Status of emittance shaker and emittance monitor for PETRAIV

Eurizon Task 4.1 Diagnostics Update Meeting

Sven Pfeiffer
Hamburg, 25.09.2023

Time-line

Status update

Timeline – work organization – Task #1:

- M36 – 01/2023
- M42 – 07/2023
- M48 – 01/2024

#	Task/Month		36	37	38	39	40	41	42	43	44	45	46	47	48
1	*Define the work organization (M4.1.4)*														
2	*Simulation task*	WORK IN PROGRESS													
3	*Emittance monitor selection*	WORK IN PROGRESS													
4	*Shaker evaluation / selection (M4.1.5)*		today												
5	*HW/FW/SW implementation aspects*	WORK IN PROGRESS													
6	*Summarize and write the report (D4.1.3)*														

IPAC paper on simulations for PIV ?

Outline:

- Emittance monitor / diagnostics
- Recap of T-MBFB for shaker integration
- Stripline kicker as beam shaker → feasible, see next slides
- Simulations required for MBFB integration

Emittance monitor selection

The selection and the integration of the emittance monitor from beamline into the emittance control scheme will be in close collaboration with the DESY beam diagnostics group to address following aspects:

- Emittance BL integration into PIV as 2 stage process for installation
  - 1: simplified setup
  - 2: final installation with BLs

PIV - no manpower (expert moved to BESSY) – open point for HW, no further integration info's

- Expected resolution of emittance monitor
- Expected update rate/time for feed-forward/feedback integration
  - Not critical as long as adaptive FF scheme is used
- Expected processing time/latency of the monitor
  - Not critical as long as adaptive FF scheme is used

Only required for FB scheme, propose to work with adjustable lookup table with > 1Hz update time

→ Update Gero

PIV – T-MBFB operation requirements

Emittance control using MBFB system

Technical spec.: MBFB is expected to play two major roles in PETRA IV operation

- Damping coherent transverse motion, including if any injection oscillations;
- Providing an online tool for beam stability monitoring and impedance characterization.

Update to "… three major roles in PETRA IV operation"

- **Acting as actuator for emittance control in H and V plane**

Remark:

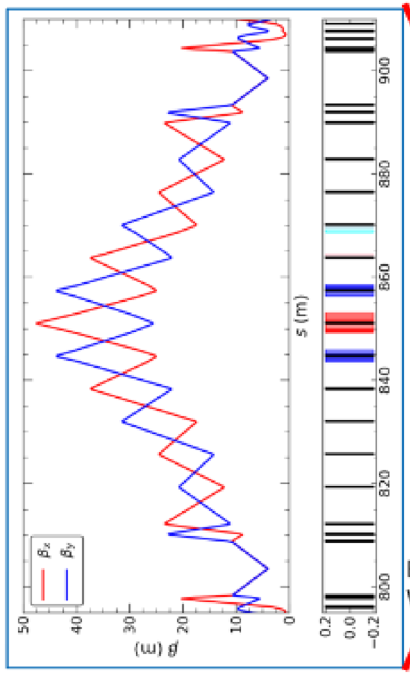
- *MBFB kickers are not intended to be used for emittance blow up for machine protection during beam dump.*
- *Betatron frequencies* $f_x = 23.4kHz$, $f_y = 35.2kHz$

