Further uses of fast orbit feedback controllers

Matthew Furseman

16:30, Tuesday 20th September, 2016

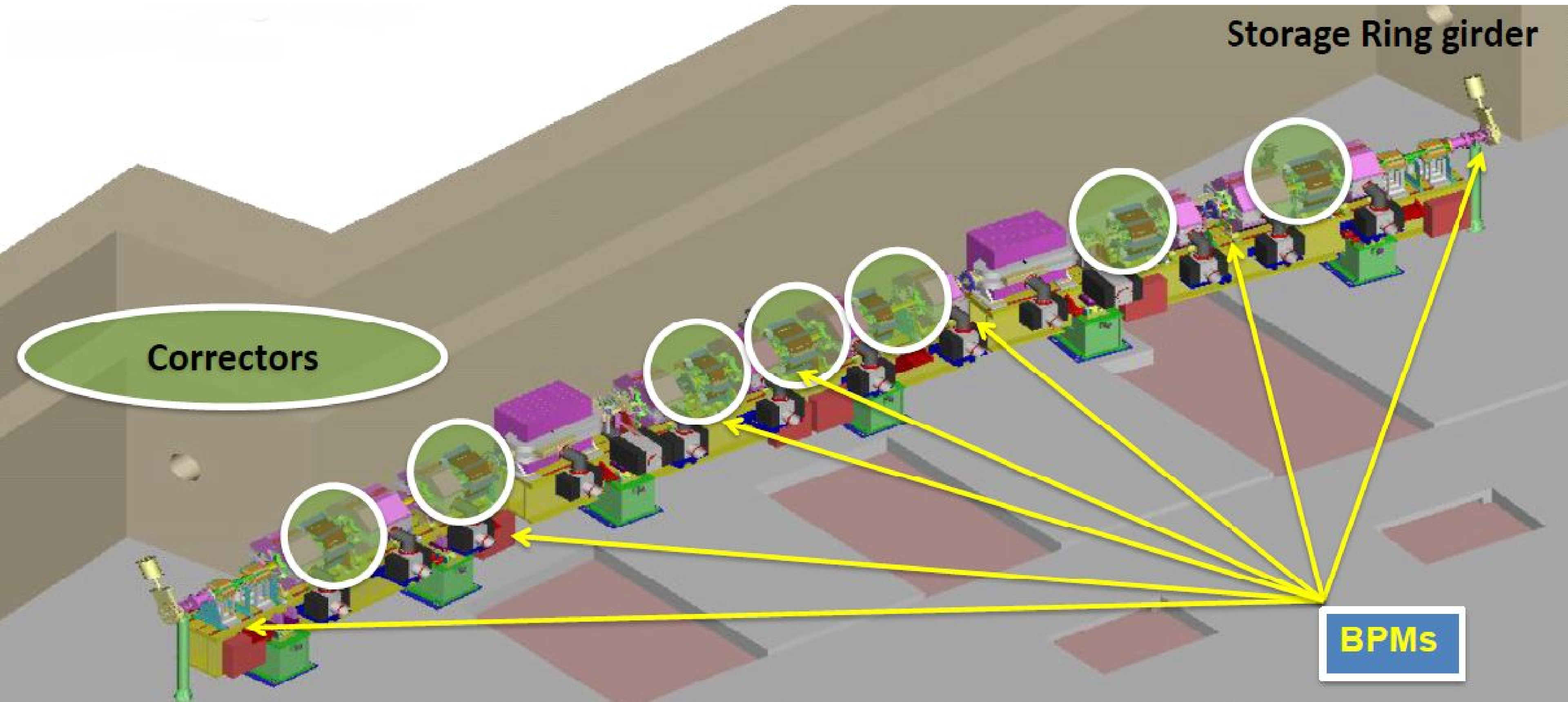
Contents

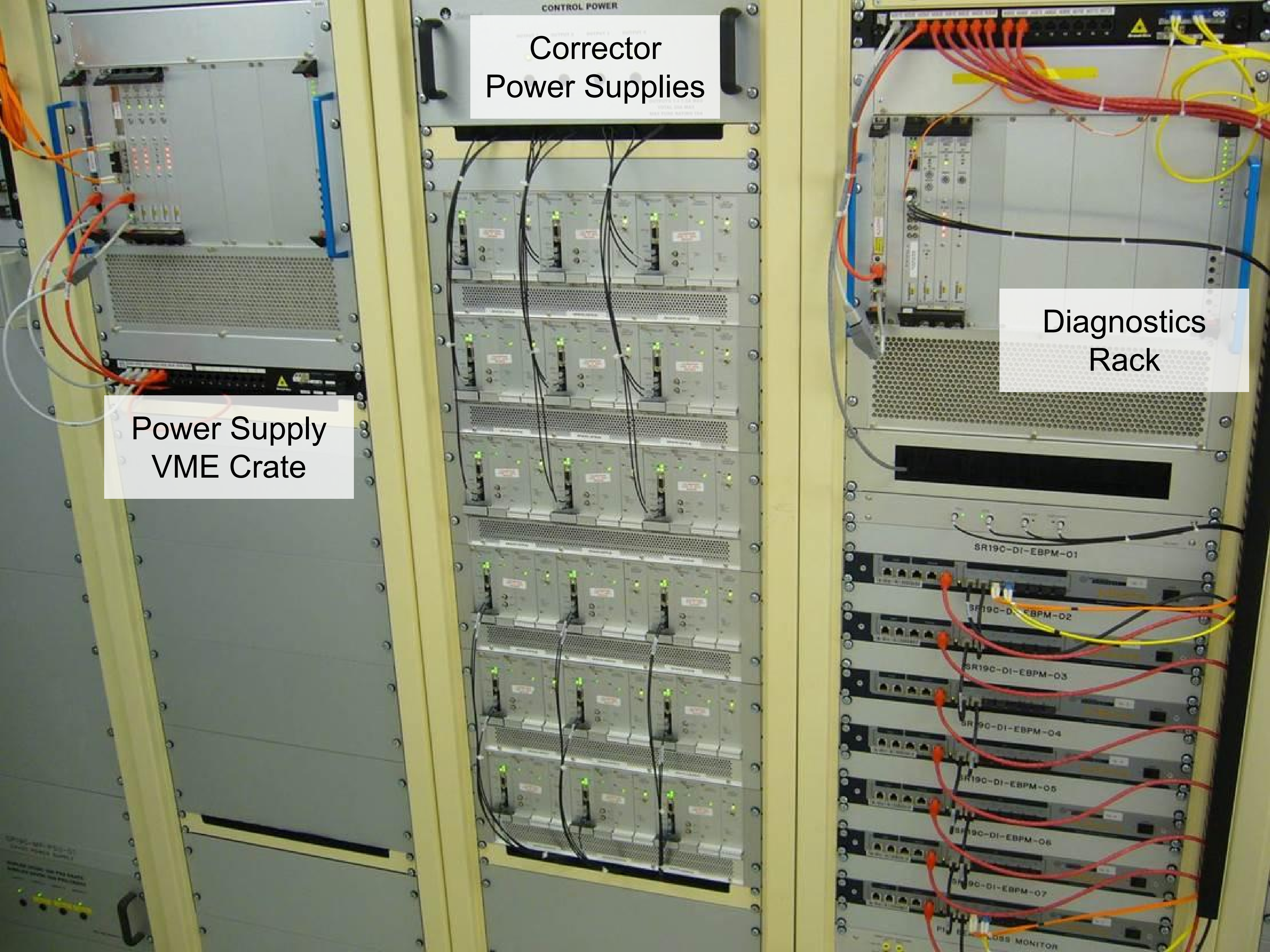
- Overview of FOFB system
- Excitation behaviour and interface
- Dynamic closed bumps
- Response matrix measurement
- Dynamic response of corrector magnets
- I10 switching suppression

