FCC-ee compensation scheme: update

M. Koratzinos

Optics meeting

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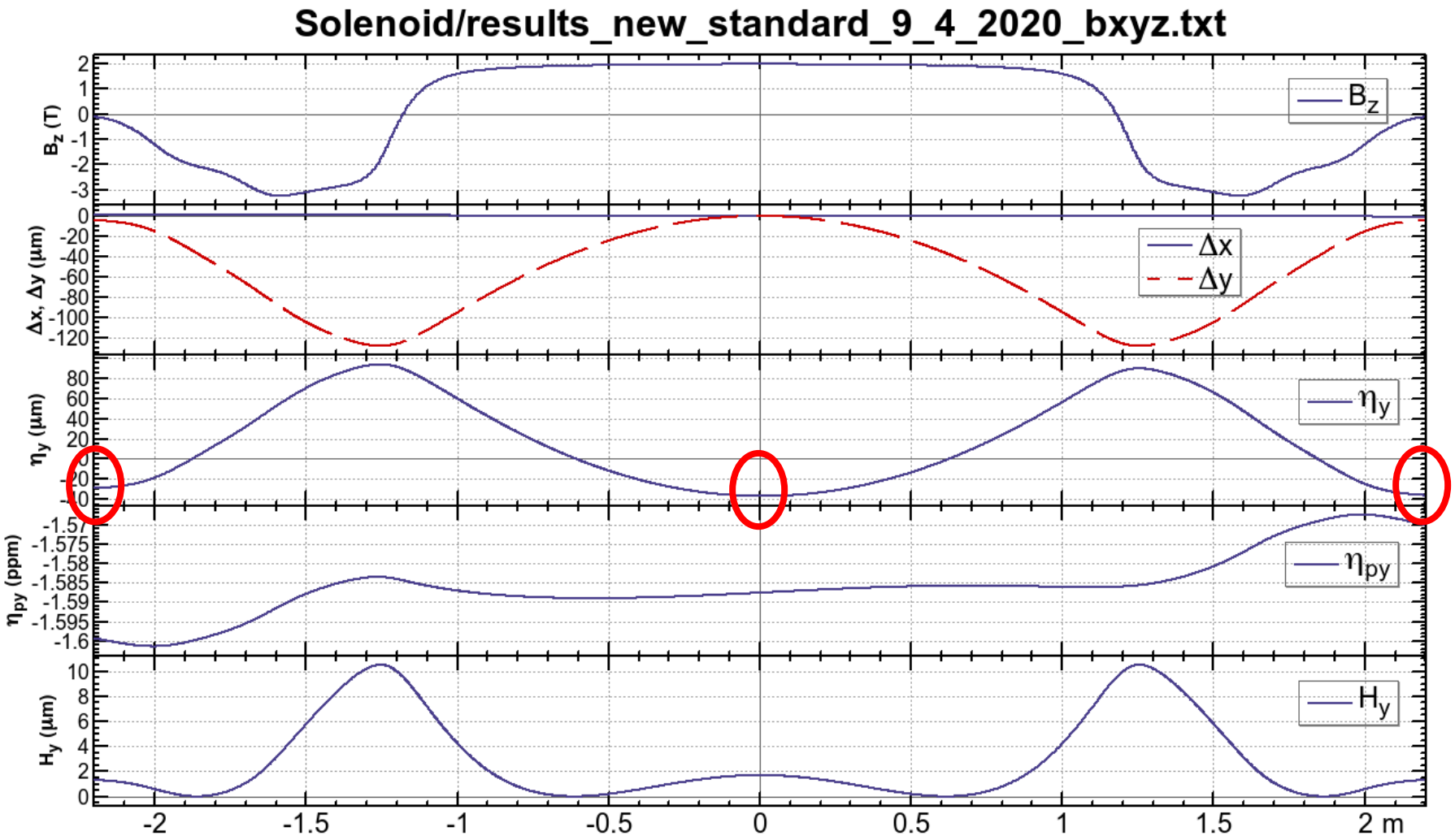
The story so far

- What I presented last time was a revisit and clean up of the compensation scheme
- I found extra space for the cryostat without increasing the emittance
- I introduced variable pitch that gives us limitless optimization options
- The results were good BUT vertical dispersion (about 30um at the IP) leaked to the rest of the ring

