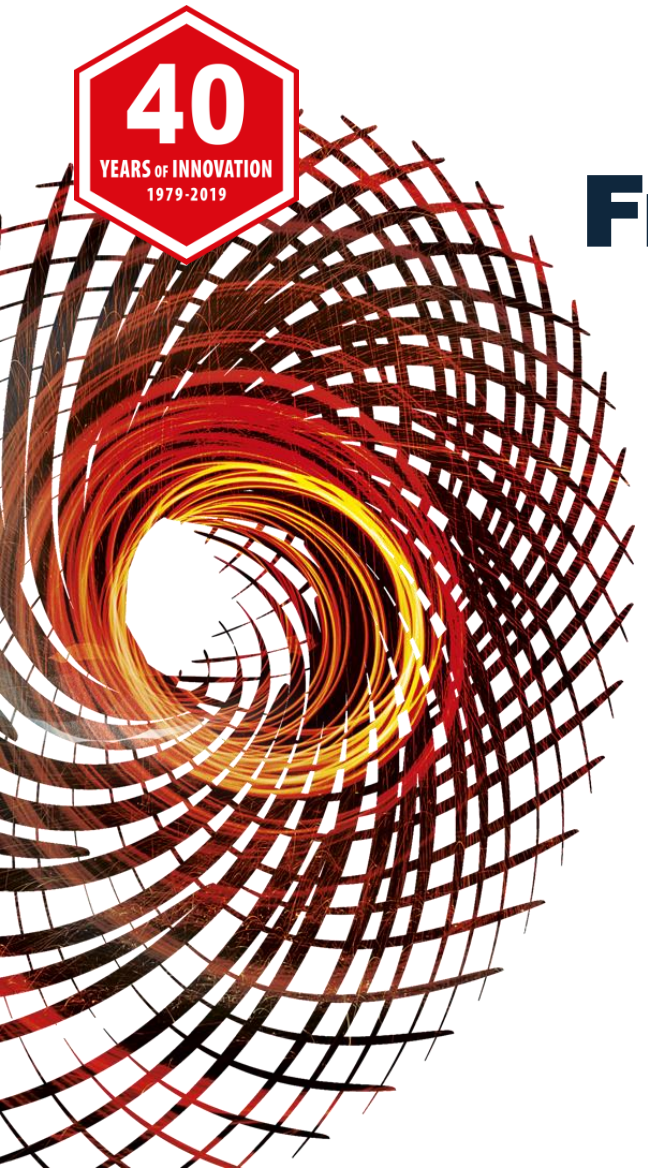
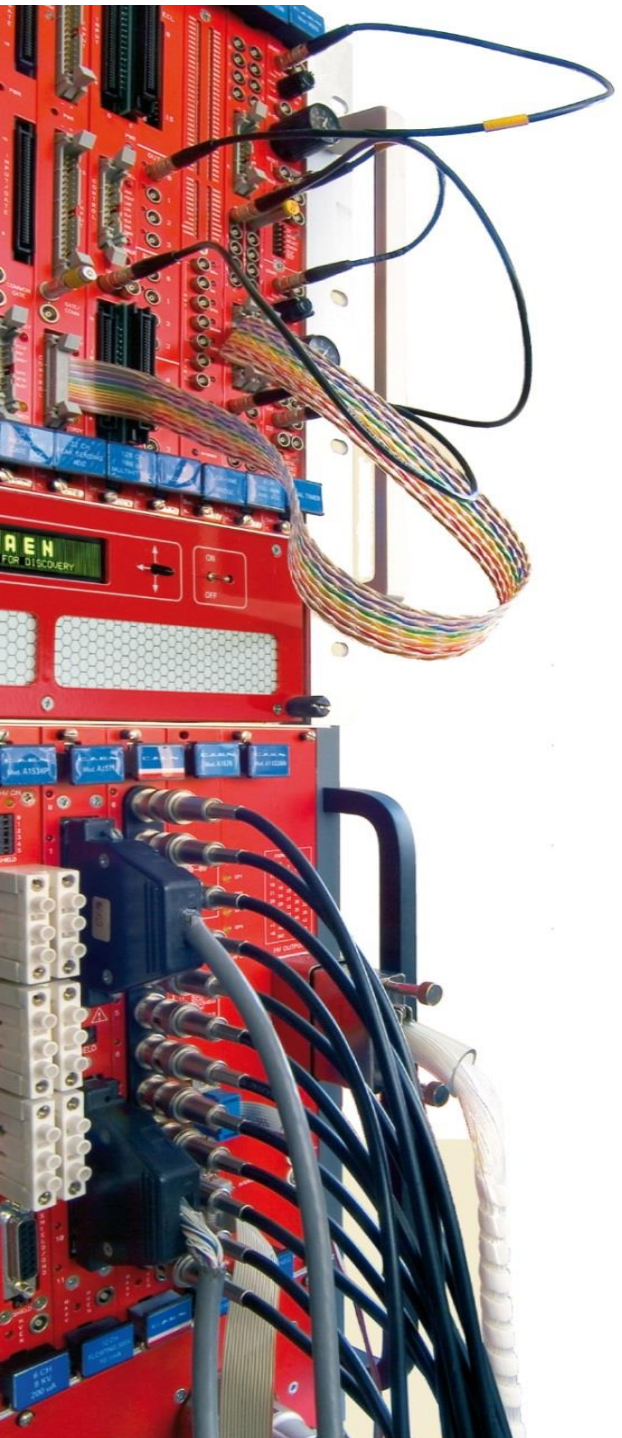
CAEN Electronic Instrumentation
Tools for Discovery



