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

DHCAL with μMegas chambers

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DHCAL @ LAPP

- HCAL R&D activities
  - Engineering studies for SiD
  - Simulation
    - We use SILC and JAS3 to optimize the DHCAL
  - μMegas chambers development
    - From small prototypes 8x16 cm^2 already tested in test beam to 100x100 cm^2
  - Read out and DAQ electronics
    - HARDROC users and DIRAC development with IPNL (Lyon)
    - DIF and inter DIF boards

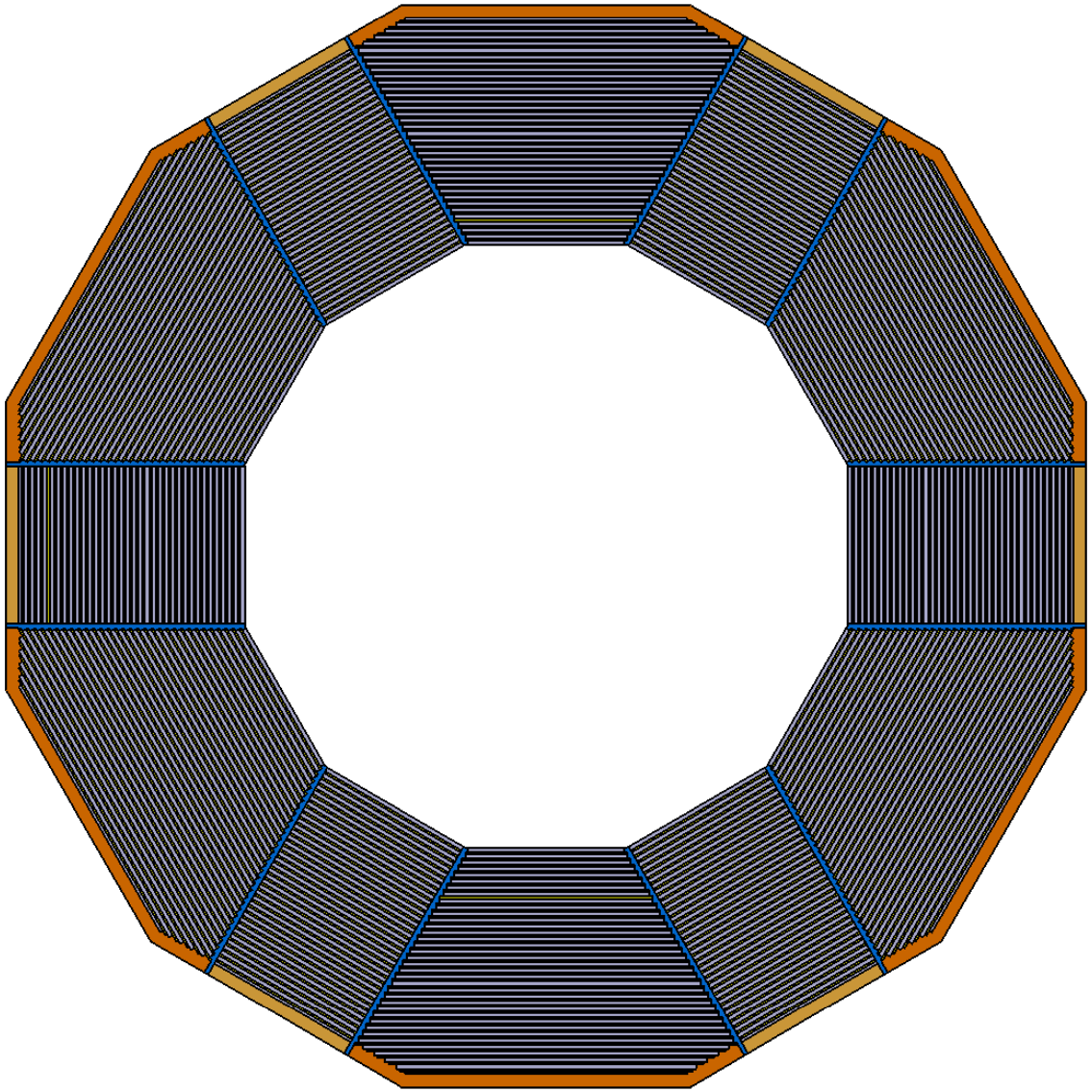
Hcal barrel: baseline pour SiD

12 modules
non projectifs

↓

6 rectangles
+
6 trapèzes

NB: même encombrement que la version projective



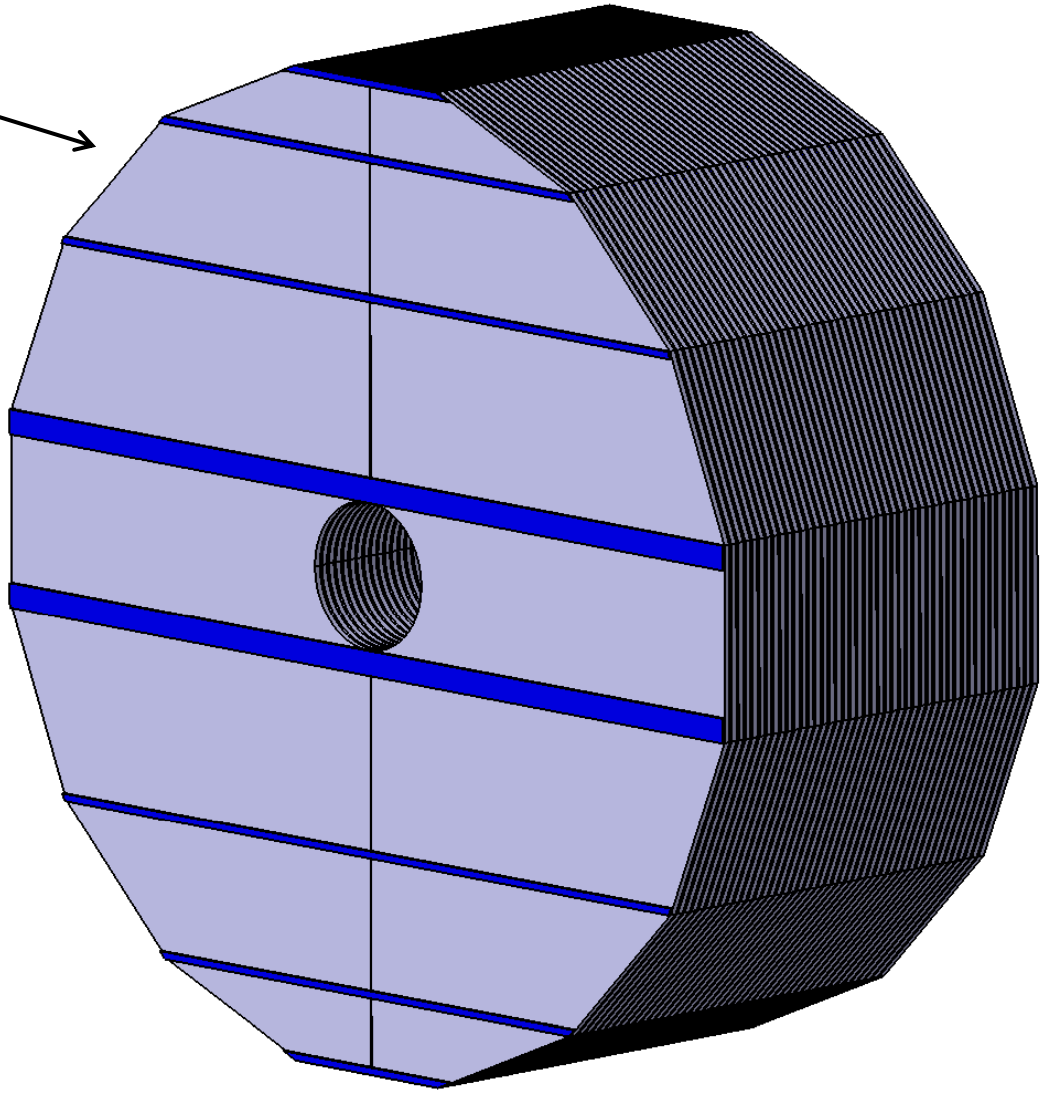
Bouchons du Hcal : baseline pour SiD

Structure encastrée-libre

Plan d'absorbeurs constitués de 2 parties en C

Utilisation d'entretoises entre les plans d'absorbeur

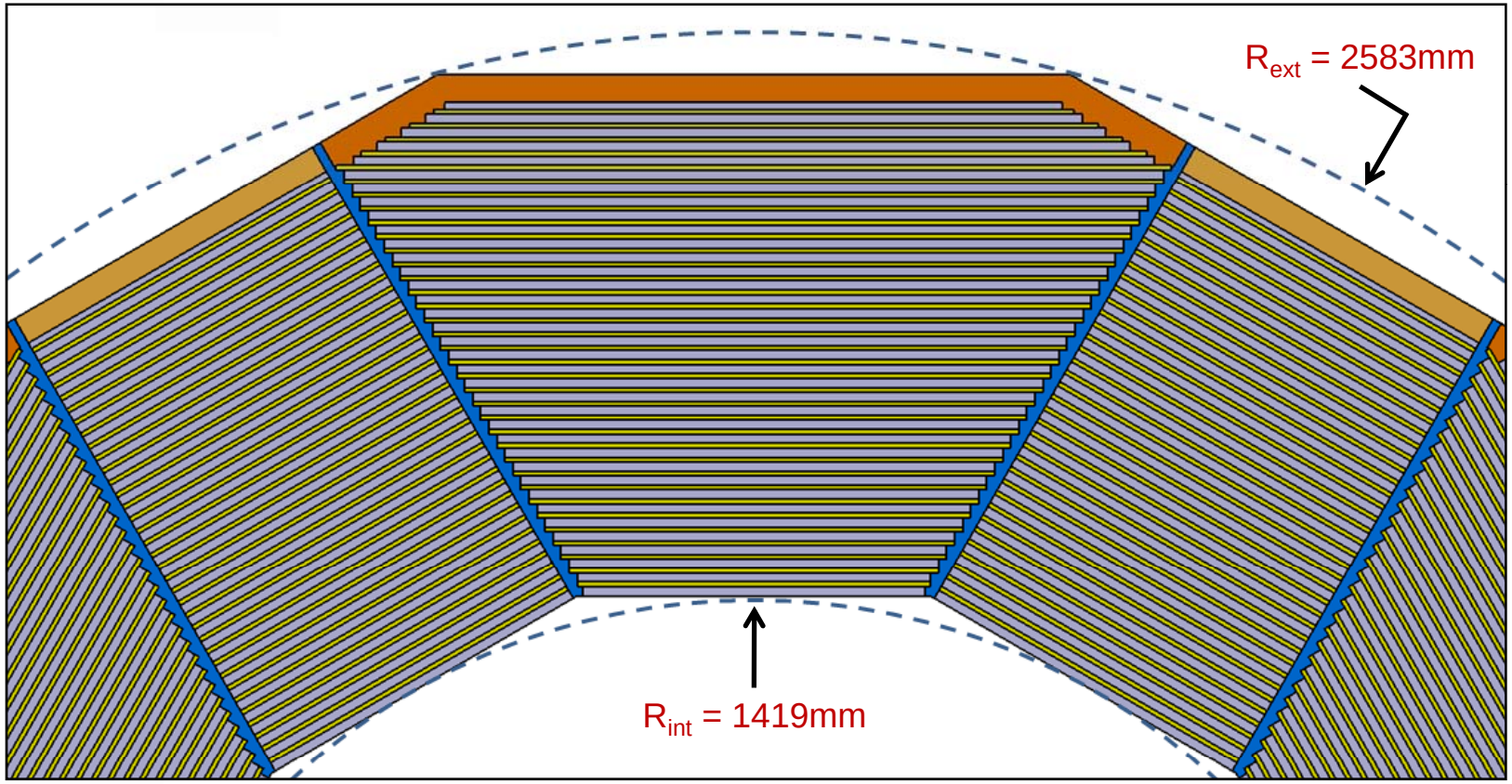
Ecartement entre deux plans (insertion des chambres)



