# LCWS07 Tracking Summary

The combined Vertexing/Tracking sessions:

scheduled 11.5 hours , 37 presentations

Of these, 23 were Tracking, which is the content of this talk.

In addition,

there were a few presentations in Simulation/Reconstruction sessions that are relevant to this discussion.


CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

# the presentations

The 23 tracking presentations covered topics relevant to the R&D organizations.

**SiD Tracking**

| | |
|---|---|
| Track resolution studies with the 'LiC Detector Toy' MC tool | Winfried Mitaroff (*OEAW Vienna*) |
| Digitization and hit reconstruction for Silicon Tracker in MarlinReco | Sergey Shulga (*JINR Dubna*) |
| Tracking in SiD | Robert Kutschke (*Fermilab*) |
| Non-Prompt Track Reconstruction with a Calorimeter Assisted Tracking Algorithm | Dmitry Onoprienko (*Kansas State Univ.*) |
| (simulation session) Simulation of an All-Silicon Tracker | Bruce Schumm (*UCSC Santa Cruz*) |

**SiLC**

| | |
|---|---|
| Progress on long-shaping-time readout at SCIPP | Bruce Schumm (*UCSC Santa Cruz*) |
| SiLC tracking studies report | Marcel Vos (*IFIC Valencia*) |
| Source Test of the 180 nm chip with GLAST and CMS sensors | Wilfrid Da Silva (*LPNHE - Paris*) |

**4$^{th}$ Concept Tracking**

| | |
|---|---|
| The Cluster Counting Drift Chamber of the 4th Concept | Franco Grancagnolo (*INFN Lecce*) |

**(generic)**

| | |
|---|---|
| Digital Active Pixel Array for Vertex and Tracker Systems | George Bashindzhagyan (*Moscow State Univ.*) |

# (the presentations)

(The 23 tracking presentations covered topics relevant to the R&D organizations.)

**LC-TPC** (13 presentations)

(framework/reconstrtuction)

| | |
|---|---|
| MarlinTPC: Towards a common TPC software framework | Peter Wienemann (*Bonn Univ.*) |
| Track Resolution Studies for a MPGD TPC | Klaus Dehmelt (*DESY*) |
| (simulation) TPC FADC Sim/Reco in Marlin and LCIO | James Hunt (Cornell) |

(TPC background hits)

| | |
|---|---|
| TPC reconstruction dependence on noise using a FADC simulation | Daniel Peterson (*Cornell*) |
| Geant4 Simulations of Machine-Induced Background in a TPC | Adrian Vogel (*DESY*) |

(readout)

| | |
|---|---|
| Pad occupancy in LDC TPC with TDC-based readout electronics | Alexander Kaukher (*Rostock University*) |

(studies of MPGD / gas )

| | |
|---|---|
| Measurements using a Bulk Micromegas in the Cornell/Purdue TPC Prototype | Daniel Peterson (*Cornell*) |
| A study of resolution of a GEM TPC with Ar-CF4-Isobutene gas mixtures | Hirotoshi Kuroiwa (*KEK*) |

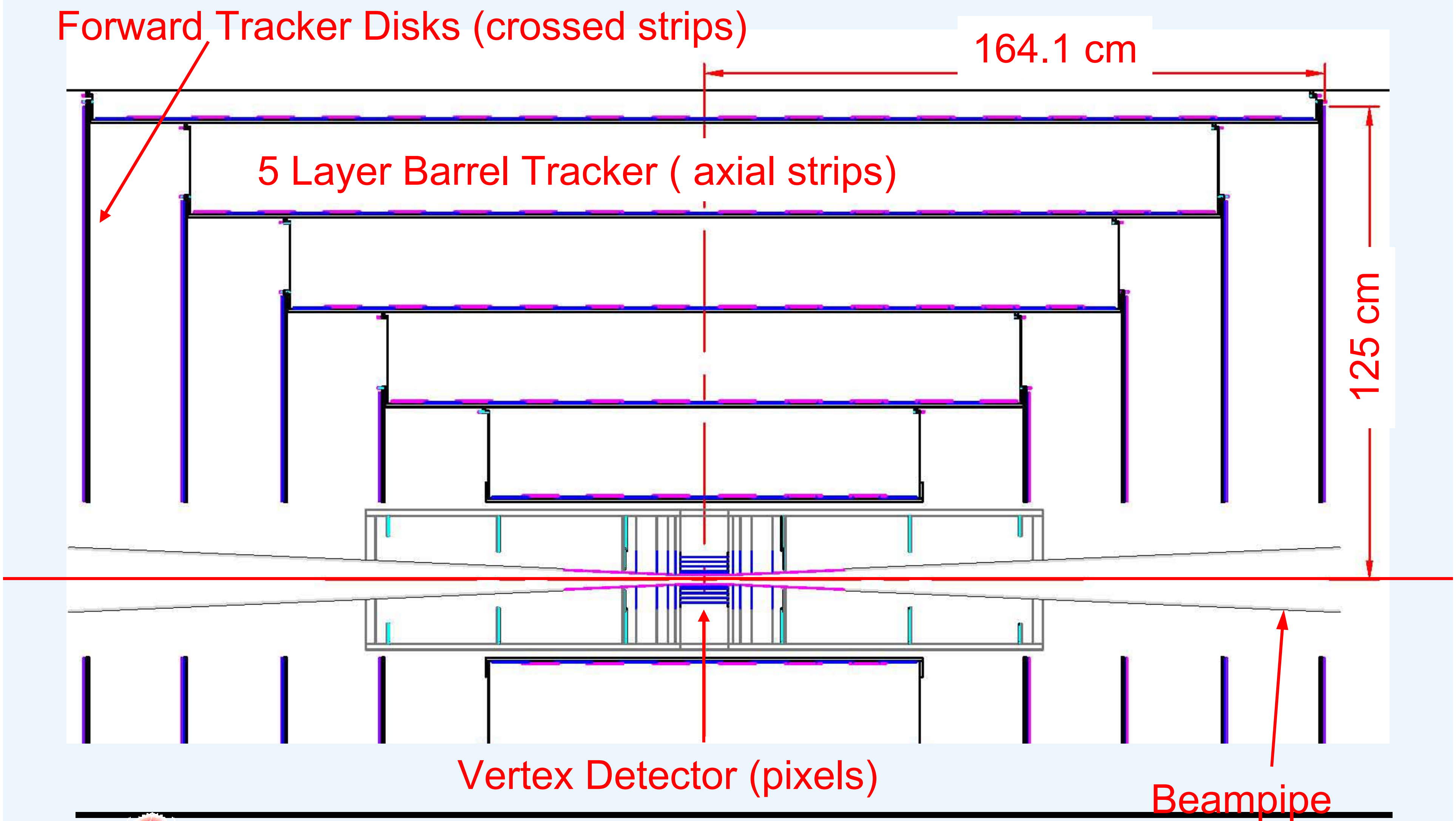
(large prototype)

| | |
|---|---|
| Study of TPC PrePrototype | Akimasa Ishikawa (*Saga Univ.*) |
| Status of the Large TPC Prototype ( note: field cage ) | Lea Hallermann (*DESY/Univ Hamburg*) |
| Measuring distortions in a TPC with photoelectrons | Dean Karlen (*Univ. Victoria and TRIUMF*) |
| Simulation study of GEM gating for LC-TPC | Akira Sugiyama (*Saga Univ.*) |

(pixel readout TPC)

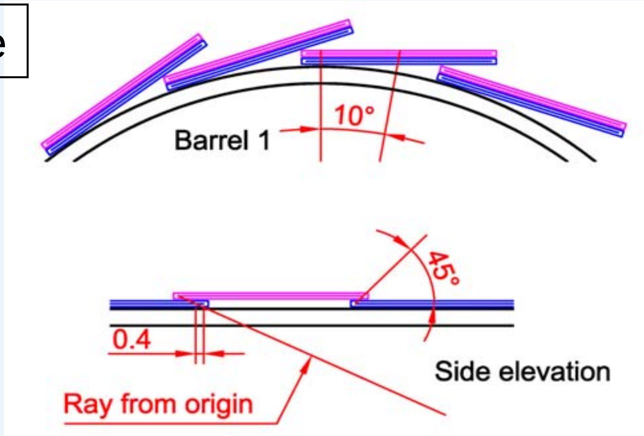
| | |
|---|---|
| Determination of track properties using the GEM-TimePix setup | N. Vlasov (*Freiburg Univ.*) |
| Recent Gridpix results | Maximilien Chefdeville (*NIKHEF Amsterdam*) |

