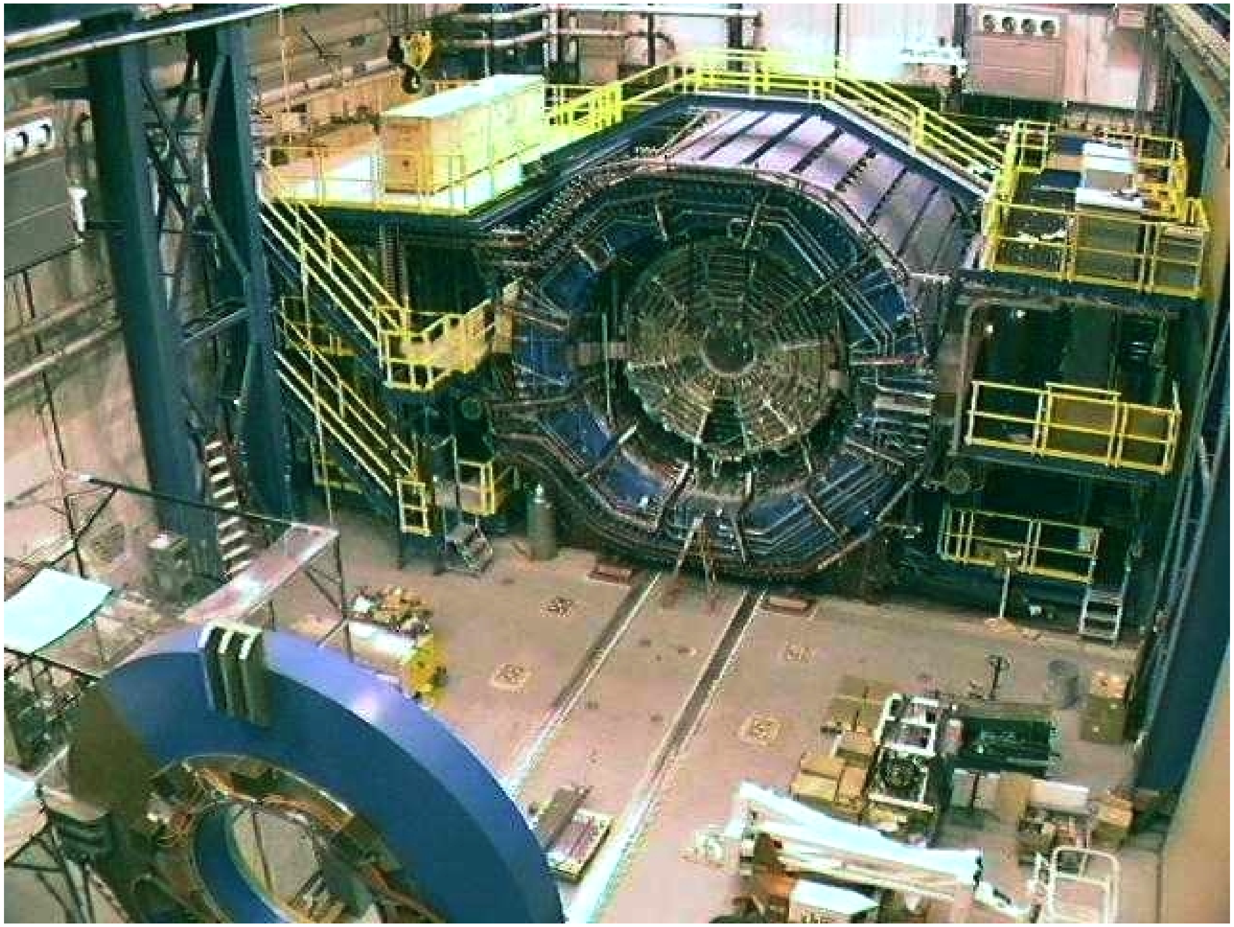
The STAR Time Projection Chamber

Fabrice Retière (LBNL)
for the STAR collaboration

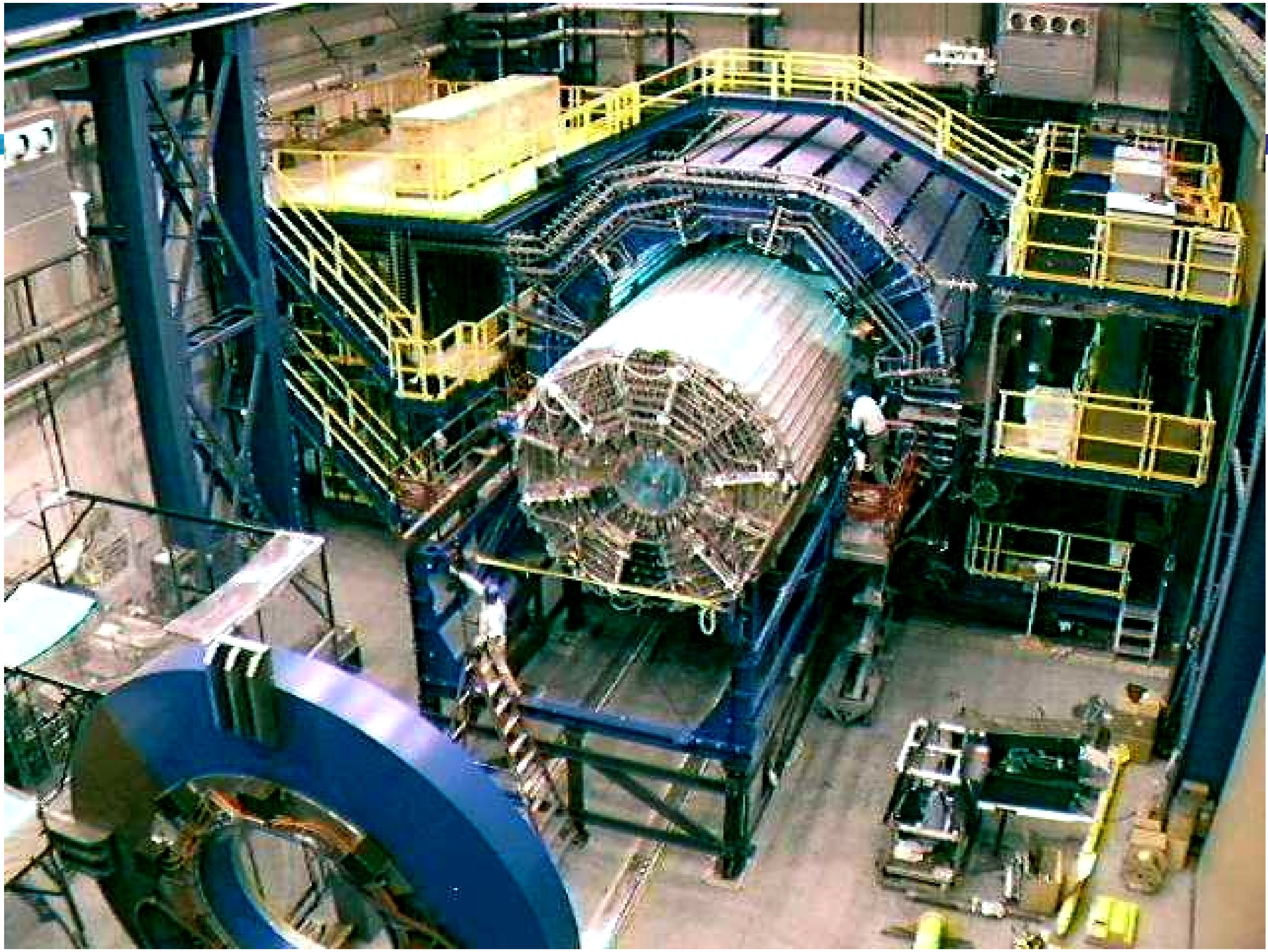
Introduction

- TPC function
  - Large acceptance gas detector
    - $|\eta|<1.8$
    - Full azimuthal coverage
  - Momentum reconstruction
    - Tracking with design hit position resolution ~500 μm
  - Pid using dE/dx
    - Design resolution : 7%
- TPC design
- Tuning the TPC
  - Position reconstruction
    - Drift velocity
    - Drift distortion
  - dE/dx
    - Understanding ionization
    - Gain calibration

