OMC linear optics

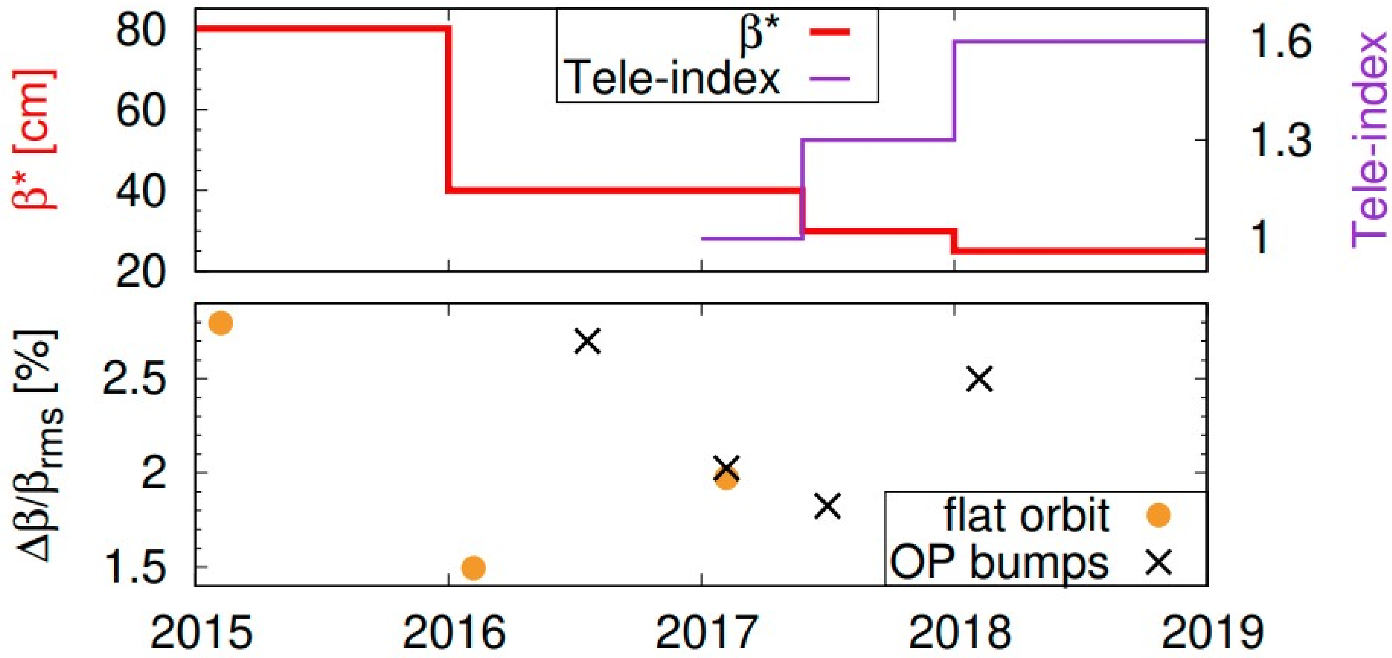
T. Persson, on behalf of the OMC-team

Journal articles with Run 2 data

- A. Wegscheider, et al. , "Analytical N beam position monitor method" Phys. Rev. Accel. Beams 20, 111002 (2017)
- F. Carlier and R. Tomas, "Accuracy and feasibility of the beta* measurement for LHC and High Luminosity LHC using k-modulation"
- T. Persson et al, "LHC optics commissioning: A journey towards 1% optics control", Phys. Rev. Accel. Beams, 20, 061002 (2017)
- E. Todesco et al, The Magnetic Model of the LHC at 6.5 TeV, IEEE Trans.Appl.Supercond. 26 (2016) no.4, 4005707
- J. Coello de Portugal et al, “New local optics measurements and correction techniques for the LHC and its luminosity upgrade”, to be published
- M. Hoffer. et al, “Effect of local linear coupling on linear and nonlinear observables in circular accelerators” , to be published

