19th ATF2 Project Meeting

13-15 January 2016

LAL, Paris

19th TB/SGC Session

Beam orbit stabilization

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Introduction

- Ground motion, vibrations and drifts create beam oscillations that harm the beam quality and stability

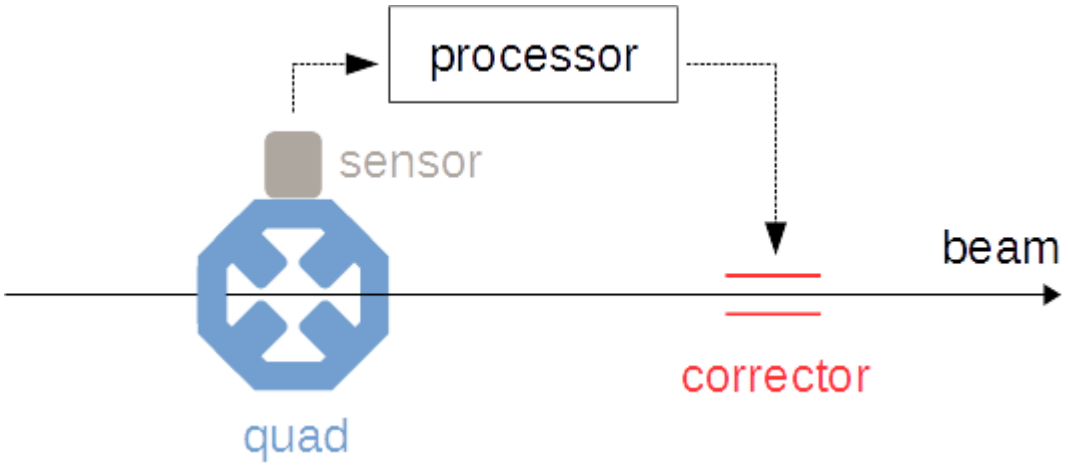
- High beam quality requirements for a future linear collider make mitigation essential

Mitigation schemes

- **Orbit feedback** can correct frequencies much smaller than the machine repetition rate
- **Intra-train feedback** essential at the IP but global orbit distortions remain uncorrected
- **Active and passive stabilization** too bulky and expensive for any but the most critical components
- Novel idea: **ground motion feed-forward**

Ground motion feed-forward

- Similar concept to orbit feedback but uses **seismometers** instead of BPMs to drive the correction

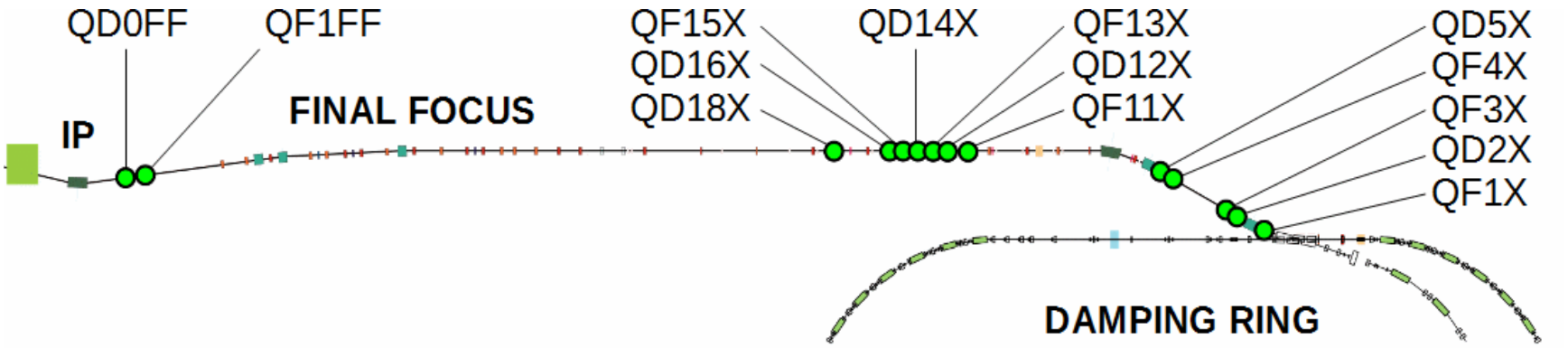


ADVANTAGES

Cheaper than active stabilization systems.

