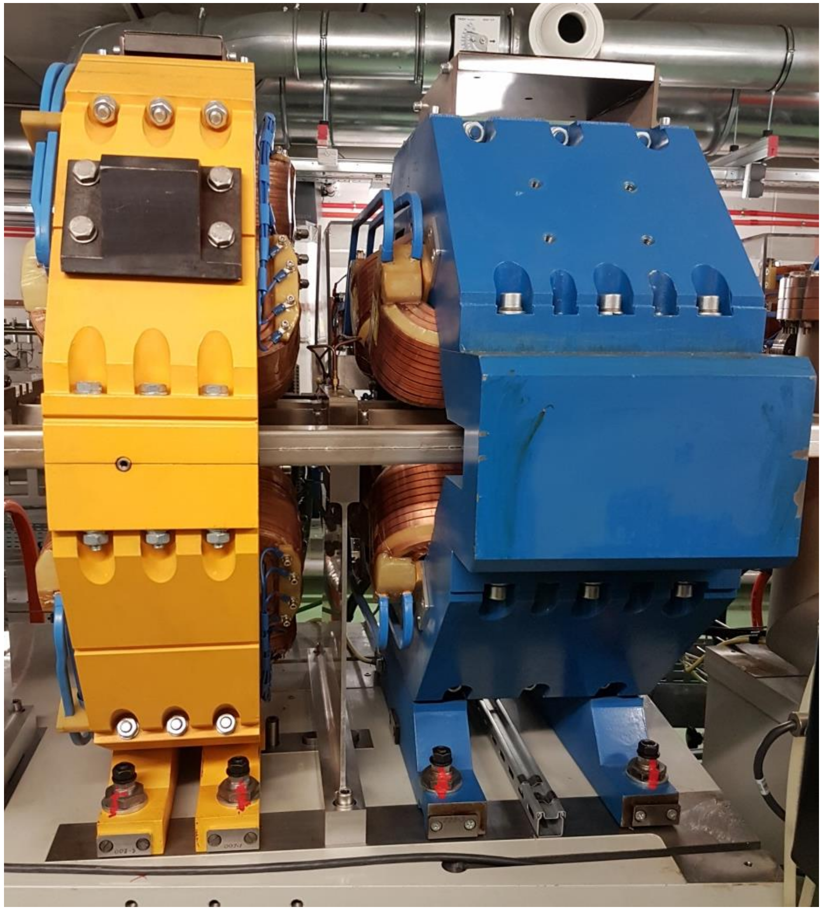
Fast Quadrupole Beam Based Alignment Using AC Corrector Excitations



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Outline

BBA	FBBA
ALBA set up	Results

BBA

It is needed for:

- Minimize multipole feed down effect, minimizes the corrector strength needed:
  - Optic & coupling errors due to Sextupoles.
  - Orbit errors due to Quadrupoles.
- To bring the machine closer to the model in-between BPMs.

BBA

Misalignments come from:

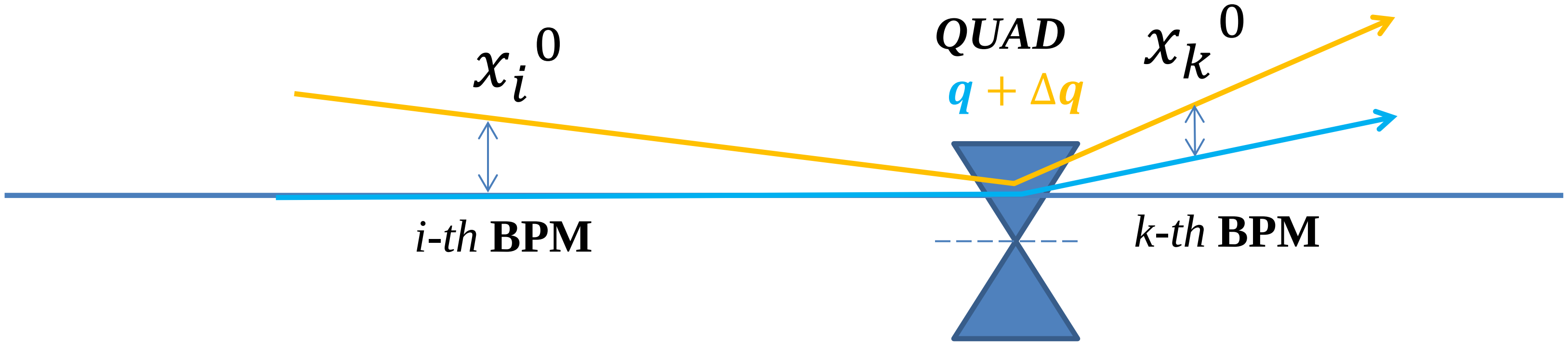
- Real: mechanical
- Apparent: electronic

