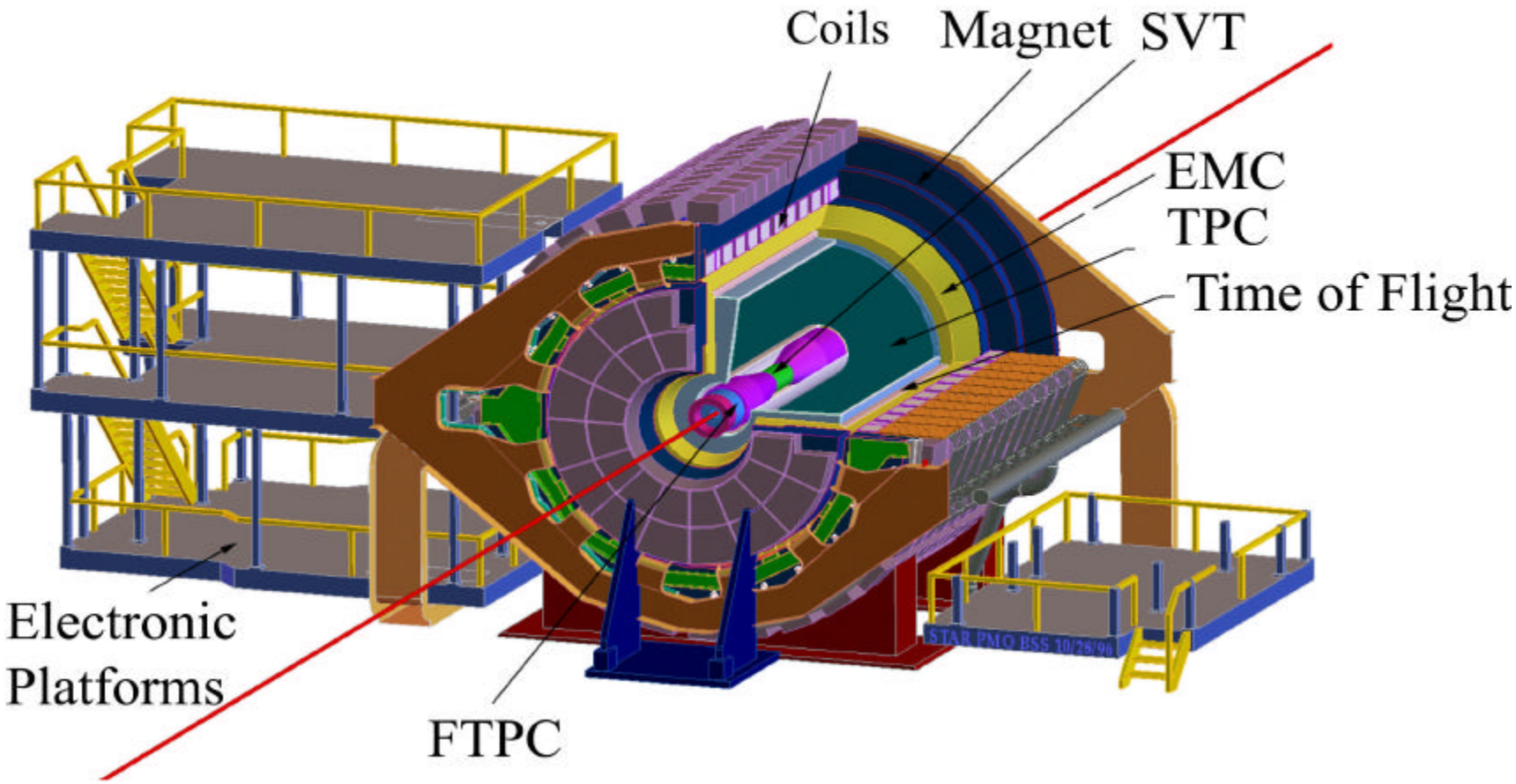
STAR TPC Cluster and Hit Finder Software

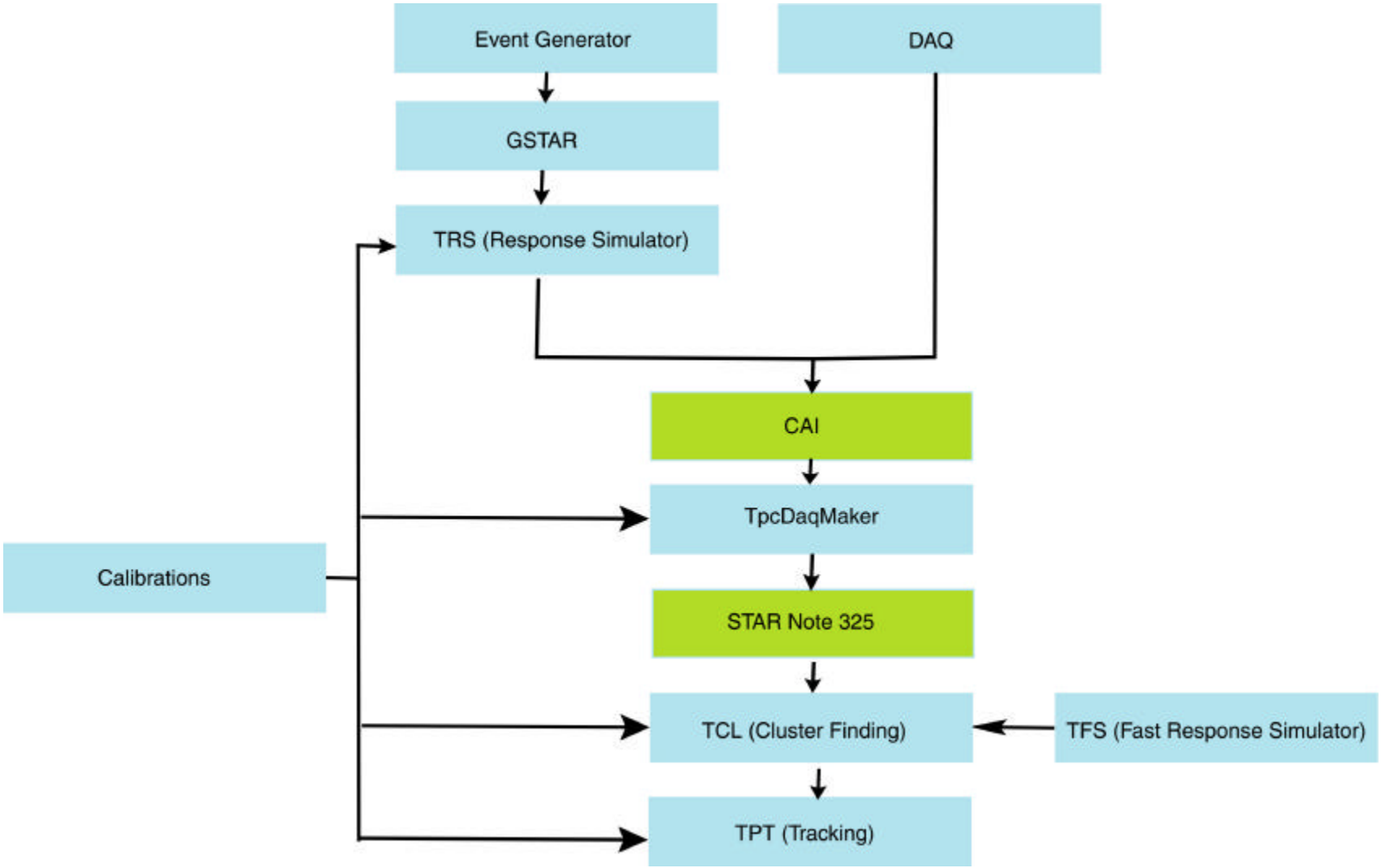


Raimond

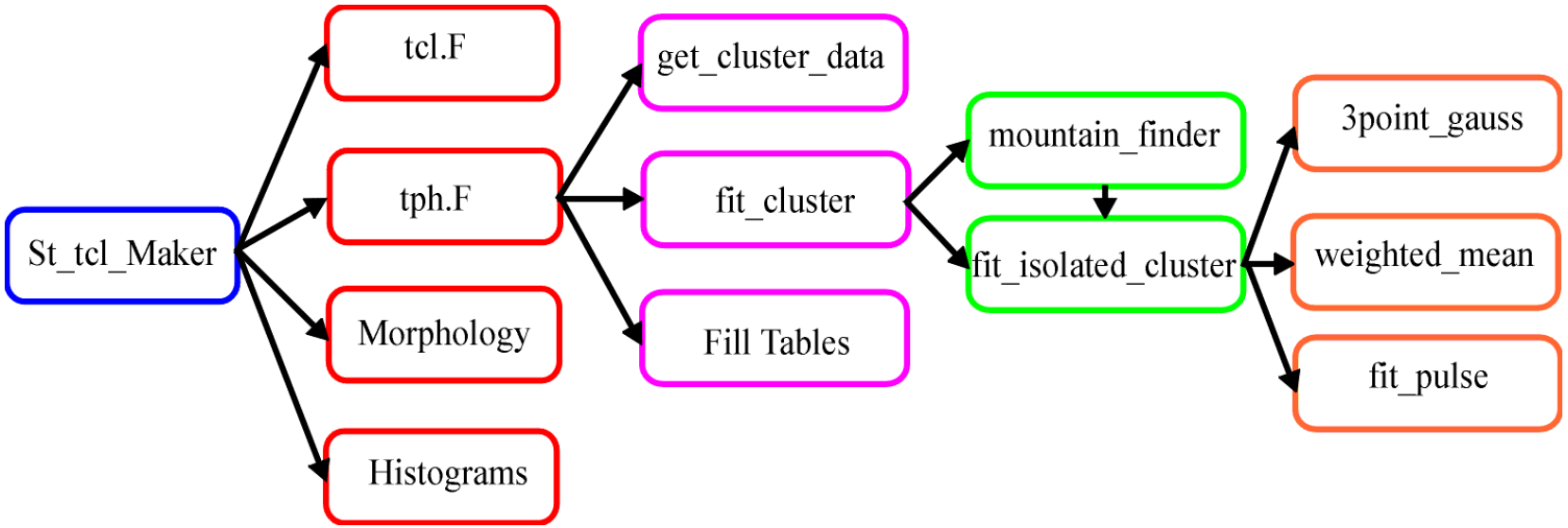
Outline

- Structure cluster finder module
- Structure tracking module
- Tracking evaluation
- Results physics analysis

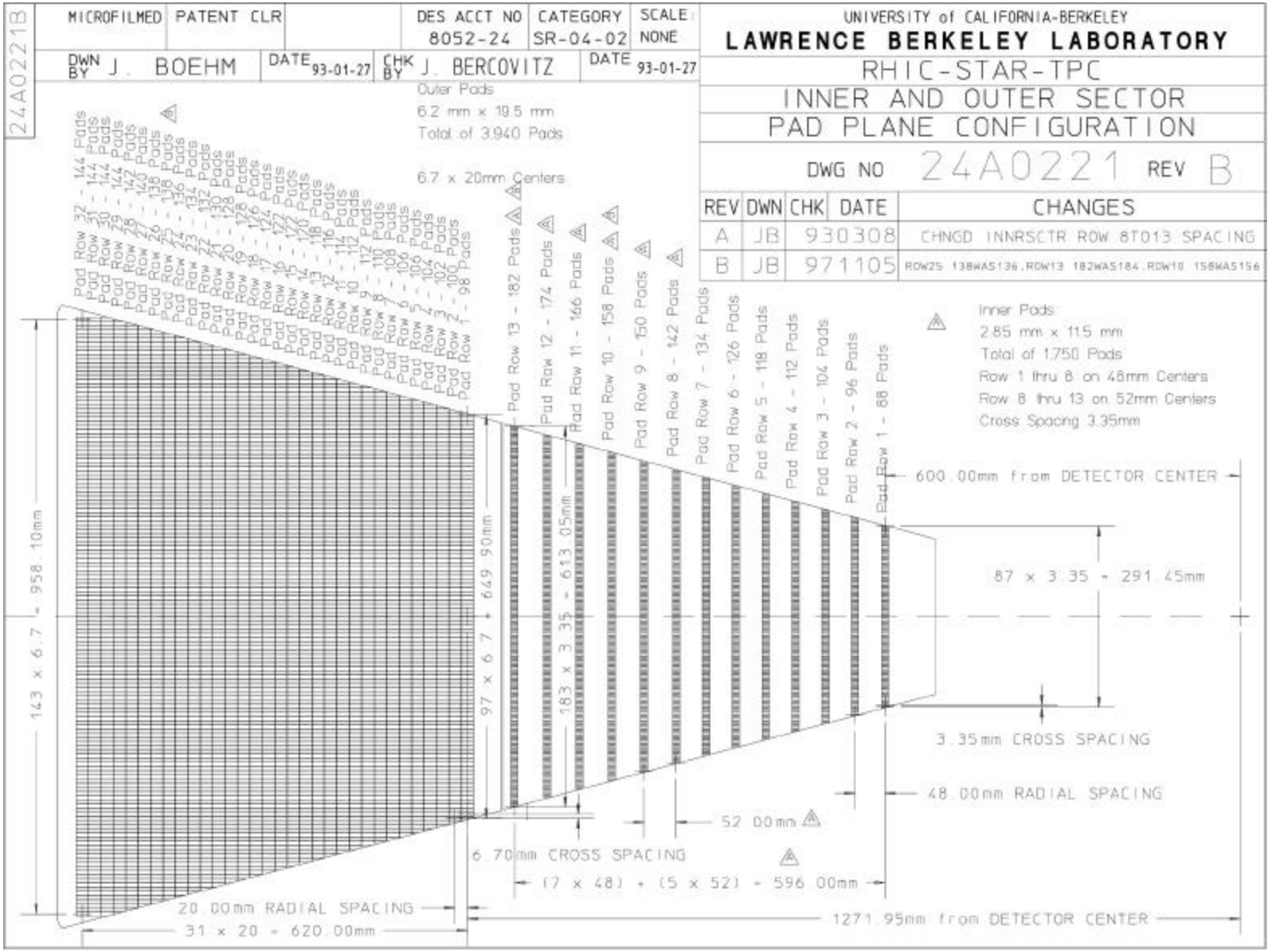
Data Flow


Event Generator
DAQ
GSTAR
TRS (Response Simulator)
CAI
TpcDaqMaker
Calibrations
STAR Note 325
TCL (Cluster Finding)
TFS (Fast Response Simulator)
TPT (Tracking)

St_tcl_Maker


St_tcl_Maker
tcl.F
tph.F
Morphology
Histograms
get_cluster_data
fit_cluster
Fill Tables
mountain_finder
fit_isolated_cluster
3point_gauss
weighted_mean
fit_pulse

