



Collaborations on Neutron Detection and MPGD detectors

Academia-Industry Matching Event Second Special Workshop on Neutron Detection with MPGDs

CERN, 17/03/2015

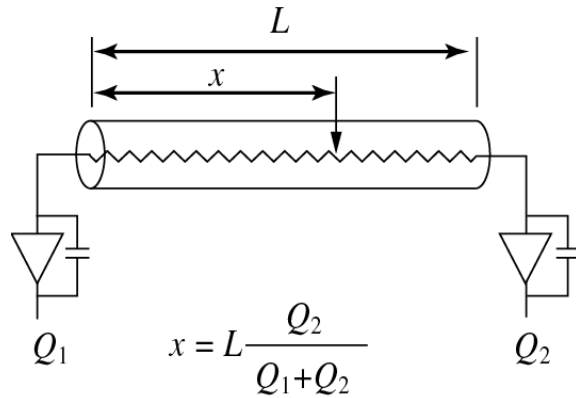
Alessandro Iovene

OUTLINE

- **CAEN digitizers for Neutron Detectors read-out:**
 - Position Sensitive Neutron Counters @ ILL
 - CVD Diamond Detectors (CNR & ENEA)
 - ITER Radial Neutron Camera (ENEA)
 - Neutron cross section measurement system @ FNG (ENEA)
 - Plutonium Hunter (University of Padova)
- **The new CAEN HV power supply for GEM detectors**
- **Past and present European Projects in the field of Neutron Detection:**
 - The **MODES_SNM** project
 - The **C-BORD** project
- **Innovative Projects on the CAEN website**

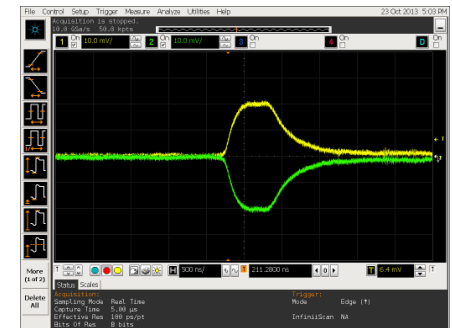
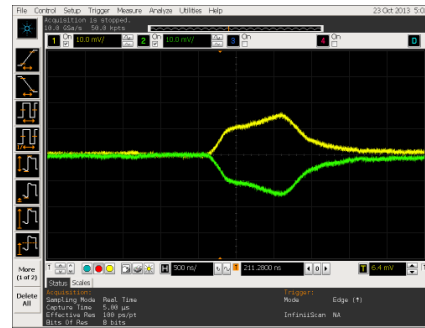
Digitizers for Position Sensitive ^3He Proportional Counters

Principle of position determination



CAEN – V1740 Digitizer

64 channels - 12 bits - 65 Msamples/s

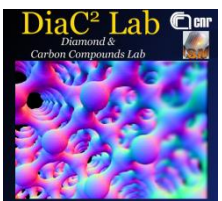


Test with ILL ^3He tubes:

Pulse-shape depends on position of interaction

- Analog pulse-shaping and Charge Integration firmware
- Position resolution from 3% to 0.5% depending on signal amplitude
- Real-time digital Gaussian pulse-shaping under test at present

Performance comparable to analog system – possible S/N improvement with digital filtering



Istituto di Fisica del Plasma "Piero Caldirola"
Consiglio Nazionale delle Ricerche

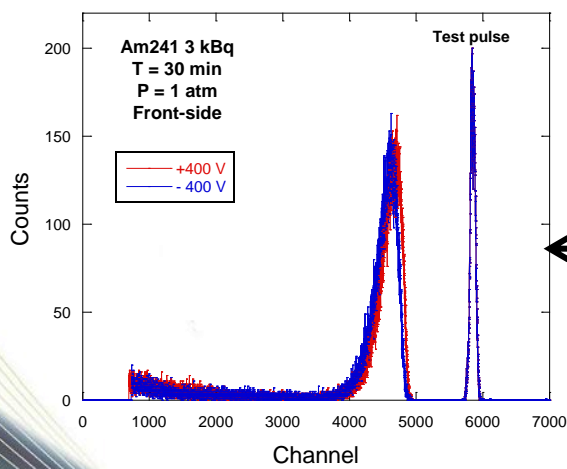


CAEN
Tools for Discovery

CVD Diamond Technology: Room-Temperature Spectrometry



- CVD Diamond detector is a compact and versatile solution for **fast neutrons, alpha and beta particles** spectroscopy and time-of-flight.
- Diamond radiation hardness, high radiation sensitivity, low dark current and high thermal conductivity allow **room temperature spectroscopy** as well as time of flight accurate measurements.



- **Charge collection efficiency close to 100%**
- **Minimized space charge effects owing to a proprietary diamond/metal junction technology**

← Single-pixel diamond spectrometer is operating at ISIS

The development of the diamond technology was performed by the Diac² Lab of CNR-ISM (Rome), in collaboration with CNR-IFP (Milan)

CAEN will sell the complete system (Detector + F/E electronics)

For details:

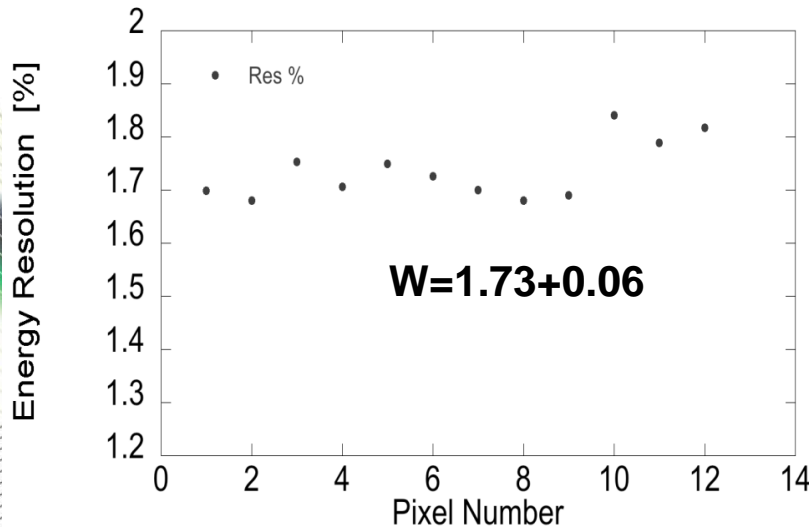
- "Pixelated Single-crystal Diamond Detector for fast neutron measurements", M. Rebai, C. Cazzaniga, G. Croci, M. Tardocchi, E. Perelli Cippo, P. Calvani, M. Girolami, D.M. Trucchi, G. Grosso and G. Gorini, Journal of Instrumentation 10 (2015) C03016.
- "A diamond based neutron spectrometer for diagnostics of deuterium-tritium fusion plasmas", C. Cazzaniga, M. Nocente, M. Rebai, M. Tardocchi, P. Calvani, G. Croci, L. Giacomelli, M. Girolami, E. Griesmayer, G. Grosso, M. Pillon, D. M. Trucchi, and G. Gorini, Review of Scientific Instruments, 85 (2014) 11E101.

