

Collimation MDs in Run 3

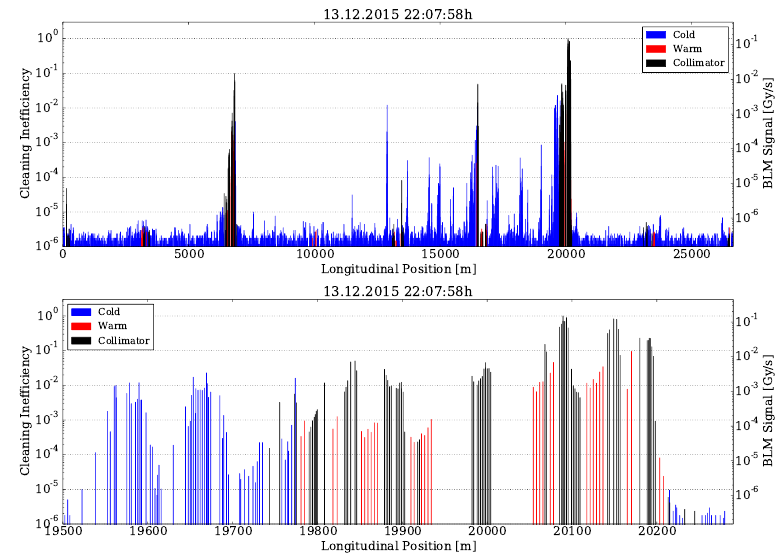
(very first thoughts...)

R. Bruce on behalf of the collimation team

- **Highest priority: Mitigation of losses and impedance with new IR7 layout**
 - Investigate quench limits and with new IR7 layout
 - Characterize new low-impedance collimators being installed in LS2 and refinements of impedance model
- **Other areas of study**
 - Preparation of crystals for ion runs (high priority if there would be delays of the 11 T magnets)
 - IR2 performance reach with Pb ions with new collimator layout
 - Study IR7 DS losses and mitigations of losses on the 11T dipole
 - Characterization of halo, tail population and diffusion measurements
 - Further development of automated collimator alignment using machine learning
 - New IR7 optics
- More ideas on the table at the end

Collimation quench tests

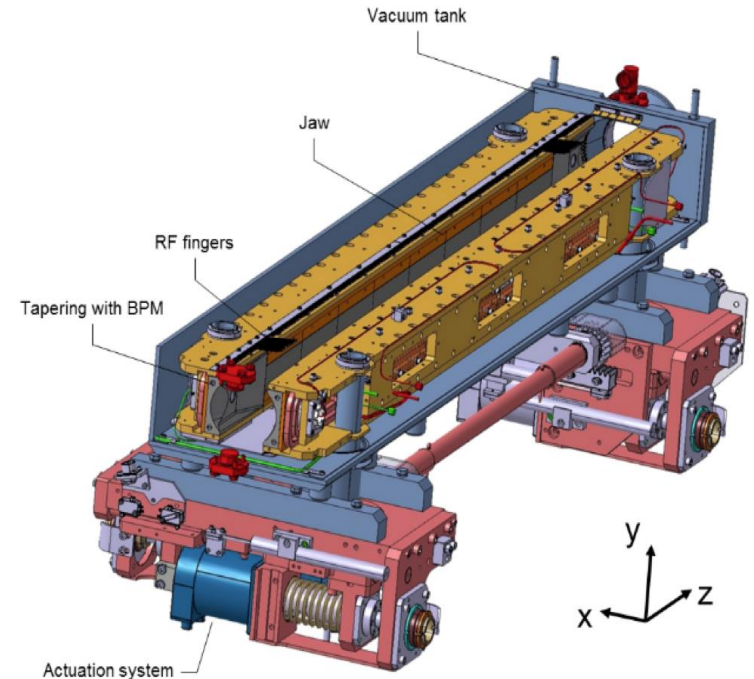
- Method for collimation quench test: induce large losses in IR7, study when/if quench occurs to infer limits on allowed loss rate
- Collimation quench tests performed in the past – latest in 2015
- **Upgrades of IR7 layout in LS2** (addition of DS collimators, low-impedance collimators) and possibly 7 TeV energy =>
 - **Need for new tests to validate performance improvements for HL-LHC**
 - No need for special LIU beams
- **Propose two MDs**
 - Proton collimation quench test
 - Pb ion collimation quench test



