

# CAEN Presentation

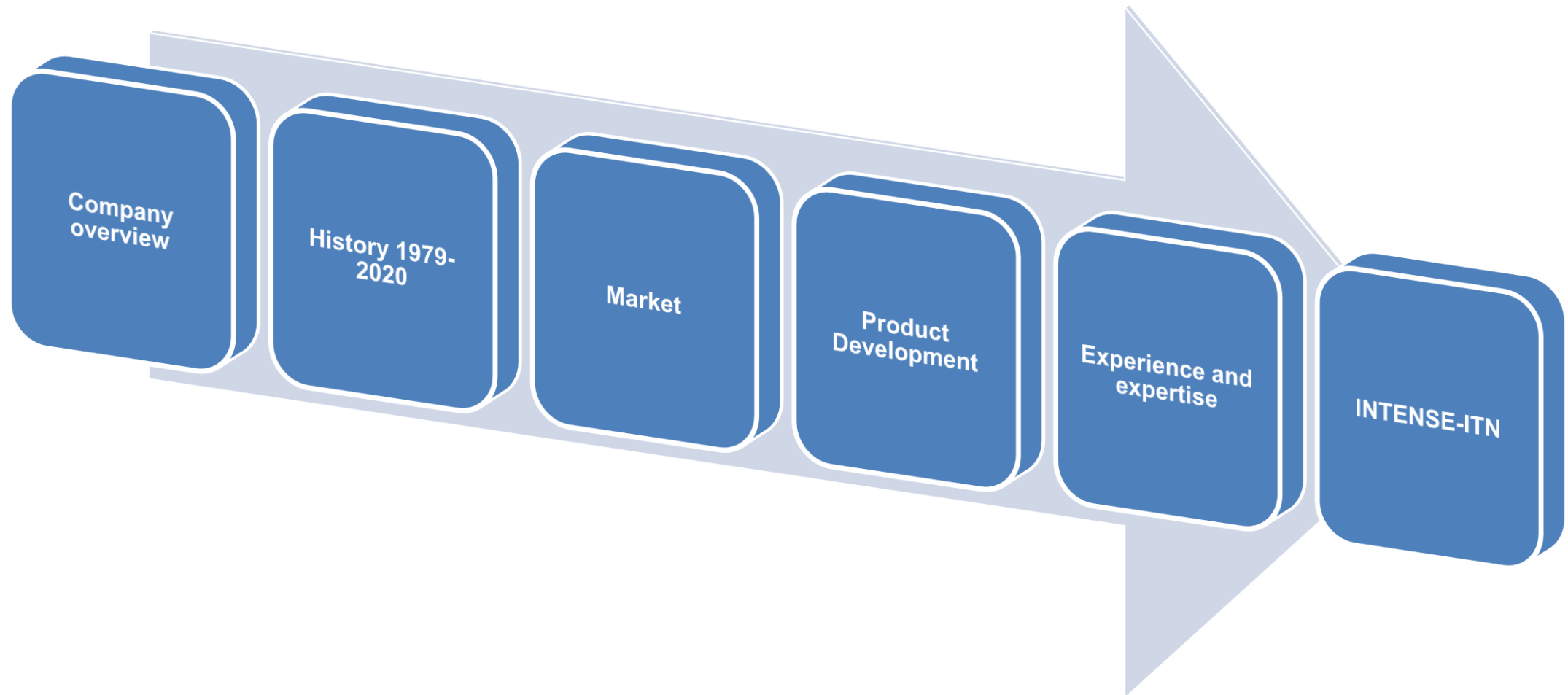
Alessandro Iovene

INTENSE-ITN KoM - 29 September 2020

**CAEN**  **Electronic Instrumentation**  
*Tools for Discovery*



# Summary





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# Company Overview

# Milestones 1979-2020



**1979**  
**CAEN** established in Viareggio by a group of senior engineers from INFN

**1986**

First High Voltage Power Supply System (400.000 HV channels delivered worldwide in 30 years)



**1994**  
**CAEN** Microelectronics spin-off

**1997**

UNI EN ISO 9001 quality certification



**1996**  
**CAEN** Aerospace spin-off

**1998**

Started electronic design for LHC/CERN experiments (1998-2016: 8.500 electronic devices 250.000 boards/sub-boards)



**2003**  
**CAEN** RFID (Radiofrequency Automatic Identification) spin-off

**2006**

**CAEN** GmbH a CAEN branch company in Germany



**2010**  
**CAEN** ELS (Accelerator Electronic Instrumentation) spin-off



**2012**  
**CAEN** qS (Cyber Security) spin-off



**2016**  
**CAEN** SyS (Systems and Spectroscopy Solutions) spin-off

**2019**



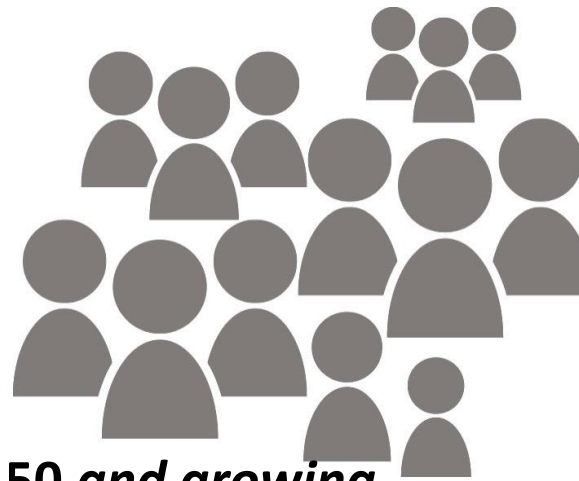
# Network of Companies

Founded in 1979, CAEN SpA (Costruzioni Apparecchiature Elettroniche Nucleare) is an important industrial spin-off of the INFN.

