

The Electron Muon Ranger

Davide Bolognini, on behalf of the EMR group

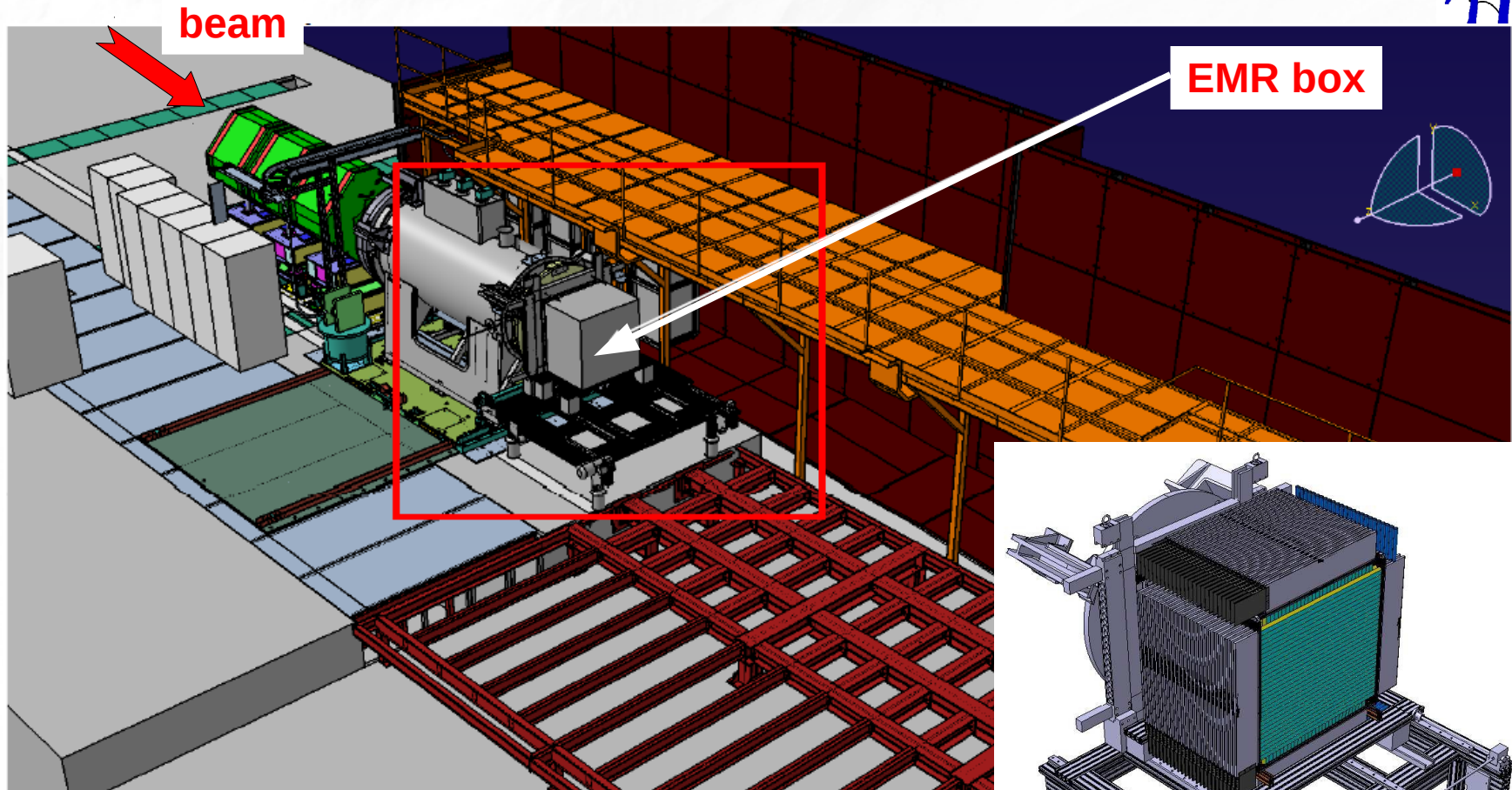
TA Meeting Dec. 9th, 2011



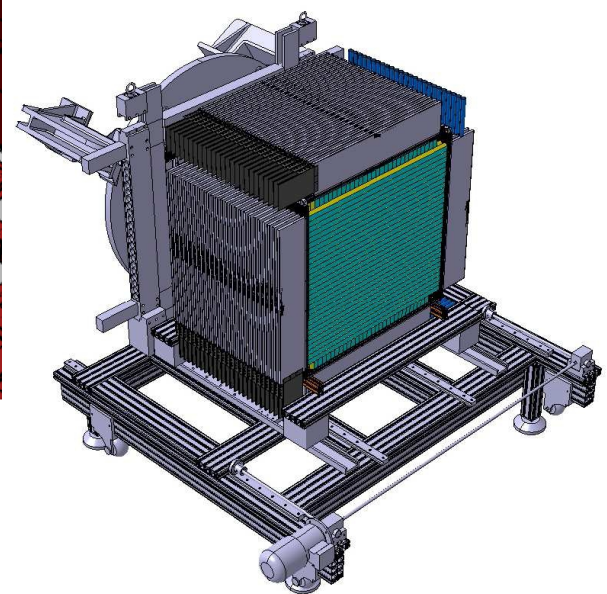
Outline

- ◆ **EMR: how, why & where**
 - ◆ Mechanical assembly
 - ◆ Electronics
- ◆ **Tests at UNIGE**
- ◆ **Installation at RAL**
- ◆ **Conclusions & Outlooks**

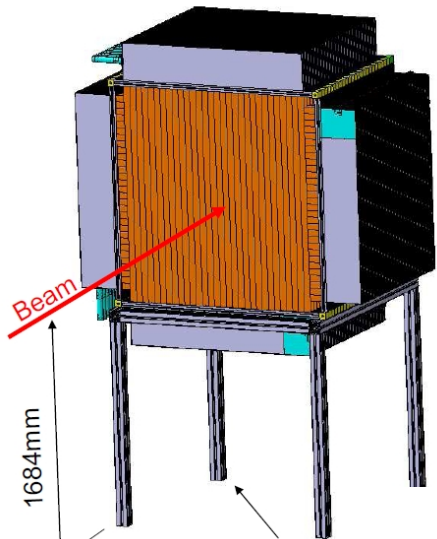
Electron Muon Ranger: where and why



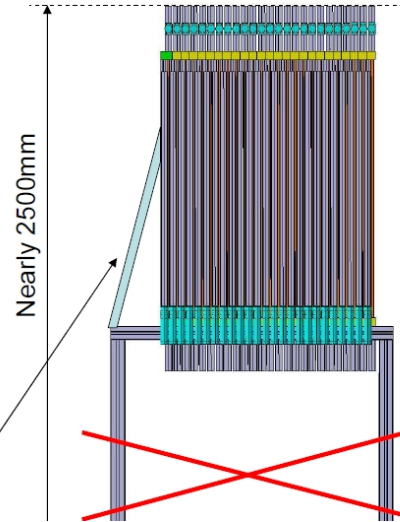
EMR is a fully active detector (tracker+calorimeter) whose aim is (together with TOF and KL) to distinguish electrons from muons



Electron Muon Ranger: how?



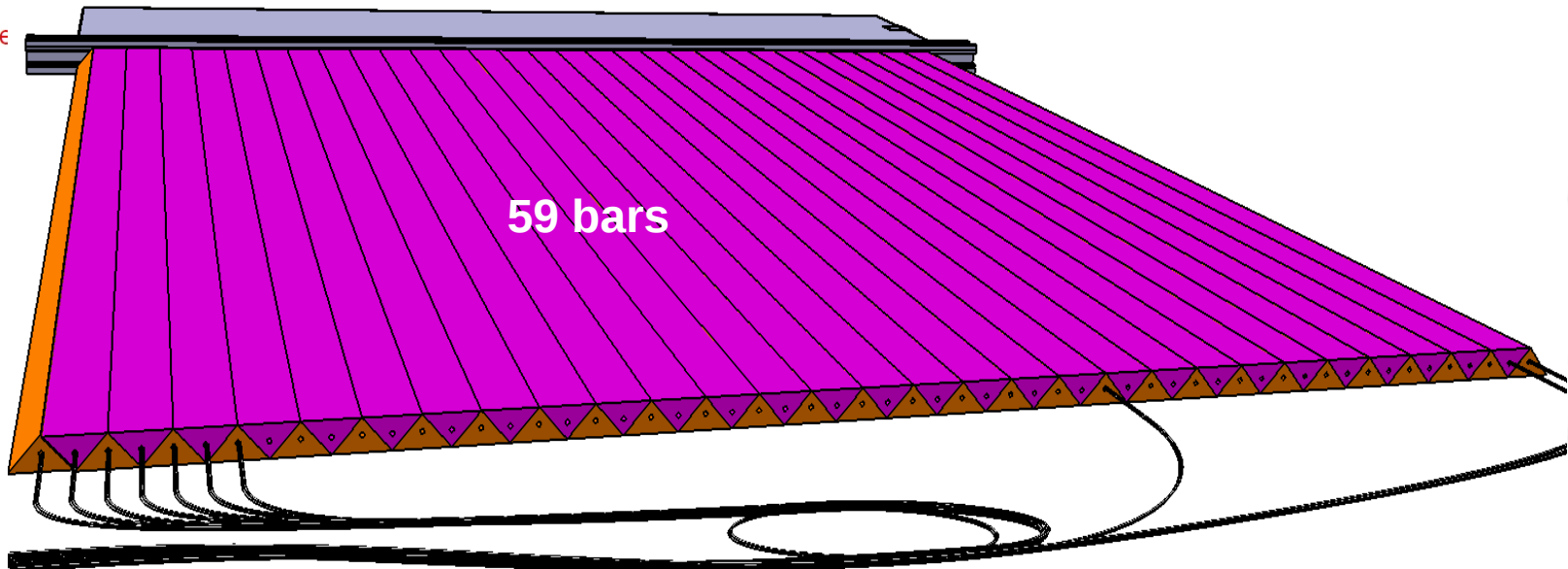
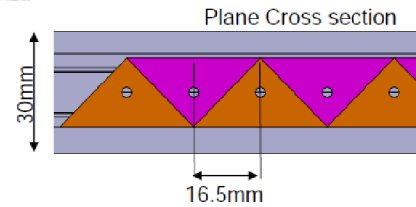
Stand still to be



EMR is a tracker/calorimeter that is able to distinguish electrons from muons

EMR consists of:

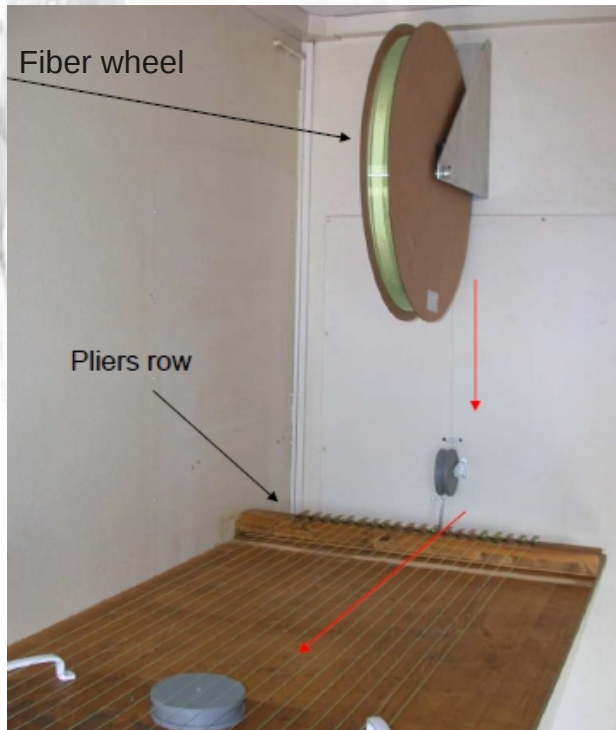
- ◆ 48 planes of extruded plastic scintillator bars (24x-24y)
- ◆ Each plane: 59 bars, 1.1 m long, triangular section
- ◆ 1 WLS fiber (1.2 mm of diameter), glued inside the bar
- ◆ 2 clear fibers from bars to PMTs (connector system)



EMR: mechanical construction



Bars (3-4 m long from FNAL) have been **cut, drilled** and **painted** (the edge in white, to increase the light yield)



One 1.2 mm WLS fiber inserted and glued in each bar

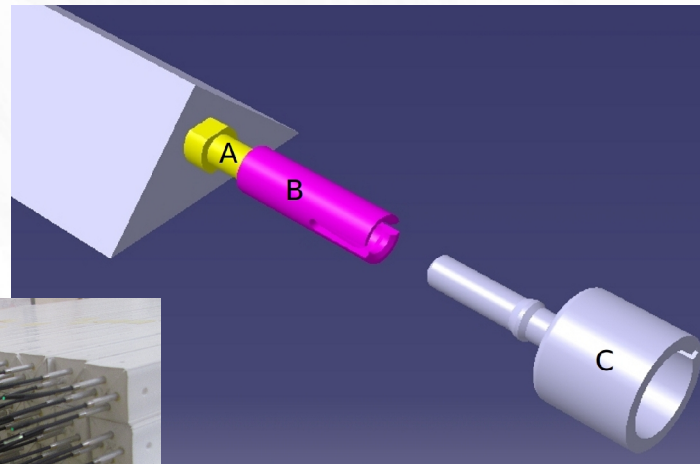
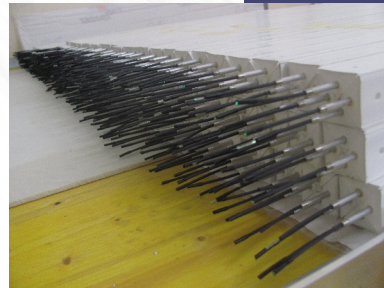
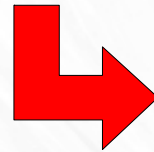
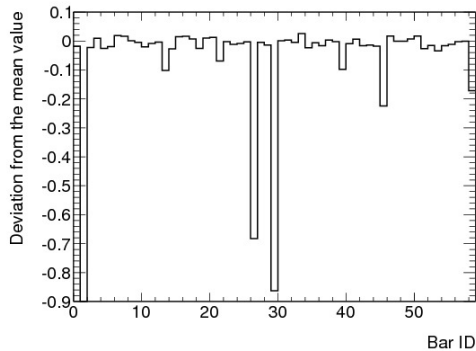
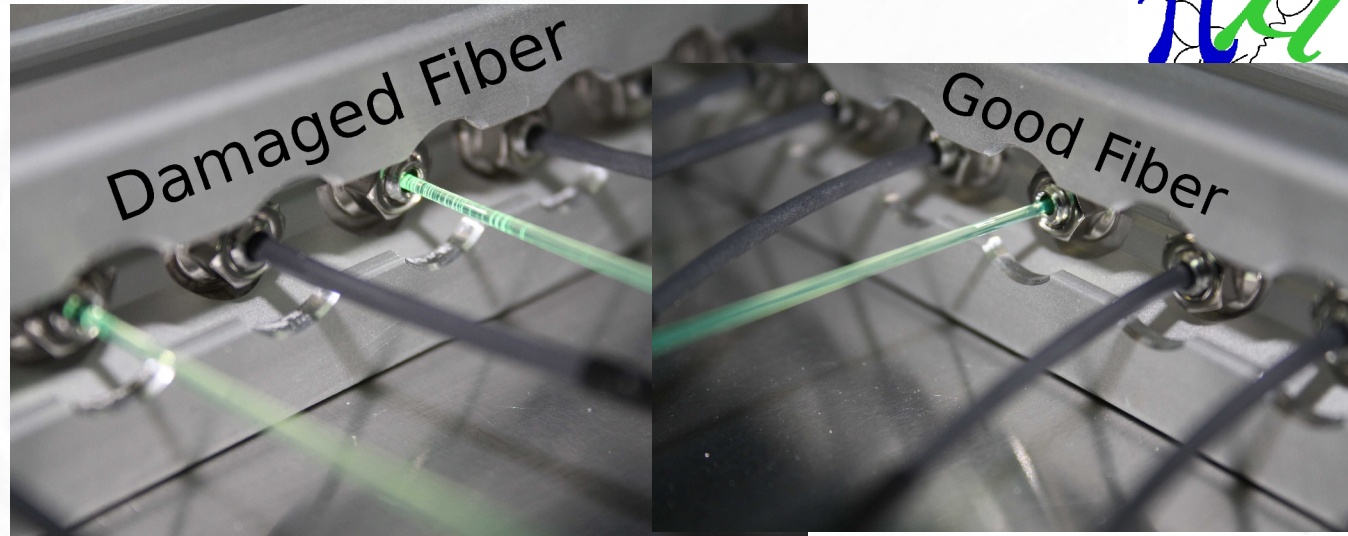
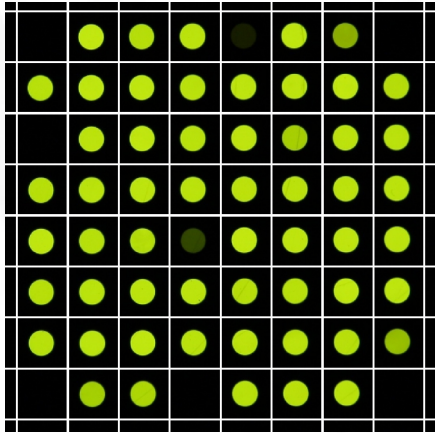
In original design a single WLS fiber carried out on both edges the scintillating light to the PMTs

BUT...

EMR: mechanical construction



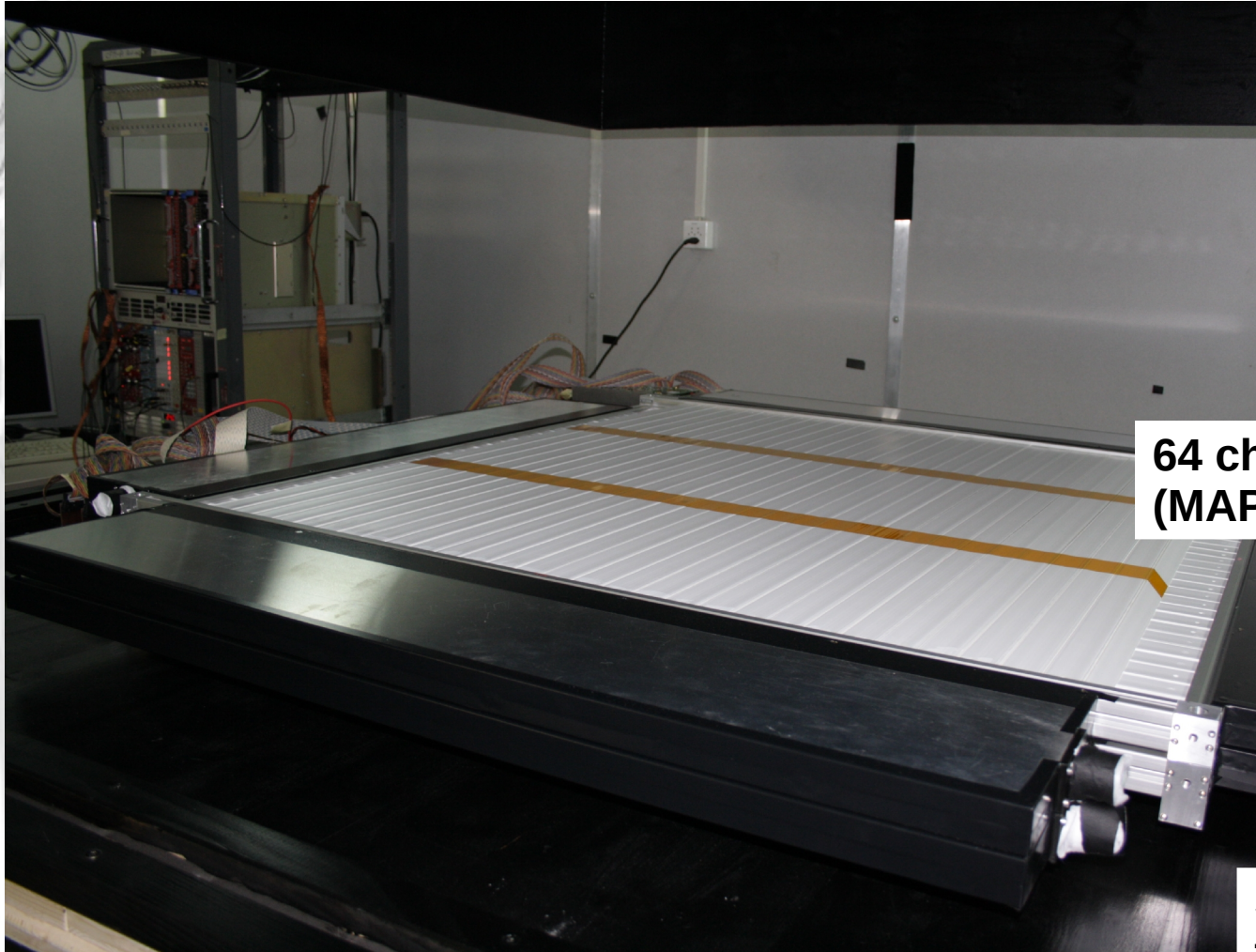
Optical test:
10% of fiber broken



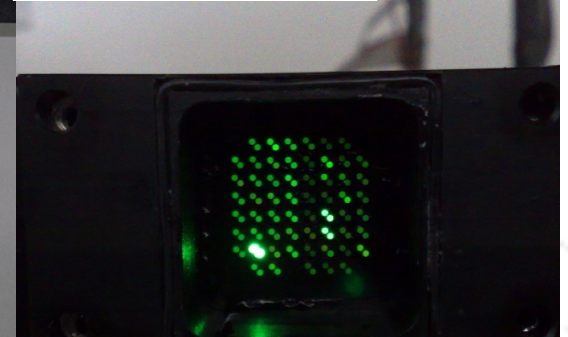
“Connector system”

Clear fiber to PMTs

EMR: mechanical construction



Two readouts:

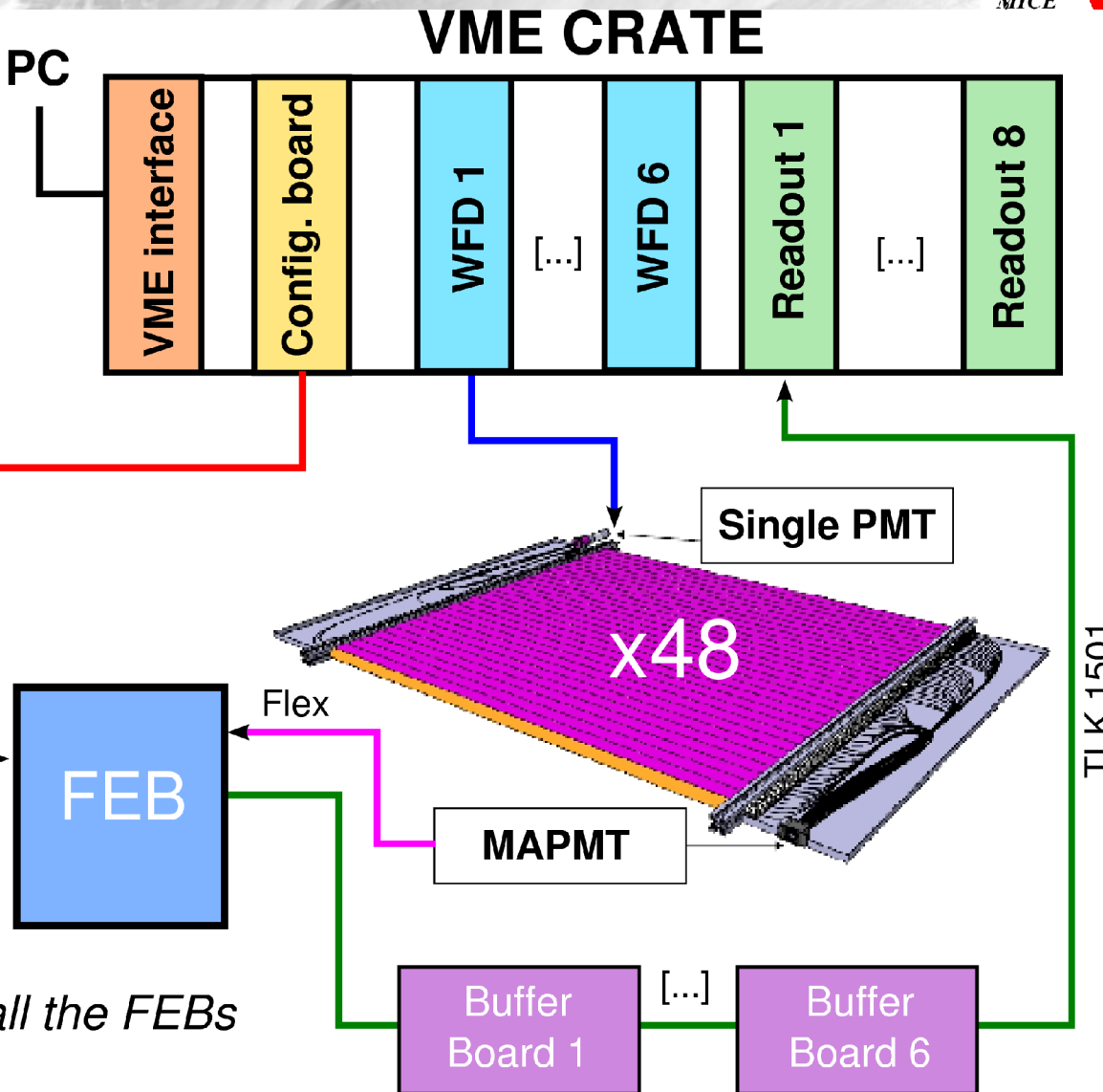


64 channels multi-anode PMT (MAPMT) to track the particles



Single PMT to measure the whole plane charge

The EMR electronics



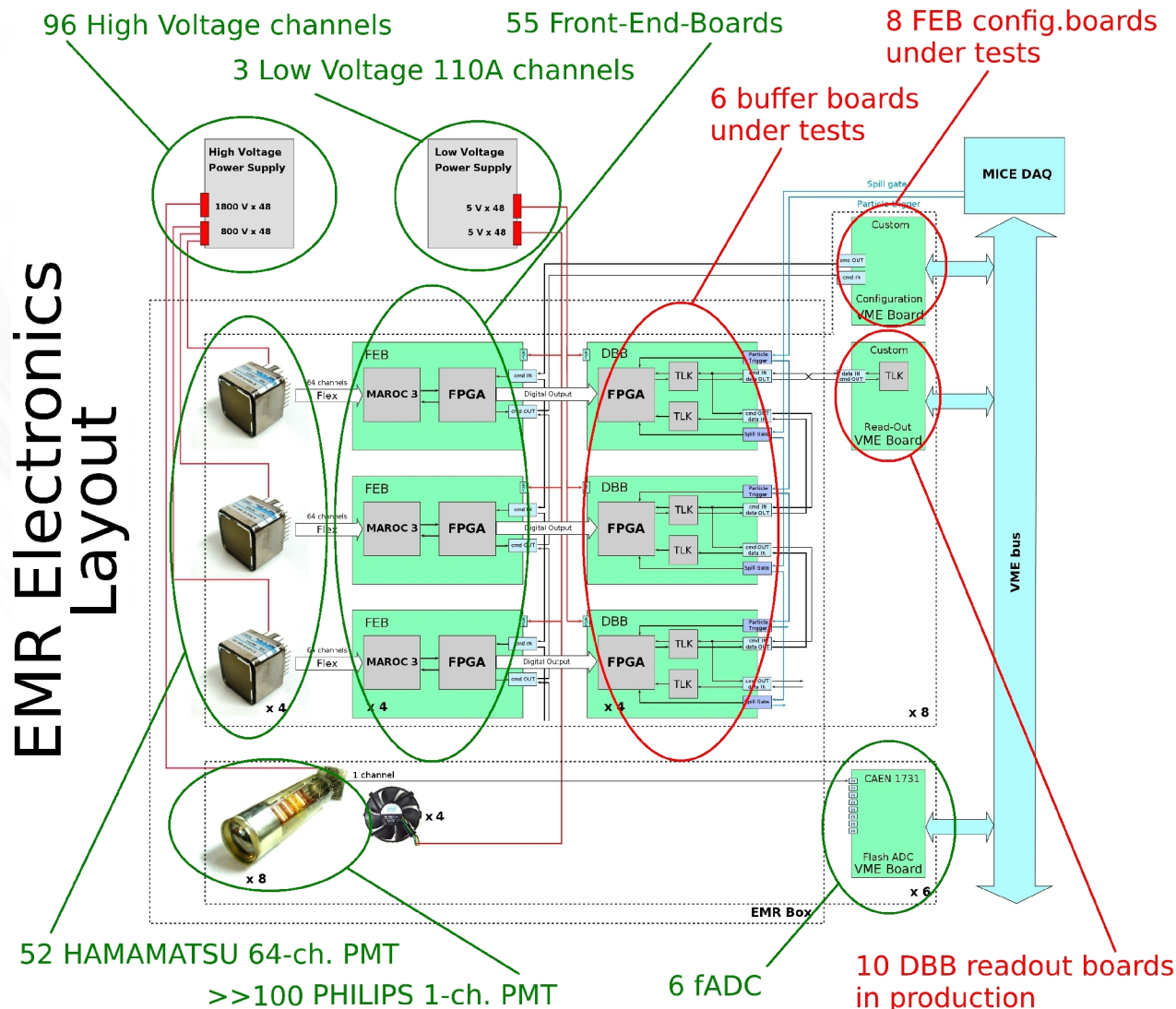
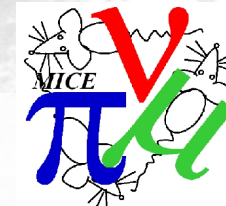
Single PMT:

- ◆ WFD: 8 ch. CAEN 1731

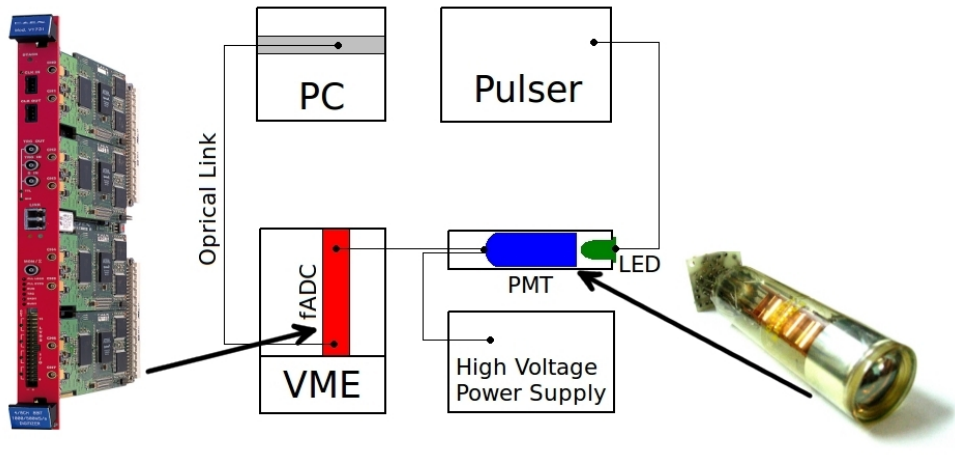
MAPMT (64 channels):

- ◆ FEB Board
- ◆ DBB board

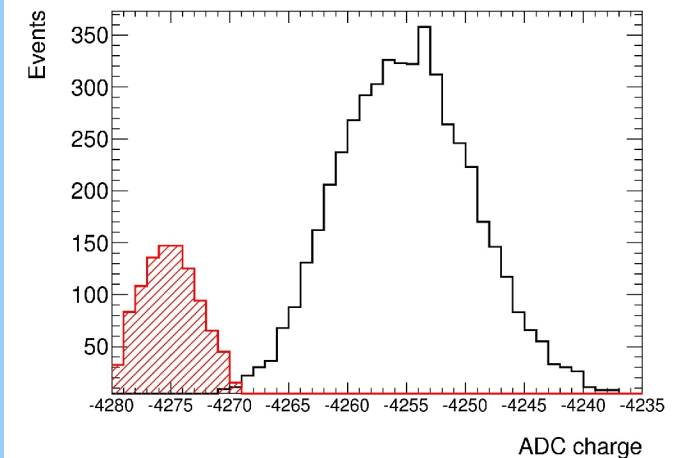
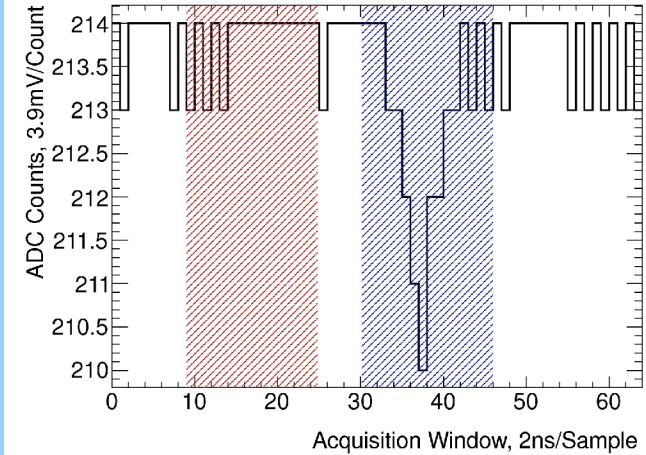
The EMR electronics



Single PMT readout system

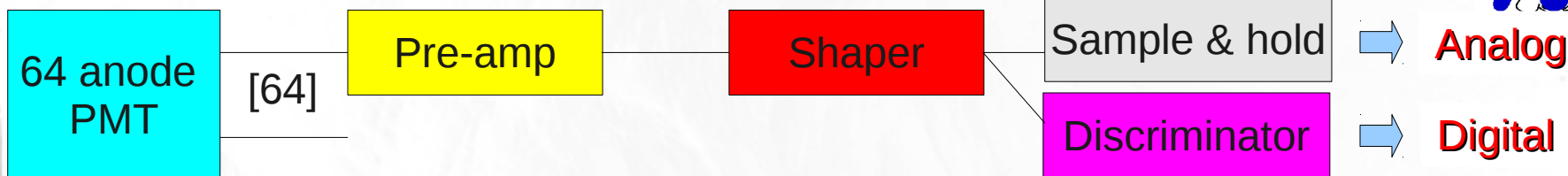


Flash ADC CAEN V1731
500MS/s, 8 channels

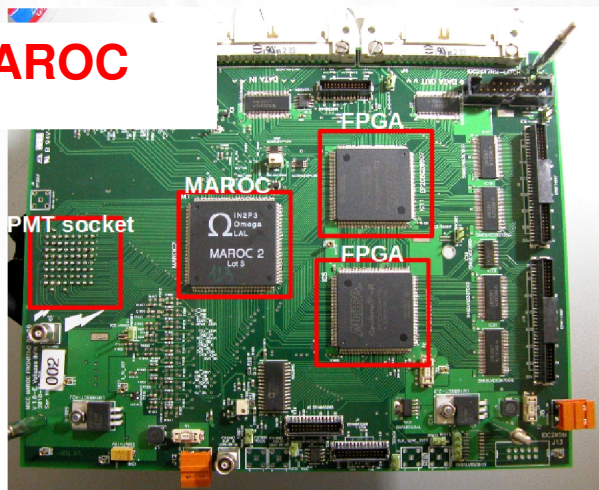


- ◆ a **test bench** is set up to study fADC behaviour
- ◆ light pulses are created by a **LED** and are similar to the ones generated by a MIP particle in triangular scintillating bars
- ◆ this setup is identical to the **final readout** of the PHILIPS 1-ch. PMT in EMR (provided by P.Hanlet, D0 experiment, Fermilab, US)

The MAPMT processing: the MAROC ASIC



MAROC



- ◆ Each **64 channel** has a pre-amplifier, shaper, sample & hold and a discriminator.
- ◆ **1 multiplexed analog output, 64 parallel digital ones**
- ◆ **Plastic packaging**
- ◆ **1 single power rail**

Because of the experimental duty cycle ($1 \text{ ev}/5 \mu\text{s}$ in a spill of 1 ms per sec), the **analog readout** (which requires 12.8 μs) is used for **tests** and for the **commissioning phase**. The **final readout** will be a **digital one**.

The FrontEnd Board (FEB)



SOCKET: MAPMT is connected by a flex cable

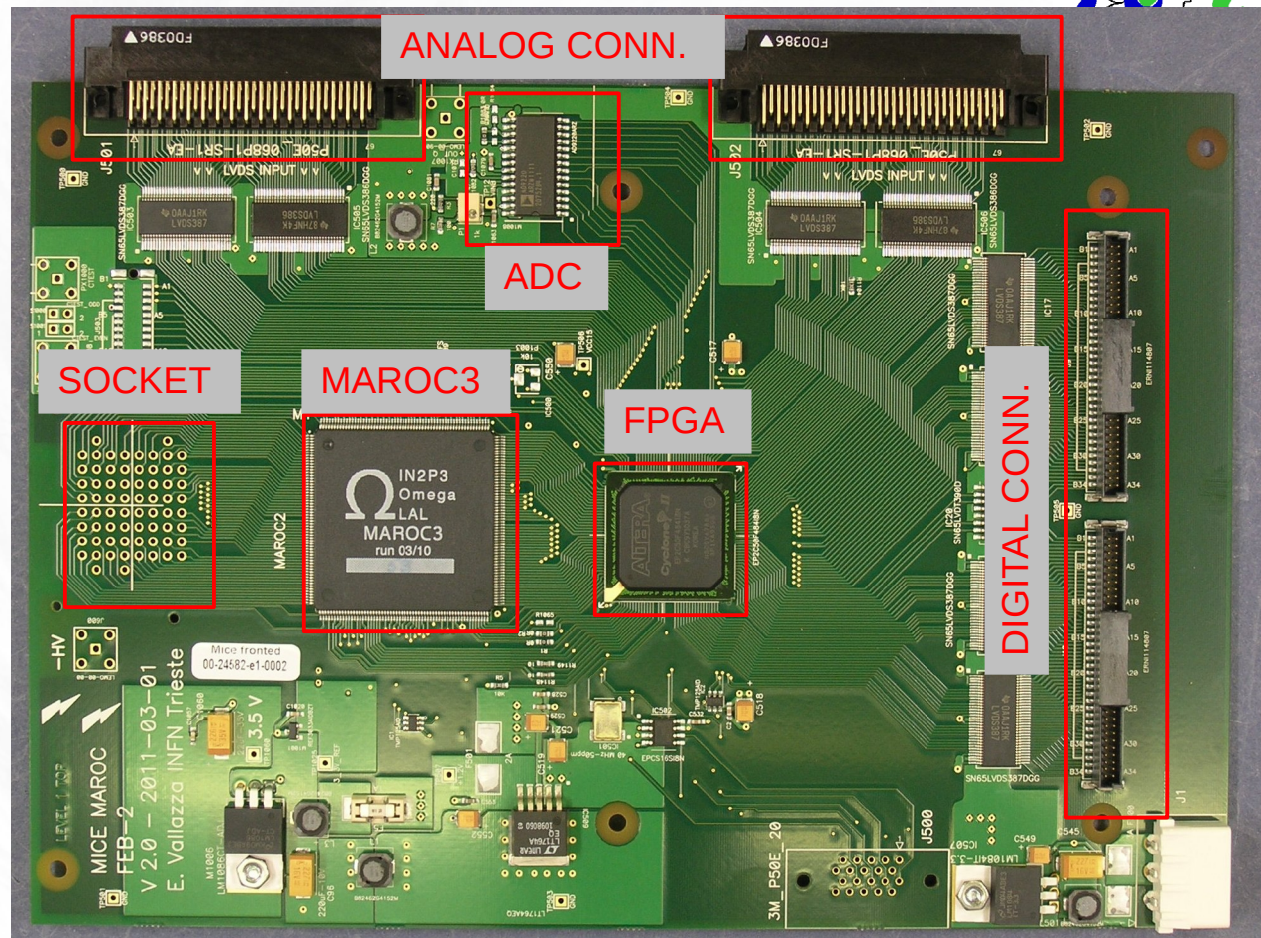
MAROC: MAROC-3

FPGA: to control the MAROC configuration (gain, DAC,...) and the readout sequence

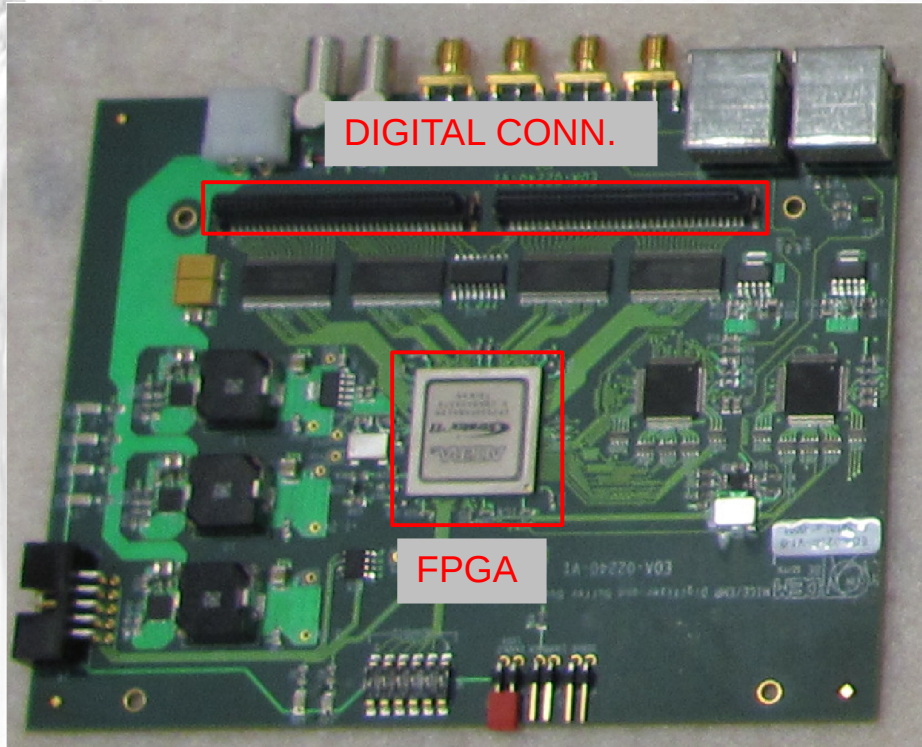
EXTERNAL ADC: for the analog readout.

DIGITAL CONNECTORS: to address digital signals to the buffer boards

ANALOG CONNECTORS: to configure the MAROC ASIC and for the analog readout



The Digitizer and Buffer Board (DBB)



- The DBB samples the **64 digital outputs in parallel** from FEB
- FPGA performs the **sampling** (400 MHz), **data buffering**, and **data-flow** control functions
- DBB transmits the event data upon request of the acquisition system via a **gigabit link** (TLK 1511)
- six DBBs are **daisy-chained** (8 VRB boards in total)

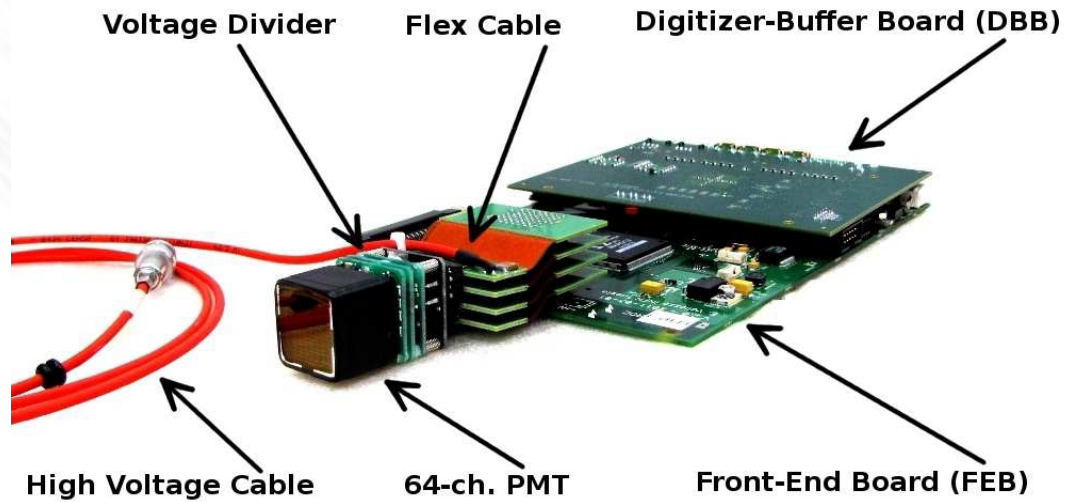
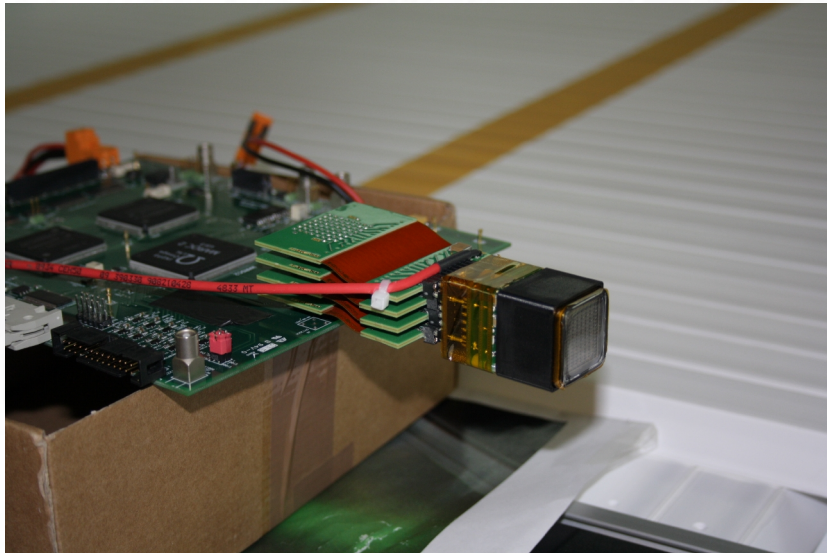
Data

Header																																	
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Header type		0	0	0	0	0	0	Board ID								Spill Number																	
0	0	0	0	0	0	Trigger count										0	0	0	Hit count														
Data Word																																	
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
Data type		Channel ID								Hit time																							
Trailer																																	
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
Trailer type		Status								Board ID								Spill Number															

Command (to configure and to check)

Command																															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Cmd type		Command								Board ID								Arguments													

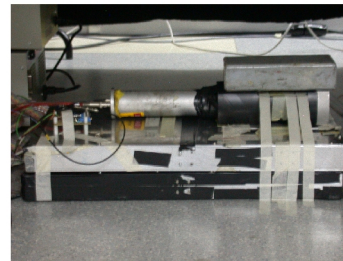
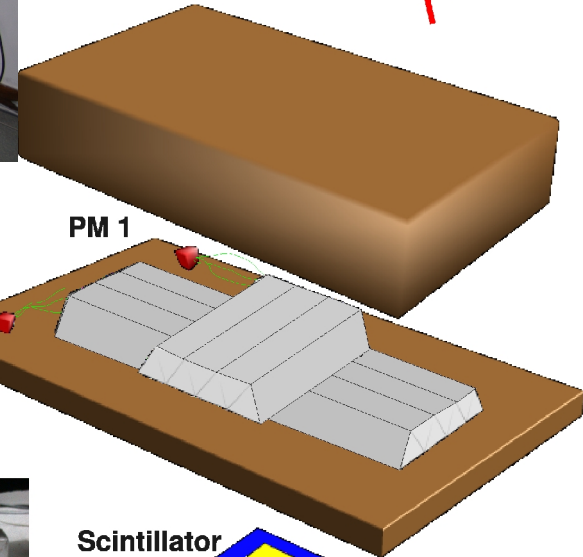
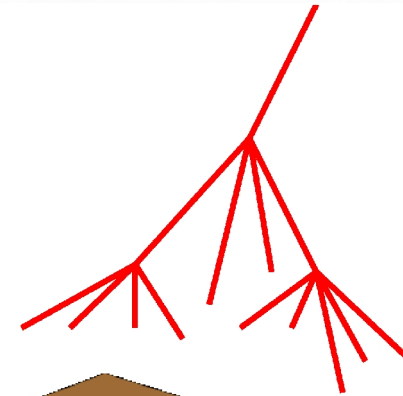
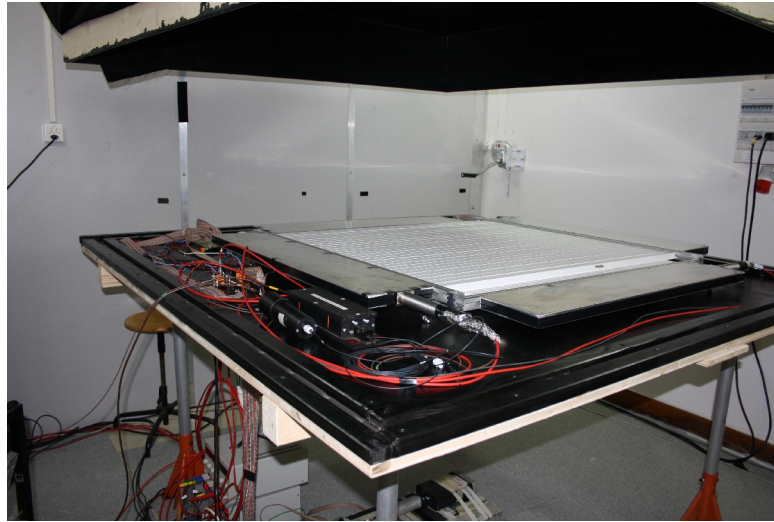
FEB + DBB