From CAEN-LHC Experience to NICA

Jacopo Givoletti
President

NICA Days 2019



CAEN Electronic Instrumentation

Tools for Discovery

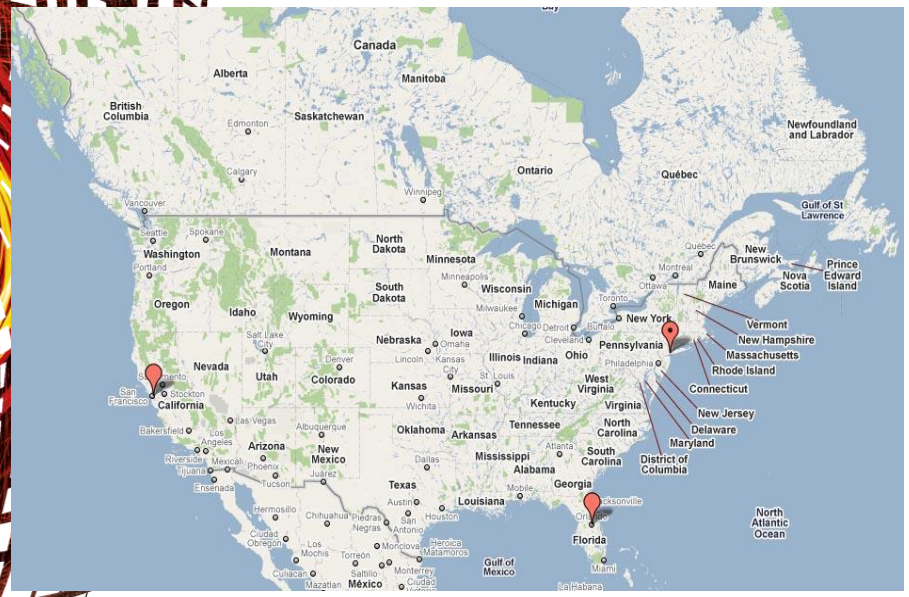
- Founded in 1979, for more than 40 years CAEN has been providing Scientists and Engineers with the most advanced electronic instrumentation designed for radiation & low light detectors
- Strong of an extremely close collaboration with the world major research laboratories CAEN is proud to produce the best tools for:
  - High Energy Physics
  - Nuclear Physics
  - Neutrino Physics
  - Astrophysics
  - Dark Matter Investigation
  - Educational
  - Medical Applications
  - Homeland Security
  - Industrial Applications
  - and more …

CAEN Electronic Instrumentation

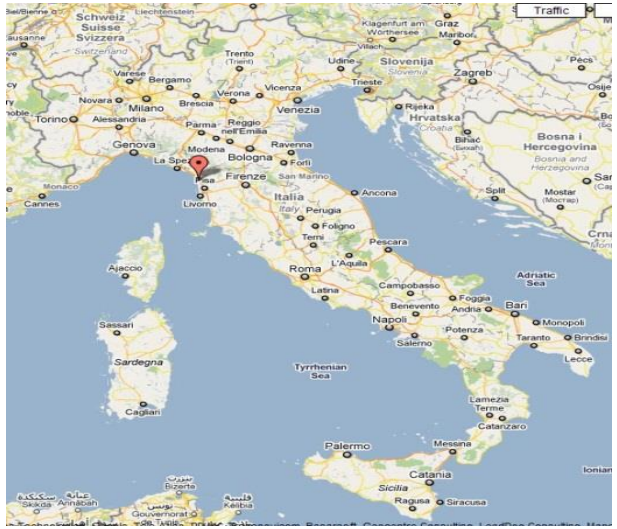
Tools for Discovery

40 YEARS OF INNOVATION 1979-2019

CAEN Technologies Inc., USA



CAEN SpA Headquarters Viareggio, Italy



CAEN Gmbh, Germany

Global Coverage

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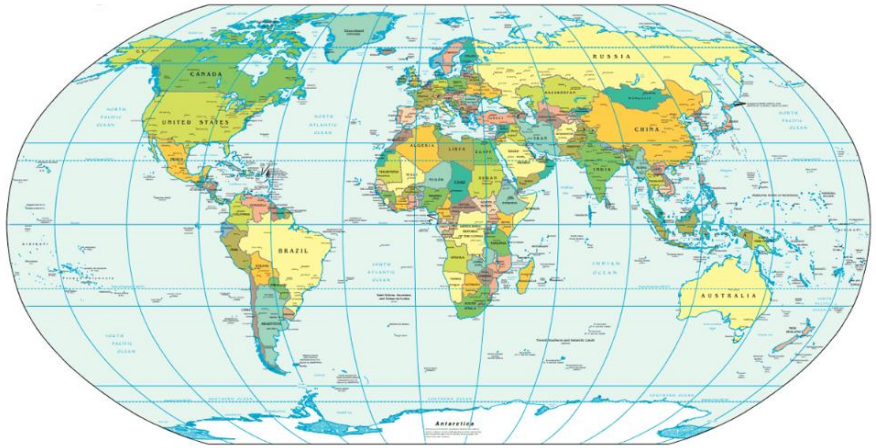
40 YEARS OF INNOVATION 1979-2019



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, JINR, INFN, CEA, CNRS, GSI, ESO, ISIS, Ganil, PSI, ESS…

USA: FNAL, SLAC, Los Alamos, BNL, Jlab, ORNL…

Asia: J-Park, KEK, Riken, IHEP, TIFR, …

Africa: iThemba Labs, …

And private companies: GE, Siemens, Intel, L3, Raytheon, Lockheed, Bosch…

CAEN Key Strengths

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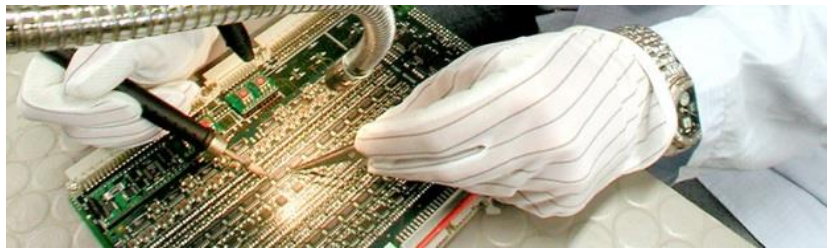
More than 40 Years of activity in Physics Research allow CAEN the right way to approach and collaborate with the big projects thanks to our:

✓ R&D Division (>50 high level Physicists and Engineers) at the forefront of technology

- Catalog Products
- Customization of catalog models
- Custom projects

✓ Production Division

- Capability: >500 complex modules/month



✓ Test Division

- Experienced group of 20 engineers

✓ Maintenance Division (15 engineers)

- Long Term Maintenance Contract (CERN 10 years and more components stock)

✓ CAEN is ISO 9001 certified since 1998

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Network of Companies

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

Spin-off activities:

> CAEN RFID (2003),
> CAENels (2010)
> CAENqS (2012)
> CAEN SyS (2016) now a CAEN Division

Total Employees: 154

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LHC & CAEN: a decade of Research & Development

- The involvement of CAEN in LHC was in the design, manufacture and supply of HV/LV power supplies and readout electronic to many sub detectors of the 4 Experiments
- The first phase of research & development began in the second half of the 90s and ended around 2005 to 2008
- The challenges faced and overcome:
  - The ” hostile environment”
  - The harmonization of the different user requirements to be implemented in a consistent line of products
  - Special requests of some users (Alice TOF; Atlas Trigger; CMS DT, ECAL e Tracker)
  - CERN preselected CAEN as reliable electronic supplier

