Micromegas TPC studies in a 5 Tesla magnetic field with a resistive readout

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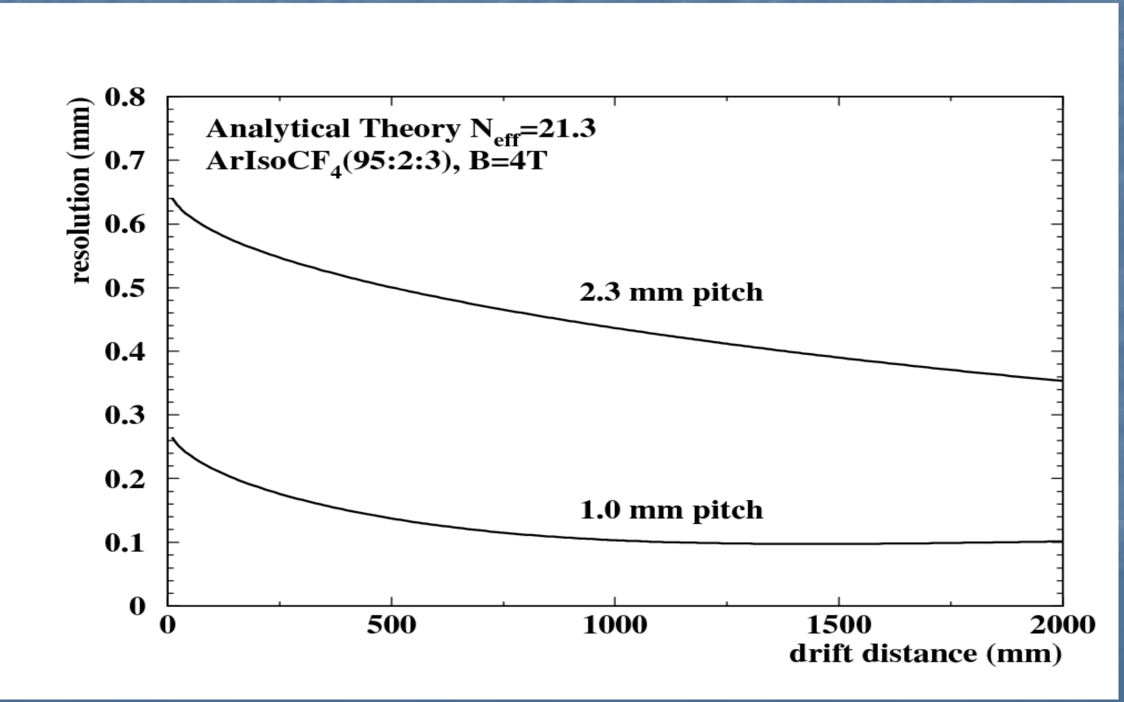
(COSMo Collaboration)

Motivation

- With 2mm x 6mm pads, an ILC-TPC has 1.2 10^6 channels, with consequences on cost, cooling, material budget...
- 2mm still too wide to give the target resolution (100-130 µm)

Not enough charge sharing, even for 1mm wide pads in the case of Micromégas

($\sigma_{avalanche}$ ~12µm)

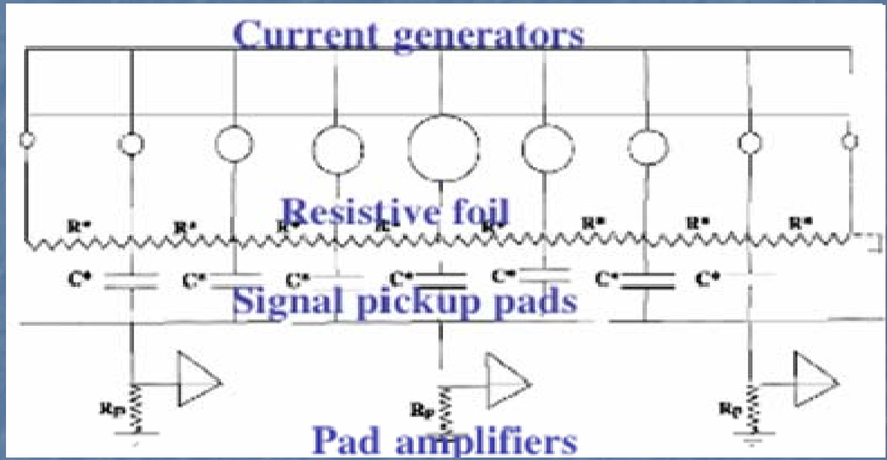


Solution

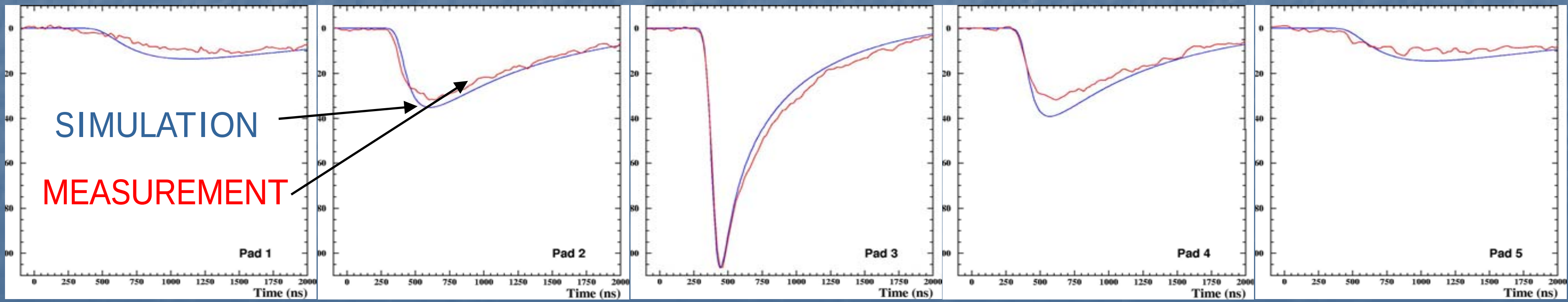
(*M.S.Dixit et.al., NIM* A518 *(2004) 721.*)

Share the charge between several neighbouring pads after amplification, using a resistive coating on an insulator.

