Ground motion study in ATF2

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18th ATF2 Project Meeting
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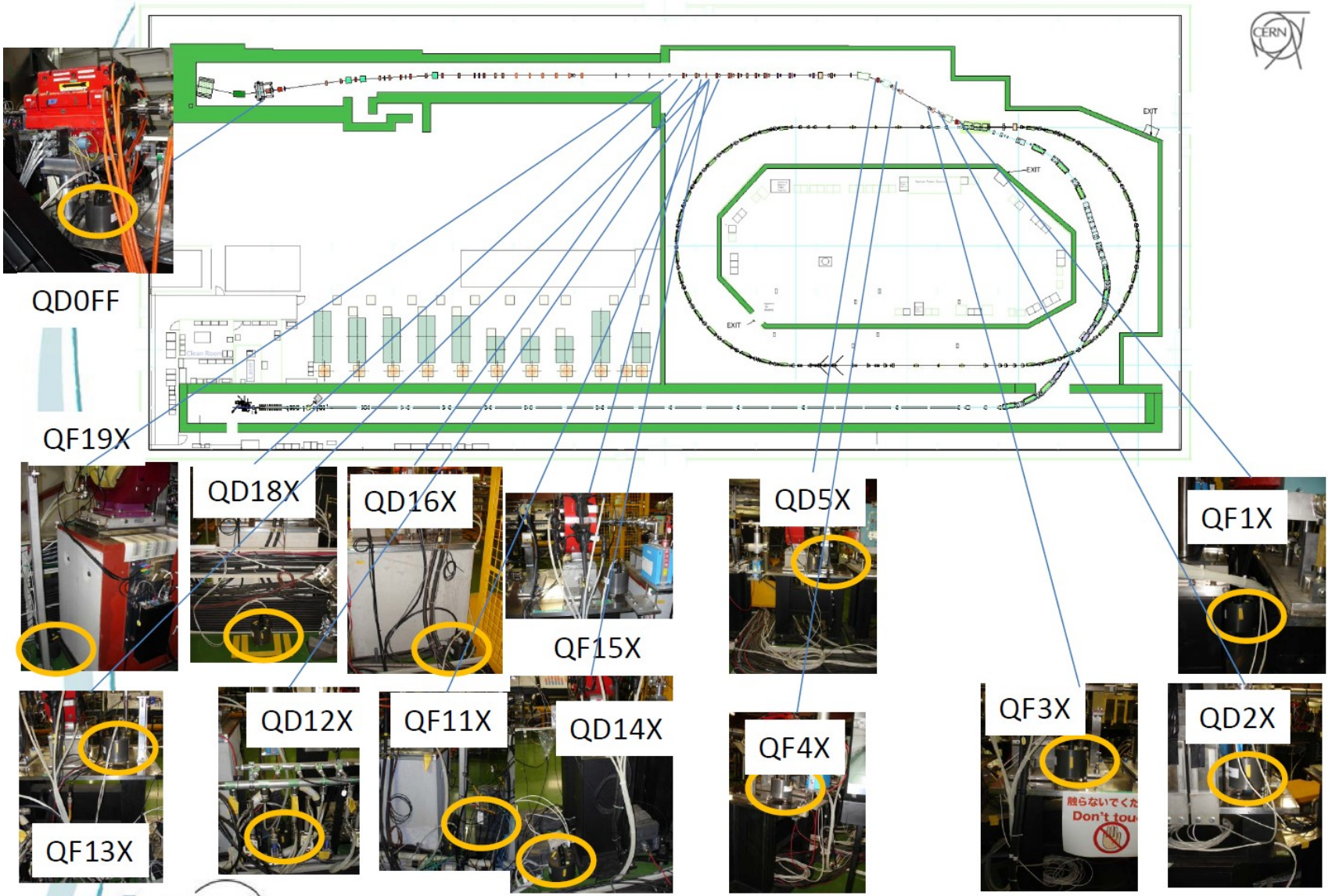
Outline

A) Comparison of Ground Motion and BPM data May/June 2014 – December 2014

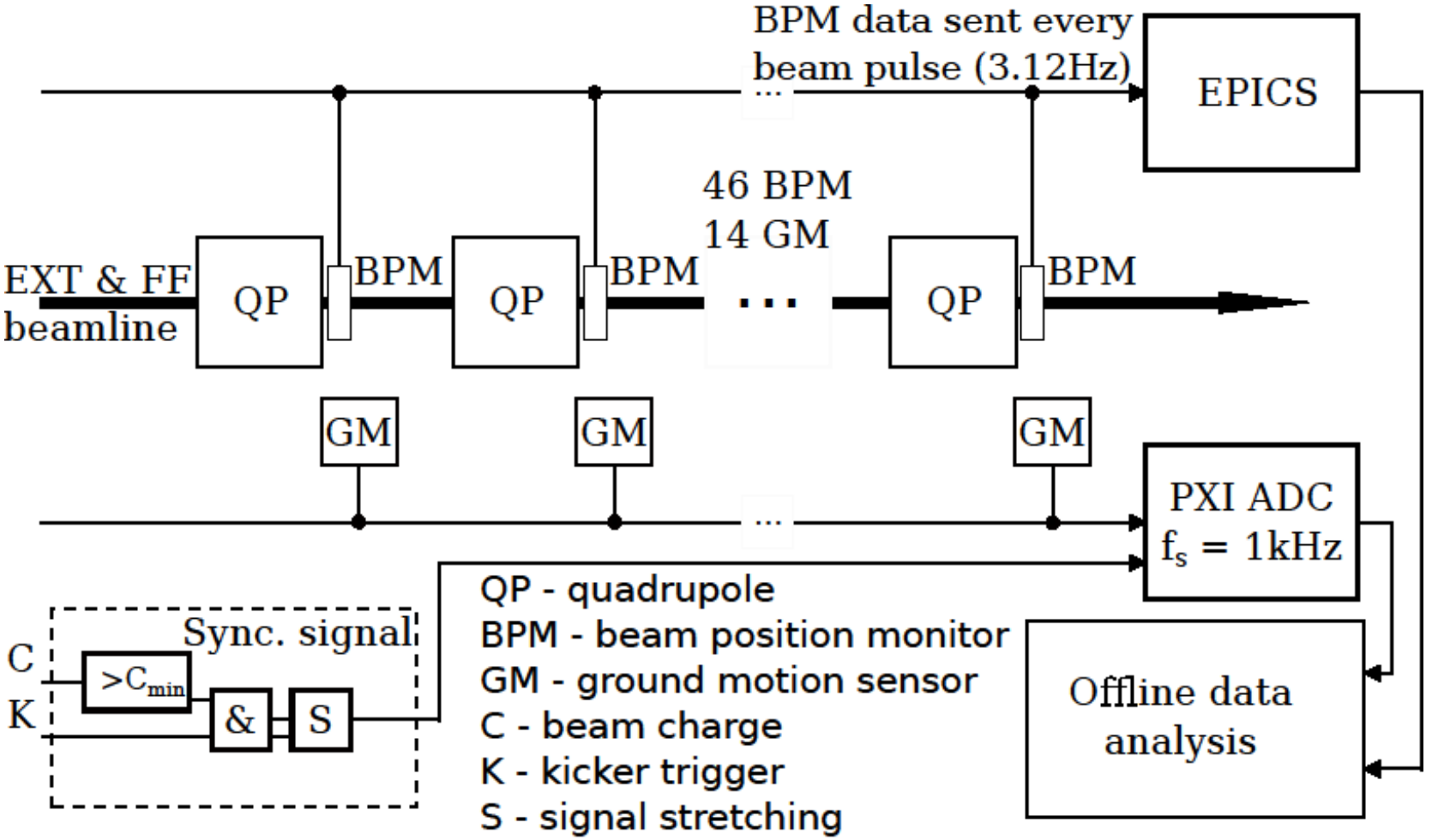
B) Investigation of QD10AFF region (October data) – suspect of vibrations being transmitted from cooling water pipes to the beamline.

C) Sensor location – why top of the quadrupole is better than any other location?

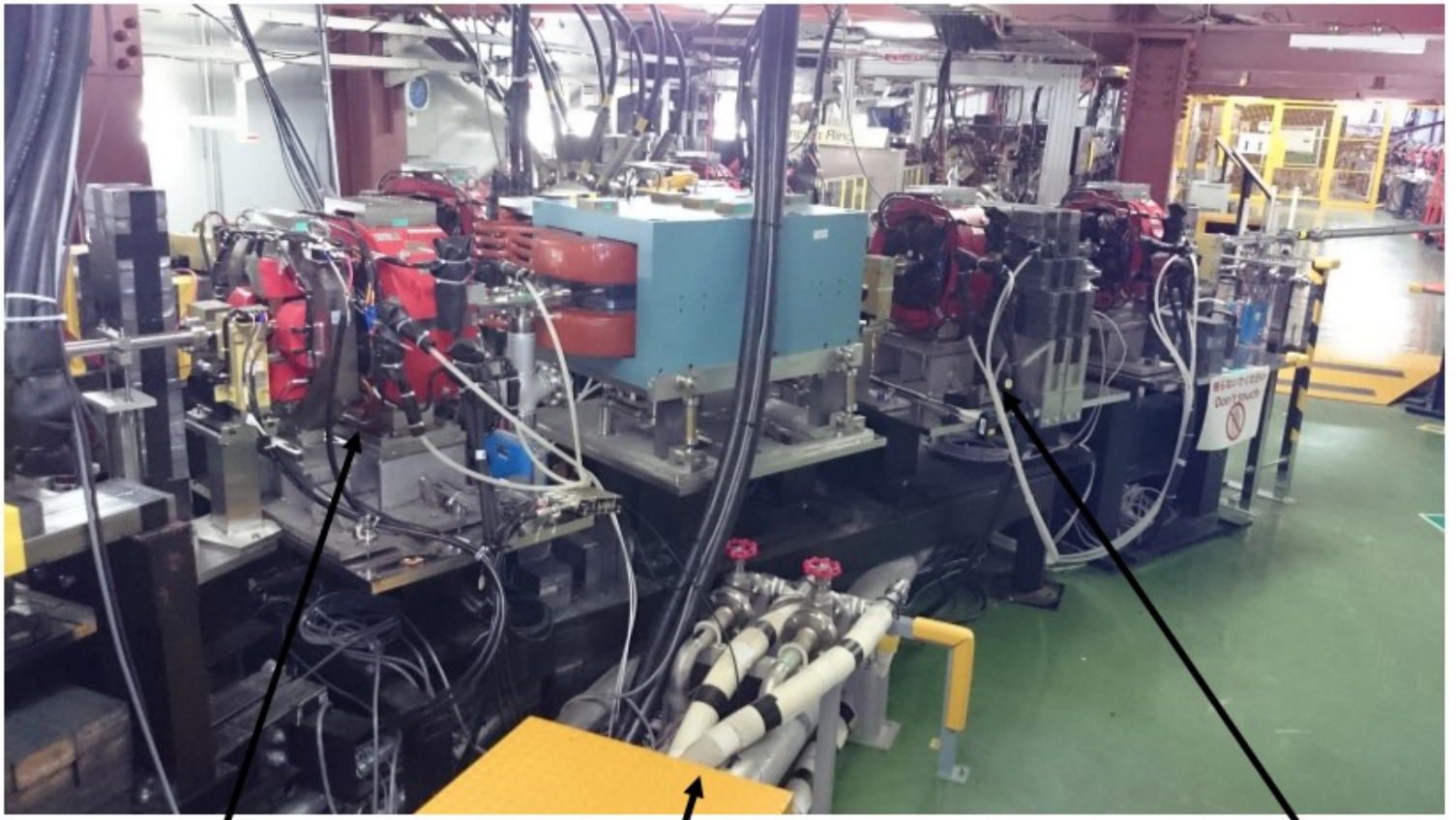
Quick reminder:
sensors locations



Quick reminder:
experimental setup

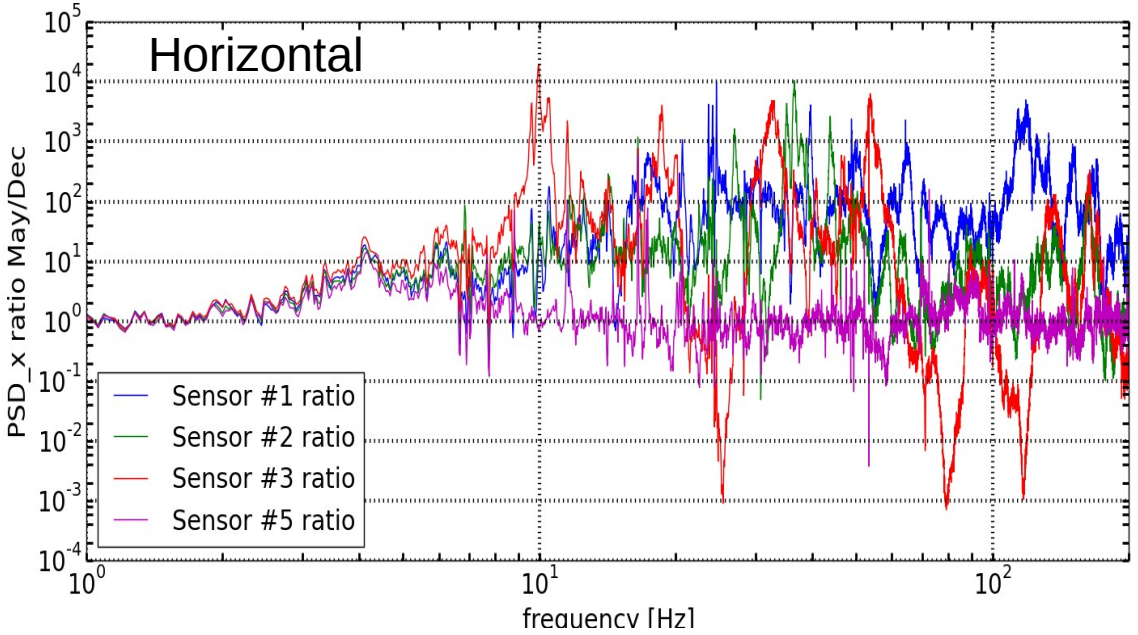


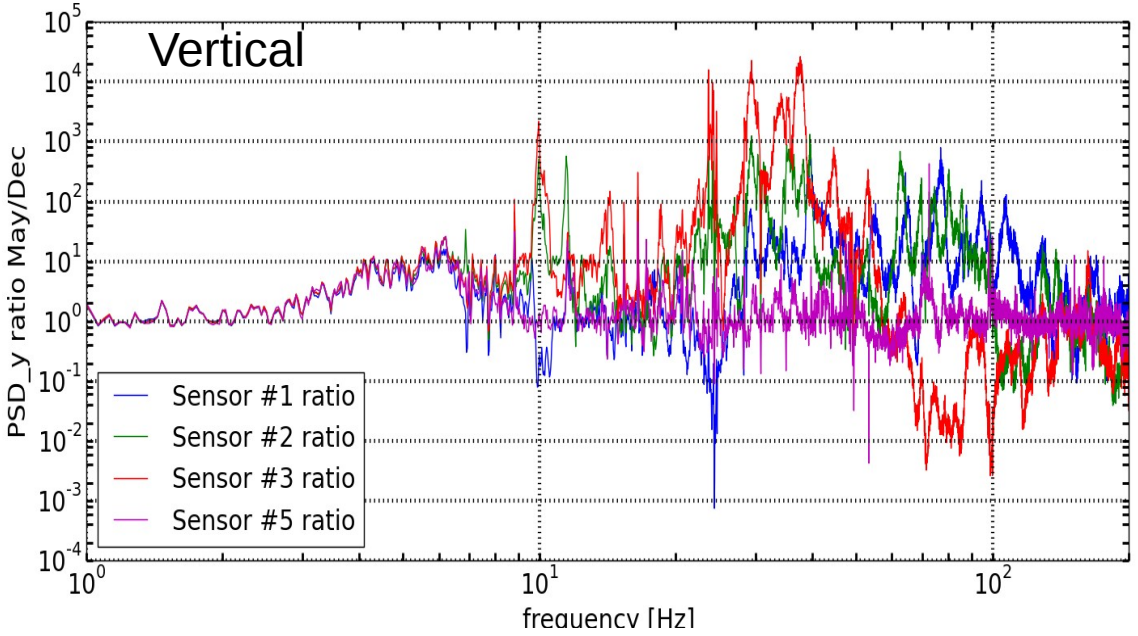
Quick reminder:
Vibration source around QF1X and QD2X removed in May/June