12-pixel CVD diamond neutron spectrometer for thermonuclear fusion plasmas

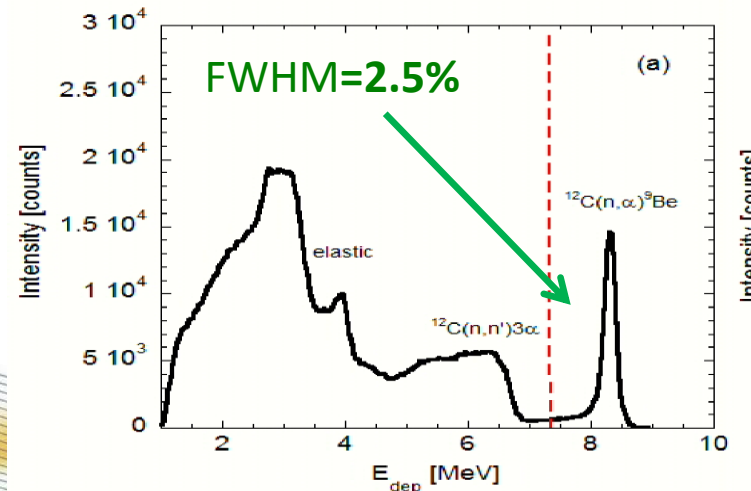


- Good energy resolution in DT plasmas for $E_n > 6$ MeV via $^{12}\text{C}(n,\alpha)^9\text{Be}$ reaction.
- Detector built by CNR
- dedicated fast electronic chain: preamplifier + CAEN V1730B digitizer) allowing for count rate $>1\text{MHz}$
- 12 independent Pixels: Thickness: 0.5 mm, Area: $4.5 \times 4.5 \text{ mm}^2$
- Neutron detection efficiency is about 1% at 14 MeV
- Radiation resistant
- It will operate at JET (ITER Radial Neutron Camera)

Excellent pixel uniformity in term of energy resolution with Am241 alpha source

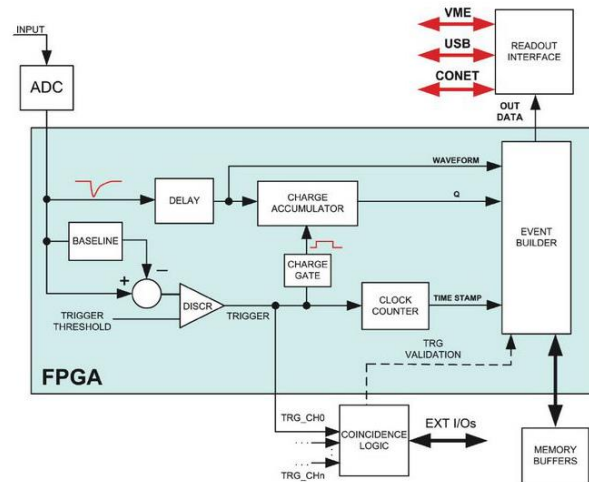


Energy resolution $<3\%$ at 14 MeV neutron from Frascati Neutron Generator with count rate capability $>1\text{MHz}$



Sistema di acquisizione per misure di attivazione

- 4 π angular coverage CsI detector + Plastic Scintillator for Beta-Gamma coincidence
- Front end electronics based on CAEN 2 channels waveform digitizer with Digital Pulse Processing Firmware
- Used for materials activation measurements and neutron cross-section measurements at 2.5MeV and 14MeV @ FNG



Block Diagram of the DPP-PHA processing chain implemented in the Digitizer AMC FPGA

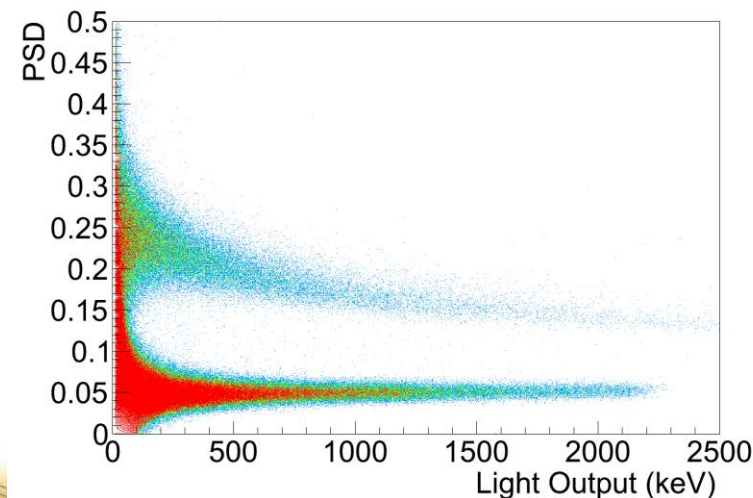
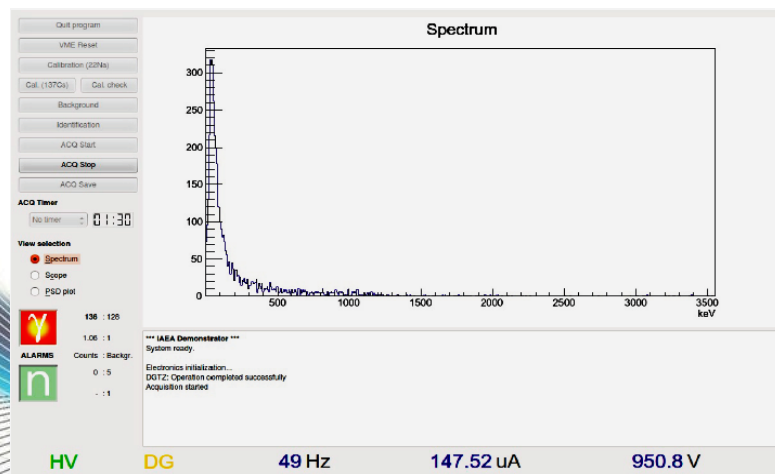
The system is in use and it has been used for FNG calibration campaign

