

# Far Detector PMT Linearity

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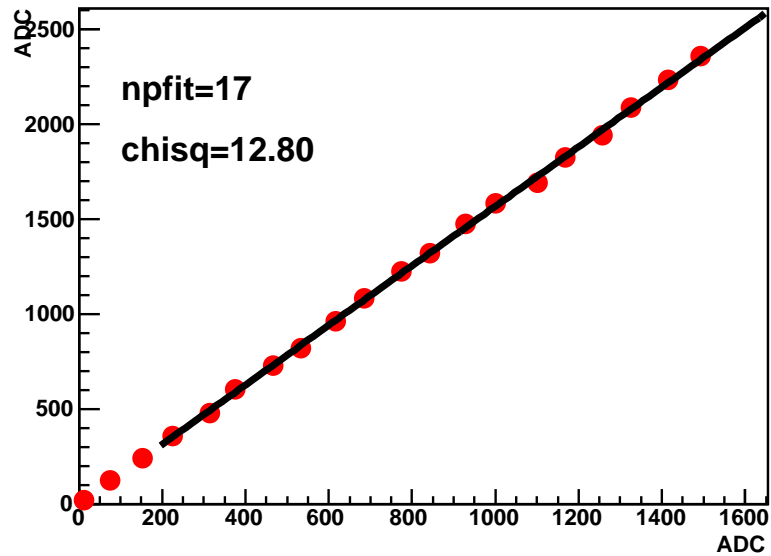
- Peter has shown plots of ADC v. PIN are not linear even in region where PMTs are expected to be linear
- Problem seems to be associated with the PINs
- It has been suggested that we could check the PMT linearity using FAR strip-end data, which should be in linear region of PMTs
- Have taken a first look at this by plotting one strip-end against all other strip-ends for a single led