STAR detector

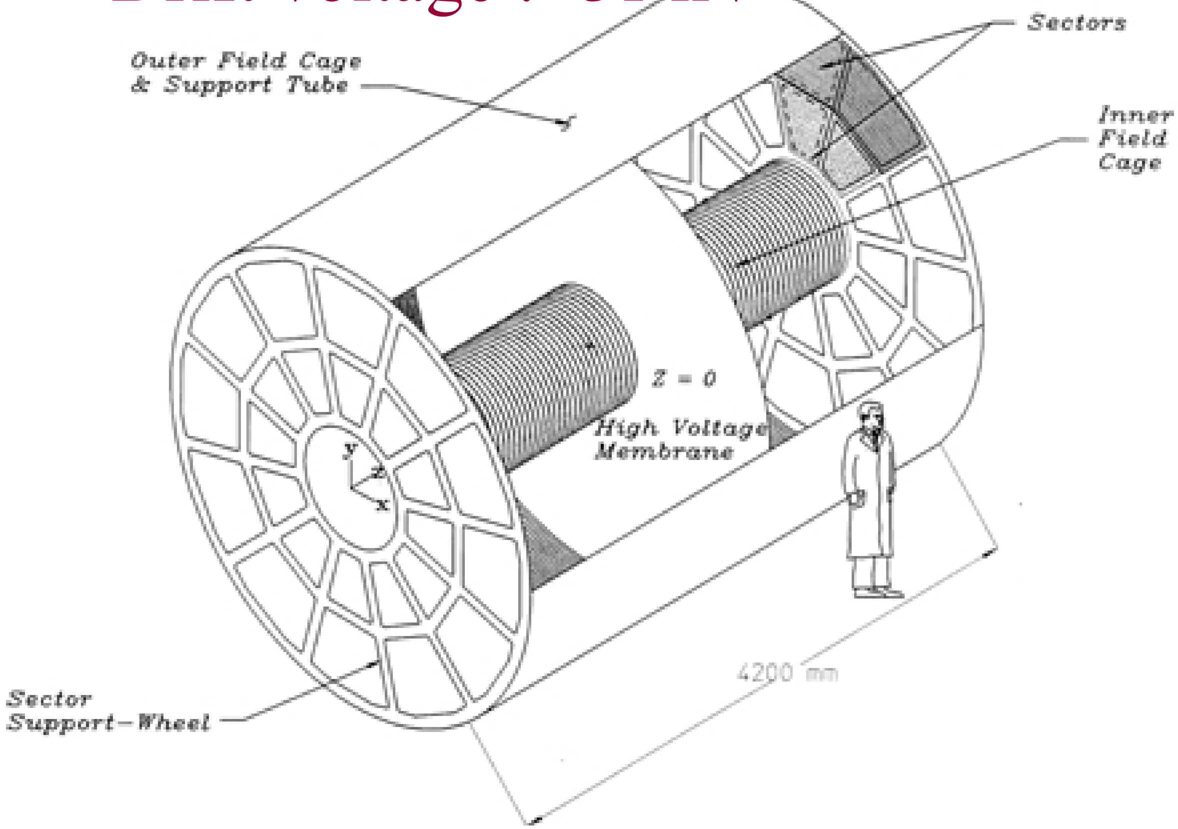


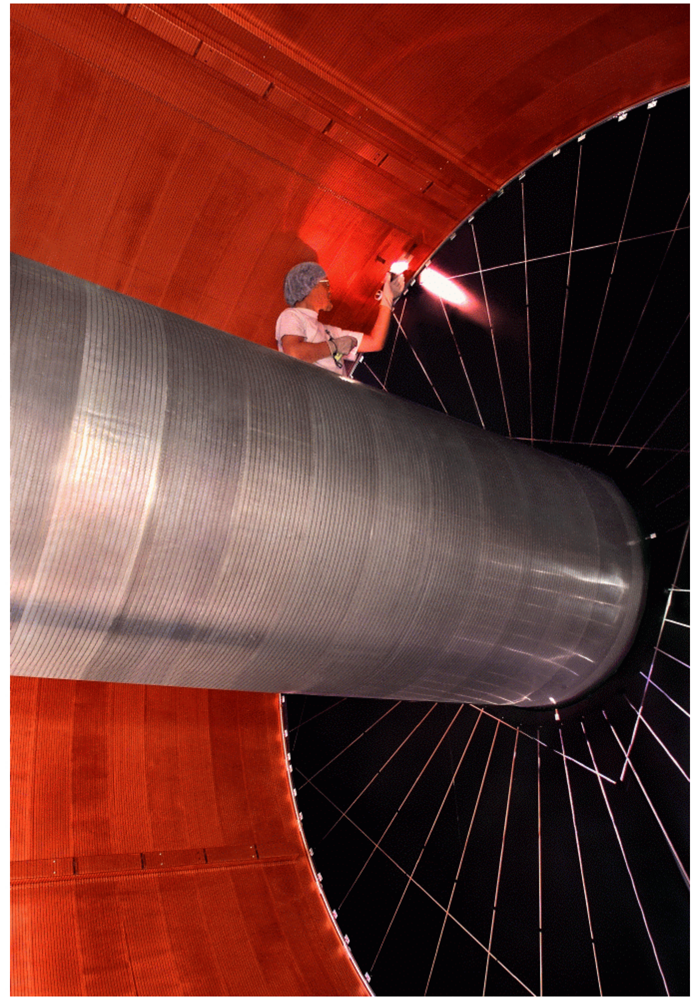
- 0.5 Tesla magnet
  - 0.25 for year 1
- Trigger
  - CTB
  - ZDC
  - Level 3
- Year 1 detectors
  - **TPC**
  - RICH
  - 1 SVT ladder



TPC gas volume

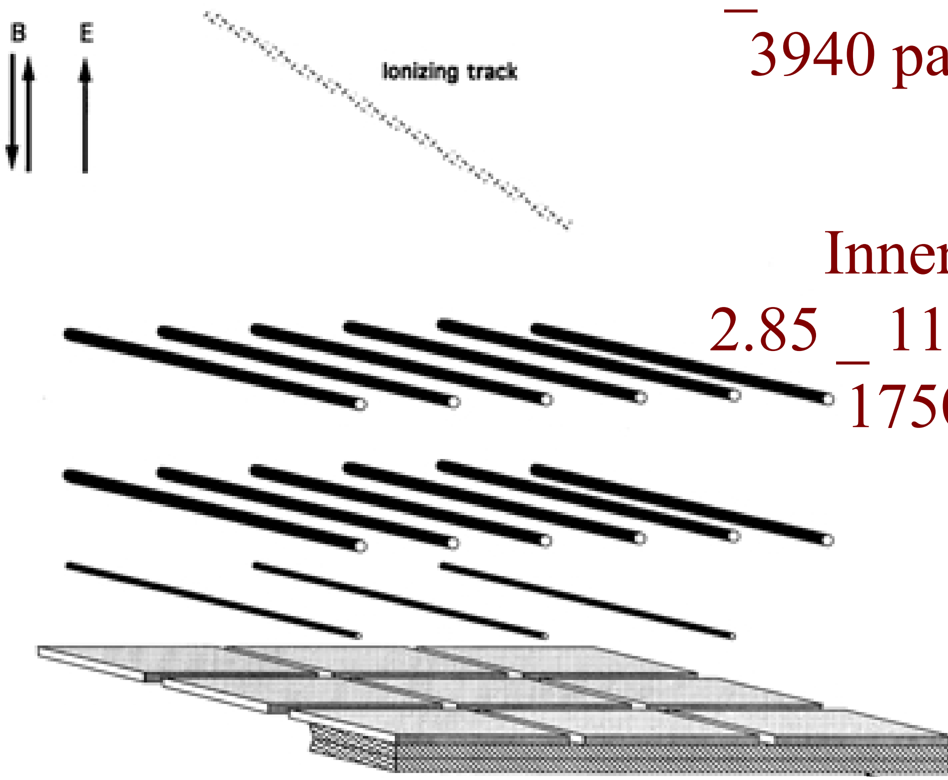
- Gas : P10 (Ar-CH4 90%-10%) @ 1 atm
- Drift voltage : -31 kV





