Beam jitter at ATF2:

A. Source localisation and
B. Ground motion correlation

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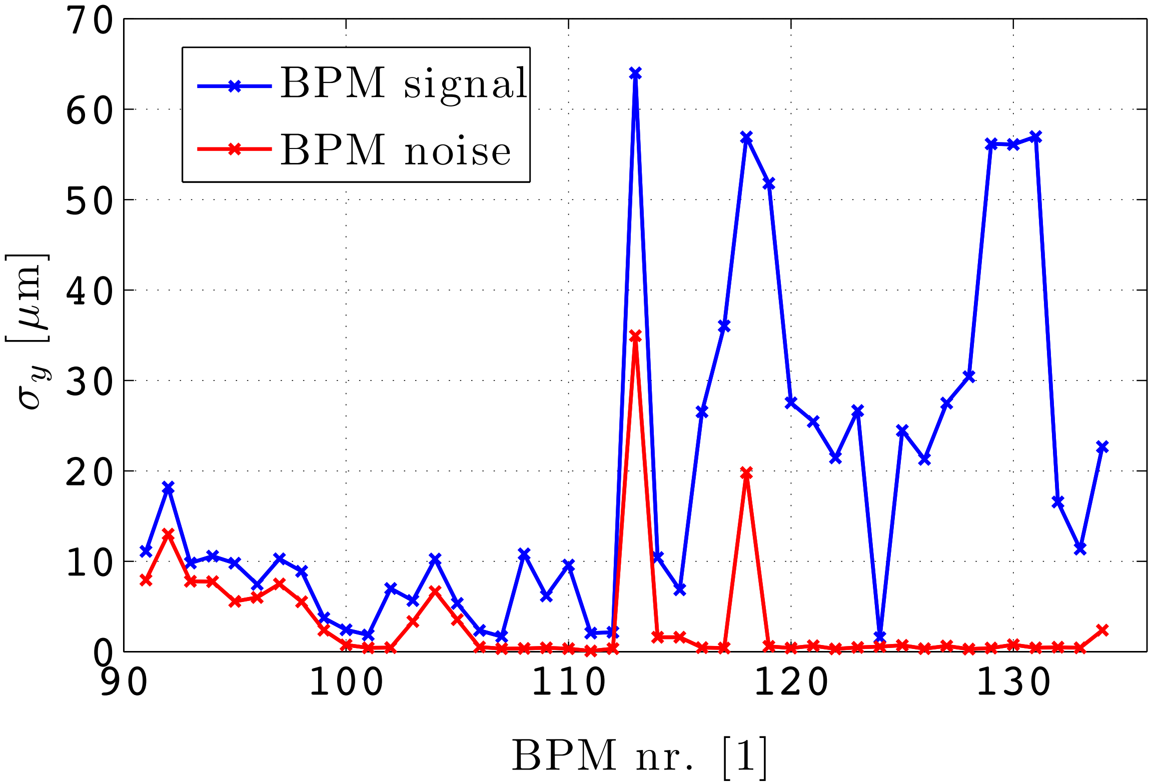
A. Beam jitter source localisation via correlation studies

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).

Signal and noise levels



- BPM noise calculation from data as described in Kim et al. PRST Accel. and Beams 15, 42801
- Jitter level fits now much better than before
- BPM 102 is the first BPM with sufficient signal to noise ratio.
- Better BPMs would help

Method 1: Detection of jitter sources with Model Independent Analysis (MIA)

Methods described in paper by J. Irwin et al. PRL 82(8) about Model Independent Analysis (MIA)

