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

Feed-Forward

L. Brunetti[1], G. Balik[1], A. Jeremie[1], M. Serluca[1], B. Caron[2], (LAViSta Team)
D. Bett[3]

1: LAPP-IN2P3-CNRS, Université de Savoie Mont Blanc, Annecy, France
2: SYMME-POLYTECH Annecy-Chambéry, Université de Savoie Mont Blanc, Annecy, France
3: University of Oxford Department of Physics

SYMME

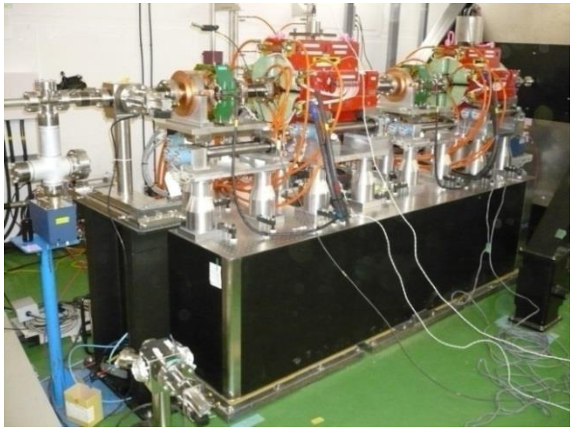
ATF2 Project Meeting, KEK, November 22, 2018

UNIVERSITÉ SAVOIE MONT BLANC

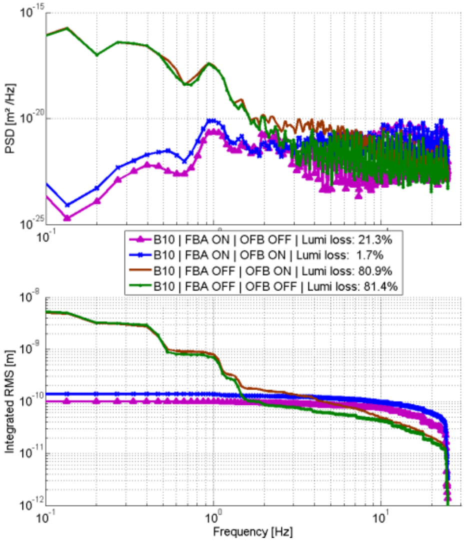
https://agenda.linearcollider.org/event/7968/

Feedforward stategy

- ***LAPP motivations***



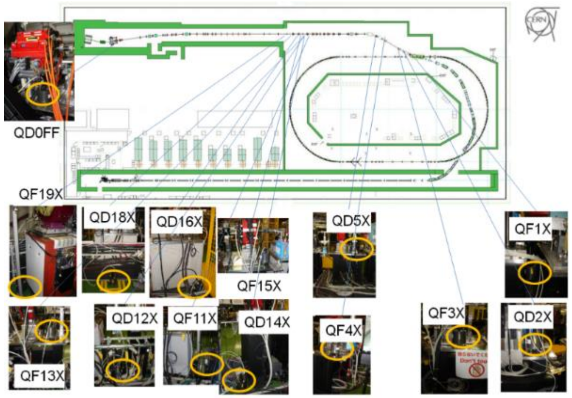
***ATF2 final focus**: coherence optimization*



0,25 nm RMS @ 4Hz

***CLIC final focus** : subnanometer demonstration*
Post BPM beam trajectory control < 4 Hz – "Mechanics" active control > 4Hz

➢ ***ATF2 Feedforward : opportunity to compare two different approaches***

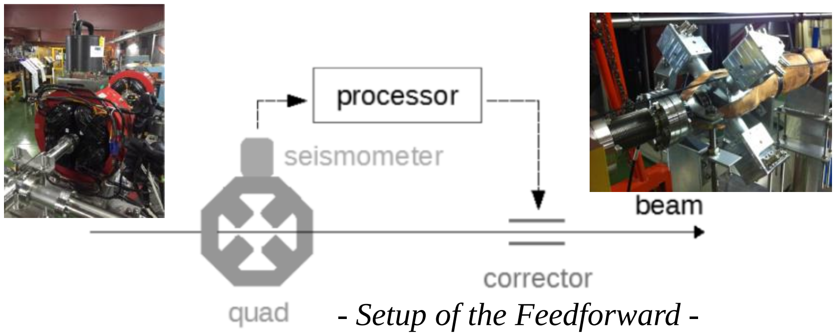


- During last years LAPP group has been responsible of the final focus mechanical stabilization and it has carried on GM measurements and identification of the vibration sources
- **Through 2017 CERN, KEK and LAPP successfully proved the principle of GM FF in operation**
- End 2017: LAPP began to study the control aspects of the FF

