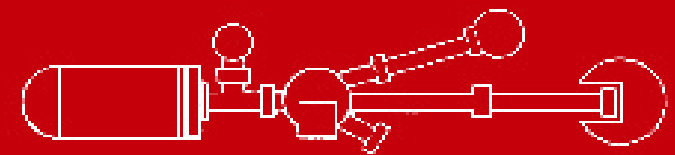




UNIVERSITÀ
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DI PADOVA



CAARI 2012

Digital front-end electronics for a Tagged Neutron Inspection System

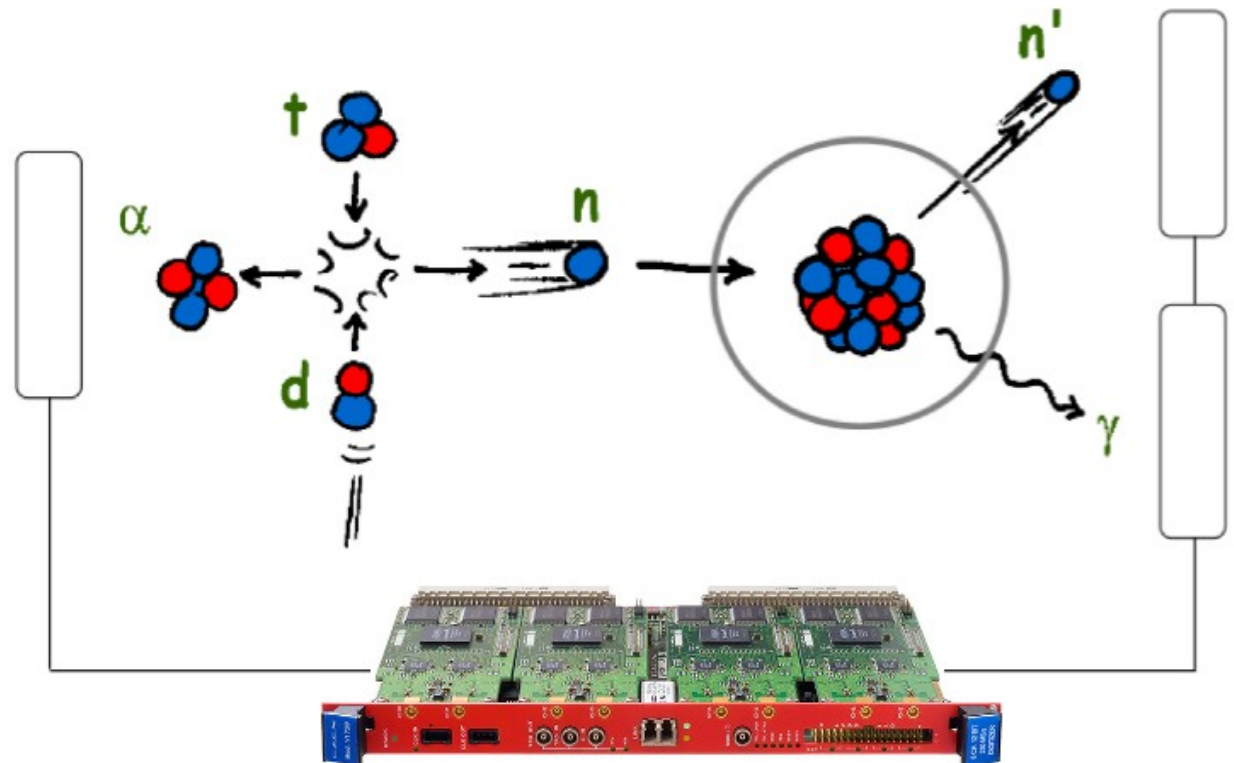
D. Cester¹, G. Nebbia², L. Stevanato¹, G. Viesti¹

¹ Dipartimento di Fisica ed Astronomia, Università di Padova, Via Marzolo 8, Padova I-35131, Italy

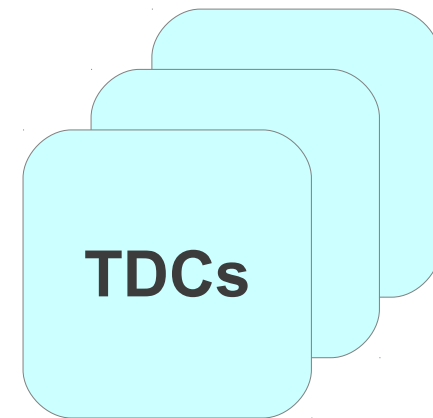
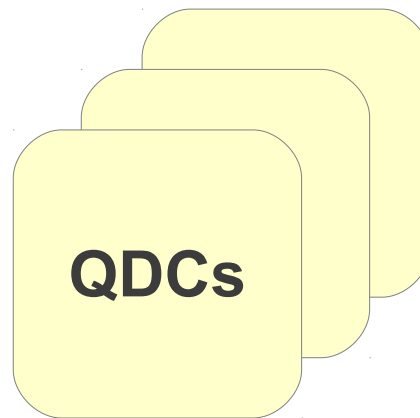
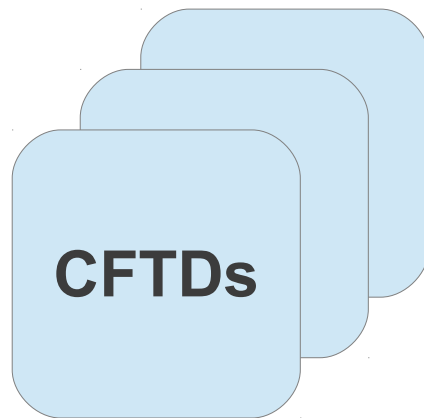
² INFN Sezione di Padova, Via Marzolo 8, Padova I-35131, Italy

TNIS: Tagged Neutron Inspection System

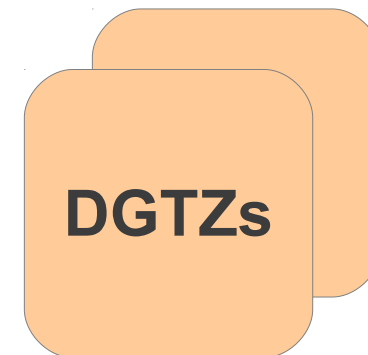
- AP: direction and timing (depth)
- Possibility to probe specific volumes
- Analysis based on coincidences



Traditional chain for Associated Particle analysis:

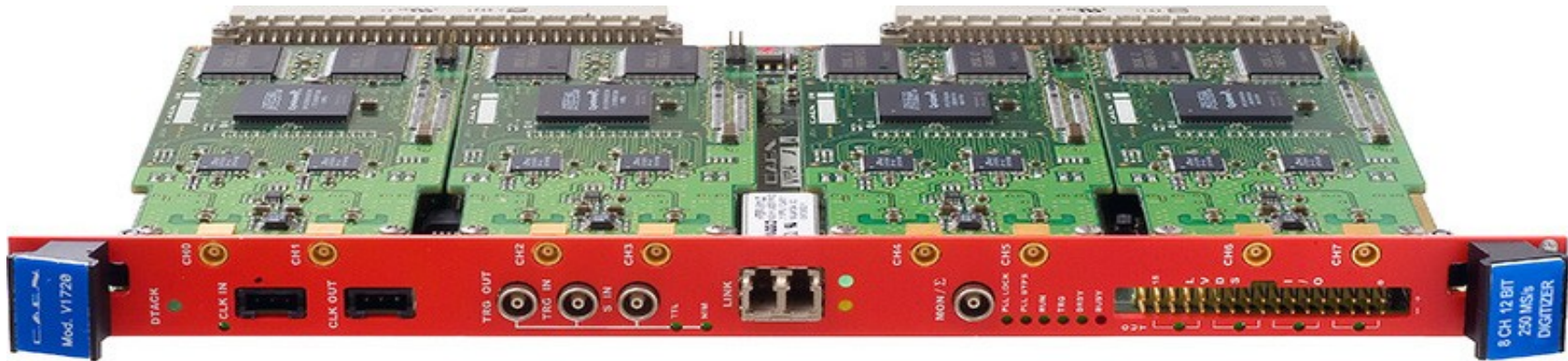


All these elements can be replaced by one or more programmable digitizers:

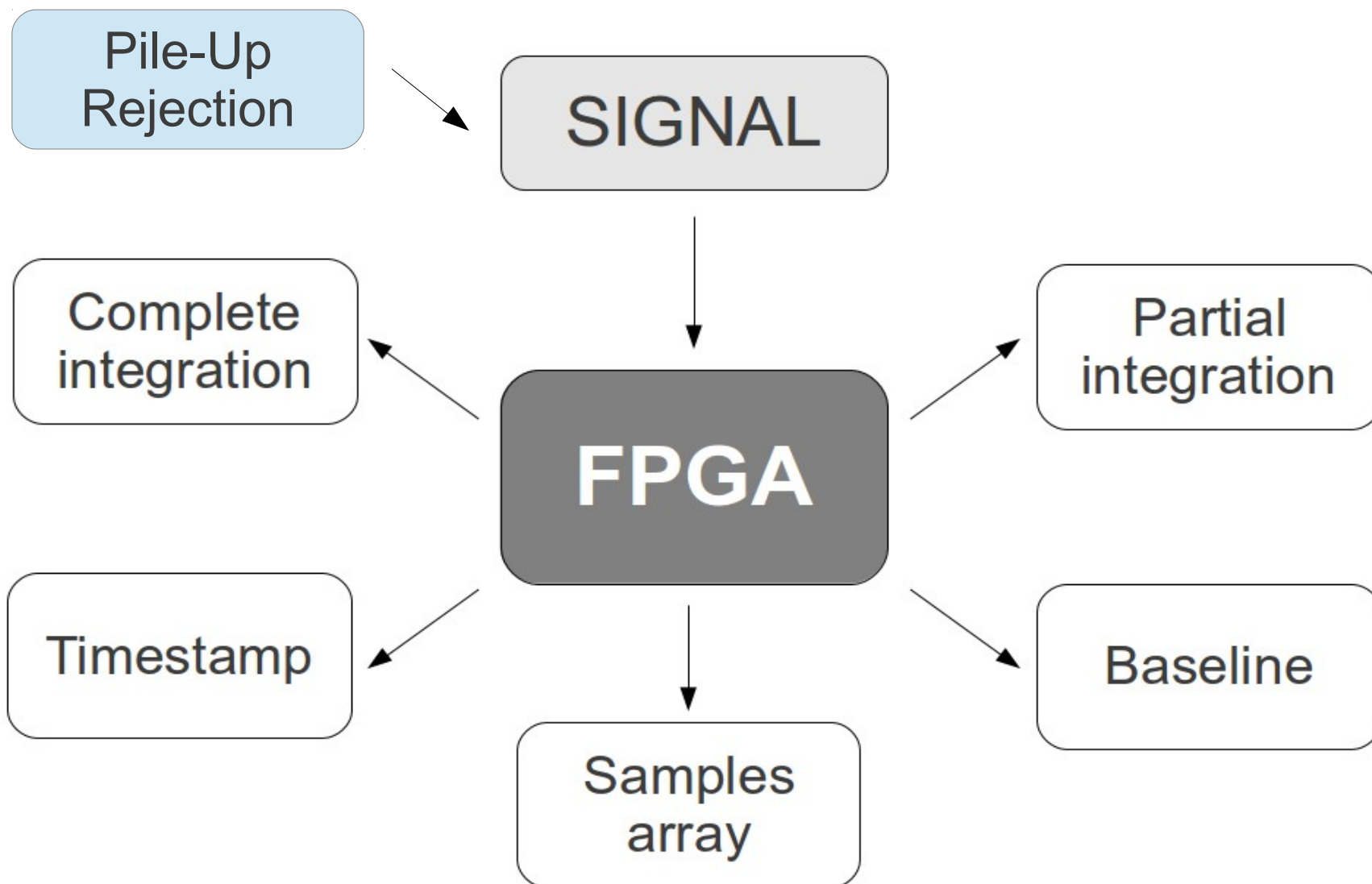


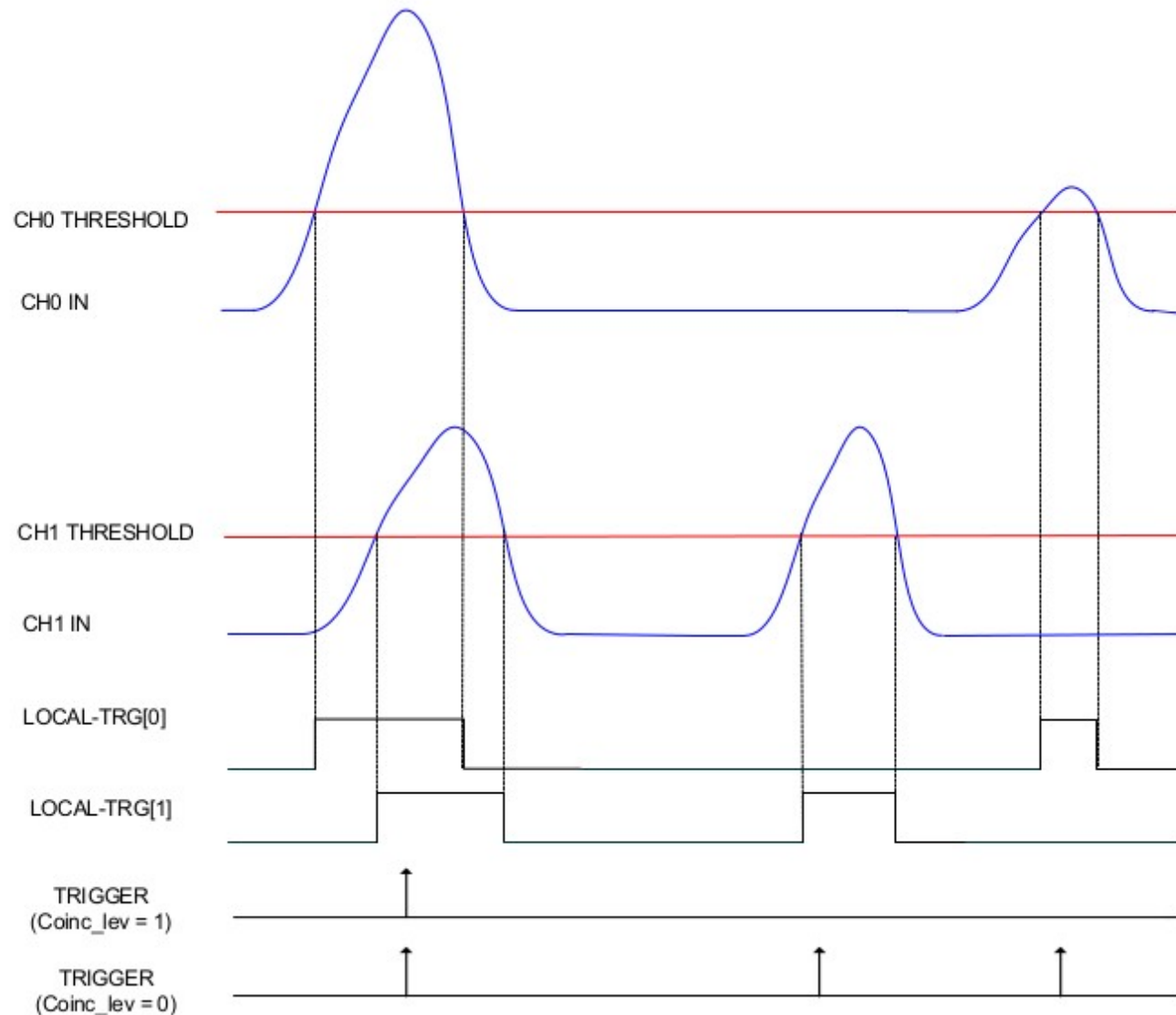


The CAEN mod. V1720 digitizer



- ◆ 8 channels
- ◆ 250 MSamples/s
- ◆ 2 Vpp in, 12bit res.
- ◆ Programmable FPGA
- ◆ Up to 6 digitizers chained together
- ◆ Built-in coincidence filter for triggers





Coincidence mode:
the board records
the event when N
channels are over
threshold at the
same time.

N is the so-called
coincidence level
and it can vary
from 0 (off) to 7.



- ♦ CAEN V1720 digitizers can be chained up to 6 boards with a single optic controller
- ♦ It is possible to synchronize the internal clocks using an external clock unit or a V1720 as master clock
- ♦ Chained boards share data link and clock, but the acquisition is the same of single-mode



The DCFD - Digital Constant Fraction Discriminator improves the time resolution of signal analysis:

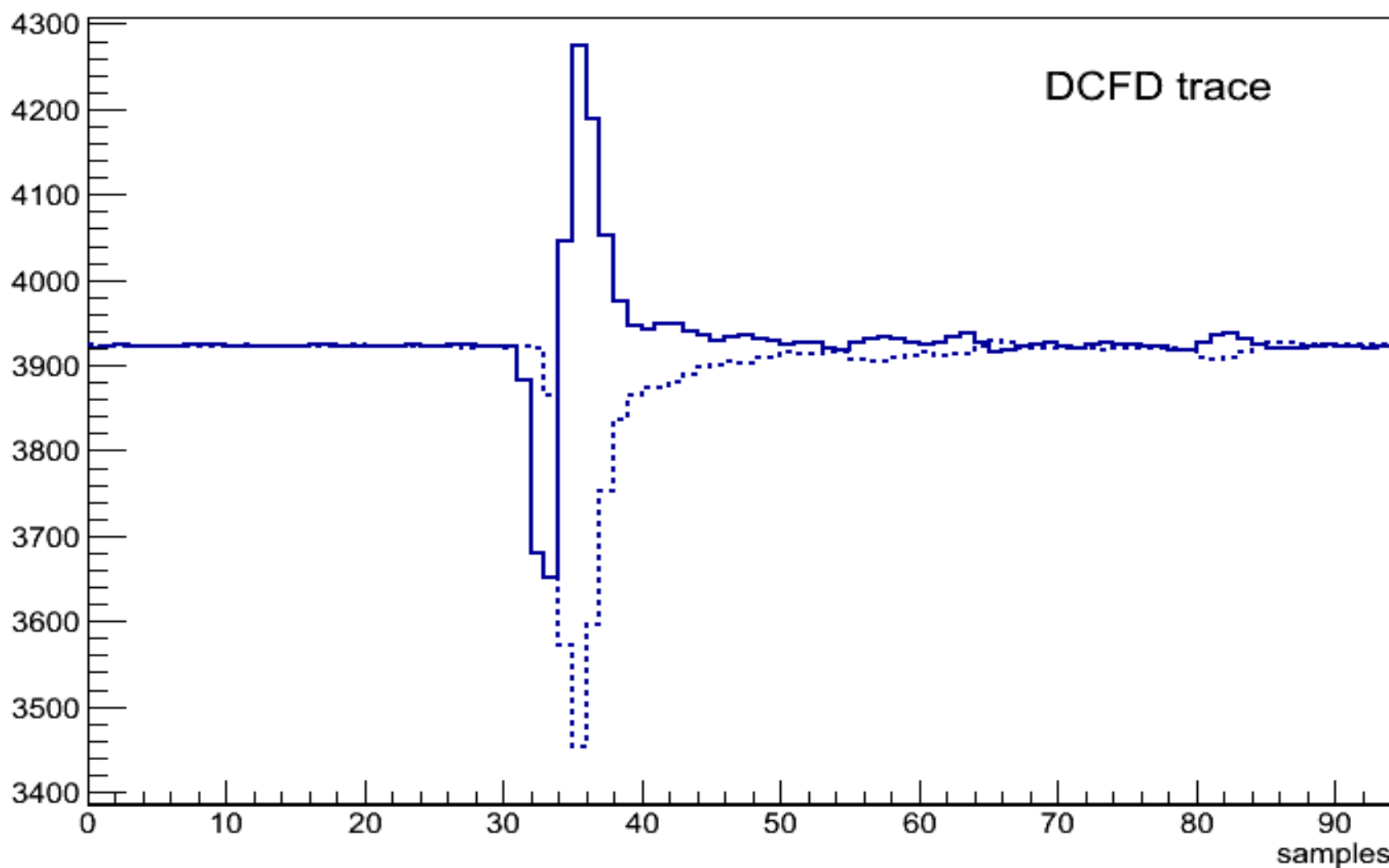
$$CFsamples[k] = \{ F * samples[k] - samples[k - D] \}$$

F = fraction of the original amplitude

D = delay applied to reduced signal

The zero crossing point is our time reference.

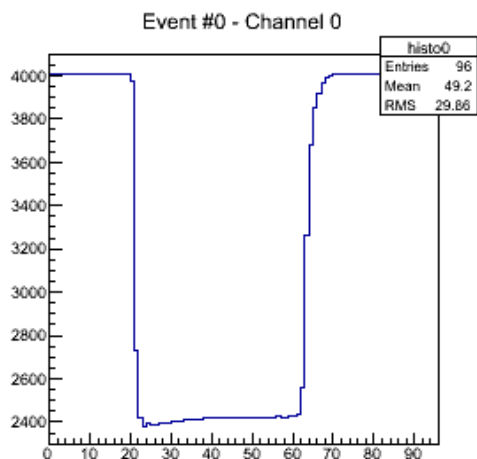
F and D must be optimized depending on the shape of the signal that outputs the detector



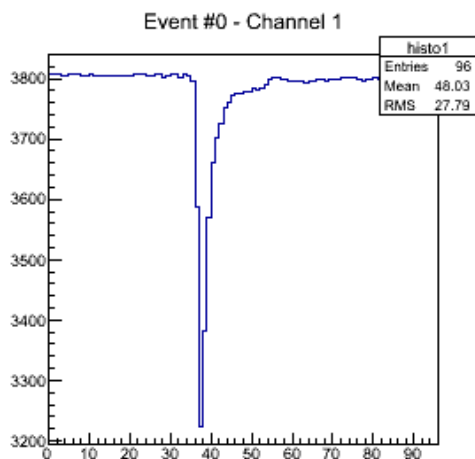


Building a coincidence window

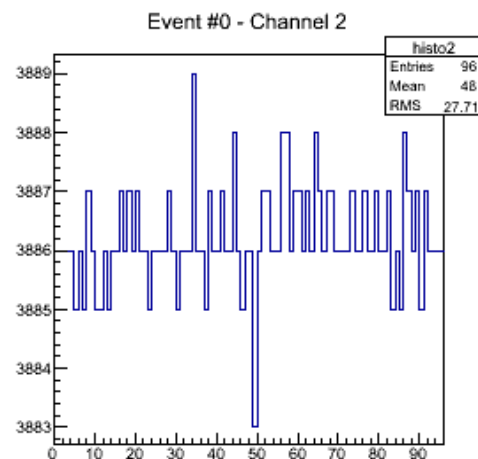
Coincidence window



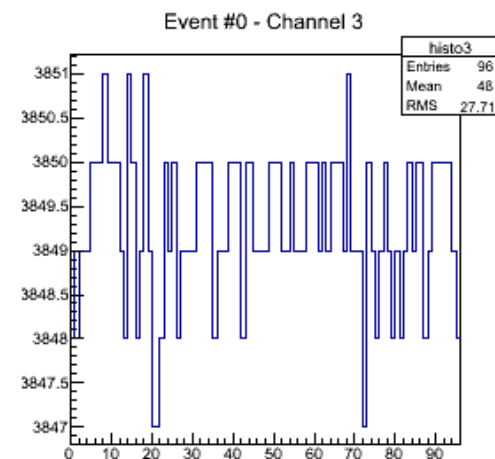
Trigger



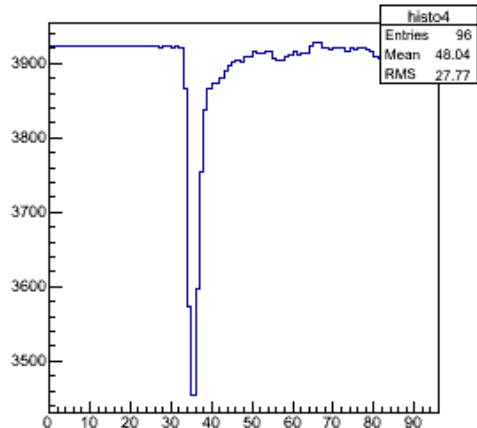
Detector



Detector

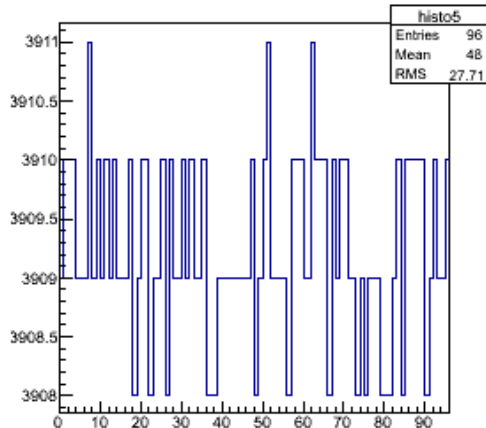


