Beam jitter experiment of exchanging power supplies

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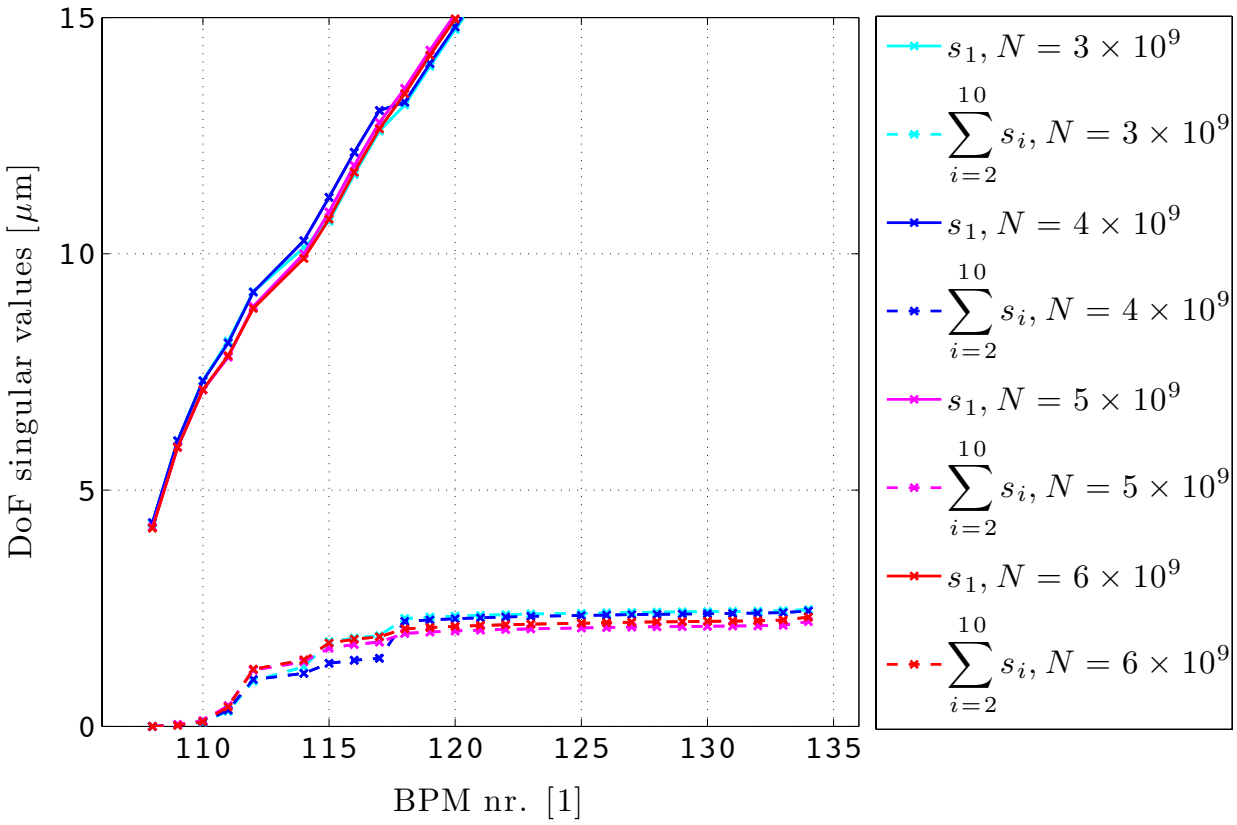
Many thanks to Okugi-san and Yves for the help with the experiment!

Motivation of the studies

- For ATF2 goal two, it is necessary to limit the beam jitter at the IP below 5% of the beam size.
- Currently the beam jitter is between 10% and 20%.

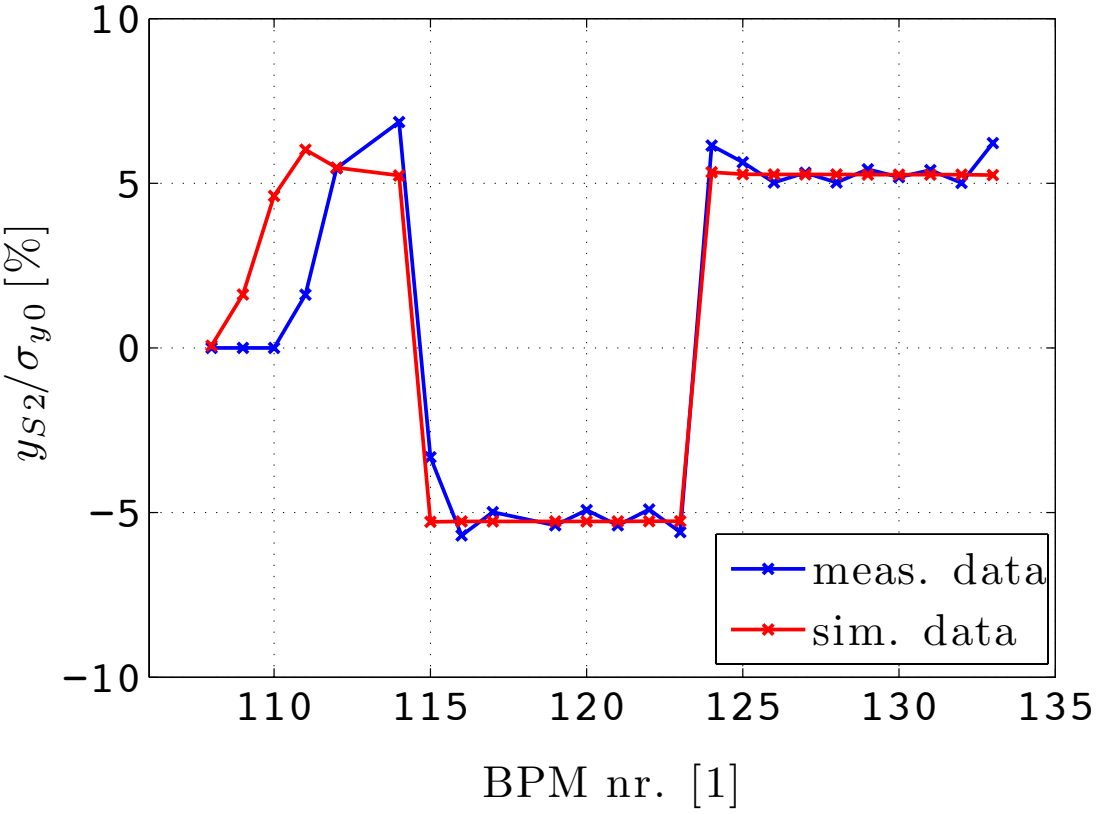
- Measurements with all BPMs in the ATF2 beam line were performed to identify the origin(s) of the current beam jitter.
- The main analysis methods are correlation studies in combination with SVD (DoF plot).

