Optics update for HE-LHC

Demin Zhou

Acknowledgements:

M. Benedikt, M. Crouch, R. De Maria, S. Fartoukh, M. Giovannozzi, Y. Nosochkov, K. Oide, D. Sagan, D. Schoerling, P. Thrane, E. Todesco, D. Tommasini, F. Zimmermann

12th HE-LHC design meeting, CERN, Apr. 26, 2017

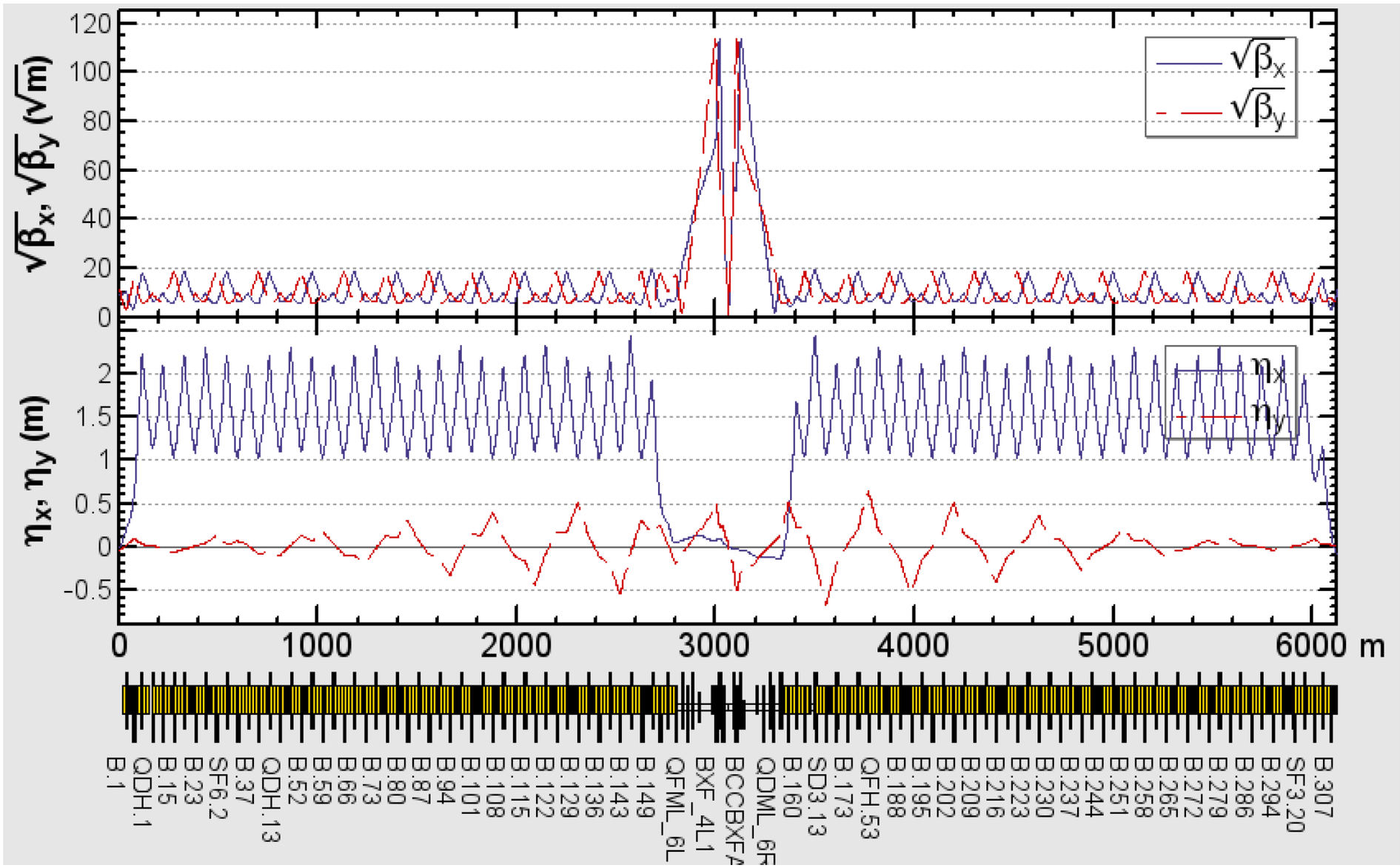
Outline

- ➤ **HL-LHC optics**
  - **HLLHCV1.2 (scaled)**
  - **Translation to SAD**
- ➤ **HE-LHC optics**
- ➤ **Discussion**

1. HL-LHC optics

➤ HLLHCV1.2

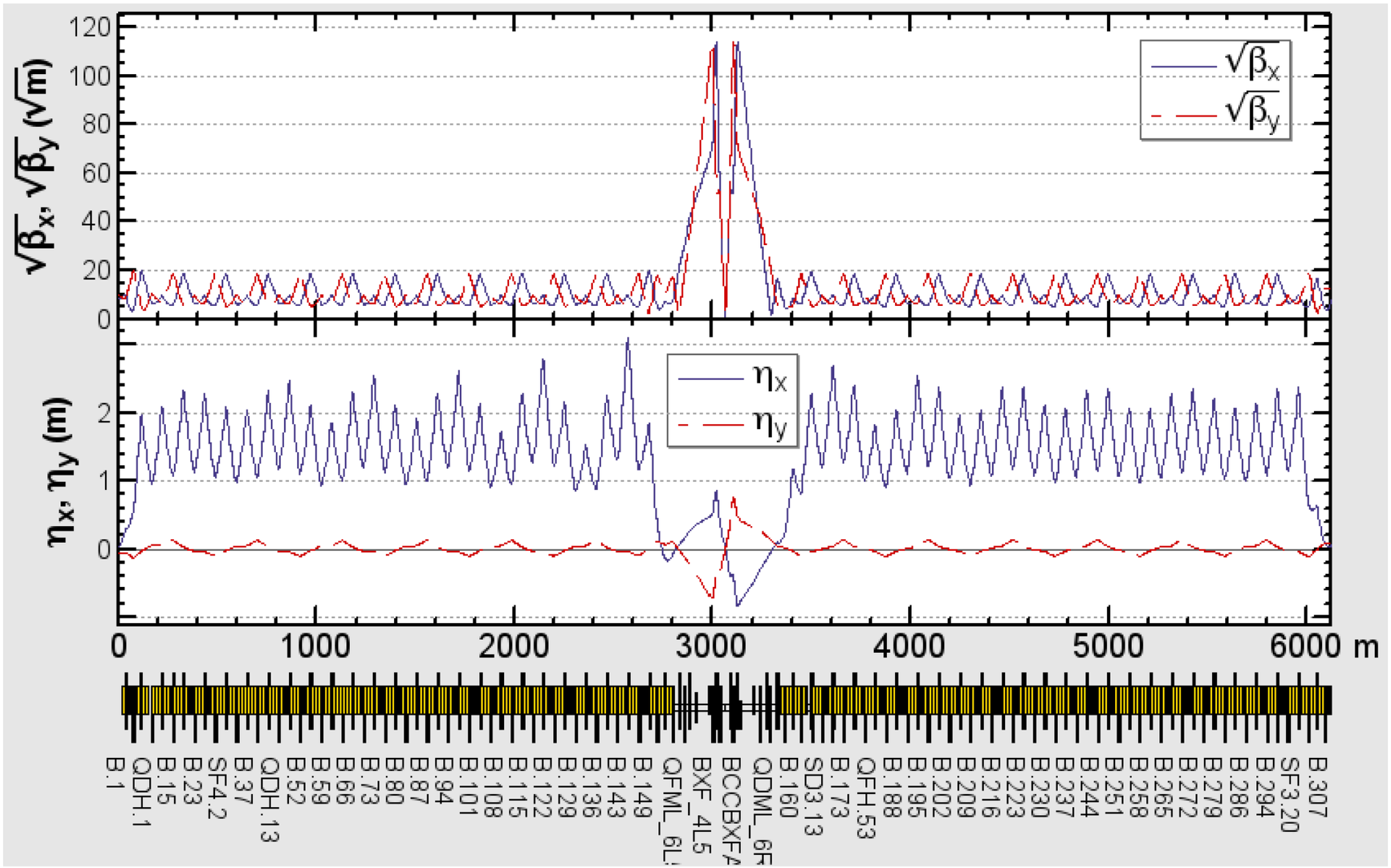
- **β*=25cm @IP#1&5**
- **IR1 with neighboring arcs (ATS)**



