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Libera Bunch-by-Bunch Feedback System

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Coupled Bunch Instabilities

- bunched beam in a storage ring
- transverse – betatron – oscillations, X and Y plane
- longitudinal – synchrotron – oscillations
- normally damped by natural damping
- cavity HOM (High Order Modes) & wake fields, resistive wall impedance, Ion instabilities
- multi-bunch modes

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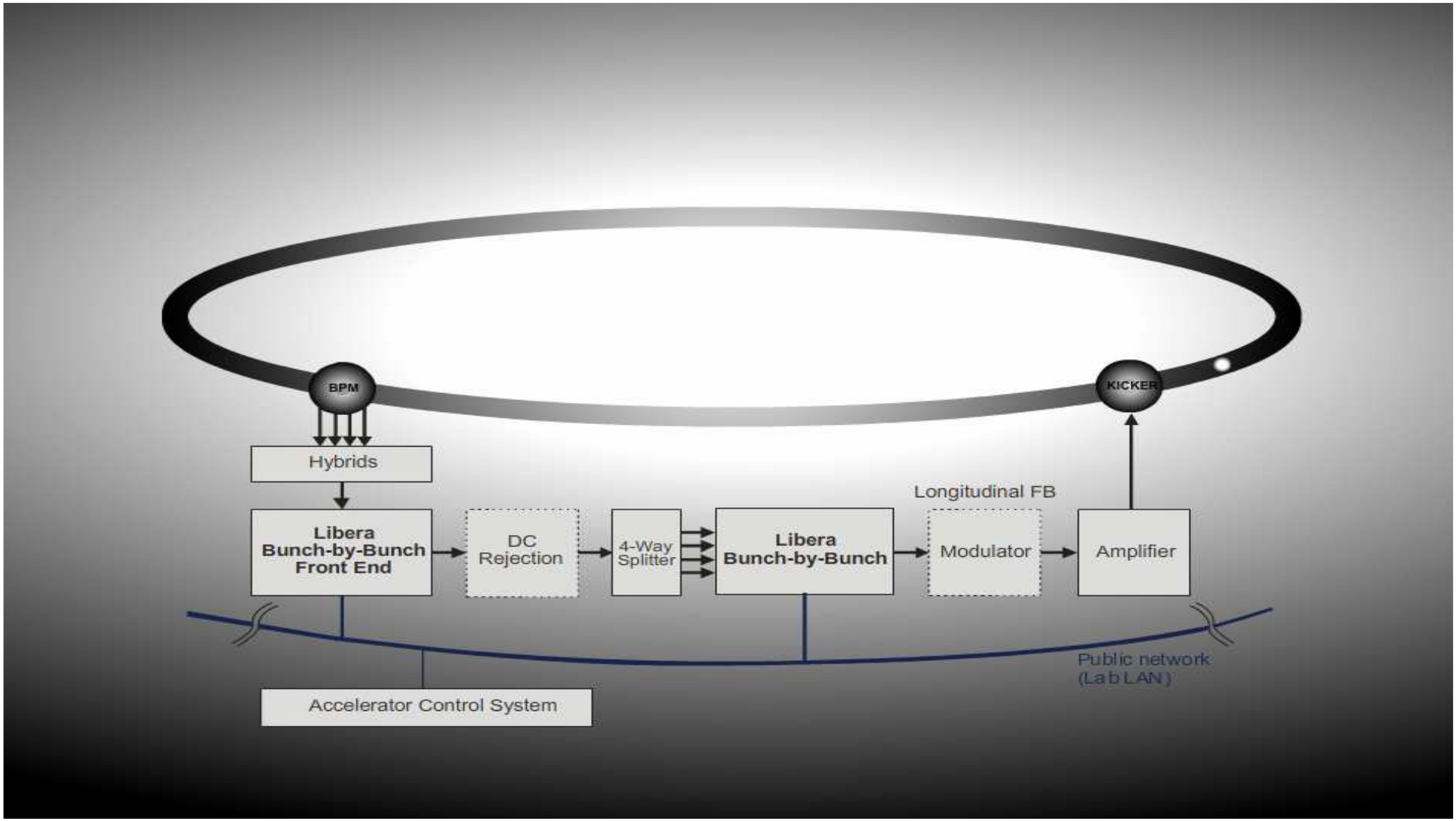
Combating Coupled Bunch Instabilities

- natural damping
- growth rate stronger than natural dumping → oscillations unstable
- dump instabilities essential for higher energies
- active feedbacks
- analog and digital processing
- numerous advantages of digital feedbacks
- digital signal processing theory embedded inside digital feedback

