A programmable readout system for $^{3}He/BF^{3}$ neutron detectors

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Introduction

Neutron sources are currently becoming a standard to investigate the structures of various materials at mesoscopic scale using elastic scattering techniques. Typical neutron physics experiments carried out at Neutron Spallation Sources and other laboratories (like ESS, SNS, CSNS, ISIS, ILL, …) make use of large arrays of 3He/BF3 position-sensitive tubes to detect neutrons. On the other hand, Nuclear Security main players need more compact systems with standalone electronics to bias and read out neutron detectors.

CAEN has developed a **19" rack-mount solution for the readout of $^{3}He/BF^{3}$ tubes**, which can be tailored for both above-mentioned scenarios, including **neutron physics experiments** and **Security/Safeguards monitoring systems**. The system is at the same time compact and scalable, allowing to put together few to hundreds neutron detectors.

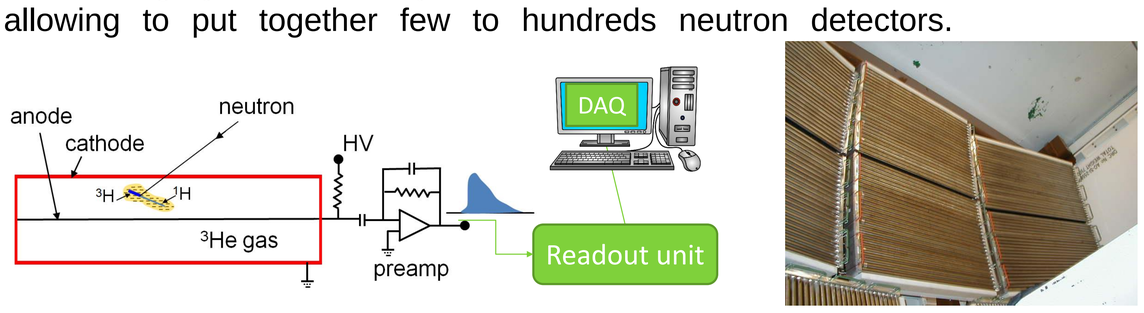


Fig. 0: Left: readout scheme of a neutron gaseous detector. Right: array of detectors @SNS

Rackmount hardware

It can be composed starting from three basic building blocks:

- **R8033:** 8-16 channels, ± 4kV/3mA High Voltage board
- **R1443:** 16-32 channels Charge Sensitive Preamplifier specifically designed for 3He/BF3 tubes. Single channel version COMING SOON
- **R5560:** Up to 128 channels, 14-bit 125MS/s open FPGA Digitizer. Thanks to its firmware programmability, this readout system can perform specific filtering to achieve the best charge, timing and position measurements.

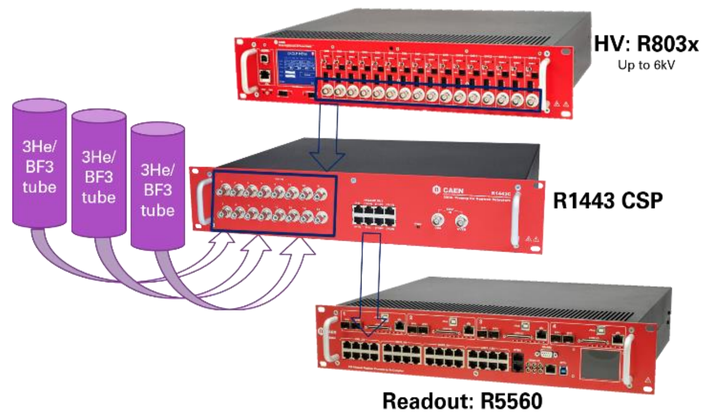


Fig. 1. hardware parts of the rackmount system for neutron detectors readout

Thanos and SCI-Compiler: DAQ with maximum flexibility

CAEN provides a DAQ software – **Thanos -** to remotely manage the system parameters, acquire waveforms, energy, ToF spectra and perform position reconstruction. Moreover, the R5560 offers the possibility to use SCI-Compiler, a block-diagram-based software which allows to easily implement custom pulse processing algorithms in the **open FPGA.**