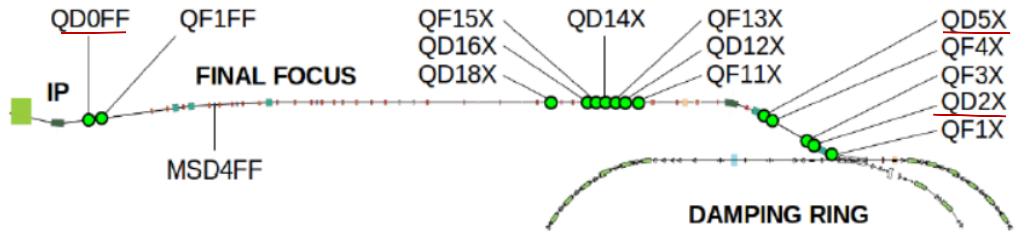
FF control

Feedforward principle

FF status is made in reference to different documents / works (Doug, Jonas, Jurgen, Rogelio and all…). The main references (plots…) comes from the article ***"D. Bett et al, Compensation of orbit distortion due to quadrupole motion using feed-forward control at KEK ATF"***



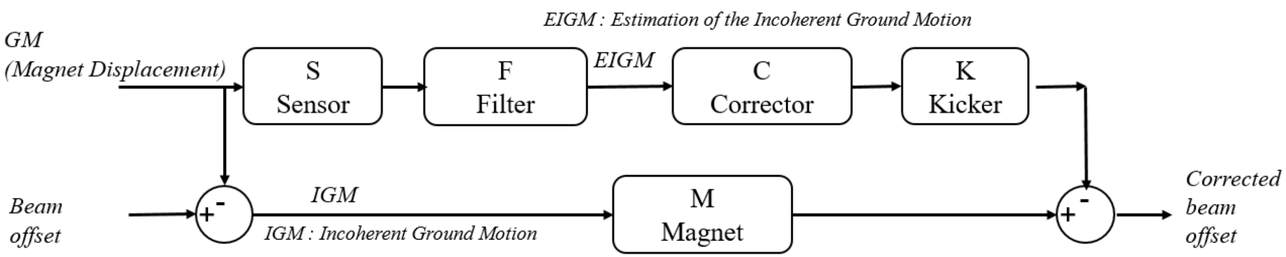
- Setup of the Feedforward -



- Layout of the GM sensors along the collider-

Feedforward concept

- The principle is quite elementary but to implement efficiently this control law, it requires :



Control law – conceptual scheme

$M = S.F.C.K$ As consequence, the corrector has to satisfy the following condition: $C = \frac{M}{S.F.K}$

Then *C is the constant gain* in the bandwidth of interest.

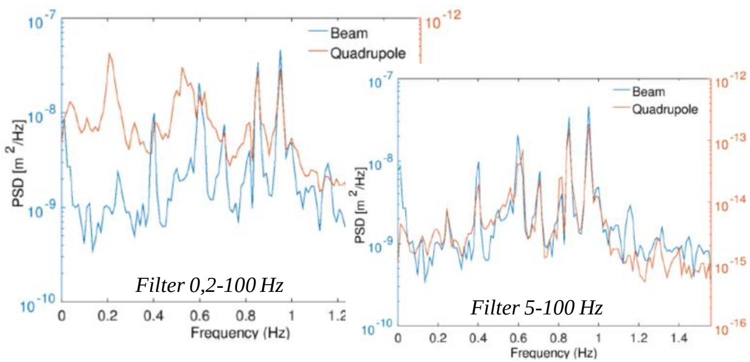
FF results and issues

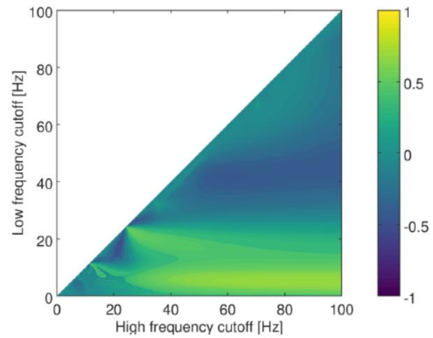
▪ *Previous results - demonstration*

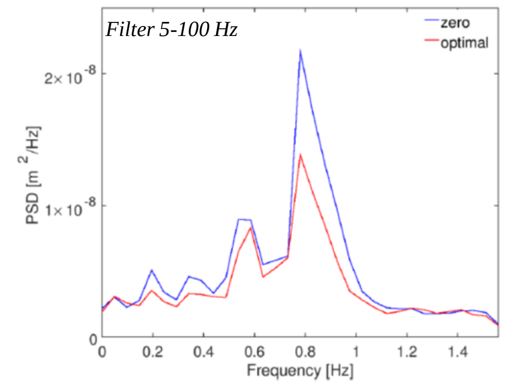
- *Only the incoherent disturbances / motions along the collider have an influence on the beam*
- *Low frequencies are quite coherent*

