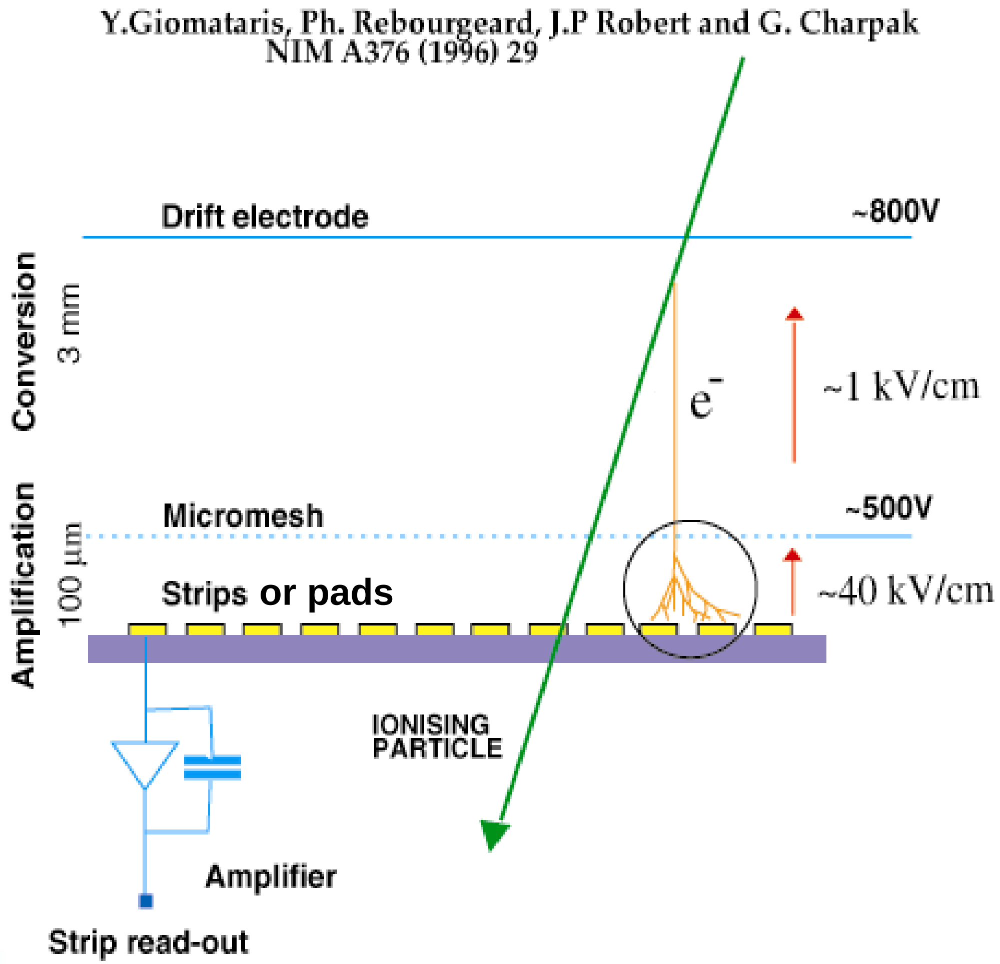
DHCAL with MICROMEGAS

Catherine Adloff

MICROMEGAS

Micro mesh gaseous structure



- **Already heavily used**
  - **COMPASS**
  - **NA48 charged kaon upstream spectrometer**
  - **high rate neutron beam profiler of the n-TOF facility at CERN**
  - **CAST**
  - **MEDICAL APPLICATIONS**
  - **Neutron imaging**
  - **T2K TPC**
  - **…**

Overview

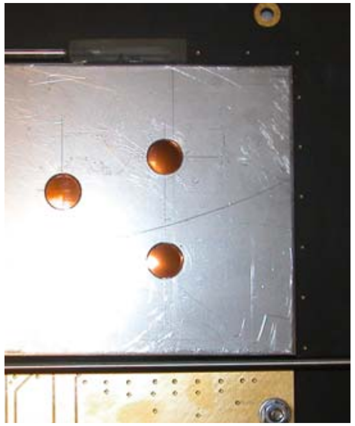
- MicroMegas with Analog Readout
- MicroMegas with Digital Readout
  - *HARDROC* (see N. Seguin talk)
  - New ASIC from IPNL: *DIRAC* (see R. Gaglione talk)
- Near future
  - Mini calorimeter prototype
  - ASU with digital readout
  - DIF (see G. Vouters talk)
  - Design of a $1m^2$ MicroMegas (see N. Geffroy talk)

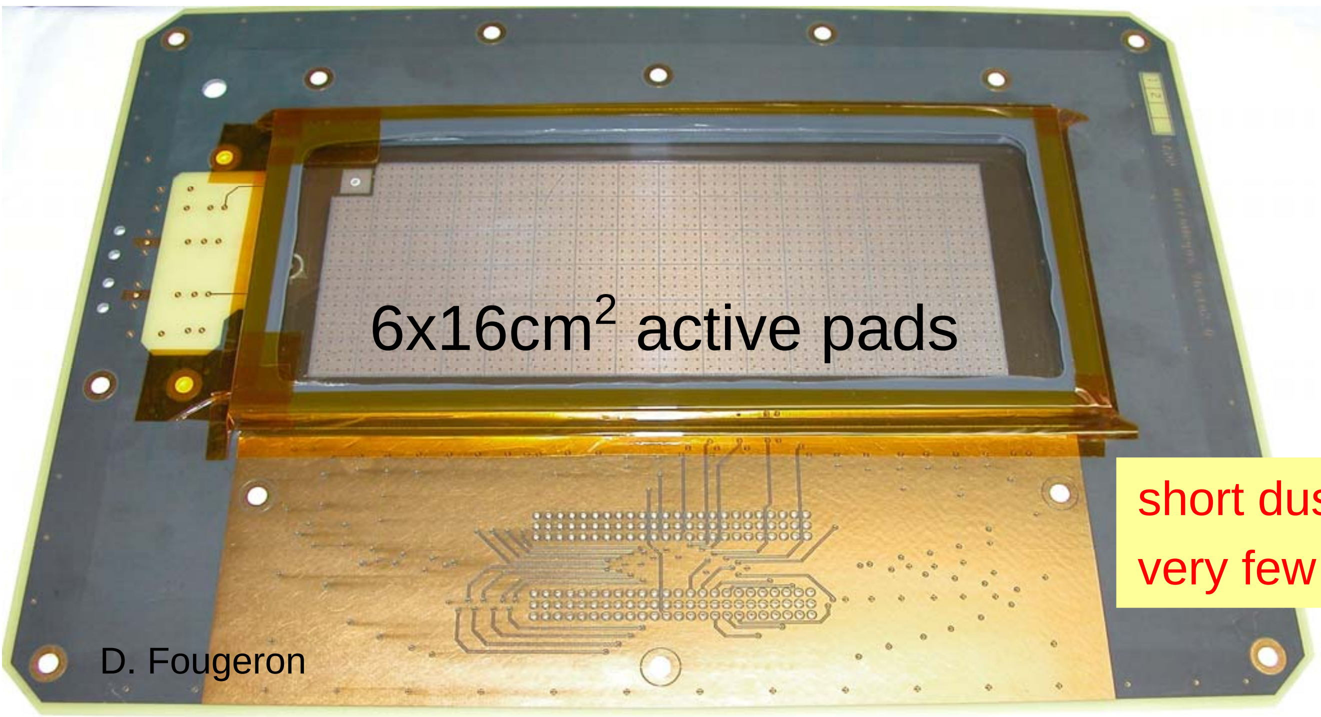
MicroMegas Prototypes

- PCB and bulk from CERN (*Rui de Oliveira*)
  - 325 LPI mesh
  - spacers : 120 μm height
    300 μm diameter
  - pads : 0.98x0.98 cm^2, 200μm between pads
- The chamber
  - 95% Argon, 5% Isobutane
  - 3mm conversion volume
  - a top in Stainless Steel with a copper drift cathode
- The pad readout : analog
  - Gassiplex board : 6 gassiplex chips - 96 channels
    Electronics card built for CAST by DAPNIA (P. Colas, P. Abbon)
  - VME sequencer and ADC from CAEN
  - CENTAURE acquisition (SUBATECH, Nantes, D.Roy)

MicroMegas Prototypes

- PCB routing with great care (4 layers)
- Stainless Steel top with holes for X-rays
- 5μm thick copper drift cathode
- Chamber assembly in clean environment



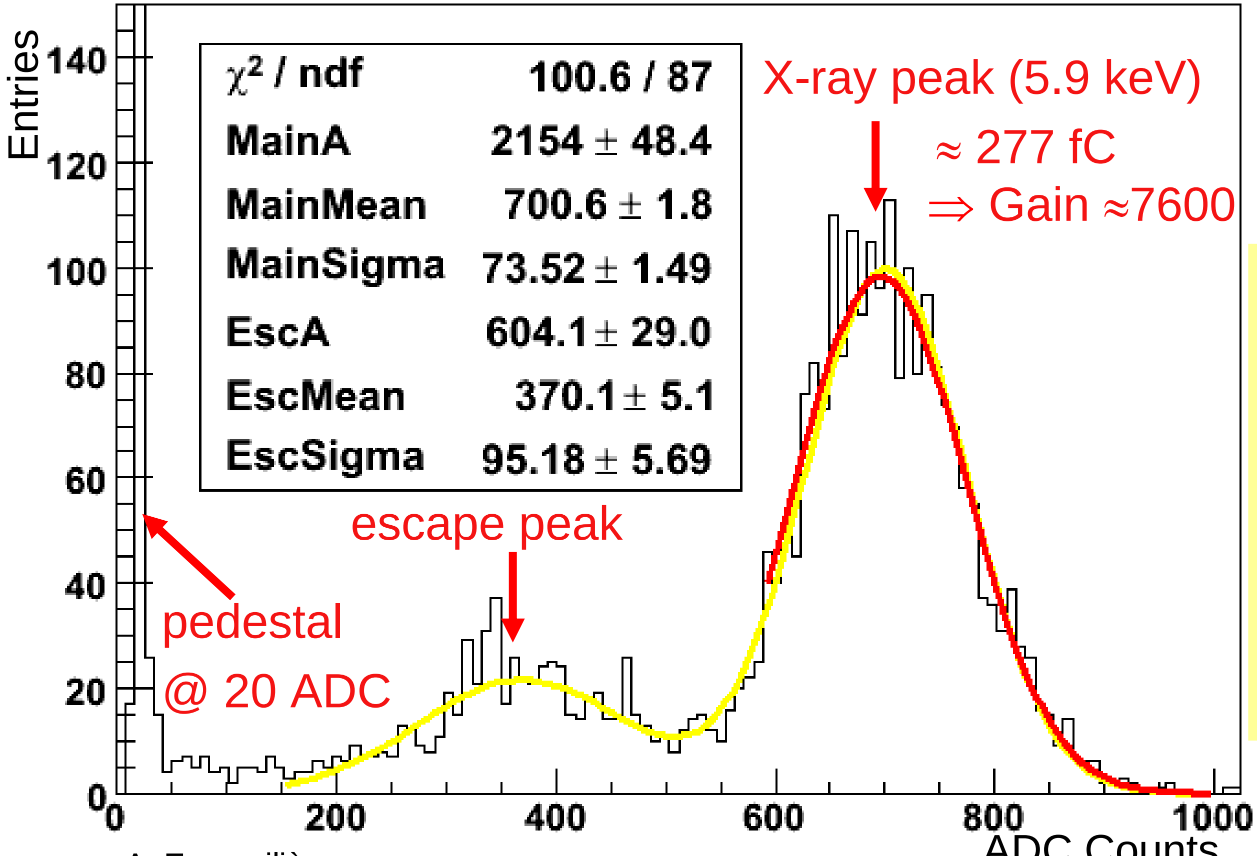


short dust burning time !
very few sparks during functioning

X-ray Results

- ^{55}Fe source (5.9 keV → 228e$^-$ in drift volume)
- Trigger on mesh : preamp (T output) + fast ampli

all pads : 96 entries for each trigger



A. Espargilière

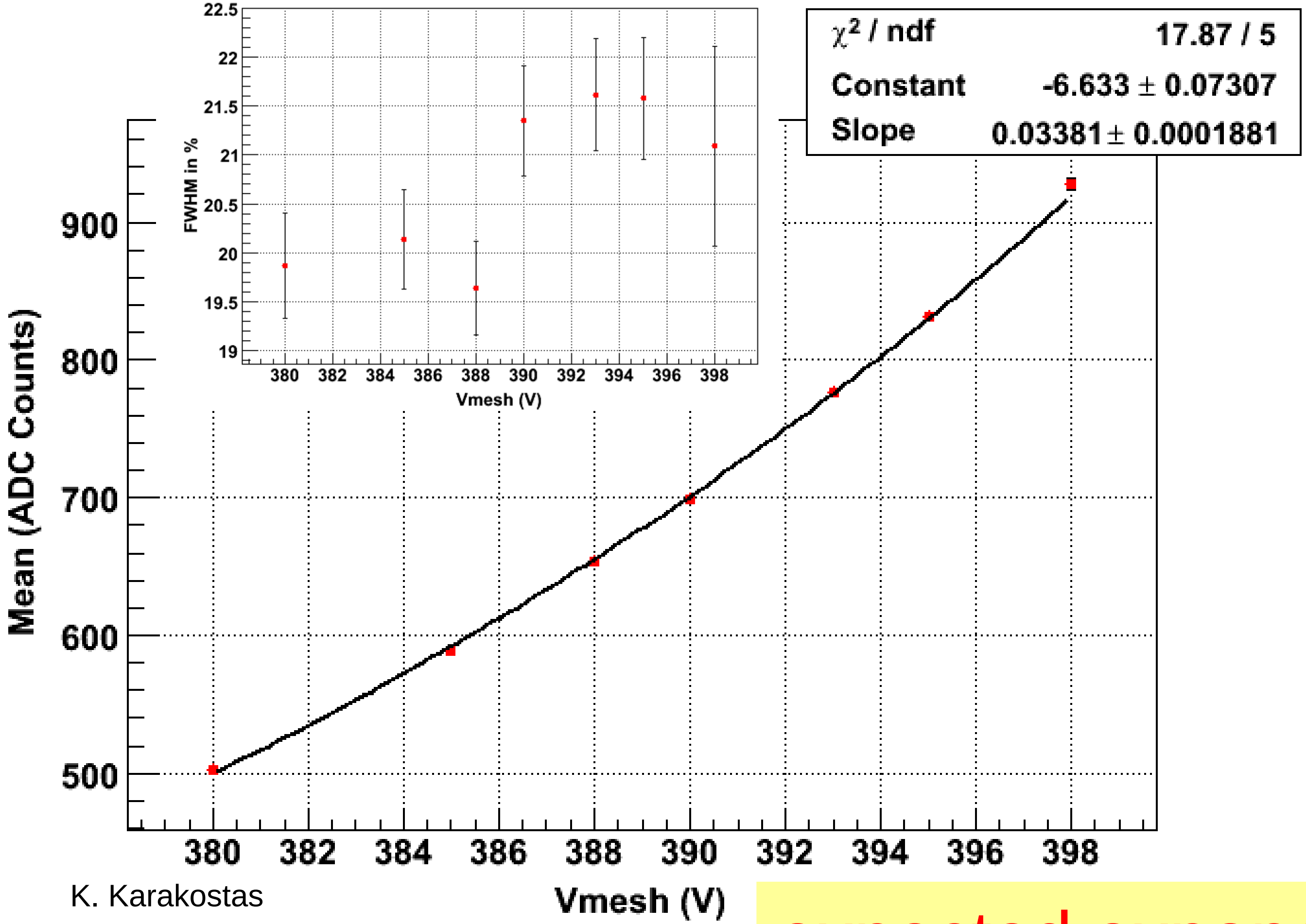
V_{mesh} = 420 V
V_{drift} = 470 V
E_{mesh} = 35 kV/cm
E_{drift} = 167 V/cm

