Tests of Carleton and MPI TPC's with a resistive foil and a Micromegas readout at the KEK PS beam

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on behalf of the

Canada, France, Germany, Japan, Philippines collaboration

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MPI, Germany, DAPNIA-CEA, Saclay, IN2P3-LAL and IPN, Orsay, France

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why this collaboration?

- 1T-magnet and 4 GeV/c hadron beam available at KEK
- 2 TPCs existing at Carleton (Ottawa) and MPI (Munich)
- read-out technologies developped previously at Saclay (Micromegas) and Carleton (resistive layer)

\+ many people enthusiast to cooperate !

→ 3 weeks of beam data taking in 2005 (June and October)

outline

- why a resistive layer ?
- how does it work ?

} remind!

- experimental set-up (TPCs and beam)
- PRF and spatial resolution results
- future and conclusion

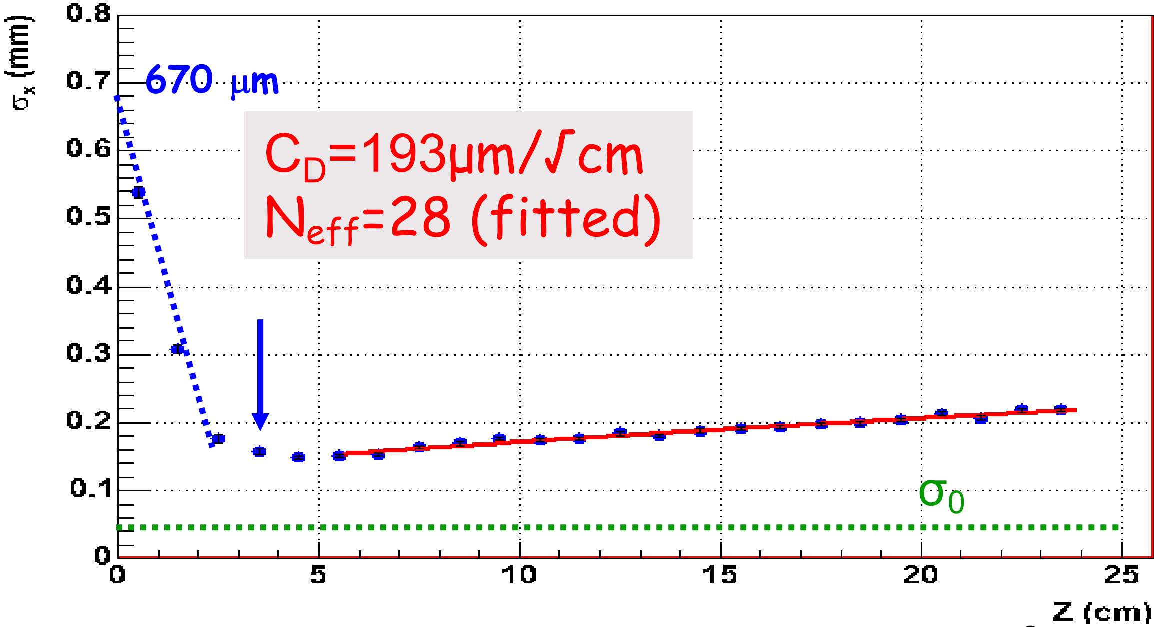
why a resistive layer ?

transverse resolution from the **full** simulation of the of the MPI Micromegas TPC (by Khalil Boudjemline, Carleton, Ottawa), with these characteristics:

2.3 x 6.3 mm^2 pads, $Ar\text{-}iC_4H_{10}$: 95-5%, B = 1T, E=200V/cm, mean gain= 10000

the spatial transverse resolution results from three contributions:

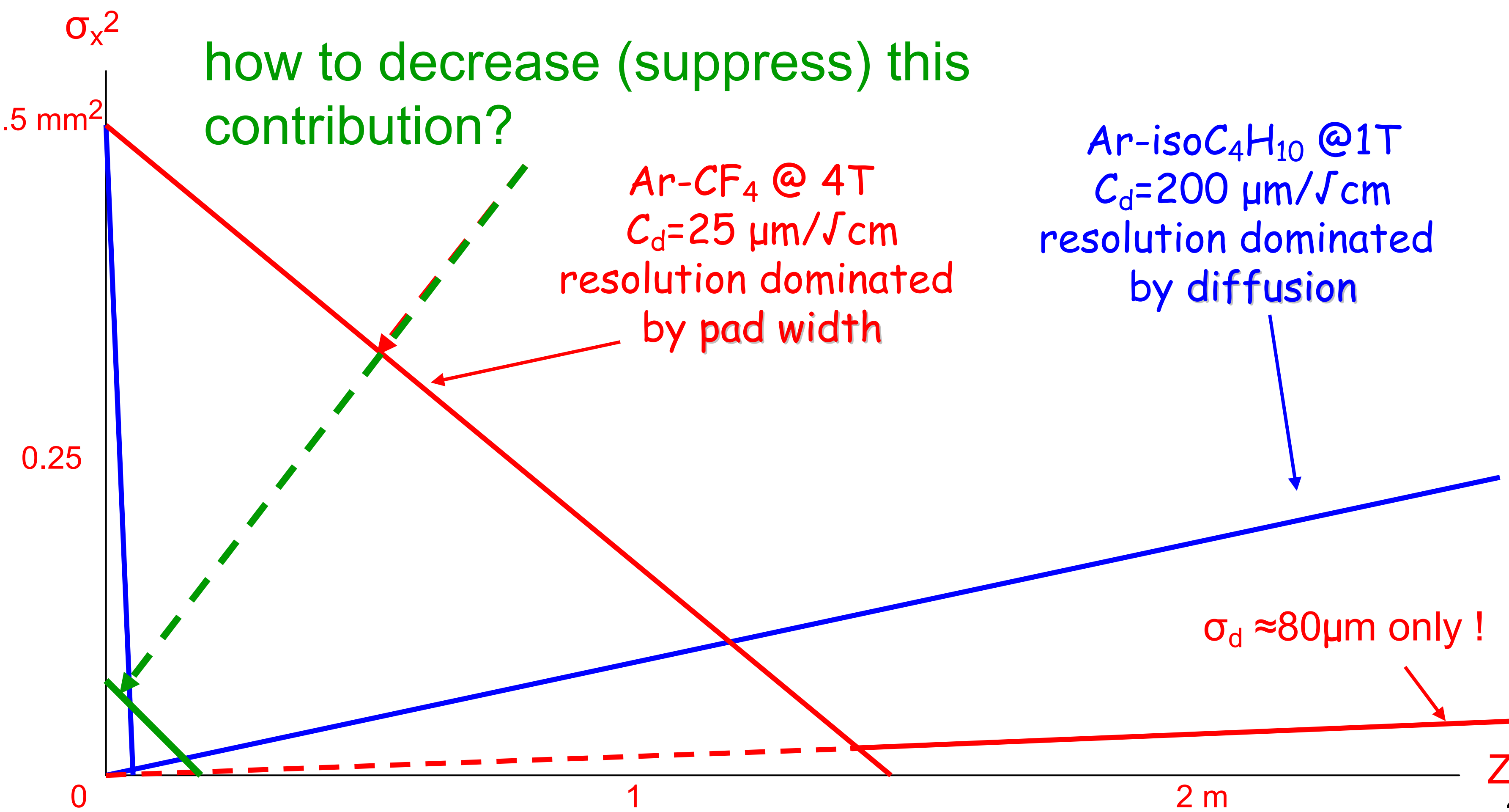
- a **constant term σ_0** mainly due to electronics, noise, …
- a term coming from **the finite pad width** s ($s/\sqrt{12} \approx 670\mu m$ for $\Phi \approx 0$, Z=0)
- a **diffusion term** $\propto \sqrt{Z}$ (and $\propto 1/\sqrt{N_{eff}}$)



