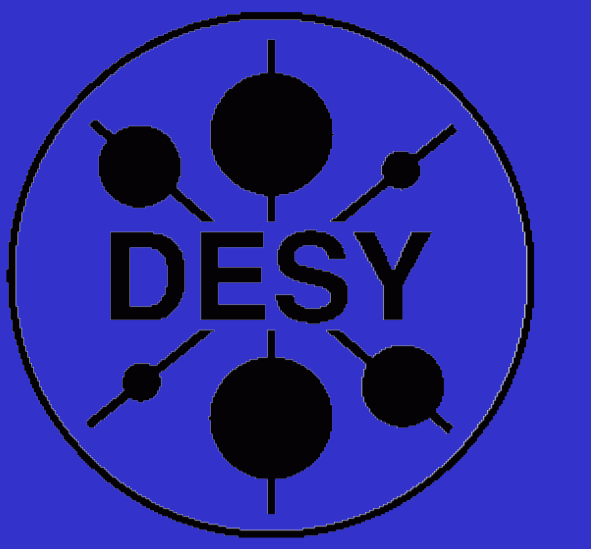
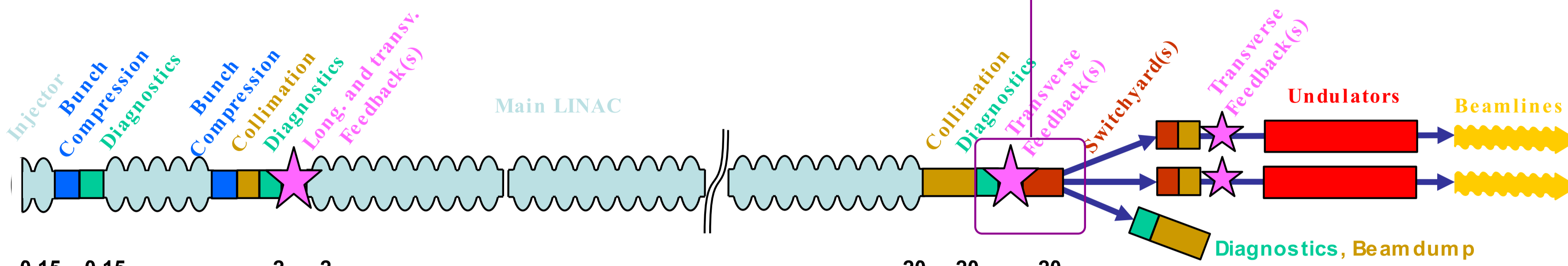


# Electron Beam Stabilization

In collaboration with: Paul Scherrer Institut (PSI)



