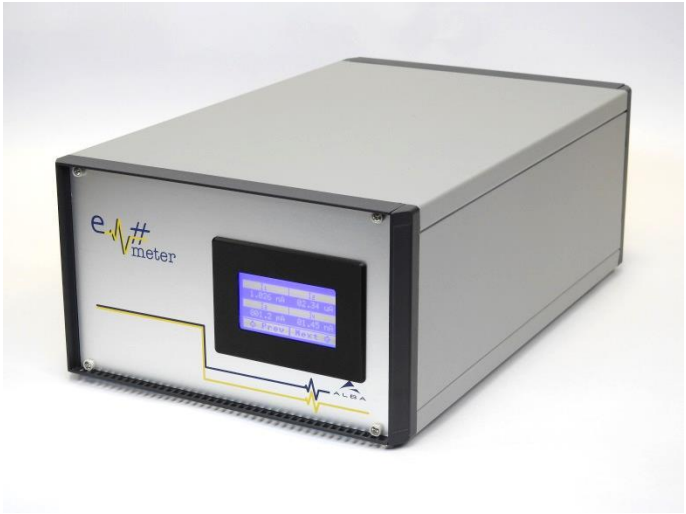
Em# Electrometer Comes to Light

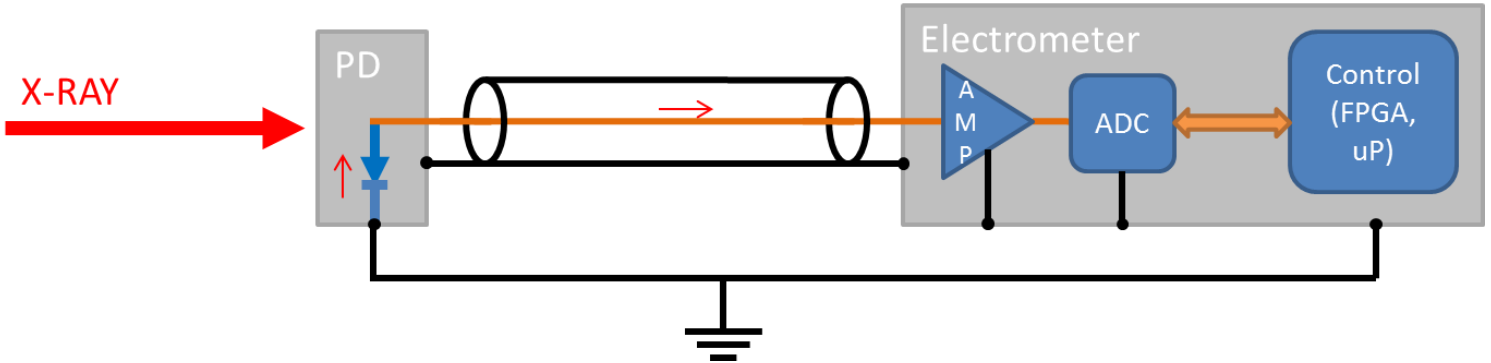


Introduction

What is an Electrometer?

- An electrometer is an electrical instrument for **measuring electric charge** or electrical potential difference. There are many different types, ranging from historical handmade mechanical instruments to **high-precision electronic devices**. Modern electrometers based on vacuum tube or solid-state technology can be used to make voltage and charge measurements with very low leakage currents, down to 1 femtoampere.
- …The most modern electrometers consist of a **solid state amplifier** using one or more field-effect transistors … allow attachment of **diodes** or **ionization chambers** for **ionizing radiation measurement.**

WIKIPEDIA
The Free Encyclopedia



The project start

Collaboration Project

- High performance electrometer
- Share development resources towards common objective

Background

- ALBA designed first ALBA Em in 2010, which was cheaper than commercial solution with comparable resolution.
- Based on:
  - In-house developed ALBA Current Amplifier
  - Commercial microcontroller core RCM4200 (custom interface) via custom HW

= 4 ×

+

RabbitCore® RCM4200

Custom Control HW

The project start (2)

Lessons Learnt

- Obsolescence problem in microcontroller with custom interface
- No more units could be produced