Correct frequencies out of limits for orbit feedback systems.

Setup at ATF2



- 14 Güralp Systems CMG-6T seismometers
- National Instruments data acquisition hardware
- Synchronization signal for BPM and ground motion data sets

Experimental results at ATF2

Two stage program to demonstrate ground motion feed-forward:

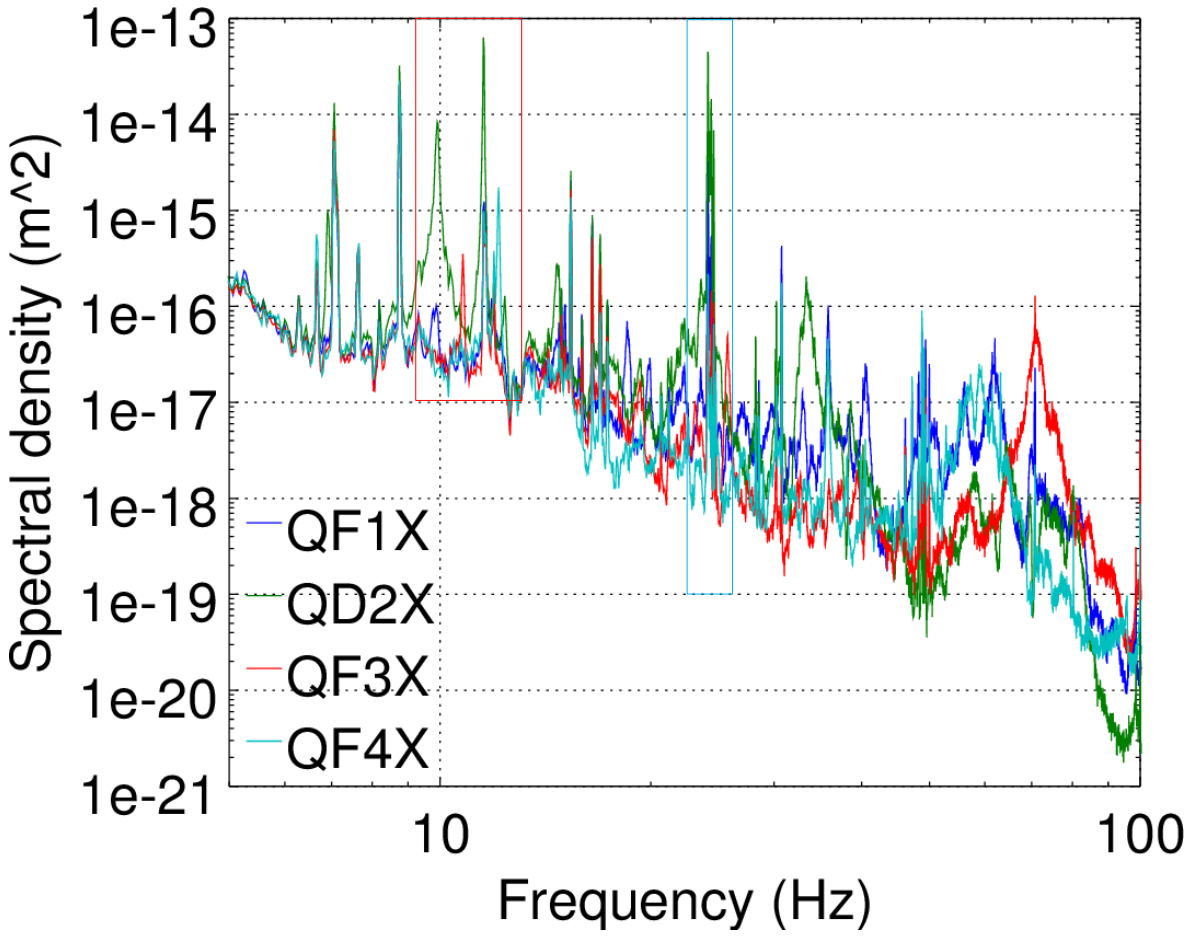
1. Demonstrate that beam position can be predicted from seismometer data

