Time Expansion Chamber (TEC)

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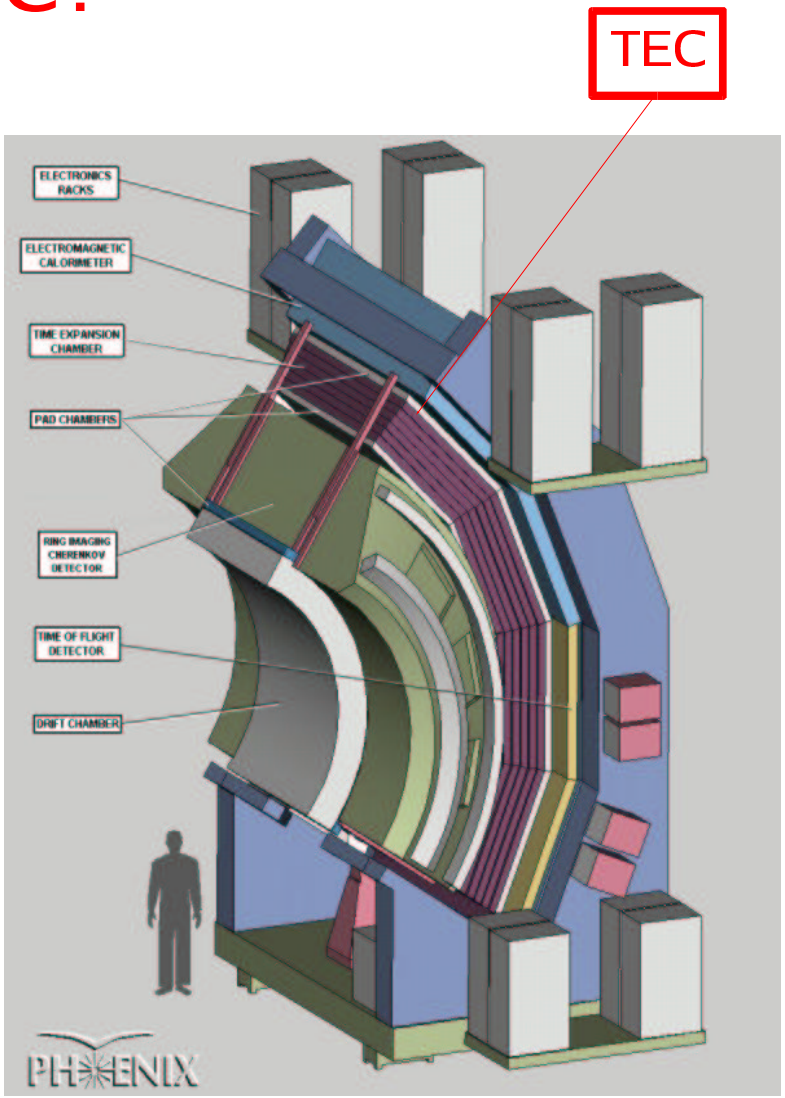
What is TEC?

Multiwire Proportional Chamber which measures radial coordinate by measuring electron drift time.

A) Track charged particles in the region between RICH and EMCal and provide, in addition to the Drift and Pad Chambers complete tracking determination.

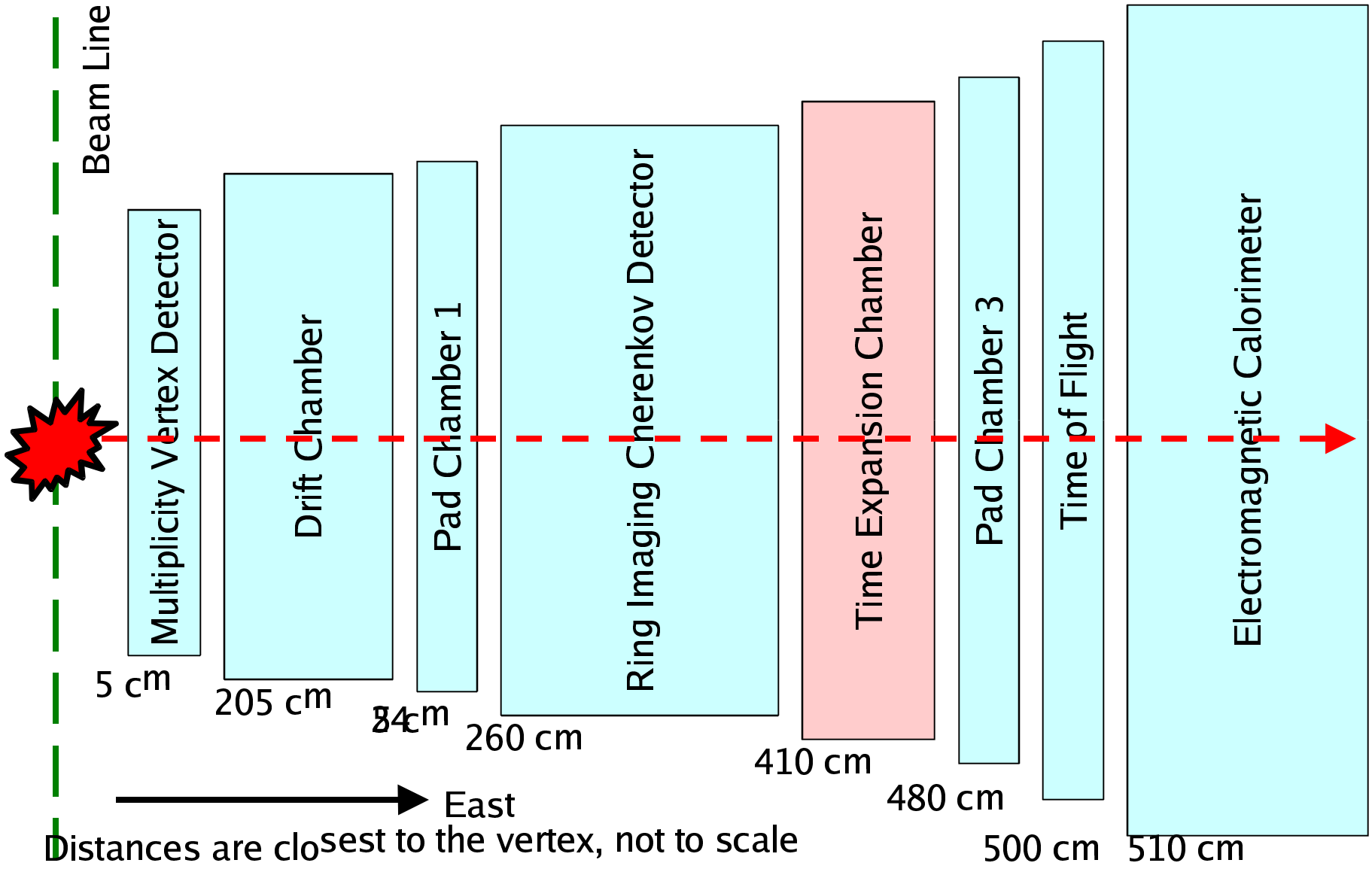
B) Identify charged particles by measuring dE/dX, improve e/pi separation.

C) Improve momentum resolution at high transverse momenta, and provide independent Pt measurement.



PHENIX East Central Arm

Where is TEC?

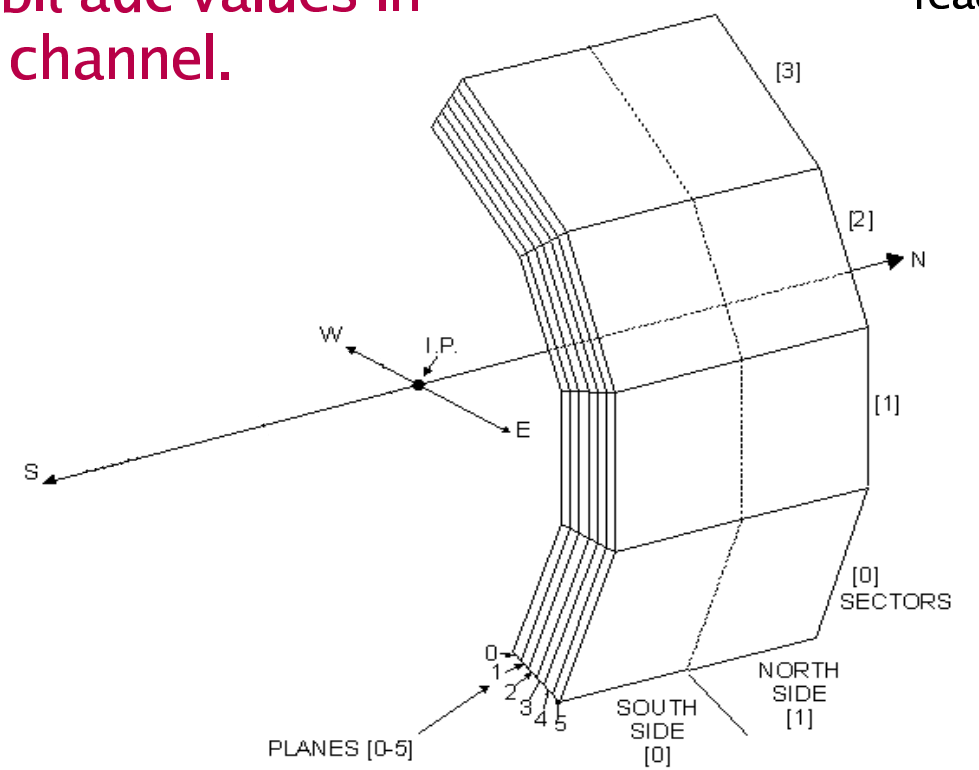


Distances are closest to the vertex, not to scale

Geometry of the TEC

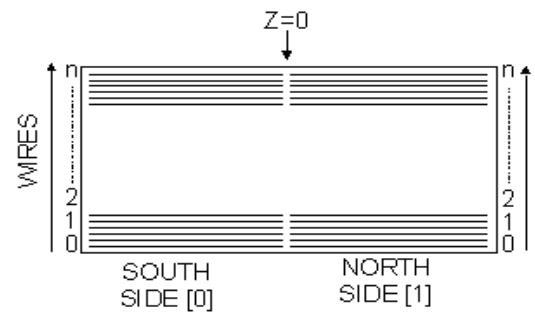
~20000 readout channels,
80 5-bit adc values in
each channel.

