weeroc

High-end Microelectronics Design

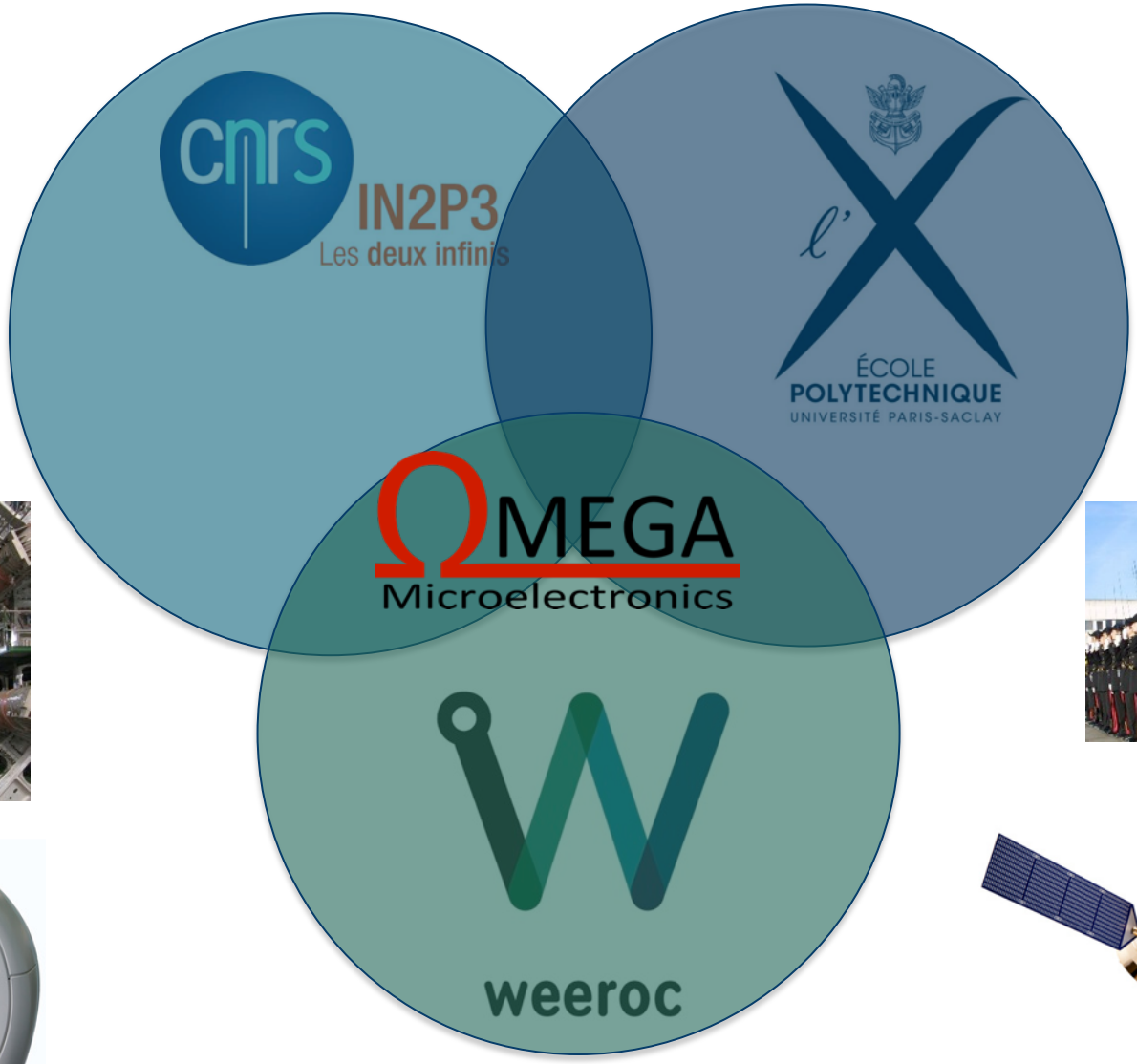
PETIROC2A : New measurement results on fast ToF SiPM read-out chip

TIPP 2017, May 23rd, Beijing

J. Fleury & Al

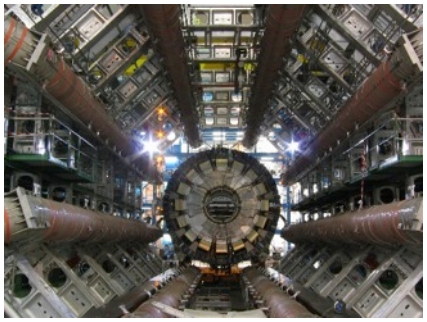
ΩMEGA Microelectronics

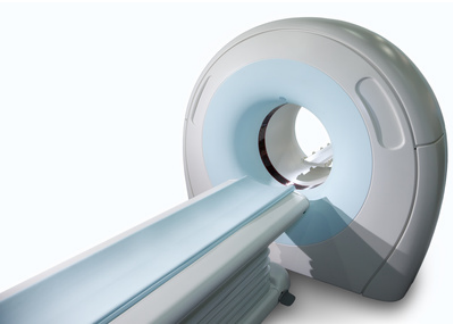
Research – Academia – Industry relationship



Research, Institutes & CNRS

Education, University & Engineering Schools





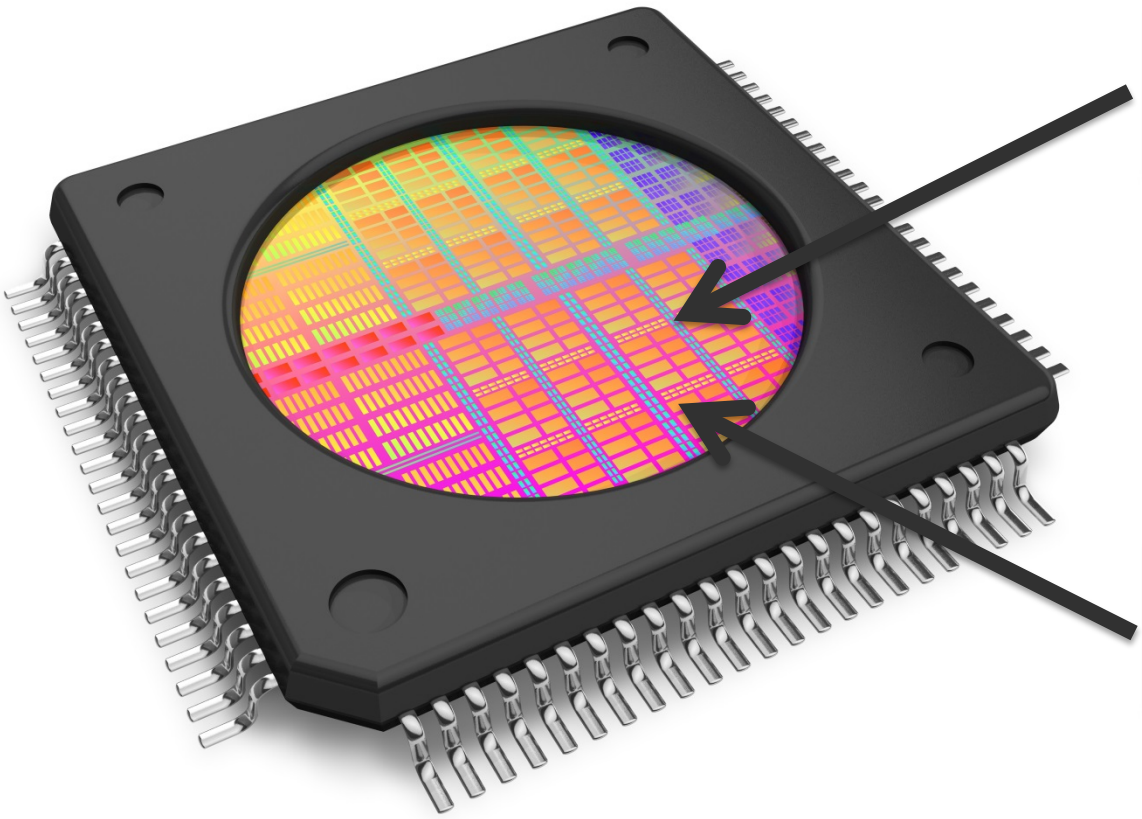
Industry, SMEs & MNCs

Weeroc Expertise

Design and marketing

Analog & mixed-signal microelectronics ICs for photodetectors read-out

and radhard application



Particle detection

Low-noise, low power, analog and mixed-signal design

Radhard design

Weeroc markets

Medical imaging

Aerospace industry

Nuclear industry

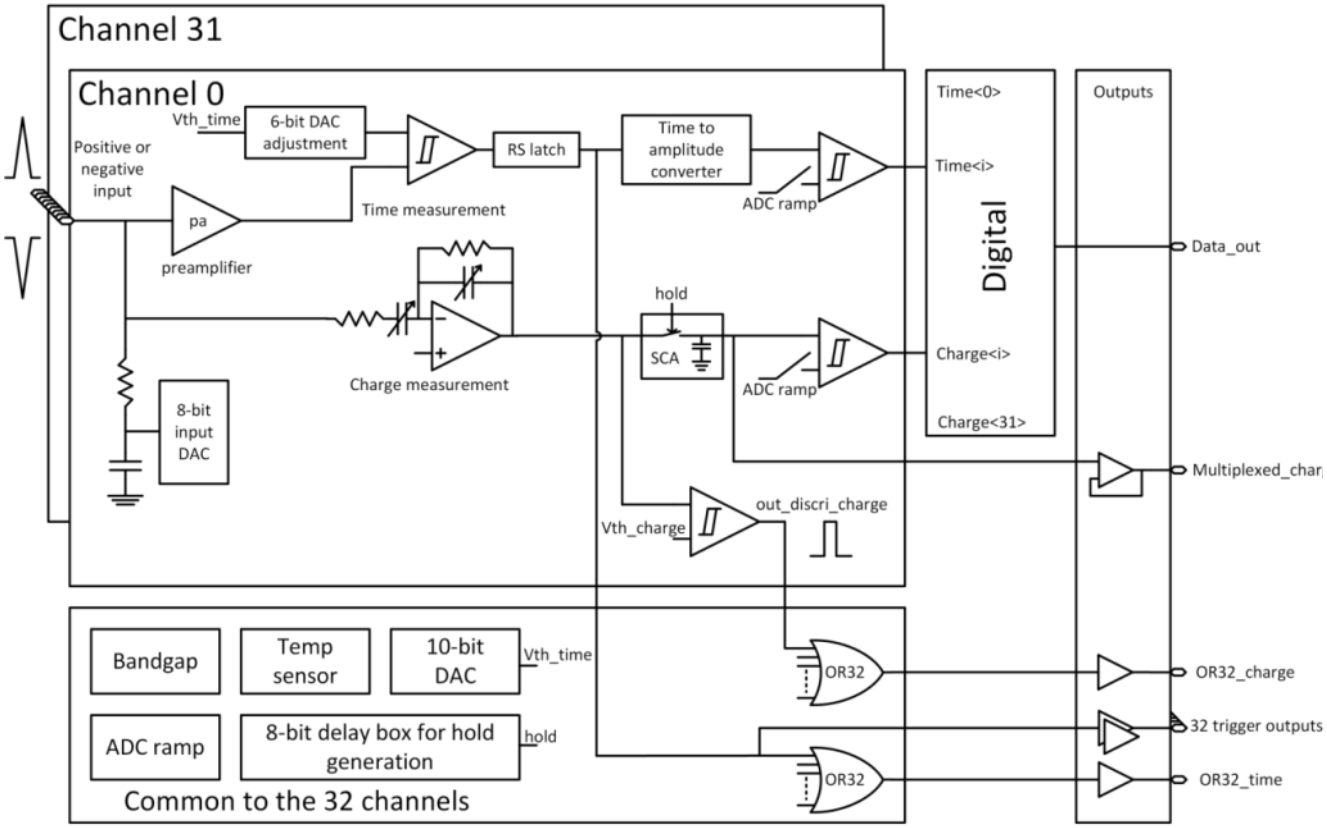
Homeland security

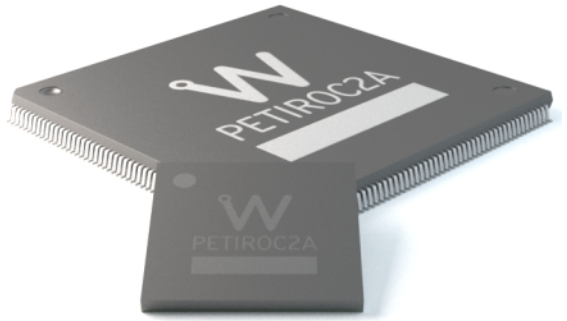
Scientific instrumentation

Analytical instrumentation

PETIROC 2A

SiPM read-out for time-of-flight PET





Detector Read-Out	SiPM, SiPM array
Number of Channels	32
Signal Polarity	Positive or Negative
Sensitivity	Trigger on first photo-electron
Timing Resolution	~ 35 ps FWHM in analogue mode (2pe injected) - ~ 100 ps FWHM with internal TDC
Dynamic Range	3000 photo-electrons (10^6 SIPM gain), Integral Non Linearity: 1% up to 2500 ph-e
Packaging & Dimension	TQFP160 – TFBGA353

Petiroc 2A Operation Modes

Photon Counting

- No system clock in the chip
- Fast preamplifier & fast discriminator
- Programmable threshold
- 32 trigger outputs
- Photon counting on each channel on trigger rising edge
- Time-Over-Threshold possible
- 120 MHz max rate

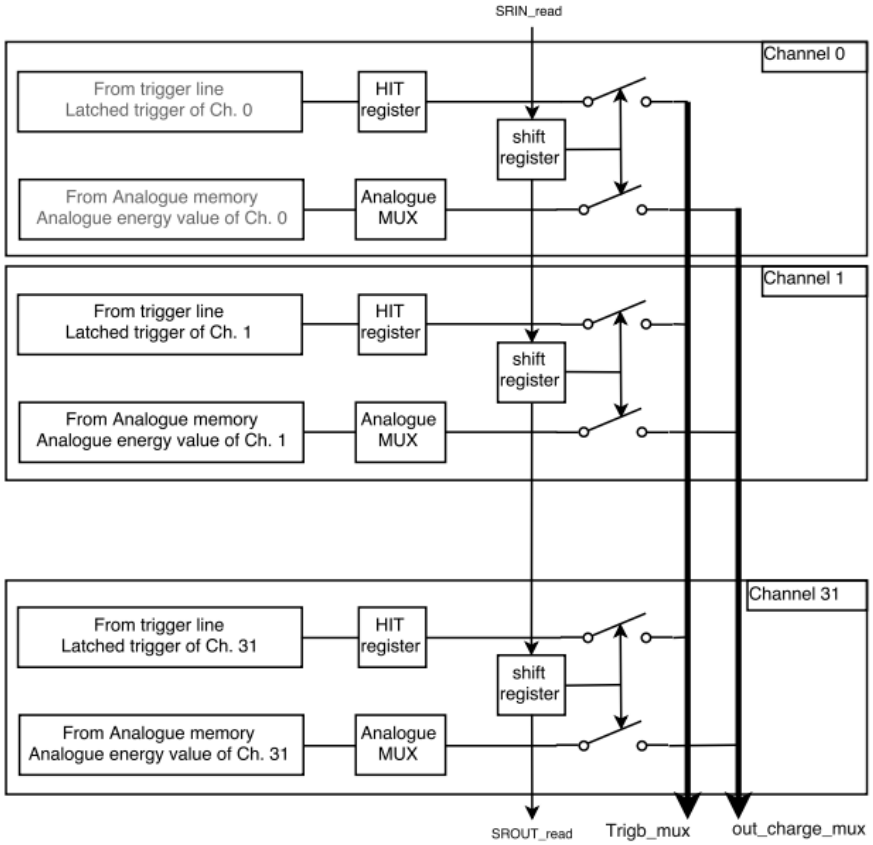
Analogue Read-out

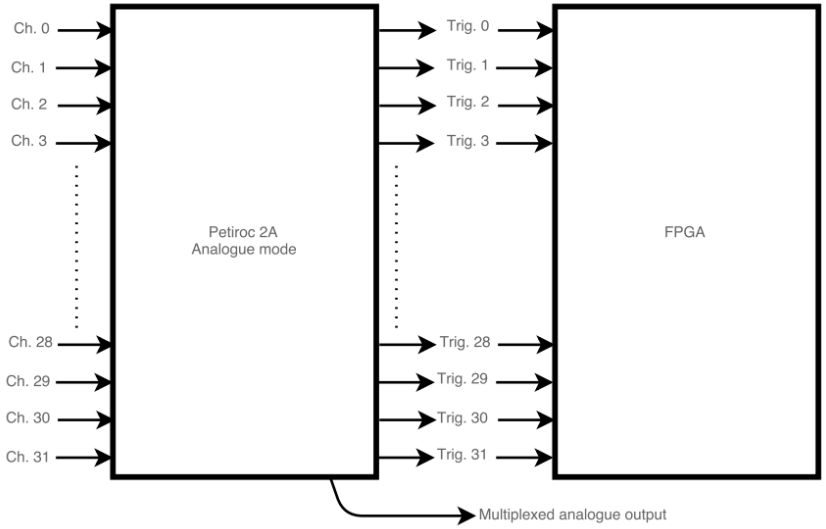
- No system clock in the chip
- Asynchronous
- 32 triggers outputs
- analogue multiplexed output
- Trigger OR, two thresholds
- External TDC and ADC required
- Count rate 500 kCPS

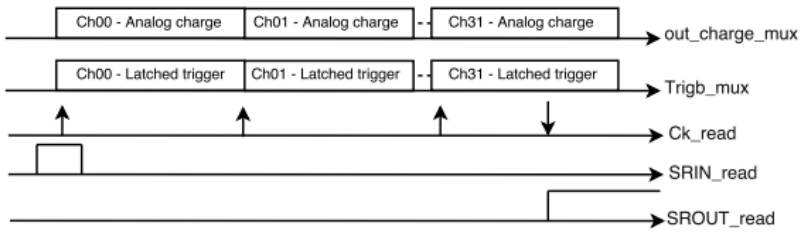
Digital Read-out

- All conversion inside Petiroc
- One wire serial data out
- Two trigger level
- No zero suppression
- Backend controlled by DAQ
- Count rate 40kCPS

