Micromegas for muography, the Annecy station and detectors

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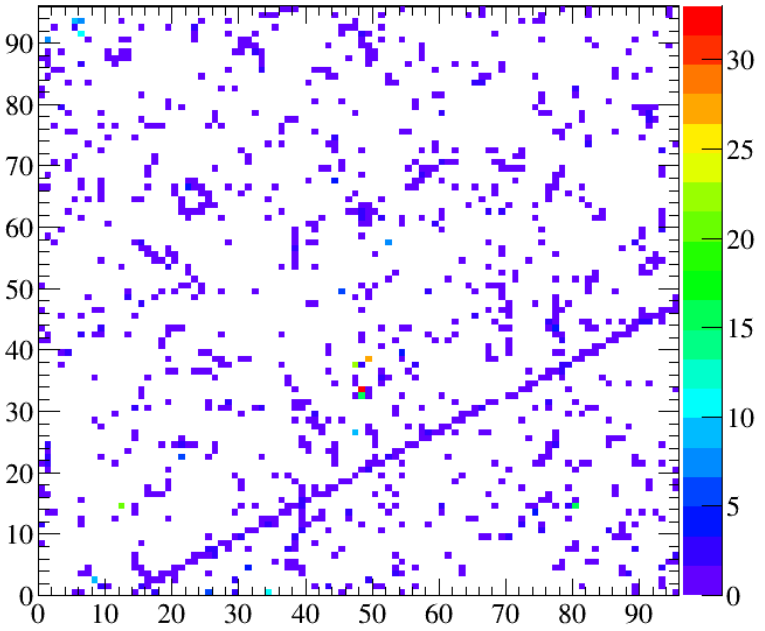
21/12/2015, Arche meeting, AUTH



Overview

- The station
- Technical review
- Detector performance (past testbeams)
- Plans in 2016

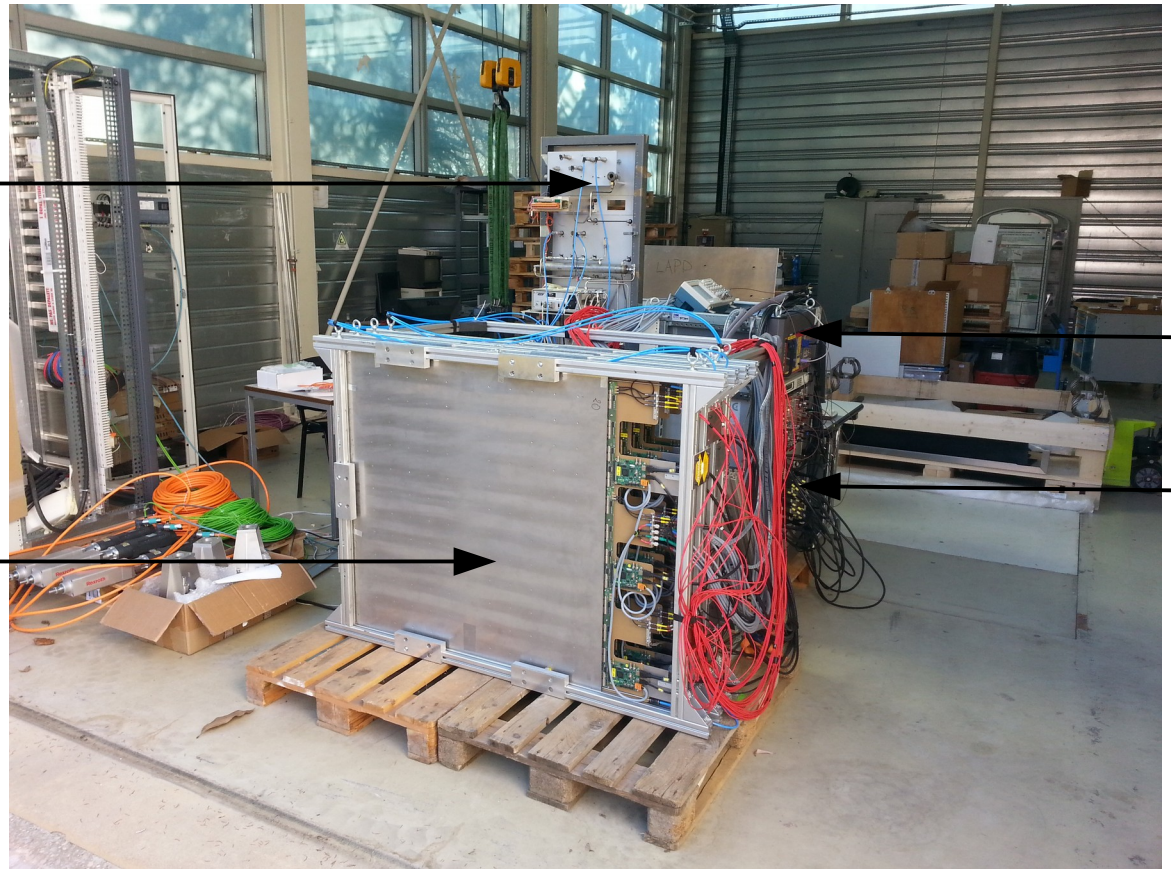
The Annecy station

4 chambers of ~ 1x1 m^2, each segmented into ~10^4 pads of 1x1 cm^2

Constructed and tested in 2012 for the CALICE SDHCAL (i.e. particle flow calorimetry)

Revived a week ago after 3 years of sleep

Current mechanical structure allow horiz. & vert. positions with 10 cm gaps between chb.