6 chambers per sector/side
(only 4 instrumented in run 2)
each plane has from 415 to 468
readout wires (twice as many cathode wires)

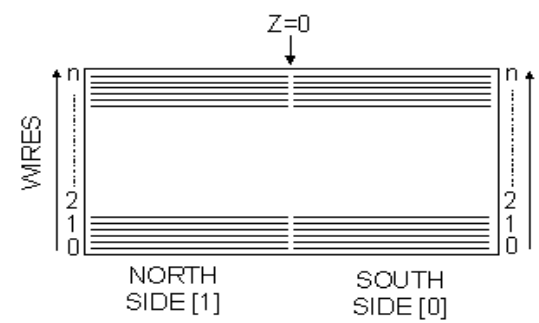


Nomenclature and Channel Numbering
for TEC

Format of channel number statement:
Arm [0-1], Side [0-1], Sector [0-3], Plane [0-5] , Wire [0-n]



TYPICAL PLANE IN WEST ARM
AS SEEN FROM IP

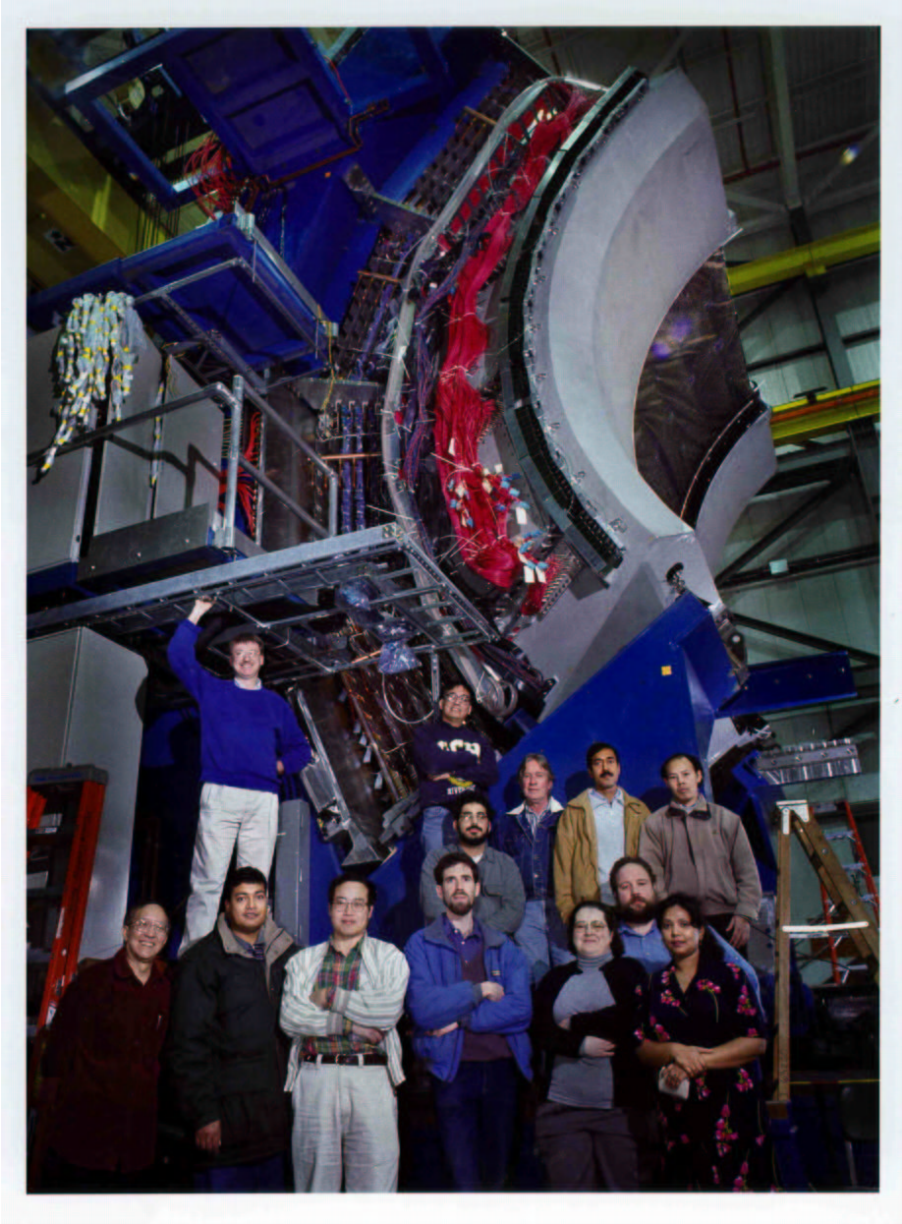


TYPICAL PLANE IN EAST ARM
AS SEEN FROM IP

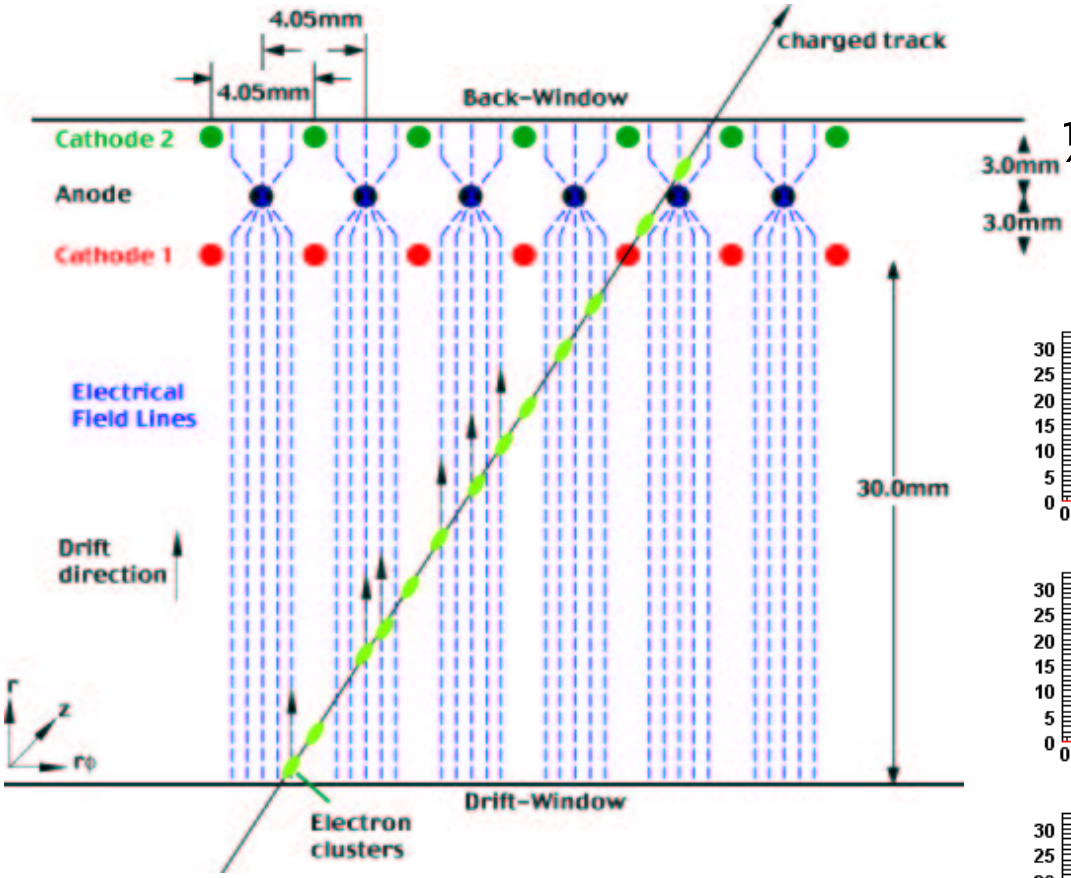
(WIRES ARE SPLIT AT Z=0)

(Number of wires veries
from plane to plane)

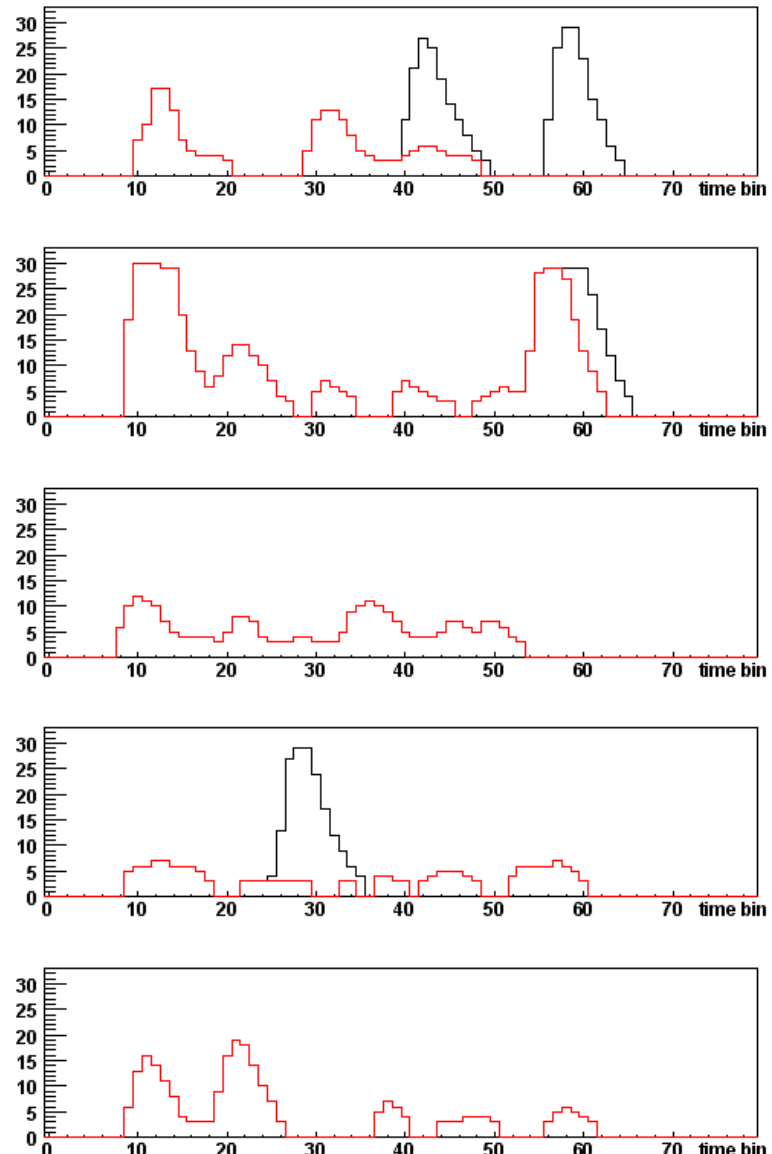
TEC in PHENIX



How TEC works?

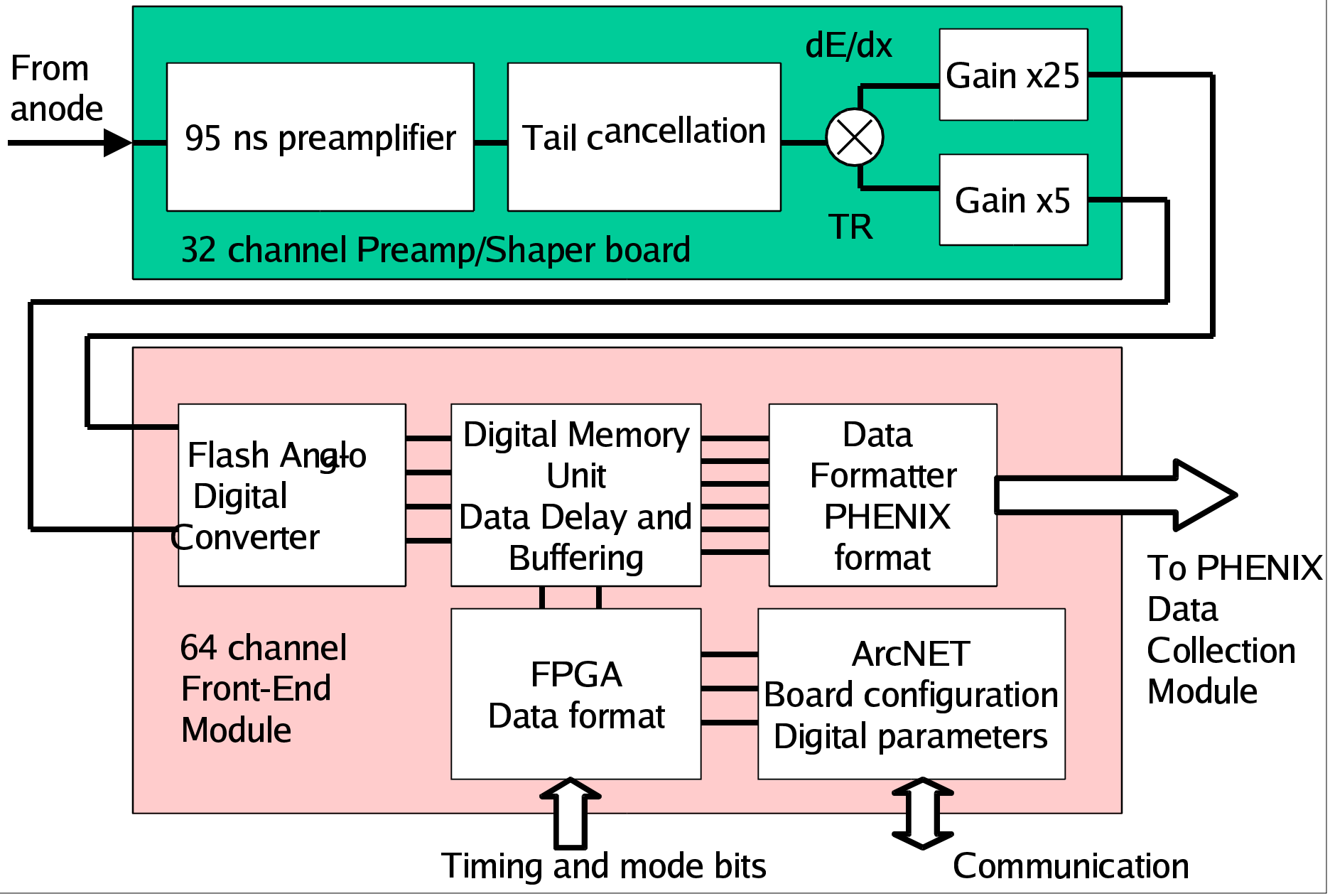


80 time bin, each bin
¼ of RHIC clock (~26 ns)

