Optics update for HE-LHC

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Acknowledgements:

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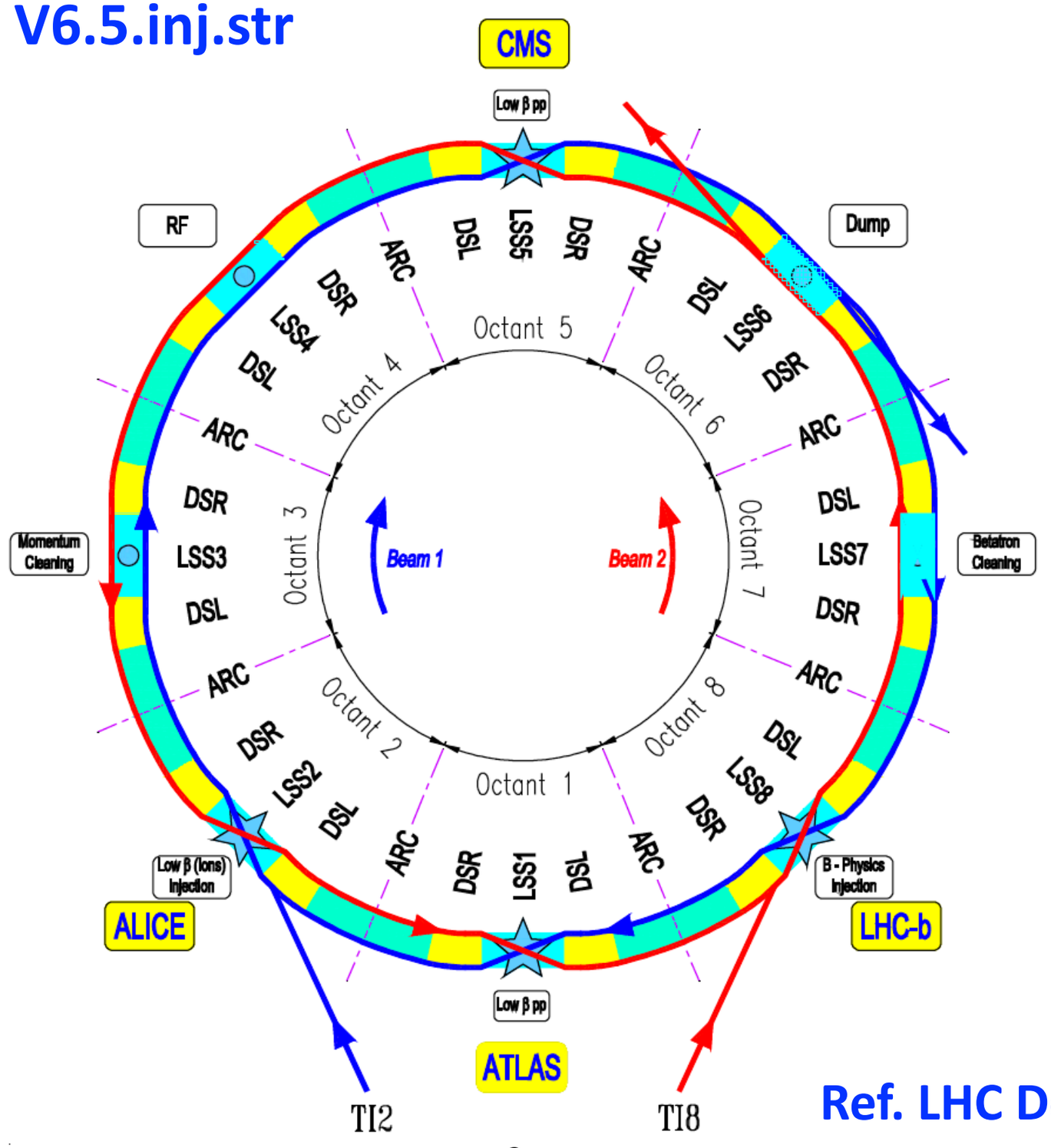
Outline

- ➤ LHC optics in SAD
- ➤ HE-LHC optics in SAD
- ➤ 60^0 cell for HE-LHC
- ➤ Summary

