OMC requests for 2024

E.H.Maclean, on behalf of the OMC team & friends
MD proposals coming from many people

2023 summary:

- **1 regular MD for nonlinear corrections at injection in MD1 [a3 and b5 corrections included in operation for first time]**
- **1 short MD (~3h) added during downtime of ION setup where only pilot proton beams available from SPS**
- **1 MD (failing IR correctors) didn't take place due to availability**

Several journal articles / Ph.D. thesis using LHC MDs submitted or published in 2023:

- **Josch Dilly defended Ph.D.** *Corrections of high-order nonlinearities in the LHC and HL-LHC beam optics*

  → *J.Dilly et. al. Phys. Rev. Accel. Beams* 26 (2023) 12100 First operational dodecapole correction in the LHC

- **Felix Soubelet defended Ph.D.** *Local interaction region coupling correction for the LHC*

  → F.Soubelet et. Al. *Phys. Rev. Accel. Beams* 26 (2023) 051001 Rigid waist shift: A new method for local coupling corrections in the LHC IRs

- **Giulia Russo defended Ph.D.** *Precise tune determination and split beam emittance reconstruction at the CERN PS synchrotron,*

  → *p*art of work actually used LHC 2012 MD to demonstrate detuning measurement from decoherence
  → *submitted to journal:* Harmonic analysis of non-stationary signals with application to LHC beam measurements

- *R.Tomas et. al. Optics for Landau damping with minimized octupolar resonances in the LHC, submitted to JINST*

MD notes – 2 published to CDS, 3 in ABP review process, 1 still being drafted

Various MD requests carried over from previous years:

MD9543 (2023) – failing IR correctors [8hours. Already scheduled in 2023]
- Test strategies for coupling correction with failing MQSX. Test detuning correction with MO in case of failing MCOX.

MD6943 (2023) - 60deg optics [12hours, need support from OP]
- LHCB1 measurements performed in 2022. Never measured LHCB2.
- Measuring with different phase advance probes errors in arcs differently
- Significantly different momentum compaction factor. LHCB1 analysis pointed to systematic BPM calibration error

MD10443 (2023) – Improved K-modulation techniques for low beta* reach [8hours]
- Test various methods to improve K-mod measurements in the LHC.
- High priority problem for HL-LHC commissioning
- Kmod at Q2/Q3. Waist scans with K-mod

MD6946 (2023) – beam-based tests of alternative OMC methods (ML and lobster). Combined with failing correctors.
- Purposefully introduce optics errors by mispowering various combinations of quads, and test if various OMC methods can correctly identify/compensate the introduced error

MD10406 (2023) – proposed by Thomas Pugnat,
-- Amplitude dependent beta-beating. Could be combined with e.g. failing IR corrs with few extra hours.
- Attempt to measure amplitude dependent beat-beating induced by applied settings of octupole correctors
- Brand new measurement never performed in any other accelerator before

## MD6904 (2022) – Methods for nonlinear optics measurement at small action /
/ MD10397 (2023) – extended ADT ACD for optics and ecloud [6hours, pilot at injection]
- Use ADT to try and measure RDTs, benchmarked against ACD measurements with various settings of correctors to artificially vary the RDTs. Compare free/forced RDT with MKA.
- Test measuring with ADT with operational MO, Q'
- Test measuring with ADT with nominal bunch
- Move towards testing linear/nonlinear optics measurement with ADT along a train

4 to 5 MDs carried over

Possible some parasitic data obtained during 2024 commissioning. T.B.S.

Some synergy of key OMC questions with Riccardo's proposed MD plan for HL

Measurements for arc errors (0h, should get essentially for free in context of HL-LHC MD request by Riccardo)

- 2022 commissioning demonstrated local arc errors starting to become important for optics correction strategy.

