BGI: Implementation during LS3

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HL-LHC Beam Halo Review

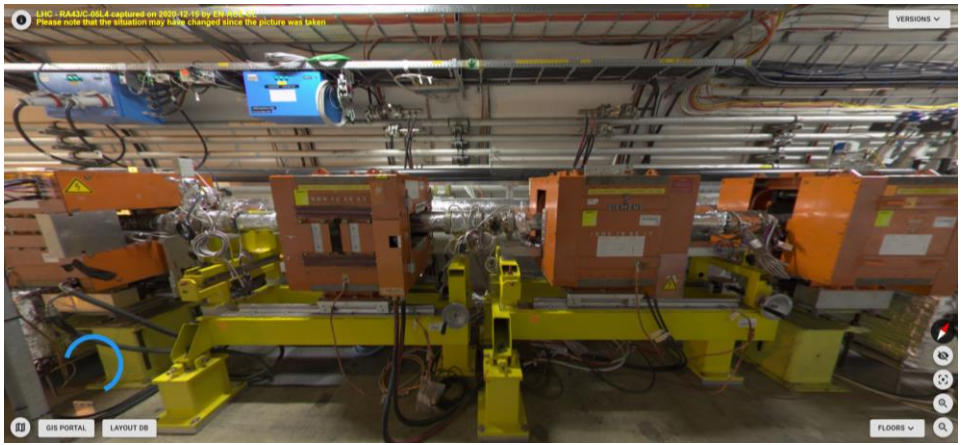
Outline

- Old installation
- New installation: magnet + PC
- New installation: vacuum chamber + instrument
- Pre-LS3: what is done & what is planned ?
- Plan for LS3
- Post-LS3 & Milestones table
- Summary

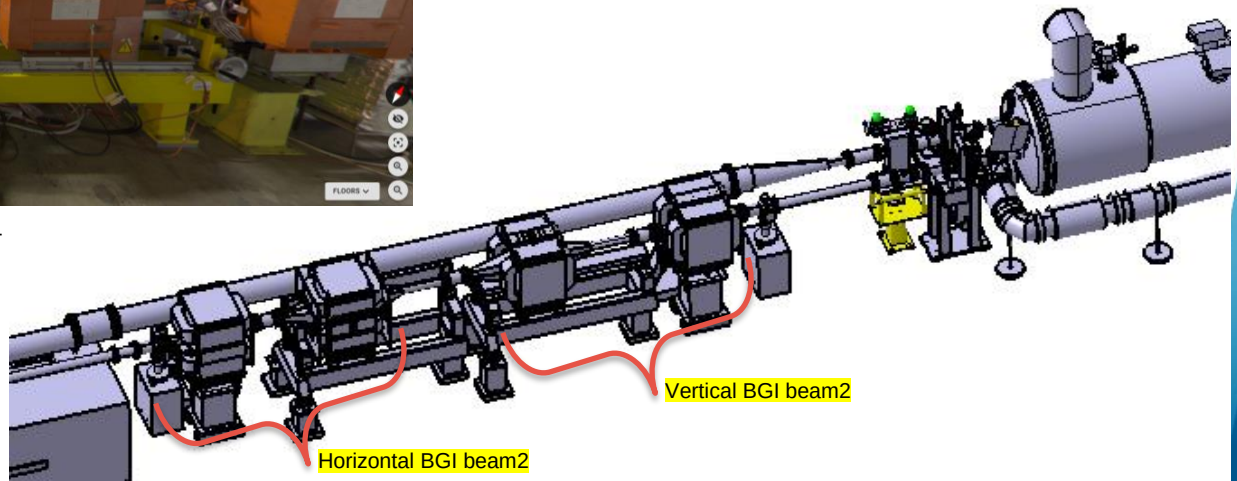
Intro: present configuration

- Doublet config: two magnets per instrument. One for detector; the other for bringing the beam back to its trajectory with a slight transverse offset.

- Nominal dipole field: 0.2 T, close to max field limit, not compatible with the new BGI detector.

