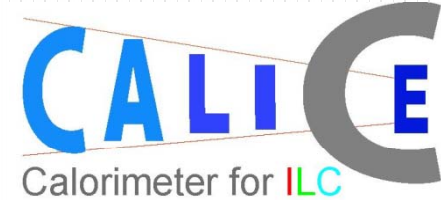




Laboratoire d'Annecy-le-Vieux
de Physique des Particules



Micromegas for a DHCAL

LAPP, Annecy

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Outline

- Micromegas R&D for DHCAL
 - X-ray and beam tests with Analog Readout
 - Micromegas with Digital Readout
- Simulation
- Future 1 m² prototype
- Conclusion

Micromegas detectors at LAPP

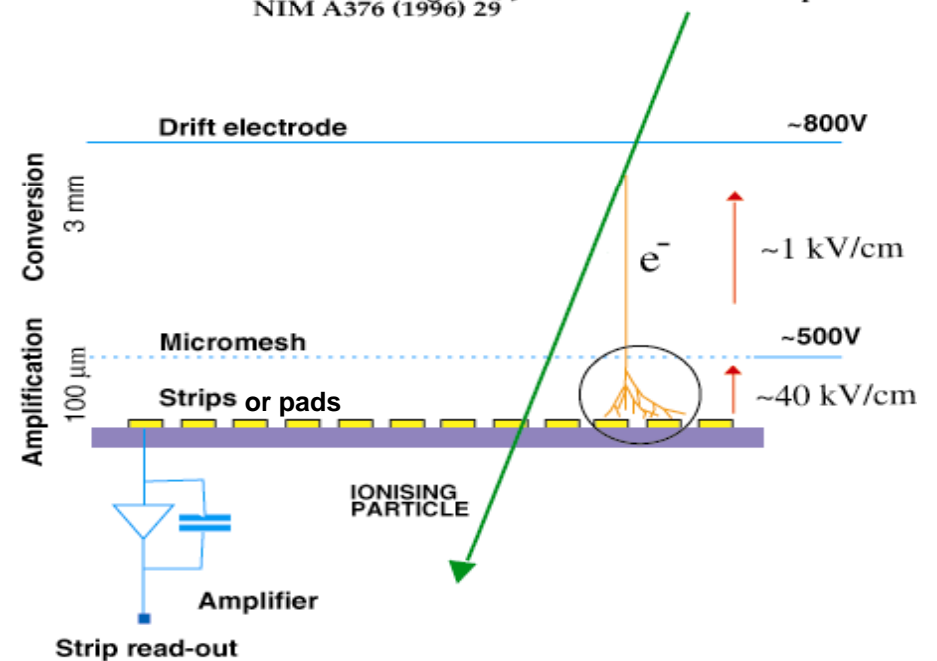
- Description:

- Gas mix: Argon+Isobutane
- Drift and Mesh HV < 500 V
- High rate capability
- Robust, cheap (industrial process)
- Thickness: 3.2 mm
- Low hit multiplicity
- High detection efficiency
- Delicate functioning: sparks

- Readout:

- Analog for characterisation
GASSIPLEX + CENTAURE DAQ
- Digital :
HARDROC or DIRAC +
Detector InterFace (DIF) board +
EUDET DAQ2 or CrossDAQ (IPNL)

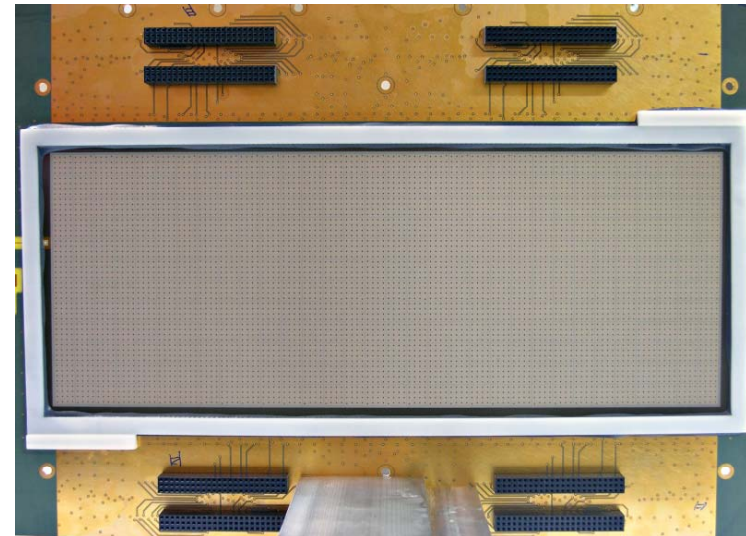
Y.Giomataris, Ph. Rebourgeard, J.P Robert and G. Charpak
NIM A376 (1996) 29



Detector layout

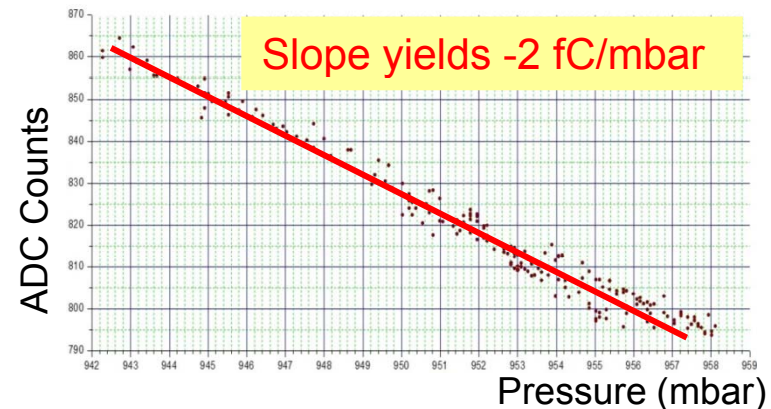
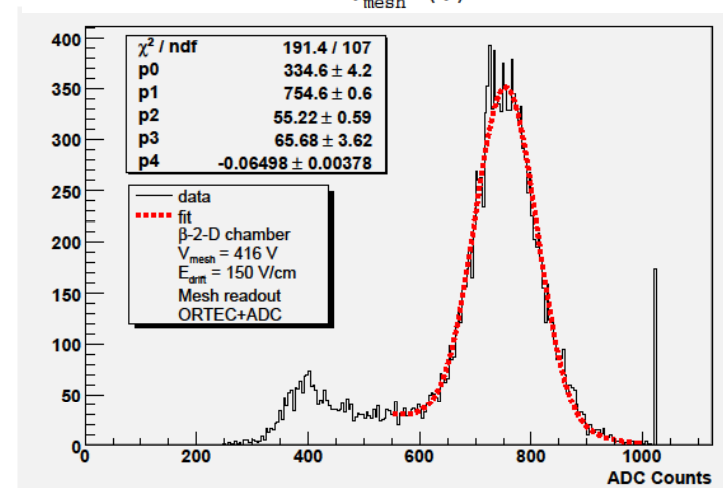
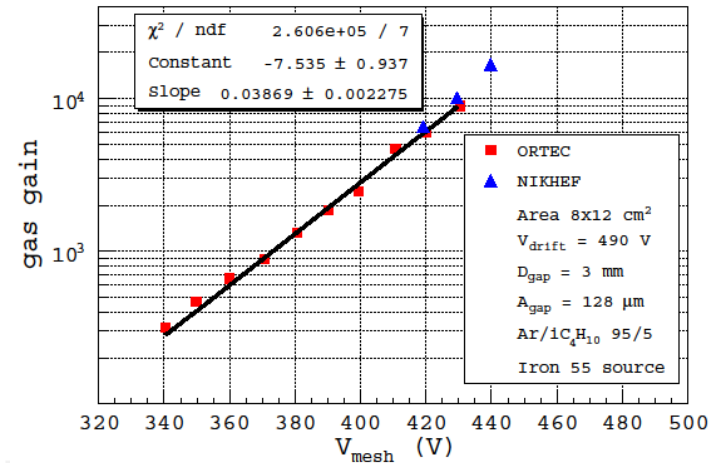
- Bulk Micromegas :
 - Mesh laminated on the PCB
 - Industrial process
 - Cheap and robust
- Steel top :
 - Part of the absorber
 - Holes for X-ray tests
 - Holds a 55 μm thick cathode
 - Glued on a plastic frame 3 mm above mesh