UNIGE tests

Tests on the UNIGE setup



Scintillator



Silicon beam chamber

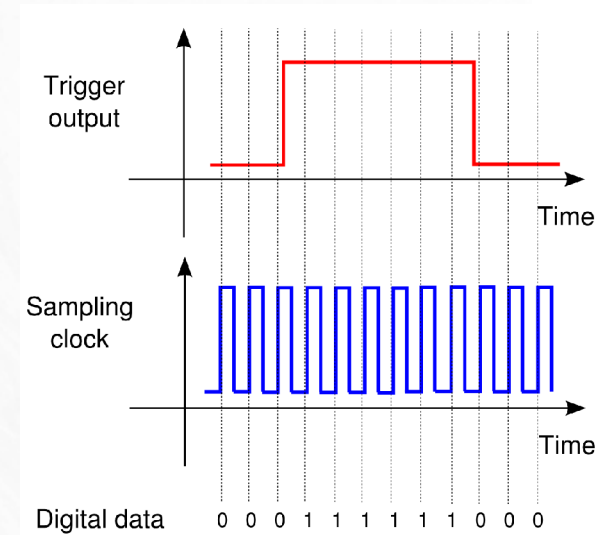
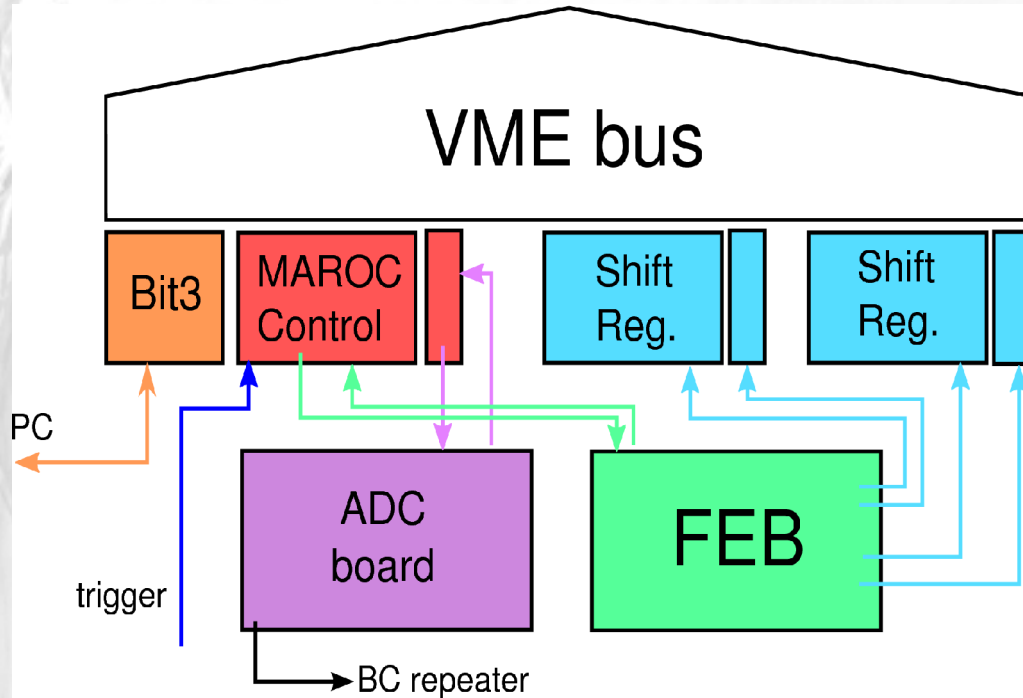
Tracking:

2 Si detectors
~ 30 μm of spatial resolution
~ 9.5x9.5 cm^2

Goal:

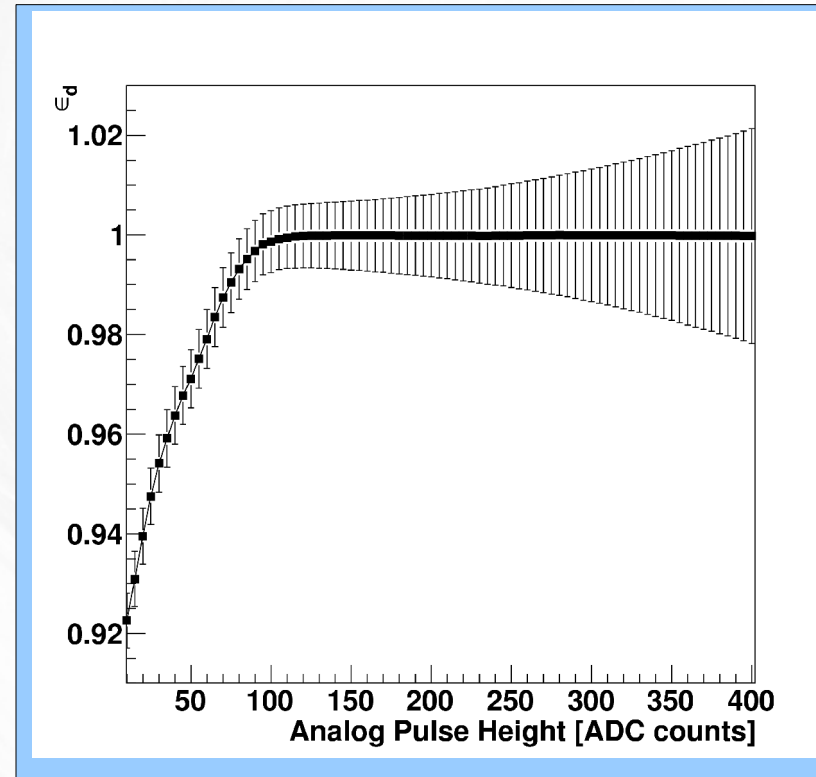
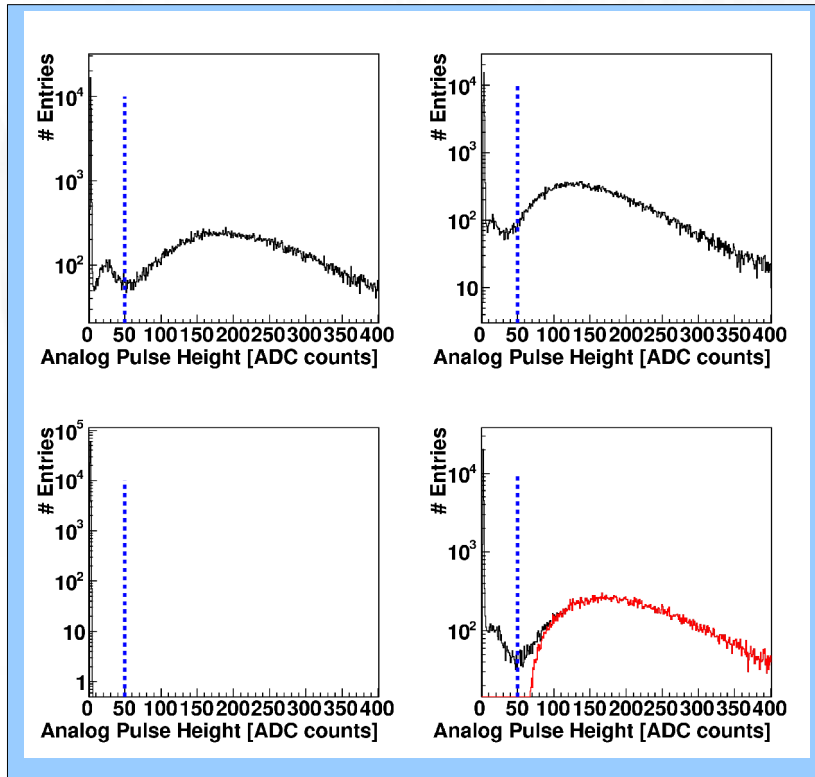
Test of the MAROC ASIC prototype board with a final module: longterm tests and final performances

Tests on the UNIGE setup: DAQ



- **BIT3 system** for PC-VME data transmission
- **MAROC control:** configuration and readout of the FEBs and Si detector readout boards
- **Shift register:** I/O boards to simulate the digital readout (sampling clock 200 MHz)

Tests on the UNIGE setup: results



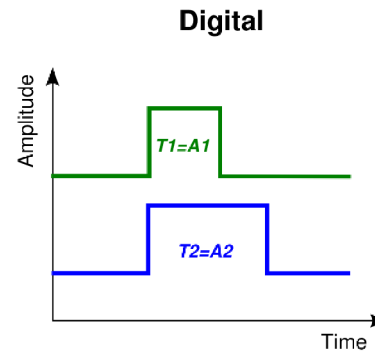
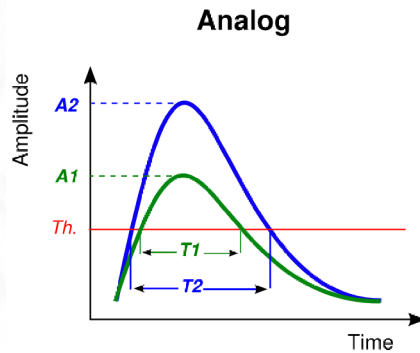
Analog pulse height

Digital efficiency

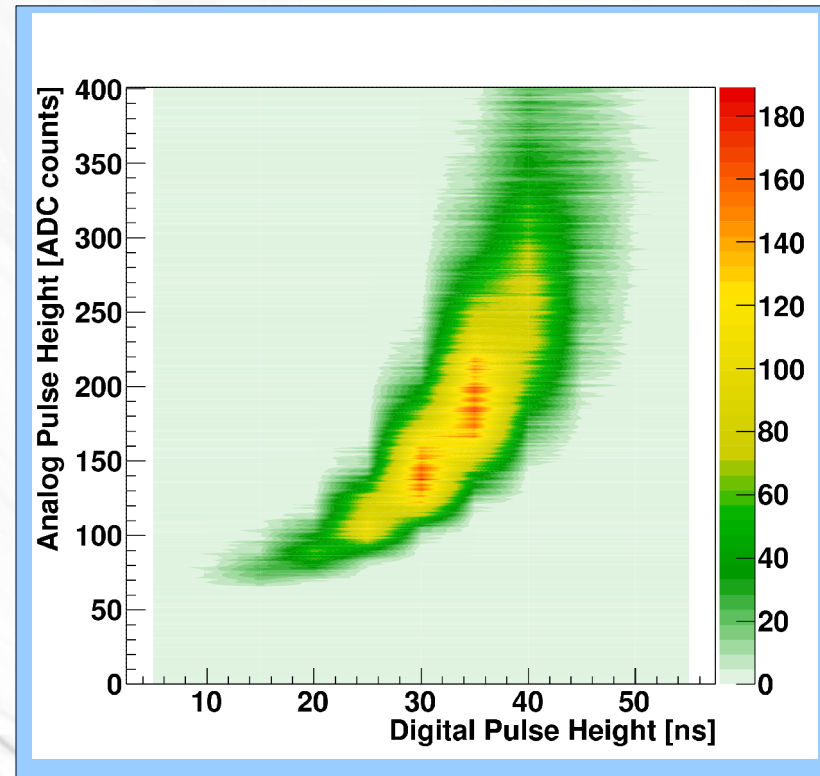
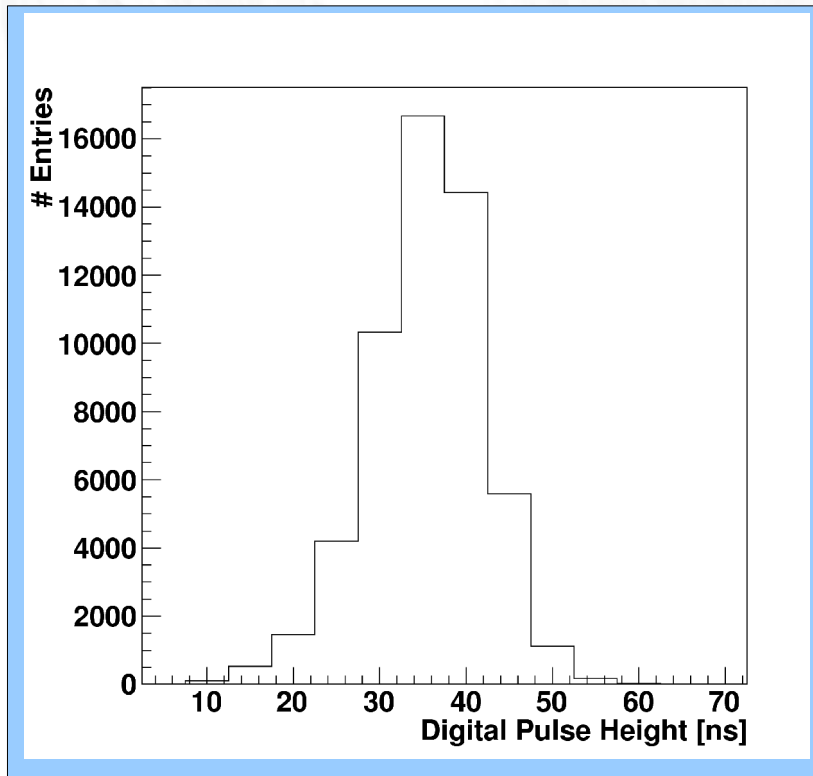
Tests on the UNIGE setup: results



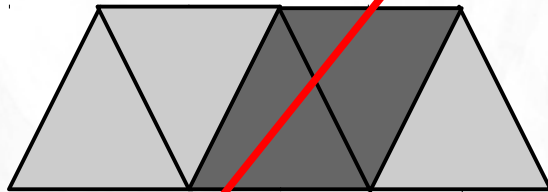
Digital PH



Analog-digital PH



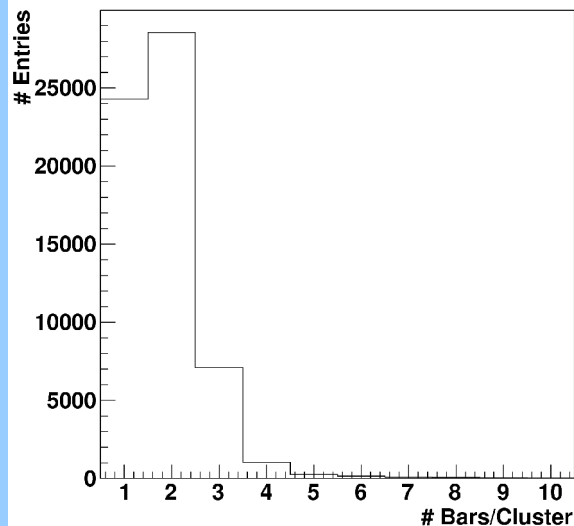
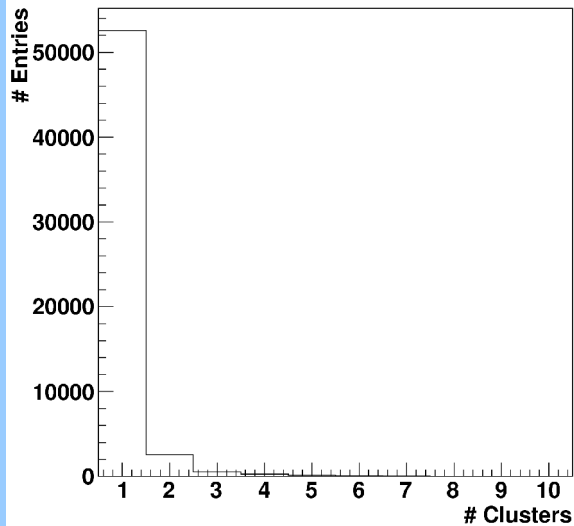
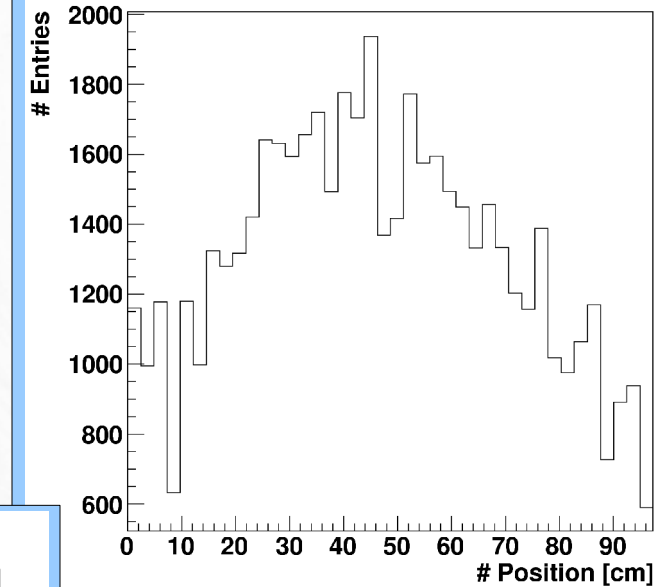
Tests on the UNIGE setup: results



