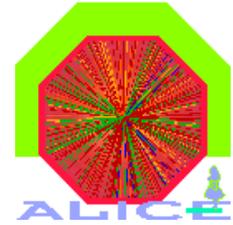


The electronics of ALICE Dimuon tracking chambers

Valérie Chambert
Institute for Nuclear Physics Orsay

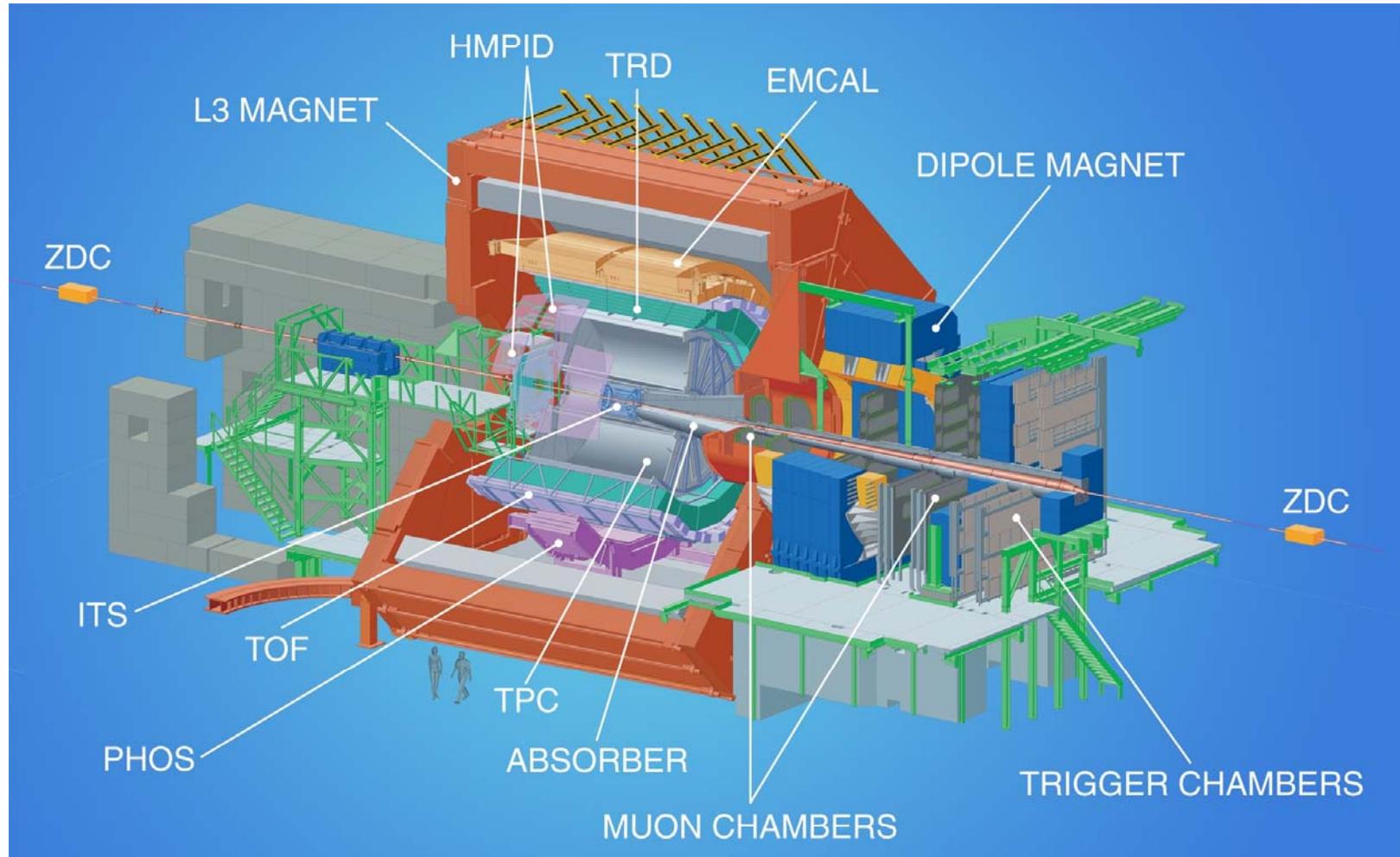
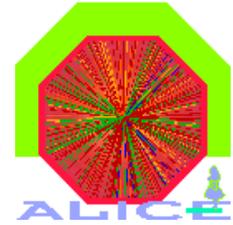
for Alice Collaboration

Outline



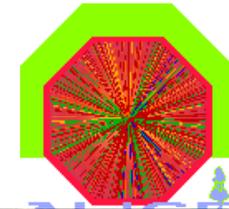
- 1) Alice and Dimuon Arm at CERN
- 2) Readout architecture
- 3) Electronics production
- 4) Integration at Cern
- 5) First data taking

ALICE experiment at CERN

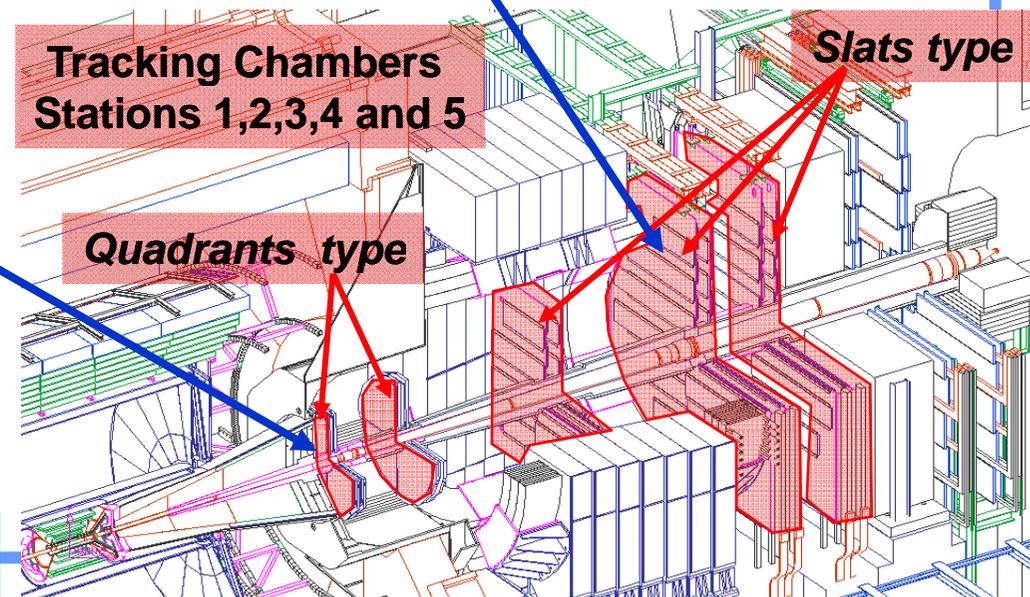
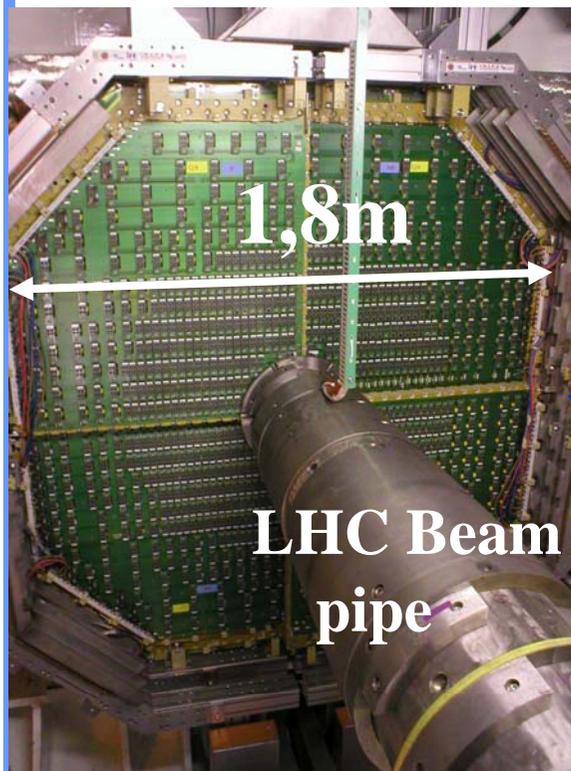
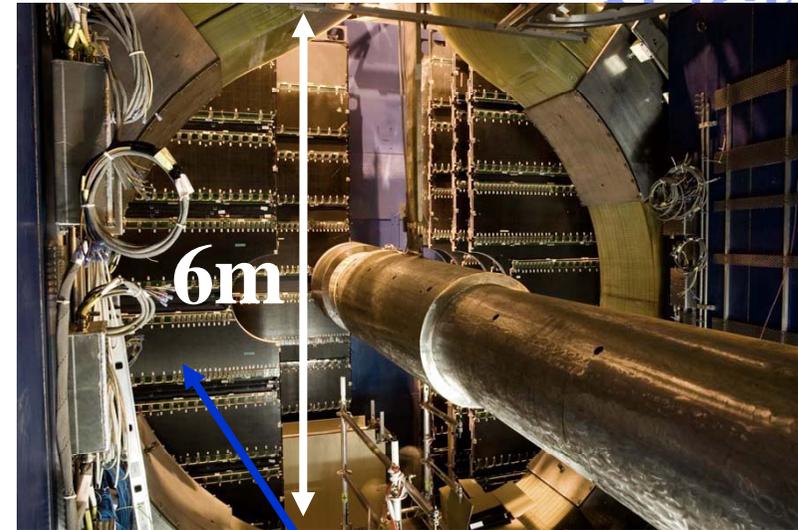


