A Survey of TBT Capabilities Using the Upgraded TeV BPMs

Rob Kutschke

Tevatron Department Meeting

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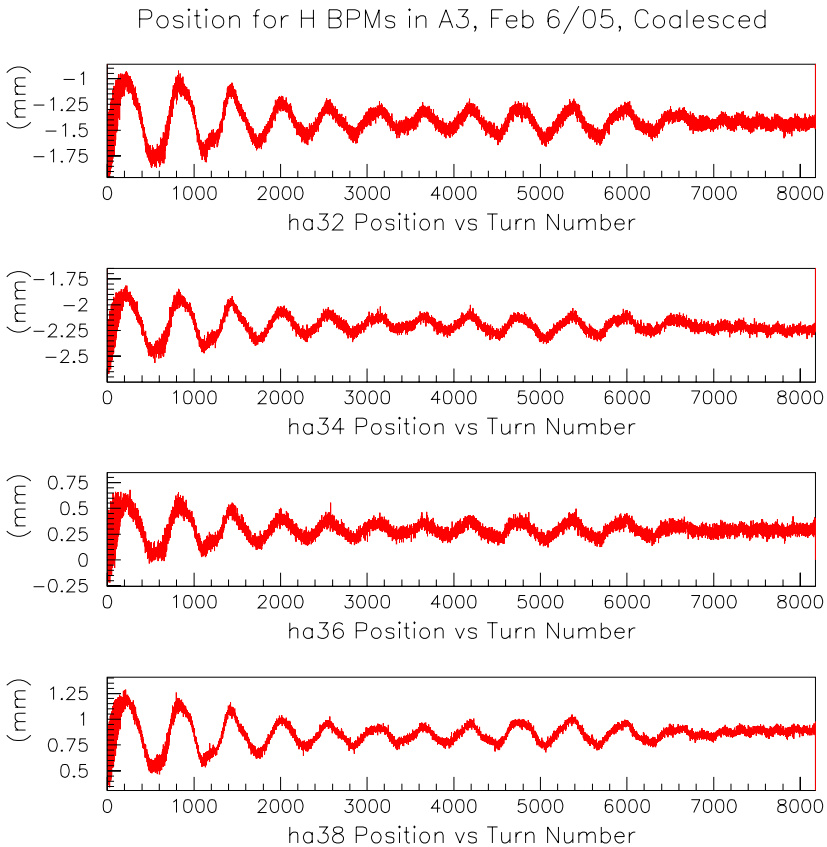
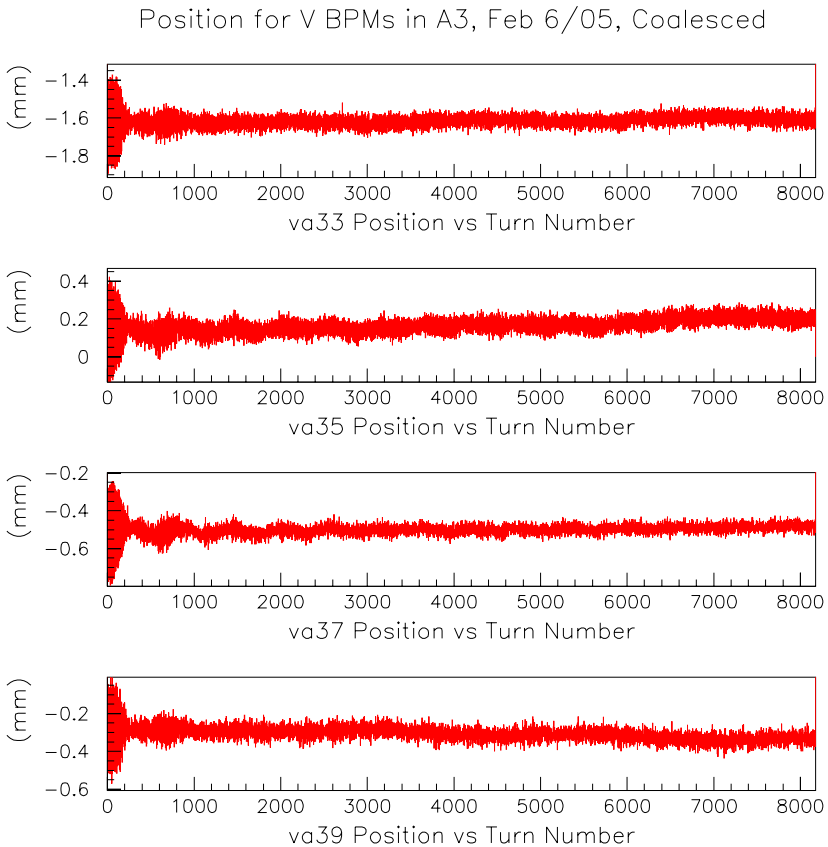
This Talk Will Show:

- Injection TBT
  - Triggered by injection.
  - Either single bunch or uncoalesced beam.
  - Can see: synchrotron motion, betatron motion, quadrupole oscillations of bunch in the bucket, HV coupling, plus some instrumental artifacts.
- TBT
  - Triggered by request.
  - Will show 36x36 during normal HEP store.
    - Do NOT ping beam.
    - Can see the “15 Hz” motion.
- Using data taken at A3 over the past two weeks.

