Fermilab

Tevatron Alignment/GM/Vibrations: Issues and Plans

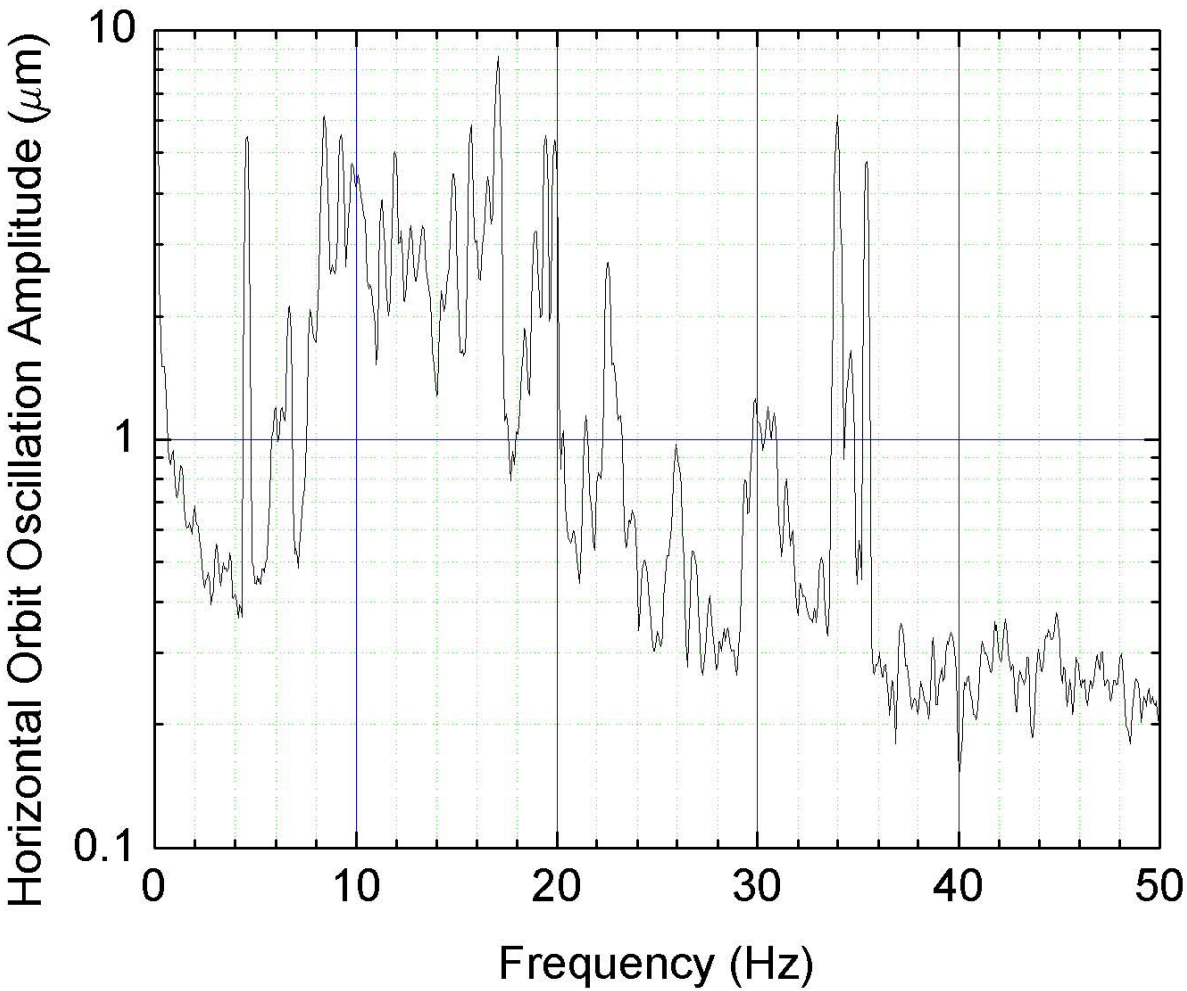
Director Review
May 4-5, 2003

Vladimir Shiltsev

High Frequency Oscillations

- 2-60 Hz, due to CHL, supports, PSs
- 20-100 micron in both H and V
- Important operationally:
  - lead to spikes in the CDF losses (movement to/out collimators)
  - RF noise due to microphonics→ DC beam
- Cures:
  - a) better CDF shielding
  - b) stabilize PSs(?)
  - c) orbit stabilization if needed
  - d) mech.damping or FB loops in RF cav's (TD)
- Diagnostics: ORBITH(V) channels on-line, geophones in tunnel in 2003-04 (Ray S.)