Many thanks to Katsunobu for patiently helping me in my debugging sessions, for checking my results and providing valuable feedback

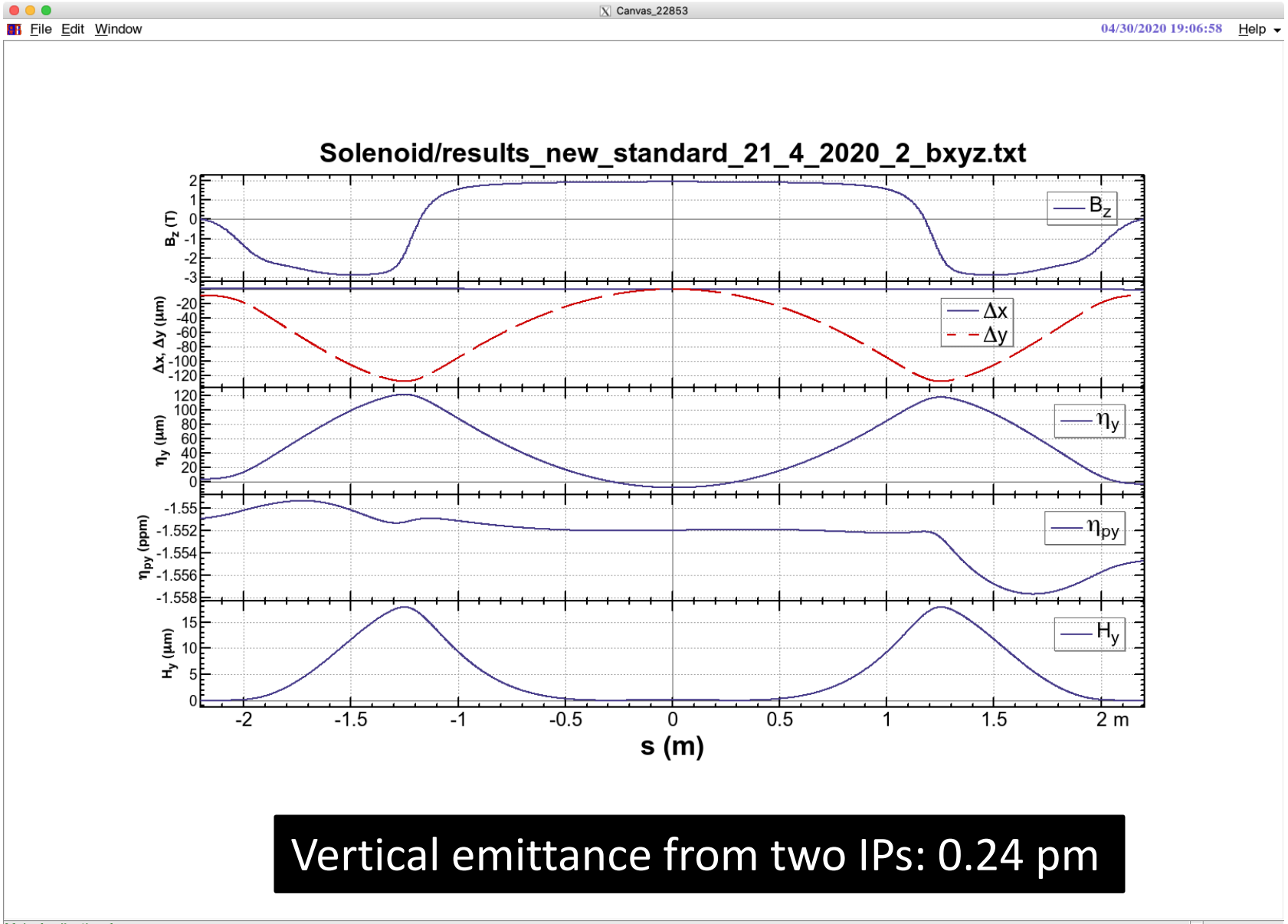
Results of SAD



Can we improve on that?