Pad readout

- 2_12 super-sectors



Outer sector

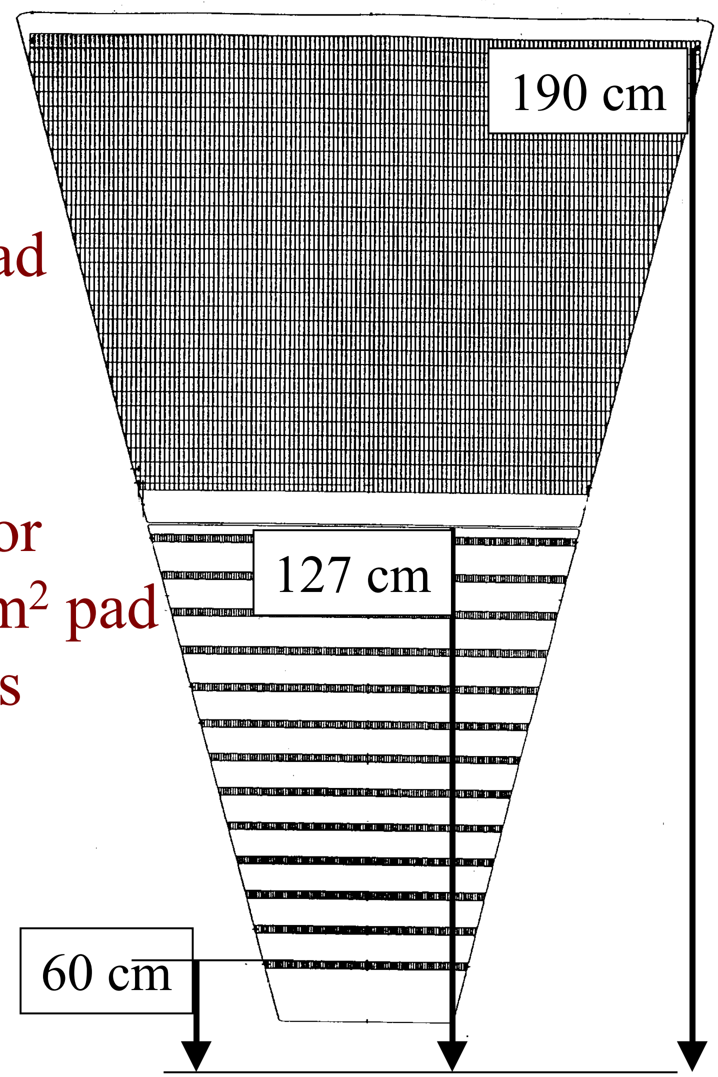
6.2 _ 19.5 mm^2 pad

3940 pads

Inner sector

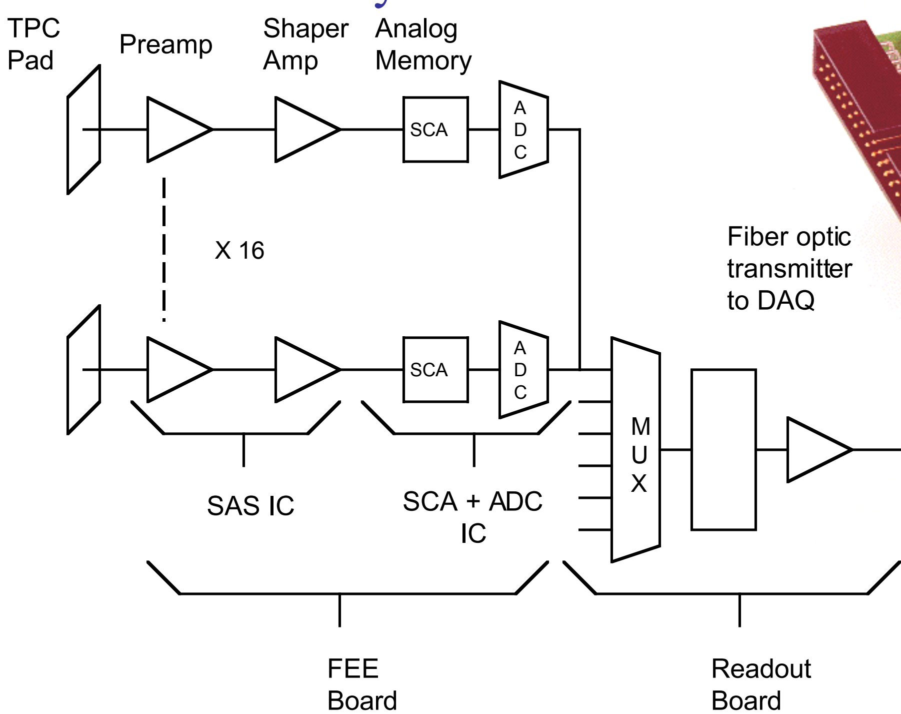
2.85 _ 11.5 mm^2 pad

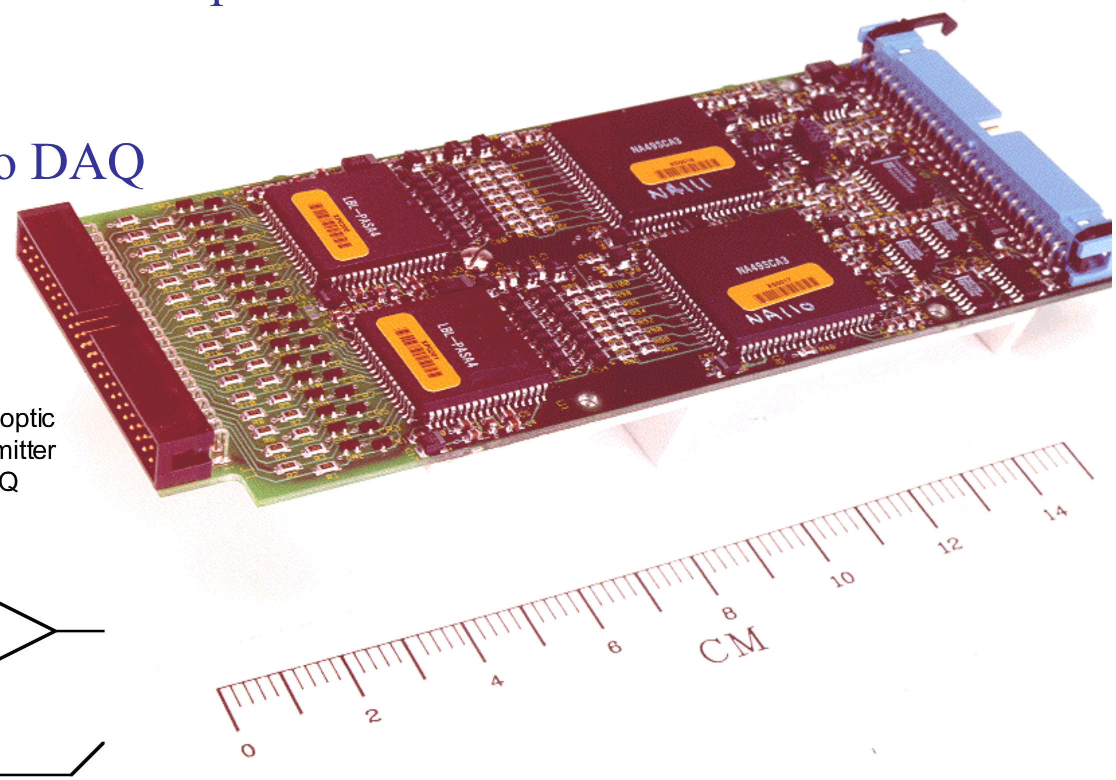
1750 pads



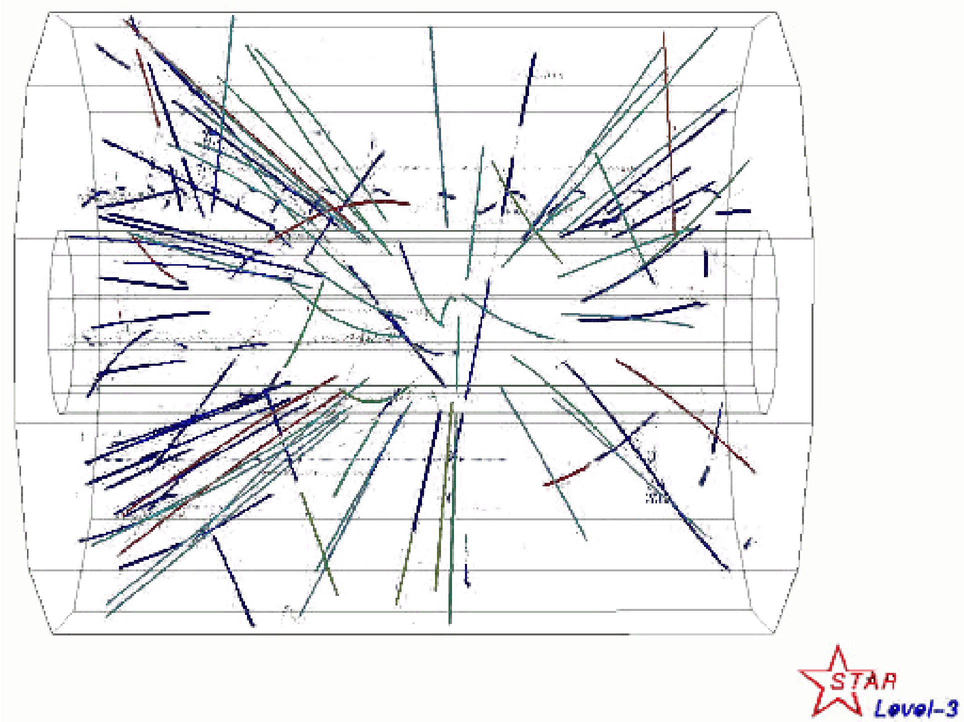
Electronic readout

- FEE, custom design IC : SAS + SCA (512 time bins)
  - Readout 140K channels, i.e. 70M pixels
- Readout board
  - Carry ~1000 Channels to DAQ