Bulk technology from R. De Oliveira & O. Pizzirusso



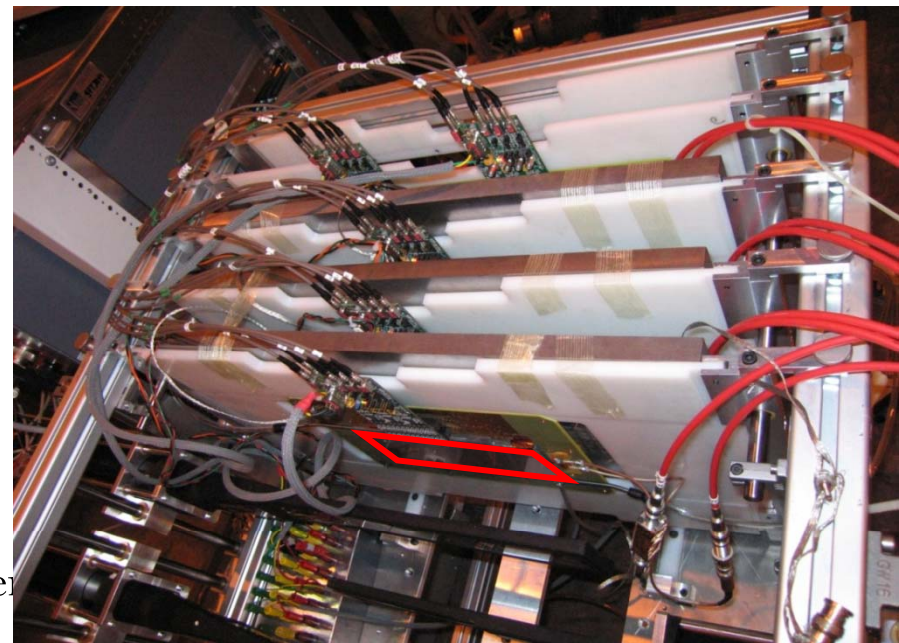
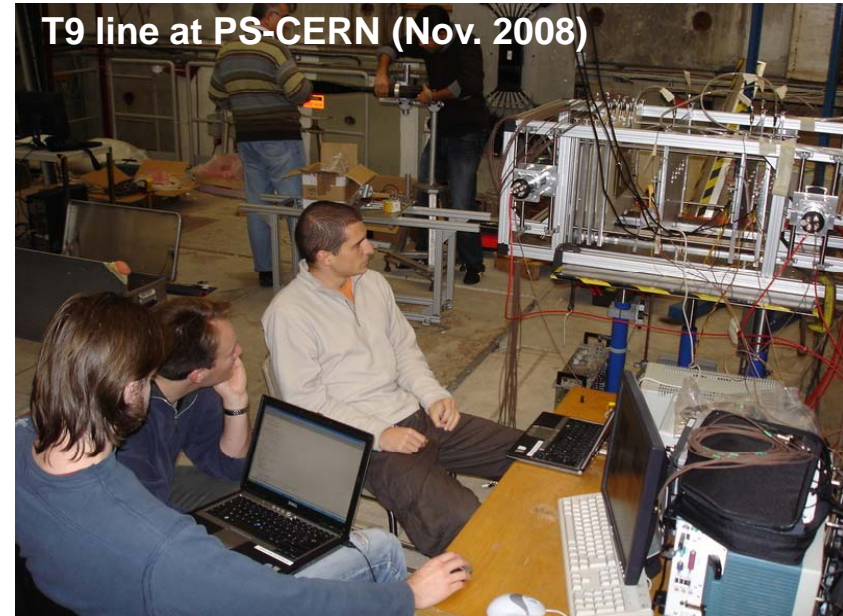
^{55}Fe X-ray test

- Setup
 - 6 x 16 cm² mesh
 - Source collimated above 1 pad
 - Readout mesh signals
- Collection efficiency
 - Plateau for field ratios larger than 50
- Gas gain (assuming 230 primary e-)
 - Gain doubles every 20 V
 - Decreases with pressure
 - Max around 2.10⁴
- Energy resolution at 5.9 keV
 - 17 % FWHM



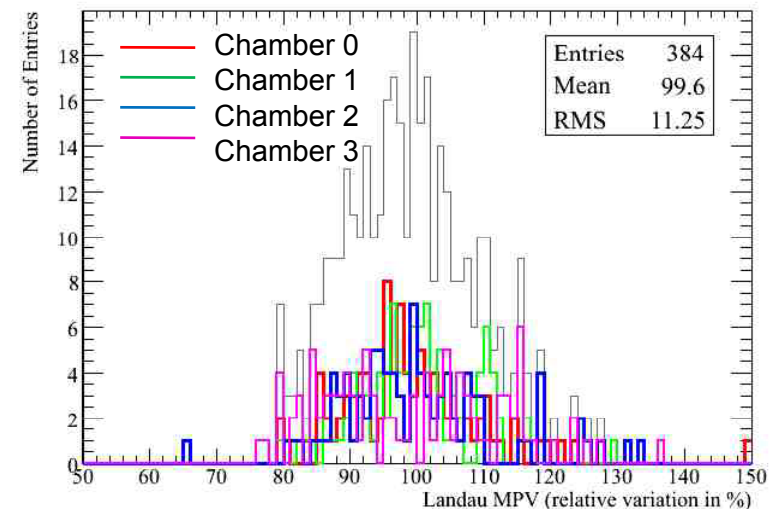
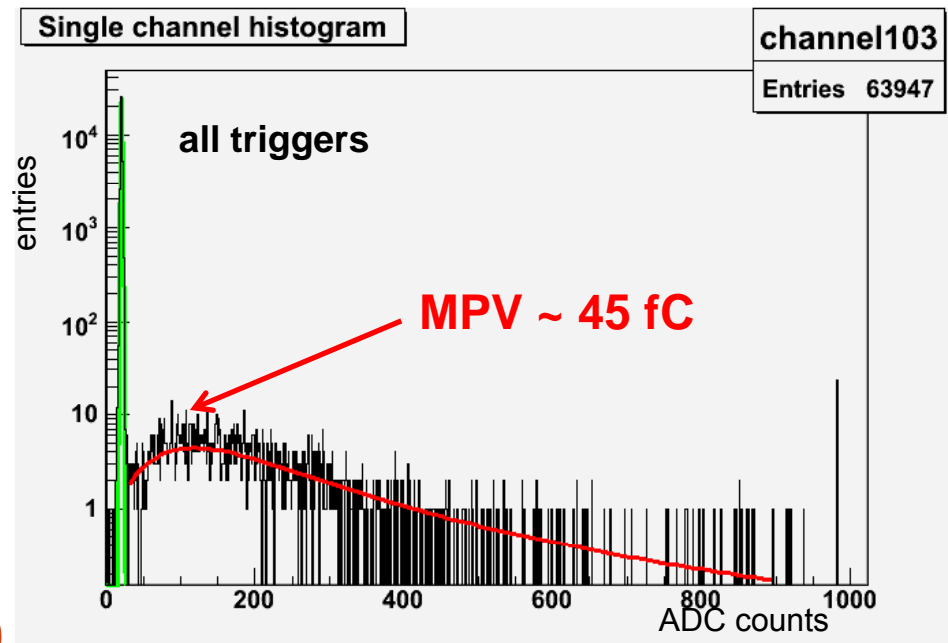
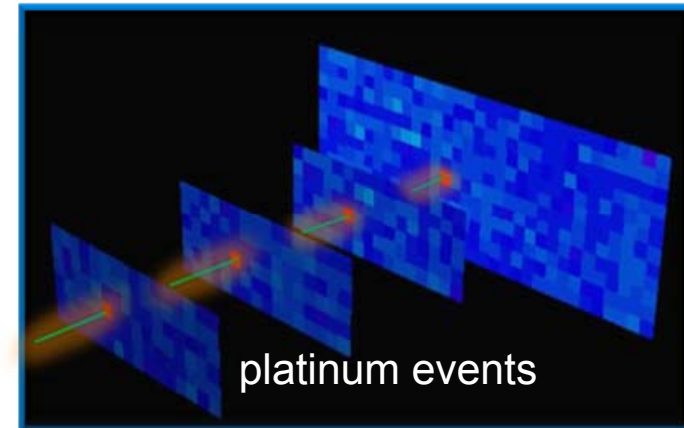
Beam test setup

