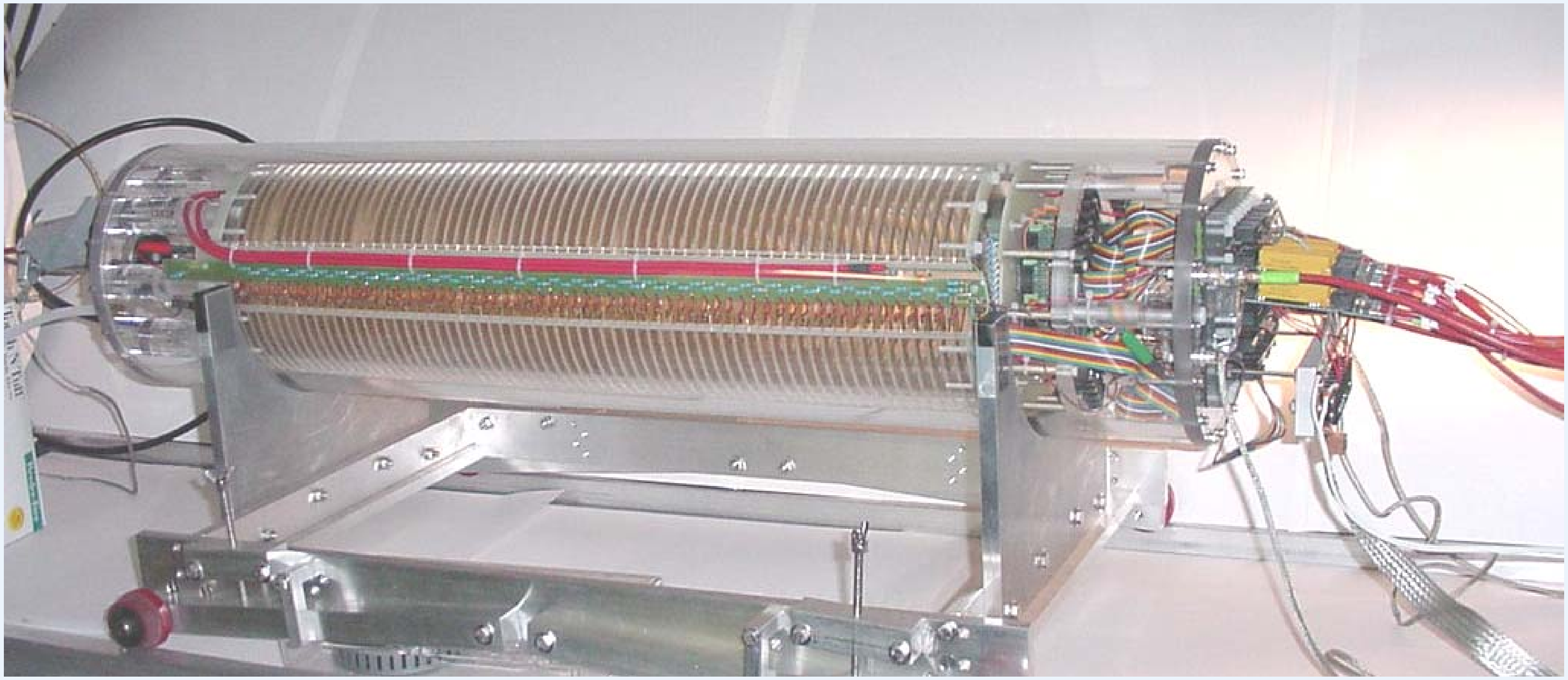
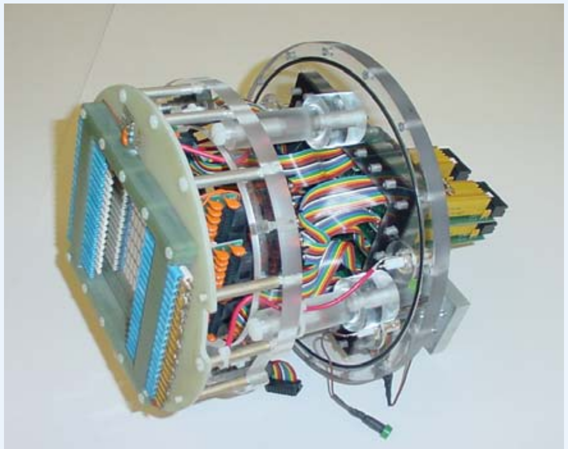
Studies with a TPC and development of a procedure to measure ion feedback

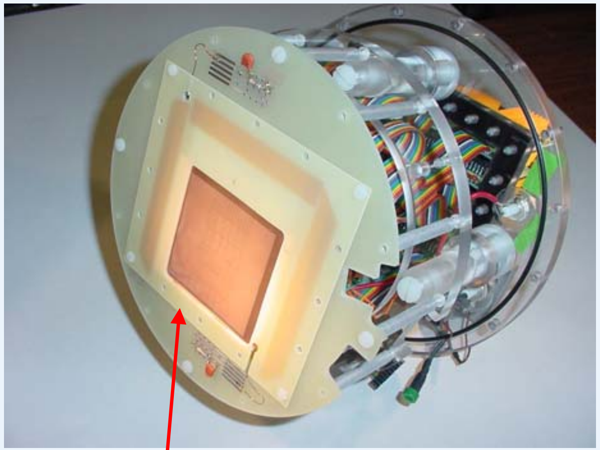
James Inman – Radford University
Dan Peterson - Cornell University



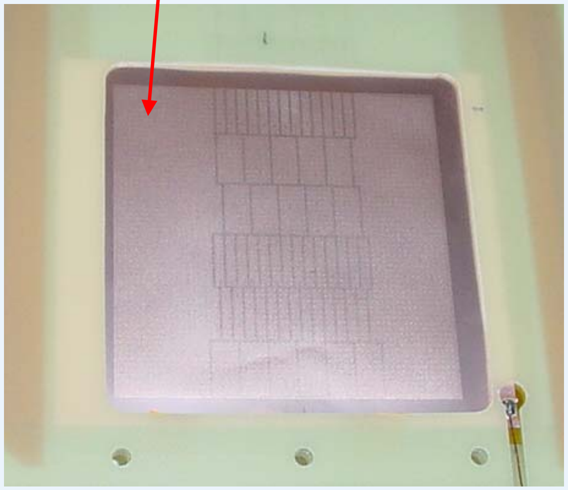
Equipment, Amplifiers and Electronics

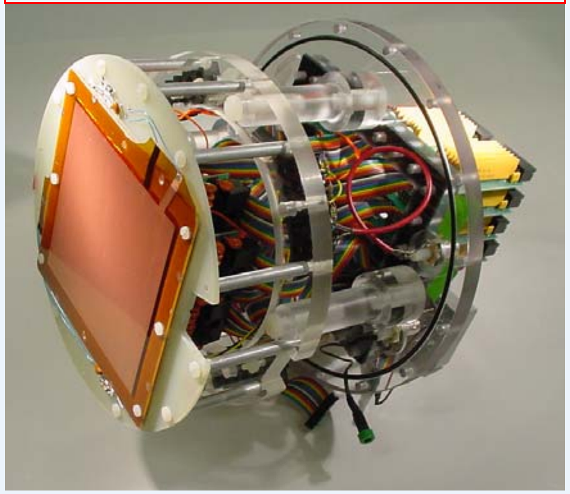


Wires
(Multi-Wire-Proportional-Chamber)



