A Review of Tracking Sessions

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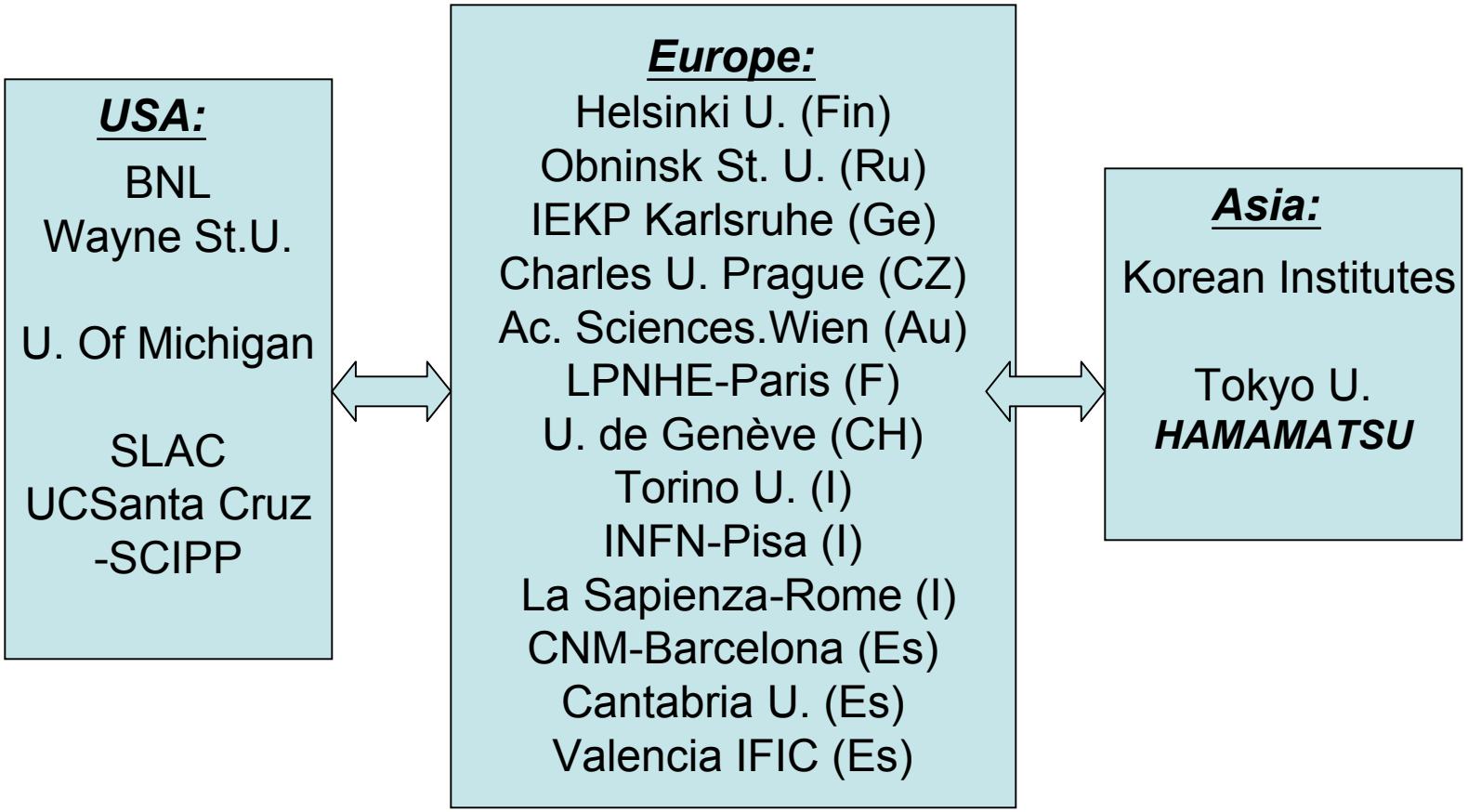
8 minutes time for this summary (allow 2 minutes for questions)
3 tracking sessions lasting ~4.5 hours (13 talks 20 minutes each)

TPC R&D (GEMs, Micromegas, wires) Magnetic field & beam tests, 2 track studies, new readout concepts, ion feedback studies and field cage design 10/13 talks (76% => allocate 6.2 min for the TPC summary)	2 talks on Silicon (15%=>1.2 min)	1 Forward tracker talk (5%=>0.6min)
1) **Adrian Vogel** - ***Charge broadening & ion feedback in triple GEM TPC*** *2)* **Ties Behnke** - ***TPC activities at DESY*** *3)* **Sabine Blatt** - ***Design & construction of GEM-TPC*** *4)* **Paul Colas** - ***Micromegas TPC tests*** *5)* **Jan Timmermans** - ***Status of Si-readout studies at Nikhef*** *6)* **Akira Sugiyama** - ***MPI TPC beam tests at KEK*** *7)* **Dean Karlen** - ***Victoria TPC Tests in DESY 5 T magnet*** *8)* **Madhu Dixit** - ***Charge dispersion resolution in GEM-TPC*** *9)* **Alexander Kaukher** - ***A GEM TPC with TDC readout*** *10)* **Dean Karlen - A proposal to build a CO_2 TPC for T2K**	*1) Status report on SiLC* **- Frederic Kapusta** *2) Electronics & DAQ for SiLC* **- Jean-Francois Genat**	***Status of forward straw tubes simulation*** **- Klaus Moenig**