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LHC & CAEN: a decade of Research & Development

- LHC accounted for CAEN a real revolution, which has challenged the company in every department
- In CAEN LHC had a strong impact in the specific areas of design and production, and in the more general business organization
- The ISO 9001 certification obtained by the company as early as 1998 was a good starting point
- It can be said that the LHC was a perfect test for verifying and improving internal procedures, as well as to increase the know-how

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The ”hostile environment”

- The specifications written in the various tender required that the power supplies worked in the so-called "hostile environment", i.e. in the presence of radiation and magnetic field, but making use of electronic components "off the shelf" (reduction of costs of wiring PS-Detector, but without having to use *space grade* versions)
- These special requirements meant that we could not use the standard catalog products, but we have been forced to design new electronics, based on knowledge coming from literature
- The validation of the solutions was carried out by performing joint testing with users at facilities such as the center of the ENEA Casaccia, or accelerators of the University of Louvain-La-Neuve and Uppsala

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The need of a new line of products

- By analyzing the requirements of various sub detectors, and crossing them with the demands of "hostile environment", it emerged that it was not possible to propose an ad hoc solution to everyone, but that it was necessary to define a new line of power supplies with the following characteristics:
  - Be able to work in “hostile environment”
  - Modularity
  - Be able to manage HV and LV modules
  - Hardware and software integration with the standard in the field of CAEN power supply for detector: the system SY1527 (*now SY4527*)
- It was therefore proposed the EASY system (**E**mbedded **A**ssembly **SY**stem), which was born in early 2000 as the culmination of a period of research and development which took a decade

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The EASY System in LHC

- The EASY system is thus the final result of a long period of research, and we can say that CAEN was the only company willing to invest heavily in this particular area
- The EASY system has been successfully used, and has been adopted in a large extent, especially in Atlas and CMS
- The ability to manage LV modules also allowed the company to expand its offerings beyond traditional HV power supplies
- An accurate analysis of the requests of the users gave birth to a rather limited set of modules, avoiding an unnecessary proliferation of different modules but very similar to each other
- About LV, was particularly interesting the 12 channels of 45W of power, missing from the catalog of the main competitors, which led to the award of a major tender

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Special requests of some users

- The EASY system has been successfully proposed to the majority of users who have appreciated the advantages of standardized product, so sharing the same types of modules with other users and having a single control system
- Nevertheless some sub detectors (CMS DT, ECAL, Tracker and Alice TOF) had so special requirements to need an *ad hoc* solution:

  CAEN carefully studied these demands and finally was awarded of these important contracts by offering ***custom solutions***, obtained by creating specific power supplies that meet the specific demands of these sub detectors
- However, we have maintained the standardization of control interfaces, so as to insert these "special" modules also within the standard control of the experiments

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40 YEARS OF INNOVATION 1979-2019

The production phase

- The LHC production was added to the standard CAEN production (Catalog products) and saw the company involved for a period of 5 years: **2004-2008**
- Can be identified two distinct phases:

  The first phase: **2004-2006** have boost production of 30% roughly and has been bear without shock

  The second phase: **2007-2008** has “de facto” doubled the standard production level in CAEN

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The 2007-2008 phase of the production (Blood and tears)

- The maximum productive effort and organization was therefore required for the phase 2007-2008, in which we were forced to concentrate in 2 years what the structure was able to produce in 4
- We came to that knowledge in the autumn of 2006, when it emerged that all the delays that had accumulated up to that point would not be absorbed by a further *shift* in the start of the LHC, scheduled for September 2007
- In other words, we were required to produce in less than a year what the company was able to do, in theory lasting 4 years!!
- The meeting at CERN with all the experiments responsible in October-November 2006 touched moments of drama: CAEN had become a critical point in the schedule of the LHC ...

