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MTCA.4 Applications for Accelerators:
Machine Protection & Beam Stabilization Systems exploiting DAMC-FMC25

Paolo Scarbolo

7th MicroTCA Workshop for Industry and Research – December 5th, 2018

Outline

Machine Protection System

- Concept of the Application
- Hardware & System Architecture

Beam Stabilization System

- Concept of the Application
- Hardware & System Architecture
- Preliminary Measurements

Conclusions

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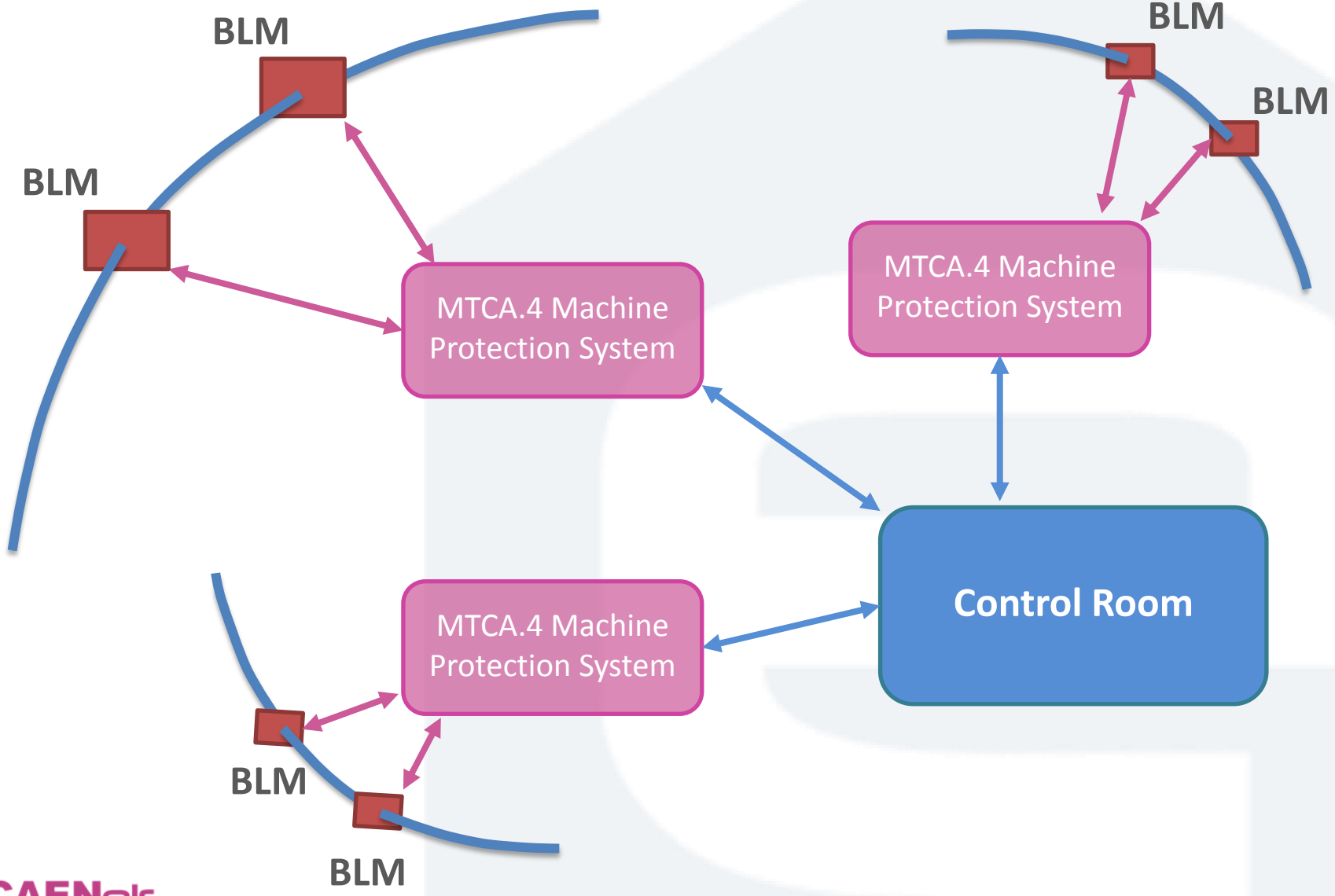
Concept of the Application

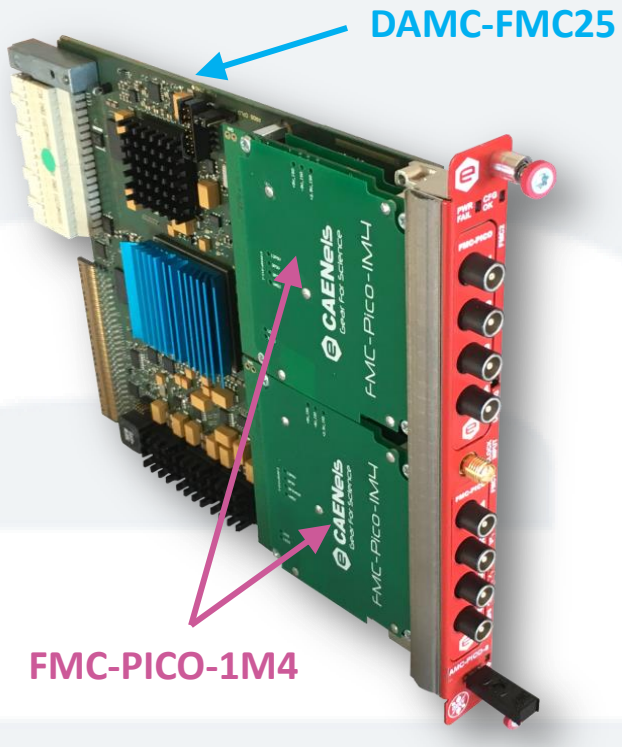


Hardware: AMC-PICO8

8-channel 20-bit 1 MSPS bipolar current-input AMC picoammeter

- 1 MSPS 20-bit simultaneous sampling (8-channels)
- Inputs floating up to 300 V
- Trigger/Oscilloscope functionality
- Based on the DAMC-FMC25 carrier designed by DESY
- 2 picoammeter FMC-Pico-1M4 supported
- **BSP, driver and GUI available**

Avoids ground loops if two different detectors are connected to the same DAMC-FMC25 - e.g. quadrature detectors



DESY

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Turnkey solution with dual 4-channel (8-channel) floating picoammeter!