1. LHC optics in SAD

➤ V6.503

- **V6.5.seq + V6.5.inj.str**

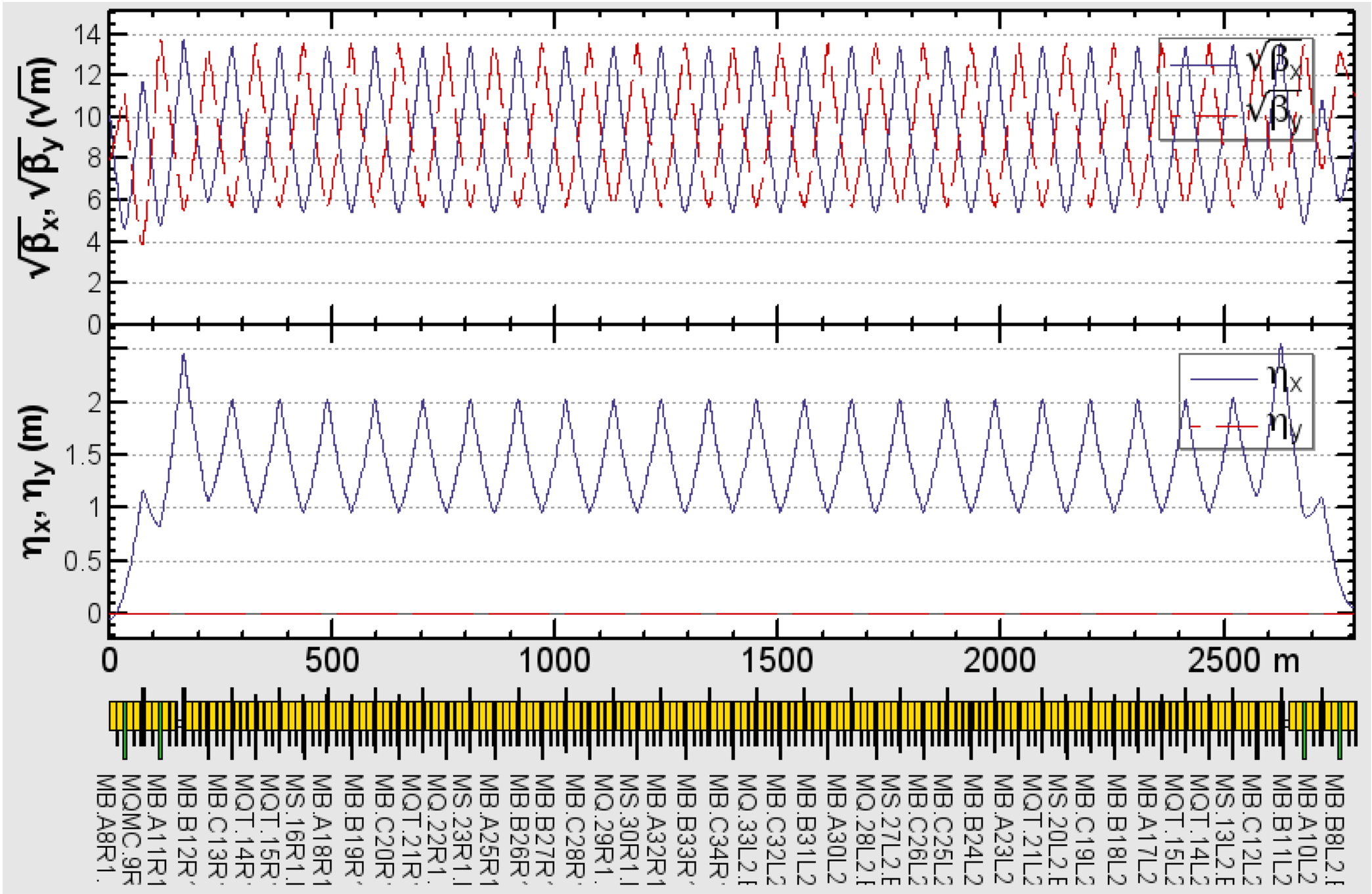


Ref. LHC Design Report

1. LHC optics in SAD

➤ V6.503

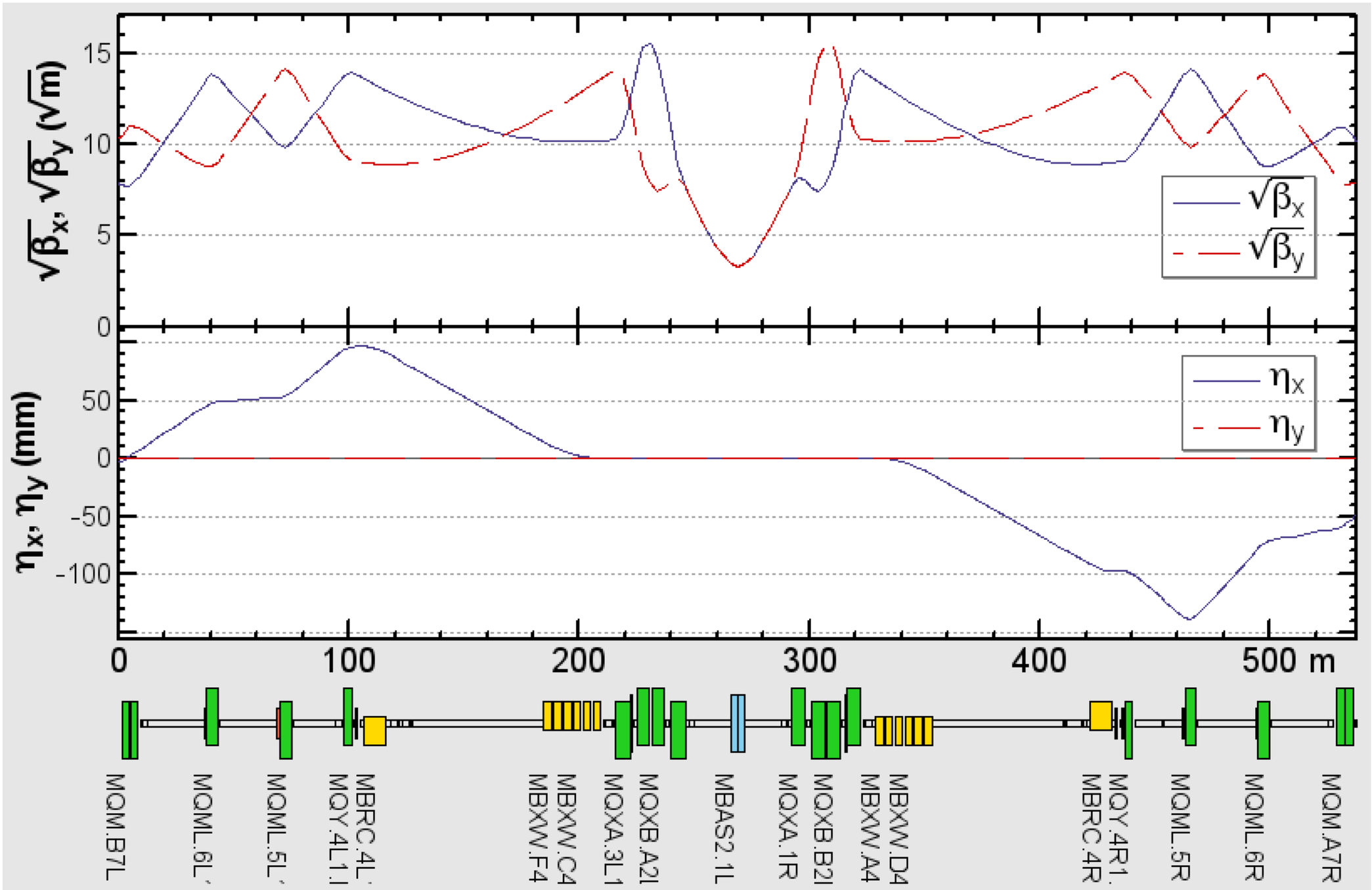
- **ARC12 [3 cells used for dispersion suppression]**