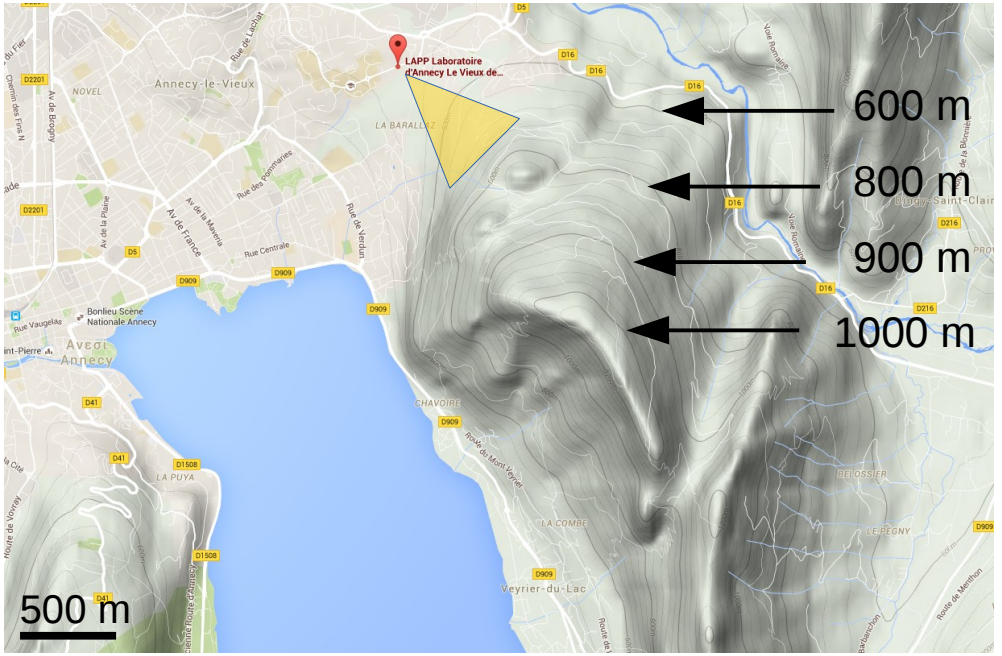


The target

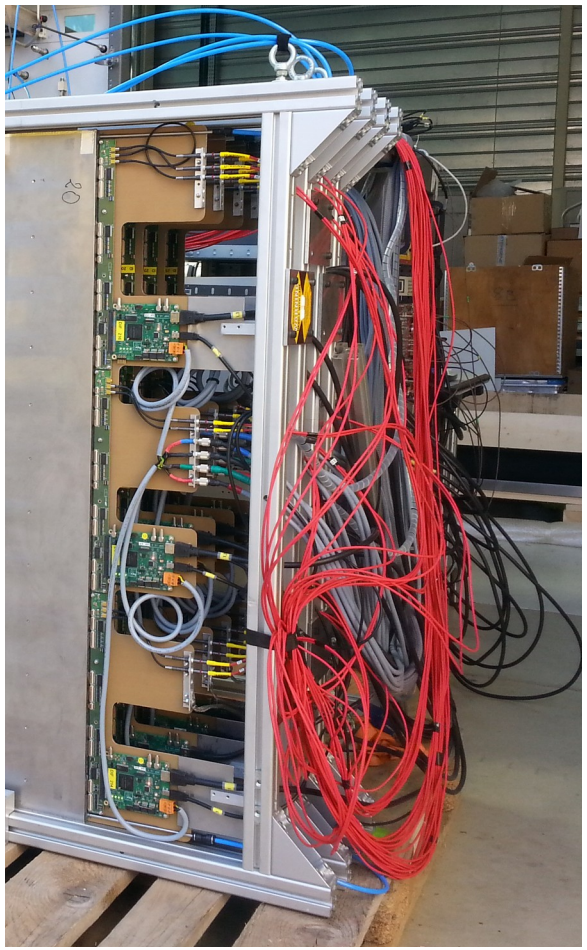
Station installed temporarilly in a mechanical assembly hall (shared with other expt.) where it is possible to point at a close-by montain (Mt Veyrier) about 1 km away.

Right now we actually point at its northen shoulder because of lack of space in the hall. Yellow structure (HESS camera handler prototype) blocking the view to the top.

The hall gate is usually closed (thin metal sheet).



The station services



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For each chamber :

Gas inlet/outlet
(Ar/CO2 90/10 flushing 1 vol./h = 3 l/h)

7 HV
6 Bulk Micromegas + 1 drift plane
Typically 500-700 V

2 LV
For ASIC and readout boards
(5V, 10 A)

3 USB
For data transfer to PC

3 HDMI
For clock distribution and synchronisation

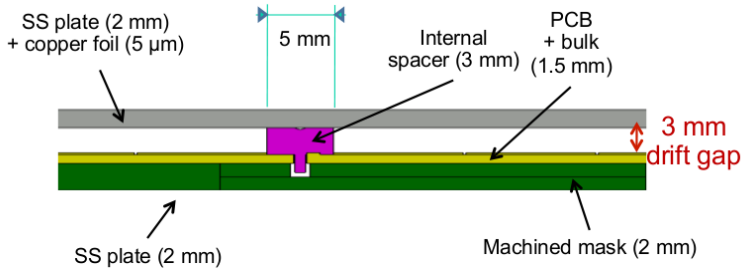
+ PC, VME crate, CAEN HV, AMREL LV

The station detectors

Prototypes designed for sampling calorimetry at a future linear collider (ILC, CLIC)

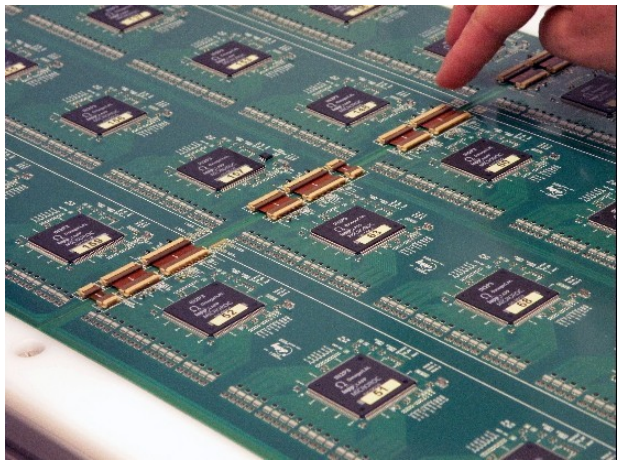
→ Compact design with front-end ASIC + Micromegas integrated on the PCB (=ASU)
→ Self-trigger electronics (hits are stored in a memory with a 200ns-timestamp)
→ Fine segmentation (pads of 1x1 cm^2)
→ Large-area (m^2- size)