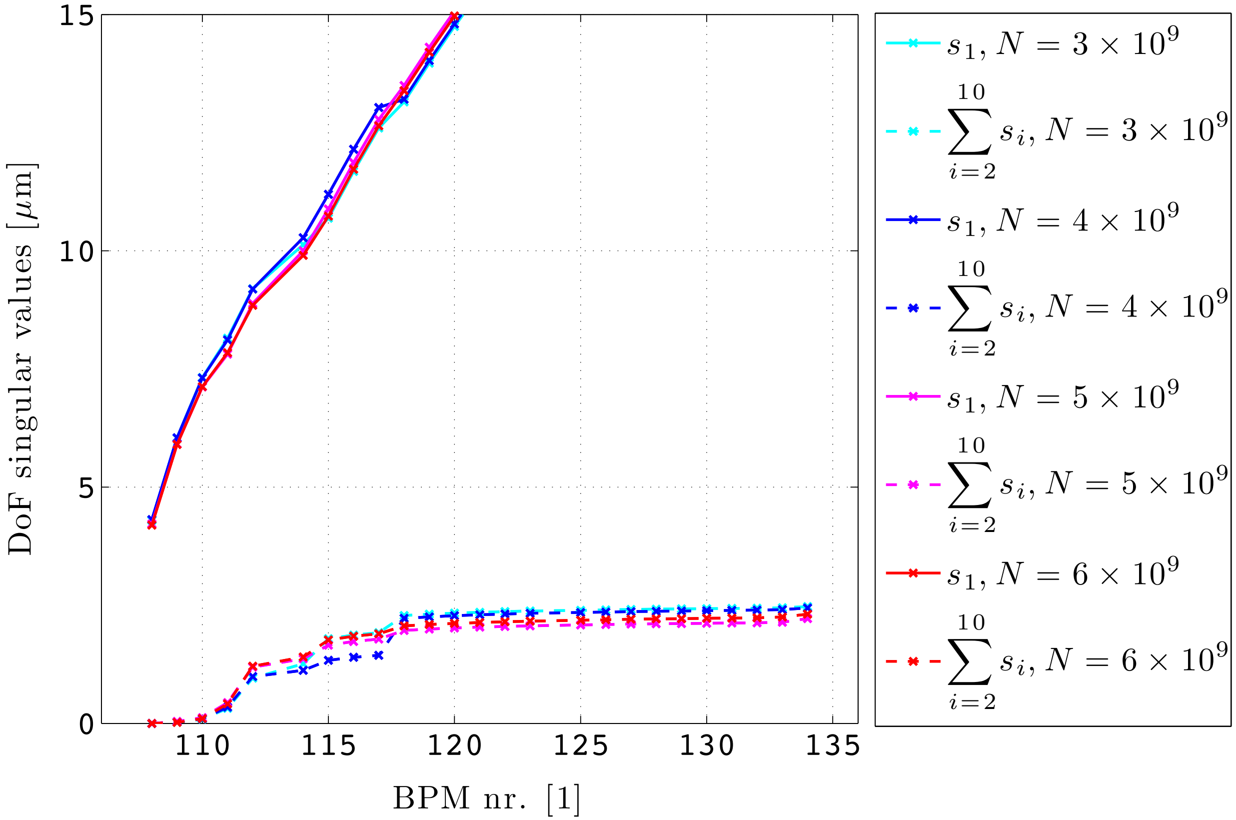
- Degree-of-Freedom plot (DoF-plot)
  - Connection of SVs for SVDs with increasing number of used BPMs.
  - Lines are the connections of largest, second largest, … SVs.
  - Change of slope indicates physical source.

Methods all just try to find location of sources, but are not capable of determining the form of the according oscillation:

> "Note that each of the eigenmodes in Eq. (4) does not correspond uniquely to the physical pattern in Eq. (2)."

- We use instead of the SVs of the full data, the SVs of the correlation matrix, because we believe that is more robust (no dependence on beta function).

DoF-plot of the jitter correlation matrix



- Change of slope indicates physical source.
- Only cavity BPM with good signal to noise ratio are used
- Change around BPM 111 (MQF21X) and 112 (MQM16FF)
- Observation of direction does not give good hinds of oscillation shape.
- No intensity dependence

Method 2: Extraction of beam jitter

- **Step 1:** Starting at the first BPM, and remove the correlation coefficients *r* of this BPM with all downstream BPMs. For details please refer to ATF report ATF-12-01.

$$r = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$$

σ_i … standard deviation σ_{ij} … cross correlation

- **Step 2:** Apply this correlation removal to all BPMs before the detected source.

- **Step 3:** From the remaining motion remove the motion that is correlated to the BPMs at the source and store it.

- **Step 4:** The source motion is now removed an can be analysed.