Cluster

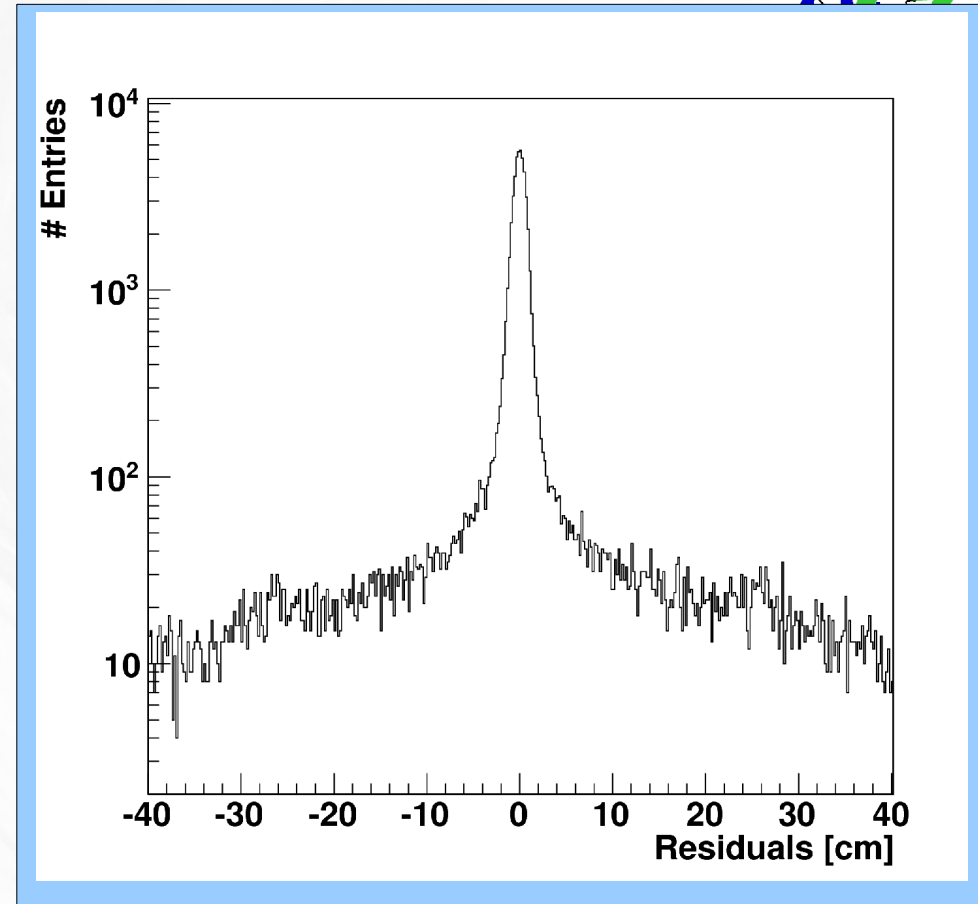
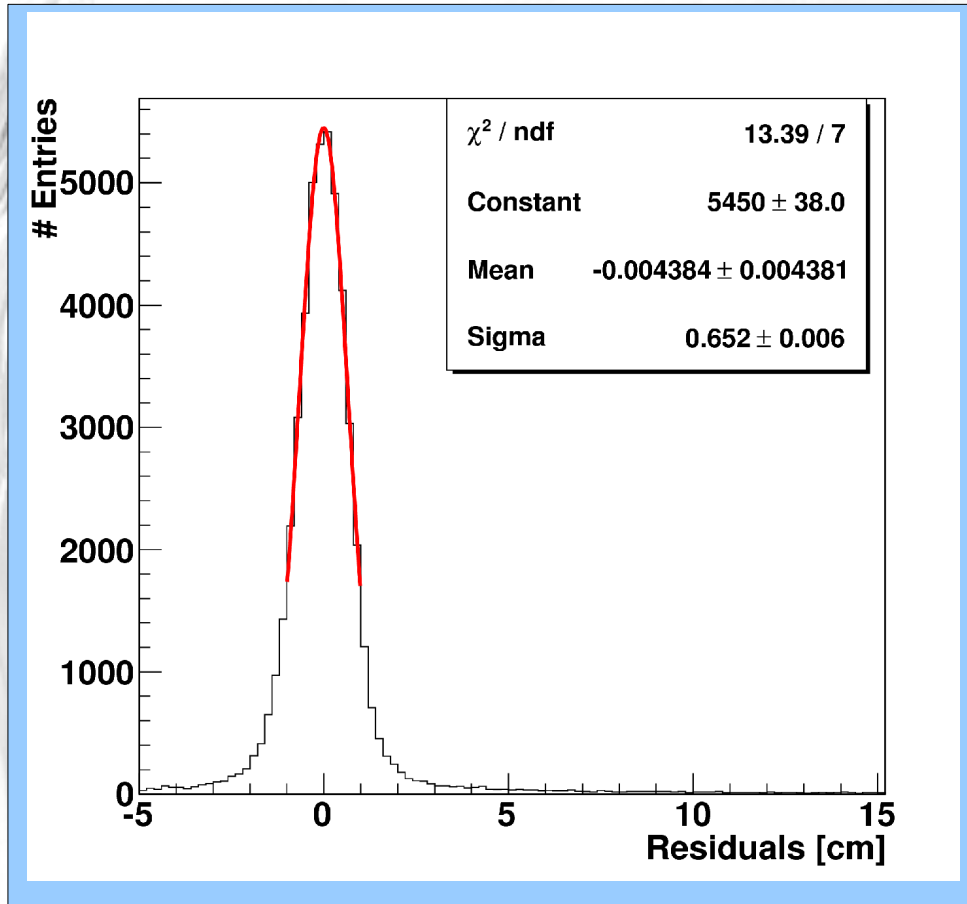
Cosmic profile

Bar/cluster



Hit position:
Charge centroid method

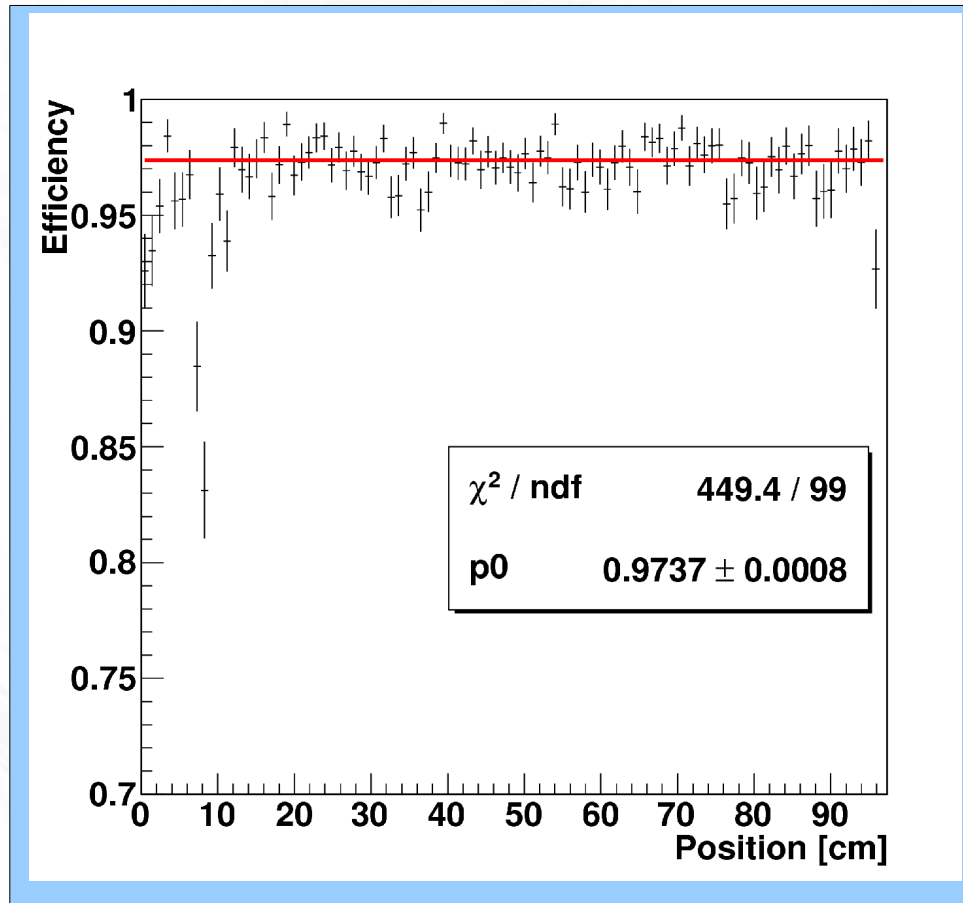
Tests on the UNIGE setup: results



**Single cluster
residual RMS: ~6.5 mm**

Residual all clusters 21

Tests on the UNIGE setup: results



Efficiency



EMR at RAL

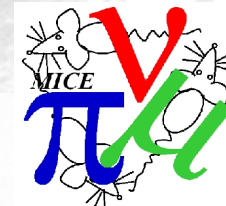
Six planes at RAL



Six planes installed on the MICE line for the July data taking period



Six planes at RAL



GOALS:

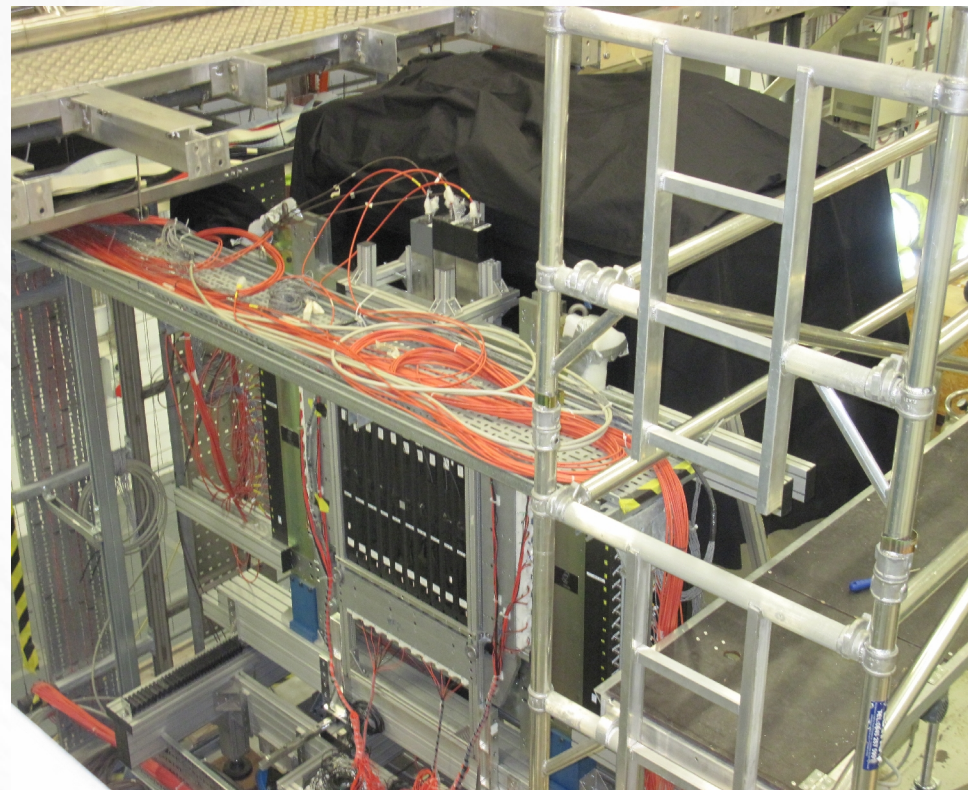
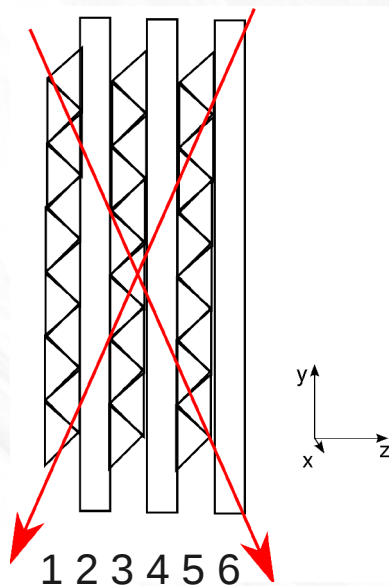
- ◆ Installation of **EMR in the KL** frame with identification of the possible problems
- ◆ Implementation of **EMR in DATE**
- ◆ **Preliminary test** with cosmic rays and beam

Two DAQ systems:

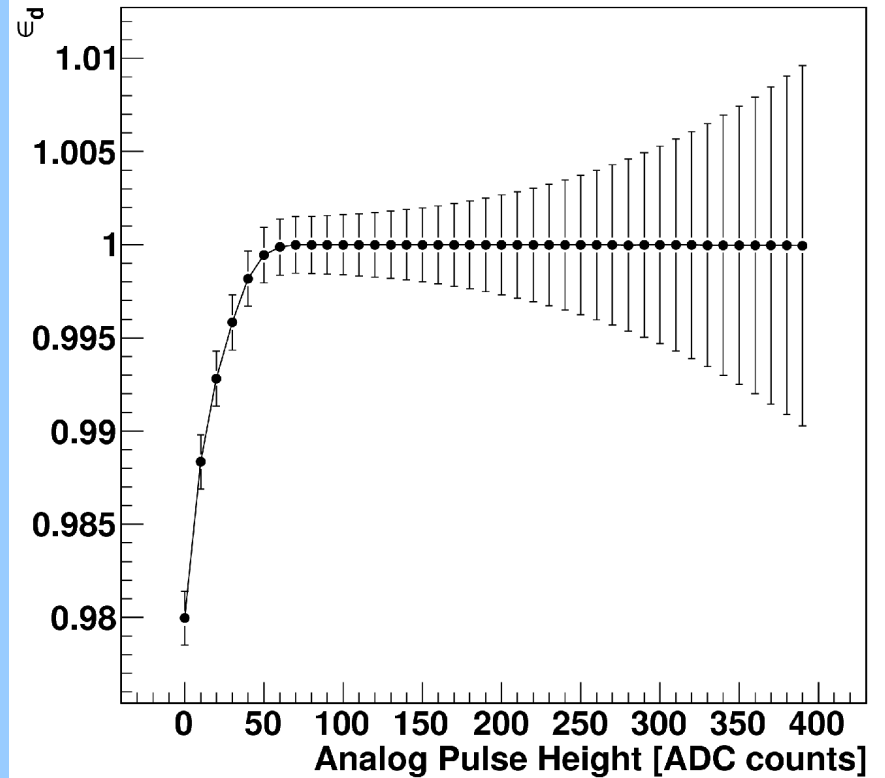
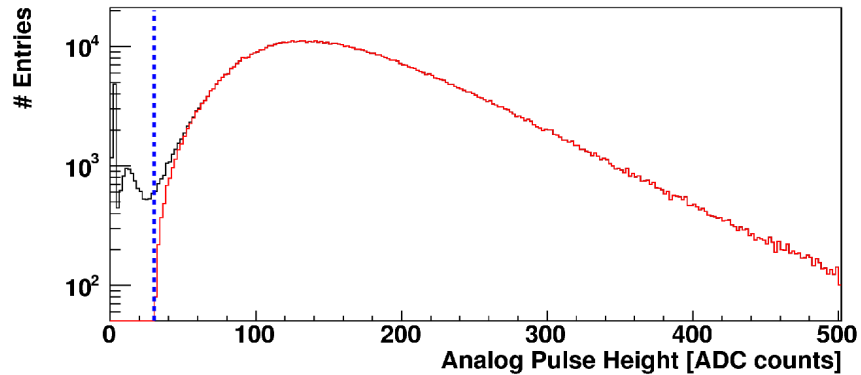
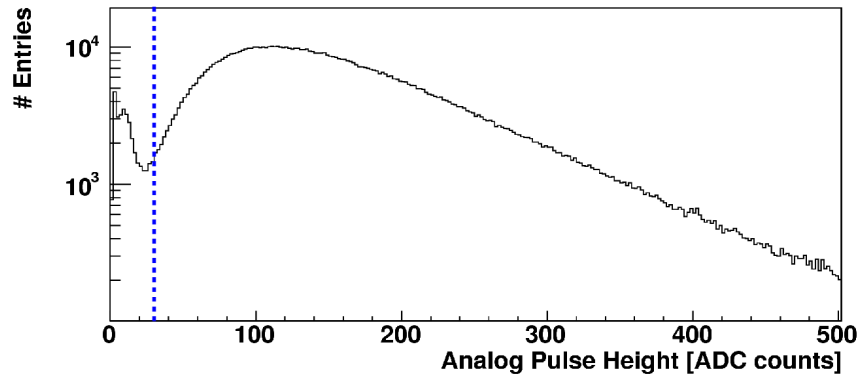
- ◆ DATE
- ◆ UNIGE-like

