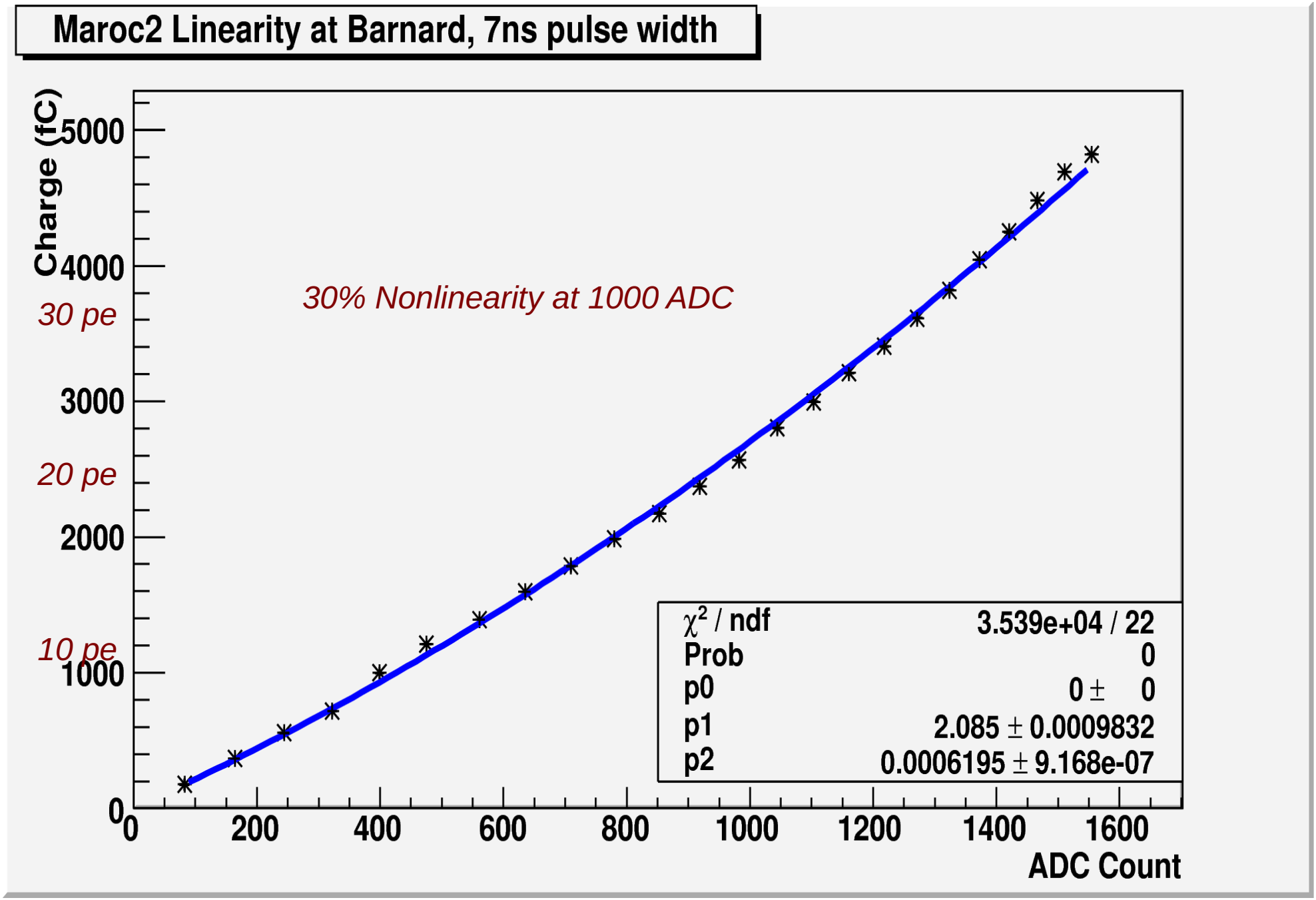
