Analysis of May 2011 Micromegas LP TPC beam test data and some considerations on pulse pileup

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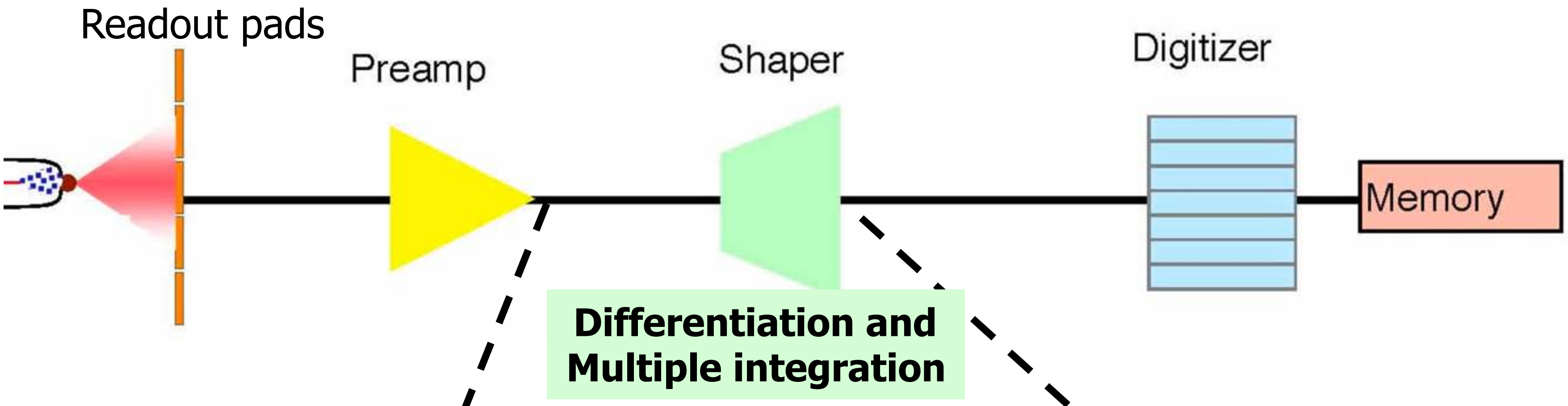
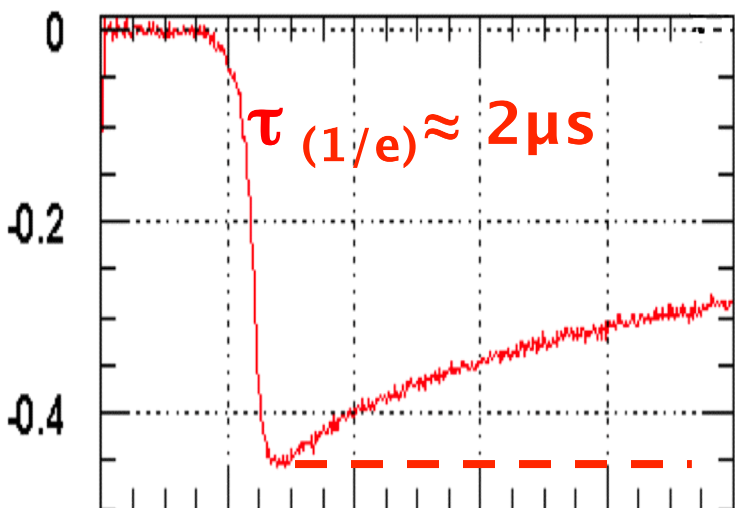
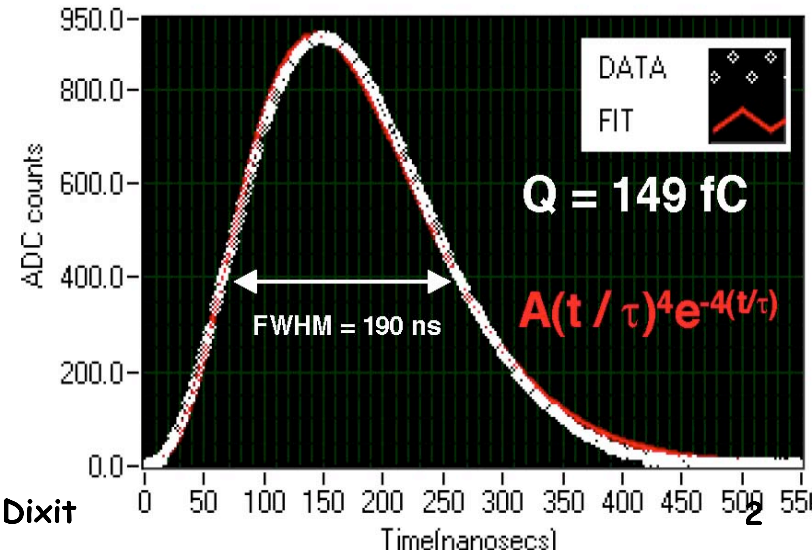
Conventional MPGD-TPC Readout á la ALTRO



Preamp charge pulse



Shaper output



GEM/Micromegas-TPC signal characteristics

Similar signals, different mechanisms:

- GEM - electron drift, ~ mm wide induction gap
- Micromegas – ion drift, ~100 μm induction gap

The charge pulse rise time is ~100 ns, for a single avalanche cluster, both for the GEM and the Micromegas

The track charge pulse rise time:

- Pad has to collect ~ 30 avalanche clusters
- Plus longitudinal diffusion, MPGD induction time, electronics
- ~300 ns to collect 95% of electrons at 2 m drift (GEMs & Micromegas)
- Rise time gets larger for charge dispersion readout

Long integration times needed - previous LP Micromegas results best with 500 ns peaking time