A.Pietropaolo, S.Loreti, M.Pillon, M.Angelone (ENEA)

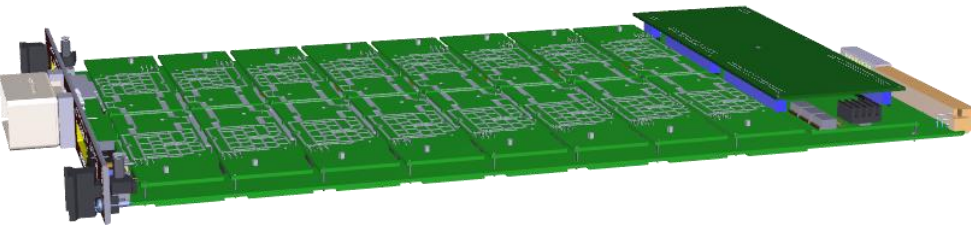
PLUTONIUM HUNTER

A compact portable Neutron/Gamma spectrometer

- A new portable neutron/gamma spectrometer is under development at the Padova University within a collaboration program between the Physics and Astronomy Department and the CAEN SpA.
- The neutron/gamma spectrometer consists of a compact detector based on a **2" x 2" EJ-309 liquid scintillator cell coupled to a flat panel PMT**. The EJ-309 provides the typical performance of liquid scintillators without chemical and fire hazards.
- The PMT anode signal is processed by the **CAEN DT5790 Digital MCA**, which also provides the PMT High Voltage. The front-end is powered by using a battery pack that allows 2.5 hours of operation. An external PC provides the front-end control by USB port.



HV Power Supplies for Triple/Quadruple GEM Detectors

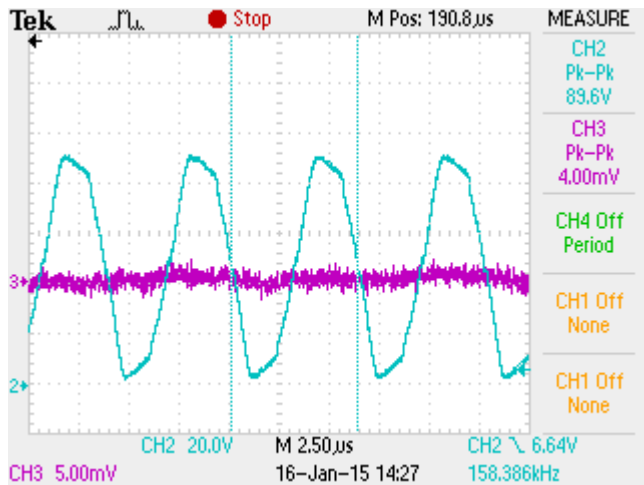


Up to 16 board in a CAEN mainframe, which means up to 32 Triple/Quadruple GEM powered by a CAEN mainframe



