Micromegas for a DHCAL

M. Chefdeville, A. Espargiliere
LAPP, Annecy

Micromegas for a DHCAL

- Introduction
  - PFA oriented detectors & DHCAL R&D @ LAPP
- Reminder: beam test results with small prototypes
  - Studies with analog prototypes
  - Studies with digital front end electronics
- The 1 m^2 Micromegas prototype
  - Design
  - Mechanical prototype
  - Active Sensor Unit (ASU) fabrication and tests
- Conclusion & future plans

Calorimetry at future e^+e^- colliders

- Jet energy resolution at future e^+e^- colliders (better than 30%/√E)
  - Dual readout

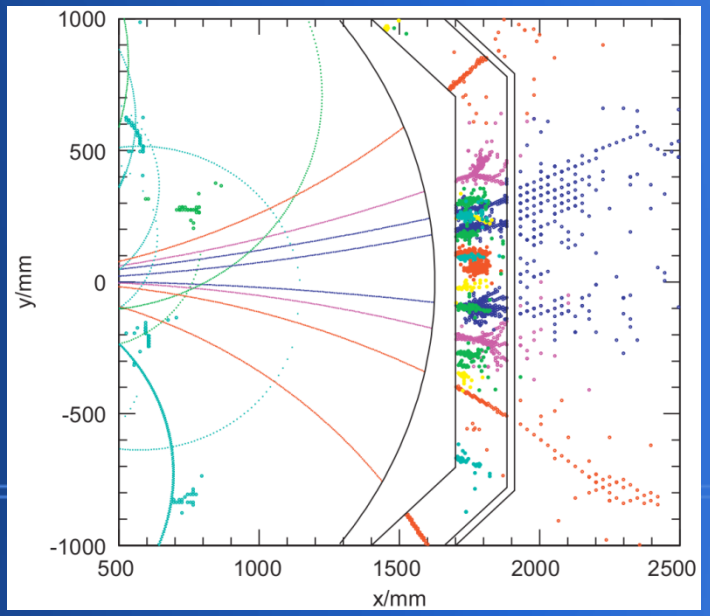
    ILC 4th concept – LOI not accepted, but original calorimetry technique
  - Particle Flow Algorithm (PFA) (SiD, ILD)

    Combine measurements of tracker and calorimeters

    Need imaging capability of calorimeters to identify single particle contributions

PFA:

- Charged particle energy measured with tracker (much more precise)
- Charged particle contribution removed from calorimeter hits
- Calorimeters measure neutral energy only



Calorimetry at future e^+e^- colliders

- PFA

  → high lateral & longitudinal segmentation of ECAL and HCAL

  - e.g. HCAL @ ILC:

    4.5 λ_i, inside coil (40 layers of steel)

    2.8 cm sampling period (8 mm gaps)

    1-9 cm^2 readout cells

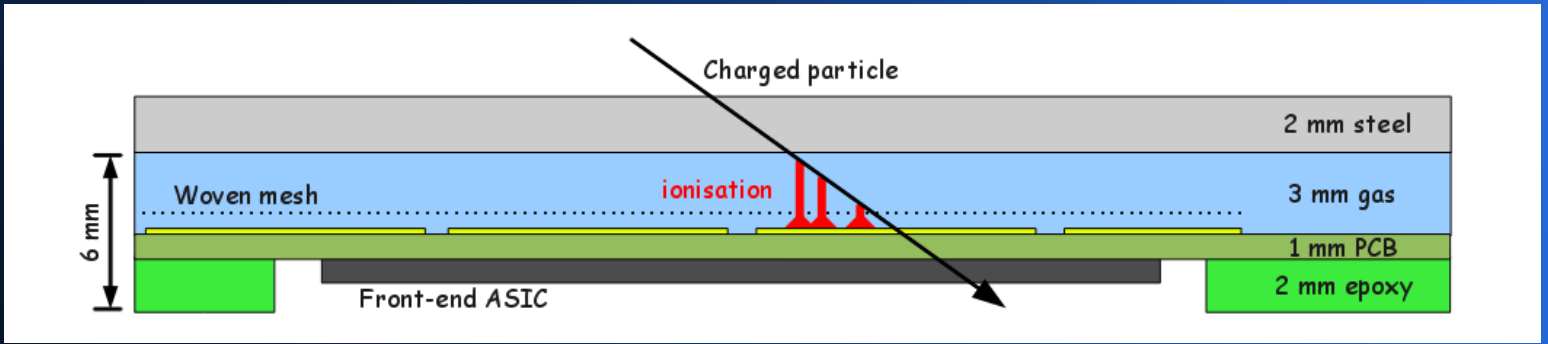
- Total area ~ 3000 m^2 (SiD) → (semi-)Digital readout

- Semi-DHCAL R&D in France

  - RPC and Micromegas
  - 1 m^3 physics prototype made of 40 m^2 planes

Micromegas for DHCAL (1)

- Prototypes layout :
  - Bulk technolgy (128 µm amplification gap)
  - 3 mm conversion gap
  - 8 mm thick (with embedded front-end chips)
  - 1 cm^2 readout pads
  - Cathode glued on 2 mm steel lid (part of absorber)