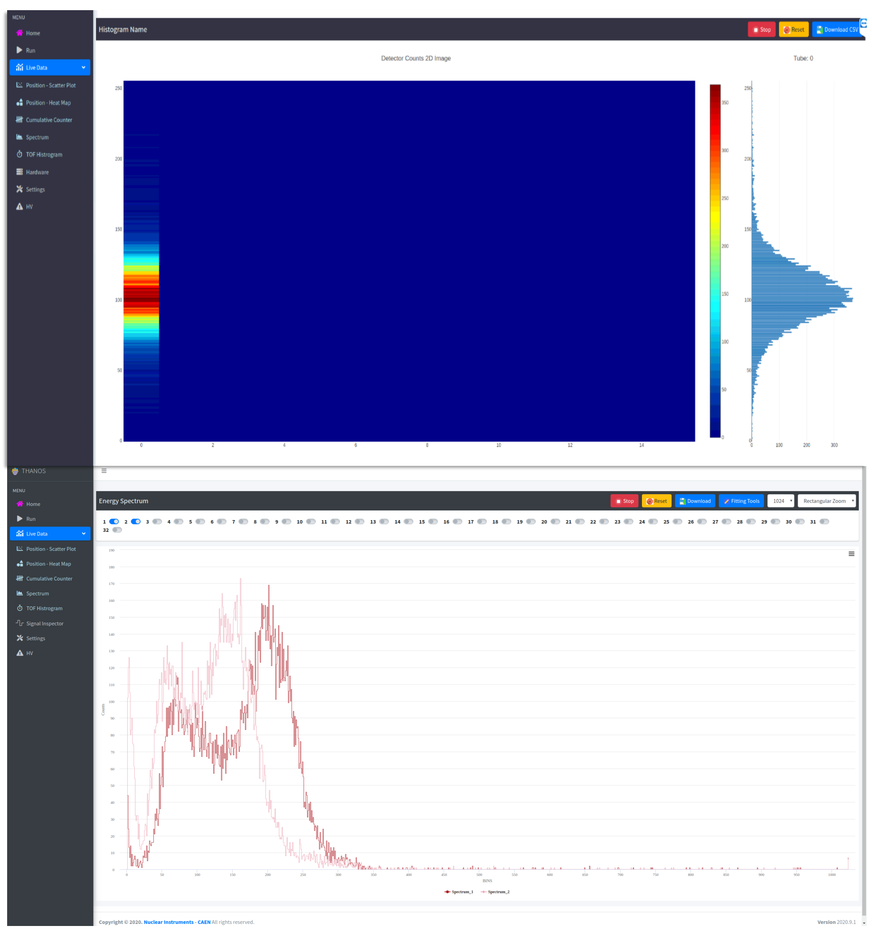


Fig. 2. Thanos DAQ, showing position reconstruction and energy spectra from a double-end He3 tubes