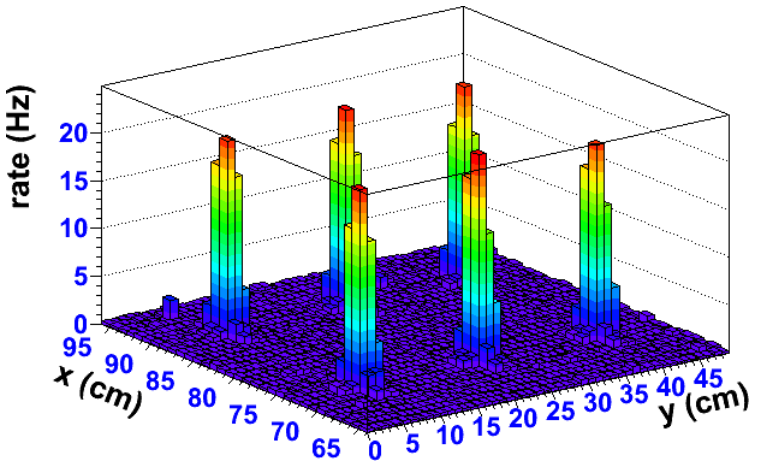
3 mm (Ar) gas gap → MPV = 15 electrons from a MIP

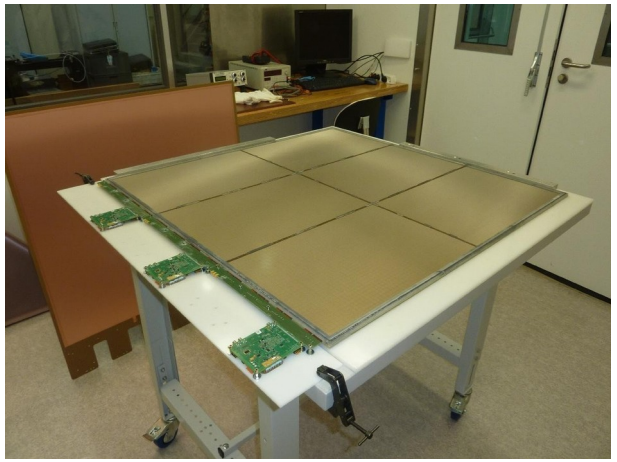


{Active Sensor Unit, 32x48 cm^2 } x 6 → 1x1 m^2 prototype

PCB with pads, font-end electronics (ASIC), flat inter-connects and Bulk Micromegas







The front-end ASIC

Charge preamplifier with a **noise of 1500 ENC** only (Cdet = 80 pF)!

After gas multiplication, MIP signal is ~ 50000 electrons

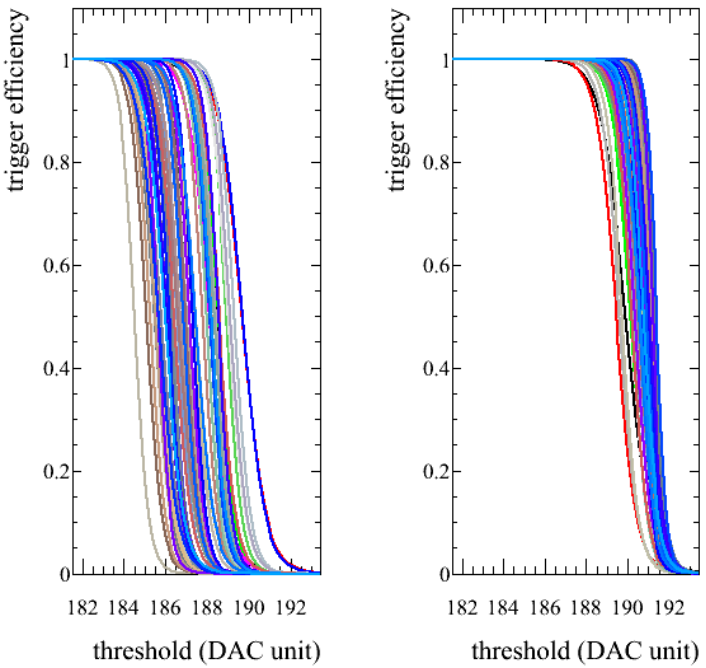
+ channel-to-channel adjustable threshold

