PHENIX

TEC/TRD for the PHENIX Detector at RHIC

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TRDs for the 3rd Millennium

Bari, Italy

September 4-7, 2003

PHENIX

12 Countries; 57 Institutions; 460 Participants*

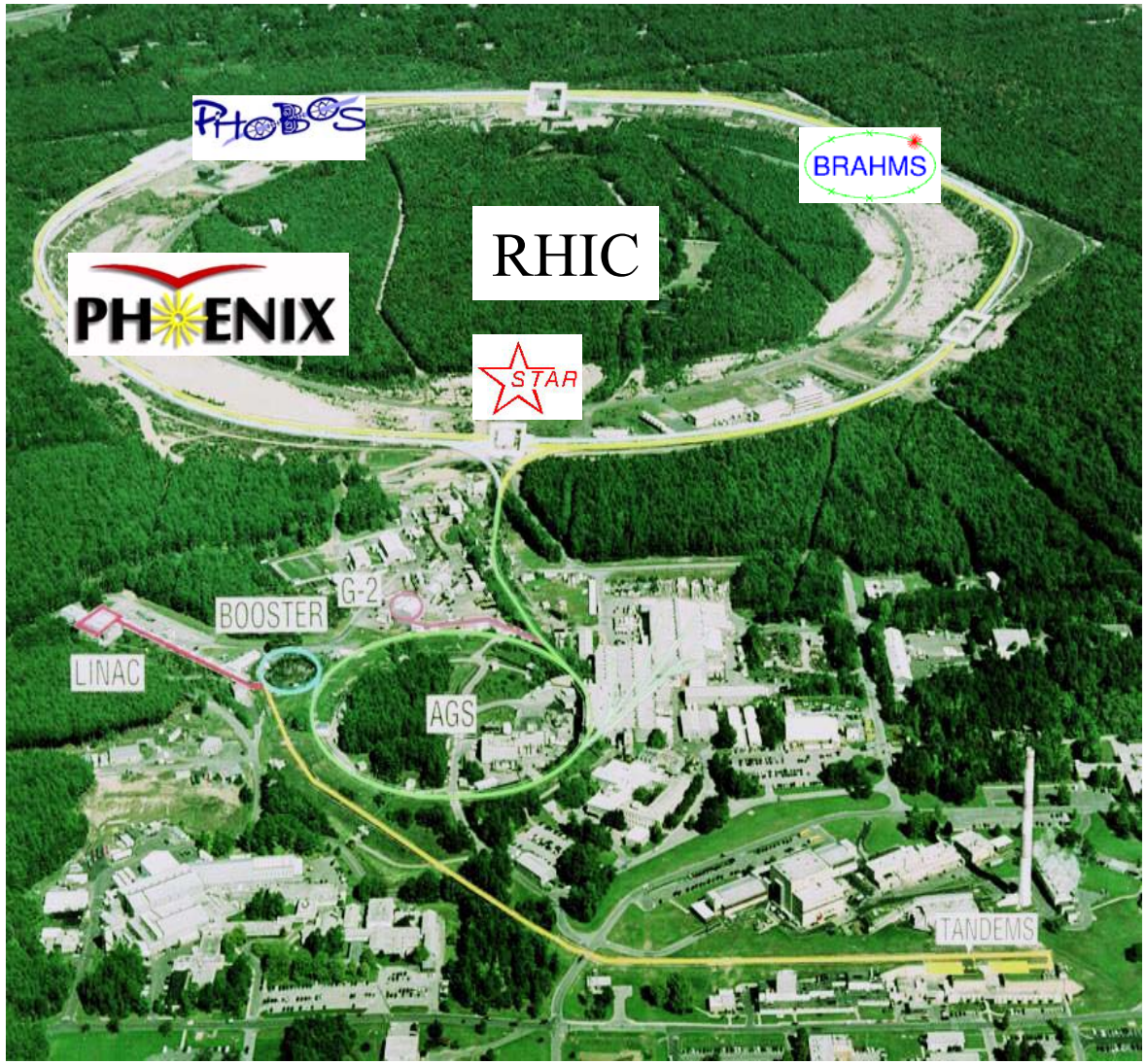
Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	University of Tokyo, Bunkyo-ku, Tokyo
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund

USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California - Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of July 2002

Relativistic Heavy Ion Collider at Brookhaven National Lab

- Two independent rings 3.83 km in circumference
  - 120 bunches/ring
  - 106 ns crossing time
- Maximum Energy
  - $s^{½}$ = 500 GeV p-p
  - $s^{½}$ = 200 GeV Au-Au per N-N collision
- Design Luminosity
  - Au-Au $2x10^{26}$ $cm^{-2}s^{-1}$
  - p - p $2x10^{32}$ $cm^{-2}s^{-1}$ (polarized)
- Capable of colliding any nuclear species on any other nuclear species

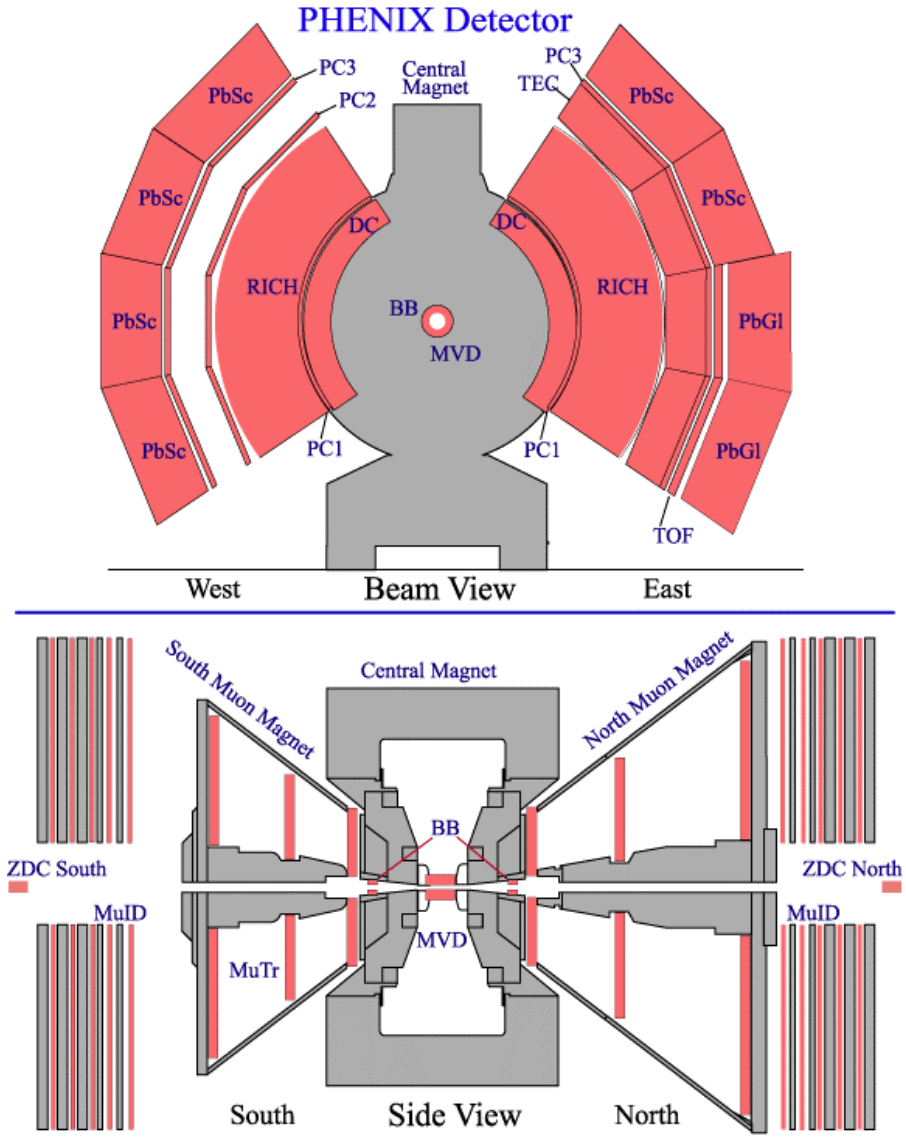


PHENIX Experiment

Philosophy:

High granularity and data rate
Good mass resolution and particle ID

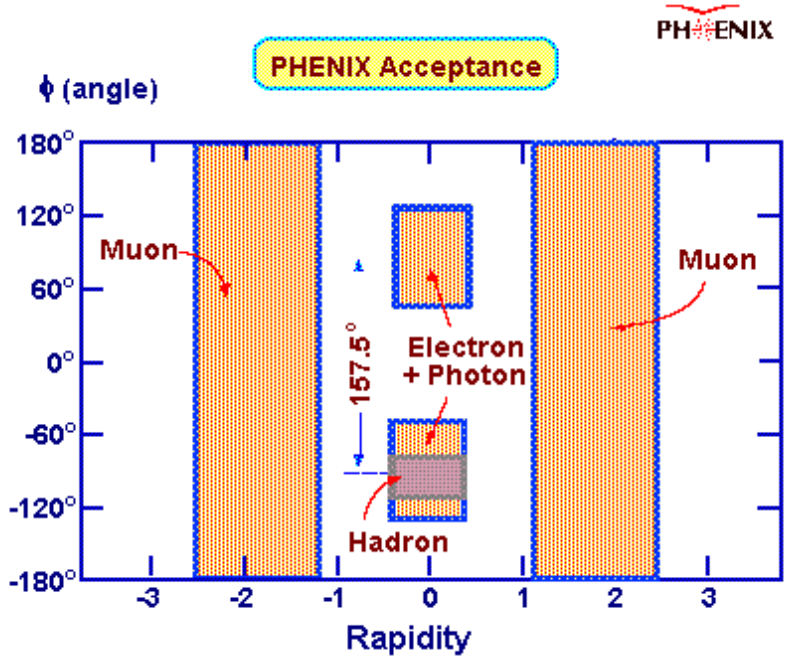
Central Arm Tracking
Drift Chamber, Pad Chambers, Time Expansion Chamber
Muon Arm Tracking
Muon Tracker
Calorimetry
PbGl and PbSc (gain balance, level 1)
Particle ID
Muon Identifier (level 1), RICH, TOF, TEC
Luminosity Counters/Vertex Detectors
BBC, ZDC/SMD, Local Polarimeter, Forward Hadron Calorimeters, NTC, MVD
DAQ
Bandwidth upgrade, event size/data volume
Trigger
Level 1 (GL1P, muID, EMC/RICH)
Level 2 (Bandwidth upgrade)
Online
Calibration and production