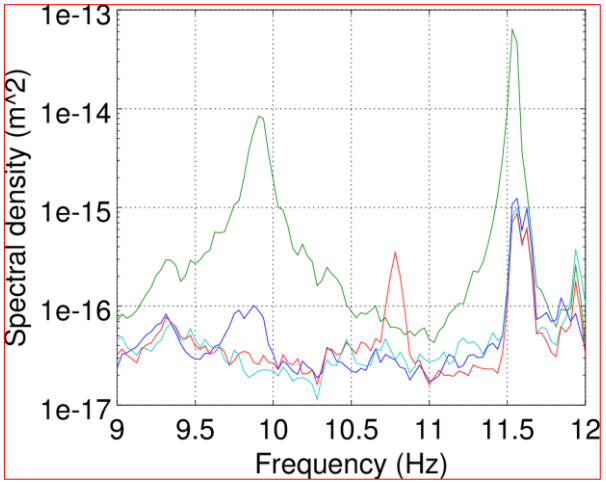
2. Demonstrate that beam jitter can be reduced using a correction based on seismometer data (see talk in session FUTURE PLANS)

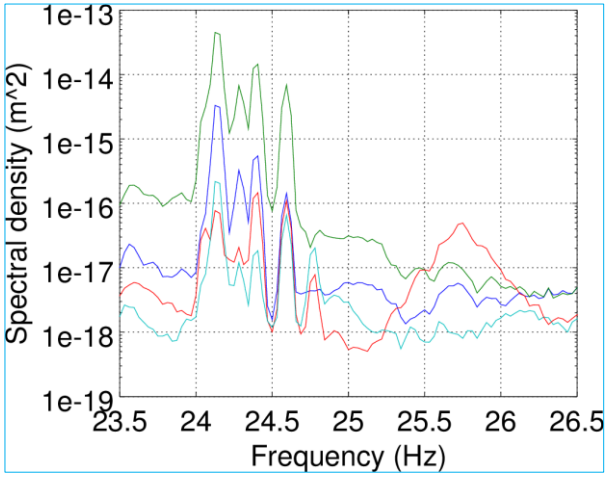
Ground motion data

