19th ATF2 Project Meeting

13-15 January 2016

LAL, Paris

Future Plans

Ground motion feed-forward

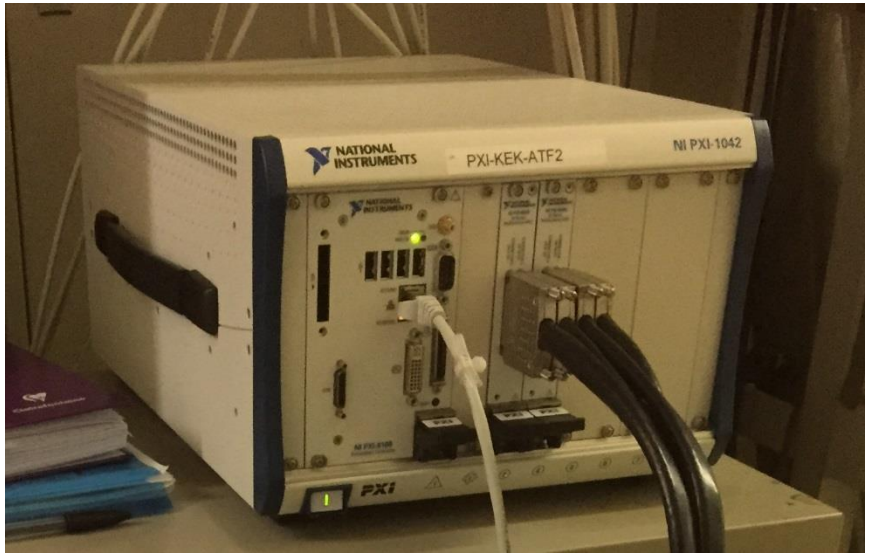
Douglas BETT

Cédric CHARRONDIÈRE, Andrea JEREMIE, Marcin PATECKI,
Juergen PFINGSTNER, Yves RENIER, Rogelio TOMÁS GARCÍA
Kiyoshi KUBO, Shigeru KURODA, Takeshi NAITO, Toshiyuki OKUGI,
Toshiaki TAUCHI, Nobuhiro TERUNUMA

Outline

- Commissioning of feed-forward hardware
- Results from first feed-forward runs
- Factors affecting feed-forward performance

Previous setup



National Instruments
PXI-1042 chassis with:
PXI-8108 controller

PXI-6289 multi-function DAQ modules (×2)

Digitizes horizontal and vertical signals from 14 seismometers plus synchronization signal (29 total)

Real-Time LabVIEW DAQ for data logging at ~1 kHz

New hardware

National Instruments
cRIO-9064 chassis with:

9263 analogue output module

9205 analogue input module

9401 digital I/O module (NEW)

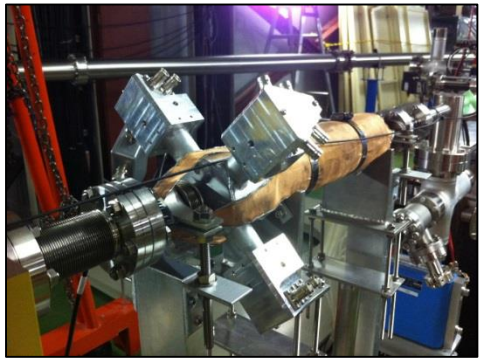
16 analogue inputs (differential) used to digitize the vertical signals from the first four sensors initially

Artix-7 FPGA supported by real-time LabVIEW

Feed-forward setup (proposed)

seismometers
(mounted on quads)

stripline kicker “K2”



drive pulse

kicker amplifier

trigger

FONT5 board

drive pulse

velocity signal

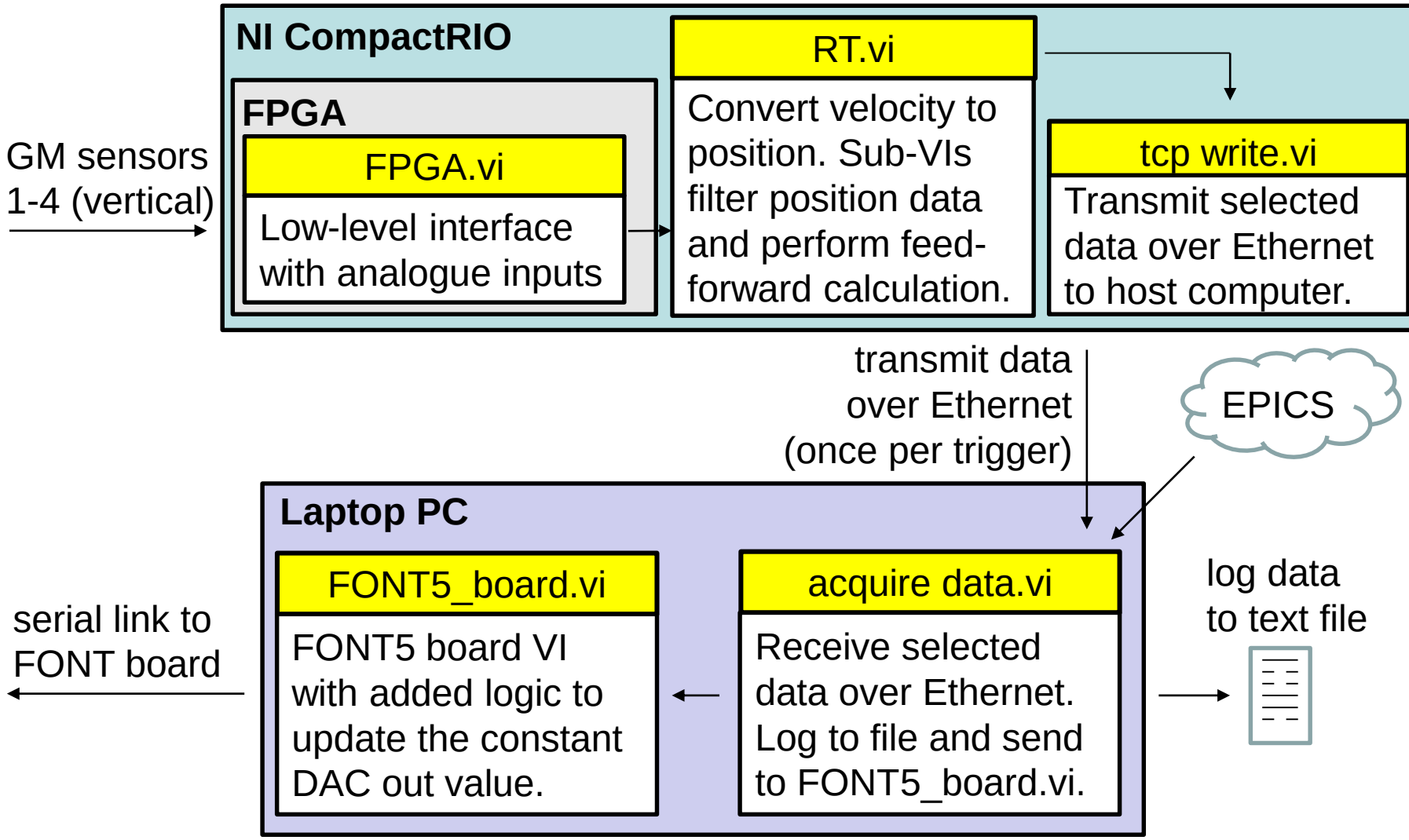
trigger

CompactRIO
(local control room)

Commissioning issues

PROBLEM	SOLUTION
Power lead has a Swiss plug.	Use Araki-san's plug adapter.
Digital input on 9205 module only recognizes TTL signals, but trigger in local control room is NIM.	Use Naito-san's Agilent 81110A to generate a TTL trigger from the NIM one.
Drive pulse output by 9263 module too unstable in time for use with kicker amplifier (jitters by ~10 μs).	Use FONT5 board to generate signal pulse for the kicker amplifier. Requires the feed-forward correction calculated by the CompactRIO to be communicated to the FONT5 board. Can be done via a PC (but not ideal due to unpredictability of network transfer times).