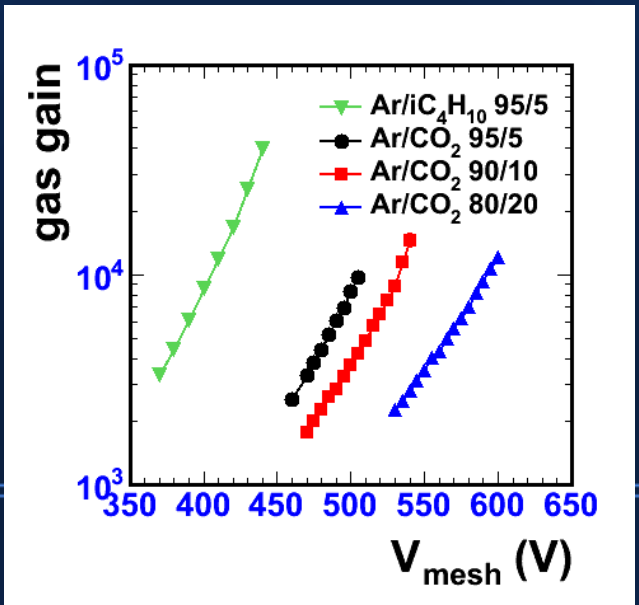


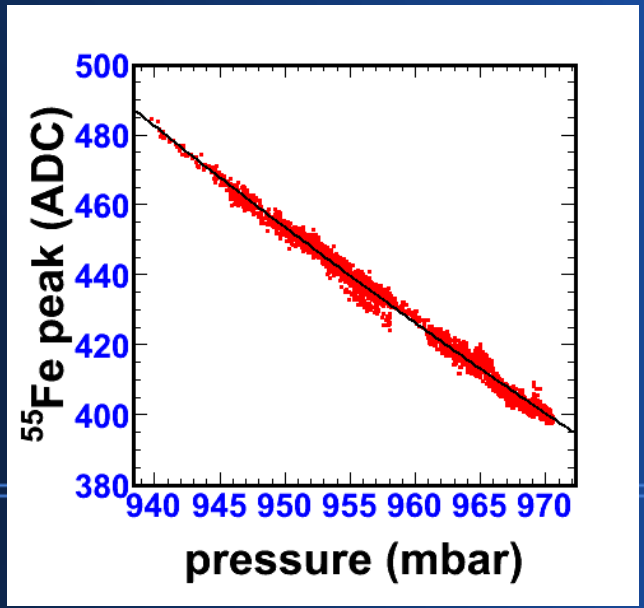
Micromegas for DHCAL (2)

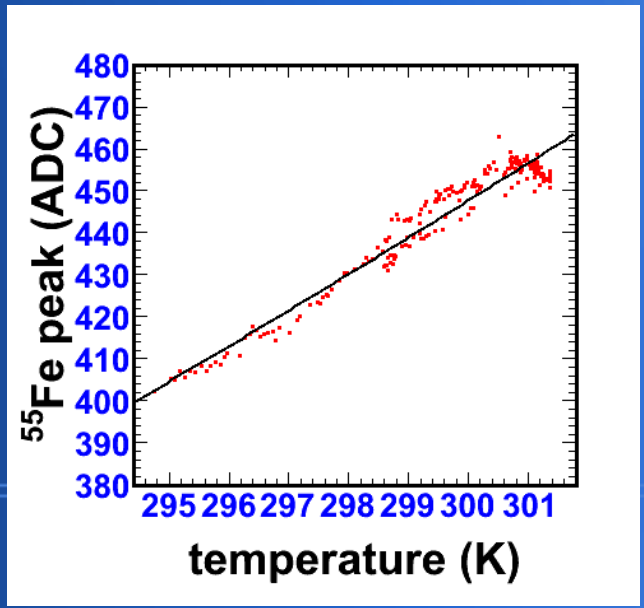
- Operating conditions
  - Argon based mixtures
    - Ar/iC_4H_{10} 95/5 (mostly used)
    - Ar/CO_2, various mixings
  - Bias voltage below 500 V
    - V_{mesh} = 420 V
    - V_{drift} = 470 V

Micromegas for DHCAL (3)

- Operational caracteristics (G(V), G(P), G(T))
  - Gain over 10^4 in all gas mixtures
  - dG/dP = -0.61% $mbar^{-1}$
  - dG/dT = 1.37% K^{-1}





