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

Frontend Electronics

M.Turisini (JLab)
E. Cisbani (INFN-Roma/ISS)
P. Musico (INFN-Genova)

CLAS12 RICH Technical Review, 2013 June 26-27

Requirements (for PMT readout)

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

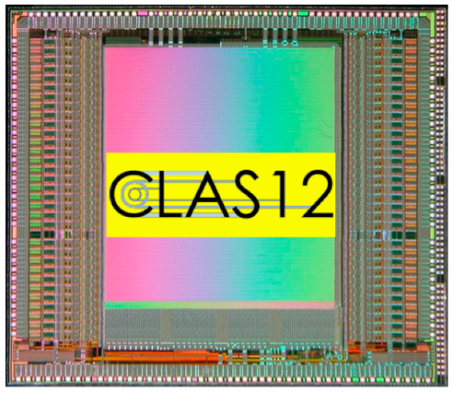
Choice of the Electronics

- 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) - Design for Micromegas @ CLAS12

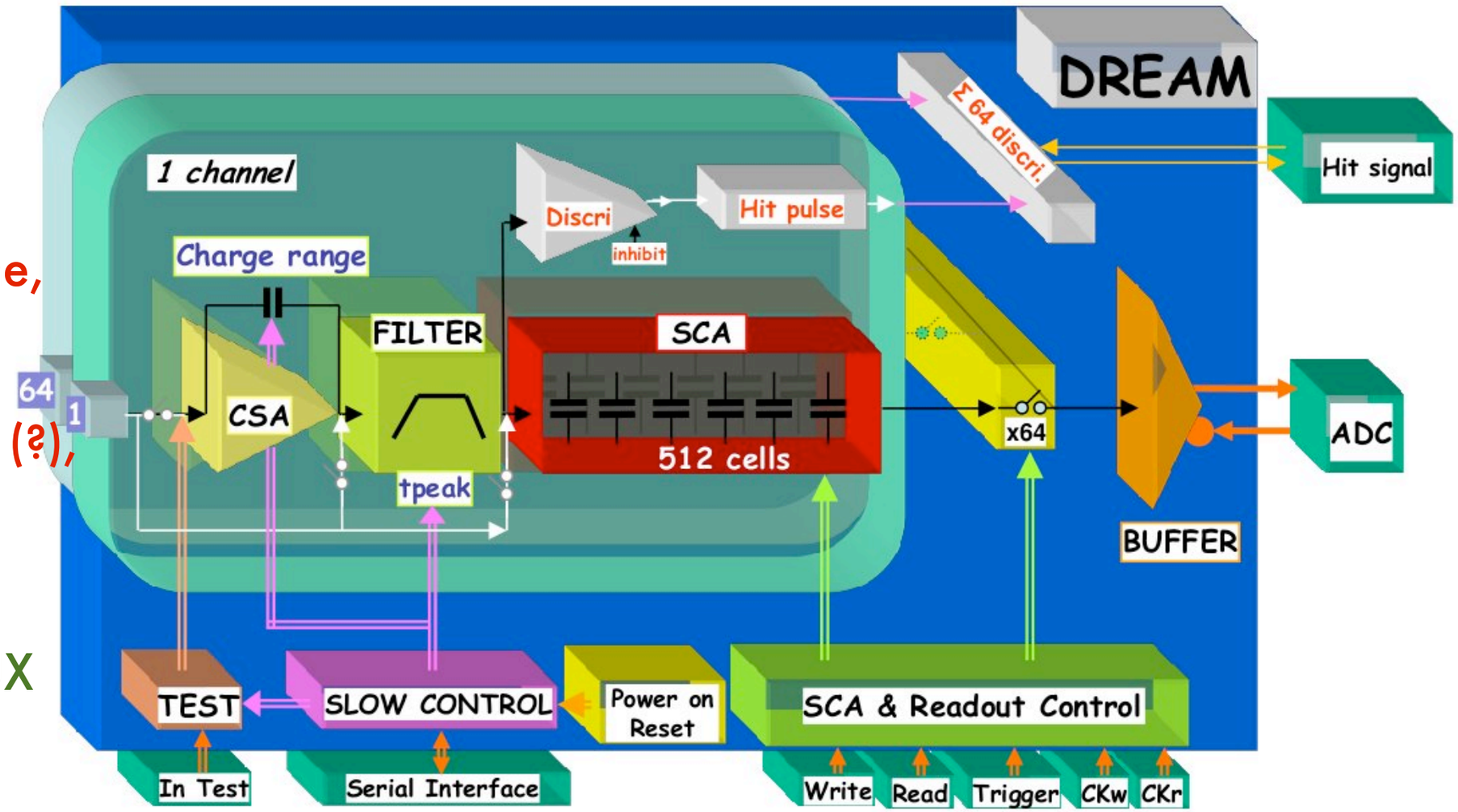
- Preamplifier, adj gain on 4 ranges (60fC,120fC,240fC,1pC)
- Shaper, adj peaking time 16 values from 50 ns to 1 µs
- Analog memory 512 cells, sampling rate 1-50MHz
- Discriminator, trigger pipeline 16 µs , sum of 64

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

PROs: analog pipeline, designed for JLAB12

CONs: dynamic range (?), time resolution.