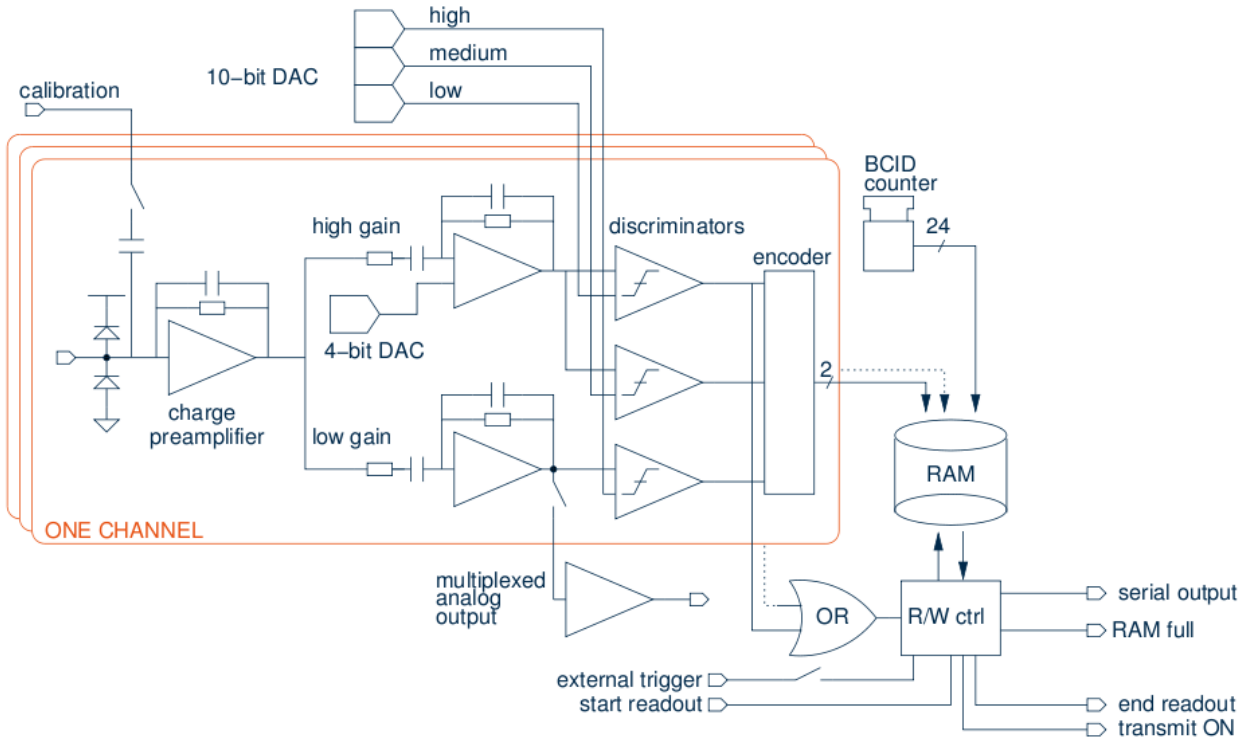
→ High sensitivity

2 shapers followed by **3 discriminators**, timestamping of 200 ns and **127 event depth memory**

Possibility to use an analogue readout, ADC on readout boards (requires an external trigger)

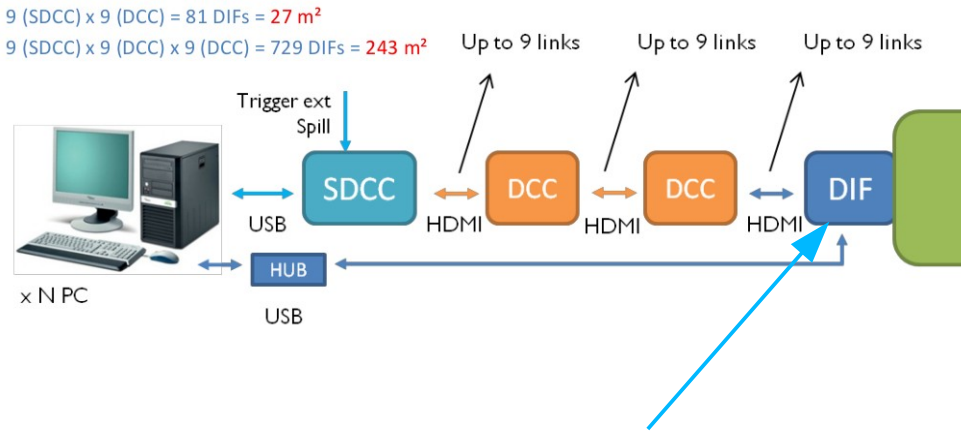
Diodes for discharge protection inside the chip (+ diodes on the PCB)





The DAQ system

We are using a DAQ developed by LAPP and IPNL for operating the SDHCAL in 2012
Compatible with RPCs and Micromegas; successfully tested up to 50 layers (half a million channels !)
Architecture based on Data Concentrator Cards (DCC) and Detector Interface boards (DIF)



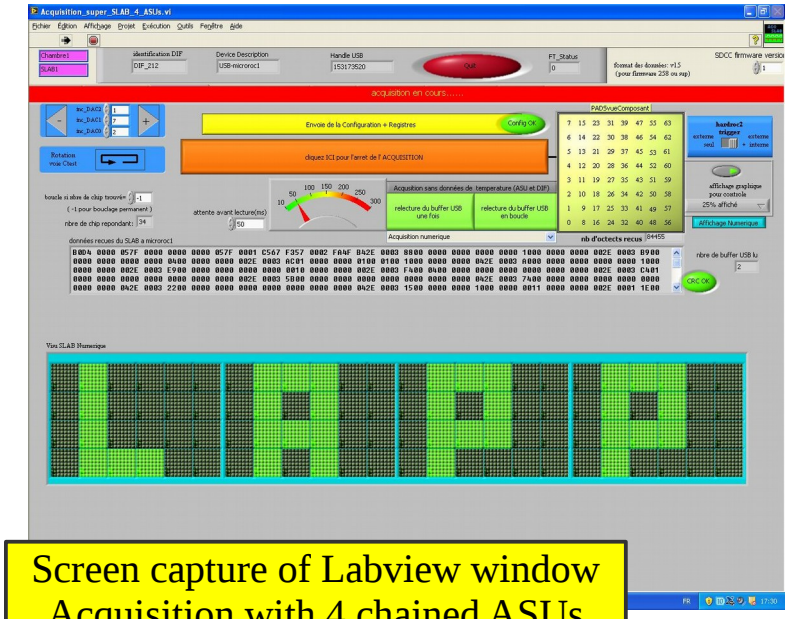
DIF: interface between DAQ and detector

Distribute power and clock to the ASIC
Write ASIC configuration, read ASIC data
Control acquisition signals (trigger, busy...)