# SiD tracking - Vertical Section

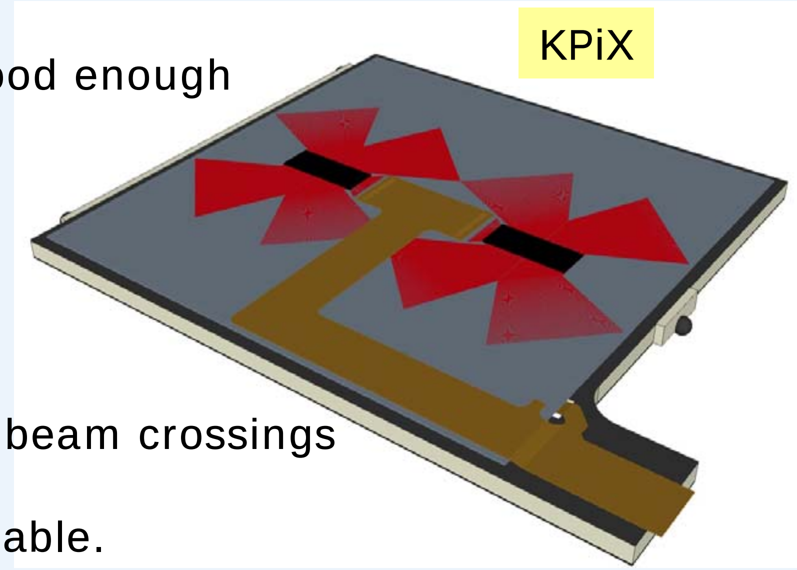


# SiD tracking Sensor options

SiD is investigating 3 Readout options: See R. Kutschke




* KPiX (baseline option)
  + shortest dead time of the 3 options
  + small, low mass package
  + synergy with W-Si ECAL
  - bump bonding is perceived as risky
  - double metal and noise
    (Power traces cross some signal traces)




* Charge Division
  + allows stand-alone tracking if the $\sigma$ is good enough
  + no double metal
  - longer dead time
  - 2x the readout, material, heat

* Time over threshold.
  + digital, no analog hold
  - longer dead time, shaping time of O(10) beam crossings

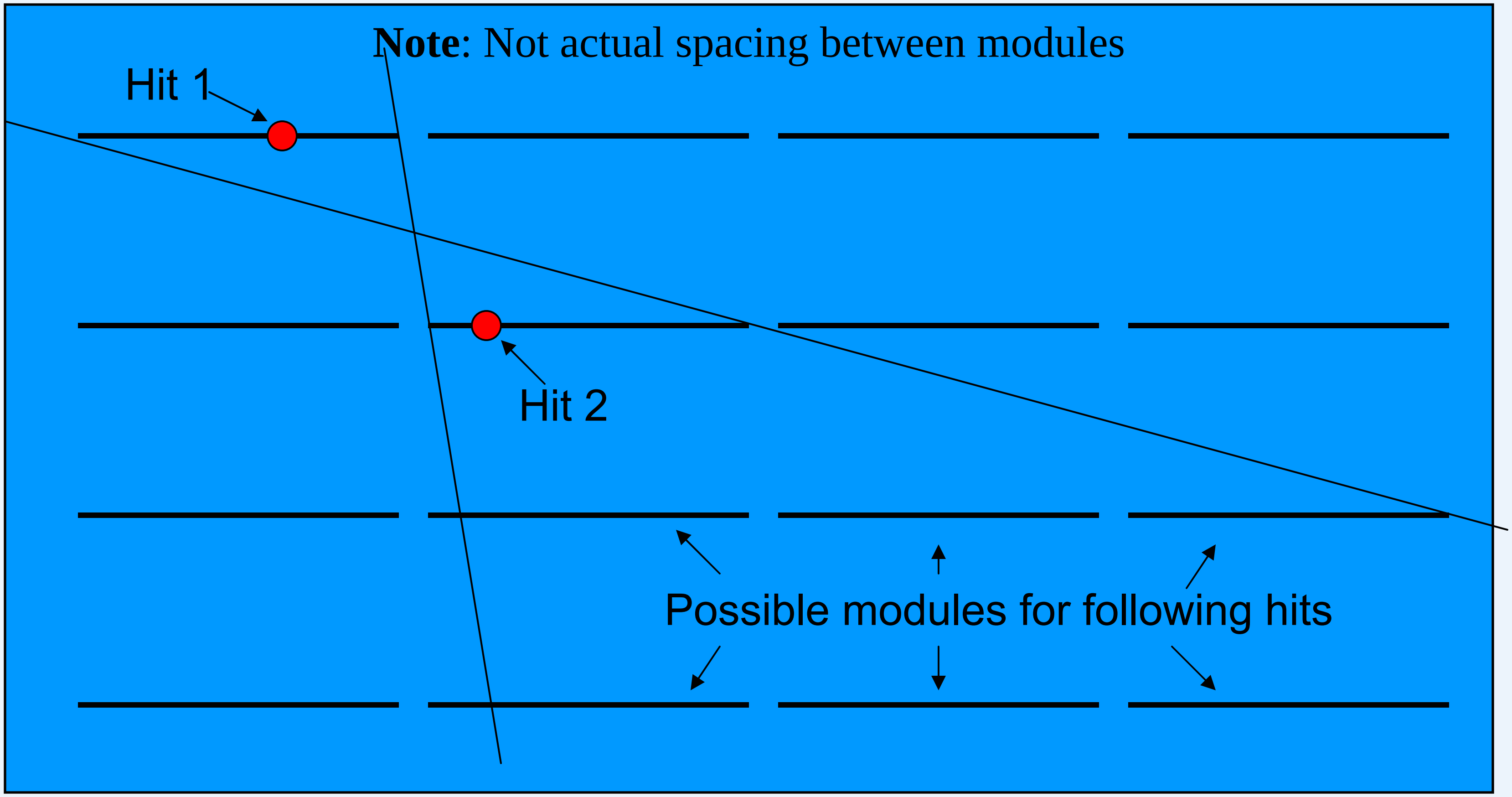
Open to other options when sample chips available.
Submissions to test all are going out – sensors by October 2007.

# SiD stand-alone tracking in main tracker

Z Segmentation

Can we use z-segmentation to further clean up seeds and eliminate fake tracks?
Can we make 4-hit tracks usable?
For now, apply only to three-hit seeds...

See B. Schumm (simulation)



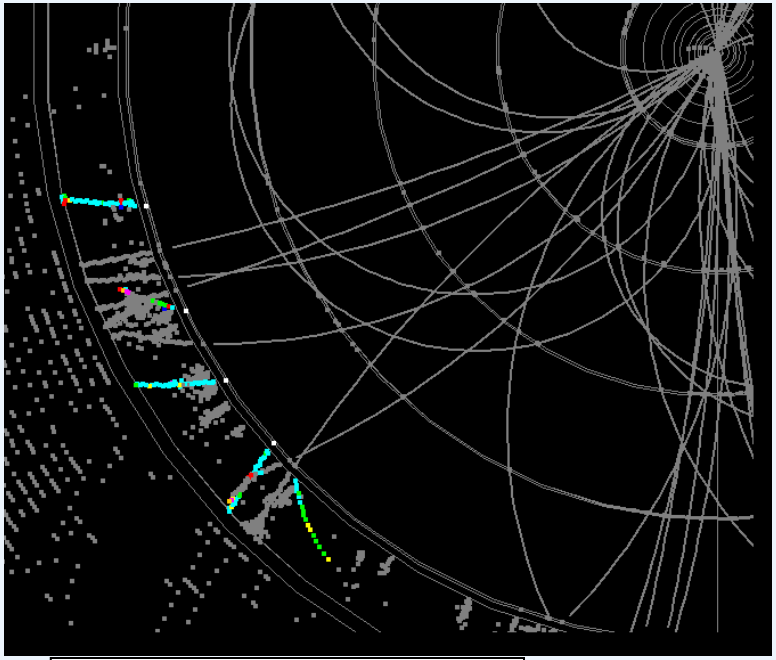
# SiD stand-alone tracking in main tracker

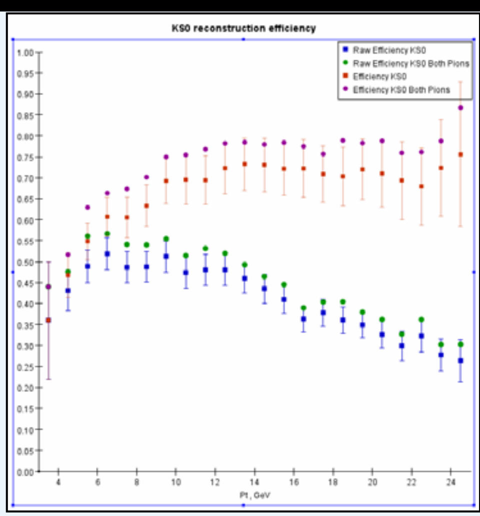
| | Two halves (original) | 30cm segments | 10cm segments | 5cm segments | 1cm segments |
|---|---|---|---|---|---|
| # MCPs | 304 | 302 | 302 | 302 | 302 |
| Found with 5 hits | 145 | 142 | 147 | 152 | 152 |
| Found with 4 hits | 112 | 113 | 114 | 110 | 101 |
| Missed | 47 | 47 | 41 | 40 | 49 |
| 4-hit fake | 157 | 201 | 141 | 108 | 45 |

"Preliminarily, need z-segmentation substantially finer than 10cm to clean up "seeds" for stand-alone central tracking"

The "charge division" sensor option may effectively provide this segmentation though resolution.

# SiD: Calorimeter assisted Tracking






See D. Onoprienko

Note MIP stubs and missing tracks

Showed performance for $K^0$

The performance numbers are just the current snapshot – significant improvements are expected.

MIP stub finder
(currently using a Calorimeter hit cluster)

MIP stub handling in a fit

Interoperability with other packages
fitters, propagators, etc.