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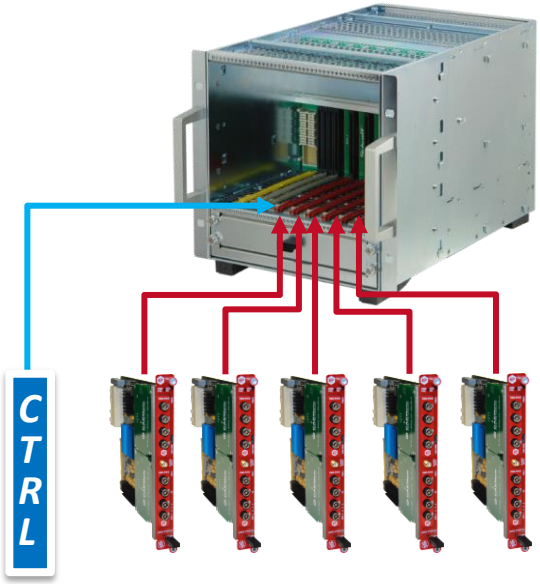
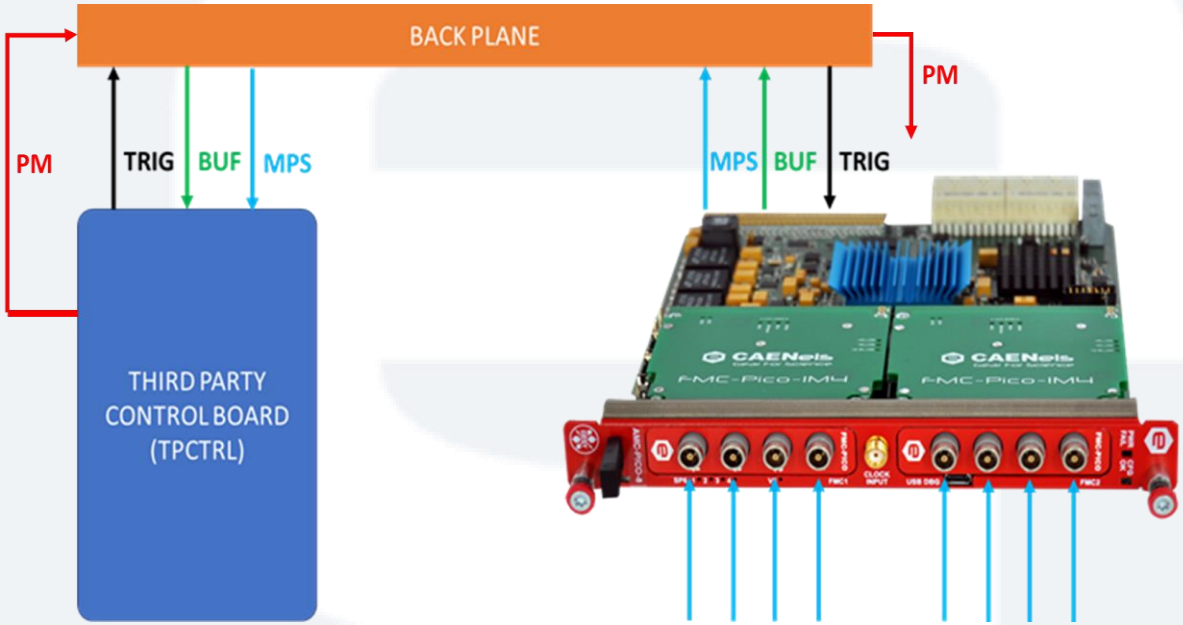
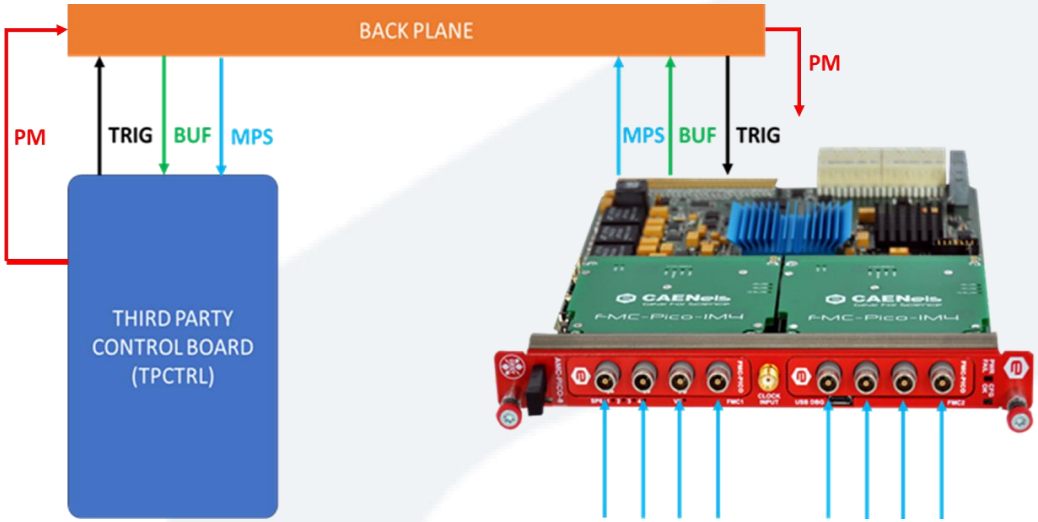
System Architecture (1/3)



Up to 5 AMC-PICO8 boards per crate
(40 channels)



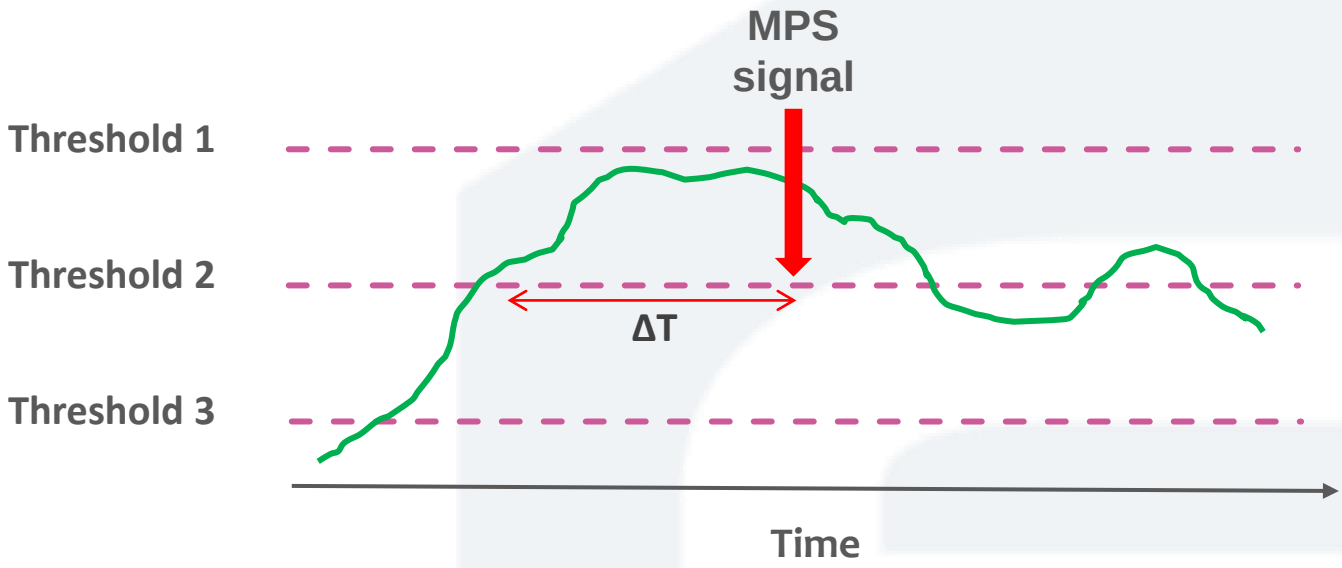
System Architecture (2/3)



In response to a trigger signal (TRIG) from the TPCTRL the AMC-PICO8, starts the acquisition, sends the data buffer (BUF) to the TPCTRL

System Architecture (3/3)

Under specific conditions the AMC-PICO8 generates a **Machine Protection Signal (MPS)** back to the TPCTRL (response time 10 µs, from simulations).



- Thresholds 1 and 2 are checked with the use of the first buffer (1 MHz) at around 10 and 100 µs (**configurable**)
- Threshold 3 is checked with the use of the second buffer (1 kHz) at around 10 ms (**configurable**)