A. Comparison of GM and BPM data
May/June 2014 – December 2014

Ratio of PSD for horizontal and vertical vibration: May/Dec





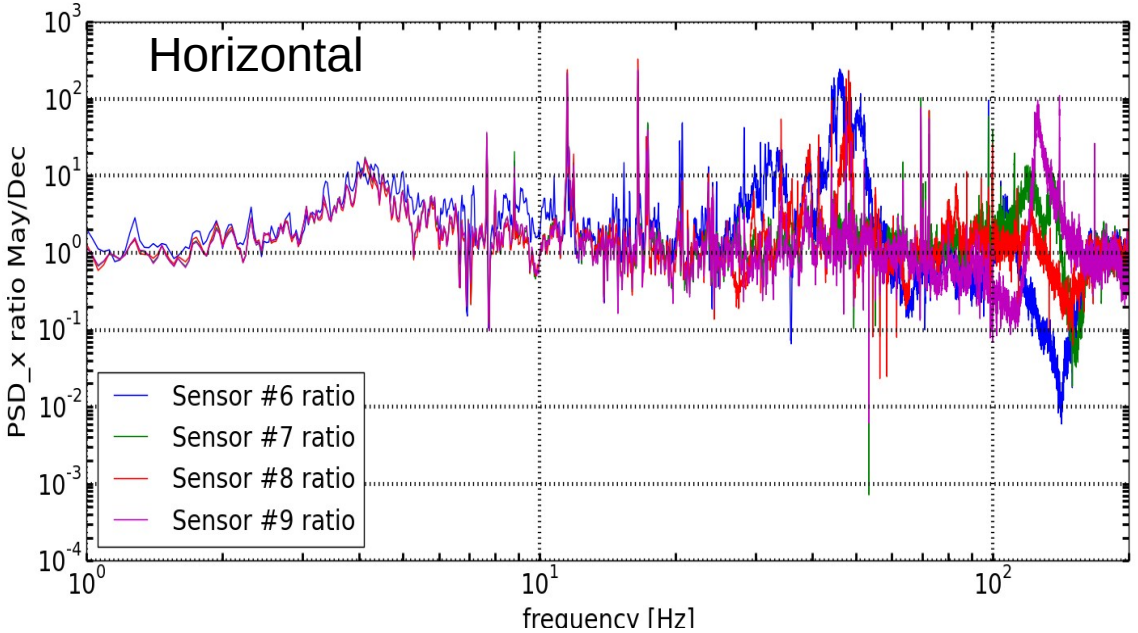
- S1 – next to QF1X
- S2 – next to QD2X
- S3 – next to QF3X
- S4 – next to QF4X
- S5 – next to QD5X

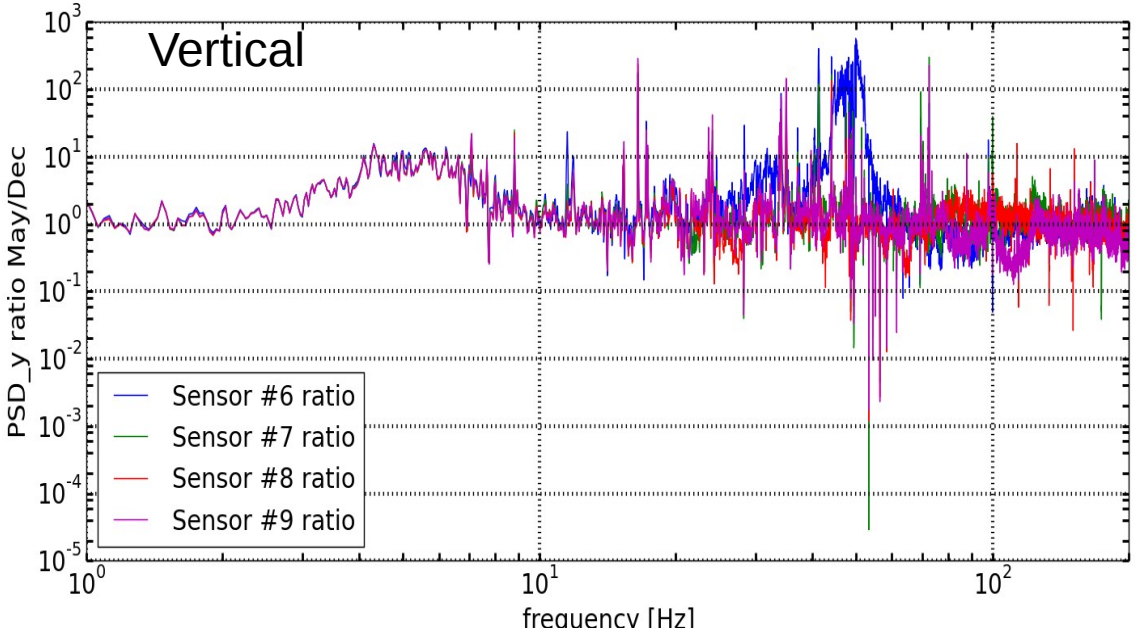
- Sensors 1,2,3 were vibrating much stronger in May than in Dec.

- Sensor 4 was not working in May (now it works – fixed by A. Jeremie and myself in Oct.)

- Sensor 5 shows similar vibration as in May

Ratio of PSD for horizontal and vertical vibration: May/Dec





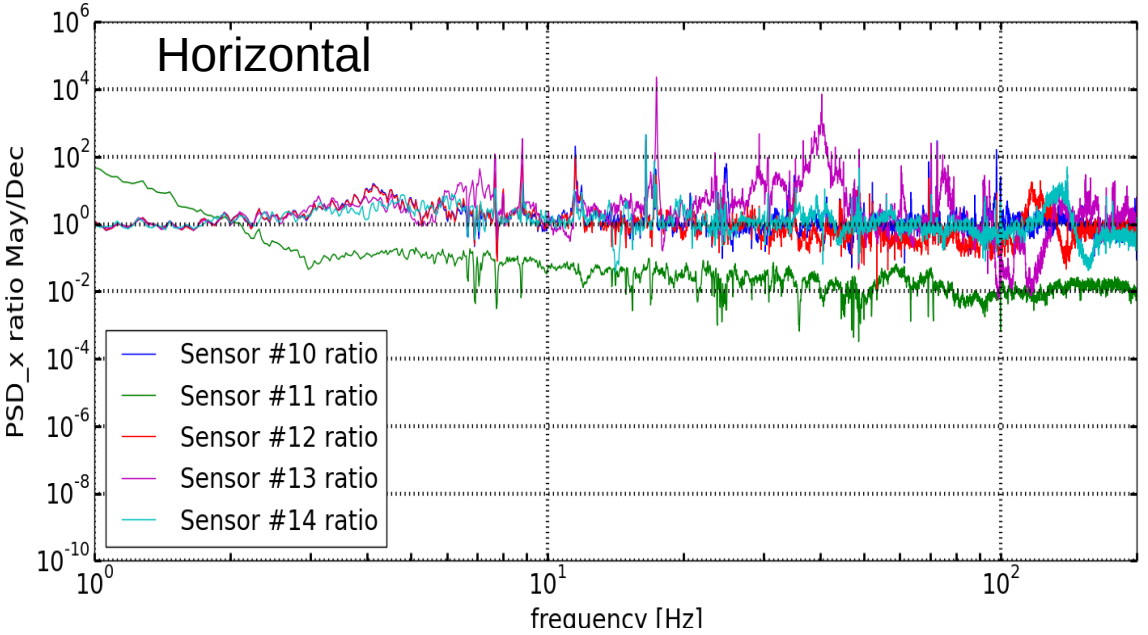
- S6 – next to QF11X
- S7 – next to QD12X
- S8 – next to QF13X
- S9 – next to QD14X

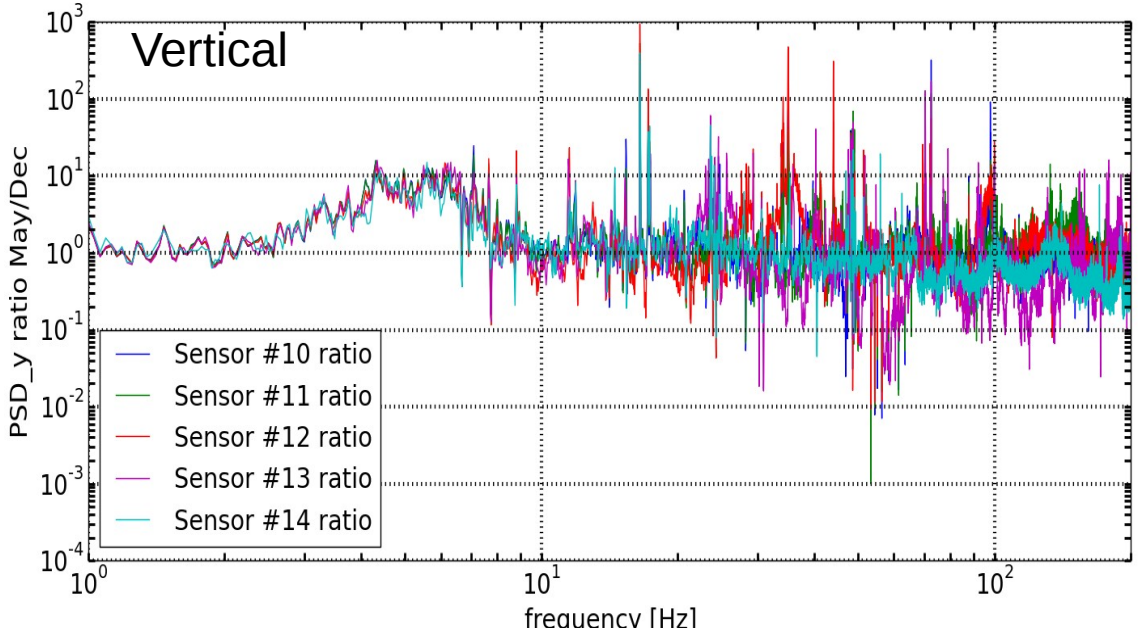
- Most of the sensors show similar vibrations as in May

- Sensors 6 and 8 were vibrating stronger for around 50Hz in horizontal direction

- Sensor 6 was vibrating stronger for around 50Hz in vertical direction

Ratio of PSD for horizontal and vertical vibration: May/Dec





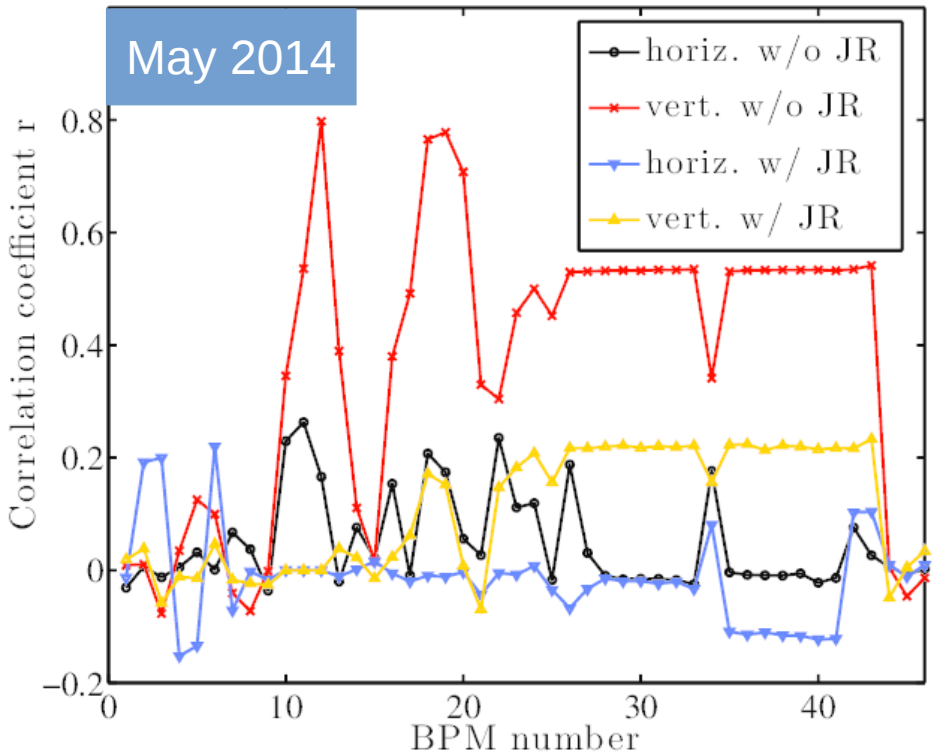
- S10 – next to QF11X
- S11 – next to QD12X
- S12 – next to QF13X
- S13 – next to QD14X
- S14 – next to QD0FF

- All sensors except of 11 show similar vibrations as in May

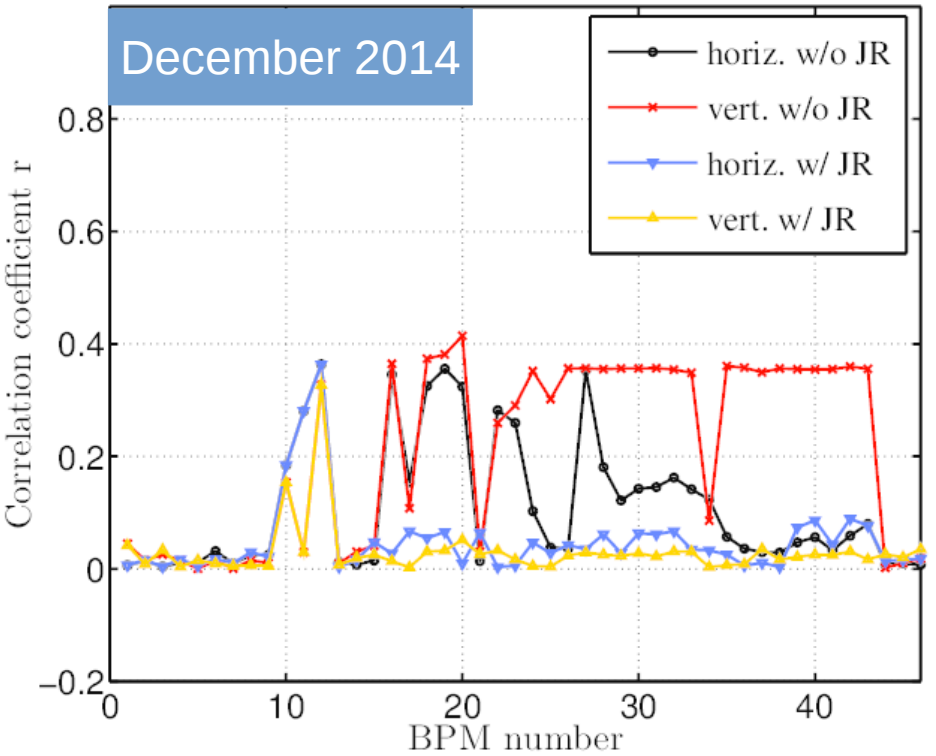
- Sensor 11 vibrates horizontally much stronger in Dec than in May. New vibration source?

- Sensors 13 cannot be compared (different location in Dec.)

Correlation coefficient along the beamline (May and December comparison)



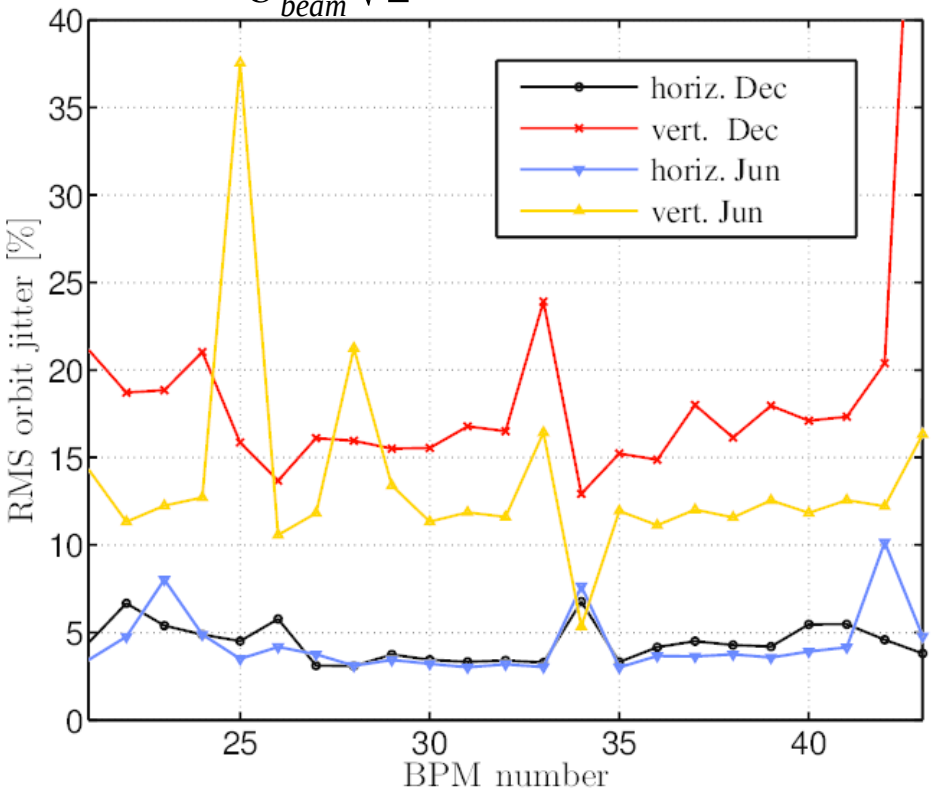
- $10\beta_x 1\beta_y$ optics (β_x= 40mm, β_y=100μm);
- BPMs #10,11,12 are used for jitter reduction (JR);
- In May there was a vibration source downstream from BPMs #10,11,12 (next to QD10X, QF11X, QD12X);



- This vibration source was removed (maybe during the OTRs investigation?);
- The only source left is upstream from BPMs #10,11,12;
- In May sensors #1,2,3 were installed on the top of QPs, in Dec next to Qps
- More horizontal correlation in Dec. (S11?)