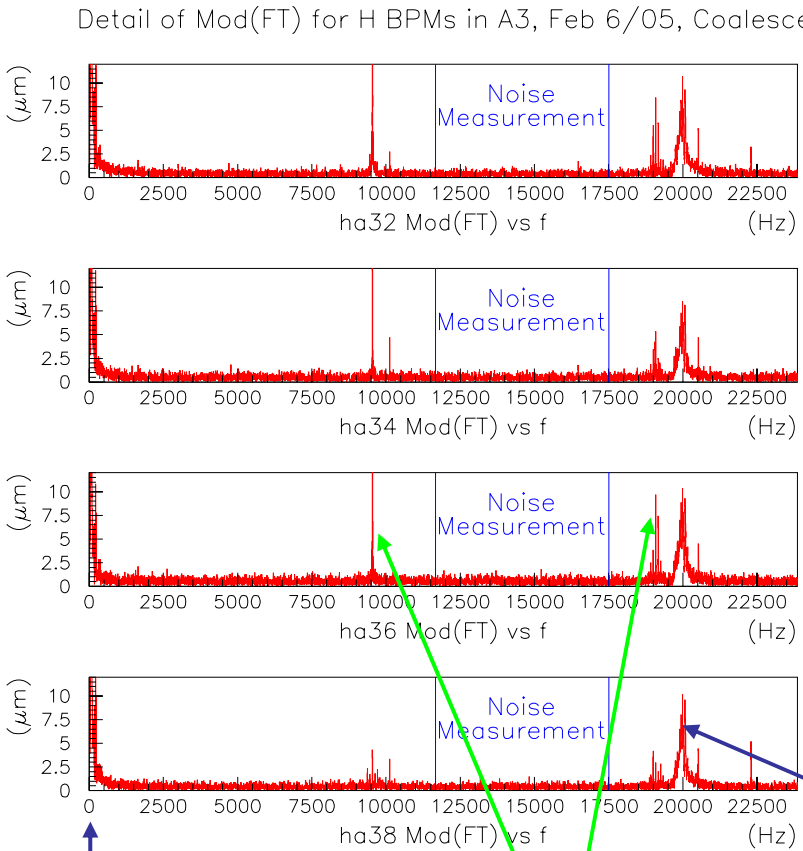


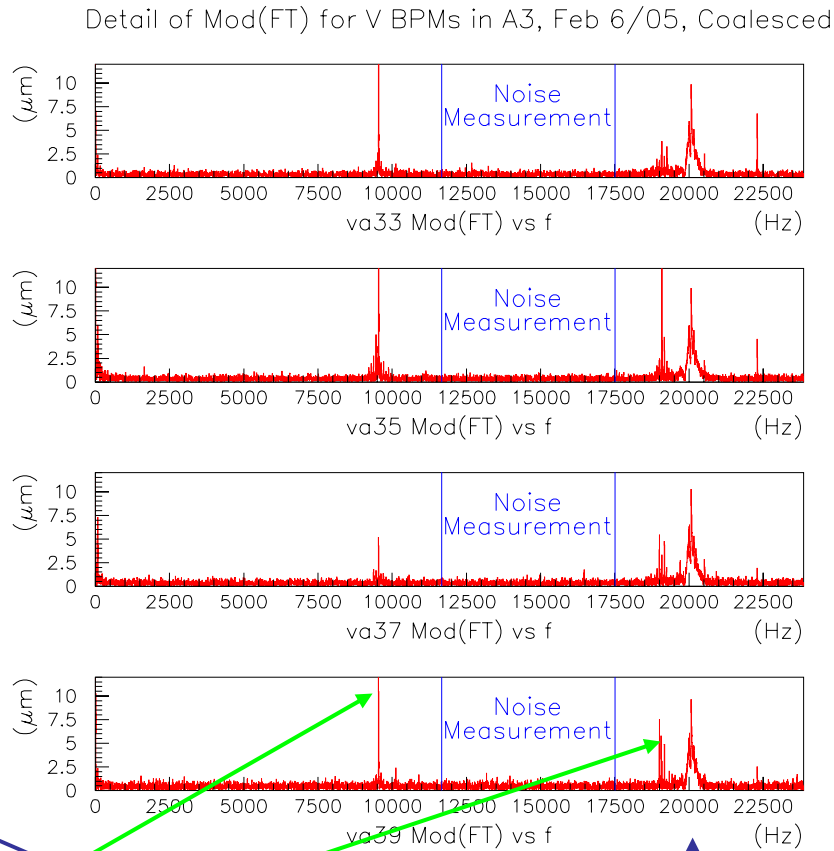


1.1 mm full vertical scale

0.6 mm full vertical scale

- Injection TBT; 150 GeV; 8192 turns.
- One coalesced bunch. HEP shot after all tuning.