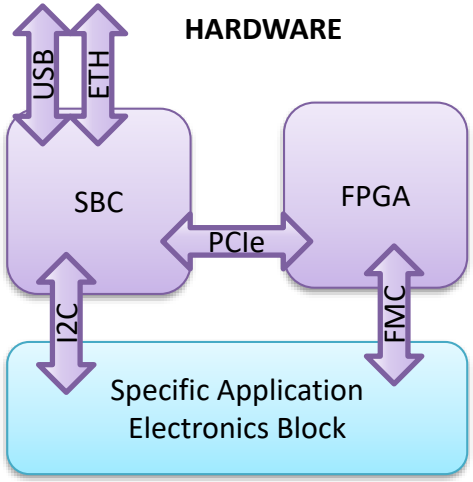
= 4 ×

+

New Strategy, design an Instrumentation Platform

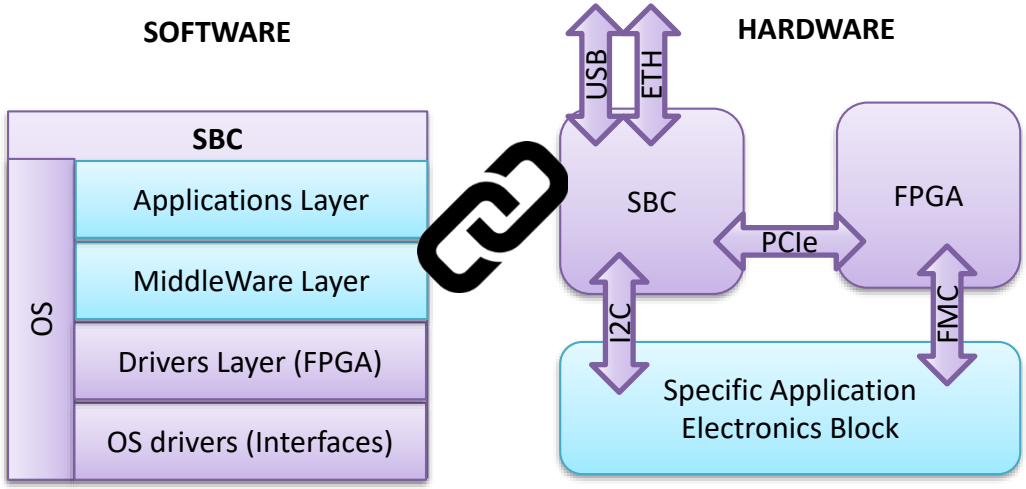
- Use a hardware interface standardization scheme
  - Reduce HW redesign impact in case of a module obsolescence
- Develop reusable SW
  - Reduce SW redesign impact in case of controller obsolescence
- Add advanced features based on the experimental needs

Instrumentation platform



- Tiny cost-effective SBC
- FPGA module (processing)
- Specific Application Electronics Block
- Use of Standard Interfaces

Instrumentation platform



- Light OS
- Driver Layers related to interfaces and FPGA
- MiddleWare and Applications layers related to the application

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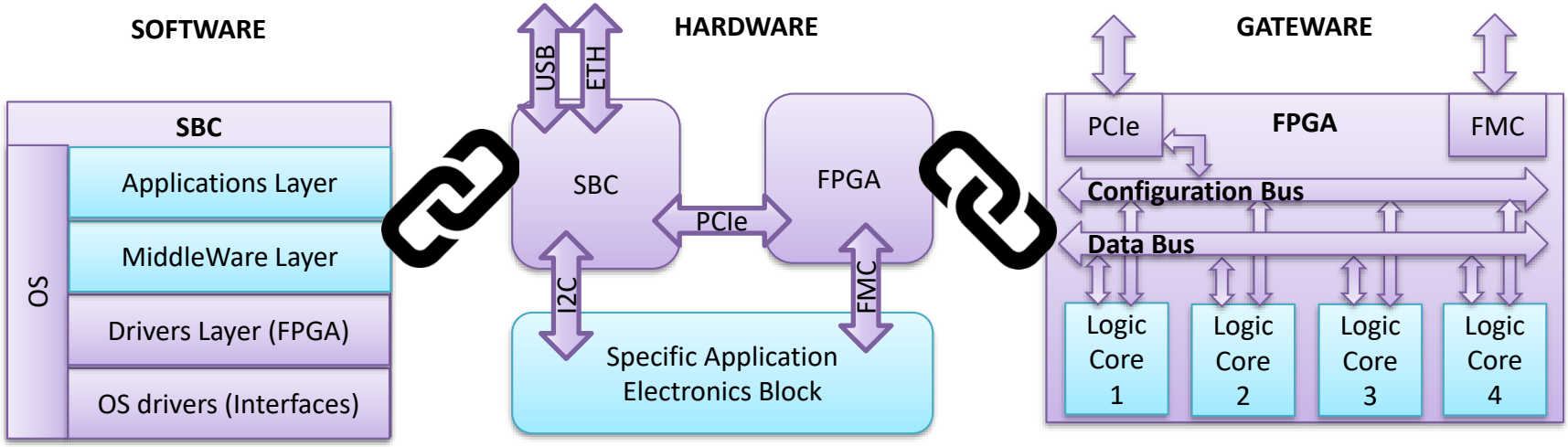
Instrumentation platform



