

**CAEN**

*Tools for Discovery*



**Electronic Instrumentation**

# Introduction to CAEN

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# Summary

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- ❑ General intro to CAEN group
- ❑ Details about Power Supply R&D group
  - ❑ High reliability
  - ❑ Hostile Area
- ❑ Details about Data Acquisition R&D group
  - ❑ Digitizers
  - ❑ Front-End Readout System (FERS)
  - ❑ OpenFPGA



# CAEN group

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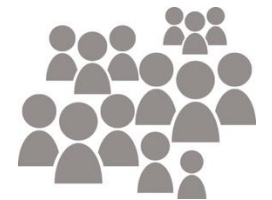
Founded in 1979, CAEN S.p.A. (Costruzioni Apparecchiature Elettroniche Nucleari) is an important industrial spin-off of the INFN.  
Core business: Electronic Instrumentation for physics experiments (world leader)

Spin-off activities:

- CAEN SyS – CAEN Spectroscopy Division (2016)
- CAEN RFID s.r.l. (2003)
- CAENels s.r.l. (2010)
- CAENqS s.r.l. (2012)

**Total Employees** (production not included)

- **186 People**
- 18 Ph.D.s
- 91 Master's Degrees
- 67 Bachelor's Degrees
- 10 Technicians





# Worldwide presence

Worldwide sales network offices in Italy, Germany, USA, Distributors in more than 30 countries.

Portfolio: > 5000 customers

Customers include all world leading research centres as:

Europe: CERN, INFN, CEA, CNRS; GSI, ESO, ISIS, Ganil, PSI, ...

USA: FNAL, SLAC, Los Alamos, BNL, Jlab, ...

Asia: J-Parc, KEK, Riken, IHEP, TIFR, ...

Africa: iThemba Labs, ...

And private companies.





# Key strengths

## > Product Development

- R&D
- System Integration
- Custom Design

## > Test and Calibration

## > After sales Services

- Maintenance
- Support



# Innovative Project Division

CAEN is involved in many R&D projects:

- ❖ researchers exchange programs like **MCSA**
- ❖ **EURATOM** projects for nuclear power plants
  - ❖ Decommissioning
  - ❖ Waste characterization
  - ❖ etc.
- ❖ Horizon-Europe
  - ❖ Border Security
  - ❖ **Research Infrastructures**
  - ❖ etc.





# JENNIFER2 contribution

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We bolstered our presence in Japan, enabling us to gather valuable insights into the research conducted in the Far East nation.

Regrettably, the COVID-19 pandemic disrupted our plans, resulting in a diminished participation in terms of personnel and visits compared to anticipated levels.

Despite these challenges, we successfully collected valuable information and feedback, which will be instrumental in refining our strategic research and development roadmap.