Layout of FOFB components

Global orbit correction at 10kHz

172 BPMs, 172 Correctors within sextupoles

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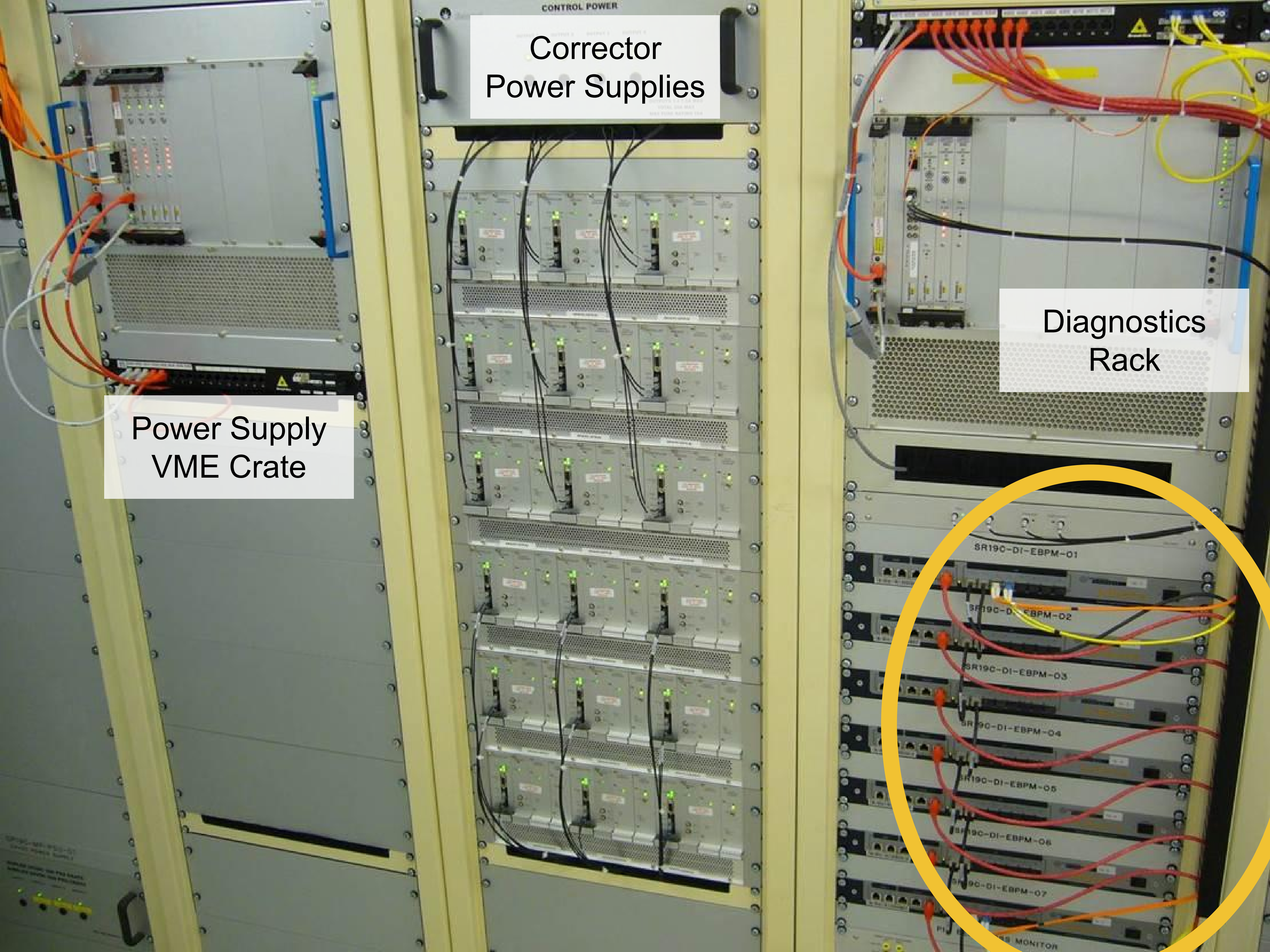
Corrector Power Supplies
Power Supply VME Crate
Diagnostics Rack
SR19C-DI-EBPM-01
SR19C-DI-EBPM-03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Power Supplies