## Far-Far Linearity Plots

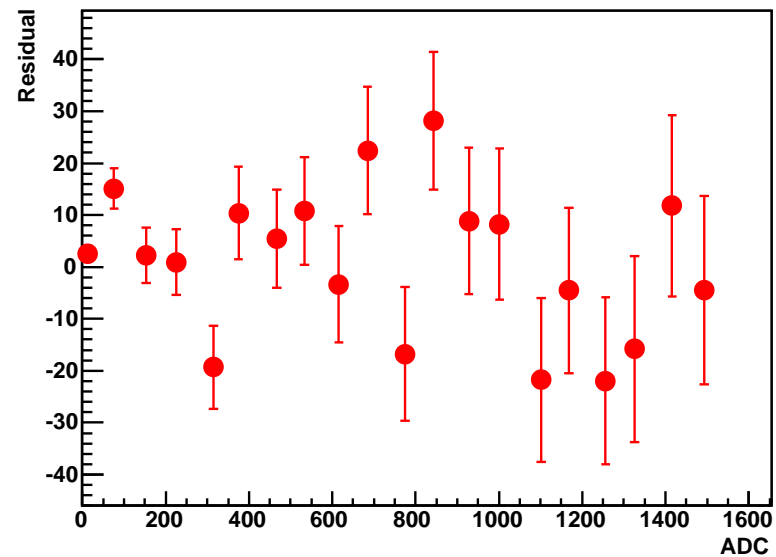
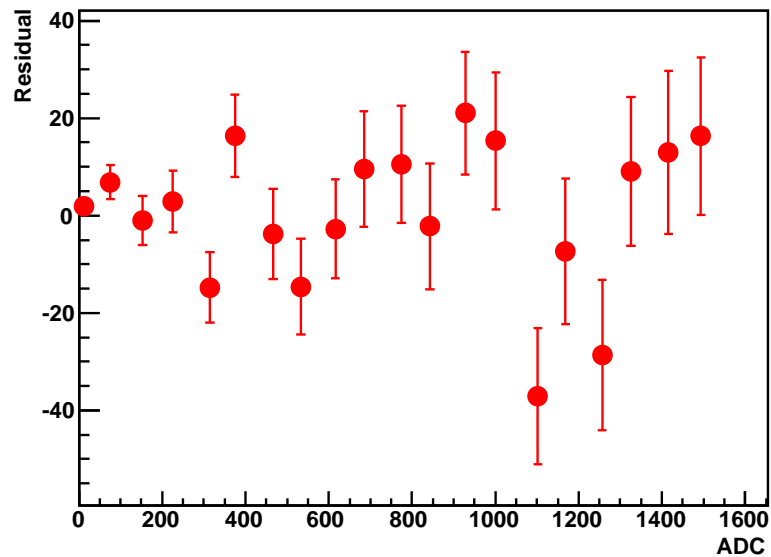
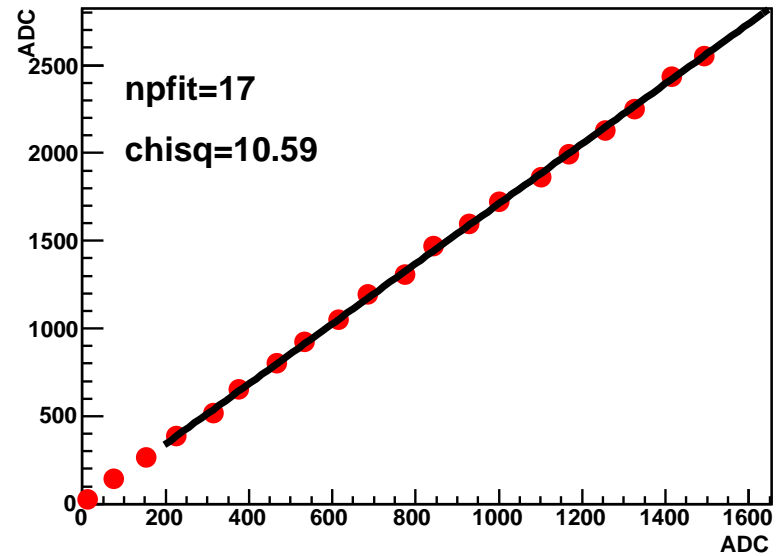
- Data from June 2005 gain curve, with zero-correction
- Plot one strip-end against another for all pairs illuminated by the same far-end LED
  - ~ 200000 pairs per led, ~55M in total
- Fit straight line in range  $200 < ADC < 7000$  (for both strip-ends)
  - Tried lower limits in range 100–300, upper limits 7000–8000
  - Makes little difference on average
  - 200–7000 probably fairly optimal if wish to use same range for all channels
- Some example fits below:
  - More on [http://www.hep.phy.cam.ac.uk/cpw1/plots/far\\_agg2\\_try2.ps](http://www.hep.phy.cam.ac.uk/cpw1/plots/far_agg2_try2.ps)