Sector Layout



TPC Layout

Sectors: 24 Inner and Outer sectors

Inner pads: 13 rows, 2.85x11.5 mm

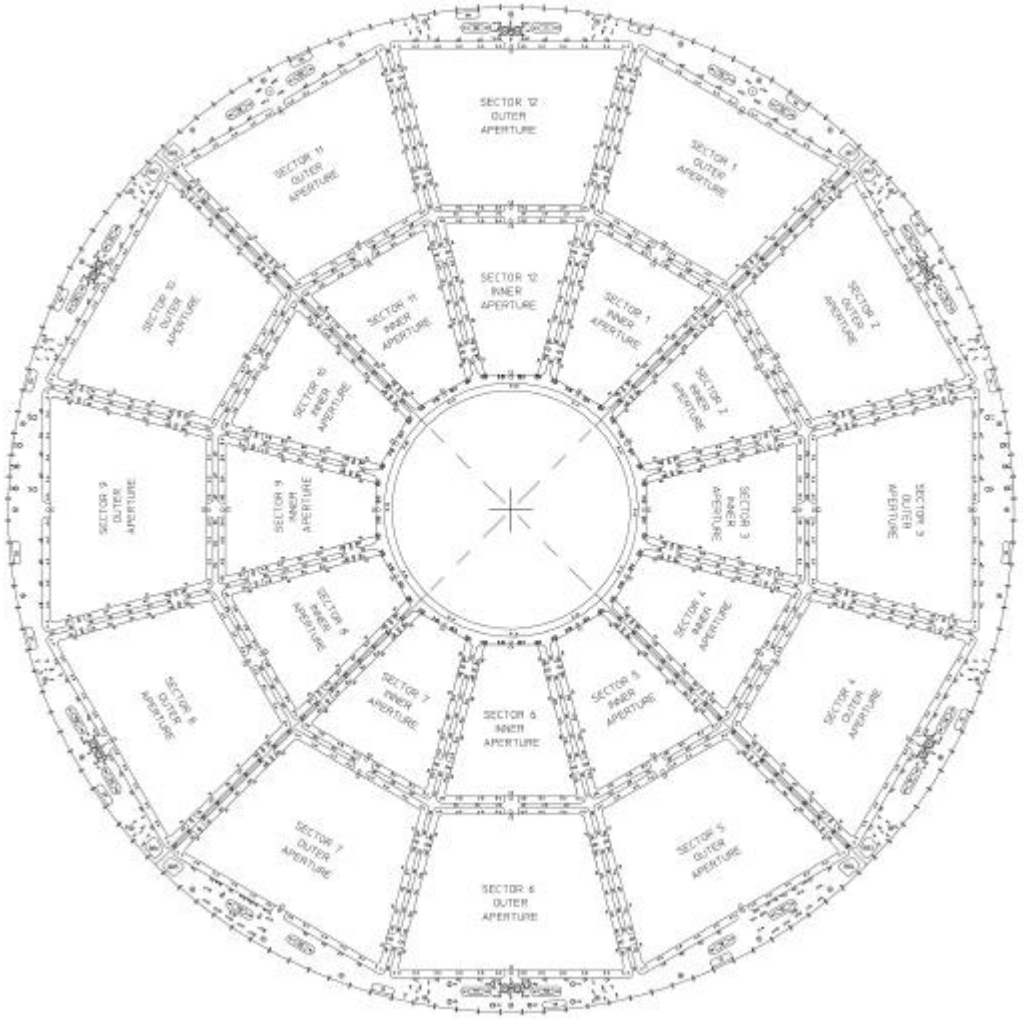
Outer pads: 32 rows, 6.2x19.5 mm

Clock Freq: 9.4 MHz

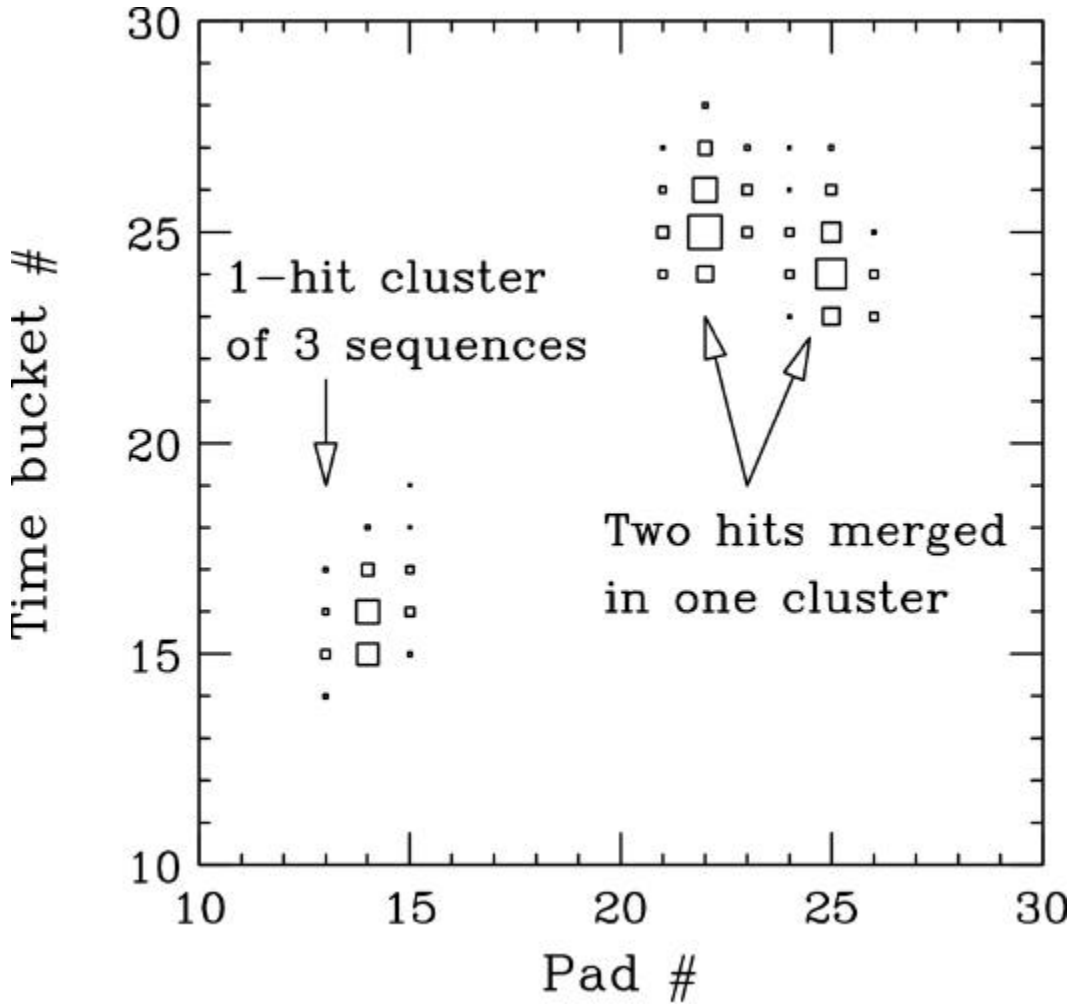
Time buckets: +/- 400 used

TPC Gas: P10

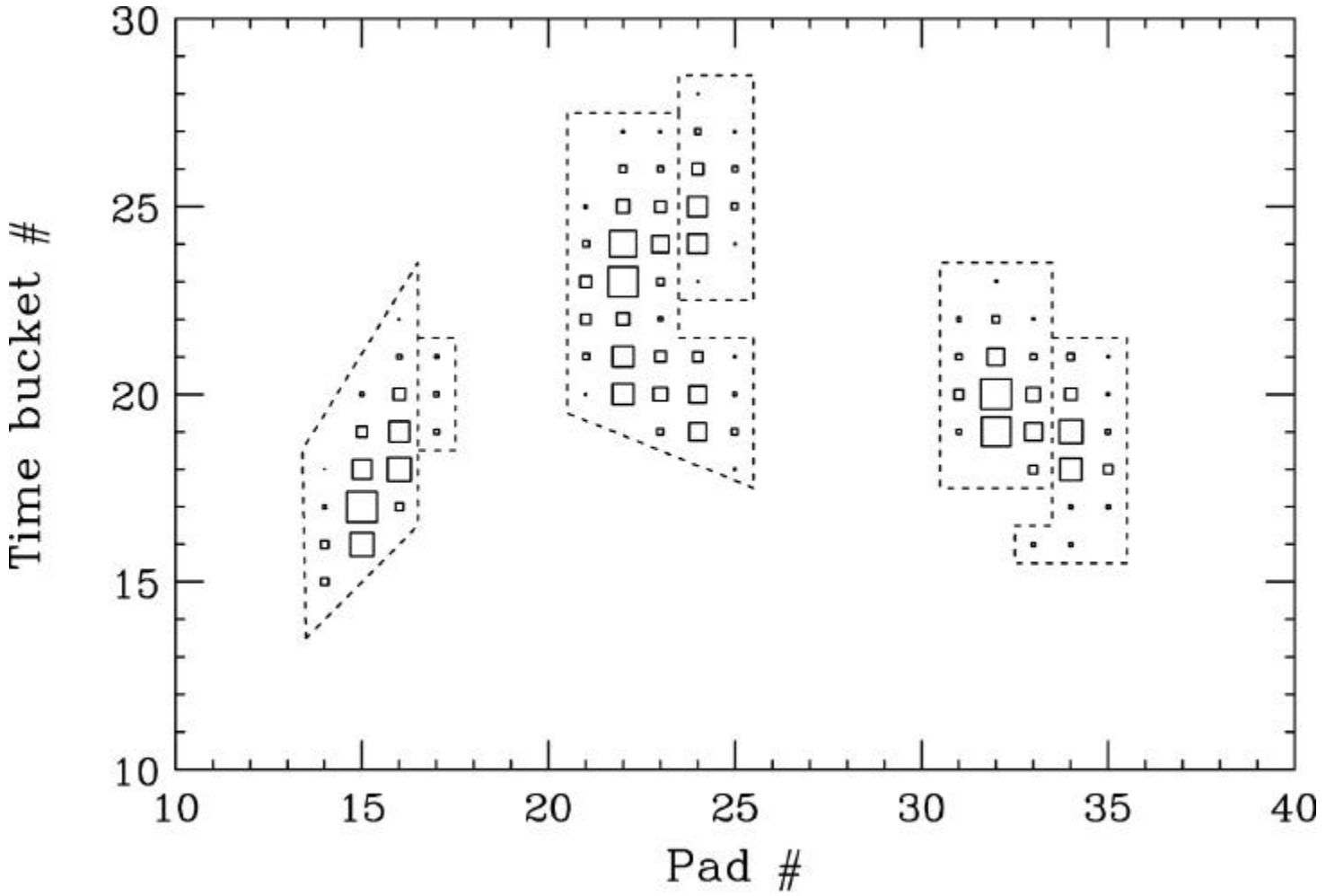
Drift Velocity: 5.4 cm/μsec



Time versus Pad



Cluster Finding



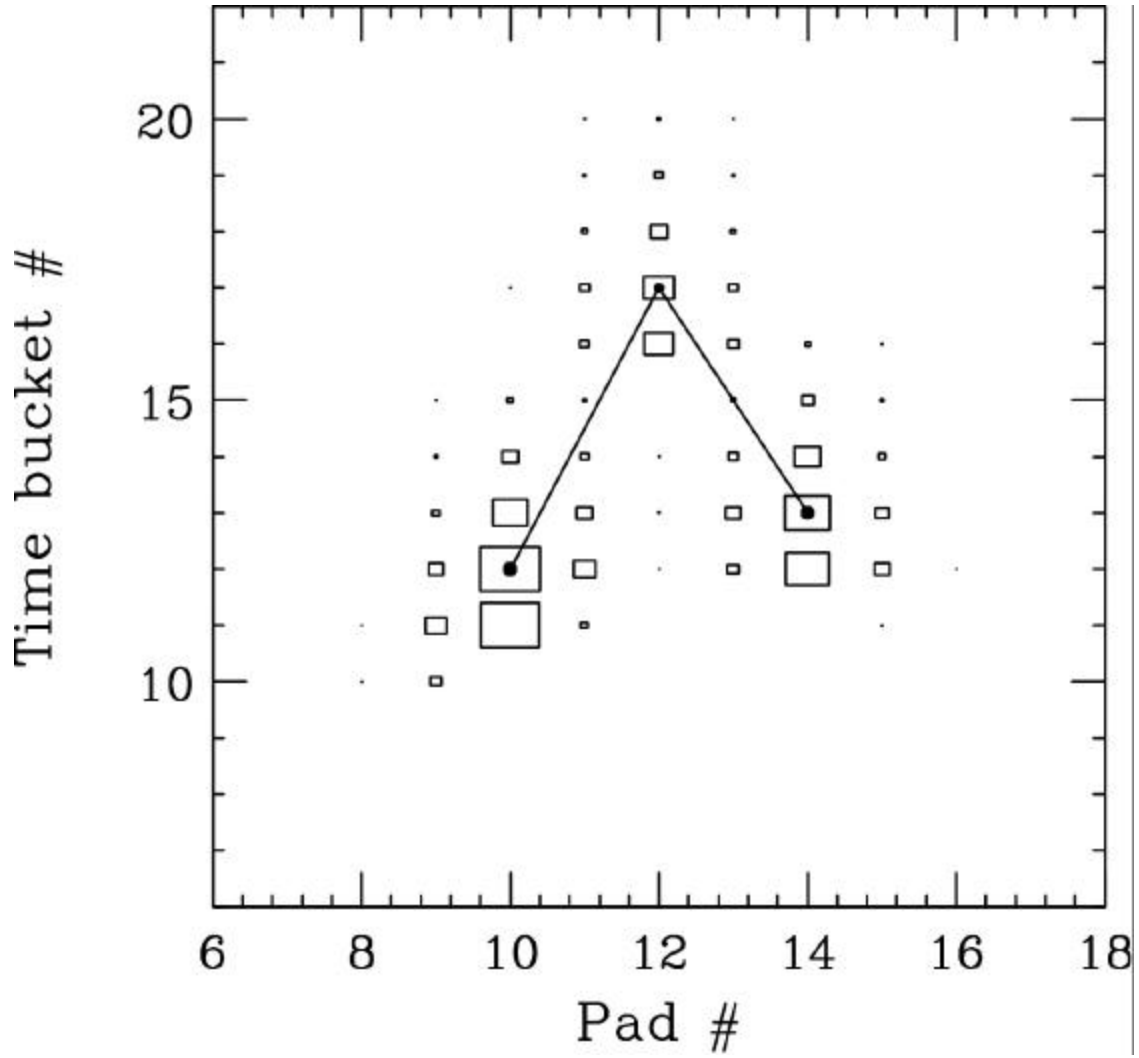
Deconvolute Clusters

Mountain Finder

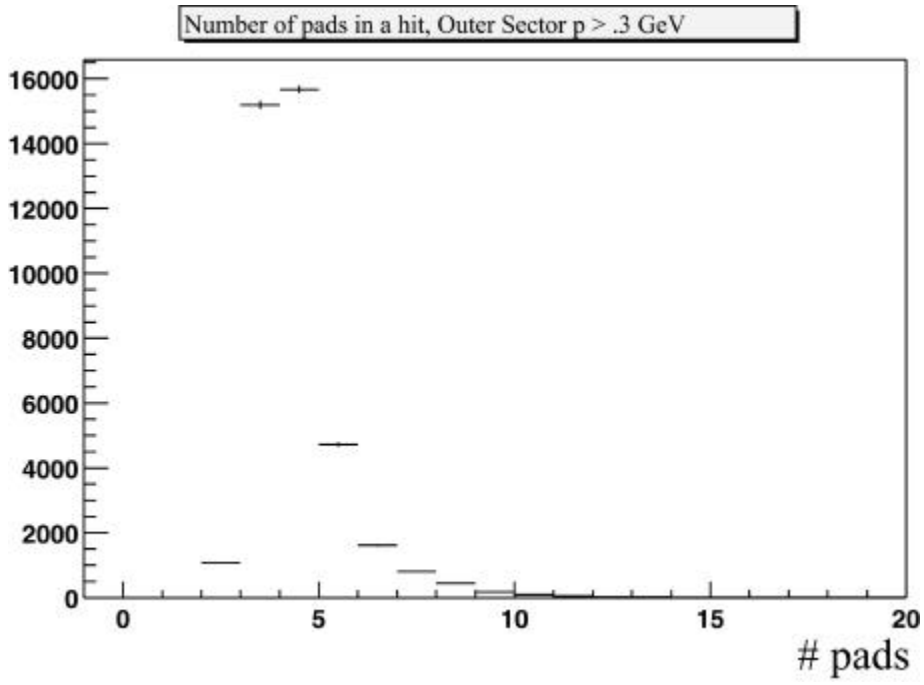
Fit isolated cluster:

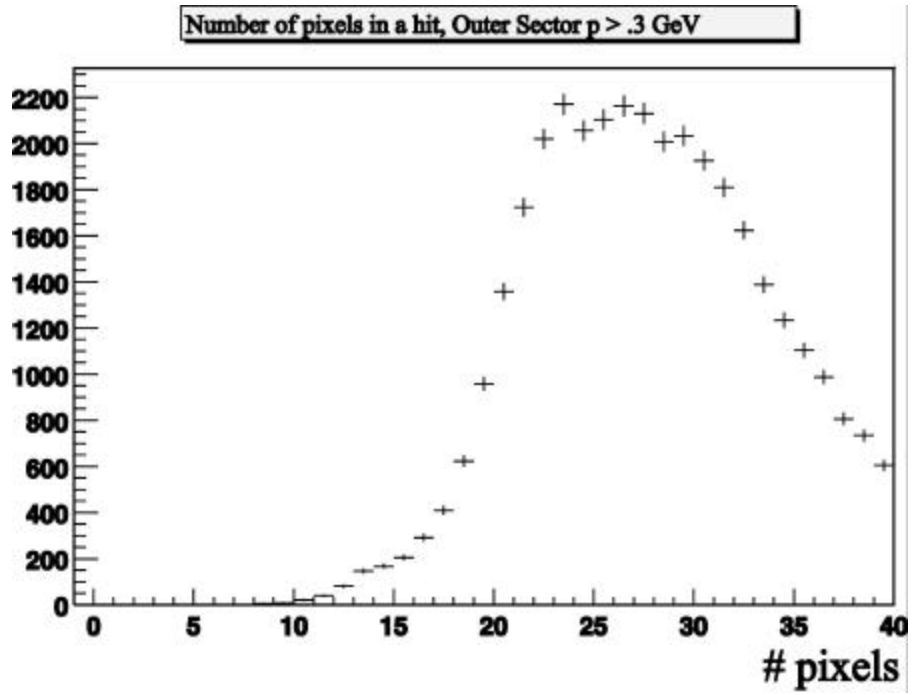
Three point Gaussian or Weighted mean in pad direction

Weighted mean in time direction



Cluster Shape

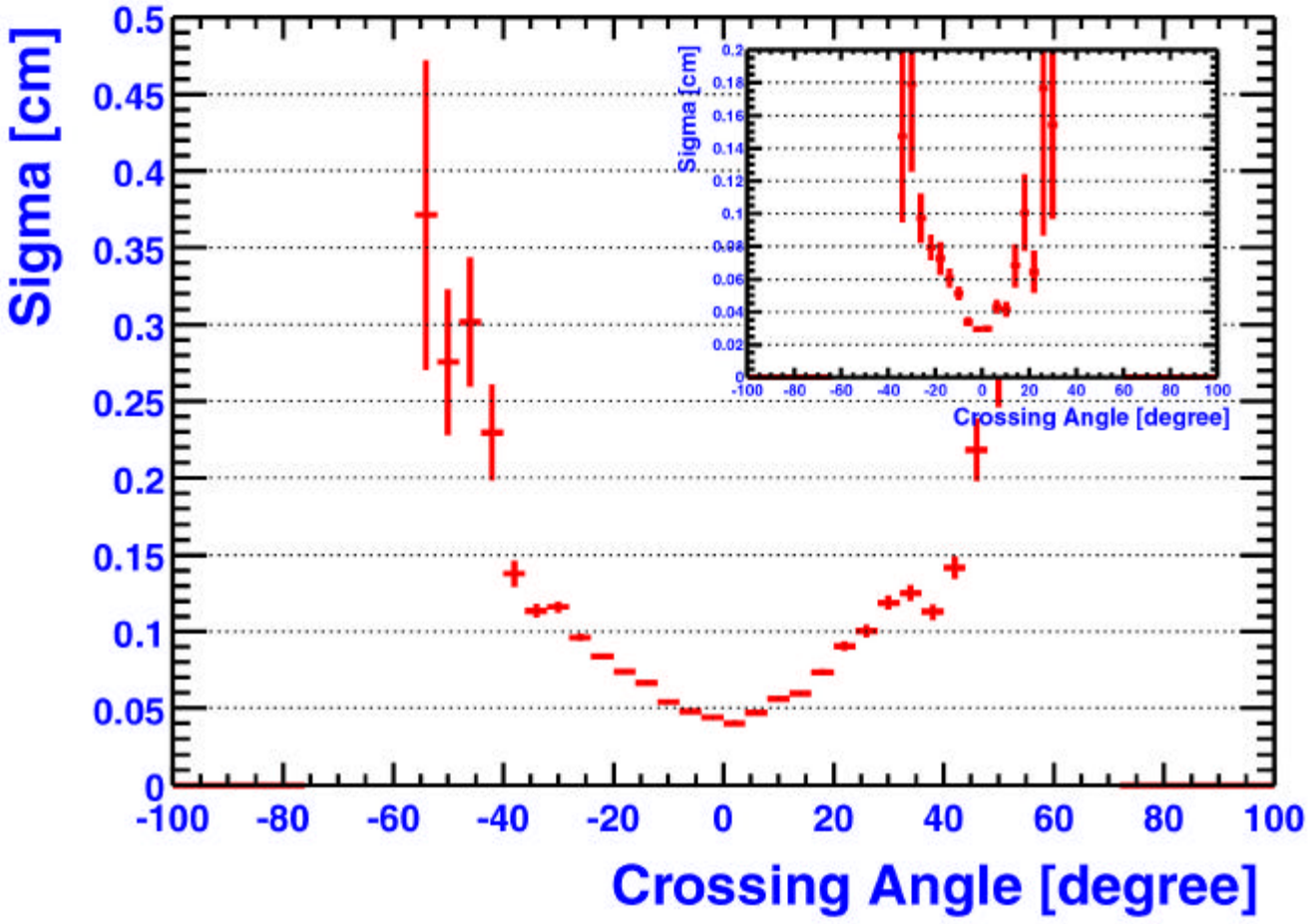




Number of pads approximately 4-5

Number of time buckets approximately 4-5

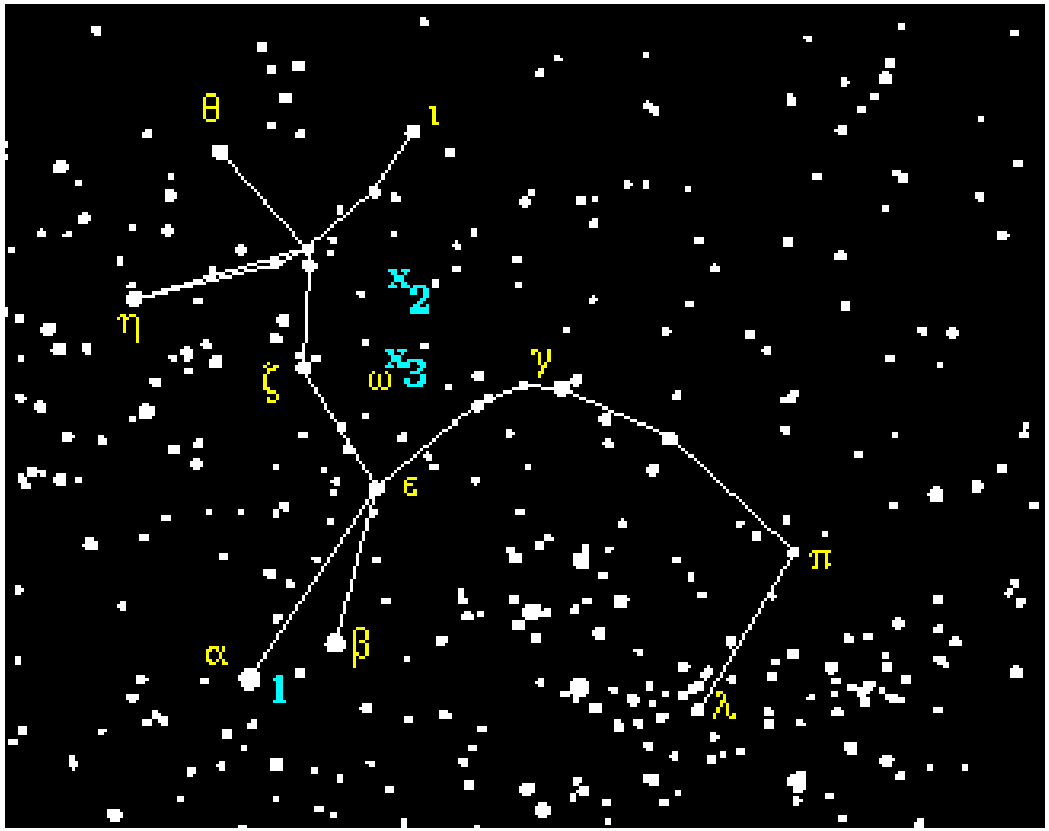
Cosmic Data


Sigma [cm]
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Crossing Angle [degree]
Sigma [cm]
Crossing Angle [degree]

To Do

- Test algorithms / parameters using TRS and real data
- Test performance, test cpu usage, see star note SN0238

STAR TPC Tracking Software

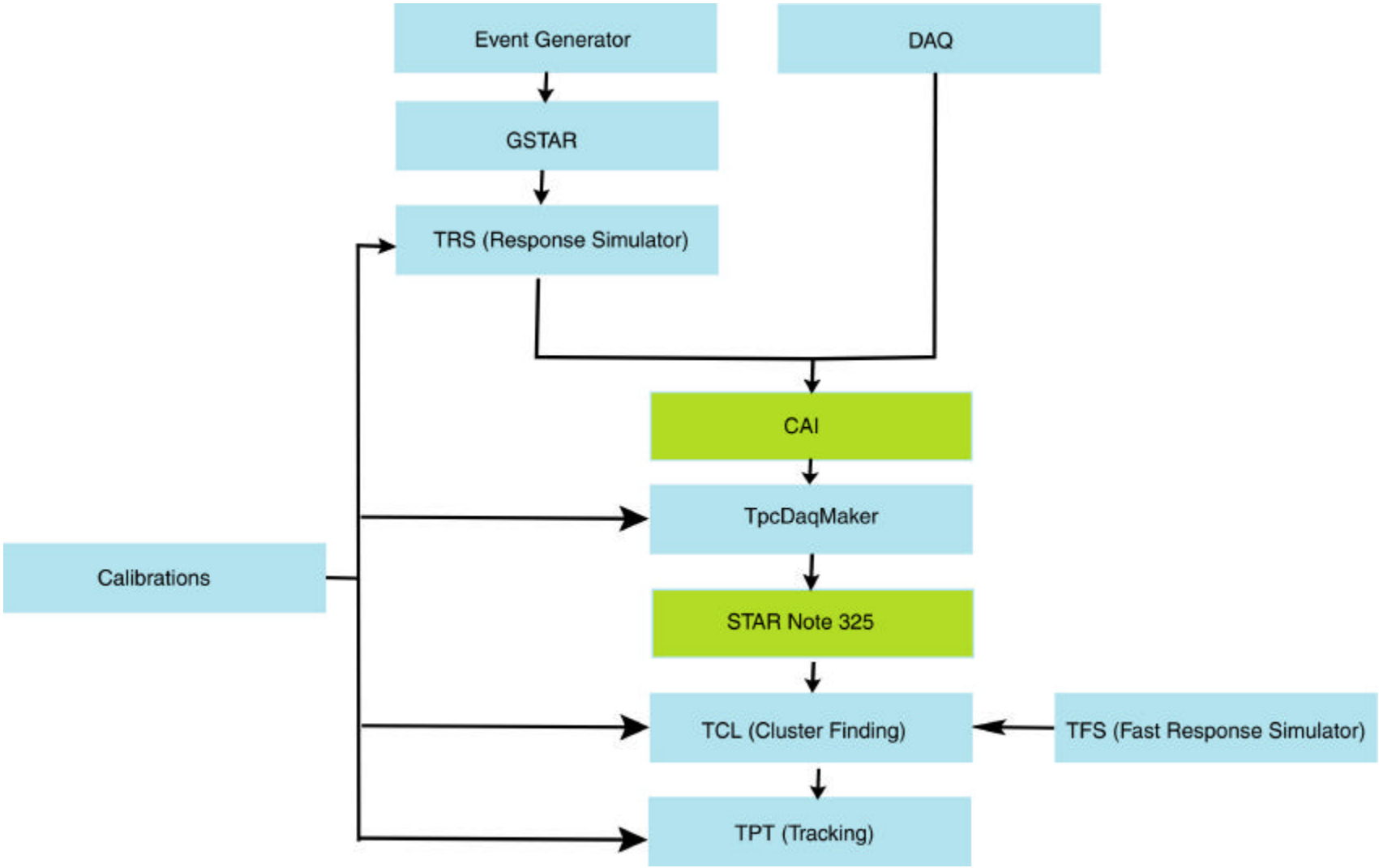


Iwona Sakrejda

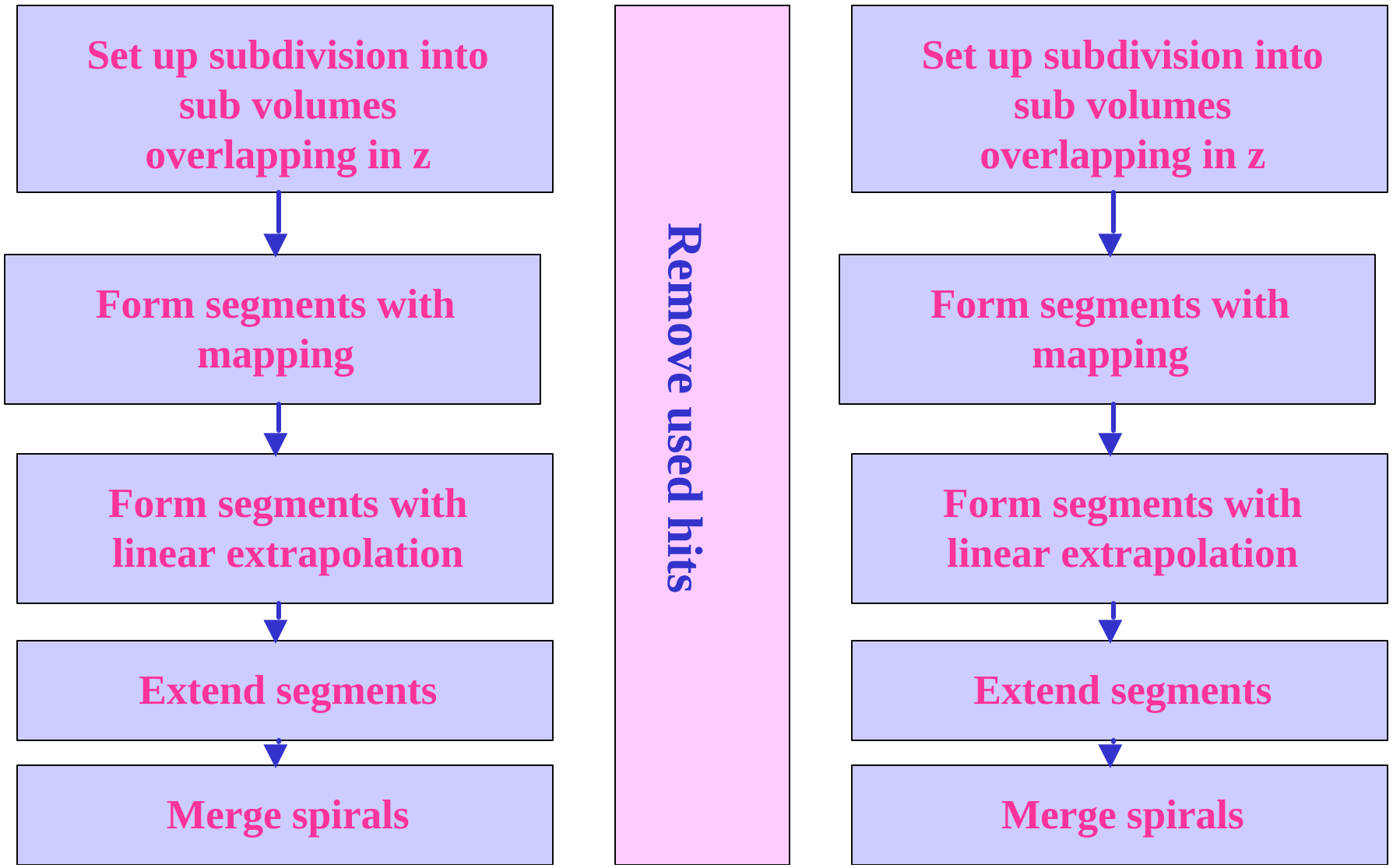
8 April 2000

STAR & ALICE Joint Software Meeting

TPC Simulations and Analysis Chain

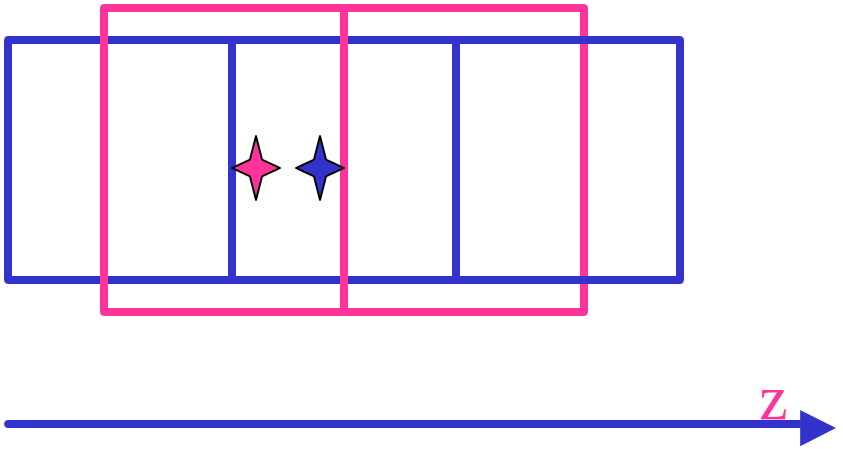


Structure of the tpt Module



Sub Divisions

Set up subdivision into
sub volumes
overlapping in z



Prediction always far from edges of a sub volume.

Within a padrow of a sector hits are sorted in z,

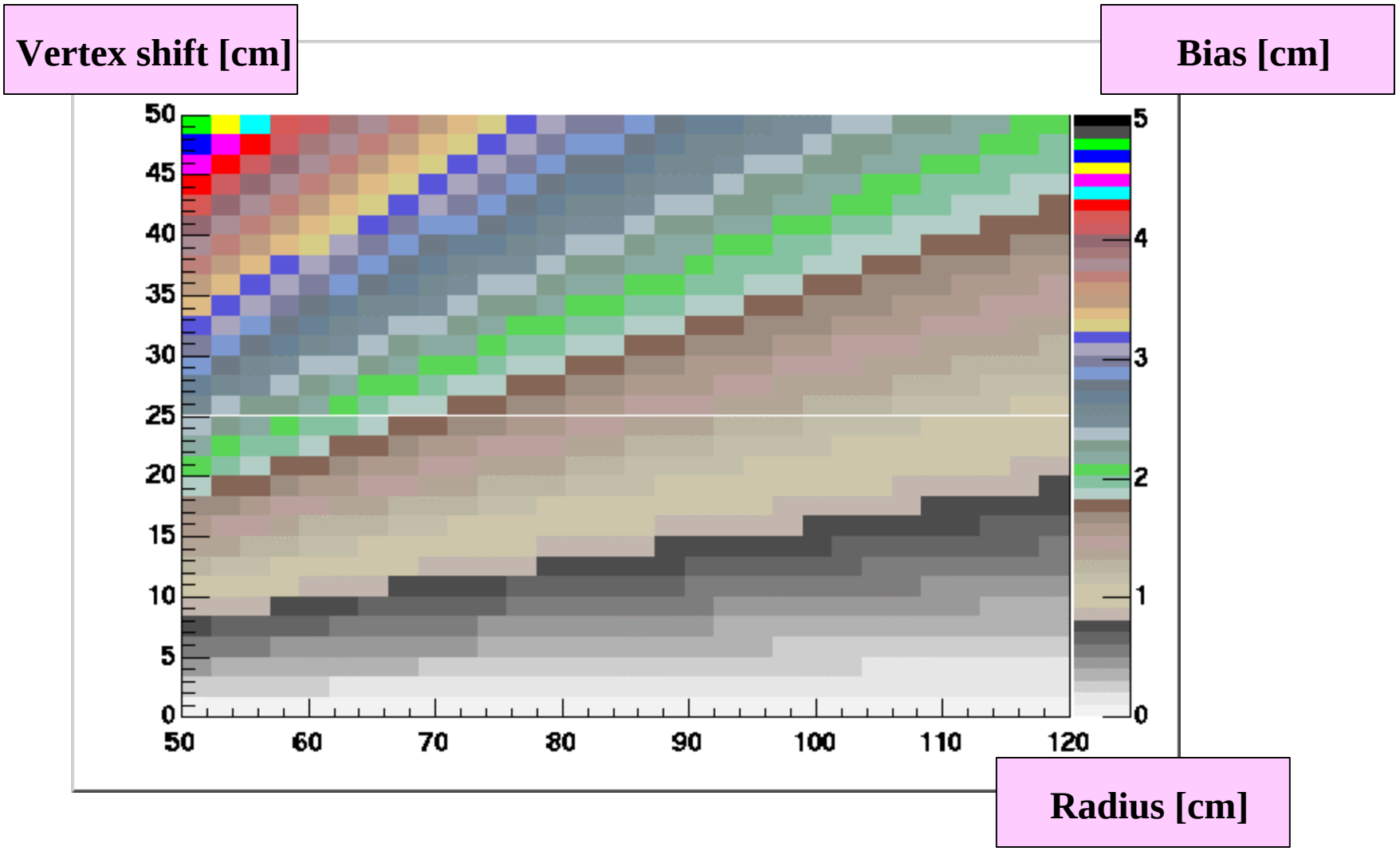
each hit points to the next one.

There is a smooth transition across the central membrane.

Root Formation

- **A free point is identified, it becomes a seed.**
- **In the outer sector hits are connected if clusters they belong to overlap in pad and time-bucket space. There is no assumption about the position of the primary vertex.**
- **In the inner sector there is a separation between padrows, so the connectivity cannot be used.**
  - **A prediction is made based on the assumption that the track originated at (0,0,0).**
  - **All the hits within tolerance around this prediction are considered candidates.**
  - **From two hits a linear prediction is formed (0,0,0 assumption dropped) and for each pair, the best candidate is accepted.**

Bias in Root Formation Z, Inner Sector



Segment Formation With Conformal Mapping

- **Track seed formation (so called roots), if requirements are fulfilled a handful of 3pt roots can start from 1 point.**
- **Roots are created in the x,y,z space**
- **All roots are extended and the best segment is kept (this part only within 1 sector).**
- **Based on track parameters a prediction for the next row is calculated and the best match is accepted.**
- **The mapping is used only to update the track parameters.**
- **Tolerances are expressed in terms of cluster width.**
- **Gaps are limited.**
- **Every time a hit is added, track parameters are updated.**
- **At the end the assumption about the vertex in x-y is dropped and track is re-fit as a circle+line.**

Form Segments Using Linear Extrapolation

- **Track seed formation (so called roots), if requirements are fulfilled a handful of 3pt roots can start from 1 point.**
- **Roots are created in the x,y,z space (as before)**
- **All roots are extended and the best segment is kept (this part only within 1 sector).**
- **Based on track parameters a prediction for the next row is calculated and the best match is accepted.**
- **Use linear extrapolation while extending track**
- **If a new point is added the earliest one is dropped.**
- **Tolerances are expressed in terms of cluster width.**
- **Gaps are limited.**
- **Every time a hit is added, track parameters are updated.**
- **At the end the track is re-fit as a circle+line.**

Extend Segments

- **All the hits from the current pass are released**
- **All the segments from the current pass are sorted from the longest to the shortest**
- **If a segment has 45 hits, it's just re-established**
- **A segment is extended within the sector where it was found and in the two neighboring sectors (if predictions lead us there)**
- **Results of the helix fit are used for predictions**
- **If points are added, the track is re-fit and the "losers" are updated - a stronger track can absorb a poor one**
- **Track that lost its hits is flagged as negative**

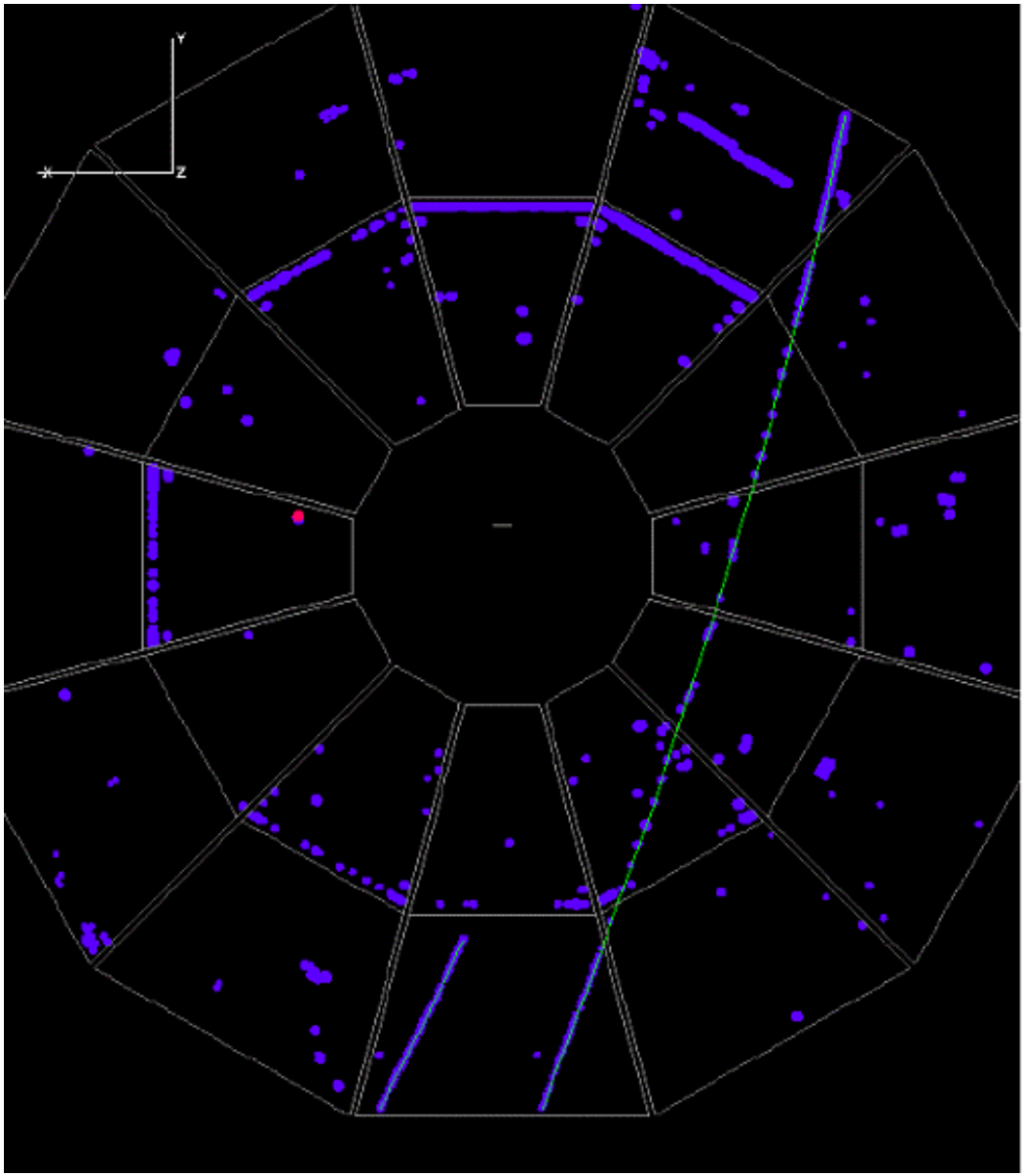
Track Fitting

- Fast 2-component helix fit based on algorithm by Chernov and Oskov
- Circle fit in the x-y plane
- Line fit in the s-z coordinates where s is the track length along the circle
- Later on the track is re-fit with a proper covariance matrix (Kalman fitting)

Methods of Tracking Evaluation

- Analysis of cosmic and test data (residuals and momentum distributions)
- Visual inspection of reconstructed events (DSV - Duncan Prindle, university of Washington)
- Evaluation histograms in root4star
- Matching tables
  - tte_mctrk - one entry per Monte Carlo track
  - tte_eval - one entry per reconstructed track
- Global reconstruction (vertex, primary tracks)
- Physics analysis
- Timing

