

CAEN
Tools for Discovery



Electronic Instrumentation

**FERS-5200:
a distributed Front End Readout System
for multi-detector arrays**

Carlo Tintori (c.tintori@caen.it)

FERS: all-in-one readout system based on FE ASICs

- Many research groups and spin-off companies develop **ASICs** for the readout of multi-detector systems in NP and HEP applications. Sometimes, they also develop the electronic boards housing the ASICs.
- The same ASICs may become interesting for other applications, but the electronics and the relevant software must be redesigned and adapted.
- **FERS** (Front End Readout System) aims to implement versatile modules facilitating the integration of ASICs, ensuring their adaptability across diverse applications through comprehensive hardware and software provision.
FERS can be used as a stand-alone evaluation board as well as a highly scalable solution.



Off-the-shelf front-end ASIC for scientific instrumentation.

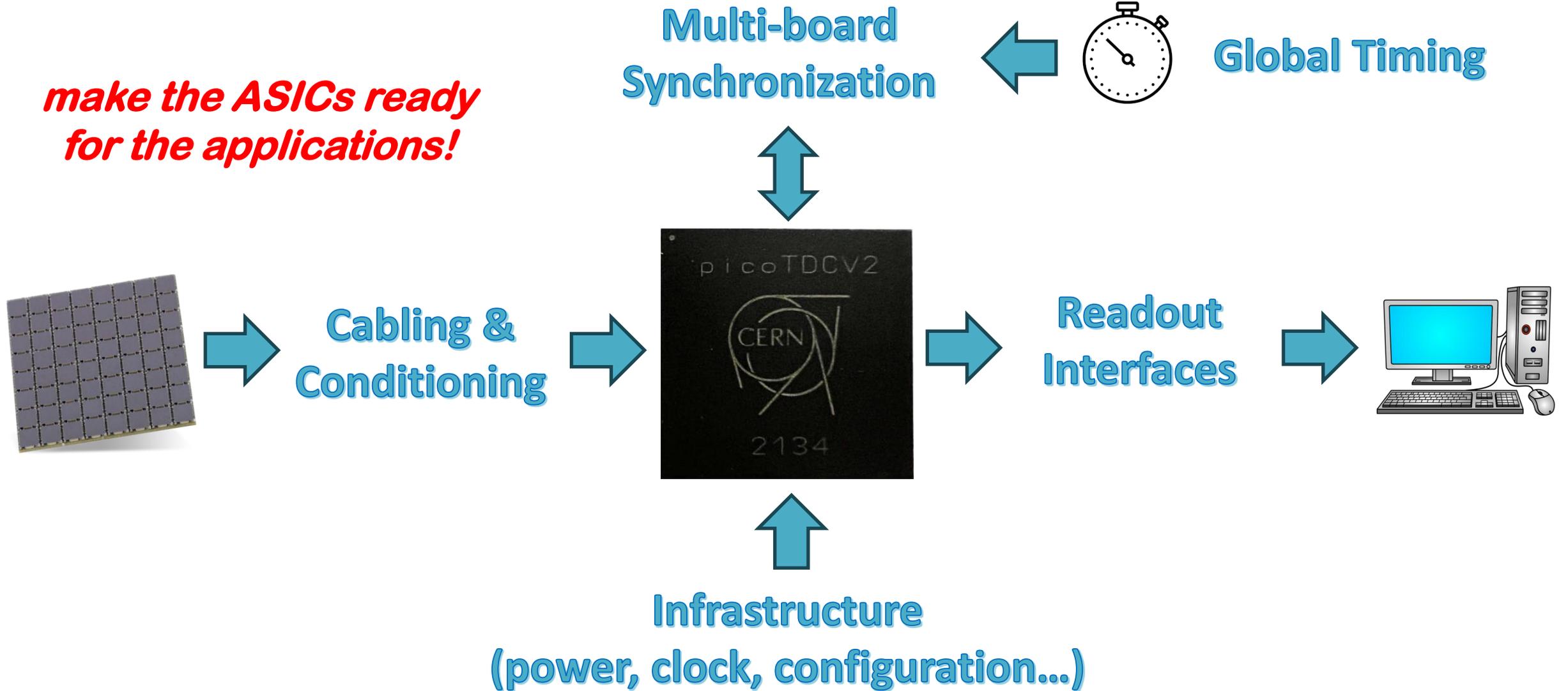
Synergies



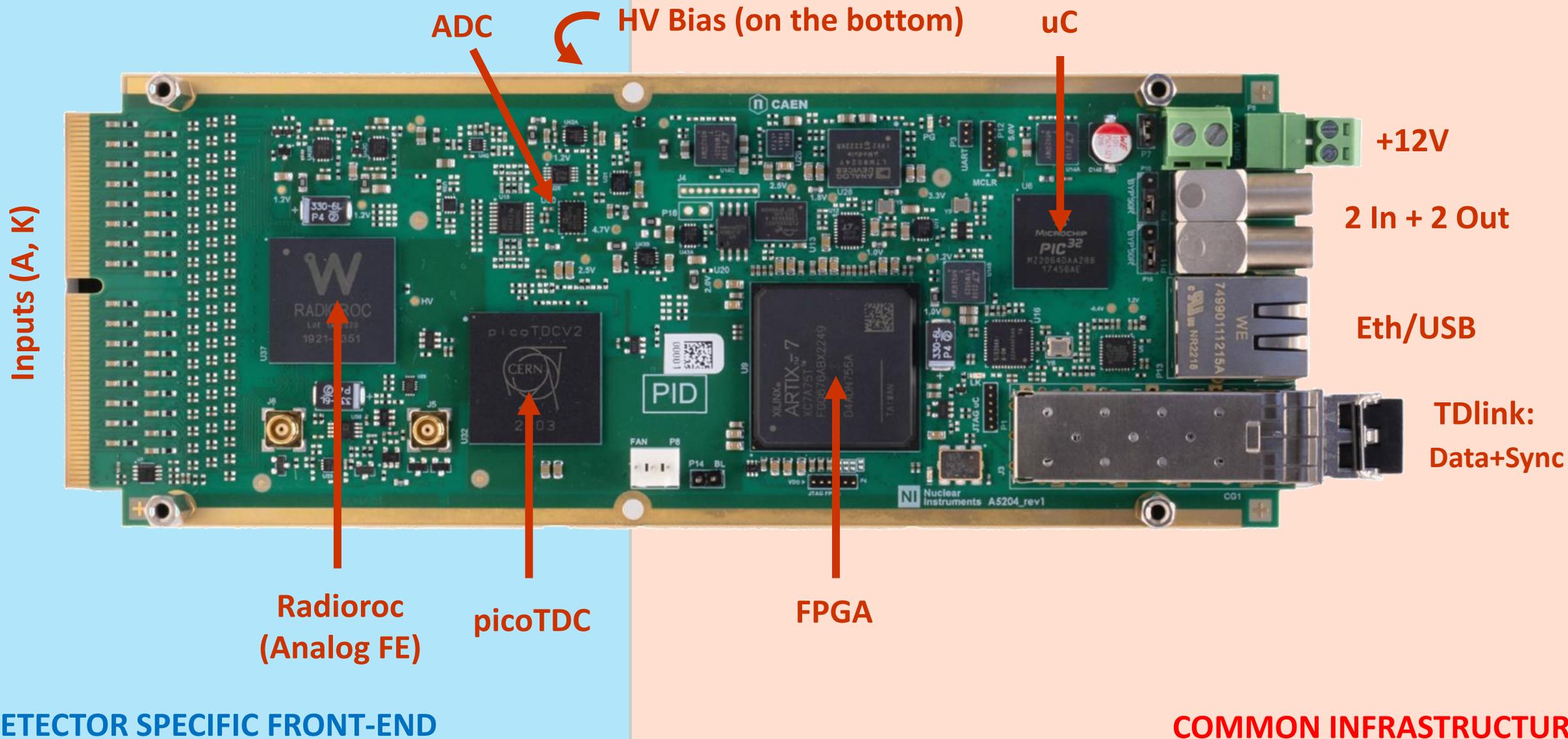
Design of Readout Electronics and Power Supply for NP and HEP

Building electronics around the ASICs

*make the ASICs ready
for the applications!*



A5204, 64 channel SiPM readout with Radioroc + picoTDC

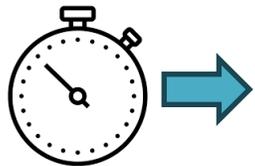


FERS scalable architecture

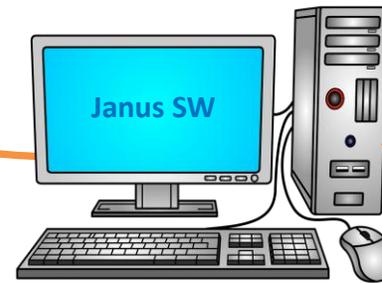
DT5215 Data Concentrator:

- 1 TDlink => up to 16 FERS
- 1 DT5215 => 128 FERS = 8k/16k ch.

Global Time



1/10G Eth
USB 3.0



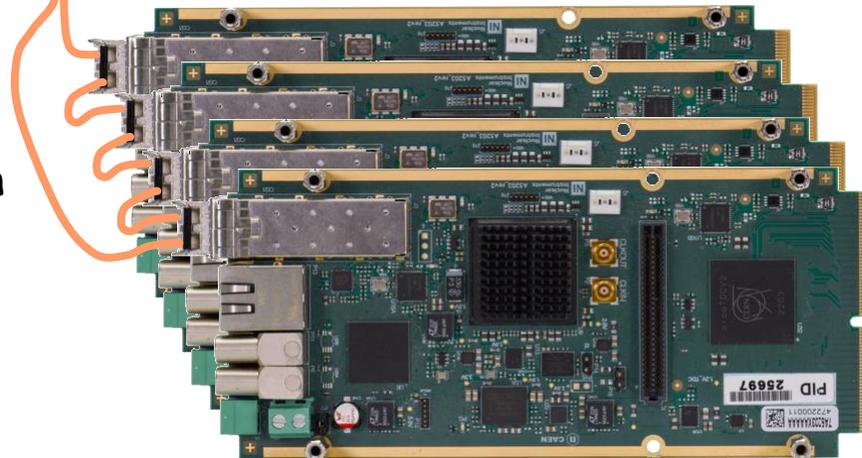
10/100M Eth
USB 2.0



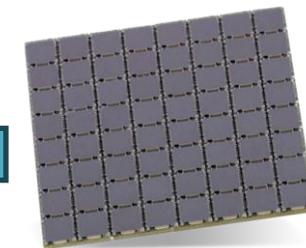
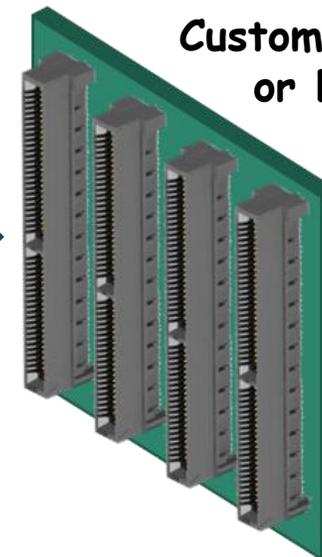
Desktop Evaluation Setup:
Low Cost, Plug & Play

Readout
+
Slow Control
+
Synchronization

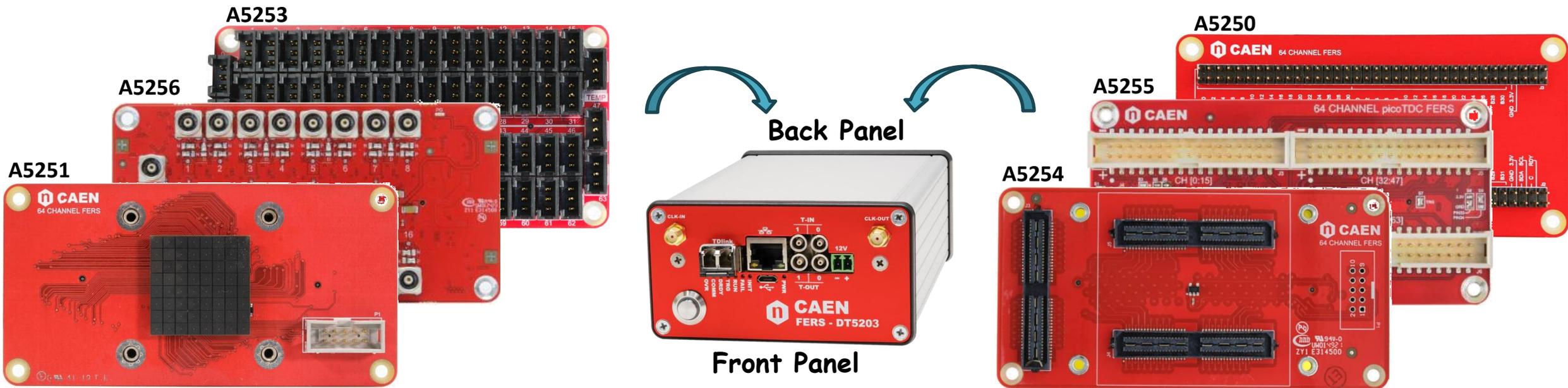
3.125 Gb/s TDlink



Custom Flange
or Backplane



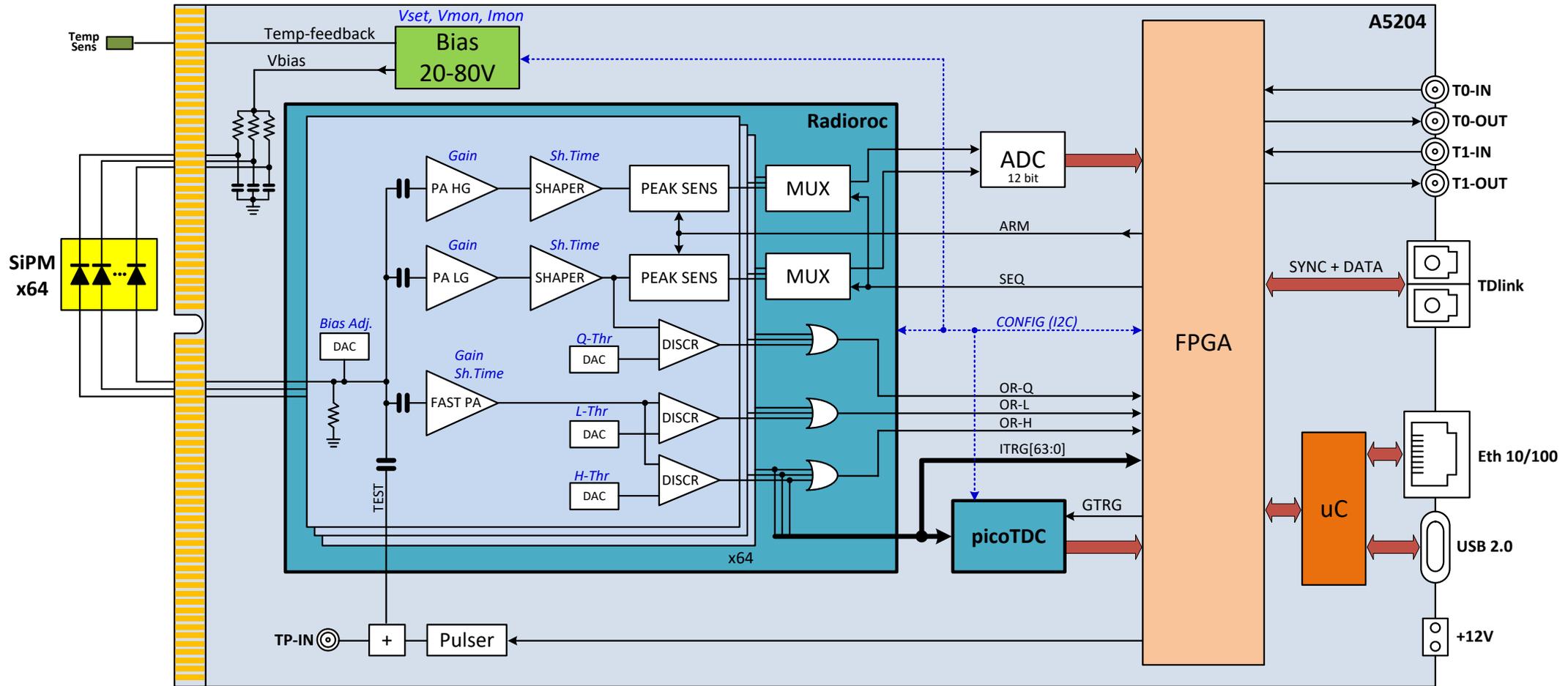
Adapters and Extensions



A5260: Remotization cable



A5204 Block Diagram



■ **SECTROSCOPY:** Preamp + Shaper + Peak ADC

- Acquisition of Pulse amplitudes (peak ADC, 8k channels). Dynamic range = 2500 p.e.
- Common trigger to all channels. Trigger source = External or internal logic based on self-triggers
- Optional Zero suppression (remove channels below a programmable threshold)
- Dead Time due to multiplexed A/D conversion (~ 20 us) => Max. trigger rate = 50 kHz

■ **TIMING:** Fast Preamp + Discriminator + TDC

- Acquisition of ToA and ToT of the discriminator outputs (min. threshold = 1/3 p.e.)
- Resolution = ~ 50 ps RMS
- ToT can be used to estimate the pulse height
- Channels are independent and self-triggered
- No dead-time