Identified sources

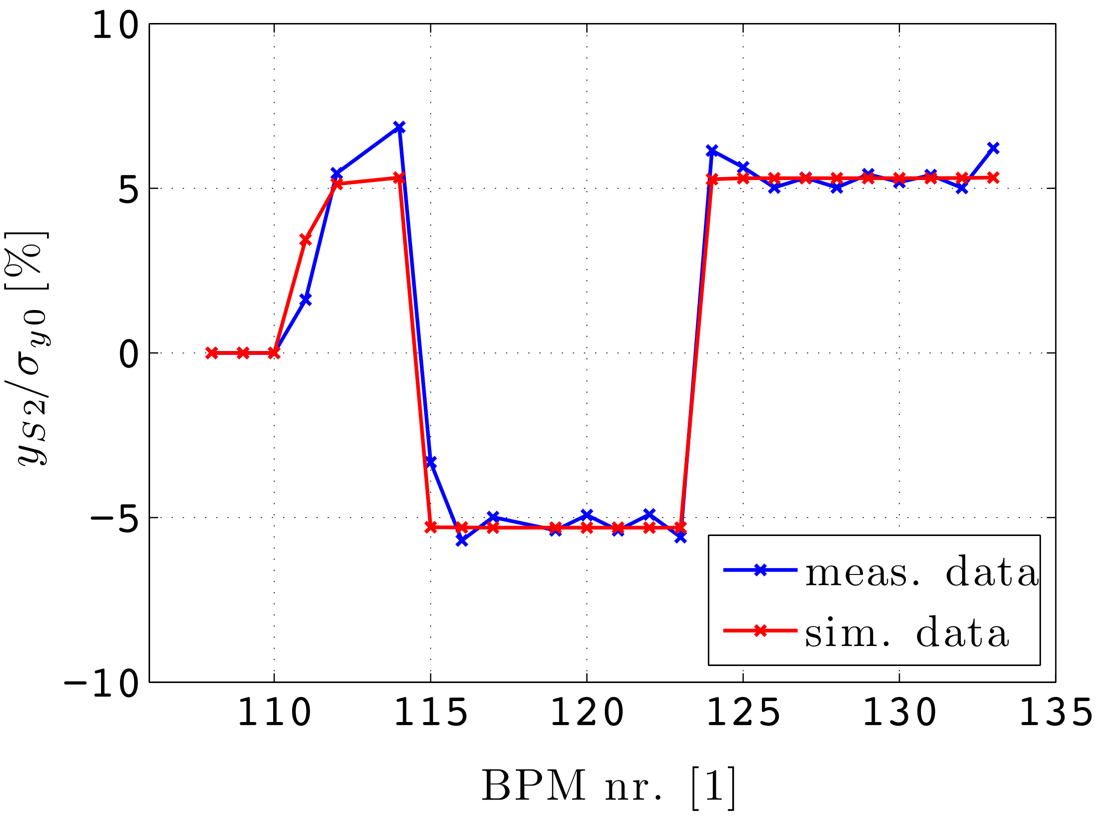
Before there where 3 sources, but with the resolution of the problem there are only 2 sources left.

- Source 1: Main contribution (19%) of the beam jitter comes from upstream of the sensitive cavity BPMs. There the resolution is not fine enough to make further statements.

- Source 2: Only contributes to about 5% of the beam jitter, but is very well localised.

- Results do not depend on the beam charge. Therefore we assume it has to be a not a wake field and therefore produced by an active device. Passive devices in the region are some wire scanners and OTRs.

