Jitter sources identification in ATF2

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January 23, 2013

Method: Correlation coefficient

- Correlation between the beam motion at two different locations.
- Mutual dependence on each other for a large number of measurements (~ 4000).

Correlation coefficient between BPM i and j

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

Linearly independent $r_{ij} = 0$
Fully linear dependence $r_{ij} = \pm 11$

where

$$\sigma_{ij} = \frac{1}{1-N} \sum_{n=1}^{N} (x_n^{(i)} - \mu^{(i)})(x_n^{(j)} - \mu^{(j)})$$

$$\sigma_i = \sqrt{\frac{1}{1-N} \sum_{n=1}^{N} (x_n^{(i)} - \mu^{(i)})^2}$$

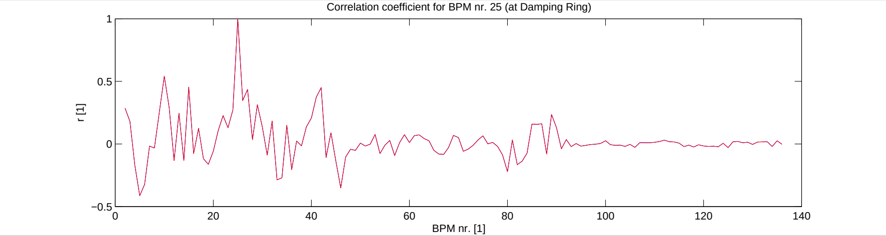
with

$$\mu^{(i)} = \frac{1}{N} \sum_{\nu=1}^{N} x_{\nu}^{i()}$$

Situation

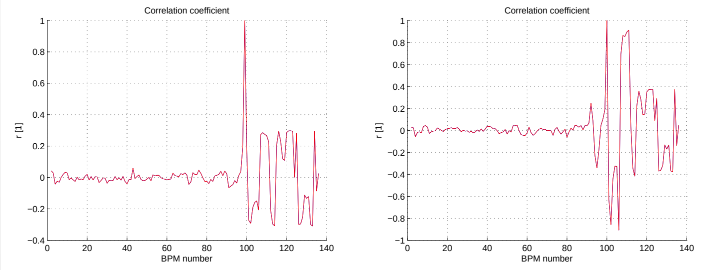
- In the ATF2 beamline, there is no effect of the beam jitter from the damping ring observable.
- The jitter from the damping ring is negligible in ATF2 and at the IP.
- But an important jitter is observed in ATF2.
- Goal: Identify possible jitter sources and see their impact on the overall jitter.

Example:



Possible jitter sources (Source 1)

- We observe a jitter source between MQD8X and MQD10X.
- Some possible jitter sources before with small impact on the overall jitter.

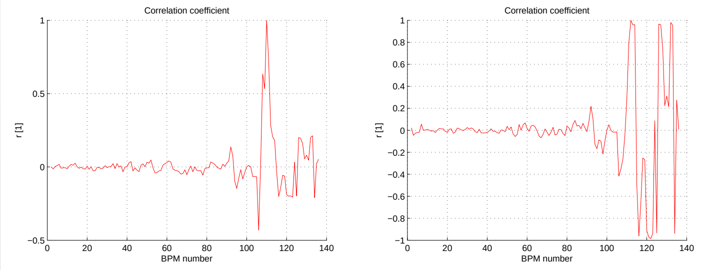


Suspects

- Quads: QF9X, QK1X.
- Correctors: ZH4X, ZH6X and ZV7X.
- Bending: BKX.
- Kicker: KEX2.
- FONT equipment.

Possible jitter sources (Source 2)

- The second and most likely strongest beam jitter source is located between the BPMs MQF21X and MQM16FF, which have the numnbers 111 and 112 respectively.



Suspects

- Wire scanners: MW3X and MW4X,
- Profile monitor: OTR3X.

Possible wakefield jitter source (Source 3)

- We observe a possible jitter source around BPMs MQD10BFF and MQD10AFF.
- This position corresponds exactly to the location of the reference cavity that caused some wakefield effects already observed for many people...
- Some more time to understand the effect of a possible wakefield.

Removing correlations

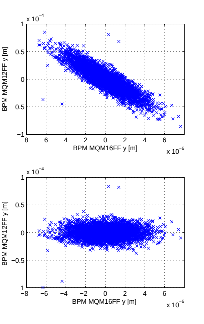
$$\hat{y}^{(j)} = y^{(j)} + k_j y^{(i)}$$

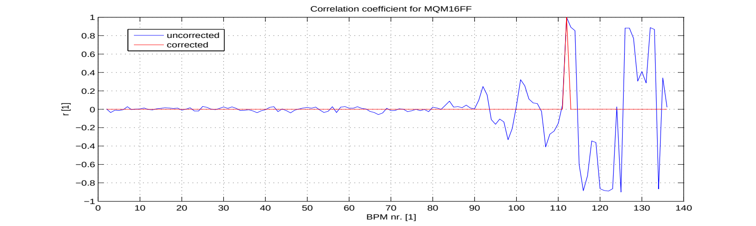
$$\sigma(y^{(i)}, \hat{y}^{(j)}) = 0$$

$$0 = \frac{1}{N}\sum_{\nu=1}^{N}\left[\left(x_\nu^{(i)} - \mu^{(i)}\right)\left(x_\nu^{(j)} k_j x_\nu^{(j)} - \mu^{(j)} + k_j \mu^{(i)}\right)\right]$$

