



# **Wrap up on beam halo monitoring status, options and path forward**

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HL-LHC Beam Halo Monitor Review, 18-Dec-2024

# Specs and beam optics

- about specifications and related discussions
  - Distinction between tails close to the core and halo close to collimators.
  - Presently not possible to follow halo formation during the cycle.
    - important are simulations predicting beam halo formation
  - can any of studies can include reduced collimator scans to benchmark BI techniques?
- on possible beam optics at IR4
  - Riccardo's options promising: what can we test before LS3?
  - A larger beam size enhances the performance of all monitors. For BSR: a reduced PSF/sigma ratio improves absolute accuracy in both contrast and integrated halo measurements. A beam size increase of a factor 1.5 or 2 (w.r.t. present optics) yields significant improvements

# BSRH

Phase	Deliverables	Dependencies
Pre-LS3	Enhance knowledge of BSRH B2 Validate BSRTMB B1 light extraction Complete integration, procure vacuum chambers	- Given priority in MD list → allocated MD time - -optimize time during commissioning (e.g. loss maps), propose/obtain eof studies
During LS3	Deploy BSRH beam1/2	
Post-LS3	Commission, tuning optimize system according to learning curve	

# BGC

Take-home message for BGC imaging:

- ✘ limited performance in acquisition rate and contrast
- ✓ robust and reproducible thanks to its simplicity

→ insufficient as single halo monitor, might provide a solid cross-reference for other monitors

Take-home message for BGC profiler:

- ✘ using BGC as beam profiler is a very recent concept
- ✓ BGC profiler configuration very similar to existing one, already validated in the machine

→ instrument has potential, but further investigations needed (before LS3) to quantify performance

# BGC

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	

# Low density materials

- R&D very relevant for beam profile measurements both at LHC and in FT facilities
- Need to find compromise among enough signal, detector lifetime, losses and quenches

Phase	Timeline	Deliverables	Dependencies	Budget Status
Pre-LS3	By 2026	<input type="checkbox"/> HRMT test <input type="checkbox"/> Material sim <input type="checkbox"/> Material chemistry optimization <input type="checkbox"/> Ball bonding	No dependencies	Covered
During LS3	By 2028?	<input type="checkbox"/> Proto for SPS	R&D dependencies	Not Covered
Post-LS3	?	<input type="checkbox"/> Proto for LHC	R&D dependencies	Not Covered

# Best estimate of expected performance

Performance Metric	Required Range	Use Case(s)	BSR	BGI	BGC
Contrast	10 <sup>-4</sup> to 10 <sup>-6</sup>	Collimation: 10 <sup>-4</sup> at upper bound	Under study	Signal = 10 kHz (residual gas) or 5 MHz (injected gas) Background = tbd.	~1%
		MP: 10 <sup>-6</sup> at 6.7σ			
Relative Integral	0.2% to 5%	Collimation: 5% to 0.5%	<0.1%	See slide #14	tbc
		MP: 1.4% to 0.2%			
Absolute Integral	10 <sup>10</sup> to few 10 <sup>12</sup>	Collimation: 1.5×10 <sup>12</sup>	1.5% during MD	See slide #14	tbc
		MP: (1-4)×10 <sup>10</sup>			
1D Profile Capability	Yes/No	Required for Beam-Beam	Yes		Yes
2D Image Capability	Yes/No	Required for Beam-Beam	Yes		No
Max. Acquisition Rate	10-60 seconds	MP: ~10s	~20Hz (time for full beam depends on the gated sample - >100s for full machine bunch per bunch, around 3s for 48b., limited by data processing)	5 MHz with injected gas → 1800 electron / bunch / s.	1 min
		Others: ~60s			
Bunch-by-Bunch Gating	Yes/No	Required for Beam-Beam	Yes	B-b-B via electrons timestamp	no
Number of Turns Needed	-	All cases accept multi-turn	Yes	With gas injection 5 MHz → 440 samples / turn.	-
Interlock Capability	Yes/No	Required for MP	tbc	tbc	SW

# General remarks questions

- BSRs: need to balance pro and cons of second light source
- BGC: can we have one version for beam emittance and beam halo
- BGI is in HL-LHC baseline as profile monitor. If it works as profile monitor, functionality as BHM comes 'for free'. Are there BGI design choices that depend on BHM specs? Question about ageing.
- General: risks, for each technique what are the risks of not achieving what 'promised' today
- From discussion: can we have more systematic studies on what happens during physics (Oliver's comment on if we can use dump line monitors?)



# General questions

Q: Is there a monitor fulfilling all specs

- A: no (as of today). ++points of each technique:
  - BGC and BGI : self calibrated , all energies, including for ion
  - BSR: high signal, high relative accuracy, bunch per bunch

Q: are there decisions that can't be postponed?

A:

- Approval / funding of BGC activities (?)
- BSR:
  - Complete BSR integration studies, procure enlarged beam pipes
  - Assess if resources are enough to maintain two additional extraction sources
  - Assess optical lines will work

Q: top importance milestones 2025?

A:

- BGC tests as a profiler with BLM
- BSRH MDs and operation during physics

Q: Do we continue with BH WG ?

- A: topical meetings to update studies and preparation work ?