Status report on the SiLC R&D activities - Kapusta



- **A international collaborative generic R&D effort studying BOTH a all-Silicon-tracking system (SiD) and a TPC + Silicon tracking (GLC/TESLA/LD)**
- **Activities: Hardware, simulation integration issues.**

R&D sensors - one example

Main R&D objectives:

- Long microstrips (long ladders)
- Si Drift
- Keeping an eye on new Si-tech (pixelisation, etc…)

Main requests: **TRANSPARENCY, PRECISION & BETTER YIELD**
increased wafers from 6" to possibly 12"
thinner and smaller pitch

Expressed interest: Hamamatsu (Now officially part of SiLC)
ST Microelectronics/Catania (tbc)
CNM-Barcelona as R&D center
Others ? New comers are welcome
For Si-drift several European teams in STAR, ALICE have good connections with various firms (Canberra …)

Lot of expertise from LEP, CDF, and now LHC (ATLAS, CMS and ALICE)
Vienna responsible for coordinating the R&D on sensors & contacts with industry (also presently in charge in CMS).
Main actions: collaboration with industry based on established connections & test quality procedures for LHC to monitor the R&D & production on sensors.

Silicon tracker data acquisition and electronics development for the Linear Collider -Jean-Francois Genat

New VLSI technologies:

- Silicon Deep Sub Micron CMOS
- Silicon-Germanium alternative (incorporate DSM CMOS)

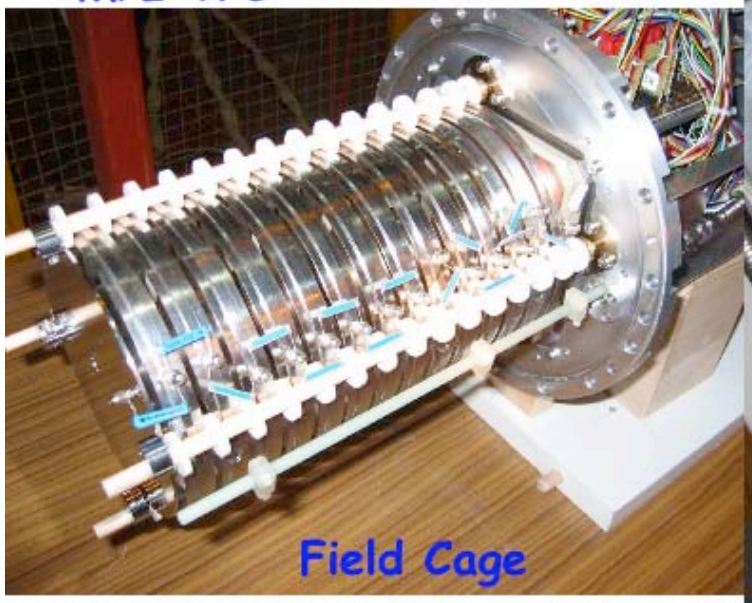
Progress in implement a highly integrated front end for SiLC that does not degrade the detector resolution
An affordable power and material budget
Implement system integration; e.g. data compaction, cluster centroid and fast tracking algorithms

MPI/TPC prototype beamtest at KEK and future plan

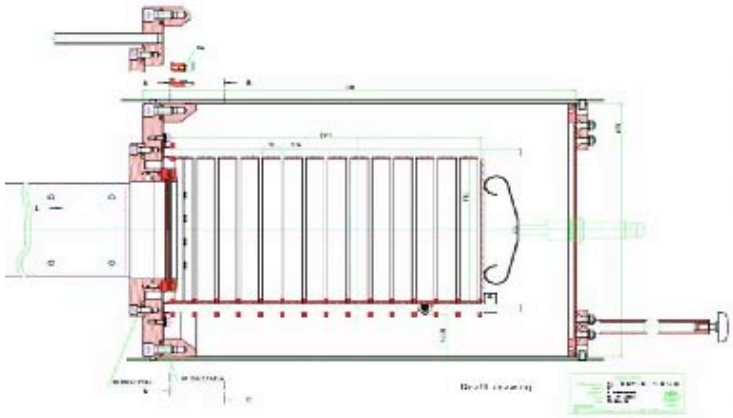
by Akira Sugiyama (Saga Univ.)
for Europa/Asia TPC collaboration
(Not an official name yet !)