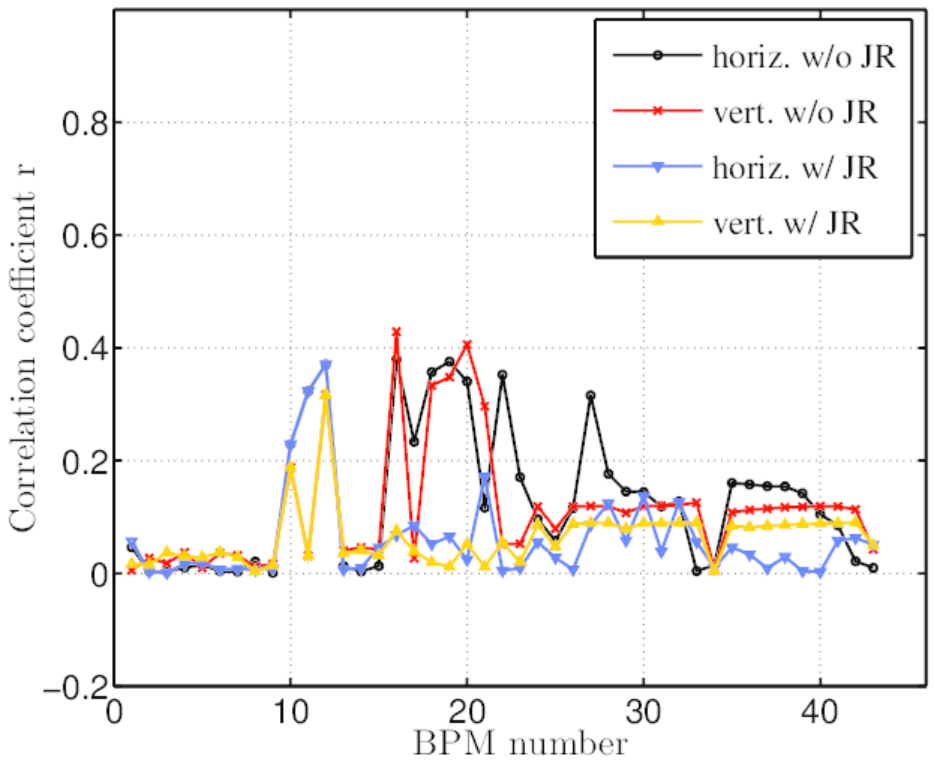
Beam orbit jitter in June and December $10\beta_x 1\beta_y$ optics

$$\frac{std\left(BPM_{n+1} - BPM_n\right)}{\sigma_{beam}\sqrt{2}}$$



- The horizontal beam orbit jitter is kept on 5% level;
- The vertical beam orbit jitter measured in December increased to ~18%;
- It is equivalent to ~1.5% increase of the vertical beam size.

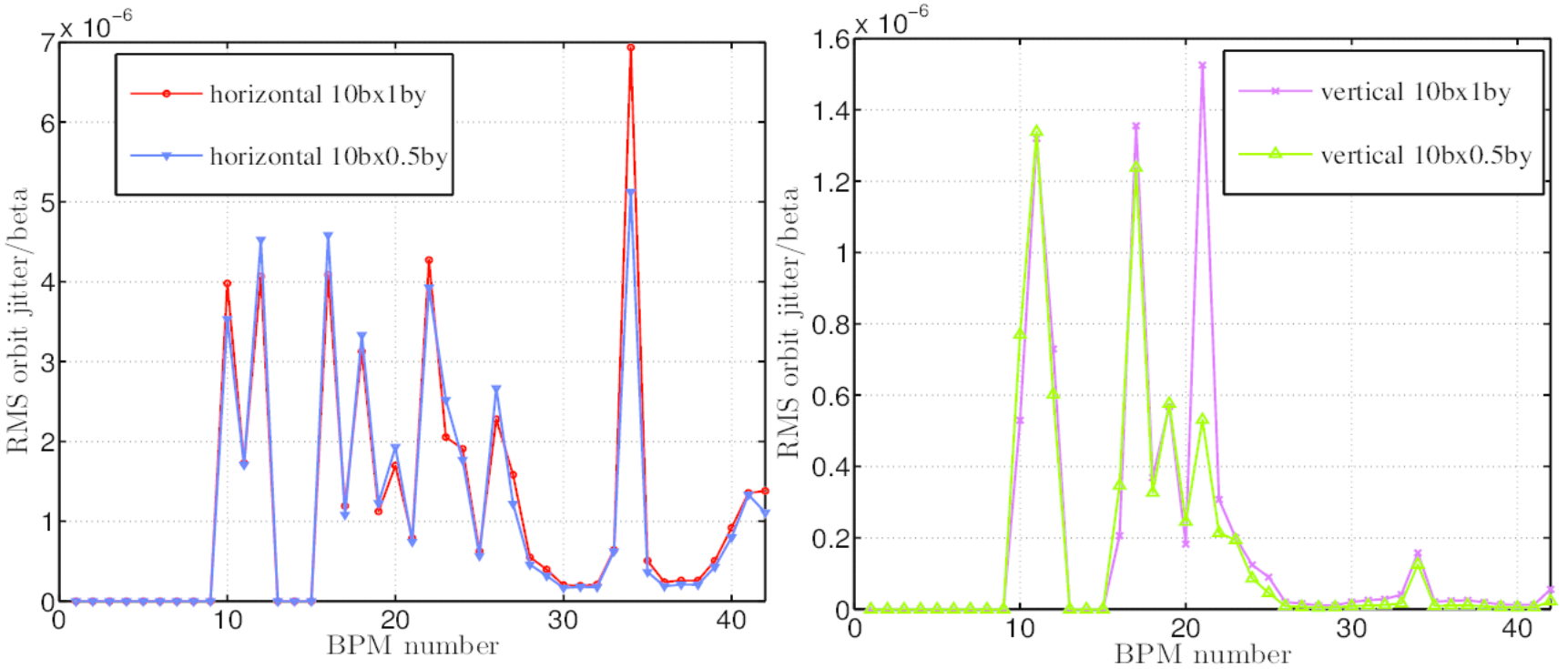
Correlation coefficient for $0.5\beta_y^*$ (50 μm)



- Horizontal correlation higher for $0.5\beta_y$* optics;
- Vertical correlation lower for $0.5\beta_y$* optics;
- However, vertical correlation is still present for after jitter reduction (JR);
- Further investigation is needed...

Beam jitter for $10\beta_x 1\beta_y$ and $10\beta_x 0.5\beta_y$ optics normalized by β

$$\frac{std\left(BPM_{n+1}-BPM_n\right)}{\beta}$$



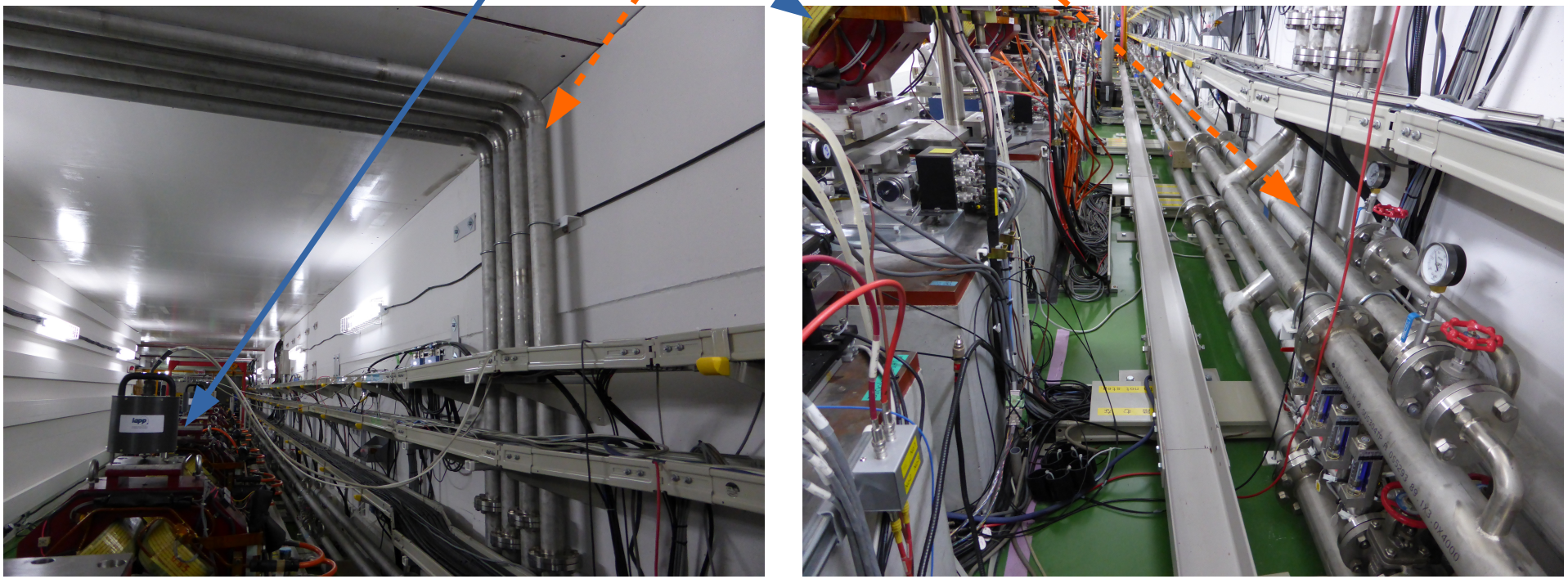
- Absolute beam orbit jitter normalized by β is nearly the same
- Both datasets taken in December

Summary A

- The most noisy region of sensor #1,#2,#3 vibrates much less in December than in May. However, in May sensors were placed on the top of QP, in Dec. next to QP.
- There is one, strong vibration source upstream from BPMs #10,#11,#12 responsible for the whole observed correlation.
- Vibration seen by sensors #6 and #8 in May was not observed in Dec.
- Sensor #11 shows stronger vibration in Dec. than in May.
- Beam orbit jitter has increased from ~14% to ~18%.

B. Investigation of QD10AFF region (October data) – suspect of vibrations being transmitted from cooling water pipes to the beamline.

Cooling water pipes near to QD10AFF magnet

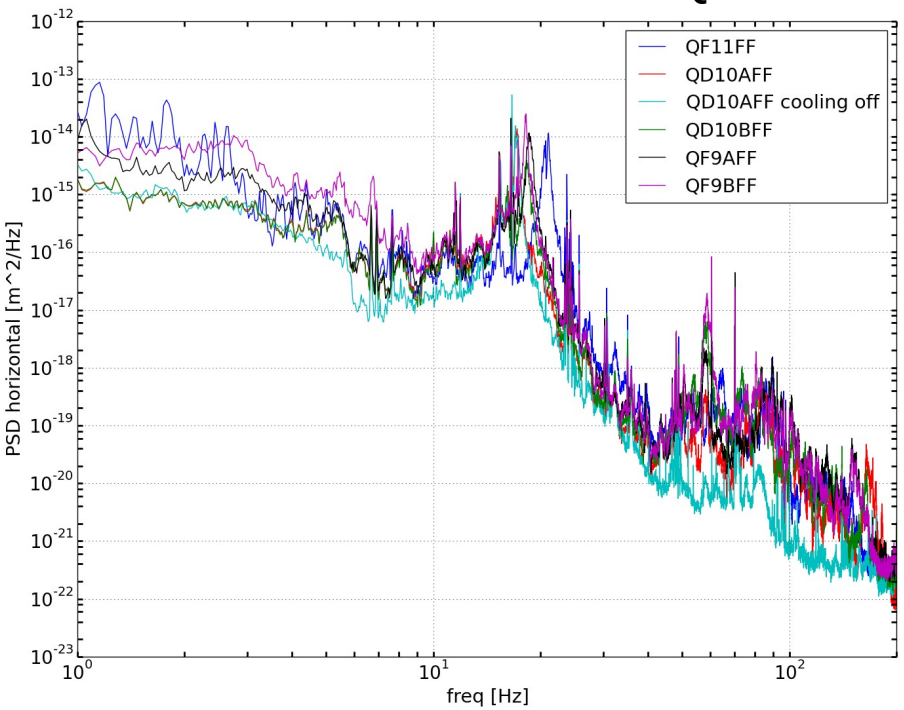


The cooling water pipes were responsible for the strong vibrations in the region of QF1X and QD2X magnets. Therefore, it was checked if the cooling water pipes near to QD10AFF are also source of vibrations.

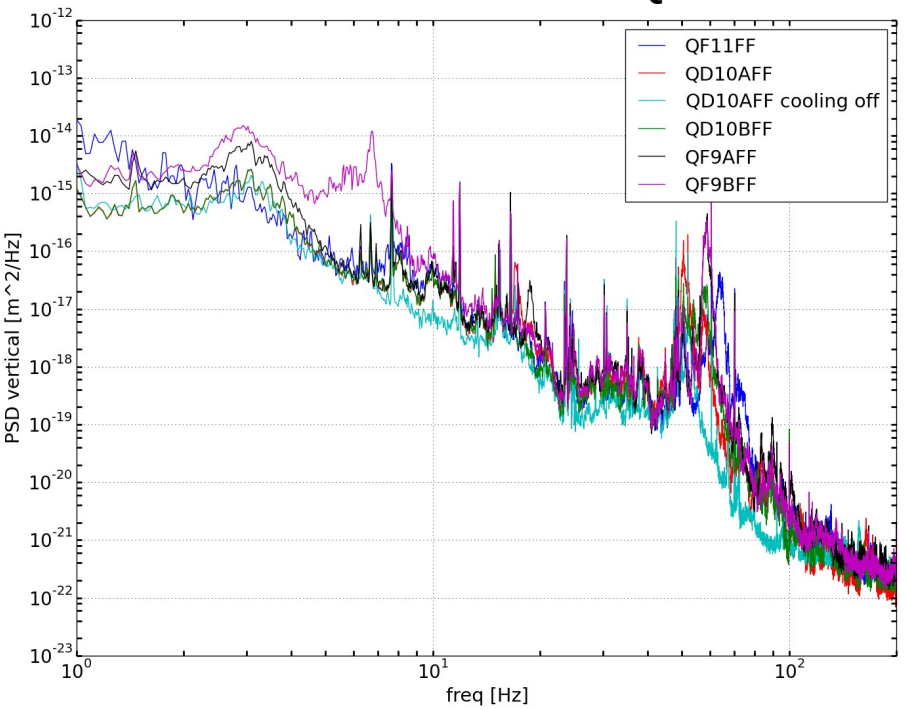
Cooling water pipes near to QD10AFF magnet

- Sensors placed on the top of quadrupoles (beginning of october):
  - QF9AFF
  - QF9BFF
  - QD10AFF:
    - Without cooling water
    - With cooling water
    - With cooling water + shims inserted under the support
  - QD10BFF
  - QF11FF

