# A Study of Resolution of a GEM TPC with Ar-CF4-Isobutane Gas Mixtures

**Preliminary Report** 

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### Gas for ILC TPC

Low diffusion at high magnetic field (large  $\omega \tau$ ). Sufficient primary electrons.

Small electron attachment.

(the drift region and the amplification region)

Reasonable drift velocity at an acceptable drift field.

Gating condition (when we use the GEM gating).

Neutron background with less or no hydrogen (quencher)

Stable operation of MPGD.

Long term stability of TPC (aging and corrosion)

### Some works underway

The intensive gas (gain) study for MicroMEGAS (Saclay) A Ar/CF<sub>4</sub> gas study for GEM (the CDC group) (May be more)

### **Ar-CF4 Gas Mixture**

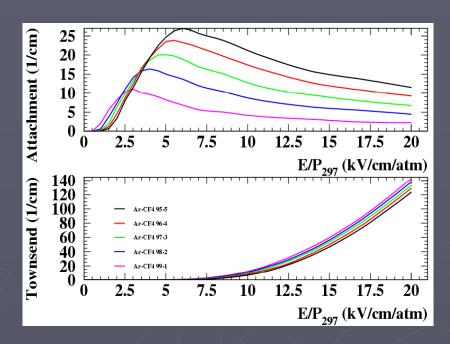
Small transverse diffusion with the large ωτ@ high magnetic field

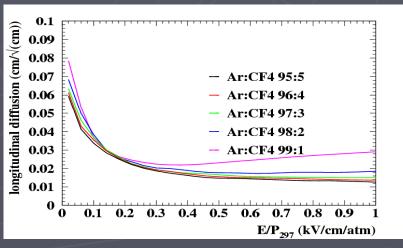
Large electron attachment for E > a several 100V/cm -> The question if GEM works?

Need some quencher (Isobutene)
both for MicroMEGAS (unstable operation) and GEM (no signal)

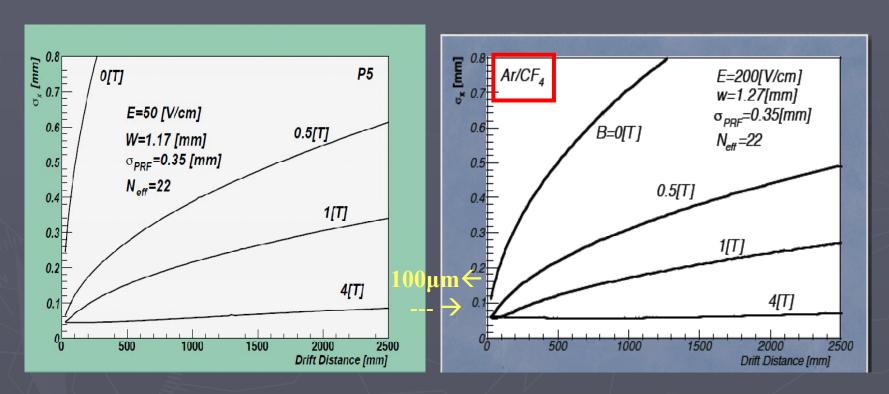
- (1) MicroMEGAS: Nice result@5T (M. Dixit et. al. 2007)
- (2) GEM: Known to work with Isobutene (T2K 2006)

This measurement with MP-TPC is to confirm (2) and measure Neff.





GEM with narrow (1mm) pads: Transverse resolution calculated by the analytic formula for MPGD TPC:



(The diffusion constants were calculated by the Magboltz simulation. Neff of 22 measured for P5 at 0 - 1T was used.)

Resolution of < 100 μm over the full drift length of ILC TPC (2- 2.5 m). with the low diffusion gases P5 and Ar/CF4.

### **Ar-CF4 Gas Mixture for MicroMEGAS**

**MicroMEGAS** with resistive anode readout:

Transverse resolutions measured in the DESY 5T magnet for cosmic rays (M. Dixit et al. 2007)

50 μm resolution all over the drift distance (16 cm) for 5T.