- Correcting today with local orbit bumps in relevant arcs

- Want to nail down good corrections in Run3 to simplify HL-LHC commissioning

- Optics measurements with strong ATS factors in arcs / special optics to probe differently arc errors
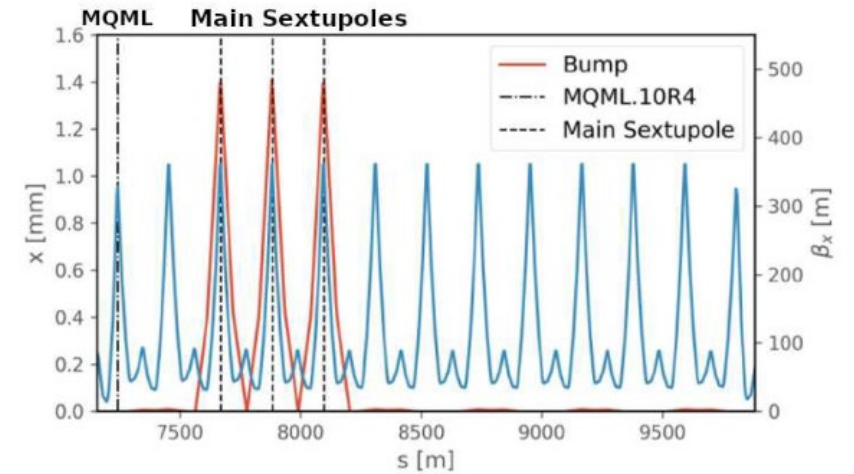
Detuning degradation (+2h to Riccardo's HL-LHC planning)

- Observed large degradation of Amplitude detuning between Run2 – Run3.

- 20% of available MO powering at 30cm

- Not expected: Run1-Run2 detuning extremely stable.

- Larger than expected from model with ideal sextupoles / b3 corrections

- MD in 2022 to measure detuning through squeeze showed detuning degradation develops through squeeze. Measure detuning with strong ATS factors to understand if source of the extra detuning is in the arcs.
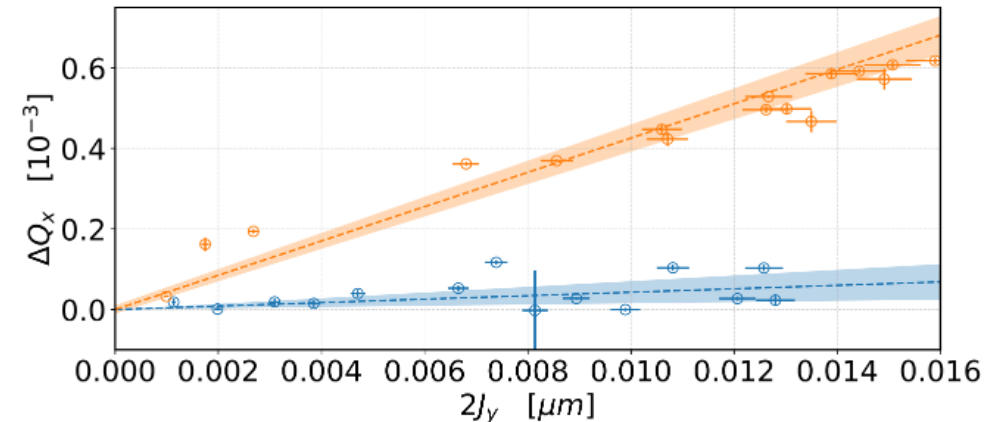
Some key open questions, for potential pilot MDs at injection
→ An actual plan of MD proposals and priorities will depend on commissioning outcomes
→ one option would be parallel MDs on the 2 beams

Impact of higher-order RDT contributions from MO [6h, pilot MD at injection]
- Beam and simulation studies are pointing to large higher-order RDT contributions from MO
- MO+a2 drives large skew-octupole RDT f1012 (Qx-Qy)
- MO+MS should generate very strong f1004 (Qx-4Qy) decapole resonance.
- effective trims of correctors to vary RDT on level expected, to check impact on lifetime, DA

**Normal and skew sextupole correction at injection** [6h pilot MD at injection]
- F1020 is only RDT regularly observed in linear optics measurements. Big beam1/beam2 asymmetry.
- Aim to test new correction to understand if impact of f1020 on lifetime, DA, …
- 3Qy corrections need to be re-done due to RP.

