LCWS04

First Magnetic Field Tests of a large Micromegas TPC

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with help from many people of these labs!

A LARGE TPC PROTOTYPE FOR THE LINEAR COLLIDER

- experimental set-up
- results on:
  - tracking
  - amplitude distribution
  - drift velocity
  - attachment
  - diffusion
- spatial resolution
- future
- conclusions

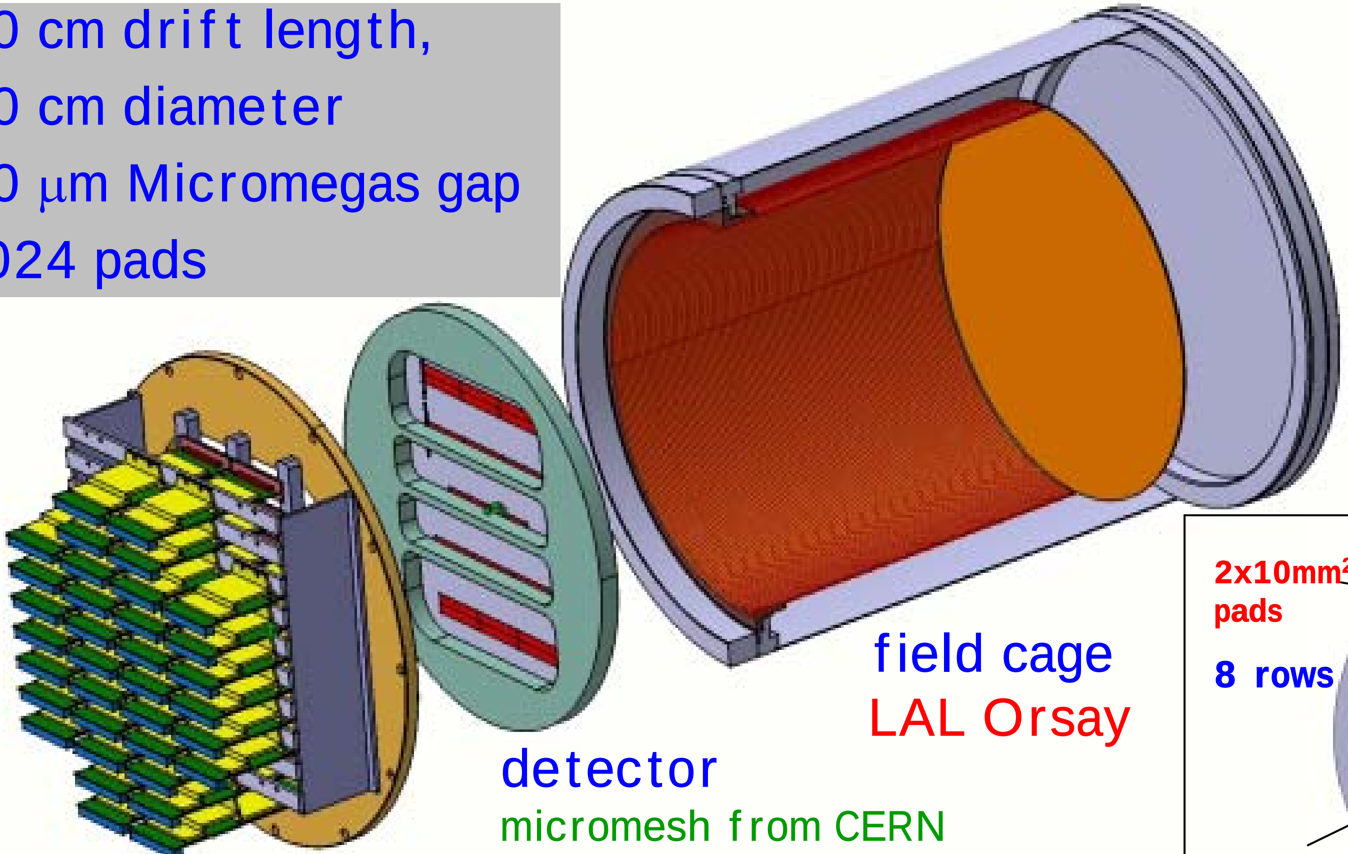
data taken with the following gas mixtures:

- Ar-CH_4 10% v = 5cm/µs @ 120 V/cm
- Ar-IsoC_4H_{10} 5% v = 4.2 cm/µs @200 V/cm
- Ar-CF_4 3% v = 8.6 cm/µs @ 200 V/cm