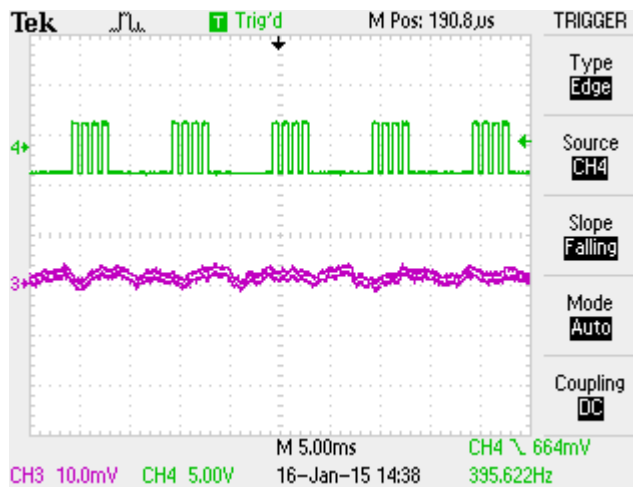
- **16 HV channels** grouped into 2 complex channels to power 2 Quadruple GEM detectors
- **14 HV channels** version to power 2 Triple GEM detectors
- Grounding: **Each channel floating up to 5 kV**
- Voltage: **1 kV**
- Current: **1 mA/100 uA dual range**
- Vset resolution: **50 mV**
- Vmon resolution: **10 mV**
- Iset resolution: **20 nA**
- Imon resolution (High range): **1 nA**
- Imon resolution (Low range): **100 pA**
- Ramp Up/Down: **programmable channel by channel from 1 V/s to 500 V/s**
- Voltage Ripple common mode: **< 15 mV**
- Voltage Ripple differential mode: **< 10 mV**

HV Power Supplies for Triple/Quadruple GEM Detectors



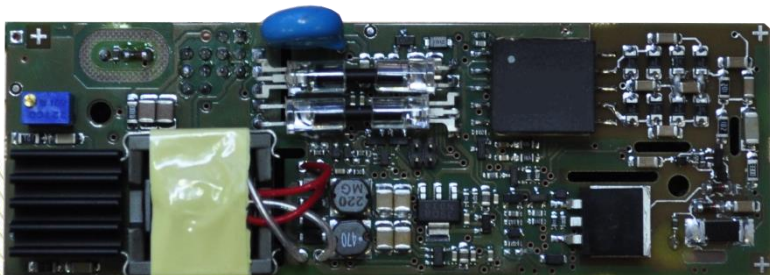
Primary MOSFET voltage (@ 500V/500uA)

Differential mode noise (@ 500V/500uA) ---> 4 mV pk-pk

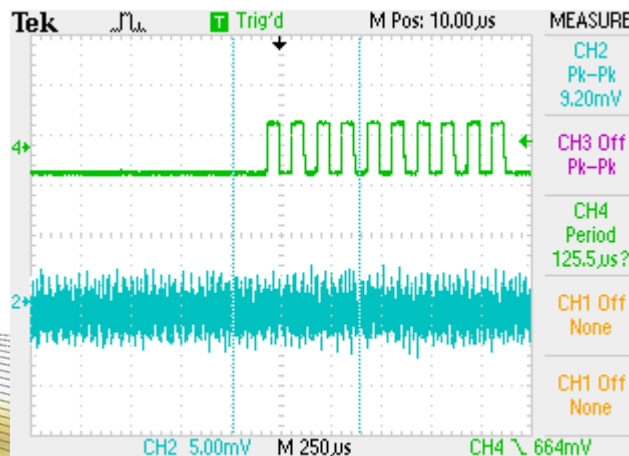


Differential mode noise (@ 500V/ 0uA) during communication bursts

---> less than 5 mV pk-pk



First channel prototype under tests



Common mode noise (@ 500V/ 0uA) during communication bursts

-----> 9.20 mV pk-pk

Push an option button to change its measurement

modes SNM

MOdular DEtection System for Special Nuclear Materials

- Funded by: **EUROPEAN COMMISSION**
- Programme: **FP7 – Cooperation**
- Theme: **SECURITY**



