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?

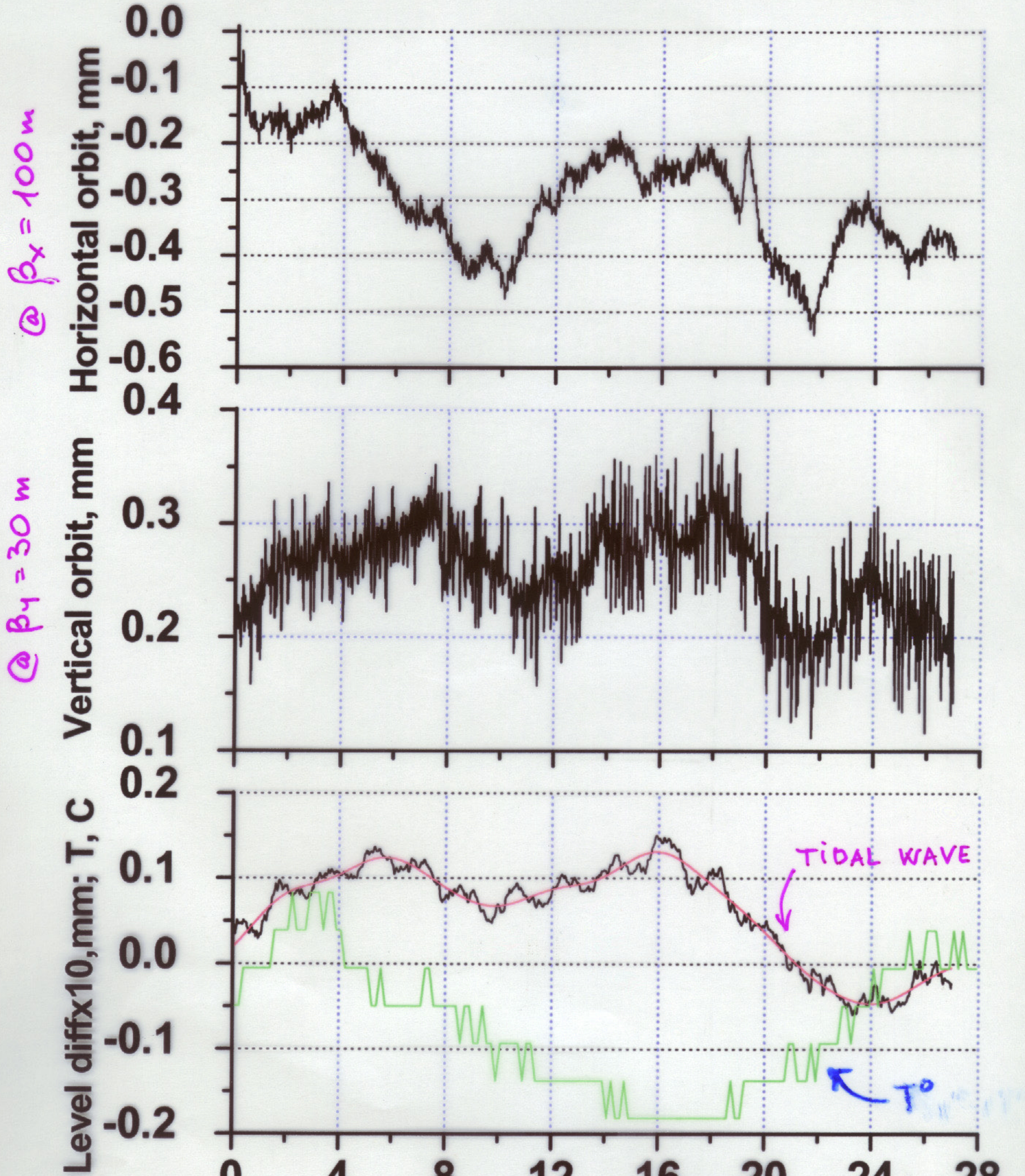
__first look:__

- aperture is large ϕ70 mm
- beams are small ~ 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 $\bar{p}$ and p's
- @ inj 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

