Review Orbit MCBX correction budget

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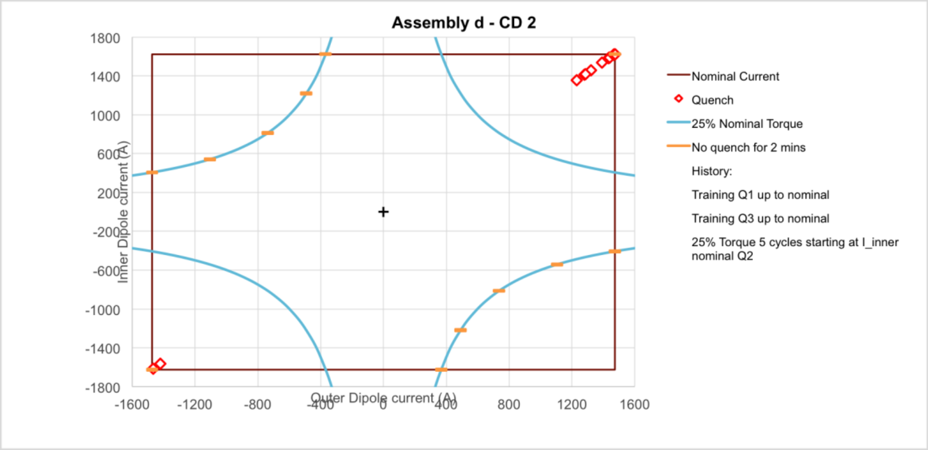
Status of MCBXF (nested corrector) E. Todesco

- The first prototype reached nominal current in combined mode
  - Retraining is needed to get more than 25% of the torque when changing the torque sign
  - A second magnet is being tested, thermal cycle ongoing
  - Two action lines being explored
    - Options to improve the design, optimization of shimming plan
    - Review the operational needs (requirements were established before the inclusion of remote alignment system)

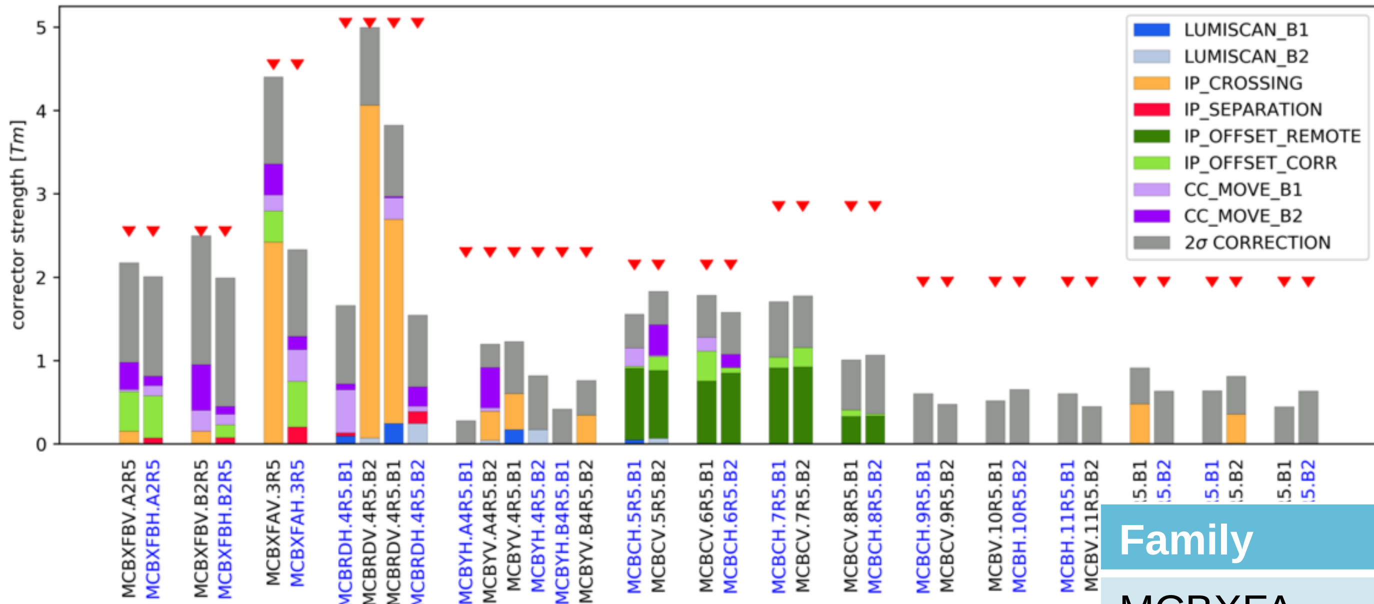


MCBXFP1d operational space [courtesy of J. C. Perez]

