



**High
Luminosity
LHC**

Latest tracking results from CEA

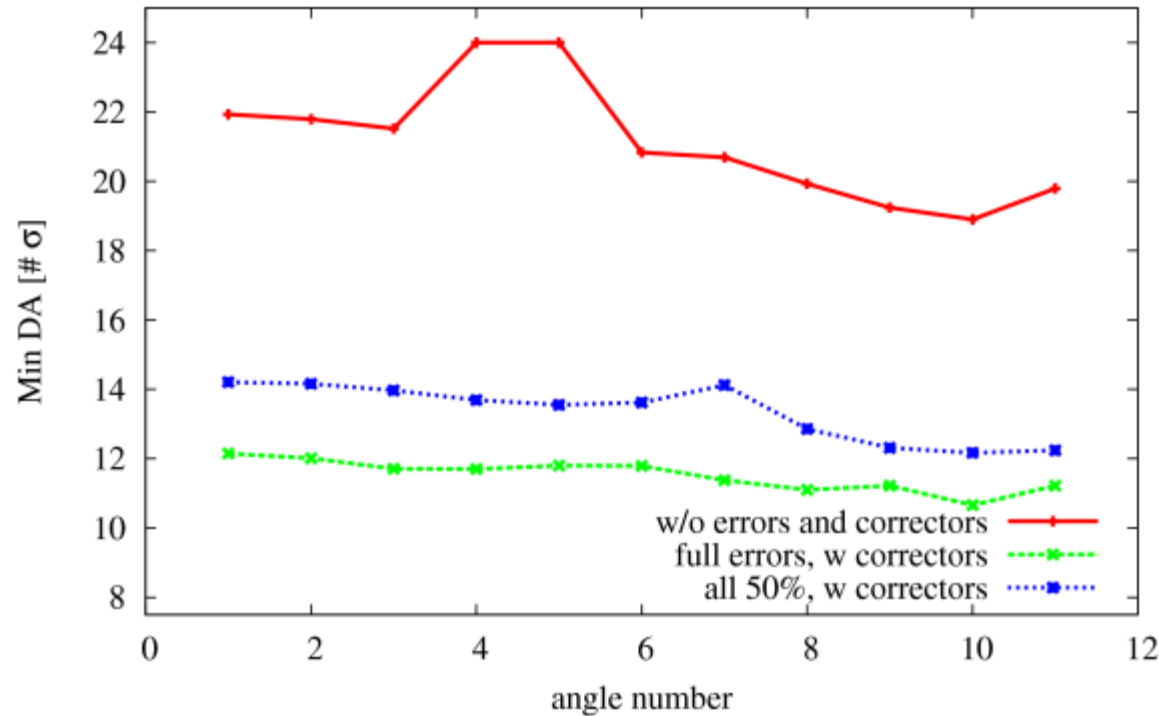
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Thanks to R. De Maria & M. Giovannozzi

