1. Requirements
2. Description of selected chips
3. MAROC implementation
4. MAROC Binary output tests

Frontend Electronics

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CLAS12 RICH Technical Review, 2013 June 26-27

Requirements

Single PhotoElectron Sensitivity	~50 fC
Number of channels	25600/sector
MAPMT anodes gain spread compensation	1:4
Event Rate	20kHz
Dead Time	few%
CLAS12 trigger latency	8 μs
Time resolution	~1 ns

to disentangle direct and reflected photons (can be done off line)

Positive HV anodes

reduce PMT electrostatic interference and noise

Electronics needs to be able to comple with positive HV anodes

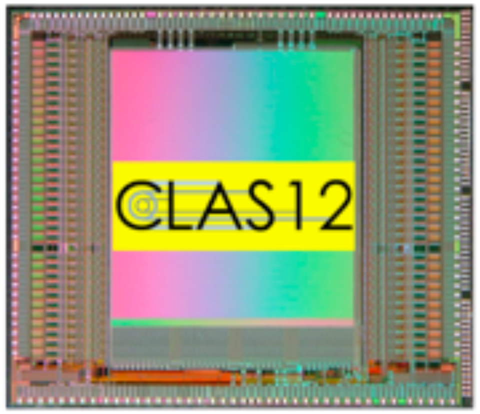
Choice of the Electronics

- On-the-shelf components (no brand new development)
- Fulfill the requirements
- High channel density
- Existing expertise in the collaboration

☐	VMM1/FermiLab	non consolidated , interesting specs
☐	CLARO/INFN	early stage,few channels
☐	APV25/CMS	not enough latency
☑	DREAM/JLAB	CLAS12 Micromegas
☑	MAROC/LAL	ATLAS Luminometer

DREAM asic

Dead-timeless Readout Electronics Asic for Micromegas



Single Channel (x64)

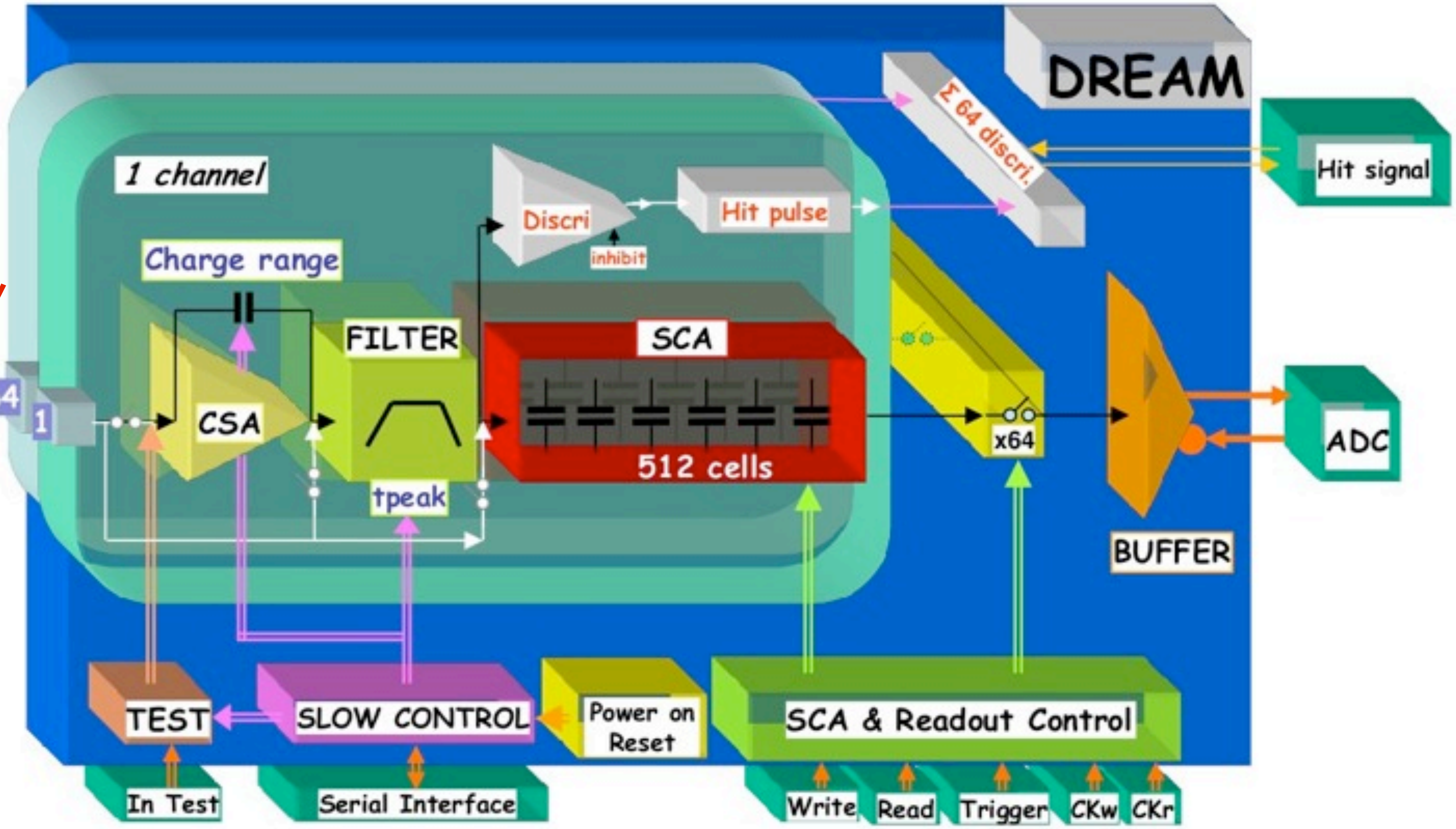
- Preamplifier, adj gain on 4 ranges (60fC,120fC,240fC,1pC)
- Shaper, adj peaking time 16 values from 50 ns to 1 µs
- Analog memory 512 cells, sampling rate 1-50MHz
- Discriminator, trigger pipeline 16 µs , sum of 64

- 140-pin
- 0.4mm package,
- 17mm x17 mm footprint

PROs: analog pipeline, desigend for JLAB12

CONs: dynamic range (?), time res.

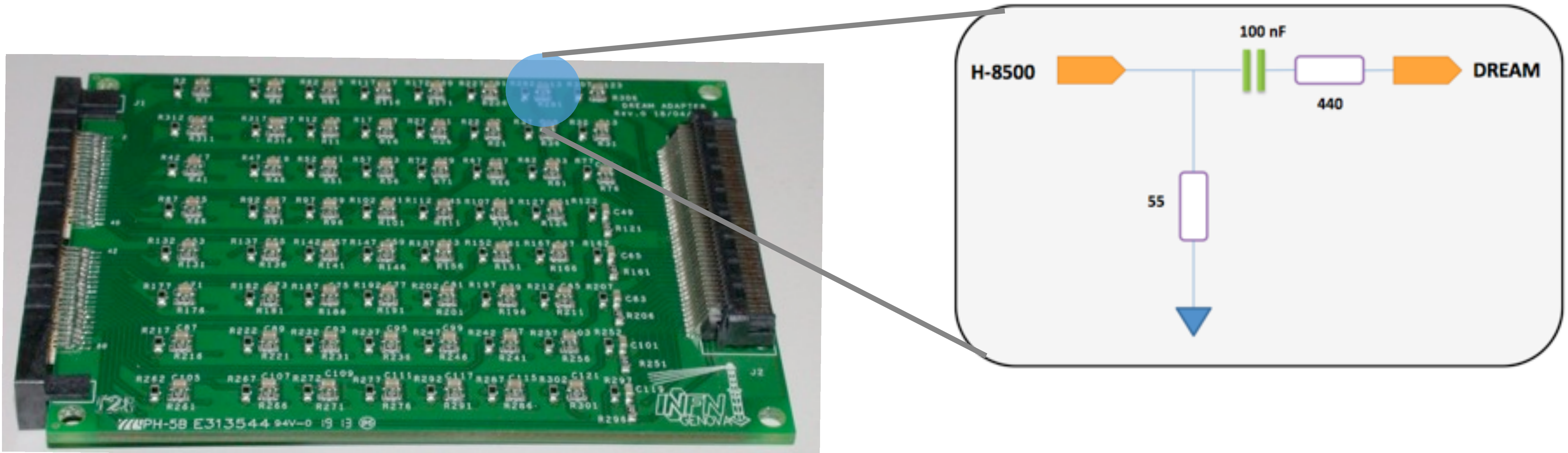
Output: Analog MUX and Digital Sum



PMT DREAM interface

Dead-timeless **R**eadout **E**lectronics **A**sic for **M**icromegas

R&D from Micromegas group



Attenuation board for H8500
with various divider ratio for testing

TEST SCHEDULED 2013 JULY at INFN-FRASCATI

MAROC asic

Multi Anode Read Out Chip

- 240-pin
- 16 mm^2

Single Channel (x64)