- Trigger: 3 scintillators
- 3 Micromegas 6x16 pads
- 1 Micromegas 12x32 pads
- Steel absorber option
- GASSIPLEX readout
 - VME modules (ADC) + CENTAURE
- Characterisation of the prototypes
 - efficiency and multiplicity
 - response uniformity over area
 - X-talk studies
 - behaviour in hadronic shower
- Aug & Nov 2008 at CERN PS and SPS
 - $400 \cdot 10^3$ Pions and Muons of 200 GeV
 - $250 \cdot 10^3$ Pions with 1 steel block + absorber
 - $200 \cdot 10^3$ Pions of 7 GeV



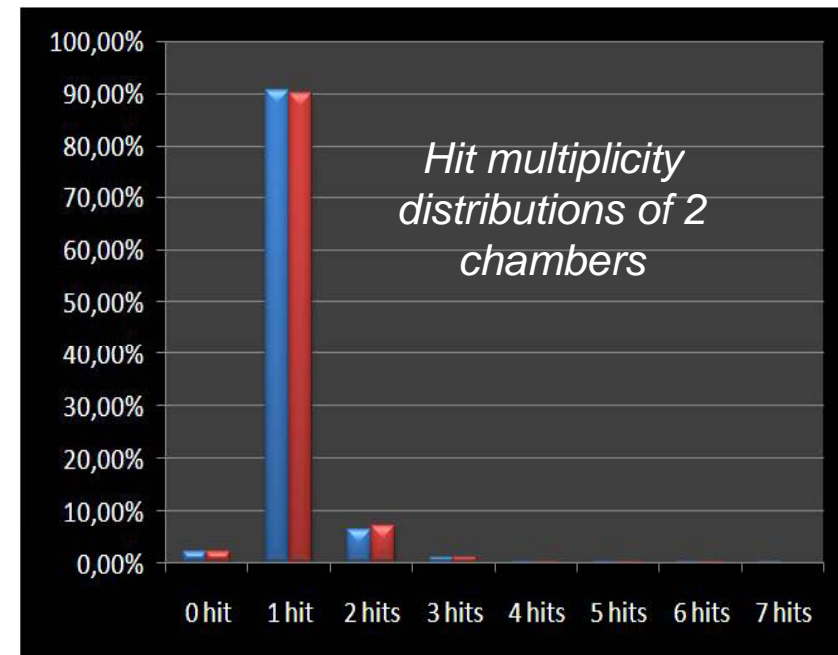
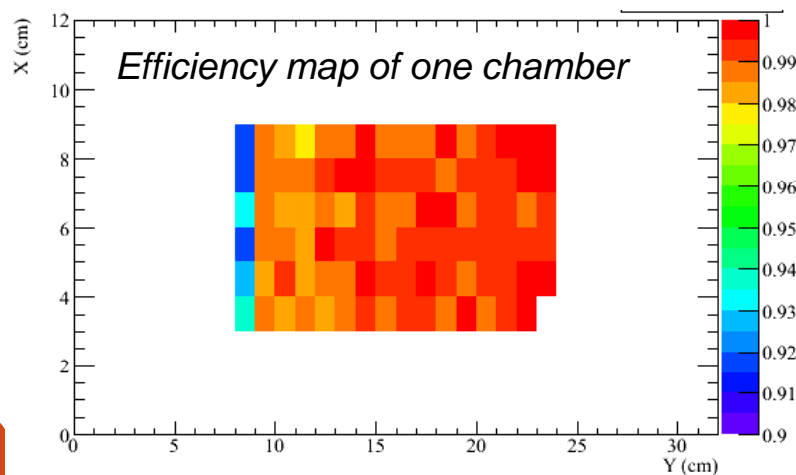
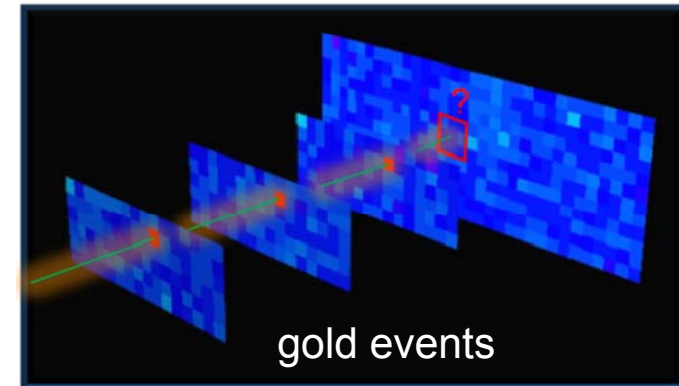
Signal distribution on each pad

- Select event with one and only one hit in each chamber
 - Insure all charge collected on one pad
 - Hit if $\text{ADC} > 27$ counts
- Landau distribution MPV is at 45 fC
 - Shows variations of 10% RMS over all pads



Efficiency and multiplicity

- Require one and only one « safe » hit in three chambers
 - $ADC > 51$ counts (5.3 fC)
 - Hit position in fourth chamber extrapolated
 - Count hit ($ADC > 27$ counts) in 3x3 pad area
- Efficiency between 92 and 99 %
- Multiplicity between 1.07 and 1.15