The charge is spread in this continuous network of R, C

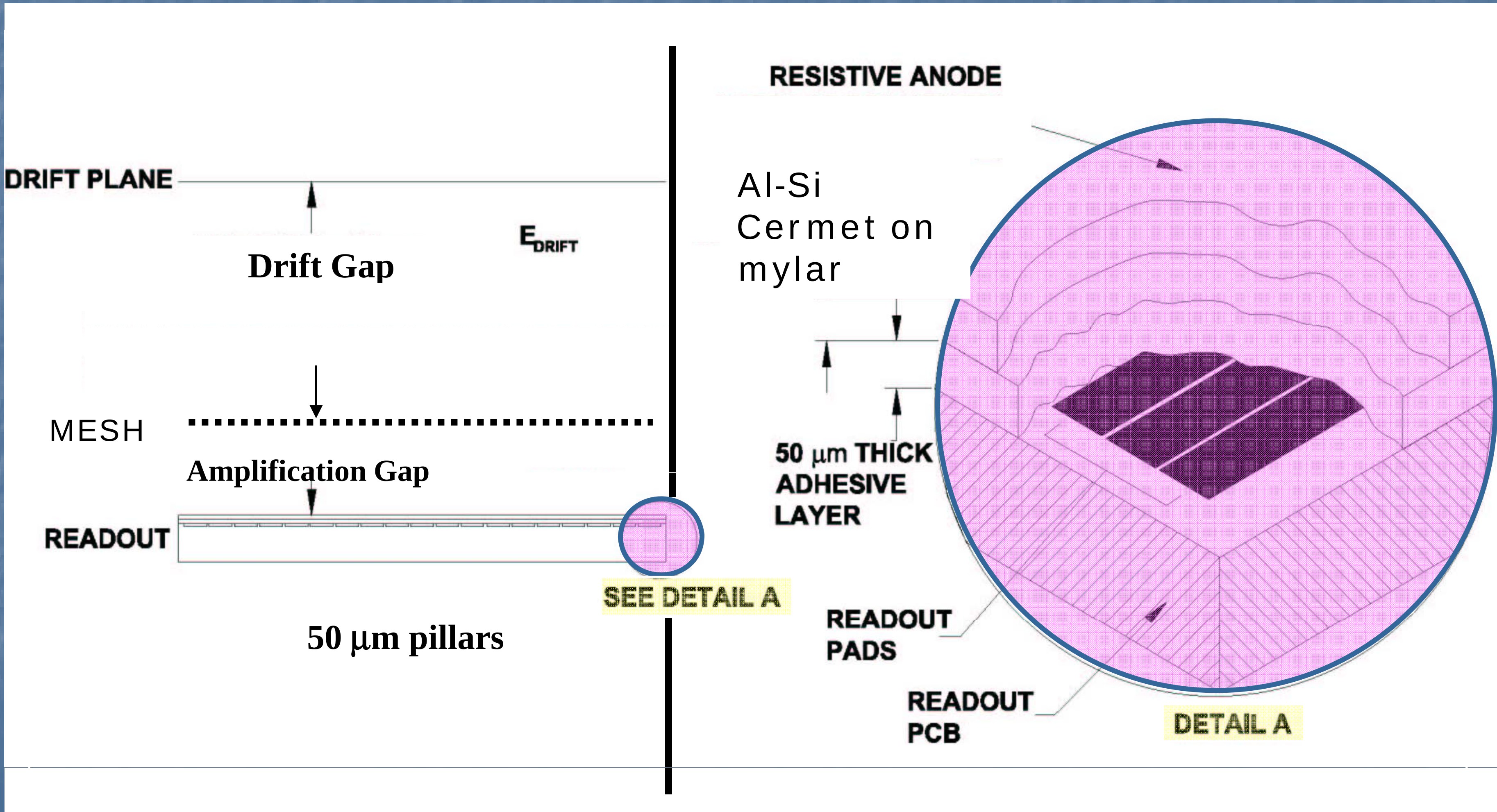


M.S.Dixit and A. Rankin NIM A566 (2006) 281



25 µm mylar with Cermet (1 MΩ/☐) glued onto the pads with 50 µm thick dry adhesive

Cermet selection and gluing technique are essential

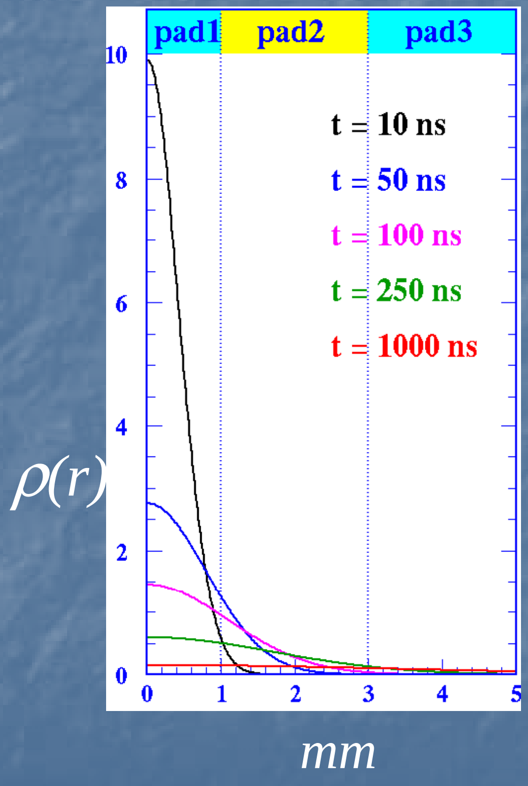


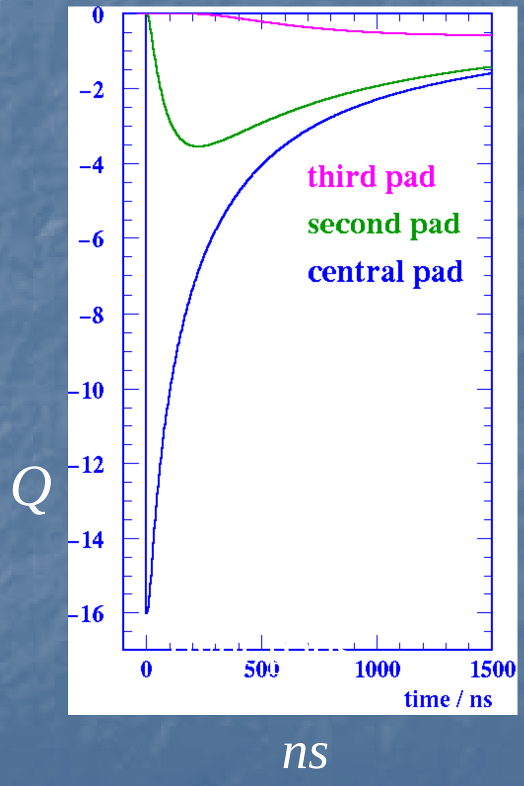
A point charge being deposited at t=0, r=0, the charge density at (r,t) is a solution of the 2D telegraph equation.