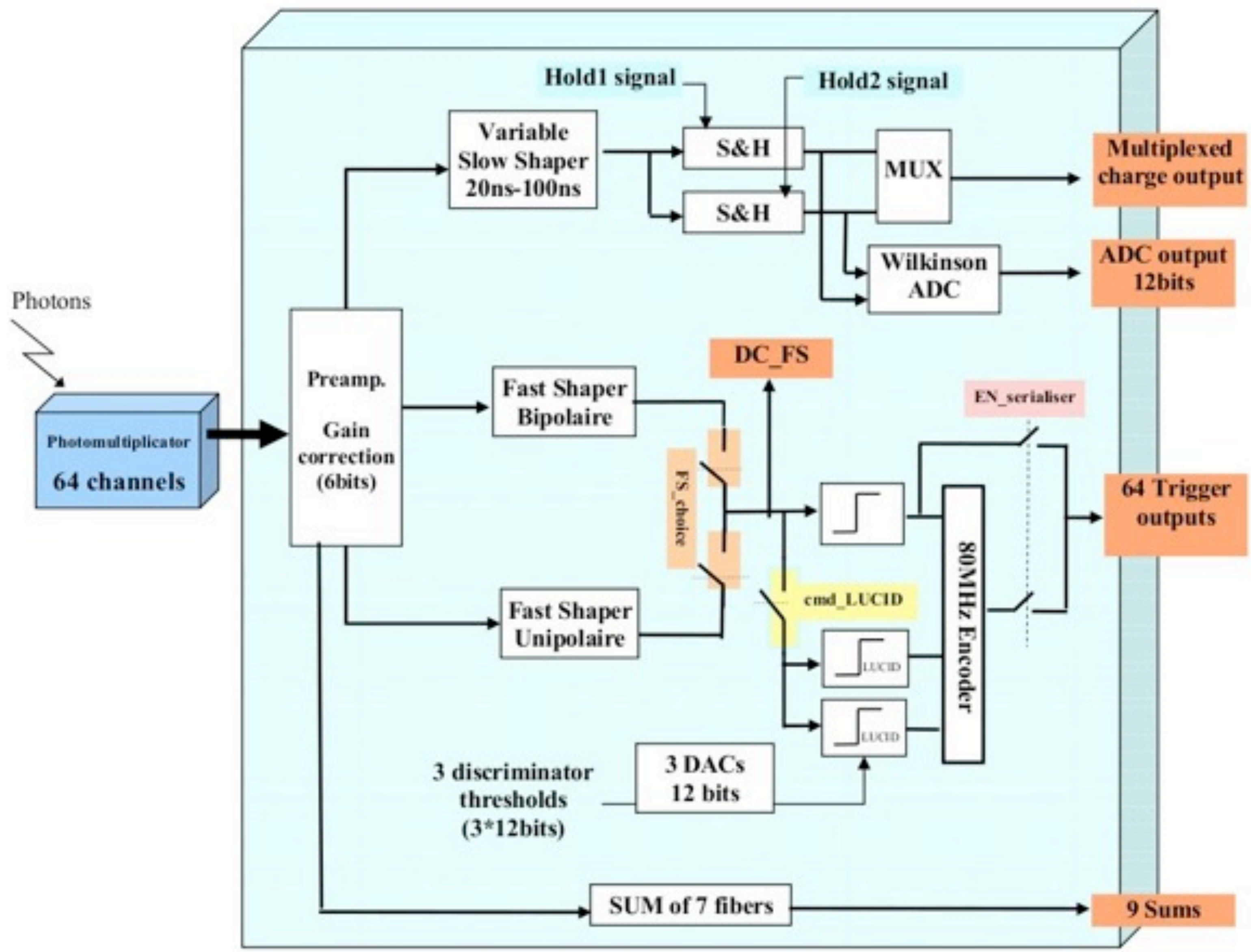
- Preamplifier, adj gain 8 bit
- Fast Shaper (25 ns) + Discriminator
- Slow Shaper (100 ns) + Internal ADC

Originally designed for ATLAS

PROs: Designed for MAPMT apps, existing expertise

CONs: limited latency, time resolution

Output: Analog MUX and Digital parallel



In House MAROC based DAQ

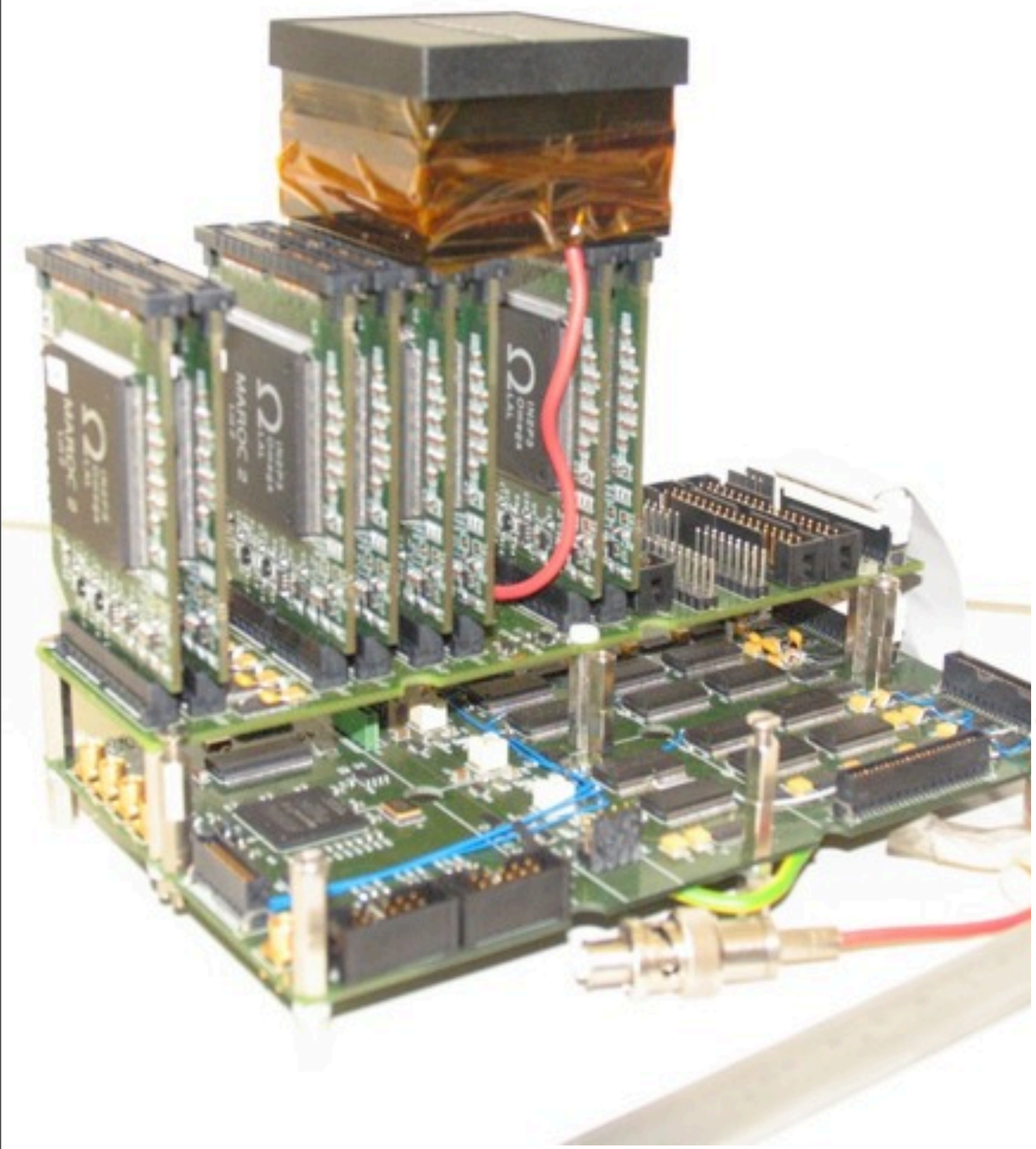
Original system developed for Radionuclides Imaging