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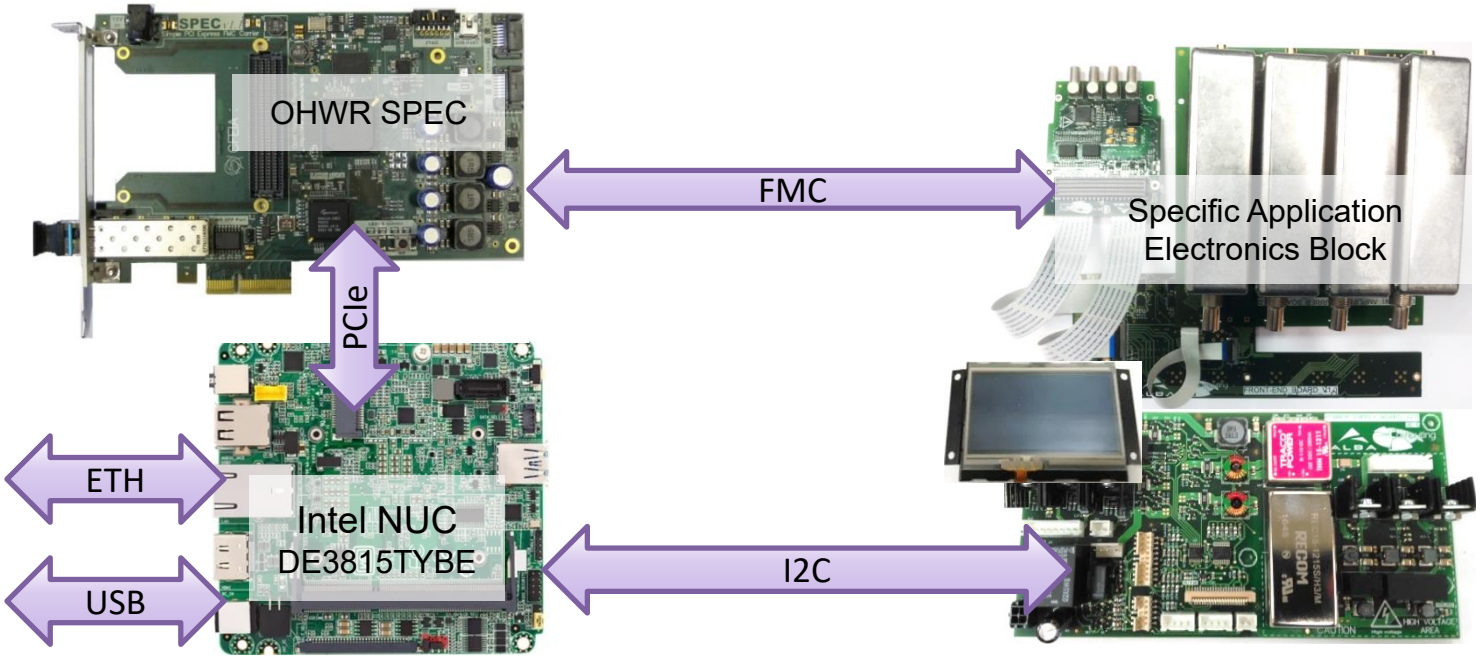
- Dual bus strategy
  - Configuration Bus
  - Data Bus
- Logic Cores related to application