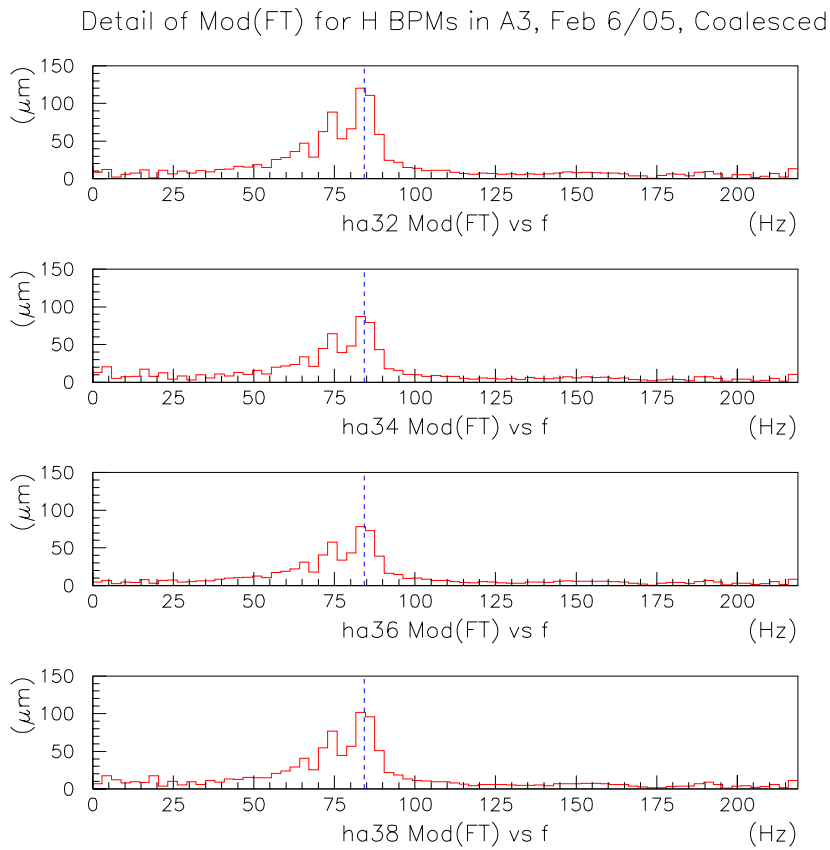


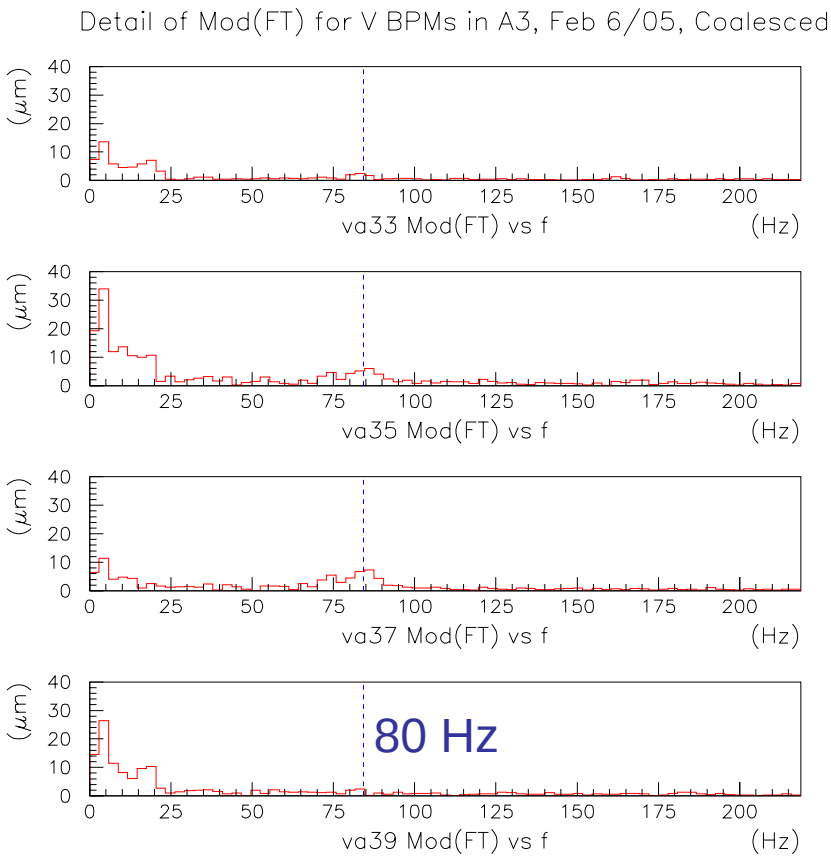
1113 / 5 Artifacts

Synchrotron Line

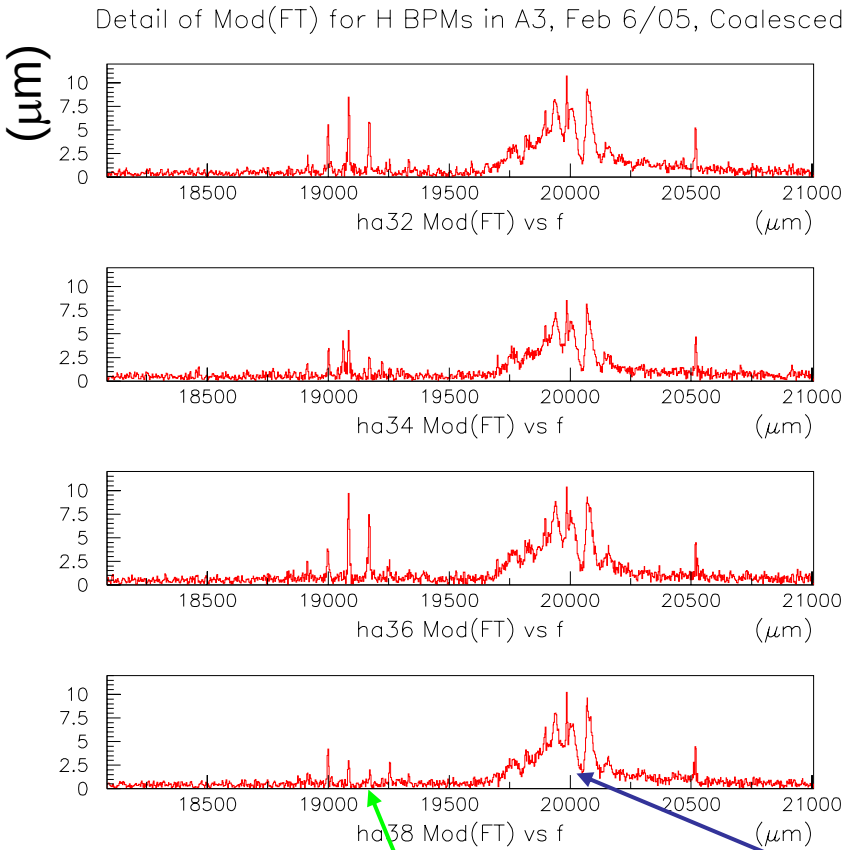
Bin Size: ~3 Hz

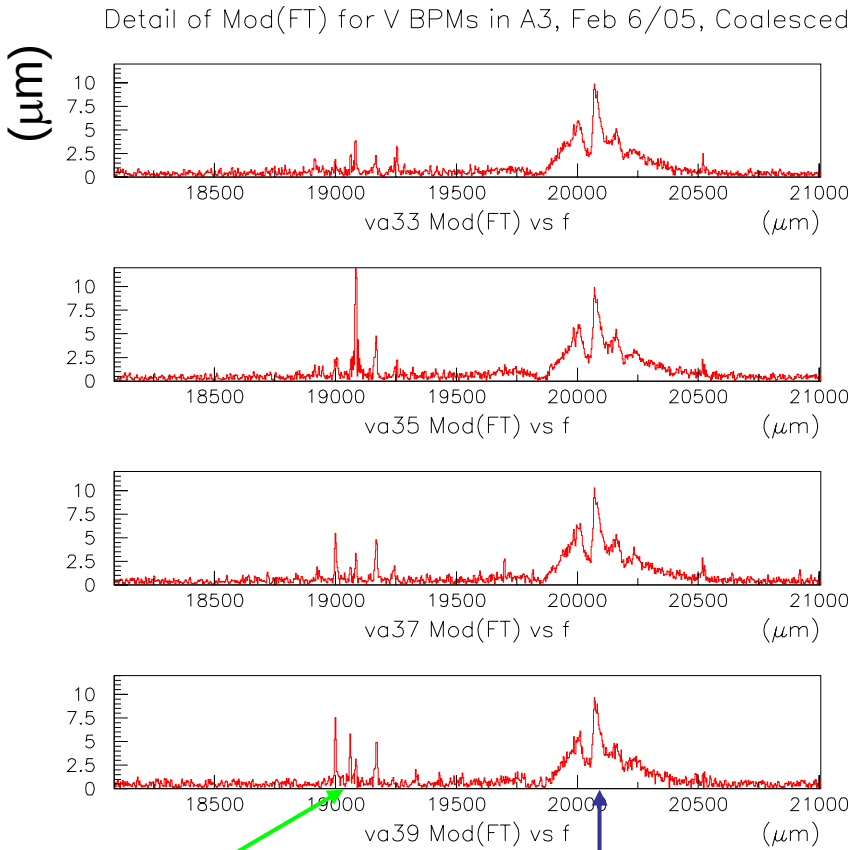
Betatron Lines