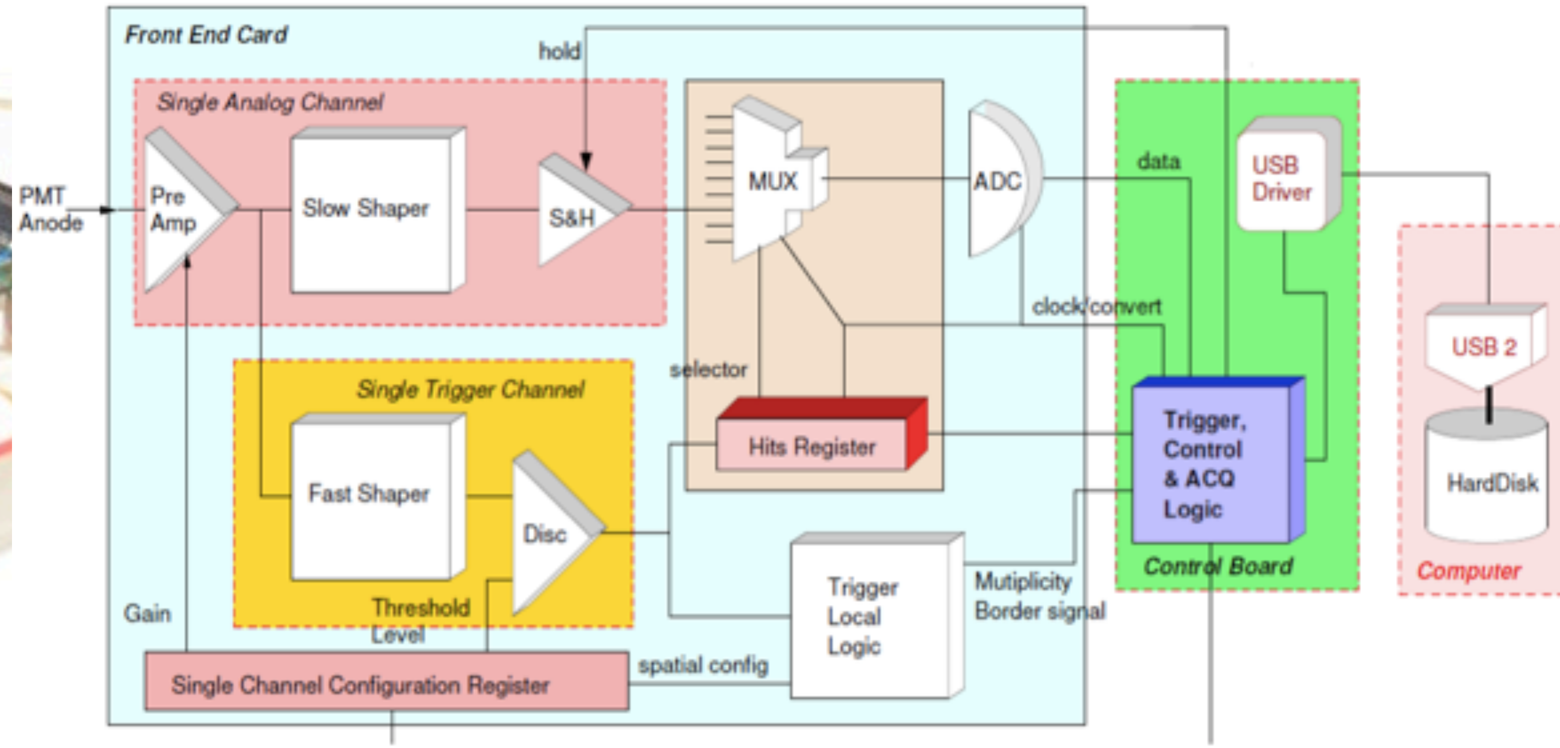
System 4096 Channels

Many optical photons

Binary output used for self trigger

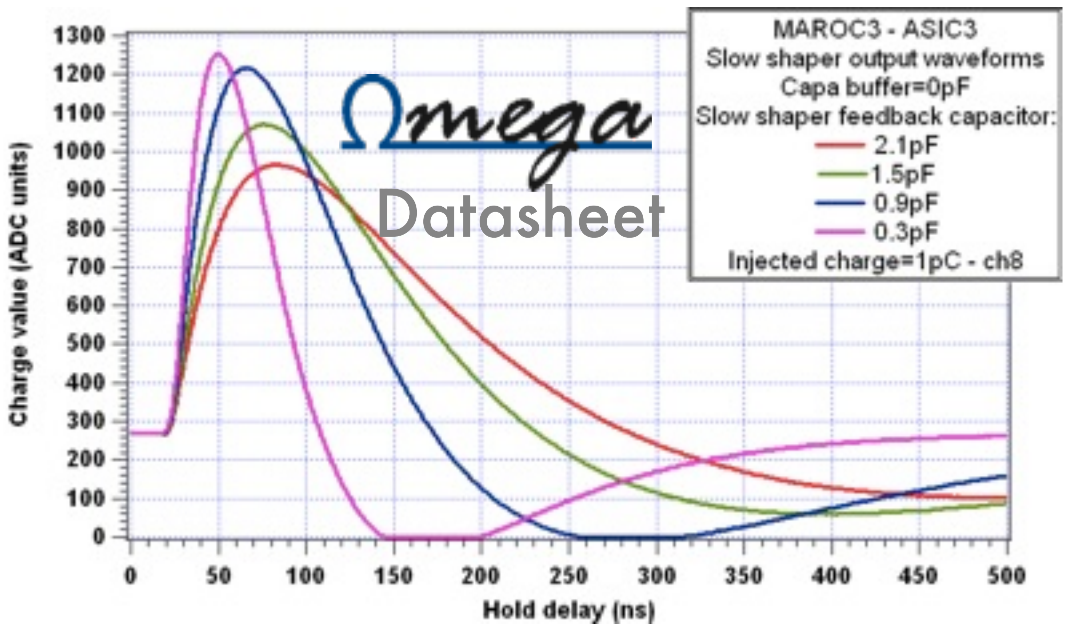
Not Optimized for Single Photon

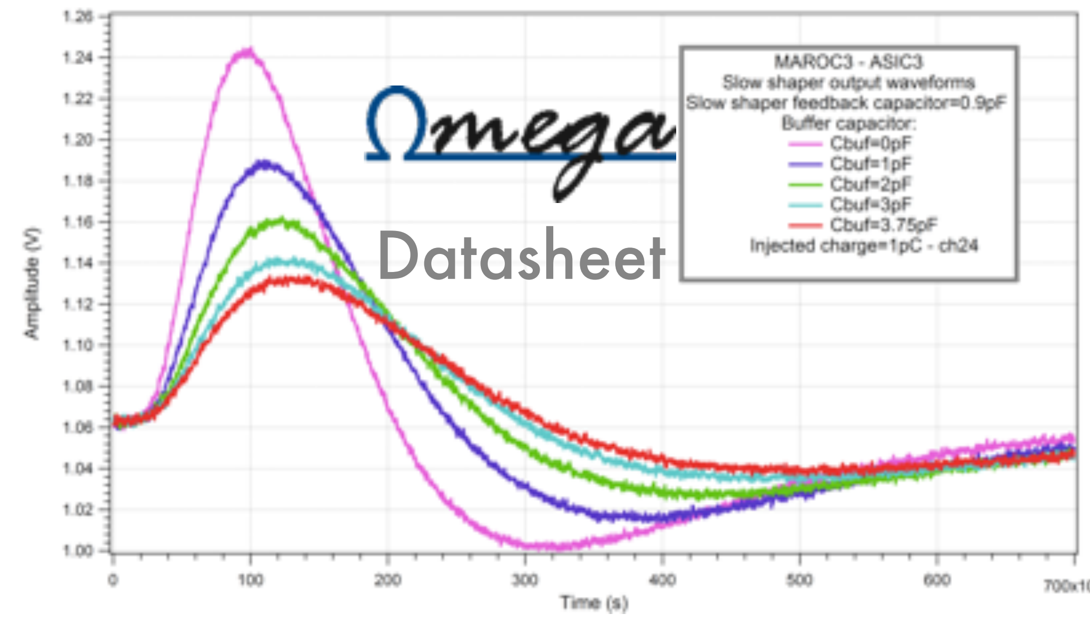




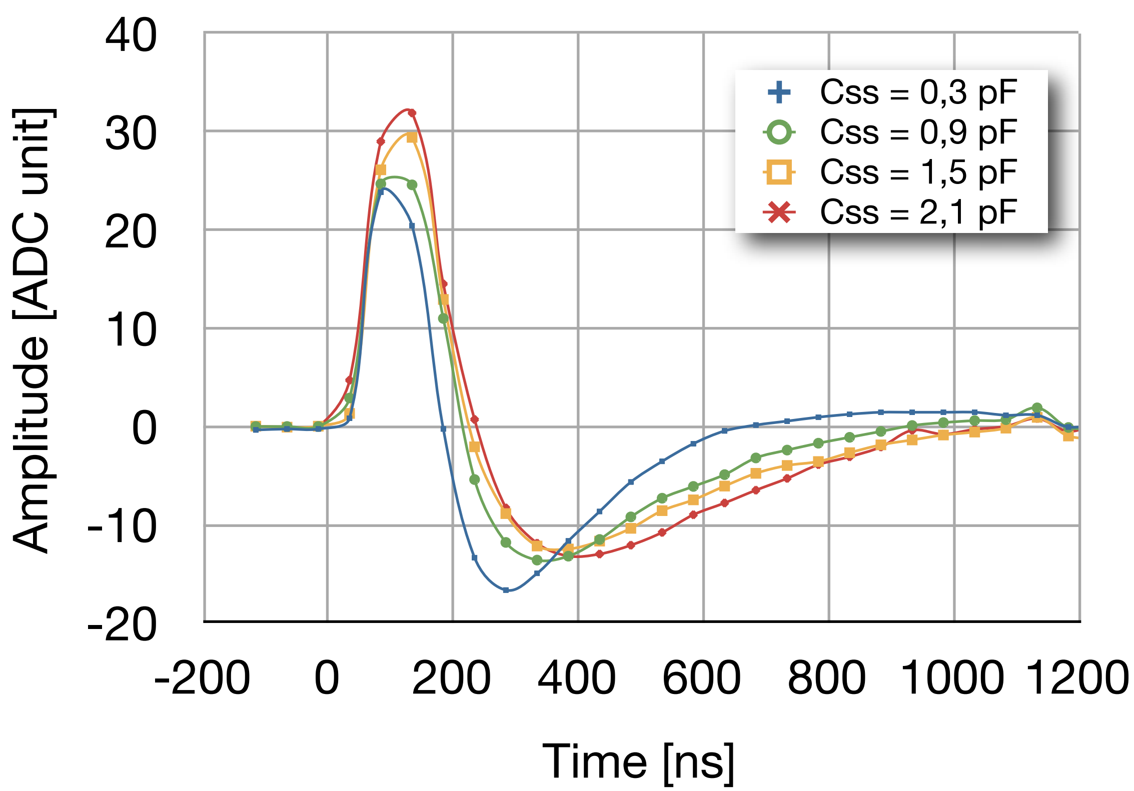
Adopted for the RICH prototype in analog output mode

Reproduce MAROC specs

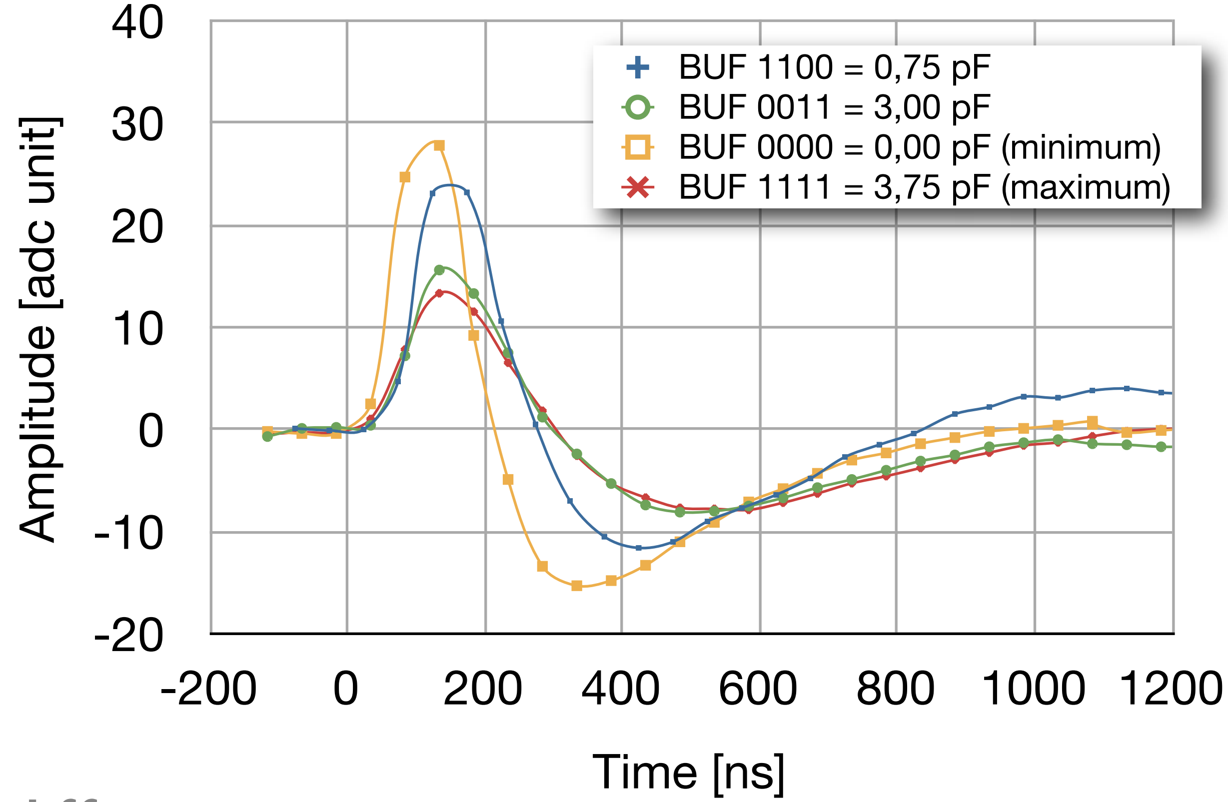




Slow Channel Pulses CBUF = 0 pF



Slow Channel Pulses Css = 0.9 pF



Well reproduced but different output range

MAROC from Analog to Binary

