Control of slow orbit motion in the Tevatron

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Slow orbit motion problem in the Tevatron

- Can lead to high losses at the experiments
- Lowers beam lifetime and leads to tune and chromatic drift.
- Causes of orbit motion:
  - Ground motion: tectonic motion, Tides, human activity
  - Ground motion differentials between Experiment halls and rest of ring.
  - Temperature, humidity, driven by HVAC cycles

- Changes at the low Beta quads are magnified by as much as 20 times. So a 20 micron change could cause a 0.4 mm change in orbit.
- Due to this motion it has been necessary to smooth about once every store. However we found that swings on the order of 1 mm can occur during less than 2 hours. This has motivated the development of an orbit stabilization program which can cycle every 30 secs.
Store 4250 example of slow orbit motion
Using SVD to calculate location of Orbit Corrections.

• Using betas and phases of correctors and BPMS a Corrector to position response Matrix can be constructed:

\[ R_{ij} = \frac{\sqrt{\beta_i \beta_{cj}}}{2 \sin(\frac{\pi \nu}{2})} \cos(|\psi_i - \psi_{cj}| - \pi \nu) \]

\[ \Delta X = R \Delta \theta \]

• This matrix can be inverted using SVD to find the position to corrector matrix

\[ \Delta \theta = R_{\text{inv}} \Delta X \]

where

\[ R_{\text{inv}} = VW_{\text{inv}} U^T \]
Identifying Correctors necessary to Control motion

• Applying SVD correction algorithm every 30 secs we to the sampled orbit we could identify the most effective correctors necessary to control this motion.

• They occur at HA49 and HC49
• For VerticalMost correction occurred at VB11 and VD11.
C55 Orbit stabilization program

- Turns on once HEP is reached.
- Sets up SVD matrix for horizontal and vertical correction based on optics.
- Samples initial orbit and then every 30 secs applies corrections to HA49, HC49 and VB11 and VD11 correctors to maintain existing orbit.
- Along the way does bpm and correction error checks. Limiting the maximum correction change applied and bpm change.
- Turns off at the end of HEP.
- Can be run as a slot 7 program. Controlled by state device V:TORBFB
- Status of program indicated on C:TORFBST
With orbit stabilization running half way through store.
Remaining orbit issues

- While we now have a system to correct orbit motion < 1 Hz. There remains a persistent horizontal orbit motion on the order of 17 Hz at 0.04 mm.
- Additionally there are occasional fast spikes in losses caused by sudden orbit motion. (earthquakes, human motion.)
- To control this motion out to 17 Hz we are in the process of building a fast orbit stabilization system using only a few BPMS which will transmit their positions over Ethernet > 50 Hz and drive correctors using either MDAT channels or CAMAC summing modules.