EUROPEAN SPALLATION SOURCE

BPM System / Electronics

Meeting BI forum

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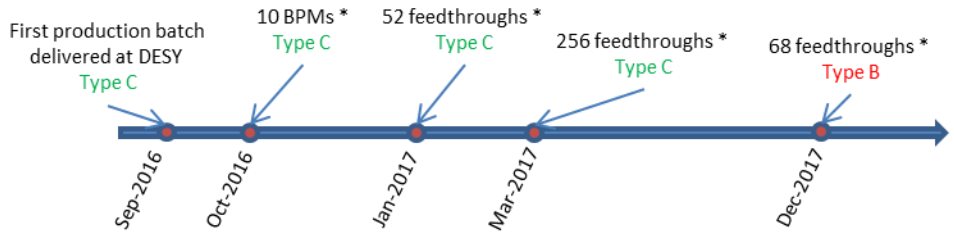
Bilbao - Spain
2016 - Oct

BPM System

- Summary
  - BPM schedule and planning
  - BPM sensors status
  - BPM Electronics design
    - MicroTCA.4
    - BPM-LLRF solution
    - BPM electronics performance results

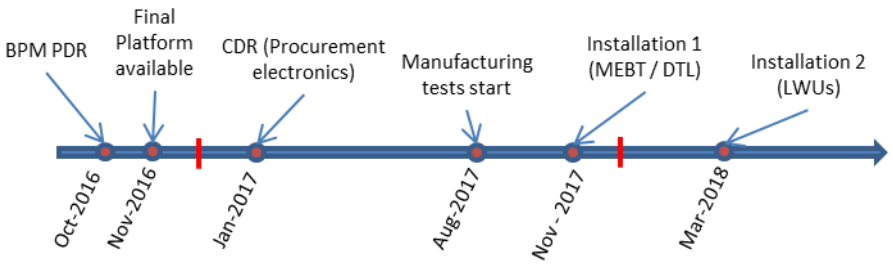
BPM electronics Schedule

- Schedule
  - BPM sensors: Production status report (https://ess-ics.atlassian.net/wiki/display/PSP/BPM+-+Production+Status+Report)



* Delivered at Daresbury

  - BPM Electronics: Building blocks (https://ess-ics.atlassian.net/wiki/display/BB/BPM+-+building+blocks)



BPM electronics planning

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Summary	T	Due	Status	Group	Domain	Description
Calibration service	S	May 31, 2017 00:00	TO DO	ICS	Control room	Calibration service tool
Compare save and restore	S	Jan 31, 2017 00:00	TO DO	ICS	Control room	Handle snapshots of PVs
EEE server	S	Nov 30, 2016 00:00	DELIVERED	ICS	Control room	OS and DM for ESS or IKC EEE server
Platform management	S	Jun 30, 2017 00:00	TO DO	ICS	Control box	Remote monitoring and management of the MicroTCA system
Operating system	S	Jun 30, 2016 00:00	DELIVERED	ICS	Control box	Supported ICS Linux distribution
EEE	S	Jun 30, 2016 00:00	DELIVERED	ICS	Control box	EEE (NFS, CI, build, modules)
Naming database	S	Jan 31, 2017 00:00	TO DO	ICS	Control room	For storing PBI system information
Application specific	S	Oct 31, 2016 00:00	TO DO	BD	Control box	BPM application specific functionality
Digitizer	S	Oct 31, 2016 00:00	TO DO	ICS	Control box	EEE module for final digitizer
Timing system	S	Oct 31, 2016 00:00	TO DO	ICS	Control box	EEE module for timing system
Cables	H	Nov 30, 2016 00:00	TO DO	BD		BPM signal cables (RF generator to RFFE and RFFE-RTM)
MicroTCA.4 crate	H	Nov 30, 2016 00:00	TO DO	ICS	Control box	MicroTCA.4 complete crate. Se Term table for explanation.
Timing generator	H	Nov 30, 2016 00:00	LATE	ICS	Control box	Timing generator (crate, EVG and fanout).
RTM	H	Nov 30, 2016 00:00	TO DO	BD	Control box	DESY Struck RTM DWC10-LF
AMC	H	Nov 30, 2016 00:00	TO DO	ICS	Control box	IOxOS IFC1420 ready for final production
Ethernet Switch	H	Nov 30, 2016 00:00	TO DO	ICS	Control room	Ethernet Switch needed for the BPM electronics racks

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BPM electronics planning

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Risks

BPM Electronics:

Key	Summary	Status	Description
BB-45	AFE / BFE delayed	TO DO	Cause: Not enough resources Response: Contract consultant / external company Severity: Low
BB-44	Hardware delayed / not purchased on time	TO DO	Cause: Internal delays / external company delays Response: Priority on the purchasing process. Re-schedule activities. Severity: Significant
BB-43	IOxOS IFC1420 delay	TO DO	Cause: IOxOS IFC1420 not available and not supported for production Response: Proceed with Struck SIS8300L2 board Severity: Low
BB-41	AFE / ABE hardware does not satisfy the specifications	TO DO	Cause: Not enough resources Response: Commercial hardware/support Severity: Significant
BB-40	Software developer not available	TO DO	Cause: Not enough resources Response: Contract consultant Severity: Significant
BB-39	Analog hardware designer not available	TO DO	Cause: Not enough resources Response: Contract consultant Severity: Significant
BB-38	FPGA firmware developer not available	TO DO	Cause: Not enough resources Response: Contract consultant Severity: Moderate

Rising

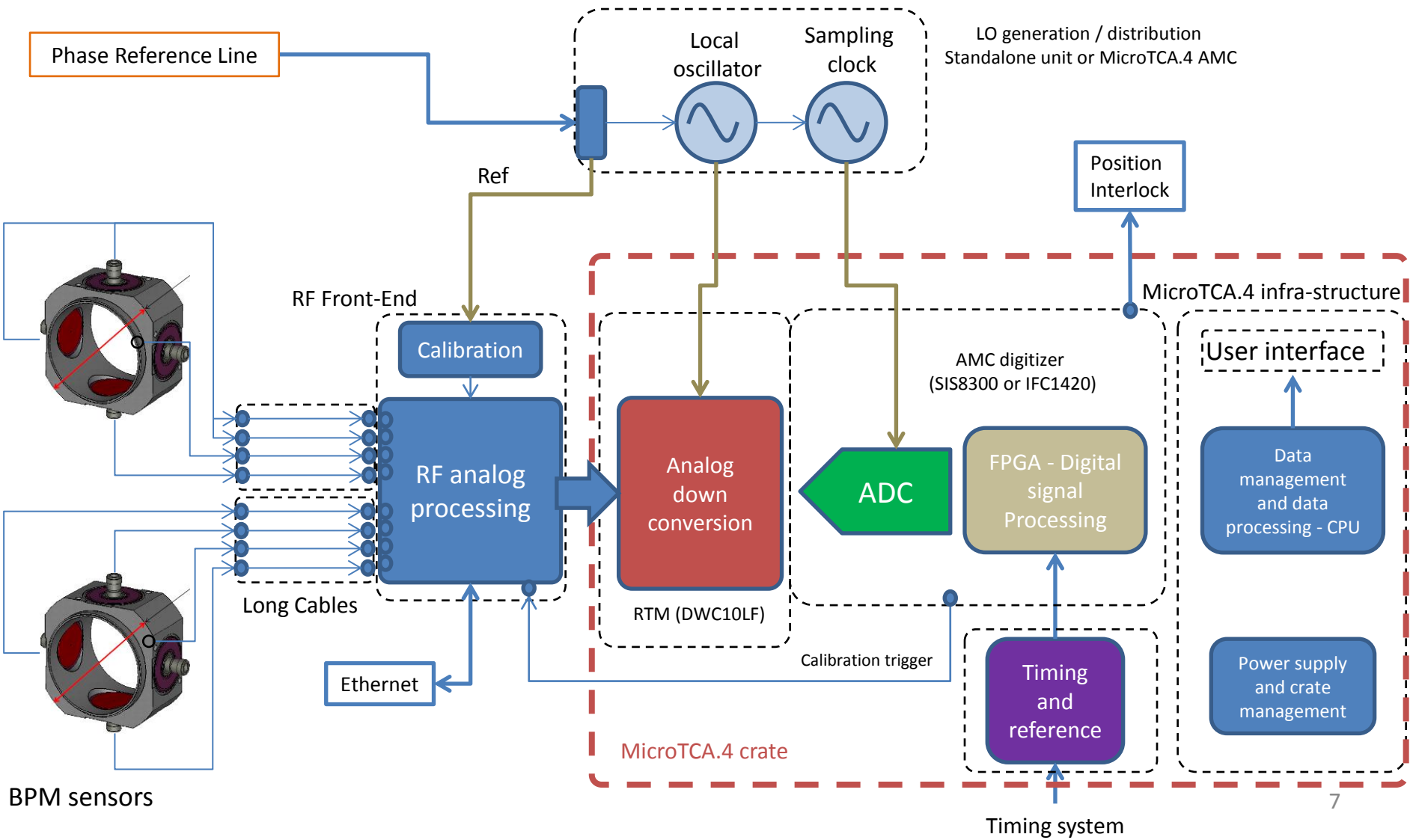
BPM electronics planning

BPM Sensor:

Risk	Description	Status
BPM feedthroughs delay from DESY	Cause: Manufacturing delays/DESY delays Response: Re-schedule with Daresbury Severity: Significant	Steady

Table: Risks for the DESY LWU feedthrough sensors

BPM system design



BPM System specifications

- Specifications

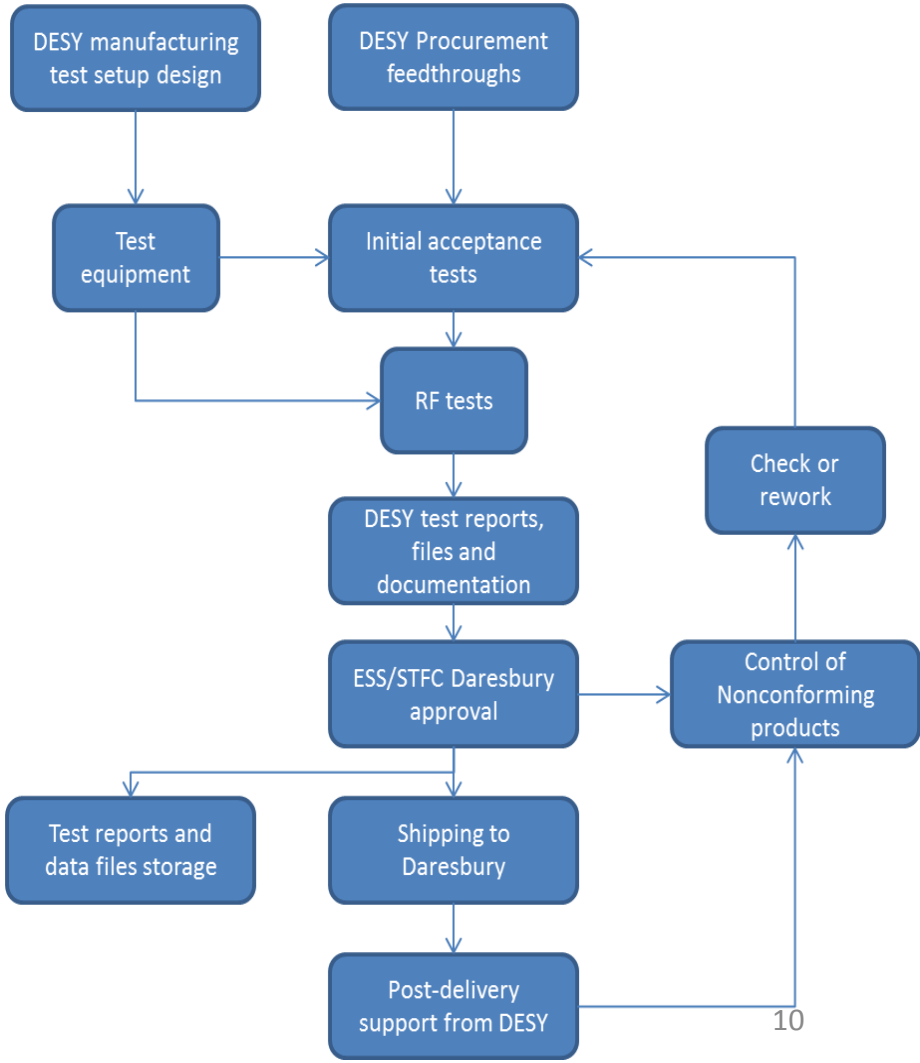
Parameter	Value	Comments
Beam phase accuracy for nominal beam	+/- 1 °	
Beam phase precision for nominal beam	0.2 °	1 MHz bandwidth
Beam phase accuracy for 6.3 mA beam and 5 us pulse length	+/- 2 °	
Beam phase precision for 6.3 mA beam and 5 us pulse length	2 °	1 MHz bandwidth
Beam phase accuracy stability over 8 hours for nominal beam	+/- 1°	
Beam position accuracy for nominal beam	+/- 200 um	
Beam position precision for nominal beam	20 um	1 MHz bandwidth
Beam position accuracy for 6.3 mA beam with pulse length of 5 us	+/- 400 um	
Beam position precision for 6.3 mA beam with pulse length of 5 us	200 um	1 MHz bandwidth
Beam position accuracy stability over 8 hours	1 mm	
Beam position dependence for 15 mm off-centered beam	+/- 200 um	
Beam position accuracy for 6.3 mA, 5 us pulse and de-bunched beam.	+/- 10 mm	
Beam position precision for 6.3 mA, 5 us pulse and de-bunched beam.	1 mm	
Phase and Position bandwidth	1 MHz	
Readout latency	2 us	
Current measurement resolution	0.5 mA	
Beam position interlock for horizontal and vertical position	-	Configurable circular threshold

BPM sensors

- MEBT: ESS – In-kind Bilbao – talk on this BI Forum
- DTL – In-kind INFN Legnaro – talk on this BI Forum
- LWUs
  - Feedthroughs: DESY
  - Housing assembly/integration: Daresbury
- Production status report wiki page (https://ess-ics.atlassian.net/wiki/display/PSP/BPM+-+Production+Status+Report)

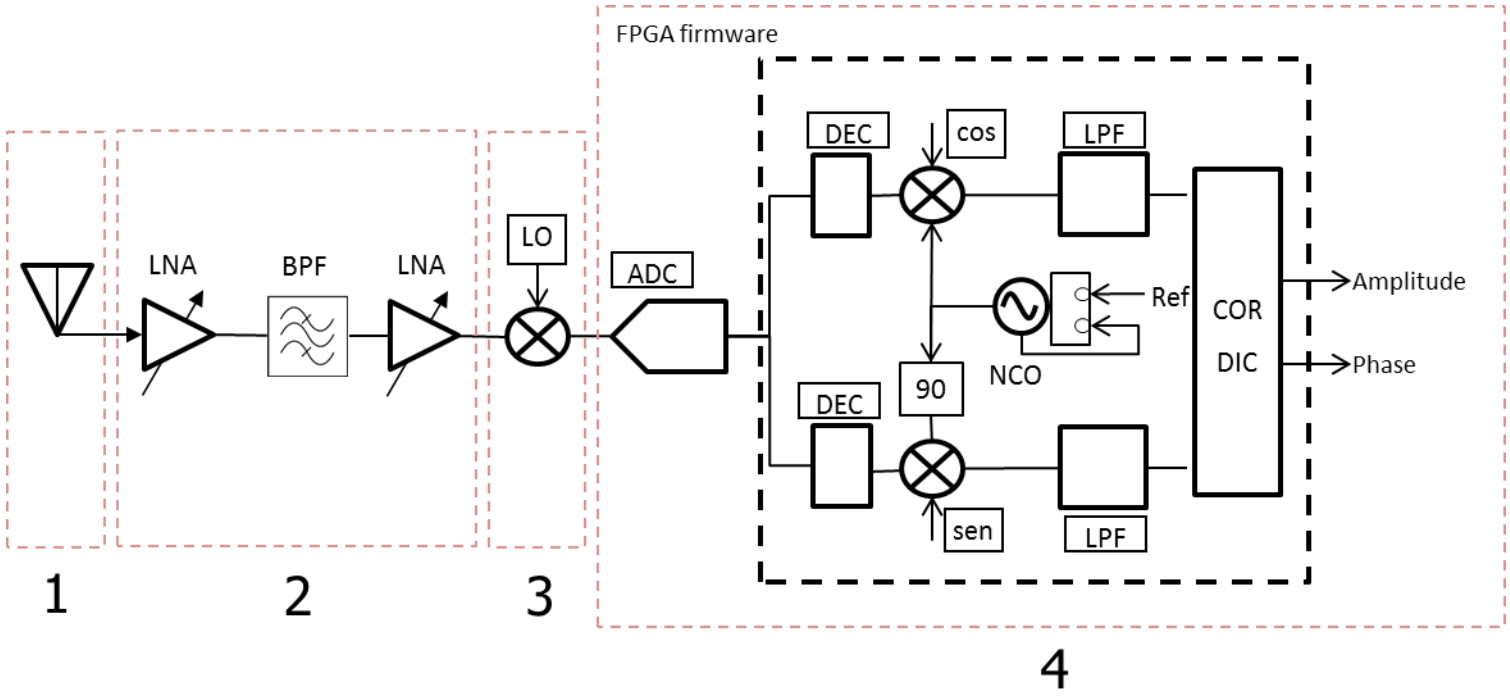
BPM sensors

- LWUs
  - Feedthroughs: DESY
    - Delay on the first units due internal DESY delays, materials and feedthroughs manufacturer delays → mitigation together with Daresbury to re-schedule the LWUs assembly
  - Housing assembly/integration: Daresbury
  - Contract for the production is at DESY for review