*Losses at quench with Pb ions
CERN-ACC-NOTE-2016-0031*

MDs on new low-impedance collimators

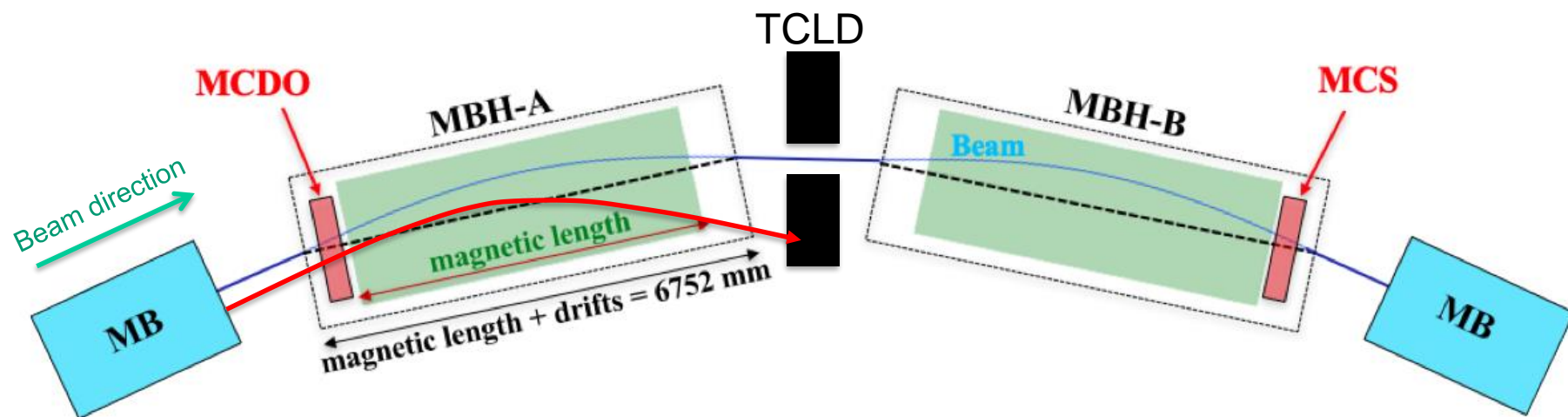
- Installing in LS2: 4 secondaries and 2 primaries per beam with new low-impedance material for HL-LHC
 - MoGr bulk + Mo-coated MoGr
- **Need to validate the expected impedance improvement**
- In HL-LHC, potential need to operate with more open collimators to mitigate impedance (ongoing WP2/WP5 studies)
- Continue monitoring impedance of the TCSPM prototype (used in OP 2 years)
- **Proposed MDs (in collaboration with impedance team)**
 - Characterization of impedance for different collimator settings, comparison of old and new collimators



[LHC-TC-EC-0014](#)

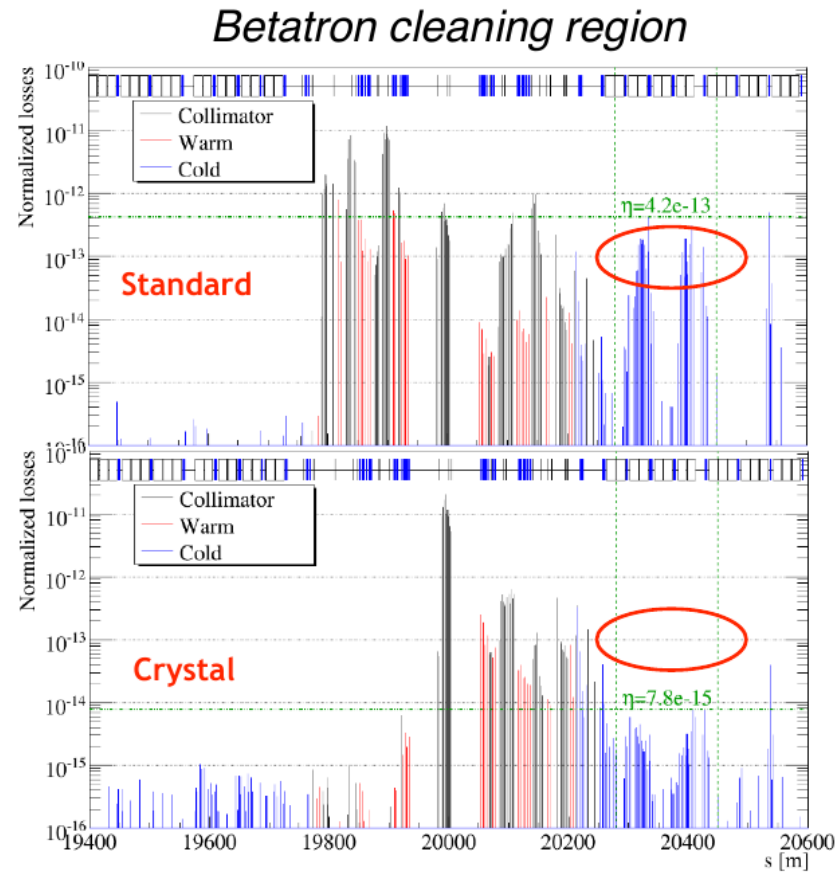
Study of IR7 DS losses

- Initial studies showed potentially **high losses on the new 11T magnets** being installed in LS2
- Effort to study possible mitigation measures in LS2: aperture misalignment (not MD), orbit bumps, collimator settings
- Need to **study the possible gain in losses in the real machine** so that they can be deployed in case of need
- **Proposed MD**
 - Study of losses in the IR7 DS with orbit bumps and different collimator settings