Handling of low Pt tracks

Geometry optimization

CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

# SiLC

**http://silc.in2p3.fr/ Urgent simulation studies**

See M. Voss

**(due by the end of 2007)**

Tracking in mixed gas-silicon concepts.

Especially important is the transition in the forward region between TPC and forward disks.

Machine and physics backgrounds and their impact on tracking in the very forward and internal barrel regions.

Study background levels in different detector,
and study pattern recognition in the presence of this background.

Pattern recognition:

Requirements that derive from pattern recognition are not well studied.
What granularity is needed in the different tracking regions to ensure that pattern recognition converges even for some of the toughest cases: in dense jet topologies and for non-prompt tracks?

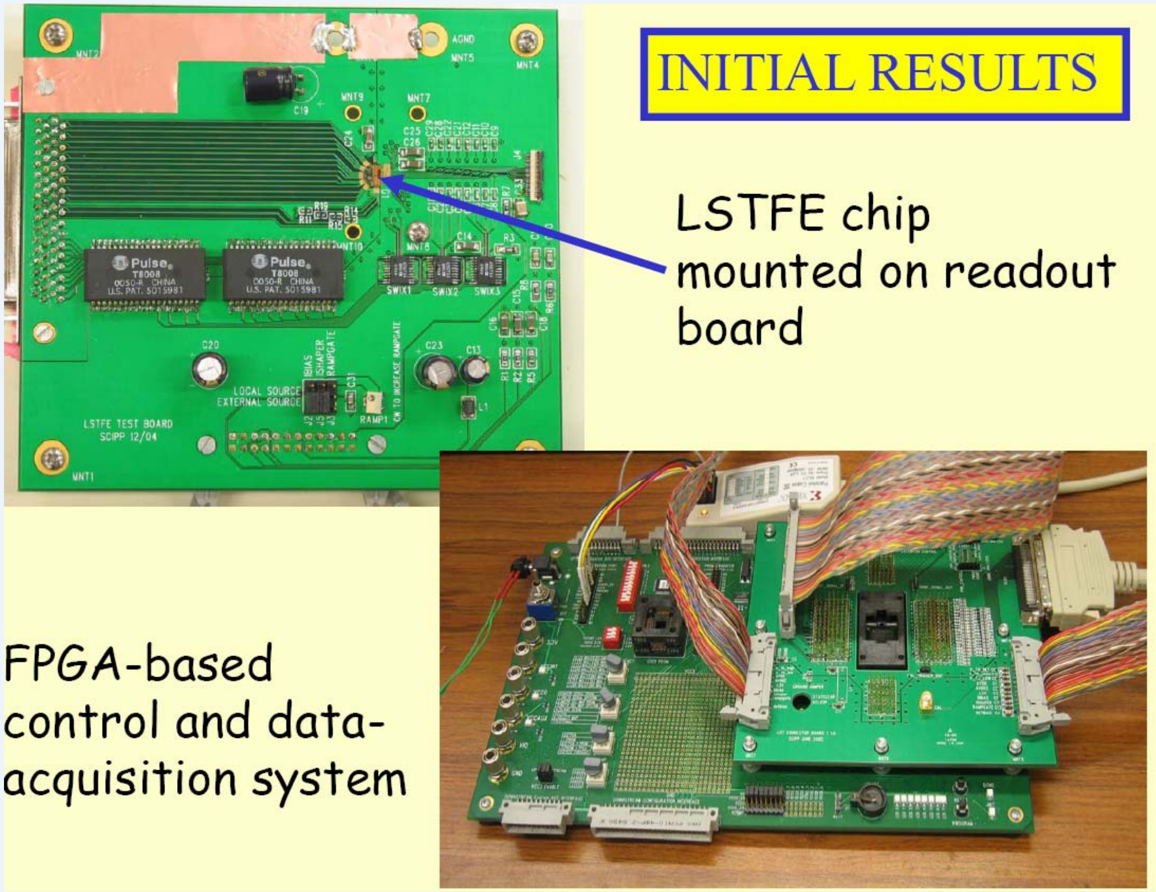
Feedback to global layout optimization.

Optimize the overall design based on physics requirements.
Special attention to the material budget.

# SiLC

See B. Schumm

long shaping time
long ladder
**T**ime **O**ver **T**hreshold readout - relevant to SiD readout technology



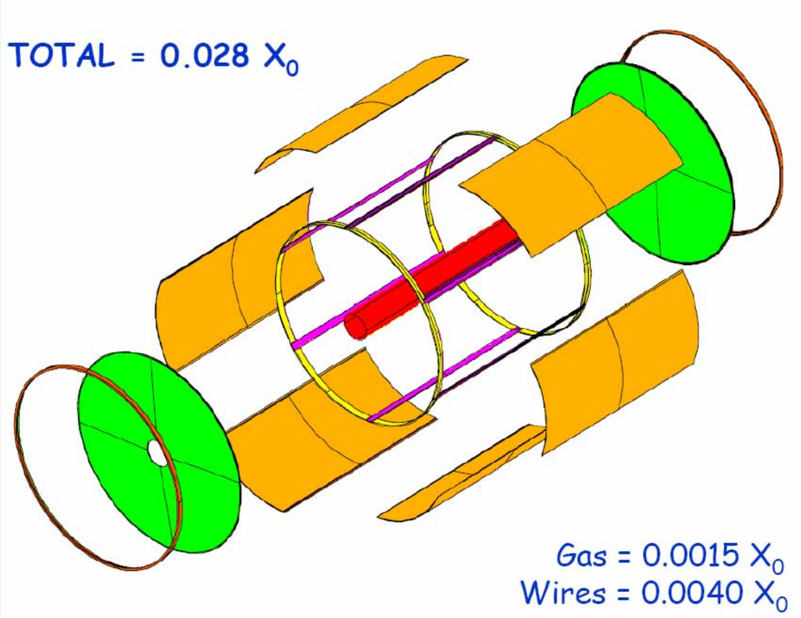
# $4^{th}$ Concept – cluster counting drift chamber

Proposal is to implement a low-mass drift chamber as a central tracker

*The multiple scattering term is reduced through the use of a Helium gas mixture.*

Multiple scattering contribution (equivalent $L/X_0$):
60,000 20 µm W sense wires → $1.8 \times 10^{-3}$ ($X_0$ = 0.35 cm)
120,000 80 µm Al field wires → $2.2 \times 10^{-3}$ ($X_0$ = 8.9 cm)
2 m gas (90% He + 10% $iC_4H_{10}$) → $1.5 \times 10^{-3}$ ($X^0$ = 1300 m)

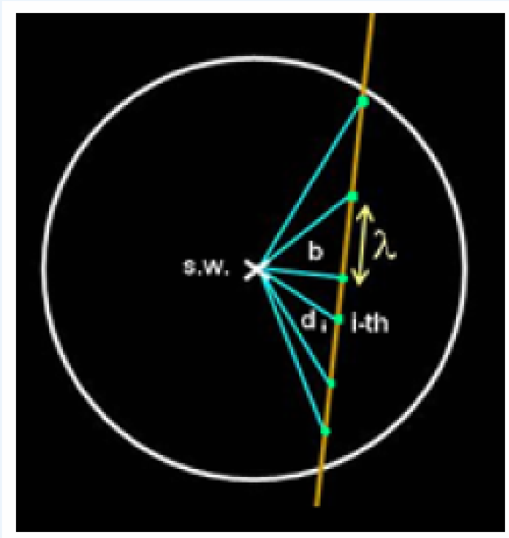
**Equivalent $L/X_0 = 5.5 \times 10^{-3}$**




*The point measurement term is reduced through the of a cluster-counting readout. (follows)*