THE BERKELEY-ORSAY-SACLAY TPC SET-UP

50 cm drift length,
50 cm diameter
50 μm Micromegas gap
1024 pads

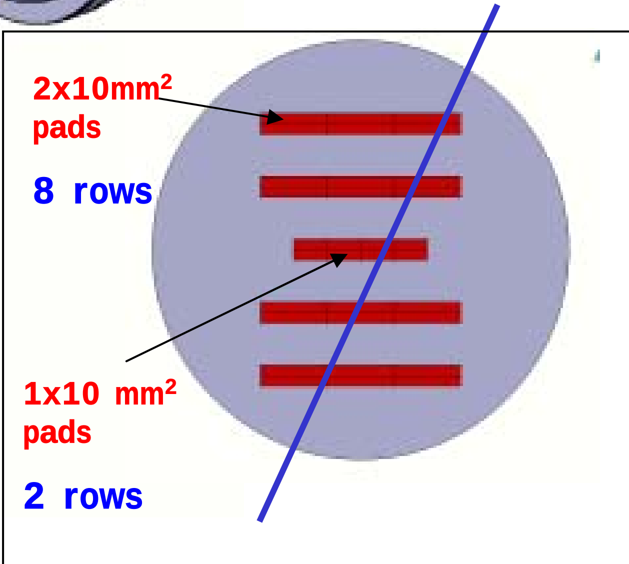
the largest Micropattern TPC ever built



field cage
LAL Orsay

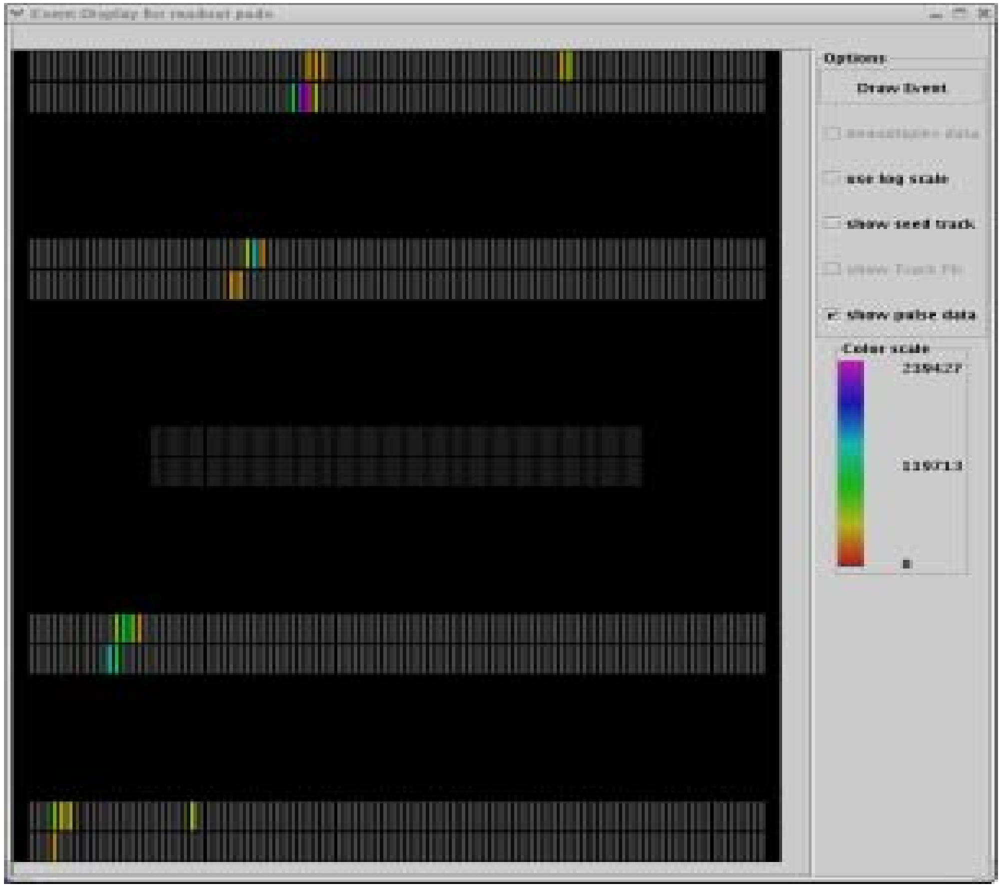
detector
micromesh from CERN
pad plane + pillars from industry
DAPNIA-CEA Saclay

front end electronics
(STAR TPC at BNL)
1024 readout channels
with preamplification,
shaping, 20 MHz sampling
over 10 bit ADC
LBNL Berkeley



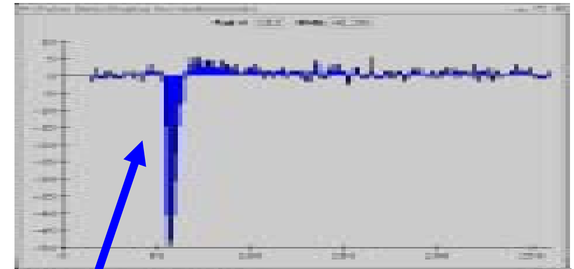
in operation since July 2003 with cosmic rays
data taking with B field in Nov. 2003
DAQ again very soon with B (next week!)

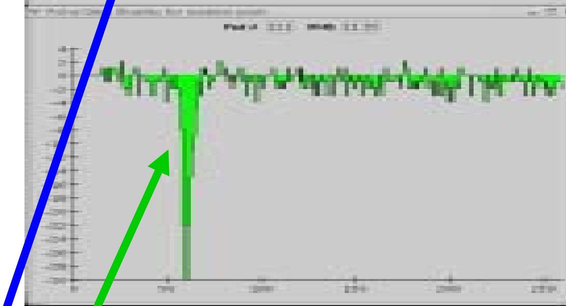
cosmic ray tracking



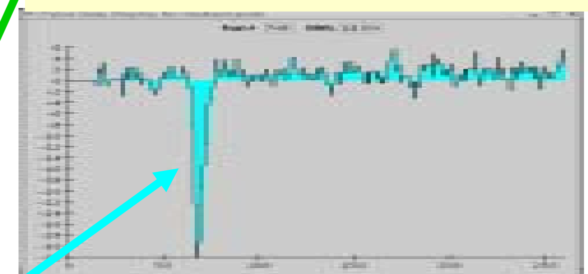
typical cosmic ray track
no B and central pads not active