Field Quality Study

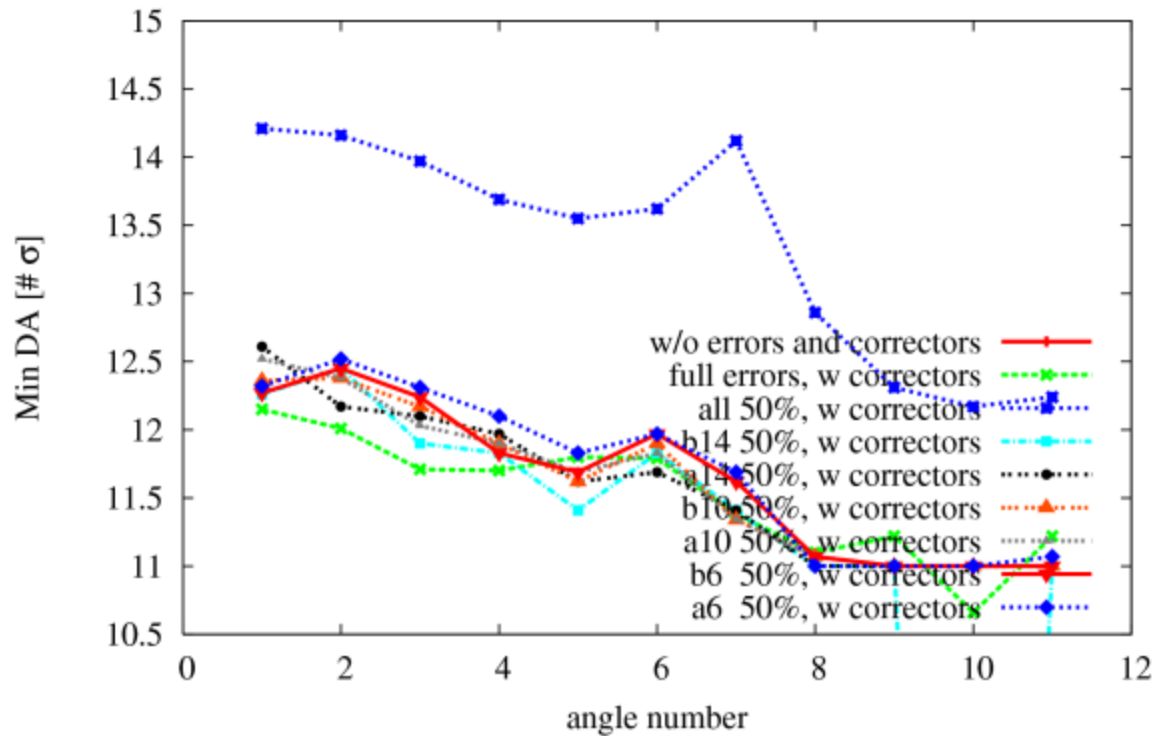
- LHC v3.1b @ collision (round beam with $\beta^* = 15\text{cm}$)
- Search for the error set which gives the largest minima of the DA
- Standard errors and corrections for the arcs
- IT errors : [slhc/errors/IT_errortable_v2](#)
- Corrections b3, b4, b5, b6, a2, a3, a4, a5, a6 turned on for the IT and D1 (corr_tripD1_v1, M.Giovanozzi, WEPEA048, IPAC'13)
- The error amplitudes can be divided by 2, at most
- DA for 11 angles ($0, \pi/2$), 9 amplitudes ($11\sigma, 27\sigma$, step 2σ), 60 particles, 100000 turns, 60 error seeds

Starting point



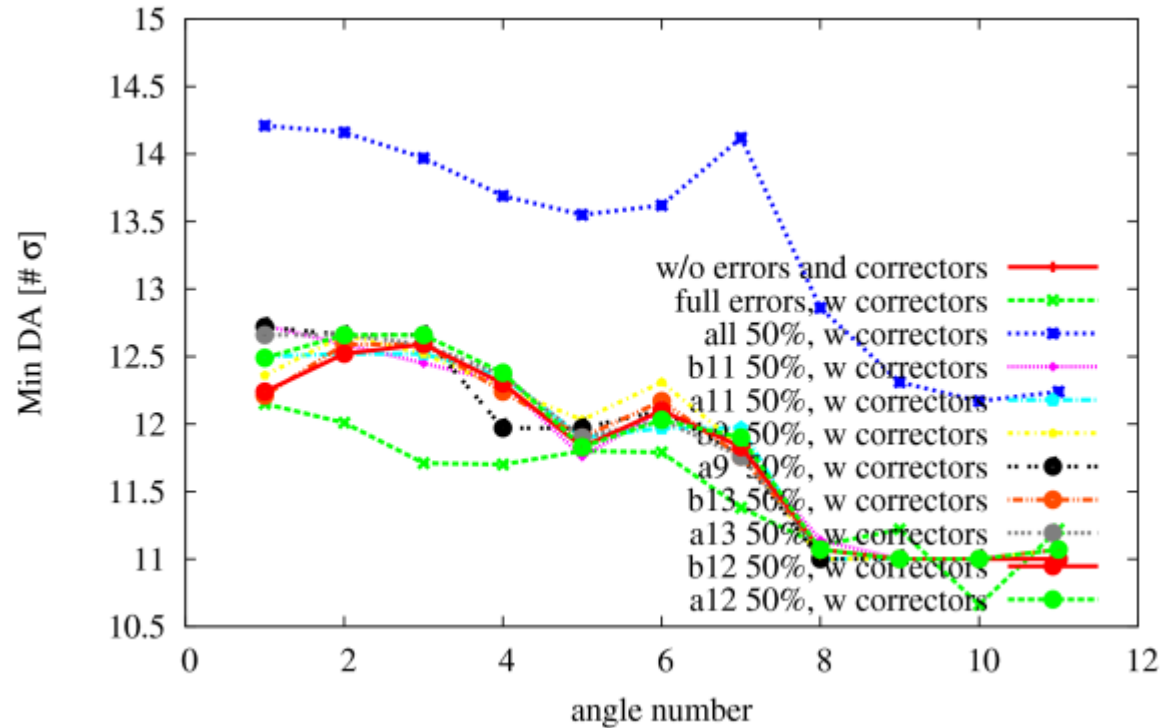
- **Green:** all errors ON, with full amplitude \Rightarrow reduction of about 50% of the minima of the acceptance (from 20σ to 11σ)
- **Blue:** all errors ON, with half amplitude (the best achievable) \Rightarrow the minima are increased by about 2σ at all angles, they remain around 14σ