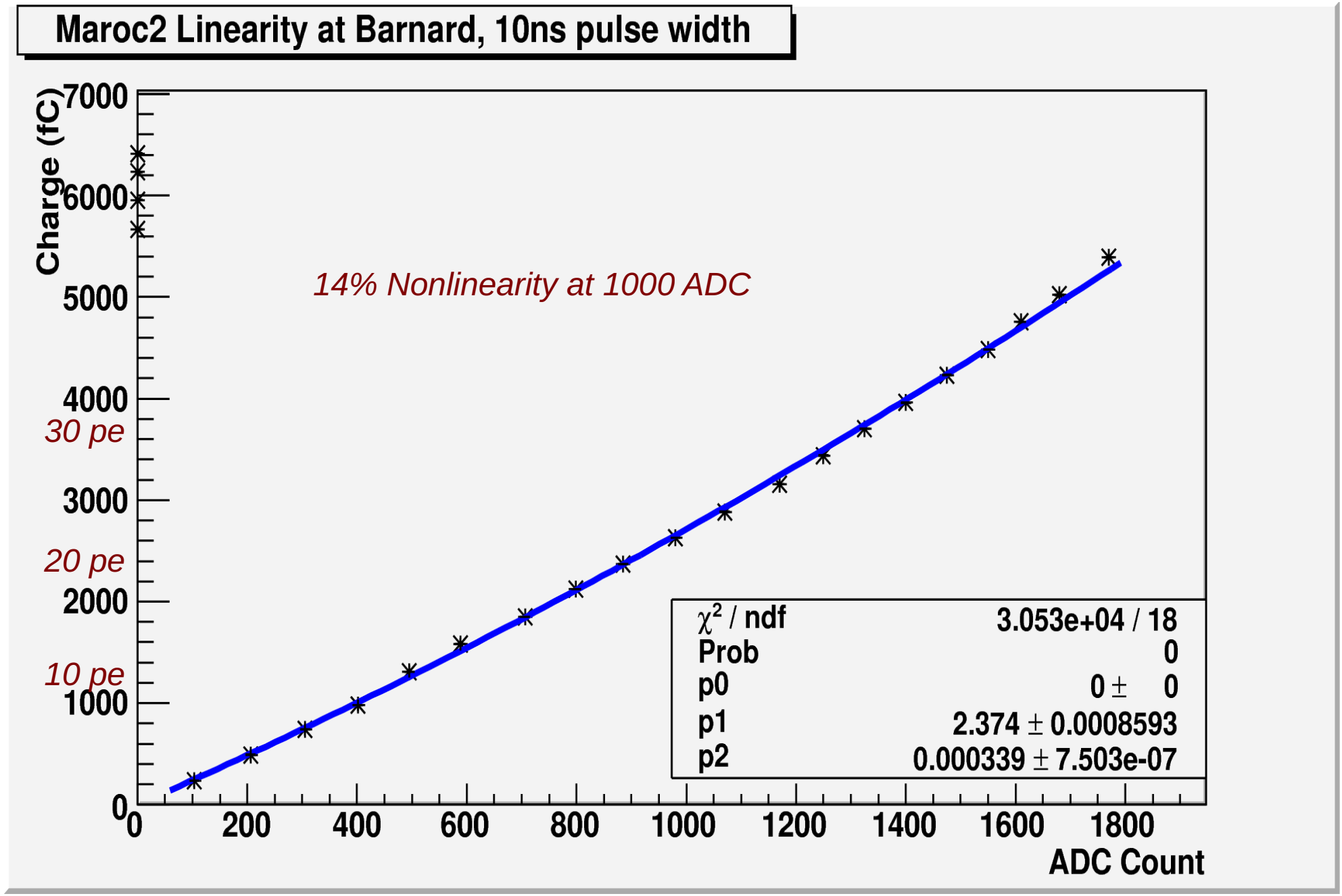
PMT & Electronics Studies