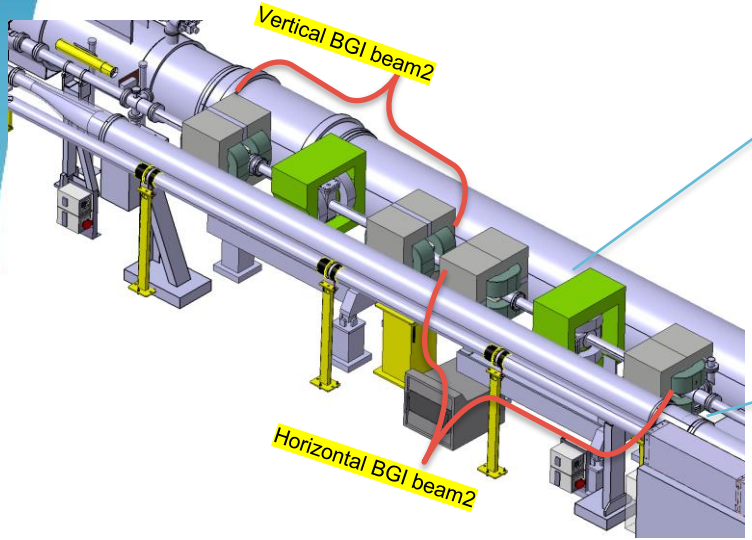


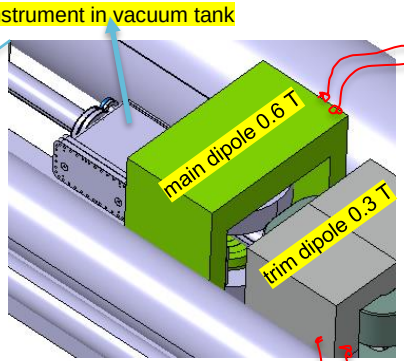
View of the magnet layout at 5L4



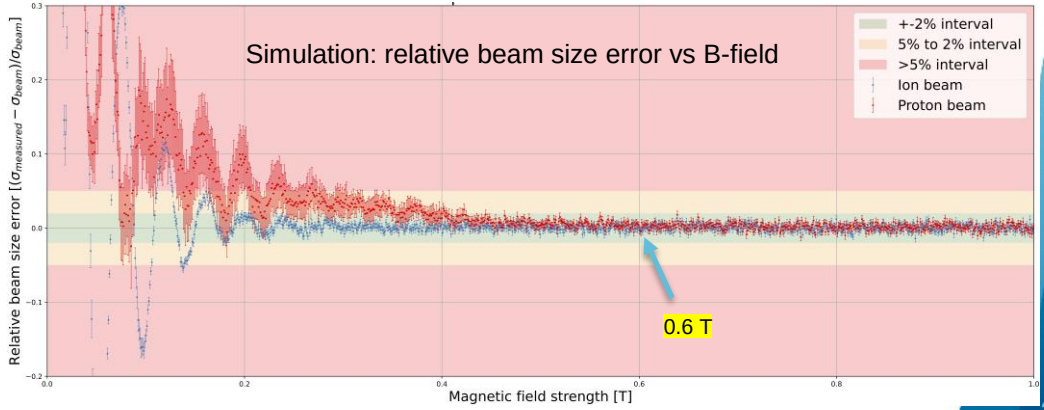
Intro: latest design integration (magnet + PC)

- BGI is HL baseline for non destructive transverse beam profile monitor (BGV-BGI review)

