

CLAS12 RICH front end electronics

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on behalf of CLAS12 RICH electronics group

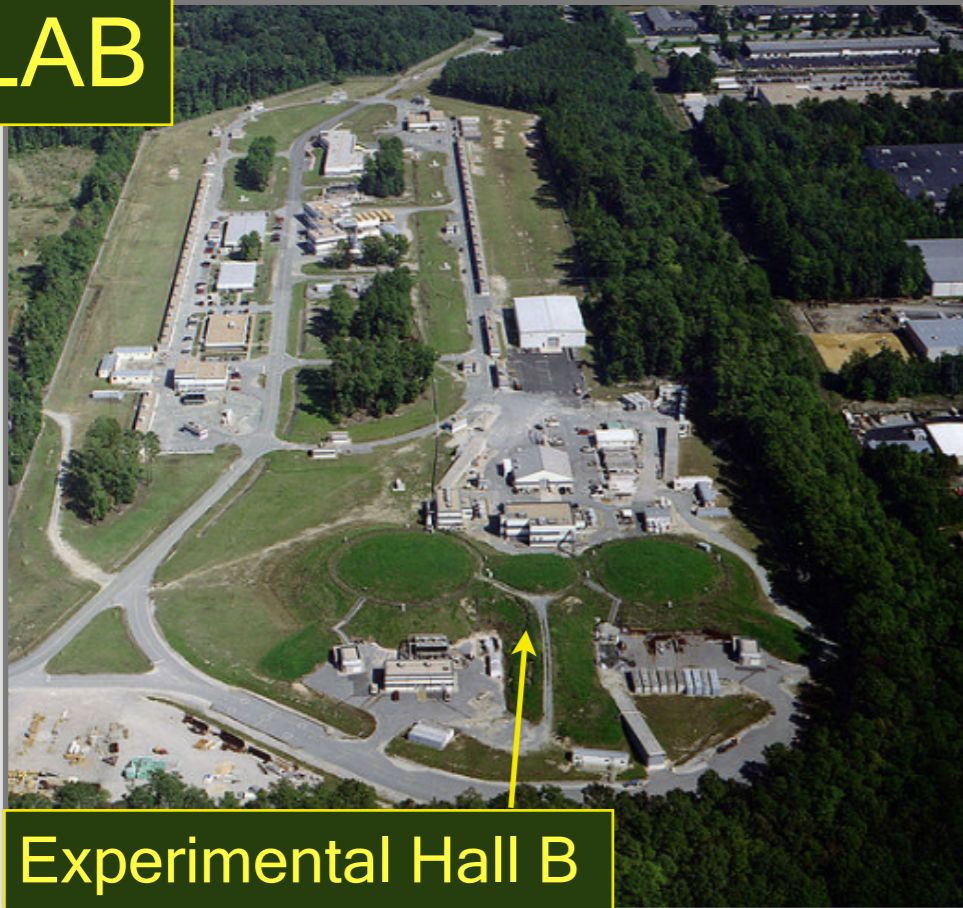
November 11-13, 2015 - Castle Rauschholzhauser, Justus-Liebig-Universität Giessen



CLAS12

at Thomas Jefferson National Laboratory, Newport News, Virginia, USA

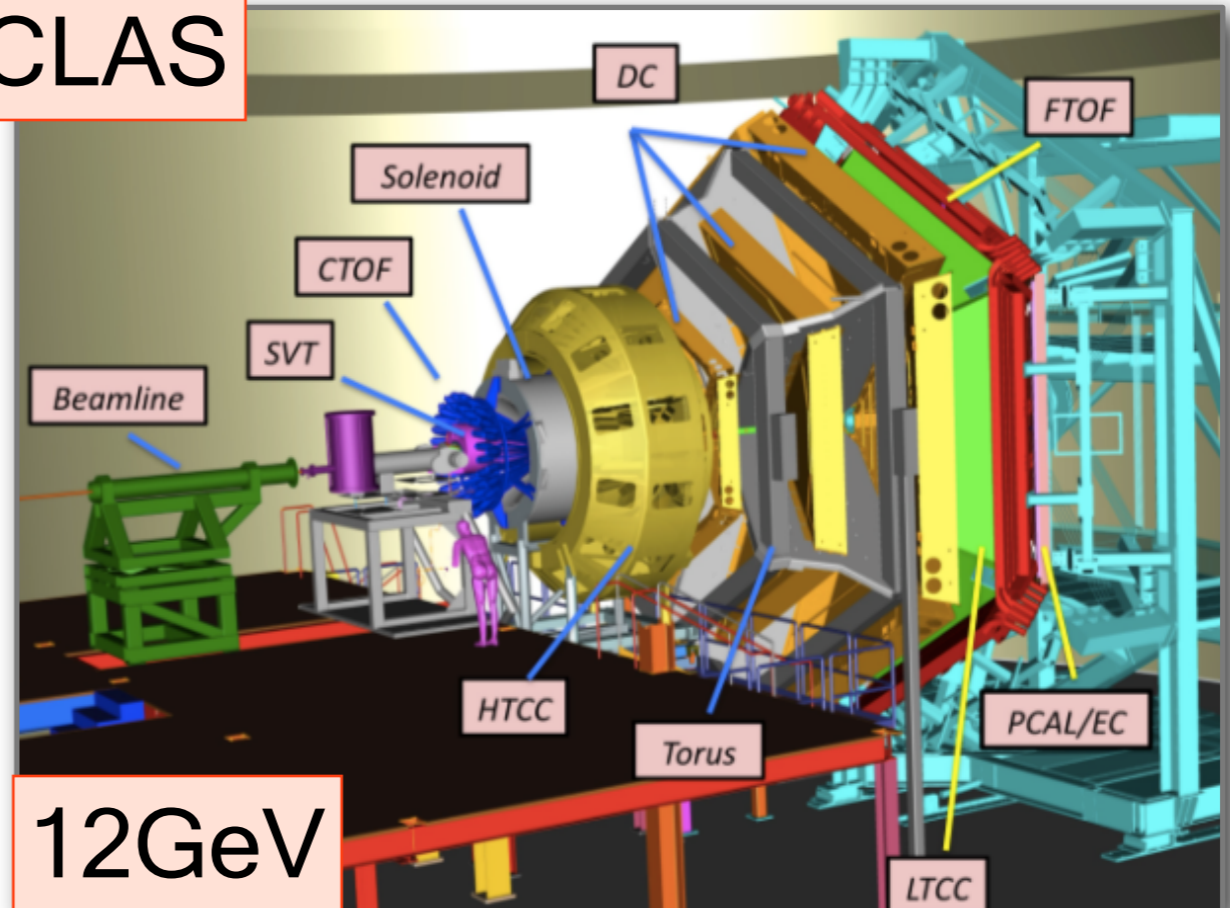
JLAB



Experimental Hall B

Continuos Electron Beam Accelerator Facility (CEBAF)

CLAS



12GeV

CEBAF Large Acceptance Spectrometer (CLAS)

RICH will be installed in the CLAS12 spectrometer in the Hall B of JLAB

RICH Project

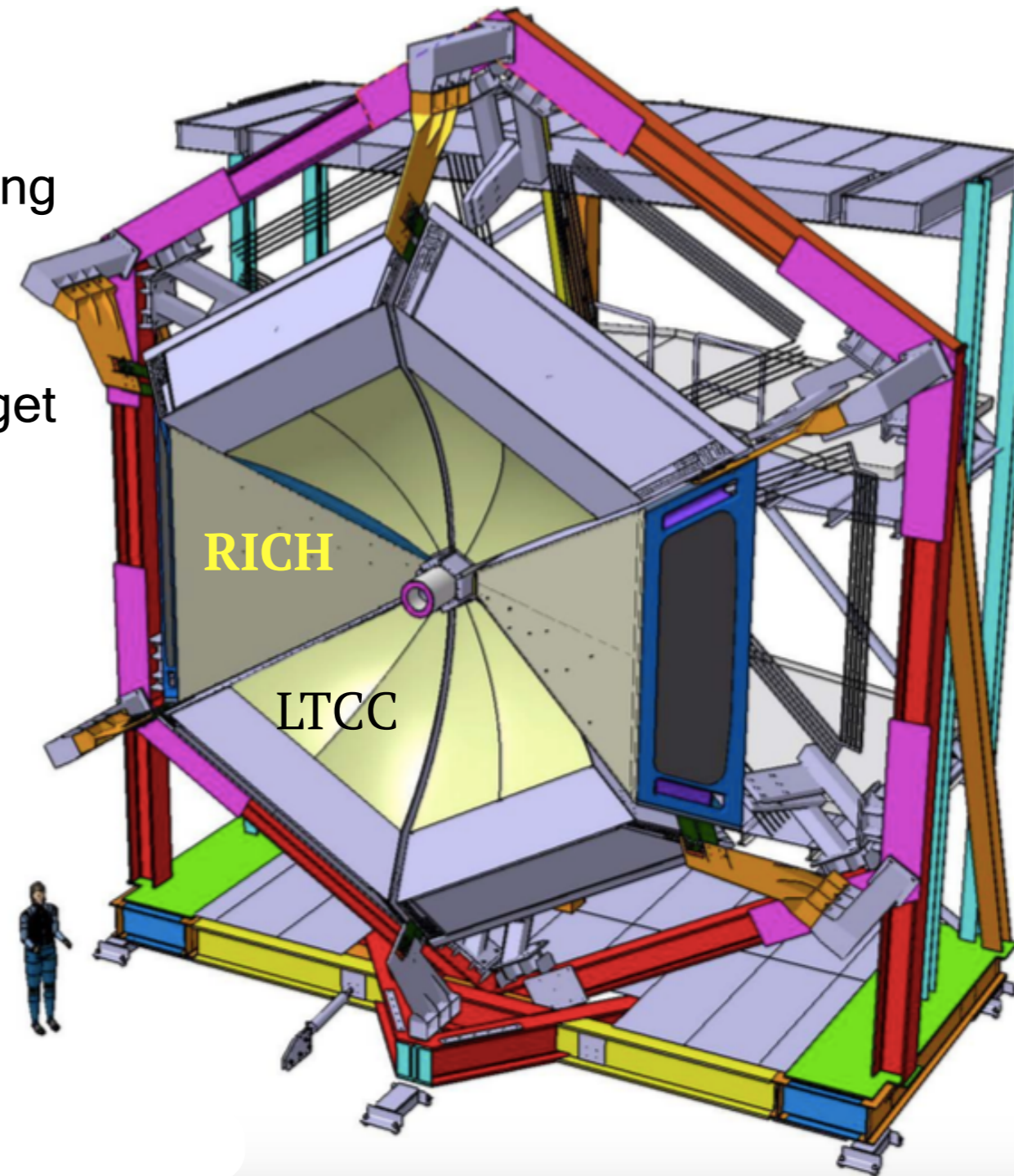


Replace conventional Cherenkov (LTCC) to achieve ~~for~~ excellent K/Pi separation

