First thoughts on active feed-forwards for ATF2 based on GM

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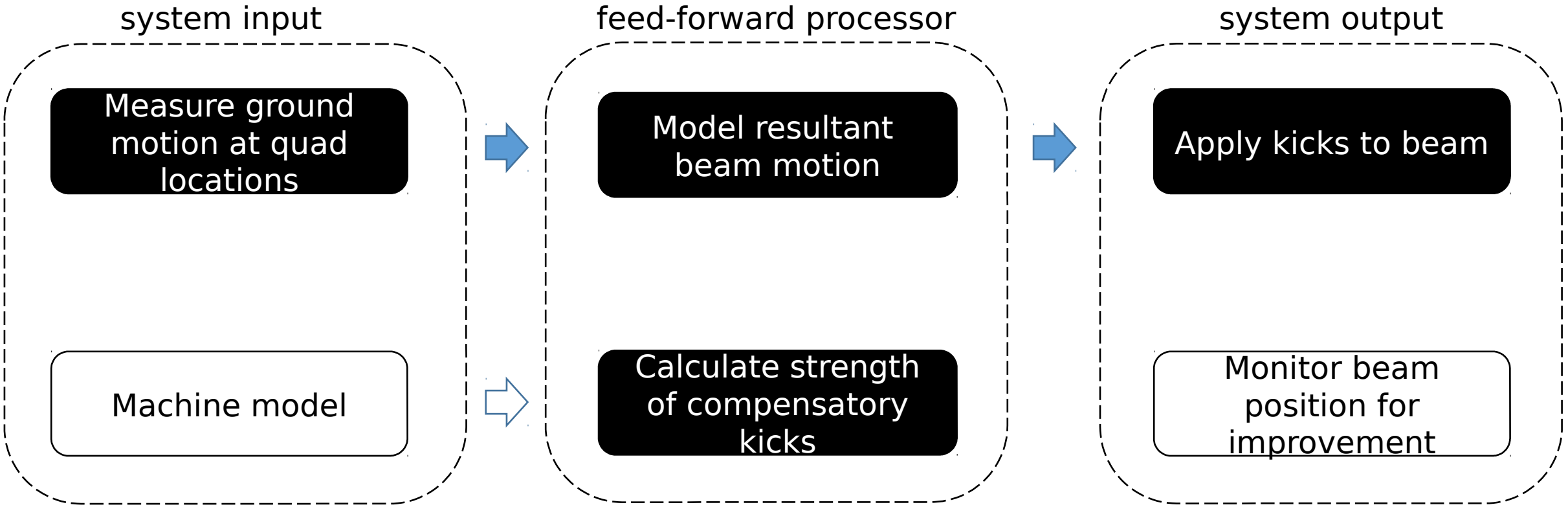
Active feed-forward

- See talk by J. Pfingstner (Wed 11.00: ATF2 session)
- Novel mitigation scheme for counteracting ground motion at frequencies not correctable with orbit feedback
- Ground motion sensors distributed along beamline measure quad displacements which are then used to drive actuators
- Cheaper and simpler to implement than mechanical stabilisation

System overview



Measure ground motion

See talk by M. Patecki (Wed 11.15: ATF2 session)

