Beam jitter localization and identification at ATF2

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A. Introduction

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 40%.

- 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).

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)

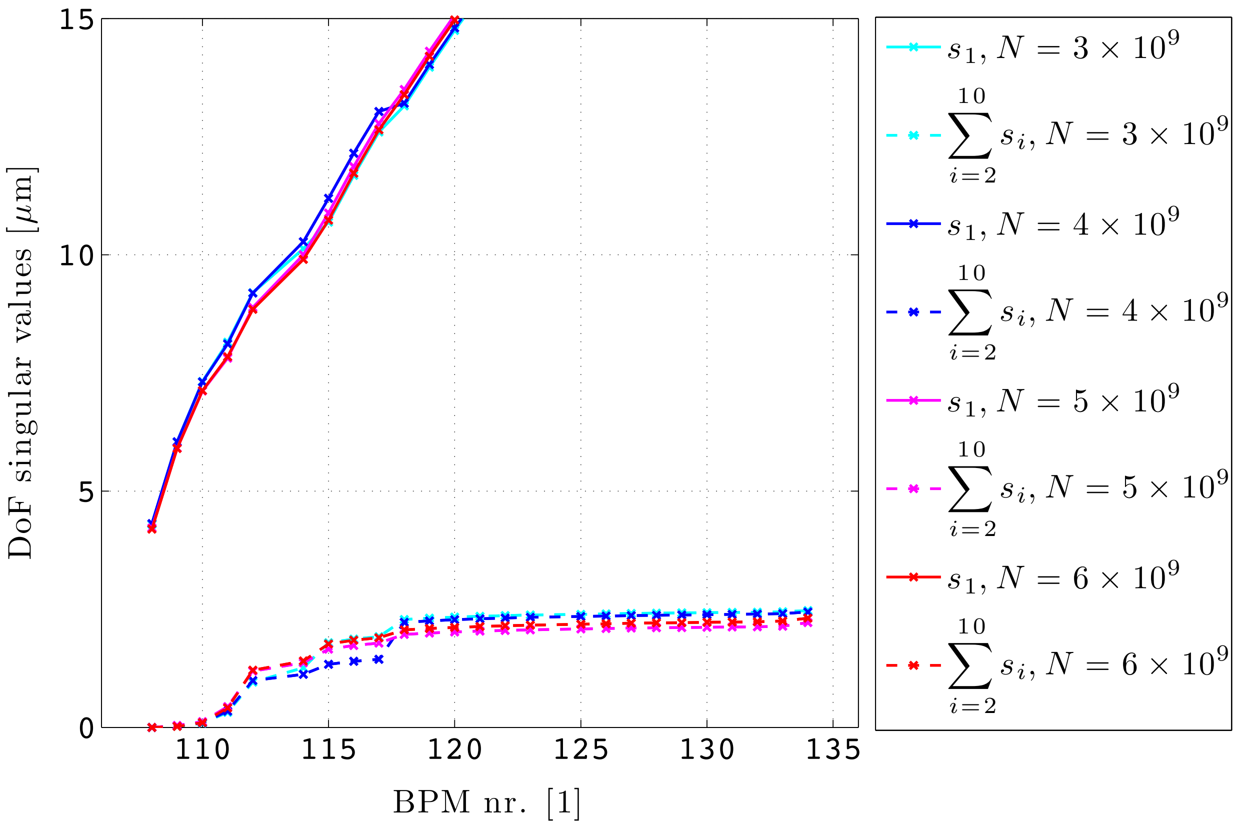
- Degree-of-Freedom plot (DoF-plot)
  - Connection of SVs for SVDs with increasing number of used BPMs.
  - Lines are the connections of largest, second largest, … SVs.
  - Change of slope indicates physical source.

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.