Hcal barrel: baseline pour SiD

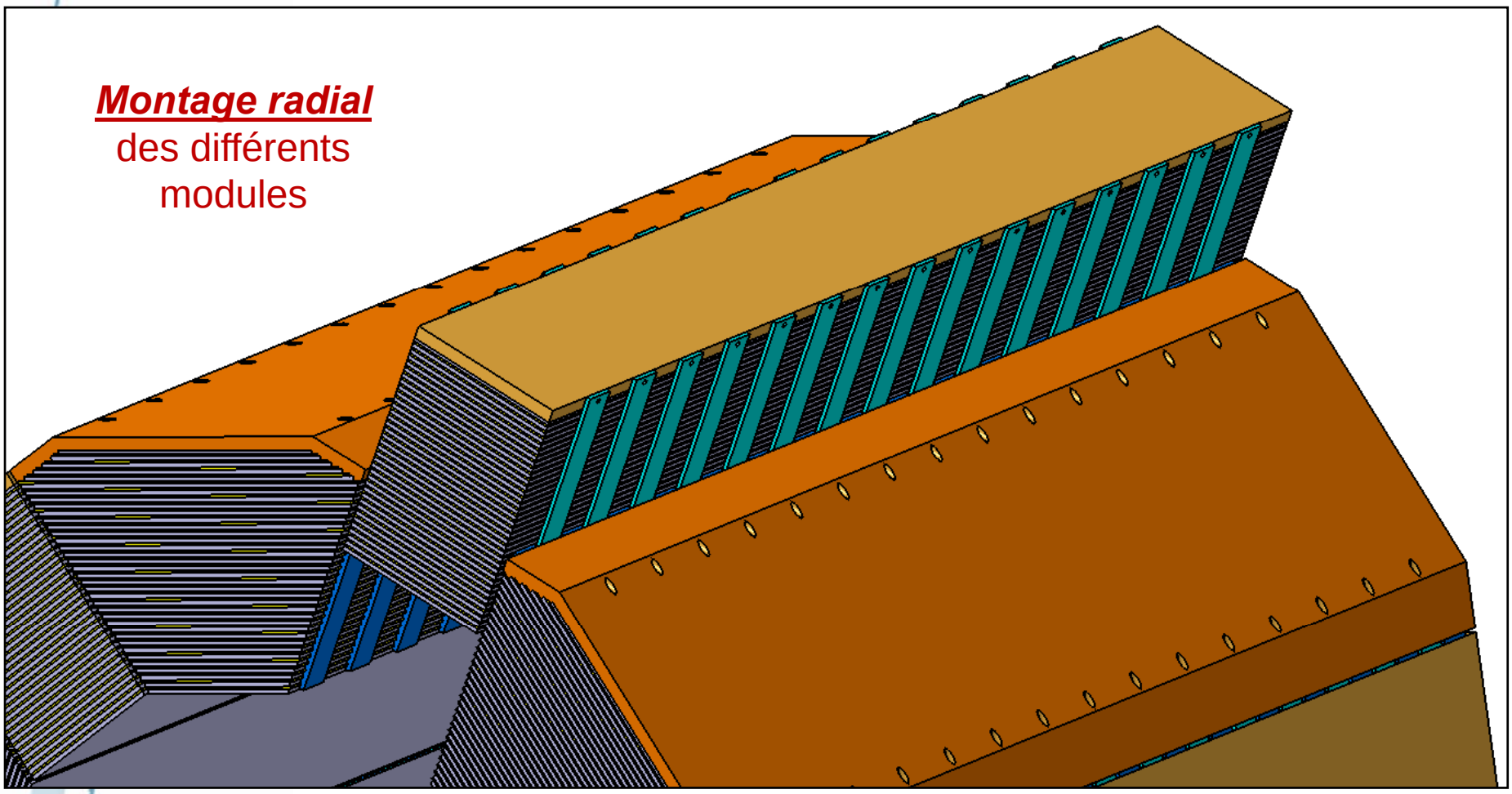
4.5 λ
Absorber SS

- 40 layers (absorber 18.9mm)
- 8mm space for detectors



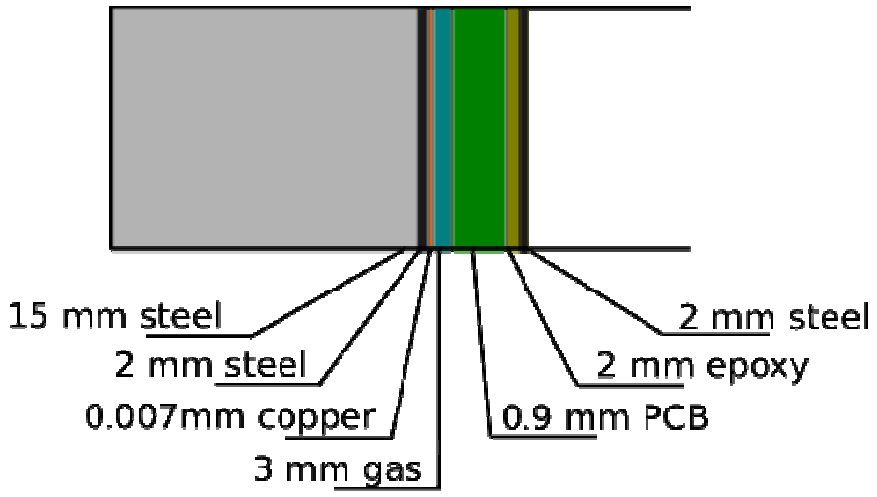
Hcal barrel: baseline pour SiD

Montage radial
des différents
modules



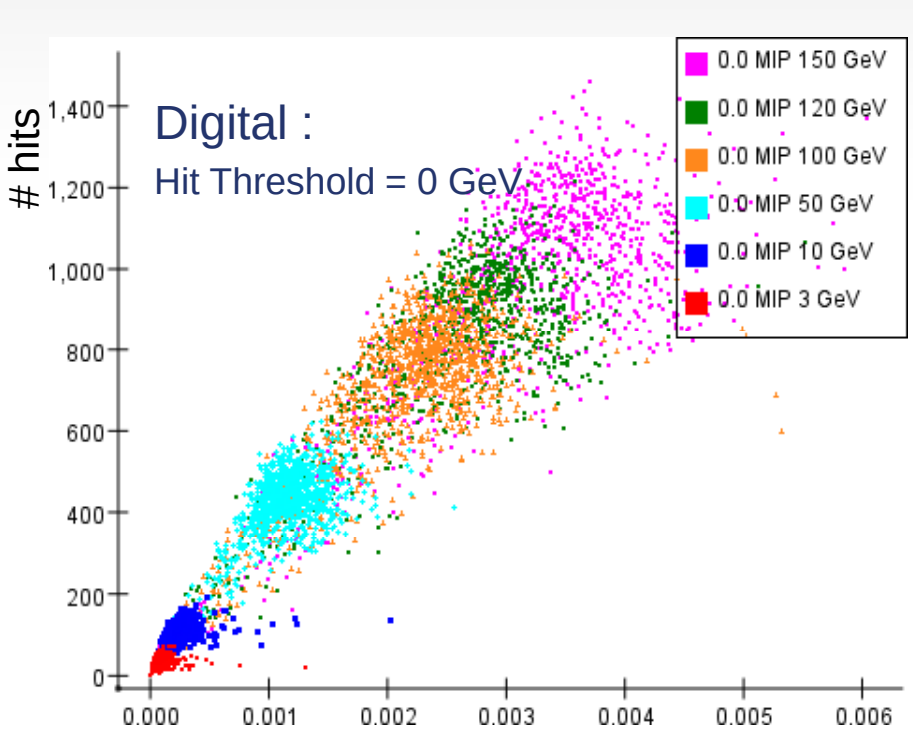
Simulation

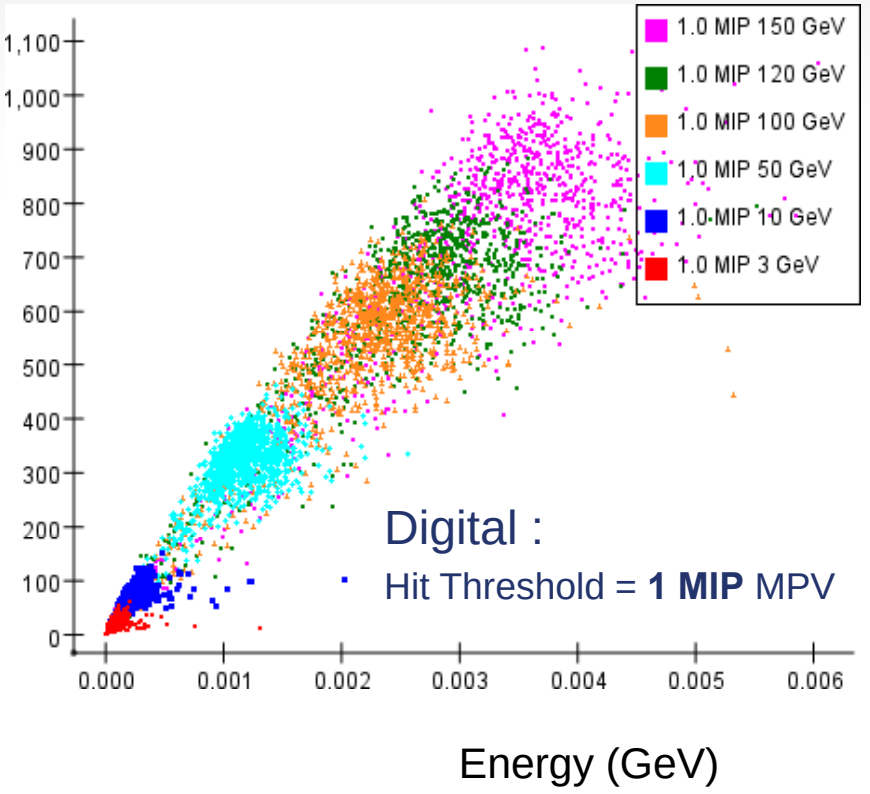
- DHCAL with MicroMegas
  - HCAL dimensions:
    - $1m^3$ HCAL prototype (40 planes of $1m^2$, 4.5 λ_I, $1m^3$)
    - Large HCAL (80 planes of $2m^2$, 9 λ_I, $8m^3$)
  - 1.9 cm thick steel absorber
  - Thickness of active layer: 6 mm
    - 3 mm Gas: 95 % Argon + 5 % Isobutane
    - 2.8 mm PCB + ASICs
  - Different readout cell size:
    - 0.5 x 0.5 cm^2
    - 1 x 1 cm^2
    - 2 x 2 cm^2
    - 4 x 4 cm^2



1 m³