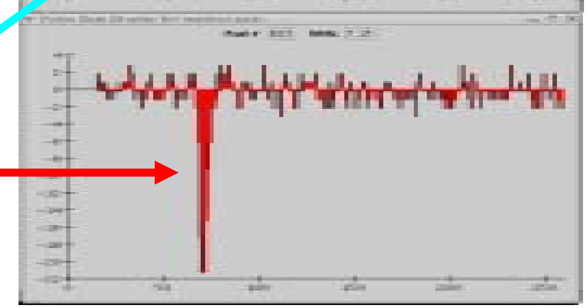
amplitude vs time distributions





P10 gas V_{mesh} = 356
gain~500 no B

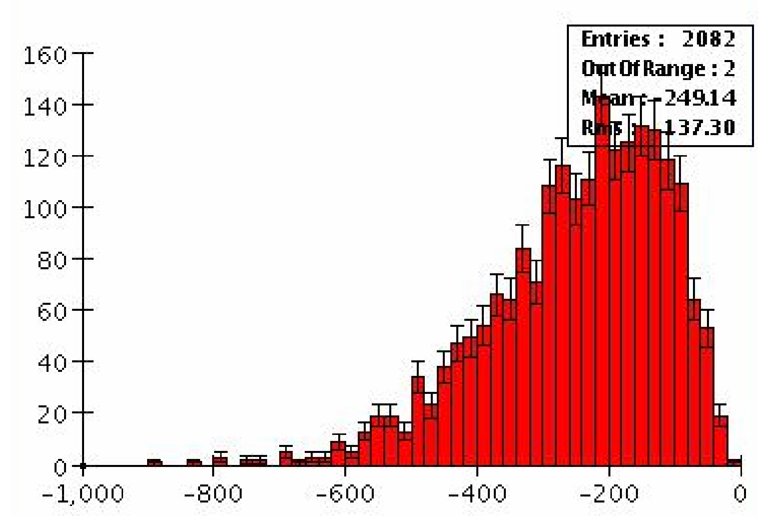




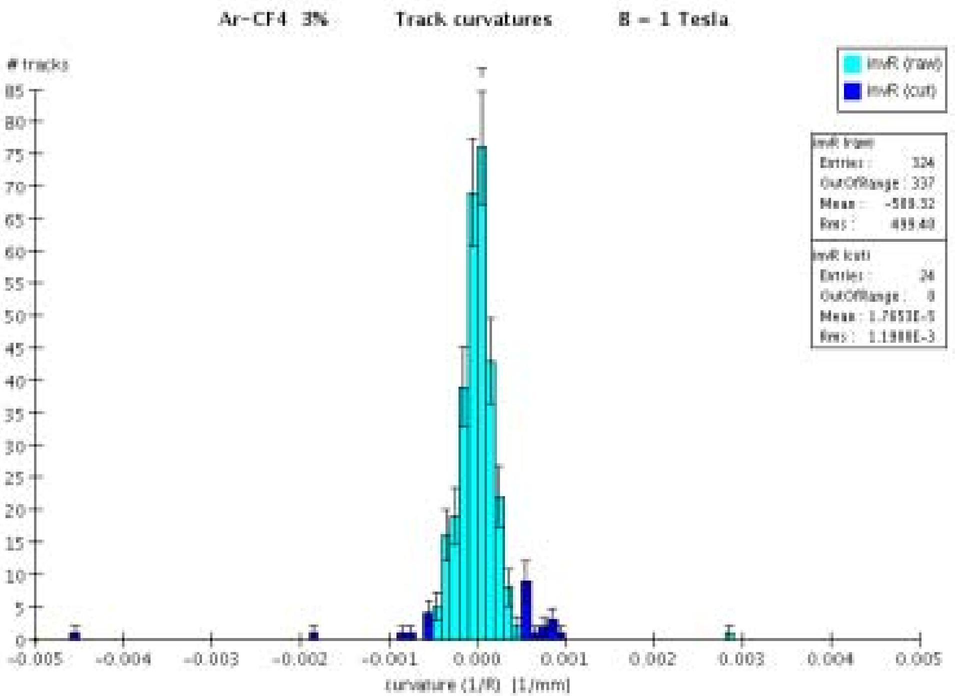
display and reconstruction using JAVA code from
Dean Karlen, adapted by Mike Ronan (JAS3 and AIDA)

- amplitude
- track curvature at 1T

with Ar-**CF4** 3%



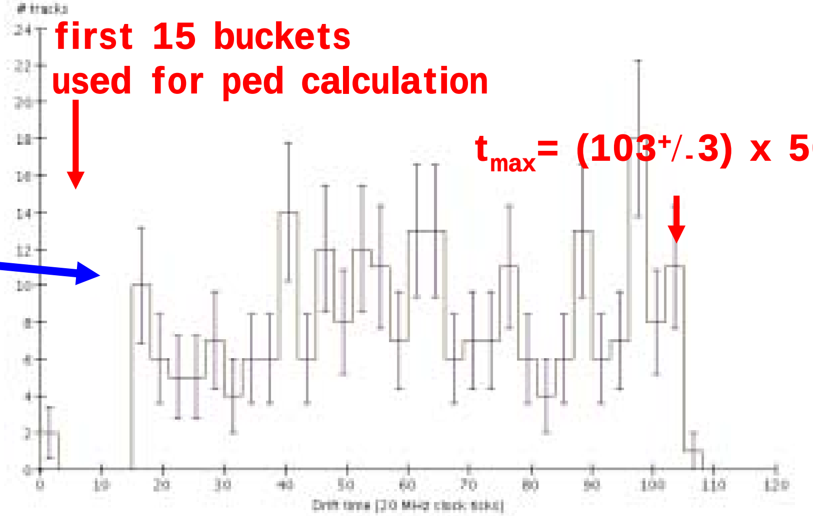
hit total amplitude (ADC counts)



curvature 1/R (mm^{-1})

Ar-CF_4: drift velocity

time distribution of the signals

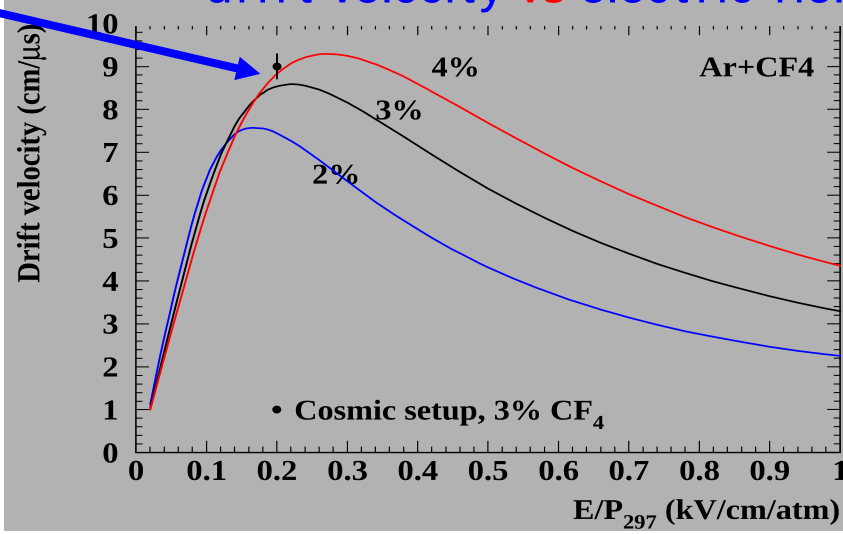


1. measurement of the drift velocity in Ar-CF_4(3%) at E=200 V/cm

Δt = 5150 + 200 ns (trigger delay) for 47.9 cm drift:

v=9.0 +/- 0.3 cm/μs consistent with Magboltz (by S. Biagi) **8.6 cm/μs**.