- Synchroton line present in H but not V.
- 150 GeV expected sync frequency: 80 Hz.





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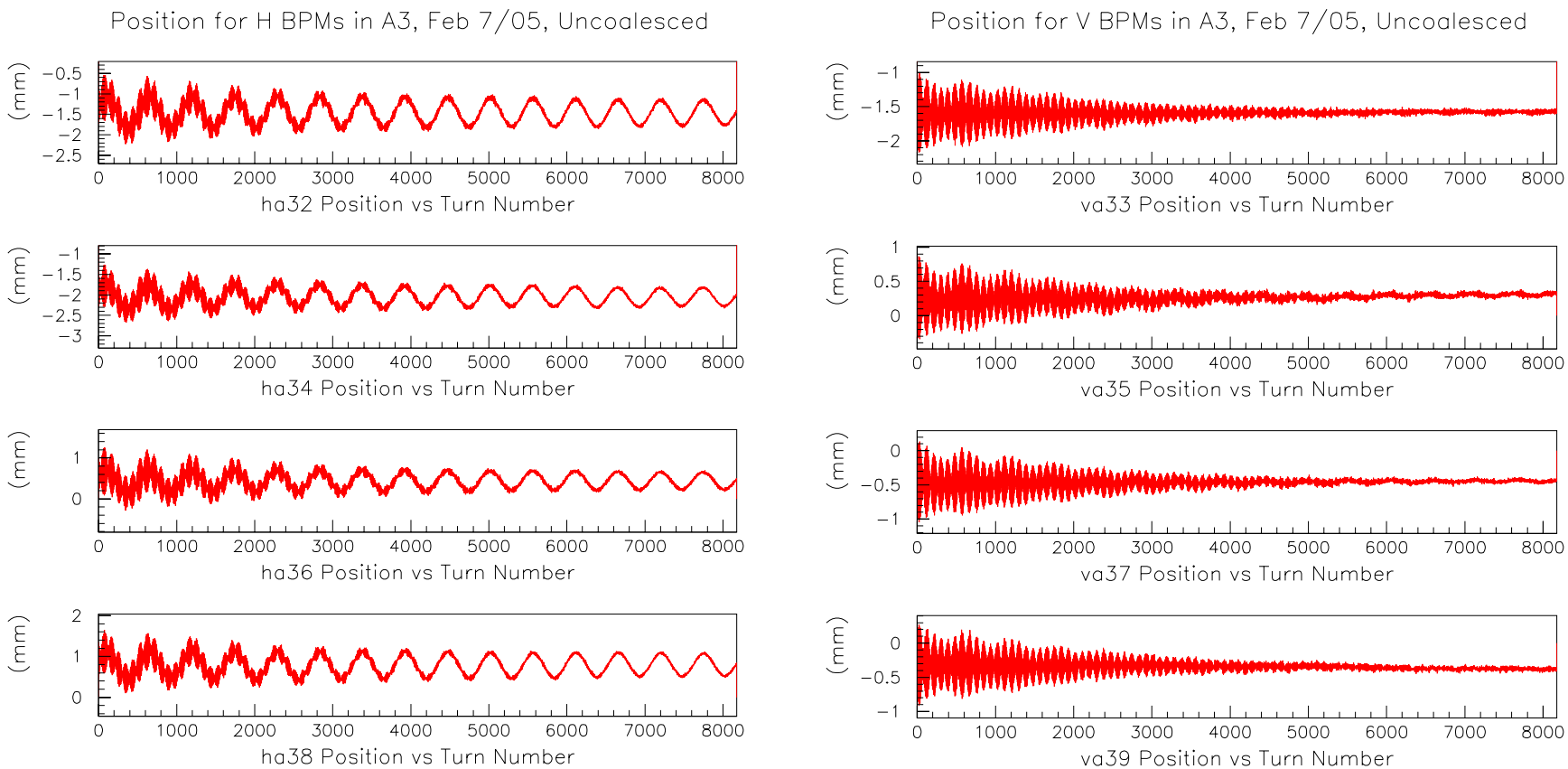
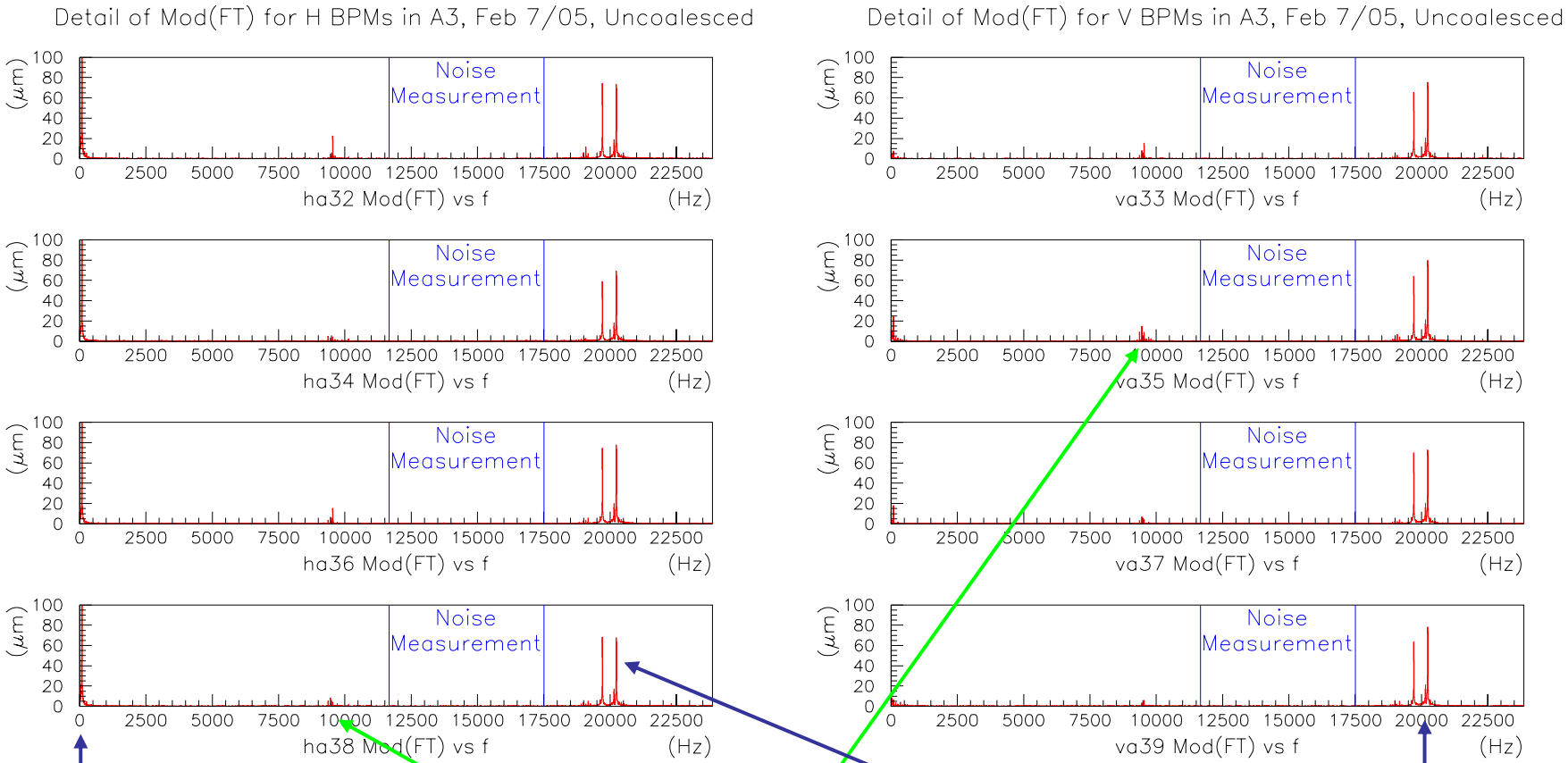
Betatron Lines