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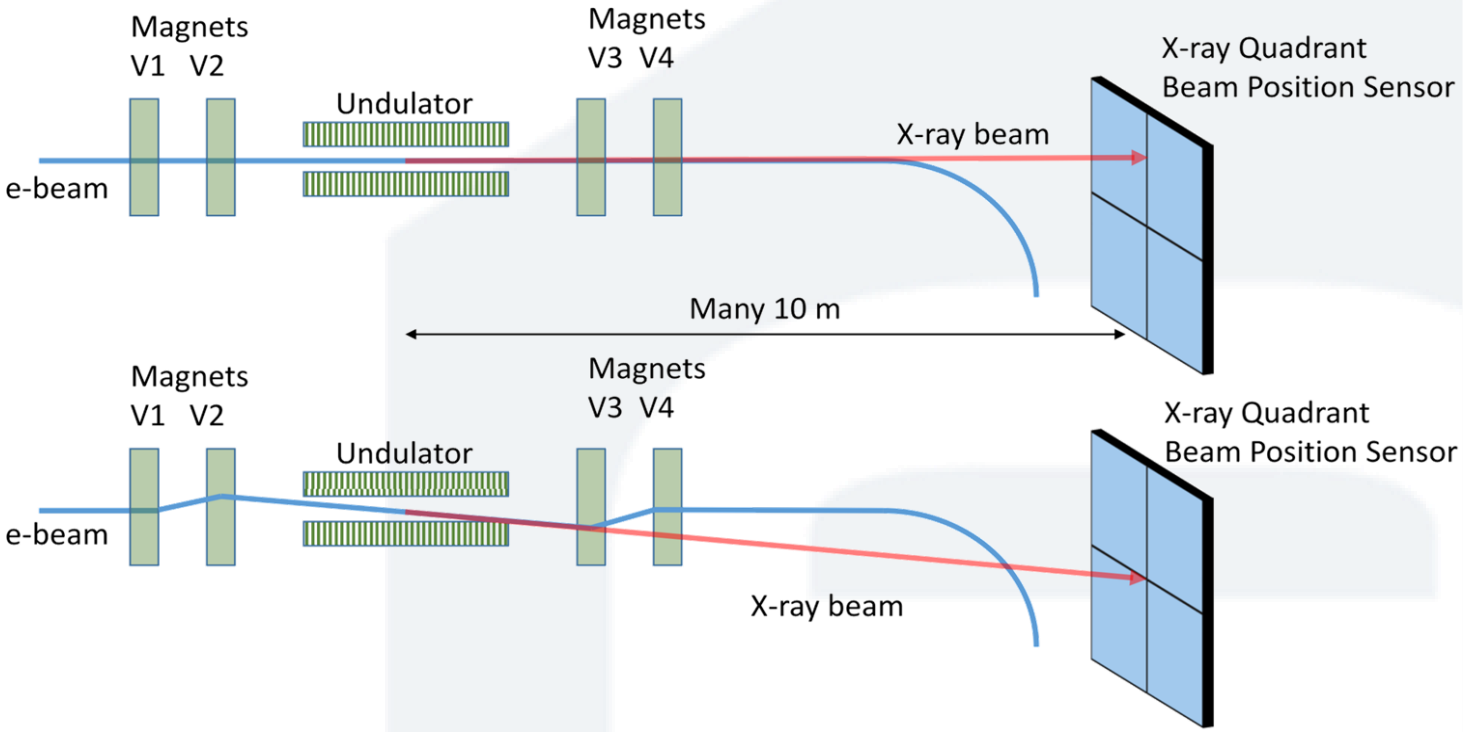
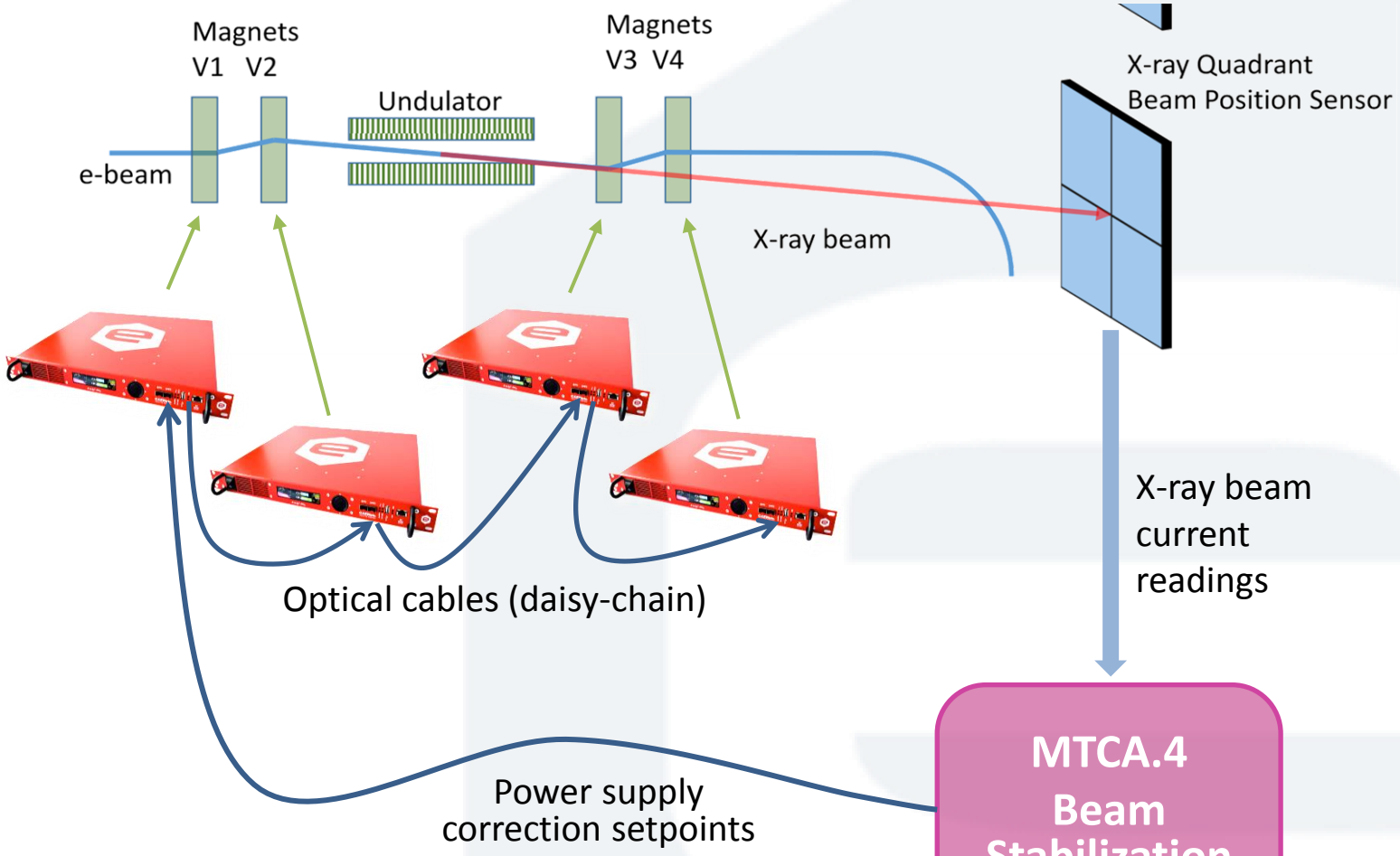
Beamline Stabilization System



The idea is to steer the electron beam in the storage ring starting from an X-ray position on a beamline

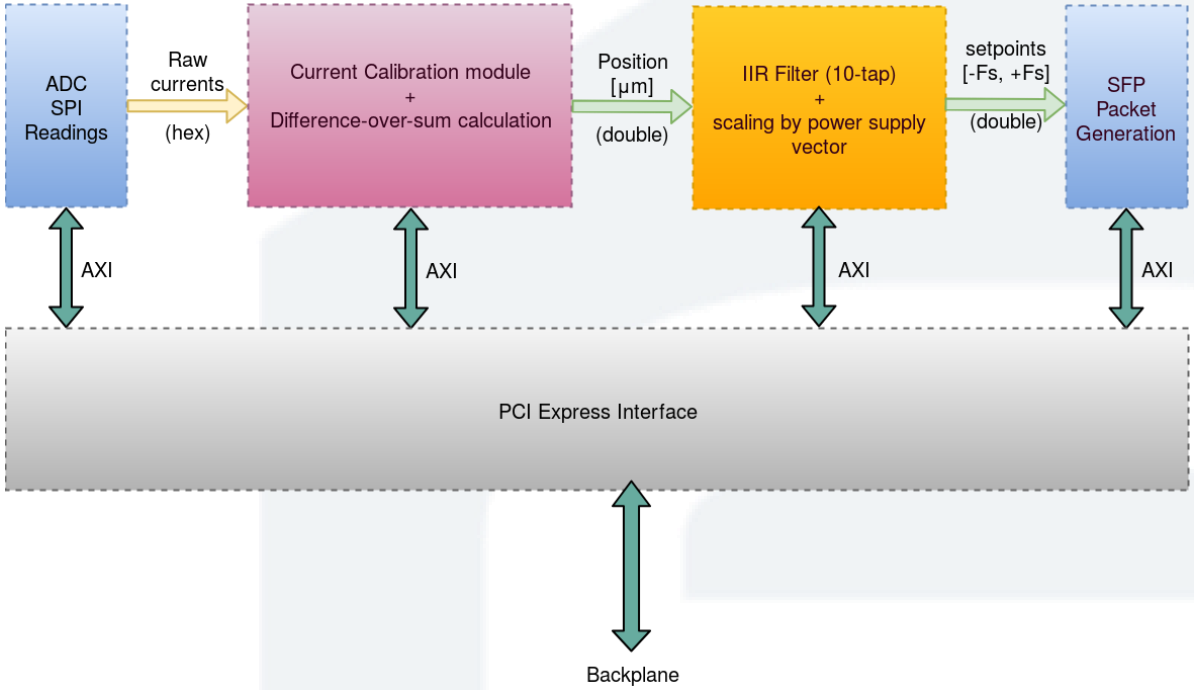
Günther Rehm
Session 4

System Architecture



The system works at 100 kHz (one setpoint every 10 µs)