Introduction

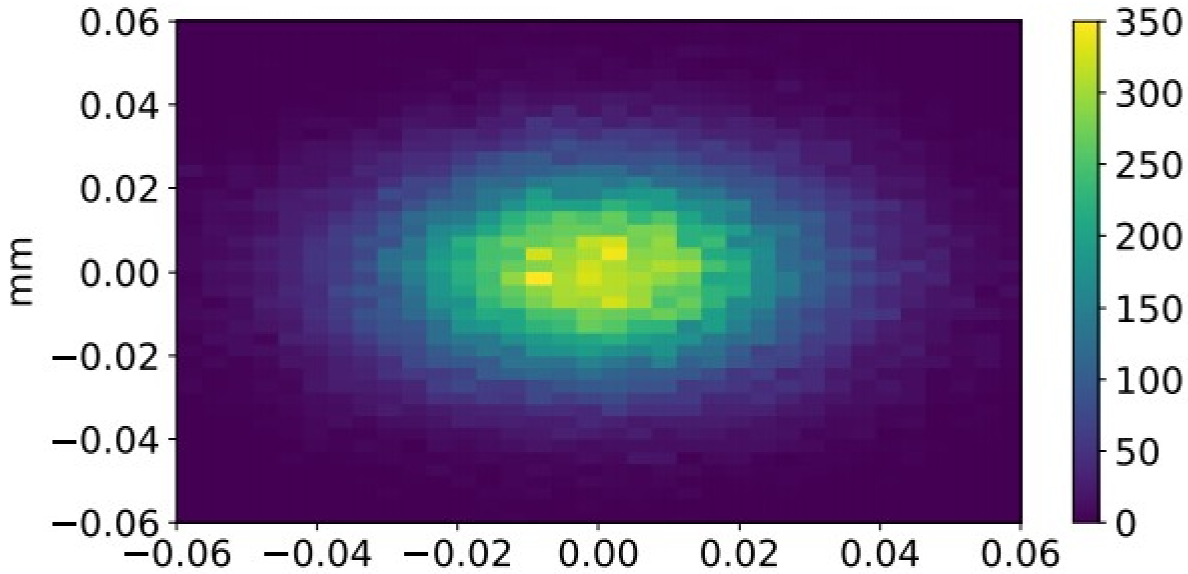
- The linear optics has in general been well corrected in the LHC
  - However, more challenging for every year!



Linear optics

- Commissioning or MDs:
  - Increase the control of the beam size at the IRs
  - Control the optics in the ramp
  - Improve the optics control
  - Additional control of the transverse coupling
- MDs:
  - Different optics

Increase the control of beam size at the IRs



Optics control at the IRs

- Goal:
  - The experiments receives the designed luminosity for the specific optics
  - Luminosity from ATLAS and CMS is within a few percent
- New Methods to calculate corrections:
  - Action and Phase Jump
  - Machine learning
- Procedures and Measurements that could help us:
  - Ballistic optics
  - Local coupling corrections
  - Additional K-modulation
  - Luminosity scans

Ballistic Optics

- Turn of the magnets in the vicinity of the IR

  → Drift space in between meaning that we can calibrate the BPMs

    → The calibrated BPMs can then be used to determine the β-function from the amplitude of oscillations

- Design of a ballistic optics in IR4 has been designed

  → Refine the optics parameters for beam instrumentation

L. Van Riesen-Haupt

Local coupling corrections

- Goal:
  - To correct the local coupling at the IRs to a level where it impacts the luminosity below 2%
- Procedure:
  - Applying a rigid waist shift knob that breaks the left-right symmetry around the IR.
  - We can then measure the global coupling which is significantly easier.
- It was tested in end of 2018 and showed promising results but only one beam was available.
- We are also working on refining the procedure.

Additional K-modulation

- In the past we only modulated Q1
- Would also like to modulate Q2-Q4

→ β-function at these magnets would help to constrain our local correction

→ Provide information of the orbit going through these magnets

Scan settings with luminosity

- Background:
  - Difficult to control the beam size at the IP down to the desired percent level
- 3 different measurements:
  - 1. Scan horizontal and vertical waist
  - 2. Scan the colinearity knob to optimize the local coupling
  - 3. Change the dp to have a direct measurement of dispersion at the IP

Optics control in the Ramp

Optics control in the Ramp

- Motivation:
  - Increase the control of the optics in the ramp in particular to understand the emittance evolution
- Procedures:
  - 3 bunches
  - K-modulation during ramp
  - Stop the ramp for measurements (see Ilias Efthymiopoulos talk)
  - Automatic kicks during ramp
  - 3D Kicks

3D kicks

- Description:
  - Exciting with the AC-dipole while modulating the RF
- Motivation:
  - Faster measurement of normalized dispersion and chromatic optics functions.
  - To study the snapback in the end of Run 3.
- Remaining Optimization:
  - To have a fully automatic system with optimized parameters

Improved control of the optics

Refine the optics corrections

- K-modulation in the arc
- Powered in series but would give the average β-function
- The impact of beam-beam on the β-beat
  - Started in collaboration with EPFL

- Measuring the momentum compaction factor

- Optics correction with sextupole and orbit bumps
  - The quadrupoles in the arcs are not able to correct the β-beat to the desired level for certain conditions
  - Demonstrated for flat optics but required manual fitting

Improved control of the transverse coupling

MCS alignment

- Background:
  - The MCS are misaligned vertically with respect to the reference orbit
- Commissioning
  - Measure the effect again and compare to Run 2
  - Implement the uneven MCS dynamic powering which prevents a drift in coupling at injection (“coupling decay”)
- MD:
  - Understand how the misalignment is distributed and also check for horizontal offsets

Impact of Beam-beam long range on transverse coupling

- Background:
  - Bunches observing different long range interaction have different coupling (PACMAN coupling)
- Commissioning
  - Measurement should be repeated and a correction could be applied
- MD:
  - Change the tilt of the crossing angle or introduce a local coupling bump at the IP and measure the effect