Only one parameter, RC (time per unit surface), links spread in space with time. R~1 MΩ/□ and C~1pF per pad area matches µs signal duration.

$$\frac{\partial \rho}{\partial t} = \frac{1}{RC}\left[\frac{\partial^2 \rho}{\partial r^2} + \frac{1}{r}\frac{\partial \rho}{\partial r}\right]$$

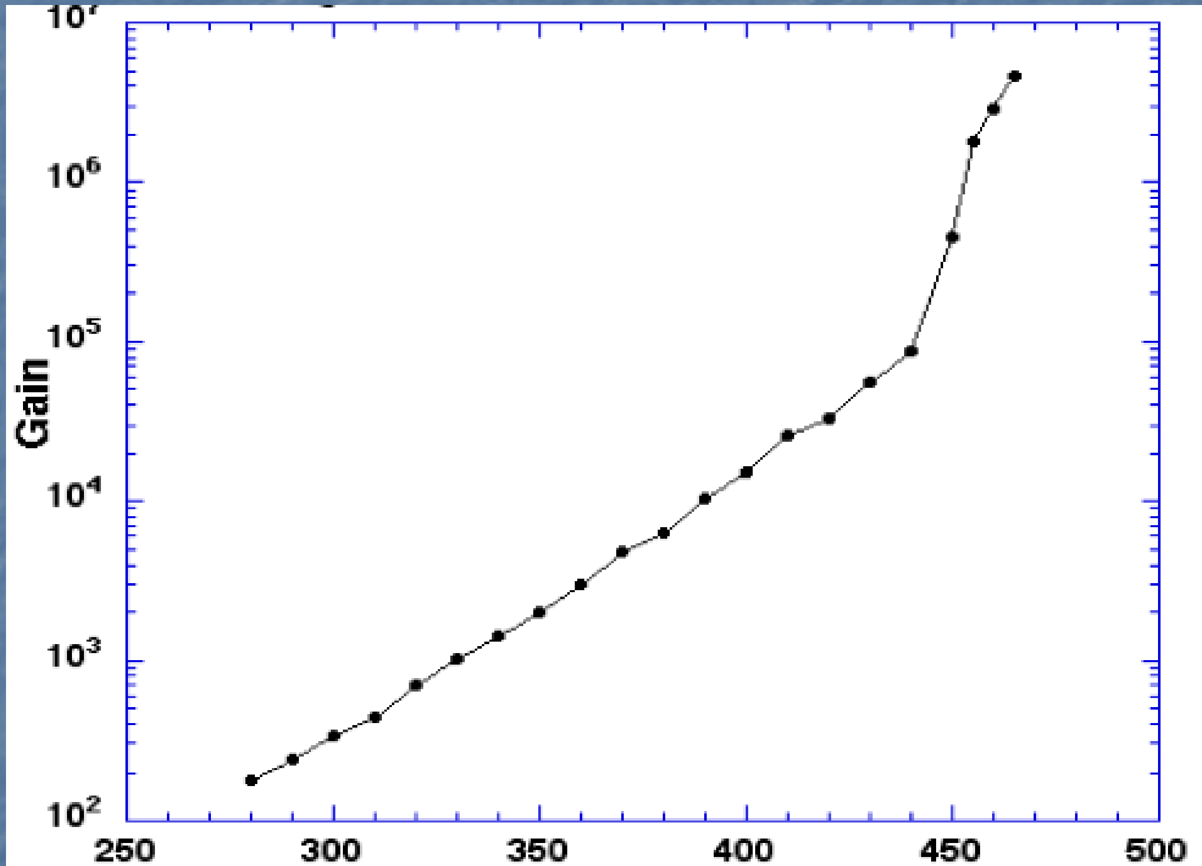
$$\Rightarrow \rho(r,t) = \frac{RC}{2t} e^{\frac{-r^2 RC}{4t}}$$





Another good property of the resistive foil: it prevents charge build-up, thus prevents sparks.

Gains 2 orders of magnitude higher than with standard anodes can be reached.



Mesh voltage (V)

Reminder of past results

- Demonstration with GEM + C-loaded kapton in a X-ray collimated source (M.S.Dixit et.al., Nucl. Instrum. Methods A518 (2004) 721)
- Demonstration with Micromegas + C-loaded kapton in a X-ray collimated source (unpublished)
- Cosmic-ray test with GEM + C-loaded kapton (K. Boudjemline et.al., to appear in NIM)
- Cosmic-ray test with Micromegas + AlSi cermet (A. Bellerive et al., in Proc. of LCWS 2005, Stanford)
- Beam test and cosmic-ray test in B=1T at KEK, October 2005

