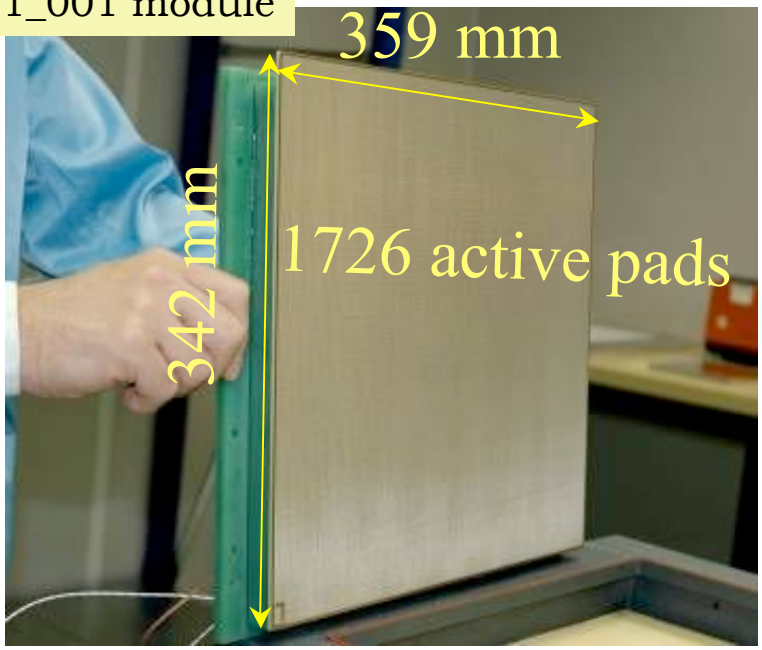
Large « bulk » Micromegas detectors

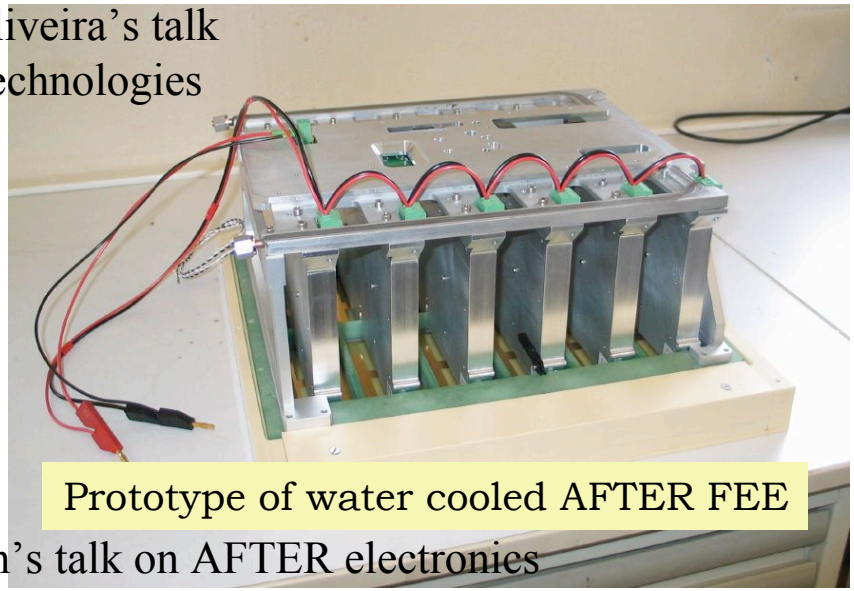
A. Delbart

DAPNIA, CE-Saclay, 91191 Gif-Yvette, France
On behalf of T2K/TPC Work Package 4
« bulk micromegas »

MM1_001 module



See R. de Oliveira's talk on MPGD technologies



Prototype of water cooled AFTER FEE

See P. Baron's talk on AFTER electronics

Within the T2K/TPC collaboration :

DAPNIA, CE-Saclay, 91191 Gif-Yvette, France

CERN/TS-DEM-PMT, CH 1211 Geneva, Switzerland

UAB, IFAE, Barcelona, Spain

LPNHE, Université Paris-VI-VII, Paris, France

TRIUMF, Canada

DPNC, Section de Physique, University of Geneva, Geneva, Switzerland

Univeristy of Valencia, Spain

University of Victoria, Canada.

Outline

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- The TPC of the T2K Near detector (ND280)
- The Micromegas module for the T2K/TPC
- The large 34x36 cm^2 « bulk » Micromegas
  - Road map of developments
  - Uniformity measurements of gain and 5,9 keV energy resolution
- Towards the production of 80 modules
  - Production steps, Q/C tests
- Conclusion

The T2K Near detector (ND280)

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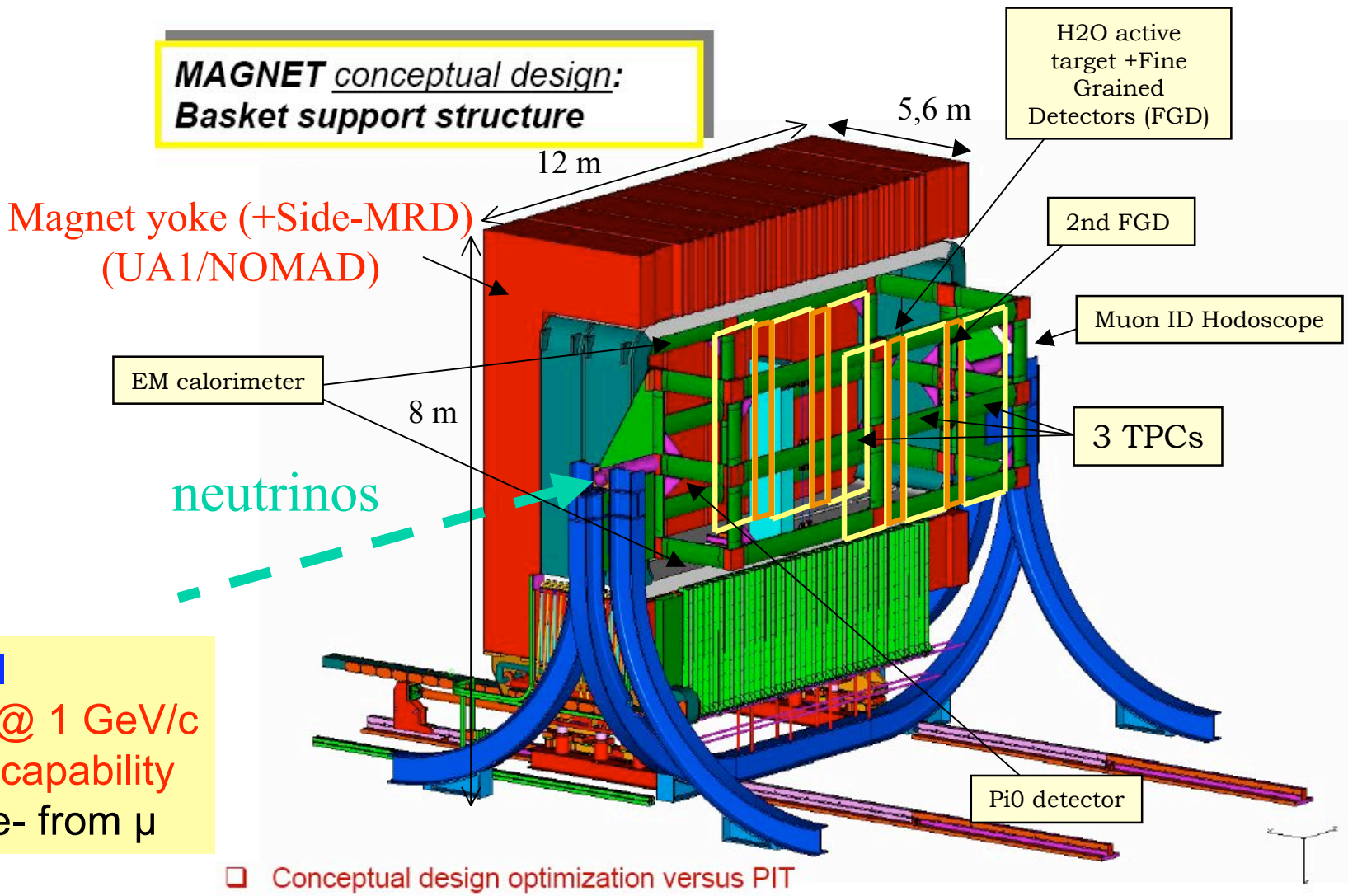