# DEEPER DIVE INTO CAEN PRODUCTS

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# Power Supplies

## Power Supply Families

SYx527 Universal  
Multichannel Systems



NIM HV power supplies



VME HV power supplies

Desktop and Rack power  
supplies



PCB and Compact power  
supplies



EASY – hostile area power  
supplies

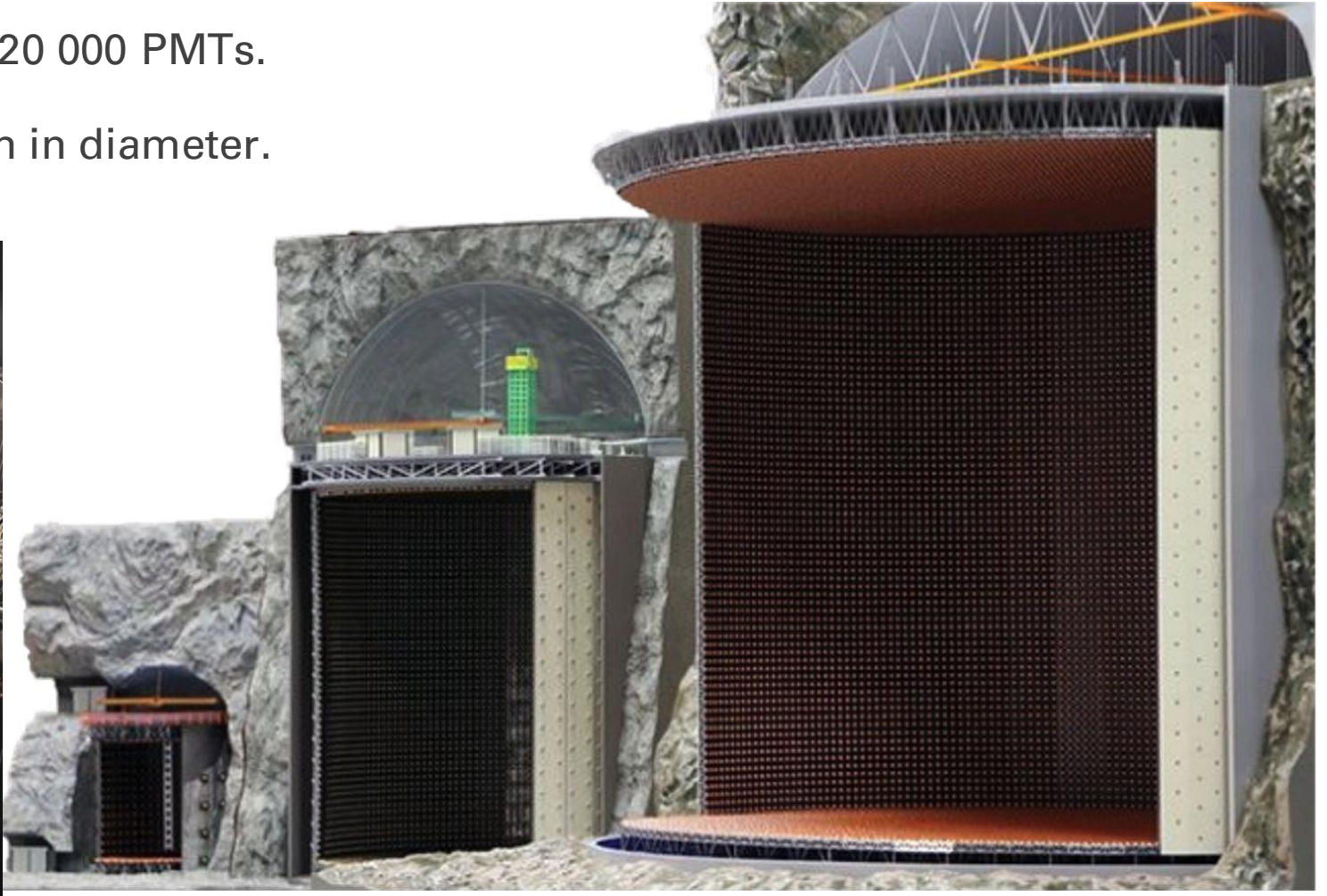
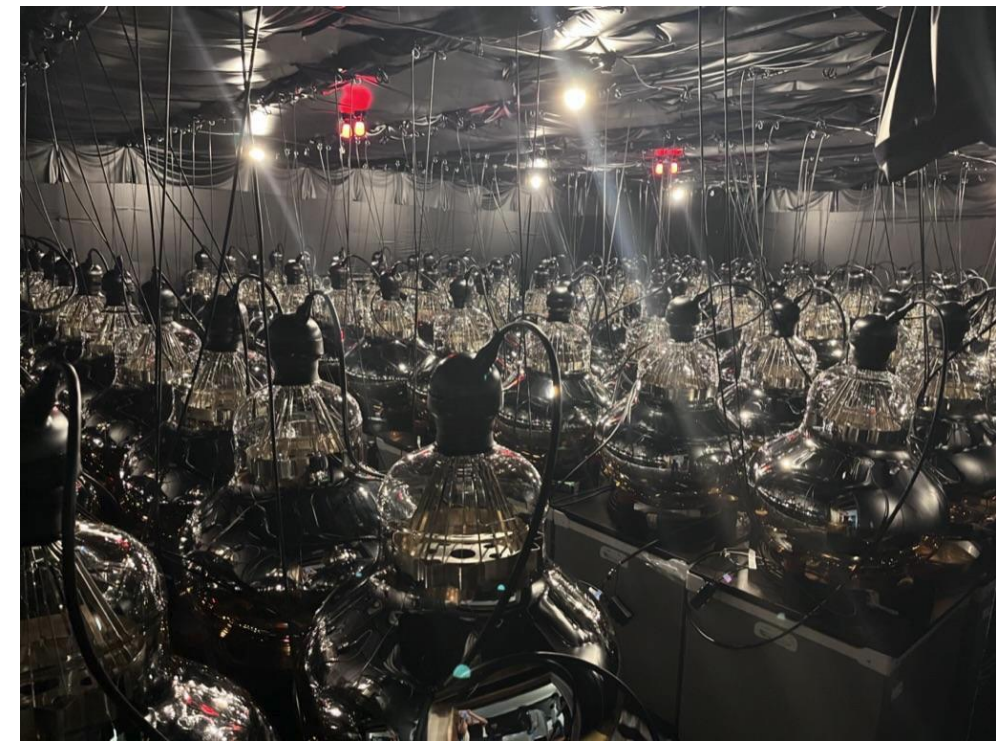




# Hyper-Kamiokande

258 kt Cherenkov detector with ~20 000 PMTs.

The tank is 71 m in high and 78 m in diameter.

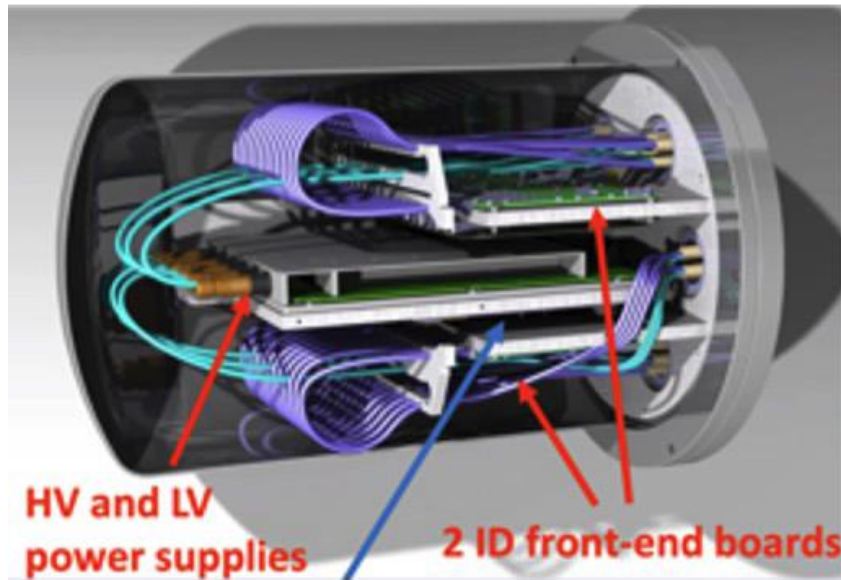






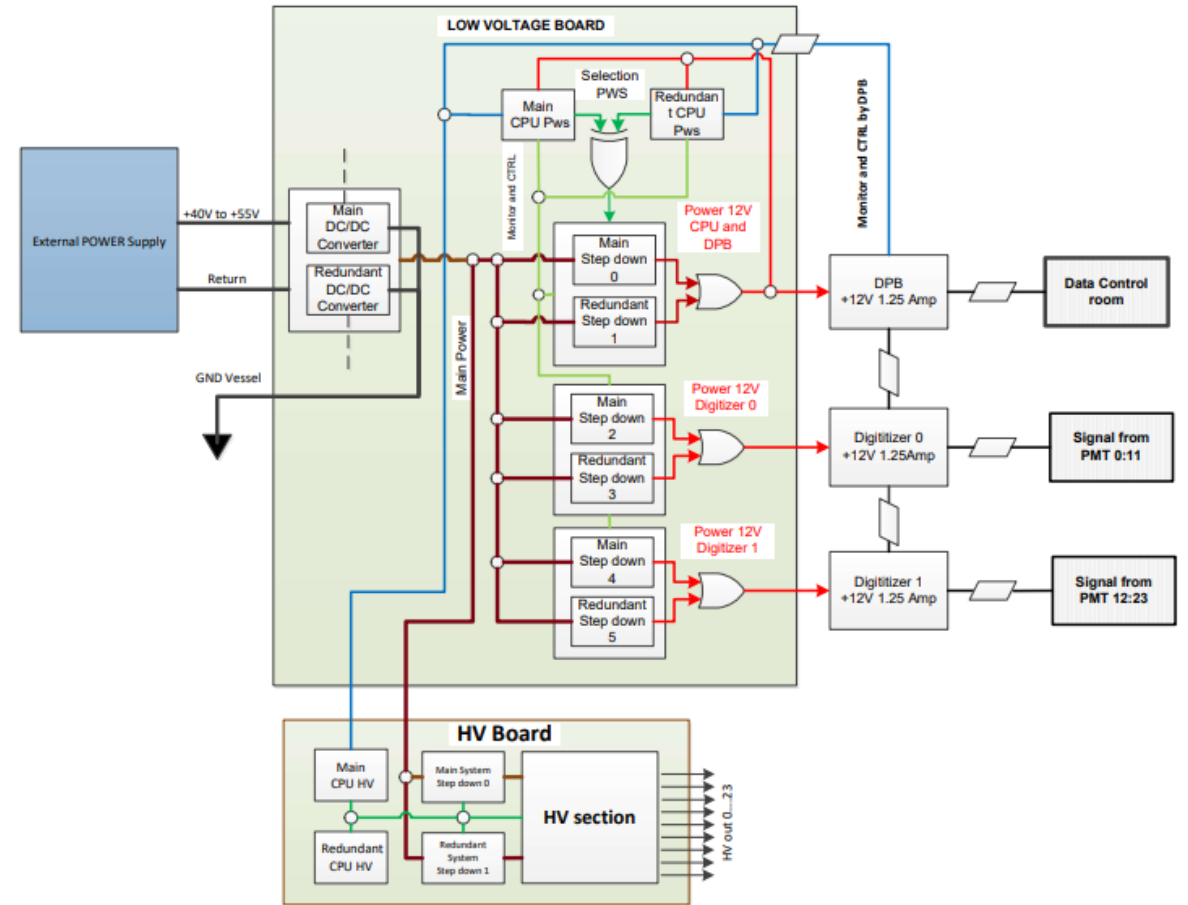
# CAEN contribution

HV and LV boards were designed and are being produced by CAEN.



