Tracking and Vertexing Summary

A. Sugiyama (Saga Univ.)

5 sessions
10 talks for Vertex
3 talks for Si Tracker
8 talks for TPC

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Vertex detectors
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Friday, March 10

Development of DEPFETs for the Vertex Detector (Ladislav Andricek)
CMOS Monolithic Pixel R&D at LBNL (Devis Contarato)
Monolithic CMOS Pixel Detectors for ILC Vertex Detection (James Brau)
Development of CMOS sensors adapted to the vertex detector requirements (Marc Winter)

Saturday, March 11

LCFI Status Report: Sensors for ILC Vertex Detector (Konstantin Stefanov)
Investigation in the Properties of Charge Traps Created in CCD by Neutron and Electron Irradiation (Nikolai Sinev)
Vertex Performance Study with a Realistic Pattern Recognition Algorithm (Alexei Raspereza)
LCFI Vertex Detector Design Studies (Andre SOPCZAK)

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Solid-state tracking
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Sunday, March 12

SiD Vertex Detector Mechanical Design (Bill Cooper)
LCFI Status Report: Physics and Mechanics for ILC Vertex Detector (Steve D. Worm)
Status on the development of FE and readout electronics for Large Silicon Trackers (Jean-Francois Genat)
SiLC R&D present status and perspectives (Aurore Savoy-Navarro)
Silicon Strip R&D Status in Korea (Hwanbae Park)

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Gaseous tracking
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Sunday, March 12

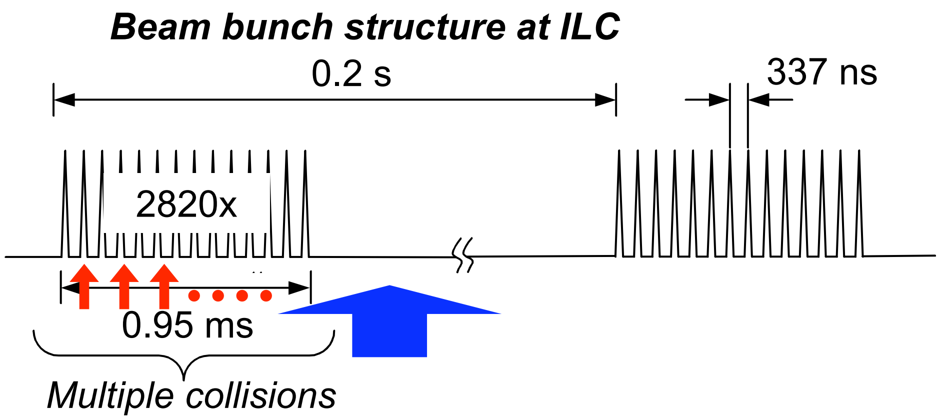
Large-Area Micromegas TPC R&D (Michael T. Ronan)
Comparison between data and simulation for MT3 (Akira Sugiyama)
Studies on the Drift Properties and Spatial Resolution Using a Micromegas-Equipped TPC (Rosario L. Reserva)
A beam test of prototype TPCs using micro-pattern gas detectors at KEK (Makoto Kobayashi)
Micromegas- and GEM-TPC resolution studies with charge dispersion in a magnetic field in a test beam. (Madhu Dixit)

Monday, March 13

ILC TPC R&D studies at DESY/U. Hamburg (Katsumasa Ikematsu)
Developments for a digital TPC : the SiTPC project (Paul Colas)
TPC R&D Plans for the Large Prototype (Ron Settles)

Brief Introduction of Vetex to "non-expert(myself)"

required point resolution ~ a few um
low material < 0.5% X_0
Occupancy < 1%



Key issue of R&D

Bkg. hits exceed "occupancy limit"
after ~3000BX(1 train) w/ standard 20um pixel

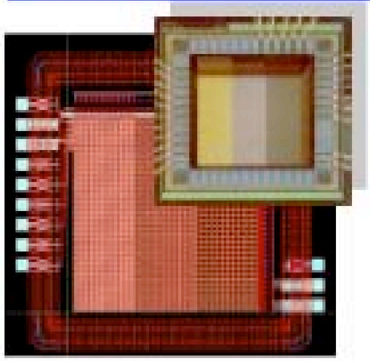
Solution: 1) read data before Occ. exceed limit (20 times/train)
can we read all data within 50usec? Column parallel CCD, CMOS, DEPFET
2) store data and reset sensor(20 depth in storage)
can we store data? read all data (within 199msec). ISIS, Macro/Micro
make pixel size small(20 times smaller in area; 5um pixel) can we make ? FPCCD
"Proof of Principle"

with reasonably low power dissipation,
high S/N,
low material (thinning) ,
tough rad. hardness
away from RF pick-up

many more things
mechanical design, support, cooling
Optimization under physics benchmark
Software development

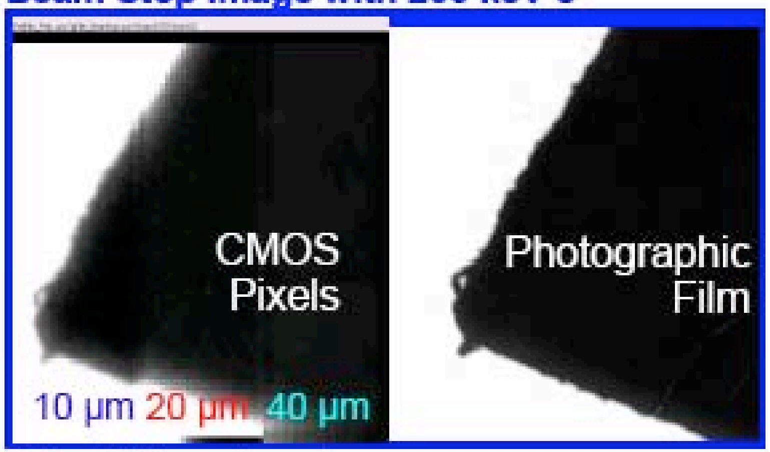
CMOS Monolithic Pixels R&D at LBNL

Devis Contarato

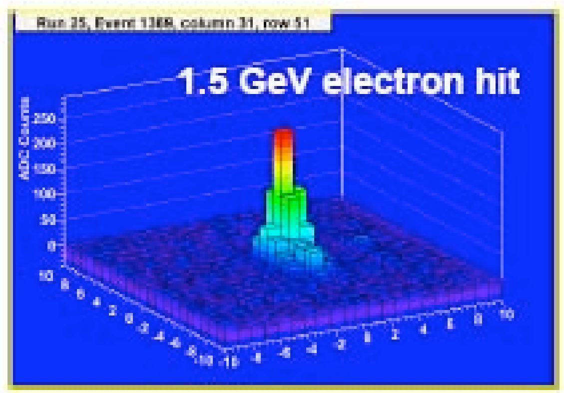


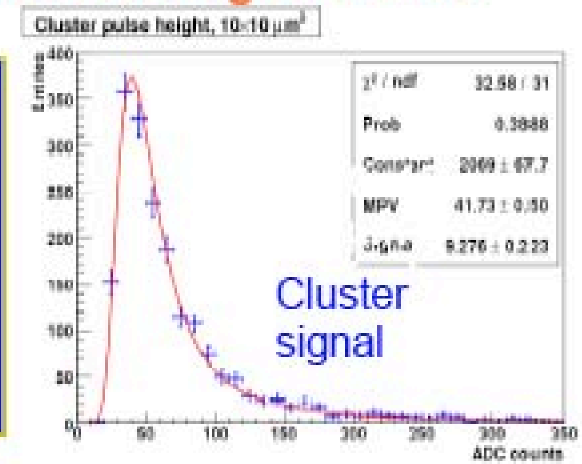
- Developed and characterized first CMOS pixel test structure in 0.35 μm OPTO AMS, with different pixel pitches (10, 20, 40 μm)
- Availability of facilities on-site: electron microscopy @ NCEM, beam-test with 1.5 GeV e^- at Advanced Light Source, 30 MeV proton irradiations at 88-inch Cyclotron
- Synergy with other on-going activities on CMOS pixels at LBNL

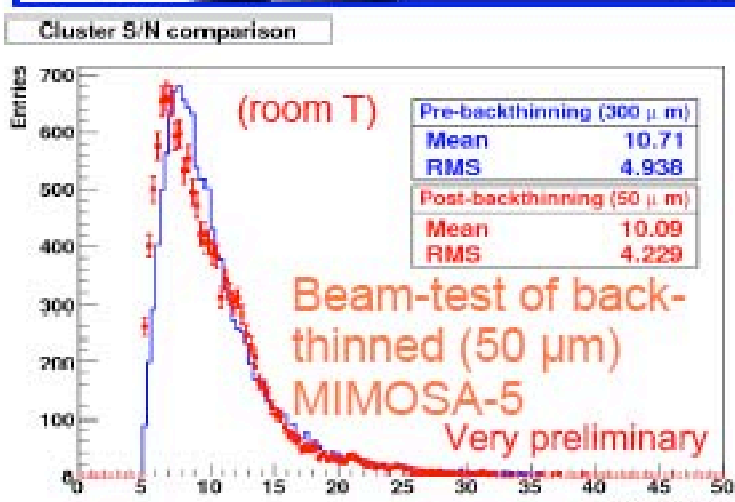
Beam Stop Image with 200 keV e^-

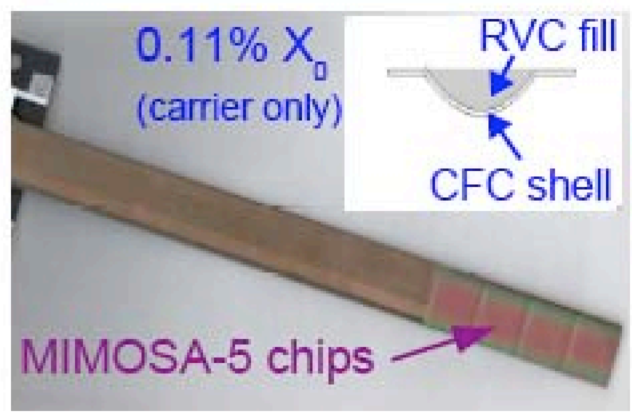


Beam-test at the Advanced Light Source









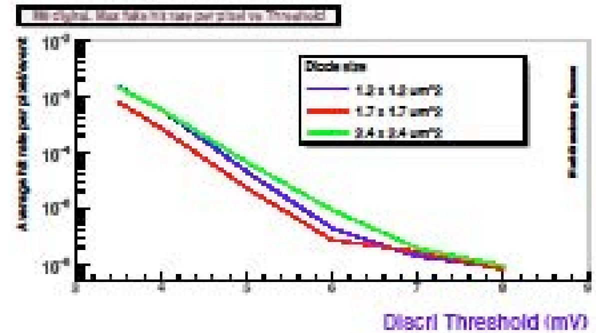
- Backthinning studies on MIMOSA-5 and pixel ladder prototype development (for STAR VXD upgrade)

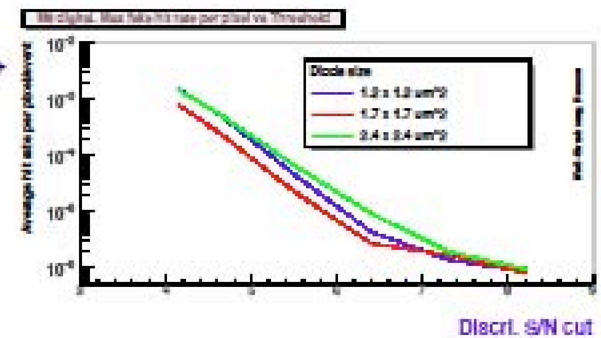
2 sensor architectures developed:

- fast column parallel architecture for L1 (25 μs) and L2 (50 μs)
- multi-memory pixel architecture with delayed read-out (FAPS) for L3–5

Recent progress:

- prototype with integrated signal discrimination tested on beam (DESY): 50 μs read-out time, N $\lesssim$ 15 e^-, detection eff. $\sim$ 99.3 %, 10^{-3} fake hits $\mapsto$
- prototype with radiation tolerant pixel validated at room temperature for doses up to 1 MRad (20 kRad/yr expected from $e^{\pm}_{BS}$)





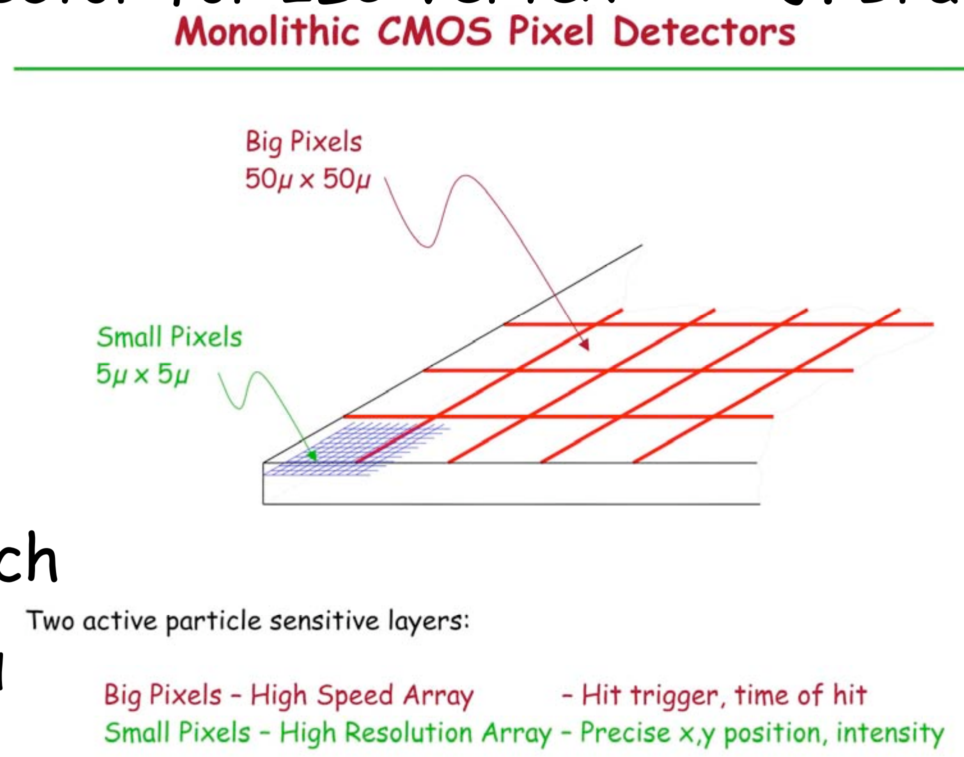
Next important steps $\mapsto$ evolve the fast column parallel architecture:

- ◇ translate in micro-circuit technology offering high S/N
- ◇ improve speed
- ◇ make pixels radiation tolerant at room temperature
- ◇ replace discriminator by ADC

Other on-going activities:

- ◇ try accommodating FAPS to L2
- ◇ try thinning to $\sim$ 35 μm
- ◇ test 2 ladders equipped with prototype sensors in STAR DAQ
- ◇ design and fabricate sensors for STAR vertex detector upgrade and for equipping EUDET beam telescope

Monolithic CMOS pixel Detector for ILC Vertex J. Brau



Macro / Micro
(50um pitch / 5um pitch)
high speed(timing) / precise position

New approach

Macro only w/ 10-15 um pitch

much more tolerant to high background

Readout
  22mmx 125mm chip
    -> 176msec @50MHz
    parallel readout ?

