**SOME LHC SINGLE-BEAM INSTABILITY DATA FROM 2012 COMPARED TO NHTVS**

E. Métral, A. Burov and N. Mounet

- 2 MDs => MD note by NicolasM et al. under publication (CERN-ATS-Note-2012-073 MD)

=> 19/06/12 on fill #2744 and 23/06/12 on fill #2771

<table>
<thead>
<tr>
<th>Fill, date and time</th>
<th>inst. rank</th>
<th>energy and plane</th>
<th>beam and plane</th>
<th>n_b</th>
<th>Q_x</th>
<th>Q_y</th>
<th>4σ_t/ ns</th>
<th>RF volt. [MV]</th>
<th>Q'_x</th>
<th>Q'_y</th>
<th>Int. [10^{11} p^+/b]</th>
<th>ε_x [μm.rad]</th>
<th>ε_y [μm.rad]</th>
<th>τ_x^d [tr.]</th>
<th>τ_y^d [tr.]</th>
<th>foc. oct. cur. [A]</th>
<th>coll. settings</th>
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<tbody>
<tr>
<td>2744 19/06/12 23:48</td>
<td>1st</td>
<td>4TeV/c 11m</td>
<td>B2V</td>
<td>1380</td>
<td>64.28 ±0.001</td>
<td>59.31 ±0.001</td>
<td>1.21 ±3%</td>
<td>12</td>
<td>8.7 ±2</td>
<td>3.3 ±2</td>
<td>1.5 ±0.2</td>
<td>2.35 ±0.45</td>
<td>2.35 ±0.45</td>
<td>100</td>
<td>200</td>
<td>−110</td>
<td>physics except TCL</td>
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<tr>
<td>2771 23/06/12 19:06</td>
<td>1st</td>
<td>4TeV/c 0.6m</td>
<td>B2V</td>
<td>1380</td>
<td>64.31 ±0.003</td>
<td>59.32 ±0.003</td>
<td>1.24 ±5%</td>
<td>12</td>
<td>9.3 ±2</td>
<td>1.9 ±2</td>
<td>1.43 ±0.21</td>
<td>2.3 ±0.5</td>
<td>2.3 ±0.5</td>
<td>50</td>
<td>100</td>
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<td>physics except TCL</td>
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<td>2nd</td>
<td>4TeV/c 0.6m</td>
<td>B2V</td>
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<td>64.31 ±0.003</td>
<td>59.32 ±0.003</td>
<td>1.26 ±5%</td>
<td>12</td>
<td>−3 ±2</td>
<td>−7 ±2</td>
<td>1.4 ±0.2</td>
<td>2.3 ±0.5</td>
<td>2.3 ±0.5</td>
<td>50</td>
<td>100</td>
<td>−235</td>
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<td>2771 23/06/12 20:49</td>
<td>3rd</td>
<td>4TeV/c 0.6m</td>
<td>B2H</td>
<td>1380</td>
<td>64.31 ±0.003</td>
<td>59.32 ±0.003</td>
<td>1.26 ±5%</td>
<td>12</td>
<td>5.9 ±2</td>
<td>−0.9 ±2</td>
<td>1.4 ±0.2</td>
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<td>B2V</td>
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<td>1.26 ±5%</td>
<td>12</td>
<td>2.3 ±2</td>
<td>0.8 ±2</td>
<td>1.37 ±0.2</td>
<td>2.3 ±0.5</td>
<td>2.3 ±0.5</td>
<td>Inf</td>
<td>Inf</td>
<td>−402</td>
<td>physics except TCL</td>
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</table>
For $1.5 \times 10^{11}$ p/b within 2 microm and LOF $> 0$ => For LOF $< 0$, ~ 1.6 less octupoles are needed (Gaussian)

1.4 $\Rightarrow$ 50 turns

Valley with 0 octupoles

Same as SB

2 $\times$ nominal impedance

Valley is lost

Same as SB

Alexey Burov
For 1.5E11 p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

BEFORE SQUEEZE
(0.28/0.31)

Unstable in V
(ADT = 200 turns)

Stable in H
(ADT = 100 turns)

2 × nominal impedance
Unstable in V (ADT = 200 turns)

Stable in H (ADT = 100 turns)

BEFORE SQUEEZE (0.28/0.31)

For 1.5E11 p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

SB stabilizing octupole current, A

Valley is lost

2 × nominal impedance

CB stabilizing octupole current, A

Same as SB

Same as SB
For $1.5 \times 10^{11}$ p/b within 2 microm and LOF $> 0$ => For LOF $< 0$, ~ 1.6 less octupoles are needed (Gaussian)
2\textsuperscript{nd} MD => 1\textsuperscript{st} instability

- **END SQUEEZE** (0.31/0.32)
- **Stable in H** (ADT = 50 turns)
- **Unstable in V** (ADT = 100 turns)

For 1.5E11 p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

- **Same as SB**

2 × nominal impedance

Valley is lost

- **Same as SB**

Elias Métral, HSC meeting, 27/04/2015

Alexey Burov
2\textsuperscript{nd} MD $\Rightarrow$ 1\textsuperscript{st} instability

END SQUEEZE (0.31/0.32)