TPC Reconstruction: Test Runs



Summer 99’ ~100K events

December 99’ ~100K events

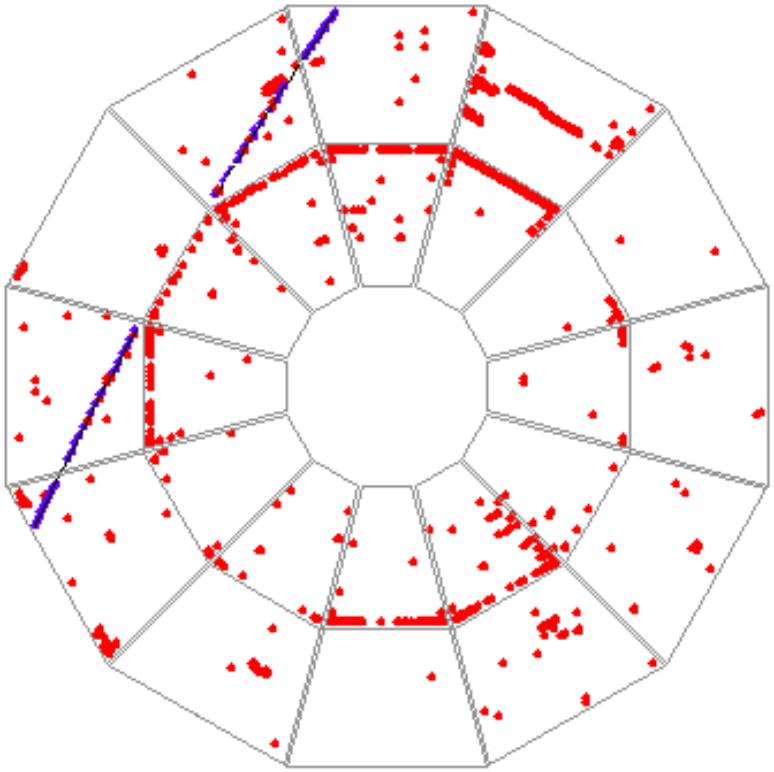
February/March 2000 ~1M events

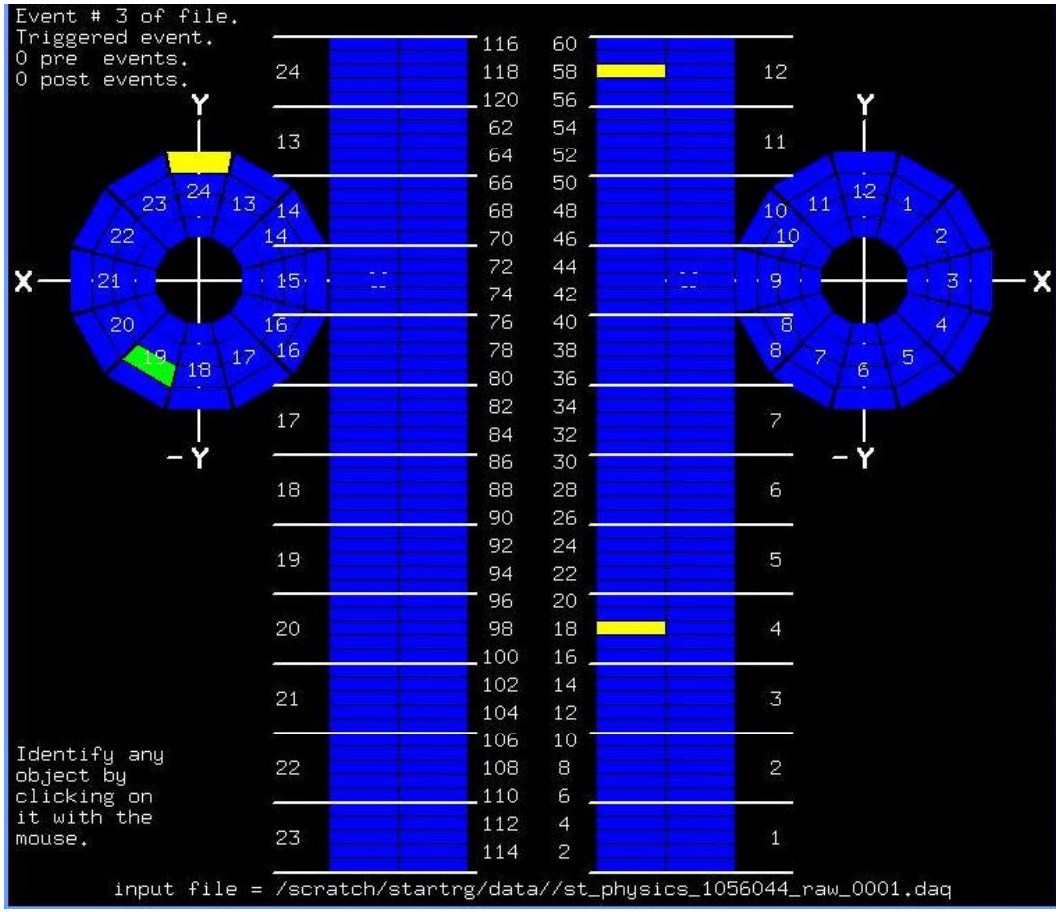
During the 3 running periods cosmic and laser events were taken with all the magnetic field configurations (full, half, no field).

Tested not only the detector, but also the reconstruction chain, calibrations and the Data Base software.

Provided information for testing the trigger, RICH, SVT

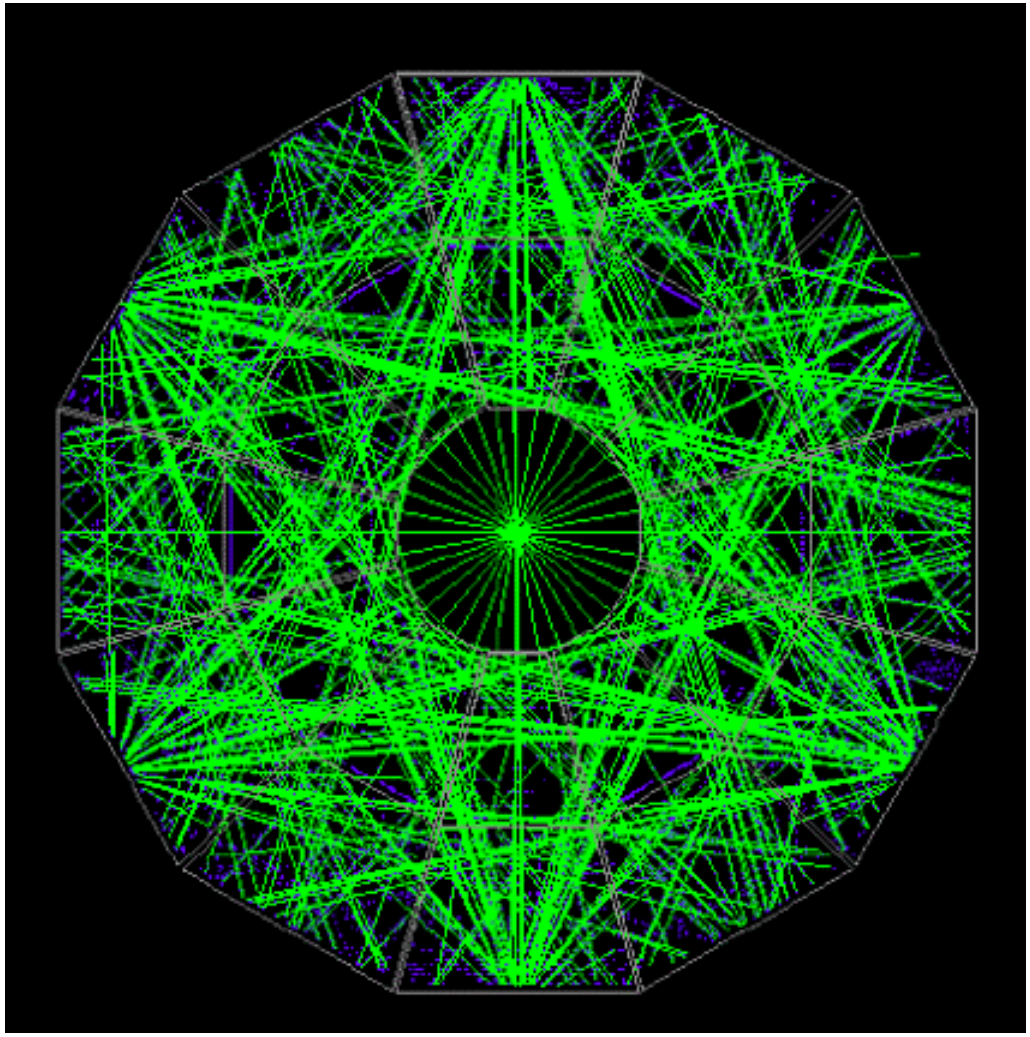
Cosmic Ray in TPC and STAR Trigger Detectors





H.J. Crawford - STAR Trigger

TPC Reconstruction - Lasers

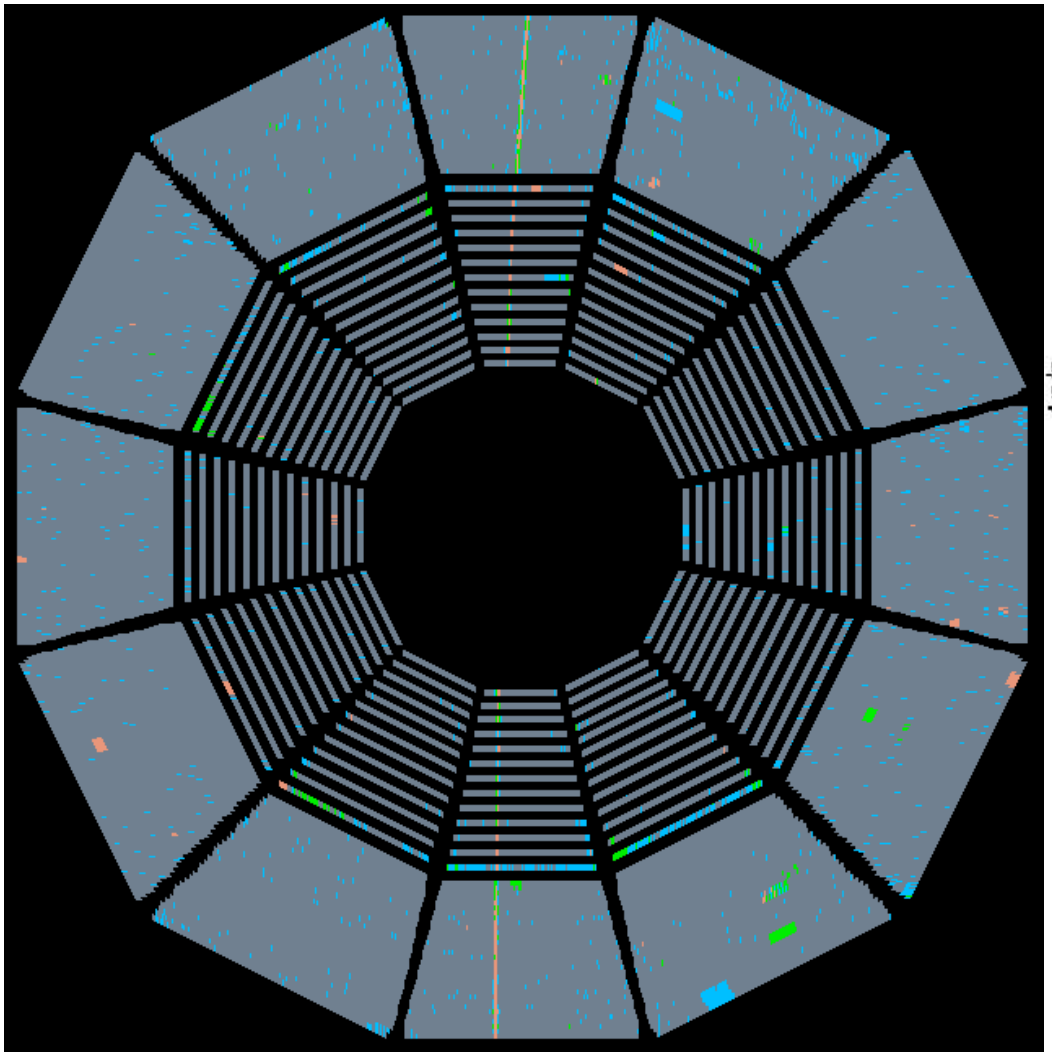


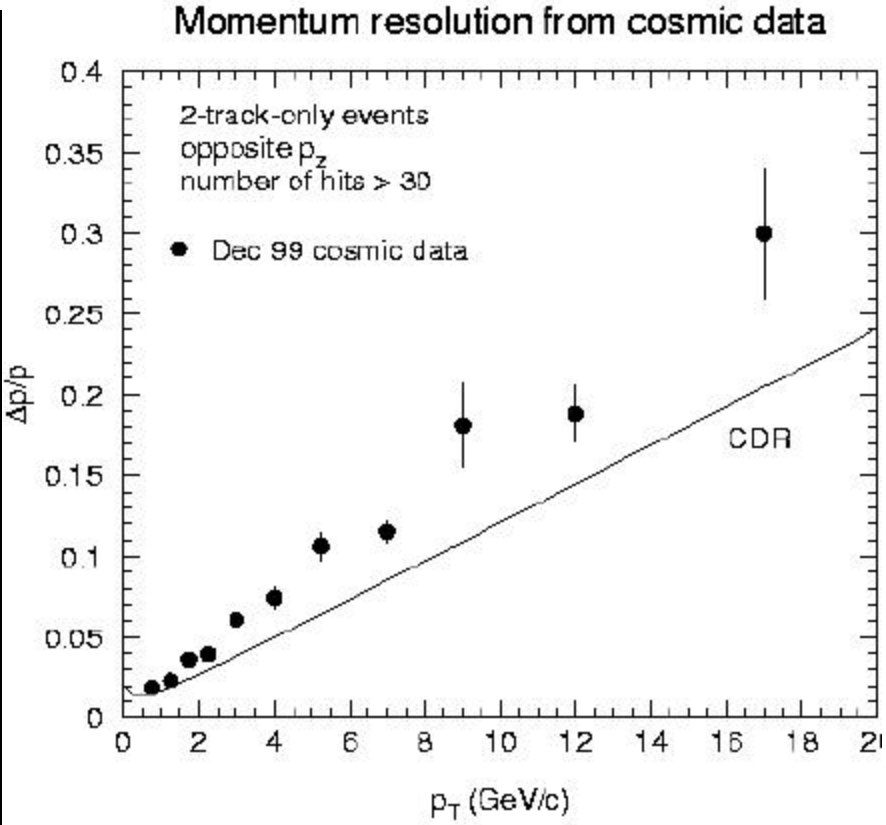
Laser events were used to

- verify the clock frequency
- calculate the drift velocity
- measure the trigger offset

There are ~500 laser beams in the chamber and a radial pattern on the central memebrane