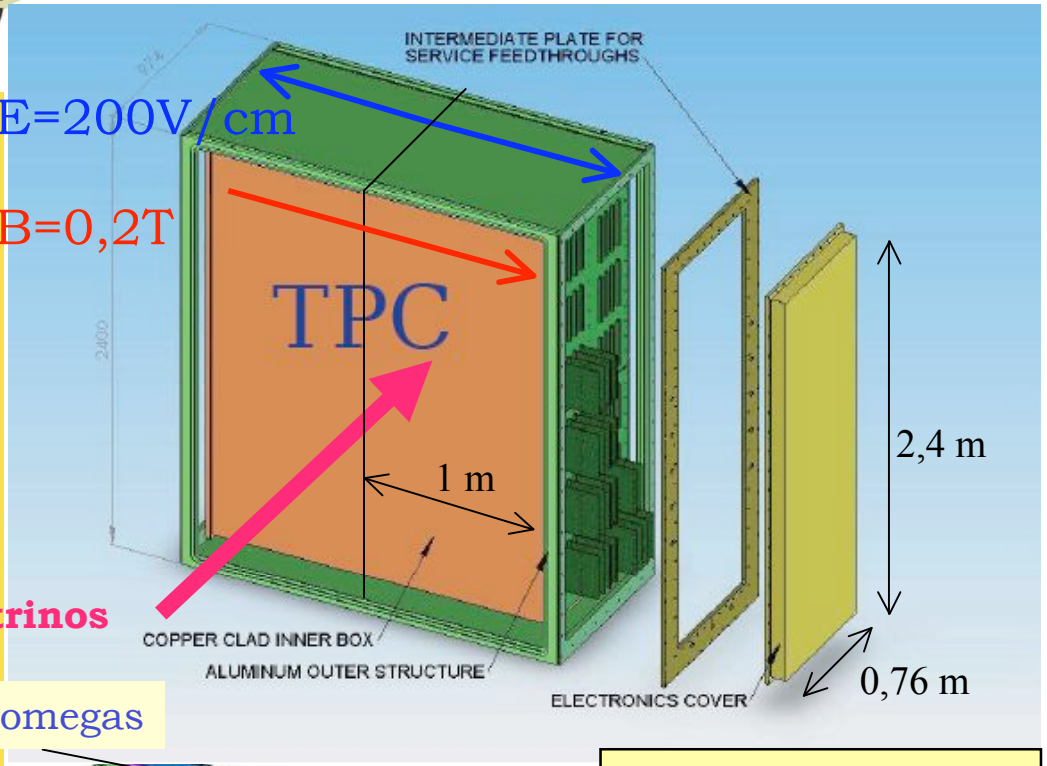
Goal

σ(p)/p < 10 % @ 1 GeV/c

dE/dx < 10% capability

to separate e- from μ

The T2K/ND280 TPC



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- Pave a surface of arbitrary size
- Minimize the dead space / maximize Tracking length
- Easy replacement of a detector unit

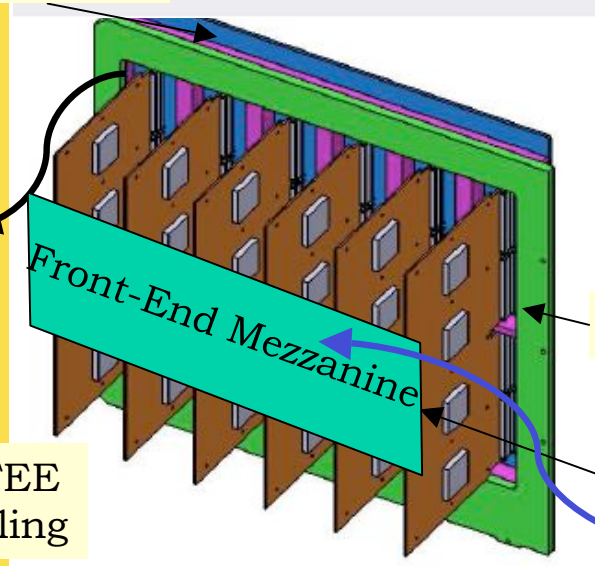
- 34x36 cm² detector unit
- bulk Micromegas for :

⇨ robust, simple, no delicate assembly of the Micromesh

⇨ good gain & energy resolution uniformity over active area

- Mounting from outside (no connection inside)

Bulk Micromegas



72 modules (9 m²)
124416 channels

See P. Baron's talk on AFTER electronics

Mechanical Stiffener

6 AFTER based Front-End Cards

2 Opt. Fibers

The 2007 « bulk » Micromegas

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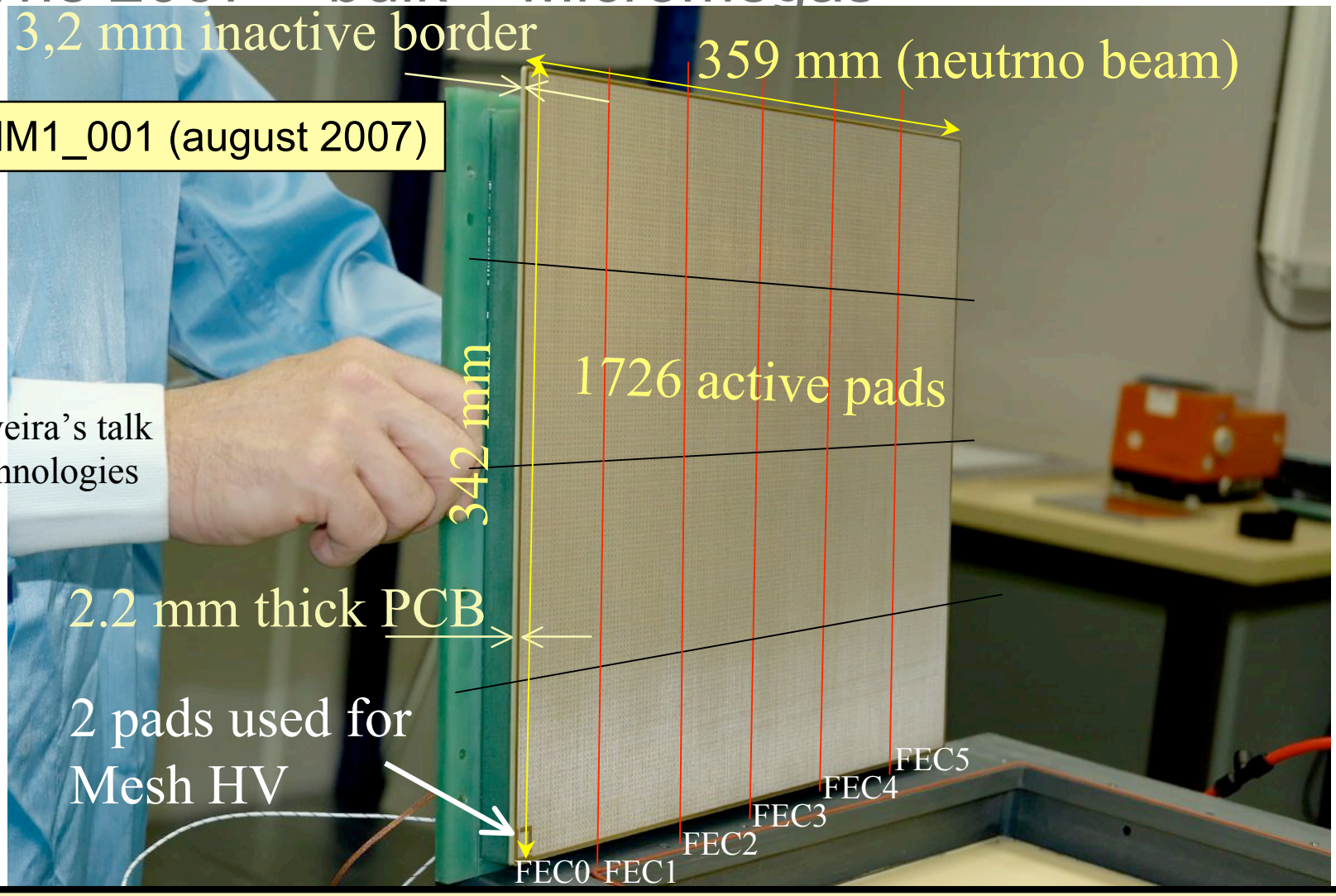
MM1_001 (august 2007)



See R. de Oliveira's talk on MPGD technologies

- a 30 μm thick 440 Lpi woven micromesh is embedded between 2 layers of pyralux
- 4 layers PCB with internal shielding layer & 6,9x9,7 mm pads with 7x9,8 mm pitch
- 128 μm amp. gap / 12 x ϕ0,5 mm pillars per pad / « stretched » mesh procedure
- 93% of PCB surface is active area / less than 2 faulty pads per module

Road map of developments

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2004

2004 « bulk » Micromegas
- 8x8 cm² / 1 central anode
- Vacrel (soldermask)

2005

T2kn# 2005 prototypes (5)
- 24x26 cm² / 1024 pads (8x8 mm²)
- 3 layers PCB with blind vias

2006

Choice of bulk micromegas
By T2K/ND280

Cosmics tests on HARP cage

2007

MM0# 2006 prototypes (7)
- 34x36 cm² / 1728 pads (6,9x9,7 mm²)

MM1# 2007 module (4)
- 4 layers PCB with internal shielding
- NEW « stretched » mesh procedure