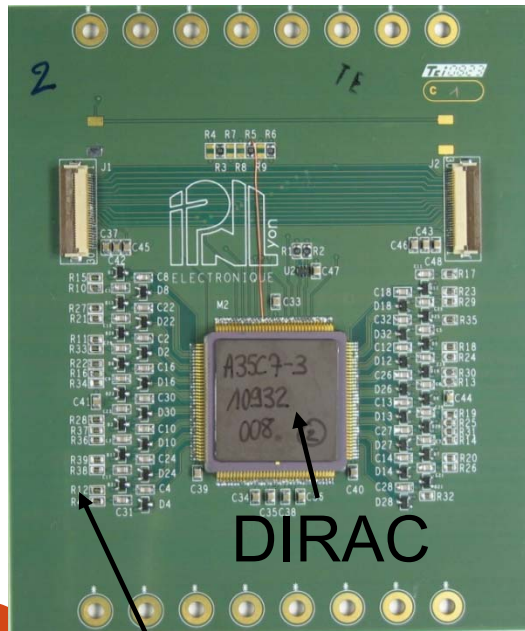


Micromegas with Digital readout

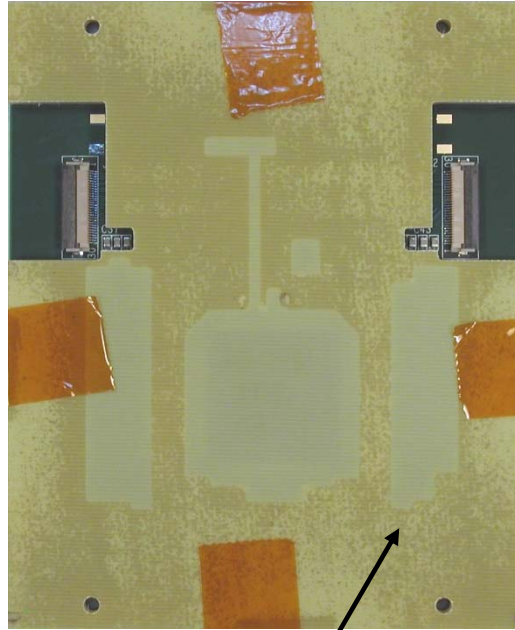
- PCB with DIRAC1 64 channels ASIC (R. Gaglione et al., IPNL)
 - Digital link to DAQ (possibility to chain detectors)
 - 3 thresholds and 2 gains (RPC and Micromegas modes)
 - Synchronous architecture
- First operational Bulk Micromegas with embedded readout electronics !



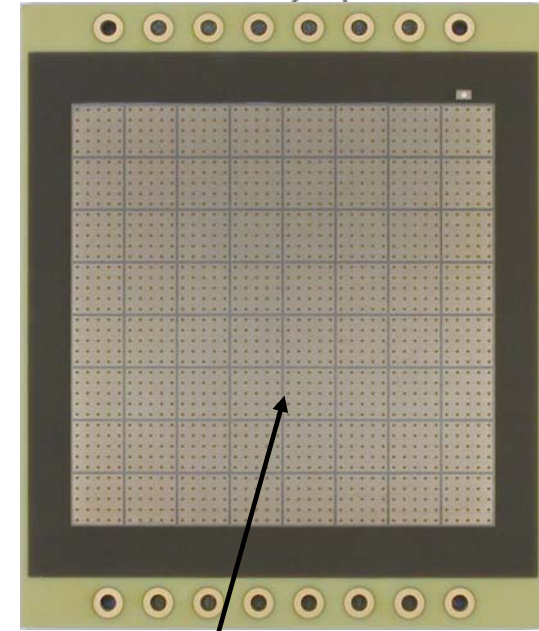
Bulk from R. De Oliveira & O. Pizzirusso



Sparks protections



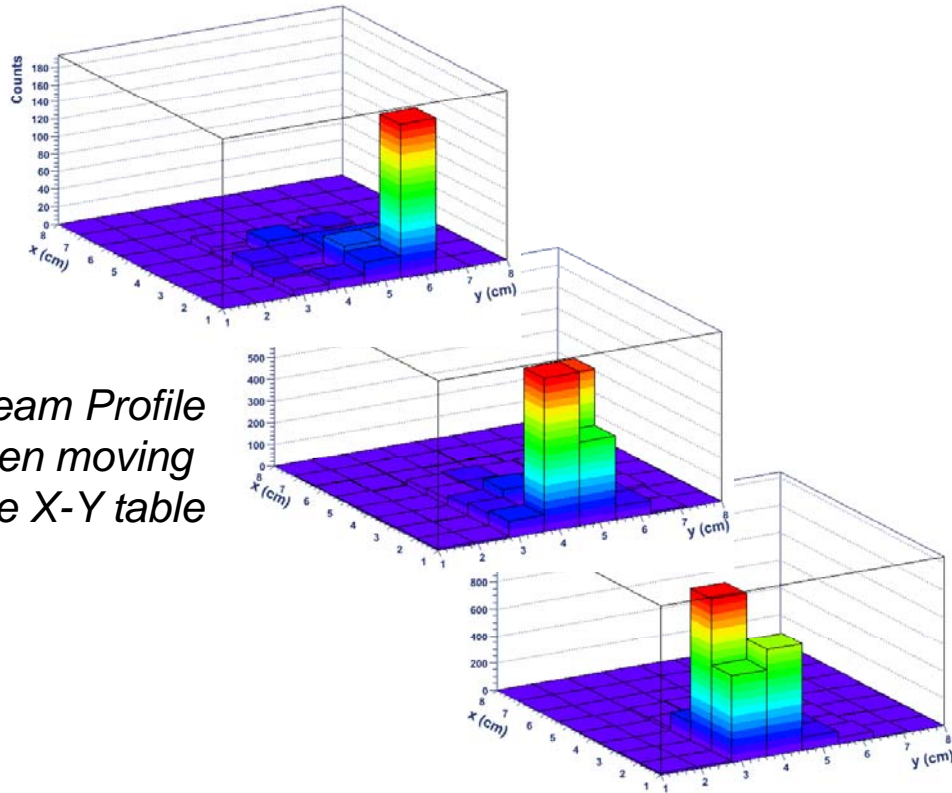
mask for bulk laying



8x8 pads with bulk

Micromegas with digital readout

- Tested during August 2008 test beam
- Minimum threshold of 19 fC
- Only one detector available
 - No efficiency/multiplicity measurements yet
 - Prepare more prototype for next beam test