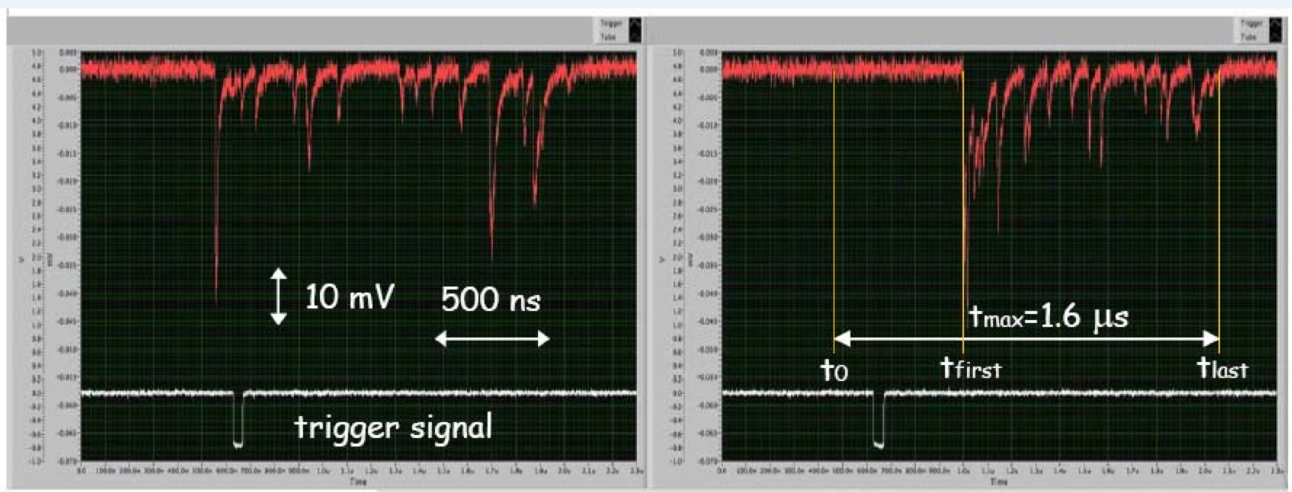
See F. Grancagnolo

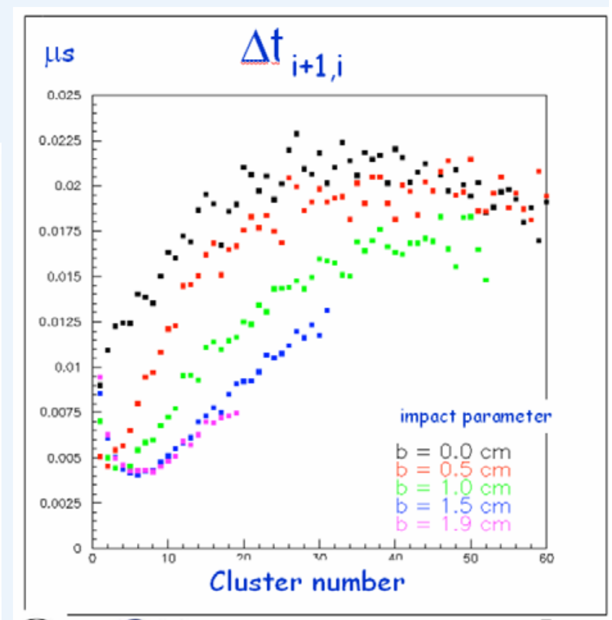
# 4th Concept – cluster counting drift chamber



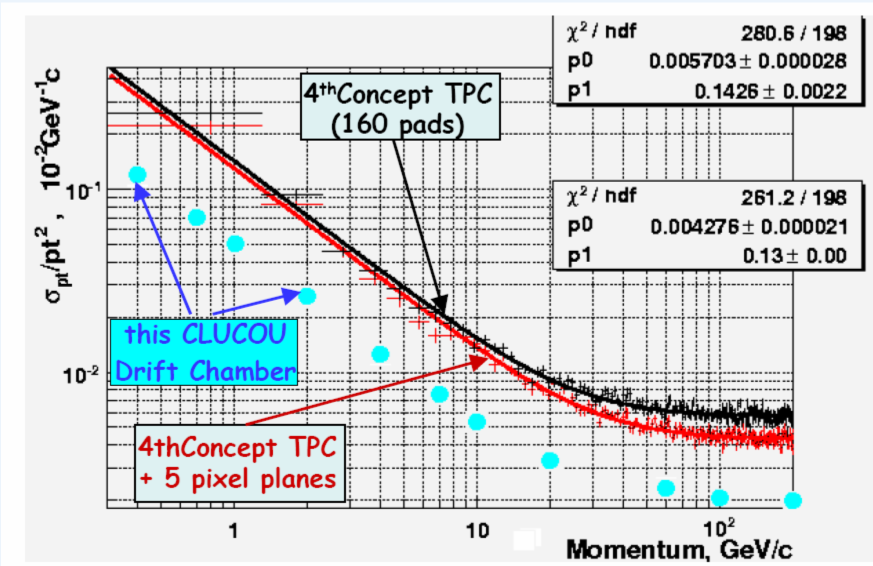

Sampling the drift chamber signal provides more information than the threshold-crossing time.

Measurement resolution = 50 μm expected.

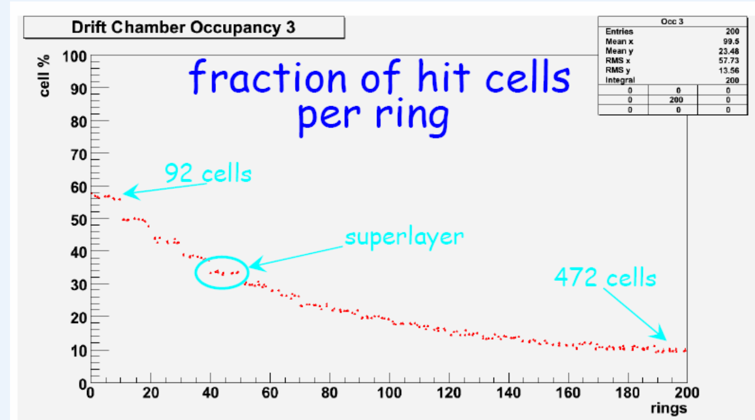


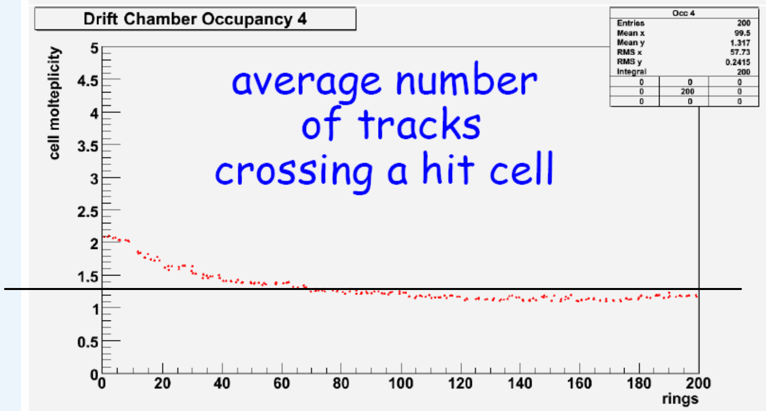



# $4^{th}$ Concept – cluster counting drift chamber




*The Reduced scattering and point resolution are expected to provide improved momentum resolution.*



