Thoughts on FCC-he IR optics

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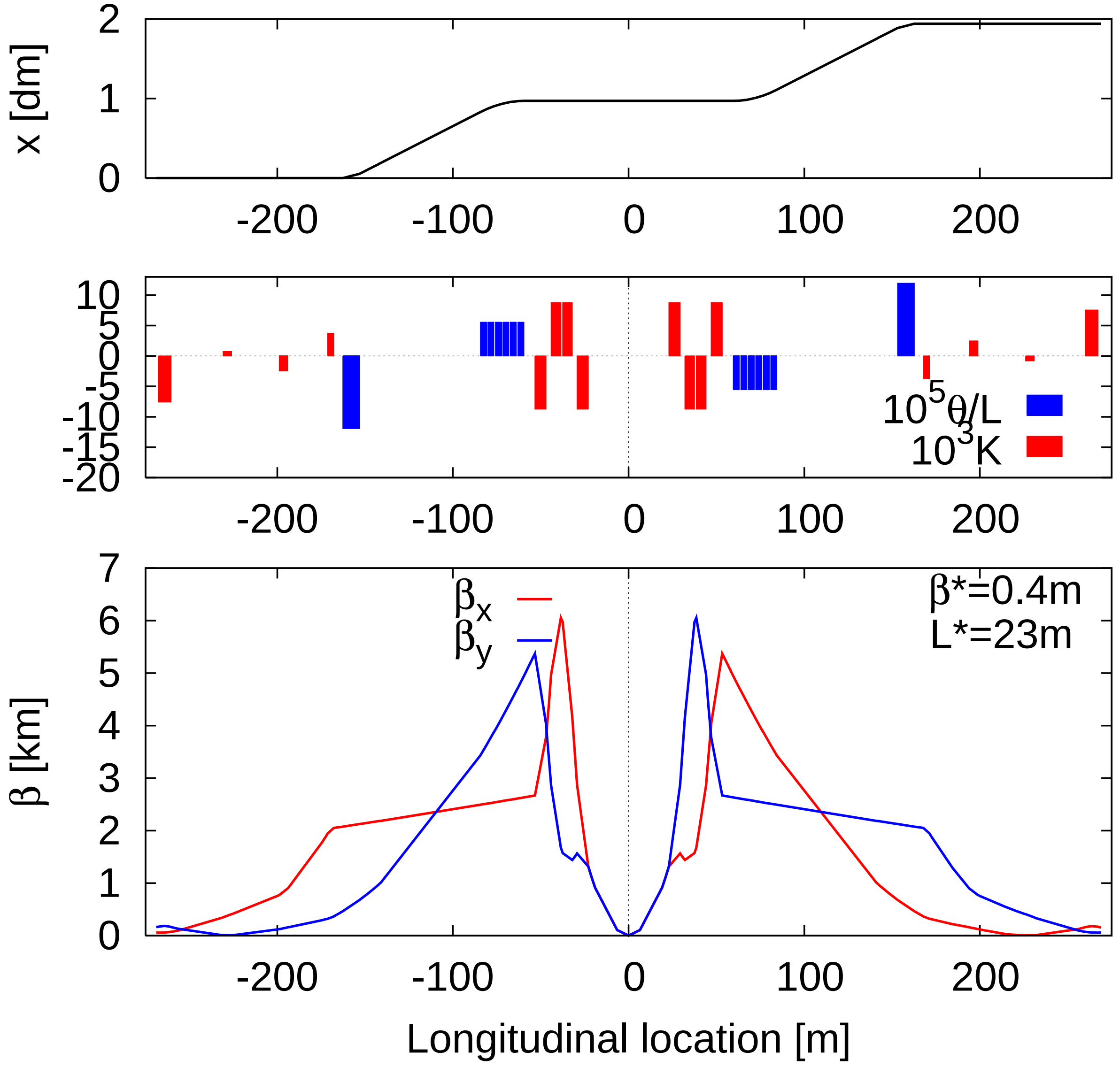
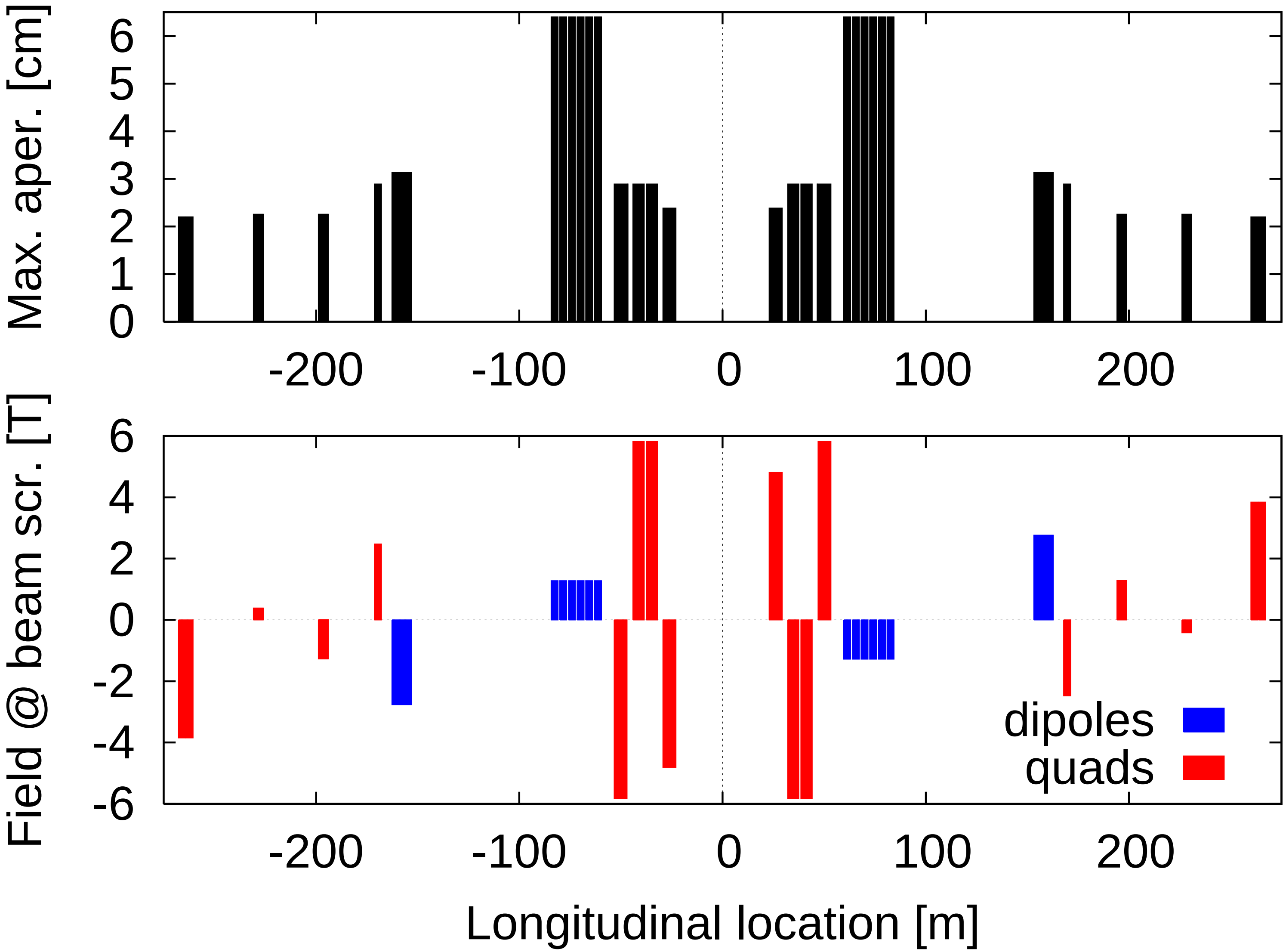
FCC kick-off meeting, February, 2014