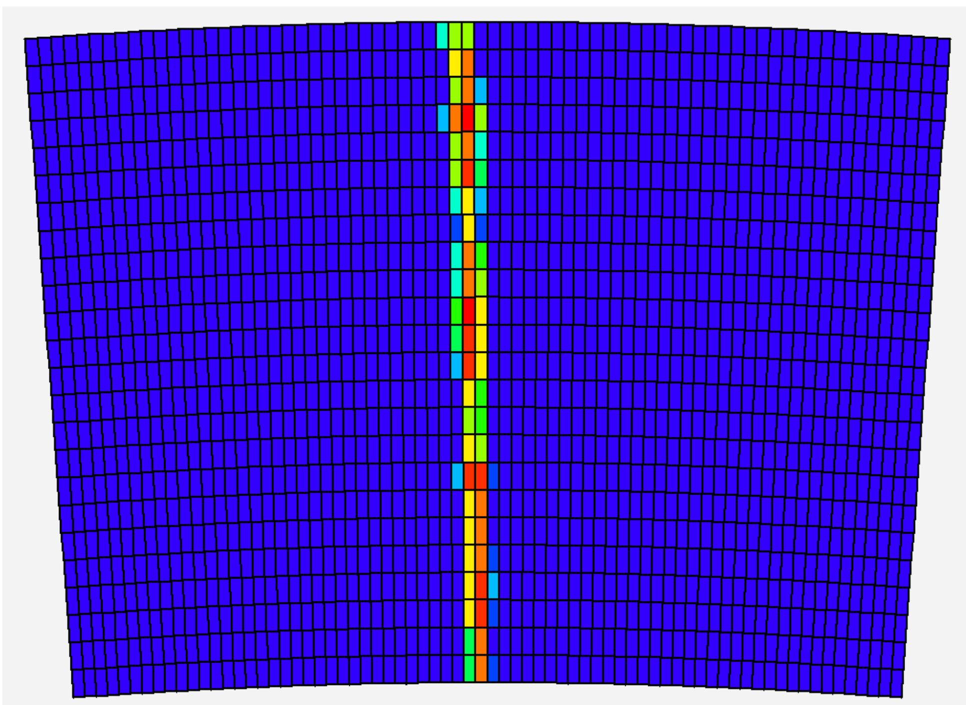
- Not good for timing and two hit resolving power

How to get good Micromegas resolution with short peaking time?

Beam test results presented based on Nicholi Shiell's MSc thesis research at Carleton

Amplitude calculation with charge dispersion readout

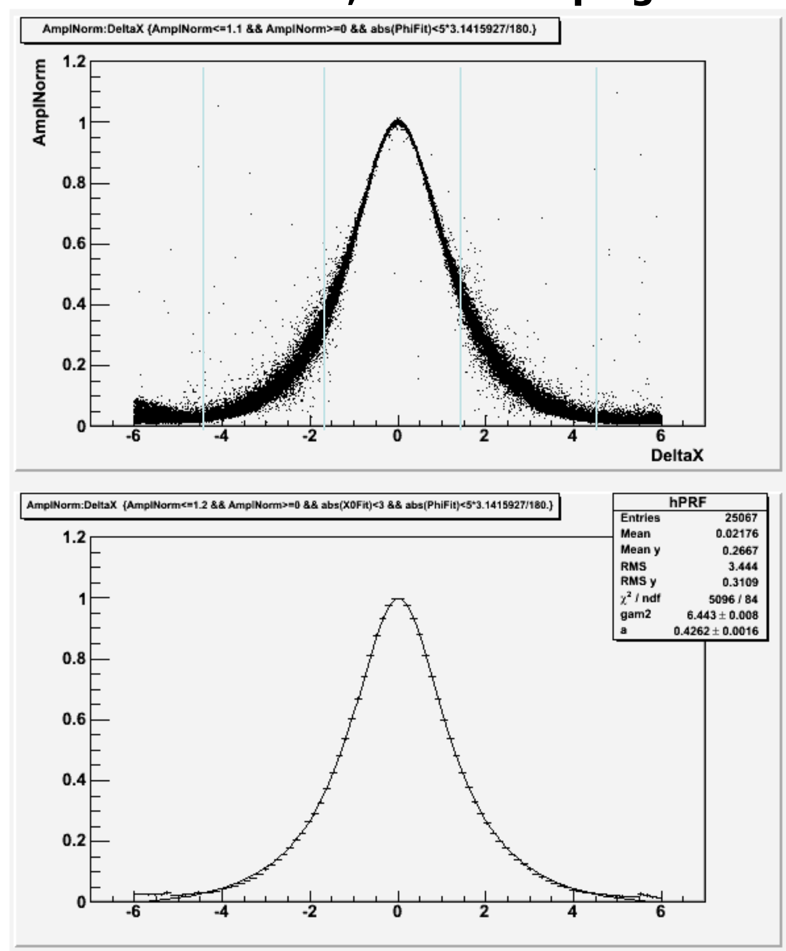
With variable pulse shape, there is considerable freedom in how to define & compute an "amplitude"



24 rows x 72 columns 3 x 6.8 mm² pads

Pad amplitude as a function of distance from the track [x(pad)-x(track)]