Hardware: MTCA.4



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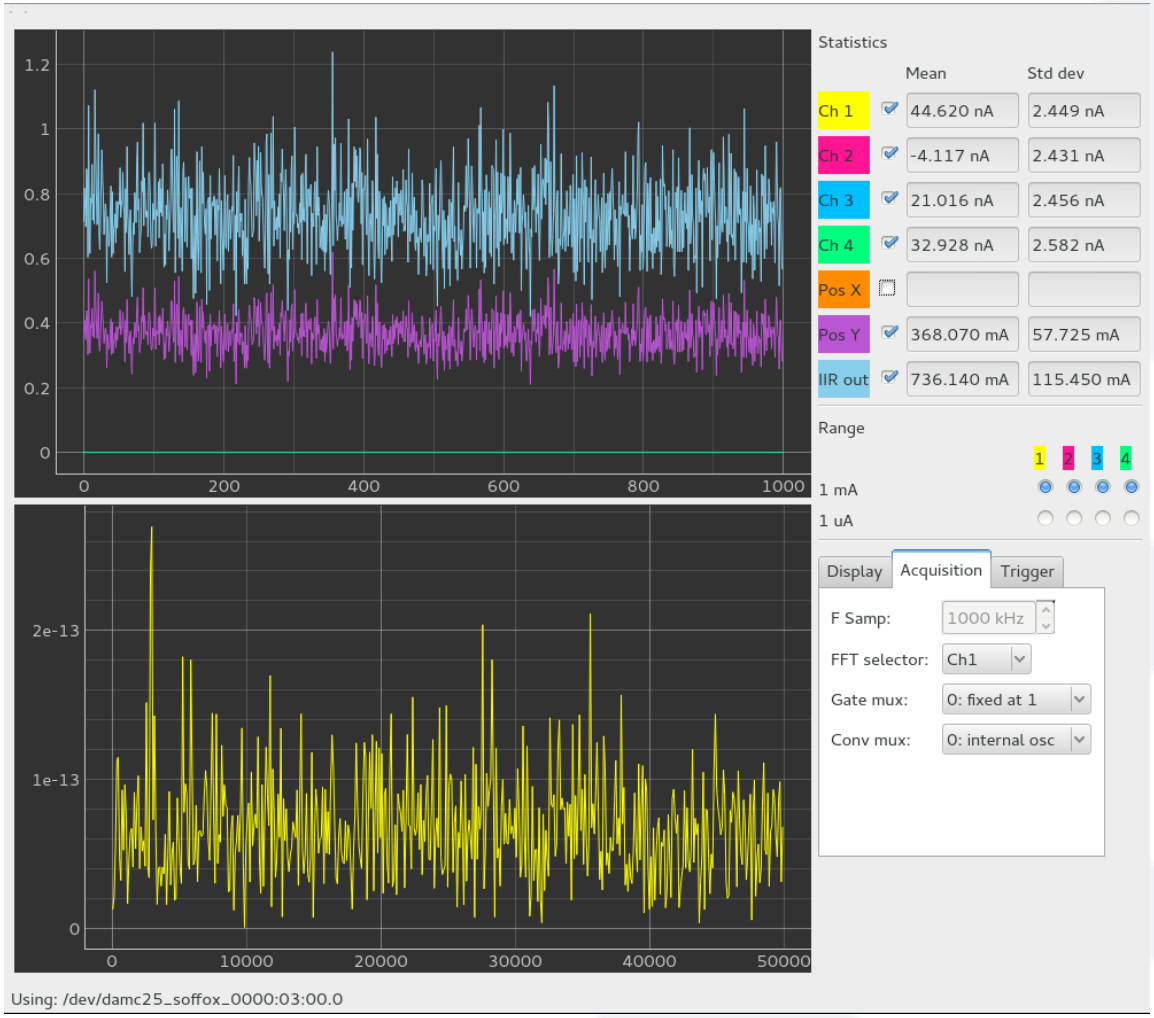
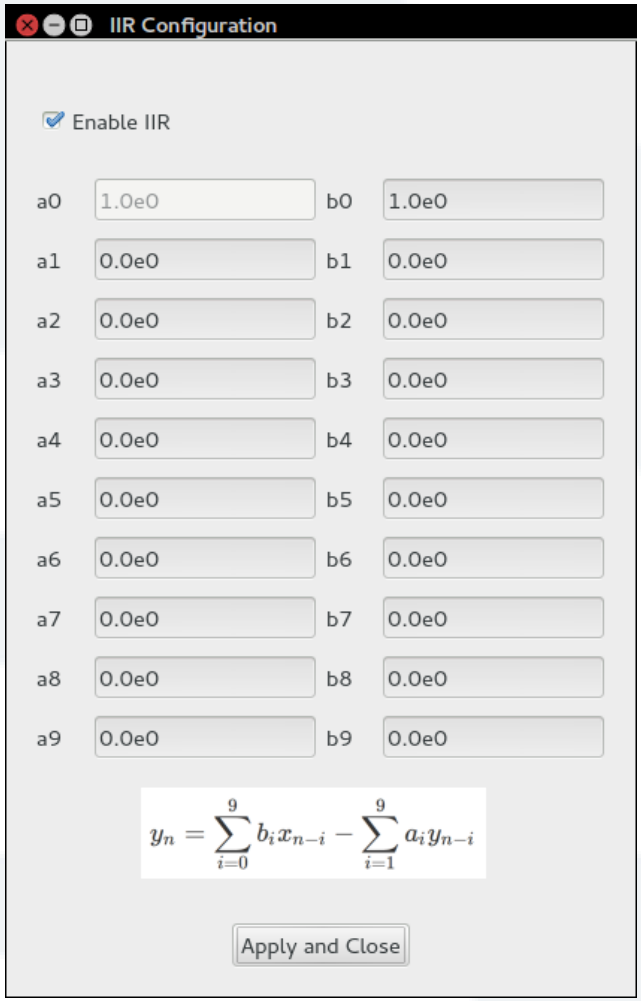
Software: Graphical User Interface





Hardware: FAST-PS

High-Performance Bipolar Power Supply

- Ideal for fast-feedback application
- 19” – 1U stand-alone crate
- Different current and voltage ratings
- 10/100/1000 Ethernet
- 2x Fast SFP interface (10 kHz update)
- Current or Voltage regulation
- High analog bandwidth
- Analog control and Trigger Input - optional
- Low noise
- Configurable Digital control loop
- Internal protections and auxiliary readbacks
- Local display and control

Regulation Type	Current- or Voltage- Control
Output current range	± 5 A, ± 10 A, ± 20 A, ± 30 A
Output voltage range	± 20 V, ± 40 V, ± 80 V
Maximum output power	up to 600 W
Setting resolution	18 bit
Output readbacks	20 bit
Output current ripple*	30 ppm / FS
Output current stability	< 50 ppm / FS
Output voltage stability	< 50 ppm / FS
Switching Frequency	100 kHz
Max Current/Voltage update rate	10 kHz
Accuracy	0.05%
External Interlocks/States	2 Inputs: user-configurable "dry" contacts 1 Outputs: relay (2 magnetic contacts)
Internal Interlocks	DC Link Under-Voltage MOSFETs Over-Temperature Over-Current and Over-Voltage Earth Fault Current Regulation Fault and Excessive Current Ripple
Hardware protections	Input Fuses Earth Fuse Over-Voltage
Auxiliary ADC Read-Backs	DC Link Voltage Ground Leakage Current Temperature
Connection	1 x Ethernet 10/100/100 2 x SFP ports
Extra-Features	Point-by-Point Current Waveform Loading User-definable interlock thresholds, active levels and timings Firmware Remote Updates
Input Voltage	90/260 V(AC) (47-63 Hz)
Efficiency	up to 84 %
Power Factor	> 0.95

