

# MD4505: Forced 3D oscillations

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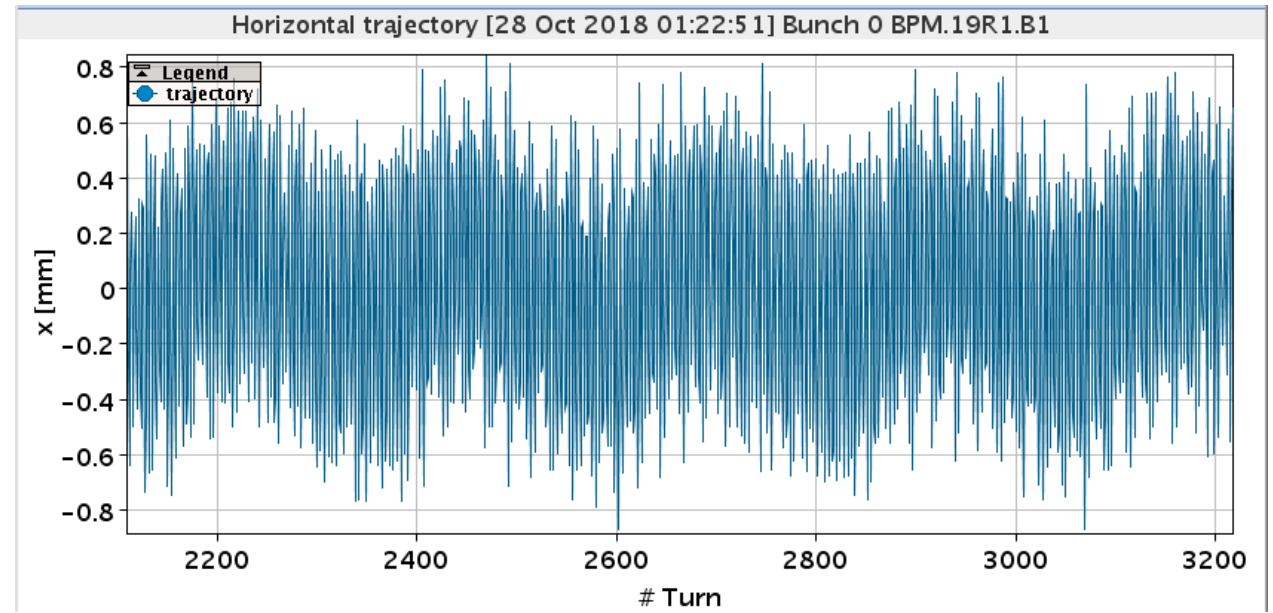


# Motivation

- Combine forced betatron oscillations by AC dipoles and longitudinal oscillations with the RF (close to  $Q_s$ )
- Continue to develop faster optics measurements
- Test new techniques to measure chromaticity, dispersion and do sanity checks
- Learn the beam response to such an excitation
  - AC dipole measurements feature some unwanted near- $Q_s$  modulation

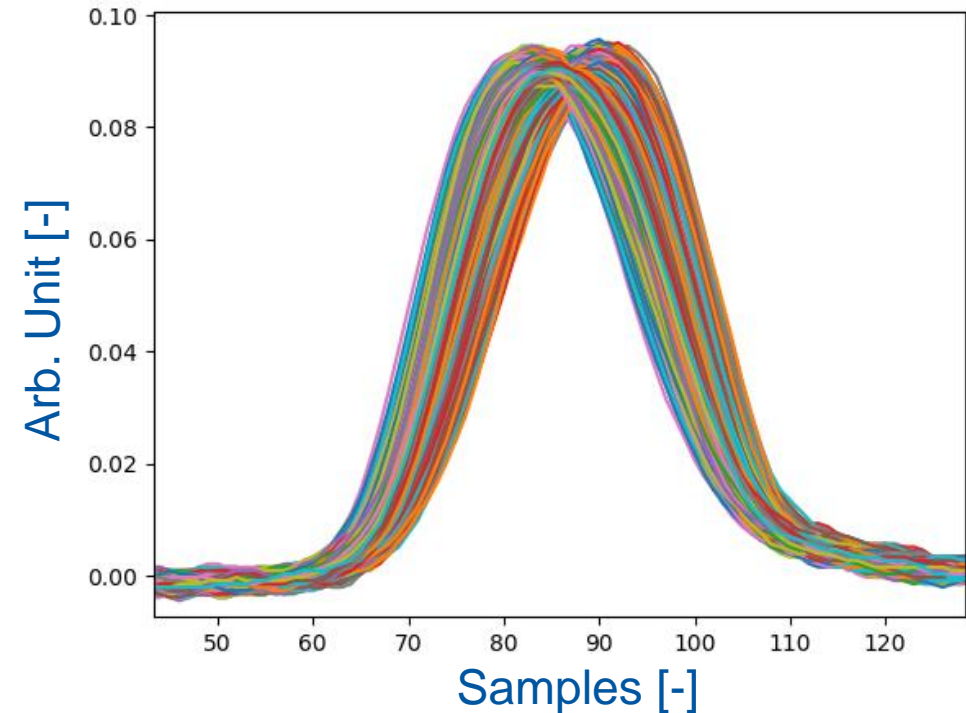
# MD – what we did?