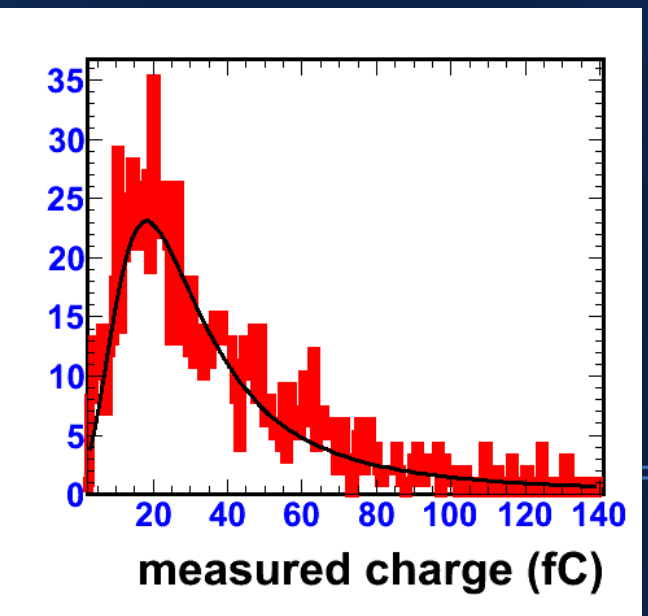


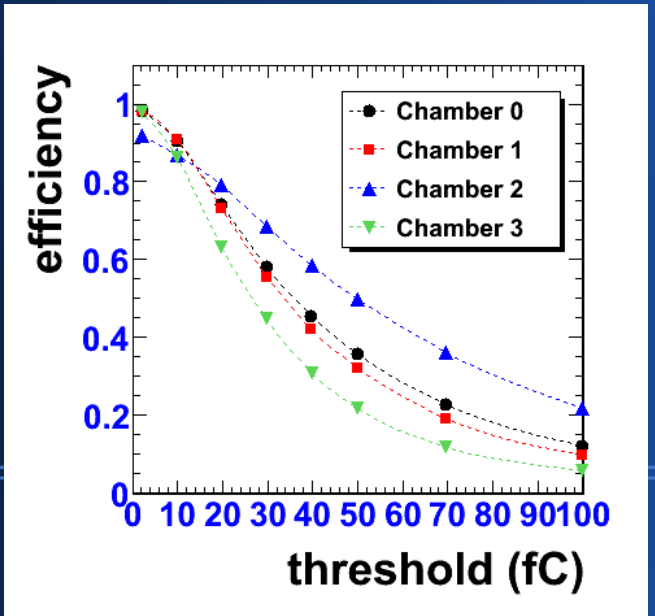
Analog readout prototype beam tests

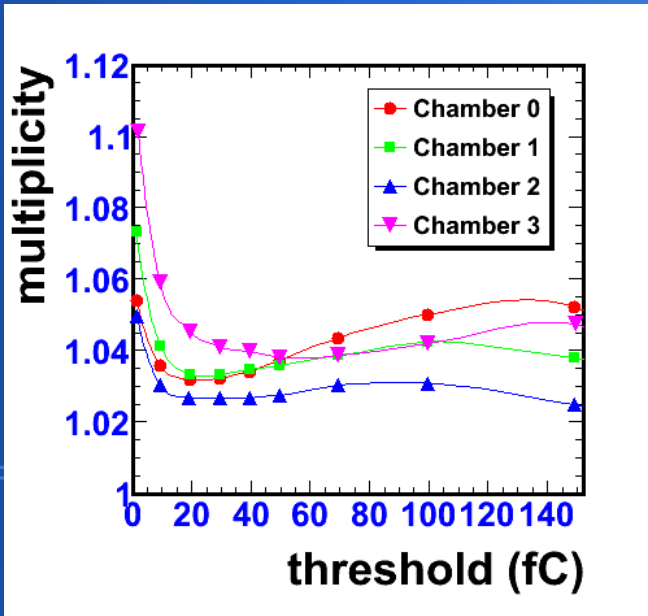
- Four prototypes (3 of 6x16 pads and 1 of 12x32 pads)
  - GASSIPLEX readout + VME ADC
- TB @ CERN for caracterisation
  - SPS/H2 august 2008 (200 GeV/c muons)
  - PS/T10 november 2008 (7 GeV/c pions)

At 1.5 fC threshold

- Landau MPV ~22 fC
- Variations ~ 1 %
- Efficiency > 97 %
- Variations < 1 %
- Multiplicity < 1.12



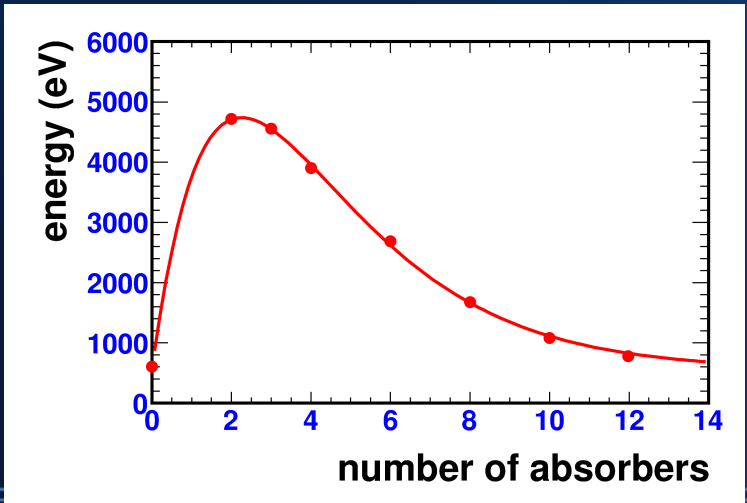


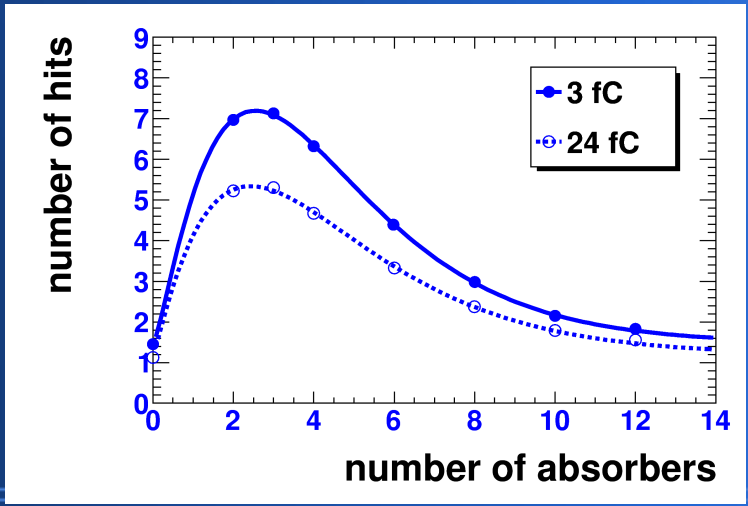


Analog readout prototypes Profile of 2 GeV/c e^- showers

- Data acquisition with varying number of absorber plates in front of the 12x32 cm^2 prototype (CERN/PS/T10, may 2009)
- Validates prototypes functioning in showers
- Data corrected for T and P variations