Tev Orbit Drifts, Tides and T°, 08/17/02



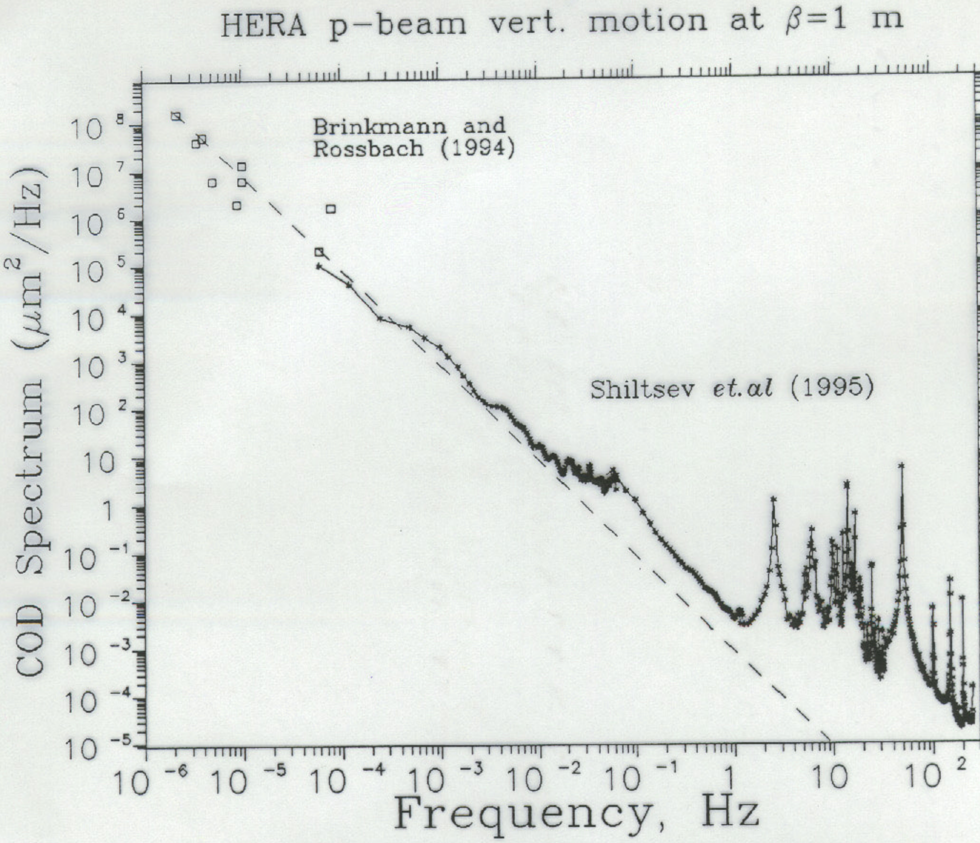


Fig.6 PSD of HERA proton orbit vertical motion normalized to β =1 m. Dashed line is for the ATL expectation (from Ref.[18, 9]).