➢ ***Filter*** *the sensor signals to select the incoherent part*

➢ *Control these perturbations with the optimized* ***gain***







- The obtained experimental results by CERN team with 1 geophone and 1 kicker -

▪ *Feedforward issues*

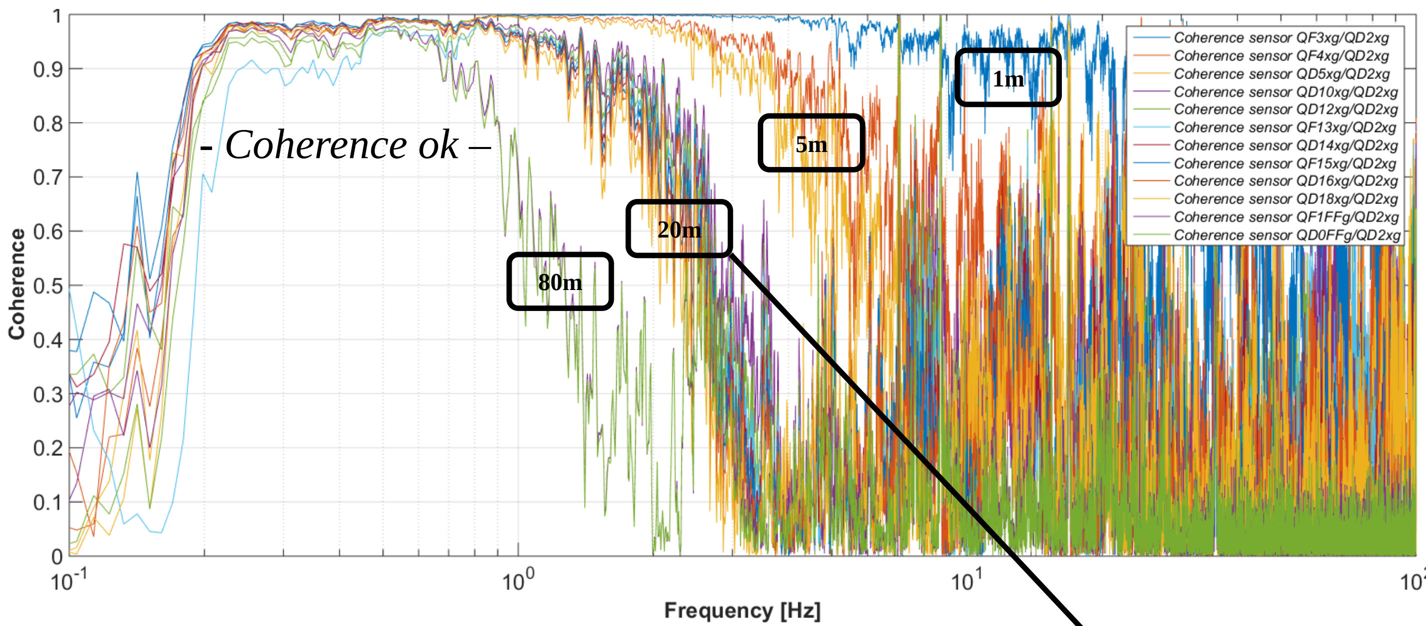
- To extract very accurately the disturbances (coherent vs incoherent motion)
- **To know very well the system** (the effects of the vibrations and of the magnets on the beam)

▪ 2 preliminary stages

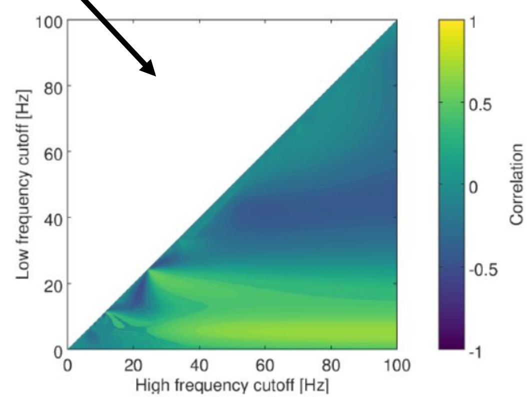
- Dedicated measurements : shifts of 2017 November
- Optics simulations: Spring 2018

FF preparation: PSD and Coherence measurements - 2017

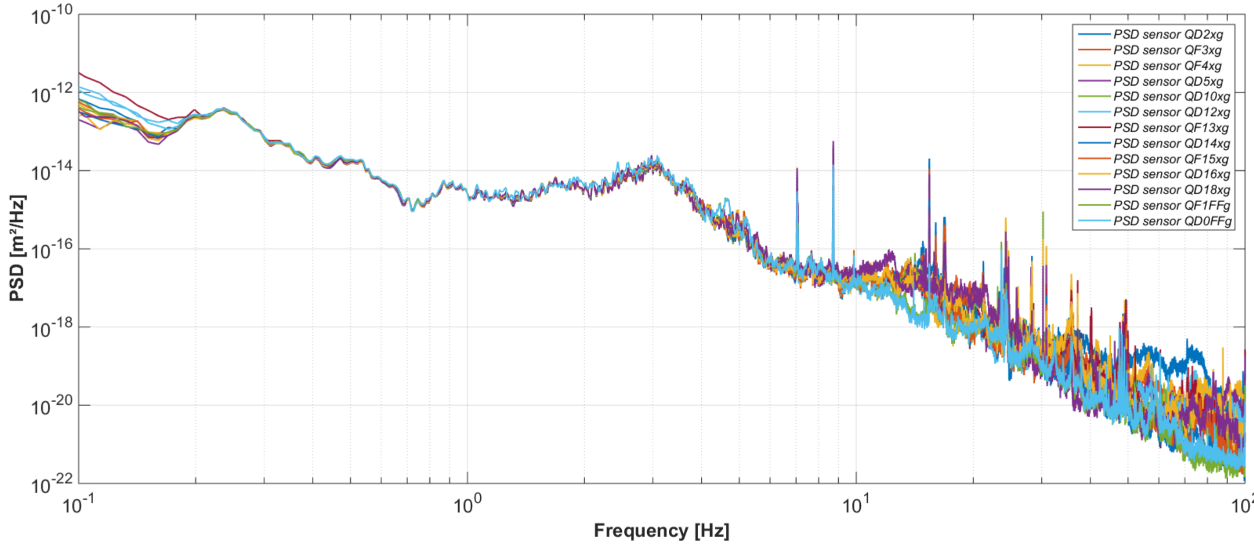
- ***Evaluation of the cut-off frequencies vs coherence measurement along the collider***
  - *More accurate evaluation with coherence (in this case as function of QD2)*