Powe Consumption
  ~4mW/cm2

Read Noise
Signal to noise of 10 to 20

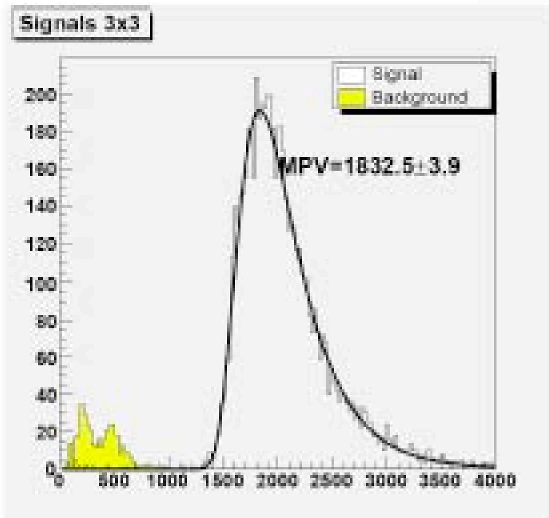
Macro pixel design is completed

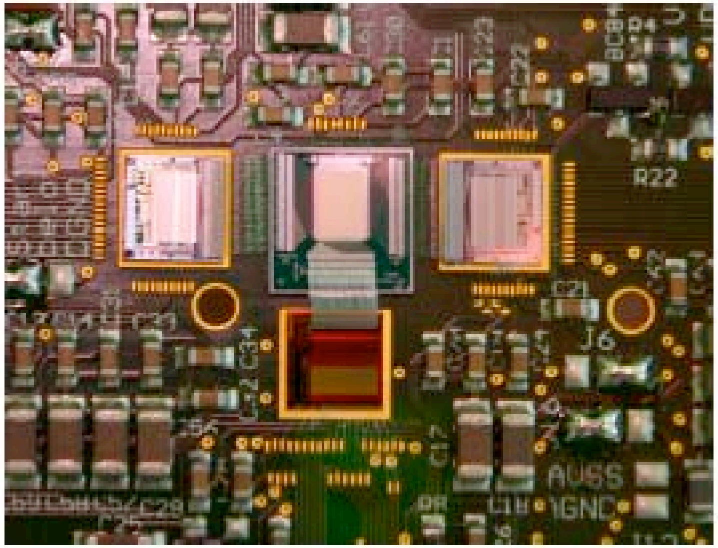
DEPFET Development

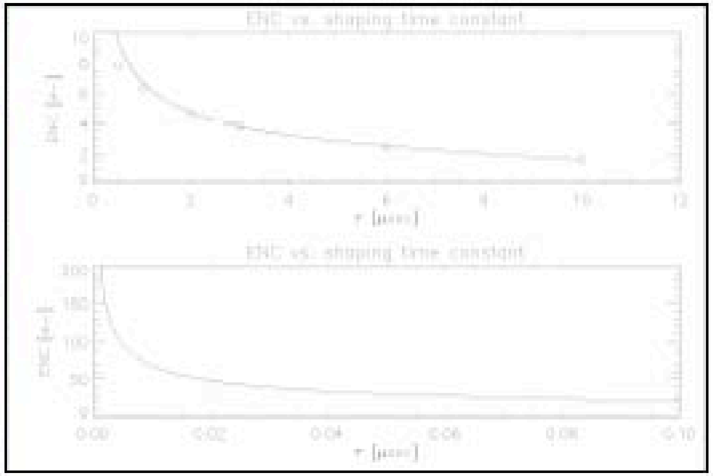
Laci Andricek

mpi halbleiterlabor

64x128 pixel DEPFET matrix, cellsize 36 x 24 μm^2







New system in beam test at DESY:

- f/e Bandwidth and Clock: 50 Mhz
- ~ 6 μs/row with full data transf. to PC
- Sample-clear-sample: ~ 240 ns
- Clear duration 20 ns

→ S/N ≈ 111 for 450 μm sensor

Single pixel tests pre and post irrad. with 1 Mrad:

→ DEPFET noise in the 50 MHz range: ENC ≈ 50 electrons

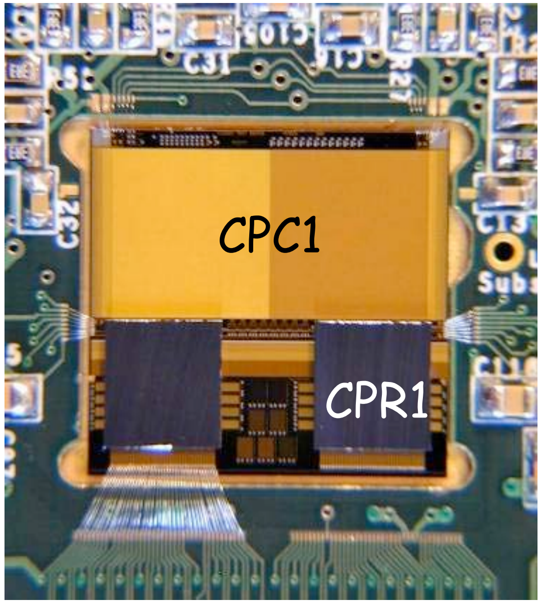
2006: new sensor production, new submissions for r/o chip CURO and SWITCHER

LCFI Status Report: Sensors for the ILC

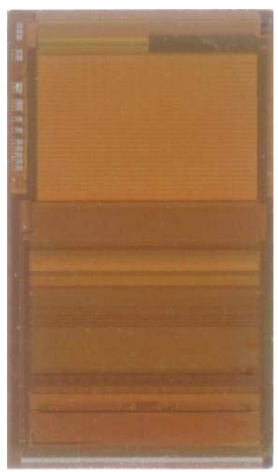
Konstantin Stefanov

Column Parallel CCD + CMOS readout

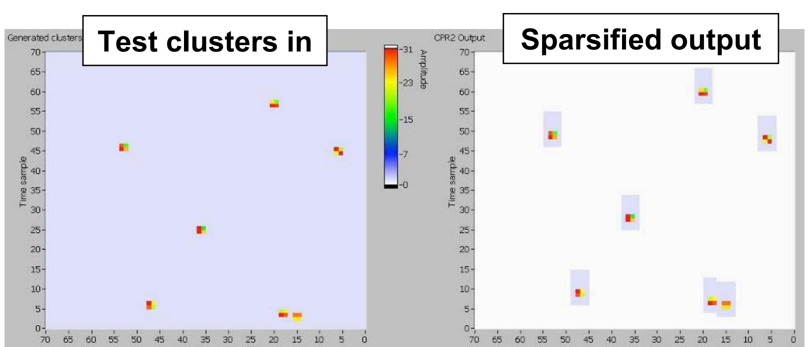
CPC1(400x750: 20um) CPR1



CPR2



CPR1 +
Cluster Finding
Sparse Readout



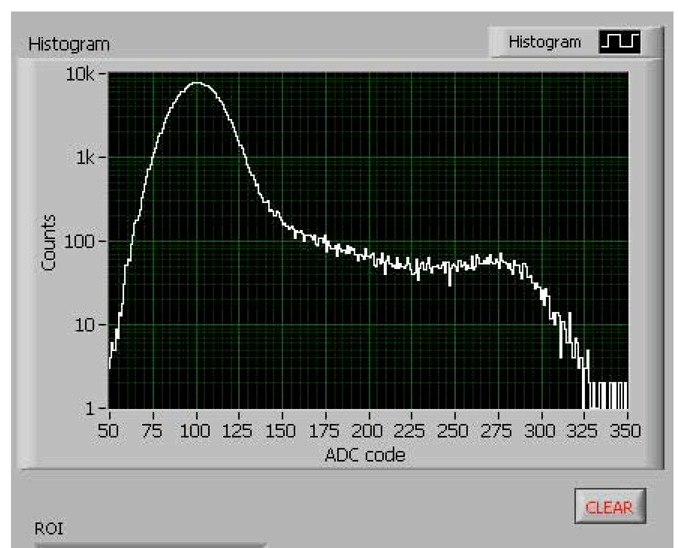
ISIS(In-situ Storage Image Sensor)

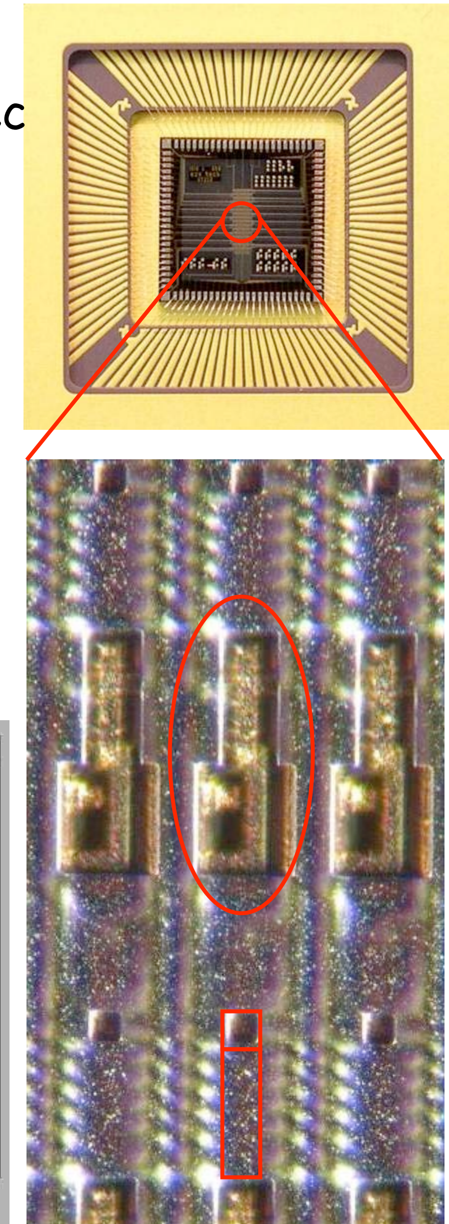
charges are stored in 20-pixel storage

1MHz column parallel ro
is enough within 200msec

RF pickup is avoidable

Source Test w/ Fe55





Investigation into properties of neutron and electron irradiated CCD

Nick Sinev

Charge traps are produced by neutron irradiation

Study of traps

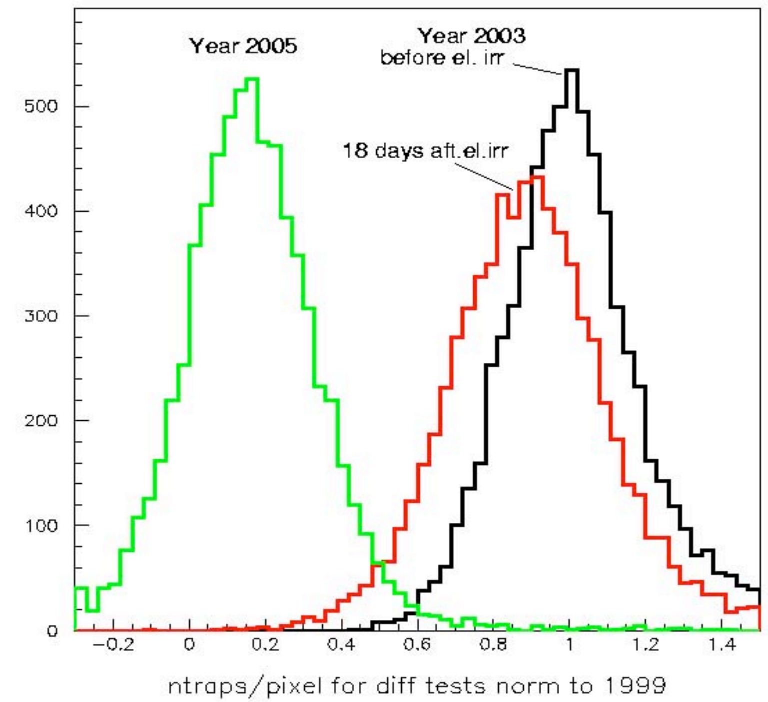
- charge retention time by traps
- annealing
- Charge Transfer Inefficiency

PUZZLE

electron capture to traps takes long O(msec) though O(nsec) is expected.