# Far-Far Fit: example 1

PI1St175vPI1St174

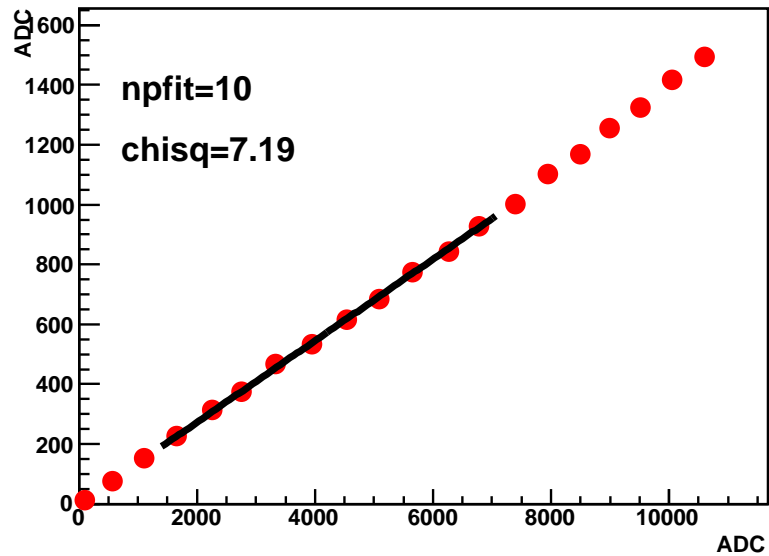


PI1St176vPI1St174