how to extrapolate the transverse resolution to:

a 250cm long TPC with a low diffusion gas mixture

for example $Ar\text{-}CF_4$ at 4T, C_d=25 µm/√cm (200) with ωτ≈20 (2.5)



how to decrease (suppress) the pad width contribution?

1. **decrease** by a factor (>5?) the **pad width** ⇒ 10^7 channels irrealistic (loss of resolution with Φ angle)

   but leads to a **new promising concept of digital TPC**:
   minipads (<<1mm²), with **single electron** detection
   (see presentations by Jan Timmermans , Klaus Desch & Michael Hauschild)

2. **diffuse electrons AFTER** multiplication (proposed by VL)

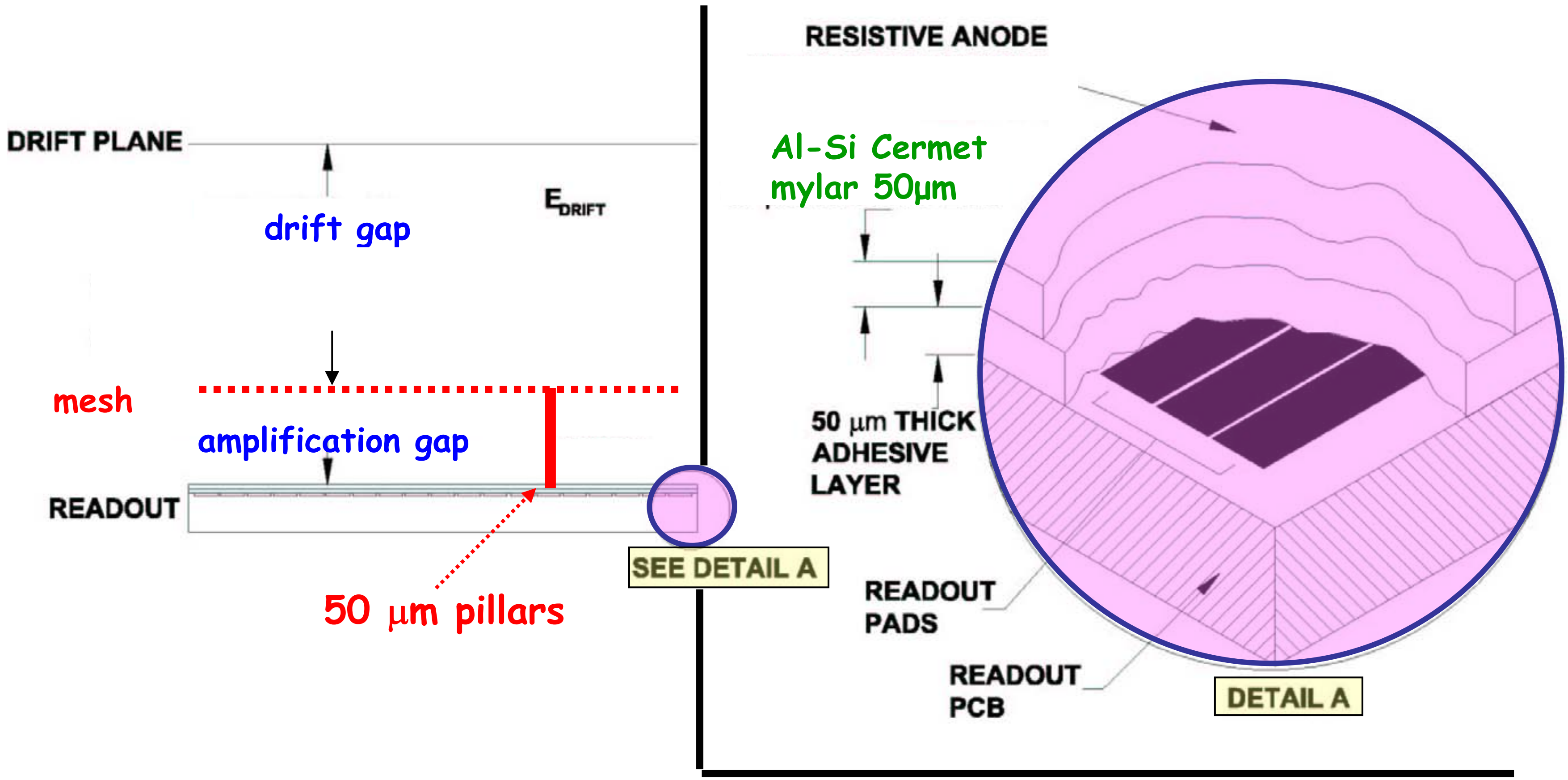
   «impossible» with Micromegas
   difficult with GEM: needs for $\sigma_{diff} \approx$ 700-800μm (for 2mm pad width),
   i.e. typically ~3cm defocusing at 2-3 kV/cm

3. set a **resistive foil** on the pad plane

   proposed by Madhu Dixit (Carleton, Ottawa) ~4 years ago ←

idea:

a uniform high resistivity 1 MΩ/□ Al-Si Cermet is glued on the pad plane



for more info: see presentation by Madhu Dixit at the ILC 2005 Snowmass workshop

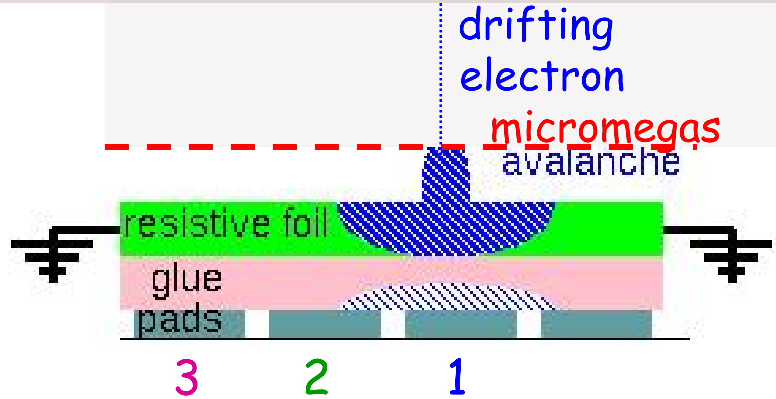
charge dispersion with a resistive anode