Detector's Final design

2008

Start of detectors' production

2004

commercial Ortec 142
1 channel

2005

Start of AFTER

128 ch. ALTRO cards
+ inv./protec

2006

First AFTER ASIC

2007

AFTER validated

Saclay/AFTER FEE
On detector

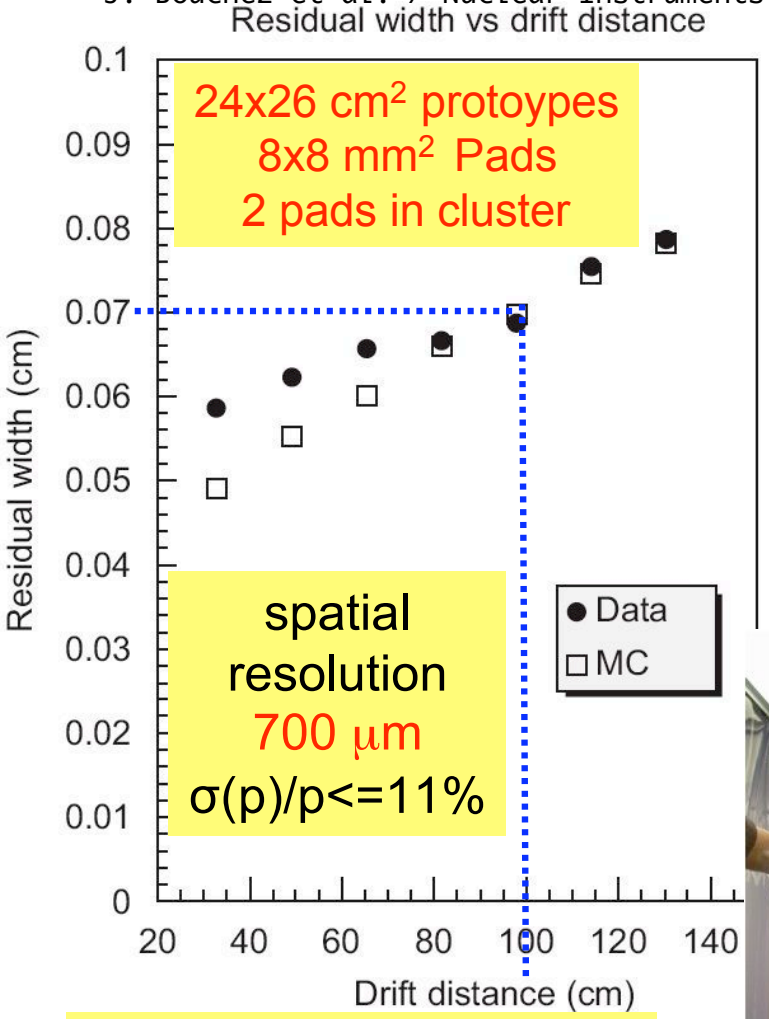
Cosmics tests on HARP cage with 1728 AFTER FEE channels

2008

Start of AFTER ASIC production

Cosmics resolution studies on HARP cage (T2kn2/2005)

J. Bouchez et al. / Nuclear Instruments and Methods in Physics Research A 574 (2007) 425-432

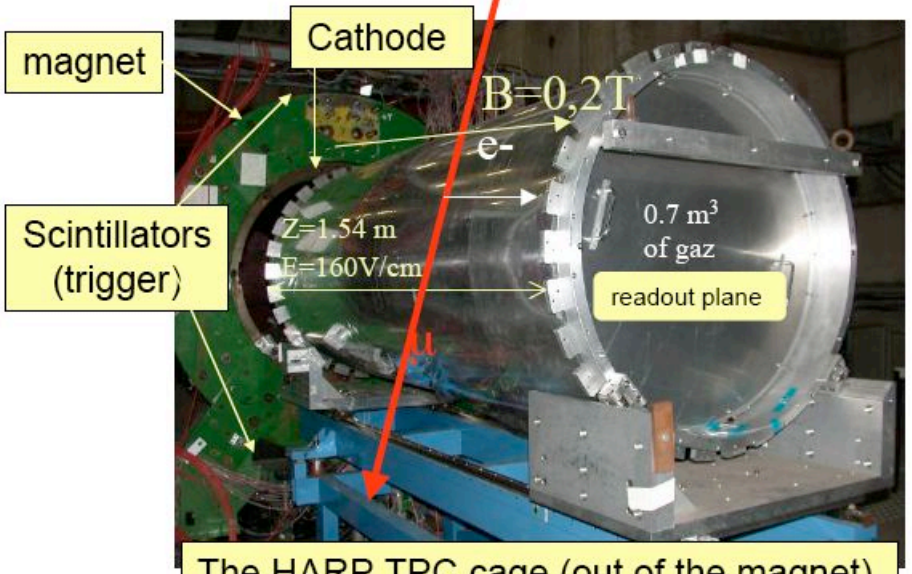


24x26 cm^2 protoypes
8x8 mm^2 Pads
2 pads in cluster

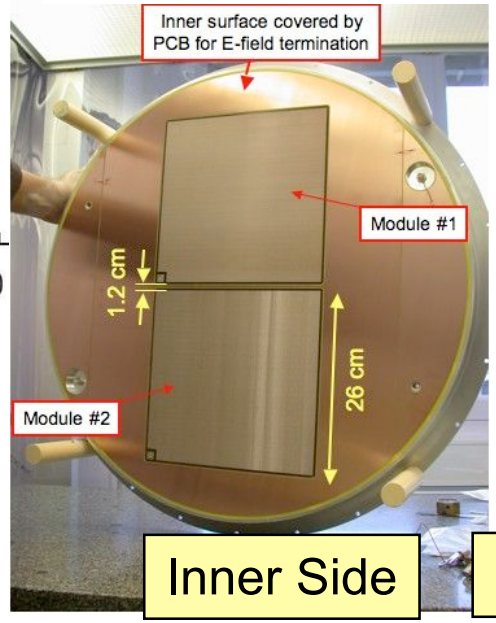
spatial resolution
700 μm
σ(p)/p<=11%

Includes track extrapolation uncertainty (200-300 μm)

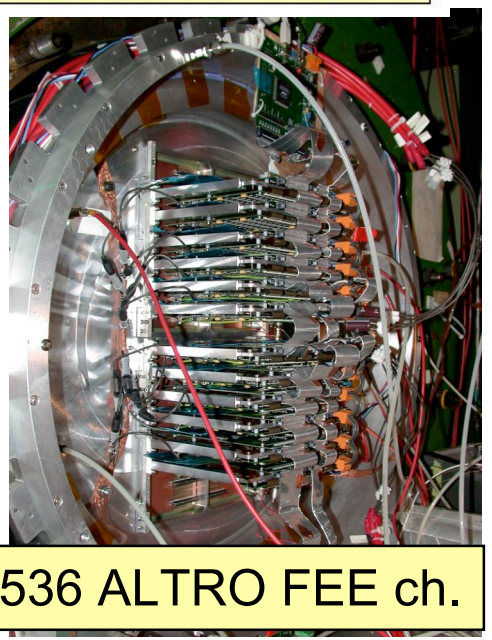
Ar+3%CF4+2%iC$_4$H$_{10}$



The HARP TPC cage (out of the magnet)



Inner Side



1536 ALTRO FEE ch.

Gain and Sparking rate studies

- Main constraints for the T2K/TPC: non-flammable, low transverse diffusion for small B, operation close to the maximum drift velocity and minimization of the effect of impurities
- baseline T2K/TPC gas : Ar+2%C_4H_{10}+3%CF_4
- Transv. Diff. 240 μm/cm$^{1/2}$, drift velocity 6,5 cm/μs @ 200V/cm (Magboltz & measured on harp cage)

