Compatibility of beta functions during the squeeze in IR4 with ADT

Wolfgang Hofle

Some material taken from presentations for Run 1 and initial Run 2 situation:
W. Höfle: HL-TCC, 20 Aug. 2020
Run 1 ADT System

pick-ups are dedicated BPMCS integrated with cryostats of quadrupoles
Original Specifications (ADT)

- **Pick-ups**
  - two pick-ups per plane per beam (8 in total)
  - coupler type pick-ups BPMC provided by BI group
  - The modulated signal at 400 MHz is used
  - integrated with Q7 and Q9 cryostats left and right of point 4
  - minimum $\beta$ functions of 100 m
  - low dispersion preferable (Q7LHB1 and Q7RHB1 very good)
  - higher than specified $\beta$ functions allowed for better performance

- **Kickers**
  - Four kickers per beam and plane (16 in total)
  - minimum $\beta$ functions 100 m
  - higher than specified values allowed for better than planned performance and allowed additional functionalities without upgrades
Pickups for ADT after LS1 (optics 6.5xx) make available four Q8 PU (LBOC 15.04.2014)

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<td>Q9L</td>
<td>Q7L</td>
<td>Q8R</td>
<td>Q9R</td>
<td>Q10R</td>
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<tr>
<td>β</td>
<td>32 m</td>
<td><strong>111</strong> m</td>
<td>106 m</td>
<td>133 m</td>
<td>19 m</td>
<td>153 m</td>
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<td>new run 2</td>
<td>run 1</td>
<td>new run 2</td>
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<td>Q8L</td>
<td>Q7R</td>
<td>Q9R</td>
<td>Q10R</td>
</tr>
<tr>
<td>β</td>
<td>175 m</td>
<td>54 m</td>
<td>155 m</td>
<td>161 m</td>
<td>142 m</td>
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<td>Q7R</td>
<td>Q9R</td>
<td>Q10R</td>
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<td>22 m</td>
<td>96 m</td>
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<td>101 m</td>
<td>29 m</td>
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<td>Q7L</td>
<td>Q8R</td>
<td>Q9R</td>
<td>Q10R</td>
</tr>
<tr>
<td>β</td>
<td>44 m</td>
<td>160 m</td>
<td>167 m</td>
<td>151 m</td>
<td>56 m</td>
<td>180 m</td>
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<td>run 1</td>
<td>new run 2</td>
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All PUs are couplers (BPMCS type) that already exist, high beta preferable. Agreement in 2014 with BI on the usage of the Q8’s.
HL squeeze – ADT

Squeeze from 50 cm to 15 cm, 36 twiss files from R. de Maria script for extraction by D. Valuch
Horizontal Beam 1

large increase of $\beta_x$ for Q10R $\rightarrow$ 15 cm kickers: only small change
Vertical Beam 1

- significant increase of $\beta_y$ for Q9R $\rightarrow$ 15 cm
- decreasing $\beta_y$ for Q7R and Q8L
- kickers: significant increase, making B1 and B2 more equal
Horizontal Beam 2

- significant increase of $\beta_x$ for Q9R $\Rightarrow$ 15 cm
- decreasing $\beta_x$ for Q7R
- kickers: only small change
Vertical Beam 2

- significant increase of $\beta_y$ for Q10R $\rightarrow$ 15 cm
- decreasing $\beta_y$ for Q8R
- kickers: only small change
ADT kickers run 1, initial run2 and HL-squeeze

- **Kickers: improvement proportional to $\beta^{1/2}$**

<table>
<thead>
<tr>
<th>Damper</th>
<th>Run 1: $\beta$</th>
<th>Run 2: $\beta$ (initial)</th>
<th>HL-squeeze</th>
<th>Improvement Factor cf run 1</th>
</tr>
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<tbody>
<tr>
<td>H.B1 (L4)</td>
<td>253 m</td>
<td>271 m</td>
<td>265 m</td>
<td>1.02</td>
</tr>
<tr>
<td>V.B1 (R4)</td>
<td>160 m</td>
<td>268 m</td>
<td>332 m</td>
<td>1.44</td>
</tr>
<tr>
<td>H.B2 (R4)</td>
<td>204 m</td>
<td>263 m</td>
<td>265 m</td>
<td>1.02</td>
</tr>
<tr>
<td>V.B2 (L4)</td>
<td>306 m</td>
<td>336 m</td>
<td>359 m</td>
<td>1.08</td>
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</table>