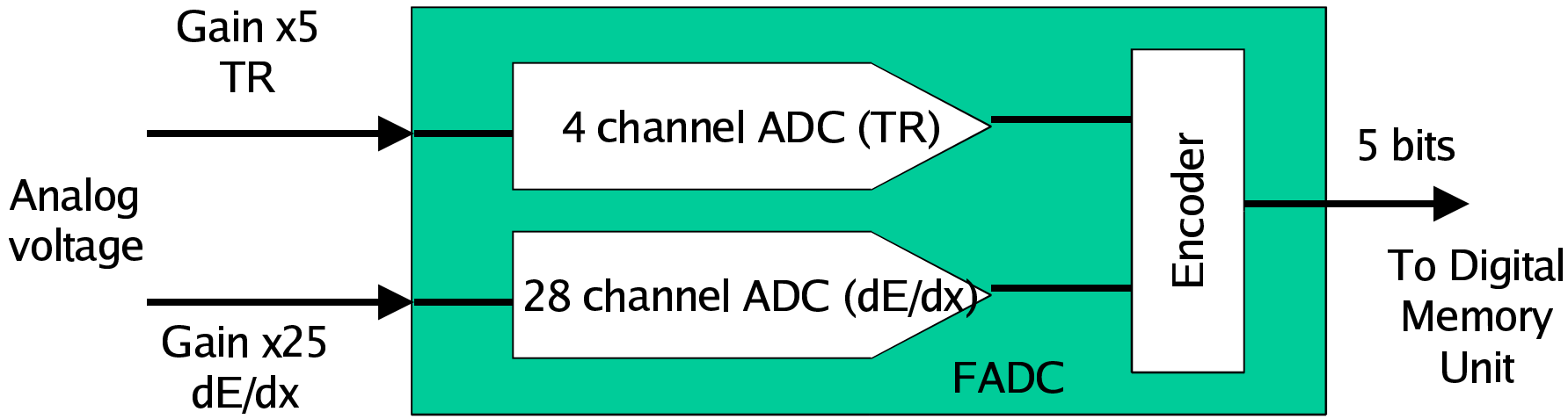


When a charged particle traverses Tec plane, it ionizes the gas and electrons from the ionization start to drift in electric field to anode wires.
Electric filed lines are parallel in the drift region.
Arrival time of electrons is proportional to the radial position in the drift region where they were created.

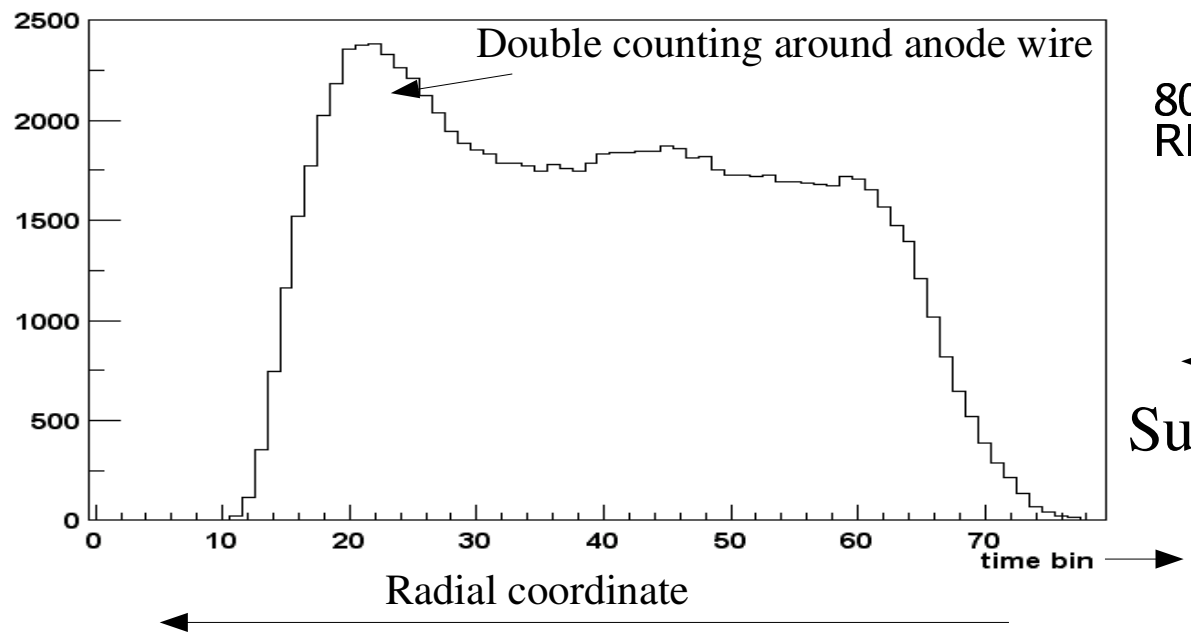
Electronics chain



Signal sampling



dE/dx signal: 0.2-0.3 keV (MIP in Xe) TR signal: 3-10 keV (X-rays in Xe)



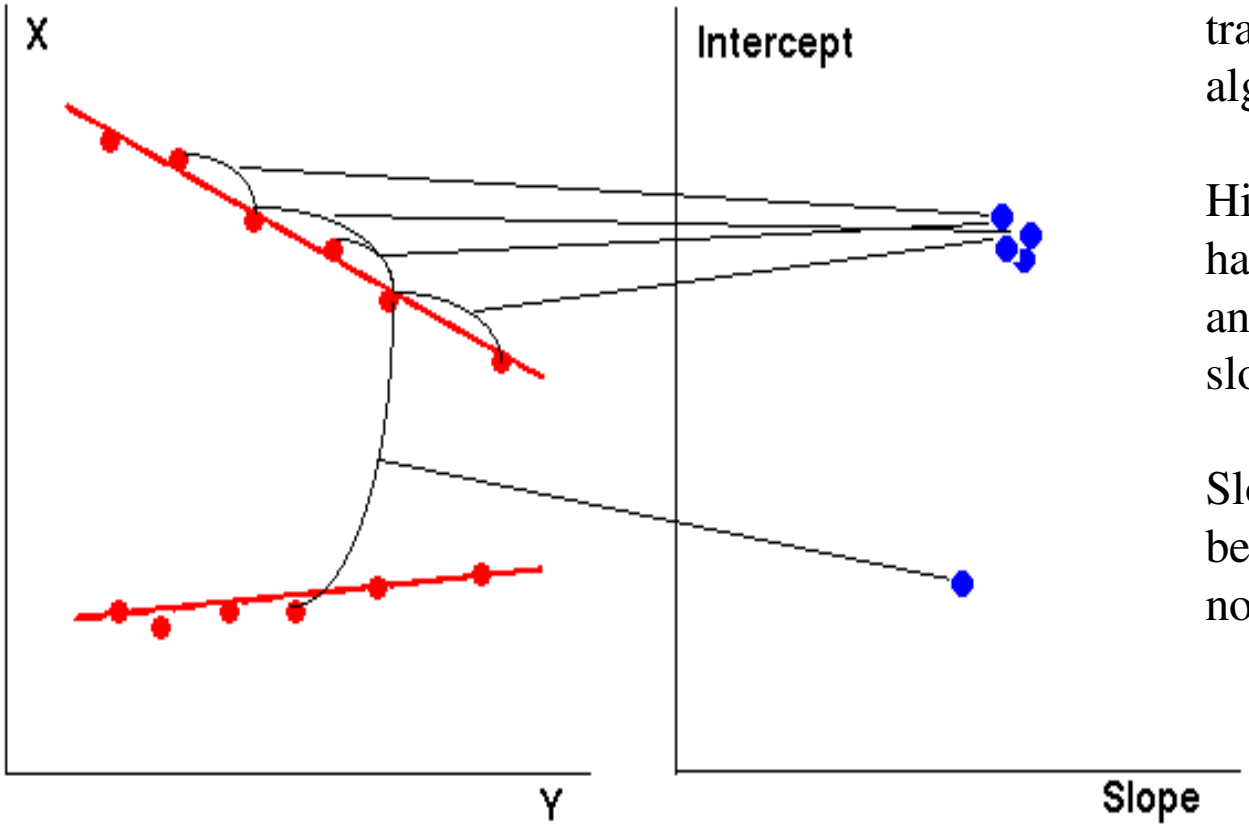
80 time bins, each bin ¼ of RHIC clock (approx. 25 ns).