Petiroc 2A – Analogue & photon counting



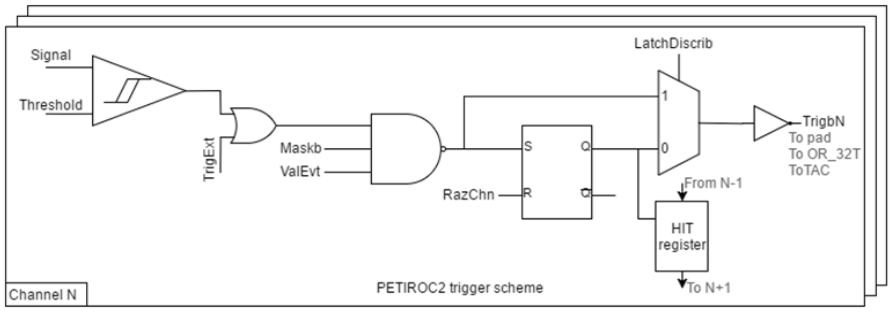




Back-end

- 32 trigger (latched or unlatched)
- 2 trigger OR for system triggering
- 1 multiplexed analogue output

Petiroc 2A operation mode : full digital

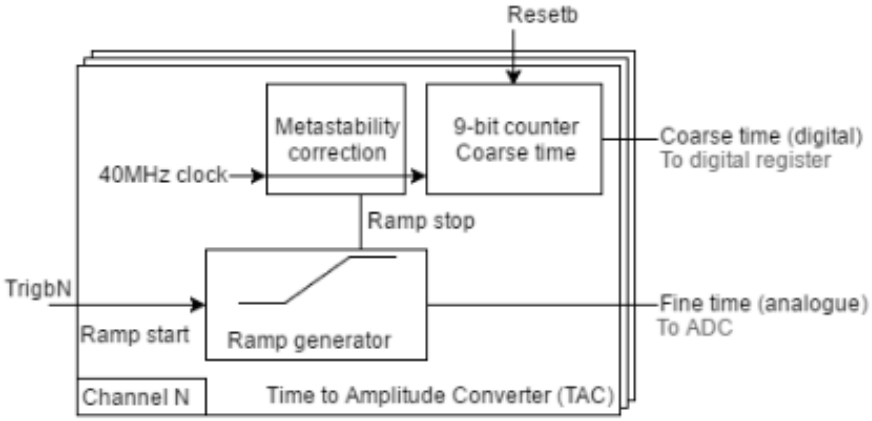


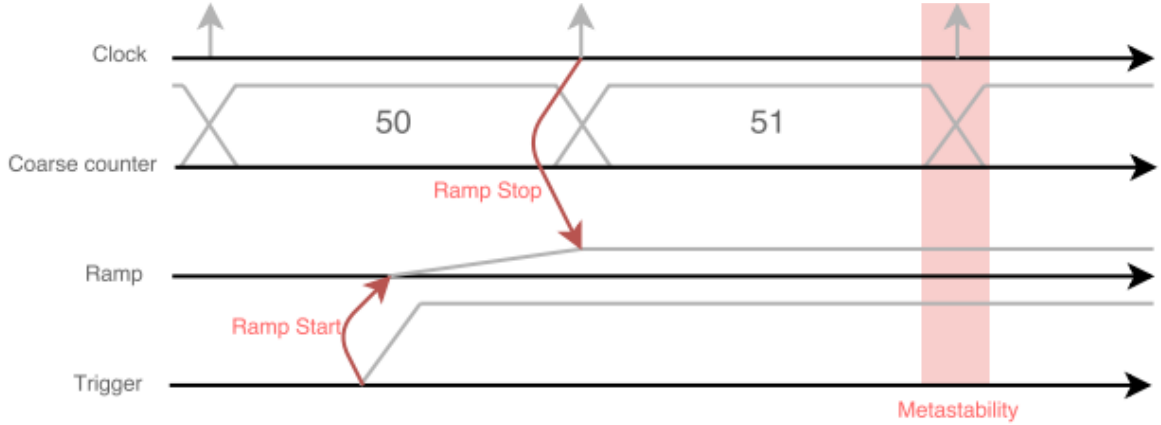
Trigger scheme

- External trigger available
- Channel-by-channel mask & general ASIC time windowing
- Latched trigger output

Time interpolation

- Time-to-amplitude converter
- Metastability correction
- 9-bit coarse counter @ 40MHz (12us)

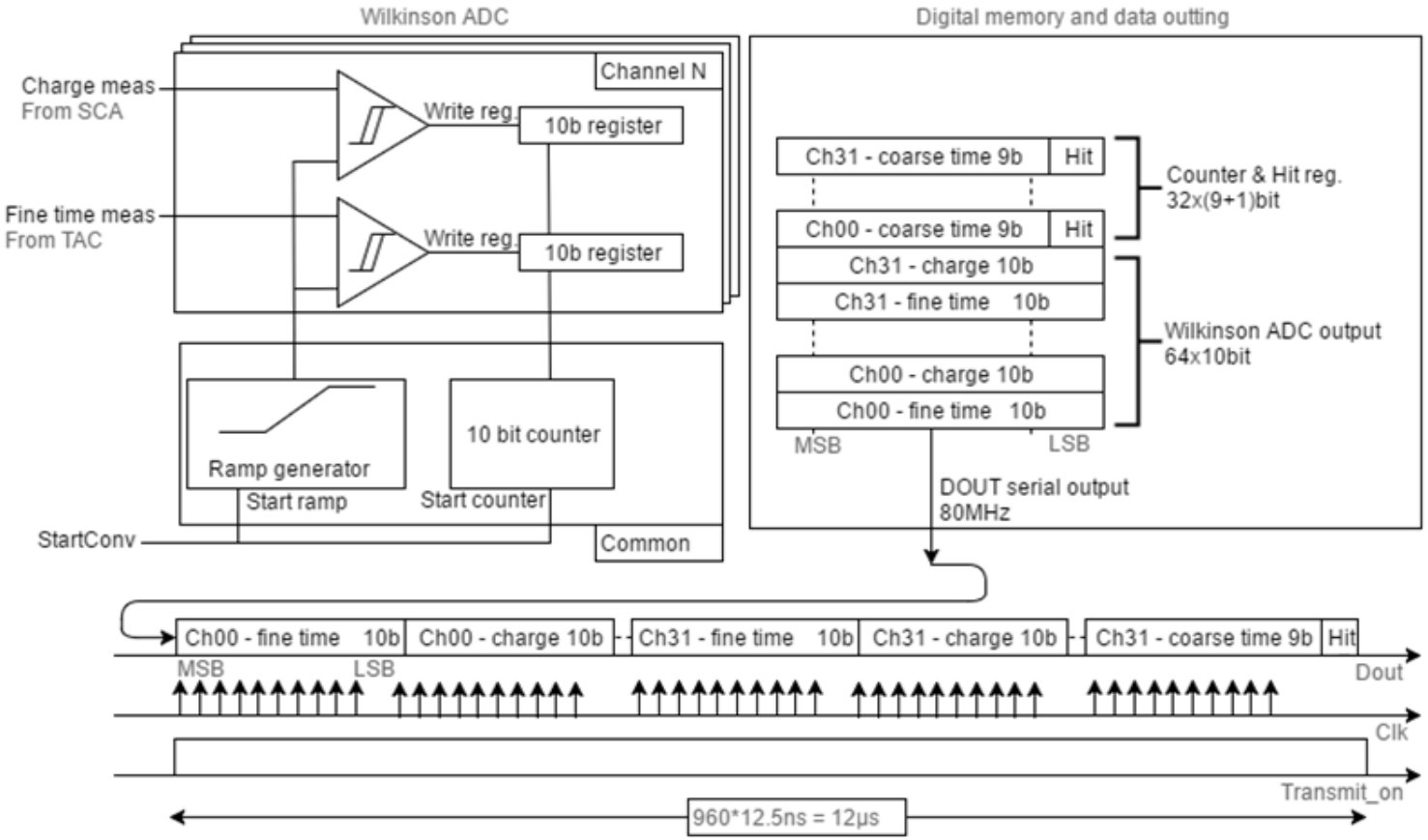


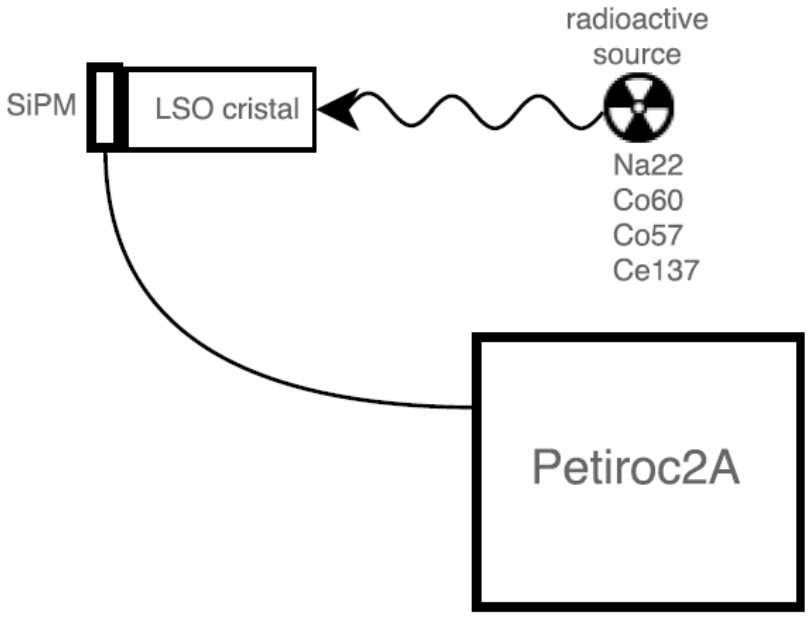


Petiroc 2A operation mode : full digital

Digital conversion & data outing on user request

- Analog data of charge and time are converted in a row with a 64ch. Wilkinson ADC
- Digital data are streamed out upon conversion completion
- Maximum event rate : 40kE/s