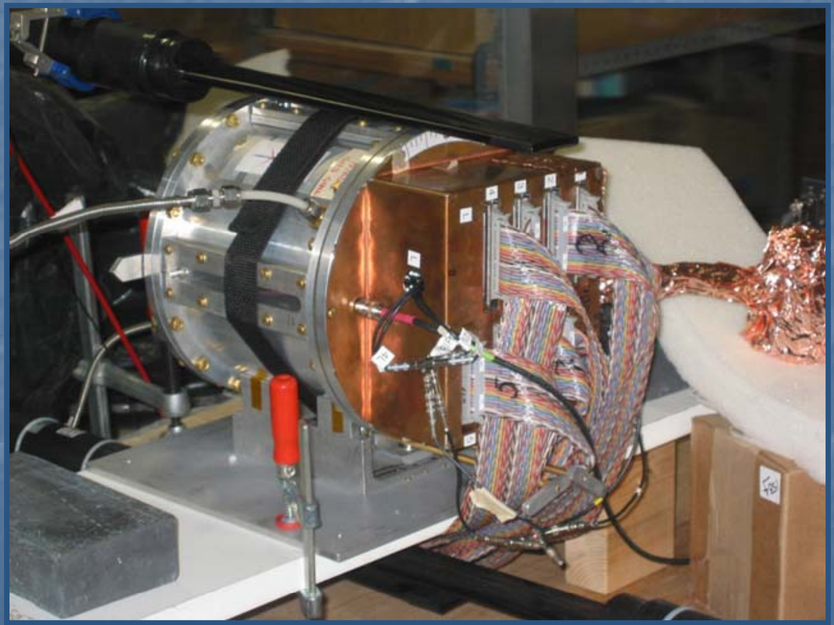
The Carleton chamber

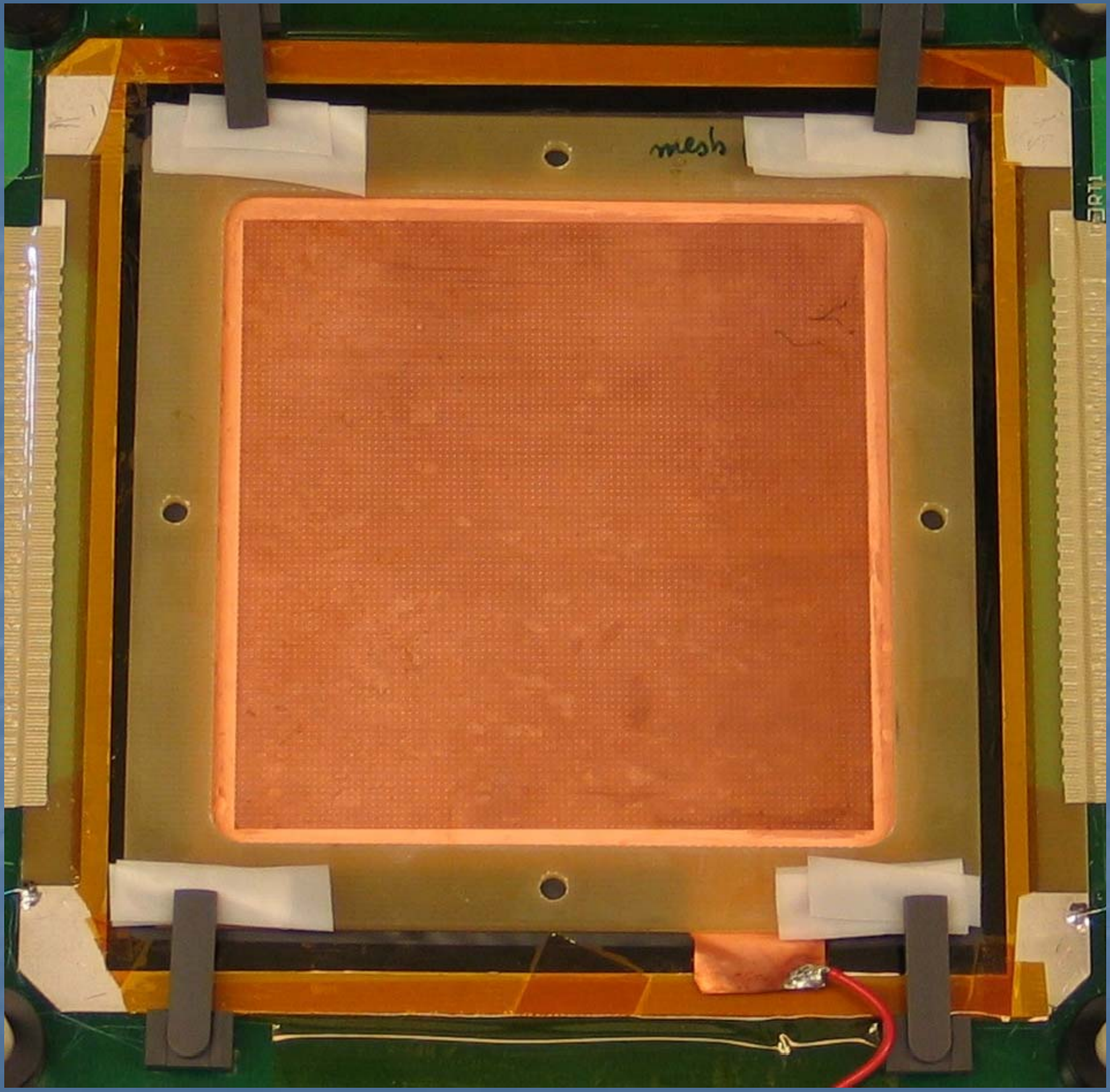
Carleton-Saclay Micromegas endplate with resistive anode.

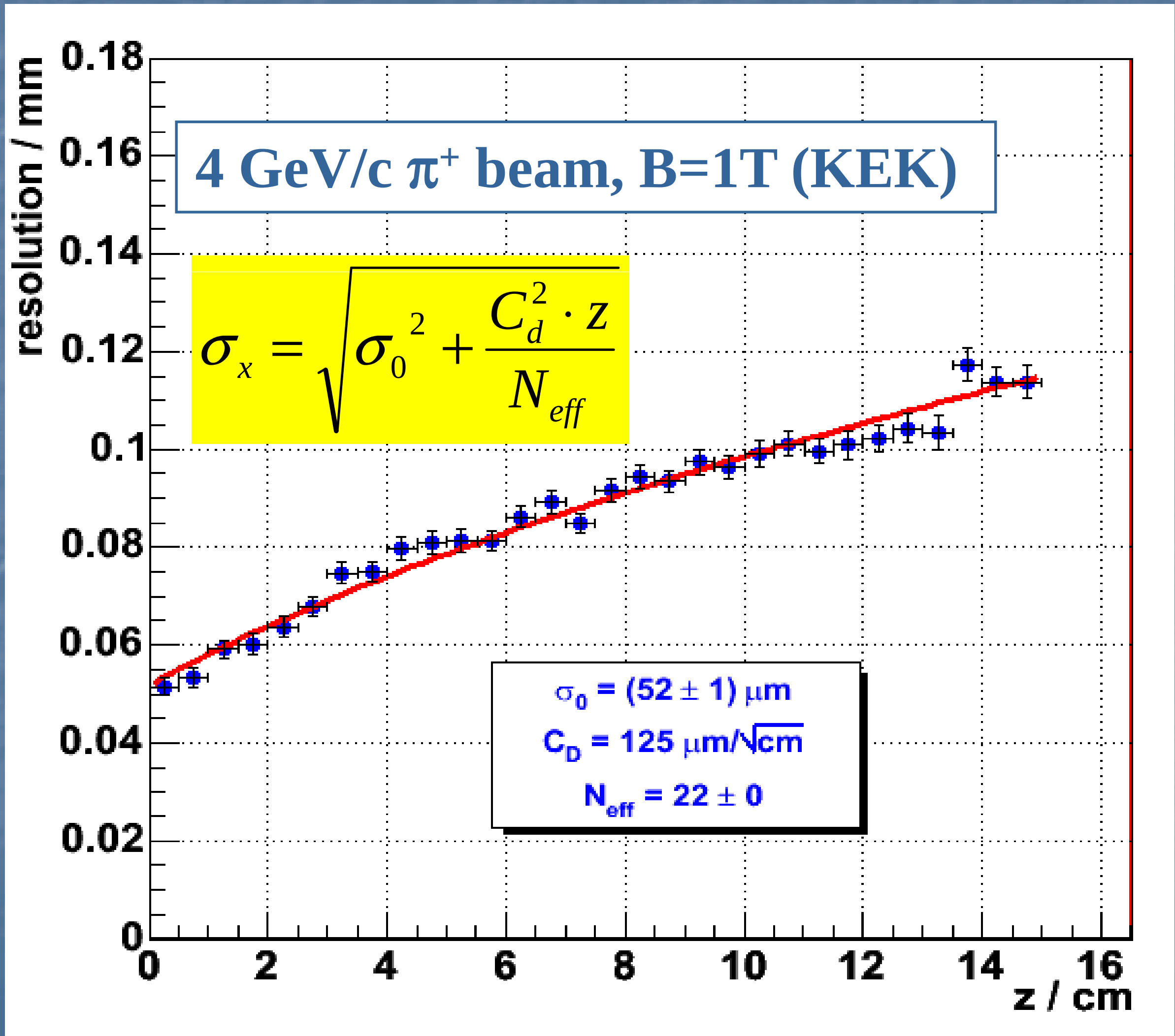
128 pads (126 2mmx6mm in 7 rows plus 2 large trigger pads)

Drift length: 15.7 cm

ALEPH preamps + 200 MHz digitizers




mesh



Effect of diffusion: should become negligible at high magnetic field for a high τ gas

The 5T cosmic-ray test at DESY

4 weeks of data taking (thanks to DESY and T. Behnke et al.)