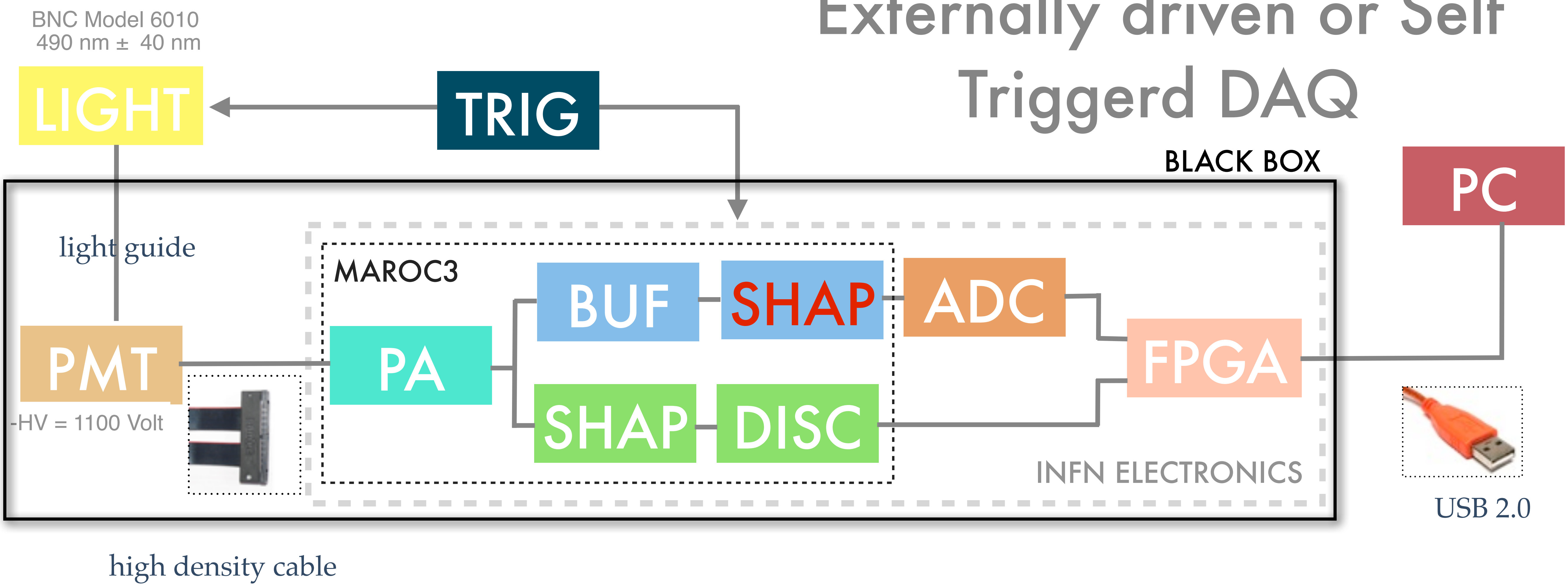
MAROC analog output works pretty well in RICH prototype test, but cannot be use in CLAS12 due to limited latency (200 ns)

MAROC binary information (64 parallel outputs) can be a valid alternative

- Binary data latency depends on external logic!
- Stability/sensitivity of threshold to single photoelectron? test
- Noise in MAROC fast shaper? measured
- Implemented electronics not suitable for binary readout with external trigger (need significant FIRMWARE revision) postponed