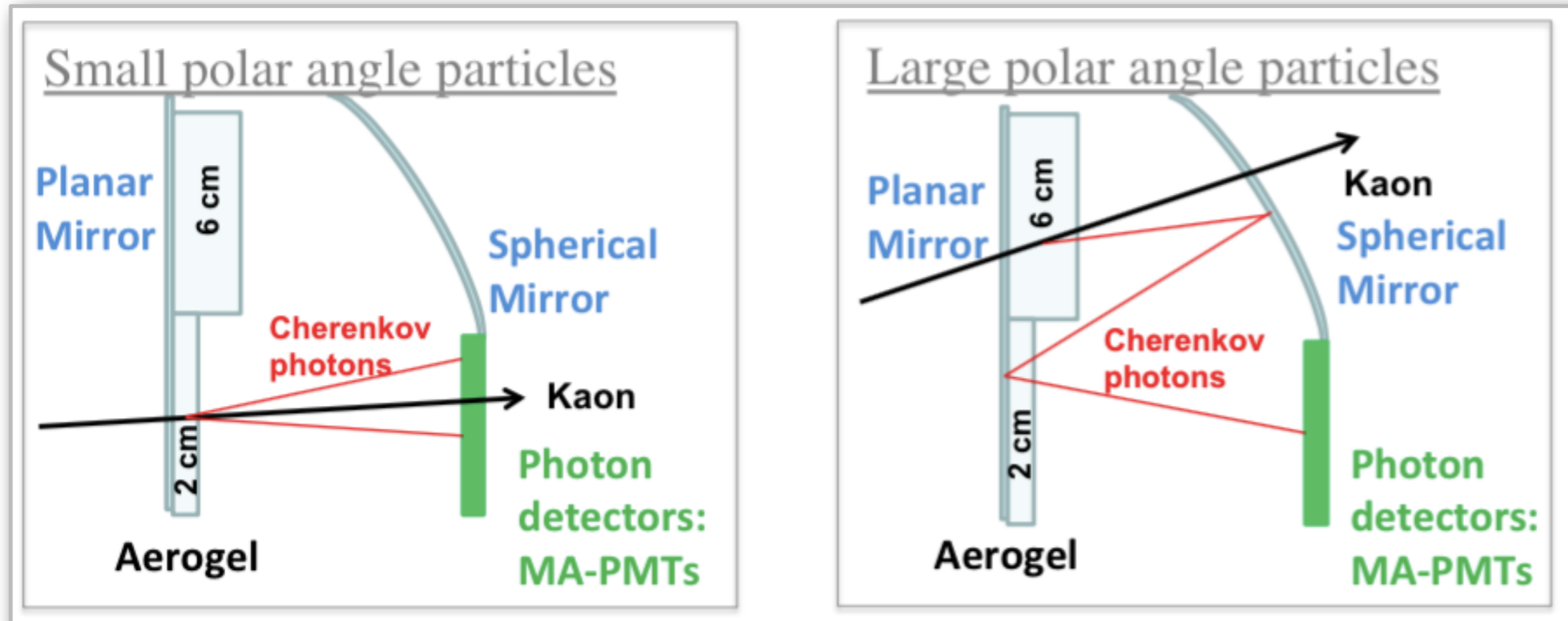
- First sector:
 - ready for the beginning of CLAS12 data taking
- Second sector:
 - Simmetric setup for transverse polarized target


International collaboration

(Italy, USA, Korea, Germany, Chile, UK)

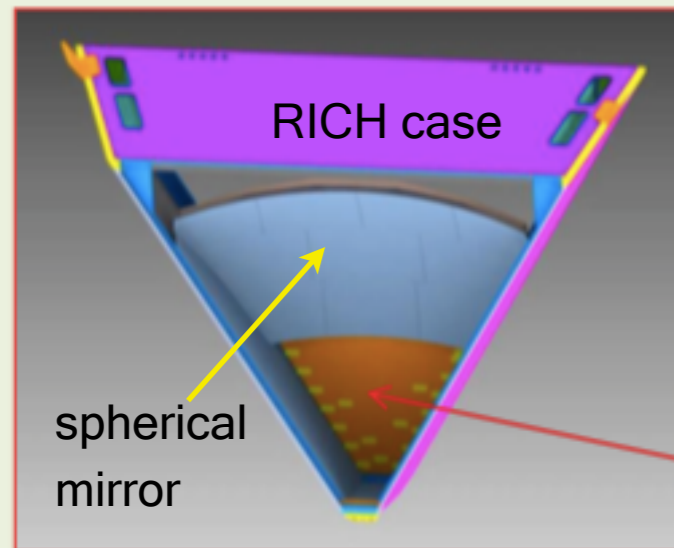


RICH Design



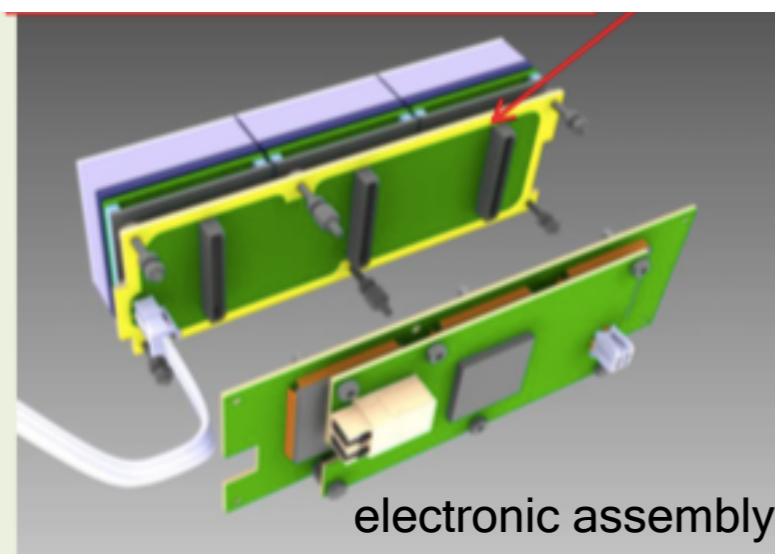
- Hybrid geometry reduces instrumented area (1 m², 25k channels, MA-PMTs)
- Detector concepts validated at CERN T9 (December 2012) [NIM A766 \(2014\) 22](#)
- Aerogel radiator imposed  by momentum range 3-8 GeV (optical photons)
- Isolated N₂ volume to avoid moisture

RICH Electronics Panel

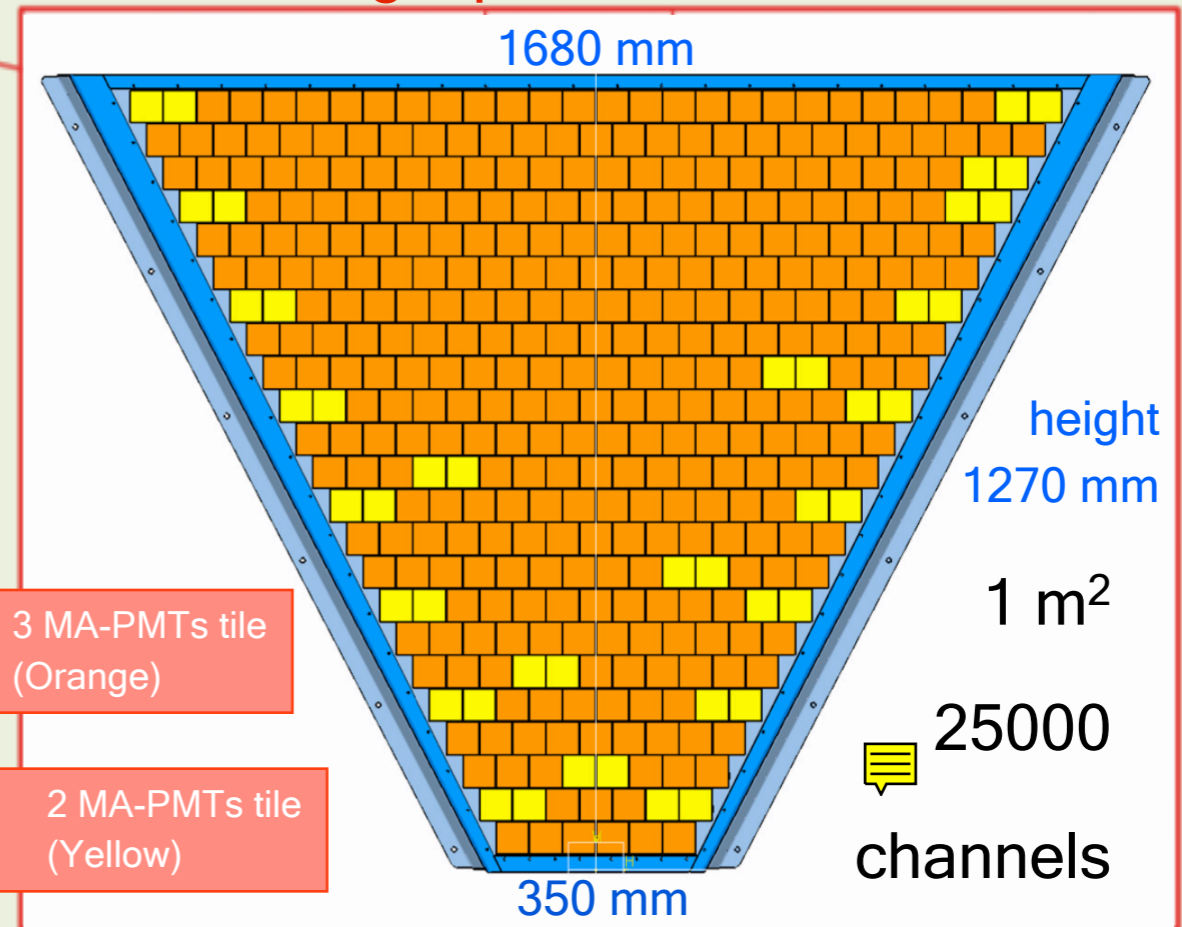


Tessellation approach: 2 or 3 MA-PMT tiles
Services out of acceptance (lateral loglines)