Micromegas



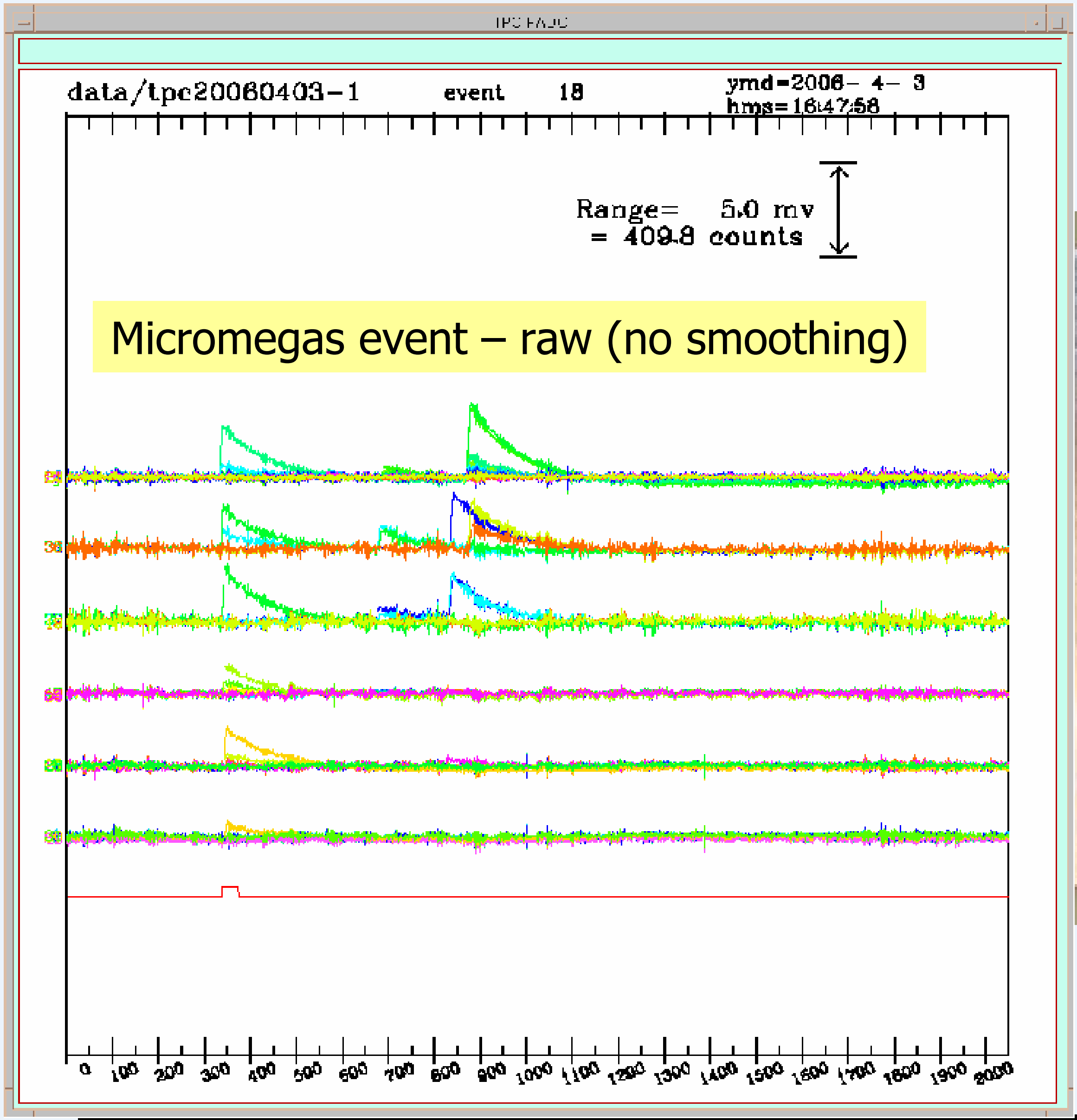


GEM

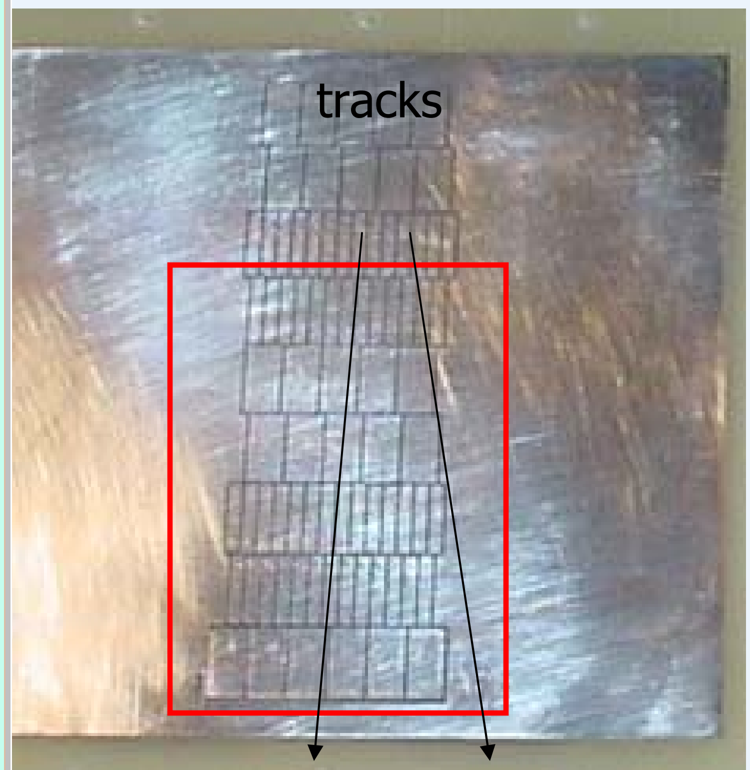
High voltage system:
- -20 kV module, 2 channels
- -2 kV module, 4 channels

Readout:
- VME crate
- Struck FADC

Sample data taken with Cornell TPC

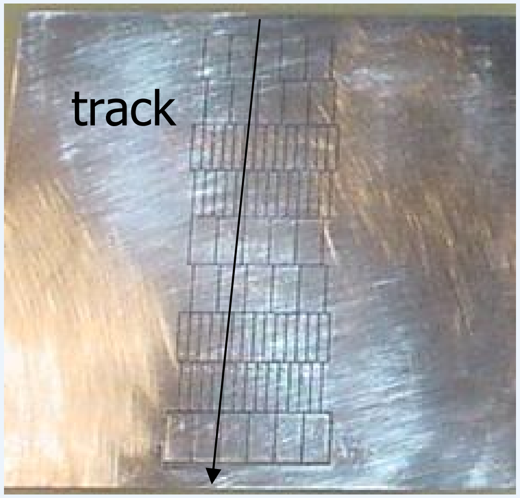


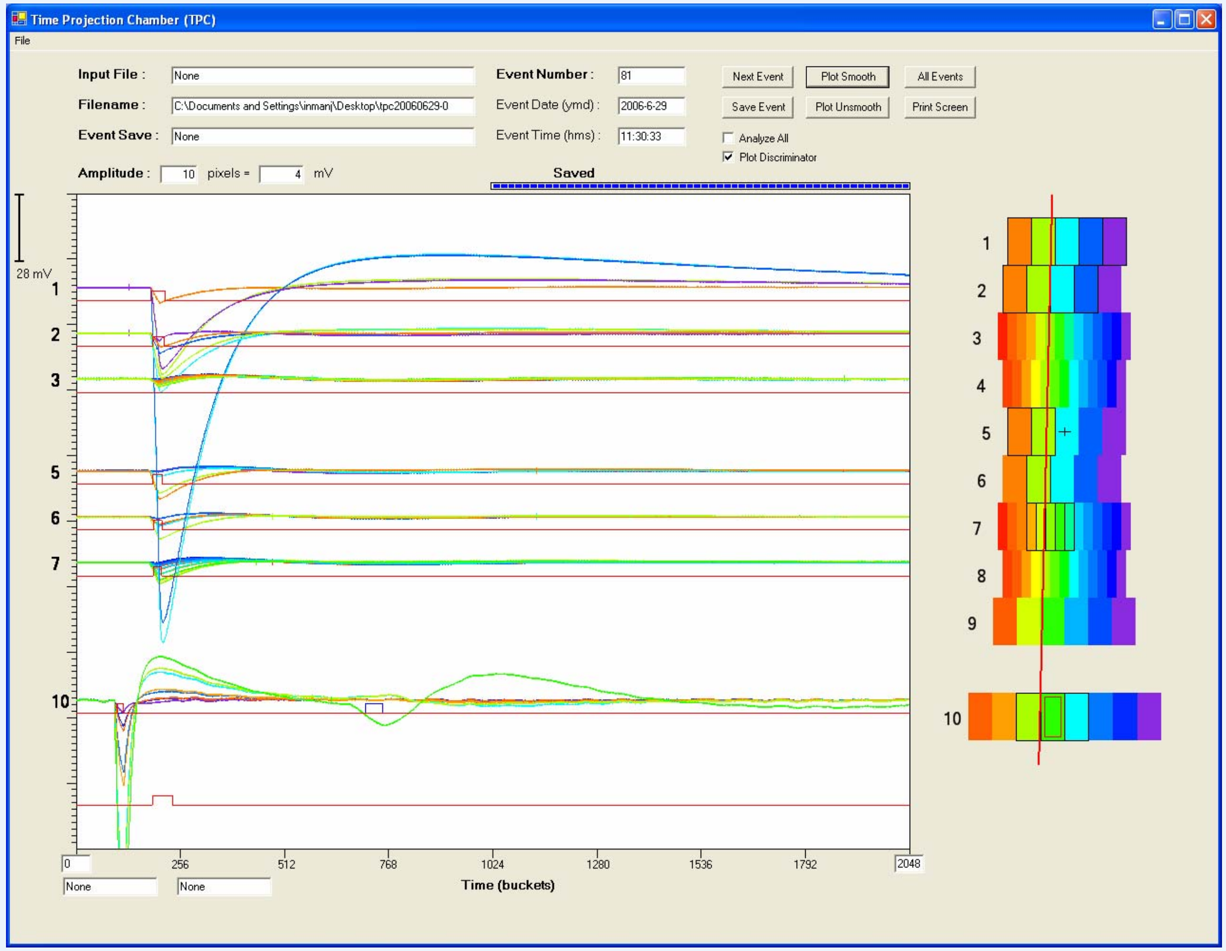
$ArCO_2$ (10%) , 300V/cm
Gas gain: ~ 300