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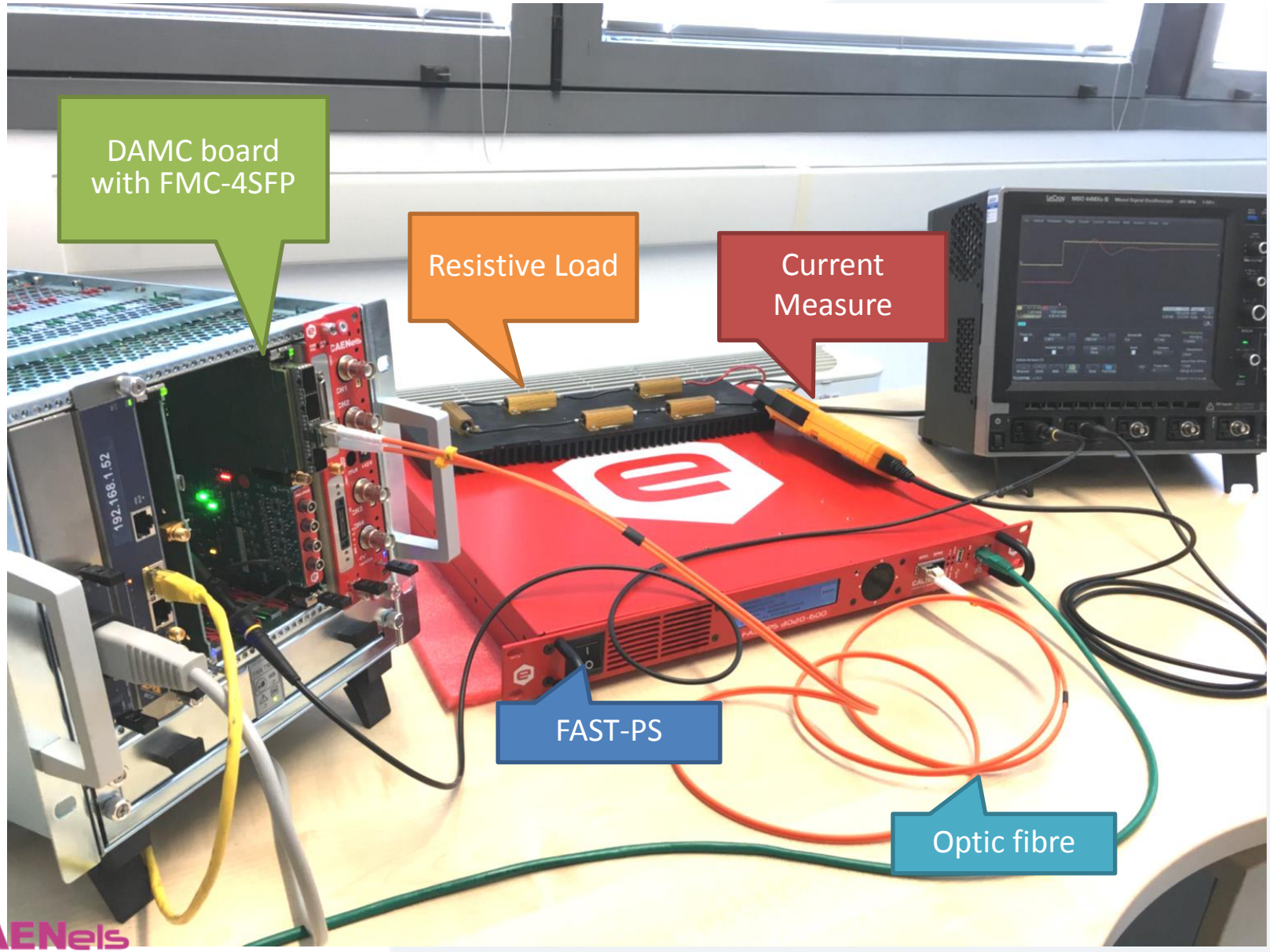
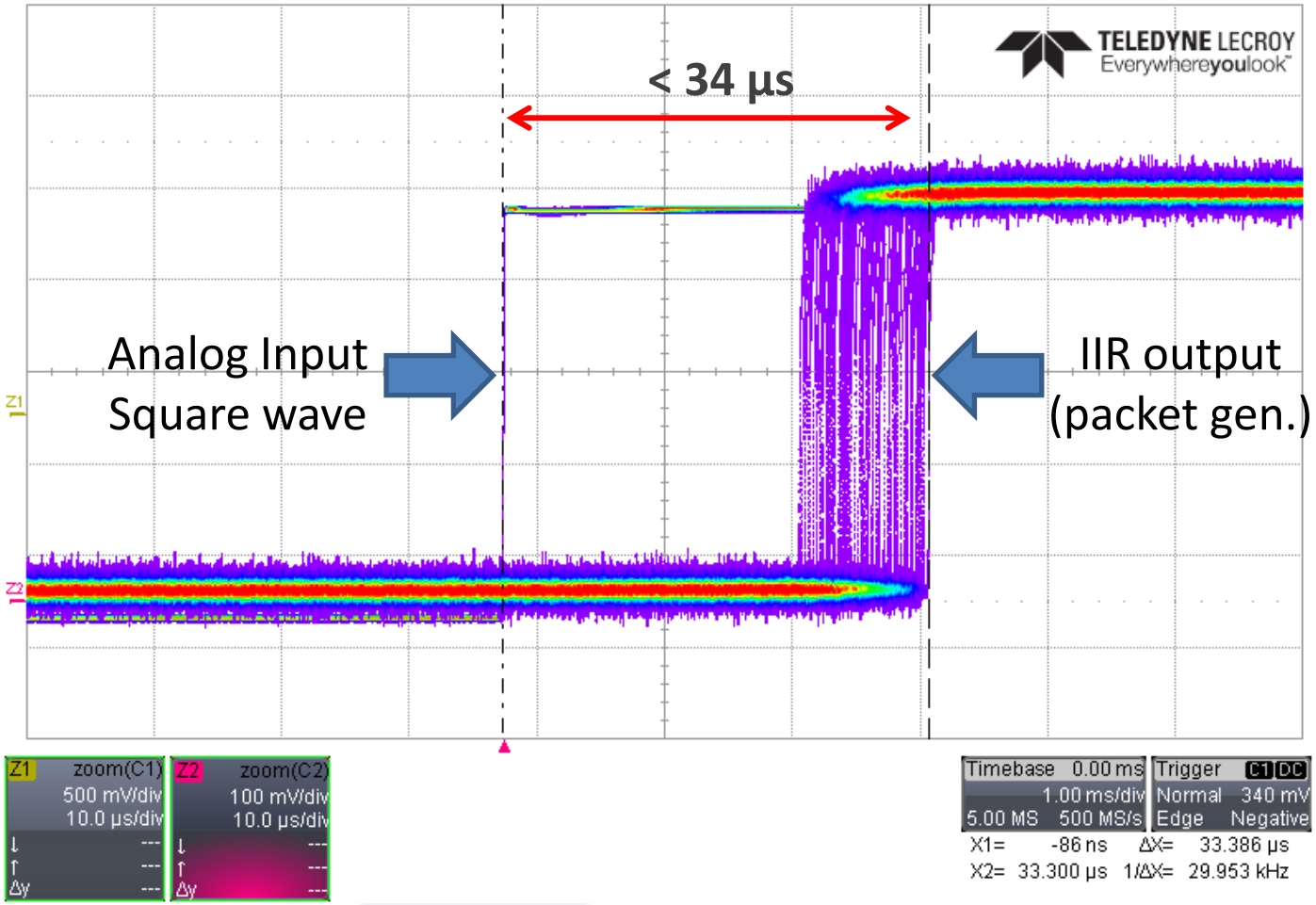
Measurement Setup



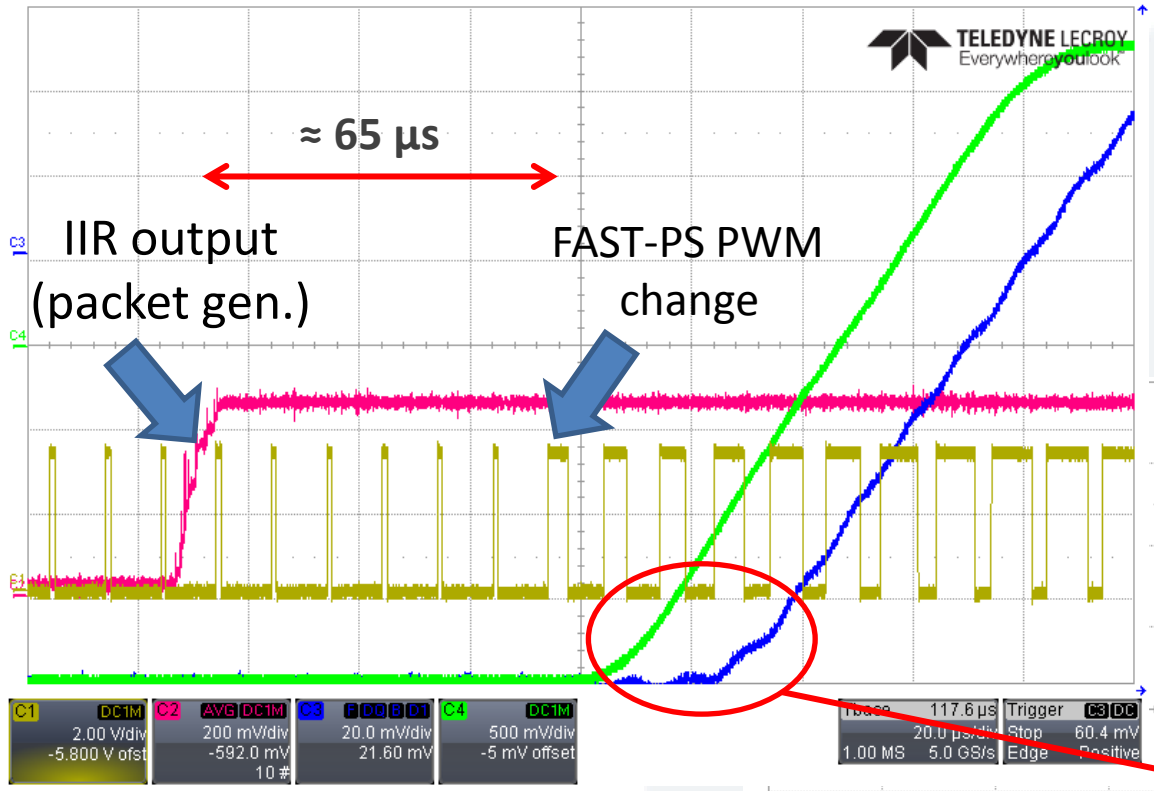
Measurement Results (1)

