Laboratoire d'Annecy-le-Vieux
de Physique des Particules

Technical Board
ATF2 GM FF progress report

A.Jeremie

ATF2 GM System team:

K.Artoos, C.Charrondière, A.Jeremie, J.Pfingstner (a lot of figures from him), Y.Renier (most slides from him), D.Schulte, R.Tomas-Garcia

In2p3

Outline

- Introduction
- Parameters
- Results; jitter subtraction
- Conclusions

Introduction

Goal and motivation of the ATF2 experiment

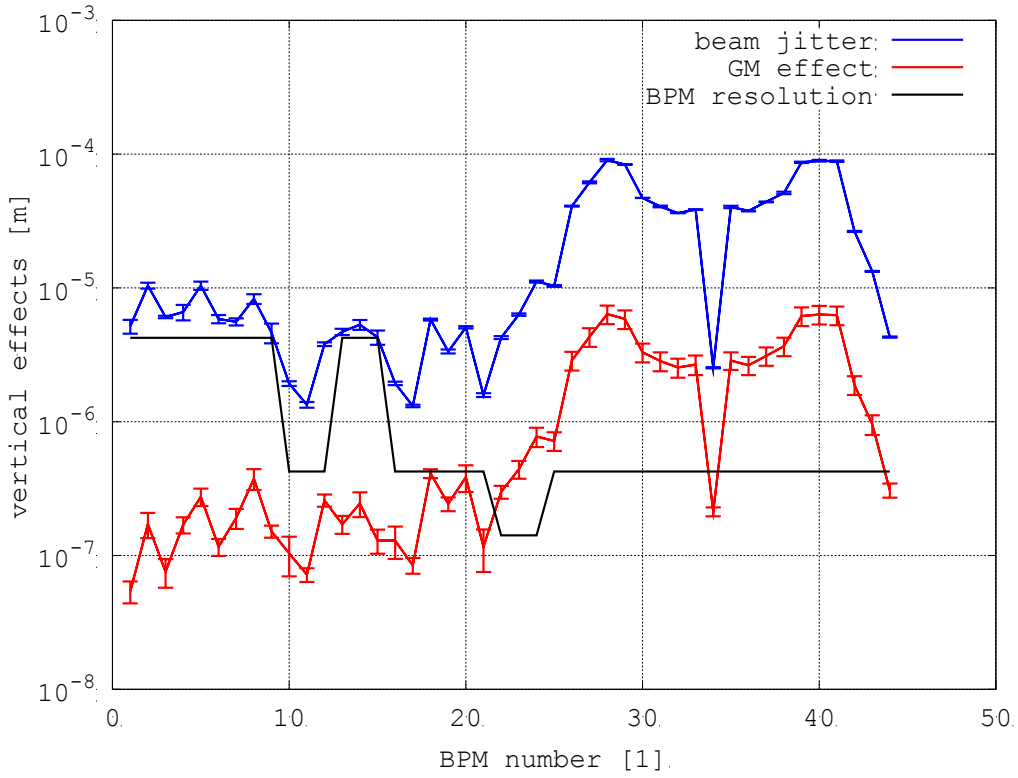
Goal

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

Motivation

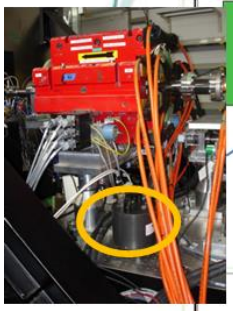
- GM sensors are usually only compared to other GM sensors
- It would demonstrate possibility to make a feed forward with GM sensors.
- Feed forward would allow trajectory correction based on GM measurements in CLIC.
- Feed forward would allow big saving (avoid/relaxing specification of quadrupole stabilization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

Difficulty of the experiment



- Ground motion is smaller than the measured beam jitter by a factor of about 100 in horizontal and 20 in vertical.
- To be able to observe the ground motion, jitter has to be removed very efficiently.
- Experiment at ATF2 is much more difficult than it would be at CLIC, were ground motion is the dominant jitter source.