- design peak kick strength 7.5 kV is 2 $\mu$rad (450 GeV/c); assumed $\beta=100$ m
- Run1 impact on beam is factor 1.6 higher for H.B1, V.B1, H.B2, and 1.8 higher for V.B2 (because $\beta$’s much higher than 100 m)
- cf. to run 1 optics, the initial optics brought improvement for all beams and planes
- we need higher than 100 m values to keep the performance of all additional features invented and implemented along runs 1 and 2 (about gap cleaning, loss maps, excitations for measurement purposes and quench tests)
**Reminder - Figure of merit for pick-ups**

- motivated by S/N improvement for multiple pick-up usage compared to the reference case of a single pick-up @ $\beta = 100\ m$

$$\frac{S}{N} = 20\text{dB} \times \log_{10}\frac{\sum_{n=1}^{N} \sqrt{\beta_n / 100m}}{\sqrt{N}}$$

<table>
<thead>
<tr>
<th></th>
<th>Run 1 (2 PU) Q7,Q9</th>
<th>Run 2 (4 PU) Q7,Q9,Q10</th>
<th>Run 2 Q7,Q8,Q9,Q10</th>
<th>Improvement with BI swap</th>
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</thead>
<tbody>
<tr>
<td>H.B1</td>
<td>3.8 dB</td>
<td>5.6 dB</td>
<td>7.0 dB</td>
<td>1.4 dB</td>
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<tr>
<td>V.B1</td>
<td>4.2 dB</td>
<td>7.4 dB</td>
<td>8.0 dB</td>
<td>0.6 dB</td>
</tr>
<tr>
<td>H.B2</td>
<td>4.4 dB</td>
<td>5.9 dB</td>
<td>8.0 dB</td>
<td>2.1 dB</td>
</tr>
<tr>
<td>V.B2</td>
<td>4.9 dB</td>
<td>6.6 dB</td>
<td>8.2 dB</td>
<td>1.6 dB</td>
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From LBOC 15.04.2014
PU Figure of Merit HL-squeeze

• general improvement during squeeze $\rightarrow$ 15 cm, except V.B1
• similar starting value at $\beta=50$ cm as in initial run 2 optics except for HB2 which slightly worse
• V-plane $\beta$’s better than H-plane at $\beta=50$ for both beams
Preliminary Summary

- higher $\beta$ at V.B1 kickers welcome
- PU figure of merit for combined set of pick-ups seems OK, however
  - achieved by large increase of $\beta$-functions at Q9R and Q10R
  - possibility to leverage on this large increase must be checked by ADT team experts
Spare
2016: ADT Digital Signal Processing Unit (mDSPU)

BeamPos receiver + coarse delay
Closed orbit suppression
Pickup β-function compensation
Phase advance compensation

Link receiver
Hold
Notch
Gain balance
Phase rotation
Pickup enable switch

Loop A
enable
Loop A
activity mask
Activity switch
Predis-tortion phase
Predis-tortion gain
DAC

Q7
ΔΣ
Link receiver
Hold
Notch
Gain balance
Phase rotation
Pickup enable switch

Loop A
enable
Loop B
activity mask
Activity switch
Predis-tortion phase
Predis-tortion gain
DAC

Q9
ΔΣ
Link receiver
Hold
Notch
Gain balance
Phase rotation
Pickup enable switch

Loop B
enable
Loop C
activity mask
Activity switch
Predis-tortion phase
Predis-tortion gain
DAC

Q8
ΔΣ
Link receiver
Hold
Notch
Gain balance
Phase rotation
Pickup enable switch

Loop C
enable
Loop D
activity mask
Activity switch
Predis-tortion phase
Predis-tortion gain
DAC

Q10
ΔΣ
Link receiver
Hold
Notch
Gain balance
Phase rotation
Pickup enable switch

Loop D
enable

DAC

ADT digital signal processing unit (mDSPU)
Pickups for ADT after LS1 proposal as presented at LMC: 5th Feb 2014

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