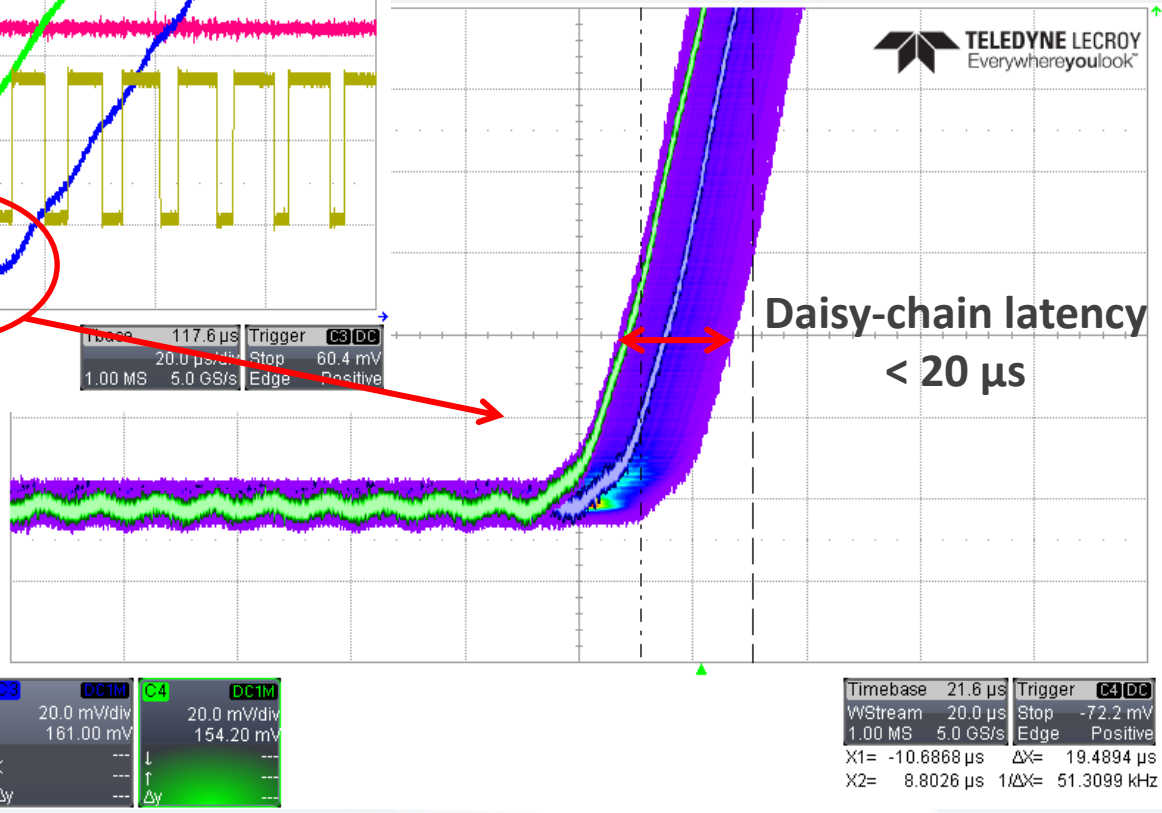


Measurement Results (2)

FAST-PS n°1

FAST-PS n°2 (daisy-chain)





Overall latency ≈ 100 µs
+ 20 µs each FAST-PS

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Conclusions

Beam Stabilization System:

- Hardware is already available on the CAEN ELS catalogue
- The Beam Stabilization System has been implemented and it’s ready to be tested at DLS
- The power supply firmware has been updated to handle the daisy-chain

Machine Protection System:

- Hardware is already available on the CAEN ELS catalogue
- The application firmware is currently under developement
- End of Q1 2019 - first prototype for testing

Thank you for your attention!

BACKUP SLIDES

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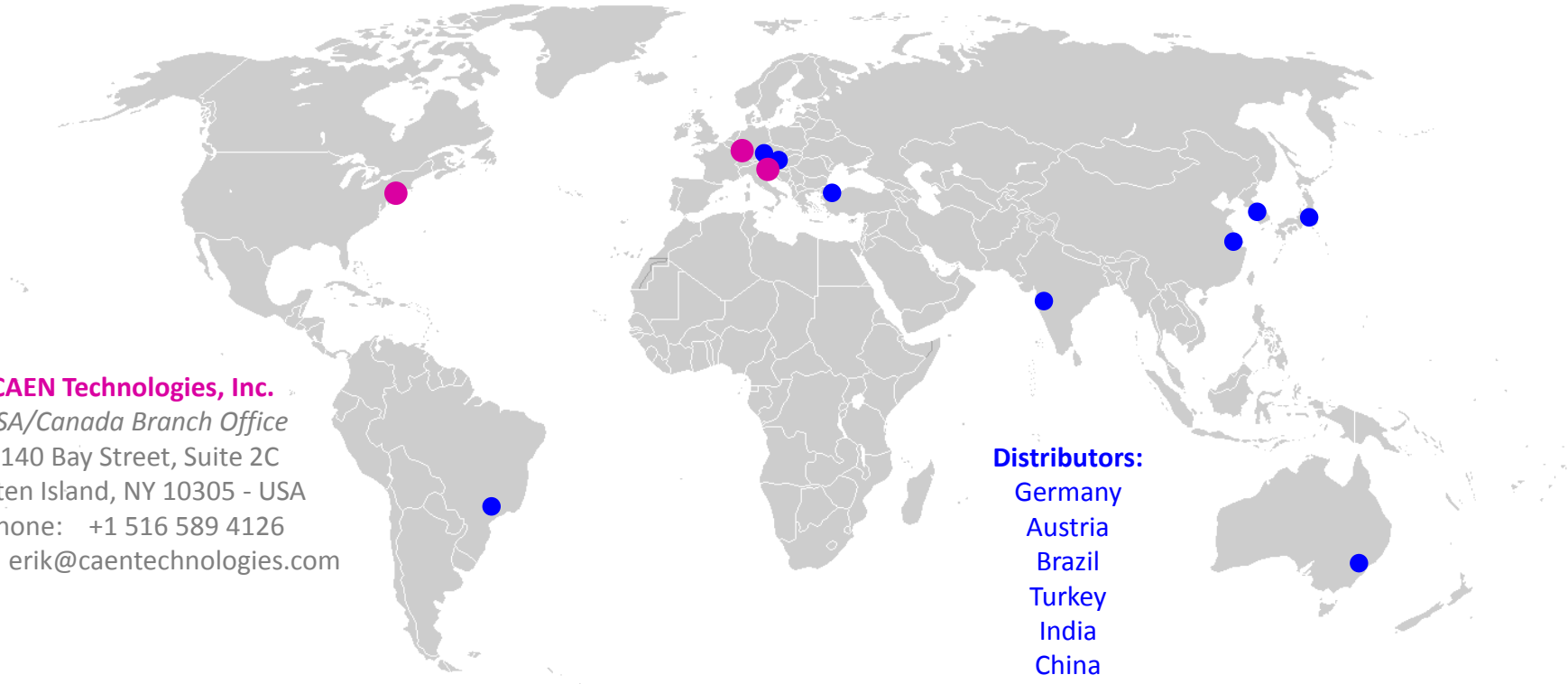

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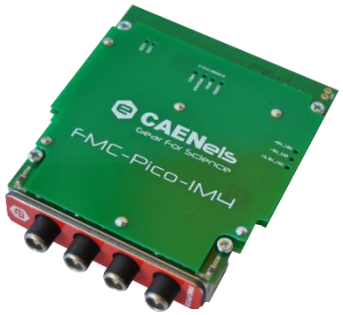
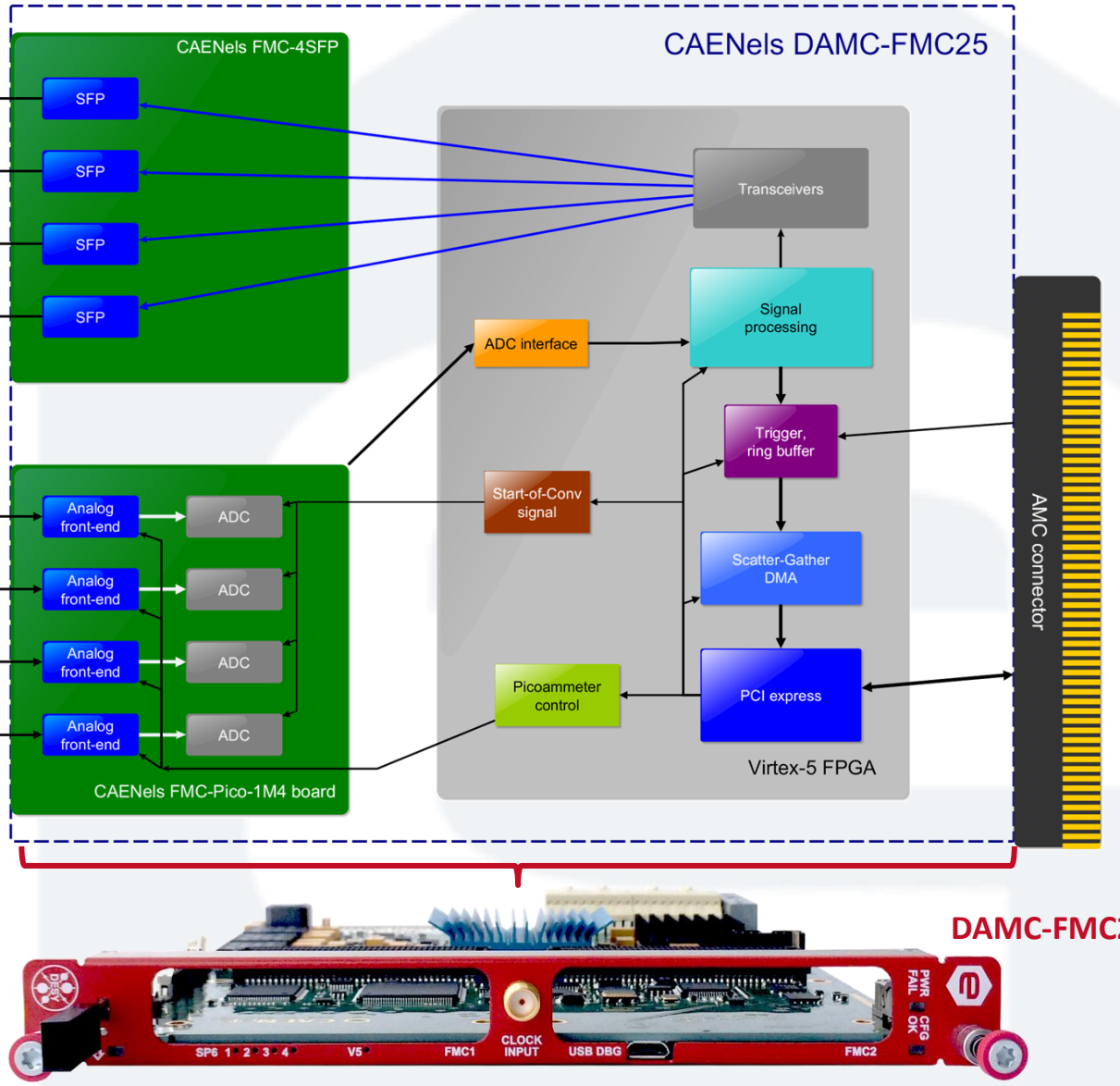
Custom Application

