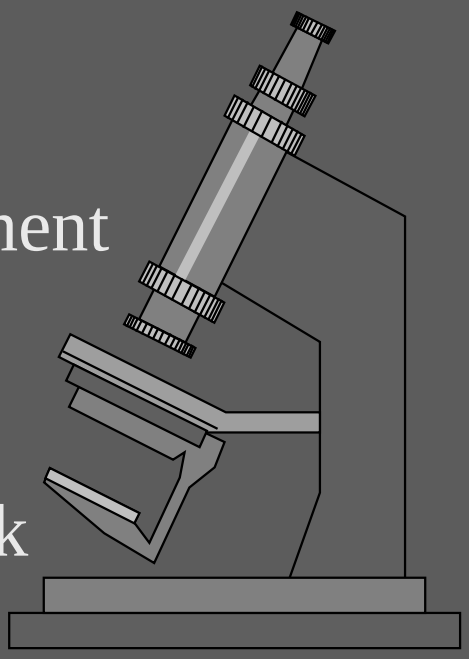
Session II

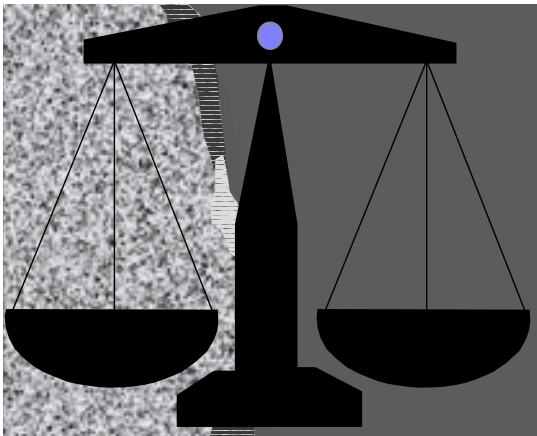
Analysis Software and Results

- Data Analysis - Maher
  - Analysis of the August 1997 data
  - Conclusions regarding the E614 chamber design
  - What needs to be done
    - Analysis software
    - Chamber hardware
    - Measurements
- Noise problem - Grant
- Cross talk - Vladimir

Analysis of ‘97 Data

- Calibrations
- Timing and drift characteristics
- Cuts
- Tracking & Alignment
- Efficiency
- Noise and cross talk



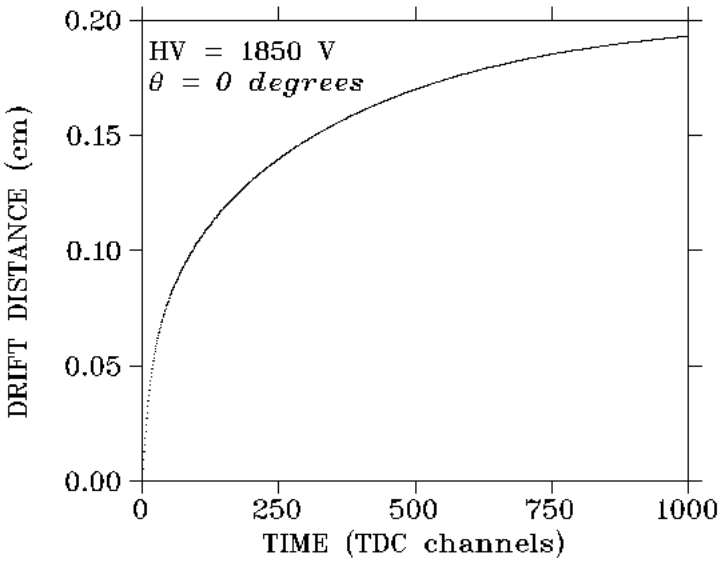


Calibration

- TDC time zero
  - Front end dependent
  - High voltage dependent
- Drift distance $R_d(t,\theta_t,HV)$
  - Use data assuming

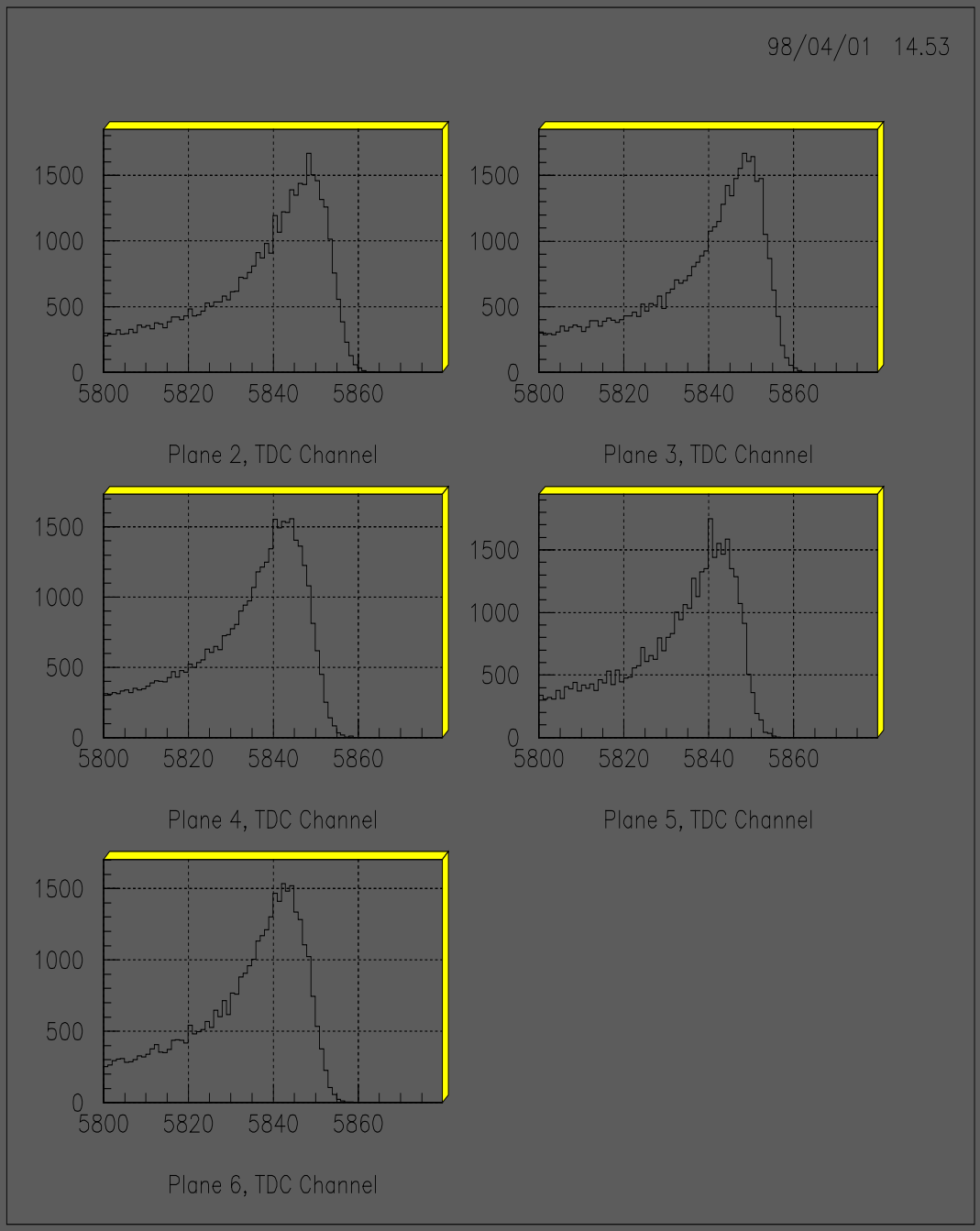
    R_d α integral of TDC spectrum
  - Use GARFIELD
- Plane and wire positions

GARFIELD


HV = 1850 V
θ = 0 degrees
DRIFT DISTANCE (cm)
0.20
0.15
0.10
0.05
0.00
0
250
500
750
1000
TIME (TDC channels)