The small diffusion constant  $(20 \mu \text{m}/\text{cm}^{1/2})$  of Ar-CF<sub>4</sub>-Isobutaine(95:3:2) mixture at B= 1T.

Need to understand why 50 µm but not less.

Neff = 27 - 29 at B = 0.5T

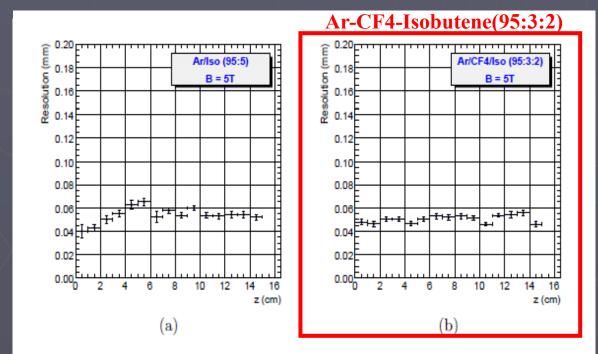


Fig. 3. Transverse resolution as a function of drift distance for 2 mm x 6 mm pads for a magnetic field of 5 T for two gases mixtures: (a)  $Ar:iC_4H_{10}/95:5$  and (b)  $Ar:CF_4:iC_4H_{10}/95:3:2$ .

## **MP TPC Prototype with Cosmic Rays**

TPC: MP-TPC

**MPGD:** 

3 layers of CERN GEM

10cm x 10cm

1.17 x 6 mm pads

7 pad-rows readout

**Inter-GEM and GEM-pad** 

gap: 1mm (so far)

 $Vgap = V_{GEM}$  (so far)

**Electronics: ALEPH** 

Gas: Ar-CF4(3%)-Isobutene

Magnet: Max. 1T



**KEK Cryogenic Center** 

### Data Taken So Far

- (1) Ar-CF<sub>4</sub>-iC<sub>4</sub>H<sub>10</sub> (94:3:"3") @ B = 1T  $V_{GEM}$ =320V,  $E_{DRIFT}$  = 102.8V/cm, 60,000events
- (2) Ar-CF<sub>4</sub>-iC<sub>4</sub>H<sub>10</sub> (96:3:"1") @ B = 1T  $V_{GEM} = 270V, \quad E_{DRIFT} = 88.8V/cm, \\ 60,000 events$
- (3) Ar-CF<sub>4</sub>-iC<sub>4</sub>H<sub>10</sub>(96:3:"1") @ B = 0T

### Please note! $V_{GEM}=270V$ , $E_{DRIFT}=88.8V/cm$ ,

- (a) The above Isologoceventsntration were wrong due to the uncertainly (1%) of the mass flow controller (200cc/min) used for the Isobutene gas. The actual concentration of isobutene were found to be larger. (See next slide.) We have replaced the MFC by one of a smaller capacity after these measurement.
- (b) E<sub>DRIFT</sub> was too low in these preliminary measurements.

# **Isobutene Concentration From Measured Drift Velocity**

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(1) The "3" % Isobutene:
        V_{DRIFT} (measured) = 3.3 cm/\mus
        V_{DRIFT} (Garfield) = 4.06 cm/\mus
                 \rightarrow ~5 % isobutene (Garfield: 3.32 cm/\mus)
(2) The "1" % Isobutene:
        V_{DRIFT} (measured) = 3.4 cm/\mus
        V_{DRIFT} (Garfield) = 4.52 cm/\mus
                 \rightarrow ~3 % isobutene (Garfield: 3.51 cm/µs)
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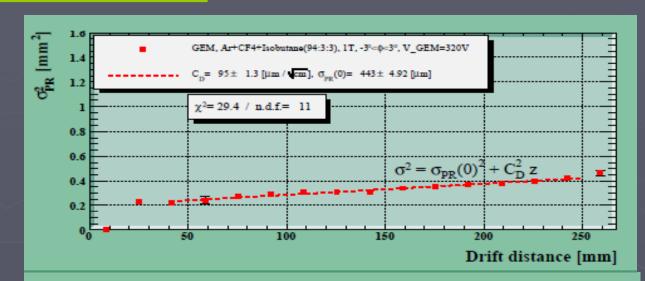
Ar-CF<sub>4</sub>-Isobutene(94:3:"3") B =1T