1. HL-LHC optics

➤ HLLHCV1.2

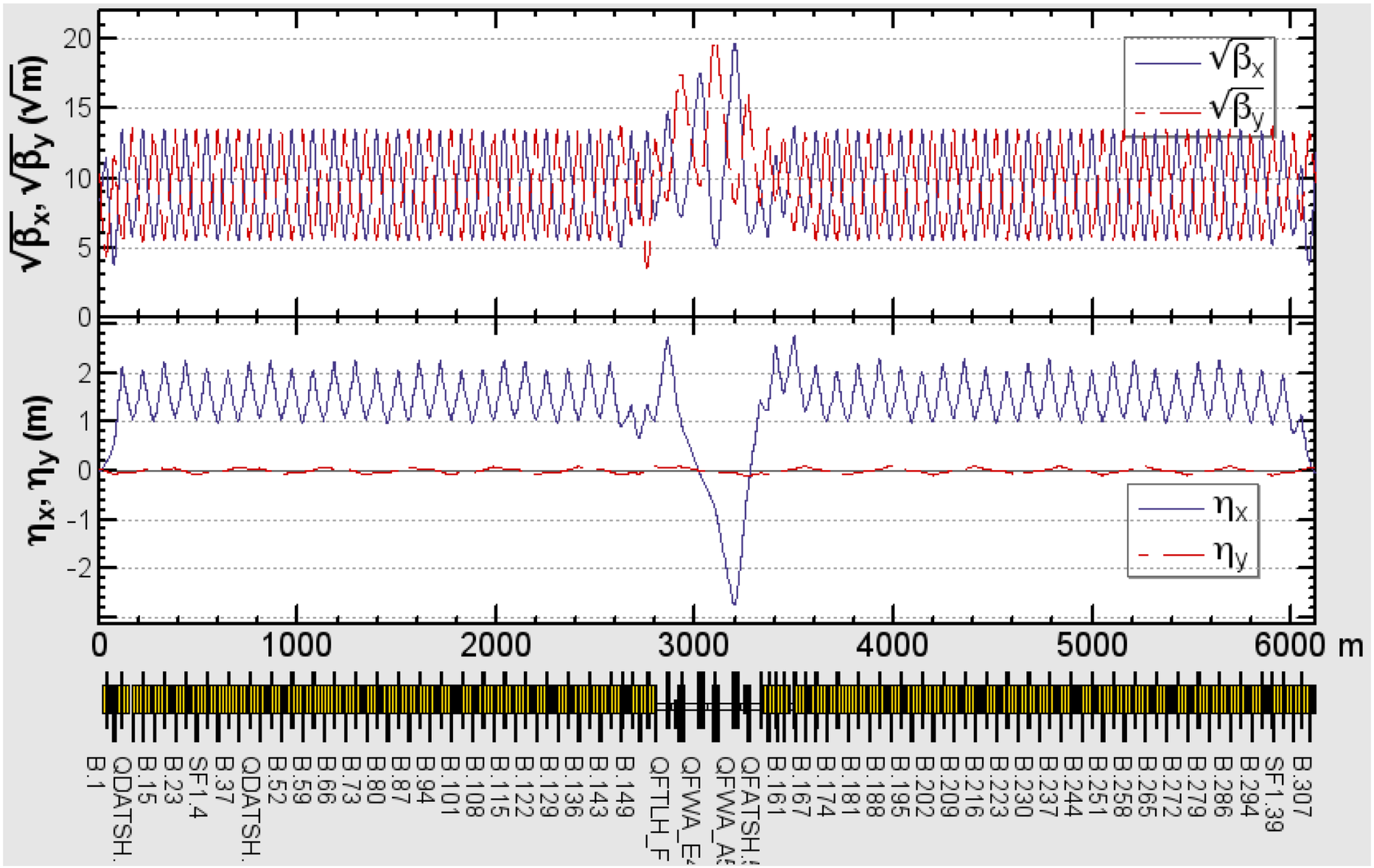
- **β*=25cm @IP#1&5**
- **IR5 with neighboring arcs (ATS)**



1. HL-LHC optics

➤ HLLHCV1.2

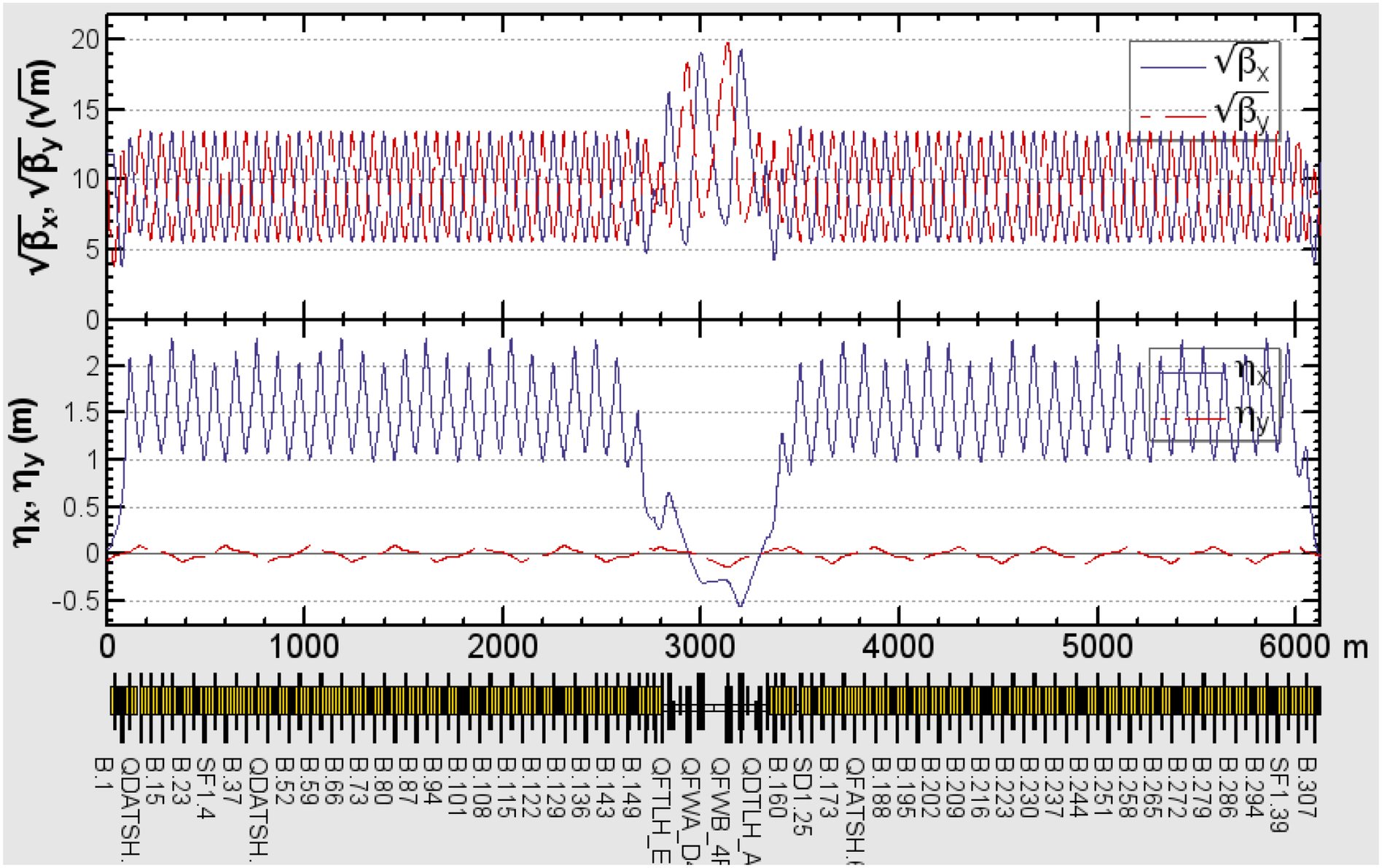
- β*=25cm @IP#1&5
- IR3 (momentum cleaning) with neighboring arcs (normal arcs)