- Injection TBT; 150 GeV; 8192 turns.
- Uncoalesced beam. Tuneup shot with large injection mismatches.

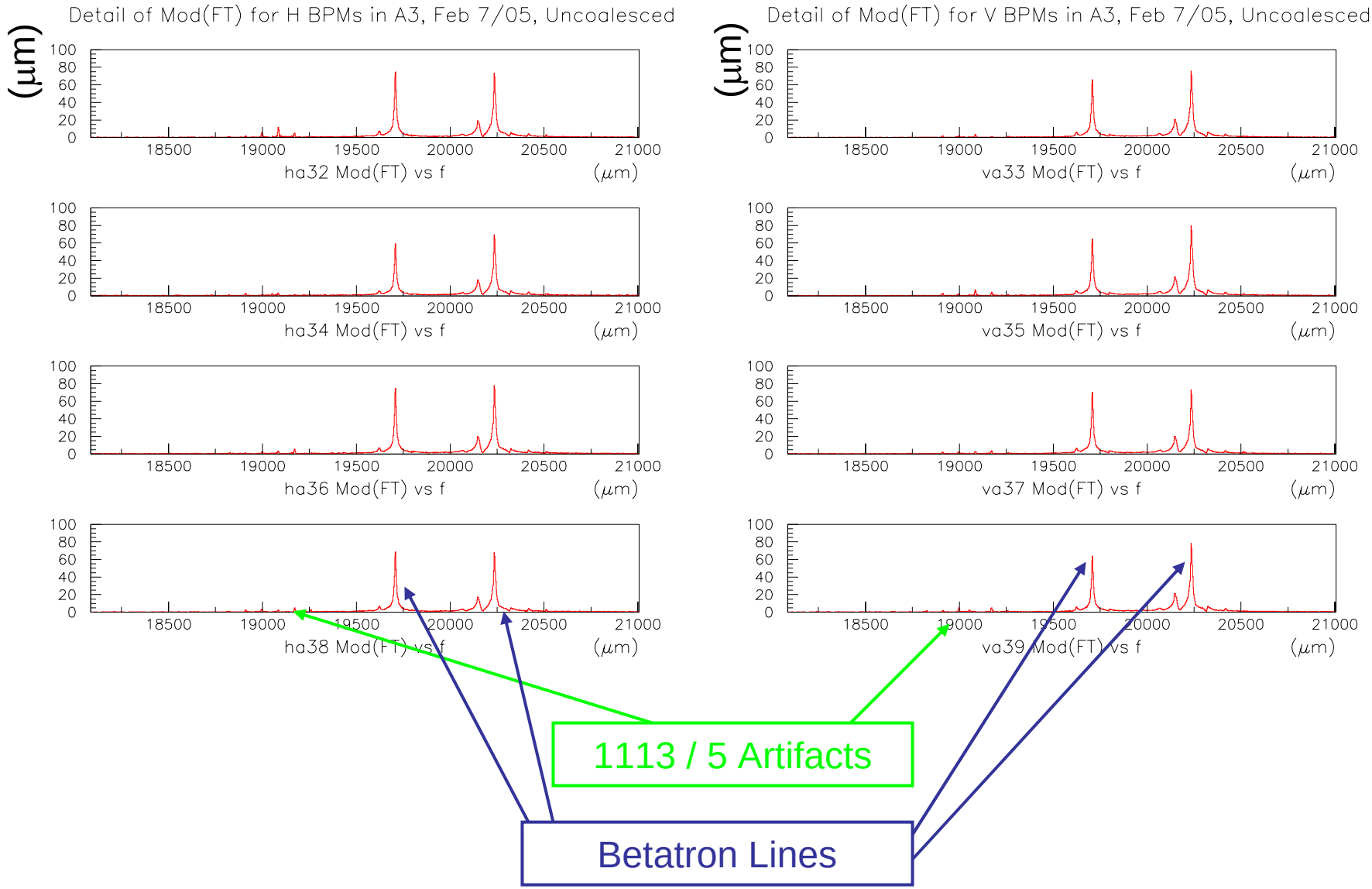


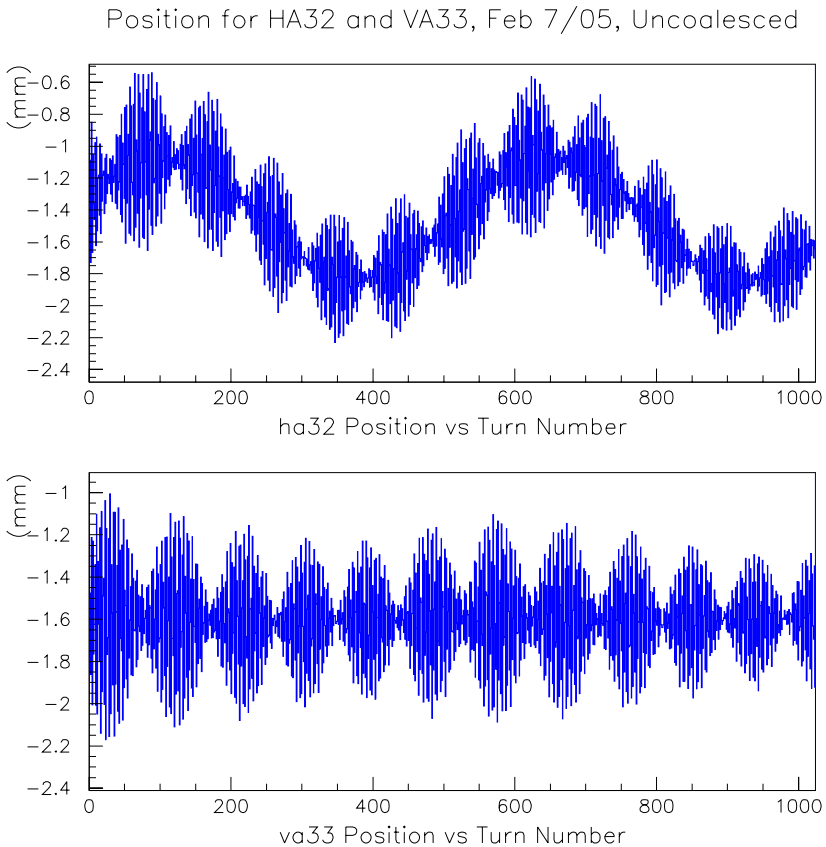
1113 / 5 Artifacts

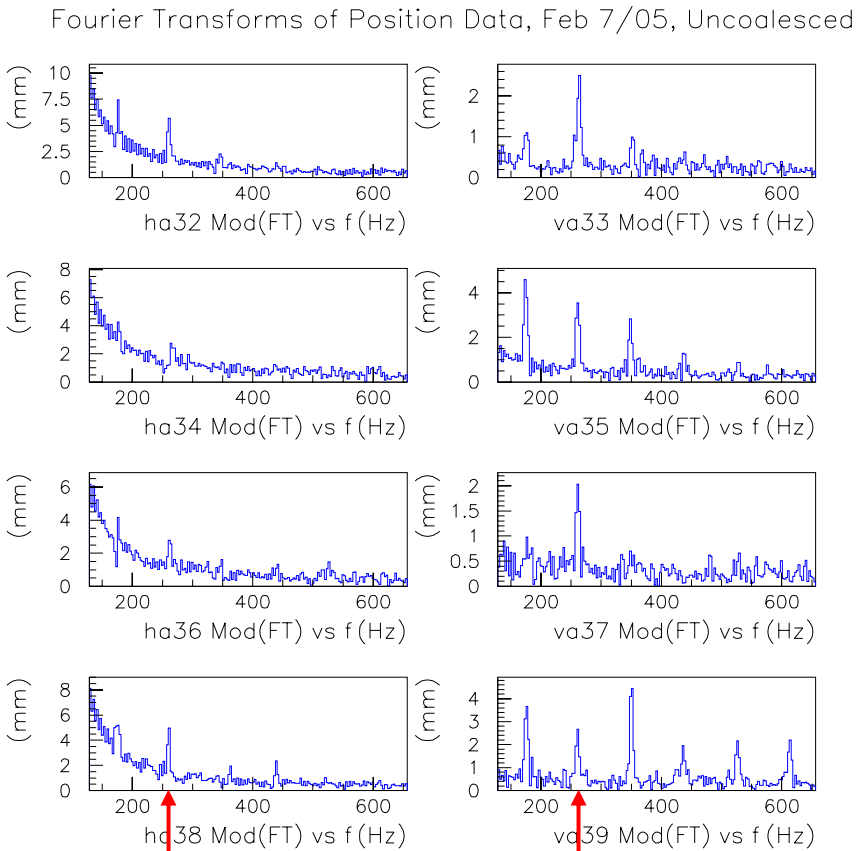
Synchrotron Line

Bin Size: ~3 Hz

Betatron Lines

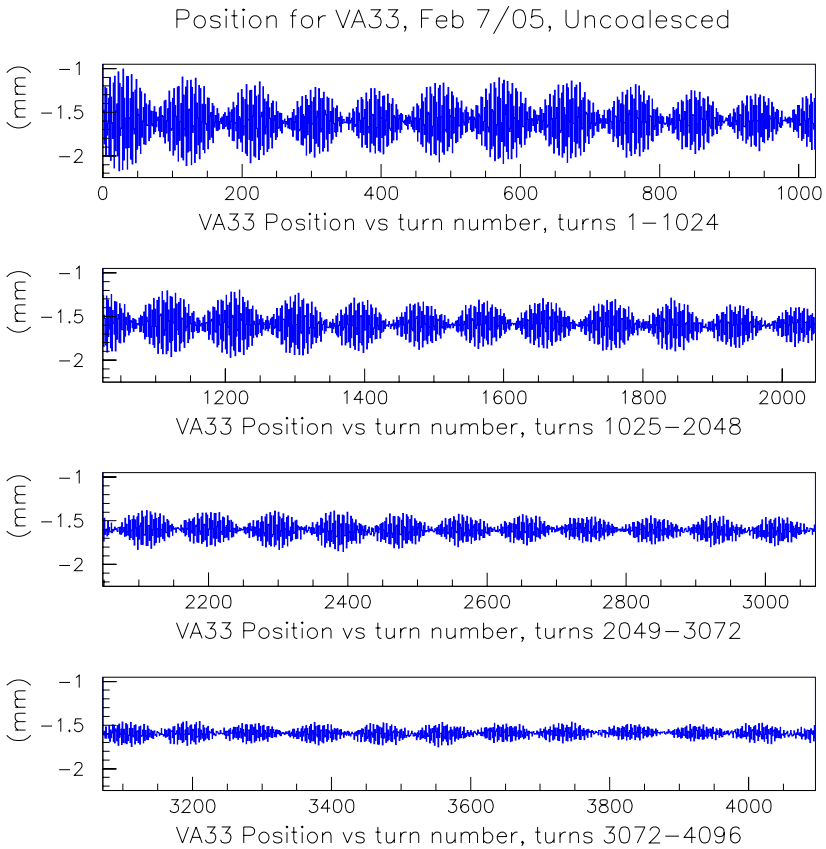

Detail of Mod(FT) for H BPMs in A3, Feb 7/05, Uncoalesced
Detail of Mod(FT) for V BPMs in A3, Feb 7/05, Uncoalesced
(μm)
ha32 Mod(FT) vs f
ha34 Mod(FT) vs f
ha36 Mod(FT) vs f
ha38 Mod(FT) vs f
va33 Mod(FT) vs f
va35 Mod(FT) vs f
va37 Mod(FT) vs f
va39 Mod(FT) vs f
1113 / 5 Artifacts
Betatron Lines

