# n3He Target Chamber Voltage Scan

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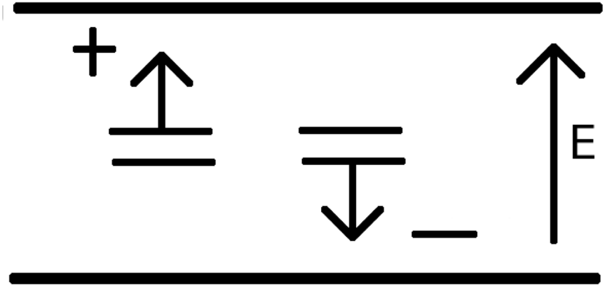
# Basic Information

- 60 Hertz pulsed spallation source
- 49 time bins per pulse for Clean DAQs
- 144 chamber wires to read out.
- 1624 time bins per pulse for dirty daq (spin flipper and beam monitor)
- One M1 Monitor

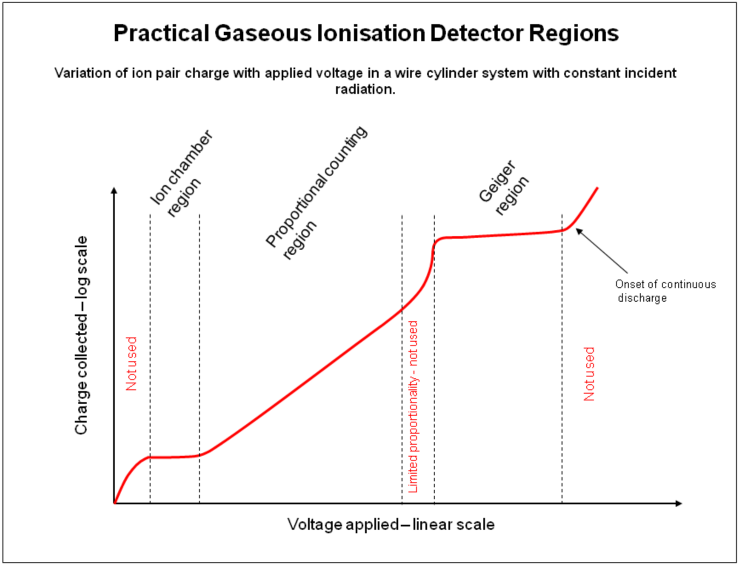



$$U = K_+ E \qquad\qquad V = K_- E$$

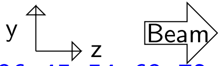
where

- $U$ is the drift velocity of the positive ions
- $V$ is the drift velocity of the negative ions
- $E$ is the electric field
- $K$ is a proportionality constant for the gas mix, $E$ and charged particle ($K_+ \ll K_-$)

# Basic Modes of Operation



# Wire Indices




| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| i | 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 | 90 | 99 | 108 | 117 | 126 | 135 | 144 |
| h | 8 | 17 | 26 | 35 | 44 | 53 | 62 | 71 | 80 | 89 | 98 | 107 | 116 | 125 | 134 | 143 |
| g | 7 | 16 | 25 | 34 | 43 | 52 | 61 | 70 | 79 | 88 | 97 | 106 | 115 | 124 | 133 | 142 |
| f | 6 | 15 | 24 | 33 | 42 | 51 | 60 | 69 | 78 | 87 | 96 | 105 | 114 | 123 | 132 | 141 |
| e | 5 | 14 | 23 | 32 | 41 | 50 | 59 | 68 | 77 | 86 | 95 | 104 | 113 | 122 | 131 | 140 |
| d | 4 | 13 | 22 | 31 | 40 | 49 | 58 | 67 | 76 | 85 | 94 | 103 | 112 | 121 | 130 | 139 |
| c | 3 | 12 | 21 | 30 | 39 | 48 | 57 | 66 | 75 | 84 | 93 | 102 | 111 | 120 | 129 | 138 |
| b | 2 | 11 | 20 | 29 | 38 | 47 | 56 | 65 | 74 | 83 | 92 | 101 | 110 | 119 | 128 | 137 |
| a | 1 | 10 | 19 | 28 | 37 | 46 | 55 | 64 | 73 | 82 | 91 | 100 | 109 | 118 | 127 | 136 |
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 |

- HV 17 HV Frames with 8 wires each
- Signal 16 signal Frames with 9 wires each

# Run Numbers Looked At

| BiasVoltage | Run Number |
|---|---|
| 0 | 57178 |
| 0 | 57181 |
| -52 | 59817 |
| -86 | 59819 |
| -99 | 59821 |
| -150 | 59823 |
| -201 | 59825 |
| -250 | 59827 |
| -253 | 57185 |
| -300 | 59829 |
| -303 | 57187 |
| -337 | 57177 |
| -351 | 59831 |
| -355 | 57193 |
| -397 | 57195 |

| BiasVoltage | Run Number |
|---|---|
| -400 | 59833 |
| -450 | 59835 |
| -500 | 59839 |
| -552 | 59837 |

# Averaging Method

- Integrated each pulse in a run for all wires and M1

$$x_{j,i} = \frac{1}{60 \times N} \sum_{k=1}^{N} s_{j,i}(k) \quad N = 49 \text{ or } 1624 \tag{1}$$

where $x_{j,i}$ is the integrated total of the $i$th pulse in the $j$th run.

- Average pulse integrals and form standard error for run averages

$$Avg = \langle x_j \rangle = \frac{1}{q} \sum_{i=1}^{q} x_{j,i} \tag{2}$$

$$q = \text{number of uncut entries in run}$$

$$StdErr = \frac{\sigma}{\sqrt{q}} = \frac{1}{\sqrt{q}} \sqrt{\langle x^2 \rangle - \langle x \rangle^2} \tag{3}$$

- M1 cut used to remove dropped pulses if $M1[600] < 0.9\langle M1[600] \rangle$
- M1 and Chamber correlations not accounted for.

# Averaging Method

A beam off power supply off run was used as the pedestal and designated by $j = 0$. The wire and M1 values were pedestal subtracted before division.

$$R_j = \frac{\langle x_j \rangle - \langle x_0 \rangle}{\langle M1_j \rangle - \langle M1_0 \rangle} \tag{4}$$