16m x 26m ; 10.000 tonnes

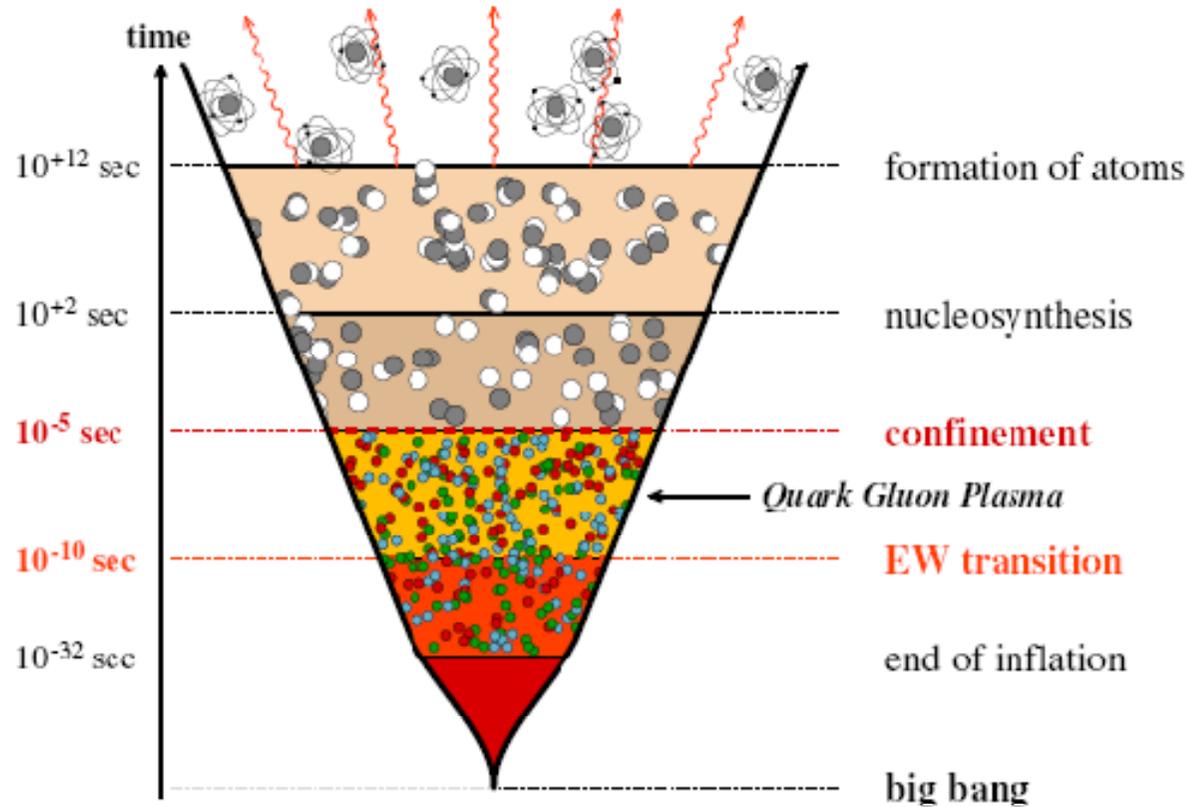
Dimuon Arm architecture



- 5 stations of two Cathode Pad Chambers $\sim 100 \text{ m}^2$
- 1.076×10^6 electronic channels



Dimuon Arm Physics : searching for evidence of Quark Gluon Plasma formation

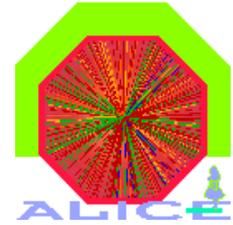


Quark-gluon plasma (QGP) is expected to be formed in heavy-ion collisions at LHC energies, as it is supposed to have been formed before...

Dimuon Arm Physics : searching for evidence of Quark Gluon Plasma formation

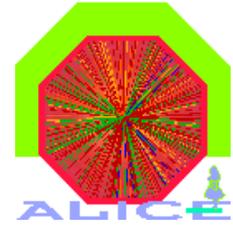
- Mainly, measurement of **quarkonia** J/ψ (c-cbar) or Y (b-bbar) and **heavy flavors** which decay in muon pairs
- Measurement by tracking : the main issue is the **mass resolution** which requires a very good spacial chamber resolution with consequences on electronics design.

Dimuon tracking responsibilities



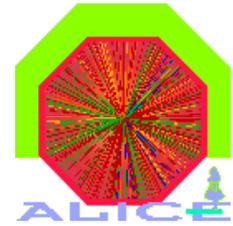
- 1) Station 1 *IPN Orsay*
- 2) Station 2 *SAHA Institute India*
- 3) Stations 345 *CEA Saclay, Subatech Nantes, INFN Cagliari, PNPI Gatchina*
- 4) MANAS circuit design *India*, MARC circuit design *INFN Cagliari*
- 5) Readout electronics design and production for the Dimuon Arm *IPN Orsay*
- 6) Embedded software design *IPN Orsay*