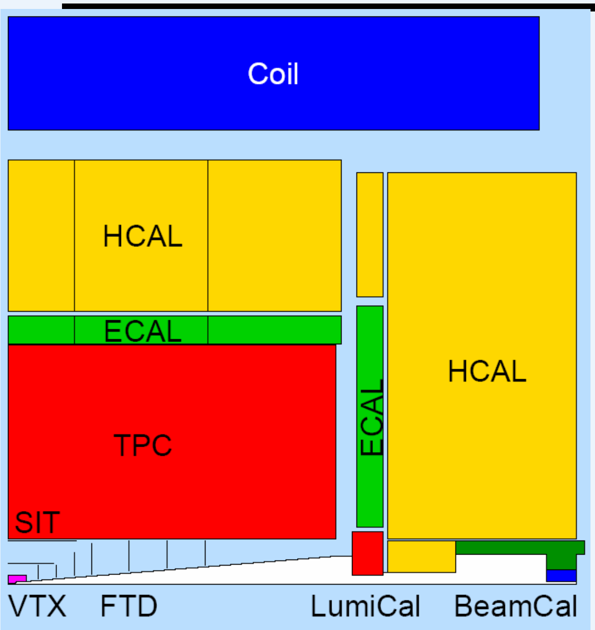



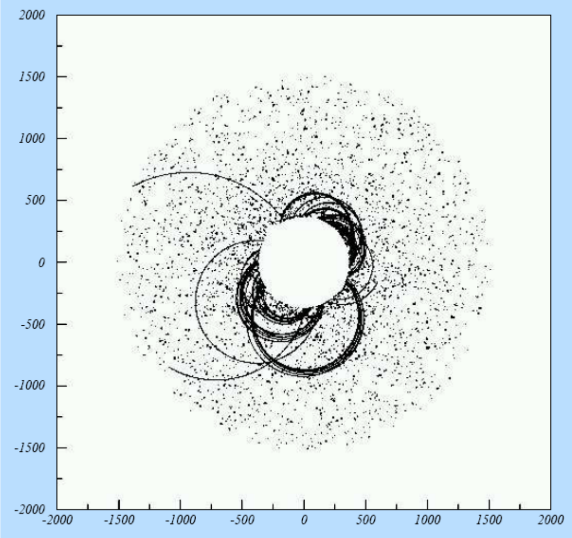

higher multiplicity

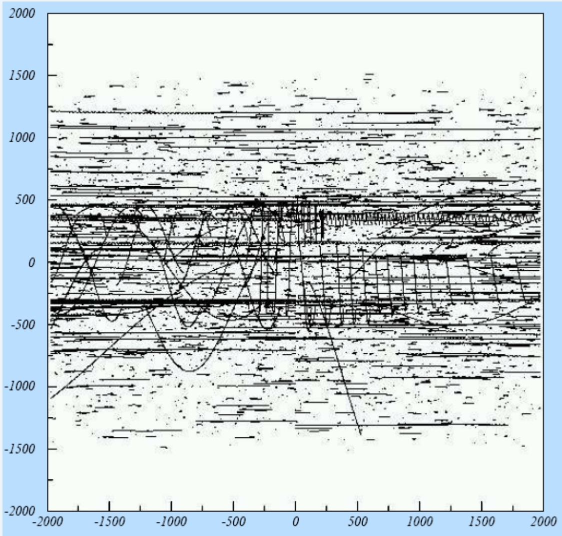
$e^+e^-$ -> $\tau\tau$ -> 6 jets

*10% of cells, at large radius, have multiple tracks.*

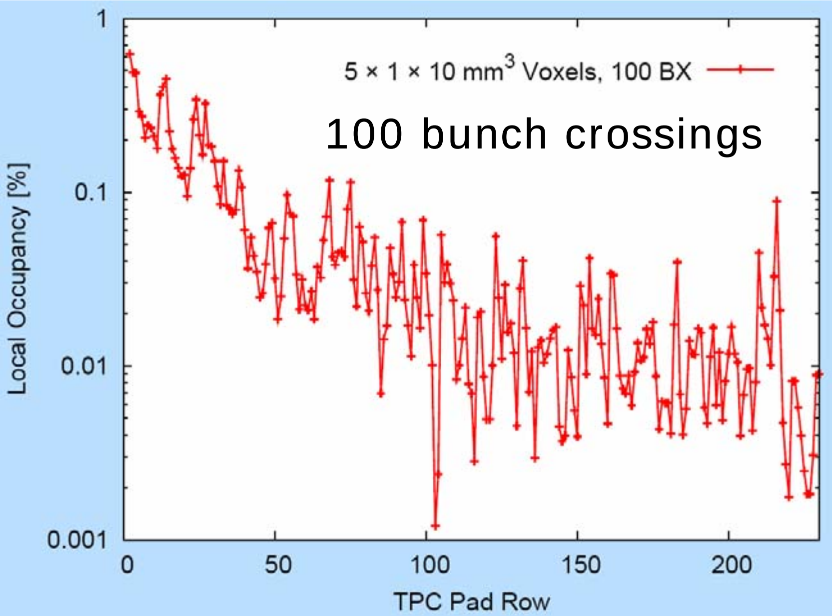
# LC-TPC: beam noise hit issues





See A. Vogel

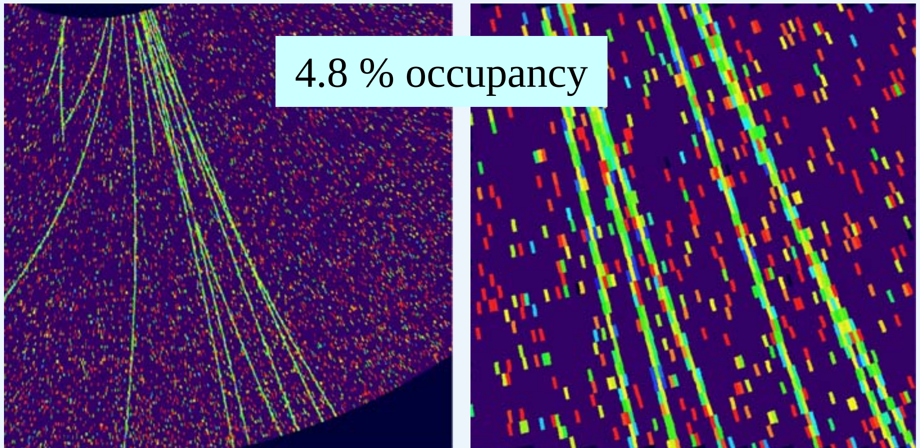


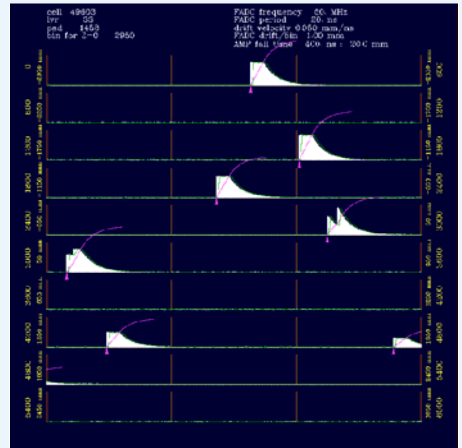

Beam particles are simulated in "Guinea Pig".
TPC "hits" (ionization centers in the detector) are simulated in Mokka.
(Grid computing)

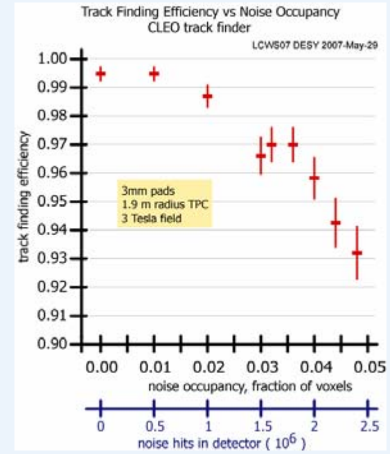
*New! This information is converted to a voxel occupancy.*

*The occupancy is 0.01% at large radius, and as high as 1% at low radius.*

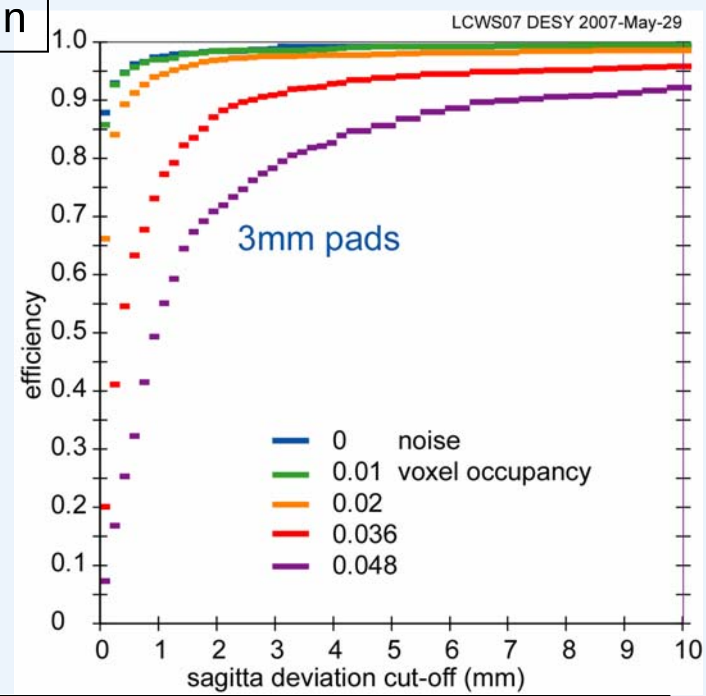
# LC-TPC: beam noise hit issues






See D. Peterson



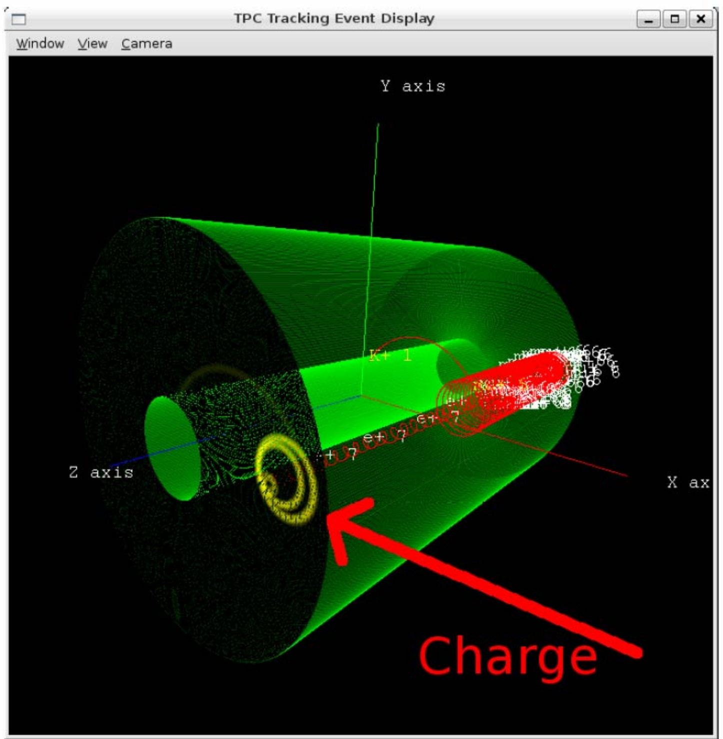

The effects of (salt and pepper) noise hits are studied by overlaying the FADC time response of track-related ionization with the response from the noise hits.

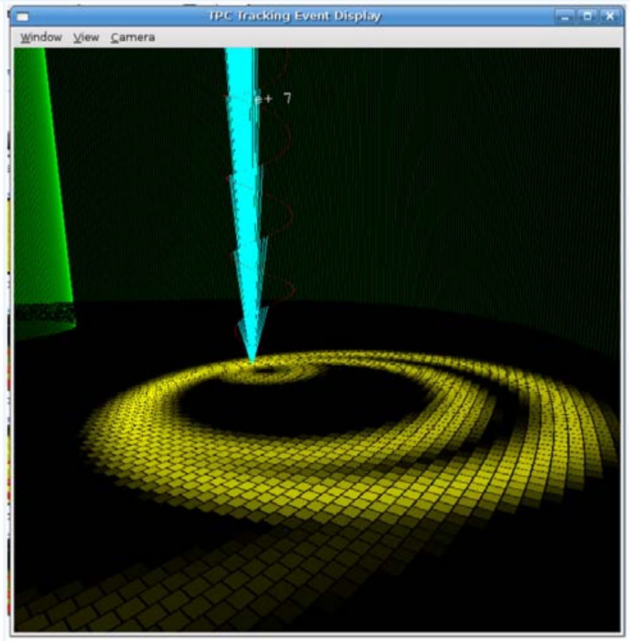
Efficiency loss is small up to 2% occupancy.