ENERGY MEASUREMENT

Petiroc in digital mode

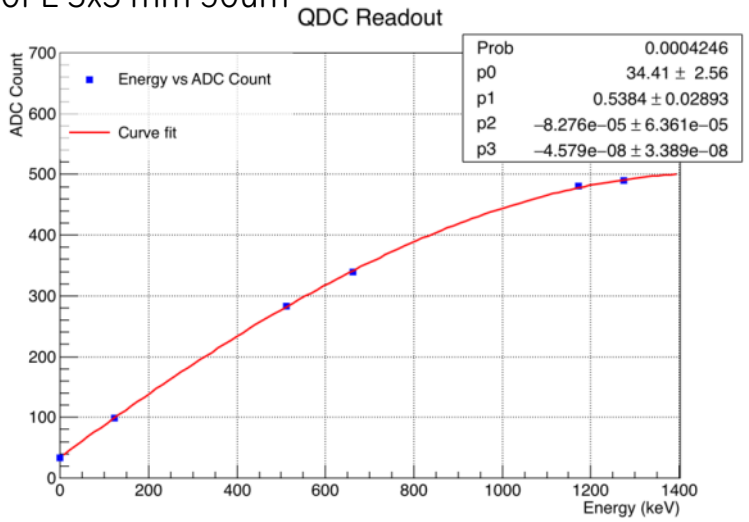
Measurement made at CERN

Thanks to Stefan Gundacker @ CERN for kind help and support

Petiroc 2A energy resolution

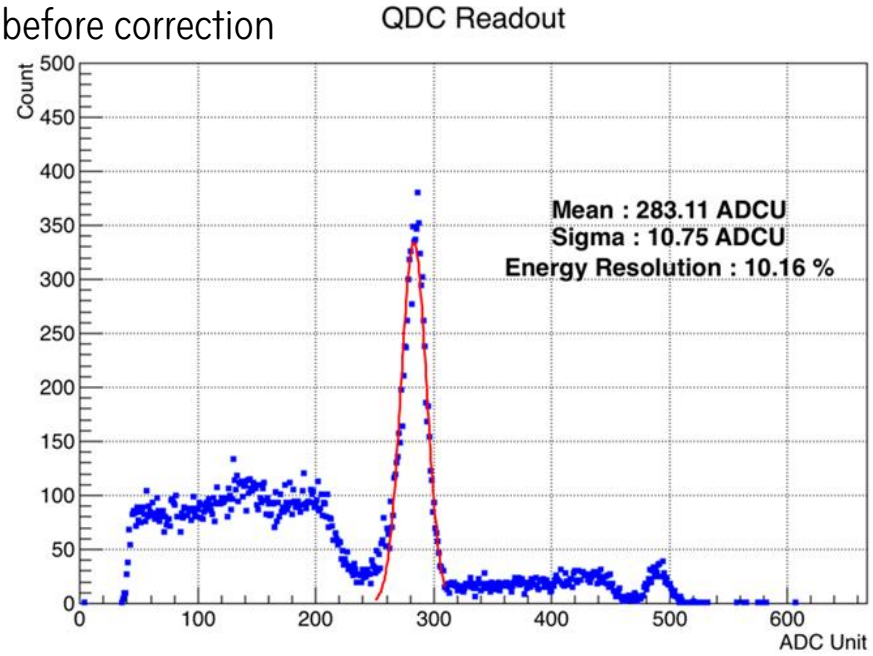
Scintillator : 3x3x20mm LSO:Ce codoped Ca (TBC)

SiPM : Hamamatsu MPPC S13360 3050PE 3x3 mm 50um

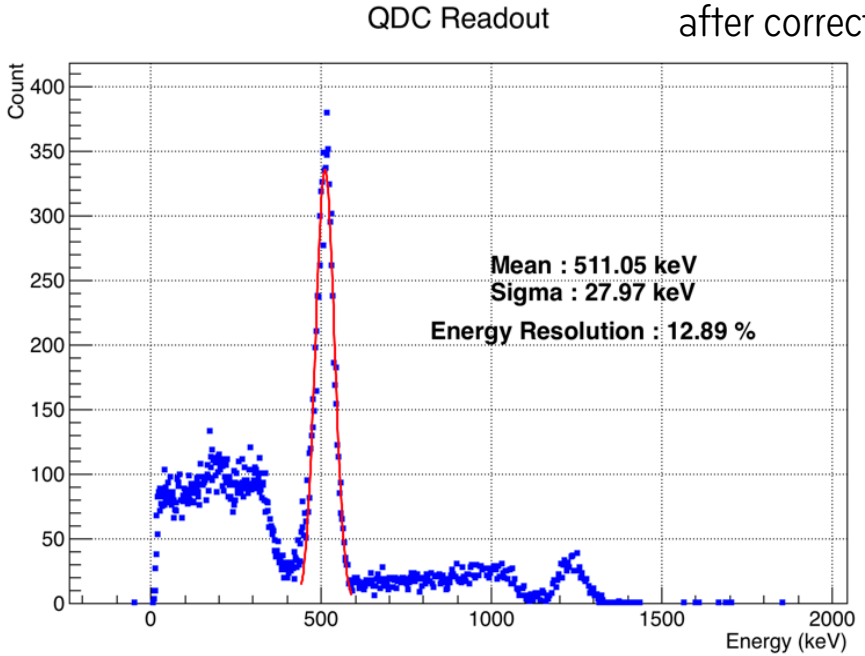


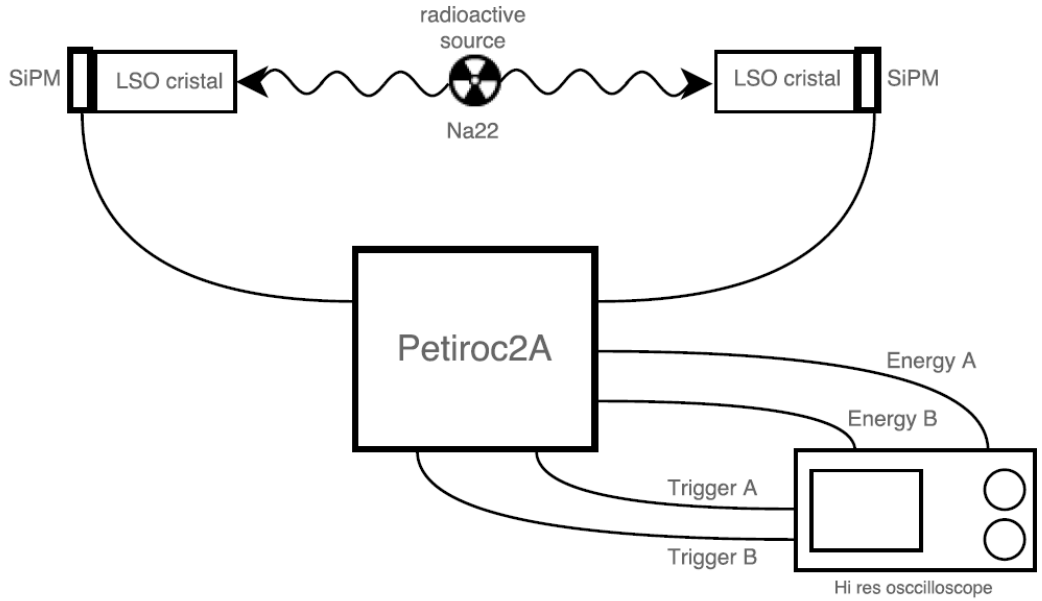
Isotope	Photopeak	energy (MeV)
Na22	1	0,511
Na22	2	1,274
Co60	1	1,173
Co60	2	1,332
Cs137	1	0,662
Co57	1	0,122