Motivation for the experiment



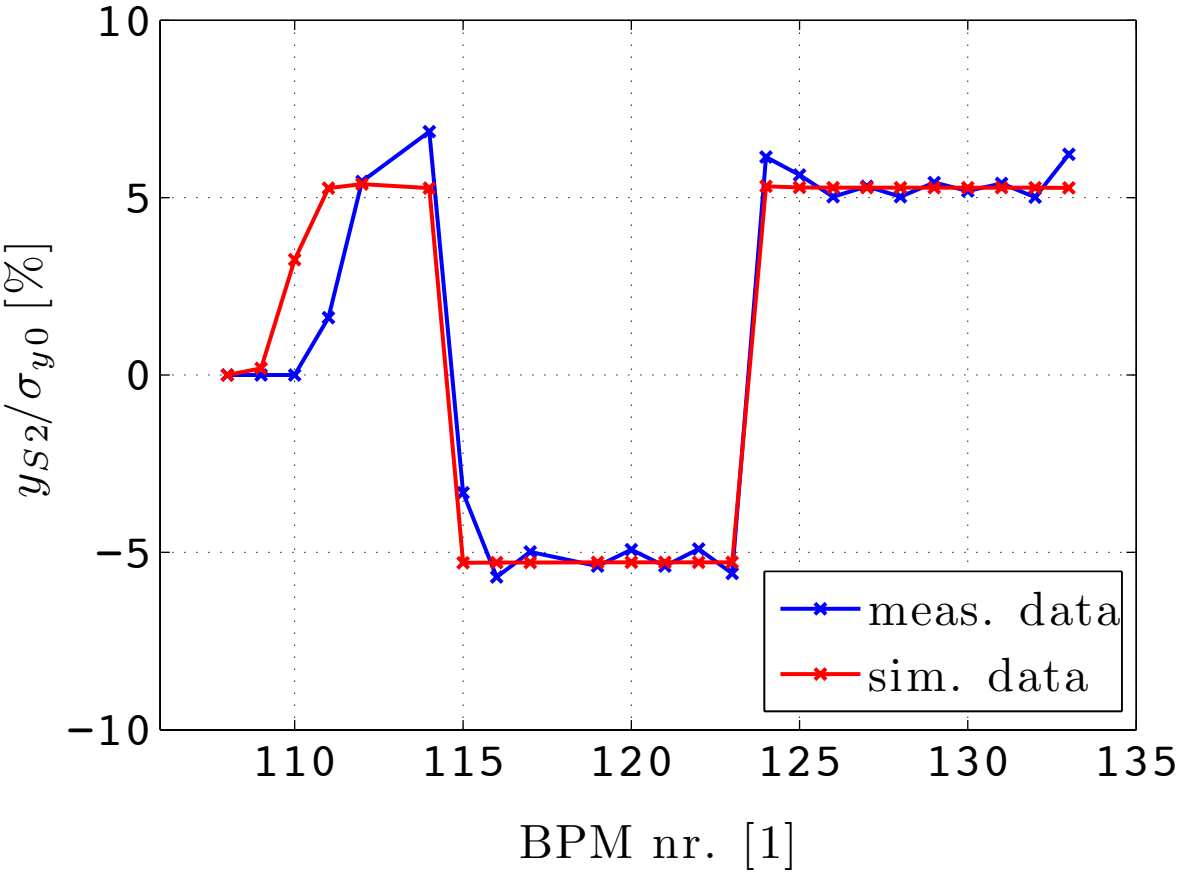
- DoF plot of the jitter covariance matrice
- Two jitter sources have been identified
- The second jitter source can be located very well: around the BPMs 20X and 21FF.
- No charge dependence was observed