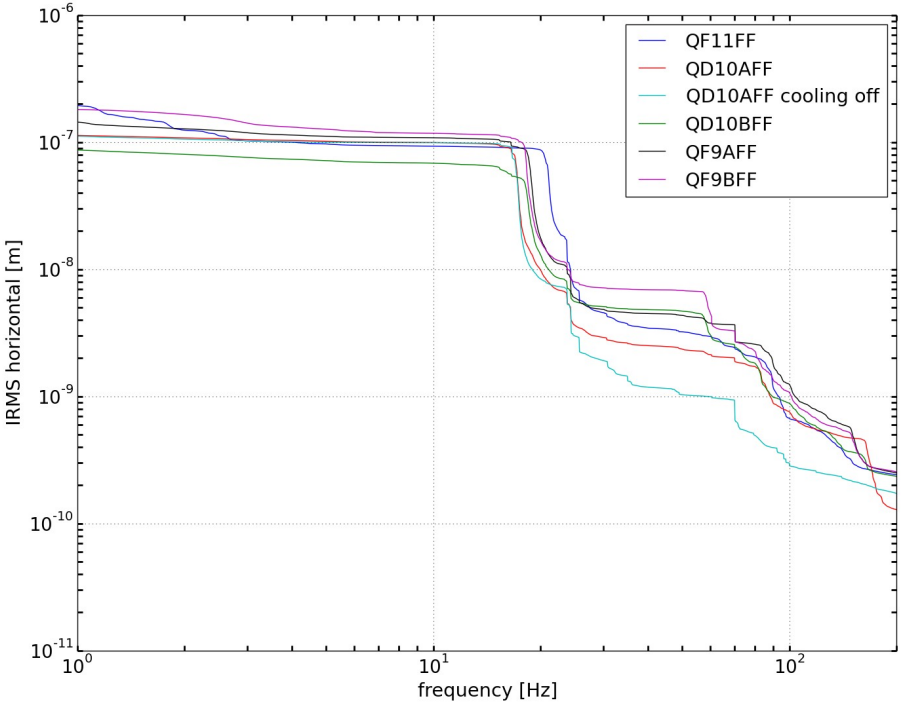
PSD of horizontal vibr. for 5 QPs in FF



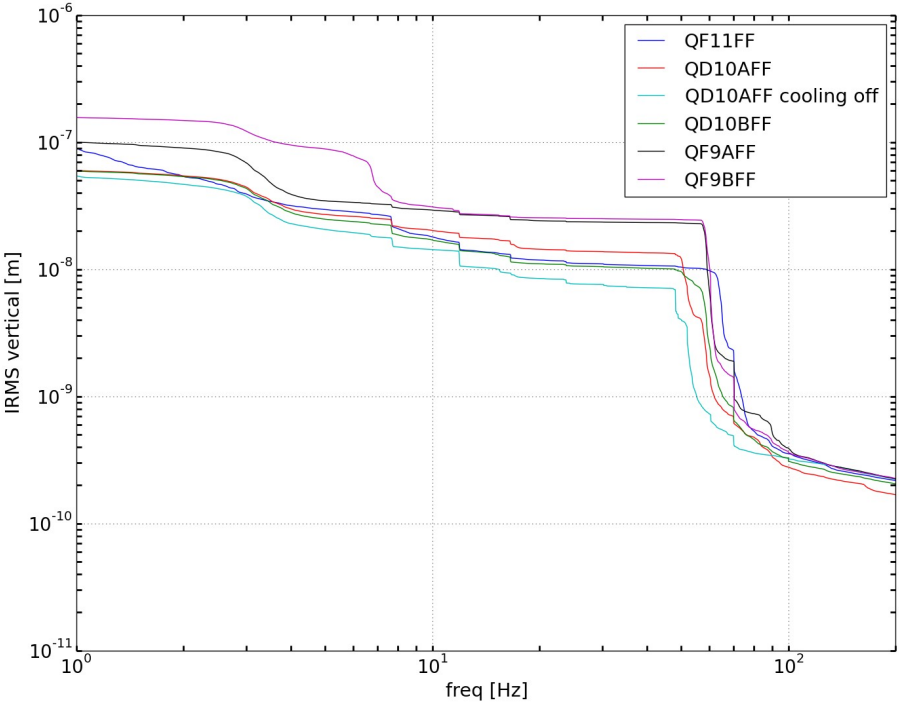
PSD of vertical vibr. For 5 QPs in FF



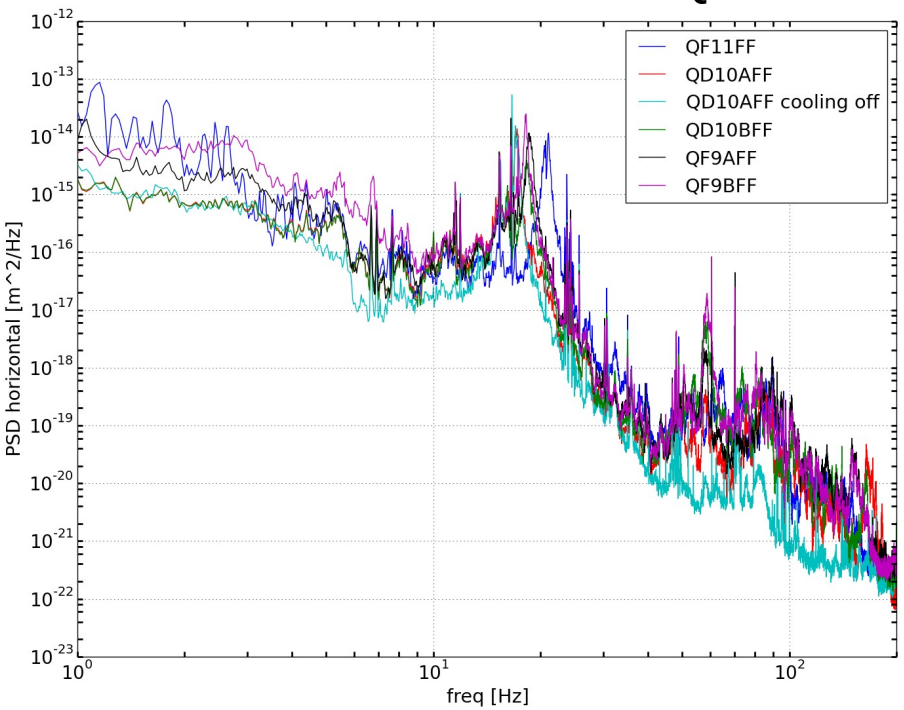
IRMS of horizontal vibr. for 5 QPs in FF



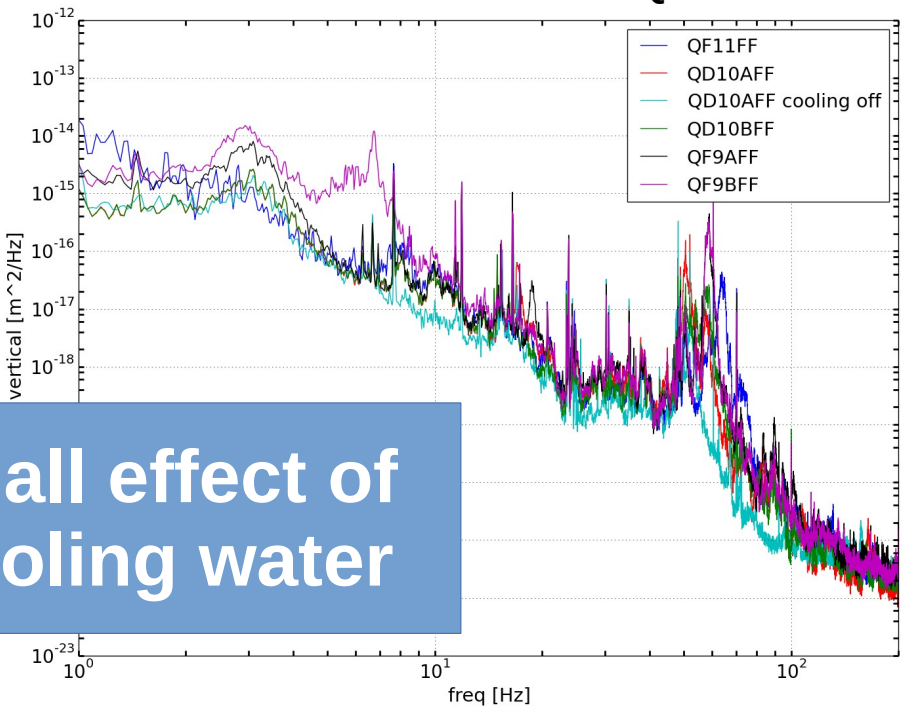
IRMS of vertical vibr. for 5 QPs in FF



PSD of horizontal vibr. for 5 QPs in FF

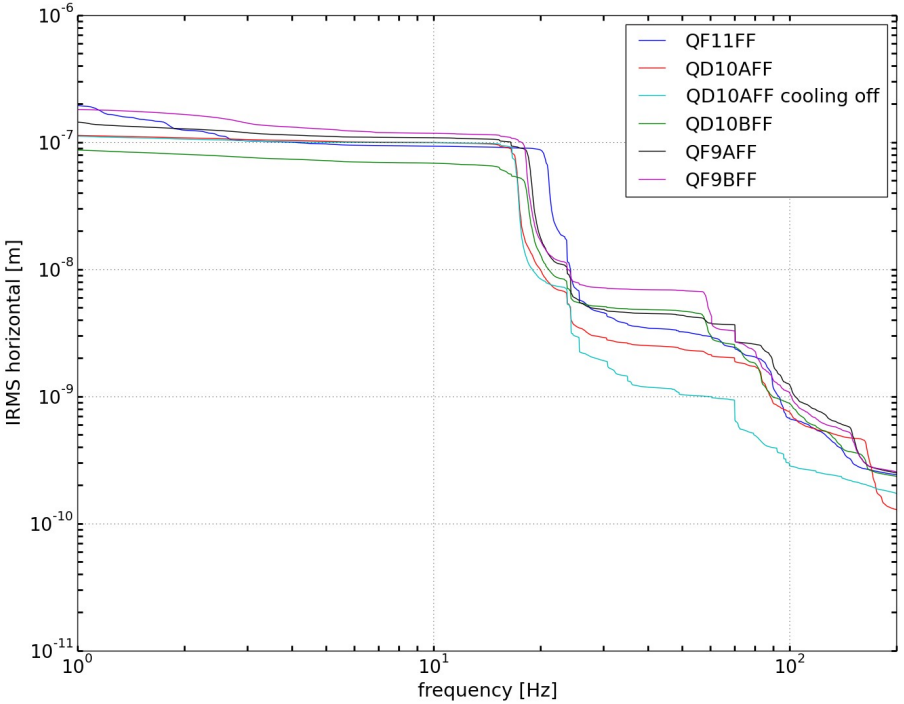


PSD of vertical vibr. For 5 QPs in FF

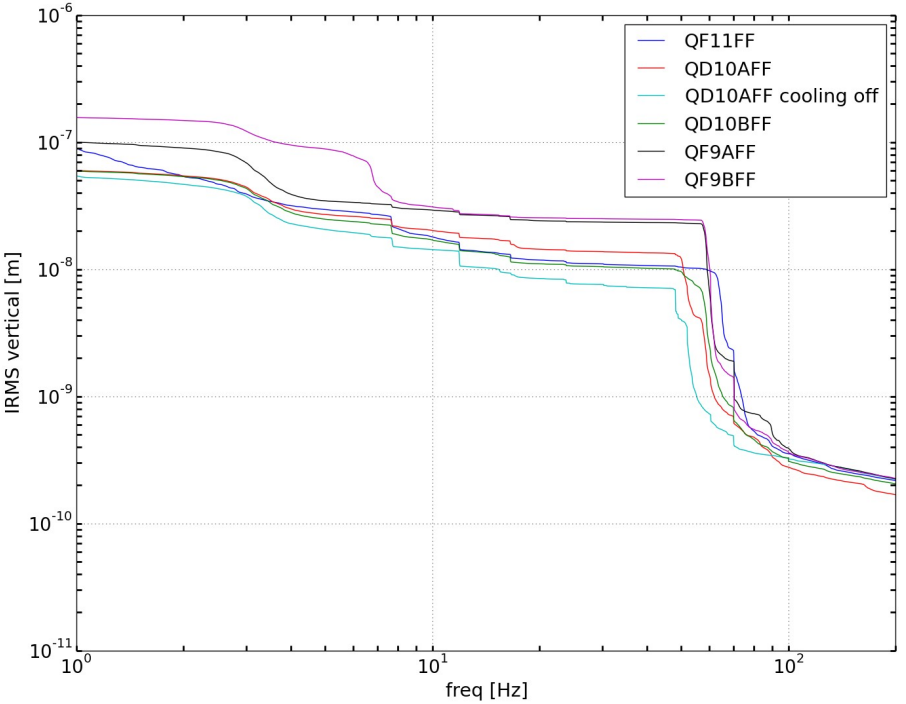


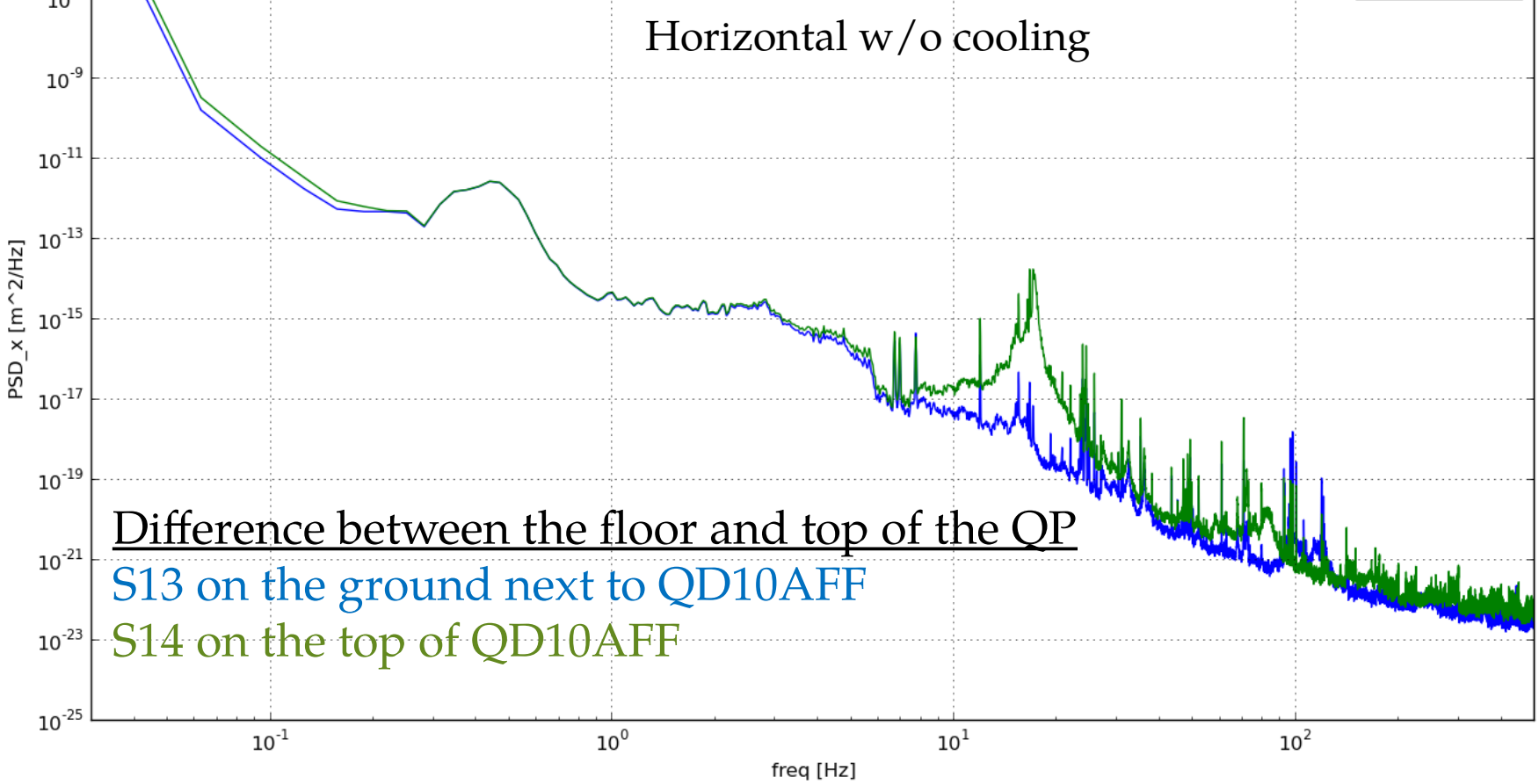
Small effect of cooling water

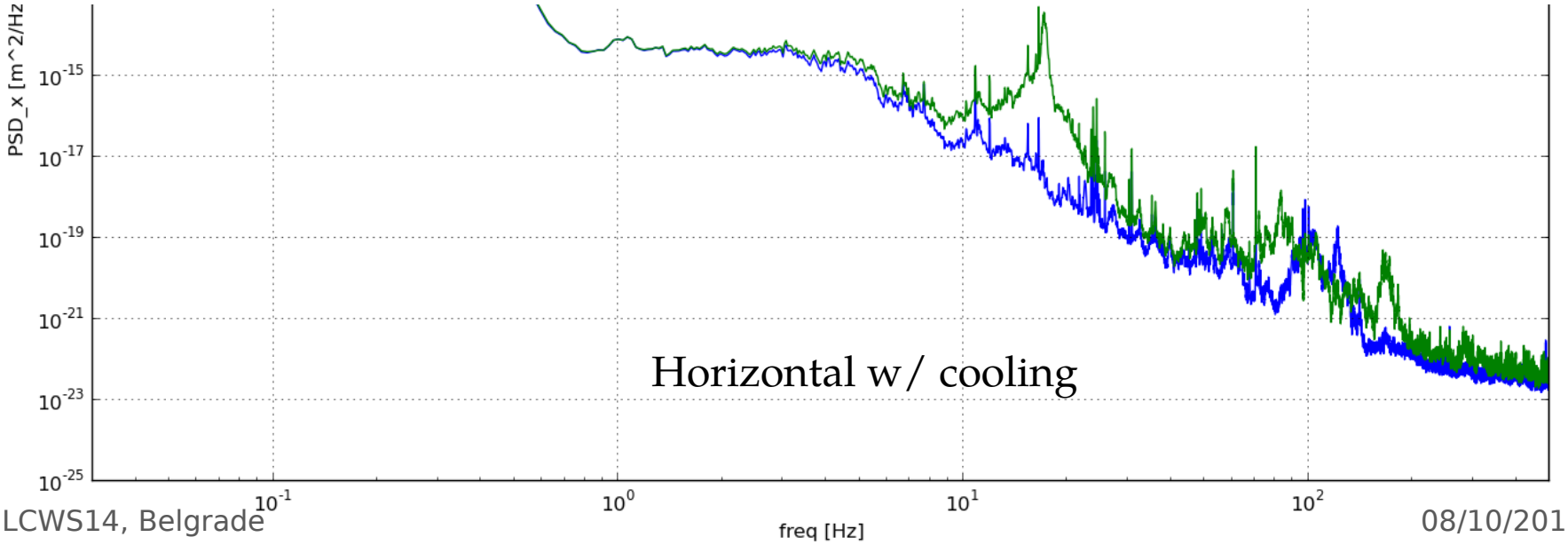
IRMS of horizontal vibr. for 5 QPs in FF