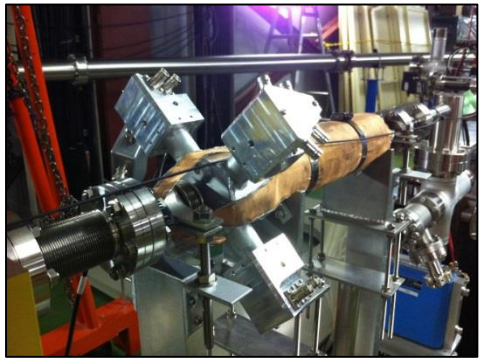
Schematic of feed-forward software



Feed-forward setup (actual)

seismometers
(mounted on quads)

stripline kicker “K2”



drive pulse

kicker amplifier

trigger

drive pulse

FONT5 board

feed-forward correction value (via ethernet)

PC

constant DAC value

velocity signal

81110A

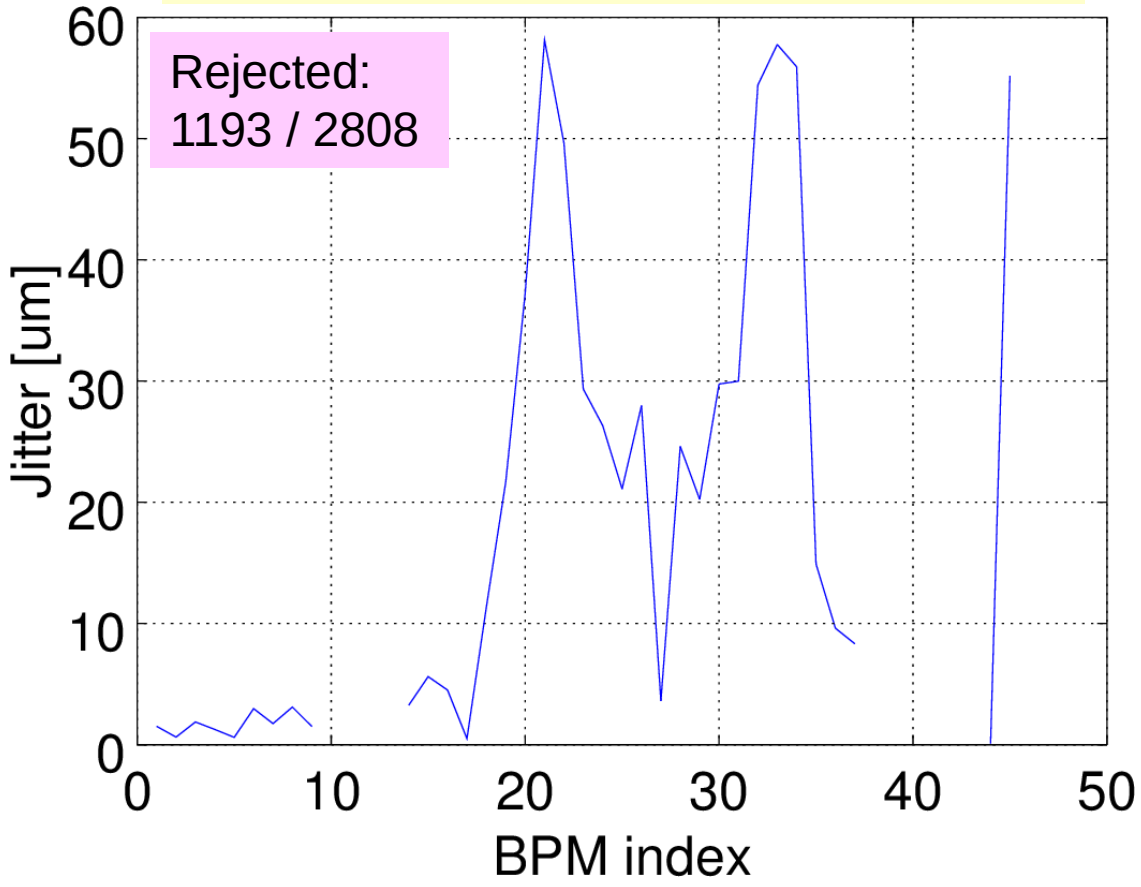
trigger

CompactRIO
(local control room)

Results: BPM data

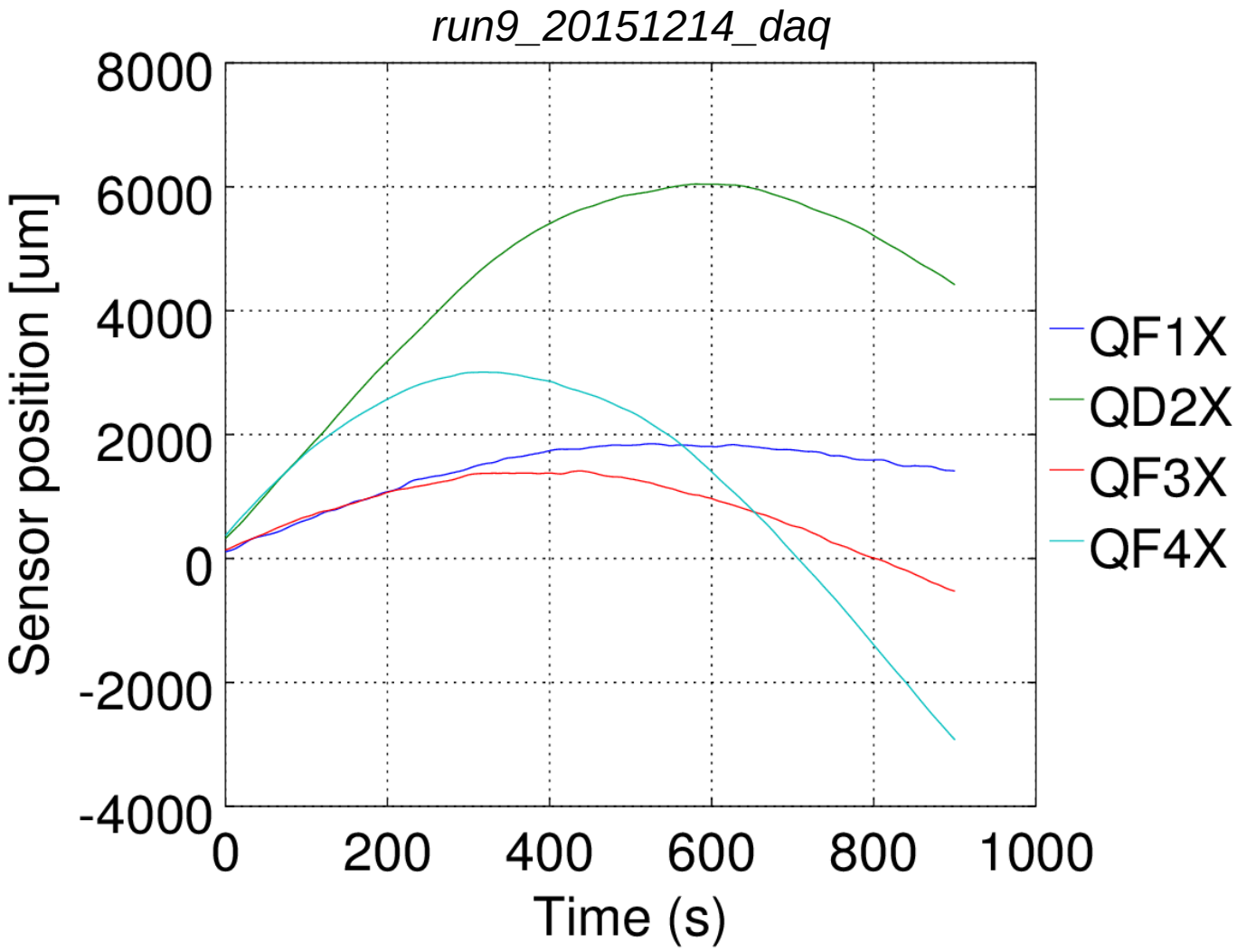
run9_20151214_daq

BPMs excluded: IPT1-4, MSF1FF, MQF1FF, MSD0FF, MQD0FF, PREIP, IPA



- For the PXI system, BPM data is collected using FlightSim
- For the CompactRIO system, data is taken with LabVIEW (EPICS)
- Many pulses rejected due to EPICS not having updated when data fetched