After irradiation of electrons

all traps disappeared



Alexei Raspereza

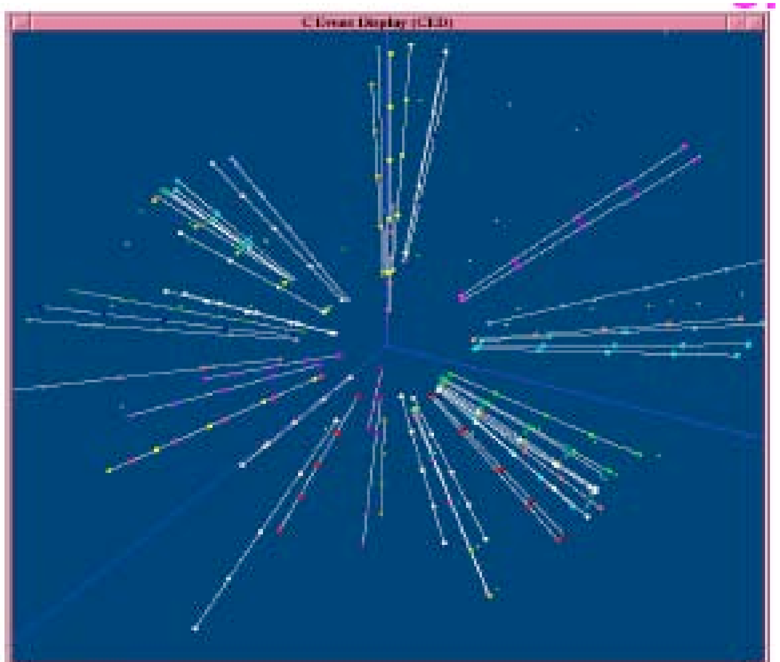
Simulation Studies of VXD Performance

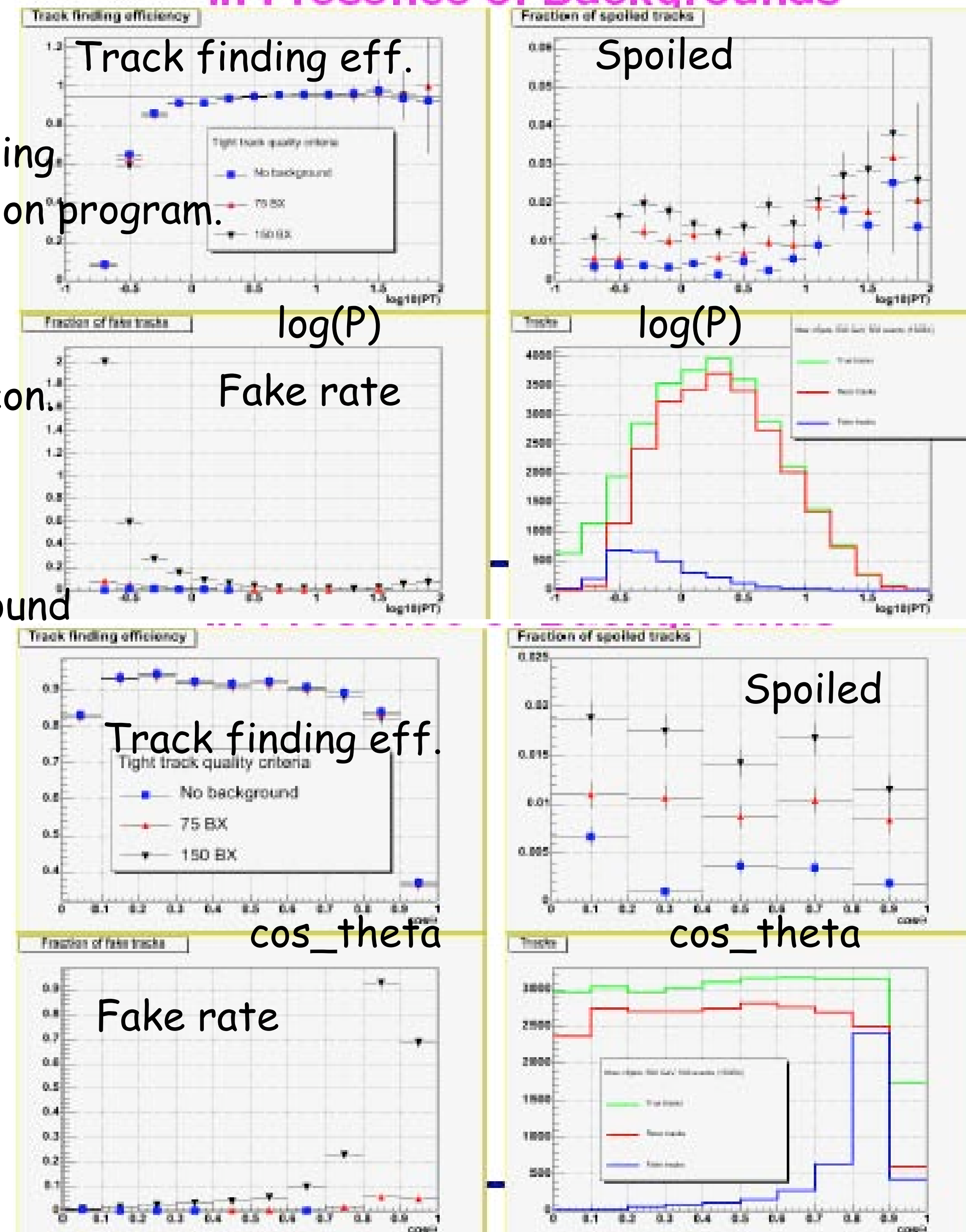
Pattern Recognition Performance in Presence of Backgrounds

Detector optimization has been started using full simulator and realistic reconstruction program.

Mokka	MARLIN
w/VXD,TPC,FT	implement VXD
Ecal, Hcal, Fcal	digitization + recon.

tt -> 6jets @500GeV   with beam background





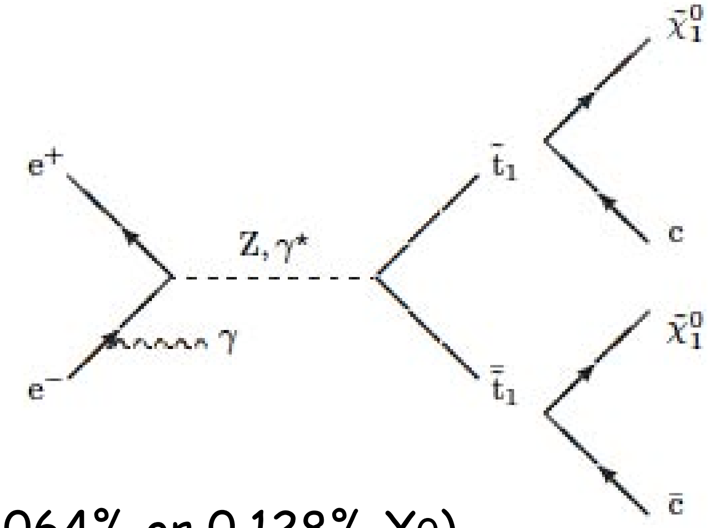
Scalar Top Study: Detector Optimization

Andre Sopczak

Cold Dark Matter can be a neutralino

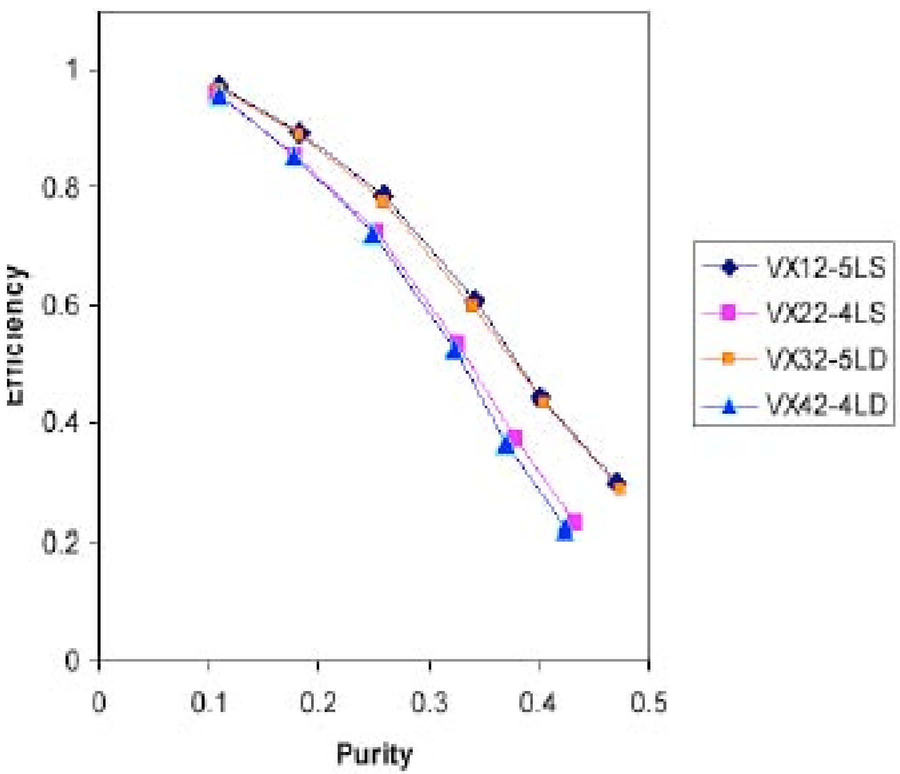
Amount of CDM is depend on
the mass difference to stop or stau

$We\nu$ is the dominant background.



VTX configuration (5 or 4 layers) x (material 0.064% or 0.128% X0)

reduce the innermost layer

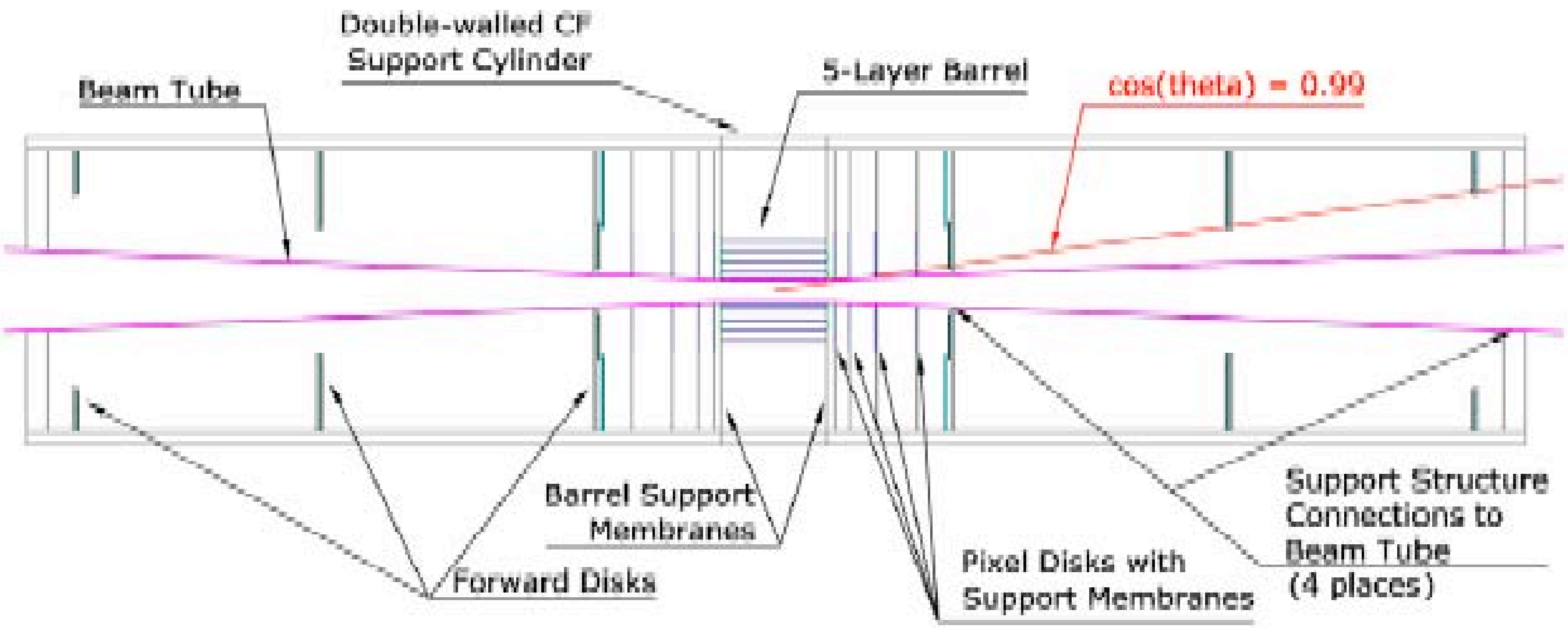


Large effect whether Layer 0 exist or not

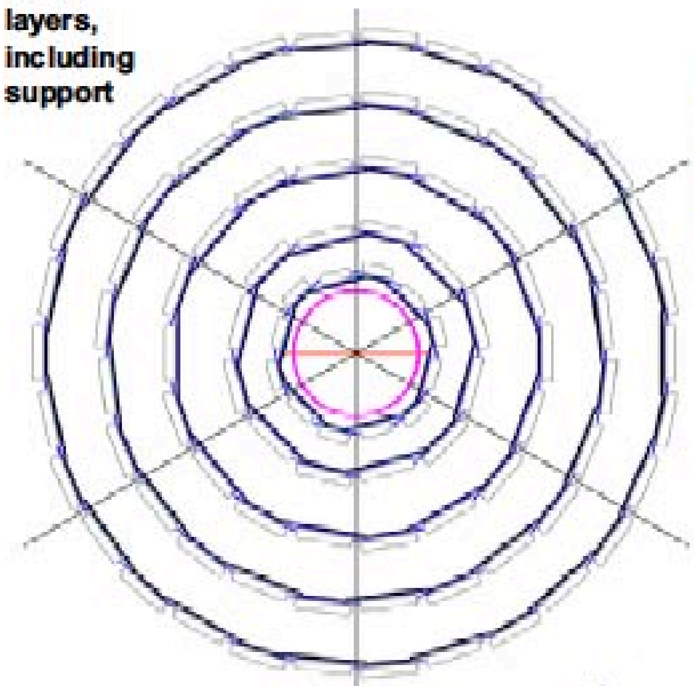
Doubling material doesn't change results.

VXD Elevation & End Views

Bill Cooper



~1.6% RL at normal incidence for all 5 barrel layers, including support

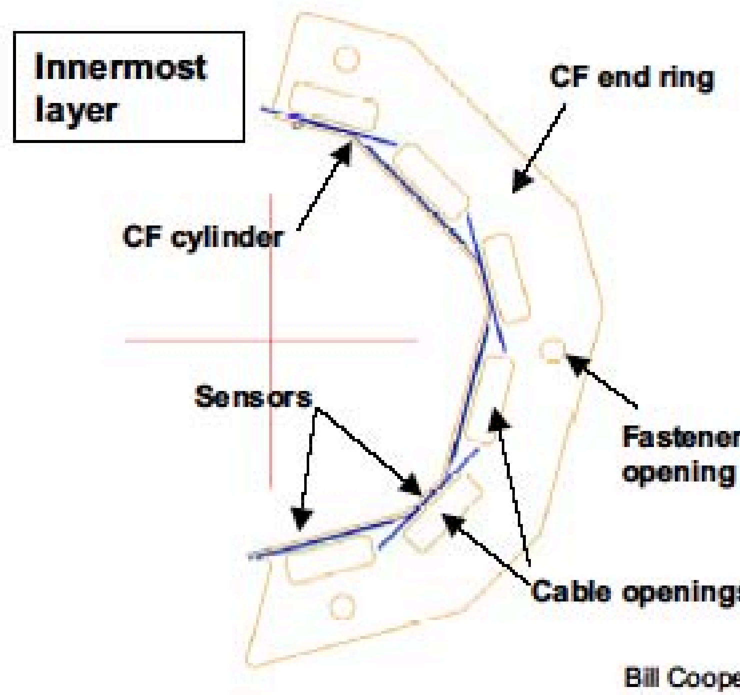


Sensors:
IR_A = 14, 22, 35, 47.6, 60 mm
IR_B = 15.15, 23.13, 35.89, 48.41, 60.77 mm
Active widths: 9.1, 13.3 mm
Cut widths: 9.6, 13.8 mm
Beam pipe IR: 12 mm
Beam pipe OR: 12.4 mm
March 3, 2006

Oblong boxes are openings in end rings and end membranes for cables, optical fibers, and air flow.