RUN 3 data

Sum over many events

TEC Tracking – Hough Transform

Example of Hough Transform
from X and Y to Slope and Intersept

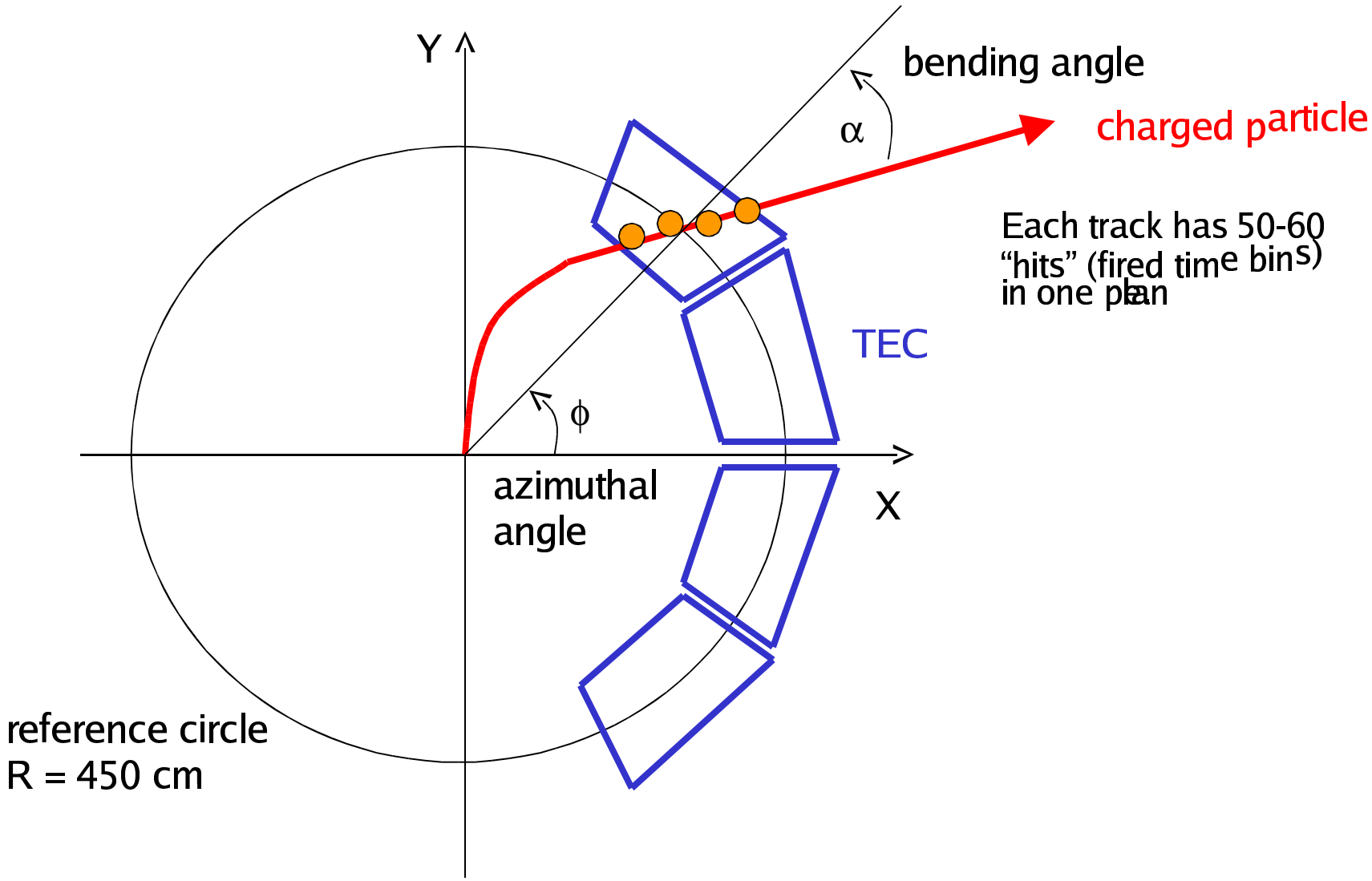


TEC uses Hough Transform for tracking, similar to Drift Chamber algorithm.

Hits pairs from the same track have the same slope and intercept and will form peaks in slope/intercept space.

Slope and intercept are not the best variables, because they are not bound.

TEC Tracking

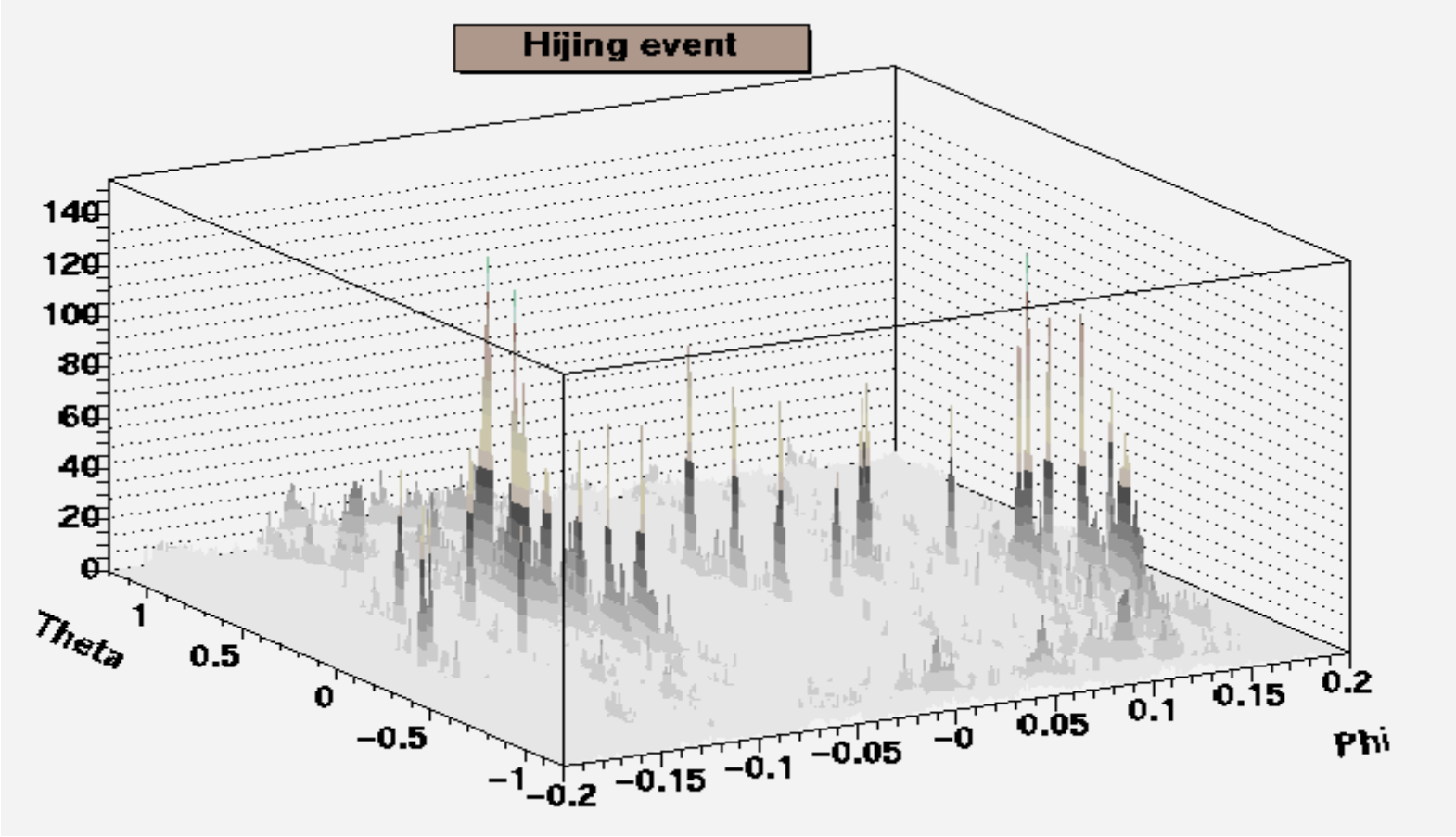


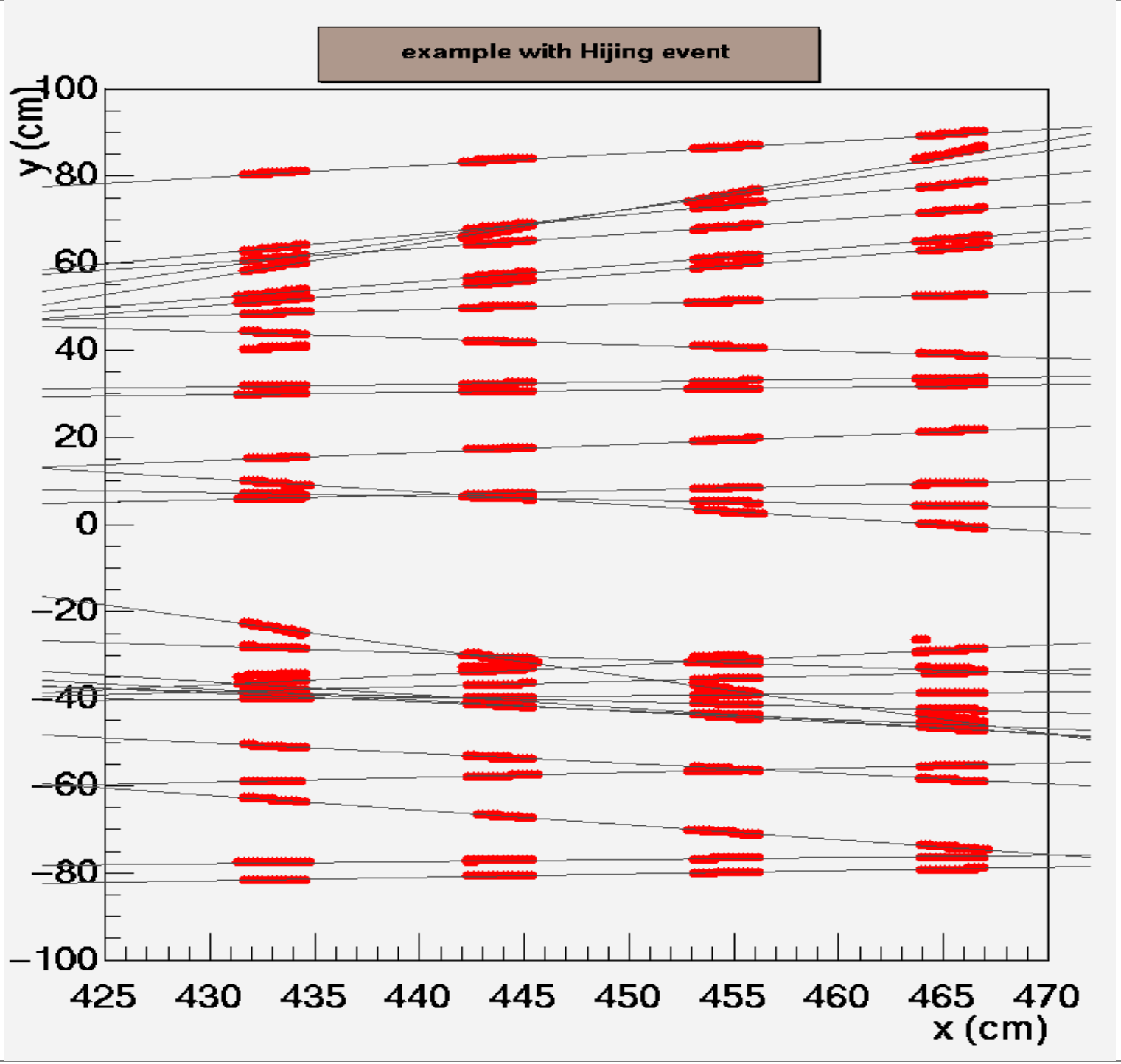
Tracking Algorithm

Select randomly hit pairs and plot α and ϕ for the lines they form.