Crystal collimation

- Crystals recently integrated in HL-LHC baseline
 - Could give good cleaning improvement with ion beams
 - Becomes high priority if 11T dipoles would have delays
- Very promising results from Run 2 MDs
- Changes for Run 3
 - Possibly one new crystal installed in LS2? Need to be characterized
 - Work on new crystal controls for possible use in operation – need dedicated tests
- Proposed MDs
 - Crystal collimation studies with protons
 - Crystal collimation studies with Pb ions (and maybe oxygen?)
 - Crystal collimation with partially stripped Pb beams (see also talk on ion MDs)

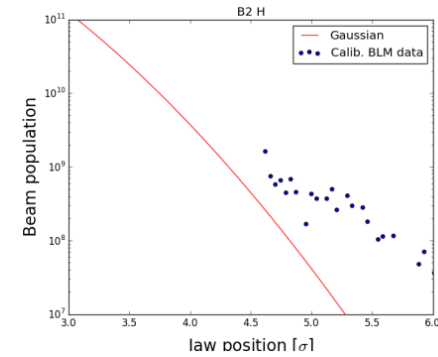
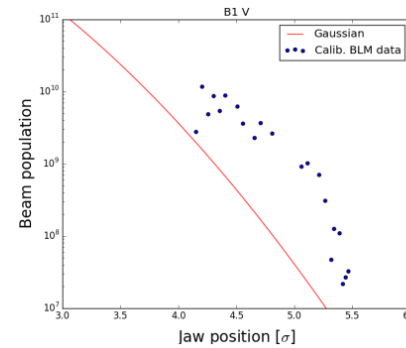


From 2018 tests with Pb beams
M. D'Andrea, D. Mirarchi et al.

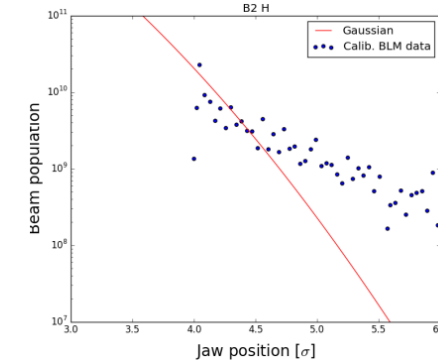
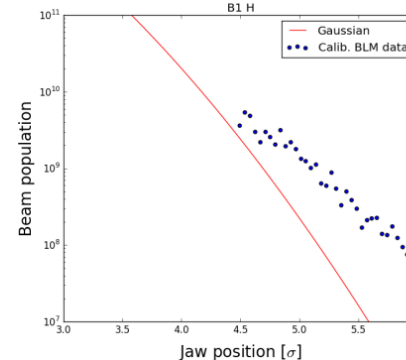
Characterization of beam halo

- Sudden losses from overpopulated beam tails is a concern for HL-LHC (crab cavity failures, orbit jitter....)
- **Hollow electron lens recently incorporated in the HL-LHC baseline to control the halo**
- Important to continue **characterization of the halo, tail population and diffusion measurements**, especially when high-intensity LIU beams become available
- Interest from other teams (MPE, ABP...)

300b:



2076b:



Proposed MDs

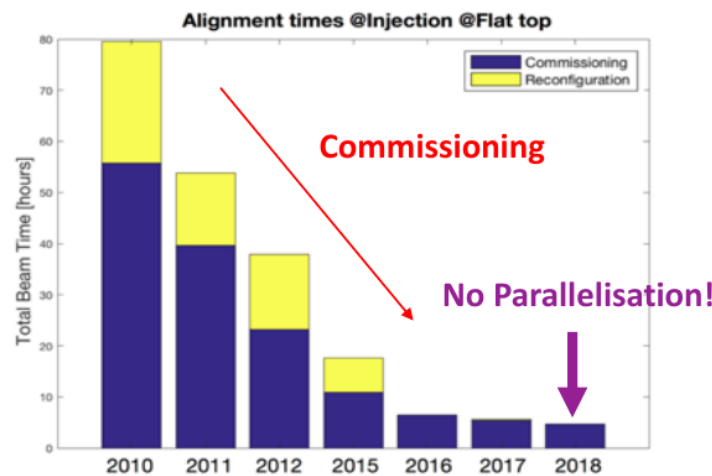
- Tail scraping with collimators of high-intensity beams to infer halo population in different parts of the cycle
- Dedicated tests for characterization of diffusion coefficient