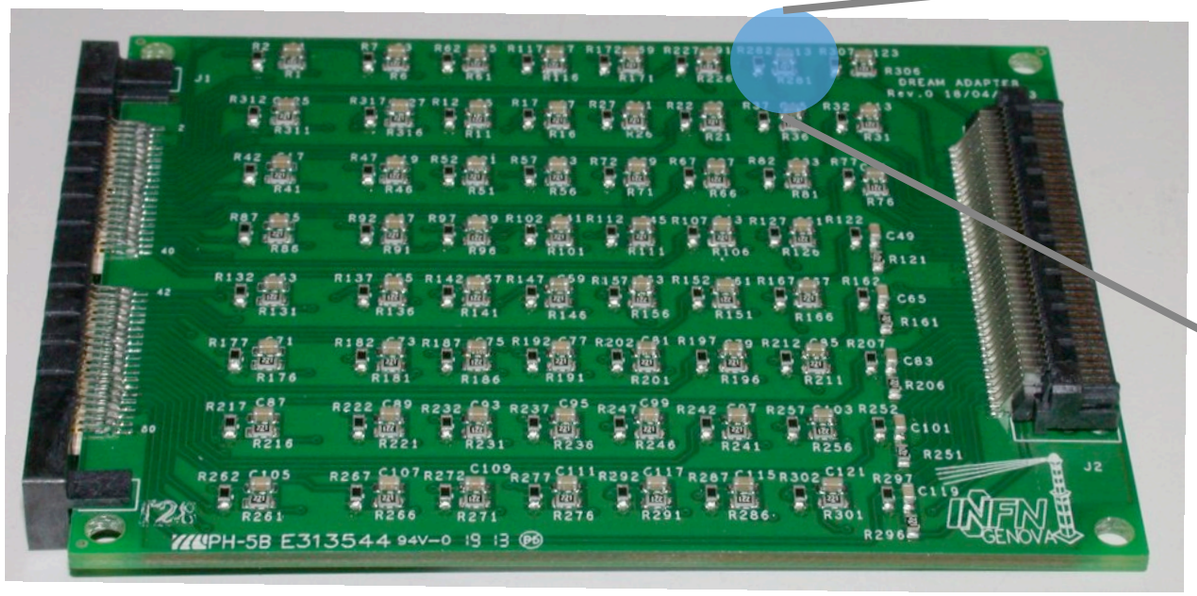
Output: Analog MUX and Digital Sum

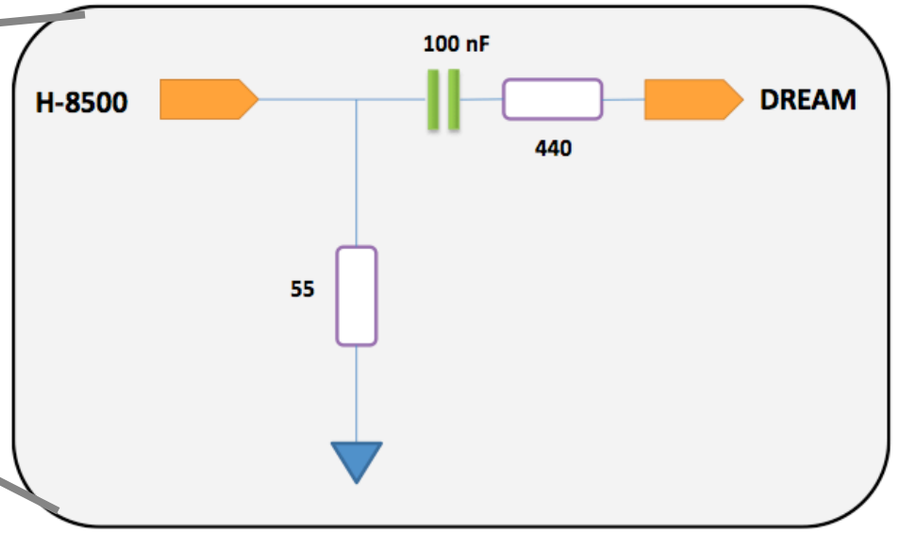


PMT DREAM interface

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

R&D from Micromegas group



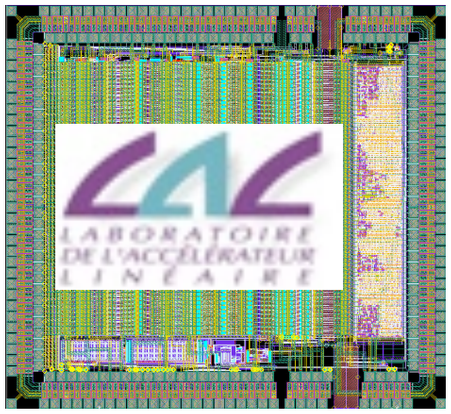


Attenuation board for H8500
with various divider ratio for testing

TEST SCHEDULED 2013 JULY at INFN-FRASCATI

MAROC asic

Multi Anode Read Out Chip

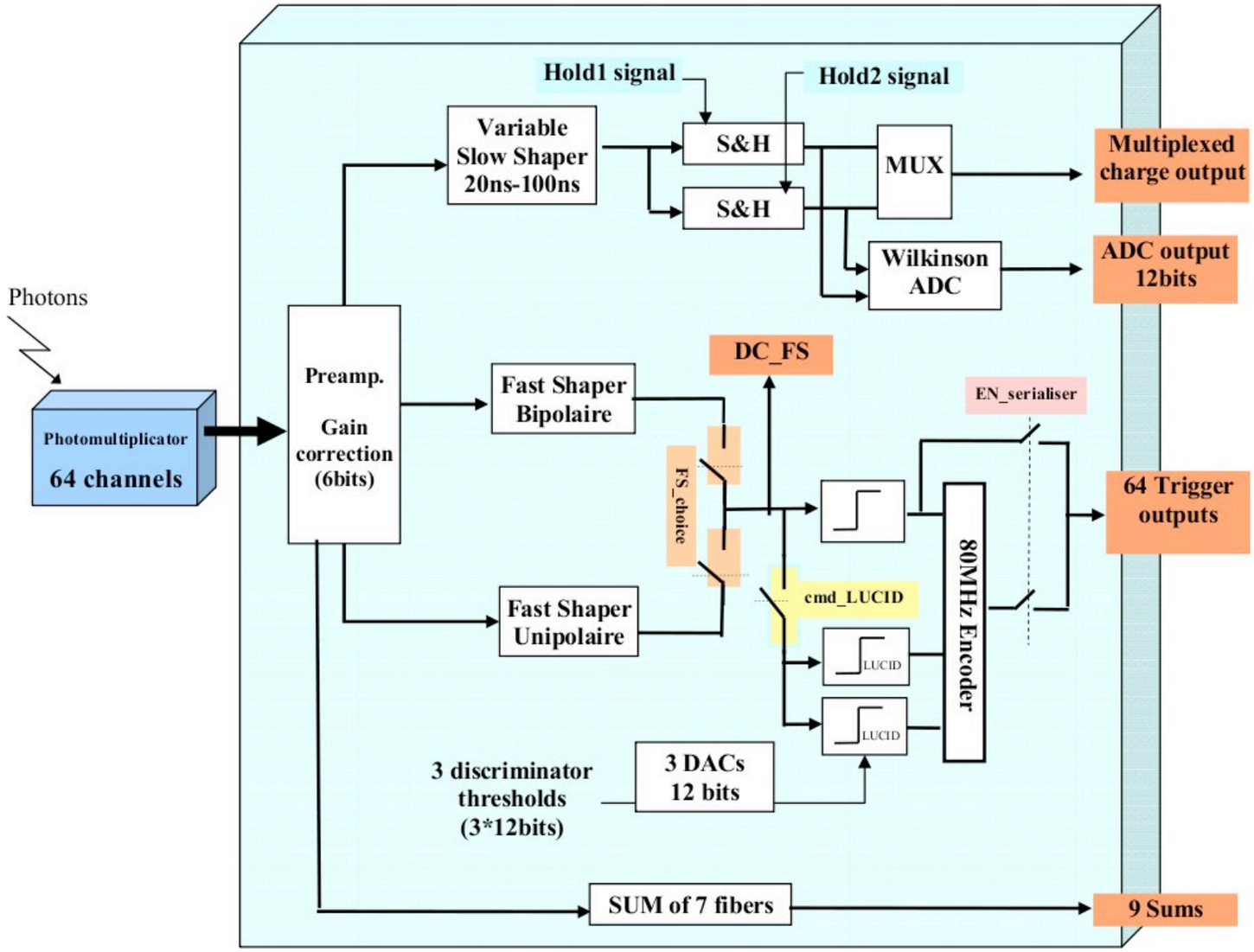


- 240-pin
- 16 mm^2

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

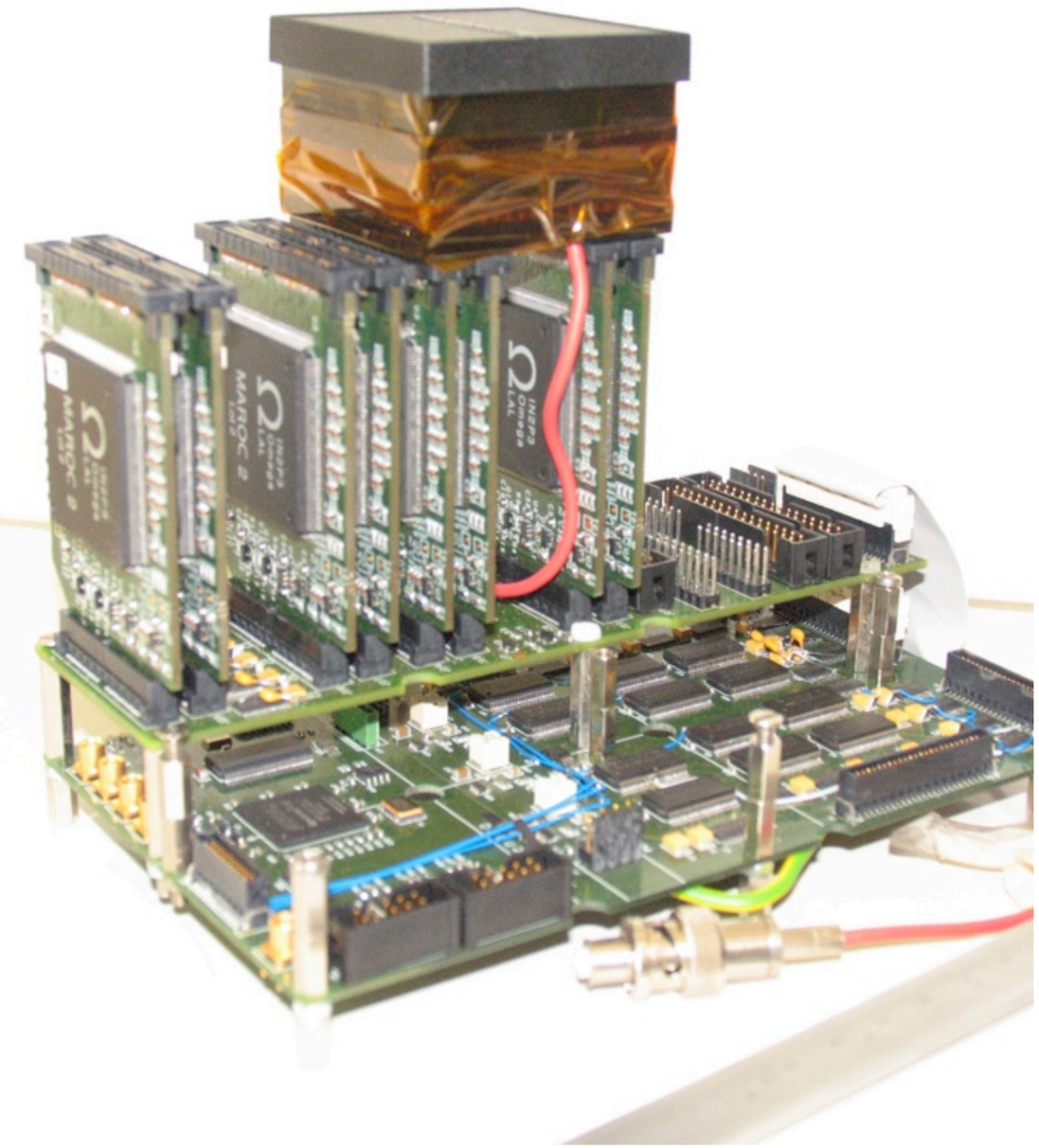
Original system developed for Radionuclides Imaging