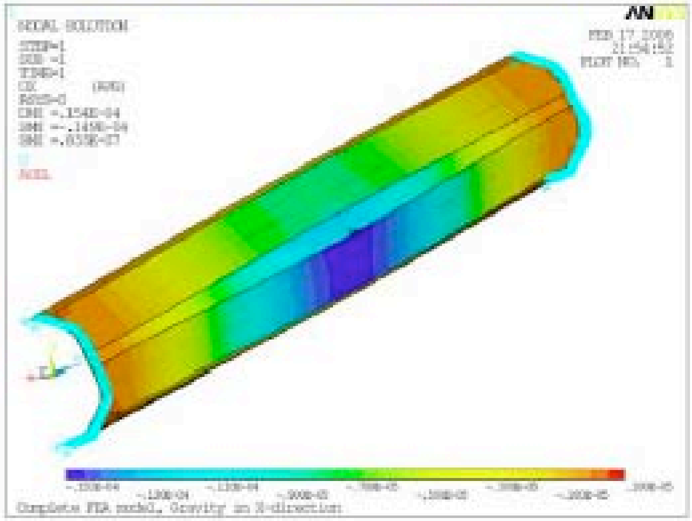
Splitting into two halves allows assembly about the beam pipe.

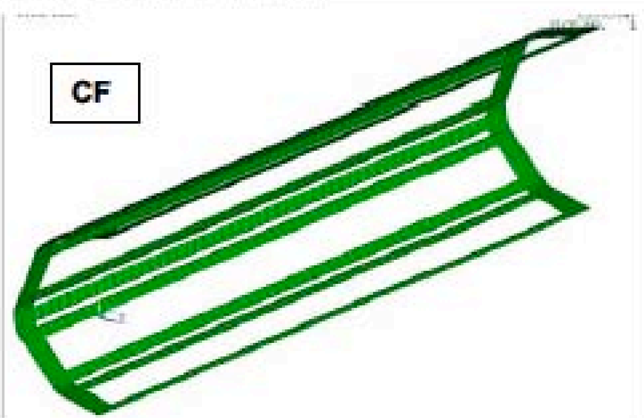
Approximate clam-shell split line

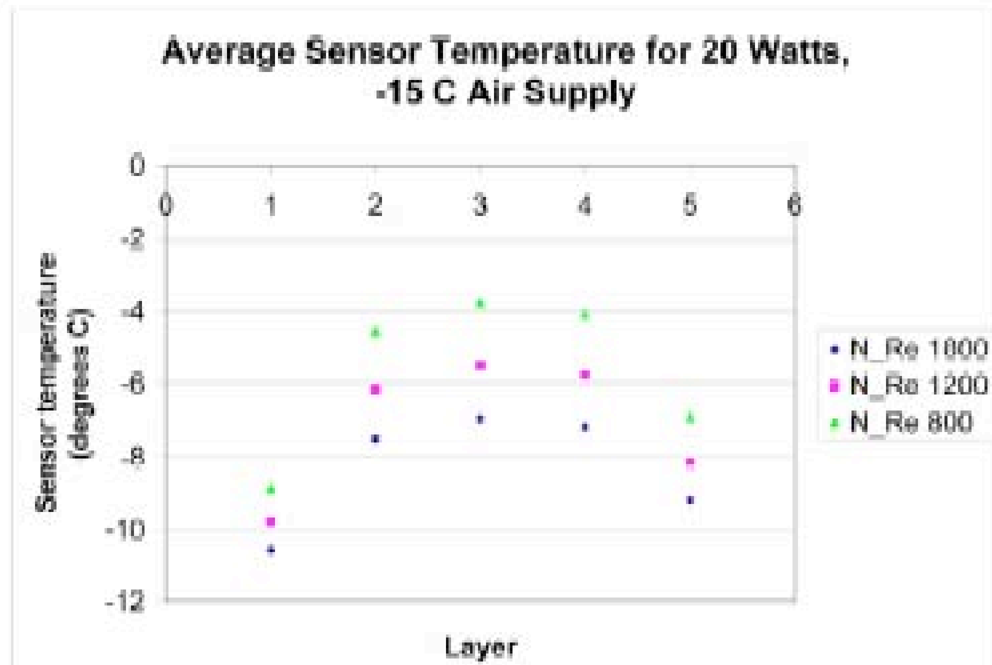


VXD: FEA & Cooling

- FEA of innermost layer gives 15 µm gravitational deflection (5 µm for a length of 125 mm)







- Study of air cooling gives sensor temperatures ~ -4° C to -10° C for -15° C supply

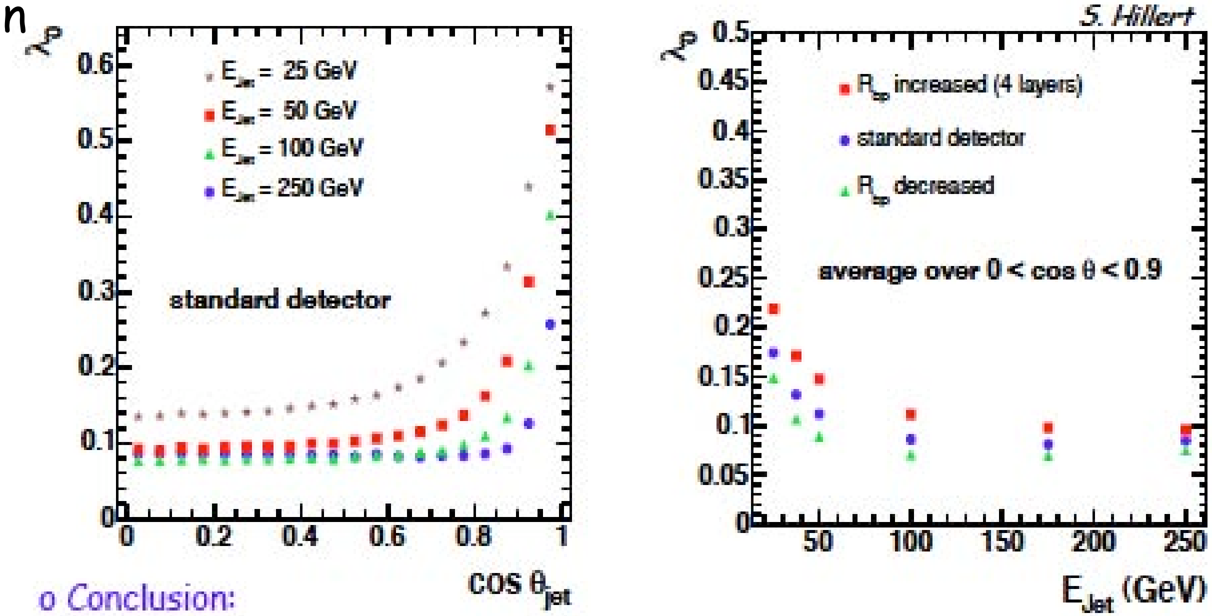
Bill Cooper

LCFI status report: Physics & Mechanical for ILC VTX Steve Worm

Software tool for detector optimization
realistic recon. program is necessary

C++ based Vertex package:
ZVTOP, Flavor Tag, Vertex Charge

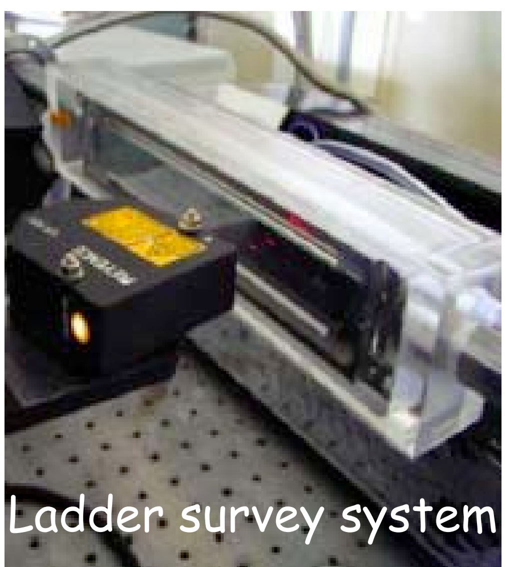
probability of reconstructing neutral hadron as charged (λ_0)



o Conclusion:
vertex charge performance strongly depends on low momentum tracks
→ differences between designs most pronounced for low jet energy and large cos θ_{jet}

Mechanical studies

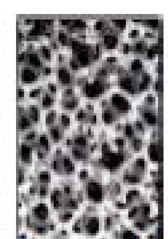
Ladder mechanics



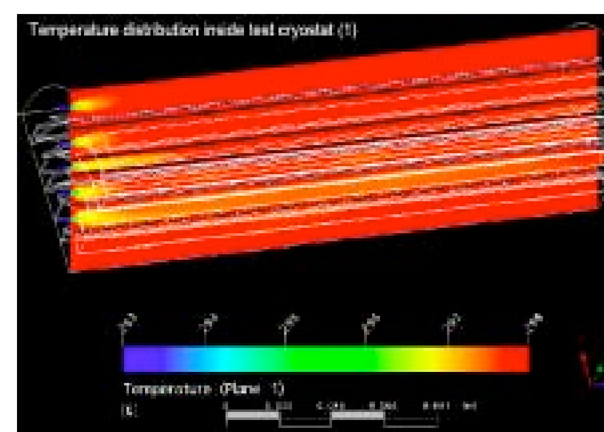
practical ladder design

rigid structure
is promising

RVC	0.09%
SiCarbide+foam	0.14%



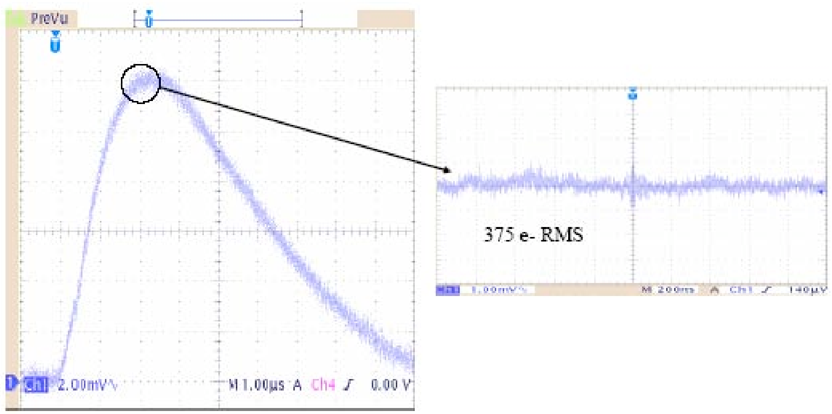
cooling
Gas cooling

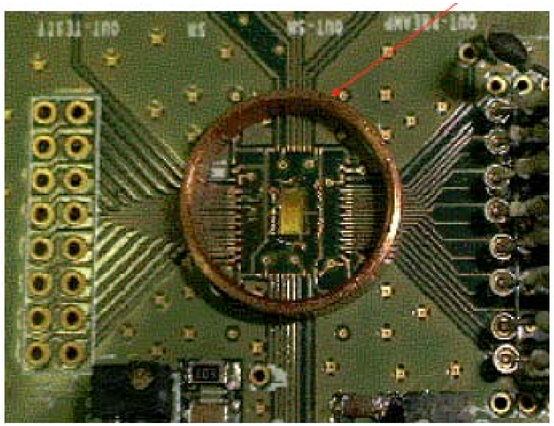


Status on the Development of FE & Readout Electronics for Large Silicon Trackers

Aurore Savoy-Navarro

Final results from the first prototype FE chip in 180 nm: Very encouraging

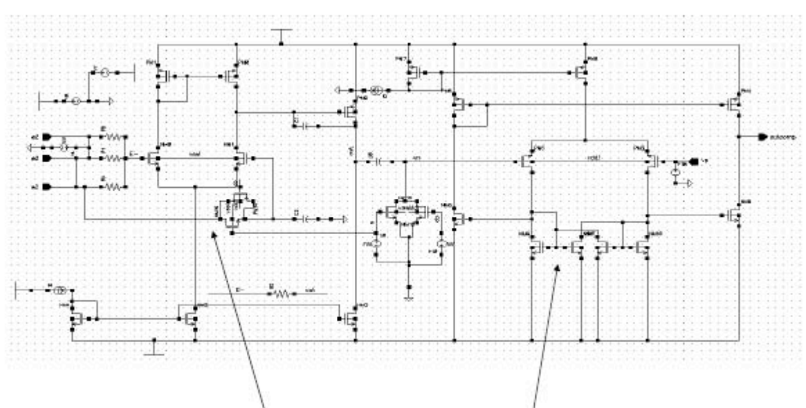




375 e- input noise with chip-on-board wire-bonding (against 280 simulat ed)