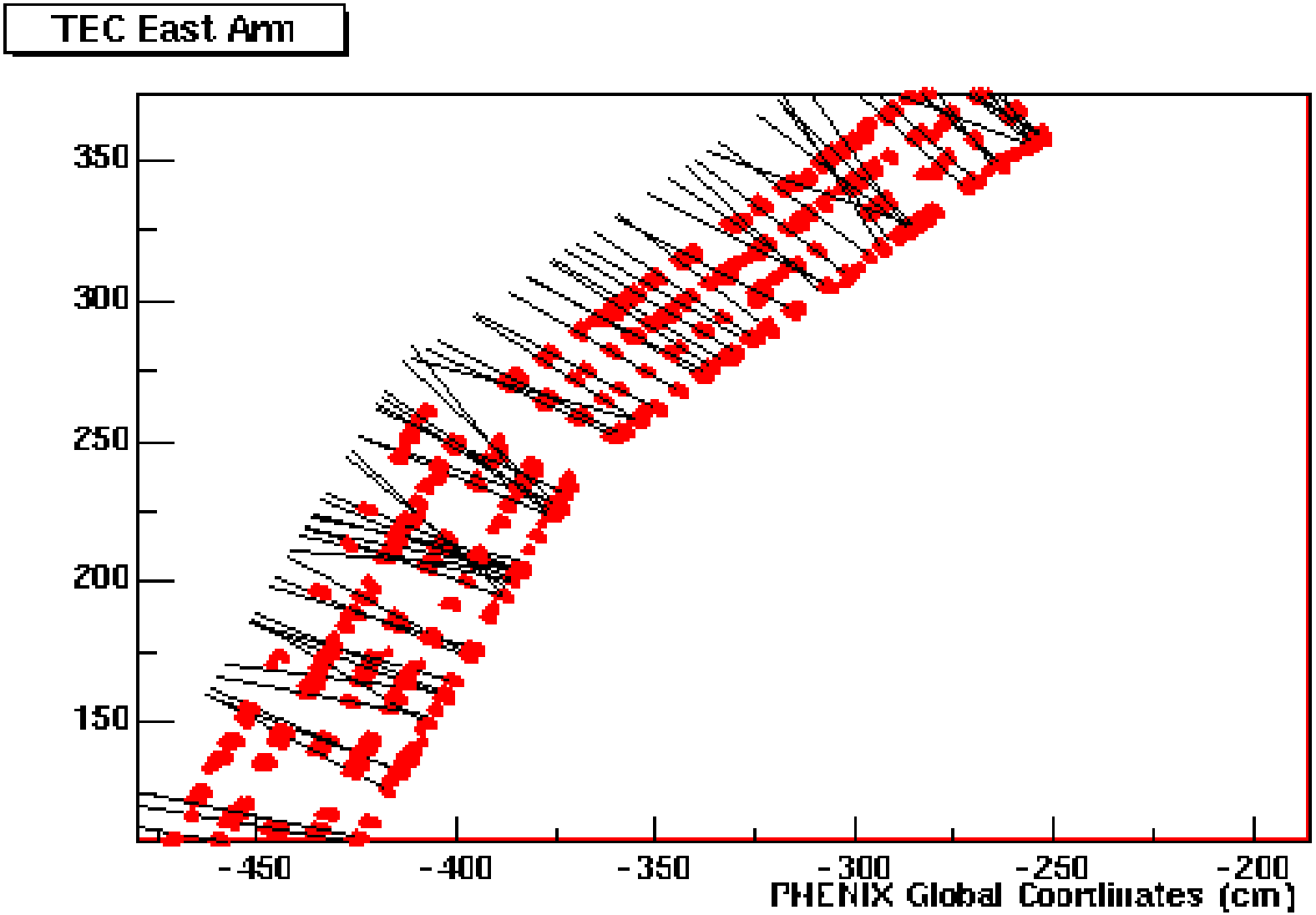
Hit pairs on the same track have the same α and ϕ.

A peak in the α–ϕ space indicates a track.
Random selection allows to save time by not using all possible hit pairs.




example with Hijing event
y (cm)
100
80
60
40
20
0
−20
−40
−60
−80
−100
425
430
435
440
445
450
455
460
465
470
x (cm)

Data

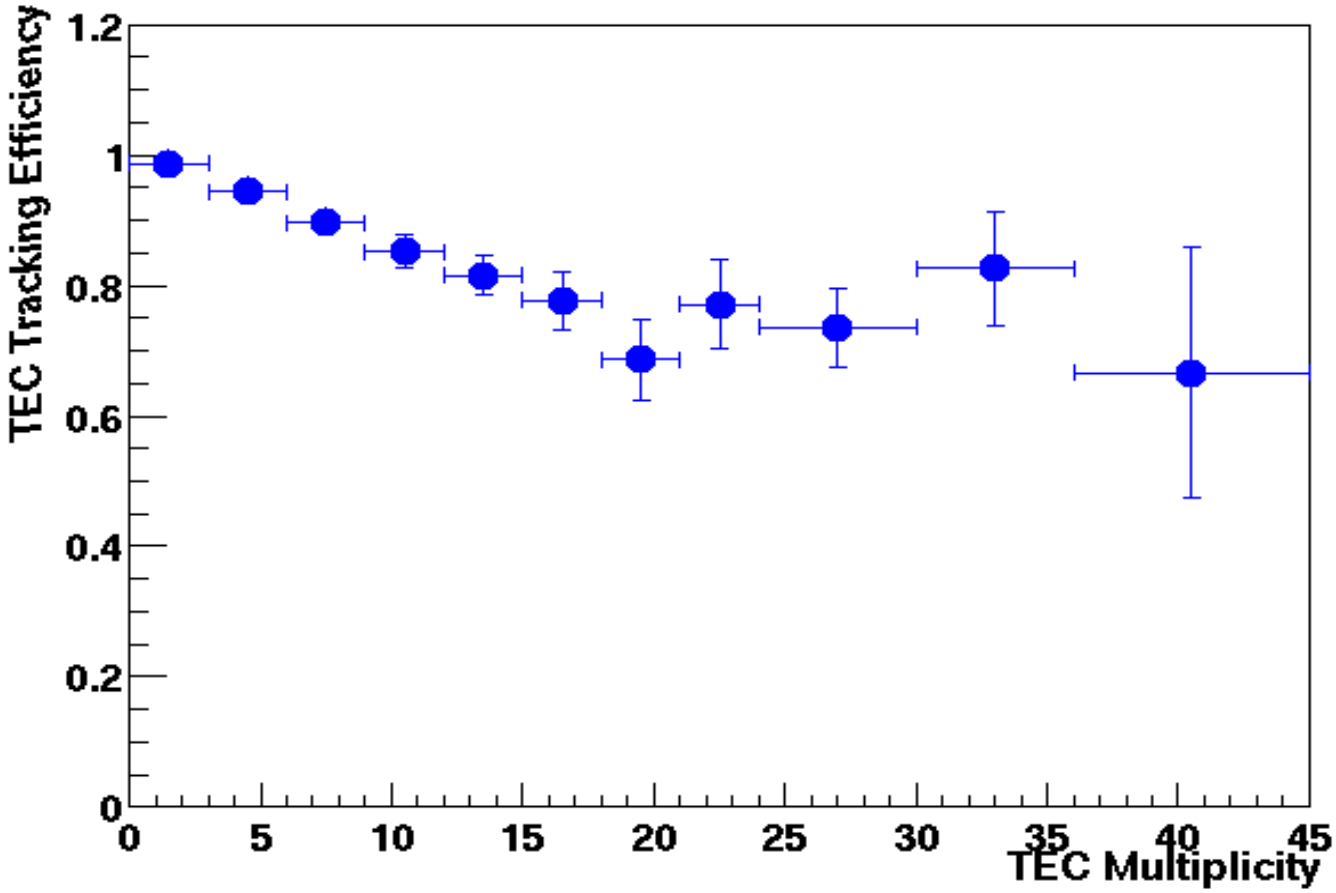


Event # 27

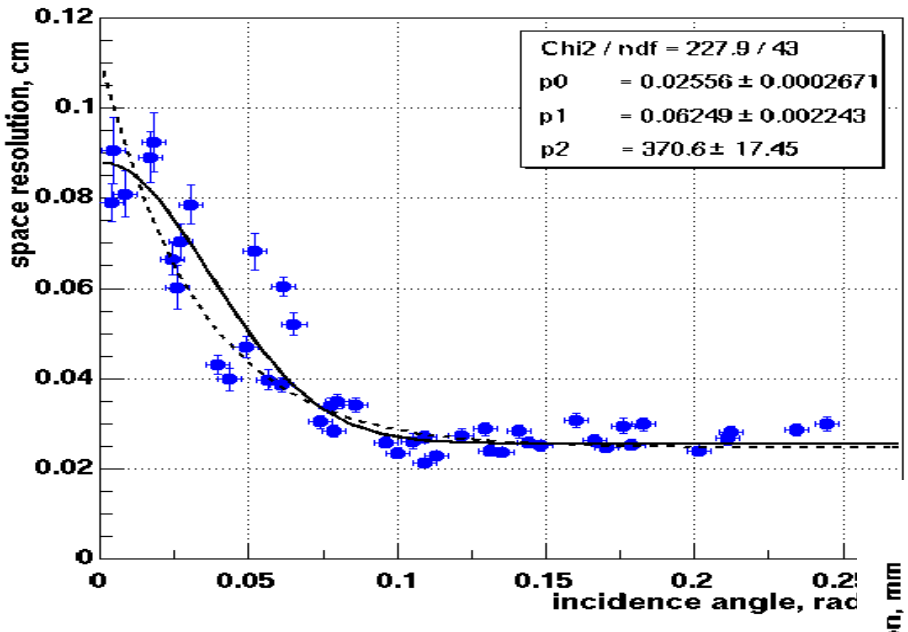
/common/buffer2/eventdata/EVENTDATAxxx_P01 0000022626 0000.PRDFF

TEC Performance – Tracking Efficiency

Tracking efficiency was determined by merging single simulated tracks and real events with single tracks with minimum bias events.



TEC Performance - Space Resolution

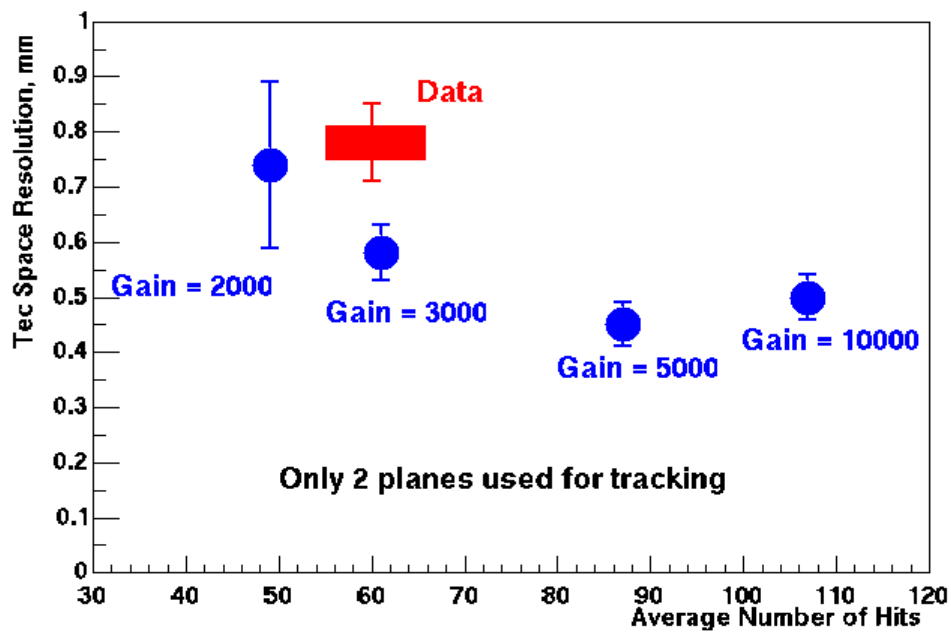


Tec space resolution depends on incidence angle (more exactly, on number of fired wires per plane) and gas gain.

For incidence angles > 5-6 degrees Tec space resolution is

0.35 mm

Space resolution is determined by tracking with two planes, then with twoother planes, and comparing the results. Incidence angle dependence is studied in simulation.