Used 2 gas mixtures:

Ar+5% isobutane (easy gas, for reference)

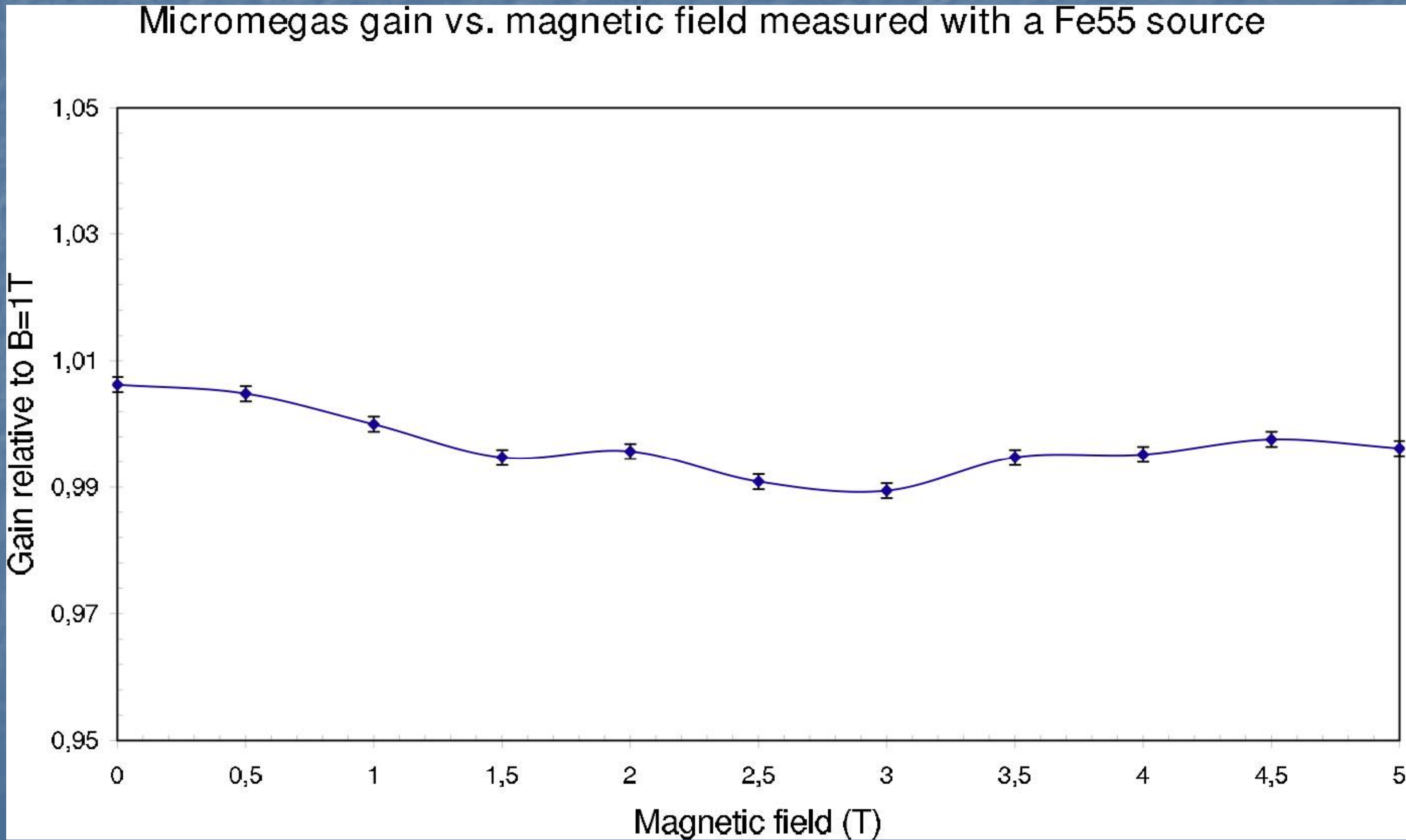
Ar+3% CF4+2% isobutane (so-called T2K gas, good trade-off for safety, velocity, large $\omega\tau$)

Most data taken at 5 T (highest field) and 0.5 T (low enough field to check the effect of diffusion)

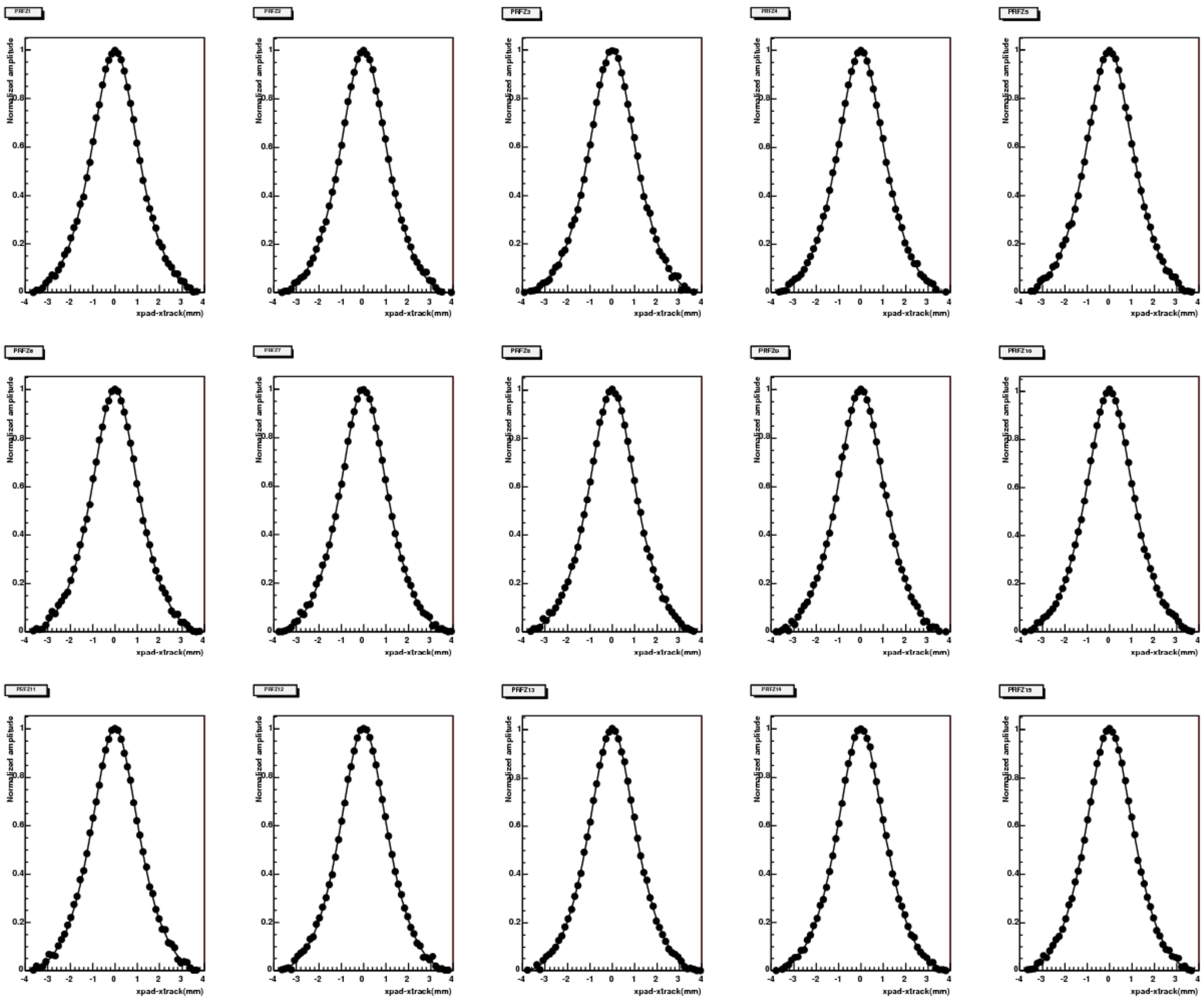
Note: same foil used since more than a year. Still works perfectly.

