# On MADX sequence file and optics matching for HE-LHC

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# Outline

- > On MADX sequence file for HE-LHC
- **Comments on HE-LHC V0.1 via SAD**
- **Future plan**

# Compare the "average beam" of LEP and (HE-)LHC

- Current baseline: merged\_HE-LHC.18x60\_v102.seq (Orange line)
- Need to switch to merged\_HE-LHC.18x60\_tr.seq, but need further improvement in geometry (by Thys)
  - HE-LHC V0.2 can be based on merged\_HE-LHC.18x60\_v102.seq



# ► Global variables: Ring separation

#### • merged\_HE-LHC.18x60\_v102.seq:

const aip1 = 0.008285831213598\*bsep; const aip2 = 0.007899520984845\*bsep; const aip3 = 0.000566187234257; const aip4 = 0.001571604107948; const aip5 = 0.008285831213598\*bsep; const aip7 = 0.000377458178579; const aip8 = 0.007899520984845\*bsep;

#### • LHC V6.5.seq:

REAL CONST sep\_ARC REAL CONST sep\_IR3 REAL CONST sep\_IR4 REAL CONST sep\_IR7 REAL CONST AIP1 = REAL CONST AIP2 = REAL CONST AIP3 = REAL CONST AIP4 = REAL CONST AIP5 = REAL CONST AIP5 = REAL CONST AIP5 =

= 0.194; = 0.224; = 0.420;

- = 0.224;
- = ATAN(sep\_ARC/2/Dsep1);
- = ATAN(sep\_ARC/2/Dsep2);
- = ATAN((sep\_IR3-sep\_ARC)/2/Dsep3);
- = ATAN((sep\_IR4-sep\_ARC)/2/Dsep4);
- = ATAN(sep\_ARC/2/Dsep5);
- = ATAN((sep\_IR7-sep\_ARC)/2/Dsep7);
- = ATAN((sep\_ARC)/2/Dsep8);

**Comment:** 

**Switch to LHC definitions?** 

REAL CONST Dsep1	= 85.913;
REAL CONST Dsep2	= <b>6</b> 3.295;
REAL CONST Dsep3	= 26.493;
REAL CONST Dsep4	= 71.901;
REAL CONST Dsep5	= 85.913;
REAL CONST Dsep7	= 39.7395;
REAL CONST Dsep8	= 63.295;

# Global variables: Others

#### • merged\_HE-LHC.18x60\_v102.seq:

const r0 = 0; ! separation ON const bsep = 0.204\*(1-r0); on\_sol\_atlas := 0.000000000000; on\_x1 := 0.000000000000; on sep1 := 0.0000000000000; on sep2 := 0.0000000000000; on\_x2 := 0.000000000000; on\_alice := 0.000000000000; on\_sol\_alice := 0.0000000000000; on x5 := 0.000000000000; on\_sep5 := 0.000000000000; on\_sol\_cms := 0.0000000000000; on x8 := 0.0000000000000; on\_sep8 := 0.0000000000000; on\_lhcb := 0.000000000000; phi ir1 := 90.000000000000; phi ir5 := 0.0000000000000; abas := 12.00/6.0\*clight/(7e12)\*on\_sol\_atlas; abls := 6.05/12.1\*clight/(7e12)\*on\_sol\_alice; abcs := 52.00/13.0\*clight/(7e12)\*on\_sol\_cms;

Comment: Consistency in the dependence of global constants and derived variables to be checked?

## ► Global variables: DS

#### • merged\_HE-LHC.seq (24x60 sequence):

```
! inner-outer path length differences in main bends
ds = bsep/2 * twopi/1280;
sumds = 0;
```

••• •••

mbds,	at = sumds + 277.520526004 + 0.5*ds; sumds = sumds + ds;
mbds,	at = sumds + 292.553250504 + 0.5*ds; sumds = sumds + ds;
mq.8r1.b1,	at = sumds + 301.737250504;
mq.8r1.b1 <i>,</i>	at = sumds + 304.137250504;
mbds,	at = sumds + 314.017250504 + 0.5*ds; sumds = sumds + ds;
mbds,	at = sumds + 329.049975004 + 0.5*ds; sumds = sumds + ds;

••• •••

#### **Comment:**

DS: to keep the ring survey closed when beam separation is turned on. To be added to 18x60, 17x90 and 20x90 sequence files

## ► IR2

- Injection for beam 1
- To be improved by injection group (?)