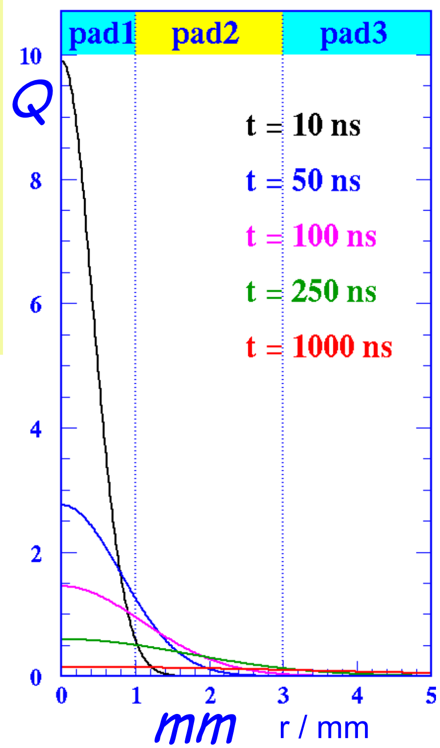
- Micromegas anode with a highly 50µm resistive film bonded to a readout plane with an insulating spacer.
- 2-dimensional continuous RC network defined by material properties(R) & geometry (C).
- point charge at $r = 0$ & $t = 0$ disperses with time.
- time dependent anode charge density sampled by readout pads.

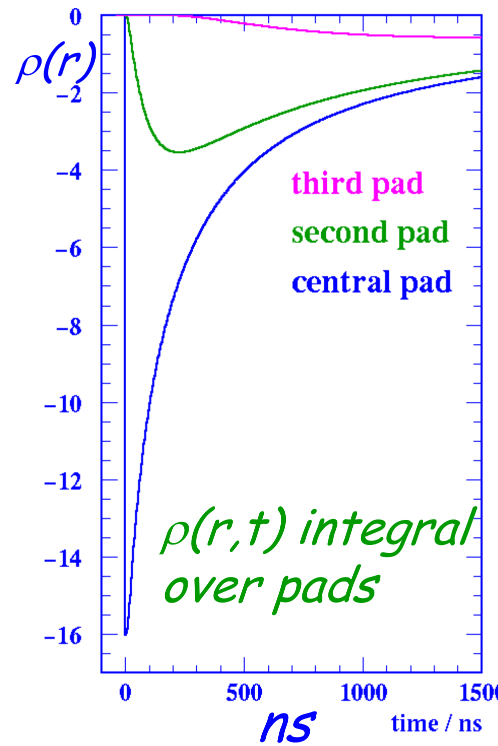
the charge evolution in r and t is the "telegraph" equation, governed by the RC time constant parameter:

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

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







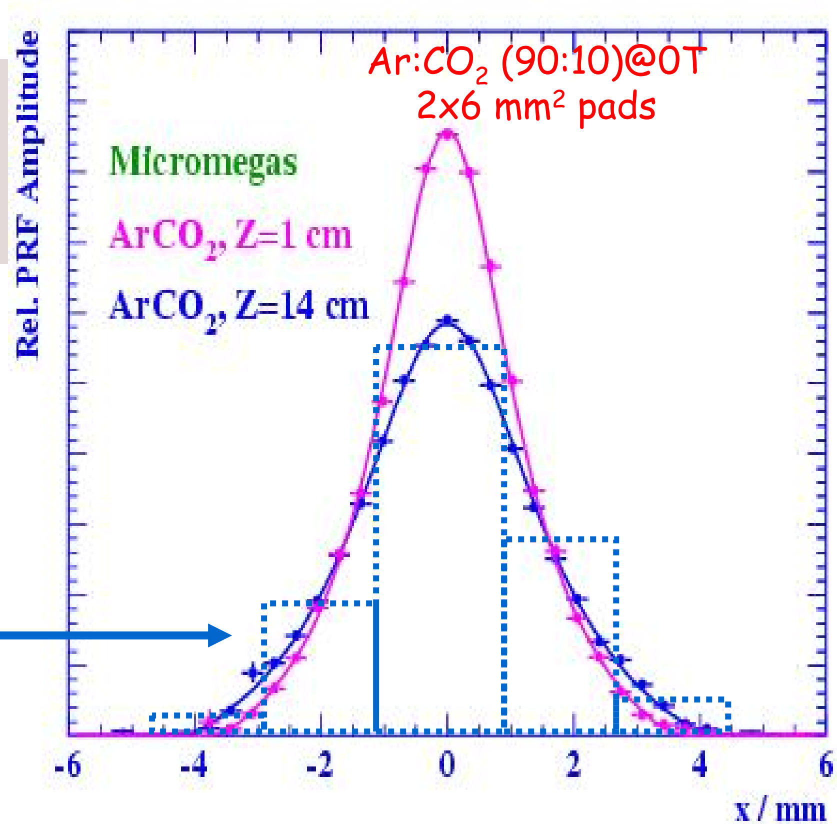
TPC track PRFs with Micromegas

- the PRF (Pad Response Function) is not Gaussian
- the PRF depends on track position relative to the pad PRF = PRF(x,z)
- PRF can be characterized by its FWHM $\Gamma(z)$ & base width $\Delta(z)$.
- PRFs determined from the data have been fitted to a functional form consisting of a ratio of two symmetric 4th order polynomials.

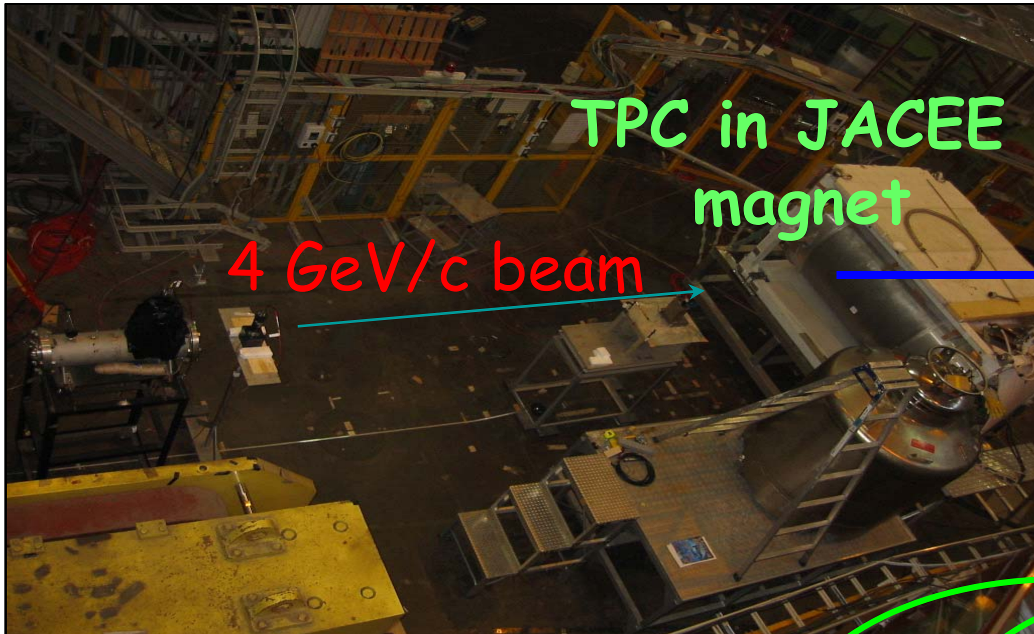
$$PRF[x,\Gamma(z),\Delta,a,b] = \frac{(1+a_2x^2+a_4x^4)}{(1+b_2x^2+b_4x^4)}$$