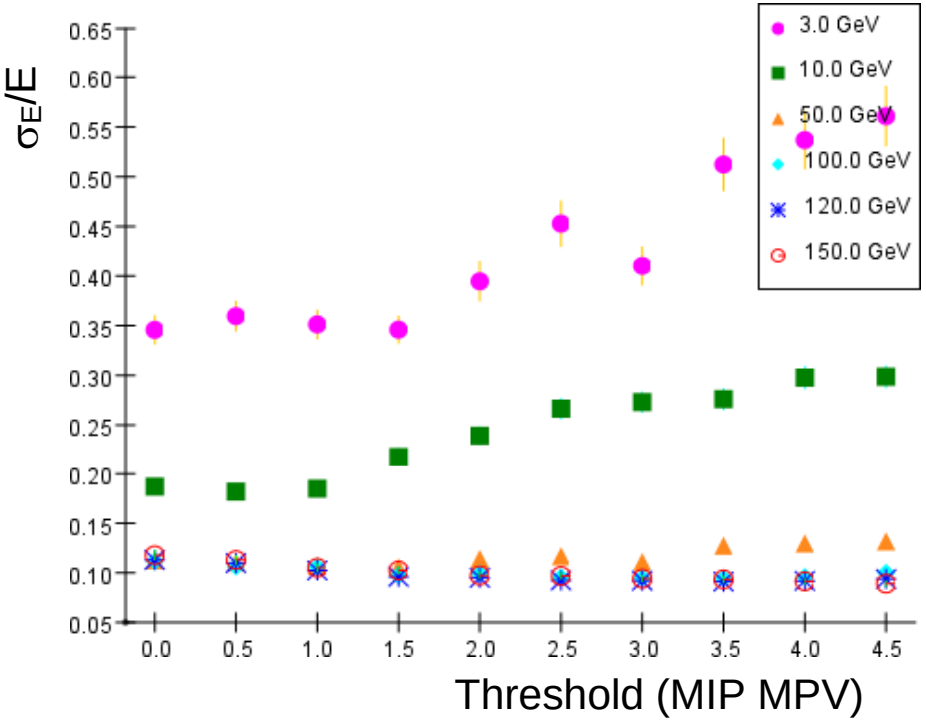
- Nb of Hits versus deposited energy

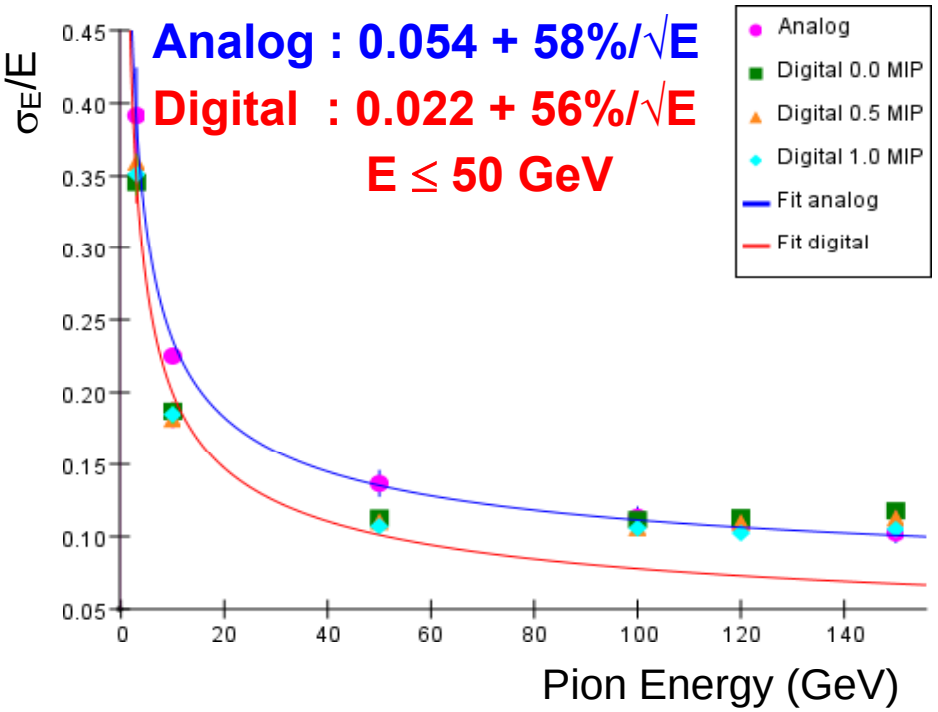




1 m³

- Threshold studies versus Energy Resolution





Do we need a semi-digital electronics ???

Plans

- **Build and test with beam small prototypes with analog electronics** *(Done)*
- **Build small prototypes with on board electronics. Test with beam (Nov '08 and spring 09)** (In progress)
  - HARDROC and DIRAC chips
- **Build one $1m^2$ chamber, test on beam** (conceptual design and initial tests)
- **Build $1m^3$ for physics** (conceptual design)

Test beam (August 08)

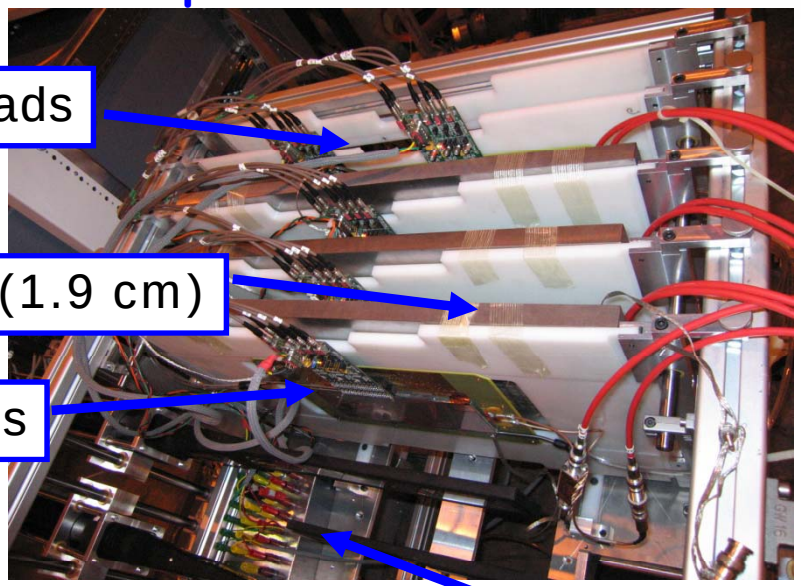
Main objectives

- Prototypes diversity
- Pad homogeneity
- Efficiency and multiplicity
- Crosstalk study
- Behavior in hadronic showers