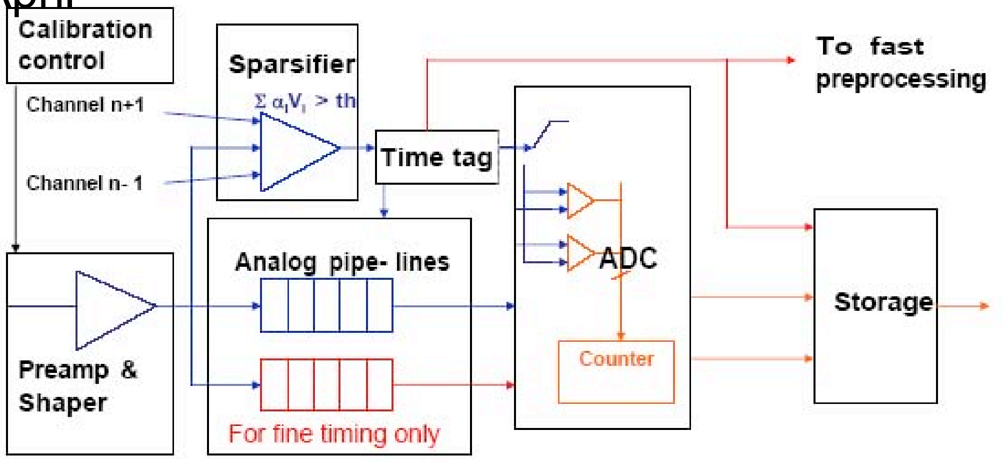
Second prototype underway in 130nm and full electronic chain (A/D and power cycling included), to be submitted end April

130nm Sparsifier



- Sum of adjacent channels
- Offset cancelled Threshold detection

Front-end architecture

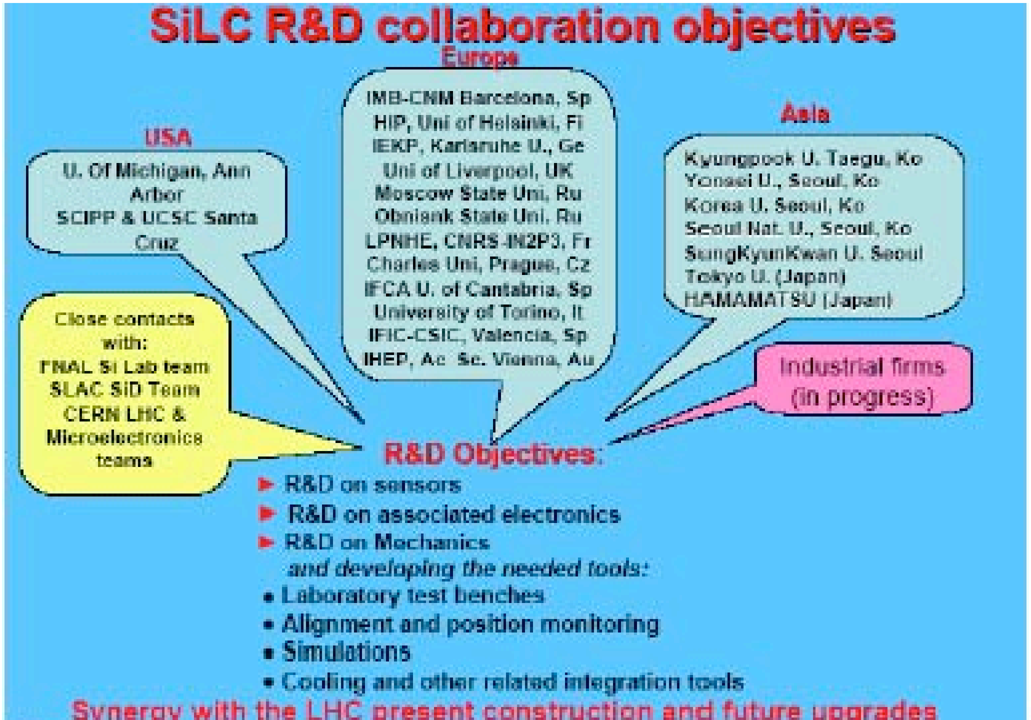


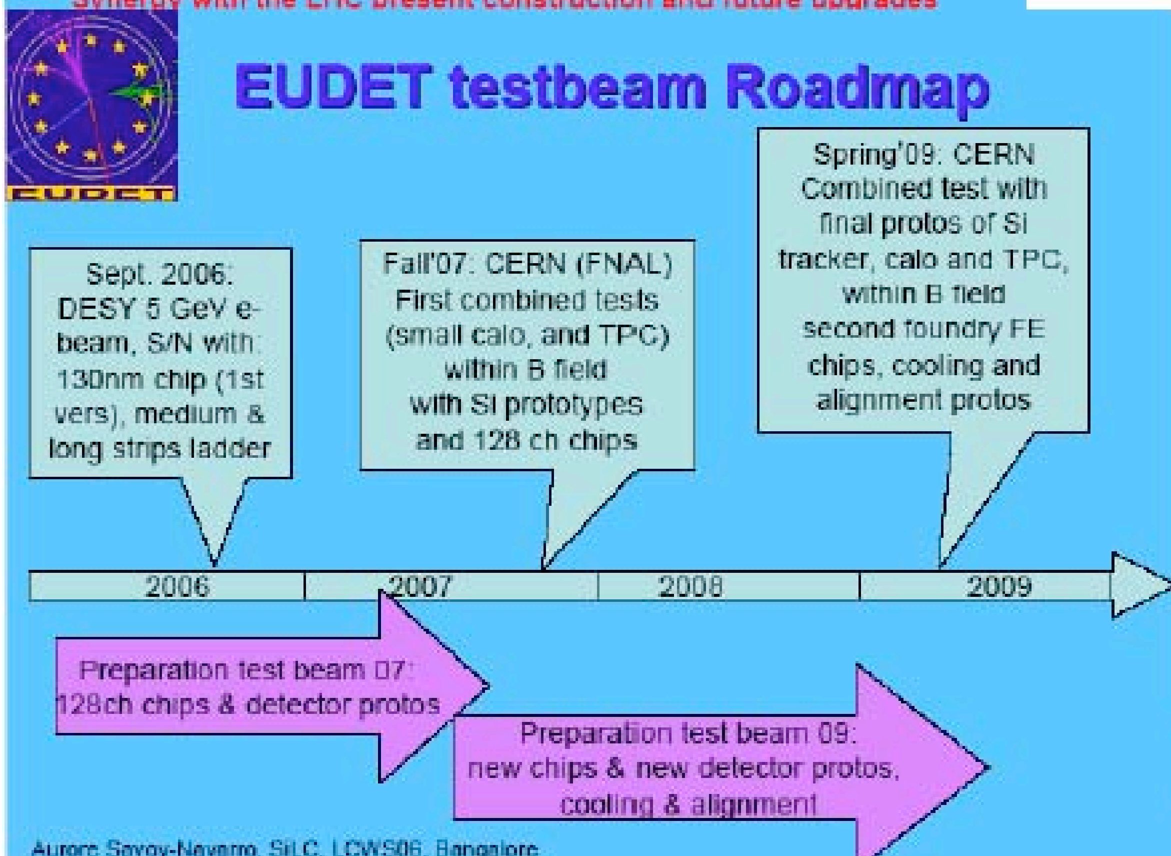
Charge 1- 40 MIP, S/N~ 15- 20, Time resolutions: BC tagging, fine: ~ 2ns

Present technologies - Deep Sub-Micron CMOS
UMC 0.18 µm, 0.13 µm

Time-stamping on all layers
fine time resolution
on some layers

Jean- Francois Genat, LCWS06, March 9- 13th, Bangalore, India



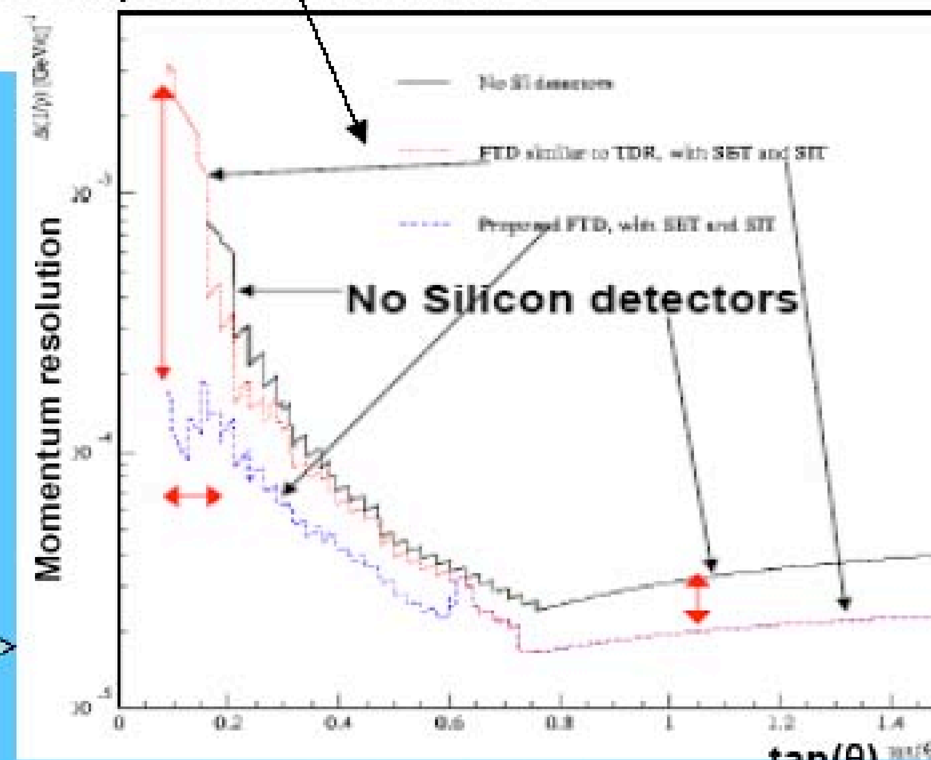


Some novelties

- Preliminary measured pulse velocity on Lab test bench: 22ns/m

  Applying constant fraction threshold gives of the order 5 cm spatial resolution and few ns time resolution.
- Elementary module revisited:

  FE electronics on sensors using flip chip bump bonding
- Full chain F.E readout chip in UMC 130nm to be sent by April 24.
- Improvements of tracking performances with Silicon components added to TPC

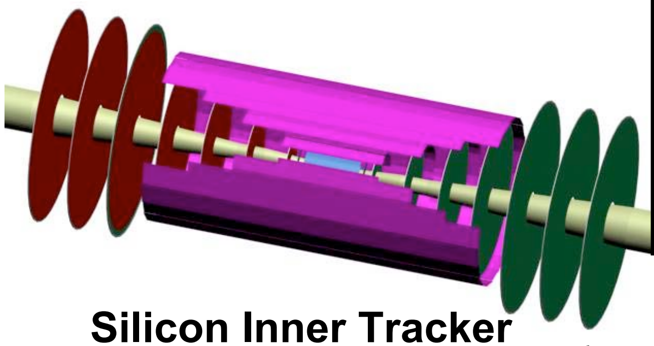


Only TPC (no Silicon trackers)
FTD as TESLA TDR + SIT & SET
FTD new + SIT + SET

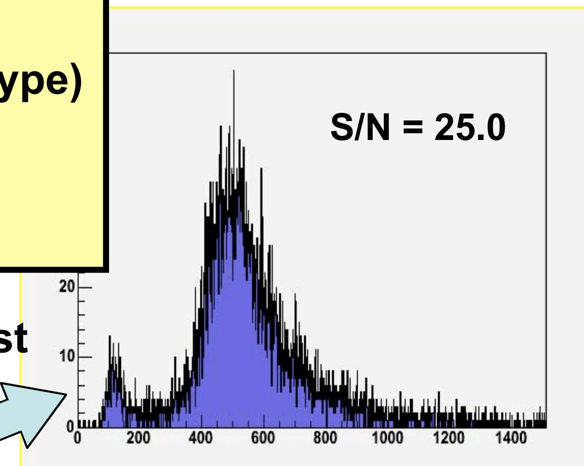
Hwanbae Park

Silicon R&D in Korea

- Aiming
  - silicon sensor (DC- and AC-type) on large wafer
  - thinning
  - relatively cheap price

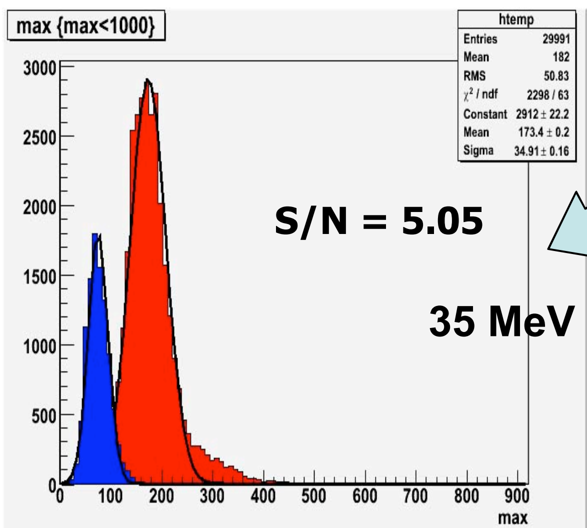


Silicon Inner Tracker



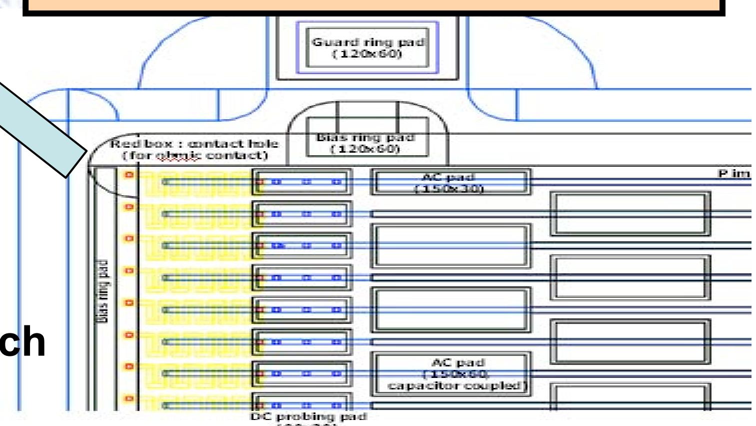
^{90}Sr Source Test

- DC-sensor fabrication and test
  - DSSD, SSD, Si diode
- AC-sensor is being fabricated
  - SSD



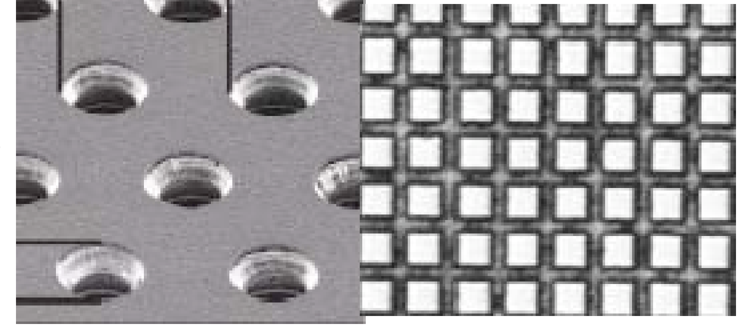
35 MeV proton beam test

H. Park



mask design on 7inch

Brief Introduction of TPC



Required position resolution ~ 100-120um □P/P ~ 10^{-4}P

Good two track separation

Key Issue

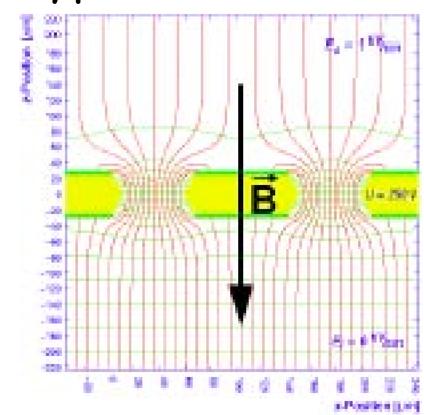
Can we achieve this resolution @ 2.5m drift ?