*Beam Profile
when moving
the X-Y table*



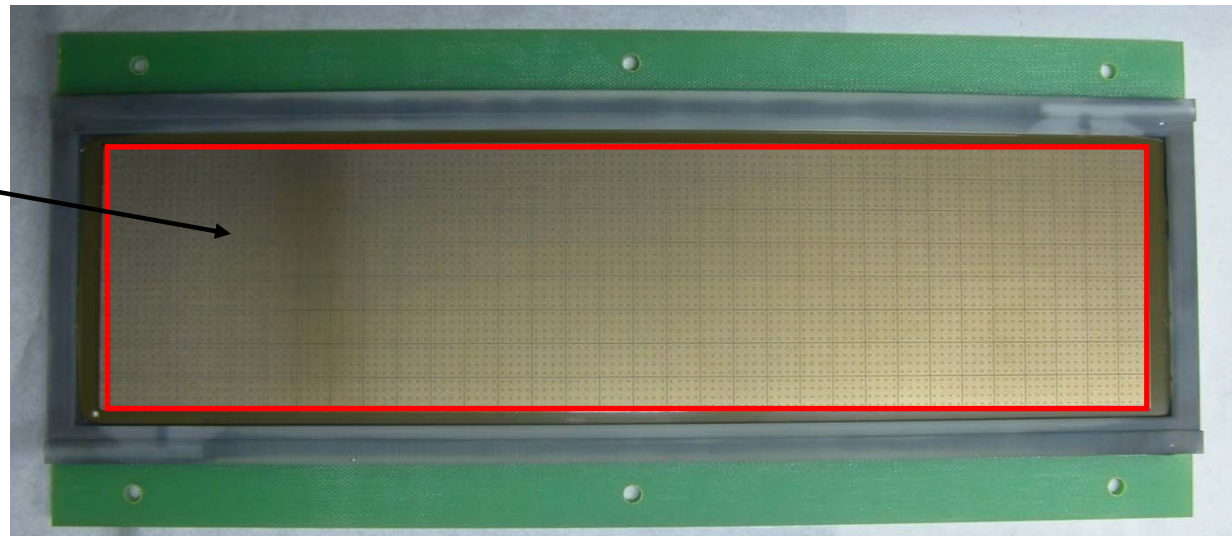
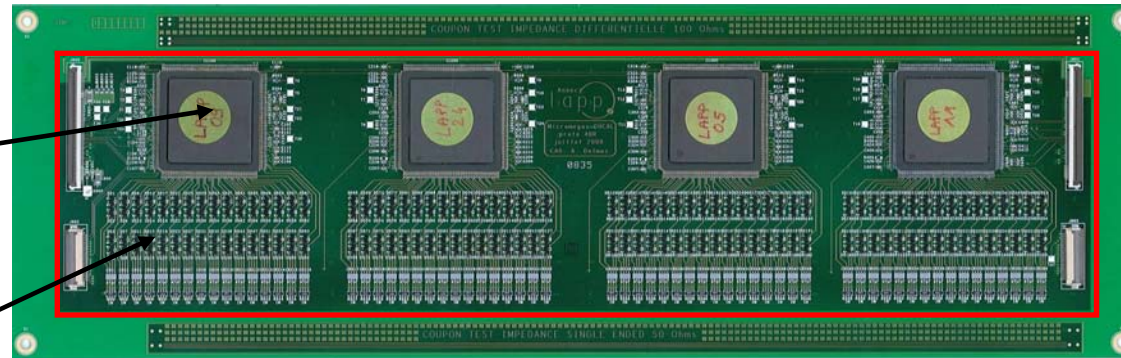
Micromegas with digital readout

- PCB with 4 HARDROC1
 - 64 channels ASIC, detector active area $8 \times 32 \text{ cm}^2$

HARDROC1

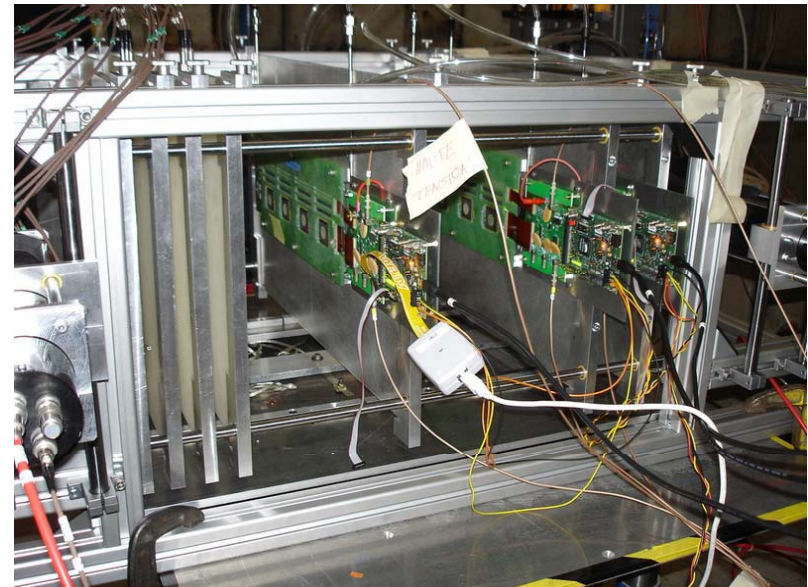
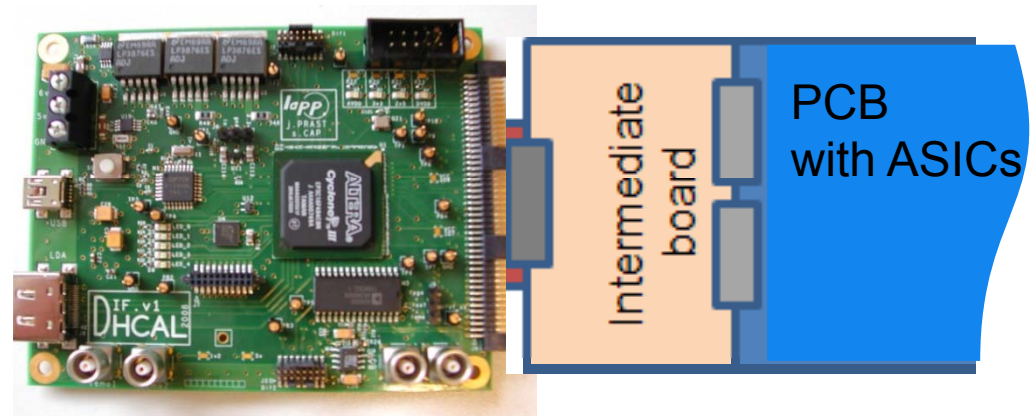
sparks
protections