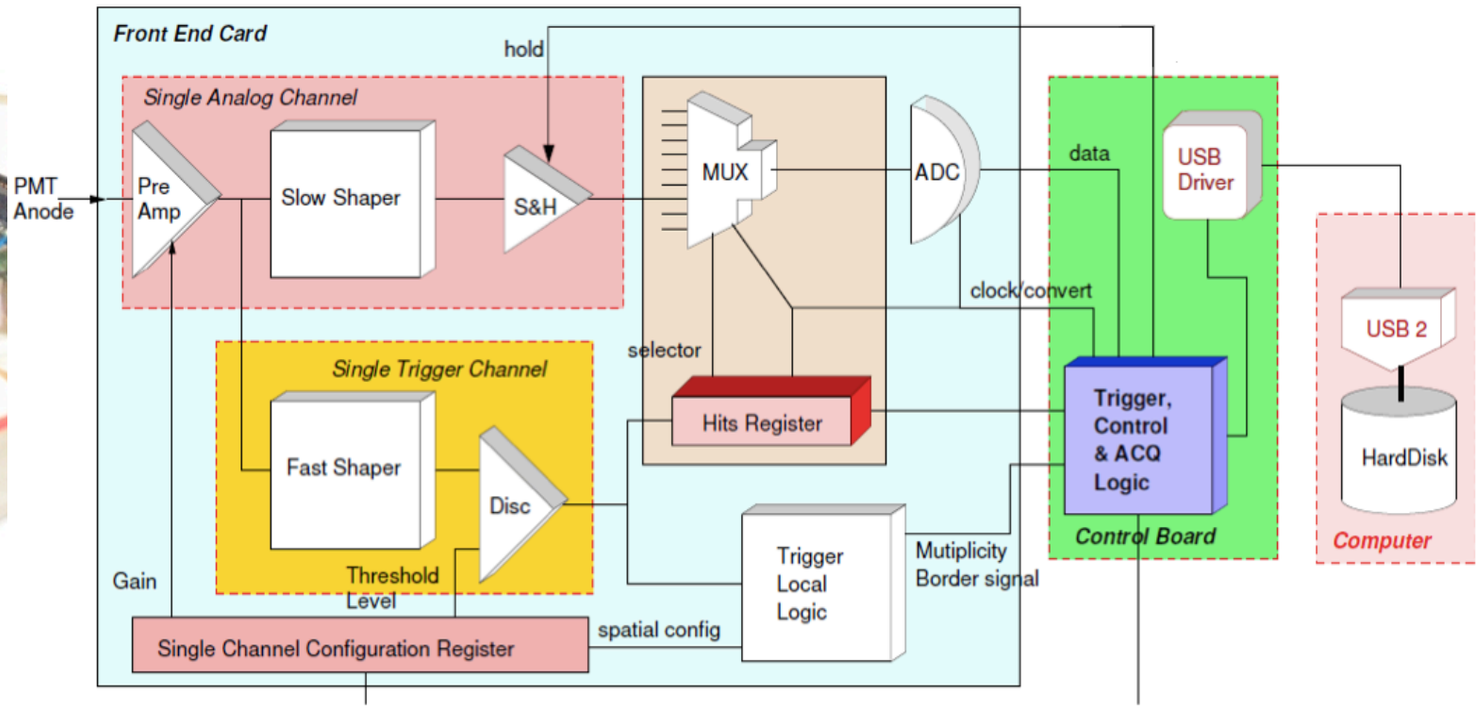
System 4096 Channels

Many optical photons

Binary output used for self trigger

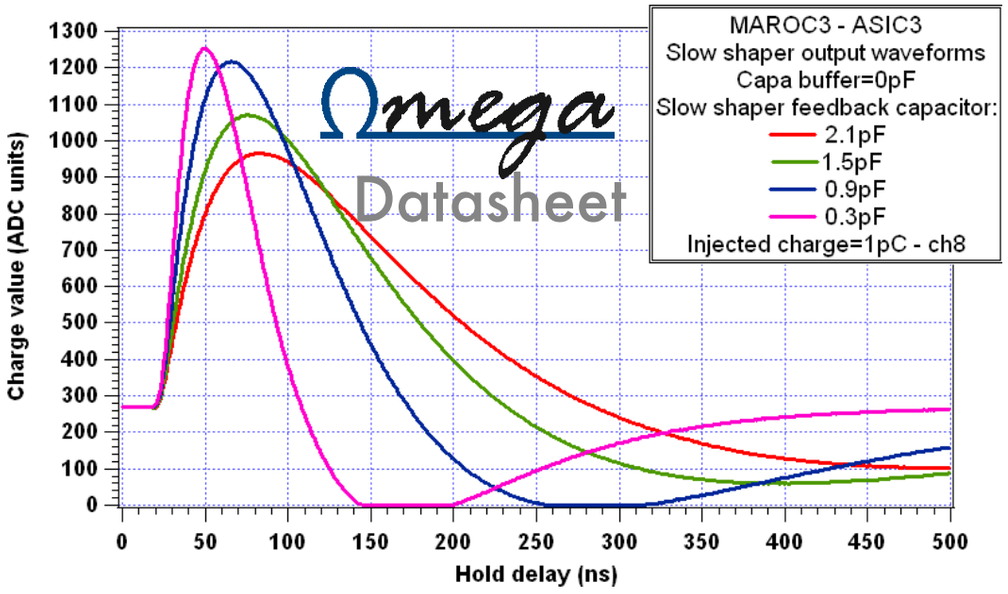
Not Optimized for Single Photon



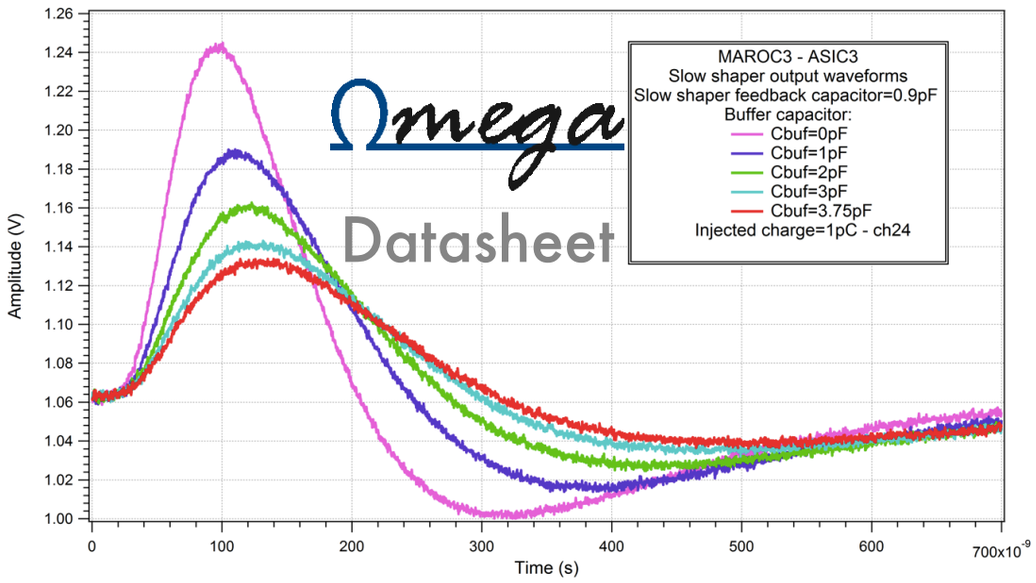


Adopted for the RICH prototype in analog output mode

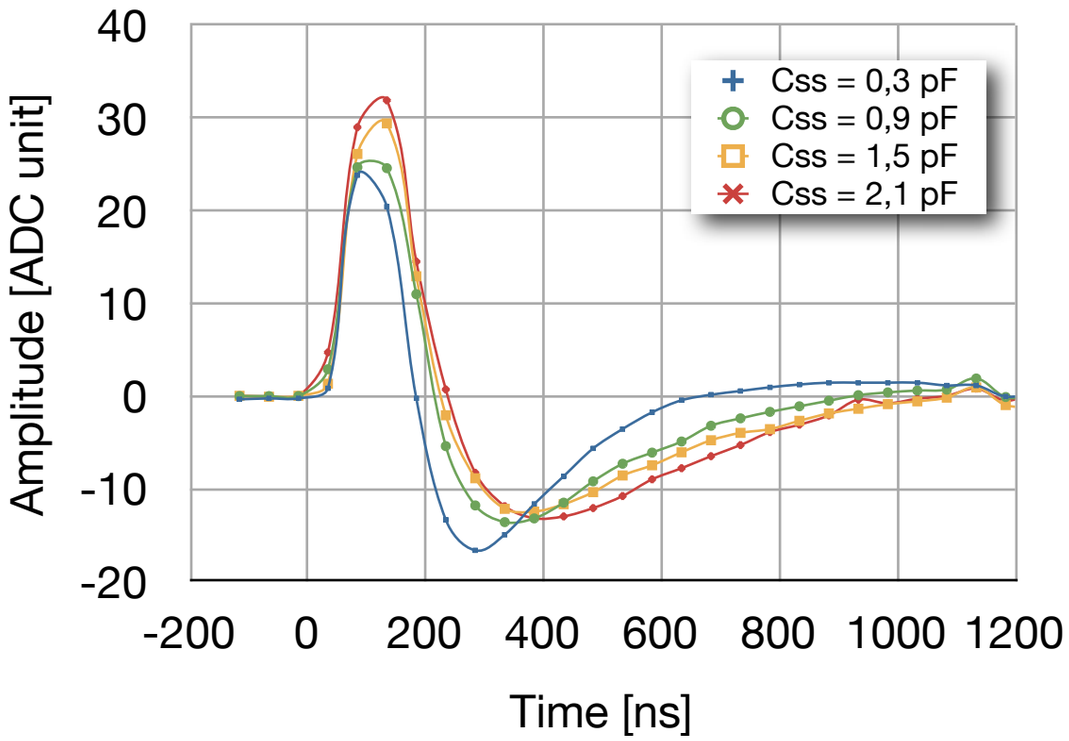
Reproduce MAROC specs

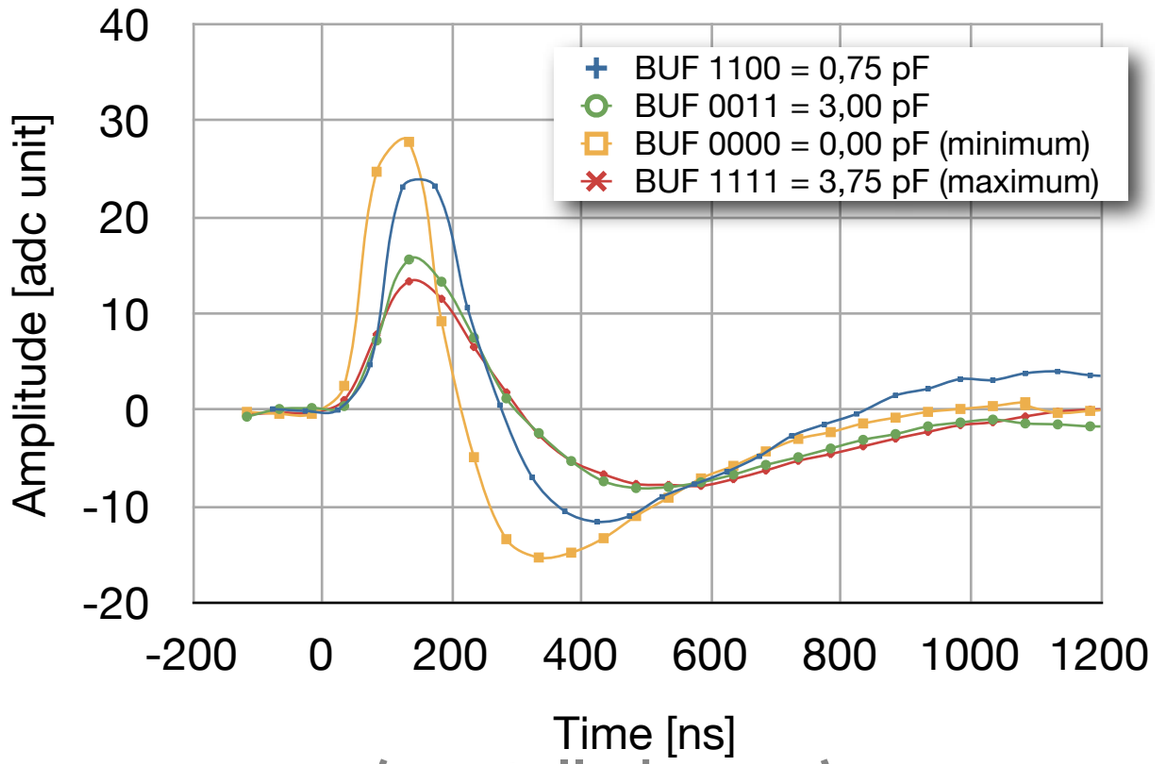


Slow Channel Pulses CBUF = 0 pF



Slow Channel Pulses Css = 0.9 pF





Well reproduced but different output range (partially known)