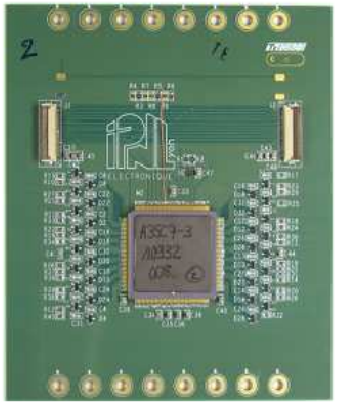
  Almost no effect on profiles



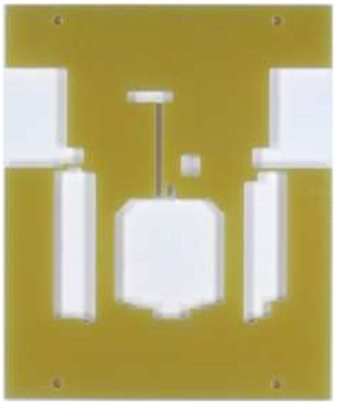


Prototypes with embedded digital readout

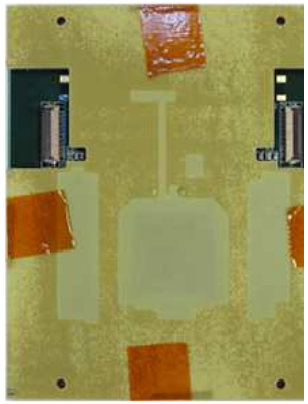
- DHCAL compactness → embedded front-end
- Modify Bulk process:
  - Readout chips are soldered first on PCB
  - Mesh laminated using a mask for chips protection
- First prototype: 8x8 cm^2 with 1 DIRAC version 1 ASIC



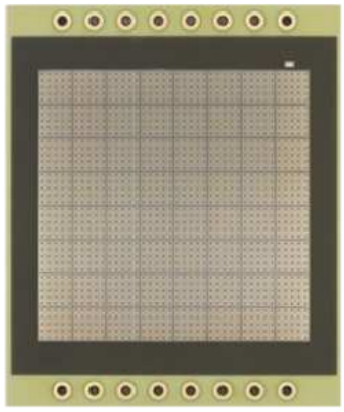
(a) PCB with electronics.



(b) Mask for lamination.

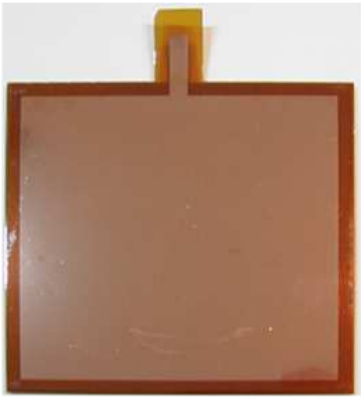


(c) Mask glued to PCB.



(d) PCB: anodes with the mesh.

(e) Drift frame.

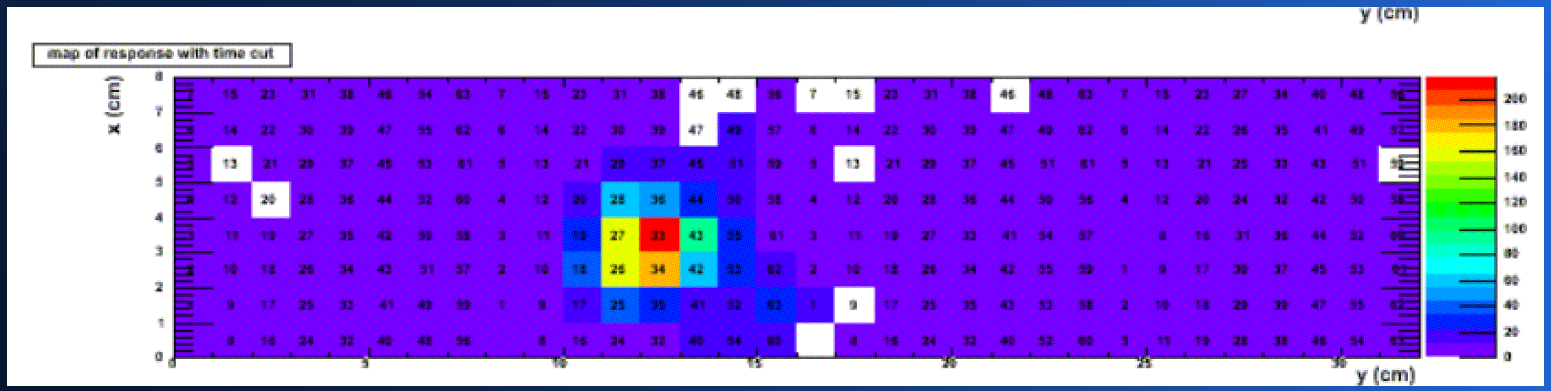


(f) Drift cathode.

TB results with digital prototypes Active Sensor Units (ASU)

- HARDROC v1
  - PS/T10 in May/June 2009
  - DAQ problems, event reconstruction difficult
  - Beam profile obtained, analysis on-going
  - Low efficiency, shaping time too short wrt µM signals
- Micromegas specific chip needed

Beam profile in an 8x32 cm2 chamber



TB results with digital prototypes Active Sensor Units (ASU)