14 GM sensors have been installed in EXT and FD



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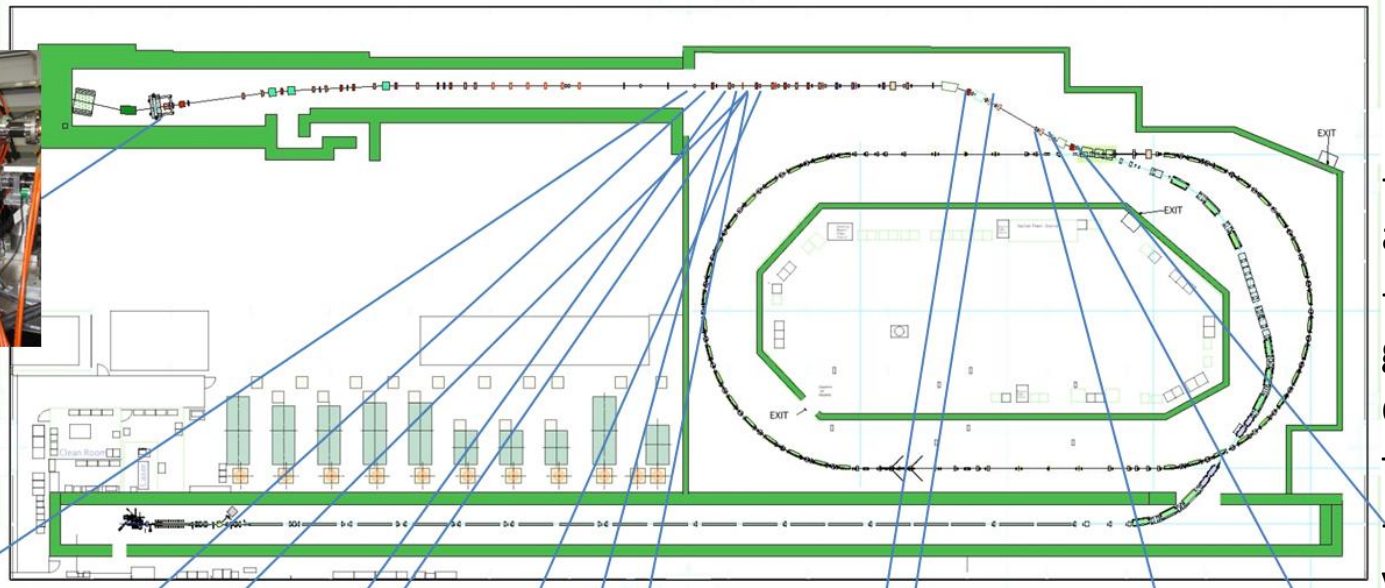

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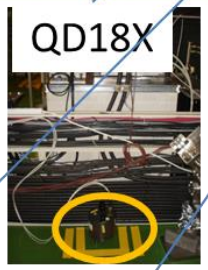

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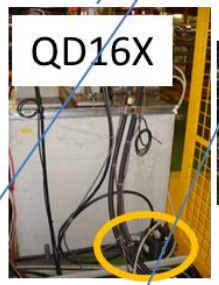

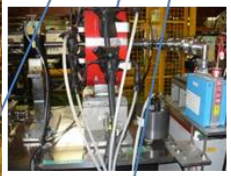

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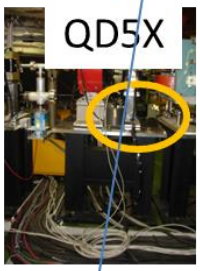

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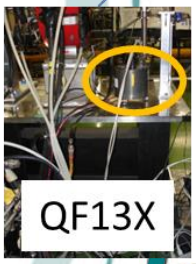

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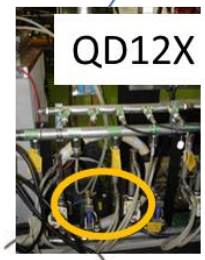