Results: Ground motion data

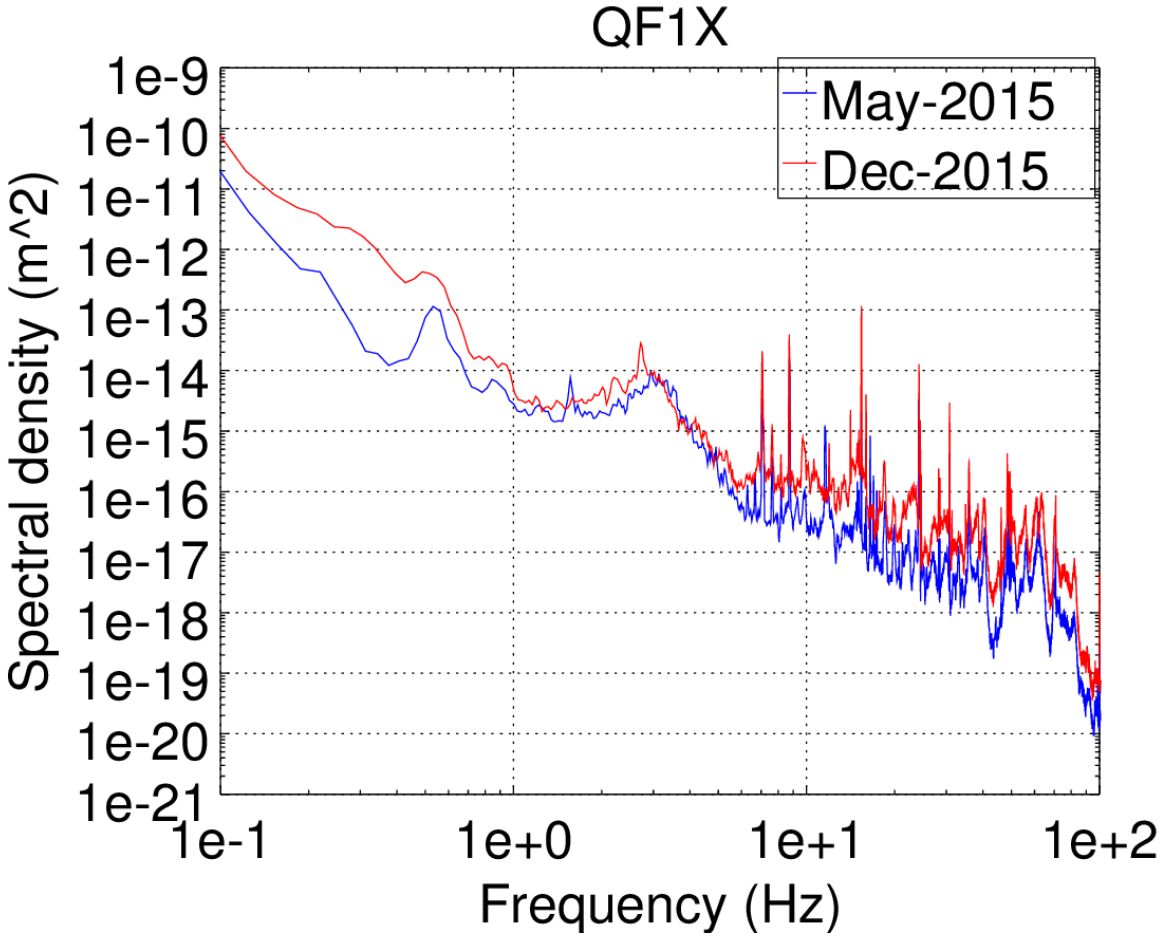


BPM data unreliable and thus impossible to synchronize with ground motion data (no correlations)

Issue appears to be fixed by waiting 200 ms before fetching data, but no good GM/BPM data set to test correlations