25 MHz , 40 ns
2048 time buckets (81.92 μs)

Implementing Program in Visual C++

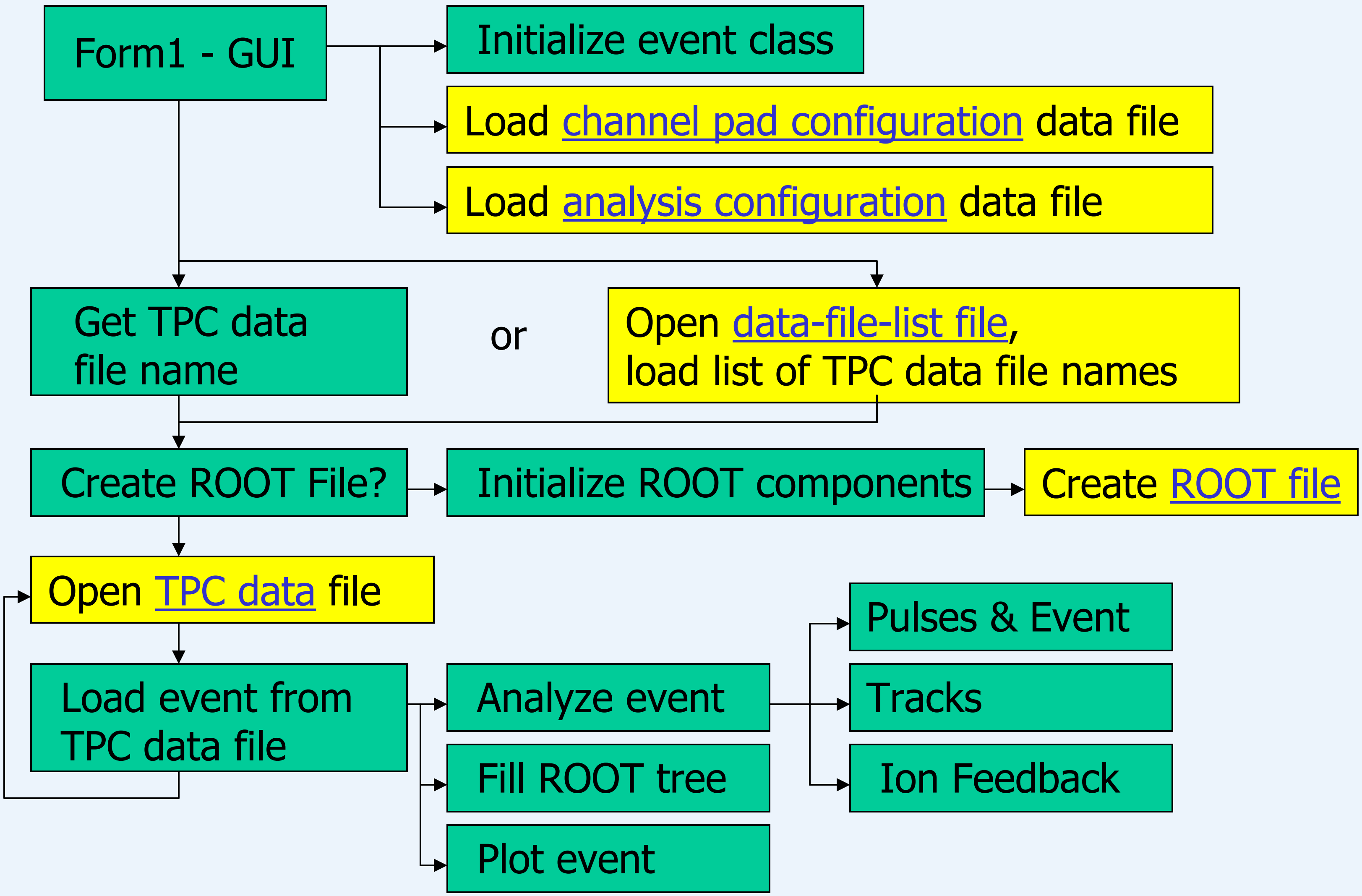




Design Goals:

- Maintain functionality of old program
- Allow for analysis of ion feedback
- Interactive control
- Optimize run speed

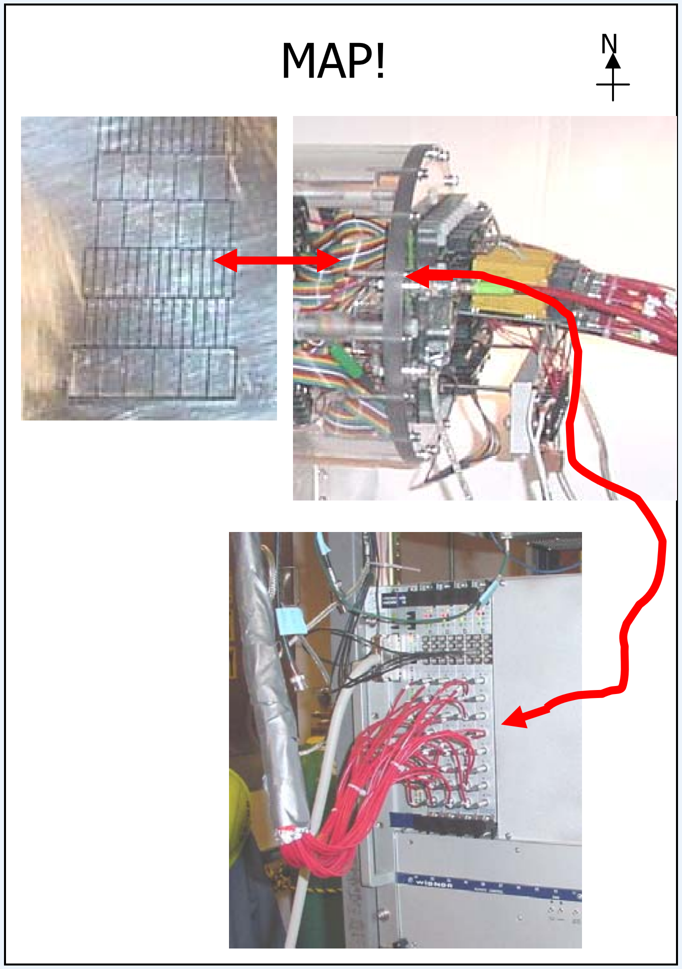
TPC Data Analysis Program – Block Diagram



TPC Data Analysis Program - Data Files

Channel Pad Configuration

- Contains information about the layout of the TPC (# rows, #pads, …)
- Maps the channels of data in the TPC data files to the pad board layout (channel# -> (row, pad))
- Contains the geometry of the padboard, used for track fitting and plotting



Analyze Configuration

- Has 3 sets of 35 input parameters that are used to analyze data
- Data smoothing (smoothwidth)
- Pulse identity (thresh, recoverwidth)
- Track fitting (pad pulse sharing)

TPC Data Analysis Program - ROOT

Create an ntuple tree

• A tree stores data

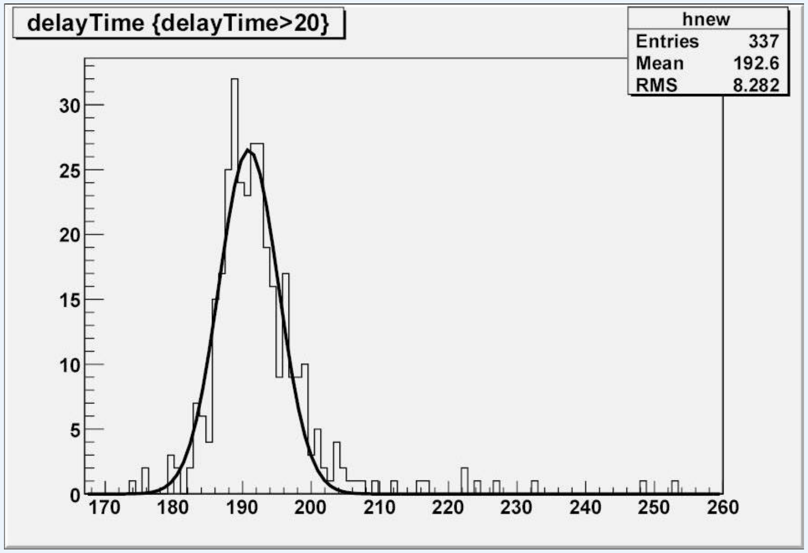
• TTree object consists of branches that can hold any type of data from integers to classes

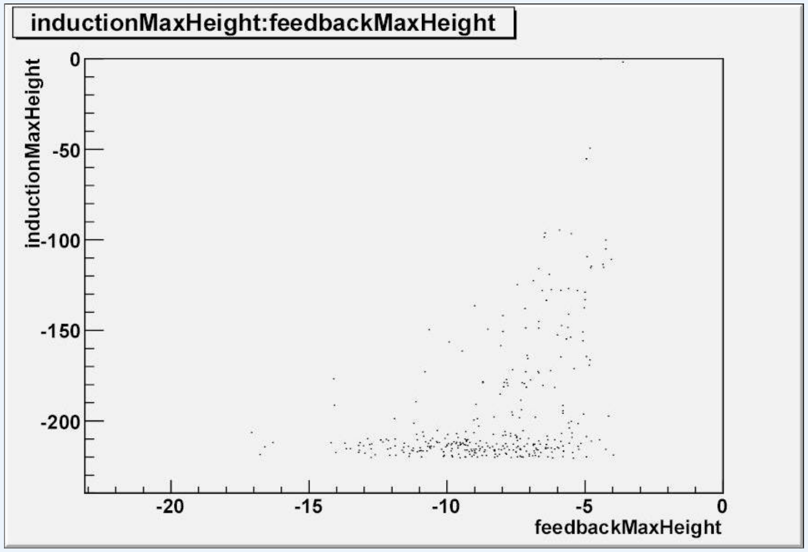
• Branches are filled for each event

Create ROOT file

• Contains ROOT objects (in particular my TTree)

• ROOT is run in “interactive” mode (root.exe) and file is opened to make cuts on the data and then plot histograms





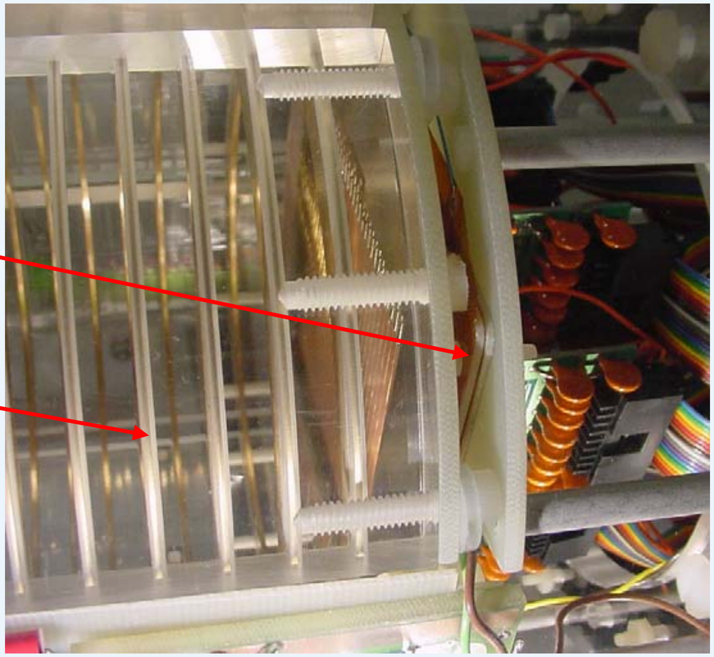
Ion Feedback Measurement

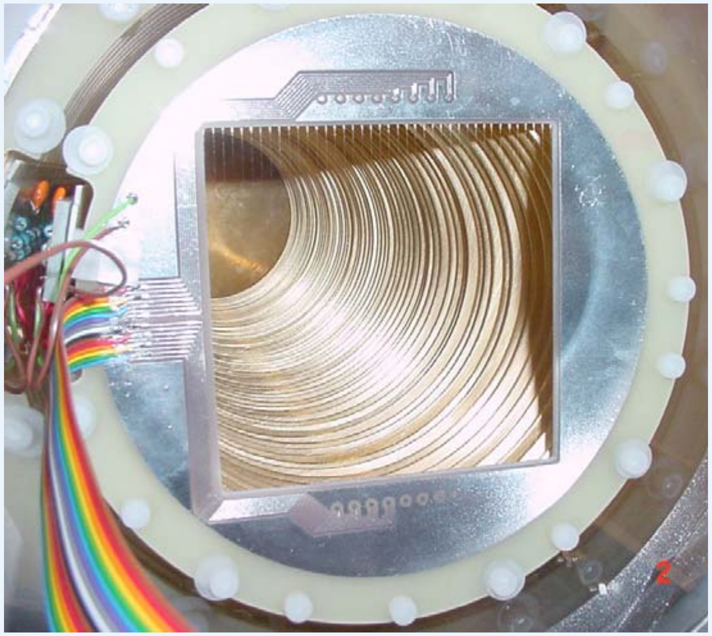
Positive ions are created in the amplification
and
drift back into the field cage.