USB port → transmit data
HDMI port → transmit clock and control signals

Software for small number of layers

Labview based program
Suitable for calibration and physics runs
Provide easy control of all ASIC parameters



Screen capture of Labview window
Acquisition with 4 chained ASUs

Operating modes

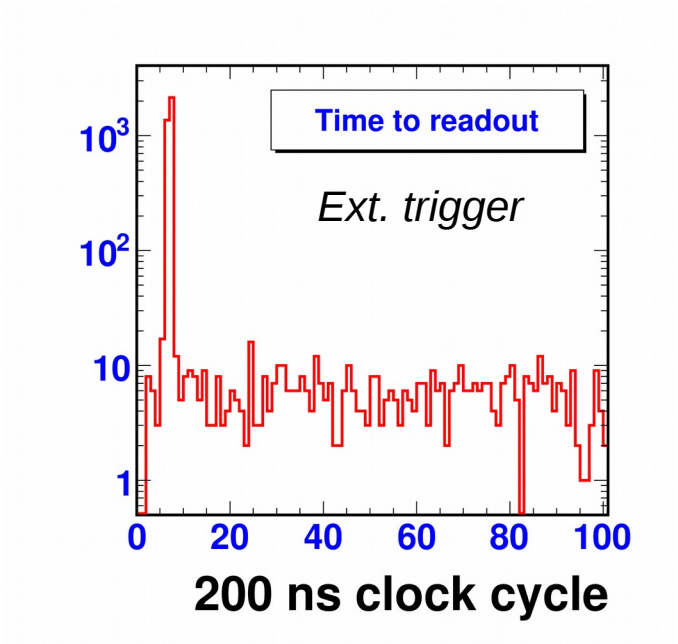
External trigger (for instance from PMT)

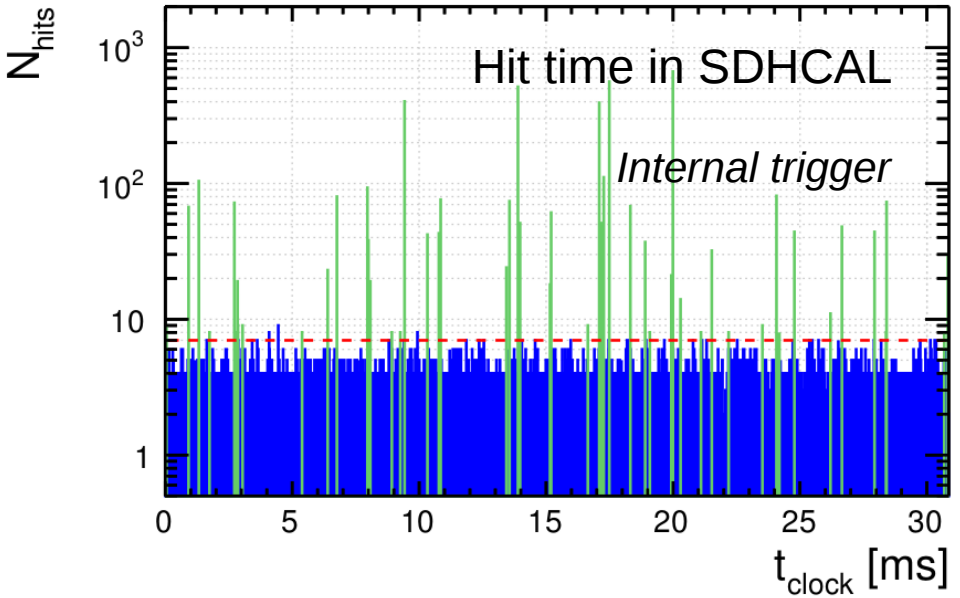
- Apply delay between trigger & readout
- Track hits easily found by looking at their time w.r.t. to readout time

Internal trigger (generated by a chip when its memory is full)

- RAMULL signal sent from 1 chip to DAQ which sends it back to all chips
- Track hits found by looking at time coincidence in all chambers
- Event created when at least 1 hit in 3 chambers.

Now, we do not have large enough scintillators to trigger so we use the RAMFULL mode. Makes event reconstruction efficiency dependent on chamber performance.