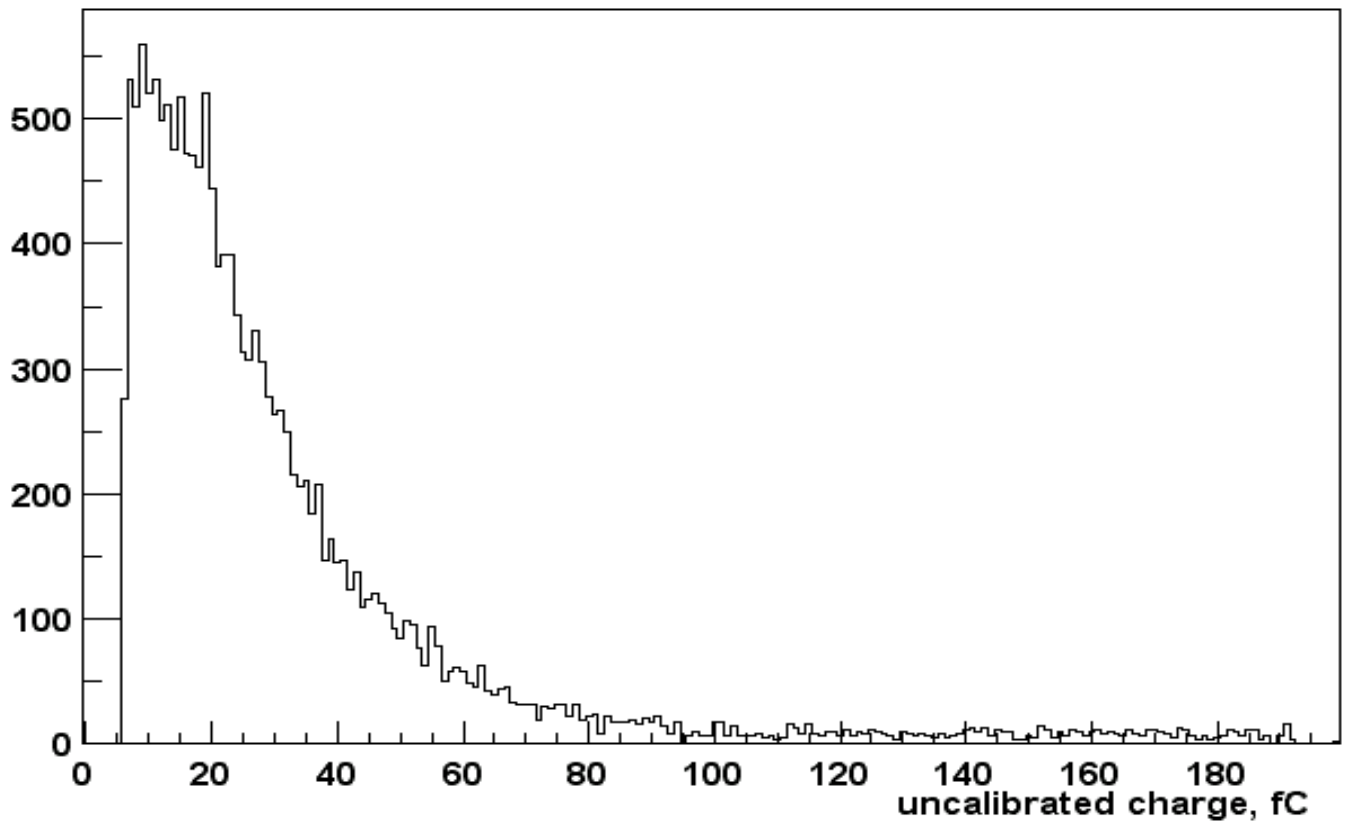


Tec space resolution is much better than Pad or Drift Chamber projection to Tec. -> MUST use Tec info for measuring space resolution.

TEC dE/dX

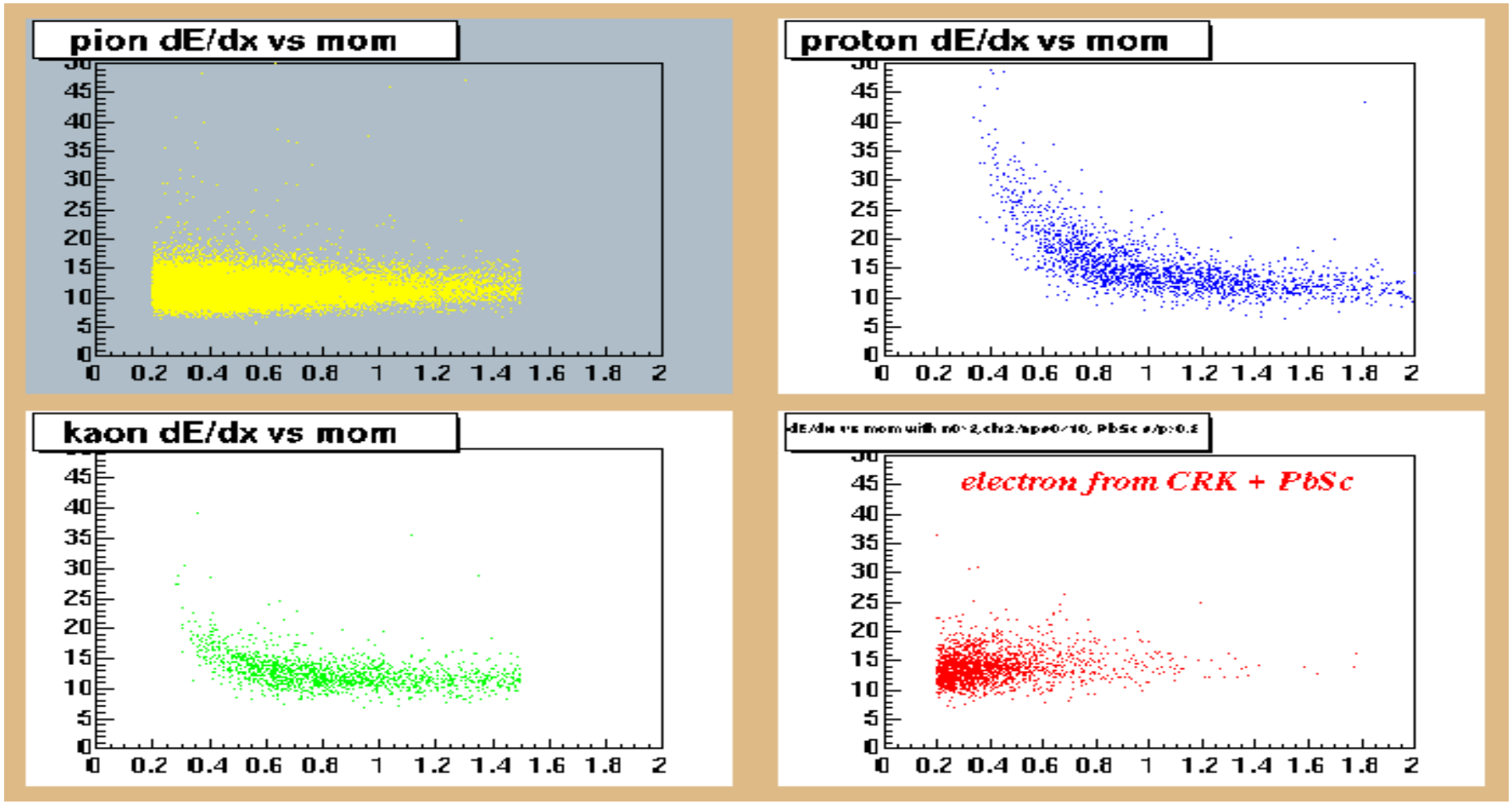
Each track has 50-60 dE/dX samples, which makes it 300-350 samples for 6 planes

Landau fluctuations are removed by truncation. Optimum truncation is apprx. 50%.



RUN 3 DATA

TEC Performance – dE/dX in Run 2



*Studied by X.H. Li

In run 2 dE/dX resolution was rather bad because of low gain and only 4 active plane

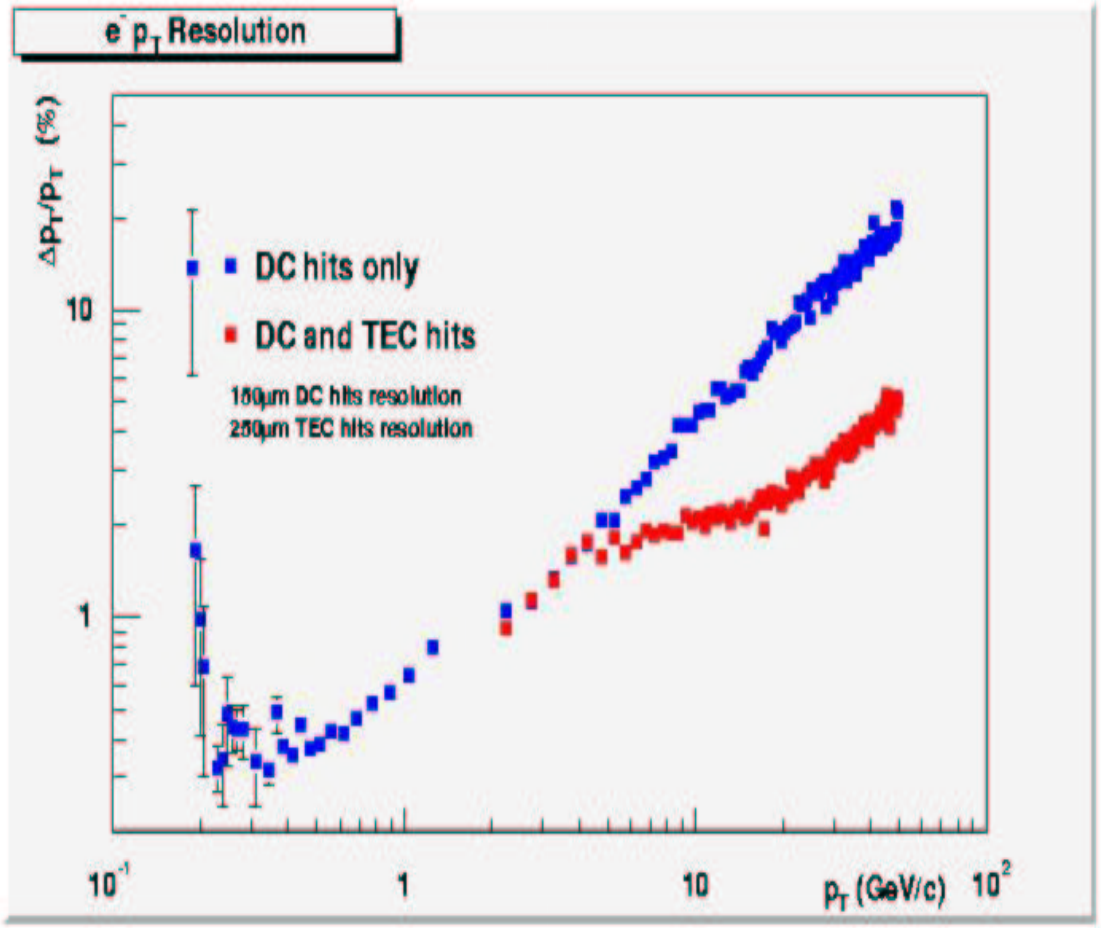
In run 3 with all 6 planes active and TRD upgrade we expect better results.