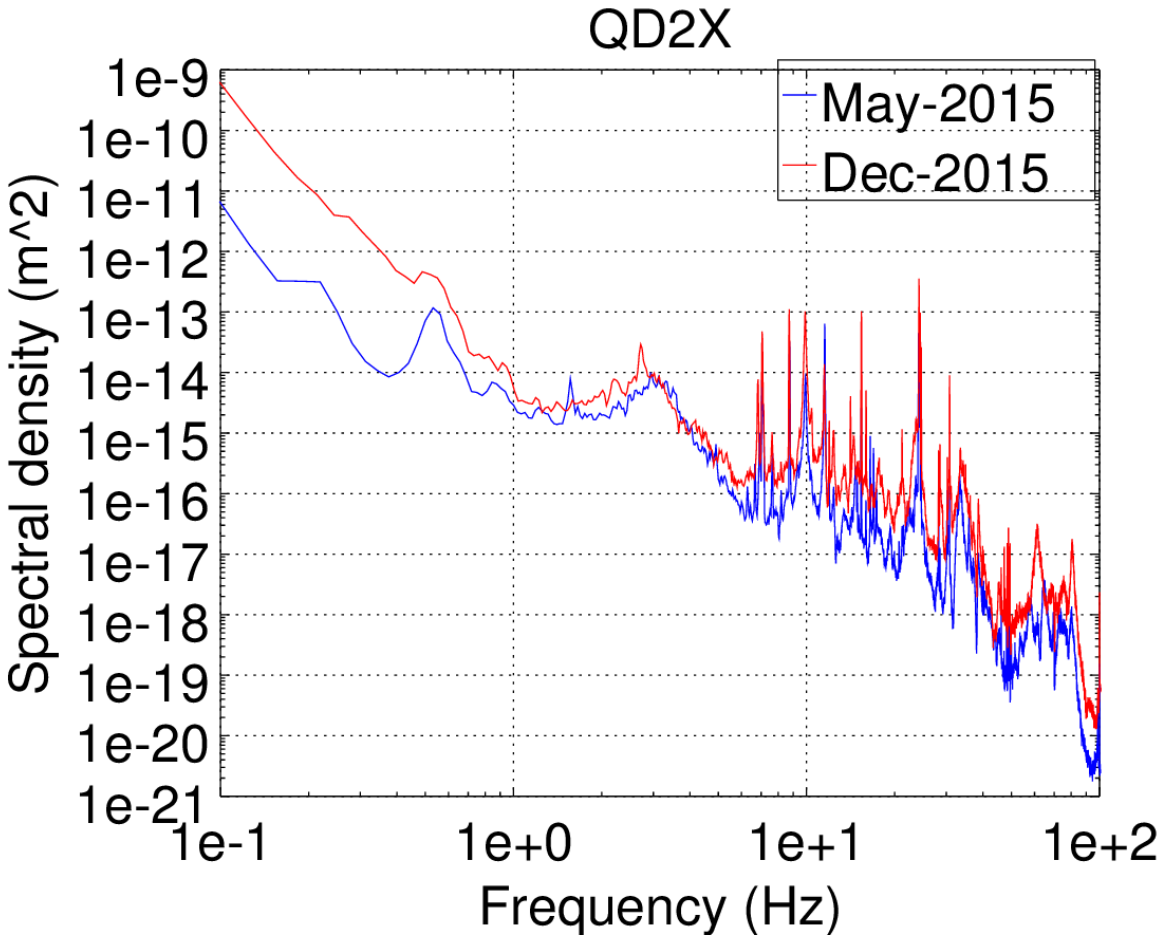
Ground motion spectrum: QF1X

May: data_20150522_1430
Dec: run9_20151214



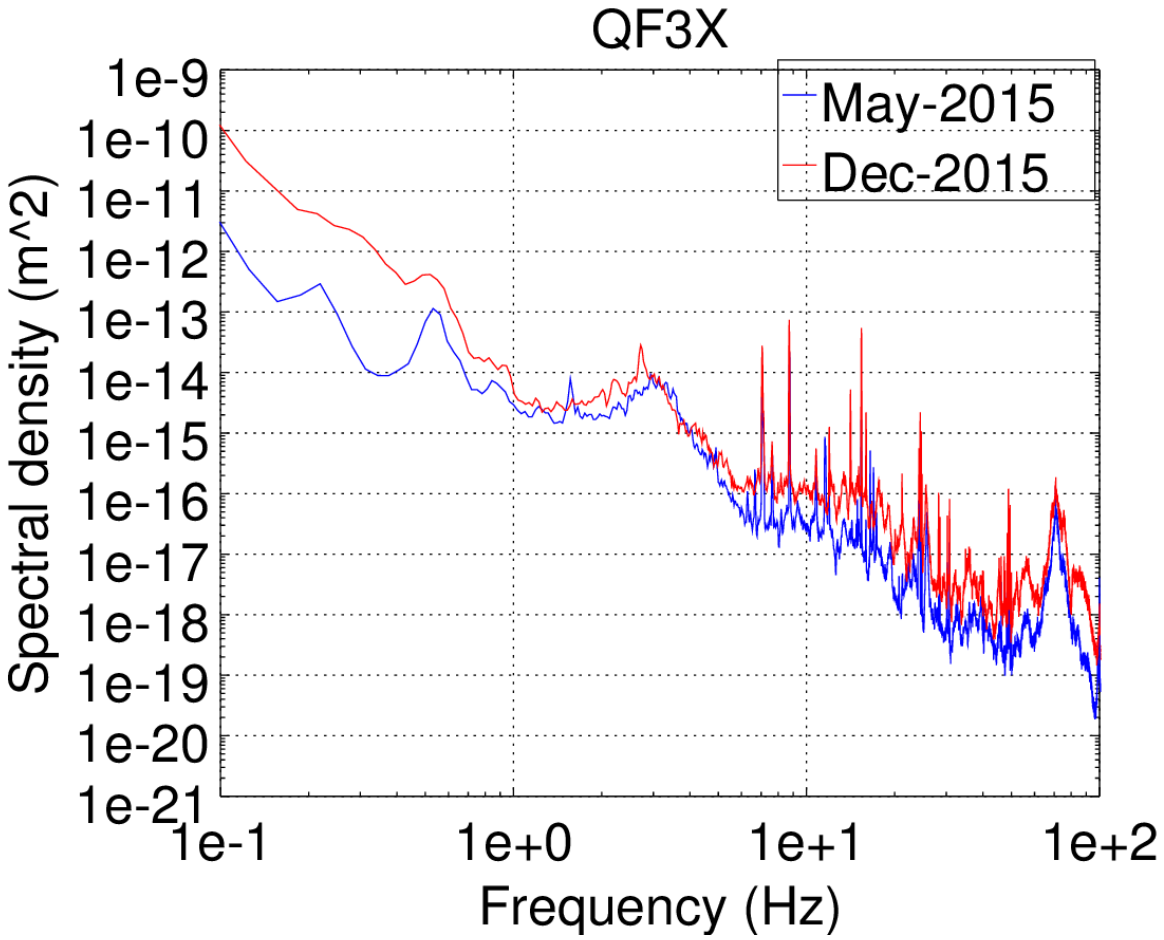
Ground motion spectrum: QD2X

May: data_20150522_1430
Dec: run9_20151214



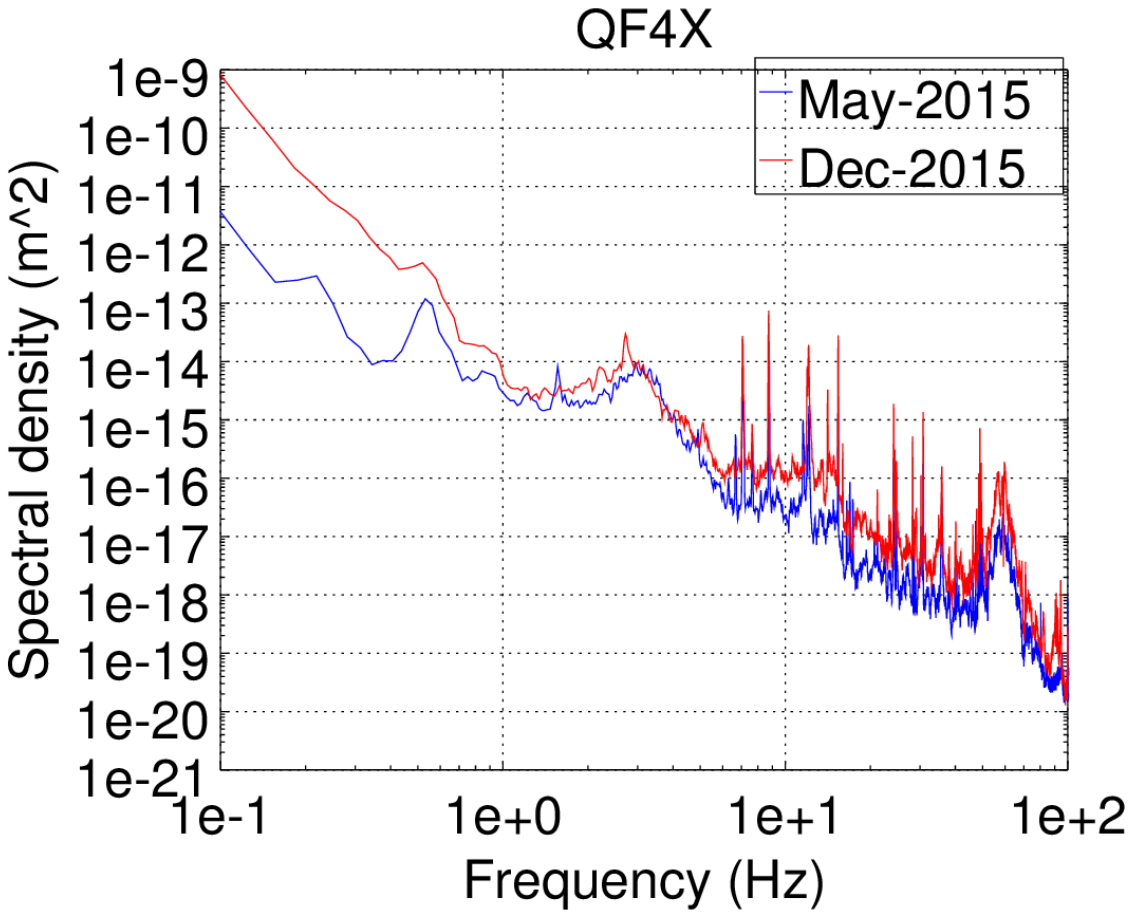
Ground motion spectrum: QF3X

May: data_20150522_1430
Dec: run9_20151214



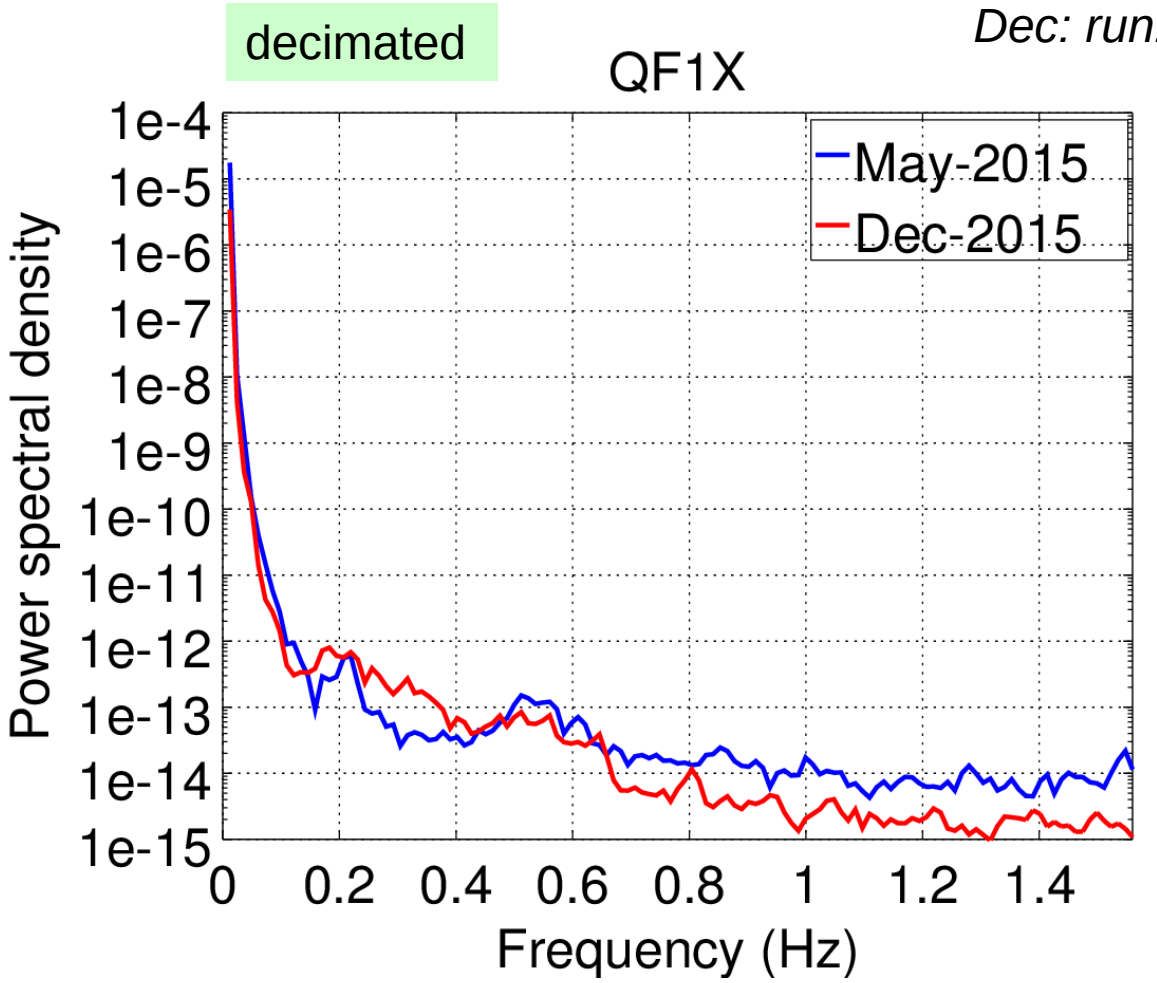
Ground motion spectrum: QF4X

May: data_20150522_1430