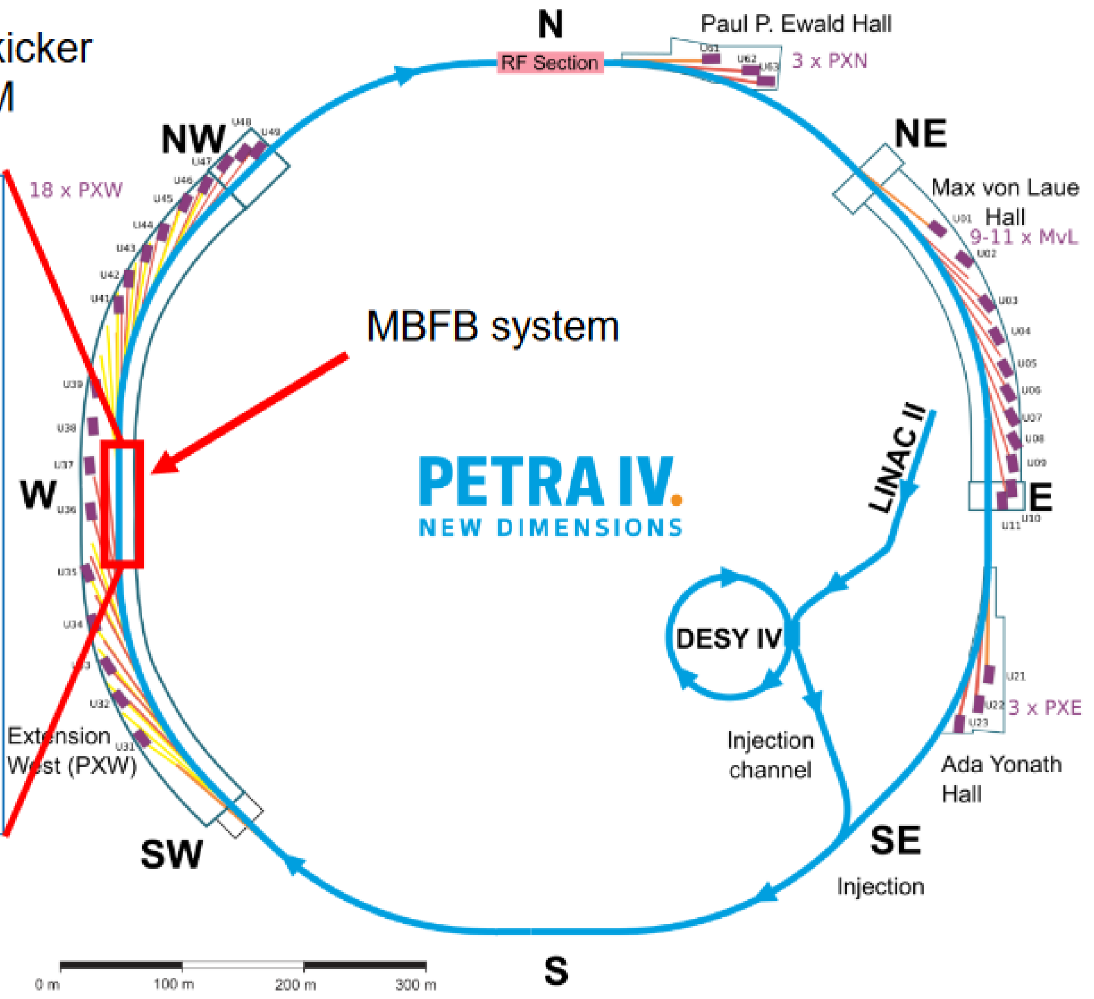
PIV - MBFB technical requirements

Table 1: Summary of functional requi

Parameter	Value
Min. bunch spacing	2 ns
Max. beam current	200 mA
Max. bunch current	2.5 mA
Max. damping rate	$1/40$ turn^{-1}
Position resolution	$1\ \mu$m
Damping range	1 mm
Stripline aperture (full)	34 mm
Wakefield kick factor	$\leq 3.3 \times 10^{13}$ V/C/m
Wakefield loss factor	$\leq 10^{12}$ V/C