Reasoning about possible sources

- Elements in the area:
  - Active elements: Q20X Q21X, ZV11X, ZH10X
  - Passive elements: Wire scanners, OTRs, ICT,

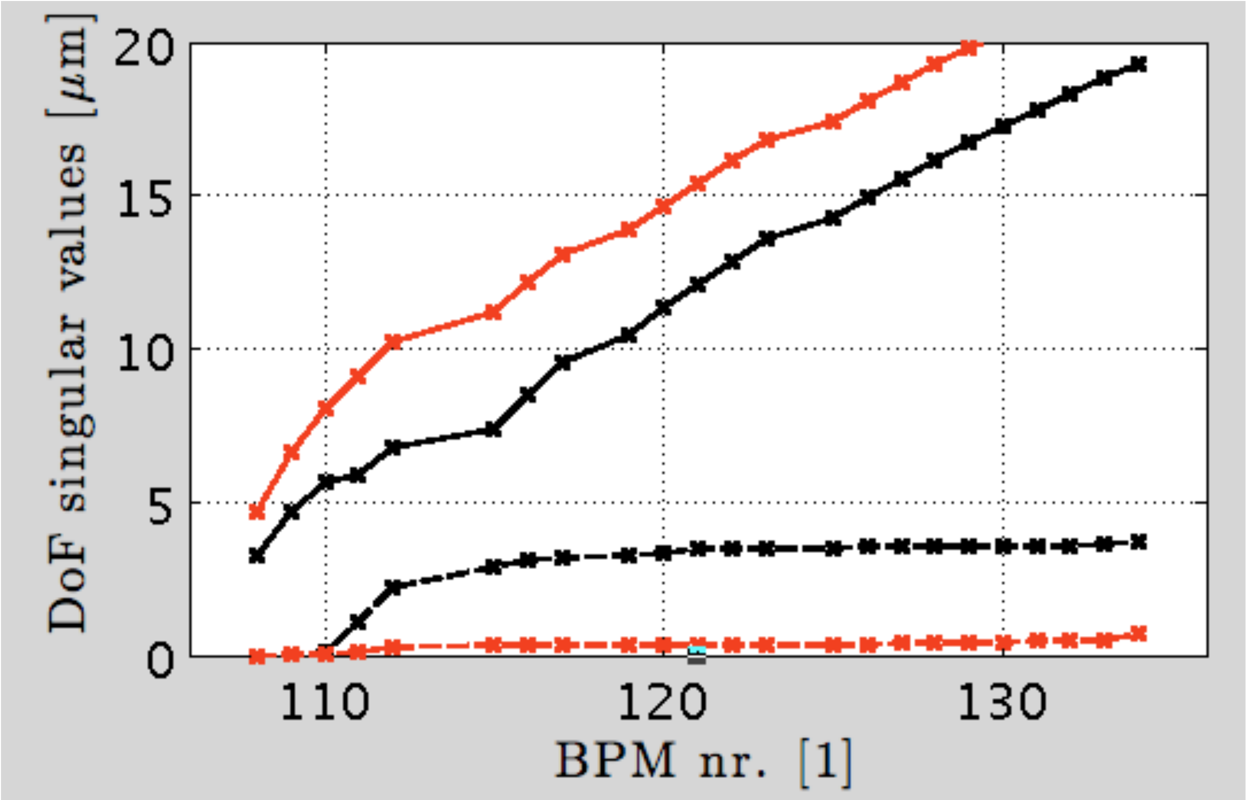
- The following field would explain the observed kicks:
  - In Q20X: 3 microT, 1kV
  - In Q21X: 10 microT, 3kV

- Since there was not wake field dependence and electric field must be rather high, we concluded that the device responsible for the jitter should be active.