Already done :

- Response versus V_{mesh}
- Response versus V_{drift}
- Gas flow dependencies
- Time stability
- HV supply dependencies

X-ray Results

- Response versus V_{mesh}



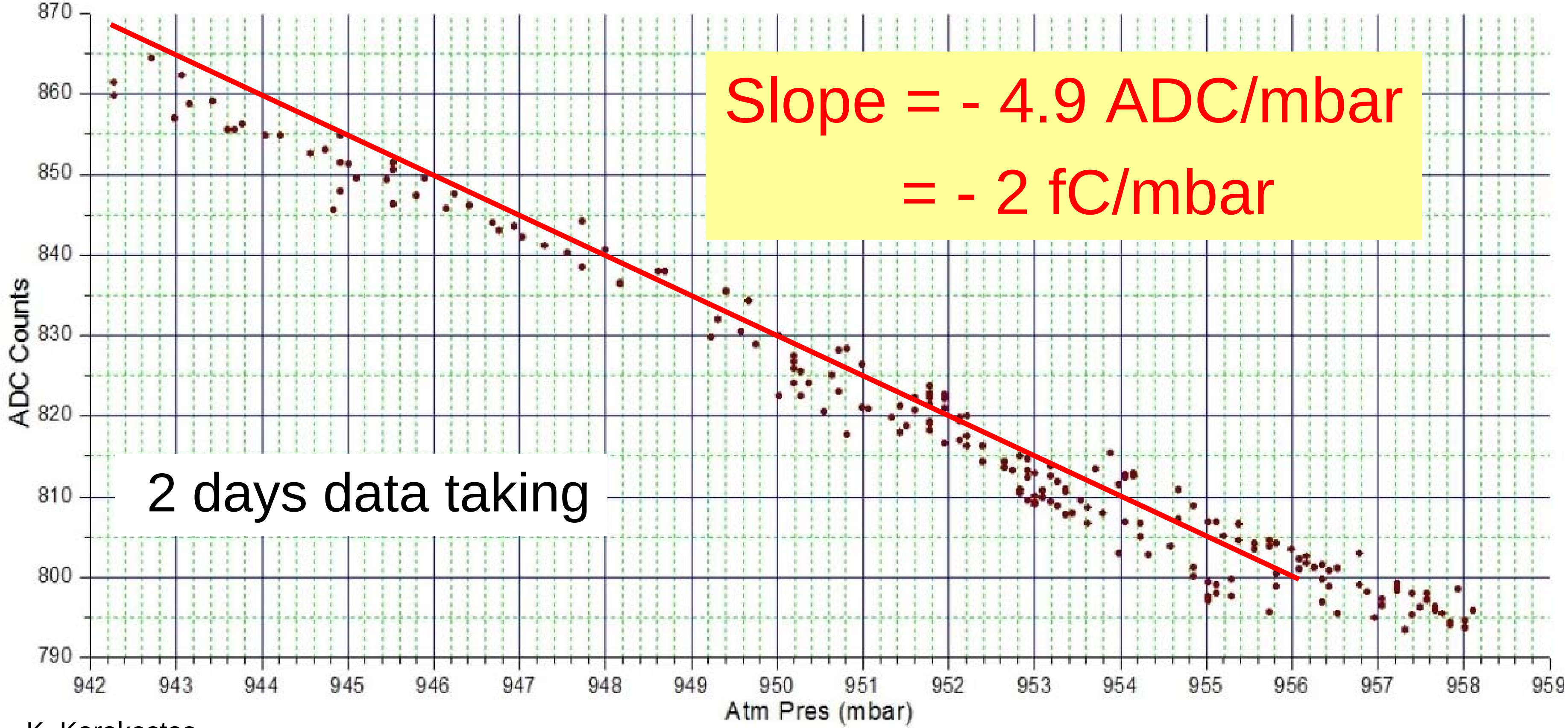
K. Karakostas

$V_{drift} = V_{mesh} + 70$ V
$E_{drift} = 233$ V/cm

expected exponential behaviour

X-ray Results

- Response versus pressure



K. Karakostas

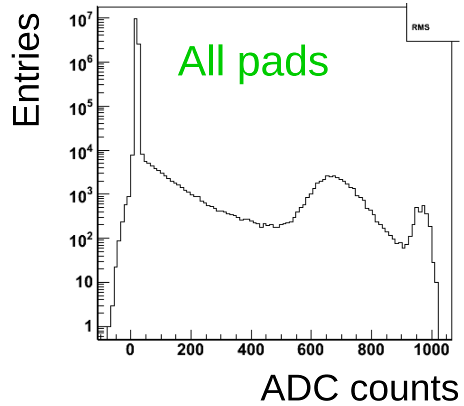
Gain ↘ when Atmospheric Pressure ↗

X-ray + Cosmics

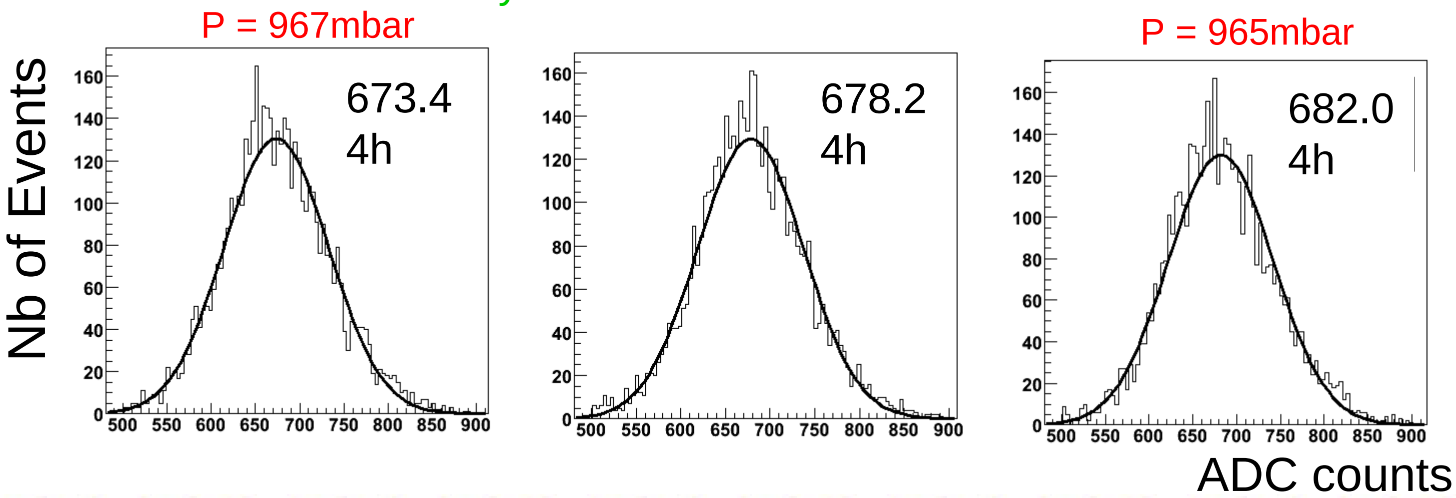
- ^{55}Fe source (5.9 keV → 228e$^-$ in drift volume) on top of one pad for gain monitoring
- Trigger on mesh : preamp (T output) + fast ampli
  or
  Trigger on 3 scintillators coincidence

V_{mesh} = 400 V
V_{drift} = 450 V
E_{mesh} = 33 kV/cm
E_{drift} = 167 V/cm

Example : 1 night data taking
2 chambers



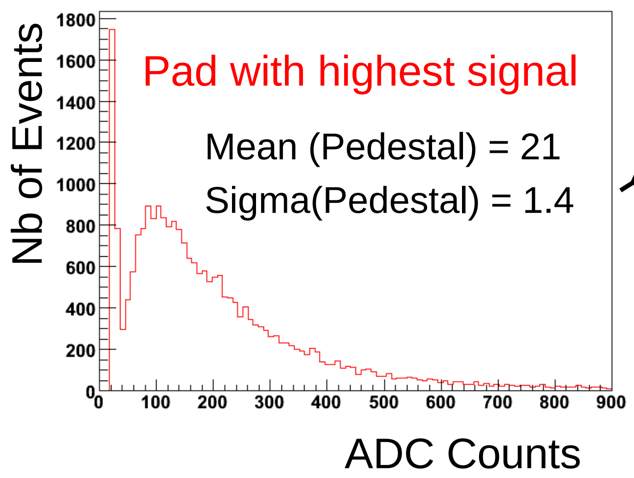
Pad with source only:

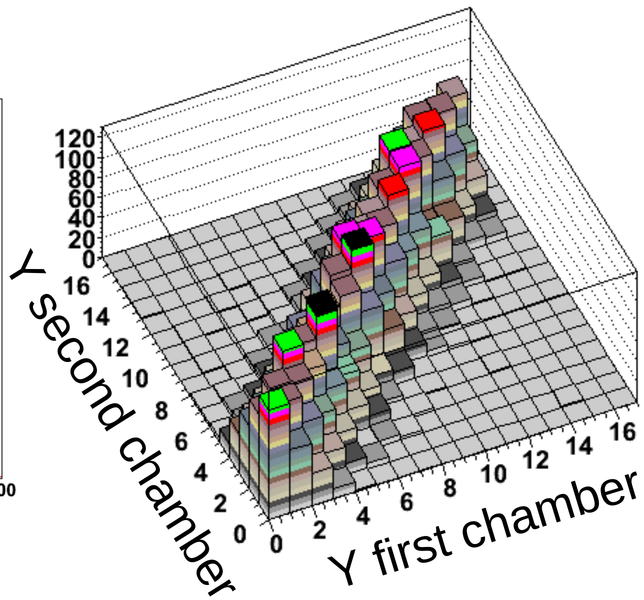


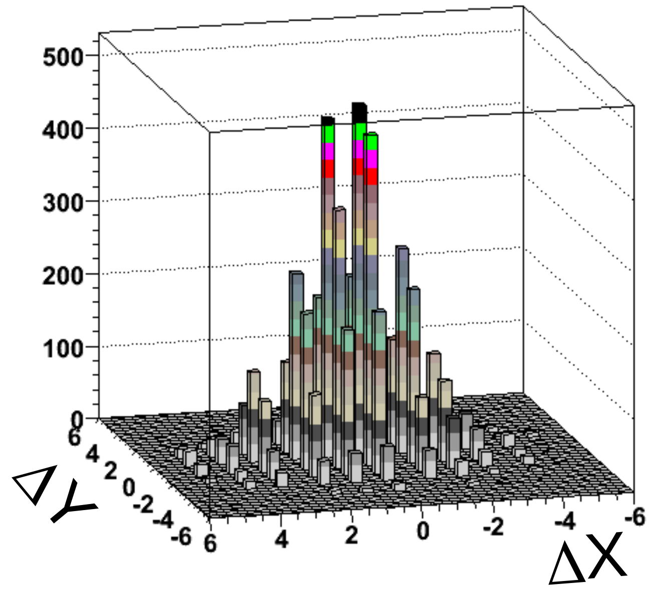
X-ray + Cosmics

- Pad with source cut out
- Muon selection : ADC(Pad with highest signal) > 40

Example : 1 night data taking
2 chambers (overlapped pads)





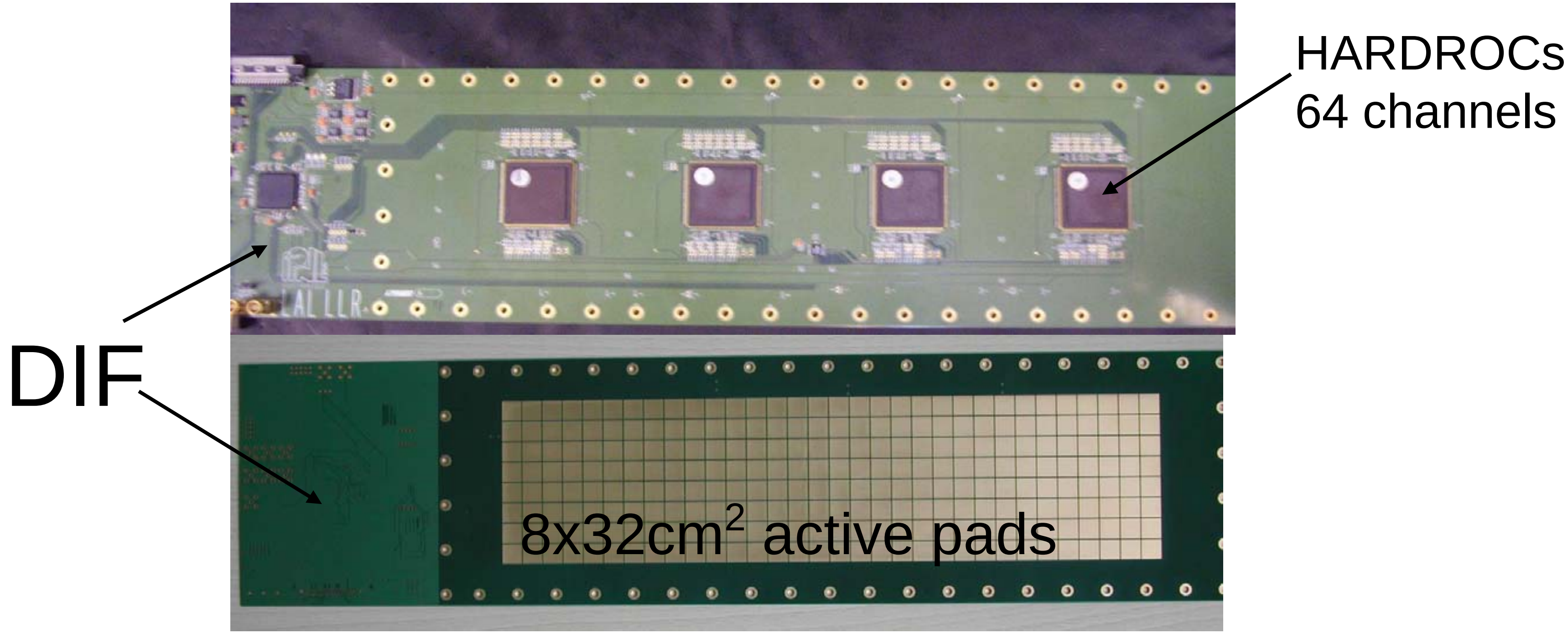


Ready for cosmics acquisitions for days with 4 prototypes!