BPM Electronics

- FPGA-based radio receiver:
  - MicroTCA.4 based electronics
  - RF Front-End unit for analog and RF processing
  - RTM LO for frequency down-conversion
  - FPGA based for fast signal acquisition from high speed ADCs

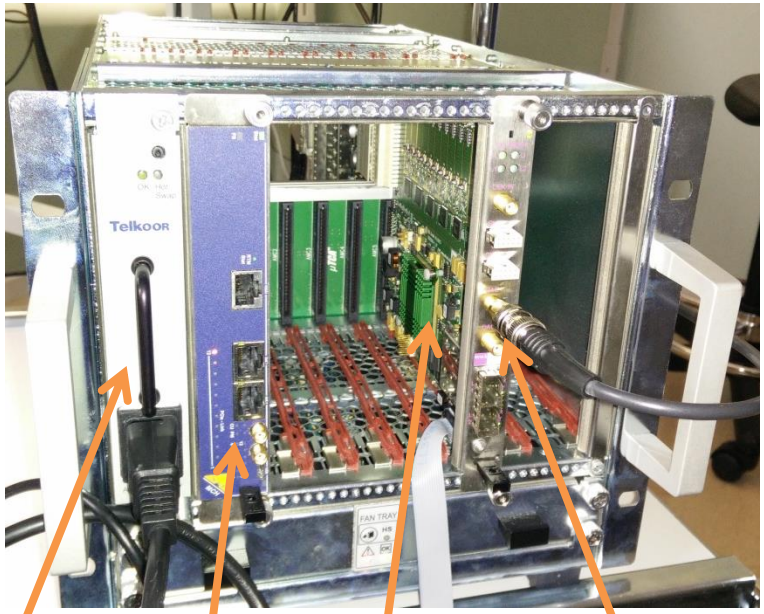


BPM Electronics – BPM+LLRF solution

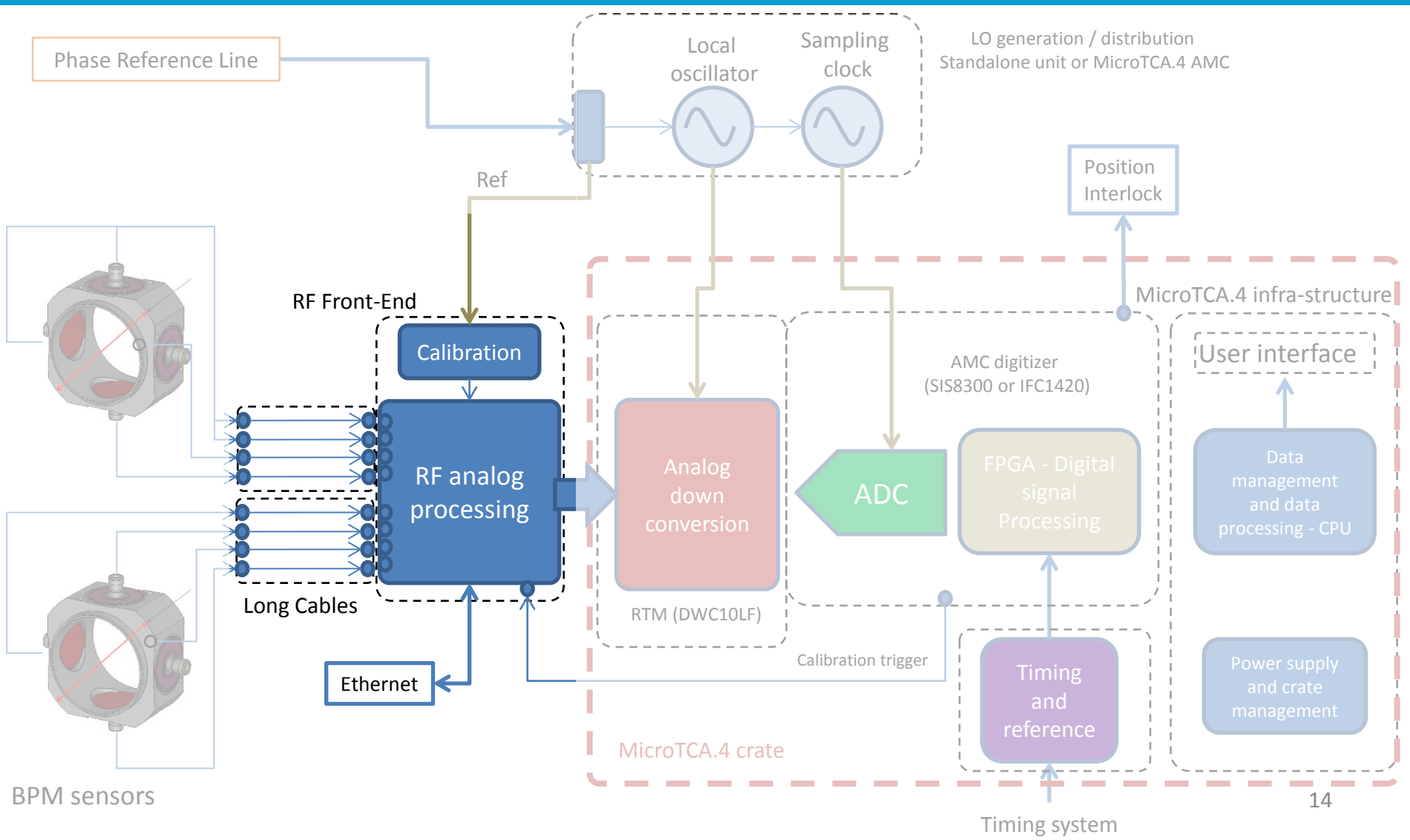
- BPM – LLRF solution advantages:
  - BPM and LLRF systems are very similar in terms of RF processing (hardware and firmware)
  - Reuse of common and debugged hardware and firmware from the LLRF system – almost no need for new designs.
  - Same support for both systems in terms of FPGA firmware (almost the same FPGA firmware design)
    - The BPM firmware was designed in less than one week using the existing LLRF firmware!
  - EPICS IOC support for both systems is similar
  - Almost the same hardware support for both systems (AMC+RTM. Additional support needed for the RF Front-End).
  - The use of COTS RTM is possible (Desy/Struck RTM: SIS8300LF)

- BPM – LLRF solution disadvantages:
  - Custom enclosure needed → Under manufacturing.
  - Standard Ethernet interface solution needed.