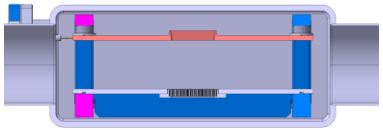


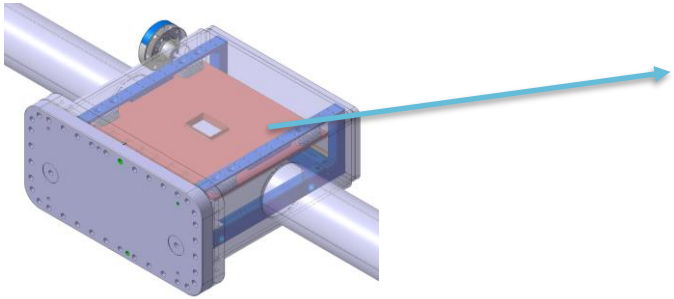


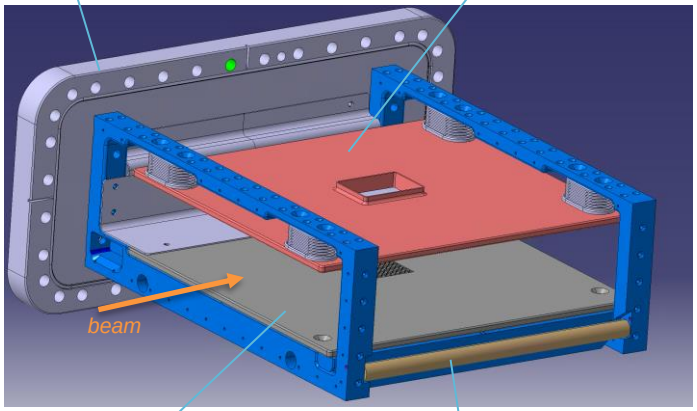
- Triplet magnet configuration
- Green: new main dipole ($$$)
- Grey: 2x MDX magnets recycled (free)
- Recycle 4x RPMCx and 4x RPPCE converters



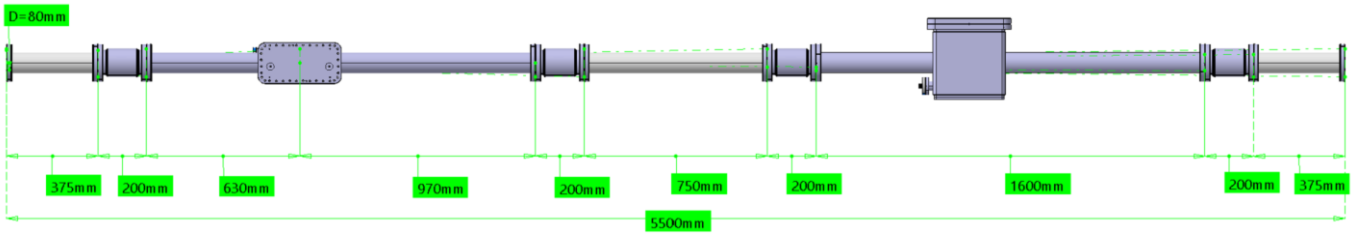
Intro: latest design integration (instrument)







- Impedance studies & general result promising : indico
- Vacuum studies, EDM:2894071 & EDMS: 2618330
- Thermal interface - Timepix4 & cooling plate, being optimized, should not be a technical showstopper



Pre-LS3 Development Phase

What is already designed (completed), installed, validated

- Old instruments removed & replaced by standard vacuum pipe (2018)
- Field cage design and ionization electron detector:
  - optimized using (CST+Virtual IPM) beam profile simulations
  - Timepix3 or Timepix4 (PS and SPS experience)
- Magnet design:
  - Magnetic field strength of 0.6 Tesla for profile error < 2.5% (emittance error < 5%)
  - Triplet magnet configurations for zero integrated B field (transparent to LHC beam)
  - Several options studied (~~PS like single triplet~~, ~~permanent~~, ~~recycle MDX in doublet~~, MDX trim + new main)
  - Converging to an option with cost optimization in terms of magnet + power converter + cables
- Impedance studies
- Vacuum studies
- Machine protection (indico)
- SRR, EDMS: 2873104
- Integration study, EDMS: 2932261
- ECR EYETS24-25 infrastructure upgrade (racks, water, cables, fibers etc), EDMS: 3070734

Pre-LS3 Development Phase

What is planned and expected to be implemented before LS3

- Infrastructure - new DC/Signal cables, optical fibers, cooling water (EYETS24-25), remove old 28 SHV cables (DIC, DEC, DIF)
- TPX3-BLM – measure background for halo, validate timepix readout system (2025 run)
- Installation of prototype in YETS25-26
  - Feasibility to install SPS BGI under investigation (impedance + vacuum)
  - Otherwise fix design in April 2025 & manufacture LHC specific prototype

LS3 Implementation Phase

- LS3
  - Remove old magnets
  - New magnets need to be installed together with new beamline components
  - A new main dipole magnet + two recycled MDX as corrector
  - Recycle power converters: BBLR for main and current ones for correctors
- Confirmed installation plans:
  - Cooling water, DC/Signal cables, optical fibers (EYETS24-25)
- Non confirmed plan and open items requiring resolution/decision:
  - 40 kV DC cables – not-CERN standard, discussing solution with DRAKA
  - Vacuum compatible thermal interface between Timepix3 and cooling plate