High B field suppress transverse diffusion.

MPGD (GEM, Micromegas) -TPC is a candidate as it is free from ExB effect.

Many groups have been studied performances using small prototype.

R&D towards TDR



We are here

phase I	phase II(~3years)	phase III
"Demonstration"	"Consolidation"	"Design"
Small Prototype	Large Prototype	

besides the resolution

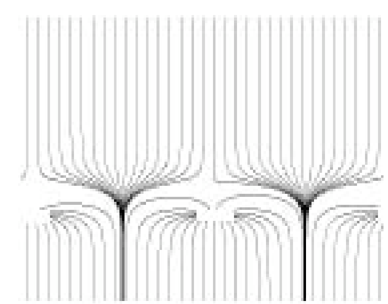
- gas study
- ion backdrift
- neutron background
- non-uniform B/E field
- software

Readout method

- standard pad readout
- std+charge dispersion
- advanced pixel readout

electronics

material budget at endplate



Point resolution vs. Drift distance

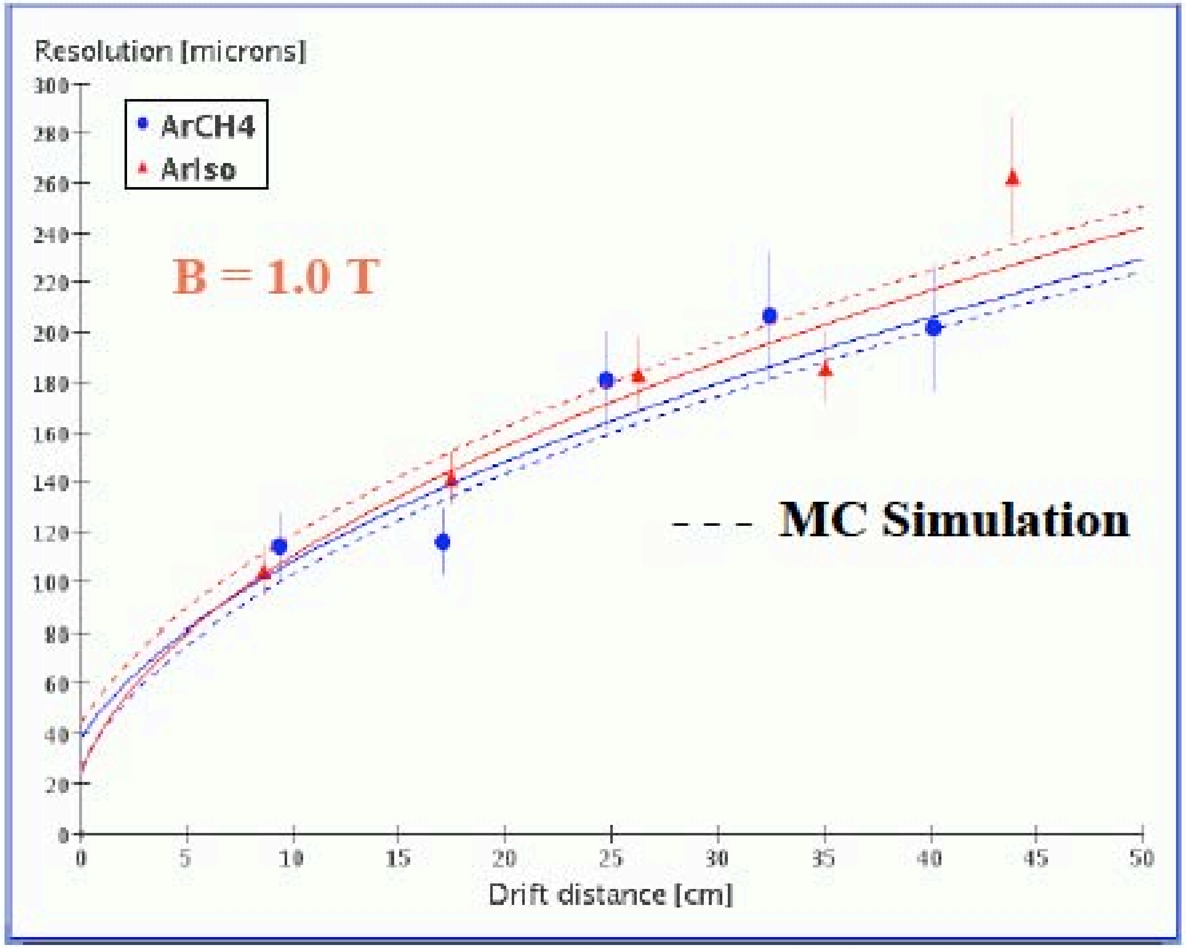
Mike Ronan

Similar point resolution results were obtained for both **Ar-Methane: 10% (P10)** and **Ar-Isobutane: 5%**. The larger diffusion in Ar-Isobutane is compensated by a larger number of effective electrons.

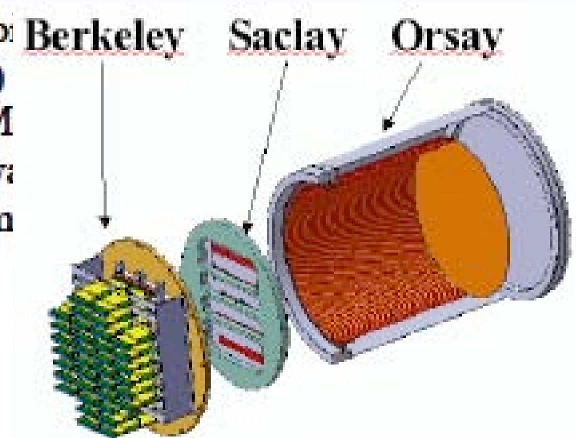
We find

	Data	Monte Carlo
Ar CH4	19.1 +- 4.6	19.4 +- 0.5
Ar Isobutane	32.1 +- 4.8	30.8 +- 1.3

The extrapolated point resolution at zero drift is at or below 50 microns for both gases.



Measured Micromegas TPC po
Argon-Methane: 10% (P10)
magnetic field of 1. tesla. A M
ionization, electron drift and ava
to be in excellent agreem

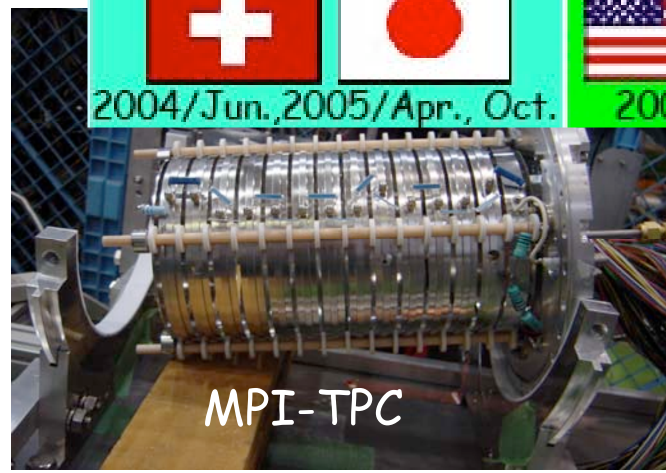


However, Ar-CF4 is quite different.

MT3/MPT collaboration

Multi Techonologies testing TPC
Multi Prototype TPC

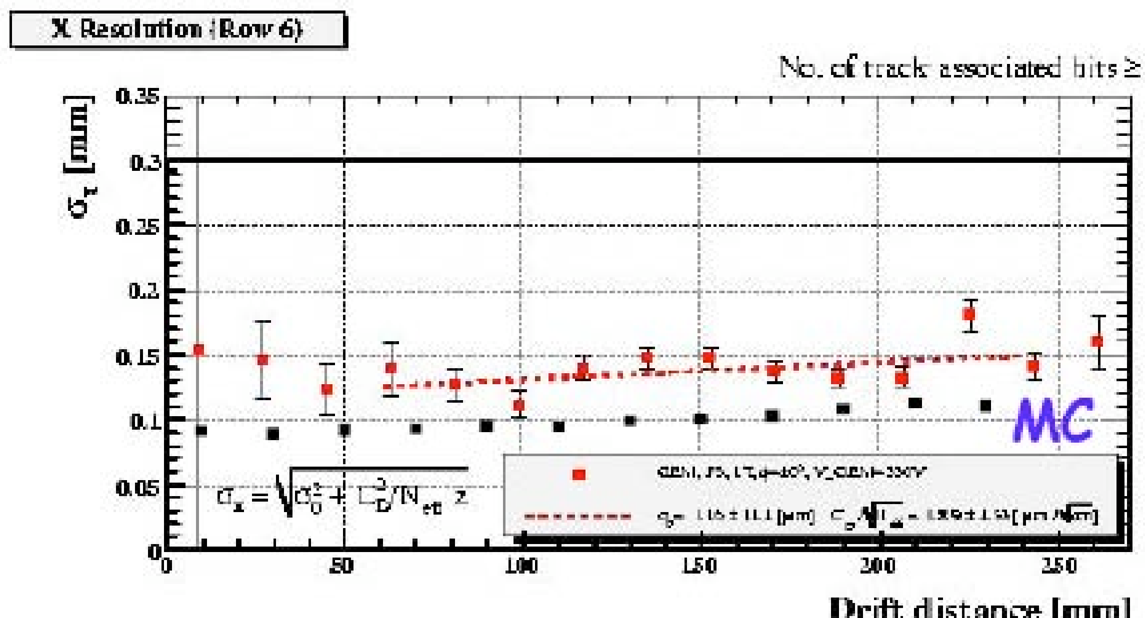
test MWPC, GEM & Micromegas



GEM with 1.27mm staggered pad
in P5 gas under 1T B field

Oct. P5 50V/cm

$$\sigma_x = \sqrt{\sigma_0^2 + \frac{C_D^2}{N_{eff}} z}$$



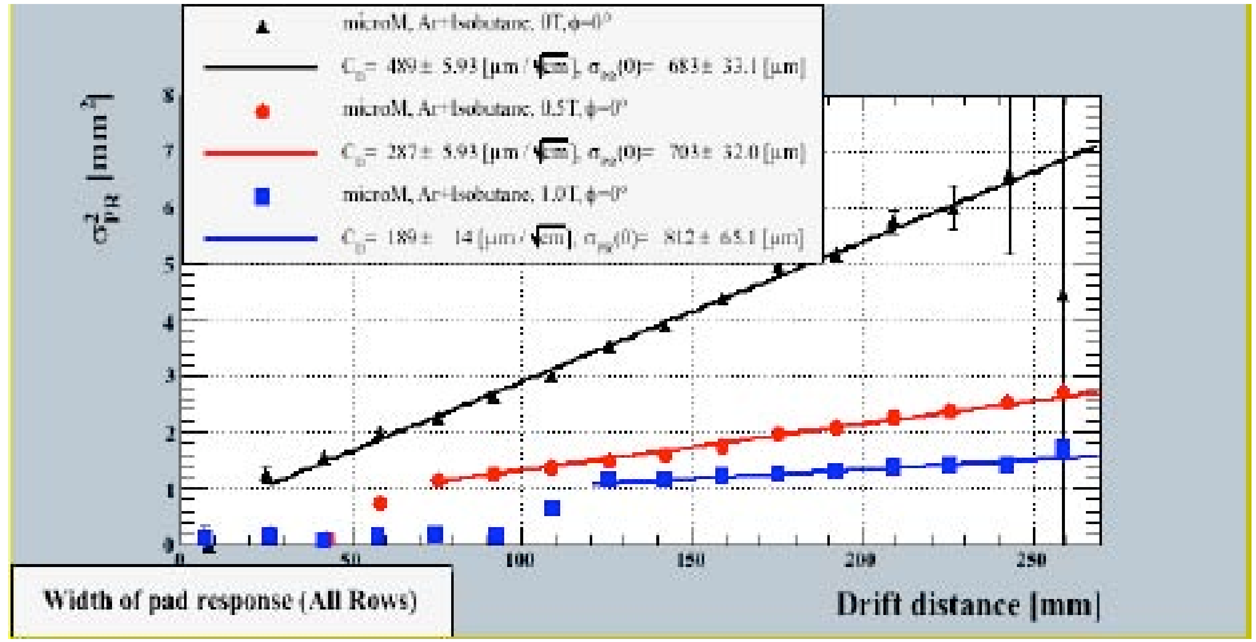
Micromegas-TPC at MT3

Rose Reserva

Ar:isoC4H10
2.3mm pad

CD measurement

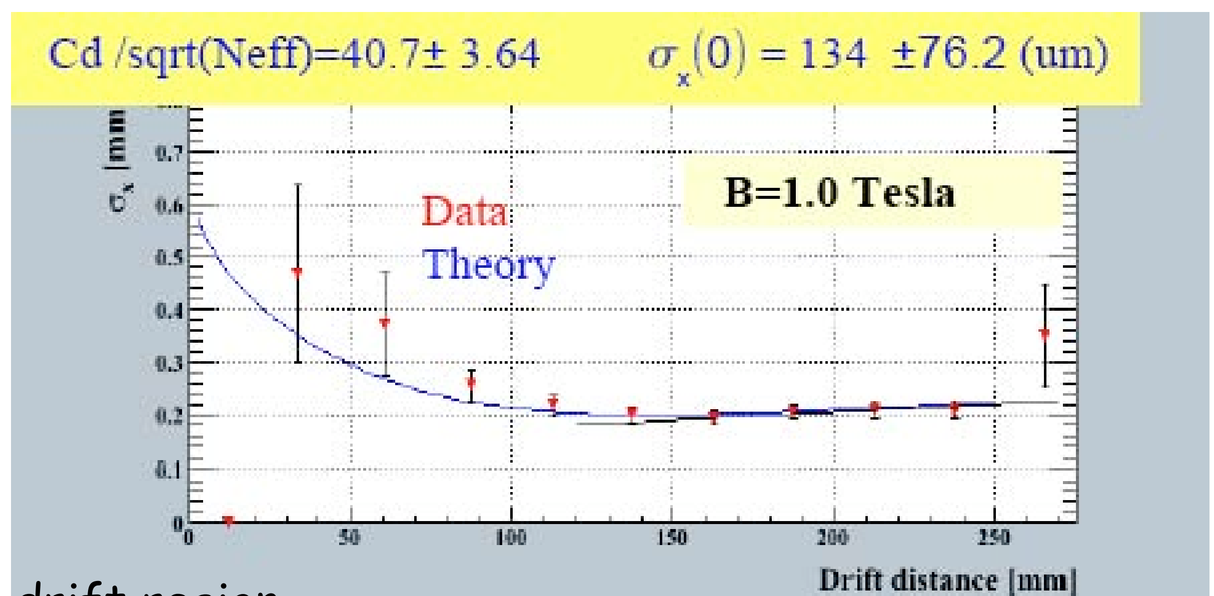
$$\sigma_{PR} = \sqrt{{\sigma^0_{PR}}^2 + C_D^2 \times z}$$