Error Propagation:

$$C = A - B \tag{5}$$

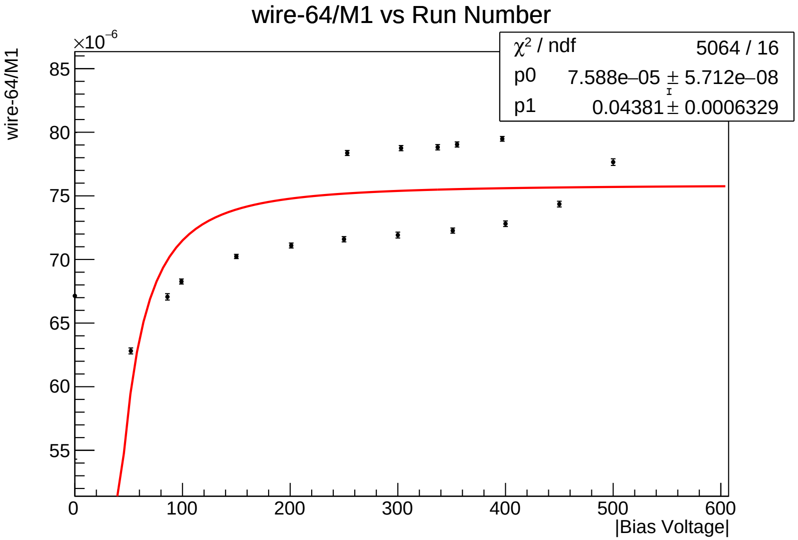
$$\sigma_C = \sqrt{\sigma_A^2 + \sigma_B^2} \tag{6}$$

$$C = \frac{A}{B} \tag{7}$$

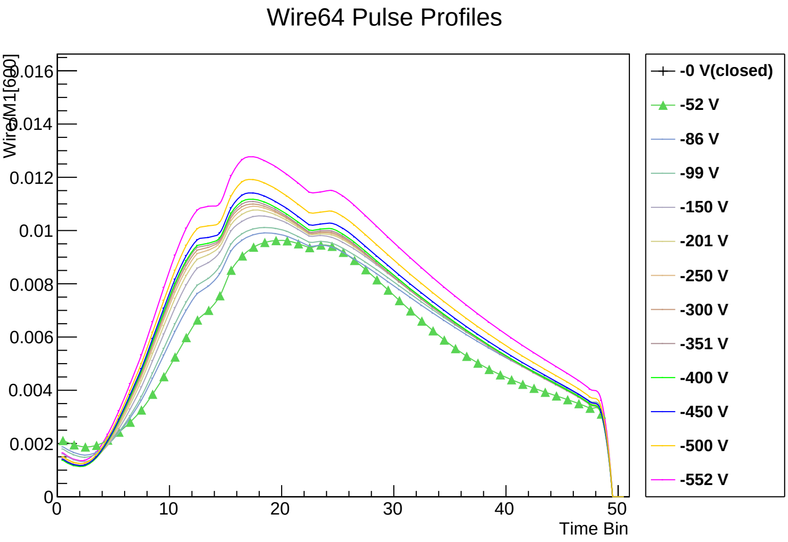
$$\sigma_C = \frac{A}{B}\sqrt{\left(\frac{\sigma_A}{A}\right)^2 + \left(\frac{\sigma_B}{B}\right)^2} \tag{8}$$

where $\sigma$ is the uncertainty for the values.

# Wire 64 - Curve

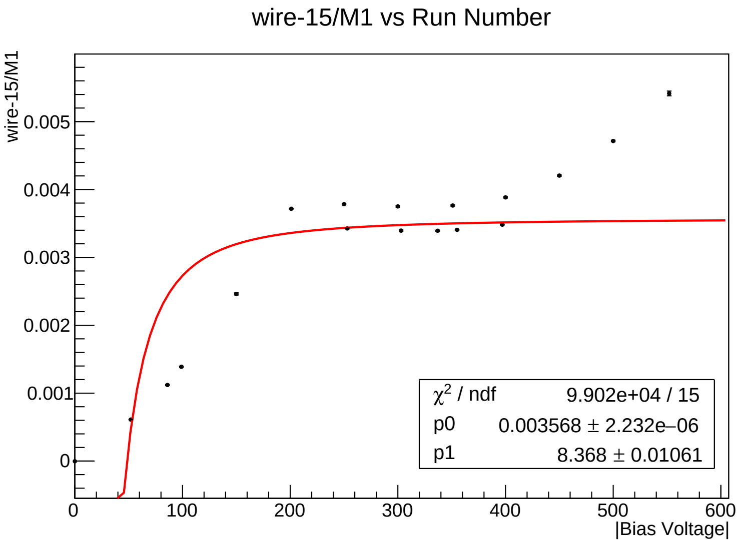


# Wire 64 - Pulse Overlay

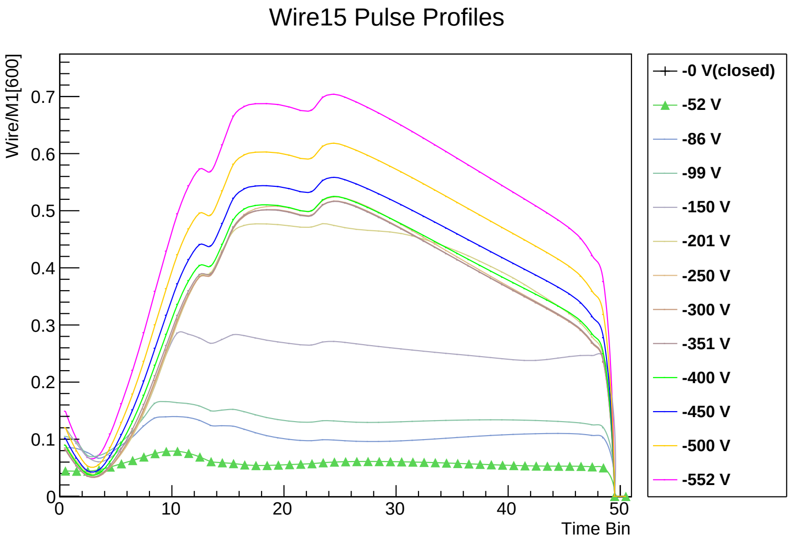



Note: Error are small and not plotted on line overlay plots.

# Wire 15 - Volt Scan Results

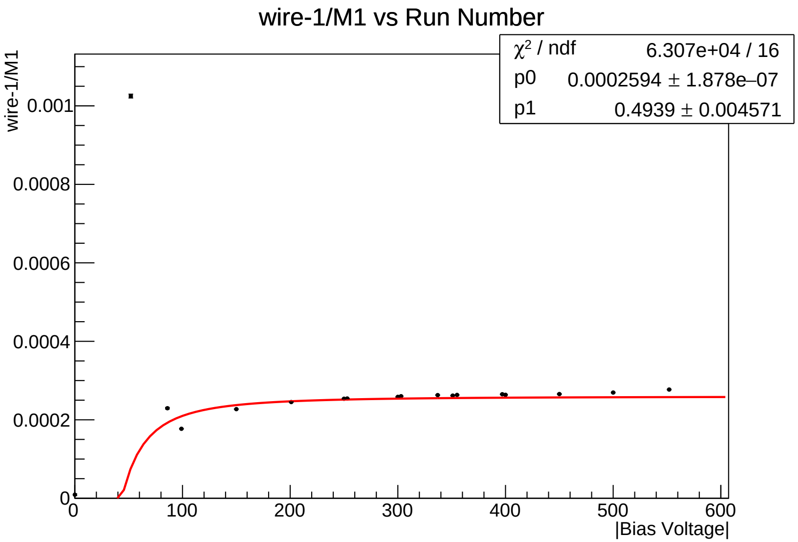


# Wire 15 - Pulse Overlay

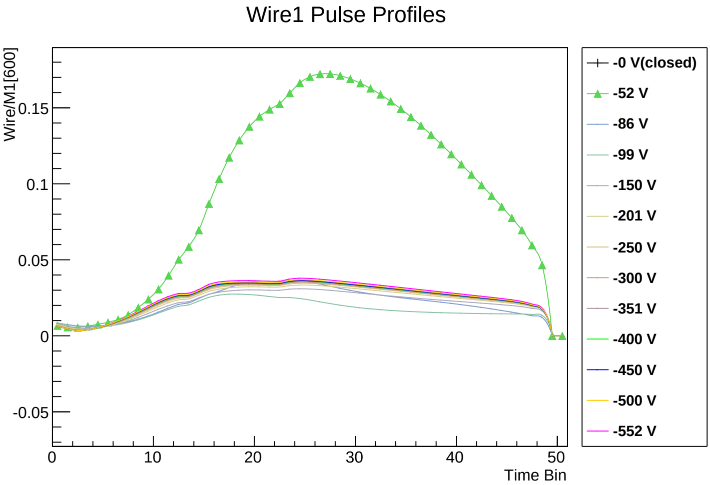



t.Draw("x:y","","prof hist l");