Diagnostics
Rack
Power Supply
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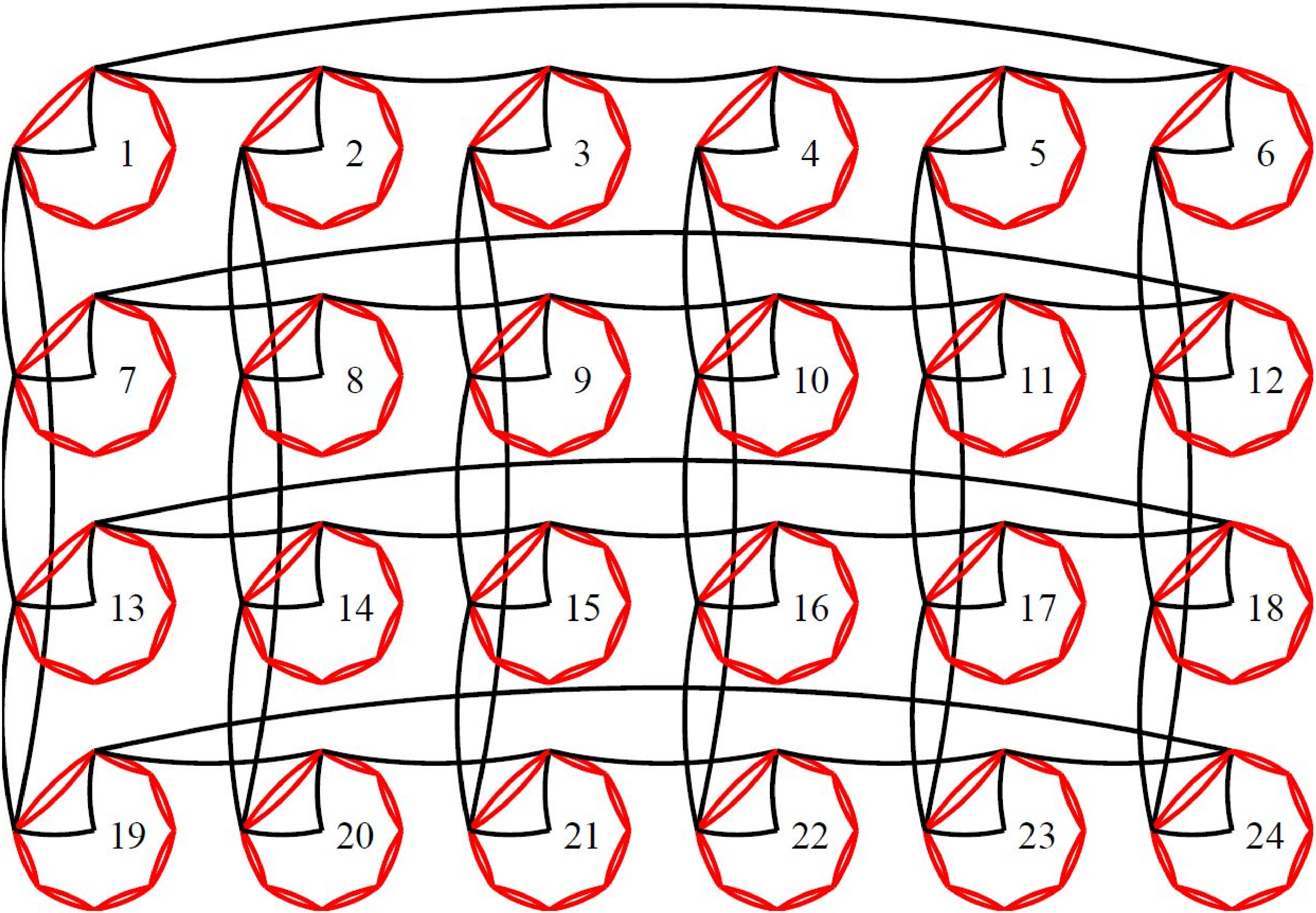
SR19C-DI-EBPM-05
SR19C-DI-EBPM-06
SR19C-DI-EBPM-07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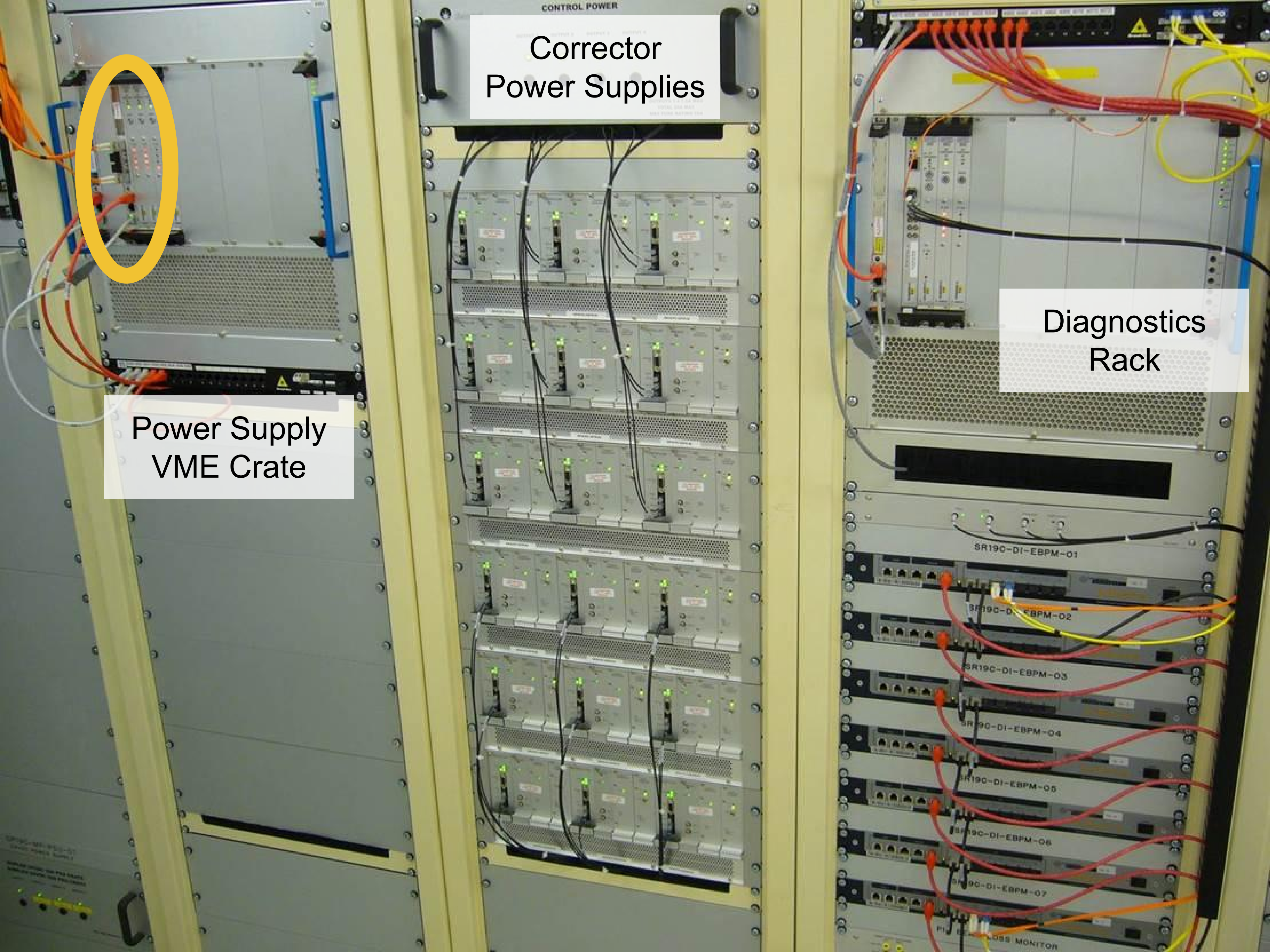
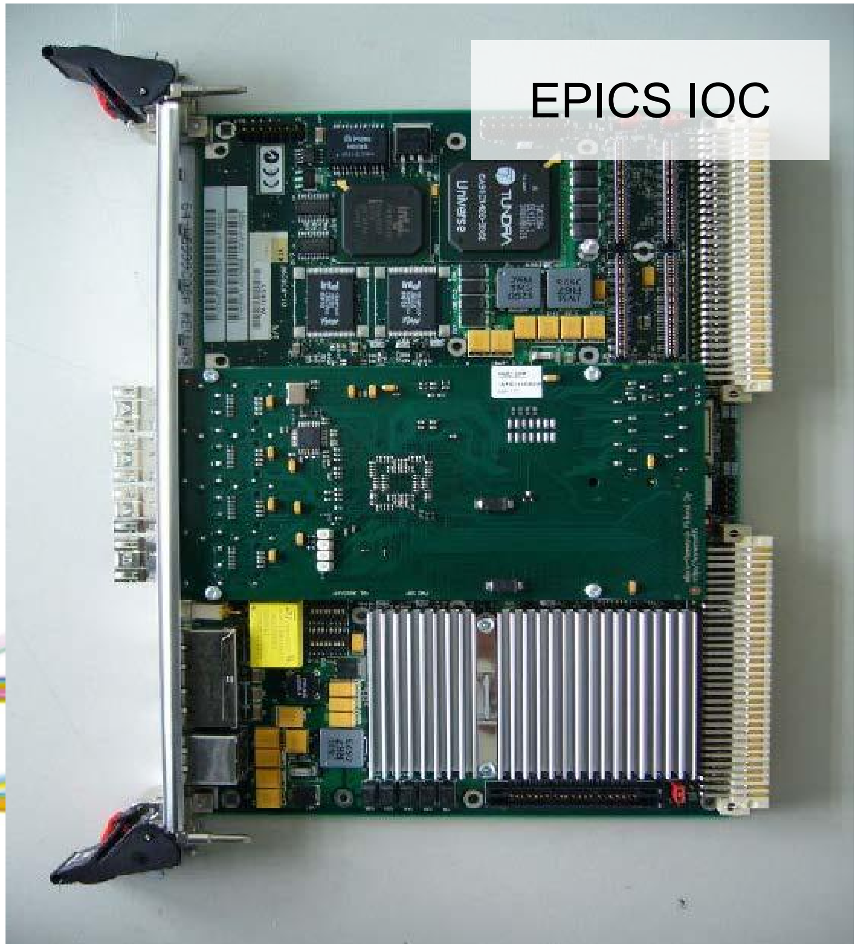
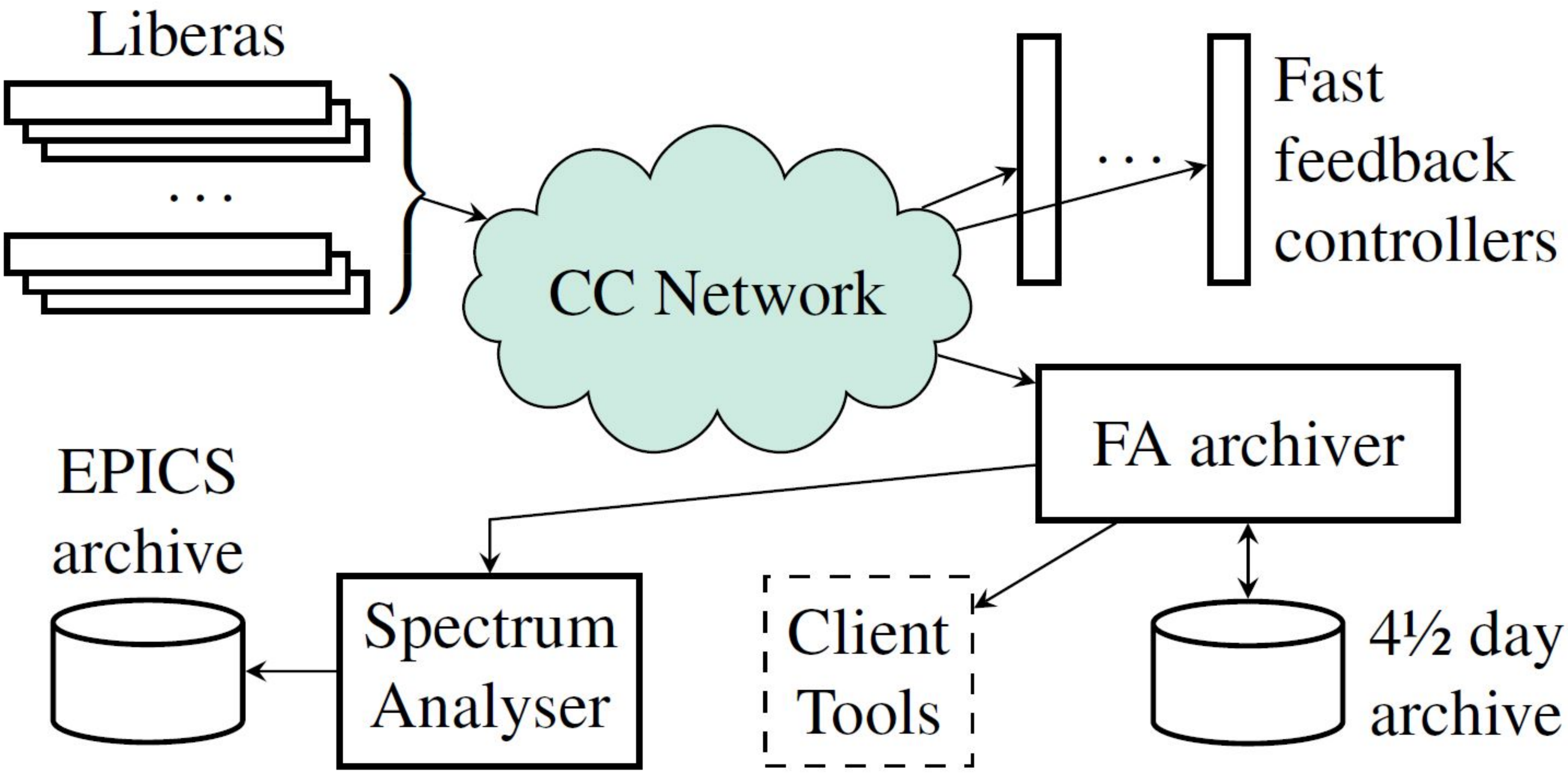