TPC at work
First RHIC events

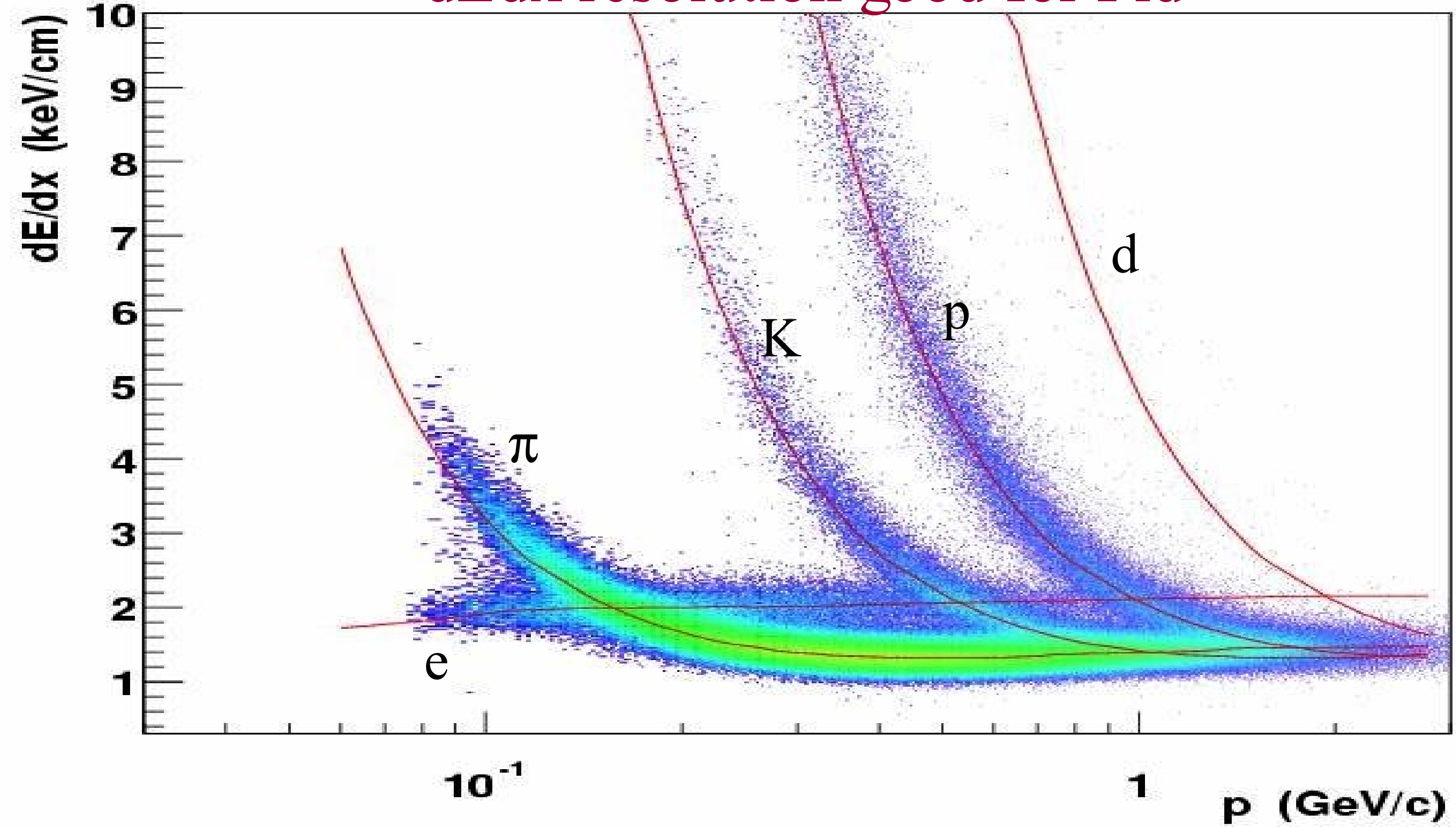


Detector very stable

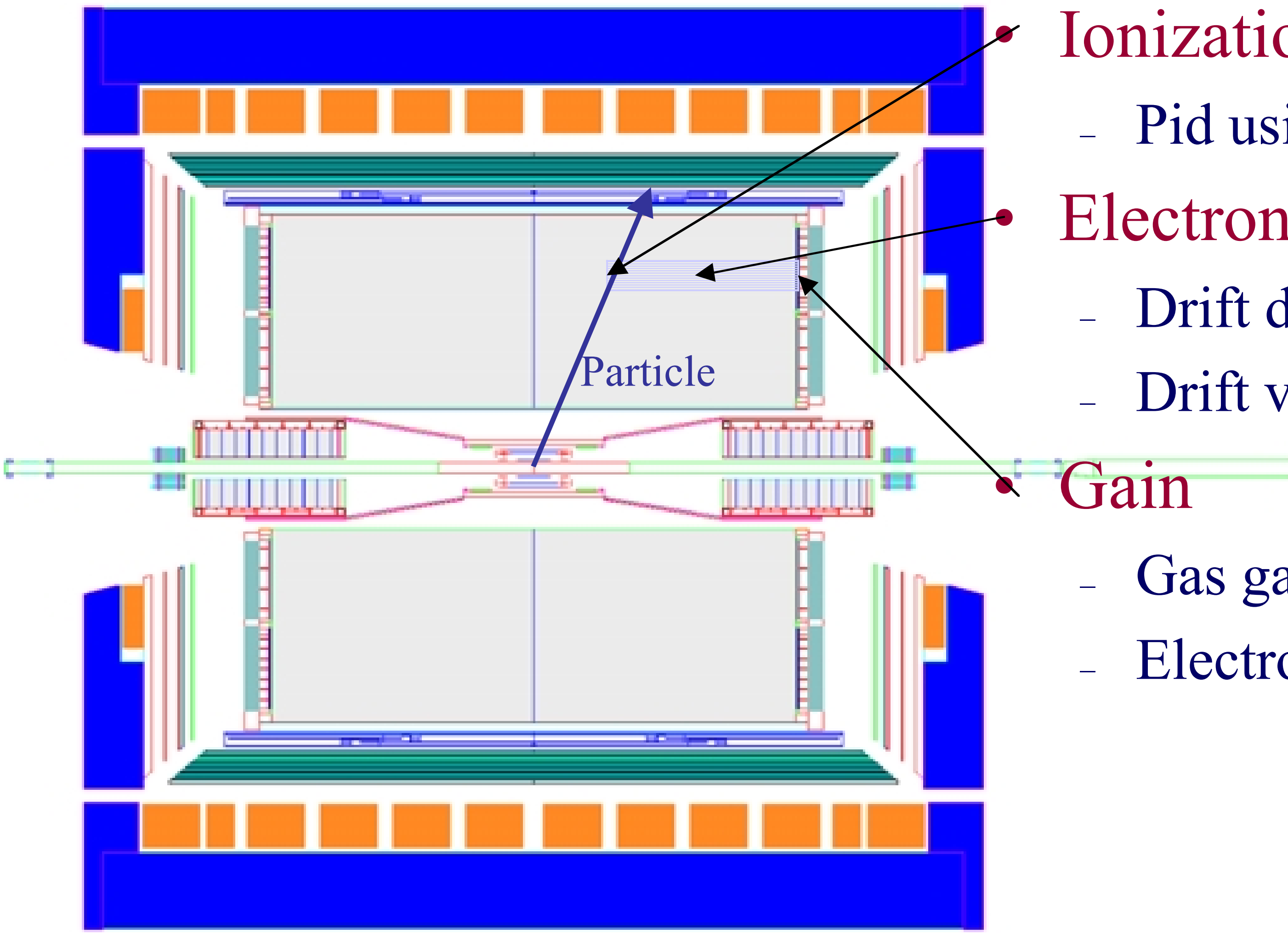
Good for physics without calibration

TPC at work
dE/dx measurement before calibration

dEdx resolution good for Pid

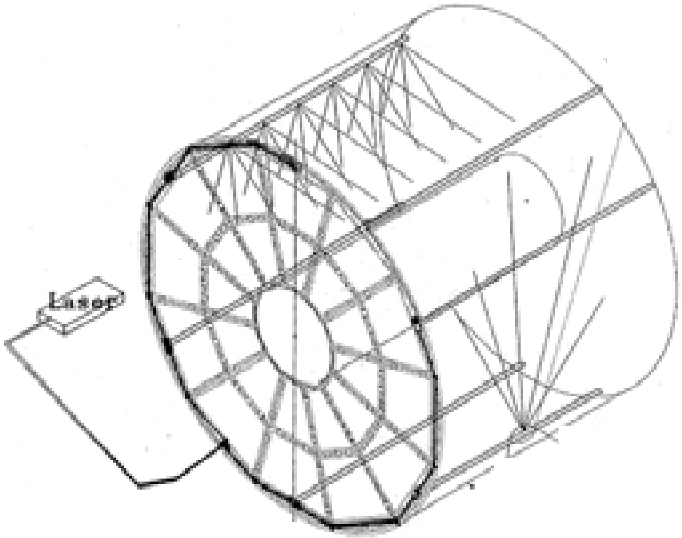


Tuning the TPC
Processes to control

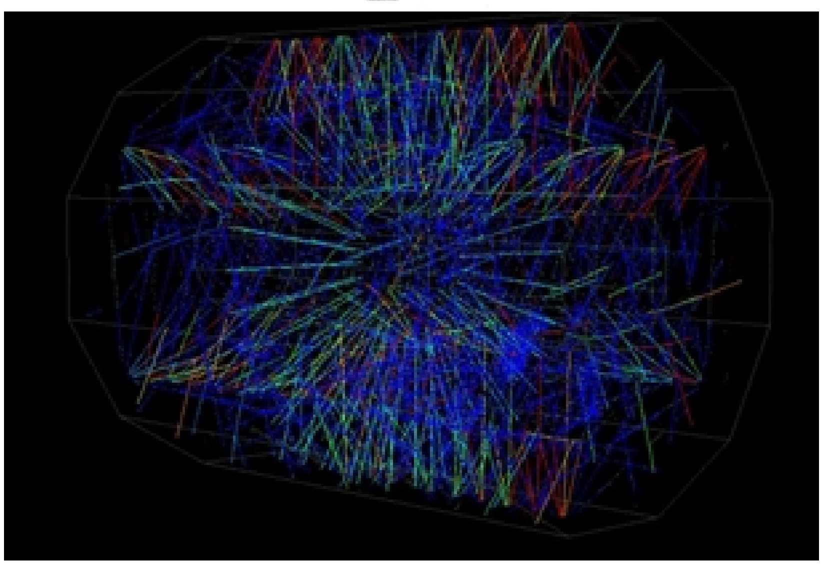


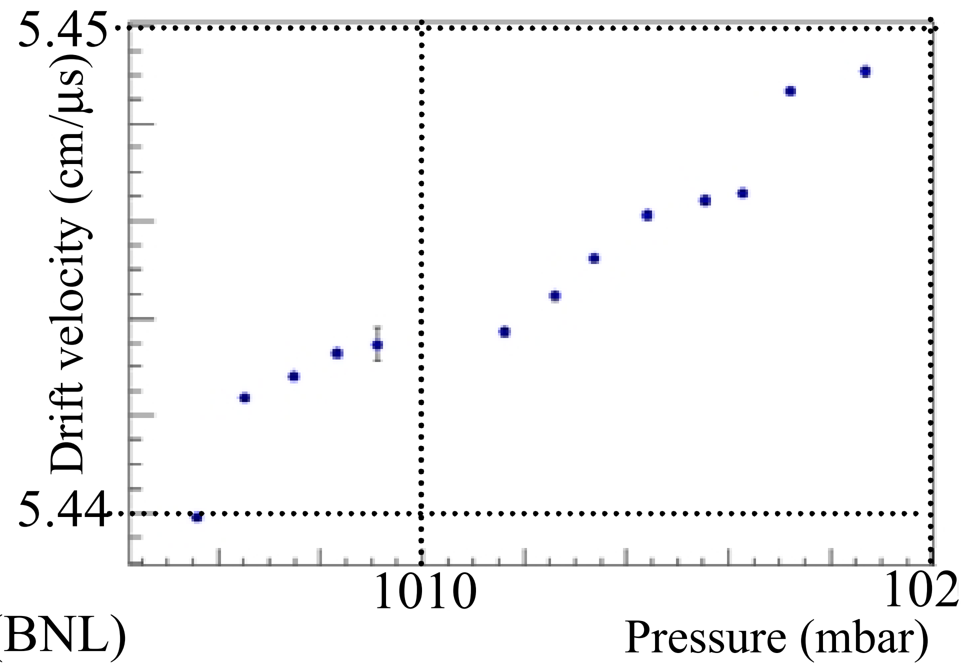