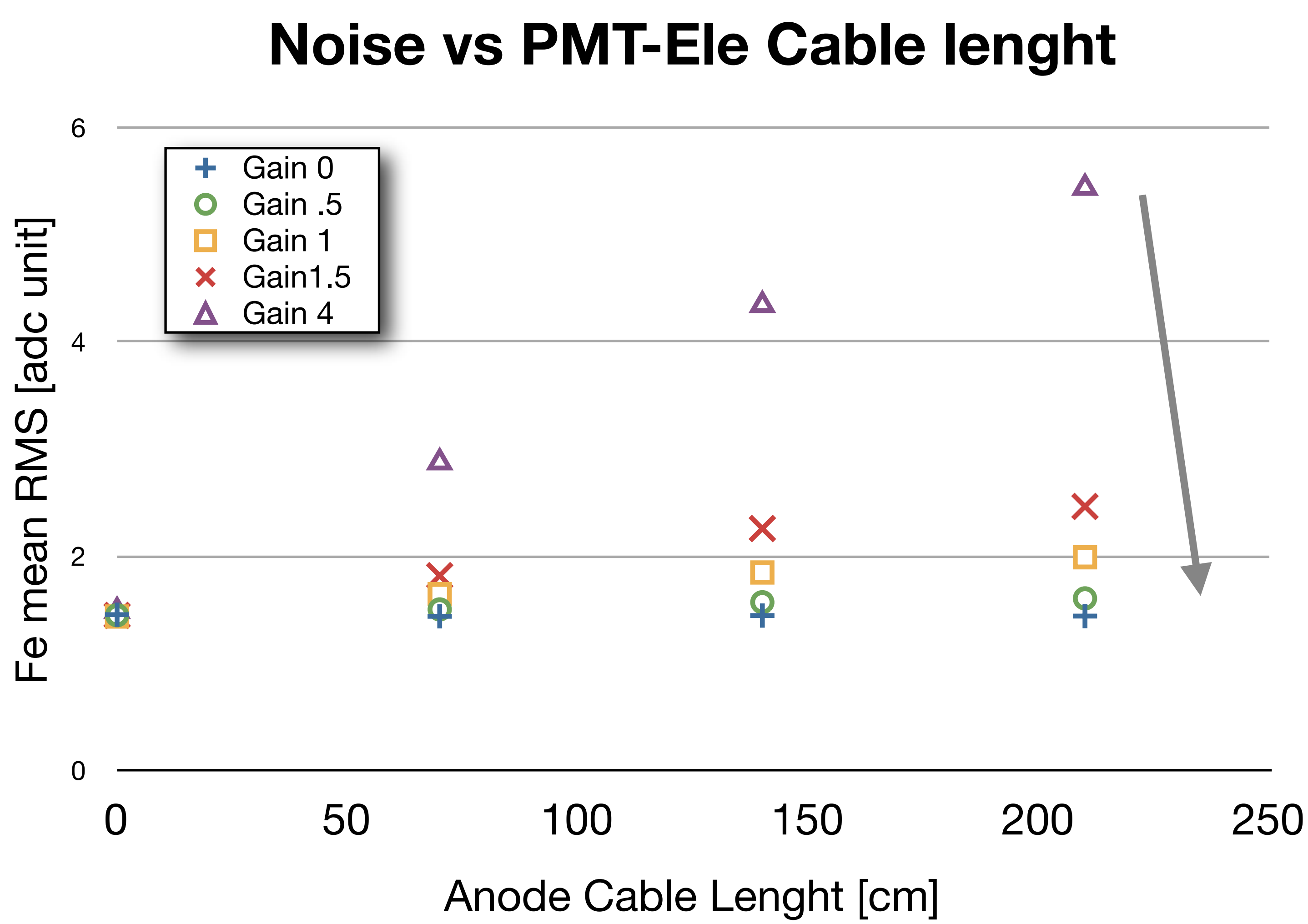
TEST SETUP

Externally driven or Self Triggerd DAQ



- Measure «digital» noise with PMT on, no light (and other configurations)
- Compare/Correlate analog and binary information, with internal and external (need synch) triggers.
  Analog assumed as reference (working)
- Measure range (in threshold) of the ~single photon signal by threshold scan to estimate SNR