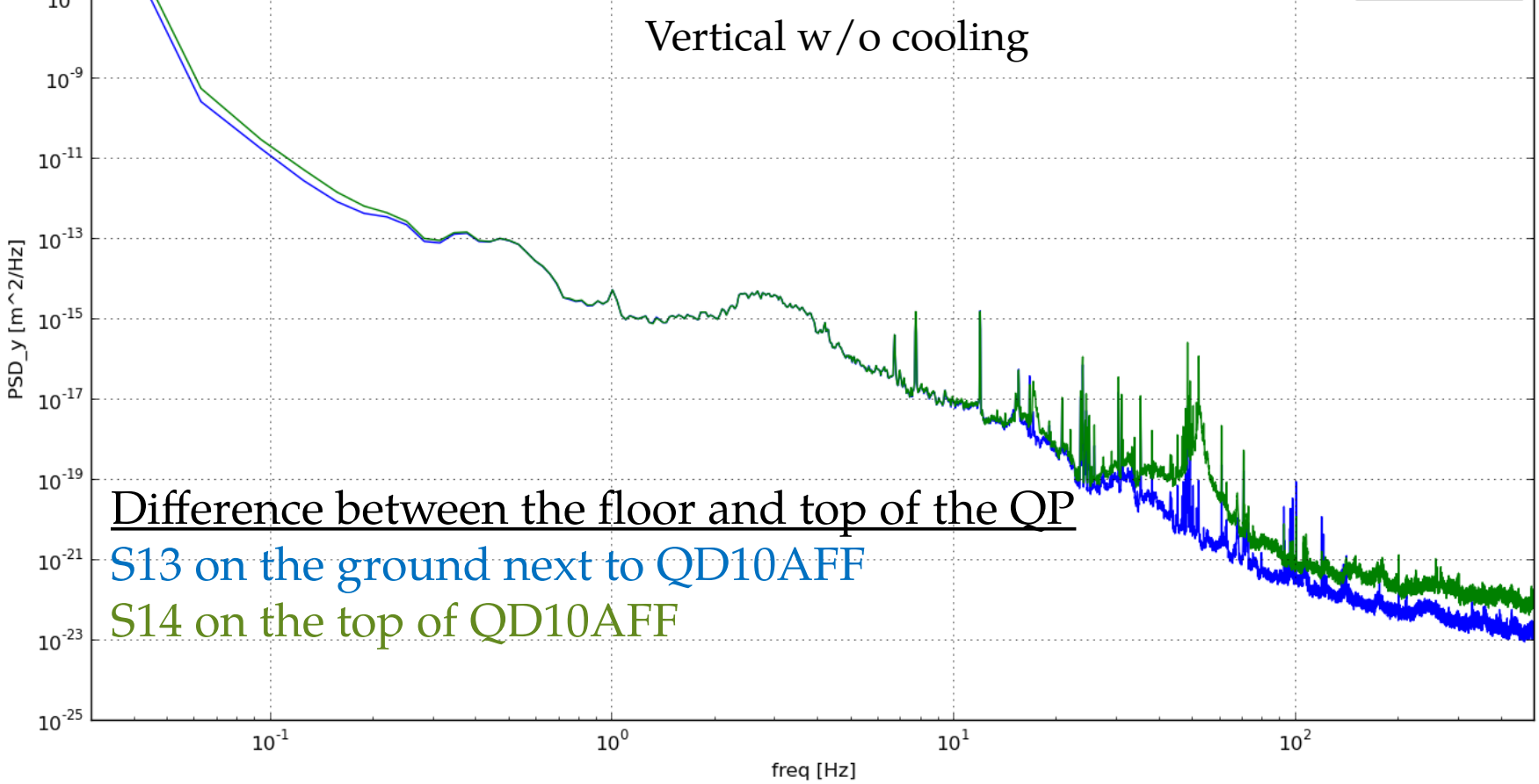


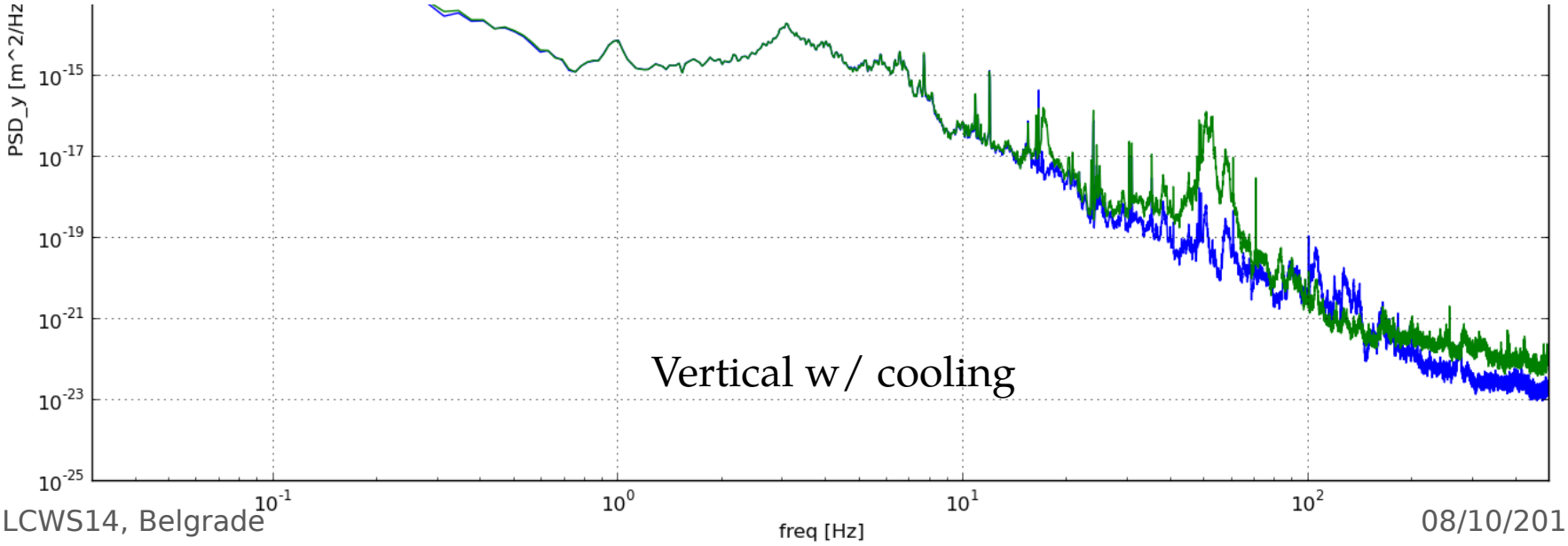
IRMS of vertical vibr. for 5 QPs in FF

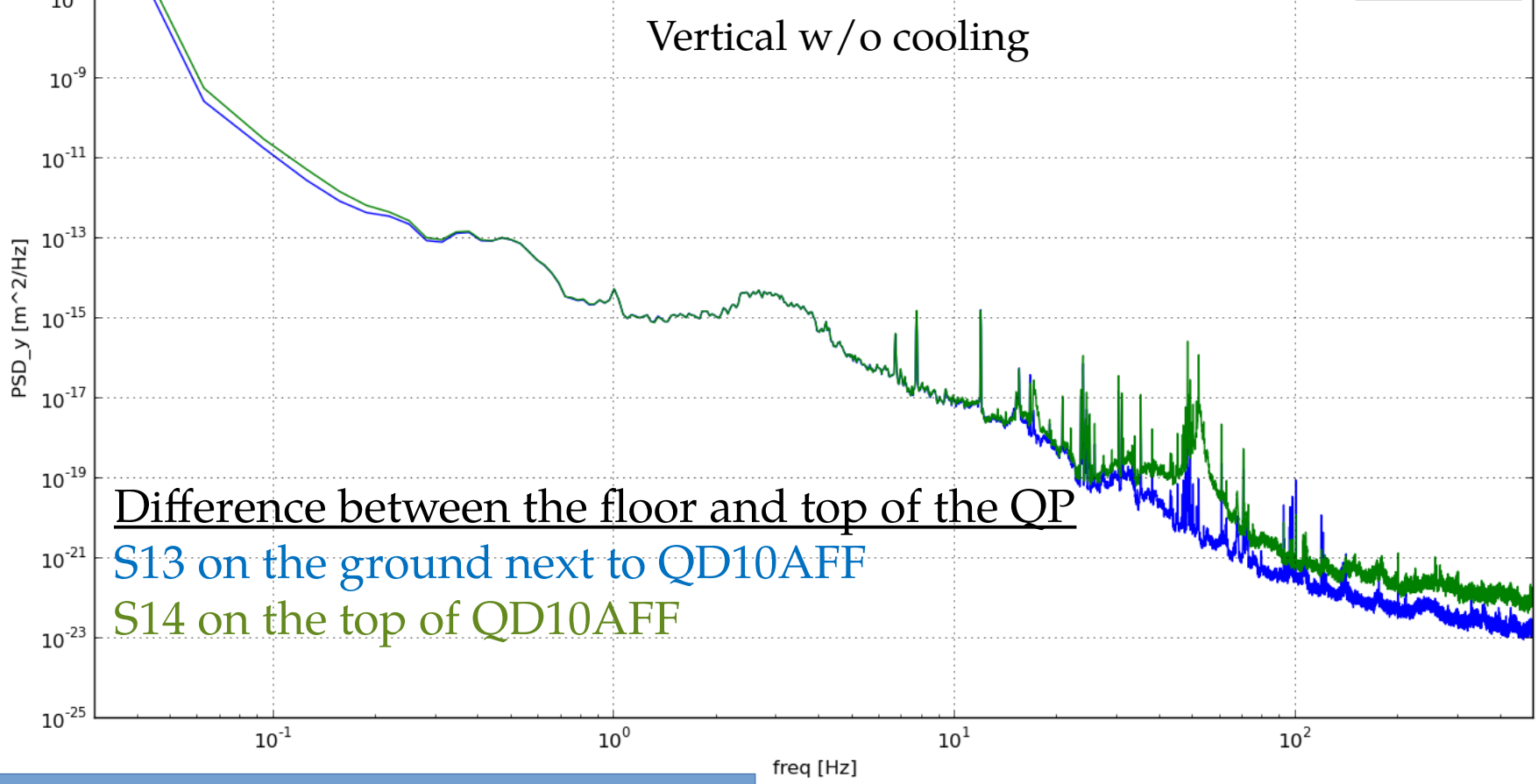



Horizontal w/o cooling
PSD_x [m^2/Hz]
freq [Hz]
Difference between the floor and top of the QP
S13 on the ground next to QD10AFF
S14 on the top of QD10AFF

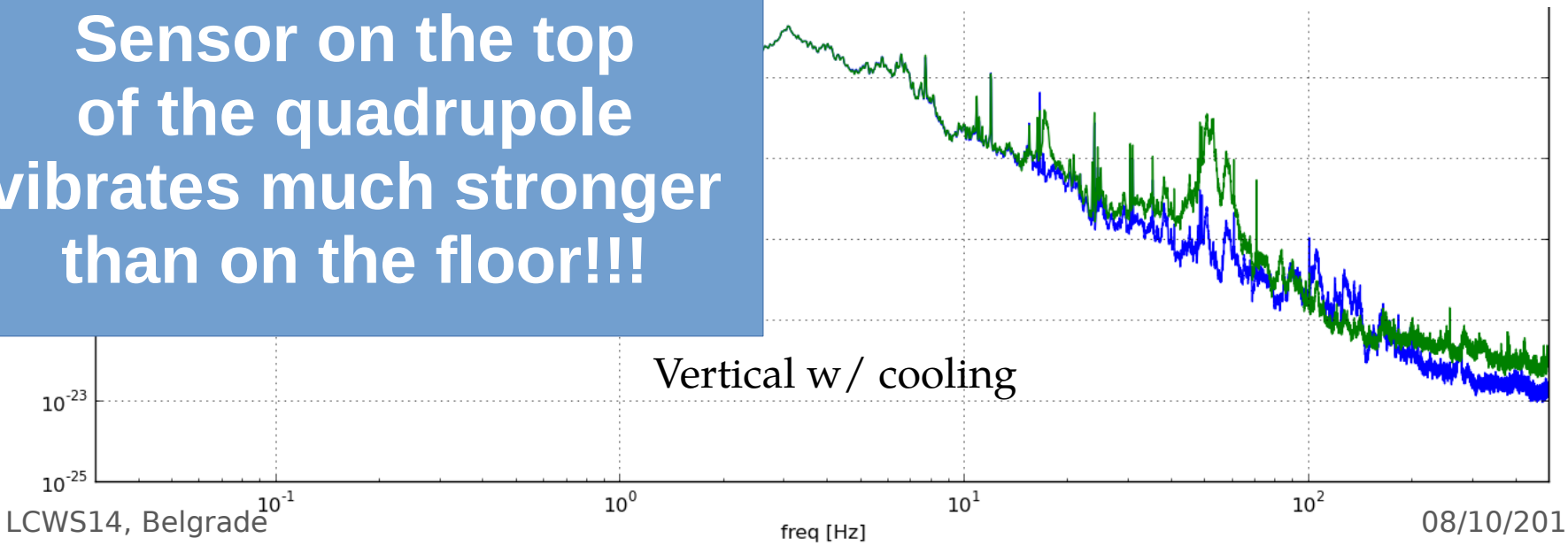

Horizontal w/ cooling
PSD_x [m^2/Hz]
freq [Hz]


Vertical w/o cooling
PSD_y [m^2/Hz]
freq [Hz]
Difference between the floor and top of the QP
S13 on the ground next to QD10AFF
S14 on the top of QD10AFF


Vertical w/ cooling
PSD_y [m^2/Hz]
freq [Hz]



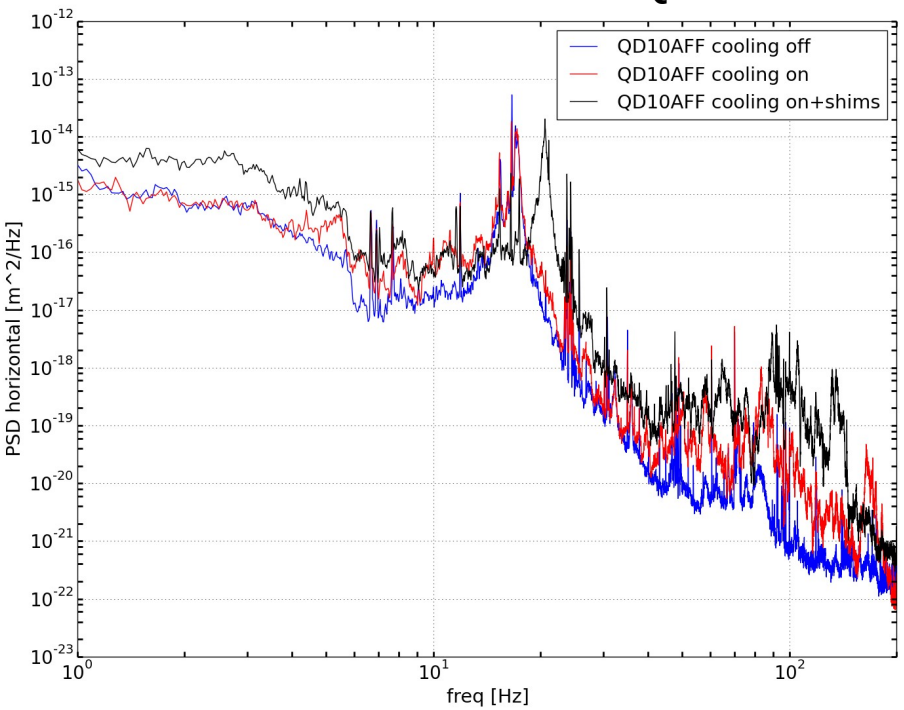
Sensor on the top of the quadrupole vibrates much stronger than on the floor!!!