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)

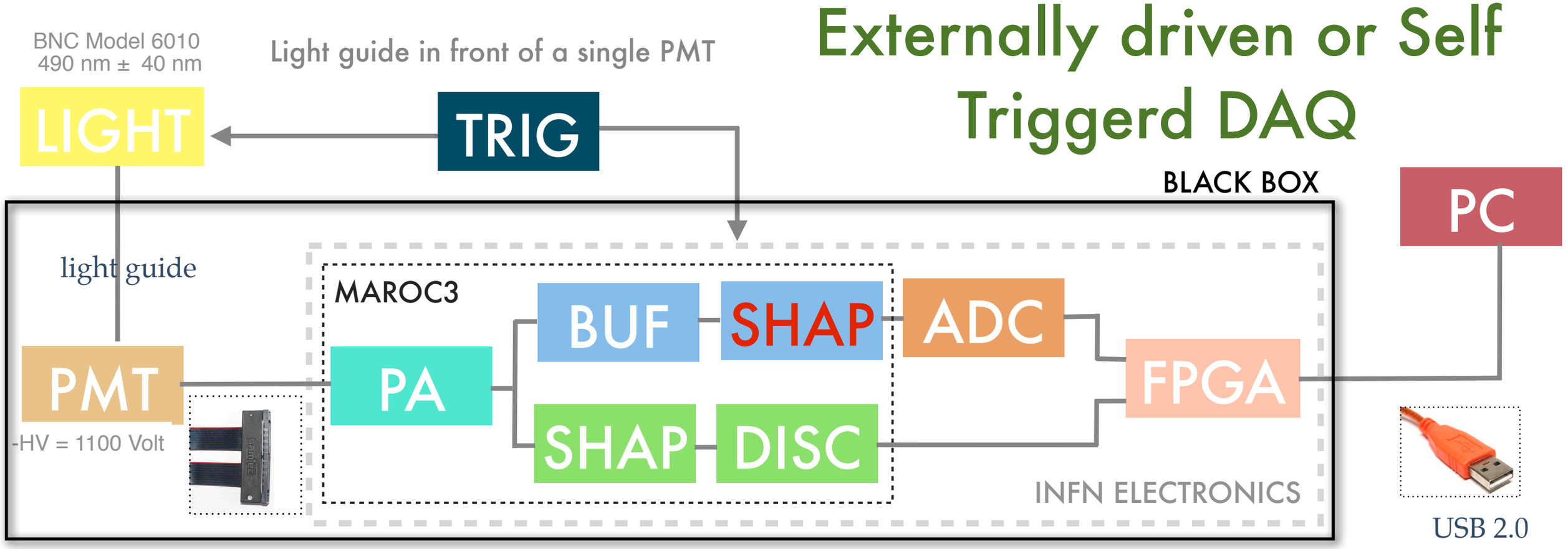
MAROC binary information (64 parallel outputs) can be a valid alternative

see talk by Benjamin Raydo

- Binary data latency depends on external logic! **Feasible**
- Stability/sensitivity of threshold to single photoelectron? **Tested**
- Noise in MAROC fast shaper? **Measured**
- Implemented electronics not optimized for binary readout with external trigger (need significant FIRMWARE revision) **Postponed**