It can be measured:

- At the quadrupole: beam2quad
- At the BPM: beam2bpm

BBA

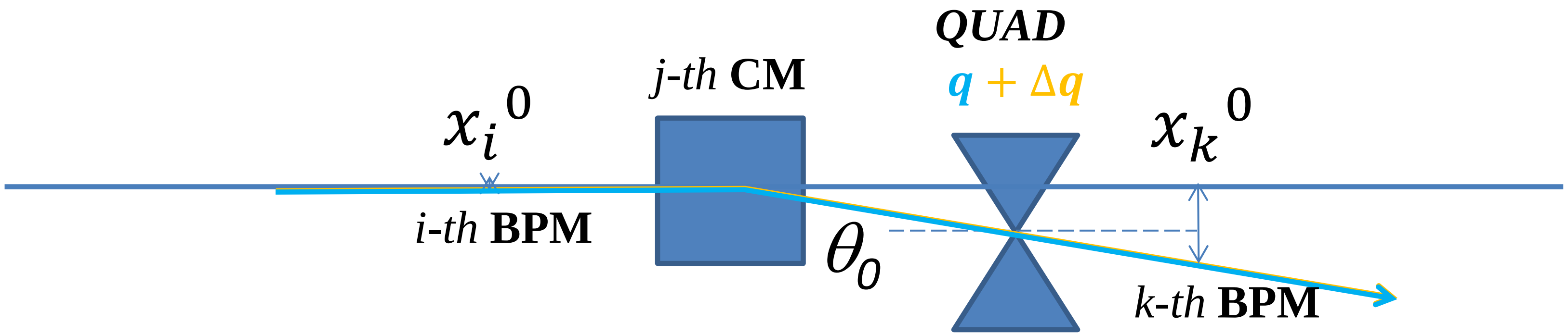
Beam2quad:



- Faster (only quads varied)
- Linear Model dependent (tune and orbit restored after every measurement)
- To ailing we need to translate it to the BPMs.

BBA

Beam2bpm:



- Slow (Both CM and quads are scanned, ~5h at ALBA!)
- Model independent, no need to correct after each measurement.
- There is a systematic error in case of large misalignments depending on the orbit angle.