Instrumentation Technologies


BPM
KICKER
Hybrids
Longitudinal FB
Libera
Bunch-by-Bunch
Front End
DC
Rejection
4-Way
Splitter
Libera
Bunch-by-Bunch
Modulator
Amplifier
Public network
(Lab LAN)
Accelerator Control System

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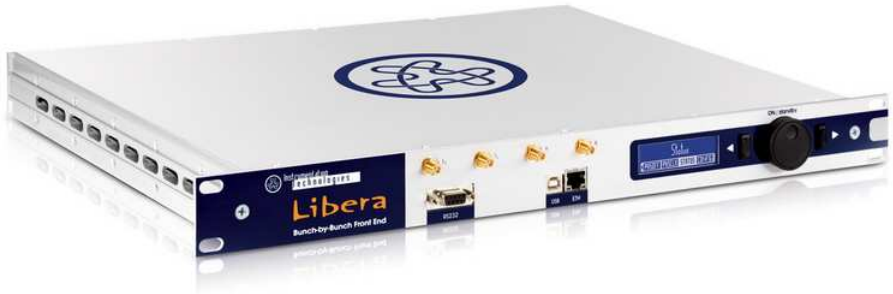
Libera Bunch-by-Bunch Front End



- one unit for pre-processing signals for all feedback loops
- simple installation and usage
- high dynamic range
- low noise
- remote and local control/monitoring over Ethernet, RS232 and USB

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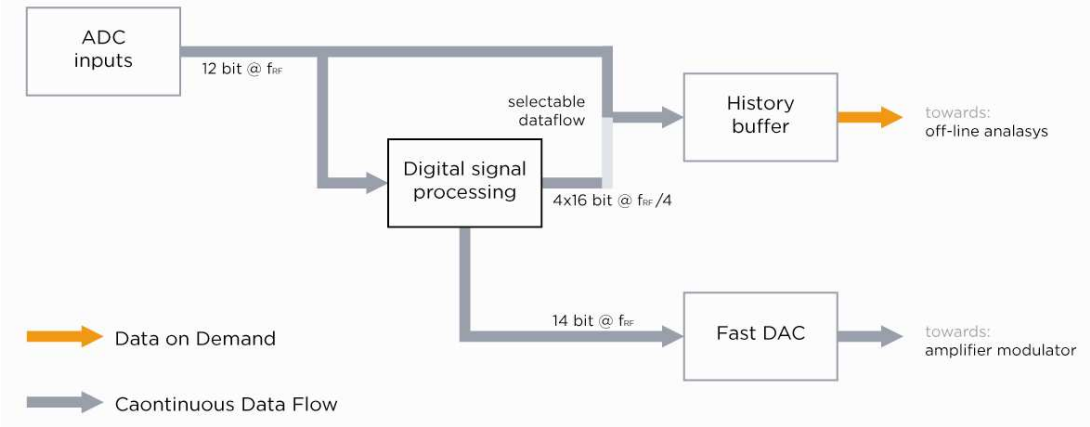
Libera Bunch-by-Bunch

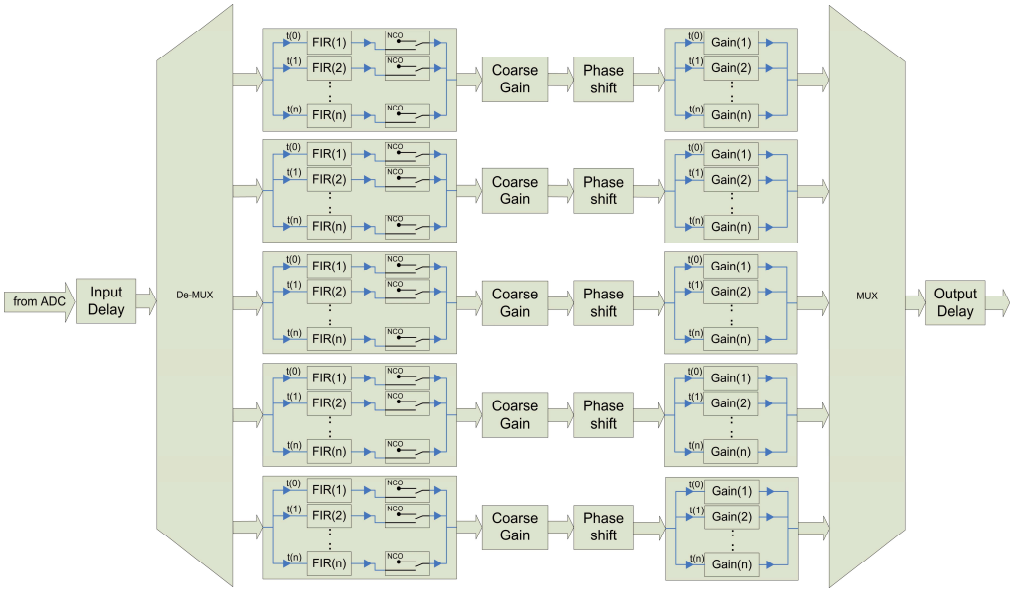
- data signal processing, sampling and storage
- ready for feedback loop closure
- integration to control system → Tango (generic server), EPICS,
  user-made application on entirely open source platform
- all-in-one 1U unit
- directly connects to Libera Bunch-by-Bunch Front End