Reduction of the natural quadrupole harmonics



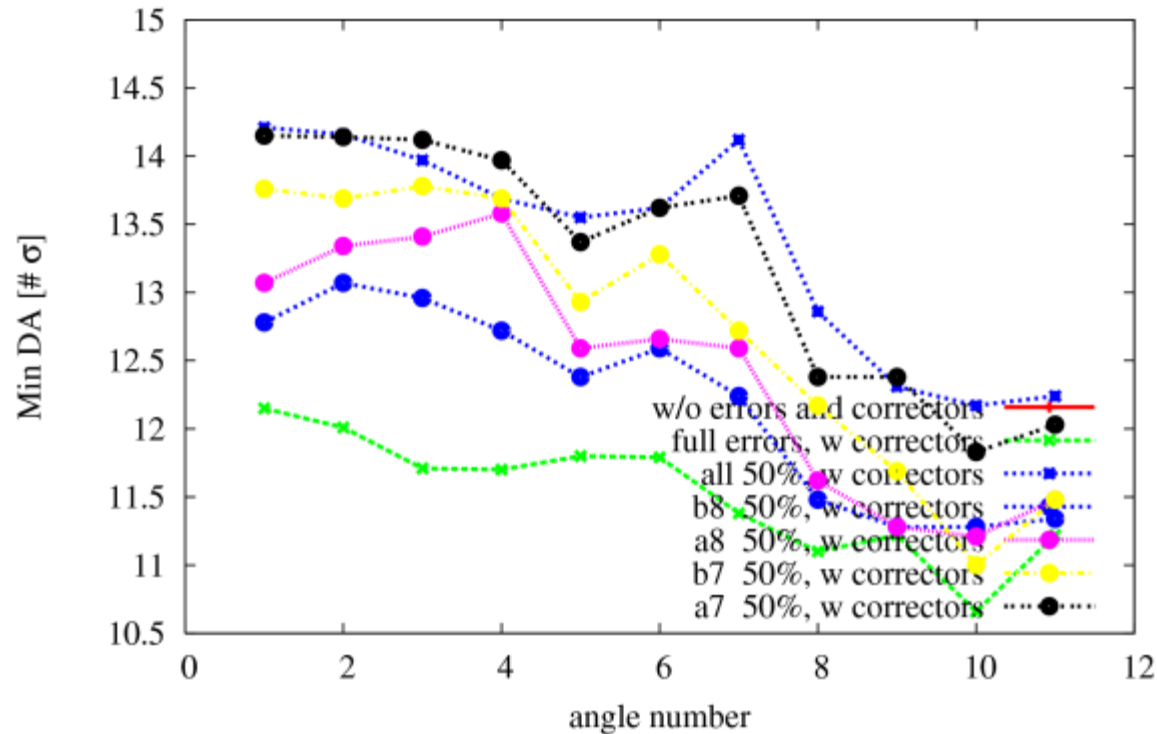
- All the multipoles errors are set to 100%, the correctors are turned ON
- The multipoles are then reduced by 50% one after the other (b14, then b14+a14, then b14+a14+b10, and so on)
- Small gain with the reduction of the natural multipoles

Reduction of the harmonics (2)



