Large « bulk » Micromegas detectors

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On behalf of T2K/TPC Work Package 4
« bulk micromegas »

Within the T2K/TPC collaboration:
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TRIUMF, Canada
DPNC, Section de Physique, University of Geneva, Geneva, Switzerland
University of Valencia, Spain
University of Victoria, Canada.

See R. de Oliveira’s talk on MPGD technologies
See P. Baron’s talk on AFTER electronics

MM1_001 module
Prototype of water cooled AFTER FEE

359 mm
1726 active pads
342 mm

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Micro-pattern Gaseous Detectors Workshop (09/10-11/2007, CERN)
Outline

• 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)

**Goal**

$\sigma(p)/p < 10 \% @ 1 \text{ GeV/c}$

dE/dx < 10% capability to separate e- from $\mu$

- Magnet yoke (+Side-MRD) (UA1/NOMAD)
- EM calorimeter
- Neutrinos
- 3 TPCs
- Pi0 detector
- H2O active target + Fine Grained Detectors (FGD)
- 2nd FGD
- Muon ID Hodoscope

Conceptual design optimization versus PIT

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Micro-pattern Gaseous Detectors Workshop (09/10-11/2007, CERN)
The T2K/ND280 TPC

- 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)

E=200V/cm
B=0.2T

TPC

Front-End Mezzanine

72 modules (9 m²)
124416 channels

See P. Baron’s talk on AFTER electronics

Mechanical Stiffener

Front-End Mezzanine

Mesh HV

+ FEE cooling

2 Opt. Fibers

Bulk Micromegas

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Micro-pattern Gaseous Detectors Workshop (09/10-11/2007, CERN)
The 2007 « bulk » Micromegas

3,2 mm inactive border

359 mm (neutrino beam)

MM1_001 (august 2007)

2.2 mm thick PCB

1726 active pads

2 pads used for Mesh HV

- 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

See R. de Oliveira’s talk on MPGD technologies
Road map of developments

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

2004

T2k

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

2005

128 ch. ALTRO cards + inv./protec

Start of AFTER

2006

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

Cosmics tests on HARP cage

2006

First AFTER ASIC

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

AFTER validated

Saclay/AFTER FEE On detector

Cosmics tests on HARP cage with 1728 AFTER FEE channels

2007

Start of AFTER ASIC production

2008

Choice of bulk micromegas By T2K/ND280

Choice of detectors' Final design

Start of detectors' production

Commercial Ortec 142 1 channel

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Micro-pattern Gaseous Detectors Workshop (09/10-11/2007, CERN)
Cosmics resolution studies on HARP cage (T2kn2/2005)


Residual width vs drift distance

24x26 cm² prototypes
8x8 mm² Pads
2 pads in cluster

Spatial resolution
700 μm
σ(p)/p<=11%

Includes track extrapolation uncertainty (200-300 μm)

Ar+3%CF4+2%C4H10

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%C₄H₁₀+3%CF₄
  - Transv. Diff. 240 µm/cm¹/², drift velocity 6.5 cm/µs @ 200V/cm (Magboltz & measured on harp cage)

Gain Vs \( V_{\text{mesh}} \)

- **Ar/iC₄H₁₀/CF₄ (95%/2%/3%)**
  - T2Kn2 (95 µm gap, 9 mm drift, ALTR0) Nov. 2006
  - MM0-007 (128 µm gap, 10 mm drift, AFTER) Jun. 2007

Sparkling rate Vs Gain

- **For Gain<1000**

**Preliminary results**

E_{drift} = 200V/cm

1200@-350V

<0.1 spark/h
55Fe 5.9 keV resolution of a detector made with « unstretched 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

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

**FWHM = 26%**

- 95 µm measured gap
- gain~5300
- 95% Ar + 5% iC₄H₁₀
- E_{drift} = 200V / 9mm
- FEE: 128 ch ALTRO card
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

Pyralux laminator roller
PCB support roller

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

FWHM = 19%

ID  10030
χ²/ndf 54.83  / 30
P1  91.15 ±  5.481
P2  30.32 ±  0.1110
P3  2.677 ±  0.1236
P4  11.08 ±  1.062
P5  15.67 ±  0.4938
P6  4.171 ±  0.2312

MM1_001 (august 2007) : “streched mesh”

• 128 μm gap, gain~1000
• 95% Ar + 2% iC₄H₁₀ + 3% CF₄
• E_drift = 200V / cm
• FEE: AFTER T2K/TPC card

Better energy resolution / controlled & reproducible 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

Mesh = -350V

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

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 cm² MM0_004 detector

8 pads
Grounded through 8,4 MΩ

To preamp

Mesh HV

D1

D24
Examples of MM04 55Fe spectra

D1
Upper left corner

5,9 keV pic

Ar+2%C4H10
10 mm drift
Ortec 142AG+472A
Fed to amptek MCA

17,7%

D21
Upper right corner

17,1%

D4
Bottom left corner

17,4%

D24
Bottom right corner

17,8%

Vmesh=360V
Vdrift=560V

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Micro-pattern Gaseous Detectors Workshop (09/10-11/2007, CERN)
MM04 55Fe 5.9keV uniformity measurements

Estimated source spot
Connected 8 pads

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Faulty pad

: 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)

MM1_001

288 ch. FEC

AFTER based FEE readout side

MM0_007 illumination
First results of uniformity at pad level

487 pads measured

7% rms Gain uniformity

21% FWHM 5.9 keV resolution

12% rms 5.9 keV resolution uniformity

Will be further investigated on automated test bench

Ref: E. Mazzucato, F. Pierre (Saclay)
Towards production of 80 modules at CERN

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

✓ Large 34x36 cm² 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