Libera Bunch-by-Bunch – Data Paths



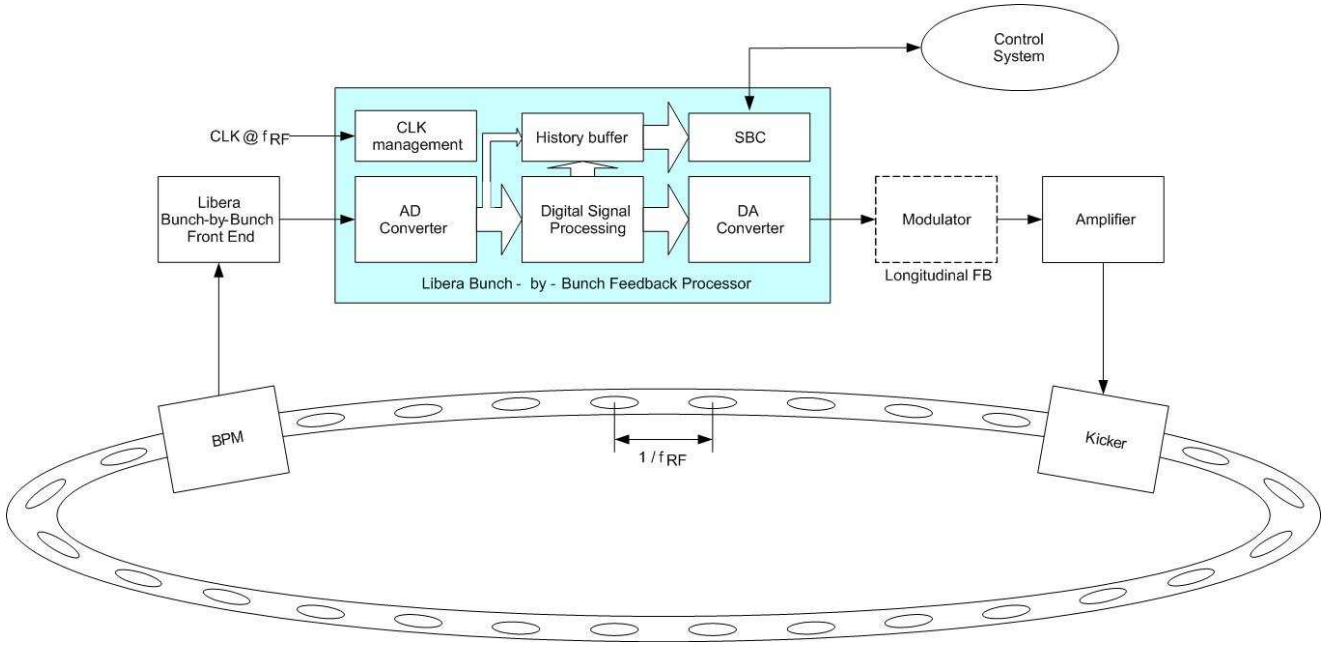
- 12-bit ADC sampling at RF frequency (500 MHz)
- DSP block – open source Matlab/Xilinx model
- huge memory buffer – ¼ second (128 million samples)
- 14-bit DAC at RF frequency