Project Partners



UNIVERSITÀ
DEGLI STUDI
DI PADOVA



CAEN
Tools for Discovery



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



UNIVERSITY OF
LIVERPOOL

Revenue

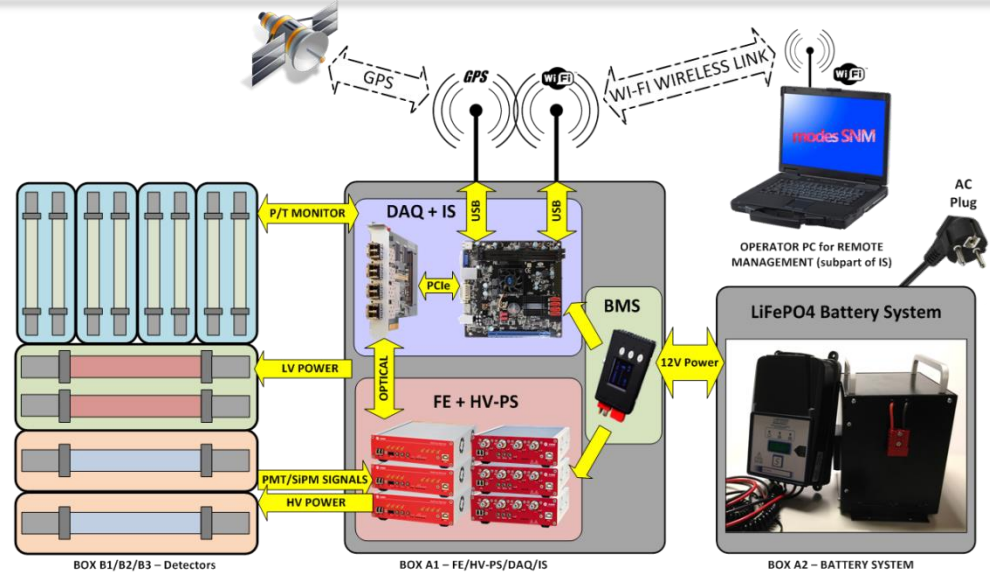


- The MODES_SNM project aimed to carry out technical research in order to develop a **prototype for a mobile, modular detection system for radioactive and Special Nuclear Materials (SNM)**.
- To maximize the detection capability for SNM the project developed **new detectors for fast and thermal neutrons, as well as gamma-rays**, based on the technology of high pressure scintillation cells using noble gases (as ^4He and Xe) recently developed by ARKTIS.
- The proof-of-principle of the new detectors has already been recently demonstrated.

www.modes-snm.eu

modes SNM

MOdular DEtection System for Special Nuclear Materials



DT5730 Digitizer with DPP-PSD

DT5533 HV MODULES

A3818 PCIe Optical



modes SNM

MOdular DEtection System for Special Nuclear Materials



- The commercial exploitation of the system was done by ARKTIS, expert in the detector technology
- The Front-end electronics for the system is provided by CAEN
- The software for the system has been developed by University of Padova

effective Container inspection at BORDer control points

The project aims at proving a complete system for cargo scanning in harbours

- Funded by: **EUROPEAN COMMISSION**
- Programme: **H2020 – Secure Societies**
- Theme: **Border Security, Supply chains**



- The C-BORD system will include the following technologies:

- ✓ X-RAY
- ✓ Rapidly Relocatable Tagged Neutrons Inspection System
- ✓ Passive Radiation sensors
- ✓ Photofission System
- ✓ Sniffer sensors