**Core business:** Electronic Instrumentation for physics experiments (world leader)

## CAEN incubated and launched:

- > CAEN Nuclear (1979)
- > Aurelia Microelectronics (1994, *Sold in 2010*),
- > CAEN Aerospace (1996, *Sold in 2010*),
- > RFID (2003),
- > CAENels (2010),
- > CAENqS (2012),
- > CAEN SyS (started in 2016)



**Total Employees: 150 and growing**

**CAEN SyS**  
Systems and Spectroscopy Solutions

**CAENqS**  
build security awareness

**CAENels**  
Gear For Science

**CAENRFID**  
THE ART OF IDENTIFICATION

# 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-Park, KEK, Riken, IHEP, TIFR, ...

Africa: iThemba Labs, ...

And private companies:  
GE, Siemens, SAIC, L3, Raytheon, Lockheed...

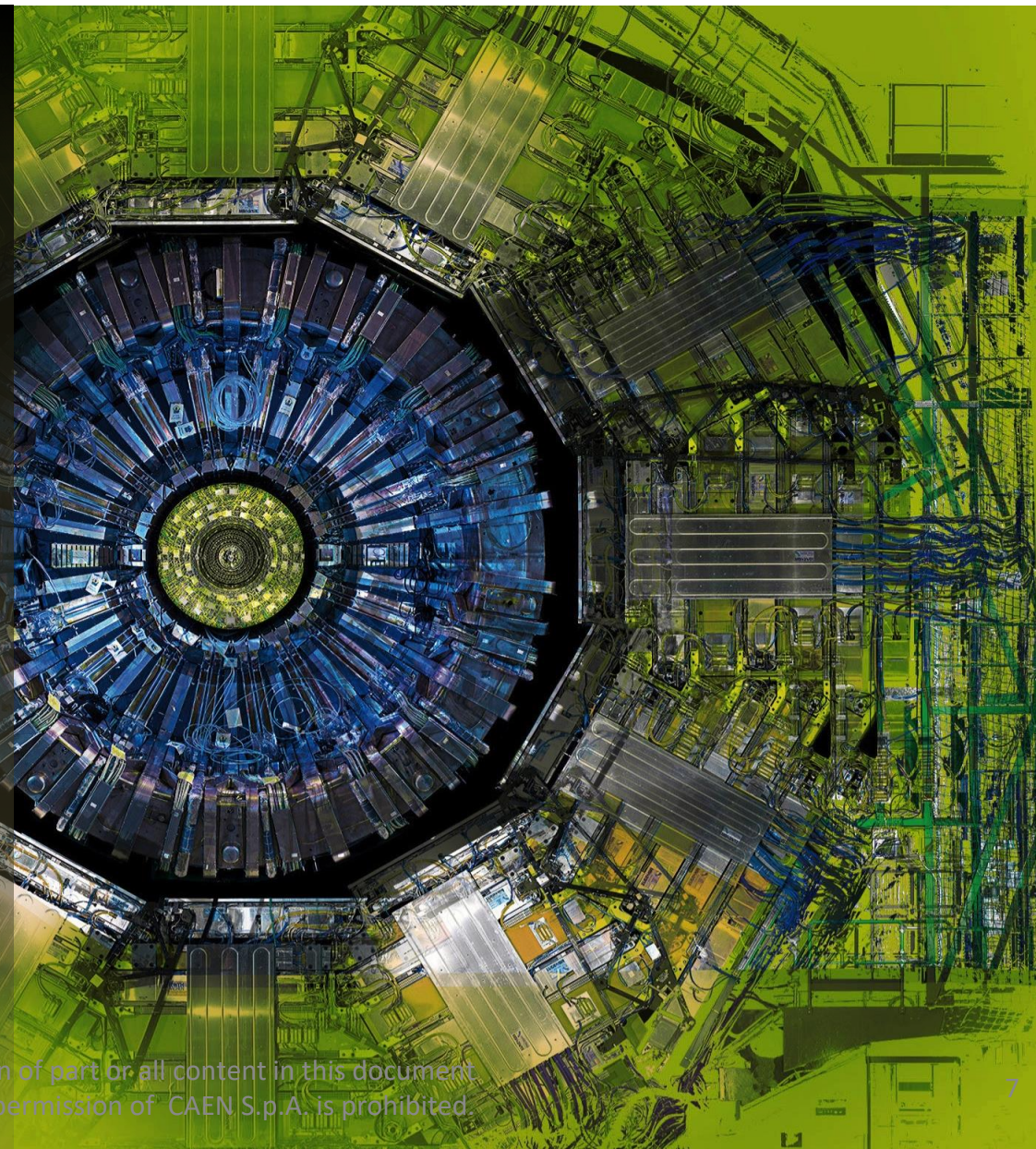


# Market

For more than 40 years CAEN has been providing Scientists and Engineers with the most advanced electronic instrumentation for any particle or radiation detectors

Strong of an extremely close collaboration with the world major research laboratories CAEN is proud to produce the best tools for:

- > High Energy Physics
- > Astrophysics
- > Neutrino Physics
- > Dark Matter Investigation
- > Nuclear Physics
- > Material Science
- > Medical Applications
- > Homeland Security
- > Industrial Applications