B. Beam jitter source localization: experiment for source 2

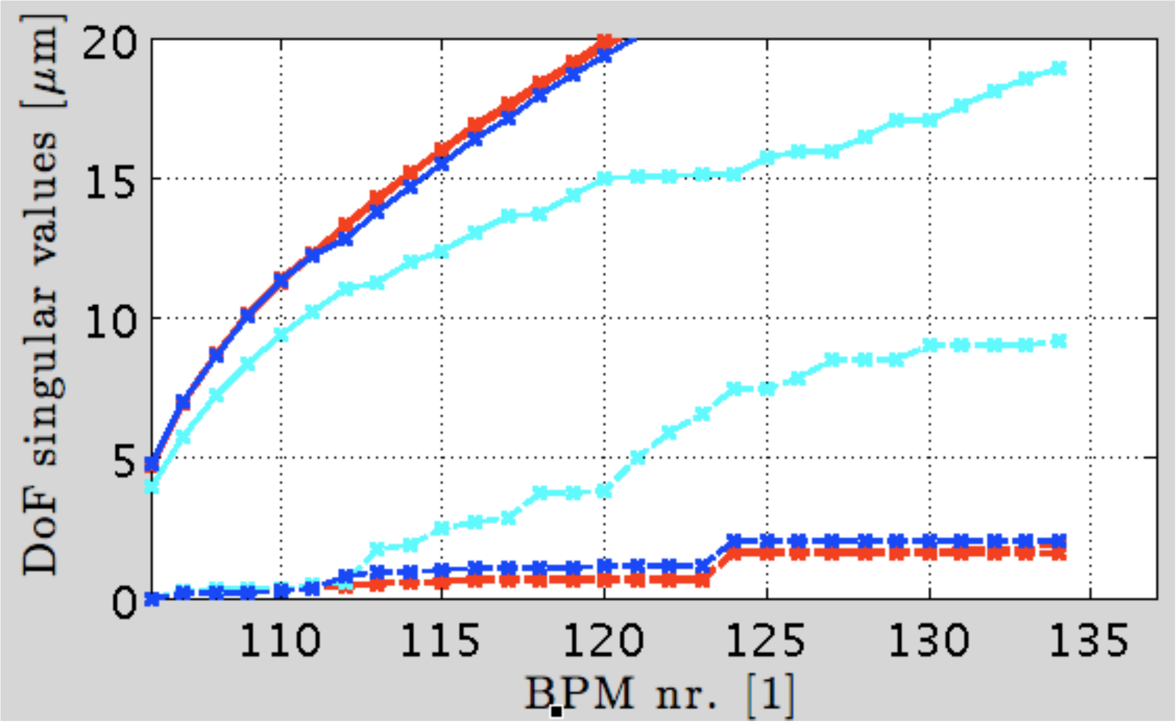
November 2013

Nominal operation (red)



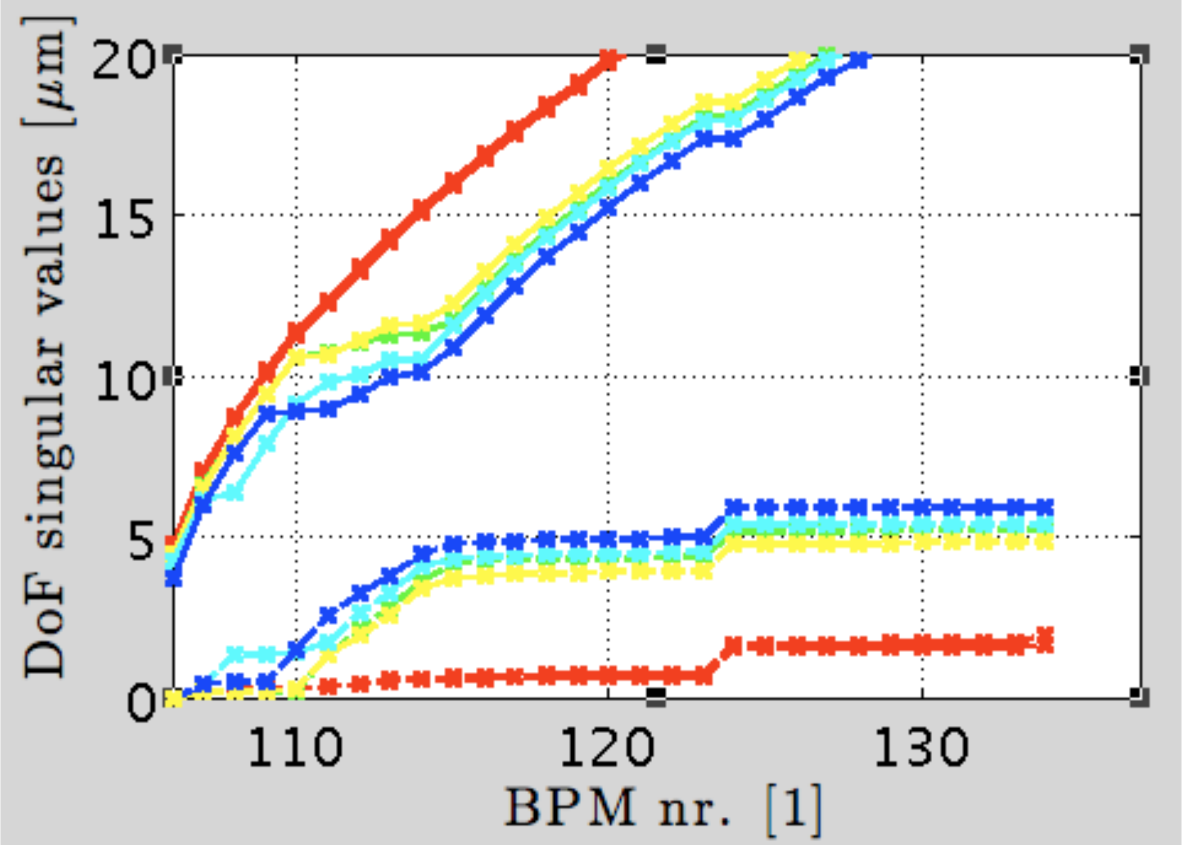
- General jitter level was about 40%(strongly increased)
- Jitter source 2 was gone!