Na22 spectrum before correction



Na22 spectrum after correction





CTR MEASUREMENT – ANALOG OUTPUTS

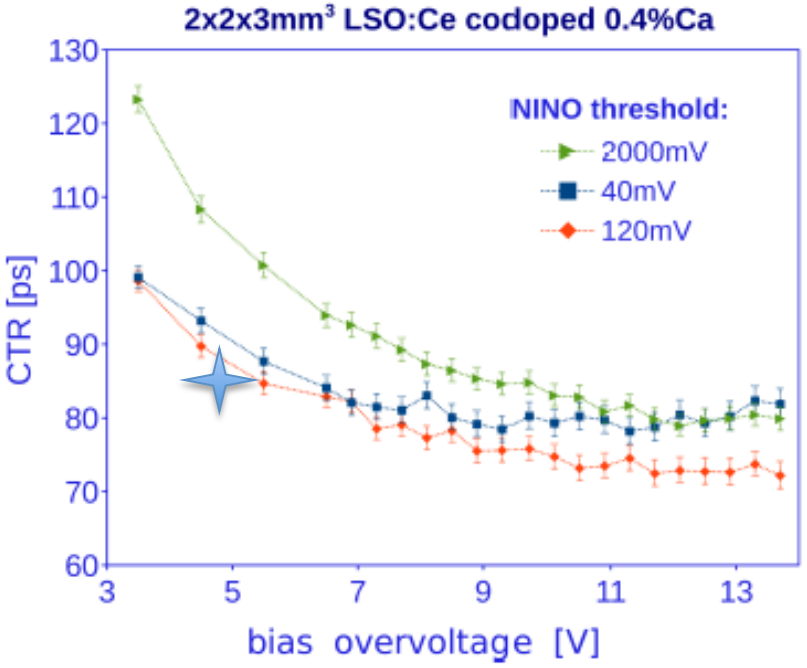
Petiroc in analogue mode

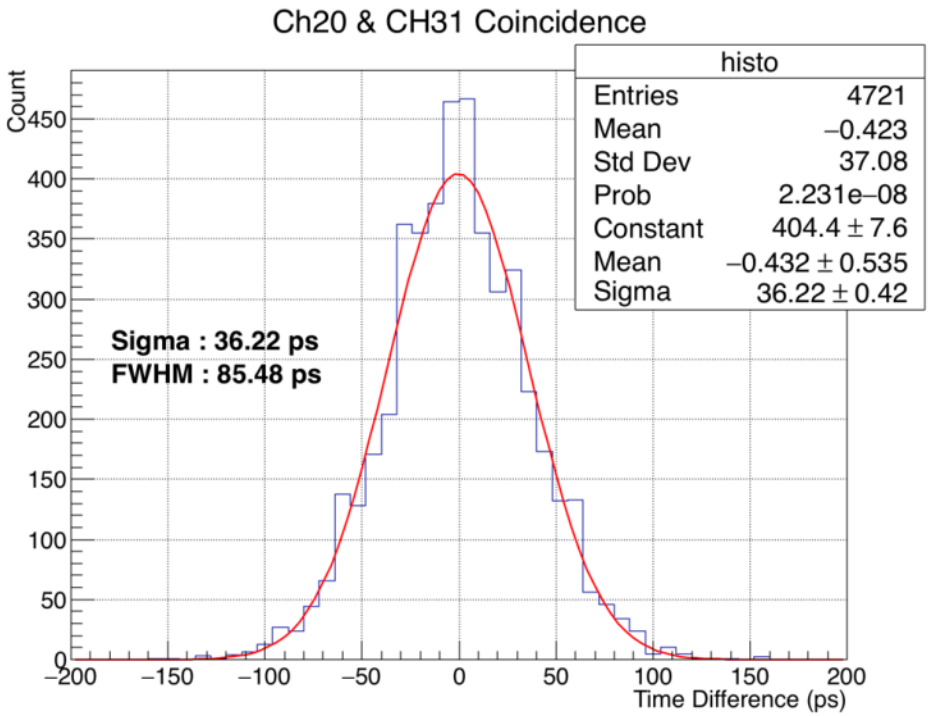
Measurement made at CERN

Thanks to Stefan Gundacker @ CERN for kind help and support

Petiroc 2A – CTR measurement, analog mode

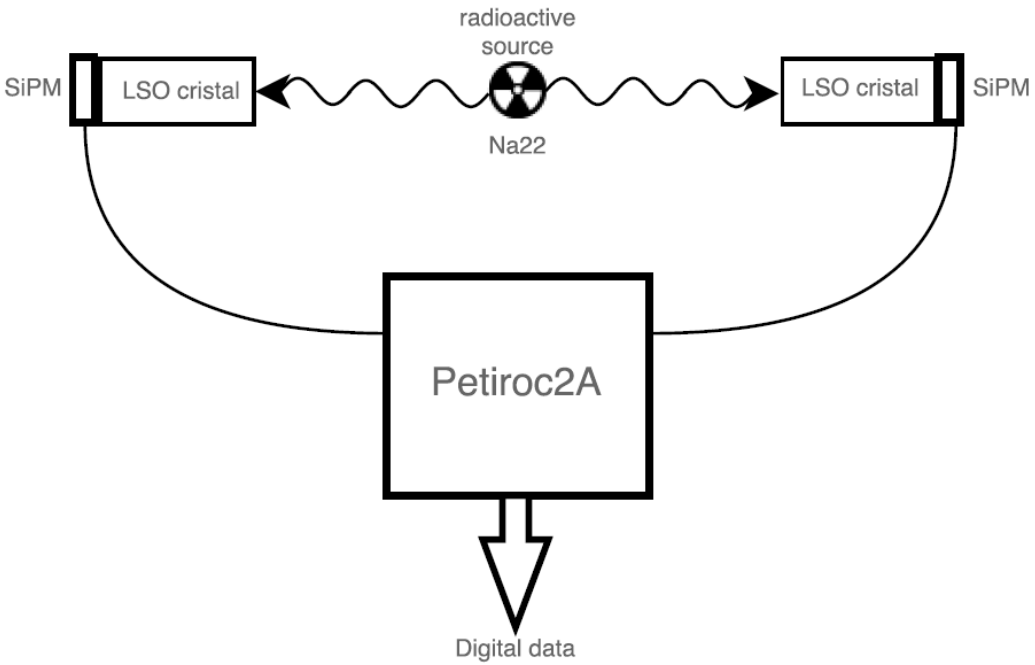
Petiroc2A Threshold	Digital Part	CTR (FWHM)
450	OFF	85.48 ps
500		91.91 ps
700		100.57 ps
450	ON	125.07 ps
500		104.07 ps





Source : Na22
Scintillator : 2x2x3mm LSO:Ce codoped Ca
SiPM : Advansid/FBK NUV-HD 40um
HV : 35V
FWHM : 85ps

State of the art timing in TOF-PET detectors with LuAG, GAGG and L(Y)SO scintillators of various sizes coupled to FBK-SiPMs
S. Gundacker & AI, CERN
JINST - 10.1088/1748-0221/11/08/P08008