drift velocity vs electric field



2. cross-check: for Ar-isoC_4H_{10}(5%) at E=200 V/cm

we find **v = 4.2 +/- 0.1 cm/μs**

good agreement with Magboltz:

v = 4.15 cm/μs

Ar-CF_4:attachment

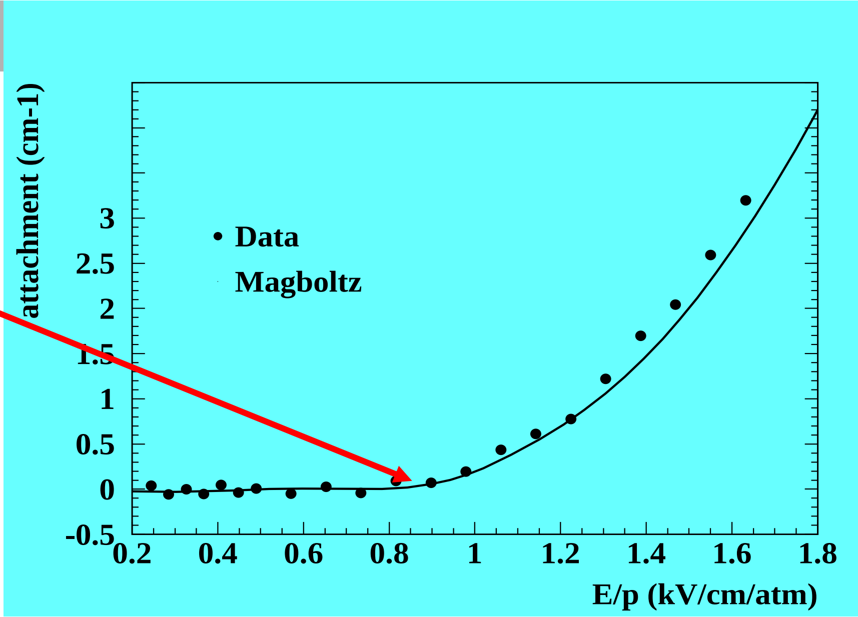
1.measurement with 1.29cm drift

signal attenuation from electrons produced by a N_2 laser (June 2002)

$I = I_0 \, e^{-ad}$

- good agreement with simulation
- no attachment below ~ 700V/cm

-> Magboltz reliable

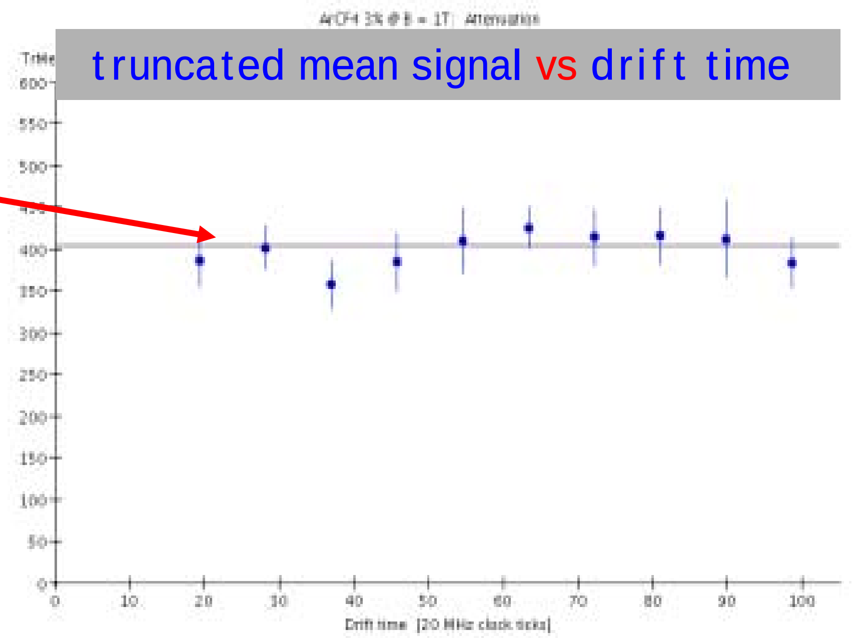


2.measurement with the cosmic setup

exponential fit to the mean signal vs distance gives the attachment limit :

attachment < 4.1 10^{-3} cm^{-1} @ 90% C.L.

-> OK for a large TPC



Ar-CF_4: diffusion

at 200 V/cm, for Ar+3%CF_4,

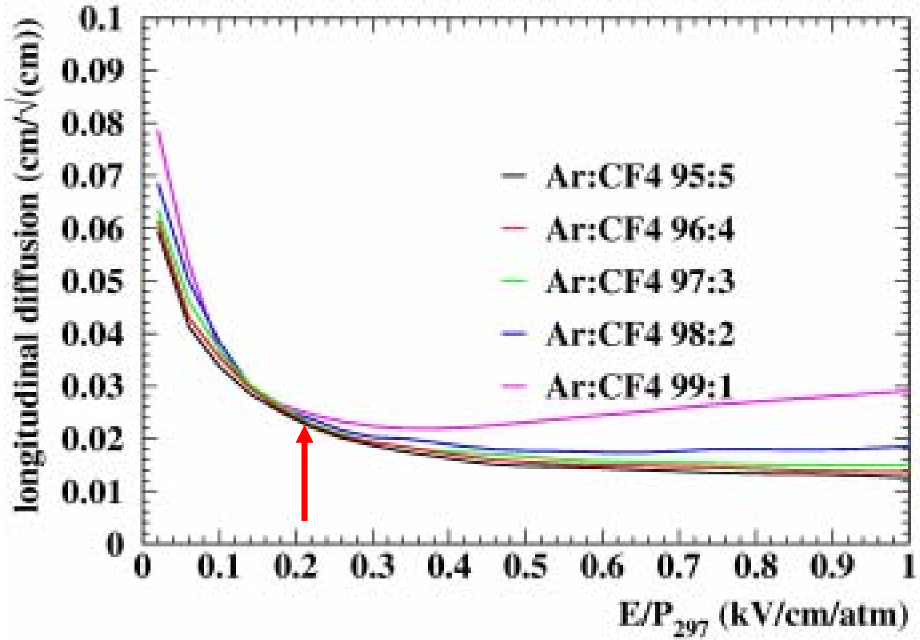
Monte Carlo predicts:

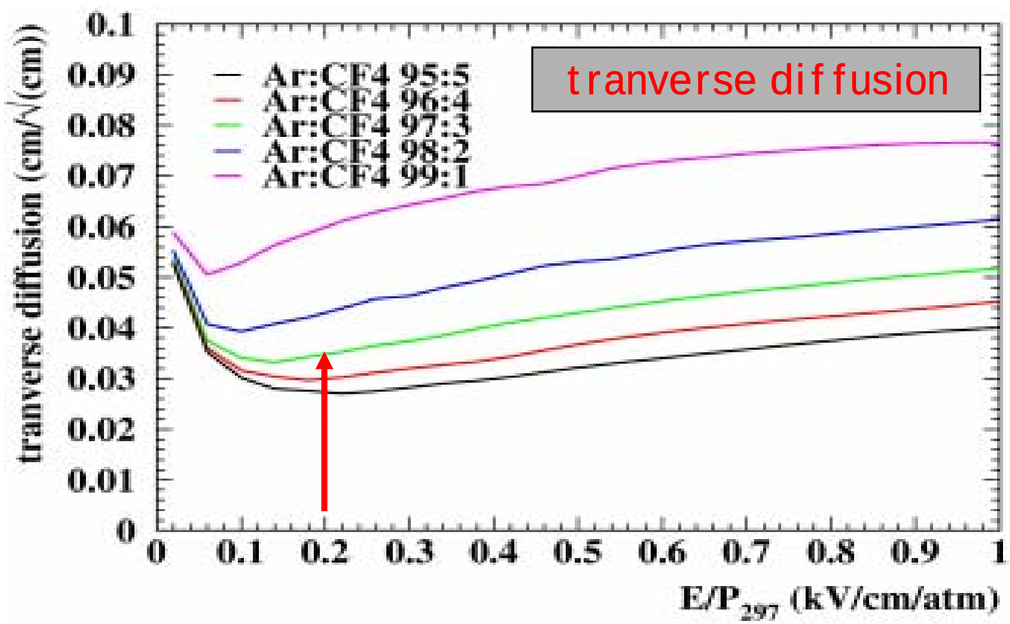
$D_t(B=0) = 350\ \mu m \times cm^{-1/2}$

$D_t(B) = Dt(B=0)/\sqrt{(1+\omega^2\tau^2)}$,

$\omega\tau = 4.5$ at 1T (18 at 4T)
($\omega = eB/m_e$)

=> expect ~75 $\mu m \times cm^{-1/2}$ for B=1T





Ar-CF_4: transverse diffusion

measurement in the cosmic setup :

1. compute the rms width of hits for each track.

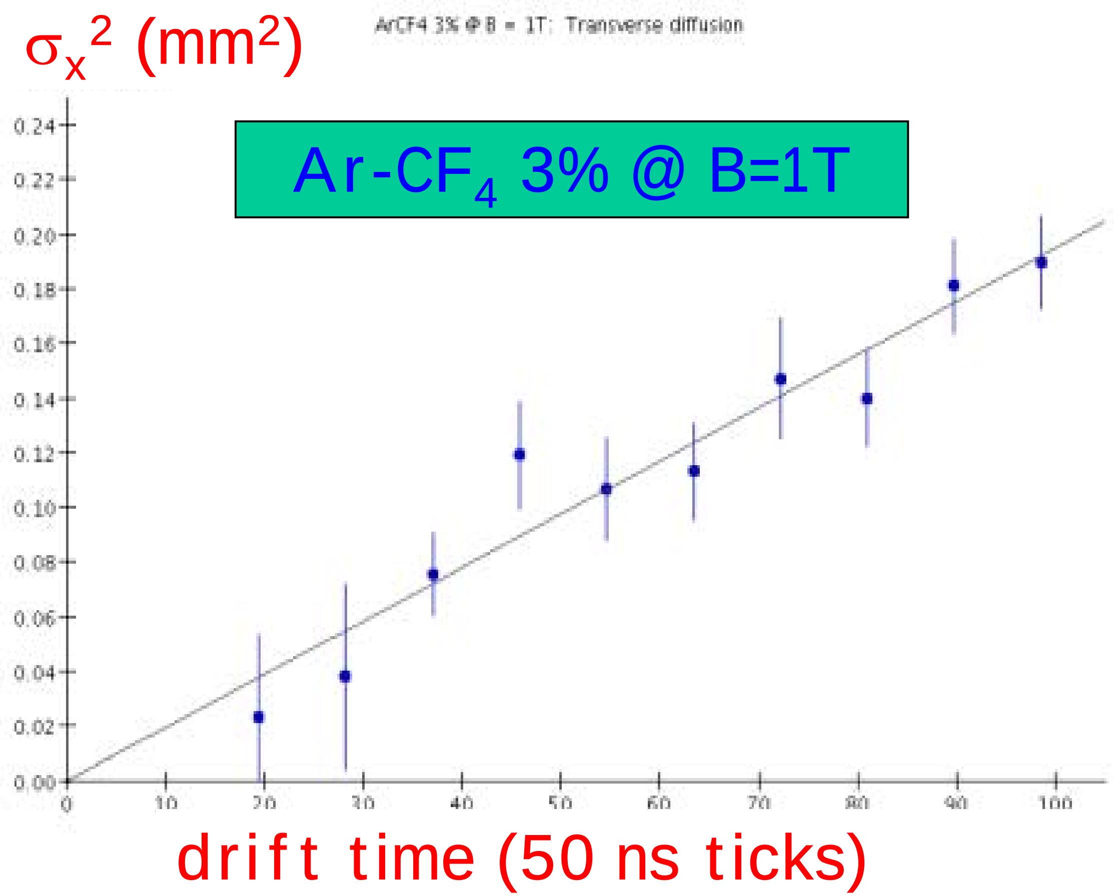
2. plot σ_x^2 as a function of the drift time