TDC Signal Arrival Time

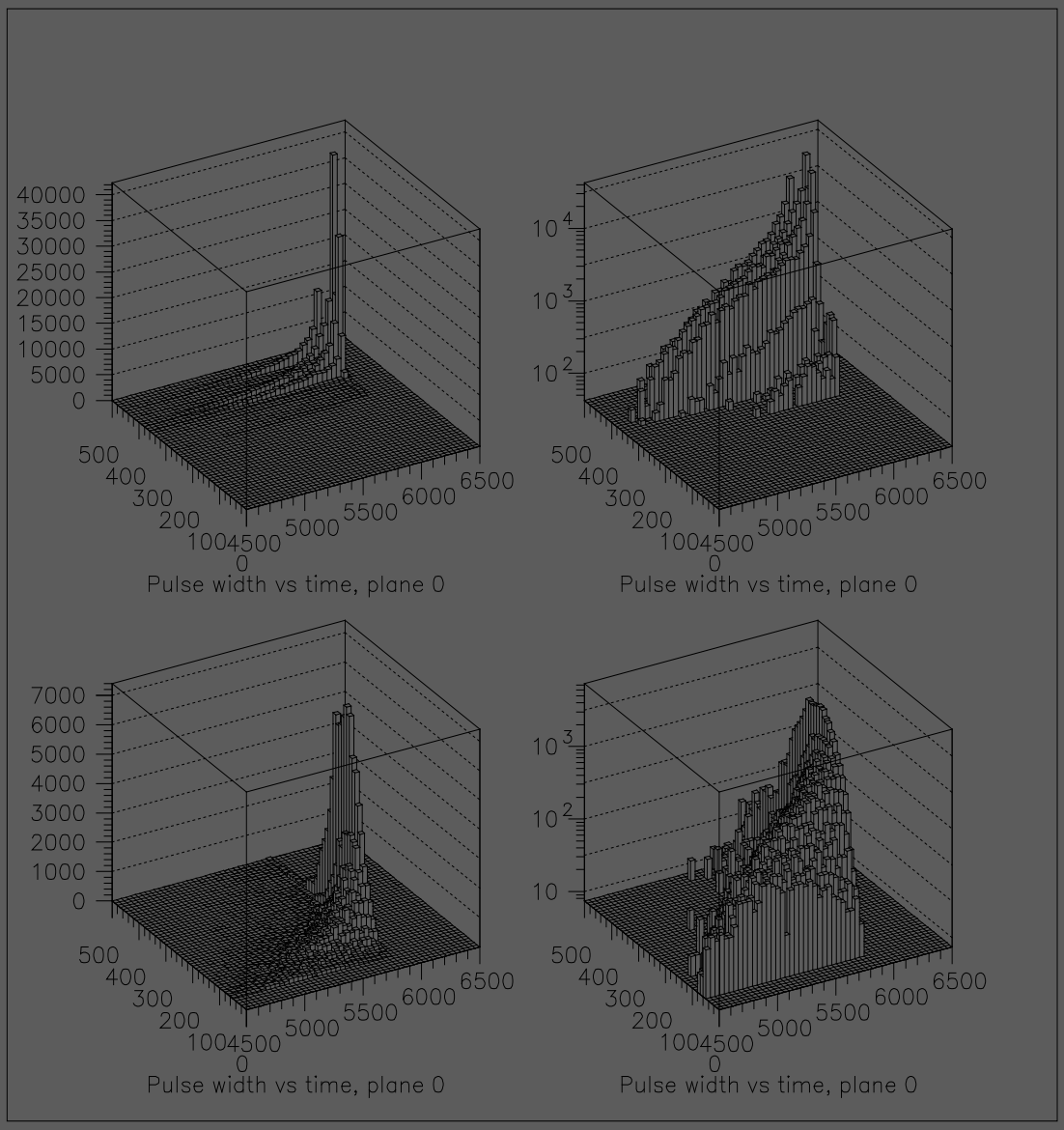
- New front end @140mV, 1850V, 0^0



TDC Signal Arrival Time and Width

A) Old front end, 1850V, 0^0

B) New front end, 1850V, 0^0

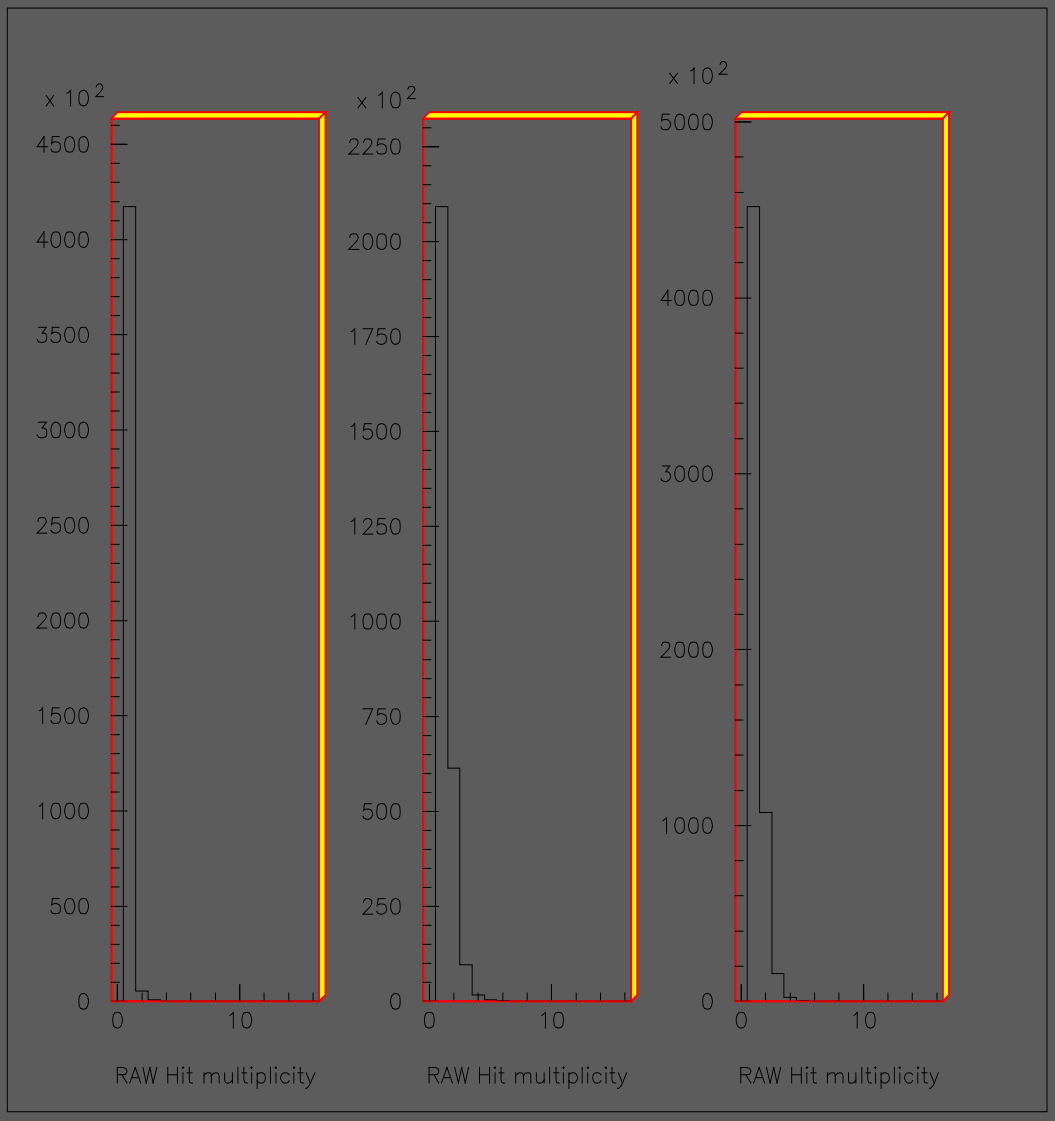


TDC Multiplicity

A) Old front end @200 mV threshold, 1850V, 0^0

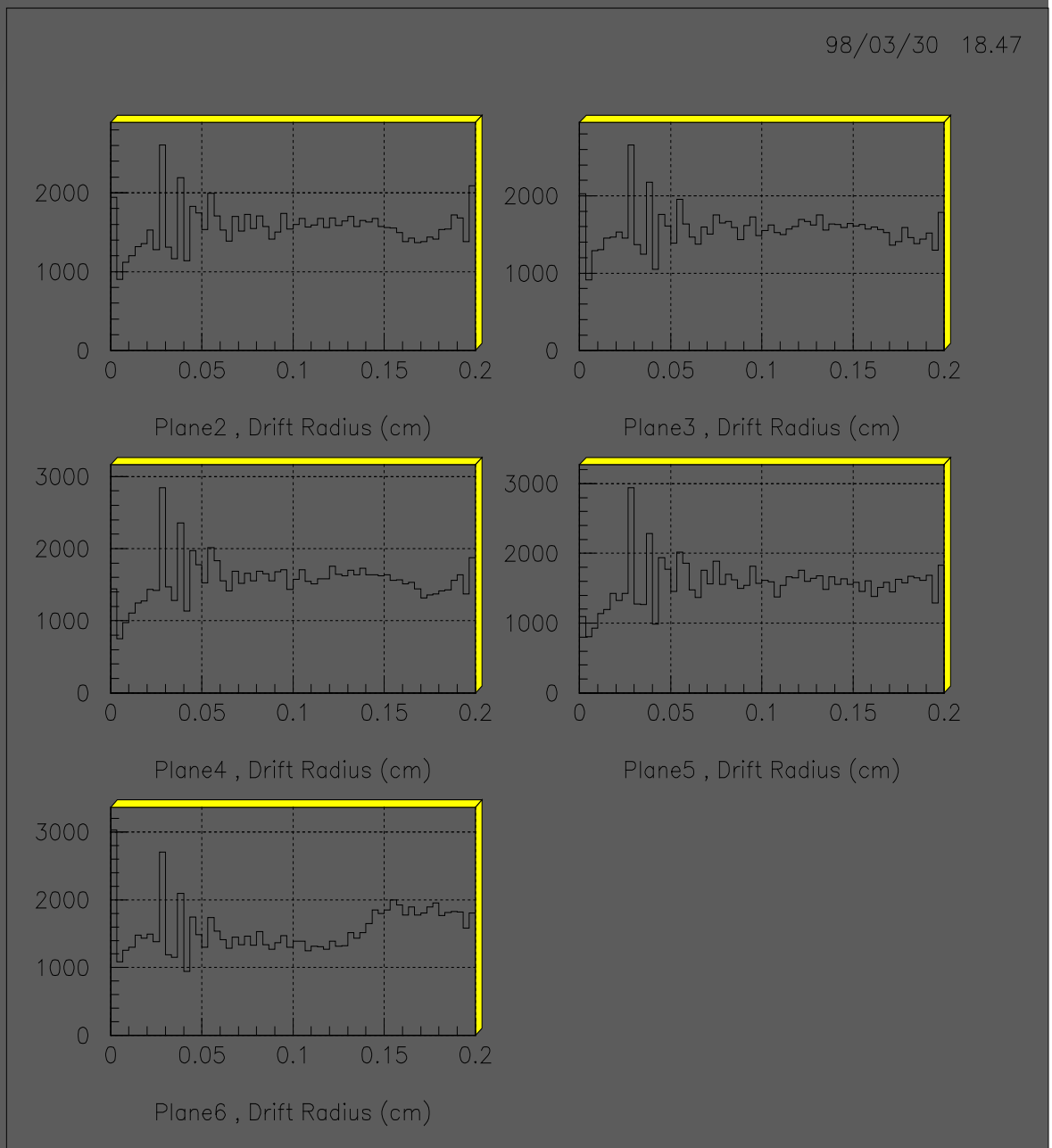
B) New front end @220 mV threshold, 1850V, 0^0