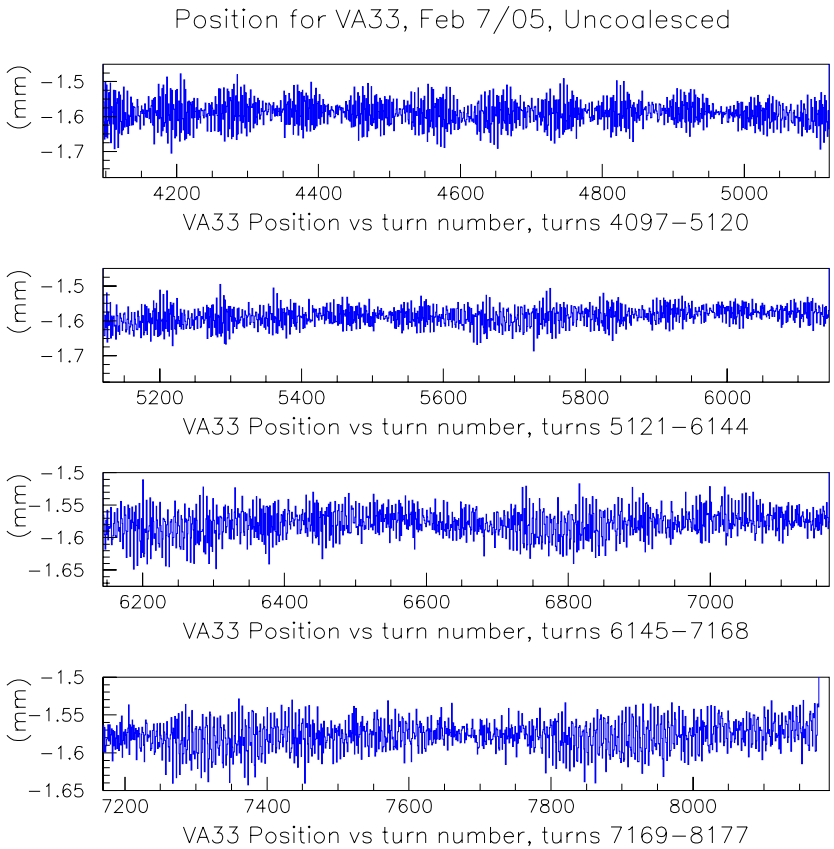


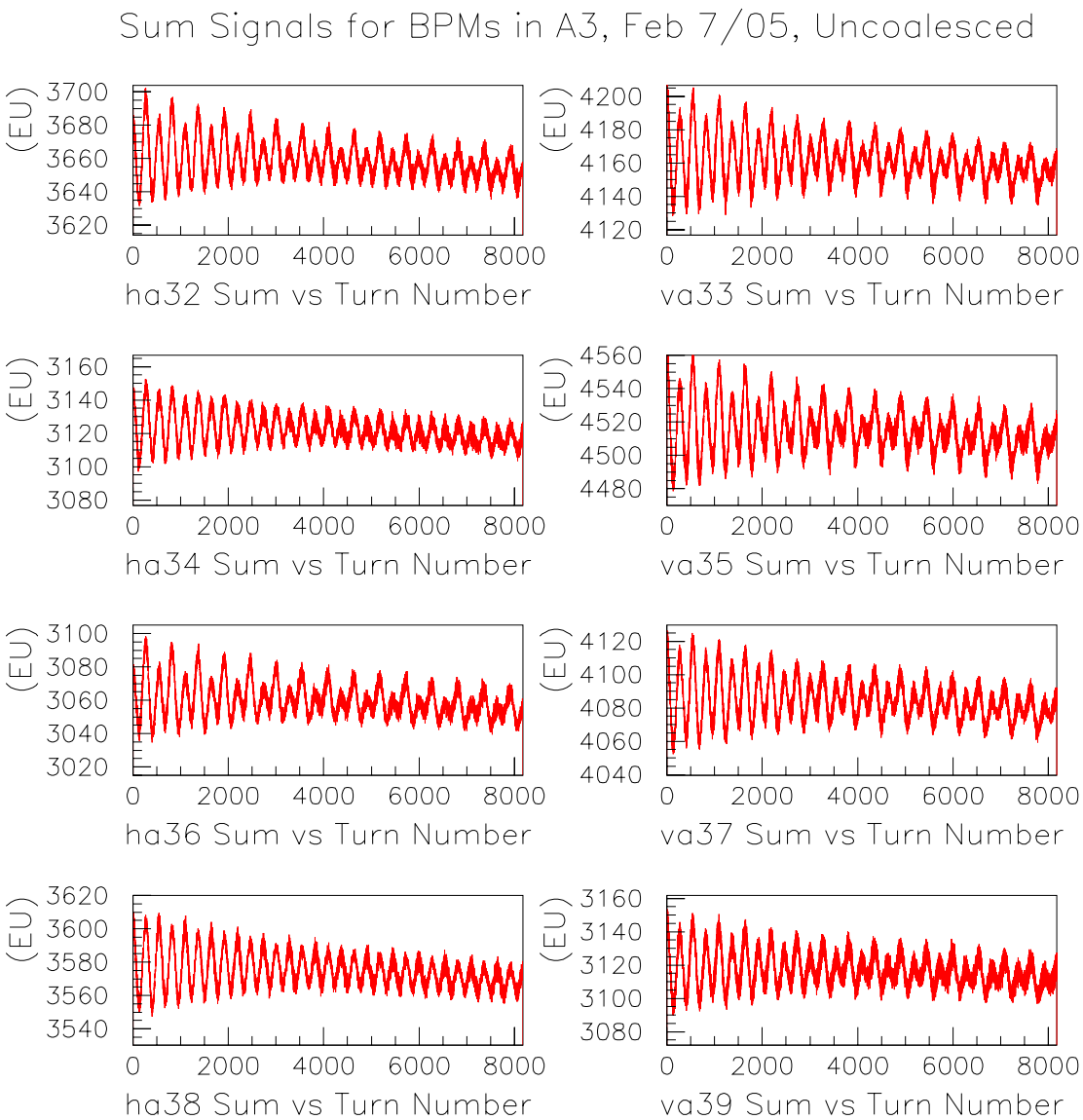


- HV coupling is clear.
- Frequency of envelope is about 260 Hz.

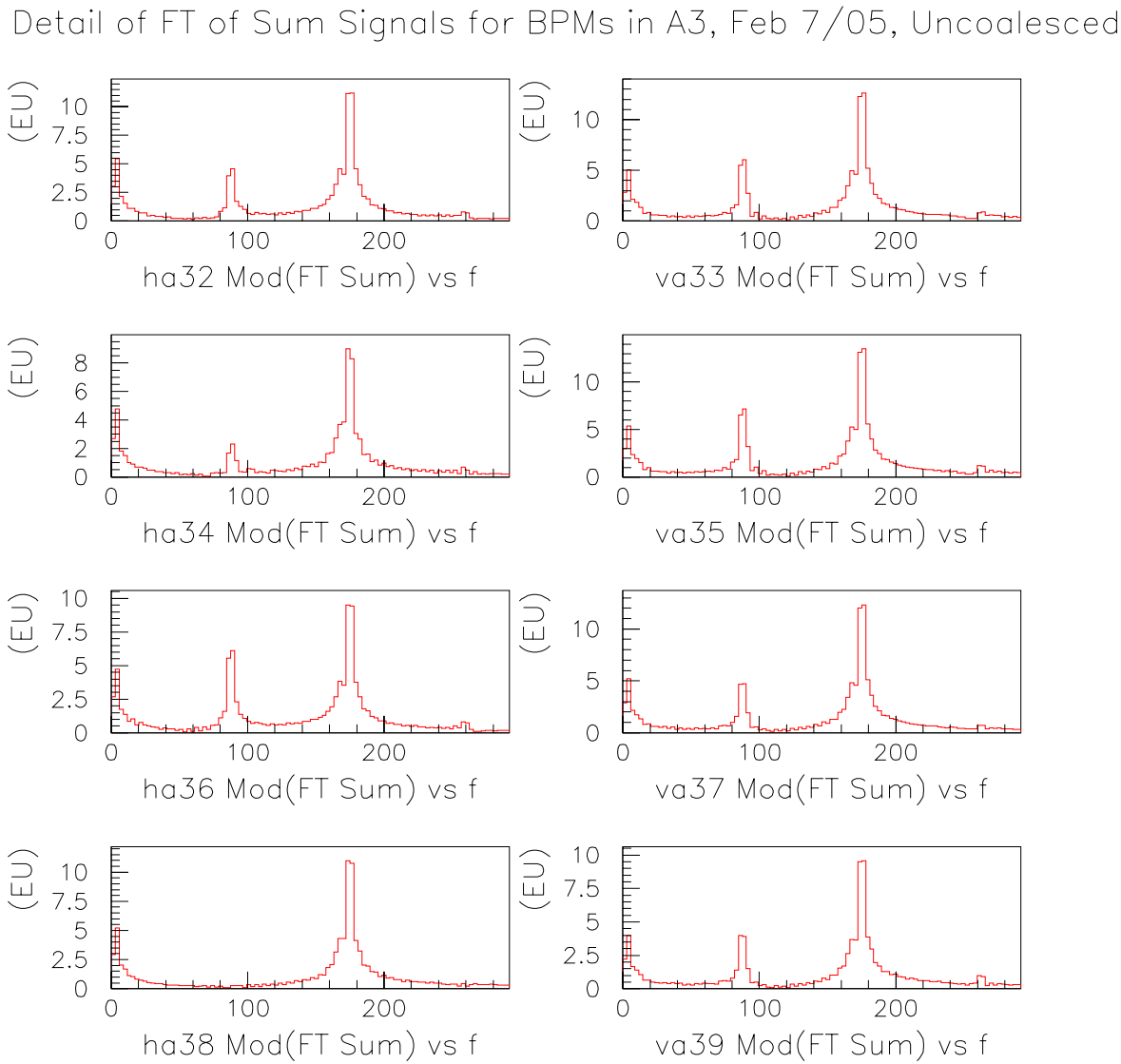
HV Coupling Frequency


Position for VA33, Feb 7/05, Uncoalesced
(mm)
VA33 Position vs turn number, turns 1−1024
VA33 Position vs turn number, turns 1025−2048
VA33 Position vs turn number, turns 2049−3072
VA33 Position vs turn number, turns 3072−4096