- pad homogeneity
- X-talk studies
- prototypes disparity
- efficiency measurements

MicroMegas 8cmx32cm

- With digital readout (4 HARDROC ASICs) IPNL-LLR PCB (500 μm interpad)



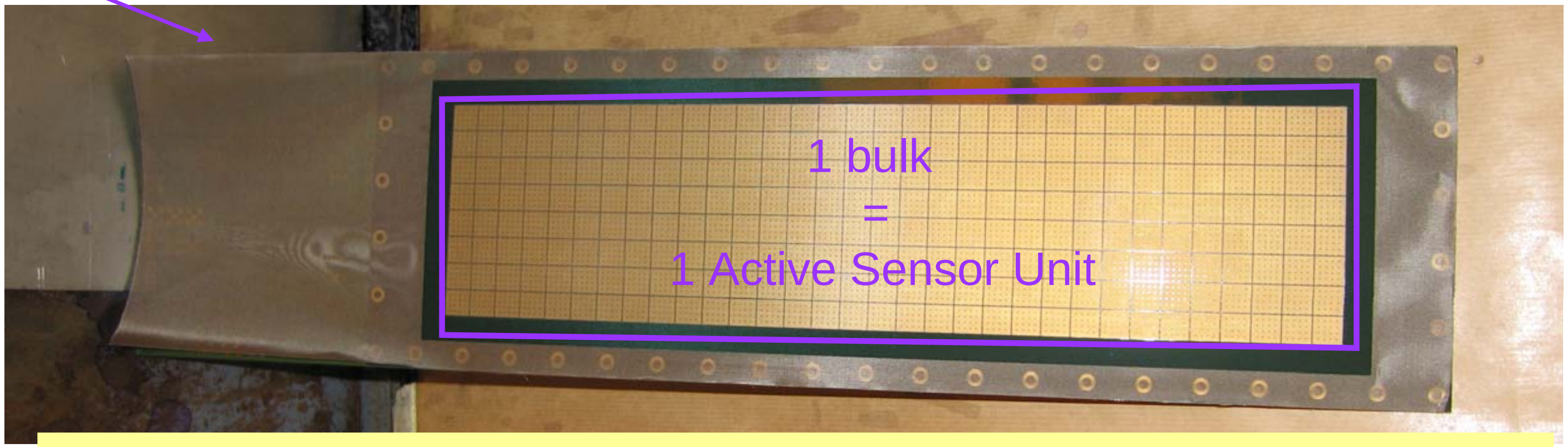
Toward a DHCAL!

(also equipped with RPC : IPNL)

MicroMegas 8cmx32cm

- The first bulk with ASICs on PCB active part !

DIF

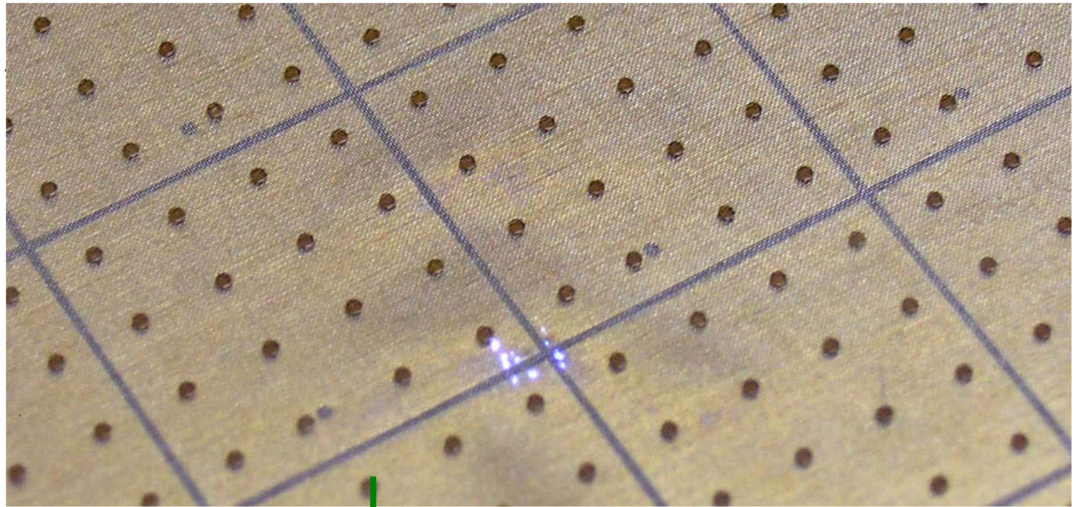


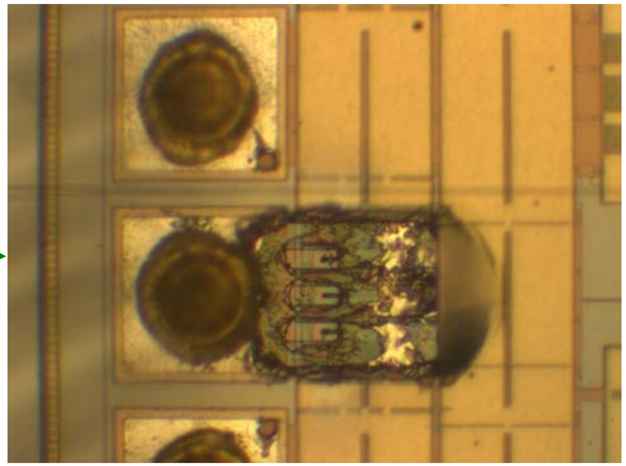
under test right now at IPNL (H. Mathez):

Power Supply ✓ USB Interface ✓

New ASIC from IPNL

- Some nasty tests with the previous 4 channels

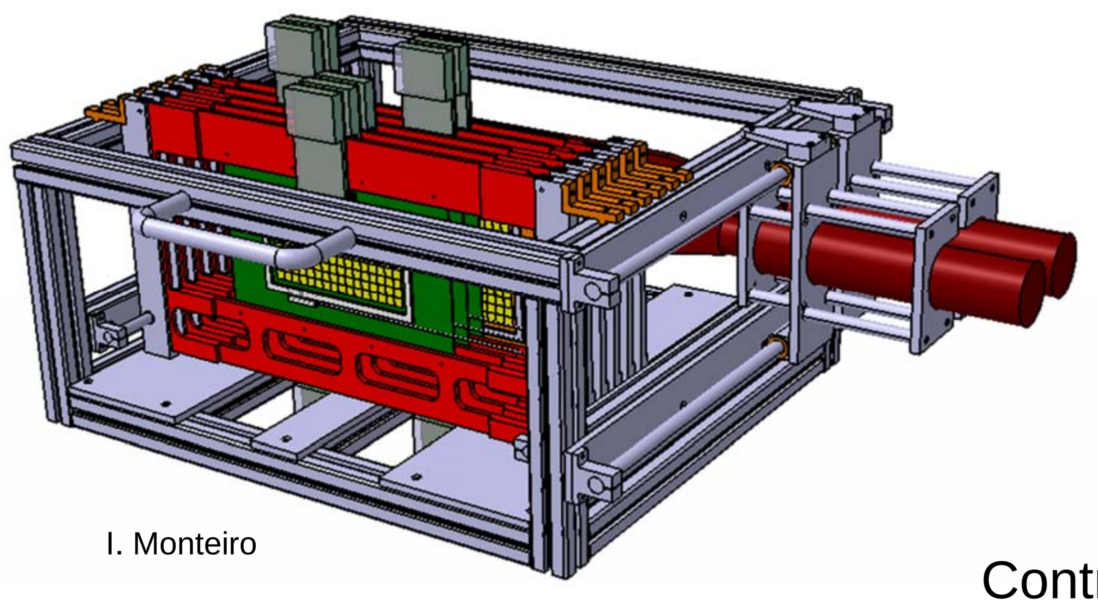




⇒ **strong** protection
for sparks
is compulsory
(see Gassiplex card)

Mini calorimeter prototype

- Test Beam : August 2008 at CERN
  - 3 to 4 MicroMegas-Gassiplex 6cmx16cm ✓
  - 1 to 2 MicroMegas-Gassiplex 12cmx32cm ✓
  - Stainless Steel Absorbers



I. Monteiro

MIPs:
- pad homogeneity
- prototypes disparity
- X-talk studies
- efficiency measurements

Hadronic showers:
- behaviour in showers

Contribution of the IRFU(CEA-Saclay)

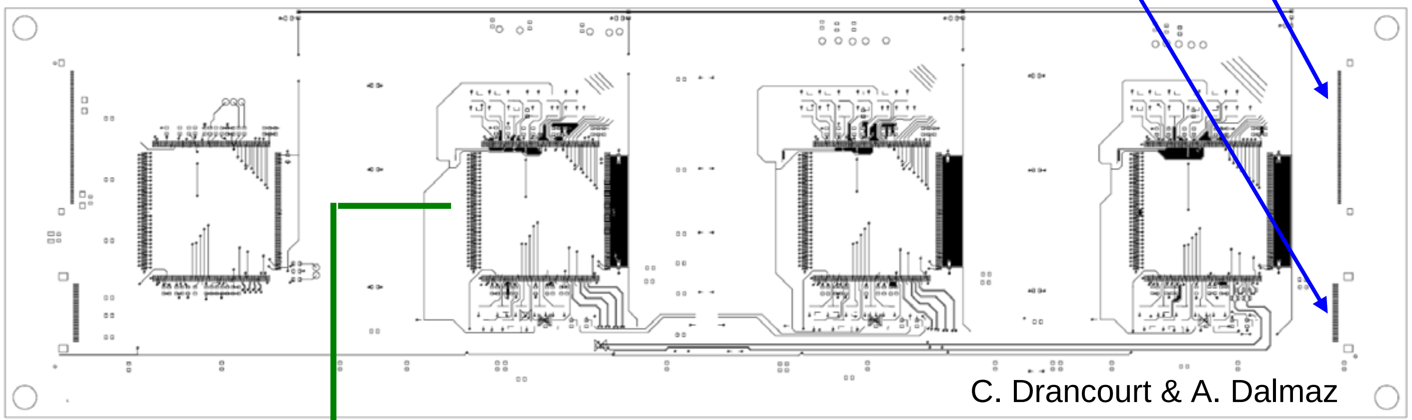
Mini calorimeter prototype

- Test Beam : November 2008 at CERN
  - 3 to 4 MicroMegas-Gassiplex 6cmx16cm ✓
  - 1 to 2 MicroMegas-Gassiplex 12cmx32cm ✓
  - 3 to 4 MicroMegas with **digital** Readout
    ASU and DIF separated
    - ASU with HARDROC 8cmx32cm
    - ASU with IPNL ASIC 8cmx8cm
  - Stainless Steel Absorbers

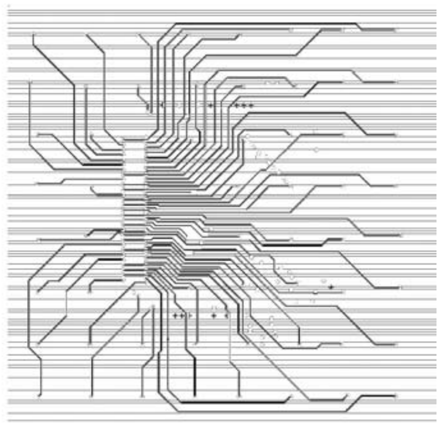
ASU with HARDROC

- Based on the IPNL 8 layers PCB with 4 HARDROCs
- No more lines or components outside the pads area (see ASU assembly)
- Analogue Input **with sparks protections**

Daisy chain In/Out
(hirose connetors)