MAROC Analog Noise



Here 2 Plots:
before and after
Common Noise Subtraction

Before CNS

After CNS

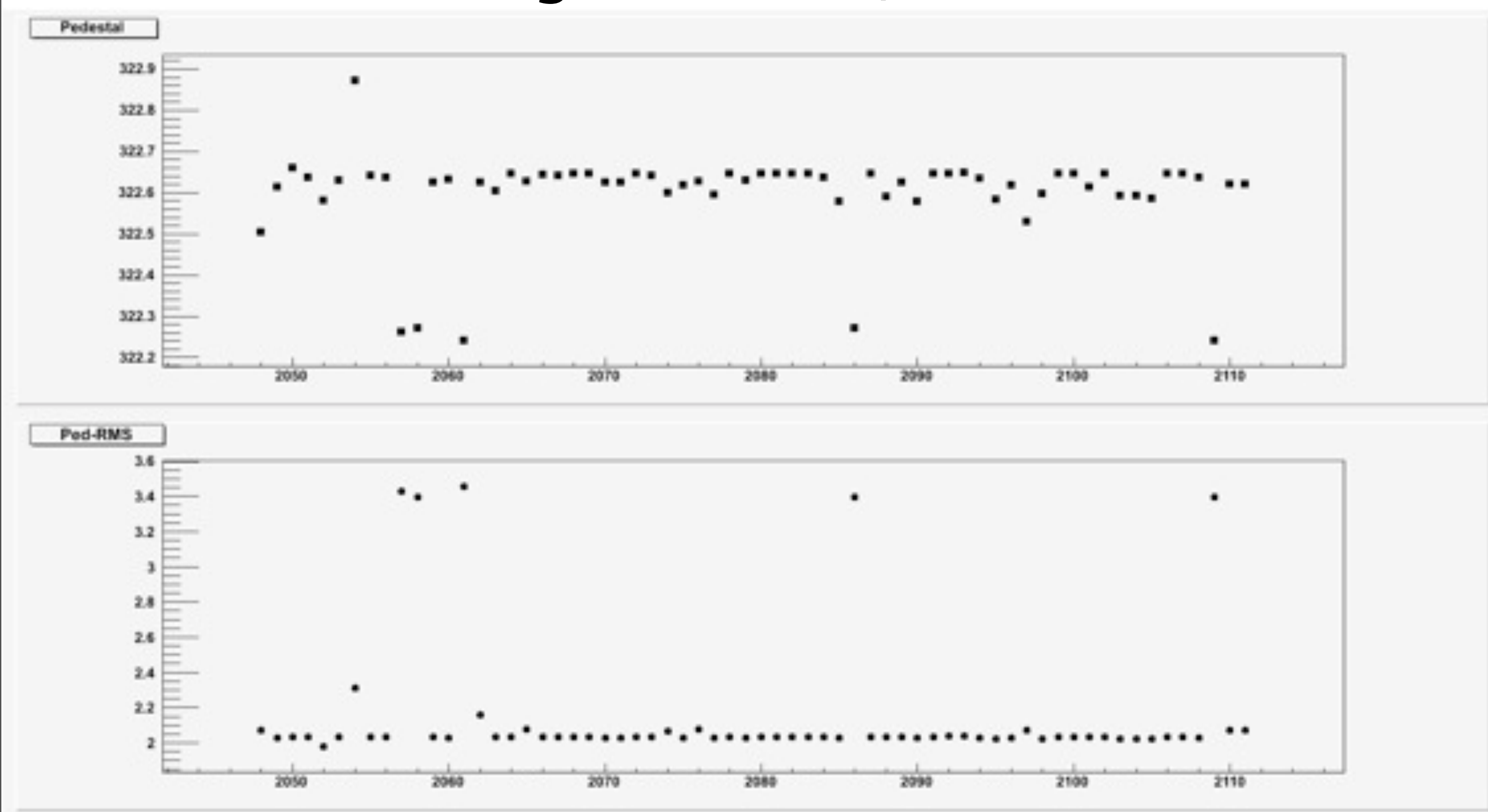
Most of the noise is
COMMON NOISE

Noise suppressed offline
signficantly reduce the
pedestal RMS

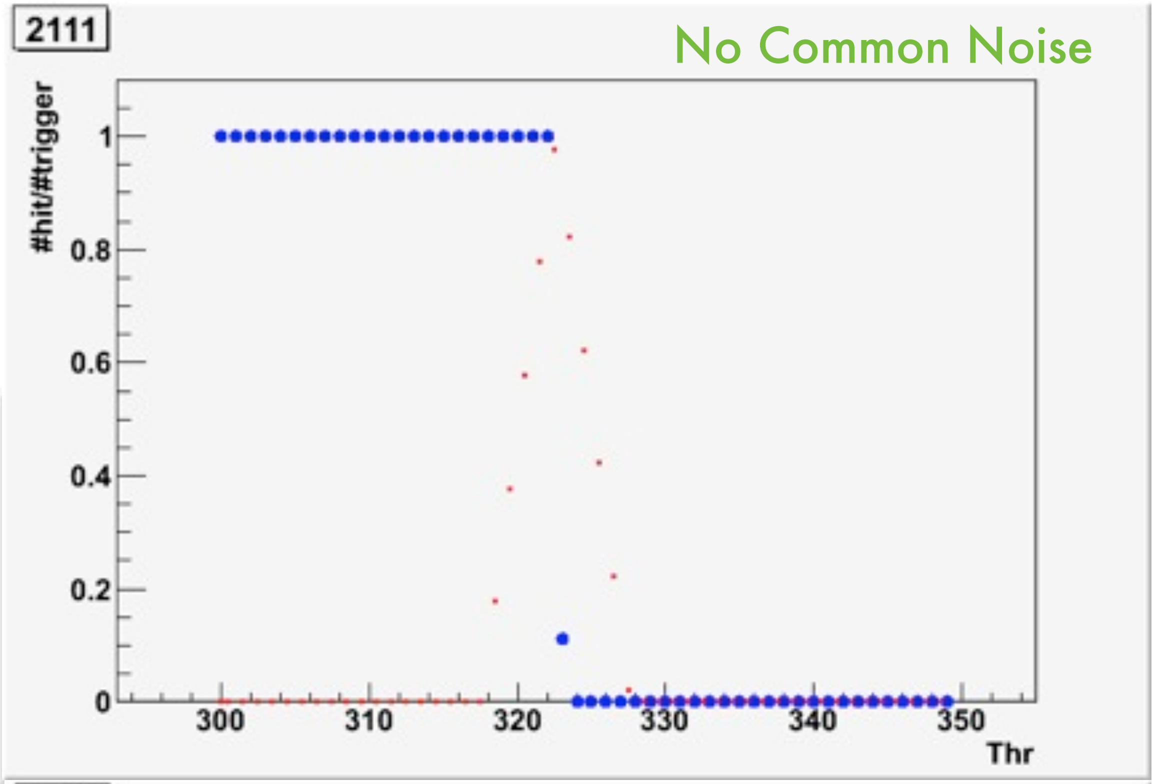
MAROC Digital Noise

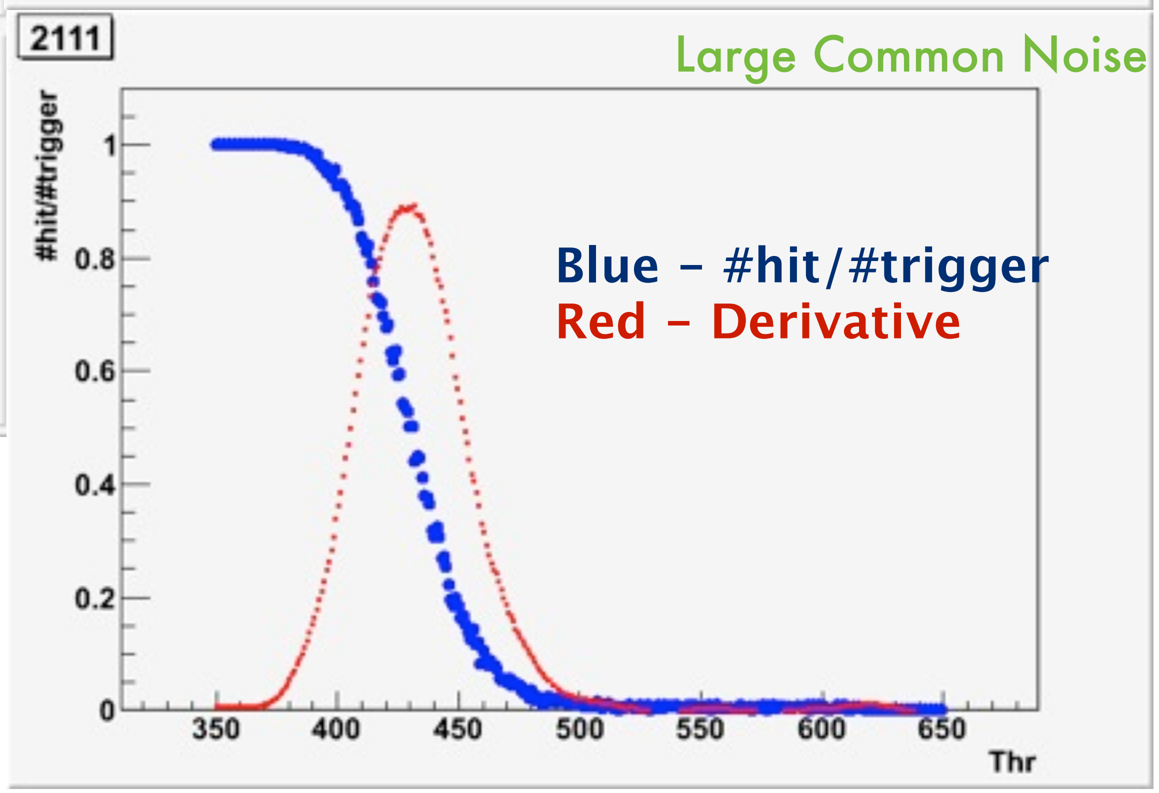
- Binary pedestal as derivative of the «hit efficiency» threshold scan

Single MAPMT/64 chs



Channel →





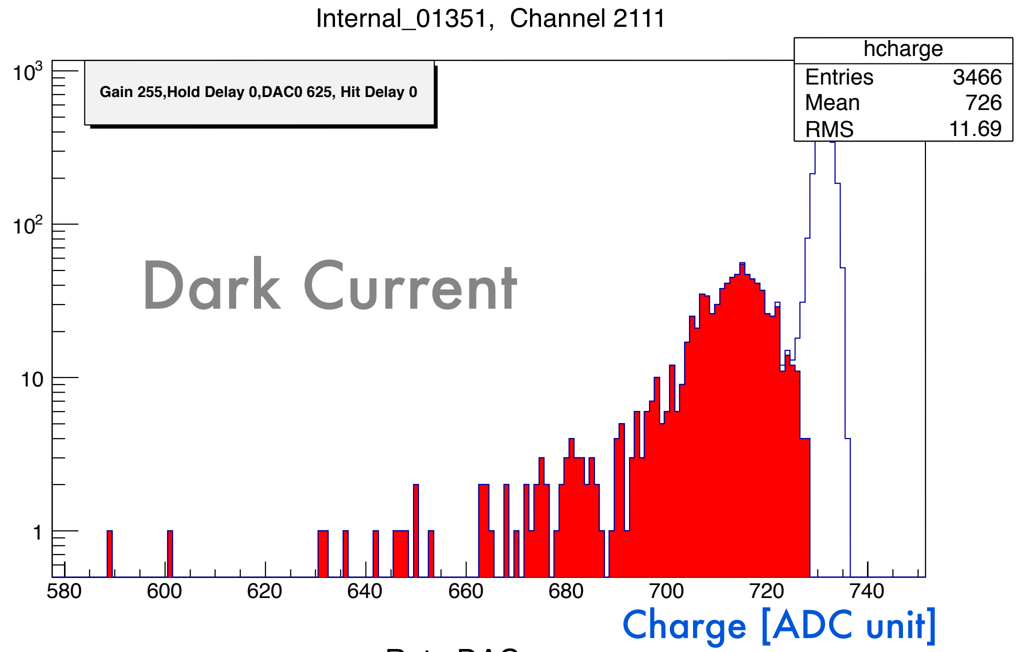
⇨ **RMS~2-3 thr unit (6-9 mV)**

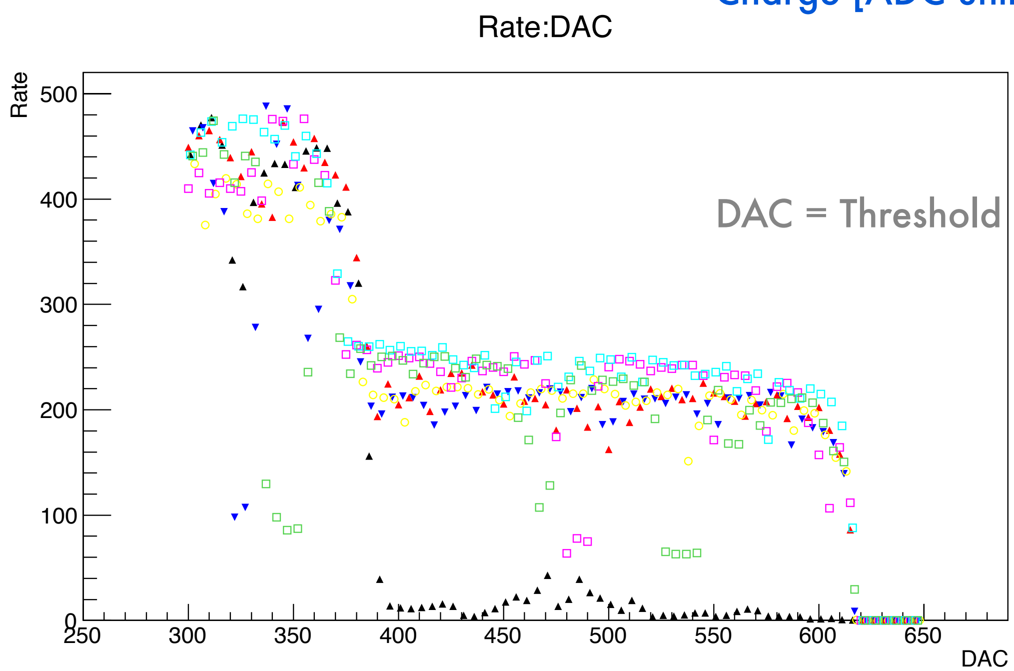
Analog pedestal RMS ~3-5 ADC unit (2-4 mV)