1. LHC optics in SAD

➤ V6.503

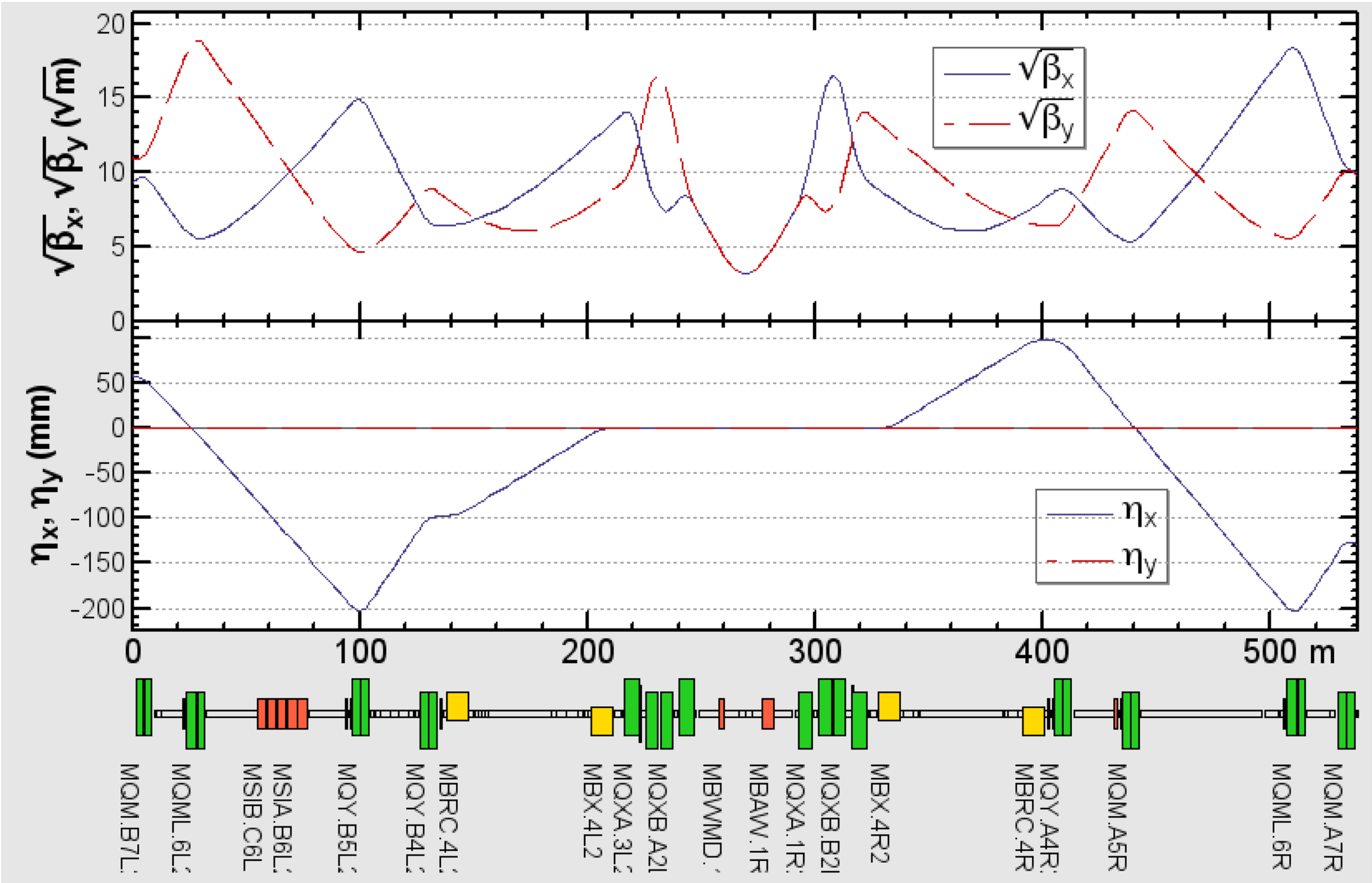
- **IR1**



1. LHC optics in SAD

➤ V6.503

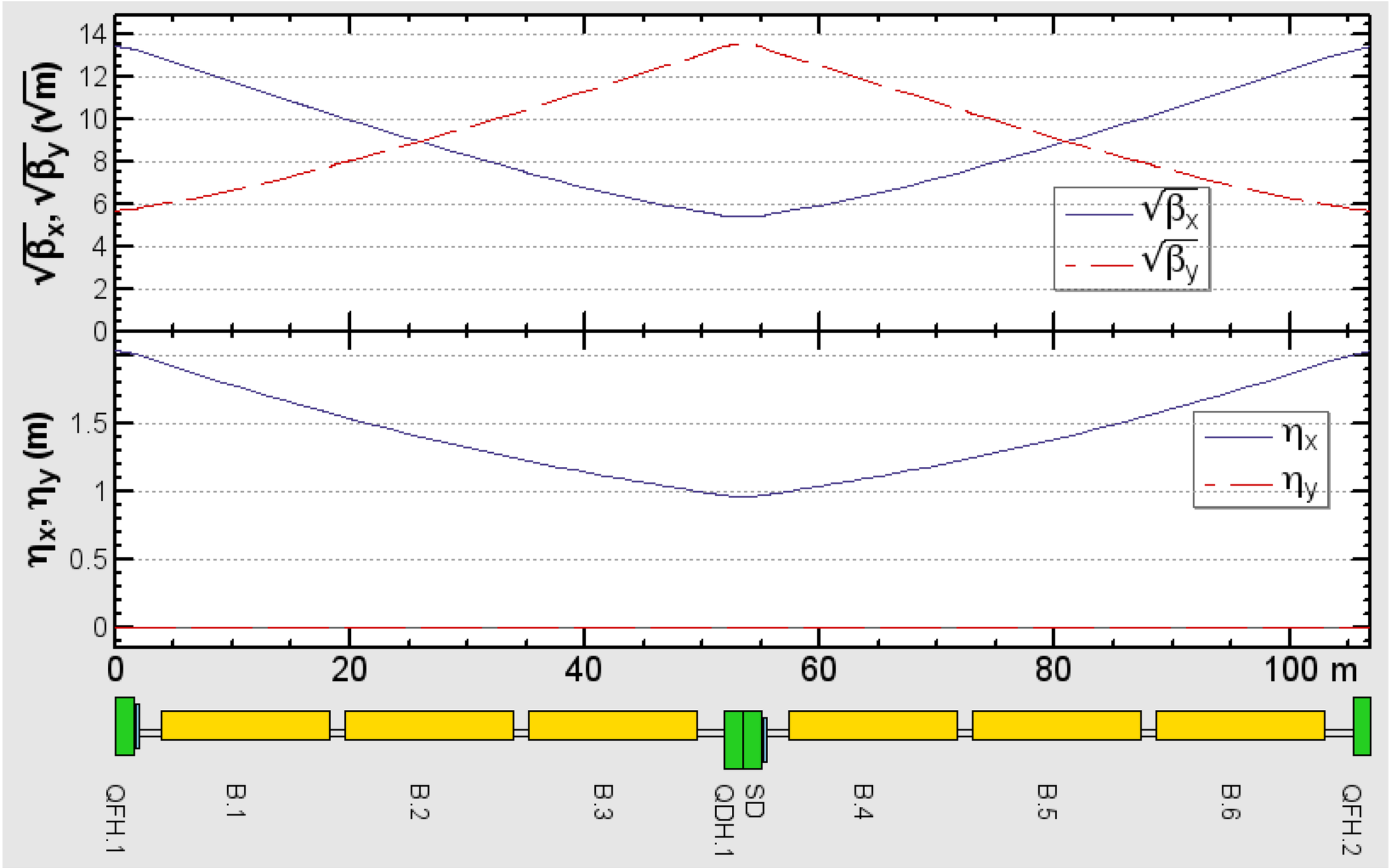
- **IR2**



1. LHC optics in SAD

➤ V6.503

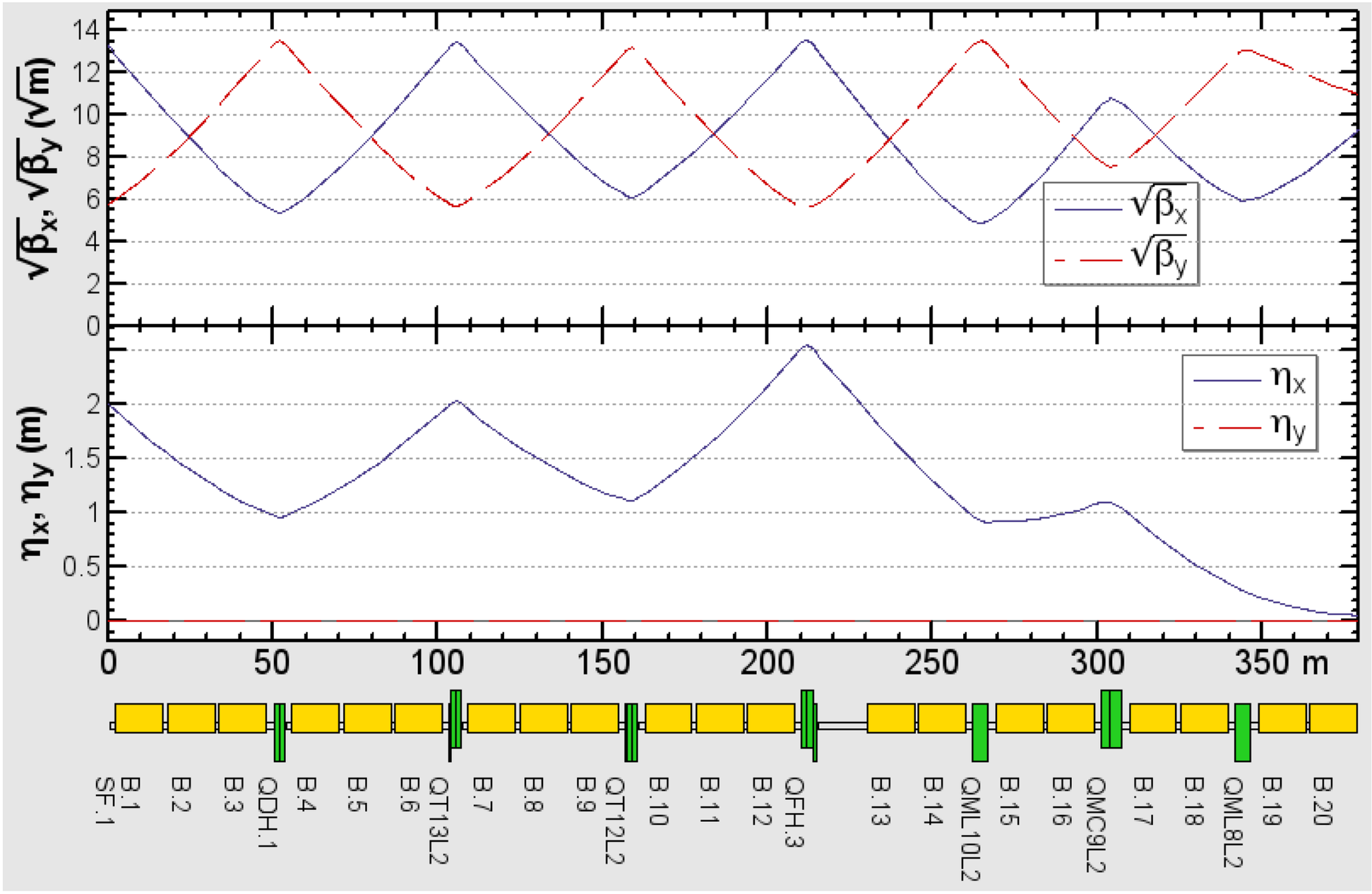
- **Unit cell in ARC12 (simplified) [~90^0, 23 cells per arc]**