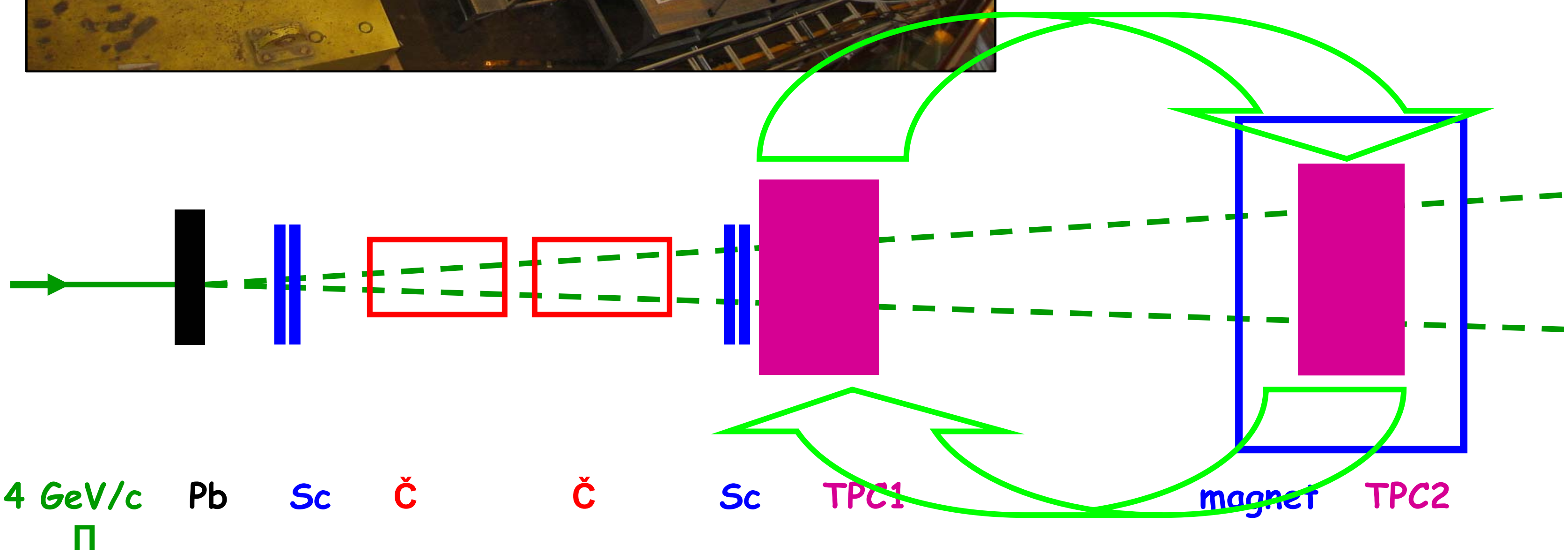
a_2, a_4, b_2 & b_4 can be written down in terms of Γ and Δ & two scale parameters a & b.

the PRF fits well with at least three pads

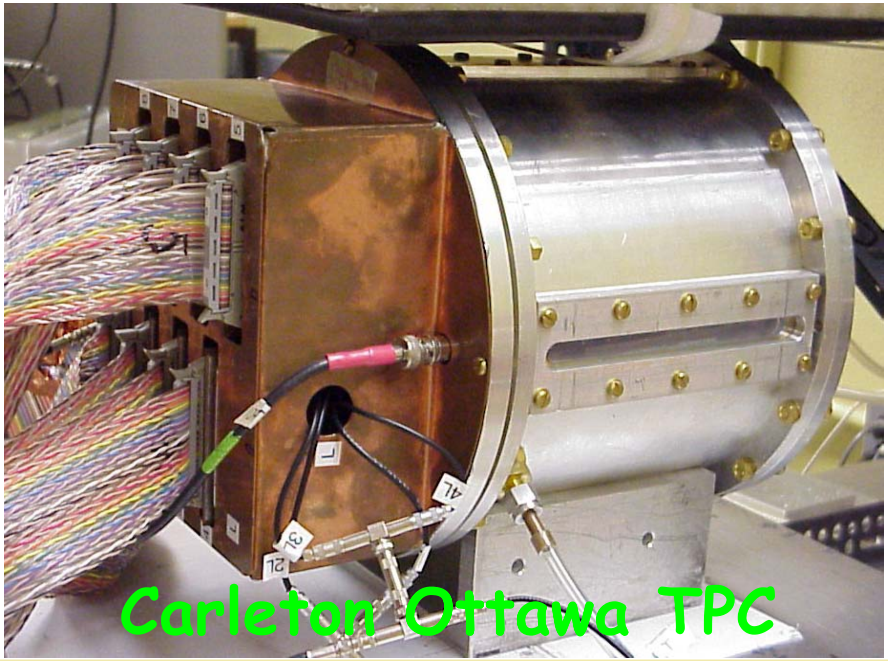


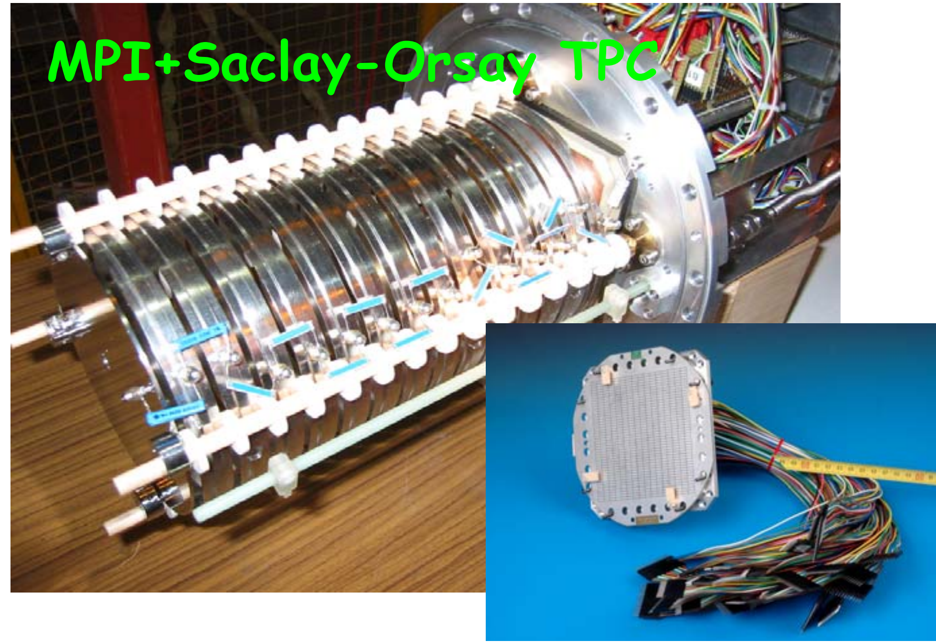
experimental set-up at KEK: the beam line