Localisation via tracking: QD18X



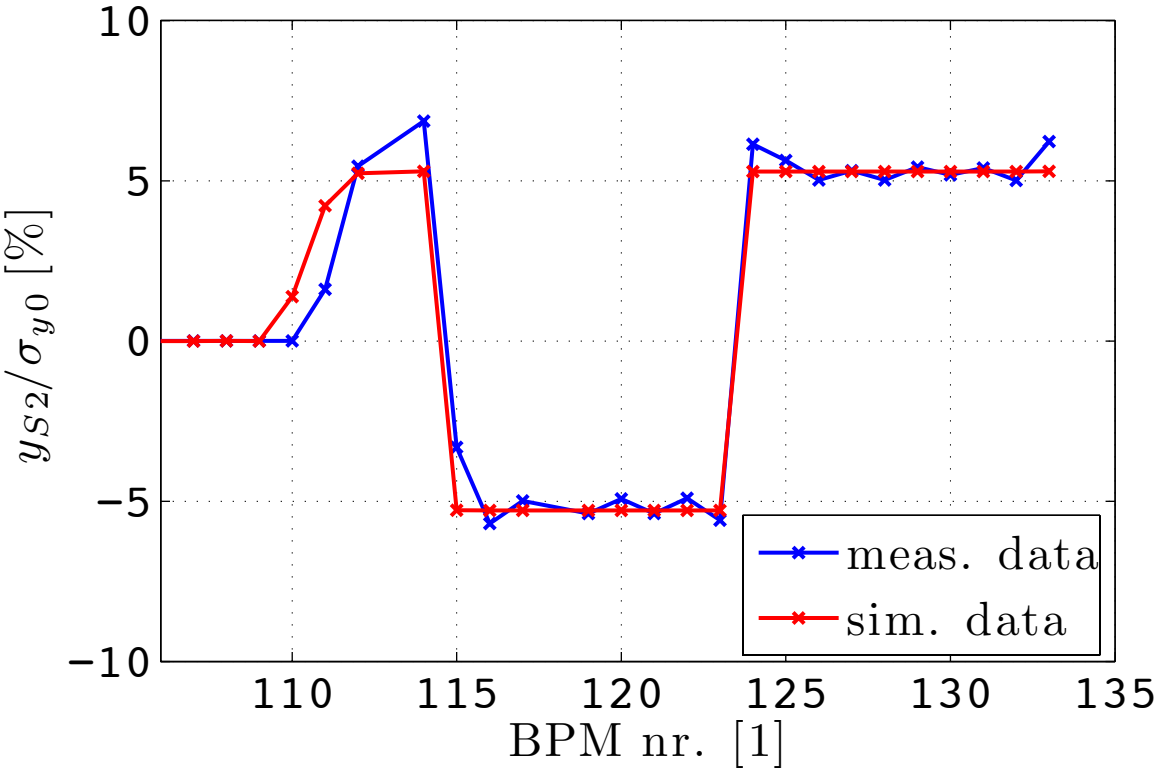
Does not really fit in the begin

Localisation via tracking: QF19X



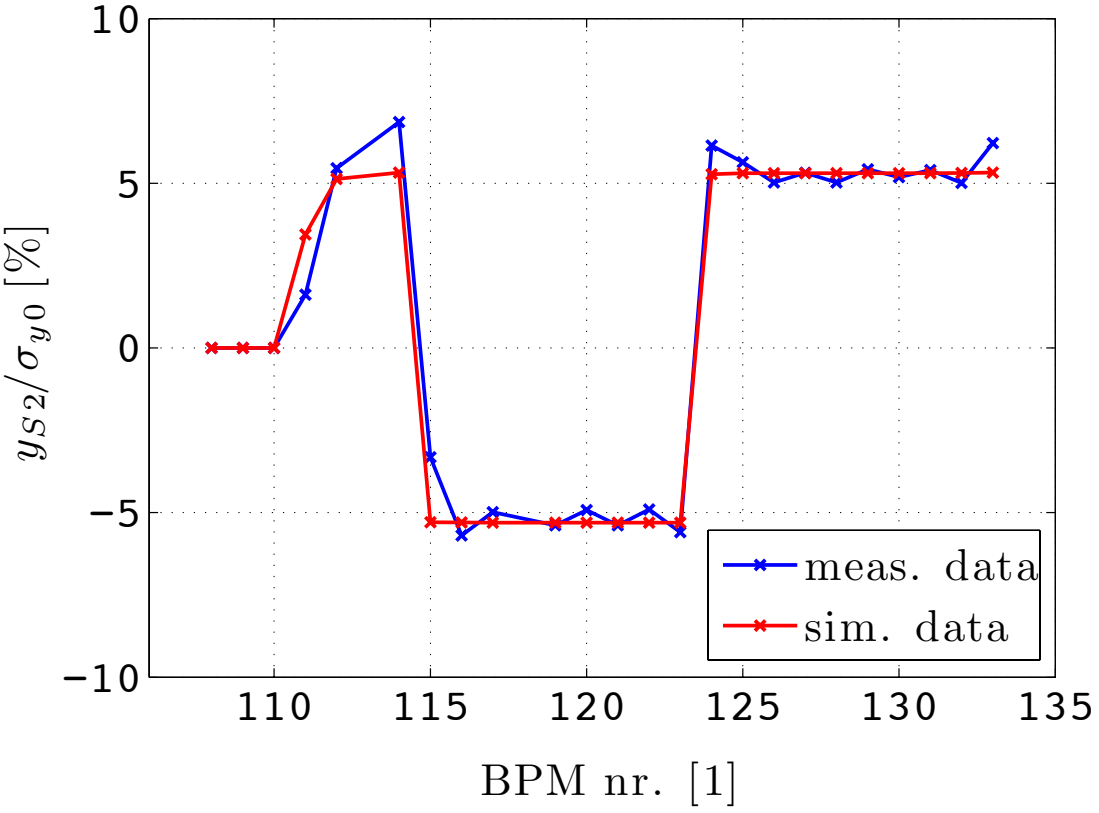
Does not really fit in the begin