Stable in H (ADT = 50 turns)

Unstable in V (ADT = 100 turns)

For 1.5E11 p/b within 2 microm and LOF $>$ 0 $\Rightarrow$ For LOF $<$ 0, $\sim$ 1.6 less octupoles are needed (Gaussian)

2 $\times$ nominal impedance

Valley is lost

Same as SB

Same as SB

End of squeeze (0.31/0.32)

2\textsuperscript{nd} MD $\Rightarrow$ 1\textsuperscript{st} instability

For 1.5E11 p/b within 2 microm and LOF $>$ 0 $\Rightarrow$ For LOF $<$ 0, $\sim$ 1.6 less octupoles are needed (Gaussian)

2 $\times$ nominal impedance
For 1.5E11 p/b within 2 microns and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)
2nd MD => 2nd instability

END SQUEEZE
(0.31/0.32)

Stable in H
(ADT = 50 turns)

Unstable in V
(ADT = 100 turns)

For 1.5E11 p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

2 × nominal impedance

Valley is lost

Same as SB

Same as SB

Elias Métral, H5C meeting, 27/04/2015
For $1.5 \times 10^{11}$ p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

Unstable in V (ADT = 100 turns)

Stable in H (ADT = 50 turns)

END SQUEEZE (0.31/0.32)

2nd MD => 2nd instability

2 × nominal impedance
For $1.5 \times 10^{11}$ p/b within 2 microm and $\text{LOF} > 0$ => For $\text{LOF} < 0$, ~1.6 less octupoles are needed (Gaussian)

$2^{\text{nd}} \text{ MD} \Rightarrow 3^{\text{rd}} \text{ instability}$

Valley with 0 octupoles

$1.4 \leftrightarrow 50 \text{ turns}$

Damper gain

$Q'$

$2 \times \text{nominal impedance}$

Valley is lost

Same as SB

Same as SB

Alexey Burov
2\textsuperscript{nd} MD $\Rightarrow$ 3\textsuperscript{rd} instability

END SQUEEZE
(0.31/0.32)

Stable in V
(ADT = 100 turns)

Unstable in H
(ADT = 50 turns)

For 1.5E11 p/b within 2 microm and LOF $> 0$ $\Rightarrow$ For LOF $< 0$, $\sim 1.6$ less octupoles are needed (Gaussian)

SB stabilizing octupole current, A

2 $\times$ nominal impedance

Valley is lost

CB stabilizing octupole current, A

Same as SB

Same as SB
For $1.5 \times 10^{11}$ p/b within 2 microm and LOF > 0 => For LOF < 0, ~1.6 less octupoles are needed (Gaussian)
For $1.5 \times 10^{11}$ p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

2nd MD => 4th instability

SB stabilizing octupole current, A

- Valley with 0 octupoles
- Same as SB

CB stabilizing octupole current, A

- Valley is lost
- Same as SB

$2 \times$ nominal impedance

1.4 $\Leftrightarrow$ 50 turns

damper gain
2\textsuperscript{nd} MD $=>$ 4\textsuperscript{th} instability

END SQUEEZE

(0.31/0.32)

Unstable in V
(ADT = infinity)

Stable in H
(ADT = infinity)

For 1.5E11 p/b within 2 microm and LOF $> 0$ $=>$ For LOF $< 0$, $\sim 1.6$ less octupoles are needed (Gaussian)

2 $\times$ nominal impedance

Valley is lost

Same as SB

Same as SB

Alexey Burov
2\textsuperscript{nd} MD $\Rightarrow$ 4\textsuperscript{th} instability

- END SQUEEZE (0.31/0.32)
- Stable in H (ADT = infinity)
- Unstable in V (ADT = infinity)

For 1.5E11 p/b within 2 microm and LOF > 0 $\Rightarrow$ For LOF < 0, $\sim$ 1.6 less octupoles are needed (Gaussian)

2 $\times$ nominal impedance

Valley is lost

Same as SB

Alexey Burov
2nd MD => No instability case

For 1.5E11 p/b within 2 microm and LOF > 0 => For LOF < 0, ~ 1.6 less octupoles are needed (Gaussian)

SB stabilizing octupole current, A

Valley with 0 octupoles

Q’

2 × nominal impedance

Valley is lost

Same as SB

1.4 ⇔ 50 turns

damper gain

Same as SB

Alexey Burov
2\textsuperscript{nd} MD $\Rightarrow$ No instability case

- LOD $\sim$ 450 A

- ADT as in physics (50 turns in H and 100 turns in V)

- Chromaticity scanned from – 10 to + 10

$\Rightarrow$ Beam always stable

For $1.5\times10^{11}$ p/b within 2 microm and LOF > 0 $\Rightarrow$ For LOF < 0, $\sim$ 1.6 less octupoles are needed (Gaussian)
CONCLUSIONS

- A detailed data analysis has been done by NicolasM for the 2 MDs: 19/06/12 on fill #2744 and 23/06/12 on fill #2771

- Comparing (roughly) to the past predictions from AlexeyB with the impedance model of 2012, it seems that we could be not that far…

- Next step would be to redo the NHTVS (and DELPHI) simulations for the measured data (see first slide)