Libera Bunch-by-Bunch – Digital Signal Processing

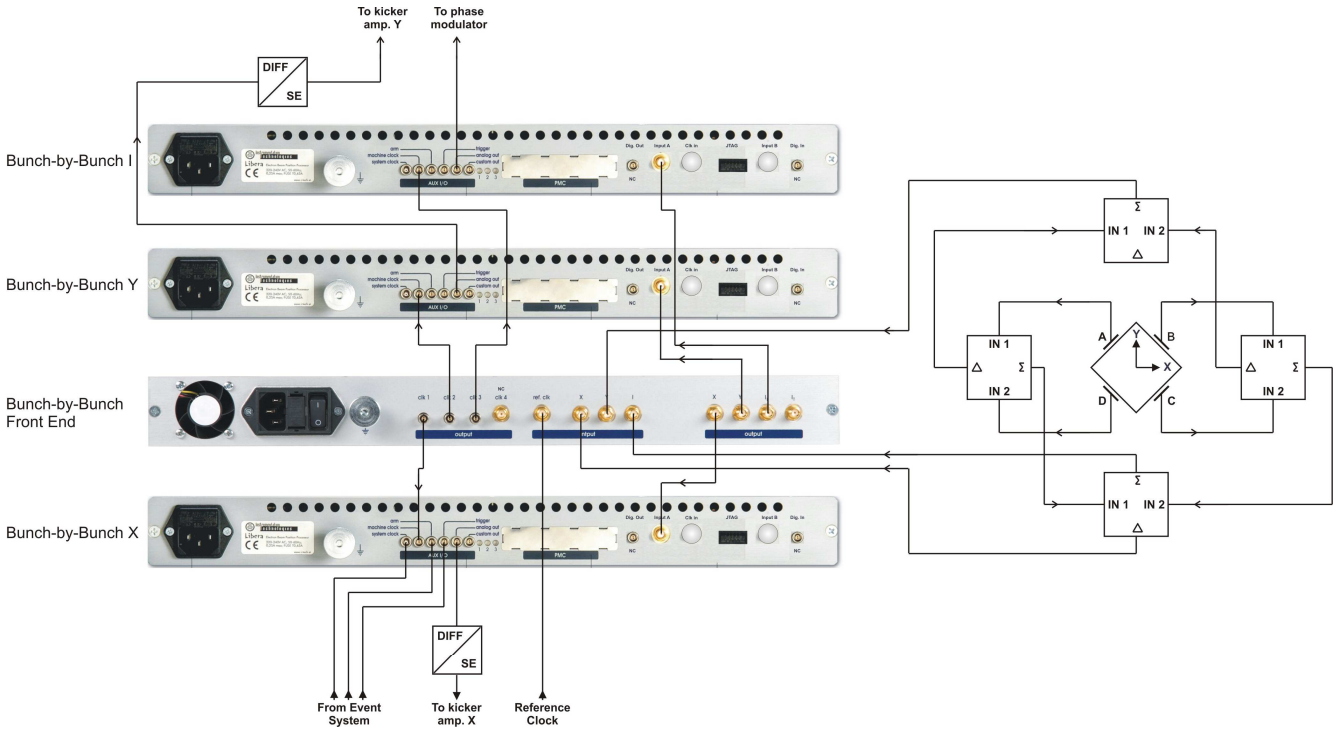


- entirely implemented in FPGA
- FIR Filtering – 16 tap
- delays
- digital Phase Shifter
- gains – general & per bunch
- NCO – selectable per bunch
- open platform → easy to change number of FIR taps (example)

Libera Bunch-by-Bunch Instruments – Feedback Loop



Bunch-by-Bunch Active Feedback – System Connection Diagram



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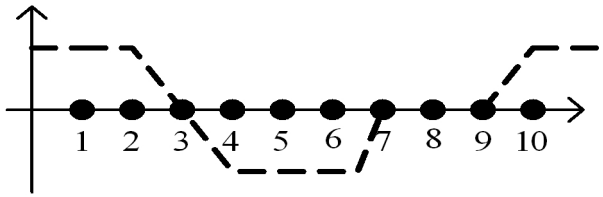
USERS – Feedback Loop and New Applications

- Bunch-by-bunch cleaning (CLS, Canada)
- Beam Energy Measurement (CLS, Canada)



- Closing of bunch-by-bunch feedback loop without any support from Instrumentation Technologies (Australian Synchrotron, Australia)

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USERS – Feedback Loop and New Applications

- Measurement of Lattice Parameters without visible disturbance to user beam (Diamond Light Source, UK)

Measurement	Excitation	Detection
Tune	Stripline TMBF	TMBF
Chromaticity	Stripline TMBF	TMBF, Matlab
βmag/phase	Stripline TMBF	EBPMs, TbT data
Corrector response	Corrector FOFB	EBPMs, FA data

Instrumentation Technologies

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USERS – Feedback Loop and New Applications

- Measurement of Lattice Parameters without visible disturbance to user beam (Diamond Light Source, UK)
- Horizontal betatron tune
- Betafunction magnitude
- Betafunction phase