Z=20cm, 200 ns shaping



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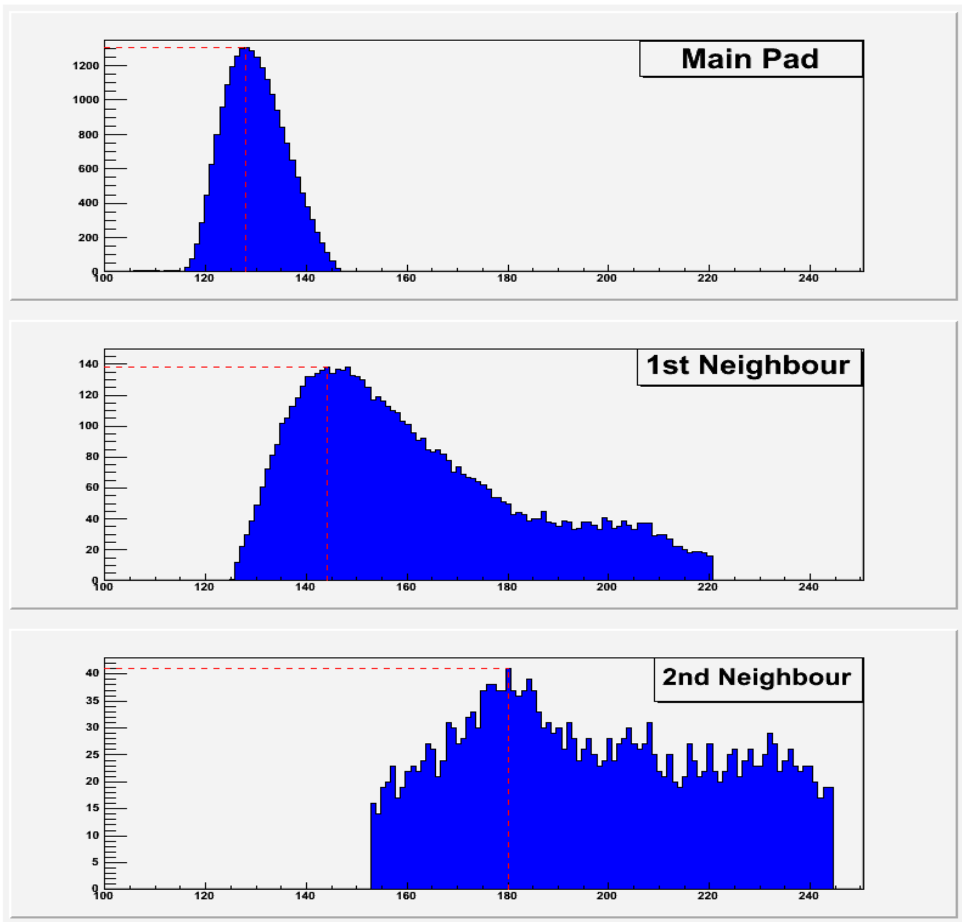
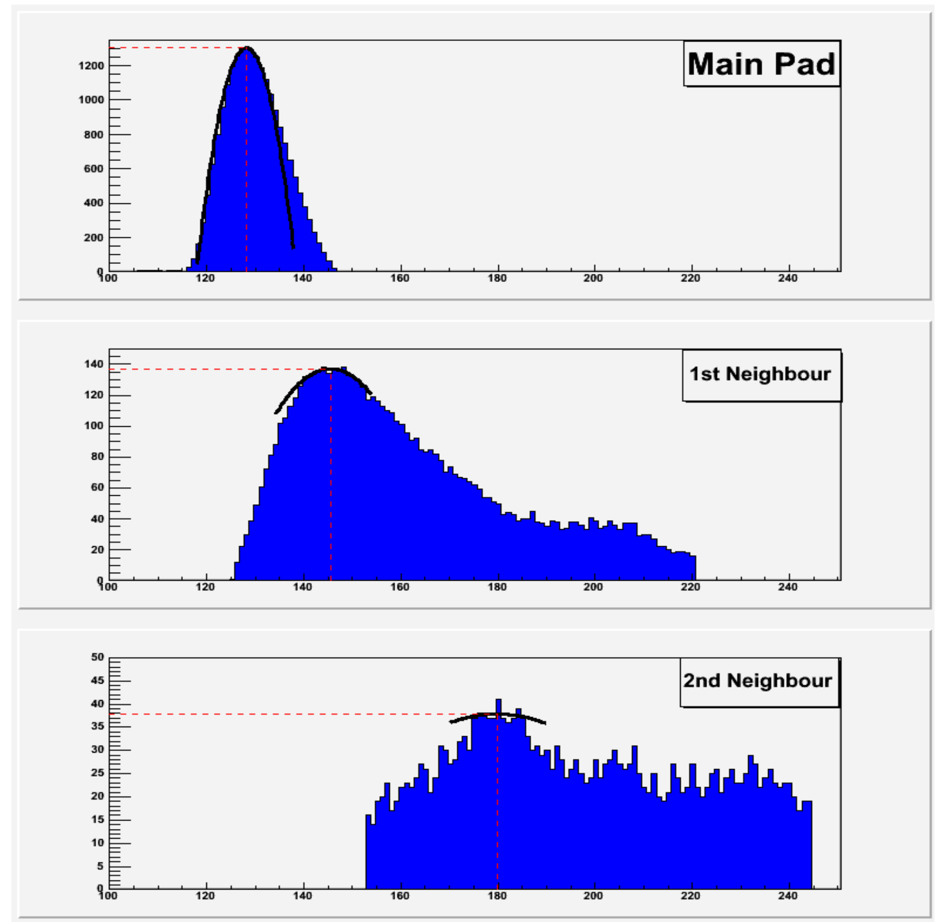
Computing "amplitude" – previous ideas requiring long peaking time





The old - Fit Point Max:

Amp = Largest Signal

T0 = Time of bin with largest signal

More recent - Quadratic Fit:

Amp = Max Pt. of fit

T0 = Time of Max Pt.

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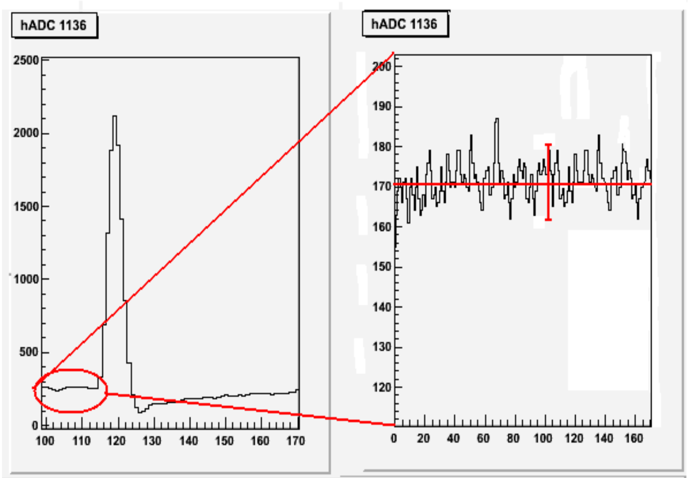
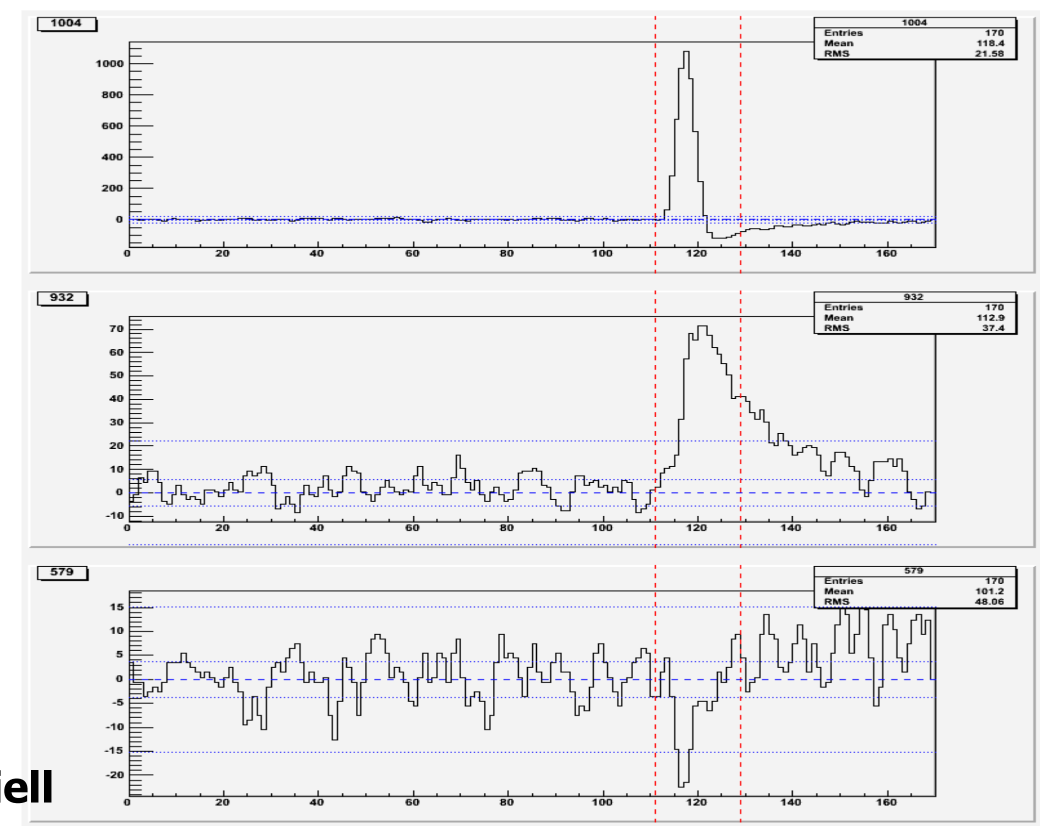
Getting good resolution with short peaking time - Reintegrate