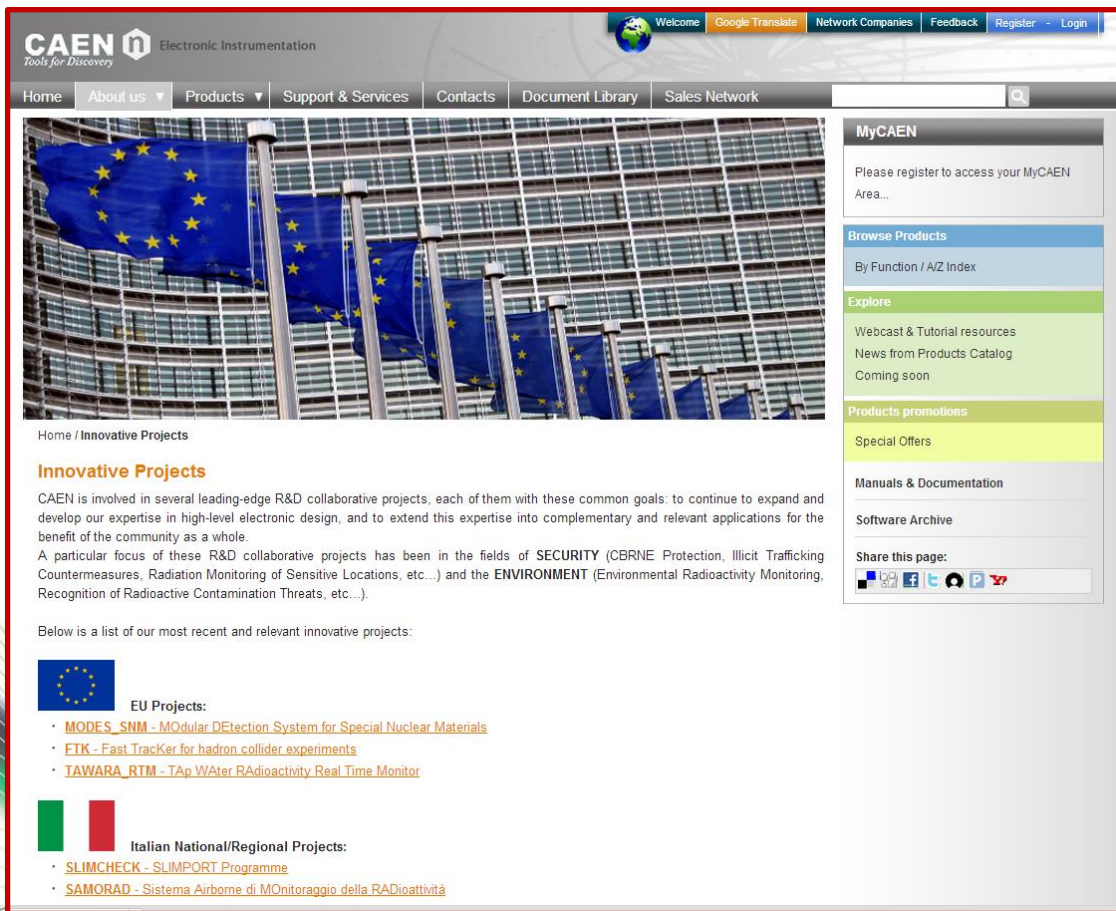
Some numbers

- 19 Partners from 9 EU countries
- 4 companies involved
- 5 end-users
- 10 research institutions
- Total budget 11.8 MEuro

CAEN will develop the F/E electronics for the RRTNIS and for the Prompt neutron detector for the photofission systems

INNOVATIVE PROJECTS WEBPAGE

CAEN Homepage > About us > Innovative Projects



The screenshot shows the CAEN website's 'Innovative Projects' page. At the top, there is a navigation bar with links for Home, About us, Products, Support & Services, Contacts, Document Library, and Sales Network. A search bar is also present. The main content area features a large image of the European Union flag in front of a modern building. Below the image, the text reads: 'Home / Innovative Projects' and 'Innovative Projects'. The main text states: 'CAEN is involved in several leading-edge R&D collaborative projects, each of them with these common goals: to continue to expand and develop our expertise in high-level electronic design, and to extend this expertise into complementary and relevant applications for the benefit of the community as a whole. A particular focus of these R&D collaborative projects has been in the fields of SECURITY (CBRNE Protection, Illicit Trafficking Countermeasures, Radiation Monitoring of Sensitive Locations, etc...) and the ENVIRONMENT (Environmental Radioactivity Monitoring, Recognition of Radioactive Contamination Threats, etc...).' Below this, it says 'Below is a list of our most recent and relevant innovative projects:'. There are two sections: 'EU Projects' with a list of three projects: 'MODES_SNM - MODular DEtection System for Special Nuclear Materials', 'FTK - Fast TrackKer for hadron collider experiments', and 'TAWARA_RTM - TAp WAter RAdioactivity Real Time Monitor'. The second section is 'Italian National/Regional Projects' with a list of two projects: 'SLIMCHECK - SLIMPORT Programme' and 'SAMORAD - Sistema Airborne di MOnitoraggio della RAdioattività'.

For information about the status of our ongoing projects and to discuss about new projects

innovativeprojects@caen.it

CONCLUSIONS

- We are involved in several collaborations focused on Neutron Detection and MPGD, and we are opened to new ones
- We are involved in several Funded Projects at **Regional, National and EU level** where we select topics which **maximise our added value** and which stay in the **CAEN Roadmap**
- The participation to these projects is very useful for various reason:
 - **To develop a strong collaborative relation with research actors**
 - **To test our products in different applications and benefit from the induced know-how exchange**
 - **To receive a financial support for developing products which are fitting well in our product development roadmap**

Thank you for your attention!

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