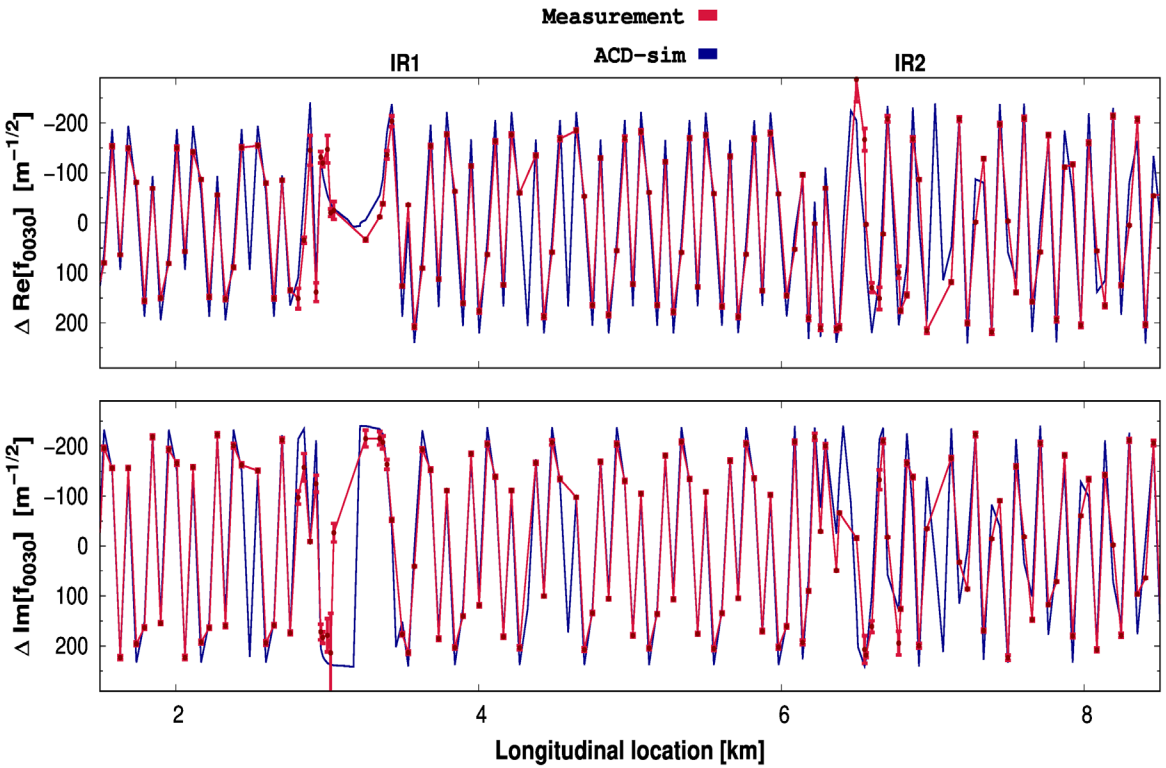
MD13547 Measurement and correction of weak/strong long-range beam-beam continued

E.H.Maclean, T.H.B Persson, R. Tomas and the OMC team

Motivation

- Long-range beam-beam strongly drives specific nonlinear resonances – in particular 3Qy which is close to WP
- 3Qy variously linked to lifetime and collimator hierarchy breakage (Qy dependence, Q' mitigation, a3 mitigation, on-disp)
- MD12263 in MD2 we performed first ever measurements of LRBB driven resonances in Beam2



Physics motivation:

→ measure shift to LHCB1 resonance strength caused by LRBB to allow quantitative benchmarking w.r.t. simulation tools

Operational motivation

→ test compensation of the beam-beam resonances using the existing corrector magnets
→ if successful can look to use in operation in coming years → significant change to OMC strategy for LHC and future colliders

- **Very similar procedure to MD12263 performed in MD2**
  → RMPP review performed on 10/05/24 https://indico.cern.ch/event/1418360/

- **In previous MD performed classic OMC measurements (linear optics and RDTs) on low-intensity Beam2, which was in collision with high-intensity train in Beam1**

- **In this MD plan to perform same weak-strong measurements, but reversing the beam-roles over 2 fills.**

- **In low-intensity beam have 3 pilots.**
  1 x no collisions
  1 x full LR in IP1/5
  1 x partial LR in IP1/5

For second fill use same filling scheme as previous MD: BBMD_36b-trains-In-B1-INDIVS-in-B2_v2
For first fill use equivalent but with Beam1/2 roles swapped

Fill 1:

- **Beam1:** 3 pilots 10^{10}p/b safe beam flag NLO collimators ACD kicks MO off
- **Beam2:** 144 nominal 1.6×10^{11}p/b unsafe beam nominal collimators No kicks MO on

Fill 2:

- **Beam1:** 144 nominal 1.6×10^{11}p/b unsafe beam nominal collimators No kicks MO on
- **Beam2:** 3 pilots 10^{10}p/b safe beam flag NLO collimators ACD kicks MO off

Key Points (as in MD2)