High beta section
~ 40m … 50m for kicker
~ 30m … 40m BPM





Remark: Diagnostics BL in PXW → Intra-room optical link to MBFB system

PIV - MBFB architecture

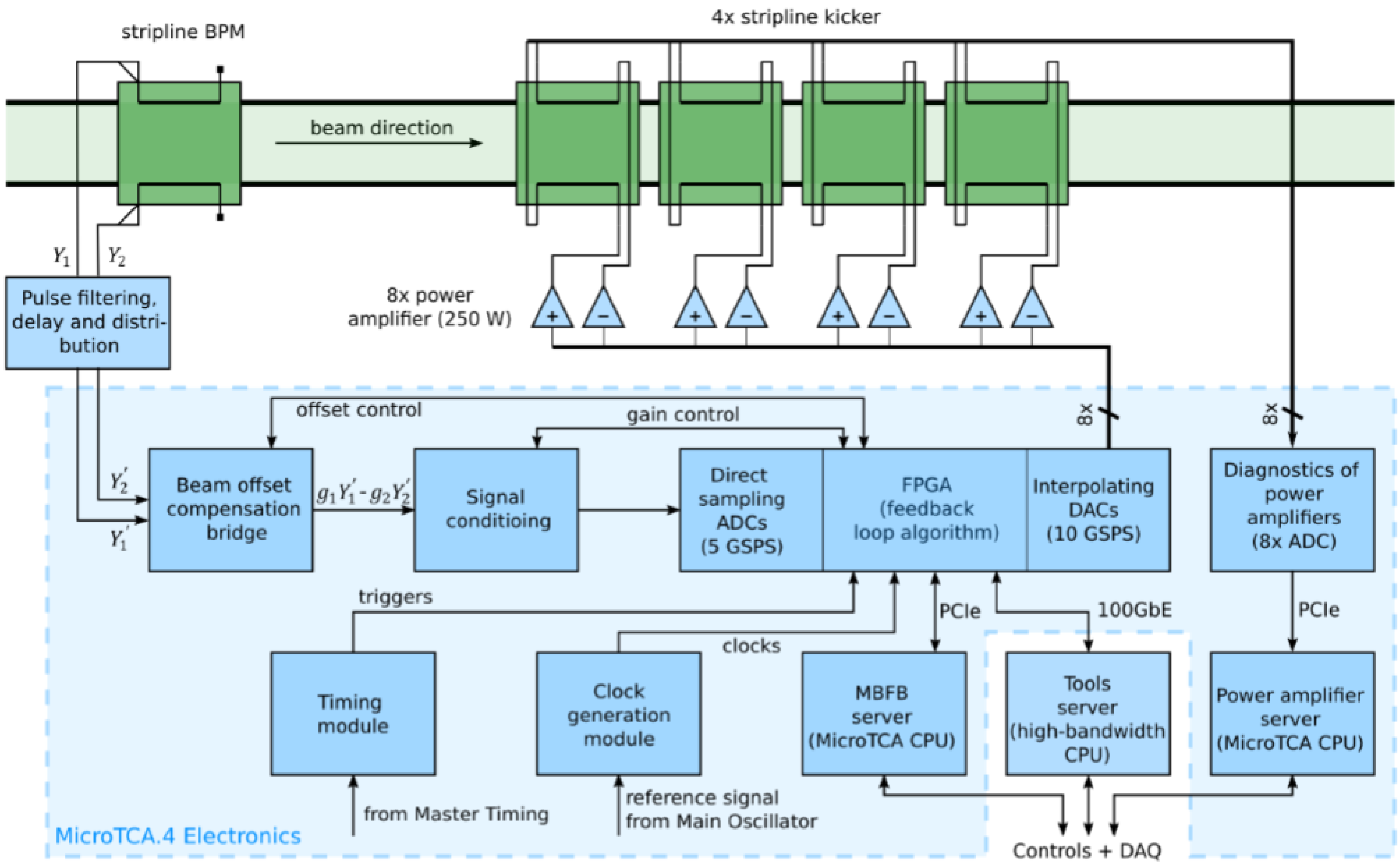
Feedback signal flow and diagnostics

Up to 257nrad per kicker using 2x250W HPA (~350W at kicker)

kickers reduced by 2 (TAC action)

- Feedback signal flow
  - Stripline BPM (1 GHz)
  - Pulse multiplier and filtering (increase SNR) (*)
  - Beam offset compensation bridge
  - Signal conditioning and combline filter (*)
  - ADC, processing, DAC
    - 5 GSPS ADCs
    - Processing + control
    - 10 GSPS DACs

    } DAMC-DS5014DR
  - High power amplifiers (HPAs)
  - Stripline kickers (DC-250 MHz)
- Diagnostics and tools for machine studies
  - Diagnostics of HPAs
  - Diagnostics of bunch position, phase, charge
  - Tune measurement, growth-damp analysis

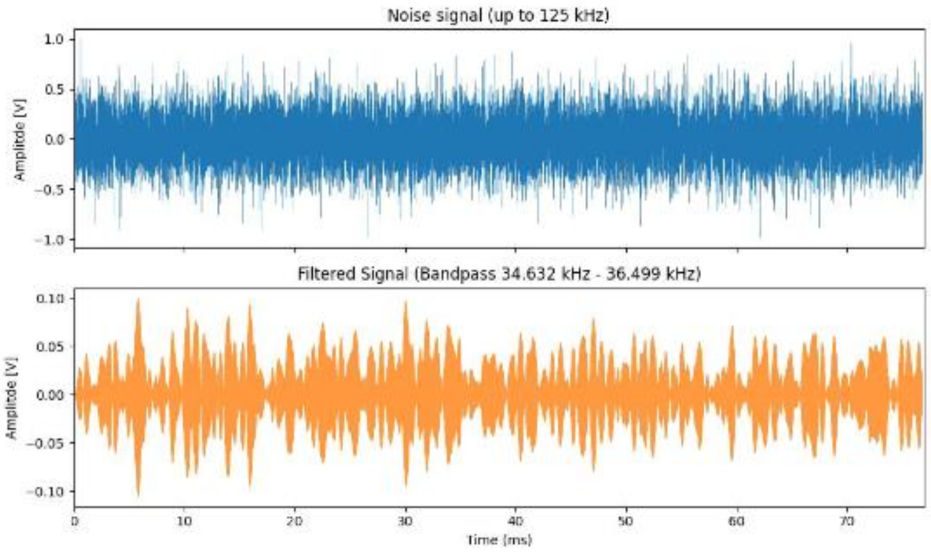


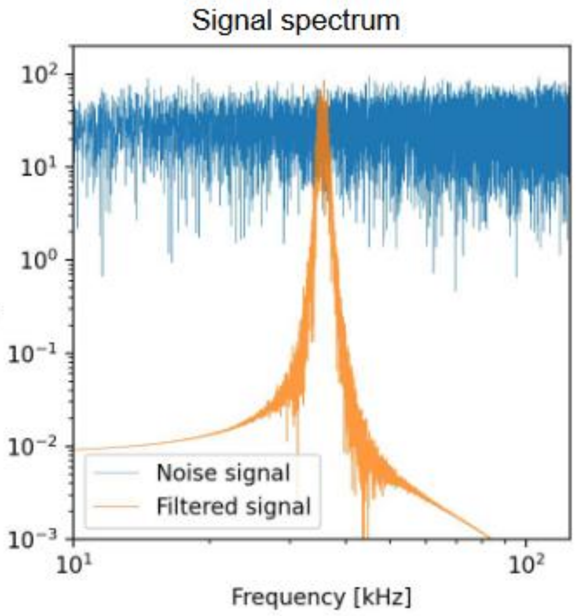
PIV – shaker simulation

C. Cortés (MPY) - Vertical emittance control

Blow-up with noise

PETRA IV NEW DIMENSIONS





- Noise band up to 125 kHz
- Filtered 2 kHz around the vertical betatron resonance (35.565 kHz)
- Filter from scipy signal

HELMHOLTZ

DESY.