High Frequency Orbit Vibrations

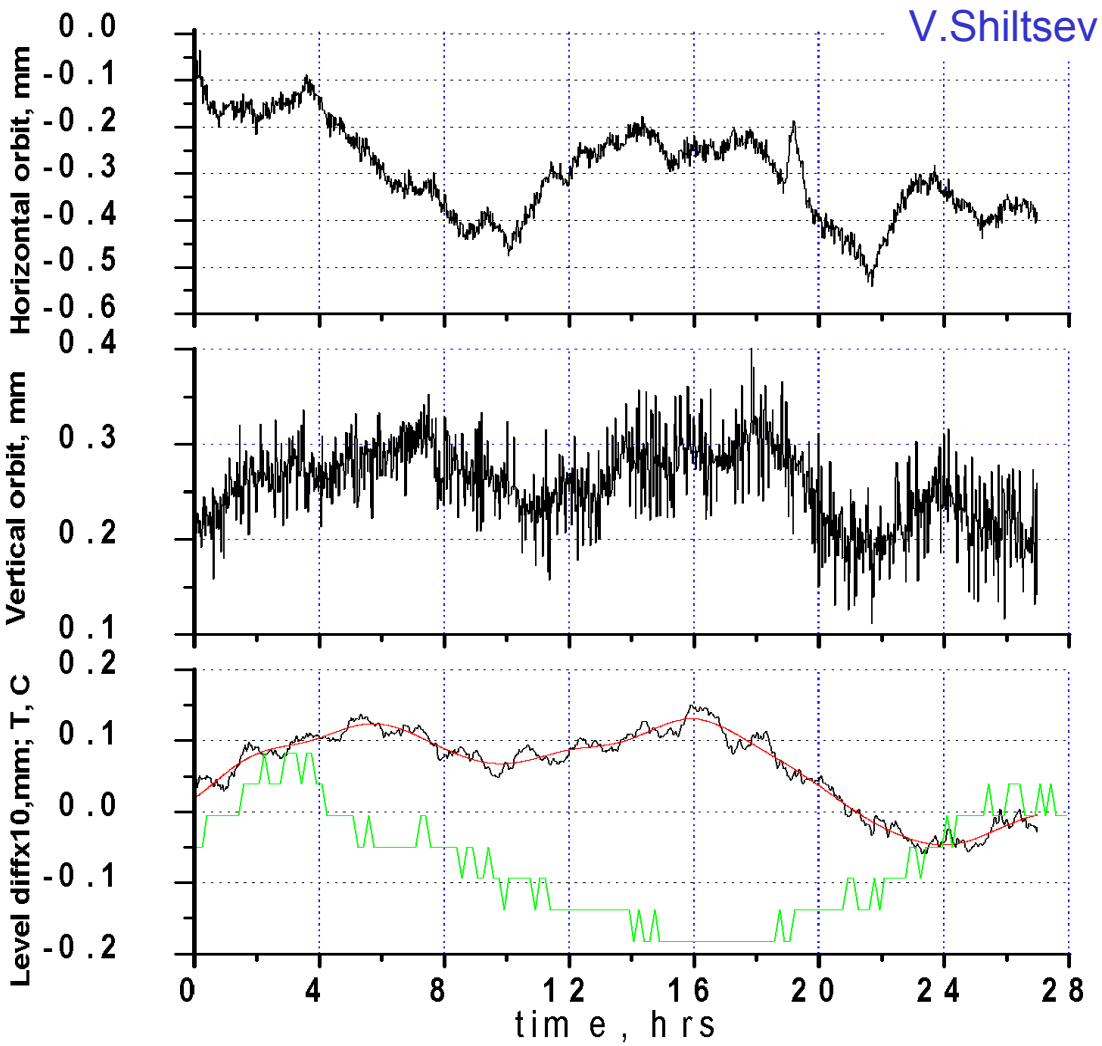


Medium Term Orbit Movements

- <0.5 mm/day (1/2 day), temperature, tides, drifts
- 0.5-1 mm/week^1/2 , ATL: A=2e-6 (?)
- Affected by quenches
- Important operationally:
  - affects tunes/coupling/chromaticities
  - affects injection mismatch?
- Cures:
  - operational tuneup and correctors control
  - operational orbit smoothing
- Diagnostics:
  - BPMs…need to be upgraded → FY04? (Tev Project)
  - Tiltmeters (have a dozen)
  - 2 water levels at sector A1
  - plan for 26 HLSs in B-sector (shutdn)→ on-line (Ray S)