Studies carried out togheter with X. Buffat and J. Wenninger

Studies of different optics

- **60 deg phase advance optics**
  - An optics to explore the ultimate energy for the LHC

ATS with a telescopic index of > 6 (See S. Fartoukh's talk)

- Understand how far we can go and if we can correct such an optic
- Try the improved K-modulation algorithms

- **Half integer optics**
  - Potentially better beam lifetime
- **Optics to increase the β-function at the 11 T magnets**
- **Ballistic Optics for IR 4**
- All these studies would also help to constraint the magnets errors since they are probed slightly different

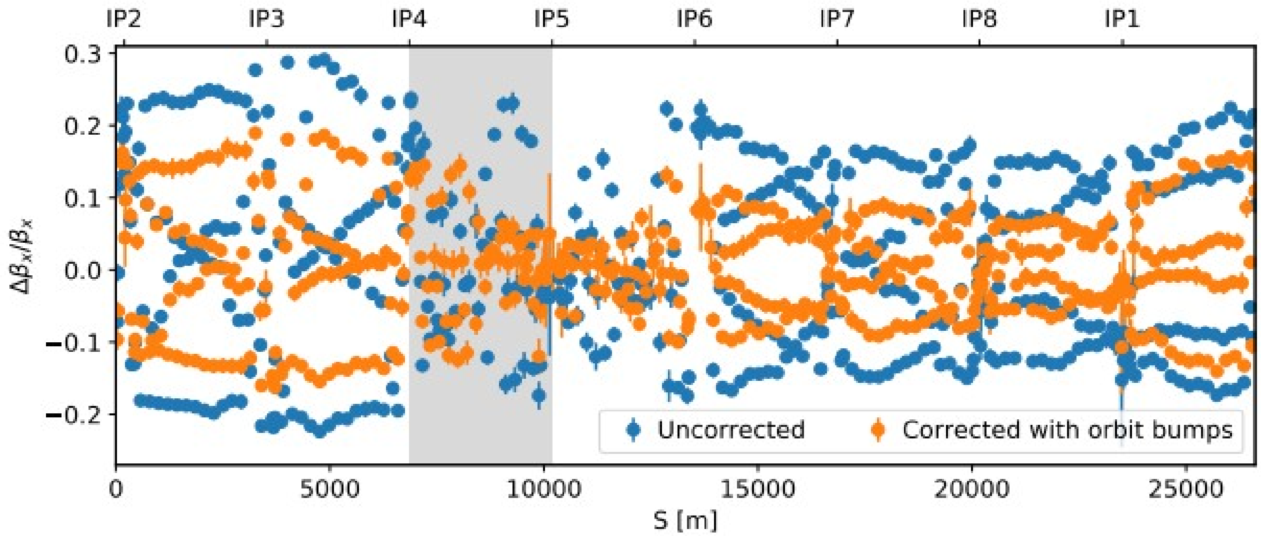
Conclusion

- Highest priority is to develop techniques to ensure the beam size at the IRs (6 shifts)
  - Ballistic optics (1-2)
  - Additional K-modulation (1)
  - Better local coupling corrections (1)
  - Direct luminosity optimization with waist shift knobs (2)
- Control the optics in the ramp (2 shifts)
- Improve the optics control (3 shifts)
- Additional control of the transverse coupling (3 shifts)
- Studies of different optics (5 shifts)

  → 19 shifts in total

Optics correction with sextupole and orbit bumps

- Motivation:
  -
- Refine the automatic correction method and validate it to be ready challenging optics



Action and Phase Jump

- Background:
  - Alternative method to calculate local corrections
- Plan:
  - Test it in commissioning and possibly later in dedicated MD

- -Flat optics Run3: beta* control (improved k-modulation)
- -Offsets and betas in Q1-Q4 with k-modulation (improved analysis) -> use Totem data?
- ---Using orbit in sextupoles to correct
- -MCS + dipole b3 misalignment studies (H & V, add bumps, after full decay)
- -K-modulation: arc, during the ramp
- -Local coupling control: IPs and IR4
- -
- -New ballistic flavors: adding IR4, large horizontal and vertical dispersion in IRs, telescopic ballistic?
- -0.5 um pilot bunch from injectors for measurements and BSRT calibration
- Beam-beam long range with coupling?
- **MDs?**
- -Action-phase jump analysis for local optics corrections, comparisons to S-b-S
- -BPM performance monitoring: calibration + ageing (review Manfred proposal**)**
- **-**Ramp measurements with 3 bunches
- **Nonlinear:**
- - Amplitude dependent beta-beating: Ac dip method and single kick (donut) + k-modulation
- -Islands Oct+Q': (emit motivation)
- -ADT large single bunch kick
- -(ADECTA at top energy with a fancy kick method)
- -(Momentum compaction factor by measuring tune Qs versus voltage)
- -MCD at 50% at injection, chromatic amplitude detuning.
- -b6 correction (first tests and validation in commissioning at 25cm ? with magnetic data)
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- -Amplitude detuning with CMS solenoid on and off