Change position of QM16FF and QM15FF with movers



- Nominal
- Cyan: QM15FF 0.5mm
- Blue QM16FF: 1mm
- Dependence of jitter on the beam orbit far downstream of the creation (offset was very large). No kicker changed

Change of strength of different steering magnets and limiting offset in FF with ZV1FF

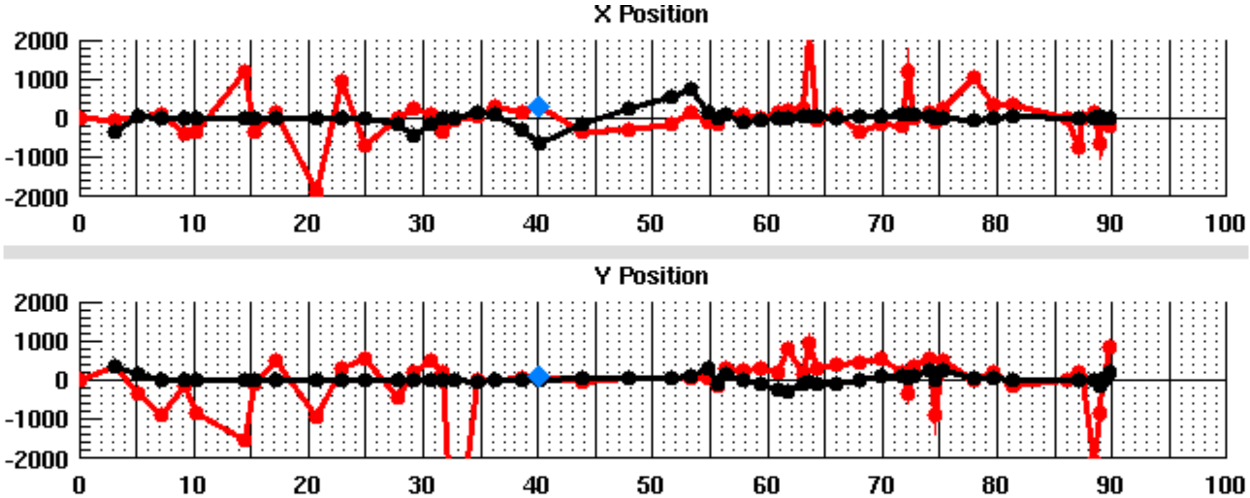


- Nominal
- Green: ZV11X
- Yellow: ZV10X
- Cyan: ZV09X
- Blue ZV08X:
- Actuations created similarly large offsets in the area of Q20X Q21X, Q16FF, Q15FF