BPM electronics – microTCA.4 prototype



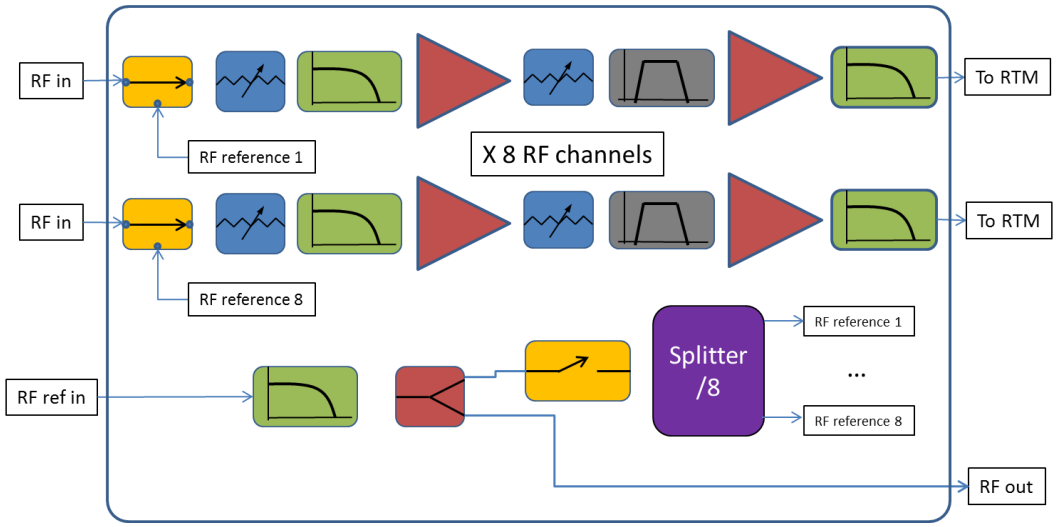
BPM system diagram



BPM electronics RF Front-End

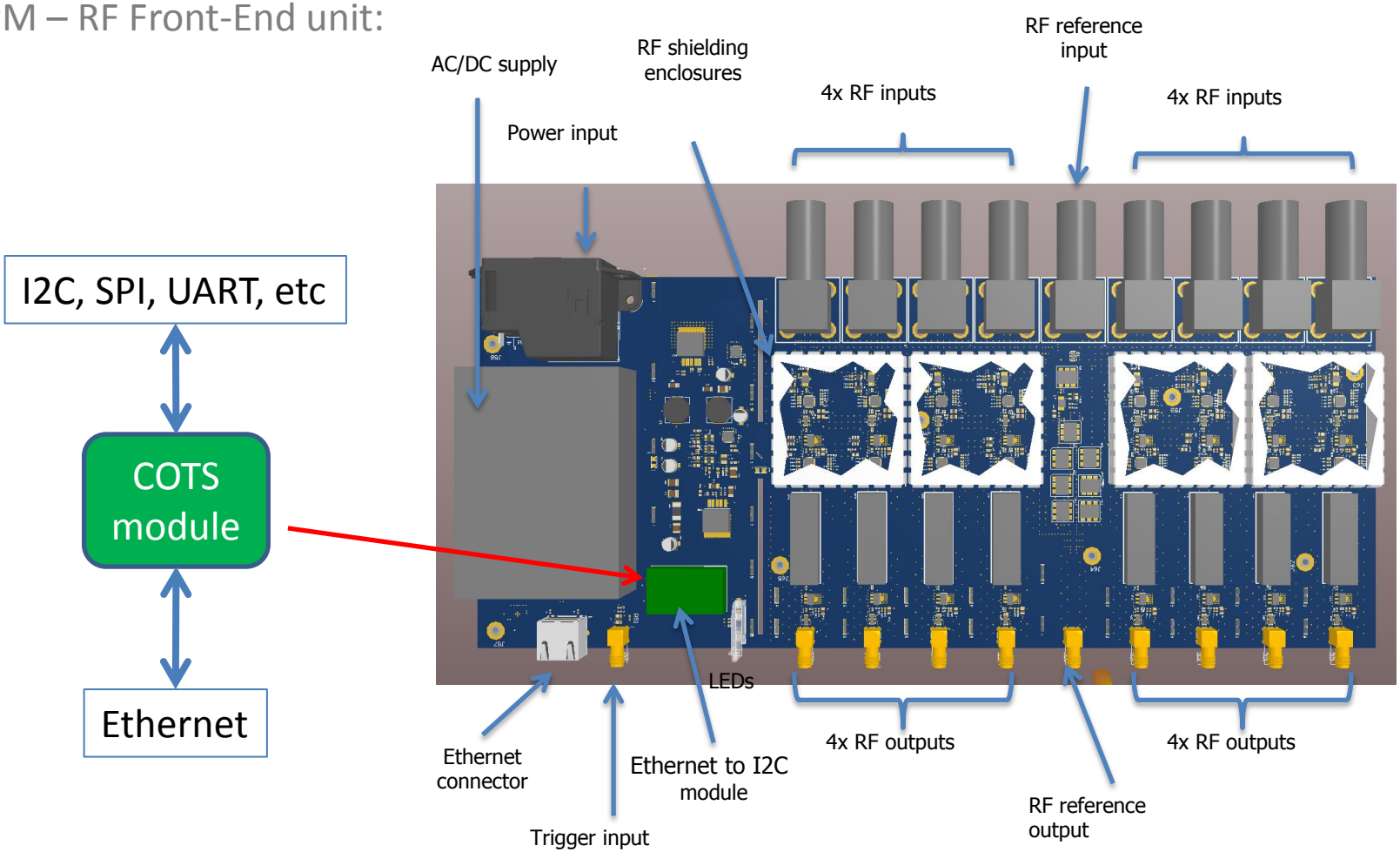
- BPM – RF Front-End unit:
  - Signal filtering
  - RF amplification for dynamic range
  - Long term drifts calibration

Parameter	Value	Comments
Max Input Power	20 dBm	For max attenuation and operating bellow P1dB
RF Chain Gain	35 dB	
RF chain attenuation	30 dB	
Center Frequency	100 - 800 MHz	Configurable center frequency
Bandwidth (3 dB)	100 MHz	
Bandwidth (60 dB)	200 MHz	
Crosstalk	>50 dB	For max gain @ 352 and 704 MHz
Nonlinearity	0.1 dB	Over 80 dB input range (-80 dBm to 0 dBm)
Noise Figure	10 dB	Estimated for 5 dB attenuators
Temperature Dependence	TBD	
MTBF	20	Years
Dynamic Range	60 dB	



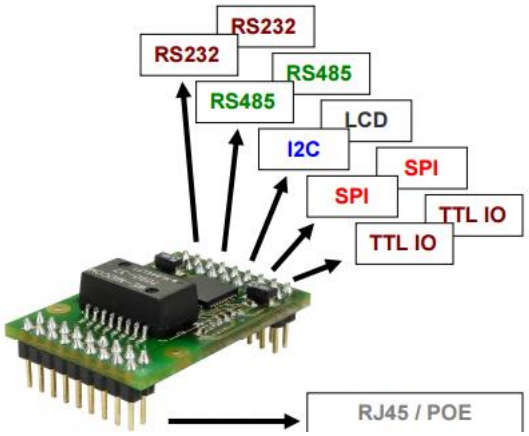
BPM electronics RF Front-End

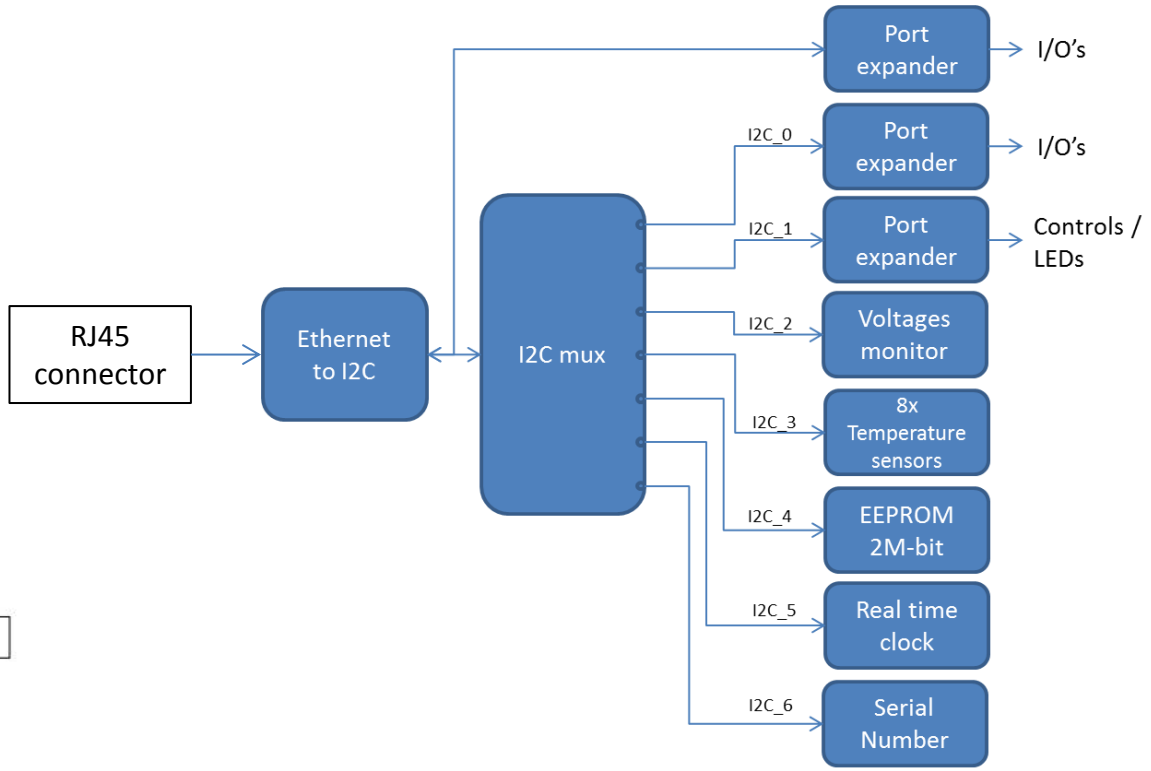
- BPM – RF Front-End unit:



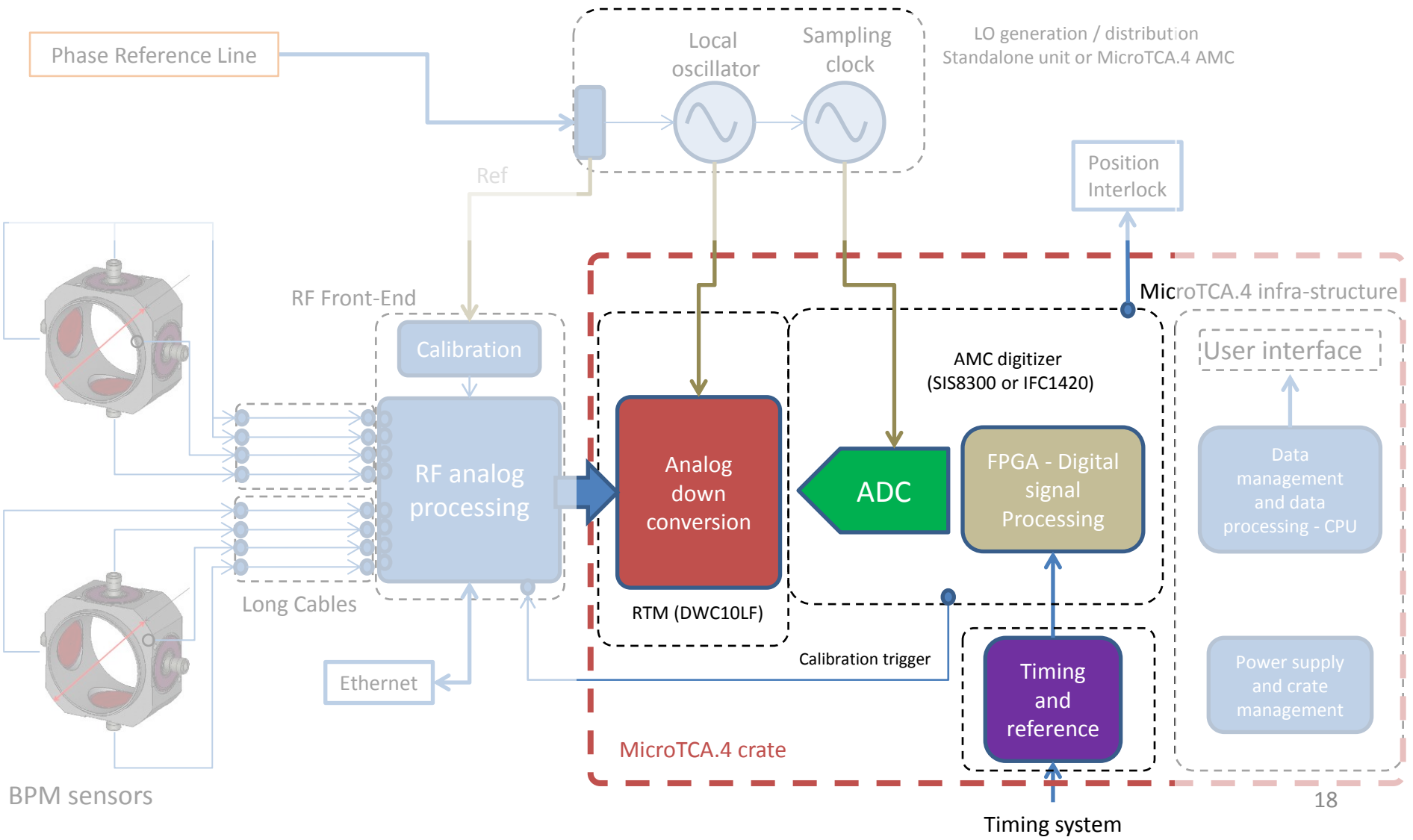
BPM electronics RF Front-End

- BPM – RF Front-End unit: Ethernet interface

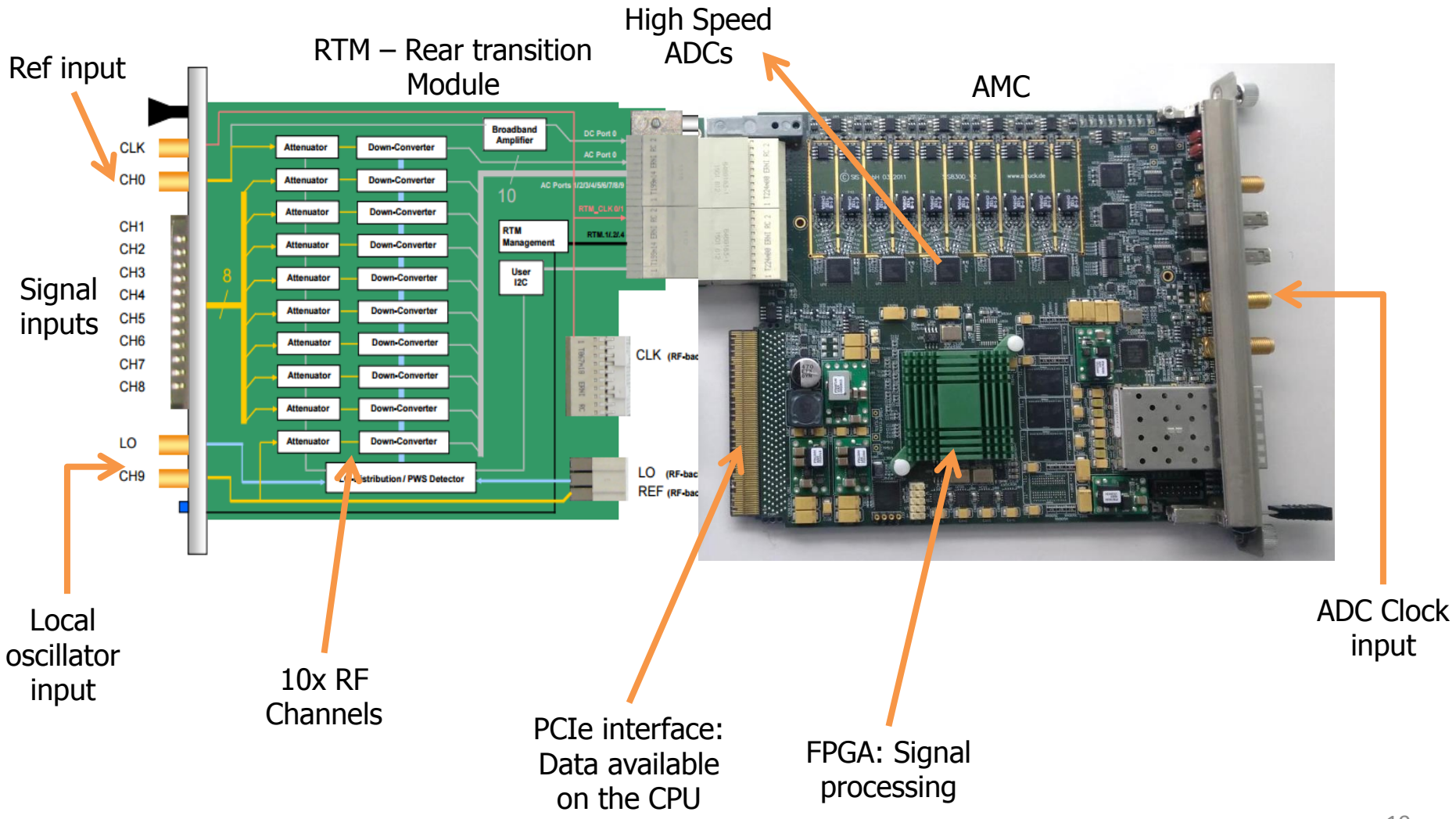




BPM system diagram

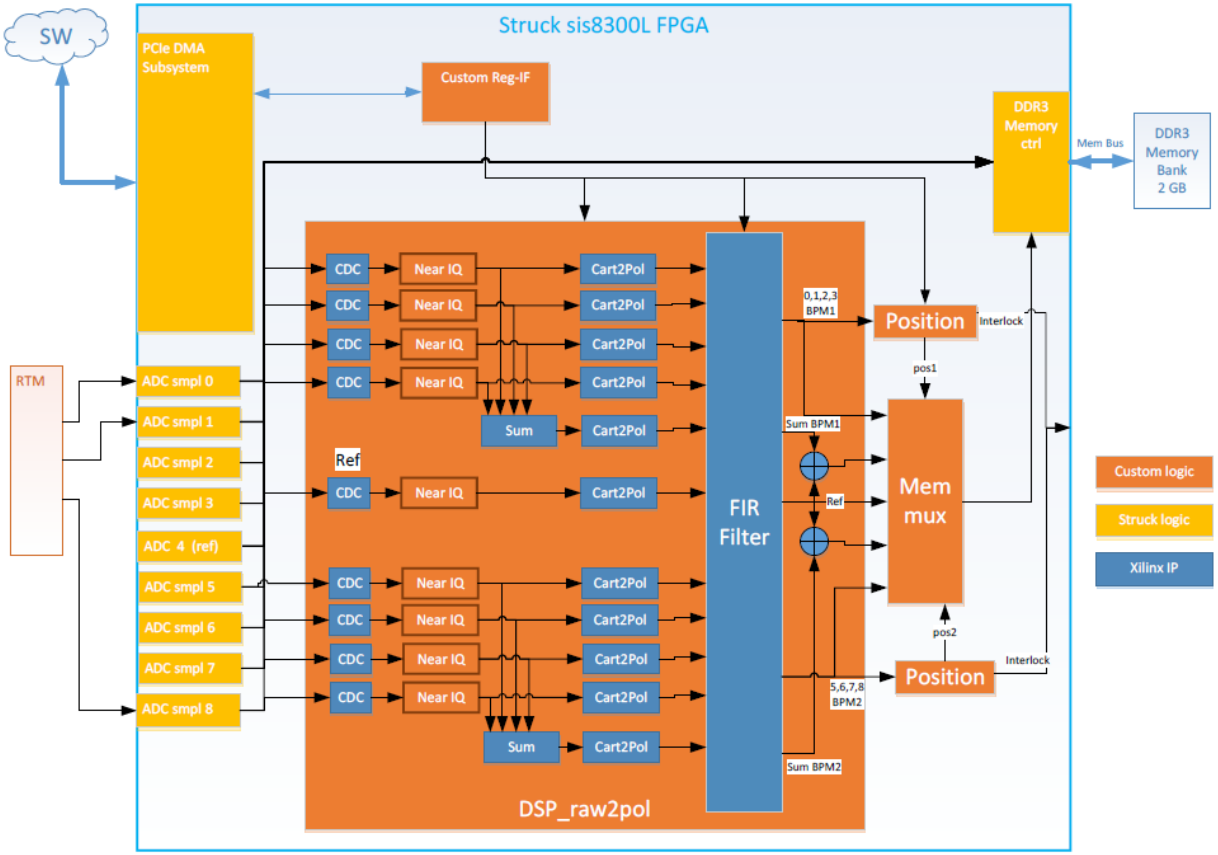


BPM electronics - hardware



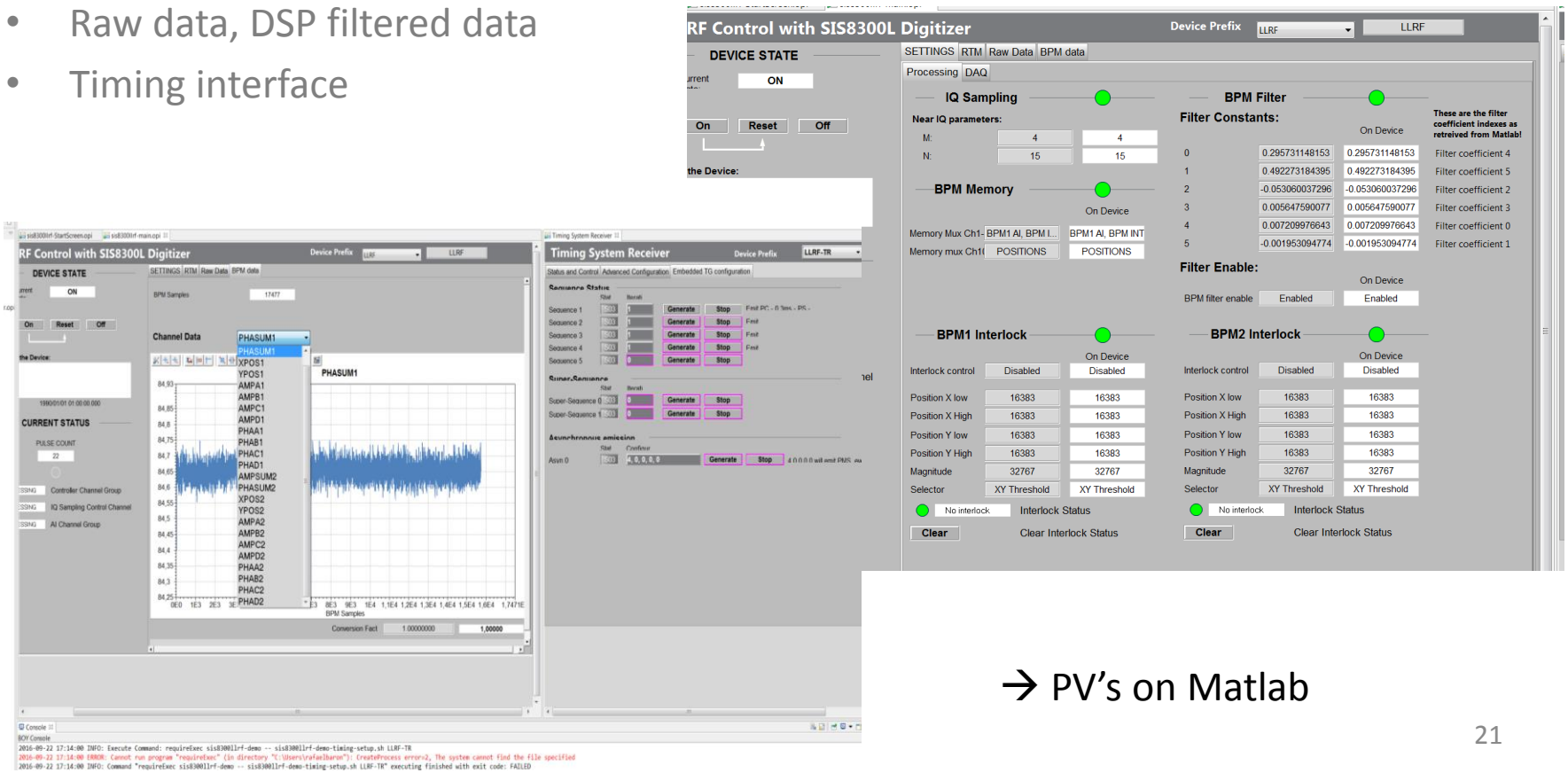
BPM-LLRF solution - firmware

- BPM FPGA firmware:
  - FPGA firmware designed based on the LLRF application