QF11X

QD14X

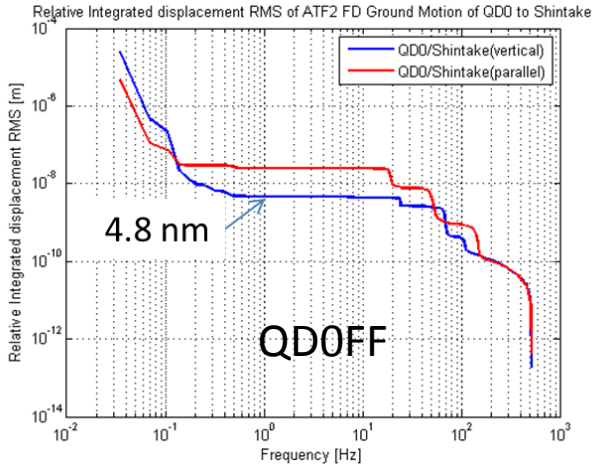
QF4X

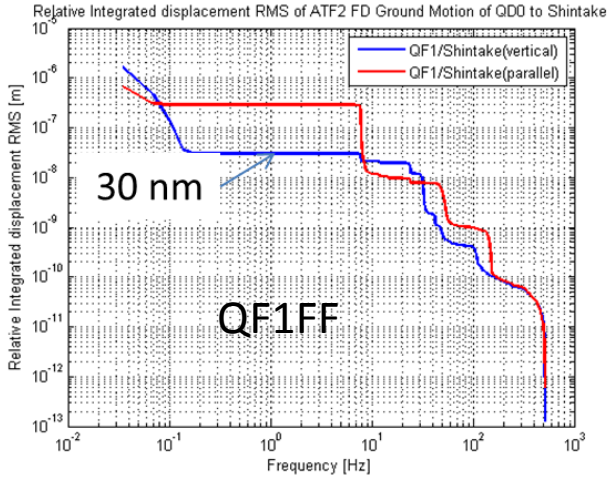
QF3X

QD2X

-Measurements are available
-BPM and ground motion data have been taken in parallel.
-Setup works very well.

System has also been used for Relative Displacement studies at FD





Presented by Okugi-san (Sept 27, 2013)

Andrea presented the FD magnet position jitter at ATF2 meeting on 8/30/2013

2013 by Andrea JEREMIE (same analysis)	Tolerance	Measurement (between QD0)	Measurement (between new QF1)
Vertical	7 nm (for QD0) 20 nm (for QF1)	4.8 nm	30 nm
Parallel to the beam	~ 10,000 nm	25 nm	290 nm

Outside tolerance for 2% effect on beam!

A.Jeremie ATF2 Meet 11

The magnet position jitter was converted to the IP vertical beam size contribution

	QD0	QF1
Vertical	7.3 nm	12.6 nm
Parallel	0.4 nm	0.8 nm

Total IP vertical beam size contribution of magnet position jitter is 14.6 nm.
37.0 nm -> 39.8 nm (7.5% of IP vertical beam size growth)

People

Person	Tasks	Timeline
J.Pfingstner (replacing Y.Renier)	Data taking; jitter identification, analysis	Until June 2014 of CERN fellow
A.Jeremie	Sensors; System maintenance; data taking (analysis)	25% on ATF2
M.Patecki	PhD student	3 years
R.Tomas-Garcia	Supervision; ATF2 contact	10% on ATF2
D.Schulte	Initial idea; Supervision	-
New CERN Fellow	to come	2 years
C.Charrondière	DAQ maintenance hot-line	-

ATF2 ILC Programme Review

April 2013

"Finally, this system* coupled with the upstream system can help characterize the sources of beam jitter in the ATF2. Moving high resolution BPMs to a location upstream (exit of the EXT line) would aid in separating injection from FFS sources. Installation of vibration sensors would further help characterization of jitter sources by separating mechanical (i.e. vibration) from wakefield driven sources."