experimental set-up at KEK: the two TPC's



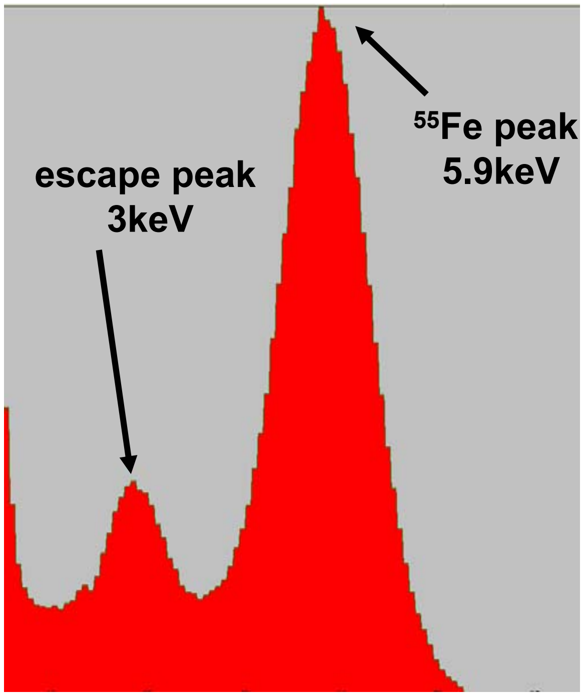


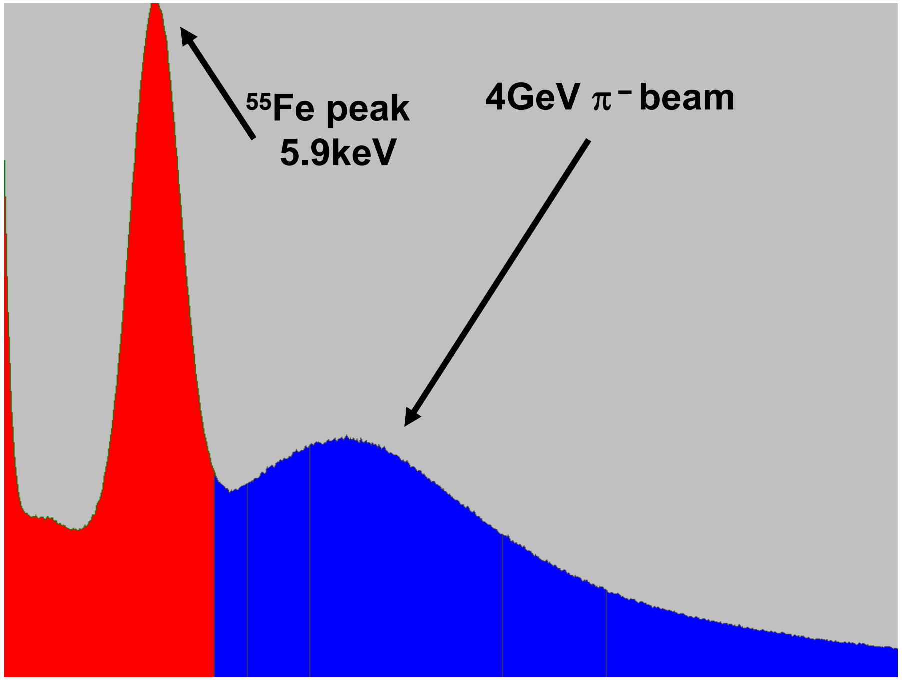
- Micromegas mesh 10x10 cm2
- drift distance: 16 cm
- 126 2.3 x 6.3 mm^2 pads in 7 rows
- ALEPH preamps + 25MHz Montréal FADC
- gas mixtures:
  Ar-5%isoC_4H_{10} B=1T,80kevts@220&80V/cm
  Ar-10%CO_2 B =0T,80kevts
- evt rate ~3Hz (2.5 Gb/hr).
- beam $\pi^+/\pi^-/e$

- Micromegas mesh 10x10 cm^2
- drift distance 26cm
- 512 2x6.3 mm2 pads in 16 rows
- ALEPH preamps + 11MHz FADC
- gas mixtures:
  Ar-5%isoC_4H_{10} B=1T,19kevts@220V/cm
  " B=1T,20kevts@80V/cm
  " B=1T,11kevts@Φ=10°
  Ar-10%CO_2 B=0T,14 kevts
- evt rate ~0.3Hz
- beam $\pi^+/\pi^-/e$