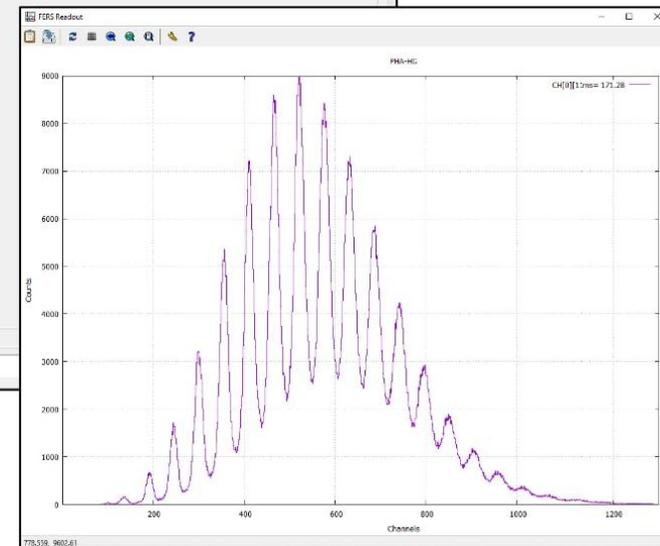
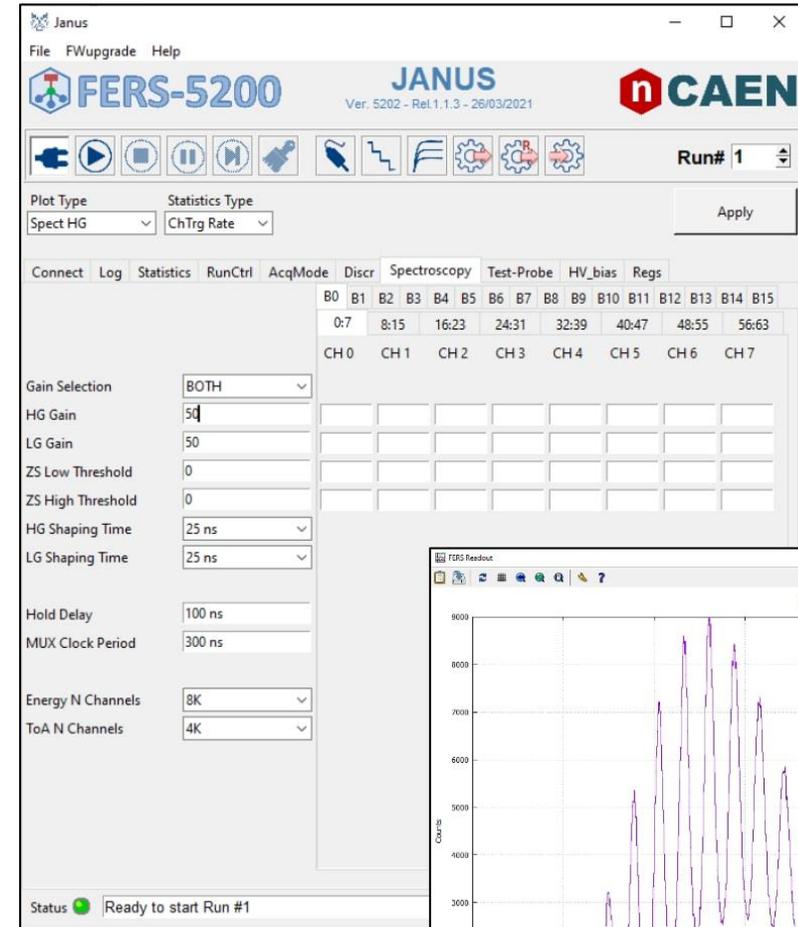
■ **SPECTROSCOPY + TIMING:** simultaneous ADC + TDC

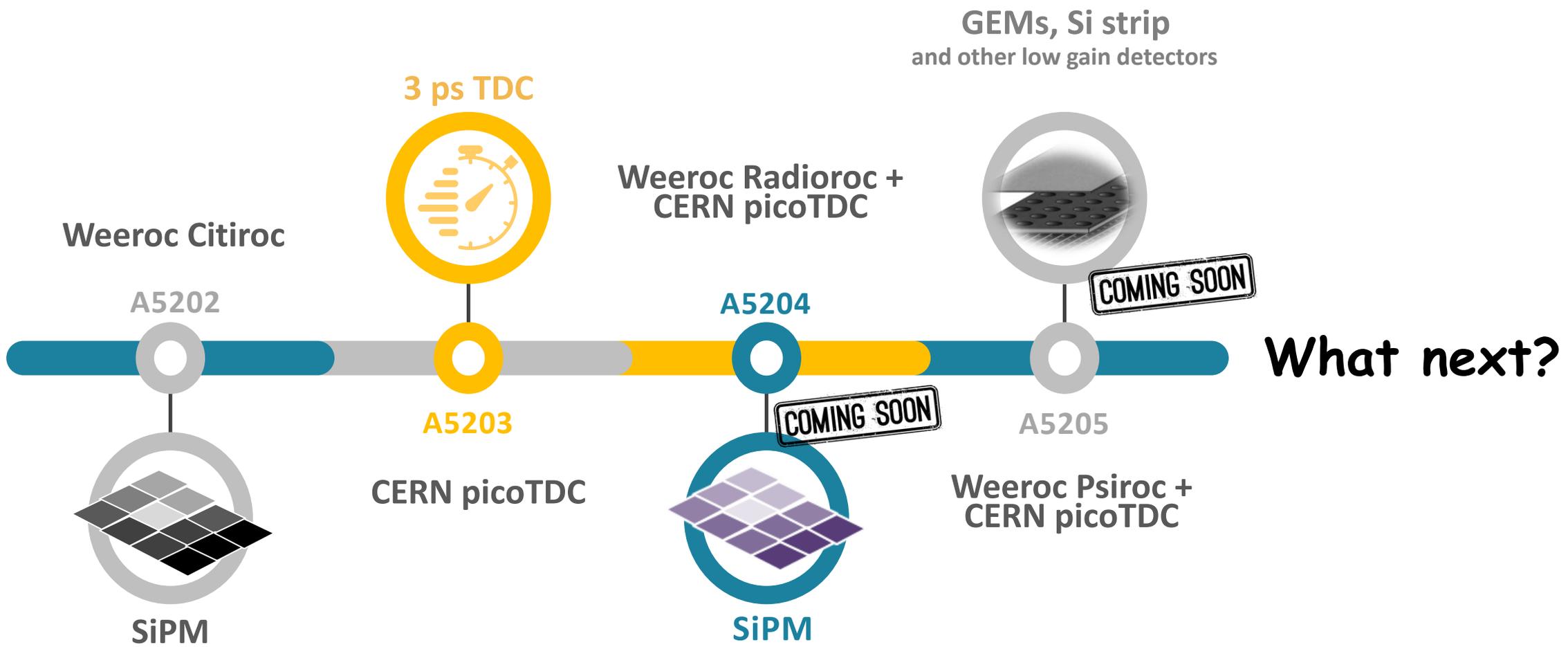
- Combination of amplitudes from ADC and ToA/ToT from TDC
- The common trigger starts the Peak ADC and opens an acquisition window for the TDC