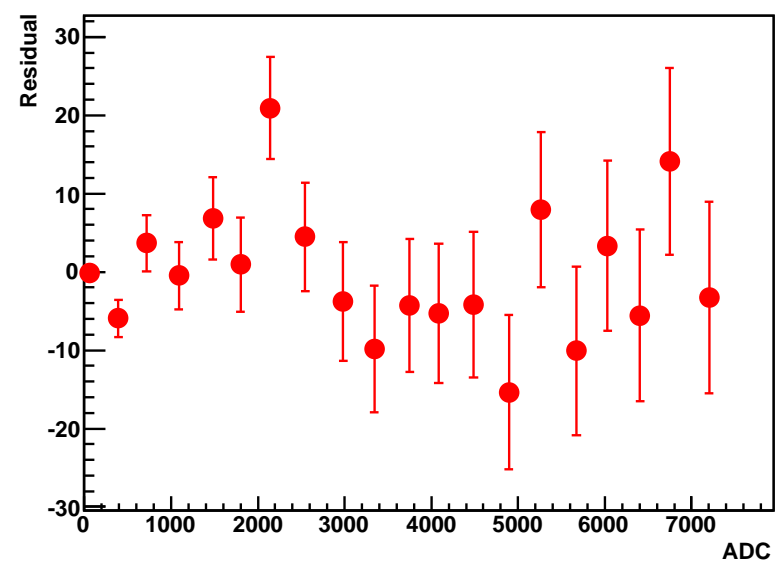
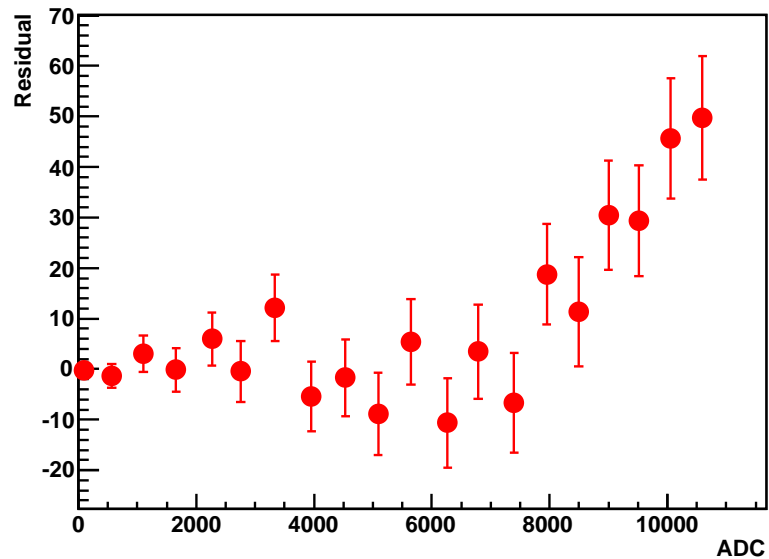
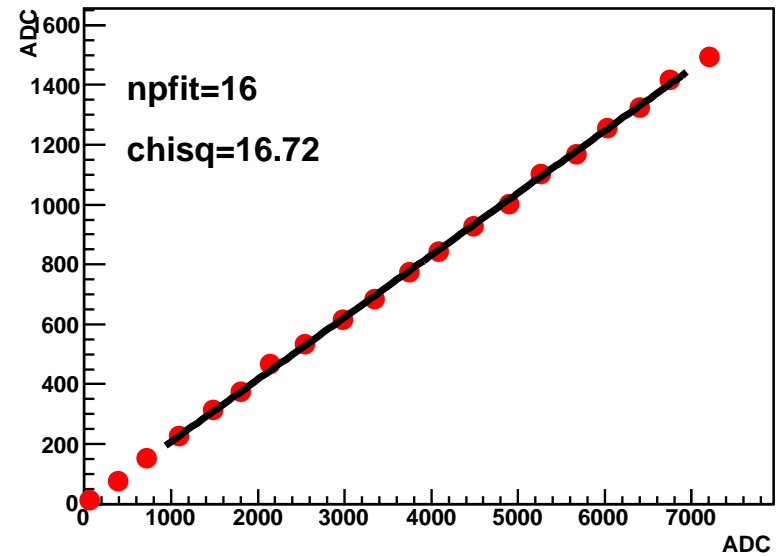