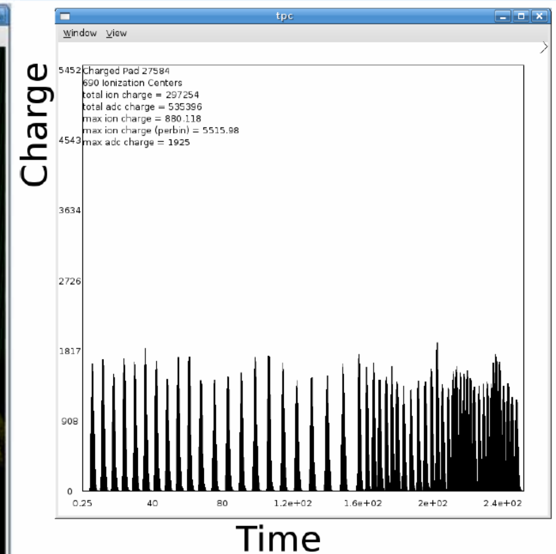
*New! "Efficiency vs. resolution" has no degradation at 1% (uniform) occupancy.*

*Combined with previous page, TPC occupancy appears to be under control.*

# LC-TPC: beam noise hit issues




See J. Hunt (simulation)

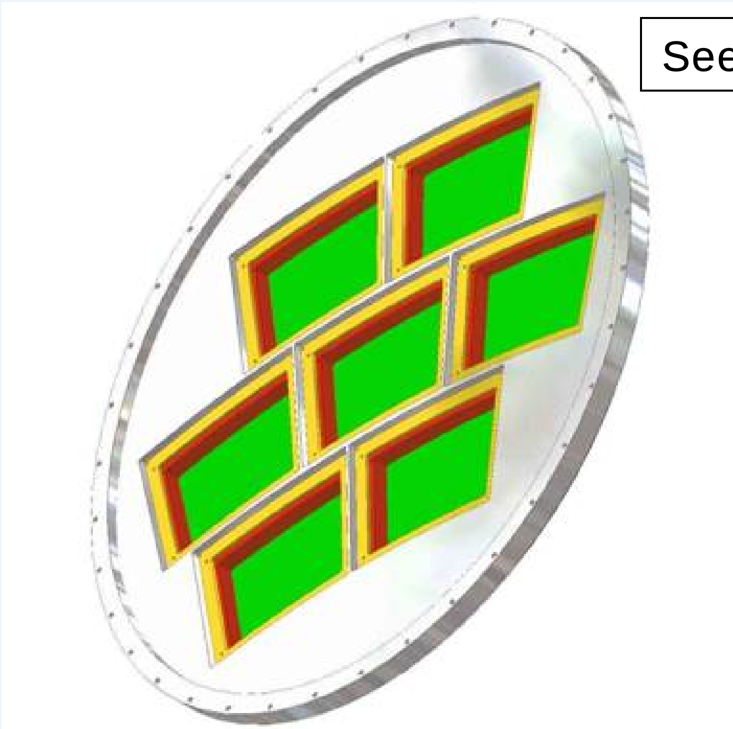
The problem with the old FADC simulation is that it is stand-alone, not part of Marlin.

*New! A Marlin processor has been developed to convert the SimTrackerHits (ionization centers) to TrackerHits (TPC FADC “data”).*

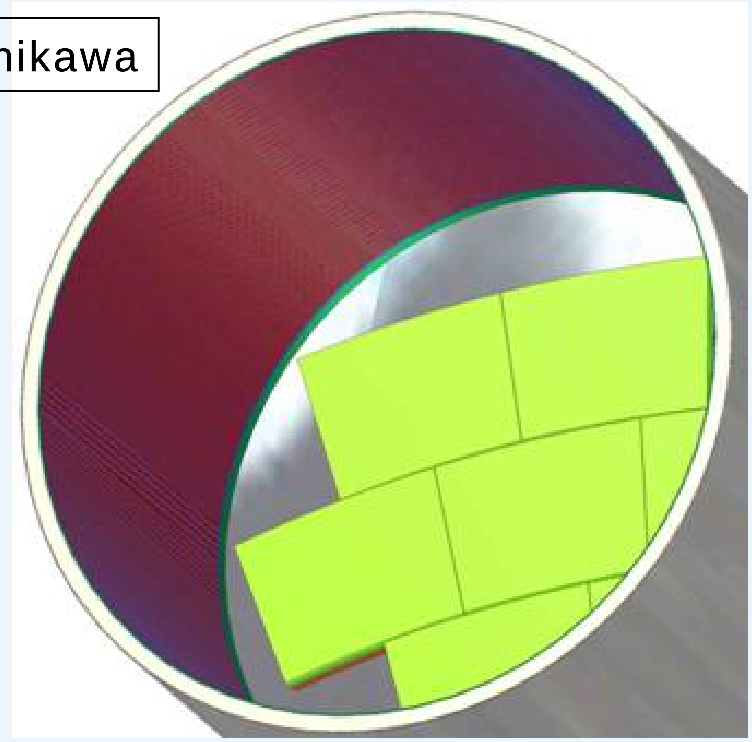
*This will allow the full overlap of the machine backgrounds with any physics process.*

CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

# LC-TPC: the large prototype



See A. Ishikawa

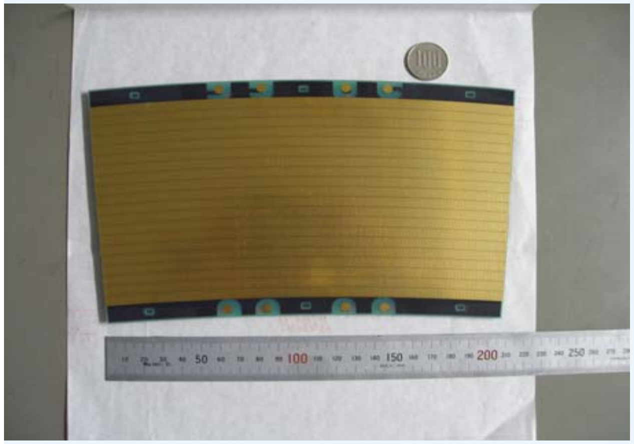


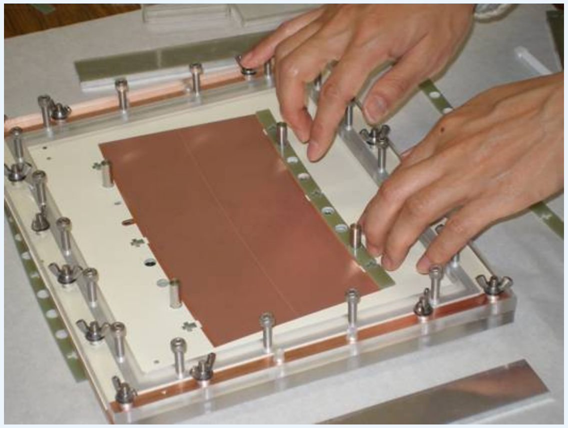
LC-TPC is constructing a "large prototype"
~80cm diameter, ~80cm length field cage.

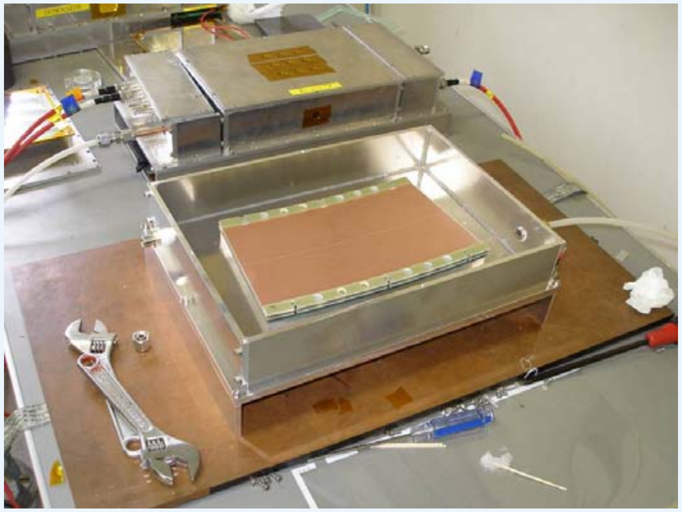
(various MPGD technologies will be used)
7 modules, each 39000 $mm^2$ (~4x the $(10cm)^2$ used in many small prototypes)