Event #0 - Channel 4



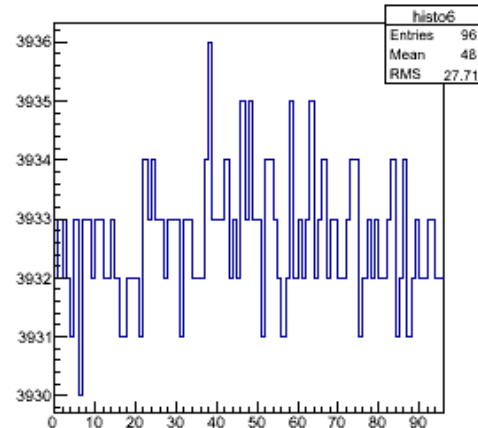
Detector

Event #0 - Channel 5



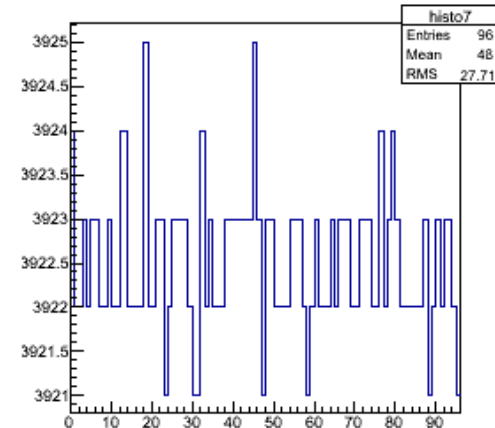
Detector

Event #0 - Channel 6



Detector

Event #0 - Channel 7



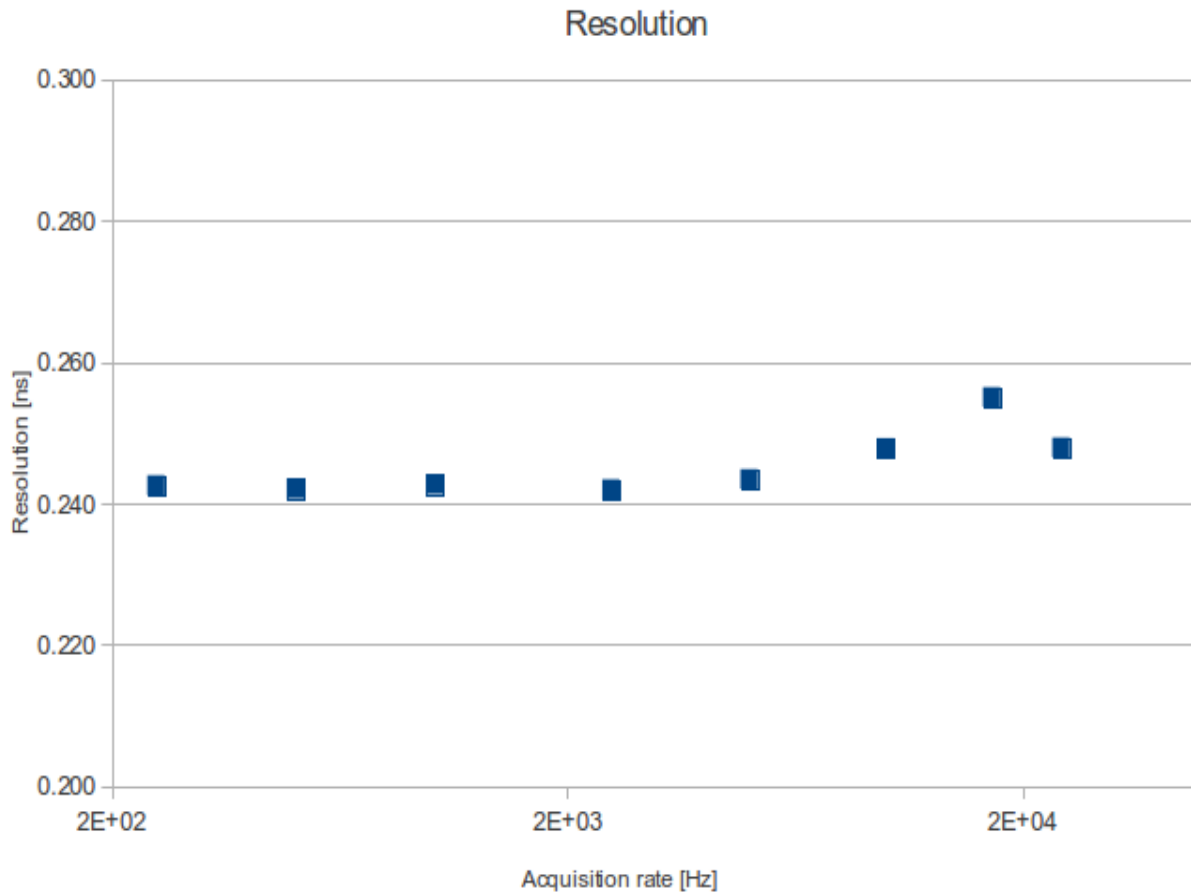
Detector



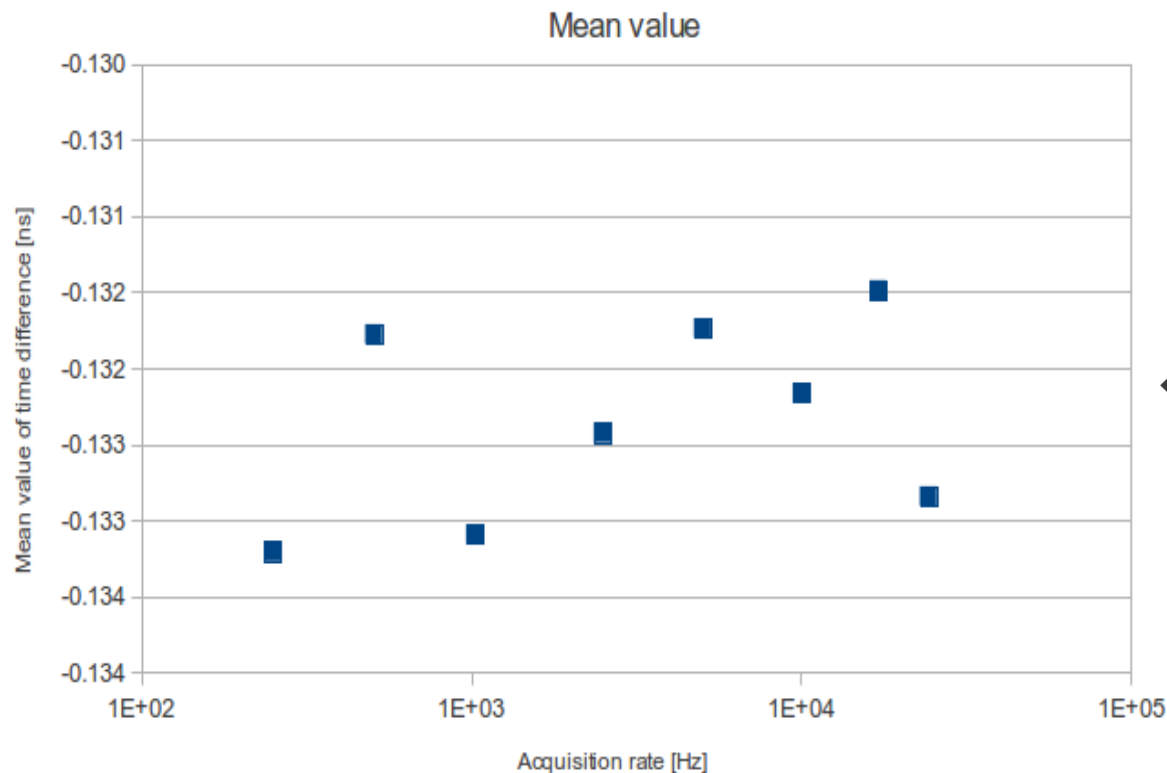
Initial test: we put the same signal from a pulser as input of two channels of a single board, then:

- ♦ varied the acquisition rate
- ♦ applied different delays to one signal

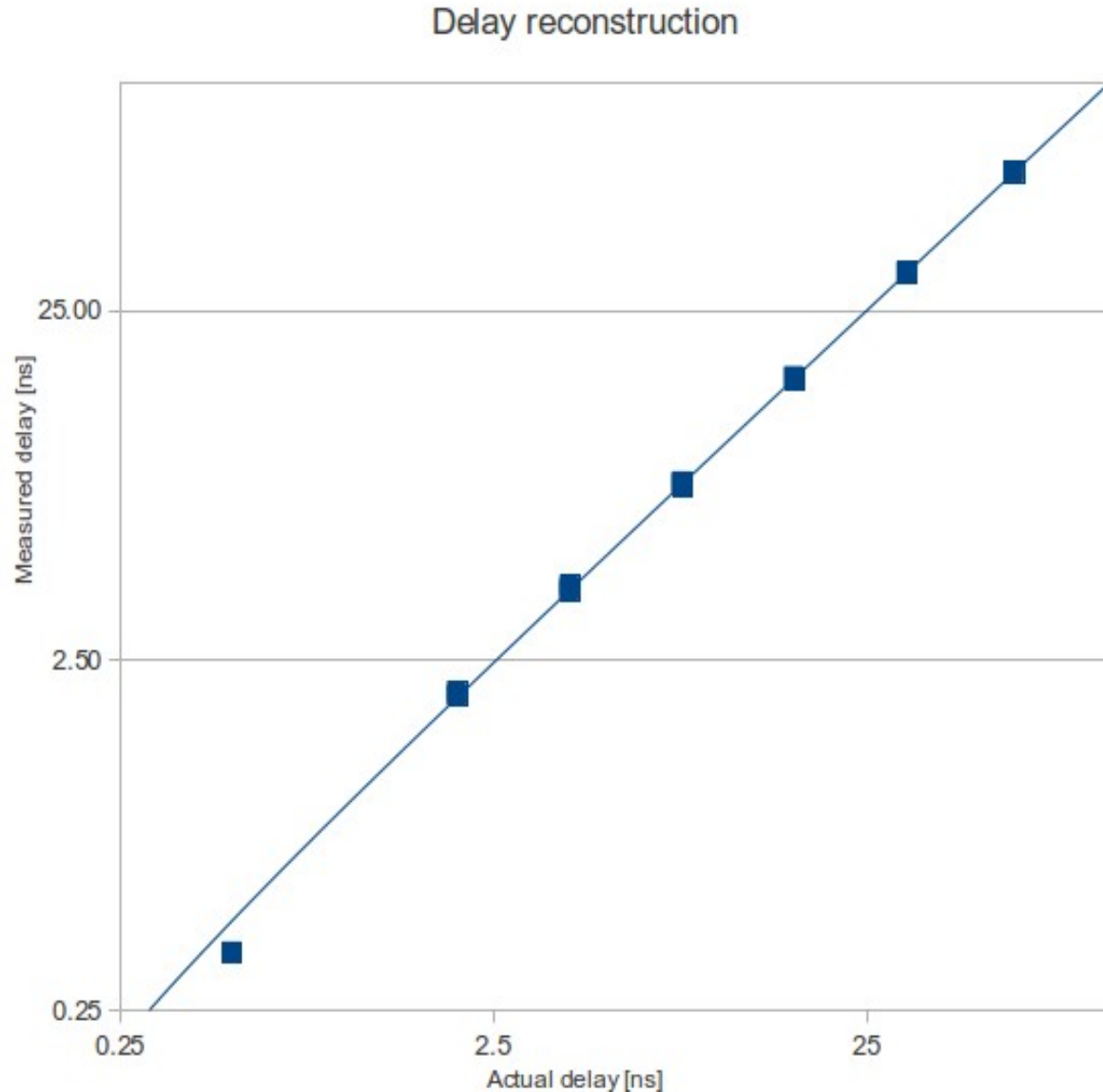
and analyzed the behavior of the board in the different conditions.



Resolution is stable
up to an acquisition
rate of 50'000 events
per second



- ♦ mean value of delay does not depend on acquisition rate
 - ♦ is related to internal signal propagation inside the board
- can be compensated



- ♦ delays are correctly reconstructed
 - ♦ fixed additional delay depending on setup
- **we can reconstruct times of flight**

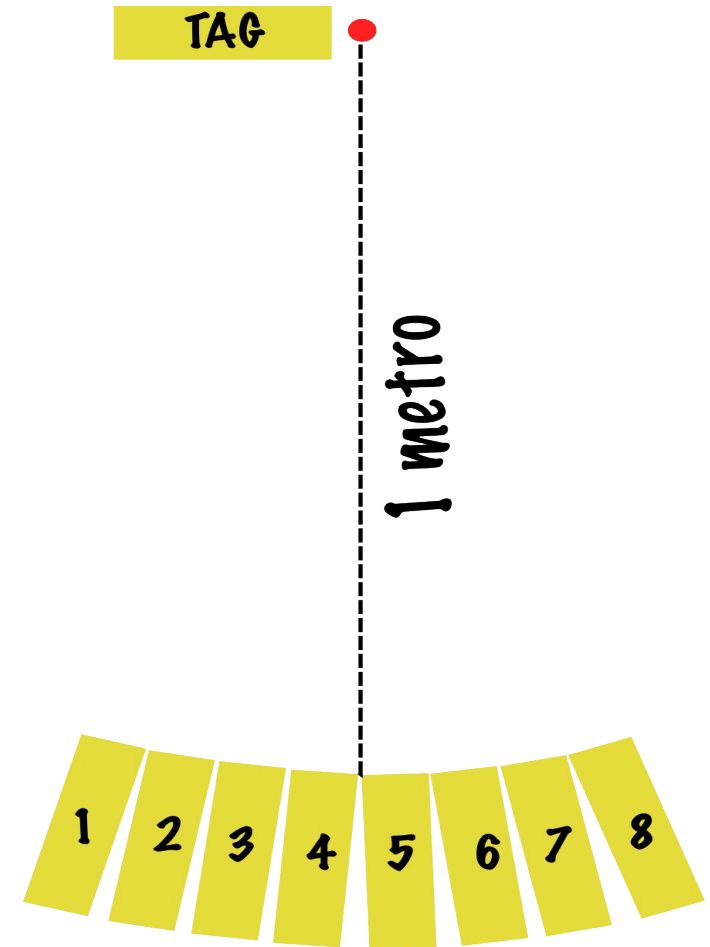


Best resolution is about 240 ps [FWHM]; this correspond to a space resolution of 1.2 cm for 14 MeV neutrons while probing a voxel

We are very close to the limits of the board as measured in standard mode (~190 ps).



