Offset studies
DQW (Vertical Crabbing)

WP2 Meeting, 22\textsuperscript{nd} May 2018
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Beam Loading

- Beam can drive the dipole mode in the cavity.
- No effect at 0 mm offset.
- Beam induced voltage due to offset in crossing plane calculated:
- The power requirement from the IOT to maintain the deflecting voltage will hence differ with offset.

Beam Loading Formula:

\[ V_b = Q_L I_b \frac{R_{\perp}}{Q} (k\Delta x) \]

Cavity Parameters:
- \( f \) [MHz]: 400.8
- \( V_T \) [MV]: 3.4
- \( I_b \) [A]: 1.1
- \( \frac{R}{Q_{\text{trans.v}}} \): 429

Cavity QL = \( 5.5 \times 10^5 \)

+-1 mm in the crossing plane.
HOMs

- HOM power at multiple beam offsets calculated.
- Bunch spectra parameters from [1].
- Average and maximum from 1000 stochastic variations of $f$ and $Q_e$ (varied within measured values).
- For transverse impedance, all modes except 1 are below 1 MOhm/m/cavity.

![SPS HOM Couplers](image)

- Linear variation of power in vertical plane due to 680 MHz mode.
- Quadratic increase of power in horizontal plane due to 960 MHz mode.

![LHC HOM Couplers](image)

Frequency of modes (manufacture tolerances) is much higher influence than offset.

$\pm 5$ mm - unless 680 or 960 MHz modes are near bunch harmonic.

Multipoles

- Scaled to 10 MV deflecting voltage.
- Measurements on SPS cavities inconclusive, further improvements are currently in work.

<table>
<thead>
<tr>
<th></th>
<th>$b_2$ [mTm/m]</th>
<th>$b_3$ [mTm/m^2]</th>
<th>$b_4$ [mTm/m^3]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Re b_2$</td>
<td>$\Im b_2$</td>
<td>$\Re b_3$</td>
</tr>
<tr>
<td>PoP DQW (Bare) 2011 - M. Navarro-Tapia</td>
<td>111.34</td>
<td>0.00</td>
<td>1266.75</td>
</tr>
<tr>
<td>PoP DQW (Bare) 2012 - M. Navarro-Tapia</td>
<td>0.36</td>
<td>0.06</td>
<td>1076.75</td>
</tr>
<tr>
<td>PoP DQW (Bare)</td>
<td>-0.23</td>
<td>0.00</td>
<td>1047.65</td>
</tr>
<tr>
<td>SPS_DQW (Bare)</td>
<td>-5.93</td>
<td>2.41</td>
<td>1502.51</td>
</tr>
<tr>
<td>SPS_DQW + PU Port (Bare)</td>
<td>-5.98</td>
<td>2.50</td>
<td>1507.54</td>
</tr>
<tr>
<td>SPS_DQW + FPC + SPS HOM Couplers + PU</td>
<td>-5.96</td>
<td>2.53</td>
<td>1495.88</td>
</tr>
<tr>
<td>SPS_DQW + FPC + LHC HOM Couplers + PU</td>
<td>-5.80</td>
<td>2.33</td>
<td>1494.09</td>
</tr>
</tbody>
</table>

@ 3.4 MV

-1.97 | 0.79 | 507.99 | 19.07 | -282.06 | 46.0

Need to assess with new estimates:

TDR: ‘the $b_3$ component should be limited to approximately 1000 mTm/m^2’
TDR: ‘For $n \geq 4$, ... Better estimates are pending; results from long-term tracking are needed’
Conclusion

- For vertical crabbing.
- Aperture evaluation to be looked at, from ±5 mm in non-crossing plane.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Vertical [mm]</th>
<th>Horizontal [mm]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Loading</td>
<td>-1 +1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOMs</td>
<td>-5 +5</td>
<td>-5 +5</td>
<td>Have to assess mode frequencies when cavities are manufactured.</td>
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<tr>
<td>Multipoles</td>
<td>-1 +1</td>
<td></td>
<td>Need to discuss limitations on b4 component.</td>
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<tr>
<td>Aperture</td>
<td></td>
<td></td>
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<tr>
<td>Limitation</td>
<td>-1 +1</td>
<td>-9 +9</td>
<td></td>
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</tbody>
</table>
IOT Power with Offset, $Q_L = 5.5 \times 10^5$

Limit of 30 kW