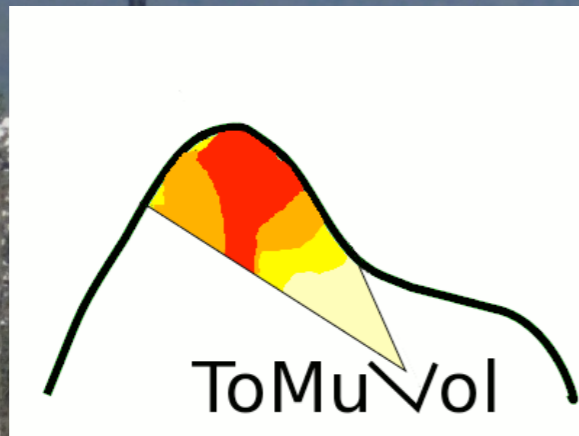


# Volcano Radiography with GRPCs

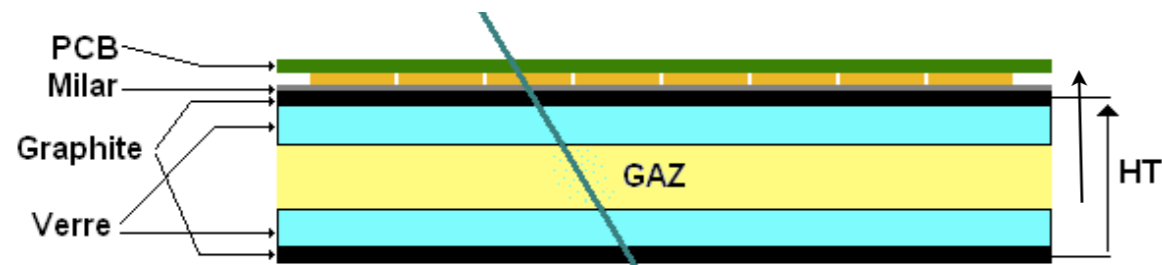
Cristina Cârloganu  
LPC Clermont-Ferrand  
On behalf of the Tomuvol Collaboration



**IN2P3**  
Les deux infinis



Avalanche mode: total mean MIP charge 2.6pC, RMS: 1.6pC

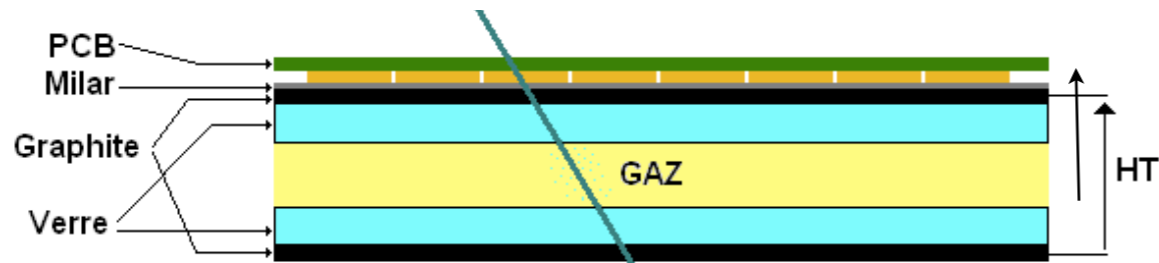


Gas: 93% TFE, 5% Isobutane, 2% SF<sub>6</sub>

M. Bedjidian et al, "Performance of Glass Resistive Plate Chambers for a high granularity semi-digital calorimeter", JINST 6:P02001,2011



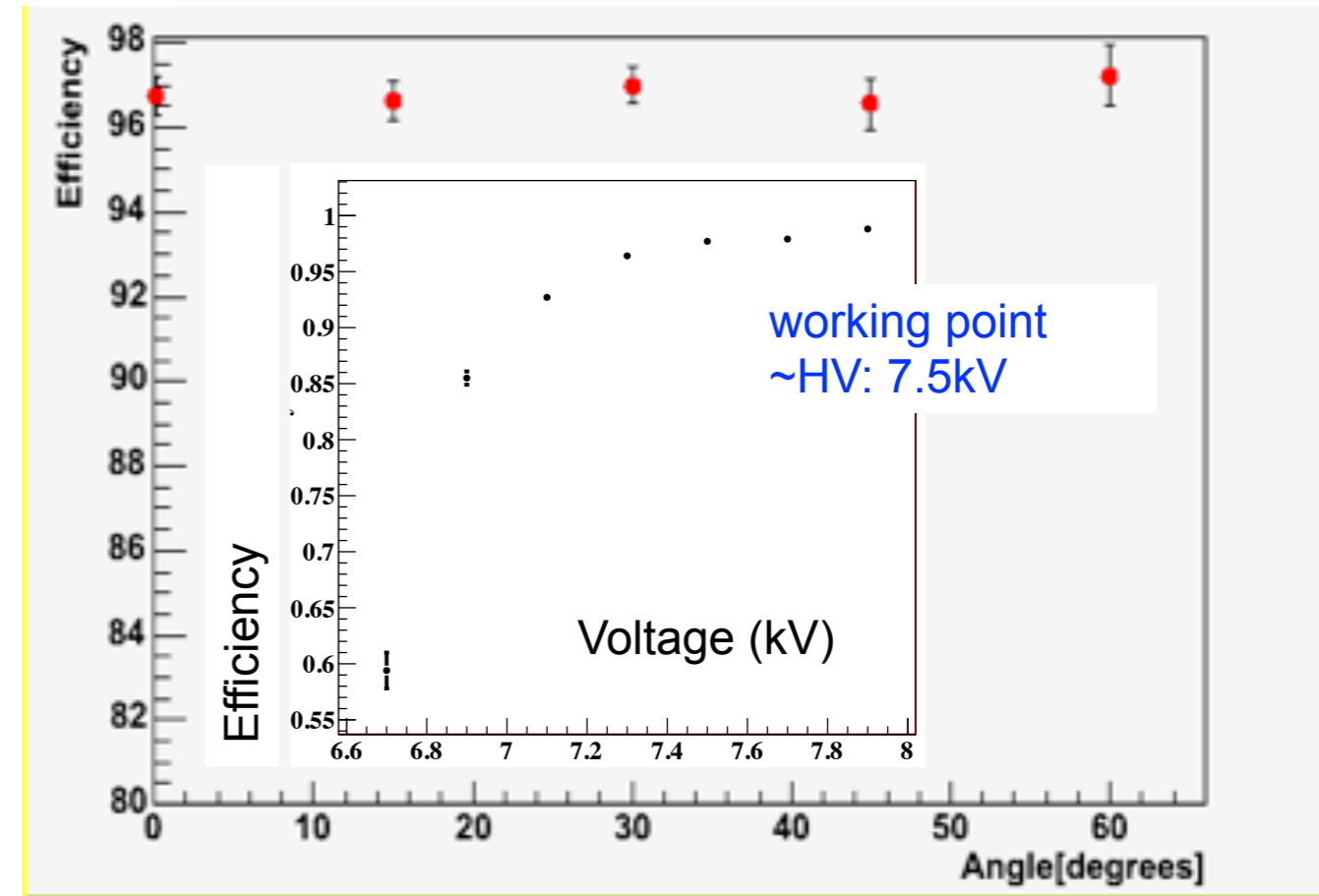
Avalanche mode: total mean MIP charge 2.6pC, RMS: 1.6pC



Gas: 93% TFE, 5% Isobutane, 2% SF<sub>6</sub>

M. Bedjidian et al, "Performance of Glass Resistive Plate Chambers for a high granularity semi-digital calorimeter", JINST 6:P02001,2011

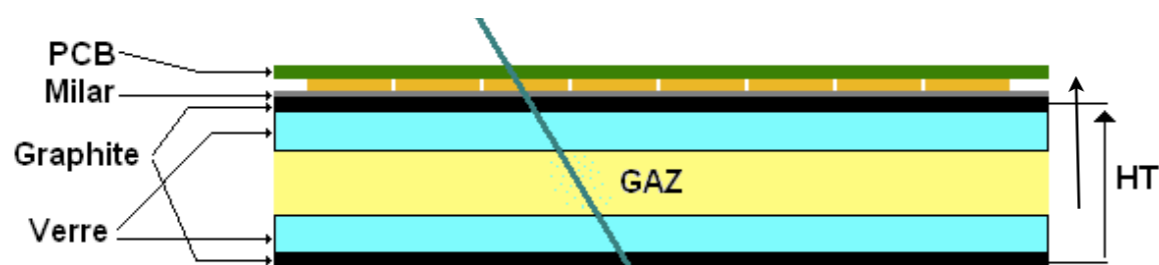
## Efficiency vs. HV & track incident angle



- large area (1m<sup>2</sup>)
- detection rate up to 100Hz/cm<sup>2</sup>
- robust, highly efficient
- noise level less than 1Hz/cm<sup>2</sup>
- very cheap