Electronics specifications

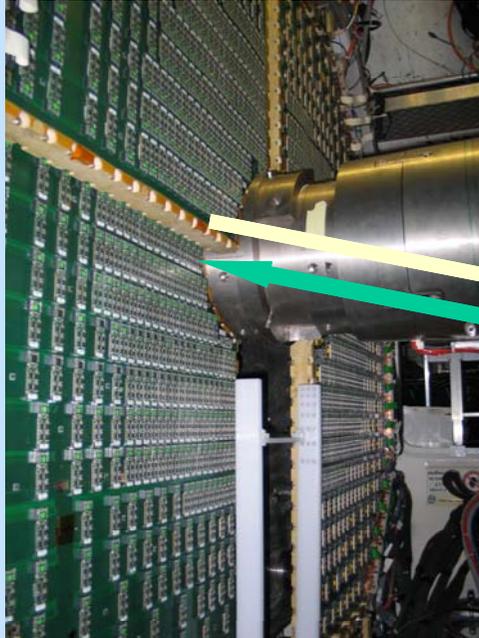


- Chamber resolution $< 100\mu\text{m}$
- $\sim 1.1 \times 10^6$ electronic channels
- 12 bits conversions, noise < 2 ADC channels
- ST1 and ST2 in a confined space \Rightarrow cooling
- FE Electronics within detector acceptance \Rightarrow consequences on boards design
- Digital crates embedded close to the detectors
- Radiations : neutrons ($E_n > 2 \text{ MeV}$) flux $\varphi_n \approx 27 \text{ cm}^{-2} \text{ s}^{-1}$ and Total Dose 500Rad for ST1 (worst case)
- Magnetic field : 7000 Gauss

Chambers readout



FE Electronics : MANU Boards
connected on BUS lines

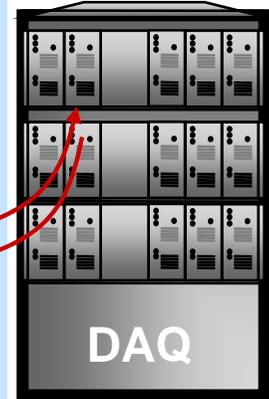


CONCENTRATOR READ-OUT
CLUSTER
UNIT SYSTEM (CROCUS)



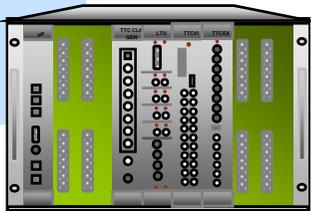
40 Gbits/s
LVDS

Optical links
25.6 Gbits/s

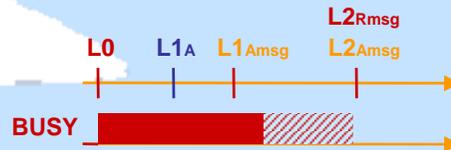


DAQ

CENTRAL TRIGGER PROCESSOR
+
TIMING TRIGGER & CONTROL



TRIGGER FRAMES



LVDS

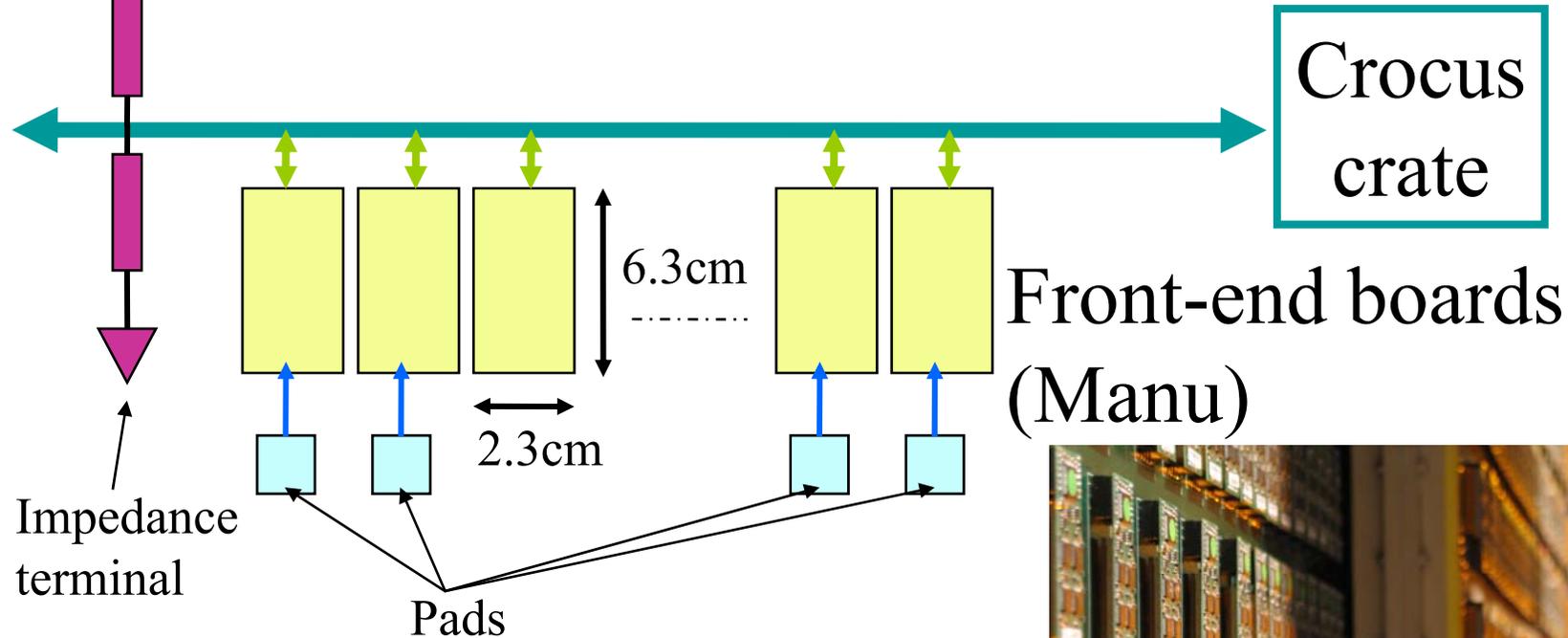
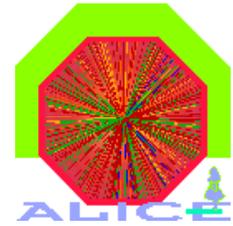


VME

Optical link & LVDS TRIGGER CRUCUS INTERFACE (TCI)