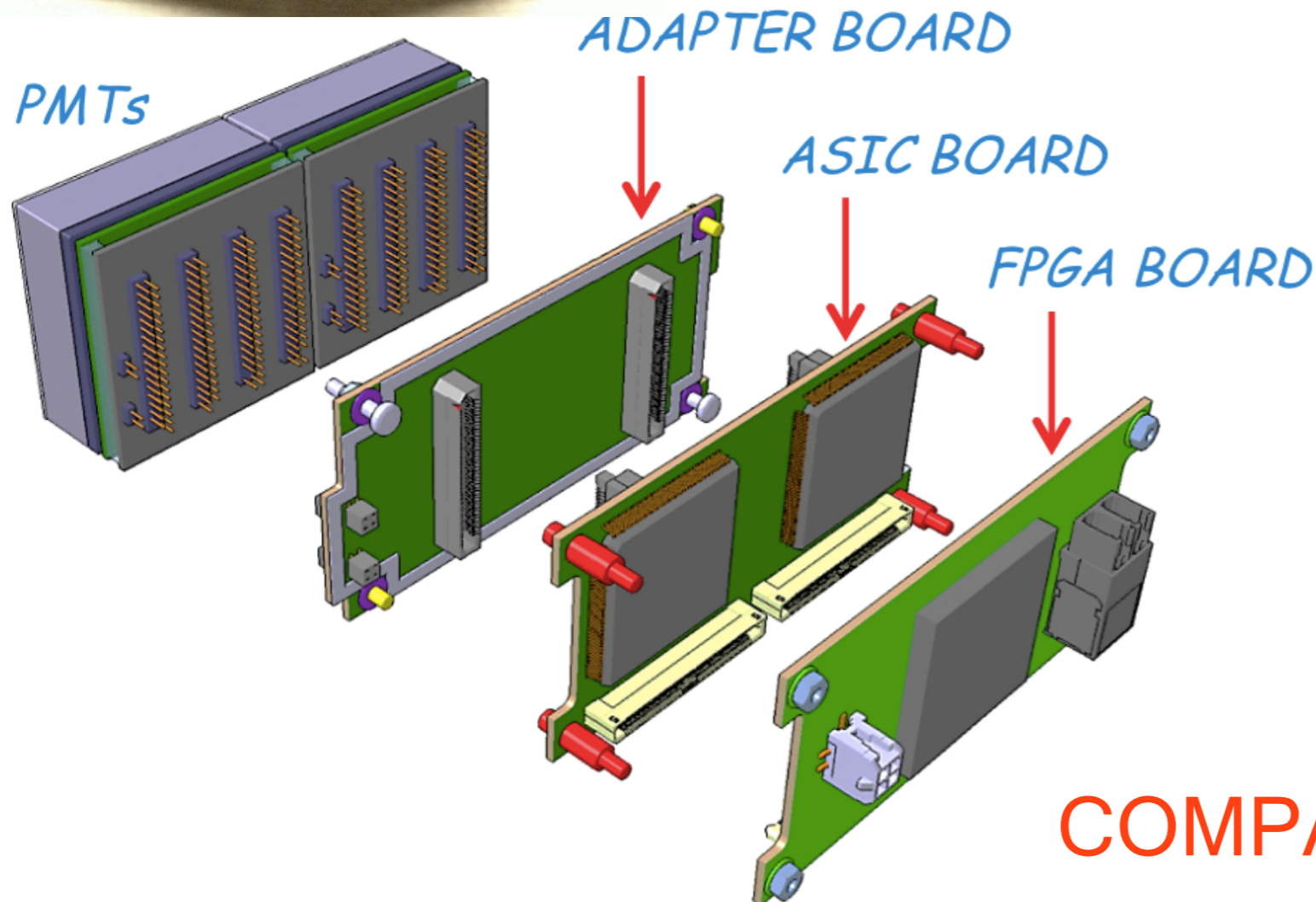
400 Hamamatsu MA-PMTs
H8500 and H12700



single photon sensitive surface



RICH Electronics Module



CLAS12-RICH Requirements

Single photoelectron capability

Adjustable gain 1:4

Time resolution 1 ns

Trigger rate 20kHz

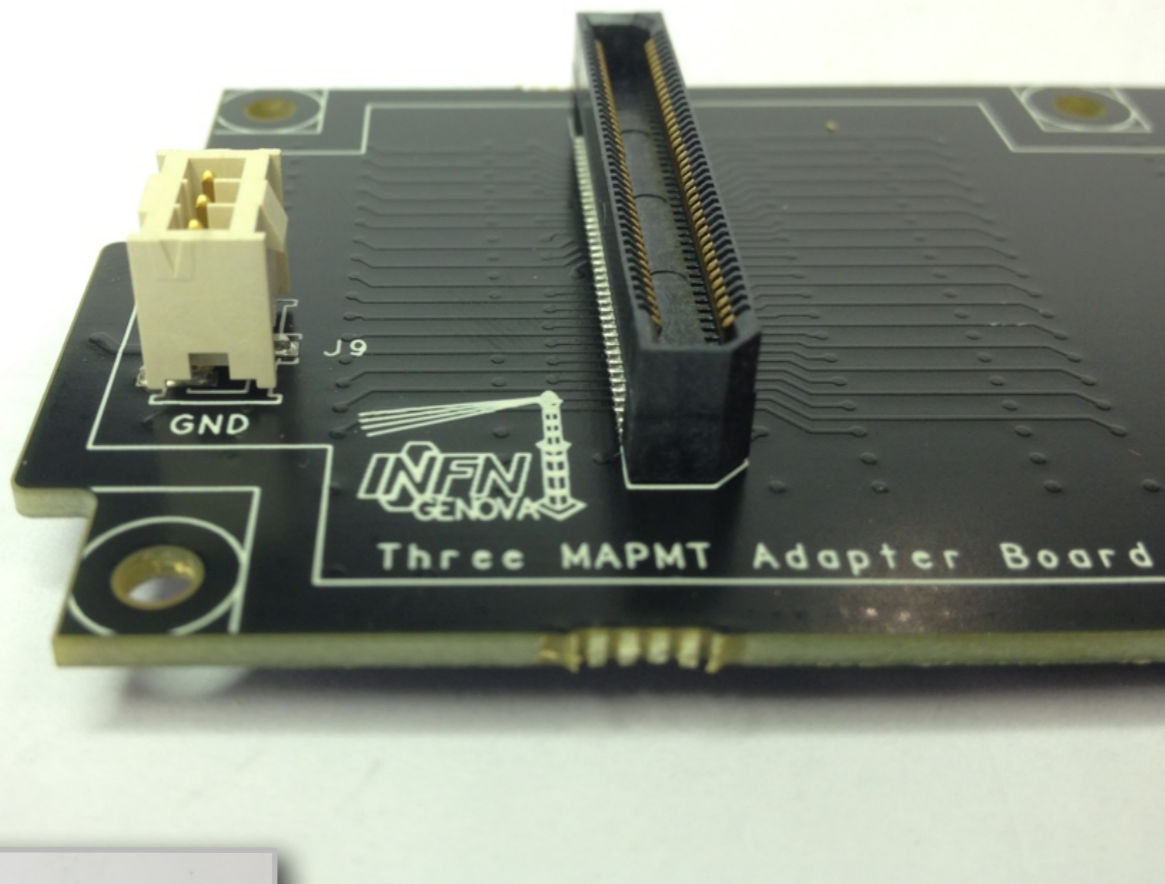
Trigger latency 8 μ s

<4 Watts/module

Radiation tolerance adequate
for CLAS12 environment

COMPACT! ON DETECTOR!!

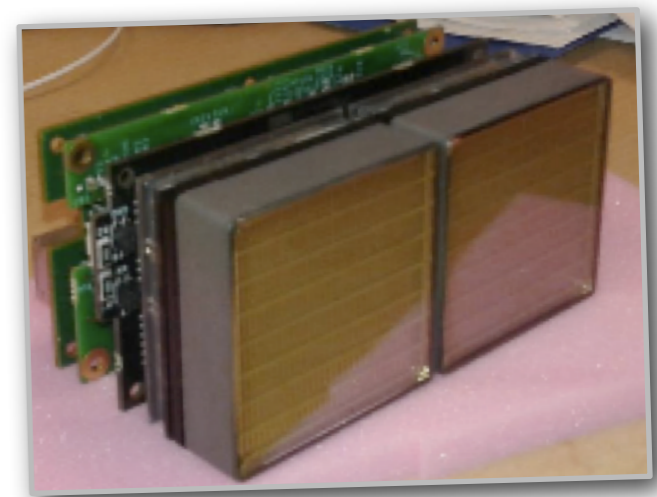
Adapter Board



- Feed through passive board:
- Distribute HV power to MAPMTs
 - Light & gas tight
 - Low capacitance electrical connectivity with front end chip



Design to achieve 99% PMT packaging factor
(1 mm gap)



ASIC Board

Application Specific Integrated Circuit (ASIC) board features:

Multi Anode Read Out Chip (MAROC)

- 64 inputs
- 64 outputs (binary)
- Common **THRESHOLD** (10 bits)
- Individual Preamplifier **GAIN** 0 to 4 (8 bits)
- Charge output (12bit ADC, serial)
- Highly Configurable shaping sections
- Total 829 bits for slow control

Test Pulse (12 bit DAC, 0 to 5pC)*

Voltage regulators (High Speed Transceiver Logic optimized)*



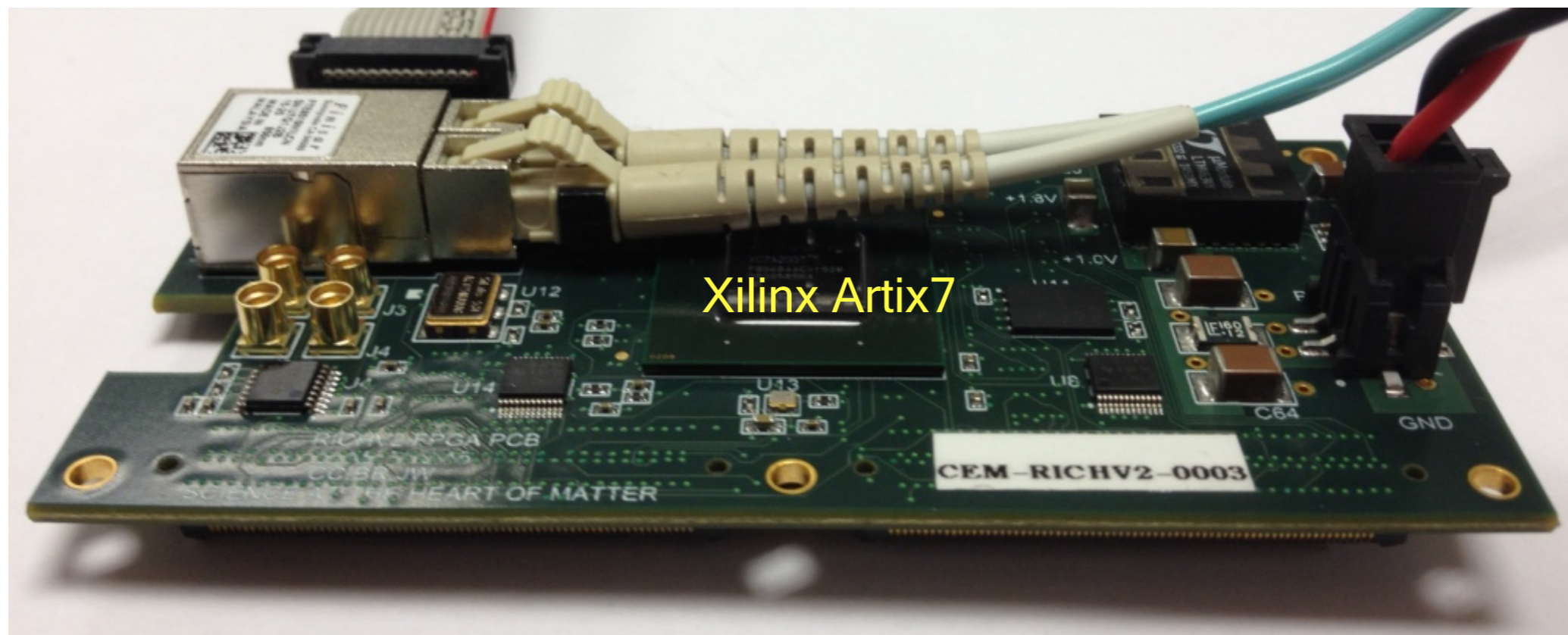
3 ASIC variant

* pre production run Dec 2015

FPGA Board

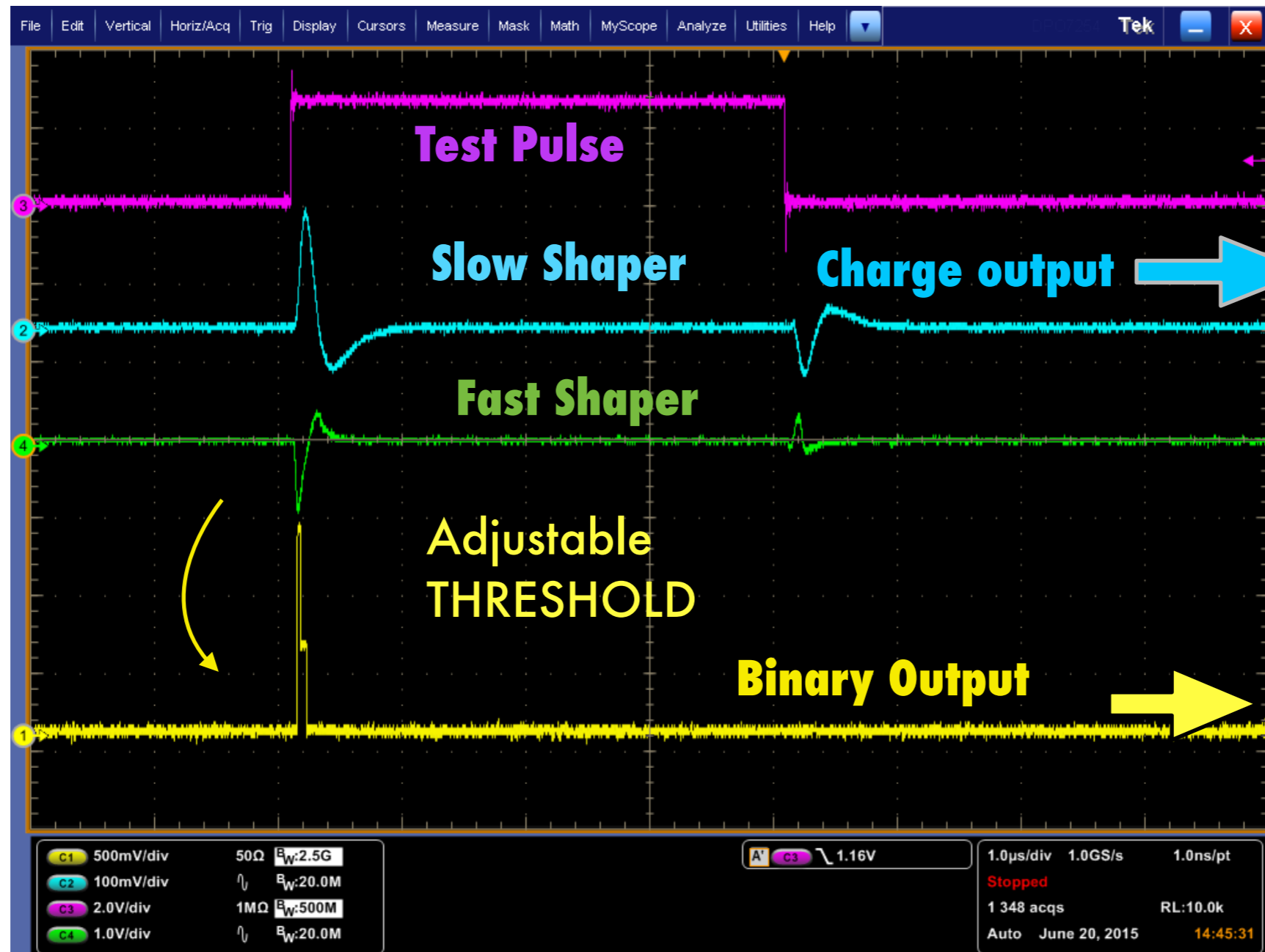
Field Programmable Gate Array (FPGA)Board

- TDC reference clock (1 ns)
- Fixed Latency Trigger (up to 8 μ s)
- MAROC slow controls,
- Stream triggered data to event builder
- Scalers
- FIRMWARE support 192 or 128 channels
- OPTICAL ETHERNET: up to 2.5 Gbps
- TRIGGER MODES: External, Internal, Self (on MAROC binary outputs)



MAROC Signals

example of MAROC signal processing



INPUT
On Board
Test Pulse
1pC

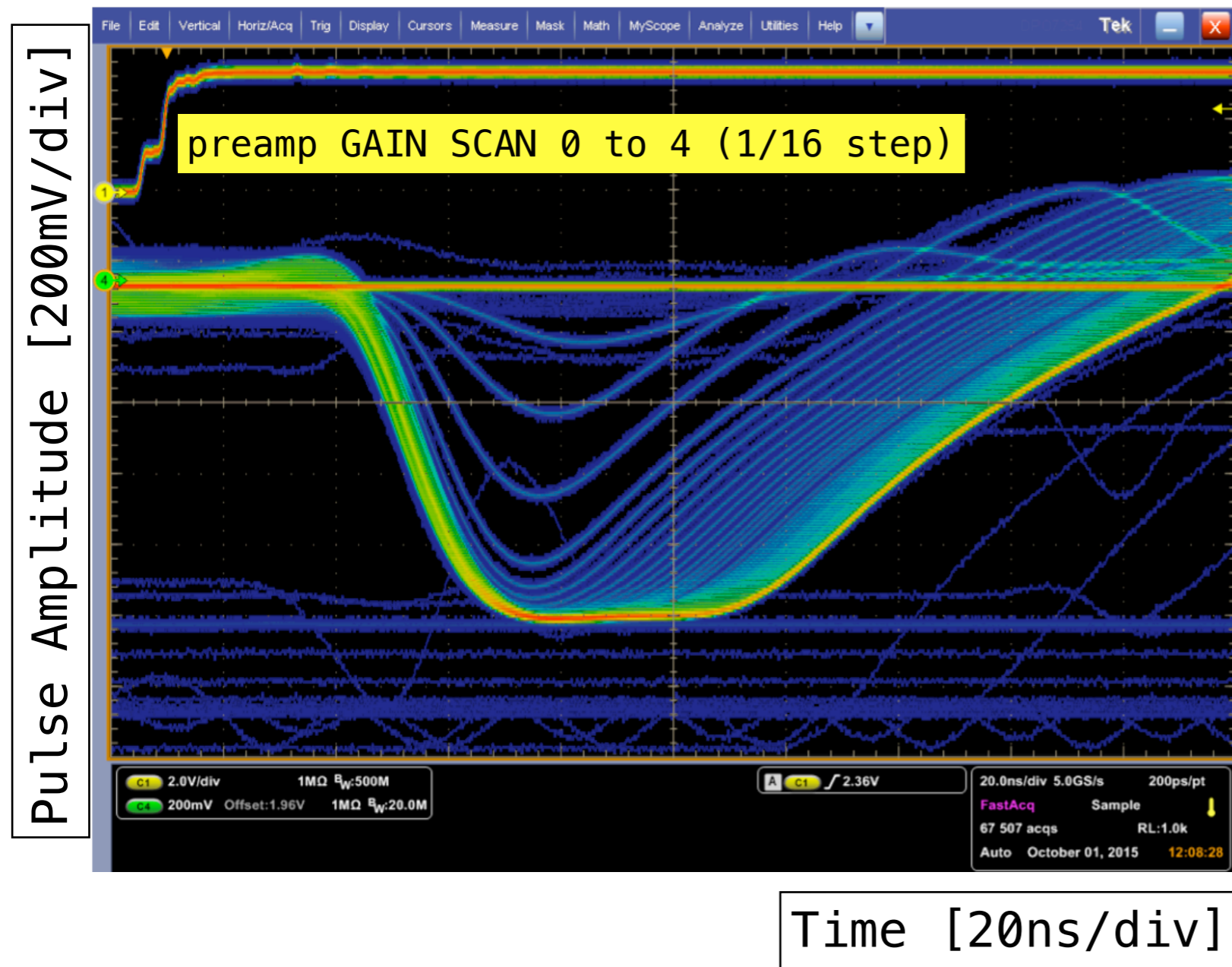
ADC
(MAROC)
calibration only
more on backup slide

SCALER/TDC
(FPGA)