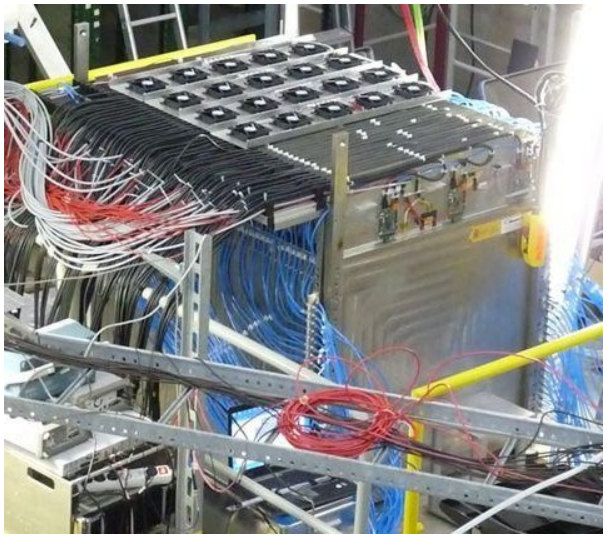




TESTBEAMS

4 Micromegas prototypes of 1x1 m^2 constructed

Tested at CERN in standalone and inside the CALICE RPC-SDHCAL



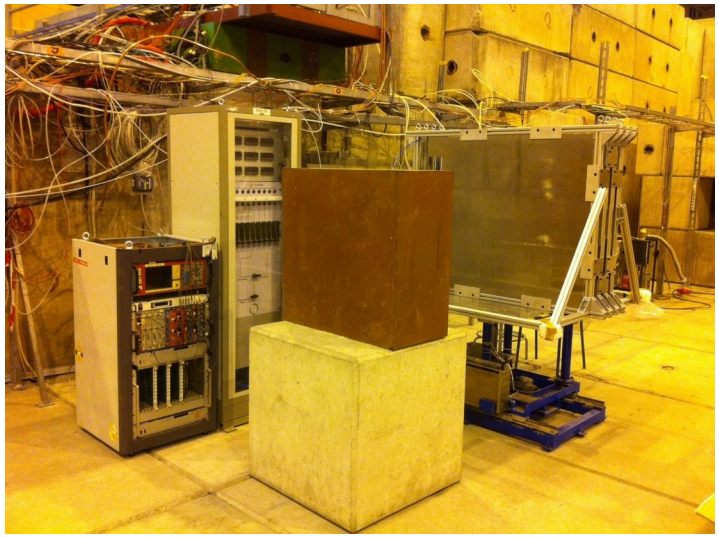
CALICE SDHCAL

Standalone test

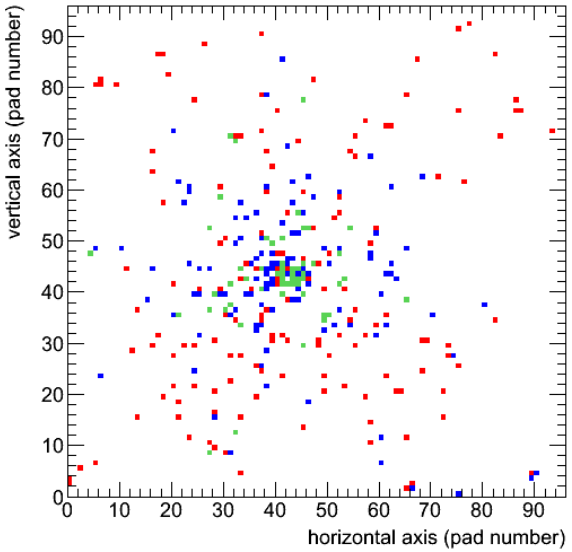
150 GeV muons and pions → operational characteristics

Excellent uniformity, noisy channel < 0.1 %

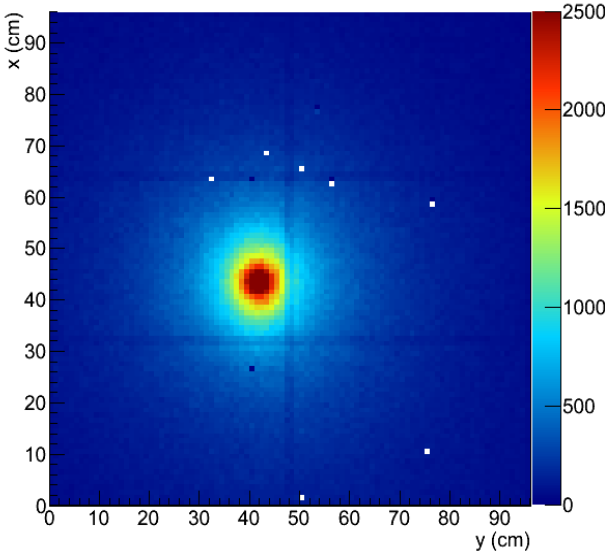
Standalone setup



1 pion shower event



50 k pion shower events



RESPONSE TO HIGH-ENERGY MUONS

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Response measurement inside the SDHCAL

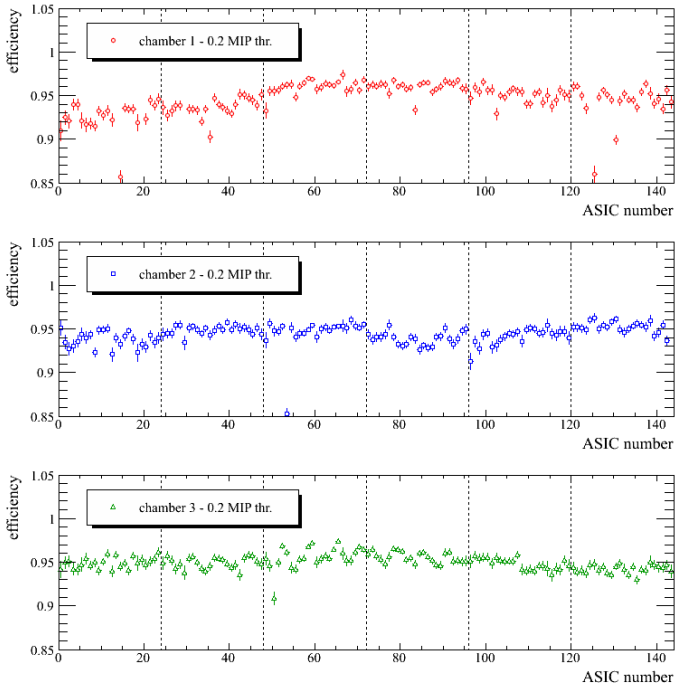
Beam muons (20-150 GeV) traverse the SDHCAL

Use RPC layers as telescope → test Micromegas layers over whole area

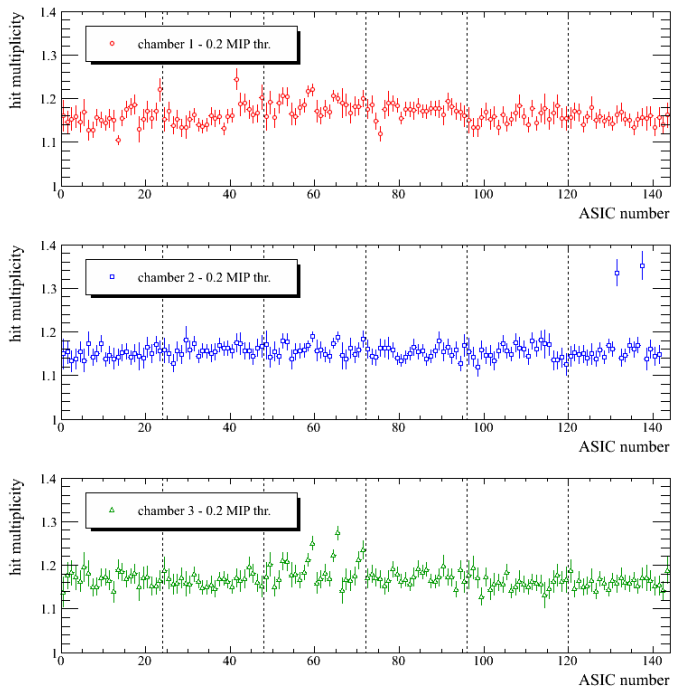
Build ASIC map → 144 regions of 8x8 cm^2

Excellent uniformity → track efficiency do not depend on position (except at ASU junctions)