$\langle \Delta y^2 \rangle = ATL$

→ COD $\langle \Delta Y^2 \rangle = G \cdot A \cdot T \cdot C$

→ PSD_COD $= \dfrac{6 G \cdot A \cdot C}{\pi^2 f^2}$

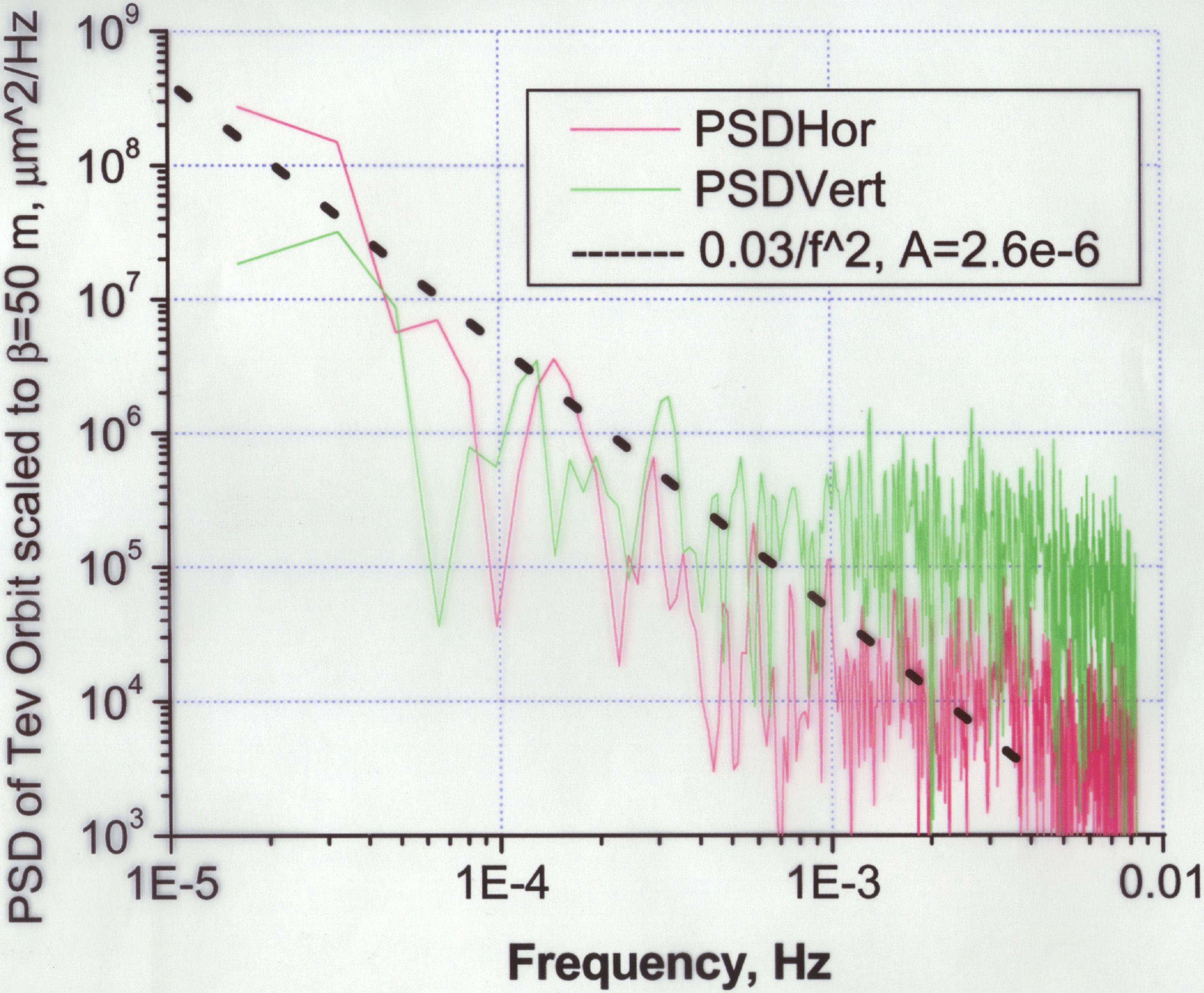
→ HERA $A = (4 \pm 2) \cdot 10^{-6} \dfrac{\mu m^2}{m \cdot s}$