Dec: run9_20151214



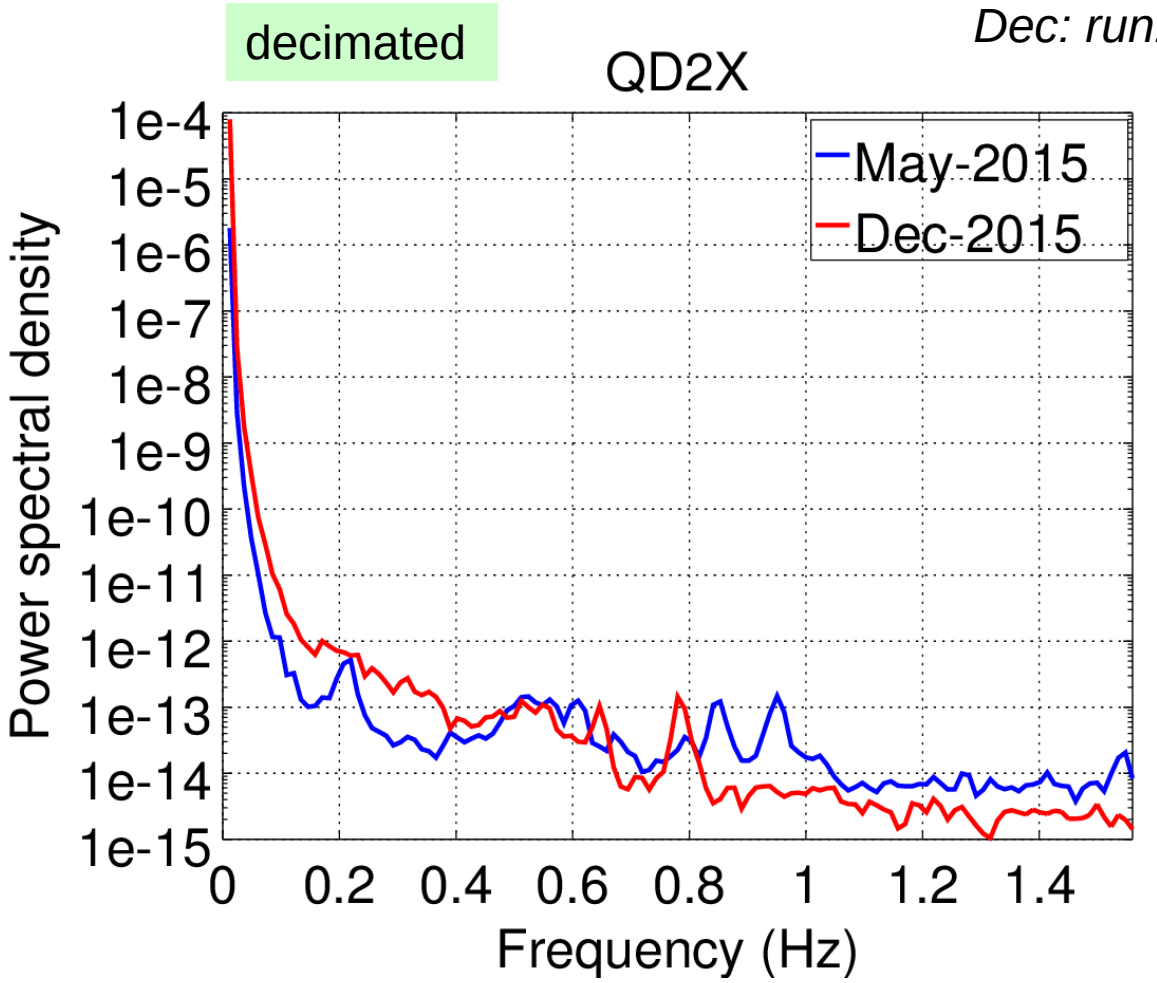
Ground motion spectrum: QF1X

May: data_20150522_1430
Dec: run10_20151214



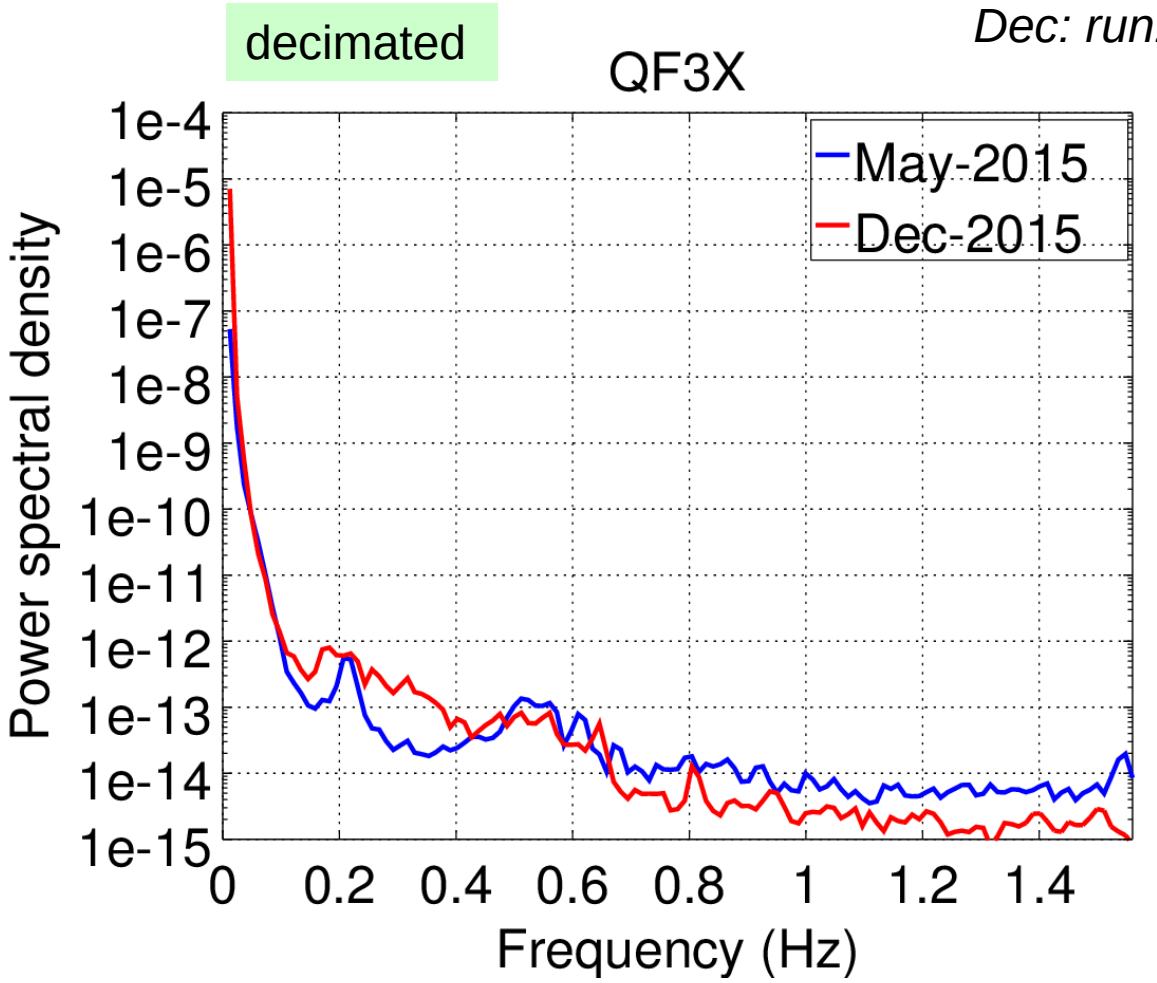
Ground motion spectrum: QD2X

May: data_20150522_1430
Dec: run10_20151214



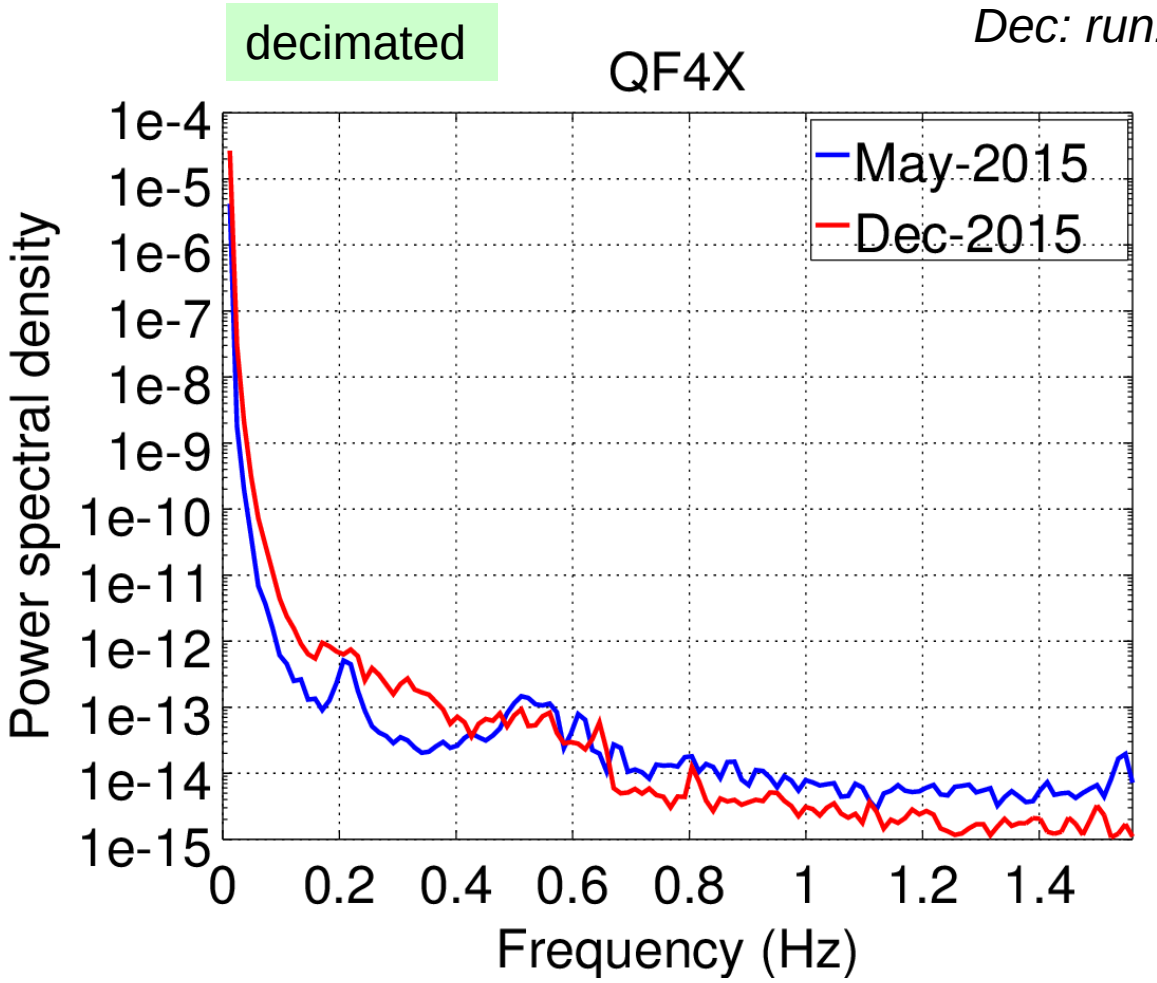
Ground motion spectrum: QF3X

May: data_20150522_1430
Dec: run10_20151214



Ground motion spectrum: QF4X

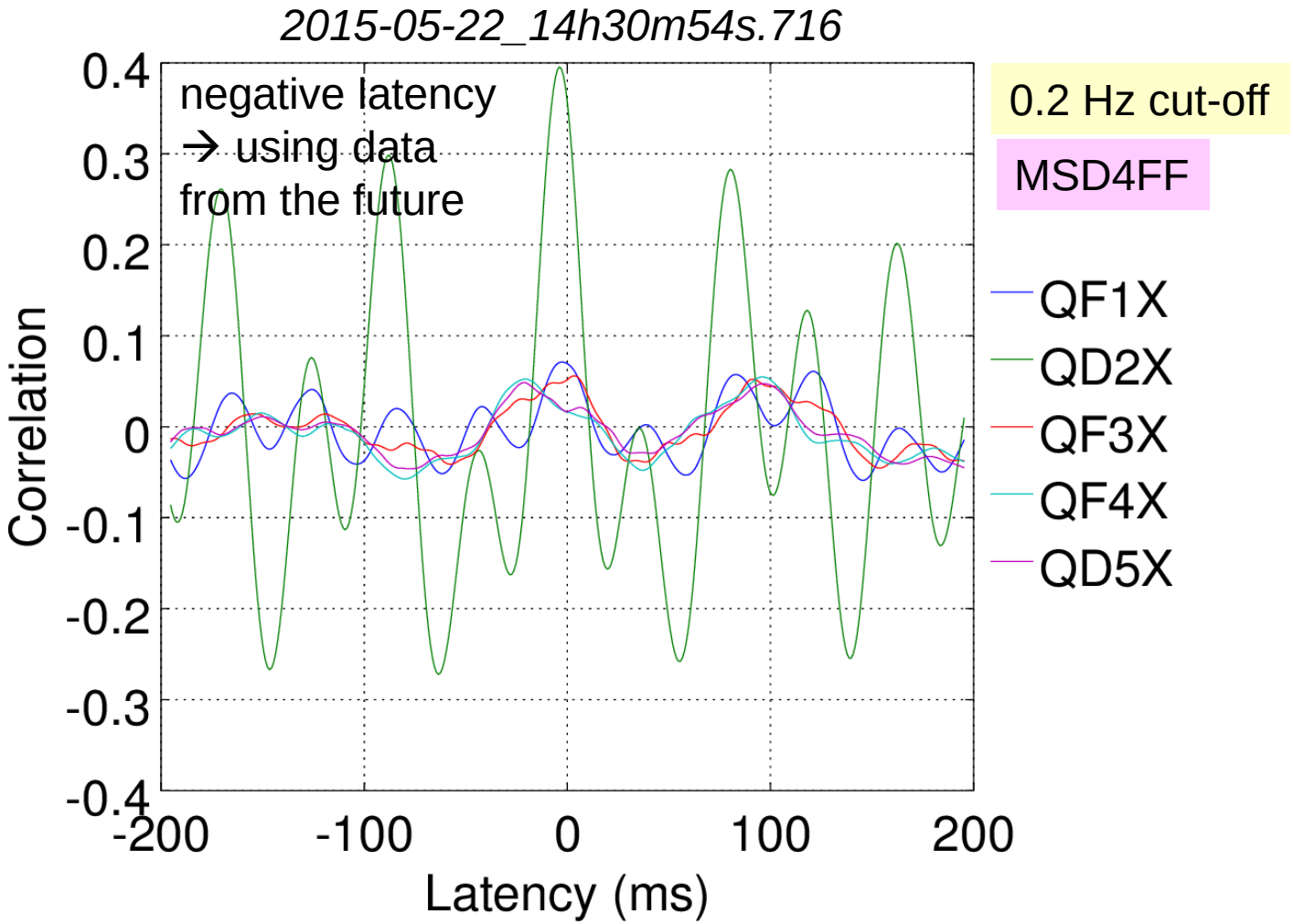
