument has successfully demonstrated functionality as beam profile monitor in LHC runs 23 and 24 with now real time display in CCC.
- Robust and operational instrument installed in the LHC fully functional with beam.
- Halo Measurements with an optimised BGC system are promising, see talk Daniele, resources needed for simulation and engineering.
- Adaptation and optimisation for BGC Beam 2 will include
  - → Less space constraints compared to operation as HEL overlap instrument
  - → Optimised for cost
  - → Optimised as beam profile measurement
  - → Opimisation possible for operation as Halo Instrument
- Installation in LS3 fully realistic if increase of resources required for simulation and engineering are granted

Questions?

Skimmer to be mounted in week 3 2025

- Width 0.2 mm (existing skimmer is 0.3 mm)
- Drawing number LHCBGCAB0141
- Manufacturing ongoing in industry



Operation Options 2026

- Operation as Halo Instrument
  - Skimmers options seen on drawings LHCBGCAB0139, 140, 143 and 144
- Operation with Neon or Nitrogen
- Any further preparations needed?