Pedestal Subtraction:

- Averaged and RMS calculated
- Average subtracted from signals
- RMS used to define beginning of integration



Reintegration Method:

$$\text{Amp} = \sum_{i=n}^{n+w} |s_i|$$

$n = t_{\text{signal} > 4\ \text{RMS}} - 5$

w = integration width

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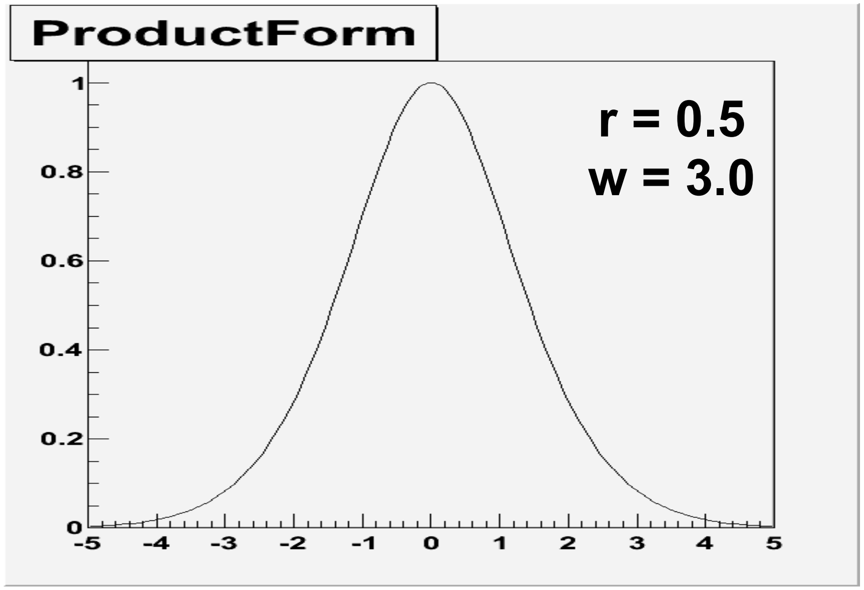
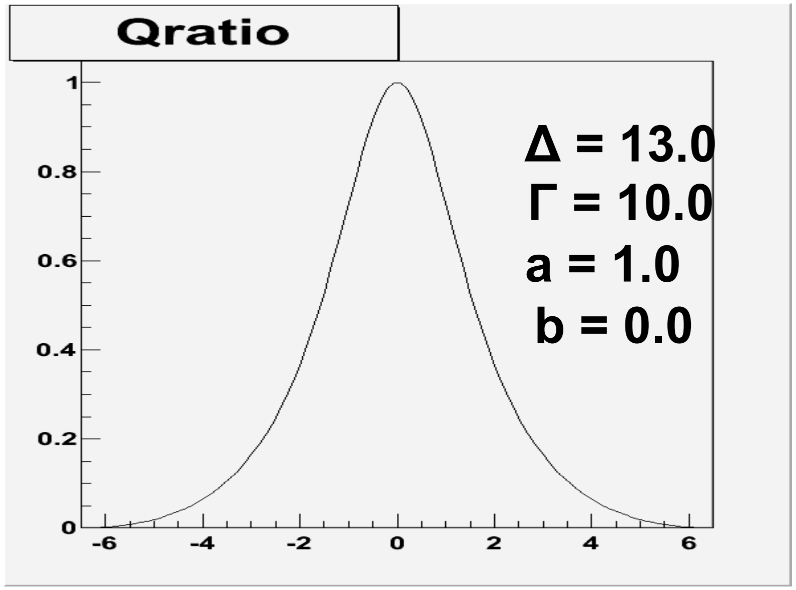
A new PRF parameterization to replace Qratio





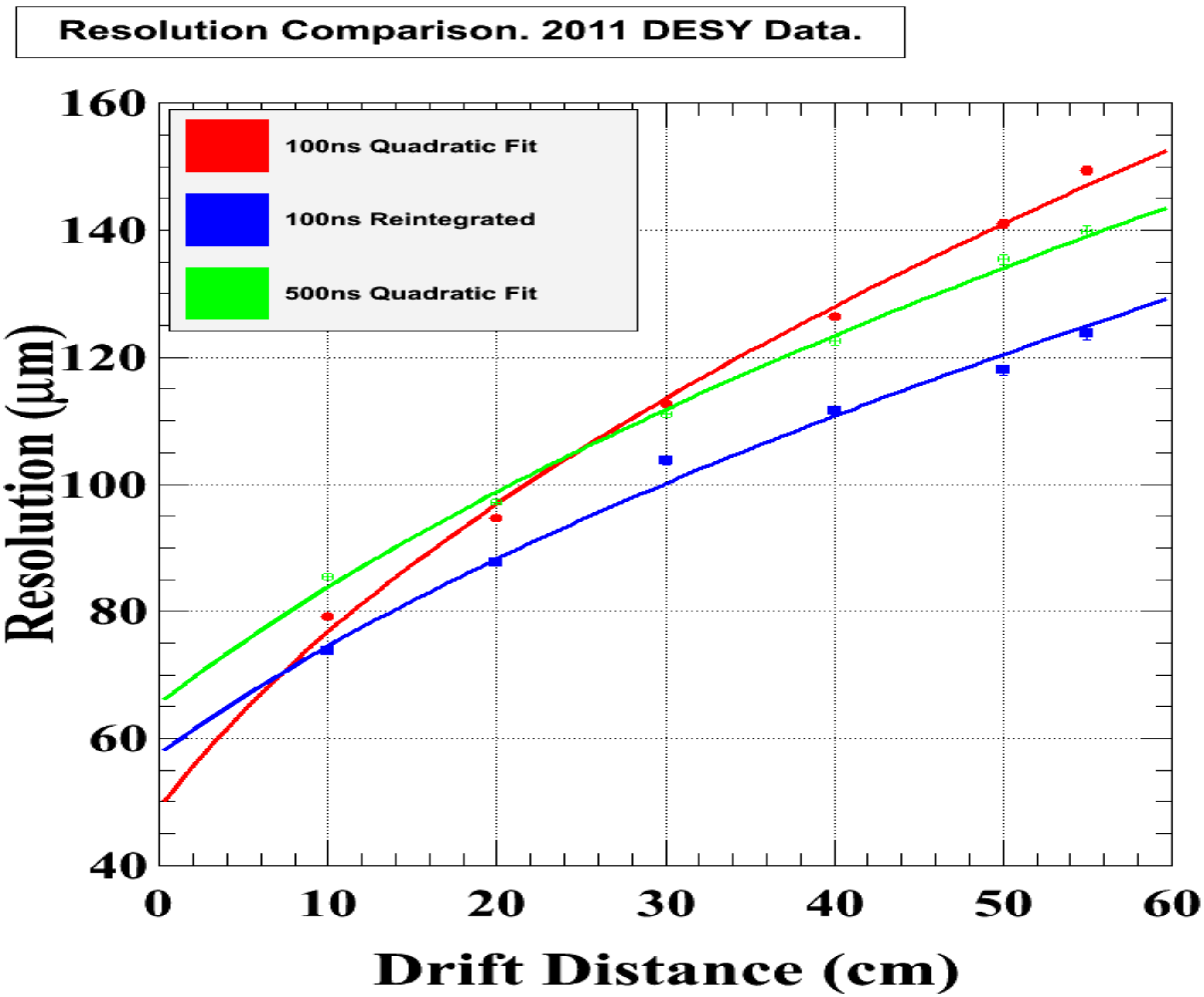
$$PRF(x;r,w) = \frac{exp(-4ln(2)(1-r)x^2/w^2)}{1+4x^2/w^2}$$