Data set: ATF2_2015-05-22_14h30m54s.716.mat

Sensors on quads

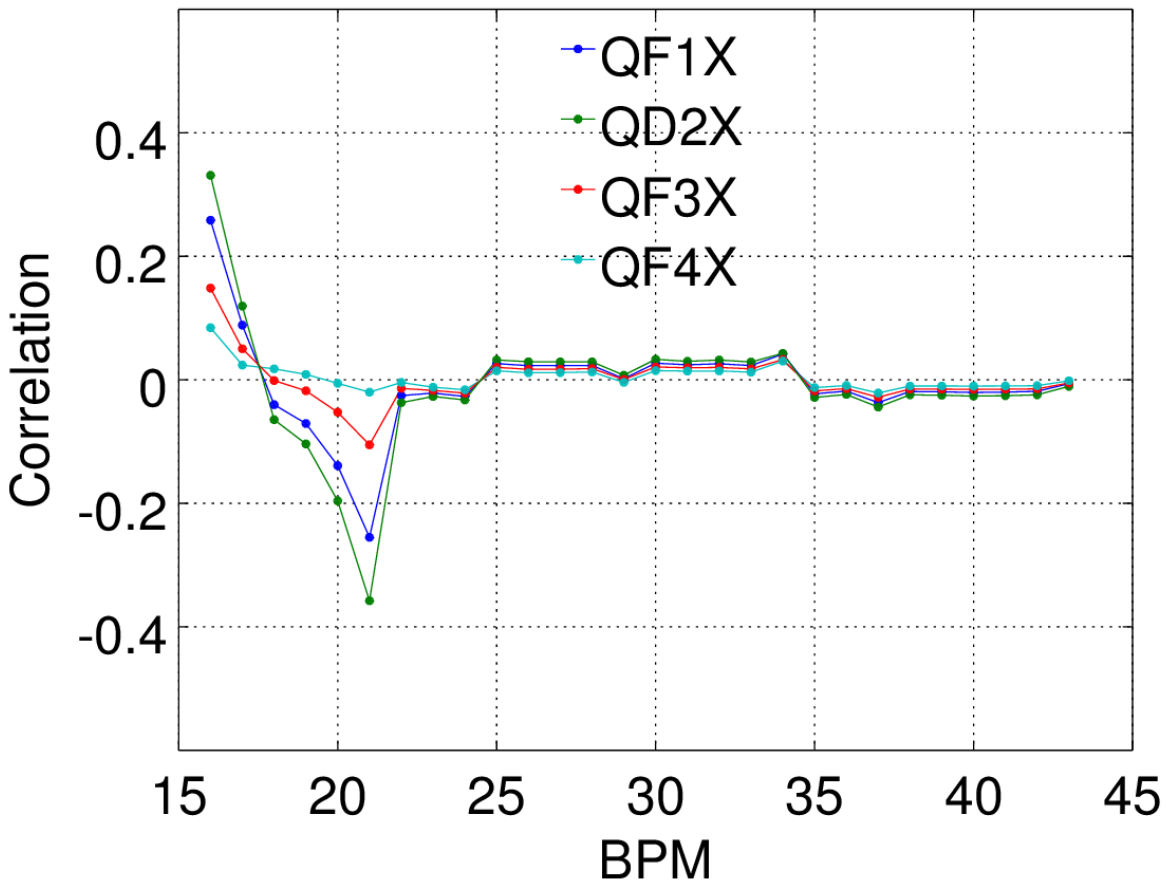






Sensor-BPM correlation

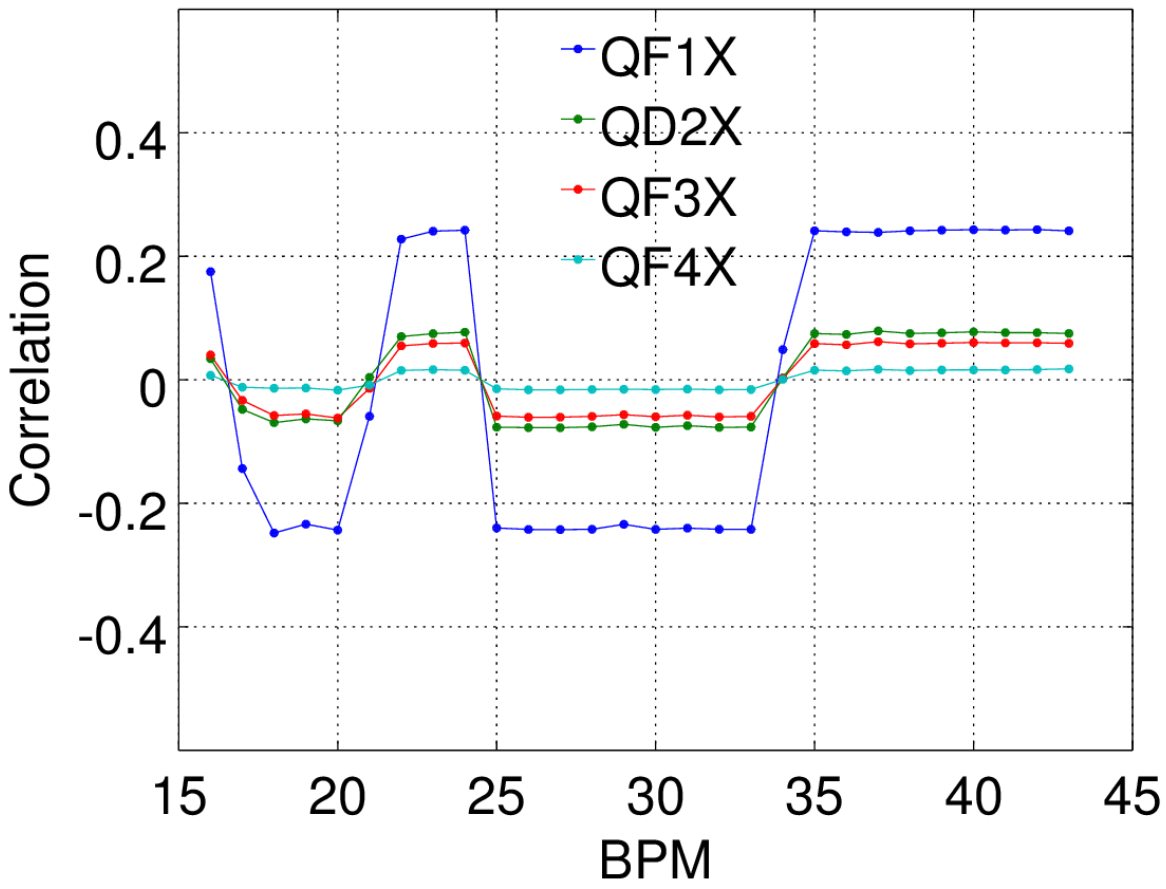
Data set: ATF2_2015-05-22_11h38m40s.278.mat