■ **COUNTING:** Fast Preamp + Discriminator + Counter

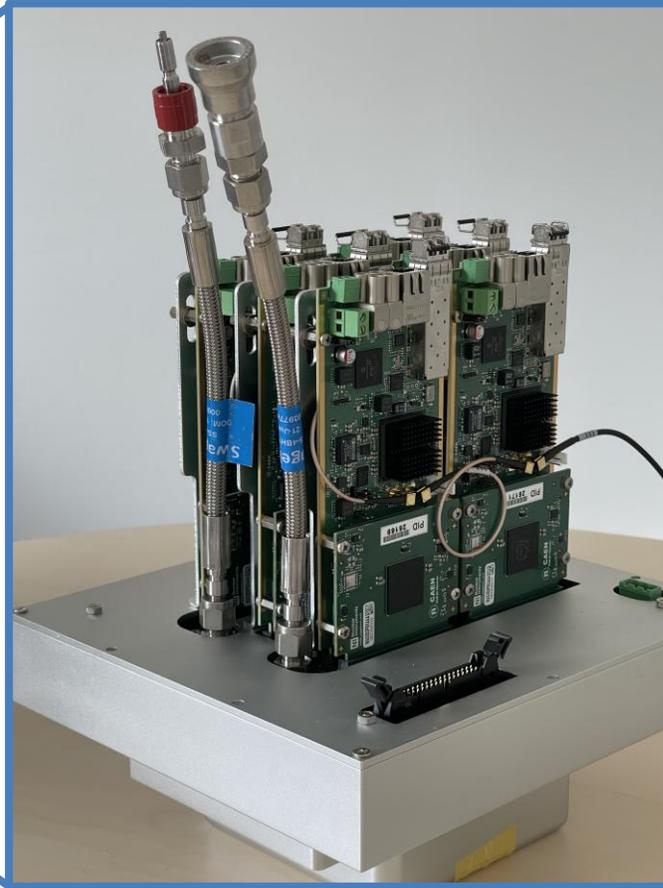
- Each channel has a 32 bit counter that counts the input pulses (i.e. discriminator outputs)
- Max. count rate = ~ 200 Mcps
- Programmable dwell time (counting period).
- Counters are latched, saved to memory and cleared at the end of every period (MCS mode)

- **Open source** software for multi-board configuration and data readout
- Python GUI and C/C++ readout program
- **SDK** for user customization (libs + demo)
- Multi parametric Jobs and Runs with time or counts preset
- Output files: lists in **.bin** or **.csv** format, spectra, raw data
- Converter to ROOT format
- Off-line runs for Post-processing and Event Building
- Live plots (with gnuplot) and statistics monitor
- Up to 300 MB/s data throughput (with DT5215 Concentrator via USB 3.0 or 10G Eth)

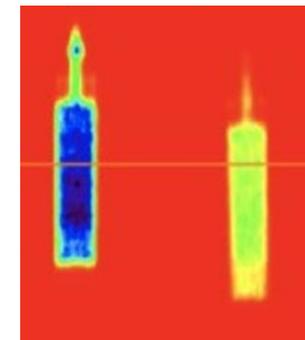
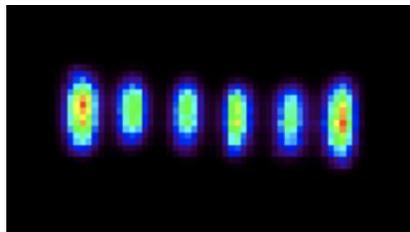
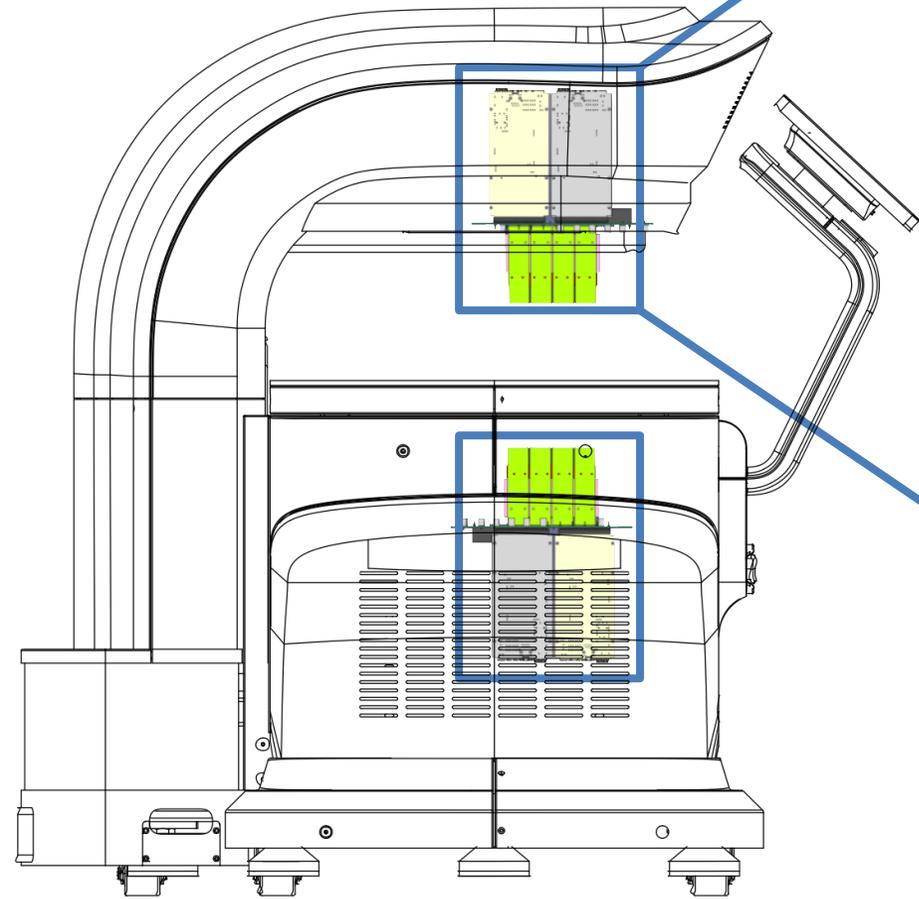




picoTech ProVision PET scanner



- 2x768 SiPM channels
- 2x6 A5203Bs (128 ch. TDC)
- 1 DT5215 Concentrator
- Precise timing and TOT measurement
- High throughput – almost zero deadtime
- ToT cut for Dark Count and noise suppression