Efficiency = 95%, var. 1% RMS



Multiplicity = 1.15 hit / muon



Chb. 1

Chb. 2

Chb. 3

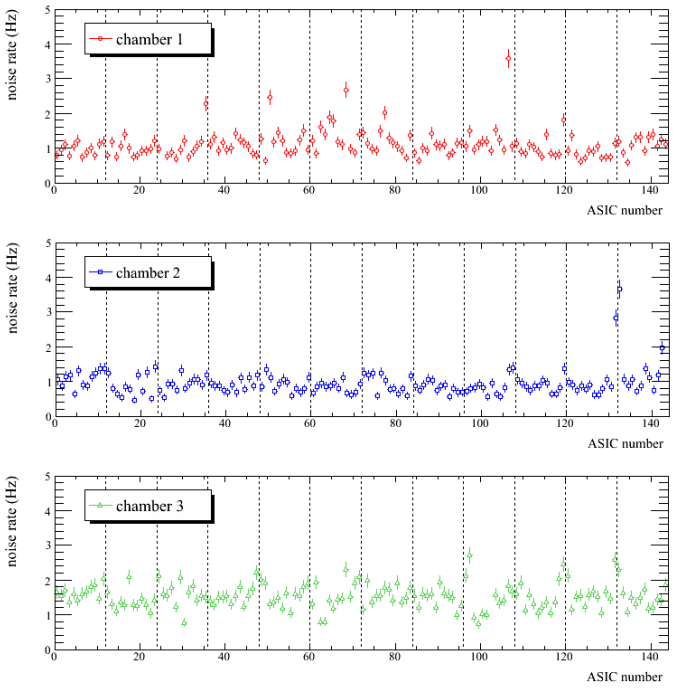
NOISE DURING OPERATION (2/2)

Readout when 1 ASIC memory is full (127 event depth) → **relevant quantity is noise rate / ASIC**

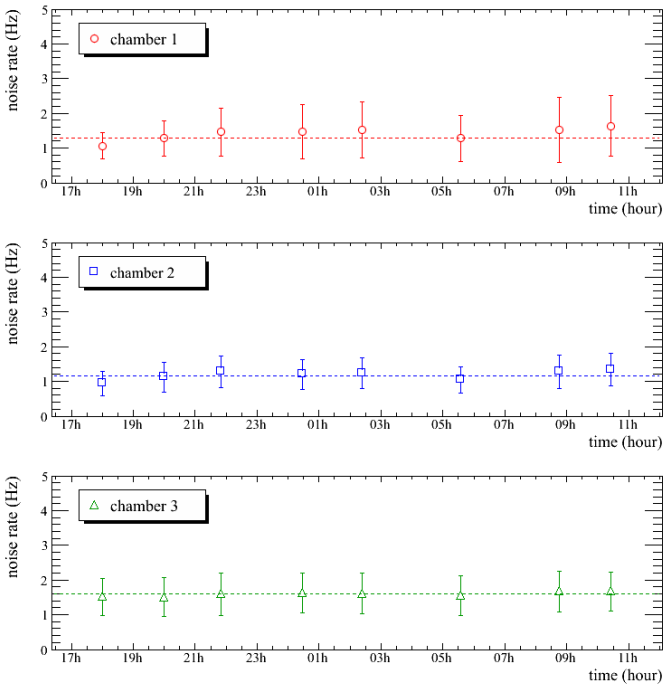
1 Hz/ASIC is achieved. Stable with time.

In a horizontal position, one expects comparable rate for cosmics muons.
Time information (200 ns clock) can be used to separate muon hits from noise hits.

Noise / ASIC ~ 1 Hz



Stability over time (17 hours)



Chb. 1

Chb. 2

Chb. 3

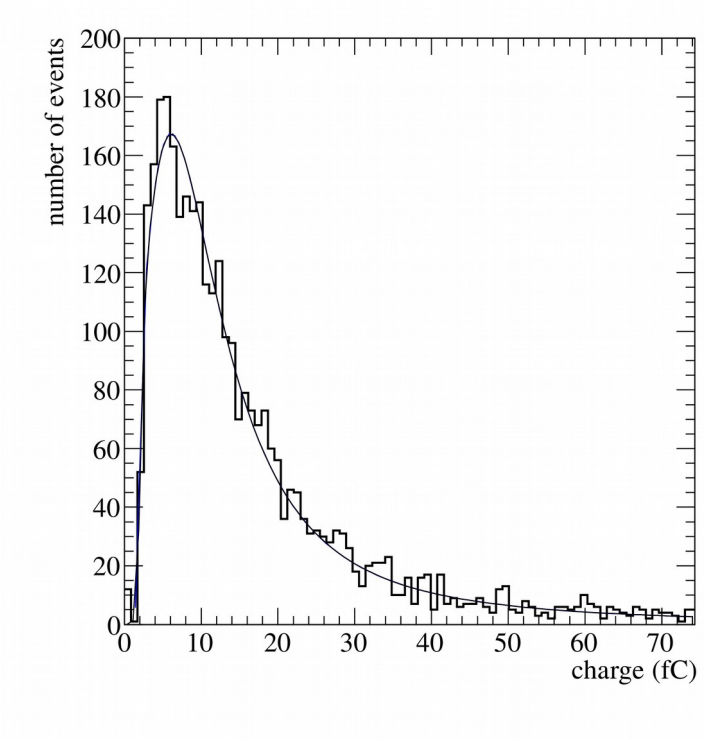
ANALOGUE READOUT

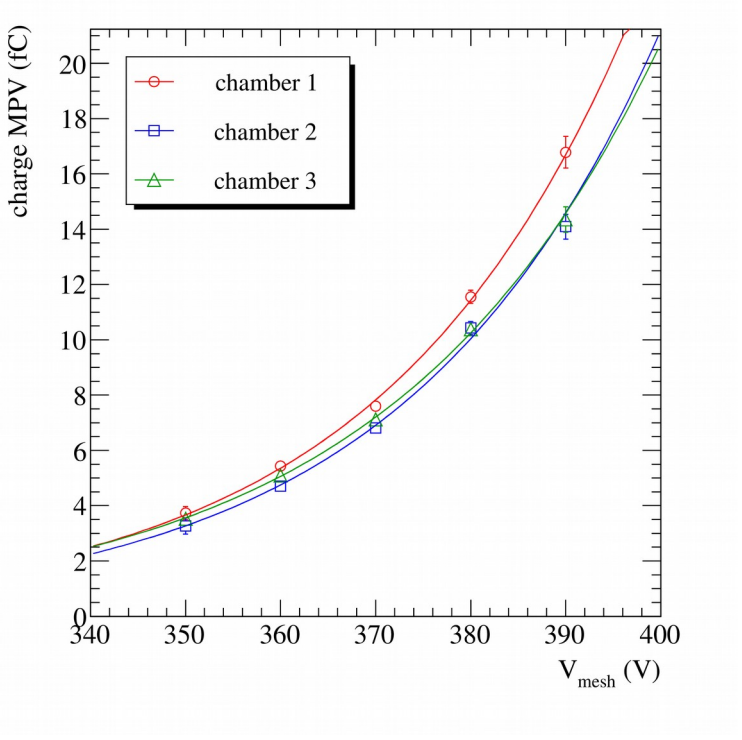
Fast scintillator+PMT signal to trigger is sent to the chips to hold the shaper voltage.