# Key strengths

- > **Product Development**
  - R&D (HW, FW, SW)
  - System Integration
  - Custom Design
- > **Test and Calibration**
- > **After sales Services**
  - Maintenance
  - Support





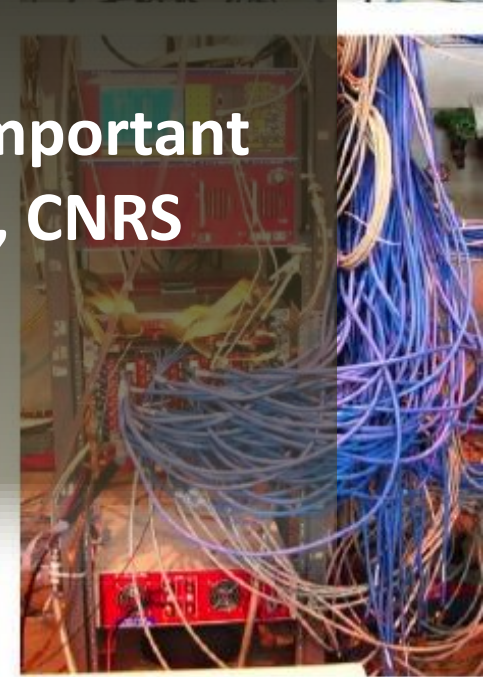
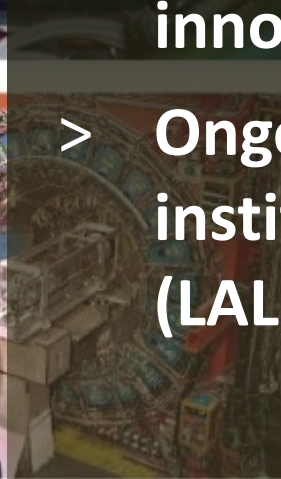
# Product Development



> The R&D division is strong of 50 high level Physicists and Engineers who adopt forefront technologies to design innovative products



> Ongoing collaborations with important institutes such as: Elettra, CEA, CNRS (LAL, IRES..), PSI, INFN...





# Test

- > All assembling activities are outsourced
- > Experienced group of 20 engineers dedicated to in-house Test and Calibration of the entire production
- > Capability: 500 complex modules/month
- > All procedures are ISO certified providing the complete traceability of the products



# Power Supplies Expertise

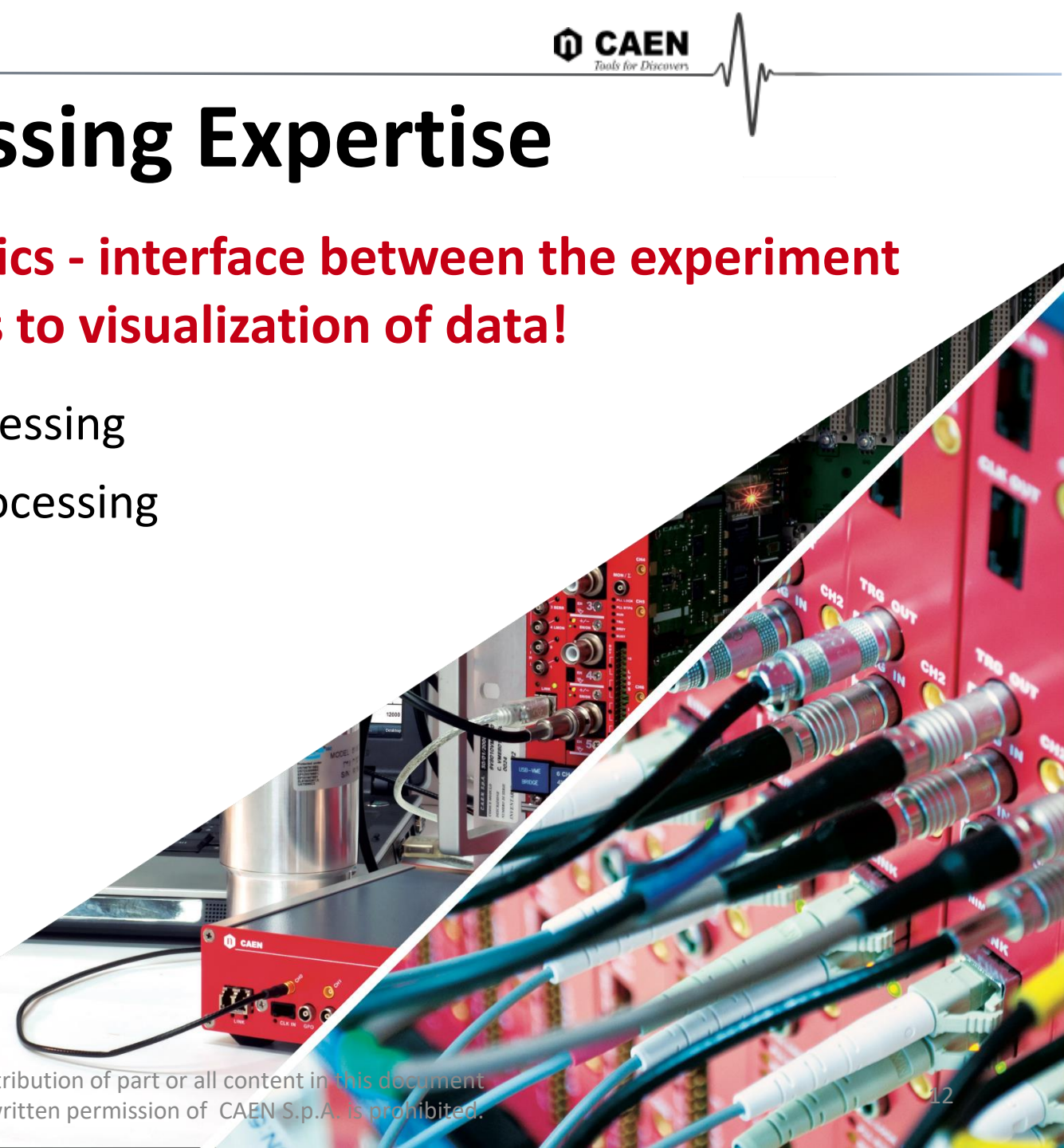
## High Voltage & Low Voltage Power Supplies for Particle Physics Experiments and Laboratories providing:

- Integration: Multi-Channel CAEN Systems (up to 768 HV ch/system)
- Granularity: NIM, VME Modules, Rack-Mount And Desktop Devices (from 1 ch to 8 ch/module)
- Custom: Stand-alone Power Supplies
- HV Components: PCB mountable HV DC-DC converters
- Hostile Area developments for LHC

# Pulse Processing Expertise

**Signal Conditioning, Read-out Electronics - interface between the experiment and the scientist: from detector signals to visualization of data!**

- Waveform Digitizers & Digital Pulse Processing
- FPGA algorithms for the Digital Pulse Processing
- Analog Pulse Processing
- Programmable Trigger module
- Multichannel Analyzer
- Preamplifiers
- Custom project



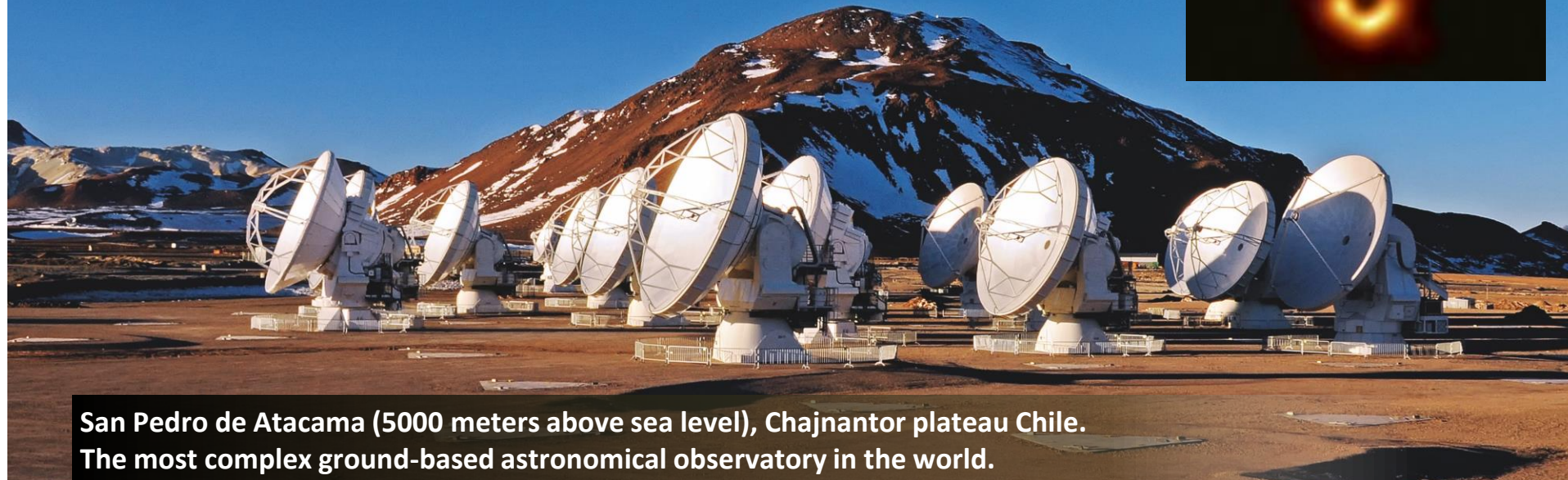
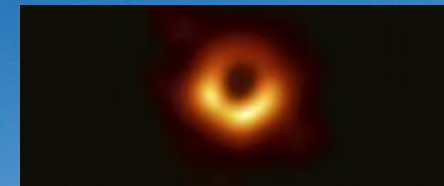
# Maintenance and Support

- > Excellent pre - and after - sales support
- > Strong maintenance division (25 engineers)
- > Long Term Maintenance Contract (CERN 10 years and more)
- > On line support service
- > Short intervention time (on request, on-site within one day only in Europe)
- > Short delivery (on request worldwide)



# LV Power Supply for ALMA (ESO)

- > Design of custom LV Power Supply System for ALMA
- > **86 Complex LV Systems delivered (688 power channels)**
- > **Harsh environmental condition (desert at 5,000 m altitude)**
- > **Designed to operate for at least 30 years; 24/7 (24 hours a day, seven days a week)**