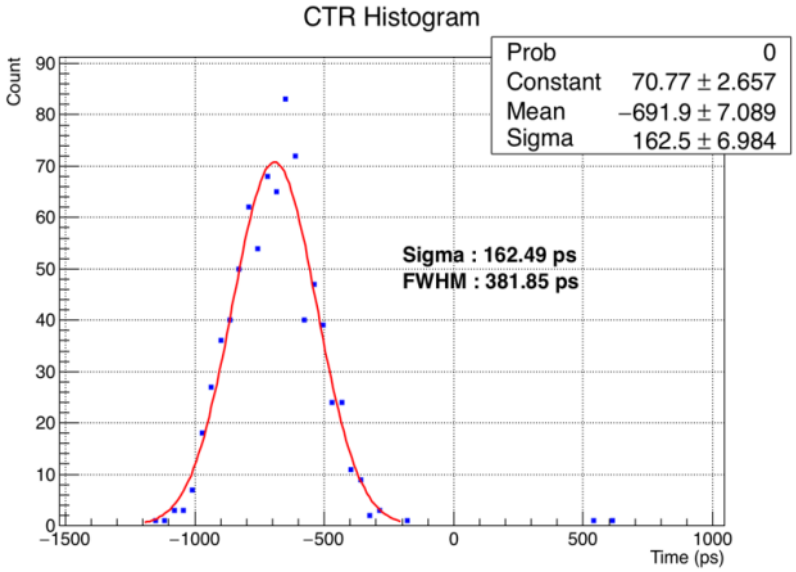
CTR MEASUREMENT – DIGITAL OUTPUTS

Petiroc in digital mode

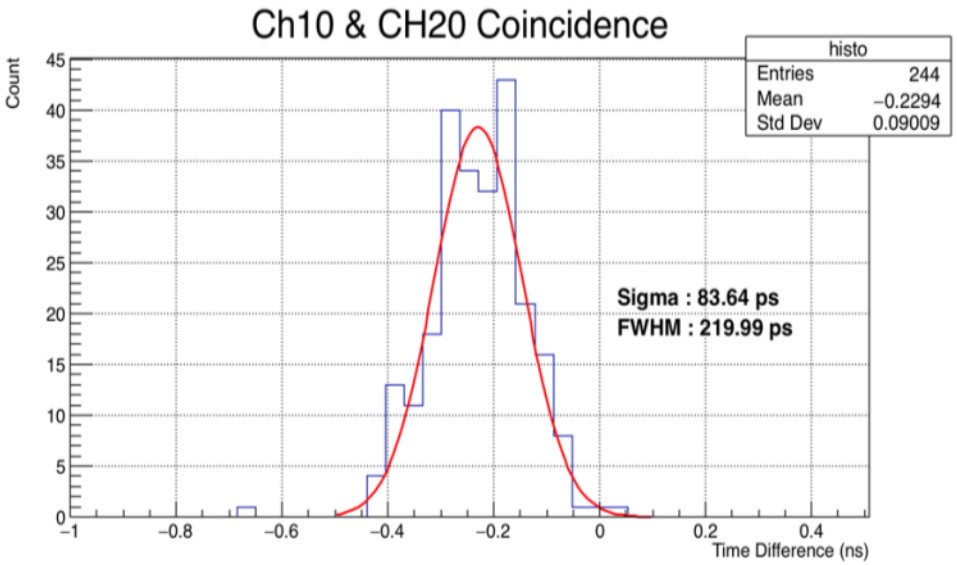
Measurement made at CERN

Thanks to Stefan Gundacker @ CERN for kind help and support

Petiroc 2A – CTR measurement, digital mode

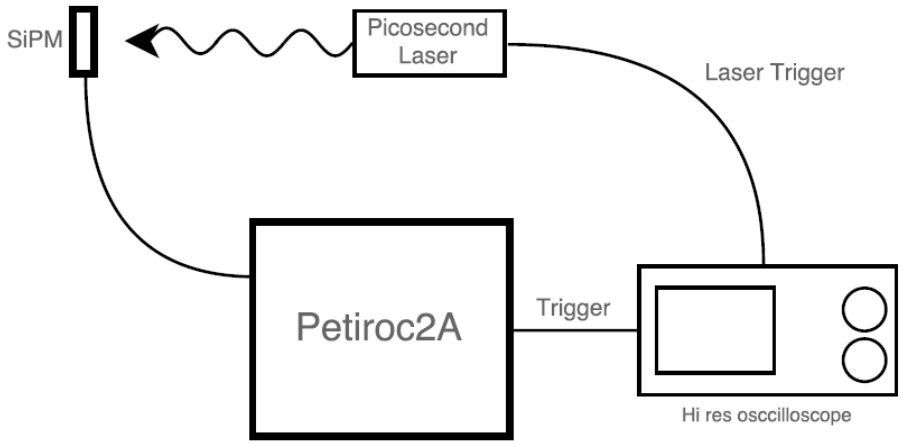


Source : Na22
Scintillator : 3x3x20mm LSO:Ce codoped Ca
SiPM : MPPC S13360 3050PE 3x3 mm 50um
HV : 54V
FWHM : 380ps



Source : Na22
Scintillator : 2x2x3mm LSO:Ce codoped Ca
SiPM : Advansid/FBK NUV-HD 40um
HV : 35V
FWHM : 220ps

Full system Coincidence Timing Resolution including all errors : from Crystal to data processing in Computer



SPTR MEASUREMENT

Petiroc in analogue mode

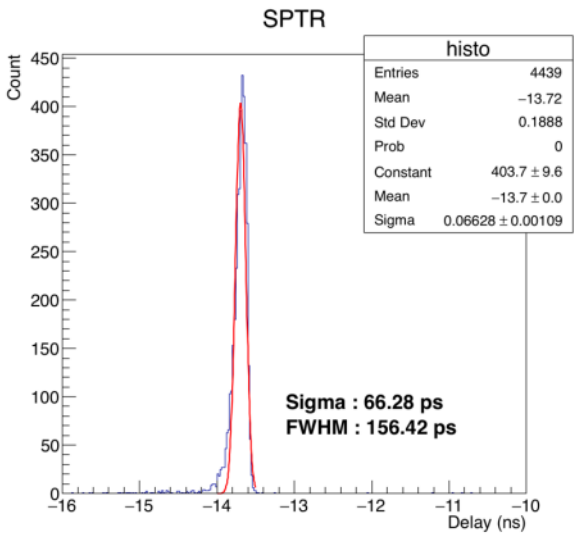
Measurement made at CERN

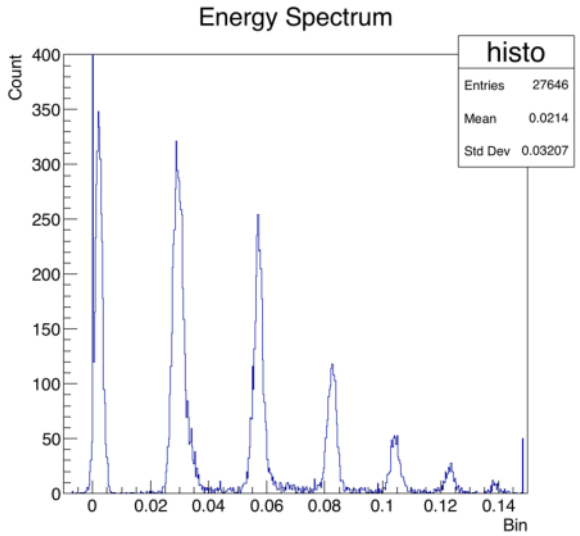
Thanks to Stefan Gundacker @ CERN for kind help and support