Replaces what was shown at Granada

$$PRF(x,\Gamma,\Delta,a,b) = \frac{1+a_2x^2+a_4x^4}{1+b_2x^2+b_4x^4}$$

$$a_2 = -(2/\Delta)^2(1+a)$$
$$a_4 = (2/\Delta)^4 a$$
$$b_2 = (2/\Gamma)^2(1-b-2(1+a)(\Gamma/\Delta)^2+2a(\Gamma/\Delta)^4)$$
$$b_4 = (2/\Gamma)^4 b$$

Resolution Comparison



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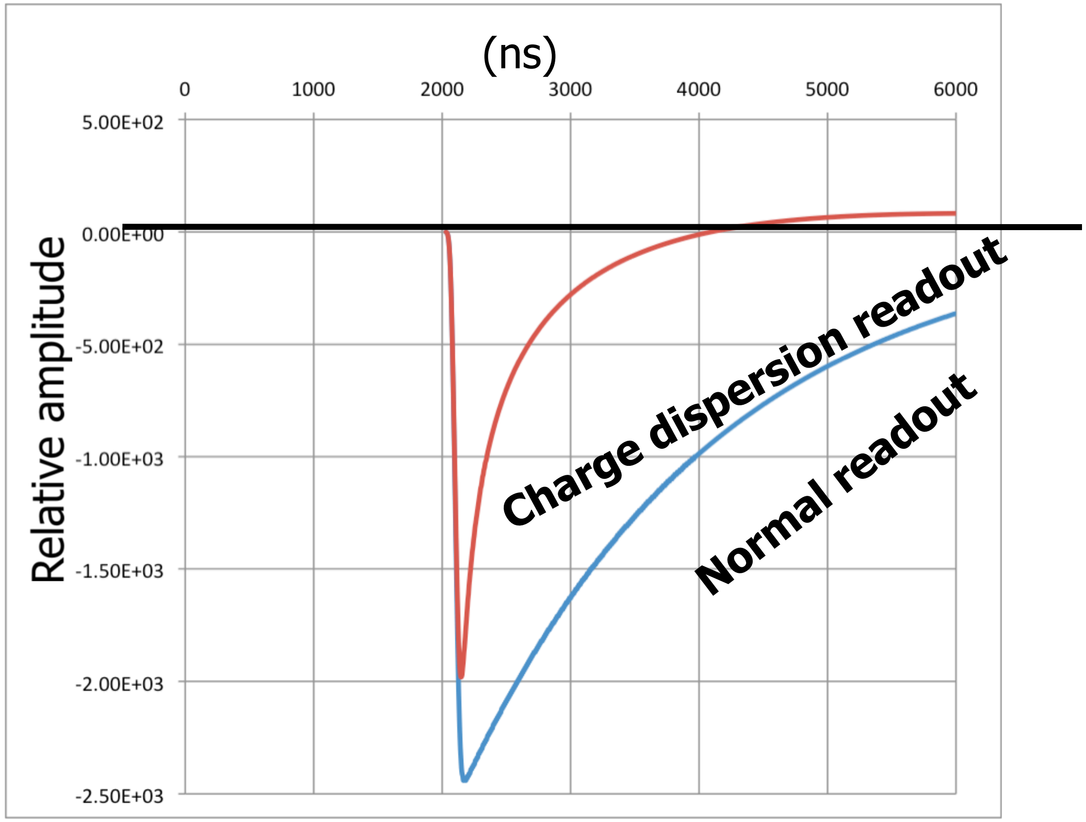
About signal pileup

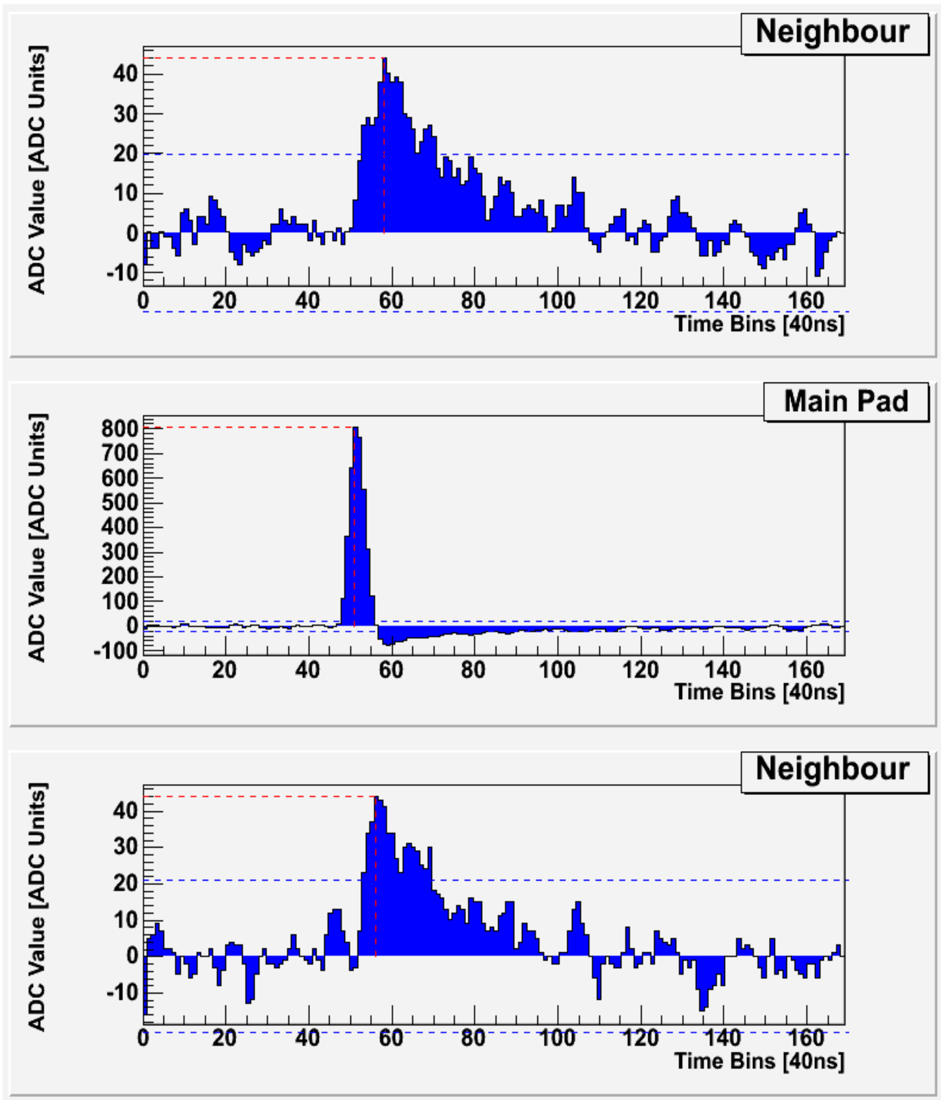
- For the conventional readout with 2 μs decay time preamp, it takes 6 μs for the pulse to get down to 5% level
- Charge dispersion readout brings down the preamp output to zero in a little over 2 μs depending on the system RC
- Signal pileup directly affects the front-end charge preamplifier output seen by the shaper
- Pileup at the preamplifier can reduce its dynamic range, but this is not visible at the output of the shaper
- Differentiation and pole zero cancelation in shaper amplifier cannot completely remove the effect of pulse pileup