**TDC used for
physics runs!**

Single channel response, 1 microsecond/div

Gain Scan



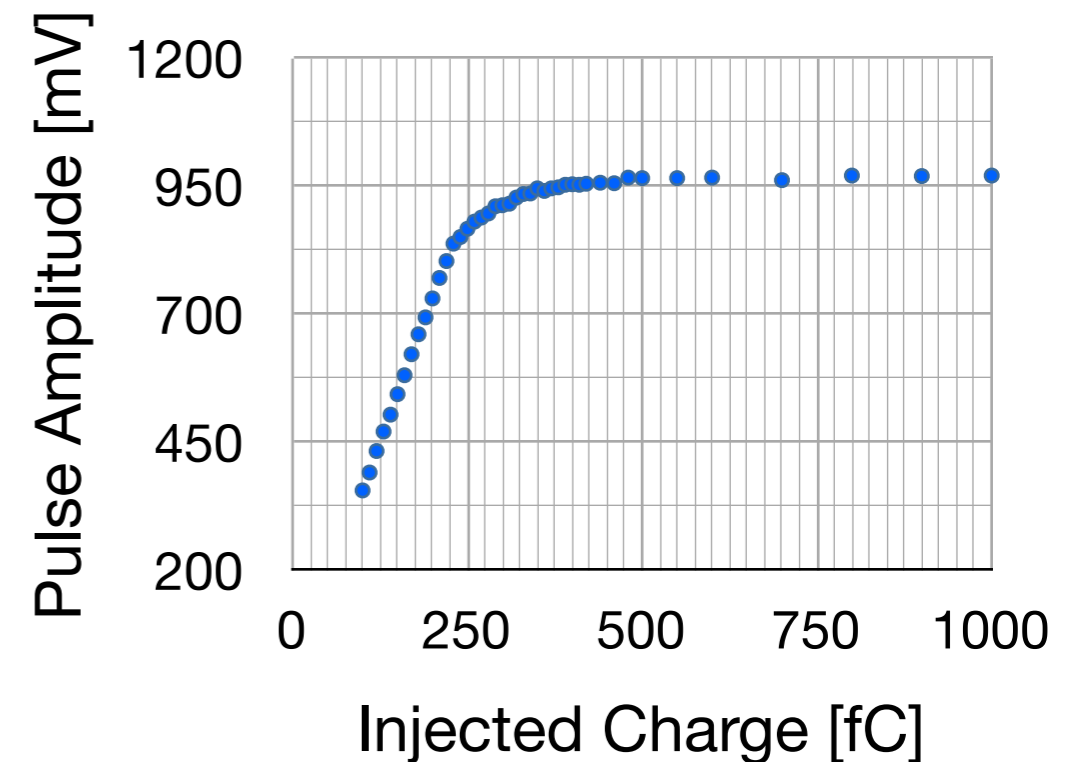
Single channel fast shaper response,

High gain shaper precedes the discriminator

3.75 Volt/pC in the linear region

20-25 ns rise time

Fast Shaper Gain



Counting Efficiency

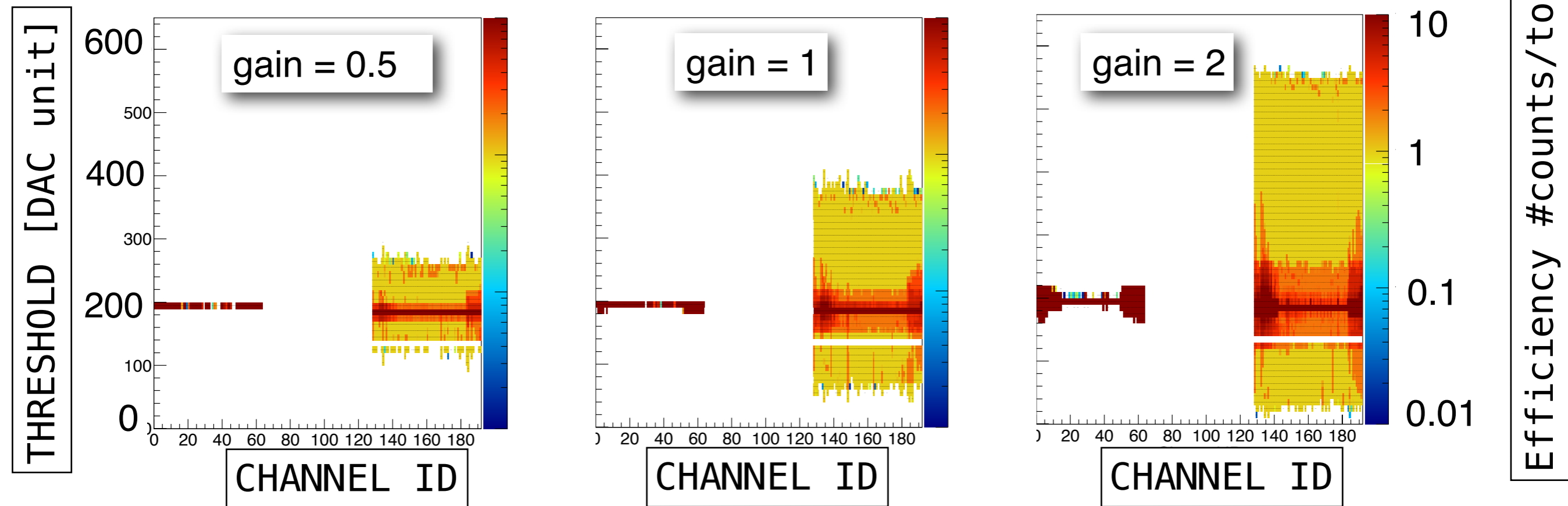


Single photoelectron level (160 fC) 100kHz external pulse generator

128 channels (64 injected, 64 for baseline) **X axis**

Threshold scan for different preamp gains **Y axis**

Scaler firmware counting **efficiency** (100% inside yellow regions) **Z axis**



MA-PMT Dark Rate

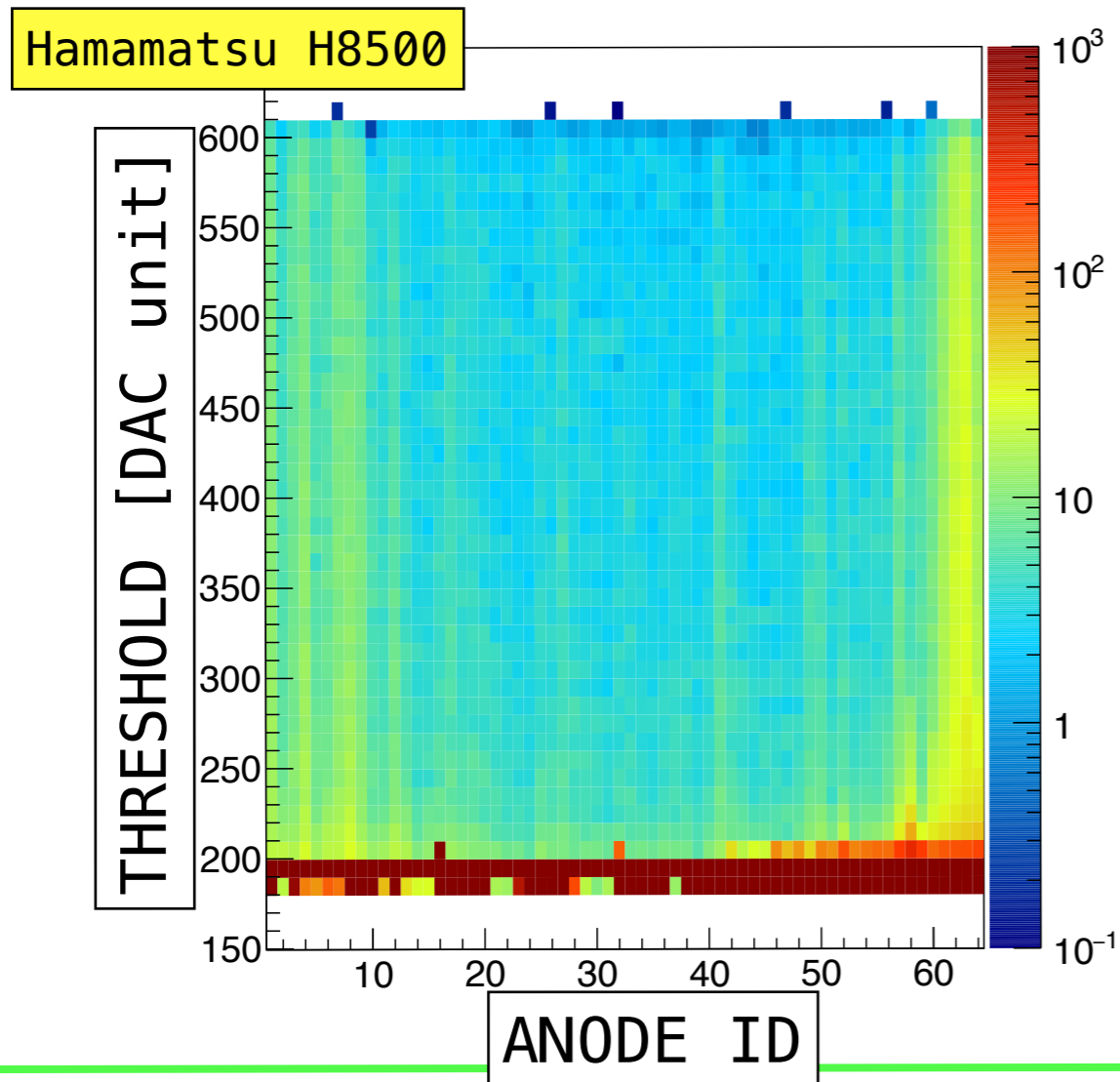
Scaler measurements 30 seconds

Typical rate
10 Hz/pixel

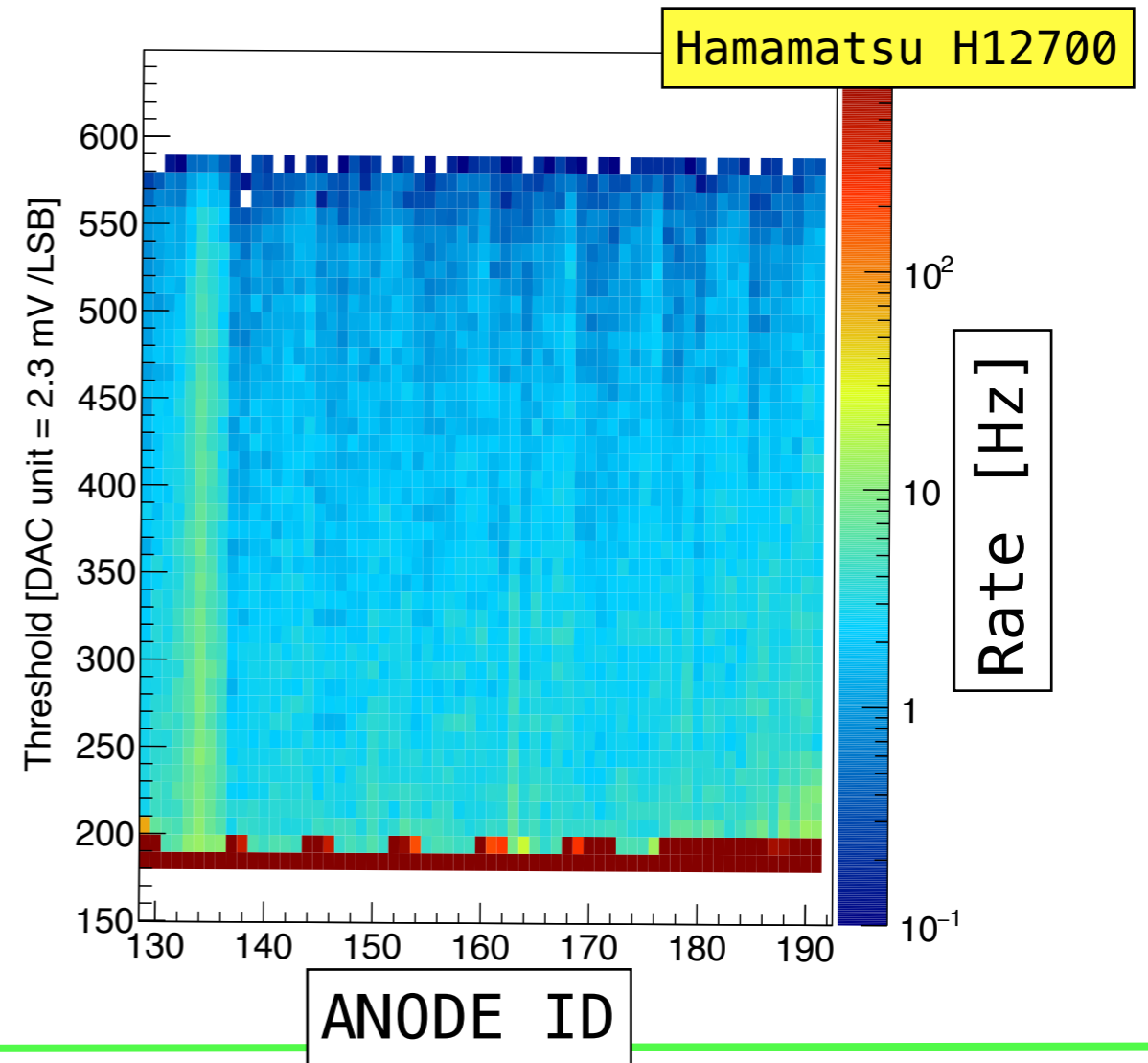


Compatible
with
Hamamatsu
specification

Dark Rate CA7482 HV 1000



Dark Rate GA0507 HV 1000



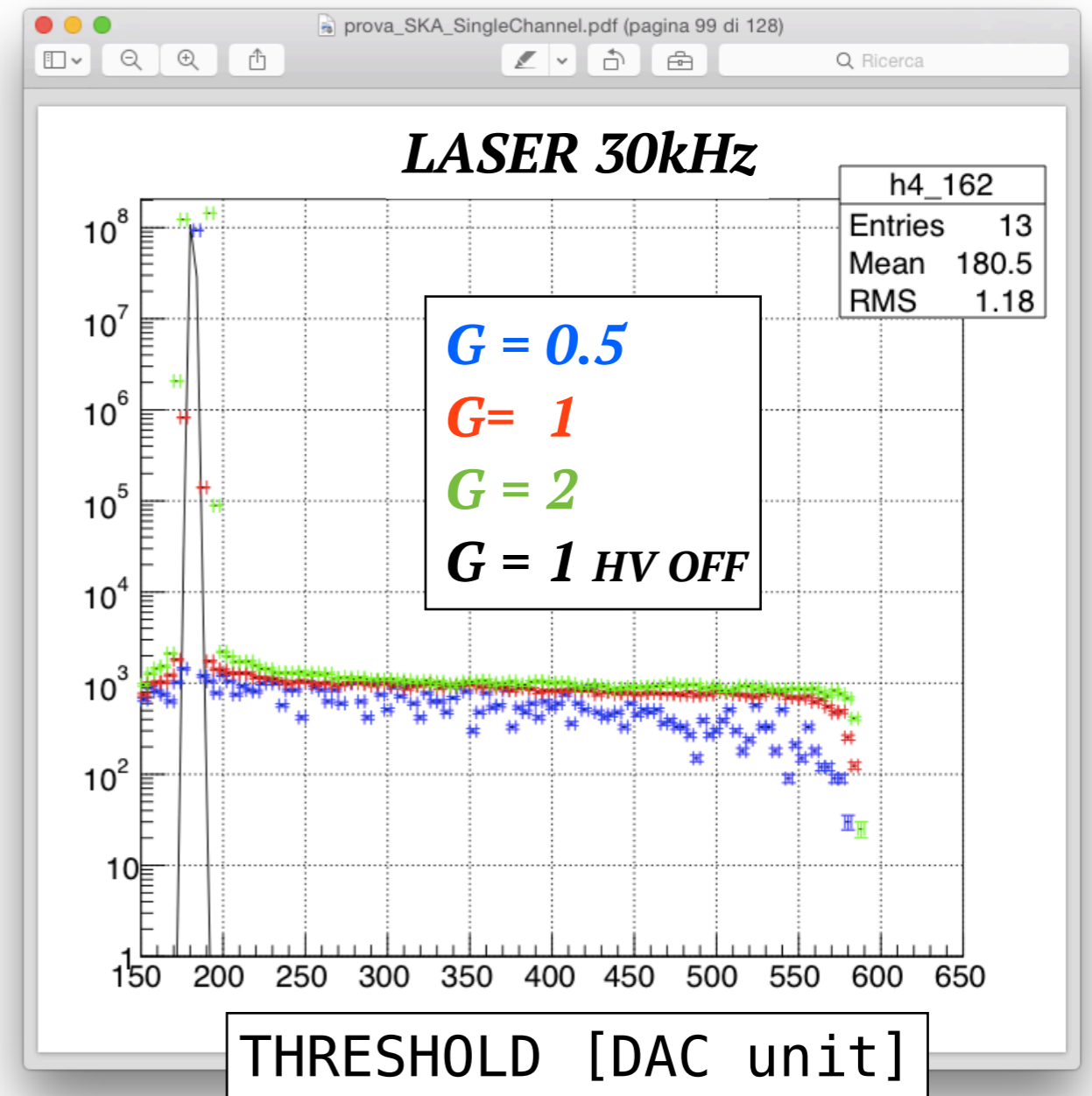
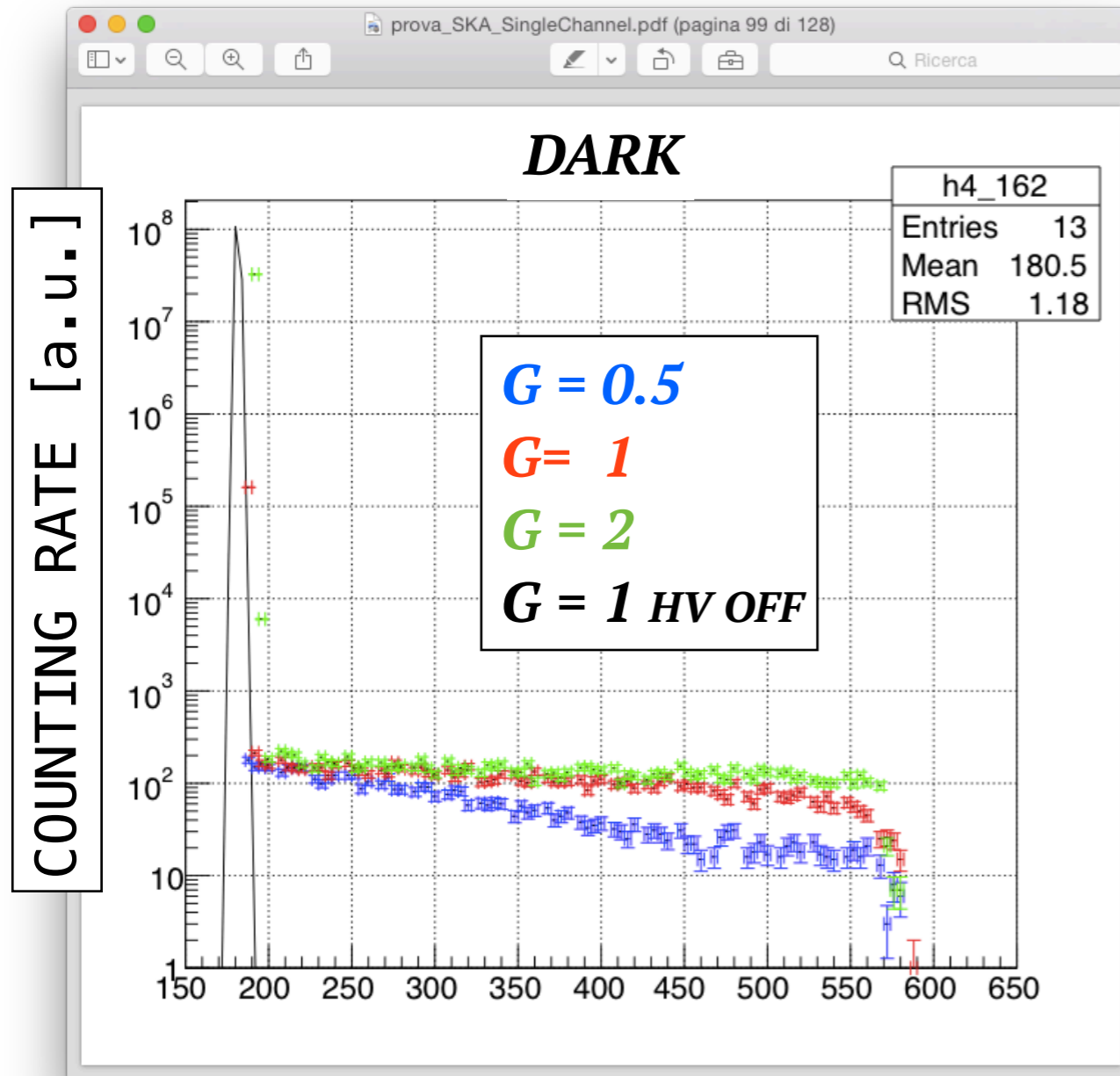
Dark & Laser