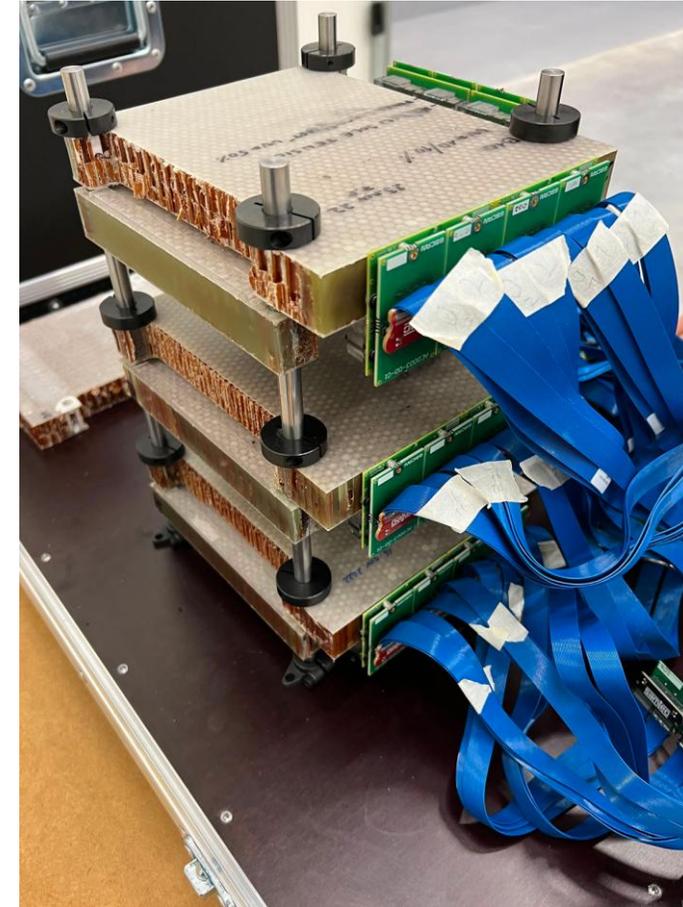
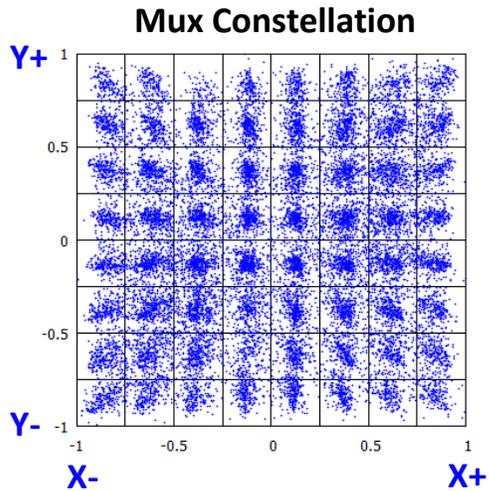
Courtesy of C. Williams

Silent Border

**Silent
Border**

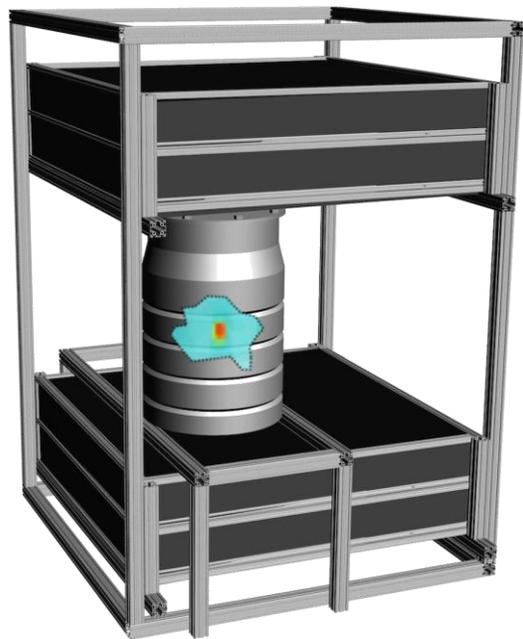
Cosmic Ray Tomograph for identification of hazardous and illegal goods hidden in Trucks and Sea Containers

- 221.184 Fibers + SiPMs
- 1 mux = 64 SiPMs = 4 FERS channels (X+, X-, Y+, Y-)
- 216 A5202 FERS units
- 3 DT5215 (Data Concentrator)