Ion feedback is expected to be
suppressed with the
GEM or Micromegas devices
relative to MWPC.

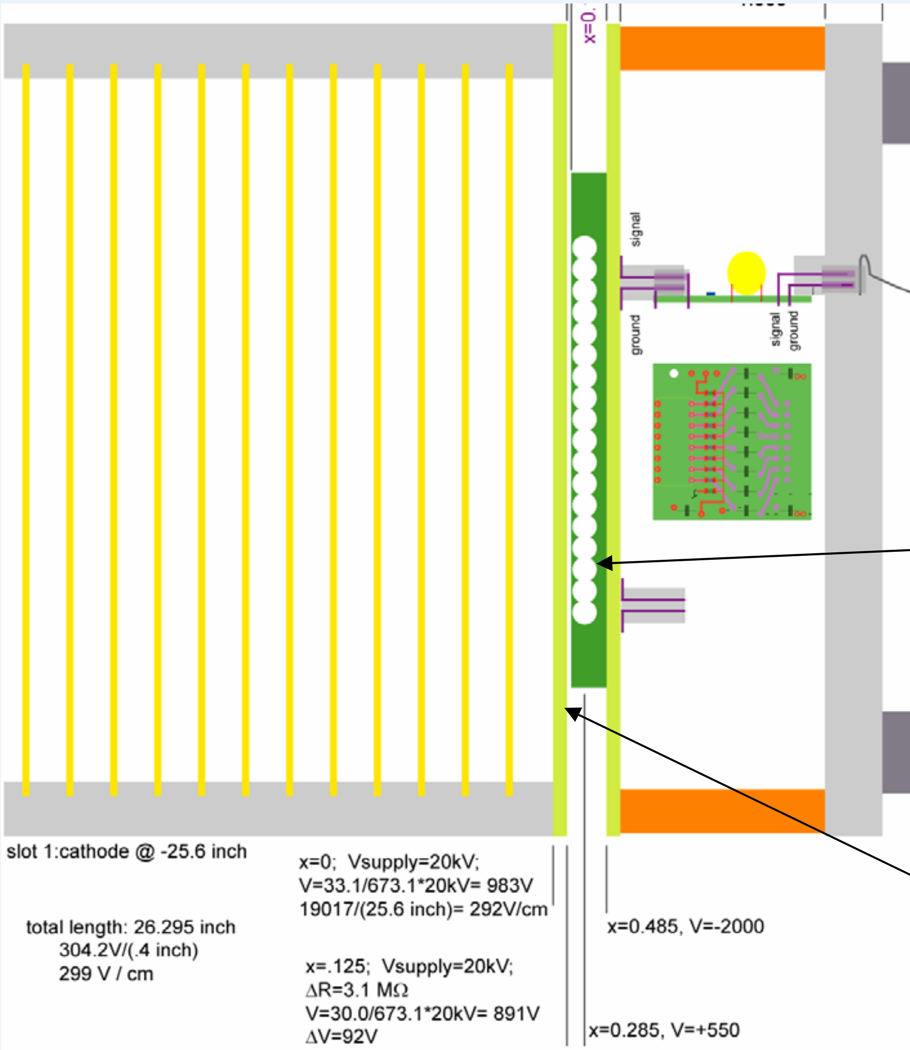
We measured ion feedback
on the field cage termination plane,
for individual tracks.

This is a different method than used by other groups
and will allow
a more direct comparative measurement
of ion feedback in the various devices.

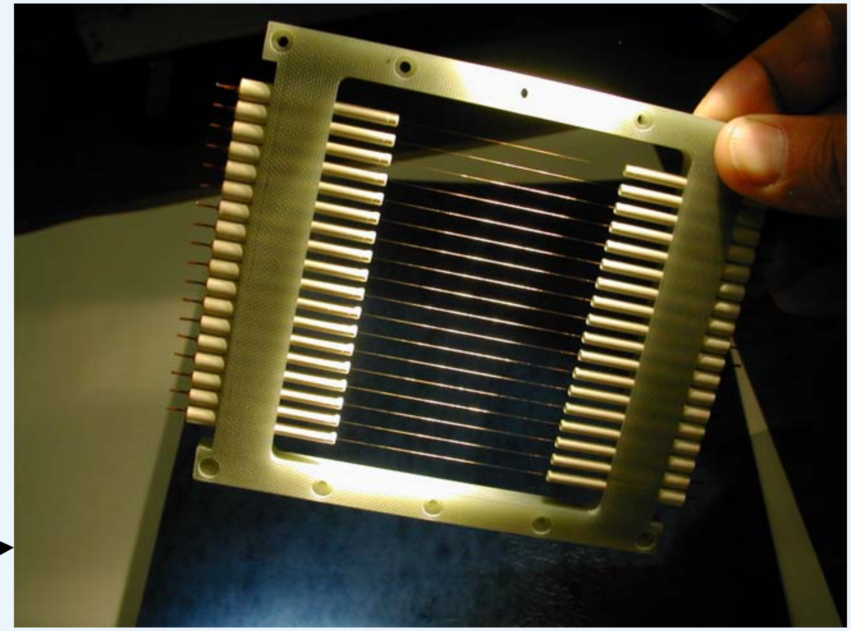




Ion Feedback Measurement



Wire Amplifier



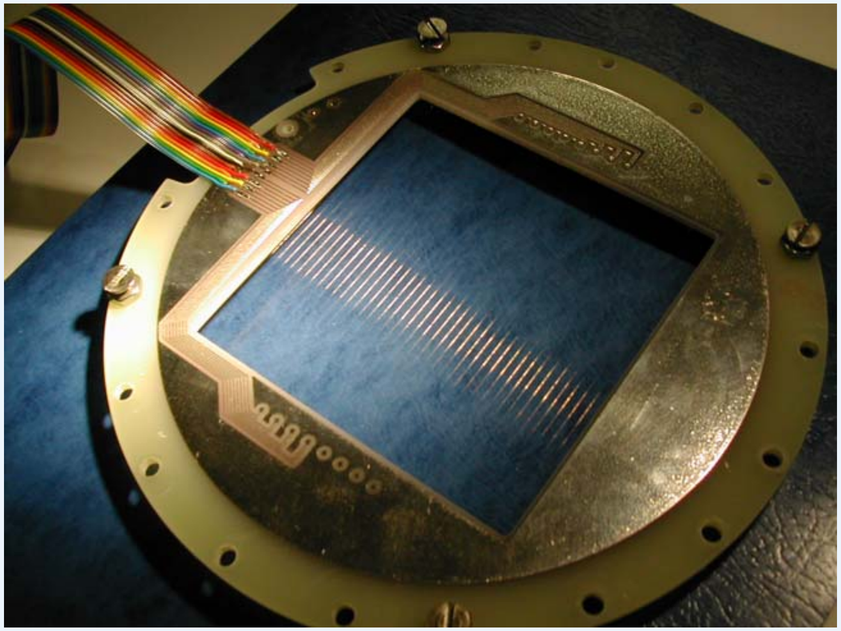
Wire amplifier produces large feedback signal this is why it is unsuitable for use in the ILC

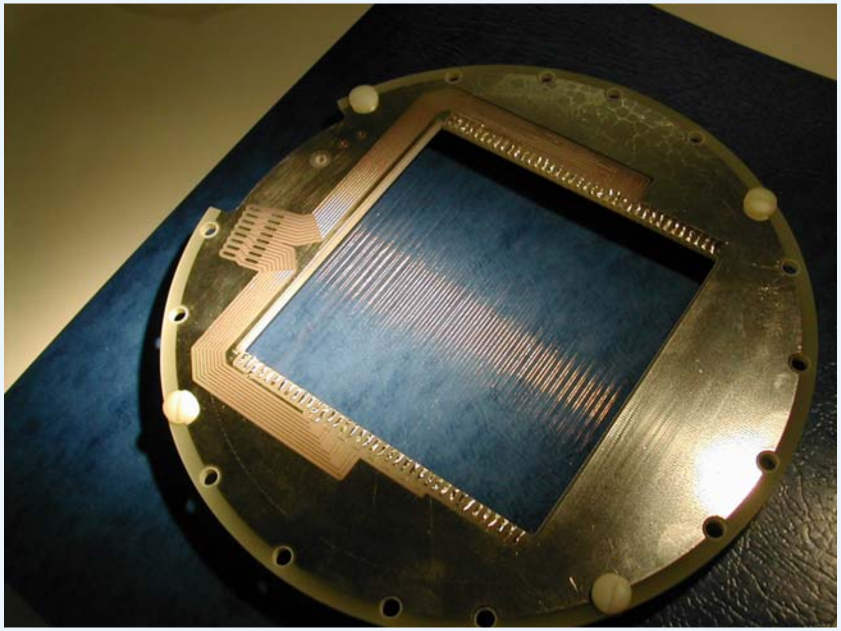
It is used as a starting point for measuring ion feedback