  - Near-IQ
  - FIR filtering
  - Phase and position calculation
  - Position interlock
  - 2 BPMs per RTM/AMC



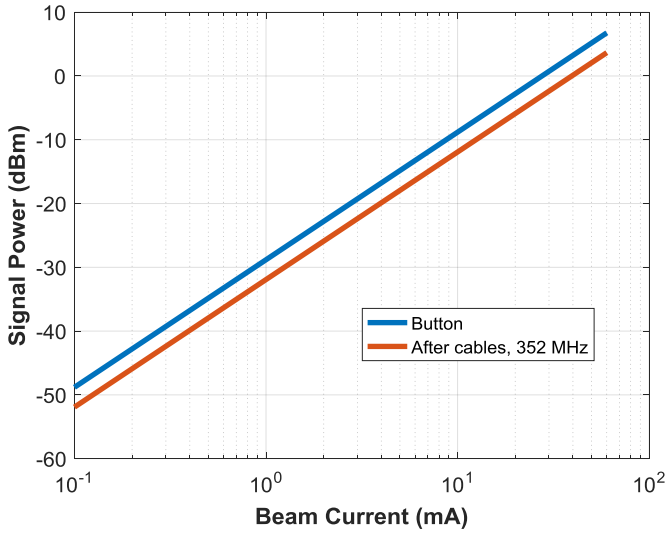
BPM-LLRF solution - IOC

- Controlling /monitoring electronics parameters (RF attenuators, temperature, clk source, non-IQ factors, filter coefficients, etc.
- Phases, amplitudes, positions, position interlock
- Raw data, DSP filtered data
- Timing interface