- Ionization
  - Pid using dE/dx
- Electron drift
  - Drift distortion
  - Drift velocity (laser)
- Gain
  - Gas gain
  - Electronic gain

Electron drift
Drift velocity under control



- Laser for coarse value
- Fine adjustment from tracking matching both side of the TPC

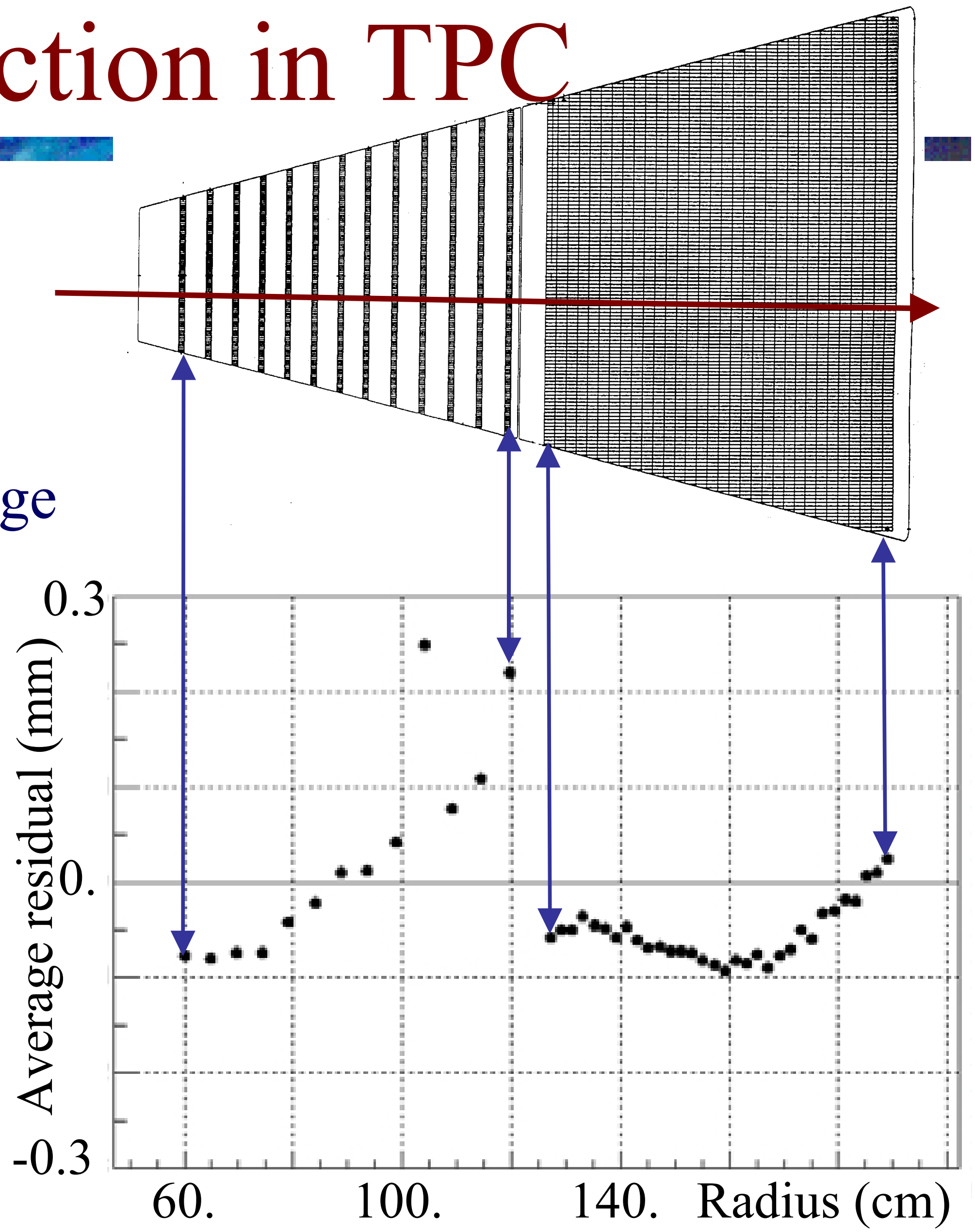




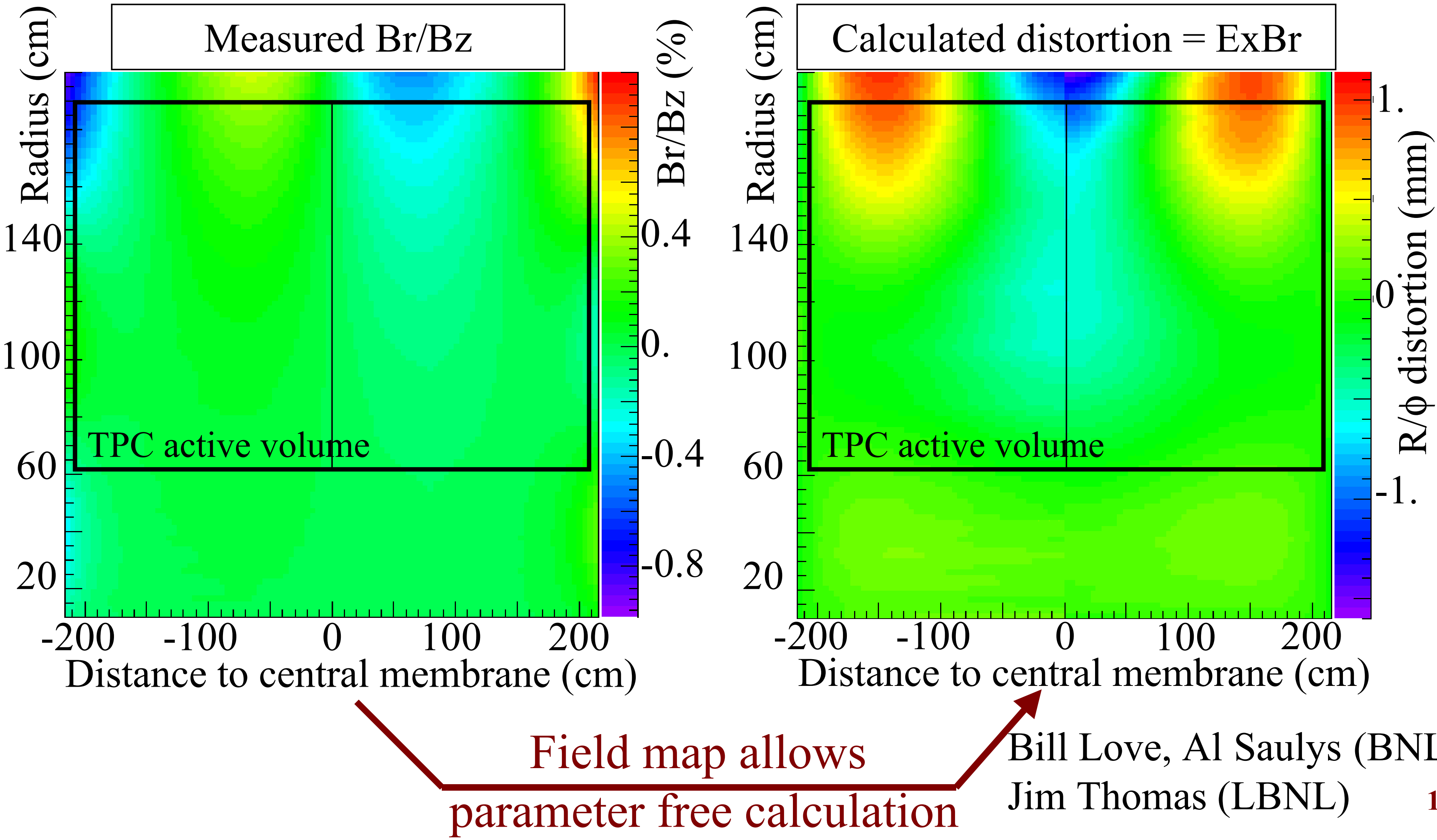
Alexei Lebedev, Bill Love, Jeff Porter (BNL)