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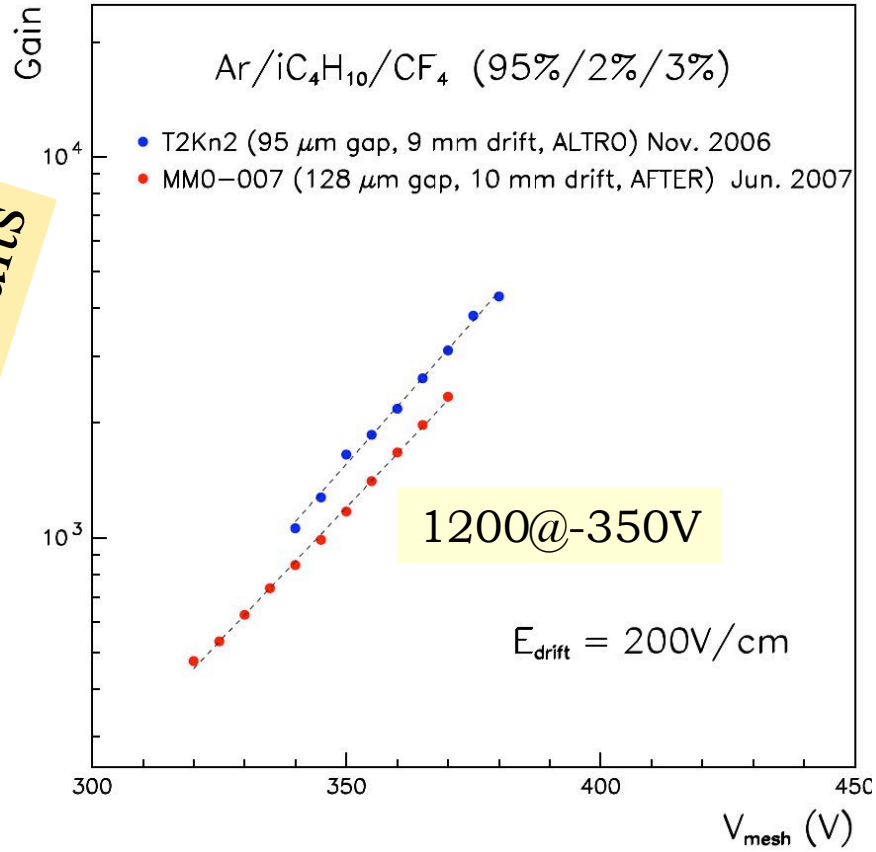
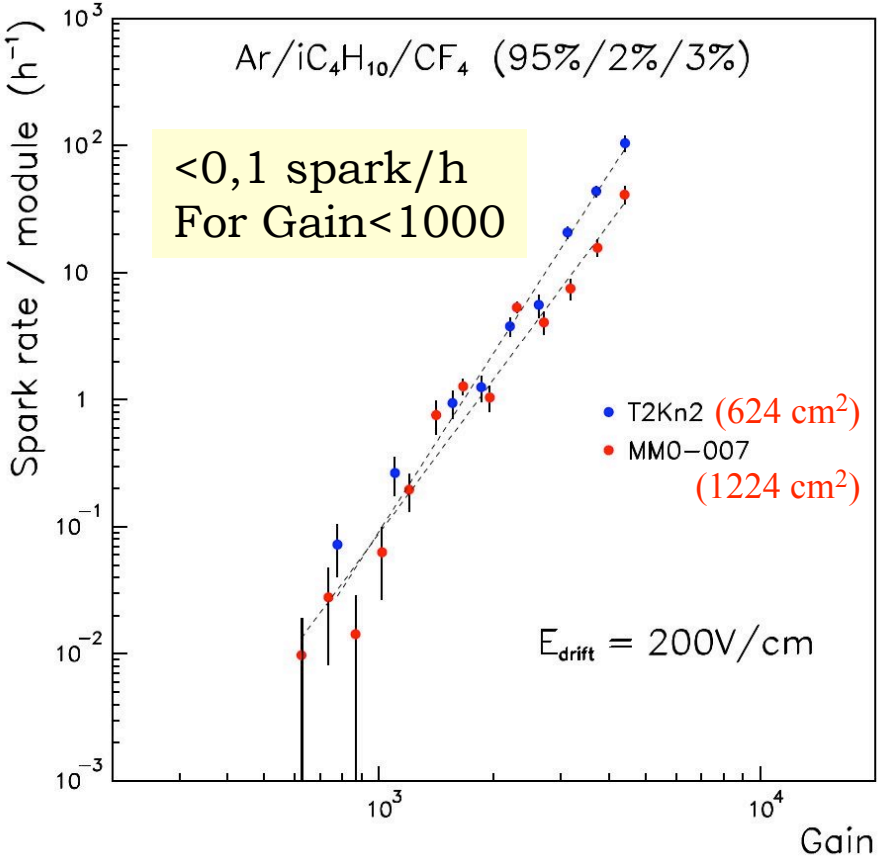
Preliminary results

Gain Vs V_{mesh}

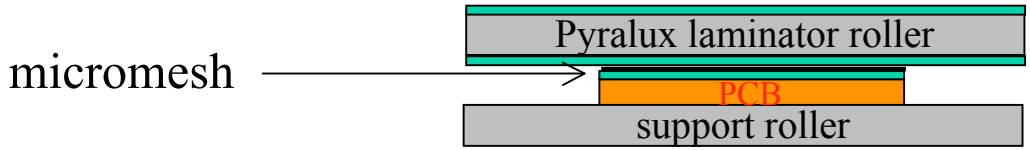


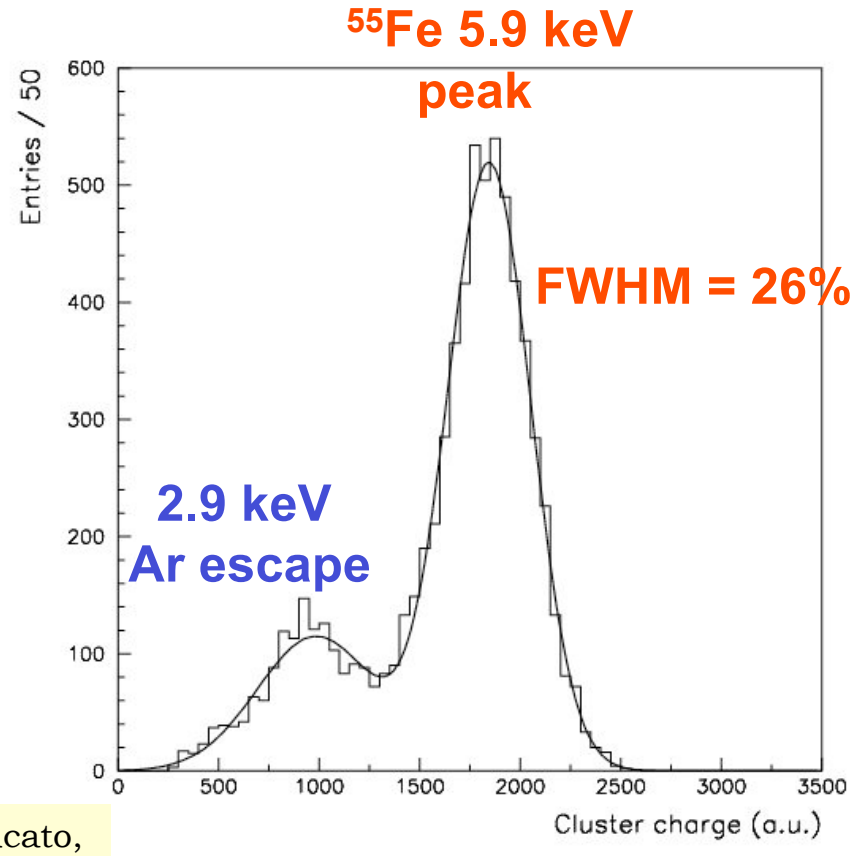
Sparking rate Vs Gain
(Cosmics in 7 mm drift)



55Fe 5,9 keV resolution of a detector made with « unstreched mesh » procedure

1/ the micromesh is laid on the PCB+first layer of pyralux (amplification gap)
2/ it is then "naturally" stretched by rollers during the lamination process





T2kn2 (2005)
"unstreched mesh" procedure

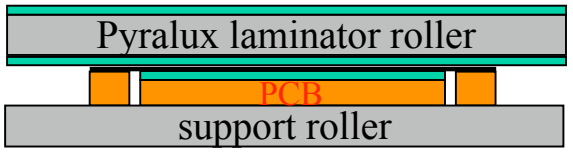
- 95 µm measured gap
- gain~5300
- 95% Ar + 5% iC_4H_{10}
- E_{drift} = 200V / 9mm
- FEE: 128 ch ALTRO card

Ref: E. Mazzucato, F. Pierre (Saclay)

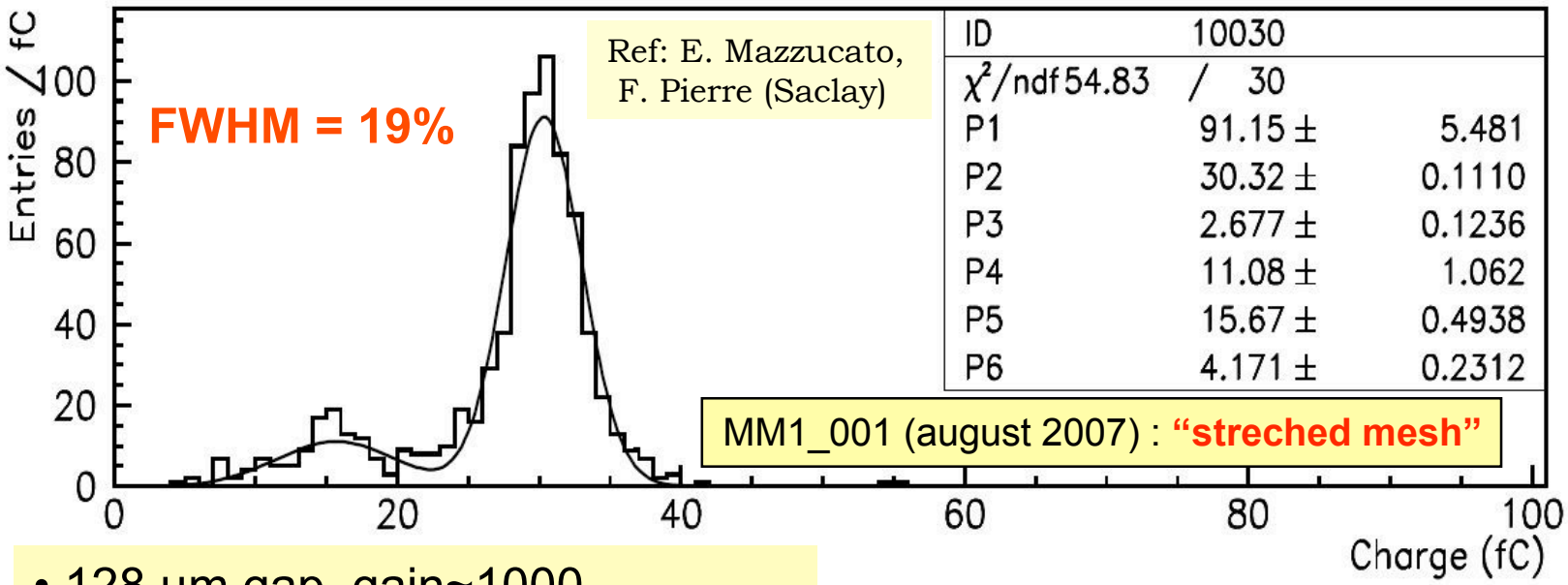
55Fe 5,9 keV resolution with the NEW 2007 « streched mesh » procedure

1/ Mesh is streched on an external frame

15N tension



2/ the frame+mesh is laminated together with the PCB



- 128 µm gap, gain~1000
- 95% Ar + 2% iC_4H_{10} + 3% CF_4
- E_{drift} = 200V / cm
- FEE: AFTER T2K/TPC card

Preliminary results

Better energy resolution / controlled & reproductible procedure

Measured Noise level with AFTER FEE

Ref: P. Baron,X. De la Broise,E. Delagnes, E. Virique

Energy range : 120 fC /peaking time : 100 ns / SCA sampling freq. : 50 MHz

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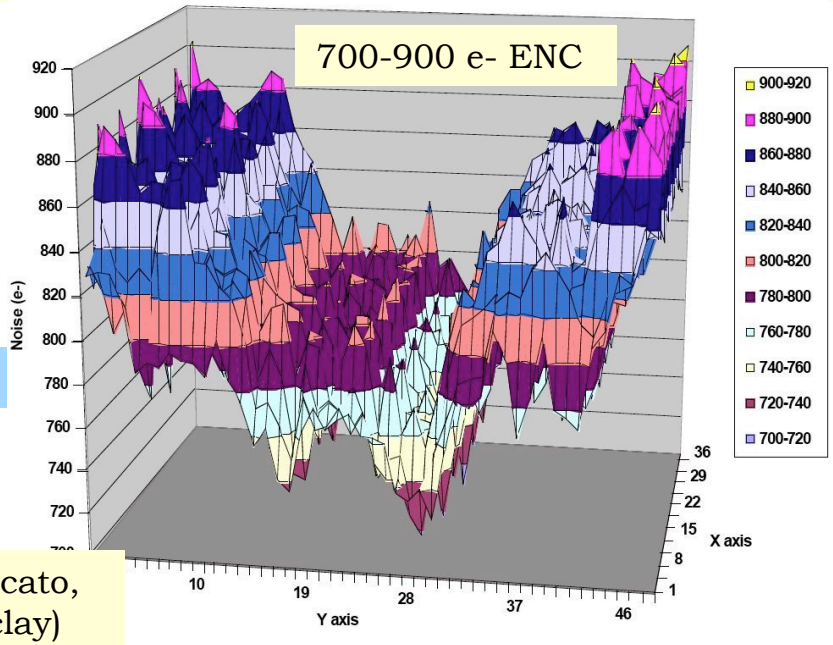
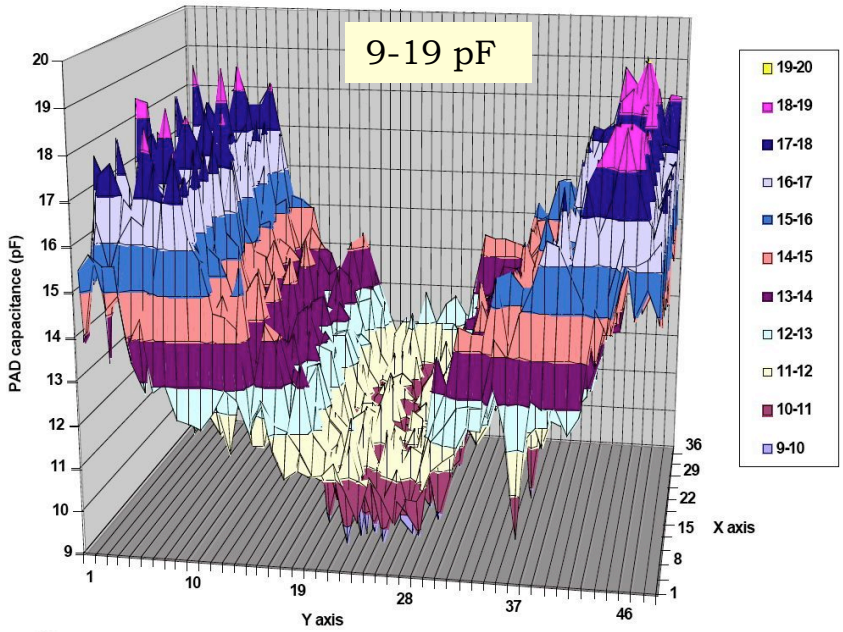
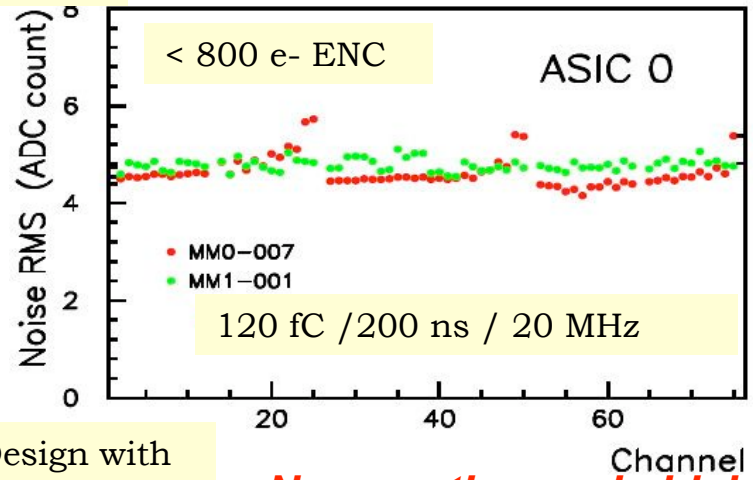
Mesh@GND

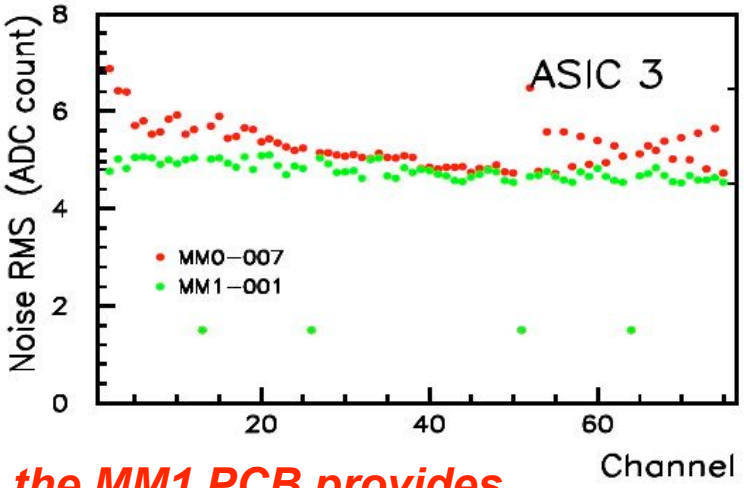




Ref: E. Mazzucato, F. Pierre (Saclay)

Mesh= -350V



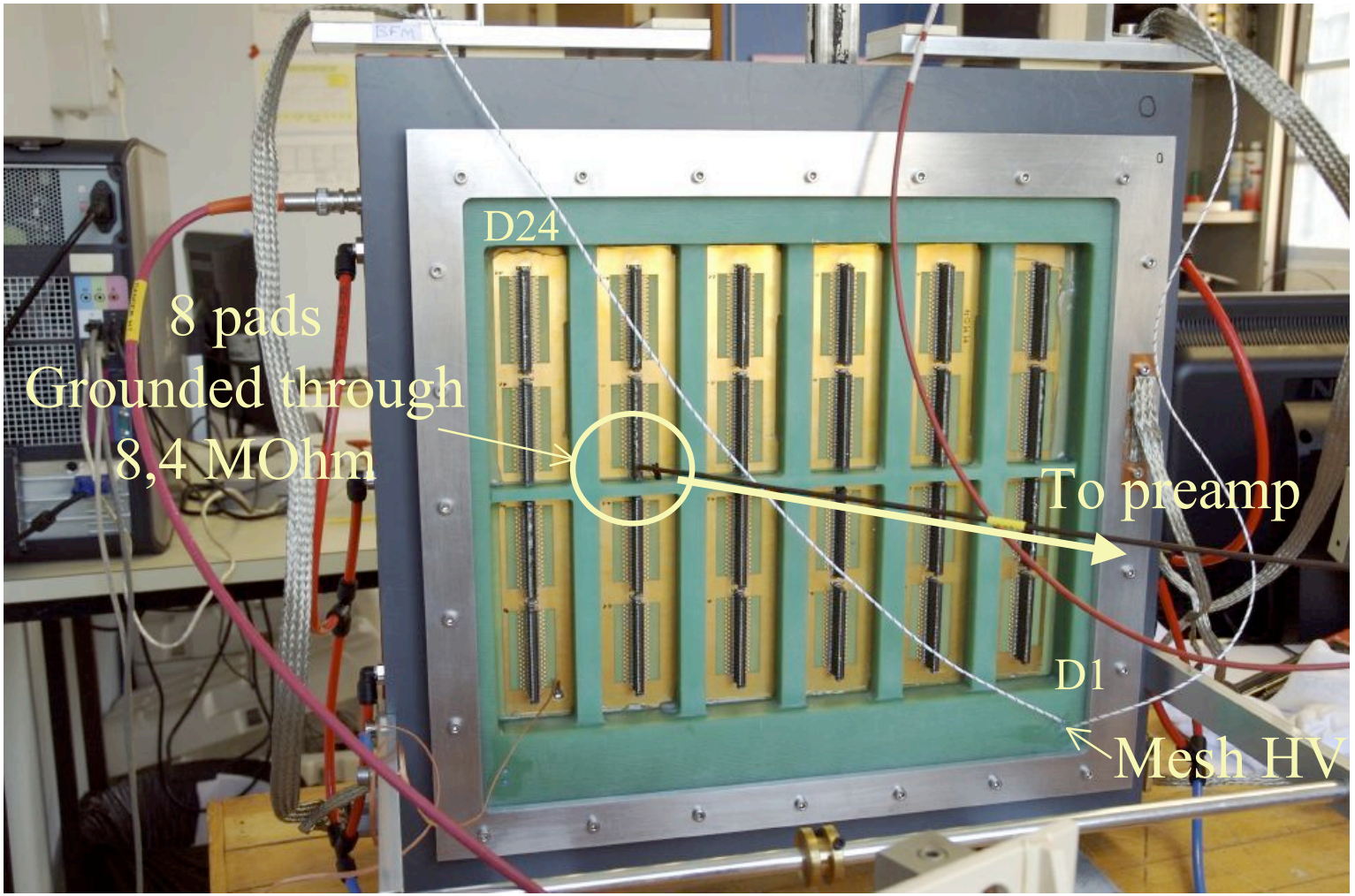


MM1 PCB Design with M. Sanchez / S. Baiteche CERN-TS-DEM

New routing and shielding in the MM1 PCB provides better noise uniformity and smaller sensitivity to pick-up noise.

First look at uniformity of gain and energy resolution

34x36 cm^2 MM0_004 detector



Examples of MM04 55Fe spectra

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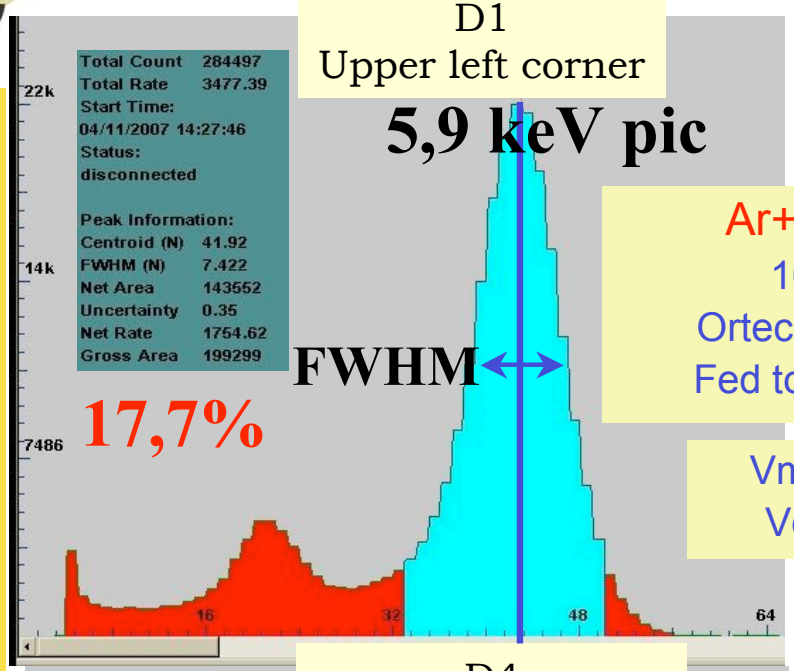
D1
Upper left corner



5,9 keV pic

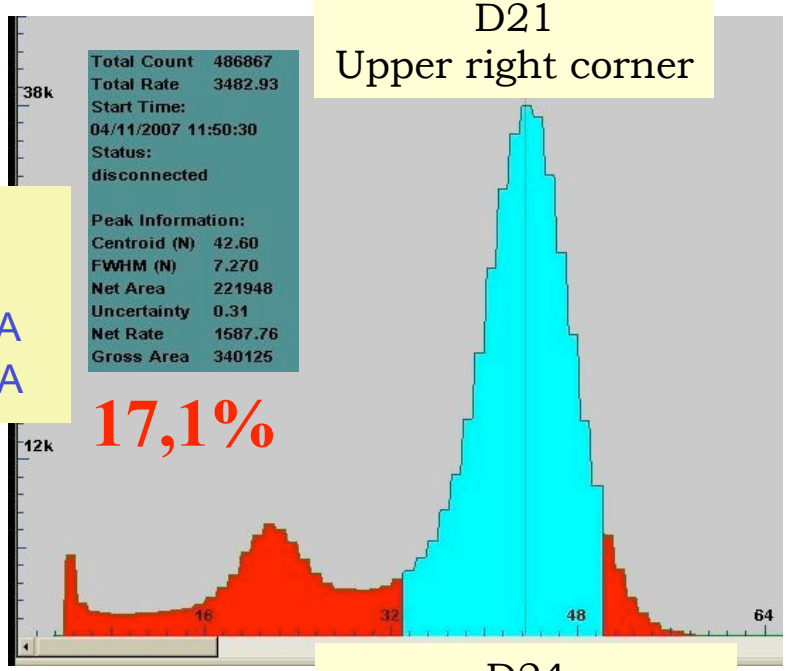
FWHM

17,7%

Ar+2%iC4H10
10 mm drift
Ortec 142AG+472A
Fed to amptek MCA

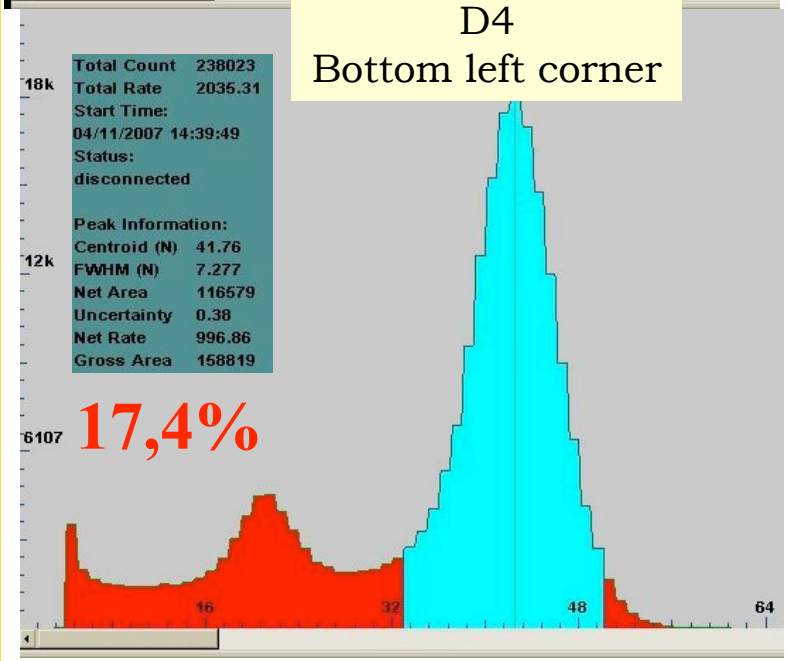
Vmesh=360V
Vdrift=560V

D21
Upper right corner



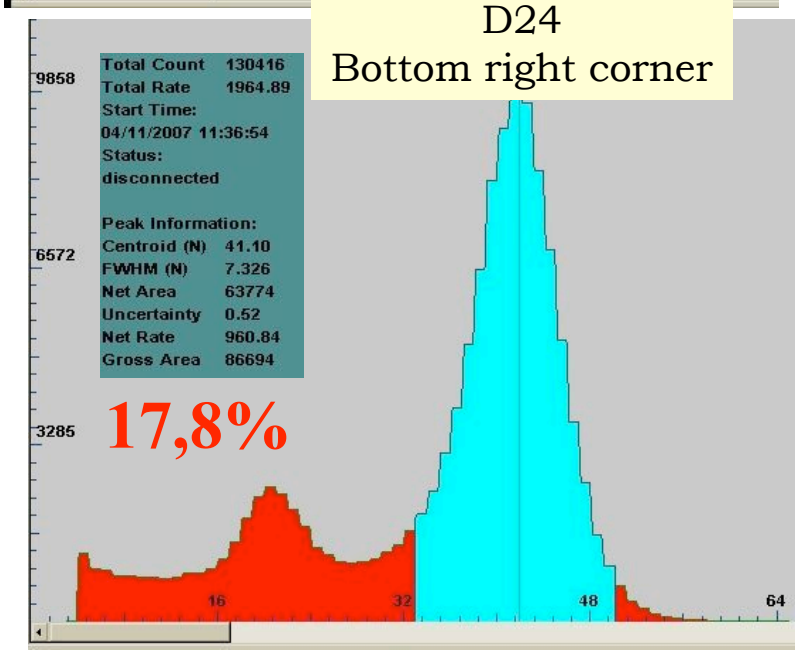
17,1%

D4
Bottom left corner



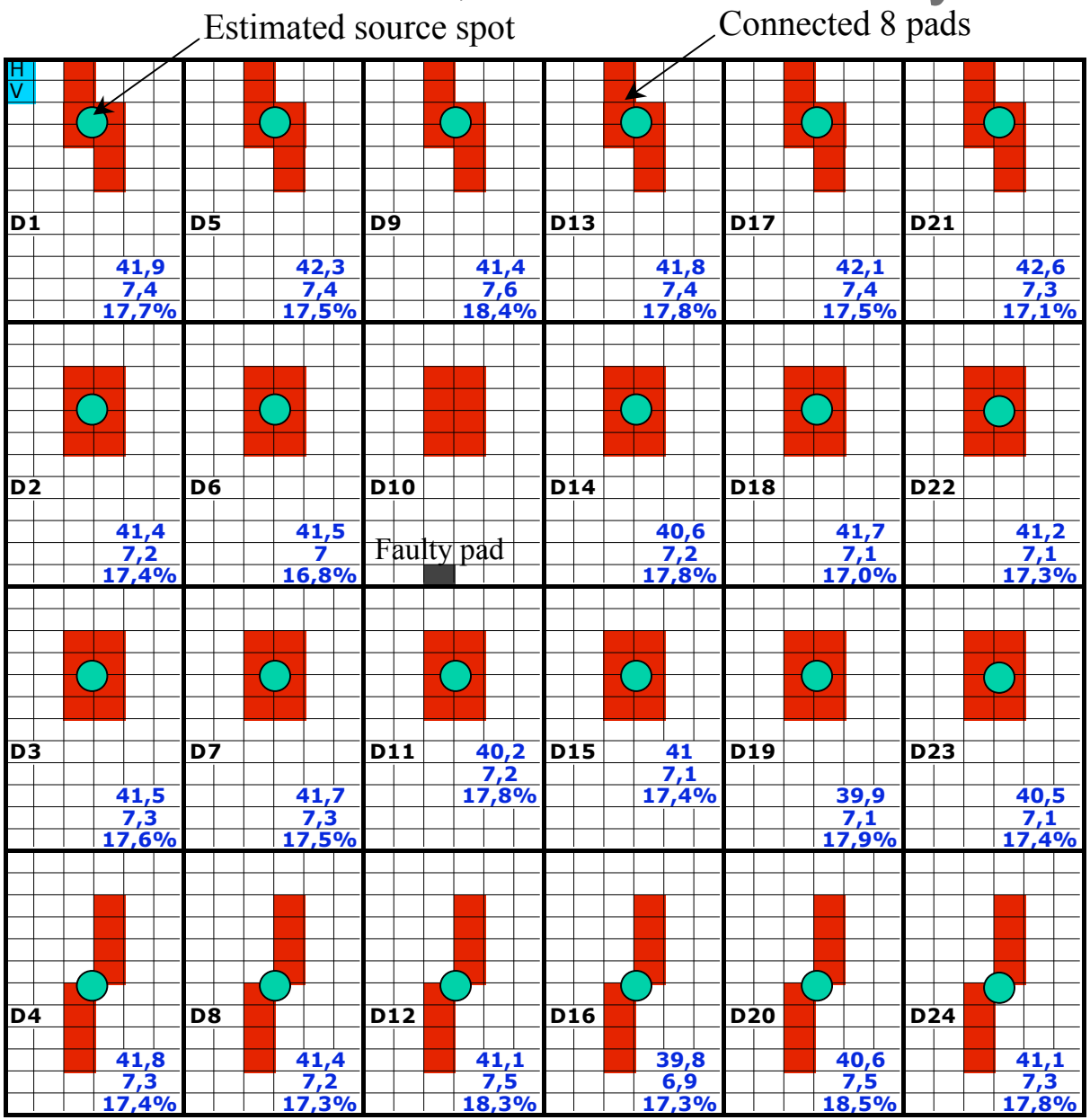
17,4%

D24
Bottom right corner



17,8%

MM04 55Fe 5,9keV uniformity measurements



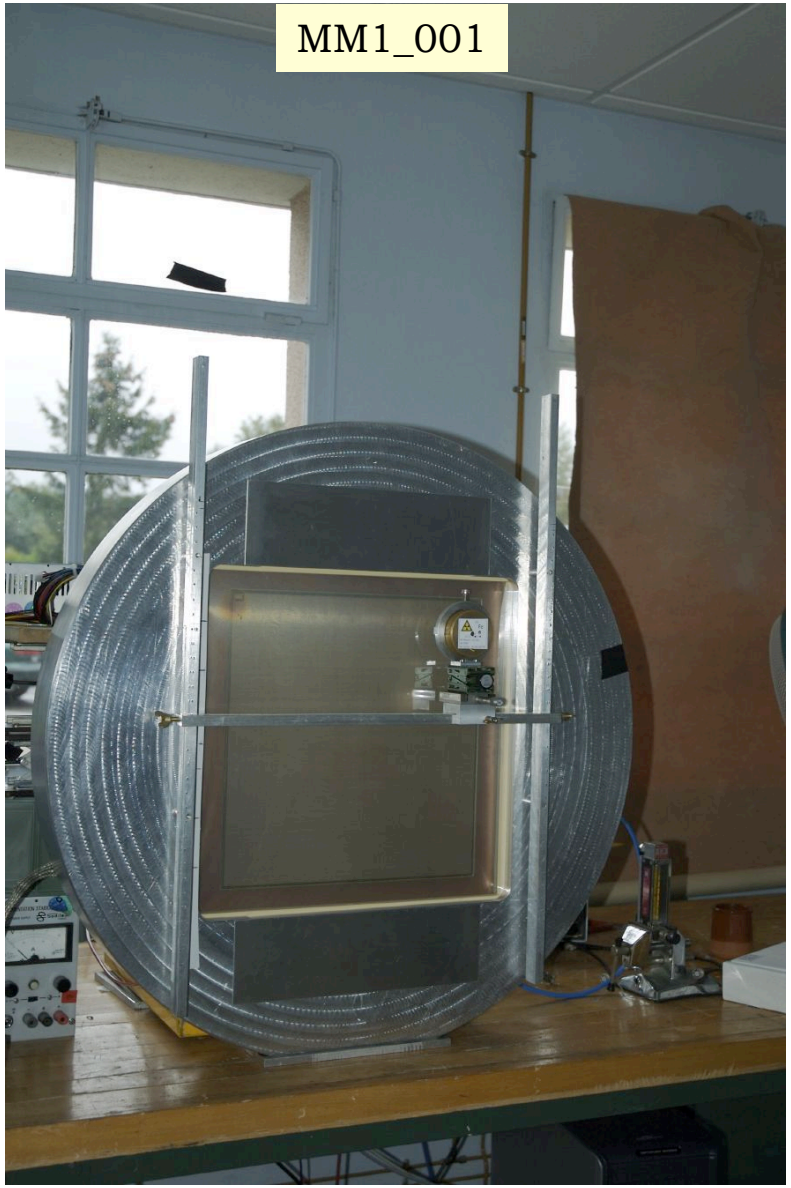
: 5,9 keV centroid
: 5,9 keV FWHM
: FWHM/centroid @ 5,9 keV

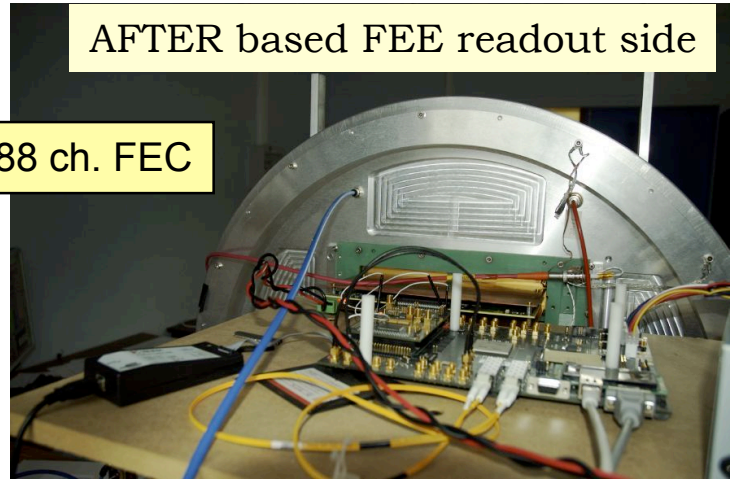
Mean 5,9 keV resolution

17,6 % FWHM

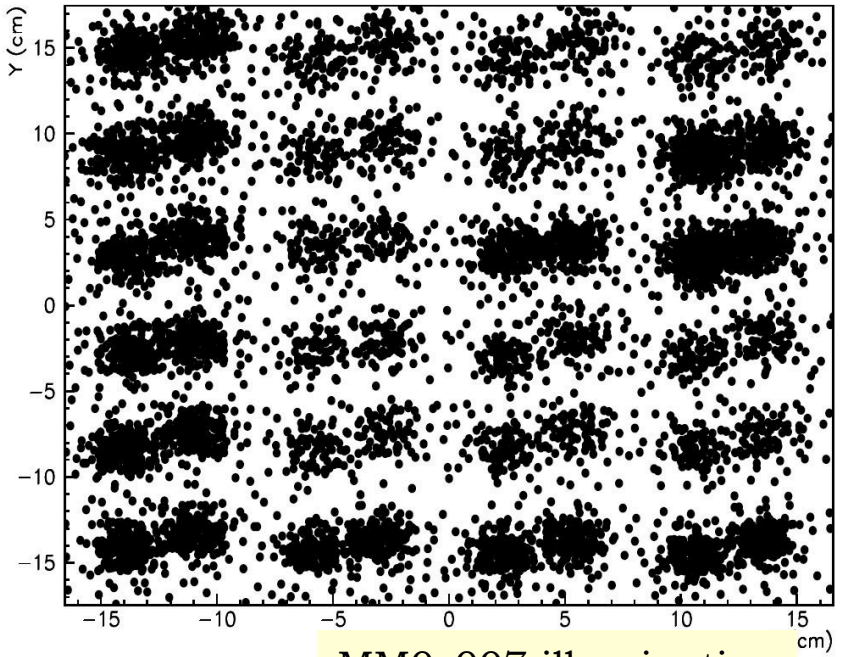
Gain & energy resolution uniformity at 5% rms level

55Fe 5,9keV uniformity measurements with AFTER electronics



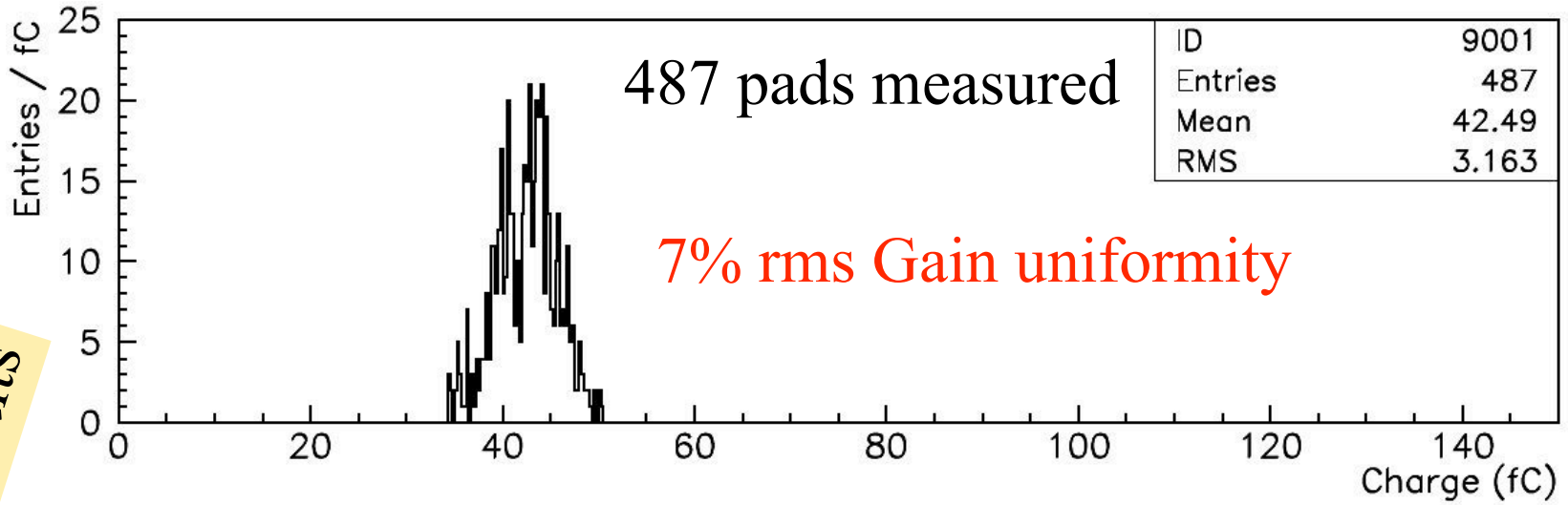


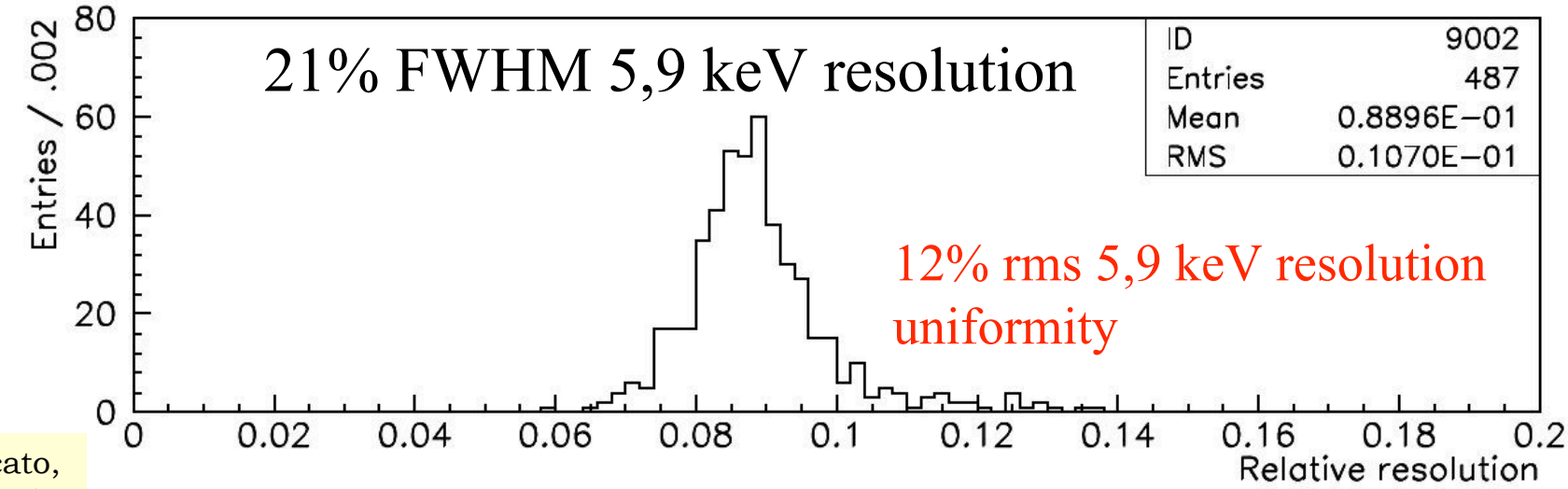
Illumination with a ^{55}Fe source (370 MBq)



MM0_007 illumination

First results of uniformity at pad level





Preliminary results

Ref: E. Mazzucato, F. Pierre (Saclay)

Will be further investigated on automated test bench

Towards production of 80 modules at CERN

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CERN/TS-DEM-PMT

- PCB production
- PCB electrical Automated Quality Control + thickness & flatness metrology
- Bulk micromegas production
- Global current quality control in Air (@600 V)
- Bulk micromegas final cutting
- Global current & pad per pad current quality control in Air (@600V)
- Connectors soldering

Detector's delivery

T2K/TPC Europe lab. with 1000 class cleanroom

- Mechanical Stiffener gluing
- Gas tightness & thickness metrology
- Detector baking in dry air (~1day, increasing HV)
- Final gain calibration on UNIGE/IFAE test bench
- 55Fe pad scanning, with Automated x-y stage and AFTER FEE

Module Storage

Conclusion

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✓ Large 34x36 cm^2 bulk Micromegas have been produced with good quality thanks to fine tuning of the manufacturing procedures and a NEW « stretched mesh » lamination process :

- ❑ High quality Pad/mesh insulation (>910V i.e 71 kV/cm in air / 10 nA)
- ❑ less than 2 faulty pads per module (mostly no defects)
- ❑ 700-900 e- ENC noise with AFTER FEE
- ❑ Good 5,9 keV energy resolution (18-21%FWHM)
- ❑ First measurements of response uniformity (better than 10% rms)

✓ a MM1_001 will be equipped with 1726 AFTER channels for a T2K/TPC module system test with cosmics on the 1,5 m drift HARP cage, under 0,2-0,4 T at CERN (09/19-10/05 2007)

✓ Start of Pre-production of T2K/TPC bulk micromegas is scheduled for beginning of 2008 with a goal of :

- ❑ absolute gain uniformity (from a module to another) below 10% rms
- ❑ less than 1 faulty pad per module