Resolution

not behave like this

$$\sigma_x = \sqrt{\sigma_0^2 + \frac{C_D^2}{N_{eff}} z}$$



Pad size is too wide comparing
to the narrow MM signal.
It dominates the resolution at short drift region

Makoto Kobayashi

Formulation of Spatial Resolution

for tracks perpendicular to the pad row

$$\sigma_X^2 = \int_{-1/2}^{+1/2} d\left(\frac{x^*}{w}\right)\left\{ [\mathrm{i}] + \frac{1}{N_{\mathrm{eff}}}[\mathrm{ii}] \right\} + [\mathrm{III}]$$

$$[\mathrm{i}] \equiv \left[\sum_j (jw)\left\langle F_j(x^*+\delta x)\right\rangle - x^* \right]^2$$

$$[\mathrm{ii}] \equiv \sum_{j,k} jkw^2 \left\langle F_j(x^*+\delta x) F_k(x^*+\delta x)\right\rangle - \left[\sum_j jw\left\langle F_j(x^*+\delta x)\right\rangle \right]^2$$

$$[\mathrm{III}] \equiv \frac{\left\langle (\delta q)^2 \right\rangle}{\left\langle Q \right\rangle^2} \left\langle \frac{1}{N^2} \right\rangle \sum_j (jw)^2$$

(δq : electric noise charge on a pad

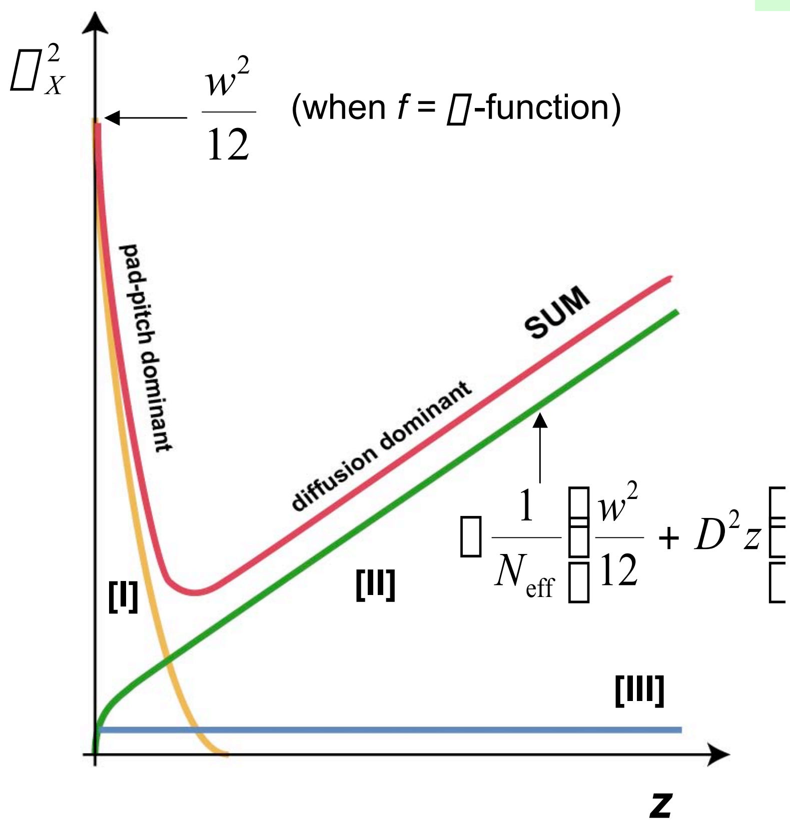
When pad response is narrow (like Micromegas) resolution can be described analytically.

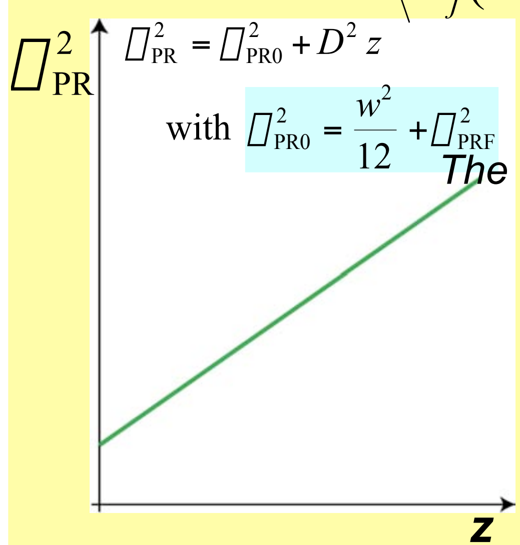
where $N_{\mathrm{eff}} \equiv \left[\left\langle \frac{1}{N} \right\rangle \frac{\left\langle Q^2 \right\rangle}{\left\langle Q \right\rangle^2} \right]^{-1}$ **and**

Pad Response $\left\langle F_j(x^*+\delta x)\right\rangle \equiv \int_{-\infty}^{+\infty} d(\delta x) P_D F_j(x^*+\delta x)$

with $P_D \equiv \frac{1}{\sqrt{2\pi}D} \exp\left[-\frac{(\delta x)^2}{2D^2} \right]$.

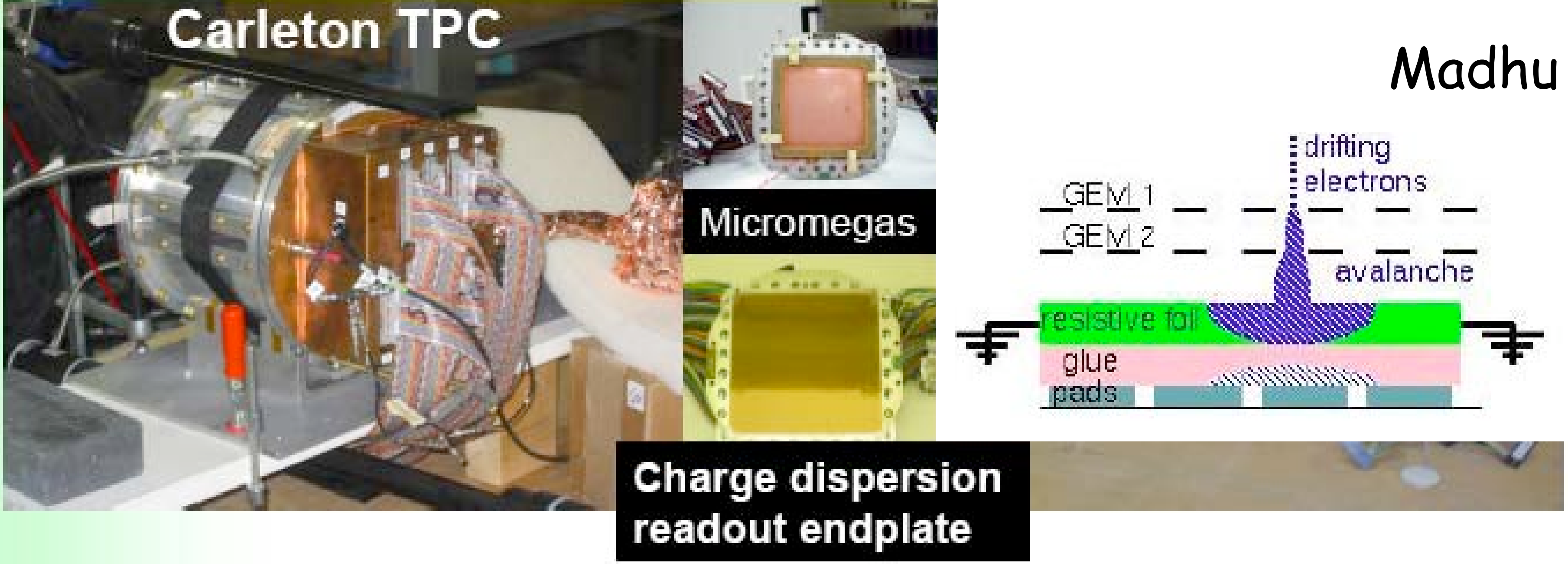
The definition is similar for < Fj ·Fk > .

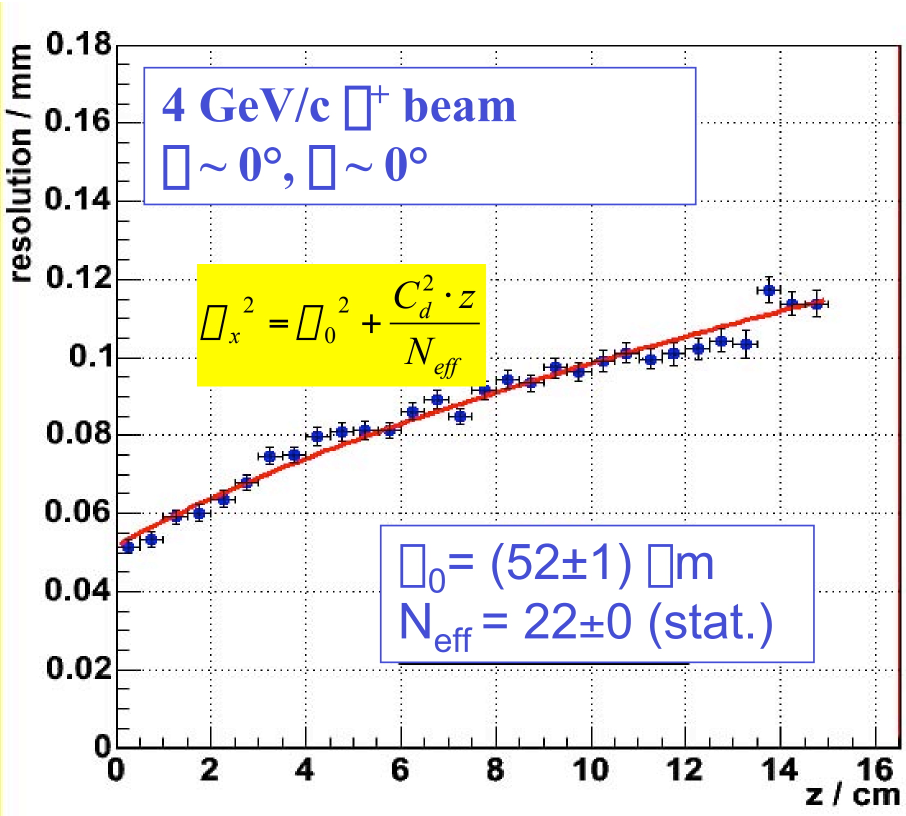




narrow pad is necessary or..

Madhu Dixit





- Significant suppression of transverse diffusion at 4 T. Example gases:

D_{Tr} ~ 32 μm/√cm (P10)

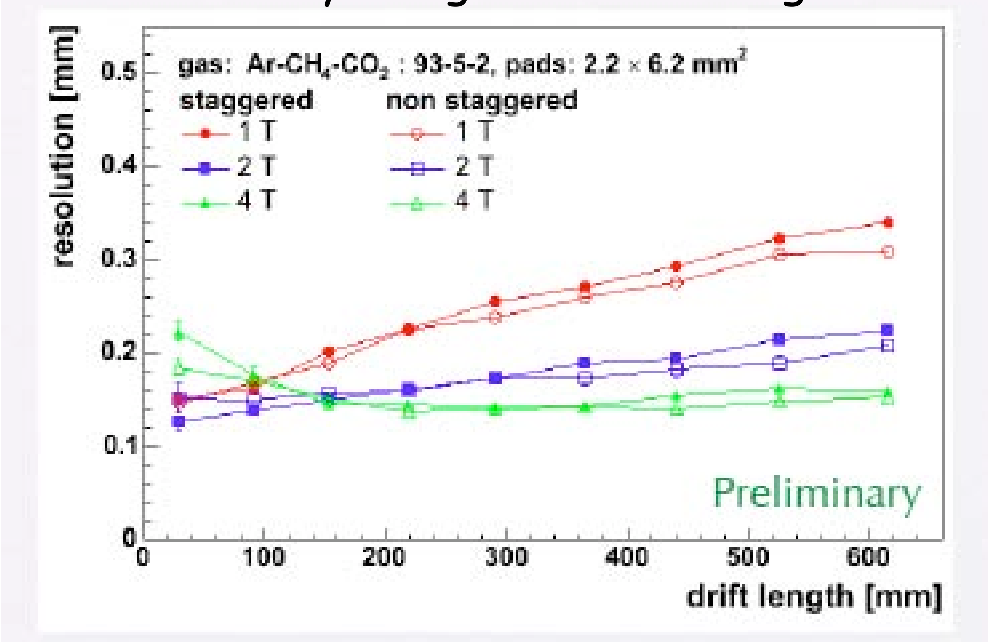
~ 20-30 μm/√cm (Ar/CF4 mixtures)