Field cage termination plane

Located between field cage and amplifier (next slide)

Field Cage Termination





Single Field Cage Termination

The field cage termination provides a close to uniform potential plane while still being transparent

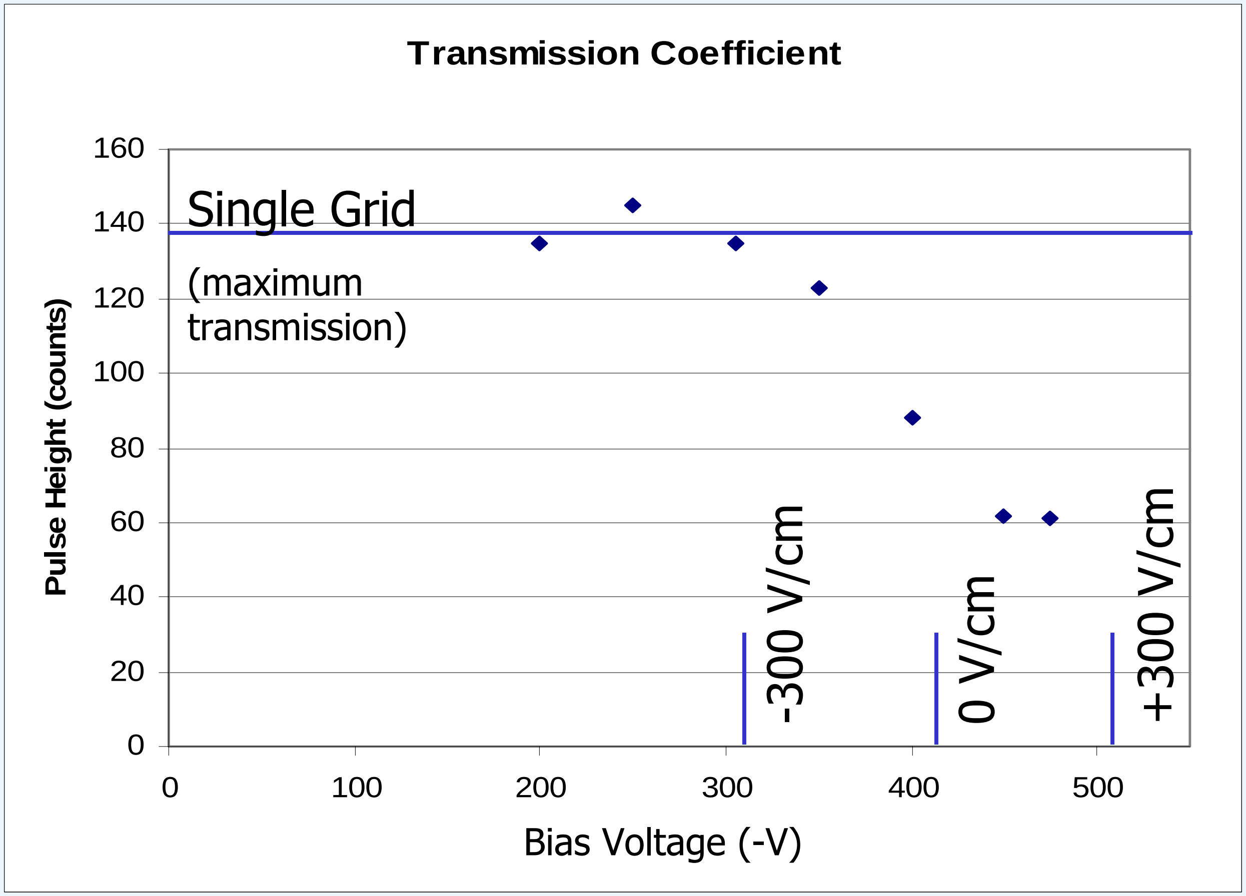
It would not collect ion signal; ions drift past the plane into the field cage

Double Field Cage Termination

Allows for an area to be defined with a reverse electric field

This reduces transmission of elections from track and allows for ions drifting back into the field cage to be collected on wires

Partial Transmission Mode

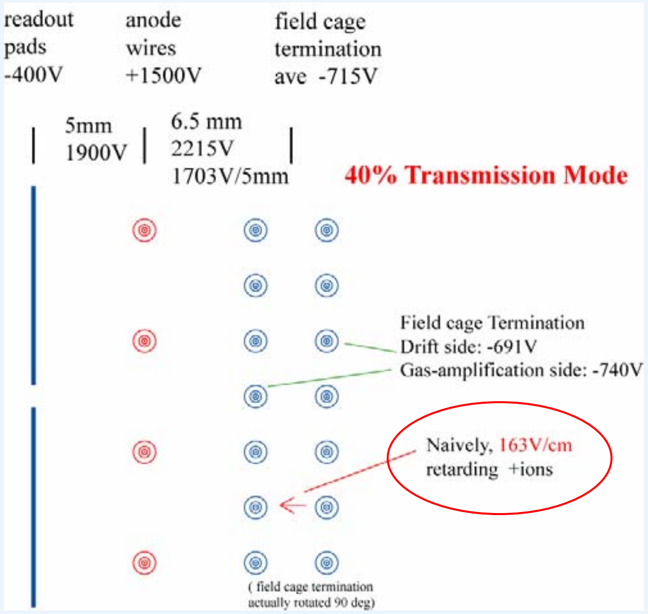


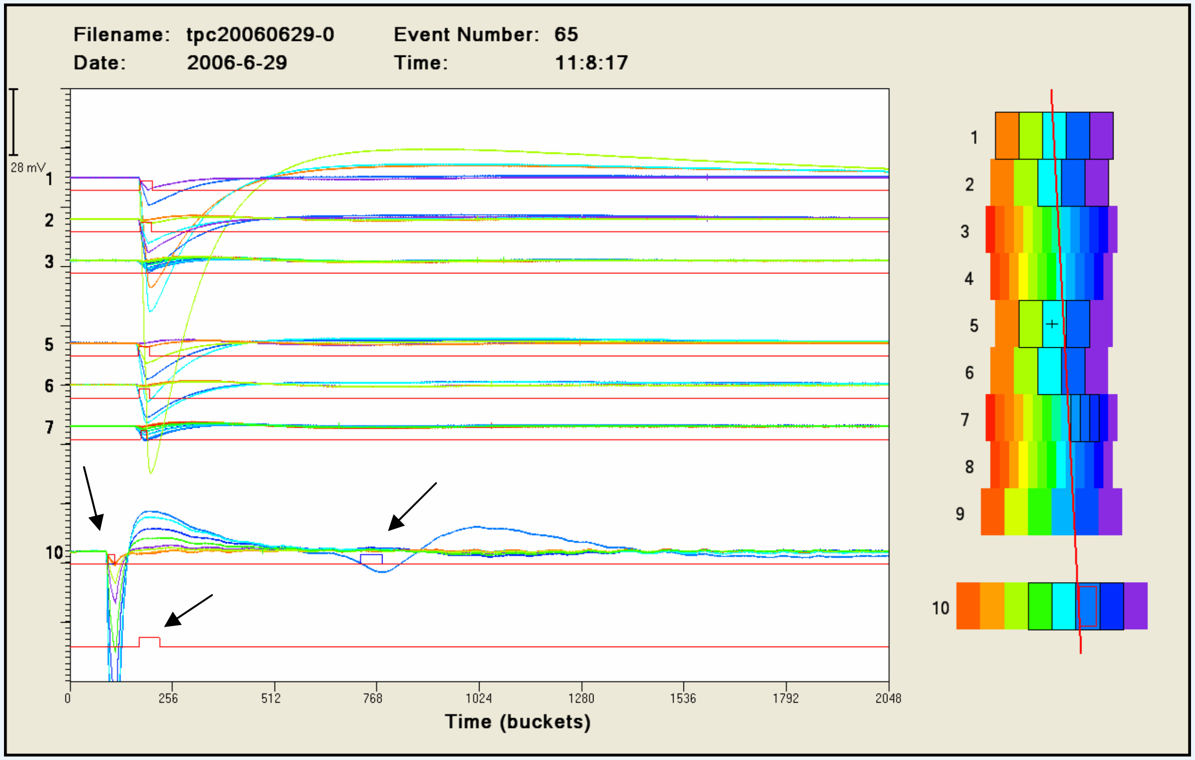
Transmission coefficient of electrons through double field cage termination wires using Micromegas

~40% transmission at bias voltage of -450 V

~60% of the ion feedback should be detected by the field cage termination wires

40% Transmission Mode, 5mm Drift





Pulse observed on field cage termination, is this ion feedback?