C) New front end @140 mV threshold, 1850V, 0^0



Drift Distance

- New front end @ 140mV, 1850V, 0^0



Cuts

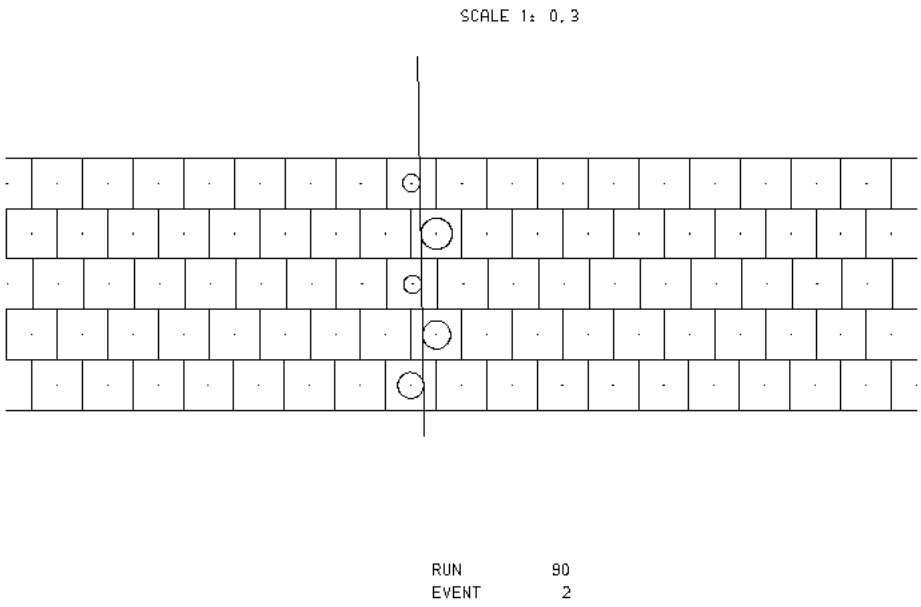
- Global cuts
  - Only one hit in small scintillator
  - Only one hit in large scintillator
  - 5/5 X planes firing for tracking, 2/5 X planes firing for Efficiency
- Tracking cuts
  - Hit is required to be within the GARFIELD file range to be used in fit
  - Plot tracking residuals only if $-1<\theta_t<1$
- Efficiency cuts
  - Average tracking residual < 100 μm

Tracking

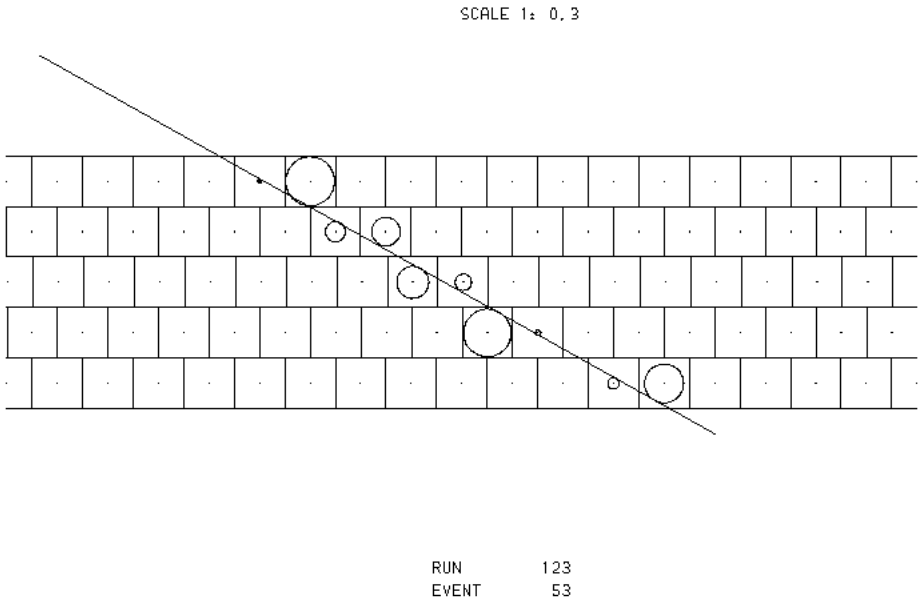
- Tracking method
  - For “clean” data (1 firing wire/plane @ 0^0)
  - When multiple TDC hits are present
  - When cross talk hits are present
- Position resolution
- Alignment
  - Plane alignment
  - Wire positions

Event Display

A) 0^0



B) 60^0



Tracking Method I

- Obtain a track using wire positions - no timing

  ==> θ_t

- Obtain drift distance from GARFIELD calibration file
- Use θ_t to find hit position on drift circle
  - two possible choices “left”/”right” of drift circle
  - choose side that is closer to the track (smaller residual)
- Re-fit track using hit position
- Repeat until θ_t converges

Tracking Method II

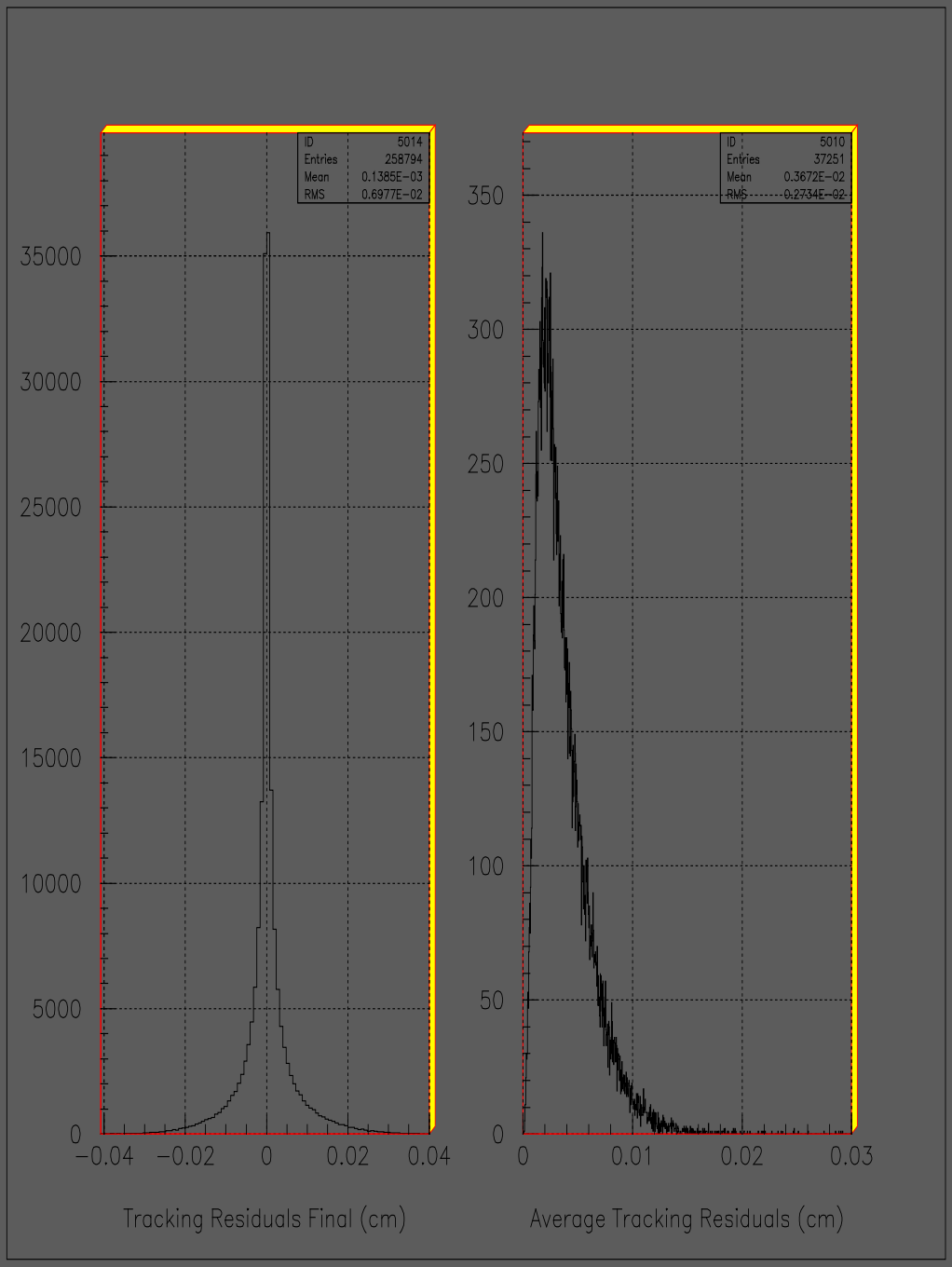
- When multiple TDC hits are present:
  - try all possible combinations and choose the combination that gives best average tracking residual
    - 90% of the cases the first arrived hit gives the best result
    - the average number of combinations is ~4 at 0^0 and 18 at 60^0
- When cross talk hits are present
  - start by fitting all the hits
  - obtain tracking residuals for each hit and cut out hits > cut-level1
  - refit the track with the remaining hits
  - obtain tracking residuals for each hit and cut out hits > cut-level 2
  - continue iteration to last cut

Tracking Residuals

- Definitions:
  - Hit residual (δd): closest distance of approach between track and hit
  - Event residual: $\Sigma\, \delta d/N$
- The width of the tracking residuals reflect
  - Accuracy of GARFIELD file
  - Accuracy of TDC time zero
  - Wire and plane positions
  - Accuracy of position resolution
  - Accuracy of the tracking method