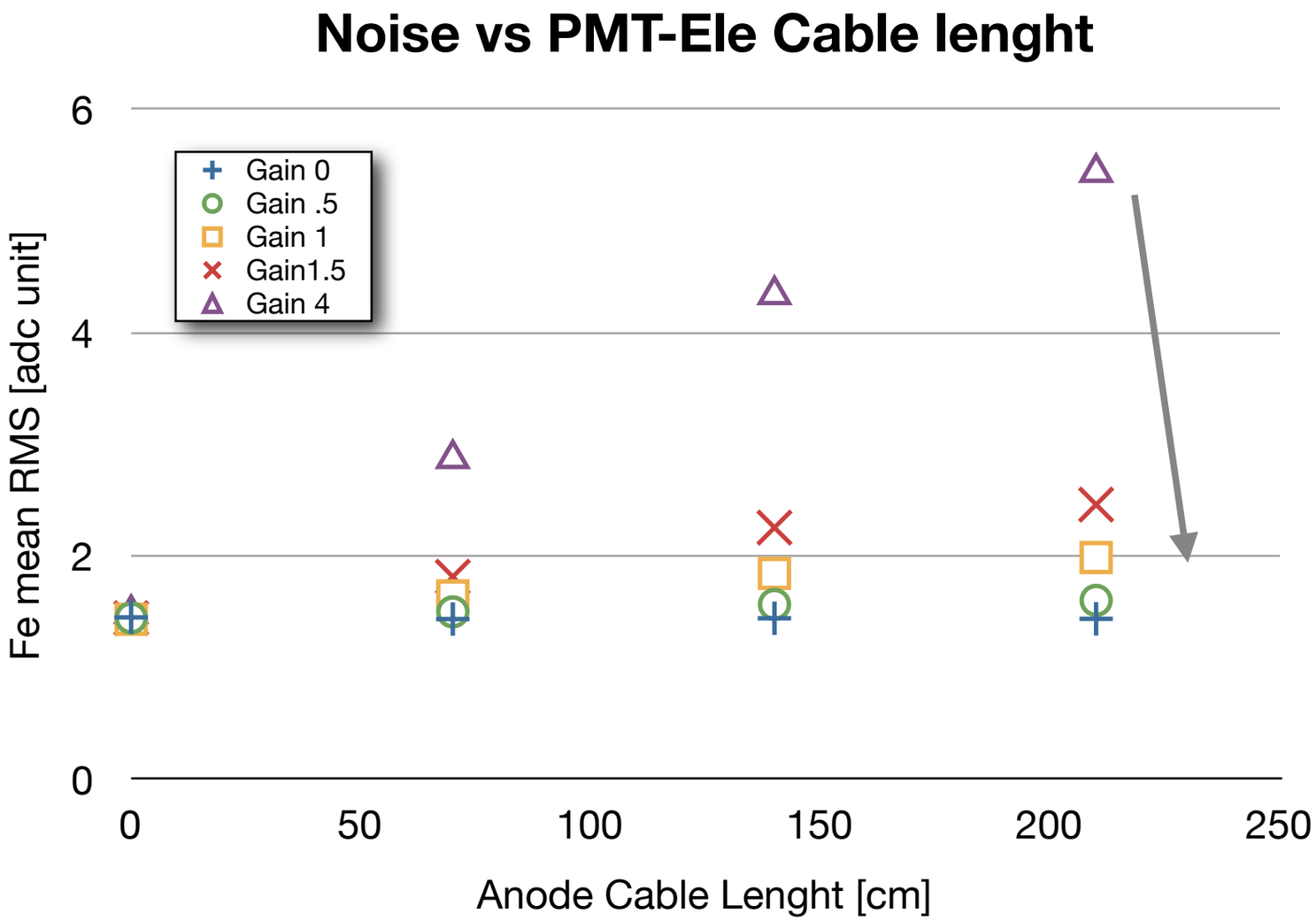
Light Test Setup

Externally driven or Self Triggerd DAQ

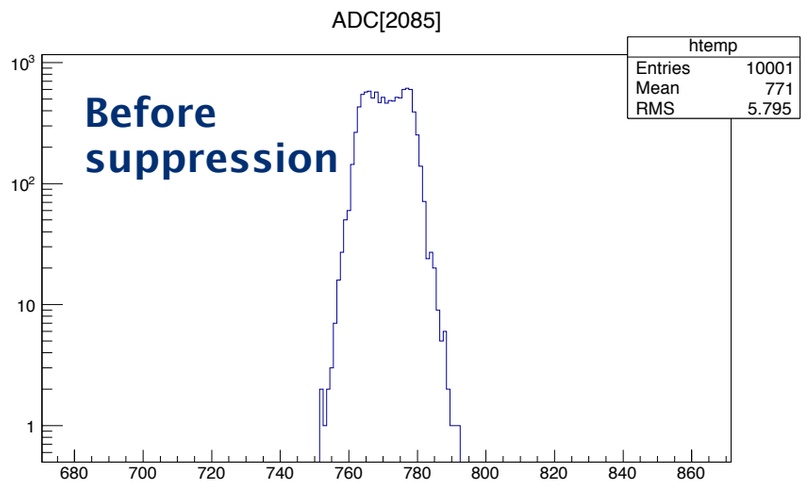


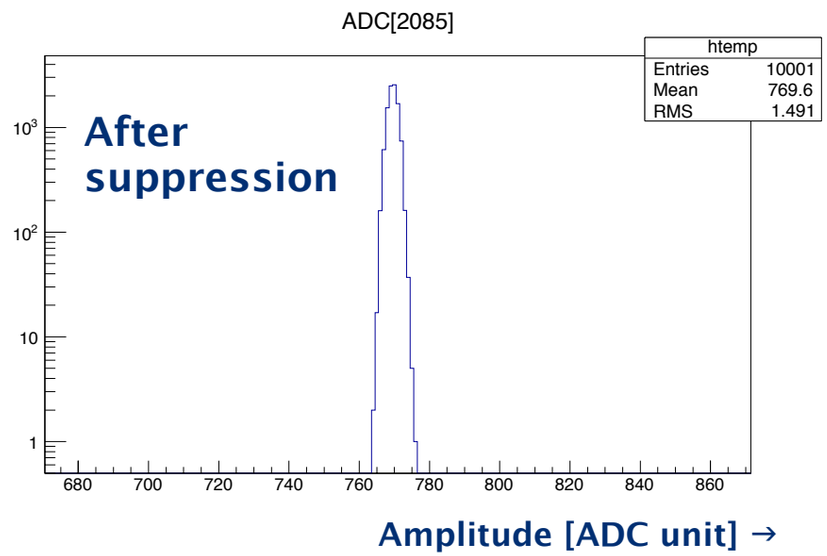
- Assume analog output as reference
- Measure "digital" noise with PMT on, no light (and other configurations)
- Compare/Correlate analog and binary information, with internal and external (need synch) triggers
- Measure range (in threshold) of the ~single photon signal by threshold scan to estimate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