Collaboration
Goal of this this collab.
Facilities at KEK
Results
Future plan

MPI TPC


Field Cage


Readout Pad w/ broken wire




"aged" readout electronics

Summary for TPC w/ MWPC

We start MPI/TPC operation at KEK using beam and CR

Analysis is on going.

some basic parameters are observed, but very preliminary

σ_x ~ 200(@0 drift) - 300um(@20cm drift w/1T),

σ_z ~ 400-600um small diff. w/ w/o B

We need to study more detail w/ calib., corr.

comparison to Simulation is necessary.

Status/Plan MPGD readout for TPC

GEM readout is tested using beam

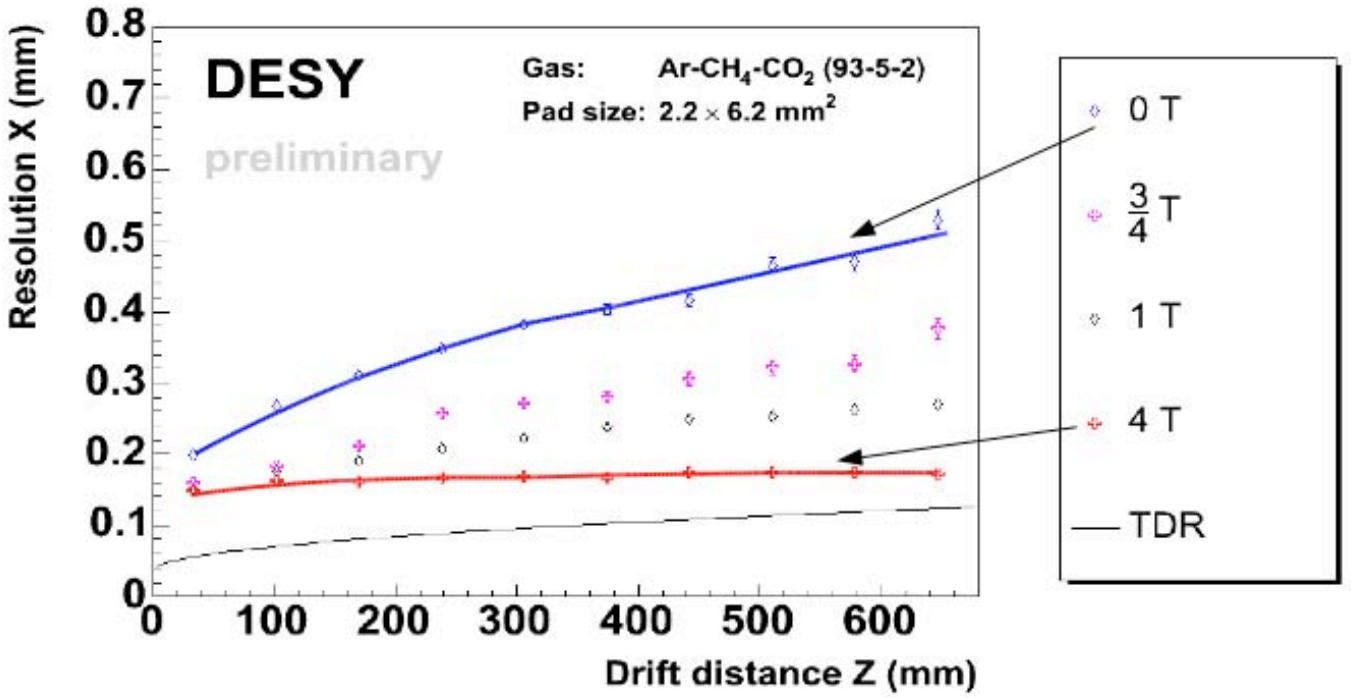
Preparation to install it into TPC is on going.

MPGD R&D for LC/TPC will be started

DESY TPC magnetic field tests - Behnke

Transverse resolution

Determined from circle fit using four central pad rows
(reason: see previous slide)



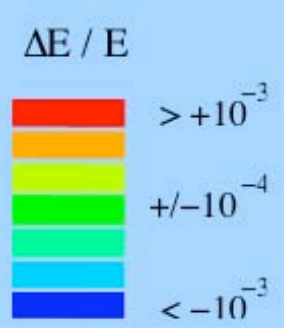
Resolution at 4 T: ≈ 160 μm

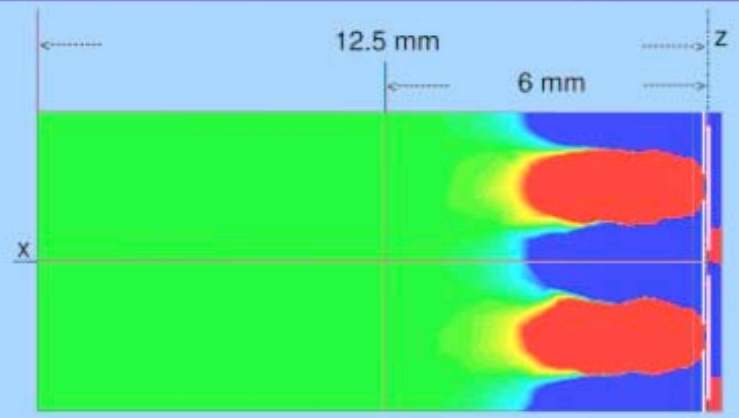
Clearly not diffusion limited,
but readout geometry limited at B=4T