1. HL-LHC optics

➤ HLLHCV1.2

- β*=25cm @IP#1&5
- IR7 (betatron cleaning) with neighboring arcs (normal arcs)



1. HL-LHC optics

➤ HLLHCV1.2 (scaled)

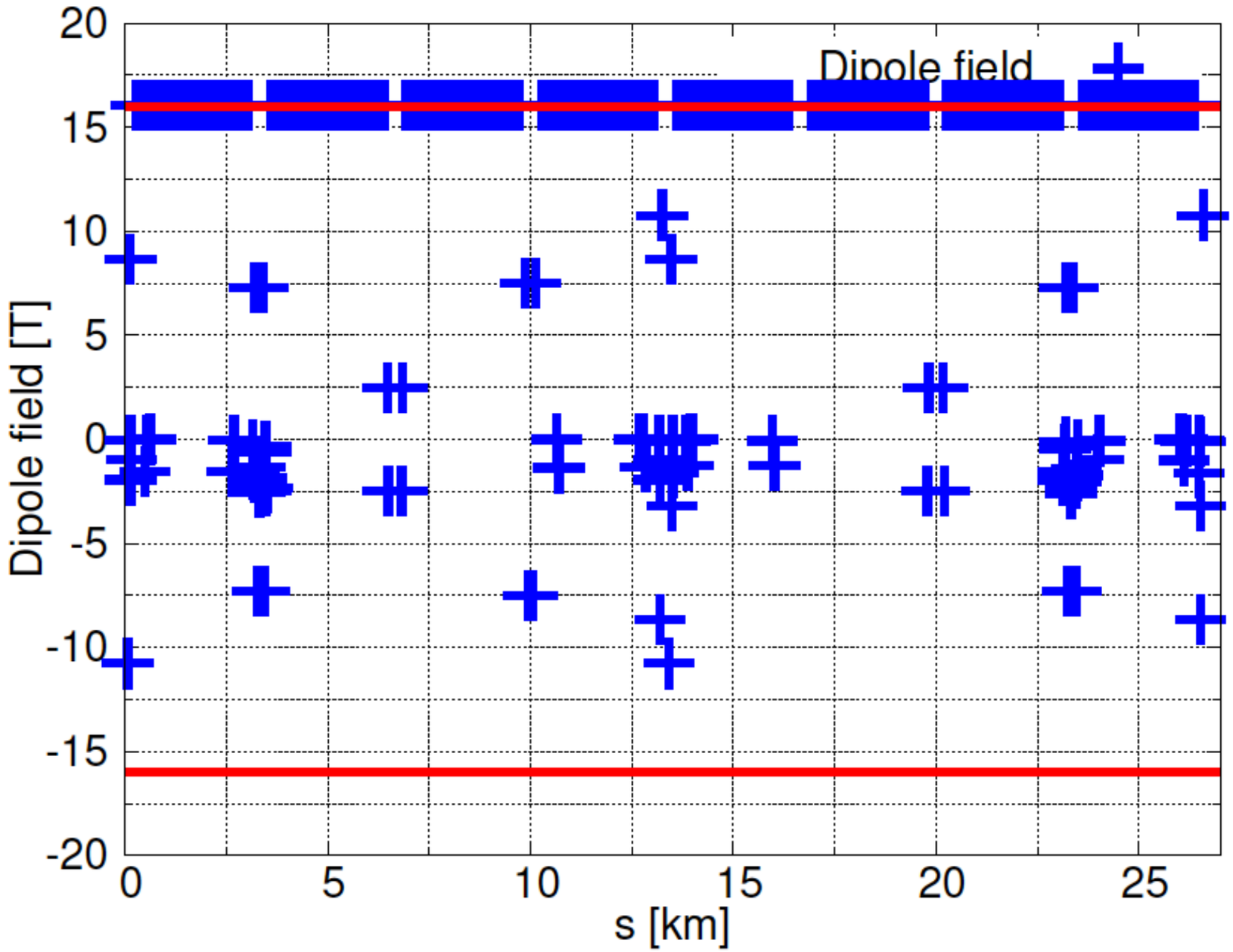
- E=13.5 TeV, β*=25cm @IP#1&5
- Dipole: L=14.3m

K_n: MAD convention

$$K_n L = \frac{B^{(n)} L}{B\rho}$$

FCC specification:

B_{max}≈16T



1. HL-LHC optics

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- E=13.5 TeV, β*=25cm @IP#1&5
- Quadrupole: L=3.1m in arcs [Typical]

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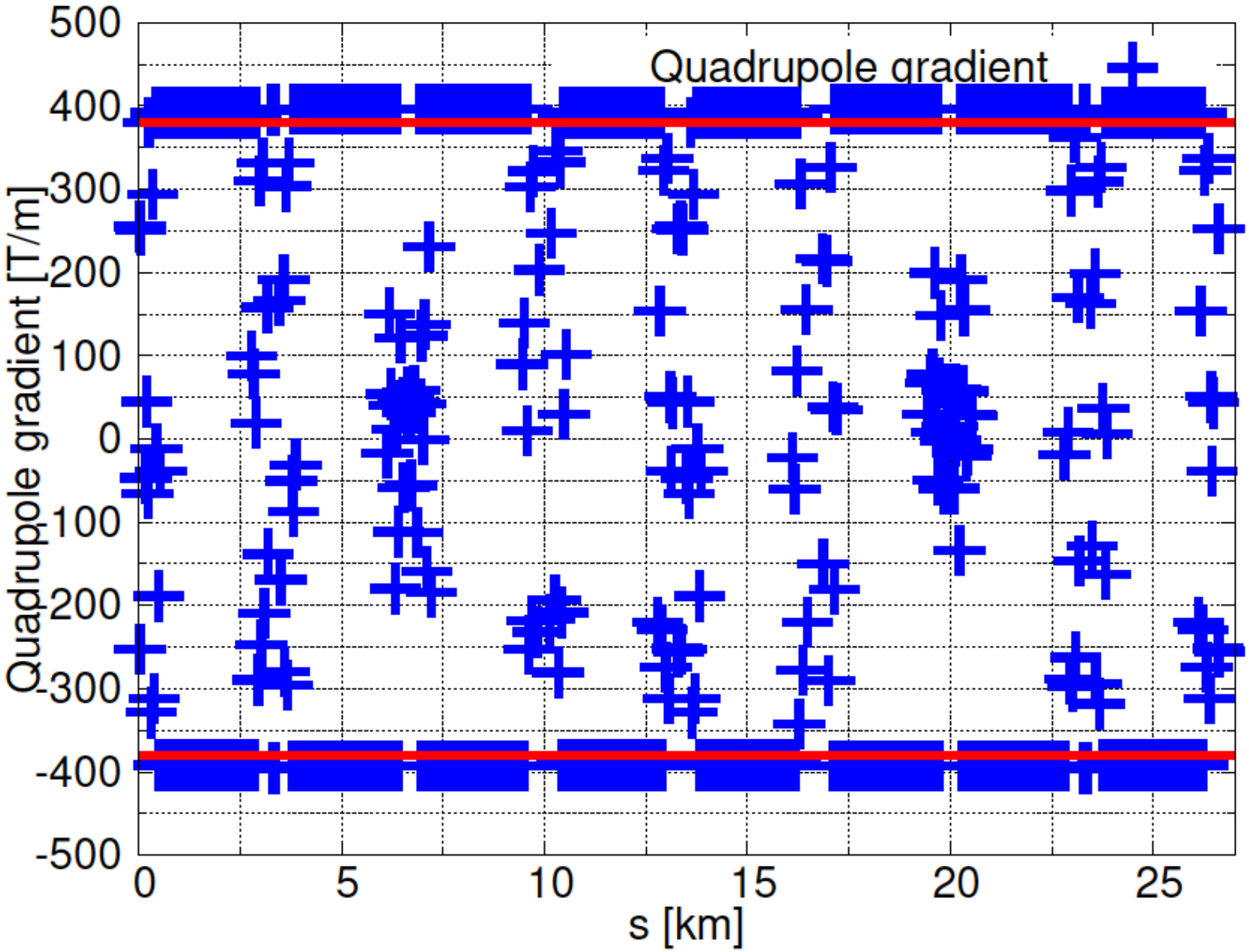
FCC specification:
G_{max}≈380T/m[1](?)
with aperture
ϕ=50mm