MAROC Analog Noise



Common noise **suppressed offline** signficantly reduce the pedestal RMS





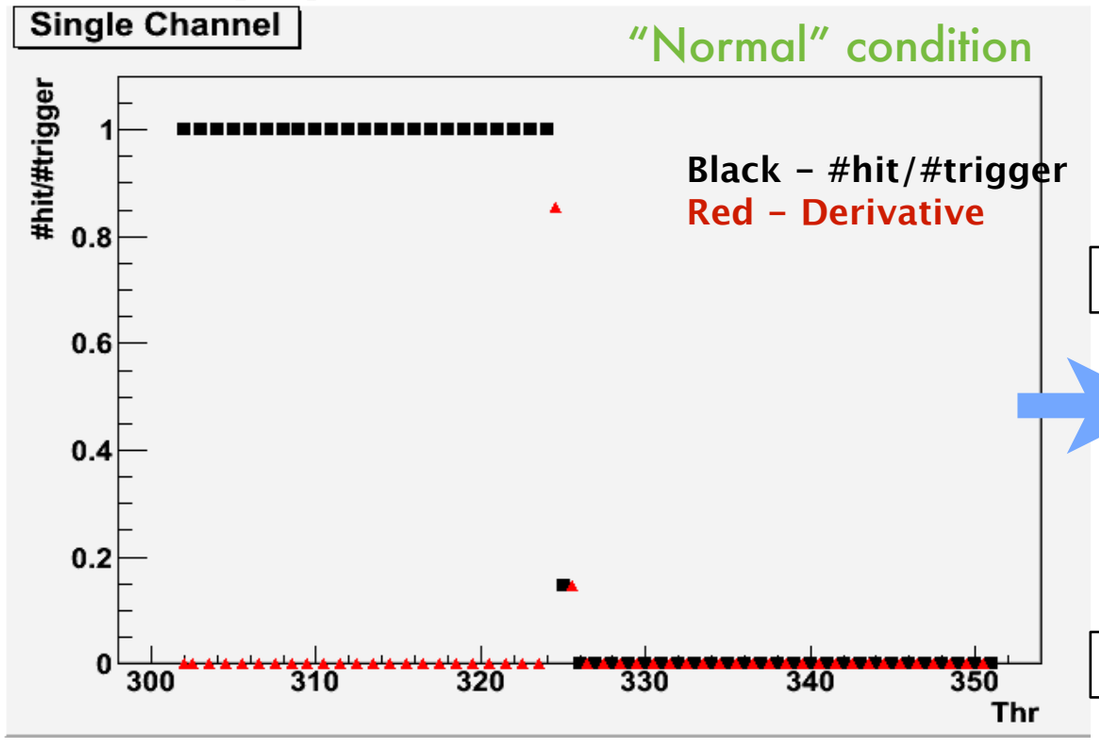
Most of the noise seems to come from

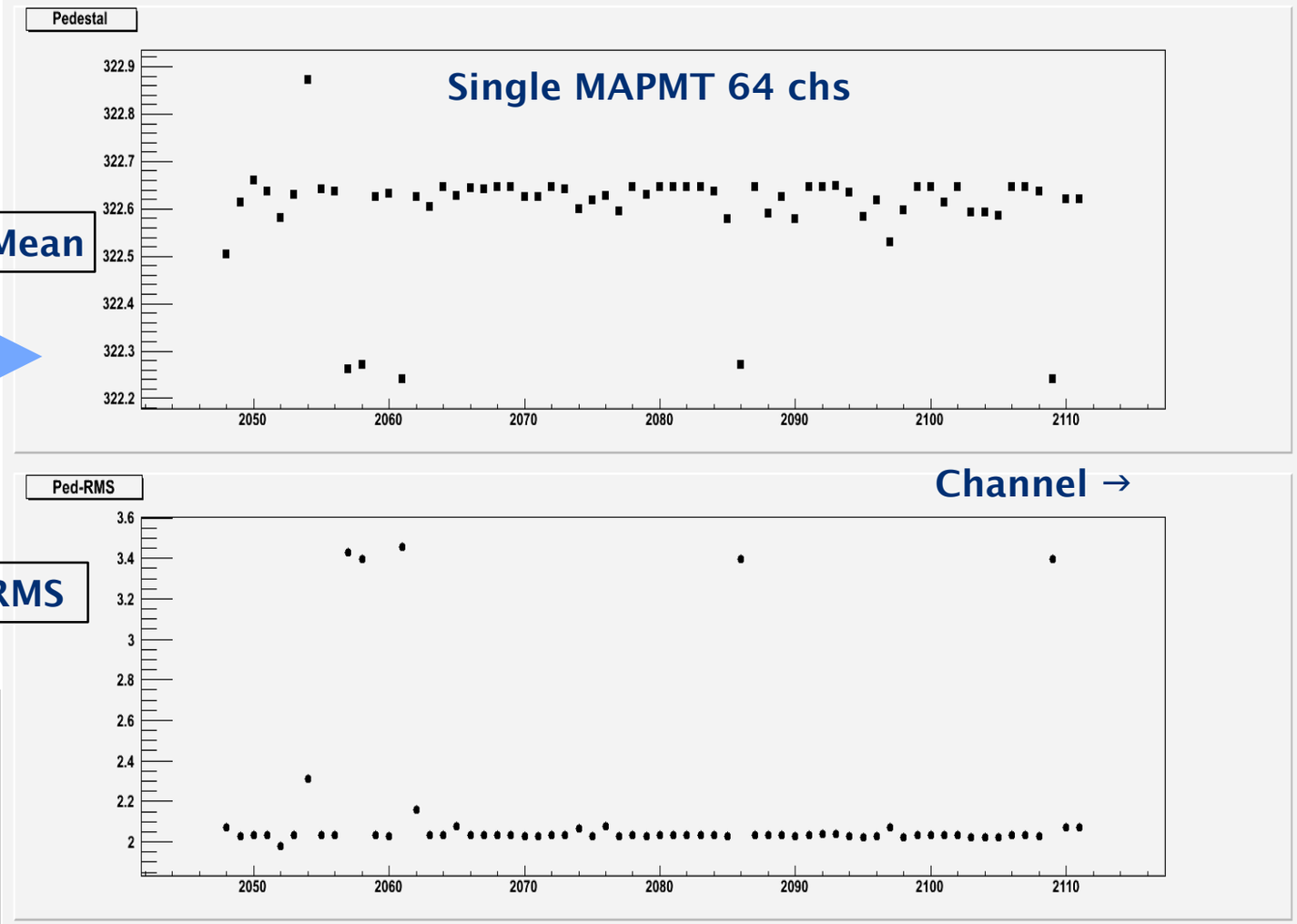
COMMON NOISE

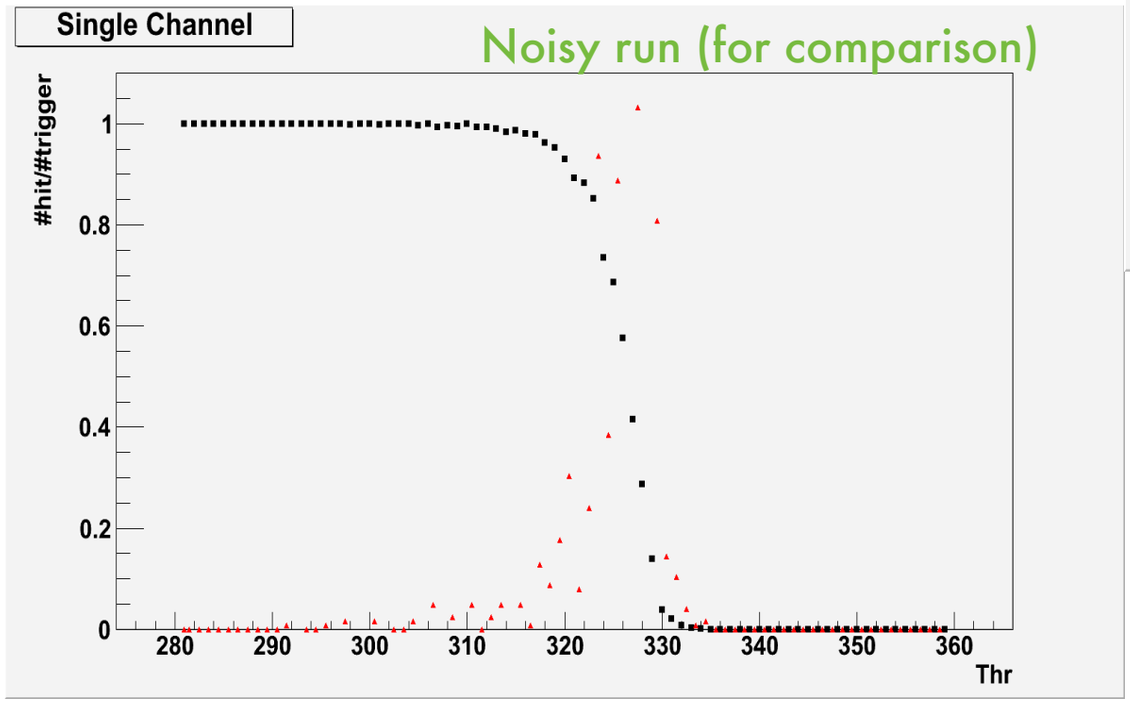
Noise conditions are site dependent!

MAROC Digital Noise

Binary pedestal as derivative of the "hit efficiency" threshold scan







=>Digital RMS <1thr unit (<3mV)

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

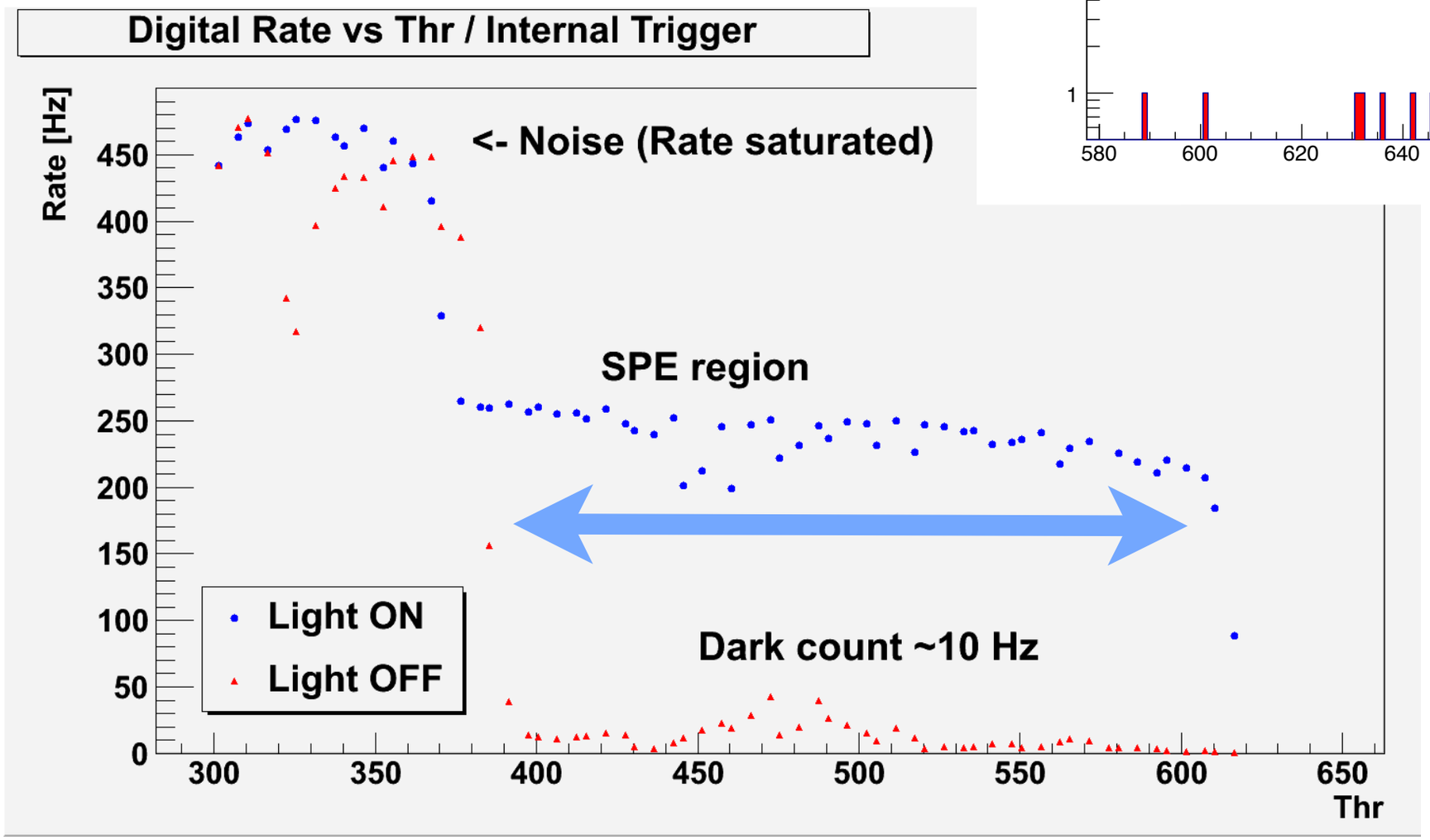
Digital/Analog comparable =>see next for SNR