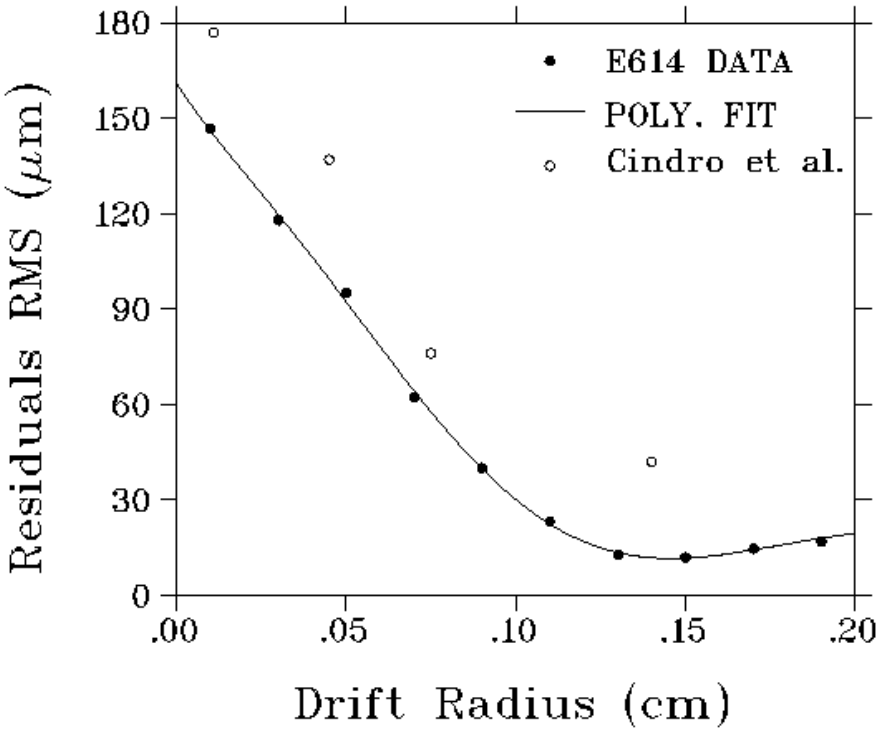
Tracking Residuals

- New front end @220mV, 1850V, 0^0



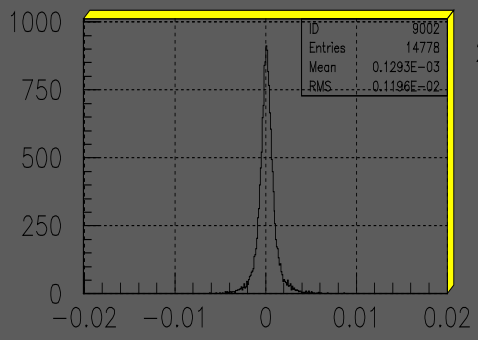
Position Resolution

- New front end @220mV, 1850V, 0^0

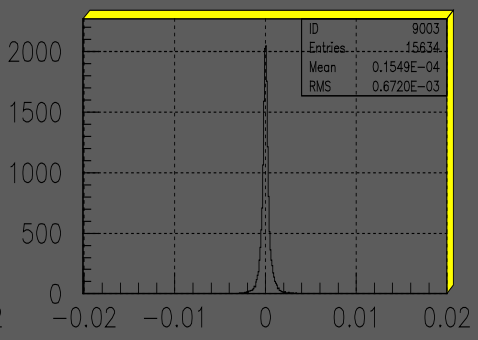


Plane Residuals

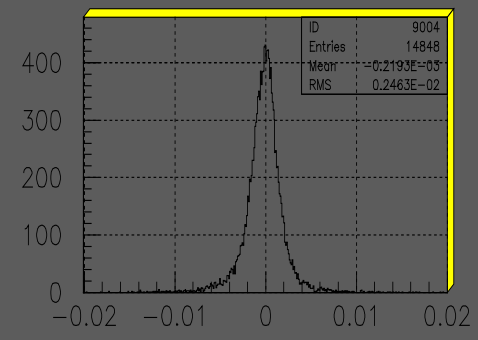
- New front end @220mV, 1850V, 0^0



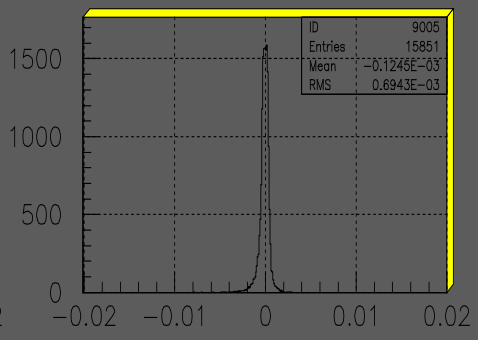
Plane 2, Residuals (cm)



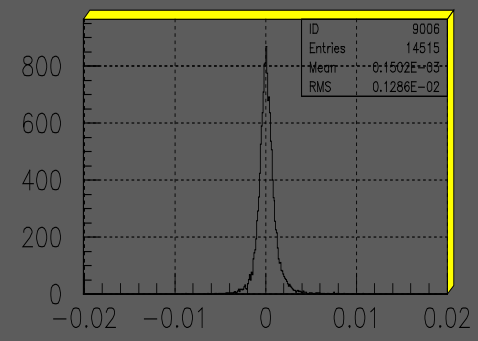
Plane 3, Residuals (cm)



Plane 4, Residuals (cm)



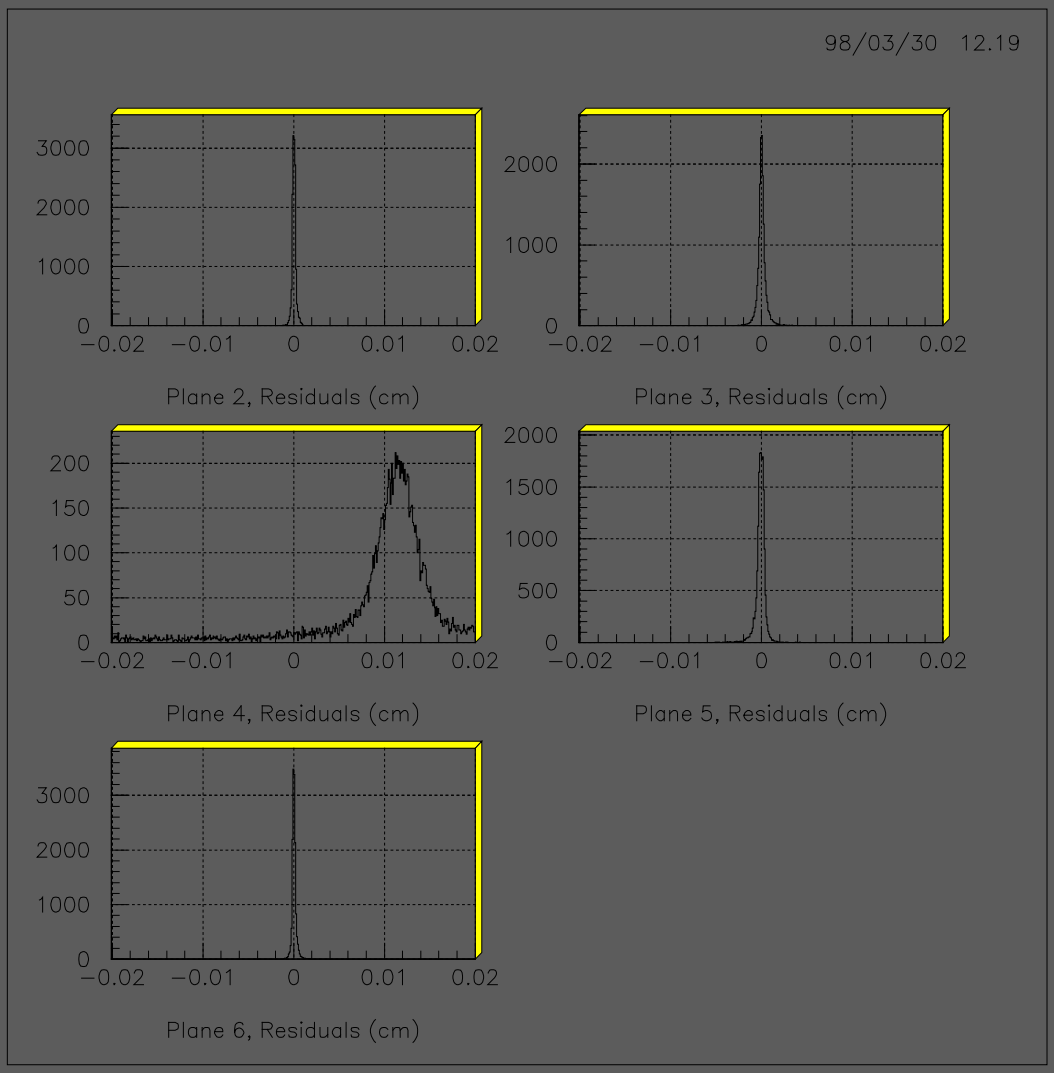
Plane 5, Residuals (cm)

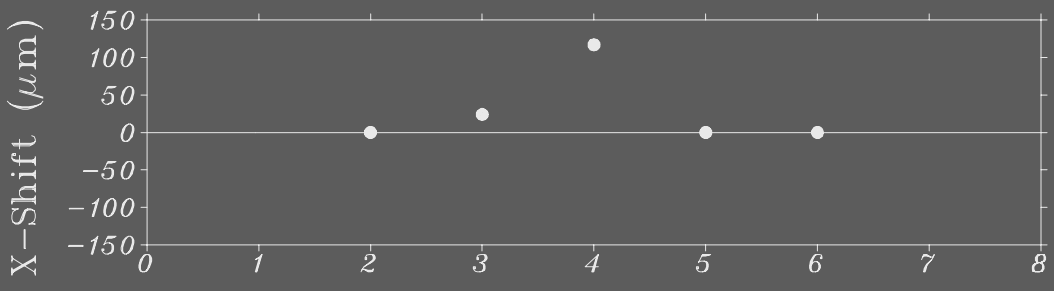


Plane 6, Residuals (cm)