Localisation via tracking: ZV11X



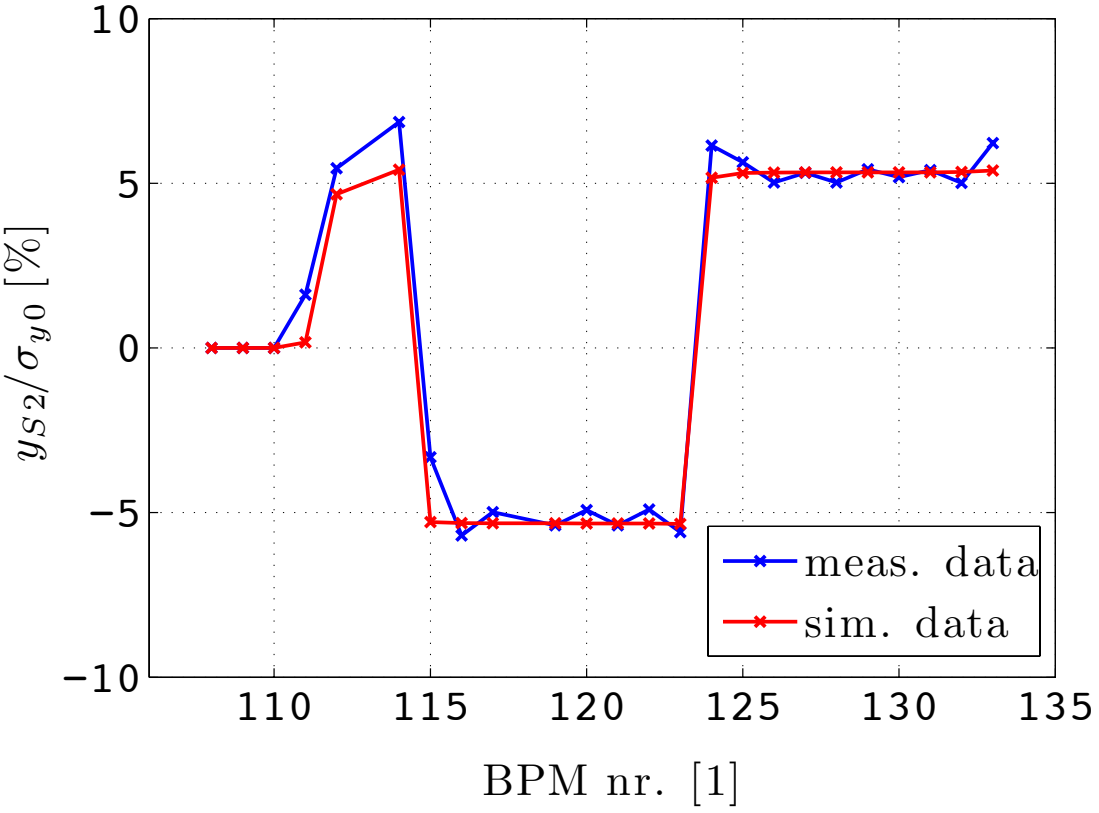
Also does not really fit in the begin.

Localisation via tracking: QD20X



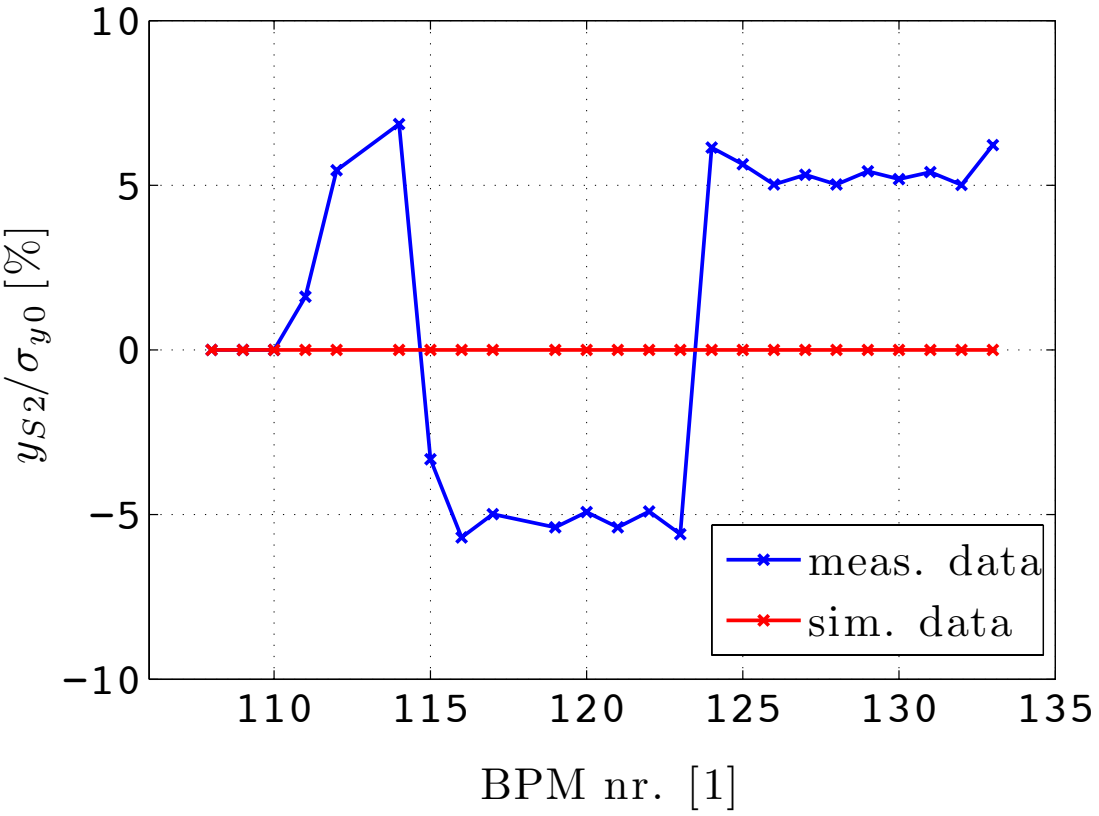
Fits quite well (offset of 0.2 micron)