# Wire 1 - Volt Scan Results

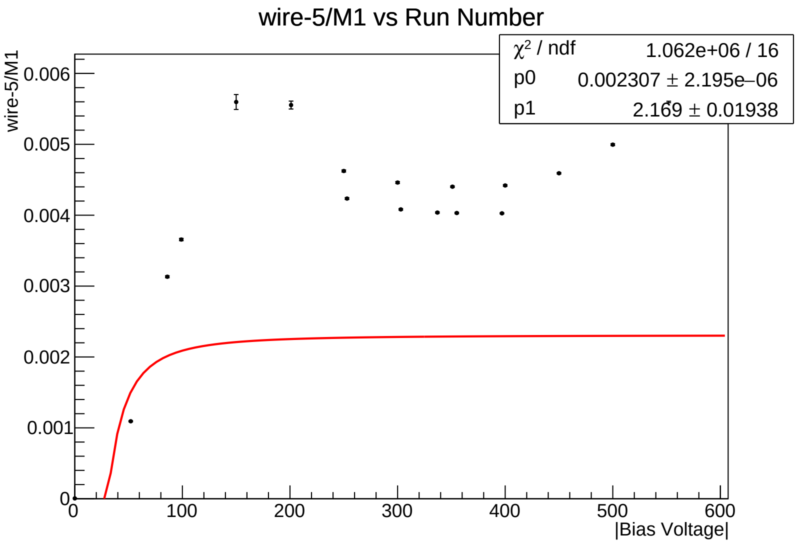


# Wire 1 - Pulse Overlay

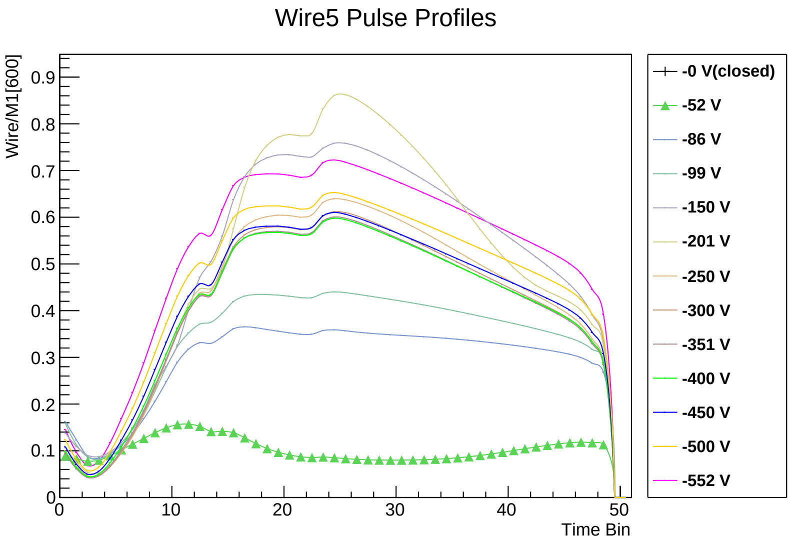



Note: These are not pedestal subtracted and the same relative trends are seen here with regards to -56V peak height.

# Wire 5 - Volt Scan Results



# Wire 5 - Pulse Overlay



# Trends - Low Voltage

- row 1: first point (-52V) is high in most wires, this is repeated in other rows but mainly outside two, rows 1 and 9.
- row 2: second two points (-86V and -99V) are high along with occasional -52V point.
- row 3: 3, 30, 39 have -86V and -99V deviations
  48,57,66 have -52V deviations.
  wire 129 curves downward instead of upward, seems to be inverted overall.
- row 4: 4, 40, 49 have -86V and -99V deviations,
- row 5: wires 5, 41, 50 have -86V and -99V deviations
- row 6: wires 51, 69 have -86V and -99V deviations
- row 7: 7, 43, 53 have -86V and -99V deviations
  70 61 have -52V deviations
  wire 142 inverted
- row 8: 8,17,26,35 have -86V and -99V deviations,
- row 9: 9,18,27,36,45,54,63 -52V deviations

# Fitting Method

For fitting the proportional region first a constant line from 200 - 340V was fit in the ionization region for most wires. This was used to set $p0$ in the piece wise function

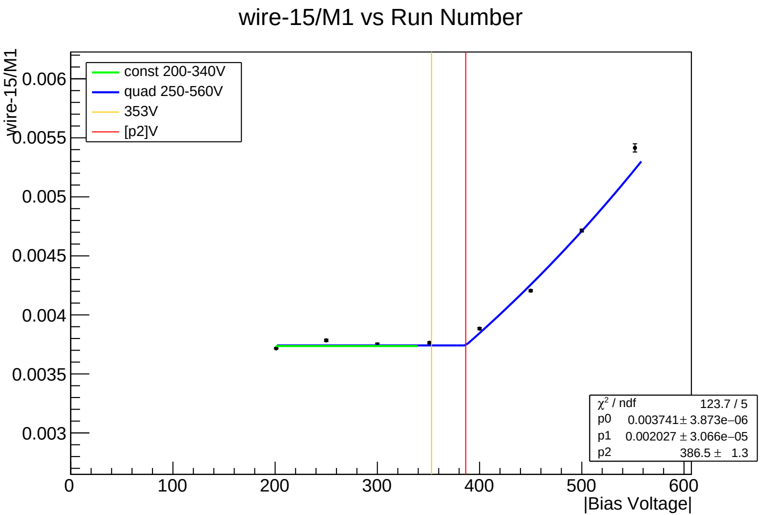
$$f(x) = \begin{cases} p0 & \text{if } x < p2 \\ p0 + p1(x - p2)^2 & \text{if } x > p2 \end{cases} \tag{9}$$

Root Formula Definition:

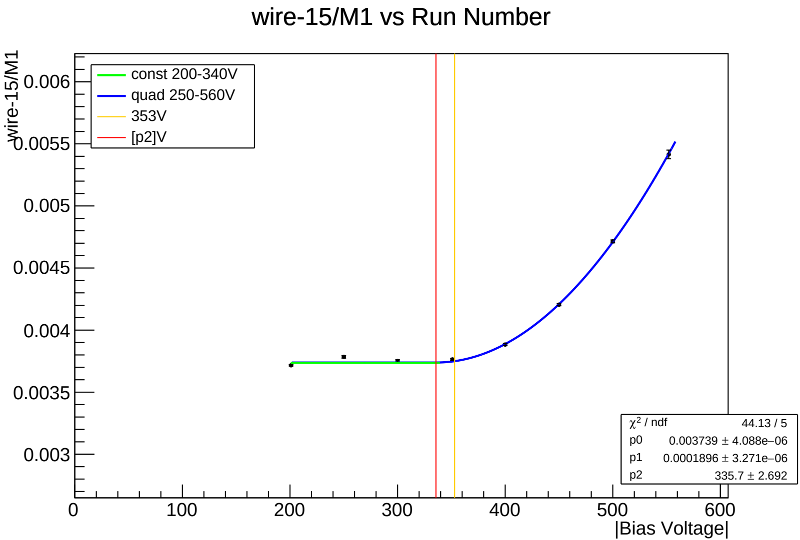
```
TF1 *fm3 = new TF1("fm3","(x<[2])*[0]
+(x>[2])*([0]+([1]*(x-[2]))**2)",200,560);
```

giving a continuous curve that starts linear and transitions at voltage $p2$ to quadratic.
An exponential second part was tried but it did not give as good of fits overall.

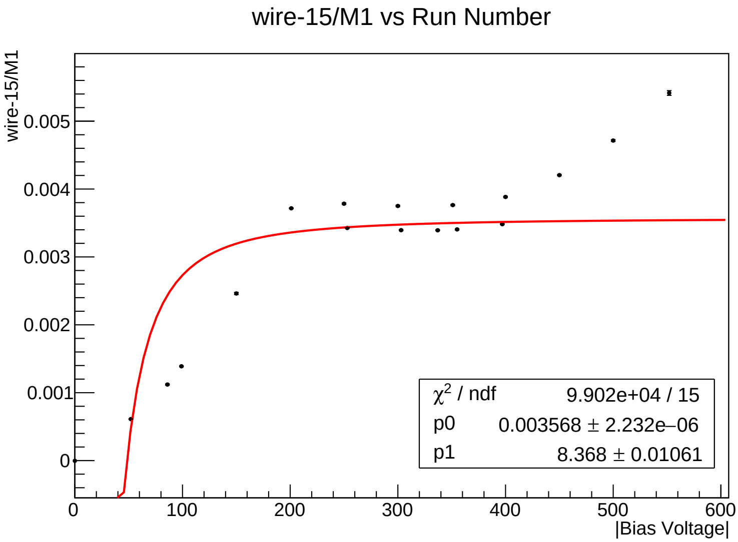
# Proportional Fitting - Exponential



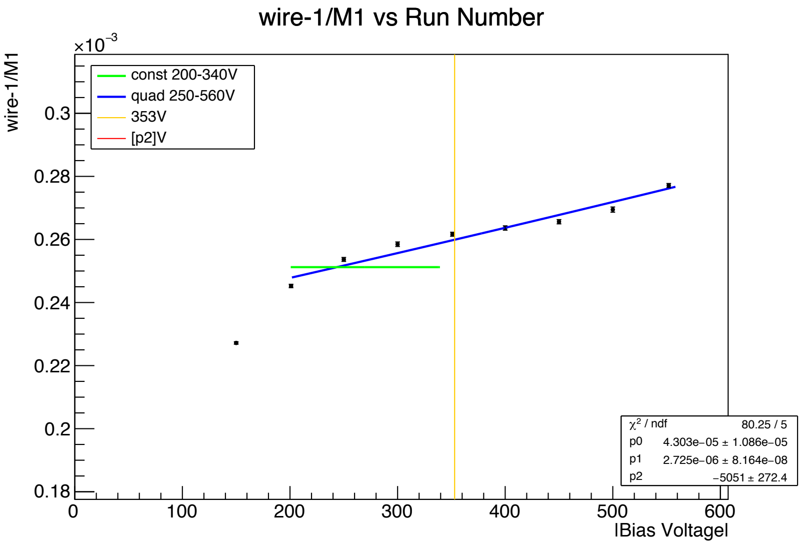
# Proportional Fitting - Quadratic



# Wire 15 - Pulse overlay

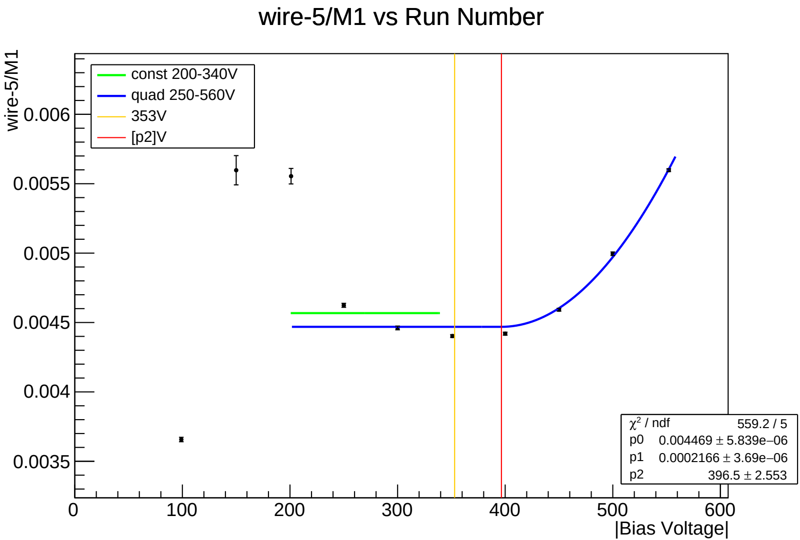


# Proportional Fitting - Wire 1

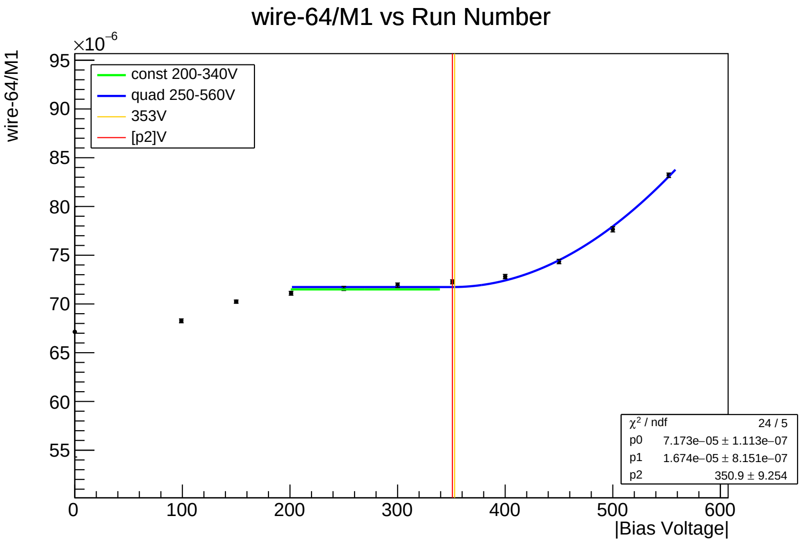



The same pattern is seen for all outer wires in the front third or so of the target chamber.