- Single beam with pilot bunch(es) at injection energy
- Excite in 3D by AC-dipoles and RF phase modulation
- Record: TbT BPM, Schottky, bunch profiles, 2D BSRT images
- Scanned chromaticity
- Scanned  $\Delta Q_s$
- Measured with 3 bunches



# RF – phase modulation

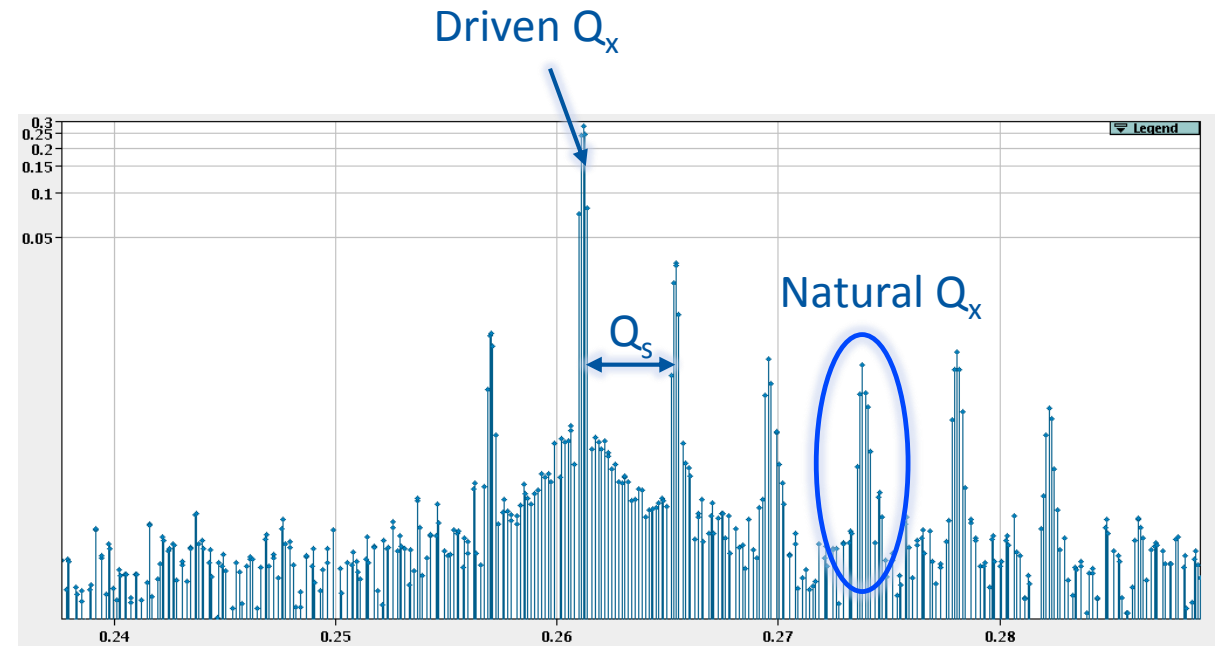
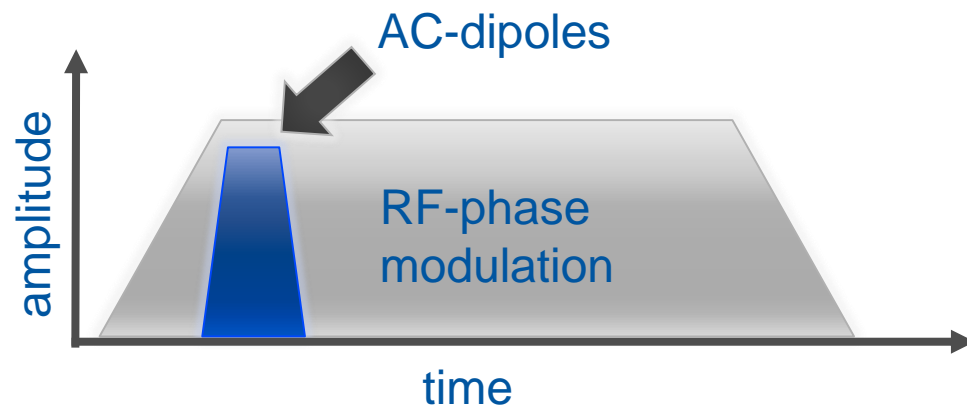
- Scan frequency and amplitude to find optimal settings
  - Not to blow-up the bunch
  - Measurable on BPMs
- Best settings at injection:
  - $Q_{d,s} = 1.02 * Q_s$
  - amplitude  $8 * 1.2^\circ$
  - Corresponds to  $|dp/p| \approx 5 * 10^{-5}$