Contents

Example: Nominal LHC IR optics I



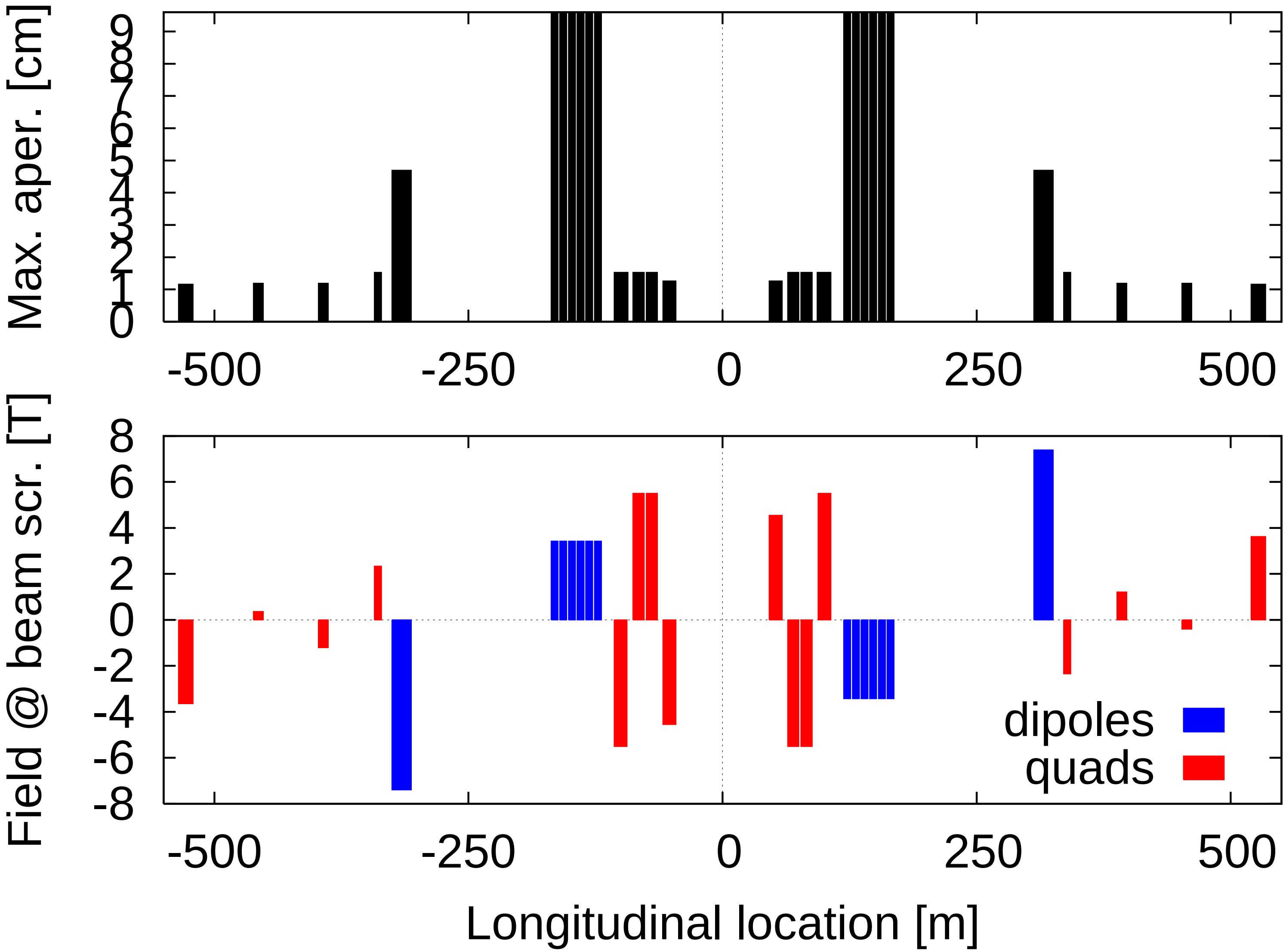
Example: Nominal LHC IR optics II



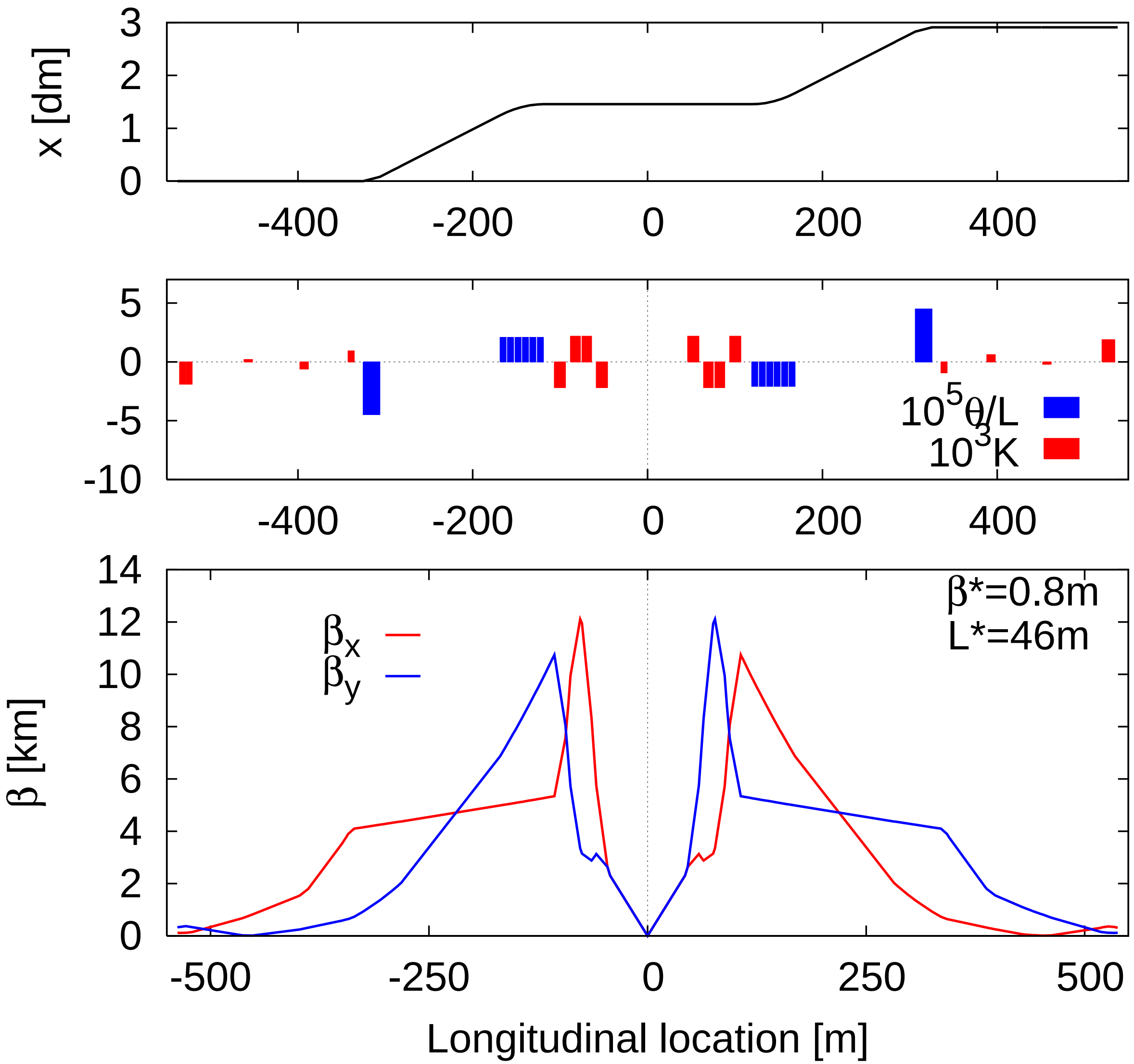
Scaling from 7 to 50 TeV

- Scale all lengths by factor f,
- all quadrupole gradients by $f^{-2}50/7$,
- quadrupole apertures by $\sqrt{f7/50}$
- peak quadrupole field $f^{-3/4}\sqrt{50/7}$
- dipole angles strongly dependend on beam1-beam2 separation (bs_{50})
- dipole field scales with $f^{-2}50/7 \times bs_{50}/bs_7$
- reasonable range for $f \in [1.5,\ 3]$