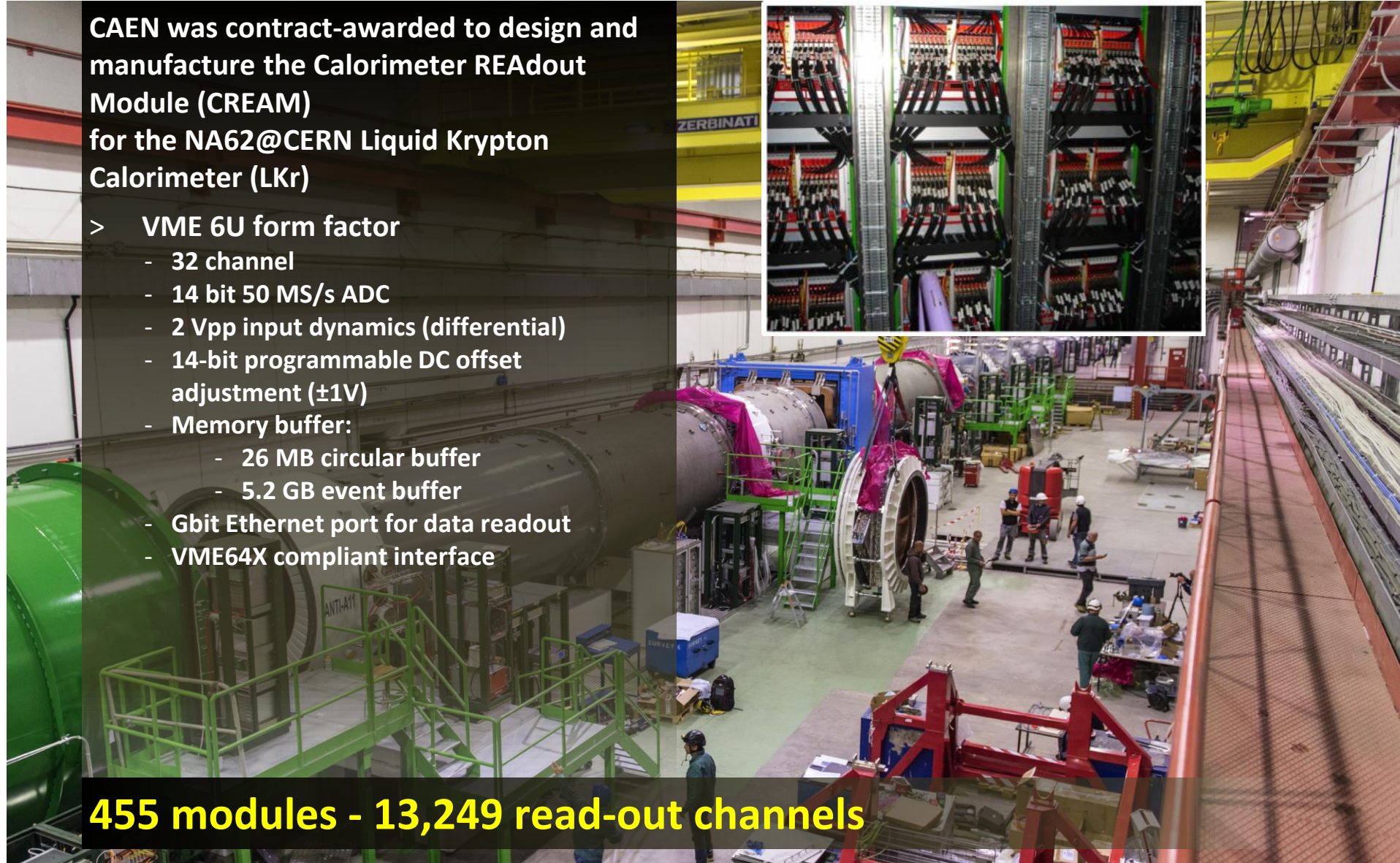
San Pedro de Atacama (5000 meters above sea level), Chajnantor plateau Chile.  
The most complex ground-based astronomical observatory in the world.



# NA62@CERN

CAEN was contract-awarded to design and manufacture the Calorimeter REAdout Module (CREAM) for the NA62@CERN Liquid Krypton Calorimeter (LKr)