**Longitudinal bunch profile**

# 3D driven oscillation

- Manually synchronised RF-phase modulation with AC-dipoles
- RF 10s + 70s + 10s
- AC-dipole 0.2s + 0.6s + 0.2s



**Beam spectra with high chromaticity**

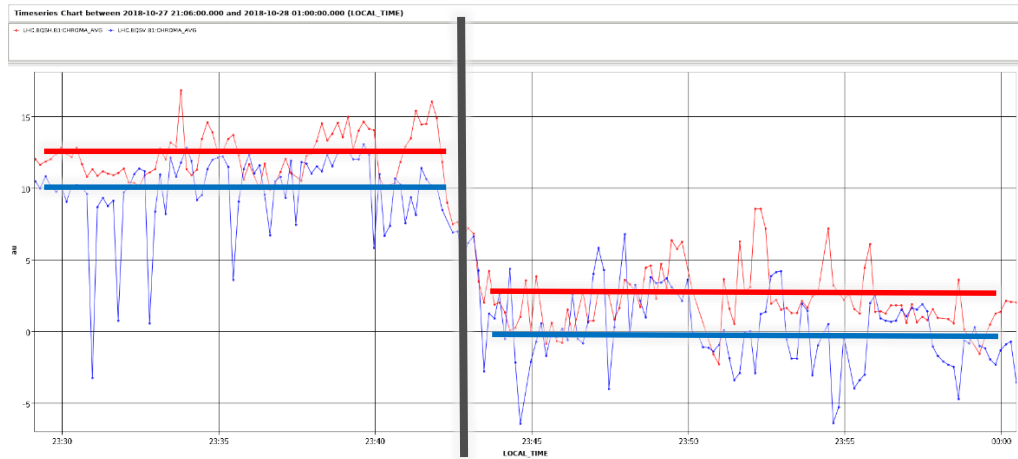
# Optics measurements in 3D (2D BPM data)