Partially correct, see next slides

Orbit corrector budget

http://cds.cern.ch/record/2731920/files/CERN-ACC-NOTE-2020-0045.pdf



Family	Budget
MCBXFA	2.5 Tm
MCBXFB	4.5 Tm
MCBRD	5 Tm
MCBY(s)	2.25 Tm
MCBC	2.1 Tm

- Lumi scan: 100 um
- IP Crossing: 295 μrad
- IP Separation: 0.75 mm
- IP Offset FRA: 2 mm

- IP Offset Corr: 0.5 mm
- CC Move: 0.5 mm
- 2σ CORR: 0.5 mm transverse - 0.1 mrad roll

FRAS is already considered in the budget to

- Shift Q1-Q5 L/R (and therefore the IP) to follow the detector ground motion (2 mm)
- Absorb yearly ground motions in the tunnel to keep the elements aligned (>0.5 mm)

HiLumi HL-LHC PROJECT

Ground motion

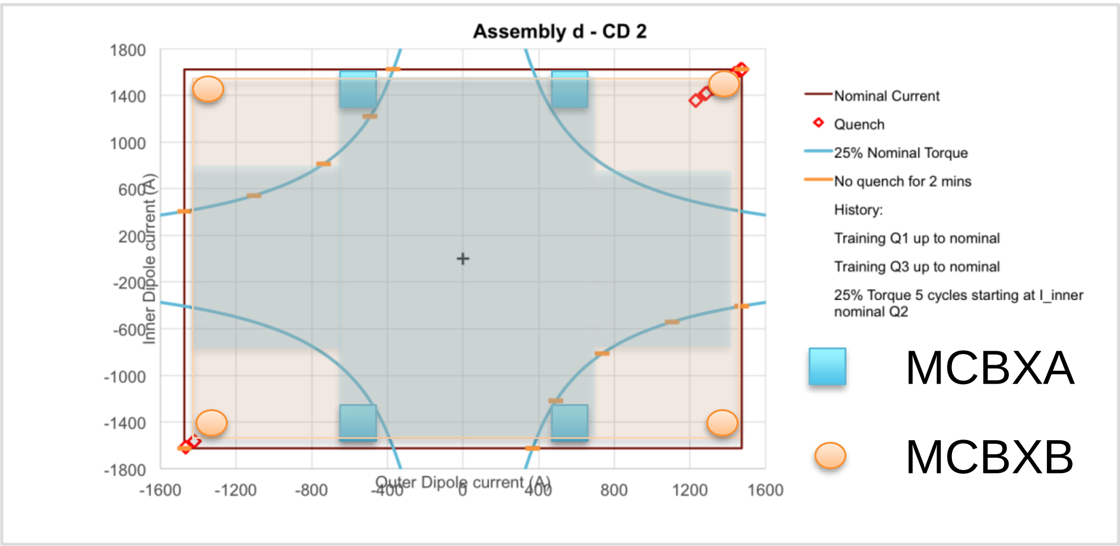
Table 2: maximum displacement in millimetre per year measured between the detector and the machine.

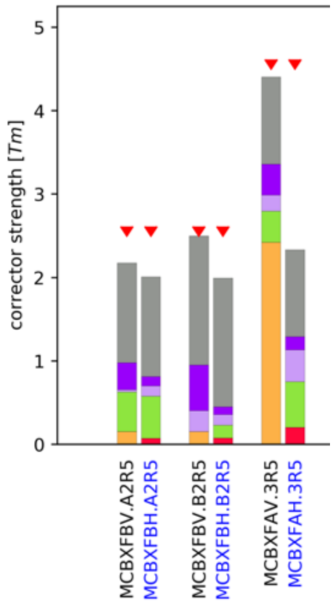
	Radial (mm/year)	Vertical (mm/year)
Around IP5 (CMS)	± 0.3	+ 0.7 in 5L (120 m to 140 m, 205 m to 275 m from IP5) + 0.5 in 5R (85 m to 120 m, 205 m to 275 m from IP5) + 0.2 in any other area
Around IP1 (ATLAS)	± 0.2	± 0.3