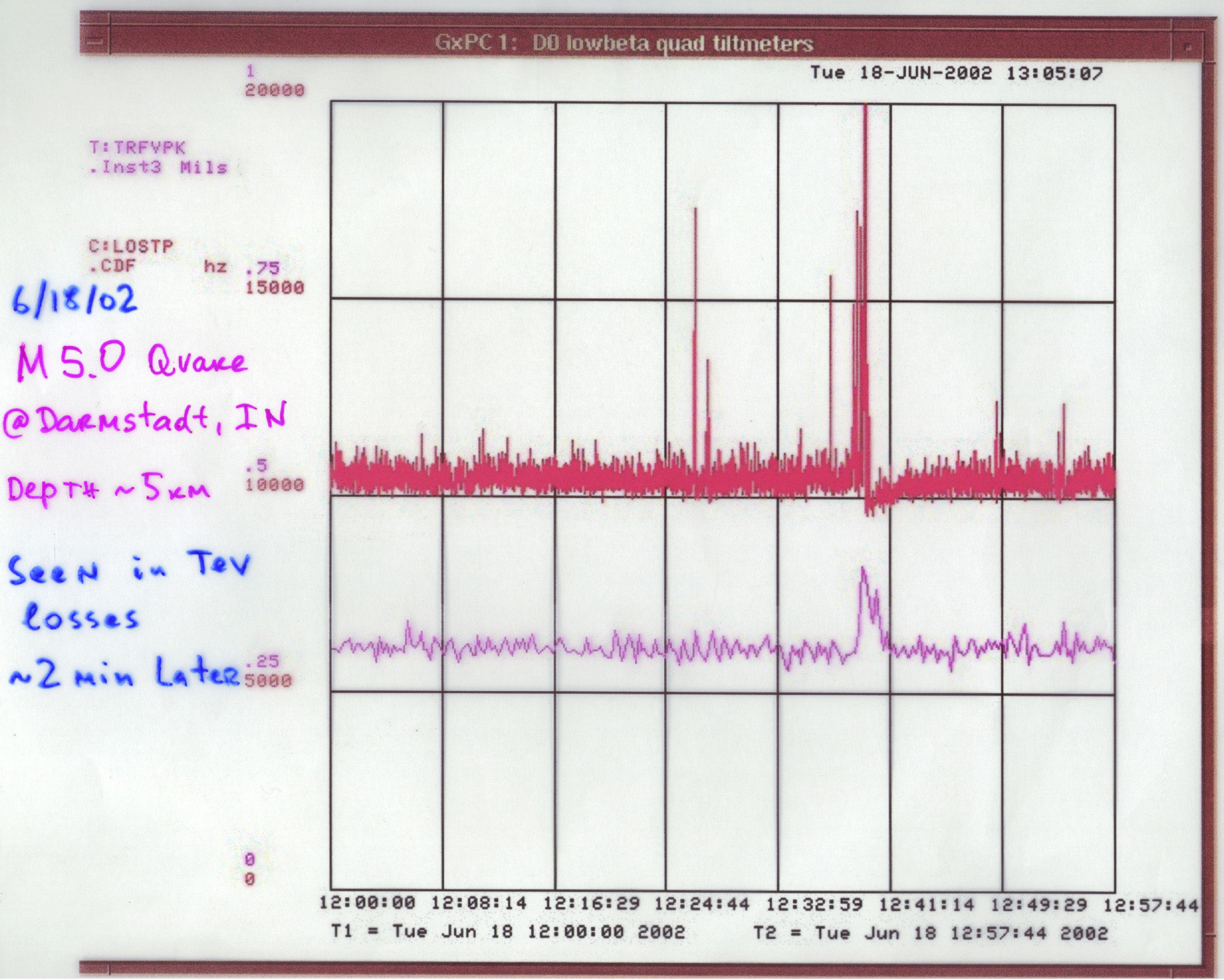
TEVATRON $A \lesssim (2.6 \pm 1) \cdot 10^{-6} \dfrac{\mu m^2}{m \cdot s}$