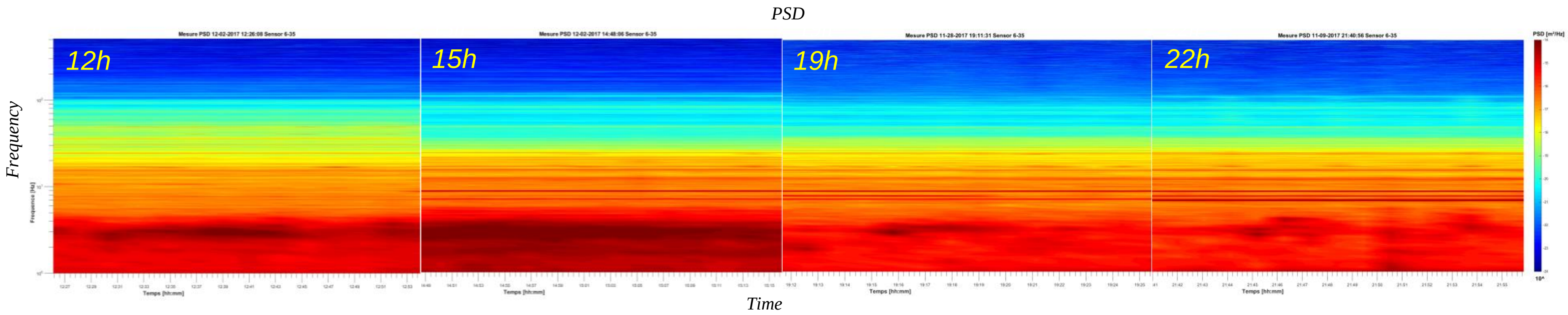
➢ ***The coherence plot could define the pattern of the filters which have to be used as function of the magnet positions (all the data with a coherence of 1 have to be filtered out)***



- *Upgrade of the transfer functions - PSD of all the magnets*
  - ***The amplitude in low frequencies seems to be equal along the collider***



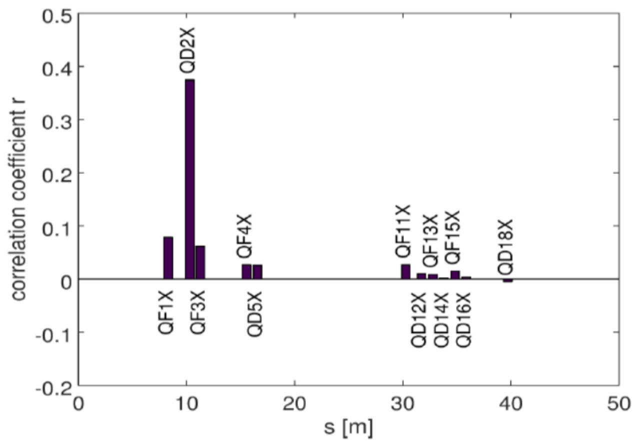
- ***QD Transfer function amplitudes***



- ***Amplitudes variation in time***

FF preparation – Simulation extraction area

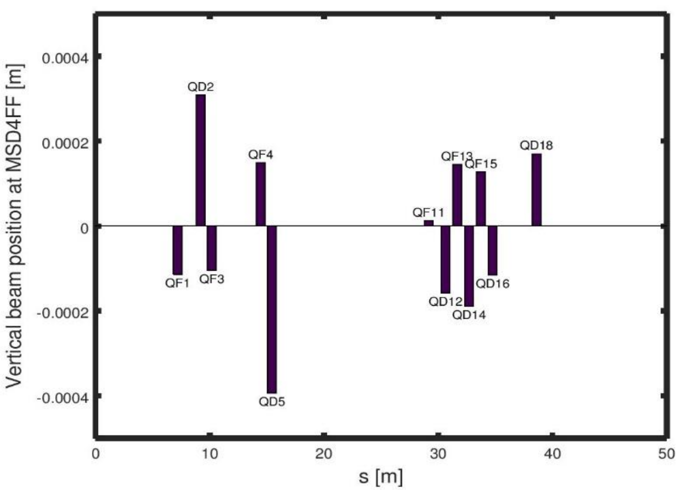
- ***Choice of the sensor for Feedforward operation – example of correlation***
  - *QD2 has been selected as function of the **measured correlation** between magnet motion vs beam position*