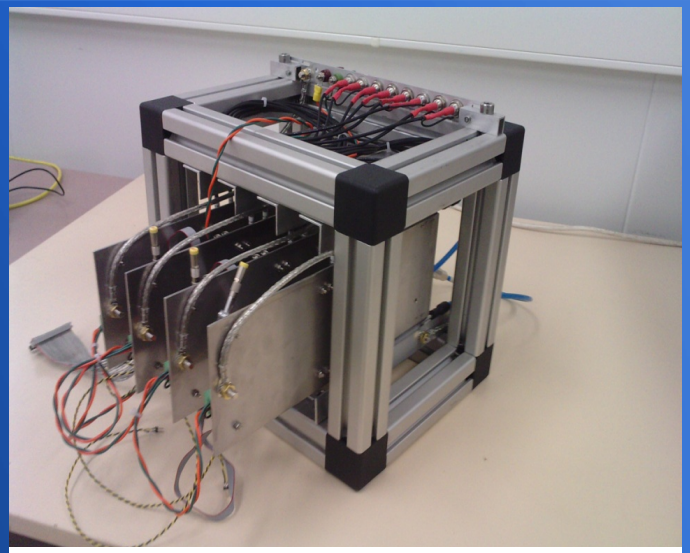
- DIRAC version 2

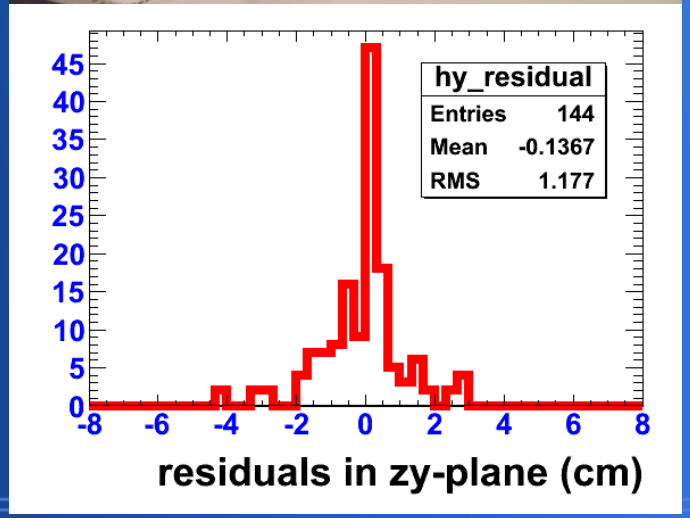
  PS/T9 in November 2009

- Short life time in beam due to spark problem understood, design mistake should be fixed in next version
- Few data available, preliminary results
- Efficiency ~50%

  OK considering duty cycle of ASIC

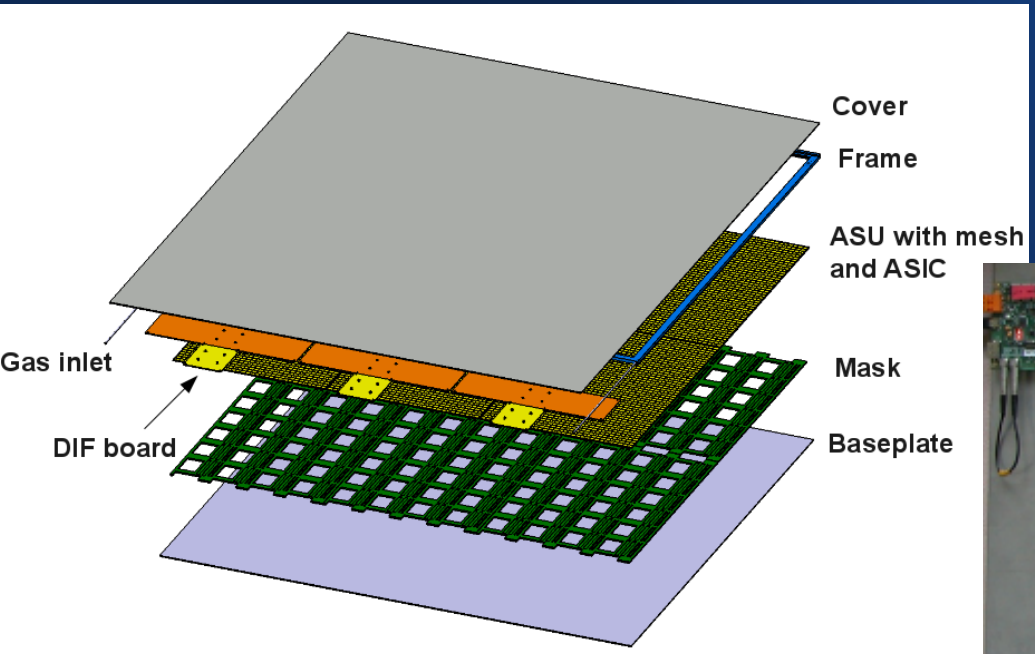
- Multiplicity = 1.06 – 1.13





1 m^2 Micromegas prototype

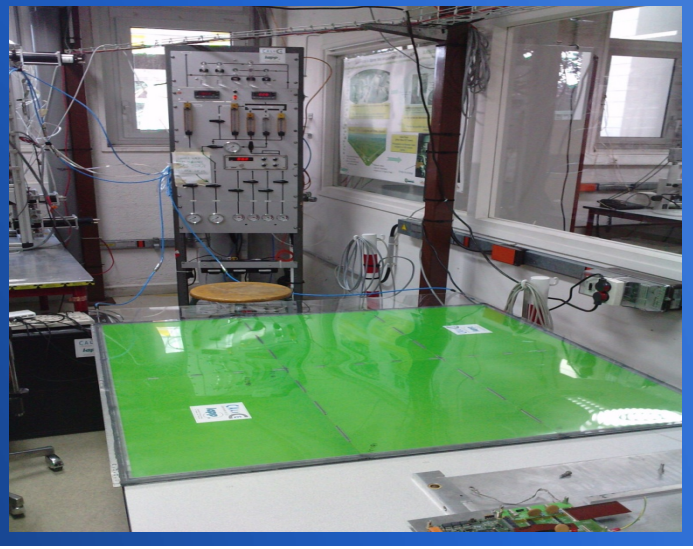
- 6 ASUs of 32x48 cm^2 (24 ASIC each)
  - 3 times 2 ASU chained
  - 1536 channels x 6 = 9216 channels
  - Dead area < 10%