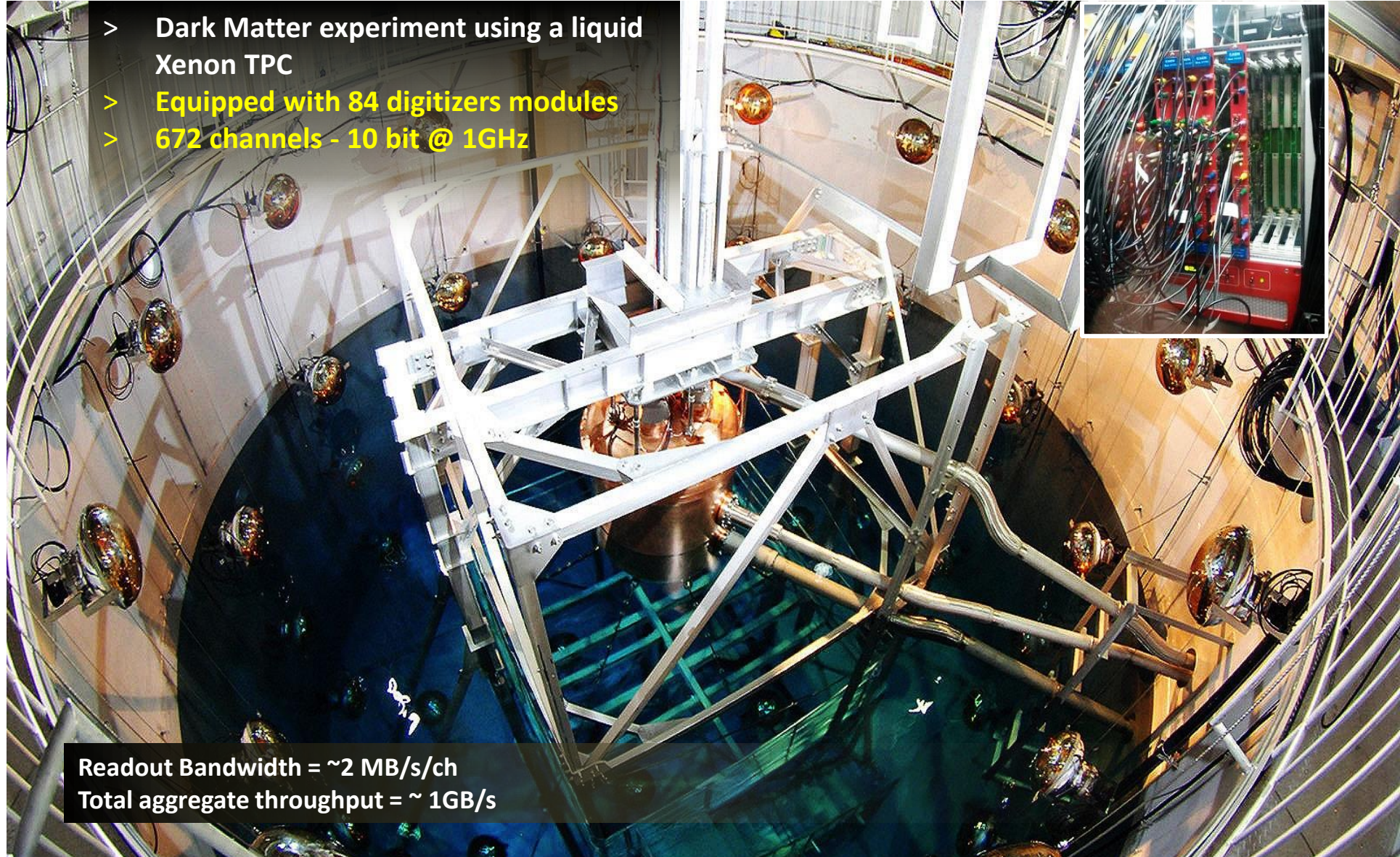
- > VME 6U form factor
  - 32 channel
  - 14 bit 50 MS/s ADC
  - 2 Vpp input dynamics (differential)
  - 14-bit programmable DC offset adjustment ( $\pm 1V$ )
  - Memory buffer:
    - 26 MB circular buffer
    - 5.2 GB event buffer
  - Gbit Ethernet port for data readout
  - VME64X compliant interface



**455 modules - 13,249 read-out channels**

# XMass @ Kamioka, Japan

- > Dark Matter experiment using a liquid Xenon TPC
- > Equipped with 84 digitizers modules
- > 672 channels - 10 bit @ 1GHz



Readout Bandwidth =  $\sim 2$  MB/s/ch  
Total aggregate throughput =  $\sim 1$  GB/s



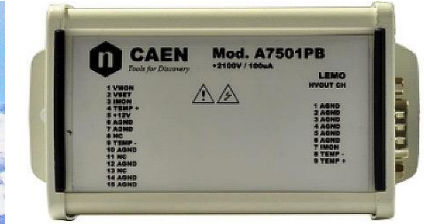


# Pierre Auger Observatory

- > Based on A7501 PCB mount HV DC-DC converter
- > Extended Temperature working range:  $-10^{\circ}\text{C} \div 70^{\circ}\text{C}$
- > Designed for long working life in harsh environment



- > A detection area of  $3.000 \text{ km}^2$  (the size of Luxembourg)
- > Mendoza Province (Argentina)



- > High efficiency
- > 2100 V/100  $\mu\text{A}$  output ranges
- > Available with positive or negative polarity
- > Stand alone architecture
- > Compact package: 34,5 x 62,9 x 119 mm<sup>3</sup>

A tailored solution for Large Area experiments in harsh environment: A7501PB

# CERN/LHC Experiments, electronics in Hostile Area

“EASY” Multi Function System

- > 2 kGauss magnetic field
- >  $1 \cdot 10^{11}$  p/cm<sup>2</sup> TD - 15 kRad TID
- >  $2 \cdot 10^{12}$  n/cm<sup>2</sup> TD



Designed with COTS components to work in “hostile” areas

# CAEN & LHC Experiments

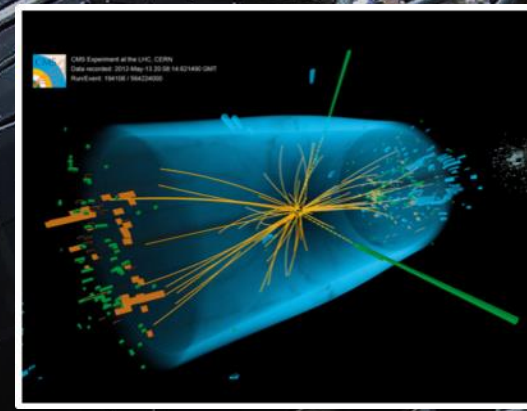
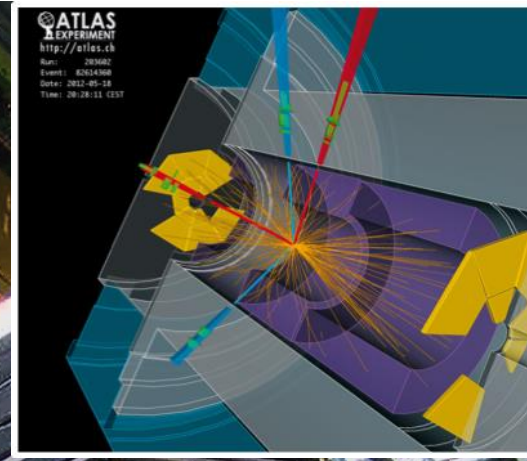
1998 – 2016  
SYNERGY for SUCCESS