Electron drift
Drift correction in TPC

- Distortion sources
  - Radial B field *(<2mm)*
  - End cap location *(800 µm)*
  - E field corrections to field cage *(400 µm)*
  - 0.5 mrad E/B field misalignment (400 µm)
- Detected using residual average over many tracks
- Corrections using field maps and geometry survey
  - No tuning on data required



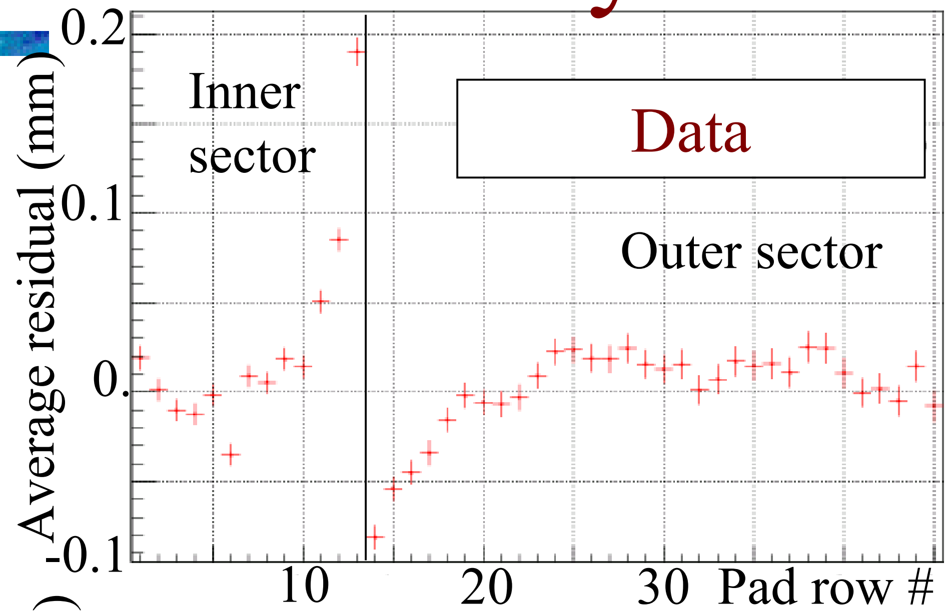
Electron drift
B field map correction

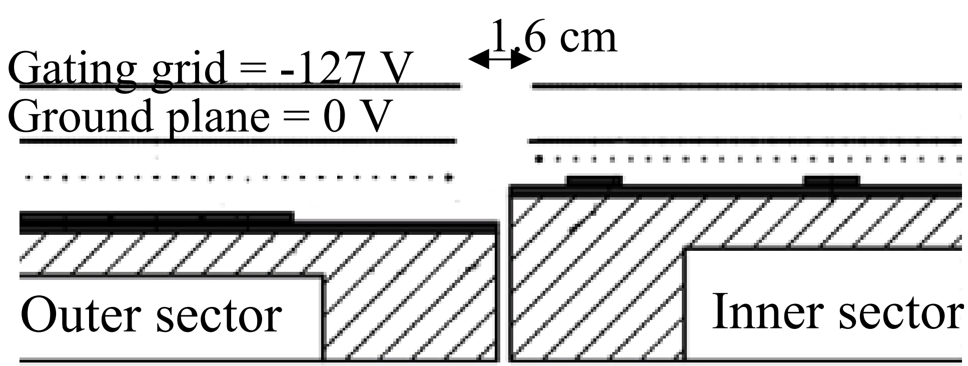


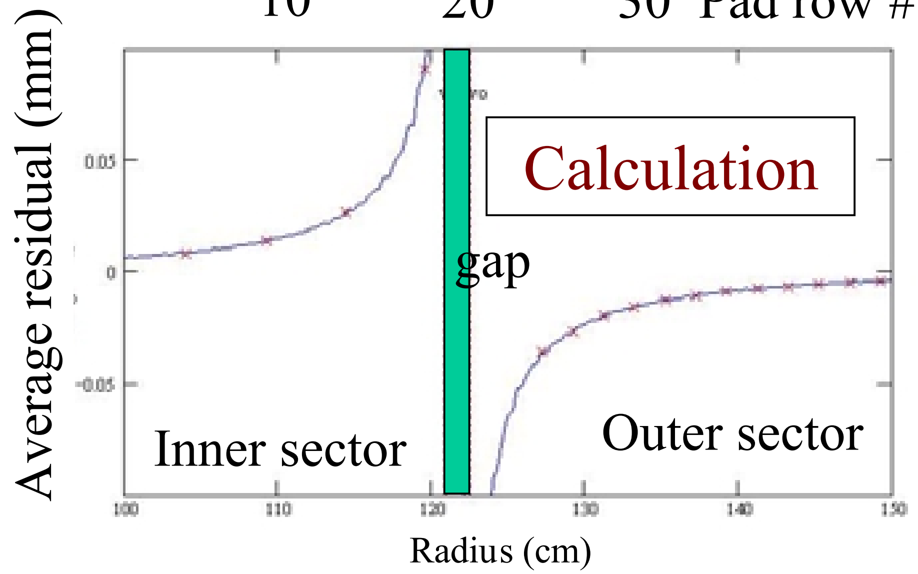
Bill Love, Al Saulys (BNL), Jim Thomas (LBNL)

Electron drift
Inner/outer sector boundary

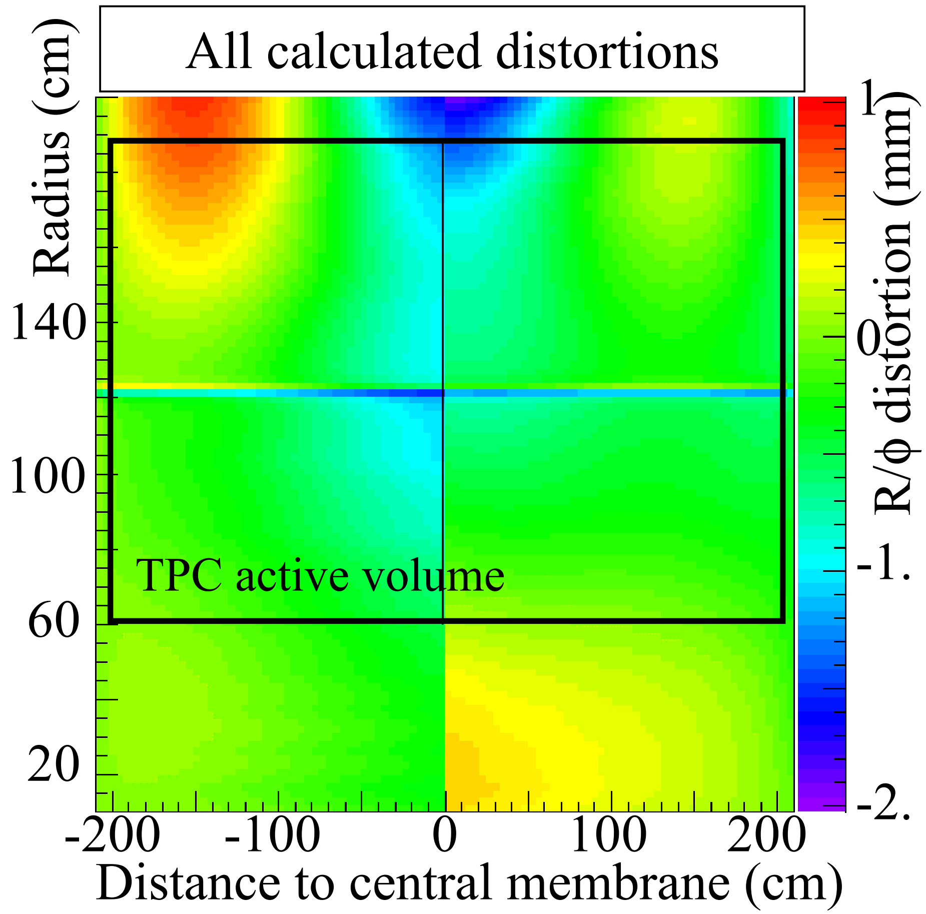
- No wires at the boundary between inner and outer sector
  - E field leak
    - E field radial component
    - ExB effect on R/ϕ