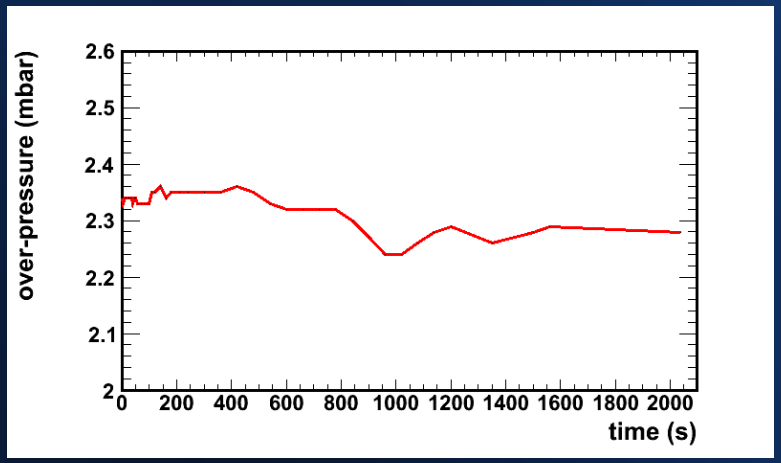


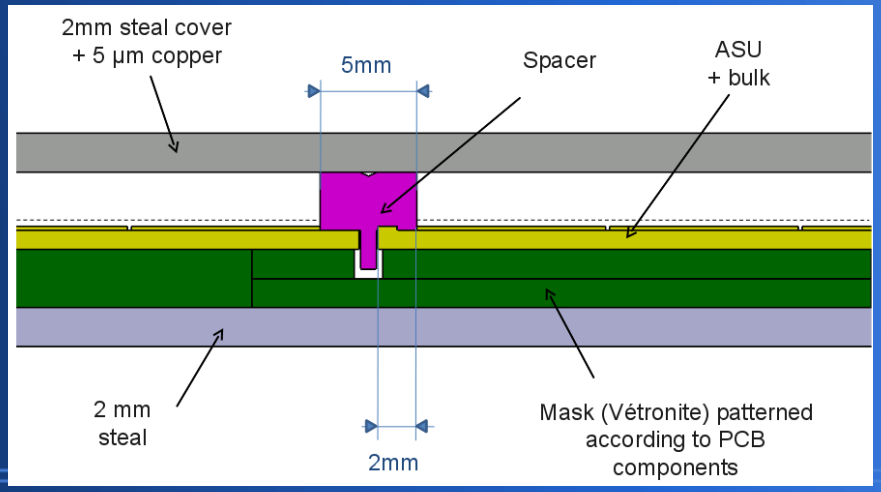
2 chained ASU with 24 HRv2 each

Mechanical prototype

- Dummy PCB
  Validate assembly procedure
  Choice of components
- Gas tightness verified







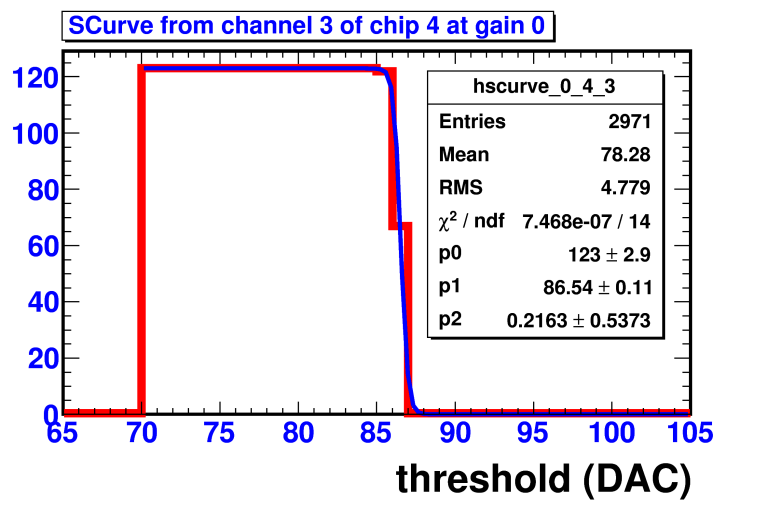
ASU fabrication

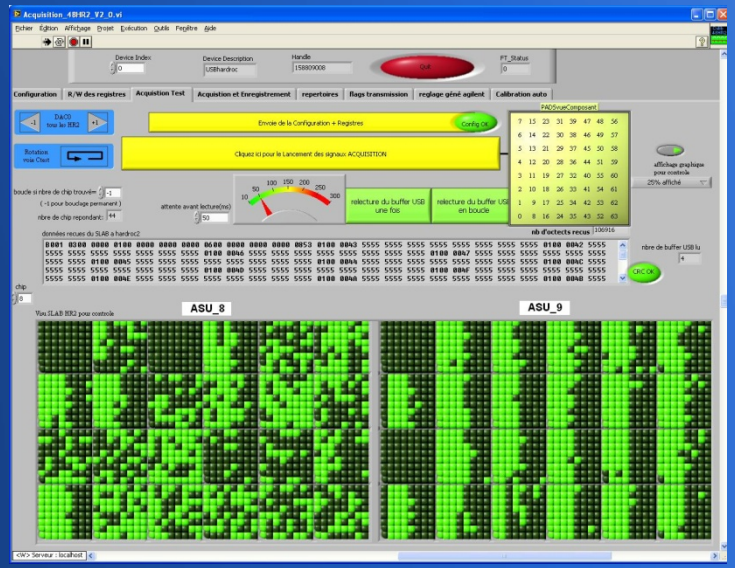
- Connection of 24 ASIC HARDROC v2
  + spark protection components on 32x48 cm^2 PCB
- Mesh lamination at CERN on 4 ASU so far
  - Mesh tension issues on the 2 first processed
    → disconnect a few pads close to PCB edges
- Prior to m^2 assembly, test of each ASU
  - Electronic test and calibration
  - ”Cooking” of mesh
  - Gas box for testing single ASU with radiations

ASU electronic test

- S-curves measurements:
  - Pedestals and charge injection runs
  - Identify noisy channels
  - Measure and correct for channel to channel gain variations

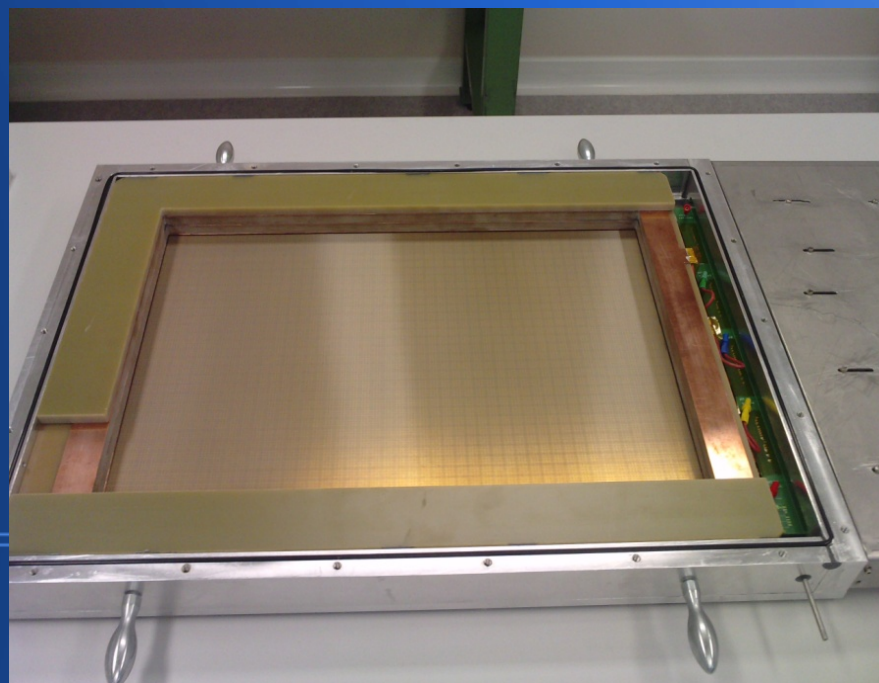
  → Set detection threshold to minimum





ASU ”cooking”

- Aimed at removing dust particles that could remain after Bulk process
  - Connect mesh to HV through 2 MΩ R
  - Current limit of ~ 200 nA
  - Raise mesh voltage up to 900 V in air
- About 3 h long
- Plans to do it automatically with a LabView program

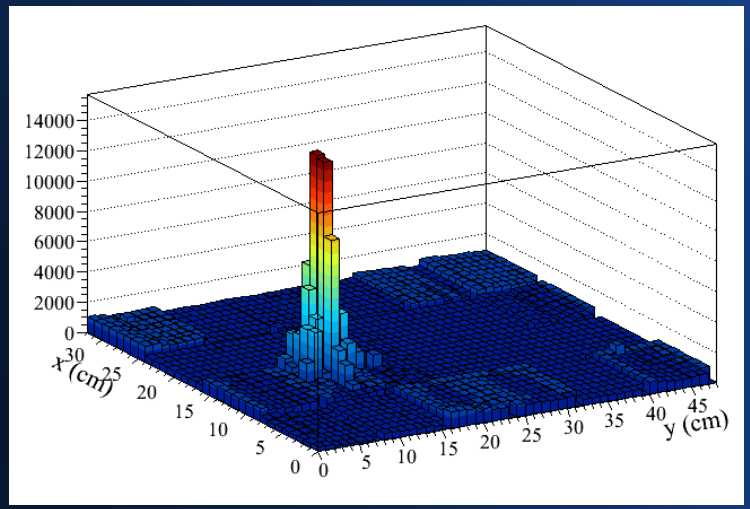


ASU test in gas box

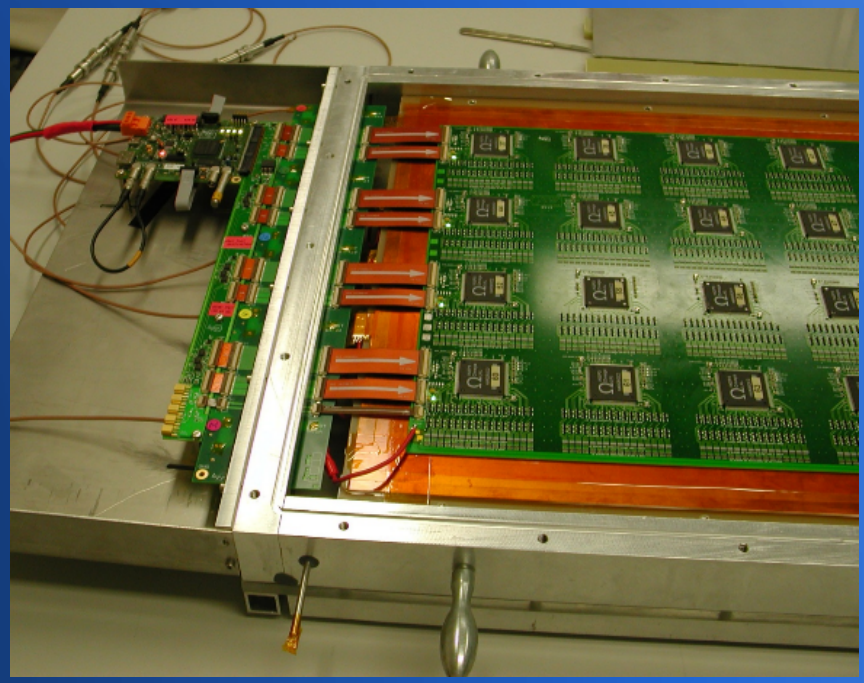
- Gas test box
  - 3 cm drift gap (8 liters)
  - Guard electrodes for field uniformity
  - Thin cathode for X-ray test
  - Perforated cover