Extrapolate from present data to B = 4T
Use D_{Tr} = 32 μm/√cm
Resolution (2 mm pads)
σ_{Tr} ≈ 100 μm (2 m drift)

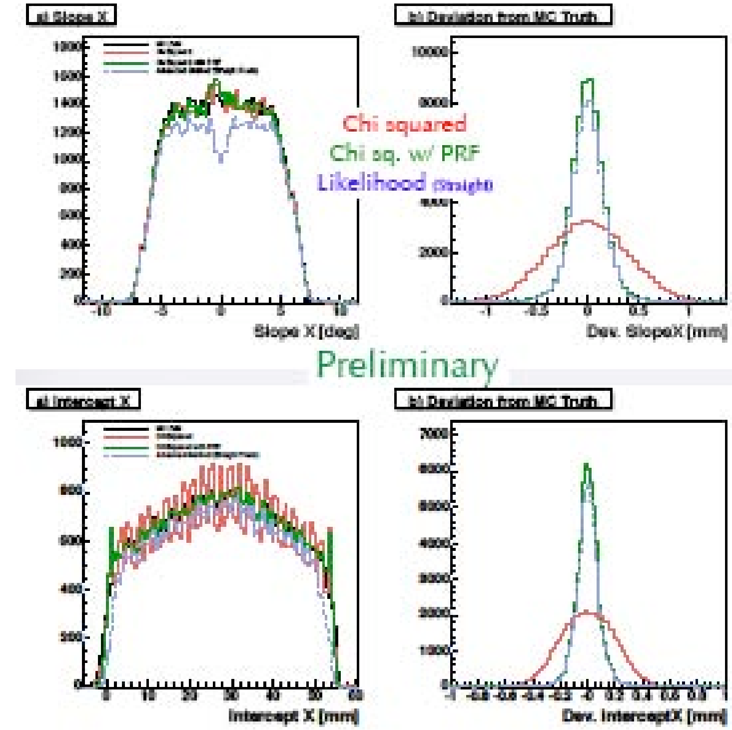
ILC TPC R&D studies at DESY/U. Hamburg

Katsumasa Ikematsu

resolution study using several fitting methods



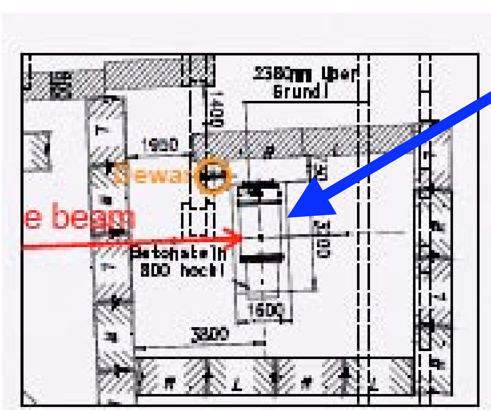
Efficency study using MC



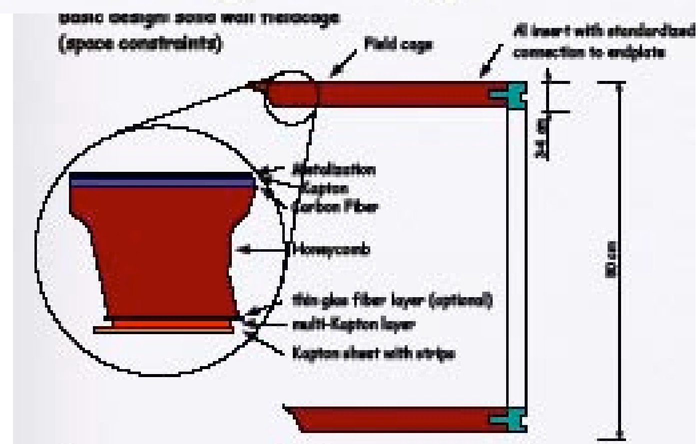
Effort to EUDET & Large Prototype TPC

Preparation of test beam

PCMAG



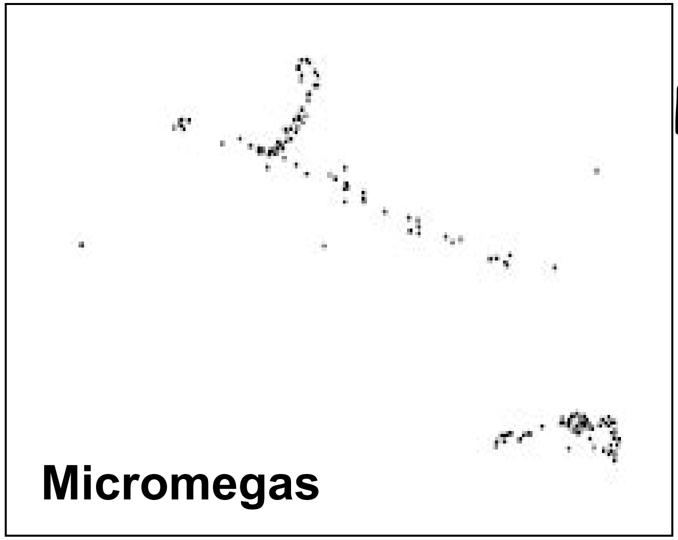
Field cage design



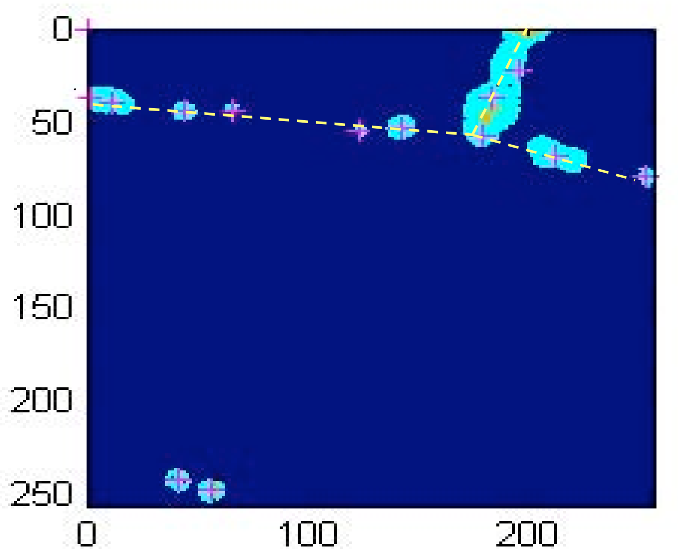
SiTPC : digital TPC

Paul Colas

- Readout a TPC with CMOS VLSI chips
- Tracks seen, single-e or single-clusters, with Micromegas or GEM amplification
- MC and theoretical studies show ultimate resolution

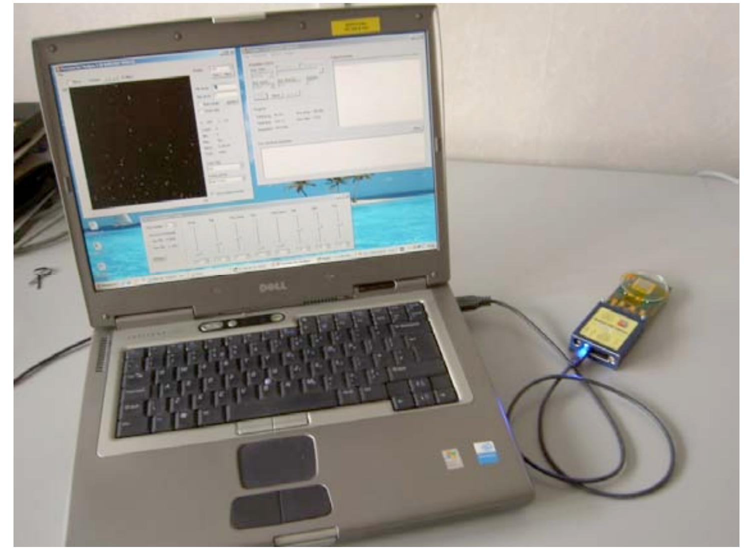


GEM



A EUDET project

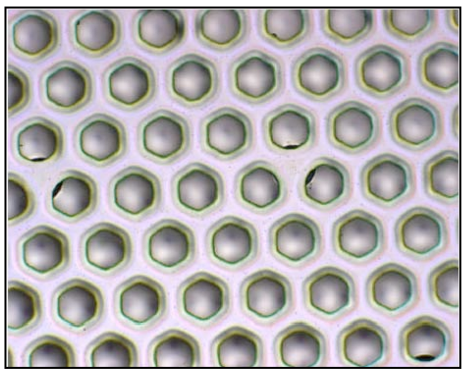
Developments in progress



USB pluggable readout, new Medipix2 chip

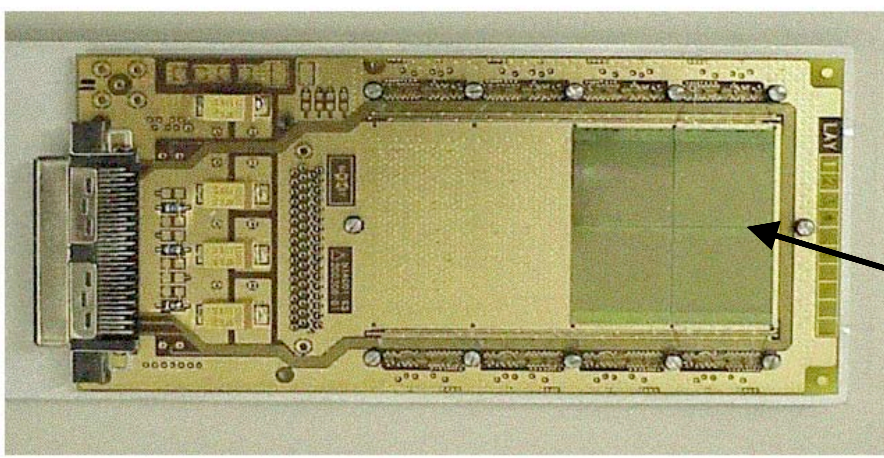
Noise under study

Integrate Micromesh onto the chip by post-processing (InGrid)

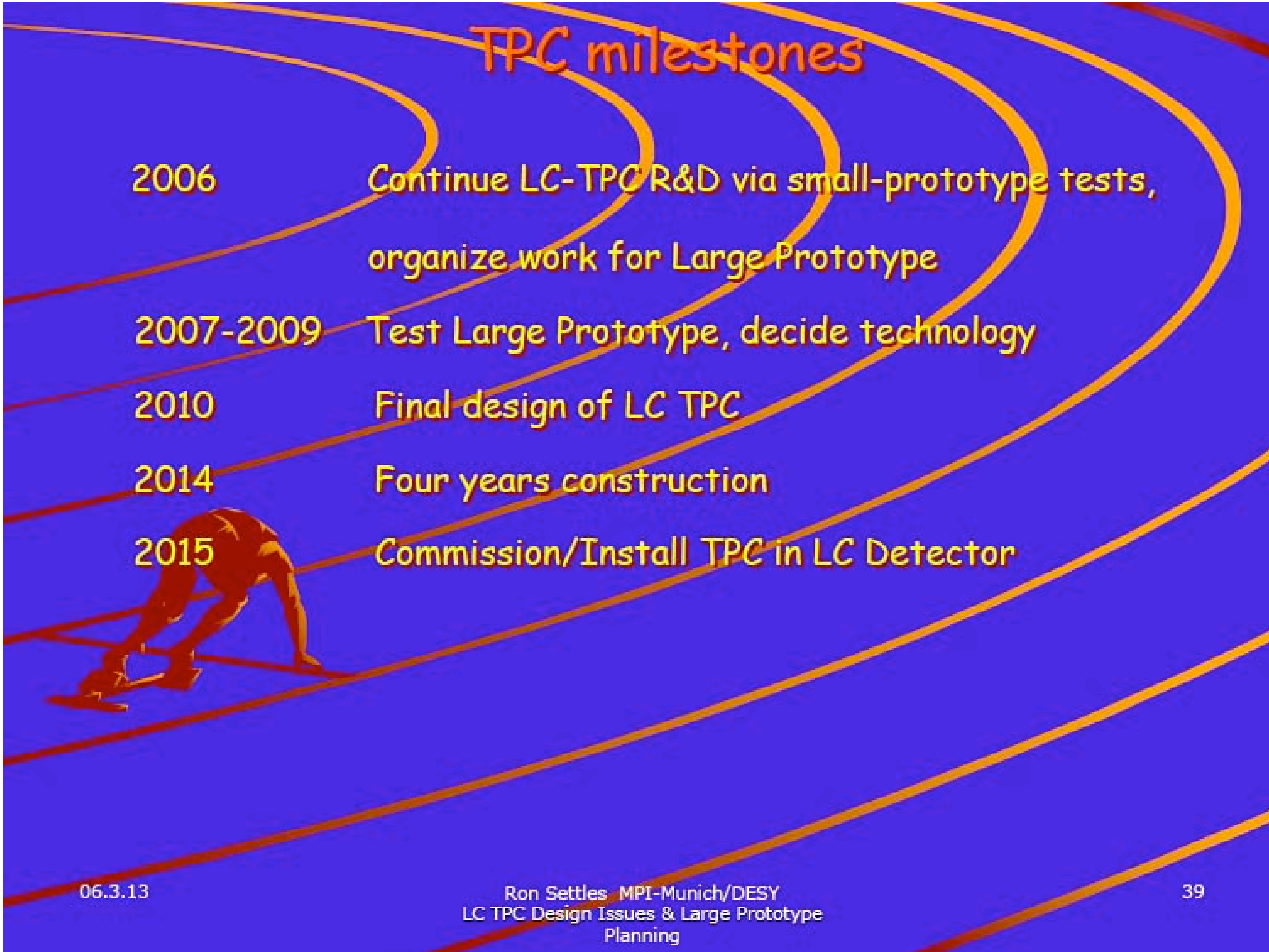


Add a protective layer

Provide time measurement (switchable with time over threshold) -> TimePix



Tile-up chips and speed-up readout (RELAXD project)


TPC milestones
2006 Continue LC-TPC R&D via small-prototype tests,
organize work for Large Prototype
2007-2009 Test Large Prototype, decide technology
2010 Final design of LC TPC
2014 Four years construction
2015 Commission/Install TPC in LC Detector
06.3.13
Ron Settles MPI-Munich/DESY
LC TPC Design Issues & Large Prototype
Planning
39