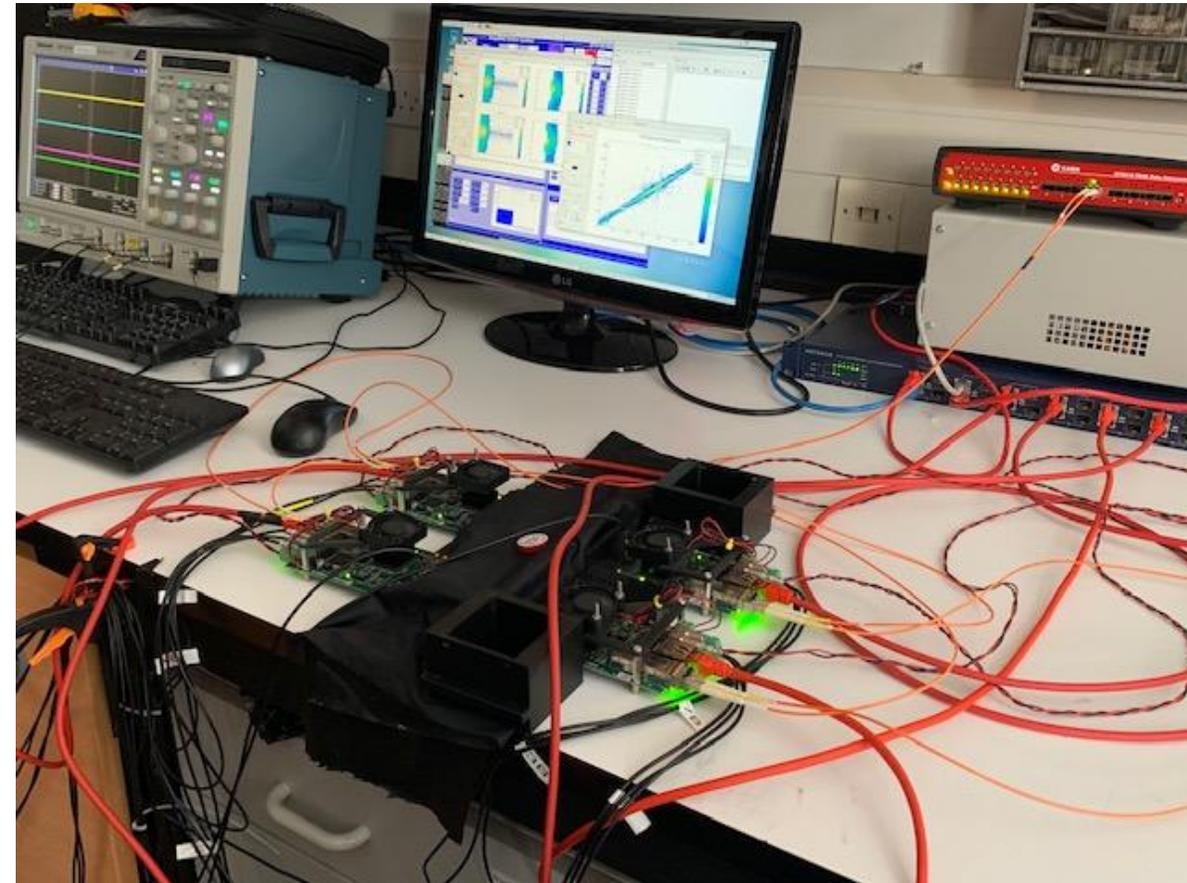


Muon tomography of nuclear waste

- Muon tomography scanner, suitable for nuclear waste characterization, by Lynkeos Technology (Scotland)
- First design with MA-PMTs and MAROC chip readout
- Device successfully deployed at Sellafield site (UK)
- Upgrading to **SiPMs** detectors in 2021 – readout electronics based on FERS A5202 (CITIROC)



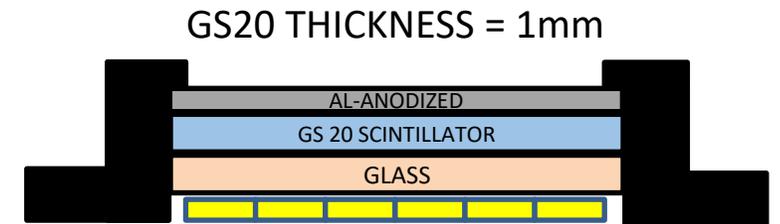
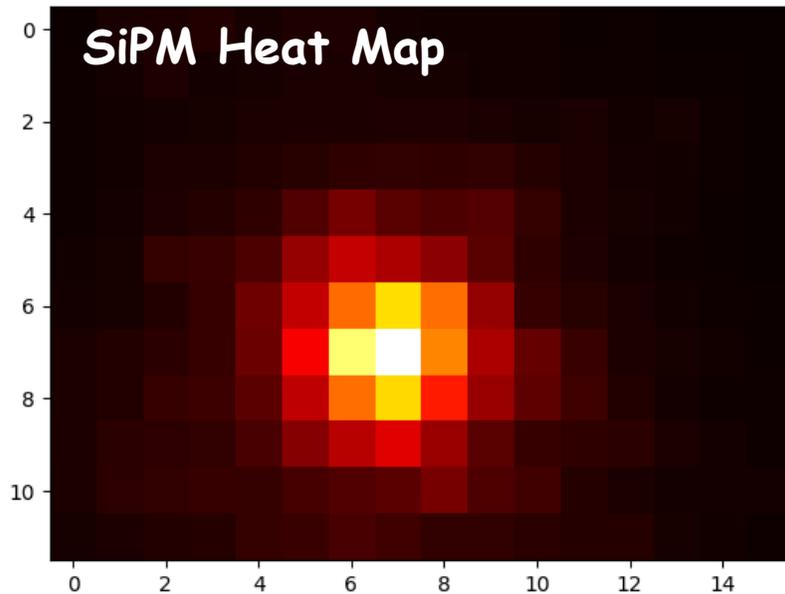
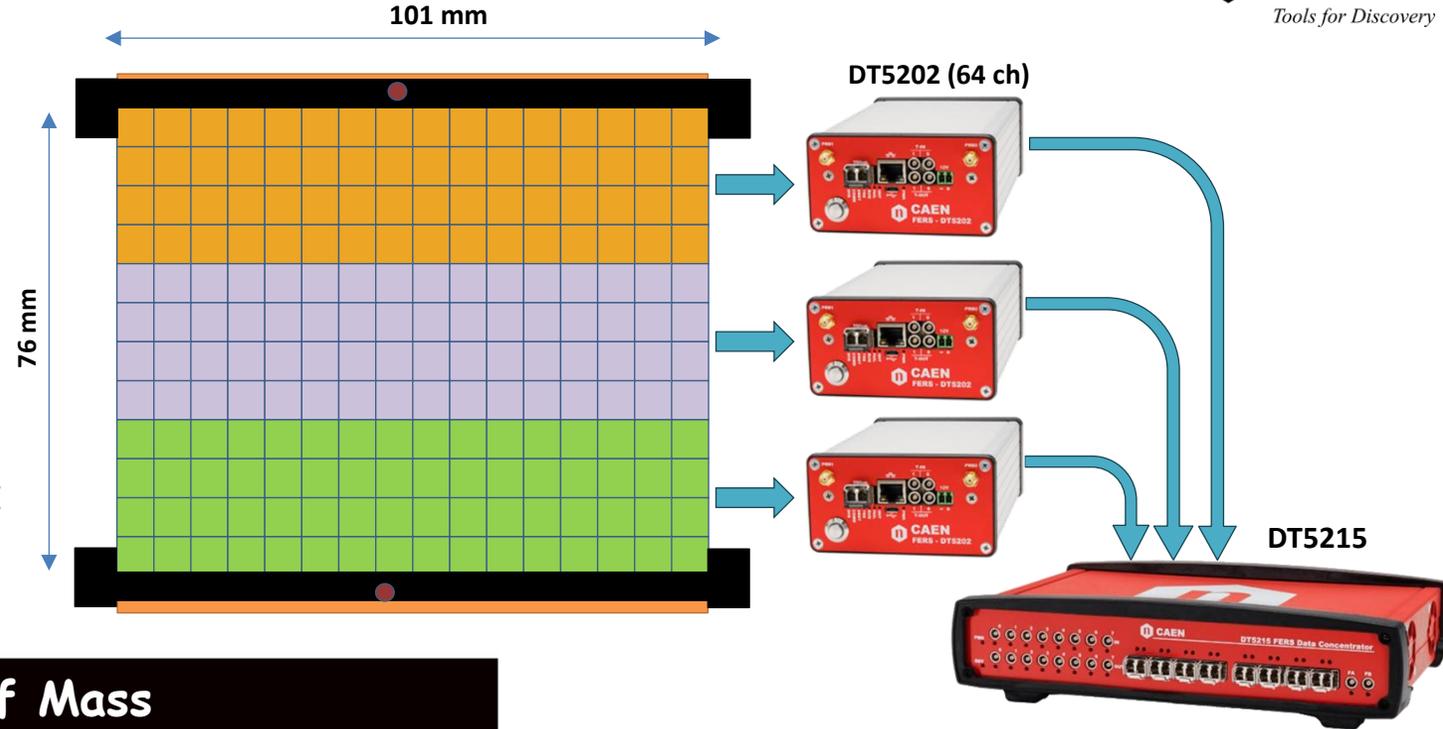
- 1024 fibers + SiPMs
- 16 A5202s + 1 DT5215
- ~ 1m x 1m active area