May: data_20150522_1430
Dec: run10_20151214



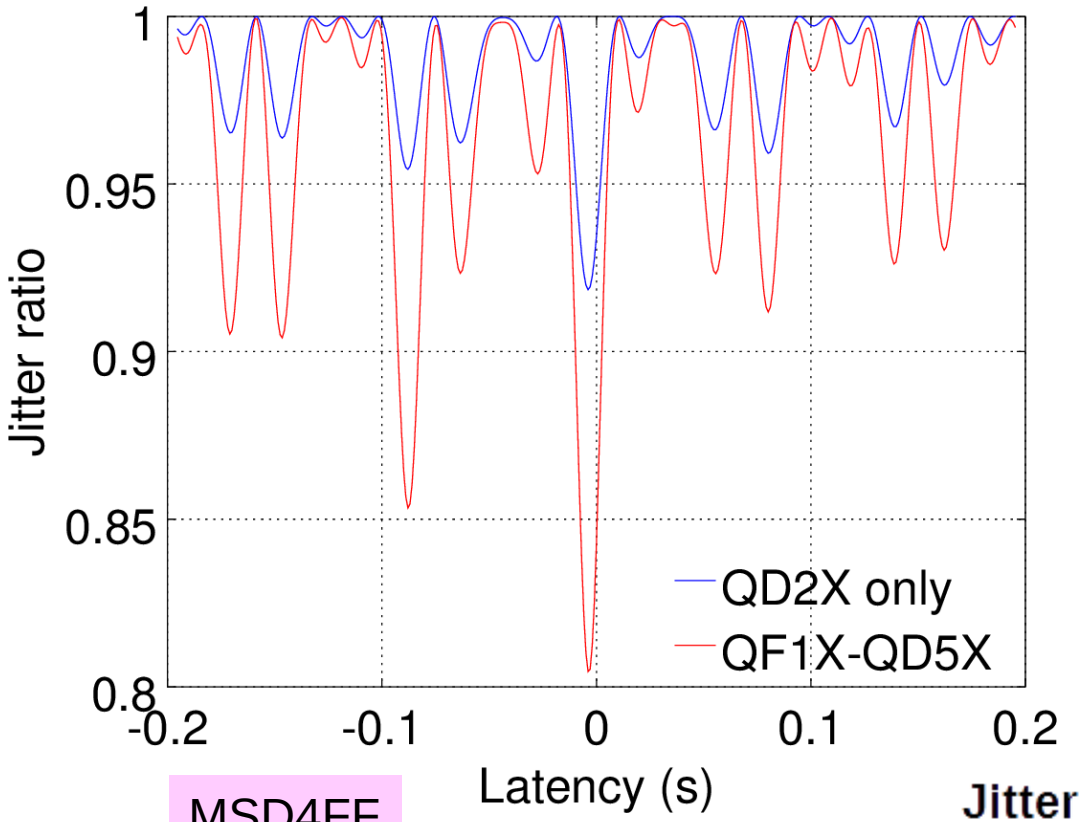
Latency

- Finite processing time of components (sensors, feed-forward controller) means that correction inevitably based on measurements that are slightly “out of date”.
- As sensor data oversampled relative to BPM data, effect of latency can be estimated by selecting from sensor data different samples to those identified using the synchronization signal.