detector quality control plots

energy resolution σ= 8% for Ar-5%isobutane

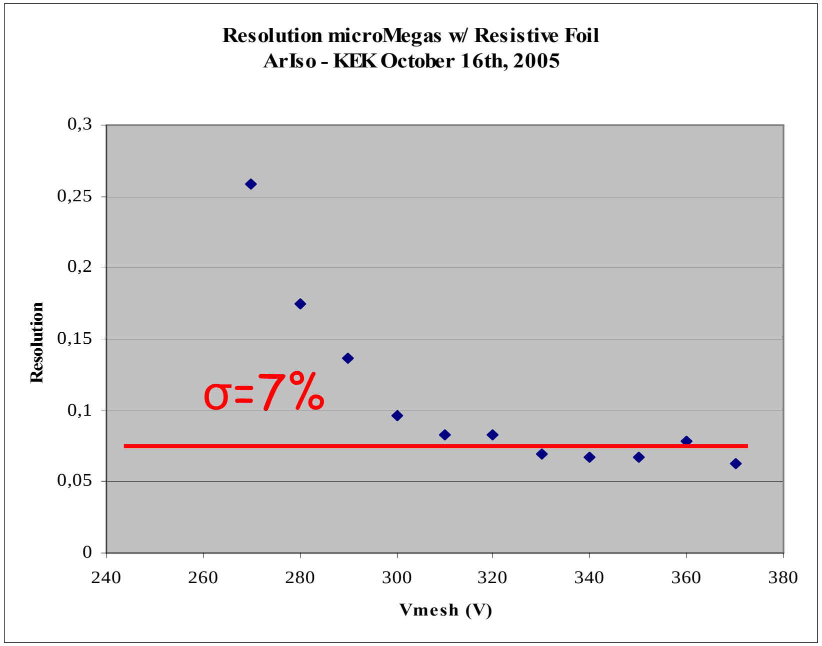


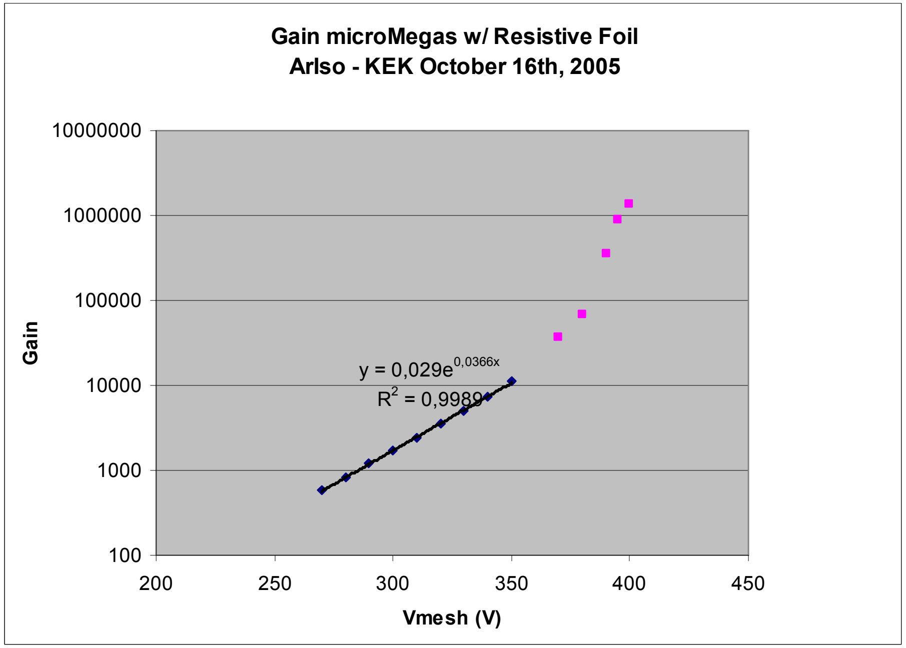


MPI TPC micromesh signal (10x10cm^2)