First-of-a-kind muography for nuclear waste characterization
D. Mahon *et al.*
Philos. Trans. R. Soc. A, 377 (2018), p. 0048,
[10.1098/rsta.2018.0048](https://doi.org/10.1098/rsta.2018.0048)

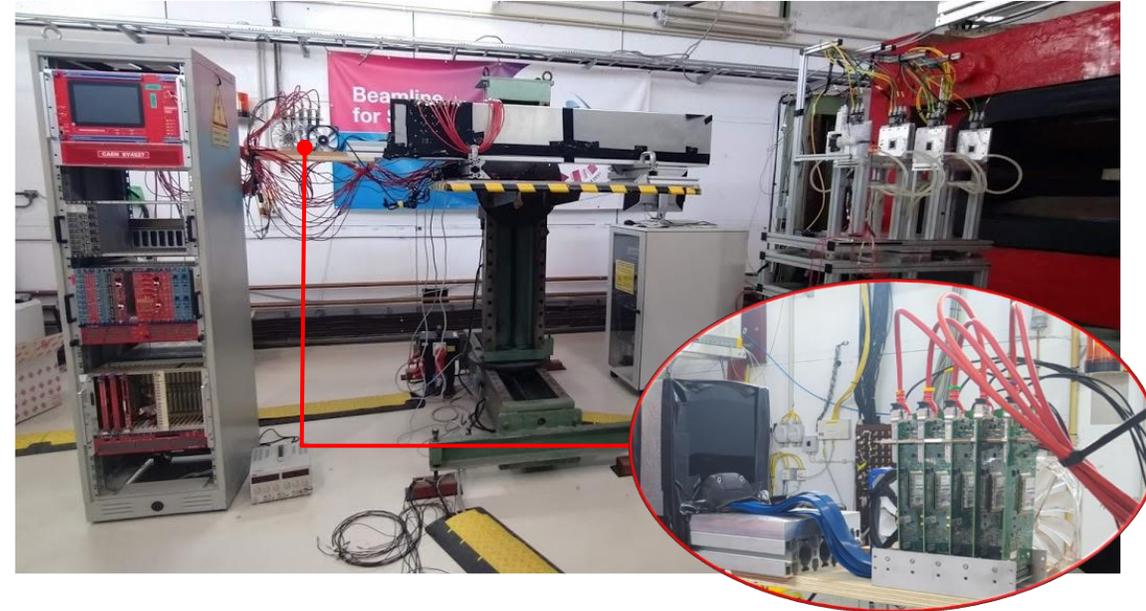
Neutron anger camera

- Based on GS20 scintillators
- 6x6 mm SiPMs, 16x12 array (192 channels)
- 3 DT5203 + 1 DT5215 Concentrator
- Majority trigger implemented in FERS cards
- Gamma discrimination based on Energy Cut
- < 1 mm spatial resolution

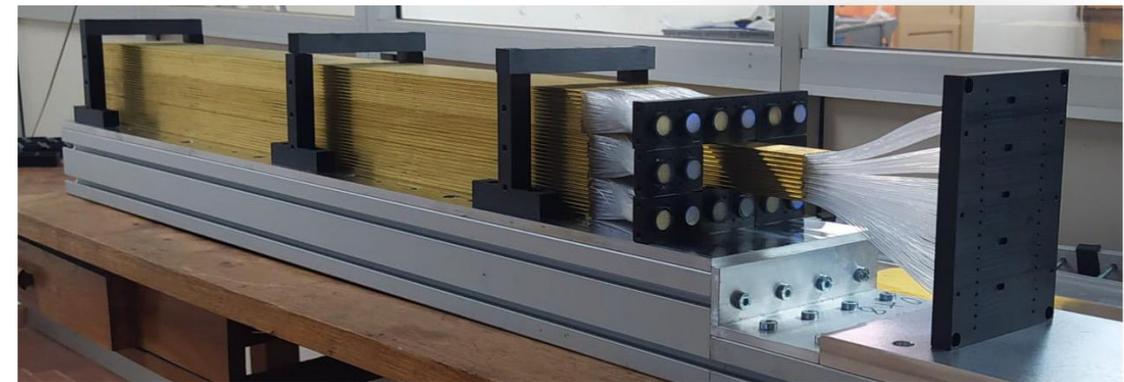
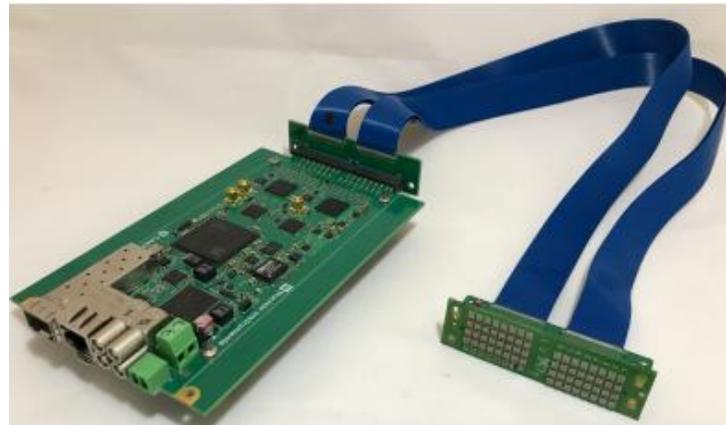


IDEA: dual readout calorimeter

- Development and testing of **dual readout highly granular calorimeter**, exploiting SiPM technology and CAEN A5202 board.
- Successful qualification of a module on beam with EM shower containment @Desy (June 2021) and @CERN (August 2021)
- Plans to **scale-up the system** to handle more SiPMs for hadronic containment



- **320 SiPM = 5 A5202s**
- **No Concentrator**
- **Sync via LEMO cable**
- **Custom SiPM holder with remotization cable**



Courtesy of R. Santoro

<https://indico.ihep.ac.cn/event/14967/contribution/1/material/slides/0.pdf>

Thank you!