Localisation via tracking: QF21X



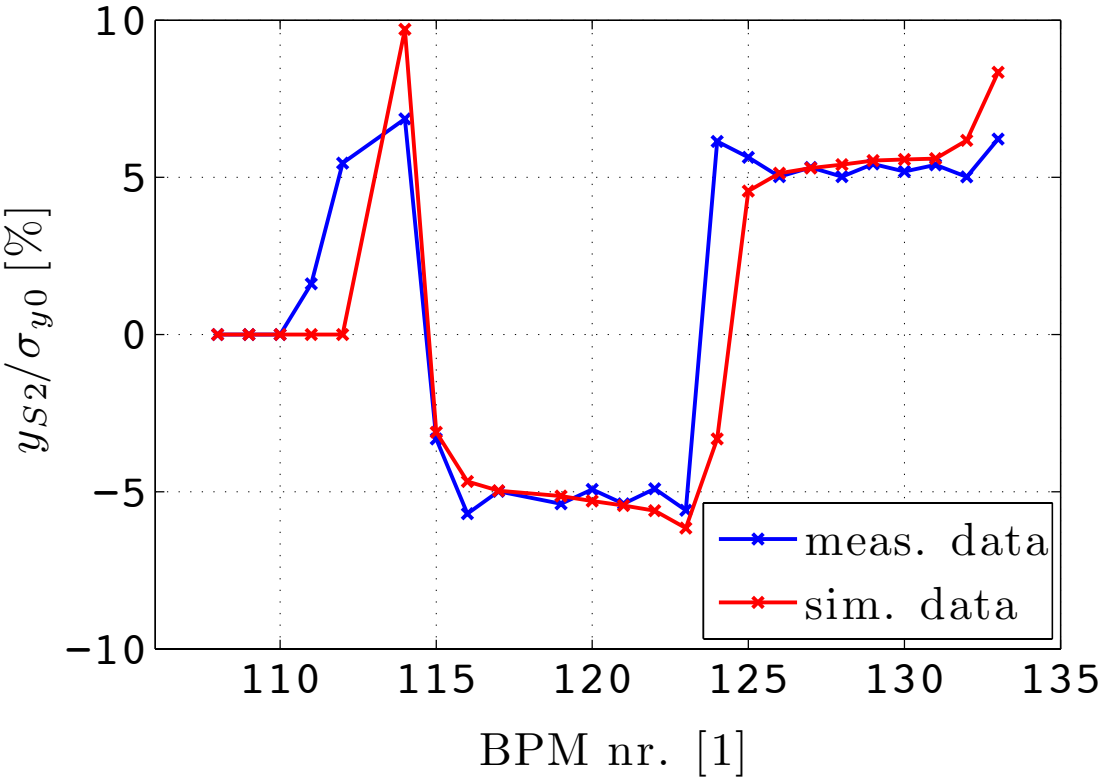
Fits quite well (offset of -0.4 micron)

Localisation via tracking: QM16FF



Magnet is turned off

Localisation via tracking: QM15X



Does not really fit

Reasoning about possible sources

- Elements in the area:
  - Active elements: Q20X Q21X, ZV11X, ZH10X
  - Passive elements: Wire scanners, OTRs, ICT,
- The following field would explain the observed kicks:
  - In Q20X: 3 microT, 1kV
  - In Q21X: 10 microT, 3kV
- Since there was not wake field dependence and electric field must be rather high, we concluded that the device responsible for the jitter should create a magnetic field fluctuation.

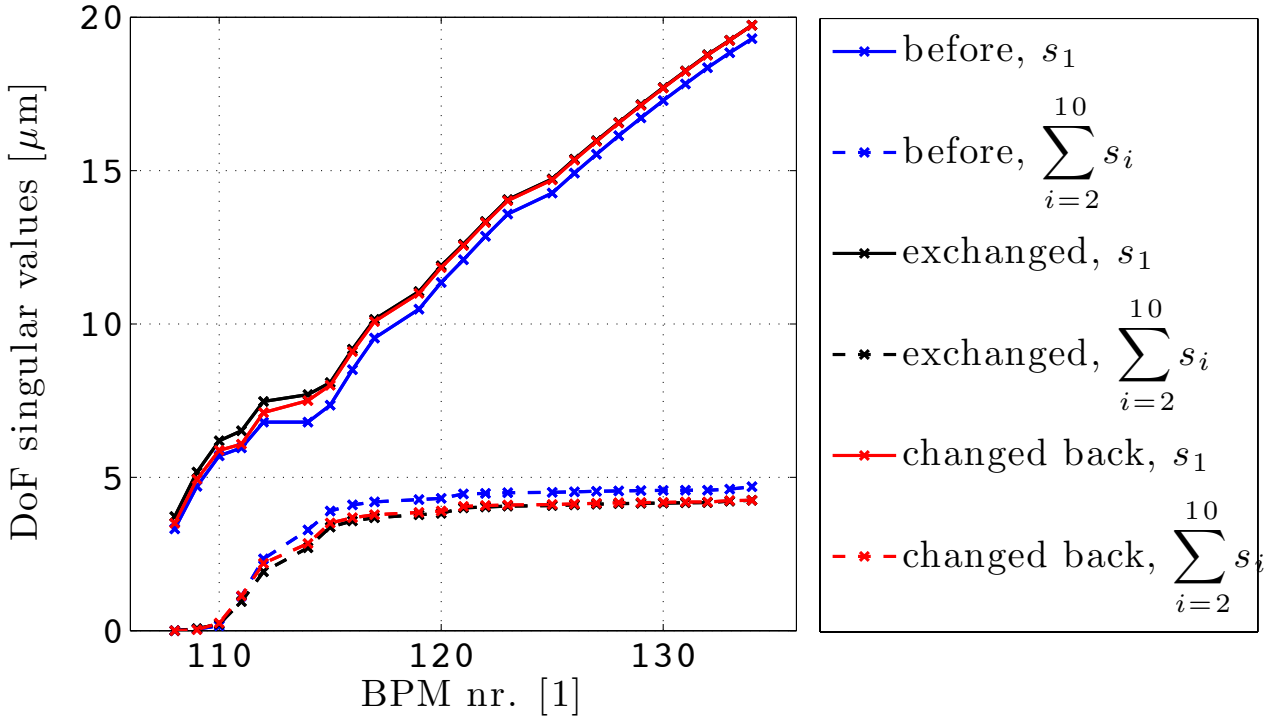
Proposed experiment

1. Measure the beam jitter (M1)
2. Exchange the power converters of QD20X and QF21X with two other ones
3. Measure the beam jitter (M2)
4. Revert the change of the power converters
5. Measure again (M3)