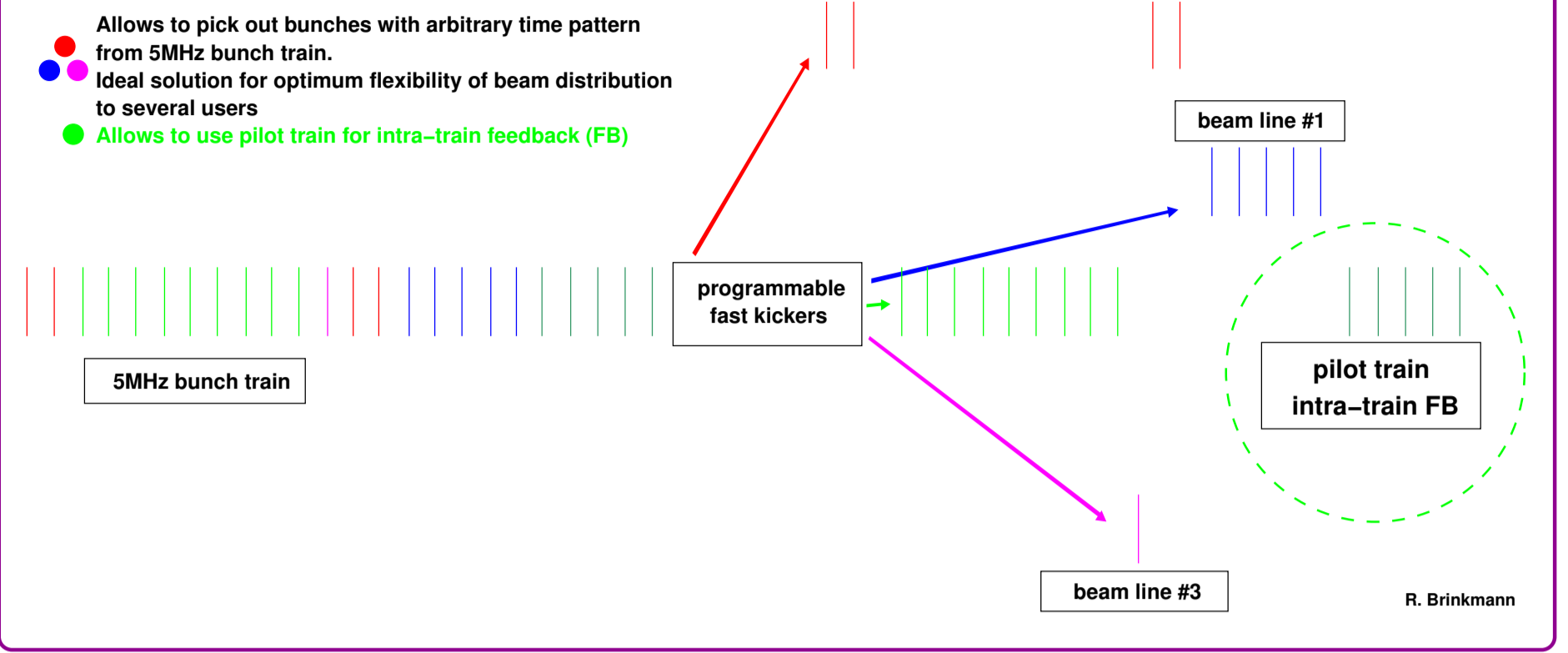
## Schematic X-FEL Overview



Energy [GeV]:	0.15	0.15	2	2	20	20	20	35	35
Beta [m]:	50	1	20	50	50	500	100	35	35
Beams size [ $\mu\text{m}$ ]:	400	60	70	100	35	100	50	30	30
Bunchlength [mm]:	2	0.5	0.025		0.025	0.025		0.025	0.025
Transverse Stability	$\sigma/10$		$\sigma/10$		$\sigma/10$			$\sigma/10$	$\sigma/10$
Requirements* [ $\mu\text{m}$ ]:	6		7	100	100			3	3

\* defined for SASE conditions

## Programmable Fast Kickers



## Beam parameters - Overview

normalized emittance	1.4 mm mrad
energy	20 GeV
energy spread	2.5 MeV
peak current	5 kA
minimum bunch distance	200 ns
maximum pulse length	0.65 ms
repetition rate	10 Hz
average beam power	650 kW
bunch charge	1 nC

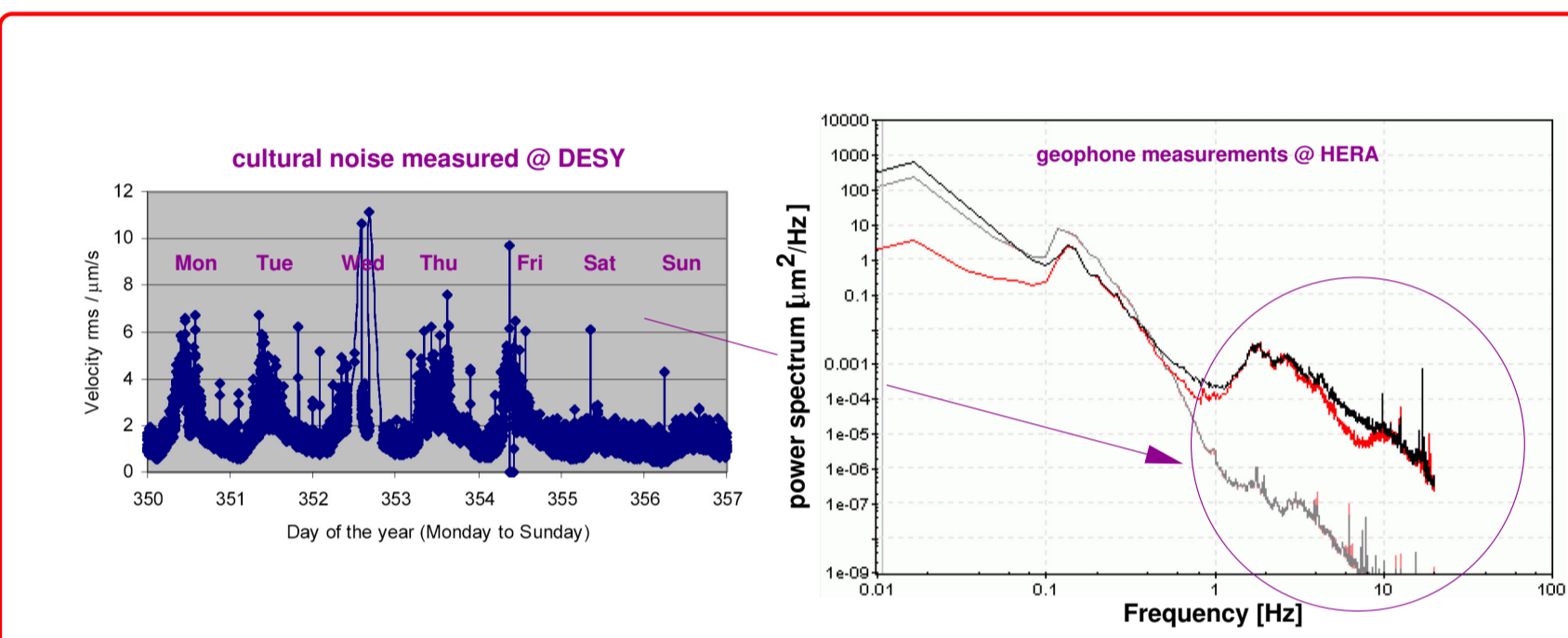
## Noise Sources:

- Long Term Motions (day(s) – years):**
    - ground settlement (> 1 mm)
    - seasonal ground motion (< 1 mm)
    - diurnal temperature (< 100  $\mu\text{m}$ )
  - Cultural Noise Sources (1 Hz – 200 Hz):**
    - gravitational earth tides (< 50  $\mu\text{m}$ )
    - ground vibrations... (< 10  $\mu\text{m}$ )
  - High Frequency Motions (> 200 Hz):**
    - RF induced transients (< 50  $\mu\text{m}$ )
    - HOM induced instab. (< 10  $\mu\text{m}$ )
- The stability from bunchtrain to bunchtrain is predominantly affected.
- Bunch by bunch and intra-bunchtrain stability is affected.

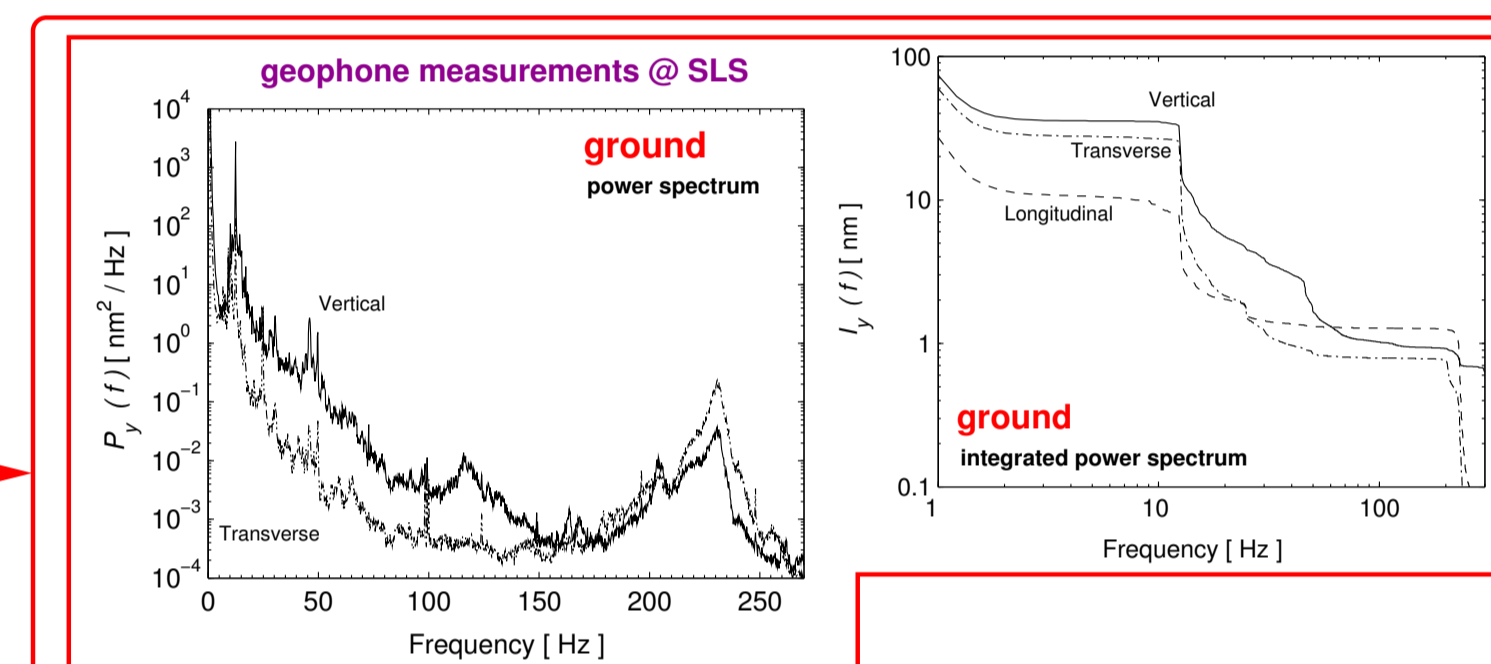
## Stabilization and Correction Strategies:

- Long Term Motions (day(s) – years):**
    - Measurement of mechanical drifts using hydrostatic levelling and horizontal positioning systems (HLS, HPS)
    - Dynamic correction possible by using girder movers
  - Cultural Noise Sources (1 Hz – 200 Hz):**
    - FEA-analyses of mechanical constructions (girders etc...)
    - Measurement with high resolution BPMs
    - Correction (5 Hz BW) using corrector magnets (slow feedback)
  - High Frequency Motions (> 200 Hz):**
    - Bunch by bunch feedback using fast (digital) electronics and longitudinal as well as transverse kickers for stabilization.
- Main Task for X-FEL Beam Stabilization Work Package!**

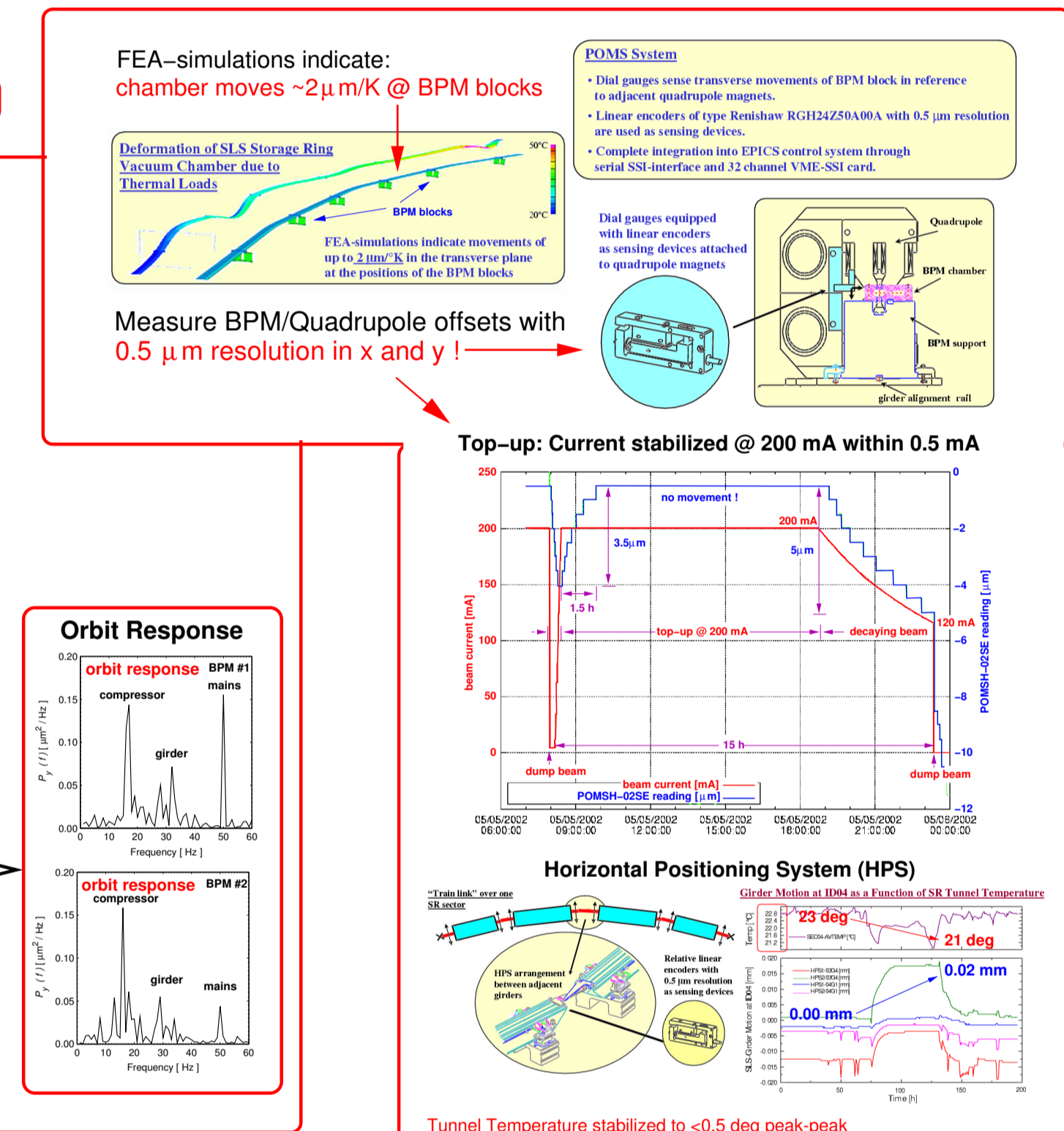
## Cultural Noise Sources @ HERA (1 Hz – 200 Hz)



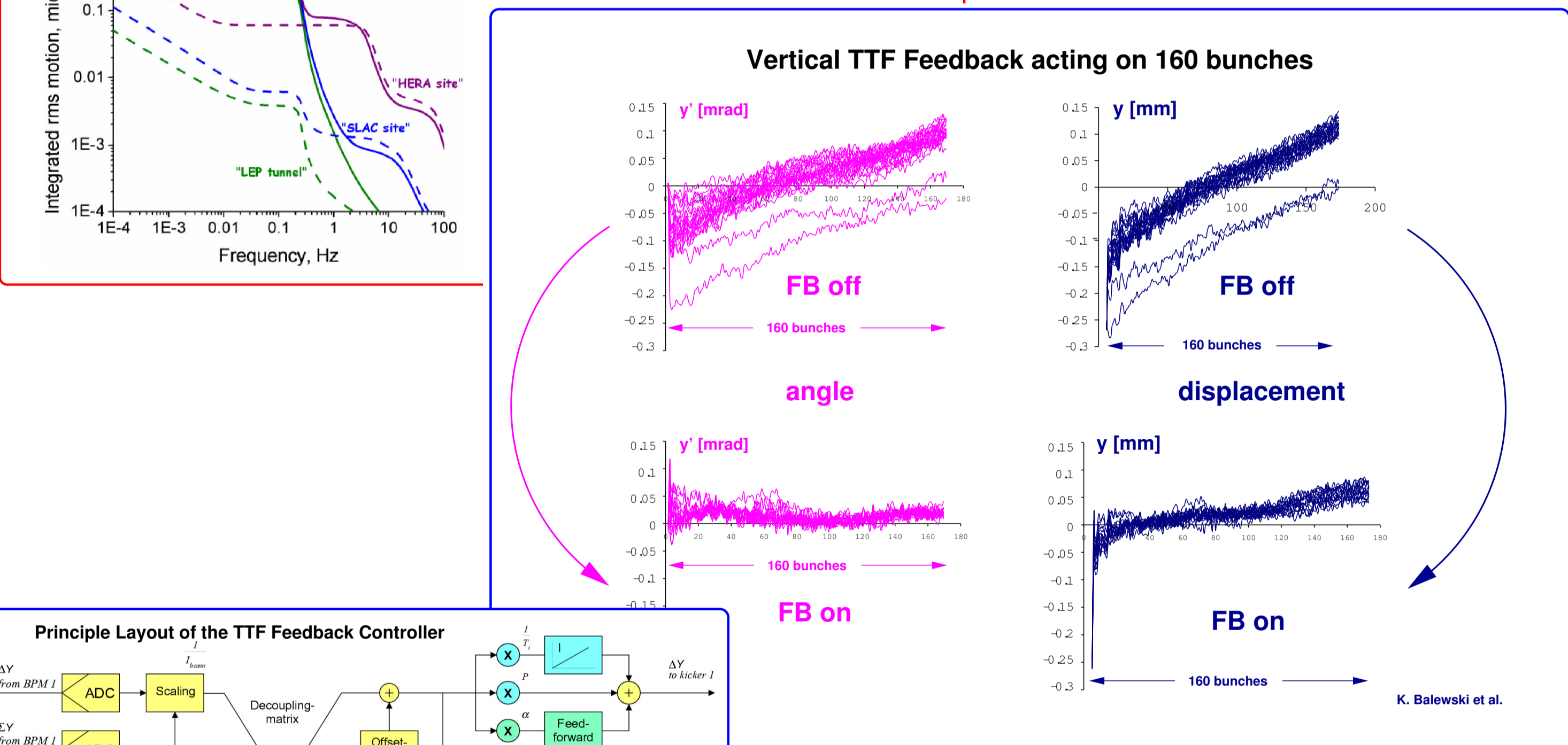
## Cultural Noise Sources @ SLS (1 Hz – 200 Hz)