Collected data

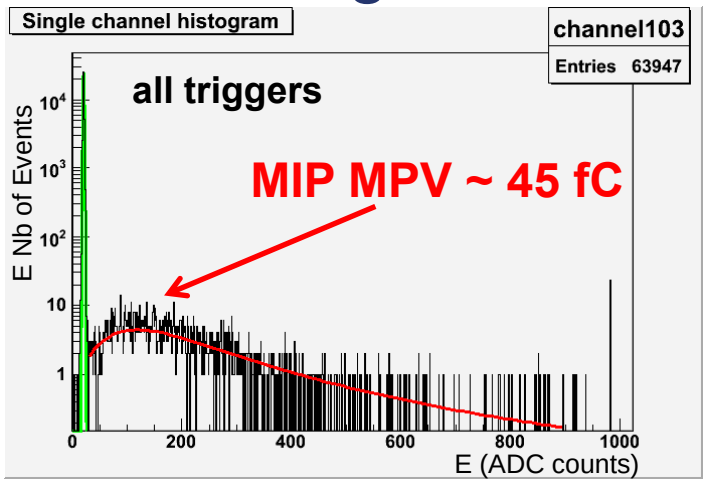
- 50 and 200 GeV pions
- 200 GeV muons
- 200 GeV pions with and without iron absorber in front of the system

Set-up at H2 line SPS-CERN



Preliminary Results

- MIP Signal observed on every Single Channel



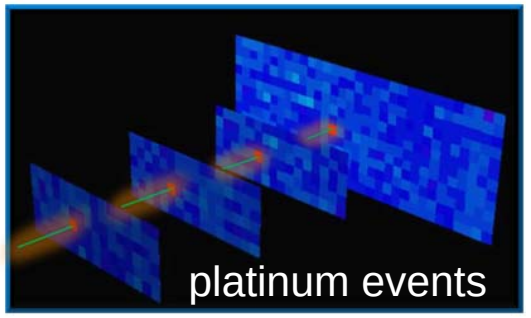
Pedestal:

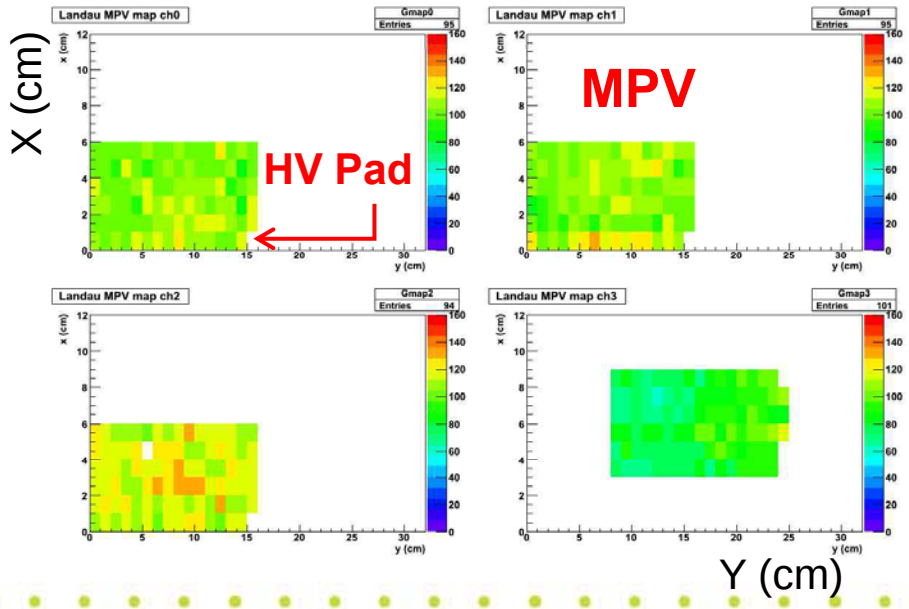
aligned online (0.2 fC RMS)

constant over time

average sigma = 0.6 fC

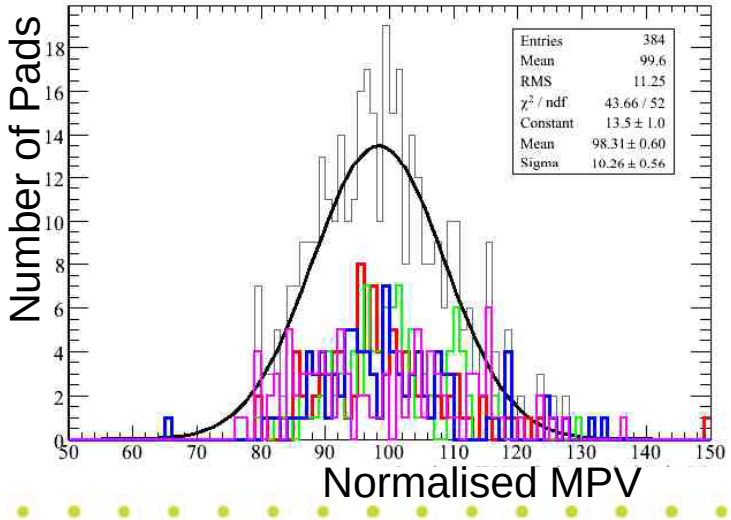
⇒ Good noise conditions!





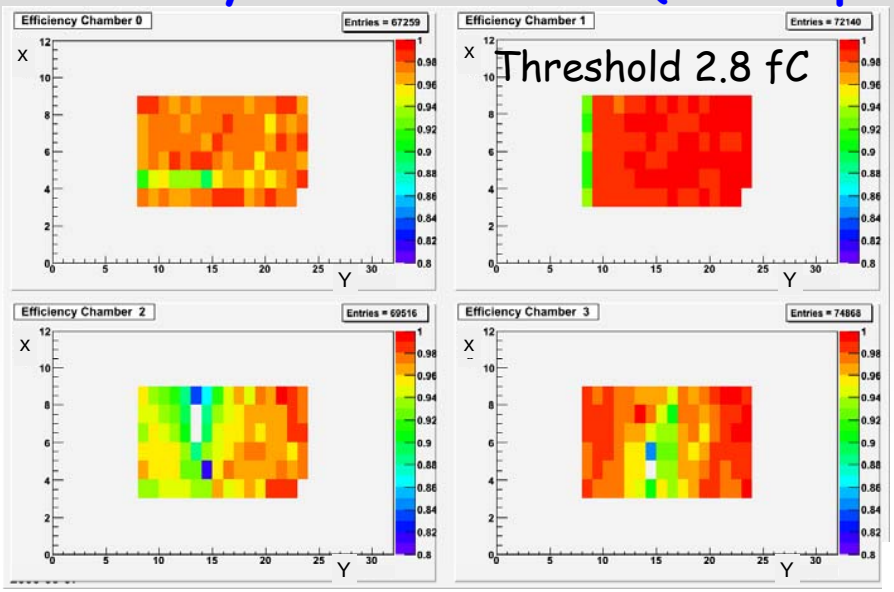
MPV variation under study:

- Electronics channels disparity
- Drift space and gain uniformity

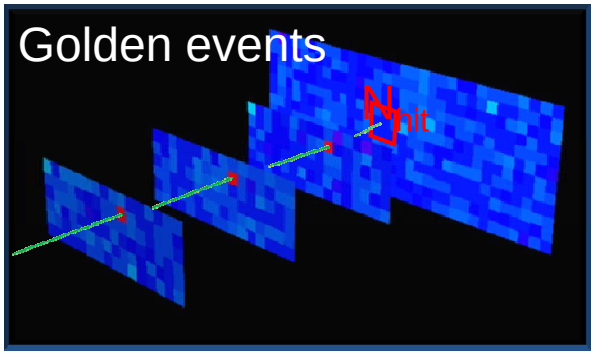


Efficiency

Efficiency for 4 chambers (for all pads)



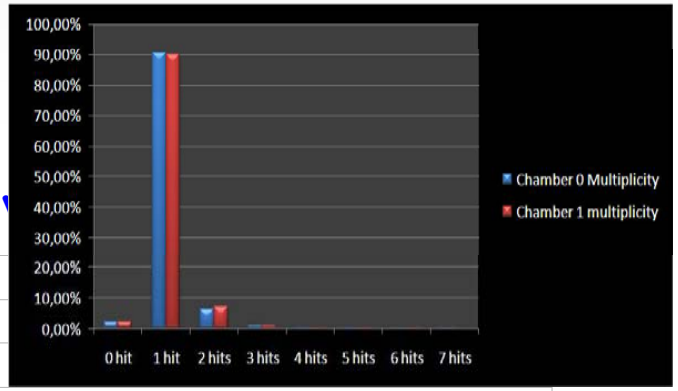
	Efficiency
Chamber 0	97,05 ± 0,07%
Chamber 1	98,54 ± 0,05%
Chamber 2	92,99 ± 0,10%
Chamber 3	96,17 ± 0,07%