#### LHC V6.503

#### **HE-LHC**



## ► IR3

- Momentum collimation section
- Used for tune matching in V0.1 (to use IR4&6 instead in V0.2)
- Keep features of LHC IR3 (preferred by collimation group?)
- To be reviewed by collimation group

LHC V6.503

**HE-LHC** 



#### ► IR4

- To be used for tune matching
- Quads in the last arc cell individually powered
- Need to be reviewed by RF and BI groups?

#### LHC V6.503

#### **HE-LHC**



## ► IR5

- Experimental IR
- Triplets longer than LHC
- Matching sections could be improved? For example, positions of matching quads to be optimized?

**HE-LHC** 

LHC V6.503

20 15  $\sqrt{\beta_x}, \sqrt{\beta_y} (\sqrt{m})$  $\sqrt{\beta_{x}},\sqrt{\beta_{y}}$  ( $\sqrt{m}$ ) 15  $\eta_{x}$ 2 ղ<sub>x</sub>, ղ<sub>y</sub> (m) η<sub>x</sub>, η<sub>y</sub> (m)  $\eta_y$ 1.5  $\eta_x$ 0.5  $\eta_y$ 0 200 400 600 800 1000 m 200 400 600 800 1000 m QDML\_6F QFML\_5R BRC\_4R5 MQML.6 MQYL.5 MCBYY MBRD.4 QDXA\_3L BXW\_F4L MOXC.3F MOXD.A: TASC.1R BXW\_A4F QFXA\_1R BDS MCBXD BDS. B.21 B.20 QFMC BRC\_4L MOML. MBRD.4 QFM\_A7I B.24 QFH.3 õ QFML\_ QDML\_5 MQYL.5 ğ IQ.9R5 .DS.L5

## ► IR6

- To be used as beam dump and for tune matching
- More quads necessary in matching sections?
- To be reviewed by beam dump group?

#### LHC V6.503





### ► IR7

- Betatron collimation section
- Keep features of LHC IR7 (preferred by collimation group?)
- Dispersion functions acceptable?
- To be reviewed by collimation group

LHC V6.503





## ► IR8

- Injection for beam 2
- To be improved by injection group (?)

#### LHC V6.503





# ► Quad. gradient

- E=13.5 TeV, β\*=25cm @IP#1&5
- Quadrupole: L=3.1m in arcs [Typical]
- Some quads in IR3&7 exceed FCC tech. limit
- Some quads in IR2&8 critical (to be reviewed by injection group?)



FCC specification: B<sup>(1)</sup>max≈400 T/m<sup>[1]</sup> with aperture φ=50 mm

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

# Sext. gradient

- E=13.5 TeV, β\*=25cm @IP#1&5
- Sextupole: L=0.369m in arcs [Typical]
- Sext. gradient well below FCC tech. limit



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



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FCC specification: B<sup>(2)</sup>max≈7800 T/m<sup>2[2]</sup> with aperture φ=50 mm

<sup>[2]</sup>D. Schoerling, FCC-hh magnet-beam dynamics coordination meeting, Apr. 28, 2017

# **3.** Future plan

# Strategy for optics developments and beam dynamics simulations using SAD

- Assume ring layout fixed
- Translate MADX sequence file to SAD format
- Do matching/optimizations and simulations using SAD
- Use SAD to print strength file in MADX format

# Optional optics for HE-LHC

- Improve ring geometry for 17x90 and 20x90 (manually)
- Adapt MADX scripts developed for 18x90 to 17x90 and 20x90 => Create sequence file
  - Optics matching in SAD => Create strength file