14 Güralp Systems CMG-6T seismometers
frequency response: 0.03 - 100 Hz
output range: ± 10 V

Best results when mounted directly on quads

Model resultant beam motion

Effect of ground motion on beam orbit: $\vec{b}_q = \boldsymbol{R}_q \vec{x}_q$

where

$\boldsymbol{R}_q$ = orbit response matrix to quad displacement

$\vec{x}_q$ = measured change in quad position

Calculate kick strengths

Effect of correctors on beam orbit: $\vec{b}_c = \boldsymbol{R}_c \vec{k}_c$

where

$\boldsymbol{R}_c$ = orbit response matrix to quad displacement

$\vec{k}_c$ = change in corrector strength

$\vec{b}_c = -\vec{b}_q$

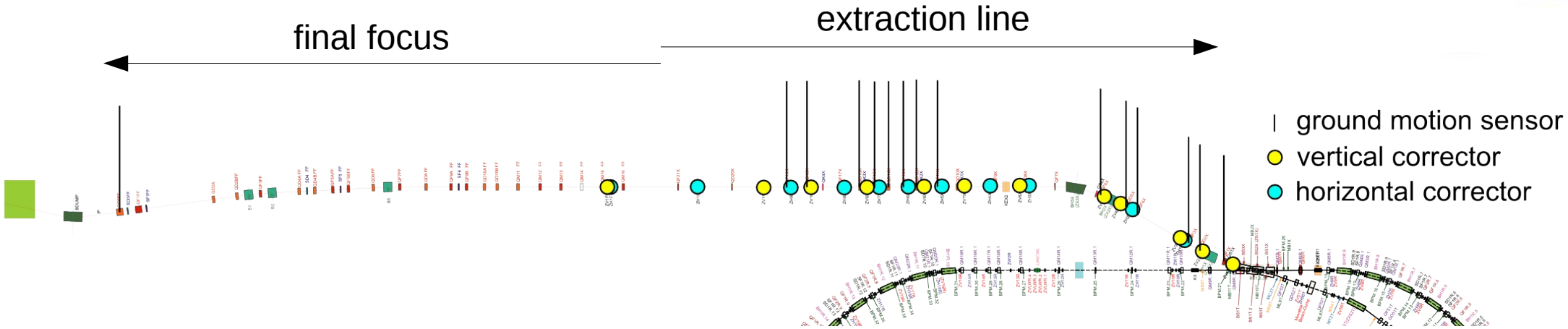
$$\vec{k}_c = -\boldsymbol{R}_c^{-1} \boldsymbol{R}_q \vec{x}_q$$

Feed-forward processor

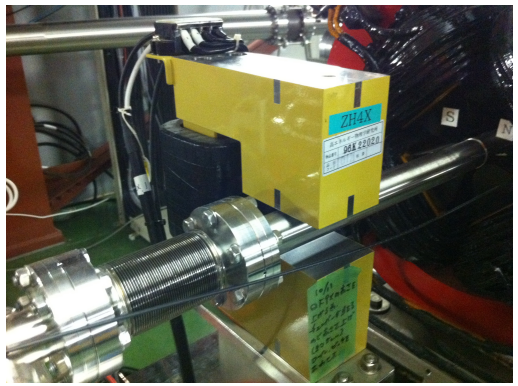
- FPGA implementation ideal as it offers fast and efficient calculations along with flexibility

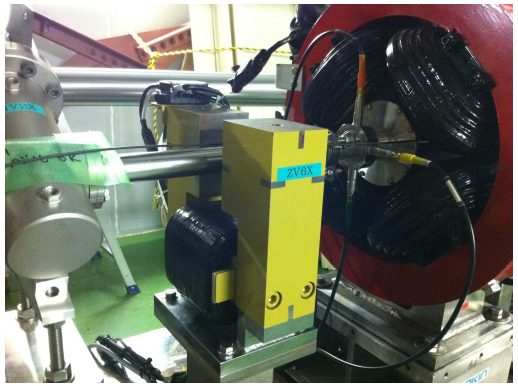
- $\boldsymbol{R}_c, \boldsymbol{R}_q$ measured with beam; $\boldsymbol{R}_c^{-1}\boldsymbol{R}_q$ calculated “off-line”
- Result stored in lookup table so time-critical calculation reduced to single matrix-vector multiplication
- For realistic clock speed estimate calculation will take O(10 μs)