Sensors on table

Sensor-BPM correlation

Data set: ATF2_2015-05-22_11h38m40s.278.mat

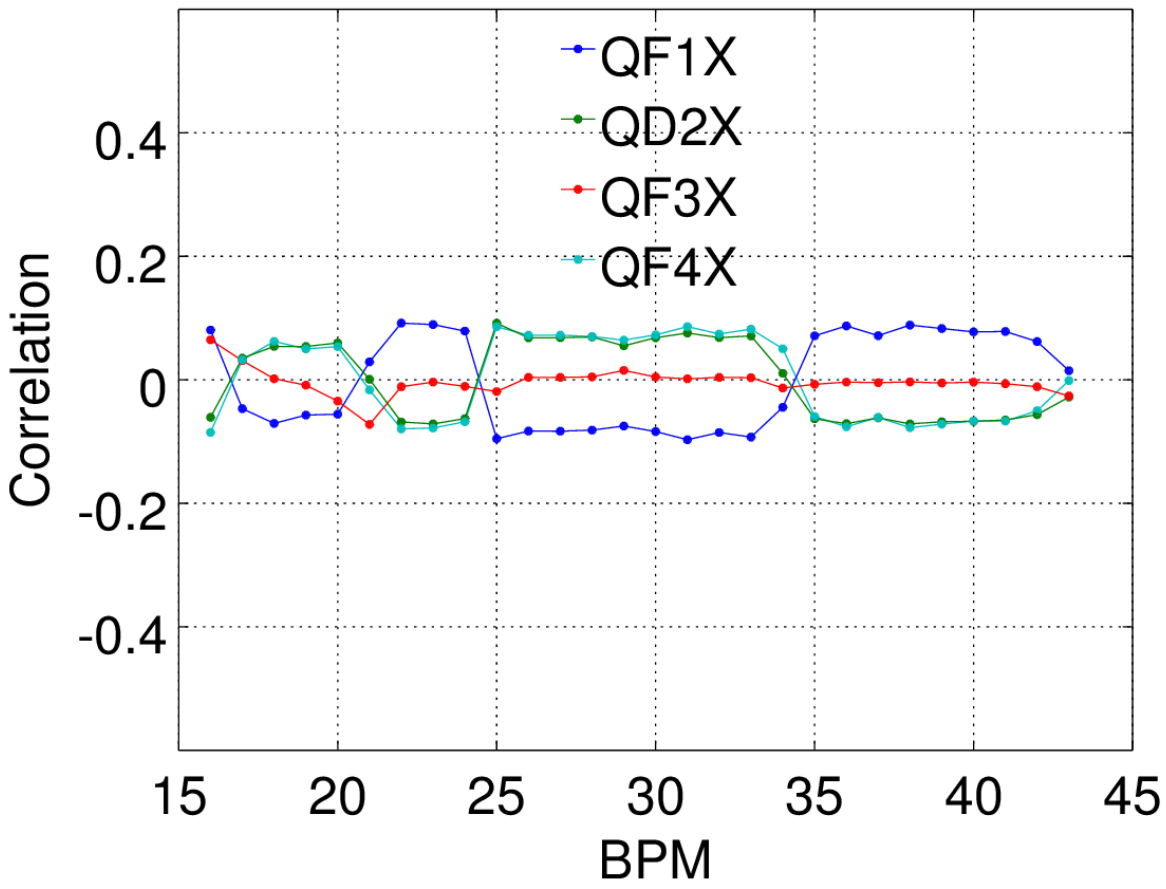


Sensors on table

0.2 Hz high-pass

Sensor-BPM correlation