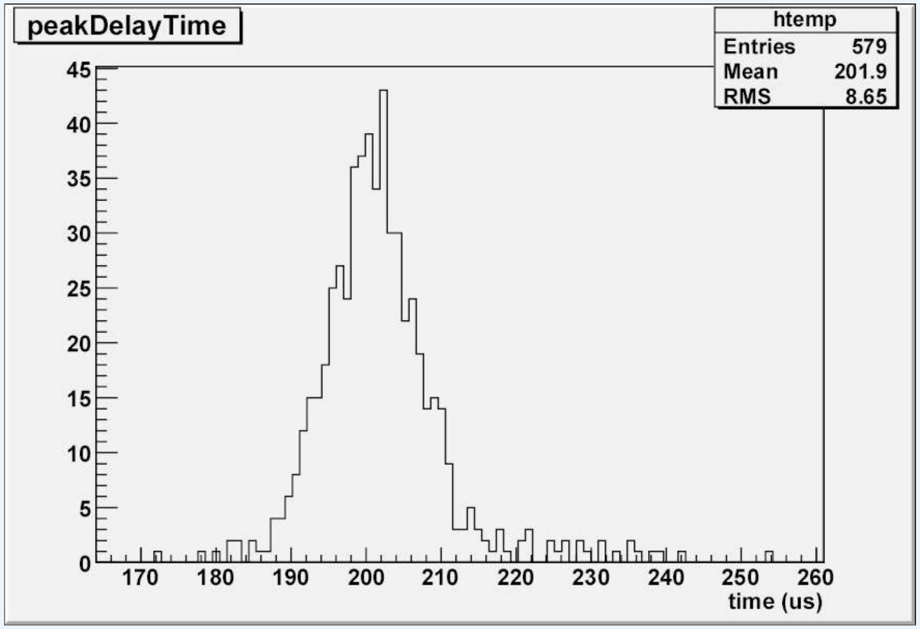
X-axis is in units of data buckets

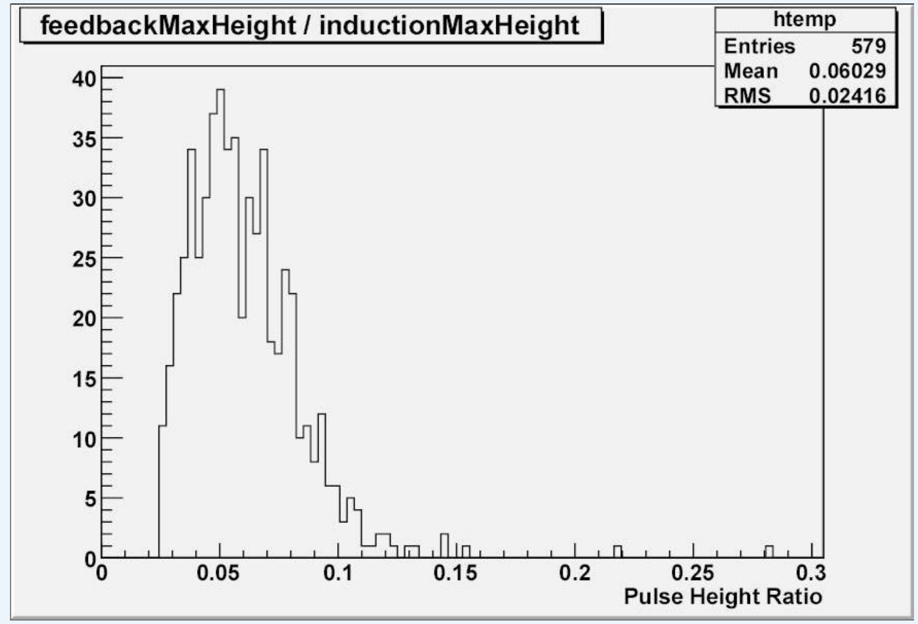
Top 6 traces are from pad board, data collected at 20ns/bucket (82 μs)

Bottom traces are from FCT, data collected at 320ns/bucket (655 μs)

Logic pulses identify pulse threshold crossings

40% Transmission Mode, 5mm Drift

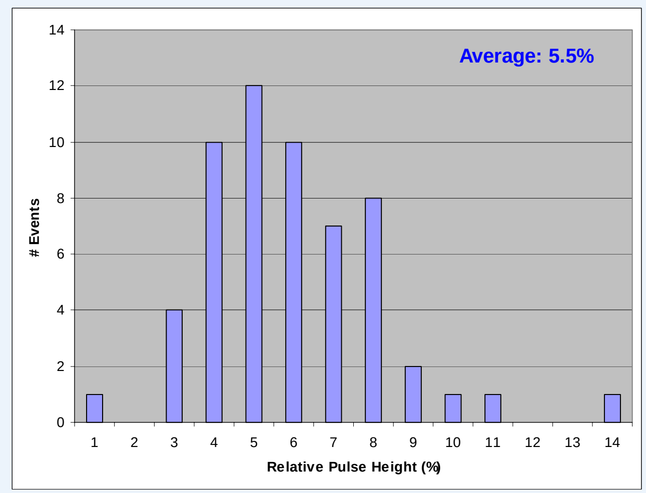




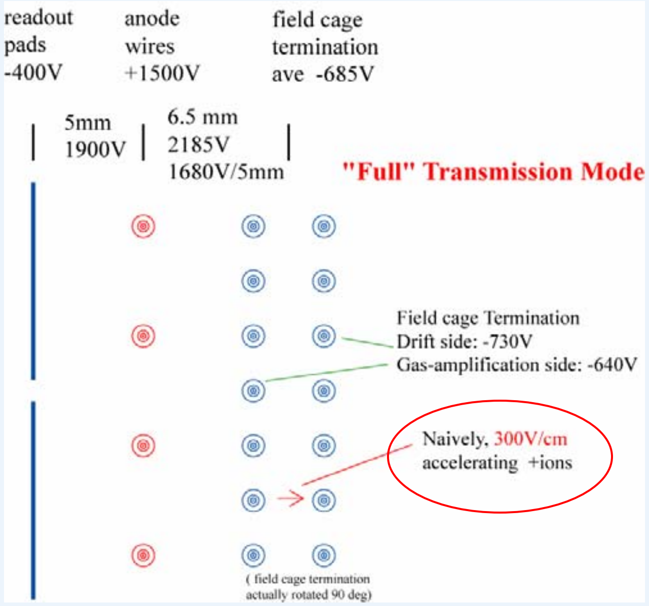
Average pulse delay time is 202 μs with σ = 8.7 μs