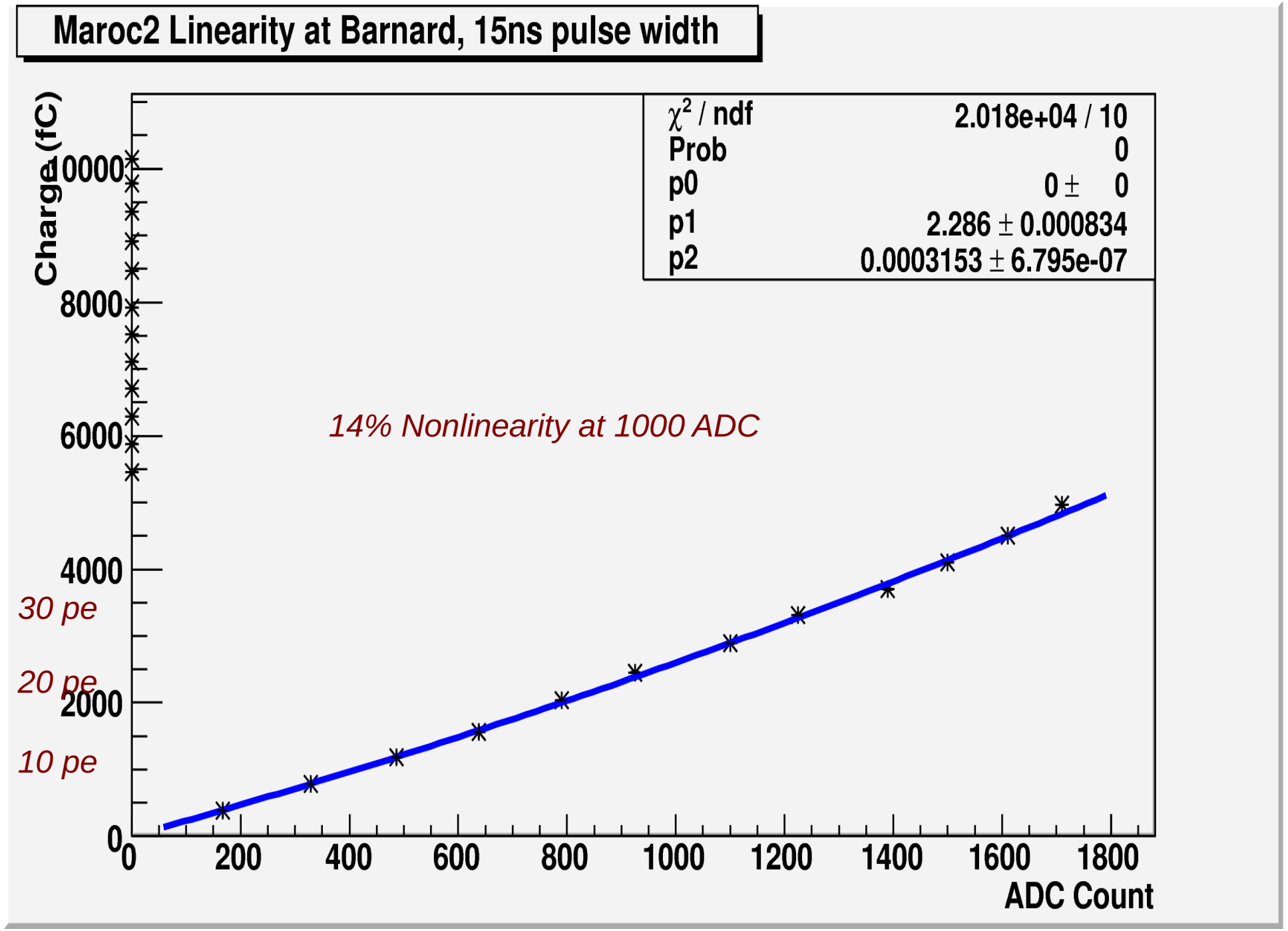
Nevis Labs, Columbia University & Barnard