Laser at single photoelectron level

Hamamatsu H12700 GA0507

HV = 1000 V

Preamp can push low gain pixels to saturation (plateau) allowing an excellent efficiency

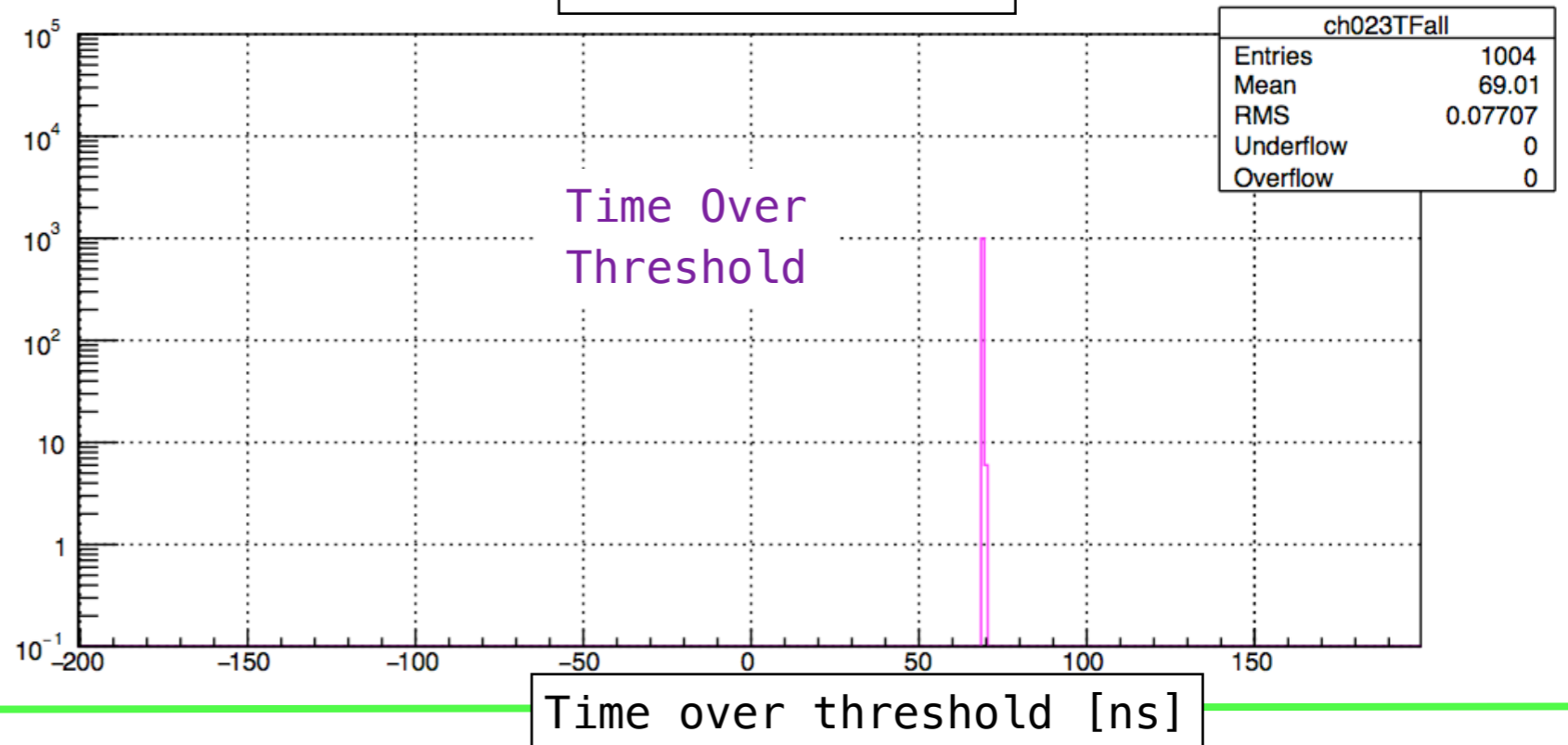
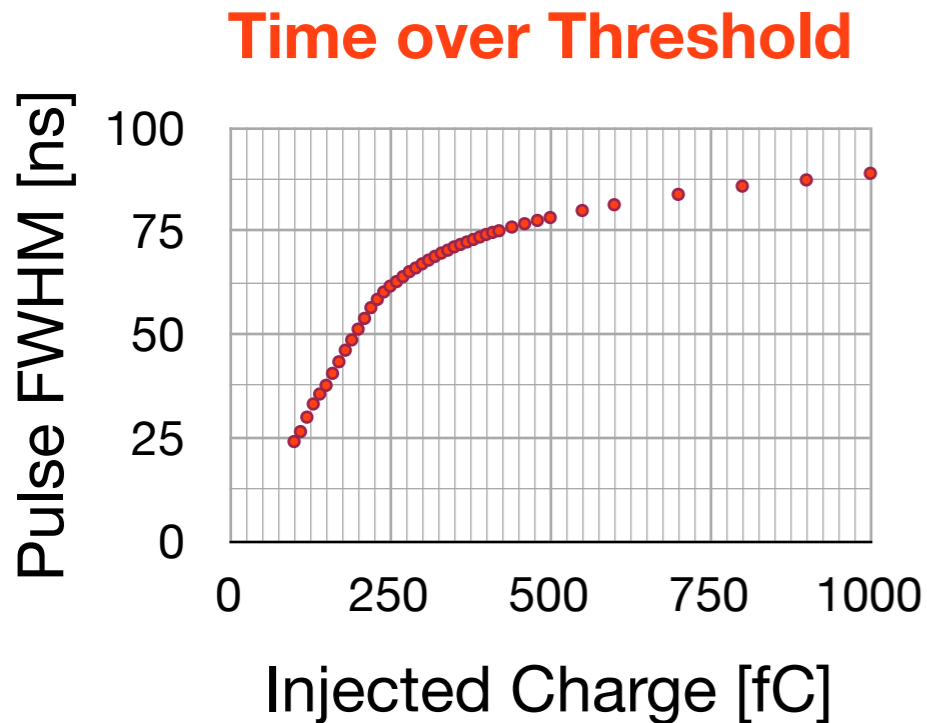
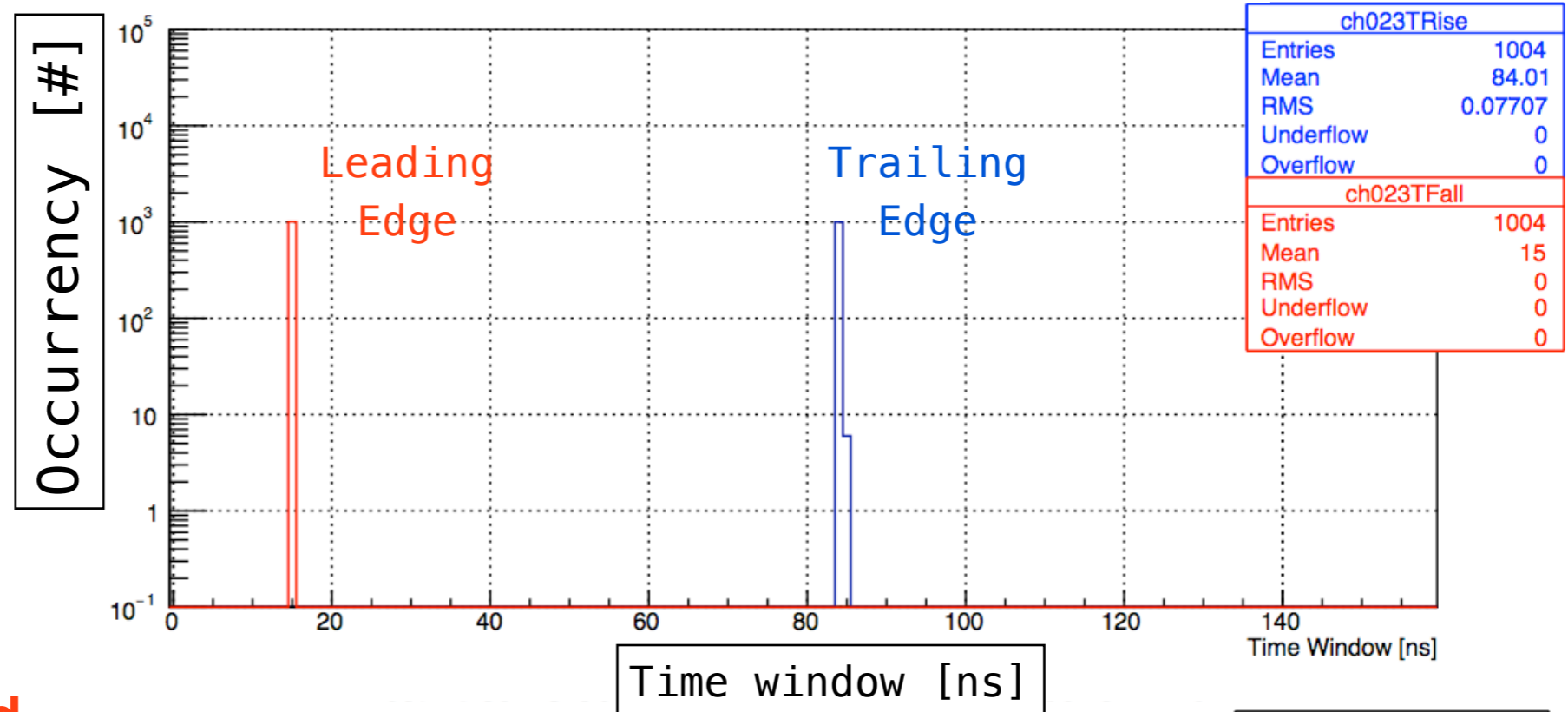


Scaler measurements 30 seconds

TDC Response Test Pulse

Main acquired data are MAROC binary outputs time information

- Jitter introduced by MAROC is below the sensitivity of the TDC (1ns)
- Time over Threshold measurement is feasible