Plane Residuals

- New front end @220mV, 1850V, 0^0





Plane Alignment

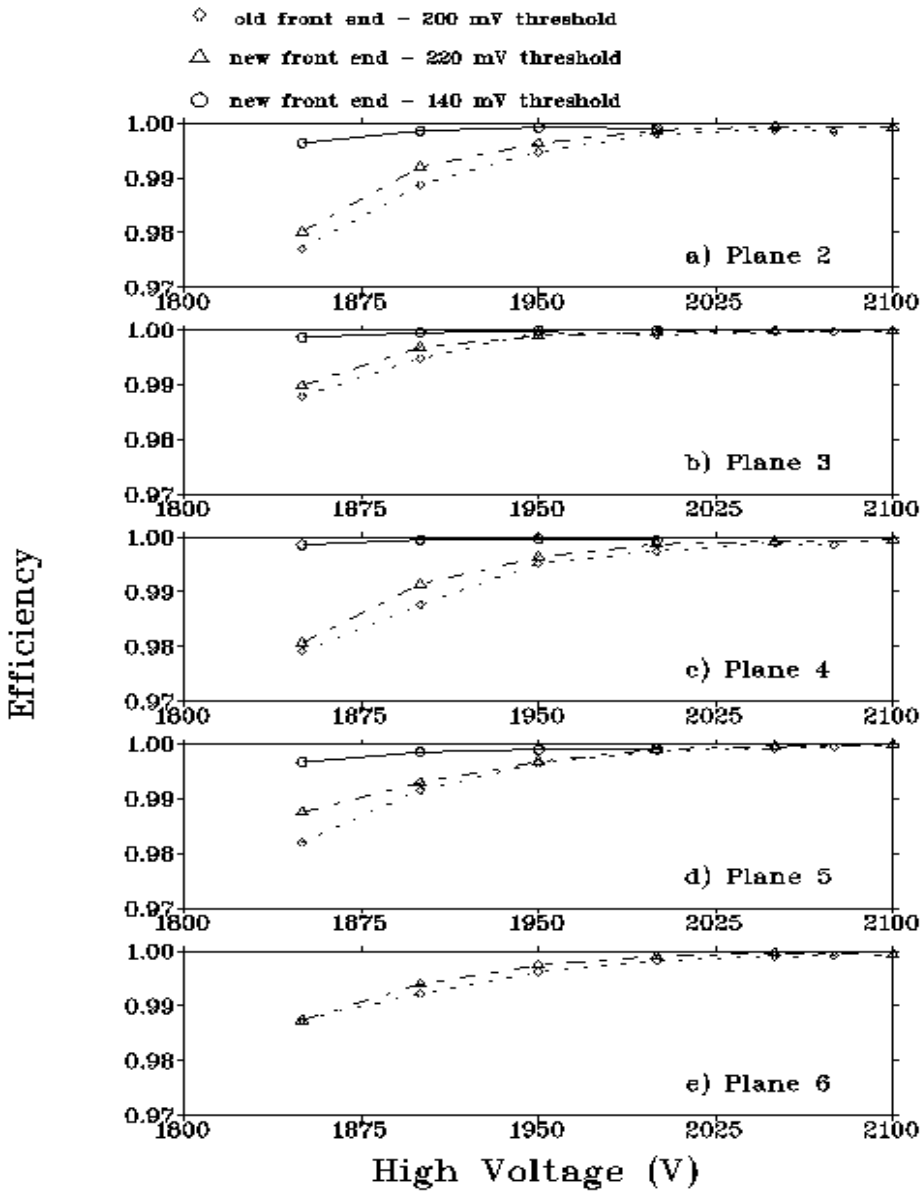
- Track N events
- Calculate an average tracking residual for each plane
- Find plane with largest average residual and remove from fit
- Track N events and compute new average residuals
- Shift the “removed plane” by its average residual

Efficiency

- High voltage dependence
- Threshold dependence
- Plane-to-plane variations
- Cell-to-cell variations
- Variation with distance from the sense wire
- Intensity dependence