Physics in PHENIX

Quark Gluon Plasma

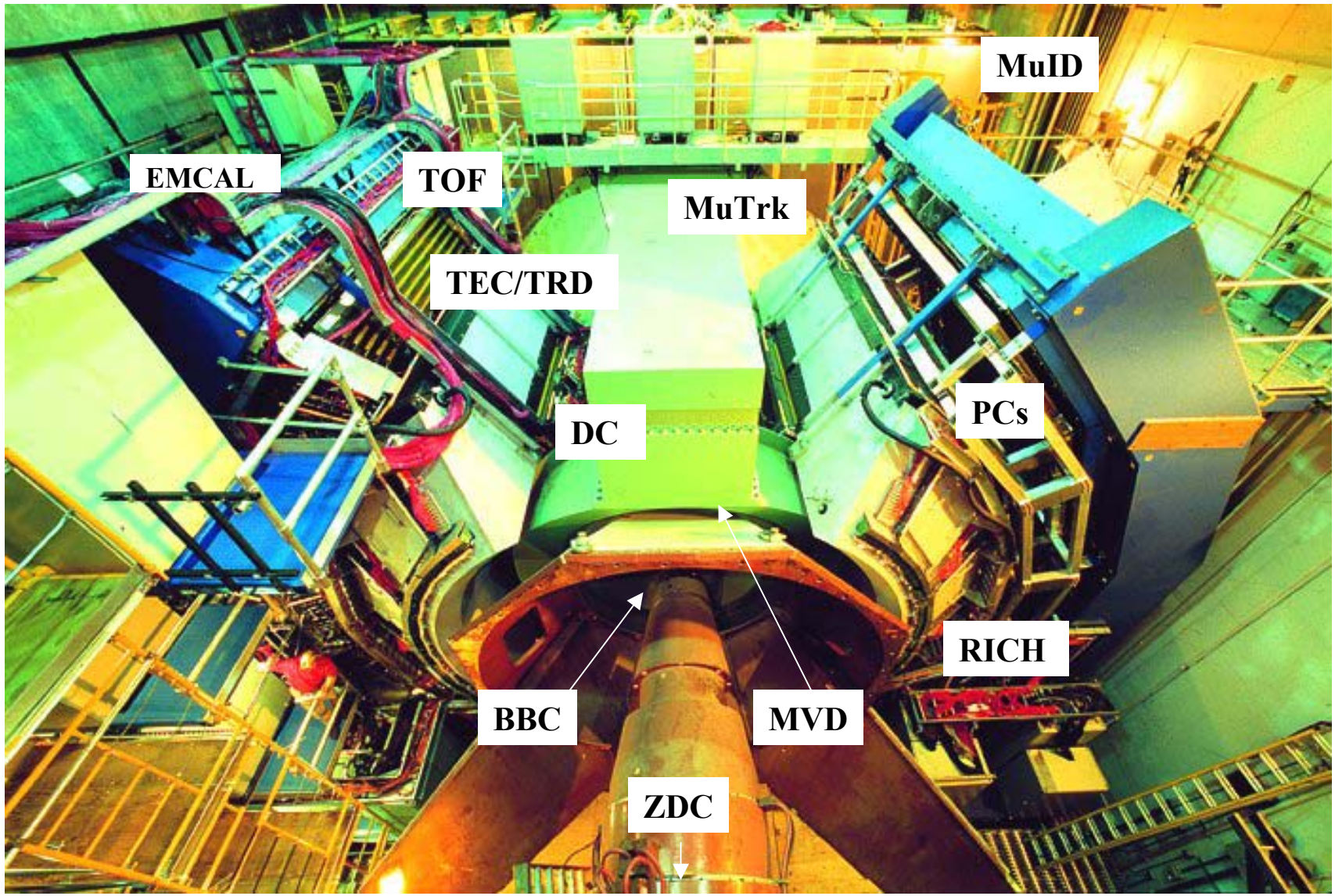
- **Temperature, Energy Density**
  - dN/dy, E_T , Single particle spectra
- **Medium Effects , Jet Suppression**
  - High p_T jets using leading π^0, $\pi^{\pm}$
- **Space –Time Evolution**
  - HBT($\pi\pi$, KK,pp), Flow
  - Event by Event Fluctuations
- **Deconfinement**
  - J/Ψ, Ψ'→ e^+e^-, $\mu^+\mu^-$, Υ→ $\mu^+\mu^-$
- **Chiral Symmetry Restoration**
  - $\phi \rightarrow e^+e^-$, $K^+ K^-$, ϕ,ω,ρ width/shift
  - DCC's $\pi^0/\pi^{\pm}$
- **Heavy Quark Production**
  - K/ π , ϕ, J/Ψ, Ψ', Υ, D, B mesons
- **Thermal Radiation**
  - γ, $\gamma^* \rightarrow e^+e^-$, $\mu^+\mu^-$



Proton Spin

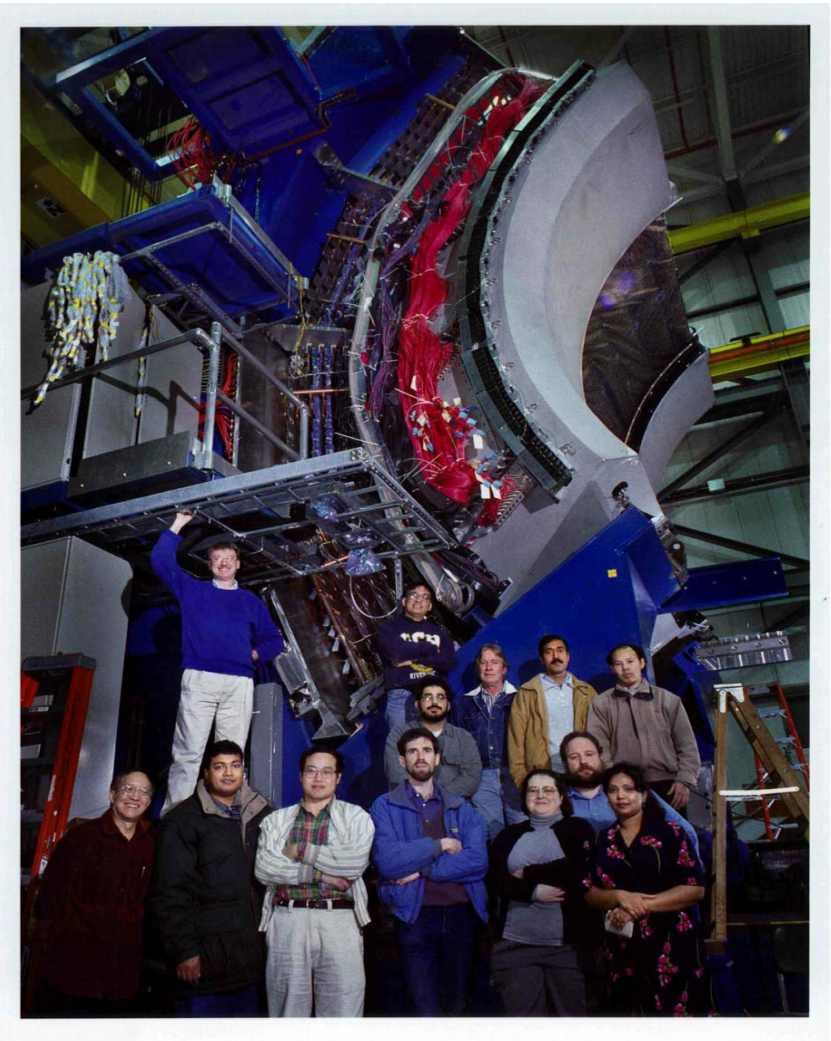
- **Gluon polarization: ΔG**
  - Prompt γ
  - Heavy flavors
  - Leading hadrons
- **Anti-quark helicity**
  - Drell-Yan production
  - W → (e, μ) + ν

Crowded Experimental Hall



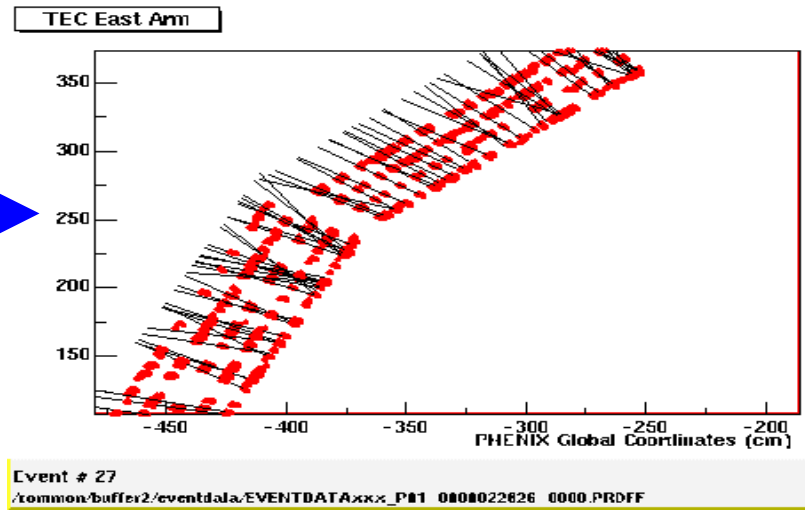
PHENIX Time Expansion Chamber/ Transition Radiation Detector

