



Aperture considerations on BSRTMB settings for Run 3

R. De Maria, R. Bruce, S. Redaelli, F. Van Der Veken

CWG 29/4/2022

Aperture consideration

Summary

- BSRTMB is part of an instrument foreseen for HL-LHC.
- BSRTMB requested to operate in Run 3 for validation purposes.
- Target settings given for HL-LHC based on the nominal HL optics V1.5 and expected aperture. See [WP2 meeting on 7/9/2021](#).
- Actual settings for Run 3 and Run 4 depends on actual optics, machine conditions and commissioning state (see [LHC-BSRTM-EC-0003 v.0.1](#))

Considerations for actual Run 3 settings:

- Should account for measured Run 3 apertures
- Should not worsen global aperture as BSRTMB is not a critical device for Run 3
 - Compare with aperture measurements
- No close BLM installed => cannot be sure to detect local losses if device would be closer to the beam than thought => does not allow to trust beam loss pattern to validate mirror positions, and requires special commissioning
- Mirror is a thin scatterer => potentially different loss behaviour from other aperture bottlenecks (tentative settings do not take into account this), requires extra care.
 - Simulation would be required to approach target settings.

Run 3 settings and commissioning strategy

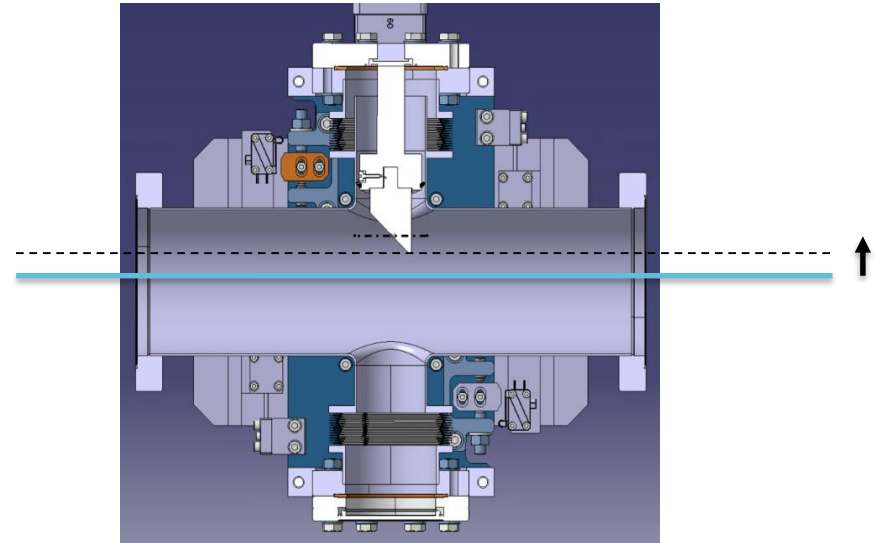
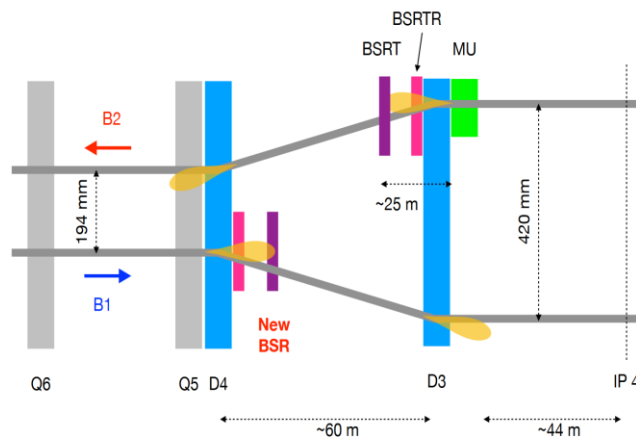
	450 GeV	6800 GeV
Target BSRTMB HL-LHC settings	22.9 mm	11.2 mm
Calculated aperture using Run 3 optics	11.2 sigma	17.7 sigma
Additional margin	1.7 mm	0 mm
Estimated settings (present proposal)	24.5 mm	11.2 mm

- Injection: calculated aperture close to ring aperture, tentatively add 1 sigma margin to stay in the shadow
- Top energy: other bottlenecks expected to be smaller at flat top, possibly don't need to add additional margin
- Commissioning procedure to validate mirror position:
 - Mirror to be part of aperture measurements and standard loss maps and asynchronous dump tests.
 - No BLM installed, potentially blind to local losses => request additional aperture measurements to compare loss pattern and global aperture (from BBA measurement) with mirror parked and at nominal position. 2 hours additional commissioning time.
- If found in measurements that mirror is not transparent to the loss pattern, step back in setting

Back-up

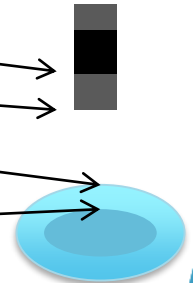
BSRTM

New synchrotron radiation monitor installed in Point 4: [LHC-BSRTM-EC-0003-0-1.docx](#) at