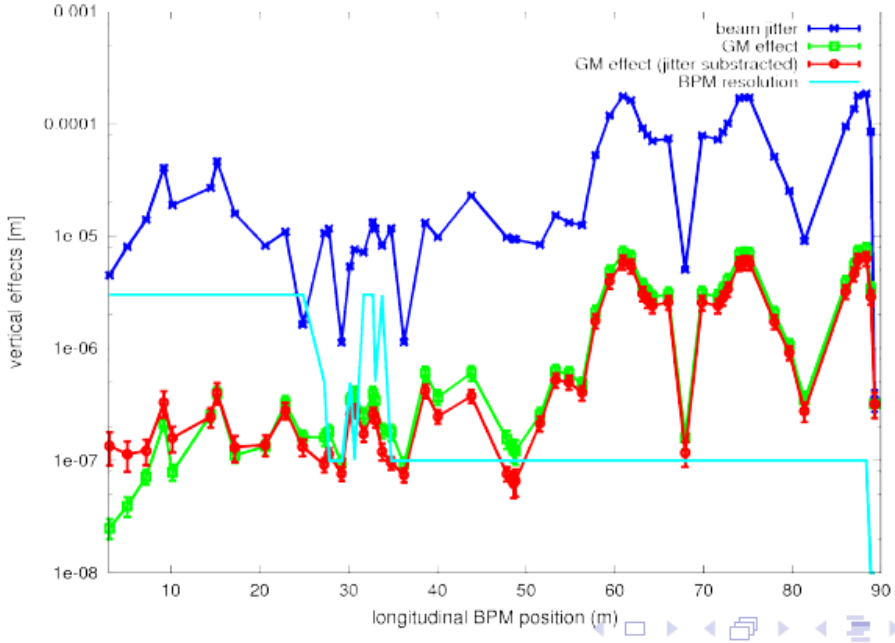
*in the paragraph about FONT

Parameters

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.



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 1^{st} 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 very effective jitter reduction
- Very optimistic to see something

Results

Measurement results

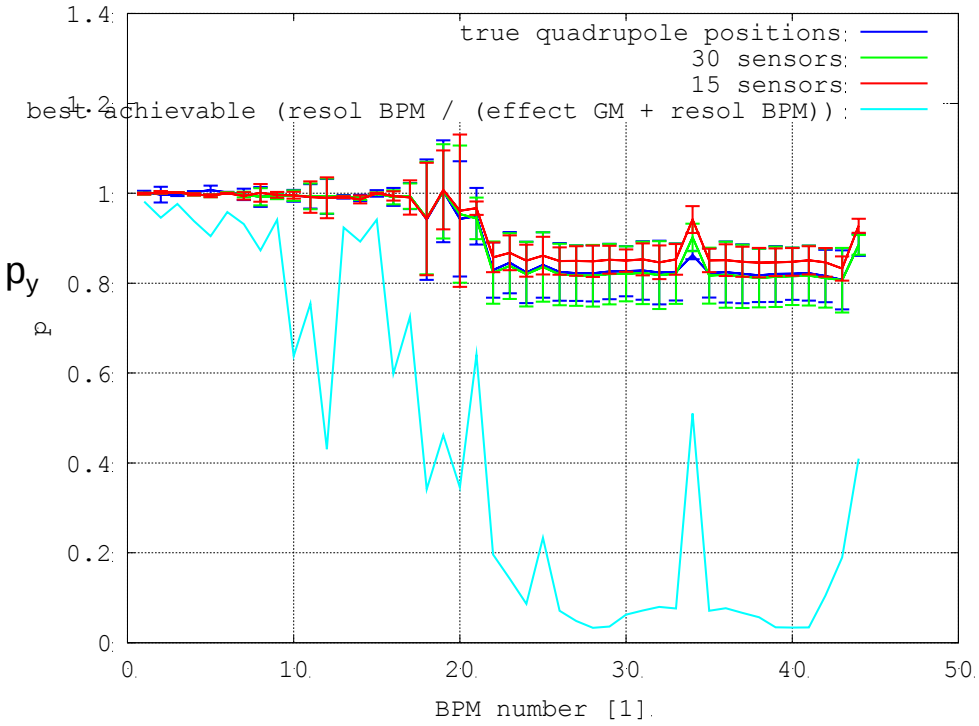
- Jitter subtraction did not work on real data as expected.
- BPM signal got bigger after jitter subtraction!