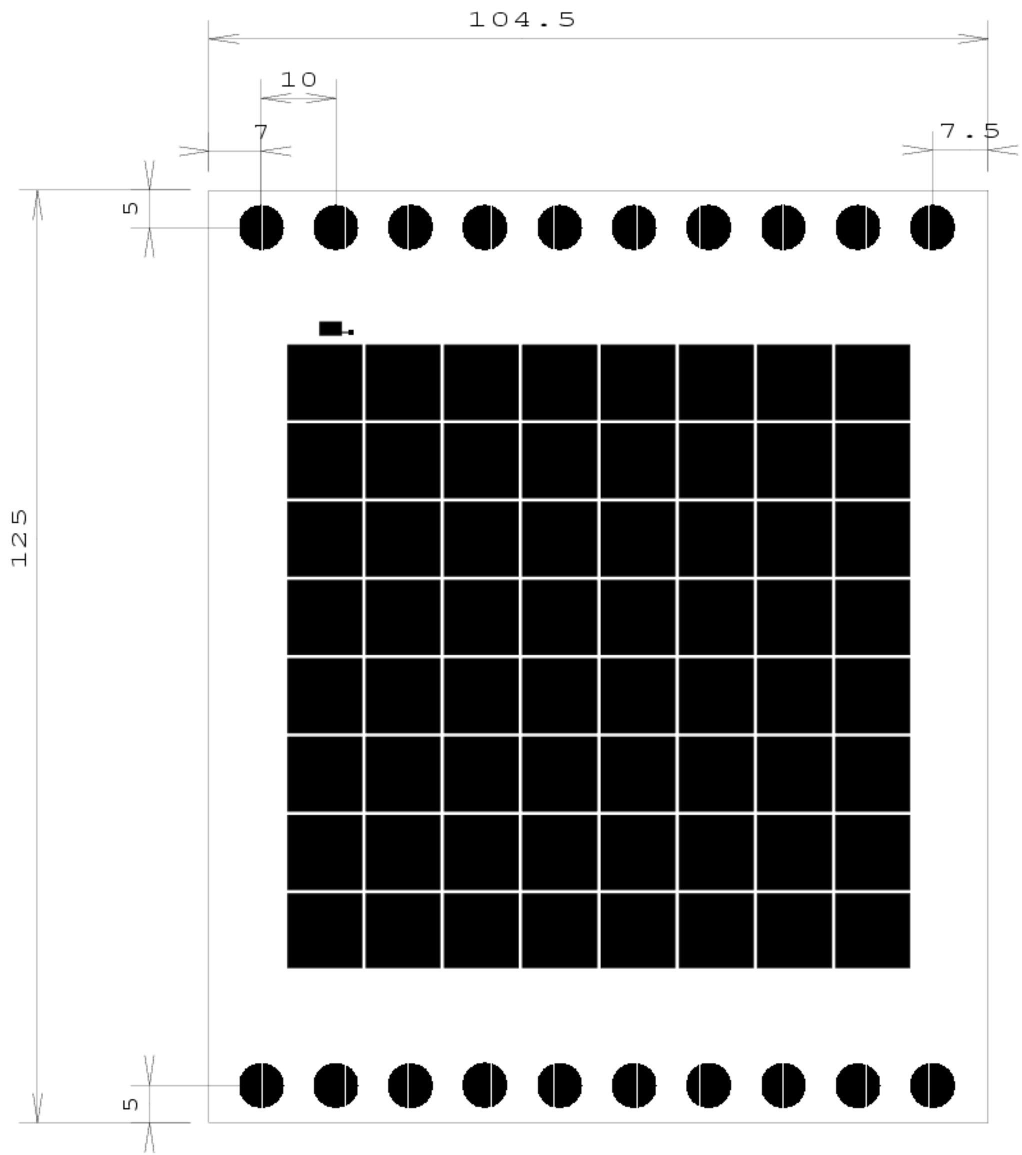


Analog Inputs

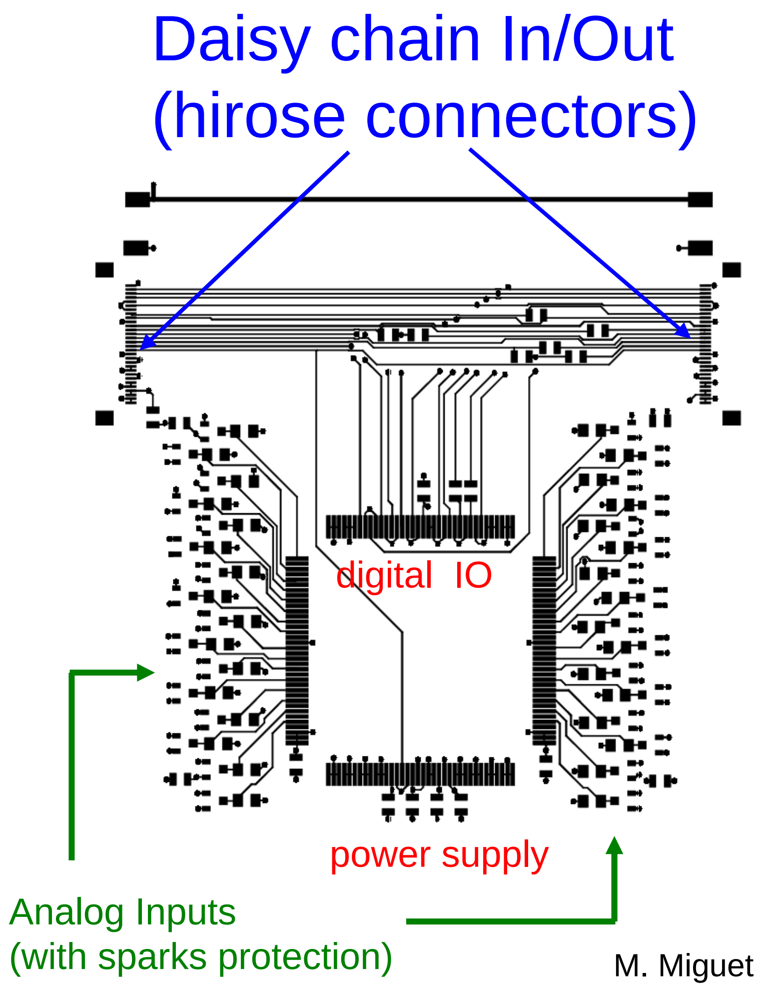


ongoing work

ASU with IPNL ASIC



- 6 layers PCB



Conclusion

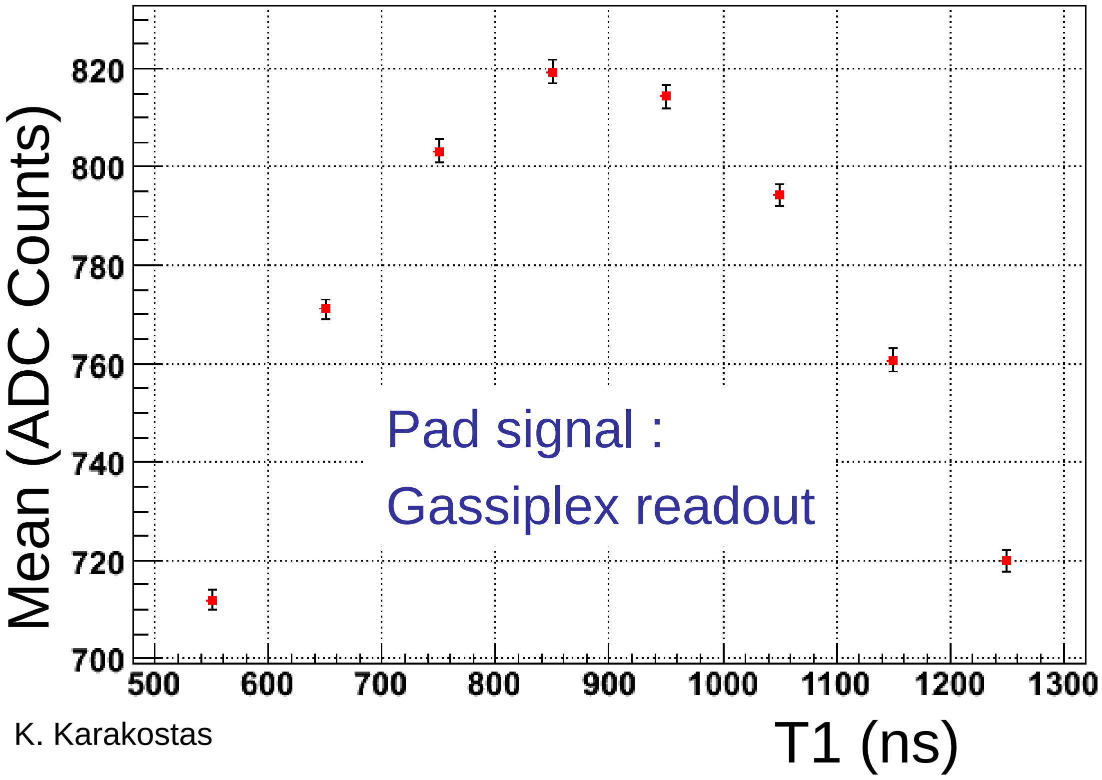
- First results on small MicroMegas prototypes
- MicroMegas Techno looks promising and competitive with other gas detectors.
- Dedicated studies on FE protection are compulsory
- Further tests are ongoing (Cosmics and TB)

Backup slides

X-ray Results

- T1 Optimisation for Gassiplex readout

V_{mesh} = 390 V
V_{drift} = 440 V
E_{mesh} = 32.5 kV/cm
E_{drift} = 167 V/cm



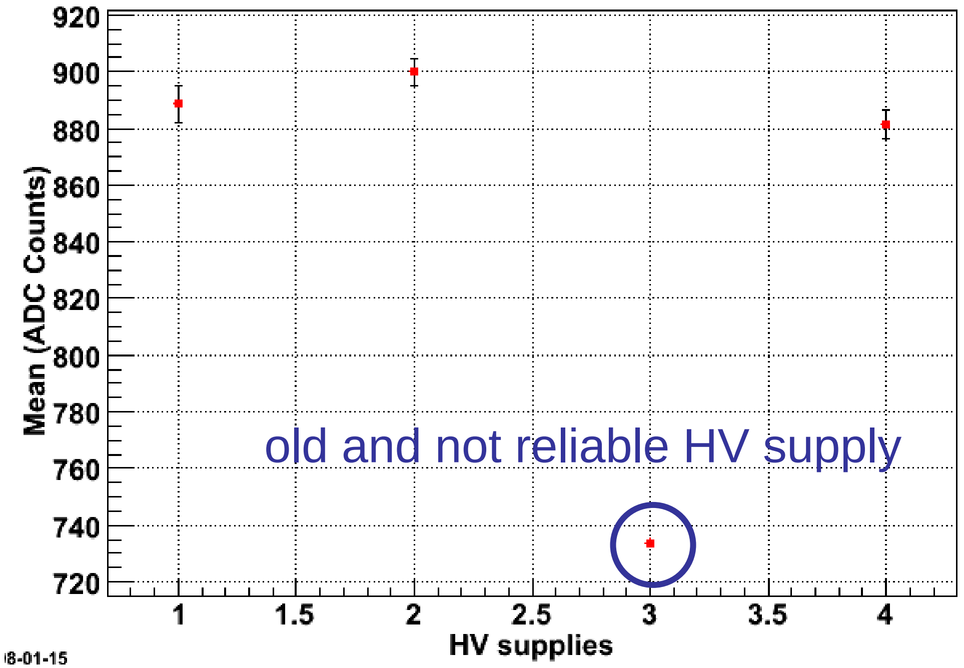
K. Karakostas

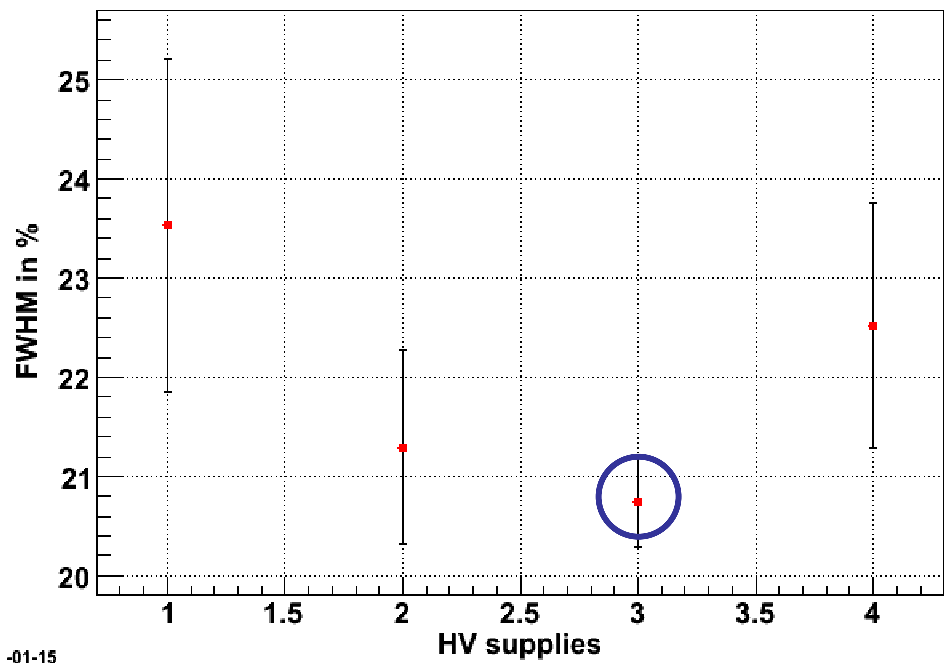
Charge = 820(1500mV)/1024/3.6(mV/fC) = 334 fC

X-ray Results

- HV supply dependencies

V_{mesh} = 390 V
V_{drift} = 450 V
E_{mesh} = 32.5 kV/cm
E_{drift} = 200 V/cm

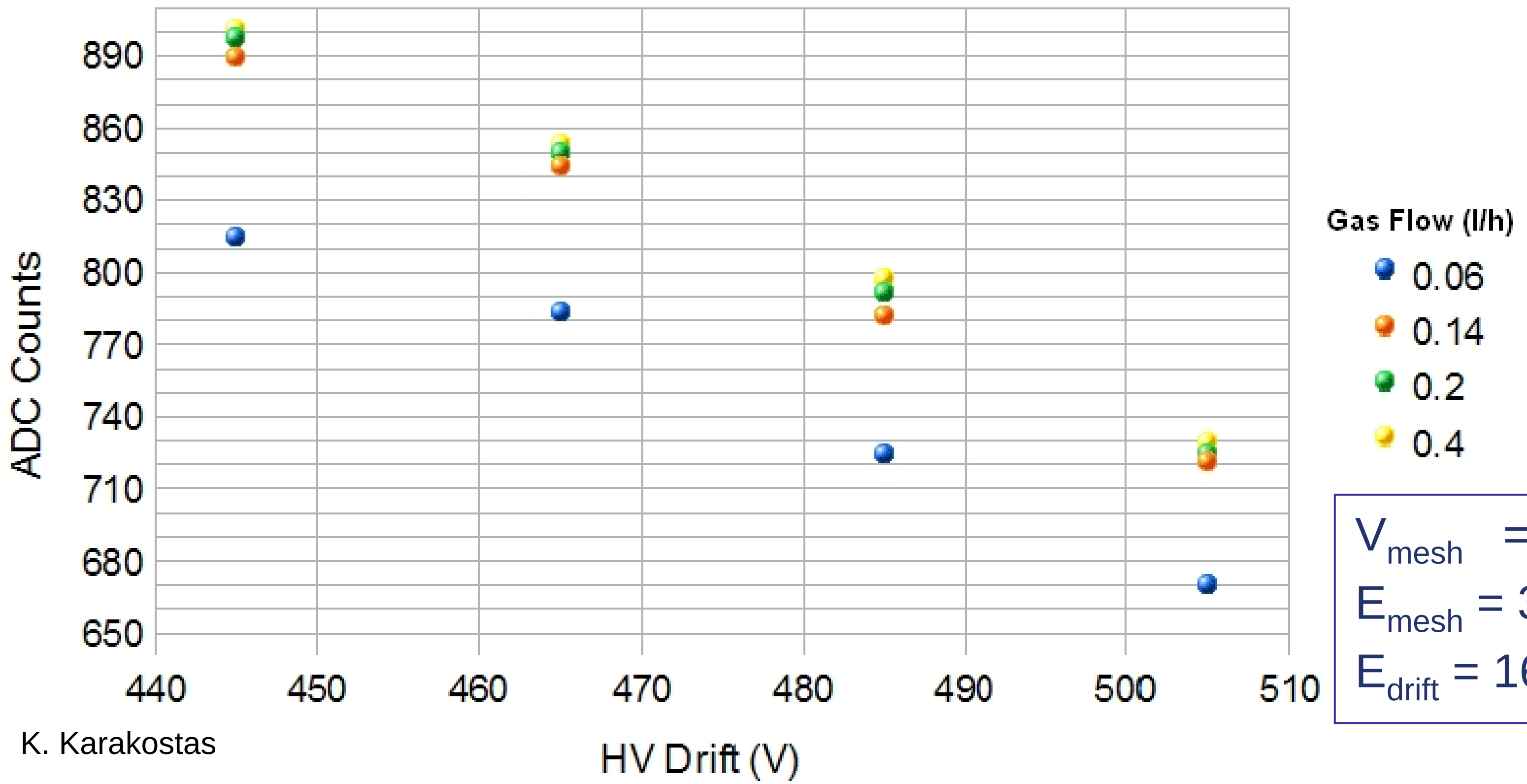




No significant difference between HV supplies

X-ray Results

- Response versus V_{drift} and Gas flow dependencies



V_{mesh} = 395 V
E_{mesh} = 33 kV/cm
E_{drift} = 167-367 V/cm

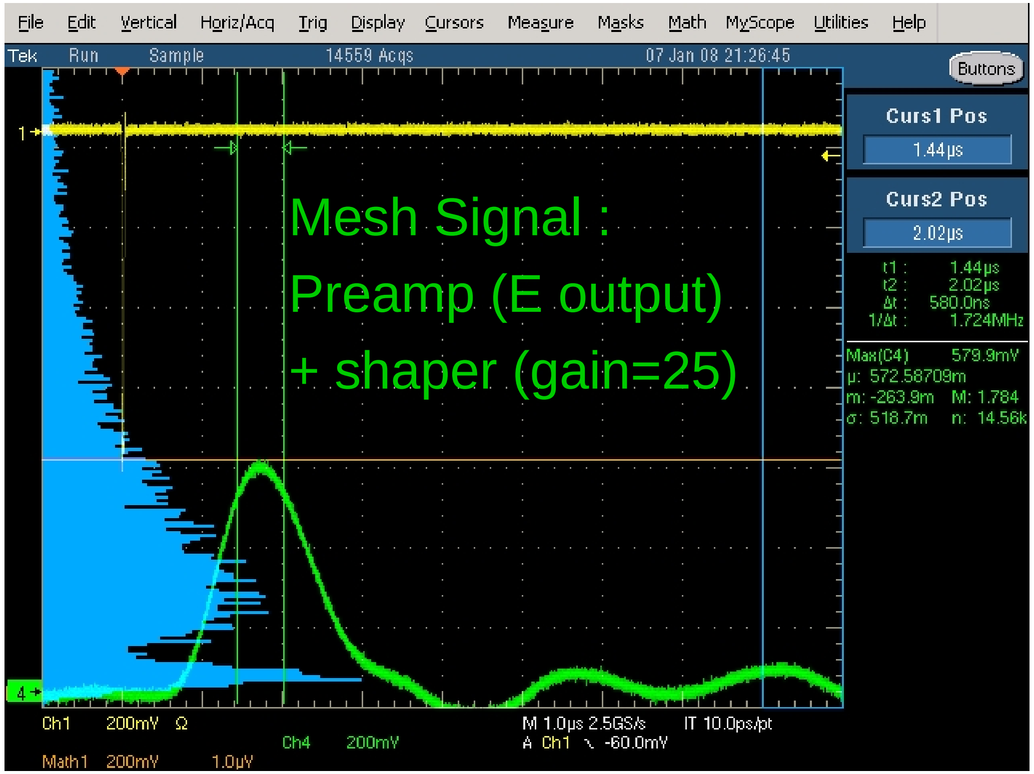
K. Karakostas

Saturates for Flow > 0.20 l/h ≈ 7 volume/h

Gain ↘ when Drift field ↗

Cosmics

- Trigger on 3 scintillators coincidence

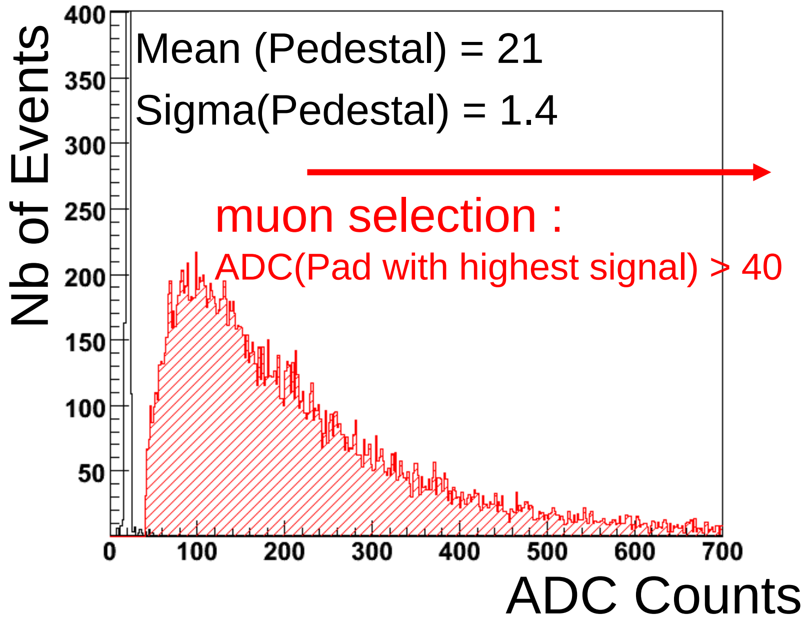


Charge ≈ 210(mV)/25/0.312(mV/fC) = 27 fC

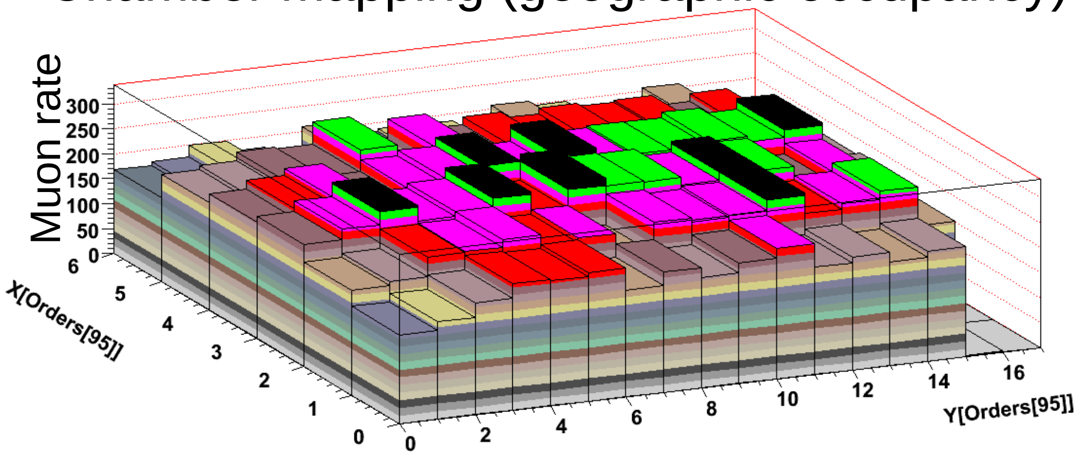
Cosmics

- Muon in 3mm drift volume = 29e$^-$
- Gassiplex Readout :

V_{mesh} = 410 V
V_{drift} = 470 V
E_{mesh} = 34 kV/cm
E_{drift} = 167 V/cm



Chamber mapping (geographic occupancy)



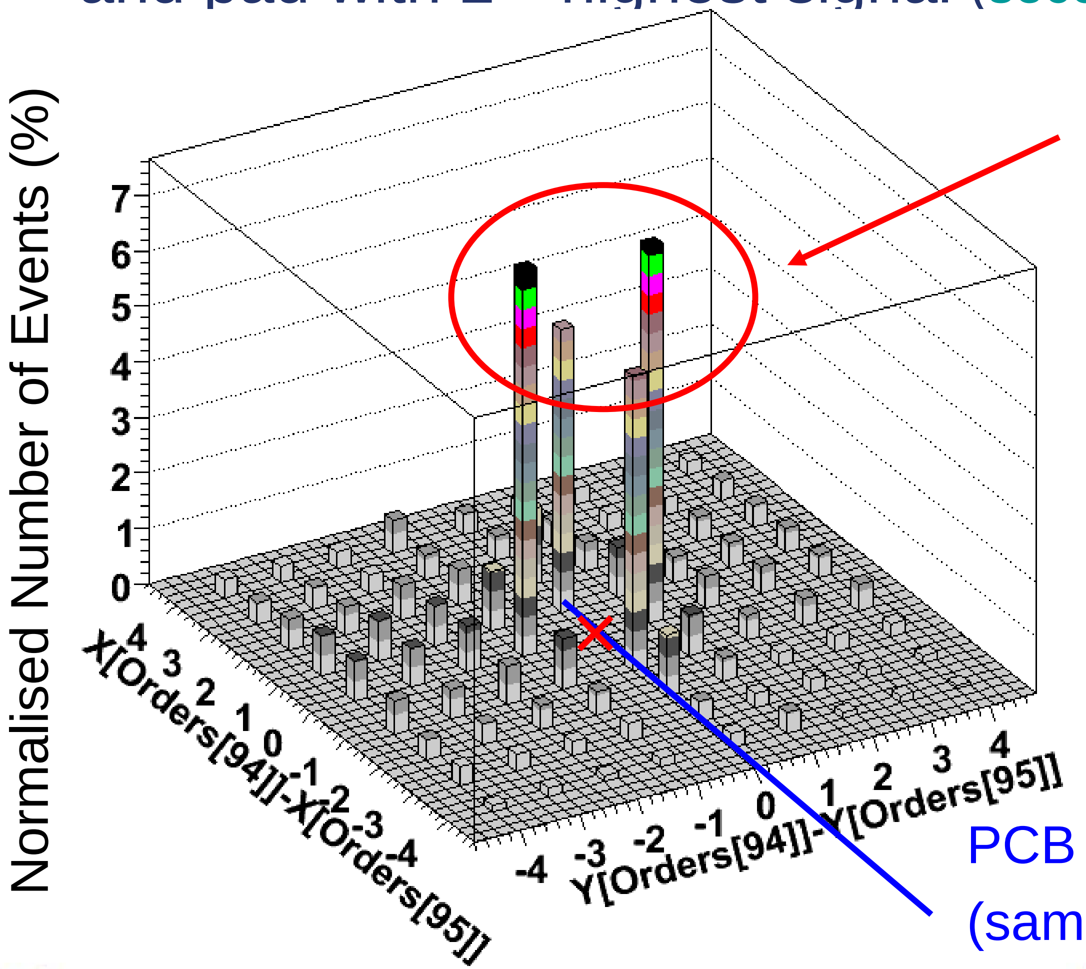
reflects scintillators geometry

Charge ≈ 80(1500mV)/1024/3.6(mV/fC) = 32 fC

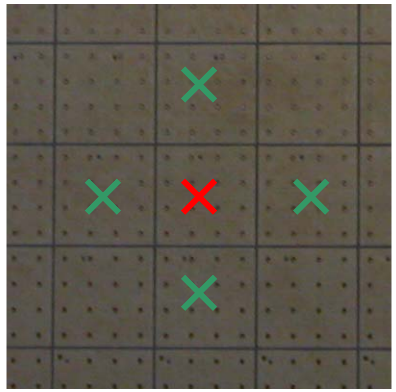
Gain ≈ 6900

Cosmics

- After muon selection :
  distance between pad with highest signal (muon pad)
  and pad with 2nd highest signal (second pad)



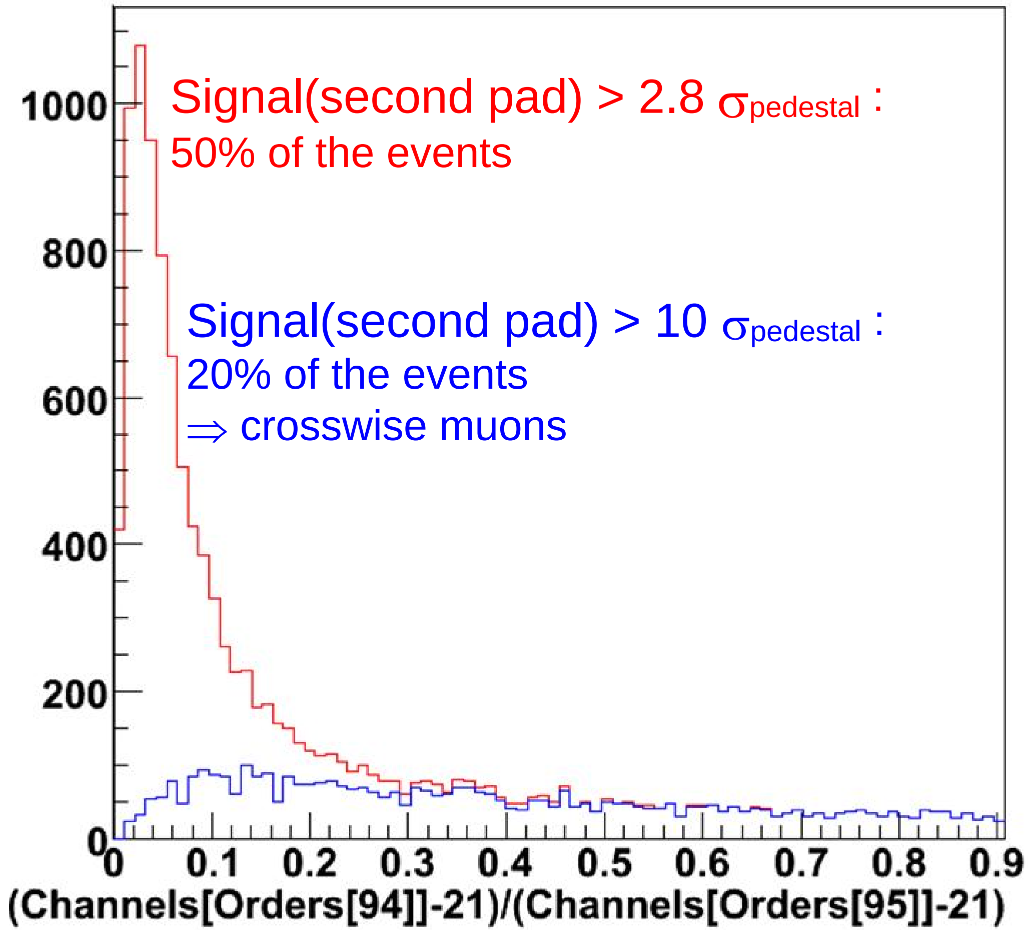
20% of the events with a muon have the second highest signal close to the muon pad



Dominant Crosstalk?

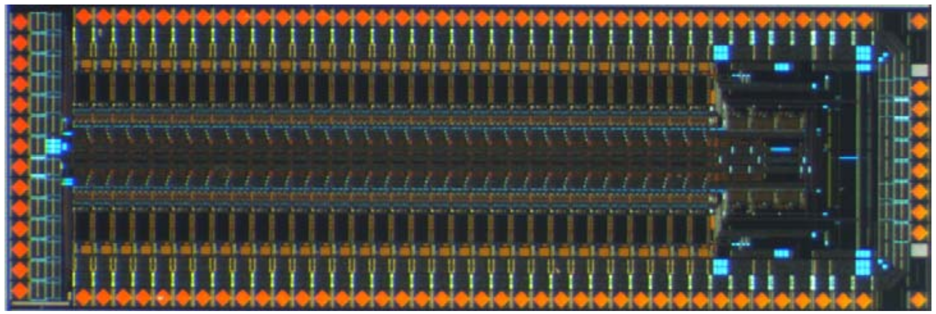
Cosmics

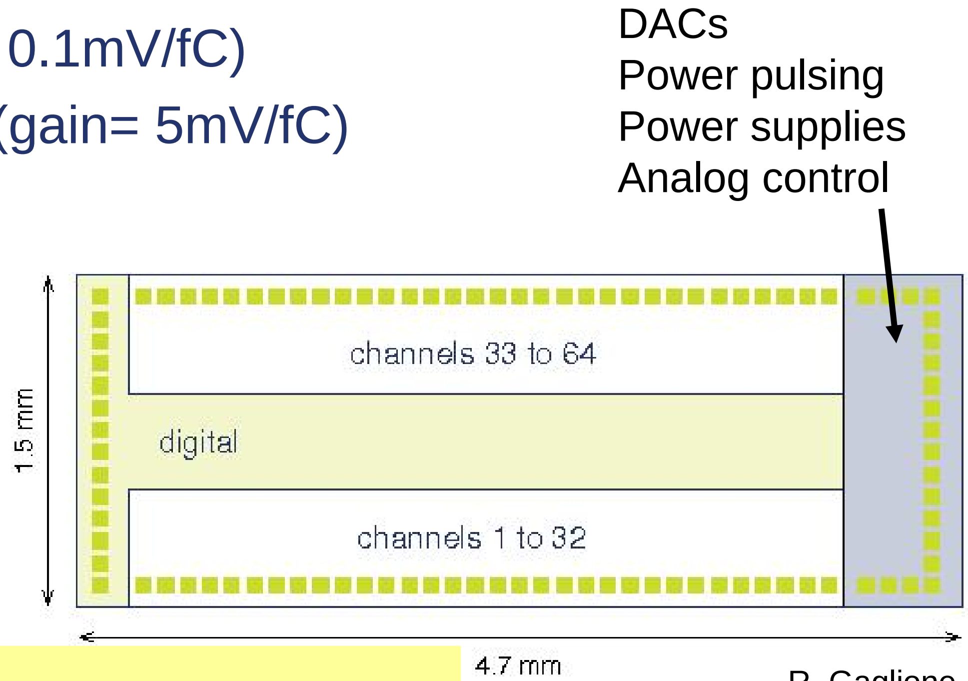
- Signal(second pad) / Signal(muon pad)



New ASIC from IPNL

- 0.35 μm CMOS technology
- 64 Analog Inputs
- 3 thresholds (DAC 8 bits)
- Covers a large dynamic range
  - RPC : 100 fC to 10 pC (gain= 0.1mV/fC)
  - MicroMegas : 10 fC to 200fC (gain= 5mV/fC)
- Power pulsing



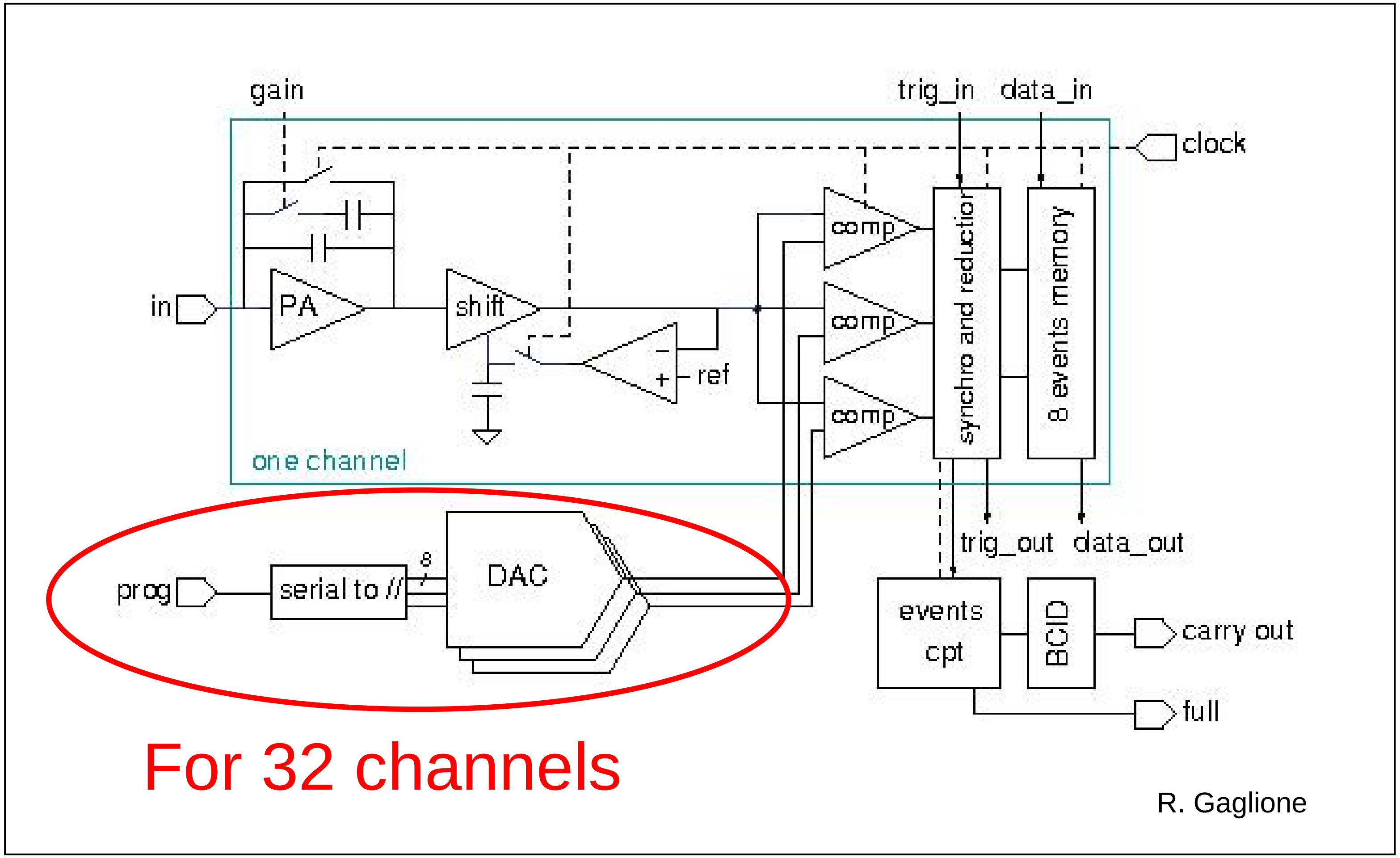


R. Gaglione

Cheap and Easy PCB routing

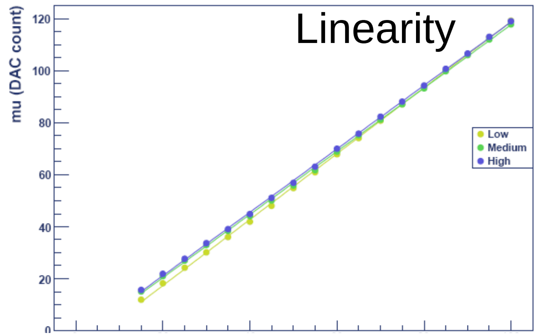
New ASIC from IPNL

- Schematic

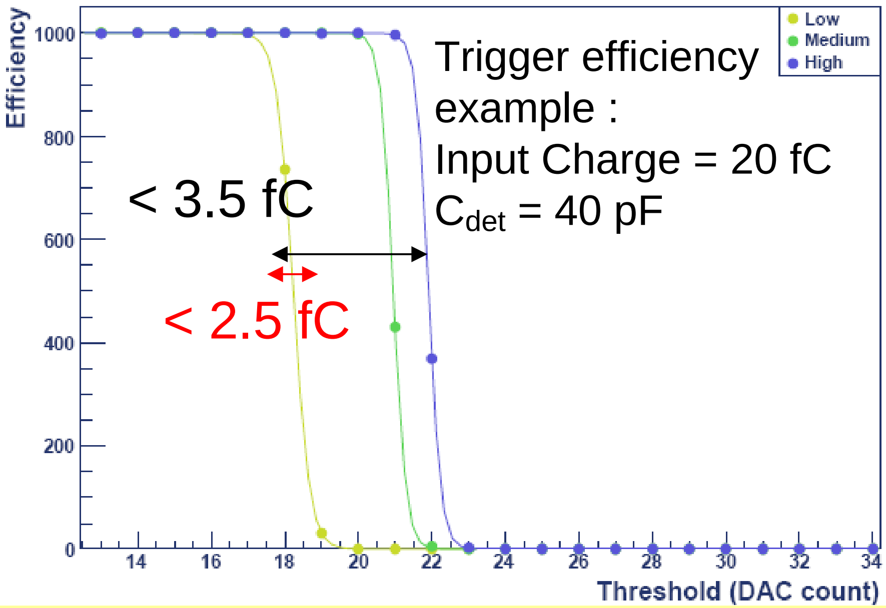


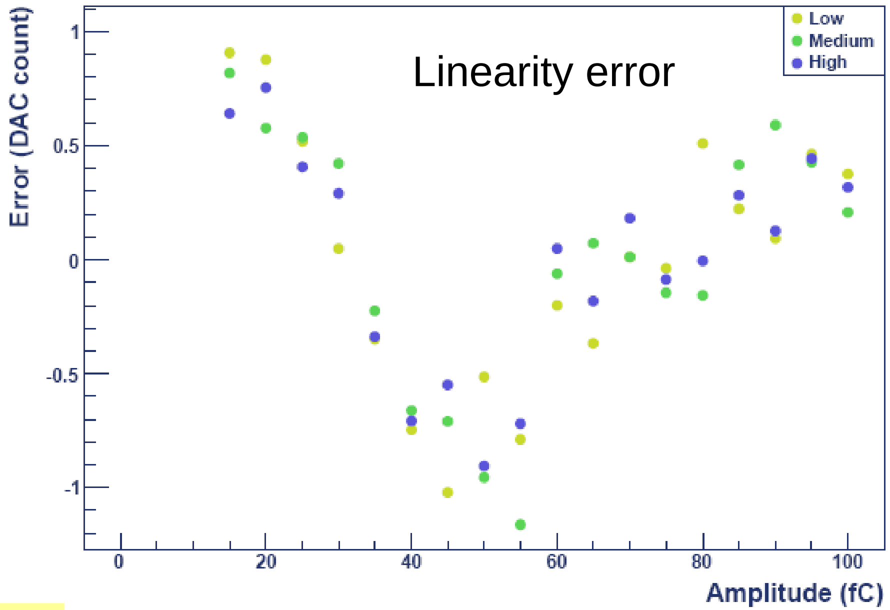
New ASIC from IPNL

- First Results
  (MIP @ 30 fC)



R. Gaglione





Noise for one comparator < 2.5 fC

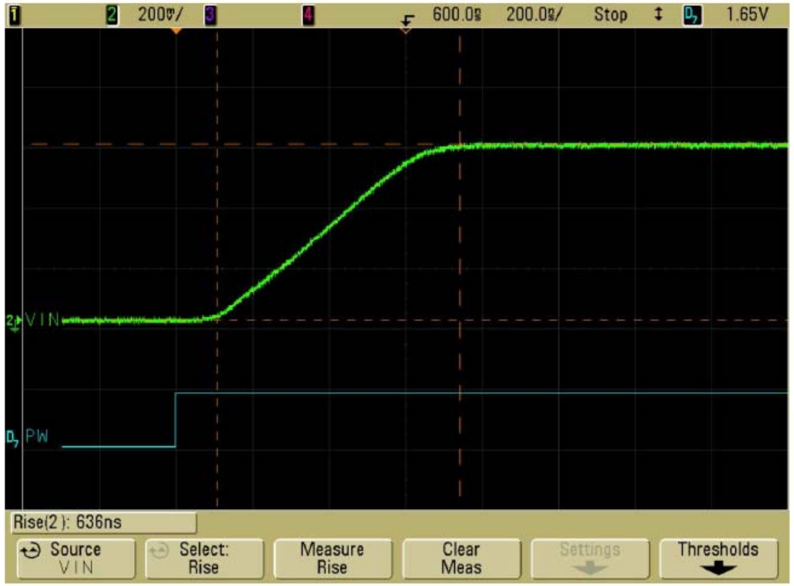
Total dispersion < 3.5 fC

Linearity error < 1.6 fC

(MIP @ 30 fC)

New ASIC from IPNL

- Power Pulsing



Preamp
Bias Voltage

Wake up time < 800 ns

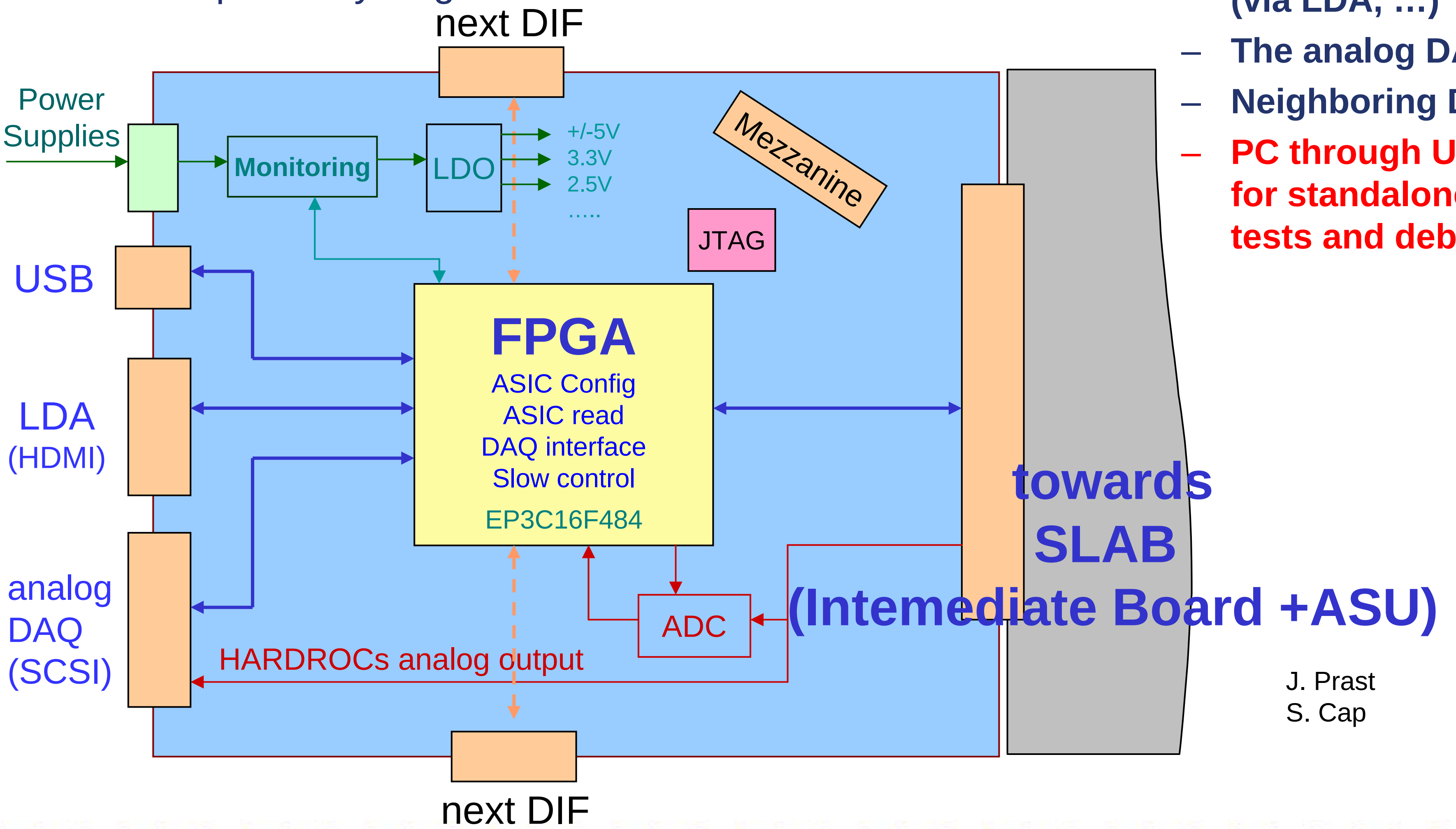
- Power Consumption :
  1 mW/channel

$\Rightarrow$ 10 μW/Channel with power pulsing
500 W for a 50 Million channels DHCAL

Digital InterFace (DIF)

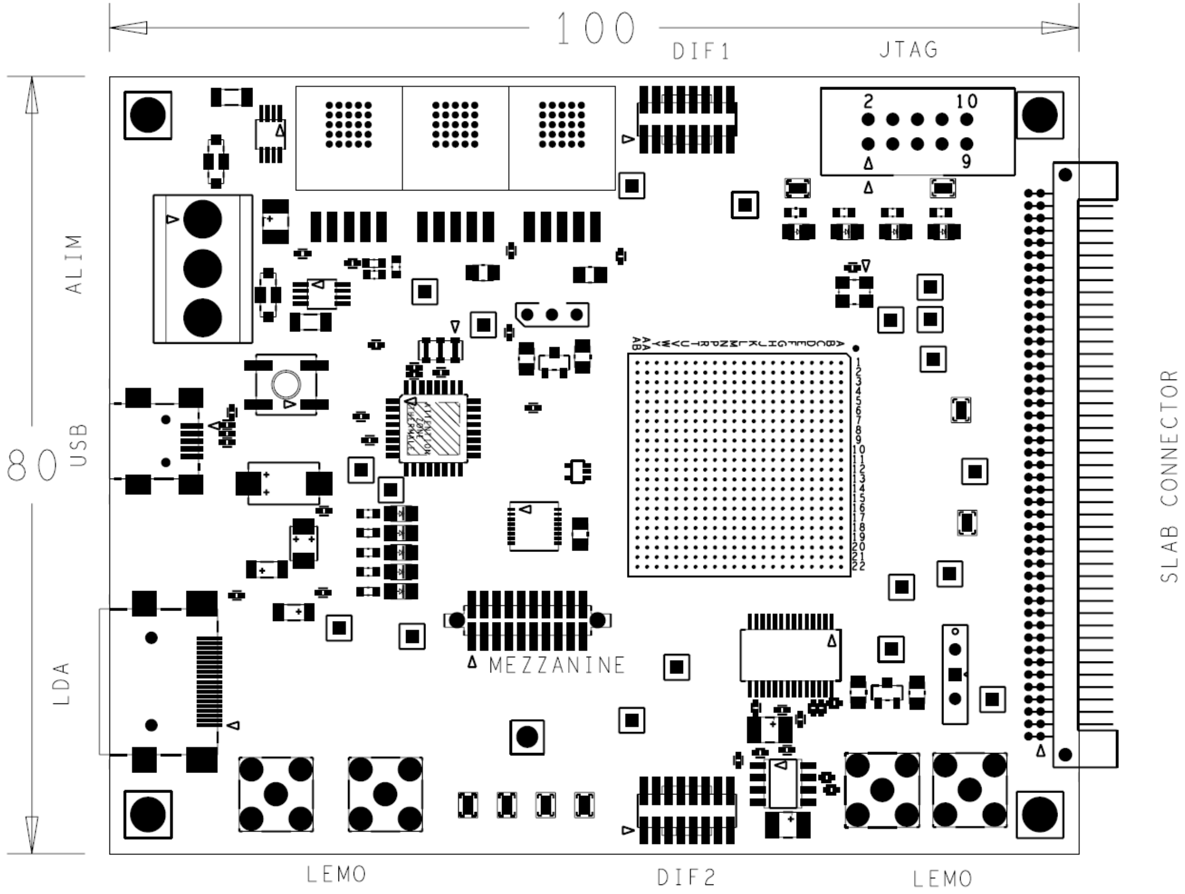
- Separated from the slab for more flexibility.
- up to 100 FE ASICs (HARDROC or IPNL ASIC) with power cycling

- Interfaces with :
  - **The final DAQ (via LDA, …)**
  - **The analog DAQ**
  - **Neighboring DIFs.**
  - **PC through USB for standalone tests and debugs.**



J. Prast
S. Cap

Digital InterFace (DIF)



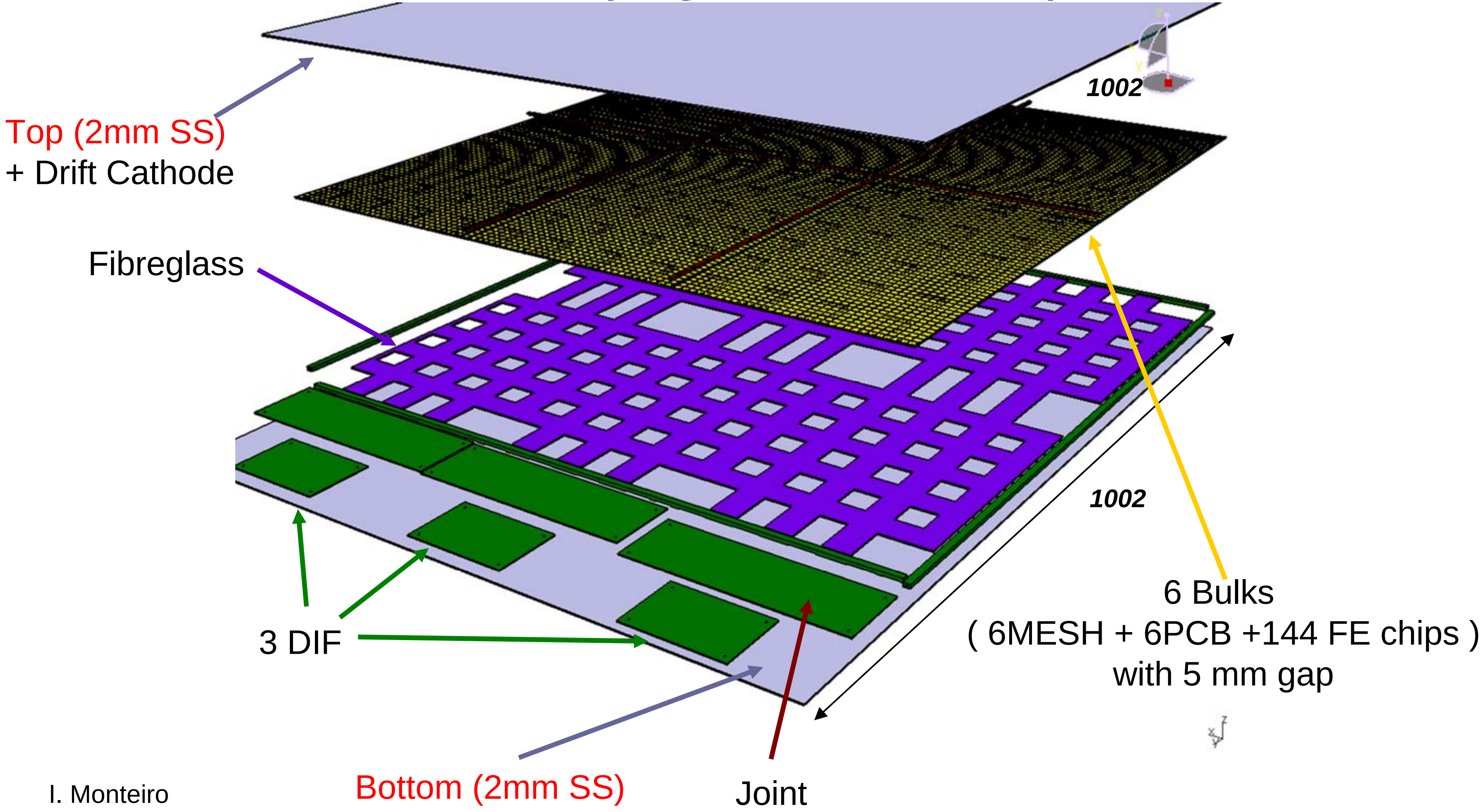
J. Prast
S. Cap

- 12 layers PCB

Ready for tests : end of May

Design of a 1m^2 MicroMegas

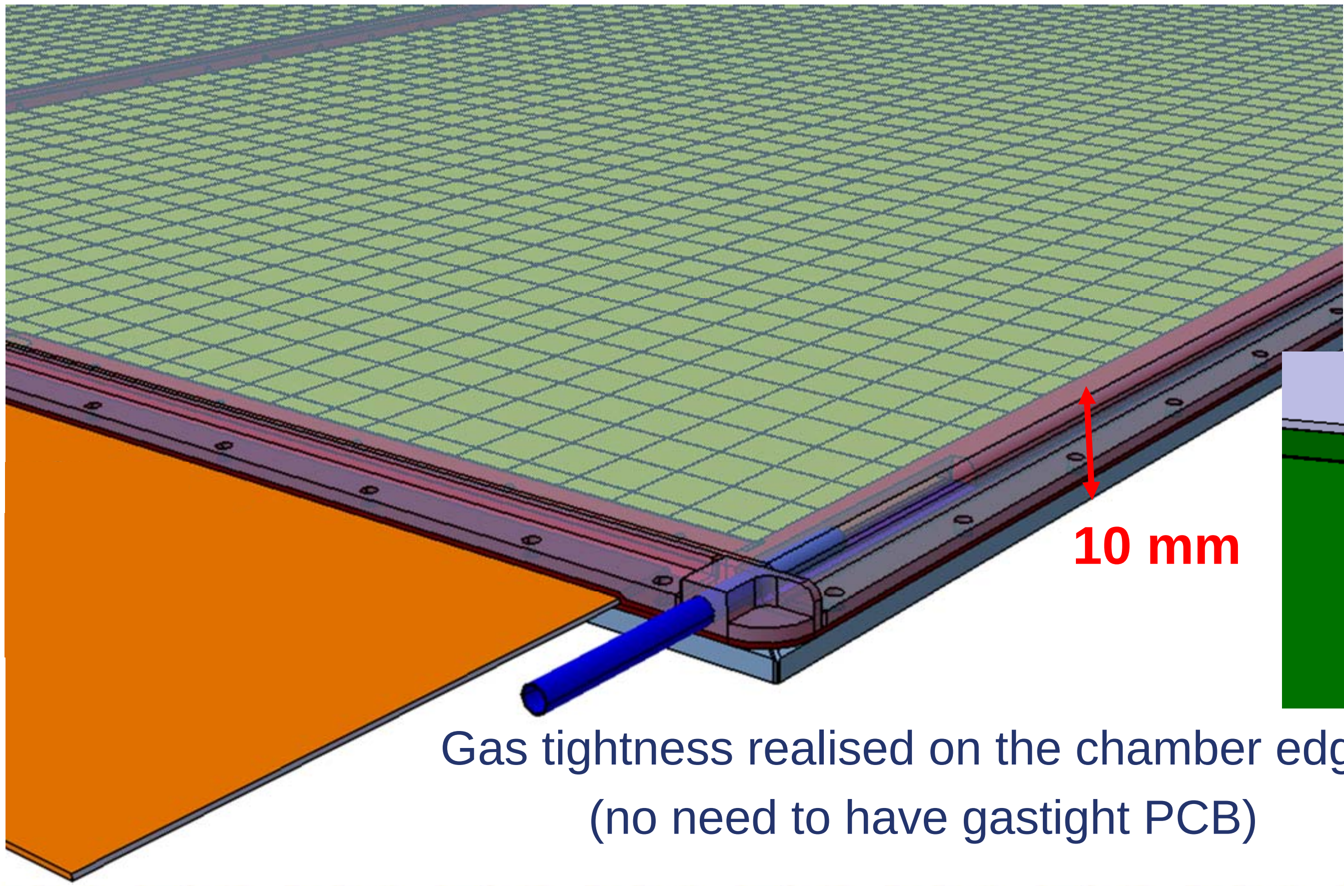
- Case with 3 DIF (Digital InterFace)



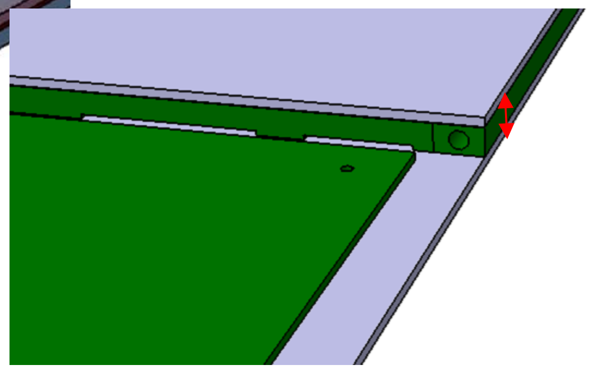
I. Monteiro

Design of a 1m^2 MicroMegas

- 10 mm total thickness including
  - **4 mm SS (absorber)**
  - **6 mm active volume**



Other design

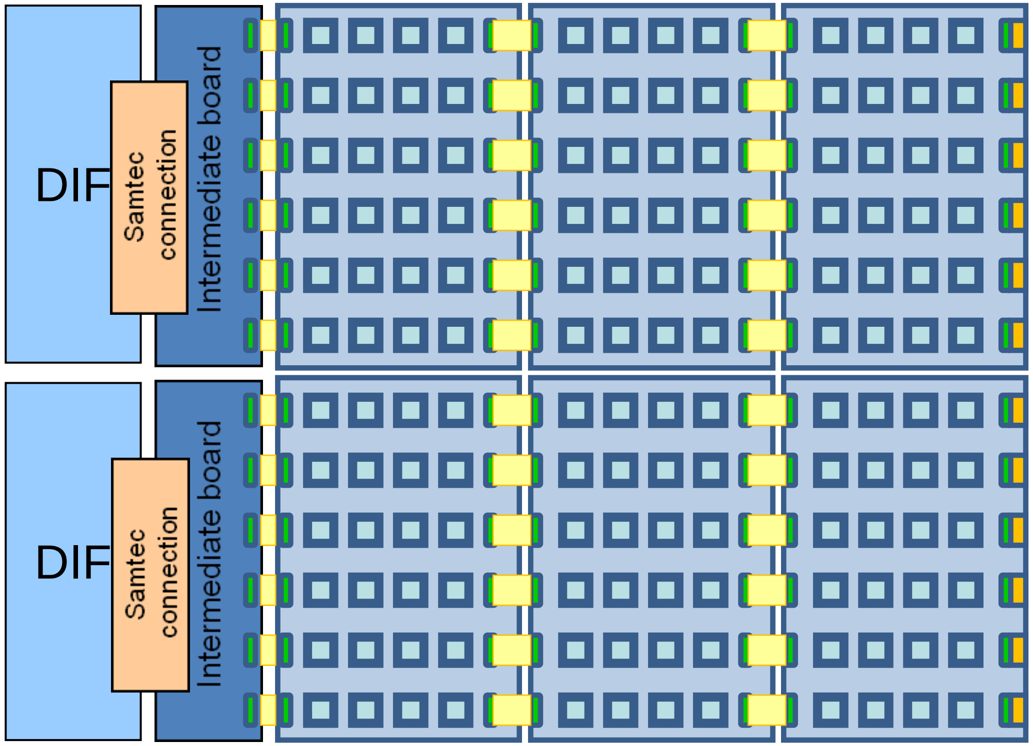


Gas tightness realised on the chamber edges
(no need to have gastight PCB)

I. Monteiro

Different designs

- 2 DIF case



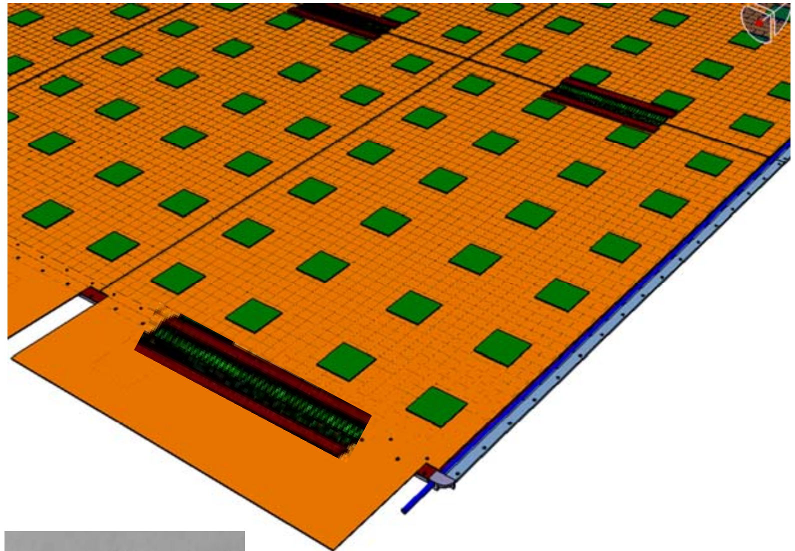
: Flat Printed Circuit (kapton)

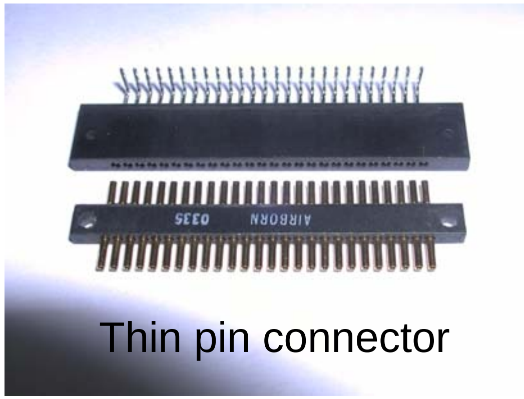
: FE chip

: Hirose connector

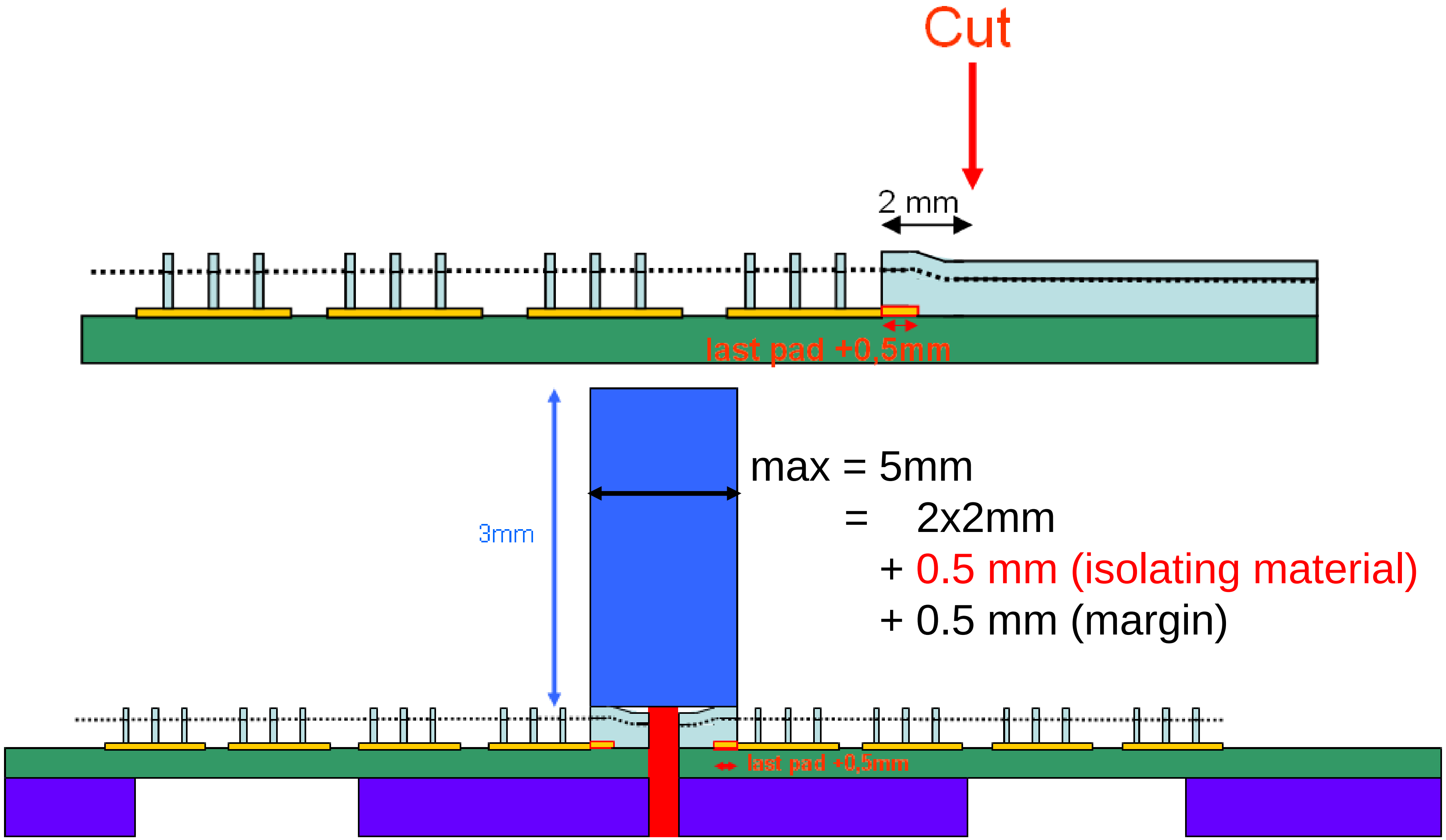
: Terminaison board

- 3 DIF case





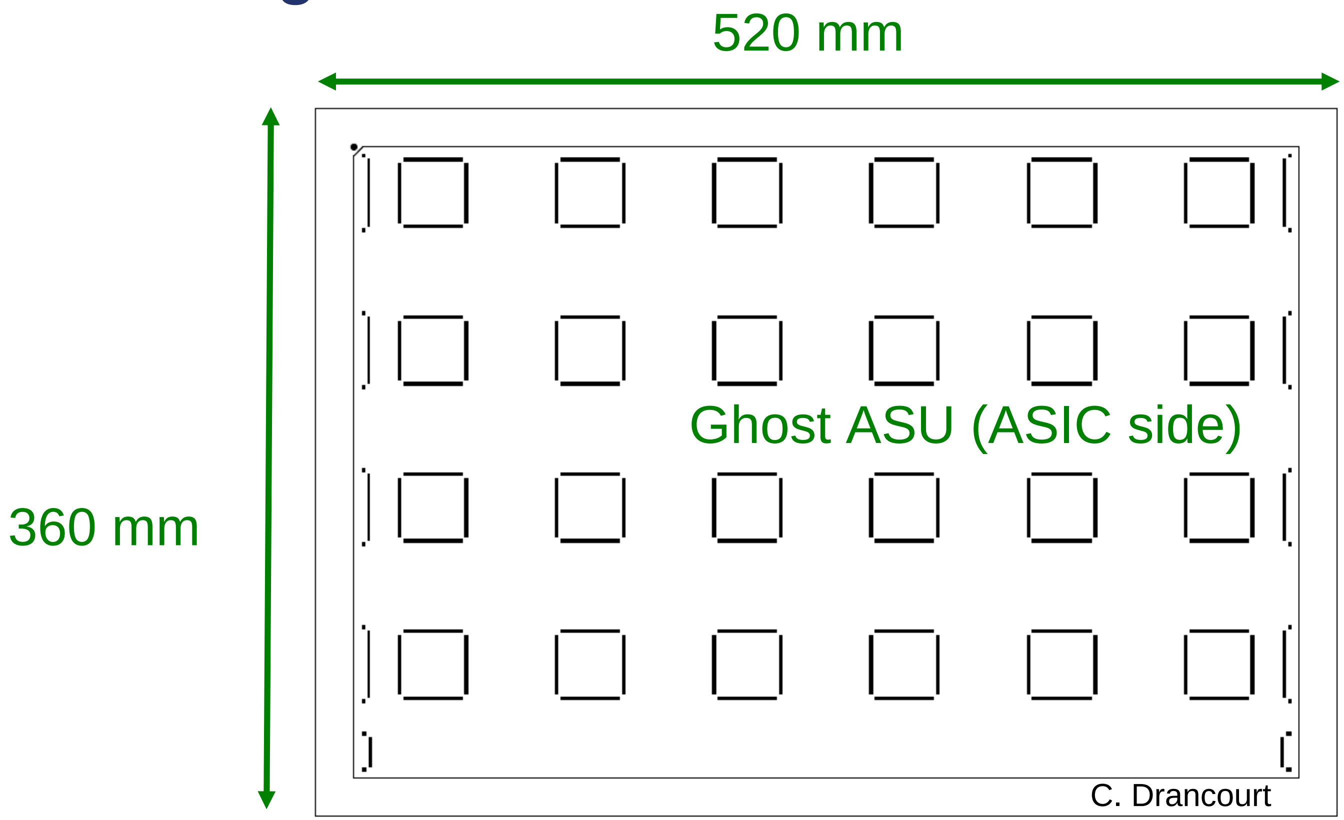
ASU Assembly



max = 5mm
= 2x2mm
+ 0.5 mm (isolating material)
+ 0.5 mm (margin)

Mechanics Prototype

- $1m^2$ prototype :
  - **assembly tests with ghost ASU**
  - **Gastight tests**



Mechanics Prototype