CONTROL POWER
Corrector Power Supplies
Power Supply VME Crate
Diagnostics Rack
SR19C-DI-EBPM-01
SR19C-DI-EBPM-03
SR19C-DI-EBPM-05

Fast orbit feedback IOC and PMC

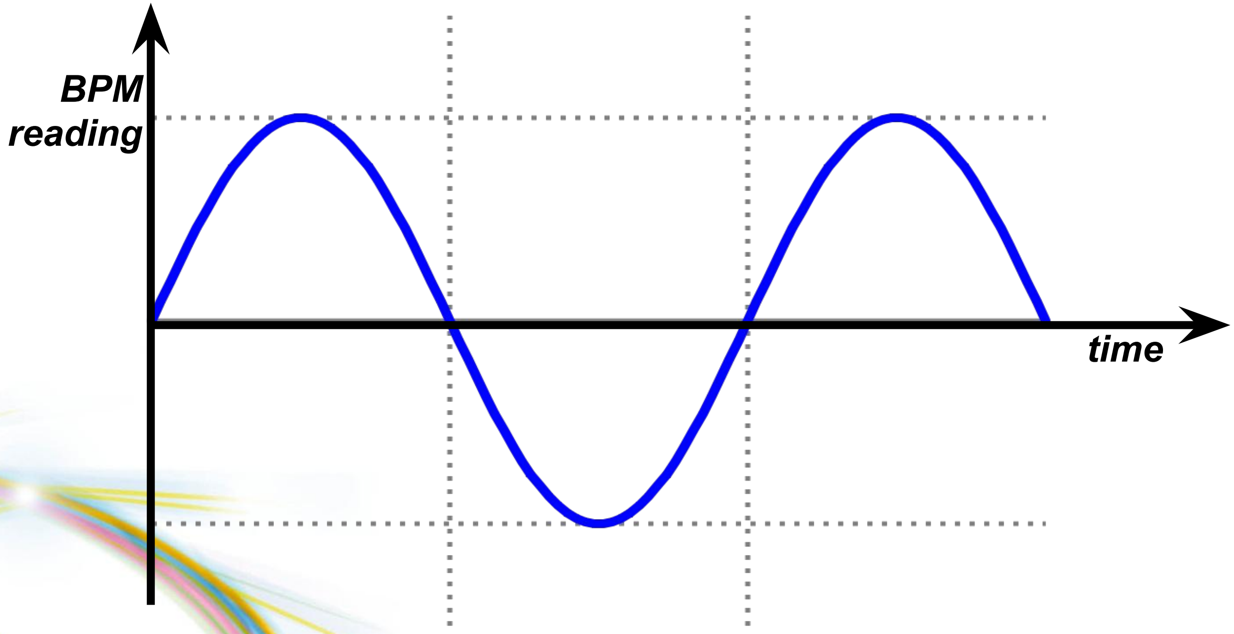


Fast acquisition archiver



What is an excitation?

Perturb the electron beam using a corrector magnet so that the reading from a BPM follows a sine wave:



Excitation interface

Each IOC is running a synchronised 10 kHz loop connected to power supply controllers. Why not modify it to provide a sinusoidal disturbance around the ring?

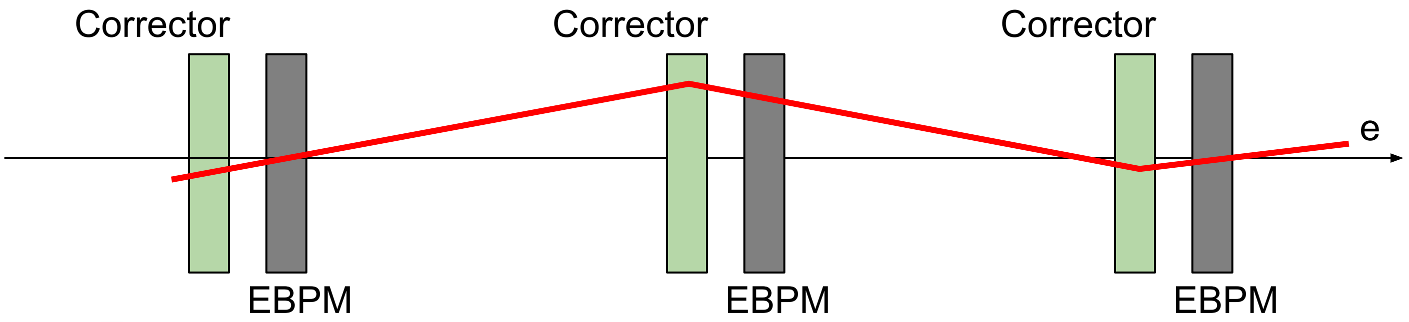
- Excitations are programmed into the IOC via PVs.
- The start times of excitations are specified in synchronised ‘FA’ ticks.
- Almost arbitrary frequencies are achieved using a phase advance per tick.
- Separate frequency, amplitude and start time control for each horizontal and vertical corrector.

diamond

Uses of excitations

- **Dynamic closed bumps**
- Response matrix measurement
- Dynamic response of corrector magnets
- I10 switching suppression