- ◆ Source of ^{252}Cf , 10^6 neutron/s
- ◆ Fast plastic EJ-228 trigger detector
- ◆ 6 more fast plastic EJ-228 detectors at 1m distance
- ◆ On-line analysis: ToF, energy distribution, n- γ discrimination





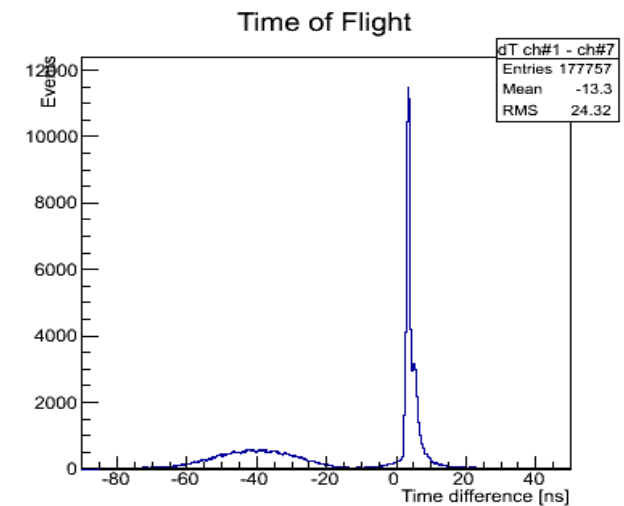
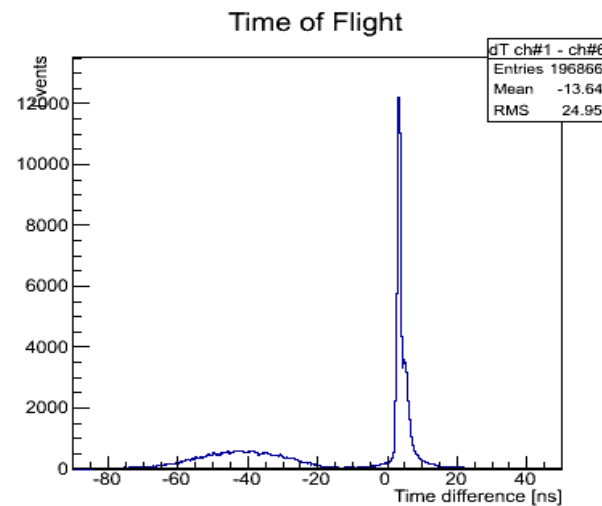
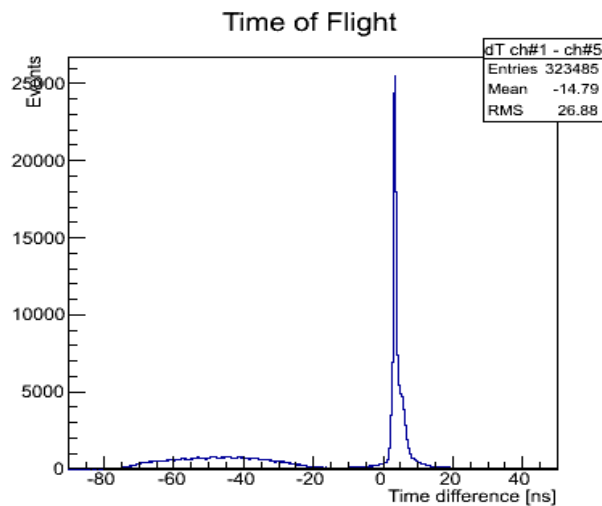
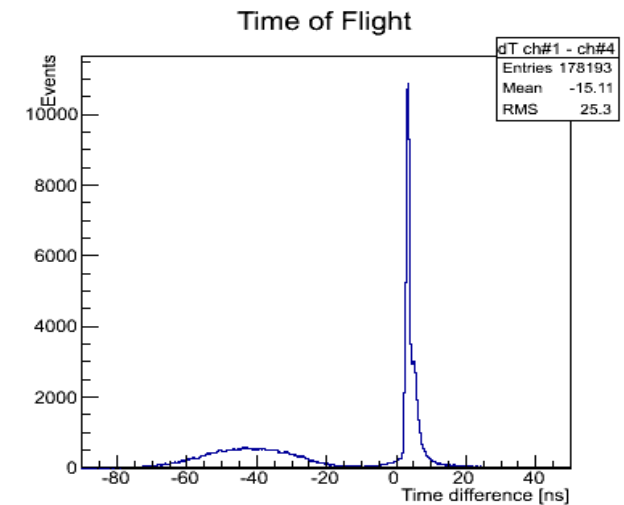
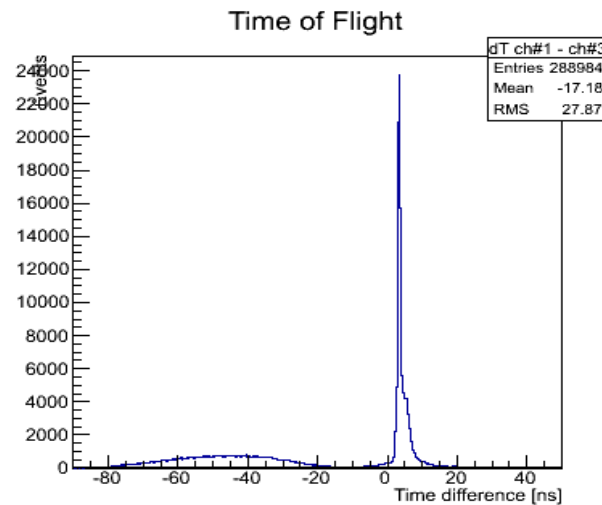
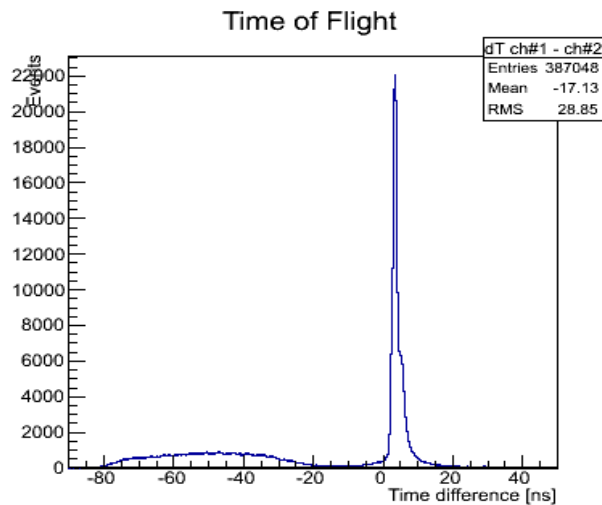
Without filtering:

- ♦ 4h acquisition
- ♦ 10^4 events/s on trigger detector
- ♦ 9 GB data file
- ♦ analysis takes hours

Coincidences ON:

- ♦ 4h acquisition
- ♦ 10^2 events/s to be recorded
- ♦ 890 MB data file
- ♦ 30' data processing