- 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)

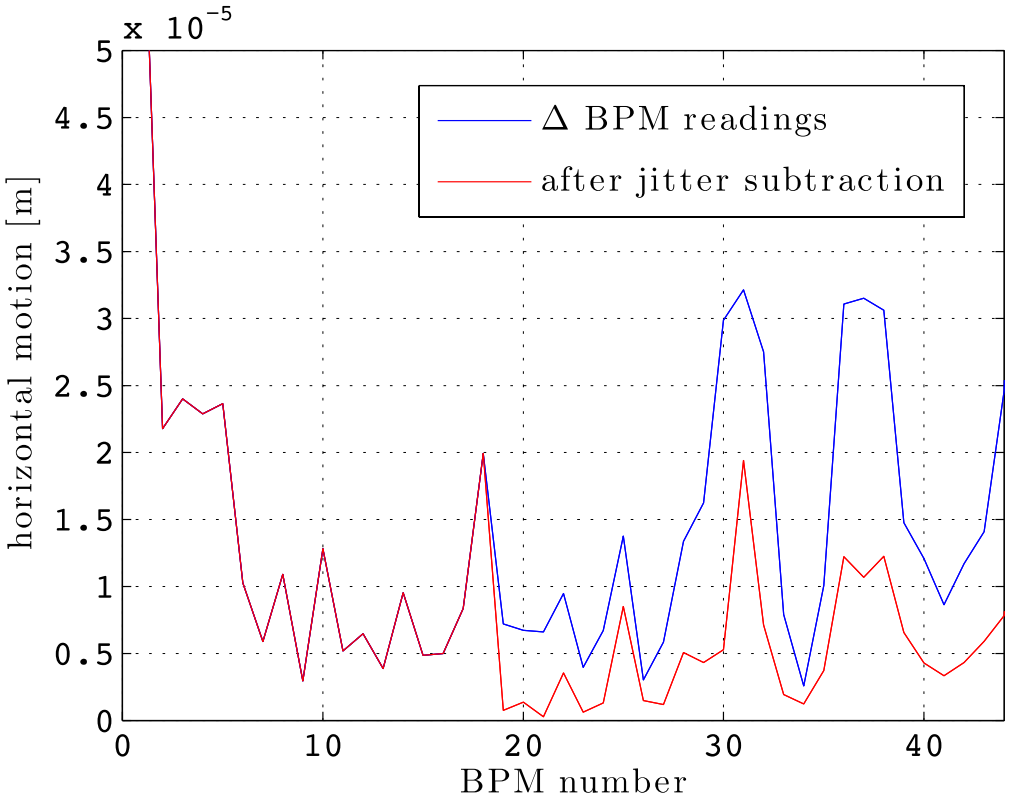
Use of a different jitter reduction

In simulation: $p_y = 0.85$



- All meas. of downstream BPMs are decorrelated from selected upstream BPMs.
- This is done via the multiplication with the inverse of the covariance matrix.
- Advantage:
  - No system knowledge assumed
  - No structure of noise assumed
  - Assumed to be more more robust
- Method is more sensitive vertically than horizontally.

Application to the real jitter measurements



- Jitter subtraction is starting to work (also horizontally).
- The p-value is still around 1 at the moment.
- But further investigations are ongoing.