Digital "Pedestal"

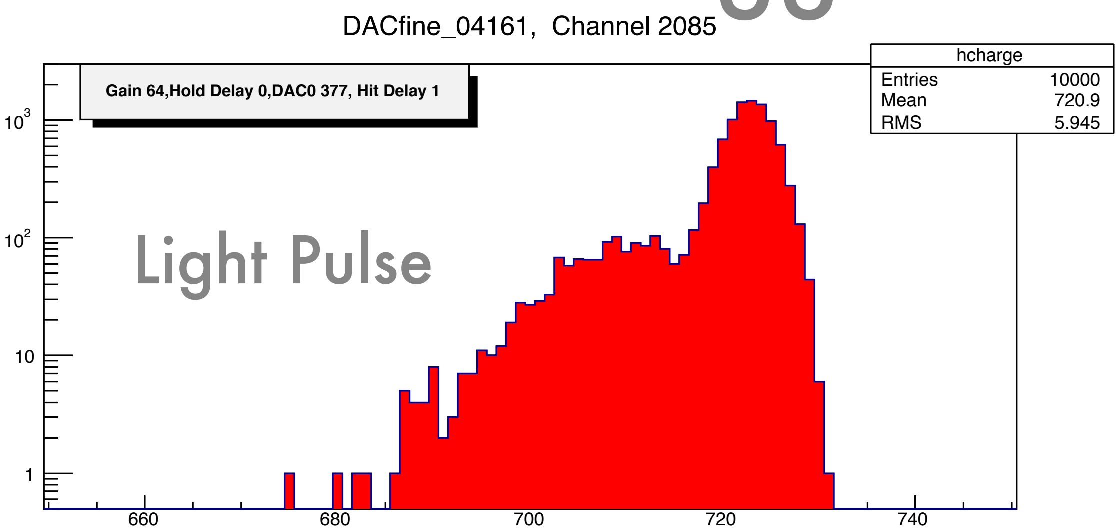
Single PhotoElectron Level

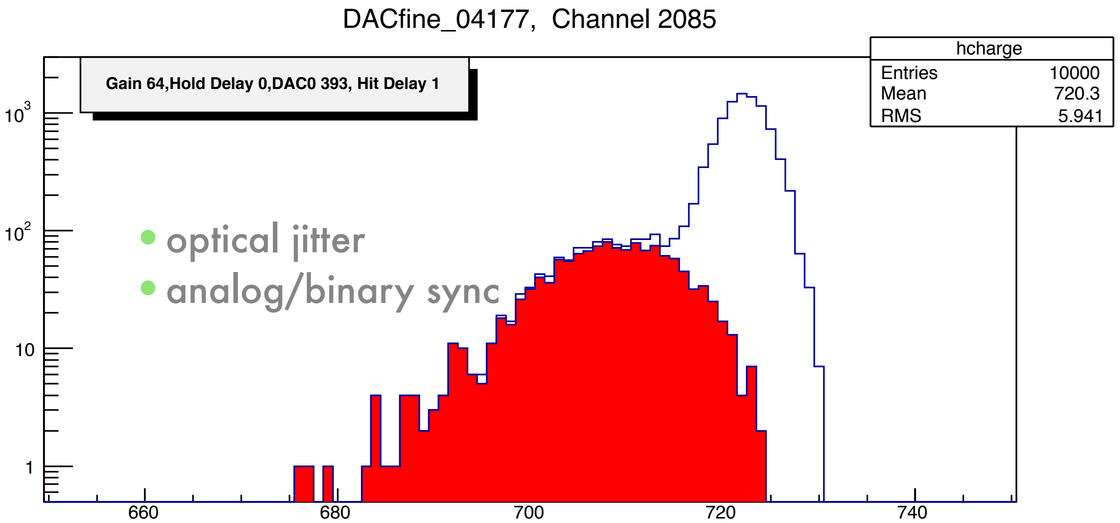
Internal trigger

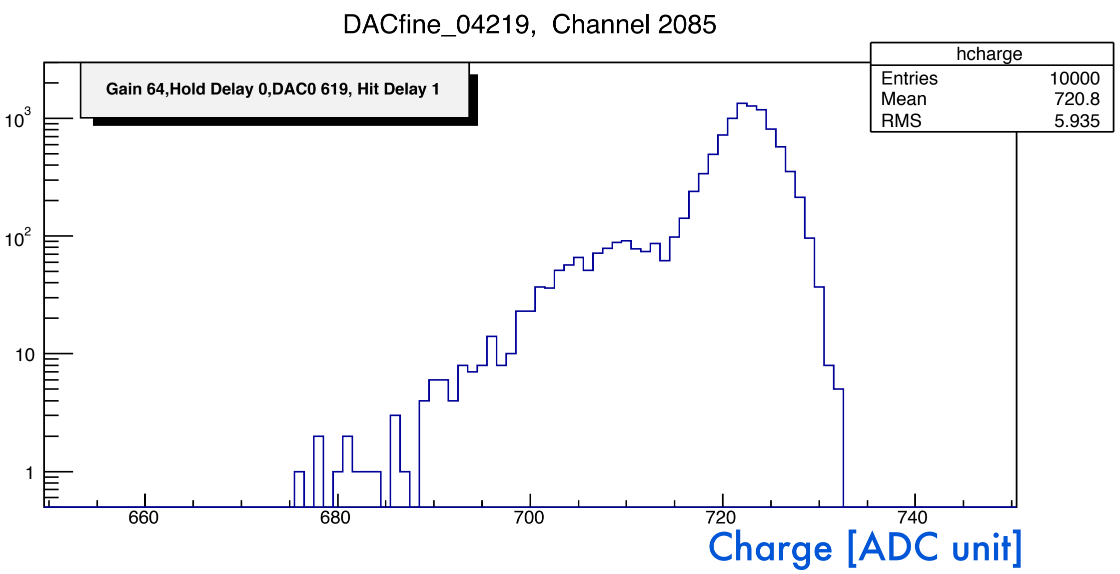




External trigger







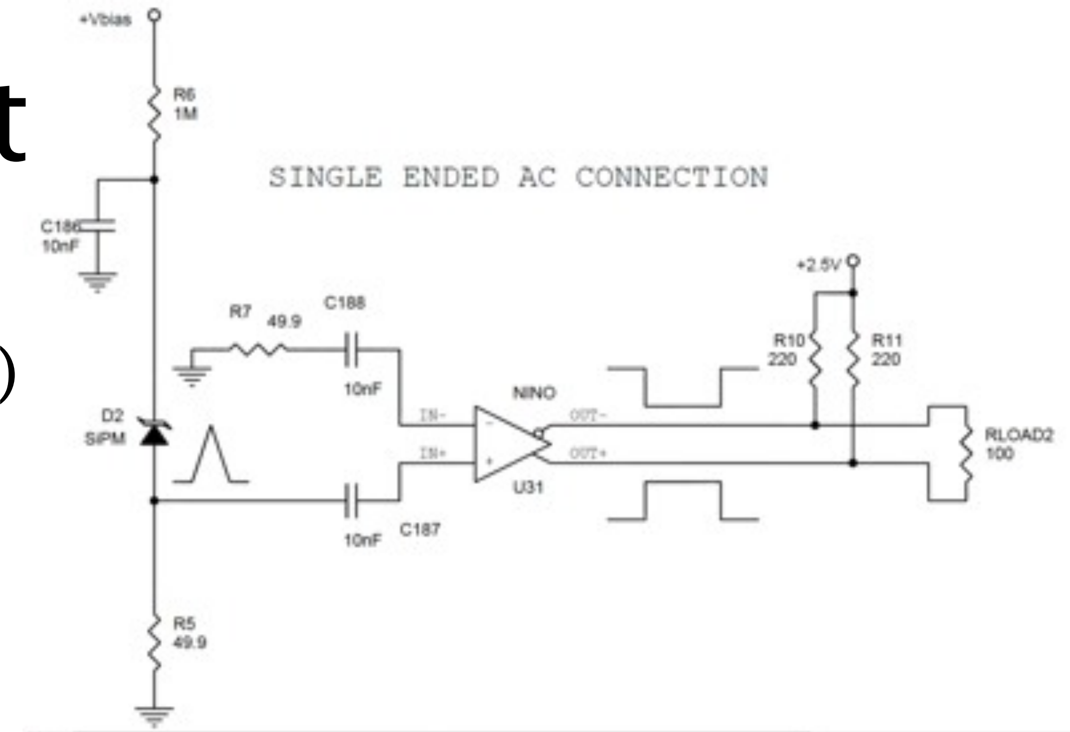
Clean SPE binary identification

Expertise in SiPM readout

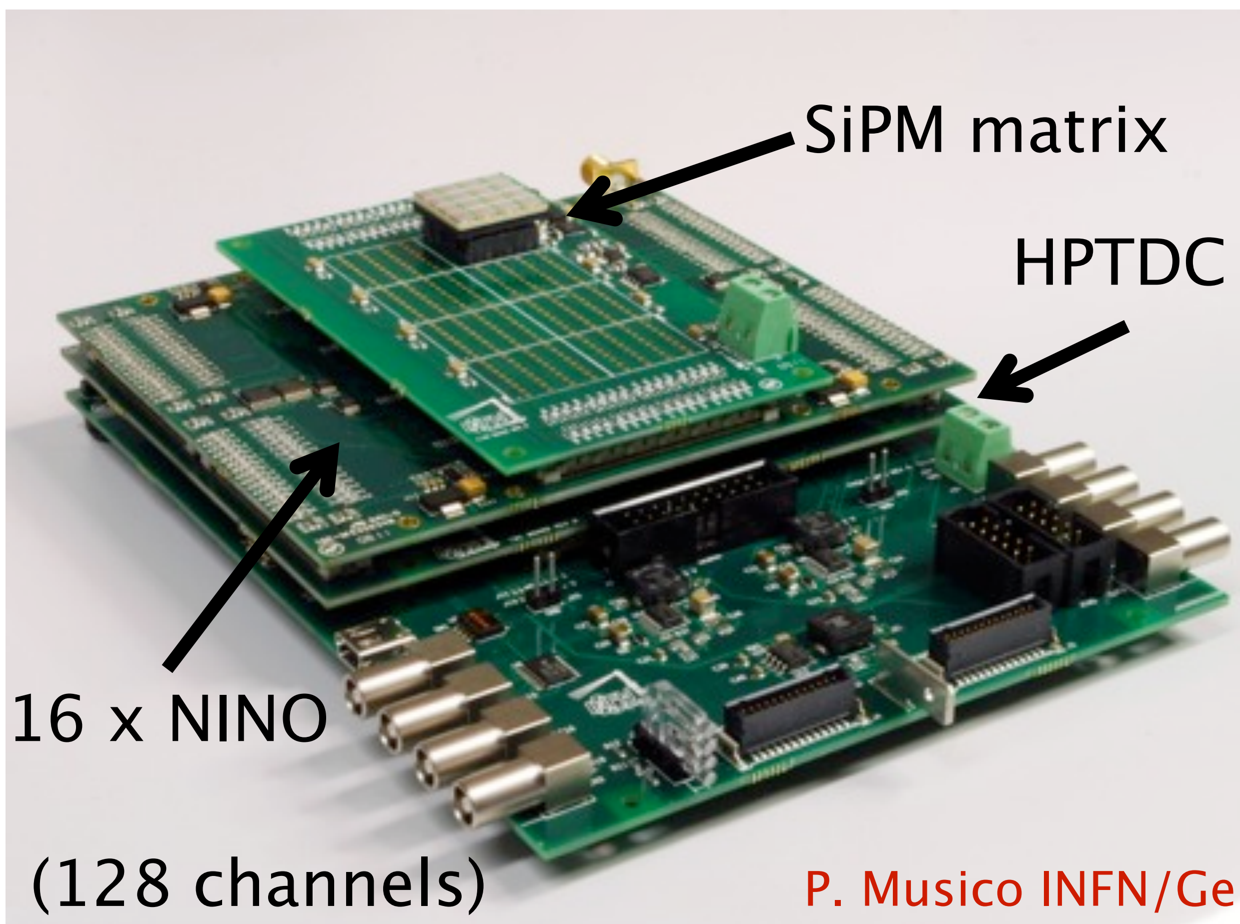
Use of NINO chip as a preamp in precise time measurement with SiPM (TOF-PET application)

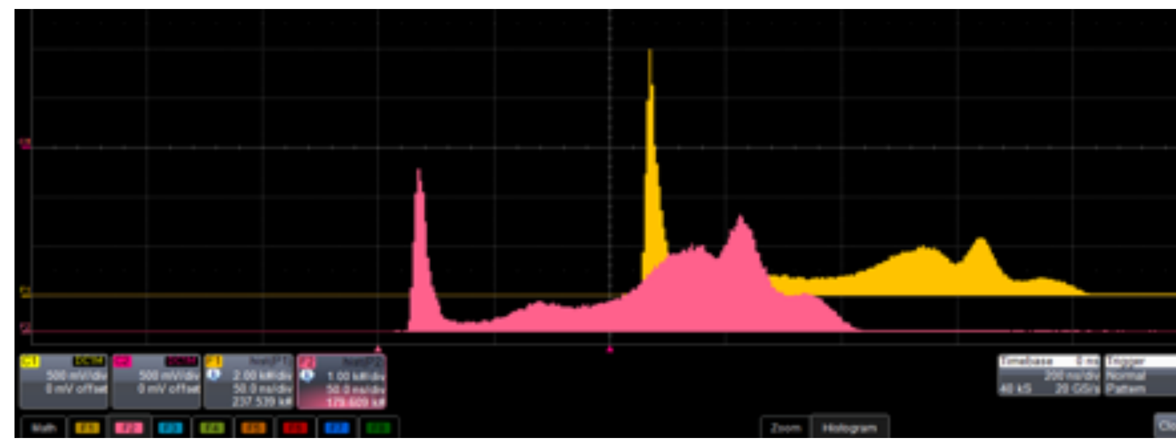
Could be extended to SiPM for RICH

More integrated solutions to be considered

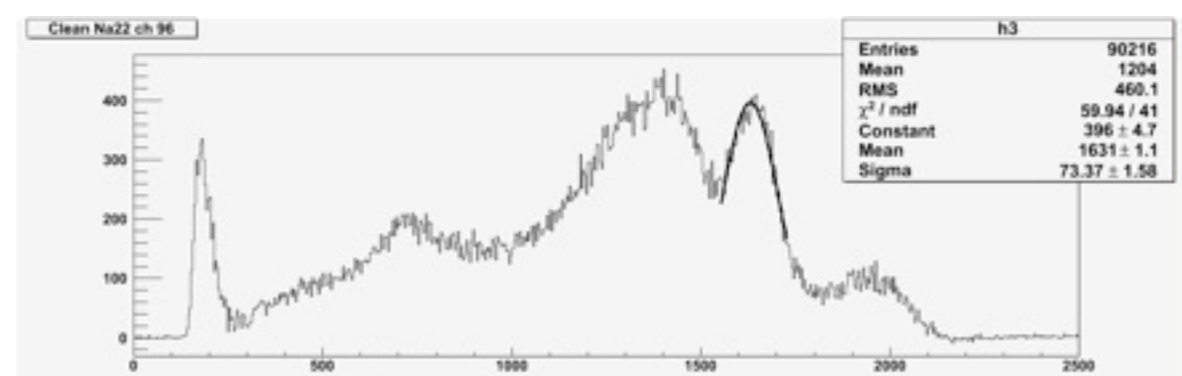


SiPM to NINO implementation





^{22}Na SiPM width spectrum (O-scope)



^{22}Na SiPM width spectrum (HPTDC)

Conclusion

Two candidate solutions for the RICH readout based either on MAROC or on DREAM

MAROC

- Must work in binary mode (analog for calibration only)
- binary mode suitable for single photoelectron detectability
- existing implementation can be adapted to CLAS12: SSP in place of the current controller will likely minimize the work to be done

DREAM

- Provide multisample analog information
- no needs of additional development for JLab integration
- coupling to PMT must be proved (test in july)

Detailed design once the chip has been defined

End