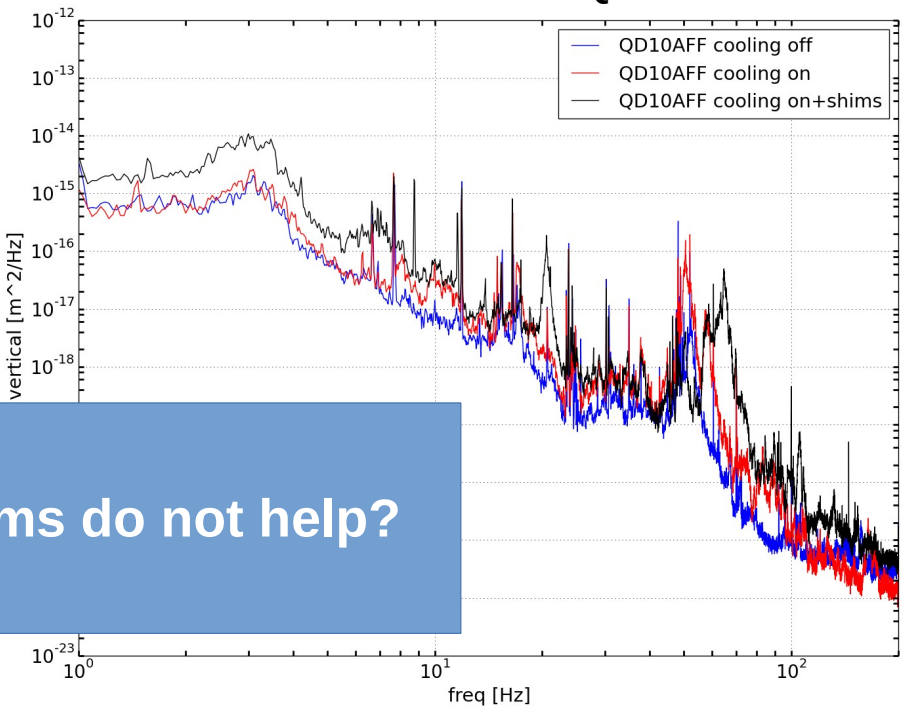
Cooling water pipes near to QD10AFF magnet

- Sensors placed on the top of quadrupoles (beginning of october):
  - QF9AFF
  - QF9BFF
  - QD10AFF:
    - Without cooling water
    - With cooling water
    - With cooling water + shims inserted under the support
  - QD10BFF
  - QF11FF

PSD of horizontal vibr. for QD10AFF

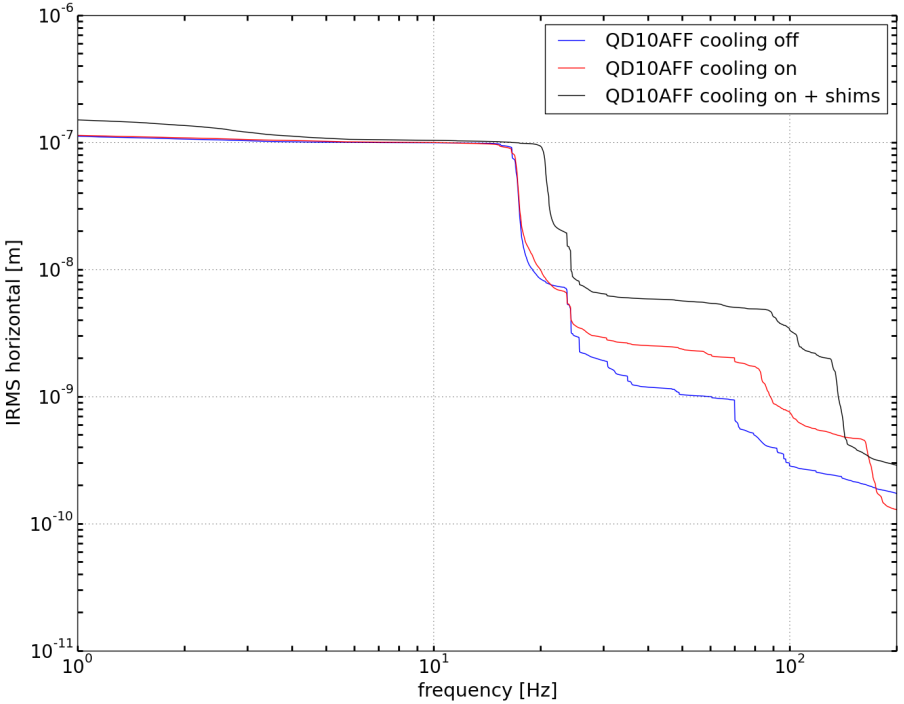


PSD of vertical vibr. for QD10AFF

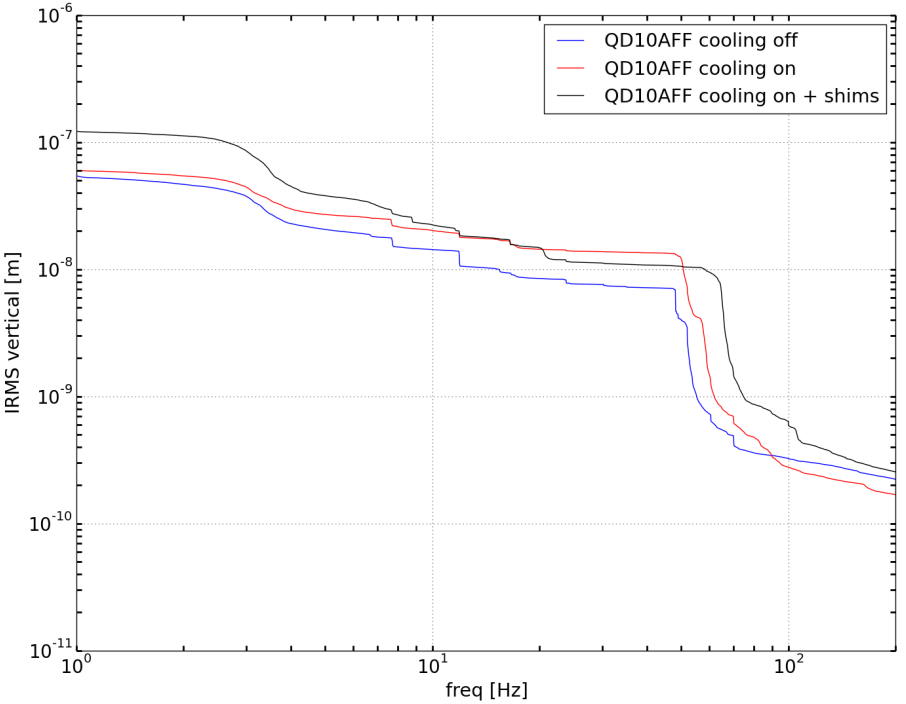


Shims do not help?

IRMS of horizontal vibr. for QD10AFF



IRMS of vertical vibr. for QD10AFF



Relative displacement of QD10AFF/floor

QD10FF/floor	Vertical relative displacement at 1Hz (nm)	Horizontal relative displacement at 1Hz (nm)
No cooling water No shims	7,3	98
FF cooling on No shims	18	150
FF cooling on Damping ring cooling on Half-moon and extra shims	15	100

Some improvement, but not very significant

Summary B

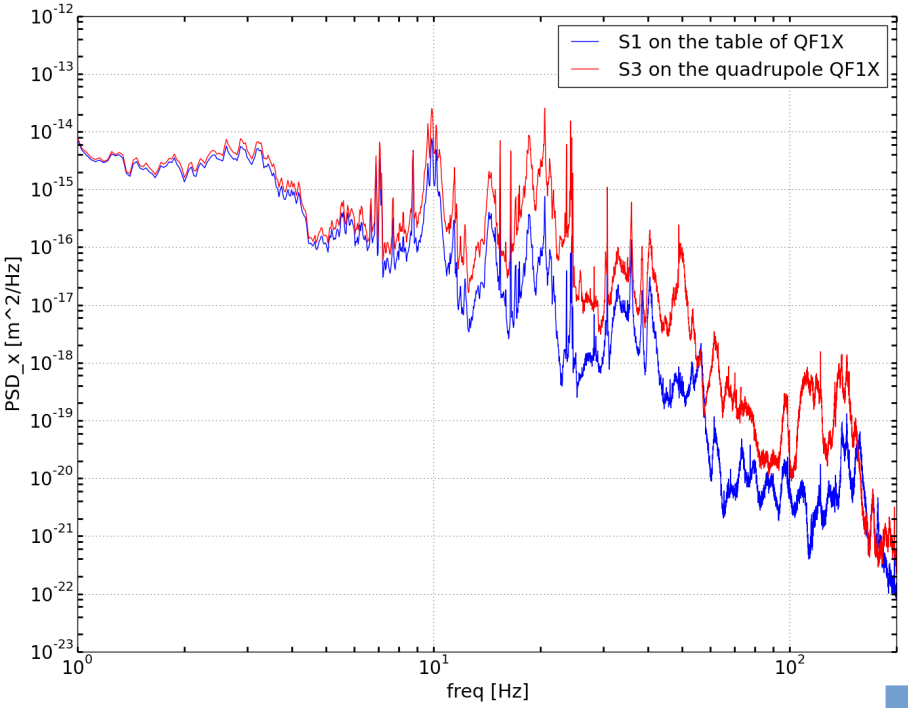
- Some vibrations are transmitted from cooling water pipes to the quadrupoles QF9A(B)FF, QD10A(B)FF, QF11FF;
- Shims do not help significantly for these magnets;
- Magnets vibrate stronger than floor nearby.

C. Difference between sensors located at the top of the quadrupoles and in available space (usually quadrupole table or floor next to quadrupole).

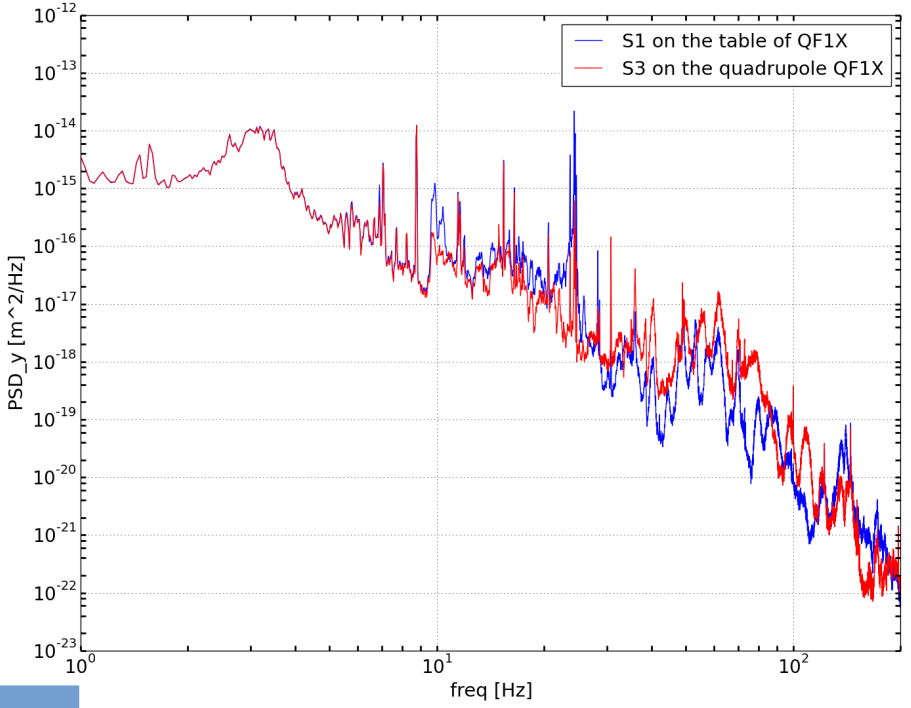
Sensors #1,#2,#3 (main contribution to the correlation factor) used for demonstration.

Measurements performed in October together with A. Jeremie.