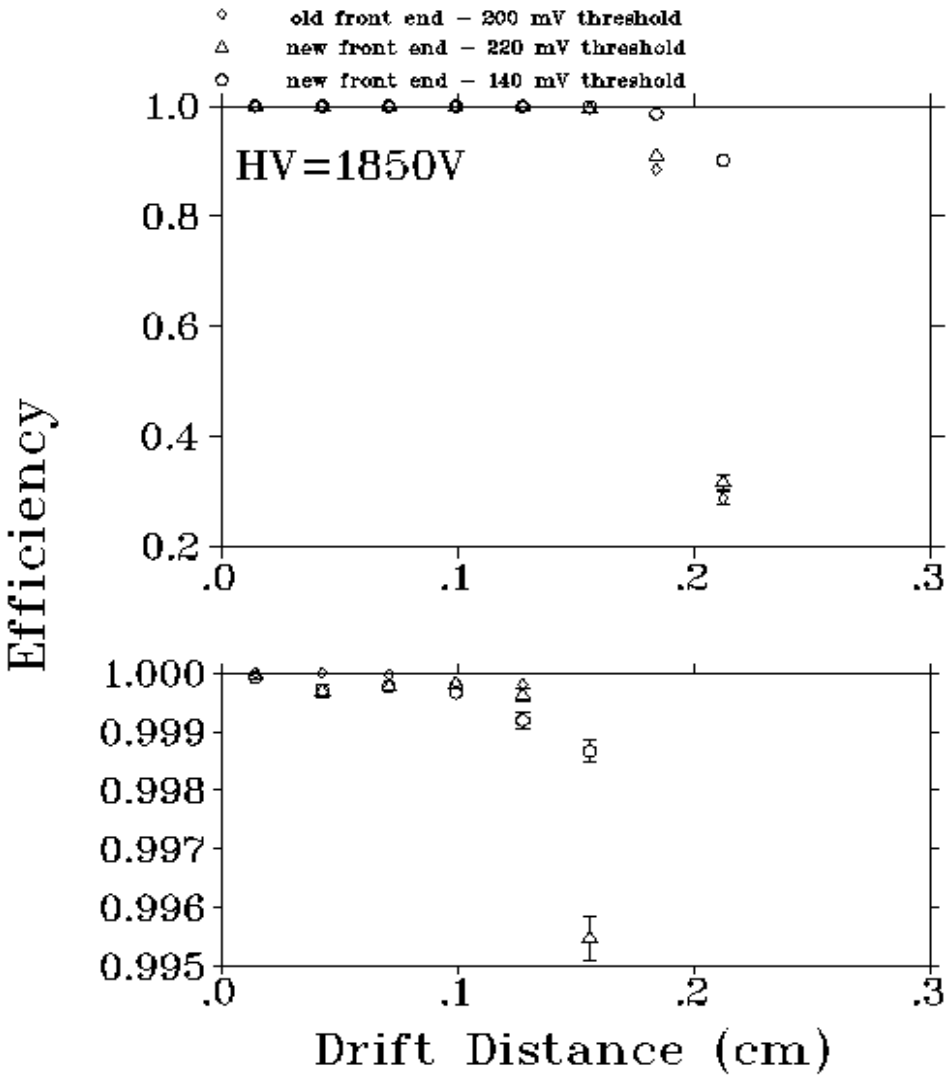
Efficiency

High Voltage and Threshold Dependence



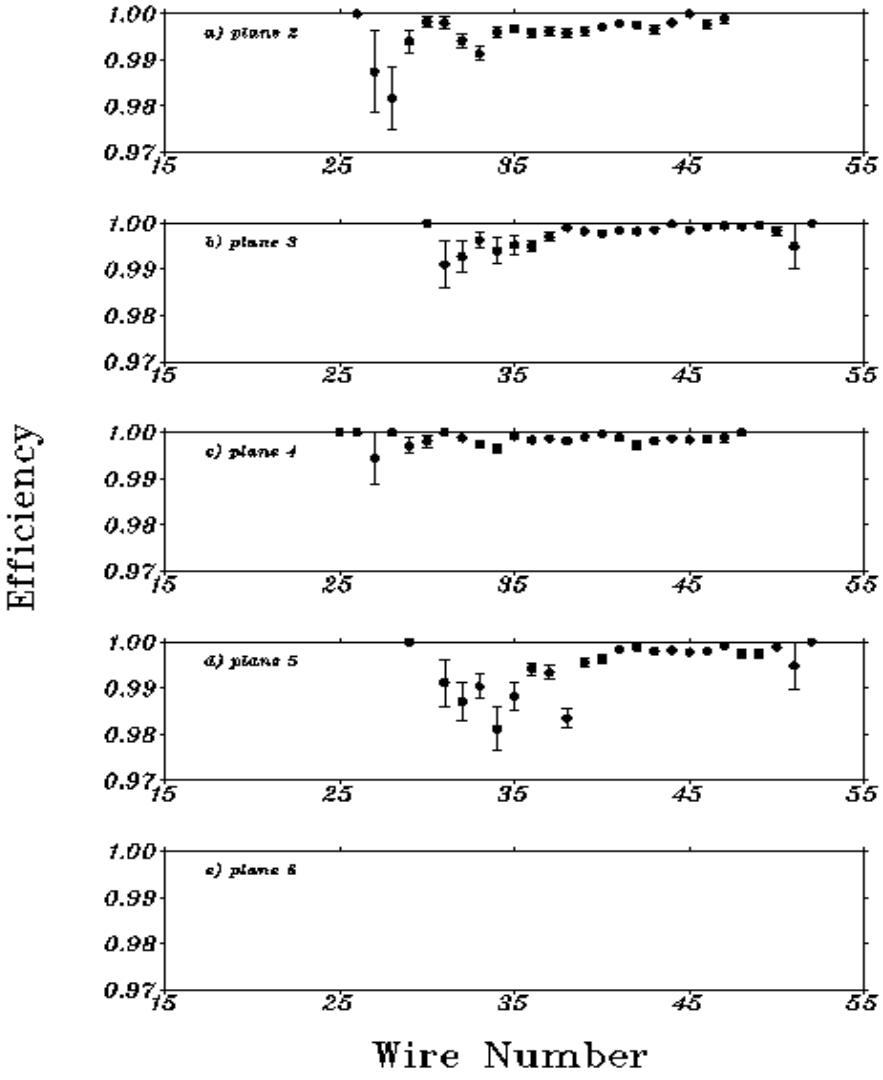
Efficiency

Drift Distance Dependence



Efficiency
Cell Dependence

- New front end @140mV, 1850V, 0^0

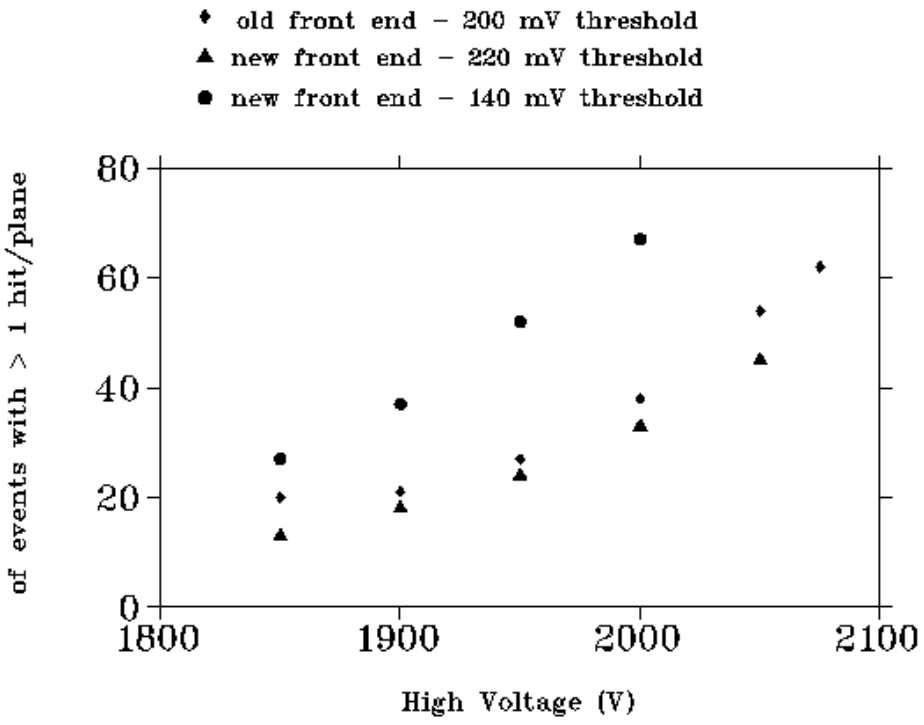


Noise and Cross Talk

- Noise
  - As a function of high voltage
  - As a function of threshold
- Cross talk
  - As a function of high voltage
  - As a function of threshold

