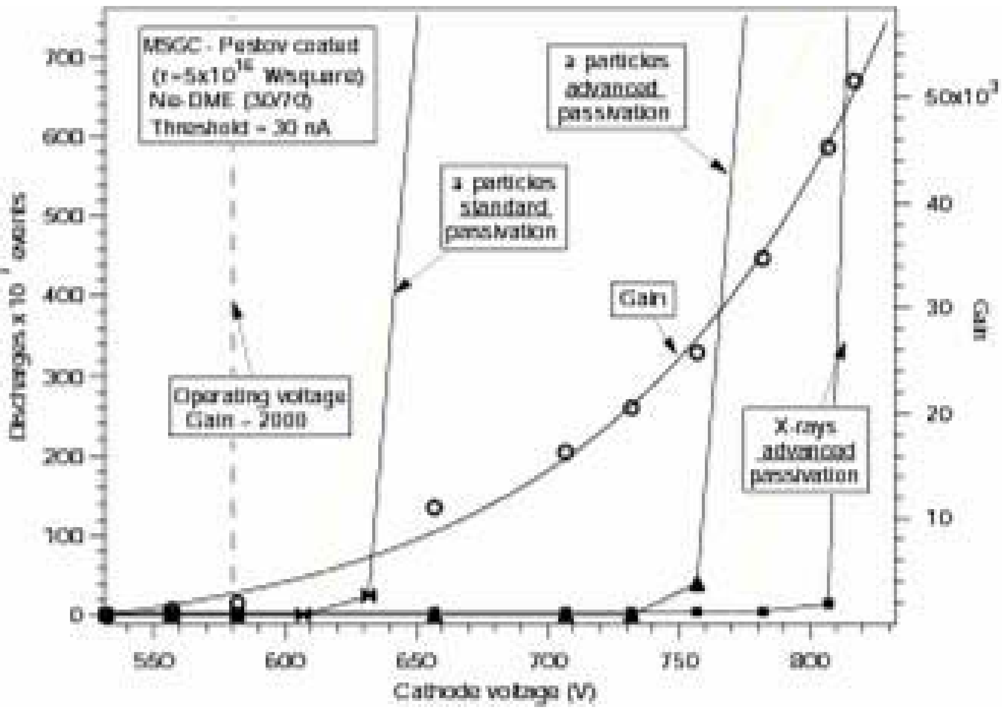
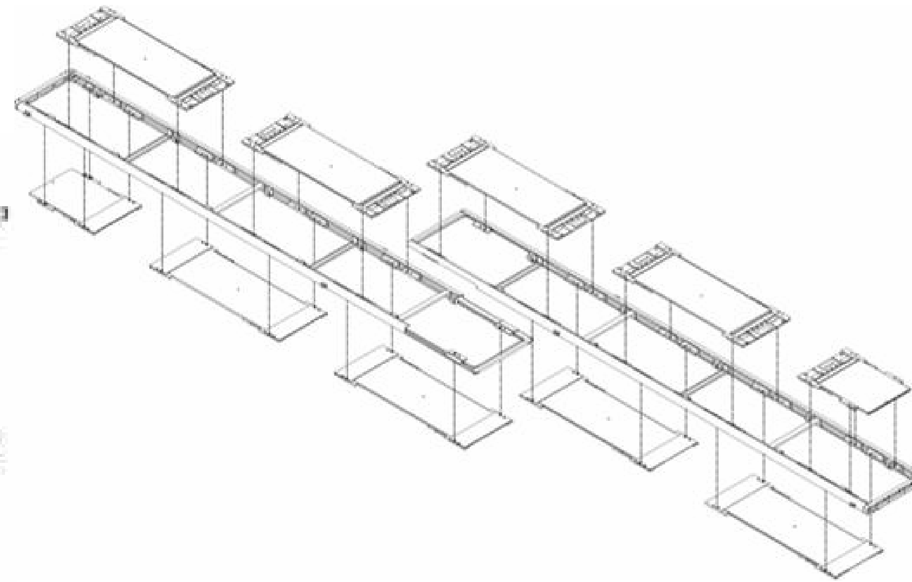
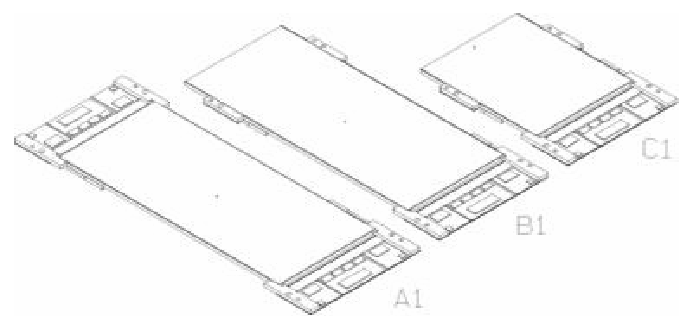
MSGC


MSGC - Pestov coated
Ne-DME (30/70)
Threshold ~ 30 nA
a particles
advanced
passivation
a particles
standard
passivation
Gain
Operating voltage
Gain ~ 2000
X-rays
advanced
passivation
700
600
500
400
300
200
100
0
550
600
650
700
750
800
Cathode voltage (V)
50x10³
40
30
20
10
Gain




A1
B1
C1

Variantes

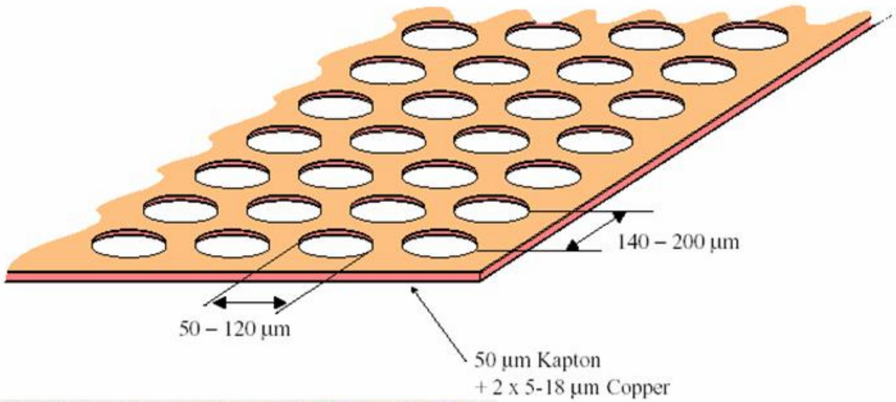
- GEM (Sauli)

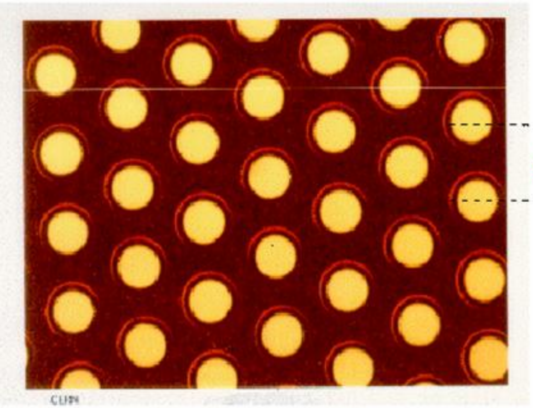
- Micromegas

(Charpak, Giomataris)

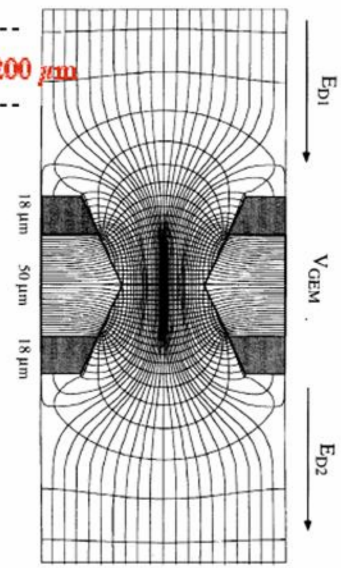
GEM 1997

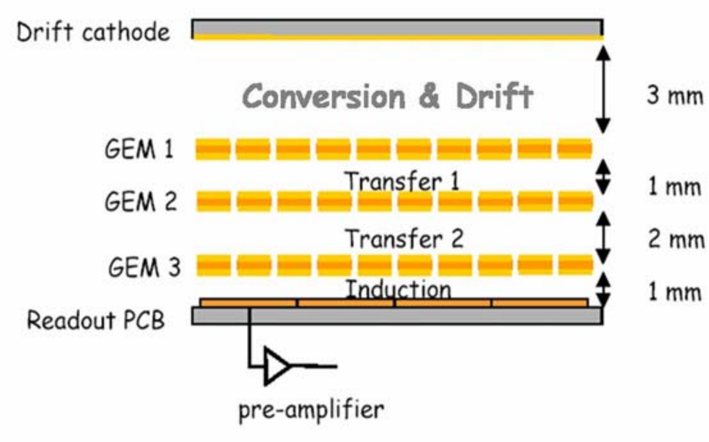
(R. Bouclier et al., NIM A 396 (1997) 50)





Micro photo of a GEM foil

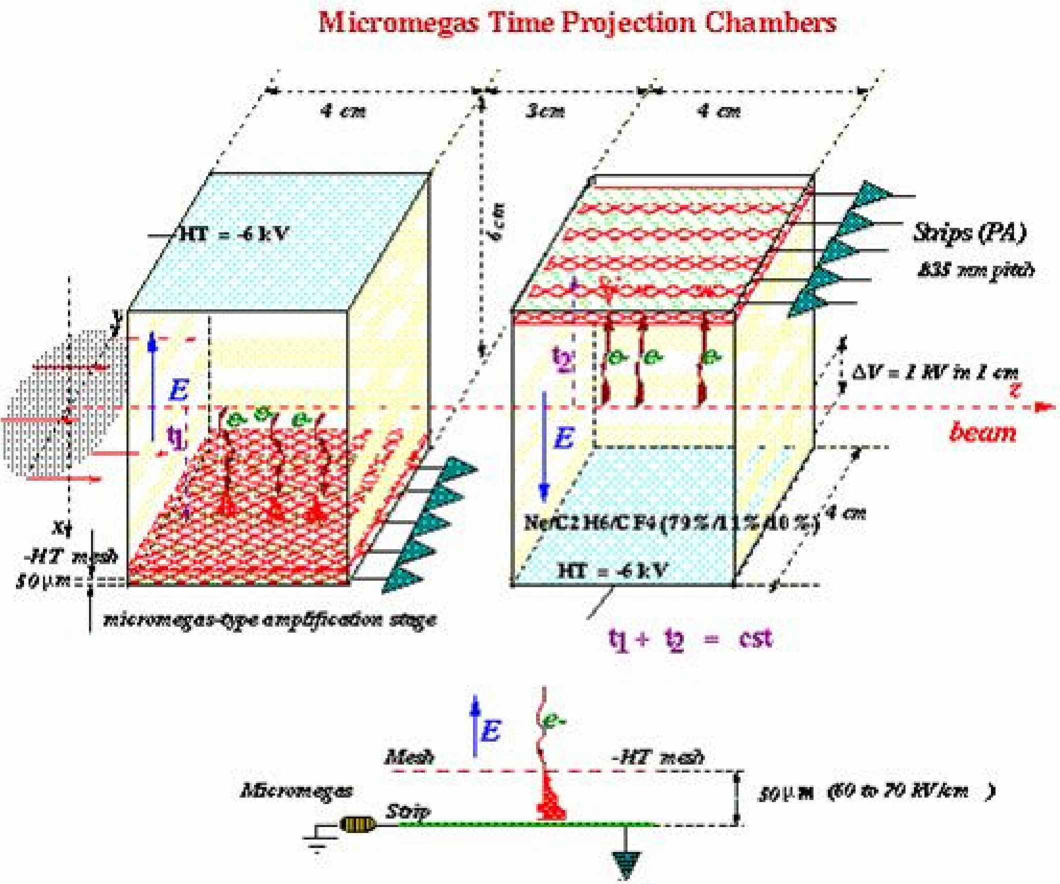




Triple GEM

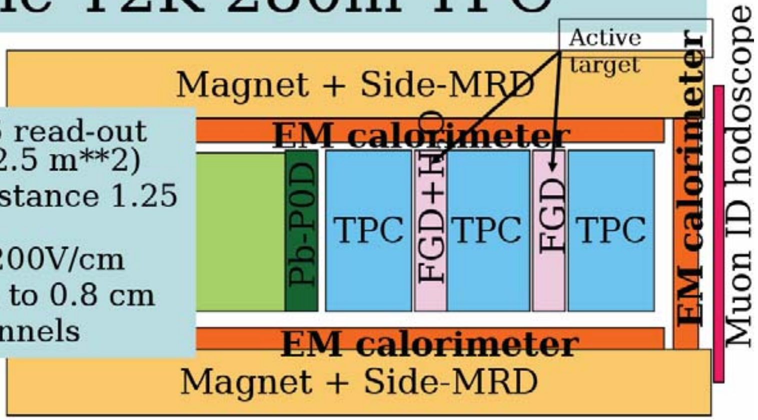
LHCb Muons

Micromegas NA48

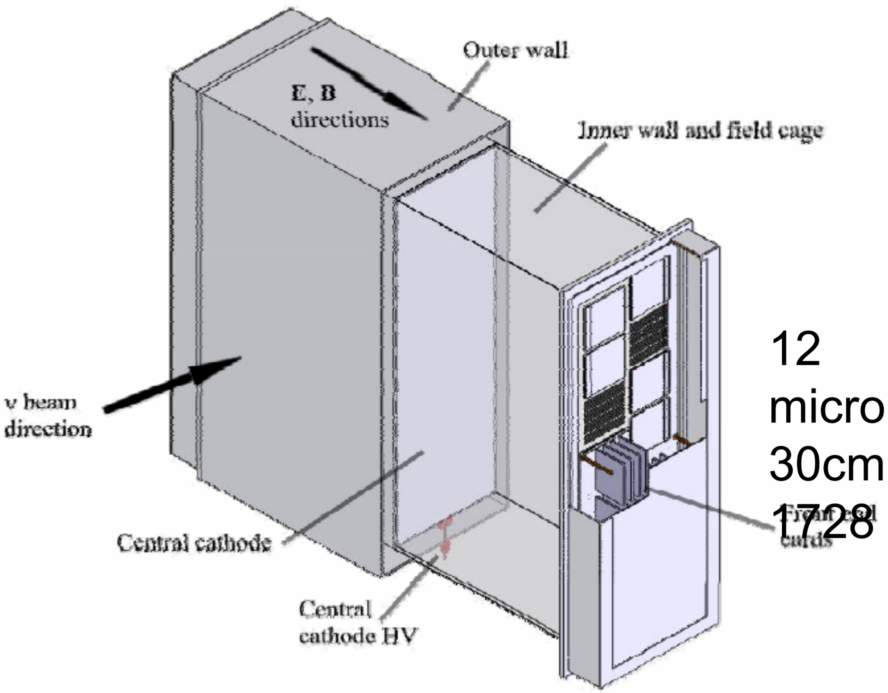


The T2K 280m TPC

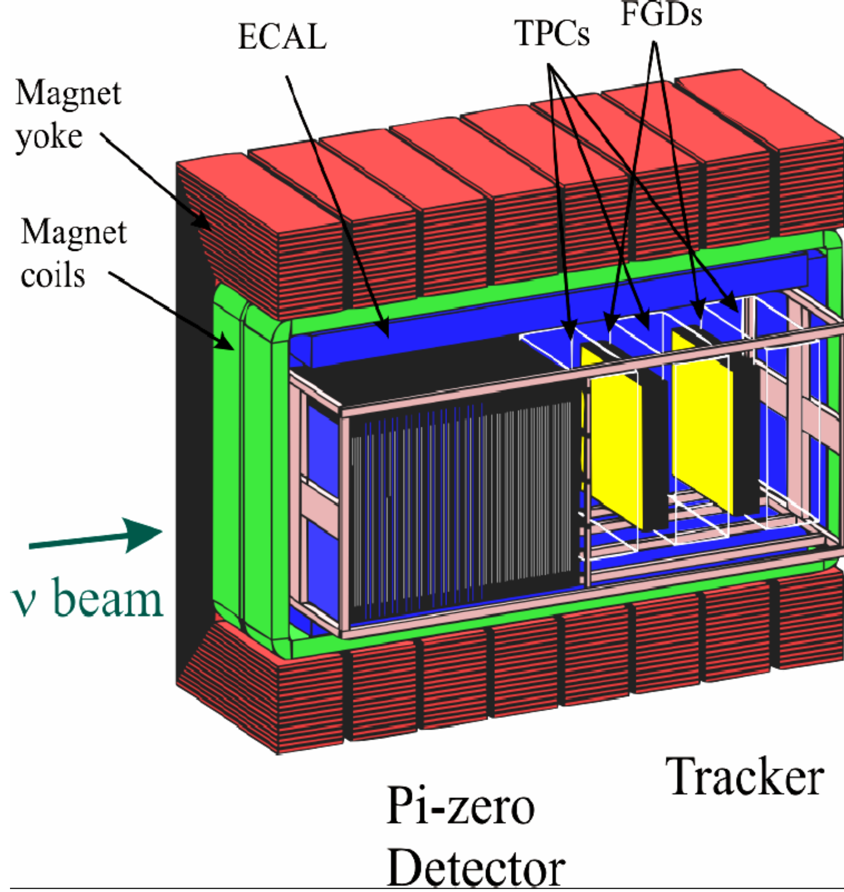
- Instrument 6 read-out planes (0.6x2.5 m**2)
- Total drift distance 1.25 m
- B=0.2 T E=200V/cm
- Pad size: 0.6 to 0.8 cm
- O(100K) channels



Requirements :
σ (p)/p < 10 % @ 1 GeV/c
dE/dx capability: separate e from μ

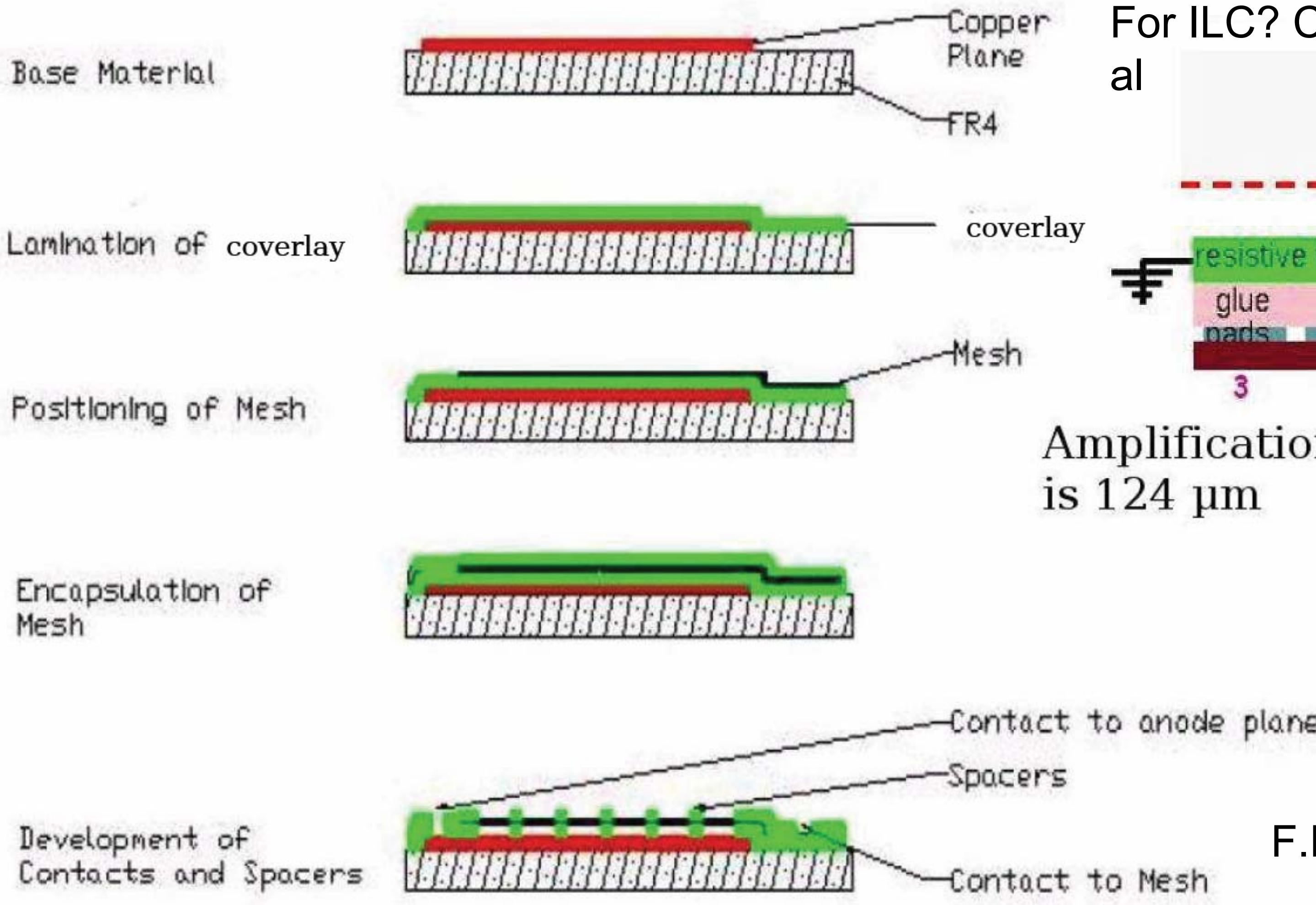


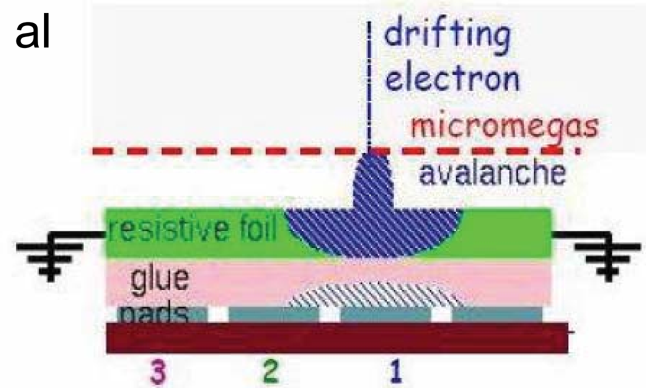
12 micromegas
30cm x30 cm
1728 pads



F. Pierre/DAPNIA-CEA

For ILC? Colas, Lepeltier et al



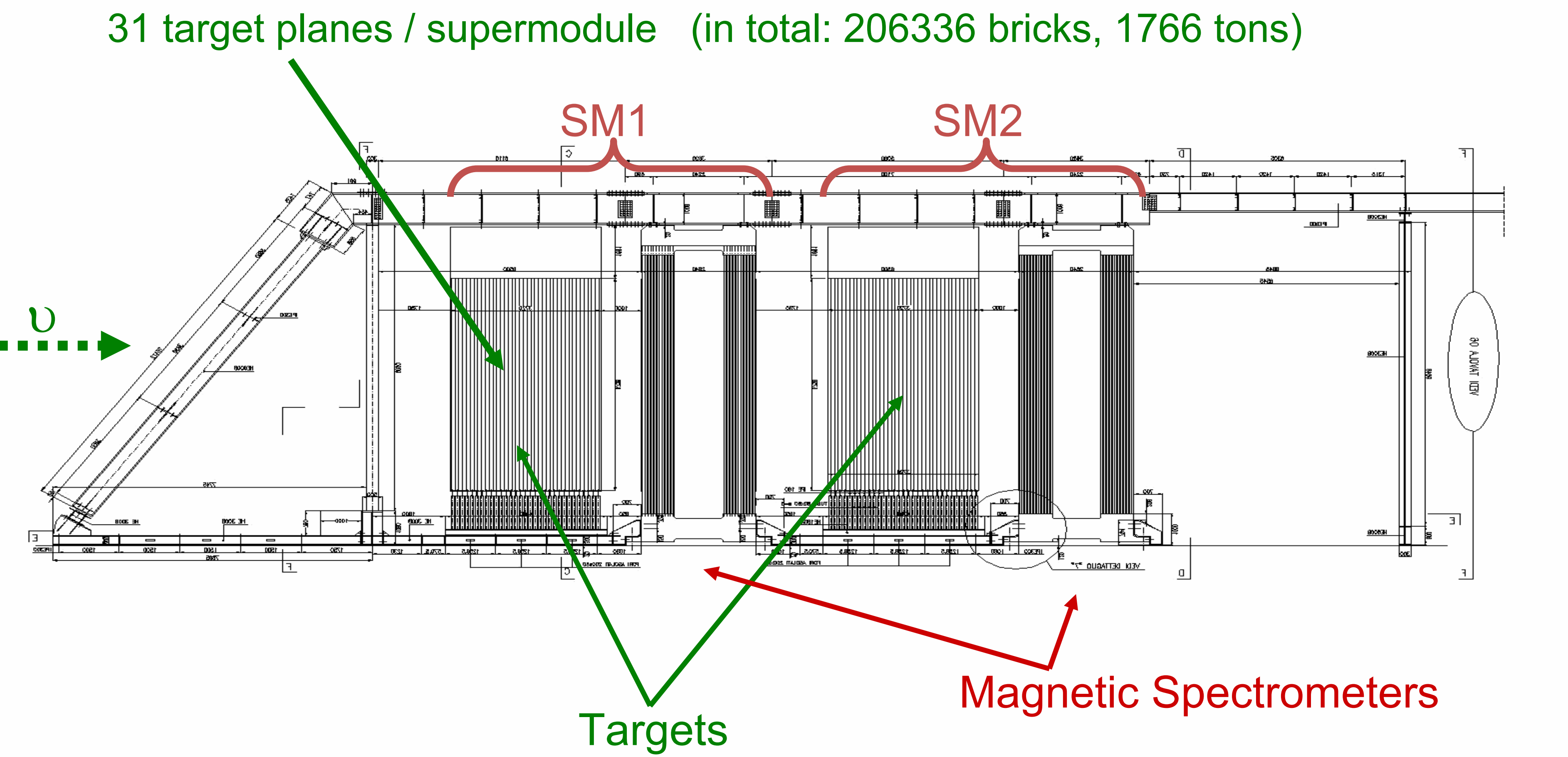


Amplification gap is 124 µm

F.Pierre Dapnia-CEA

PRODUCTION SEQUENCE OF A BULK MICROMEGAS

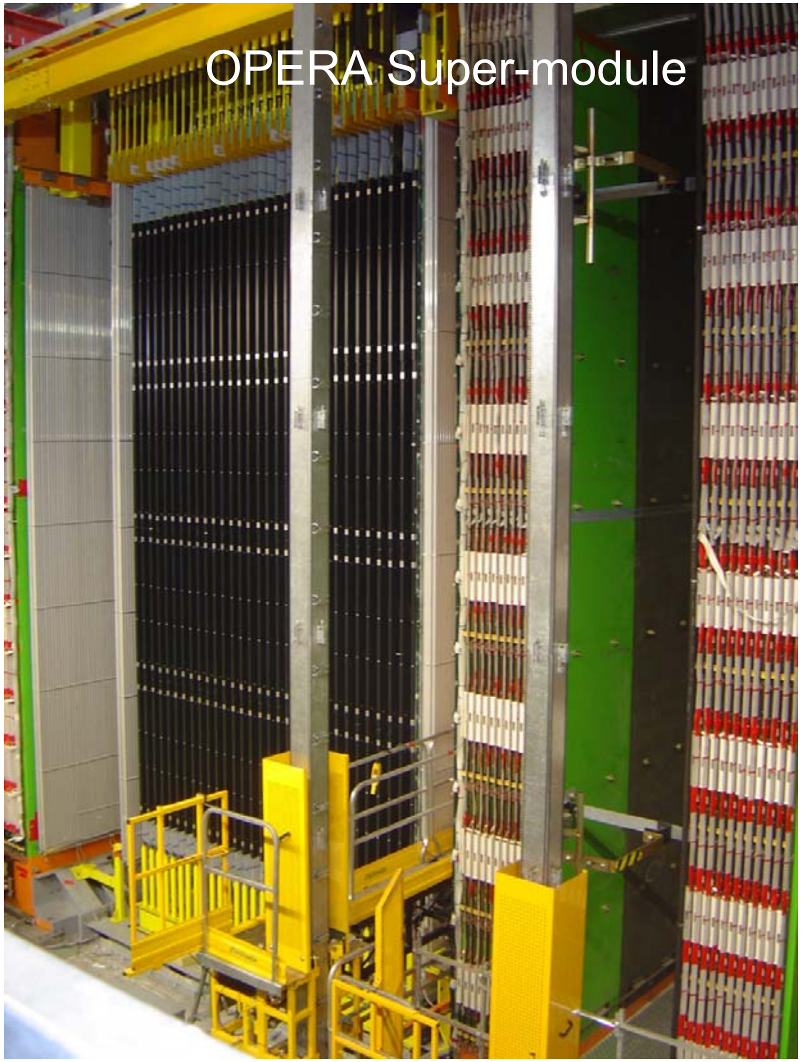
OPERA

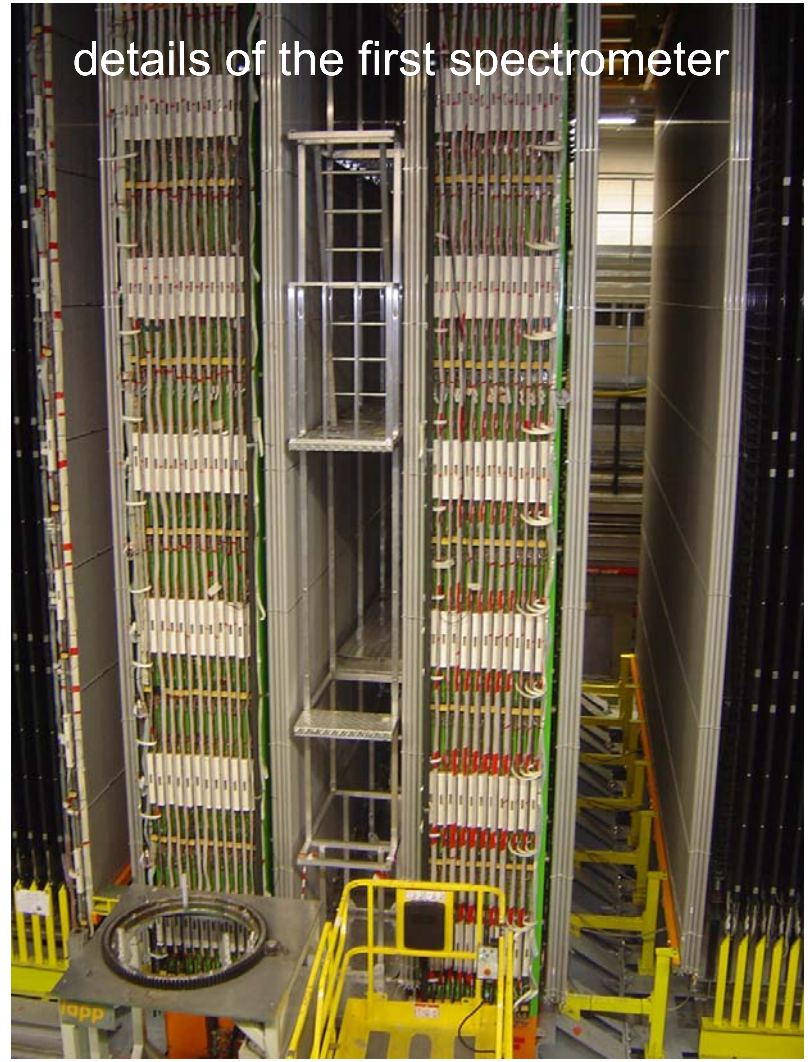

31 target planes / supermodule (in total: 206336 bricks, 1766 tons)
SM1
SM2
υ
Targets
Magnetic Spectrometers