Upstream

•The magnets further upstream are more sensitive. For 1mm offset and $2x10^{-4}$ field jitter, each QP would individually create

	QF1X	QD2X	QF3X	QF4X	QD5X	QF6F	QF7X	QD8X	QF9X
QD20X	16%	51%	19%	18%	50%	21%	8%	22%	7%
QF21X	21%	68%	25%	24%	66%	28%	10%	29%	10%

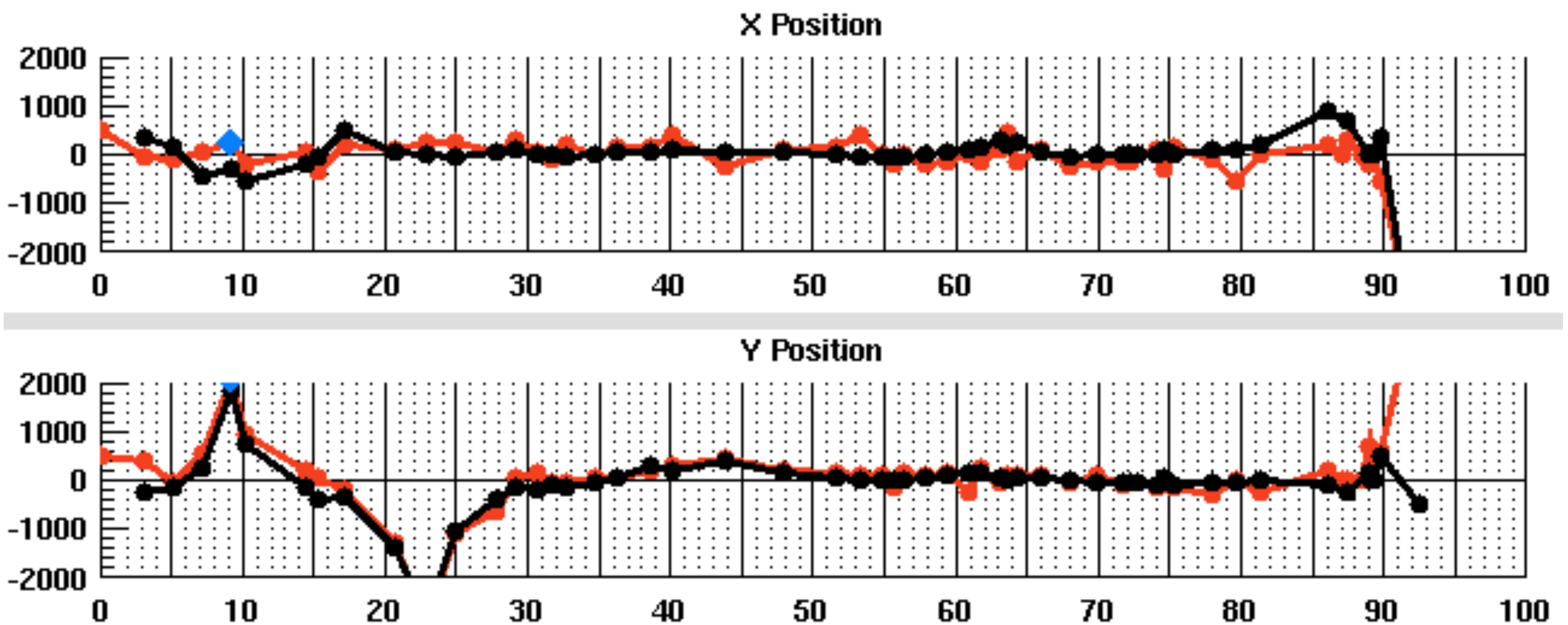