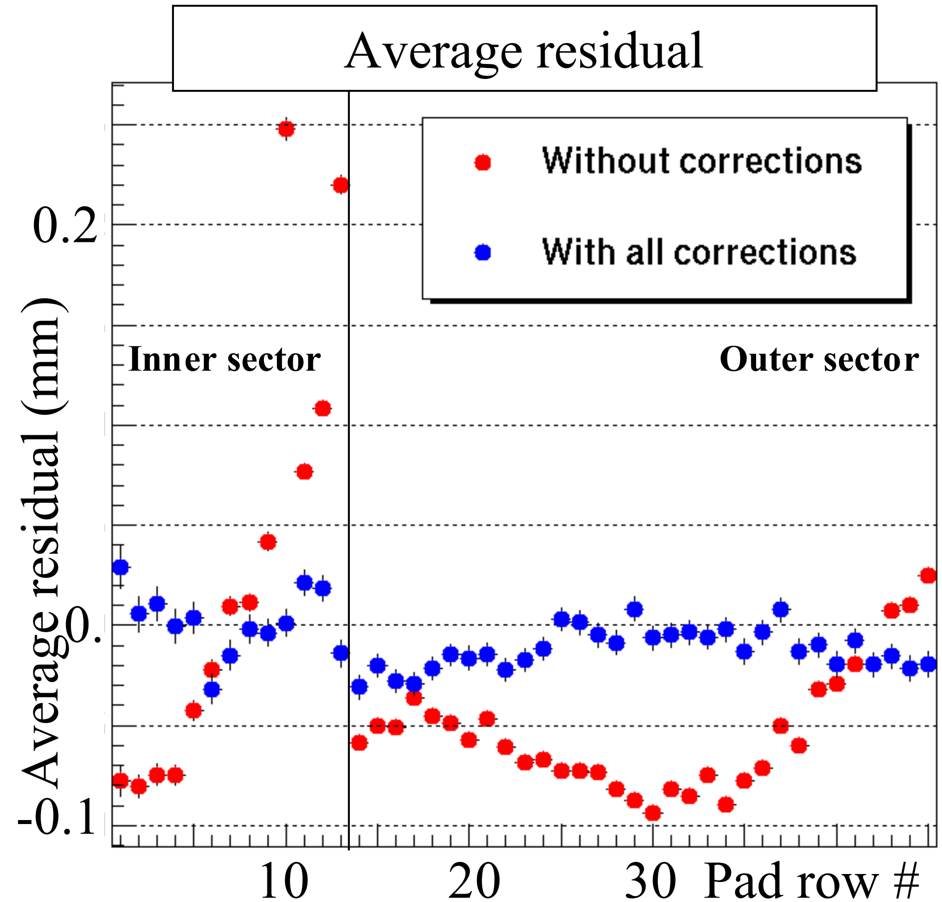




Electron drift distortions under control



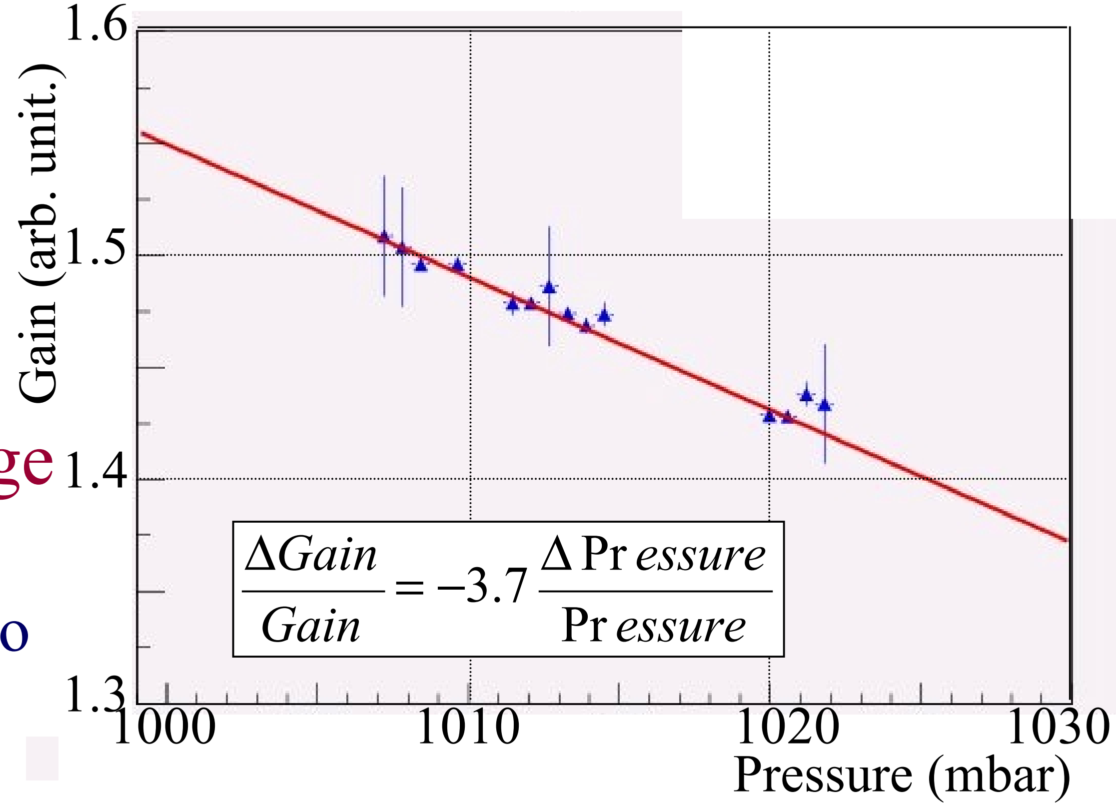
Jim Thomas (LBNL)



Huan Huang, Hui Long and Steve Trentelange (UCLA)

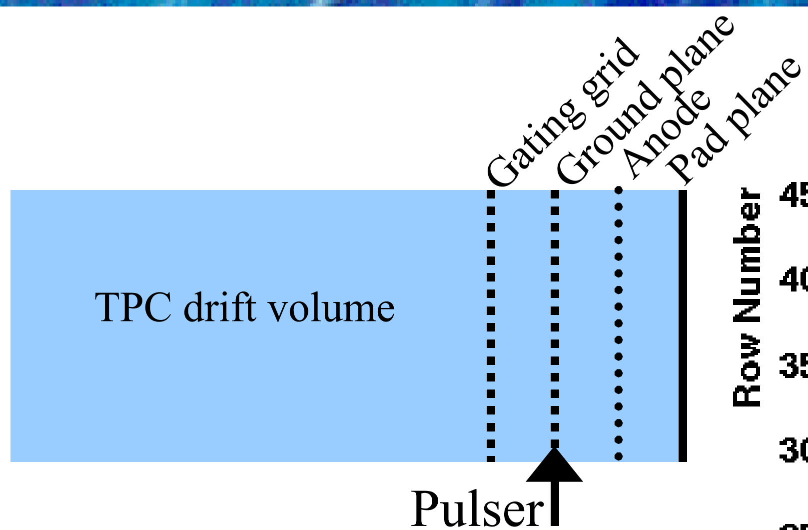
Gain uniformity
Gas gain

- Gain variation
  - Over TPC sectors
  - With time
    - Pressure
    - Temperature
    - …
- Correction using average dEdx
  - Require a lot of events to cancel out fluctuations
    - Gain monitor chamber being built
    - Pulser for electronic gain calibration

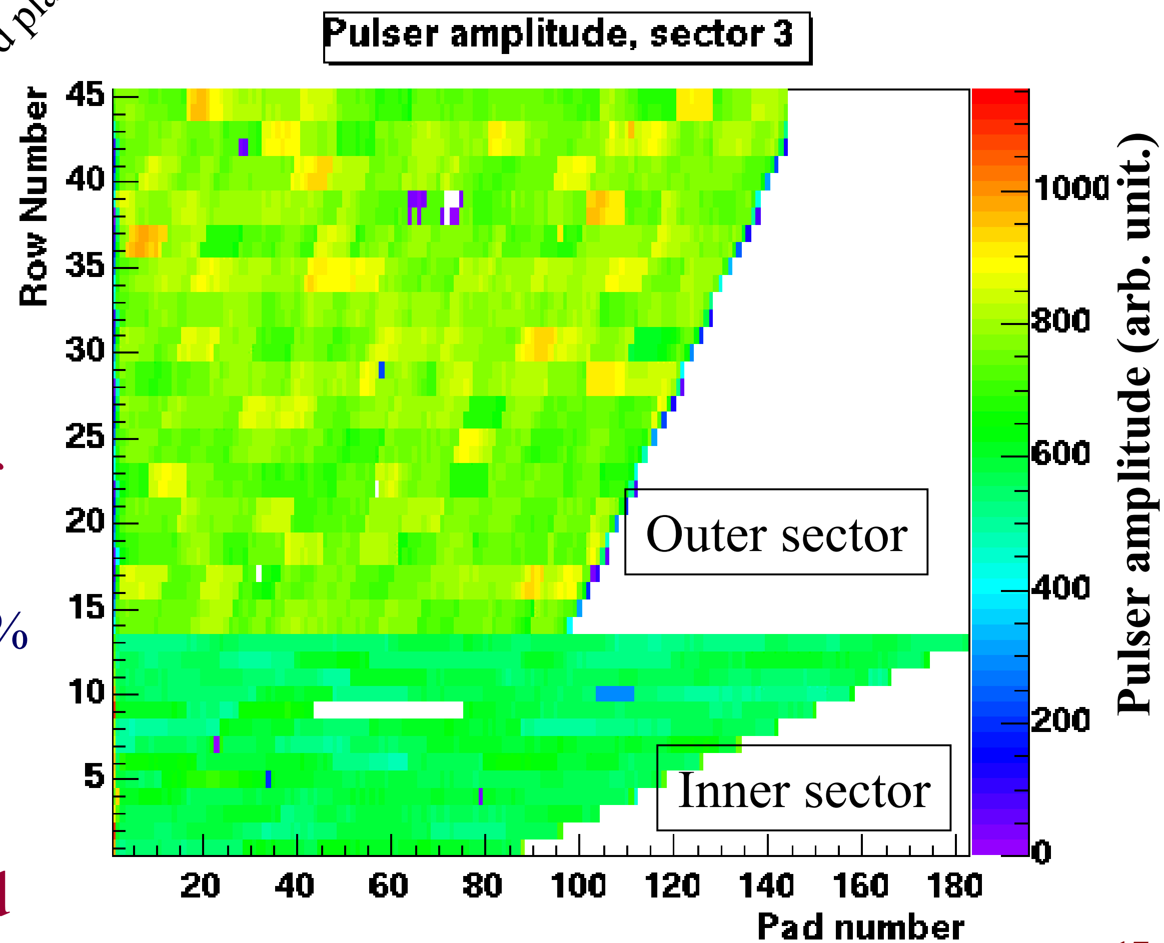


Eugene Yamamoto (UCLA)