Trackers OPERA

September 11th, 2006
LNGS and the Neutrinos
from CERN

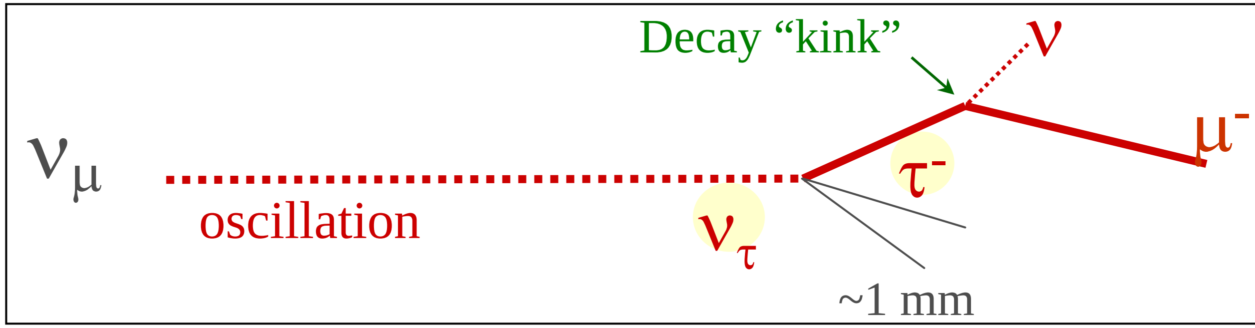
5900 m² scintillator detectors – 3050 m² Resistive Plate Chambers
8064 7m long drift tubes - ~2000 tons of Fe





OPERA-CNGS

Détecteur électronique:
trigger sur interaction neutrino
identification du muon et
mesure charge et impulsion

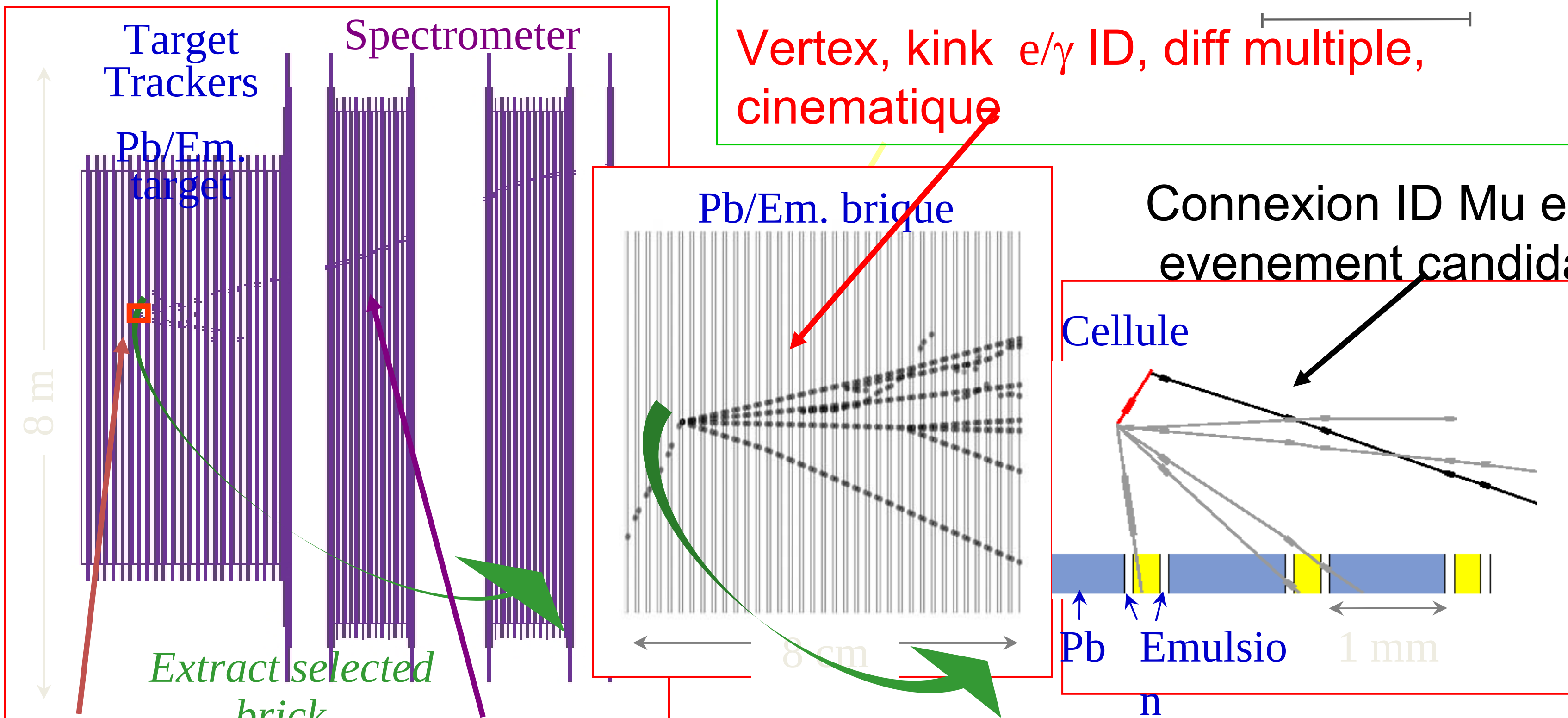


Détecteur électronique:

Analyse Emulsion :

Vertex, kink e/γ ID, diff multiple, cinematique

Connexion ID Mu et evenement candidat

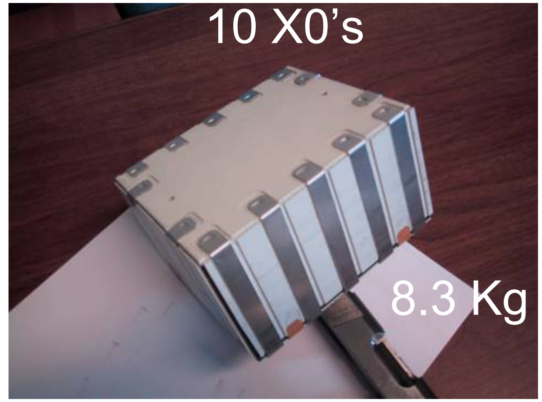


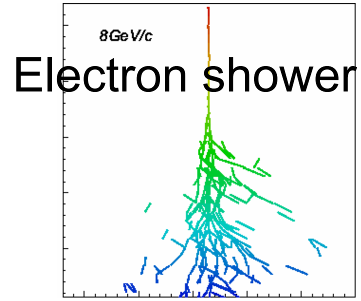
Recherche de brique muon ID, charge et p

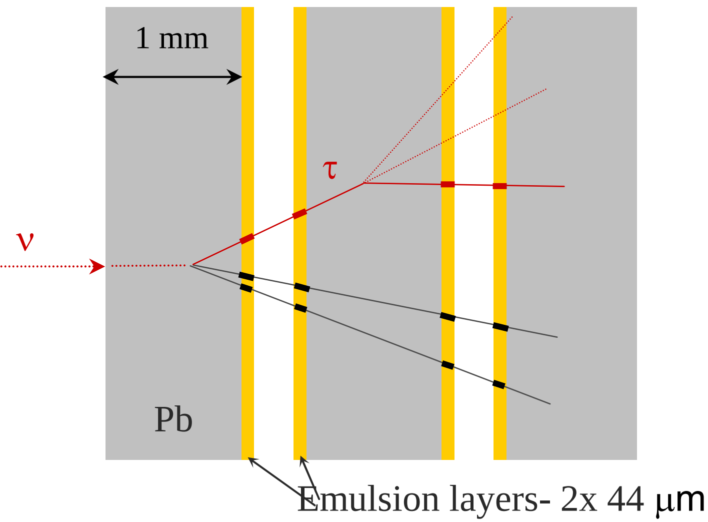
OPERA

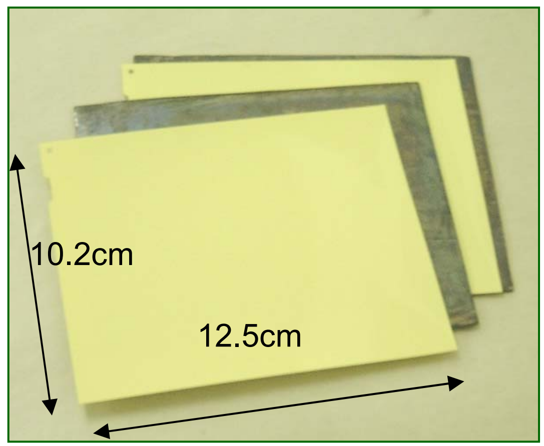
Briques: Cible active Pb + Em
31 plans,
206336 briques, 1766 tonnes