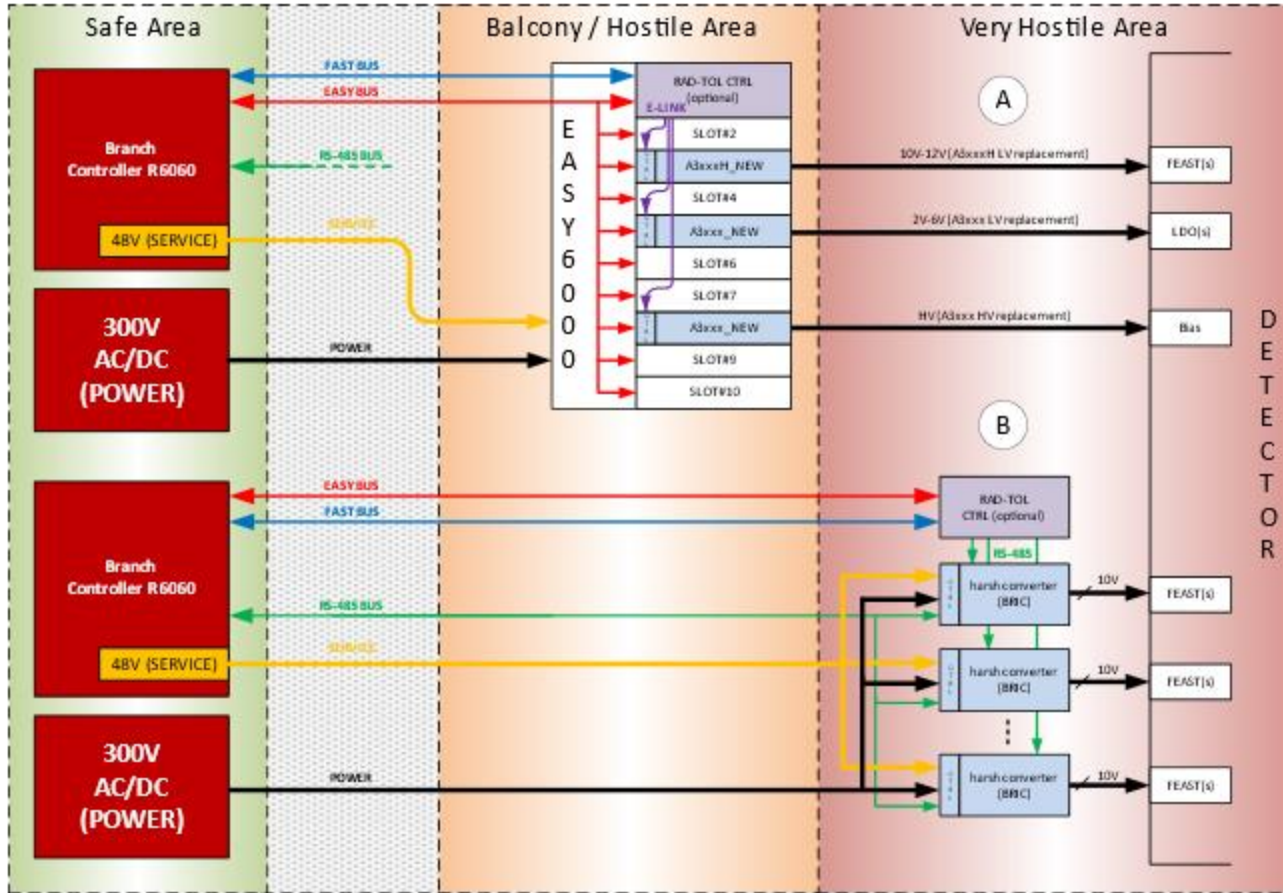
**HV and LV power supplies**  
**2 ID front-end boards**

**Data processing and timing boards**





# Power Supplies for Hostile Enviroment



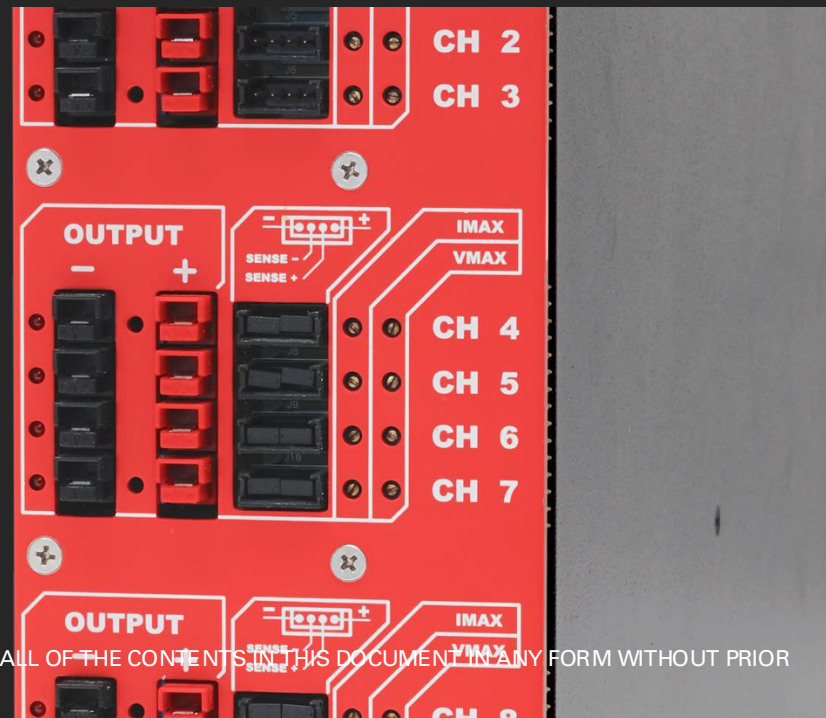
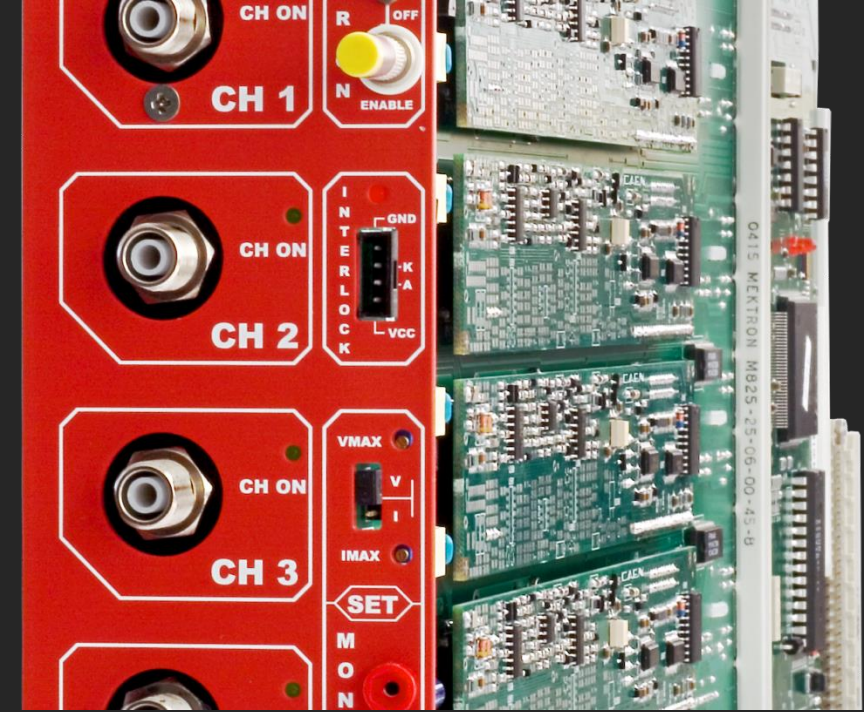
- **Extremely flexible architecture**, allowing more configurations than the previous generation
- **New harsh converters** for Very Hostile Area (>200 Gy) to be placed closer to the detector (~m) optimizing cable power loss
- **New faster** connection to DCS thanks to the brand new R6060 branch controller with Gb Ethernet
- **More power** thanks to a 300V bulk power line from service to experimental caverns:
- 6x higher voltage -> 6x less current -> **much less cable** area to have the same power efficiency or much better power efficiency keeping the same cables