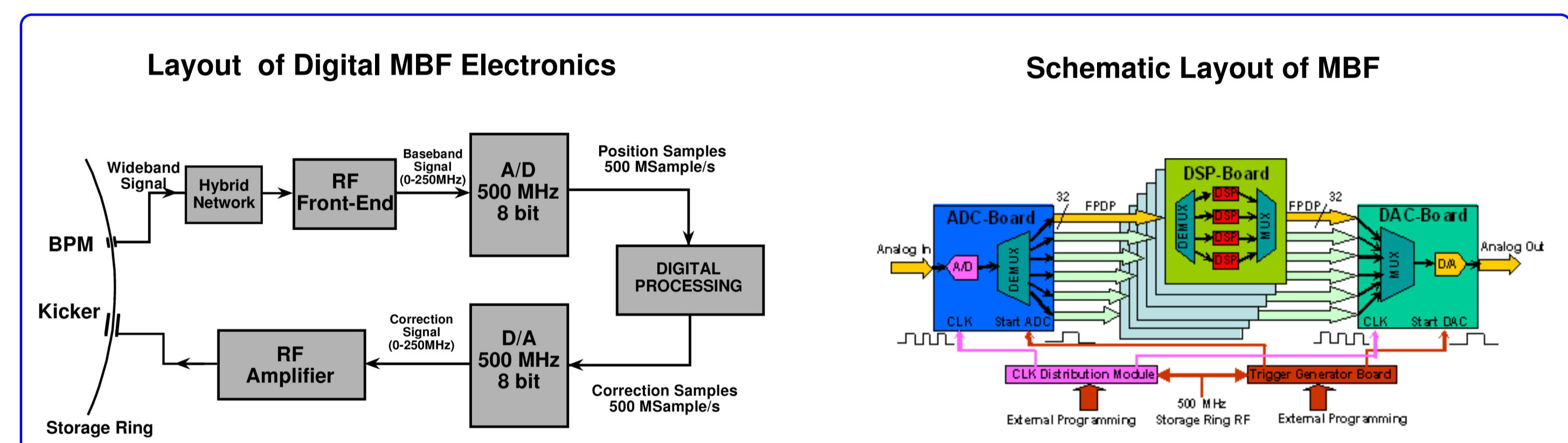
## Long Term Motion @ SLS (days – years)



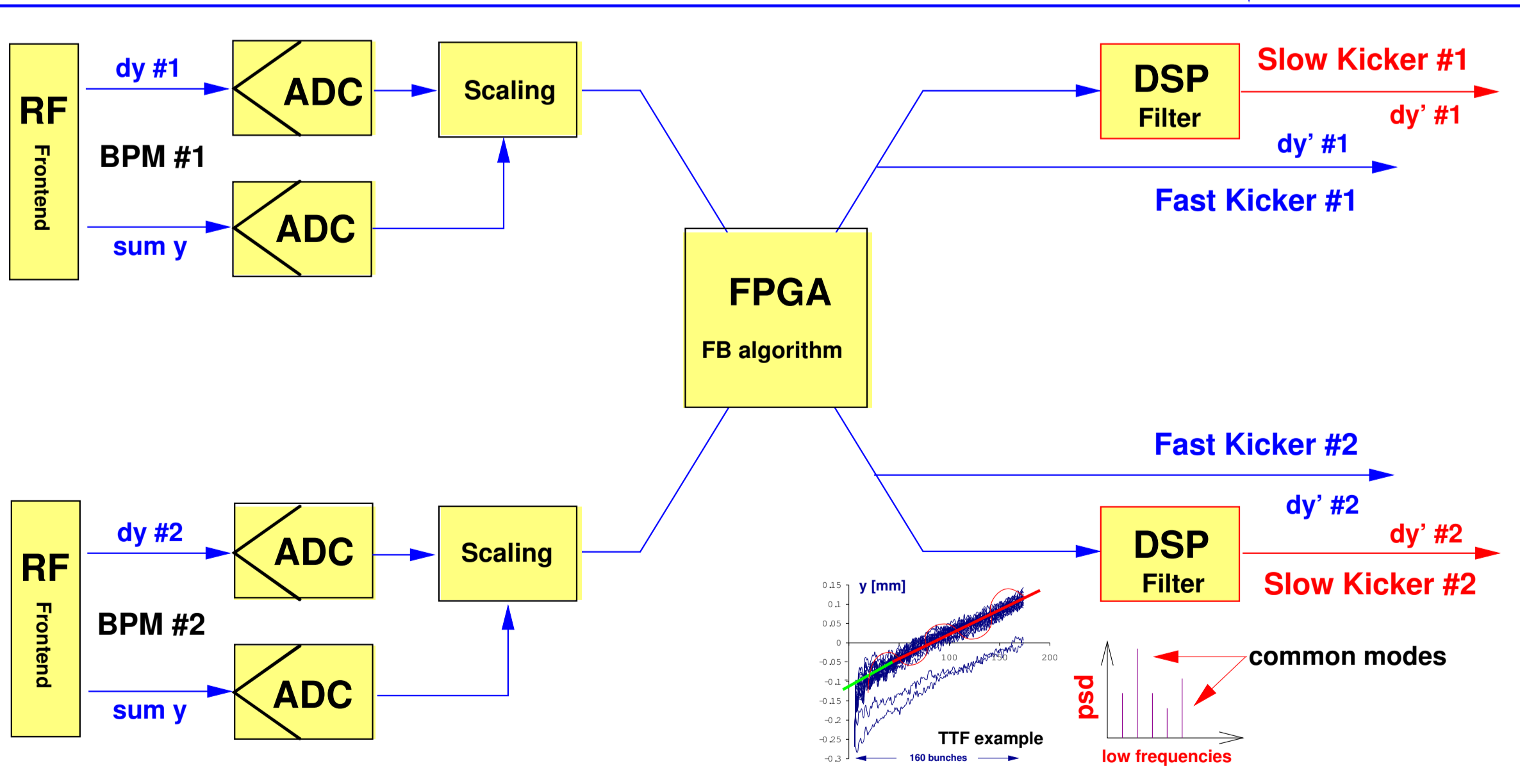
## High Frequency Motions @ TTF (> 200 Hz)