Actuators: dipole correctors



- 22 dipole corrector magnets in extraction line

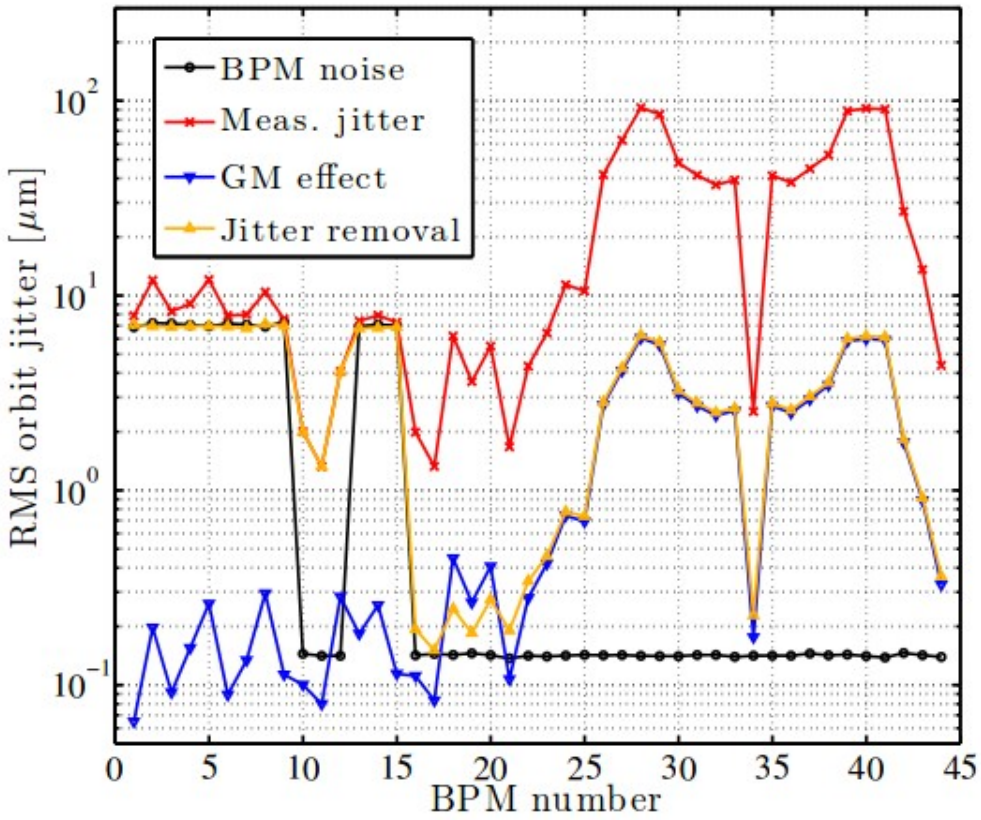




  - Used for orbit steering
  - Horizontal and vertical
  - Set through ATF control system