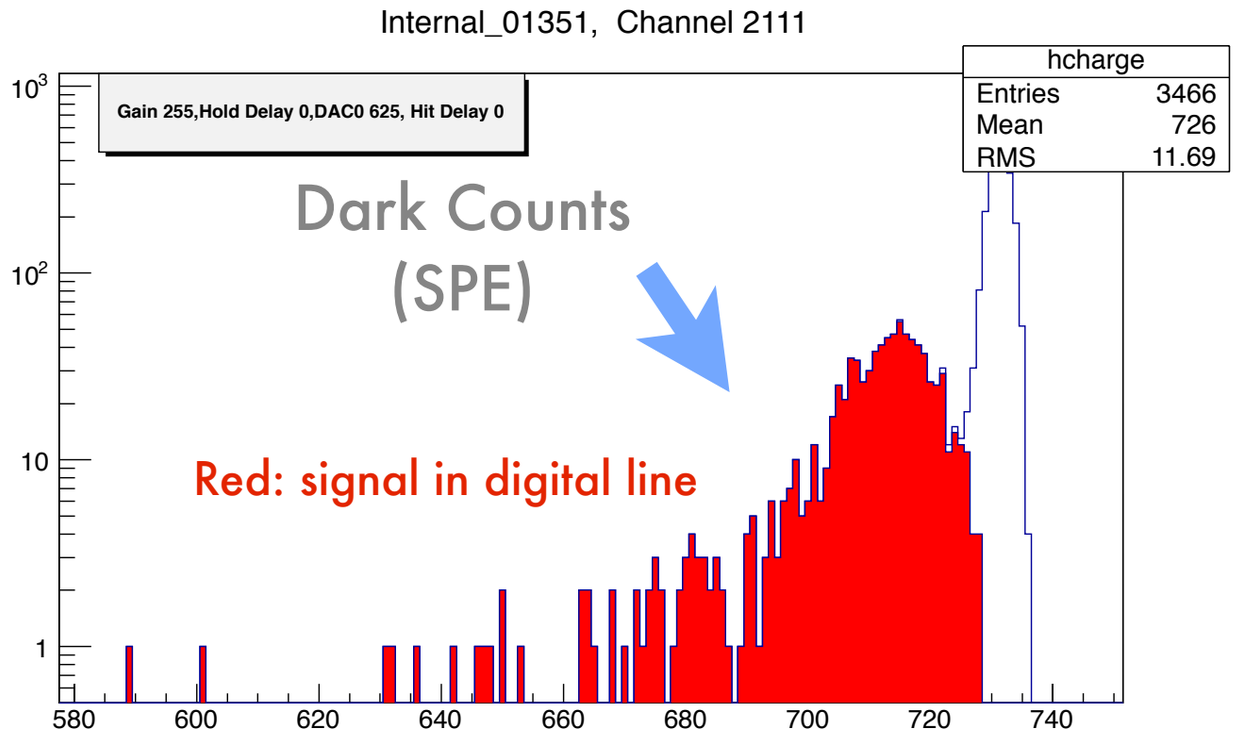
Noise uniformity vs channel

Dark Noise and SPE

Internal trigger

SPE region extent over ~200 thr unit
(compare with Ped_RMS <1)





Pretty sharp cut => clean SPE binary identification

Single PhotoElectron Level

External trigger / Light Source

The CLAS12 running conditions
(but MAROC electronics not optimized!)

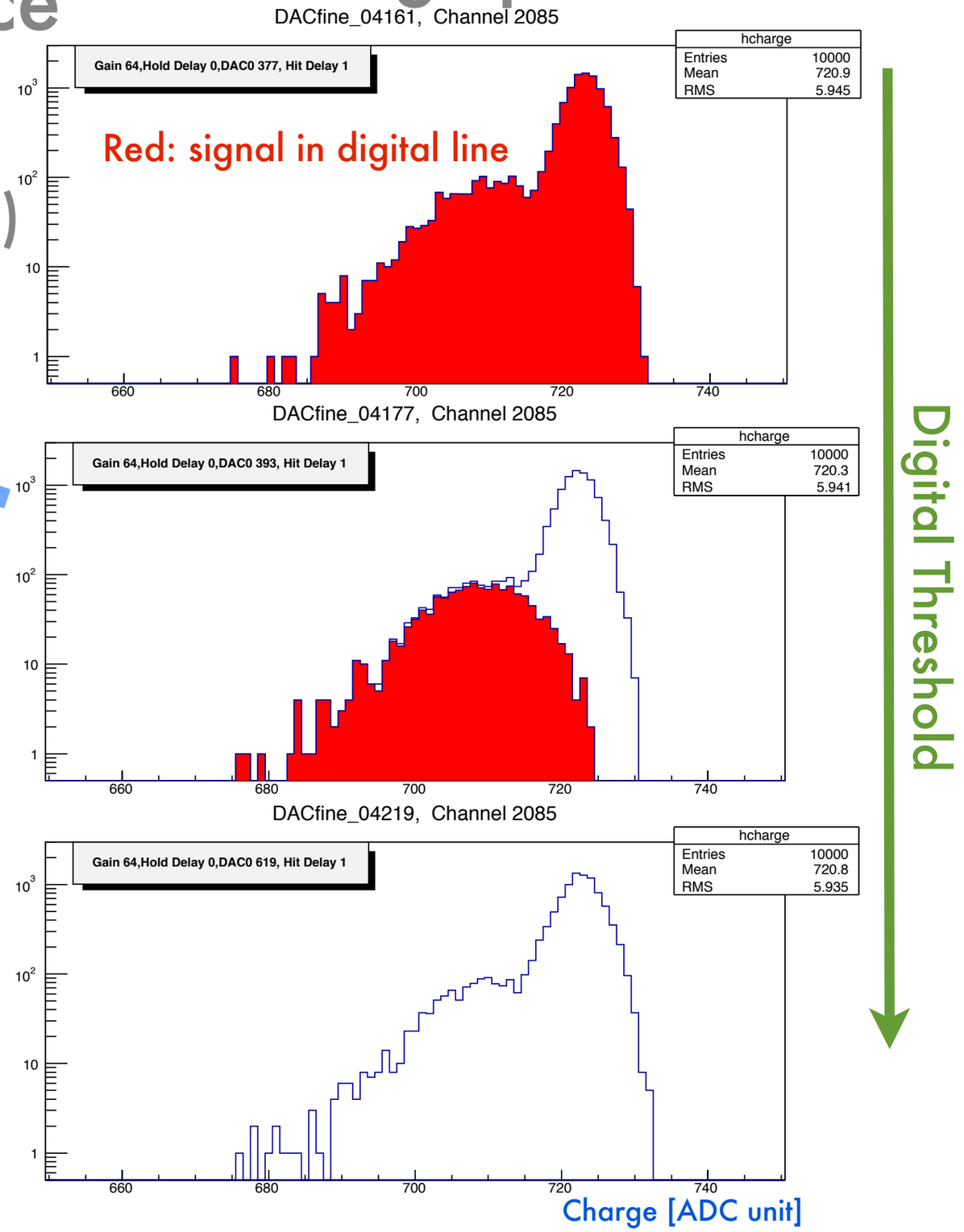
Clean SPE identification with digital threshold

Smooth cut due to:

- Light source jitter (60 ns)
- Analog and digital lines are not optimally sync (~25 ns offset)
- Noise in digital line (small effect according to previous slides)