bulk



Micromegas with digital readout

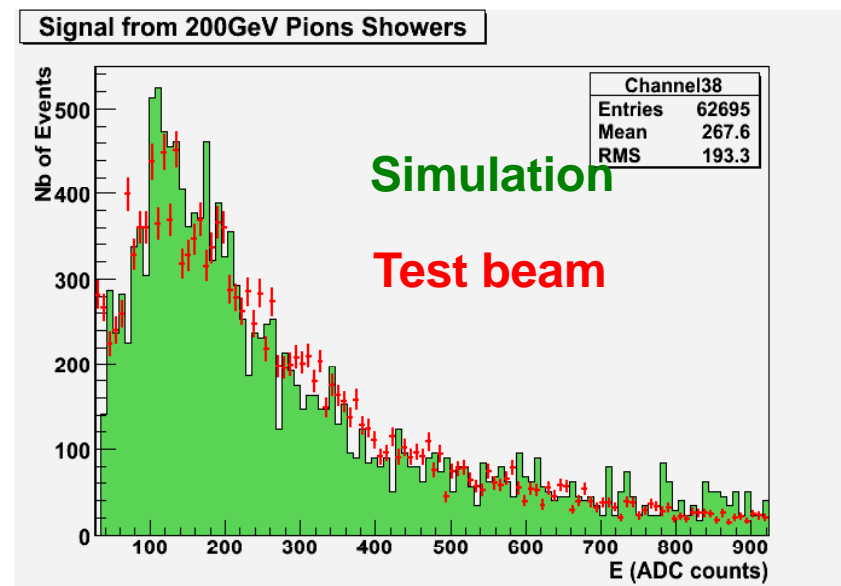
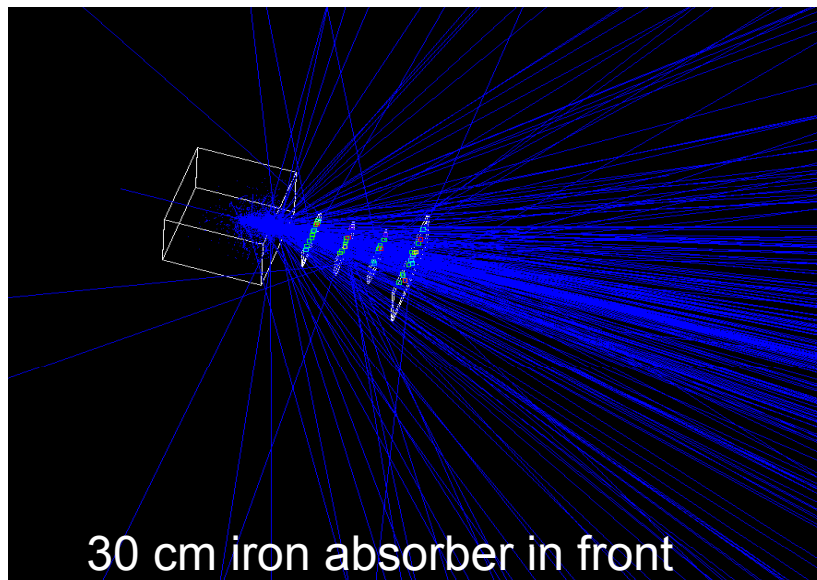
- Readout : DIF board
 - Separated from the SLAB
 - For large number of ASICs HARDROC, DIRAC and also SPIROC and SKYROC
 - DIF task force interface : USB or EUDET DAQ
- Tested during the November 2008 TB
- Excellent work from Guillaume Vouters (DIF) and Christophe Combaret (CrossDaQ)
- HV stability issues during tests
- Data (almost) under study



Simulation

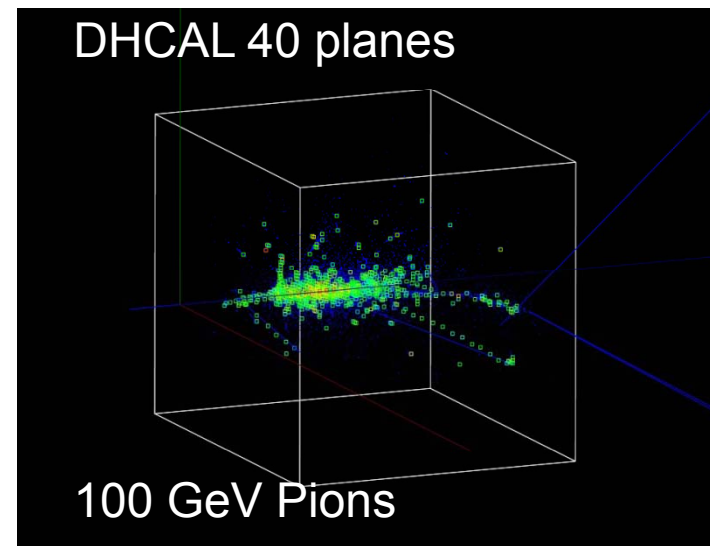
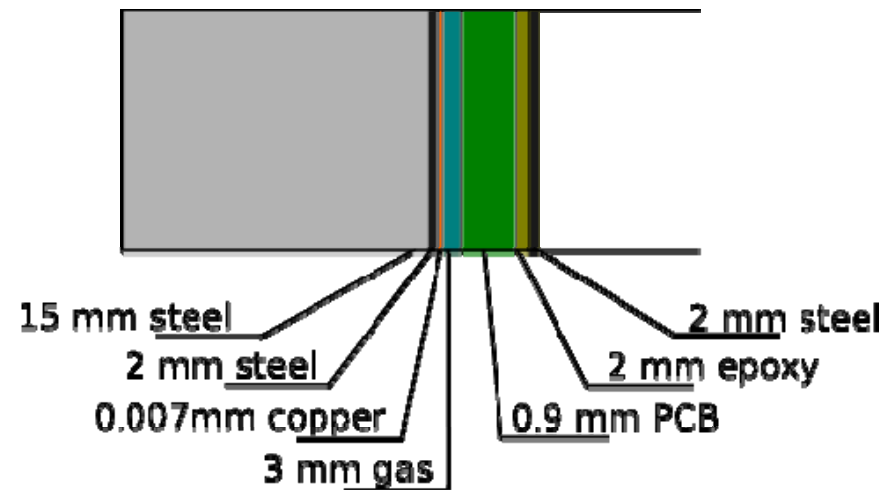
- Tools
 - SLIC full simulation (Geant 4)
 - Analysis using JAS3
- 2008 beam test setup
- DHCAL with Micromegas
 - Comparison between analog, digital and semi-digital
 - Thresholds & absorber studies

- 2008 beam test setup is being simulated
 - Comparison with real data
 - Better understanding of our detector
 - Preparation for next test beam