**GRPC-Lyon**

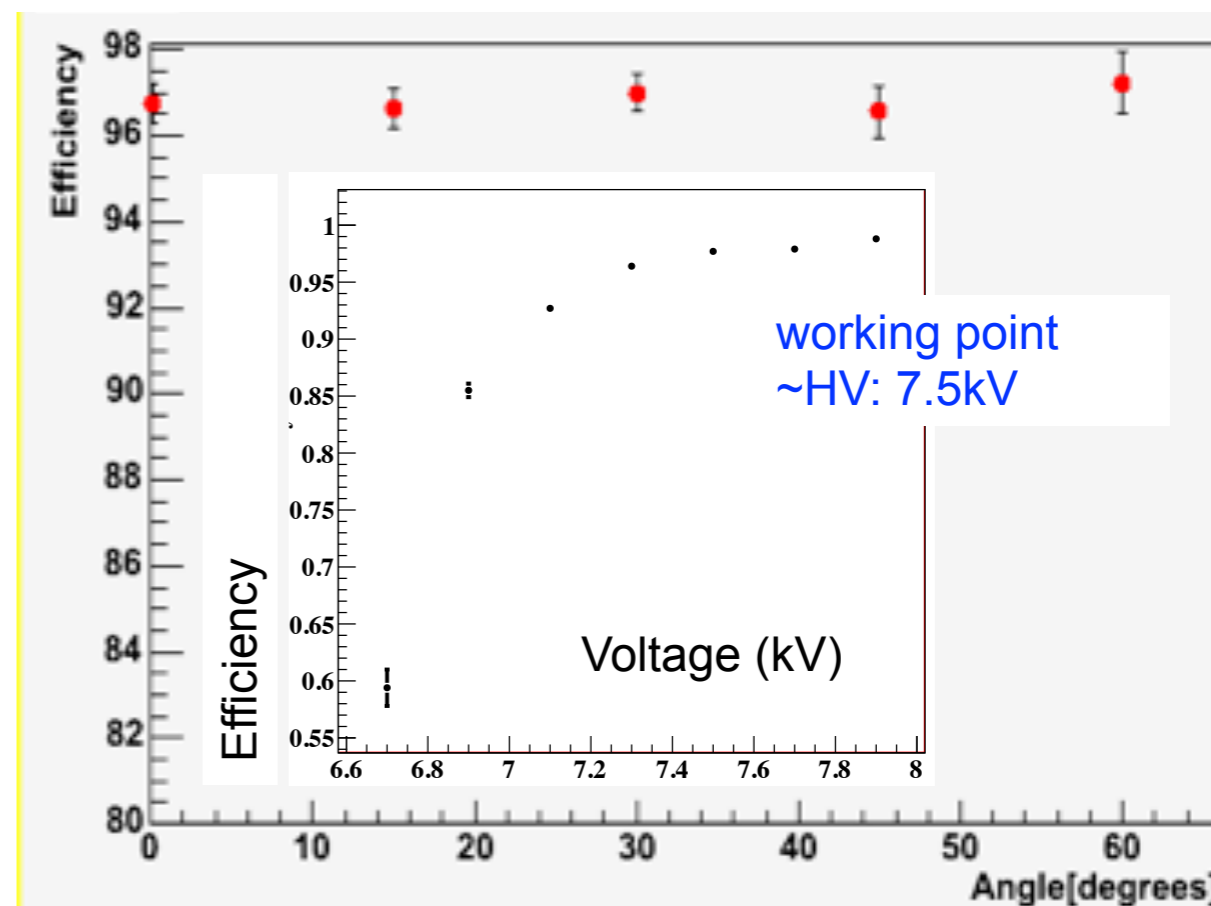
Avalanche mode: total mean MIP charge 2.6pC, RMS: 1.6pC



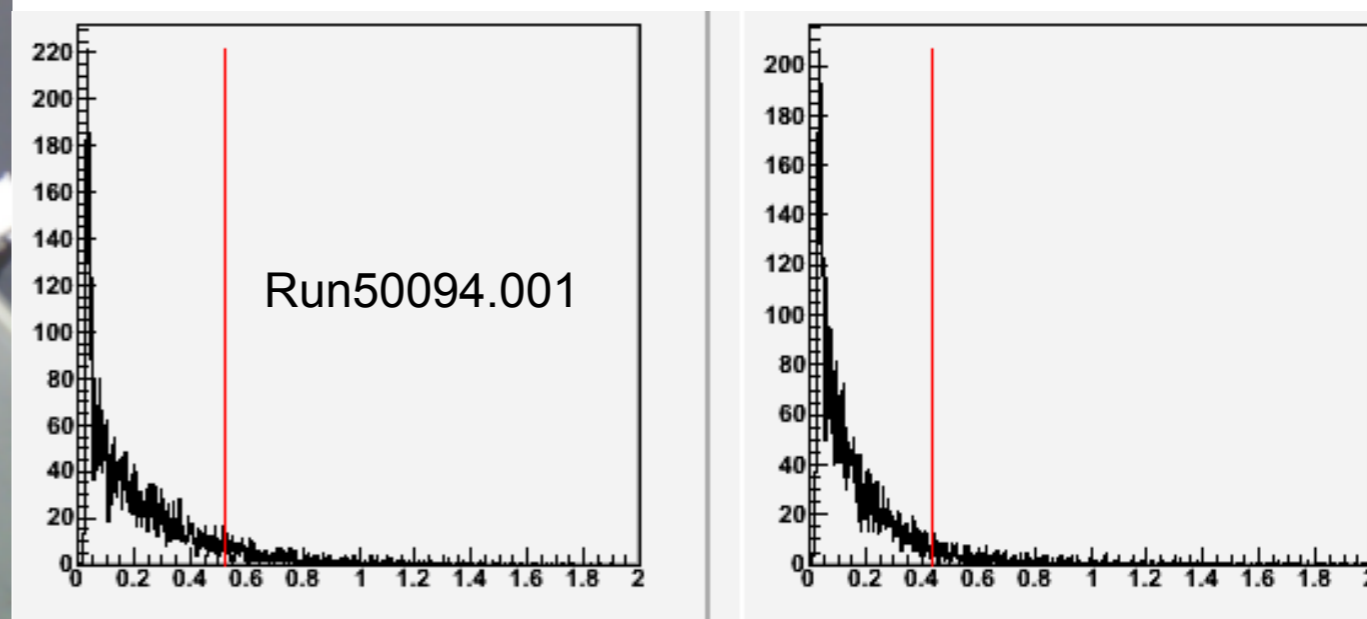
Gas: 93% TFE, 5% Isobutane, 2% SF<sub>6</sub>

M. Bedjidian et al, "Performance of Glass Resistive Plate Chambers for a high granularity semi-digital calorimeter", JINST 6:P02001,2011

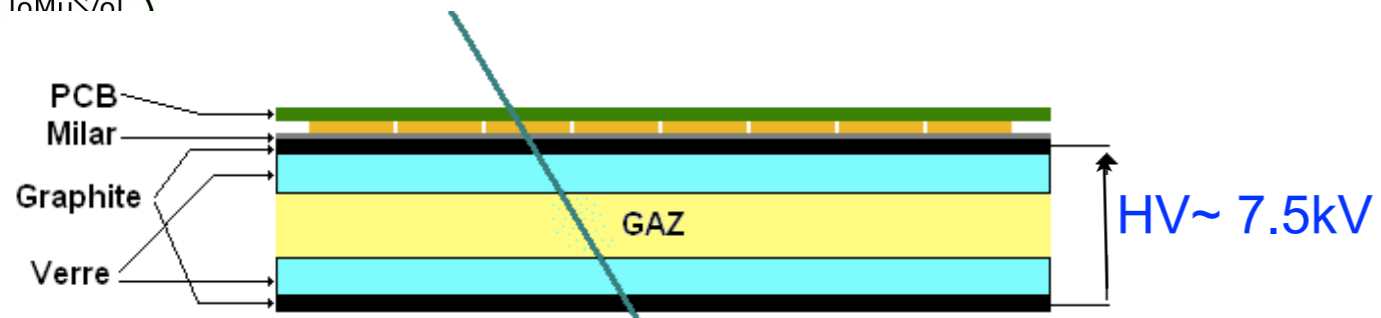
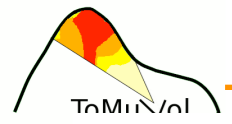
## Efficiency vs. HV & track incident angle