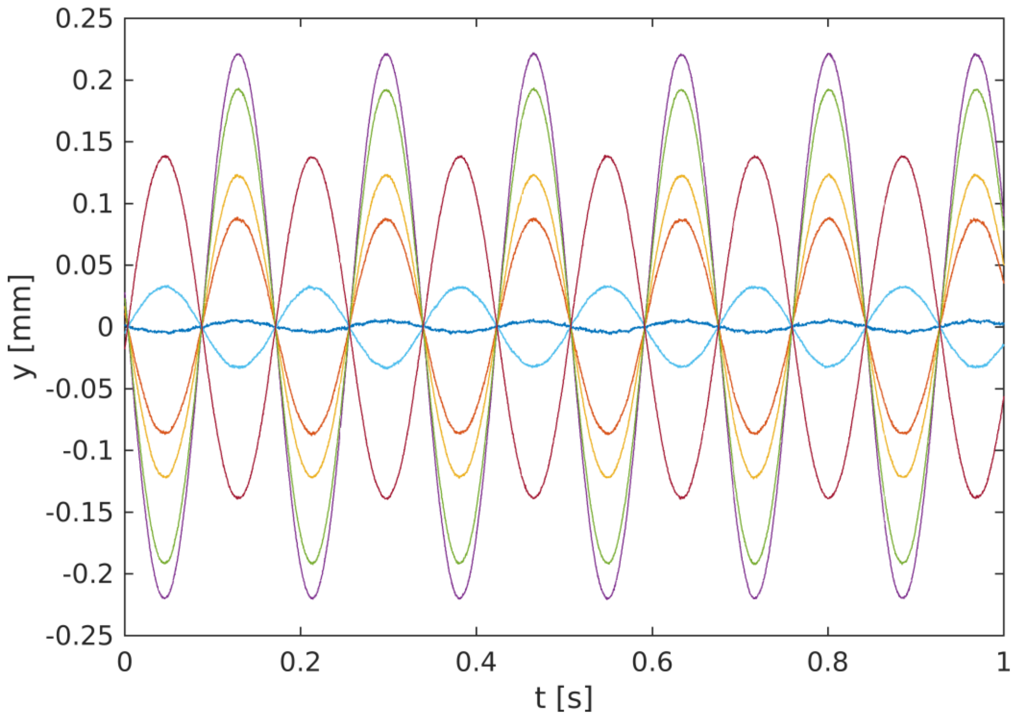
FBBA

The measurable are the same as for the beam2bpm BBA, with two differences:

- 10kHz Fast Acquisition Archiver (thanks DIAMOND)
- AC corrector magnets excitation.

FBBA

While the j-th CM changes the kick $\theta_j(t)$, the BPM readings are linearly related:



FBBA

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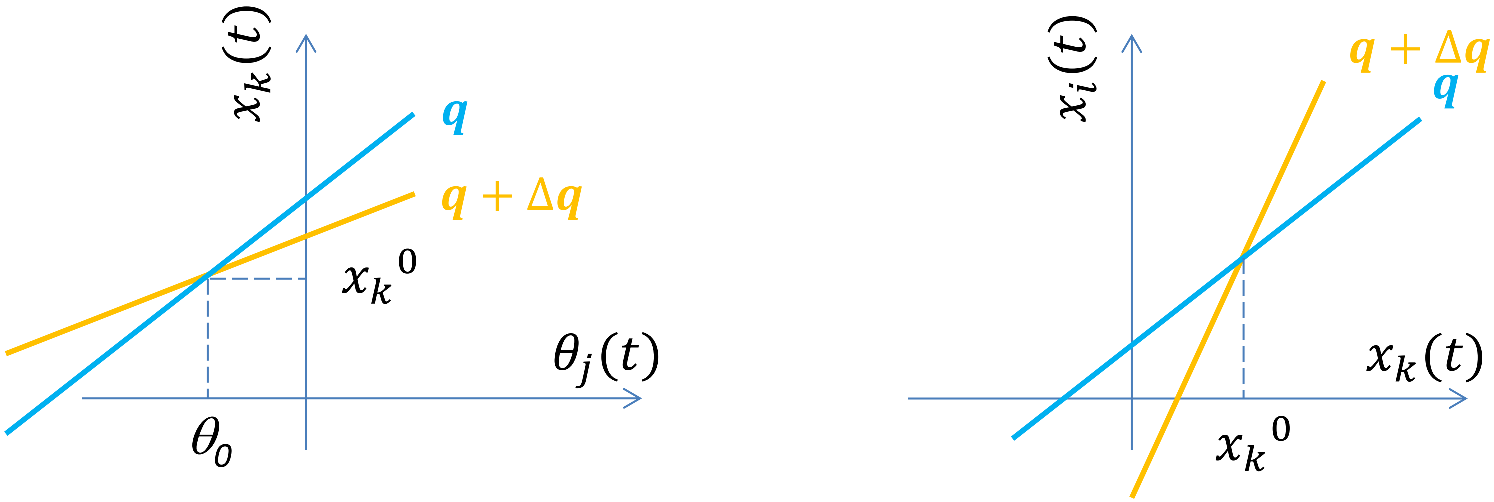


But, unfortunately, in the ALBA case, $\theta_j(t)$ are not stored synchronously nor at 10kHz…

FBBA

While the j-th CM changes the kick $\theta_j(t)$, the BPM readings are linearly related:

$$x_i(t) - x^0{}_i = R_{ij}\left(\theta_j(t) - \theta_0\right)$$
$$x_k(t) - x^0{}_k = R_{kj}\left(\theta_j(t) - \theta_0\right)$$