3. fit to a straight line

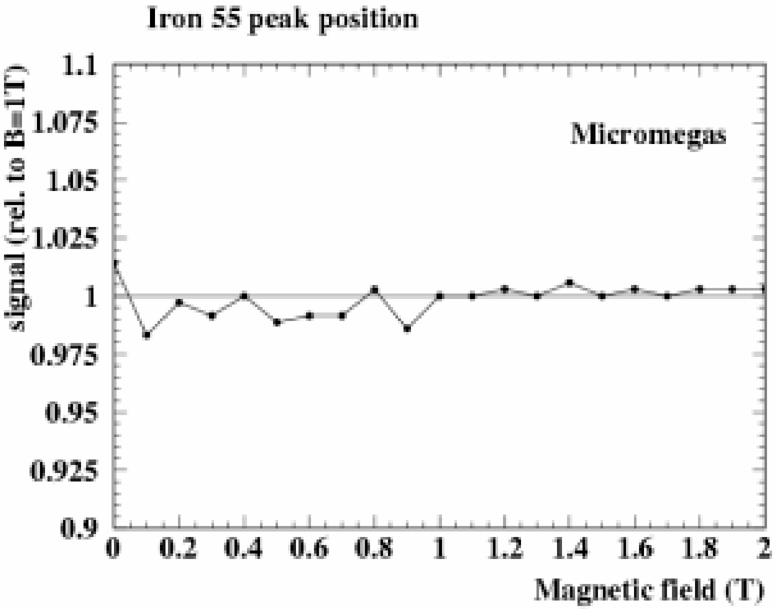
4. obtain the transverse diffusion constant at B=1T:

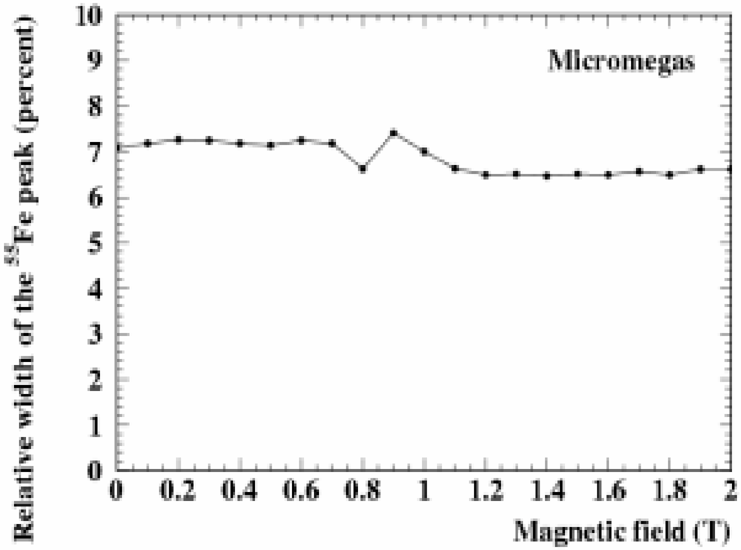
D_t = 63 $^{+}/_{-}$ 13 $\mu m/cm^{-1/2}$

consistent with expectation of 75 μm.



stability of operation of Micromegas in a magnetic field





15 cm TPC ⊗ ^{55}Fe ⊗ B

stability of the position and width of the ^{55}Fe peak as a function of the magnetic field

potential point resolution

problem:

extrapolating to B=4T ($\omega\tau$=18): D_t=15-20 μmxcm$^{-1/2}$

=> track width σ= 150-200μm only at 1 m << pad width

- for 1cm long pads (100 electrons/30 clusters)

  potential resolution <50 μm at 1m !

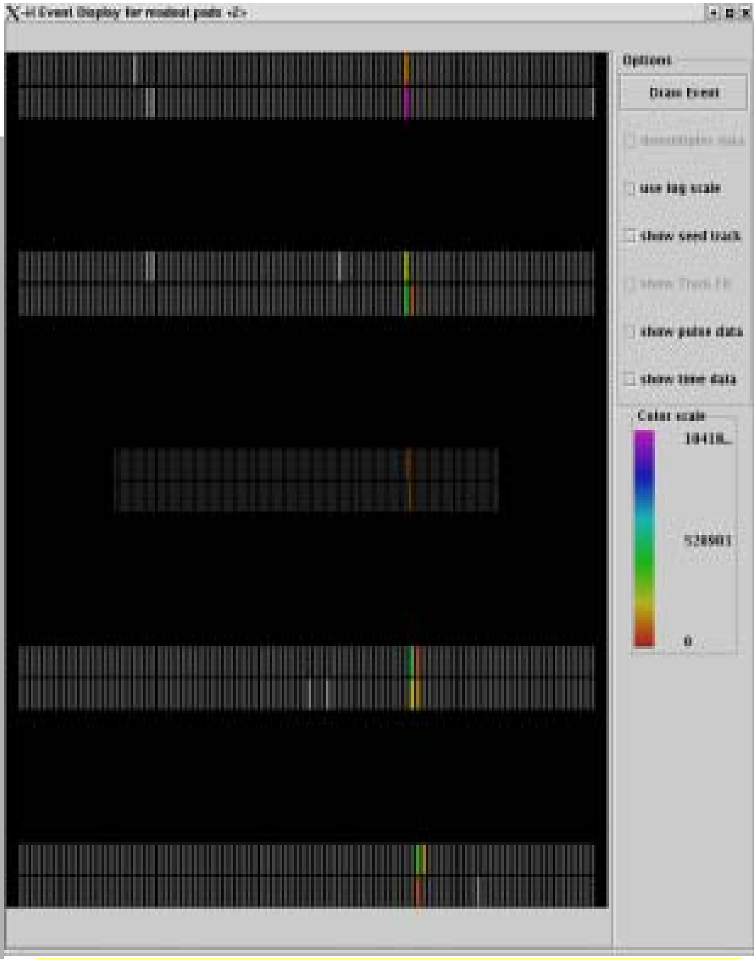
- but this would require ~ 400-500 μm-wide pads :