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The 2007-2008 phase of the production (Countermeasures)

- The company reacted at its best, especially in autumn 2006:

✓ Were identified and qualified new suppliers for the assembly of electronic components

✓ It was selected and hired additional staff to the phases of integration, testing and packing of all the material

✓ Were rented additional premises to manage the testing and storage of electronic components

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The 2007-2008 phase of the production (CAEN proposal to Experiments)

- We made a delivery plan realistic and feasible, and with this plan we went to CERN for an official meeting with the experiments in December 2006
- The plan exposed in an Excel spreadsheet production capacity of CAEN on a monthly basis, module by module
- The plan was that by 2007 it would have been delivered enough material to feed all the detectors, even if not 100%, so that if the start of the LHC was confirmed in the autumn of 2007, everyone would be able to take data
- Deliveries would have been concluded anyhow in 2008

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The 2007-2008 phase of the production (The agreement on the schedule)

- To implement the plan it was mandatory that the experiments:
  - Approve the *schedule*
  - Agree between them, staying with CAEN production capability, who will receive what, on a monthly base
- Before Christmas 2006 we received the green light
- A round table has been implemented where the Experiments electronic coordinators, CAEN and the CERN Pool responsible people would meet
- Each month, on each delivery to CERN of CAEN modules, there has been a meeting, to verify step by step the respect of the agreed plan shared between detectors

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The 2007-2008 phase of the production (contingencies and chances) 1/2

- The 2007-2008 phase took place as planned and agreed. Deliveries of PS ended in June
- To date in the history of CAEN it is without doubt the most intense period, both for the effort made by all the experts, both for the pressure the company was submitted to by the user community
- In spring 2007, the development of the accelerator LHC suffered a setback, and in fact the start of the beams was delayed one year, from September 2007 to September 2008

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The 2007-2008 phase of the production (contingencies and chances) 2/2

- In Autumn 2007, CERN, on behalf of the experiments, organized an audit of the processes of design and production of CAEN to make sure that the deliveries of the material would continue on a regular basis, and that the phase of integration and testing of the power supplies was matching the criteria of quality required
- Has been a 2 days very intense where CAEN divisions were subject to “X rays”
- The visit ended with the full recognition by the CERN experts of the validity of the CAEN activities, even and especially in light of the complexity of the processes involved (somebody spoke of "logistic nightmare")

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LHC & CAEN: some numbers

- During the LHC production phase:
  - 8.500 electronic modules build of:
    - 210.000 PCBs
    - 28.000.000 components
    - 71.000.000 soldering points

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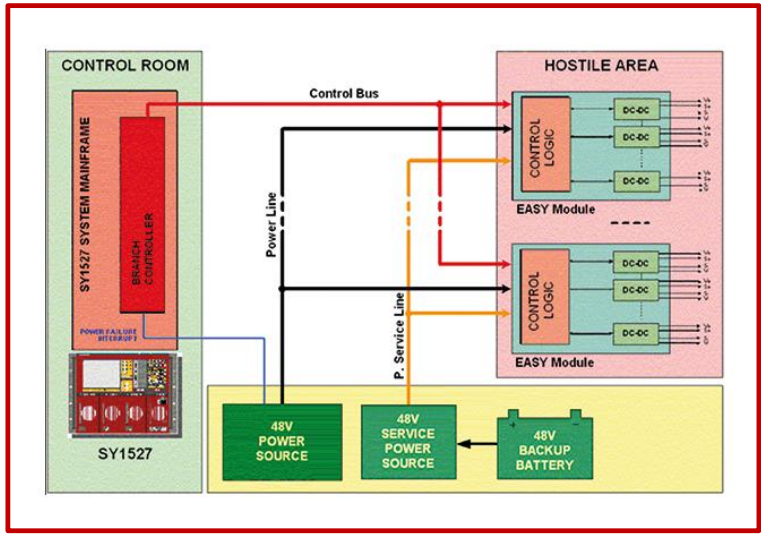
The EASY System for LHC (CERN)

- The EASY system is thus the final product of a long period of research, and we can say that CAEN was the only company willing to invest heavily in this particular area
- The EASY system has proved successful, and has been adopted in a large extent, especially in Atlas and CMS
- The ability to manage LV modules also allowed the company to expand its offerings beyond traditional HV power supplies

Main EASY System features

- 21 slots per crate
- 3 kW Maximum Output Power
- Magnetic field tolerance: 5 kGauss
- Radiation tolerance: $5*10^{10}$ p/cm^2 TD
  $2*10^{11}$ n/cm^2 TD
  15 kRad TID



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1998 – 2008

SYNERGY for SUCCESS

CAEN has received the "CMS Crystal Award of the year 2009" for the development and production of the power system for the CMS Tracker.