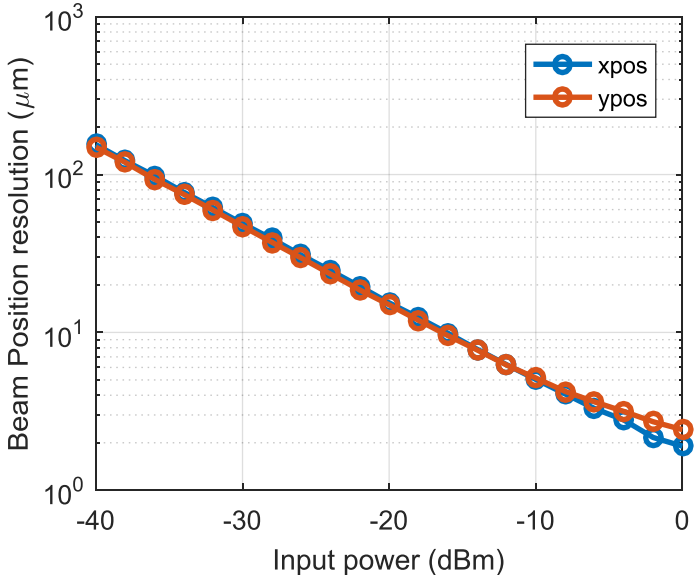


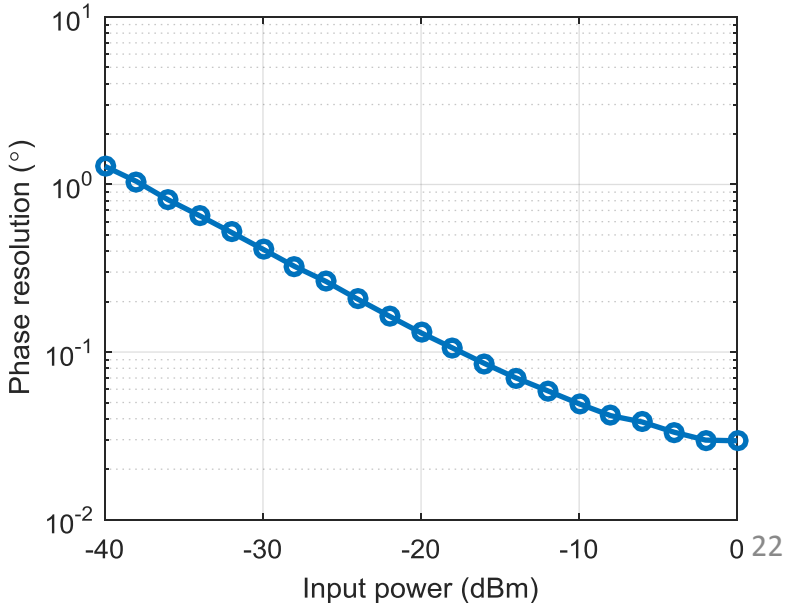
→ PV's on Matlab

BPM Electronics performance

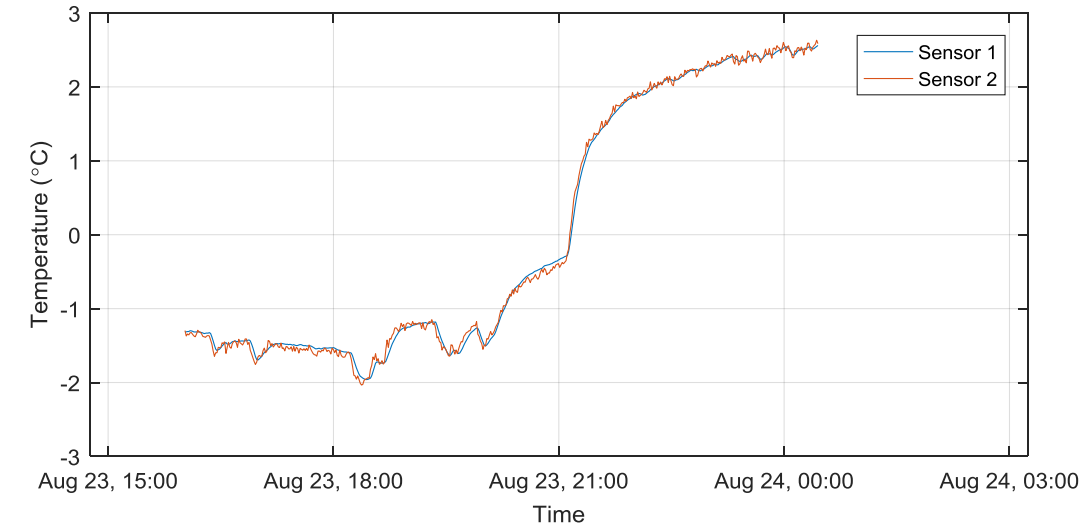


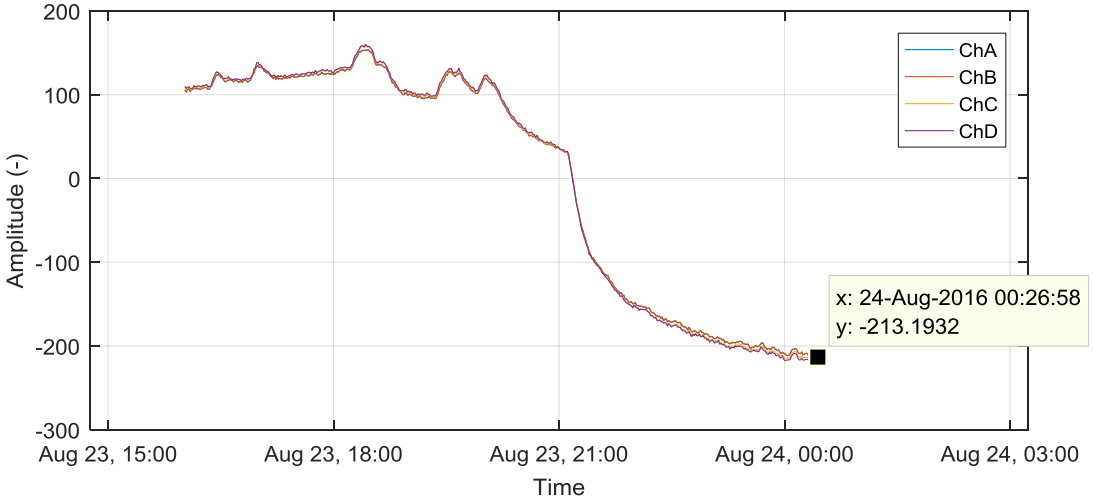
→ LWU feedthroughs EM simulations:
Beam energy: 200 MeV
Bunch length: 2.1 mm