  $\rightarrow$ too many channels (~10^7) !!!

solutions:

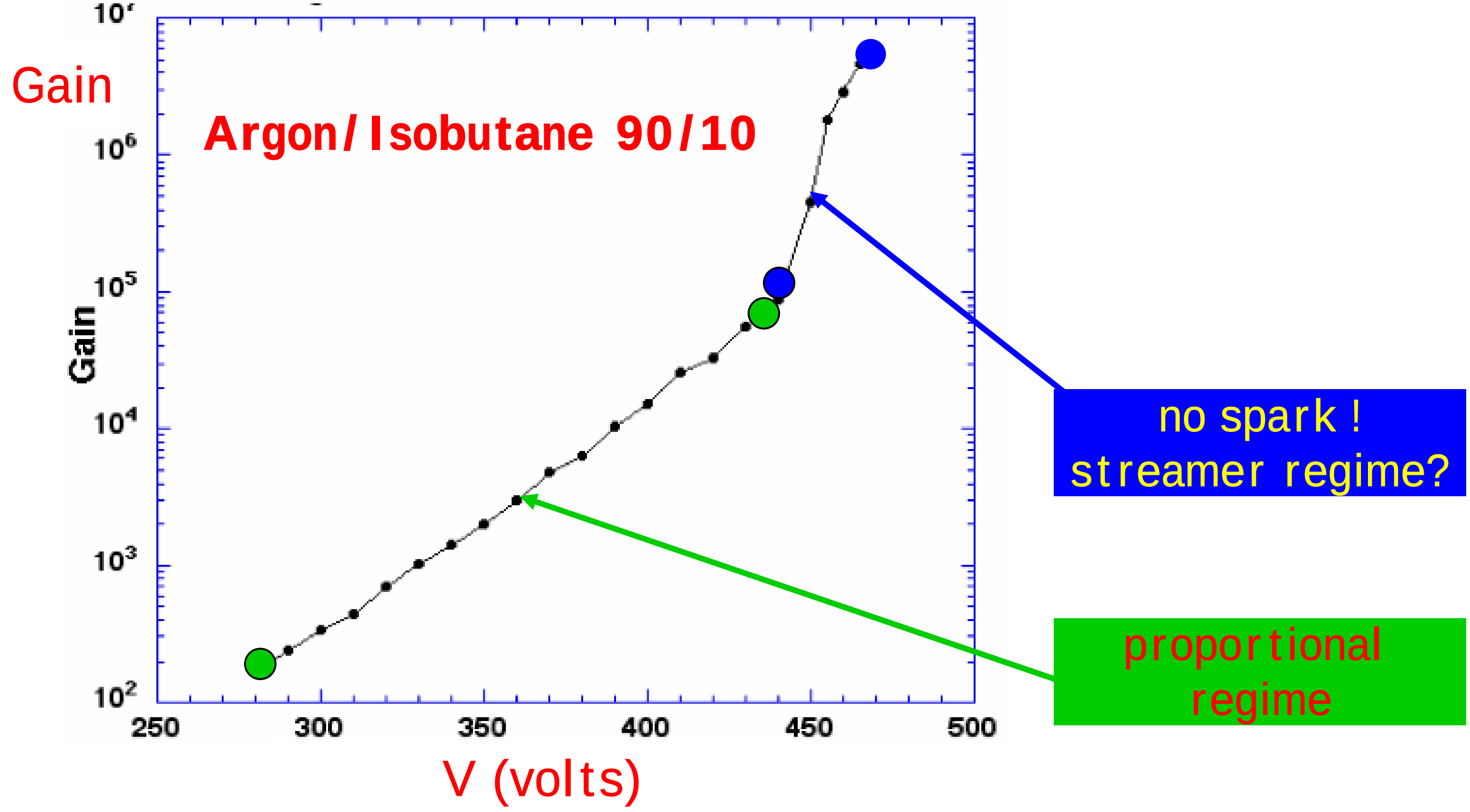
♥ **spread the charge** after amplification (resistive anode for instance)
$\rightarrow$ see presentation by Kirsten Sachs (Carleton)

♥ go to **digital pixels**
$\rightarrow$ see presentation by Jan Timmermans (NIKHEF)



Ar-CF_4 3% V_{mesh}= 340 V
B = 1 Tesla $\omega\tau$ ~ 4.5

Micromegas gain with a resistive anode



very high gain reached in proportional regime

no sparking at high field, stabilizing Micromegas

future

- end of April' 04:

large TPC ⊗B
faster DAQ rate and improved cosmic **trigger**
⇒ spatial resolution studies with B

SACLAY-LBNL-ORSAY

- next weeks:

resistive foil ⊗ small size device
collaboration with Ottawa for X-rays,
and with IPN for a point-like electron source.
⇒ spatial resolution studies