B4 RDT response to MO, and Coupling induced RDTs [6h pilot MD at injection]
- Measured response of normal octupole RDT to changes in MO powering do not agree well with the model.
- Check degaussing of MO. Check response to specific MO circuits.
- Simulations show that even very small linear coupling is acting as a significant driver of higher-order RDTs
- Benchmark the expected scale coupling dependent RDTs

Dynamic RDTs: RDT decay, L/NL optics during snapback, RDTs in the ramp. [could be combined with other OMC study]
- Expect significant shifts to f1004 RDT due to b5 decay at injection. Initial studies show some variation in b3 RDT over long period at injection, but no detailed measurement.
- Large missing contribution to 3Qy in magnetic model. One possibility is systematic roll of MCS vs MB, which should show up as f0030 decay.
- Parasitic linear optics meas in ramp show big shifts to normal/skew sextupole RDTs (particularly for ion optics). But only based on small kicks. Ramp with NL-optics scale kicks.
- In context of ramp emittance growth, interested to try and measure what happens to linear / nonlinear optics at start of ramp due to snapback. Use ADT and ACD for longer term excitation at very beginning of ramp.
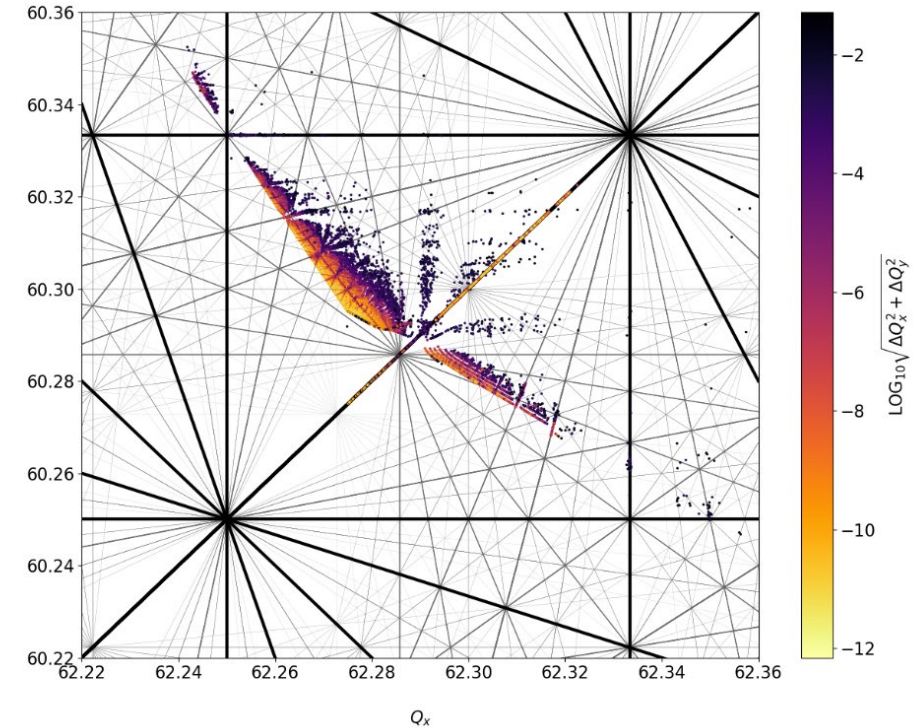
Longer term / lower priority studies:

Ballistic optics (8 hours. Late in Run 3)

- Would be of interest towards end of Run. In order to check long-term calibration quality of BPMs.

Effect of experimental magnets on optics (12h, only in very specific circumstances)

- Impact of experimental magnets on optics at extremely low beta* is long-term open question. e.g. effect of solenoid fringe field in triplets
- Of interest to HL-LHC, possibly future colliders in general
- Would need to measure linear and nonlinear optics before/after CMS solenoid is powered off. 12 hour MD to keep in mind if situation ever arises that plan to ramp down EXP magnets at end of MD block.

IR sextupole corrections and feed-down (8 hours. Low priority. Only of interest if still no resolution in commissioning)

- Several open questions regarding nonlinear optics which would be of interest to resolve in Run3. But lower priority than other studies
- IP2 sextupole corrections not behaving as expected in ION optics. Test response systematically to understand discrepancy.
- Tune butterflies seen in crossing-angle scans. Test crossing-scans with alternative bumps, check RDT on up/down scans.

General issue for 2024:

Do we need any special collimator sequence / procedure to leave TDIS out during repeated re-injection with pilots during OMC commissioning / MD, to avoid unnecessary cycles.

Historically this had been usual request for OMC measurements in any case to save time with reinjections.