FMC-2SFP+



FMC-PICO-1M4

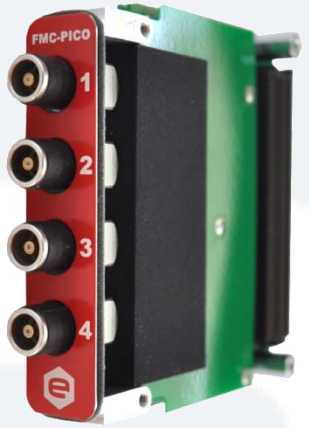


DAMC-FMC25

FMC-PICO-1M4

4-channel 20-bit 1 MSPS bipolar FMC picoammeter

- Standard FMC - Vita 57.1
- Bipolar **current-input** stage (transimpedance readout)
- **Two standard measuring ranges** (±1 mA and ±1 µA)
- **CUSTOMIZATION of ranges** upon request
  - Custom versions for FRIB, Sirius, INFN, European Spallation Source (ESS)
  - **Up to 300 kHz bandwidth** with 3-nF input capacitance (i.e. long cables)
- 20-bit resolution
- Up to 1 MSPS
- **Floating up to ±300 V**
- Extremely low unbalance between channels (by analog design)
- I2C EEPROM in-factory calibration



FMC-Pico-1M4

Equivalent Input Noise		
	RNG0: ±1 mA	**RNG1: ±1 µA**
F_S = 2 ksps	1 ppm/FS -120 dB	2.5 ppm/FS -112 dB
F_S = 20 ksps	2 ppm/FS -114 dB	7 ppm/FS -103 dB
F_S = 200 ksps	5 ppm/FS -107 dB	10 ppm/FS -100 dB
F_S = 1 Msps	8 ppm/FS -102 dB	15 ppm/FS -96 dB

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FMC-SFP+

Dual- and Quad-channel SFP/SFP+ FMC Adapter

- Dual-channel and Quad-channel versions
  - **FMC-2SFP+**
  - **FMC-4SFP+** (w/out FMC bezel)
- Wide I/O operating range: VADJ can vary from 1.5V to 3.3V
- Tested **up to 10 Gbps / channel**
- True level conversion of all SFP+ module pins including I2C lines
- I2C-controlled Oscillator (10-280 MHz)
- Compatible with the DAMC-FMC25 carrier board
- Produced and supported by CAEN ELS
- Designed by DESY

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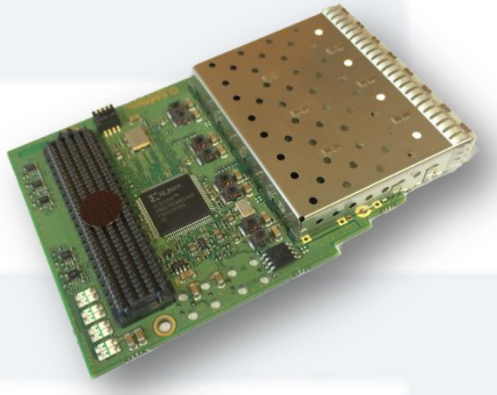
2-channel version



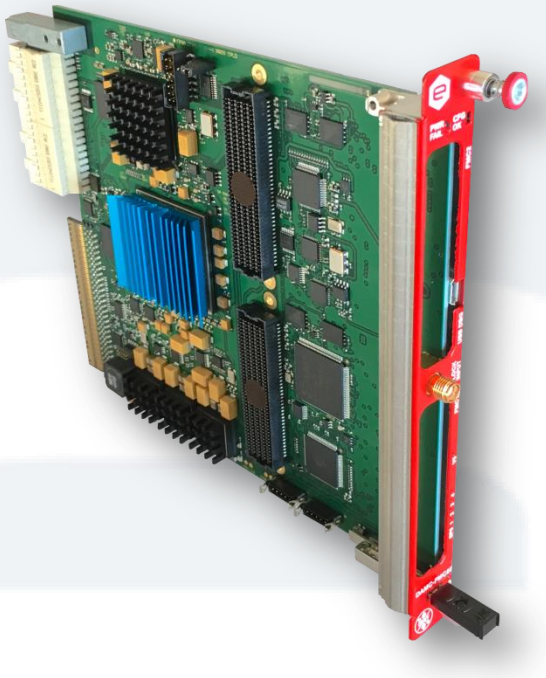
4-channel version

DAMC-FMC25

DAMC-FMC25

AMC Dual High-Pin Count FMC Carrier Board

- Double width AMC board – MTCA.4 carrier
- Two HPC FMC slots
- Data processing on Virtex-5 FPGA
- Board management on Spartan-6 FPGA
- RTM D1.1 connectivity
- DDR2 memories on both FPGAs
- External clock input on front panel SMA connector
- 6.5 Gbps ("-2") transceiver board options



DESY

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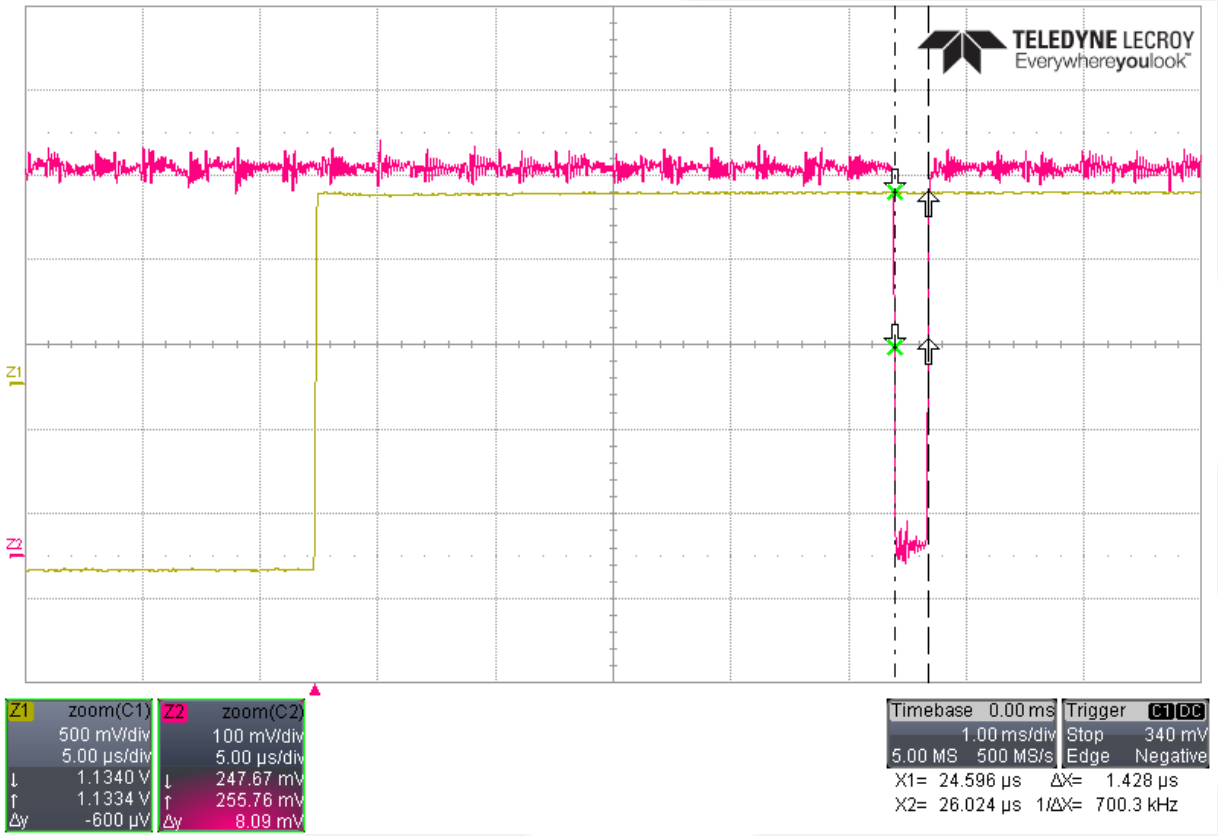
AMC-Pico-8