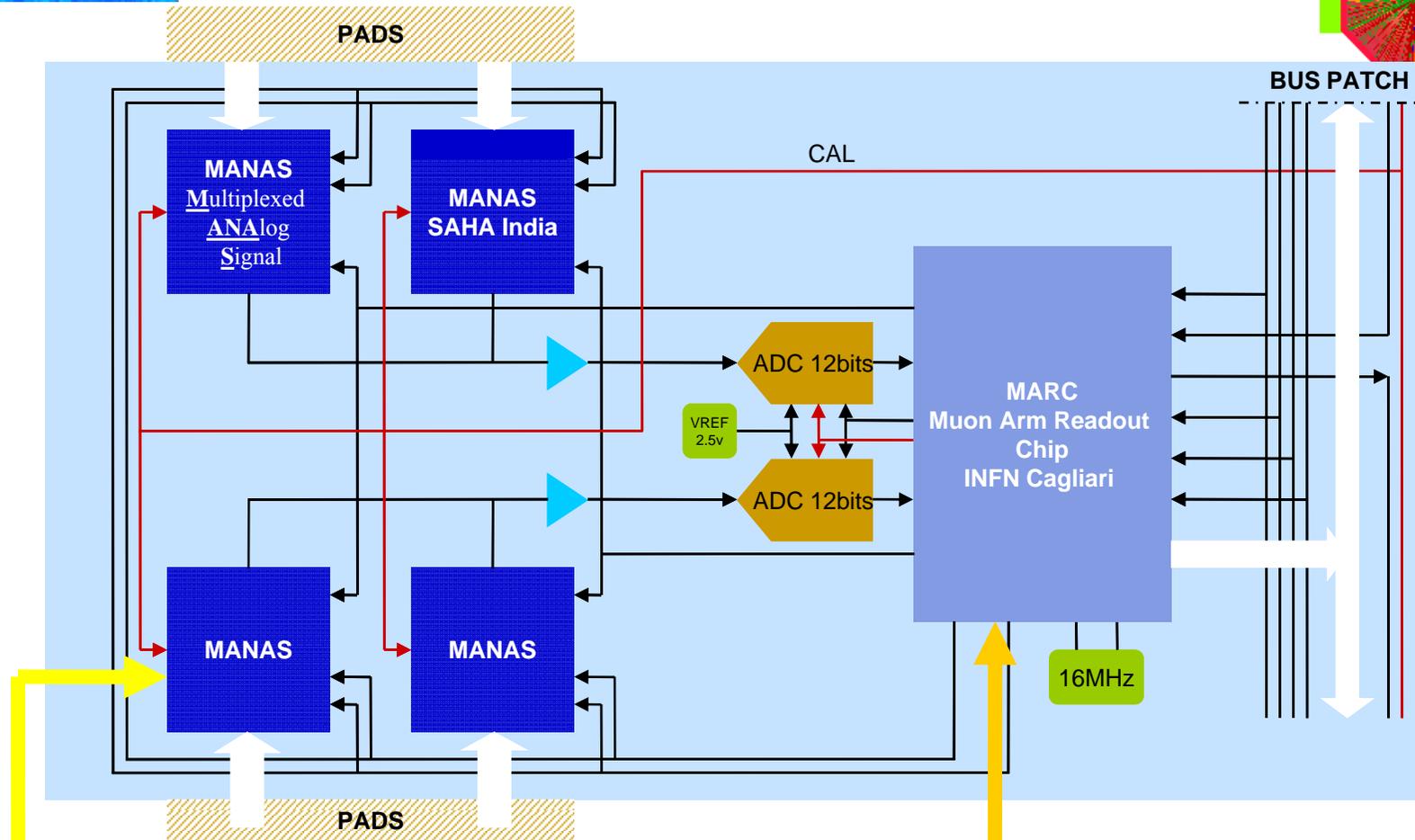
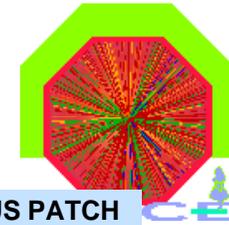
VME

A readout by BUS with a token



- No impedance matching \Rightarrow high and low thresholds to latch the signals
- Lines current tuned to get $\pm 40\text{mV}$ safety margin for each threshold

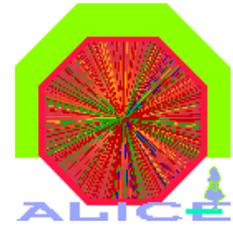
MANU Front-End boards



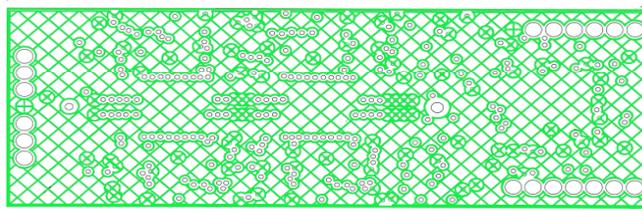
16 multiplexed channels
Preamplification, Shaping, T/H
Internal calibration capacitor for each channel

Data transfert to MANAS and to DAQ
Zero suppression
Manu ON/OFF; Manas ON/OFF

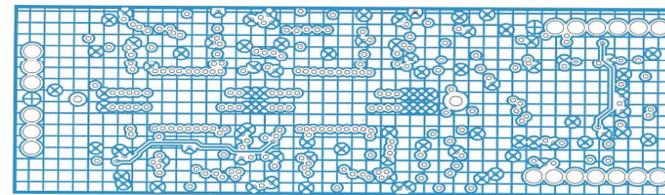
FE electronics within the detector acceptance and radiation tests



LAYER 2: GROUND

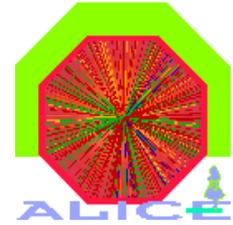


LAYER 5: GROUND



- Wire meshed ground layers to minimize the matter
- board thickness 0.5mm for 6 layers
- Radiations tests:
 - MANAS: noise and gain constant up to a 12,8kRad dose, pedestals decrease after 1kRad dose
 - MARC, 56 SEU/day \Rightarrow pedestals reloaded every 6 hours

FE Manu boards production

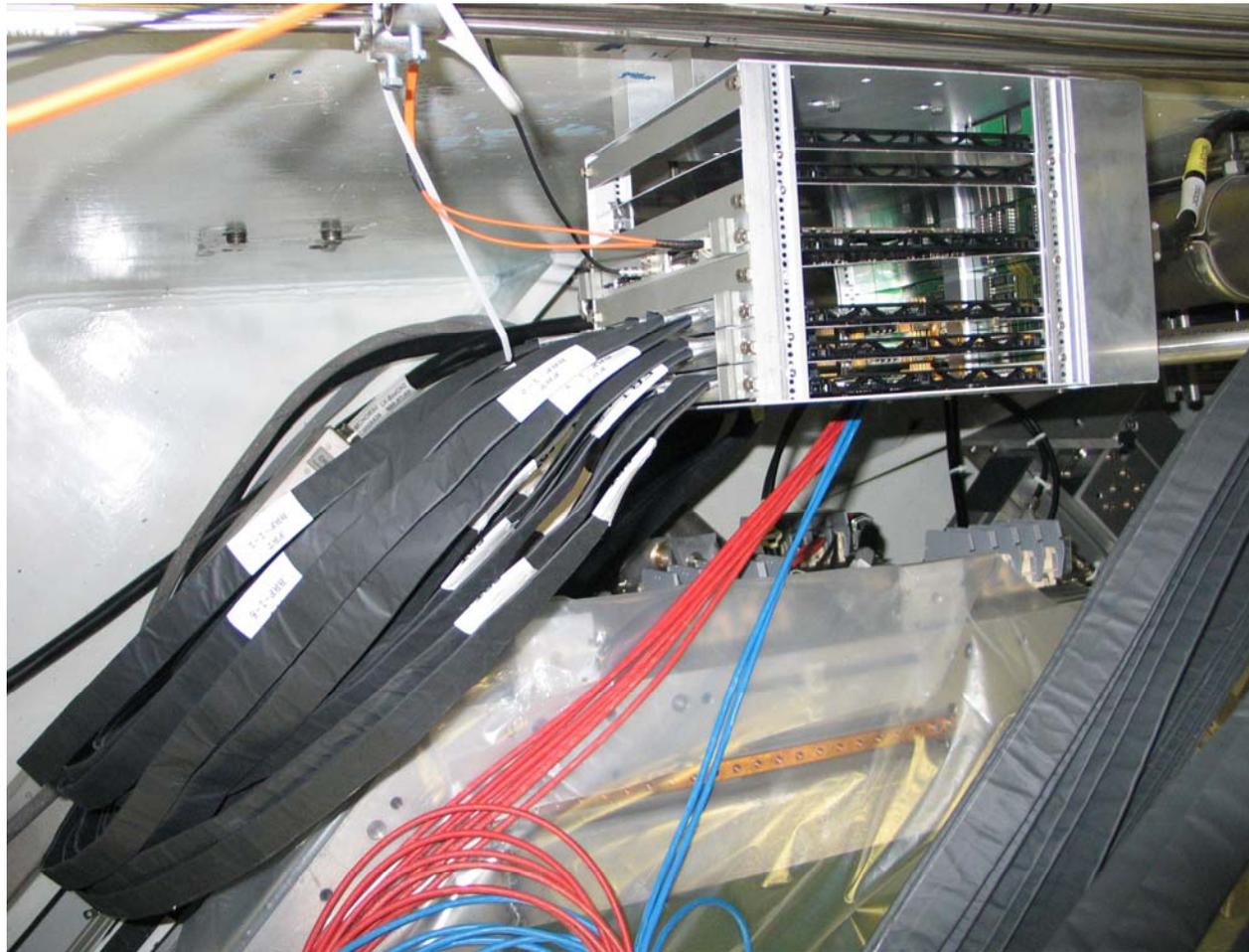
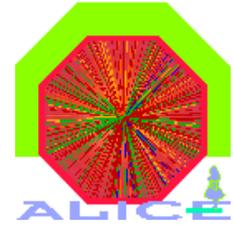


- 19.300 boards (2 types, 1.23M channels) produced, numbered and tested in industry
- Specific test benches for testing the boards functionalities
- A data base for each channel to correct channels gain dispersion : pedestal, noise, gain and internal capacitor value stored.