- Detector subdivided into 1994 Power groups
- HV (0÷600V) for silicon strip detector
- LV (1.25V - 2.5V) for FE electronics
- Itot > 15 kA
- 139 crates / 29 racks / 1200 Power Supply Units

CAEN Catalog Products

✓ High Voltage & Low Voltage Power Supplies

- Multi-Channel CAEN Systems
- Multi-Channel NIM and VME Modules
- Stand-alone Power Supplies
- PCB mountable HV DC-DC converters

✓ Signal Conditioning, Read-out Electronics & Emulation

- Waveform Digitizers & Digital Pulse Processing
- Digital MCA and instrumented PMT bases
- Digital Detector Emulators
- NIM and VME traditional electronics
- Preamplifiers

✓ Powered Crates and Chassis

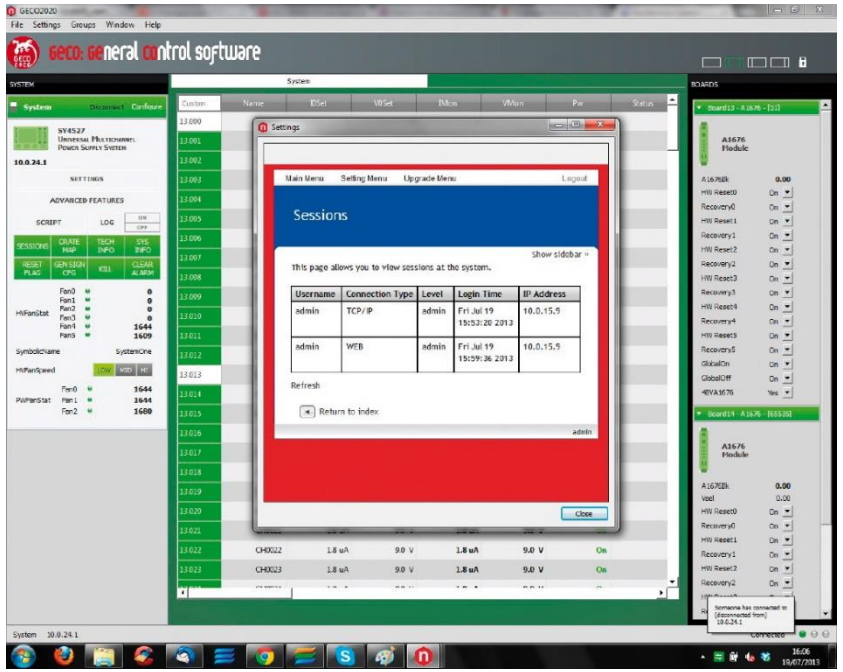
- Low Ripple Linear NIM powered Crates
- New Hi-End VME64/VME64x Crates

✓ Educational Kit

✓ Partnership

CAEN catalog includes more than 300 product categories (~1000 items)

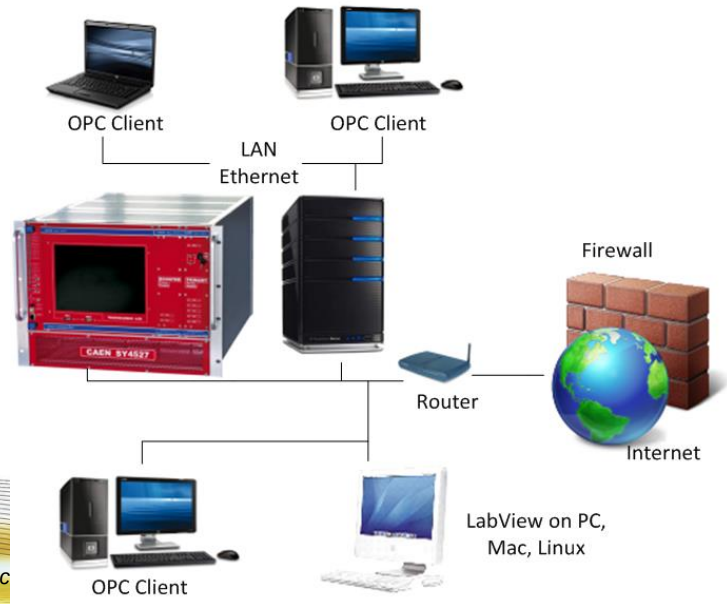
GECO2020 a complete graphical USER Interface for both Low Voltage and High Voltage Multichannel Power Supply Boards for the new Universal Multichannel Systems