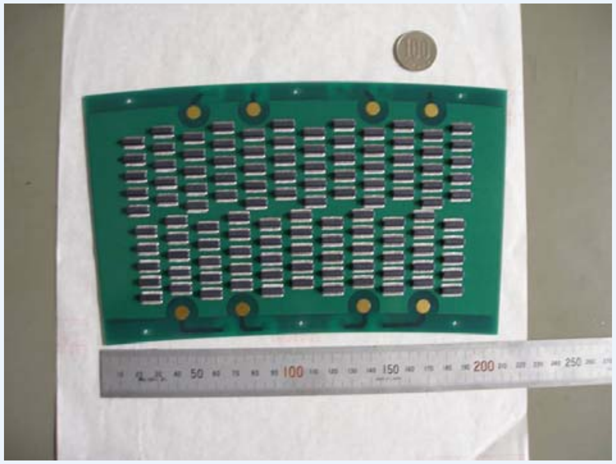
*( Discussion of endplate, including fabrication precision and assembly, will occur at the LC-TPC meeting, 04-June. )*

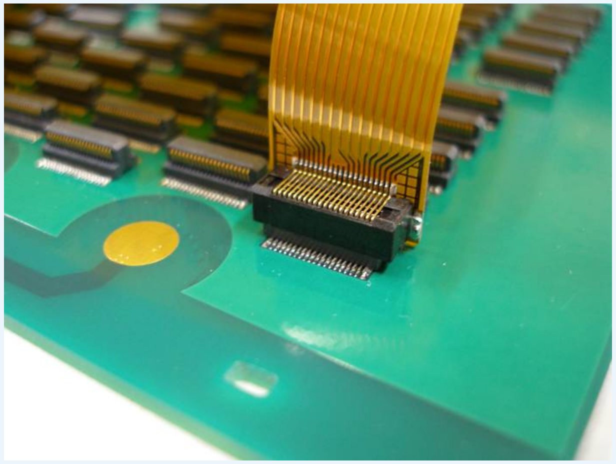
# LC-TPC: the large prototype, module











Constructing a pre-module.

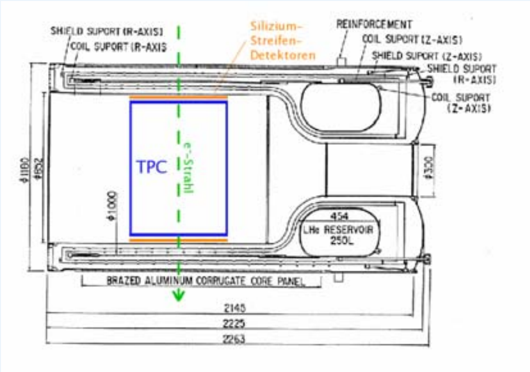
pad board
stretching a GEM
module in test box
(back) connectors

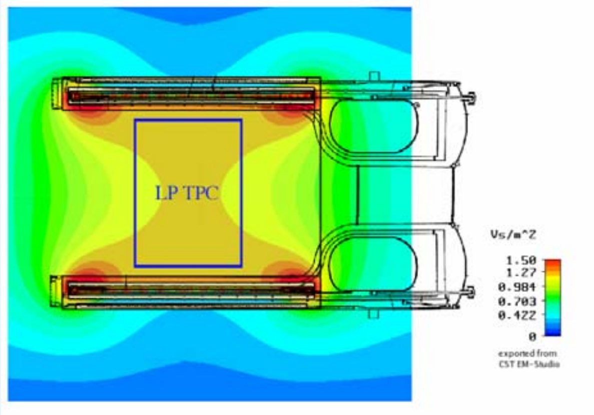
Gain tests have been done.

See A. Ishikawa

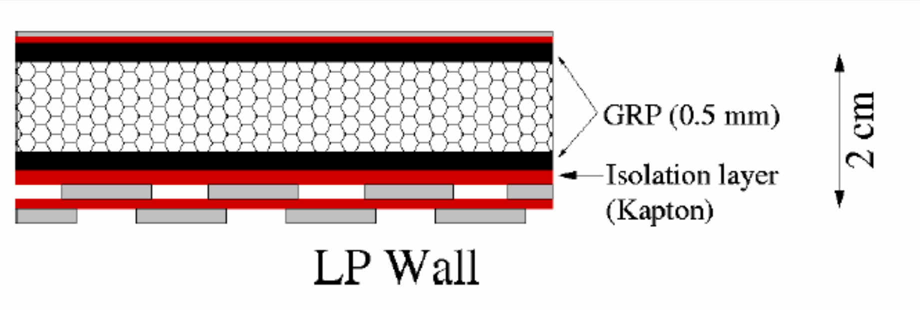
# LC TPC: large prototype field cage

See L. Hallermann

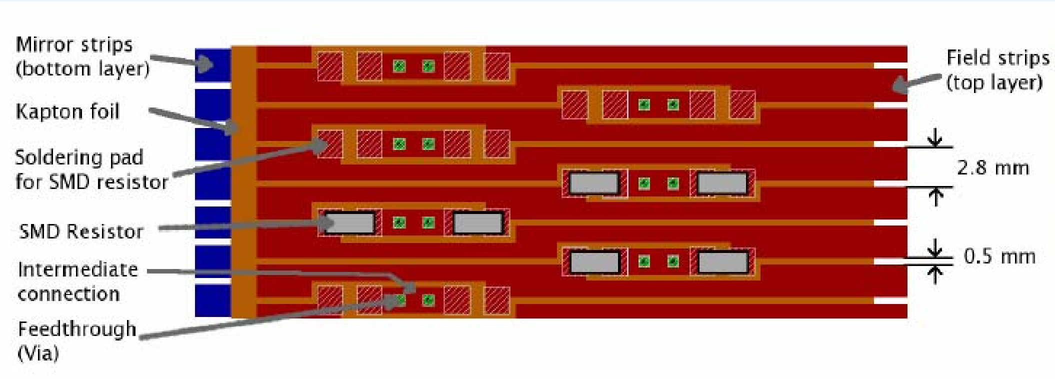


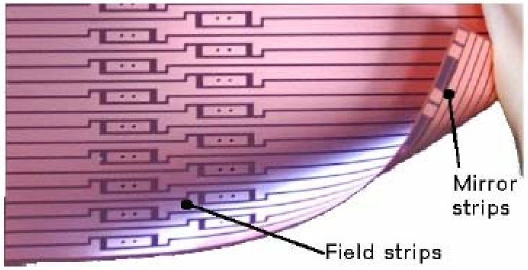




1.25 Tesla magnet at
DESY EUDET facility



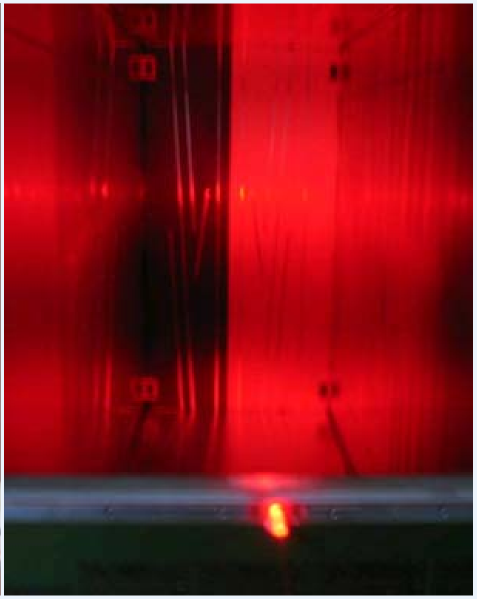

Composite field cage construction
Field strip foil expected in next few weeks.

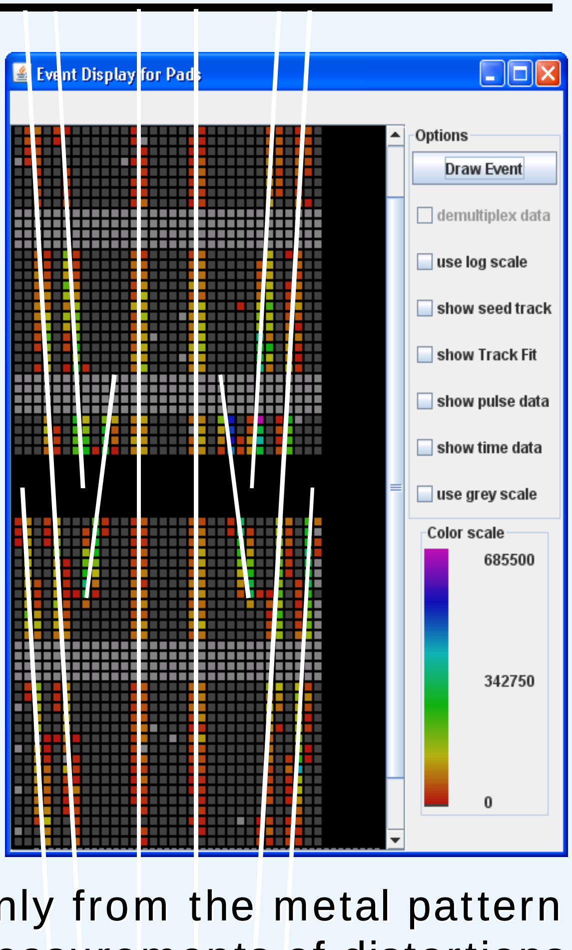



CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

# LC TPC: large prototype, distortion measurement





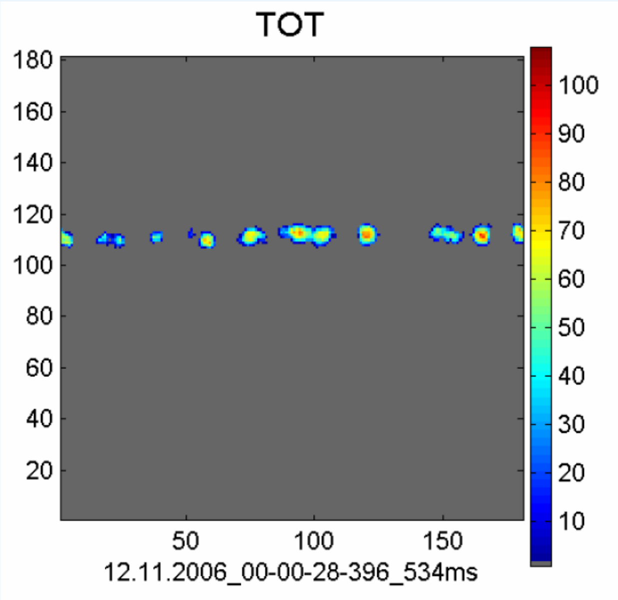

To produce photoelectrons for distortion measurements, place on the central cathode a pattern of metal with a lower work-function.