- **Safe-beam flag on weak-beam (B1 in Fill1, B2 in Fill2)**

- **Remove common BPM from OFB**

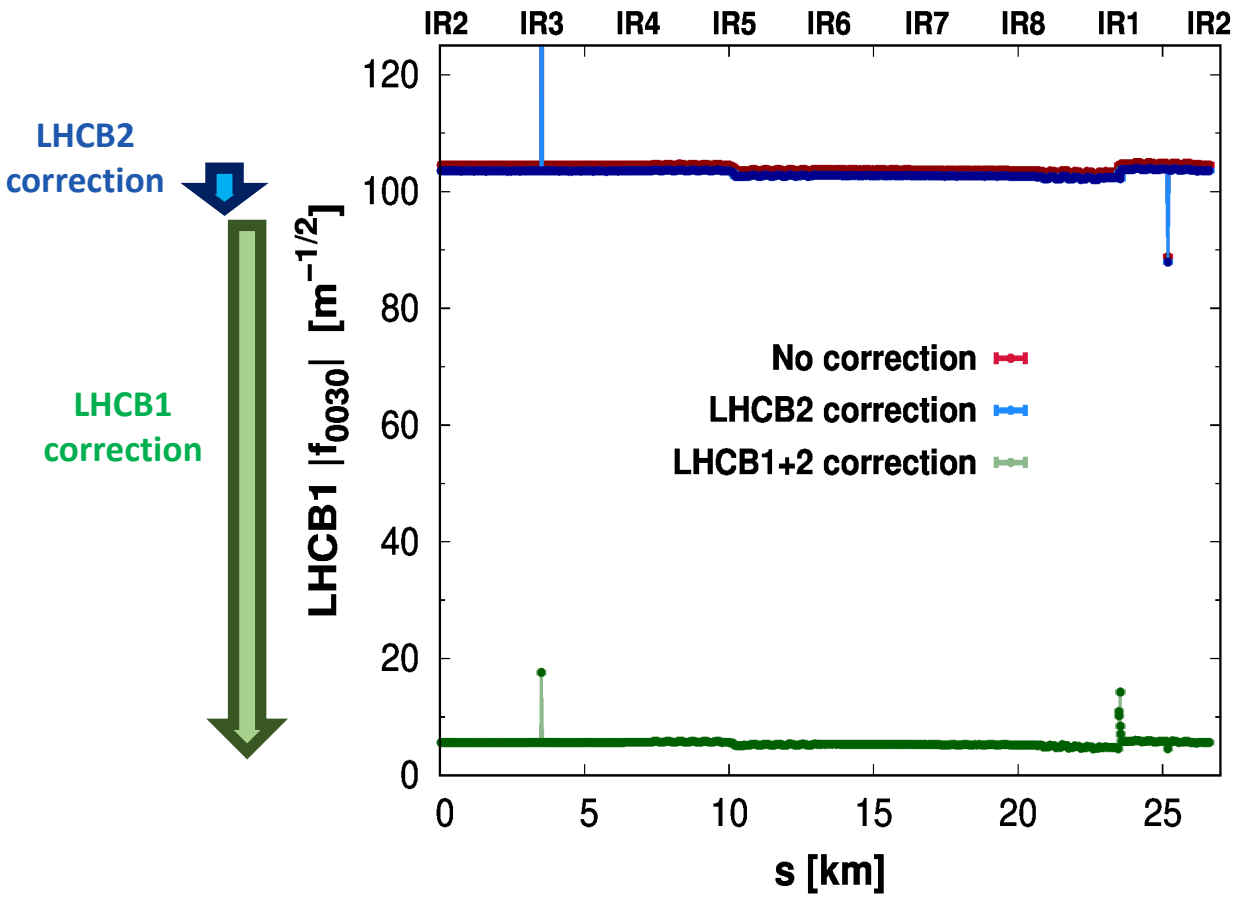
- **Prior to measuring remove strong-beam collimators from NLO 30cm HW group**

