HiLumi LHC: Impact of Bad $b_6$ in Inner Triplet Magnets

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Outline

1. Introduction
2. Large \(b_6\) in All Magnets
3. Large \(b_6\) in All Magnets, With Capped Correctors
4. Large \(b_6\) in One Magnet at a Time
5. Large \(b_6\) in Two Magnets at a Time
Aim

- The body of the MQXF magnets might have a much larger $b_6$ error than currently given in the error tables, up to -4 units. We want to investigate
  - the impact on DA of a large $b_6$ error (-4 and -6) in all MQXF magnets simultaneously
  - the impact on DA of a large $b_6$ error (-4) in one or a few of the MQXF magnets
  - if the strength assignments of the NLC package do not exceed 100% of their design values for the above scenarios
Setup

- In total **124** studies, with on average **4260** jobs each
- 0.5M jobs on a tight time schedule
  \[ \Rightarrow \text{calculations on the CERN batch system} \]

*Many thanks to A. Mereghetti for the new scripts,*

- DA is calculated over:
  - 11 angles
  - 60 random realisations of the machine (‘seeds’)
- HLLHC 1.3 optics, nominal errors (but no MCBXF errors)
  \[ \beta^* = 0.15/0.15/0.15/0.15 \text{m}, \quad Q_x = 62.31, \quad Q_y = 60.32 \]
  \[ \mu_x^{1\rightarrow5} = 31.379^\circ, \quad \mu_y^{1\rightarrow5} = 30.331^\circ \]
  \[ d_{\text{sep}}^{1,5} = 0.75 \text{mm}, \quad \theta_c = 295 \text{ mrad} \]
Setup

Q1: 132.6 T/m
Q2a: 2.1 T 2.5/4.5 T m
Q2b: 5.6 T 35 T m
Q3: 4.5 T 35 T m
D1: 2.65 T 5 T m
D2: 5.6 T 35 T m

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Bad b6 in IT Magnets
Example DA plot

absolute maximum
(maximum angle over all seeds)

individual seed lines
(average over angles per seed)

average DA
(average over angles and over seeds)

absolute minimum
(minimum angle over all seeds)
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Dodecapole corrector strength in function of $b_6$ error of all IT magnets
DA in function of $b_6$ of all IT magnets (chrom 3, $I_{oct}=0A$)
DA in function of $b_6$ of all IT magnets (chrom 3, $I_{oct} = 0A$, beam 1)

- Nominal
- $b^I_6 = -4$
- $b^I_6 = -6$
- Mean DA
- Min DA

Averaged over all angles
$\Delta DA = 0.18 \sigma$
$\Delta DA = 0.03 \sigma$
DA in function of $b_6$ of all IT magnets (chrom 3, $I_{oct} = 0A$, beam 2)

Averaged over all angles
$\Delta DA = 0.27 \sigma$
$\Delta DA = 0.13 \sigma$
DA in function of $b_6$ of all IT magnets (chrom 15, $I_{oct} = -420\text{A}$)
DA in function of $b_6$ of all IT magnets (chrom 15, $I_{oct} = -420A$, beam 1)

Averaged over all angles
\[ \Delta DA = -0.14 \sigma \]
\[ \Delta DA = -0.17 \sigma \]
DA in function of $b_5$ of all IT magnets (chrom 15, $I_{oct} = -420A$, beam 2)

Averaged over all angles
$\Delta DA = -0.15 \sigma$
$\Delta DA = -0.12 \sigma$
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DA in function of $b_6$ of all IT magnets, capped correctors (chrom 3, $I_{\text{oct}}=0A$)
DA in function of $b_y$ of all IT magnets (chrom 3, $I_{oct} = 0A$, beam 1)

Averaged over all angles
$\Delta DA = 0$, $\sigma$
DA in function of $b_6$ of all IT magnets, capped correctors (chrom 15, $I_{\text{oct}}=-420\text{A}$)
DA in function of $b_6$ of all IT magnets (chrom 15, $l_{oct} = -420A$, beam 1)

Averaged over all angles
$\Delta DA = -0.01 \sigma$
DA in function of $b_6$ of all IT magnets (chrom 15, $l_{oct} = -420A$, beam 2)

Averaged over all angles
$\Delta DA = -0.01 \sigma$

- $b_6^T = -6$
- $b_6^T = -6$, cap
- Mean DA
- Min DA
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Dodecapole corrector strength, setting low $b_6$ per IT magnet, one-by-one
DA for $b_6 = -4$, one magnet at a time (chrom 15, $I_{\text{oct}}=-420\text{A}$)
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|-------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
Dodecapole corrector strength, setting low $b_6$ for two IT magnets at random

**kctx3.l1**

**kctx3.r1**

**kctx3.l5**

**kctx3.r5**

RanID (two random IT magnets with $b_6^T = -4$)
Thank you for your attention!