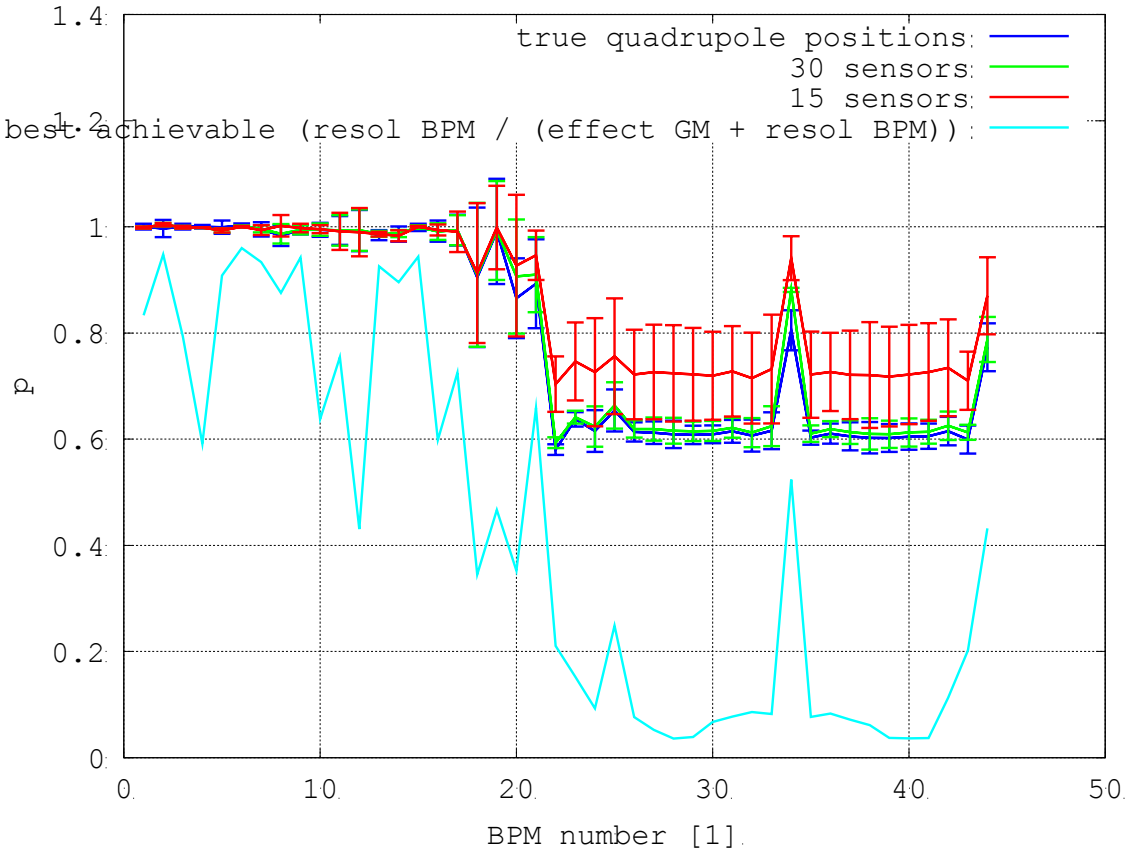
Planned improvements in collaboration with the FONT team

- BPM electronics of FONT team can improve the BPMs at the beginning of the beam line from about 5μm to about 1μm.
- Installation and measurements are planned in February and March
- This helps in two ways:

1. Potentially jitter sources can be detected and removed
   - Second experiment (jitter removal) that is performed in parallel.

2. The jitter removal algorithm is more efficient
   - High signal to noise ratio in the first BPMs is essential for the subtraction of incoming jitter.

Simulation results with FONT electronics



- Better resolution improves jitter subtraction
- $p_y = 0.79$

Conclusions

Conclusions and Prospects

- GM/BPM experiment setup installed and working
- First jitter subtraction attempts (SVD) did not work but correlation method gives better results => Starting to see possible effect , need improvements
- The upstream BPMs need to be very sensitive
  - BPM swapping initiated to EXT(still planned? If not why?)
  - New FONT electronics will help in jitter reconstruction
- Jitter identification will enhance jitter subtraction capabilities=> both projects closely linked!

Comments

- Data taking on site is not very time consuming; but sextupoles and orbit FB switched off; off-line analysis takes more time
- Check synchronization between BPM and GM sensors.
- Long term project (~2 more years) as simulations and jitter understanding grows=> first hints are there!
- Experiment remains CHALLENGING
- Customs: Sensors can stay until March 2016. Then either
  - send them back,
  - well argumented extension (a few months)
  - they stay at KEK for ever.
- Need to re-evaluate the project mid-2015.