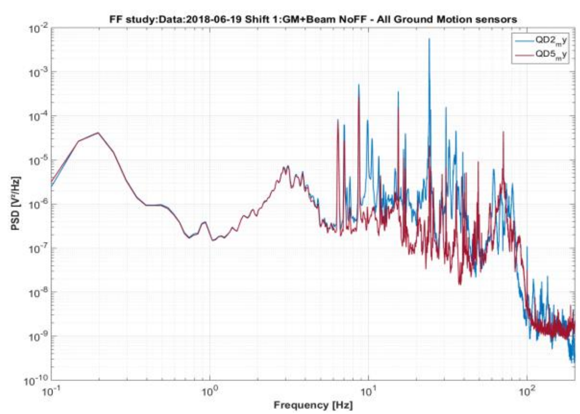
- *Correlation between the position of the beam at MSD4FF and the positions of various seismometers measured by CERN team*
- *Pearson correlation coefficient r gives an indication of FF performance and it is calculated between the reconstruction of the beam position and the actual measurement:*

$$r = \frac{cov(ym,yr)}{\sigma_{ym}\sigma_{yr}}$$

  - *But the importance of QD2X vs other magnets seems not so important in **simulation***



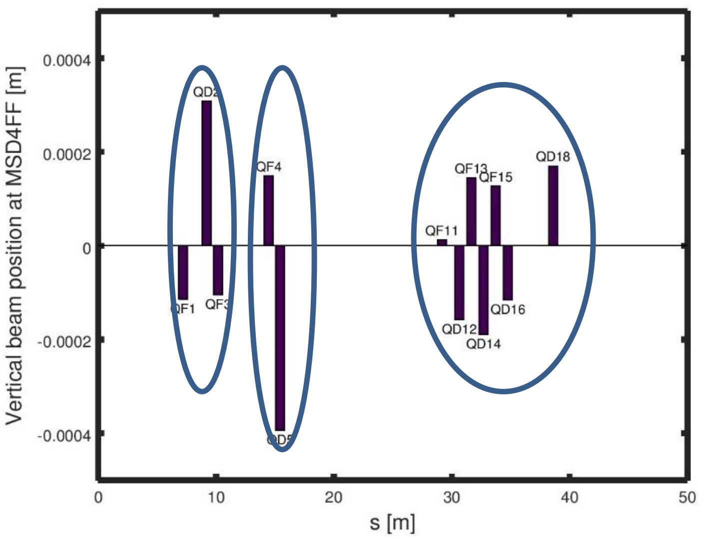
- *Optics calculation with MADX (10BX1BY optics) displacing vertically by 1µm one quadrupole at a time and extracting the vertical beam position at MSD4FF*



- *QD2 displacement is really greater than the one of QD5 for example*

Multi-Sensors FF – Extaction line

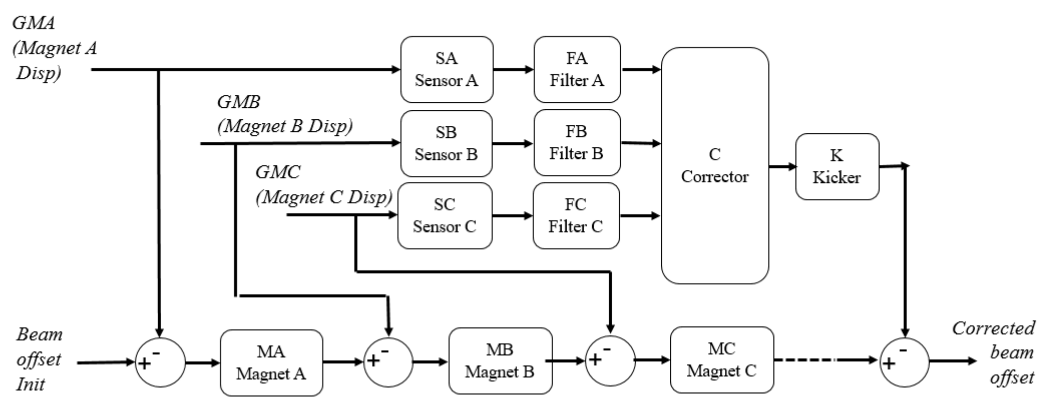
- ***Feedforward with several sensors***



- *Optics calculation with MADX displacing vertically by 1µm one quadrupole at a time and extracting the vertical beam position at MSD4FF*

- *3 groups of magnets which move probably relatively together (except the transfer function of the support)*