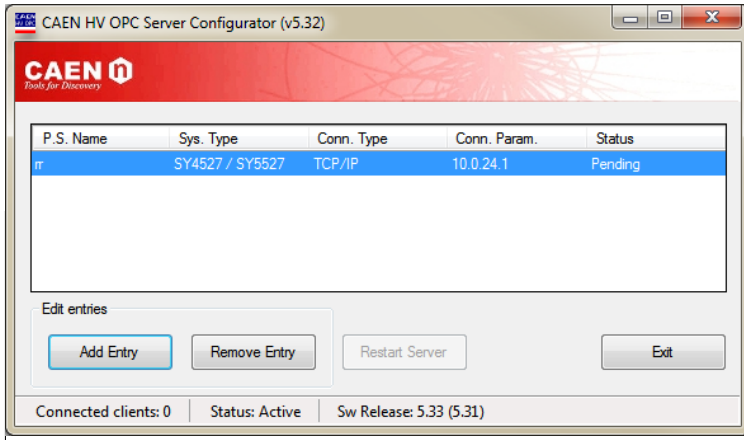


- Dashboard capability: Allows to manage all the CAEN Power Supplies in any form factor
- Supports Linux and Windows
- Optional Advanced Features (Scripting and Logging) available for SYx527 systems
- Parameter Logging capability available for NIM, VME, Desktop and Rack units
- Handles all the communication links provided in CAEN Power Supplies:
  - Ethernet
  - USB
  - Optical Link
  - Wi-Fi

OPC Server *(Integration of CAEN equipment into big systems, including SCADA at CERN)*

CAEN hardware is compatible with the OPC standard, in particular CAEN provides two versions of OPC Server, the OPC Server-DA (the one based on the OLE/COM and DCOM technology) and the new OPC-Server UA (Unified Architecture, compatible with Windows and Linux). The CAEN OPCServer UA is developed by CERN with our close collaboration and it allows an easy integration with SCADA systems like Siemens WinCC (the SCADA used at CERN).





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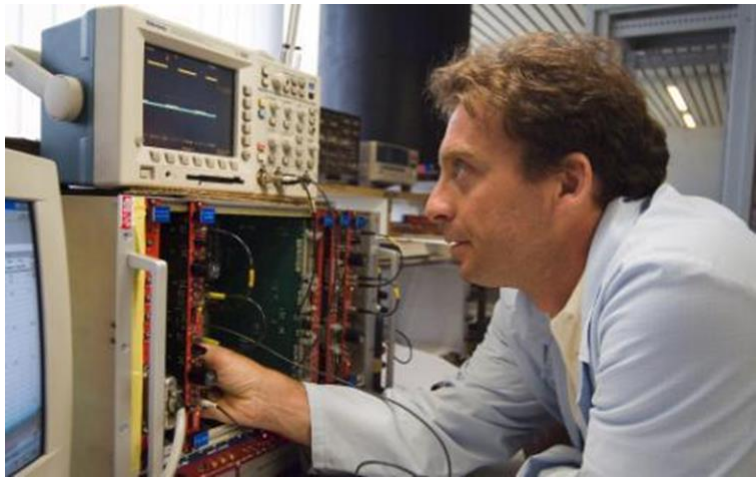
Maintenance at CERN

CAEN is present at CERN having its own laboratory (space provided by CERN) for on-site maintenance.

A 10-year maintenance contract with CERN has been signed and it has recently been extended for another 5-year term.

Due to the very large presence of CAEN equipment at CERN, CAEN Staff once per month travel at CERN for maintenance operation to LHC and non LHC CAEN equipment.



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Design Review & Production

CAEN is available to provide Design Review & Production to all it's customers who does not want to deal with Production, Testing & Long-Term Maintenance.

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Conclusions

- LHC accounted for CAEN a real revolution, which has challenged the company in every department
- It can be said that there was a CAEN "before LHC" and there is now one "after the LHC"
- The company is out of this adventure strengthened and with a greater awareness of its capabilities
- CAEN is the only company approved from CERN Market Survey team to participate for all 4 Power Supply categories for the next gen LHC phase
- We are ready to face new technological challenges
- We are open to different collaboration scenarios…

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From CAEN-LHC Experience to NICA

Jacopo Givoletti

Thank You!

NICA Days 2019