General Block Diagram

- Based on expected long-life interfaces for communication between modules
- Used COTS modules, except for the specific application



HW Architecture

Commercial Electronics

- Single Board Computer Intel NUC DE3815
  - Intel Atom x86-64, 4GB DDR3L, 4GB eMMC
  - ETH, PCIe, I2C

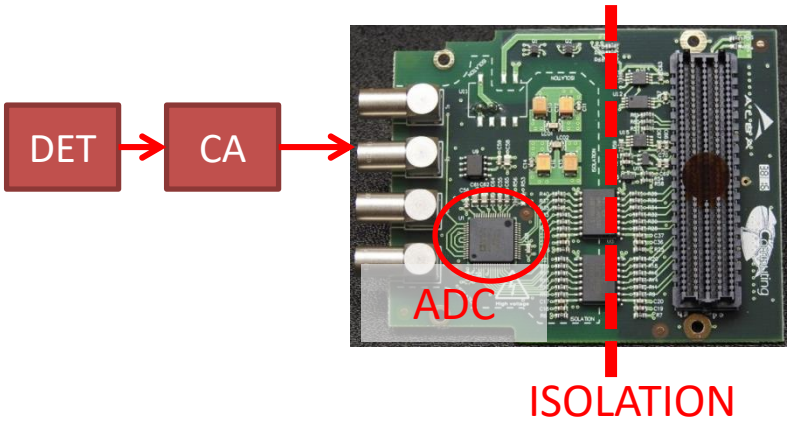
- Simple PCIe FMC carrier (SPEC) [OHWR.org]
  - SPARTAN 6 FPGA, 8Gb DDR3
  - Produced and used under CERN OHL
  - PCIe, FMC

- Display DIP128
  - HMI device
  - I2C

HW Architecture

Specific Application Electronics Block

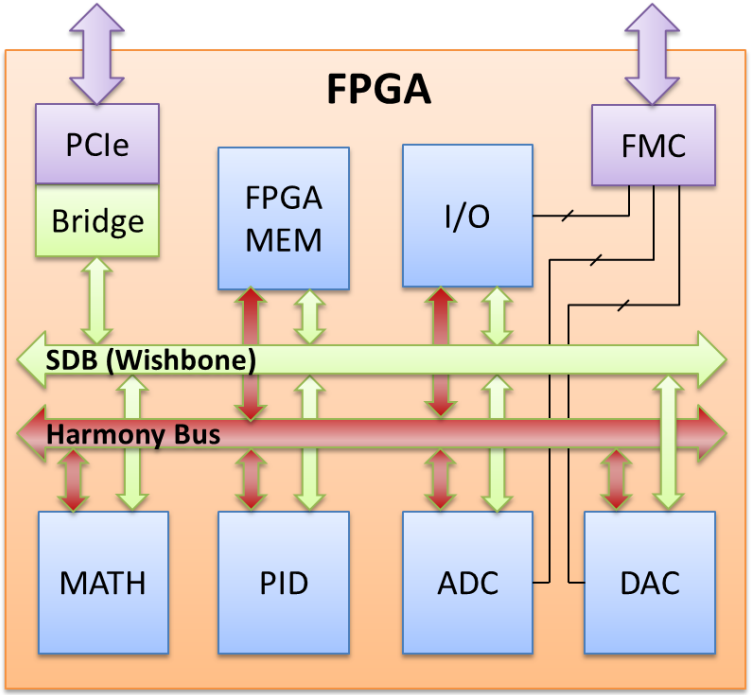
- Current sensing with ALBA Current Amplifier
  - 7 ranges from 1mA to 100pA
  - Analog output +/-10V
  - Temperature sensor for gain correction
  - Calibrated gain map in EEPROM
- Connectivity
  - 1x 200MHz Trigger IN
  - 4x 100MHz configurable I/O
  - 9x 20MHz differential configurable I/O
  - 4x 100kHz Analog Outputs
  - 4x 5V@500mA power outputs
- FMC ADC 400k 18b 4cha iso [OHWR.org]
  - ADC in isolated area. Digitalization in HV Bias
  - Up to 1kV HV bias
  - Designed at ALBA and used under CERN OHL