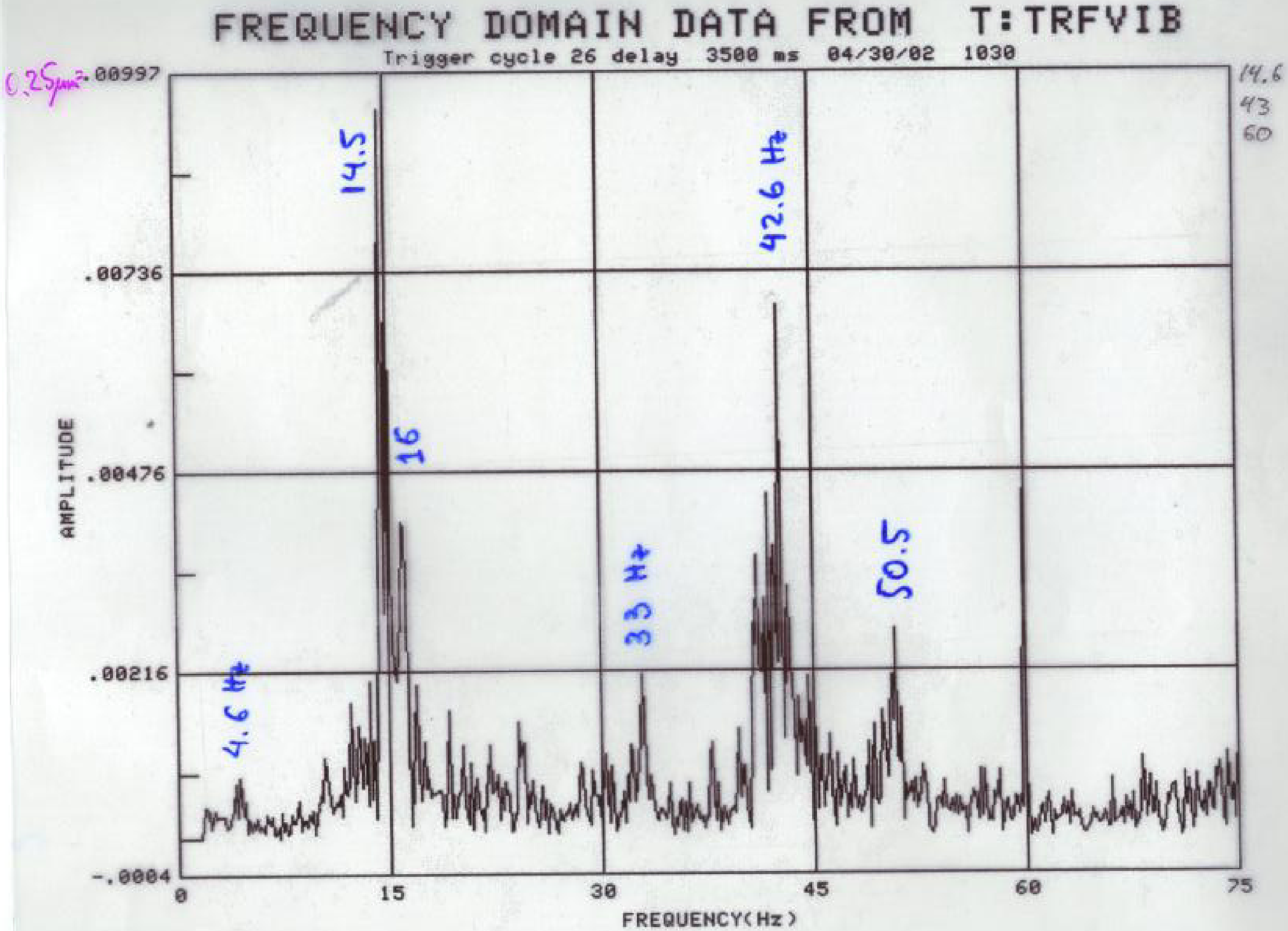
→ orbit excursions around Tevatron

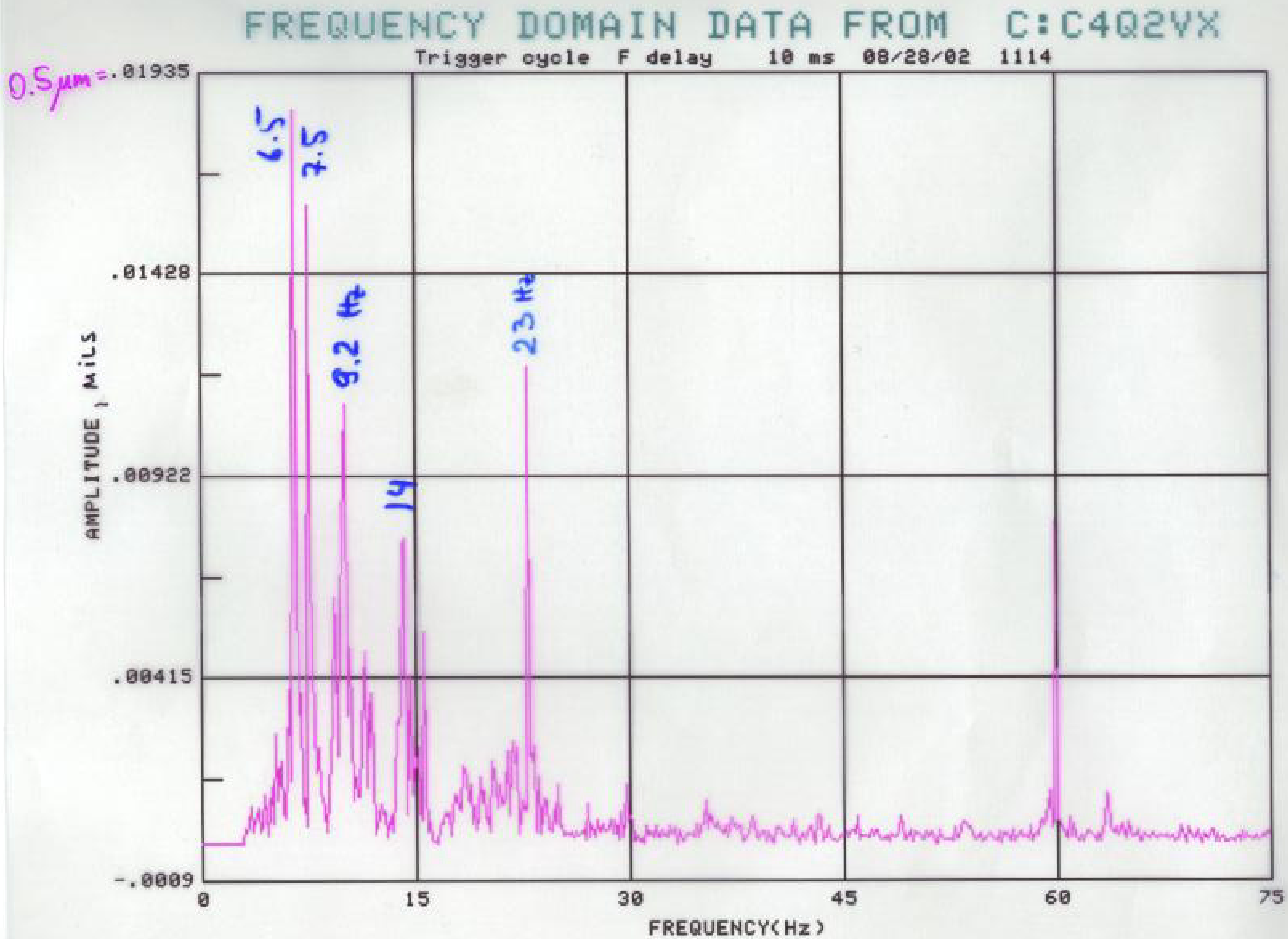
$\sim \pm 1$ mm / MONTH$^{1/2}$

PSD of the Tevatron Orbit Drifts in store 1668 (08/17/2002)