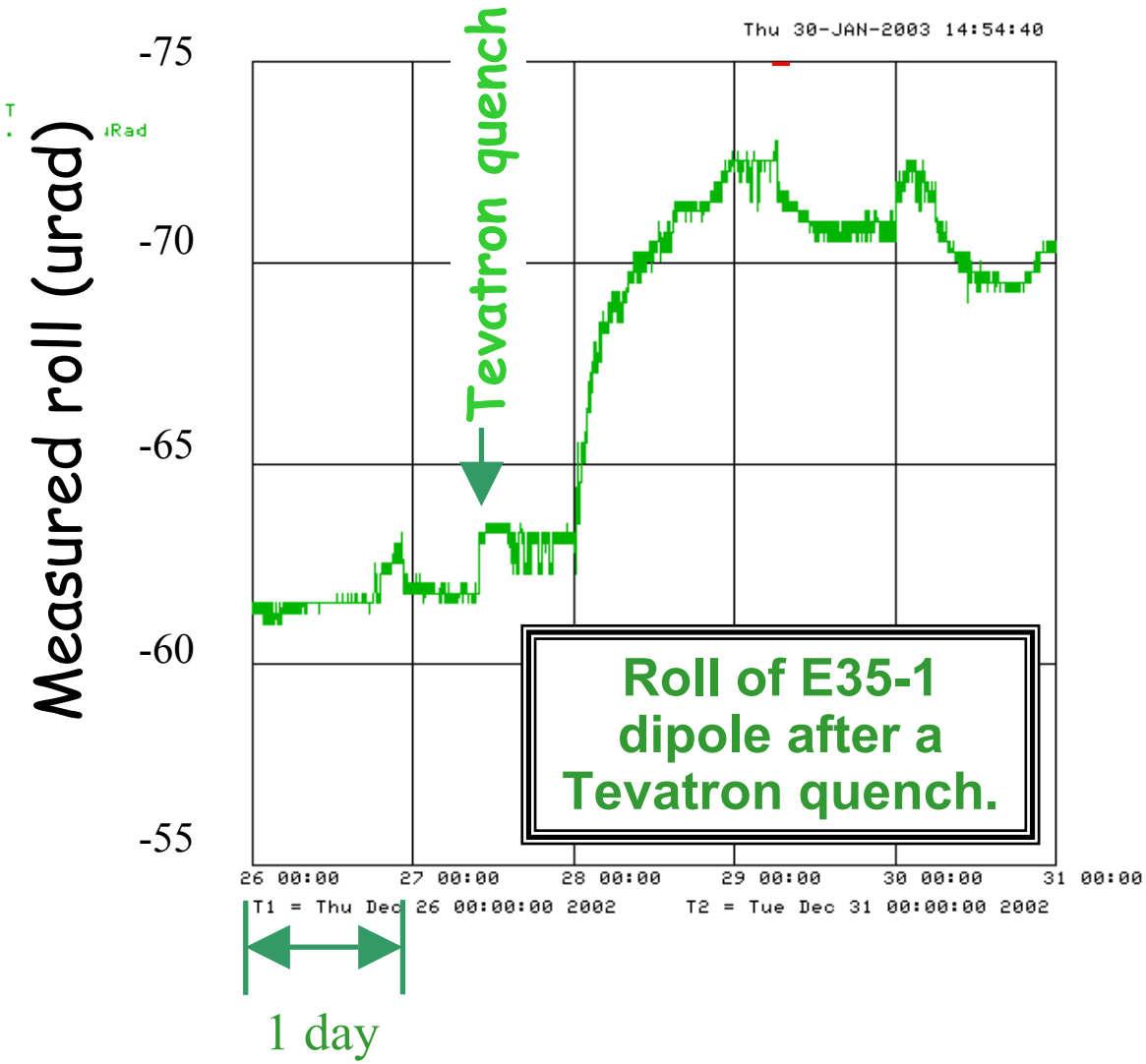
Tevatron Orbit Movements

Store #1668, Aug. 17, 2002



- Movements during stores are under 0.5 mm and contain 12-hr period due to Earthtides and 24-hr due to temperature variations
- Earthquakes are rare but seen

Motion of Tevatron Dipole



Newly added a tiltmeter to a Tevatron dipole.