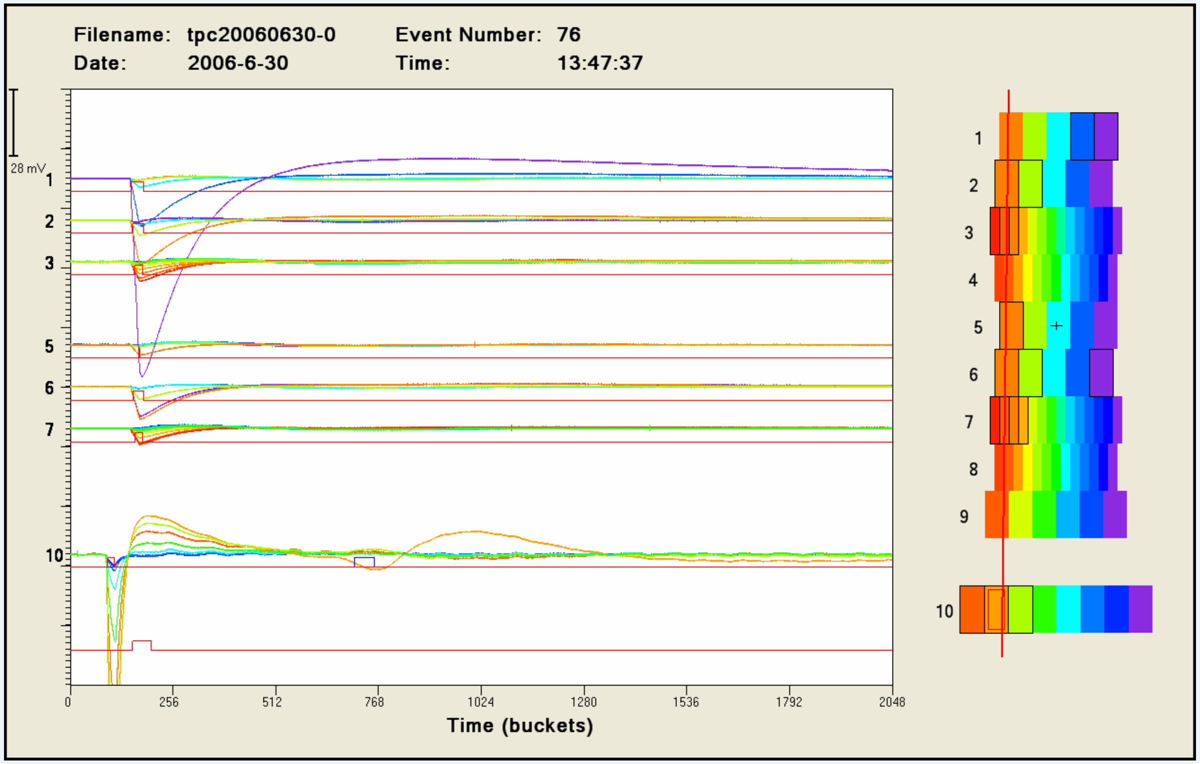
Average relative pulse height is 6.0%

Initial Results calculated by hand, not fun



"Full" Transmission Mode, 5mm Drift

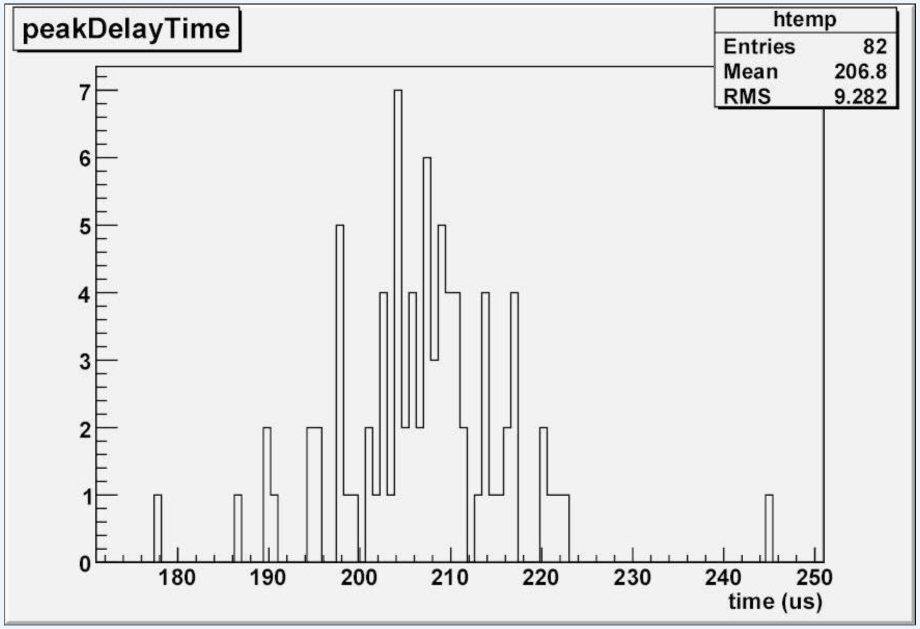


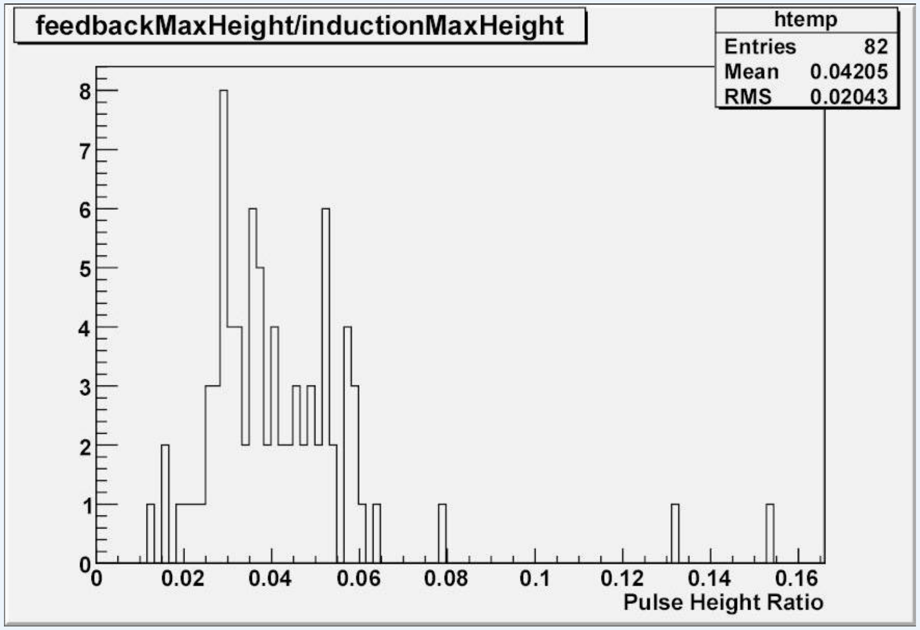


Pulse still observed on field cage termination

By observation pulse looks smaller

“Full” Transmission Mode, 5mm Drift

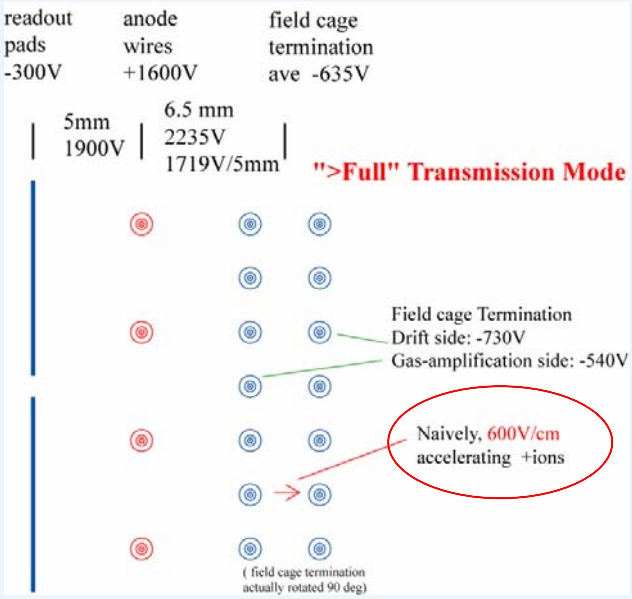


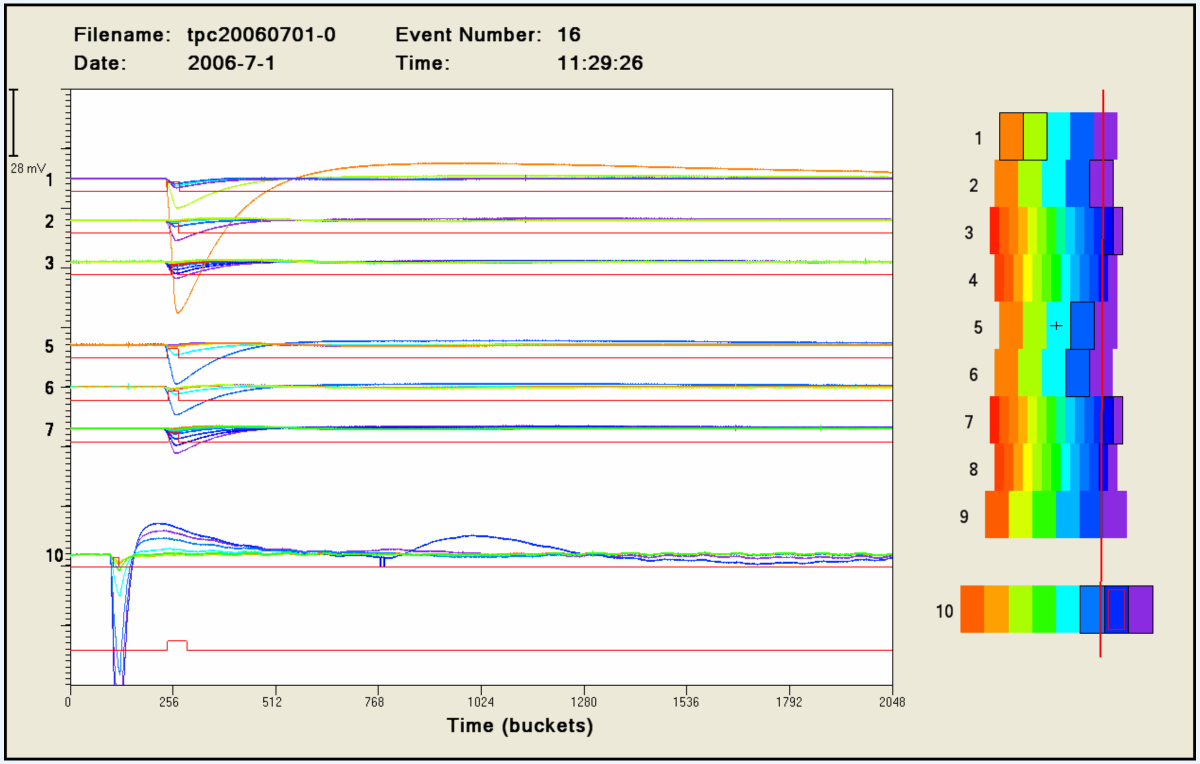


Average pulse delay time is 207 μs with σ = 9.3 μs

Average relative pulse height is 4.2%

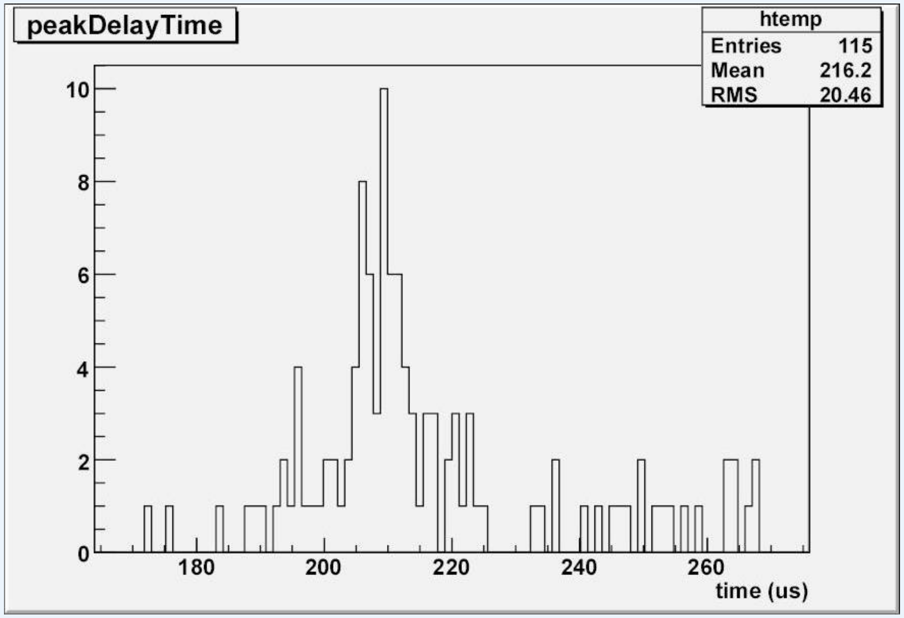
“>Full” Transmission Mode, 5mm Drift

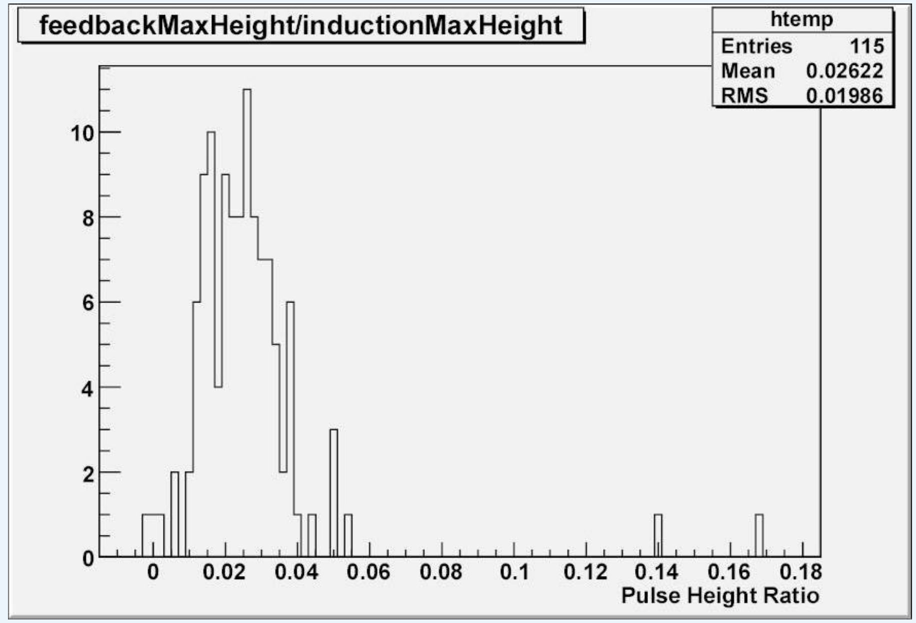




Pulse still observed on field cage termination; decreased signal to noise ratio makes pattern-recognition difficult