# Novel R&D for Hostile Environment

Designing and validating new modules for HL-LHC.

- ❑ Low Voltage high power boards
- ❑ Multi-channels High Voltage boards
- ❑ Custom mixed LV-HV boards

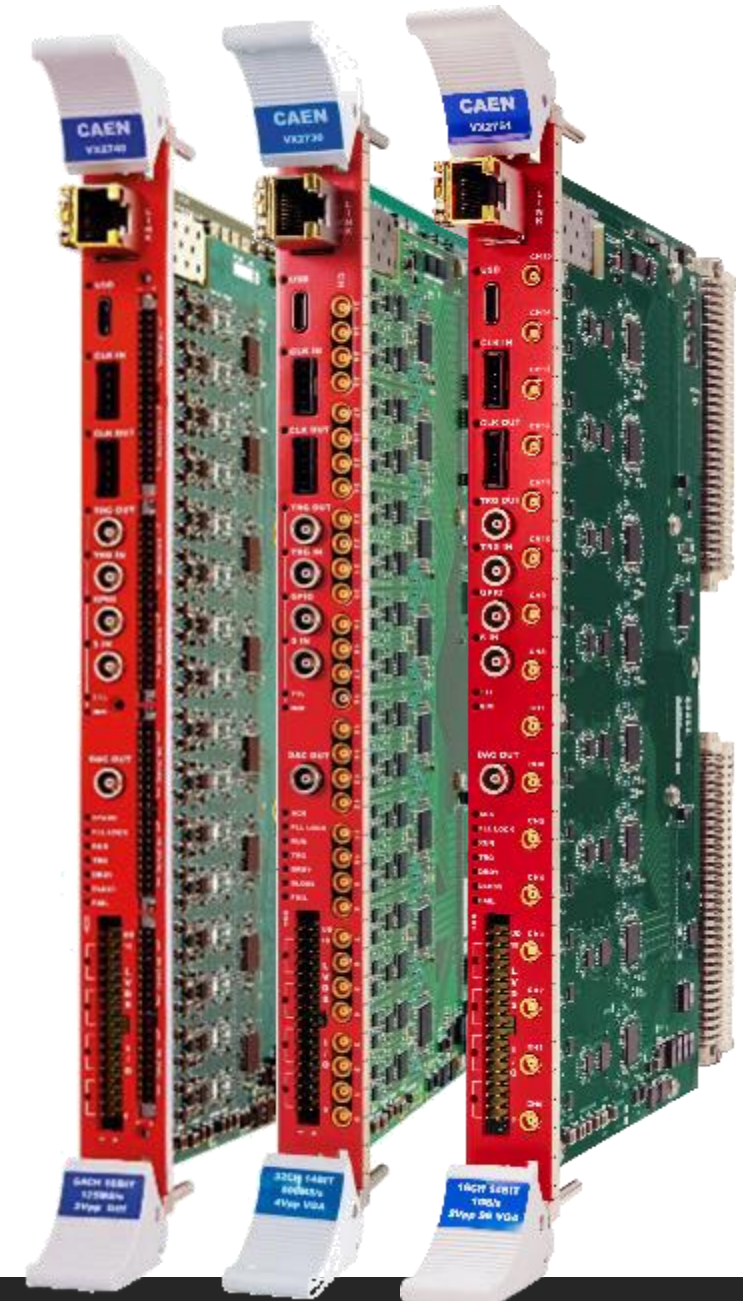




# Digitizer 2.0 - Flavors

	2740/2745	2730	2751
Channels	64	32	16
Sampling	125 MS/s @ 16 bit	500 MS/s @ 14 bit	1 GS/s @ 14 bit
Variable Gain Amplifier	x100 (2745 only)	x20	x10
Max record length	84 ms per channel ( <i>extendable by disabling channels, WIP</i> )		
Applications	<ul style="list-style-type: none"><li>• PMT with slow scintillators (e.g. NaI)</li><li>• Spectroscopy with segmented Si and HPGe</li><li>• Dark Matter and Neutrino experiments</li></ul>	<ul style="list-style-type: none"><li>• High Resolution Timing</li><li>• Fast detector readout (PMT, SiPM, etc...)</li><li>• Pulse Shape Discrimination with liquid and plastic scintillators (n/y discrimination)</li><li>• Multi parametric acquisition (Energy + Time + PSD)</li></ul>	

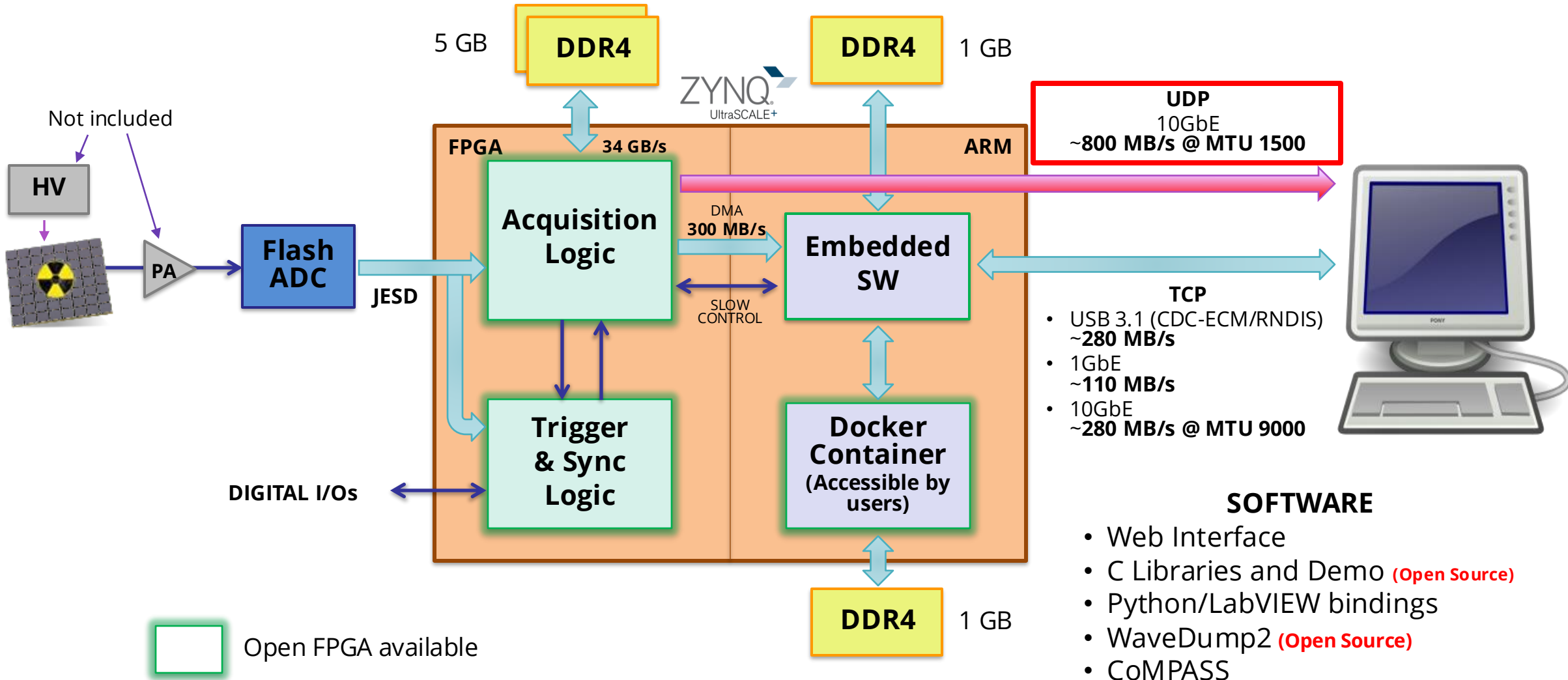
New families coming soon! Stay tuned!