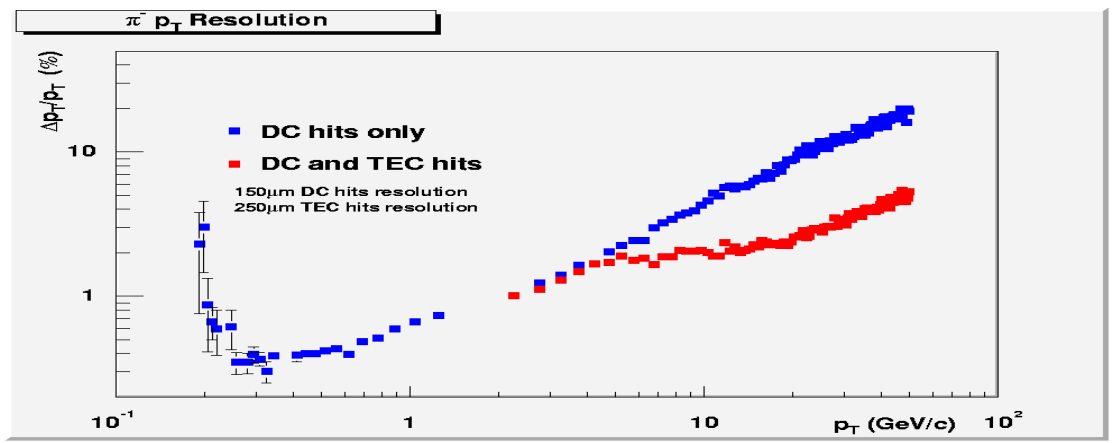
- 24 chambers arranged in 4, 6-chamber sectors
- Each 3.7m × 2.0m × 0.1m chamber contains 2700 wires



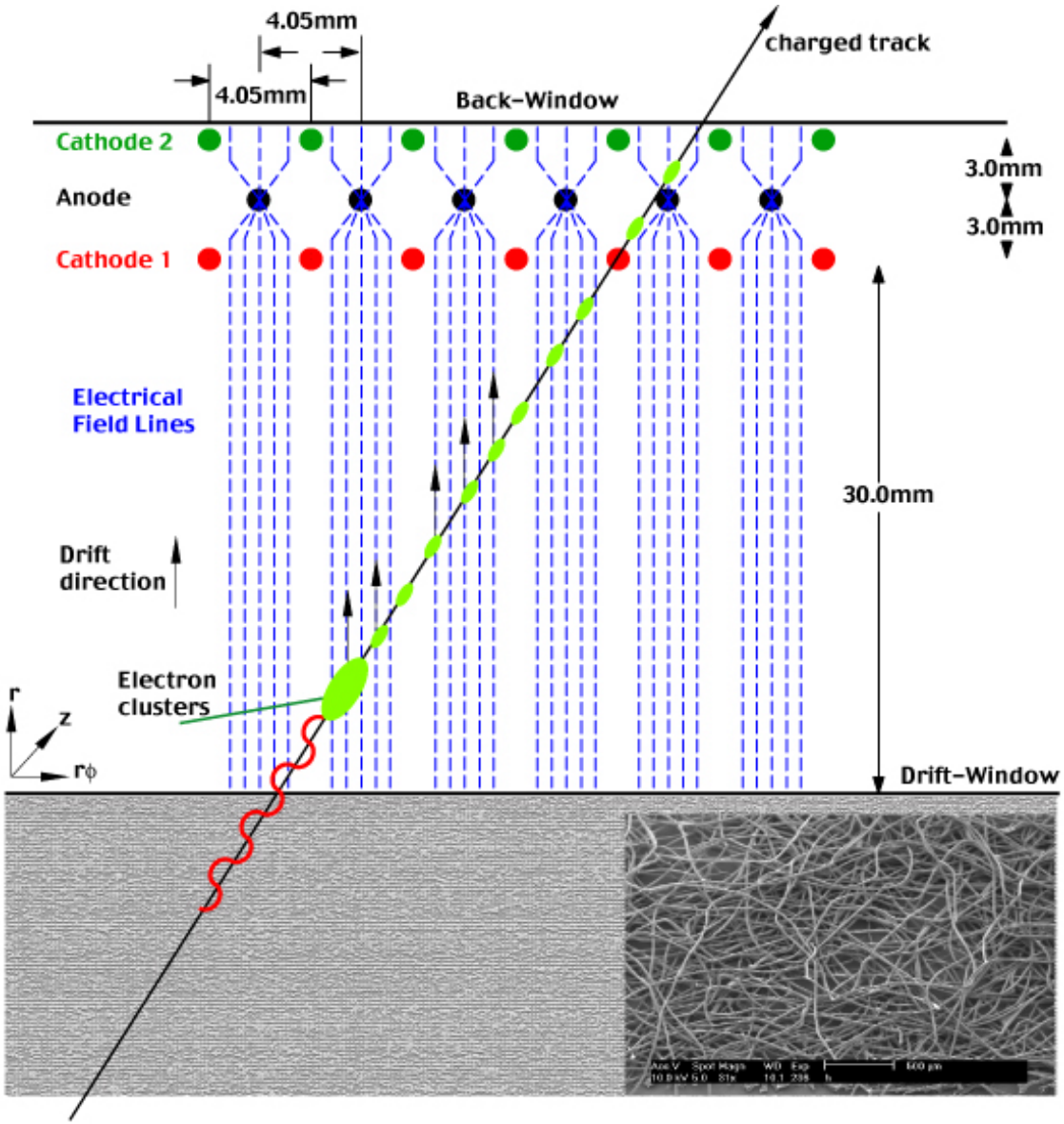
TEC/TRD Main Functions

- e/π separation by dE/dx,
  TR measurements
- Pattern recognition:
  robust at high track density
- Momentum reconstruction:
  important at high p_T



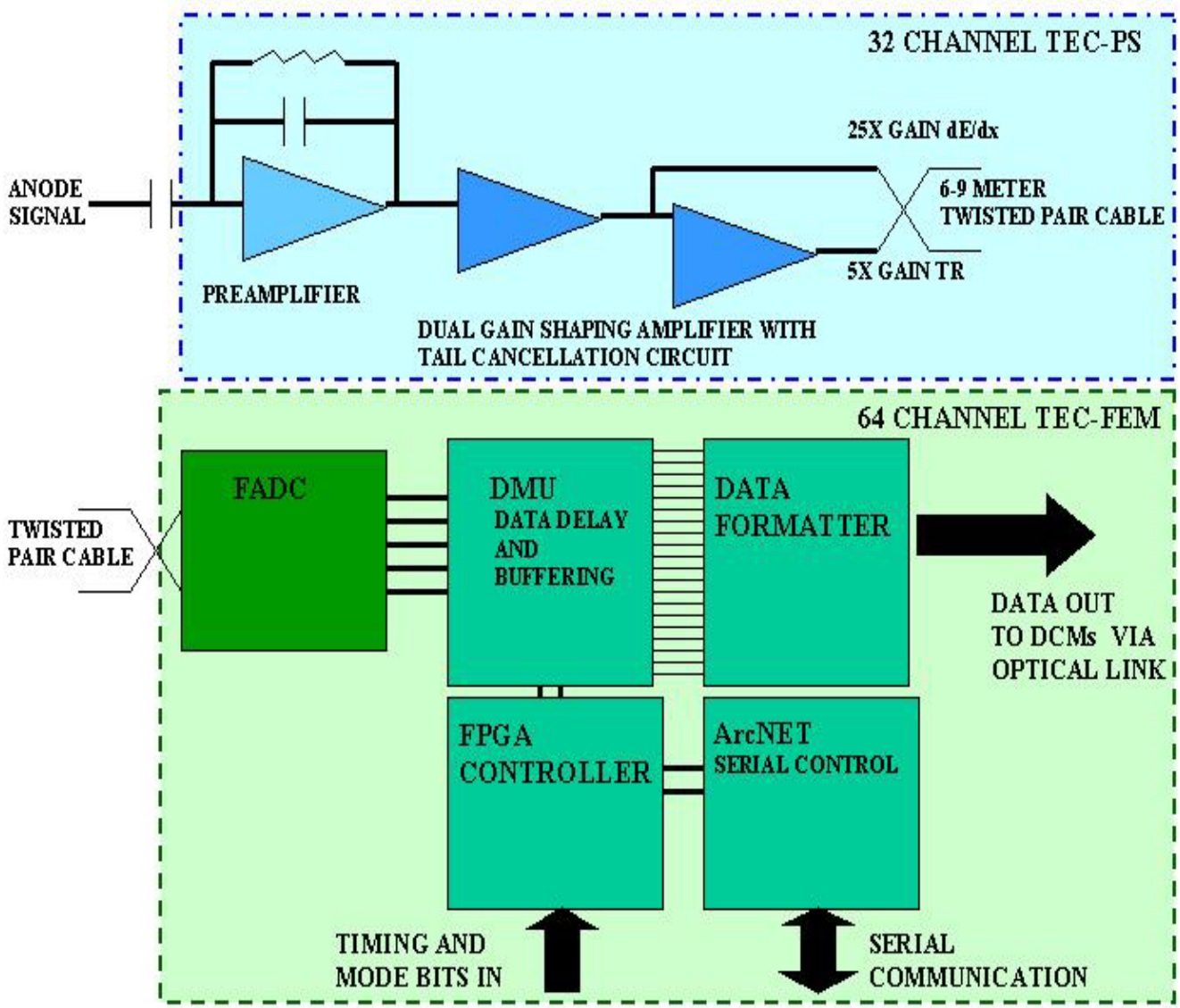


One TEC/TRD Plane



- Cu-Mylar back bias window
- 3 wire planes of cathode/anode/ cathode
- 3cm drift space
- 25 μm Cu-Mylar cathode plane
- 5cm fiber