Maroc2 Tests at Barnard

- Inject charge directly into PMT using a pulser
  - Send pulses with 1-10 V amplitudes and 7-15 ns widths through 10 kΩ resistor into PMT pin socket
  - Measure integrated charge on oscilloscope by integrating traces and then dividing by 10 kΩ.


Maroc2 Linearity at Barnard, 7ns pulse width
Charge (fC)
5000
4000
30 pe
3000
20 pe
2000
10 pe
1000
0
0
200
400
600
800
1000
1200
1400
1600
ADC Count
30% Nonlinearity at 1000 ADC
χ² / ndf 3.539e+04 / 22
Prob 0
p0 0 ± 0
p1 2.085 ± 0.0009832
p2 0.0006195 ± 9.168e-07


Maroc2 Linearity at Barnard, 10ns pulse width
Charge (fC)
7000
6000
5000
4000
3000
2000
1000
0
30 pe
20 pe
10 pe
14% Nonlinearity at 1000 ADC
χ² / ndf 3.053e+04 / 18
Prob 0
p0 0 ± 0
p1 2.374 ± 0.0008593
p2 0.000339 ± 7.503e-07
0
200
400
600
800
1000
1200
1400
1600
1800
ADC Count

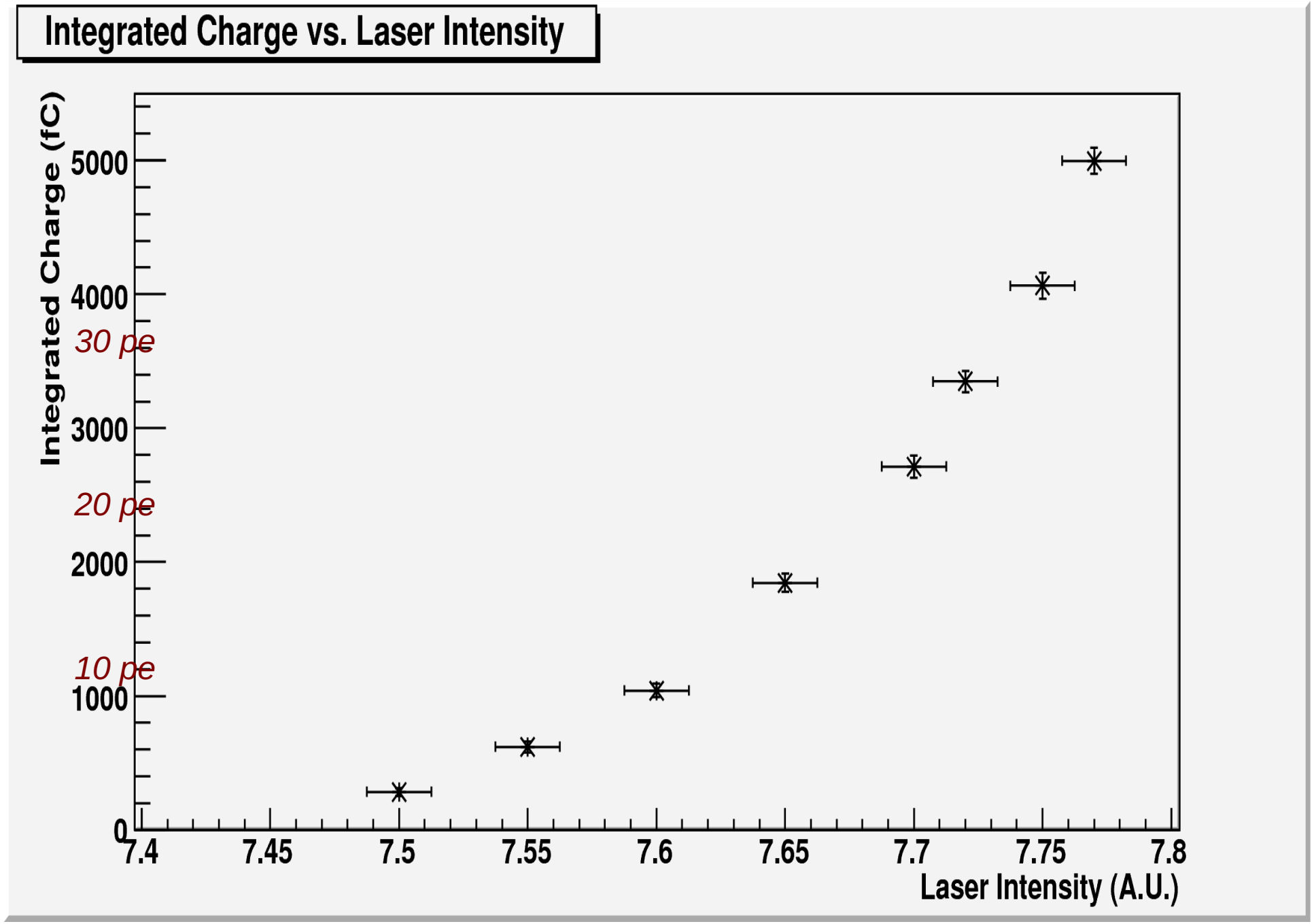

Maroc2 Linearity at Barnard, 15ns pulse width
Charge (fC)
10000
8000
6000
4000
2000
0
0
200
400
600
800
1000
1200
1400
1600
1800
ADC Count
χ² / ndf 2.018e+04 / 10
Prob 0
p0 0 ± 0
p1 2.286 ± 0.000834
p2 0.0003153 ± 6.795e-07
14% Nonlinearity at 1000 ADC
30 pe
20 pe
10 pe