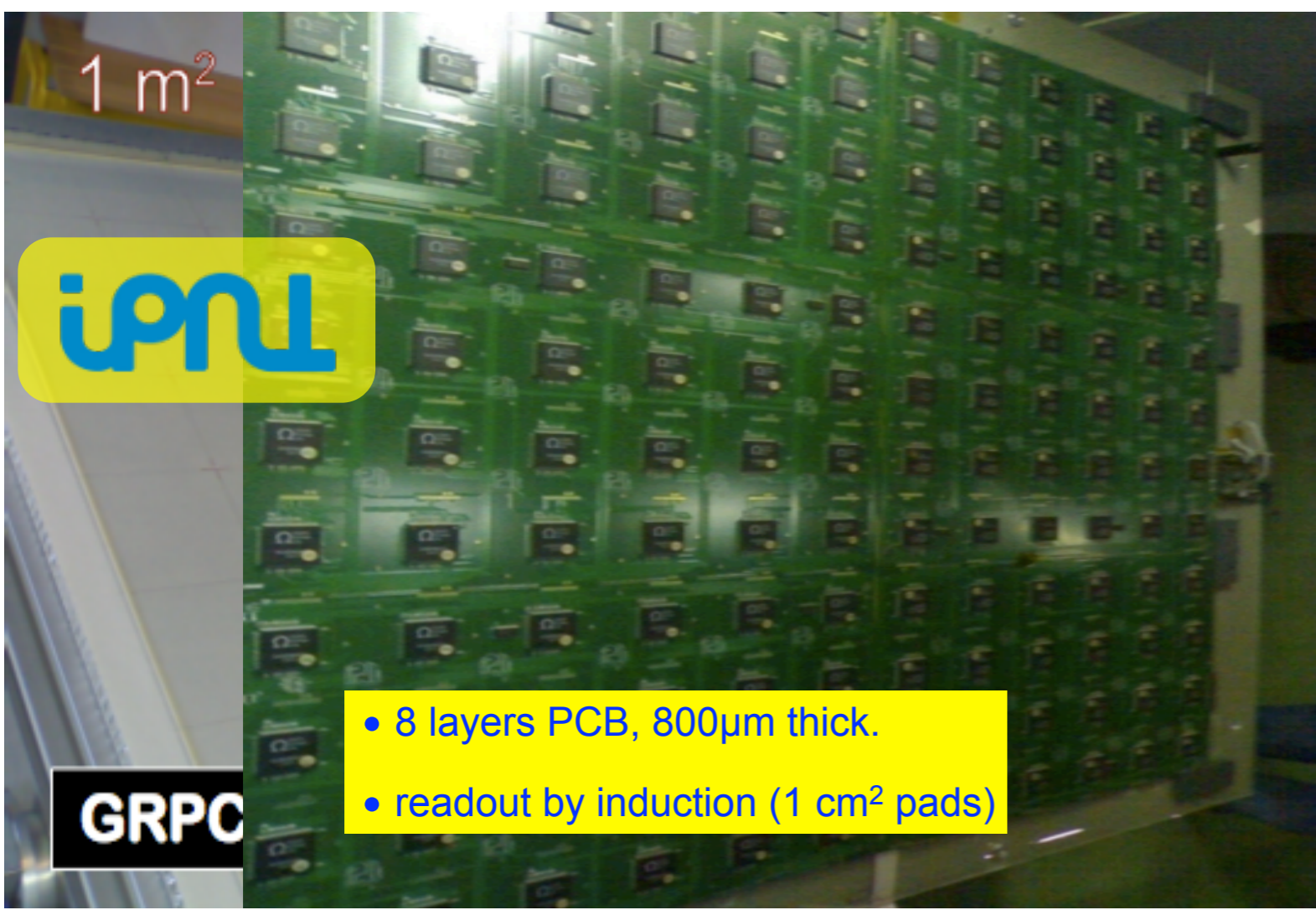
## Noise rate (Hz)



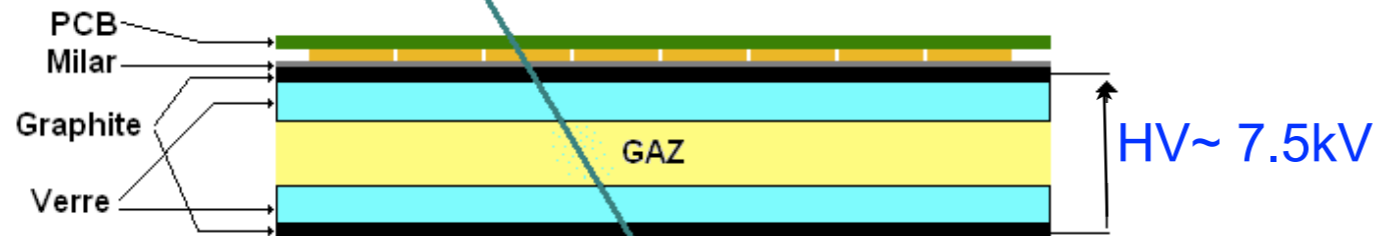
# Muon Tracker : CALICE Electronics



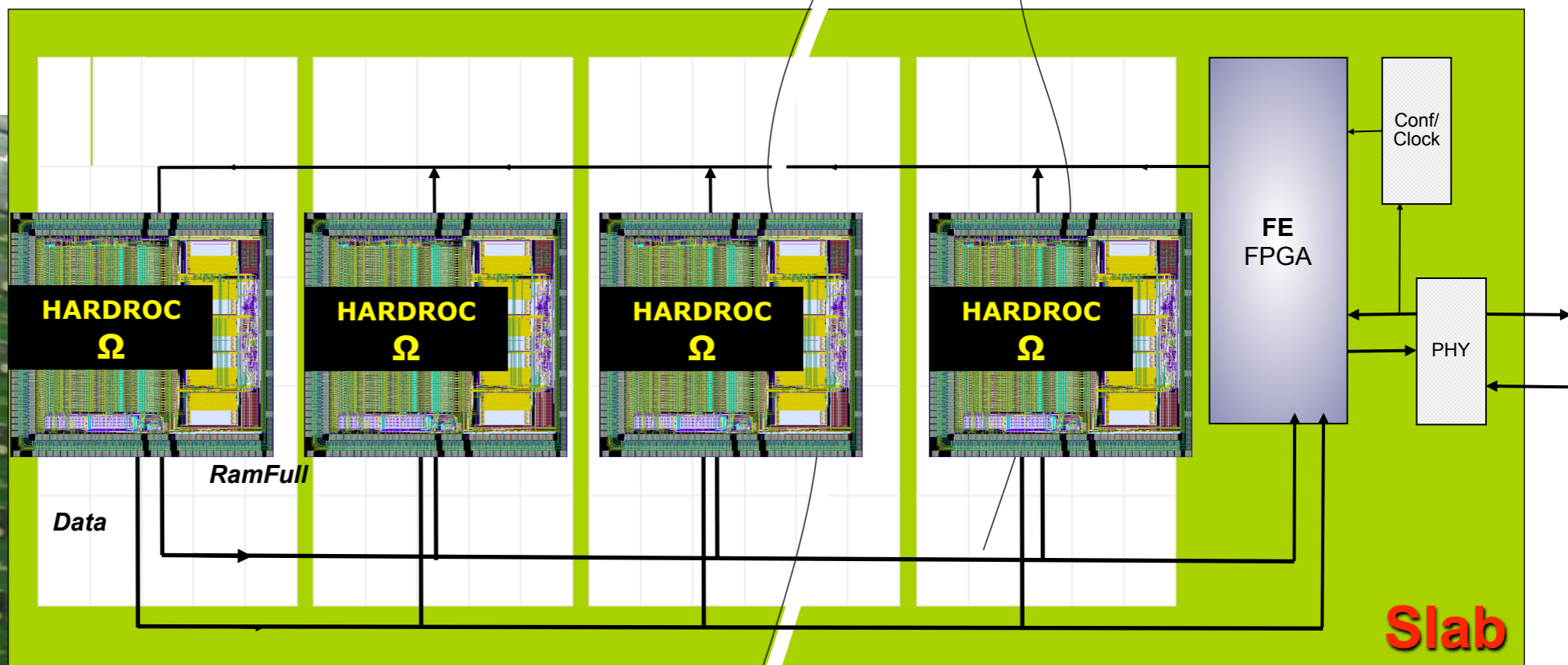
Dulucq, F.; de La Taille, C.; Martin-Chassard, G.; Seguin-Moreau, N.; , "HARDROC: Readout chip for CALICE/EUDET Digital Hadronic Calorimeter," *Nuclear Science Symposium Conference Record (NSS/MIC), 2010 IEEE*



- 8 layers PCB, 800µm thick.
- readout by induction (1 cm<sup>2</sup> pads)



Muon  
 Dulucq, F.; de La Taille, C.; Martin-Chassard, G.; Seguin-Moreau, N.; , "HARDROC: Readout chip for CALICE/EUDET Digital Hadronic Calorimeter," *Nuclear Science Symposium Conference Record (NSS/MIC), 2010 IEEE*

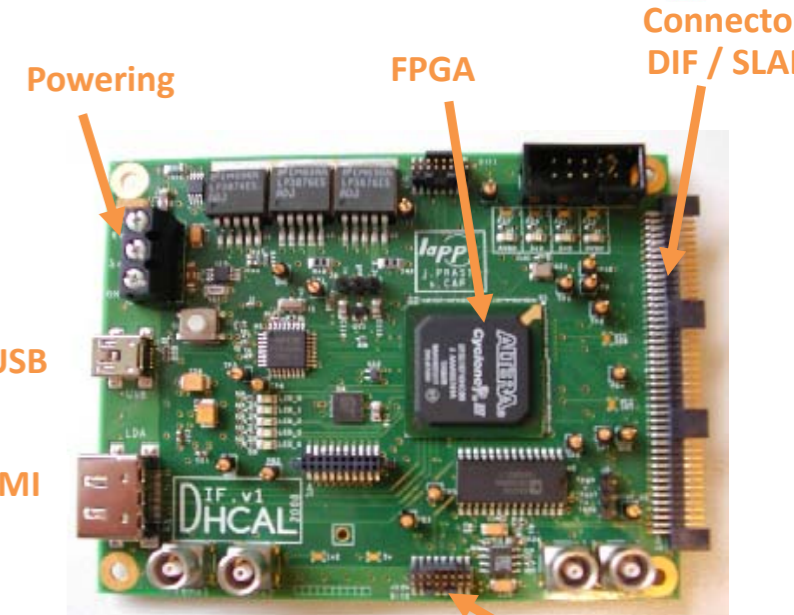
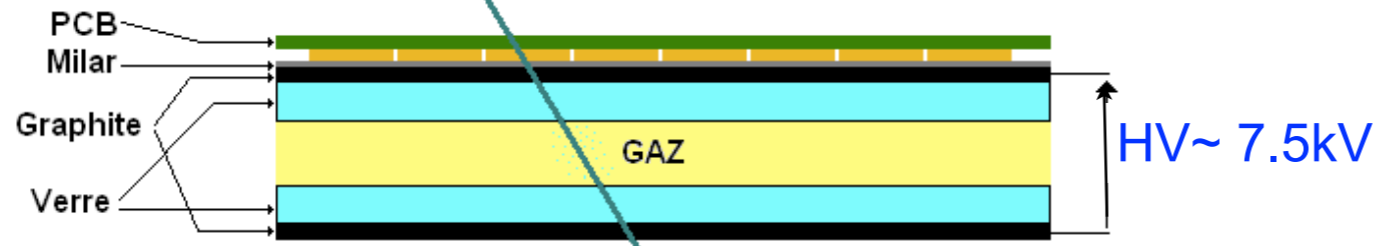
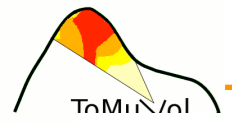