Data set: ATF2_2015-05-22_14h30m54s.716.mat



Sensors on quads

Sensor-BPM correlation

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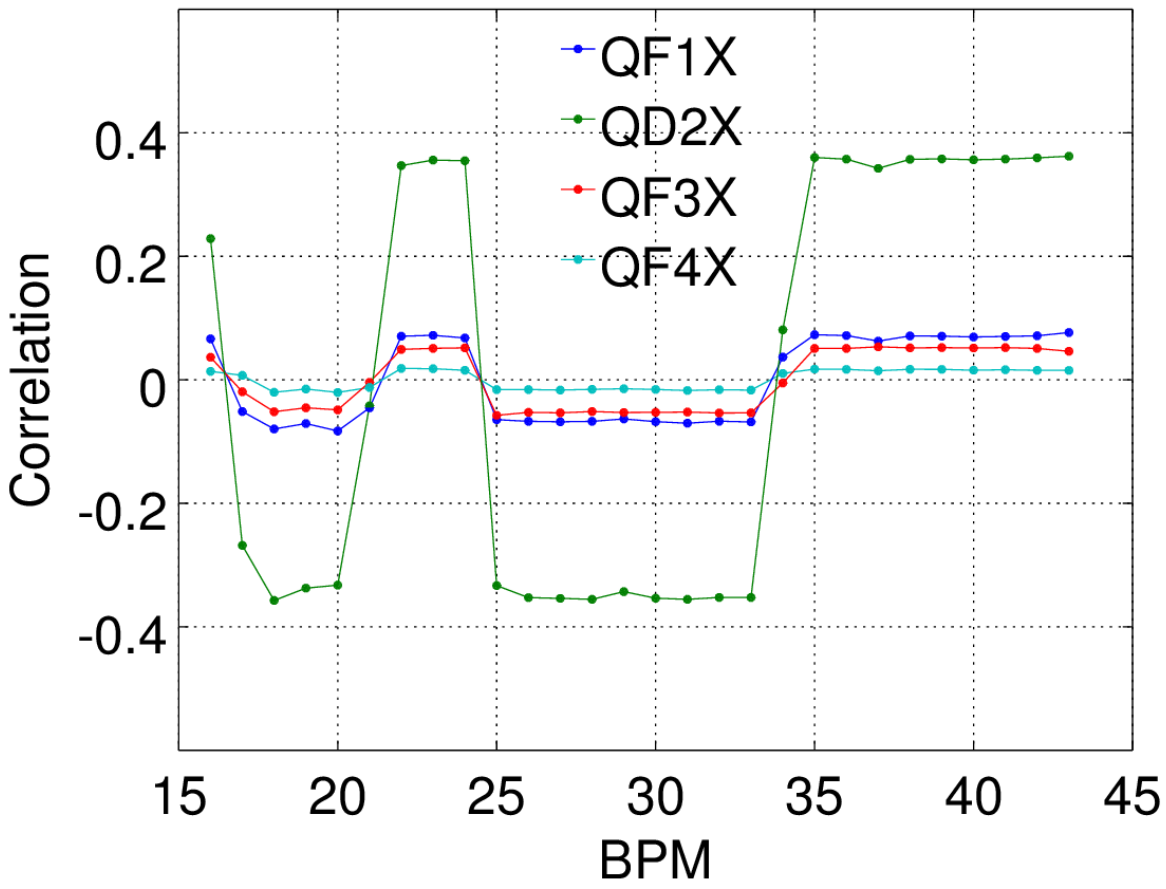