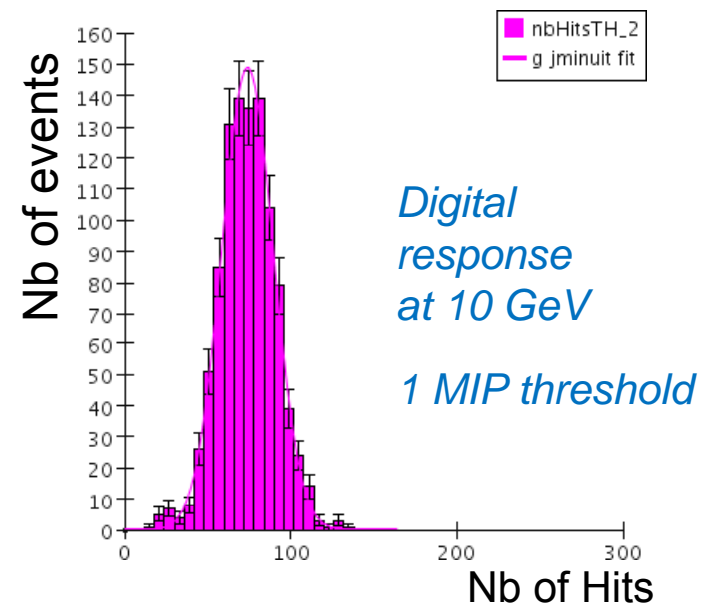
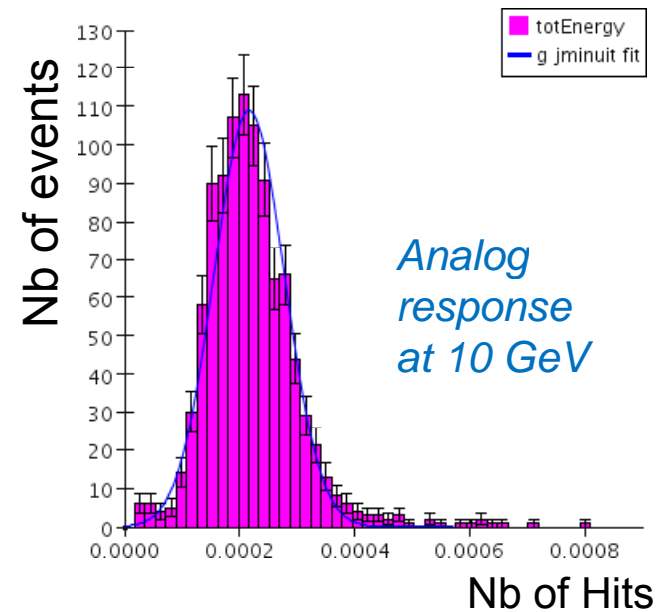
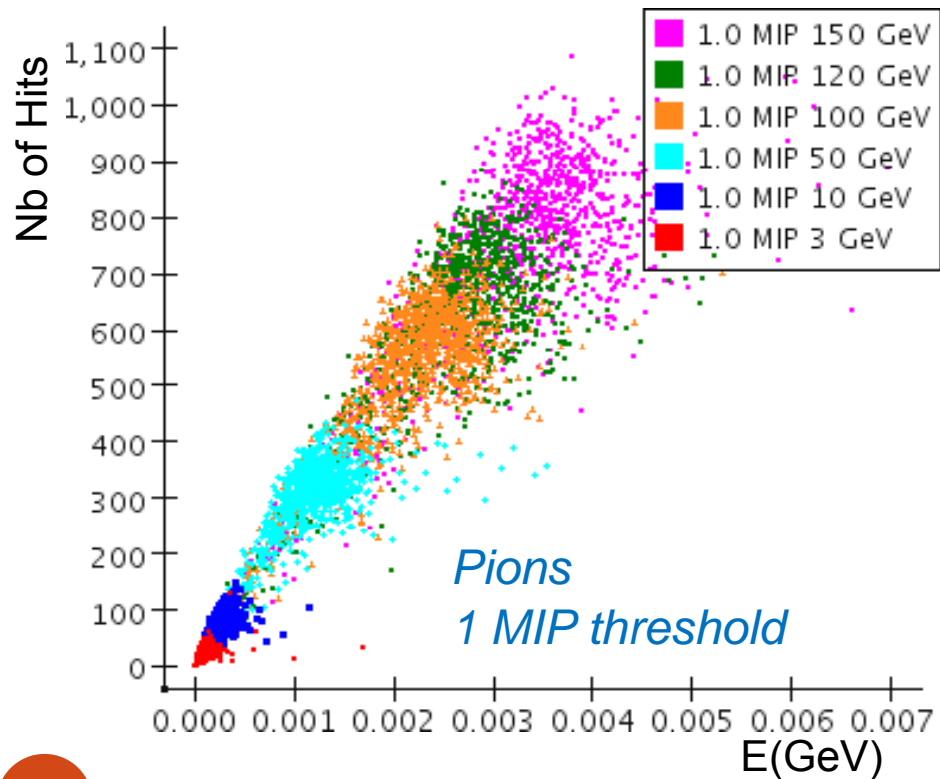


DHCAL with Micromegas

- Full 1 m² geometry implemented
 - Readout: from 0.5 x 0.5 cm² to 4x4 cm² pads
 - 3 mm drift gap
 - Gas mix. Argon/Isob. 95/5
 - 1.9 cm thick absorber between layers
 - different absorber materials
 - **40 or 80 layers** ($\sim 4, 5$ or $\sim 9 \lambda$)
 - Thickness of active layer: 3.2 mm
- Ideal Micromegas, digitization not yet fully implemented

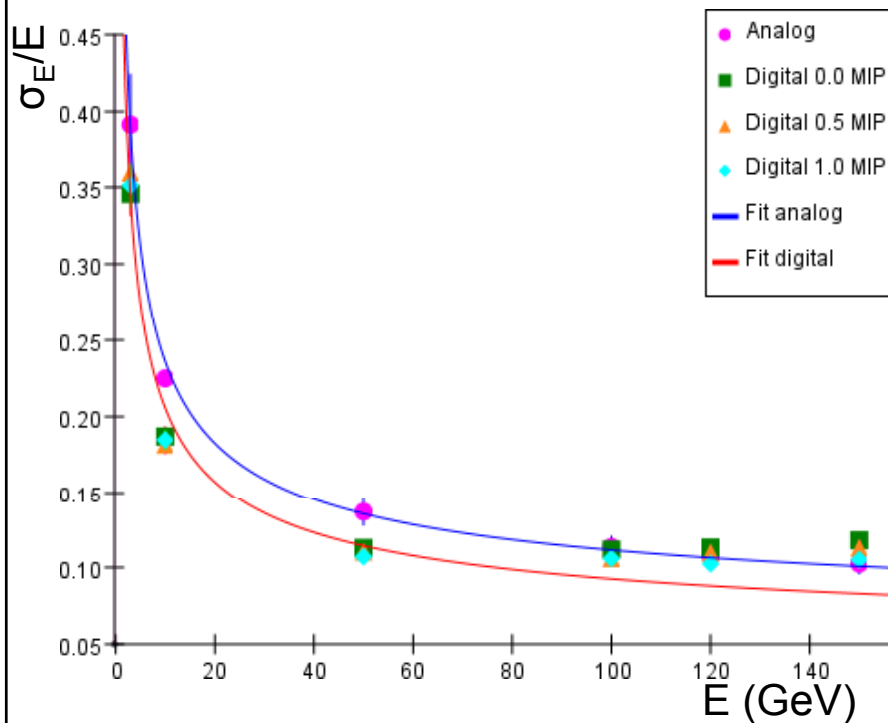


- Sum up hits and energy in all cells
- Apply a single threshold (1 MIP)
- Look at distributions RMS