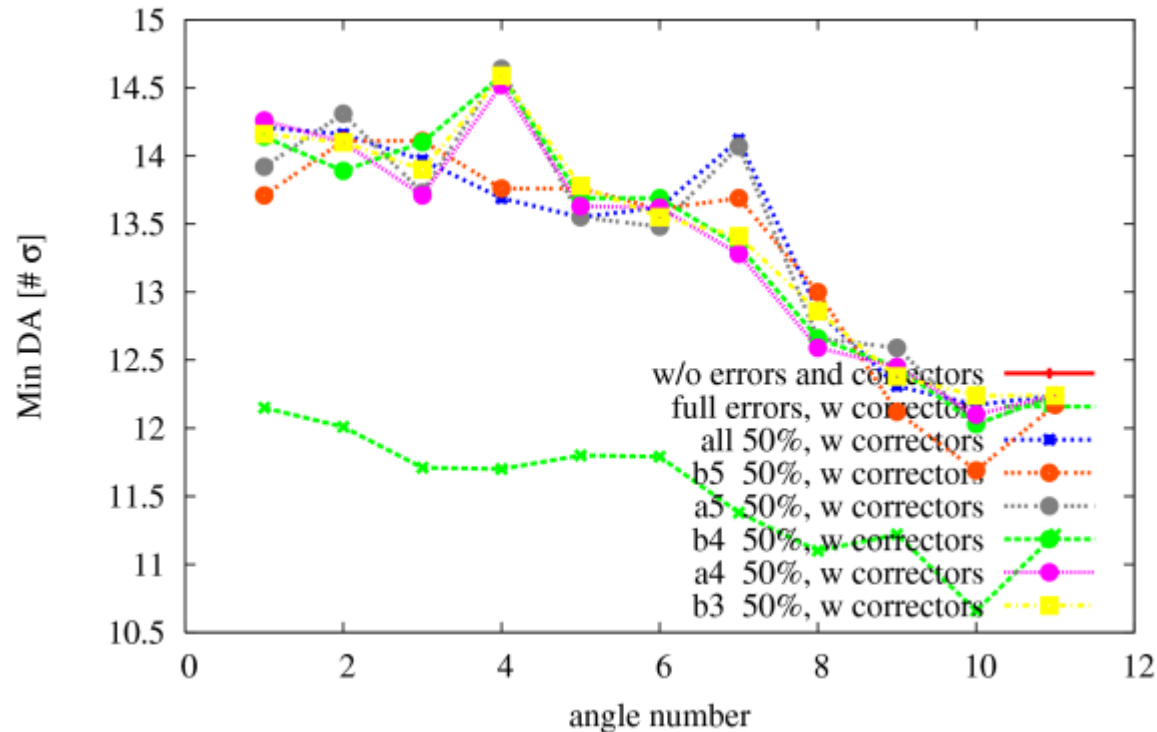
- The previous multipoles are kept at 50% and the other are reduced one after the other (b11, then b11+a11, then b11+a11 +b9, and so on..)
- No clear gain with the reduction of **these** multipoles

Reduction of the harmonics (3)



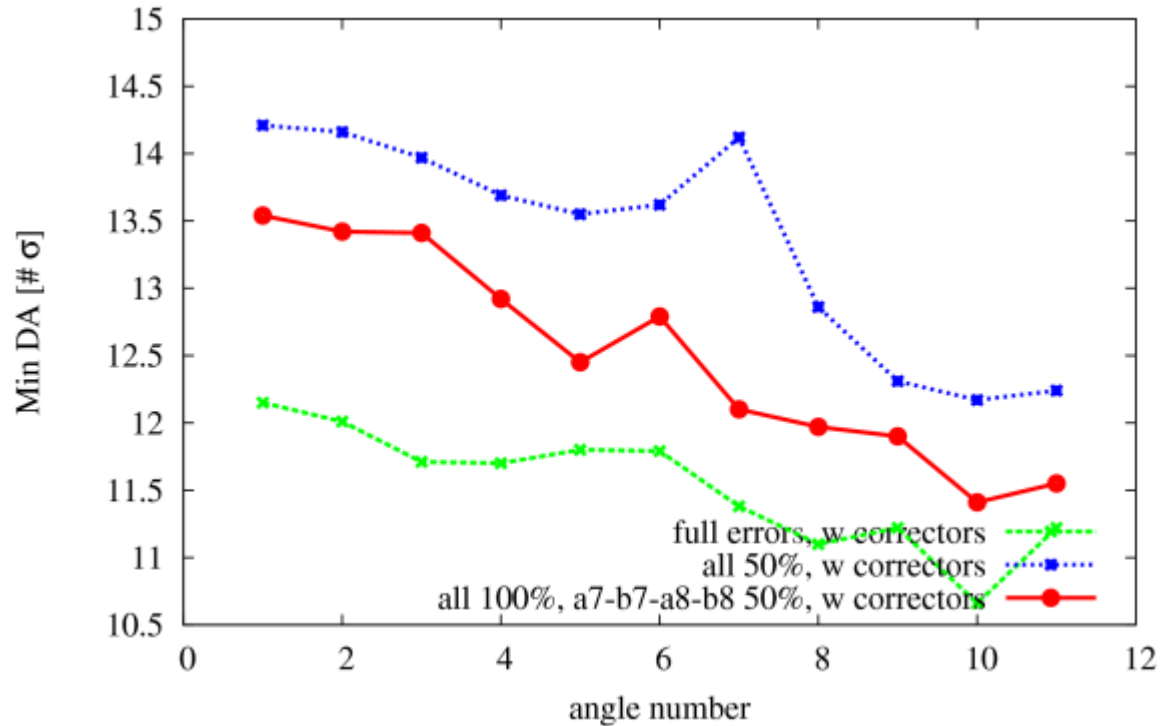
- The previous multipoles are kept at 50% and the other are reduced one after the other, ...+b8, then ...+b8+a8, then+b7+a7
- Visible effect: with the reduction of **these** multipoles the blue curve with crosses is reached