- 8 layers PCB, 800µm thick.
- readout by induction (1 cm<sup>2</sup> pads)

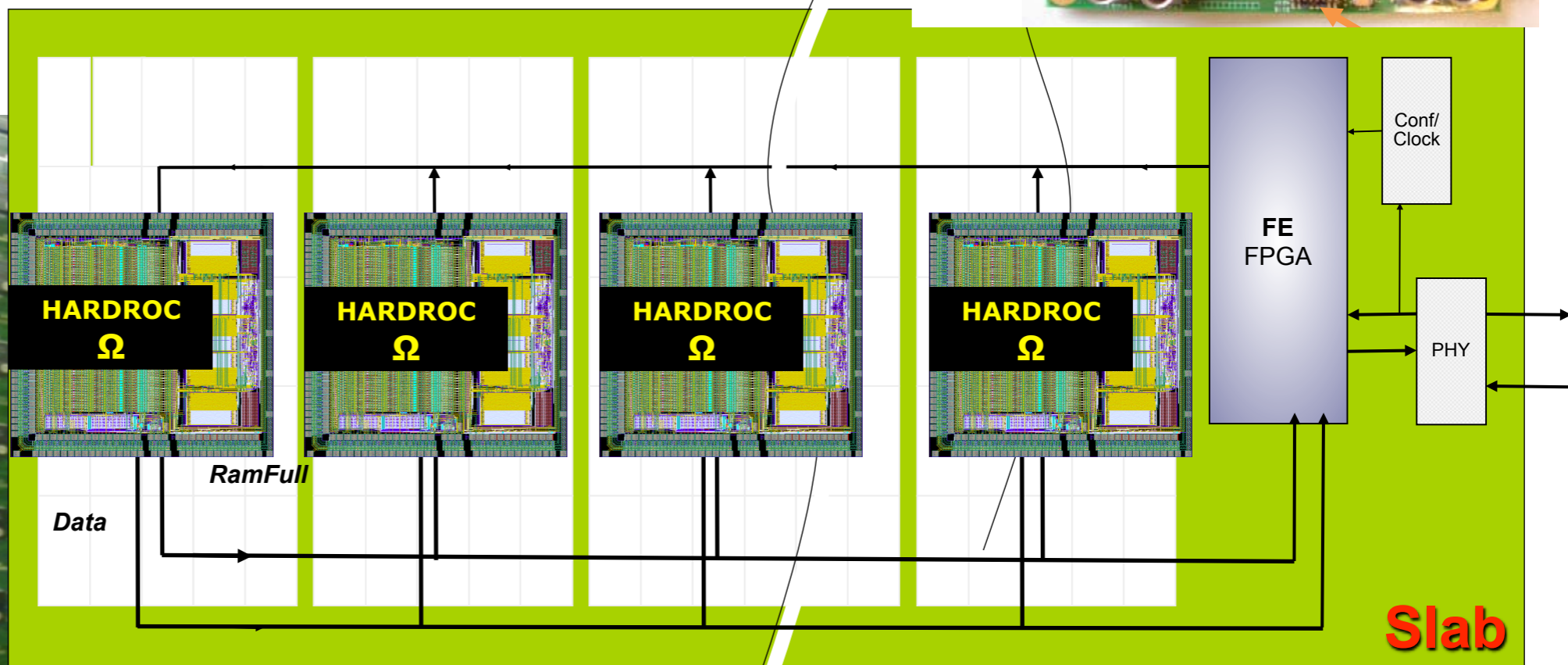
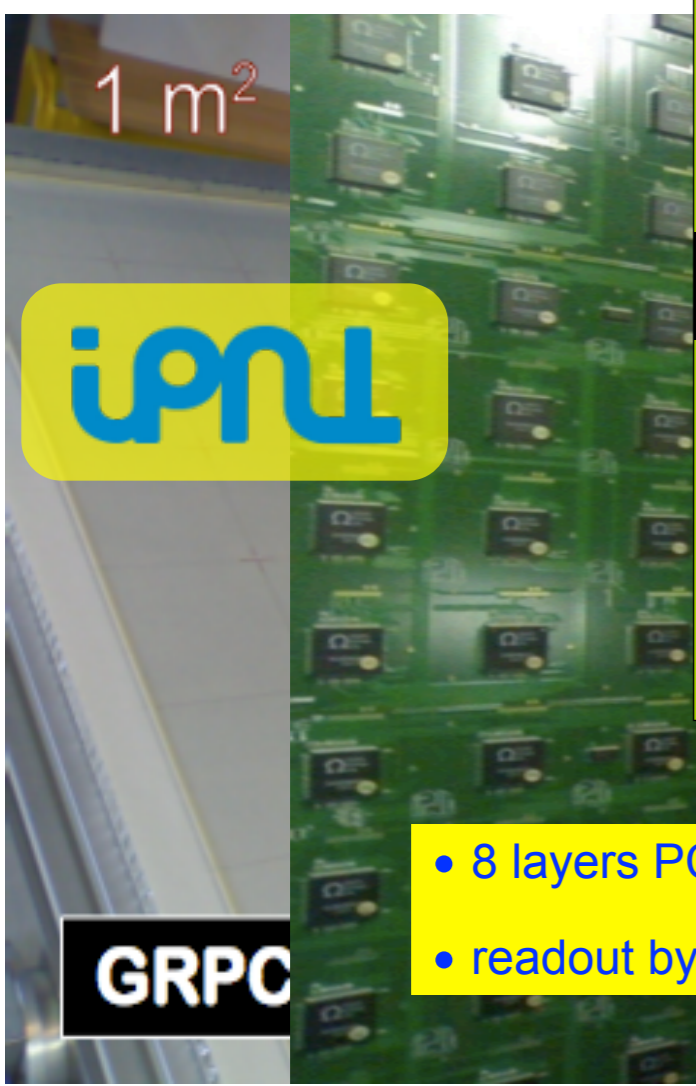
- 64 channels, 16 mm<sup>2</sup>
- digital output (3 adjustable thrs)
- low power consumption (1.5 mW/ch)
- large gain range
- xtalk < 2%
- ajustable gain for each channel



# Muon Tracker : CALICE Electronics



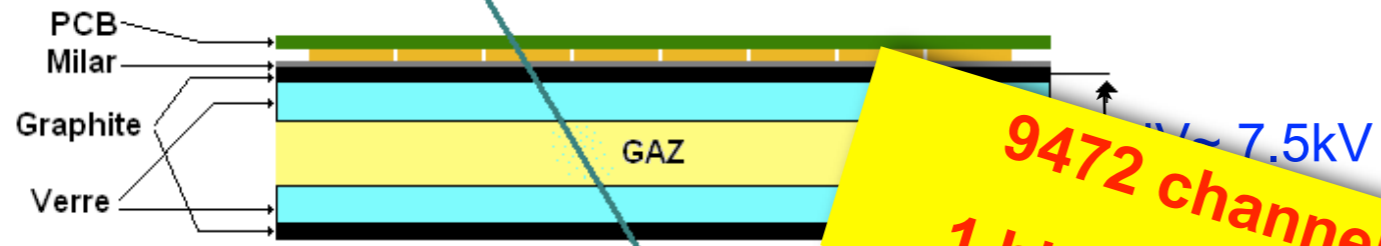
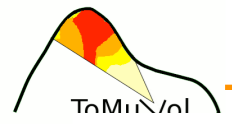
Muon  
 Dulucq, F.; de La Taille, C.; Martin-Chassard, G.; Seguin-Moreau, N.; , "HARDROC: Readout chip for CALICE/EUDET Digital Hadronic Calorimeter," *Nuclear Science Symposium Conference Record (NSS/MIC), 2010 IEEE*



- 8 layers PCB, 800µm thick.
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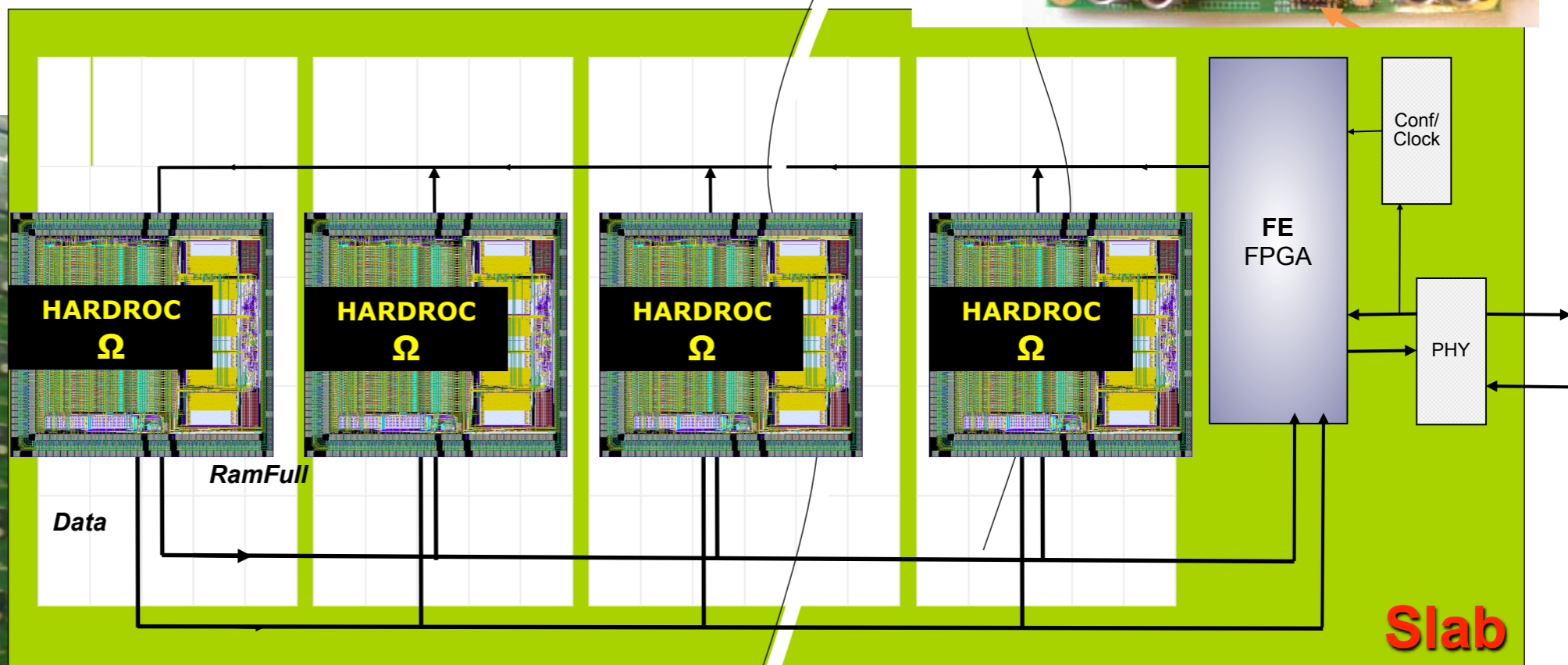
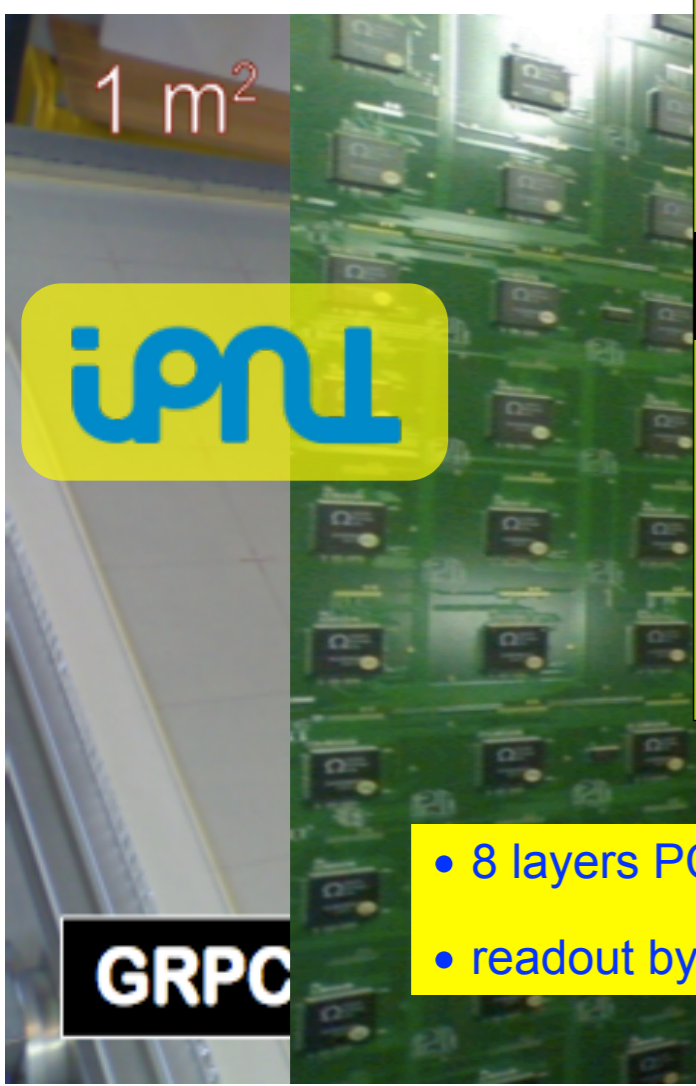
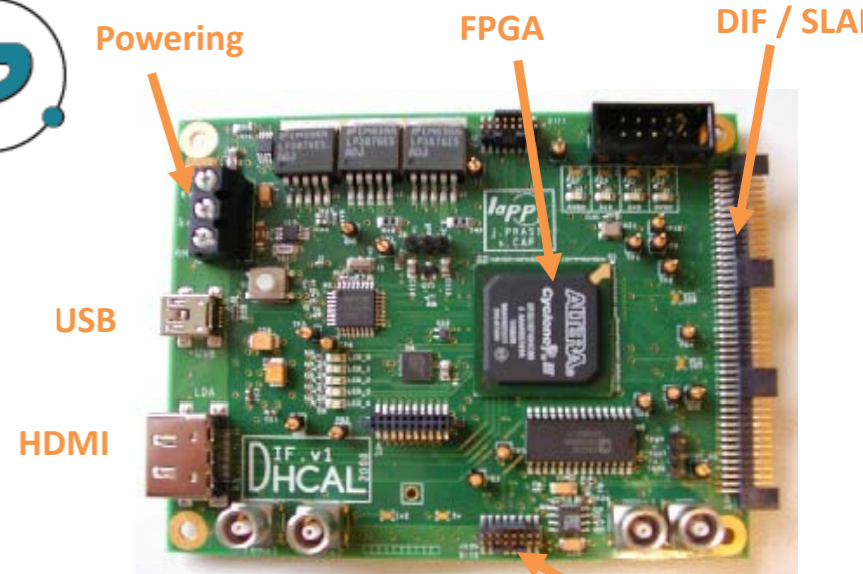
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- large gain range
- xtalk < 2%
- ajustable gain for each channel

# Muon Tracker : CALICE Electronics



**9472 channels/m<sup>2</sup>**  
**1 hit  $\equiv$  time + thresh**

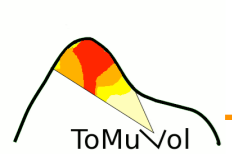
Muon  
 Dulucq, F.; de La Taille, C.; Martin-Chassard, G.; Seguin-Moreau, N.; , "HARDROC: Readout chip for CALICE/EUDET Digital Hadronic Calorimeter," *Nuclear Science Symposium Conference Record (NSS/MIC), 2010 IEEE*



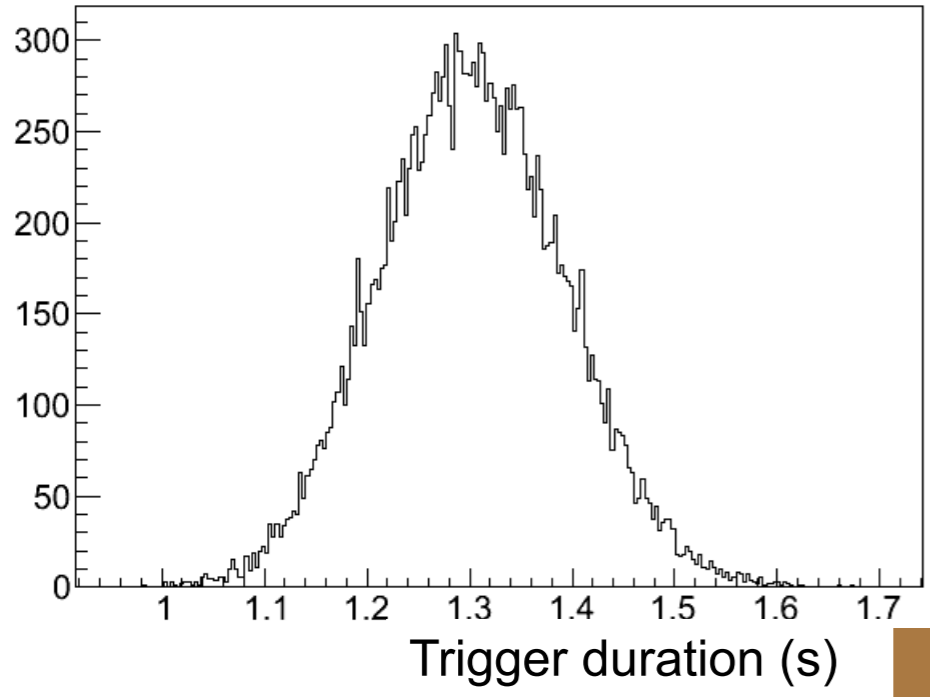
- 8 layers PCB, 800 $\mu$ m thick.
- readout by induction (1 cm<sup>2</sup> pads)

- 64 channels, 16 mm<sup>2</sup>
- digital output (3 adjustable thrs)
- low power consumption (1.5 mW/ch)
- large gain range
- xtalk < 2%
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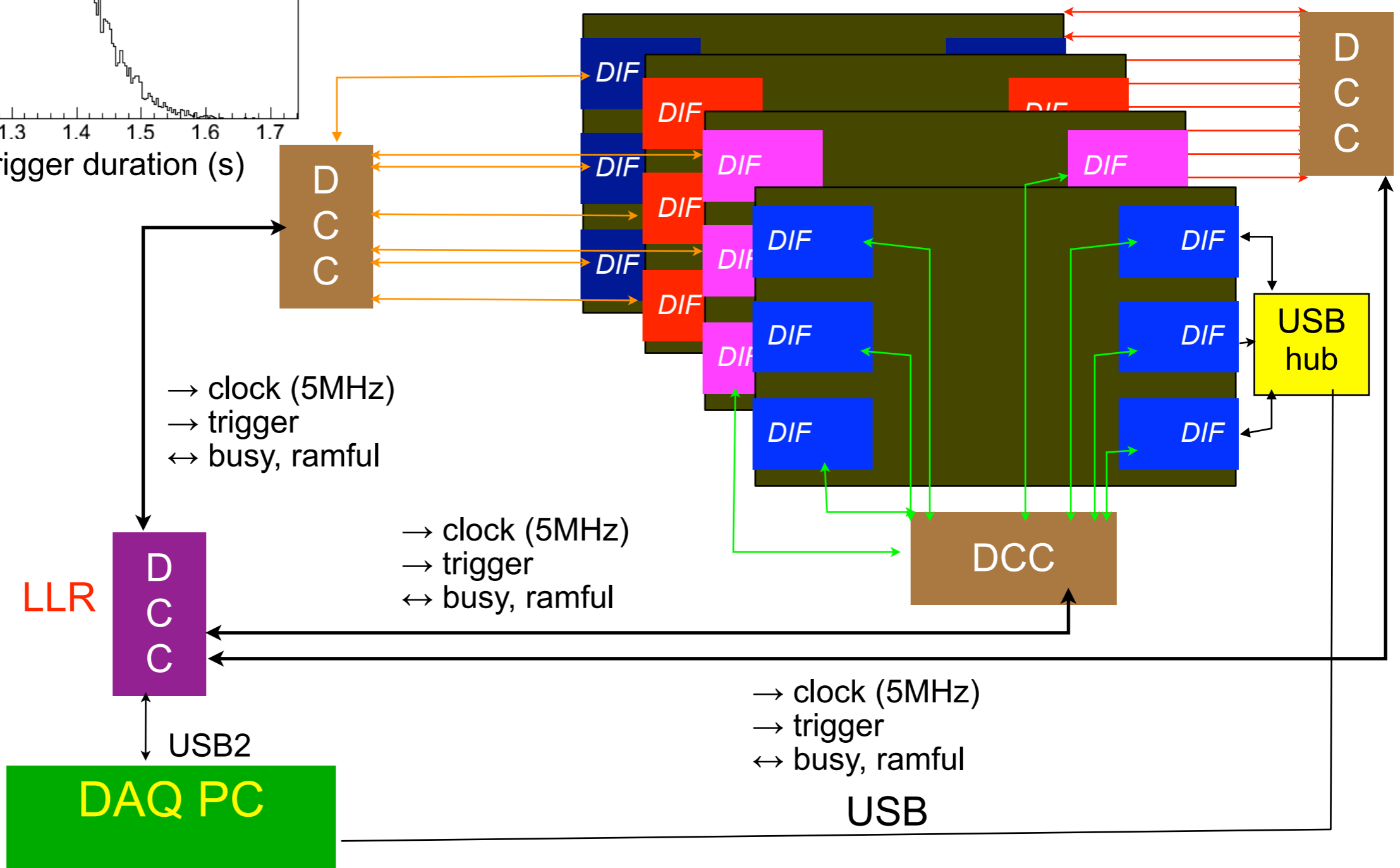


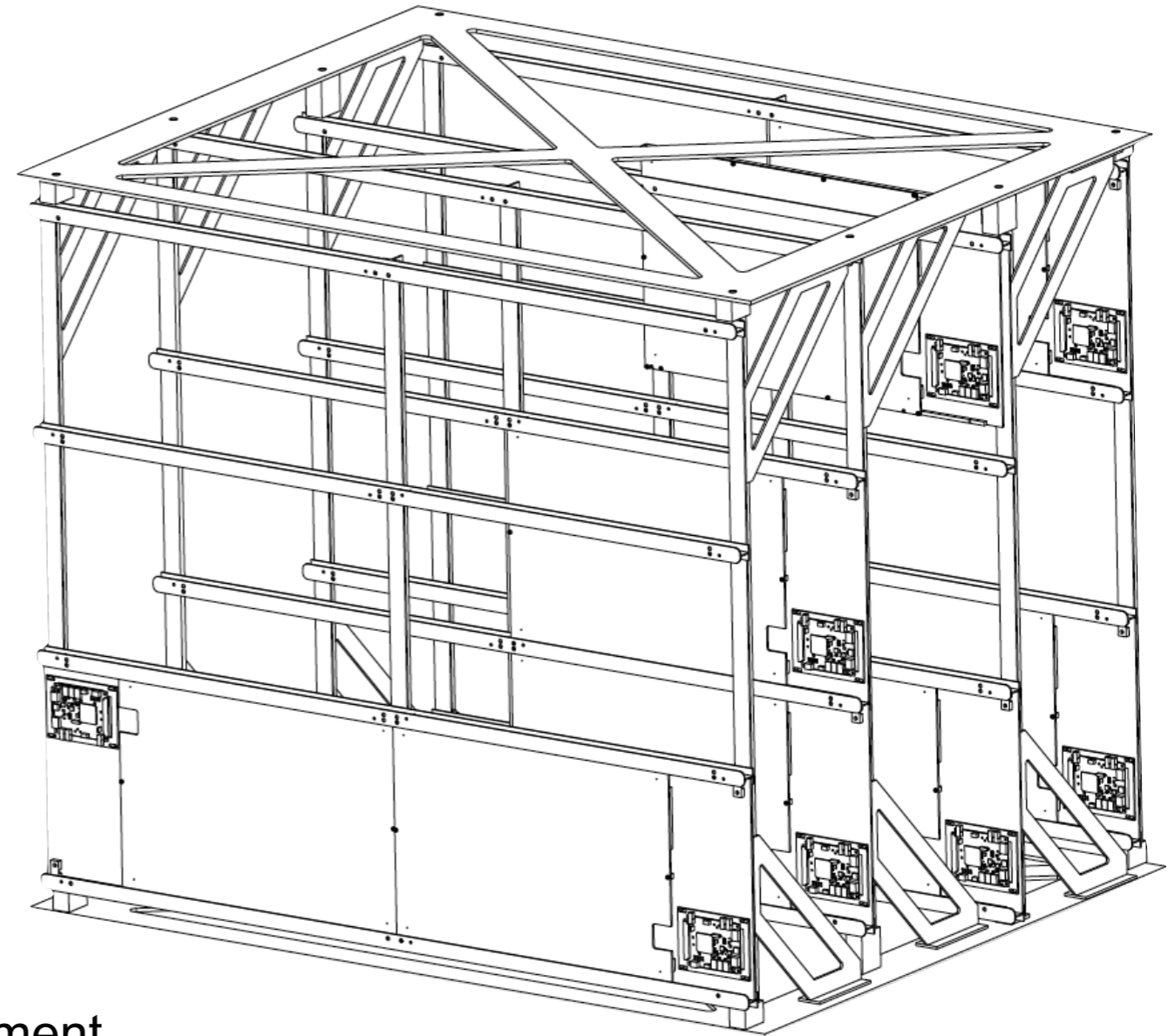


# ToMuVol Clock & DAQ Synopsis



- system operated synchronously @ 5 MHz
- each DIF reads/controls 48 HARDROC2 ASICS (autotriggered and with internal RAM holding 128 consecutive events)
- first full RAM triggers the readout of the whole detector



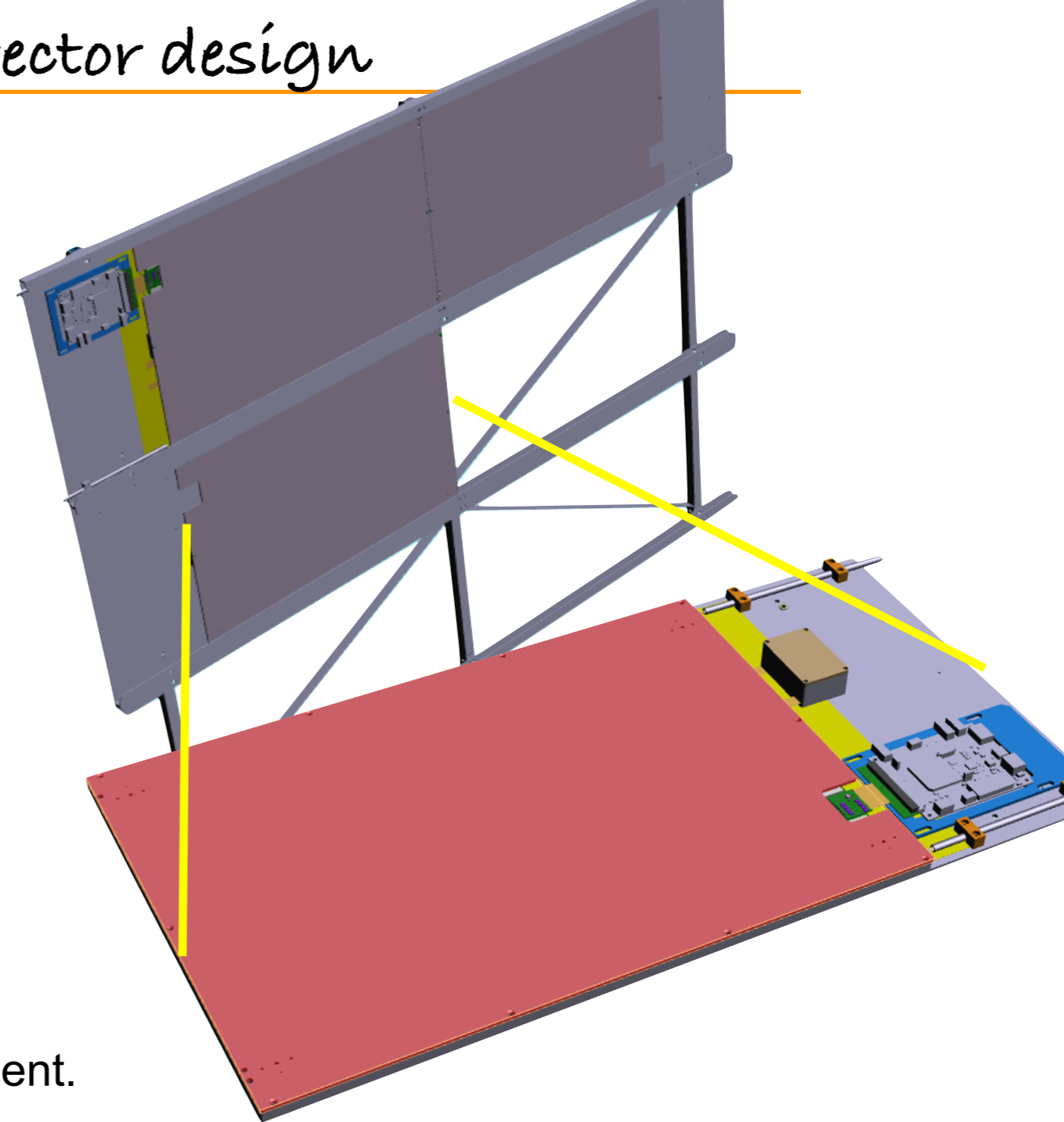


- ▶ 1m<sup>2</sup> chambers not really suited for field deployment.
- ▶ Difficult to transport (heavy, fragile).
- ▶ Price/unit too high to produce enough spares.



**1m<sup>2</sup> made out of 6 chambers 50x33 cm<sup>2</sup>**

- ▶ easy to transport
- ▶ price/unit compatible with spare production
- ▶ special care in designing the structure for precise alignment



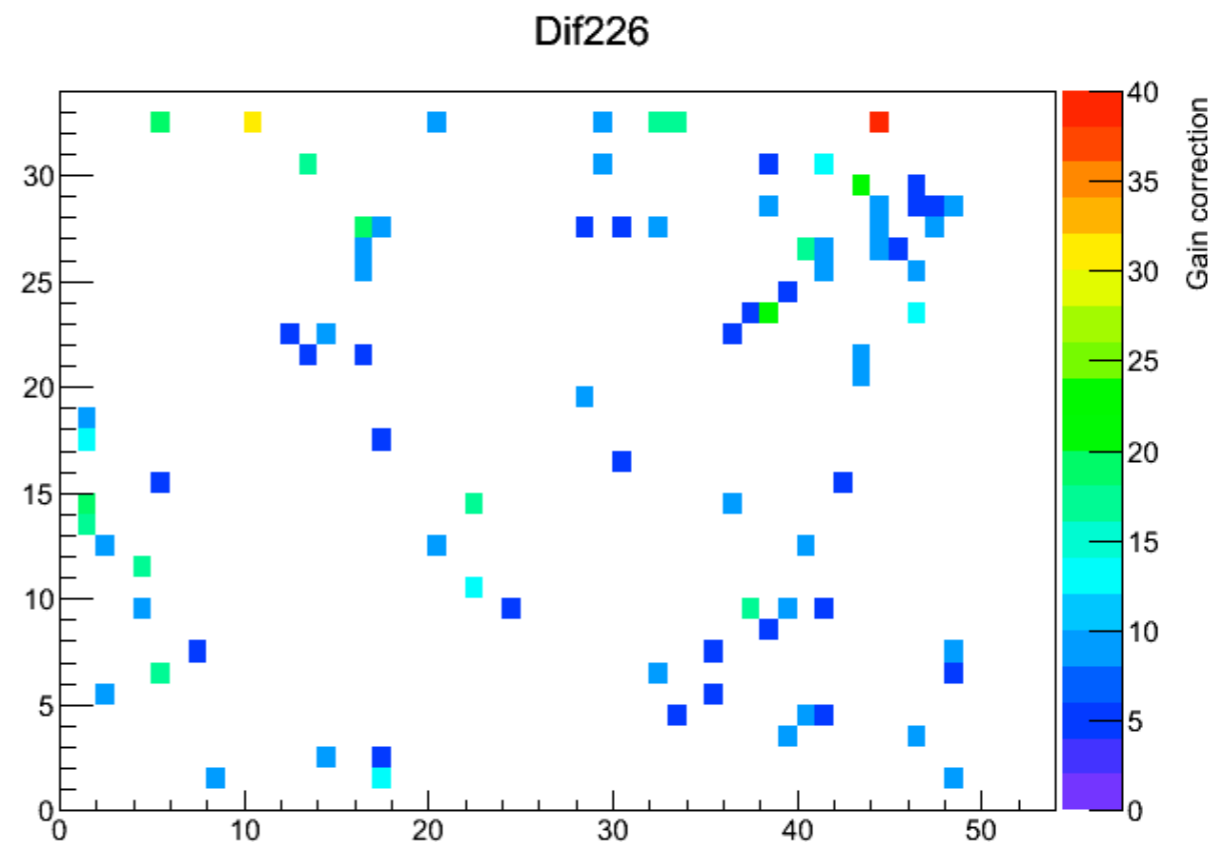
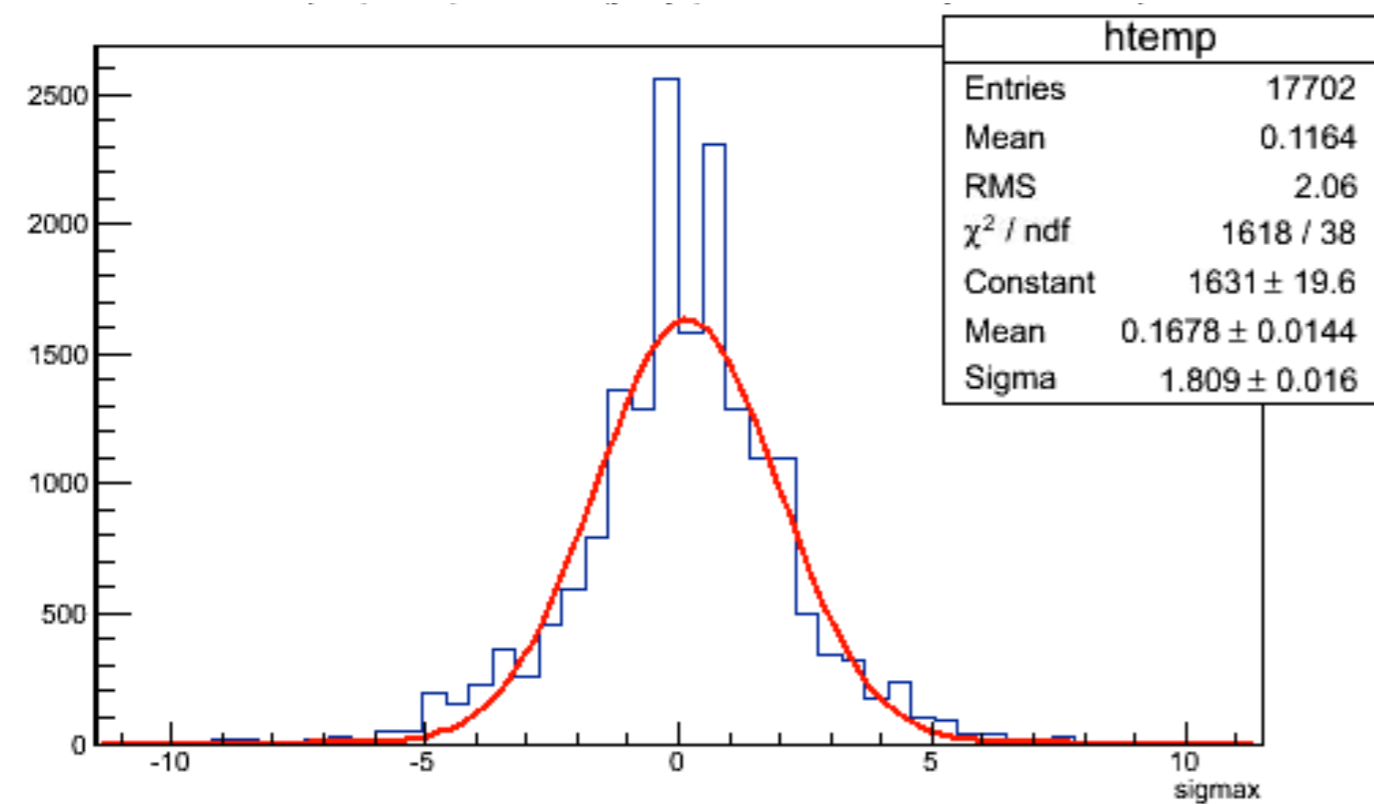
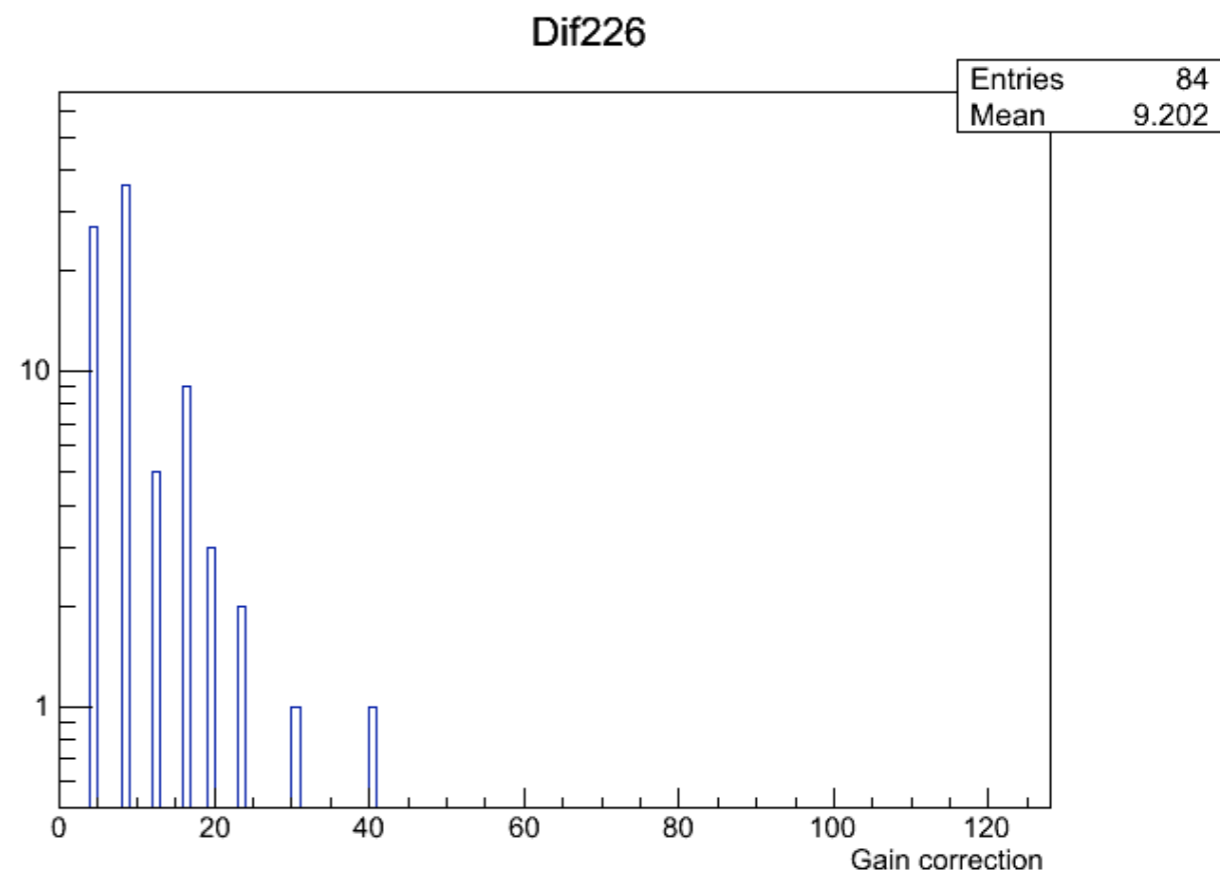
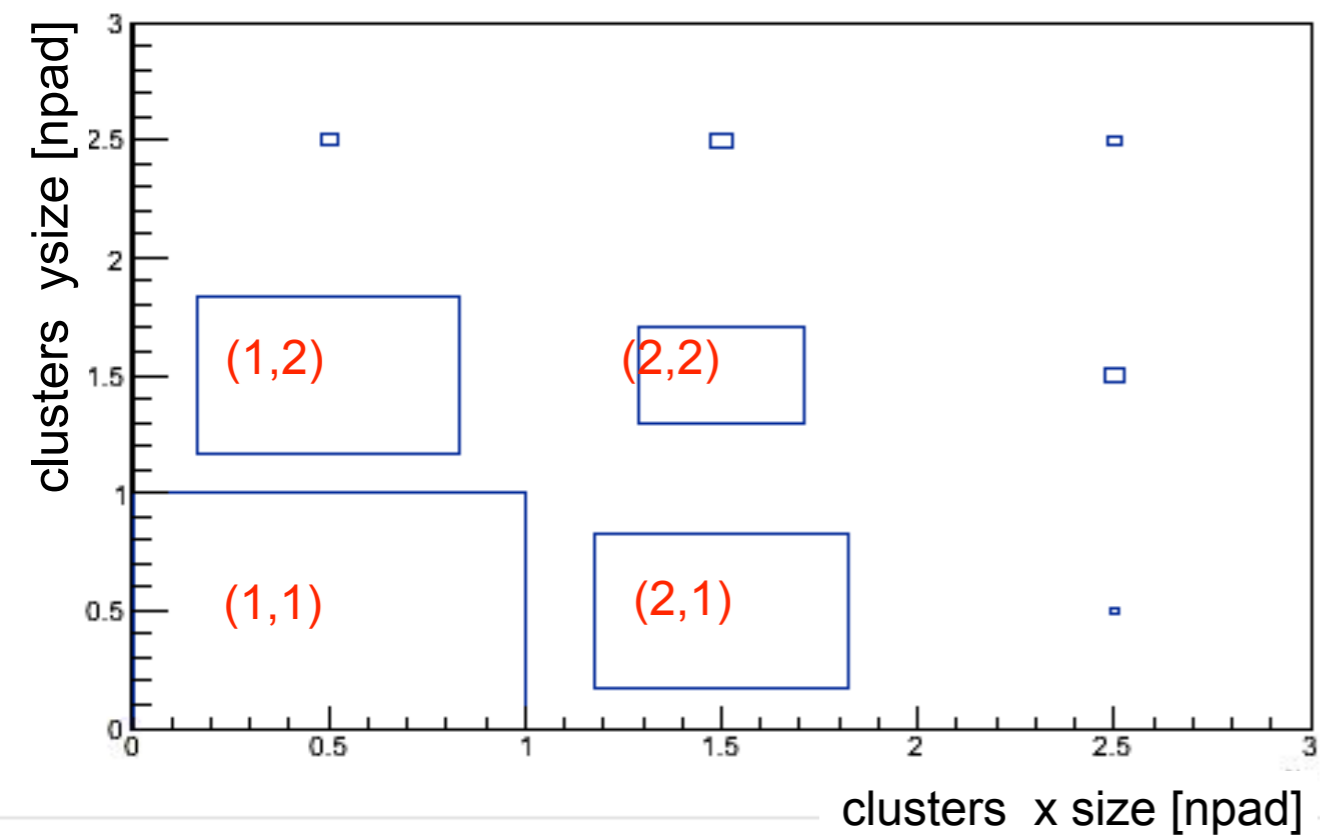
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- ▶ easy to transport
- ▶ price/unit compatible with spare production
- ▶ special care in designing the structure for precise alignment









## First measurements on the Puy-de-Dôme :

- ▶ Encouraging results with **17+11M** tracks candidate at 2 ~orthogonal positions.
- ▶ Preliminary data confirm the potential of the method.
- ▶ Borrowed detector working as prototype allowed us to define a good muon telescope (slightly optimised version of CALICE GRPC chambers for field deployment).

## **TOMUVOL detector built -> First data taking scheduled in September 2013:**

- ▶ With a **better data quality** and the knowledge acquired from preliminary measurement campaigns, a **very accurate image** of the Puy-de-Dôme can be expected within 1 year.
- ▶ Until then, need to work on the simulations and **evaluate model-dependent systematics**.