# Digitizer 2.0 - architecture

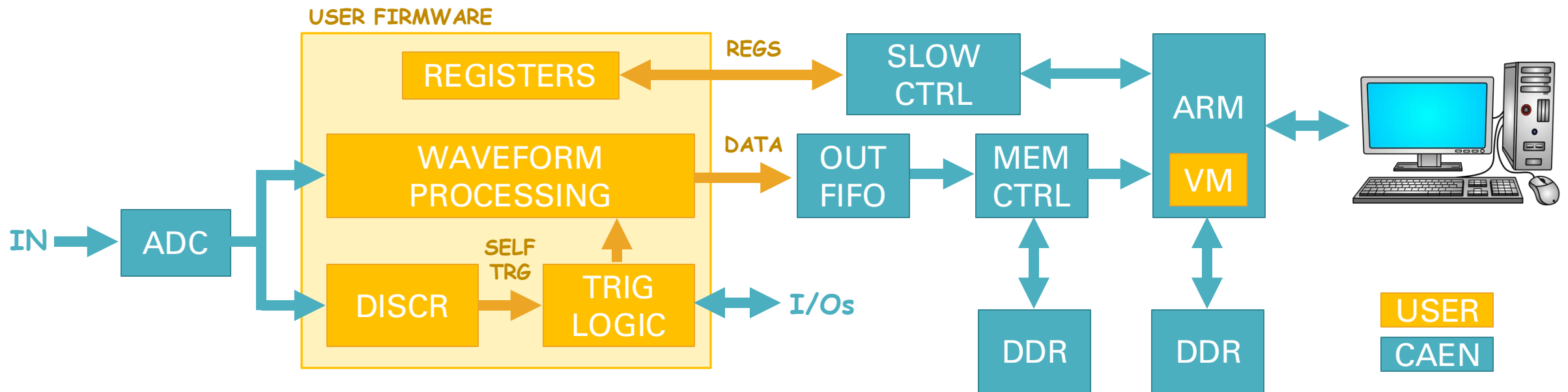




# Open FPGA

**We** provide infrastructure: ADC data flow, data buffering and transfer, slow control

**You** implement your algorithms for data processing, parameter extraction and trigger logic

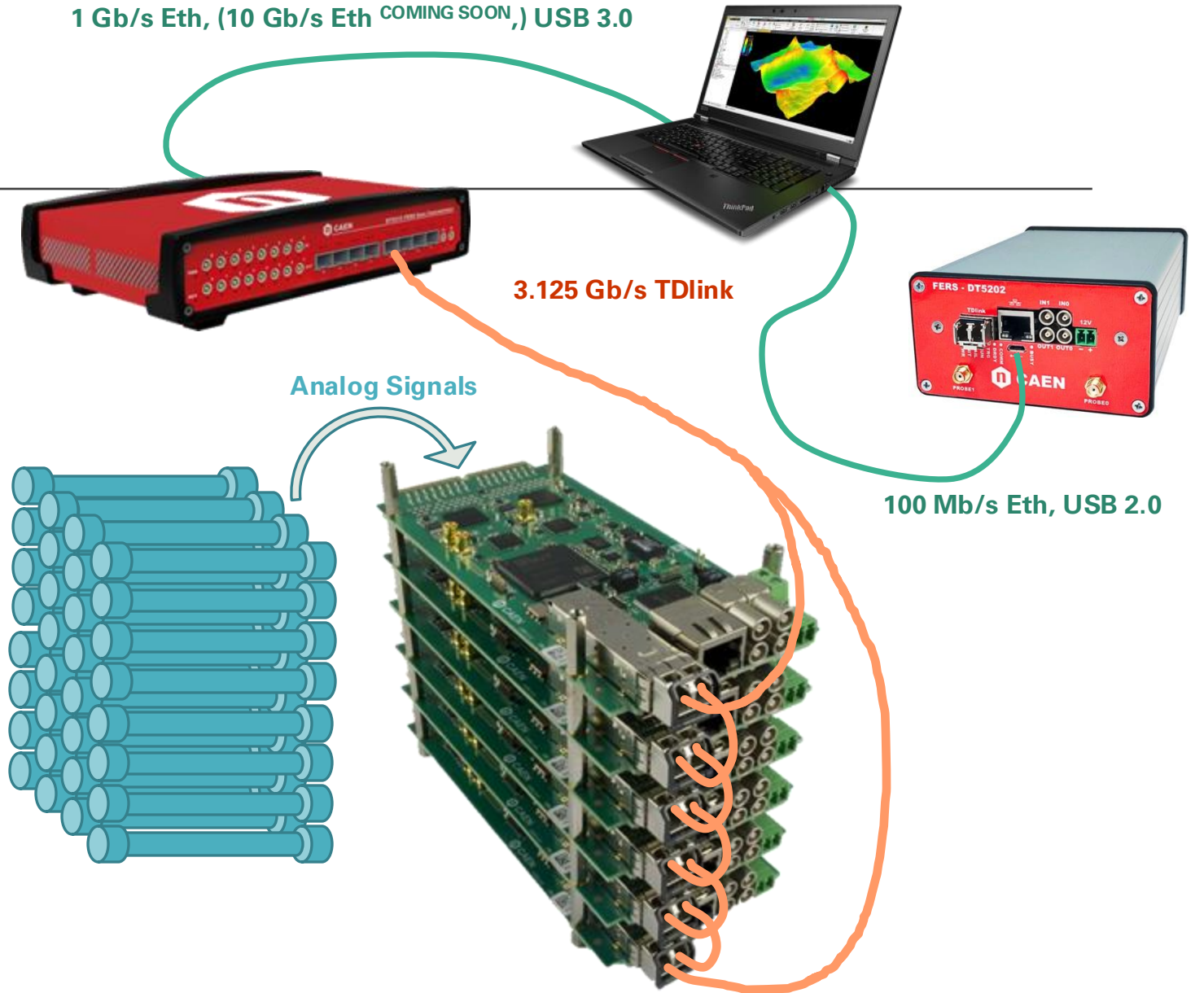






# FERS concept

1 Gb/s Eth, (10 Gb/s Eth COMING SOON,) USB 3.0

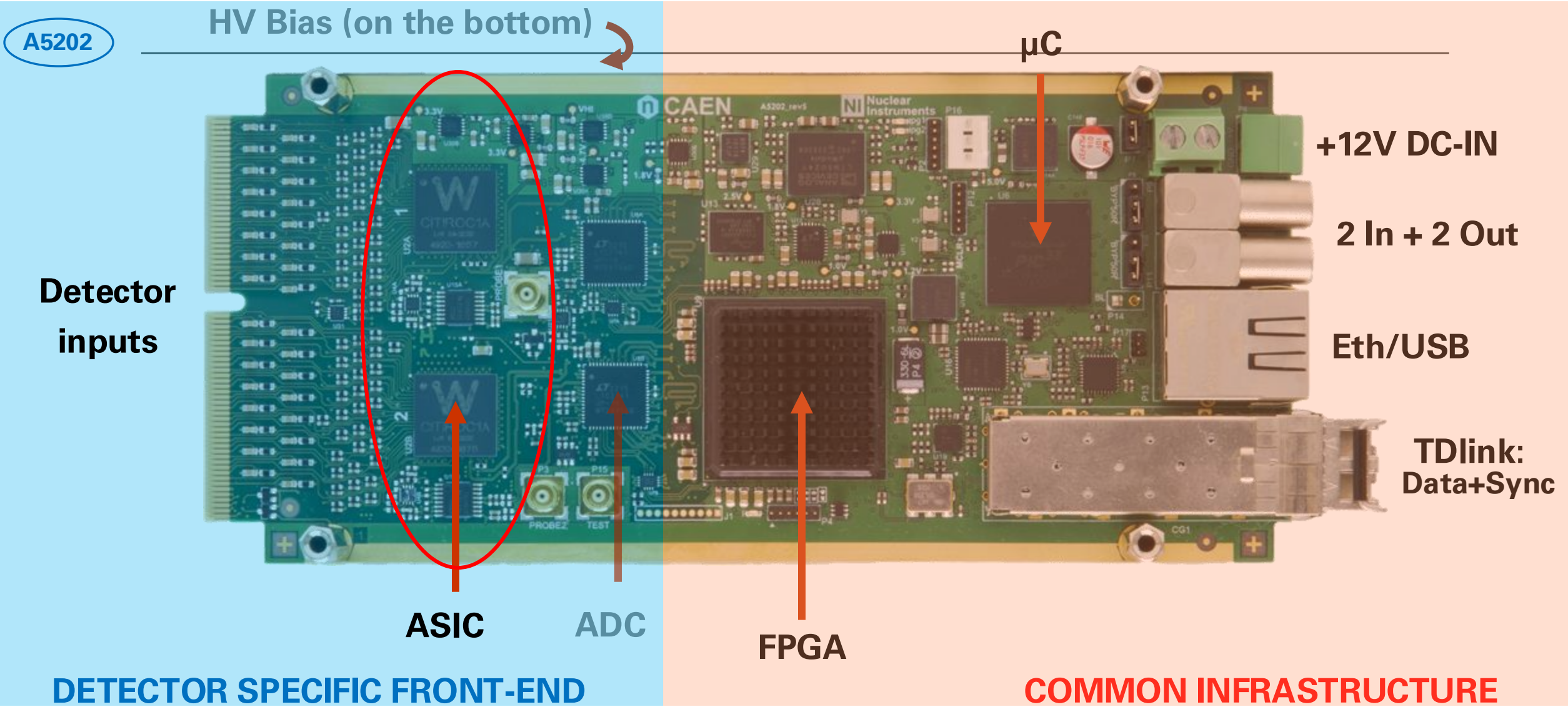


- **FERS:** Front End ASIC + A/D + Scalable Readout Infrastructure
- **Easy integration of new ASICs** => Compact solutions, tailored to the application
- **Scalability:** from single stand-alone version for evaluation, to 10k/100k channels with same electronics
- **TDlink:** daisy chainable optical link protocol with data+sync
- **Readout Tree:**
  - 1 FERS unit = 64(/128 ch for FERS 5203 type)
  - 1 link = 16 FERS units
  - 1 Concentrator = 8 links = 128 FERS = 8k(/16k channels for FERS 5203 type only)

Multiple Concentrators for unlimited readout



# FERS Units: A520X







# Conclusions

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CAEN is now a group of companies that counts more than 100 people.

Power supplies are still at the company core business and we have recently engaged on a series of R&D dedicated to Hyper-Kamiokande and HighLumi-LHC.

CAEN has developed a strong and wide family of digital acquisition systems. This effort is continuing to improve performance and flexibility.

The OpenFPGA has been implemented in two different ways:

- Sci-Compiler
- FDK (Firmware Development Kit)



# Thank you for your attention

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Any question/curiosity? Please write to [Ferdinando.Giordano@caen.it](mailto:Ferdinando.Giordano@caen.it)





# Backup slides

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