18 years of joint  
efforts to achieve top  
performances

- > 8.500  
electronic devices
- > 250.000  
boards/sub-boards



CAEN has received the "CMS Crystal Award" for the development and production of the power system for the CMS/LHC Tracker



# GammaFly: Airborn Gamma Ray Spectroscopy

Aerial monitoring system of environmental radioactivity with applications in:

- > Homeland security
- > Environmental protection
- > Geological and soil mapping
- > Uranium and mineral exploration
- > Mineral/gas and oil processing
- > Environmental radioactivity monitoring

**4x4 array of 1 liter NaI detectors**



# International Atomic Energy Agency

- > 12 liquid scintillators
- > Digital DPP and Waveform readout
- > Sustained throughput: 340 MB/s



The Fast Neutron Collar (FNCL) is a liquid scintillator-based instrument developed as an efficient NDA (non destructive assay - test) tool for verification of modern NPP's Fresh Fuel Rods

Fast neutron counting System for safeguards and non proliferation activities (IAEA): SD7750



## Digital Magnet Power Supplies

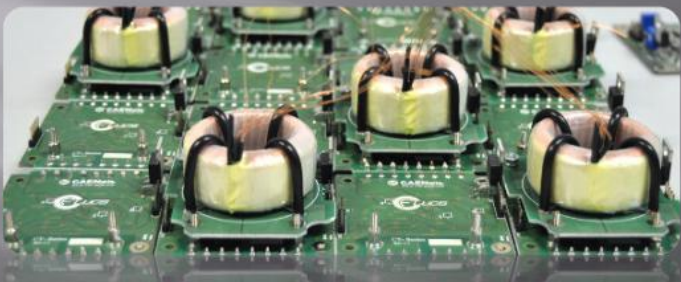
Bipolar + Monopolar

from  $\pm 5A$  (small correctors) to 135A


Ethernet Interface



MAGNET  
POWER  
SUPPLIES

PRECISION  
CURRENT  
TRANSDUCERS




DC Current Transducers  
Closed-loop Technology  
DC + AC monitoring  
Current monitoring up to kA

## Multi-channel Low Current Measurements

Dedicated Systems (Bipolar HV for Optics)

Beamline Local Feedback Integrated System



BEAMLINE  
ELECTRONIC  
INSTRUMENTATION




MTCA.4  
MicroTCA  
For Physics



MicroTCA for Physics  
High-Voltage Board  
Collaboration with DESY



# CAEN ELS

APS – Advanced Photon Source, Argonne (Chicago, USA)  
ALS – Advanced Light Source, LBNL (Berkeley, USA)  
BNL – Brookhaven National Lab (Brookhaven, USA)  
ELETTRA – Elettra Light Source (Italy)  
JLAB – Thomas Jefferson Lab (Newport News, USA)  
KEK – Photon Factory, cERL (Tsukuba, Japan)  
PAL – Pohang Accelerator Laboratory (South Korea)  
RRCAT – Raja Ramanna Centre for Advanced SPARC –  
INFN Frascati (Italy)

## Application fields

Oriented and dedicated to  
particle accelerator facilities  
e.g. synchrotron light sources  
and Free Electron Lasers-FEL



# CAEN RFID

- The first European company providing UHF RFID products
- Key player in the EU RFID scenario (EPCglobal, ETSI...)
- Worldwide customers in manufacturing, logistics, transport, healthcare, fashion, retail...
- Totally in-house HW, SW & support skills
- Key partner in EU funded projects
- An “added value manufacturer”







# CAEN RFID



UHF RFID is an enabling technology for several fields of applications:

- Embedded
- Fashion - Retail
- Cold Chain - Pharma
- Waste Management
- Access Control
- Industrial Manufacturing
- Transportation - Logistics
- FMCG - Supply Chain
- Leisure
- We are the Technology provider & design center for Datalogic Spa

**DATALOGIC™**

CAEN SyS is the new Systems & Spectroscopy of CAEN Spa. Such division relies upon an extremely strong foundational knowledge of nuclear measurement instrumentation in developing Radiation Measurements Systems and Spectroscopy Solutions. These systems and solutions are perfectly suited to operations involving Nuclear Fuel Facilities, Nuclear Power Plants, Measurements Laboratories, and Security Applications.

CAEN SyS operates in three main areas:

- Nuclear Safety
- Nuclear Security
- Laboratories





# Decommissioning & Dismantle

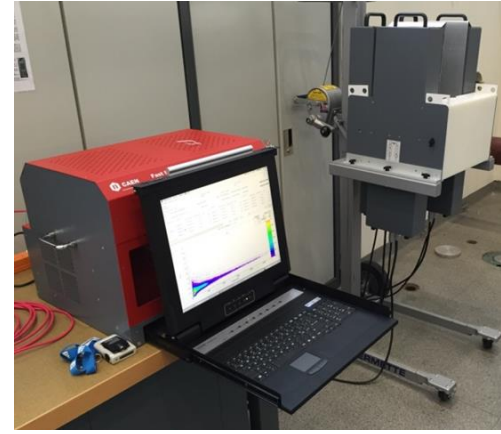
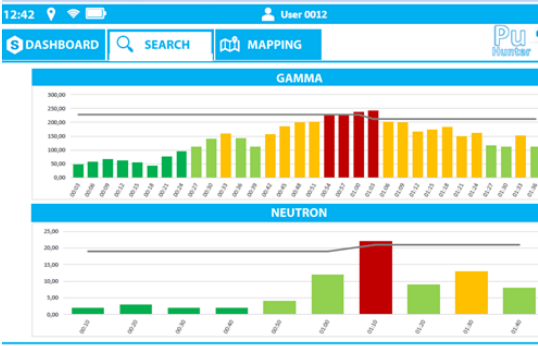
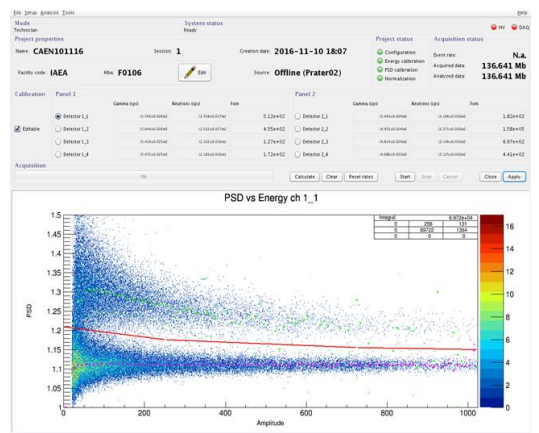
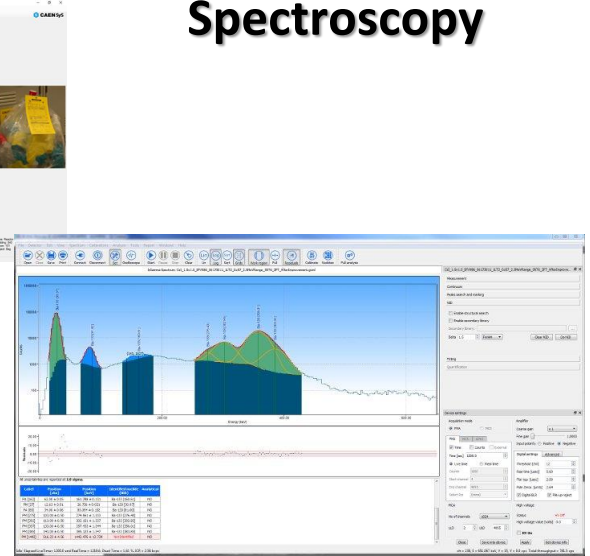
# Laboratory Spectroscopy

# Environmental Monitoring

# Nuclear Security

# Homeland Security

Channel	Energy	Area	Rate	Unit
1	100	1000	100	cts
2	200	2000	200	cts
3	300	3000	300	cts
4	400	4000	400	cts
5	500	5000	500	cts
6	600	6000	600	cts
7	700	7000	700	cts
8	800	8000	800	cts
9	900	9000	900	cts
10	1000	10000	1000	cts



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# CAEN in INTENSE-ITN

- T1.2: ICARUS construction, commissioning and data taking (INFN, UNIPD, CERN, CAEN, FNAL). Optimize data throughput and minimize dead-time of the online system and implement the beam trigger, event building and data processing infrastructure; Develop the laser-based system to perform time/charge calibration of the inner PMTs; Exploit the PMTs signal pattern to provide an online tag of neutrino interaction and define a first trigger level; Study possible trigger improvements exploiting charge signals on the TPC wires; Commission the CRT scintillation system and its CAEN front-end electronics and develop algorithms to identify and reconstruct the direction of cosmic rays in conjunction with the PMTs; Perform data taking in the years 2020-2023.
- T1.4: Develop general-purpose test stand of front-end electronics for detector prototypes (INFN, UNIPD, CERN, CAEN, FNAL, CLEVER, SEEMS). Exploit the CAEN electronics modules (A2795 for LAr-TPC readout, V1730B digitizer for PMTs, DT5702 front-end boards for the CRT) to build a general-purpose test stand to estimate performance of future detectors prototypes.
- As all partners we will contribute to WP6/WP7/WP8 activities.

# ESR hosted in CAEN for INTENSE-ITN

**Project Title and Work Package(s) to which it is related:** “Cold-Warm Read-out/DAQ electronics for future neutrino experiments”, WP 1.

**Supervisor:** Alessandro Iovene (CERN); Co-Supervisors: Marzio Nessi (CERN), Alberto Guglielmi (INFN)

**Objectives:** Starting from a comparison of available DAQ systems the ESR will define the specifications of a new kind of fast DAQ system for future 10 kton scale LAr-TPC capable of operating at high rates, with minimal deadtime, and in extreme conditions: these include but are not limited to radiation resilience, magnetic field tolerance (an environment where CAEN has a long standing experience and history of success), ability to operate at very low temperature (liquid noble gas), etc. The ESR will be trained by CAEN senior engineers and will provide a leading contribution to the design and test of this novel multi-environments/purpose DAQ system that has to guarantee excellent performance with respect to CAEN current readout boards like high channel density (>32 ch per board), sampling rate (>2 MS/s) and resolution (>12 bit).

**Expected Results:** Prototype of fast high-resolution multi-environment DAQ system for 10 kton scale LAr-TPC.

**Planned secondment(s):** 4 months at CERN (Marzio Nessi) for data acquisition with prototype DAQ in ProtoDUNE; 2 months at INFN (Alberto Guglielmi) to test DAQ prototype.

**Enrolment in Doctoral degree(s):** NO



Thanks  
for your  
attention