[1]A. Chance, FCC-hh magnet-beam dynamics coordination meeting, Mar. 17, 2017

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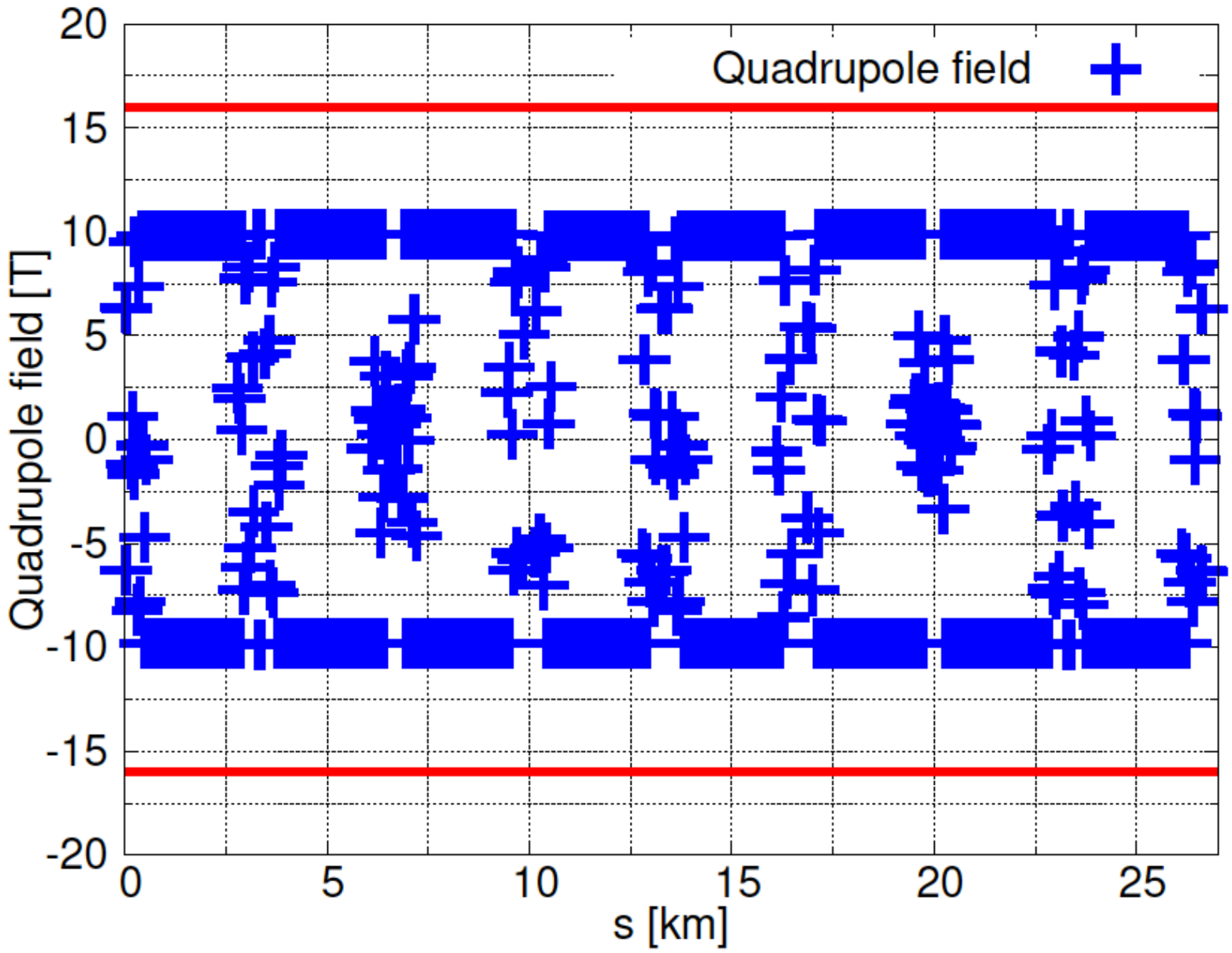
$$K_n L = \frac{B^{(n)} L}{B\rho}$$

Translate to max. field (?):

$$B_{\max} = B^{(1)}\phi/2$$

Assume ϕ=50mm for all quads [Not true for quads in IRs]



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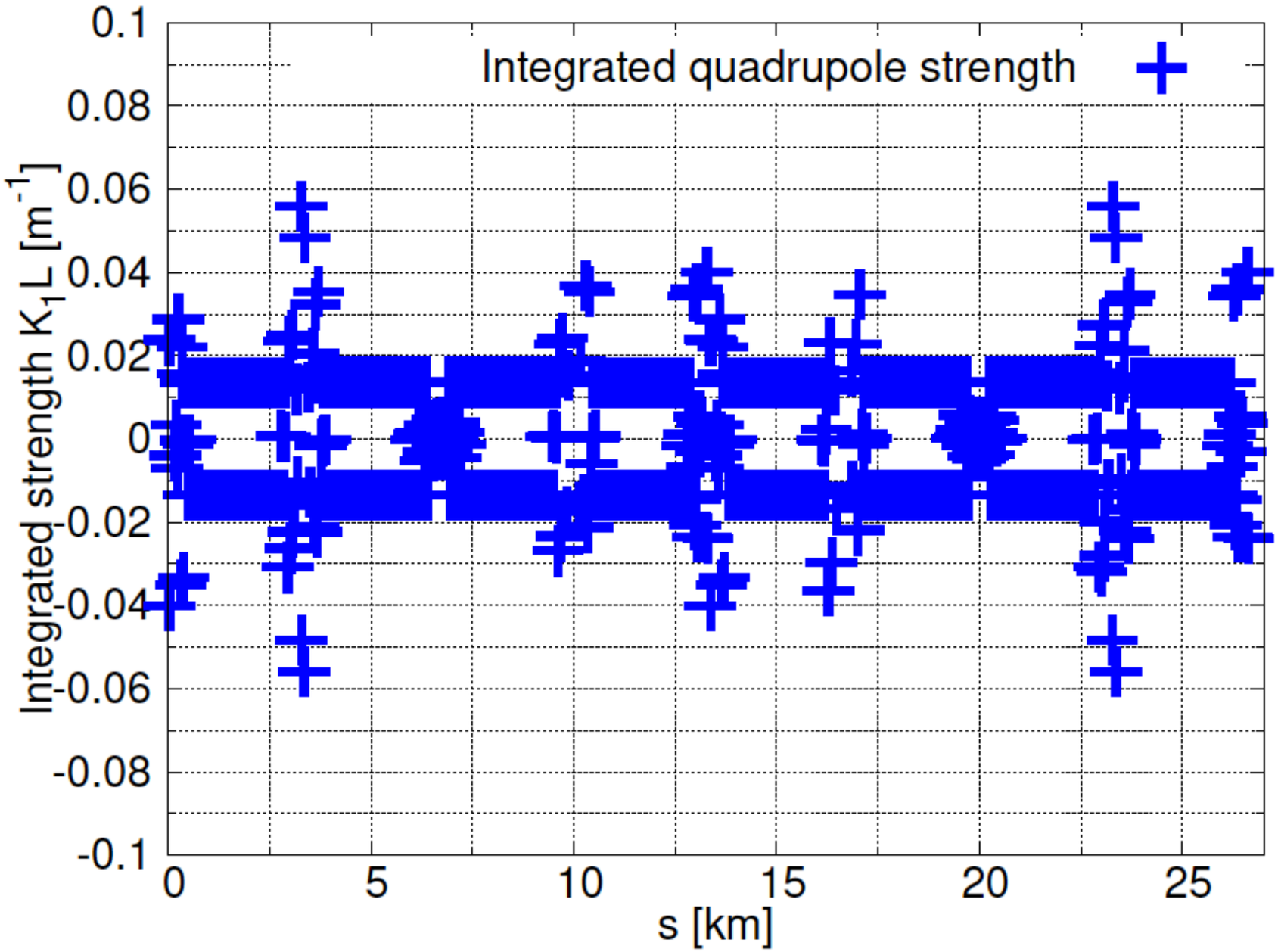