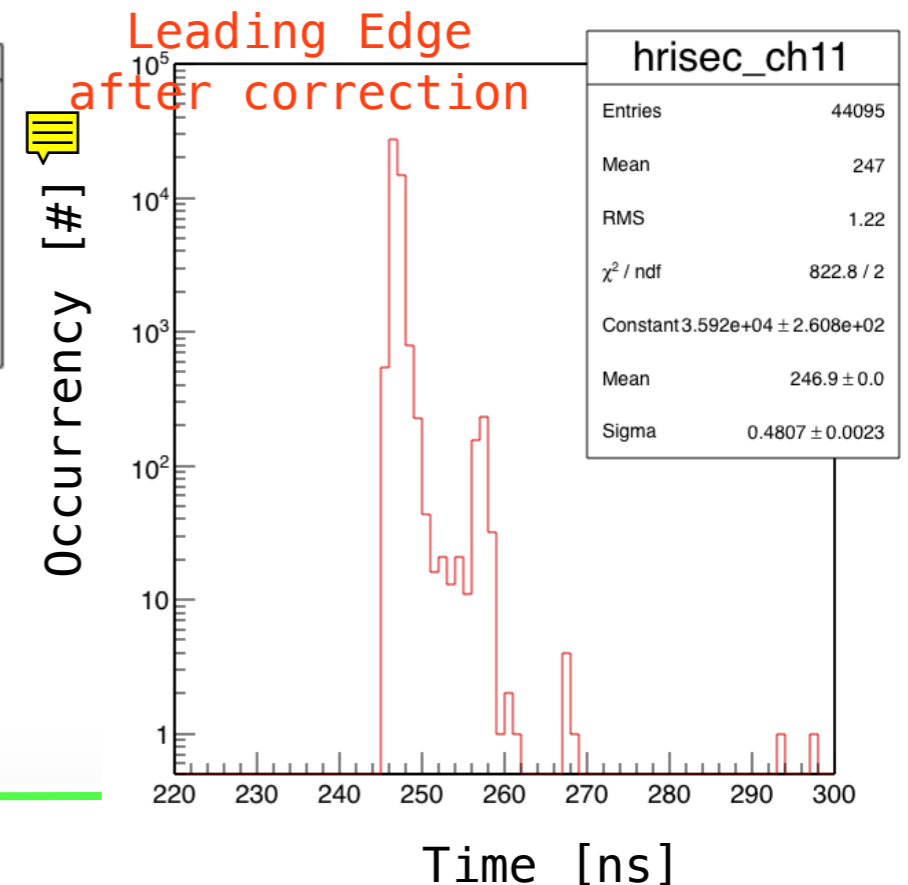
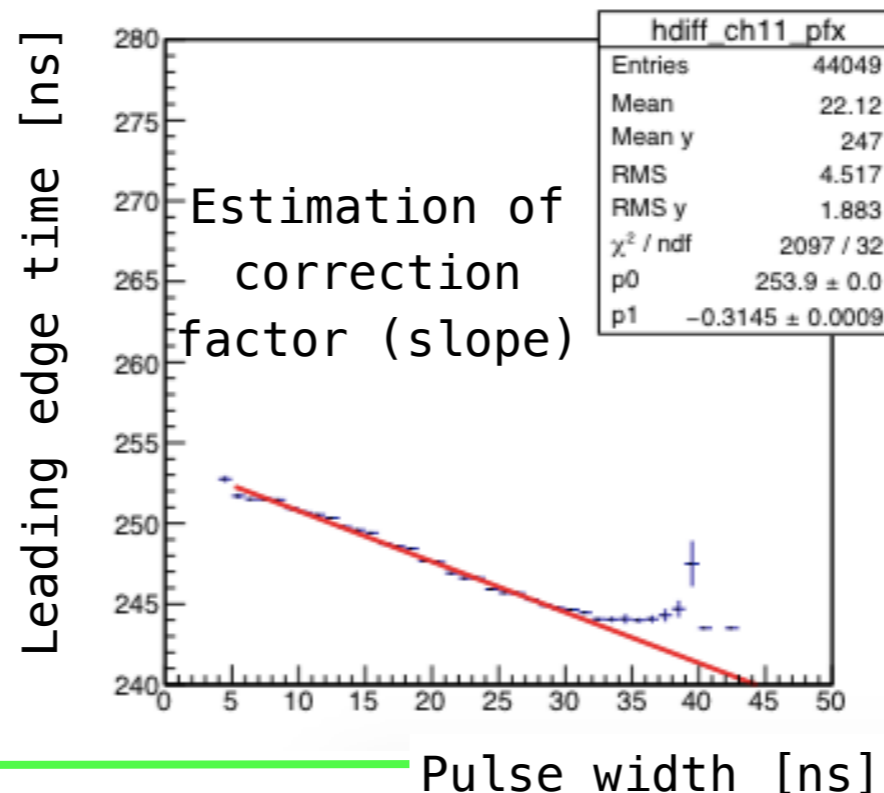
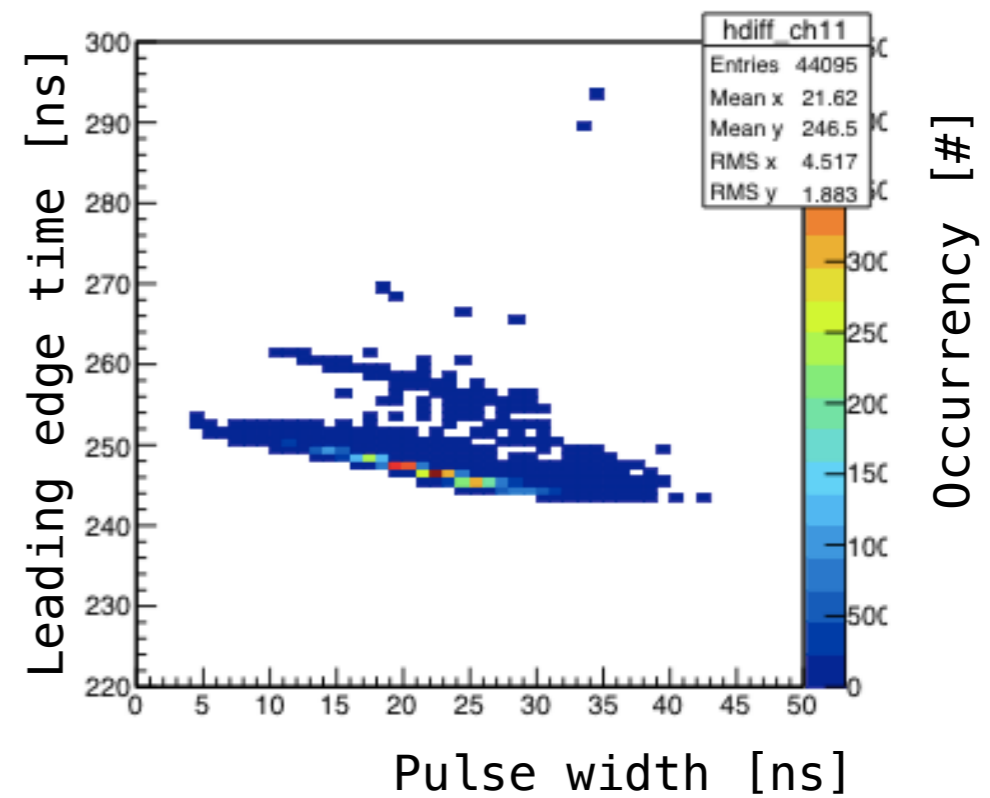
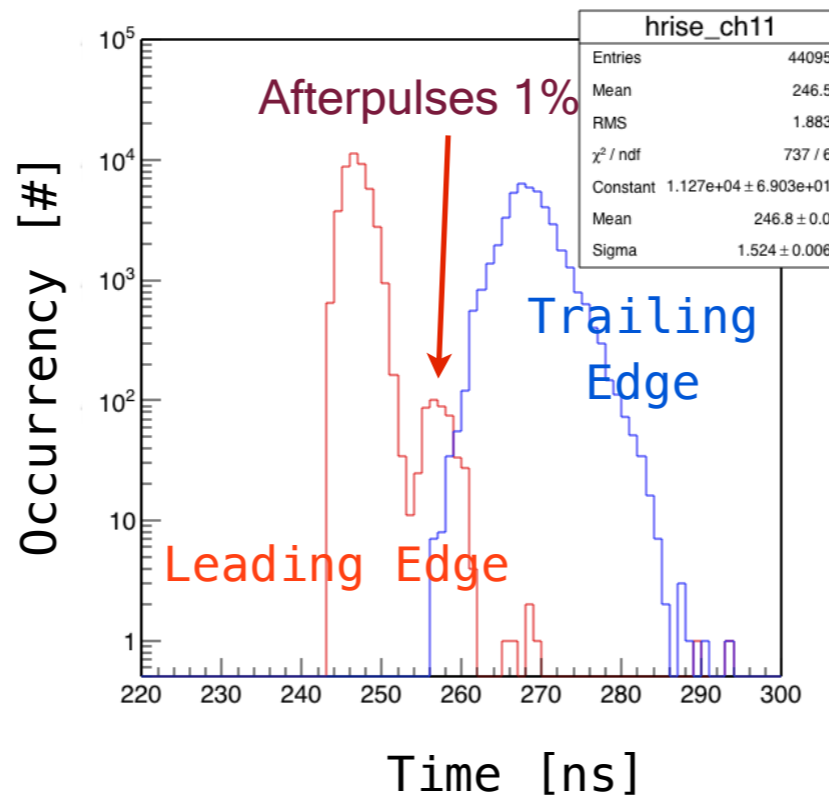


TDC Response Laser + MAPMT

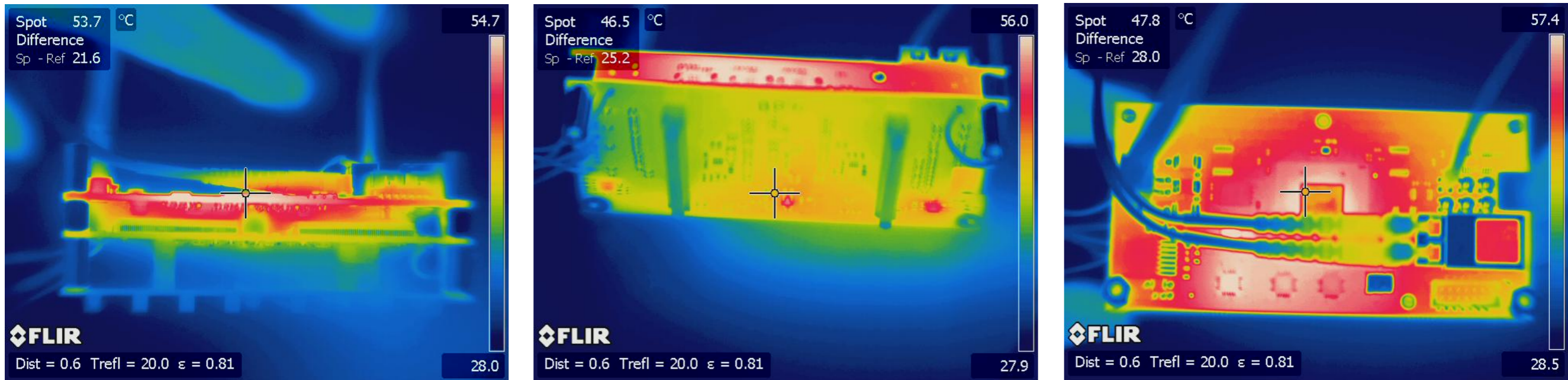
Correlation between leading time and time over threshold (proportional to the charge) allows for time walk correction

before $\sigma = 1.524 \text{ ns}$

after $\sigma = 0.480 \text{ ns}$



Heat production



Thermographic camera images of a RICH electronic module

- Power Consumption @ 5Volt:

760 mA (3.80 Watts) 3MA-PMTs variant

670 mA (3.35 Watts) 2MA-PMTs variant

Compatible with temperature requirements of CLAS12

Conclusion



Prototyping (640 channels):

Electronics design validates with test pulse and MA-PMT measurements (Dark and Laser)

 In firmware TDC full  requirements

Analog MAROC information (internal ADC) will be used for monitoring and debugging