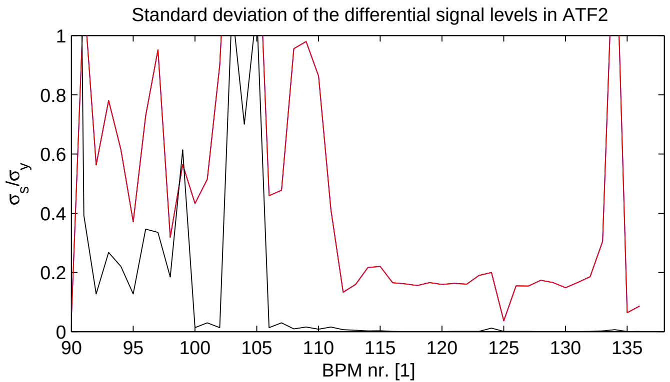
$$\boxed{k_j = -r_{ij}\frac{\sigma_i}{\sigma_j} = -\frac{\sigma_{ij}}{\sigma_j^2}}$$

$$y^{(j)} \rightarrow y^{(j)} - \frac{\sigma_{ij}}{\sigma_j^2} y^{(i)}$$

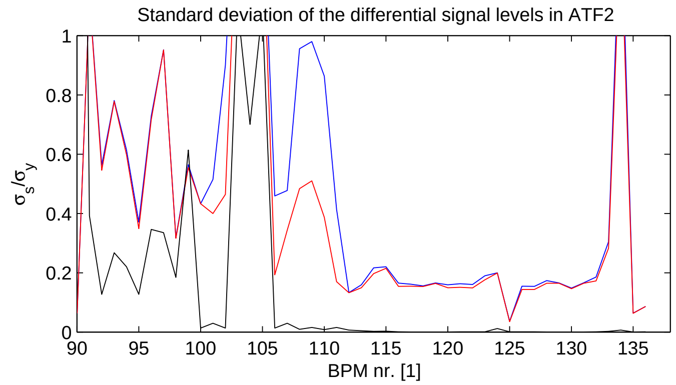




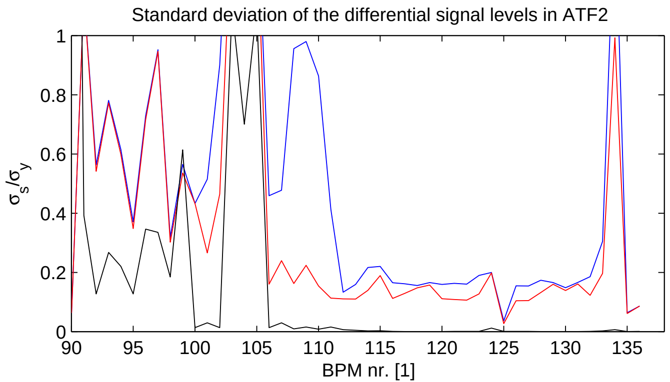
Removing BPM correlations (Uncorrected signal)



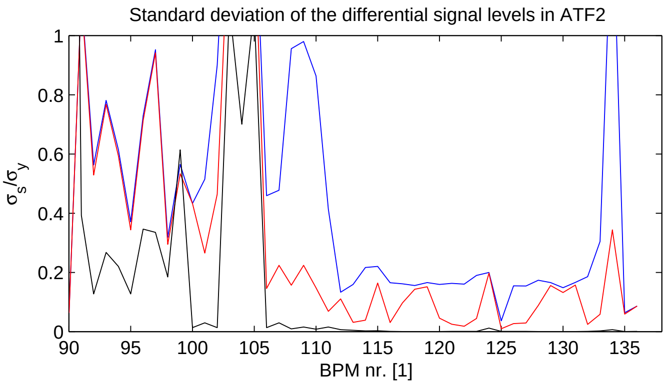
Removing BPM correlations (BPM 100 correction)



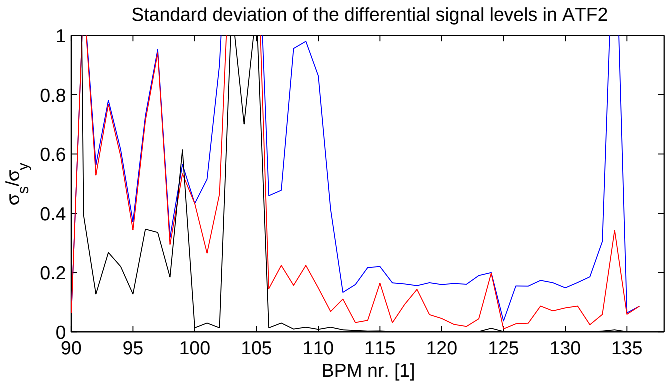
Removing BPM correlations (BPM 100 102 correction)



Removing BPM correlations (BPM 100 102 112 correction)



Removing BPM correlations (BPM 100 102 112 118 correction)



In numbers...

- Jitter from the original signal: $\sigma_s/\sigma_y = 17.0\%$
- Jitter after BPM 100 correction: $\sigma_s/\sigma_y = 16.2\%$
- Jitter after BPM 102 correction: $\sigma_s/\sigma_y = 14.4\%$
- Jitter after BPM 112 correction: $\sigma_s/\sigma_y = 11.5\% \Rightarrow$ Strongest source.
- Jitter after BPM 118 correction: $\sigma_s/\sigma_y = 14.3\%$
- Remaining jitter after full correction: $\boxed{\sigma_s/\sigma_y = 7.0\%}$

The jitter is reduced in 10 points after correction of the three identified sources.

- Several potential jitter sources have been identified. Mainly diagnostics equipment as wire scanners and profile monitor but also stabilization equipment.
- These sources create slow but also jitter-like beam motion.
- No indications were found that the extraction kicker is a notable jitter source.
- The located beam jitter sources could also be wakefield sources.
- A future inspection of these devices could be of great benefit for the jitter reduction at the IP.

- We need more time to investigate and identify more carefully the different sources.