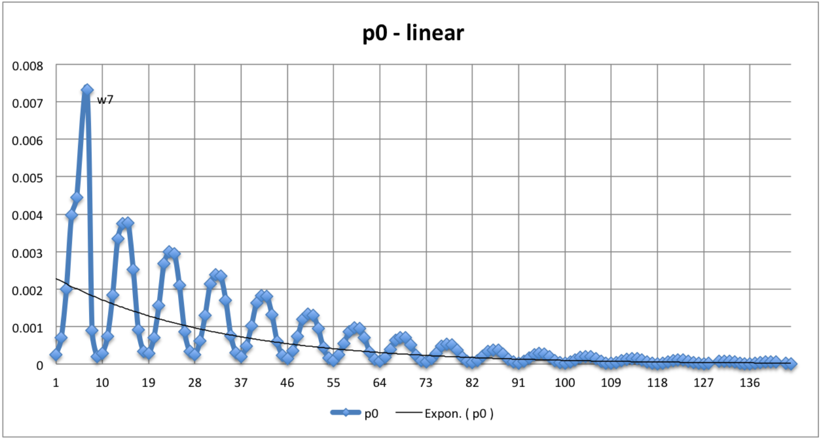
# Proportional Fitting - wire 5



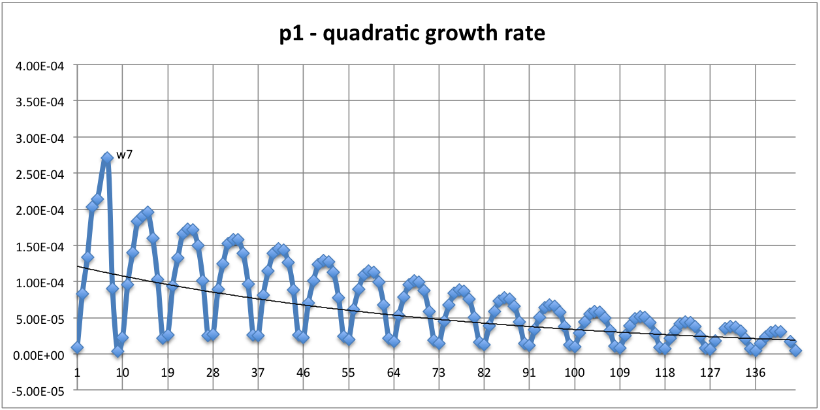
# Proportional Fitting - wire 64



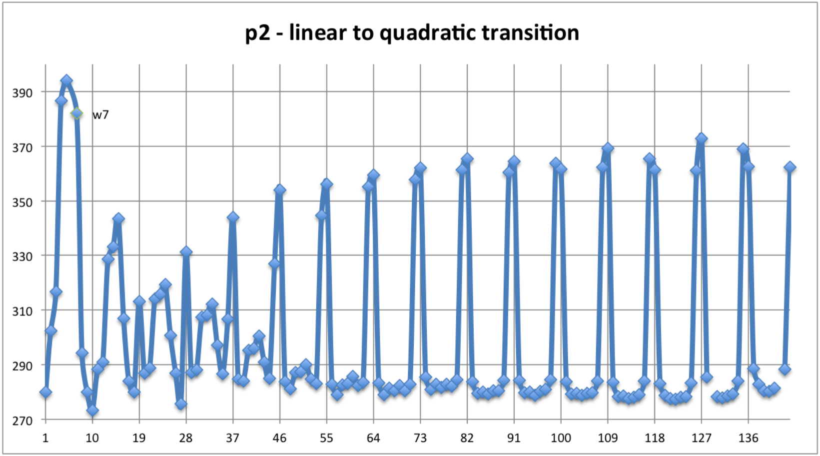
# Excel Plot - p0



# Excel Plot - p1



# Excel Plot - p2



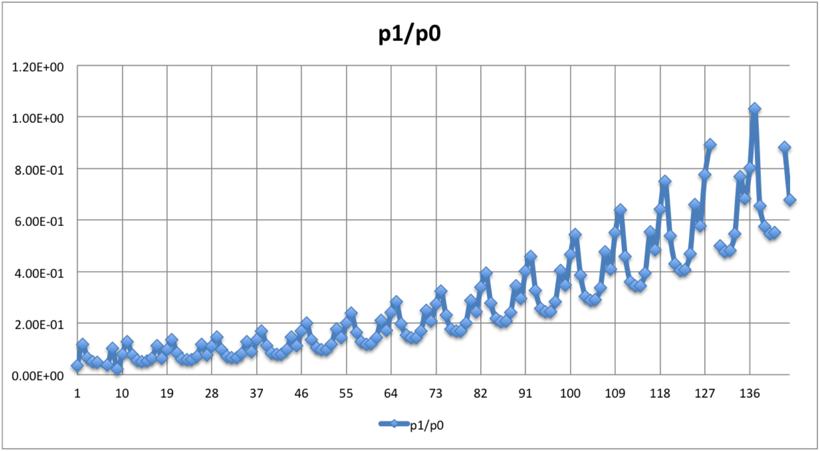
# Trends - Amplification Region

- outer rows transfer from recombination to proportional with no ionization region
- exact onset of multiplication is most variable in front of target
- Possible space charge effects. Back of chamber is more uniform than the front where the space charge is most dense and changing most rapidly.
- Possible coupling to the spin flipper in the front third and outer wires? (not very probable)

# Summary

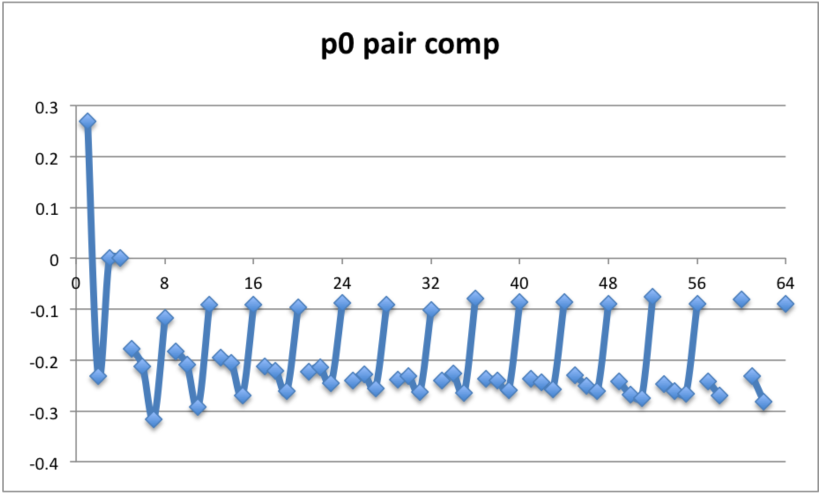
- Voltage Scan covered 0 to -550V
- operating voltage was -353V
- Some multiplication at this voltage
- Some odd results at low voltage
- deviations mainly at front and outer wires
- approximately 1/3 of wires had some kind of deviation at low voltage
- cause is unknown
- two voltage scans done weeks apart in 250-350 range gave very similar results
- Probably had stable running with multiplication during experiment.
- Can wire amplification differences be sufficiently understood from these measurements?