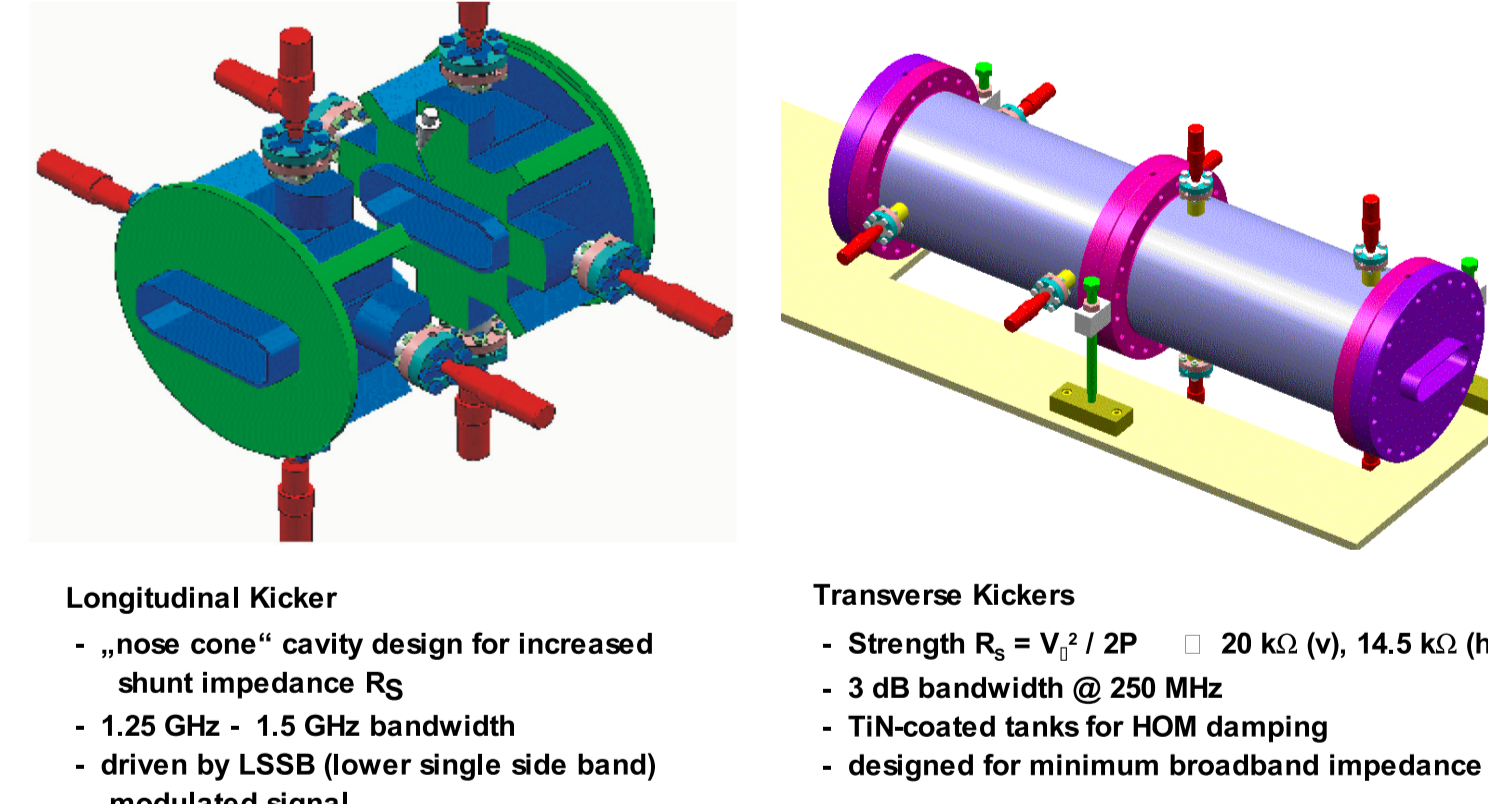
## Multibunch Feedback @ SLS / ELETTRA



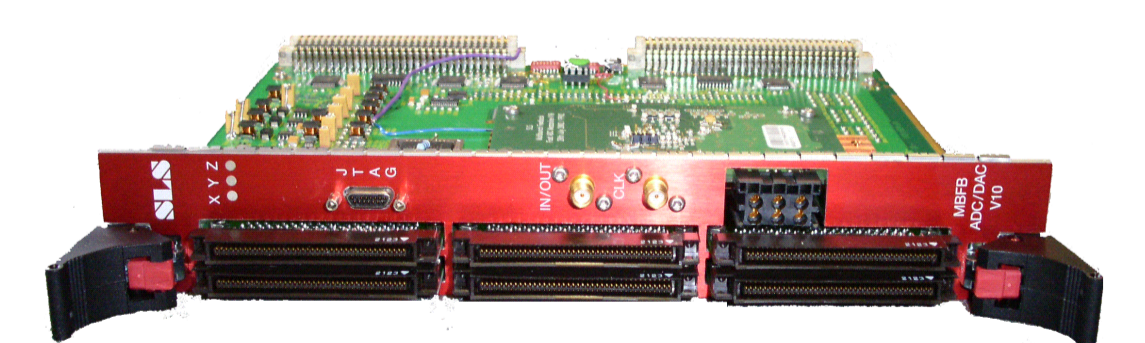
## Possible Layout of Intra-Train Feedback @ X-FEL



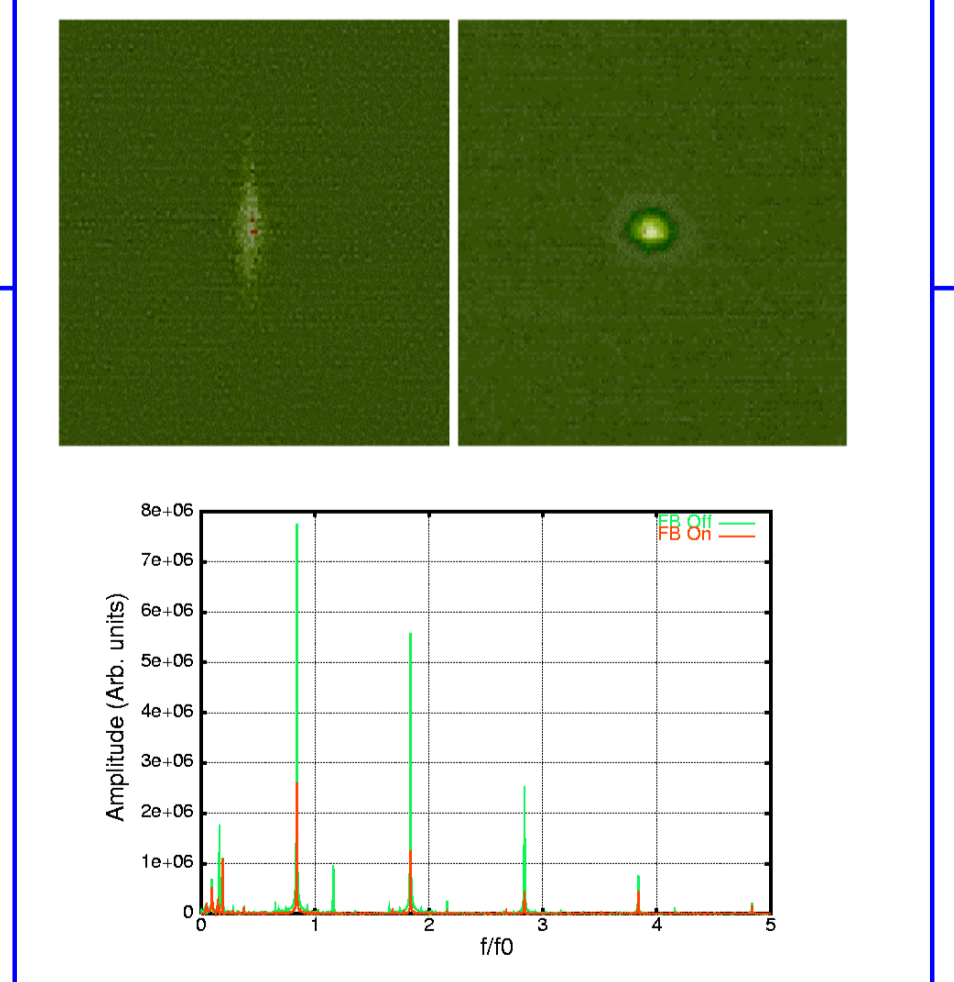
## Longitudinal and Transverse MBF Kickers



## MBF Controls Hardware



## 1st Results of Transverse MBF @ SLS



## A Possible Road Towards Beam Stabilization @ X-FEL

- System needs to be optimized for minimum latency time
  - Analog (Cables, RF front end, Amplifiers) < 150 ns
  - Digital (ADC, Data Transfer, FPGAs, DAC) < 50 ns
- Simple RF front end with only passive components (filters, amplifiers etc...)
- direct sampling of pick-up signal
- 10 to 12 bit ADCs and DACs available
- design for 16 bit resolution, if available
- FPGA for fast data processing and transfer

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