Self-Describing Bus (SDB) & Harmony Bus

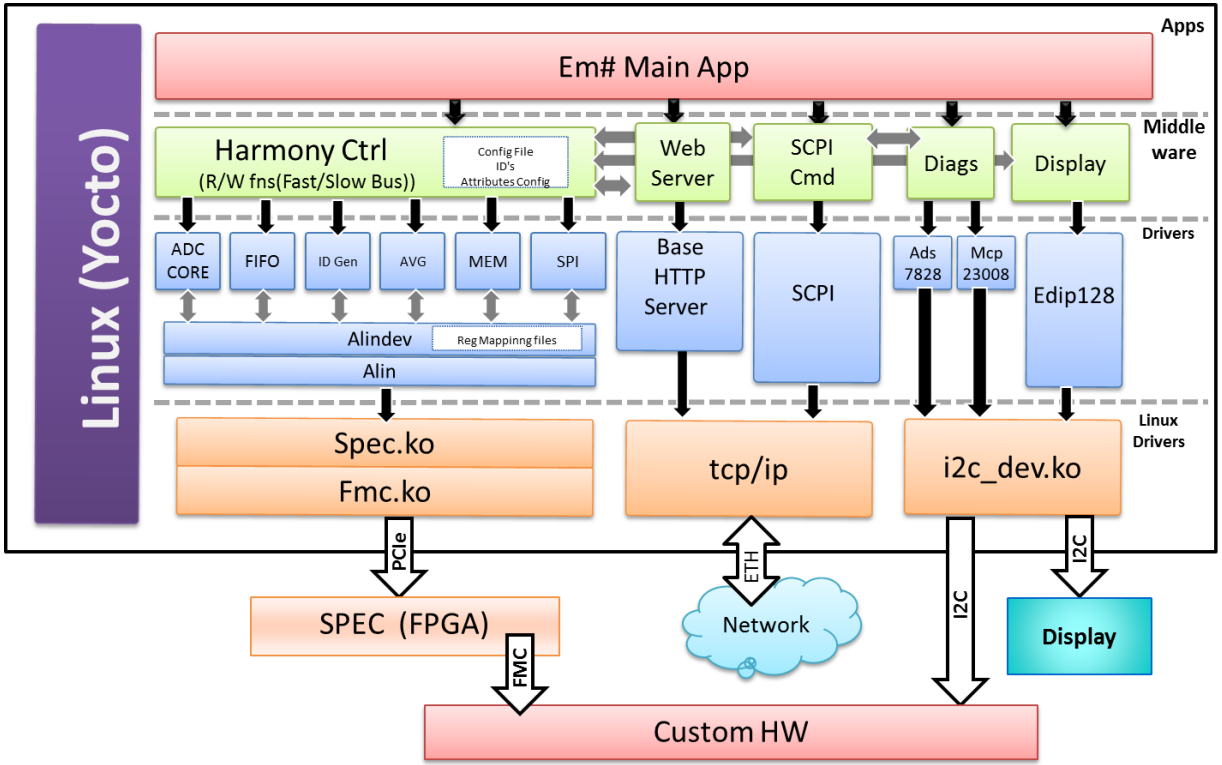
- SDB: Slow bus for configuration [OHWR.org]
  - Direct R/W of the FPGA registers and values from the SBC processor using the SDB structure and the register mapping defined in the *.wb files.
  - Implemented with a Wishbone bus.
  - Developed at CERN

- Harmony Bus: Fast bus for data [WEAPL01: M. Broseta et al. “Present and Future of Harmony Bus”]
  - Fast data transfer between FPGA cores.
  - Each FPGA core will be programmed via SDB to output data with a determined ID.
  - Each FPGA core will be programmed via SDB to react to a determined data ID present in the bus.
  - Data with timestamp.
  - Real-time processing capability.
  - Developed at ALBA.