- It turns out that I was paying attention to making sure that the integral of Bds is zero, but I did not look at the integral of Bdx.
- Since I have two degrees of freedom (the current in the compensation solenoid and the current in the screening solenoid) I can actually make both integrals arbitrary close to zero IN PRINCIPLE
- In practice, I have managed a Bdx integral of a(few)×E-5 Tm and Bdz integral of a (few)×E-3 (which can be improved further if needed)

New SAD results



Vertical emittance from two IPs: 0.24 pm

Misalignment analysis

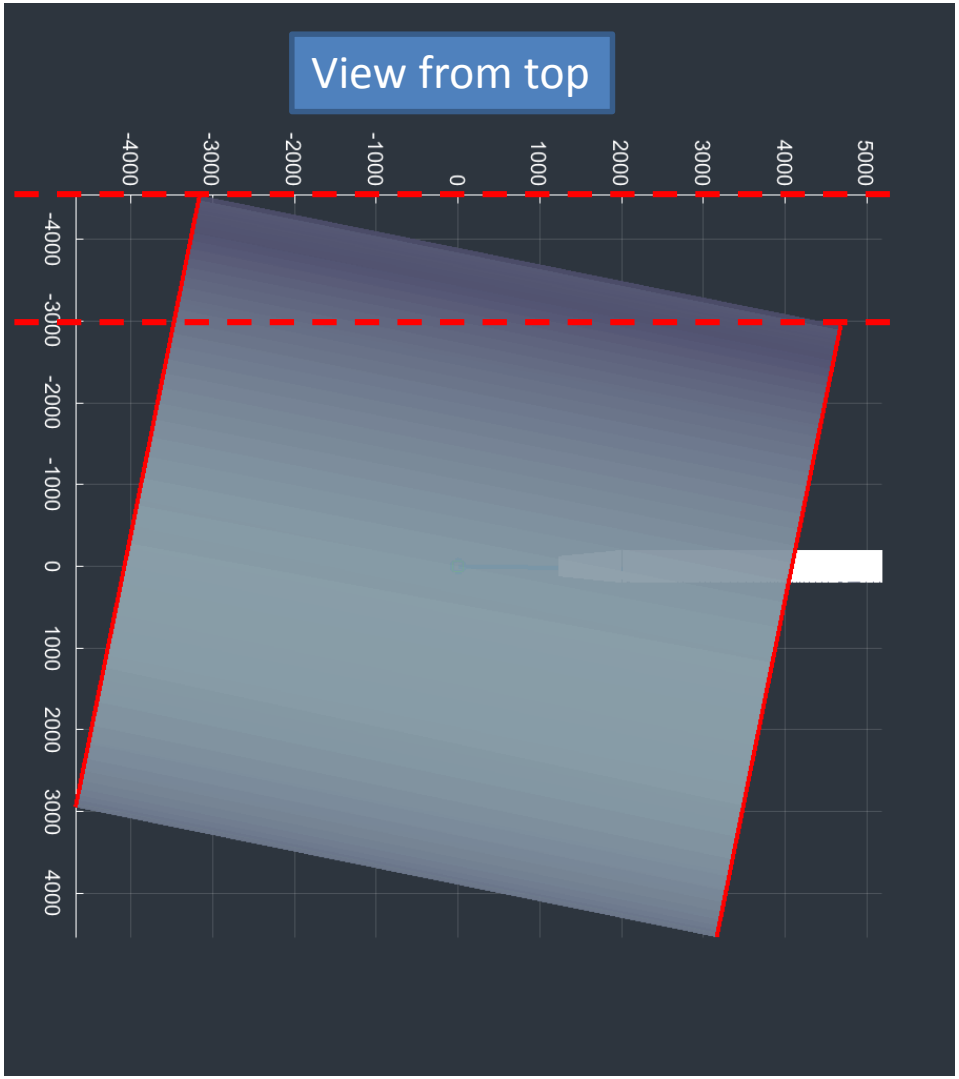
- How sensitive is the compensation system to component misalignment?
- I have moved the screening solenoid and the compensation solenoid individually by:
  - 200 um in x, y, z
  - 100 urad in theta and phi
- The results show that the emittance changes only by 5%
- The biggest change came when misaligning horizontally, so that the edge of the solenoid became closer to the beam
- This was verified by SAD