$\langle G \rangle = 3.3 \text{ mV/fC}$, from $G = 3.1 \text{ mV/fC}$ to $G = 3.45 \text{ mV/fC}$

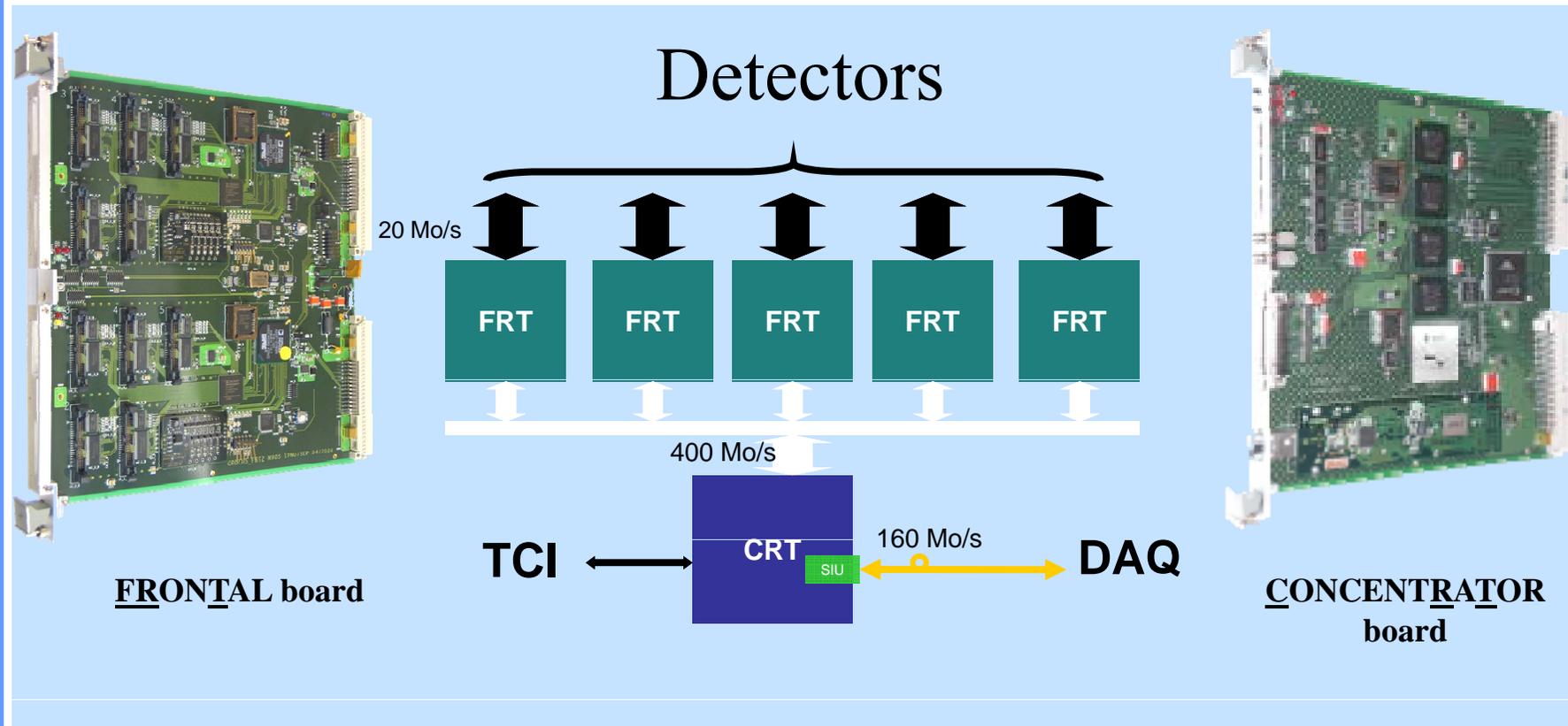
Digital embedded crate CROCUS



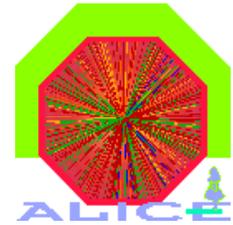
CROCUS crates



4 for one Station (20 = 100 FRT+20 CRT+spare)
 Embedded calibration electronics for gain correction



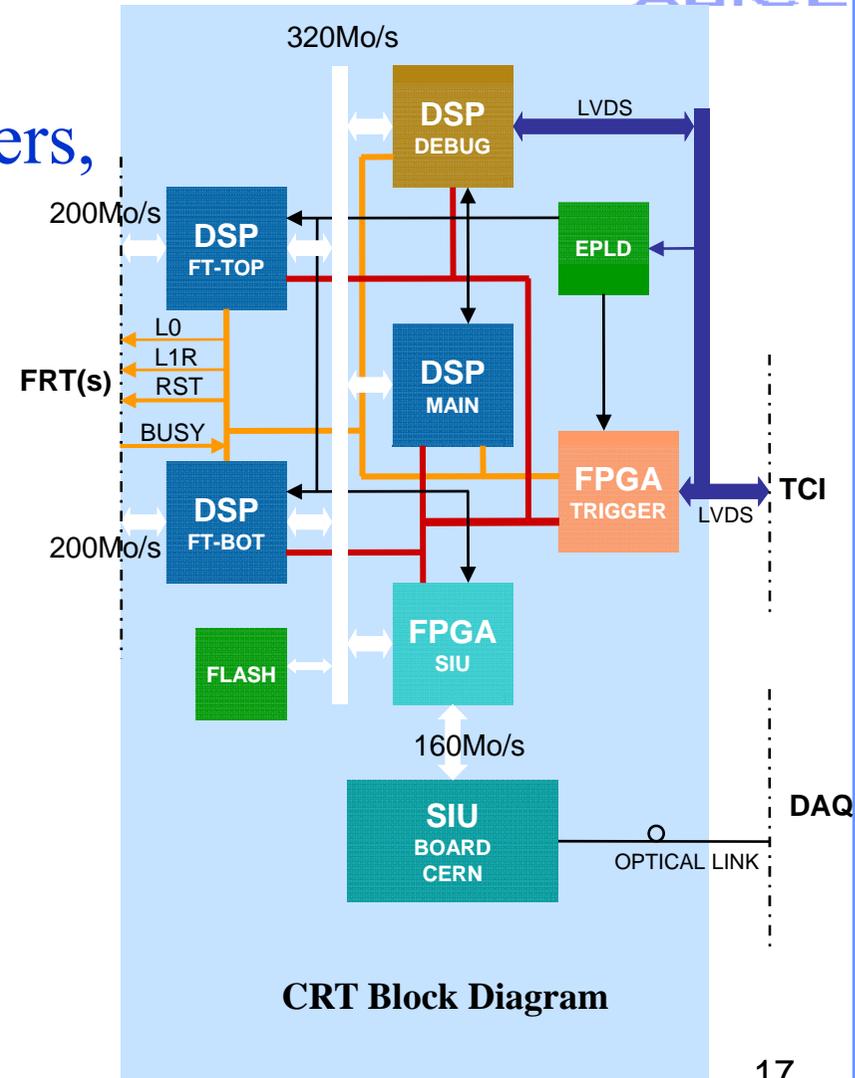
Trigger Crocus Interface



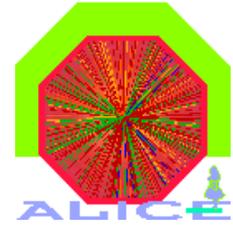
- Trigger and Busy management for Dimuon
- 1 crate for the Dimuon trigger dispatching
- 1 FTD board for each Station, 1 FFT dispatcher board