Improving Momentum Resolution

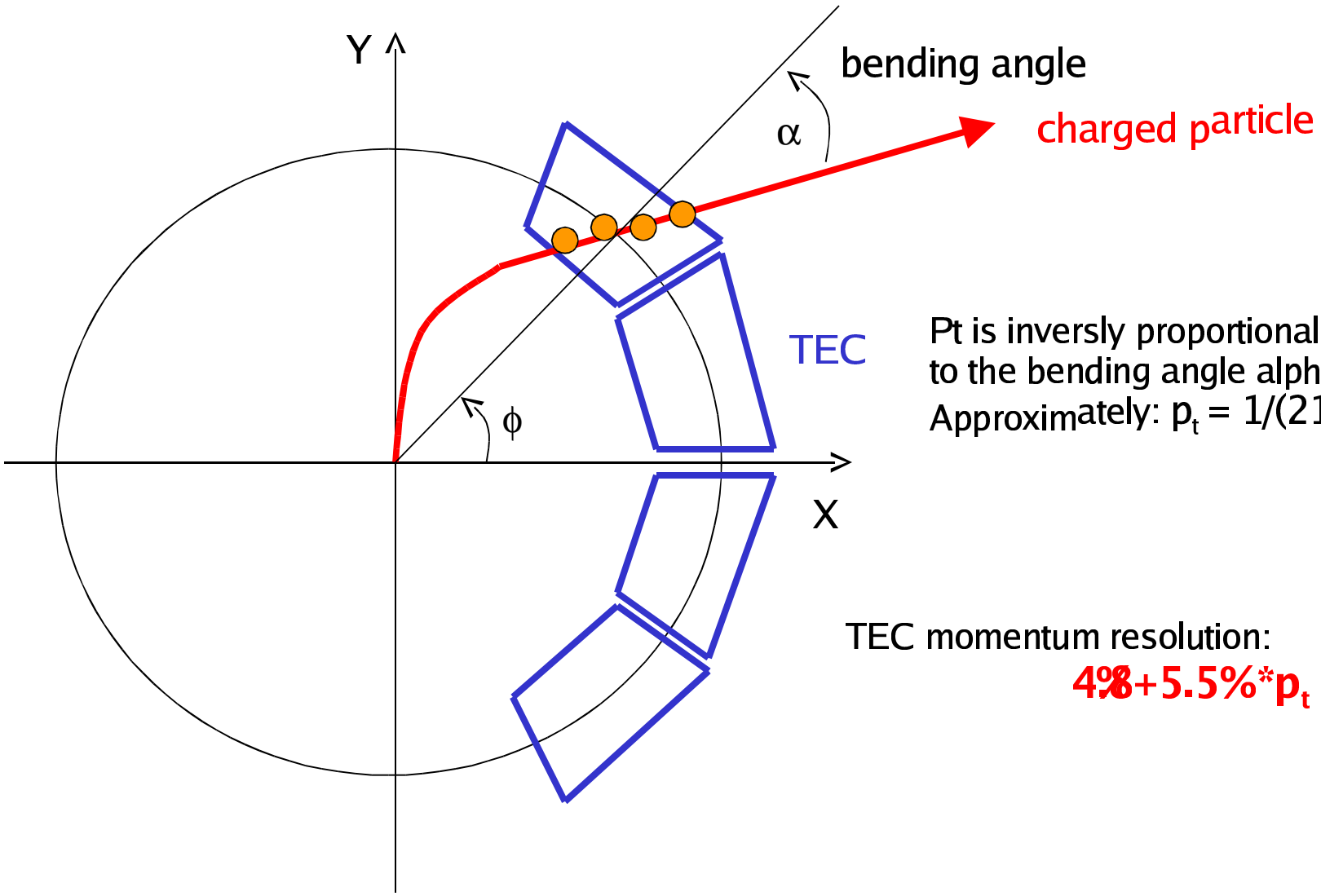
TEC provides direction vector at large radius - 450 cm, which allows to improve momentum reconstruction at high Pt. At low Pt multiple scattering makes this impossible.

Not yet implemented in data analysis.

Simulation prediction



Transverse Momentum Reconstruction

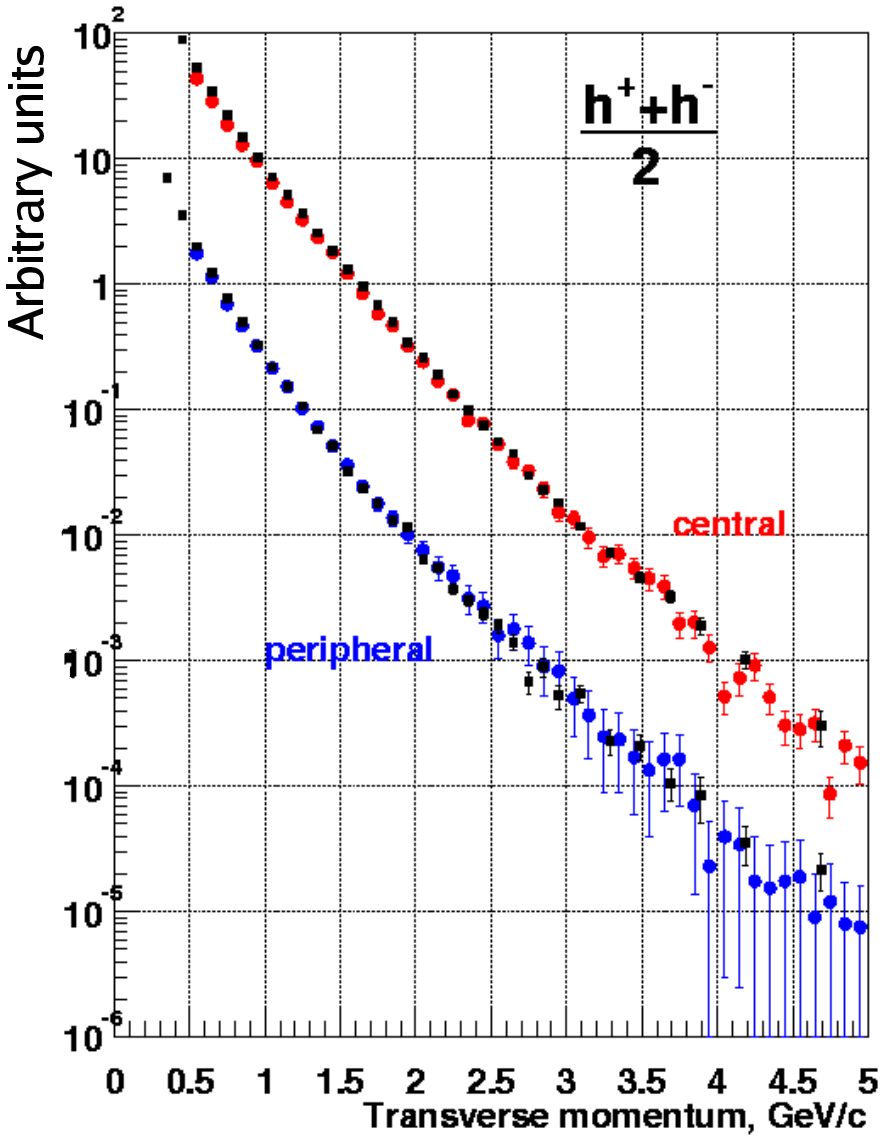


Pt is inversly proportional to the bending angle alpha.
Approximately: $p_t = 1/(21.5*\alpha)$

TEC momentum resolution:

$4.8\% + 5.5\% * p_t$

Transverse momentum spectra in Run 1



Transverse momentum spectra of charged hadrons obtained exclusively from TEC tracks match with the results from the PHENIX Drift Chamber tracks.

Black: Drift Chamber

Blue and Red: Time Expansion Chamber

TRD Upgrade in Run 3 – What is TR?

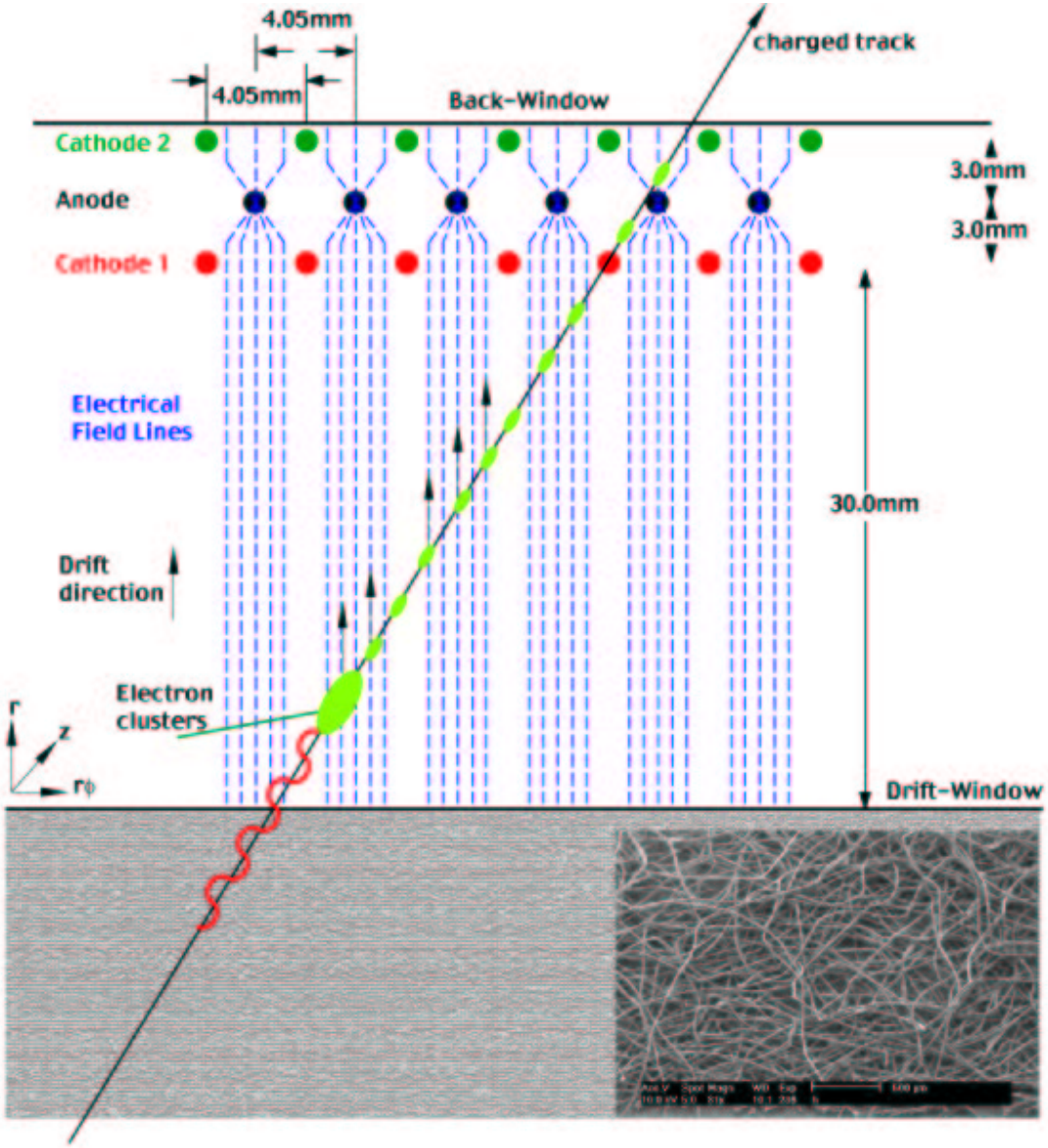
Transition radiation is emitted when a relativistic charged particle crosses a boiundary between two dielectric media with different dielectric constants.

TR becomes usefull when particle Lorentz-factor becomes greater than approx. 1000. In this case emitted photons are in X-ray range (several keV) and can be detecded by, e.g. Proportional chamber.

In a very broad momentum range (from approx. 1 to 100 GeV) TR is emitted only by electrons.

Typical TRD cosists of a radiator (dielectric fiols, fibers or foam) and X-ray detector (TEC in PHENIX).

TRD Upgrade – How TRD works?



TRD upgrade consists of:

Polypropylene fiber radiator inserted in front of each Tec ıne (5.5 cm with density -70 mg/cm3).

P10 gas will be replaced by /He/CH4 mixture (we are l using P10 right now).