➢ *3 main actions on the beam have to be corrected*

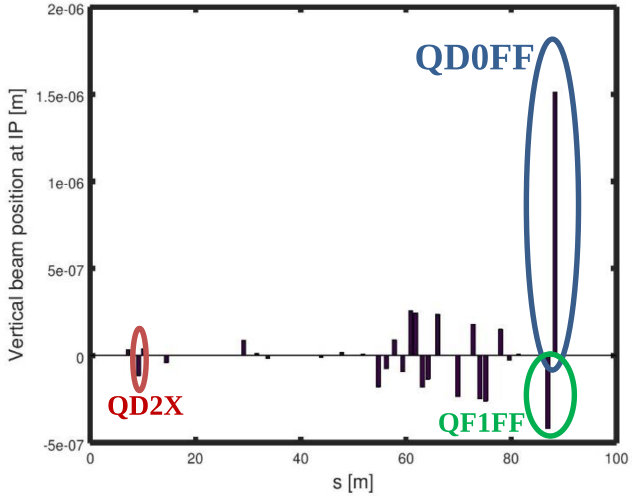


- Foreseen multi-sensors control with 3 geophones and 1 kicker -

Proposal: Take into account more than one magnet (the most critical ones) and evaluate the performance with respect to the actual system

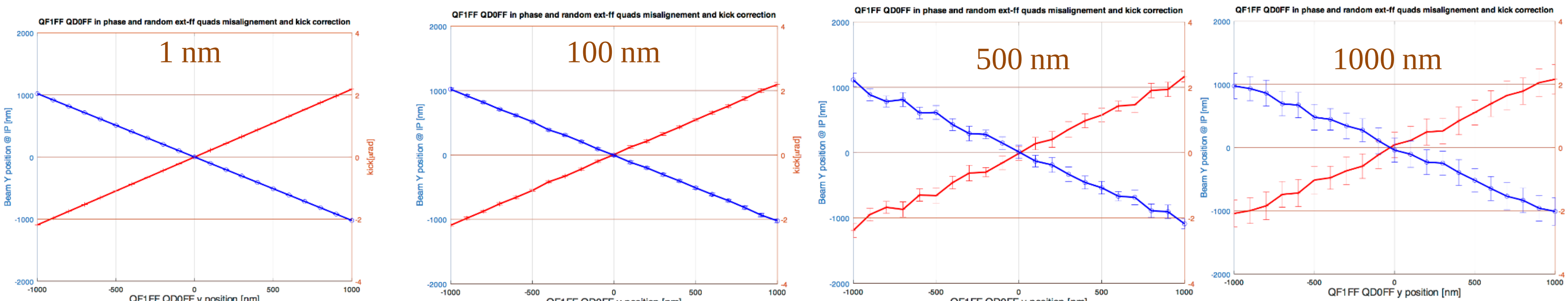
FF – Final Focus area

- ***Feedforward on the final focus***



- *Optics calculation with MADX displacing vertically by 1µm one quadrupole at a time (ext and ff quads) and extracting the vertical beam position at IP*
- *QD0FF is the most important magnet for the beam trajectory*
- *FF control with one geophone and one kicker*
- *Necessity to have access to the IP kicker in real time and to the data IP BPM for the efficiency evaluation*

- QD0FF and QF1FF moved in phase with 100 nm step, all quads in ext. and ff line with **x nm** uniform random, average over 20 seeds