    test of individual pads

55Fe profile on one HR2

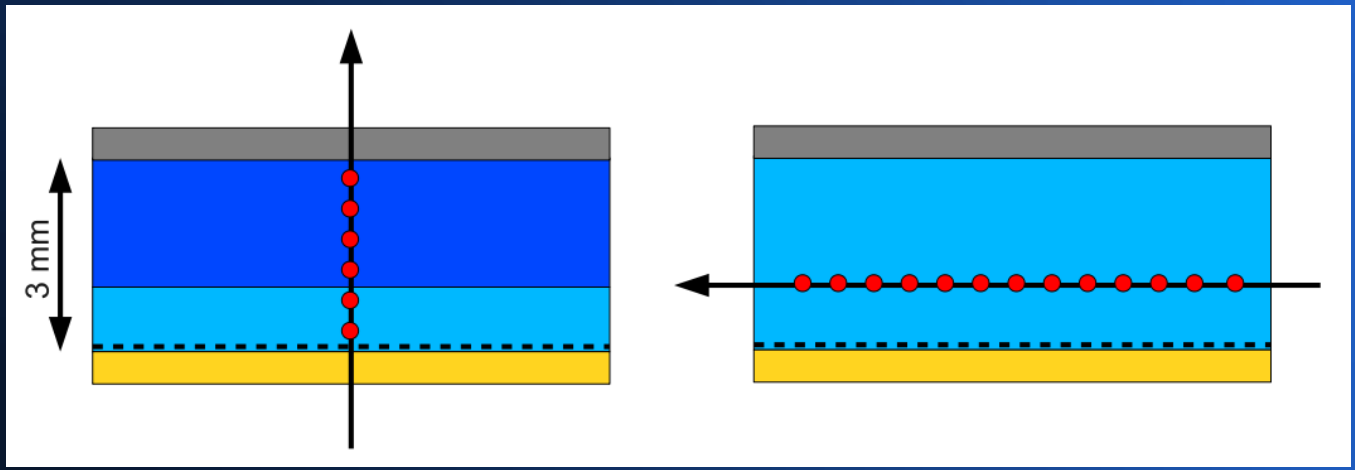


ASU in gas test box



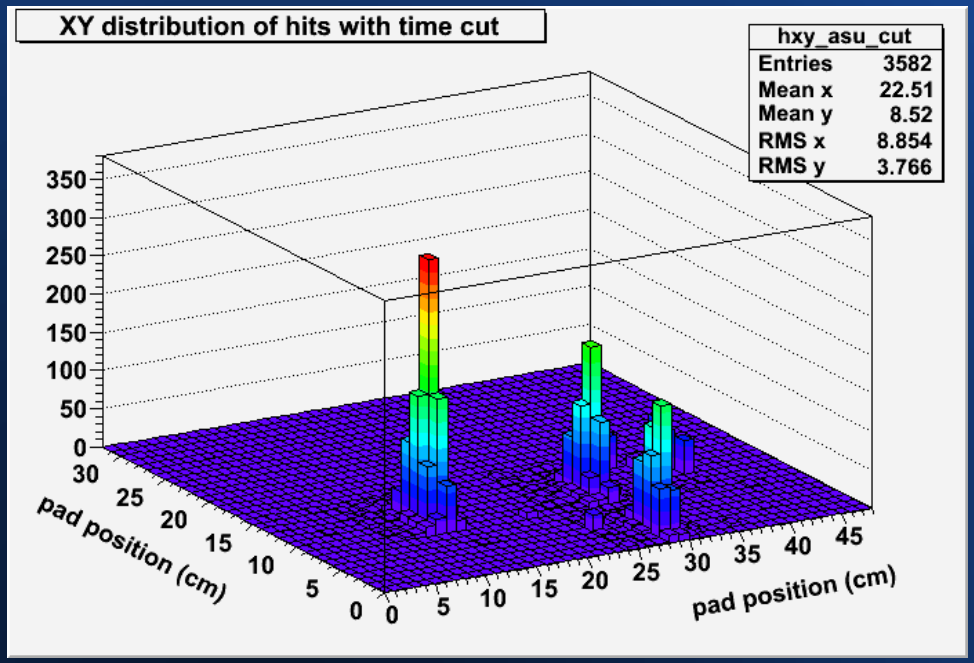
ASU test in a beam

- PS/T9 in Nov 2009, ASU in gas box
- 2 different configurations
  - Parallel for efficiency measurement as no external tracking available
  - Perpendicular (beam profile)



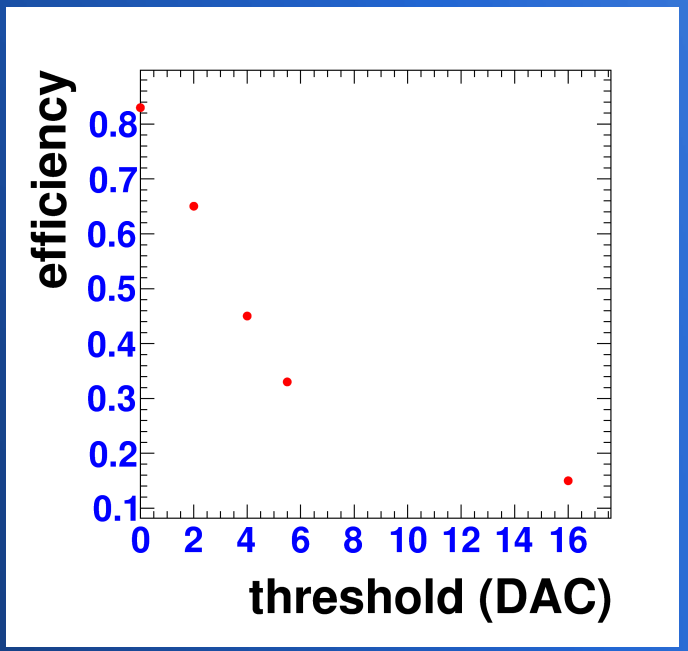
ASU test in a beam

- Perpendicular mode



Beam profile recorded on three different positions

- Parallel mode



Conclusion and future plans

- ASU test on-going, 1 m^2 assembly foressen in March, cosmic test @ LAPP before beam test
- Beam test at SPS planned in July

  Modify DAQ to read both HR1 and HR2

  → external tracking (HR1 stack)

  → efficiency, multiplicity and uniformity of m^2
- Construction of more m^2 planes
  - Which front-end ASIC: DIRAC, HARDROC?
  - New spark protection inside PCB?

Thanks for your attention!