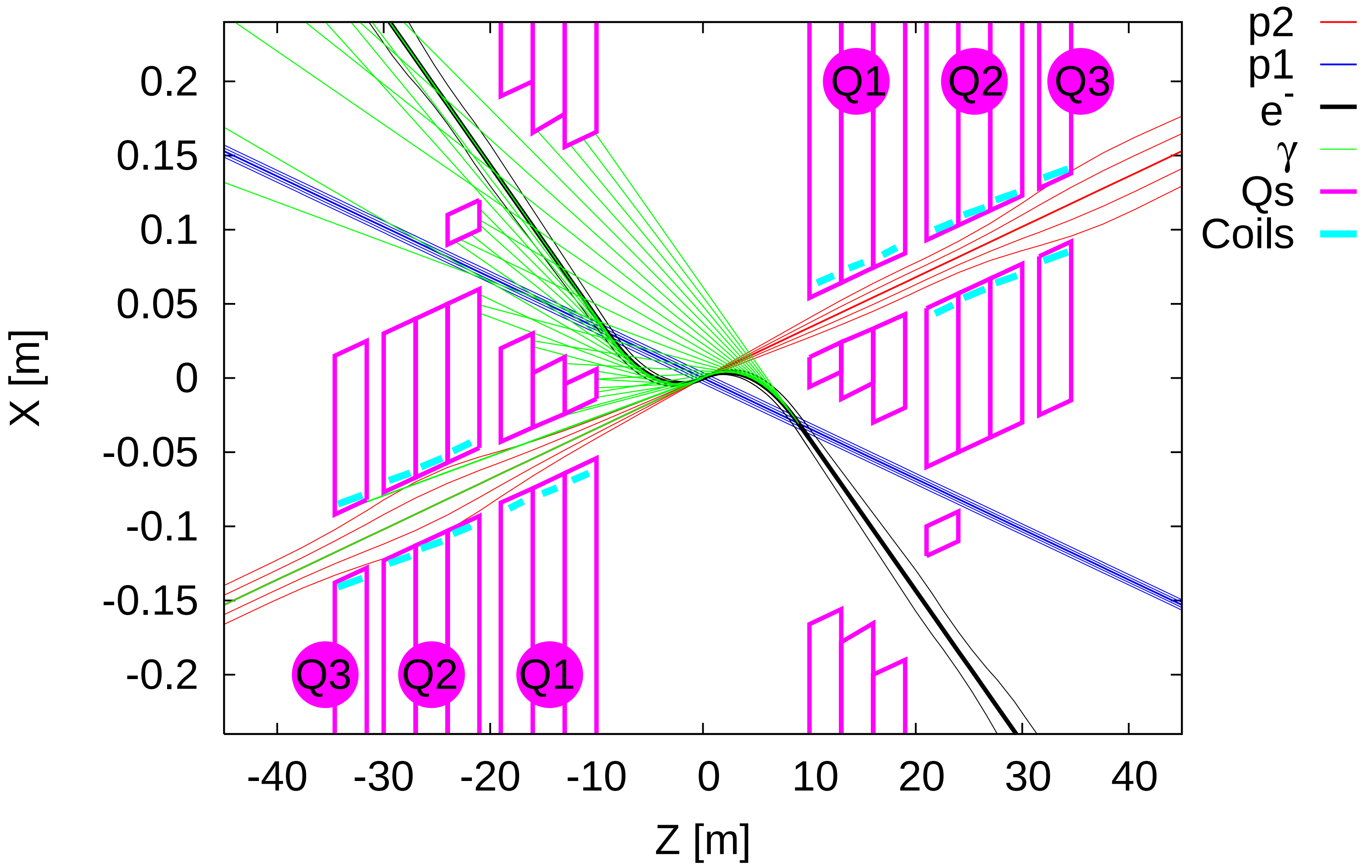
FCC-hh IR from LHC $f = 2$



FCC-hh IR from LHC, $f = 2$

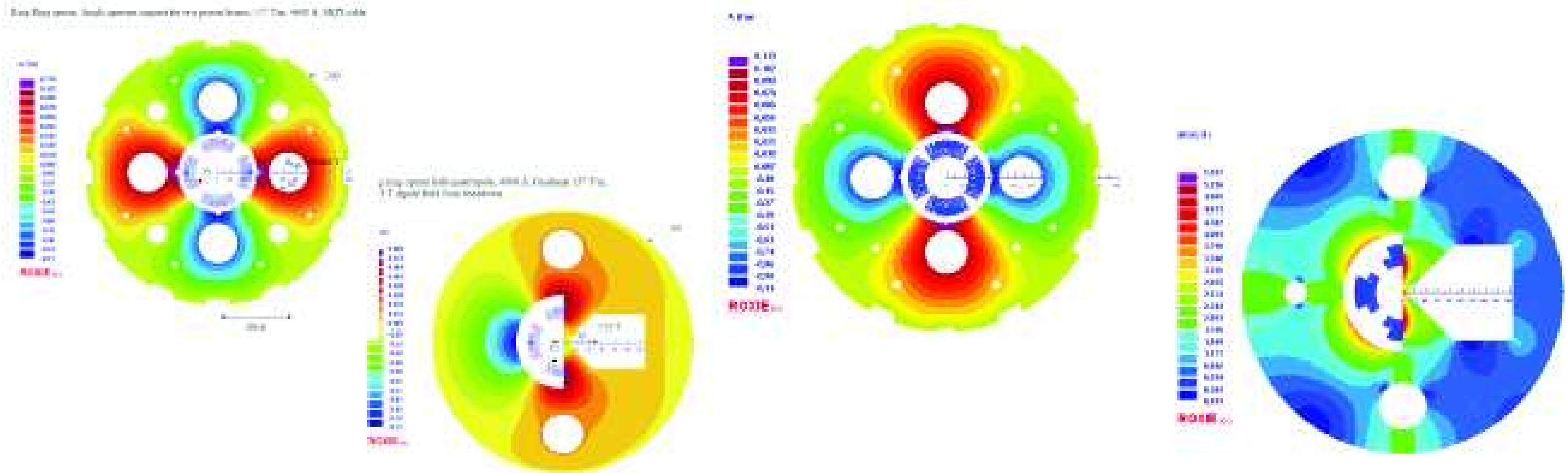


LHeC IR



X [m]
Z [m]
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-40
-30
-20
-10
0
10
20
30
40
Q1
Q2
Q3
Q3
Q2
Q1
p2
p1
e-
γ
Qs
Coils

LHeC magnets



4600 A MQY cable	4900 A MQY	NbTi: 6700 A, 248 T/m at 88% LL Nb3Sn (HFM46): 8600 A, 311 T/m, at 83% LL	NbTi: 4500 A, 145 T/m, 3.6 T at 87% Nb3Sn (HFM46): 5700 A, 175 T/m, 4.7 T at 82% on LL (4 layers)
35 mm aperture 107 mm beam sep.	35 mm (half) app. 65 mm beam sep.	23 mm app. 87 mm beam sep.	46 mm (half) app. 63 mm beam sep.
0.016 T fringe field in electr. pipe	0.03 T	0.03 T, 3.5 T/m 0.09 T, 9 T/m	0.37 T, 18 T/m 0.5 T, 25 T/m