Charge preamplifier signal with & without charge dispersion (Time constant =2μs)



With charge dispersion, the pad charge signal goes to zero faster than the preamplifier decay time reducing pileup

Can we measure a second pulse piling up on the first one? (Track in the middle of a pad)

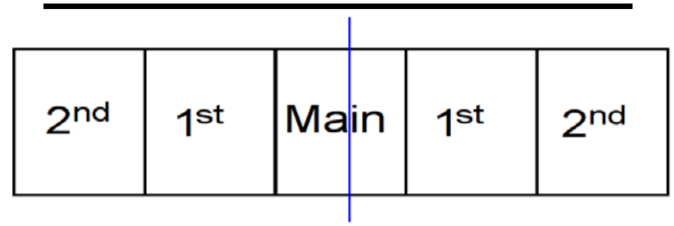


Run Information:

- **100ns Peaking time**
- **- 30 cm drift**
- **Non Zero Suppressed**

Pad	Amp	Time
Neighbour	44	58
Main	807	53
Neighbour	44	57

Track Location:



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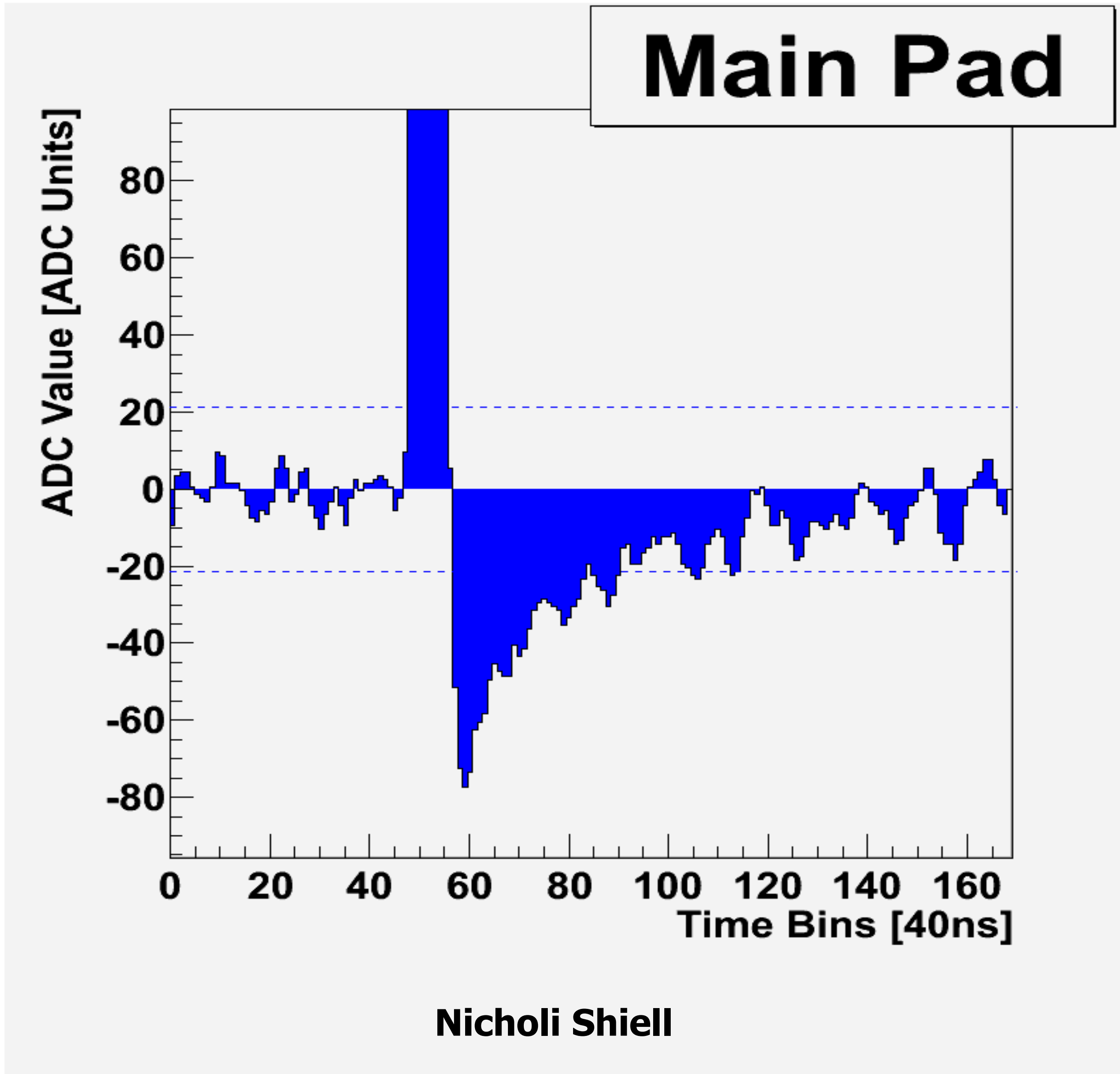
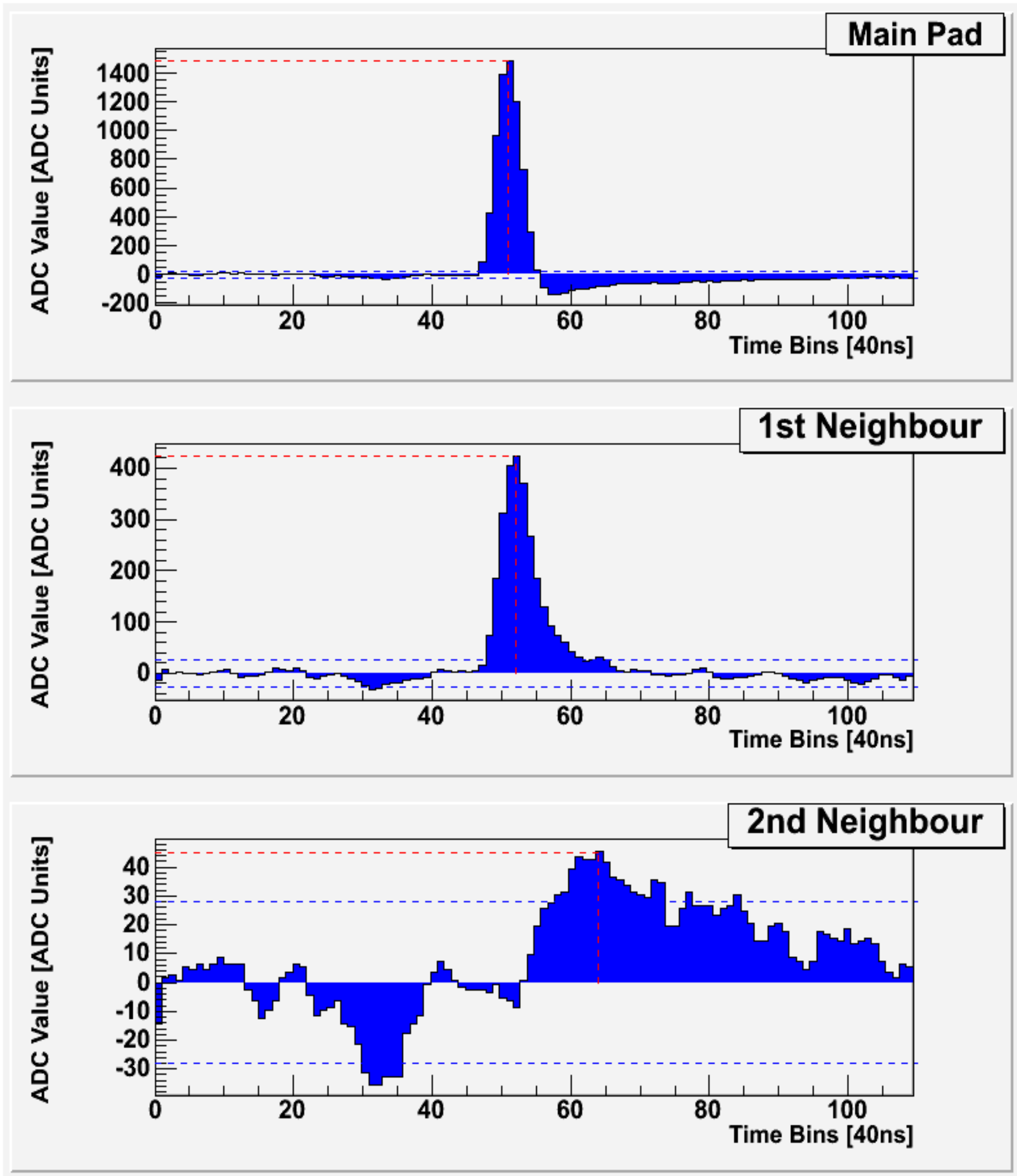
100ns Pulse(Centered Zoomed)



100ns Pulses (track off centre by ~25% pad width)

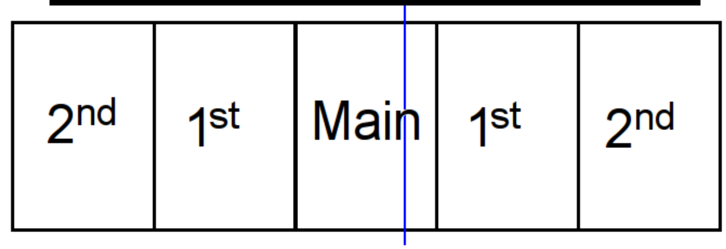


Run Information:

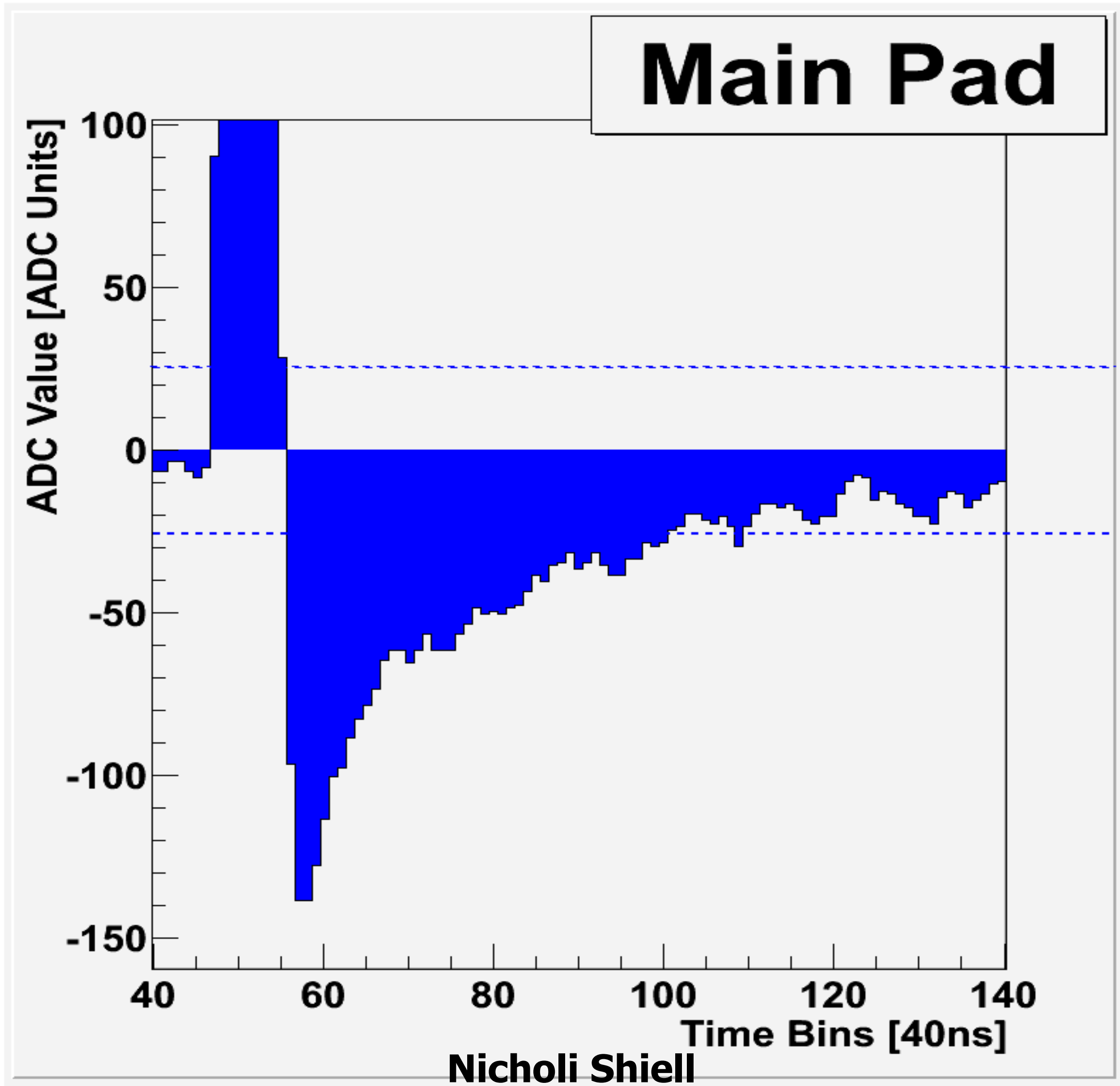
- 100ns Peaking time
- 30 cm drift
- Non Zero Suppressed