Beam orbit 27^{th} Nov. 2013

C. Beam jitter source localization: experiment for source 1

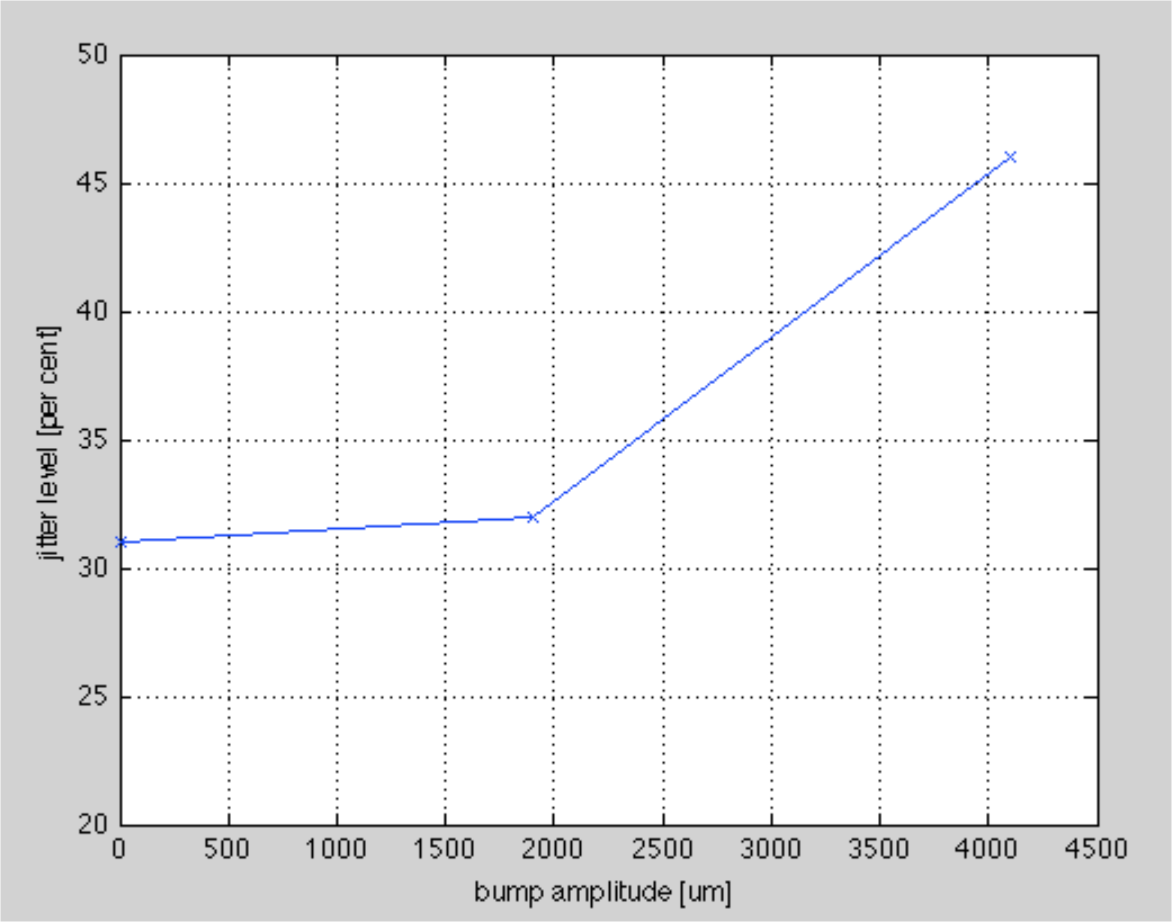
February 2014

Measurements from the 26th of February 2013



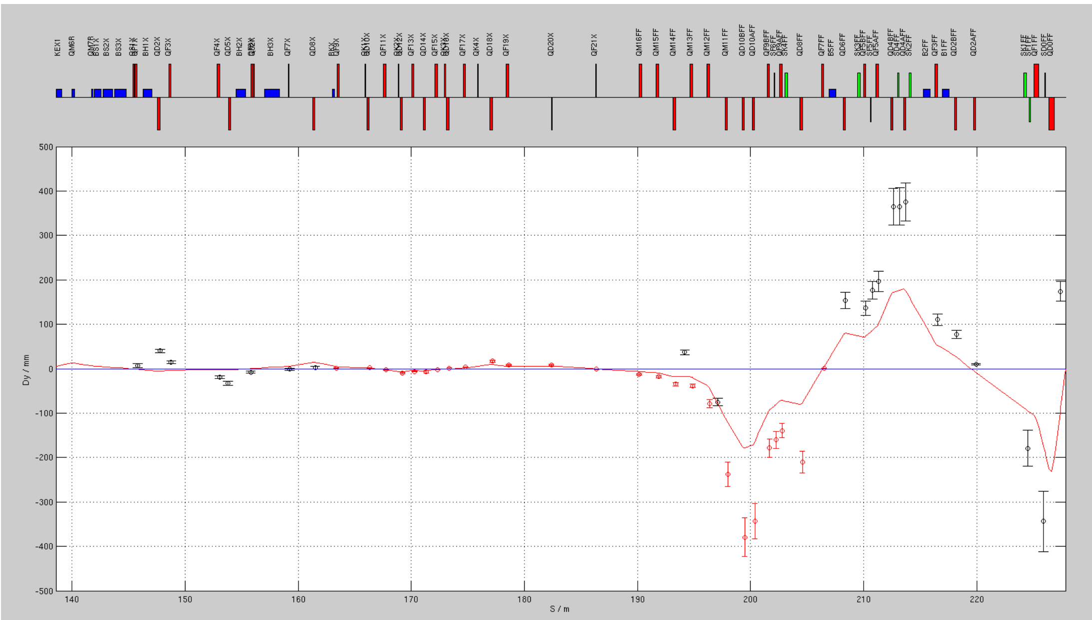
- Created large bumps at the beginning of the beam line
- Bumps were created first with three consecutive correctors (local bump)