Overview

- Development of a TPC prototype
  - Optimisation of the fieldcage
  - Construction and first measurements
  - Readout electronics
- TPC simulation

TPC Prototype: Results of the Simulation

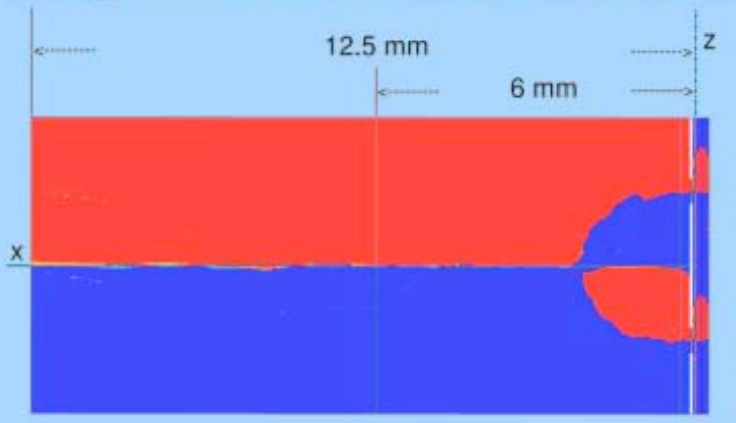




$E_{parallel}$, strips on both sides

Copper strips:
width 2.3 mm
distance 0.5 mm

$\Rightarrow$ field with double-sided strips much better than with one-sided strips



$E_{parallel}$, strips on one side

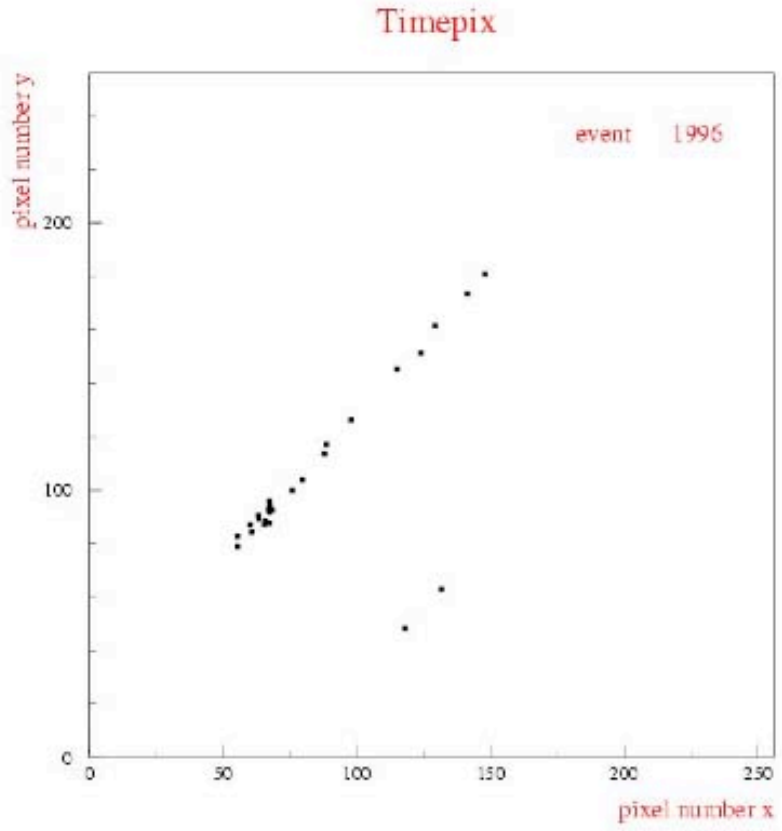
Status 'Si readout' TPC at NIKHEF -Jan Timmermans

Goals

- Gas multiplication GEM or Micromegas foil(s)
- Charge collection with granularity matching primary ionisation cluster spread
- Needs sufficiently low diffusion gas
- dE/dx using cluster counting?
  (→ M. Hauschild)

- Proof of principle based on existing Medipix2 readout chip

Example of a track reconstructed



This track:

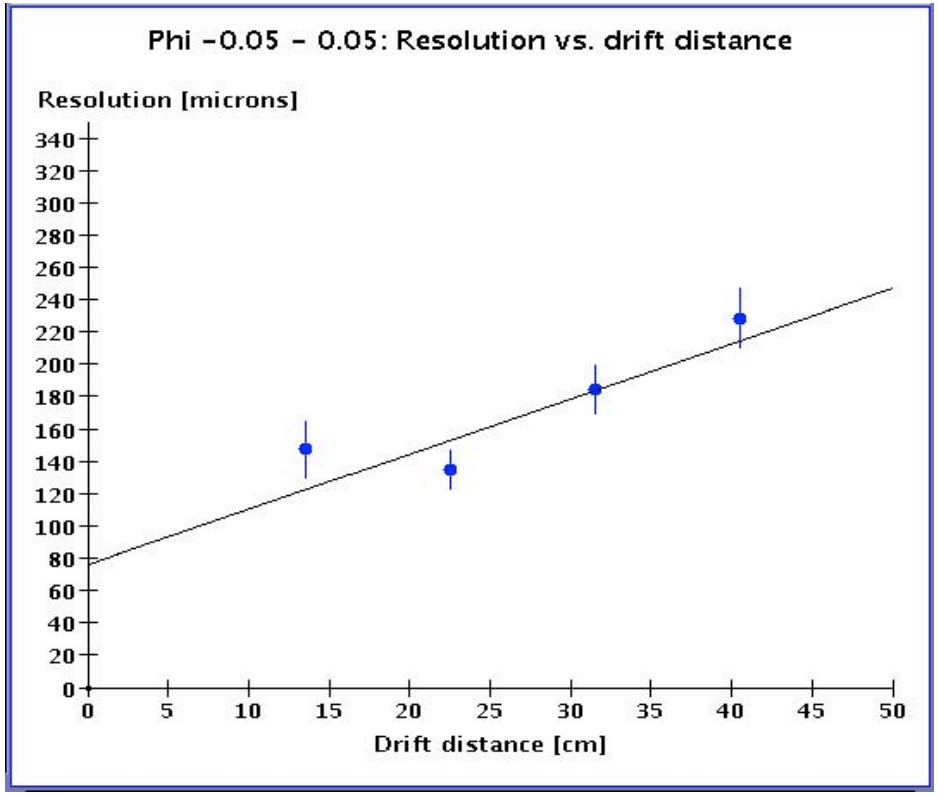
- #hits = 24
- #clusters = 11
- length (3d) = 16.8 mm
- 1.4 e^-/mm; 0.65 cl./mm

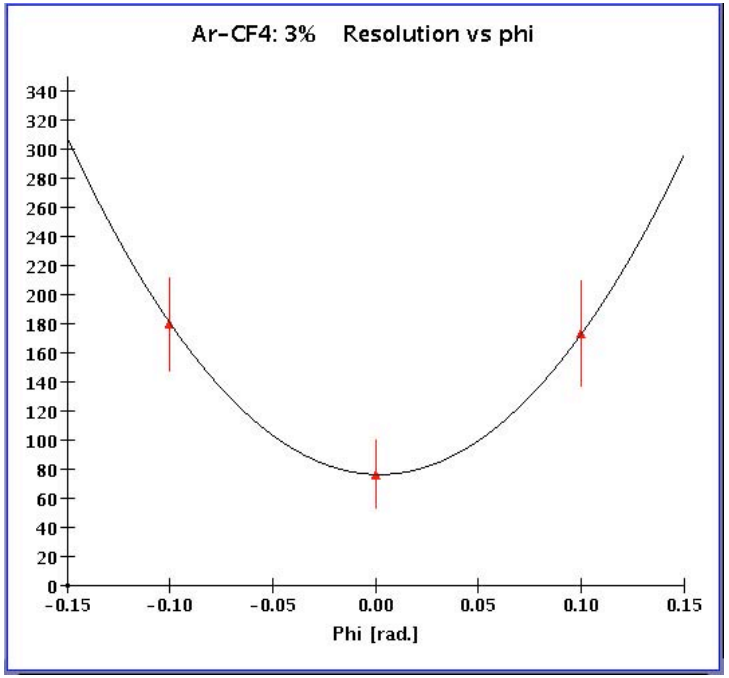
On average:

- 1.8 e^-/mm; 0.5 cl./mm

Micromegas TPC Resolution in a Magnetic Field - Colas

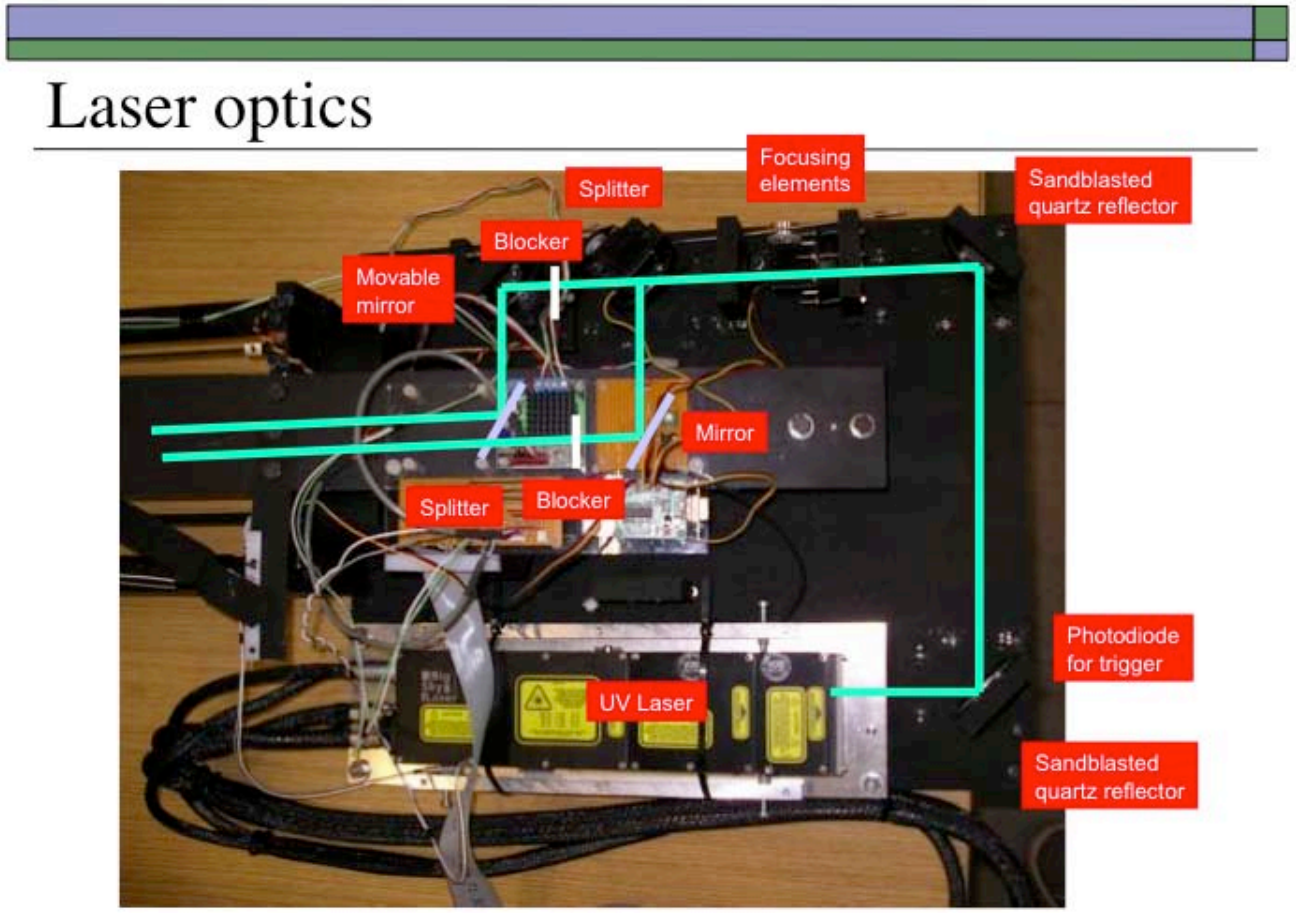
Transverse position resolution in Ar/CF4 3%





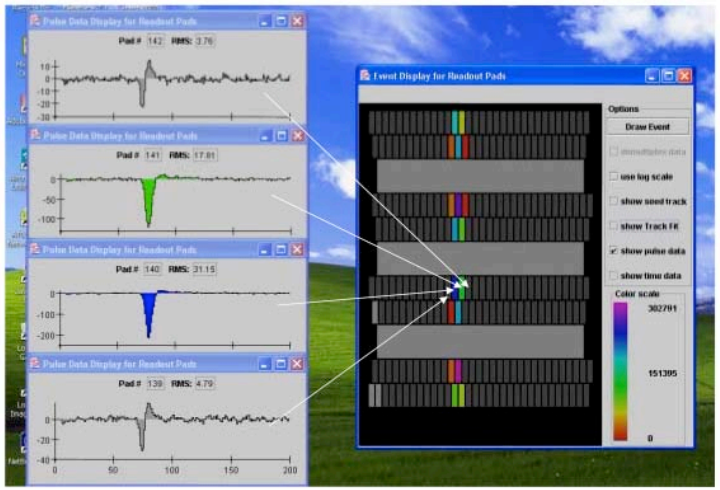
80 micron resolution for vertical tracks using 1X10 mm^2 pads.