TPC Reconstruction – Momentum Resolution

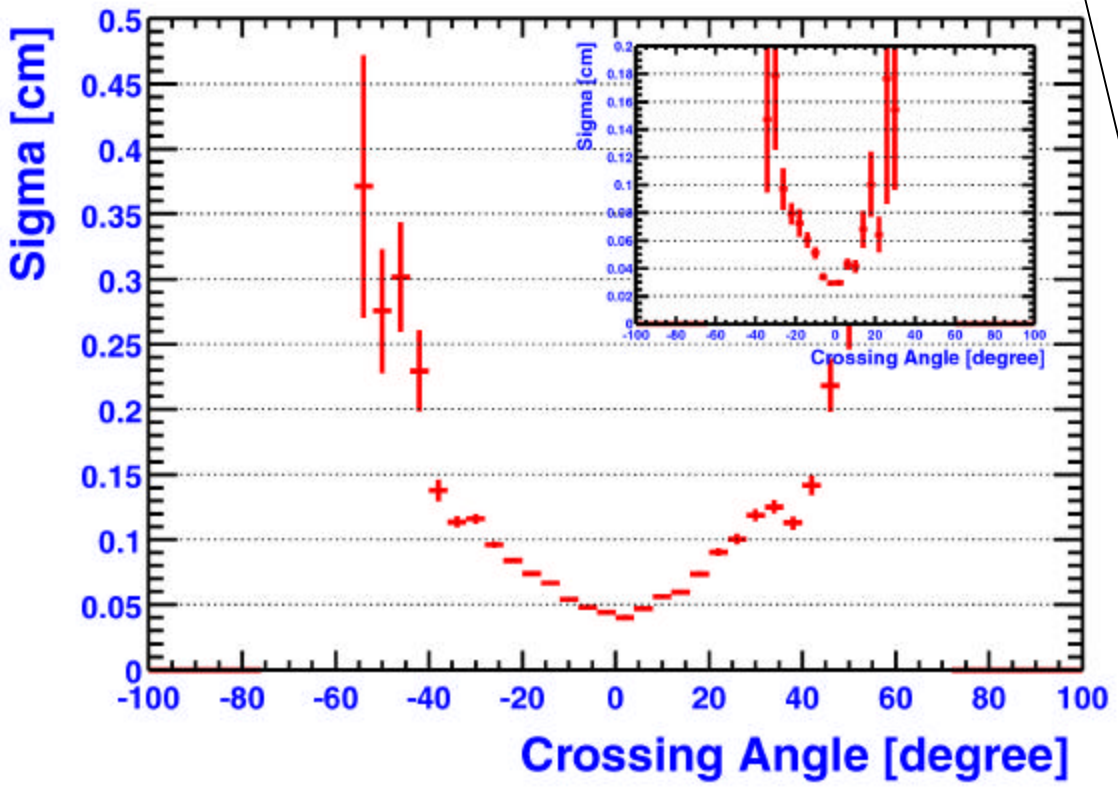


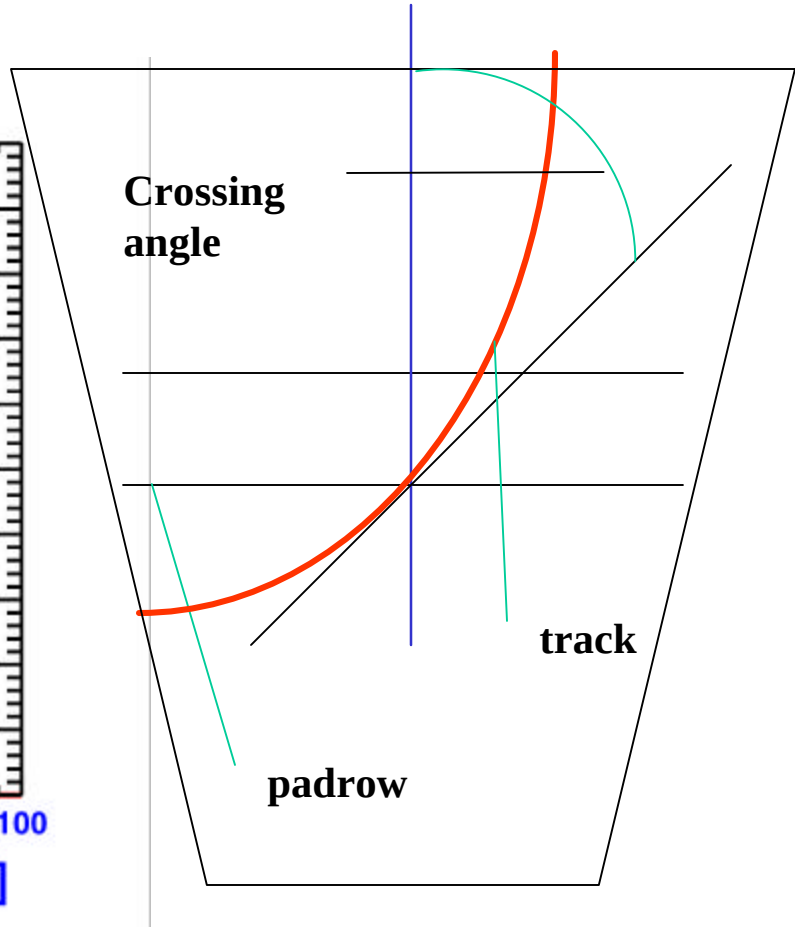


Differences between the test results and the Conceptual Design Report (CDR) understood - specifications will be met during Heavy Ion runs

F. Wang 03/30/2000

TPC Reconstruction - Position Resolution



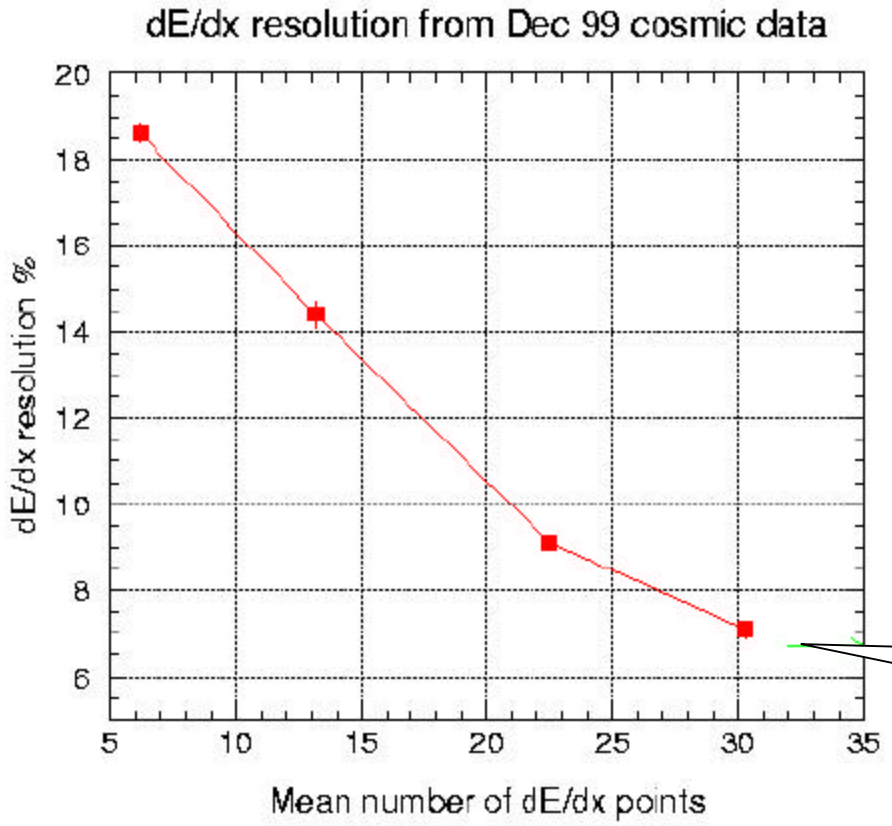


TPC Sector

TPC position resolution meets CDR specifications

R. Snellings 03/30/2000

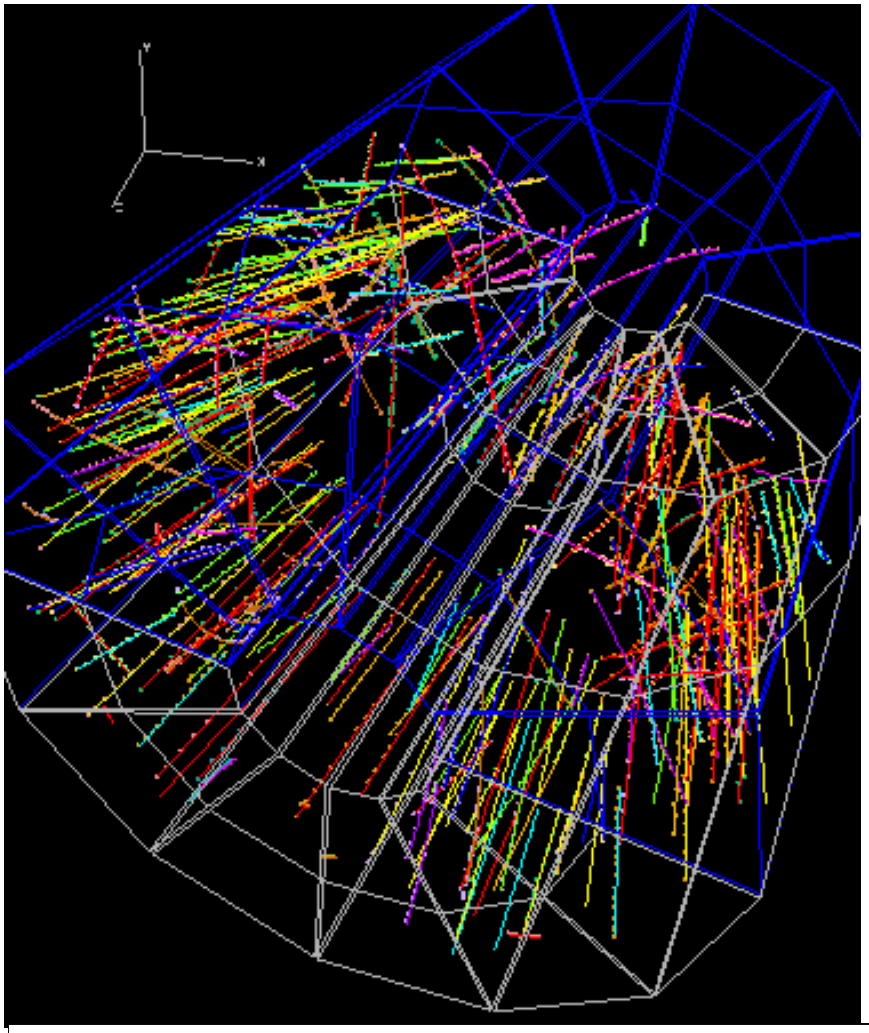
TPC Reconstruction - de/dx Resolution

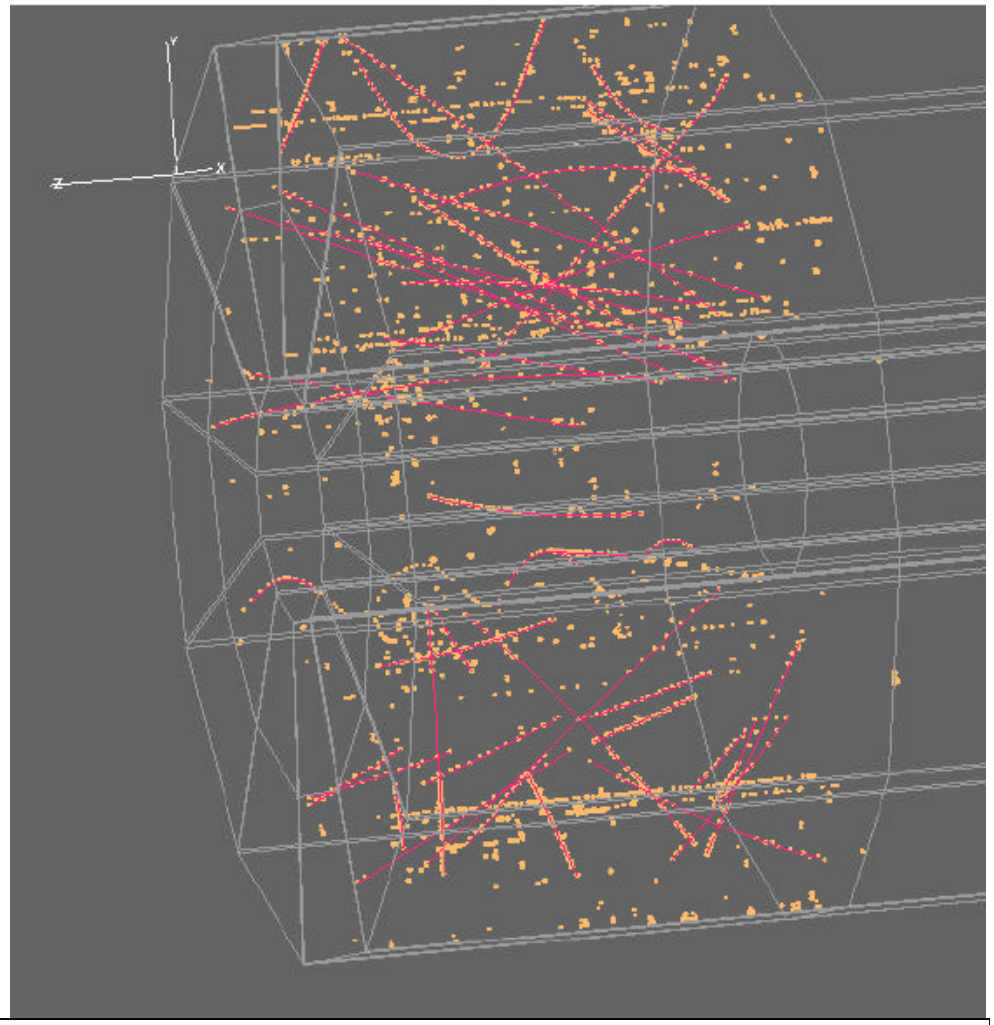


Expected value for full length tracks
6.8%

F. Wang
03/30/2000

TPC Reconstruction - Test Runs

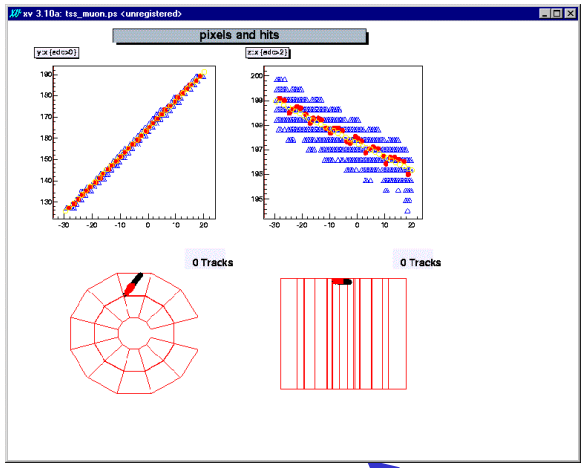




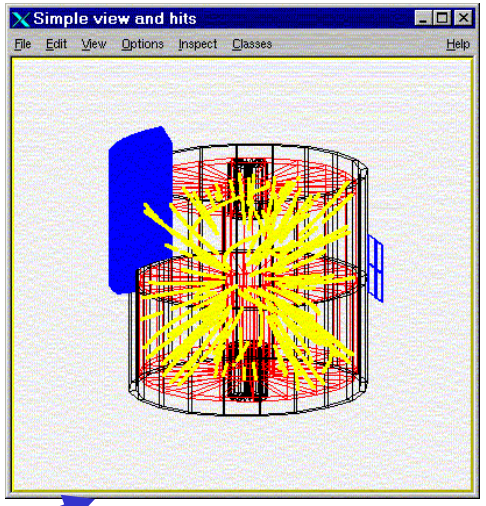
Beam gas events were reconstructed on the day they were taken.