Control System

Software Architecture



Simple applications to control the equipment

Communication protocols & Main functions: SCPI, algorithms, operations…

Physical devices drivers

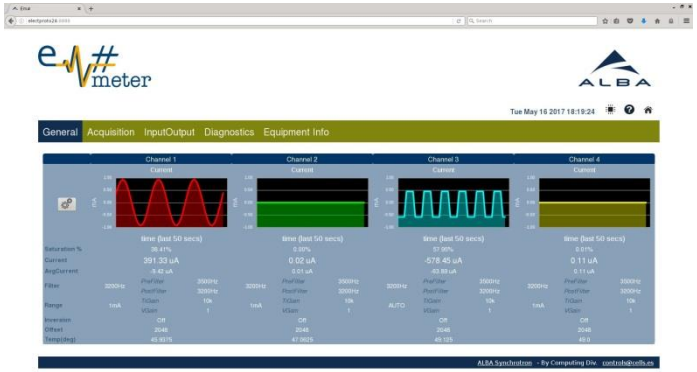
Control System

Control System Interfaces

LOCAL

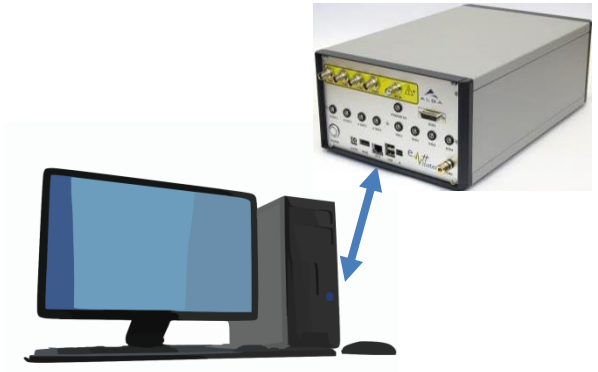
- Touch Display
- Basic configuration & monitoring

Remote (Web)



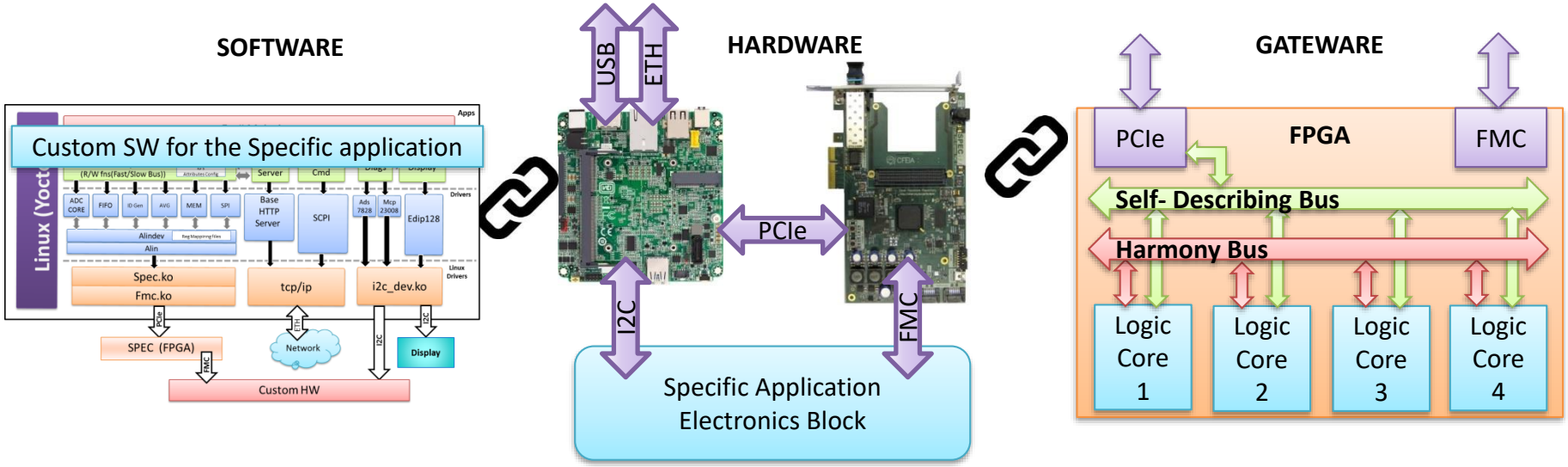
- Tornado WebServer
- Complete configuration & monitoring
- Basic acquisition