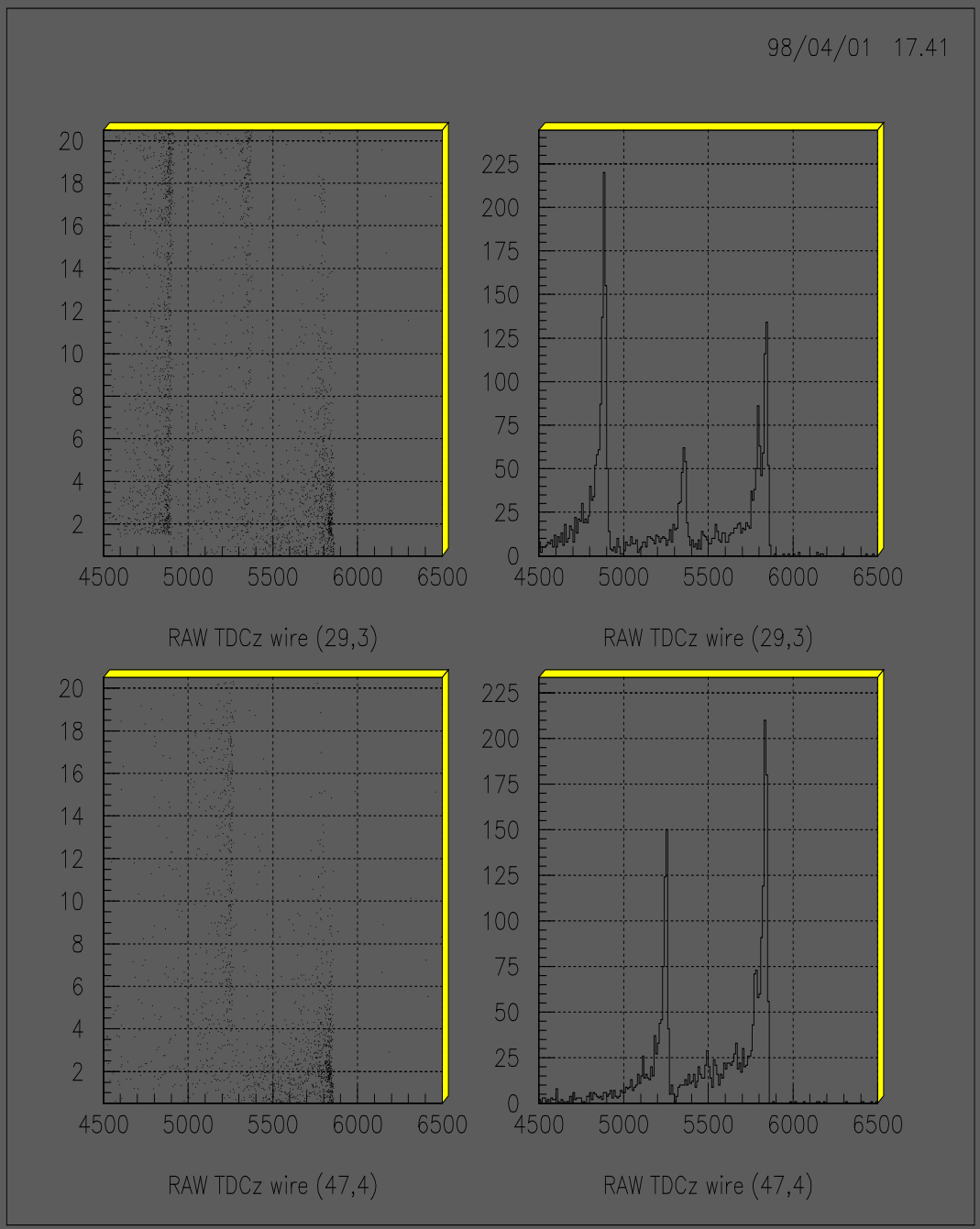
Noise and Cross Talk

As a Function of Threshold and High Voltage



Noise at Higher Voltage

- New front end @220mV, 2100V, 0^0

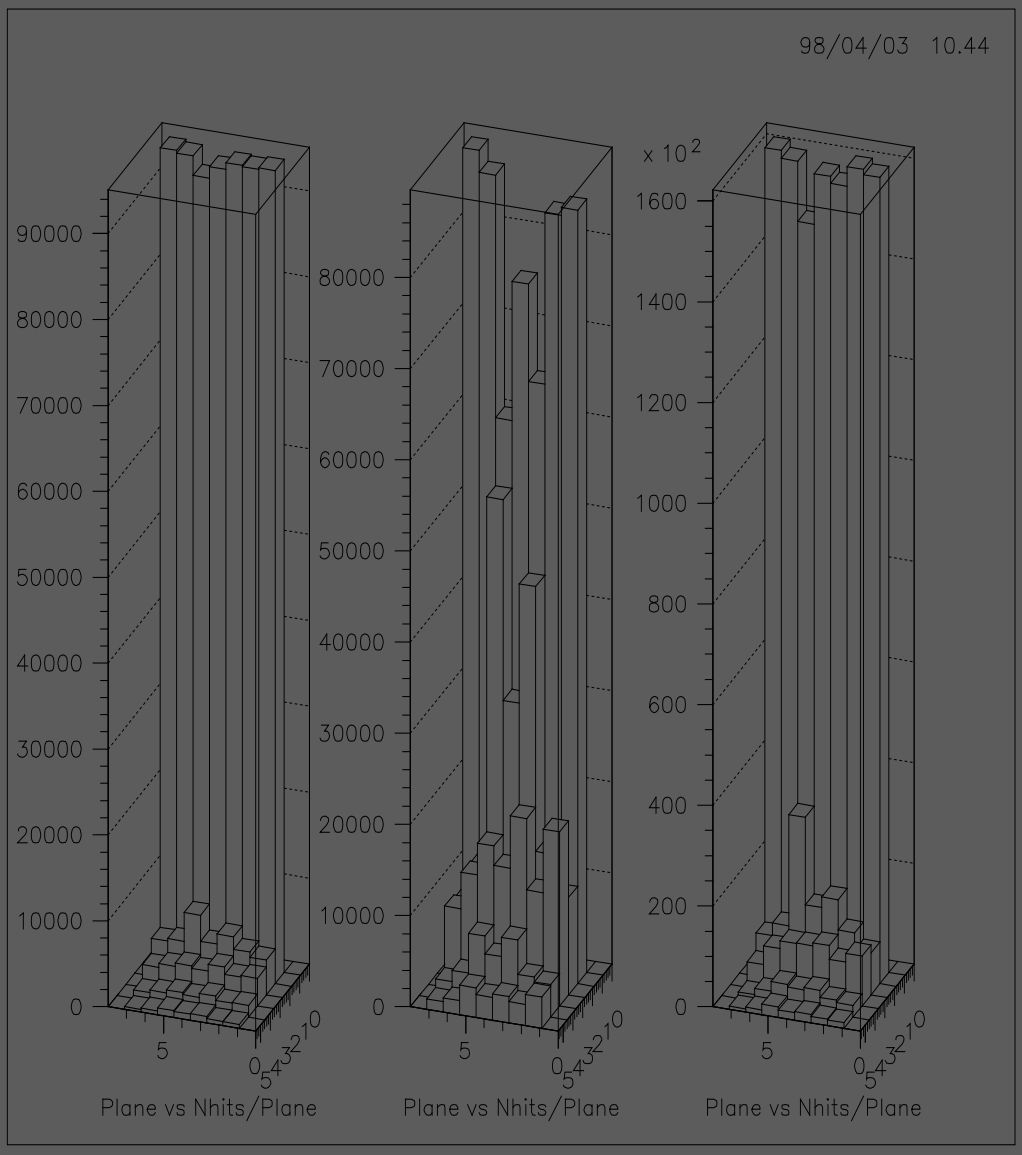


Noise and Cross Talk

A) New front end @220mV, 1850V, 0^0

B) New front end @220mV, 2100V, 0^0

C) New front end @140mV, 1850V, 0^0

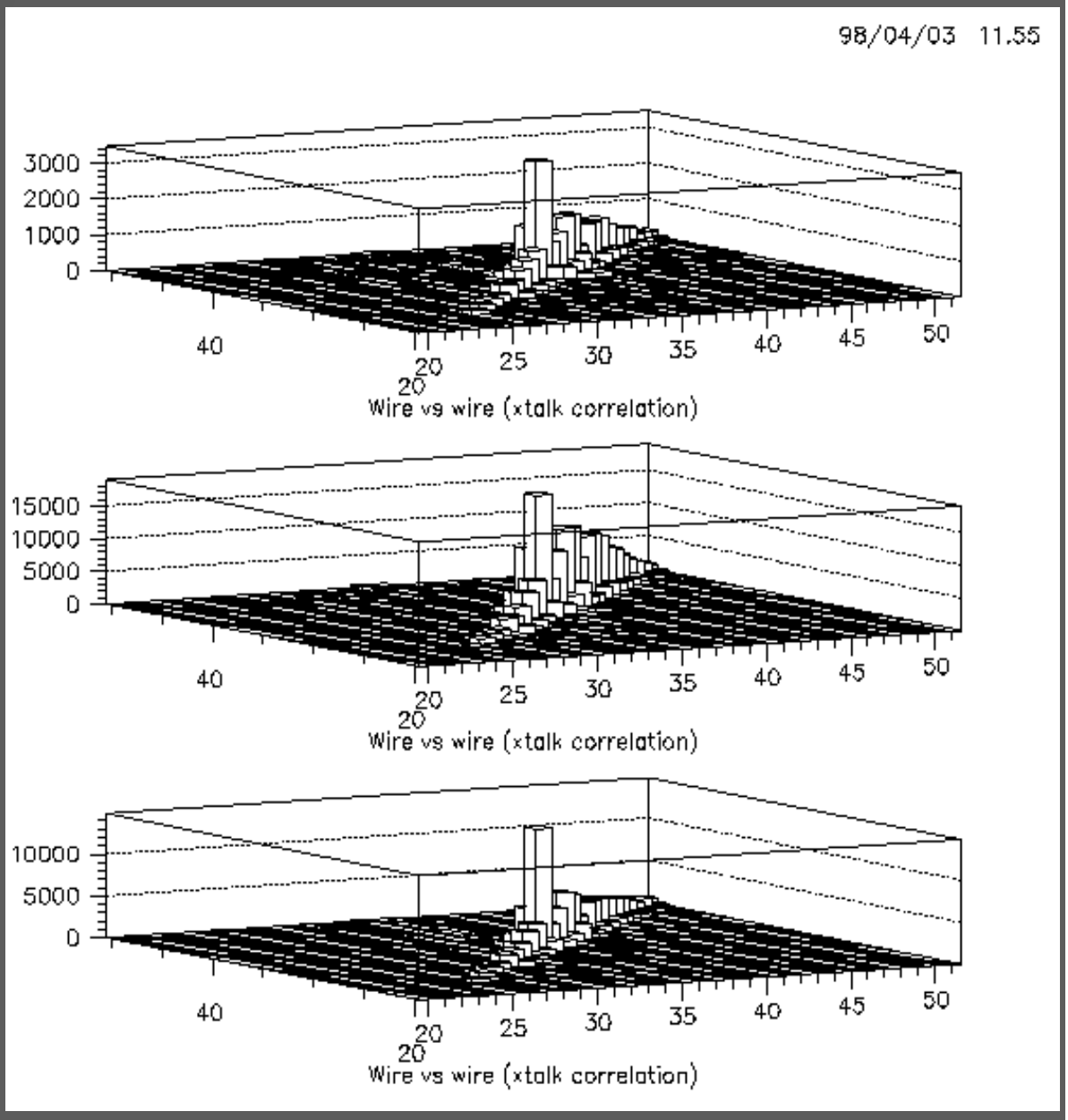


Cross Talk

A) New front end @220mV, 1850V, 0^0

B) New front end @220mV, 2100V, 0^0

C) New front end @140mV, 1850V, 0^0

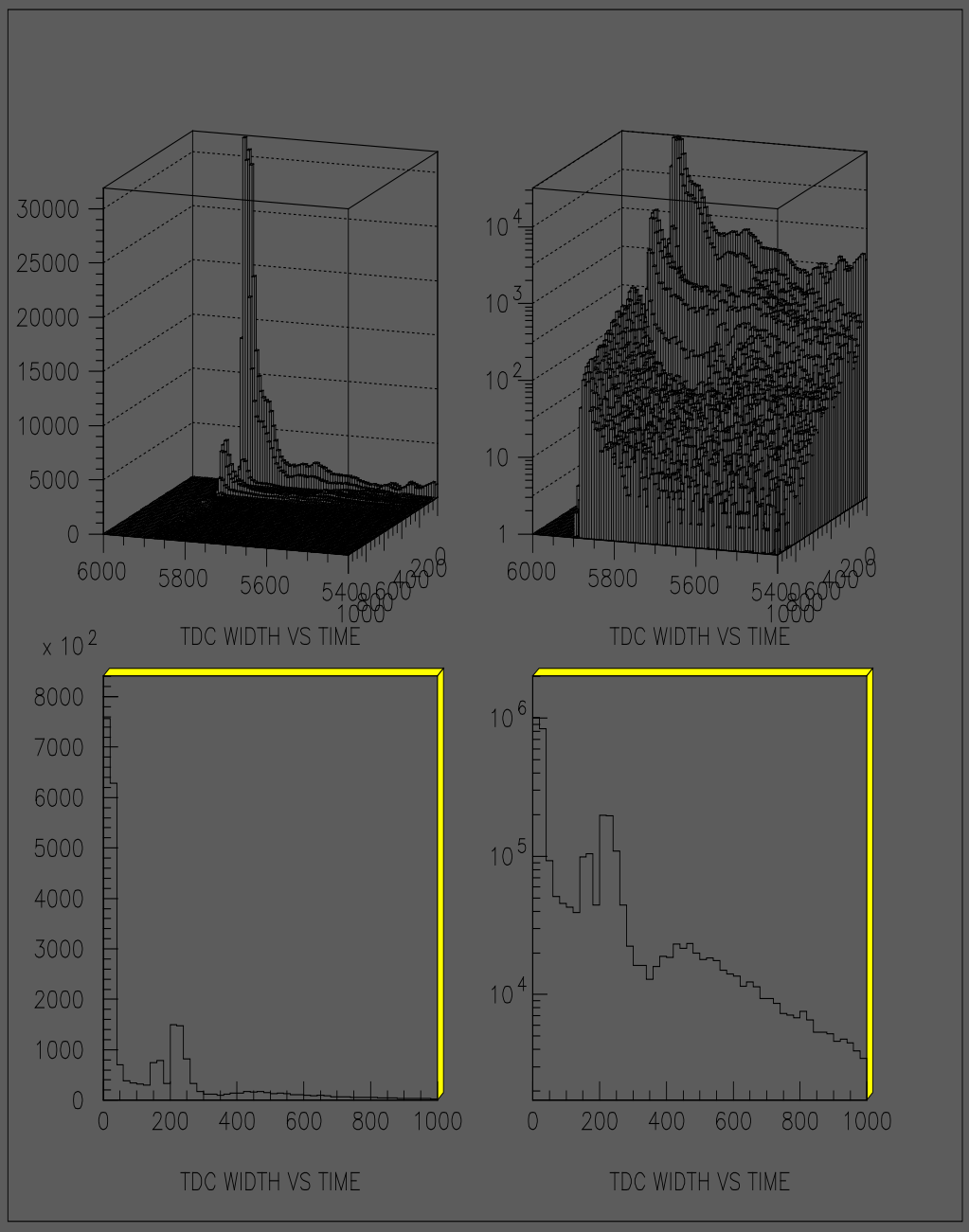


μ Runs

- Two concerns:
  - Width of the TDC signal
  - Cross talk (number of adjacent wires firing)

