Charge Dispersion Studies in MPGDs with a Resistive Anode

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Position sensing from charge dispersion in micro-pattern gas detectors with a resistive anode

Double-GEM spatial resolution ~ 70 μm reported earlier (Dixit et al, to be published in NIM) consistent with x-ray spot size for 1.5 mm wide long strip readout

Here we report on:

Energy and gain tests in Micromegas

Resolution for rectangular (2 x 6 mm ) pads in GEM and in Micromegas using a collimated x-ray source
Position sensing from charge dispersion in micro-pattern gas detectors with a resistive anode

Deposit charge cluster at r=0 at t=0

Telegraph equation in 2-D

\[
\frac{\partial Q}{\partial t} = \frac{1}{RC} \left( \frac{\partial^2 Q}{\partial r^2} + \frac{1}{r} \frac{\partial Q}{\partial r} \right)
\]

Charge density: \( Q(r, t) = \frac{RC}{2t} e^{-\frac{r^2 RC}{4t}} \)

Signal = Integral of \( Q(r, t) \) over pad area

\( Q(r, t) \) versus \( r \)
Resistive anode Micromegas gain tests at Saclay

Drift Gap

50 µm pillars

50 µm THICK MYLAR

50 µm THICK ADHESIVE LAYER

READOUT PADS

READOUT PCB

DETAIL A

RESISTIVE ANODE

~ 1 MΩ/□ (Cermet coating)
Micromegas $^{55}$Fe energy resolution

Argon/Isobutane 90/10 (Gain ~ 6000)

Mesh signal
Micromegas gain with a resistive anode

Argon/Isobutane 90/10

Resistive anode suppresses sparking stabilizing Micromegas
GEM & Micromegas Tests at Carleton

Resistive anode disperses avalanche cluster charge
Position from centroid of dispersed charge sampled by several pads
In contrast to the GEM, in Micromegas there is little transverse diffusion after gain which makes centroid determination difficult
Cermet-Mylar resistive foil replaced by C-loaded Kapton

Amplification with GEM or MicroMegas

Carbon loaded Kapton ~ 0.5 M\(\text{m}^2/\text{m}^2\)

Thickness ~ 30 \(\mu\text{m}\)
Space Point Resolution with Resistive Readout

- Test cells with double GEM & Micromegas
- 6 kV brehmstralung x-ray source
- ~ 40 μm pinhole camera produces ~ 70 μm focal spot
- Ar:CO₂ (90:10)
- 2 x 6 mm pads
Charge dispersion signals in Micromegas
Single event (2 mm wide pads)

2003/10/20

2 x 4 channel Tektronix
X-ray spot centred on pad 2

Ar/CO₂ 90/10, Gain ~ 3000
1st neighbor peak ~ 100 ns after the primary pulse peak
Slow rising 2nd neighbor pulse
~ 25 MHz digitization could replace pulse shape sampling
Pad response function (PRF)

Intrinsic PRF width from charge dispersion on resistive anode

Transverse diffusion adds significantly to the GEM PRF width

Average amplitude on 5 consecutive pads
GEM resolution (rectangular pads)

Resolution for 1.5 x 70 mm$^2$ strips for 2.5M$\square$/\Box anode resistivity $\sim$ 50-80 $\mu$m (to be published in NIM)

Point resolution for the 2 x 6 mm$^2$ rectangular pads with 0.5 M$\square$/\Box anode foil similar

Use dispersed charge center-of-gravity with bias correction
Micromegas have little diffusion after gain in contrast to GEM

The centre of gravity method appears to be inadequate

Detailed characterization of Micromegas pad response function

Normalize pad charge signals with mesh signal

Scan over 10 mm = 5 pads
A Micromegas Charge Dispersion Event
Micromegas Resolution

X-ray spot position 15.35 mm
Pad edge @ 15 mm
Centre @ 16 mm
Measured spatial resolution 68 μm
Micromegas Resolution

Scan across a 2 x 6 mm pad
Good resolution not uniform

Systematics not fully understood
Some points: bias of 100 μm

Some points: resolution of 120 μm
What's Wrong?

Possible reasons for poor resolution/bias in Micromegas

- Resistive foil not uniform - unlikely
- Quality/structural problems with our particular Micromegas setup
- In the GEM, diffusion after gain makes PRF more Gaussian makes analysis easier
- Still learning how to analyze the Micromegas data
- More measurements under different conditions to understand the problem
Conclusion

First charge dispersion resolution results for rectangular nominal TPC width pads in Micromegas & GEM very encouraging

Spatial resolution $\sim 70 \text{ m}$ consistent with x-ray spot size

Systematics not fully understood for Micromegas

Good energy resolution in Micromegas

Sparking suppressed in Micromegas detector to high gains

TPC cosmic ray tracking tests next