Remote



- SCPI: Set of ASCII commands for integration in the facility control system
- SSH: Developer tools to monitor and configure

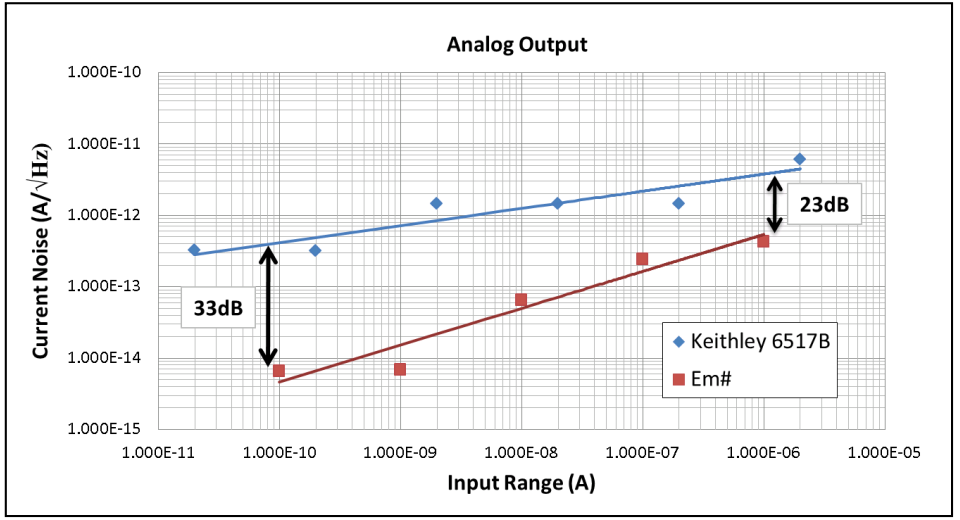
Instrumentation platform



- From a specific application development it has been created an instrumentation platform reusable for future developments.
- Only the blocks related to the specific application of the equipment should be changed.
- REUSE Software & Hardware & Gateware

Measurements

- Current Noise Density
  - Measured and calculated from Analog Out
  - Better than similar commercial electrometer



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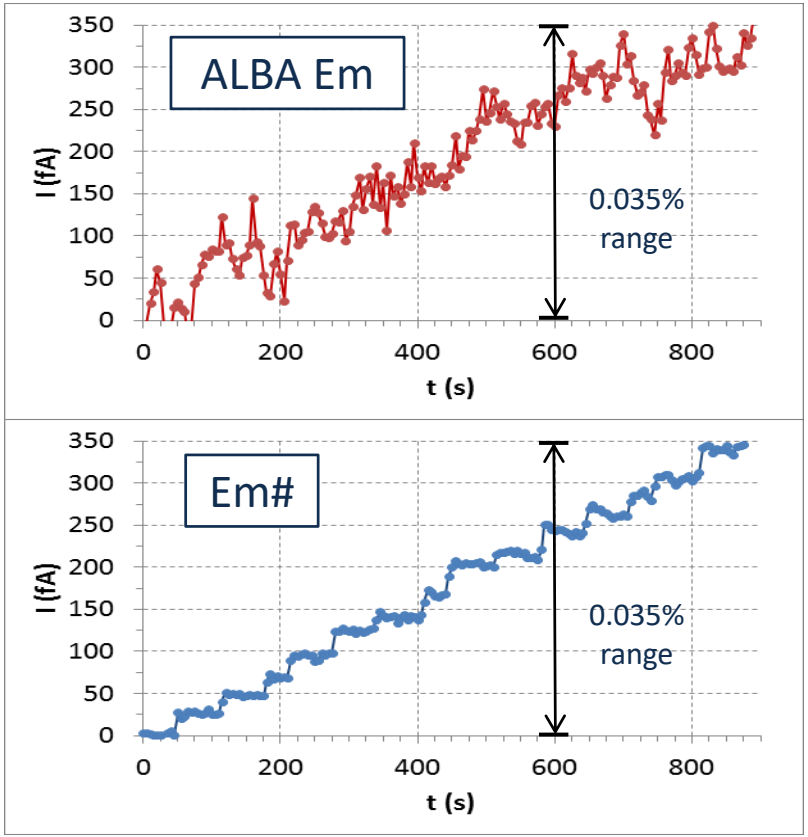
  - Input current signal with 25fA steps, 1nA range used, 0.5Hz filter, 4.8s integration time
  - Dynamic Range ~92dB



