CAEN

IX Collaboration Meeting of the MPD Experiment at the NICA Facility

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Our background

CAEN is one of the most important spin-offs of the Italian Nuclear Physics Research Institute, founded in Viareggio in **1979**. CAEN designs and manufactures sophisticated electronic equipment for nuclear physics research and is today among the world's leading companies in the field: there are several hundreds of thousand CAEN **Low/High Voltage and data acquisition channels** now working in all the most important Nuclear Physics Laboratories over the World.

In the last years CAEN diversified its offer, extending its market, taking part into national and international programs and becoming a real "Innovation Company". In this way CAEN joined to its core business new experiences in new fields such as the UHF RFID, the microelectronics, the aerospace applications, biomedicine, and homeland security.



Power Supplies

Since 1979 CAEN designed and manufactured power supplies for nuclear physics detectors. Over the decades our experience gave us a leading edge in various applications, ranging from **high voltage** detector bias to **extreme low voltage** frontend supply, as well as working in **harsh and hostile environments** (radiation, magnetic fields, high altitude, dust, etc.).

We have a dedicated engineering department capable to take on any design challenge, and a maintenance team able to assist the installation on any World location.





Power Supply Families:

- Universal Multichannel HV/LV Systems
- NIM High Voltage PS
- VME High Voltage PS
- Desktop and Rack High Voltage PS
- PCB High Voltage PS
- High Power Low Voltage System
- Hostile Area Solutions





- Founded 2009 as a spin-off from CAEN S.p.A.
- Developer and manufacturer of high-performance digital bipolar and monopolar power sources, highprecision current transducers and current measurement systems, electronic components for beamlines in accelerators and FMC and <u>MicroTCA</u> equipment









Precision Current Measurements





Beamline Electronic Instrumentation





Acquisition Systems

CAEN recently expanded its portfolio to **digital acquisition systems**, designing and producing a wide range of waveform digitizers and dedicated acquisition systems for physics experiments. Moreover, we engineered scalable solutions easily adaptable to different detector via **dedicated ASICs**, these are ideal for small laboratory setups or distributed experiments with thousands of channels all automatically synchronized.



Digitizers Features

- From 62.5 MS/s up to 5 GS/s, from 10 to 16 bits
- Up to 128 channels in a single module
- Form Factors: VME, Desktop, Rackable (also NIM in series 1)
- VME used for power supply, ventilation and mechanics
- Front panel readout (USB, Ethernet, Optical)
- Triggered (external or internal) and Trigger-less acquisition (independent channel selftriggering)
- Oscilloscope mode (Raw Waveform readout) or Digital Pulse Processing (DPP) for list mode (PHA, QDC, PSD, ...)
- Open FPGA for user algorithm customization

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Digitizer options

MS/s #ch	62.5	100/125	250	500	1000	up to 5000
<8		DT	DT		DT	
8		V	V / DT	DT	V	DT ⁽¹⁾
16			V	V		$V^{(1)} / DT^{(1)}$
32	DT					V ⁽¹⁾
64	V	V / DT / R				
128		DT / R				

(1) SCA models => Max wave length = 1024 pts, Trg dead time = ~100 µs



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EACH SERIE STREET 9

Acquisition Modes

	62.5	100/125	250	500	1000	> 1000	Description
Scope	•	•	•	•	•	•	Oscilloscope mode, all channels triggered simultaneously
РНА	•	•	•	•	•	•	Spectroscopy with Charge Preamps and PMTs
PSD	•	•	•	•	•	•	Neutron/Gamma/Alpha discriminations with Scintillators
TDC	•	•	•	•	•	•	Digital CFD or LED, Resolution < 1 ns (<100 ps with 500/1000 MS/s)
QDC	•	•	•	•	•	•	Self-gated charge integrator
ZLE/DAW	•	•	•	•	•	•	Waveform fragments (zero suppression, adaptive acquisition window)
Open FPGA	•	•	•	•	•	•	User defined Algorithms and Output Data Content
Ready Coming soon Not Available							