PIV – shaker simulation

C. Cortés (MPY) - Vertical emittance control

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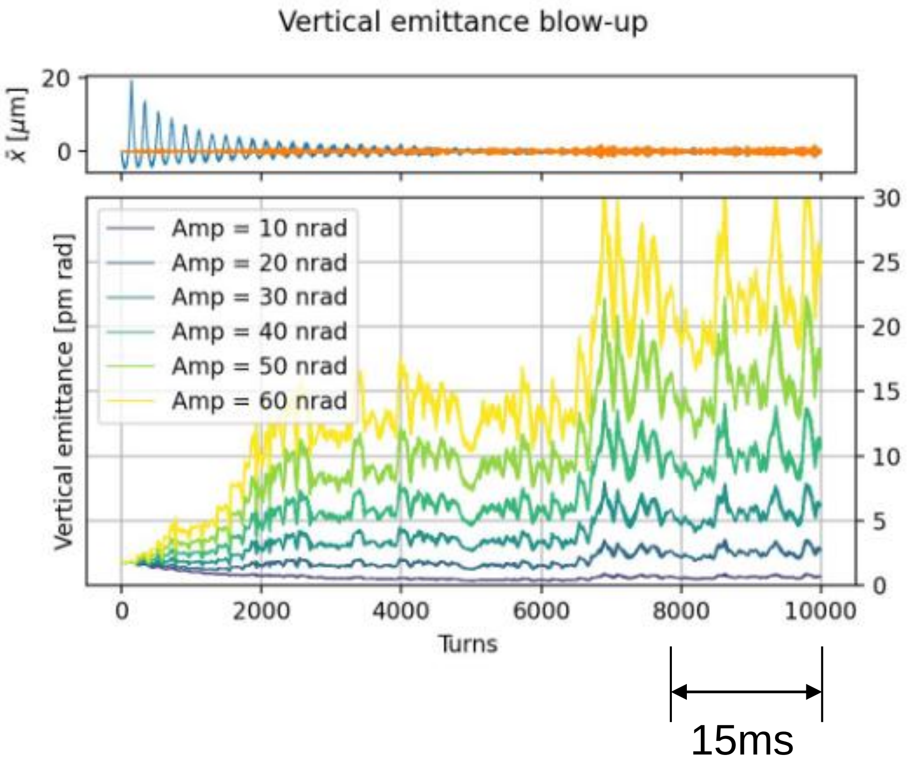
PETRA IV. NEW DIMENSIONS



- Emittance blow-up observed
- Fluctuations of the beam emittance are strong
- Further evaluation of other blow-up signals is required

- Kick at source ~60nrad for 20pm rad V emittance
- MBFB 1 kicker ~250nrad

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DESY.

Shaker Evaluation and Selection M4.1.5

Further simulations to check if MBFB kicker is sufficient …

For better understanding of the excitation of the beam shaker (underlining concept) a simulation using PETRA IV lattice is required. This simulation, performed by DESY accelerator physics group, should answer the following aspects for PETRA IV ring integration:

- What range of excitation do we need for PETRA IV integration in timing / brilliance operation mode?
  - Amplitude/kick range
  - Frequency range

  } **MBFB system able to do this → YES, seems feasible**
- What is excited by using a beam shaker – physical concept to evaluate point 3) → **On-going**
  - Simulation chromaticity vs emittance requested
- Evaluate the interaction of emittance excitation/compensation with the feedback systems → **our interest**
  - Interaction with MBFB system – Full MBFB simulation proposed last TAC → noise excitation part of it
  - Interaction with FOFB system

Shaker Evaluation and Selection M4.1.5

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→ Shaker Evaluation and Selection M4.1.5 → MBFB system as potential shaker device

Thank you

Contact

DESY. Deutsches Elektronen-Synchrotron

www.desy.de

Name Surname
Department
E-mail
Phone