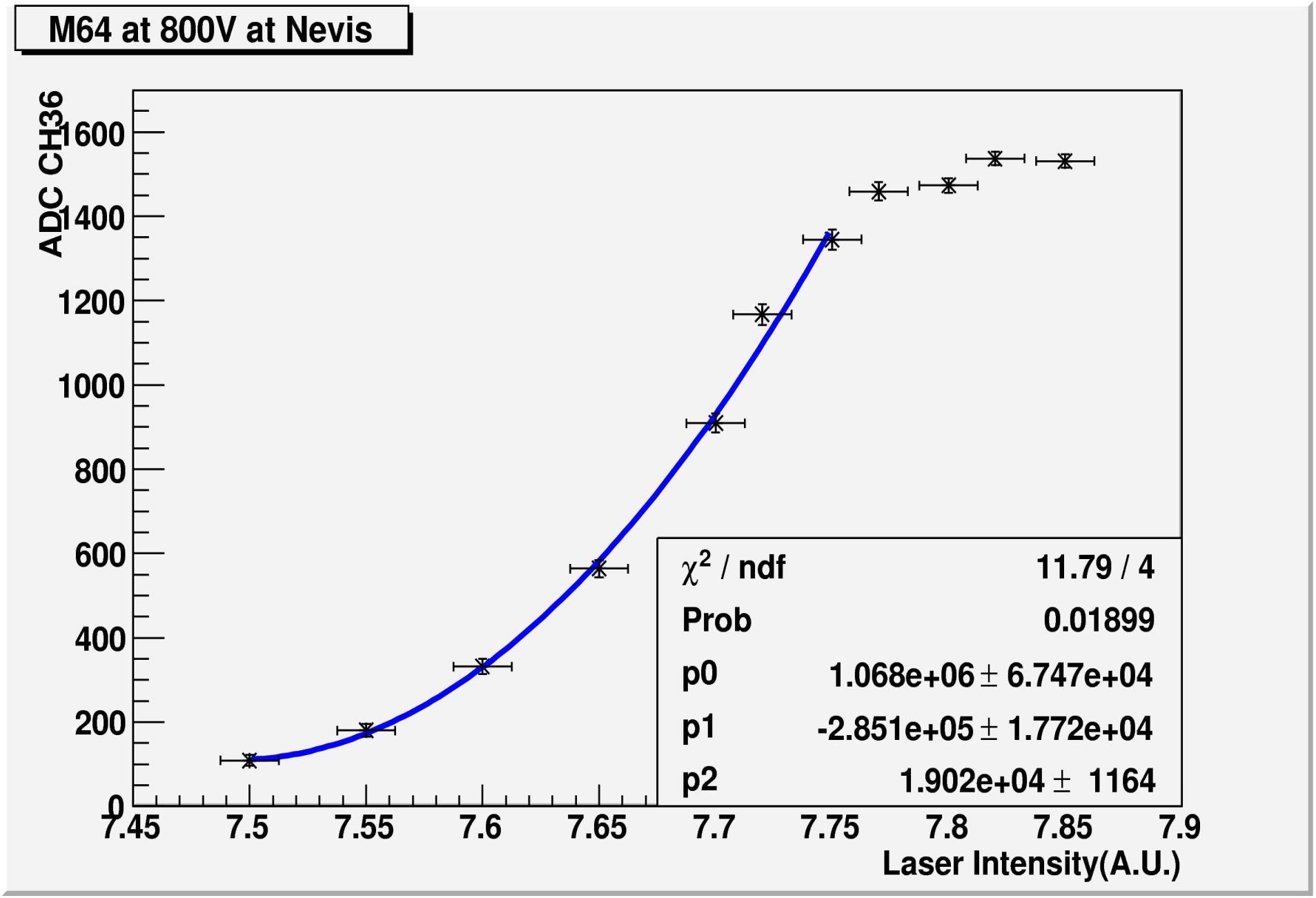
Conclusion

- There is a nonlinearity in the Maroc2 chip that depends on the pulse shape
  - We must use the actual PMT pulses to calculate our fC/ADC conversion ratio

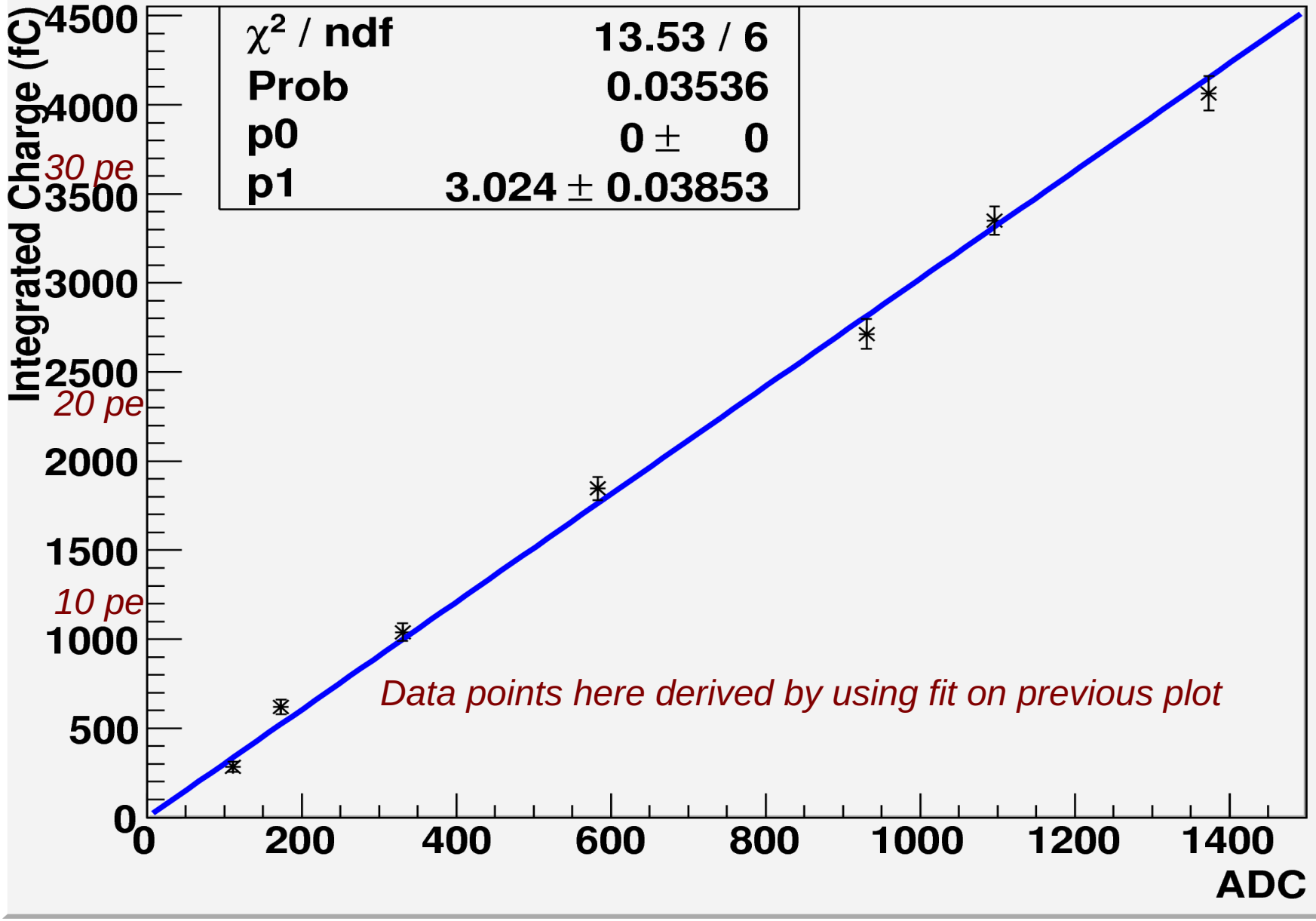
M64 + Maroc2 Tests at Nevis

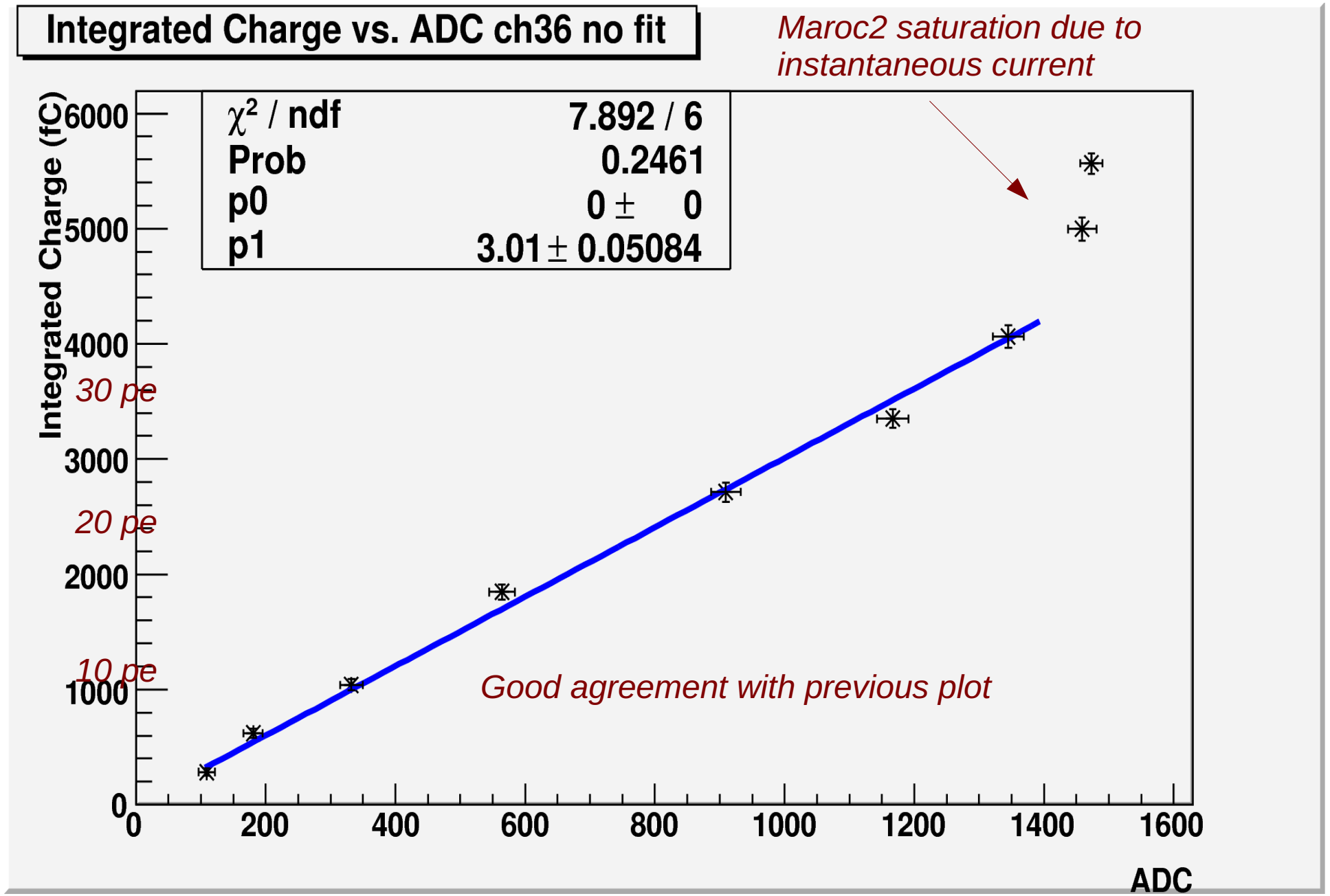
- Illuminate the M64 with a picoquant LED light source (width of light pulses < 5ns)
- Tape M64 directly to light source to insure stability of setup
- Measure integrated charge as a function of light intensity on oscilloscope by plugging M64 into the electronics base supplied by U. of Chicago
- Measure ADC counts as a function of light intensity by plugging M64 into Maroc2 electronics board developed at Nevis.


Integrated Charge vs. Laser Intensity
Integrated Charge (fC)
5000
4000
30 pe
3000
20 pe
2000
10 pe
1000
0
7.4
7.45
7.5
7.55
7.6
7.65
7.7
7.75
7.8
Laser Intensity (A.U.)


M64 at 800V at Nevis
ADC CH36
1600
1400
1200
1000
800
600
400
200
0
7.45
7.5
7.55
7.6
7.65
7.7
7.75
7.8
7.85
7.9
Laser Intensity(A.U.)
χ² / ndf 11.79 / 4
Prob 0.01899
p0 1.068e+06 ± 6.747e+04
p1 -2.851e+05 ± 1.772e+04
p2 1.902e+04 ± 1164

Integrated Charge vs. ADC




Integrated Charge vs. ADC ch36 no fit
Maroc2 saturation due to instantaneous current
χ² / ndf 7.892 / 6
Prob 0.2461
p0 0 ± 0
p1 3.01 ± 0.05084
Integrated Charge (fC)
6000
5000
4000
3000
2000
1000
0
30 pe
20 pe
10 pe
0
200
400
600
800
1000
1200
1400
1600
ADC
Good agreement with previous plot

Why don't we see Maroc2 saturation at Barnard?

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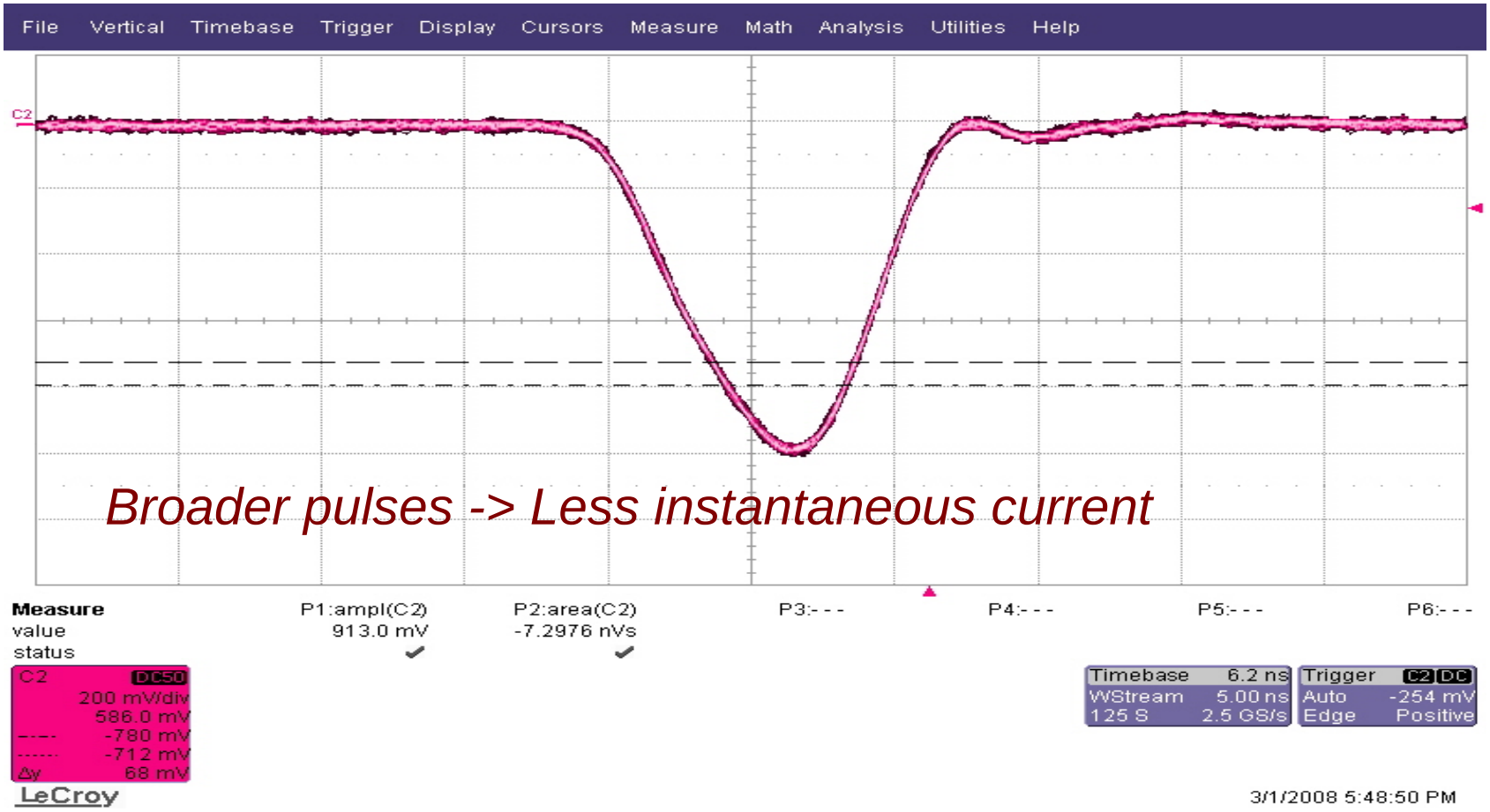
M64 pulses are ~4 ns wide, but minimum pulser width is ~7 ns!



Conclusions

- Our system is linear in the dynamic range we expect to operate during the experiment, i.e. below ~30 p.e. (1200 ADC counts)
- Our conversion ratio is roughly 3 fC / ADC

Characterization of 10 PMTs

- Noise rates of 10 PMTs have been measured and are consistent with Hammamatsu's numbers
- Gain is calculated using the mean and σ of the ADC distribution
  - At high ADC gain calculation affected by saturation
  - There is a plateau region where the gain calculation seems to be stable as a function of ADC
  - At low ADC, calculated gain increases
    - Not yet understood

Ongoing Studies

- We are still trying to understand the gain calculation of these 10 PMTs
- An alternate method using a fit to the single PE peak developed by the MINOS collaboration is also being explored
  - Gain and width of single PE peak are two of the fit parameters in this fit