1. HL-LHC optics

➤ HLLHCV1.2 (scaled)

- **E=13.5 TeV, β*=25cm @IP#1&5**
- **Sextupole: L=0.369m in arcs [Typical]**

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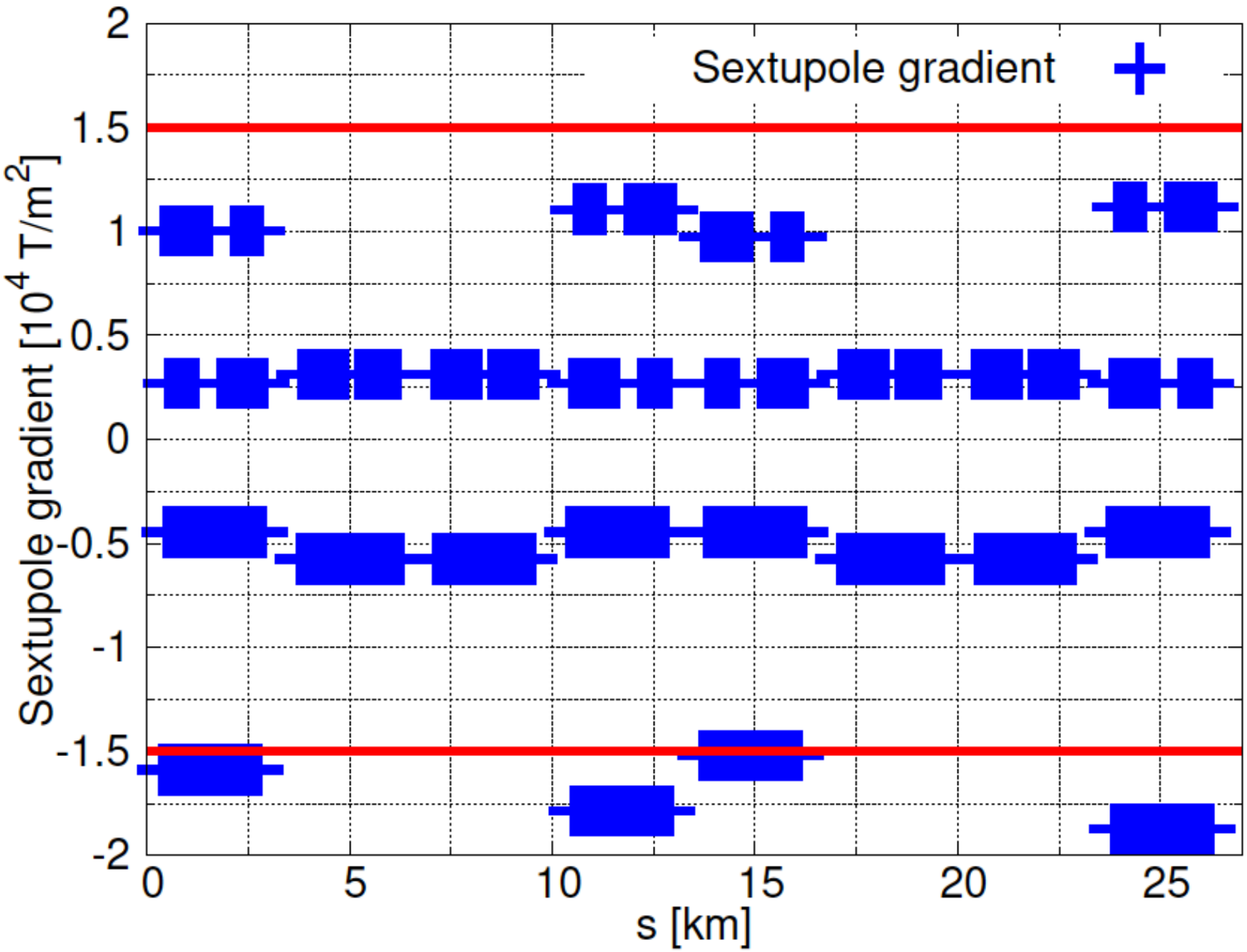
FCC specification:

G_{max}=??

with aperture

ϕ=50mm



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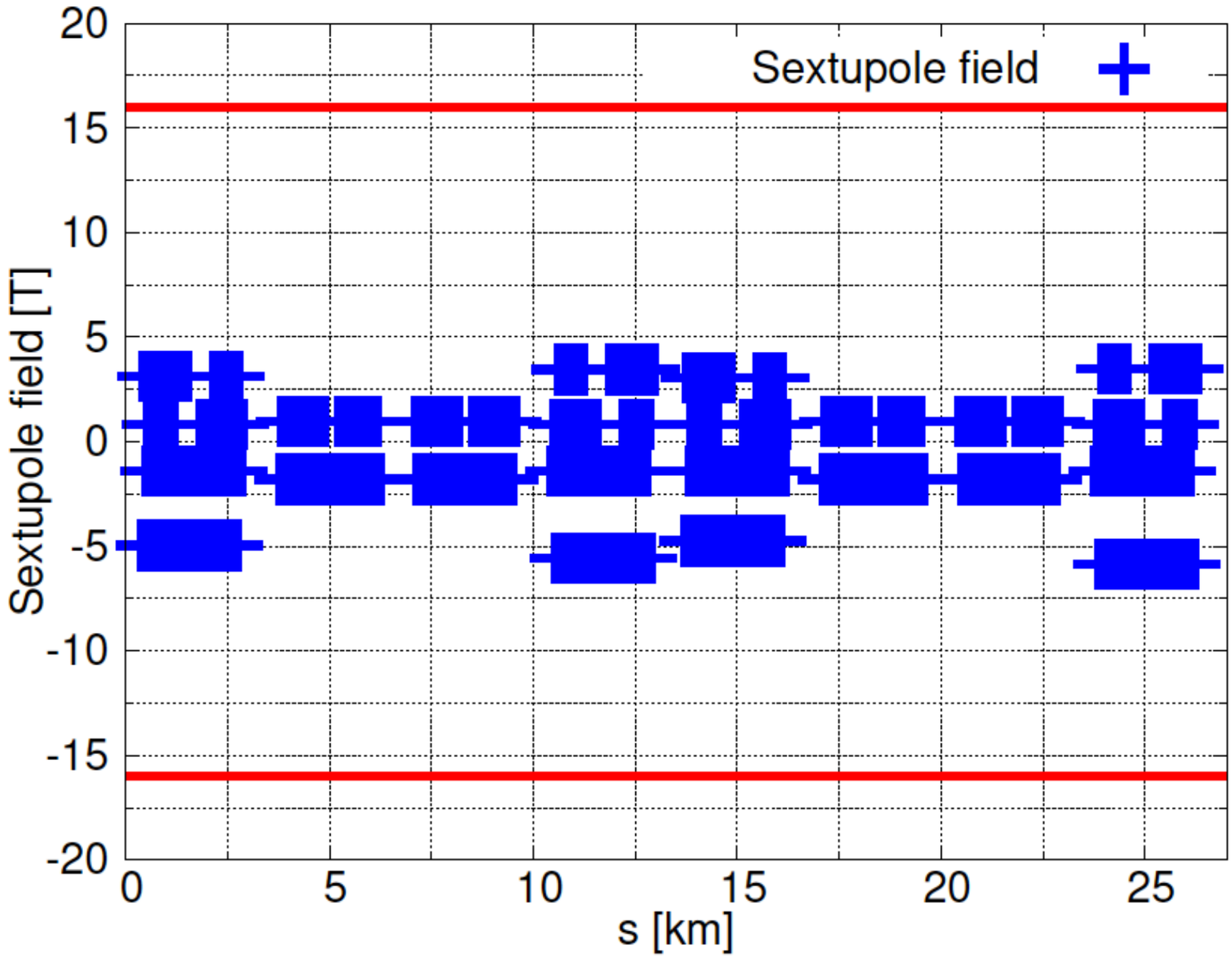
Translate to max. field (?):