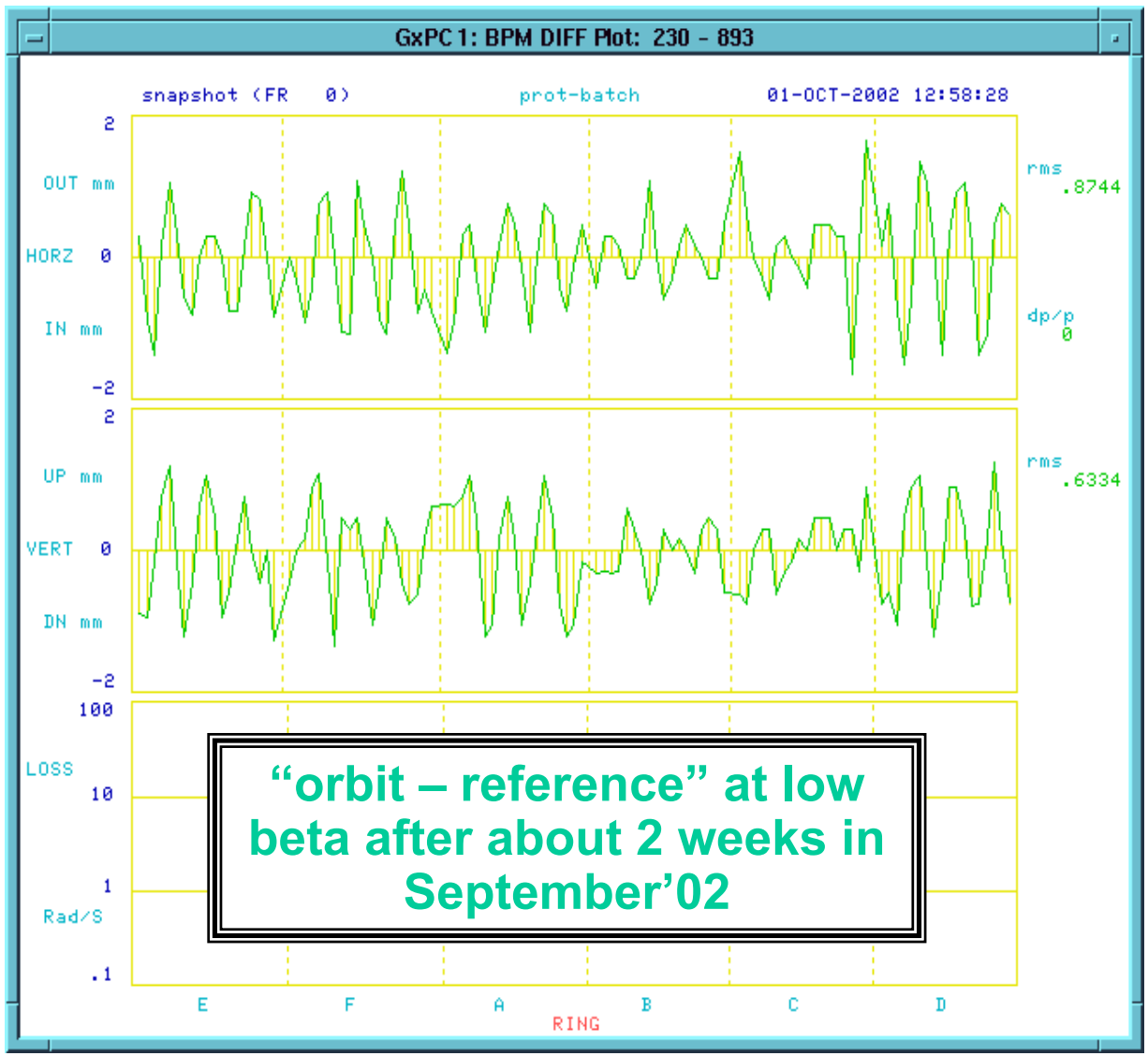
Observed 10 urad roll after a quench

Still watching!!

Larger rolls on other dipoles?

Long term drifts?

Orbit Drifts



Tunes, coupling, ξ vary with closed orbits distortions

"Rule of thumb" -- keep orbit drifts under 0.5 mm rms from "silver orbit"

Orbit drifts of that scale occur in 1-2 weeks (see picture)

Requires routine orbit smoothing at 150 Gev, ramp, flat-top, squeeze, and low-beta.

Orbit Smoothing

Goal: monitor orbit positions during shot setups and stores. (BPMs must work with coalesced beam.)

- Standard orbit smoothing procedure
  - Works well. (But some correctors near maximum strength.)
  - Requires uncoalesced protons
  - Takes time -- several hours for proton only store
  - BPMs are "less accurate" w/coalesced beam during store
- BPM system
  - Tune up/maintenance of BPMs has improved reliability
  - Position measurements not considered good enough with coalesced beam. (Under investigation)
  - Improvements are underway (Understanding electronics, removing "PSD" boxes, and BPM testing software)

Long Term Motion/ Alignment

- Over years (not well documented, estimates)
  - ~100(s) microns quad motion
  - ~mrad(s) of quad and dipole roll (upto 4-8 now)
  - ~100 micron SC coil movement in yoke - saturated?
  - additional concerns due to rusted stands
- Dangerous! - mechanical stability of bellows
- Not of immidiate operational concern unless proved to be reason of uncorrectable problem
  - Local coupling? Lattice functions? "Scallops" in orbit?
- Approach:
  - Involve BeamPhysDept to quantify effects (Mike S)
  - Will build stands for 1 sector (replace if failure)
  - Tev Alignment project formed (Ray S)
  - TD to investigate bellows breakdown /stand design / smart bolt movement