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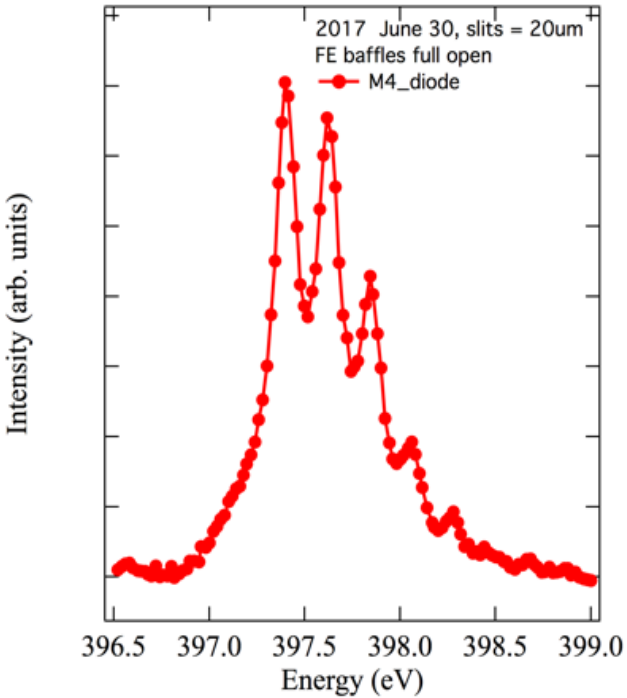
- First MAX IV Beamline Experiments
  - N2 absorption spectrum @ Veritas



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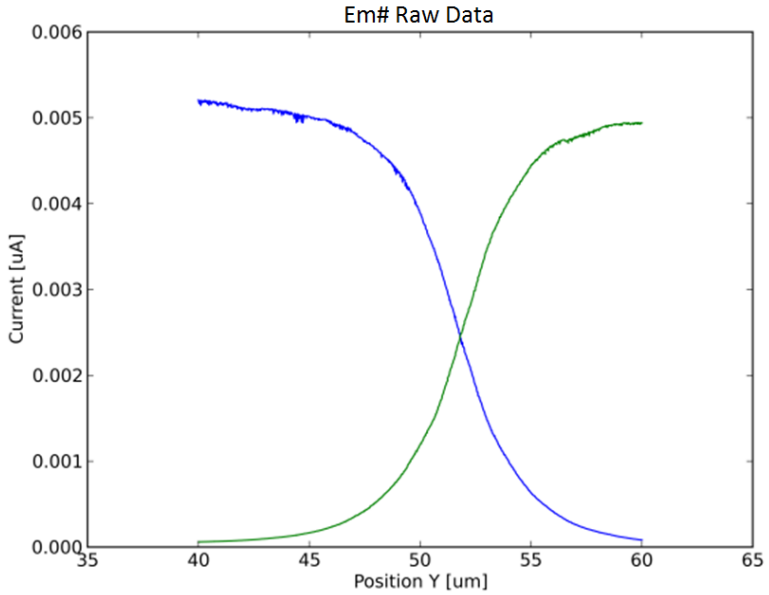
  - Beam positioning @ NanoMAX



Production & Next Steps

Production @ ALBA

- 2016 – 12 units produced (3 LV, 9 HV)
- 2017 – 12 units (planned)

Production @ MAXIV

- 2017 – 50 units produced (50 LV)
- 2017 – 25 units on-going (25 HV)

Next Steps

- Gateware and SW development for advanced Em# applications (e.g. Feedback)

Conclusions

Em# meets high performance requirements, beyond the state-of-the-art commercial electrometers

Instrumentation platform is stable, working and ready for new developments

It is time to develop advanced applications taking profit of the powerful platform

Thanks for your attention!

Questions?