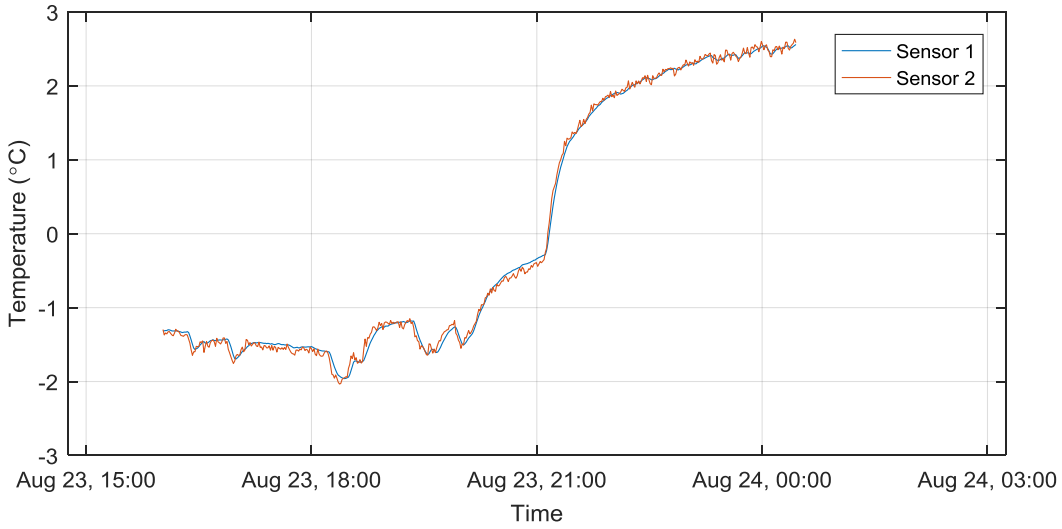


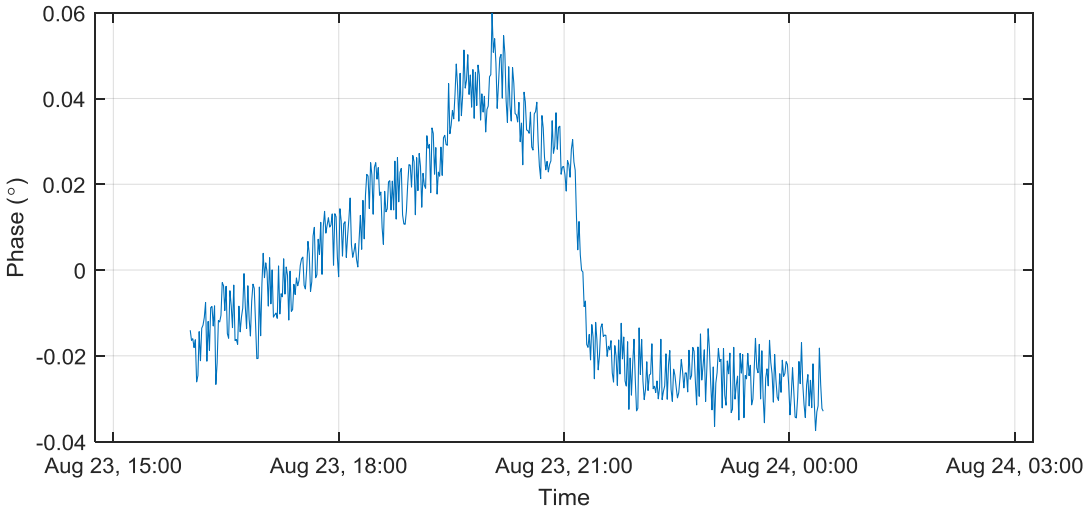
BPM Electronics performance





BPM Electronics performance





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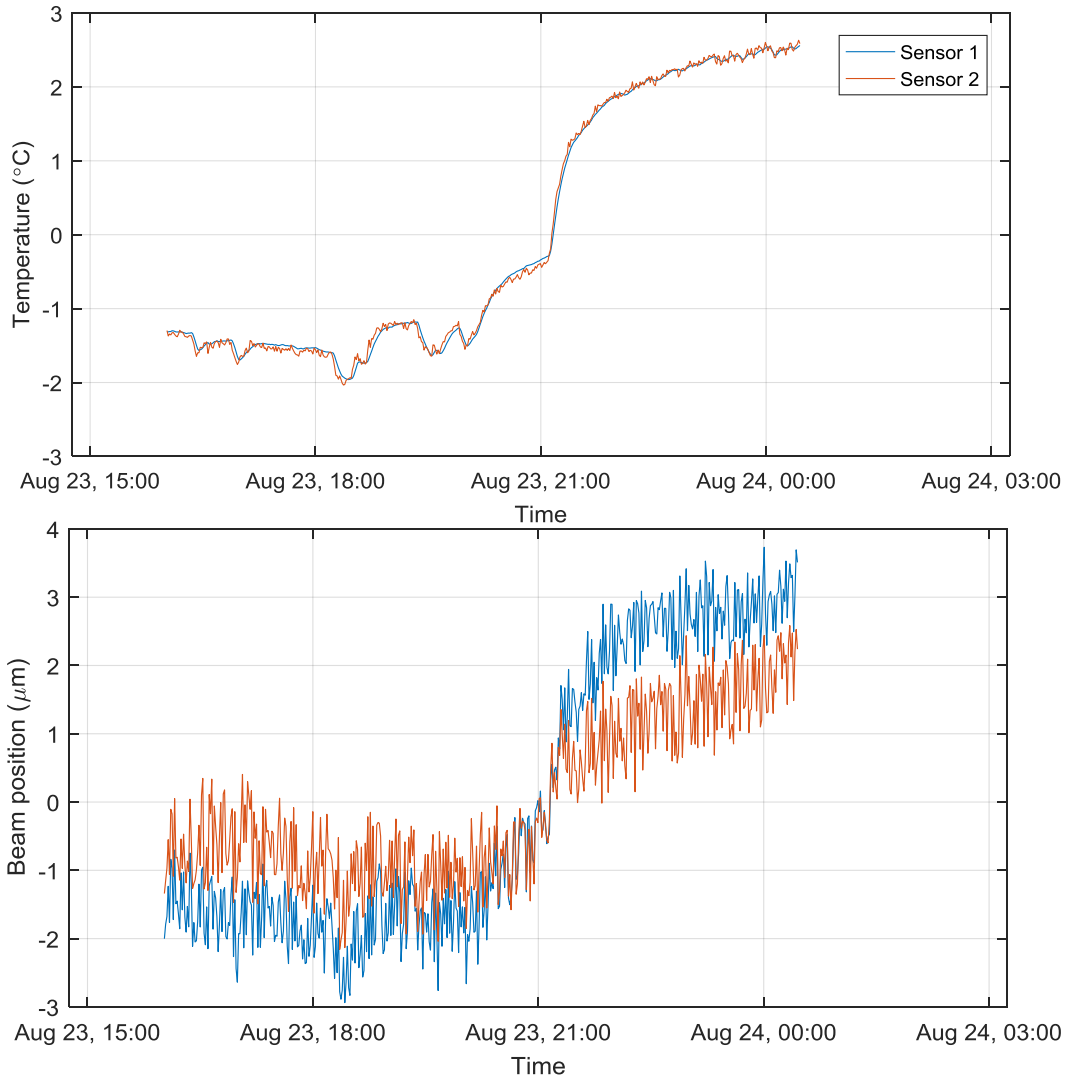
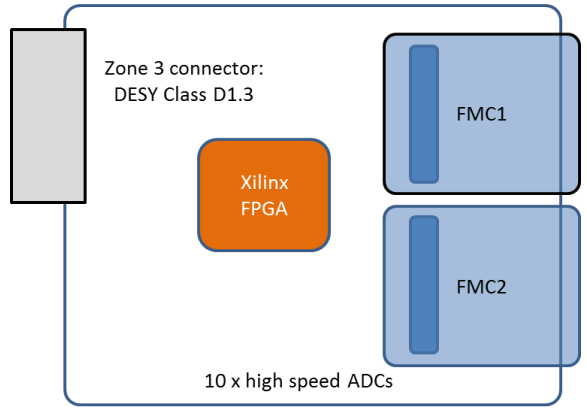


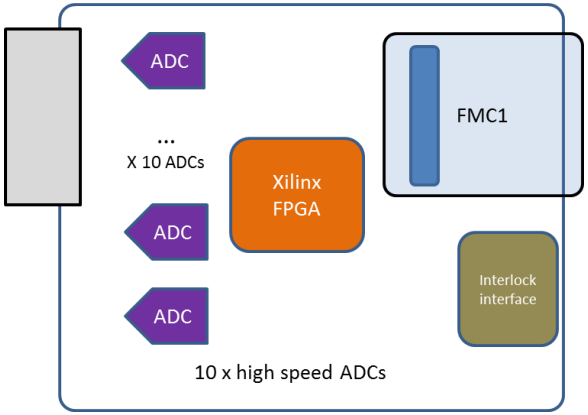
BPM System

- Thanks!
- Questions?

BPM Electronics

- AMC digitizer board:
  - A Backup solution was agreed with ICS for RF RTM and FMC based applications:





Platform	Application	FPGA	Status
Struck SIS8300-L2	High speed digitizers	Xilinx Virtex-6	COTS
Struck SIS8300-KU	High speed digitizers	Xilinx Kintex Ultrascale	COTS by Nov-16
IOxOS IFC1420	High speed digitizers	Xilinx Kintex Ultrascale	First prototype 30-Oct-16
IOxOS IFC1410	FMC applications	Xilinx Kintex Ultrascale	First prototype 30-Nov-16
CAENels DAMC25	FMC applications	Xilinx Virtex-5	COTS

BPM Electronics – Rack BPM