Latency: effect on correlation



Latency: effect on correction



MSD4FF

0.2 Hz cut-off

2015-05-22_14h30m54s.716

- Fit BPM data as function of sensor data.
- Simulate feed-forward correction by subtracting fit data from actual BPM data.
- Divide the jitter of the “corrected” data by the jitter of the actual data to get the jitter ratio.

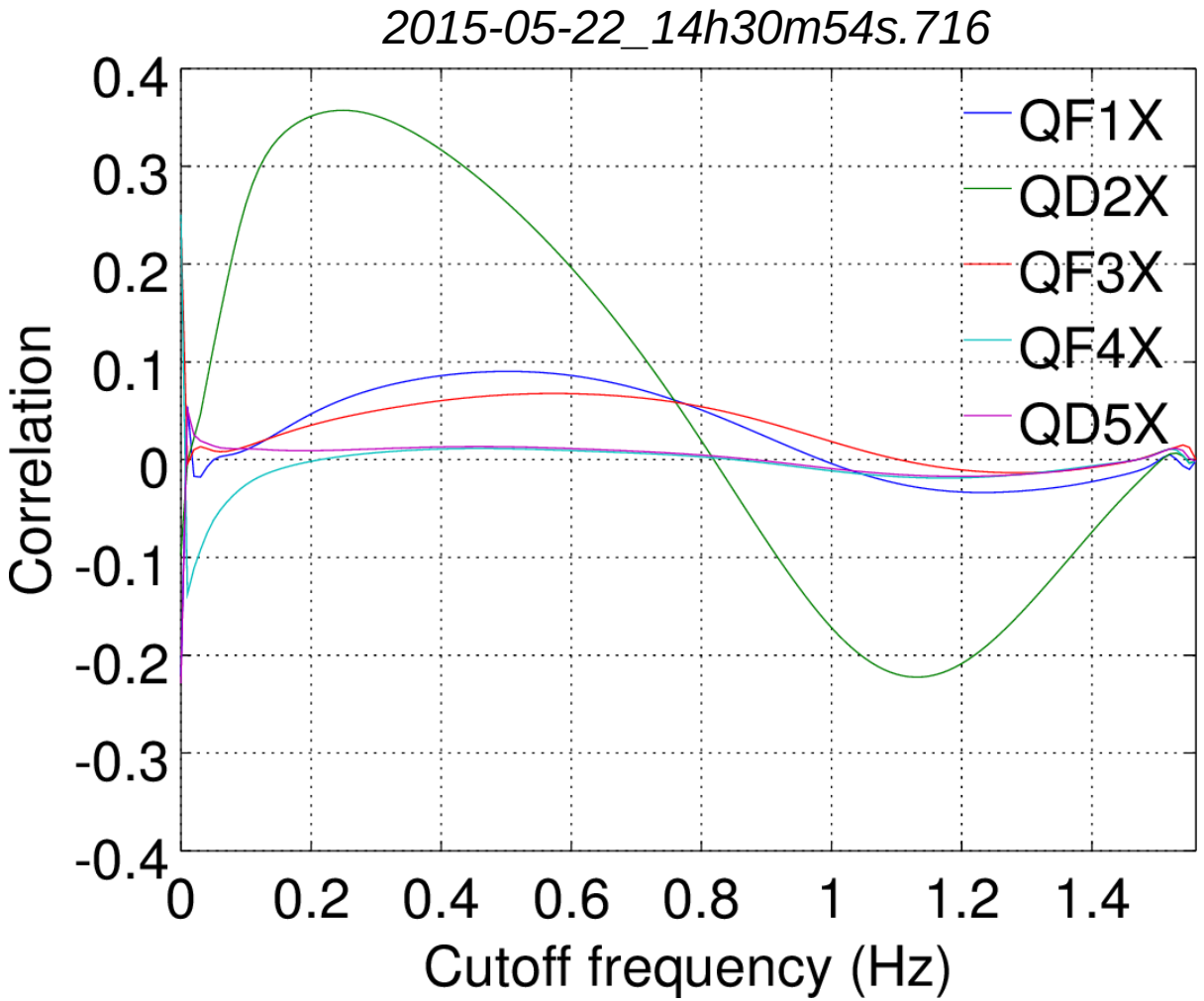
Jitter reduction

Latency (samples)	0	-4
QD2X only	6.5%	8.2%
QF1X-QD5X	15.7%	19.5%

2. Filter cut-off frequency

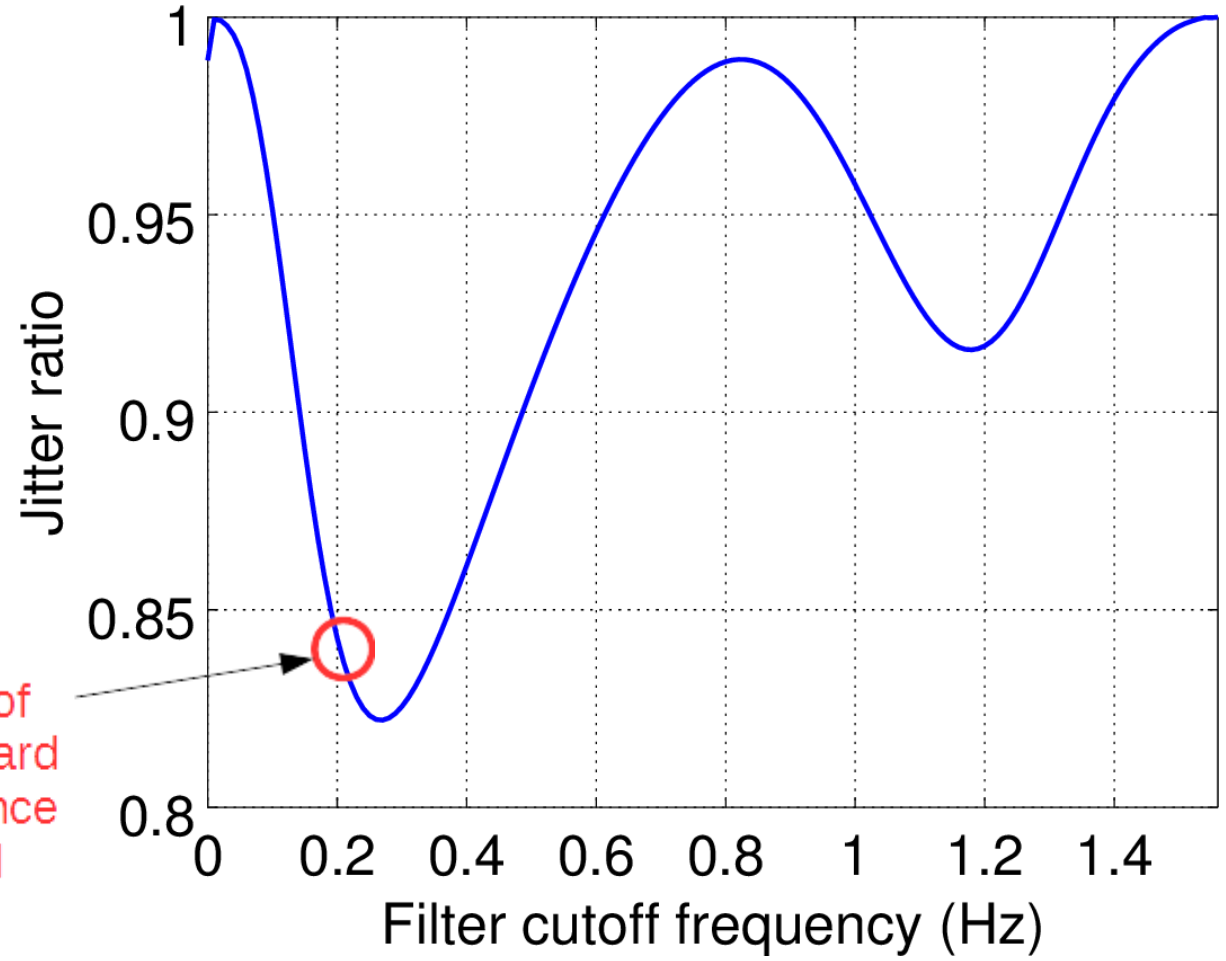
- Traditional analysis used high-pass filter with cutoff frequency of 0.208 Hz
- Justified by a review of sensor performance (“sensor noise contributions are high”)
- How does the frequency of the filter affect the results?