Common noise not subtracted

Analog spectra



Expertise in SiPM readout

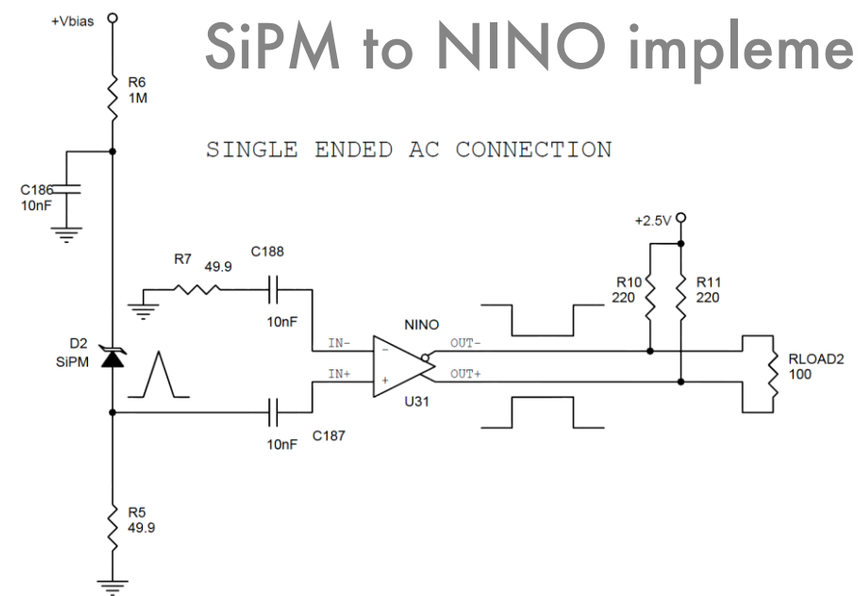
NINO : ultra fast, low power, amplifier and discriminator for TOF (ALICE)

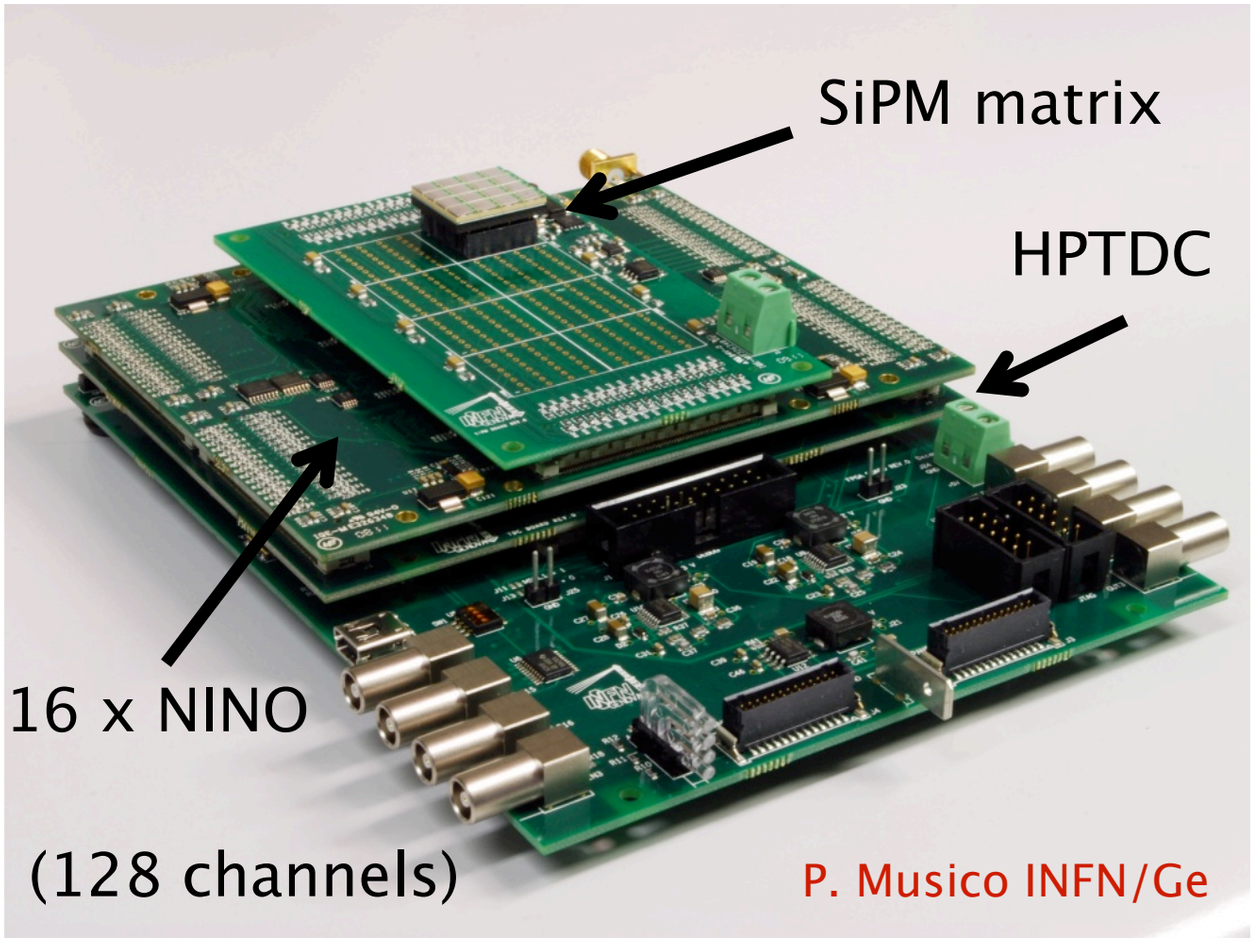
Use of NINO chip as a preamp in precise time measurement with SiPM (TOF-PET application)

Could be extended to SiPM for RICH

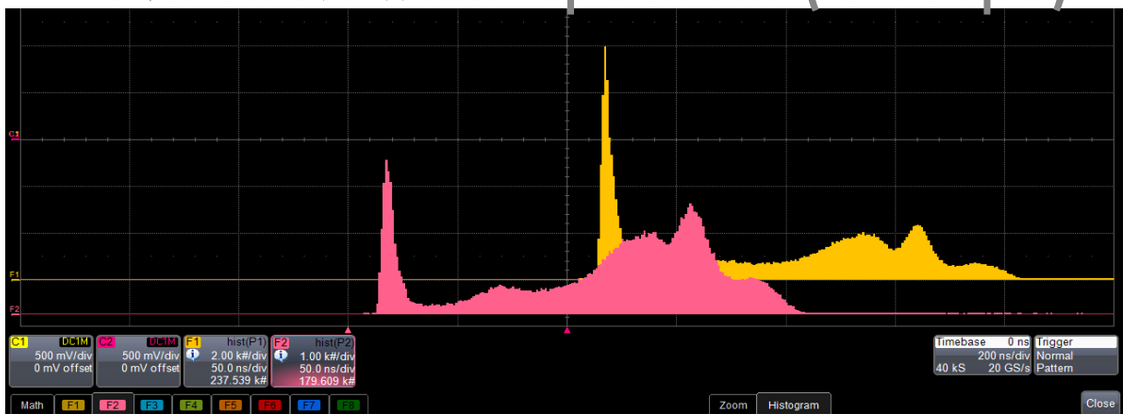
More integrated solutions to be considered

SiPM to NINO implementation

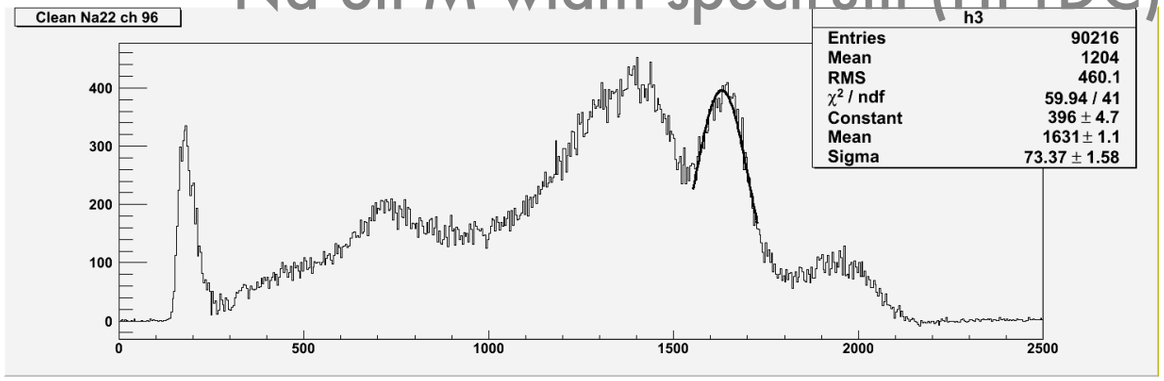




^{22}Na SiPM width spectrum (O-scope)



^{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)

Electronics Test in July on DREAM and MAROC

Detailed design once the chip has been defined

End

CLAS12 RICH Technical Review, 2013 June 26-27