Misalignment of the detector solenoid

- But this is not the end of the story…
- The detector solenoid is huge and, of course, will also suffer alignment issues
- I have used 10mm of alignment in x, y and z for the detector solenoid
  - No major emittance blowup
- I have used 1mrad tilt misalignment
  - 1mrad in theta has a large effect (20%)

Misalignment in theta

(1mrad in 10 m
➔ 10 mm)



Misalignment exaggerated 20 times

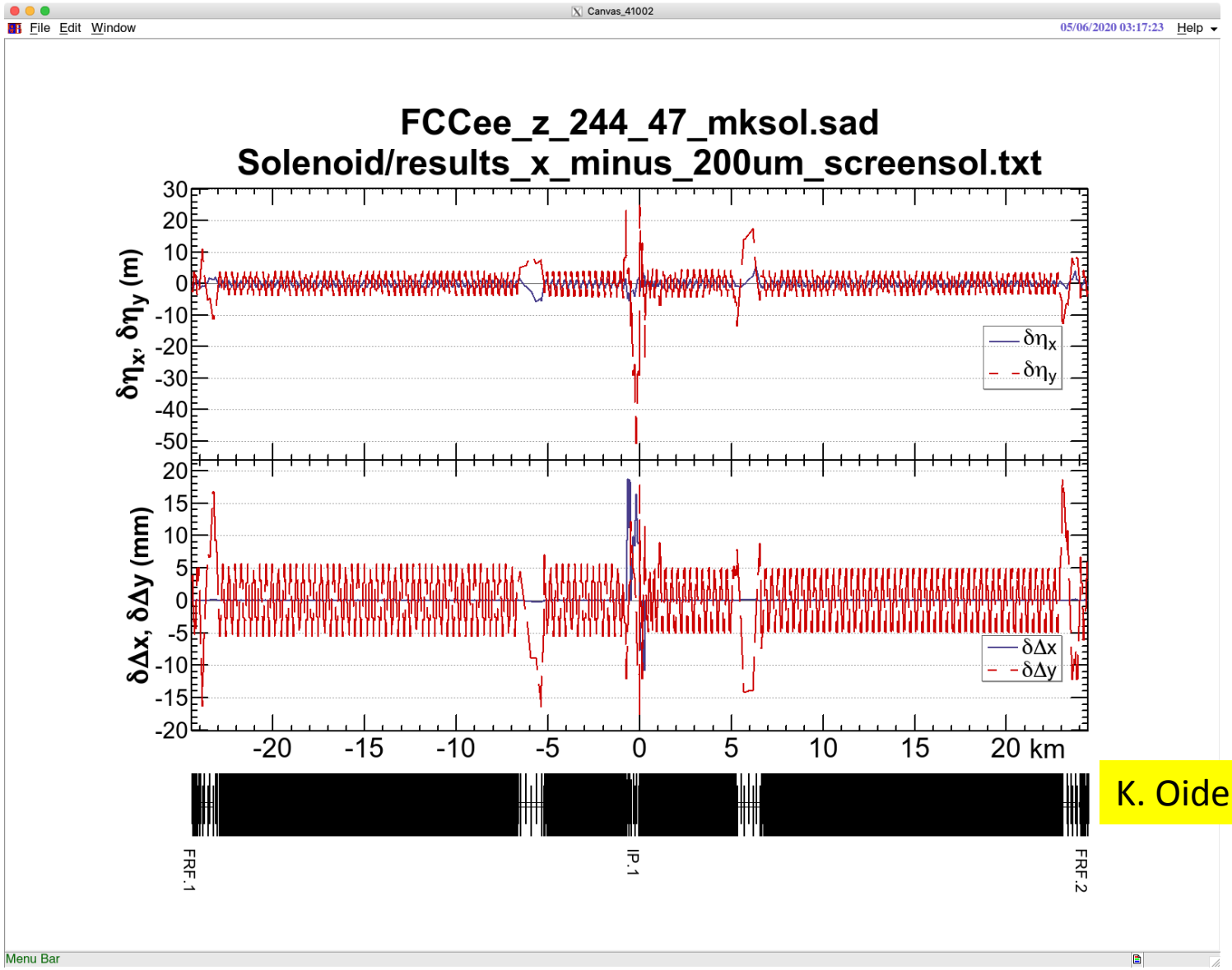
Equivalent to increasing the beam angle from 15 to 16mrad for one beam (and a decrease to the other)