OTTAWA-SACLAY-ORSAY

- after summer:

resistive foil ⊗ large TPC ⊗ B
cosmic rays data taking with B

SACLAY-LBNL-ORSAY-OTTAWA

- next months:

pixel studies with small size devices

SACLAY-NIKHEF

- bulk detector

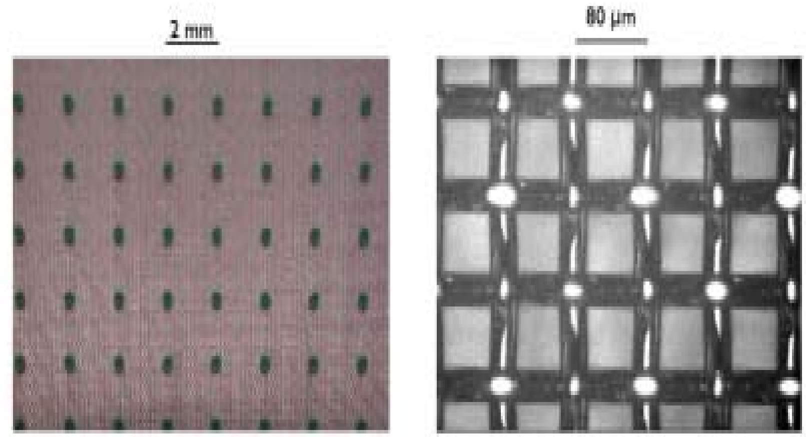
(next page)

SACLAY-CERN-PCC

- beam tests in the future ???

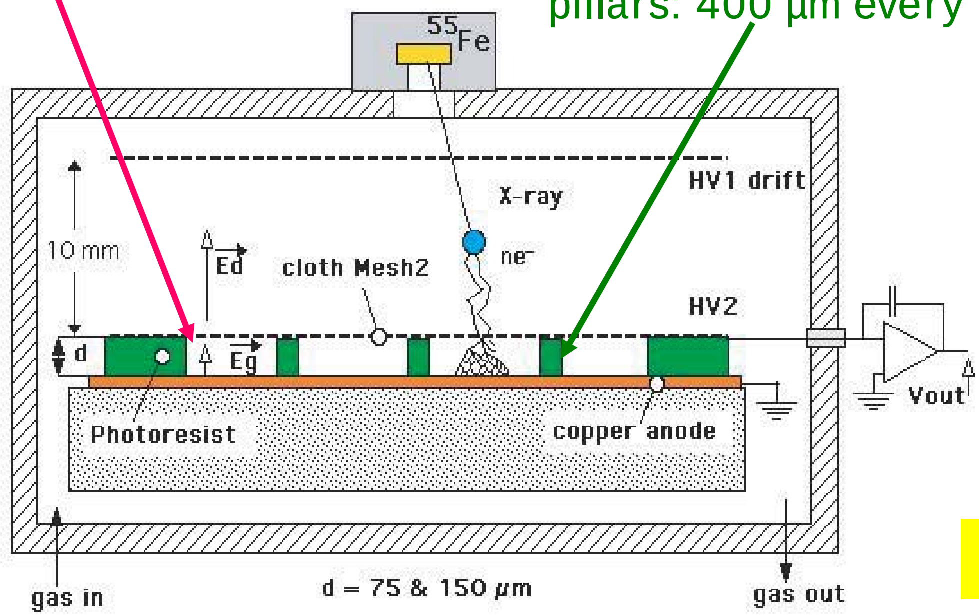
"bulk" detector

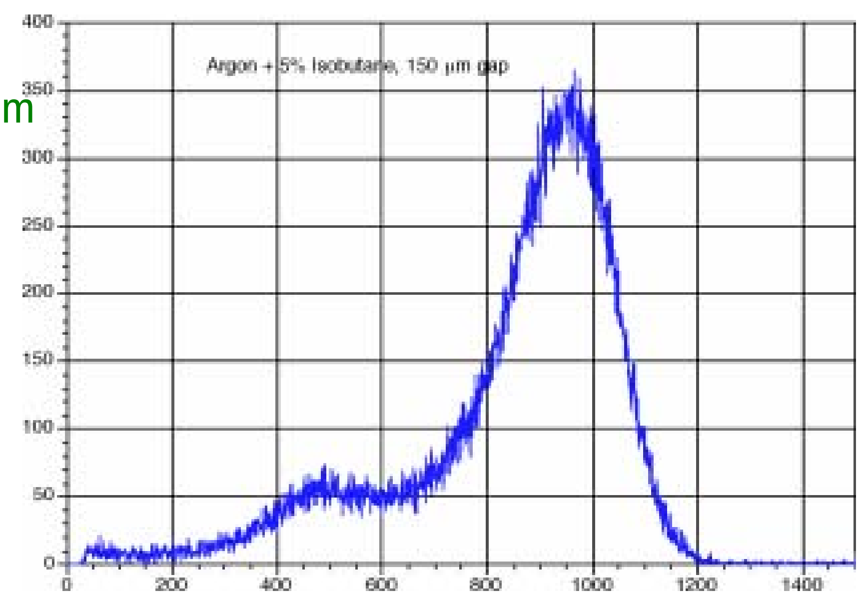
- ♥ simple process based on the PCB (Printed Circuit Board) technology
- ♥ woven wire mesh (inexpensive, large size)
- ♥ many metals available (Ni, Fe, Cu, Ti, Au…)
- ♥ low cost fabrication and robustness



cloth mesh laminated at high temperature

photo resistive film thickness 75 or 150 µm
pillars: 400 µm every 2mm





first measurements obtained at Saclay

summary and conclusions 1

results:

• gas:

experimental tests and Monte Carlo studies allowed us to limit the choice of gas mixtures for Micromegas. Ar-CF_4 is one of the favorite and is working well (many days of continuous working at high gain with only a few discharges and without loss of performances).

• ion backflow:

theoretical and experimental studies have demonstrated that it can be suppressed down to the 3 permil level.

• magnetic field:

OK, Micromegas is working without any alteration of its performances.

summary and conclusions 2

a large TPC read out by **Micromegas** is now in operation in a 2T magnet:

→ we are expecting new results in the next months on the spatial and energy resolutions:

- with cosmic rays (large TPC and B)
- with X rays and electrons (small devices and resistive foils)
- with cosmic rays (large TPC + resistive + B)

→ also:

- pixel studies (NIKHEF) are promising
- bulk Micromegas in development (including resistive plane?) for a major simplification (cost, handling, robustness, etc.)