Dynamic closed bumps



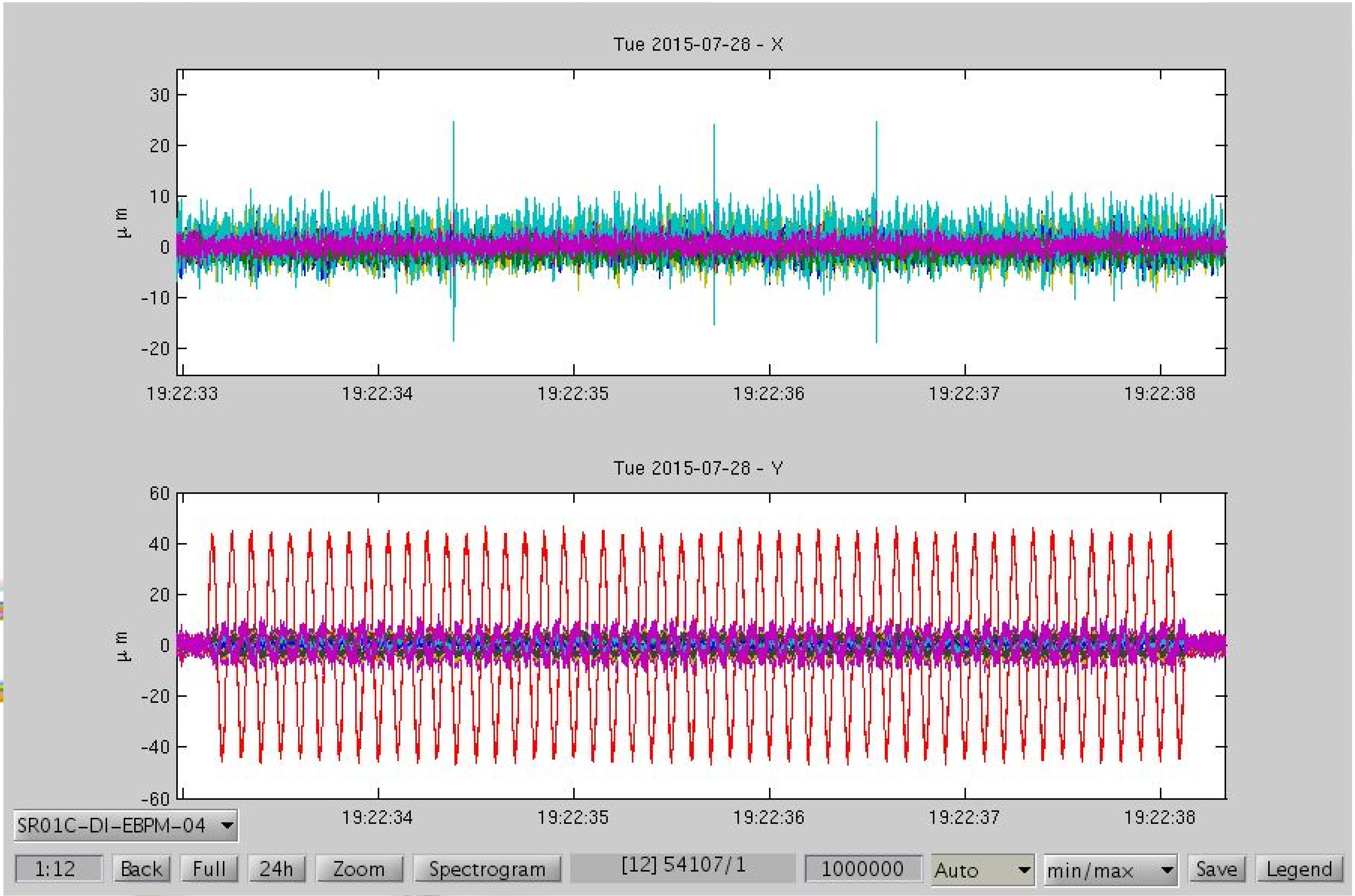
Dynamic closed bumps

Create electron beam disturbance on isolated BPMs.

- Invert the BPM to corrector response matrix.
- Take a row of the inverted matrix, these are the corrector values required to change the reading on a single BPM.
- Apply a synchronised excitation to the correctors using the magnitudes received from the inverse response matrix.