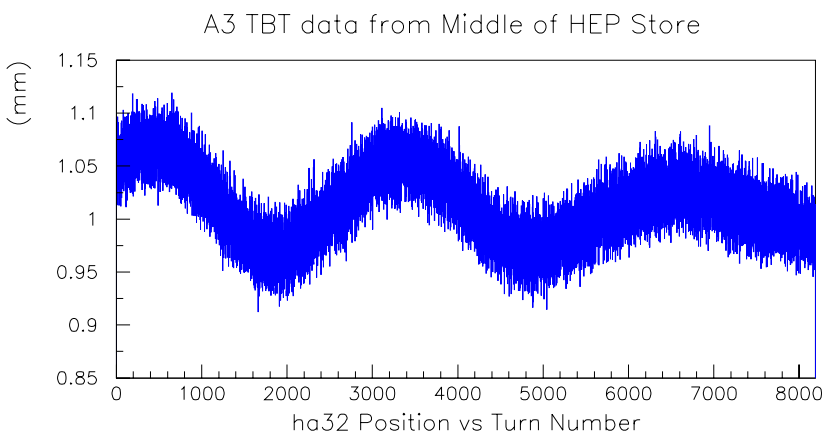

Position for VA33, Feb 7/05, Uncoalesced
(mm)
VA33 Position vs turn number, turns 4097−5120
VA33 Position vs turn number, turns 5121−6144
VA33 Position vs turn number, turns 6145−7168
VA33 Position vs turn number, turns 7169−8177

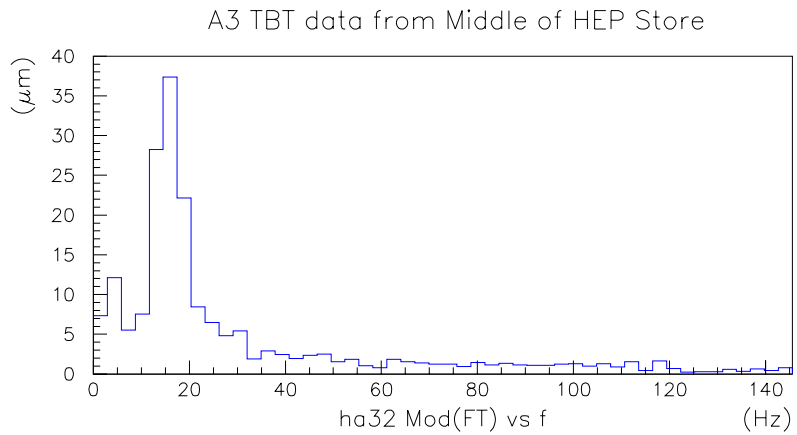


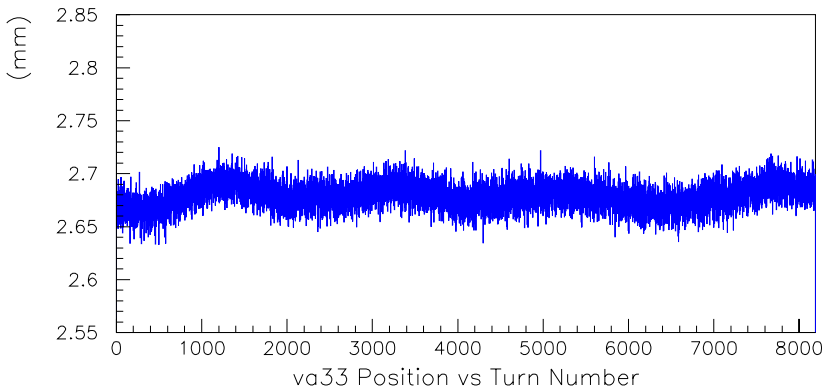
- Injection TBT.
- Sum signal (A+B)
- Same data as for positions.
  - Uncoalesced.
  - 150 GeV.
- Dominant frequency is different than in position data!

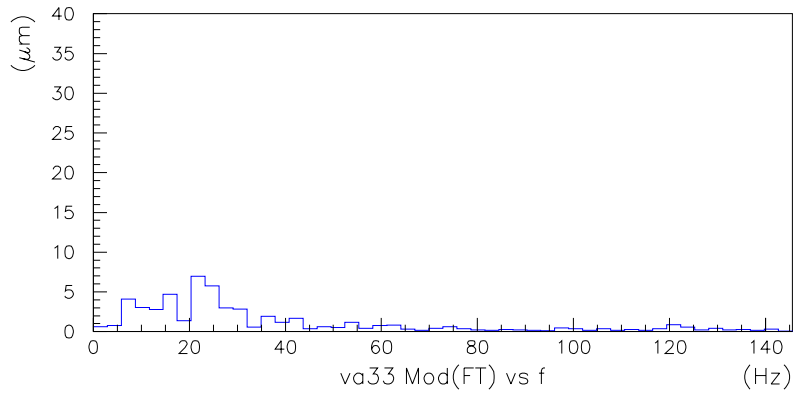


- Detail of Fourier transform.
- 150 GeV
  - f_{sync} ~80 Hz.
- Main structure at ~160 Hz is quadrupole oscillation of bunches in their buckets.