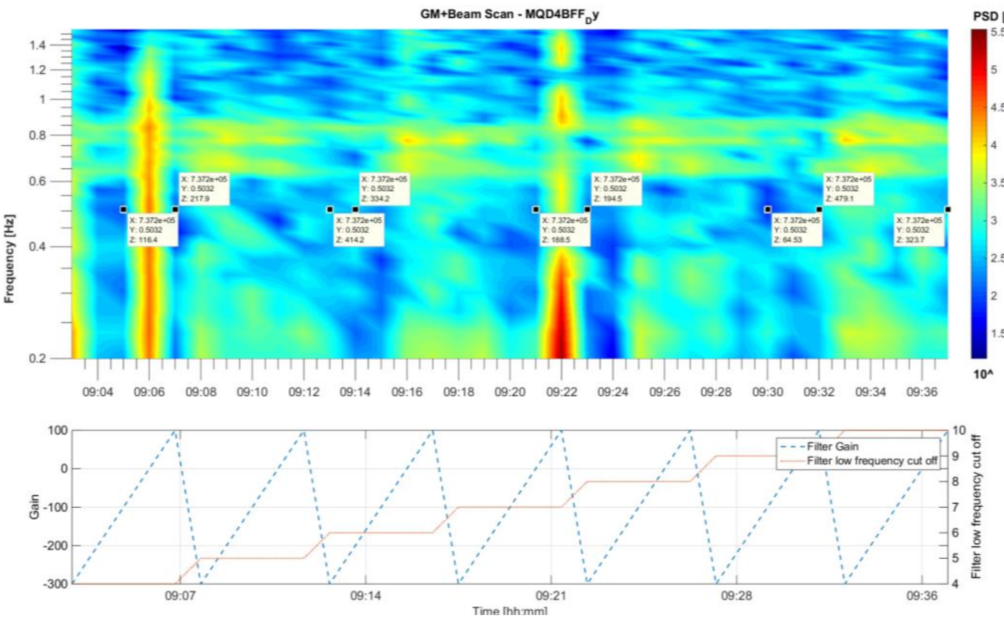


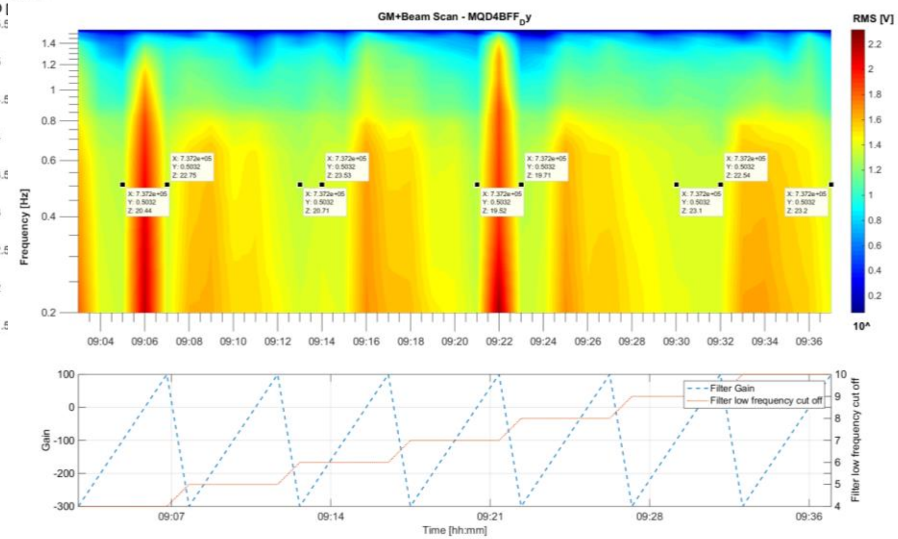
- The average value of vertical beam position at IP depends mostly on position of final doublet
- For movements of quads in ext and ff lines in the range of [-100, 100]nm position of the beam at IP is almost not affected
- For higher values of ext and ff quads movements error bars increase up to 200 nm

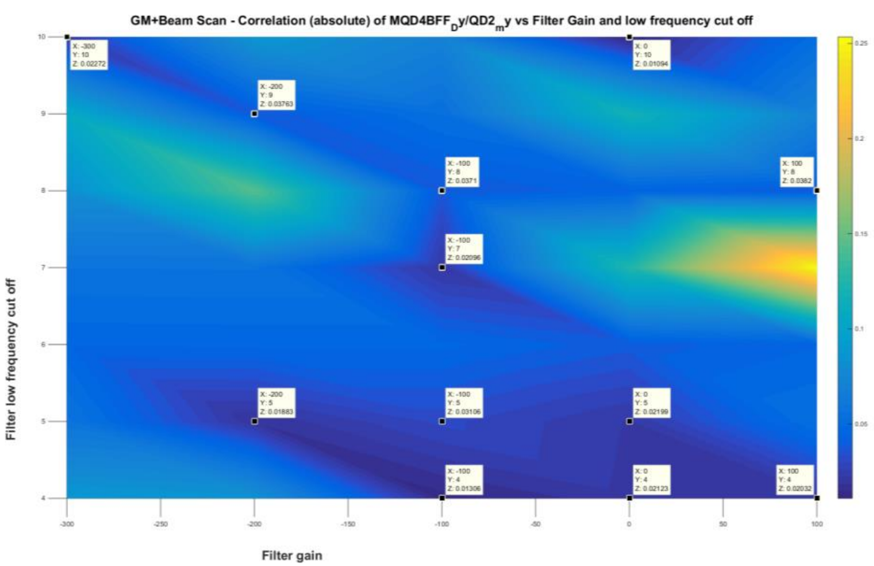
Proposal : Carry on Feed-Forward experiments using IPBPMs (*With one kicker only offset can be corrected*)