# Far-Far Fit: example 2

PI1St174vPI41St178

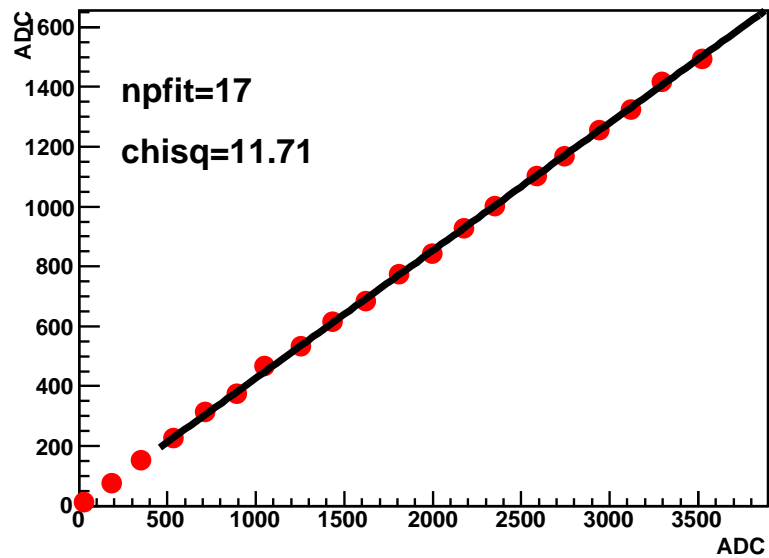


PI1St174vPI41St179

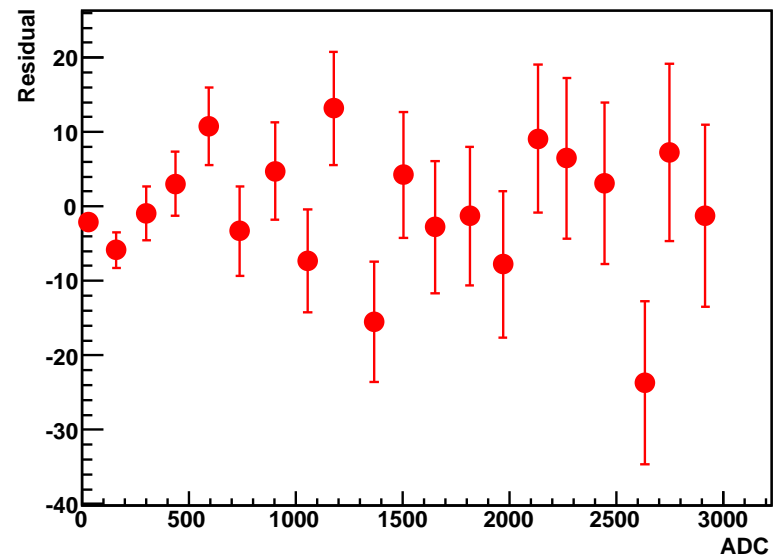
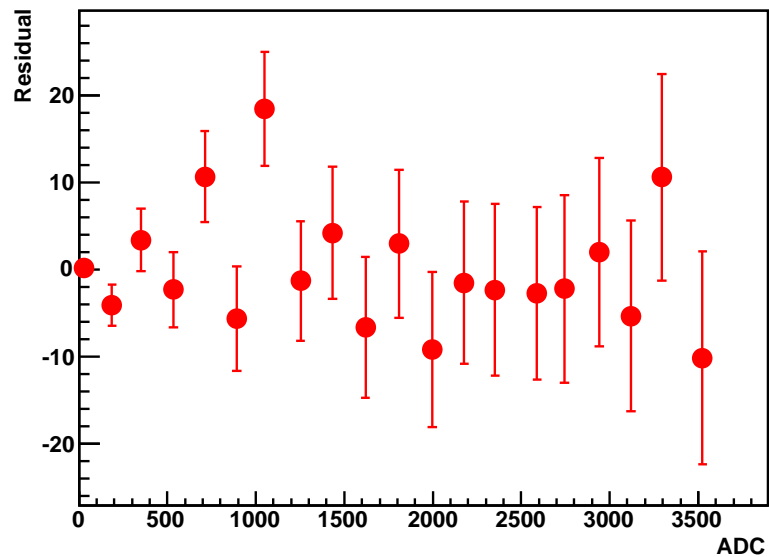
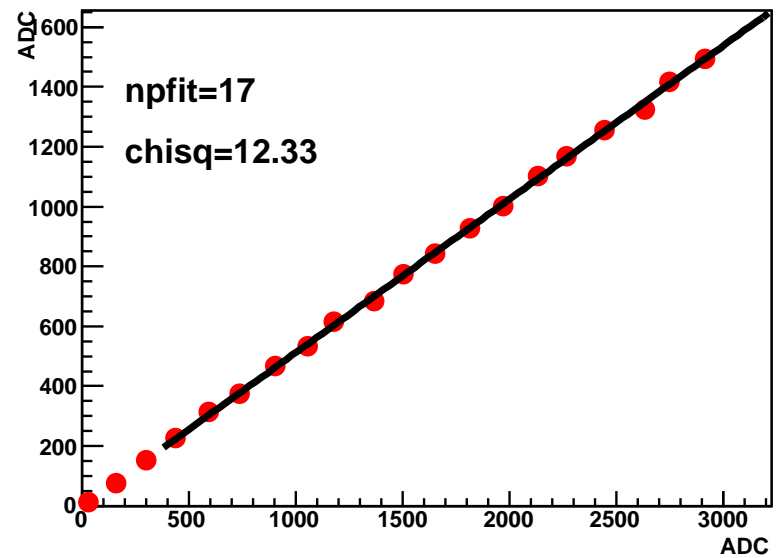