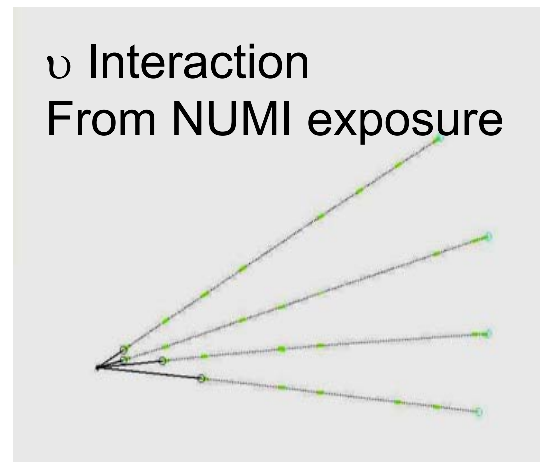
1 brique = 56 Pb + 57 Em





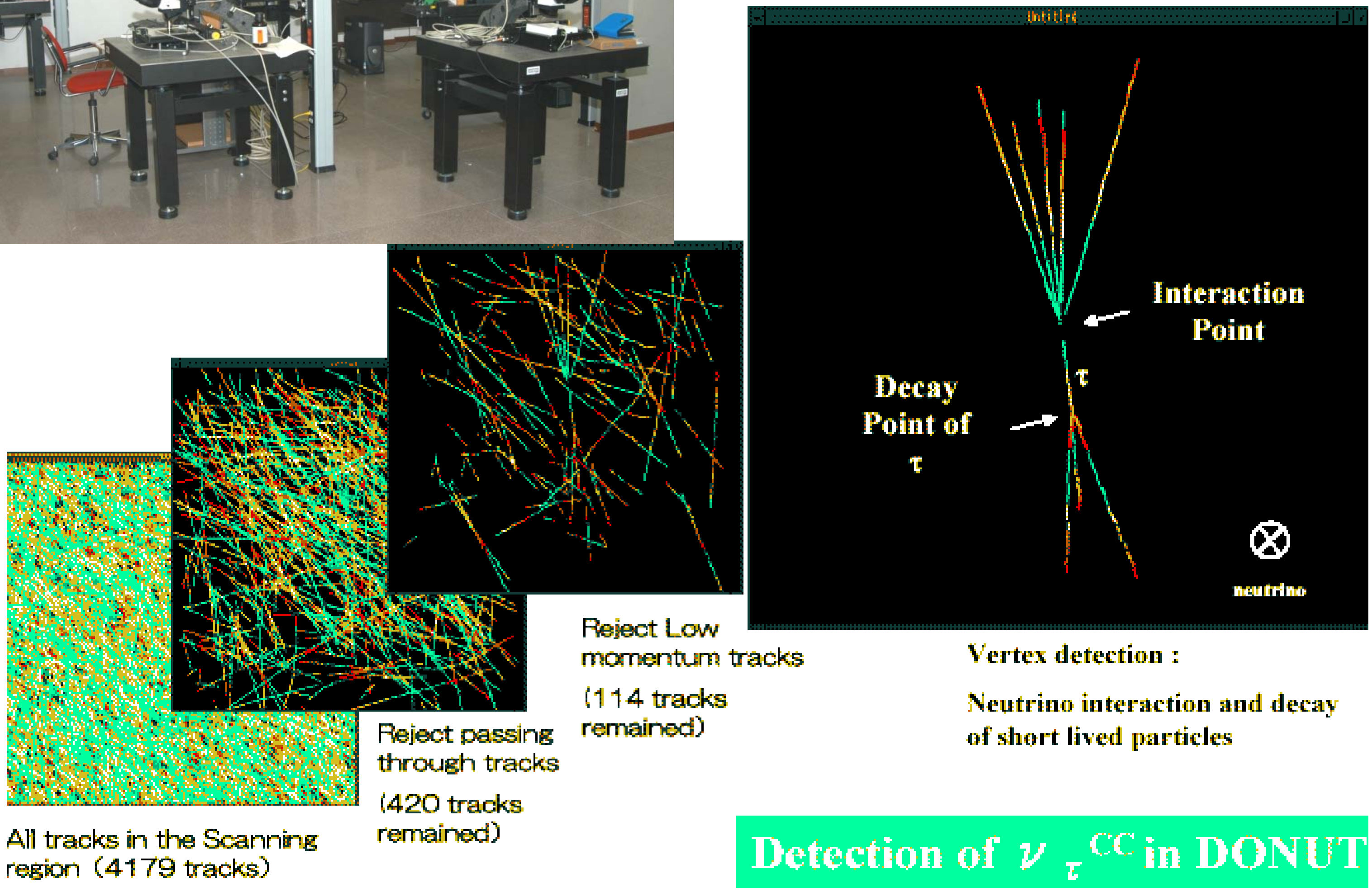






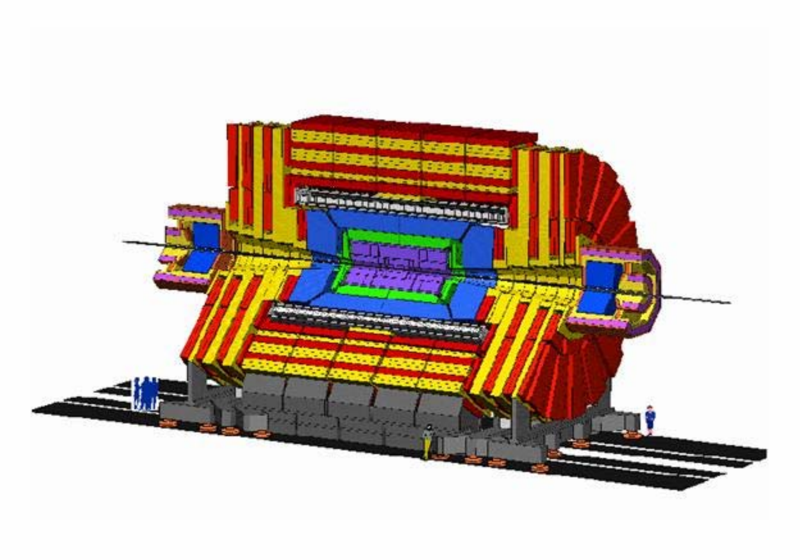
Reconstruction dans l’ émulsion

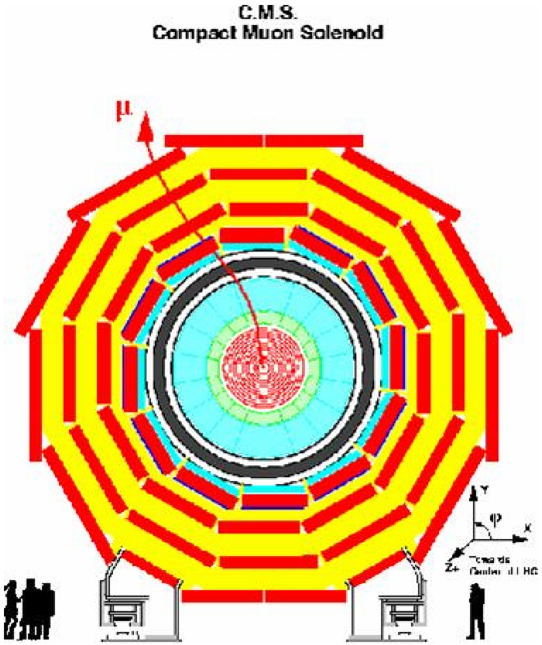
OPERA



Détecteurs muons LHC

– CMS: DT, RPC,CSC

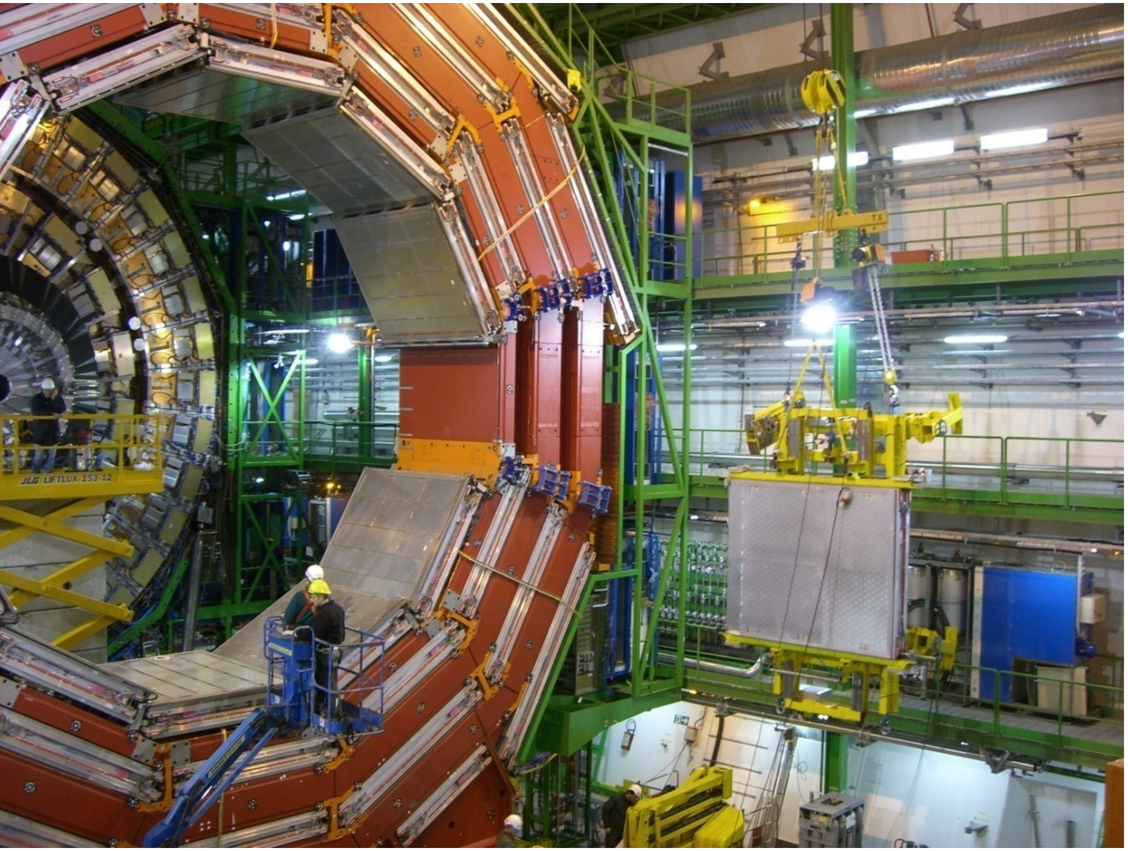




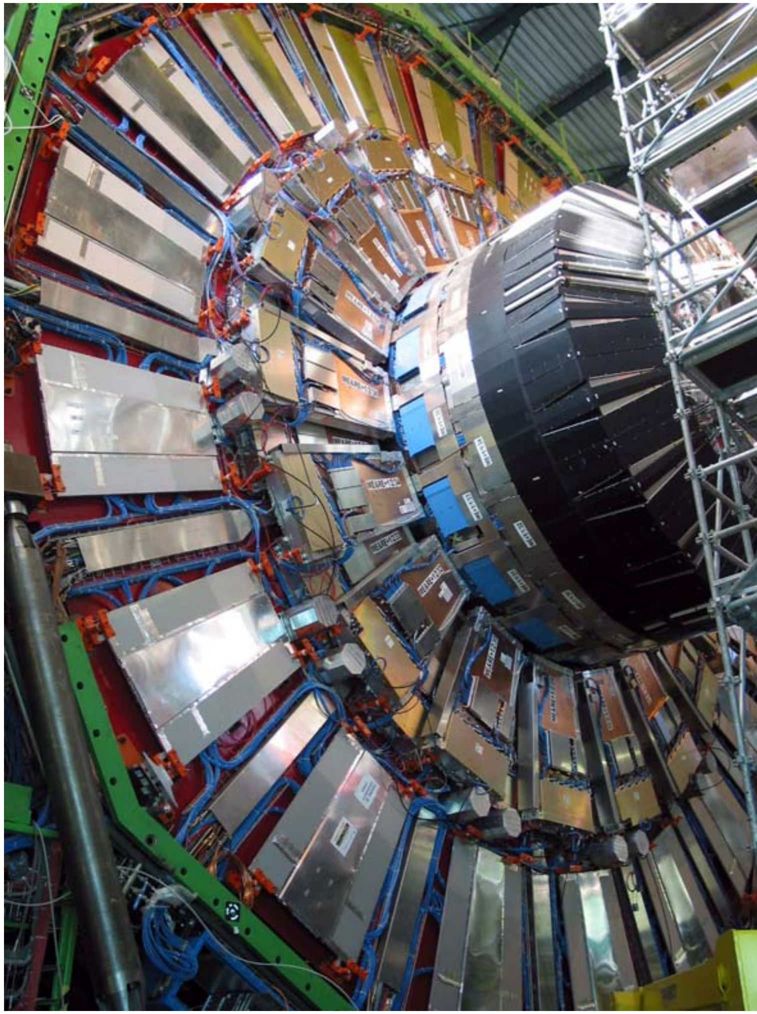
– Atlas:TGC

– LHCB: MWPC, GEM

Muons CMS



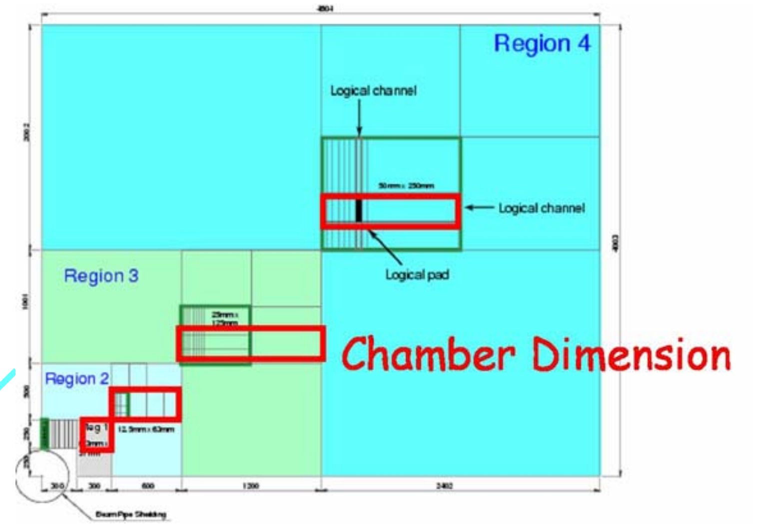
Muon Barrel

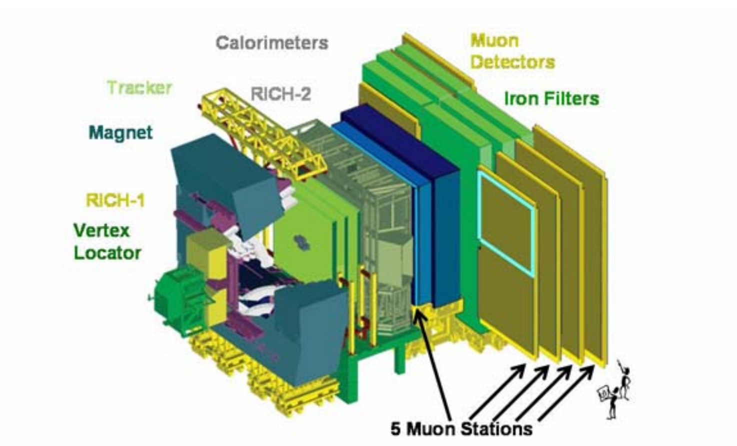


Muon End Cap

MWPCs in the LHCb Muon System

K. Mair IEEE 2005



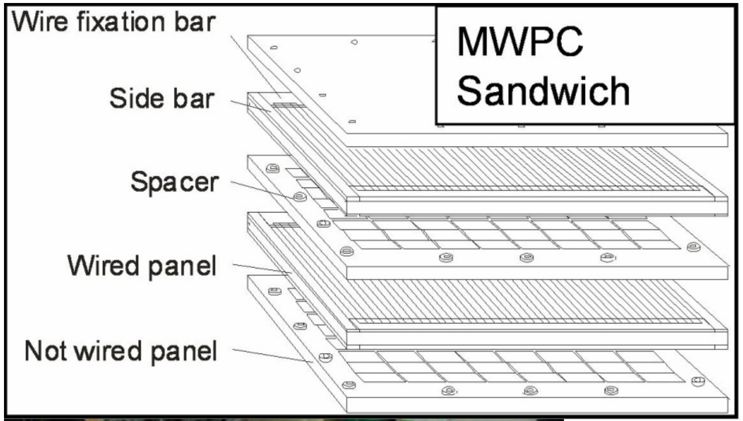


- Multi Wire Proportional Chambers (MWPCs):
  - Fast muon triggering
  - Muon identification
- 5 Muon Stations, 4 Regions / Station
  - 20 different chamber sizes
  - 1368 chambers

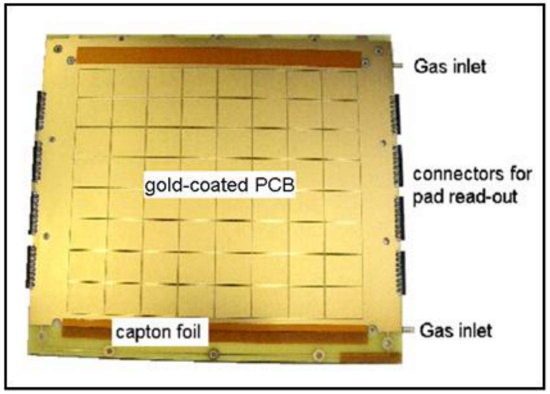
MWPC Design

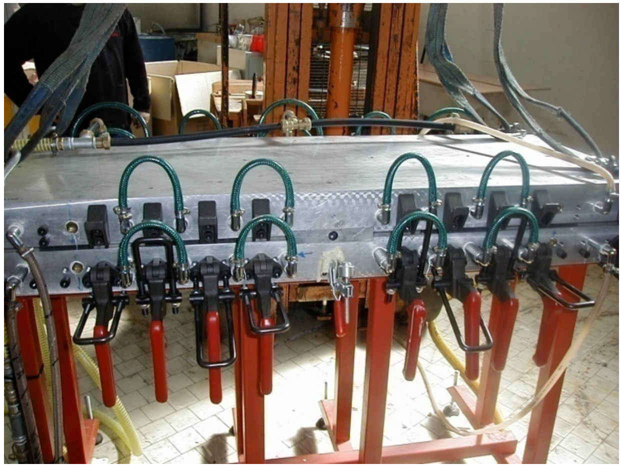
K. Mair IEEE 2005

- 4-gap MWPC
- gap size: 5 mm (wire plane centered)
- gas mixture: $Ar/CO_2/CF_4$ (40:55:5)
- wire: Gold-plated Tungsten, 30 µm Ø, 250 to 310 mm wire length
- wire spacing: 2 mm, mechanical tension: 65 gr
- HV = 2.650 kV
- field on wires: 262 kV/cm
- field on cathodes 6.2 kV/cm
- gas gain: G ≈ 50 000
- gain uniformity: ≤ 30%



- panel production:
  - PCB coated by 35 µm copper, 5 µm nickel, 0.2 µm gold
  - foam injected between 2 PCBs in mould





Détecteurs Silicium

- Micro Strips
  LEP➔ détecteurs de vertex
  LHC détecteurs de traces Atlas, CMS

- Pixels
  - Débuts à LEP (P. Delpierre et al. Delphi)
  - LHC Alice, Atlas, CMS

SI Micro-strips CMS

3.1. Substrate

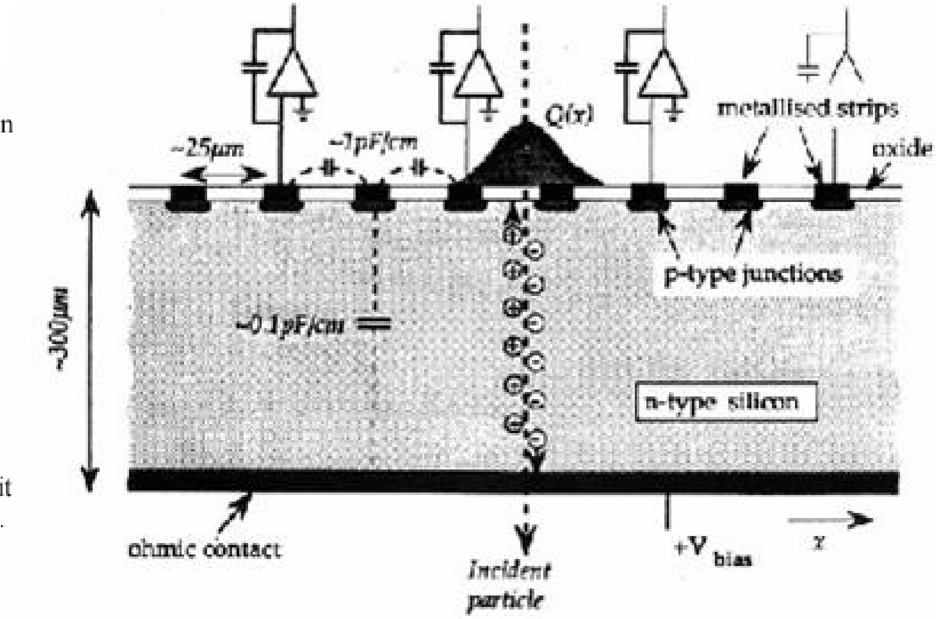
The supplier shall provide the silicon substrates. They have 6” diameter for thick sen
and thin wedge sensors, and either 6” or 4” for the thin inner barrel sensors. They are:

n-type, phosphorus doped, float-zone, <100> crystal orientation
resistivity in the range of = 1.5 – 3.0 K cm (thin sensors)
resistivity in the range of = 3.5 – 7.5 K cm (thick sensors)
thickness: 320±20 μm (thin), 500±20 μm (thick)
Both sides polished.

3.2. Dicing and Flatness

The sensors shall be diced by the supplier. The dicing tolerance is ±20 μm. The qualit
the cut edges shall be such that there are no chips greater than 40 μm and no cracks.
sensors shall be clean, with no residual on the surface when delivered.

We require a sensor flatness (unstressed) <100 μm.



19100 détecteurs épais. 500 μm
512 strips pas 182 μm
~ 10 x 10 cm2

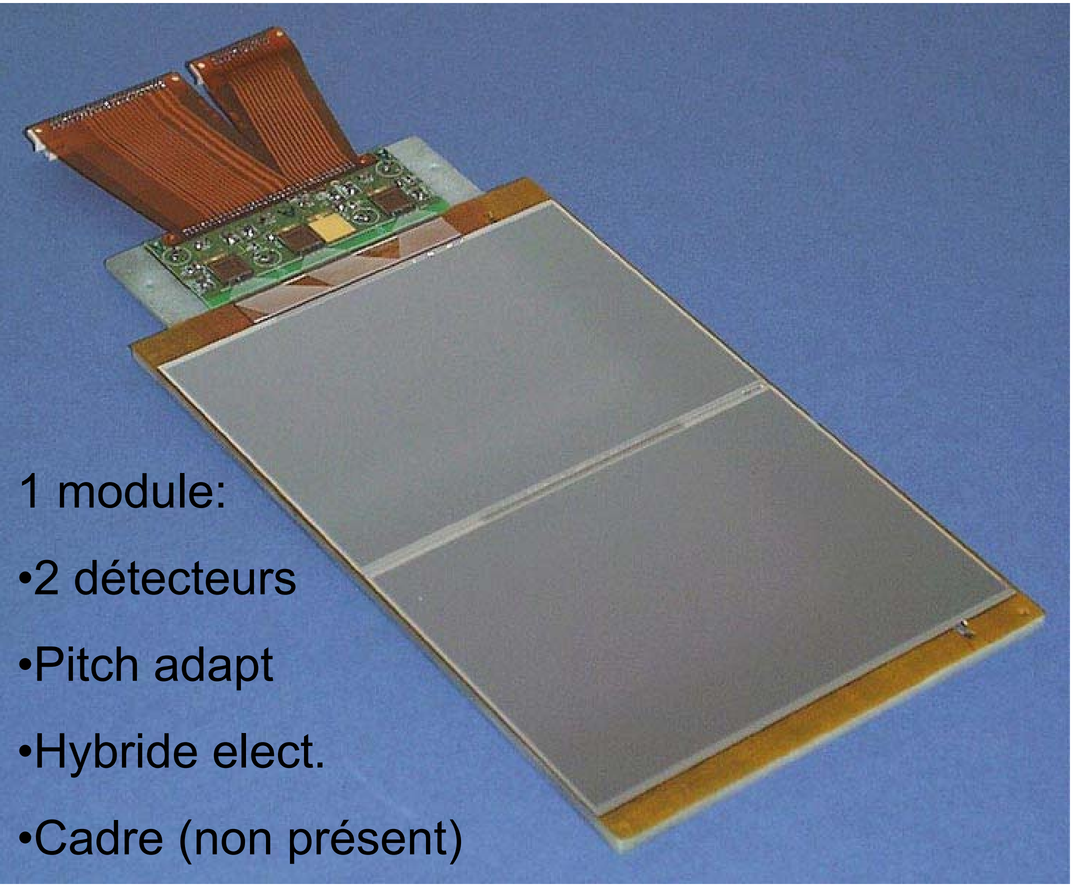
6450 détecteurs épais. 320 μm
512 strips pas 120 μm