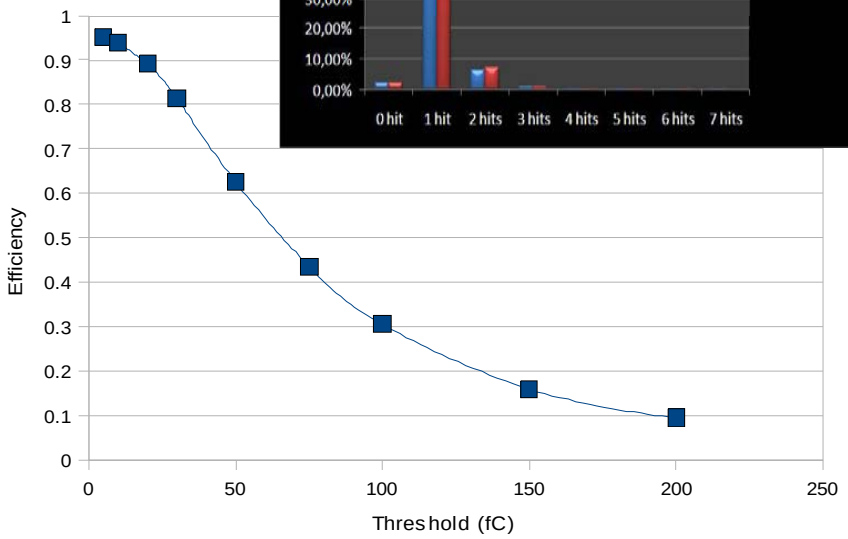


Count the Number of hit(s) in a

3x3 array around the expected hit

Efficiency

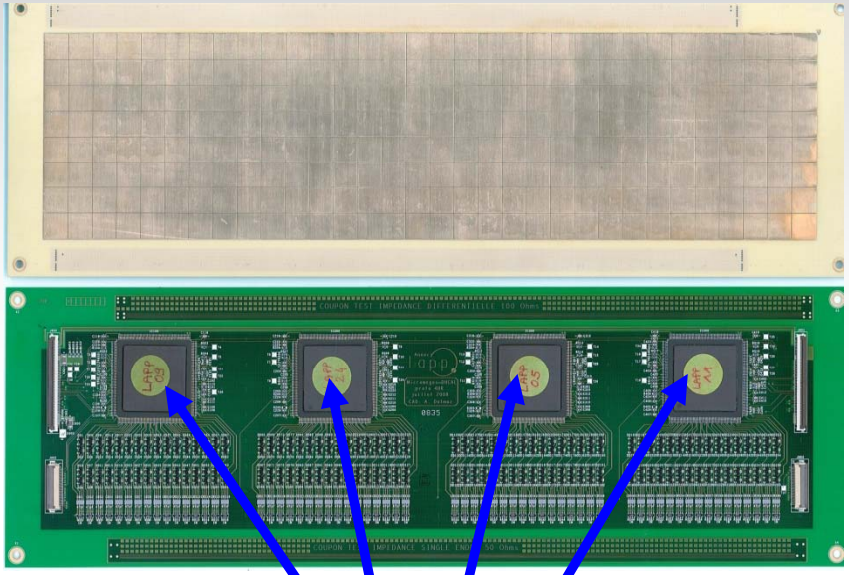




HARDROC and DIRAC

HARDROC 1 (2) (LAL)

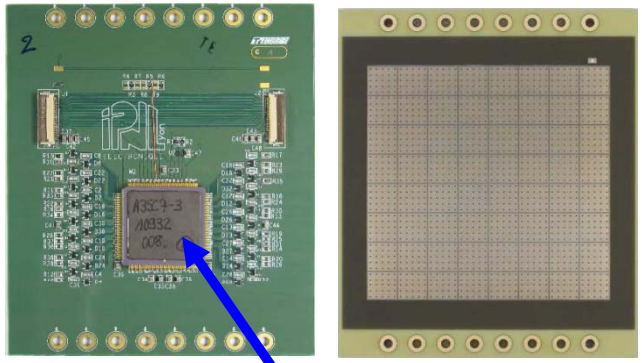
- Analog and digital readout
- 1 chip (16 mm^2, 19 mm^2) – 64 channels
- 2 (3) thresholds in 10 bit precision
- Digital memory for 128 events
- Gain – 10 fC to 1 pC (5 pC to 10 pC)
- Low consumption - < 10 µW/channel



4 HARDROC for 8x32 pads

DIRAC (IPNL)

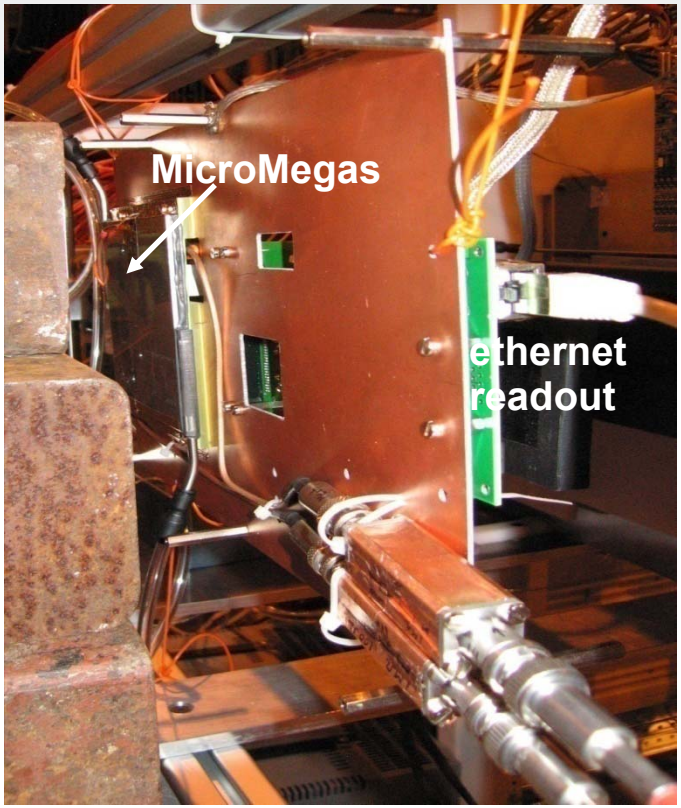
- Digital readout
- 1 chip (7 mm^2) – 64 channels
- 3 thresholds in 8 bit precision
- Digital memory for 8 events
- 2 gains – 3 fC to 200 fC
  (100 fC to 10 pC)
- Low consumption - < 10 µW/channel

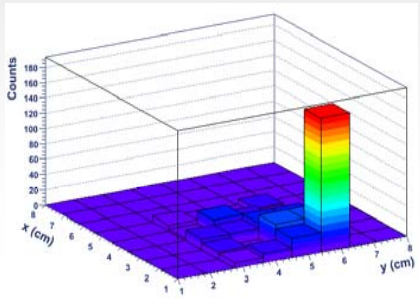


DIRAC

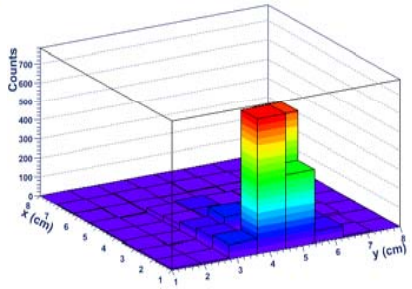
MicroMegas with digital readout

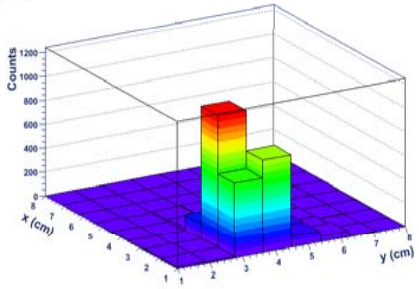
The first operational bulk µMegas with embedded readout electronics (TB in August 08):