1. LHC optics in SAD

➤ V6.503

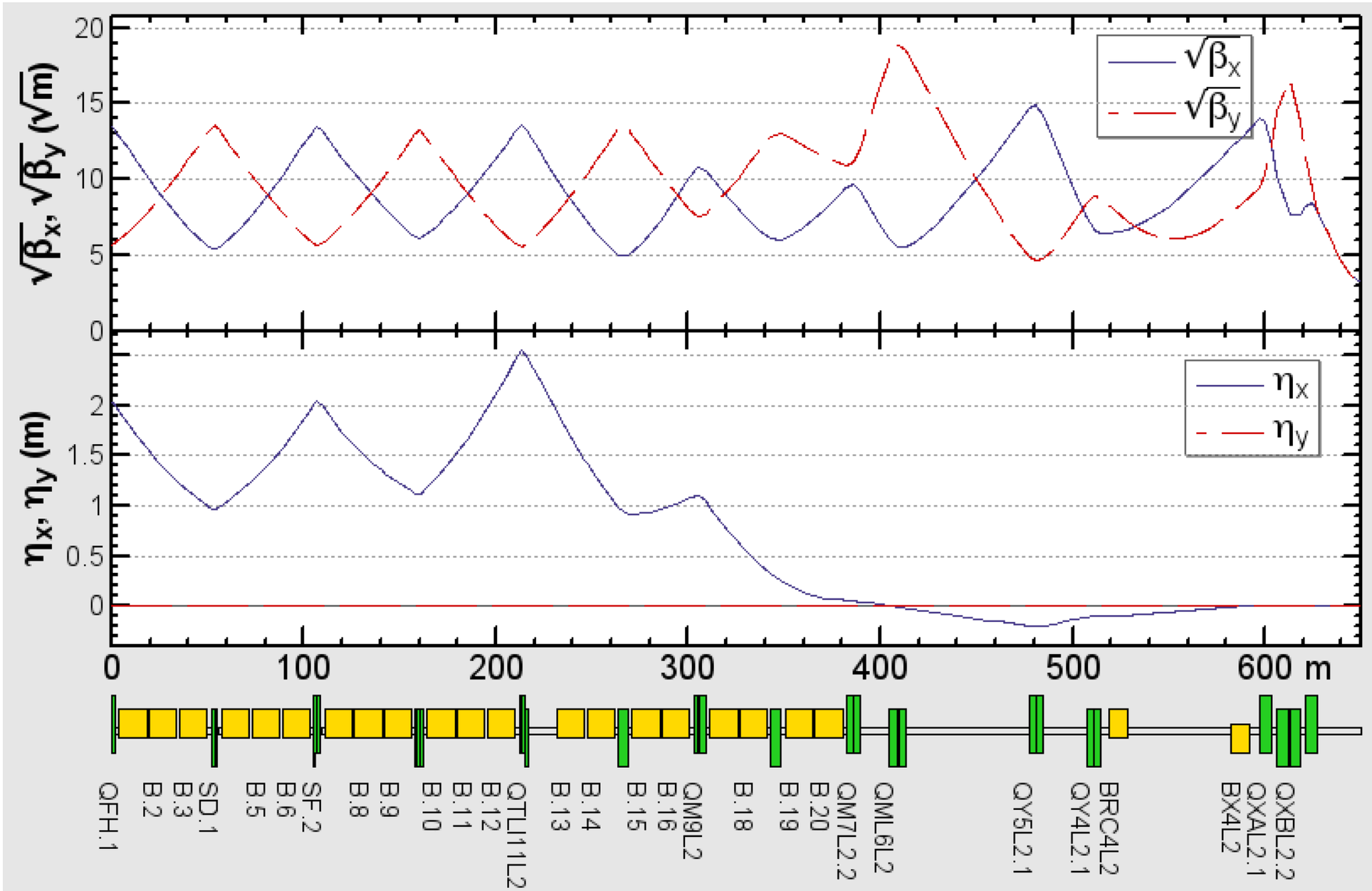
- **ARC12 to DSL2 (simplified)**
- **Trim quads in the last two cells used for dispersion suppression**