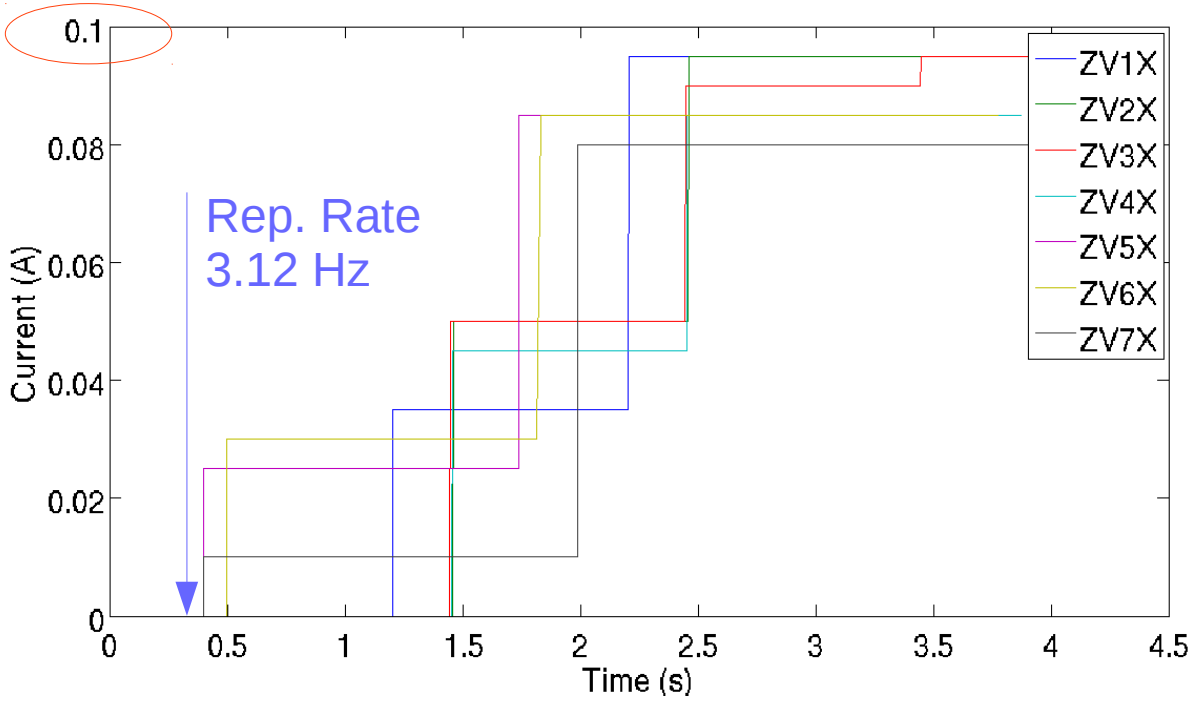
Actuators: dipole correctors II

- Jitter due to ground motion in ATF2 BPMs is O(1 μm)
- This corresponds to corrector currents O(0.1 mA)
- Latency to be measured with beam

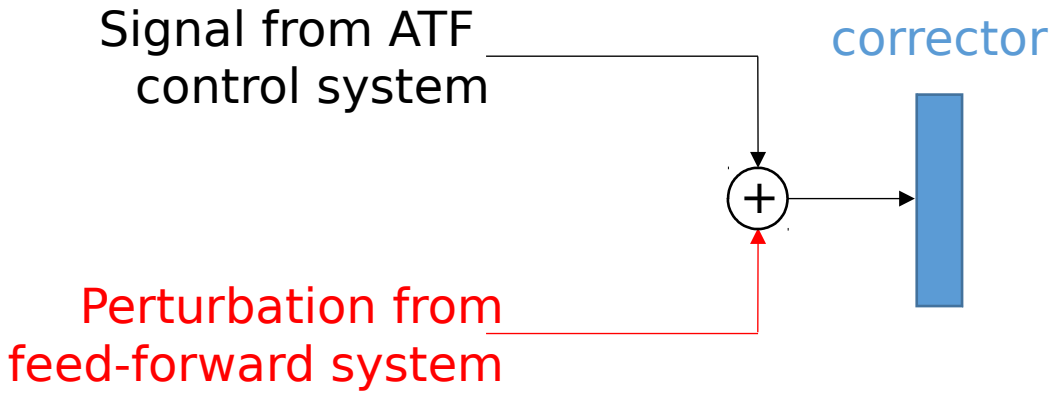


Actuators: dipole correctors III

large kick

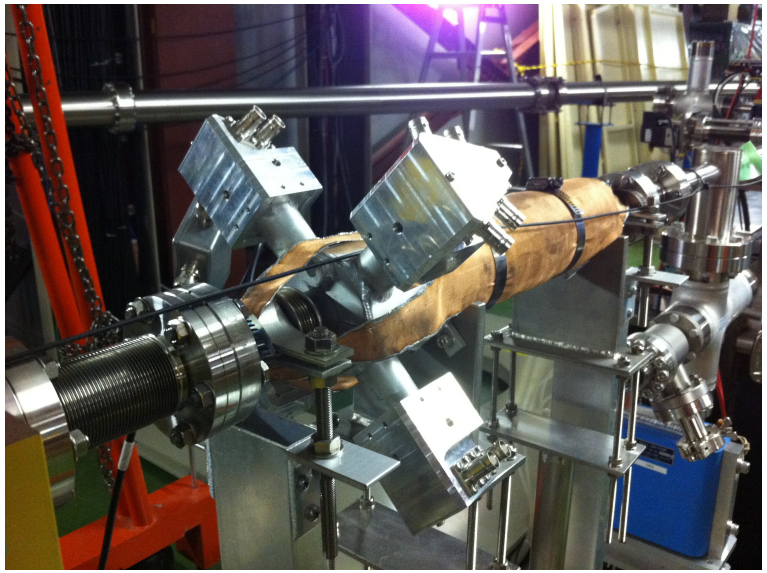


- True slow slew rate or measurement artifact?
- Option to drive directly



Actuators: stripline kickers

- Two stripline kickers: K1~ZV7X, K2~ZV8X
- Typically used for FONT intra-train feedback