Victoria TPC R&D Update - 2 track TPC resolution for laser tracks in a 4 T field - Karlen



DESY run at 4 T

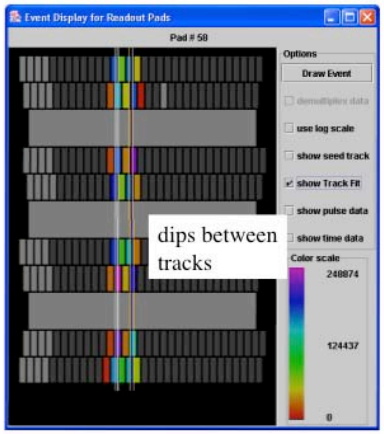
- Single laser track seen by 2 mm pads and P5 gas



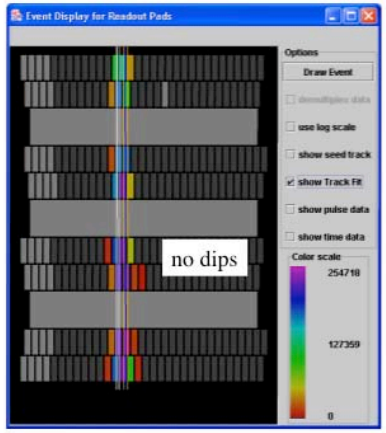
Track fits: 2mm wide pads

σ = 0.5 mm

Δx = 3.8 mm



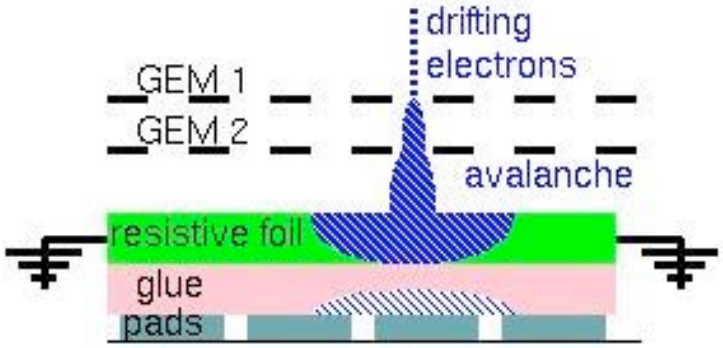
Δx = 2.0 mm



- Two track resolution is quite good: 2-4 mm for 2 mm pads

New concept of charge dispersion for improved resolution in a GEM-TPC - Dixit

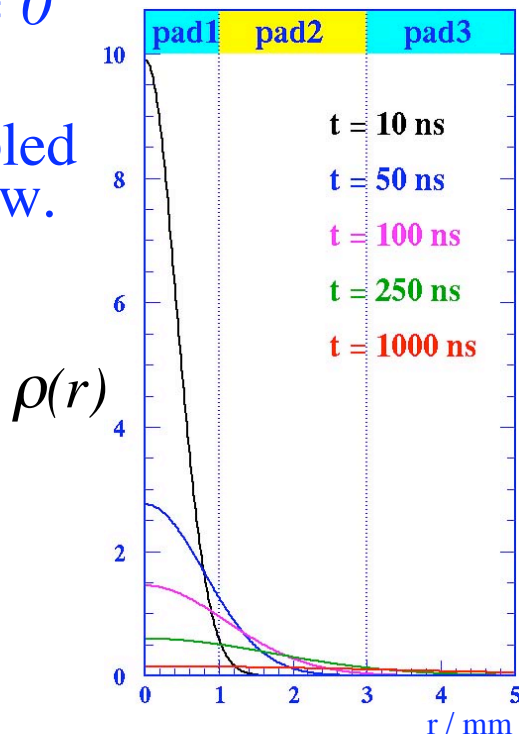
- Modified GEM anode structure with a high resistivity film bonded to the readout plane with an insulating layer of glue.
- 2-dim RC network defined by material properties & geometry.
- Point charge at $r = 0$ & $t = 0$ disperses with time.
- Measure capacitively coupled charge signals on pads below.

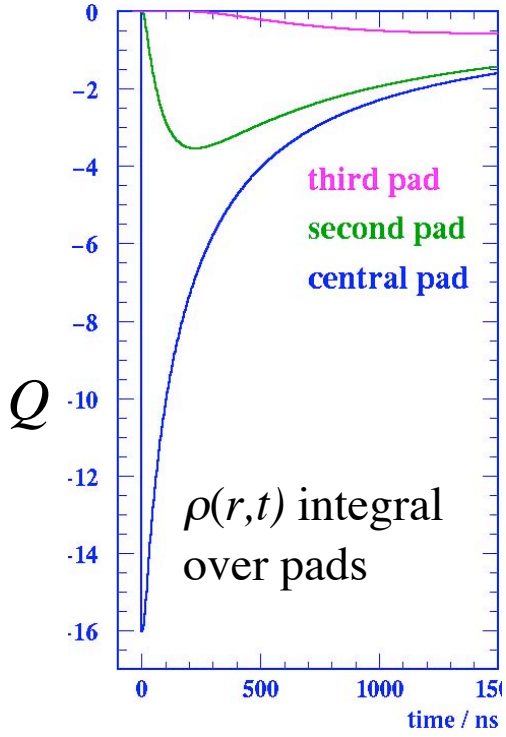


Telegraph equation for the charge density function:

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

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



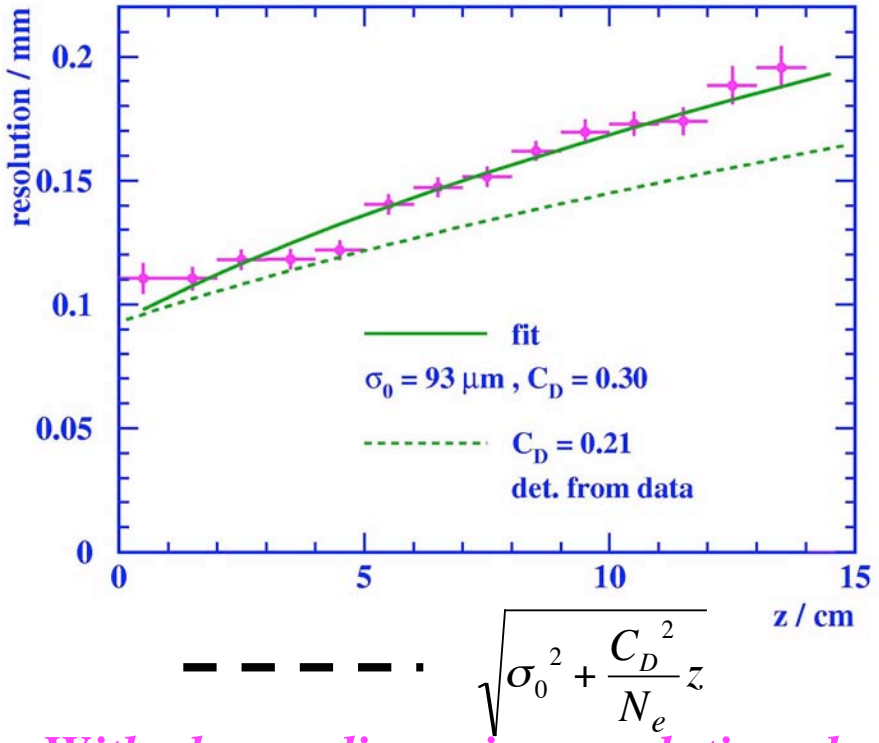


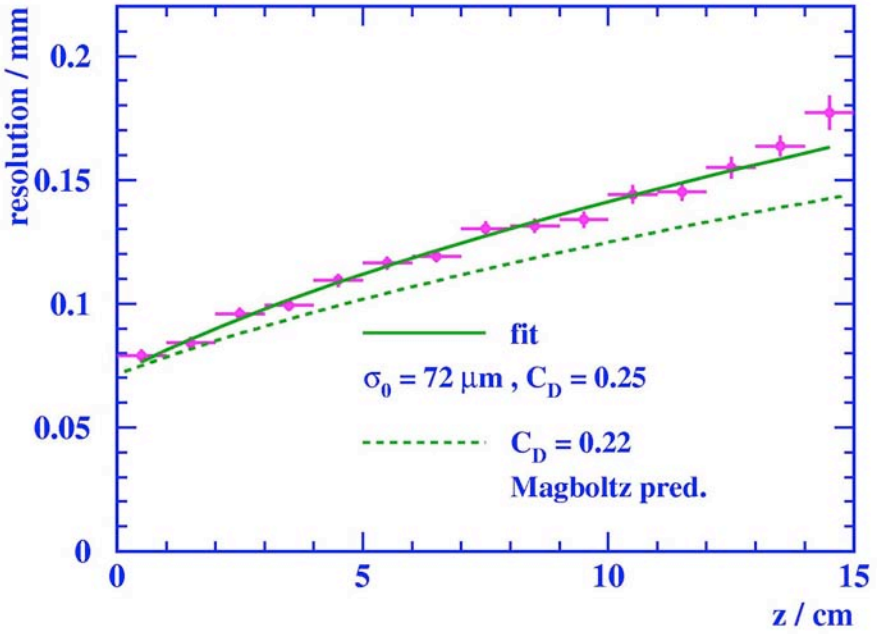
GEM-TPC transverse spatial resolution in Ar/CO_2 (90/10)

Direct charge

Charge dispersion

R.K.Carnegie et.al.,
(accepted for publication in NIM).





$$\sqrt{\sigma_0^2 + \frac{C_D^2}{N_e} z}$$

With charge dispersion resolution close to diffusion limit possible for the TPC

~ 70 μm resolution may be within reach for the ILC TPC for all drift distances

Summary - gaseous tracking

Progress in many areas; both in hardware and in simulation
Many labs working on prototype - this is needed, however, to cover various aspects of detector development.
Prototypes test results encouraging. Micropattern detectors look promising for the ILC TPC readout; resolution somewhat worse than design requirements has been reached with possibility for further improvement.
R&D at a stage where the choice of TPC readout technology appears feasible in ~ 2 years. However, more effort is needed in the area of developing the readout electronics.
Apologies to those whose work is not mentioned in this summary.