detector quality control plots

^{55}Fe source Ar+5%iso-C_4H_{10}
MPI TPC

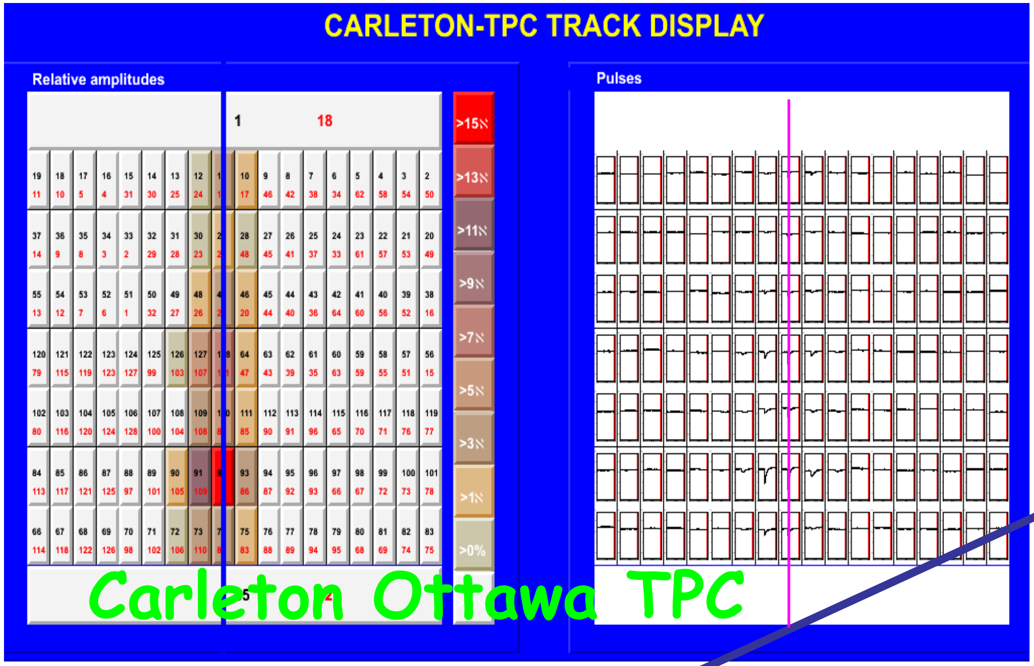




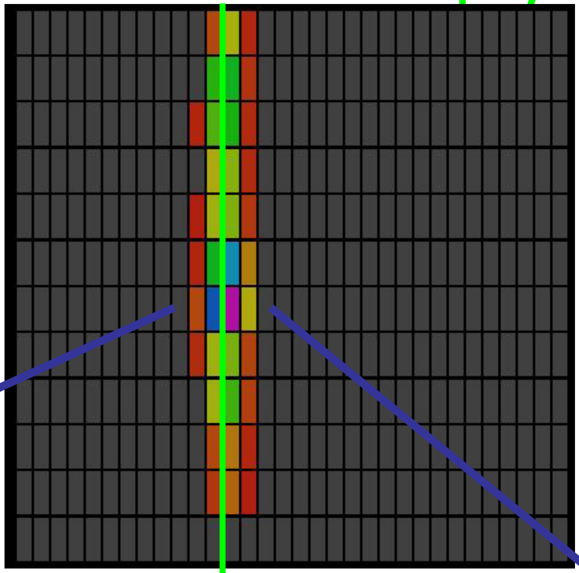
energy resolution (σ) vs mesh HV

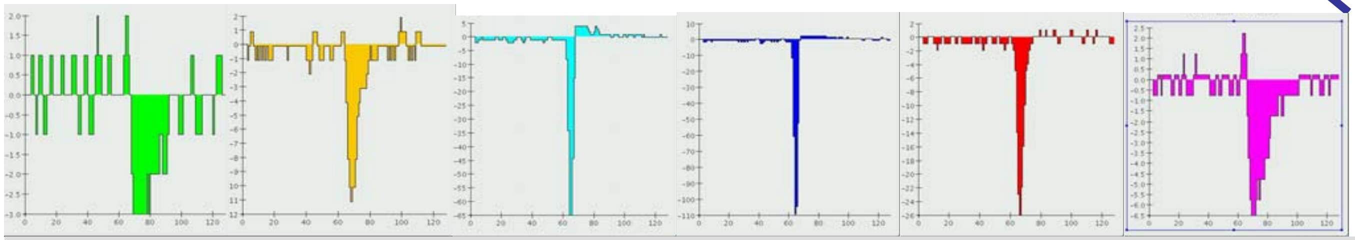
gain vs mesh HV

data quality control: event display



MPI TPC event display

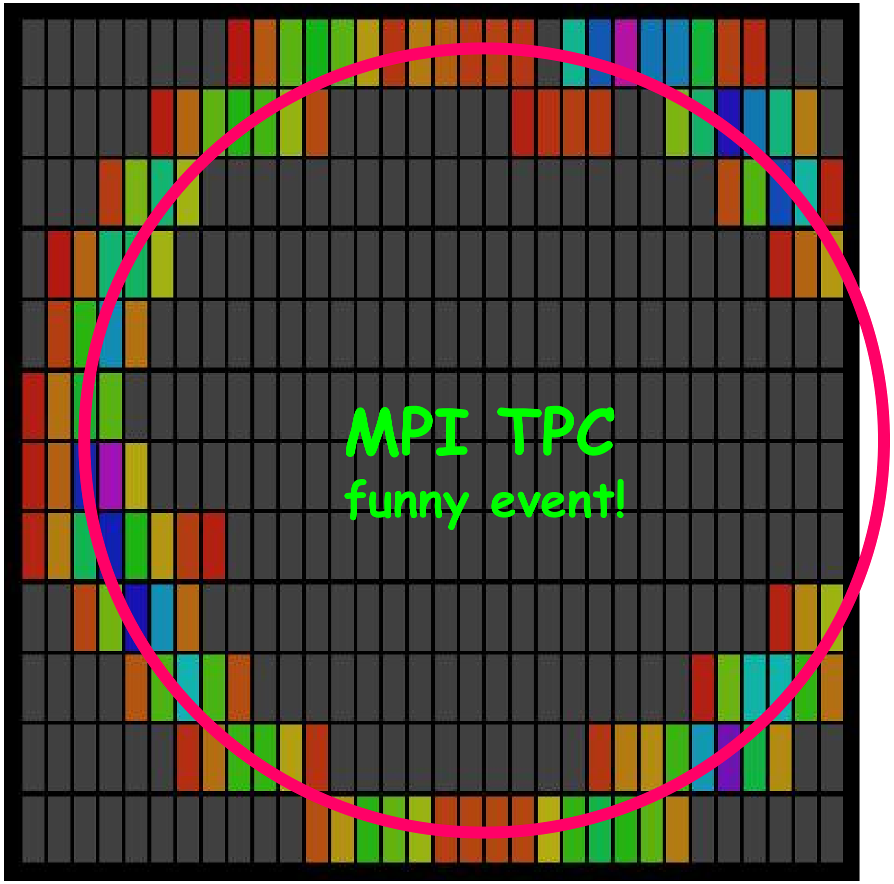


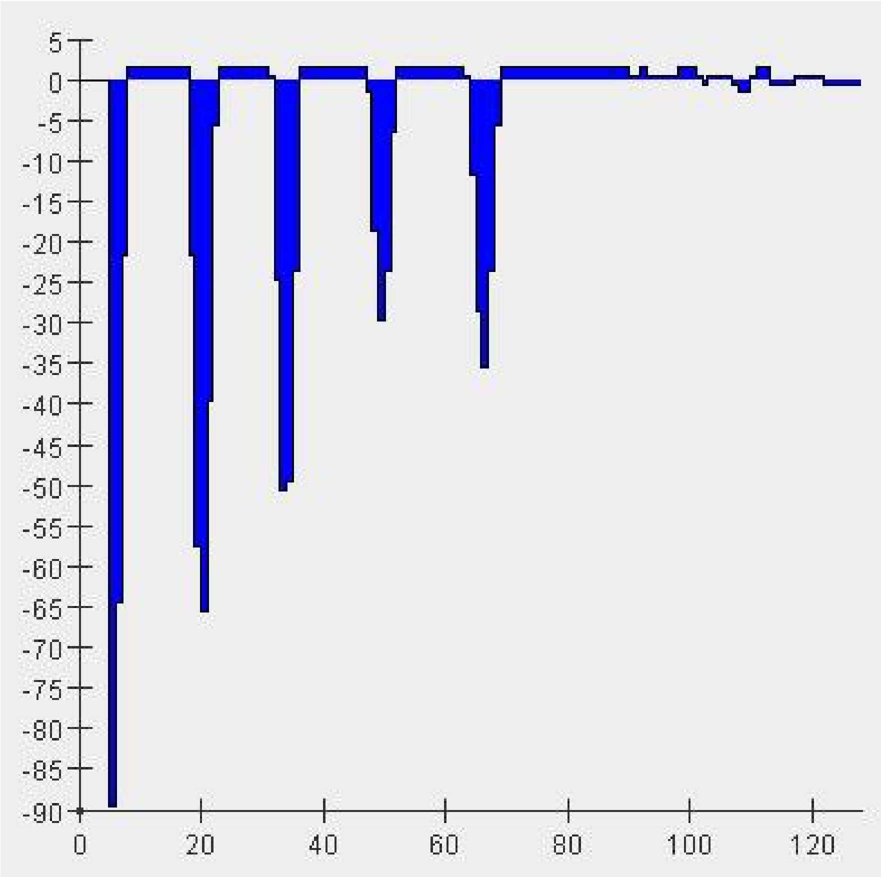


spreading of charge due to foil can be seen across six pads

amplitude vs time distributions

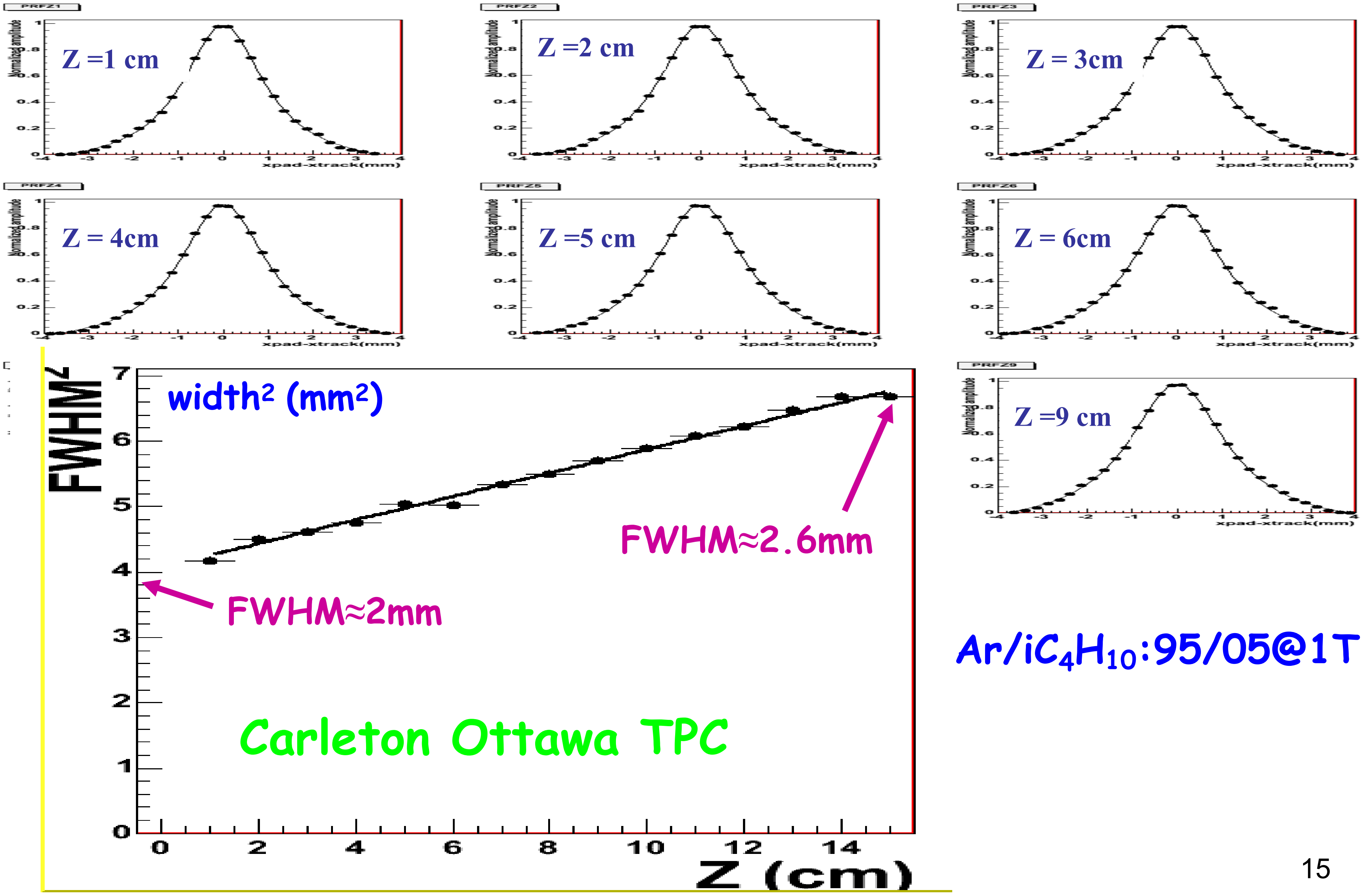
data quality control: event display





low momentum particle (r=3.5cm at 1T)

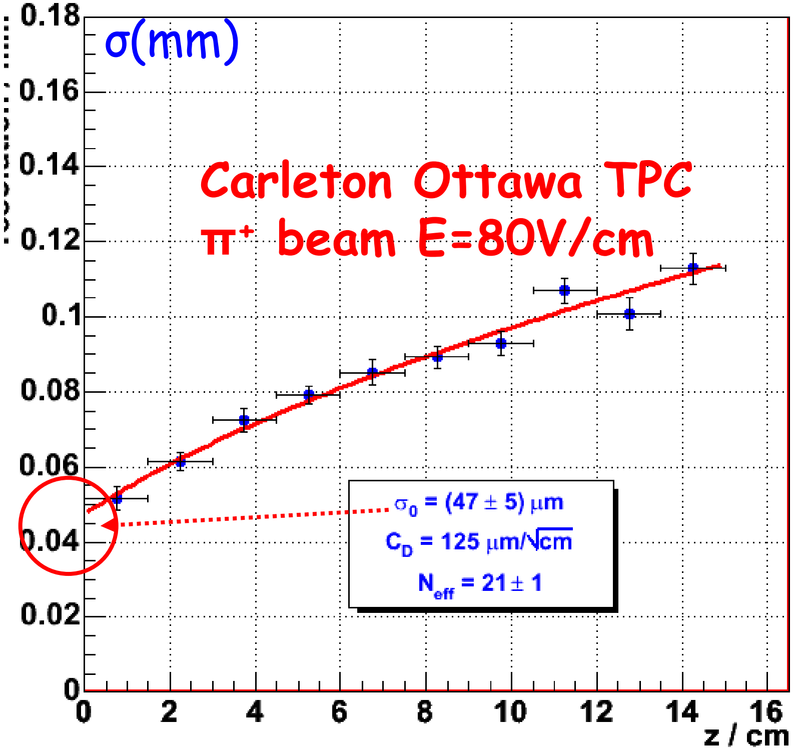
results: PRF vs Z



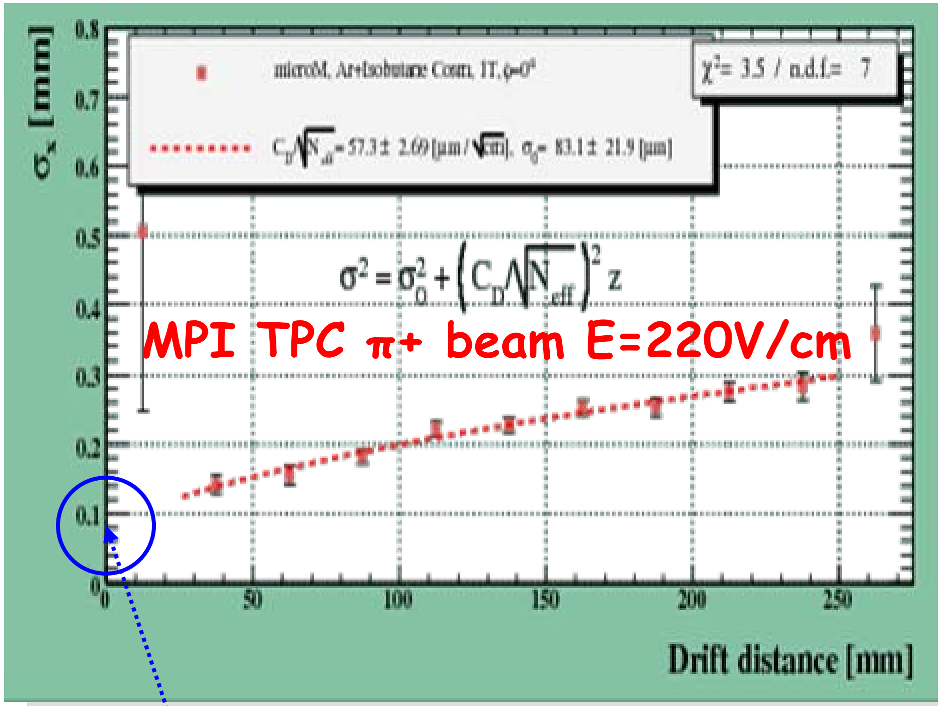
Ar/iC_4H_{10}:95/05@1T

results: resolution vs Z

Ar/iC_4H_{10}:95/05@1T



preliminary



σ_0 = 83 ± 22 μm

$C_D/\sqrt{Neff}$ = 57 ± 3 μm/√cm

VERY preliminary!!
analysis program not
optimised for PRF

conclusion and future

- it has been proven that a **transverse resolution of ~50µm** has been achieved.
- **a resistive foil** allows to suppress the limitation on the resolution due to the pad width
- with a resistive foil, and a low diffusion gas (C_d~25µm/√cm@4T), the PRF will be ~ independant of the drift distance

  (for example, for the choice made for this experiment, the PRF shoud increase from 2mm at Z=0 to 2.2mm at Z=2.5m)

  the compromise should be (easily) done between the gas mixture, the pad width and the foil resistivity -> more flexibility for the construction
- more work to be done on the **data analysis**

  and also many data to be analysed.
- **new tests in the future?**
  - no more beam at KEK
  - DESY or CERN? with JACEE?
  - new cosmic data?

    with te Saclay-Orsay-Berkeley TPC?

many thanks to the KEK support
(management and technical teams)