- Magnetic field: no ferrite filters, amagnetic materials
- Embedded crate: specific mechanical design
- Radiation hardness tested:
 - DSP, FPGA: 1 SEU every 5 hours in ST1 and 2, no errors in ST345, nor DSP or FPGA crash



Integration at CERN



- Mapping of the detectors because of channels gain dispersion: both FE board and detectors location numbering
- We were very careful on EMC issues (ST12):
 - Power Supply filtering
 - Grounding (cables, detectors, crates)
- Confined environment: cooling simulations performed with a result $T < 40\text{C}$ (ST12)

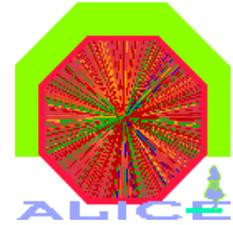
PS filtering boxes



3 100nF Schaffner capacitors
per box

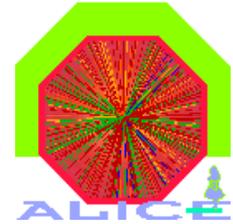


ST1 tests summary



- Beam tests \Rightarrow spacial resolution $\sim 50\mu\text{m}$
- Each board (≈ 21.000) was individually tested
- After ST1 assembly, there were cosmic runs at lab with all the system

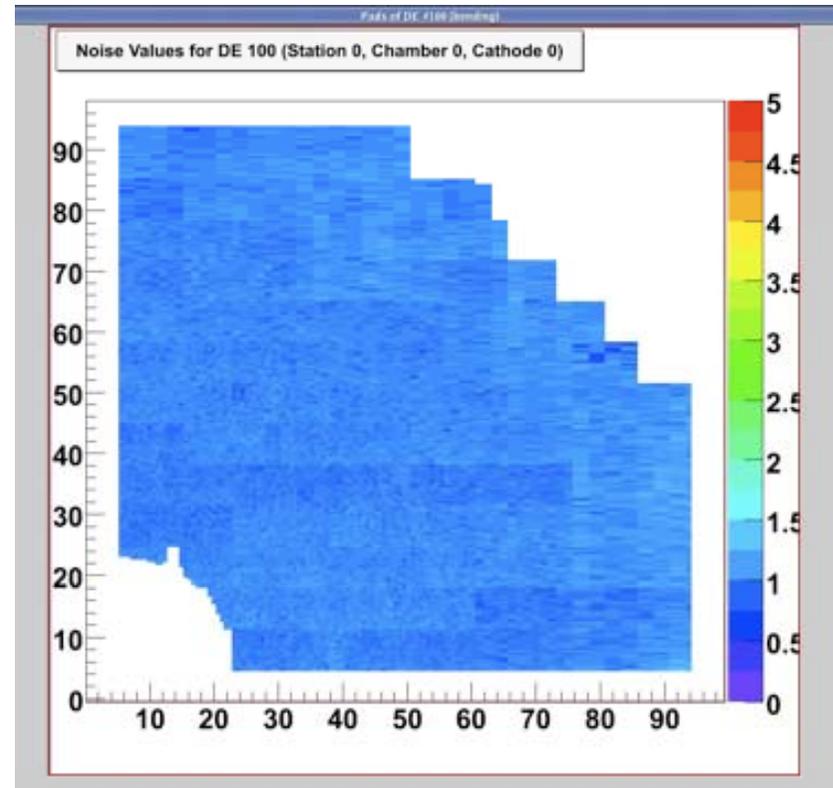
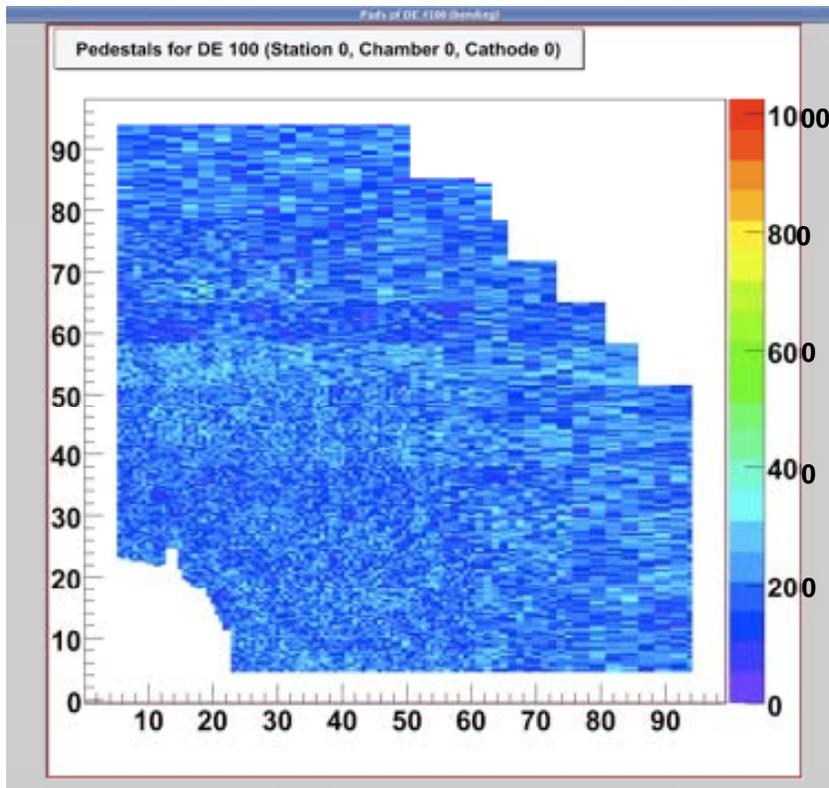
Pedestals run



