Update on single-collimator impedance measurements using ADT data

BE/RF: Gerd Kotzian, Daniel Valuch*
BE/ABP: Lee Carver

* daniel.valuch@cern.ch
Precision tune extraction using the ADT data

- Tune value can be extracted from the ADT bunch-by-bunch position data

- A single kick allows to extract the bunch by bunch tune, bunch by bunch damping time, beam transfer function and many more.

- The kick can be generated by the ADT itself, or by an external device (Q kicker, AC dipole, injection etc…)
Precision tune extraction using the ADT data

- Tune value can be extracted from the ADT bunch-by-bunch position data

**Step 1:** Induce transverse motion (kick)

**Step 2:** Record the b-b-b transverse position

**Step 3:** Compute the bunch motion

**Step 4:** Use an appropriate method to extract the fractional tune

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Setup for MD1477

- Single circulating bunch, acquisition by ADTObsBox
- Kick generated by the Q kicker, strength increased in steps 20-50-100%
- Low-ish chromaticity to allow smooth and even oscillation decay transient, damper ON
- Excitation amplitude ~30μm at 100% strength. Usable data for bit more than 1000 turns
Data analysis

- Three different algorithms run on the same data set: a simple Fourier transform, Kotzian algorithm, SUSSIX. Each extracts the Q value looking at a different parameter of the oscillating data series...

- Results of all three algorithms converge (good news!)

- With the current source data quality, we can easily see tune variation in order of few $10^{-5}$ with error bar $<10^{-5}$ (excellent news!)
  - Typical ADT Beam Pos module noise floor $\sim 1.8\mu$m$_{\text{RMS}}$
  - Initial oscillation amplitude $\sim 30\mu$m, oscillation visible for $\sim 1000$ turns

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>$&lt;\text{Q}_{\text{ver}}&gt;$ 10σ</th>
<th>$&lt;\text{Q}_{\text{ver}}&gt;$ 6.5σ</th>
<th>$&lt;\text{Q}<em>{\text{ver}10}&gt; - &lt;\text{Q}</em>{\text{ver}6.5}&gt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourier transform (1024 turns)</td>
<td>0.2921124 +/- 8.818e-06</td>
<td>0.2920750 +/- 1.131e-05</td>
<td>3.746e-05</td>
</tr>
<tr>
<td>Kotzian algorithm [1] (1289 turns)</td>
<td>0.2920791 +/- 1.100e-05</td>
<td>0.2920435 +/- 1.240e-05</td>
<td>3.559e-05</td>
</tr>
<tr>
<td>SUSSIX</td>
<td>0.292133 +/- 9.08065e-6</td>
<td>0.292094 +/- 1.06417e-5</td>
<td>3.94361e-5</td>
</tr>
</tbody>
</table>
Update on single-collimator impedance measurements

L.C: I will also paste below a comment I received from Nicolo...

“…the prediction from the impedance model of the tune shift induced by the D4L7 scans is 3.2e-5, so very close to the measurements!”
Summary

- The resolution and precision of tune extraction depends on how much transverse activity for how many turns is available in the data. We have demonstrated that we can see Q changes of few $10^{-5}$ with error bar $<10^{-5}$ with $\sim 30\mu$m initial amplitude and $\sim 100$ turns damping time.

- The prediction from the impedance model of the tune shift induced by the D4L7 scans is $3.2e-5$… Very close to the measurements!

- Extraction of tune from the transverse damper data has great potential not only for MDs. Together with active excitation by ADT options are virtually limitless…

- The ADT team is interested to participate in future MDs, we support and make possible all kinds of highly experimental set-ups to carry out various interesting measurements.

References: