TEVATRON MAGNETS AND ORBIT VIBRATIONS

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1. Introduction
2. Slow drifts
3. Quakes
4. High Frequency Vibrations
Why do we care about Tevatron orbit/ground motion?

First look:
- Aperture is large ø70 mm
- Beams are small ∼1 mm
- Orbit motion does not lead to proton-antiproton separation @ IPs
  as beams share same aperture (magnets)

But:
- 0.5-1 mm drifts from "silver orbit" lead to significant changes in betatron tunes → higher losses of P and Ps
- @ cij energy of 150 GeV beams are several mm wide and ∼1-2 mm drifts of orbit in few tight aperture locations lead to significant (∼5%) loss of particles.
- @ 980 GeV: it was found that high intensity proton beam is less stable if drifts away from center of RF cavities.
- Vibrations of RF cavities at synchrotron frequency (85 Hz @ 150 GeV, 35 Hz @ 980 GeV) may lead to longitudinal emittance growth due to microphonic effect.
HERA p-beam vert. motion at $\beta=1$ m

Brinkmann and Rossbach (1994)


Fig. 6 PSD of HERA proton orbit vertical motion normalized to $\beta=1$ m. Dashed line is for the ATL expectation (from Ref.[18, 9]).

\[
<\Delta y^2> = ATL
\]

\[
\Rightarrow \text{COD} \ <\Delta y^2> = G \cdot A \cdot T \cdot C
\]

\[
\Rightarrow \text{PSD-COD} = \frac{6G \cdot A \cdot C}{\pi^2 f^2}
\]

\[
\Rightarrow \text{HERA} \quad A = (4 \pm 2) \cdot 10^{-6} \frac{\mu m^2}{m.s}
\]

\[
\text{Tevatron} \quad A \leq (2.6 \pm 1) \cdot 10^{-6} \frac{\mu m^2}{m.s}
\]

\[
\Rightarrow \text{orbit excursions around Tevatron} \quad \sim \pm 1 \text{ mm/month}^{1/2}
\]
PSD of the Tevatron Orbit Drifts in store 1668 (08/17/2002)

- **PSDHor**
- **PSDVert**

- **0.03/f^2, A=2.6e-6**
6/18/02

M5.0 Quake @ Darmstadt, IN

Depth ~ 5 km

Seen in TeV losses ~ 2 min later
Tev Vertical Orbit Oscillation Spectrum ($\beta=30m$)
Tev Horizontal Orbit Oscillation Spectrum ($\beta=100\text{m}$)
Conclusions:

1. Tevatron orbit drifts contain
   • 24-hr variations $\leq T^0$
   • 12-hr period $\leq$ probably due to tides
   • some additional $\leq$ ATL-line, $A \leq (2.6 \pm 1)e^{-6} \text{m/s}$

2. Local earthquakes are rare, but affect TeV
   remote earthquakes are frequent but do not disturb Tevatron much

3. Spectra of low-beta quadrupole vibrations
   contain lines at:
   
   4.6, 8.5, 9.2, 13.9 kHz $\leftarrow$ due to CTHL compressor
   18.5, 21.5, 23 kHz $\leftarrow$ due to "stand" resonances
   RF cavity support resonances are at 15, 43 kHz

4. Amplitude of low-$\beta$ quad vibrations $\leq 0.5-1 \mu$

5. Beam orbit spectra contain all quad
   frequencies plus $f$-synchrotron plus mainly no

6. Amplitude of high frequency orbit
   oscillations $\leq 5 \mu$m $\leftarrow$ so, $\frac{\text{orbit}}{\text{quad}} \geq 10$