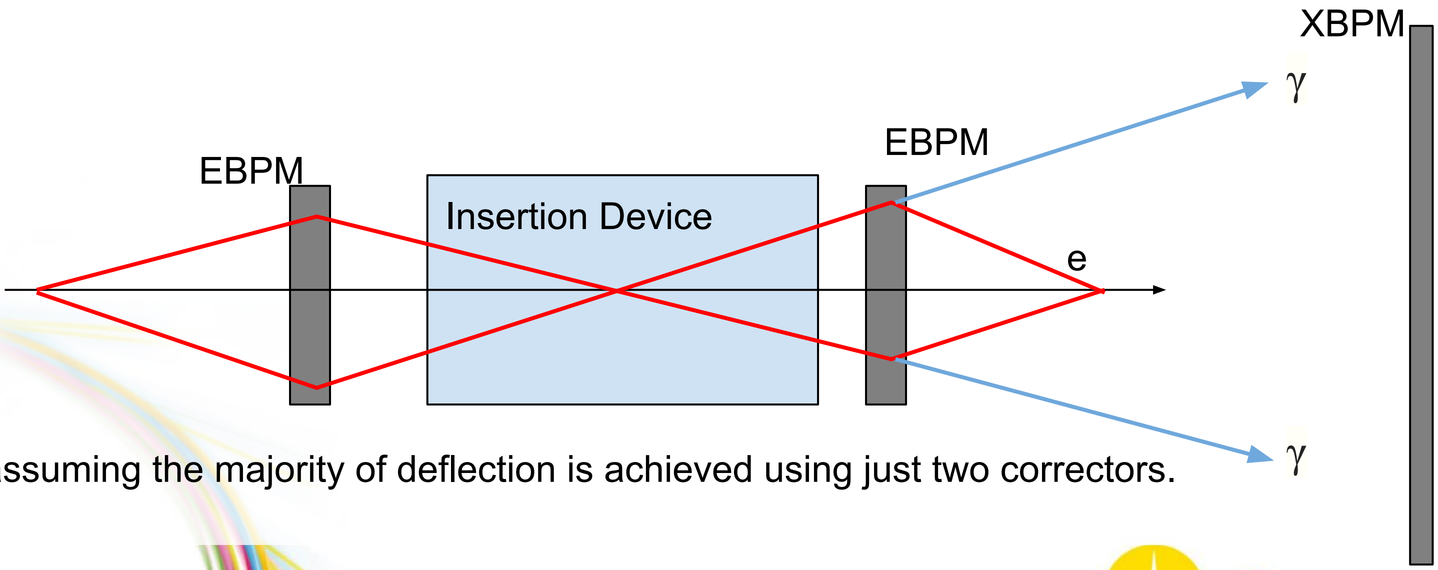
Dynamic closed bumps

Single BPM being driven by correctors at 10Hz



Dynamic closed bumps

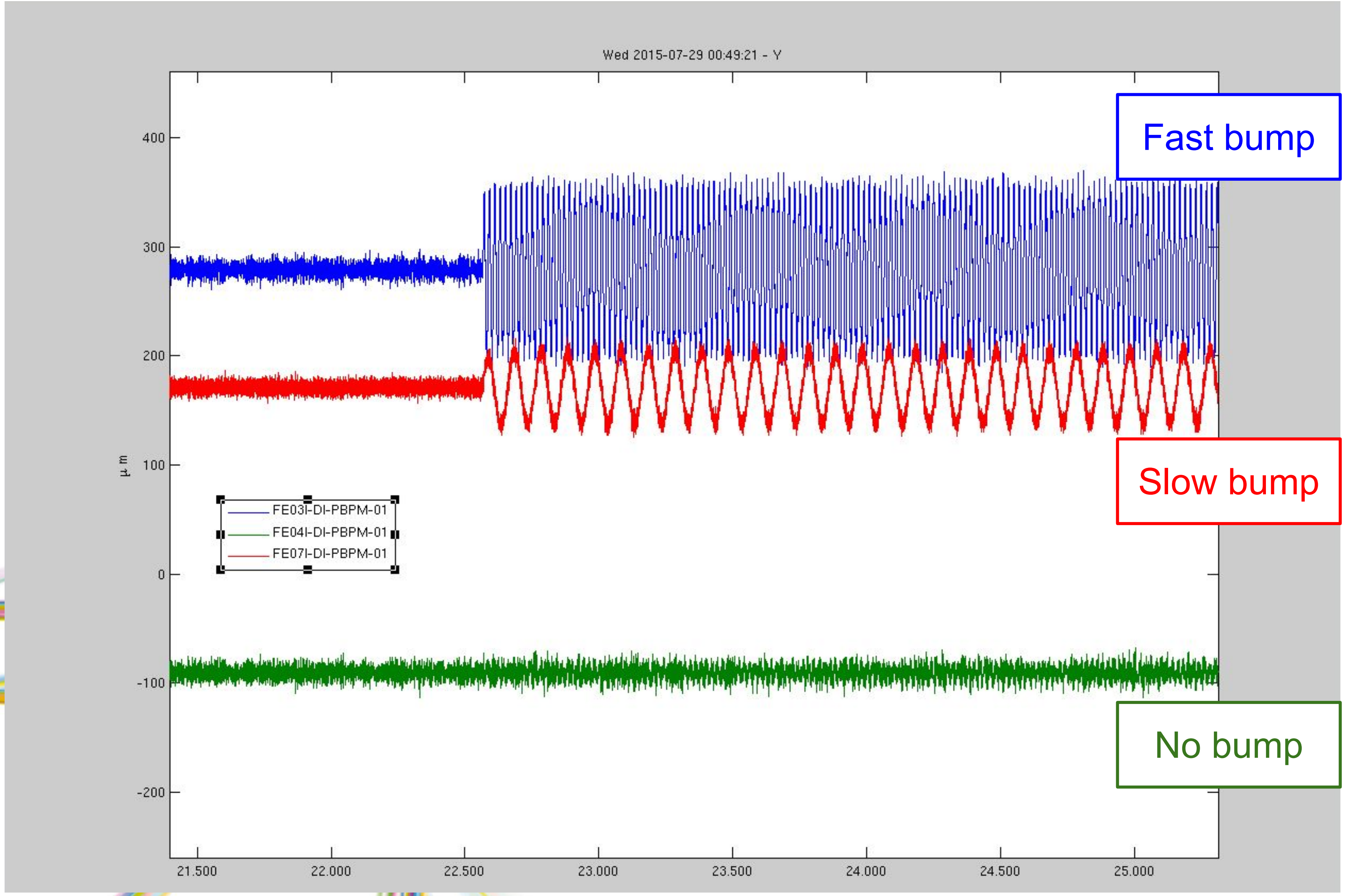
- Subtract the IRM rows for two neighbouring BPMs either side of an insertion device straight.
- Apply to the ring to ‘see-saw’ through the ID creating an oscillating photon beam.



Electron path, assuming the majority of deflection is achieved using just two correctors.

Dynamic closed bumps

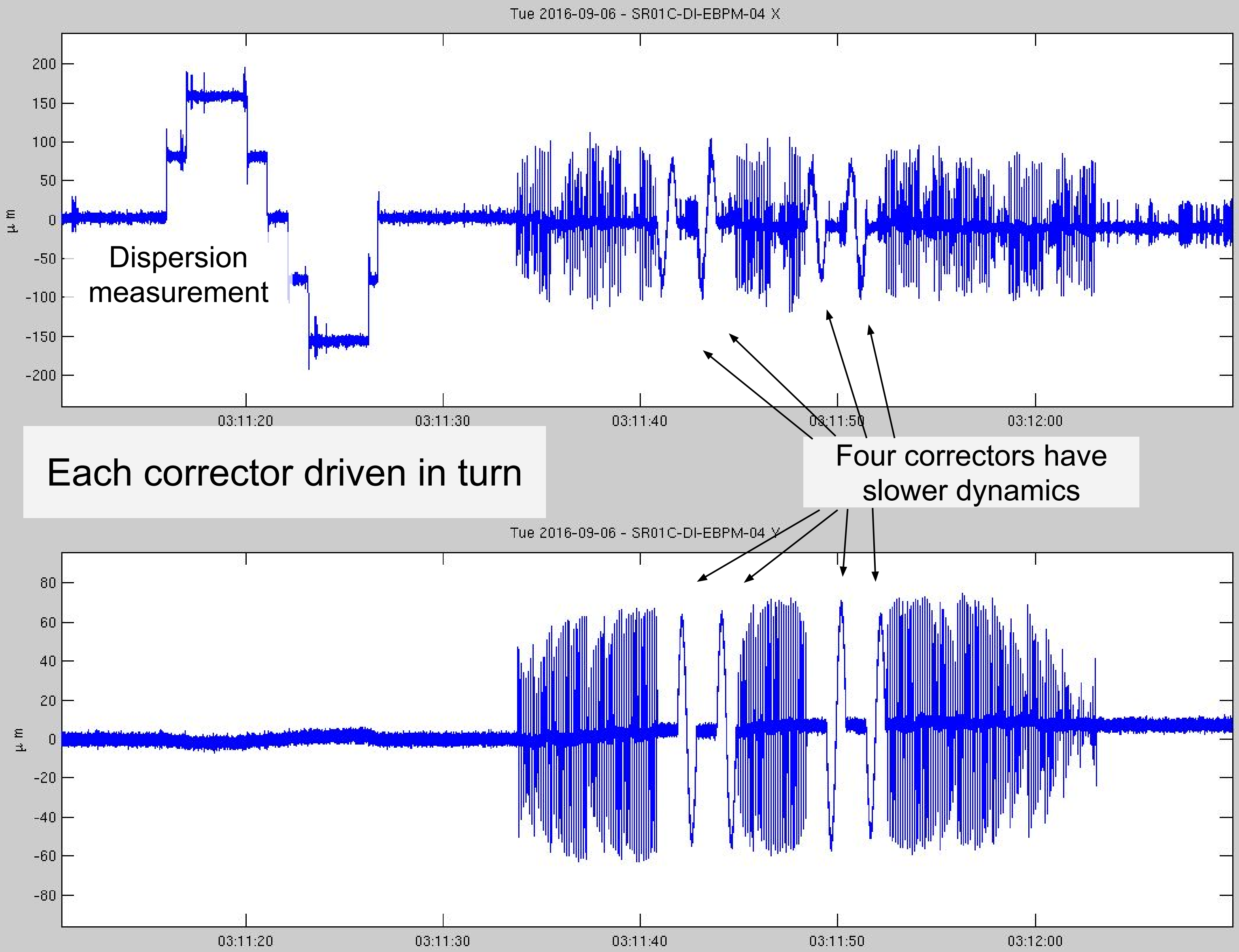
XBPM traces for three beamlines



Uses of excitations

- ~~Dynamic closed bumps~~
- **Response matrix measurement**
- Dynamic response of corrector magnets
- I10 switching suppression

Response matrix measurement



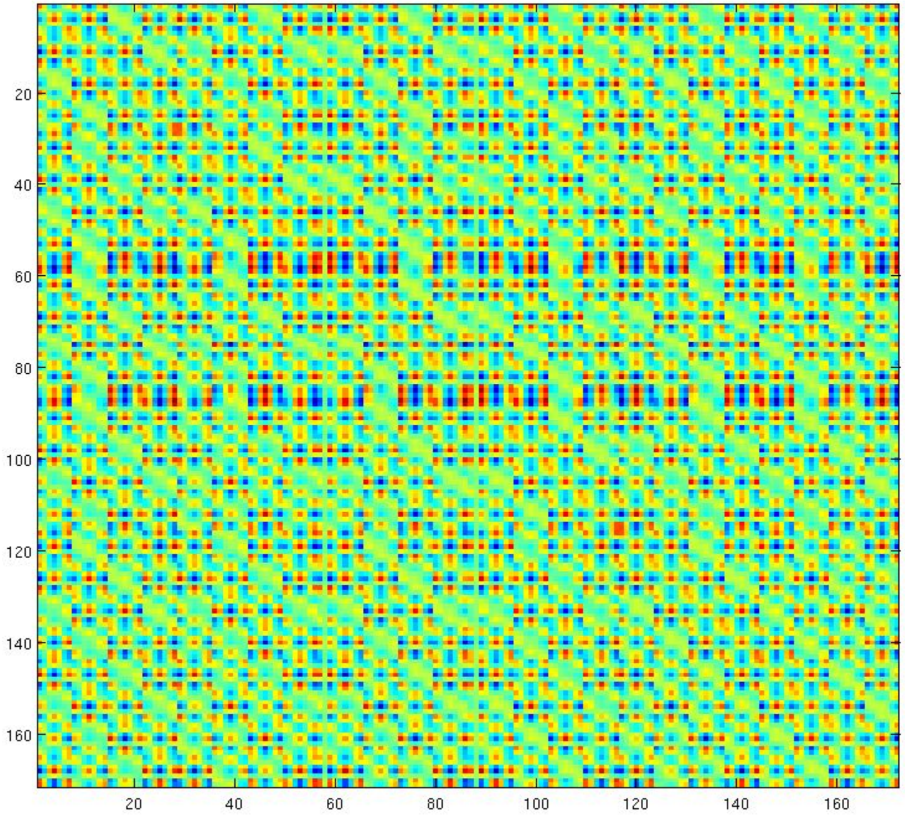
Response matrix measurement

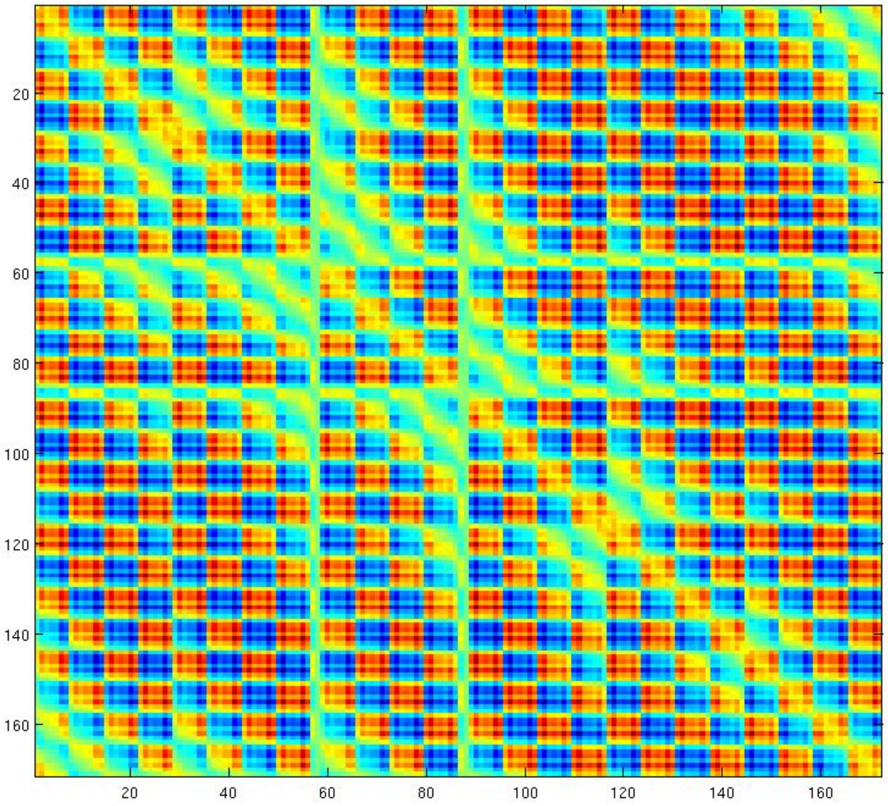
- Load BPM data from the FA archiver
- Calculate each response matrix element

$$RM_{ij} = \frac{mean(measured\ sine\ wave \times synthesised\ sine\ wave)}{amplitude}$$

Response matrix measurement

On axis response matrices in both planes, measured in 50 seconds.





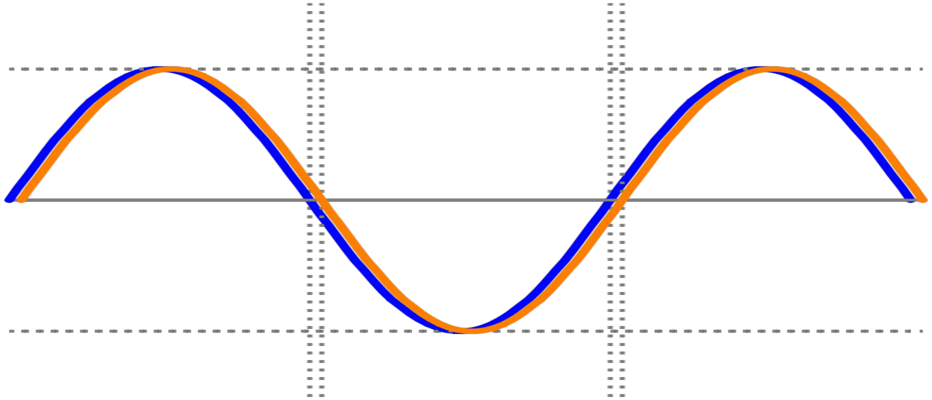
Uses of excitations

- ~~Dynamic closed bumps~~
- ~~Response matrix measurement~~
- **Dynamic response of corrector magnets**
- I10 switching suppression