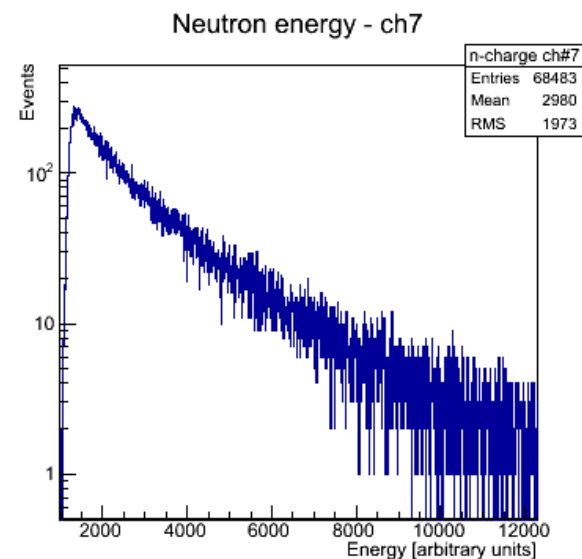
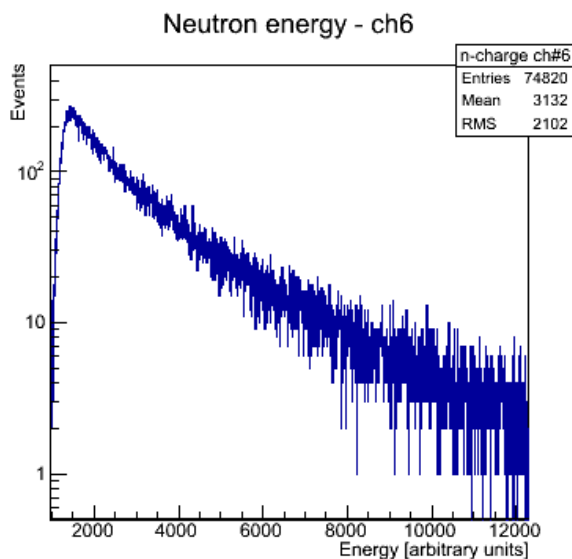
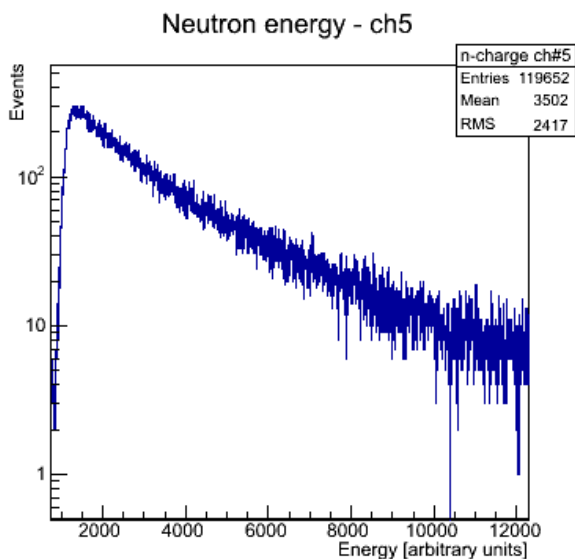
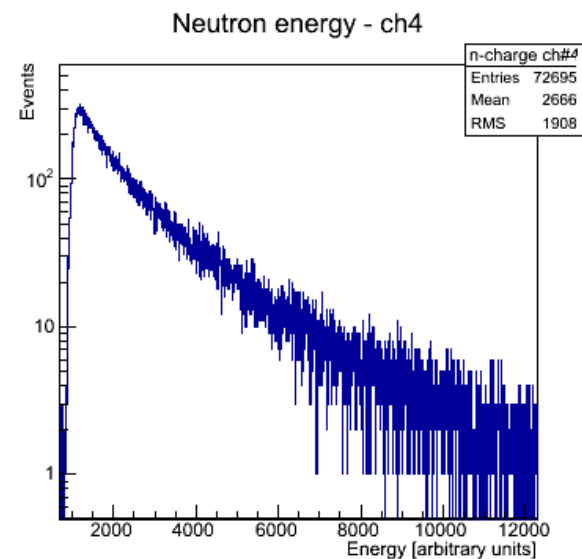
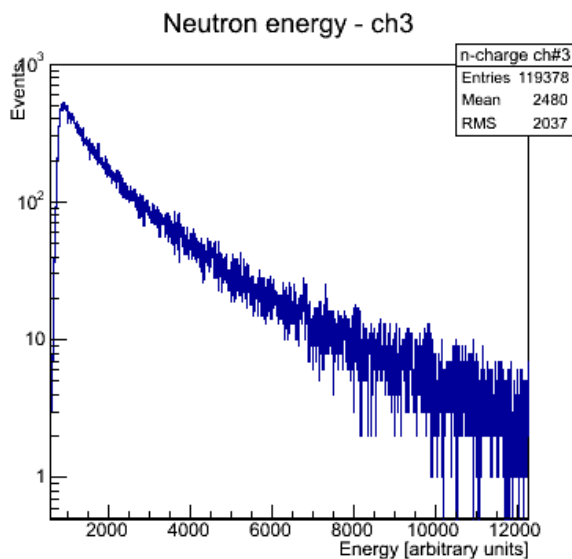
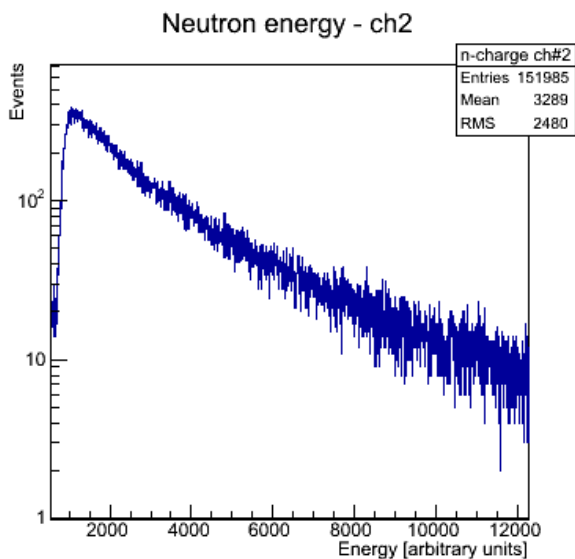
→ **Analysis can be done on-line!**



Avg. res. is 1.20 ns [FWHM] \rightarrow 6 cm (n @ 14 MeV)



Energy distribution for neutrons



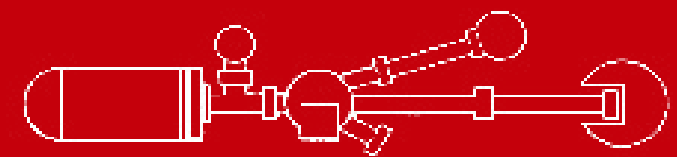


We have tested the coincidence filter of V1720:

- ◆ **Resolution is competitive** with traditional chains
- ◆ **Resolution performances are stable** with respect to acquisition rate and time distance
- ◆ The acquisition rate itself is lowered in a way that **on-line complex analysis become possible**
- **Saving money, space and elaboration time**



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Thanks for your attention

(for contacts: <http://pd.infn.it/~dcester>)