Detector solenoid tilt

- So, any tilt of the detector solenoid generating a horizontal magnetic field component, generates a huge vertical orbit and dispersion all over the ring, see figure of next slide. This makes the entire ring unstable.
- So we need an orbit/dispersion correction for this. A very primitive correction on orbit/dispersion/coupling using dipoles on QC{12}* and skew quads on a few sextupoles around the IP, have given a much better orbit/dispersion as the second figure two slides down. The resulting vertical emittance is 0.288 pm (20% larger thn the perfectly aligned case). This number depends on which correctors are used.
- In the actual machine, the measurement of dispersion and coupling at the IP will be difficult, so the final number could be worse than this. Anyway this kind of study should be done under the global correction by Tessa.

K. Oide

1 mrad tilt of defector solenoid - uncorrected



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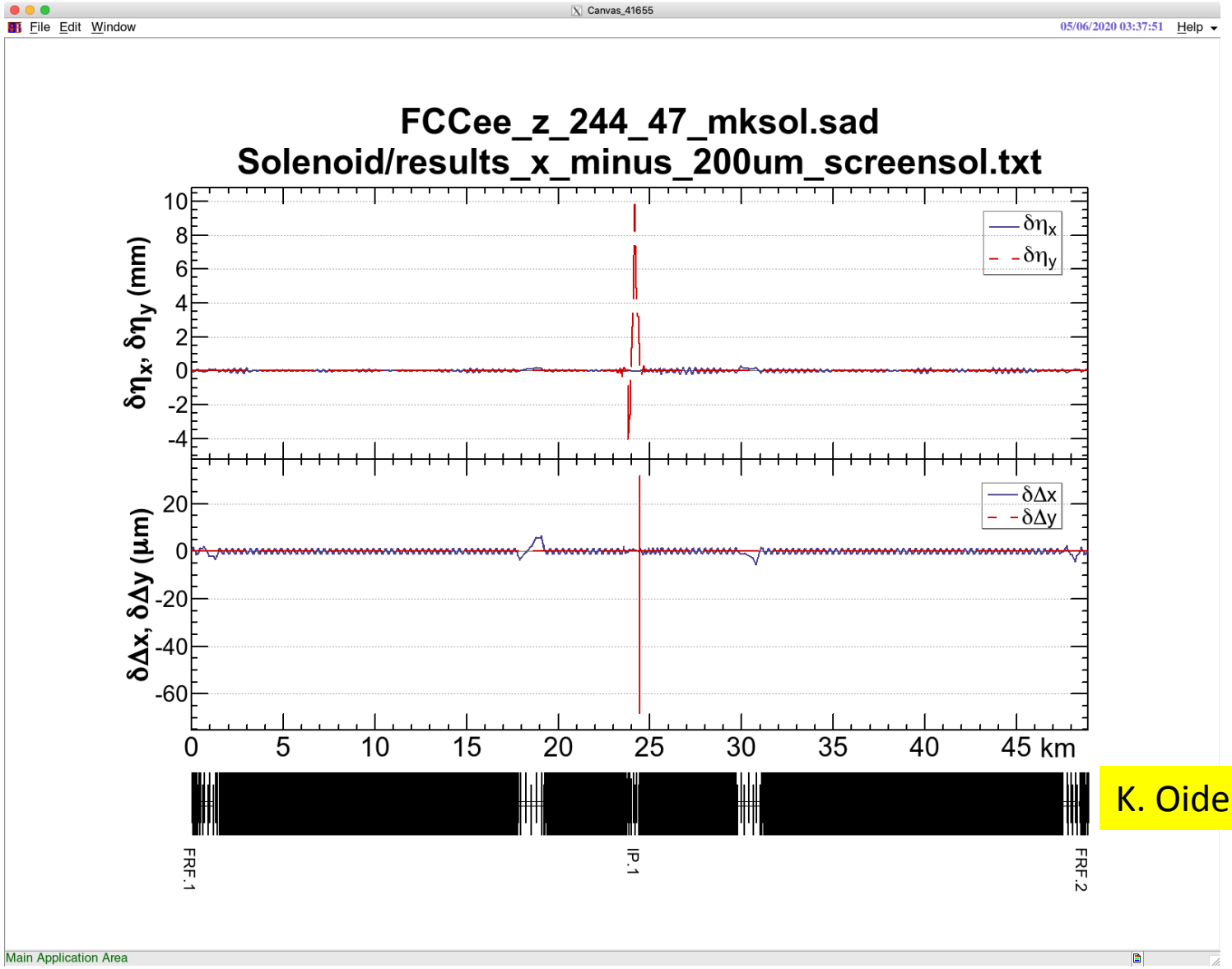
After correction