Sensors on quads

0.2 Hz high-pass

Predict beam position

- Construct the linear combination of data from the different seismometers that best matches the position observed at MSD4FF

- The correlation between this fit and the actual BPM data determines the performance of the feed-forward system:

$$\frac{\sigma_f}{\sigma_i} = \sqrt{1-\rho^2}$$

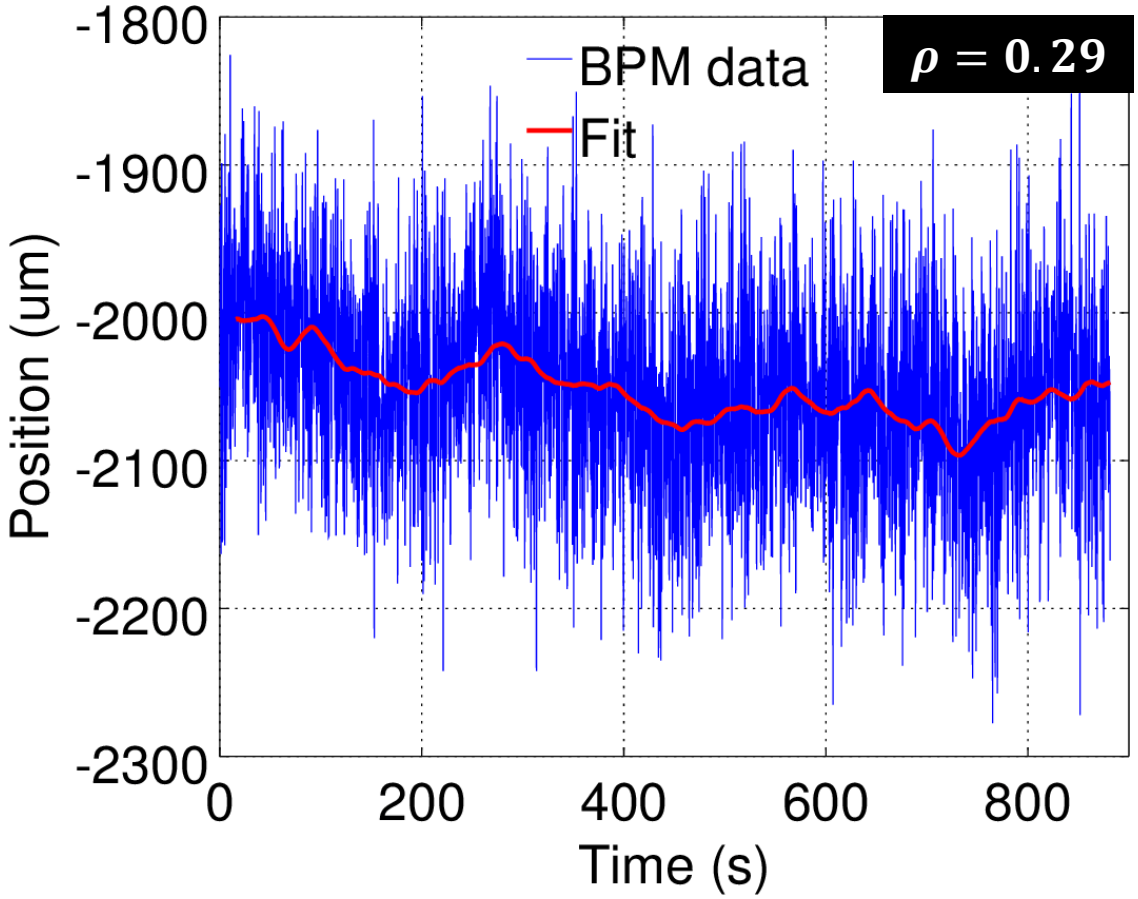
σ_i jitter before correction

σ_f jitter after correction

ρ correlation between fit and measurement

Fit to beam position

Data set: ATF2_2015-05-22_14h15m19s.502.mat



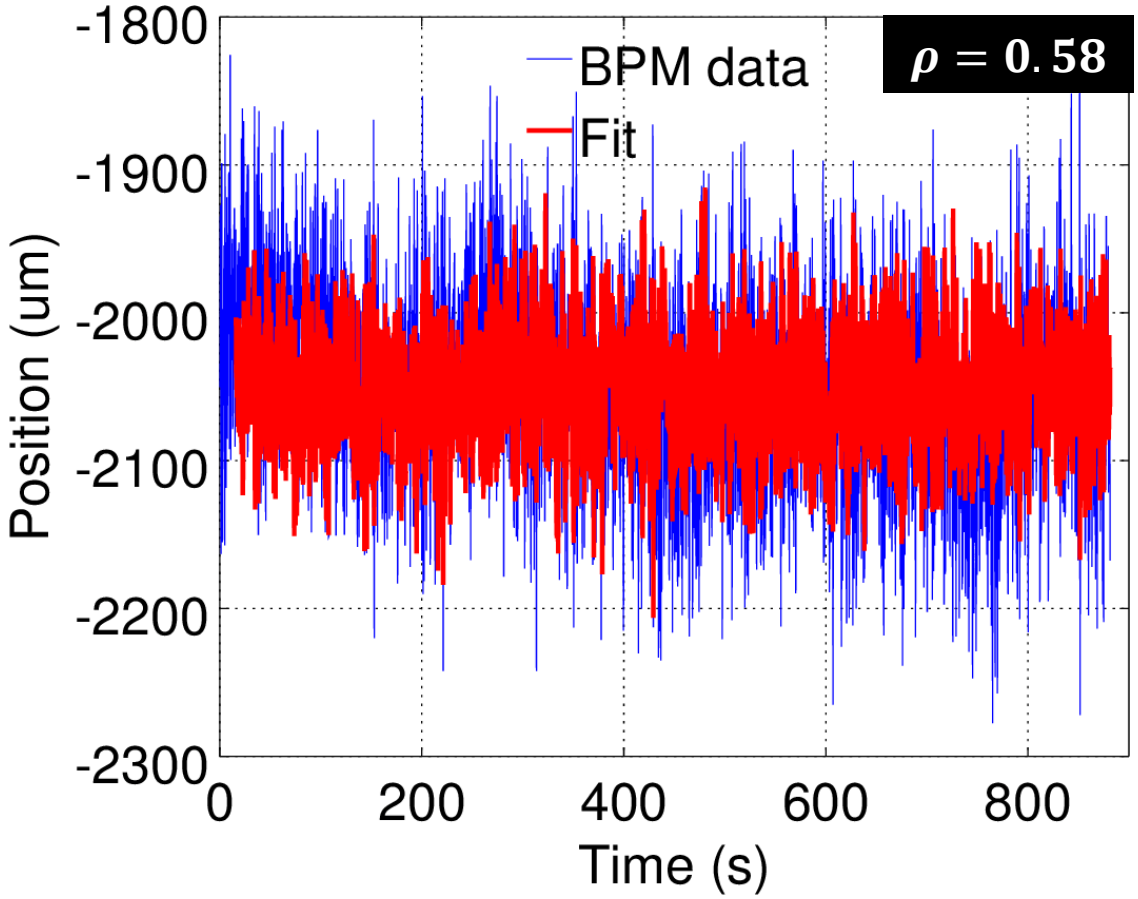
Sensors on quads

BPM MSD4FF

Fit uses sensors 1-12

Fit to beam position

Data set: ATF2_2015-05-22_14h15m19s.502.mat



Sensors on quads

0.2 Hz high-pass

BPM MSD4FF

Fit uses sensors 1-12

Expected performance

- Using a 0.2 Hz high-pass filter doubles the correlation from 0.29 to 0.58
- This increases the expected reduction in jitter from ~5% to ~20%

- 20% at the typical jitter levels of the FF BPMs corresponds to ~15 μm and thus should be easily measurable

Summary

- **Ground motion feed-forward** designed to suppress the effect of quadrupole vibrations at frequencies higher than those covered by orbit feedbacks

- Additional **beam-based alignment** methods can be envisaged to improve orbit stability (e.g. DFS removes energy dependence from orbit, WFS removes charge dependence)