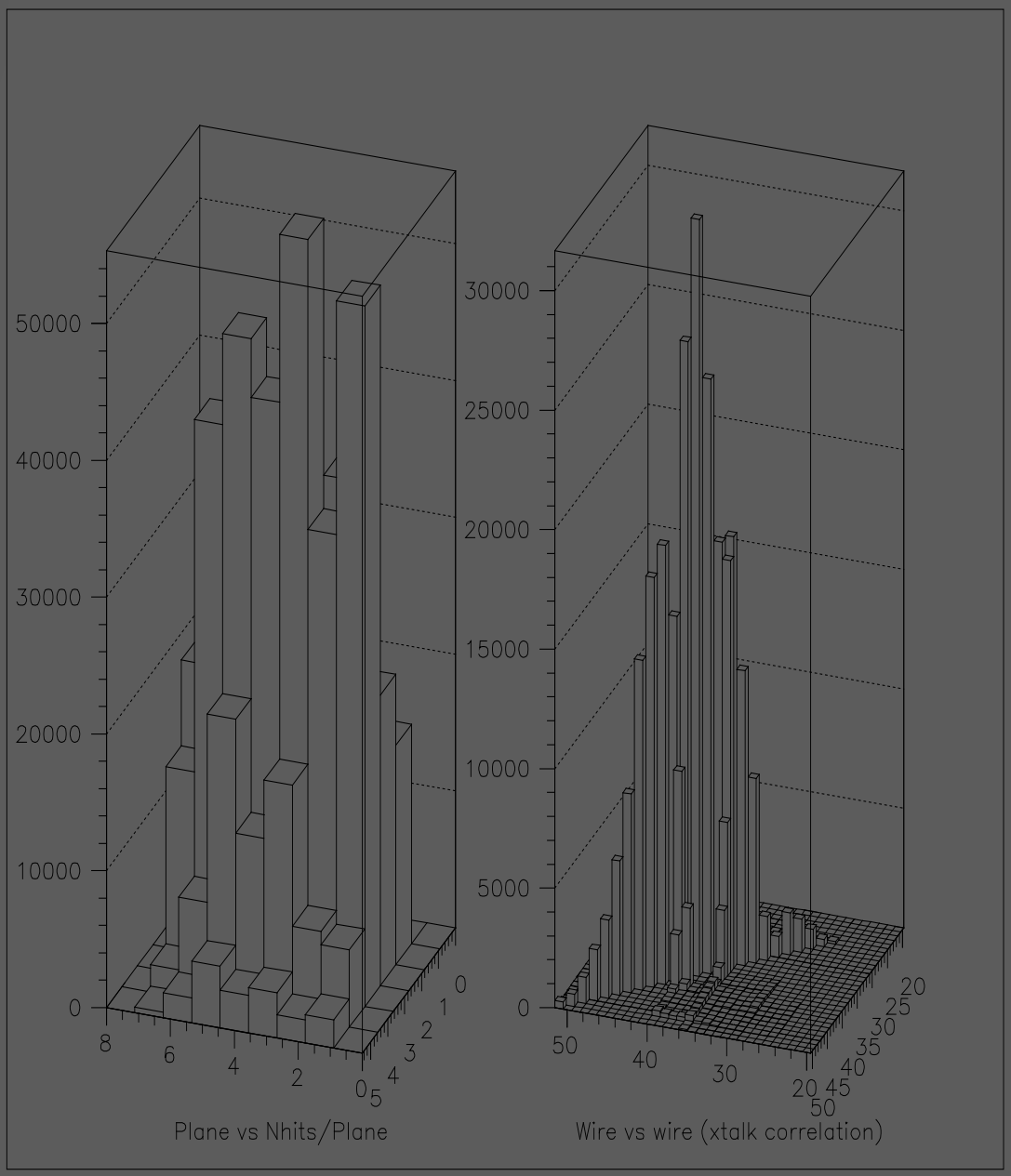
μ TDC Signal Width

- New front end @140mV, 1850V, 0^0



μ Cross Talk

- New front end @140mV, 1850V, 0^0

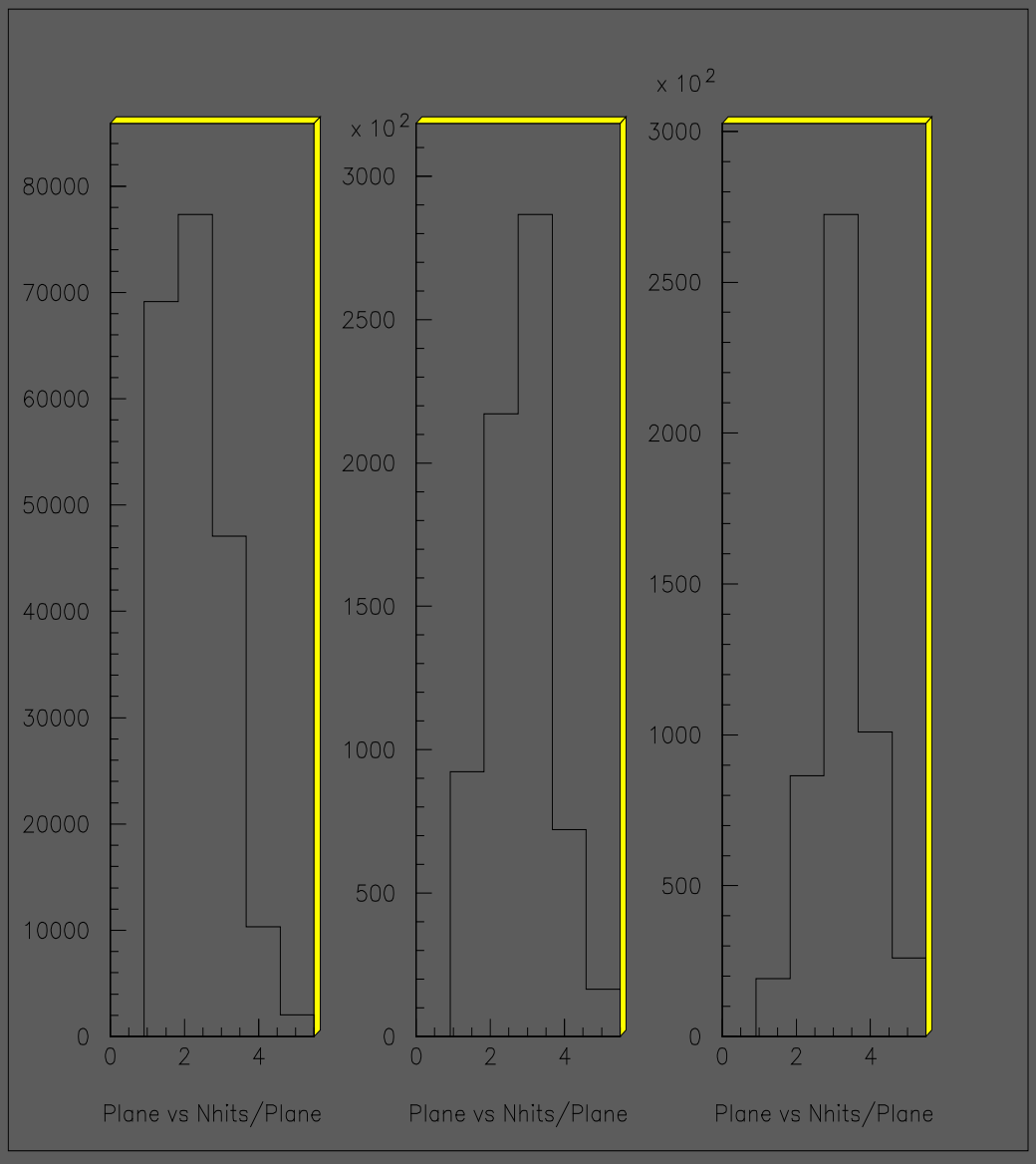


Cross Talk vs High Voltage

A) New front end @140mV, 1800V, 0^0

B) New front end @140mV, 1850V, 0^0

C) New front end @140mV, 1900V, 0^0



Conclusions

- Good efficiency and good position resolution are obtained
- Chamber's performance is adequate with no field wires
- LOTS of noise and cross talk
- A good plane-to-plane alignment and accurate wire positioning is necessary

Things to be Done (1) hardware

- Noise
  - Chamber has to be grounded properly
  - We need to locate the source of noise at TRIUMF and try to reduce it
- Cross talk
  - need to reduce cross talk significantly
- Alignment
  - More careful alignment of plane position

Things to be Done
(2) Measurements

- Best high voltage to run at
  - Present chamber ~1850 V
  - How high can we go if we successfully reduce noise and cross talk
- Best threshold to run at
  - Present chamber ~140 mV
  - Need to experiment with threshold more
- No measurement of efficiency vs intensity

Things to be Done
(3) Software I

(1) GARFIELD Calibration $R_d = R_d(t,\theta_t)$ - requires a complete understanding of GARFIELD

- Supply GARFIELD with all required information (including thresholds)
- Use GARFIELD to determine the sensitivity of R_d to:
  - Angle
  - Pressure
  - Temperature
  - Gas mixture
  - Foil Deflection and wire misalignment

Things to be Done
(3) Software II

(2) Accurate calibrations:
requires an iteration

- TDC time zero (T_0)
  - define tracking residuals such that a - ve (+ve) tracking residual reflects a small (large) T_0
  - iterate until tracking residuals for that wire are centered on zero
- Plane positions and wire positions
  - define tracking residuals such that a - ve (+ve) tracking residual reflects a left (right) wire shift
  - iterate until residuals are centered on zero
- Position resolution
- $R_d(t,\theta_t)$

Things to be Done
(3) Software III

- Investigate cross talk cuts
  - How much cross talk gets through
  - How many good hits are lost
    - How many level cuts do we need (currently 6)
    - How many bins in R_d (currently 3)
    - Where should we place these cuts
- Analyze non-zero angle runs
  - Determine resolutions
  - Determine efficiency vs drift distance

Things to be Done
(3) Software IV

- Investigate different tracking methods
  - Advantage of present method:
    - CPU time efficient since it assumes track is tangent to the drift circle
  - Disadvantages:
    - Assumes that drift distance corresponds to the minimum distance between track and wire
    - Disregards hits form other clusters generated along the track
- Include analysis results in efficiency
  - Efficiency
  - Digitization
  - noise/cross talk etc.
- Event display
- Muon runs??