PSD of horizontal vibr. for two sensors

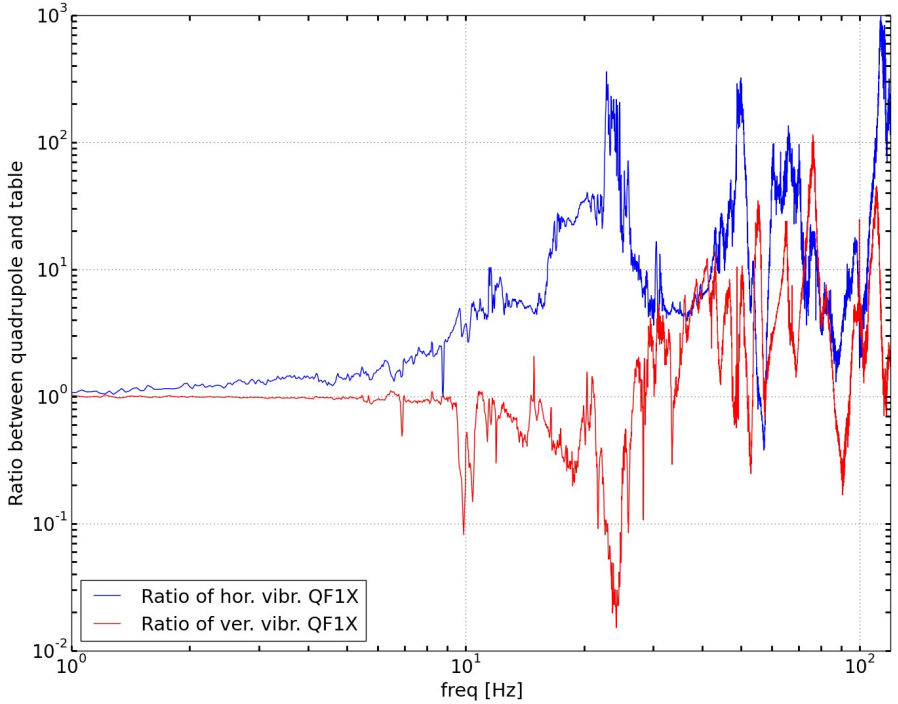


PSD of vertical vibr. for two sensors

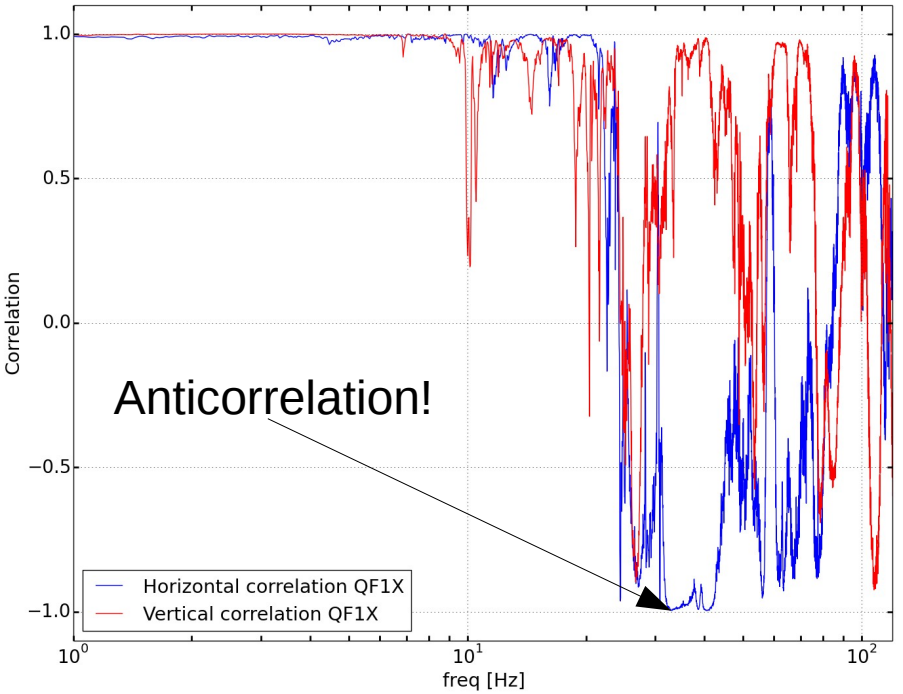


QF1X

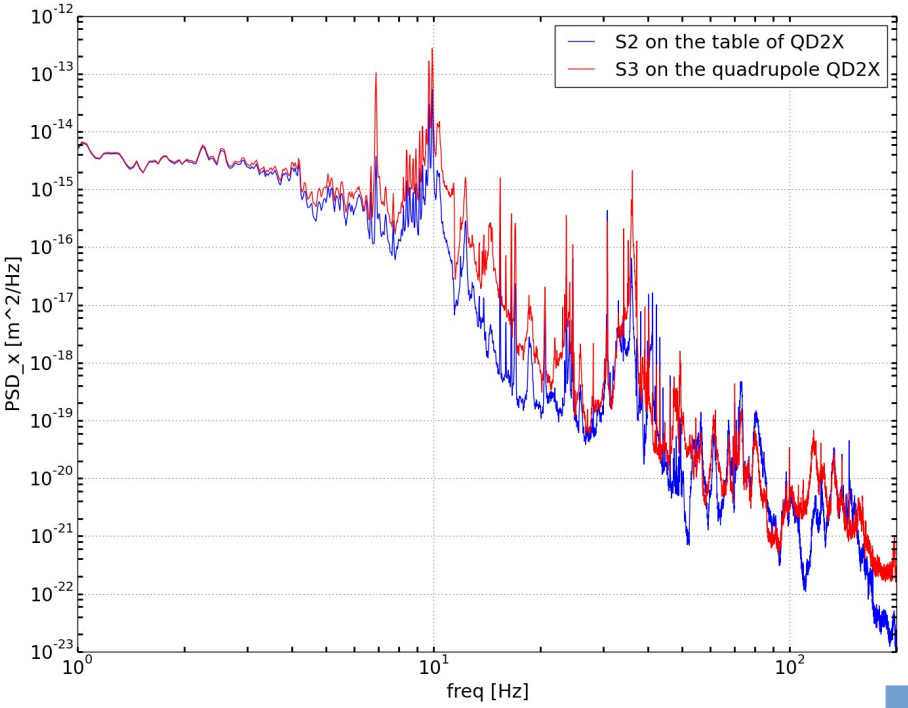
Ratio of PSD spectra for two sensors



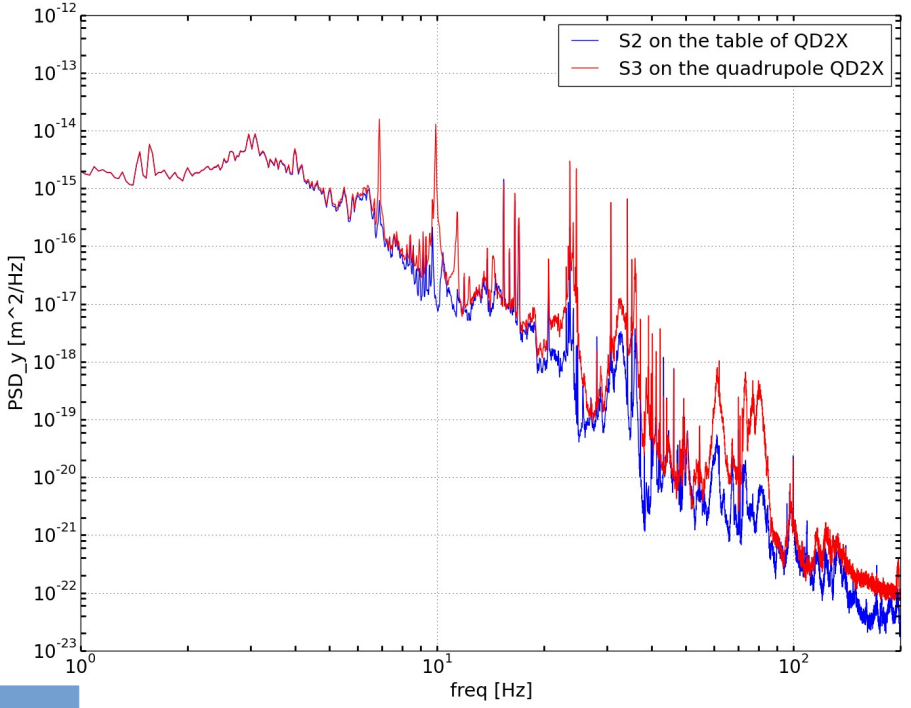
Correlation between two sensors



PSD of horizontal vibr. for two sensors

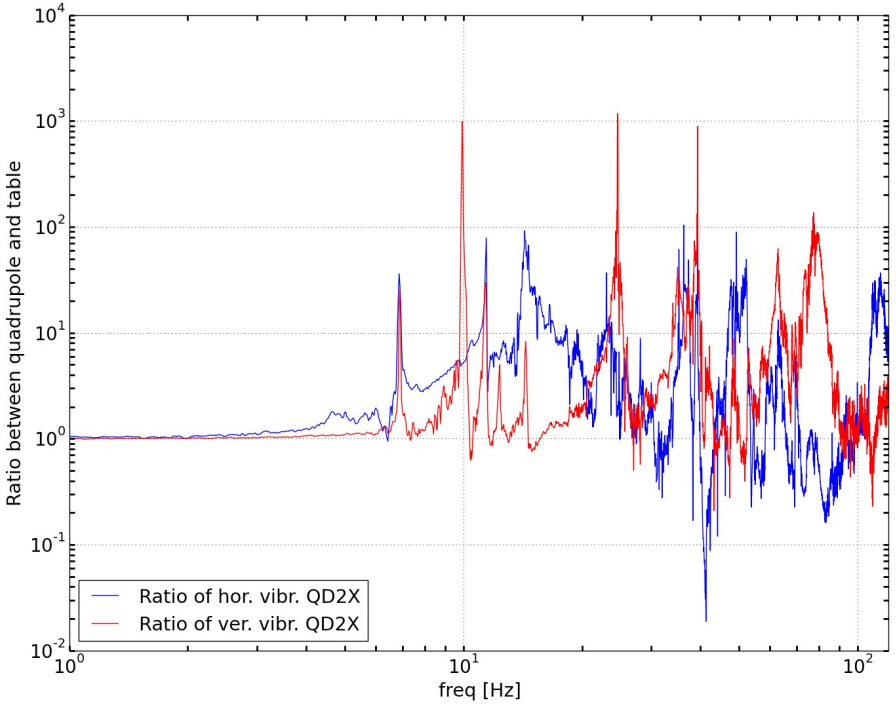


PSD of vertical vibr. for two sensors

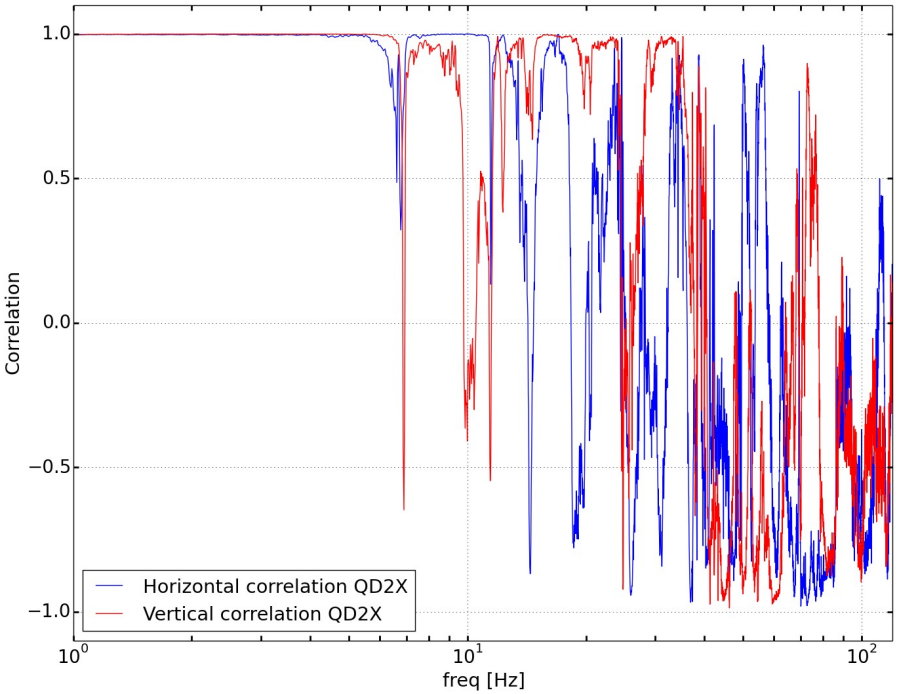


QD2X

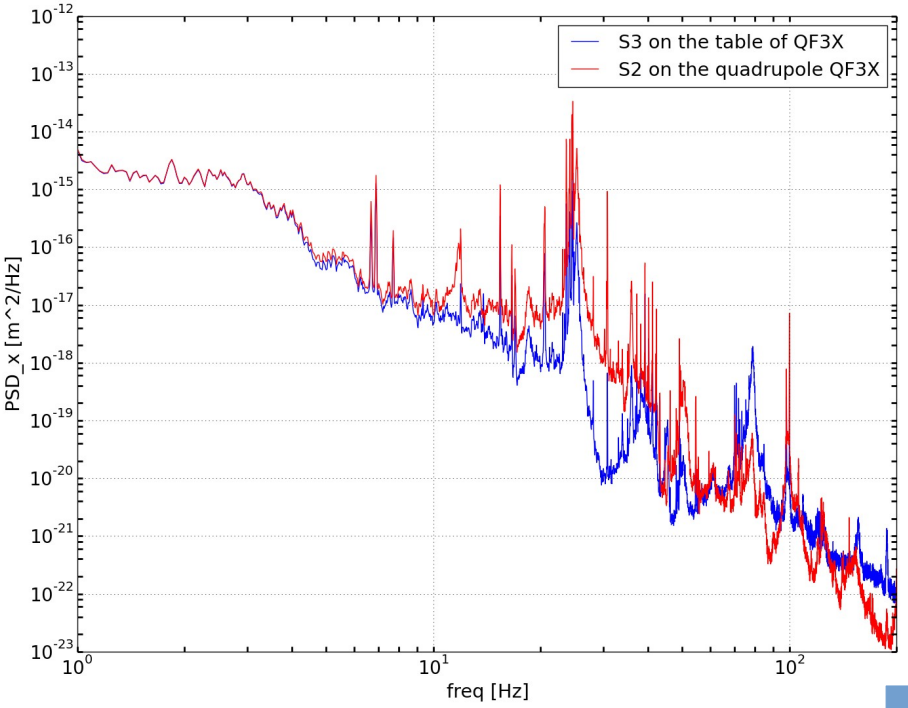
Ratio of PSD spectra for two sensors



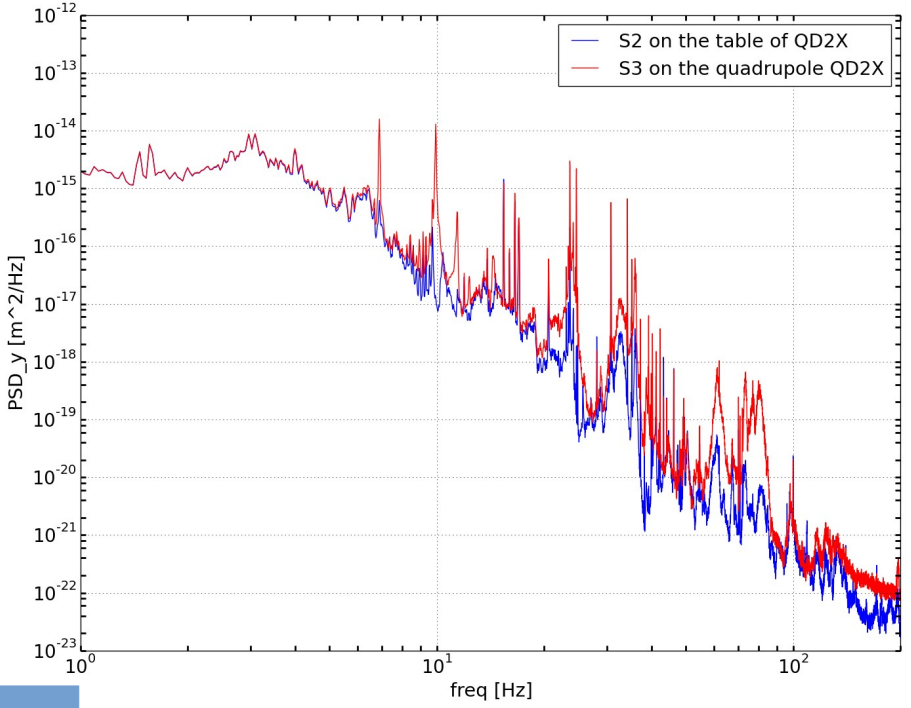
Correlation between two sensors



PSD of horizontal vibr. for two sensors

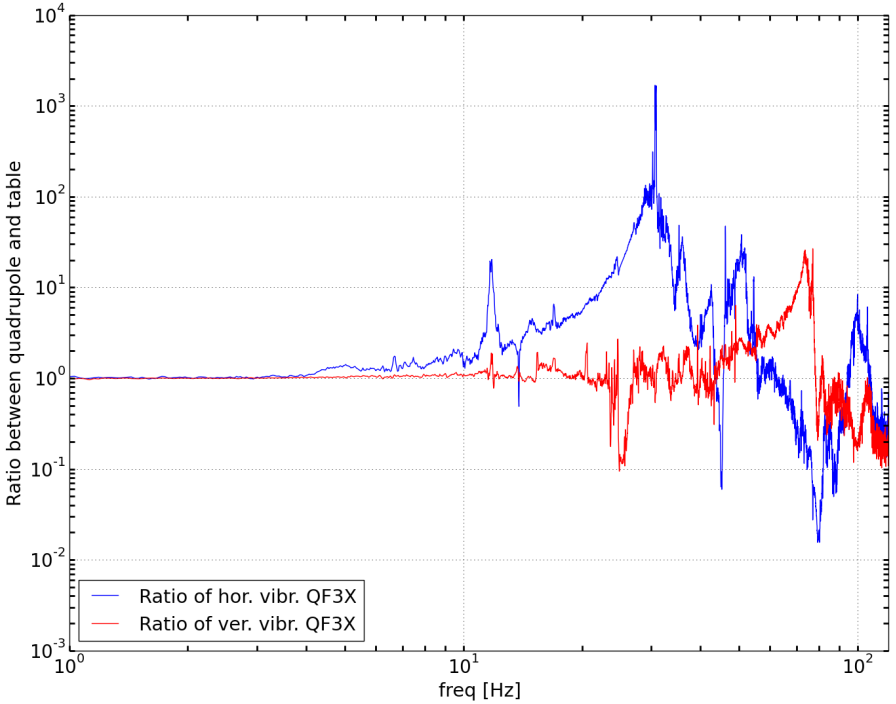


PSD of vertical vibr. for two sensors

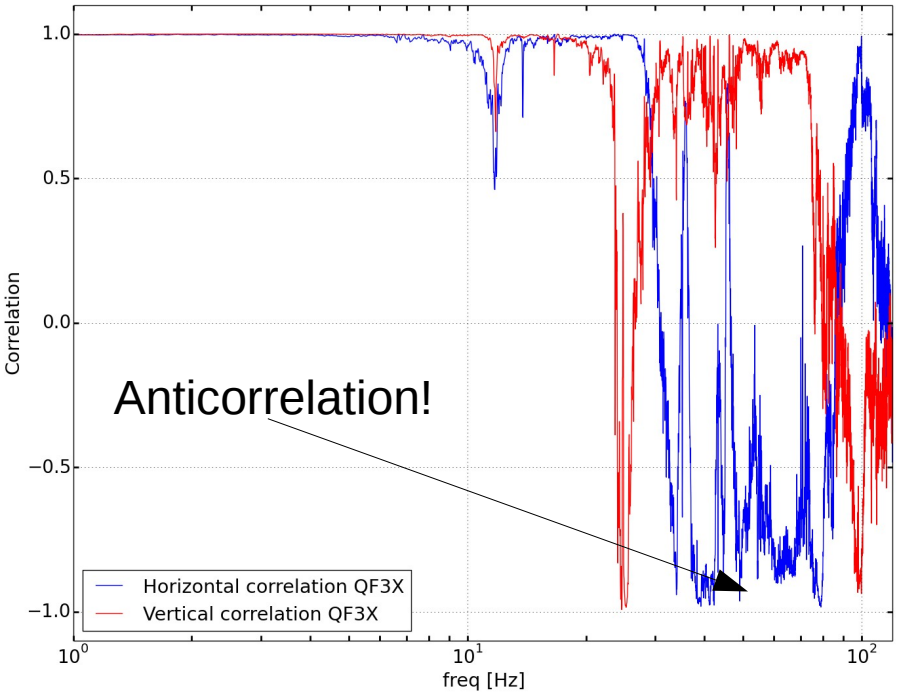


QF3X

Ratio of PSD spectra for two sensors



Correlation between two sensors



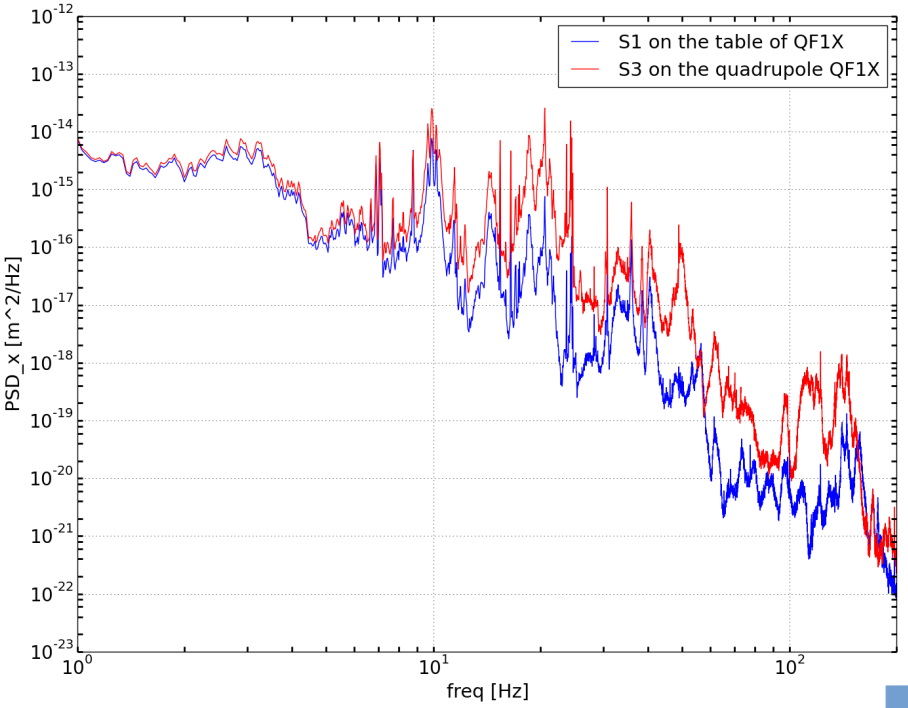
Summary C

- We observe important differences between putting the sensor on the quadrupole and another position;
- It may be a reason of small correlation;
- **There is a strong justification of placing the sensors on the top of the quadrupoles;**