\+ Availability
\+ Response time

– Just two

Latency

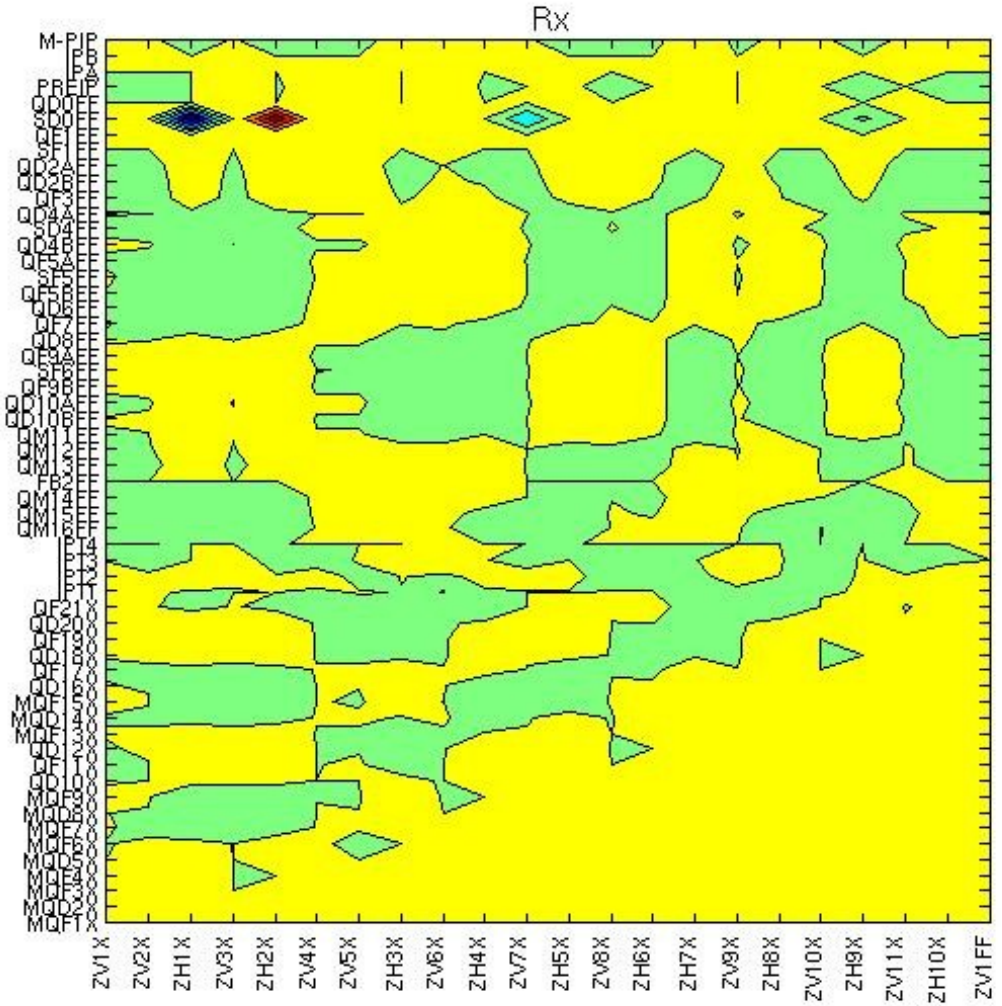
- Time response of system must be fast compared to imperfections
- Max frequency 100 Hz → aim for latency budget of 5 ms
- Latency = measurement + calculation + correction