Rusty Stands

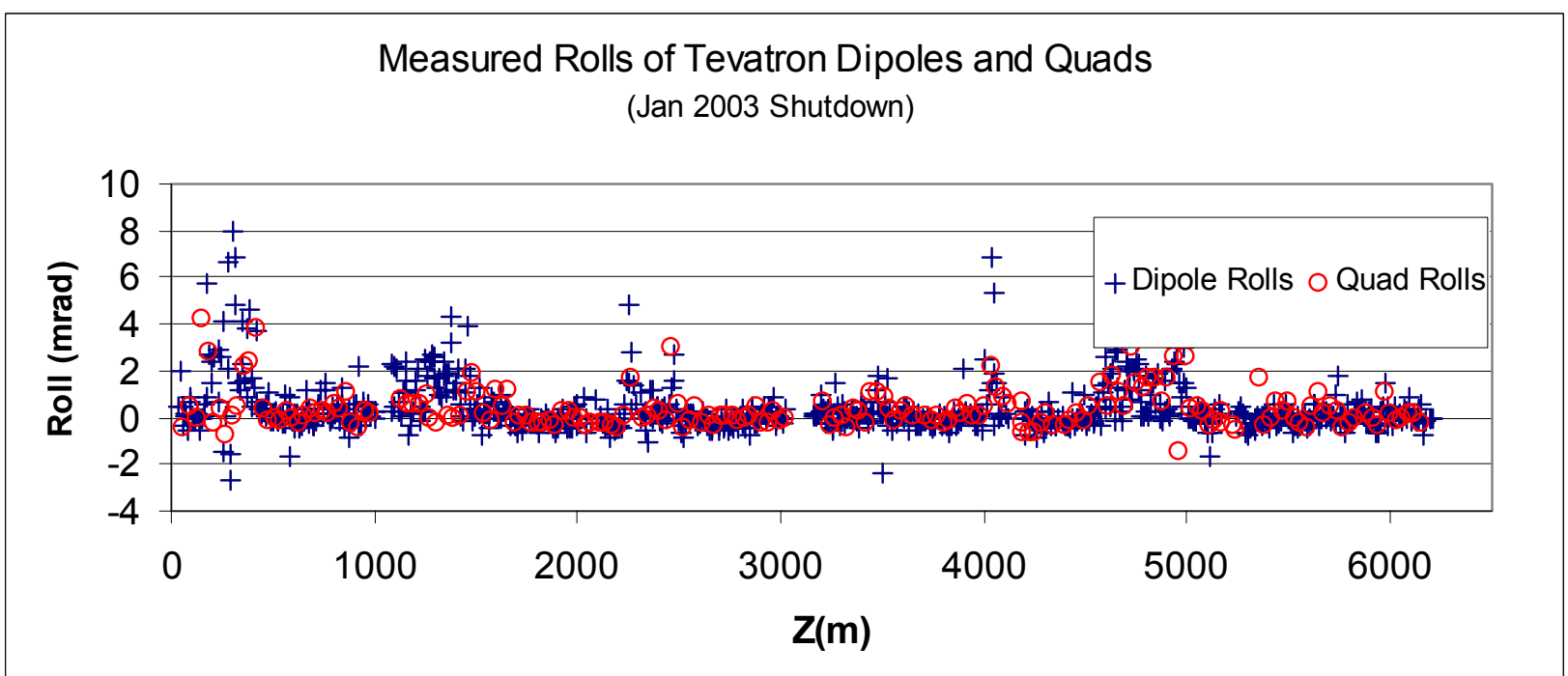
Tevatron Magnet Alignment

Sample data of surveyed rolls on dipoles (and quads)

Magnet	Roll (mrad)		Magnet	Roll (mrad)
A19-1(Quad)	-0.67		A23-1(Quad)	2.41
A19-2	**6.86**		A23-2	1.65
A19-3	1.76		A23-3	3.95
A19-4	-4.44		A23-4	0.71
A19-5	-1.94		A23-5	4.89
A21-1(Quad)	0.19		A24-1(Quad)	2.98
A21-2	**8.67**		A24-2	1.49
A21-3	**8.38**		A24-3	0.81
A21-4	4.81		A24-4	1.17
A21-5	1.19		A24-5	3.70
A22-1 (Quad)	0.44		**A25-1 (Quad)**	**3.68**
A22-2	1.06		A25-2	0.60
A22-3	1.49		A25-3	0.33
A22-4	2.33		A25-4	0.14
A22-5	4.44		A25-5	0.37

Tevatron Magnet Alignment

- Measured rolls of dipoles and quads during Jan 2003 shutdown.
- Used "portable tilt-meter" for quick measurements
- Data roughly consistent with vertical dipole corrector strengths
- Dipoles rolled 4 mrad gives ~0.5 mm "scalloped" vert orbit
- Coupling from one quad rolled 4 mrad gives min tune split ~0.0025



Plans:

- As of now:
  - Realign worst magnets when possible
  - Replace worst stands
  - Improve geodesy network
  - Build faster roll detectors (1-2 weeks/whole ring)
  - Design on-line 6-km water level system (TD+BINP)
  - Understand physics
  - Prepare for smart bolt movement compensation (TD)
- Possible "final" solutions:
  - Costly (shutdown time) … no immediate luminosity improvement expected but may pay off in long run
  - Move smart bolts (2-4 crew hours/magnet→ 1-2 mos x 8 crews) … >10% smart bolts not available
  - Replace stands/Unroll/Realign all "bad" magnets