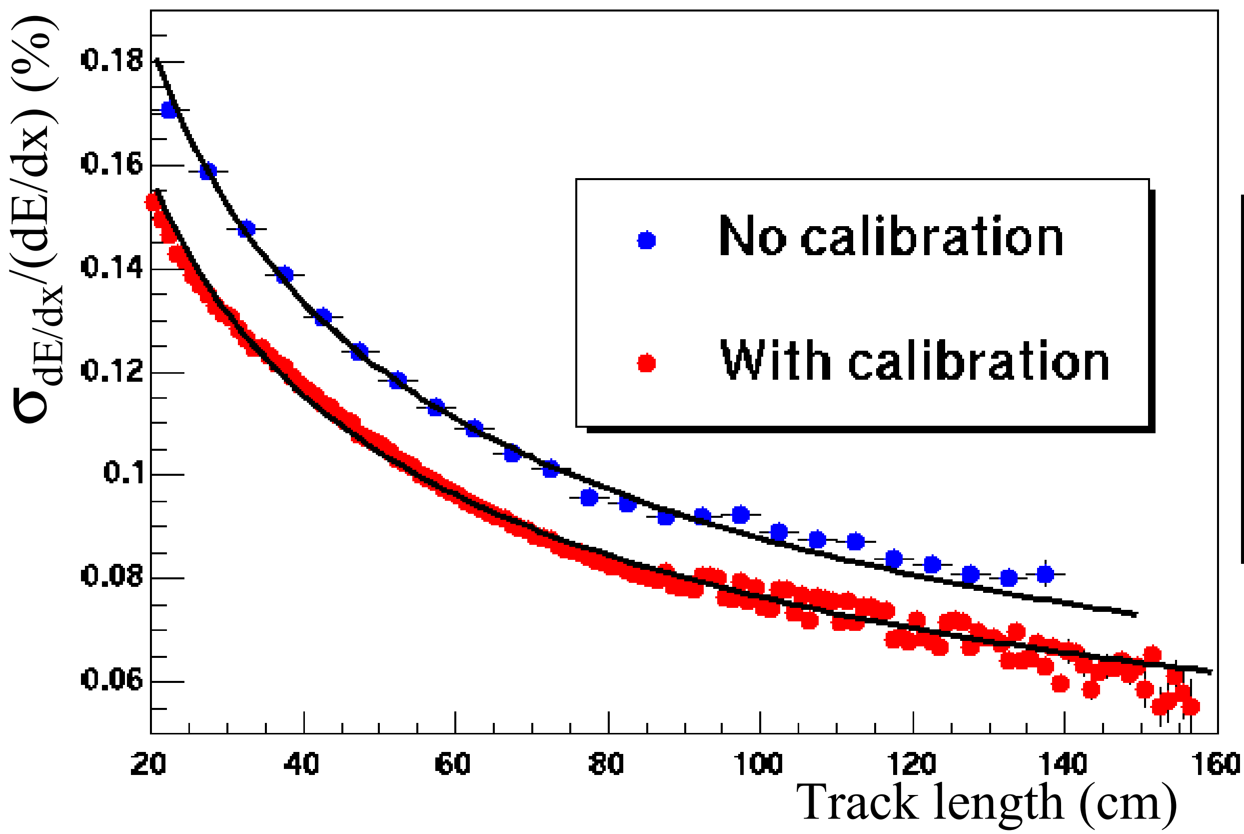
Gain uniformity
Electronic gain



- To measure uniformity of electronic gain
  - 8% sigma variation but 20% RMS (tail)
  - Precise channel level correction
- Pulser also identifies dead channels = 0.25%



Ionization and gain uniformity
dEdx resolution

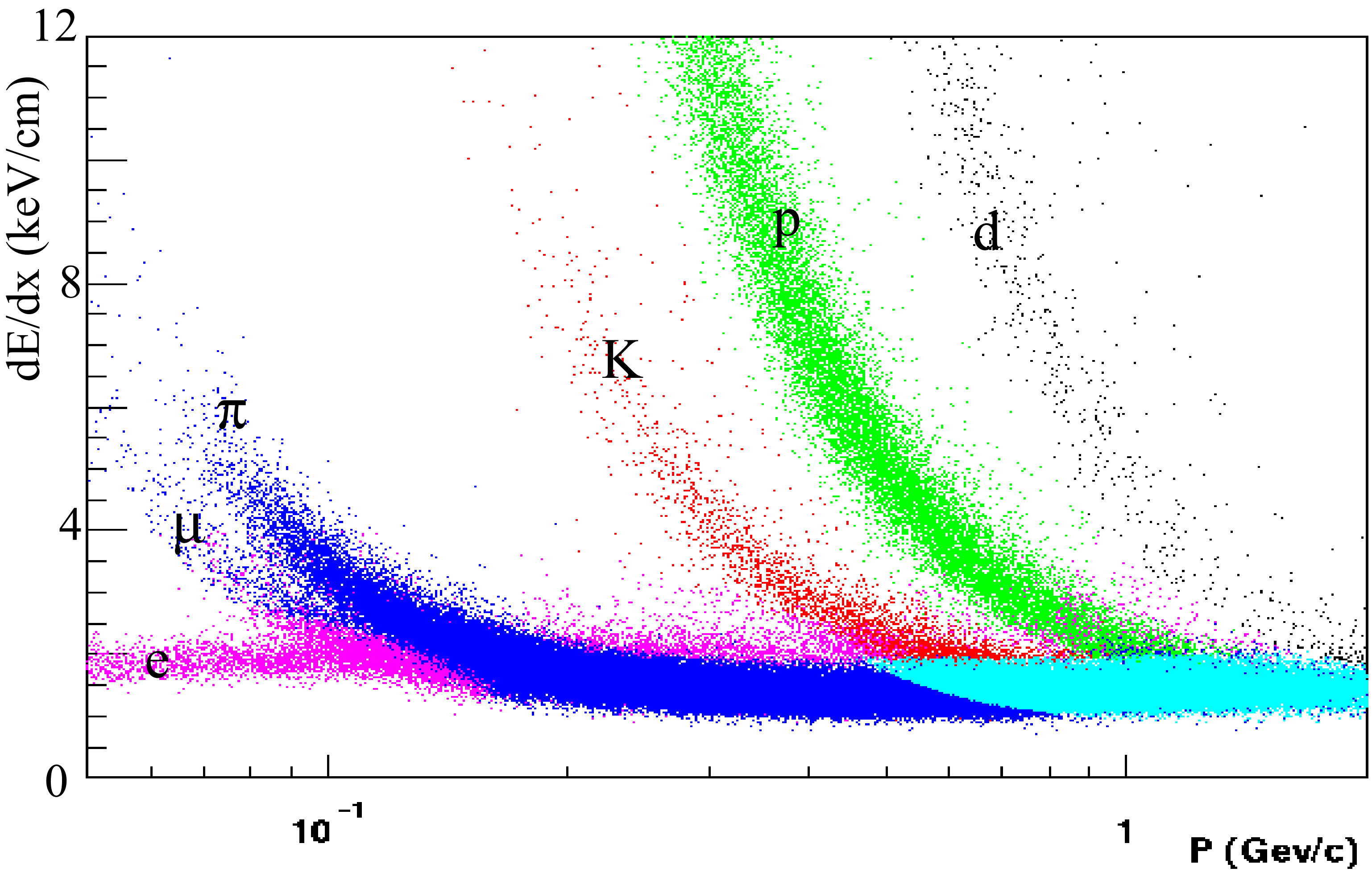


No calibration	9 %
With calibration	7.5%
Design	6.7%

Remaining issue : correlation of dE/dx between pad rows

Yuri Fisyak (BNL)

Conclusion
particle identification



Aihong Tang (Kent State U)

The TPC is an excellent tool for physics

- Approaching design performance
  - Good particle separation using dE/dx
    - 7.5%
    - π-proton separation : 1.3 GeV/c
  - Position resolution
    - 500 μm
  - 2-Track resolution
    - 2.5 cm
  - Momentum resolution
    - 2%
- Future challenges
  - Achieve turn-key operation
  - Handle increased luminosity
- Lots of physics from the year 1 data
  - Collective flow
  - Identified particle spectra
  - Particle correlations
  - Event by event physics
  - Strangeness
  - …