Flashing the central cathode with a light pulse of the right wavelength will produce photoelectrons only from the metal pattern precise survey of metal pattern allows for absolute measurements of distortions.

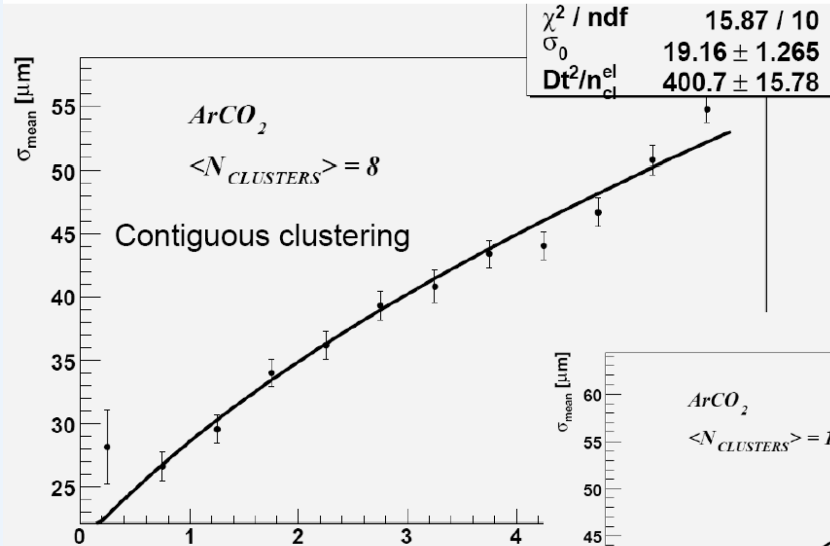
Technique is already being developed for T2K.

See D. Karlen

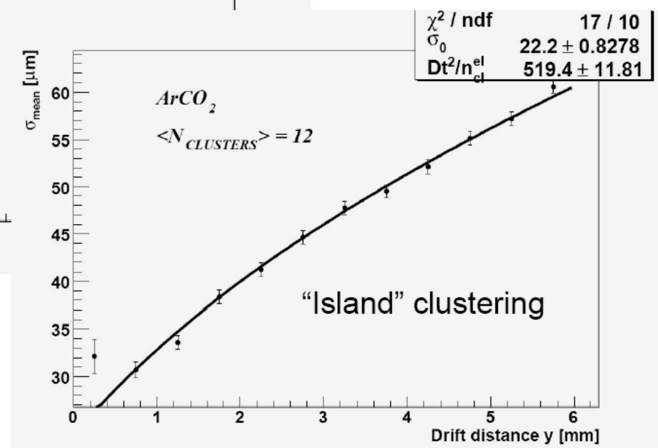
# LC TPC , pixel readout, w/GEM




**Point Resolution vs. Drift Length for Different Clustering Methods**




- High statistics runs
- Increase of number of clusters per track length



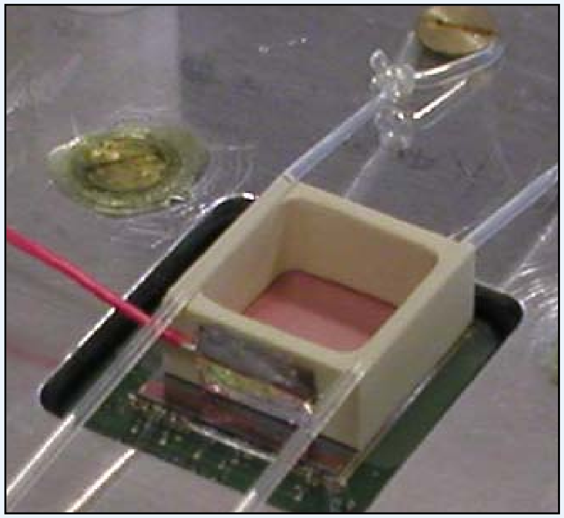

- By increasing the number of clusters the resolution per cluster goes up ~ $(12/8)^{1/2}$

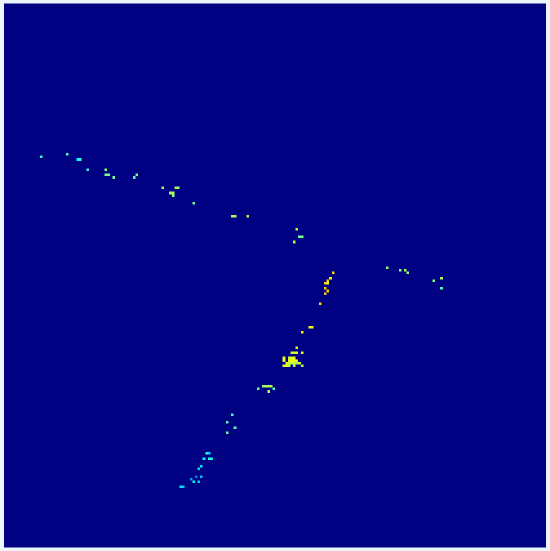
Two clustering methods were presented, with point resolution measurements.

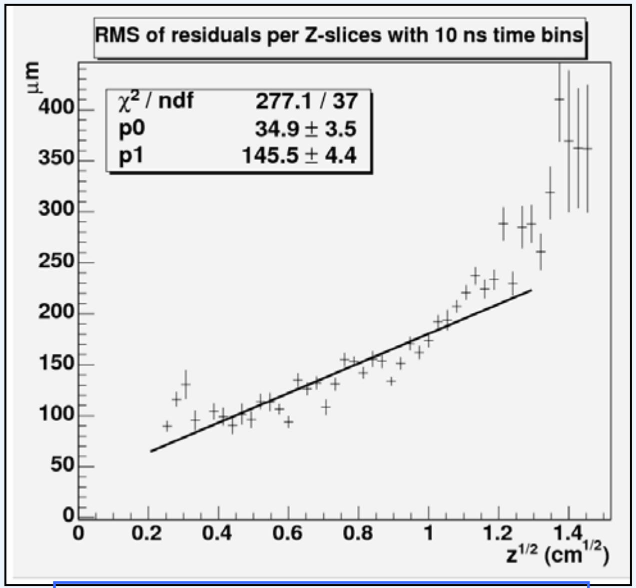
See N. Vlasov

CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

# LC TPC , pixel readout, w/Micromegas

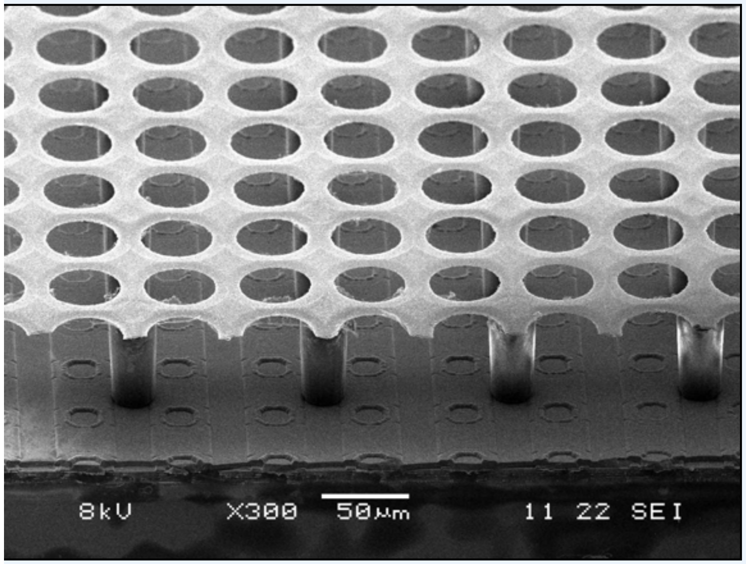







TimePix w/Micromegas
Results of cosmic tests

See M. Chefdeville




Medipix chip wafer -
Post-processing of a 4” wafer successful!
SiProt covered
InGrid covered
Diced to individual chips

CORNELL UNIVERSITY LEPP
LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS