

The Time Expansion Chamber of the PHENIX Experiment at the Relativistic Heavy Ion Collider

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The Relativistic Heavy Ion Collider (RHIC)



Project objectives:

To detect and study a new state of matter, quark-gluon plasma (QGP)

from Au-Au collisions:

in 2000 at C.M. energy of 130 GeV;

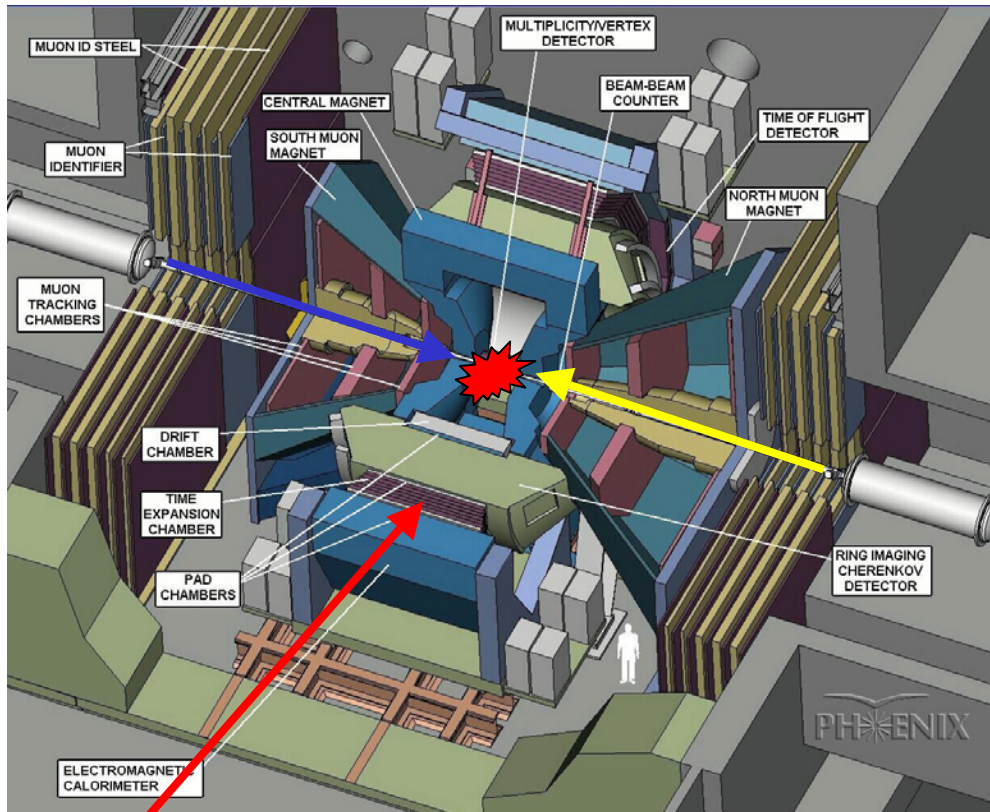
in 2001 at C.M. energy of 200 GeV (design);

To understand the spin structure of the nucleon

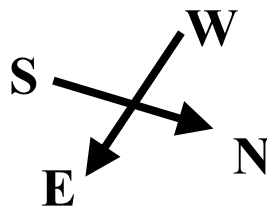
from proton-proton collisions:

in 2001 at C.M. energy of 200 GeV.

Pioneering High Energy Nuclear Interaction eXperiment (PHENIX)



The Time
Expansion
Chamber



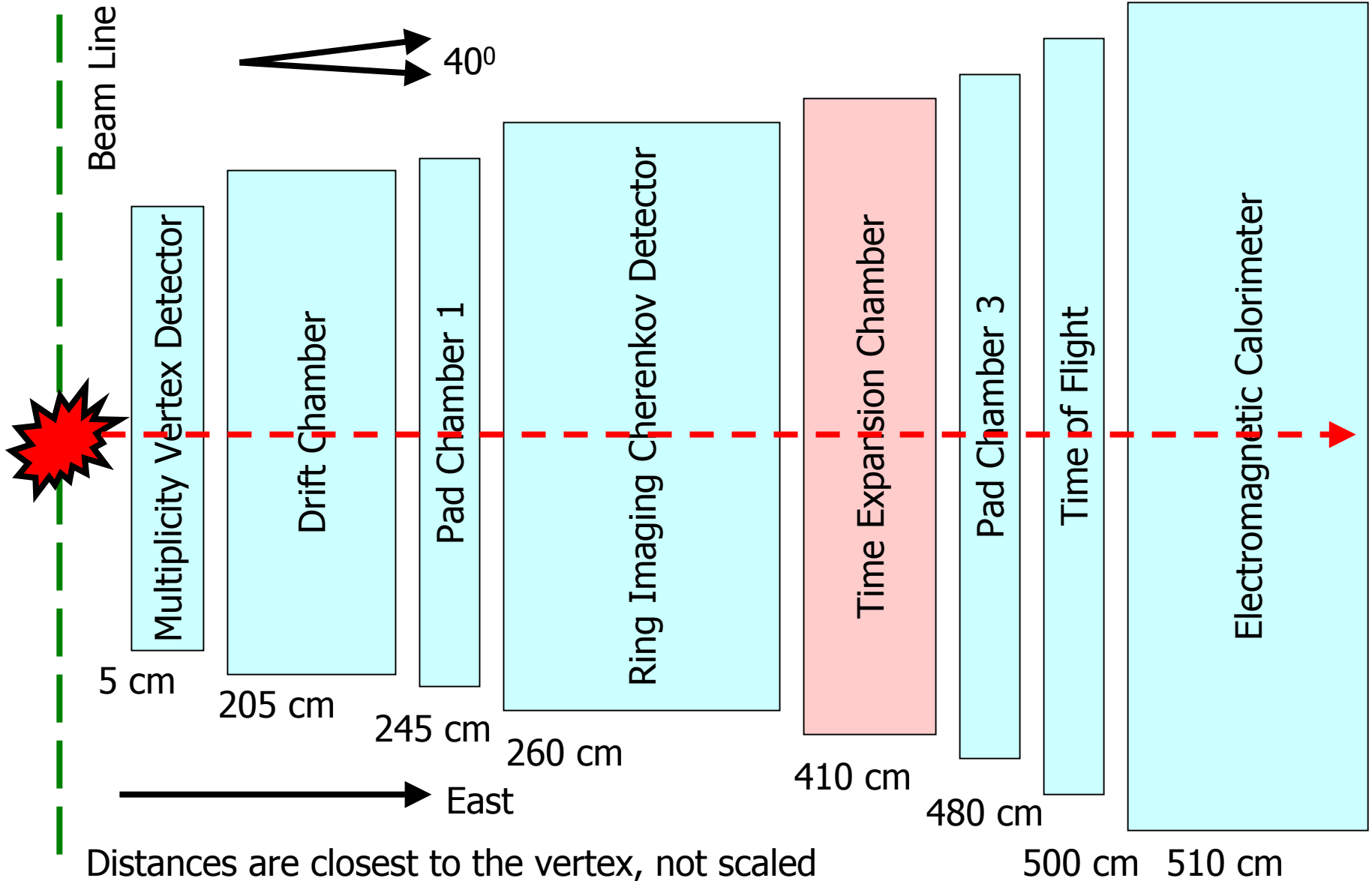
To study signatures of QGP through kinematical and dynamic properties of electrons, muons, hadrons, and photons coming out of the collision point.

Array of 11 subsystems for unbiased research.

2000: 4 million Au-Au minimum bias (all impact parameters) events recorded;

2001: 170 million Au-Au minimum bias events recorded (with 92 million minimum bias and 14 million rare events available for analysis) and 190 million p-p events.

Passage of a Track through the PHENIX East Central Arm



Functions of the Time Expansion Chamber (TEC) in the PHENIX

A) Measures charged particle ionization energy losses (dE/dx):

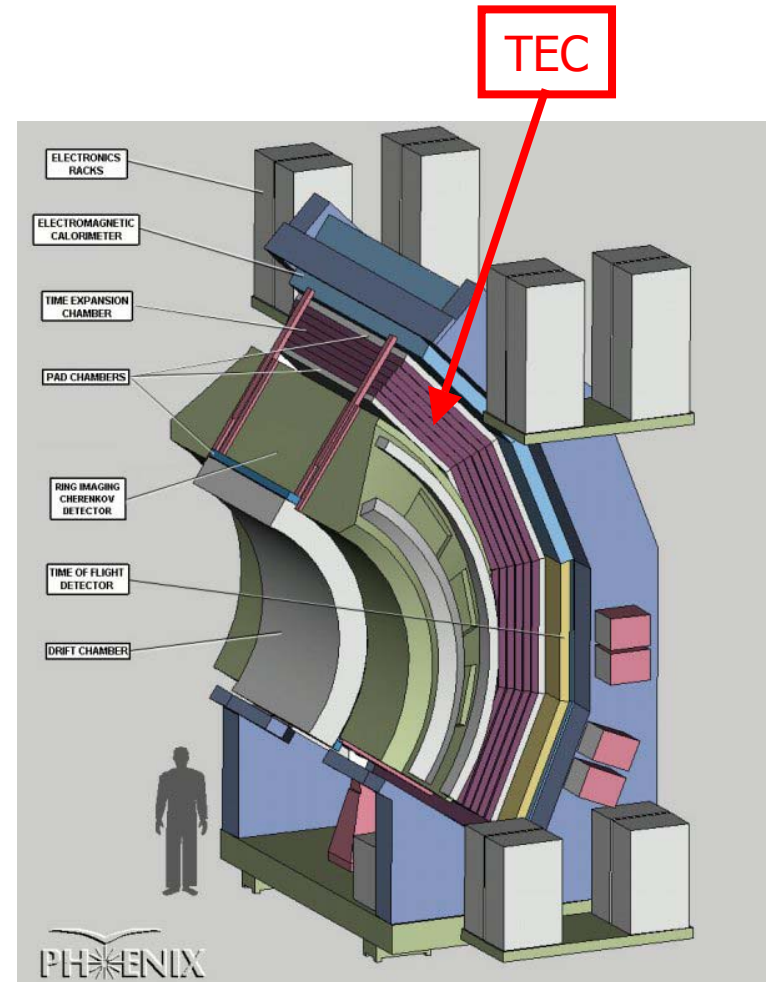
Separation of electrons from pions:

- 1) over a momentum range 0.25 -3 GeV (e/π is 5% at 500 MeV),
- 2) after upgraded to the Transition Radiation Detector (TRD), over a momentum range 0.25-50 GeV via transition X-radiation detection (e/π is 1.5% at 500 MeV).

B) Tracks all charged particles and produces direction vectors that match tracking information from the Drift and Pad Chambers to complete track determination in the PHENIX.

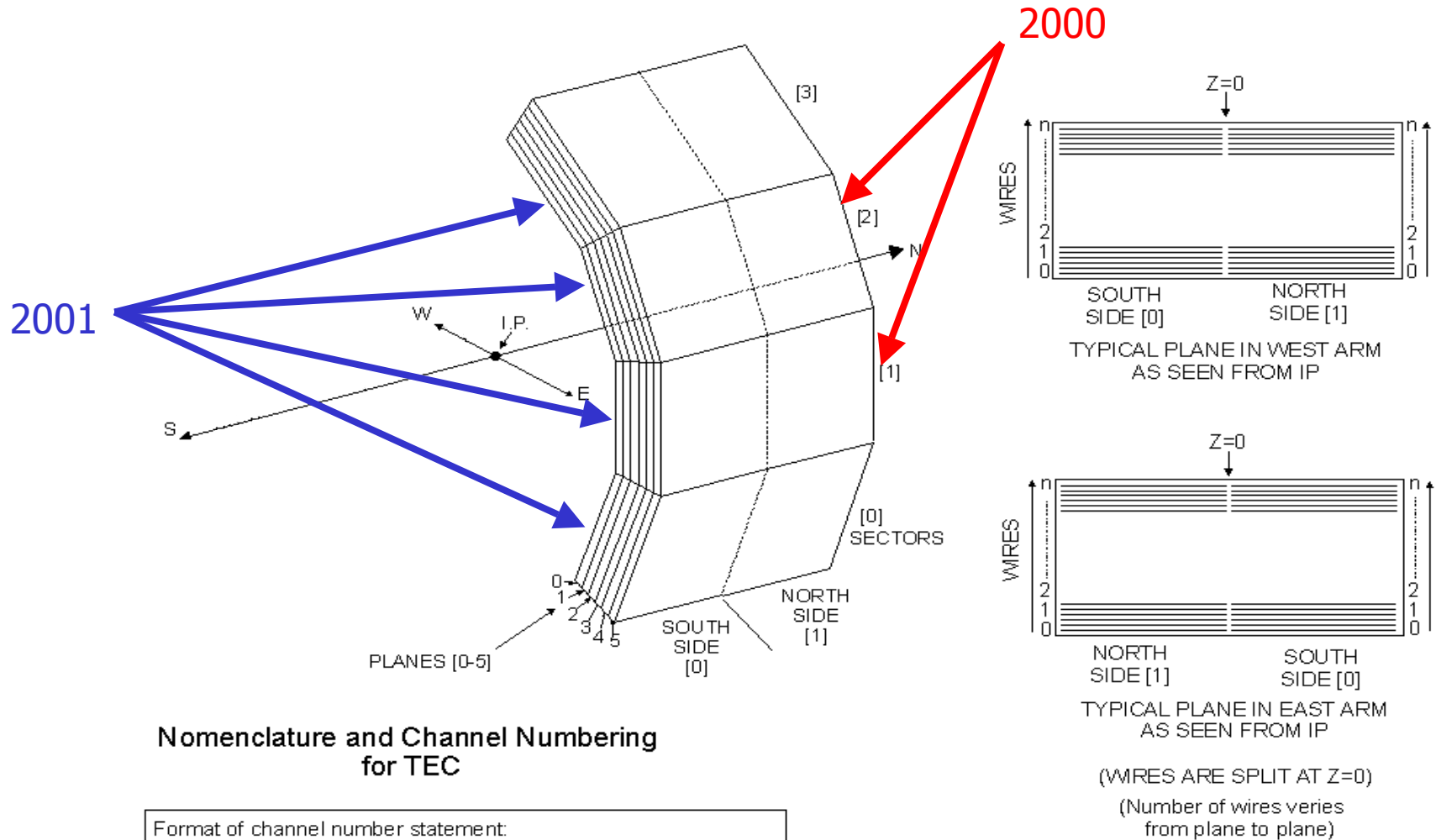
Single point track resolution of 250 μm and two track separation of 2 mm.

C) Measuring the transverse momentum of a charged particle.



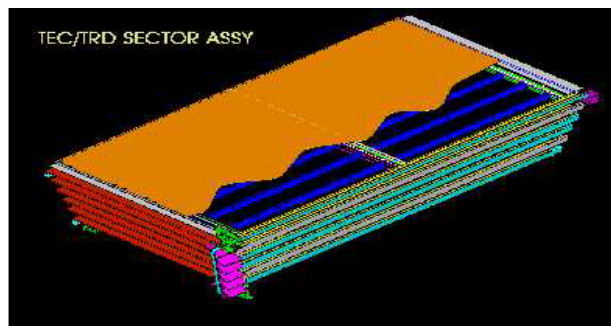
PHENIX East Central Arm

Geometry of the TEC



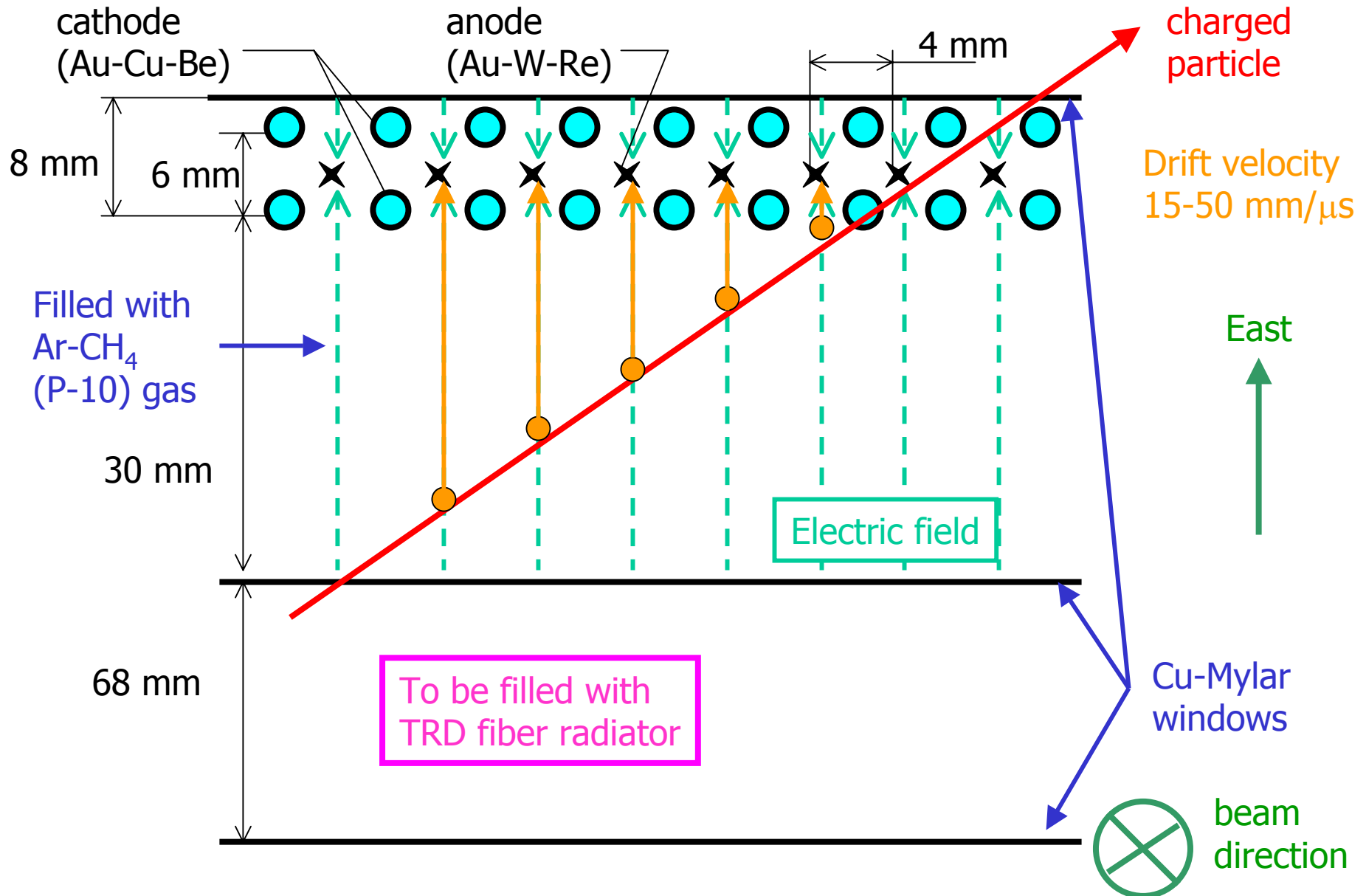
Design Parameters of the TEC

- 1) Arranged in 6-plane 4 sectors (in 2000 and 2001 only 4 planes were instrumented electronically).
- 2) Covers 90° of the PHENIX azimuthal angle ϕ and 0.35 units of pseudorapidity η (approximately 40° of the polar angle θ).
- 3) Distance from the collision vertex approximately $R = 410\text{-}457$ cm.
- 4) 64,080 wires and 20,480 readout channels.
- 5) Filled with Ar-CH₄ (P-10) gas (90% of argon and 10% of methane) with the effective gas gain of 10000 (in 2000 and 2001 the effective gas gain was 2000-5000). (Gain is the number of electrons produced in a signal wire by one electron knocked out by a charged track).
- 6) Dimensions of the planes: 3.00 m x 1.69 m for the smallest and 3.49 x 1.90 m for the largest.
- 7) 320 Front-End Modules (FEM) and 640 Preamplifier/Shaper Boards (PS) (in 2001 216 FEMs and 432 PS Boards).

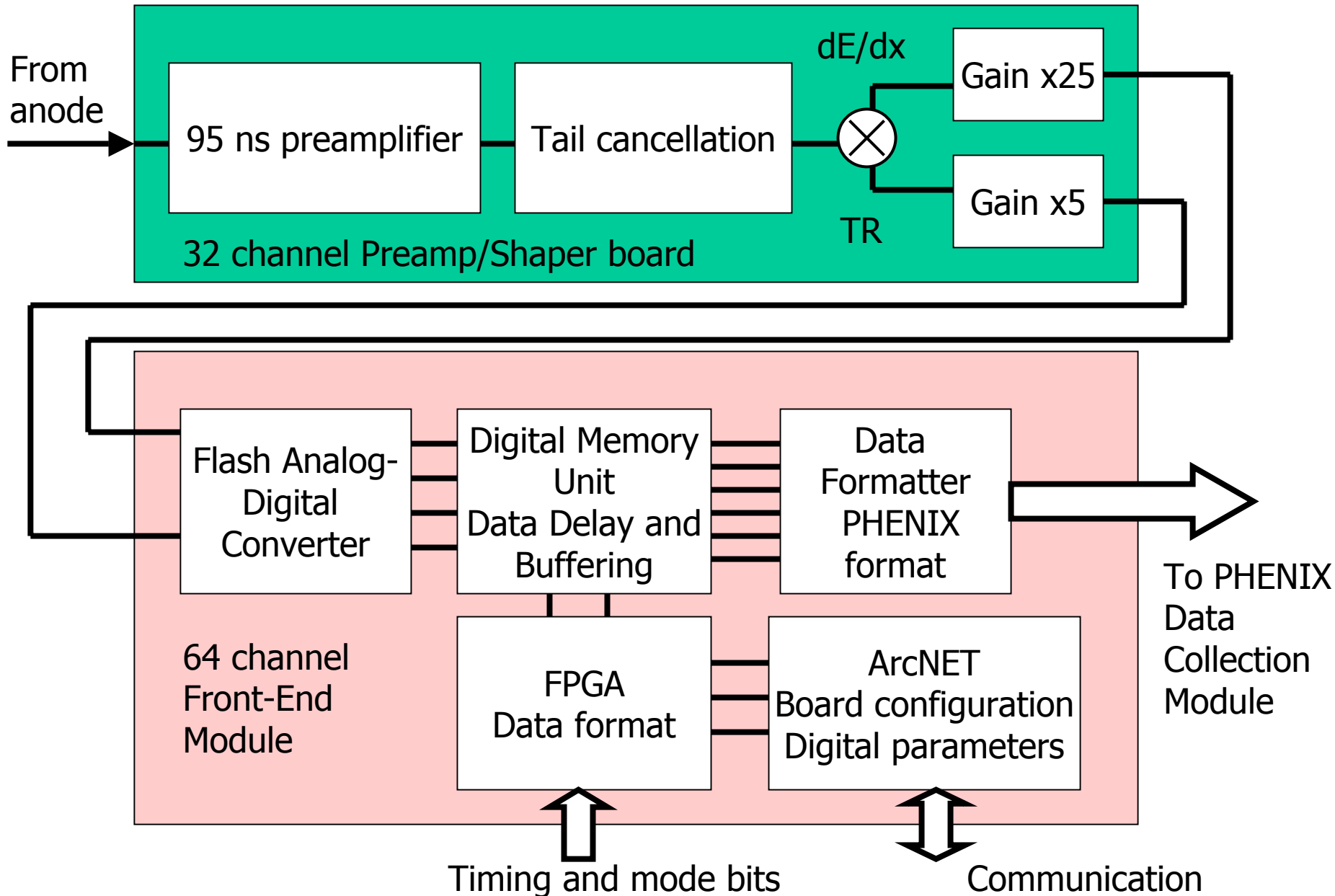


← TEC six-plane sector

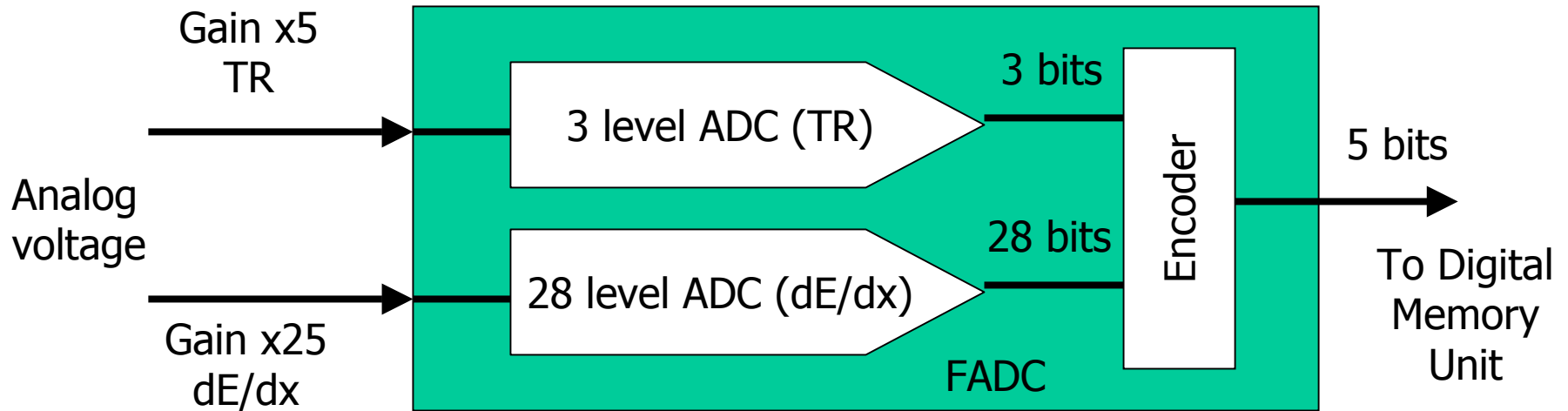
Mechanical Design of the Plane



Electronics chain



Signal sampling

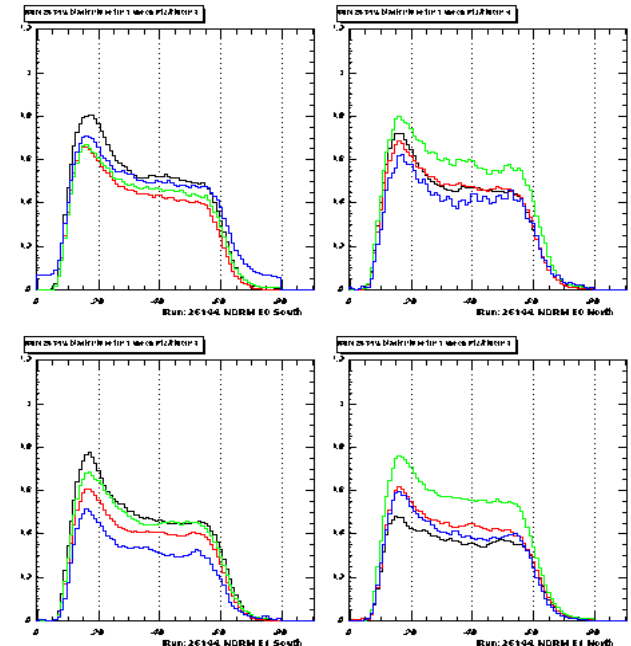


dE/dx signal: 0.2-0.3 keV (MIP in Xe)
TR signal: 3-10 keV (X-rays in Xe)

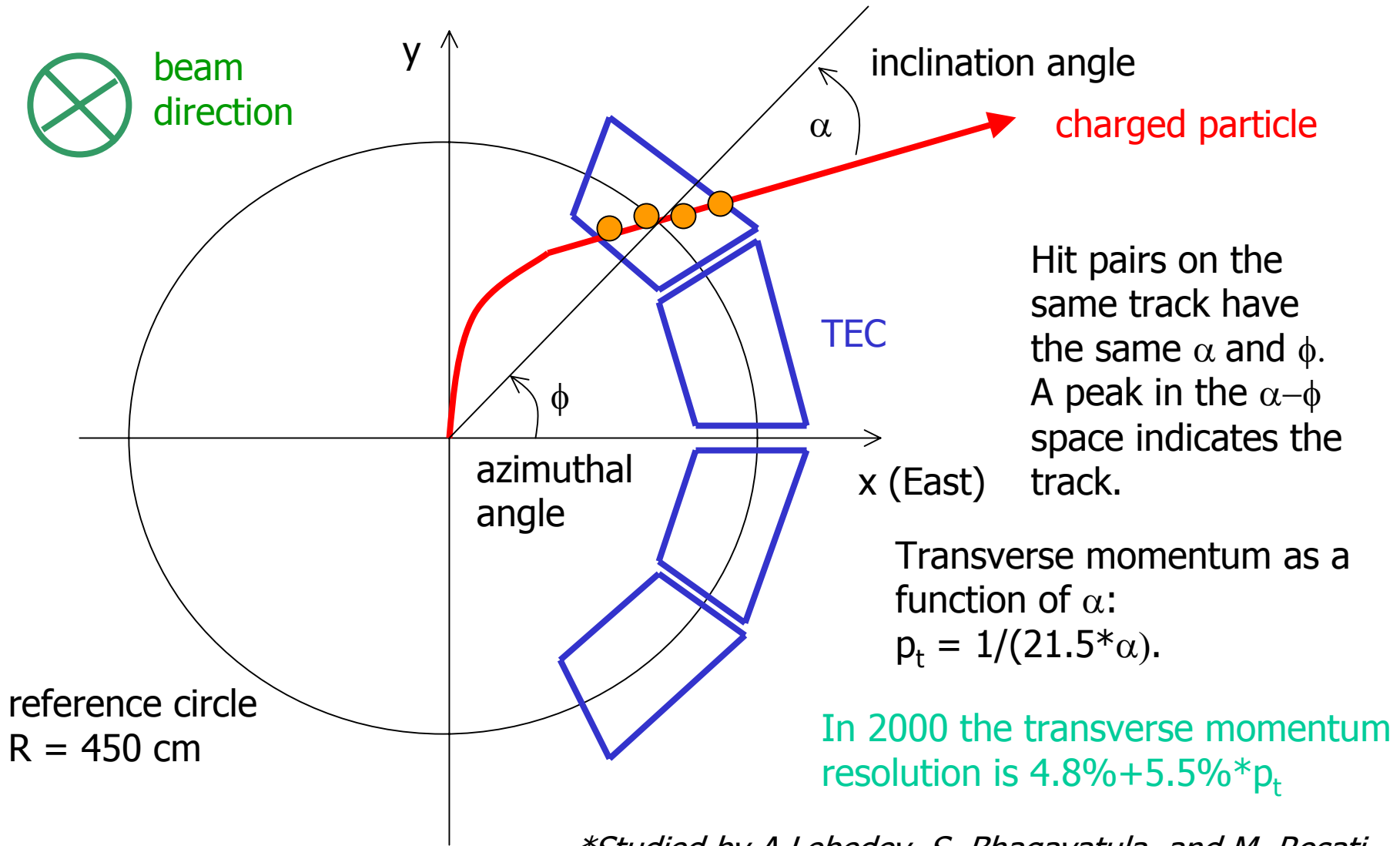
Timing distributions
for reconstructed charged
particles



NORM Timing Histogram : Sector E0 and E1
Data from Run: 26144 File: 0008
2001_08_22 18:51:19



Track reconstruction



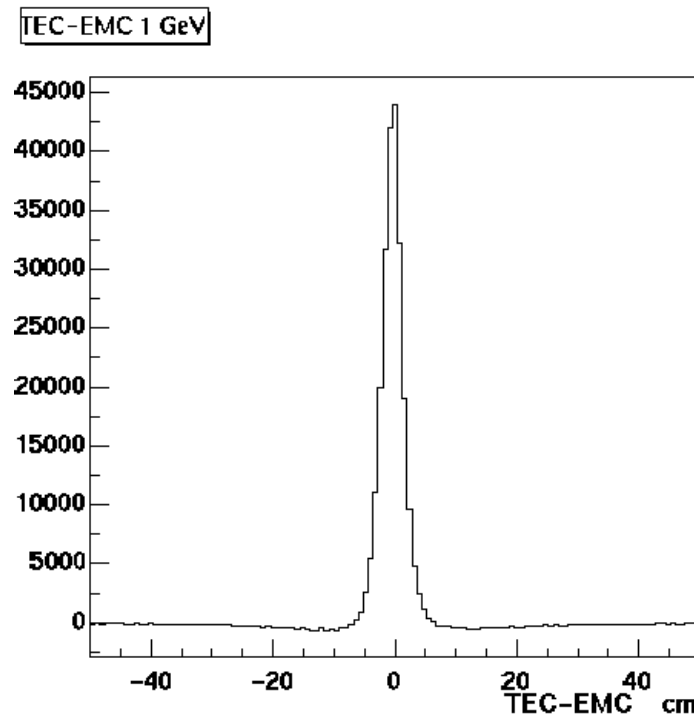
**Studied by A. Lebedev, S. Bhagavatula, and M. Rosati*

Relative space resolution in 2000

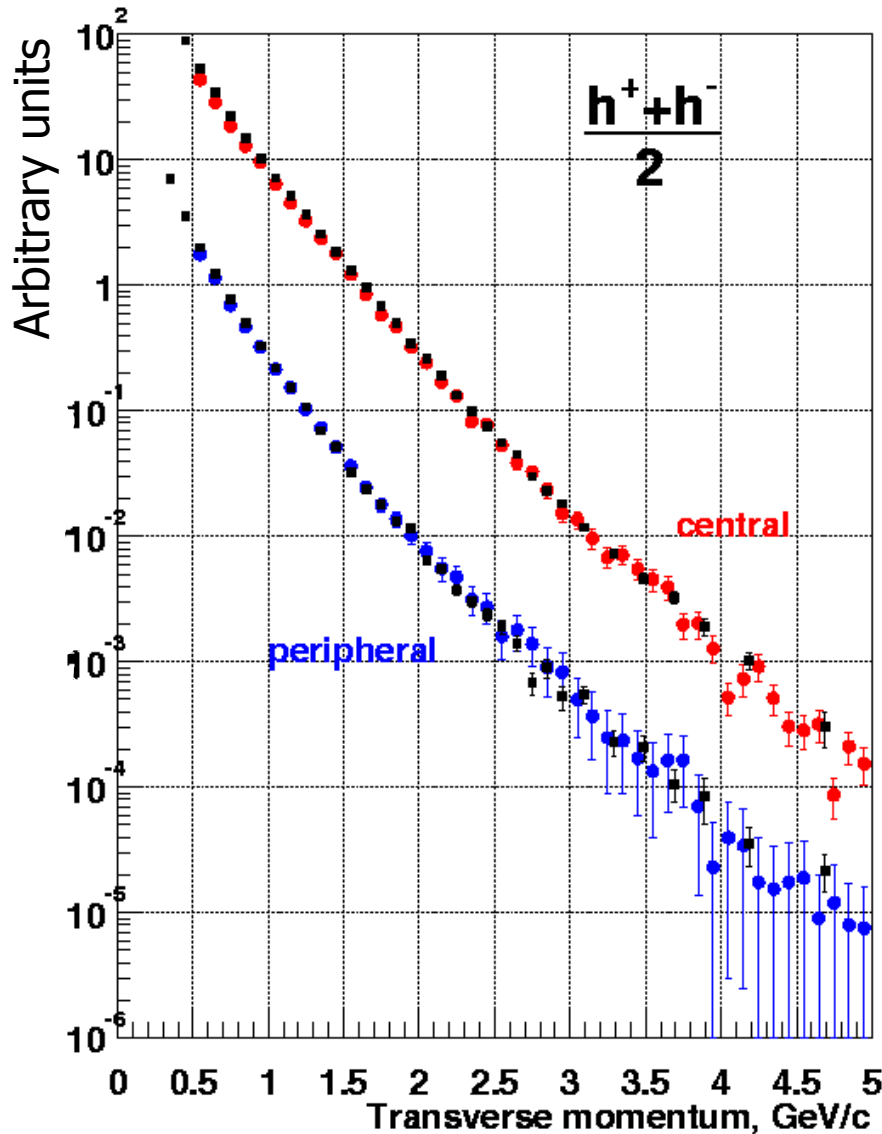
Average resolution of the TEC track in respect to associated hits in other PHENIX subsystems:

	0.5 GeV	1 GeV	2 GeV	3 GeV
PC 1	0.9 cm	0.8 cm	0.8 cm	0.9 cm
PC 3	0.7 cm	0.7 cm	0.7 cm	0.8 cm
TOF	1.3 cm	1.3 cm	1.3 cm	1.3 cm
EMC	1.9 cm	1.8 cm	1.8 cm	1.9 cm
Vertex	3.2 cm	1.4 cm	1.2 cm	1.2 cm