SPTR measurement

Source : Laser
Hamamatsu MPPC S13360 1350PE
1.3x1.3 mm 50um
HV : 61V

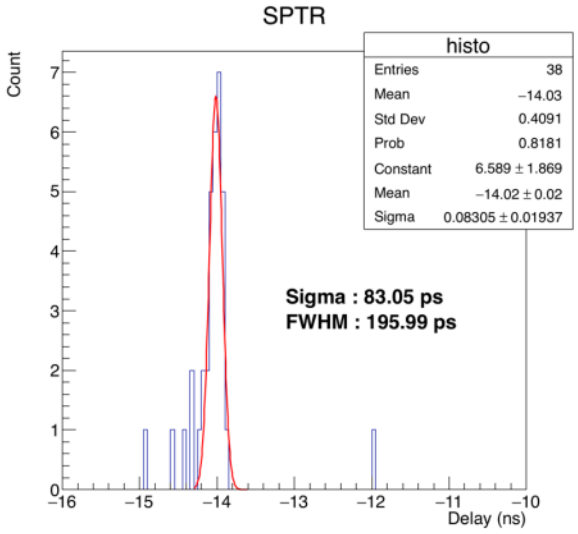
SPTR : 156.4ps FWHM

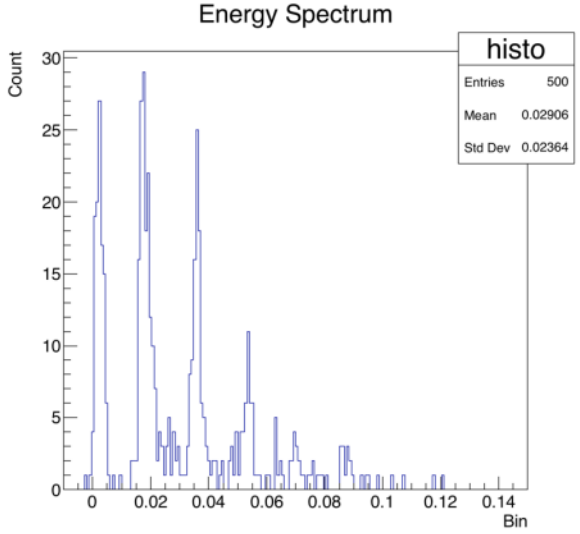




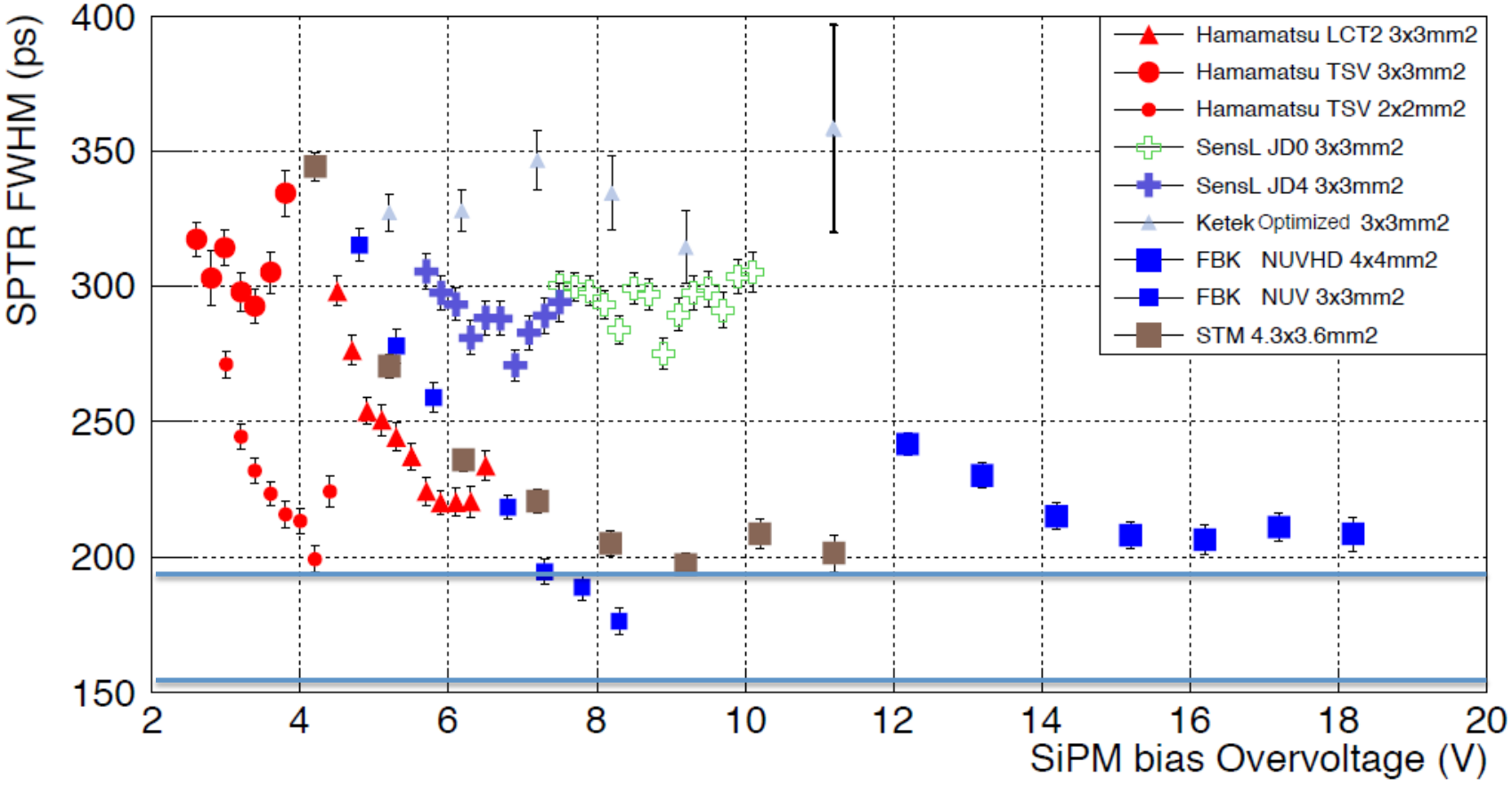
Source : Laser
Hamamatsu MPPC S13360 3050CS
3x3 mm 50um
HV : 60V