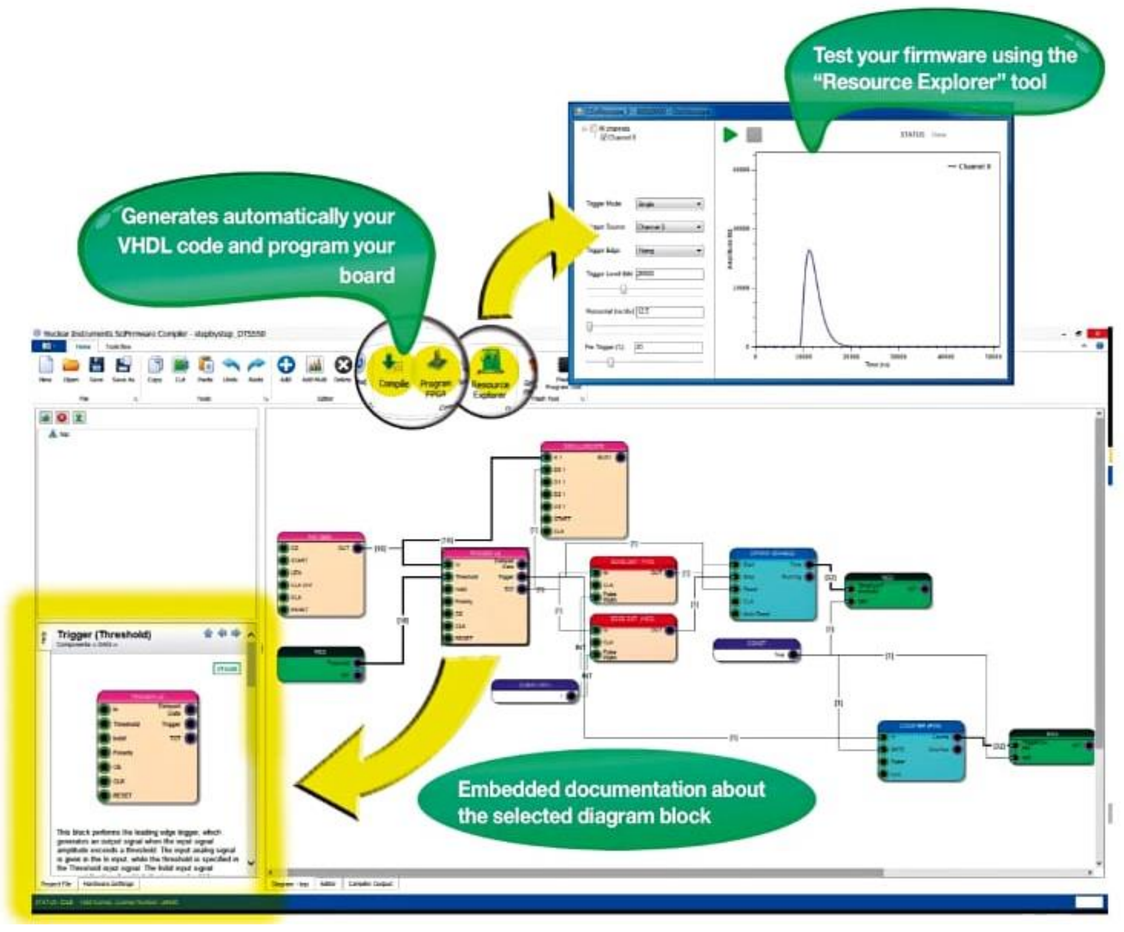


Fig. 3. Firmware customization in SCI-Compiler

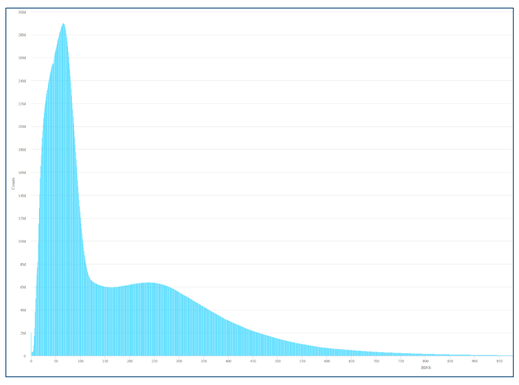
Conclusion

The modularity and scalability of the system allow to tailor the setup for both **fundamental physics experiment** and **Nuclear Security/Safeguards/Radioprotection applications**, especially in those cases where you need to locate a potentially hazardous neutron emitter, measure its energy and reconstruct its position. The proposed CAEN readout system, in different rearragements, proved to be a good match for the Loki experiment [1] developed at RAL/ISIS for installation at ESS and for Security applications at IRSN-France [2].

References

[1] https://www.isis.stfc.ac.uk/Pages/Loki.aspx

[2] https://www.irsn.fr/EN/Pages/Home.aspx



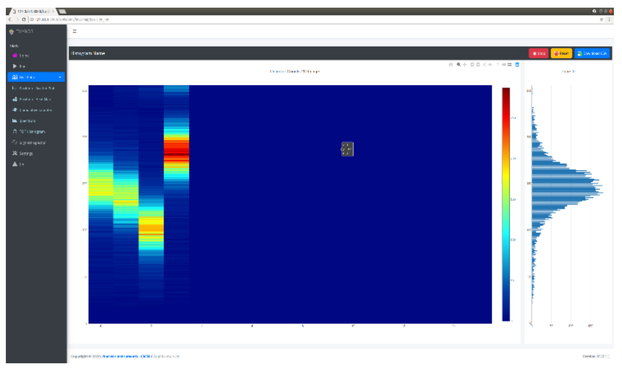


Fig. 4. Left: Neutron ToF spectrum @Loki , measured with CAEN R5560. Right: position reconstruction of a ^{252}Cf from four ^{3}He tubes using the system provided to IRSN

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