Tracking with LUCRETIA: QD20X



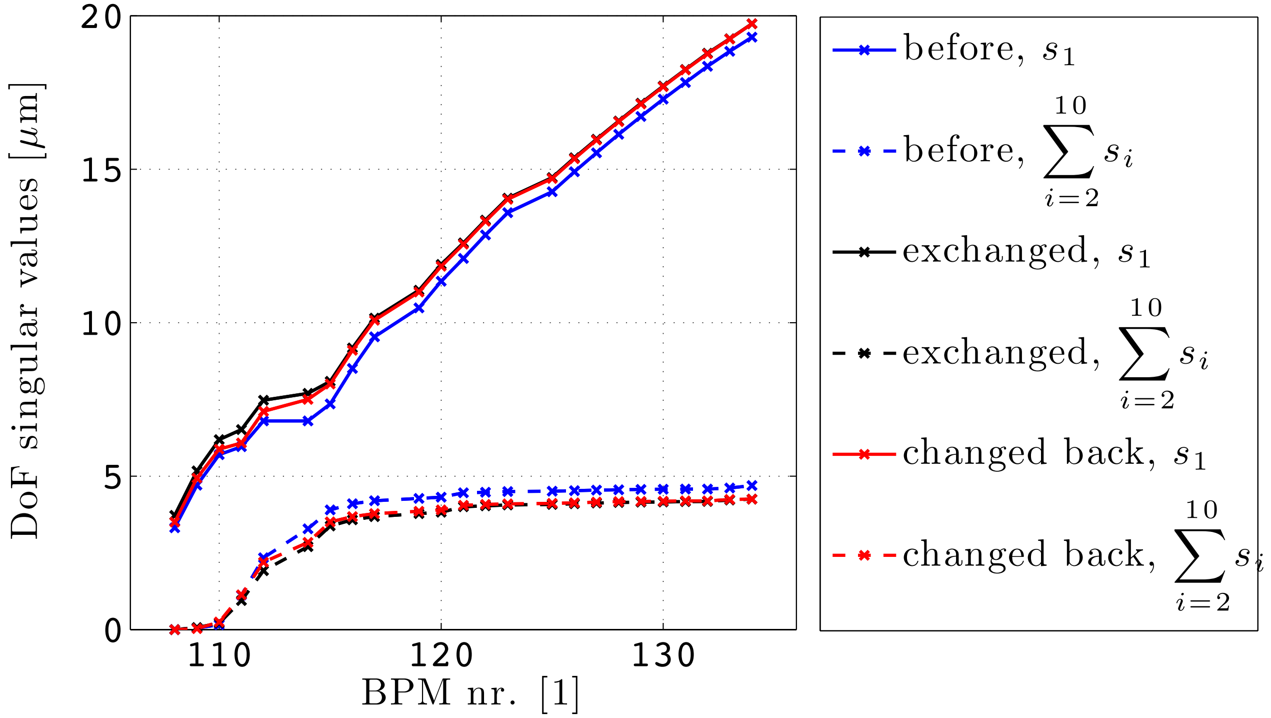
Fits quite well (offset of 0.2 micron)

Proposed experiment

1. Measure the beam jitter (M1)
2. Exchange the power converters of QD20X with another one
3. Measure the beam jitter (M2)
4. Revert the change of the power converter
5. Measure again (M3)

=> If the correlation starting around these quadrupole shows up in M1 and M3 and is gone in M2, the power converter is the reason for the beam jitter.

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.

Planned future work

1. Repeat jitter measurement with newly installed BPMs at the beginning of the beam line. This will give more insights in the origin of the identified source 1.

2. Try to find the machine component that is responsible for the beam jitter from the well localised source 2. Therefore we propose to:

   - Try to create an orbit bump in the area of interest
   - Turn of corrector magnet ZV11X (strong support needed)

Measurement of ground motion induced beam jitter

On behalf of Y. Renier (slides taken from him),
and also K. Artoos, R. Tomas, D. Schulte and R. Tomas

Goal and motivation of the ATF2 experiment

Goal

- Predict Ground Motion (GM) effect on beam trajectory with GM sensor.
- Compare with BPM reading.

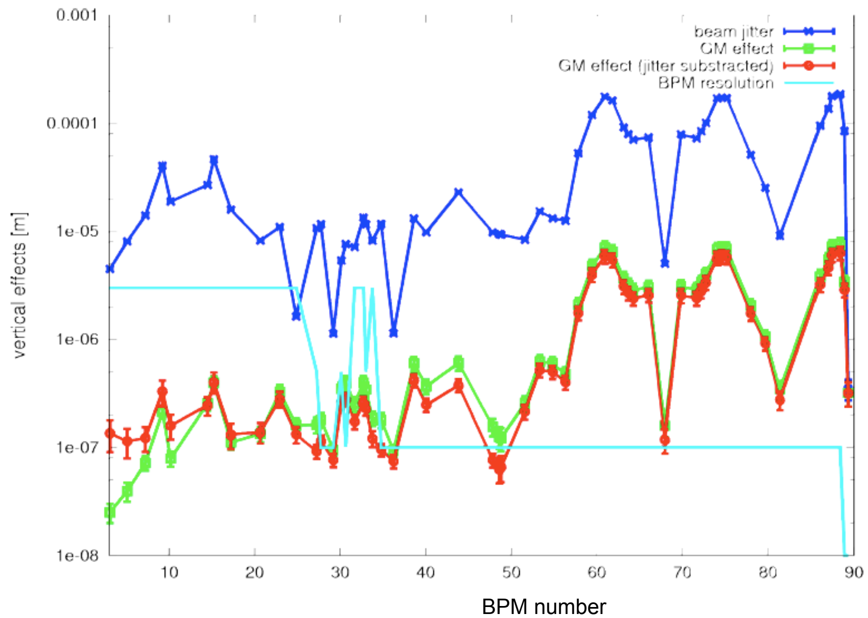
Motivation

- GM sensors are usually only compared to other GM sensors
- It would demonstrate possibility to make a feed forward with GM sensors.
- Feed forward would allow trajectory correction based on GM measurements in CLIC.
- Feed forward would allow big saving (avoid/relaxing specification of quadrupole stabilization in CLIC)

Algorithm

Algorithm - Each Pulse

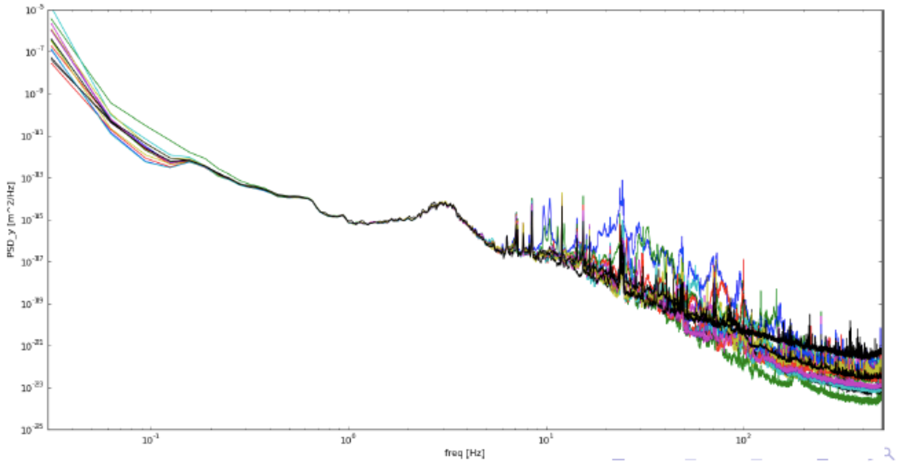
- Remove incoming jitter from BPM measurements (first 5 SVD modes).
- Evaluate GM effect on BPM readings from GM sensor measurements (minus the part removed by jitter subtraction).
- Compare these two residuals.



Status of Installation

- 14 ground motion sensors have been installed (K. Artoos, A. Jeremie, Y. Renier, ATF2 team)

- First measurements are available: (PSD)



- More details about these data are given in the talk by L. Brunetti.
- Also BPM and ground motion data have been taken in parallel (this presentation).

Simulation Parameters

Conditions

- Updated ATF2 nominal lattice (sextupoles off).
- Elements misaligned initially (RMS=100μm).
- Trajectory is then steered.
- GM model based on measurements.
- Relative GM from 1st sensor.
- Incoming beam jitter.
- Quadrupoles errors of $\frac{dK}{K} = 10^{-4}$ included.
- BPM resolution included.
- Sensors transfer function included.

Framework available at
http://svnweb.cern.ch/world/wsvn/clicsim/trunk/
in the folder ATF2/Frameworks/feedforward

Evaluation of the results

- R_1 is the GM effect obtained from GM sensors.
- R_2 is the GM effect obtained from BPMs.

$$p = \frac{||R_1 - R_2||_2}{||R_1 + R_2||_2}$$

.

- $p = 1$ if R_1 and R_2 independent.
- $p = 0$ if $R_1 = R_2$ (ideal case).
- The lower p is, the best is the determination from the GM sensors.