Interfaces

- IO Gb Ethernet: Bandwidth = ~280 MB/s (series 2 only)
- 1 Gb Ethernet: Bandwidth = ~100 MB/s (series 2 only)
- USB 3.0: Bandwidth = ~280 MB/s (series 2 only)
- USB 2.0: Bandwidth = ~30 MB/s
- PCIe: via optical links, daisy chainable. Aggregate Bandwidth = ~360 MB/s
- VME: legacy from the past... being dismissed

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Readout Modes



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FERS: easy integration of ASICs

- A **flexible architecture** for a wide range of potential applications:
 - SiPM CURRENTLY AVAILABLE
 - General purpose ps timing with picoTDC ASIC COMING SOON
 - PMTs and MA-PMTs
 - Gas Detector, wire chambers
 - GEM
 - Micromegas
 - Silicon Strip Detectors
 - Segmented HPGe detectors



Front-End:Back-End:DETECTOR SPECIFICCOMMON INFRASTRUCTURE

- Same Infrastructure, different Front Ends
- Easy integration of different ASICs

FERS-5200

- **Modular** readout of large arrays of detectors
- **Compact** FERS units: front-end + digital (standalone)
- **TDlink**: 4.25 GB/s Optical link providing Readout, Slow Control, Synchronization
- Easy-scalability:
 1 FERS unit = 64/128 ch
 1 Concentrator = 8k/16k channels
- Stand Alone version for
 Evaluation => scale up to 10k/100k channels with same electronics



Custom Developments: Case History

Strong capability to manage complex custom solutions

- High Voltage
- Digital and Analog Pulse Processing



<u>HV module</u> for PMT bias, designed to survive 15+ years of operation in harsh conditions.

Pierre Auger

ALMA

The antenna acquisition system, placed in the antenna's base cabin, is powered with CAEN custom developed <u>Low</u> Voltage Power Supply unit.





HAWC and LHAASO

CAEN supplied the necessary <u>HV</u> voltage boards for the PMTs.



VERITAS and

HELIX,

SiPM readout systems is based on the <u>CITIROC chips</u> provided by CAEN.

CAEN supplied the necessary <u>HV</u> voltage boards for the PMTs.

DARKSIDE and DEAP-3600

Various Power Supplies and data acquisition system based on the new CAEN <u>digitizer</u> VX2740.

← Botton Spring sup.

flove bo

Central (Deck e

leel shel Duter ne

Inner ne Vacuum

Cooling

0

0

JUNO and ICARUS



Power Supplies and dedicated acquisition system boards: <u>veto board A 1703</u> and <u>TPC readout A2795</u>



Educational Experiences

CAEN has a family of education products, some of them are designed to take advantage of freely available cosmic-rays.

- SP5620CH Cosmic Hunter
- SP5622B Detection system Plus
- SP5600D Kit Beta







Multi-Input Readout System for 3He/BF3 Position Sensitive Neutron Detectors. All-in-one rackmount solution



High Voltage: R8033 8-16 Ch, 4kV/3mA

Charge Sensitive Preamp: R1443

- Up to 64 ch •
- **External HV on SHV connectors**
- Detector input on SHV connectors ٠
- Signal output on RJ45 ٠

Readout unit: R5560

- Up to 128 ch ٠
- 14-bit @125MS/s FADC •
- Input on RJ45
 - Open FPGA

Use cases: security

IRSN – France: 32 channels readout system for 8 position sensitive 3He tubes – 32 ch preamp R1443, 16 ch R8033 HV and 32 ch R5560



Test Conditions	RMS noise
Open Inputs	3.0 mV
Detector connected with 2 m cables + Bias (950 V)	6.4 mV

Pulses of the peak of ~150 mV



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Use cases: research

Loki @ ESS/RAL-ISIS: 3He tubes readout by 20x R5560 synchronized and interfaced with pre-existing systems



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Outlook

- CAEN has a large portfolio of products that can be a solution readily available for many experiments/applications.
- Our R&D department is always looking for new challenges to push the technological boundaries.
- We are willing to collaborate working together with researches to achieve the best possible scientific outcome.

Thank you for your attention