Readout all channel voltages takes time (~ 50 Hz acquisition rate for 4 chambers)

Can be used to monitor the gas gain and possibly correct the mesh voltage accordingly.

(do not work in internal trigger mode)



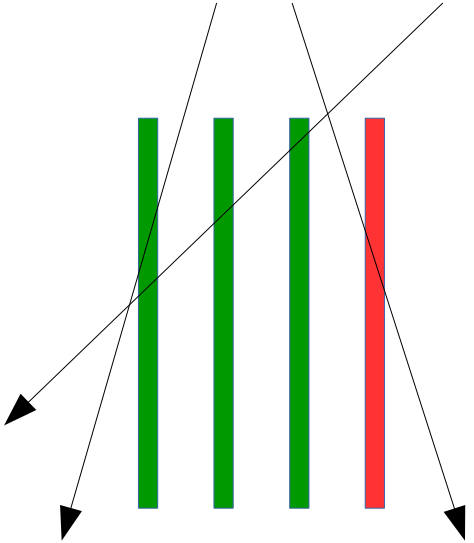


First data from the station

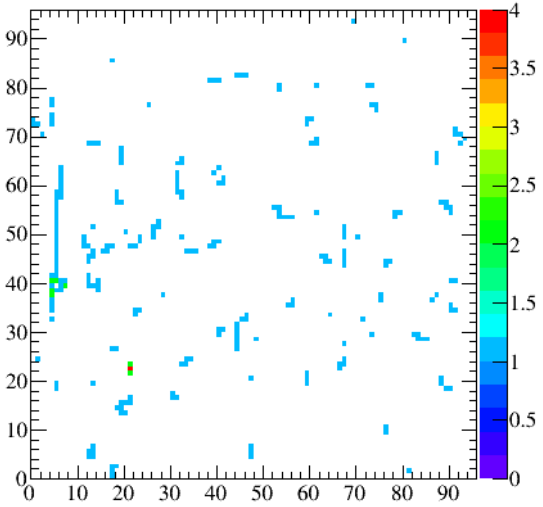
3 of 4 chambers operational, vertical position

1 problematic chamber (known since 2012)
One short on DIF readout (to be replaced)
Two meshes do not hold HV
Time for a fix !

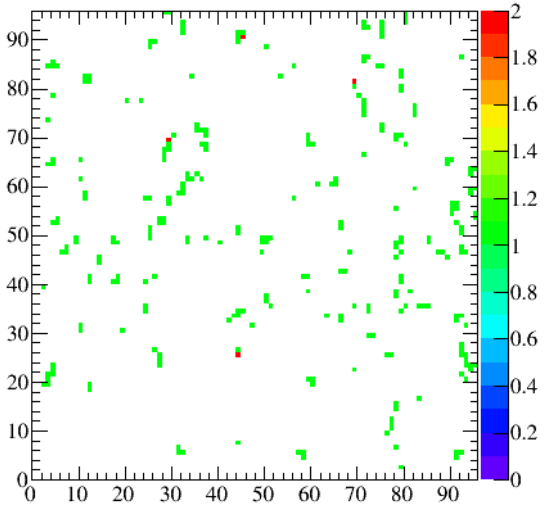
Last week : took several hours of cosmics data
at different HV to determine efficiency plateau
Offline reconstruction of events on-going.



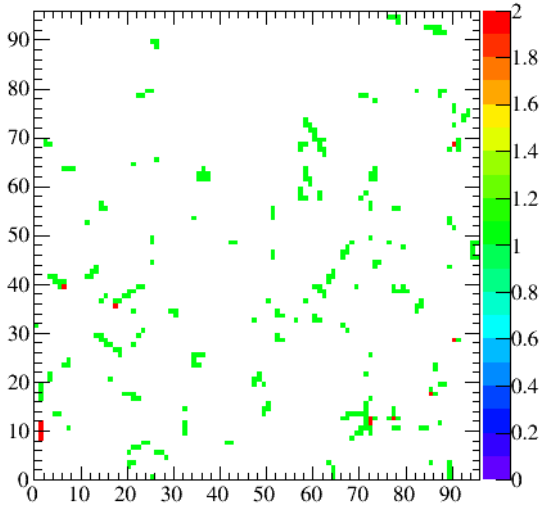
Chamber 1



Chamber 2



Chamber 3



Plans for the beginning of next year

New structure available

Enlarge gap between chambers (from 10 to 100 cm) to perform more precise measurement of track parameters.
More space in assembly hall for us starting from January (point at montain top).
Fix HV problems and replace DIF when mounting detectors on new structure.

Chamber positions

Acceptance (small gap) versus spatial resolution (large gap).
First guess : optimal depends on distance to the target. To be determined with MC.

Trigger

Would be more efficiency to triggger on grazing muons.
Mesh trigger unrealistic (24 of them !), 1x1 m^2 scintillators, hybrid detector stack (Sc.)

Slow control

Monitoring of P/T, study the possibility to correct (online) mesh voltage.

Exp. protocol

Measure (theta,phi) flux with no obstacle down to the horizon (test against MC).
Measure (theta, phi) flux when pointing at the mountain.
Produce a profile of Veyrier mountain.