Filter: effect on correlation



MSD4FF

Filter: effect on correction

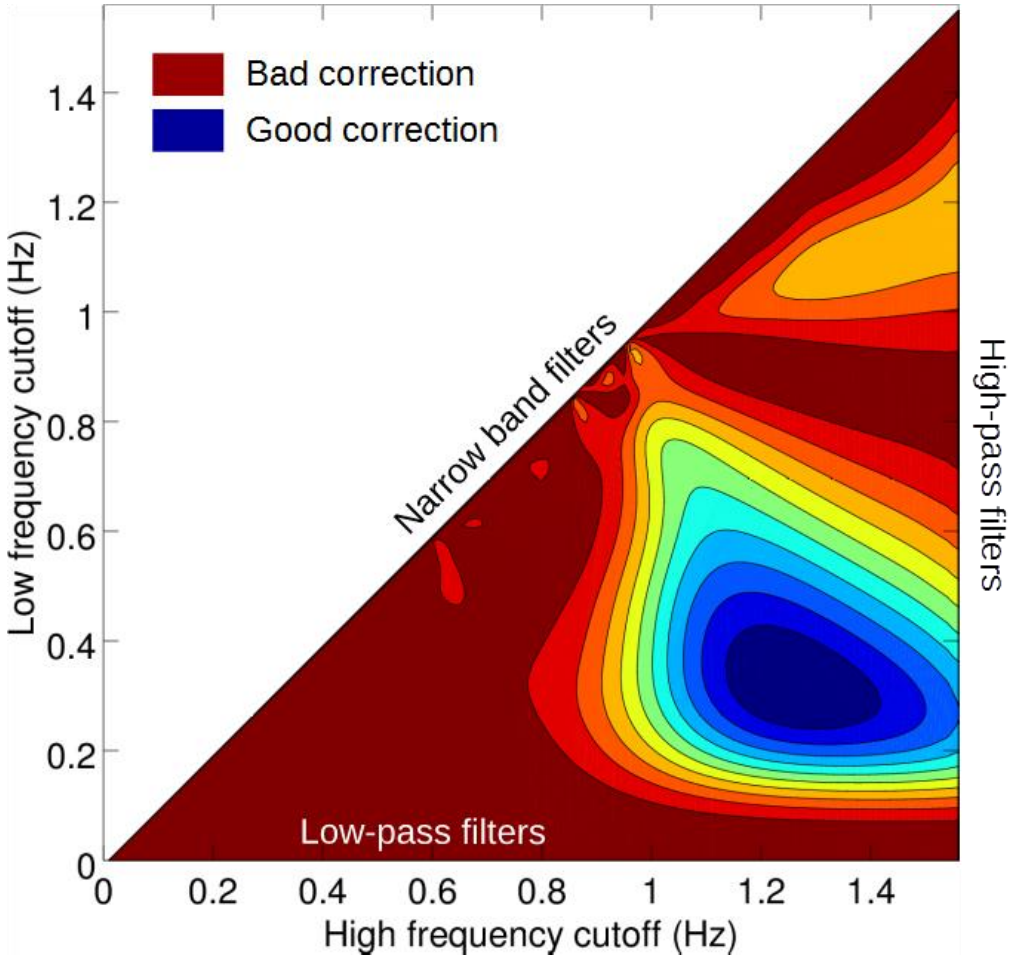


MSD4FF

Fit using sensors 1-5

Estimate of feed-forward performance presented at LCWS

Band-pass filtering



MSD4FF

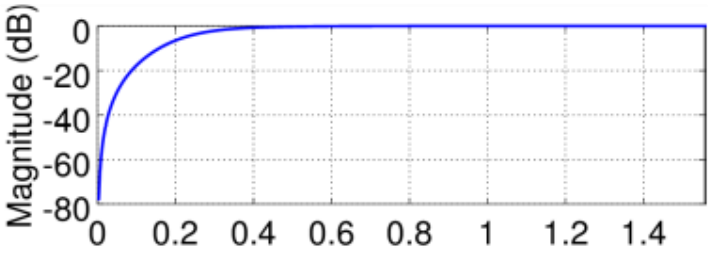
Fit using sensors 1-5

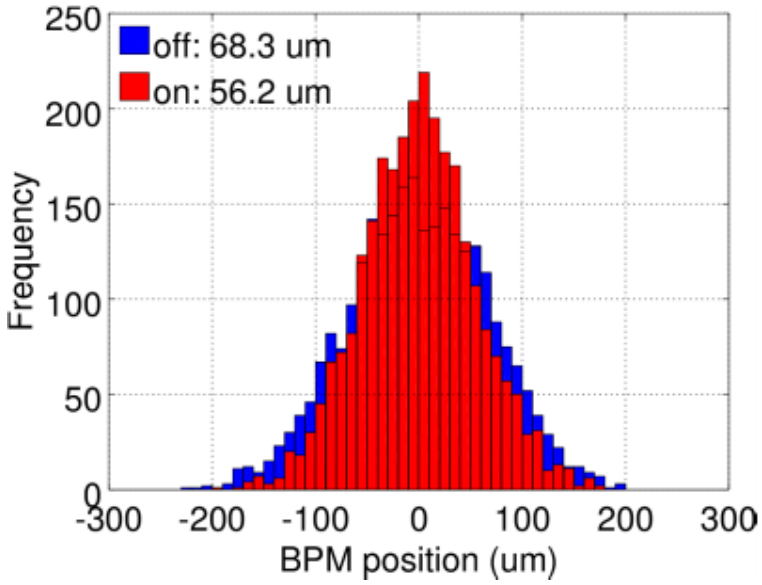
MSD4FF

Performance comparison

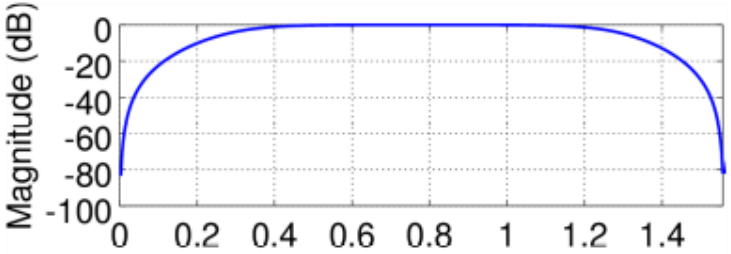
Fit using sensors 1-5

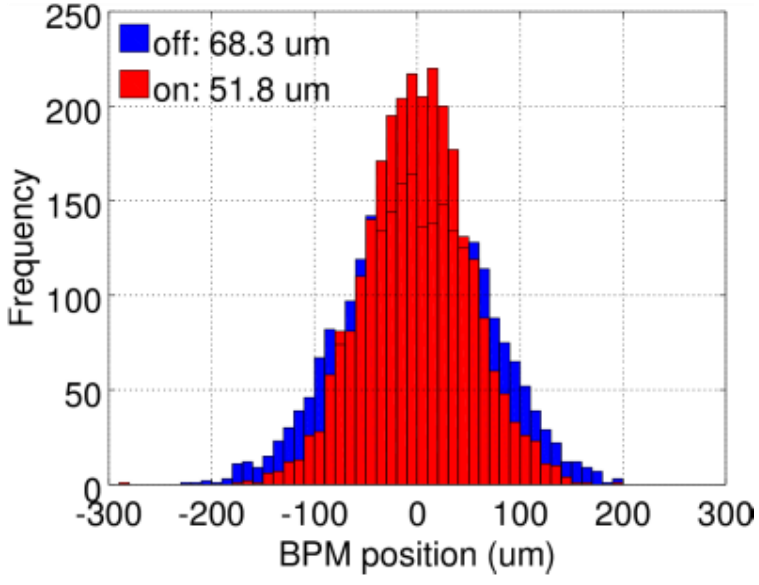
High-pass filter
> 0.27 Hz
18% reduction in jitter





Band-pass filter
0.32 Hz – 1.26 Hz
24% reduction in jitter





Summary

- Latency
  - Using a small negative latency instead of zero increases performance of feed-forward system by 25%
  - Possibly indicates intrinsic delay in ground motion measurements
- Filter frequency
  - Tuning the limits of a band-pass filter increases performance by 50% compared to using a 0.2 Hz high-pass filter
- The two effects do not “stack”
  - Using optimal filtering, the optimal latency shifts to -2 samples and the increase in performance is reduced to 6%

Conclusion

- To demonstrate ground motion feed-forward need to be able to reliably determine the BPM-sensor correlations
  - oversample BPM data / use PXI system to evaluate correlations
- Correction value transmitted to FONT5 board when trigger received by CompactRIO – need to ensure that this occurs far enough in advance of the bunch for the value to be updated
  - new NI 9401 module makes a non-software solution possible
- Band-pass filtering the ground motion data likely to improve the results