Trigger: 1-6

Test: 3-4



Results with the UNIGE-like DAQ

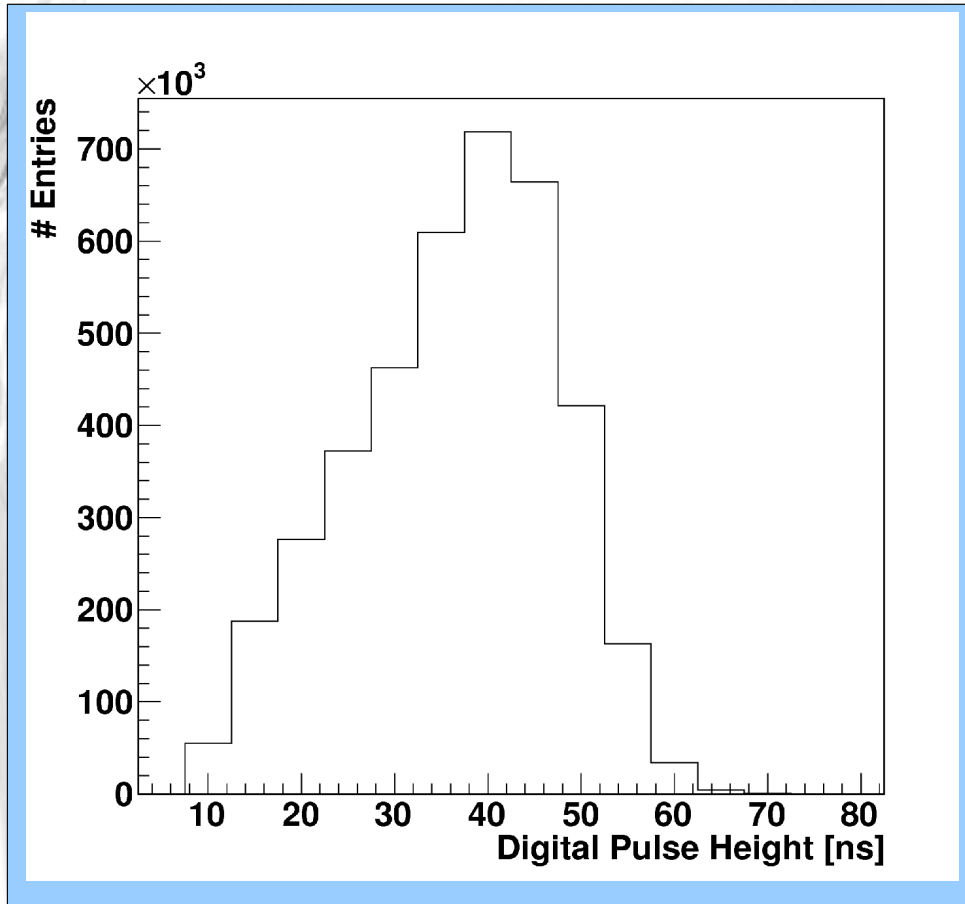


Analog PH

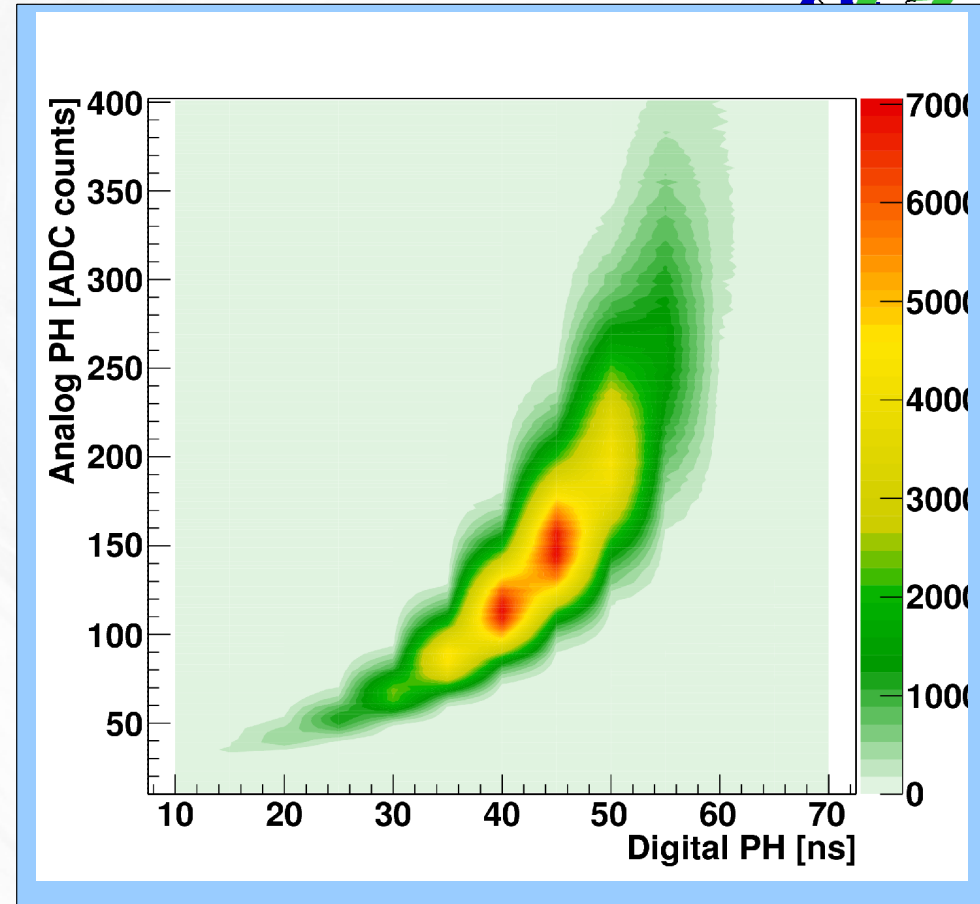
Digital efficiency

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Results with the UNIGE-like DAQ

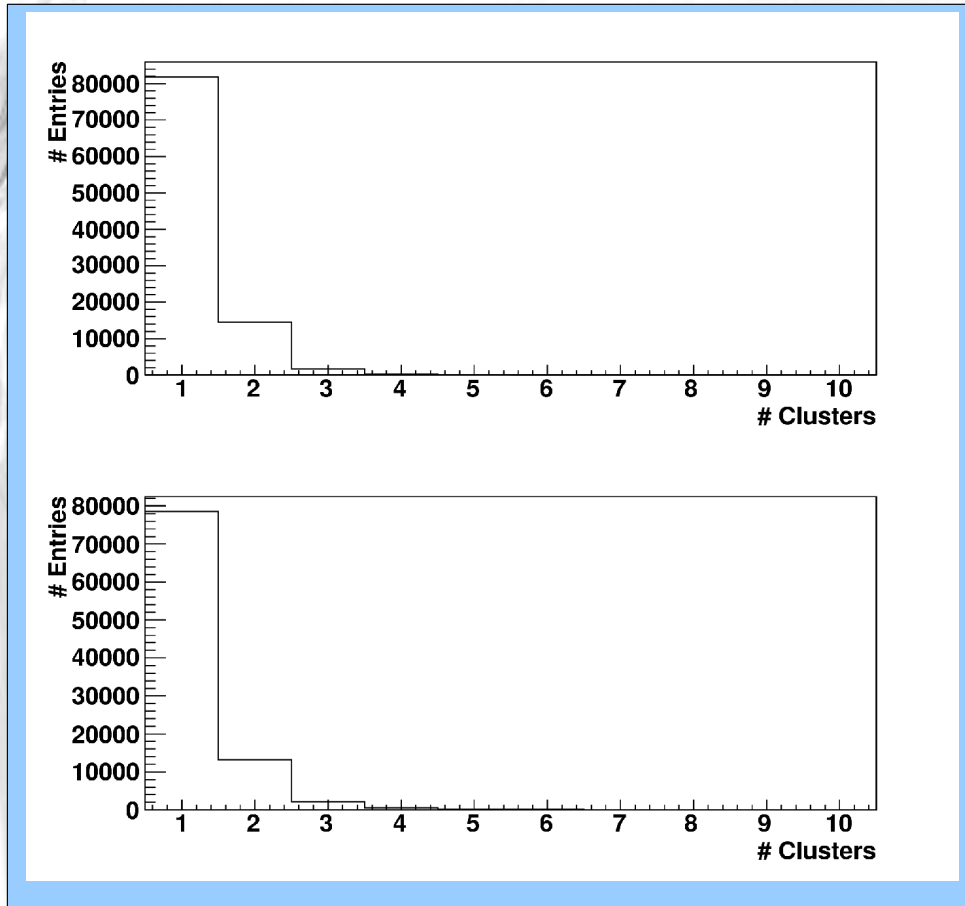


Digital PH

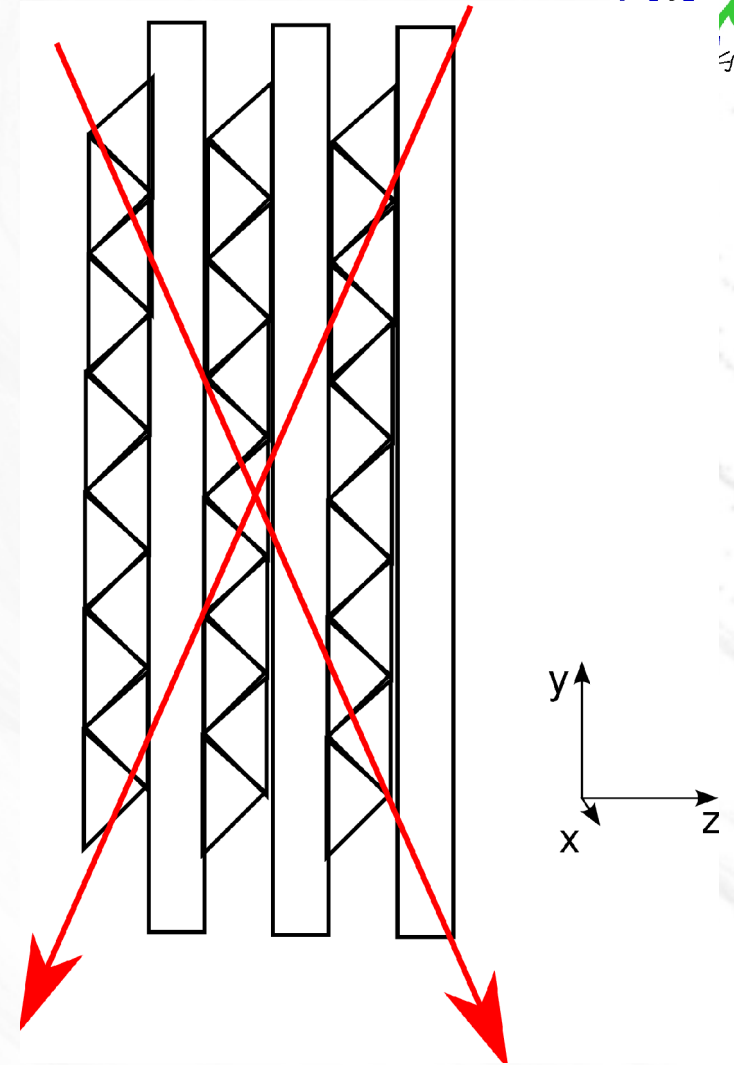


Analog-digital PH 27

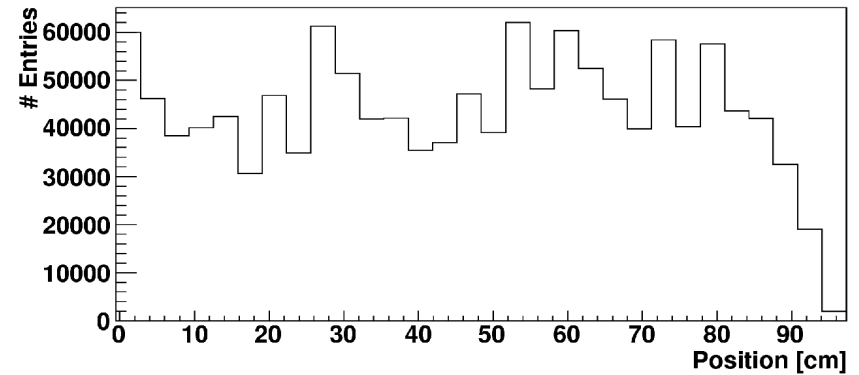
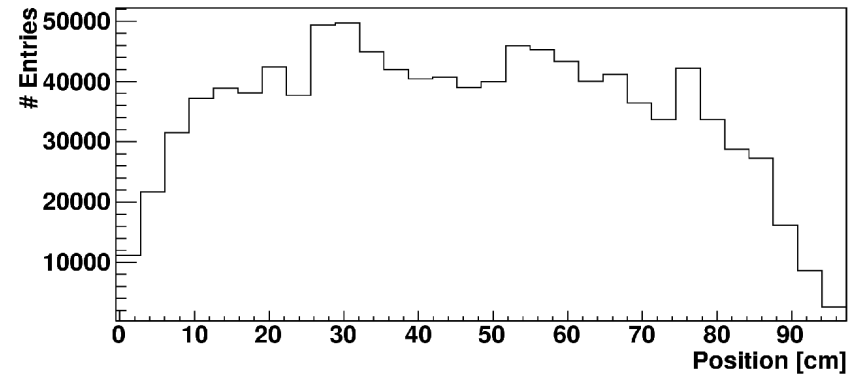
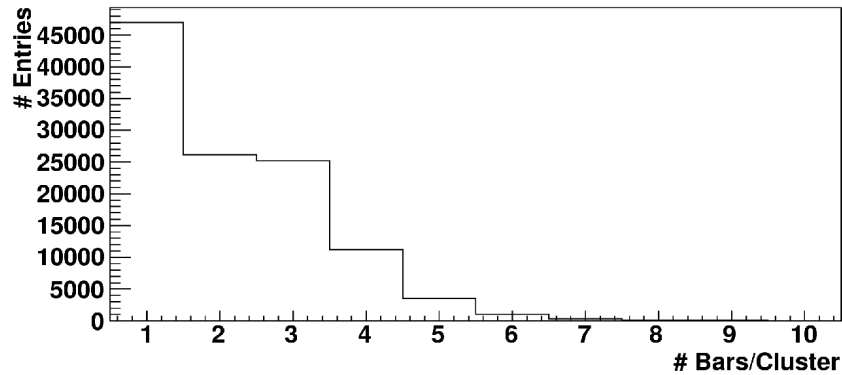
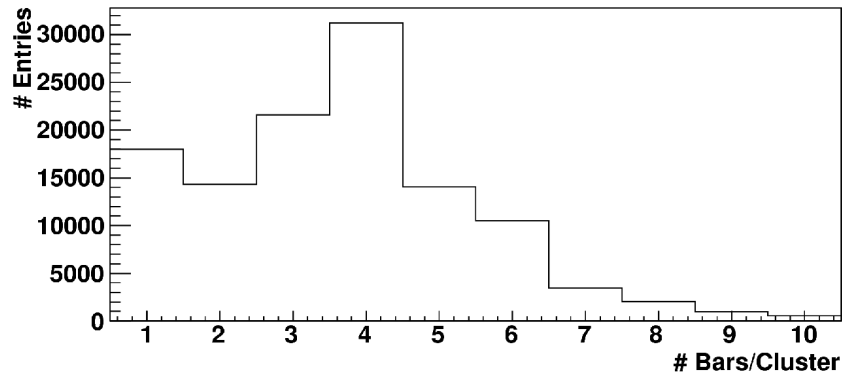
Results with the UNIGE-like DAQ



Cluster



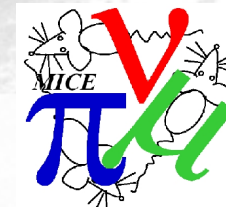
Results with the UNIGE-like DAQ



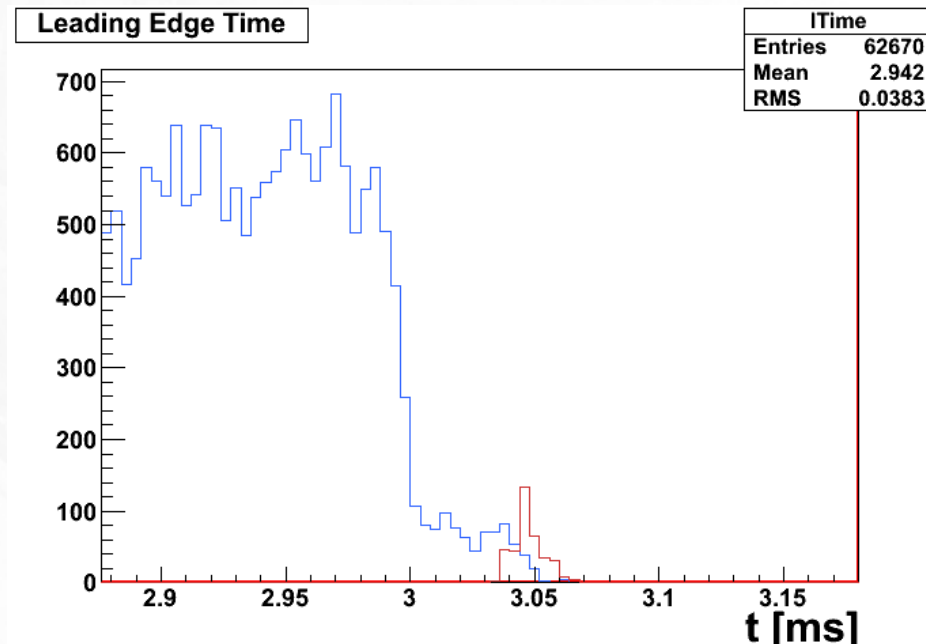
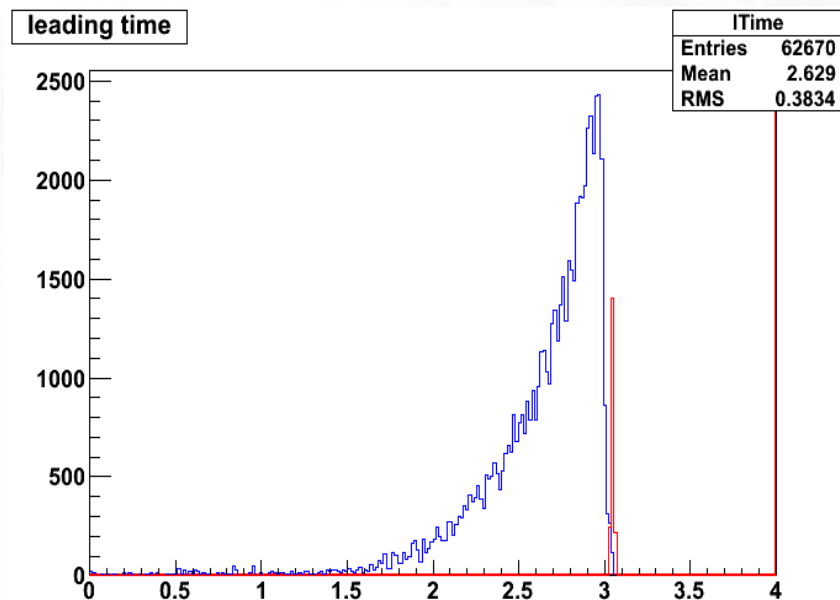
Bar/cluster