1. LHC optics in SAD

➤ V6.503

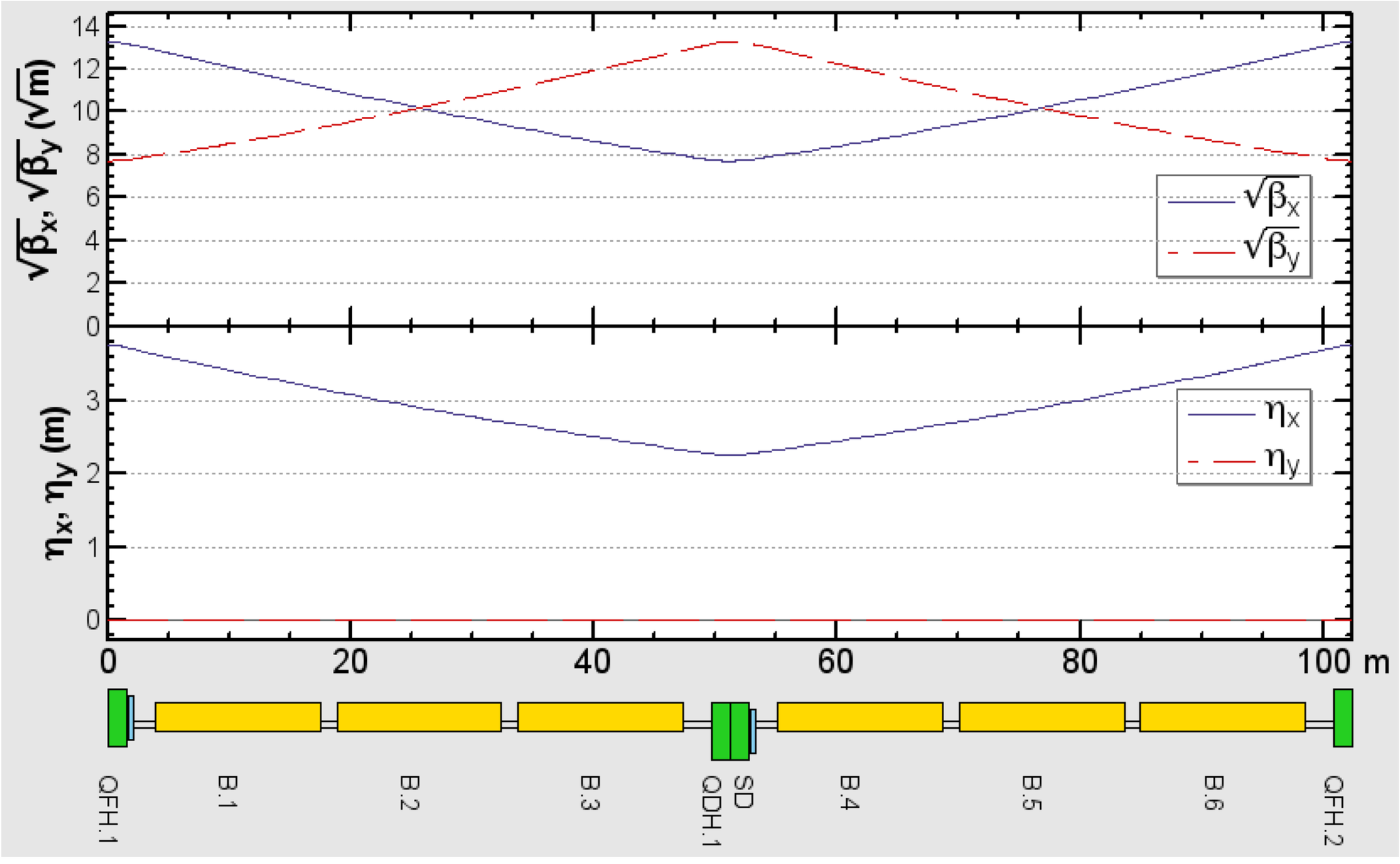
- **ARC12 to IP2 (simplified)**
- **Trim quads in the last two cells used for dispersion suppression**



2. Yuri's HE-LHC optics in SAD

➤ lhc_v5 (By Y. Nosochkov)

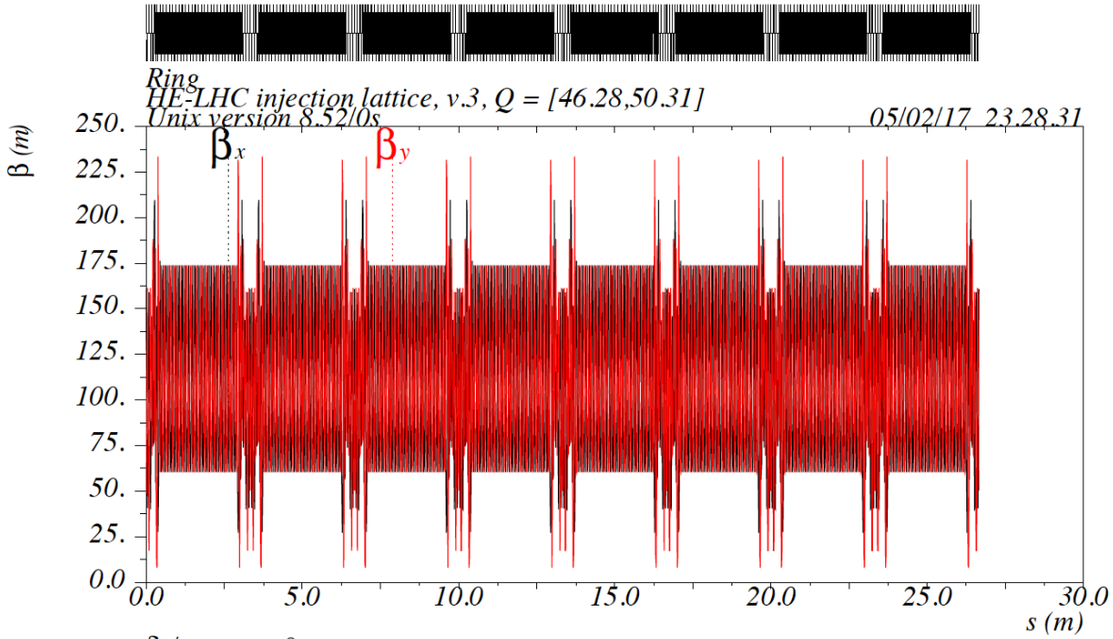
- **Unit cell in arc [60^0, 24 cells per arc]**
- **L=13.56m for dipoles**

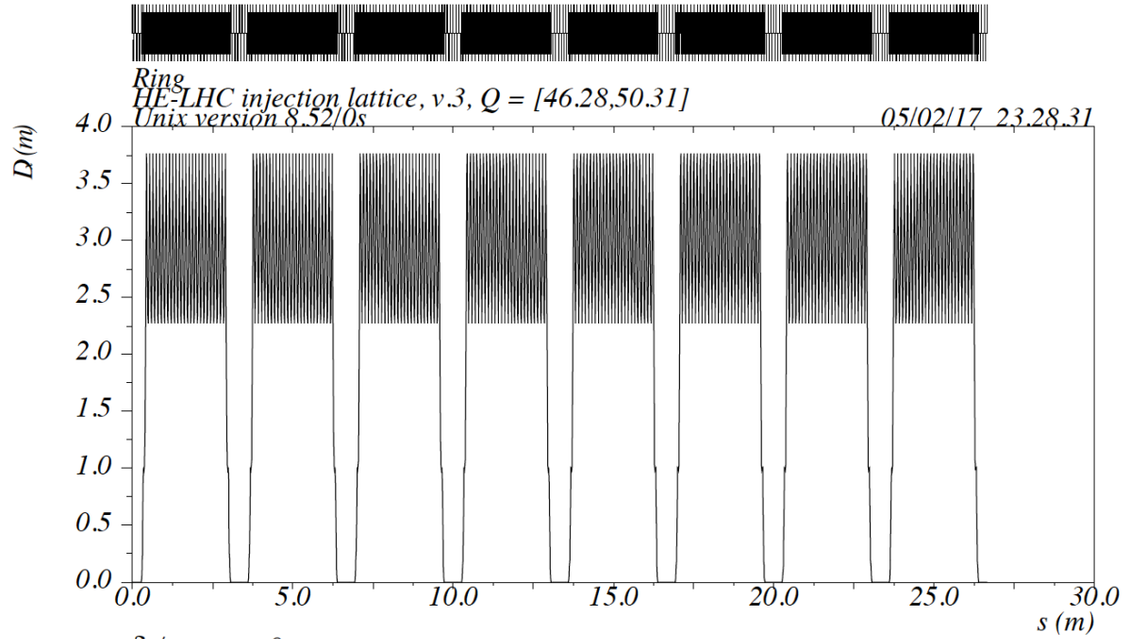


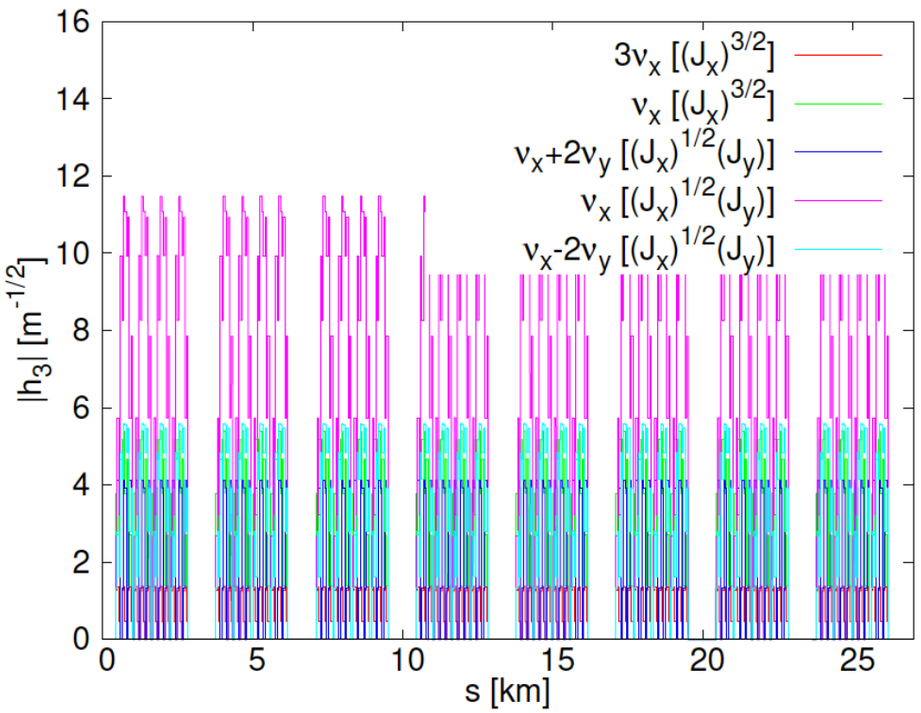
2. Yuri's HE-LHC optics in SAD

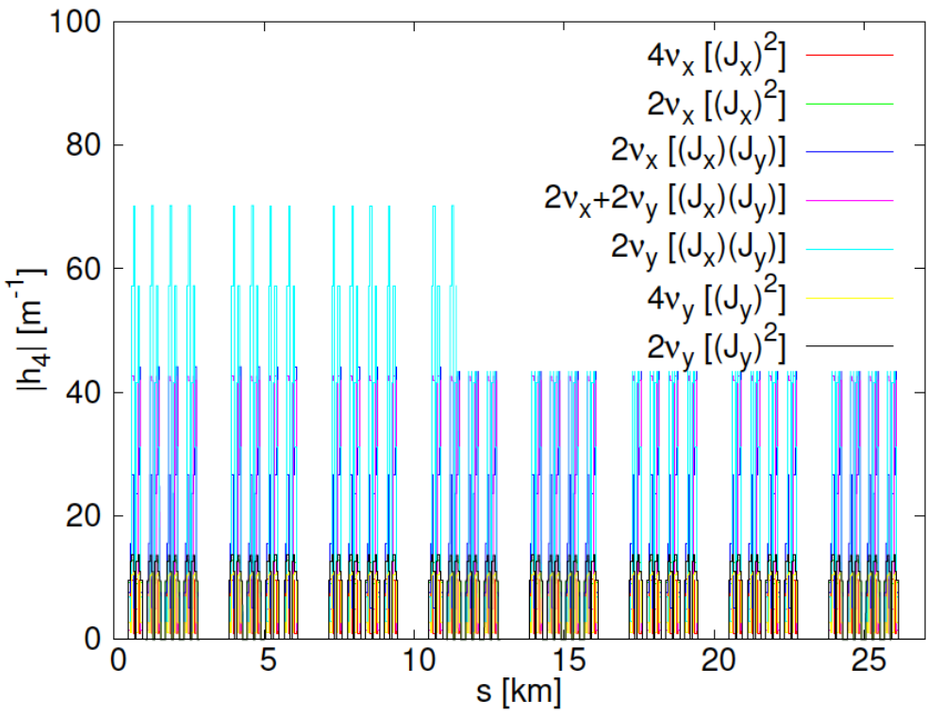
➤ lhc_v5 (By Y. Nosochkov)

- **3rd and 4th order RDTs canceled**





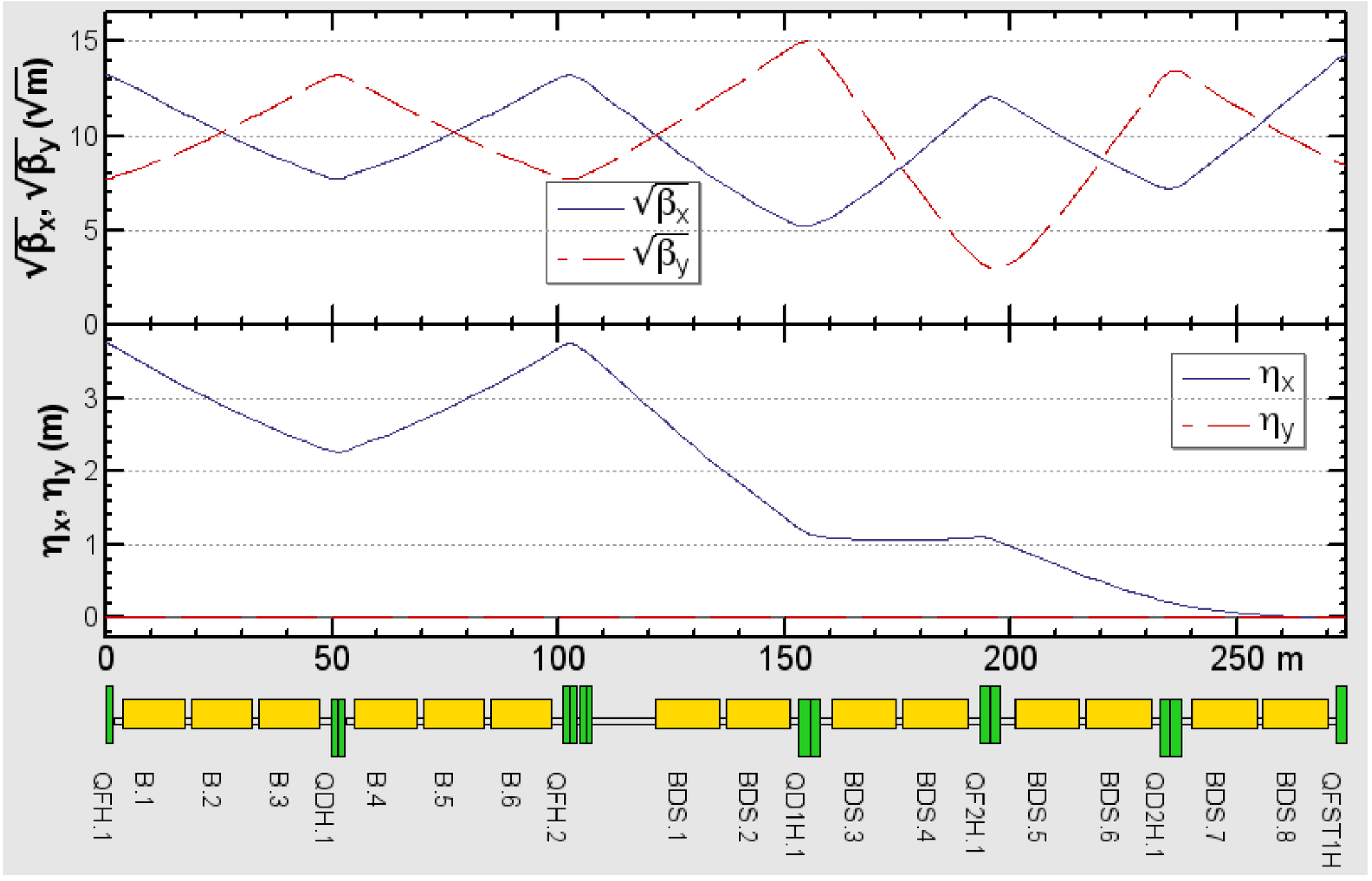




2. Yuri's HE-LHC optics in SAD

➤ lhc_v5 (By Y. Nosochkov)

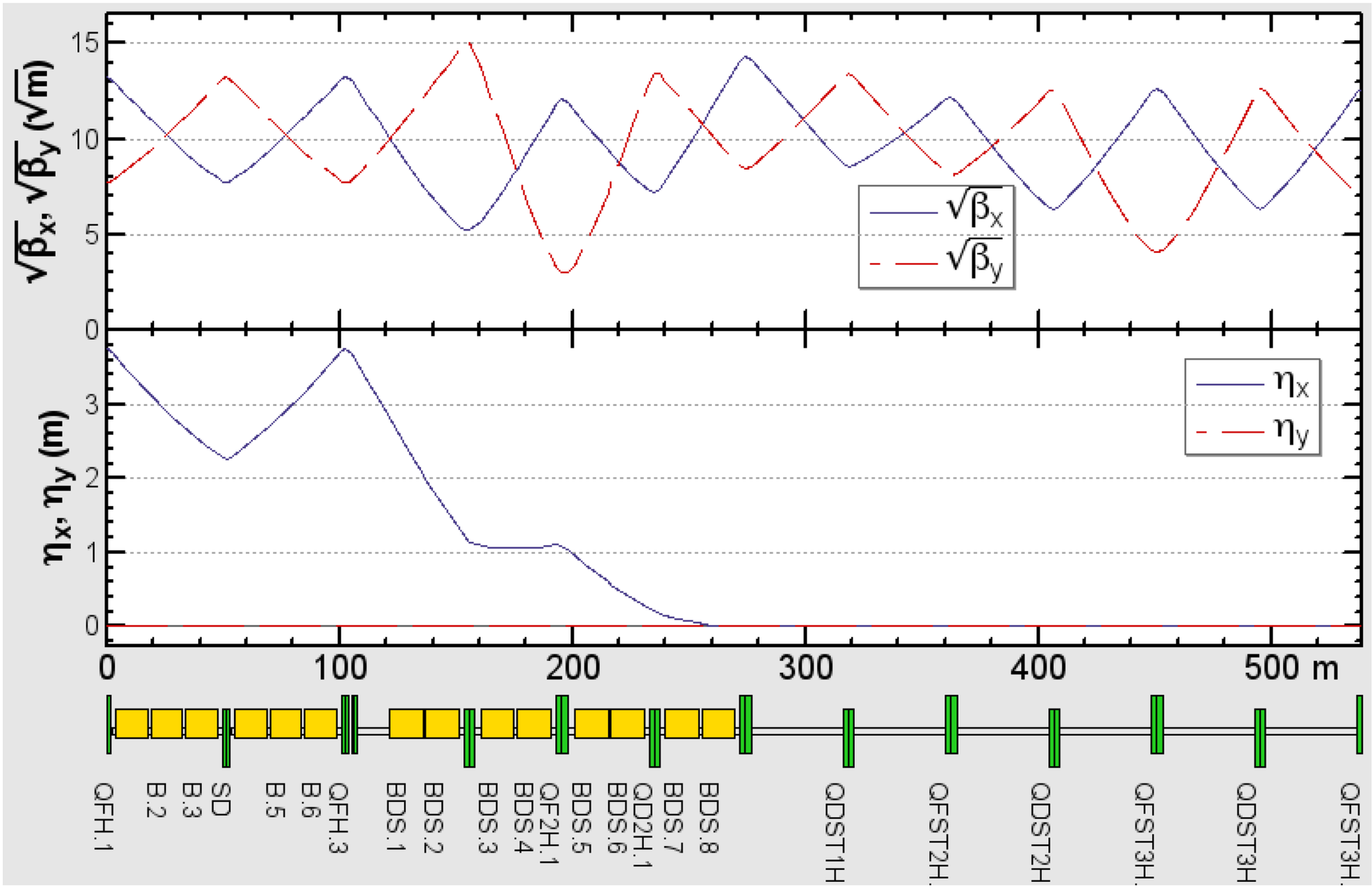
- **Arc connected to dispersion suppressor**
- **L=14.3m for dipoles in DS**



2. Yuri's HE-LHC optics in SAD

➤ lhc_v5 (By Y. Nosochkov)

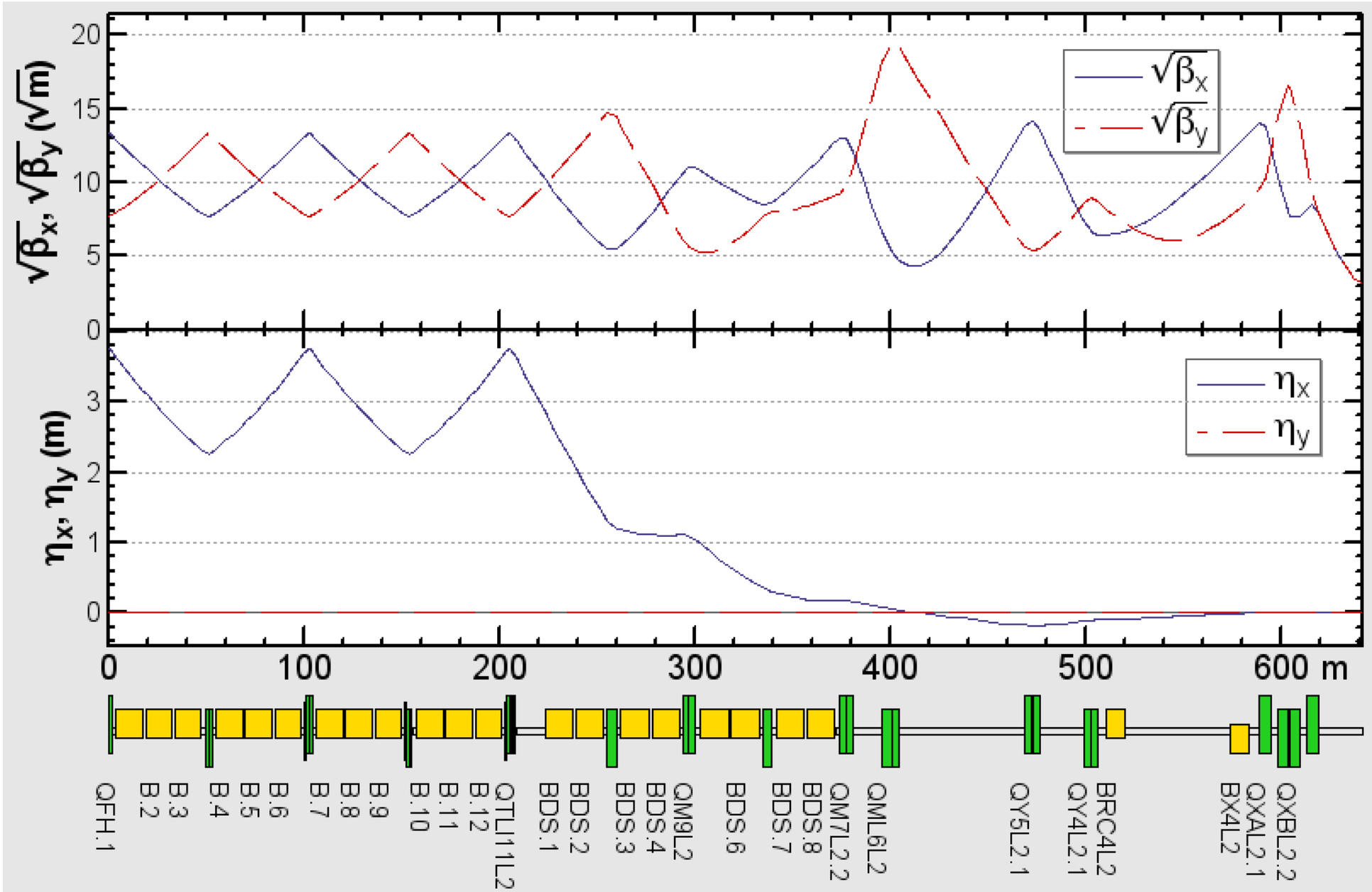
- Arc + DS + straight section
- Matched to LHC geometry