$$B_{\max} = \frac{1}{2} B^{(2)} (\phi/2)^2$$

Assume ϕ=50mm for all sext.



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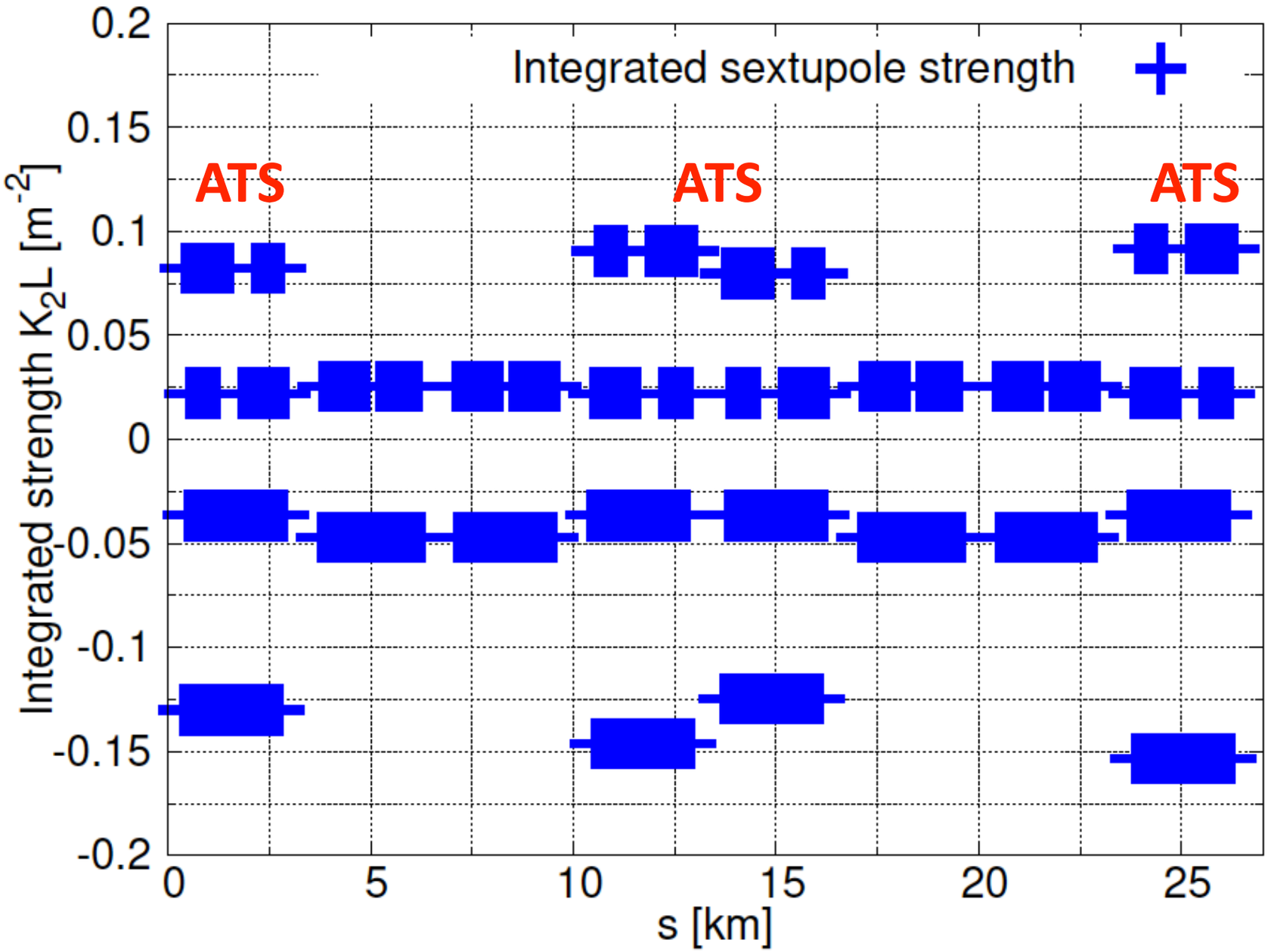
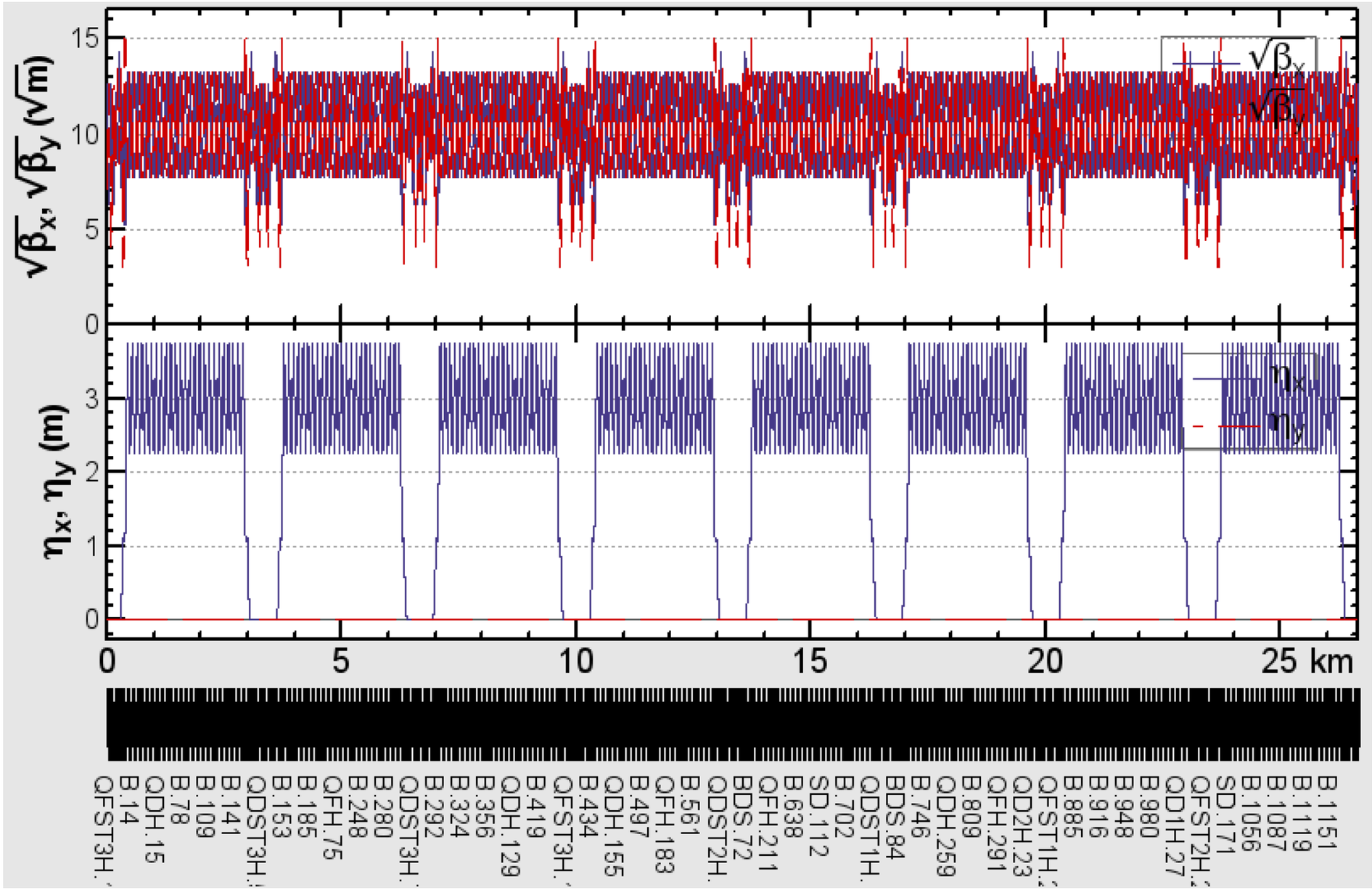