Cosmic profile

Results with DATE

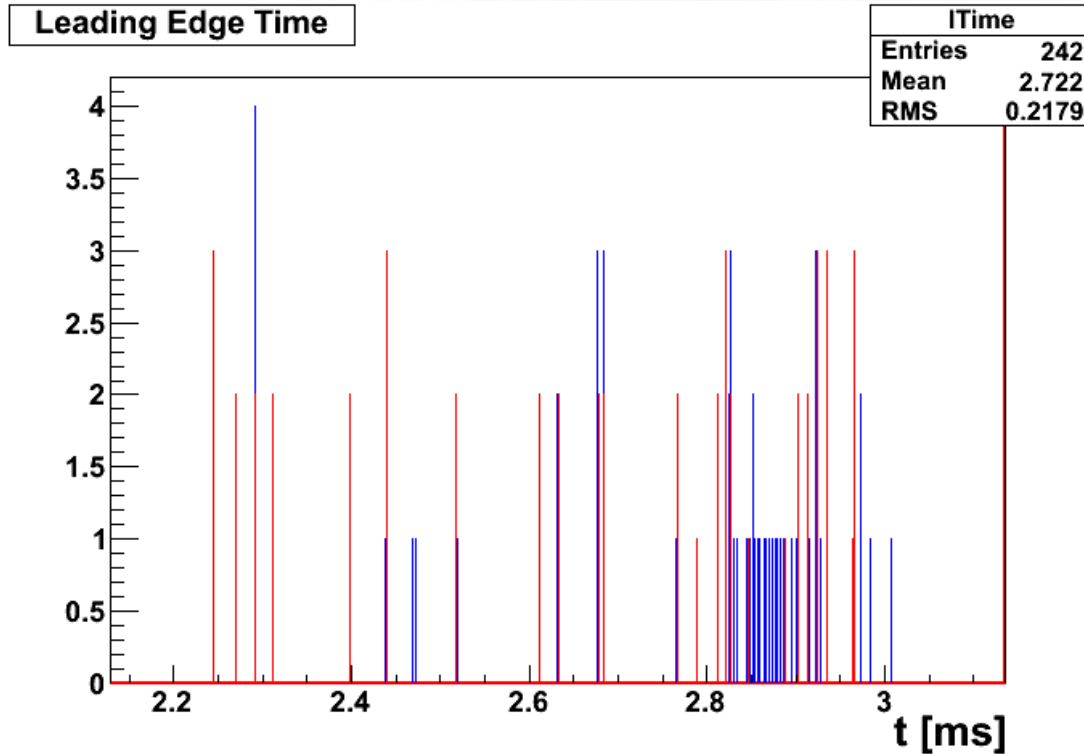


Time distribution of the **EMR hits** (blue) inside the spill window. Spill width in red



- ♦ the **spill width** is measured by DBB boards
- ♦ all hits within spill gate are recorded **together with particle trigger** signals

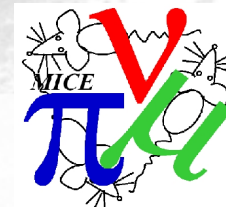
Results with DATE



EMR Hits
MICE Particle Trigger

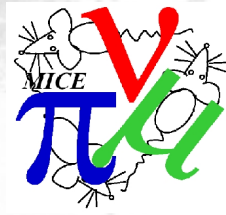
Particle triggers **should be associated** to EMR hits

Conclusions & Outlooks



- ↘ EMR is a **fully active scintillator detector** used to discriminate muons from electrons
- ↘ It is made of **48 planes of 1m scintillating bars** whose light is readout on both sides by single PMTs and MAPMTs
- ↘ The final procedure for the bar assembly has been fixed and **the production is ongoing**
- ↘ Cosmic rays tests (at UNIGE) are used **to verify the assembly procedure**

- ↘ The 48 layers will be **produced and tested in the first half of 2012**
- ↘ In the meanwhile all the **electronics boards are produced and tested**
- ↘ **EMR will be installed at RAL in May-June**



The Electron Muon Ranger

Thank you



Backup

Tests on bench



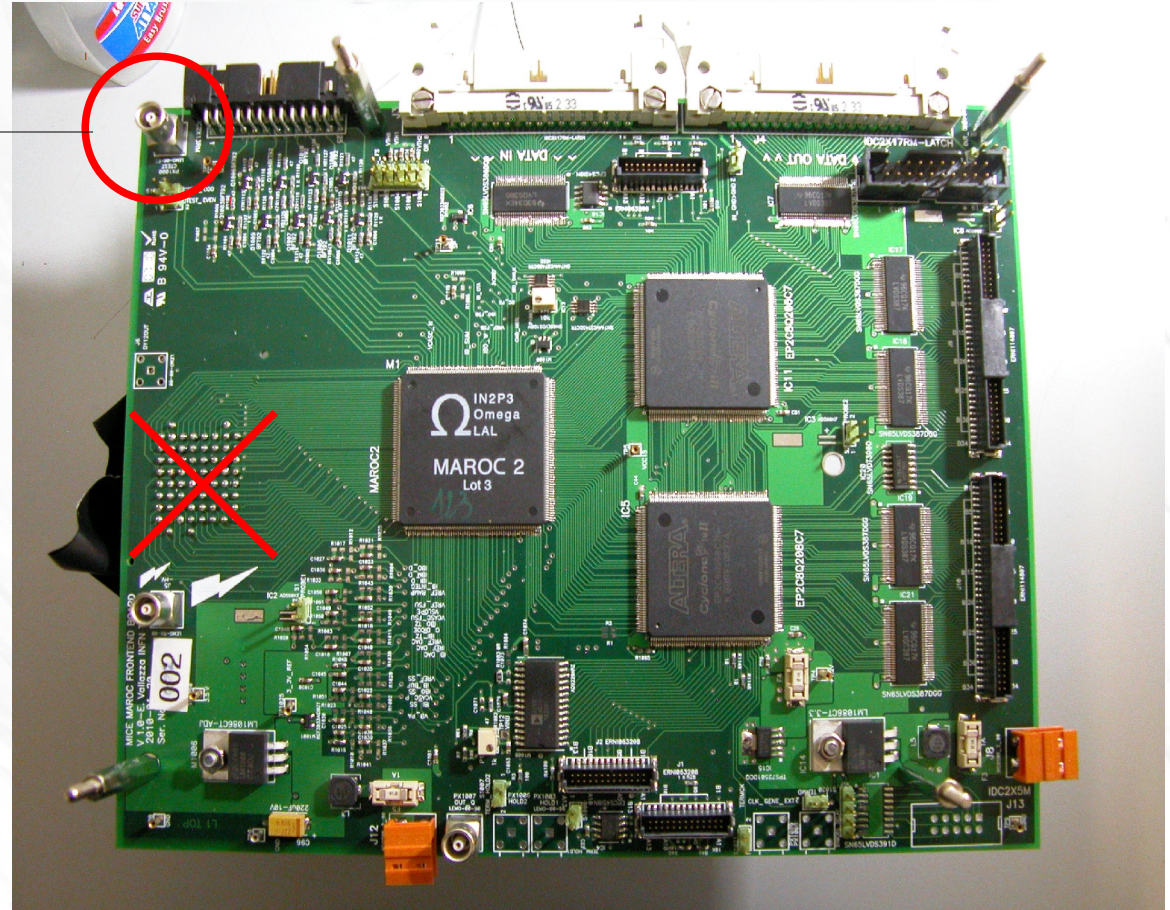
Characterization of the MAROC-2 ASIC

Pulser

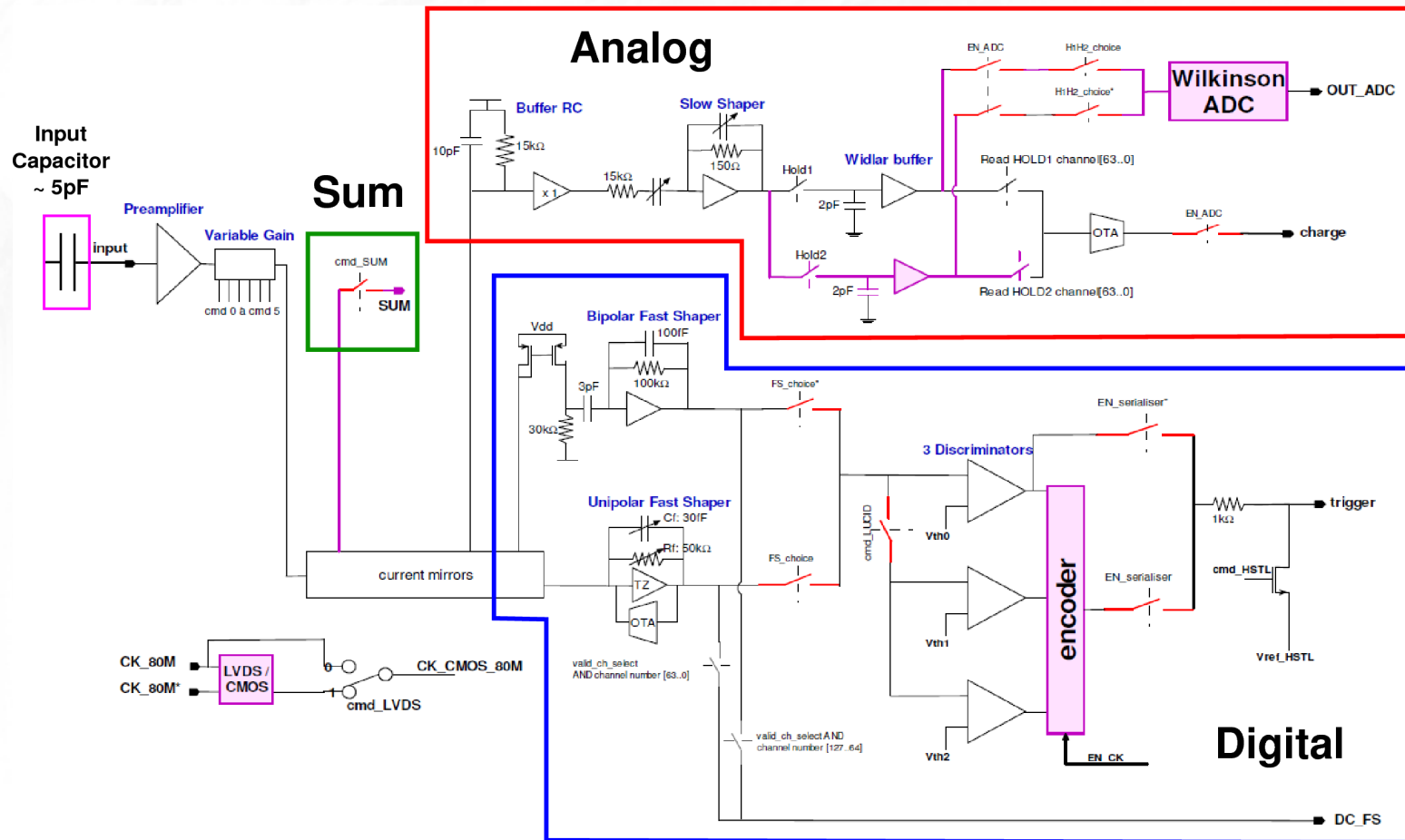


Calibration signal
(socket not used):

- shape
- frequency
- amplitude
- delay



ASIC channel



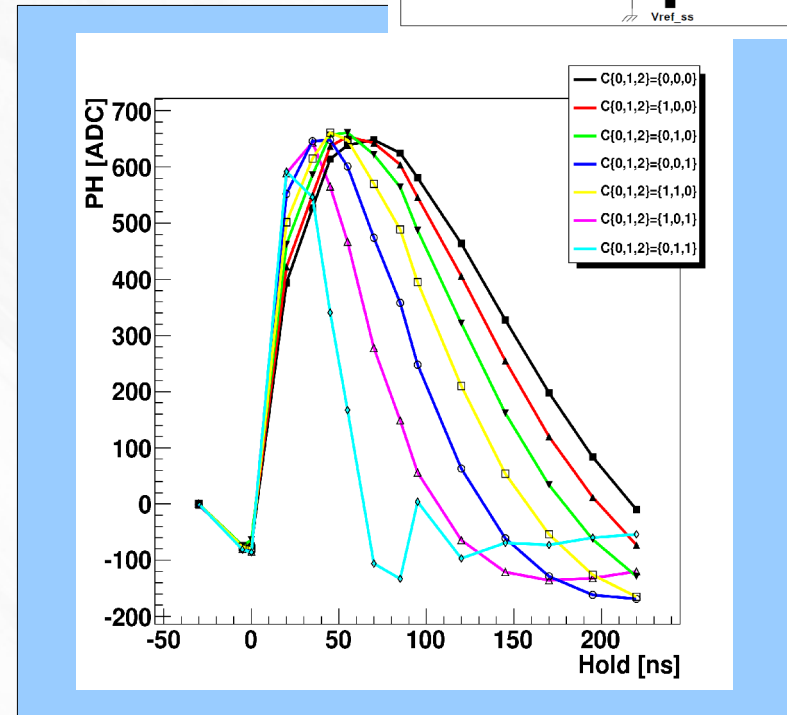
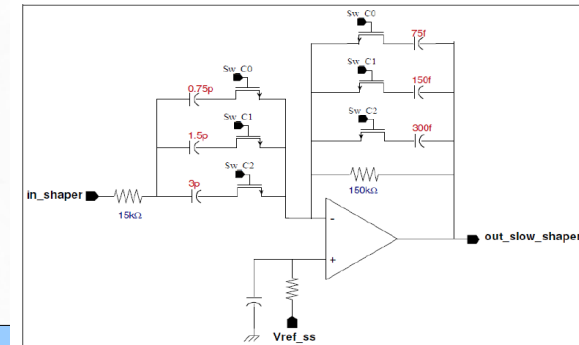
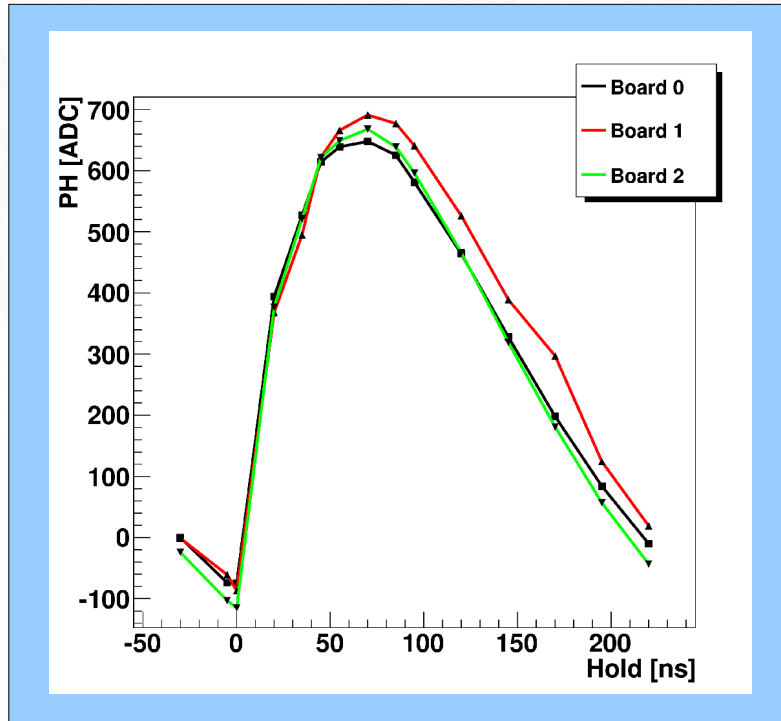
Embedded ADC works in MAROC-3