# Far-Far Fit: example 3

PI1St174vPI10St183

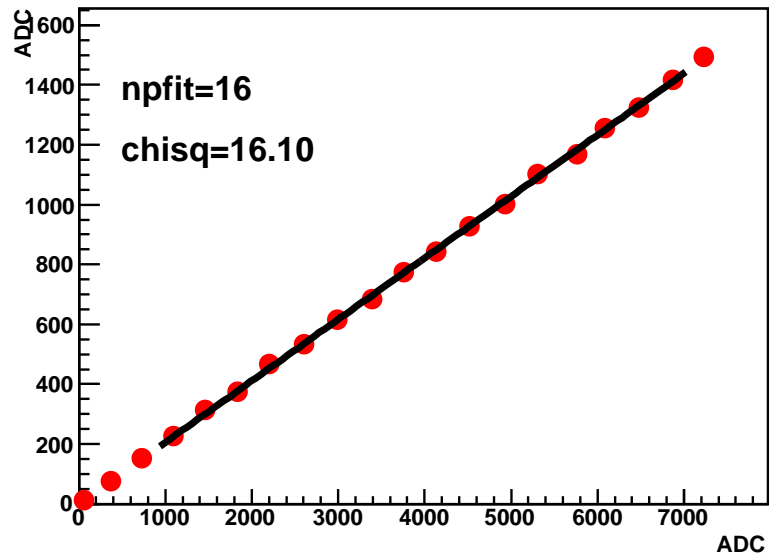


PI1St174vPI11St164

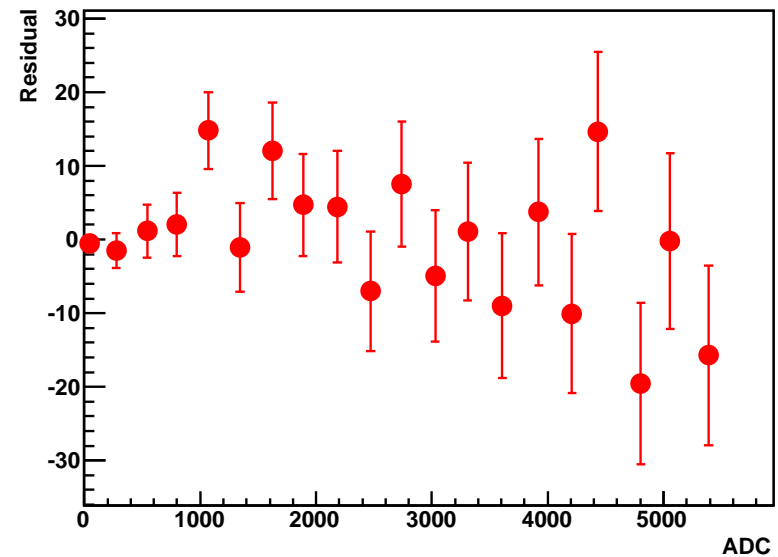
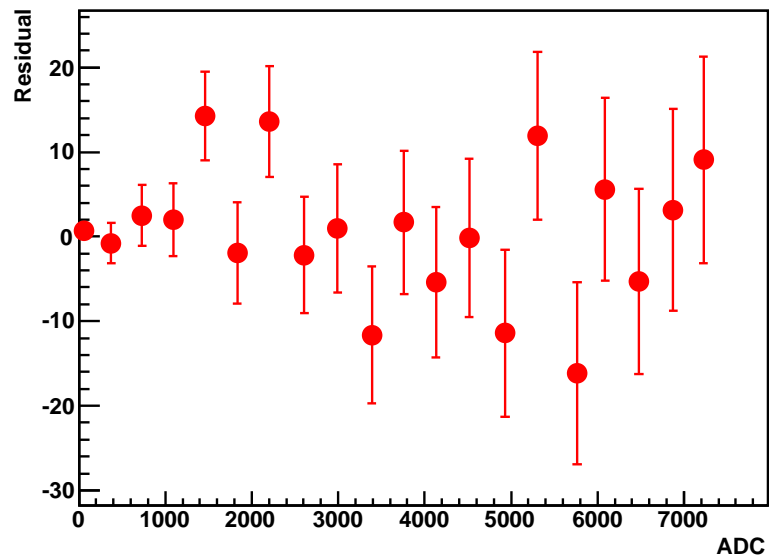
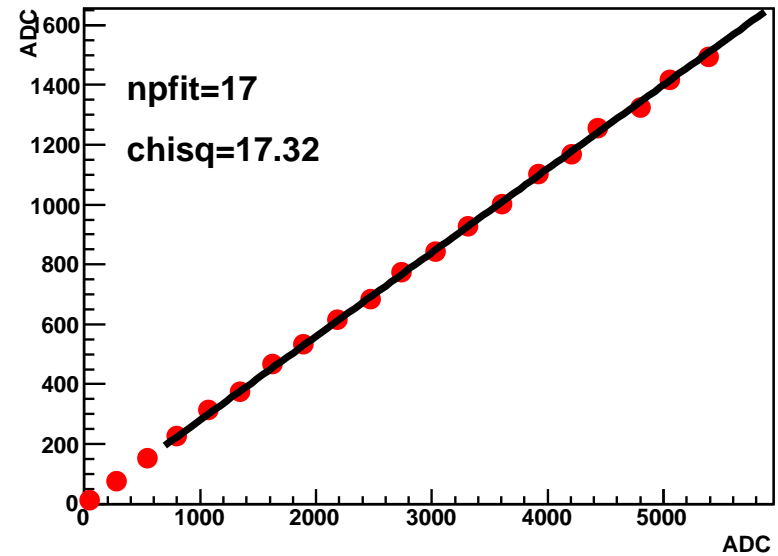