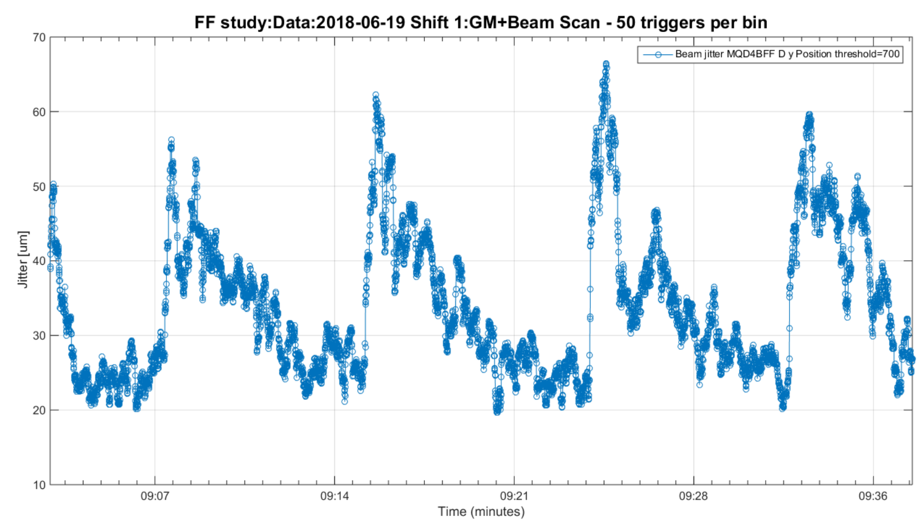
FF – Shift of June 2018

- ***Extraction line: surprising results with parameters scans***





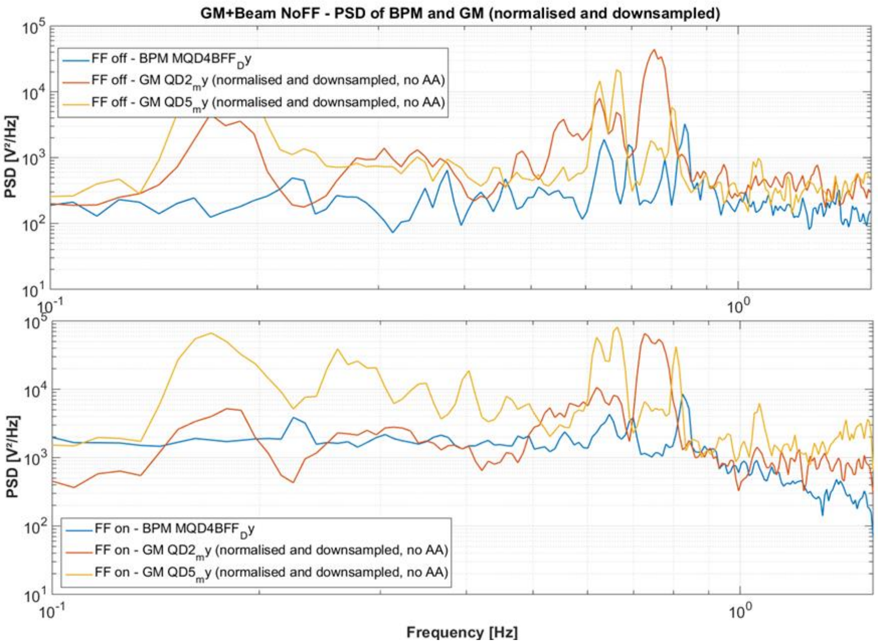


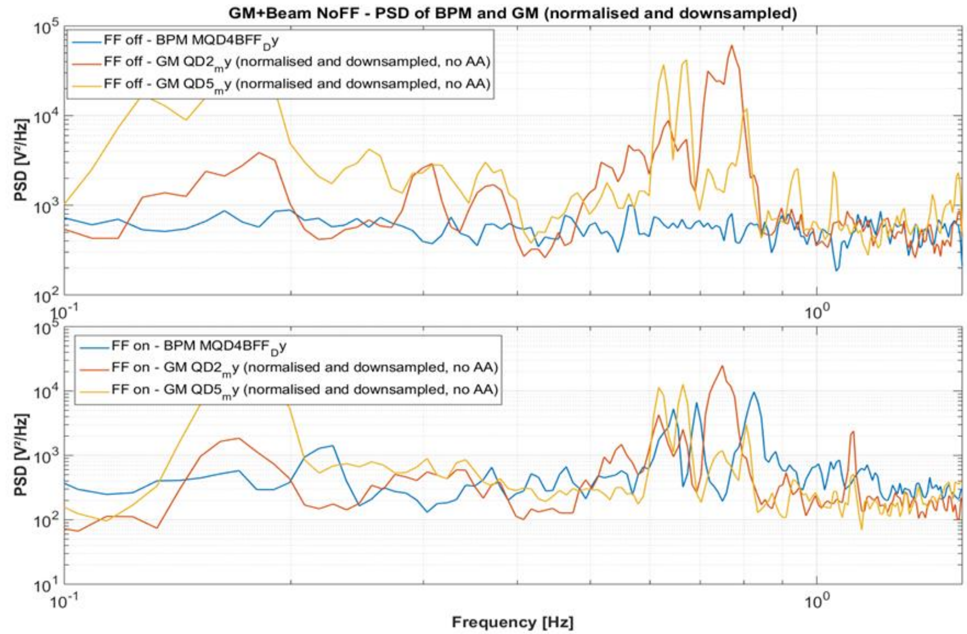


CAPP

FF – Shift of June 2018

- *Extraction line : incoherent results with FF ON and initial parameters*





- *Final focus : technical problem to manage the kicker*

CONCLUSION

- *Preparation phase is ok*
- *2 targets : multi-sensors and **final focus***

- *Plans for the next week runs:*

  - *To be sure of the initial status via QD2*
  - *Investigation with QD5*
  - *Test of the FF final focus*
  - *GM*