It doesn't work in MAROC-2 => need of an external ADC for the analog readout

Tests on bench (analog): results

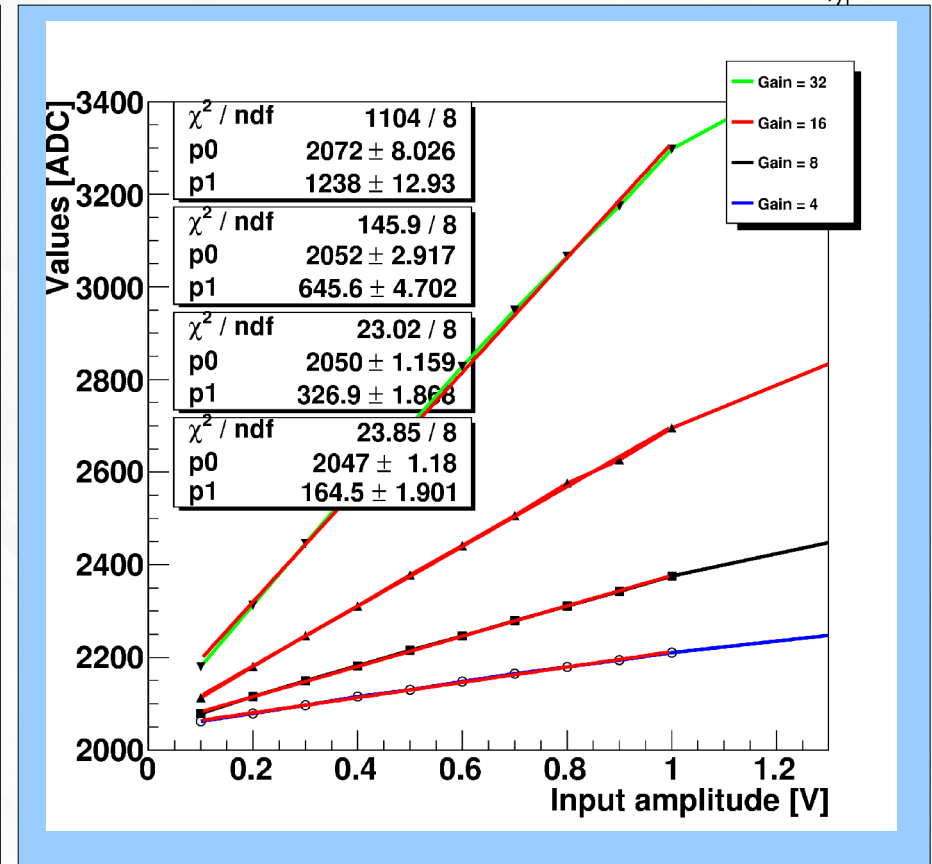
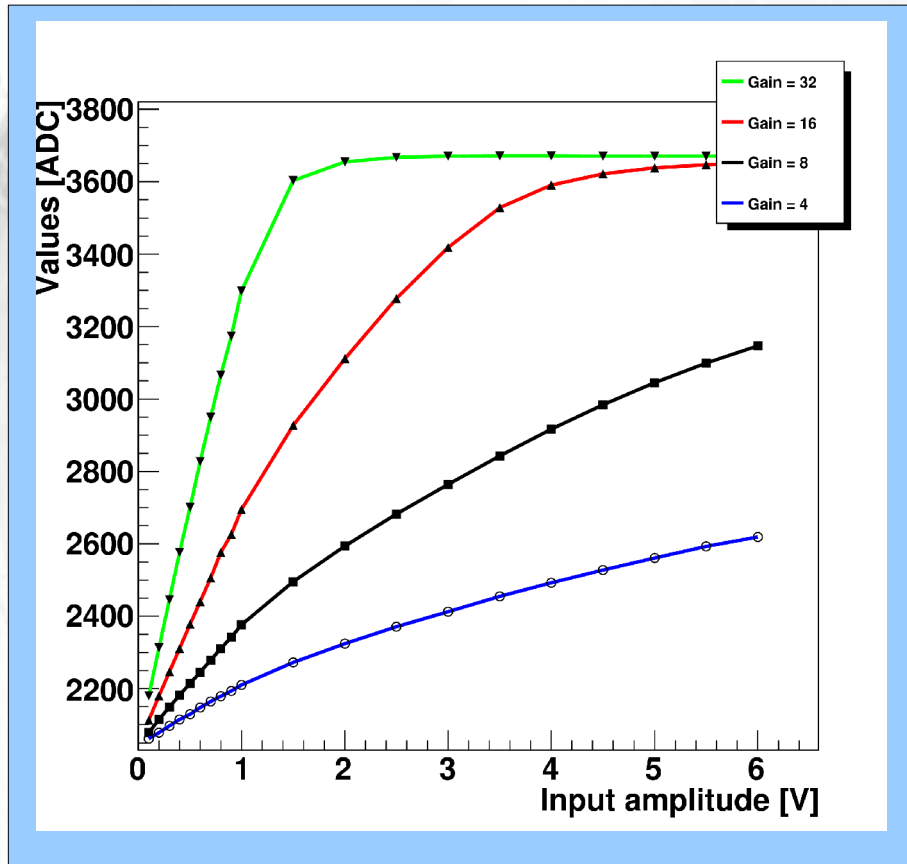


MAROC signal: peaking time ~ 70 ns



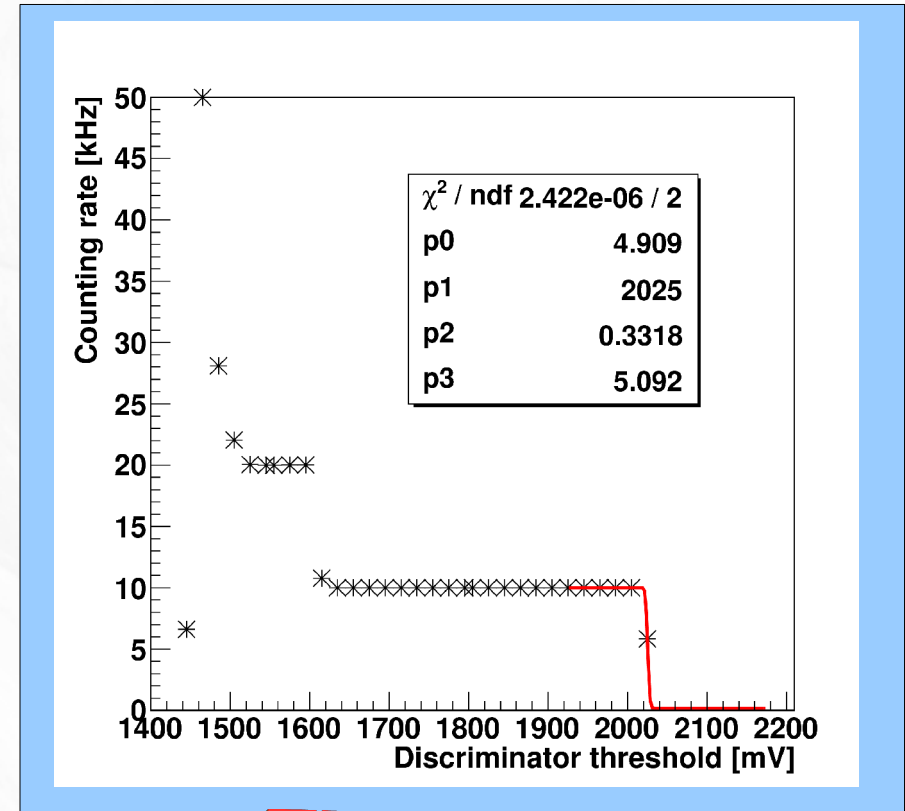
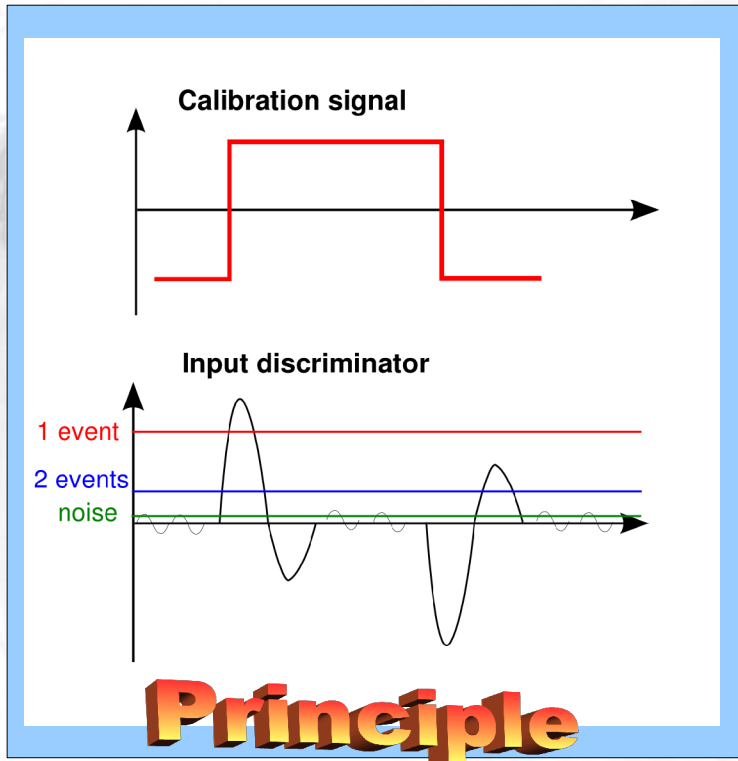
Different shaper configurations

Tests on bench (analog): results

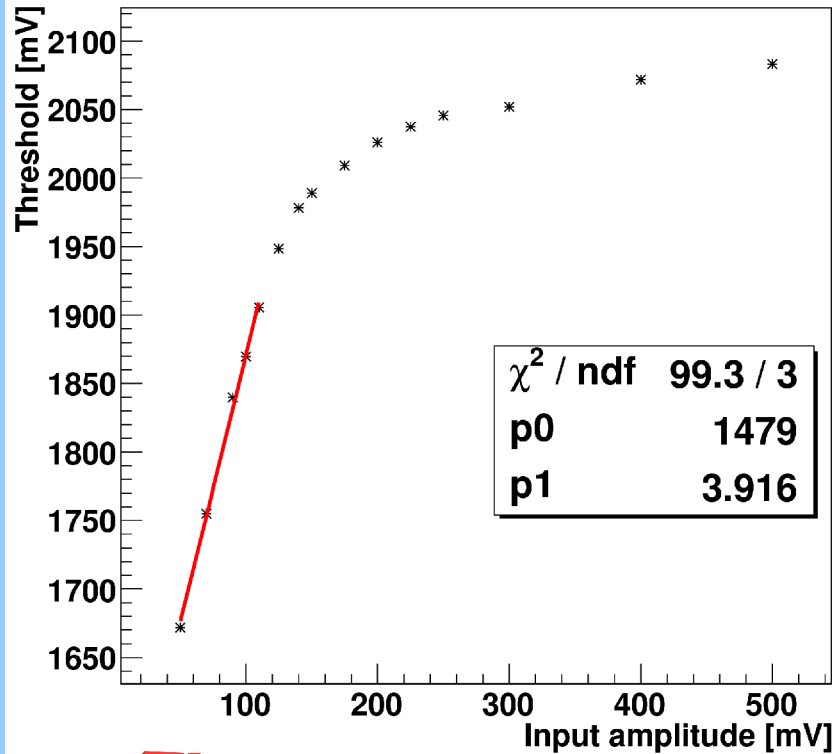


Linearity: up to 1V with different gains

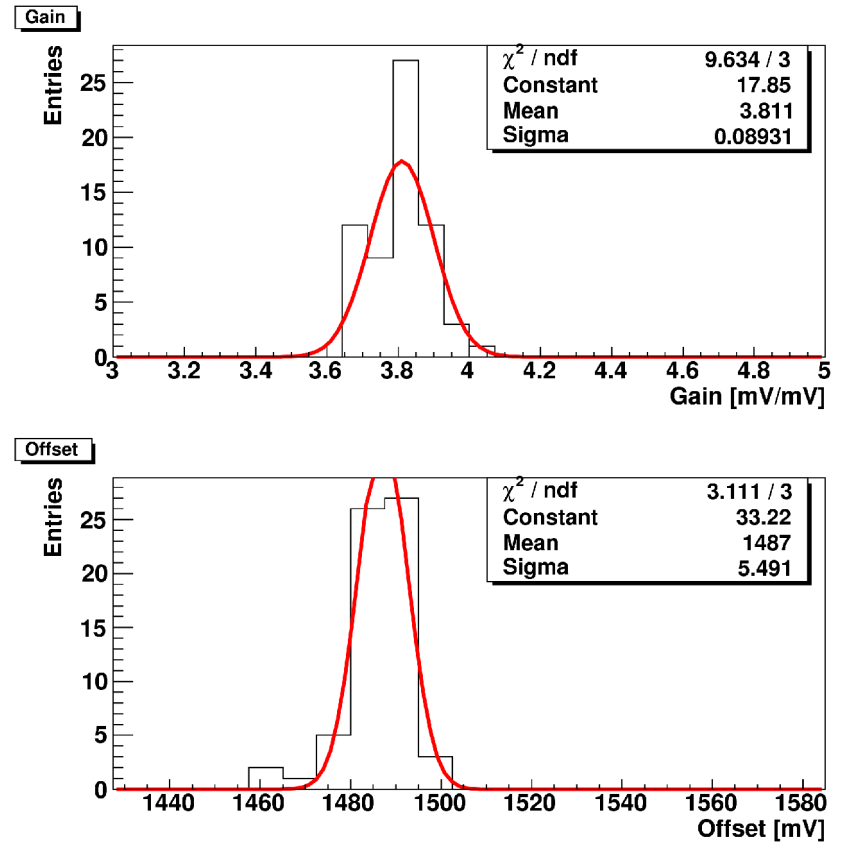
Tests on bench (digital): results



Tests on bench (digital): results



Threshold vs Input

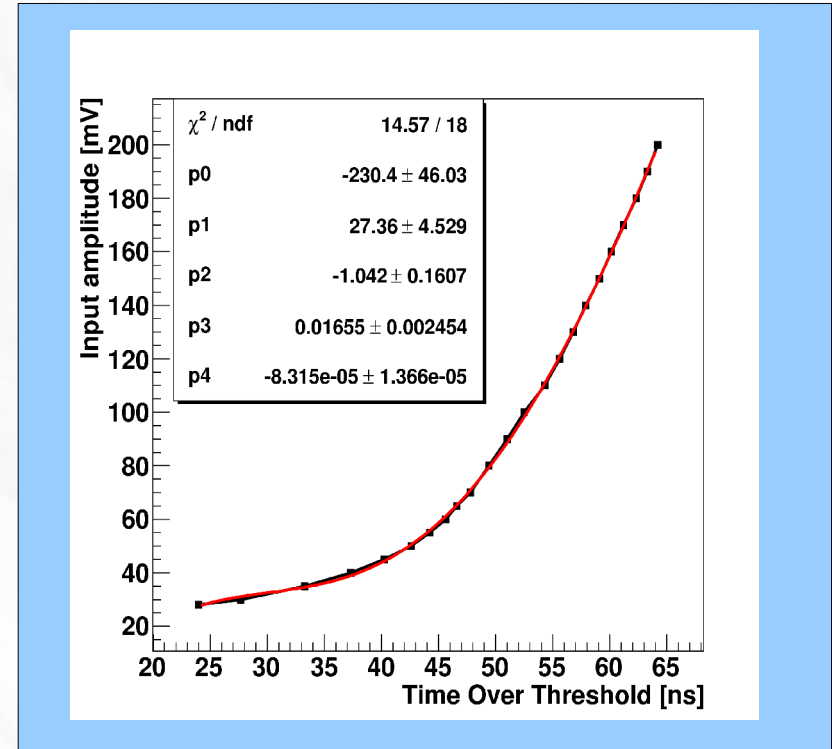
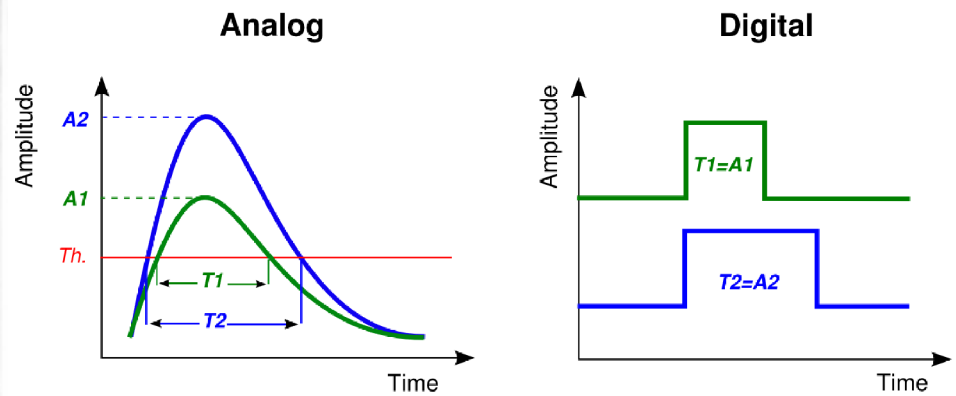


Gain & offset: uniformity $< 2\%$

Tests on bench (digital): Time Over Threshold



The MAROC ASIC allows the ToT measurement:
DIGITAL \Leftrightarrow ANALOG



Amplitude signal vs TOT (ns)