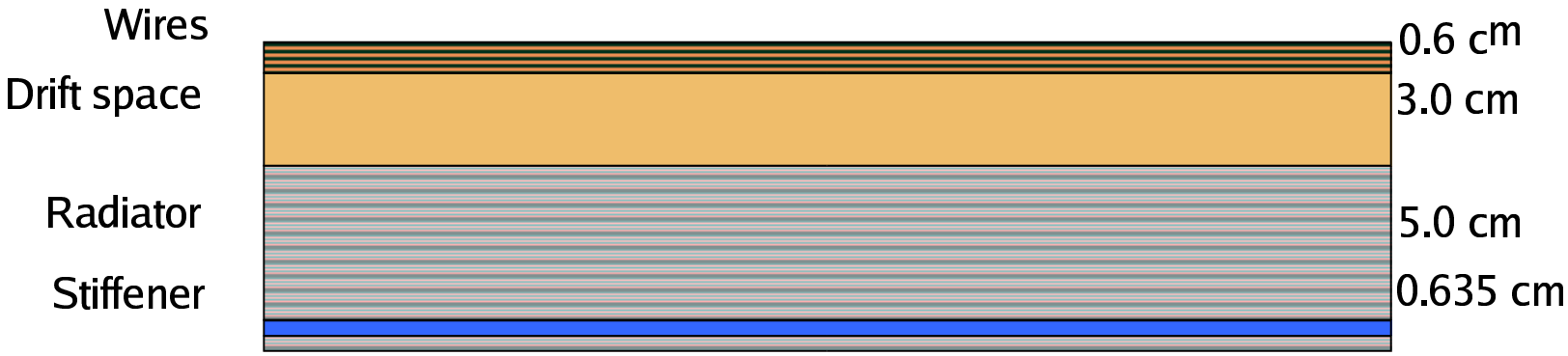
Recirculation system is needed.

Radiator Insert

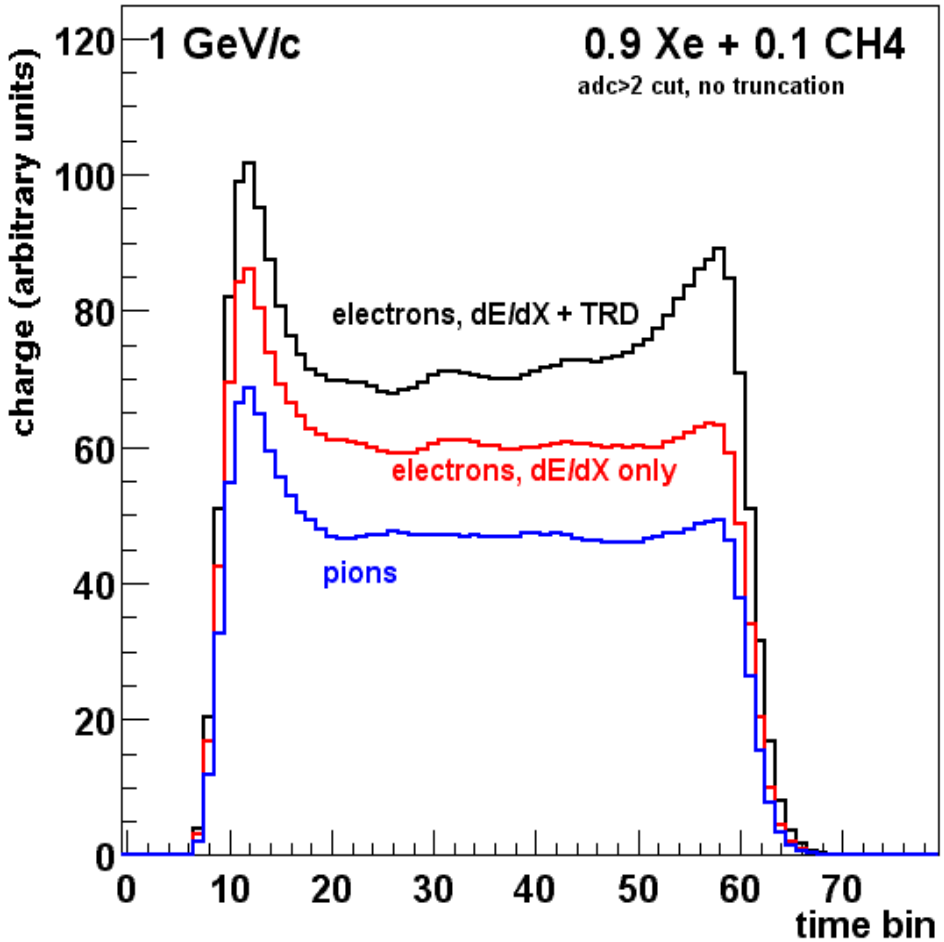
Radiator: LRP 375 BK 600 – 17 micron polypropylene fibers (density = 60-70 mg/cm^3, RL = 4.6 g/cm^2)

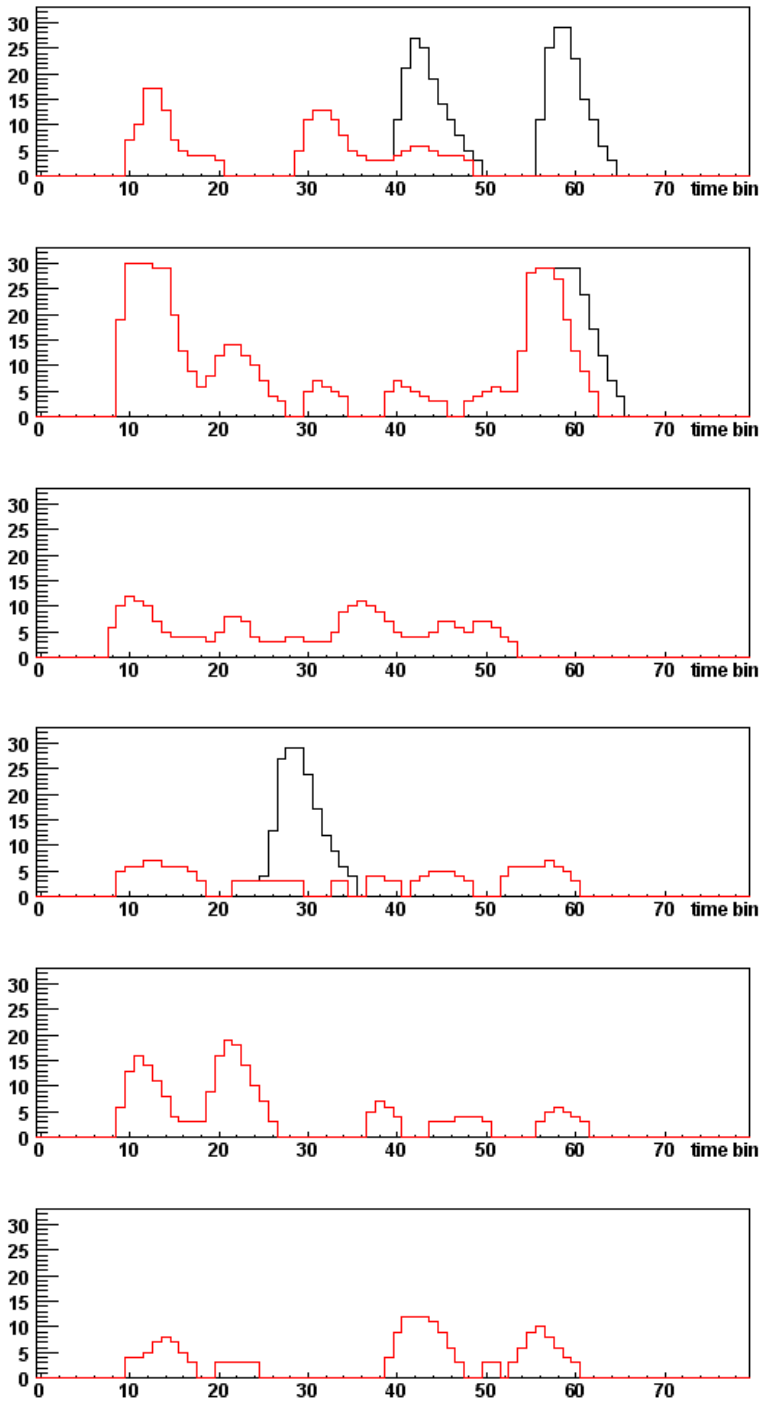
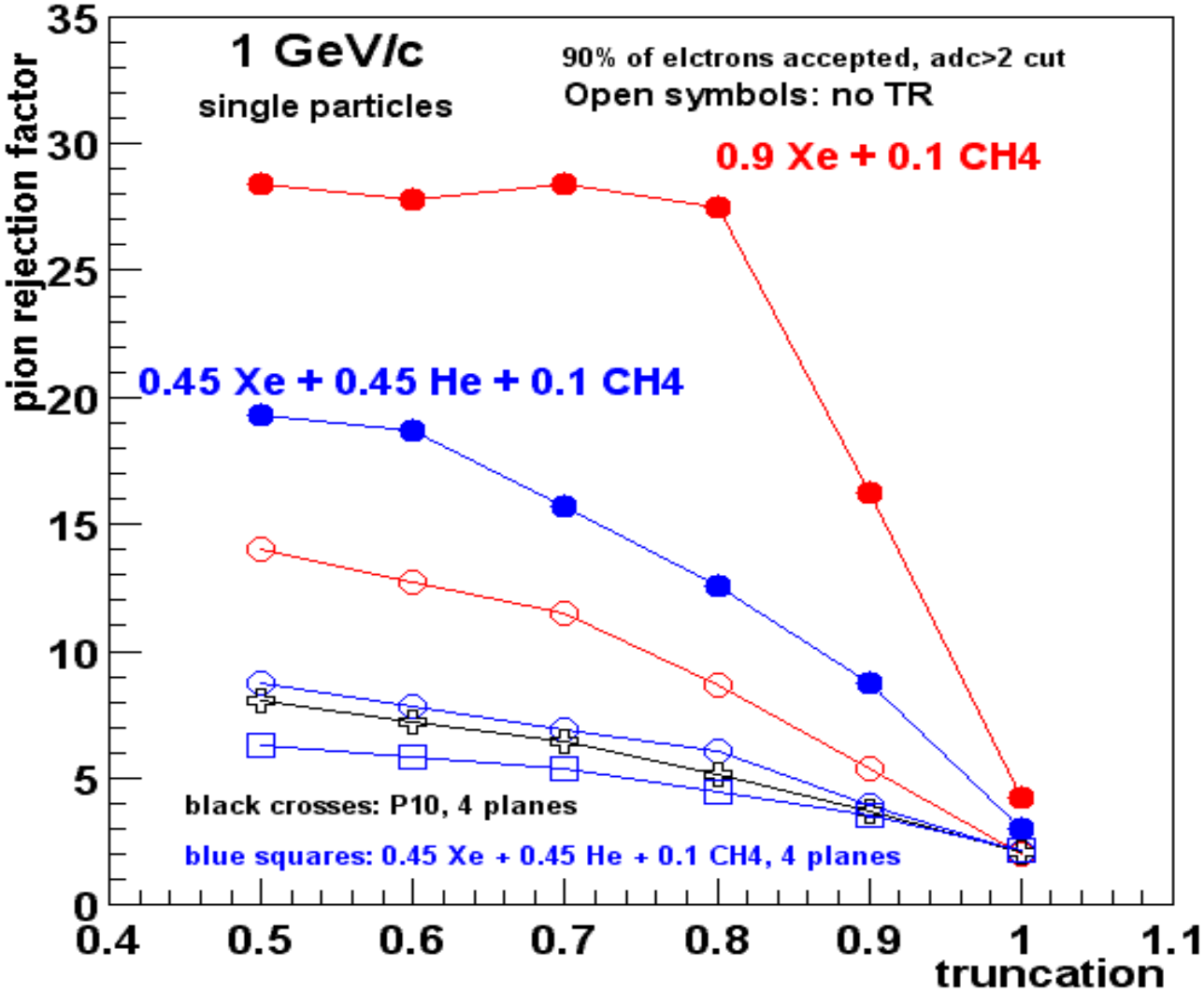
Stiffener: Rohacell IG51 (density 52 mg/cm^3, RL = 41 g/cm^2)

TRD radiator will add a little less than 1% of radiation length per TEC/TRD plane.



TR Signal


1 GeV/c
0.9 Xe + 0.1 CH4
adc>2 cut, no truncation
electrons, dE/dX + TRD
electrons, dE/dX only
pions
charge (arbitrary units)
time bin


time bin

TRD Upgrade – Simulation Predictions