Optics update for HE-LHC

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Outline

- ► LHC optics in SAD
- ► HE-LHC optics in SAD
- ► 60⁰ cell for HE-LHC
- ► Summary

- ► V6.503
 - V6.5.seq + V6.5.inj.str



► 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



► V6.503

• Unit cell in ARC12 (simplified) [~90⁰, 23 cells per arc]



► V6.503

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



► V6.503

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



2. On arc cell

► General scaling laws

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

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

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

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

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

2. On arc cell

► General scaling laws

• Bending angle for dipole

 2π $\theta_{\text{dipole}} = \frac{-\pi}{8 \times (23 \times 6 + 2 \times 2 \times 4)}$ LHC: 2π $\theta_{\text{dipole}} = \frac{2\pi}{8 \times (24 \times 6 + 2 \times 2 \times 4)}$ HE-LHC (60[°] x 24 cells): 2π HE-LHC-1 (60° x 18 cells): $\theta_{\text{dipole}} = \frac{1}{8 \times (18 \times 6 + 2 \times 2 \times 4)}$ 2π HE-LHC-2 (60° x 18 cells): $\theta_{\text{dipole}} = \frac{1}{8 \times (18 \times 8 + 2 \times 2 \times 4)}$

2. On arc cell

► General scaling laws

- Parameters according to the simple scaling laws [page.10]
- Possible choices for 60⁰ cell for HE-LHC

	LHC	60ºx24 HE-LHC (Yuri)	60ºx18 HE- LHC-1	60ºx18 HE- LHC-2
Arc cell phase advance [deg]	90/90	60/60	60/60	60/60
Arc cell length [m]	106.9	102.446	132.62	136.6
K1 [m ⁻¹] (Ideal)	0.0265	0.0195	0.0151	0.0146
β _{max/min} [m]	182/31	177/59	230/77	237/79
η _{max/min} [m]	2.2/1.1	3.8/2.3	6.3/3.8	6.7/4.0
Dipole length [m]	14.3	13.56	18.59	14.1
Filling factor	0.80	0.79	0.84	0.83

Ihc_v5 (By Y. Nosochkov)

- Unit cell in arc [60⁰, 24 cells per arc]
- L=13.56m for dipoles



Ihc_v5 (By Y. Nosochkov)

3rd and 4th order RDTs canceled





Ihc_v5 (By Y. Nosochkov)

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



Ihc_v5 (By Y. Nosochkov)

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



4. 60° cell for HE-LHC

► Use Yuri's 60⁰ 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



4. 60° cell for HE-LHC

► 60^o 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. 60° cell for HE-LHC

► 60⁰ cell with 18cells per arc +IR2 of V6.503

- 8 dipoles per cell [Constraint from installation]
- DS and matching section in IR need to be optimized



Summary

> Optics design

- Full LHC lattice translated to SAD and simplified
- Replace arc cells of LHC by 60⁰ cells [on-going, need detailed matching conditions from LHC design]
 - Design/Matching with SAD started
- Fitting 18-cell lattice to LHC tunnel under investigation [Constraints to be identified]
 - Chromaticity correction and nonlinear optimization to be studied
- Max/Min ratio ~6 to ~3 for beta function, ~2 to ~1.5 for dispersion function [The influences to be understood]

Need inputs

Geometric constraints [Survey of LHC tunnel, DS+IR layout, etc.]

• Engineering constraints for magnets [Maximum fields/gradient/ dipole length/aperture/...]