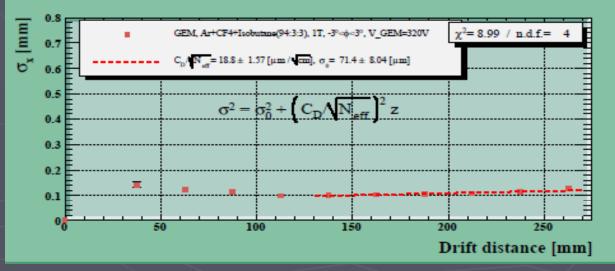
 $-3^{\circ} < \phi < 3^{\circ}$ 

 $\sigma_{\text{PRF}}^{2}$ :  $C_{\text{D}}=95\mu\text{m/cm}^{1/2}$ 

 $\sigma_X$ :
Hodoscopes effect
Neff = 25.5

To avoid the hodoscopes effect, select inclined tracks in next slide (or increase the defocusing)





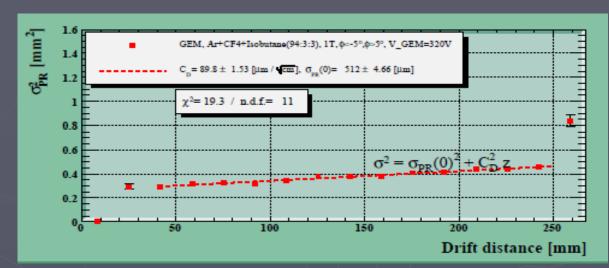
Ar-CF<sub>4</sub>-Isobutene (94:3:"3") B = 1 T

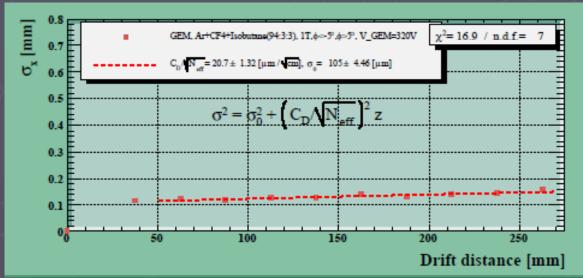
 $\varphi$ <-5 ° or  $\varphi$ >5°

$$\sigma_{PRF}^{2}$$
 $C_{D}=90\mu m/cm^{1/2}$ 

 $\sigma_{\rm X}$ Neff = 18.8

Applied the different Φ-angle cut to avoid the horoscope effect.



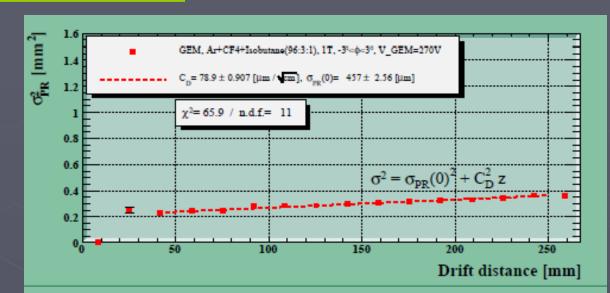


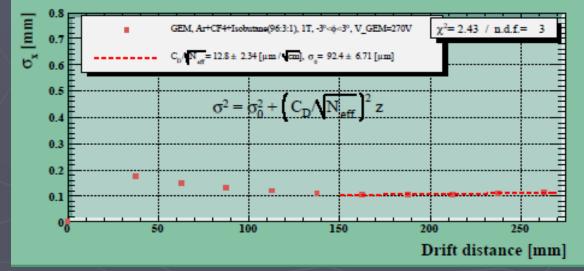
Ar-CF<sub>4</sub>-Isobutene (96:3:"1") B=1T