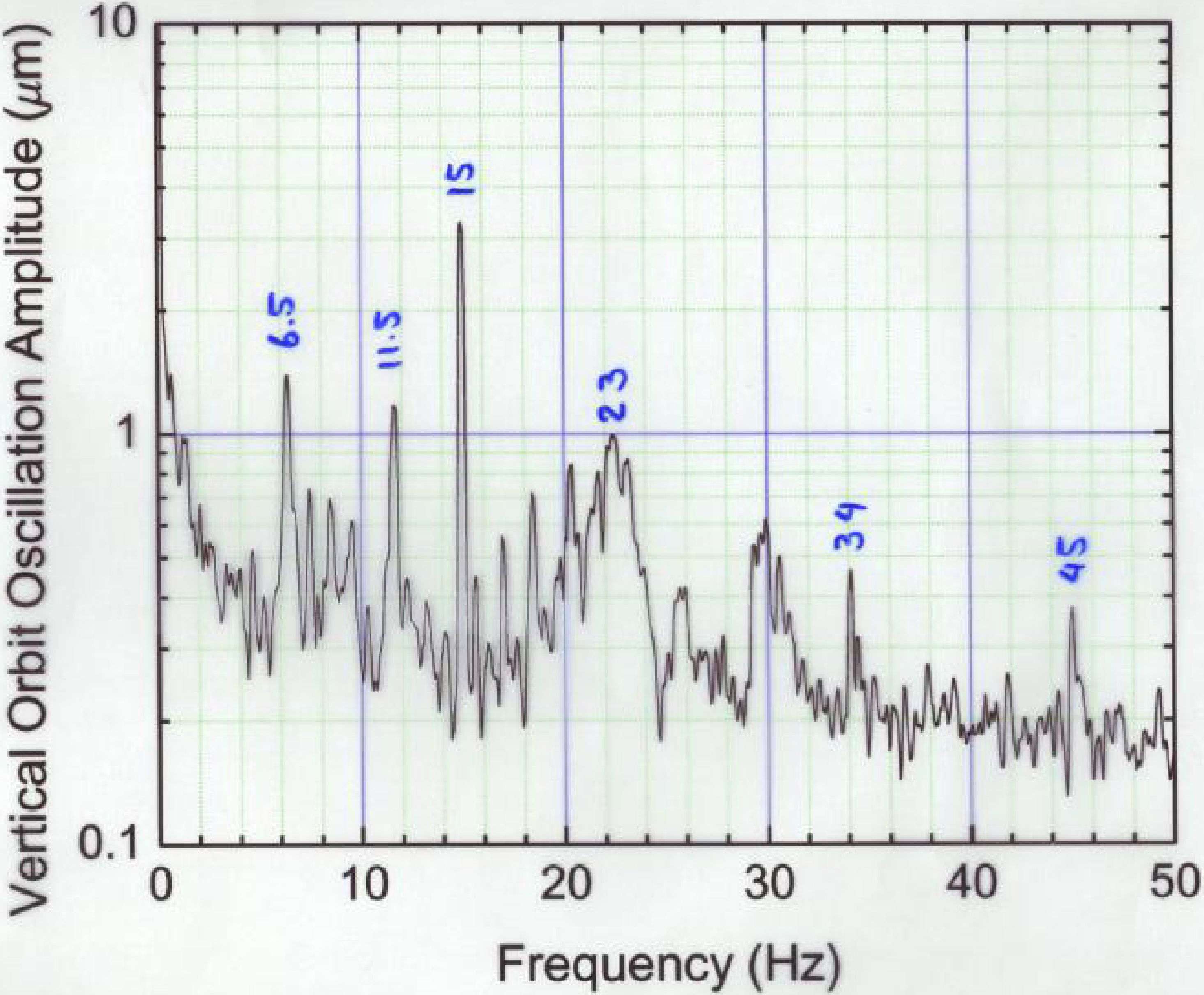

GxPC 1: D0 lowbeta quad tiltmeters
Tue 18-JUN-2002 13:05:07
1
20000
T:TRFVPK
.Inst3 Mils
C:LOSTP
.CDF hz
.75
15000
.5
10000
.25
5000
0
0
6/18/02
M 5.0 Quake
@Darmstadt, IN
Depth ~5km
Seen in Tev
losses
~2 min Later
12:00:00
12:08:14
12:16:29
12:24:44
12:32:59
12:41:14
12:49:29
12:57:44
T1 = Tue Jun 18 12:00:00 2002
T2 = Tue Jun 18 12:57:44 2002


FREQUENCY DOMAIN DATA FROM T:TRFVIB
Trigger cycle 26 delay 3500 ms 04/30/02 1030
0.25μm
.00997
.00736
.00476
.00216
-.0004
AMPLITUDE
0
15
30
45
60
75
FREQUENCY(Hz)
14.5
16
4.6 Hz
33 Hz
42.6 Hz
50.5
14.6
43
60