Reduction of the harmonics (4)



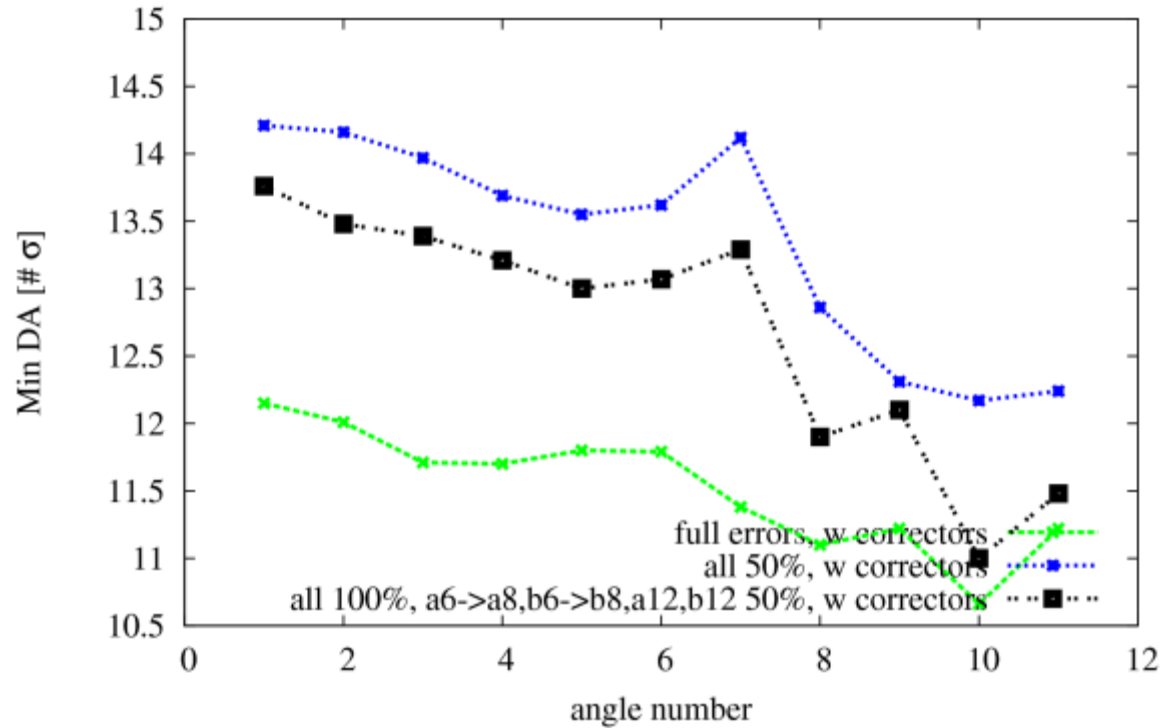
- The previous multipoles are kept at 50% and the other are reduced one after the other (from b5 up to b3)
- The blue curve with all errors at 50% is reproduced with some statistical fluctuations.

Reduction of the b7, b8, a7, a8 harmonics only



- The reduction of b7, b8, a7, a8 **only** is **not** sufficient to reach the **blue** curve (we gain $\sim 1-1.5\sigma$). Some other multipoles need to be reduced too.

A good sample of multipoles ?



- The reduction of b6, b7, b8, b12 and a6, a7, a8, a12 all together may be a good compromise between the constraints on the magnet design (few multipoles reduced to 50%) and the DA minima.

Summary

- Field Quality Study of LHC v3.1b @ collision optics has been performed with SixTrack in terms of DA.
- Minima DA w/o IT errors $\sim 20\sigma$, w 100% IT errors (with correctors) $\sim 11\sigma$, w 50% IT errors (with correctors) $\sim 14\sigma$
- The scan of the reduction of the harmonics one after the other shows that b7,a7,b8,a8 has the most important effect on the minima DA ($\sim 1-1.5\sigma$ gain).
- By reducing b6, b7, b8, b12 and a6, a7, a8, a12 all together to 50% we found perhaps a good compromise between the constraints on the magnet design and the DA minima ($\sim 1-2\sigma$ gain).
- The other multipoles individually do not give a relevant effect on the minima DA.



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