- But also by using correctors further apart (here ZV1X, ZV7X, and ZV8X)

Beam jitter due to beam offset



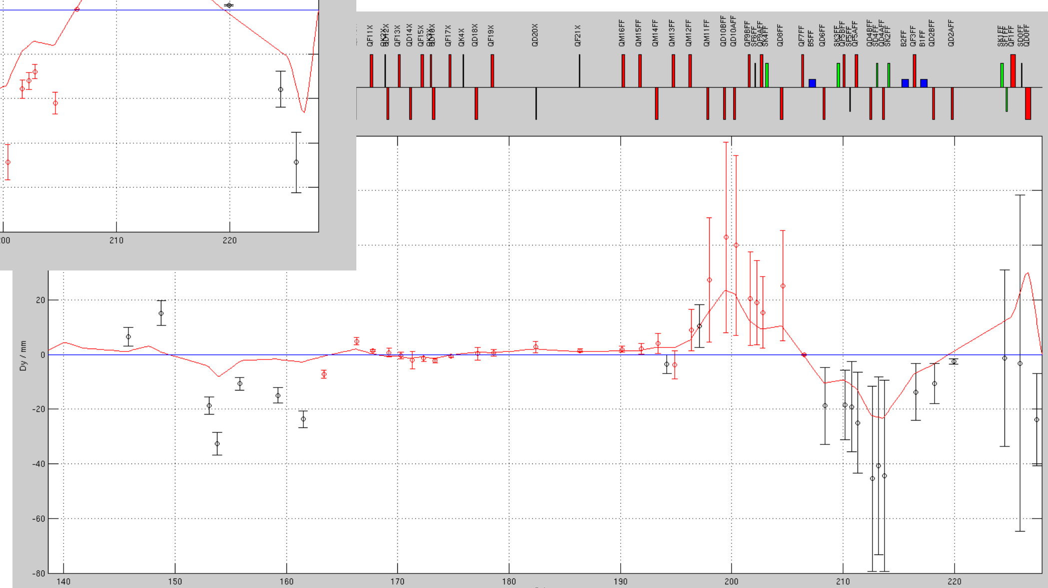
- Jitter was never decreased
- But for large bumps the jitter was increased
- Okugi-san pointed out that such bumps create large dispersion