No HV, 24h00 test, random trigger rate 2.5kHz

Pedestals ~ 300 ADC

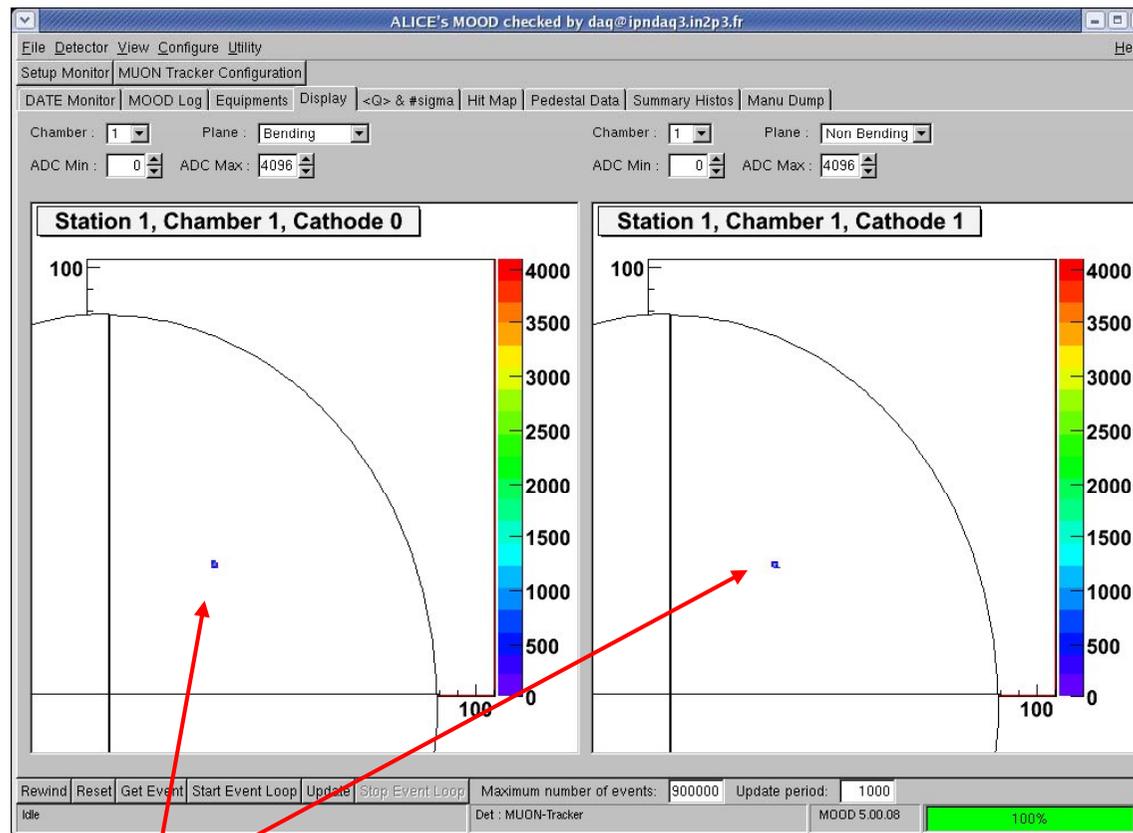
Noise ~ 1.2 ADC = 0.73mV = 1300e⁻



Cosmic run at Orsay

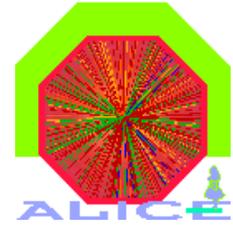


HV 1600 V, zero suppression ON



Particle hit

ST1 tests summary

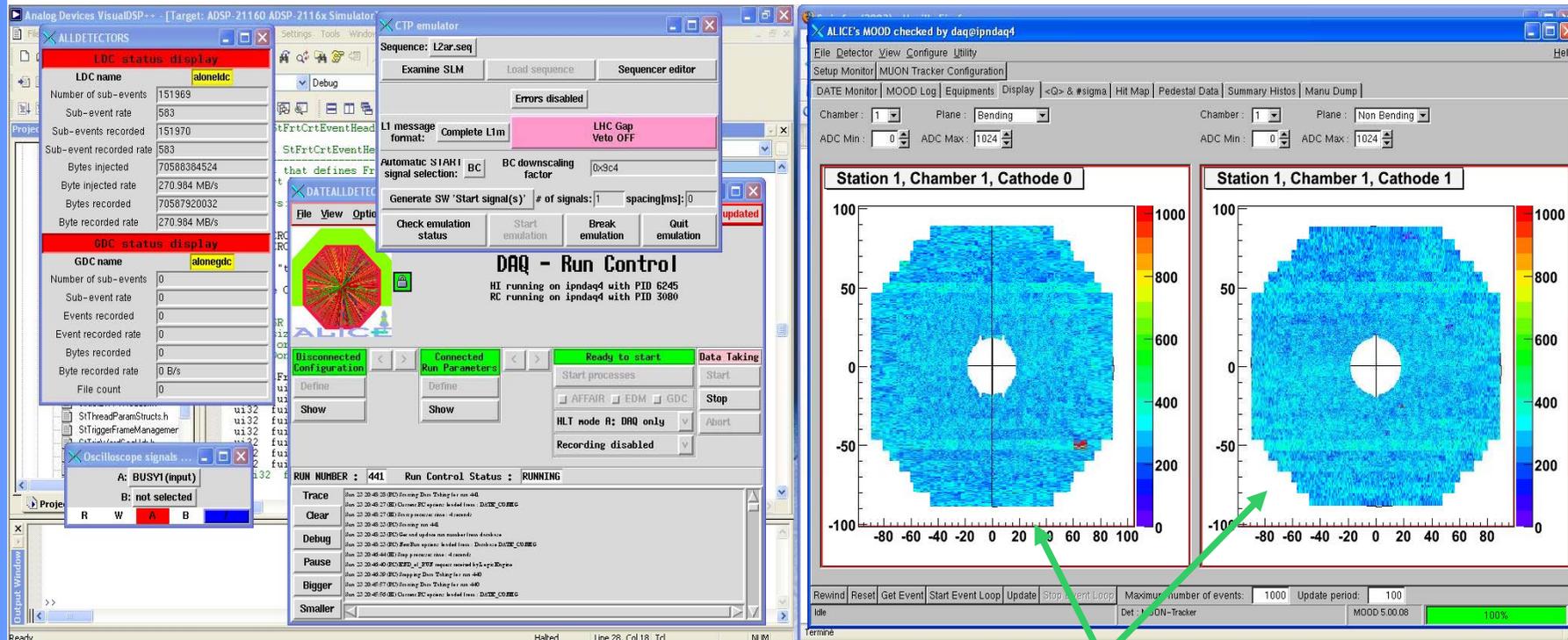


- Beam tests \Rightarrow spacial resolution $\sim 50\mu\text{m}$
- Each board (≈ 21.000) was individually tested
- After ST1 assembly, there were cosmic runs at lab with all the system
- All Dimuon detectors were tested in a surface building at CERN
- Installation and tests in the cavern