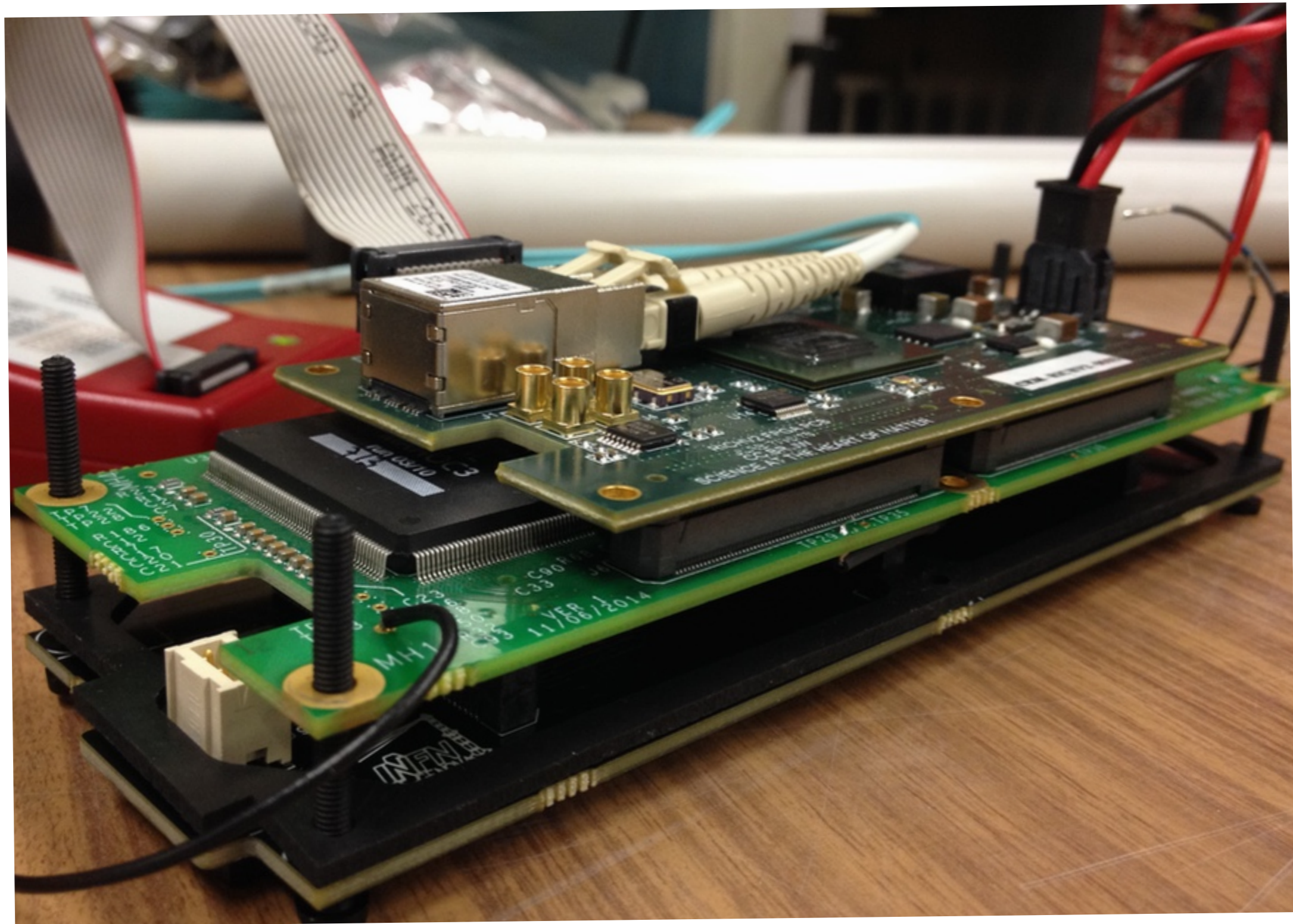
Protocol for calibration and characterization consolidated 

Production (25000 channels):

Small preproduction (2000 channels) to test little  improvements introduced during prototyping

Going to full production in 2016

RICH-MAROCC Electronics



MAROC internal ADC

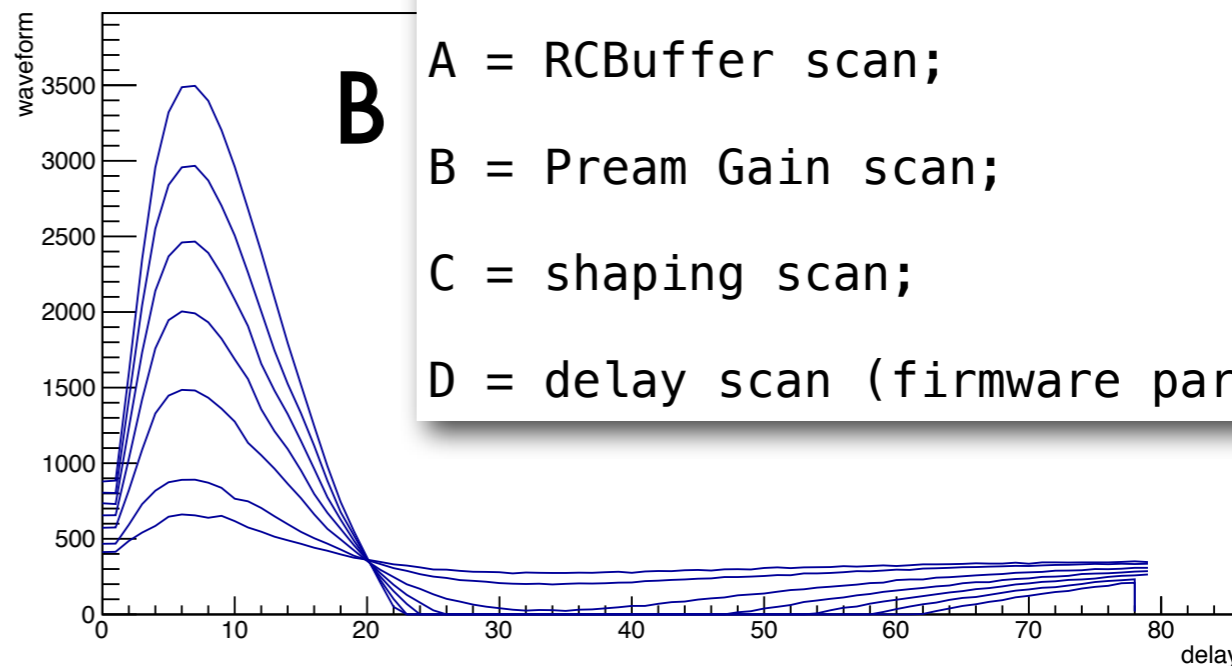
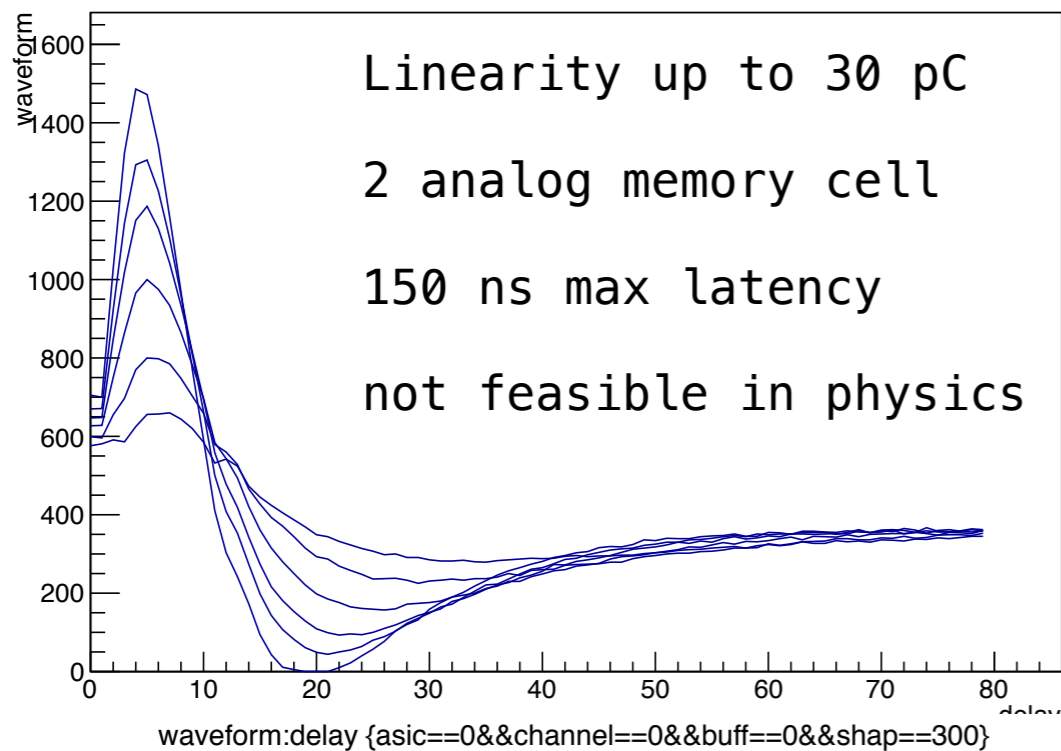
BACKUP SLIDE

Plots: reconstructed waveform using MAROC internal ADC for one channel and different MAROC slow control configurations

waveform:delay {asic==0&&channel==0&&buff==0&&shap==300}

waveform:delay {

A

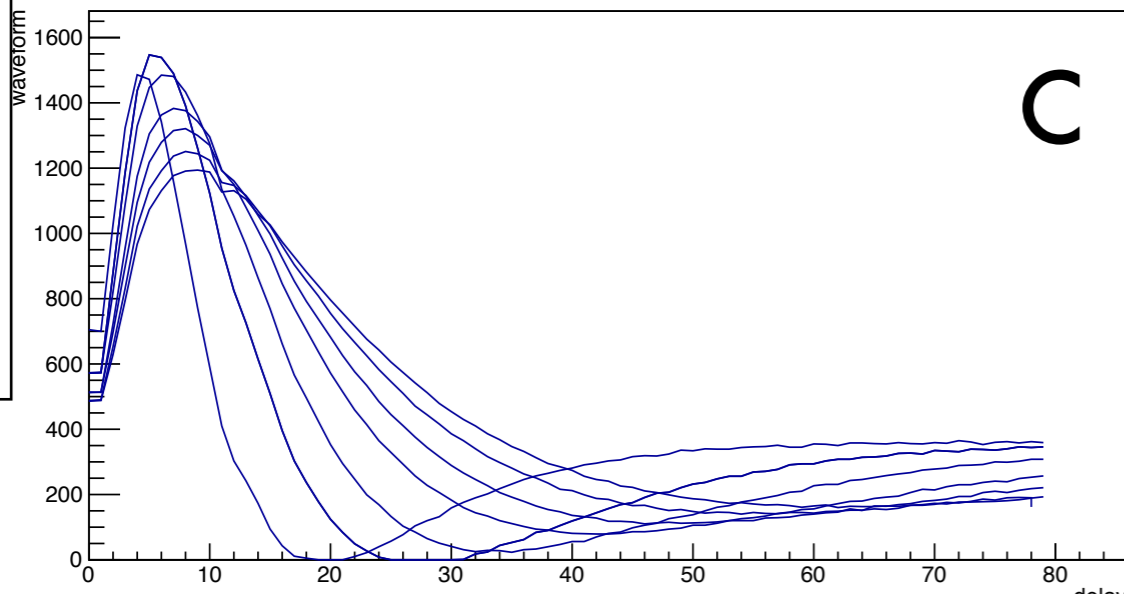


Amplitude [ADC units]

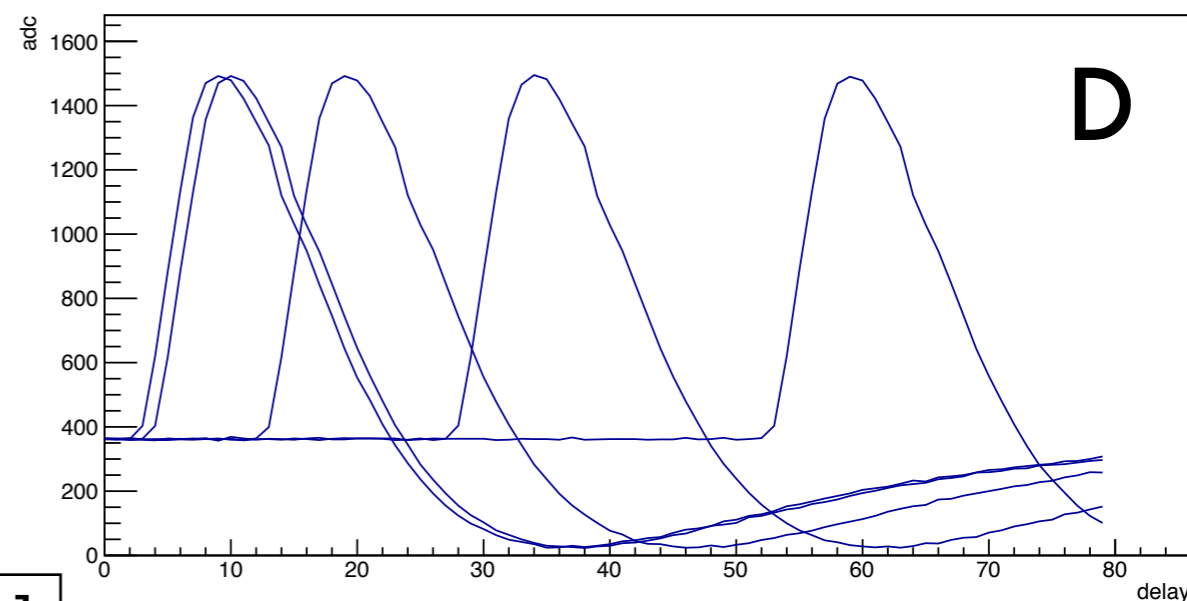
waveform:delay {asic==0&&channel==0&&buff==0&&shap==300}

adc:delay {asic==0&&channel==0&&trigdelay==50}

C



D



Time [8 ns clock ticks]