- Linear optics as in 2D excitation

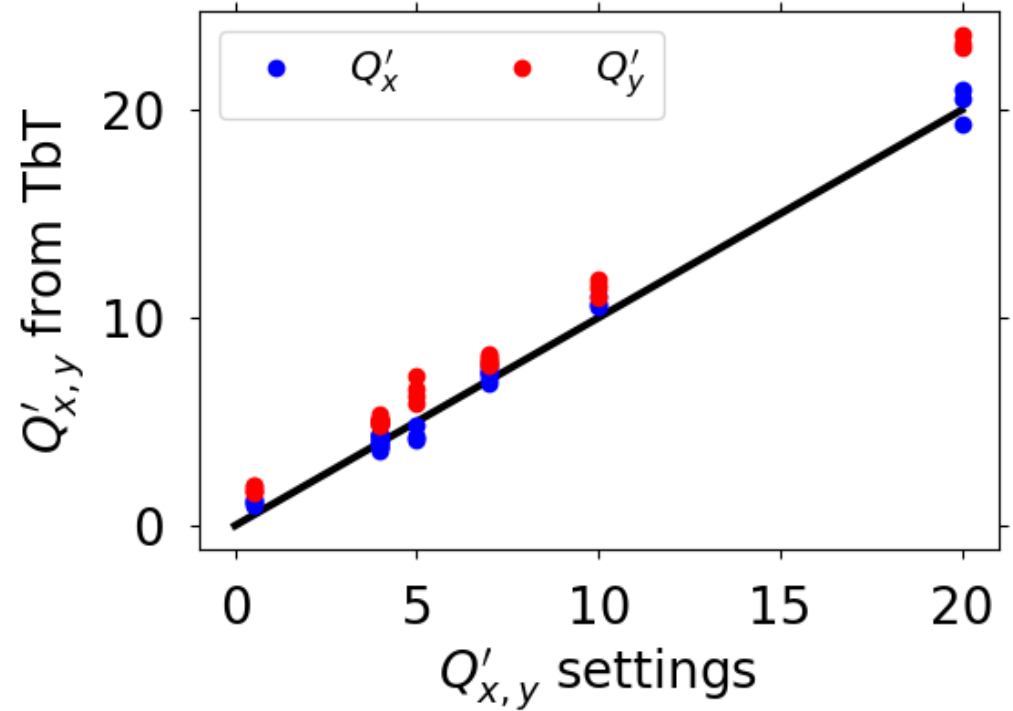


- Amplitude of energy variation, chromaticity
- Dispersion, normalised dispersion
- Chromatic  $\beta$ -beating and possibly chromatic coupling

# Chromaticity measurements



Schottky monitors



TbT BPMs

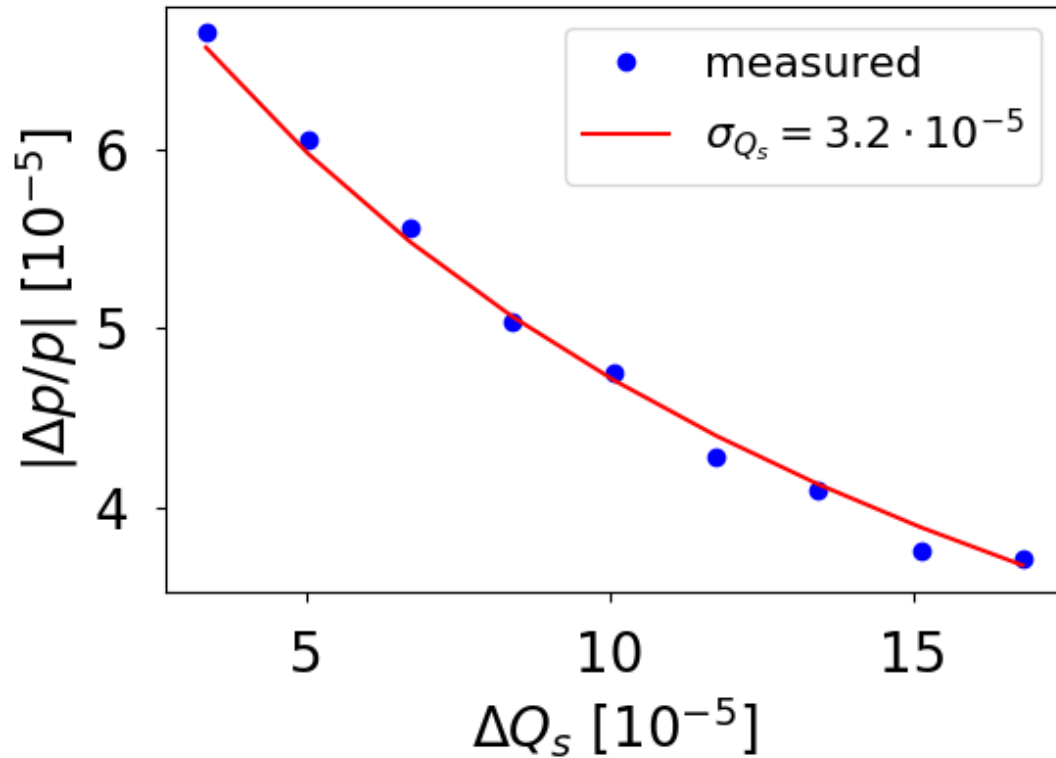
# Conclusions and outlook

- Combined AC-dipoles with RF-phase modulation
  - Optimised the excitation parameters for optics measurements
- First results are promising
  - fast optics measurements
- Analyses of various data are on-going