# Spare Slide - Ratio of P1 to P0



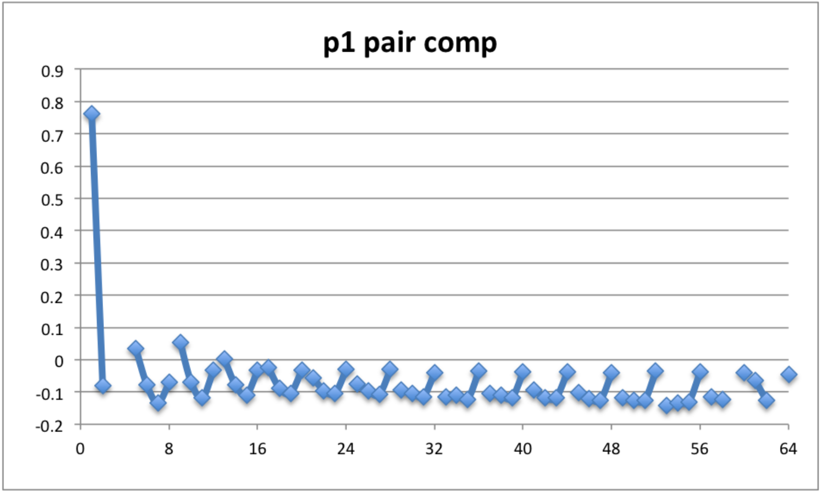
# Spare Slide - percent difference of P0 to P0 in wire pairs

$$(p0_1 - p0_2)/\left[0.5(p0_1 + p0_2)\right] \tag{10}$$

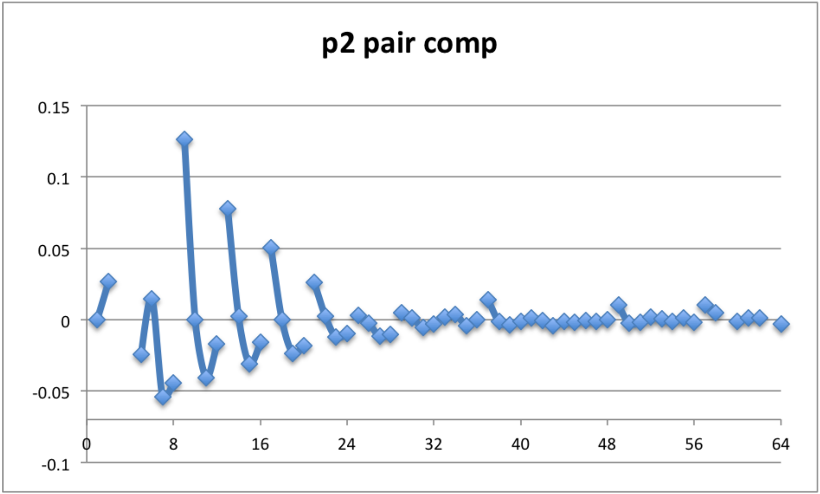



- pair 1 - wires 1 and 9
- pair 2 - wires 2 and 8
- pair 3 - wires 3 and 7
- pair 4 - wires 4 and 6

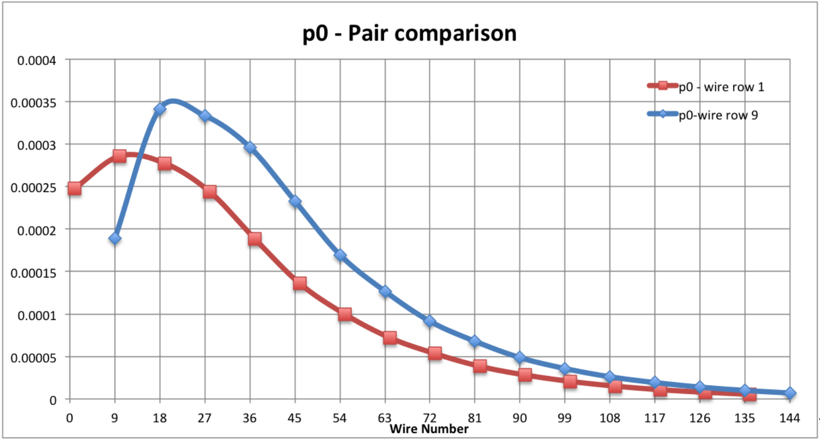
# Spare Slide - Ratio of P1 to P1 LR



# Spare Slide - Ratio of P2 to P2 LR

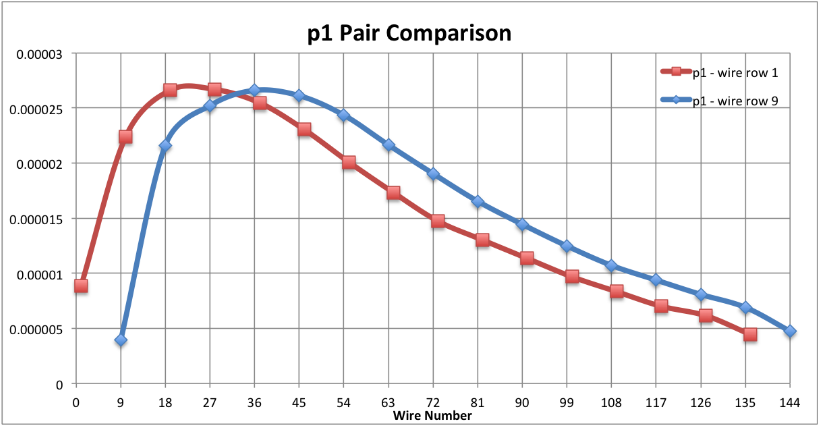


# Spare Slide - Pair 1 P0

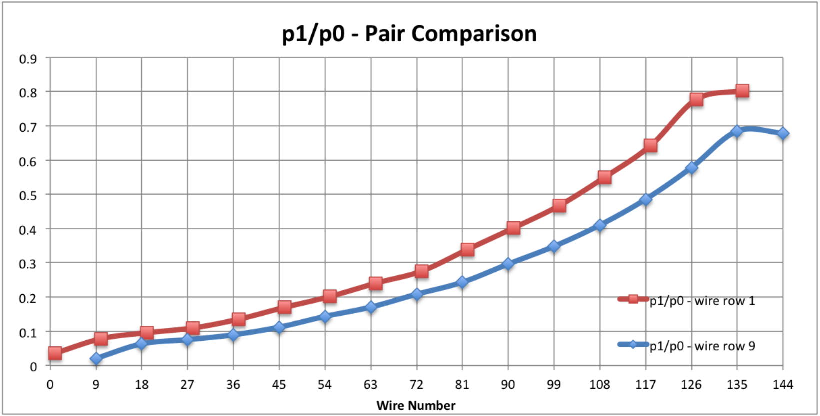



The following are the same plots as the excel plots pages, but only for the two wires that would be paired in a pair asymmetry analysis.