SPTR : 196ps FWHM





SPTR - state of the art

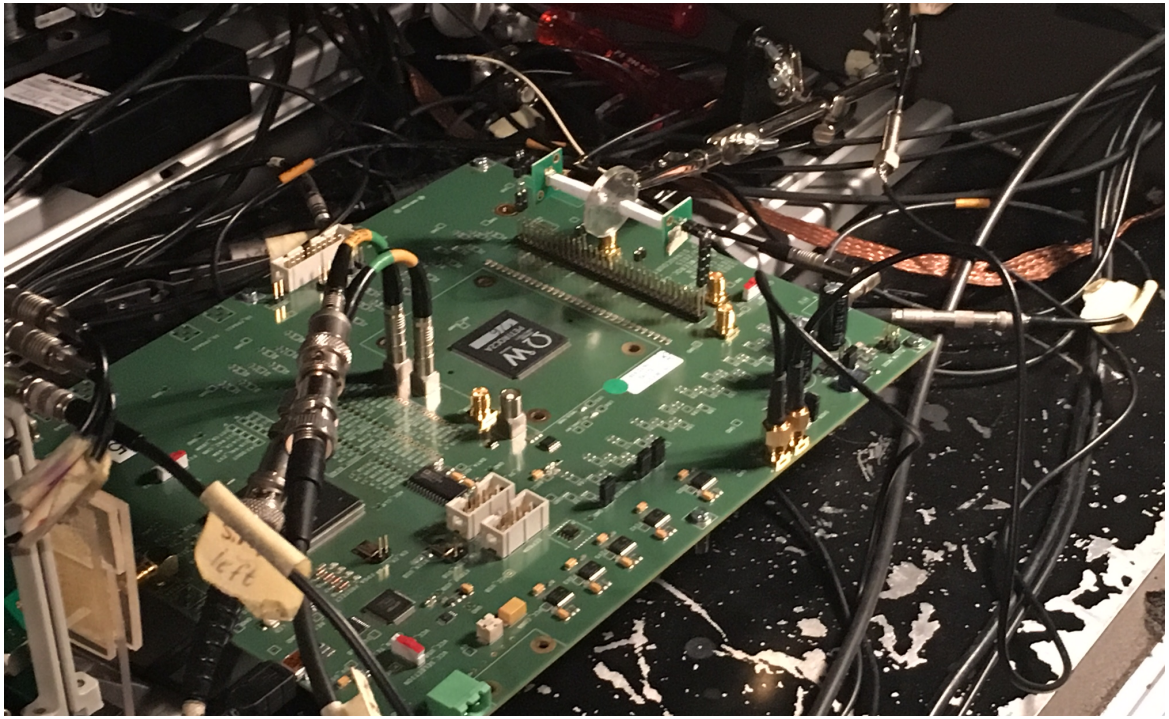


Single photon time resolution of state of the art SiPMs

JINST, published: *October 21, 2016*

M.V. Nemallapudi, S. Gundacker, P. Lecoq and E. Auffray

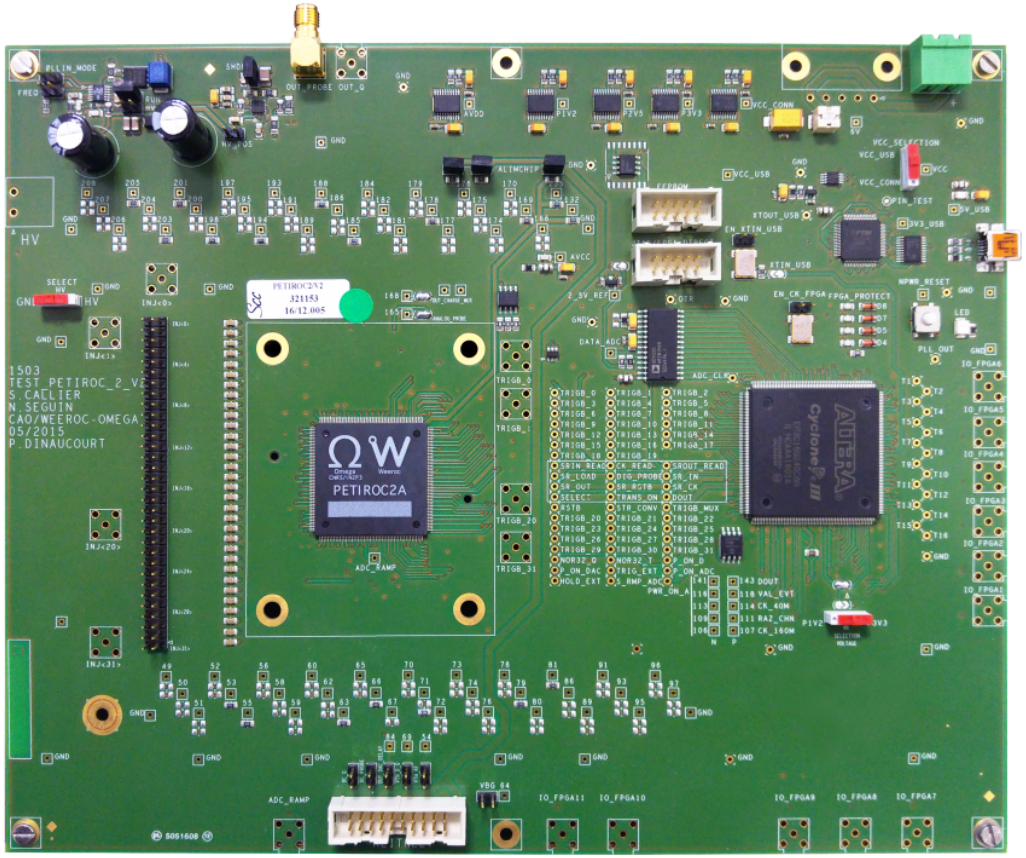
doi:10.1088/1748-0221/11/10/P10016



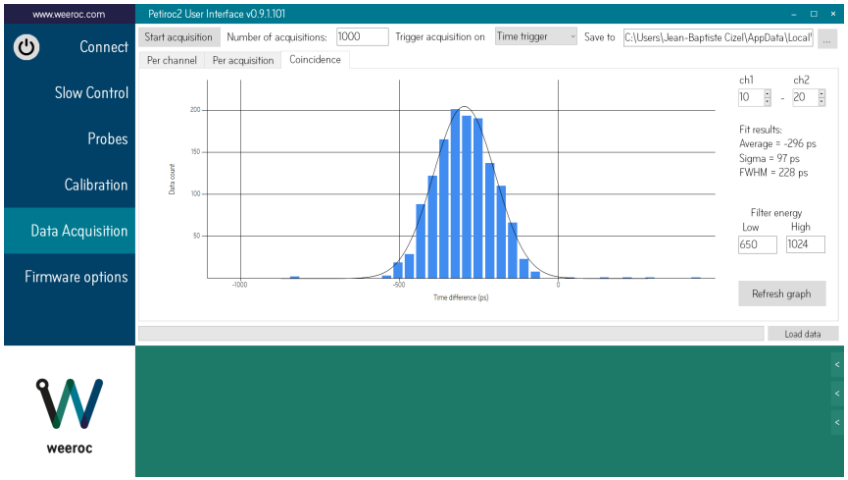
PETIROC 2A EVALUATION SYSTEMS

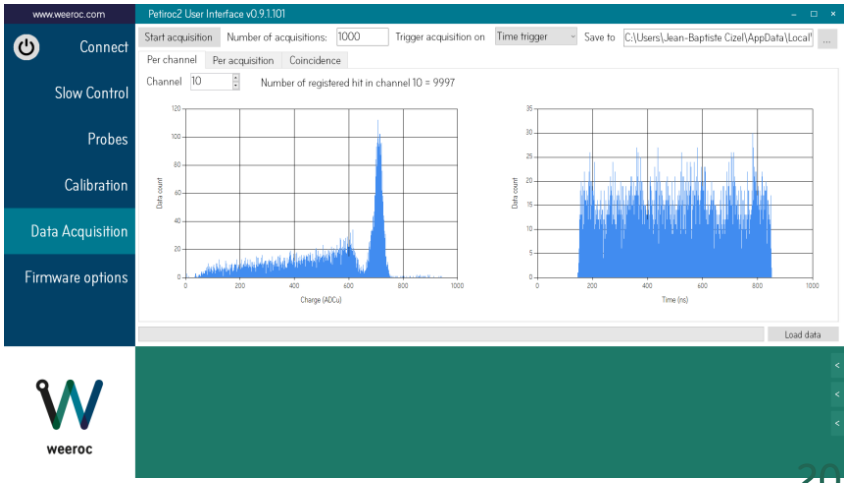
Evaluation board

32 channel – 1 Petiroc 2A evaluation system
Open source firmware and software
Reprogrammable I/Os

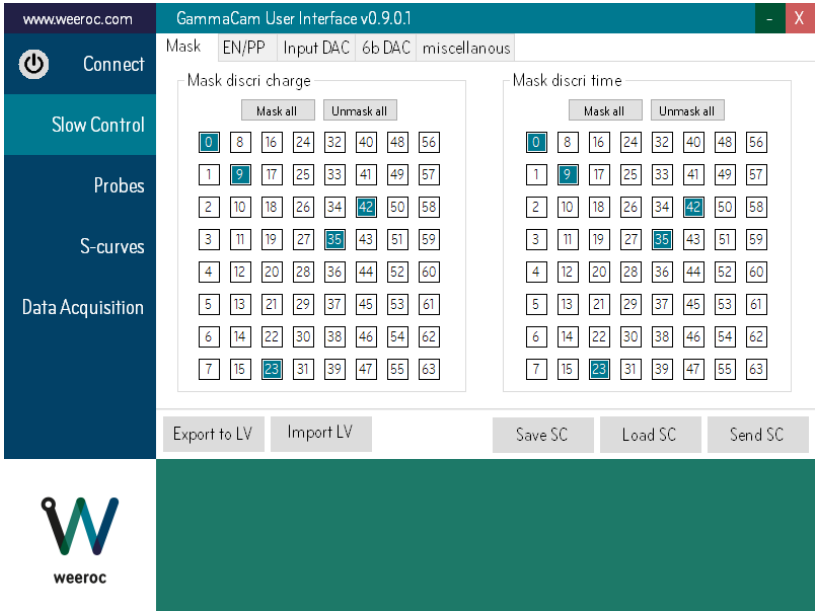


C# open source software
Automatic calibration
Direct plot & Root, csv, xml export of data





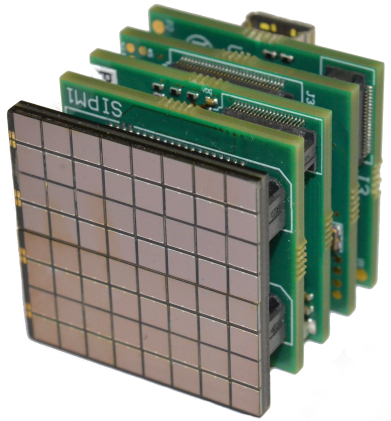
Gammacam



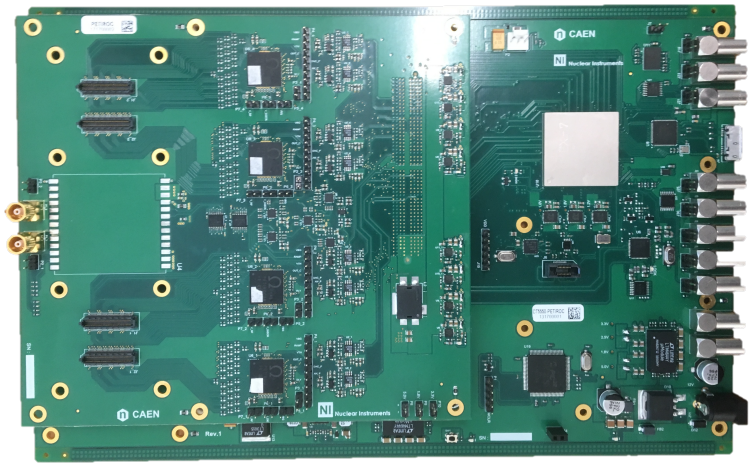
64-channel – 2 Petiroc 2A compact evaluation system
Open source firmware and software
Under debug – new release summer 2017

Modular evaluation system:

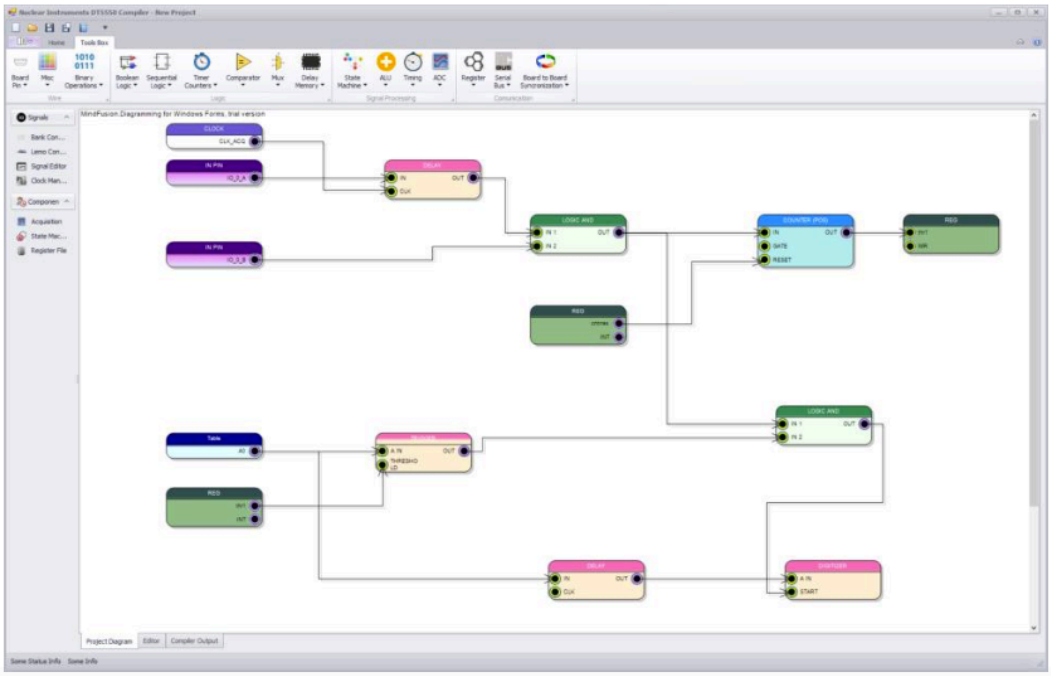
- Detector board : SiPM or injection
- ASIC board : 2 Petiroc2A
- FPGA board : Altera Cyclone 5
- COM board : FTDI USB2



DT 5550A from CAEN



128-channel – 4 Petiroc 2A Hi performance evaluation system
Open source firmware and software
Released summer 2017



Nuclear Instruments

CAEN
Tools for Discovery

Conclusion

- Petiroc2A is a front-end chip for time-of-flight SiPM read-out
- Programmable ASIC, three main operation mode :
  - Photon counting
  - Analogue read-out
  - Digital read-out

- Several evaluation system
  - Evaluation board – 32 channels, open source firmware & software
  - Compact evaluation board – 64 channels, modular, open source firmware & software – available soon
  - CAEN DT5550A – 128 channels, high performance DAQ, easy DAQ programming – available soon

Thanks for your attention

Thanks for your attention

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PETIROC@WEEROC.COM

Questions ?