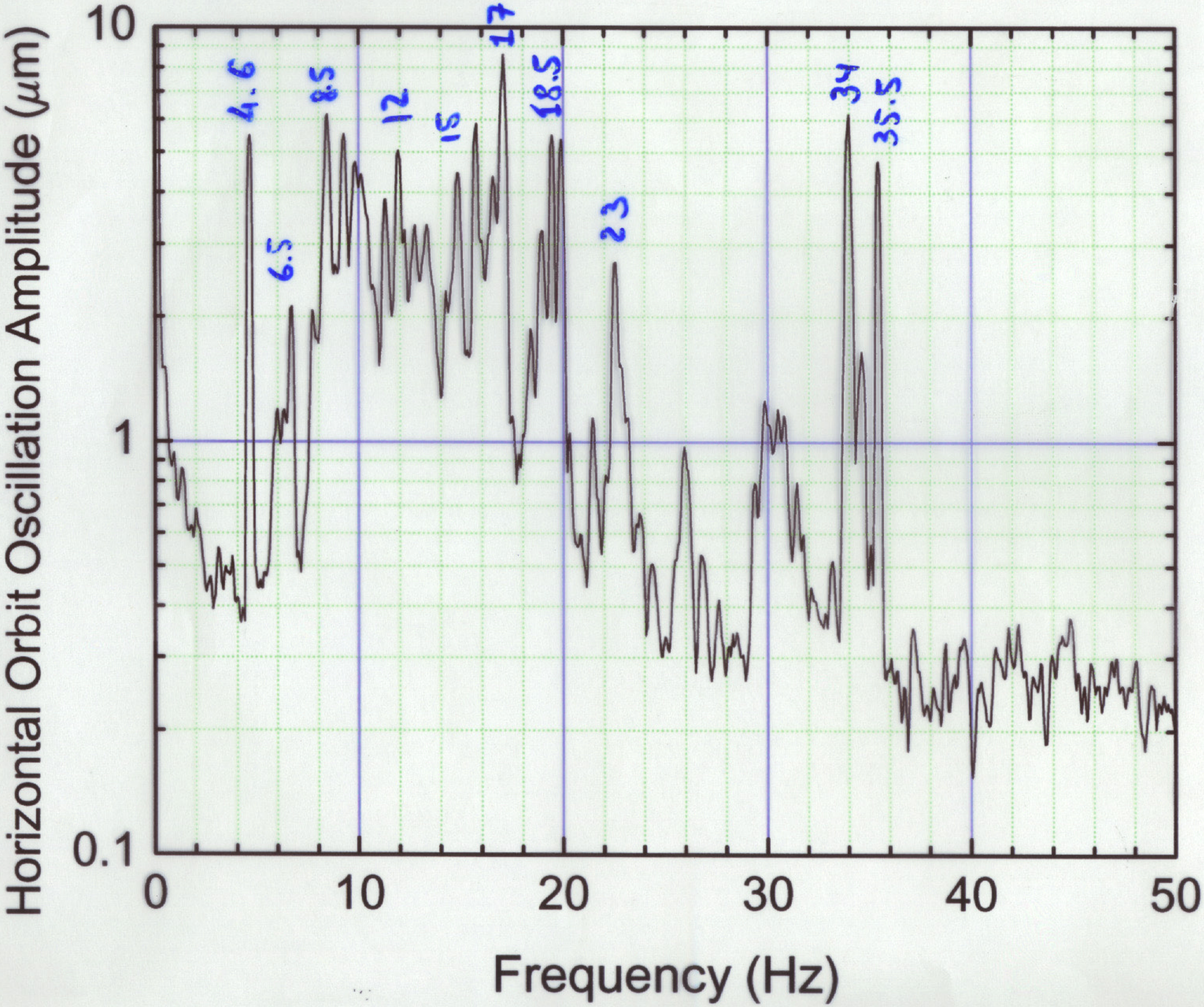


FREQUENCY DOMAIN DATA FROM C:C4Q2VX
Trigger cycle F delay 10 ms 08/28/02 1114
0.5μm=.01935
.01428
.00922
.00415
-.0009
AMPLITUDE , MILS
0
15
30
45
60
75
FREQUENCY(Hz)
6.5
7.5
9.2 Hz
14
23 Hz

Tev Vertical Orbit Oscillation Spectrum (β=30m)



Tev Horizontal Orbit Oscillation Spectrum (β=100m)



Conclusions:

1. Tevatron orbit drifts contain
   - 24-hr variations ← T°
   - 12-hr period ← probably due to tides
   - some additional ← ATL-like, $A \lesssim (2.6 \pm 1)e^{-6} \frac{\mu m^2}{m \cdot s}$
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 @:
   4.6, 8.5, 9.2, 13.9 Hz ← due to CHL compressor
   18.5, 21.5, 23 Hz ← due to "stand" resonances
   RF cavity support resonances are @ 15, 43 Hz
4. Amplitude of low-β quad vibrations < 0.5-1 μ
5. Beam orbit spectra contain all quad frequencies plus f-synchrotron plus many mo
6. Amplitude of high frequency orbit oscilations < 5 μm ← so, $\frac{\text{orbit}}{\text{quad}} \gtrsim 10$