“>Full” Transmission Mode, 5mm Drift



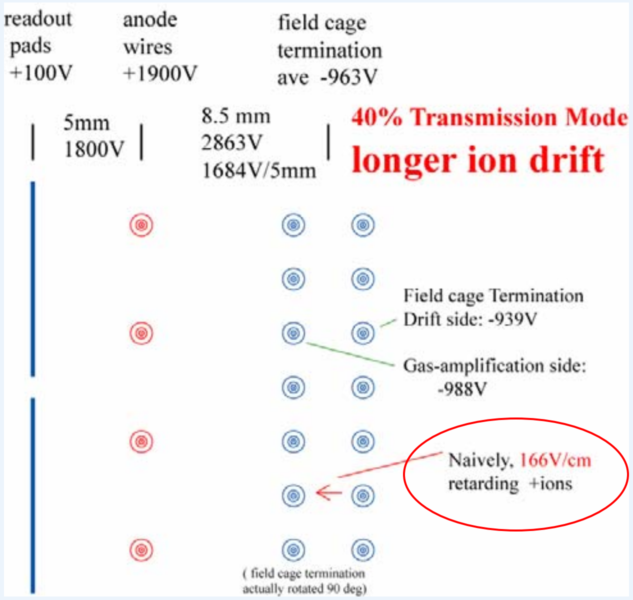


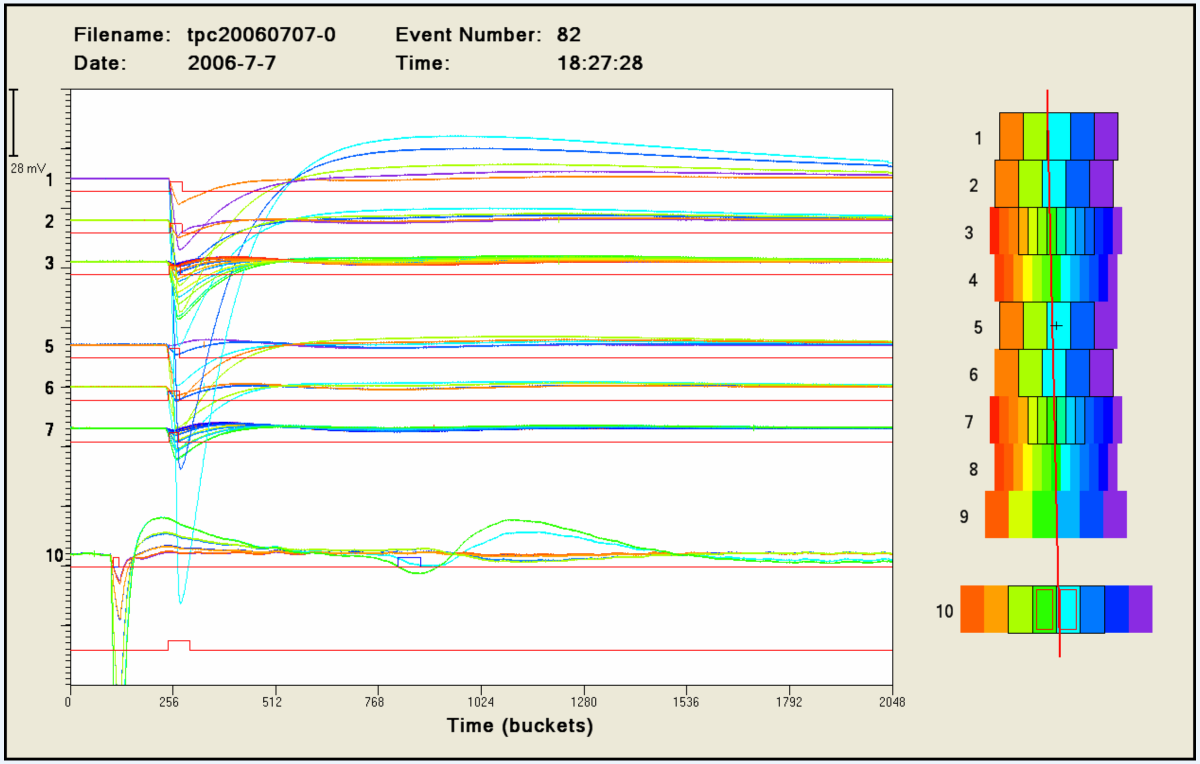
Average delay time is 216 μs with σ = 21 μs

Average relative pulse height is 2.6% (reduced by 43%)

Pulse Height is effectively controlled by bias voltage applied to field cage termination

40% Transmission Mode, 7mm Drift

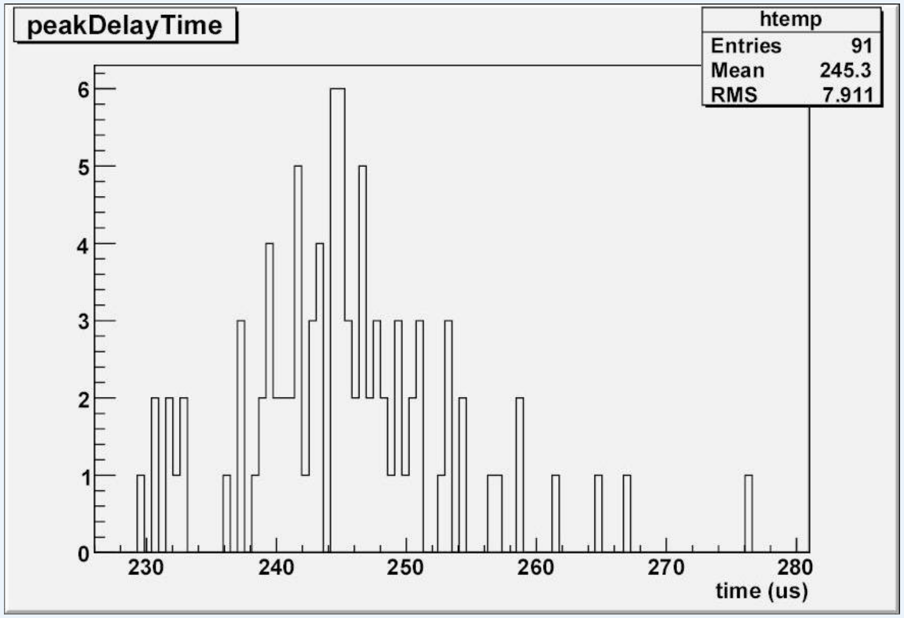


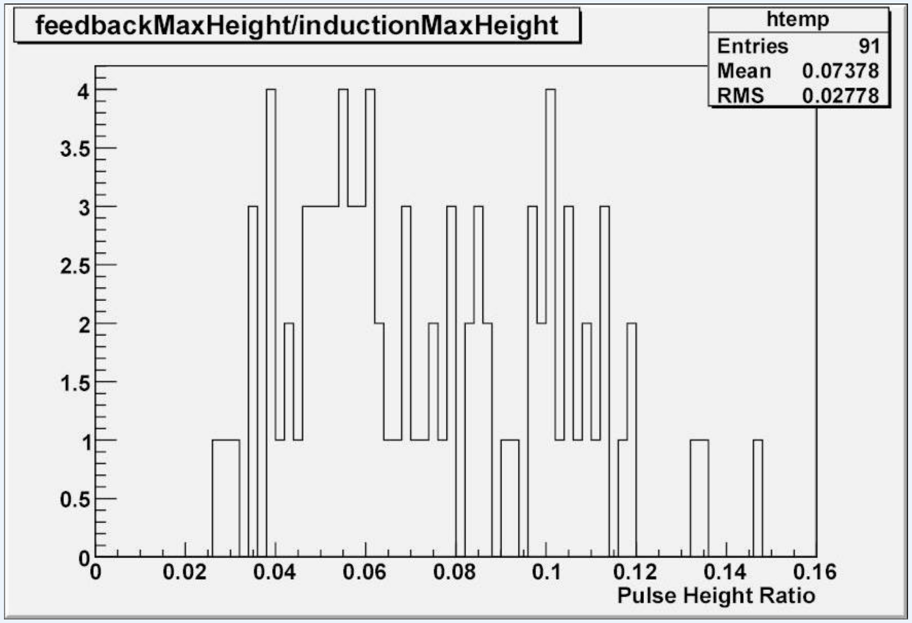


Change the ion drift distance to see if the pulse changes accordingly

Pulse observed on field cage termination with a noticeably later time

40% Transmission Mode, 7mm Drift





Average pulse delay time is 245 μs with σ = 7.9 μs (5mm – 202 μs)

Pulse delay time increase of 21% (40% drift distance increase)

Average relative pulse height is 7.4% (5mm – 6.0%)

Results / Next

Created a new display and analysis program in Microsoft C++ that can be used to analyze ion feedback

Ion feedback was measured from a wire amplifier which has a large gain (x300)

An attempt to measure ion feedback from the double layer GEM amplifier was made; however, the GEM has an expected gain that is 10% of the wire amplifier and only 5% of the ion feedback

Plan to make a pulsing voltage bias on the field cage termination to allow full transmission of electrons and then pulse field to collect ions, need pulsing circuit and electronic amplifiers that can withstand pulsing bias

Smaller diameter wires on the field cage termination would increase field near wire increasing feedback signal (20 μm -> 8 μm)

A triple layer GEM would provide much more signal amplification

Make more measurements of ion feedback ;
measure ion feedback for various amplifier devices.

Acknowledgements

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