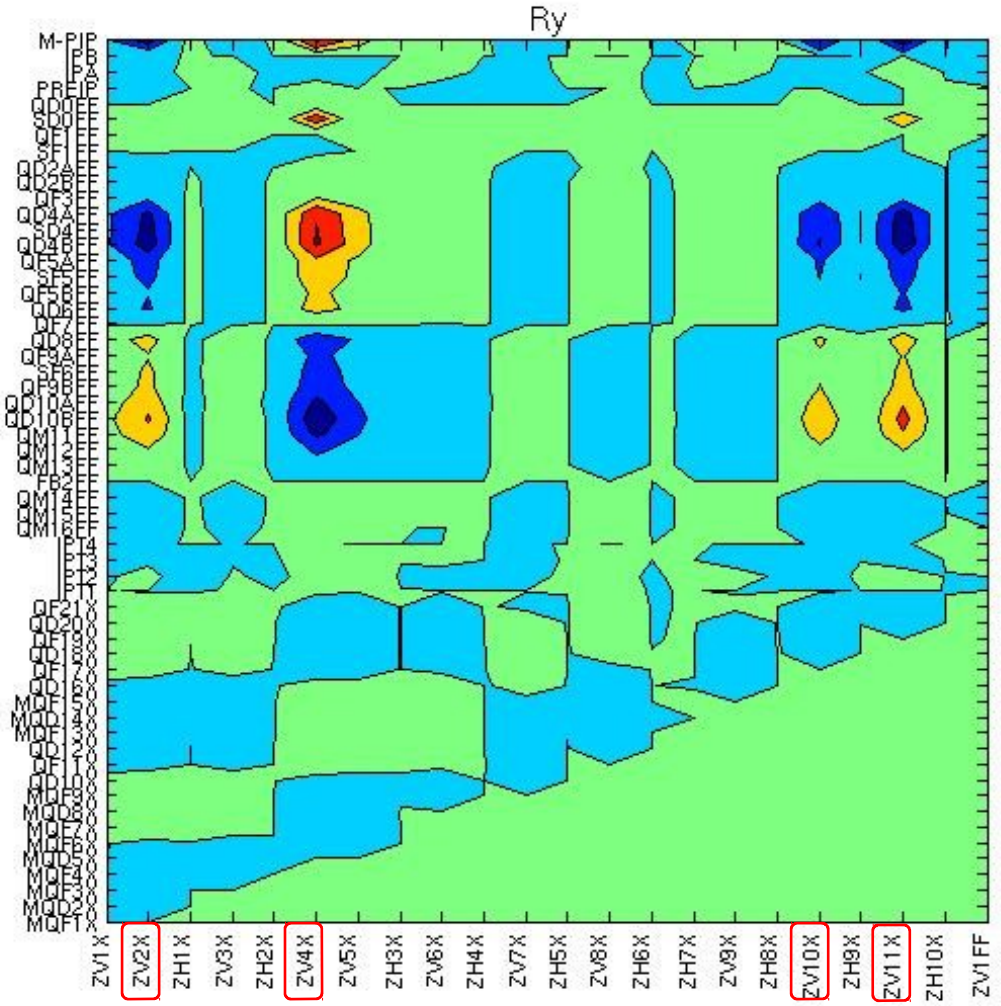
- Measurement: to be determined with spectrum analyser
- Calculation: estimate O(10 µs)
- Correction: depends

Proposed prototype system

- General requirement for an FPGA module with:
  - 2 analogue inputs per ground motion sensor (for x and y)
  - 1 analogue output per corrector magnet
  - e.g. **NI PXI-7852R** (Virtex-5 FPGA)
    - Compatible with existing PXI chassis
    - 8 analogue inputs → enough for 4 **quad-mounted** sensors (x and y)
    - 8 analogue outputs → 4 horizontal and 4 vertical corrector magnets
    - Response matrix measurement to determine quads, correctors to use
- Controller-corrector interface for ATF2 dipoles (hardware or software)

Corrector response matrix (low β)





J. Snuverink

Summary

- Ground motion mitigation vital for CLIC
- Active feed-forward uses ground motion sensors to drive correctors
- Work ongoing to deliver a prototype system for ATF2