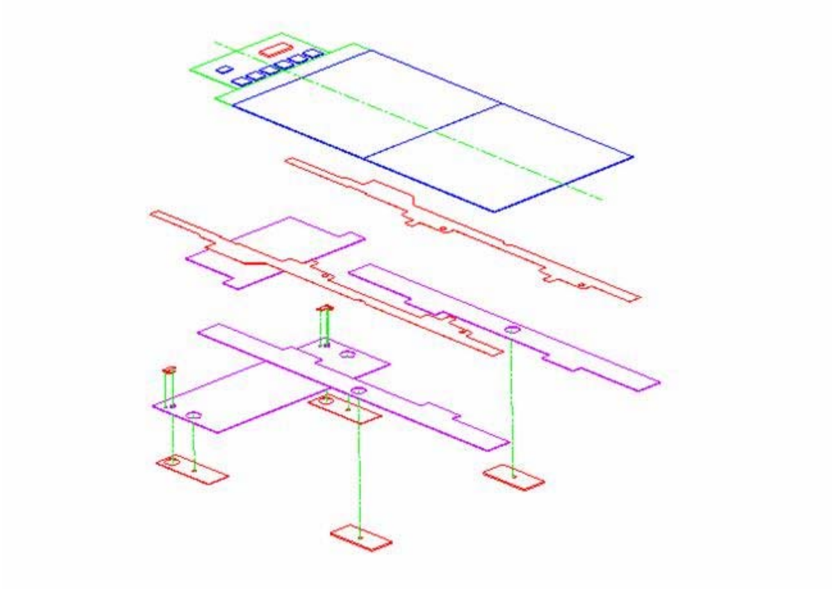
~ 6 x 6 cm2

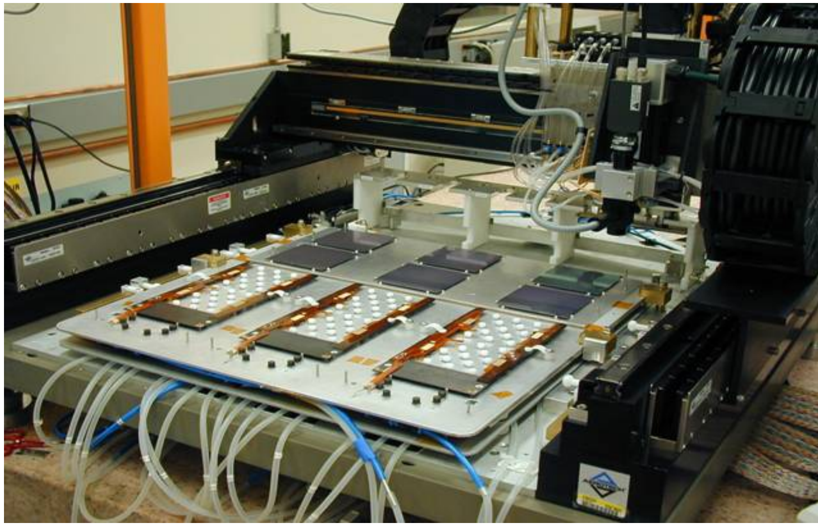
Formes ~carrés ou trapèze ➔ ~ 200 m^2 surface de détection

HV max 300 V   HV break > 500 V

Module



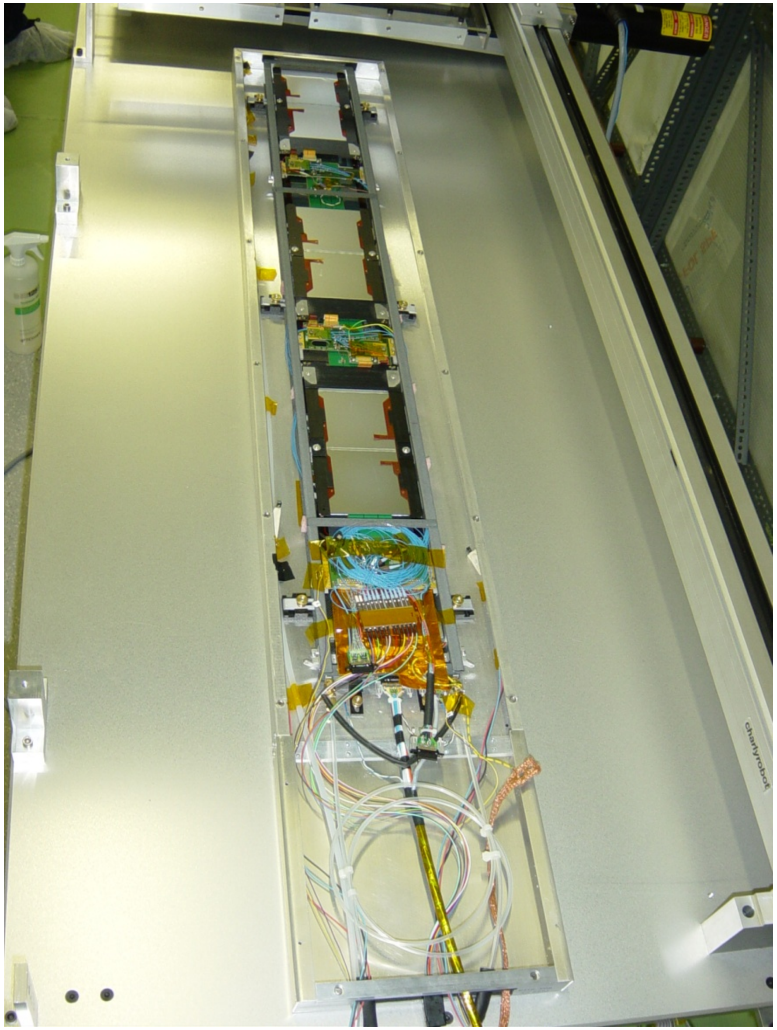




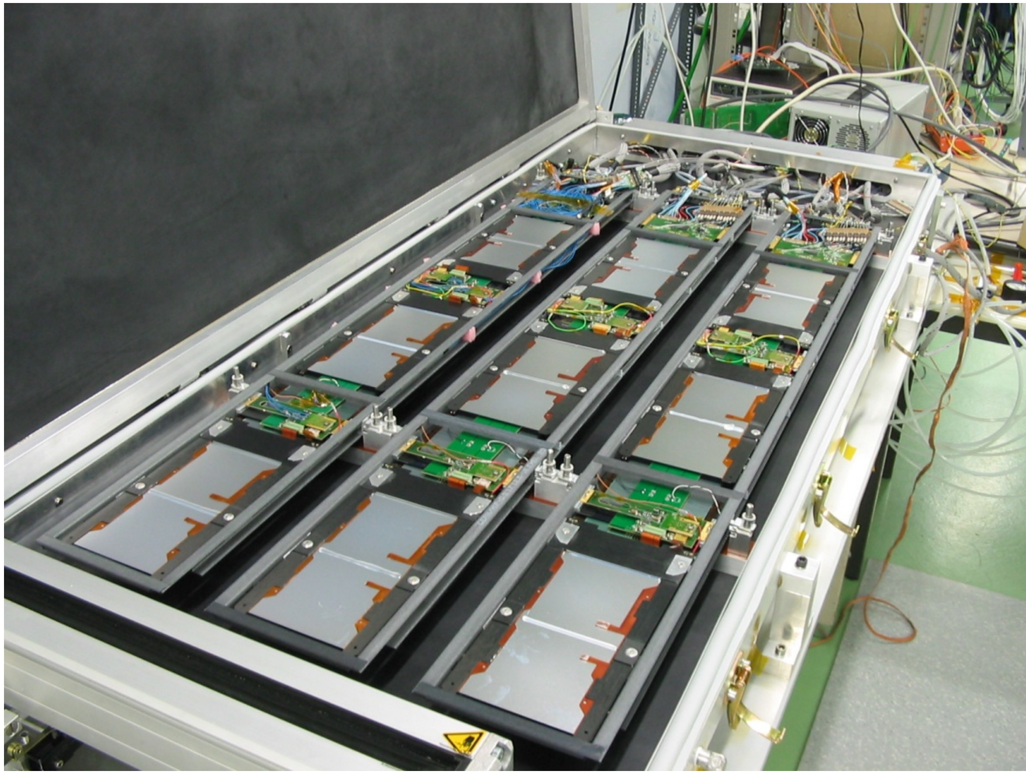
1 module:

- 2 détecteurs
- Pitch adapt
- Hybride elect.
- Cadre (non présent)

Assemblage en structures

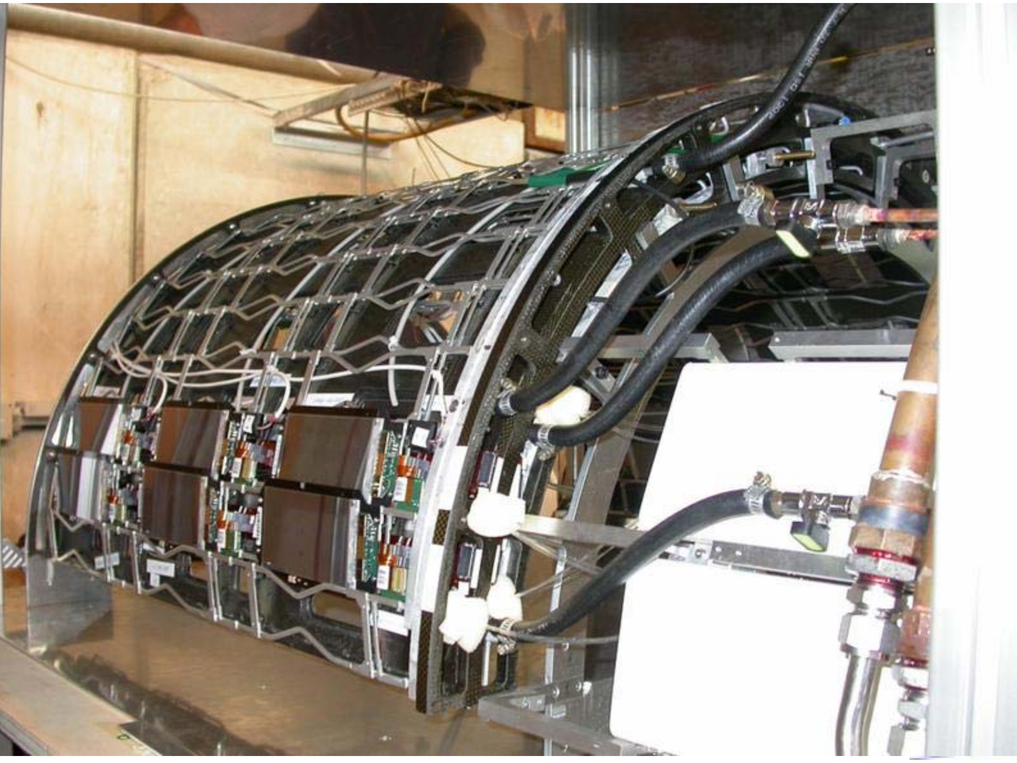


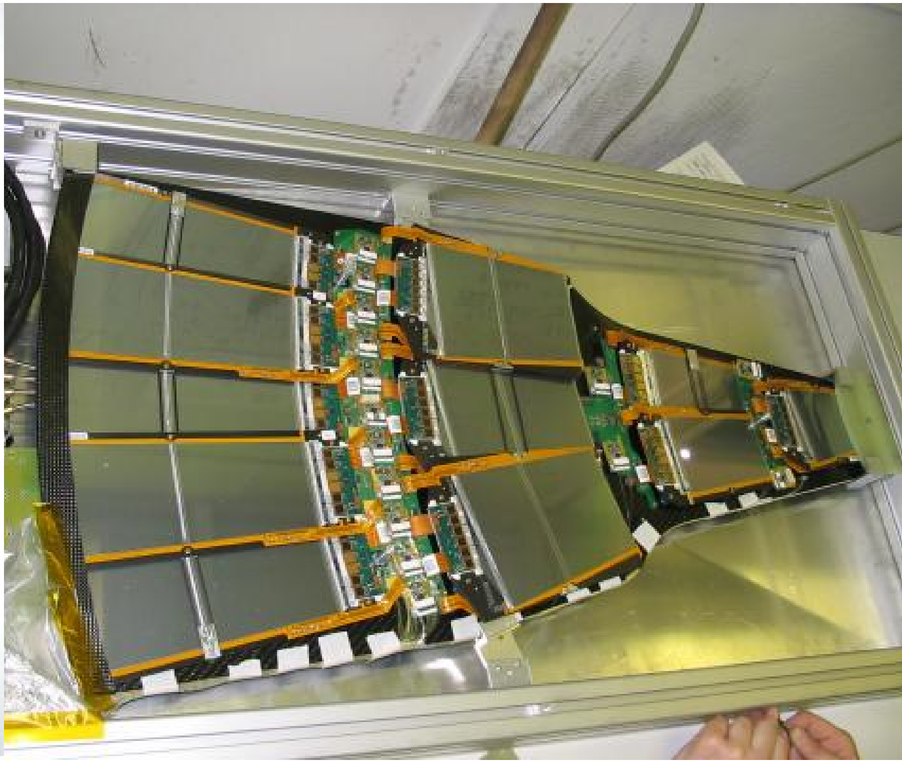
Outer Barrel



Rods ➔ 6 couches Outer Barrel

INNER BARREL FORWARD





Inner barrel 2 x 4 demi couches

Forward: Pétales
➔2 x 11 disques à 6 anneaux

Si CMS

- Pas “trop” cher
- Robuste
- Bonnes performances (S/N > 20)
- Pas de gaz!

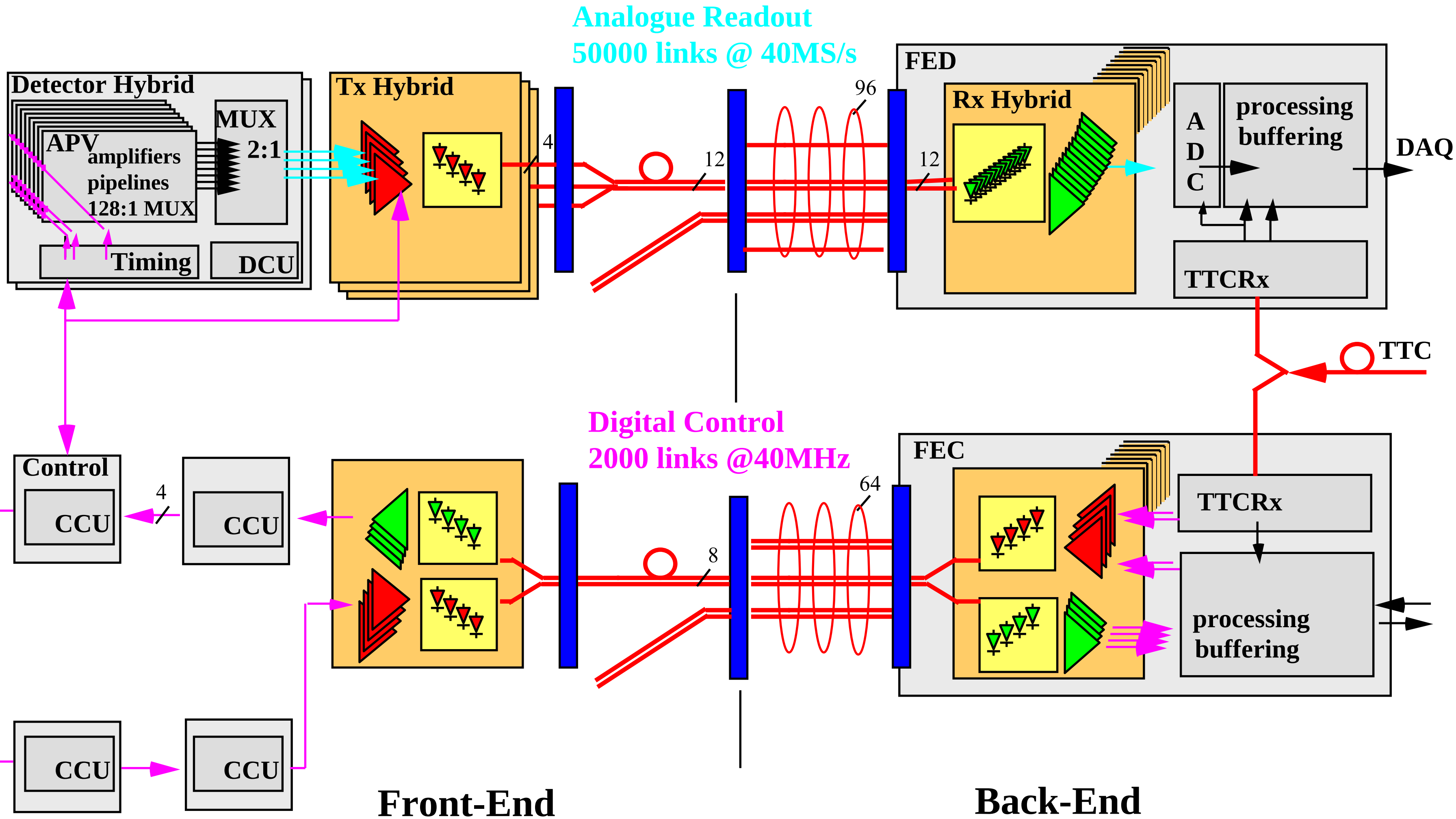
Mais

- Production “industrielle”
- Opération à -15^{o}C
- Cooling! (C_6F_{14})
- Aspect “système” reste lourd…

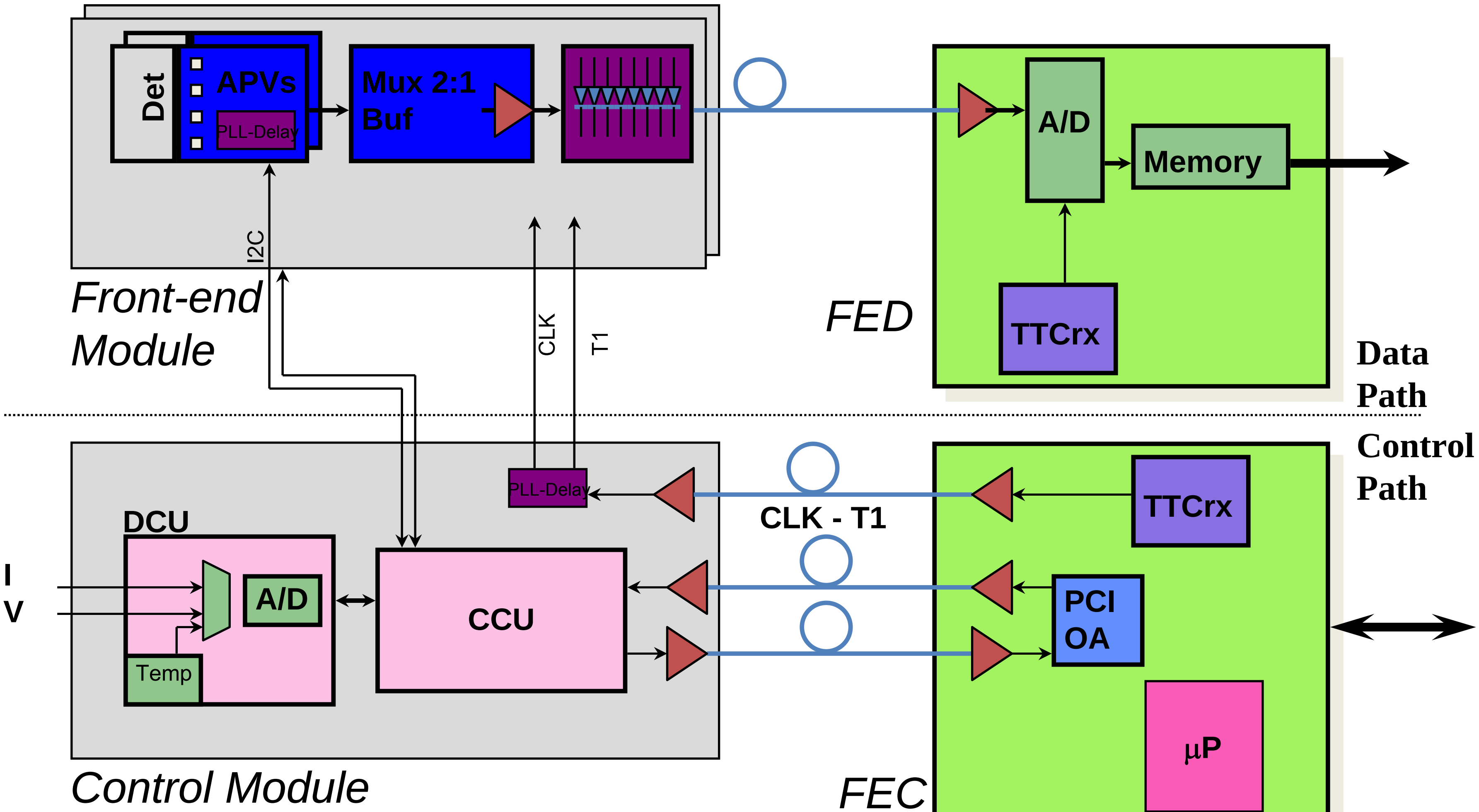
(Alim LV et HV, plomberie, masses…)

- Lecture et Contrôle

CMS Tracker readout and control architecture



Read-out and control architecture



Signals

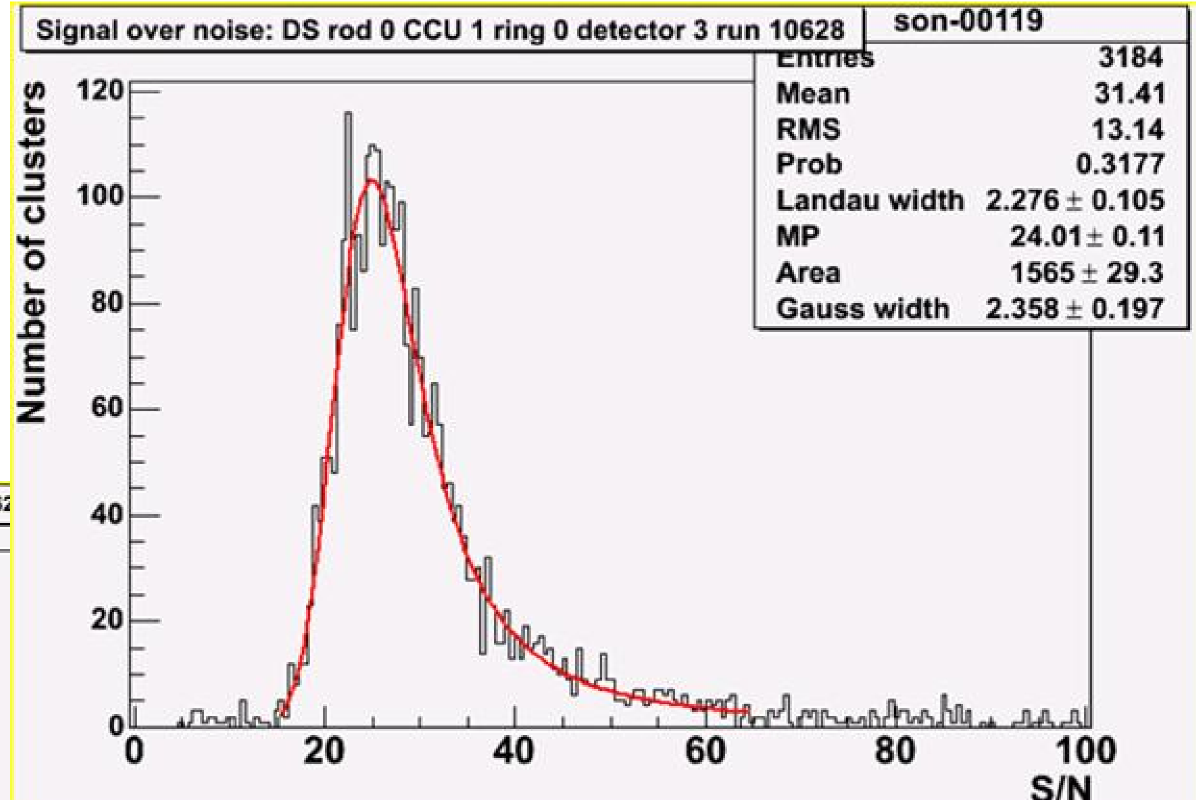
A.Dierlamm

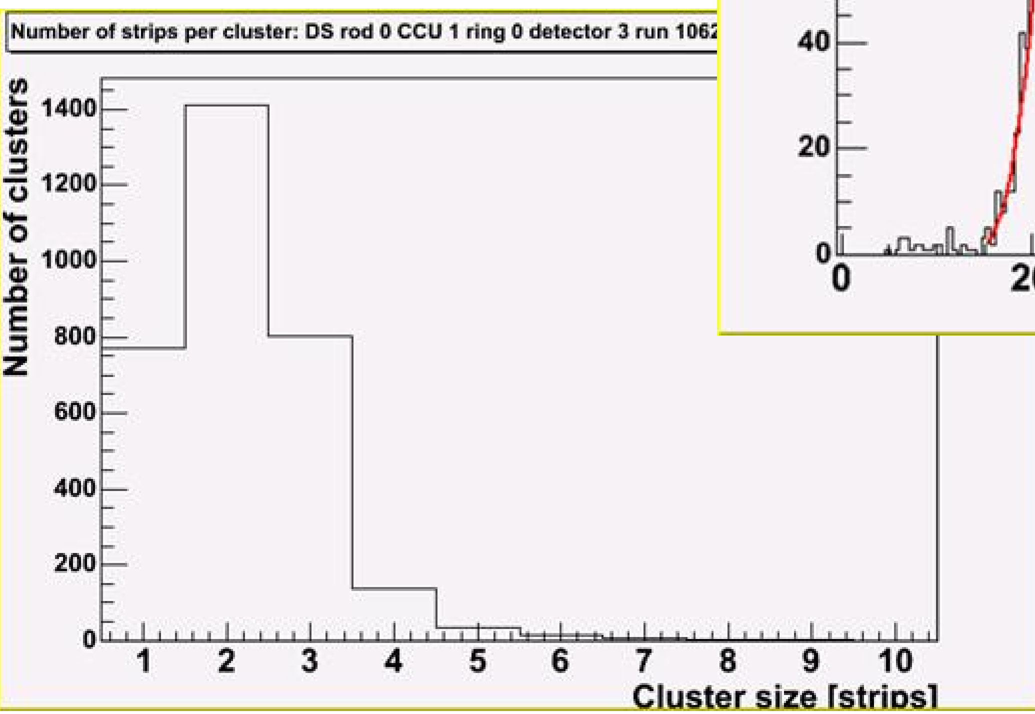
Sepembre 2004

Deconv. mode

HV = 300V

T = -20°C





S/N ~ 24

Inclination of 6° !

A.Dierlamm

Sepembre 2004

Resolution

• Analysis of the data done with AC1Analysis (written by R. Brauer). Output of cluster positions and heights further processed.

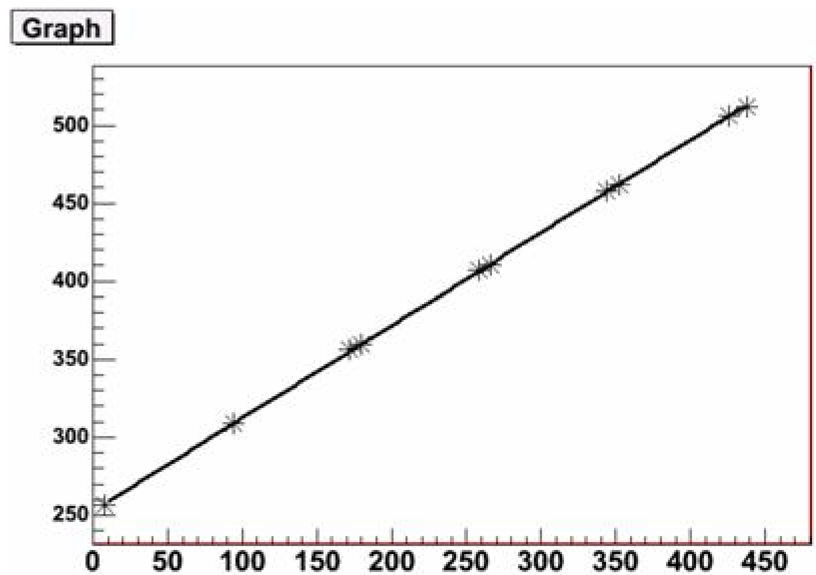
• Simple line fit to cluster positions

• Subtracting residuals gives first approximation of resolution

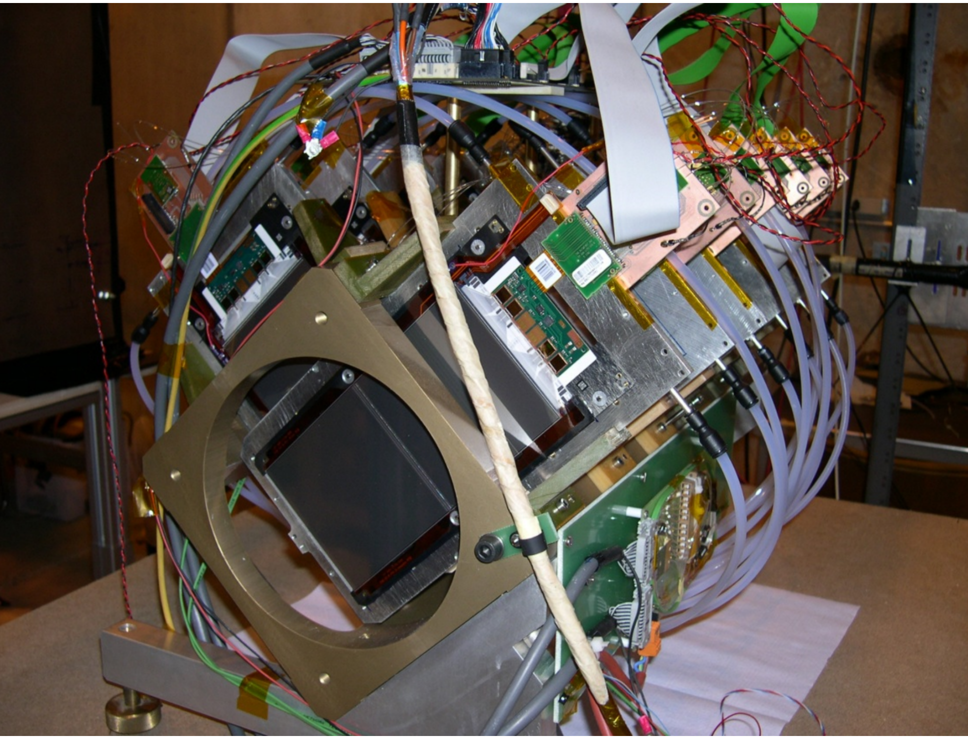
• We had straight tracks in May and inclined tracks (6°) this time => resolution improved for inclined tracks since in average 2 strips are in a cluster

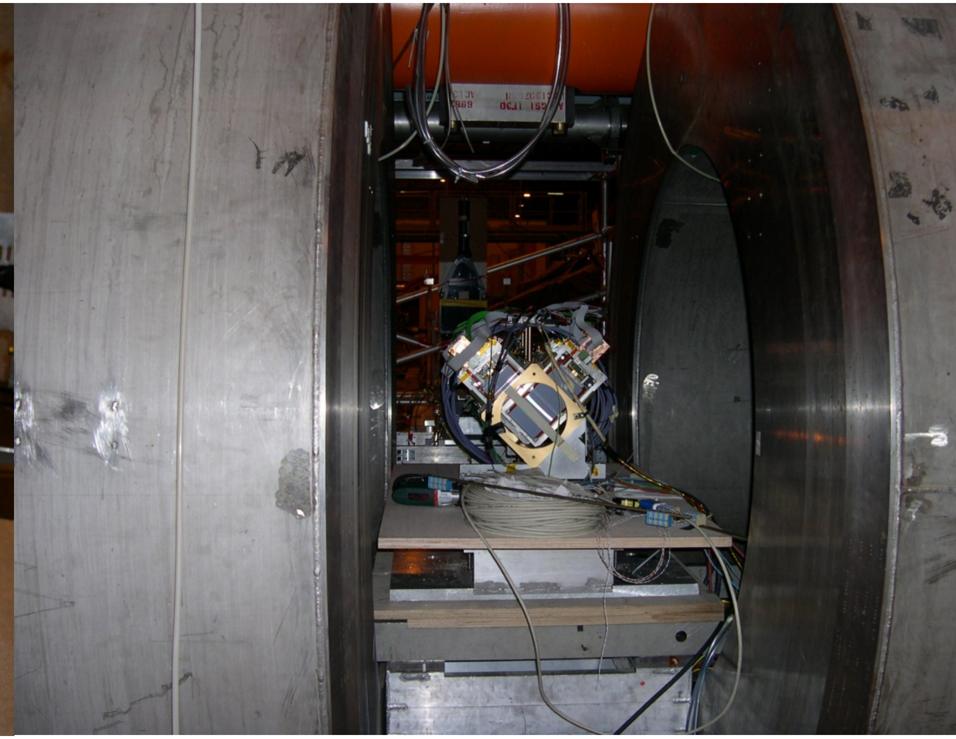
Rod ID	σ_may (μm)	σ_sept (μm)
	straight tracks	6° inclination
166 (DS)	45	29
154 (SS4)	45	34
112 (SS4)	42	38
124 (SS6)	35	28
13 (SS4)	54	33
153 (DS)	50	30

(σ_{max} = pitch(183μm) / √12 = 53 μm)



Télescope de faisceau

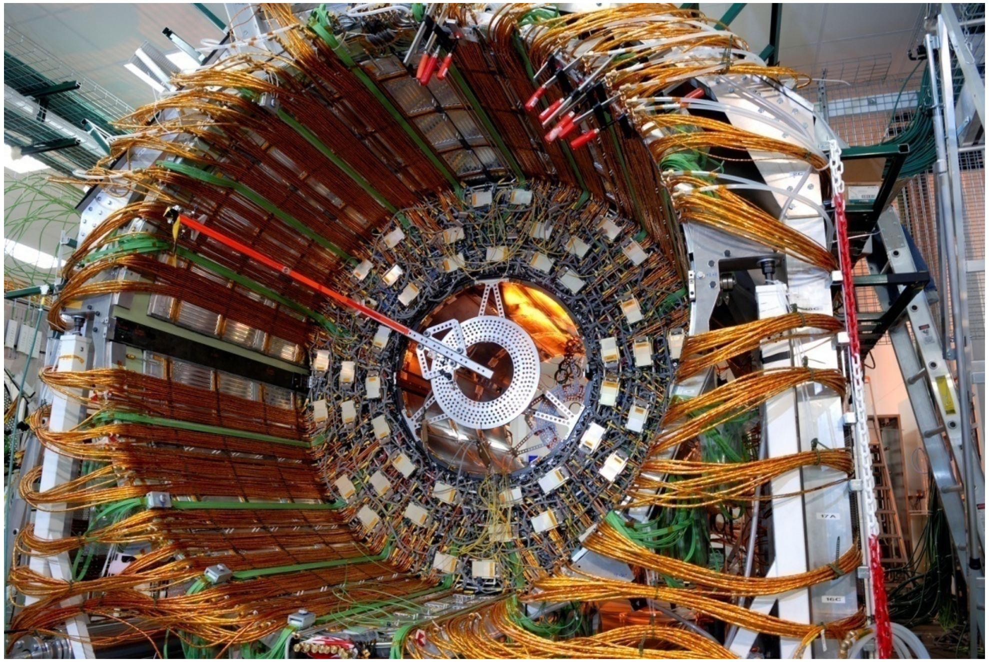




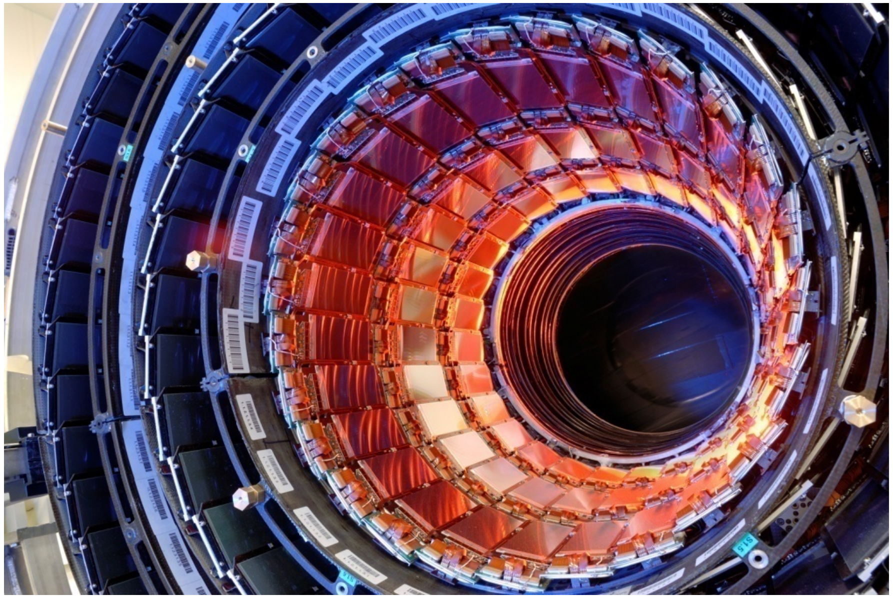
12 Modules TOB

Test en Champ Magnétique Novembre 2004

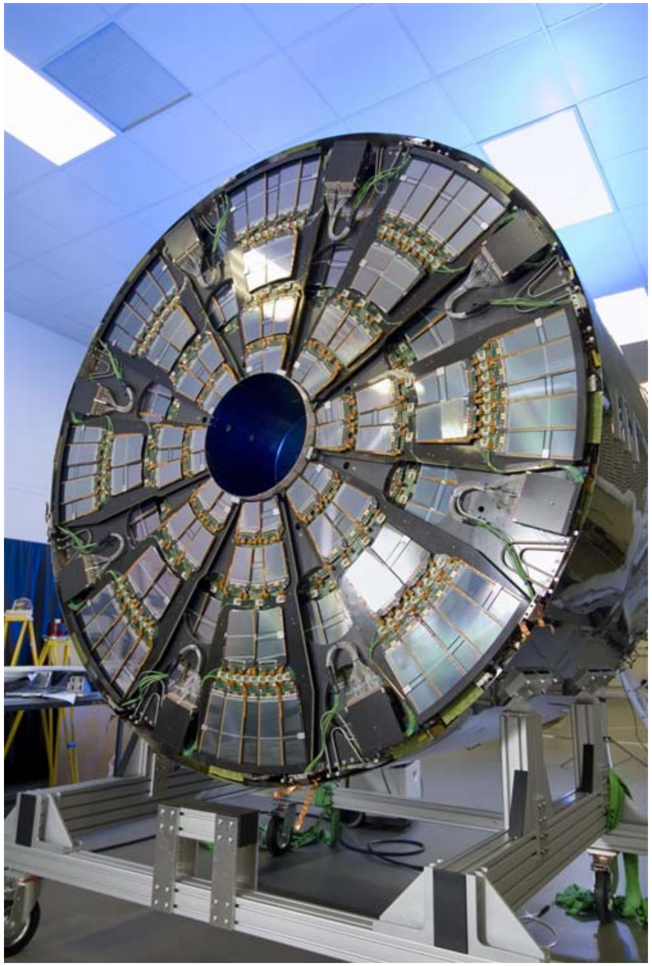
Fin 2006



T
O
B



T
I
B



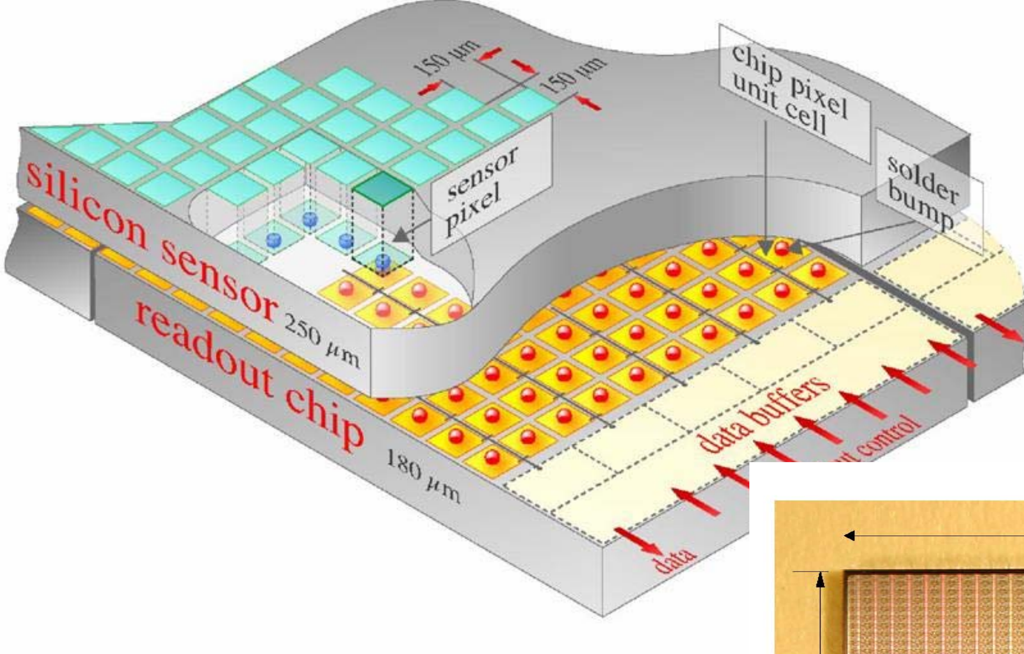
T
E
C

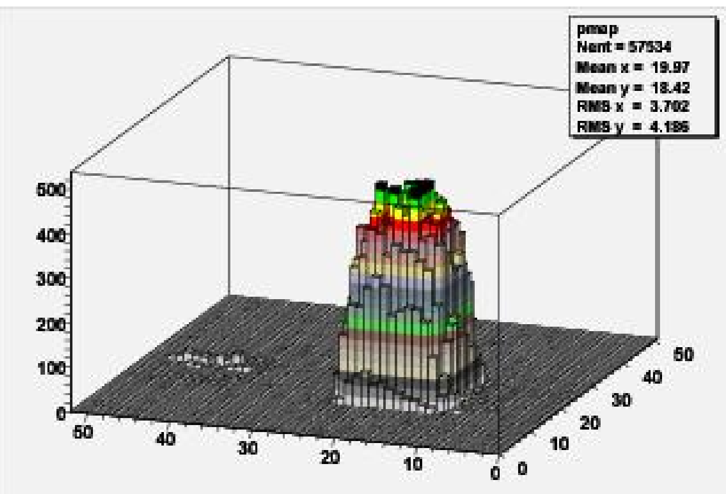
Pixels

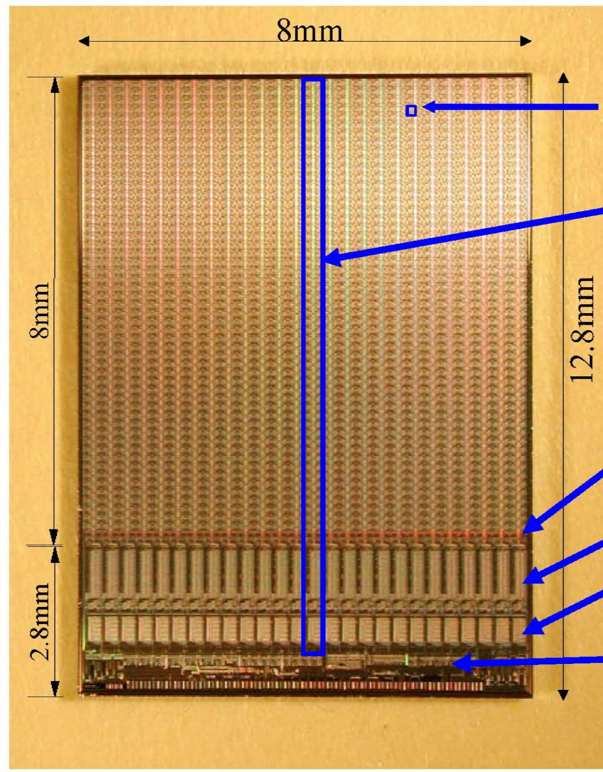
- Pixels LHC
  - Alice
  - Atlas
  - CMS
- Développements « futurs »
  - CMOS
  - Si Amorphe

Pixels CMS

R. Horisberger et al.







PSI43

- 150 µm x 150 µm pixel
- 52x53 pixels in 26 double columns
  345 k transistors

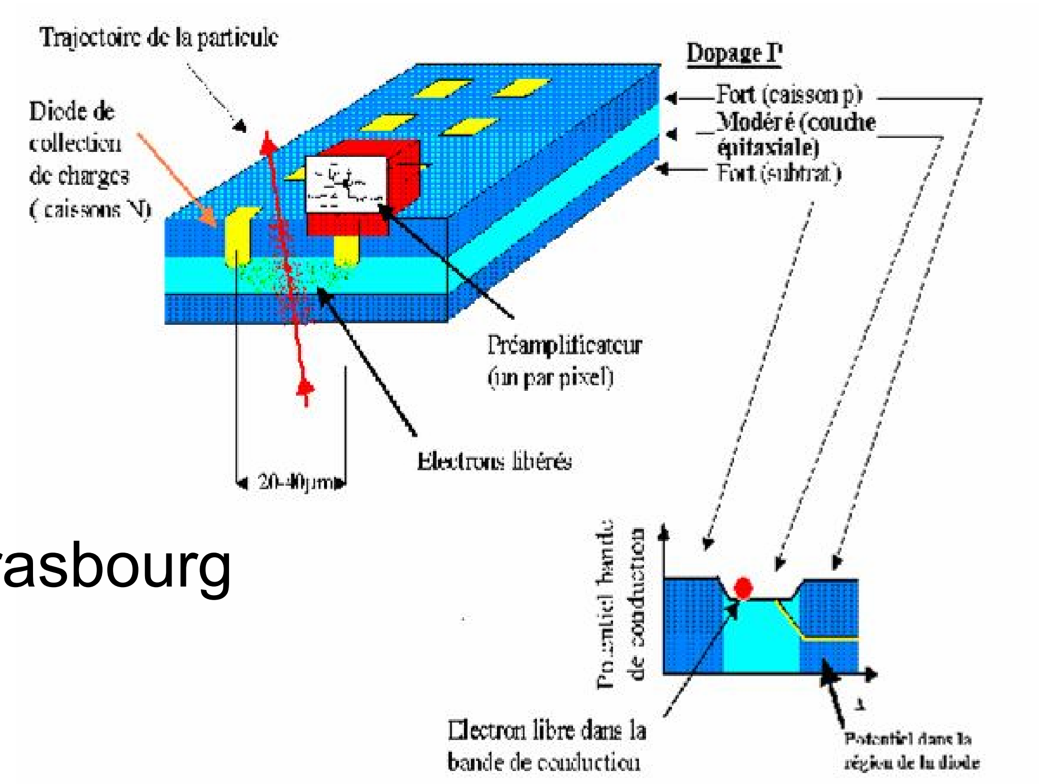
- Periphery:
  78 k transistors
- Pixel−column interface
- Data buffers (4x24 capacitors)
- Timestamp buffers (8x8 bits)
- I2C, DACs, regulators, counters, readout, wirebonds
  6 k transistors

Détecteurs CMOS

Det Vertex:Linear Colliders-ILC

STAR, CBM

Appl médicales - Imageurs



MimosaS IReS Strasbourg

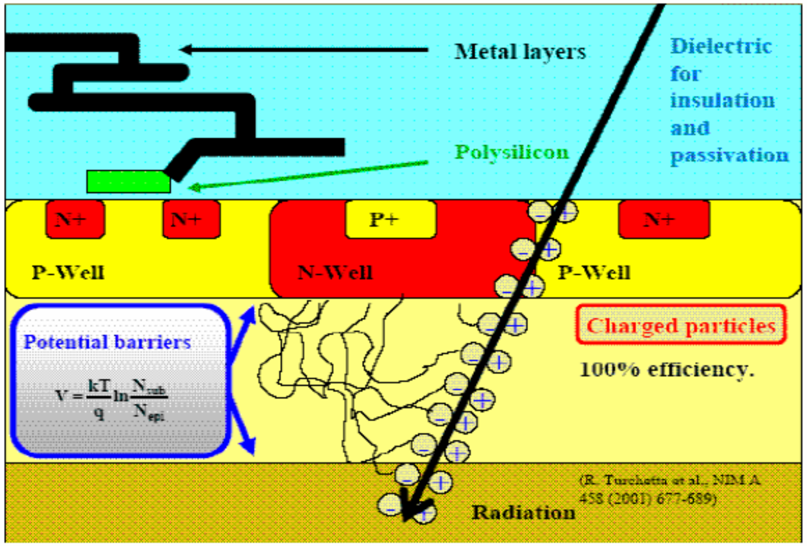
(These Arnaud Gay 2004)

Détecteurs CMOS

Avantages sécifiques des capteurs CMOS:

M. Winter et al.
MimosaS IReS Strasbourg

> 15 prototypes fabriques



- ◇ μcircuits de conditionnement du signal intégrables sur capteur (système-sur-puce) $\mapsto$ compact, souple
- ◇ Volume sensible ($\sim$ couche épitaxiale) $\sim$ 10 μm d'épaisseur $\longrightarrow$ amincissement à $<$ 20 μm permis
- ◇ Production industrielle standard de masse $\longrightarrow$ coûts modestes, fabrications fréquentes
- ◇ Aussi granulaires et minces que les CCD, MAIS sensiblement plus rapides et radio-tolérants

un détecteur de vertex ultra-léger, très ganulaire, multi-couches installé au plus près du point d'interaction

Détecteur doit être Rapide & Tolérant aux Rayonnements

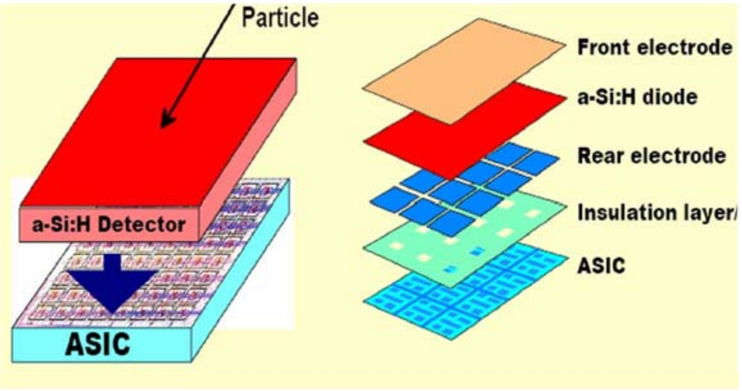
Les Capteurs CMOS sont à même d'offrir un compromis plus attrayant entre granularité, minceur, radio-tolérance et rapidité

Thin Film on ASIC (TFA) technology

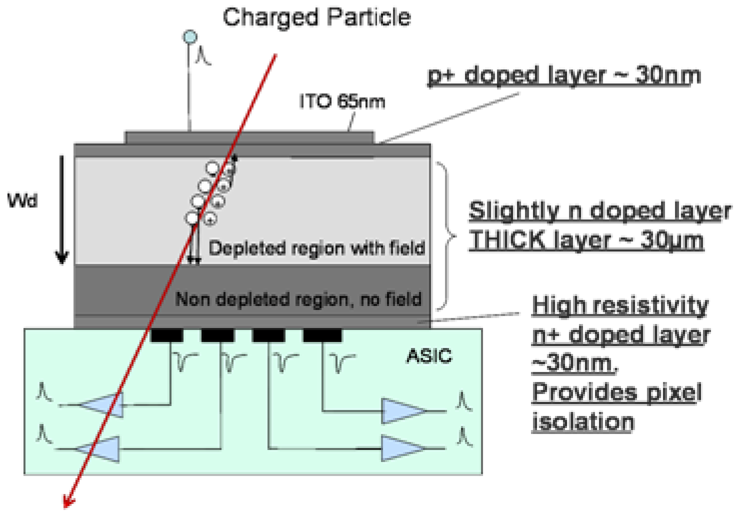
P. Jarron, M. Depeisse et al. CERN

Novel solid state detector technology :

- Deposition of n-i-p a-Si:H films on top of the integrated circuit

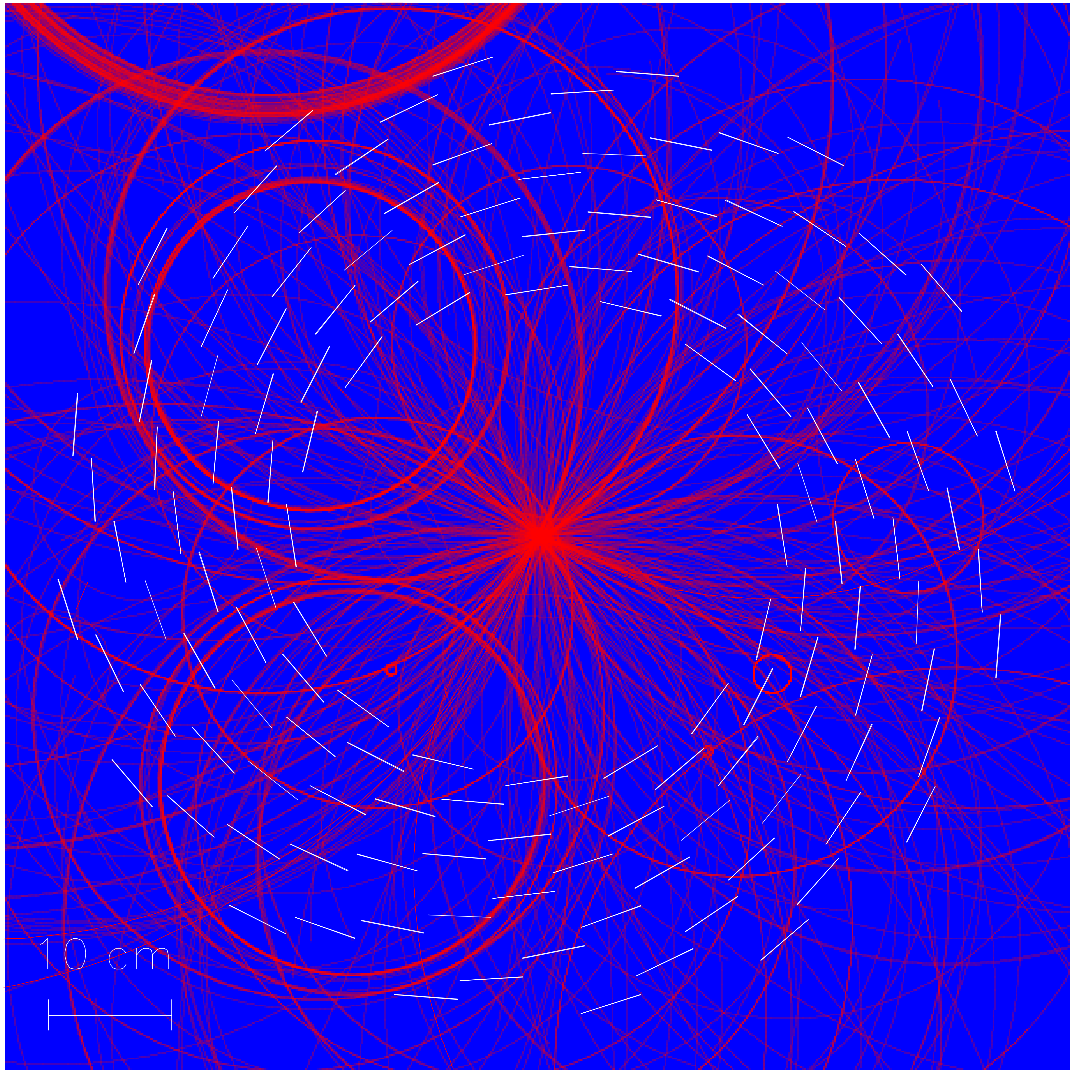


TFA Concept



“Thick” TFA sensor cross section

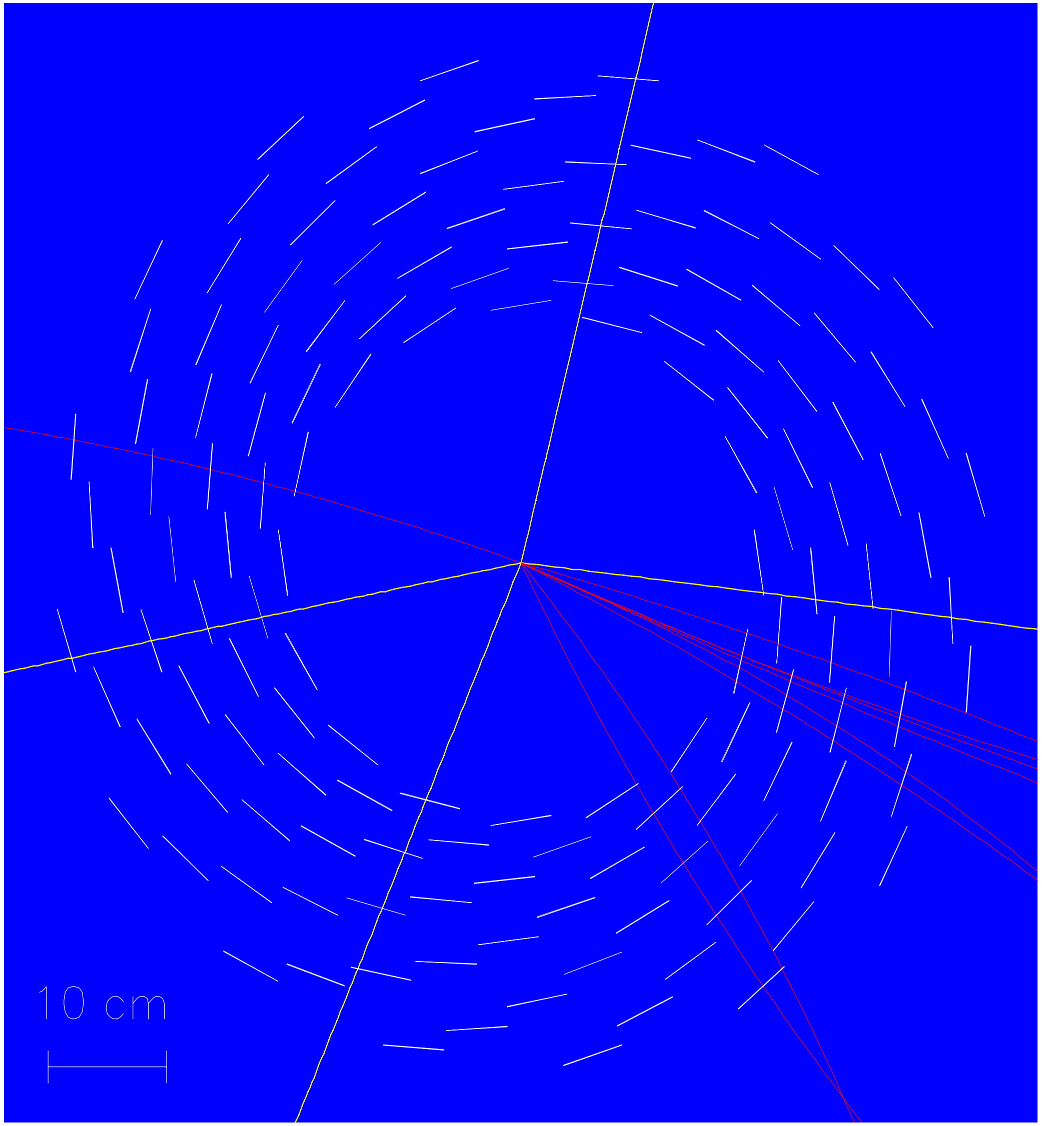
Puzzle



D. Barney

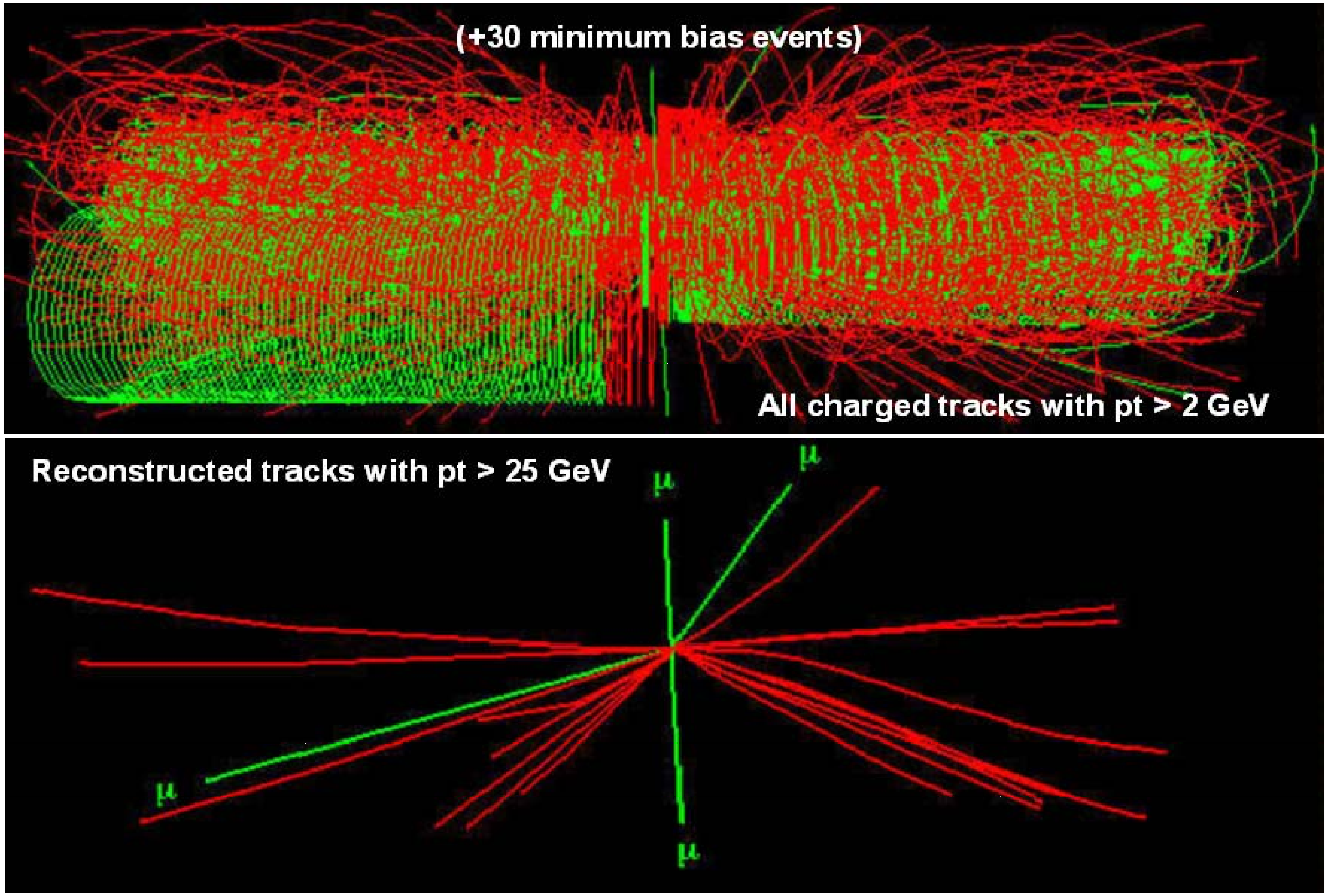
Find 4 straight tracks.

Answer



Make a "cut" on the Transverse momentum Of the tracks: $p_T>2$ GeV

S. Cittolin


(+30 minimum bias events)
All charged tracks with pt > 2 GeV
Reconstructed tracks with pt > 25 GeV
μ
μ
μ
μ

Conclusion

- Les Détecteurs de trace ont considérablement évolué en performances et en… complexité!
- A l'avenir vu le type de machines à démarrer ou annoncées, les détecteurs de traces (et ceux qui les exploitent) n'auront pas la vie facile…