Bump creation and measurement after dispersion correction



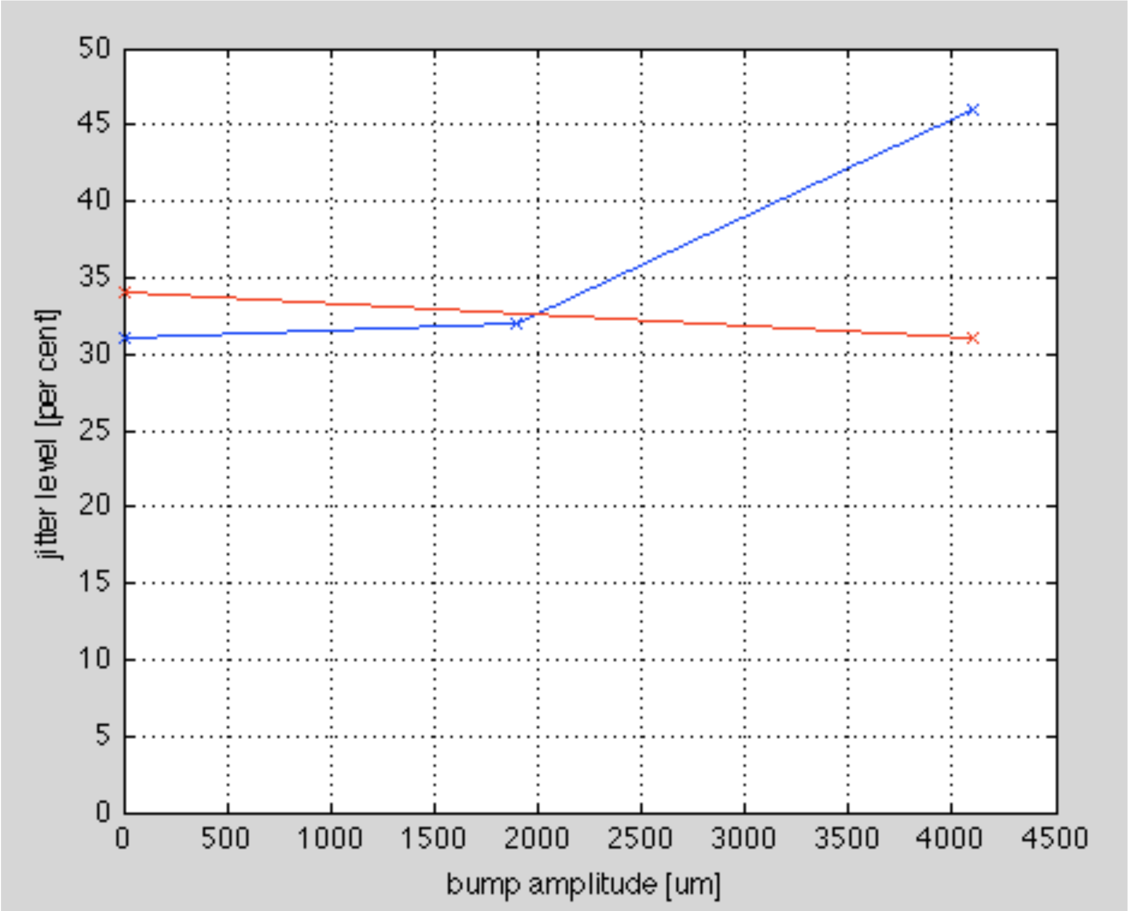
Dispersion correction

Dispersion before correction about 0.5 m to 1 m



Dispersion correction correction about 0.04 m

Beam jitter due to bump after correction



- Blue: jitter without dispersion correction
- Red: jitter with dispersion correction

Conclusions

- Field fluctuations in the quadrupoles upstream are not the source of the beam jitter of source 1 (source of interest).
- We are still searching for a fluctuation magnetic field.
- Possible reasons:
  - Sources from further upstream (Kicker, DR)
  - Changing dipole fields in bends
  - Ground motion
  - Stray fields

- With the taken data with the FONT BPM electronics it should be possible to give more insides about the location of the jitter (from upstream or were downstream).
- Data are take but not analyzed yet.

Thank you for your attention!