Distance between the TEC track and associated hit in the EMC



Transverse momentum spectra in 2000



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

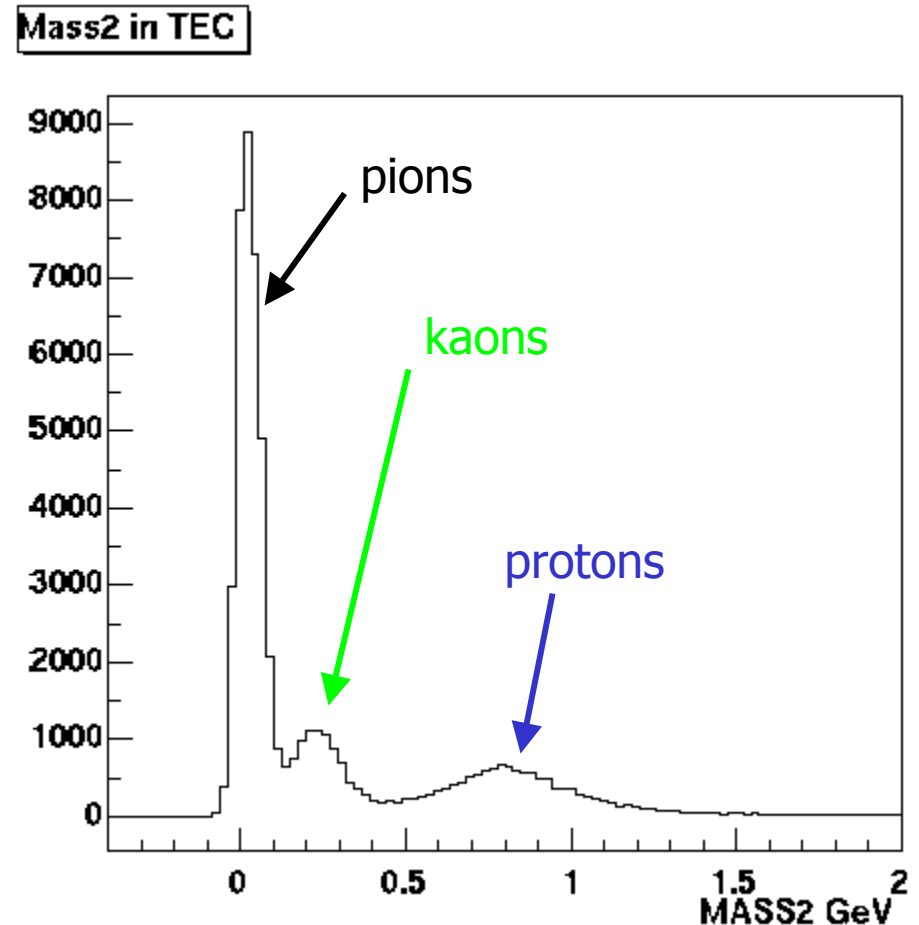
**Studied by A. Lebedev, S. Bhagavatula, and M. Rosati*

Identification of charged hadrons in 2000

Capable of effective hadron identification through m^2 measurements using Time of Flight hodoscope data. Can clear separate :

- 1) pions from kaons with transverse momenta up to 1.2 GeV;
- 2) kaons from protons with transverse momenta up to 1.4 GeV.

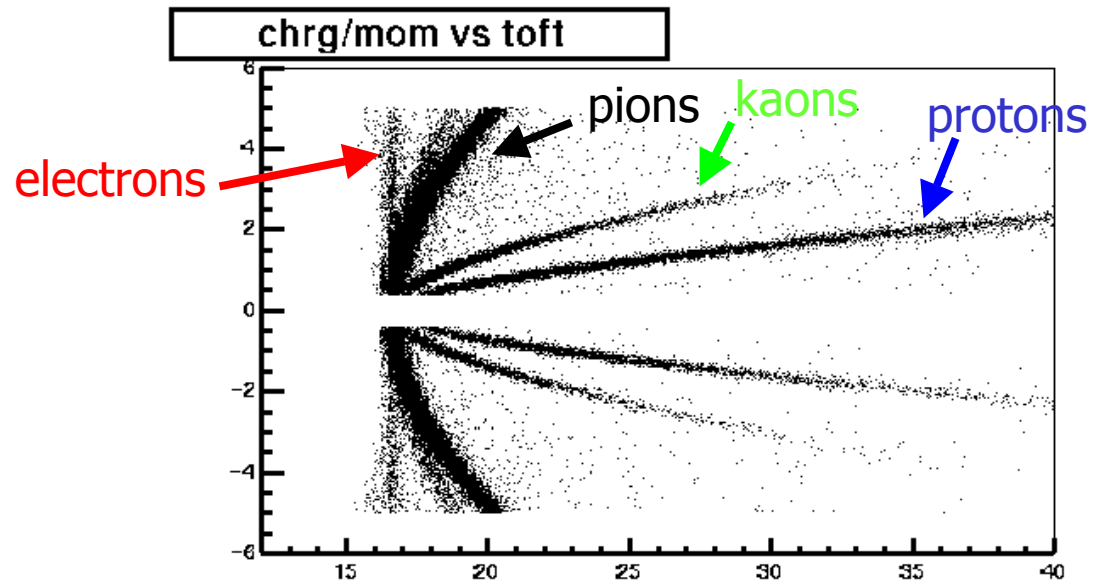
Mass² distribution of the charged particles in TEC for $p_t = 1.0 - 1.2$ GeV