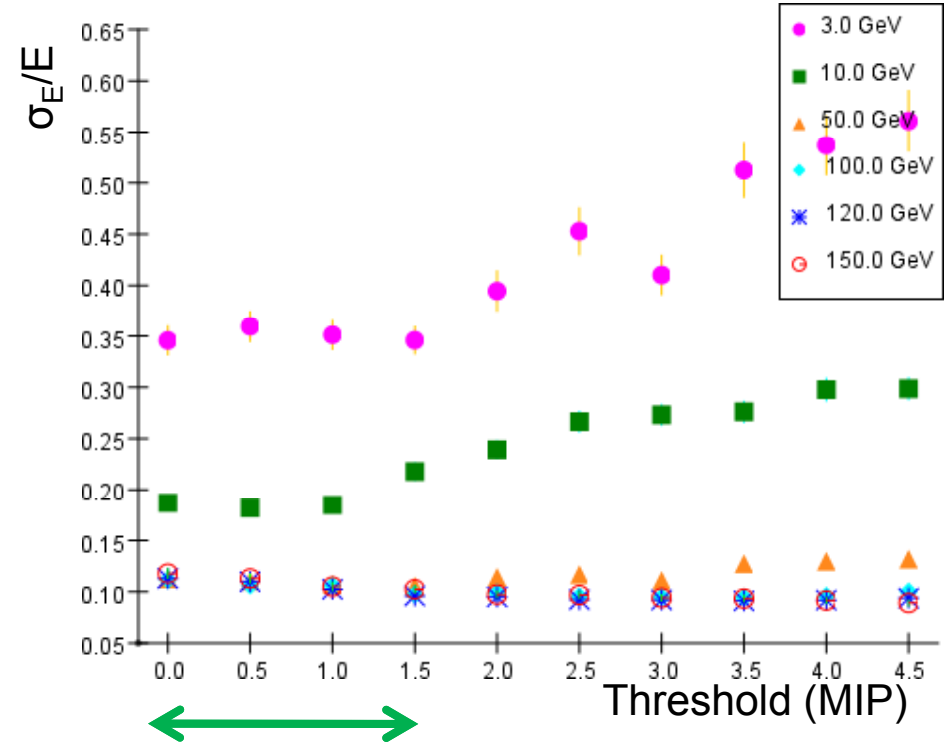
Energy resolution

Pion energy



*Worse resolution at High energy
⇒ Need more than 1 threshold ?*

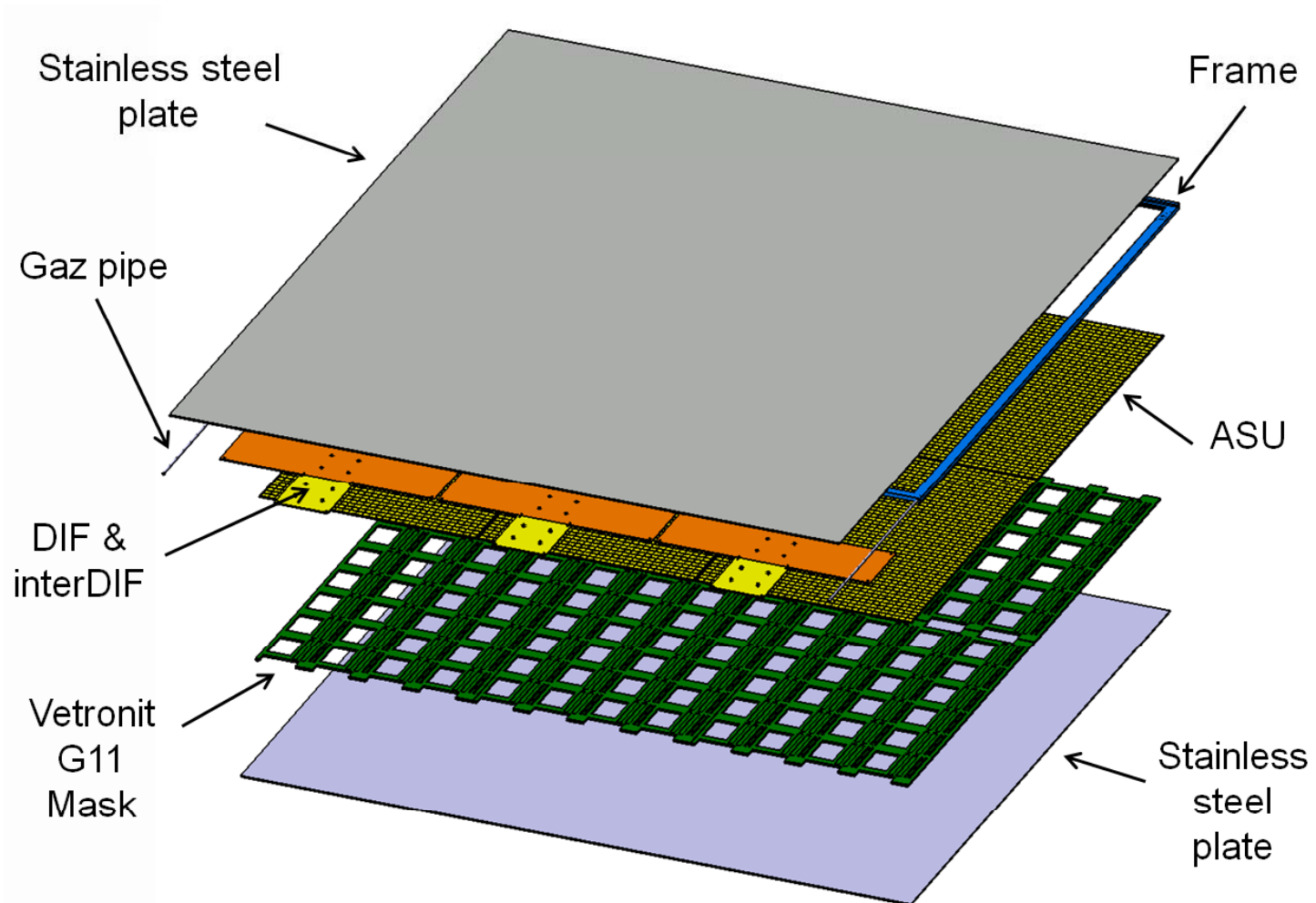
Hit threshold



*Threshold range with
constant energy resolution*

Future 1 m² prototype: 6 Active Sensor Units

9 216 channels - 96 x 96 cm² active area - 3 DIF + interDIF boards



1 m² prototype status

- DIF & DAQ almost ready
- ASU :
 - 24 HARDROC2
 - Design and routing done
 - Single ASU test box under conception
- Mechanical prototype under construction
- Price quantified (about 15 k€)

Work breakdown and schedule for a 1 m²/m³ Micromegas DHCAL

1 m³ cost
~730 k€

1 m² cost
~15 k€

WBS	Component	Number	Unit	Materials	MContingency	MTotal
1	HCAL 1m3 prototype	1	each	658 563	71 124	729 687
1.1	Structure Mecanique	1	each	12 579	0	12 579
1.1.1	Absorbeurs	1	each	6 579	0	6 579
1.1.2	Assemblage absorbeurs en module	1	each	5 000	0	5 000
1.1.3	Structure porteuse du module	1	each	1 000	0	1 000
1.2	Detecteurs	40	each	14 472	1 766	649 504
1.2.1	Circuits	6	each	1 235	260	8 970
1.2.2	Fabrication Mesh	6	each	565	23	3 526
1.2.3	Fabrication Volume Gaz	1	each	2 546	70	2 616
1.2.4	Electronique de read out	1	each	1 116	0	1 116
1.2.5	Bulleurs	1	each	10	0	10
1.3	Alimentations	1	each	41 100	500	41 600
1.3.1	Coffret Pilotage HT	1	each	10 000	0	10 000
1.3.2	Alimentations Basse tension	1	lot	16 000	0	16 000
1.3.3	Modules HT pour coffret	3	each	4 700	0	14 100
1.3.4	Module distribution HT electrode drift	1	each	1 000	500	1 500
1.4	Systeme de Gaz	1	each	10 000	0	10 000
1.4.1	Station de mixage	1	each	10 000	0	10 000
1.5	DAQ	1	each	16 004	0	16 004
1.5.1	Carte LDA	2	each	1 300	0	2 600
1.5.2	Carte concentratrice DCC	14	each	436	0	6 104
1.5.3	Carte ODR	1	each	4 300	0	4 300
1.5.4	DAQ PC	1	each	3 000	0	3 000

Conclusion

- Micromegas R&D for DHCAL very active!
 - ASIC developments
 - Innovative prototypes, first digital readout prototypes
 - Tests Beam: very promising results (still a lot to analyze)
 - Beam tests planned in 2009, first in May
- Next steps
 - 1 m² prototype should be ready for test before 2010
 - Calorimeter prototype of 1 m³
- In parallel : work on simulation
 - TB prototypes, future 1 m³ and leakage less 8 m³
 - Different absorber material, active medium, pads size...

Thanks for your attention

Acknowledgements

Catherine Adloff

Jan Blaha

Sébastien Cap

Alexandre Dalmaz

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Ambroise Espagilière

Renaud Gaglione

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