⇒ If the correlation starting around these quadrupole shows up in M1 and M3 and is gone in M2, the power converters are the reason for the beam jitter.

⇒ Experiment was approved and performed on the 18th of June 2013 (Thuseday day shiftm charge 4e9 to 5e9), but only for QD20X (exchange with QM16FF)

Results of the experiment



- No change in the amplitude of the jitter has been observed
- Also the shape of the jitter stayed approximately the same.

Possible reasons

1. Other active devices (relative field jitter)
   - Q21X, ZV11X, (ZH10X)

2. Mechanical motion of the active devices:
   - This would be independent of the power supply quality
   - FFT of jitter shows spectrum close to white

3. Constant jitter of an external device
   - Some parasitic magnetic field acting on the beam (stray field)
   - Would be independent of magnet strength
   - Would be not observable when changing magnet strength or offset

Additional information: Jitter vs. orbit

Jitter dependence on orbit:

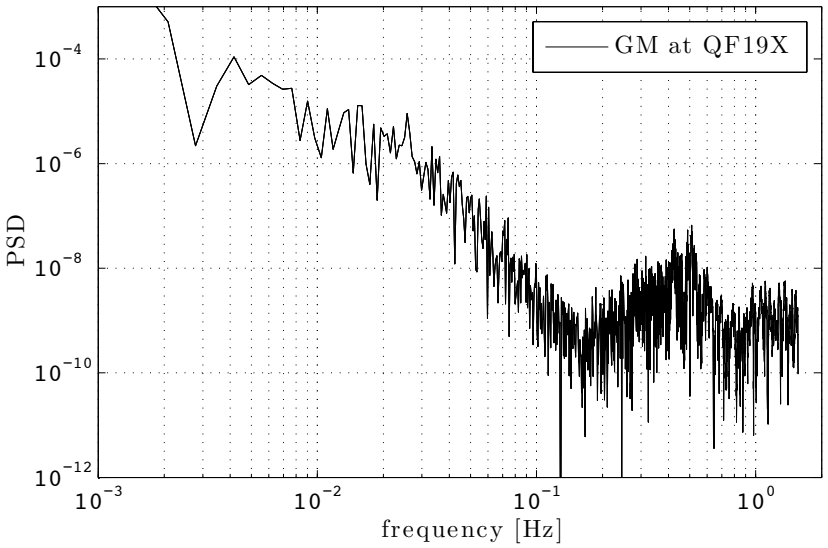
Measurement	Offset Q20X	Offset Q21X	Beam jitter
10. 04. 2013	-100um	80um	5.5%
24. 05. 2013	20um	20um	7%
18. 06. 2013	80-150um	5-25um	11%

Possible combinations for offset and relative field error:

- For Q20X:
  - 1e-3 field jitter => 200um
  - 5e-3 field jitter => 40um
  - 1e-2 field jitter => 20 um
- For Q21X: Factor two larger offset necessary at same field jitter

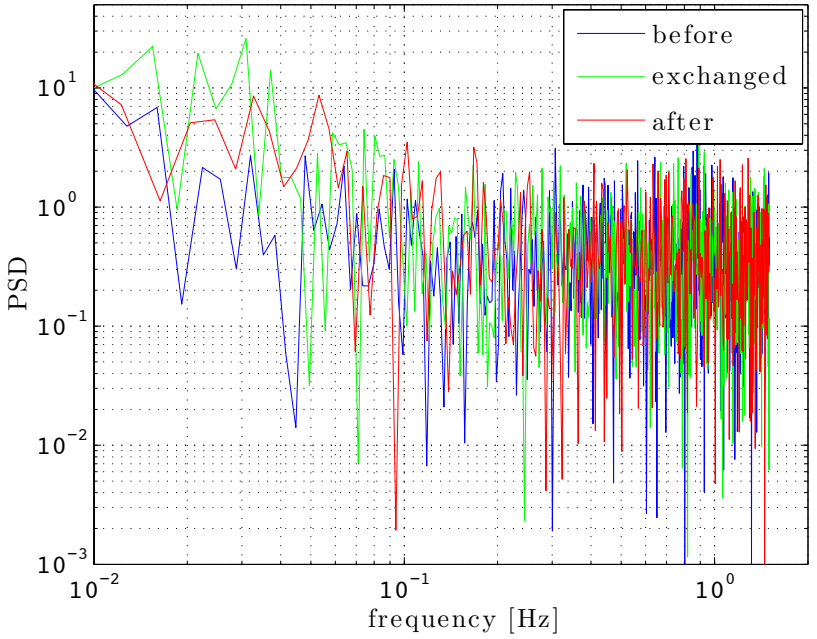
Additional information: PSD source and ground motion

Ground motion at QF19FF



- Only measurement on the floor
- Closed measurement at QF19X
- All GM spectra look very similar