Was ~2 weeks at T=55° C in the magnet: no damage

The gain is independent of the magnetic field until 5T within 0.5%

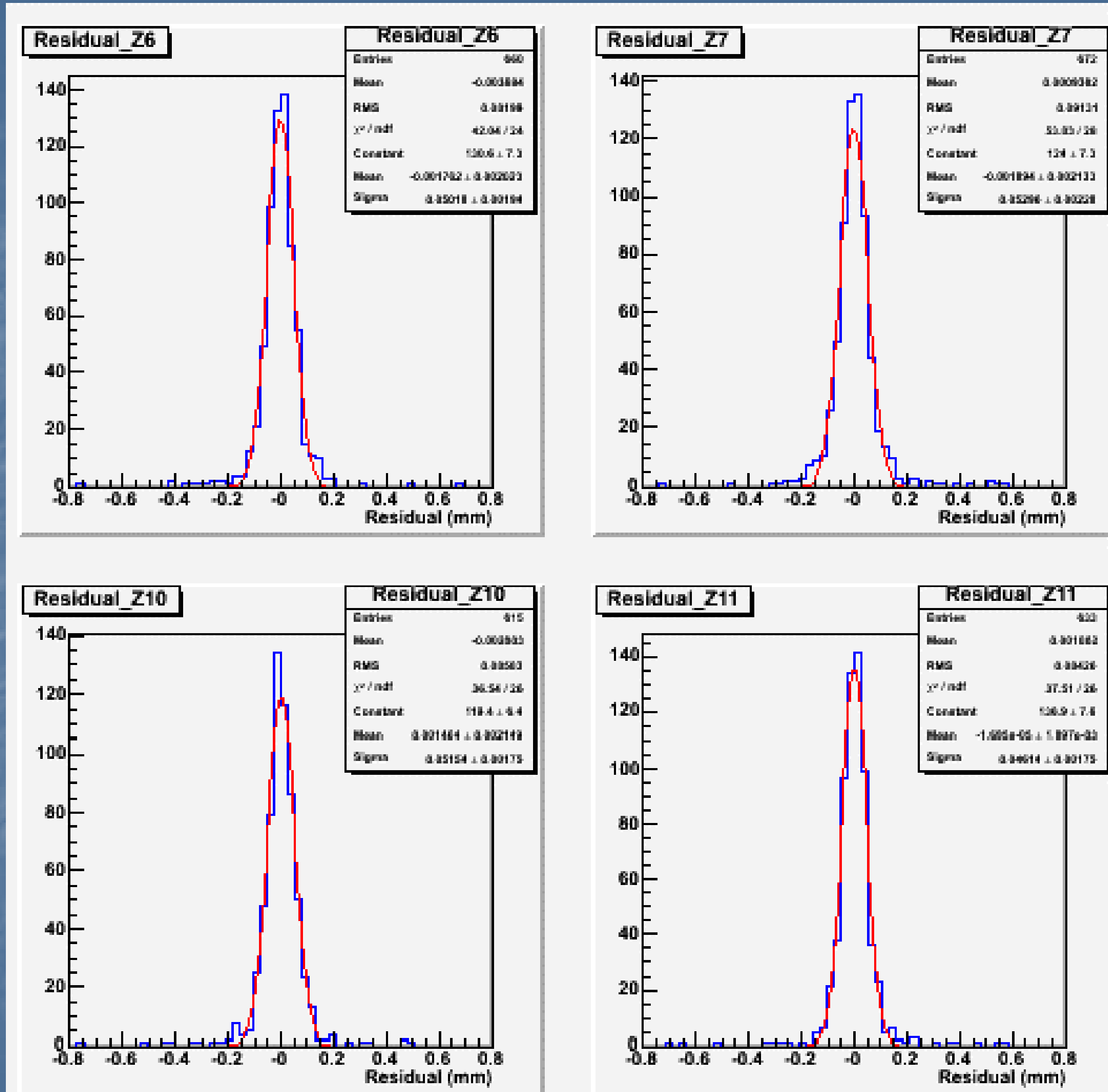


Pad Response Function

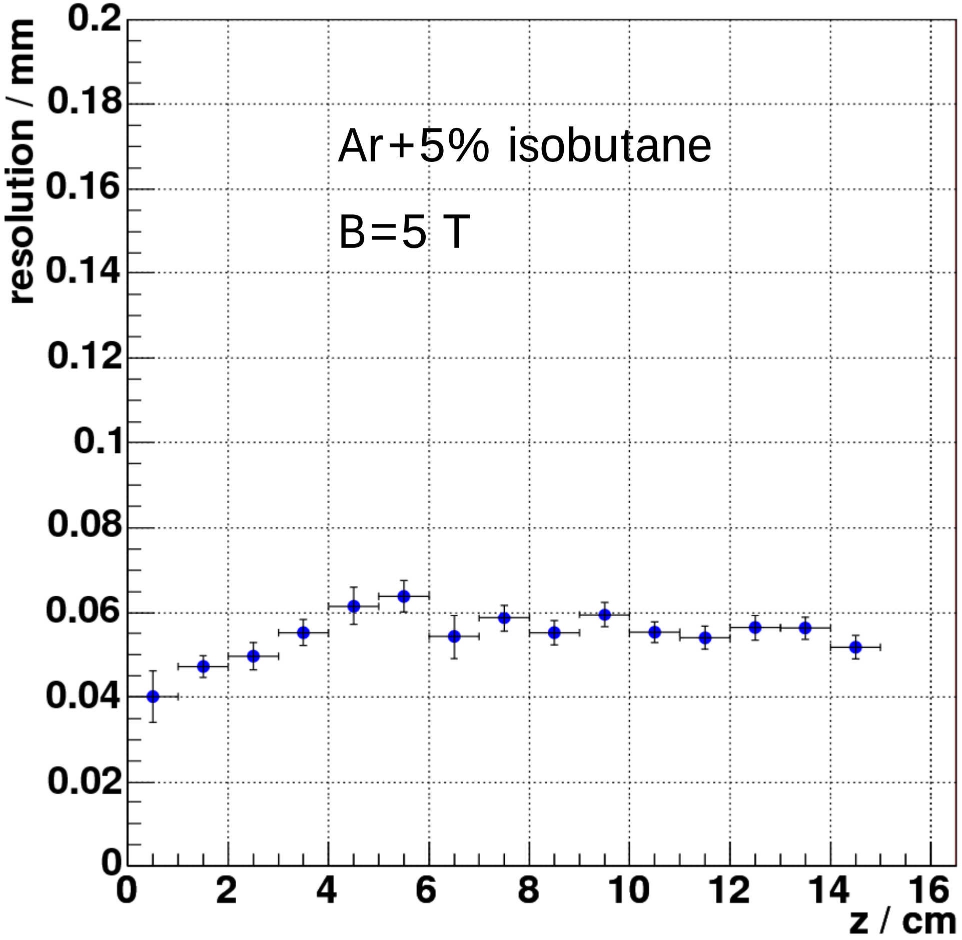


Residuals

in z slices



- Resolution = 50 μ independent of the drift distance



Analysis:

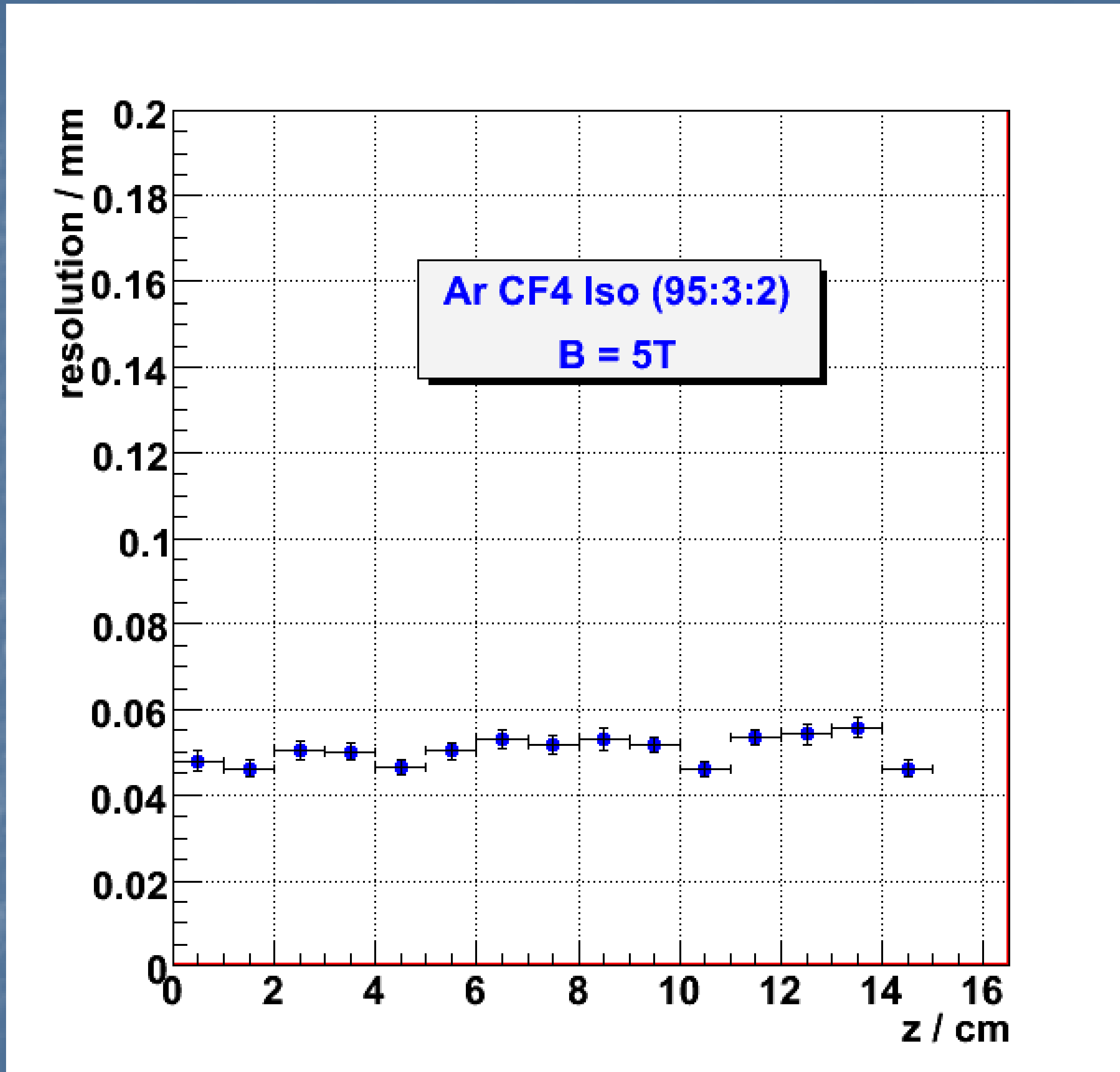
Curved track fit

P>2 GeV

$\phi < 0.05$

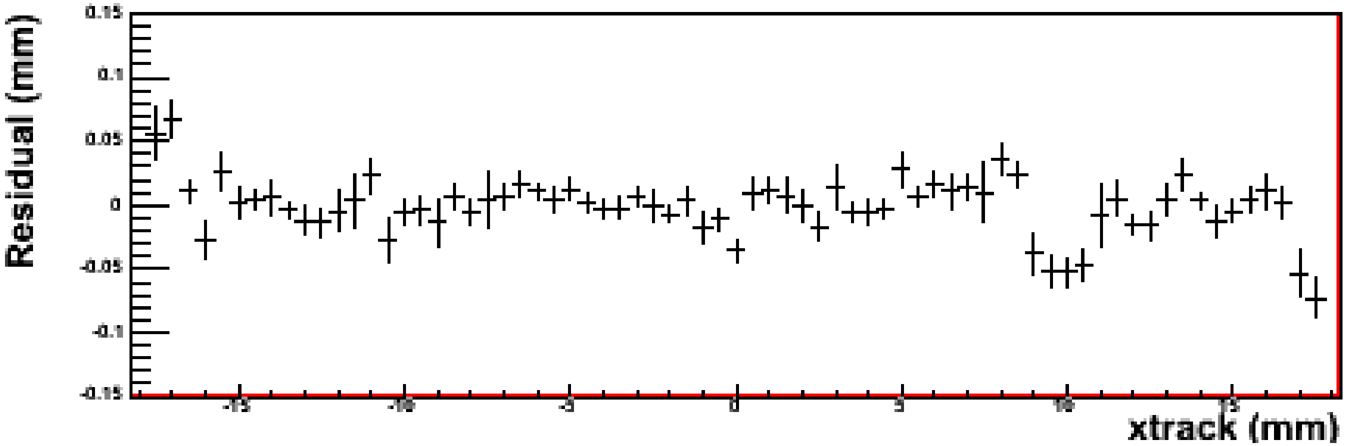
Resolution = 50 μ independent of the drift distance

'T2K gas'