2. HE-LHC

➤ lhc_v5 (by Y. Nosochkov)

- **E=13.5 TeV, dummy IRs, 24 cell/arc, 60^0/cell**
- **Dipole: L=13.56m in arcs**



2. HE-LHC

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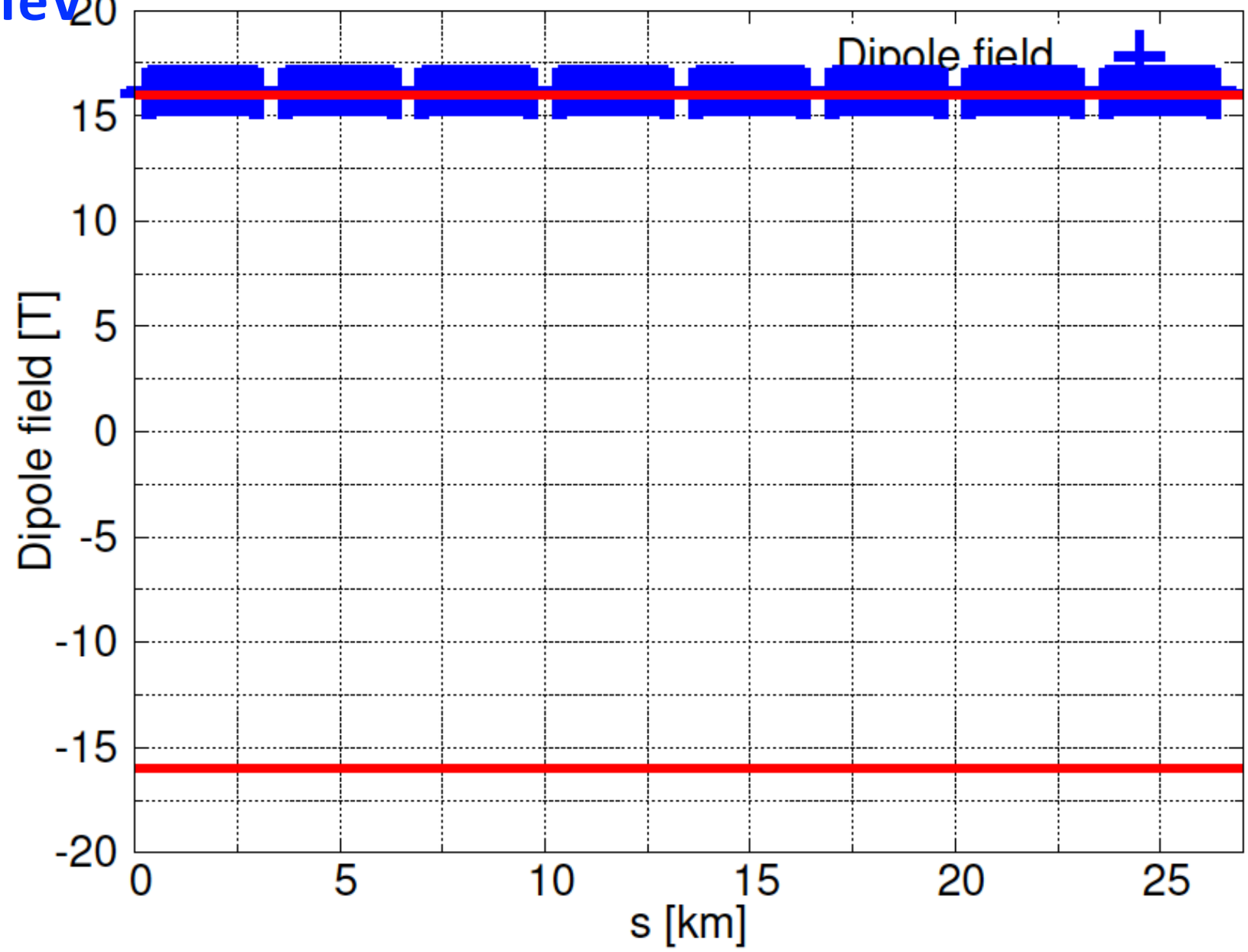
- E=13.5 TeV, dummy IRs
- Dipole: L=13.56m in arcs
  B=16.23T@13.5TeV

FCC specification:

B_{max}≈16T



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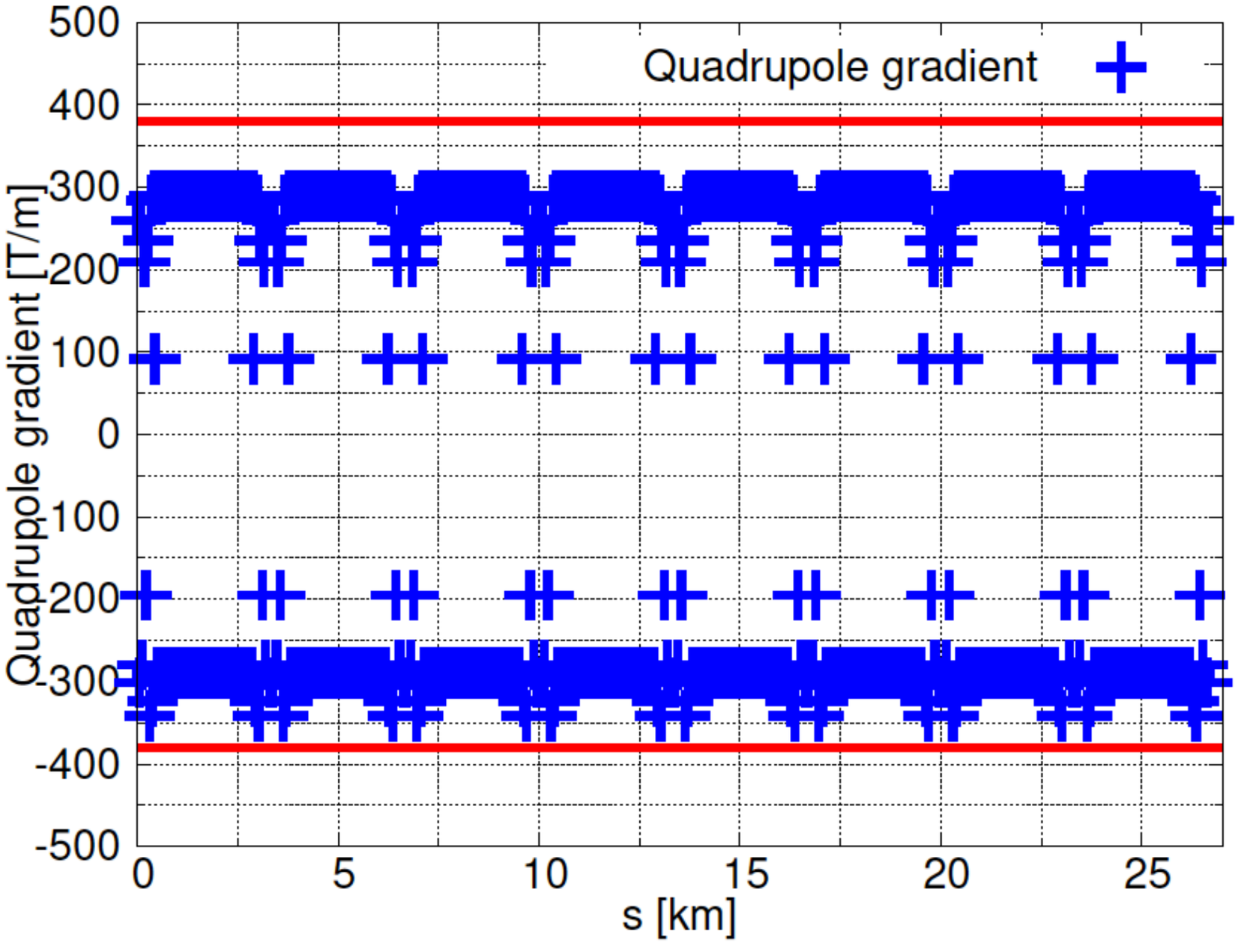

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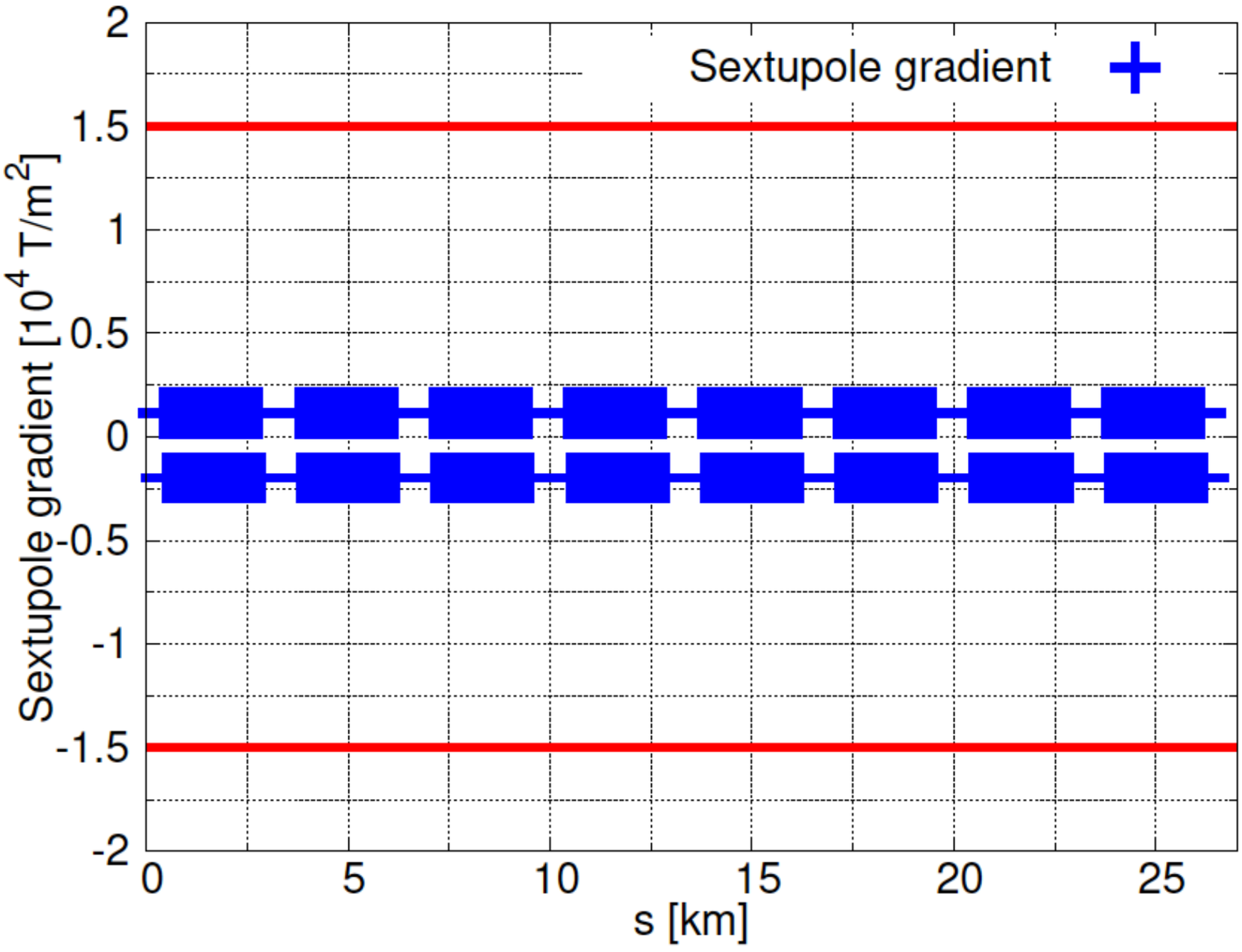

3. Discussion

➤ **HE-LHC = (HL-)LHC layout (and adapted optics) + FCC technologies (?)**

➤ **Strategies for HE-LHC optics design**

- **Scaling (HL-)LHC optics: Challenges to be identified**
- **Use 60^0 cells (Y. Nosochkov, D. Zhou, T. Risselada, etc.)**

➤ **Immediate problems of scaling (HL-)LHC to 13.5TeV**

- **Almost no margins for dipoles (need longer dipoles?)**
- **Very marginal fro arc quads given 380T/m from FCC tech. (to be confirmed)**
- **Other issues to be identified**

➤ **Immediate gains from using 60^0 cells**

- **Allow longer dipoles if 18 cells/arc adopted**
- **Weaker quads (~30% less than LHC@13.5TeV) allowed**
- **Weaker sexts (~50% less than LHC@13.5TeV) allowed**
- **Other issues to be identified**

3. Discussion

➤ Specifications for dipoles, quadrupoles and sextuples in arcs

- Coil aperture: ϕ=50mm
- Dipole: E_{max}=13.5TeV, B_{max}=16T
- Quadrupole: G_{max}=380T/m (?), B_{max}=?
- Sextupole: Gmax=?T/m^2, B_{max}=?
- Arc separation = 204mm (?)

➤ Specifications for dipoles and quadrupoles in IRs

- Triplet, separation/recombination dipoles (to be identified)

➤ Open questions

- ATS optics is necessary for HE-LHC?
- 60^0 cell is necessary for HE-LHC? Resulting impact in layout, DA, injection, etc.?
- Detailed parameter list (luminosity performance, magnet specifications, injection beam, beam dynamics, etc.) as reference for collaborators?