Available Visualizations

Macros from Raimond



TPC tables



GSTAR

DAQ

TPC reconstruction

DST

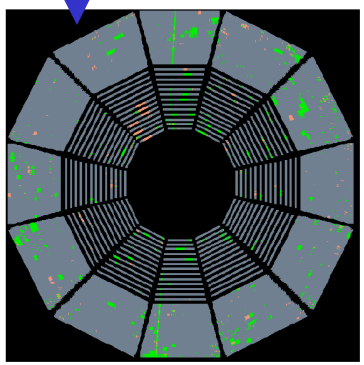
DST

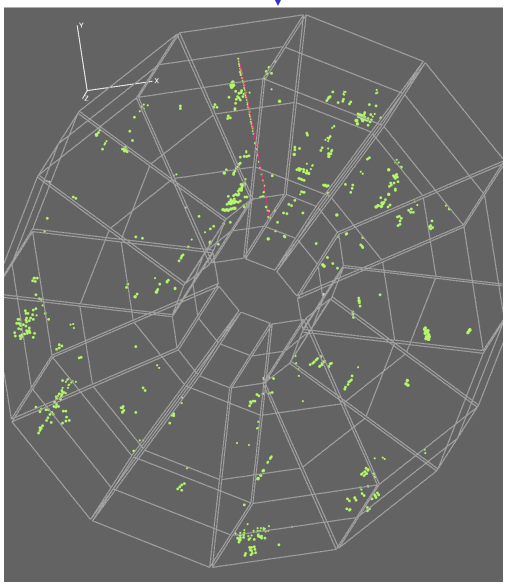
CAI

SN325

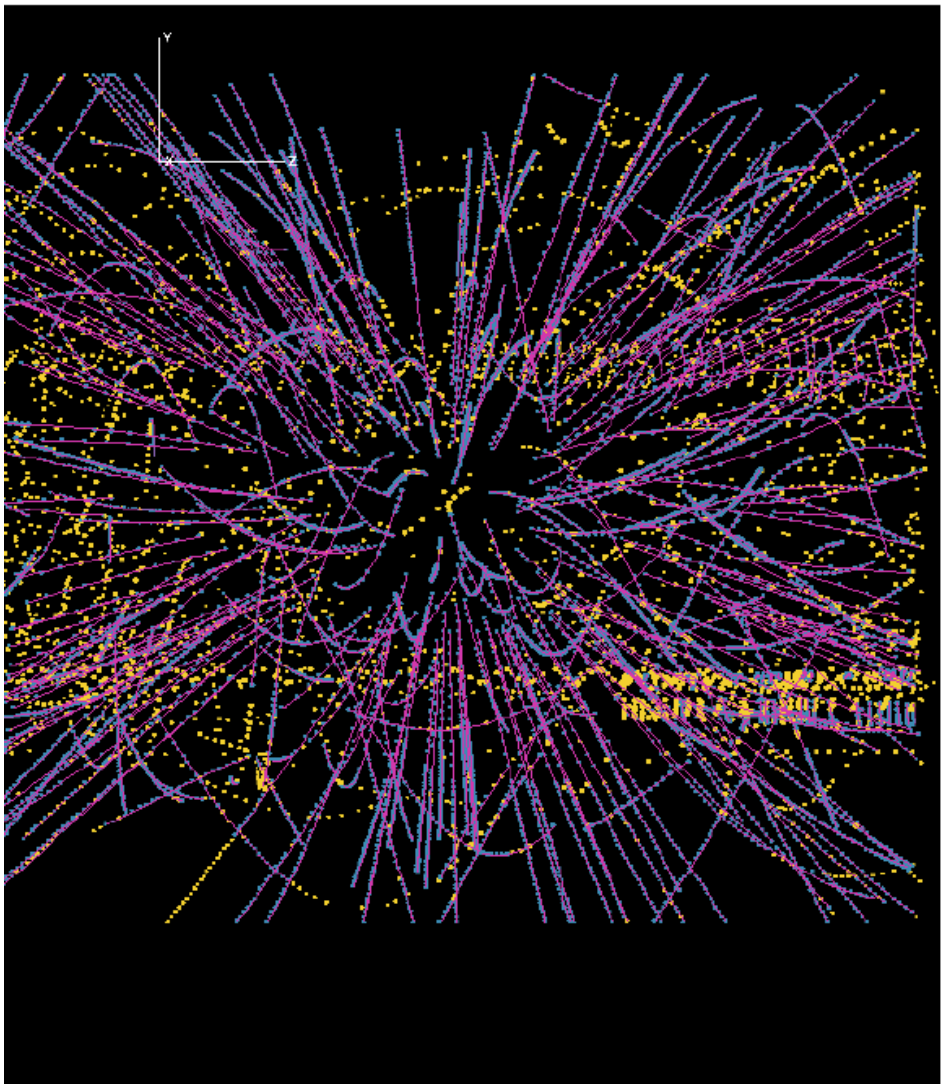
CAI

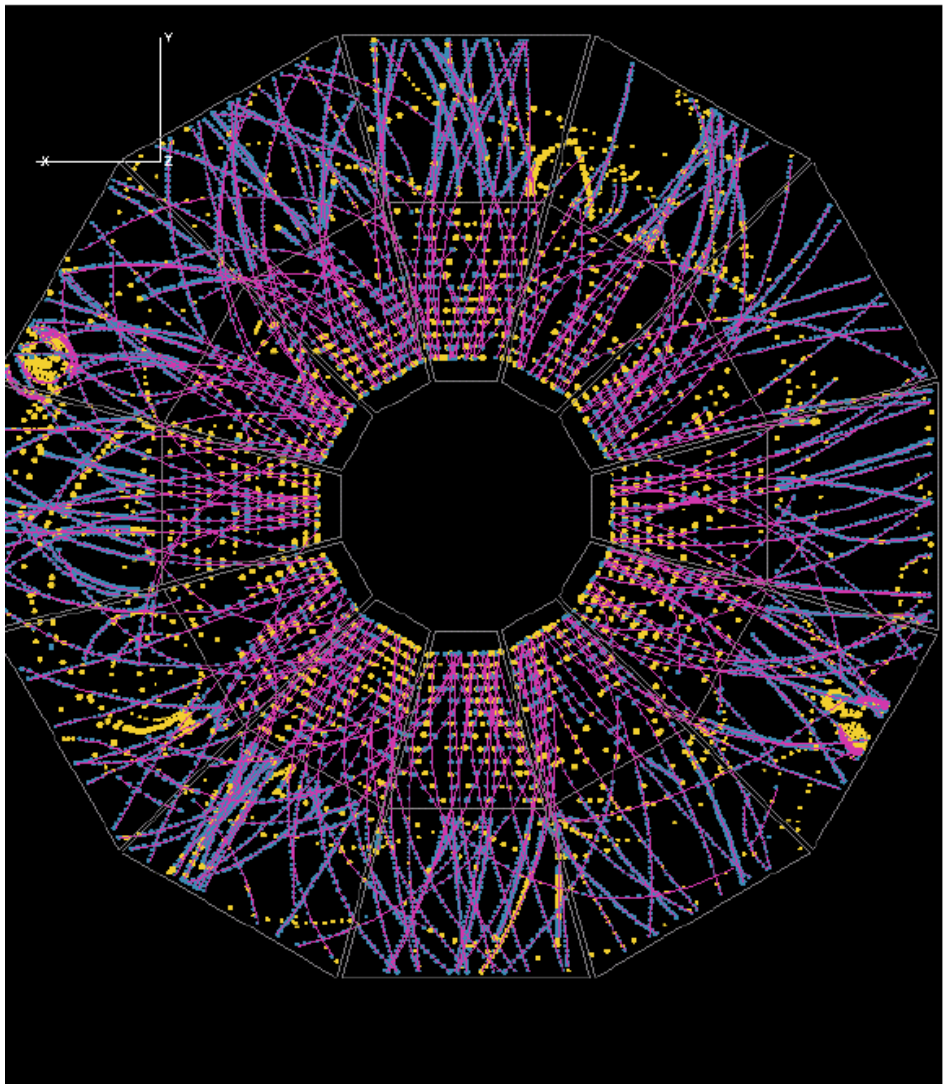
TPC Pad Monitor

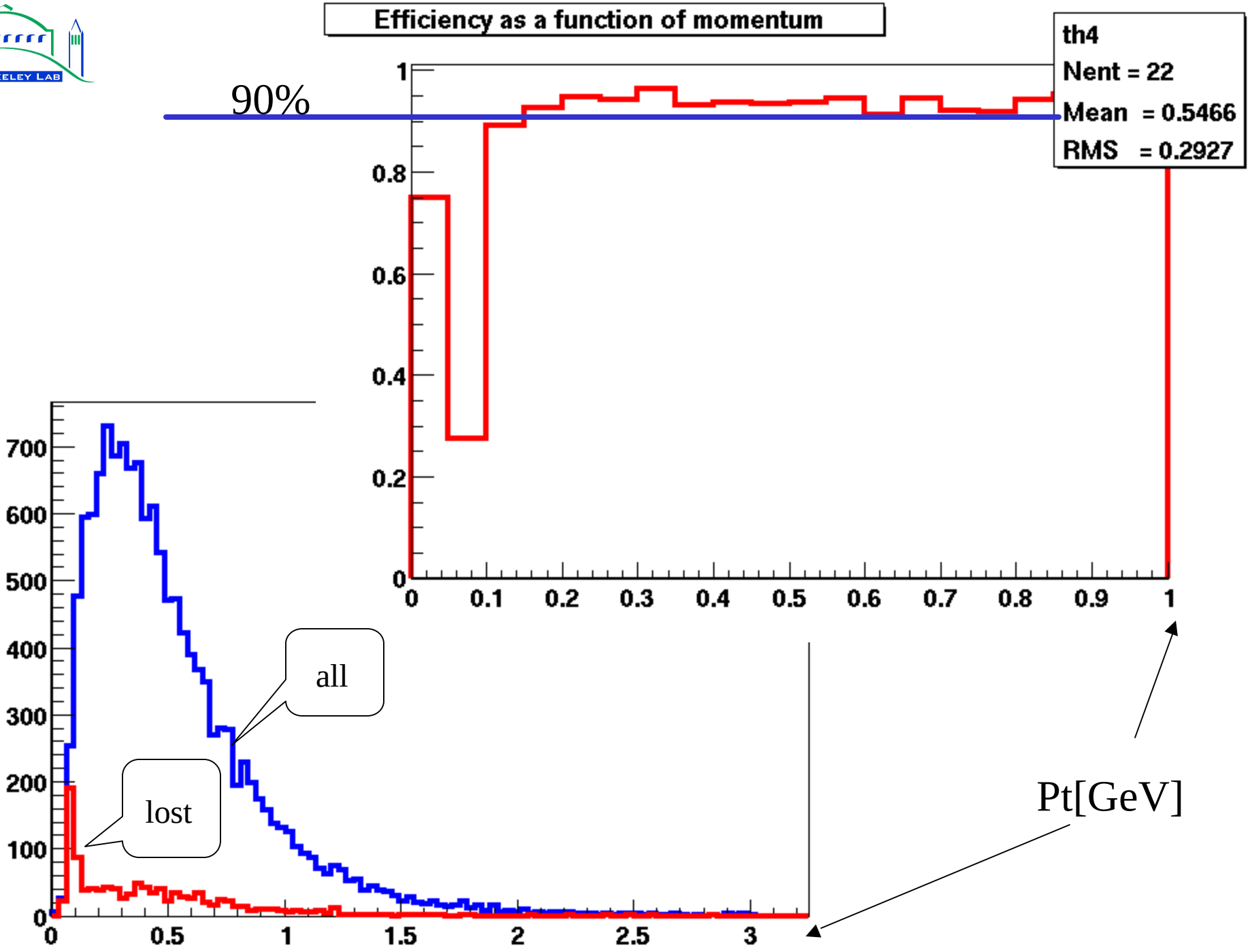




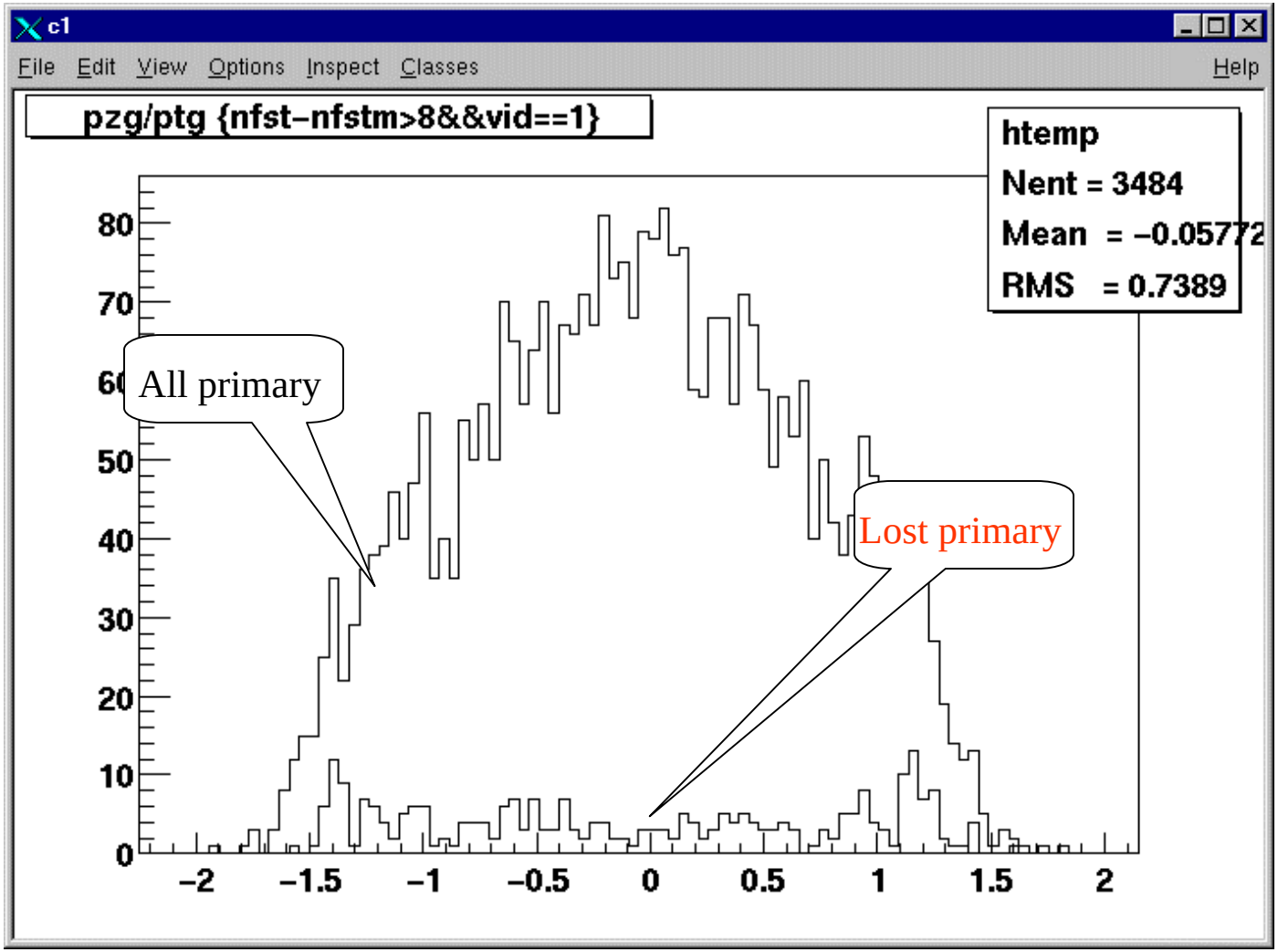
Reconstruction of Simulated Data






Efficiency as a function of momentum
th4
Nent = 22
Mean = 0.5466
RMS = 0.2927
90%
all
lost
Pt[GeV]

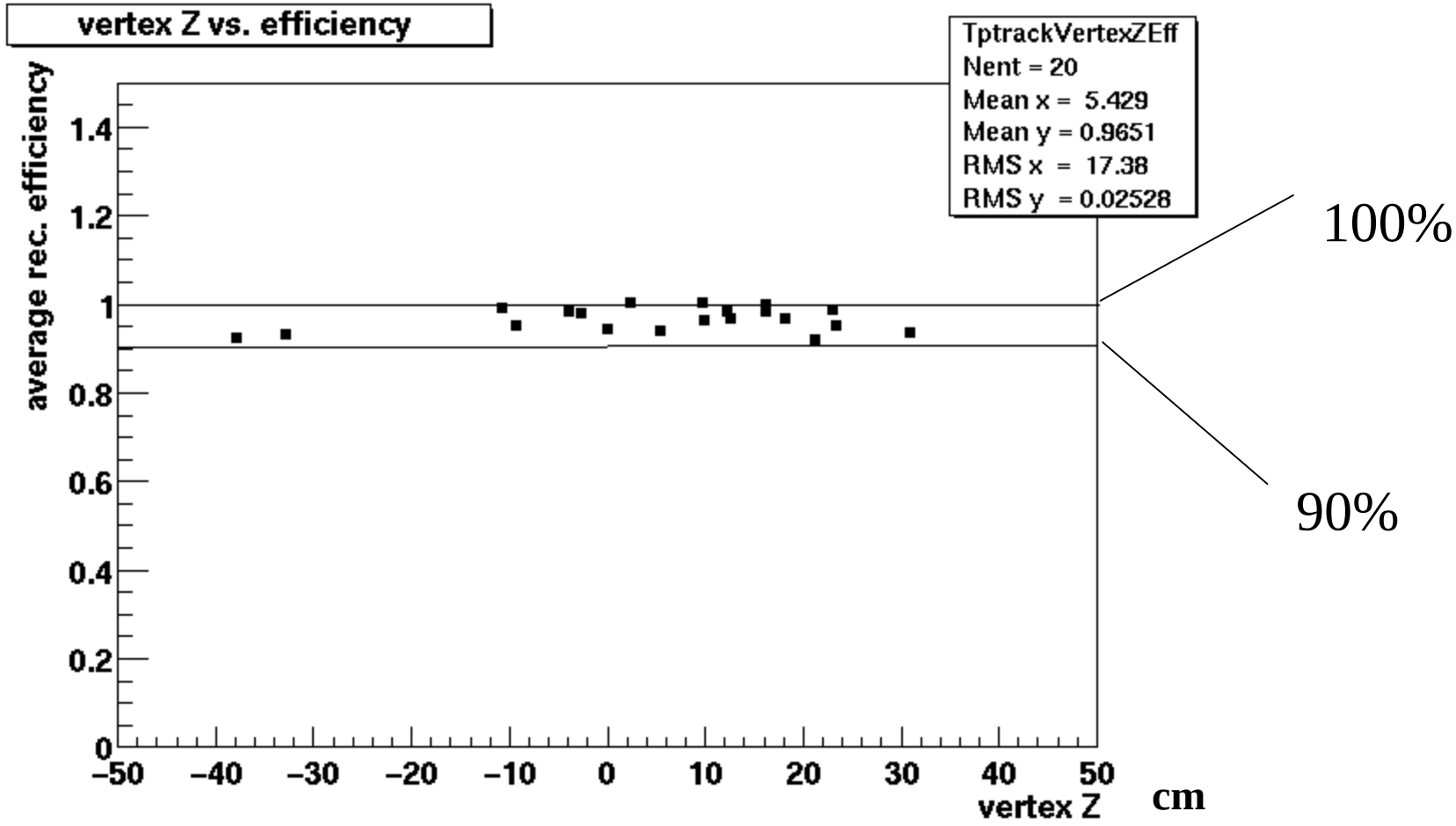
Efficiency As a Function of η



Efficiency degrades with multiplicity.

For Venus generator it averages at ~90% for central events

Track Reconstruction Efficiency

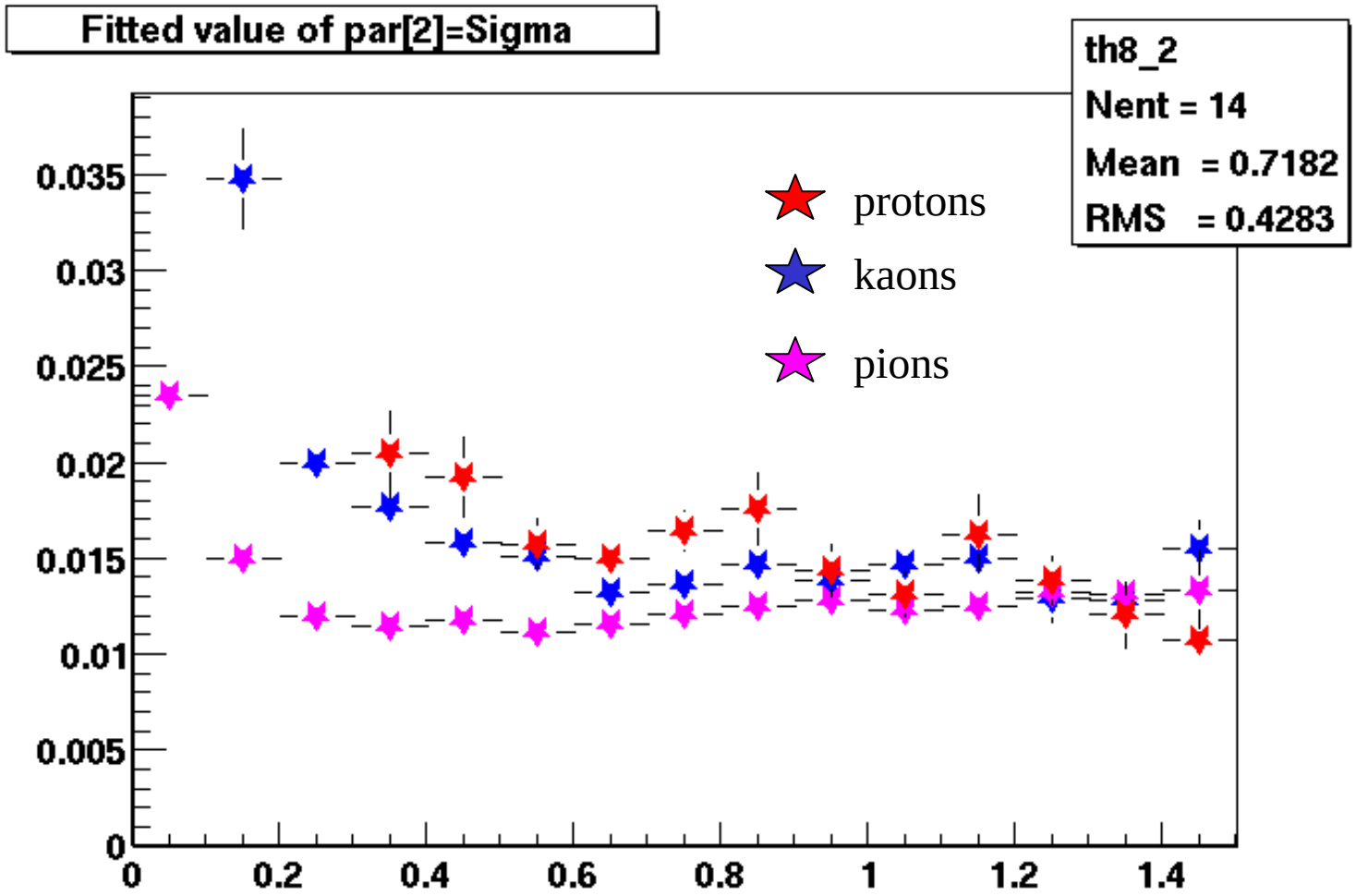


Track reconstruction efficiency at midrapidity as a function of the position of Au + Au collision

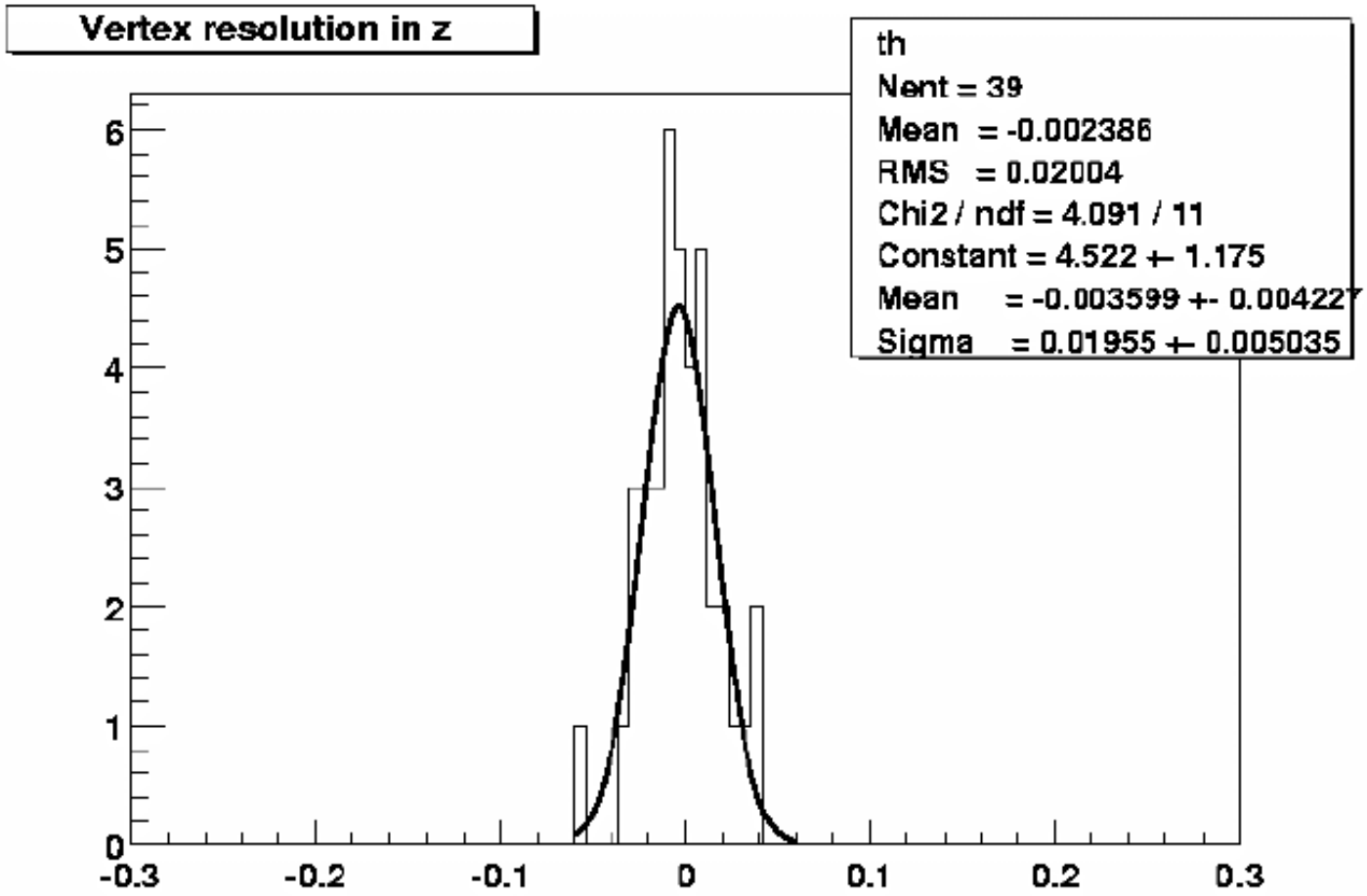
Q.Li 03/30/2000

Momentum Resolution

(simulated momentum - reconstructed momentum)/(simulated momentum)



Vertex Resolution



(Input vertex - reconstructed vertex)

Timing on Rcas6017
RHIC BNL Computing Farm
TPC Only

- 400 tracks/event

tpt Maker - 0.9s

tpt module - 0.5s

- 4000 tracks/event

tpt Maker - 12s

tpt module - 8s

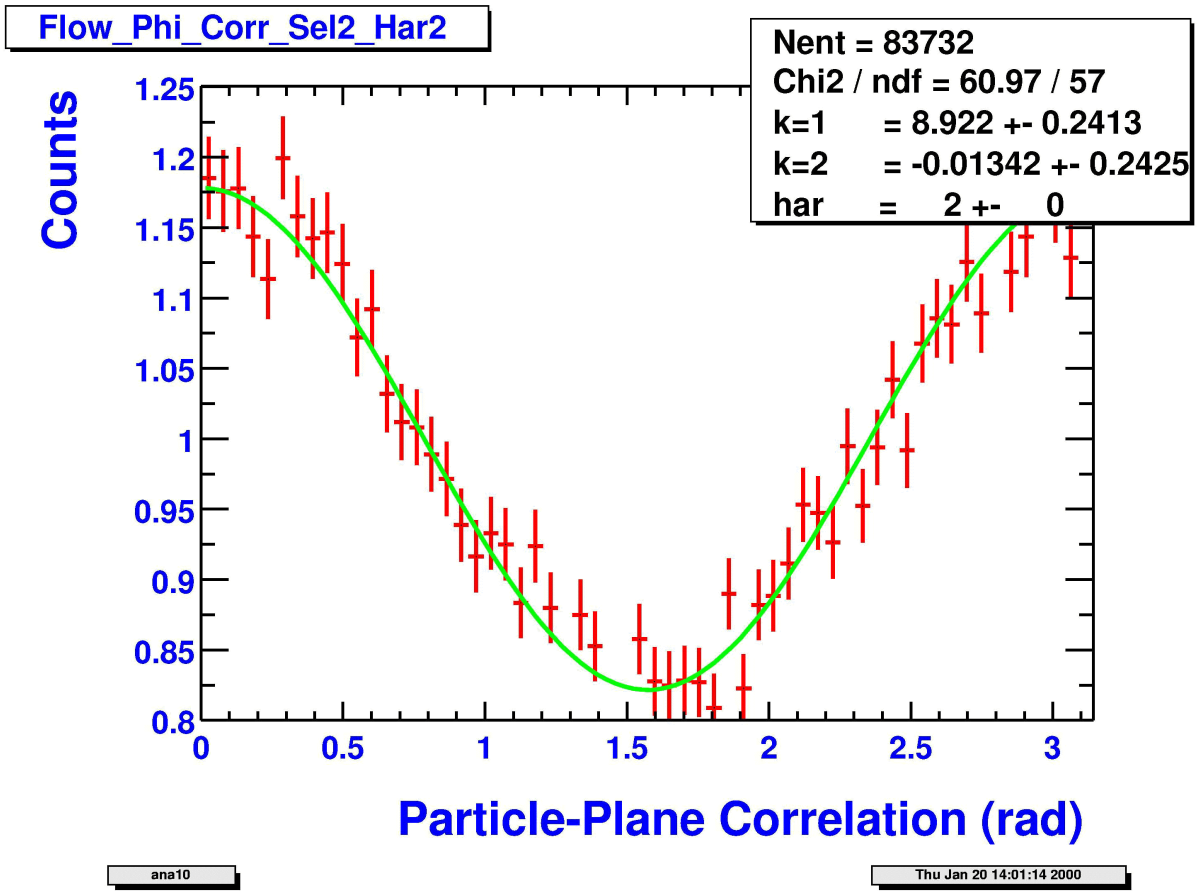
15 % of total CPU for

A chain with TPC only

This numbers were obtained before we switched from the FORTRAN based geometry routines to C++ StDbUtilities. Now Herb Ward is doing the timing.

Results of the Test Run Analysis and Simulations Show Our Readiness to Analyze Data in Summer of 2000.

Azimuthal Angle pions With Respect to the Reaction Plane



60 events

1 minute of data taking

Full reconstruction chain used

Put in 10% found 8.9%