G. Valentino et al.

Automated alignment with machine learning

- Very successful MD campaign in Run 2 to decrease collimation system alignment time
 - Used machine learning for loss spike recognition
- Continue/develop further studies on applications of machine learning to the LHC:
 - Further improvement of alignment software: alignment time and reliability for parallel alignment of both beams
 - Applications to the jaw tilt alignment

G. Azzopardi, G. Valentino et al.



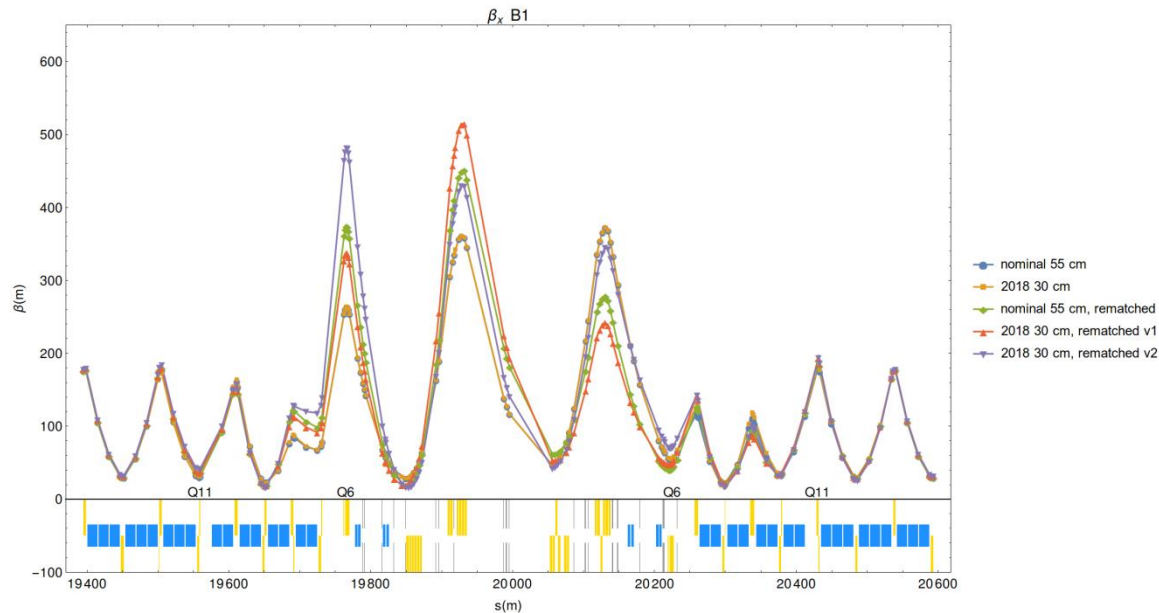
Collimation milestones over the years:

- Run 1** - 2010: Semi-automatic alignment
- 2012: 12 Hz data available
- Run 2** - 2015: BPMs introduced
- 2016: 100 Hz data available
- 2018: Fully-automatic alignment

Proposed MDs

- Further studies of automated collimator alignment
- [NEW] machine learning applied to angular controls of crystals
- Loss maps in various conditions to study automatic validation and anomaly detection
 - Interest also from OP, MPE...

- Work done in LS2 to improve IR7 optics for better impedance and cleaning
- Need to check the potential gain in the real machine
- Interest also from impedance team
- **Proposed MD**
 - Studies of cleaning efficiency and impedance with new optics



Collimation working group, 21/6/2019

- Other possible MDs under consideration
 - IP2 performance reach (with Pb ions) with upgraded DS layouts and new TCLD collimators – see earlier talk on ion MDs
 - Dedicated alignment tests of new BPM collimators
 - Beam size measurements with collimator BPMs
 - New studies of asymmetric collimator settings, with new TCLD layout
 - Continued characterization of BLM response for threshold calculations
 - Studies of noise effects on the beam, mimicking hollow electron lens
 - Collimation of partially stripped ion beams – see earlier talk on ion MDs
 - Aperture measurements in IR8 for ion operation – see earlier talk on ion MDs
 - Studies of potential limitations from off-momentum losses at the start of the ramp
 - Beam size measurements with BPMs
 - Optimal TCL settings for losses and roman pot acceptance – proposal by TOTEM

- **High-priority MDs on new hardware**
 - Investigate quench limits and with new IR7 layout
 - Characterize new low-impedance collimators being installed in LS2 and refinements of impedance model
- **Rich program of other MDs on the table**
- Happy to collaborate on **MDs with other teams** (e.g. collective effects, beam-beam, MPE...)
- **Further proposals could come when the Run 3 OP scenario has been finalized**
 - Traditionally did operational development on aperture, beta*...