# Backup

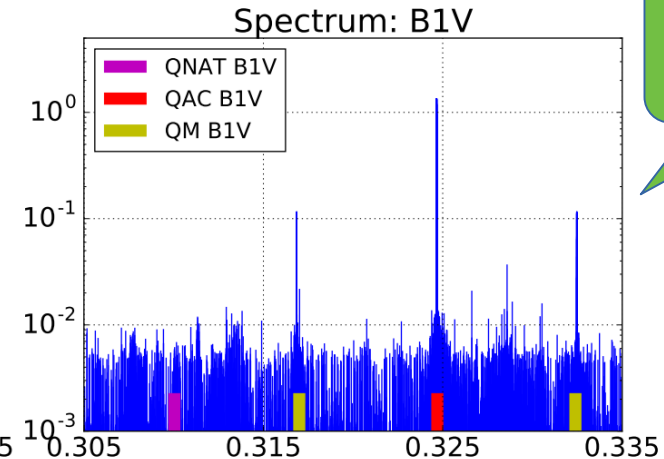
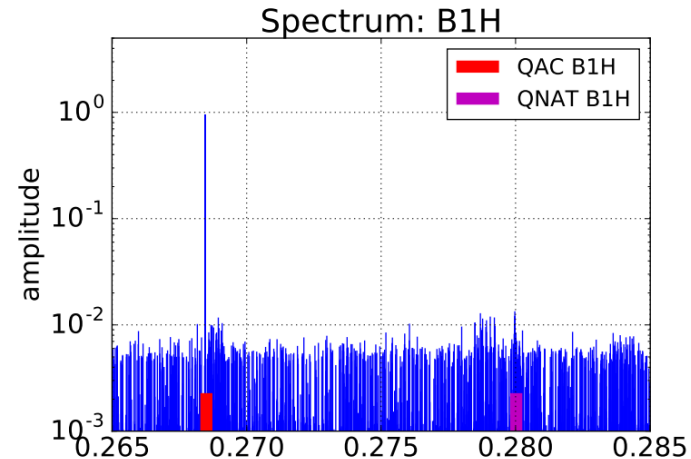
# Longitudinal optics from transverse BPMs



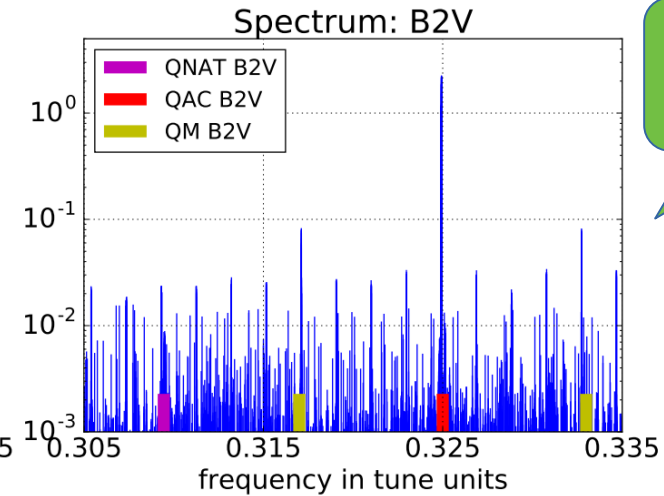
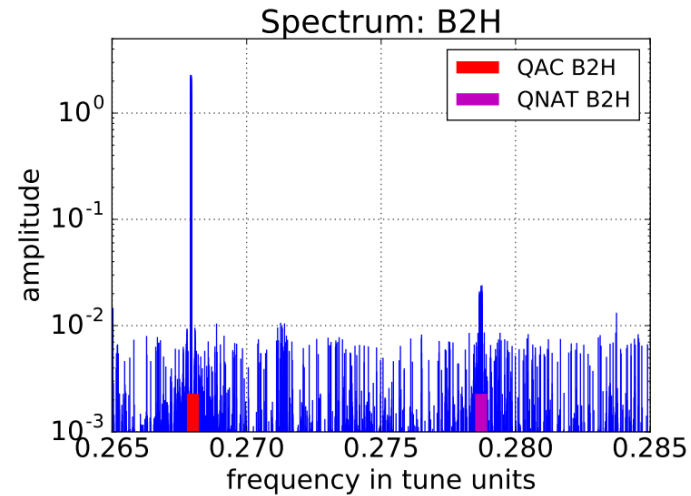
Dependency of measured amplitude of  $dp/p$  variation indicates effective spread of synchrotron tune  
**(very preliminary results)**

# Sidebands - $4Q_s$

- Affects AC dipole measurements
- Observed in vertical plane only
  - not understood
- Chromaticity can play a key role



Round flattop  
 $\beta^* = 65\text{cm}$   
June 2018



Round flattop  
 $\beta^* = 25\text{cm}$   
June 2018

D. Wolf

# References

- [1] L. Malina and J. Coello de Portugal, “Optics measurements in storage rings based on simultaneous 3-dimensional beam excitation”, IPAC’18, Vancouver, BC, Canada, paper THPAF046.