3. 60^0 cell for HE-LHC

➤ Use Yuri's 60^0 cell with DS+IR2 of V6.503

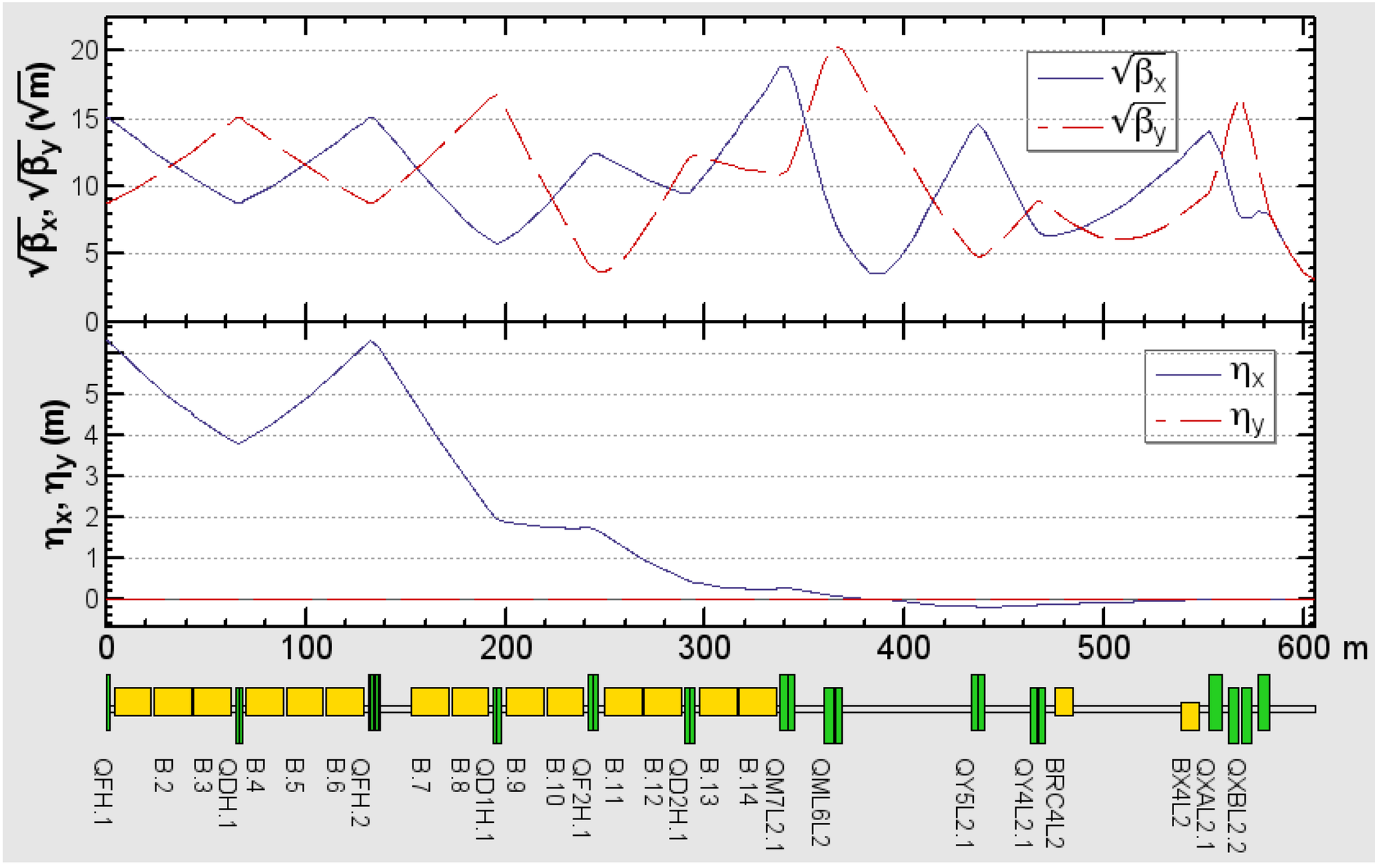
- DS+IR2 rematched [trim quads not used for matching]
- Strengths of quads in DS and IR2 in the same level of V6.503



3. 60^0 cell for HE-LHC

➤ 60^0 cell with 18cells per arc +IR2 of V6.503

- Strengths of quads in DS reduced due to longer dipoles
- Strengths of quads in IR2 in the same level of V6.503



4. Discussion

➤ General scaling laws

- **Assume ideal FODO cell [thin-lens, 100% filling factor]**

$$\sin(\Phi/2) = \frac{1}{4}\mathrm{K_1 L_{cell}}$$

$$\beta_{\pm} = \frac{2\left(1 \pm \mathrm{K_1 L_{cell}}/4\right)}{\mathrm{K_1}\sqrt{1 - \left(\mathrm{K_1 L_{cell}}/4\right)^2}}$$

$$\mathrm{B}\rho = \mathrm{P}_0/e$$

$$\eta_{\pm} = \frac{4}{\rho \mathrm{K_1^2}}\left(1 \pm \mathrm{K_1 L_{cell}}/8\right)$$

Summary

➤ Optics design

- Full LHC lattice translated to SAD and simplified
- Replace arc cells of LHC by 60^0 cells [on-going]
- Design/Matching with SAD started
- Fitting 18-cell lattice to LHC tunnel not easy, more freedoms preferred
- Chromaticity correction and nonlinear optimization to be studied

➤ Need inputs

- Geometric constraints [Survey of LHC tunnel?]
- Engineering constraints for magnets [Maximum fields/gradient/ dipole length/aperture/…]