Pad	Amp	T0
Main	1448	52
1st Neighbour	411	55
2nd Neighbour	42	64

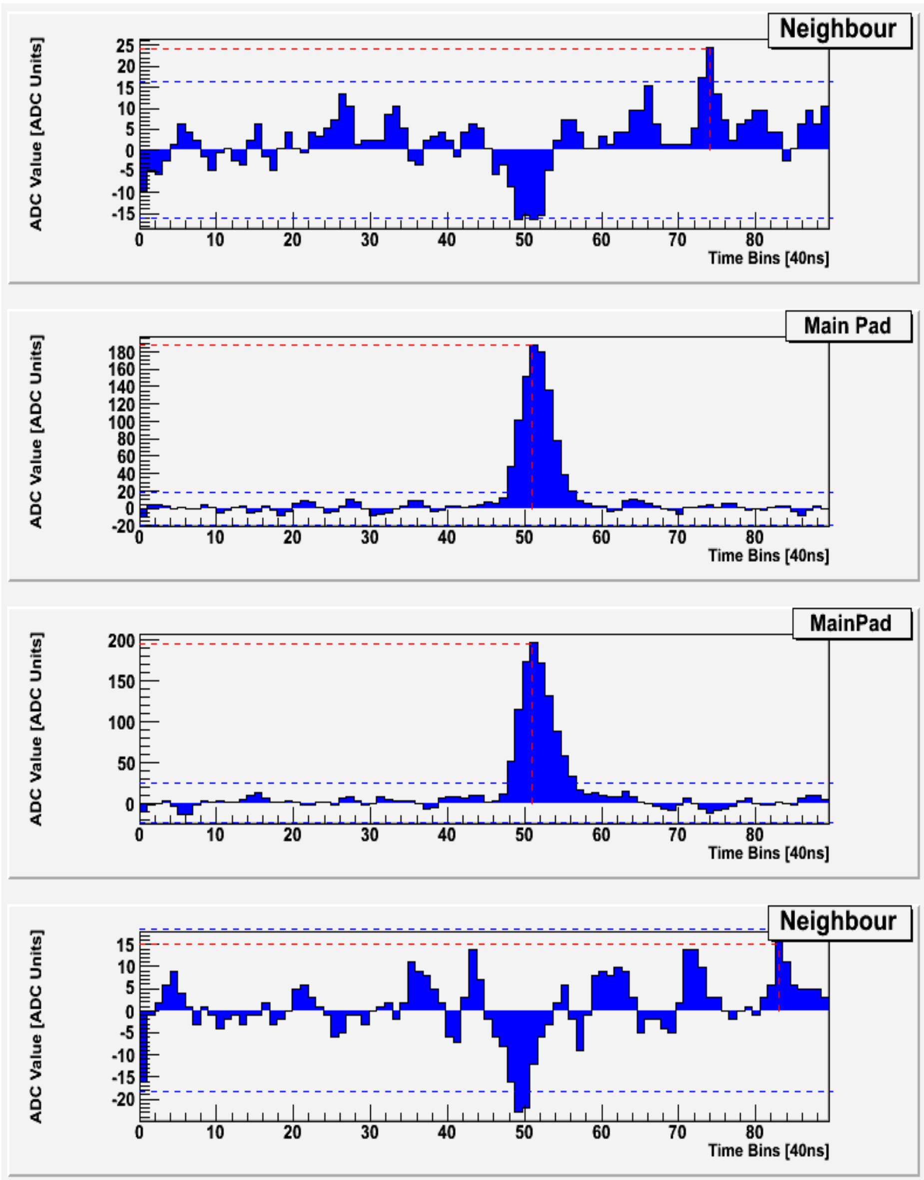
Track Location:



100ns Pulses(track 25% off center Zoomed)



100ns Pulses (track charge shared between pads)

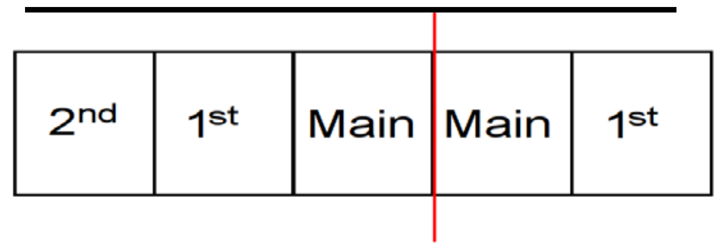


Run Information:

- 100ns Peaking time
- 30 cm drift
- Non Zero Suppressed

Pad	Amp	T0
Neighbour	24	74
Main	184	51
Main	190	51
Neighbour	15	82

Track Location:



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Comments

- Compared to normal readout, the pileup for charge dispersion is less due to the signal coming down to zero faster than the decay time of the front-end charge preamplifier
- For the adjacent pads with charge dispersion signal, one should be able to easily measure a direct charge signal piling up
- We already measure the pedestal dynamically. We can also determine the pedestal with a slope in case of pileup
- Some artifacts seen in our data not fully understood. It should be possible, however, to reduce the undershoot observed by better pole zero cancellation