Dynamic response of corrector magnets

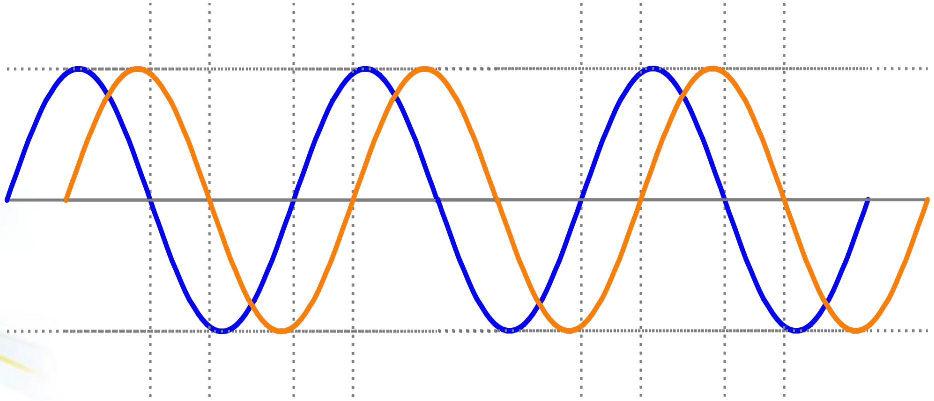
Low frequency

Magnet keeps up with demand



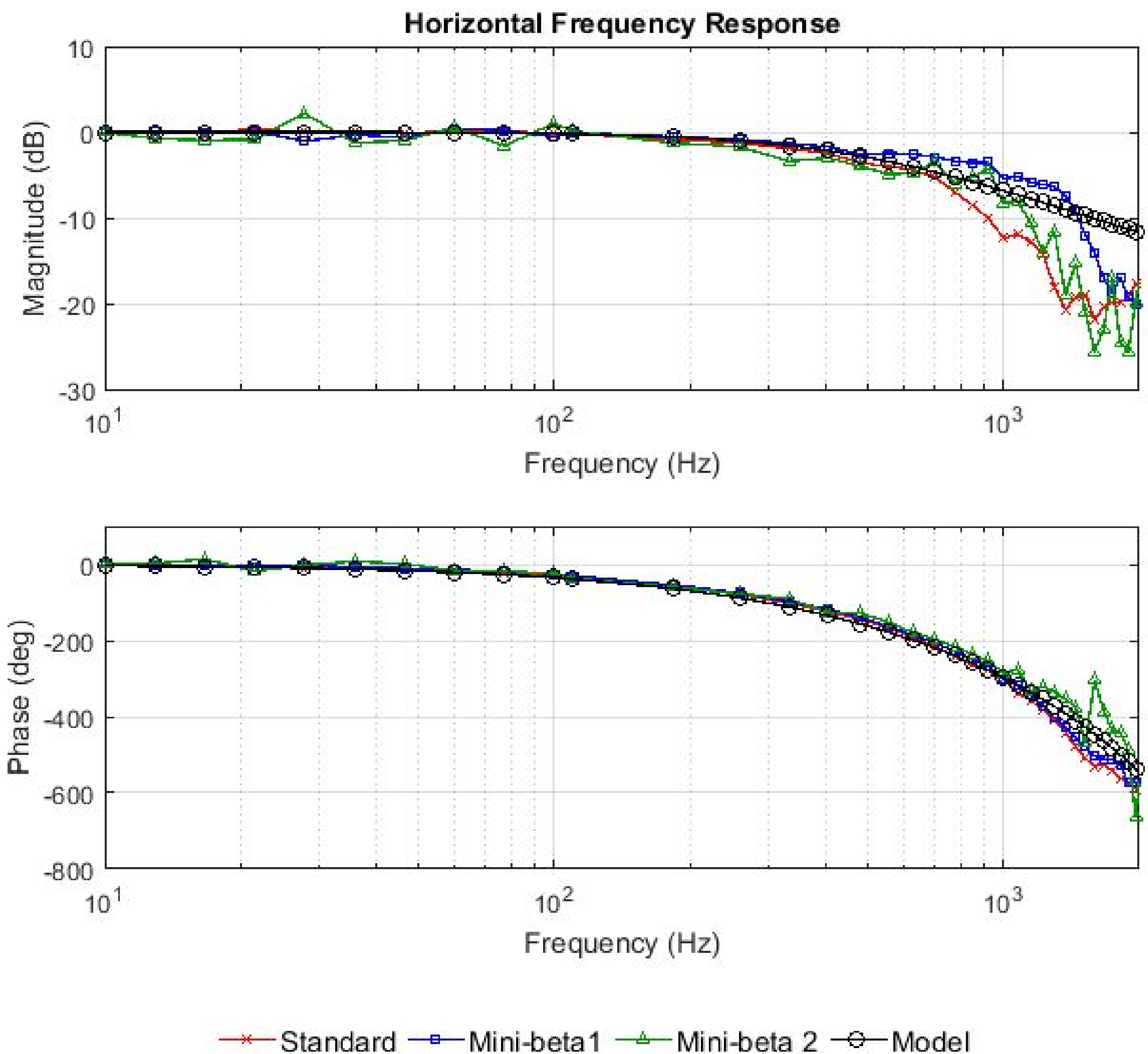
High frequency

Magnet lags



Dynamic response of corrector magnets

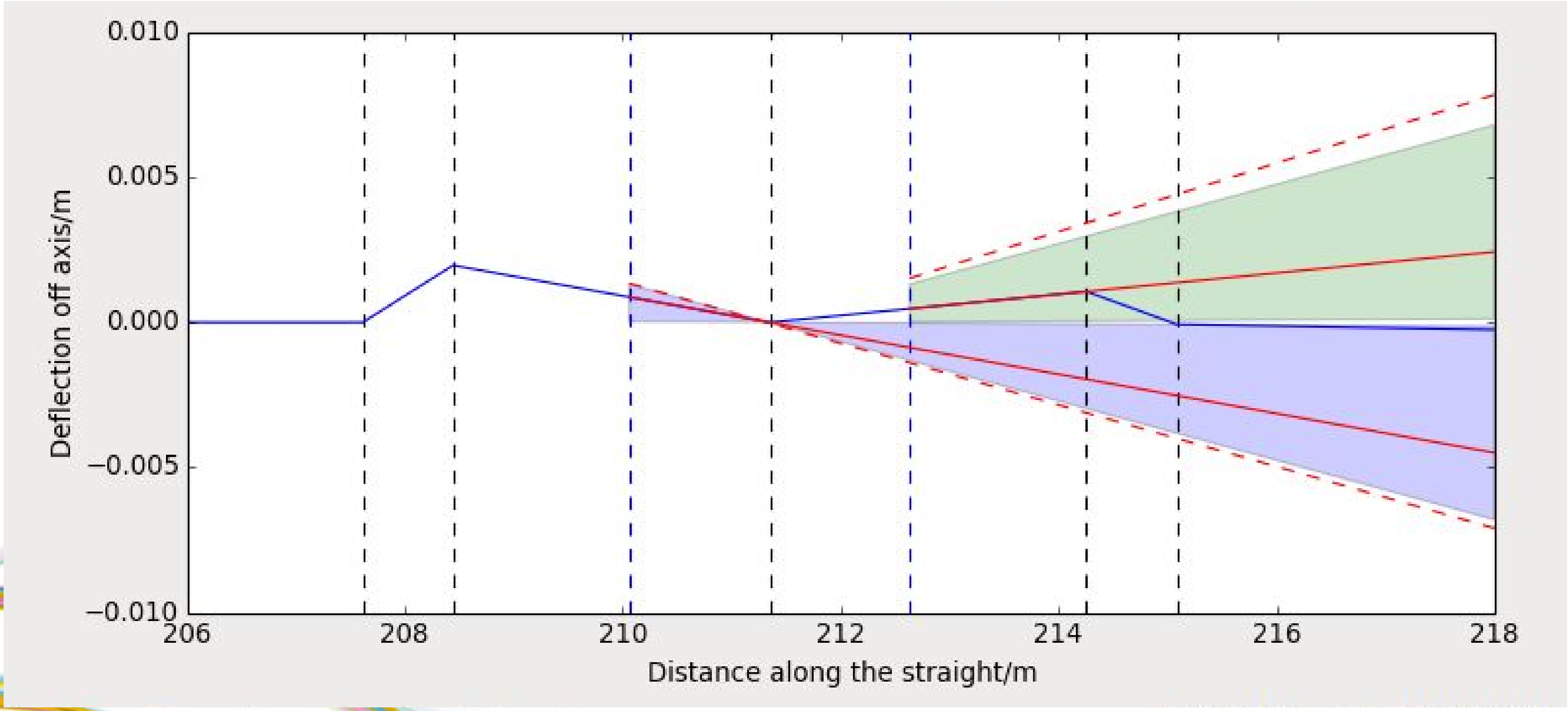
- Excite a corrector with a constant frequency sine wave.
- Mix the BPM data from the FA archiver with a synthesized sine and cosine wave as per the response matrix measurement.
- The generating wave is constant phase and magnitude, so we return a single IQ data pair representing each excitation.
- Increase frequency of excitations in steps, up to our nyquist frequency of ~5 kHz.


Horizontal Frequency Response
Magnitude (dB)
10
0
-10
-20
-30
Frequency (Hz)
Phase (deg)
0
-200
-400
-600
-800
Frequency (Hz)
Standard
Mini-beta1
Mini-beta 2
Model

Uses of excitations

- ~~Dynamic closed bumps~~
- ~~Response matrix measurement~~
- ~~Dynamic response of corrector magnets~~
- **I10 switching suppression**

I10 fast chicane switching



I10 switching suppression

- I10 Fast switching chicane: Dedicated dipole magnets installed for switching electron beam off axis between two insertion devices in different polarizations.
- Magnets are cycled at 10 Hz and are designed to act in a horizontal plane.
- Small leakage into vertical plain remains uncorrected.
- Envisage a plan to measure non-closed component and then correct with a feedforward scheme using FOFB controllers.

Thanks for listening!

Overview of fast orbit feedback system

Excitation behaviour and interface

Dynamic closed bumps

Response matrix measurement

Dynamic response of corrector magnets

I10 switching suppression