  → playing NLO 30cm sequence then allows to go to NLO in only 1 beam

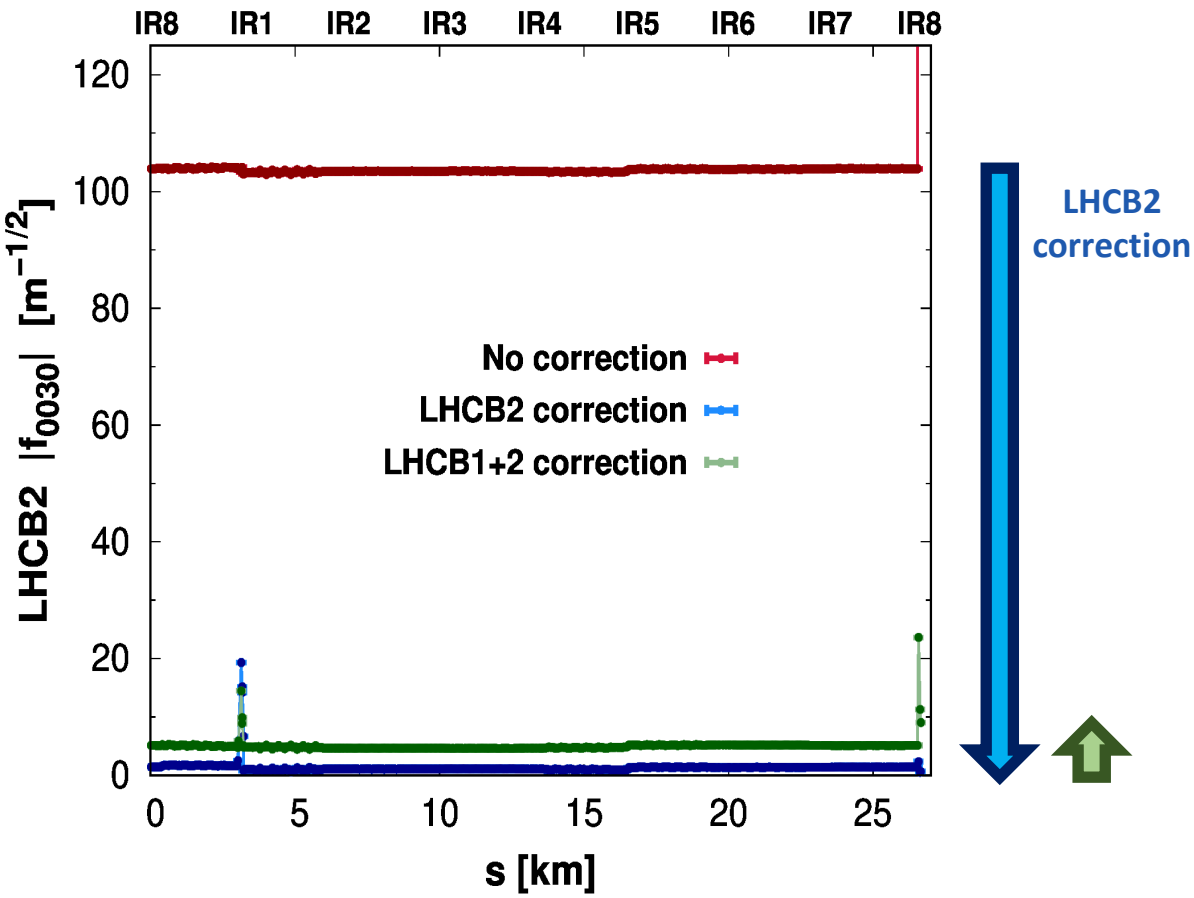
  → strong beam has unsafe beam flag so all collimator interlocks active

- **Identified corrections in LRBB simulations for 3Qy resonance driven by beam-beam using the MCSSX a3 correctors in IR1 → validate correction performance in this MD**

LHCB1



LHCB2



3Qy correction (new procedure vs MD2):

- Done via trims of MCSSX (a3 correctors) left/right of IP1

  → MCSSX are not interlocked in operation

- Max trim of 45A, trimmed in in steps, correcting Q with MQT to maintain constant WP

  → Ramp rate of MCSSX is < 25A/min

- BBLR correction with MCSSX about 5x stronger than lattice MCSSX corrections previously trimmed in during operation

- Predicted feed-down below 6% peak beta-beat, well below peak beta-beat generated by LR-beam-beam

complementary request:

- **MD13945 Long-range beam-beam RDT compensation**

Test implementation of the MCSSX corrections at end-of-fill

→ **Stepping stone to potential use of MCSSX corrections in operation in 2025**

→ Trim in the Long-range-3Qy correction and see if any impact observed at end of fill

→ In practice BBLR effect on RDT will scale with intensity, so expect significantly reduced impact at end-of-fill

If previous MD taken in MD5, EoF study would be done before the dedicated test

Key Points (as in MD2)

- PP end of fill MD, with full machine
- No feed-back changes
- Due to lower intensity increase Qy to try and see some degradation of lifetime approaching 3Qy resonance. Typically might expect Qy change around few 10^{-3} (on scale of OP lifetime optimization trims)
- Apply LHCB1 and LHCB2 LRBB 3Qy corrections slowly in steps, applying tune corrections with MQT to maintain constant WP. Observe any impact on beam.
- Apply inverse correction to purposefully degrade 3Qy if allowed by MPP?

Key points

- Same 3Qy correction principle as described previously
- Using MCSSX (a3 corrections) left/right of IP1. Same ramp rates as described previously.
- Correction at 1.6e11 p/b expected to be scaled down for surviving intensity at EoF

	Combined LHCB1/2 correction @ 1.6e11 p/bunch [k] , [A]		2/3 correction anticipated at end-of-fill [k] , [A]
RCSSX.3L1	$-0.012[\mathrm{m}^{-3}]$	-36[A]	-24[A]
RCSSX.3R1	$+0.009[\mathrm{m}^{-3}]$	+27[A]	+18[A]

- Predicted beta-beat due to feed-down from MCSSX trim is <6% for full correction