Readout tests in ALICE cavern

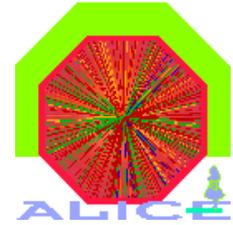


- Septembre 25th 2007: full ST1 readout implemented within ALICE DAQ



115.200 channels

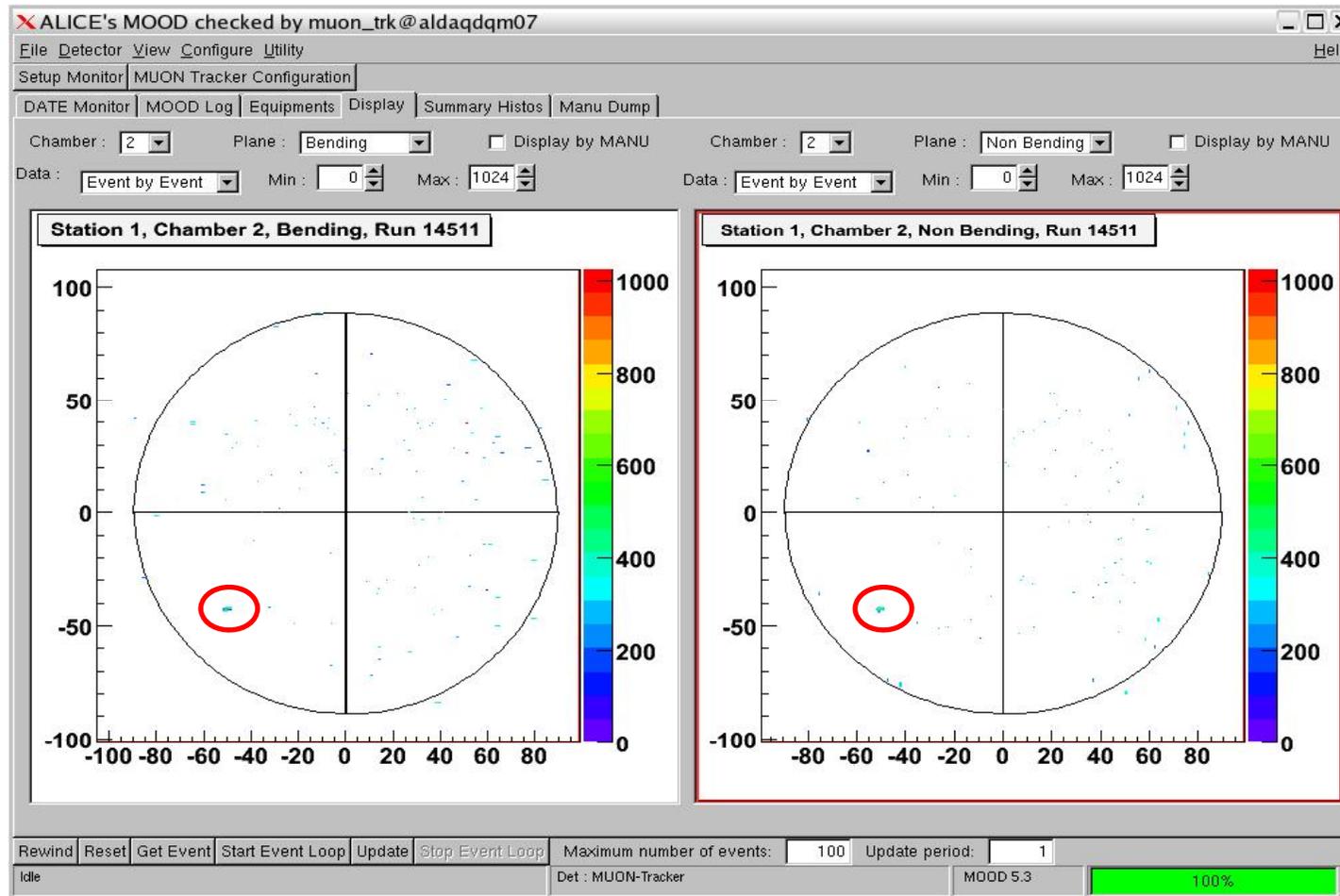
ST1 tests summary



- Beam tests \Rightarrow spacial resolution $\sim 50\mu\text{m}$
- Each board (≈ 21.000) was individually tested
- After ST1 assembly, there were cosmic runs at lab with all the system
- All Dimuon detectors were tested in a surface building at cern
- Installation and tests in the cavern
- First cosmic run at Cern December 2007

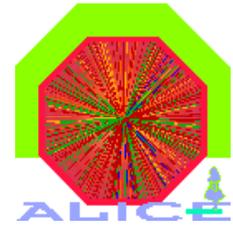
Run 14511 : Hit in chamber 2

Cosmic run Dimuon Decembre 2007



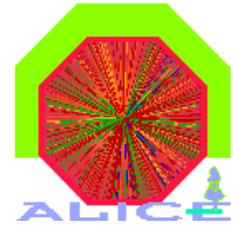
Temperature measurements performed with SC system: $\langle T \rangle = 35\text{C}$

ST1 tests summary

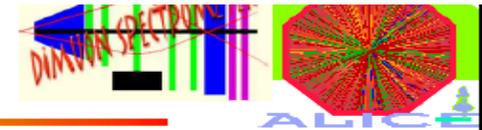


- Beam tests \Rightarrow spacial resolution $\sim 50\mu\text{m}$
- Each board (≈ 21.000) was individually tested
- After ST1 assembly, there were cosmic runs at lab with all the system
- All Dimuon detectors were tested in a surface building at cern
- Installation and tests in the cavern
- First cosmic run at Cern December 2007
- First Dimuon track in March 2008

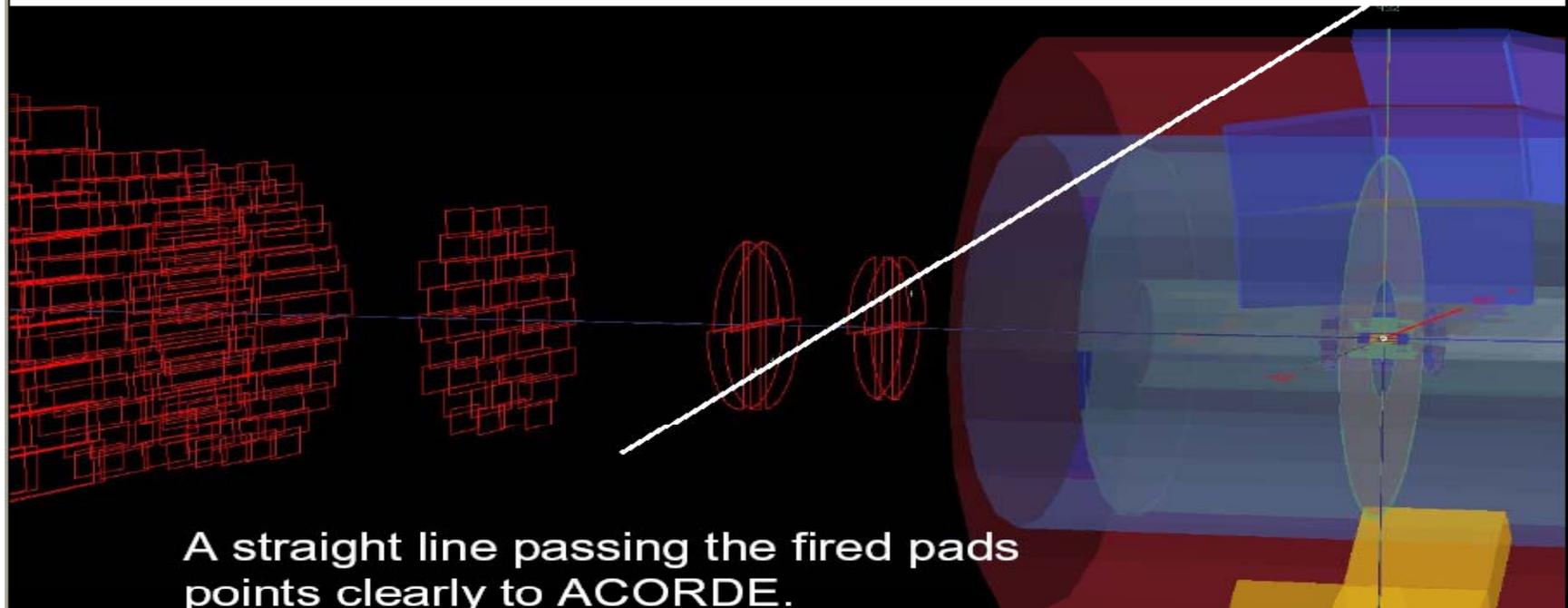
Track : march 2008



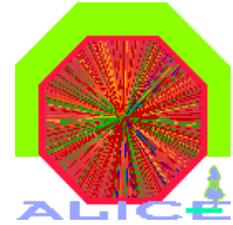
Run 23549 (HLT analysis, I.Das)



more @ <http://www.cern.ch/indranil.das/dimuon-collaboration>



Conclusion



- ~ 580.000 channels commissioned
- Power consumption: 11mW/channel
- Chamber resolution $\sim 50\mu\text{m}$
- Dimuon software integrated in Alice DAQ

We are looking forward
to getting tracks with
LHC beam !