Beam Profile when moving the X-Y table



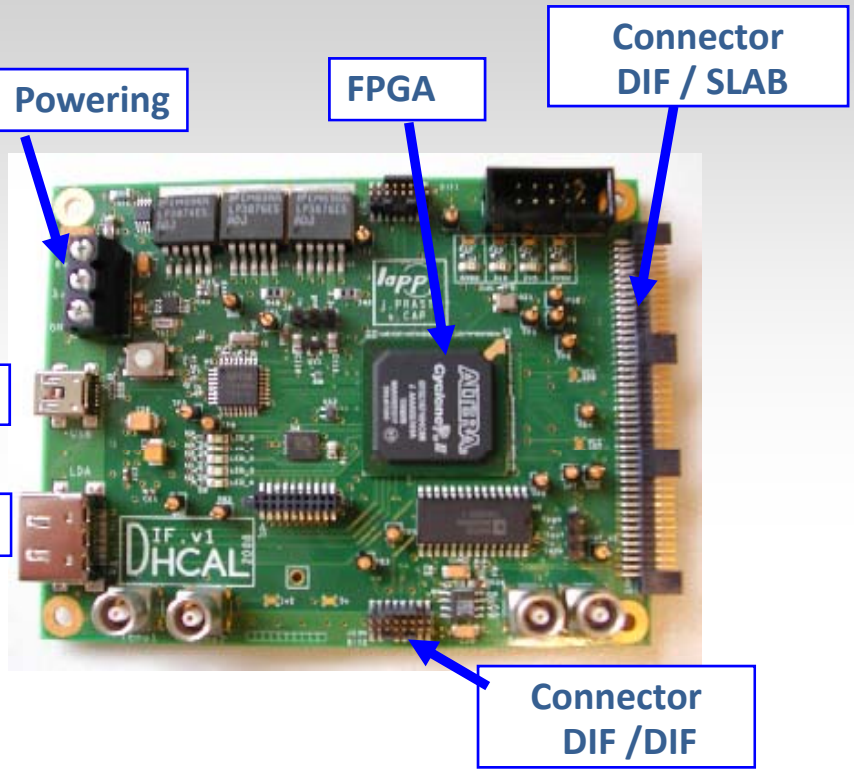


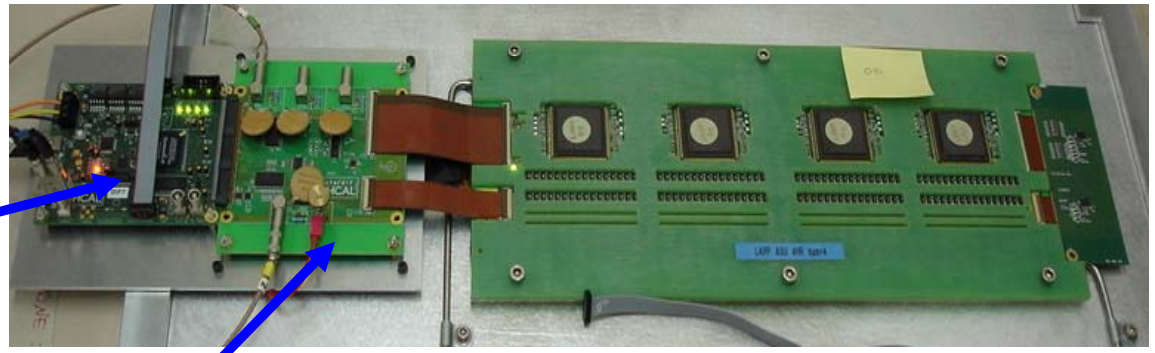
Very promising results!

Digital InterFace

DIF board (LAPP):

- Independent board to have more flexibility
- It provides the communication with PCs and HARDROCs (DIRACs) through the intermediate board (InterDIF)
- It allows ASICs configuration and performs analog and digital readout
- Also compatible with SPIROC and SKYROC

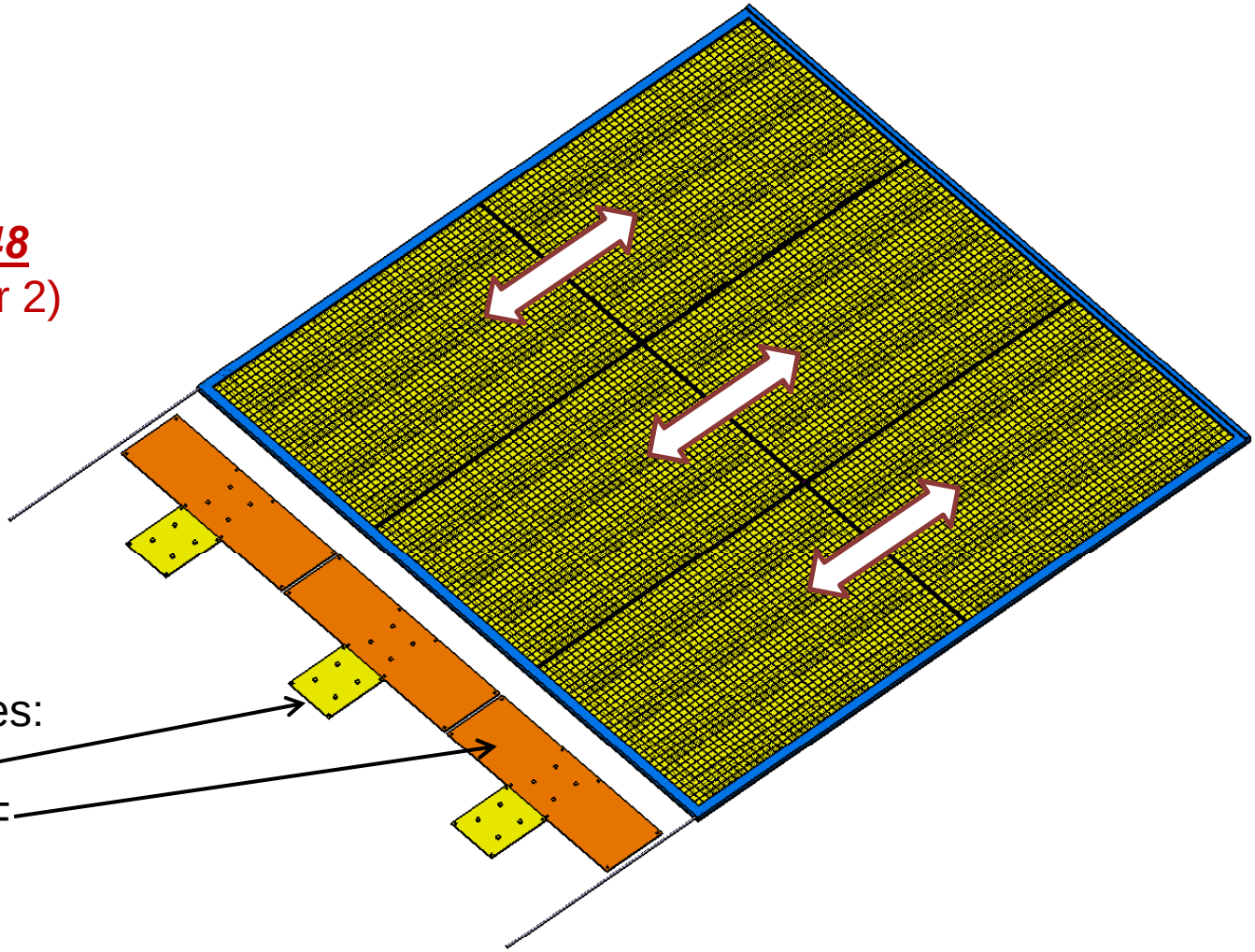




Conceptual design design of 1m²

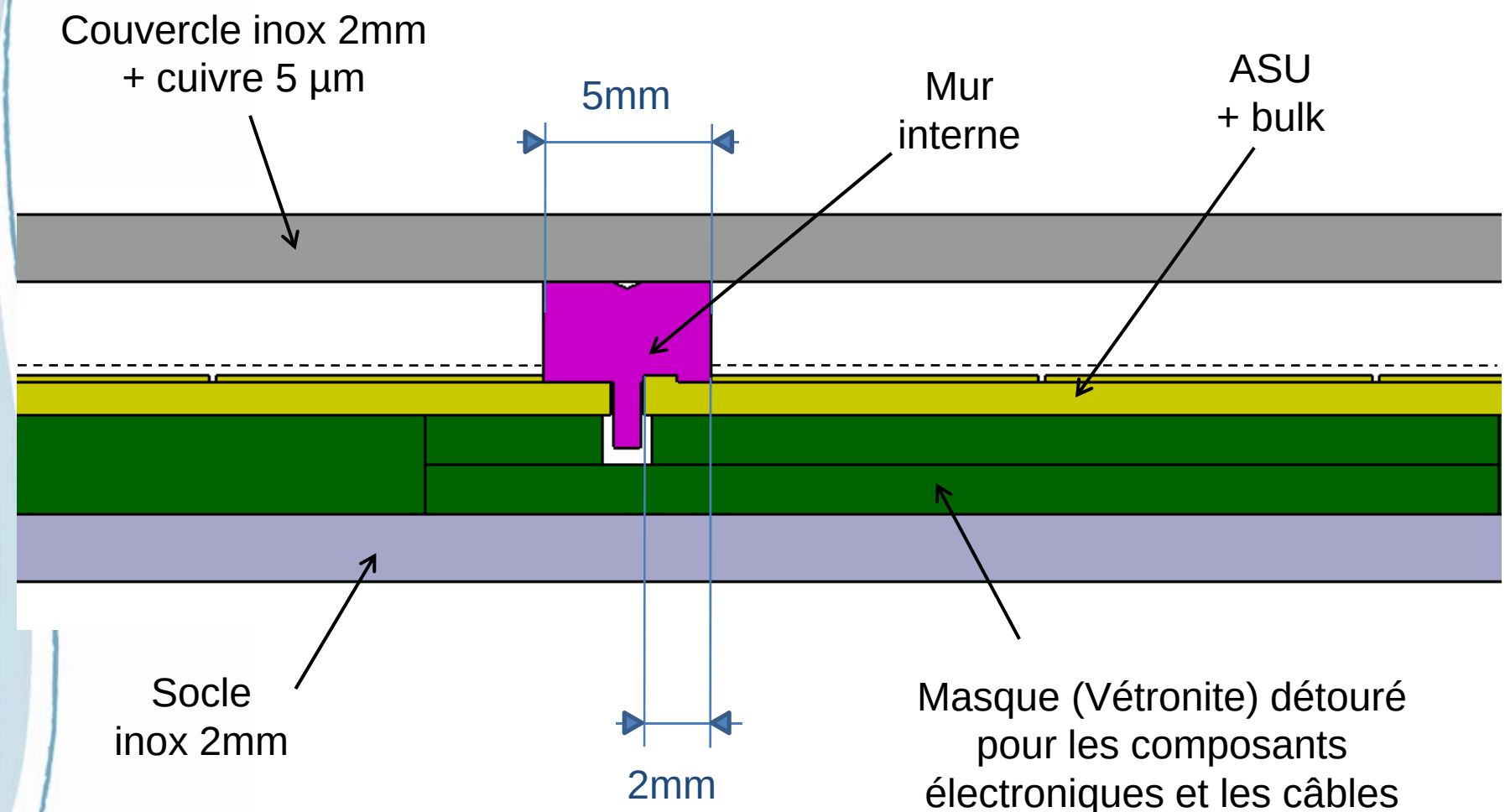
6 ASU 32x48
(chainés 2 par 2)