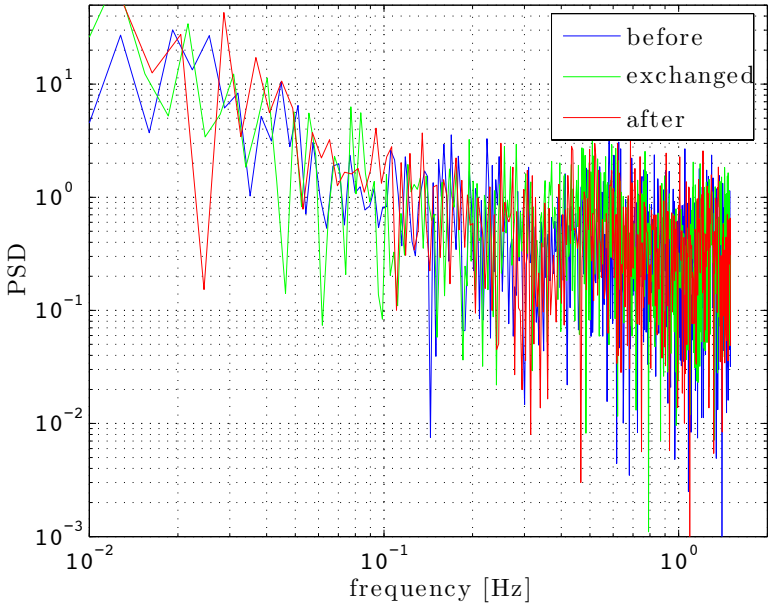
Source 2



- Jitter spectrum looks rather flat with small increase for low frequency
- PSD scaled from FFT of diff. data

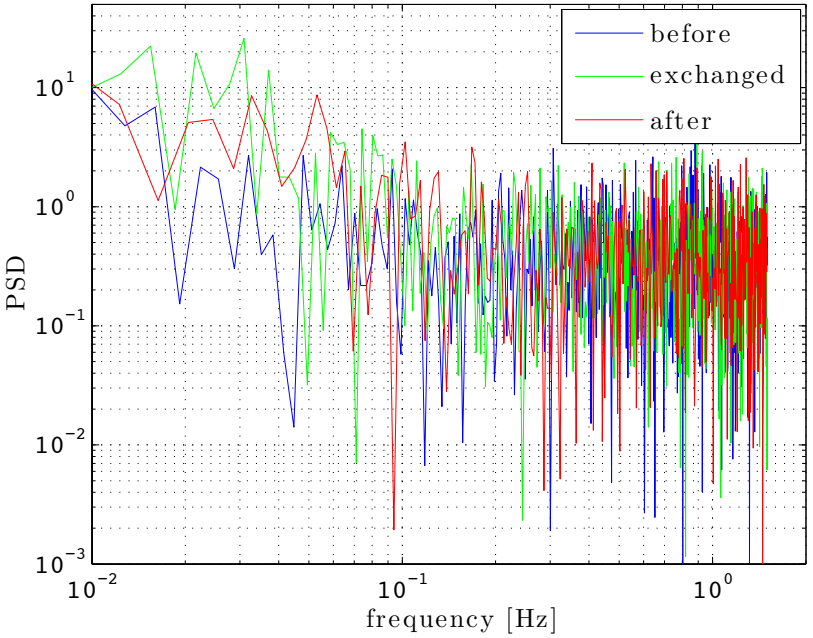
Additional information: PSD sources

Source 1



- Spectra of source 1 and 2 look very similar
- Source 1 has a stronger components at low frequencies

Source 2



- No significant difference with exchange and without

Collected information

- Since no charge dependence and necessary electrical field would be too large, cause is most likely a fluctuation magnetic field (few microT seen seen by the beam)
- Three magnets fit the shape of the extracted jitter: ZV11X, Q20X Q21X

- PSD of jitter is white (broadband excitation)
- No movement of magnet due to ground motion observable, but no direct measurement.
- At least no clear dependence of the jitter on the beam position in the adjacent BPMs.

- Therefore, it seems (to me) that a likely cause is a power supply with too high jitter.
- Q20X tested, but jitter was the same

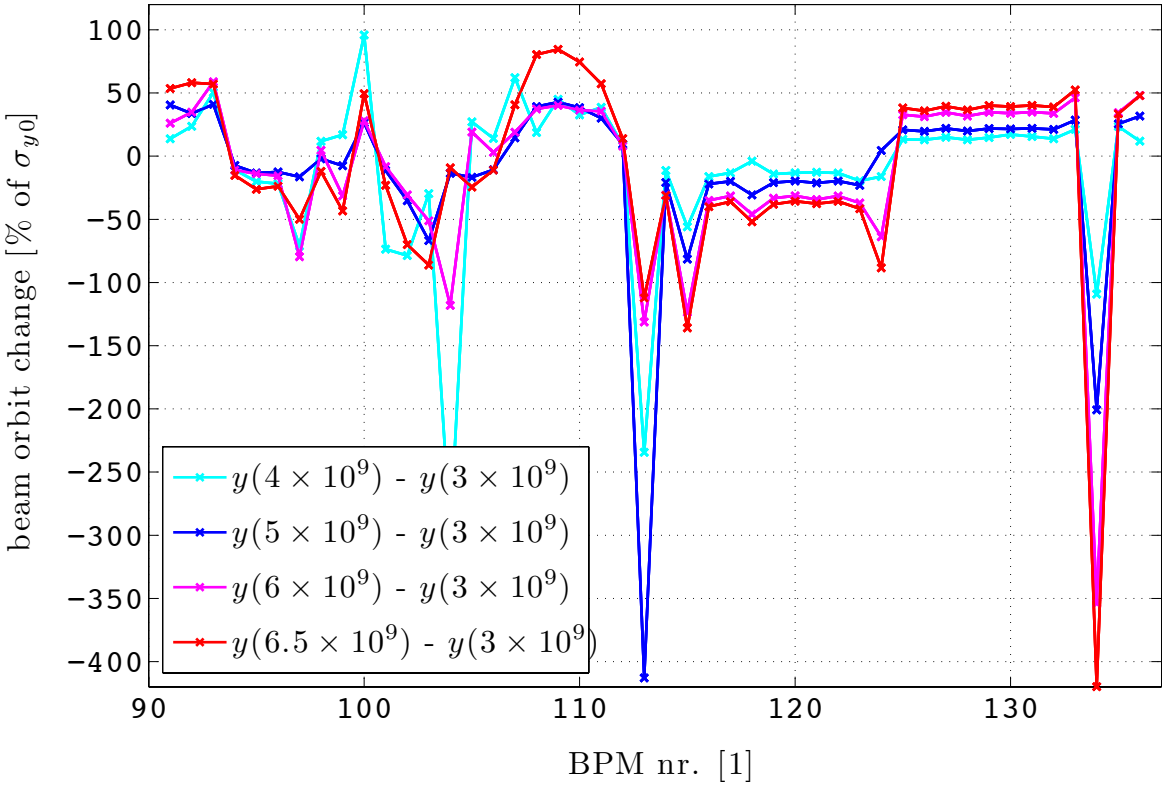
Suggestion from the CLIC community

- The results of the experiment were presented in a CLIC Beam Physics meeting.
- Since source has to be a changing magnetic field, and the source is localised well, the consensual opinion was that the best way would be to work directly on the sources again.
- Experiment out of two parts was suggested:
    1. Orbit bump over the area of interest
    2. Turning of of corrector ZV11X
- If the beam jitter does not vanish it cannot be a magnet and it is some external parasitic magnetic field

  => Stray field measurements, parasitic currents in beam pipe
- Please give your opinion about the best future strategy!!!

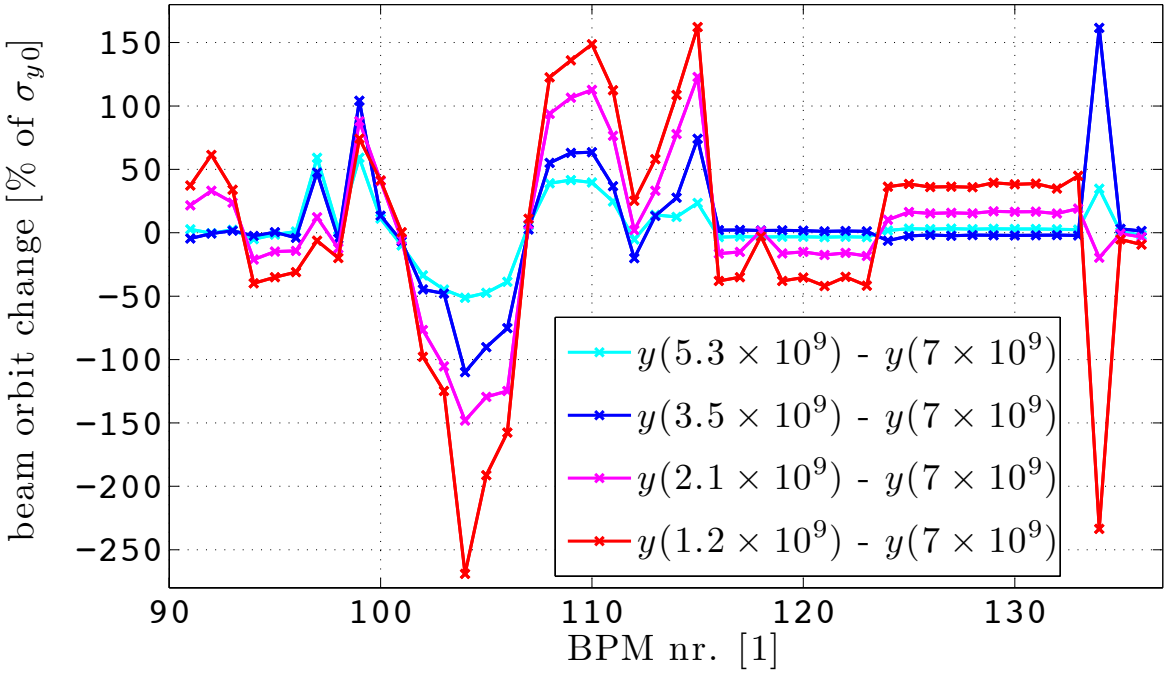
Side study: wake field source

Orbit dependence of intensity (10th of April)



- No dependence of diff. orbit but strong dependence on absolute orbit
- Some problems with scaling of BPMs.

Orbit dependence of intensity (24th of May)



- Charge change twice as large.
- Hence, effect in FF reduced!
  - Bellow shielding
- But clear effect from early in the beam line now
  - New ext.-line tuning procedure

Wake fields still seem to depend on the steering in the early extraction line!

6. Conclusions

1. Field quality of Q20X is not the reason for the jitter of source 2.

2. Several other reasons are possible, but it seem to be a fast varying magnetic field (seen by the beam).

3. Suggestions for future experiments have been made!

Thank you for your attention!

Possible future strategies

$$\frac{y_2}{\sigma_2} \propto \frac{\sqrt{\beta_1\beta_2}\,\sin(\phi_2-\phi_1)}{\sqrt{\beta_2}}\,y_1'$$

Beta function at source:

- Change of beta function at source location changes relative jitter
- Whole section could be tested
- Depends how easy it is to change beta function of certain areas.
- But has to be easy (no long re-matching)
- Phase as to be controlled
- Possibility: Use beta-beating

Change source directly:

- Can be difficult since many possibilities
- Usually invasive
- Likely to get a negative outcome