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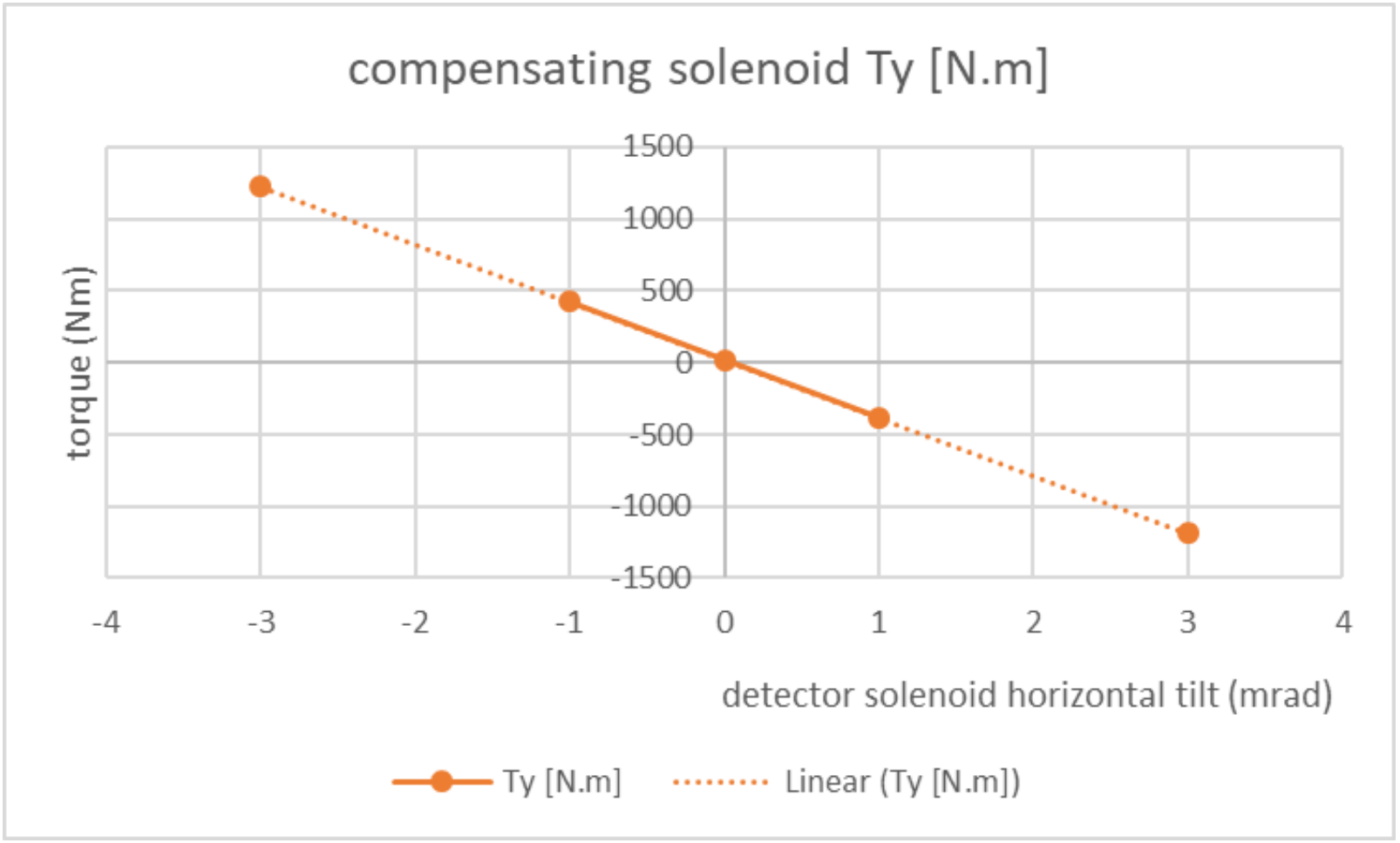
Is there a way to align the solenoids?