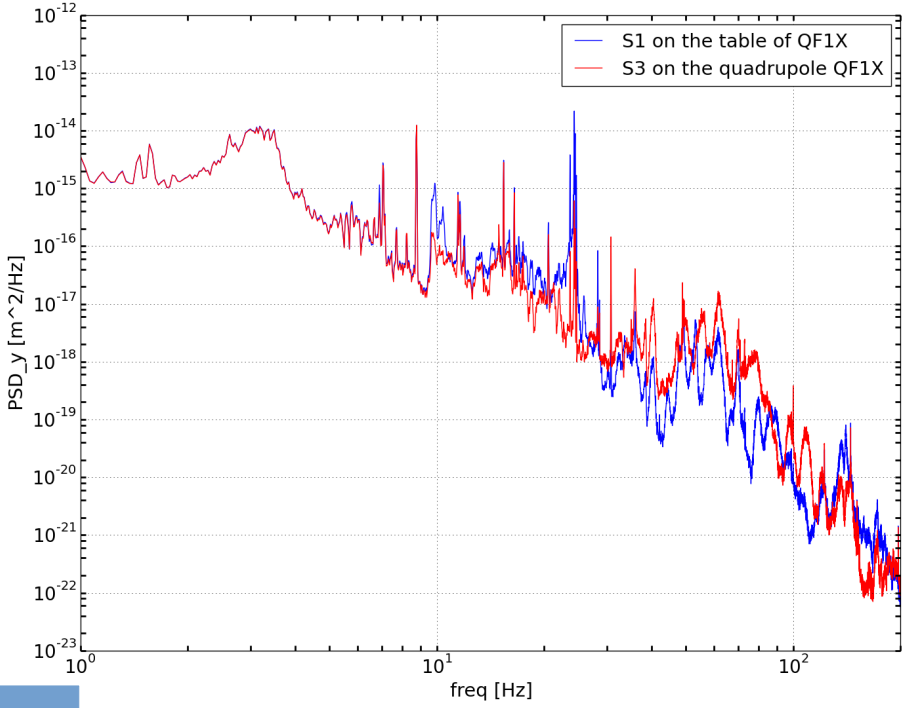
Thank you for your attention!

Backup slides

PSD of horizontal vibr. for two sensors

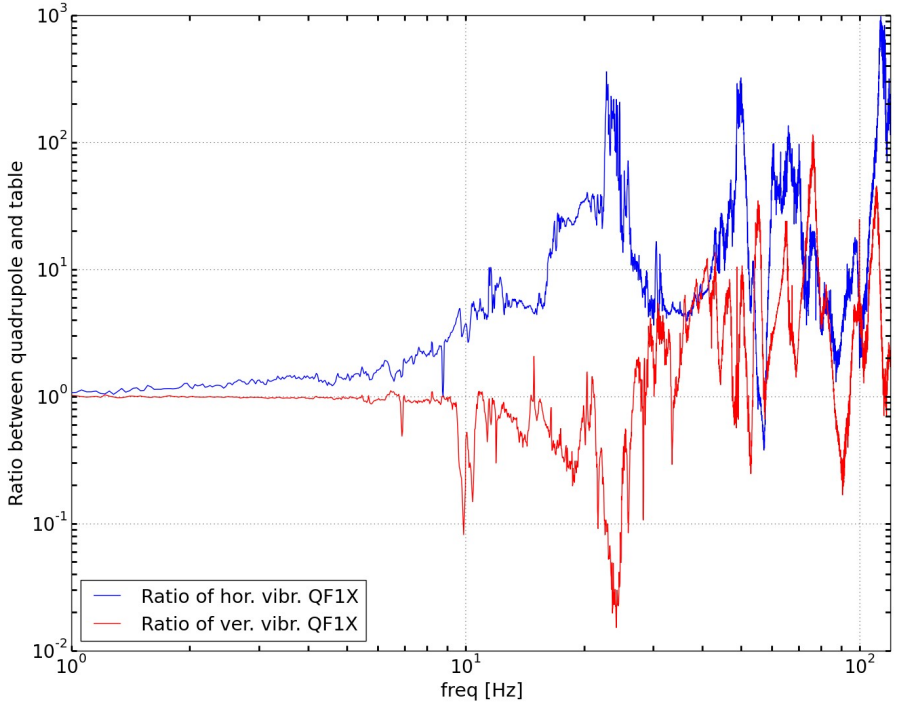


PSD of vertical vibr. for two sensors

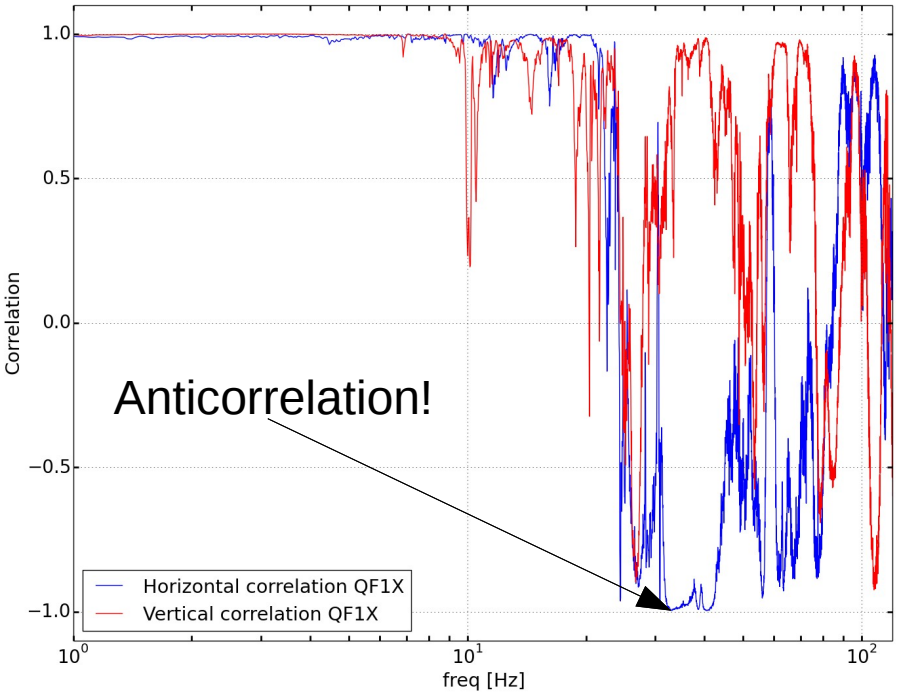


QF1X

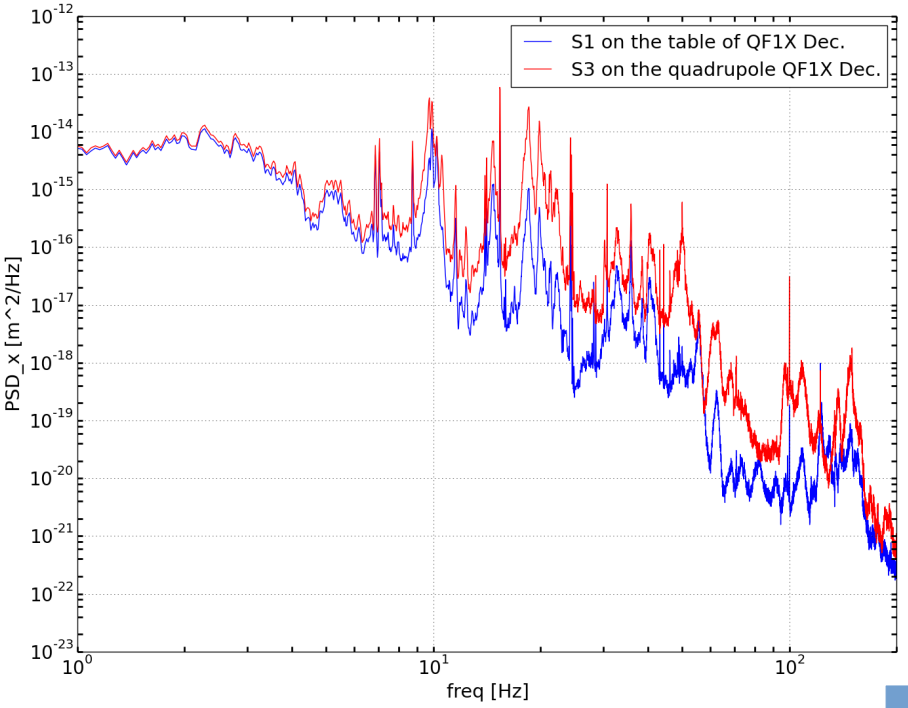
PSD of horizontal vibr. for two sensors



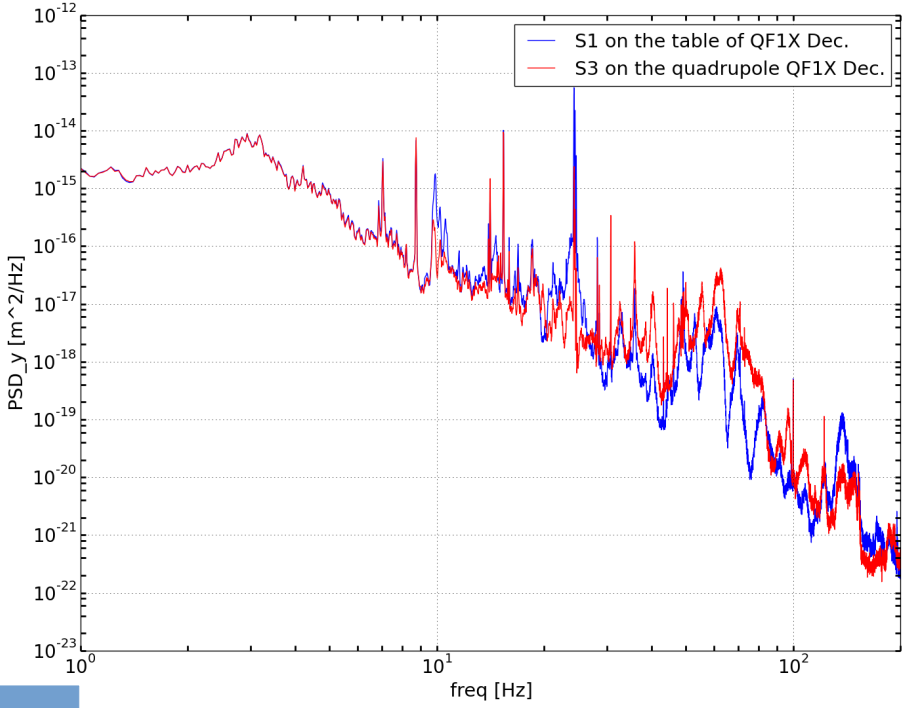
Correlation between two sensors



PSD of horizontal vibr. for two sensors

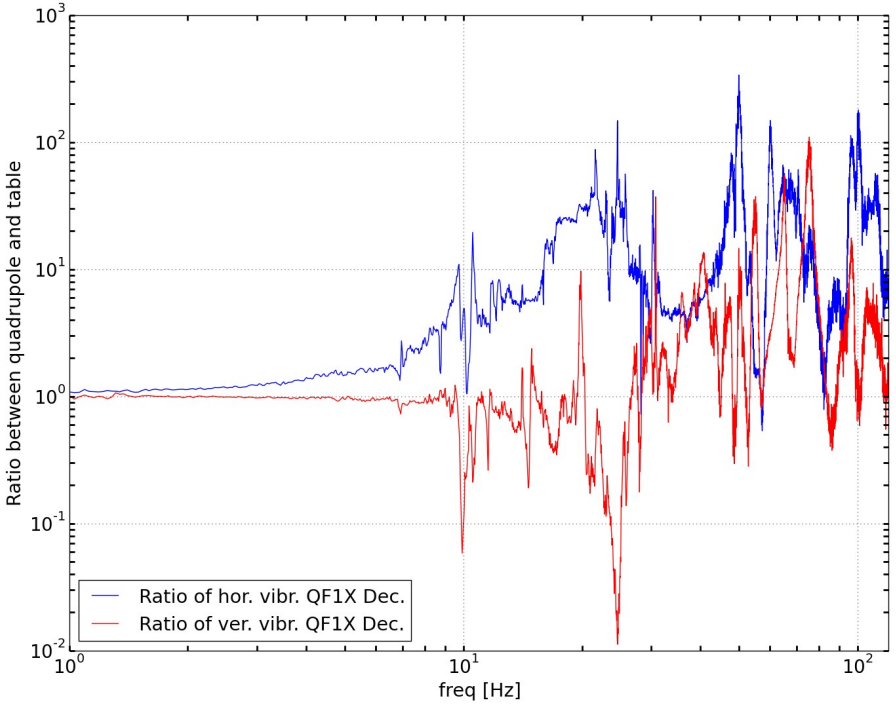
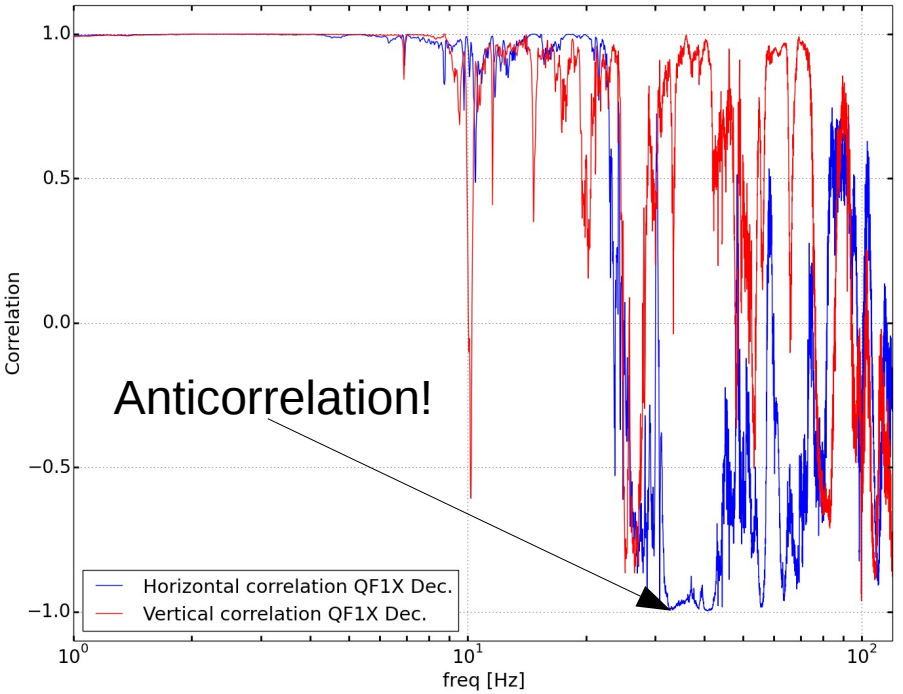


PSD of vertical vibr. for two sensors



QF1X Dec.

PSD of horizontal vibr. for two sensors



Correlation between two sensors