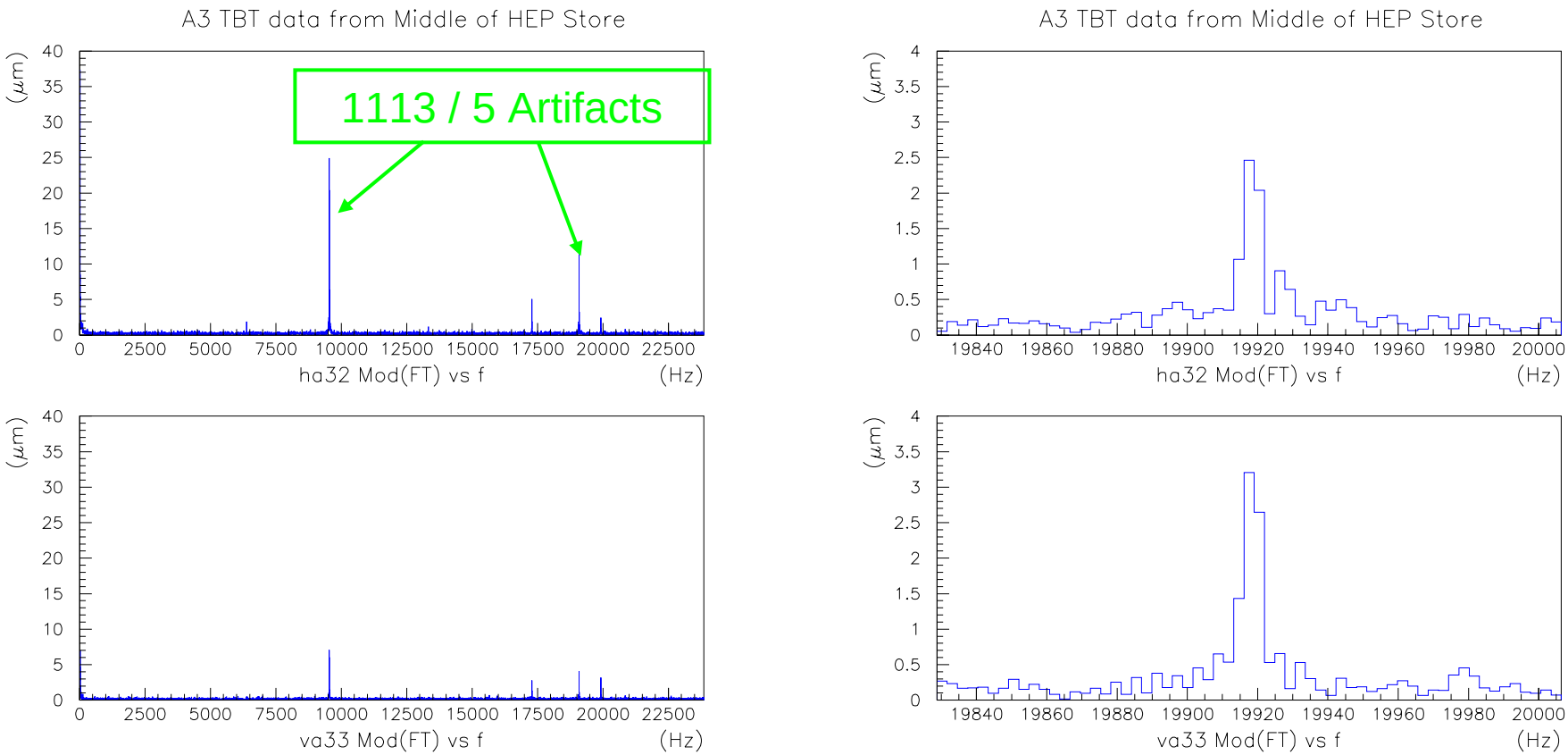








- TBT middle of HEP 36x36 store.
- 980 GeV; f_{sync} ~37 Hz.
- Similar features on other BPMs.
- Closed orbit resolution correlates with size of 15 Hz oscillations.



- Not sure why line at 19918 Hz is at the same frequency in both horizontal and vertical?

Conclusions

- TBT and Injection TBT are working.
- We can cleanly see:
  - Synchrotron lines
  - Betatron lines
  - Quadrupole oscillations
  - HV Coupling
  - 15 Hz noise.
- Can make quantitative measurements of these in 8192 turns.
- 1113/5 artifacts are present in safe places.

Further Details

- Documents earlier than 1565 discuss debugging the instrument.
- Beams-doc-1565
  - HEP Shot. One coalesced bunch.
  - Synchrotron, betatron motion.
- Beams-doc-1566
  - Tune up shot. Uncoalesced.
  - Synchrotron, betatron motion
  - Quadrupole oscillation of bunch in bucket.
  - Resolution.
- Beams-doc-1571
  - HV Coupling
- Beams-doc-1577
  - 15 Hz noise.
- Watch DocDb for latest developments.

Backup Slides

Fourier Transform

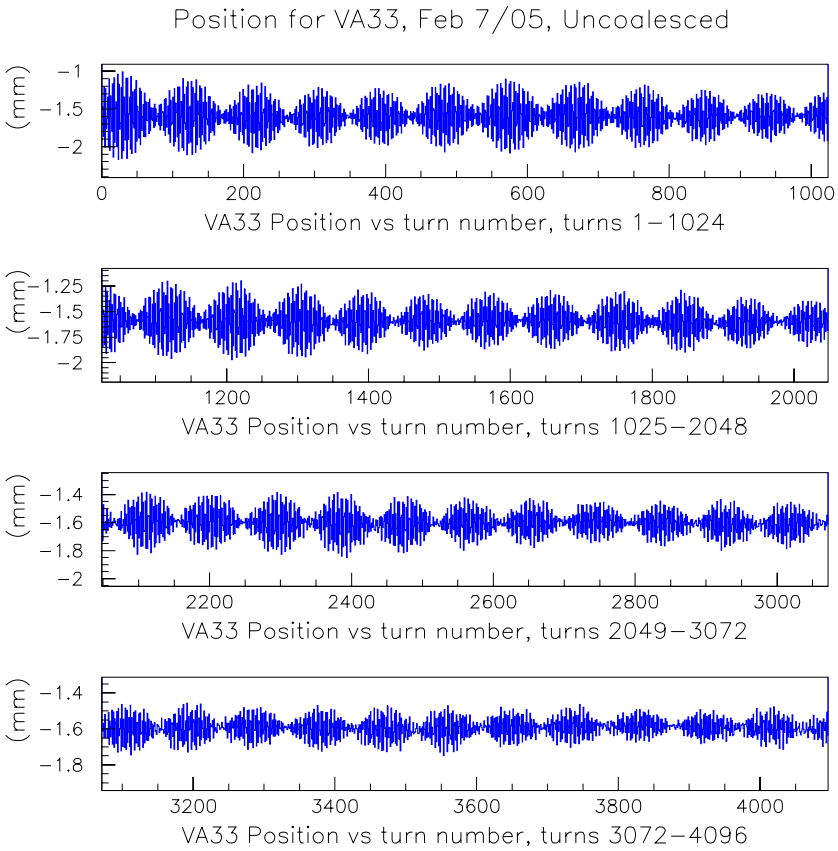
- $\tilde{F}(f)$, defined by:

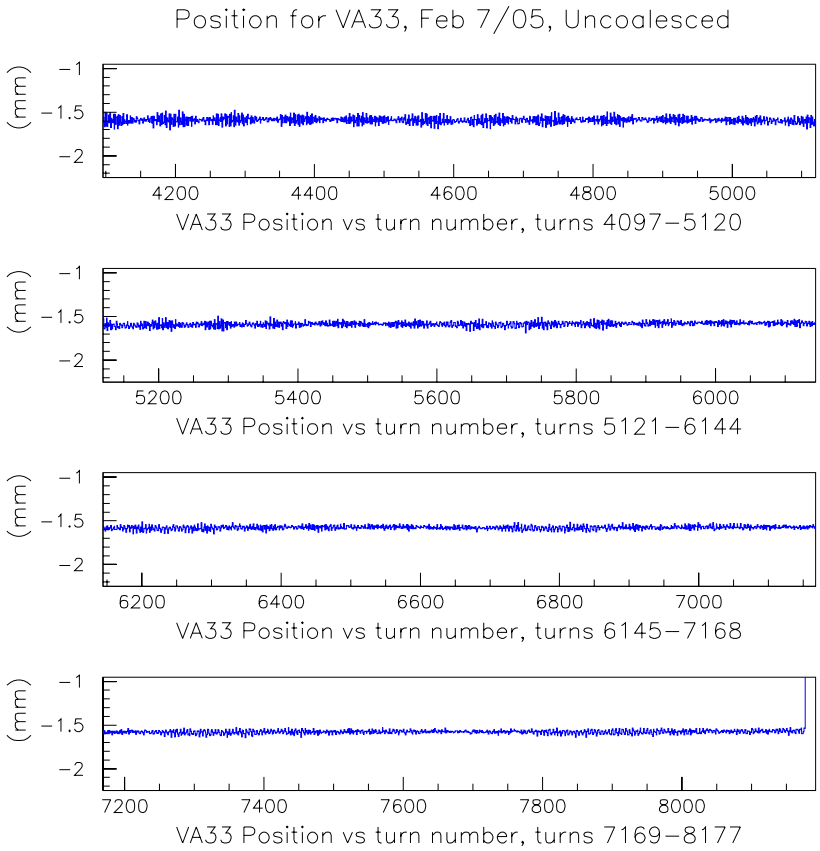
$$\tilde{F}(f) = C(f) \sum_{n=0}^{N-1} \left(P_n - \overline{P}\right) \exp\left(i 2\pi f t_n\right)$$

- N is number of data points.
- P_n, t_n are position and time on turn n.
- C(f) is a normalization factor.
- $\overline{P}$ is mean position of all data.
  - Subtracted to remove alias at 0 Hz.

1113 / 5 Artifacts

- Digitizer is clocked at 7/5 f_{RF}.
- After 7 cycles of this clock, and 5 cycles of RF, the 7/5 RF clock is back in sync with the RF.
- After one full turn of 1113 RF cycles, the 7/5 clock is not in phase with the RF.
- After 5 turns, the two clocks are back in sync.\
- Beams-doc-1066





- All 8 plots on same scale.