Cartes électroniques:
3 DIF
3 inter-DIF

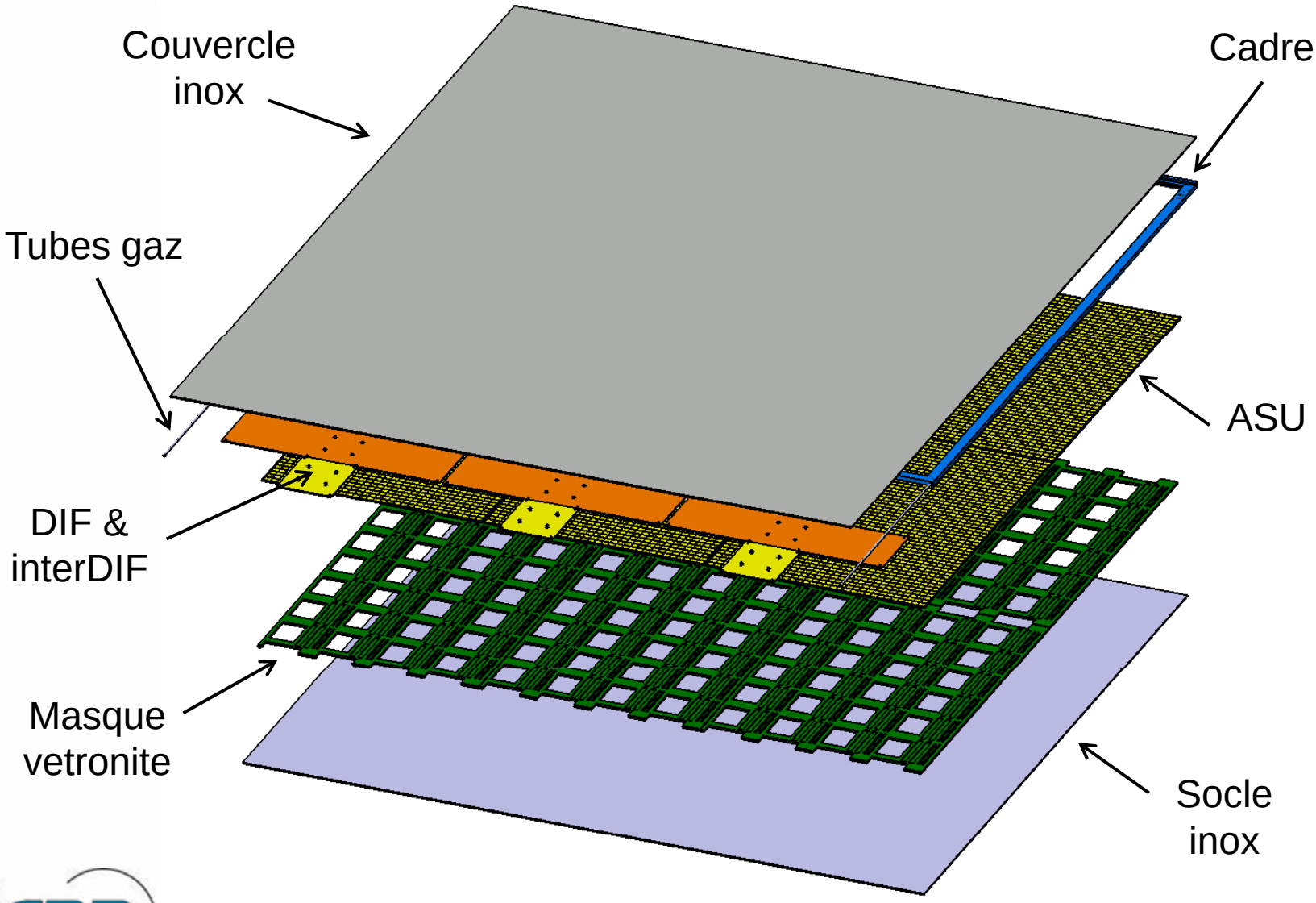


Détecteur Micromegas: design du m²

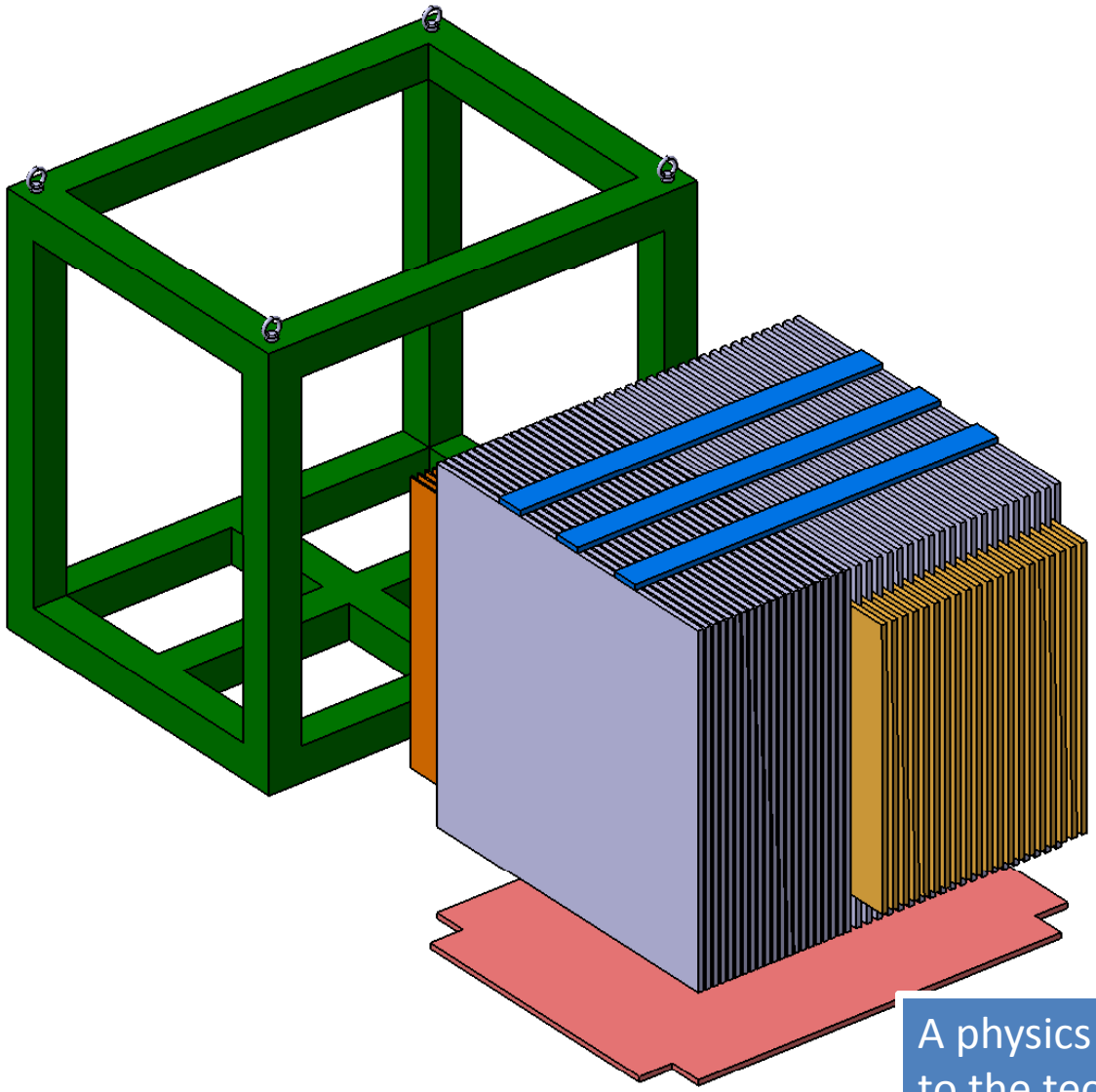
[Coupe au niveau des ASU 32x48]