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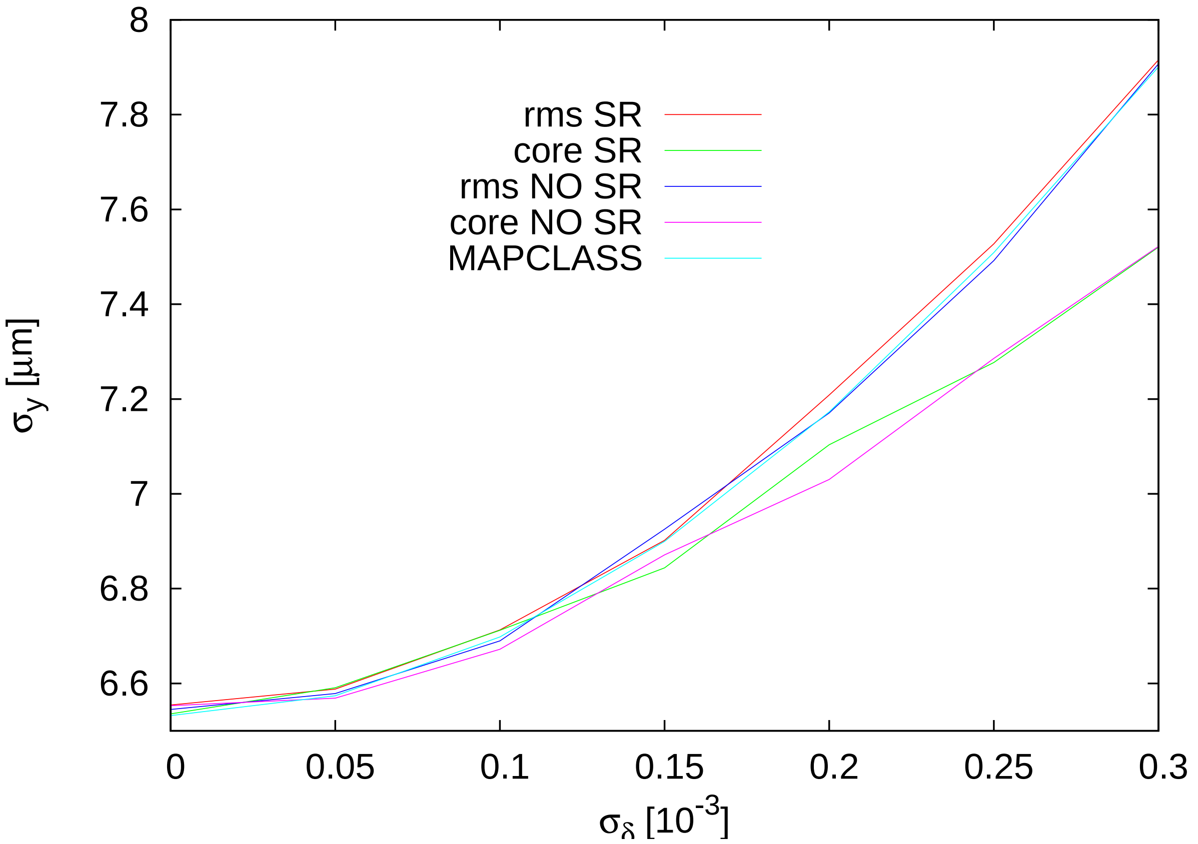
NbTi at 1.8 K, Nb3Sn at 4.2 K

Scaling considerations for LHeC

- $\star$ reasonable range for $f \in [1.5,\ 3]$
- $\star$ but baseline is to keep e- at 60 GeV
- $\star$ L* between 15-30 m $\rightarrow$ SR power $<$ 20 kW and Q1 normal quadrupoles possible
- $\star$ Proton beam size between 3.2-4.5 μm $\rightarrow$ Electron β functions to be reduced to 0.025-0.05 m !!

Nominal LHeC e-FFS IP aberrations



Aberrations already $\approx 10\%$ for nominal LHeC $\rightarrow$ Likely to increase to 30%-60% for FCC-he (lower β^*) $\rightarrow$ Need a new design for e-FFS!

Summary and outlook

- ⋆ Scaling factor from LHeC between a $[1.5, 3]$
- ⋆ FCC-he proton β^*=0.15-0.3 m, L*=15-30 m, normal quads, proton SR power?
- ⋆ FCC-he e- β^*=0.025-0.05 m, SR power $<$ 20 kW
- ⋆ Need to assess proton layout and optics and a complete redesign of e-FFS
- ⋆ Many critical R&D tasks: magnet feasibility, beams separation, energy deposition from IP debris, technology choice, e-cloud, beam-beam long-range, synchrotron radiation, beam emittances, flat beams, etc.