Based on the motion recorded so far

The construction of the new HL-LHC galleries might have an impact on such ground motion values. A regular monitoring of the tunnel floor and transverse profiles was launched one month before the start of civil engineering works beginning of 2018; measurements are performed every 3 months to control the stability of the tunnel during LS2 and Run 3 (profile measurements are the responsibility of the CE contractors). If important ground motion is monitored, there should still be some time to adapt a shimming strategy for example on specific components, or to extend the adjustment capability of their corresponding supporting adjustment platform. HL-LHC underground construction will be completed before the start of LHC Run 3.

Worst case





Assuming 25% of the torque is a limit:

- MCBXB limited in a circle of 1.15 Tm, missing ~1Tm
- MCBXA limited in to 1.5 Tm in non-crossing, missing about ~1Tm

The working point of MCBXB and the non crossing angle part of MCBXA is not know a priori before beam commissioning.

Possible strategy: correct at injection, train MCBX on a line, correct at flat top.

NB: yellow part of MCBXA is larger at pre-squeeze β*>50 cm (0.4Tm at β*=1m)

P. Fessia TCC

Possible alignment

	Scheme 1: During operation or TS up 2.5 mm	
Machine conditions	Machine operating conditions	M
Max stroke	+/- 2.5 mm	±1 limi
Time required per IP side Q1 to D1	30 min No access	60 No
Time required per IP Q1 to Q5	30 min No access	2(Ac co De th poi
	CD: NA	CD
Time required per IP side Q1 to Q6	Not possible	2 TS Be co TS
	NA	CD

Machine Protection aspects discussed MPP 09/11/2018

- Interlocks
  - Interlocks shall be implemented to avoid that nearby elements move separately in dangerous way, putting at risk the mechanical integrity
  - Interlocks could be implemented to limit the maximum amplitude movement according to the machine status
  - Key-type interlocks shall be implemented to avoid that the machine can be moved in non-safe conditions
- Machine re-qualification is required after each movement. This would make of the end of the TS the most suitable moment to intervene.
- Integrating part of the Full Remote Alignment is the tracking and logging of the movement of the elements/interconnects. This is needed to know their exact position before applying any correction

EDMS: 2166298 Small machine movements (within a few tenths of a millimetre) could be allowed without requalification during the operation of a pilot beam.

Is requalification needed when moving specifically quadrupoles with beam? Contrary to dipoles and absorbers, beam gives most accurate measure of applied offset.

Possible extension of FRAS scope

Knowing 1mm in the triplet is equivalent to 1Tm dipole kick,

if:

- FRAS can be used during beam commissioning with beam during orbit adjustments, as of specs
- the minimum step is in the order of ~45 µm (~1.5 µrad at 7TeV) as of specs
- the reliability is sufficient for frequent usage, not in specs (but motors specified for 1.5 M revolution and 135kh operation)
- the usage of FRAS is as safe as operating an orbit corrector, not in specs

then

the budget 2σ CORR, CC Move, IP Offset Corr. could be reduced by taking it from the FRAS budget of 2.5 mm.

MCBX and FRAS considerations

Assuming 25% of the torque is a limit:

- MCBXB limited in a circle of 1.15 Tm
  - FRAS needs to compensate 1Tm that is ~ 1mm for orbit correction in Q1-Q2.
- MCBXA limited in to 1.5 Tm in non-crossing plane
  - FRAS needs to compensate 1Tm that is ~1mm for orbit correction in Q3.

Other usage of FRAS needs to be reviewed for instance:

- triplet misalignment for radiation

If FRAS is used for orbit correction, one needs to redistribute the FRAS budget (2.5 mm):

- 1.5 mm IP offset
- 1 mm (ground motion and orbit correction)

Remote alignment range can then be recovered with manual re-adjustment in the tunnel if the machine is not yet too activated.