TEC/TRD Electronics Chain

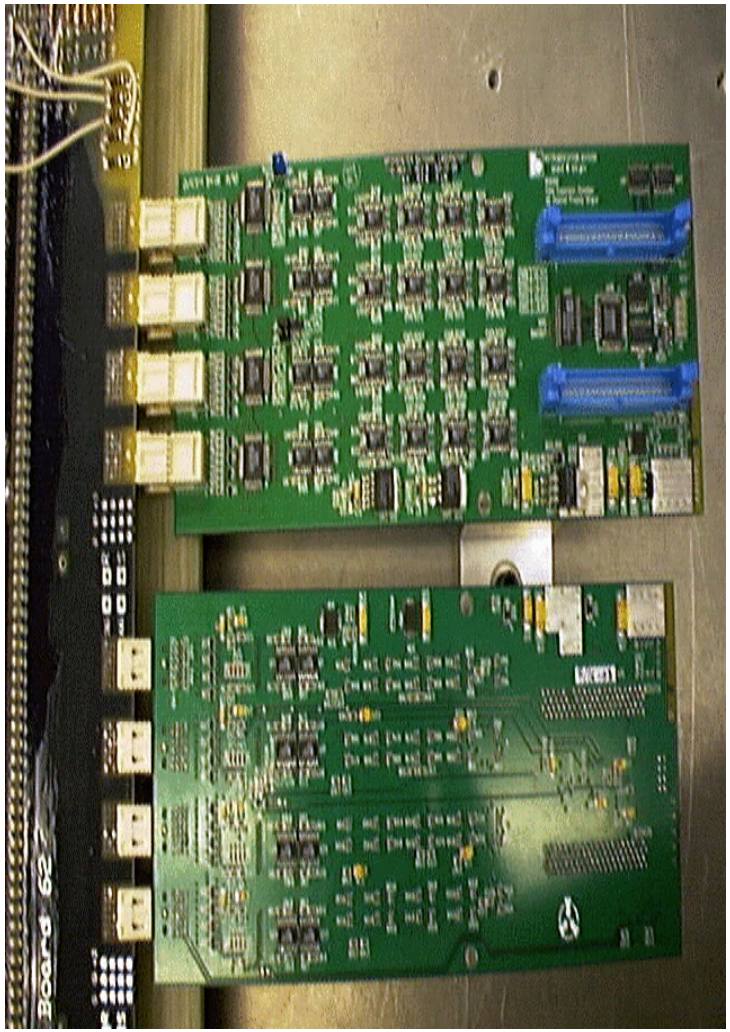


3 ASICs:

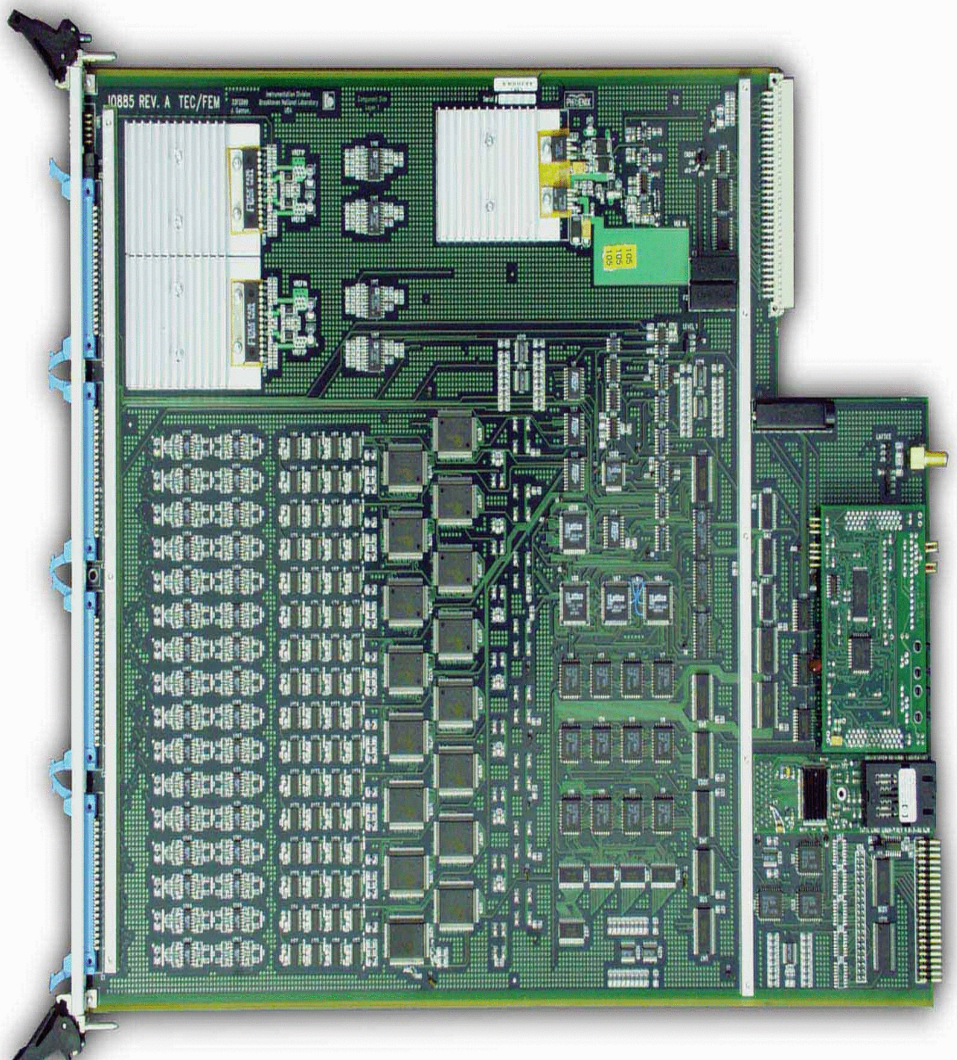
- **non-linear, 40 MHz, FADC with 9-bit dynamic range, 9-bit precision and 5-bit encoding.**
- **octal Preamp/Shaper w/ tail cancellation and dual gain for both dE/dx and TR. Full serial control of gain, shaping time and tail cancellation.**
- **Digital Memory Unit for data formatting with programmable delay and memory depth.**

20k Channels Instrumented

32 channel Preamp/Shaper PCB w/ remote calibration control and ~1 fC RMS system noise

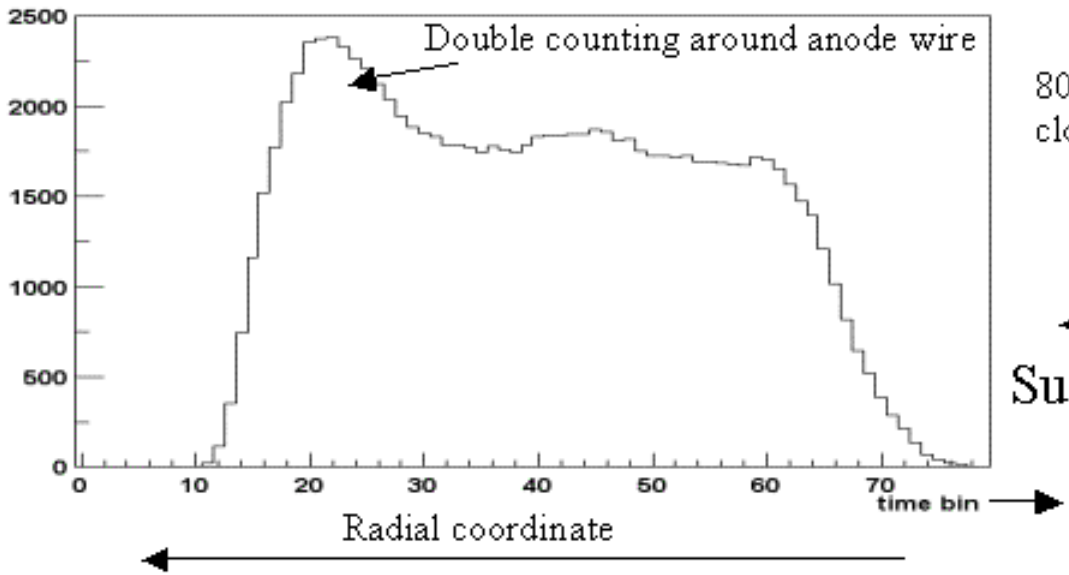


64 channel Front End Module(FEM) w/ digitizing, data formatting and optical data transmission



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/TRD Milestones

1999 Engineering Run: 1 sector × 2 planes, dE/dx only

2000/2001 Run: 2 sectors × 4 planes, dE/dx only

2001/2002 Run: 4 sectors × 4 planes, dE/dx only

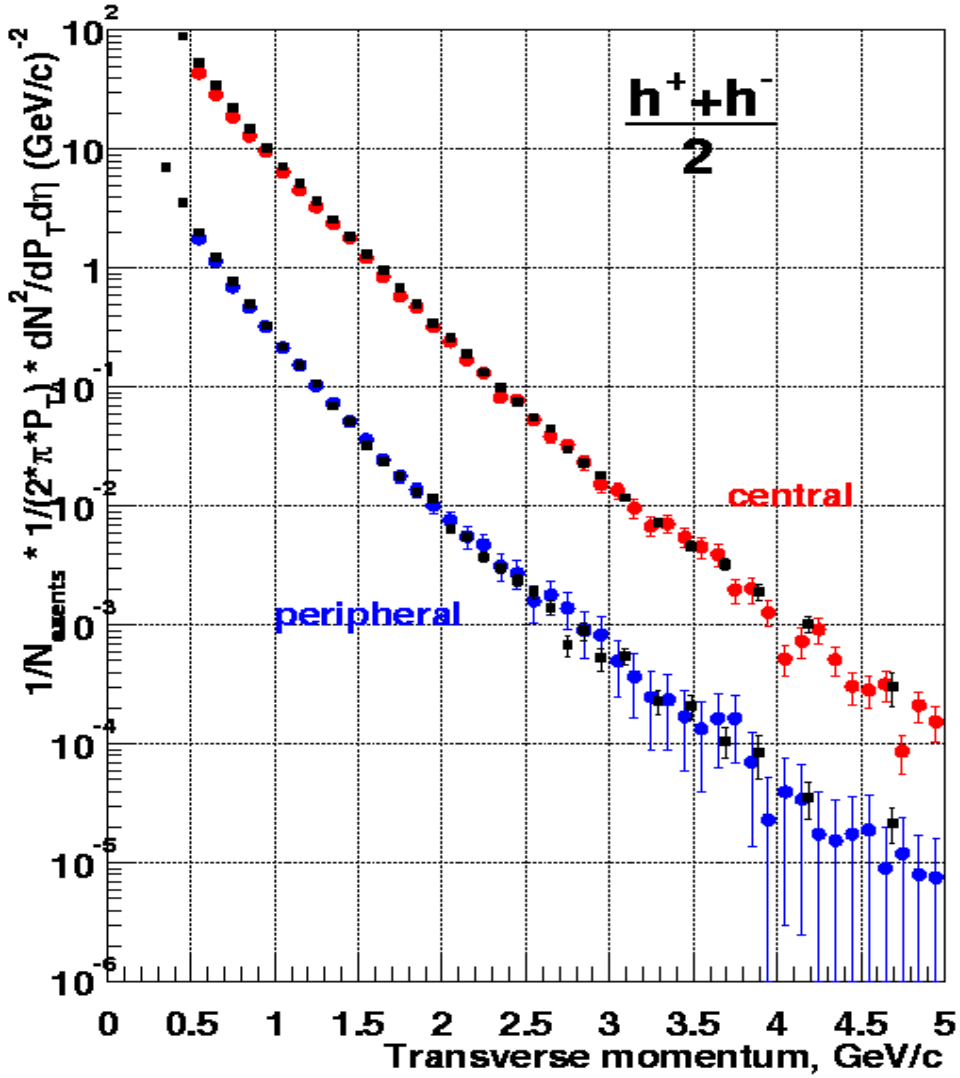
2002 Summer: TRD fiber inserted

2002/2003 Run: 4 sectors × 6 planes, dE/dx only

2003 Summer: xenon recovery system completed

2003/2004 Run: 4 sectors × 6 planes, dE/dx and TR

Performance - P_T spectra



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

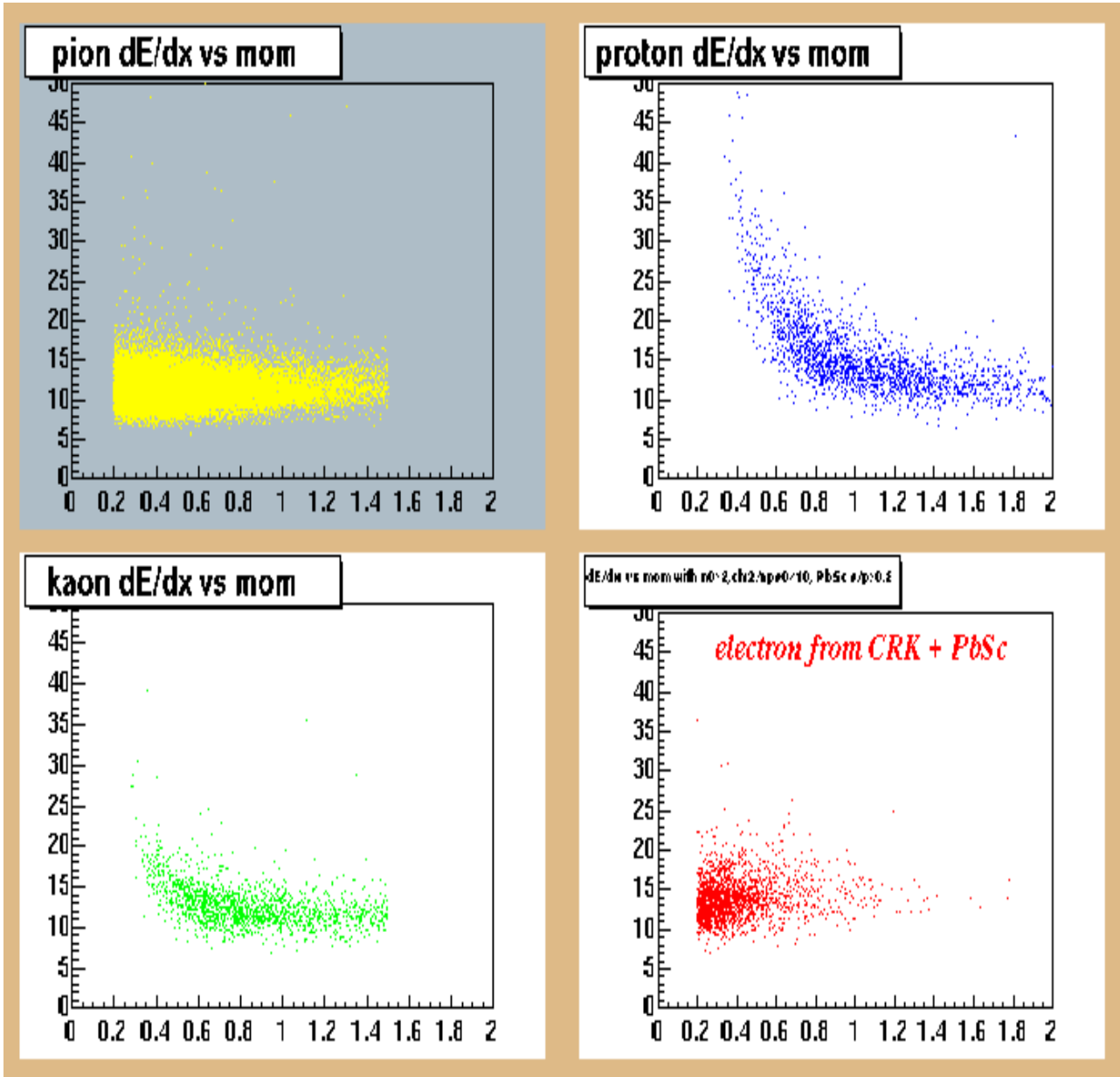
Black: Drift Chamber

Blue and Red: TEC

dE/dx Performance in Run2 – 4 planes, P10 gas gain 3000

Identify:

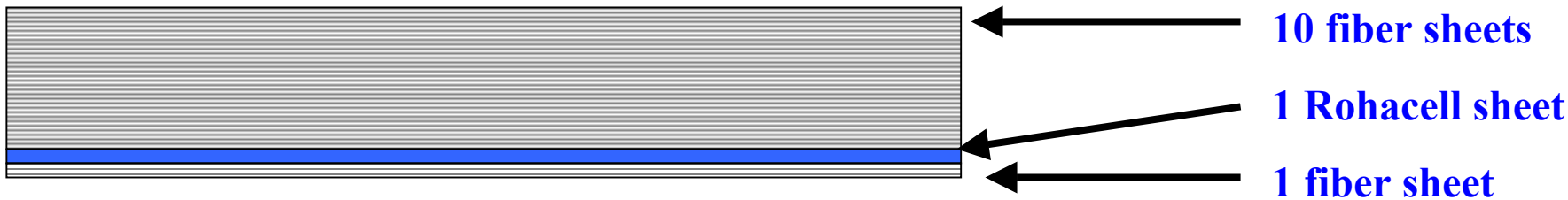
- hadrons with Time of Flight
- electrons with Ring Imaging Cherenkov and EMCal

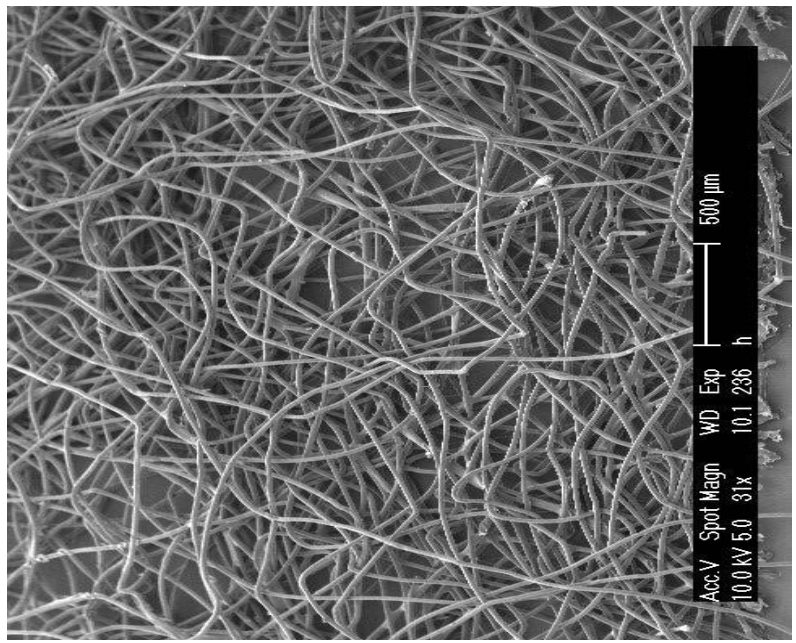


TRD Radiators

Stiffener: Rohacell IG 51, 0.636 cm, 52 mg/cm^2

Radiator: LRP 375 BK 600, 17 µm polypropylene fiber, 0.5 cm, 60 mg/cm^2





Package Being Inserted

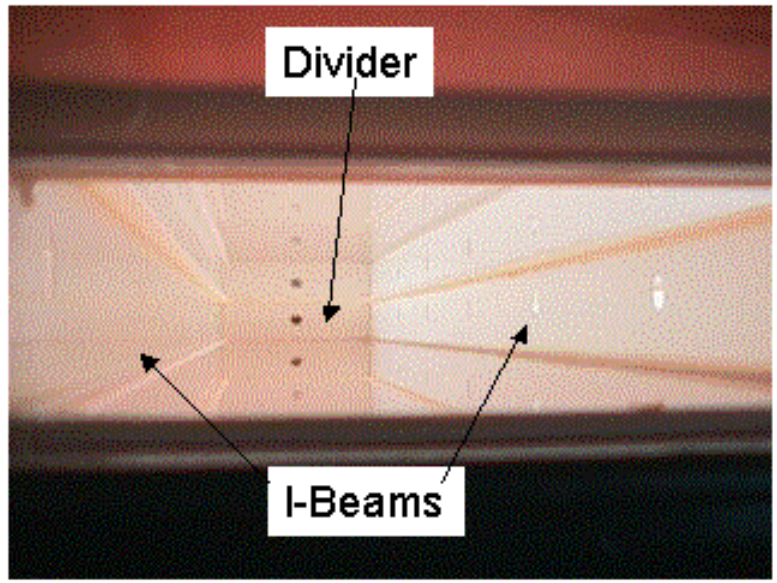
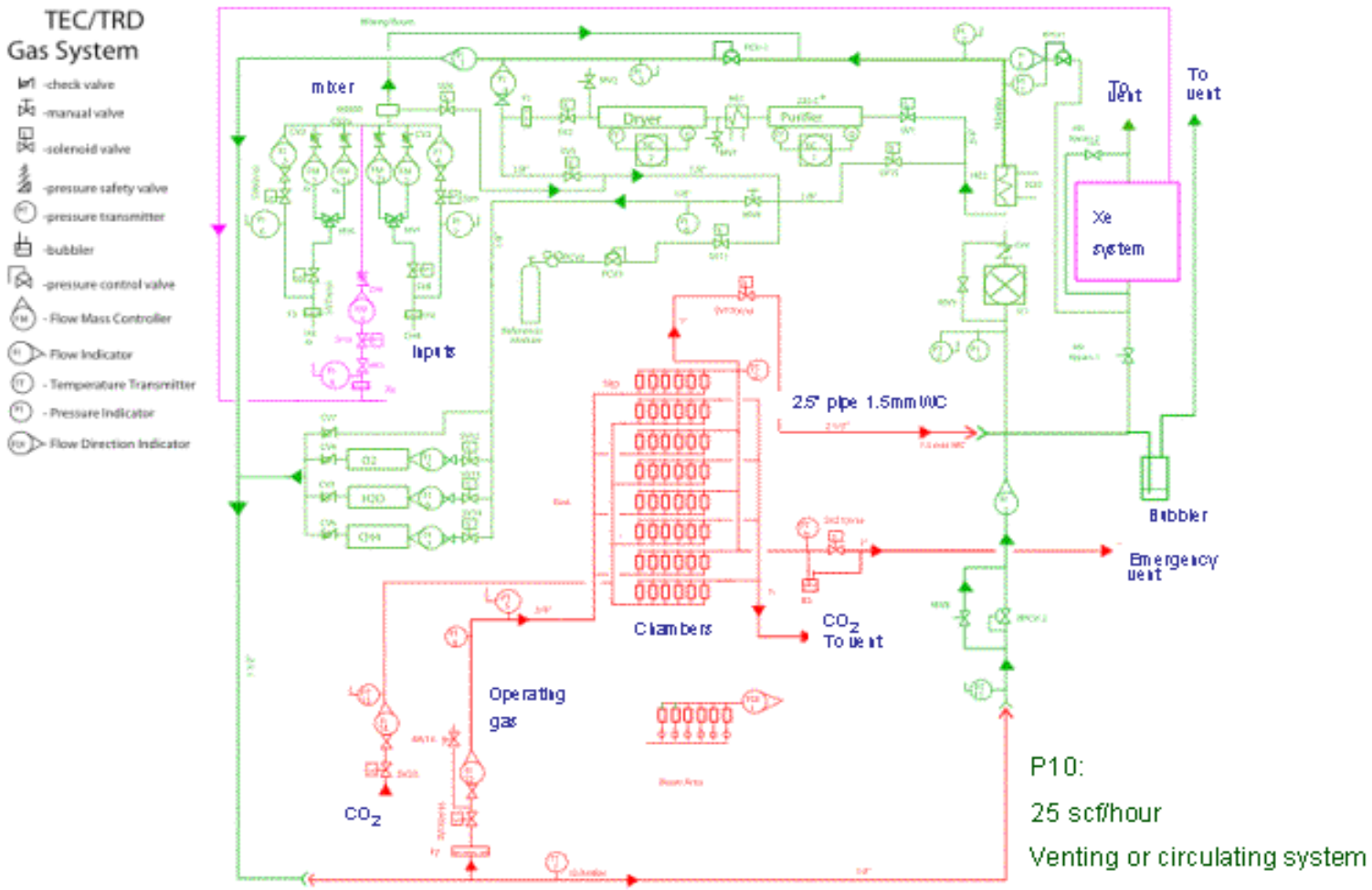


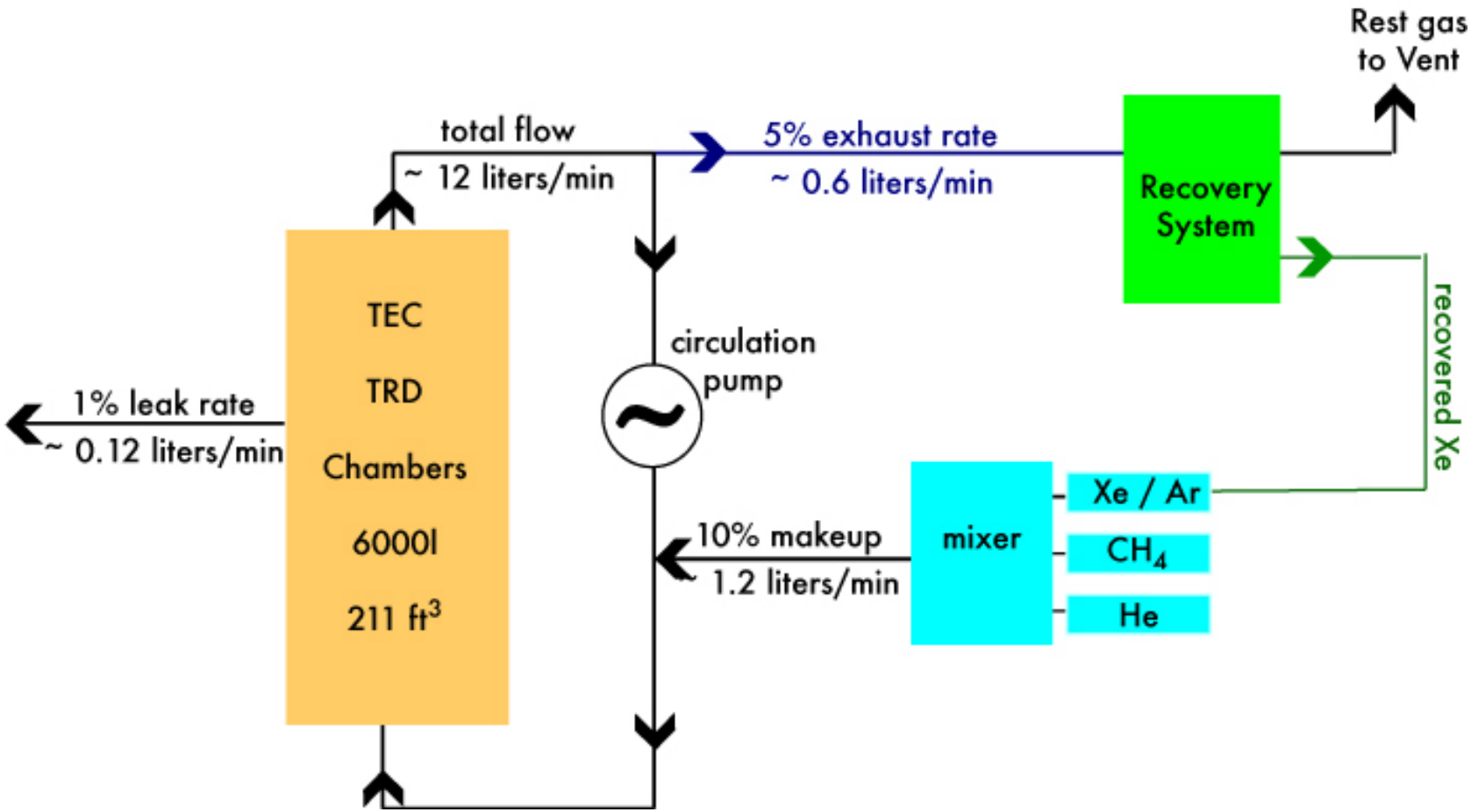
Photo shows a pack being inserted. It slid in fine with no damage to either of the 2 Mylar windows.

Photo of a TR cavity. Pack was pushed in from one side until reached the divider.

TEC/TRD Gas System



Simplified View

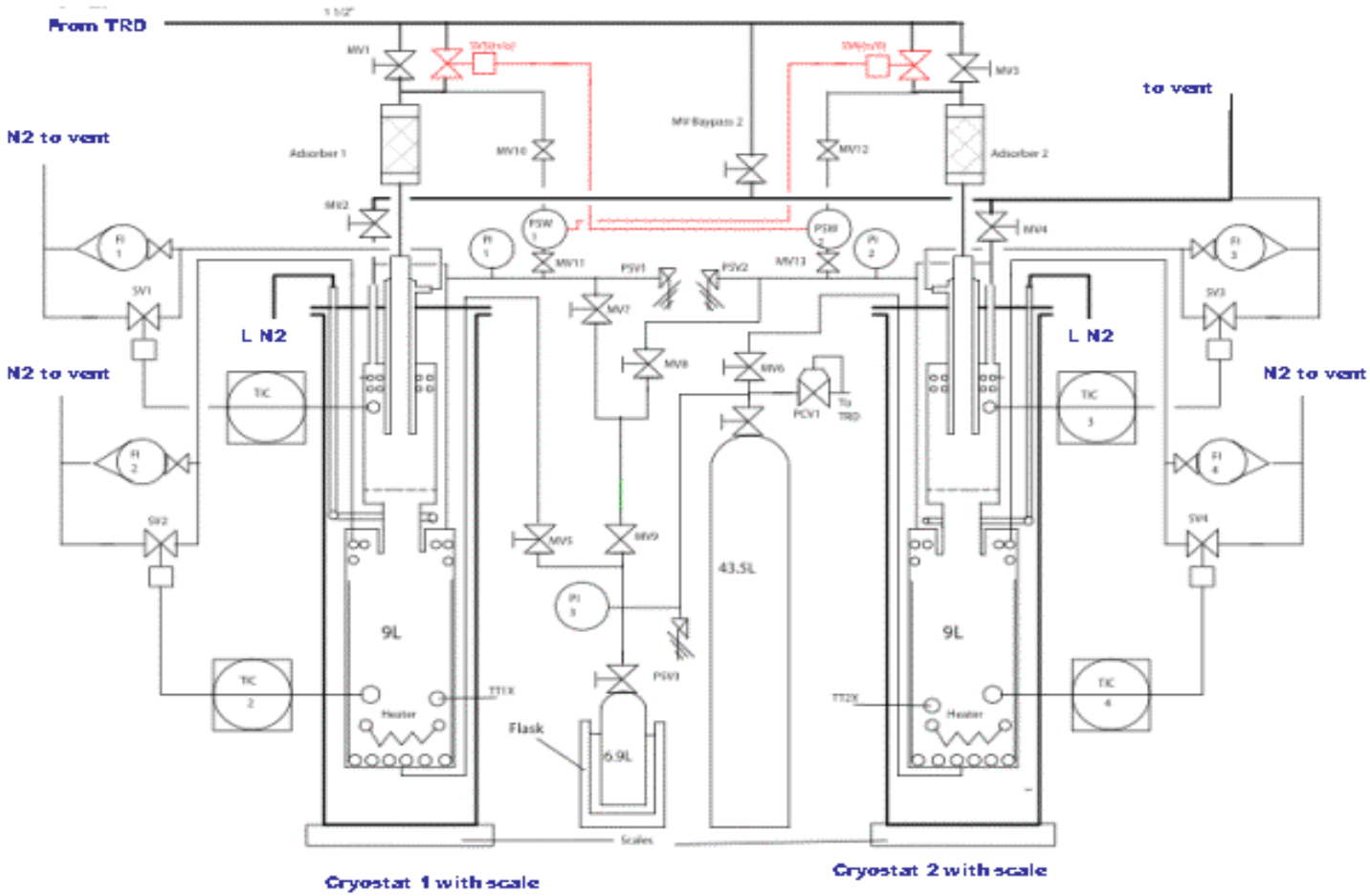


in Reality

Xenon Recovery System

Recovery System

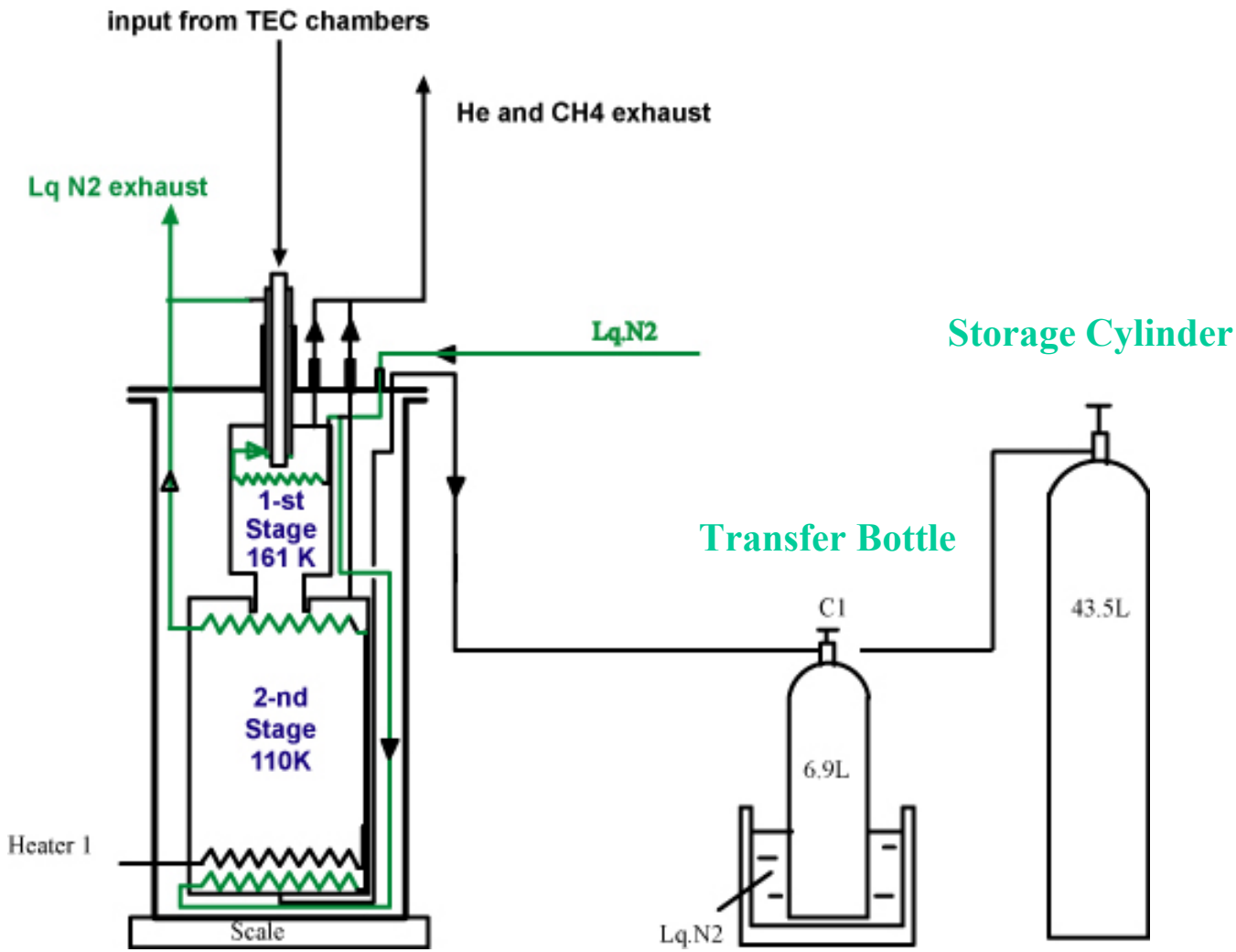
for mixture 45%He+45%Xe+10%CH_4



Xe Recovery Cryostat

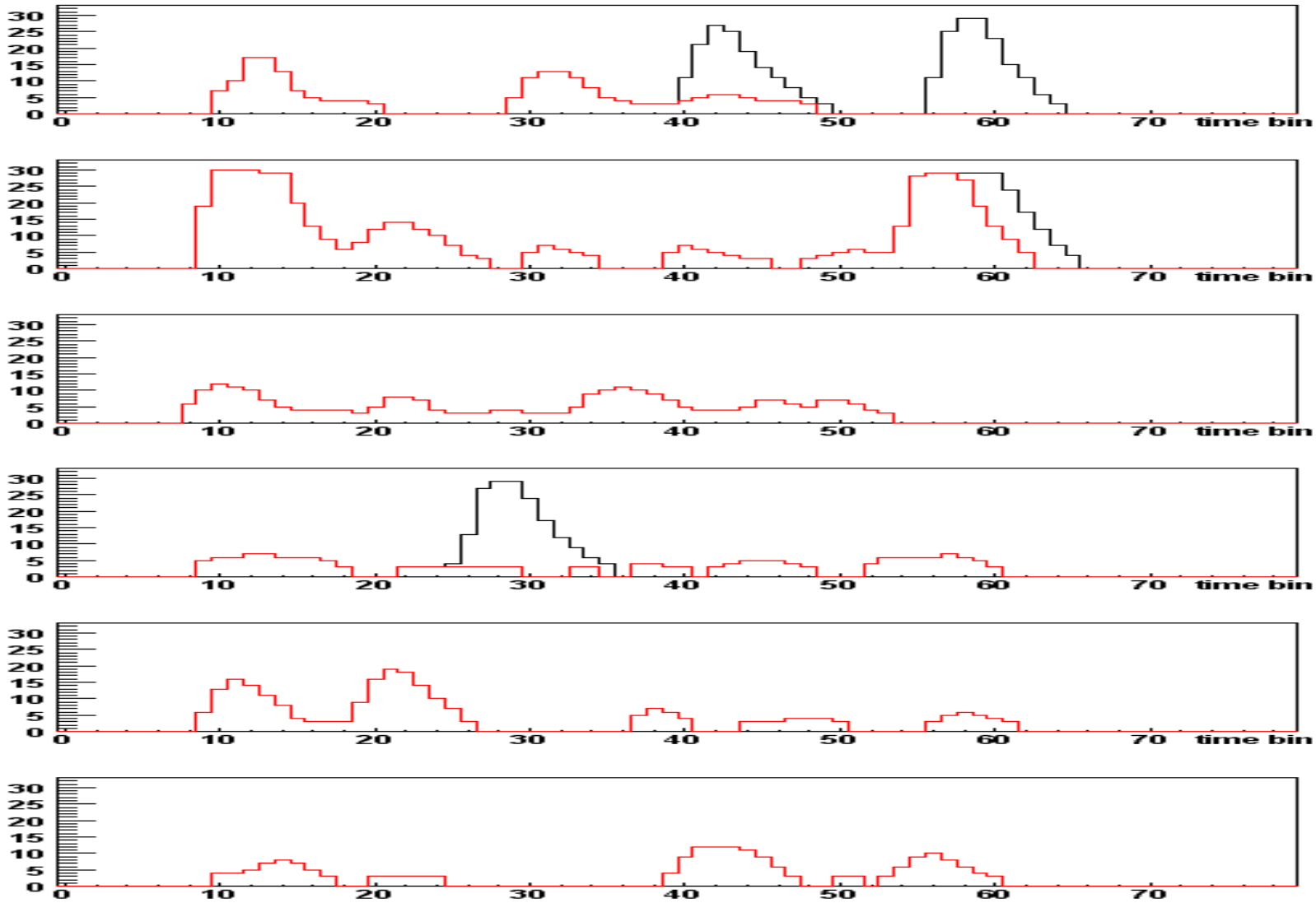
Absorber on the input line to remove CO_2, H_2O remains

2 stages of Xe separation

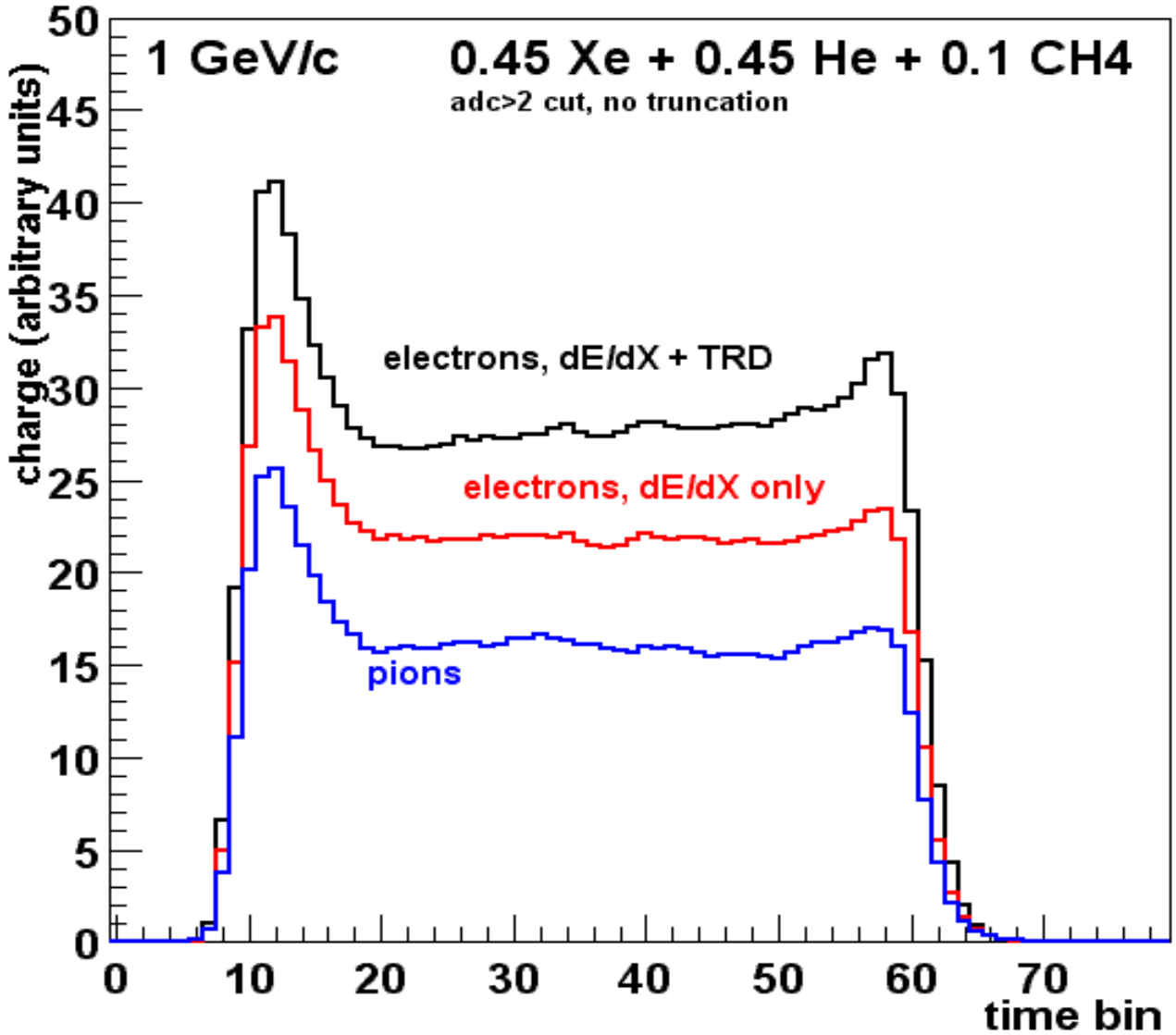


Event Simulation: 1 GeV/c electron in 6 TEC/TRD planes

0.9 Xe + 0.1 CH_4, gas gain 3000

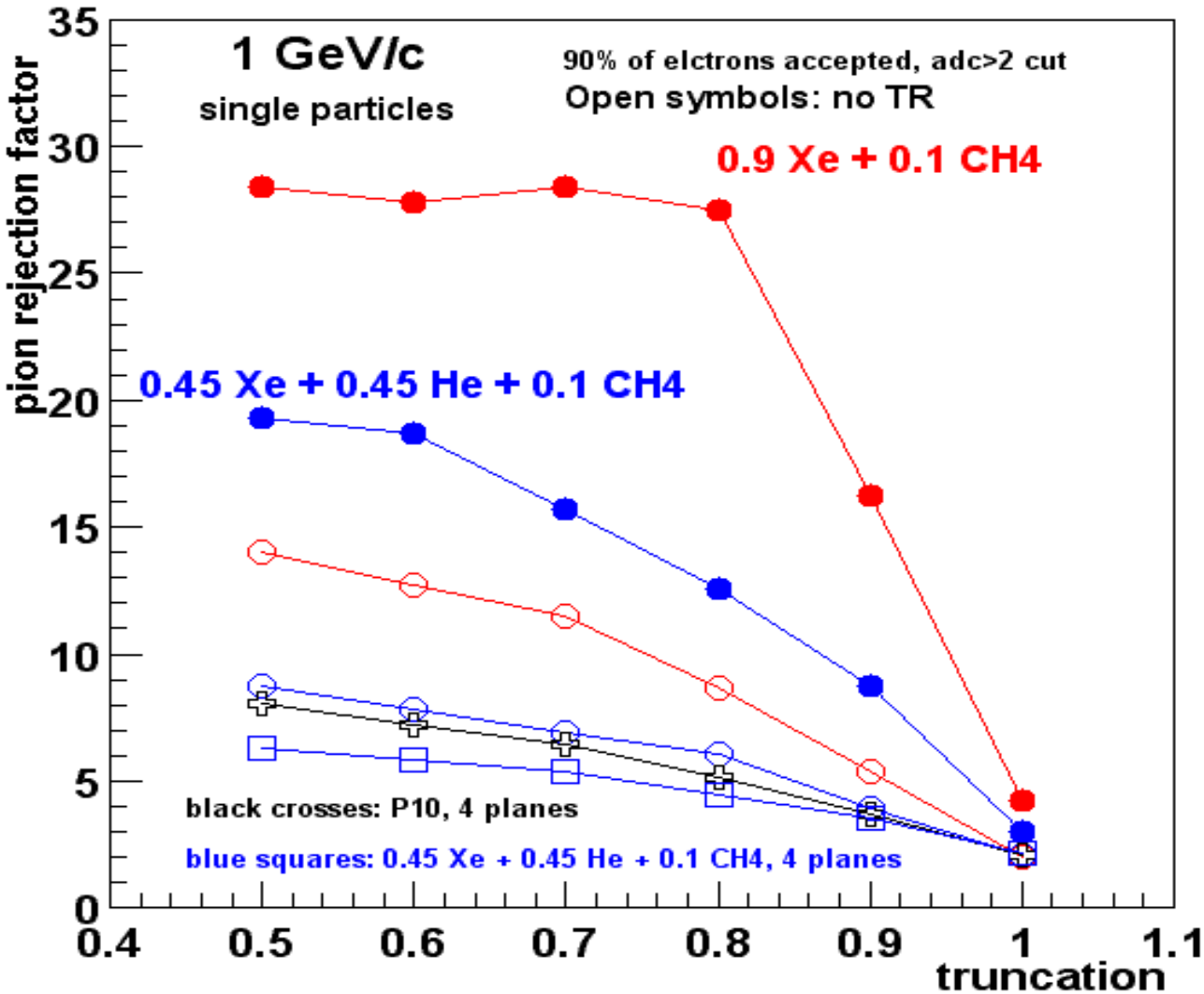


Accumulate Many Events

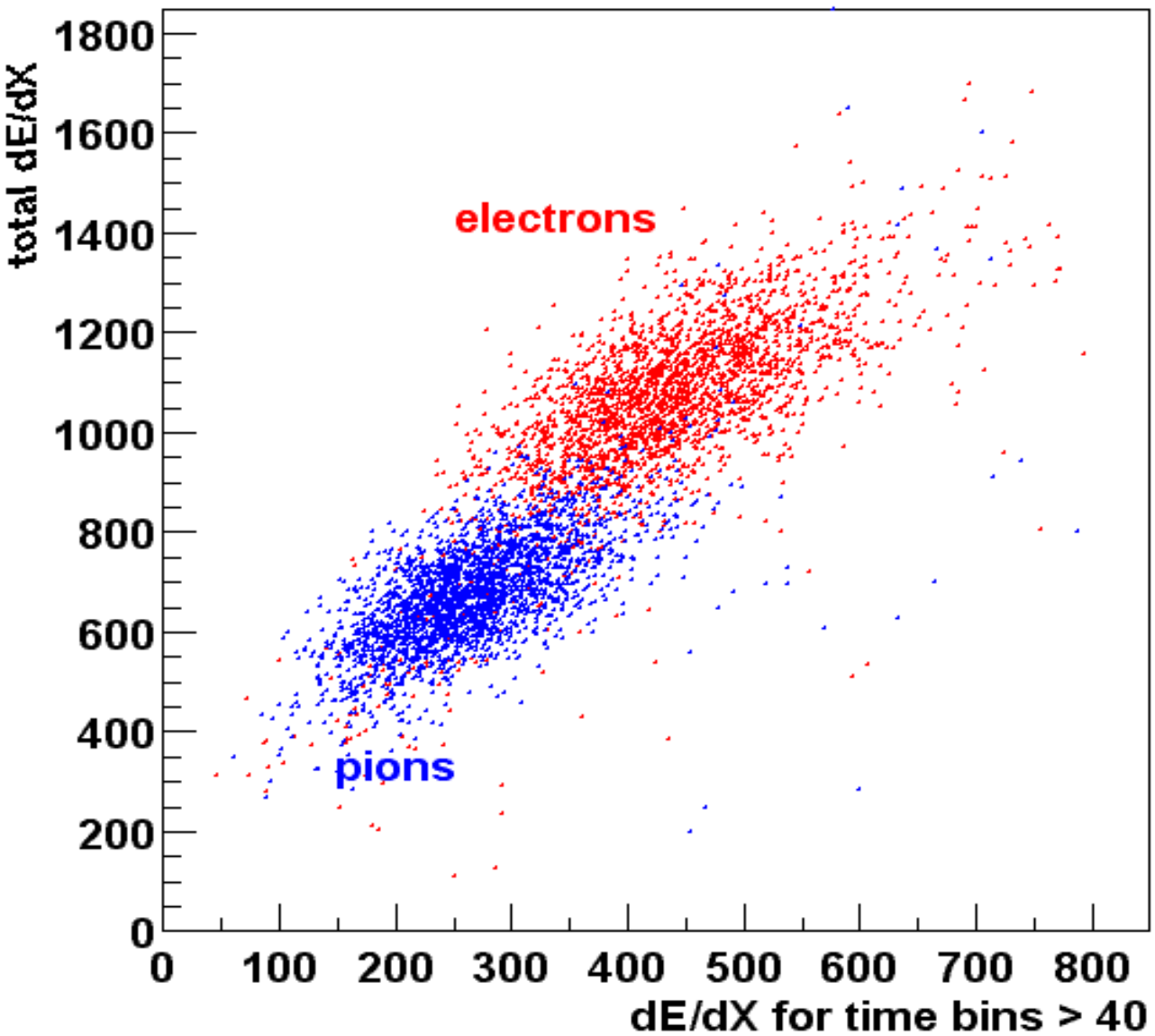


Predicted π Rejection in TEC/TRD

gas gain 3000, ADC>2 for data suppression



Another Look e/π Separation



Summary

- A large-area, 20k channel TEC/TRD has been built
- Operated in 3 RHIC runs in the PHENIX experiment as a tracking detector with dE/dx particle ID
- TR radiator installed
- Xenon recovery system completed
- New milestone in next RHIC run