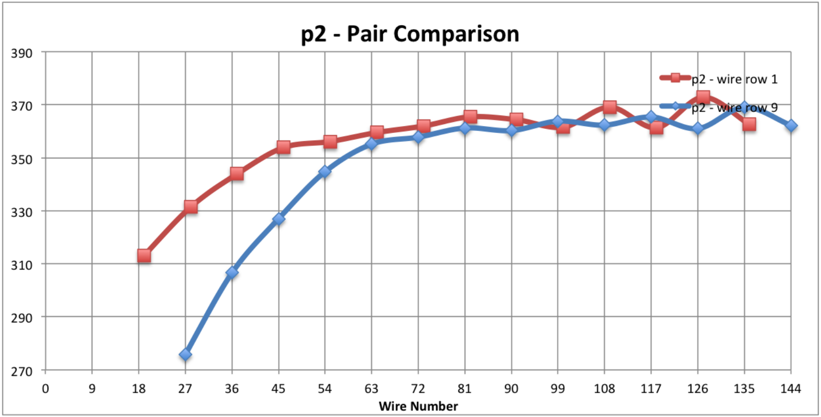
# Spare Slide - Pair 1 P1



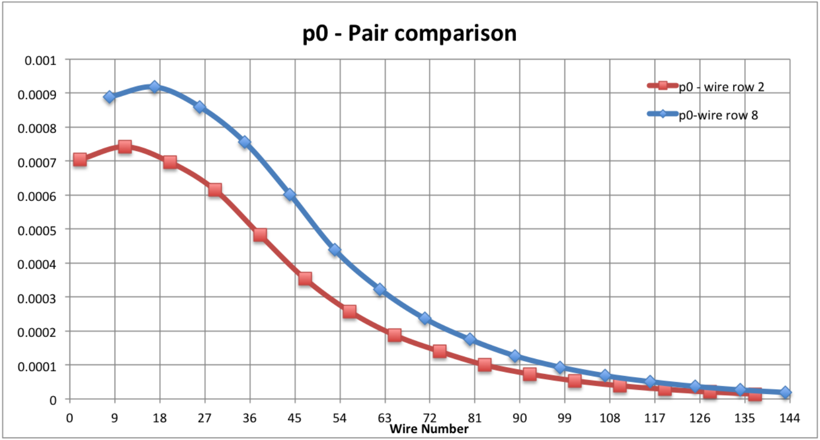
# Spare Slide - Pair 1 P1/P0



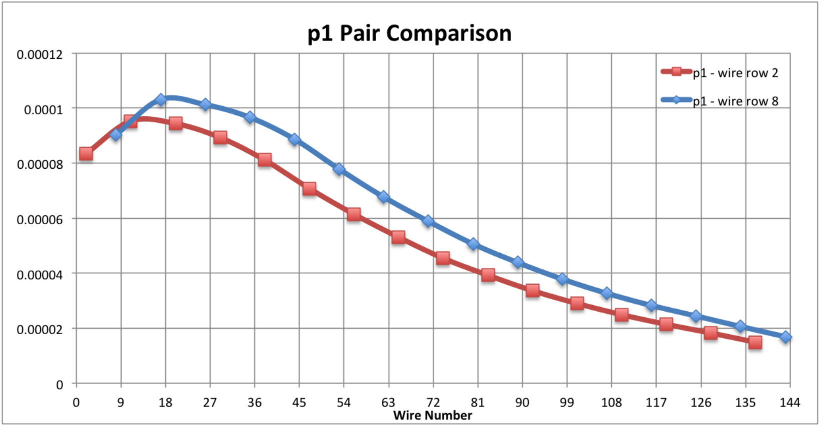
# Spare Slide - Pair 1 P2



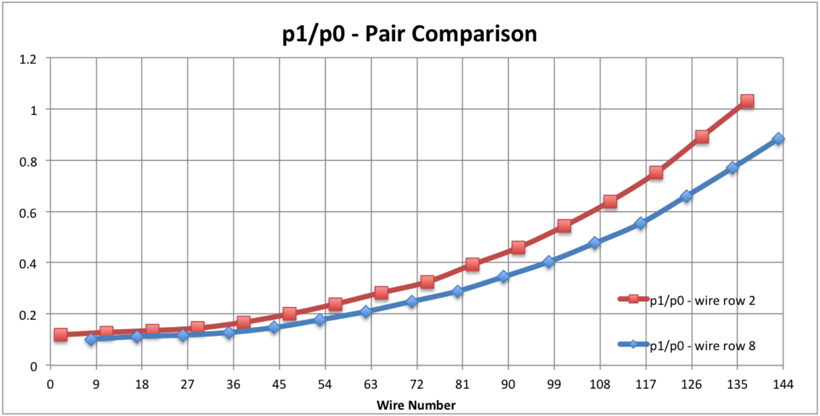
# Spare Slide - Pair 2 P0



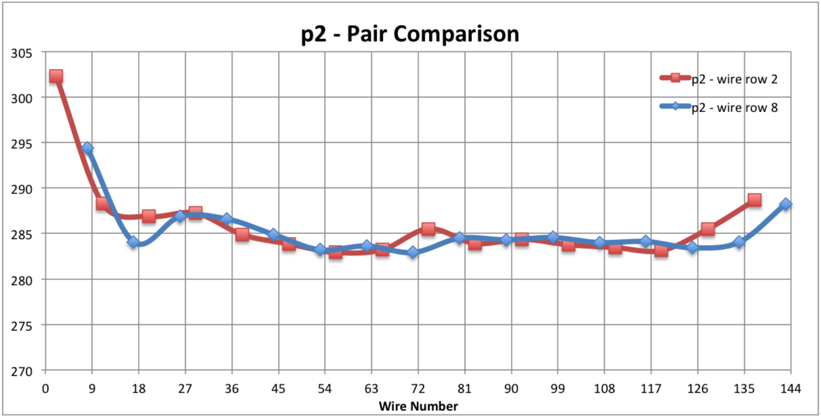
# Spare Slide - Pair 2 P1



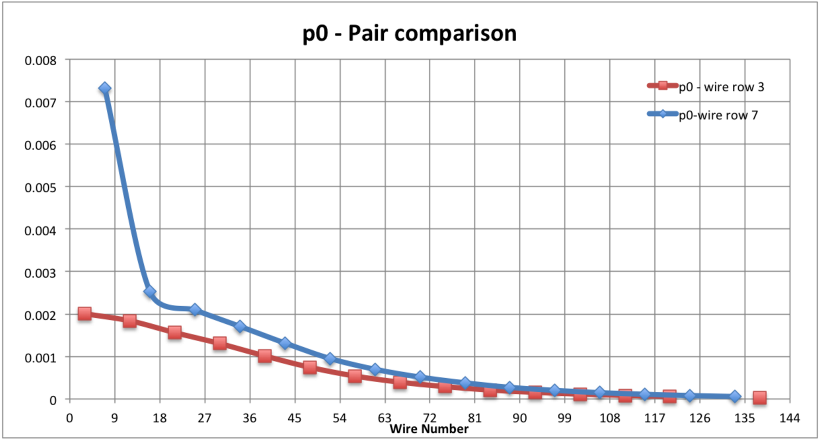
# Spare Slide - Pair 2 P1/P0



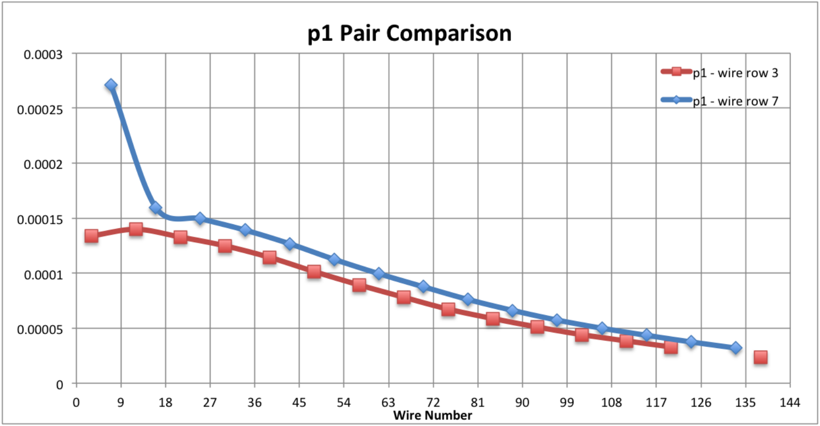
# Spare Slide - Pair 2 P2



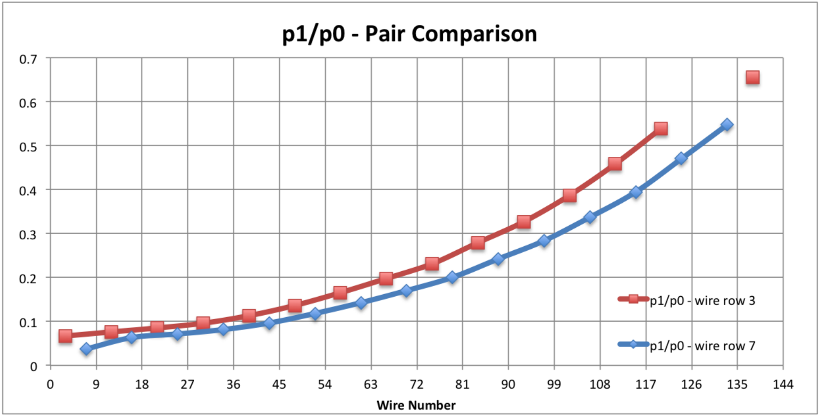
# Spare Slide - Pair 3 P0



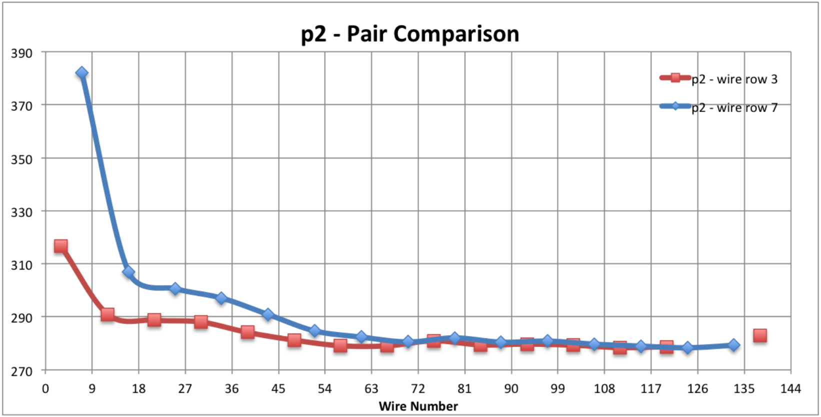
# Spare Slide - Pair 3 P1



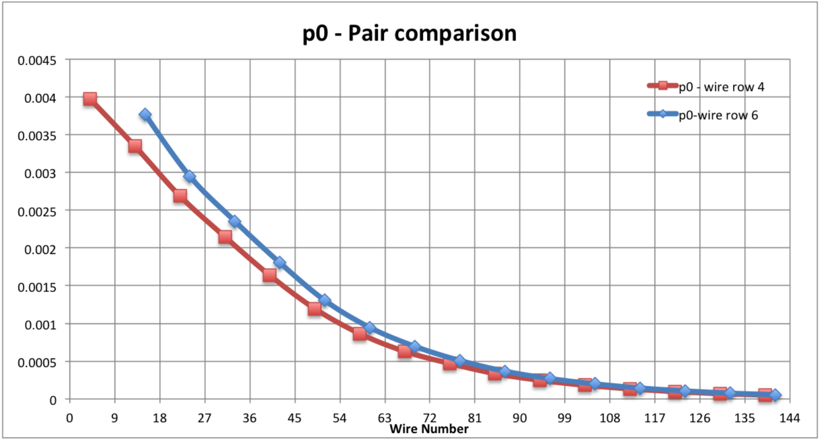
# Spare Slide - Pair 3 P1/P0



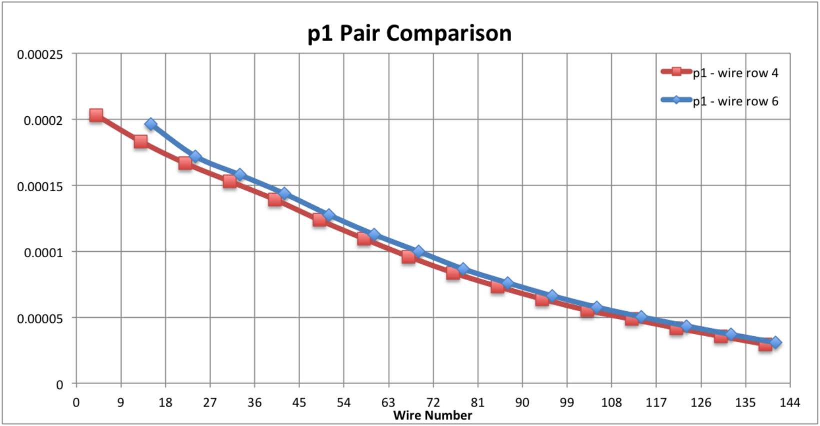
# Spare Slide - Pair 3 P2



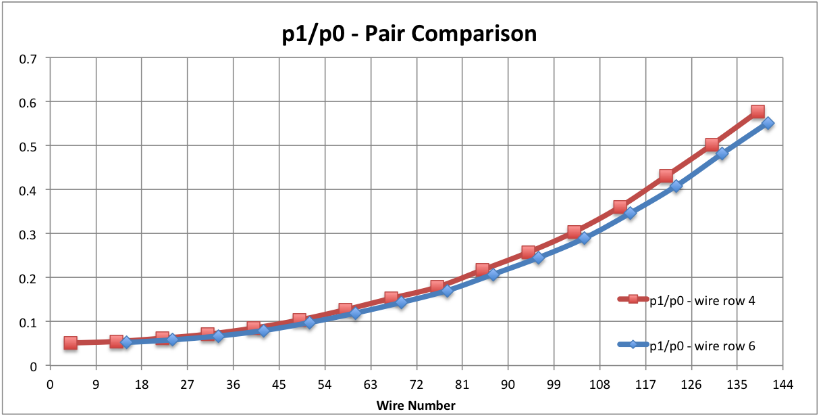
# Spare Slide - Pair 4 P0



# Spare Slide - Pair 4 P1



# Spare Slide - Pair 4 P1/P0



# Spare Slide - Pair 4 P2