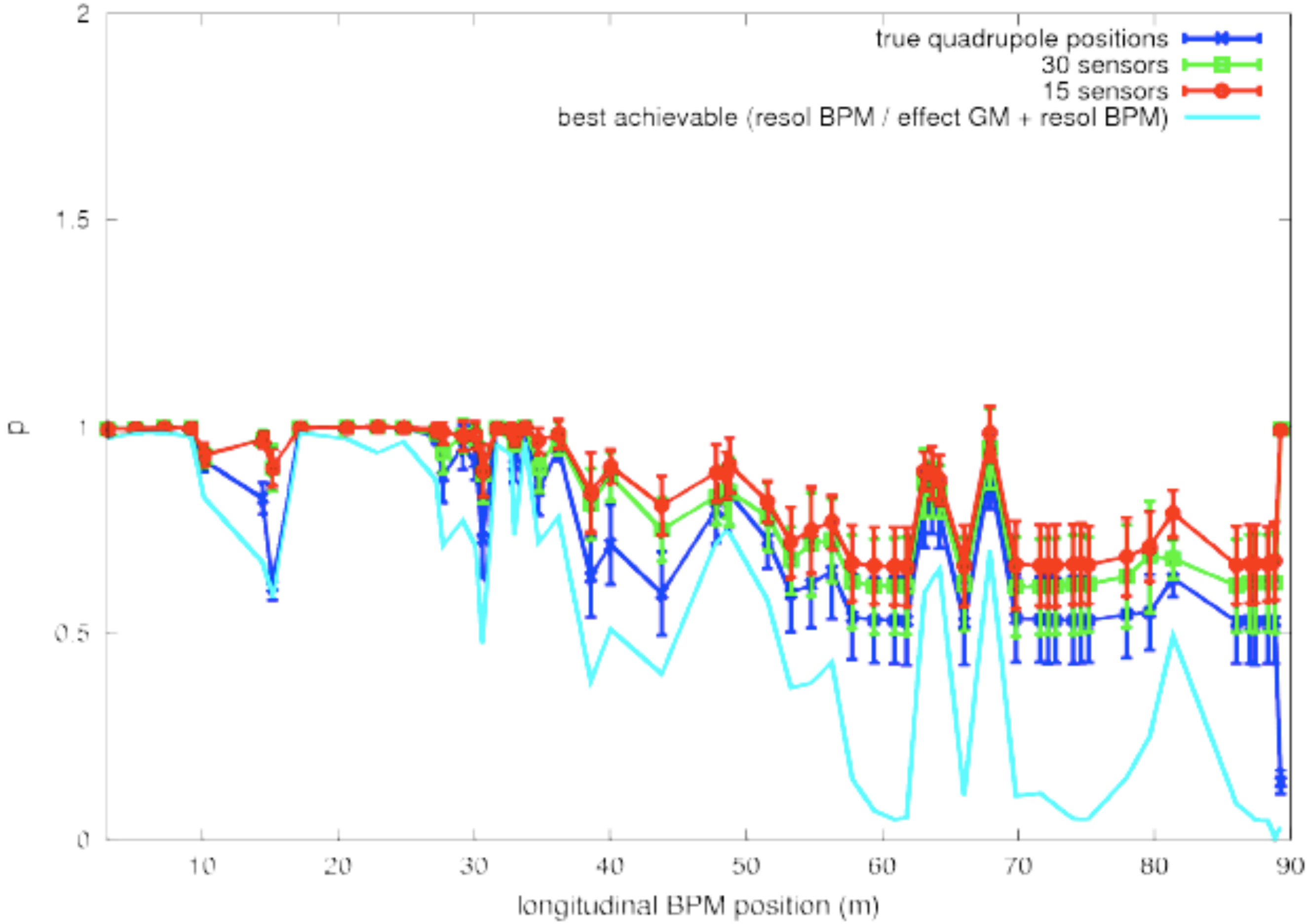
Results for nominal lattice:

- px = 0.82 +/-0.1 (in final focus)
- py = 0.96 +/-0.05 (in final focus)

- Final focus region is most sensitive
- Algorithm assumes perfect system knowledge and perfect jitter localisation
- Very optimistic to see something

With swap of three cavity BPMs to beginning of beam line

Vertical (more sensitive)



- px = 0.76 +/-0.1
- py = 0.71 +/-0.1

- Effect should be clearly visible in both planes

- But idealised assumptions!

First measurement results

- Jitter subtraction did not work on real data as expected.
- BPM signal got bigger after jitter subtraction!

- Initially, there has been a model mismatch, between optics model and real machine
- Then also the actual machine parameter were saved and optics model adapted.
- Model and real machine seem to fit together now.

- Still BPM signal could not be decreased!
- Possible reasons:
  - Residual model-mismatch
  - Jitter is not coming from the beginning of the beam line (kicker)

- Work is necessary to resolve this problem!

Conclusion & Plan

Conclusion

- Simulations show:
  - the beam jitter subtraction is critical.
  - great improvement with few BPMs swapped (done this summer).
- The GM sensors work nicely.
- Synchronization between GM sensor and BPM is done.
- Still got problems with jitter subtraction.

Prospects

- The swapping of few BPMs will make the jitter reconstruction easier.
- New measurements in October by Juergen planned.

Thank you for your attention!