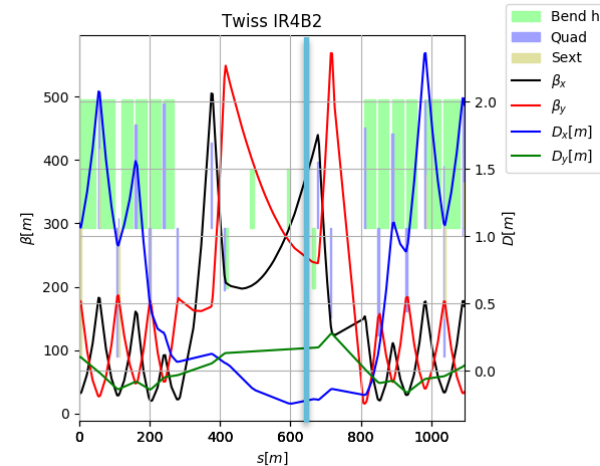
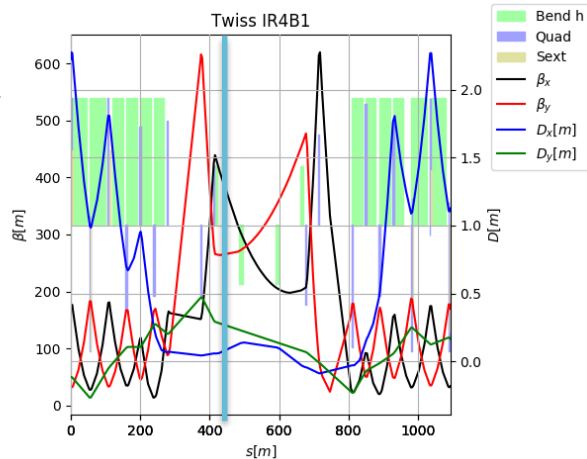
- Operational requirement: mirror as close a possible to the beam
- Operational range: 10 mm to 40 mm from the axis.

Ideal position
Position Margin
Beam Margins
Ideal beam



Optics consideration

HL-LHC



Position	DCUM [m]	From IP4 [m]	From beam axis [mm]
Non IP side	9897.9672	99.114	135.61
IP side	9898.5382	98.543	136.51

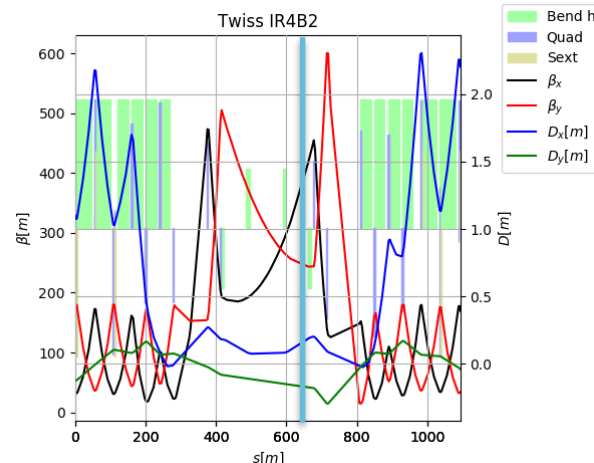
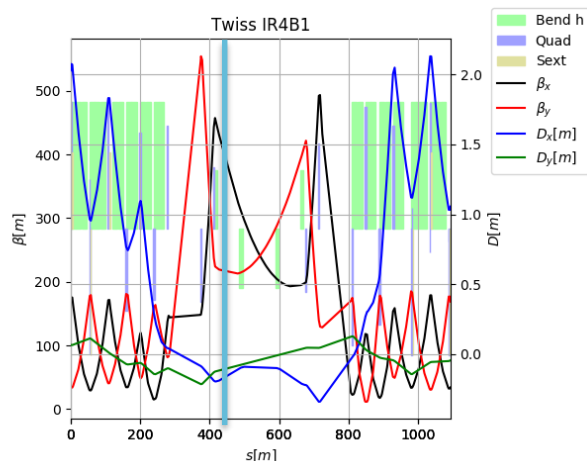
HL-LHC and Run2 optics are similar. No optics change foreseen in the dogleg during the cycle.

One can assume:

- $B_x < \sim 400$ m (based on 380m on present optics adding some margin as optics can still evolve)
- $|D_x| < \sim 20$ cm (can be smaller but depends on crossing bumps leaking which is hard to design for)

Optics consideration

Run2



Position	DCUM [m]	From IP4 [m]	From beam axis [mm]
Non IP side	9897.9672	99.114	135.61
IP side	9898.5382	98.543	136.51

HL-LHC and Run2 optics are similar. No optics change foreseen in the dogleg during the cycle.

One can assume:

- $B_x < \sim 400$ m (based on 380m on present optics adding some margin as optics can still evolve)
- $|D_x| < \sim 20$ cm (can be smaller but depends on crossing bumps leaking which is hard to design for)

Aperture consideration

Parameters	Injection	Flat top
Energy [GeV]	450	6500
Ref. emittance [$\mu\text{m}/\gamma$]	2.5	2.5
Energy Error [%]	0.0086	0.0002
Orbit error [mm]	2	2
Sigma error [%]	5	10
Dispersion Error [%]	14	10
Min protected aperture ¹ [σ]	13	20

¹ Based on nominal bottlenecks on present optics, could be reduced to 12.6 σ and 19.4 σ defined in: Updated parameters for HL-LHC aperture calculations for proton beams [CERN-ACC-2017-0051.pdf](https://cds.cern.ch/record/2269411/files/CERN-ACC-2017-0051.pdf)

Results	Injection	Flat top
Betatron component [mm]	19.71	8.36
Dispersion component [mm]	0.33	0.07
Orbit error [mm]	2.00	2.00
Minimum beam stay clear [mm]	22.04	10.42
Mirror position margins ² [mm]	0.80	
Potential Operational settings	22.86	11.22

² Includes: alignment tolerances, mechanical tolerances, motor tolerances, interlock tolerances. Enrico proposed 0.5 mm based on 0.3 from survey alignment and 0.5 mm on mechanical structure (see ECR).

Conclusion

- Minimum beam stay clear proposed for BSRTM based on the current location and present optics
- Operational settings for the mirror to be defined once alignment tolerances, mechanical tolerances, motor tolerances and interlock tolerances will be specified.
- Mirror position during the ramp cannot be compute as aperture parameters during the ramp are not specified