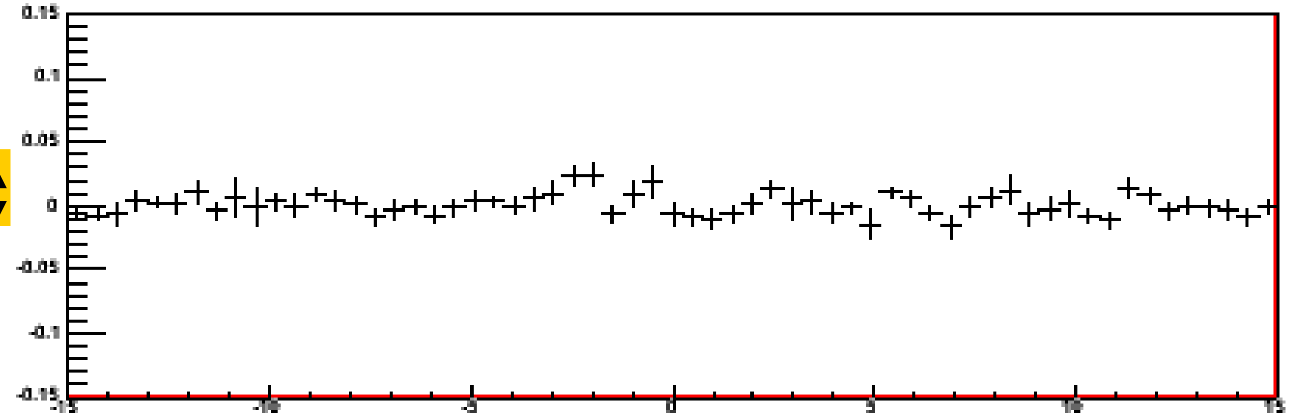


Average residual vs x position

Before bias correction

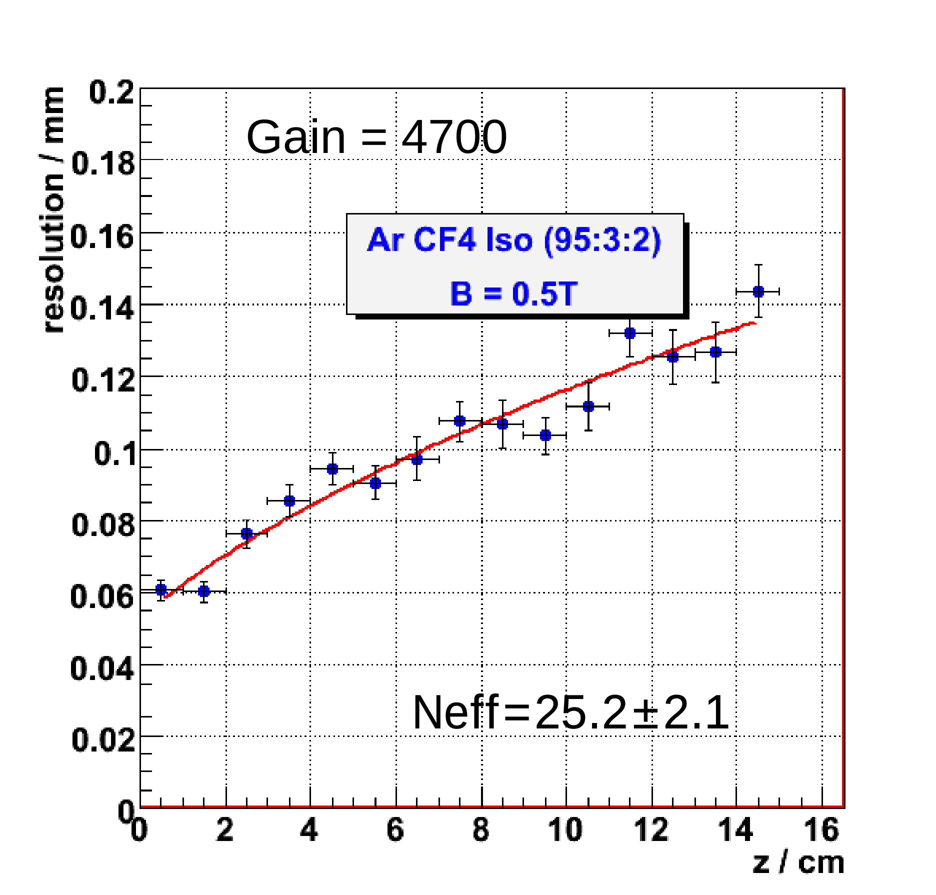


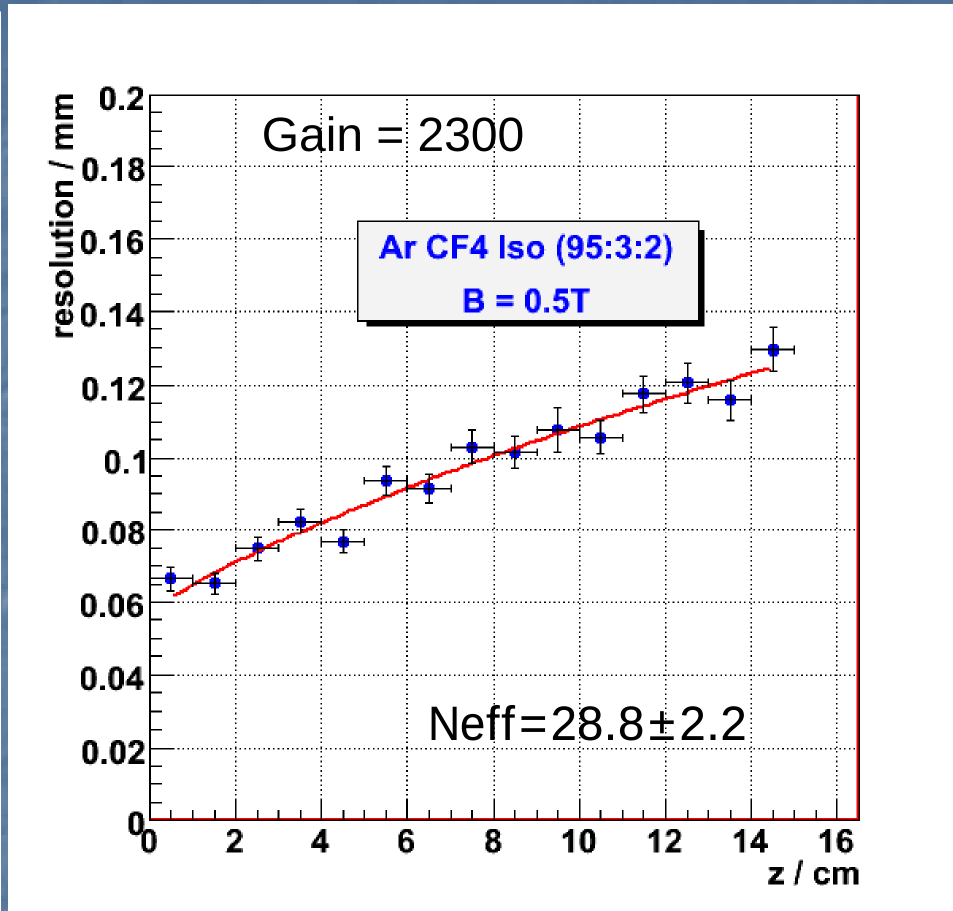
After bias correction



±20 μ

- B=0.5 T
- Resolution at 0 distance ~50 µ even at low gain





At 4 T with this gas, the point resol° is better than 80 µm at z=2m

Even higher B fields possible (A. Yamamoto): new concept?

Further developments

- Try to understand what is the ultimate resolution and what are the limitations
  - Mesh pitch, together with finite primary statistics
  - Amplifier gain spread?
  - Foil inhomogeneity?

  This will be discussed at the TPC Jamboree,

  14-16 March in Aachen
- Make bulk with resistive foil for application to T2K, LC Large prototype, etc...