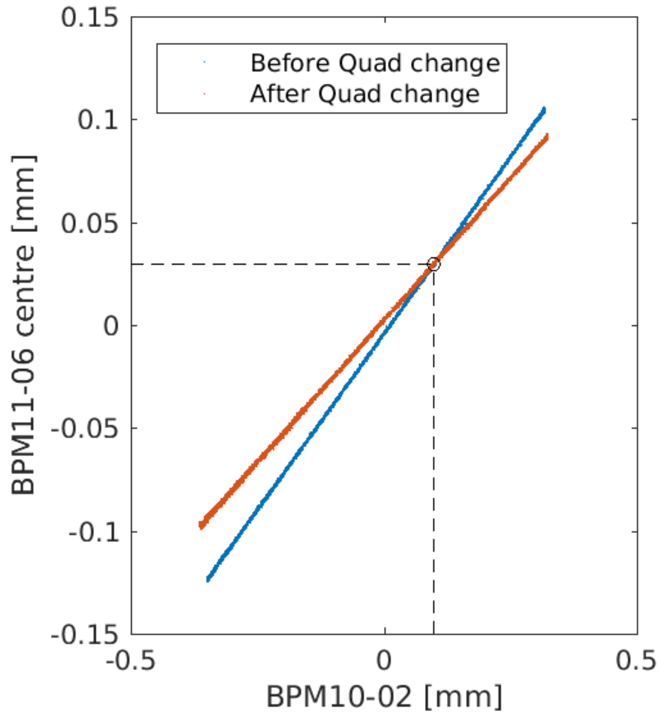
↓

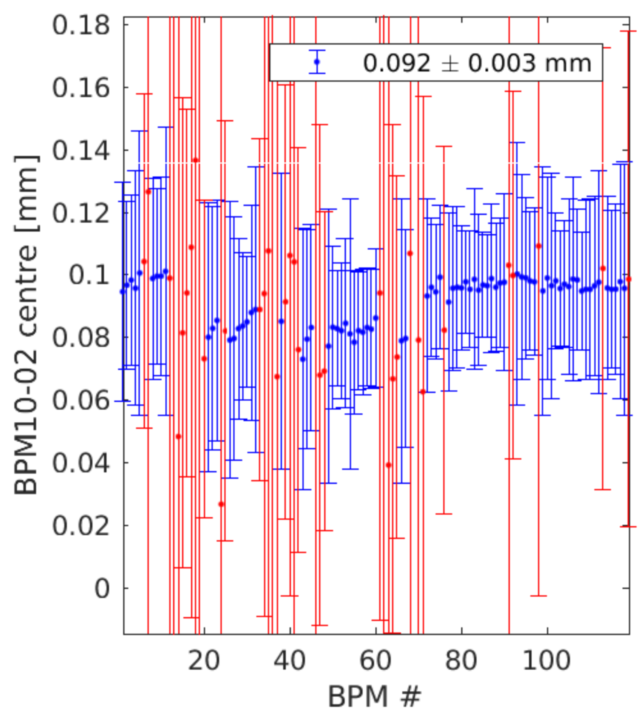
$$x_i(t) - x^0{}_i = \frac{R_{ij}}{R_{kj}}(x_k(t) - x^0{}_k)$$

Given θ_0 definition, when the quad changes, it only changes R.

FBBA

The intersection of each BPM couple relation when the quadrupole is changed is the offset:





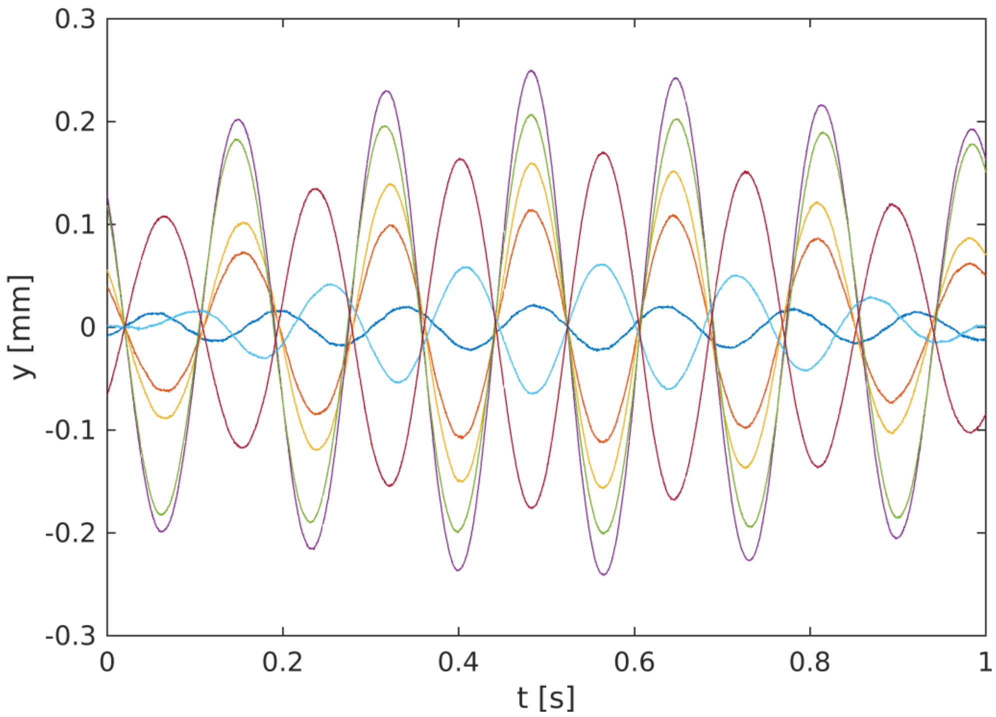
FBBA

We can make it a factor 2 faster if the two planes are measured simultaneously. Different frequencies are used in each plane.

In this case the offset is obtained from the intersection of the Fourier components of each BPM signal.

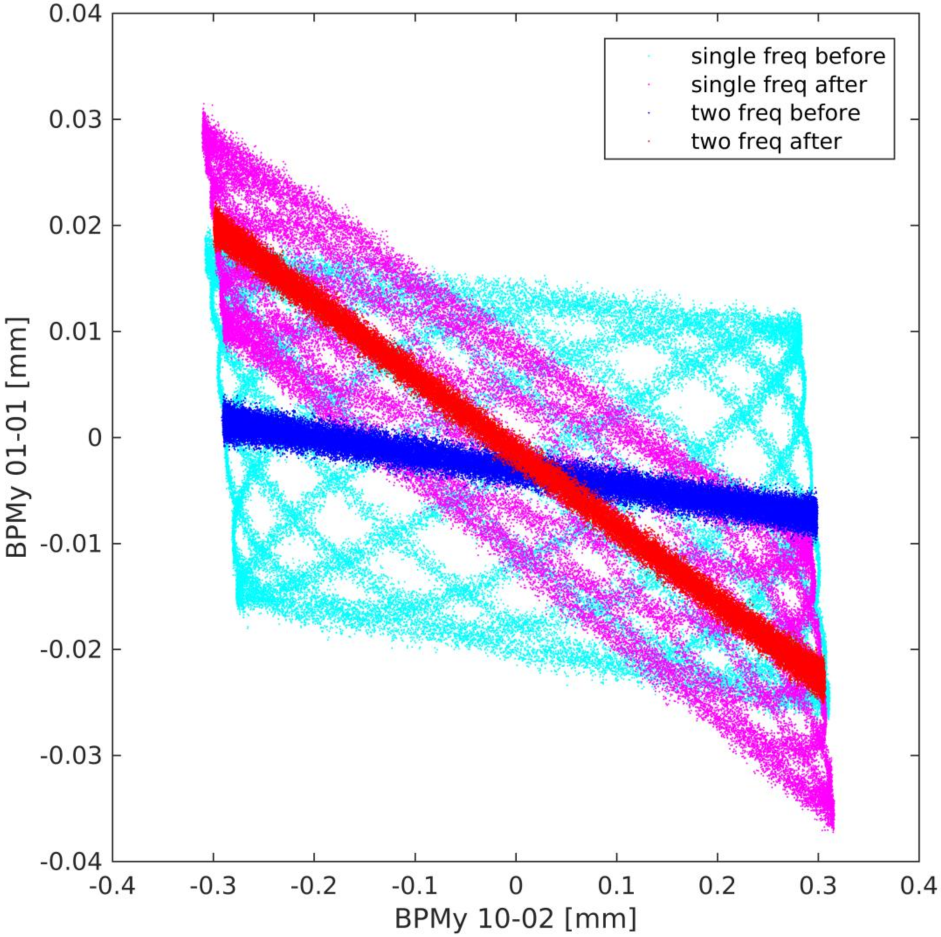
FBBA

Since the two plane frequencies are different, due to coupling, the BPMs readings out of phase and no longer linearly related:



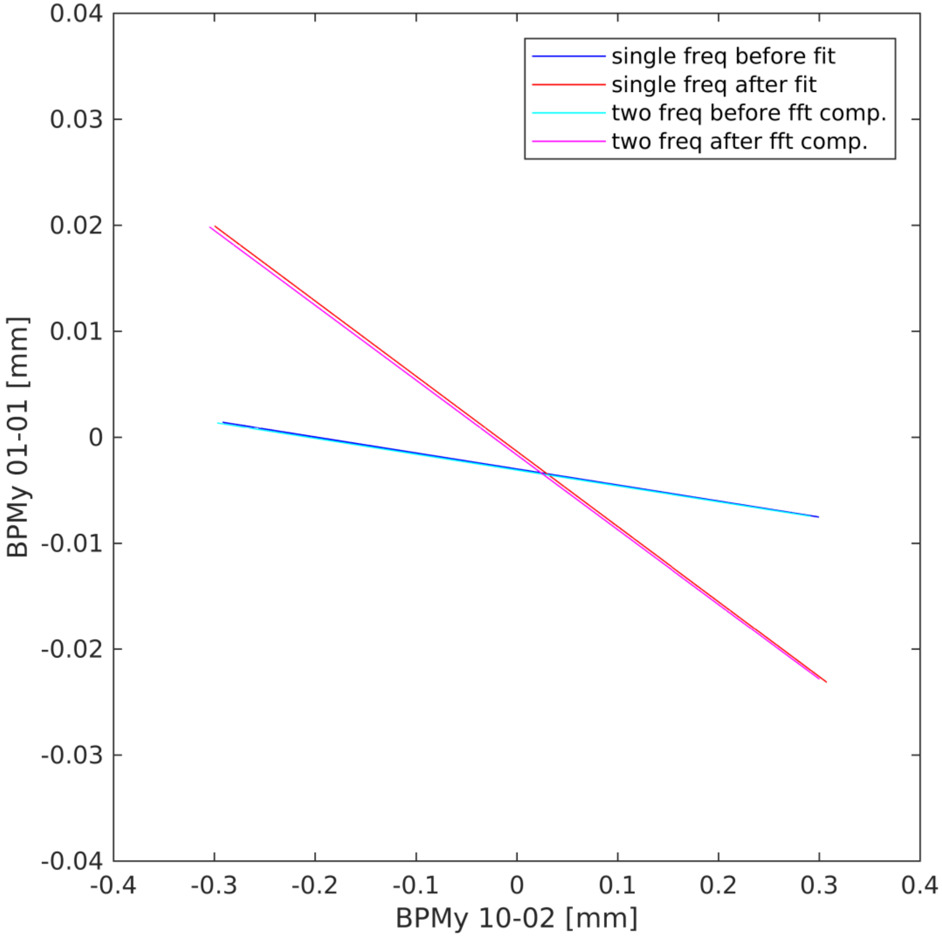
FBBA

Indeed the two frequencies spoil the linear correlation:



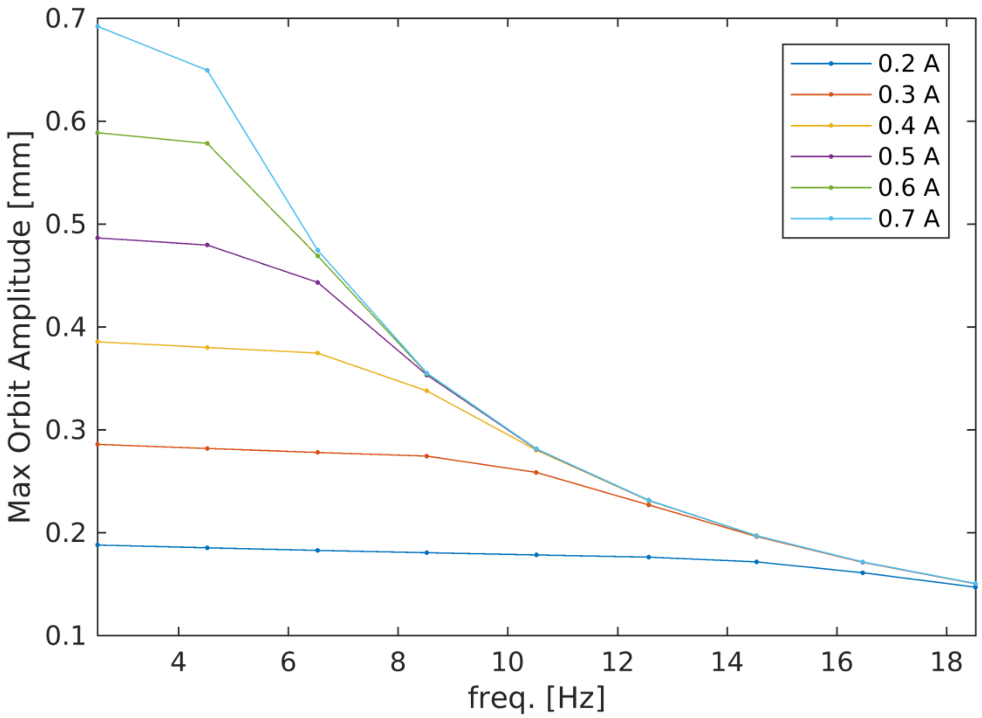
FBBA

But the linear fit and the Fourier component agree very well:



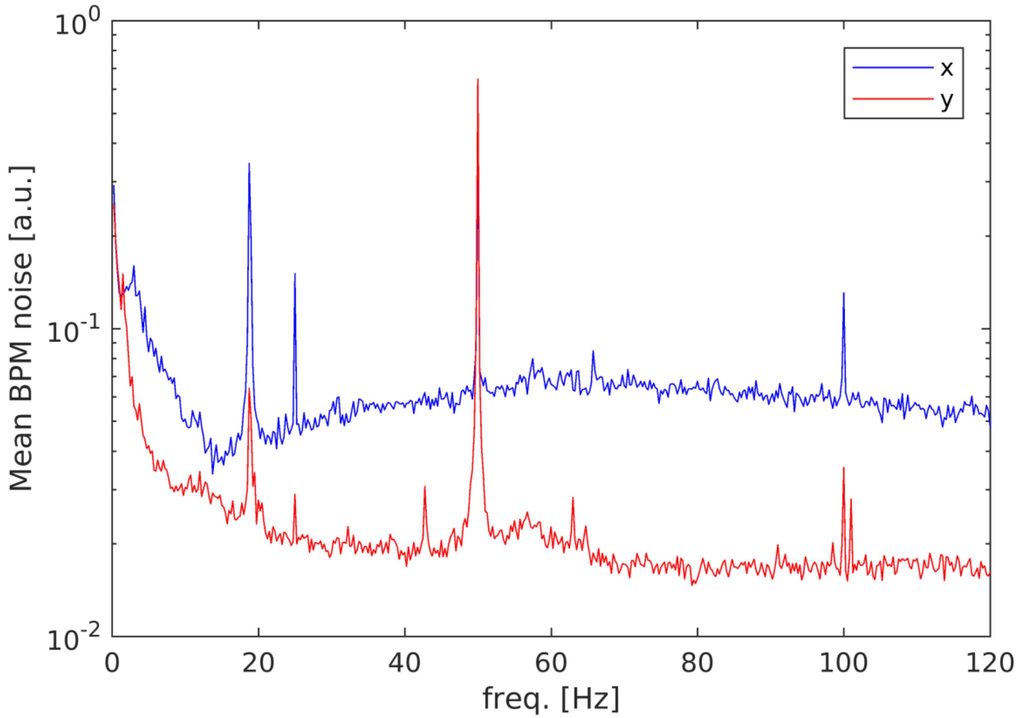
ALBA set up

The CM waveforms have a limited effective kick as a function of the frequency:



ALBA set up

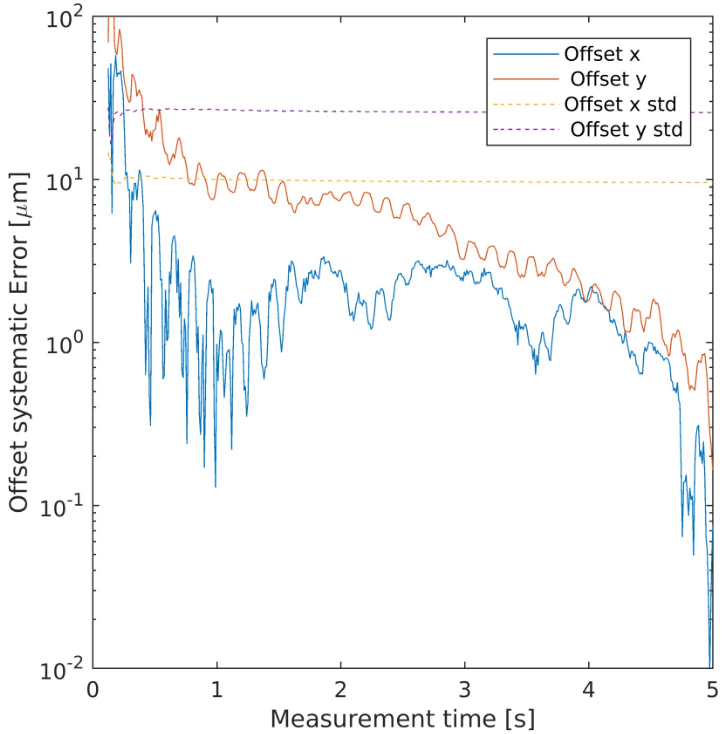
But the BPM noise gets better the higher the frequency, in the 0Hz-18Hz range:



We decided to use 6Hz and 7Hz for the vertical and horizontal plane respectively.

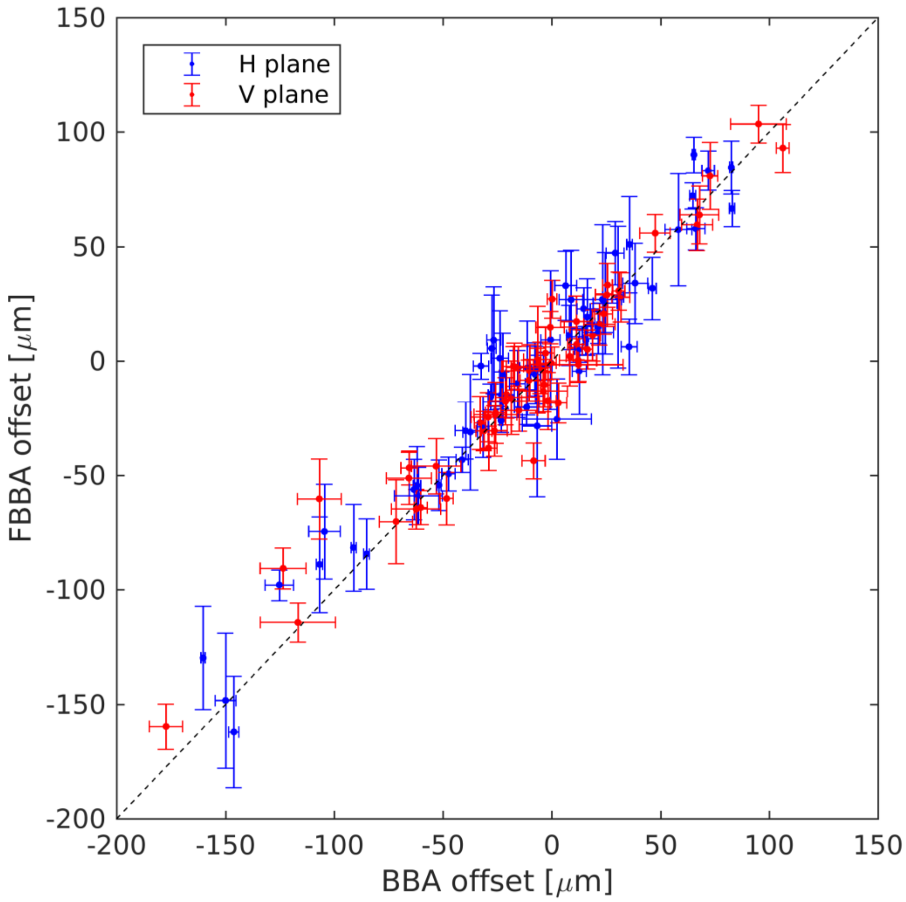
ALBA set up

The acquisition time per quad has been optimized:



1.5 seconds are enough to bring the systematic error well below the random error.

Results



- The presented FBBA is ~30 times faster (10 min vs 5h) than the standard BBA.
- The level of accuracy is similar.