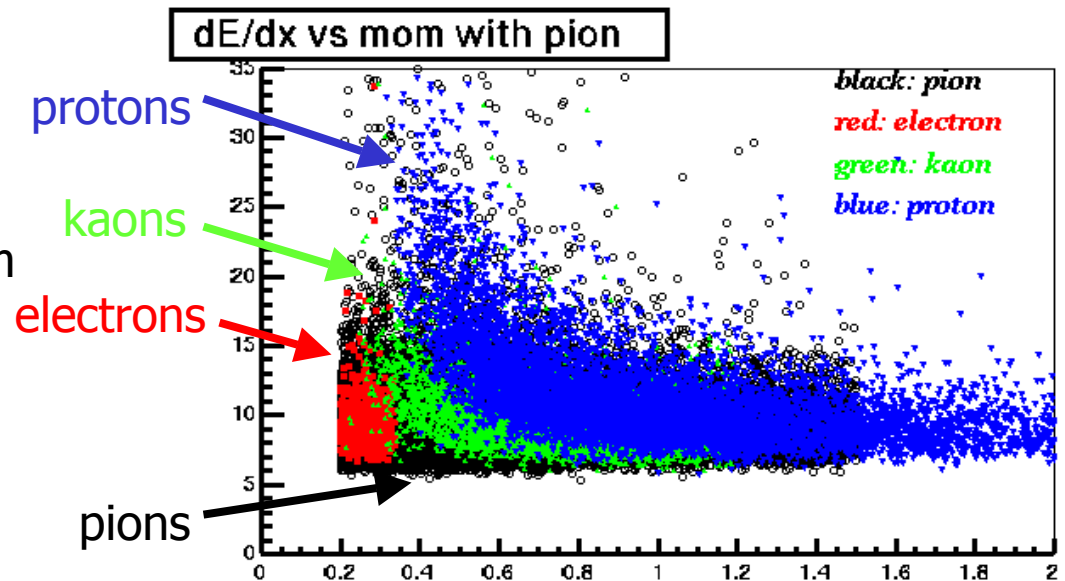
dE/dx Study in 2000

Estimated gas gain ~ 3000

Identify hadrons and electrons with the Drift Chamber, Ring Imaging Cherenkov Detector and the Time of Flight hodoscope

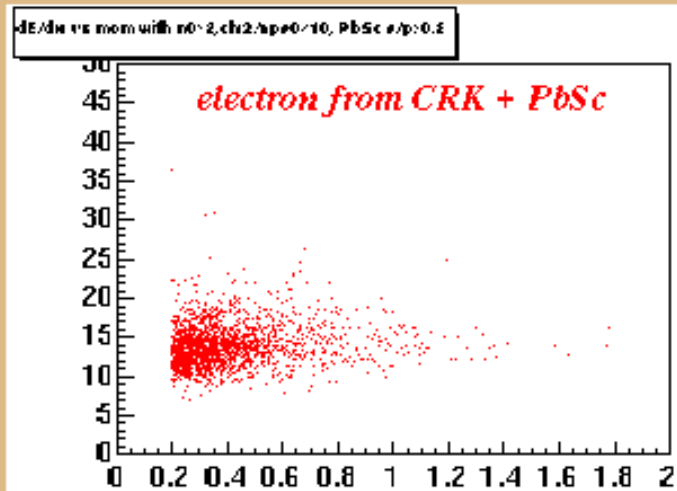
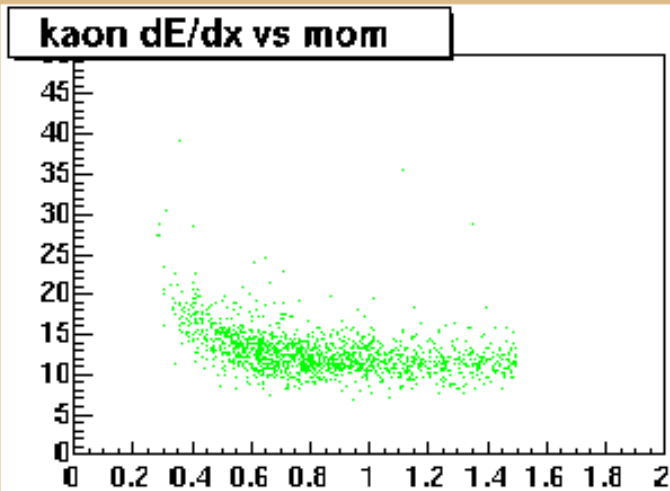
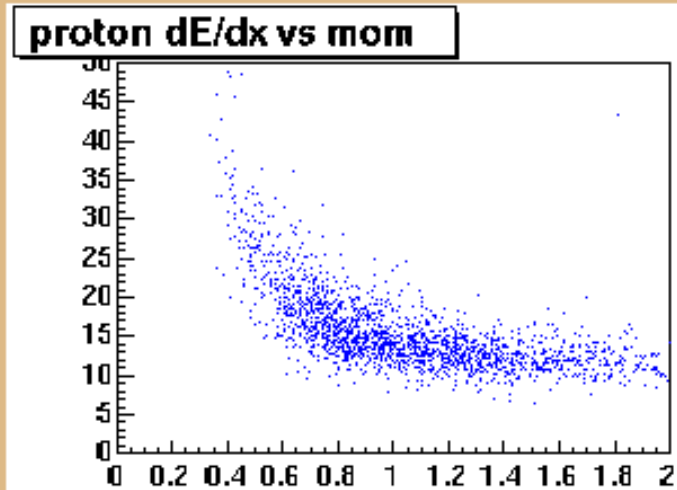
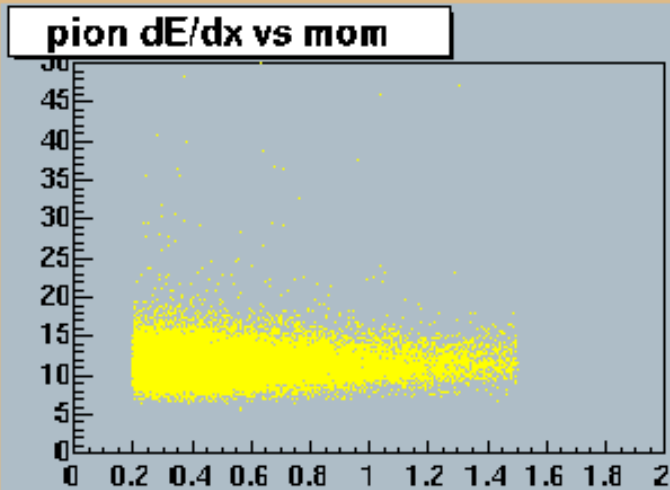


Then look at identified species in the TEC dE/dx vs. momentum distribution



**Studied by X.H. Li*

dE/dx Study in 2001



**Studied by X.H. Li*

Estimated gas gain ~5000

Future

1. Upgrade into the Transition Radiation Detector (capable of pion/electron separation for momenta beyond 50 GeV) by:
 - a) electronically instrumenting from 4 to 6 planes,
 - b) installing polypropylene fiber radiators in front of each wire plane,
 - c) use xenon-helium-methane (Xe-He-CH₄) gas mixture.
(To be done by October 2002.)
- 2) Possible construction of the TEC in the PHENIX West Central Arm (2004/2005).