-3  $^{\circ}$  <  $\phi$  < -3  $^{\circ}$ 

 $\sigma_{PRF}^{2}$   $C_{D}=79\mu m/cm^{1/2}$ 

**σ**χ
Hodoscopes
effect
Neff = 38.0

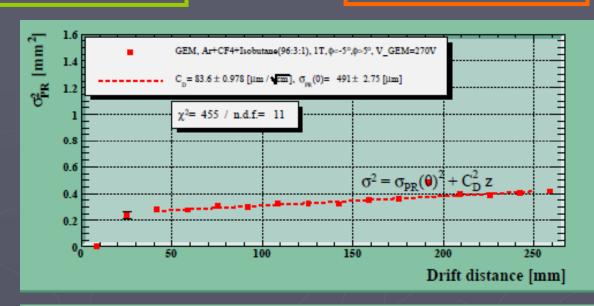




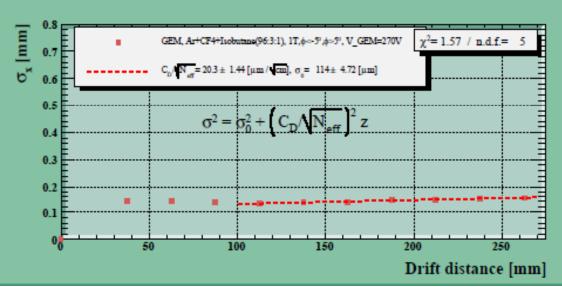
Ar-CF<sub>4</sub>-Isobutene(96:3:"1") B=1T

 $\phi < -5^{\circ} \& \phi > 5^{\circ}$ 

 $\sigma_{PRF}^{2}$   $C_{D}=95\mu m/cm^{1/2}$ 



 $\sigma_X$ :
Still Horoscope effect
Neff = 17.0



### **Summary**

- A measurement of resolution of GEM TPC for the Ar-CF4(3%)-isobutene (3-5%) gas mixtures was started using the MP-TPC prototype with cosmic rays.
- The three layer GEM of the "standard" setting was confirmed to work for this gas mixture.
- Very preliminary, Neff was measured to be around 20 at B = 1T and for the (wrong) Isobutene concentrations of 3 5%.

#### From Now

- Continue measuring Neff of the three layer GEM for this gas mixtures (but with the correct Isobutene concentrations!) by optimizing the configuration and/or the operation condition of the three layer GEM.
- Move to test the two layer GEM of 100 μm thick for the preparation of the LP1 test in next year.

Summary of V_d(cm/us) and C_D(um/sqrt(cm)) in Ar-CF4-isoC4H10 by Garfield/Magboltz
@ E=102.8(V/cm) CF4
C_D   97. 95   67. 30   60. 63   62. 40   59. 72
1 V_d   2.468   5.386   5.494   5.189   4.904   4.669 C_D   279.4   94.75   70.73   66.39   70.28   67.72
2 V_d   3.316   4.888   4.816   4.562   4.325   4.141 C_D   191.8   94.19   71.15   74.19   75.44   74.40
3 V_d   3.556   4.416   4.285   4.056   3.866   3.712 C_D   154.4   94.27   85.27   81.20   78.41   79.53
4 V_d   3.536   3.998   3.846   3.659   3.491   3.368 C_D   144.4   99.46   94.62   91.04   83.94   84.44
5 V_d   3.424   3.639   3.489   3.319   3.180   3.078 C_D   136.5   107.9   95.31   94.10   92.24   97.24
@ E=88.8(V/cm) CF4
iso 0 V_d   1   2   3   4   5   5   5   6   5   6   6   6   6   6
1 V_d   2.553   5.020   4.863   4.520   4.250   4.052 C_D   258.2   89.63   69.72   70.01   69.55   67.07
2 V_d   3.269   4.449   4.220   3.947   3.734   3.574   C_D   174.7   88.23   80.71   76.79   76.10   76.05
3 V_d   3.406   3.945   3.728   3.505   3.330   3.197 C_D   149.2   97.28   87.65   84.86   84.25   87.06
4 V_d   3.313   3.532   3.322   3.136   2.999   2.895 C_D   134.7   97.64   91.70   91.53   93.48   90.89
5 V_d   3.151   3.185   2.998   2.842   2.724   2.637 C_D   130.6   106.4   101.3   99.21   95.53   101.3