Post-LS3 Phase

- Features/capabilities available after LS3:
  - Bunch-by-bunch profile on H&V plane for beam1 & beam2
- Features/capabilities will need to be developed after LS3:
  - Consolidation of gas injection system for halo measurement ?
  - Automated masking of the beam core
- Expected timeline for transition from expert to operational mode
  - Readout system based on PS/SPS experience pre-LS3
- Known risks related to schedule and (also picking from ‘technical’ presentation before) performance
  - Potential for electromagnetic interference between the beam and Timepix4. Issue identified in SPS, investigated in ATS EMC lab, & solutions to be validated in 2025. Need to install instrument in YETS 25/26 and test instrument in 2026 to completely address this risk.
  - Expected performance based on IPMSim, which is not yet validated at LHC collision energies for rest gas ionization monitors.

Key Milestones

Phase	Timeline	Deliverables	Dependencies
Pre-LS3	2025 run 2025 Q4 YETS25-26 2026 run	• background measurement • Vacuum/impedance qualification • Installation of prototype • timepix3 operation in beam pipe	-
During LS3	LS3	instrument + magnets + converters + vacuum chamber	• LHC P4 Scheduling
Post-LS3	run 4	• Bunch-by-bunch profile in H&V plane for both the beam1 and beam2 • Beam Halo measurement	• Impedance qualification • Vacuum qualification • Test in 2026 to communicate with Timepix4 chip

Dependencies in the milestone table == critical prerequisites or external factors that could impact the timeline. Examples:

- Hardware dependencies
  - Equipment/components availability from suppliers
  - Delivery of specialised parts or custom components (mechanics or electronics)
  - Access to testing facilities
- Technical dependencies
  - Completion of specific design reviews
  - Validation of prototypes
  - SW development milestones
- Organisational dependencies
  - Availability of technical expertise
  - Support from other teams/groups
  - Required approvals and permits

Summary

- All infrastructures planned before LS3 & integration in P4
- Cost optimization by recycling magnet + PC + cables
- New main dipole magnet + instrument design ongoing
- Vacuum and RF impedance studies looking promising
- Open issues to be addressed before LS3
  - EMI & chip communication
  - Stay-stick replacement
  - 40 kV HV cables

EXTRA slides

BGI Integration in P4: some updates

- Provide detailed list of EYETS 24-25 works, including tests and installations, aiming for integration validation by June 2024. → Requested to EN/EL to install all cables & optical fibres during EYETS 24/25. Optical fibres on tunnel side will be installed next to the existing BSRT patch panel.→ VIC planned during TS2
- Clarify which racks will be utilized updating the DIR.→ For the BGI's on B1 : Racks BY01 & BY02 in UA43 and for the BGI's on B2 : Racks BY16 & BY17 in UA47.
- Finalize the selection of Power Converters considering space constraints. → **Magnet Design completed (triplet),** Work in progress with SY-EPC.→ magnet design being optimised keeping same magnetic field homogeneity and intensity but with smaller magnets, less consumption. Available 3D scans of LSS4?
- Identify the components to be removed and dismantled. This will ensure that all relevant groups are informed and can anticipate requirements for EYETS 24-25. → None in EYETS 24/25 (old instruments already removed, only old magnets remain.)
- During the EYETS 24-25, there will be an effort to maximize installations. Therefore, provide with an ECR as suggested by JO.→ ECR will be prepared by June for cable & fibre installation. →Done
- Organise a meeting with VSC.→ Meeting organised: vacuum layout modification discussed. In order to give more flexibility to everyone, it is agreed to modify the layout with drifts replacing the BGIs instruments. The vacuum reconfiguration can take place at VSC convenience, the BGI will be installed when ready (most likely Q4 2027). Collaboration ongoing.→ using the same existing slot between vacuum modules. The rest of the line would be taken by the instruments + bellows and 2 drifts. Preliminary integration can start, final integration will depend on the magnet design that is expected to be completed by dec 2024.
- Alignment team will be contacted very soon → Done, no modifications to the proposed solution as already implemented in the SPS.
- Impedance→ quite advanced and many reiterations ongoing, getting every time an improved frequency spectrum. With the last iteration we hope to mitigate the two last picks of the spectrum.