Technical Specifications

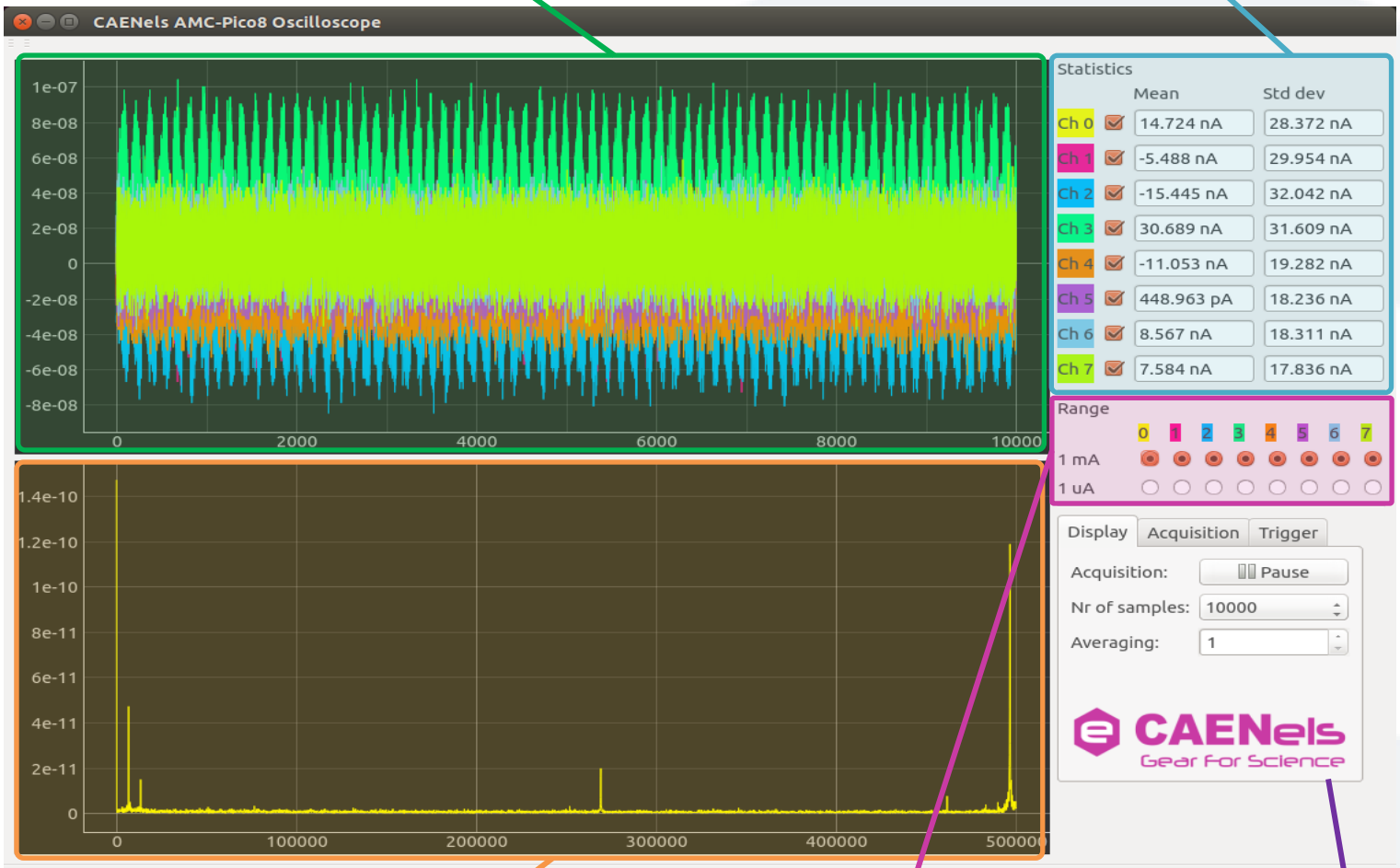
Board Size	Double-Width – Mid-Size
Input Channels	8
Input Connector Type	Triaxial – LEMO 00.650 Series (EPL.00.650)
Current Input Full-Scale Ranges (configurable upon request)	±1 mA ±1 µA
Maximum Sampling Frequency	1 MSPS (per channel)
Equivalent Signal-to-Noise	RNG0: >100 dB RNG1: >90 dB
Current Resolution	2 nA 2 pA (20-bit)
Bandwidth (-3dB)	> 10 kHz
Temperature Coefficient – TC	10 ppm/°C
Differential TC	< 25 ppm/°C
Front End Isolation Voltage	± 300 V
Standard	MicroTCA.4: AMC.0, AMC.1 Module Management: IPMI Version 1.5, MMC V1.0
Compatibility	Zone3 Classification: Class D1.1 AMC Backplane Support: Full
Trigger Inputs	Internal, AMC port #17 RX AMC port #18 RX AMC port #19 RX AMC port #20 RX
Operating Temperature	0 … 50 °C

Measurement Results (2)

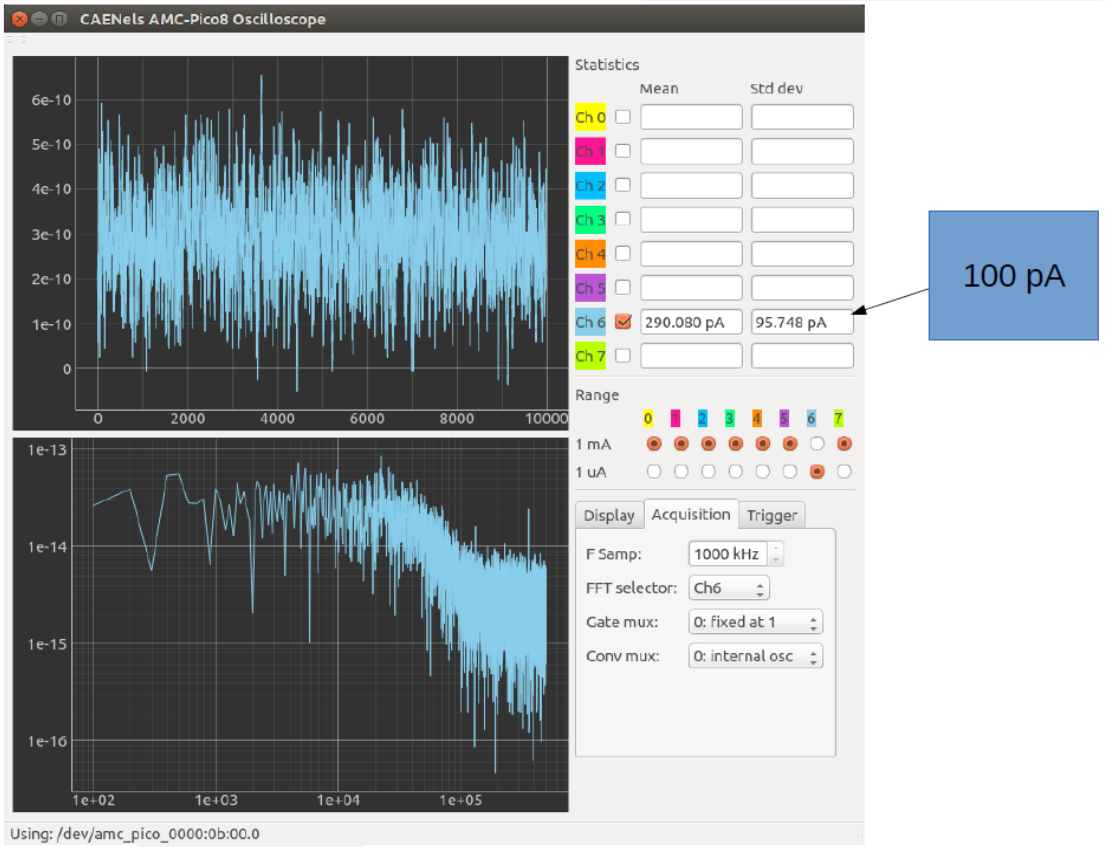
IIR computation and multiplication for power supply vector



AMC-PICO8 Software



AMC-PICO8 Noise Performance



The RMS noise with 1 MHz sampling is in the order of 100 pA (30 ppm/full scale).

This can be further reduced by on-board filtering – e.g. averaging – over a user-defined time period.