Détecteur Micromegas: design du m²



The cubic meter



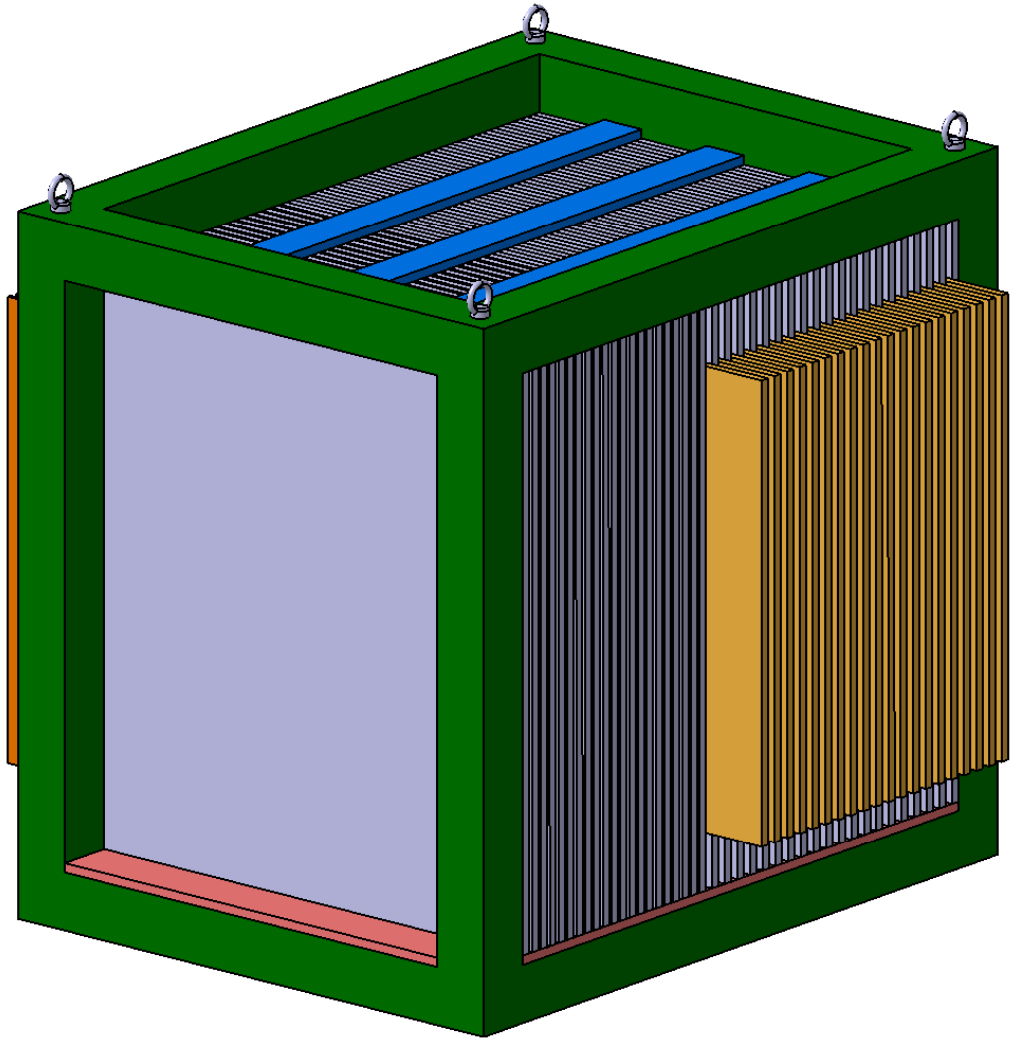
We need a cubic meter detector

- Measure hadronic showers and validate the digital concept and the simulation

- Operate a large system, validate the technology, gain experience

A physics prototype as close as possible to the technological one

Projet détecteur m^3



NB : *possibilité d'assembler deux demi-m^3*

- 40 Absorbeurs acier (1000x1000x20mm) = 6500kg
- 40 chambres de 30kg = 1200 kg
- etc…

Capacité des ponts roulants ?

Milestones

- Produce 4 chambers equipped with 4 HARDROCs each (Jan 09)
- Produce ~10 DIRAC chips and fabricate 4 single DIRAC chambers (Feb 09)
- Beam test @ CERN (Apr '09)

- Fabricate dummy mechanical prototype for 1m2 (Feb '09)
- Produce one 48x32 chamber, 24 HARDROCs (May '09)
- Beam test @ CERN medium and small chambers on it (June-July '09)
- Validate HARDROC (summer '09)
- Fabricate 1m2 detector (Oct '09)
- Beam test @ CERN (Nov '09)

- Fabricate 4 chambers equipped with 4 DIRAC each (Sept '09)
- Validate DIRAC, Beam test @ CERN (Nov '09)

- Green light for 1m3 by December '09

COST

(in Euros)

Contigency = spares

WBS	Component	Number	Unit	Materials	MContingency	MTotal
1	HCAL 1m3 prototype	1	each	680 723	71 124	751 847
1.1	Structure Mecanique	1	each	12 579	0	12 579
1.1.1	Absorbeurs	1	each	6 579	0	6 579
1.1.1.1	Plaque absorbeur 20mm	1	lot	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	15 026	1 766	671 664
1.2.1	Circuits	6	each	1 235	260	8 970
1.2.1.1	HardRoc	24	each	15	11	612
1.2.1.2	PCB Board	1	each	400	8	408
1.2.1.3	Composants PCB detecteur	1	lot	75	0	75
1.2.1.4	Cablage PCB detecteur	1	each	400	0	400
1.2.2	Fabrication Mesh	6	each	565	23	3 526
1.2.2.1	Pose de la mesh	1	each	565	23	588
1.2.3	Fabrication Volume Gaz	1	each	3 100	70	3 170
1.2.3.1	Couvercle + electrode	1	each	500	50	550
1.2.3.2	Murs externes	1	lot	1 000	0	1 000
1.2.3.3	Murs internes	1	lot	200	0	200
1.2.3.4	Masque de support	1	each	1 200	0	1 200
1.2.3.5	Plaque absorbeur 2mm	1	each	200	20	220
1.2.4	Electronique de read out	1	each	1 116	0	1 116
1.2.4.1	Carte Dif	3	each	214	0	642
1.2.4.1.1	Composants Dif	1	each	123	0	123
1.2.4.1.2	Cablage Dif	1	each	67	0	67
1.2.4.1.3	PCB DIF	1	each	24	0	24
1.2.4.2	Carte InterDif	3	each	158	0	474
1.2.4.2.1	Composants InterDif	1	each	47	0	47
1.2.4.2.2	Cablage InterDif	1	each	63	0	63
1.2.4.2.3	PCB InterDif	1	each	48	0	48
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

The people

- **Physicists**
  - C.Adloff, J.Blaha, M.Chefdeville A.Espargiliere, Y.Karyotakis (3.8 FTE)
- **Mechanical engineers and techs**
  - N.Geffroy, F. Pelltier (1.8 FTE)
- **Electronics engineers**
  - S.Cap, A.Dalmaz, C.Drancourt, R.Gaglione, R.Gallet, J.Prast, G.Vouters (5FTE)
- **Computing engineers**
  - J.Jacquemier (0,5FTE)

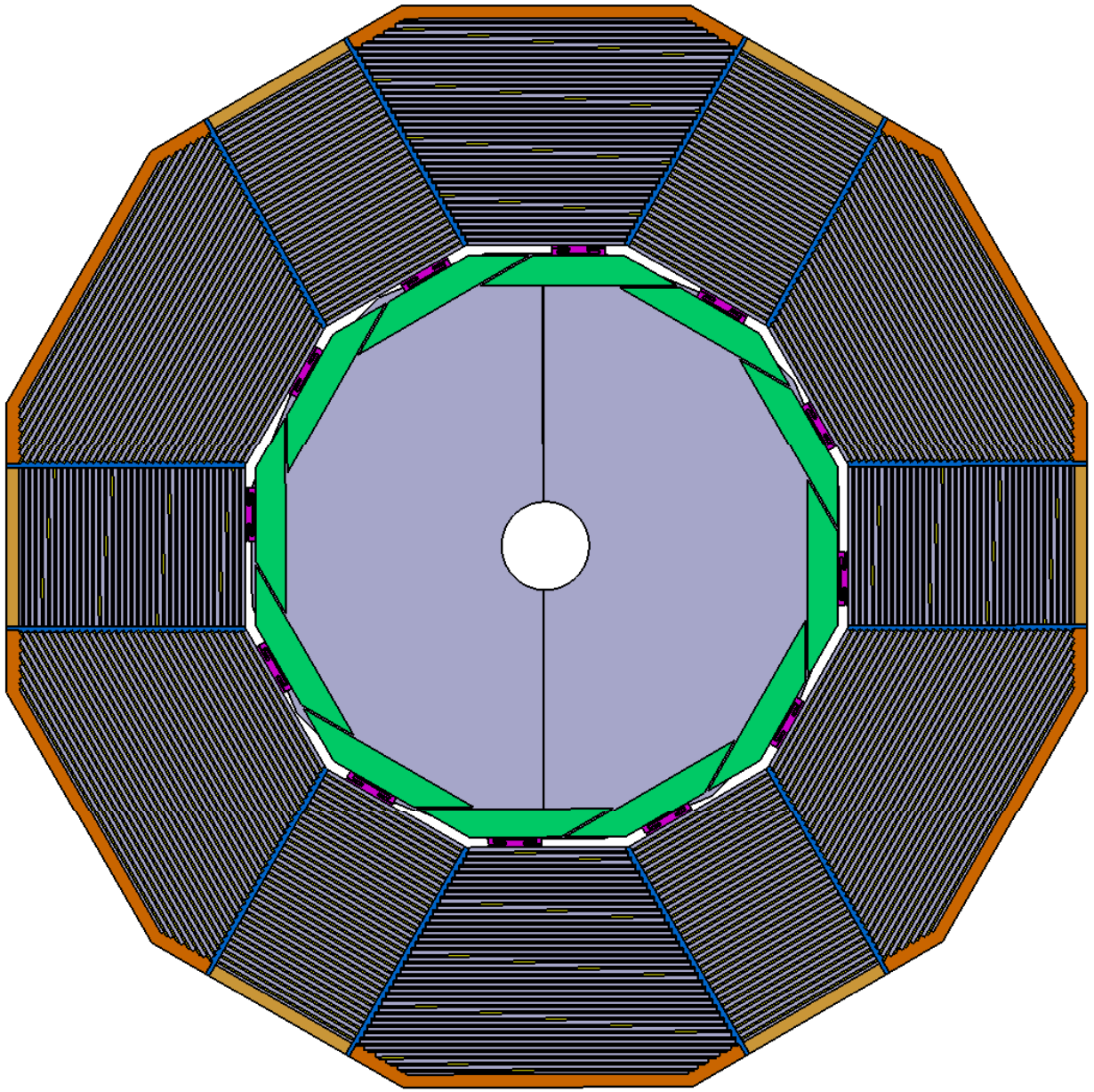
Total ~11 FTEs

- IRFU people are supporting the project (µMegas Developments)
- We are members of RD51 @ CERN Large µMegas chambers

Conclusions

- *µMegas chambers seem a valuable and robust technology for the HCAL.*
- *We have a well defined plan to build a physics/tech 1m3 prototype.*
  - *Validate each step with well defined expectations, review (à la LHCC) next one before building*
- *Strong team on place and strong support from the lab management.*

Vue 3D des détecteurs



Hcal barrel: baseline pour SiD

Longerons décalés

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No free space between modules but filled with absorbers