- Is there a way to align the real fields of the solenoids without relying on skew correctors or survey data (which for such a huge object will not be extremely accurate)?
- Yes, by using the fact that misaligned solenoids exhibit sizable torque.
- We need some hardware for that (sensors) and to develop a method, but I think it is doable.
- We would then have an aligned detector solenoid/compensating elements system.
- We still need to align this to the beam

Torque on comp. solenoid as a function of detector sol. tilt



- About 400Nm per 1mrad => possible to adjust to 50microrad

c.f. CMS survey

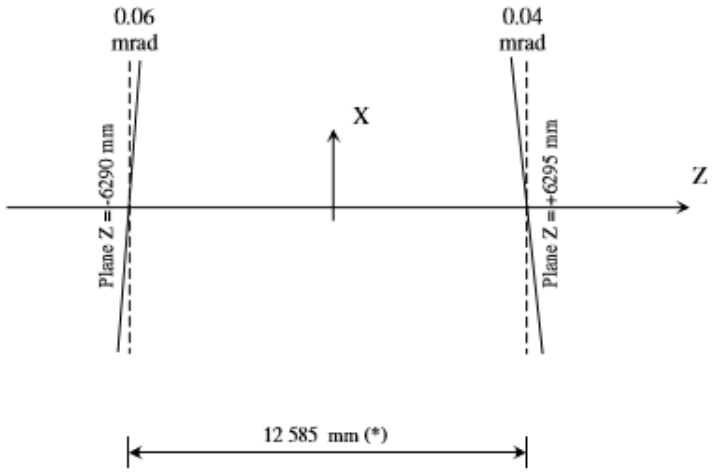
CMS-SG-UR-0018
EDMS : 659178

CMS

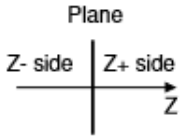
FINAL POSITION OF THE COIL

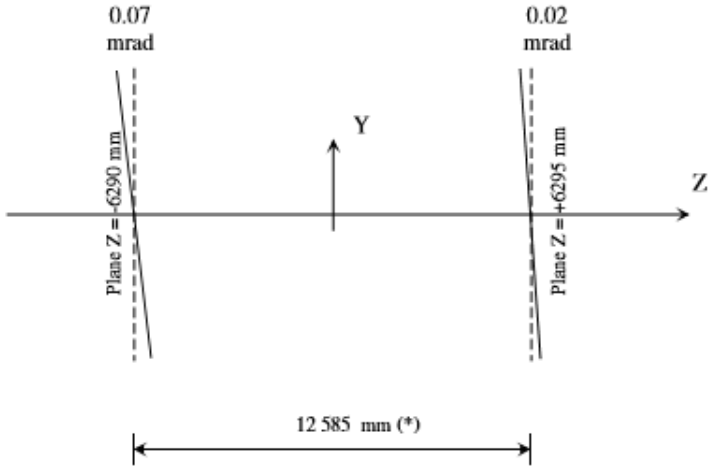
CERN SX5 – 07TH OCTOBER 2005

Numbers are around the 50urad value



Angles and distances between mean planes
View in XZ plane with Y=0





Angles and distances between mean planes
View in YZ plane with X=0

Conclusions

- The compensation scheme gives a vertical emittance blow up of 0.24pm for two IPs at the Z energies without a sizable dispersion leak.
- A misalignment analysis of the compensation components has been performed and the scheme is stable to misalignments of 200 microns and tilts of 100 microrad.
- A tilt of the detector solenoid of 1mrad yields a large dispersion and orbit distortion
- There is a way to avoid such tilts by measuring torque
- (we need to keep in mind that, although not discussed directly here, we need to have a number of strategically placed correctors to give us enough degrees of freedom to deal with all misalignment and imperfections ➔ we need a corrector strategy)
- We also need an alignment strategy and specs