# Far-Far Fit: example 4

PI1St174vPI56St169

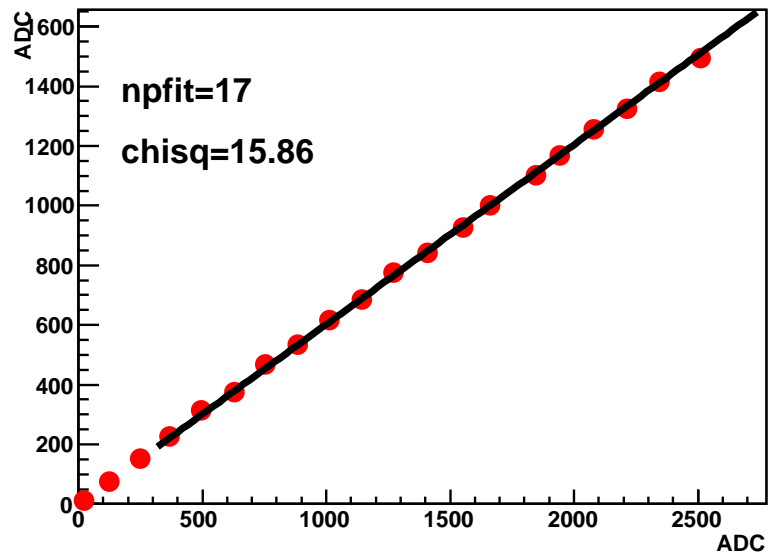


PI1St174vPI56St170

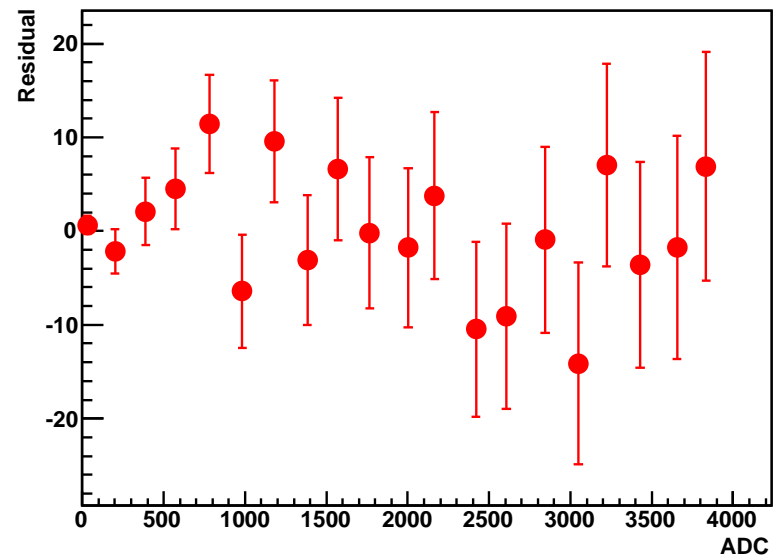
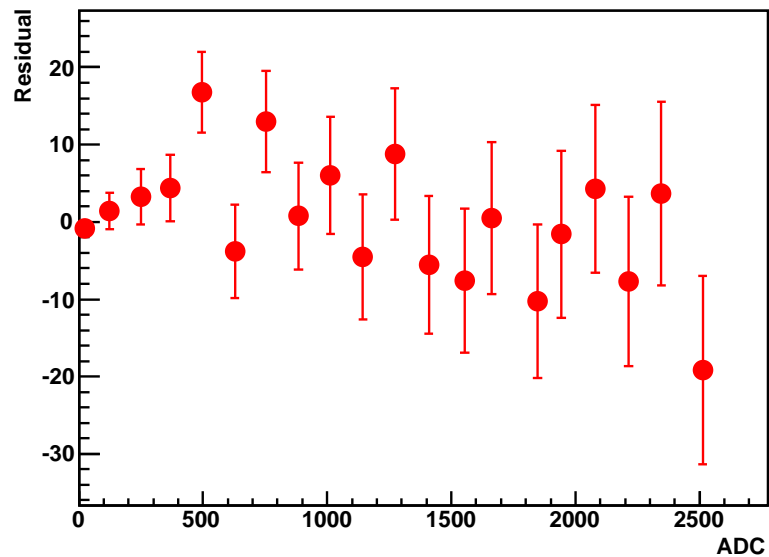
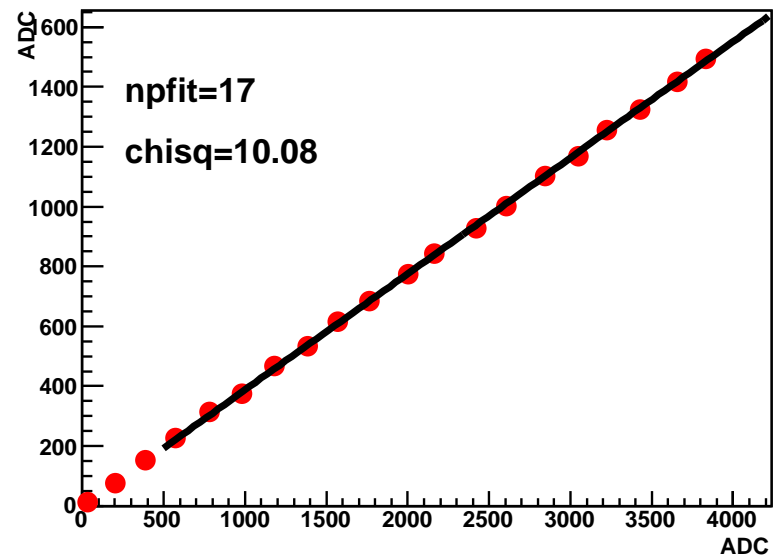


# Far-Far Fit: example 5

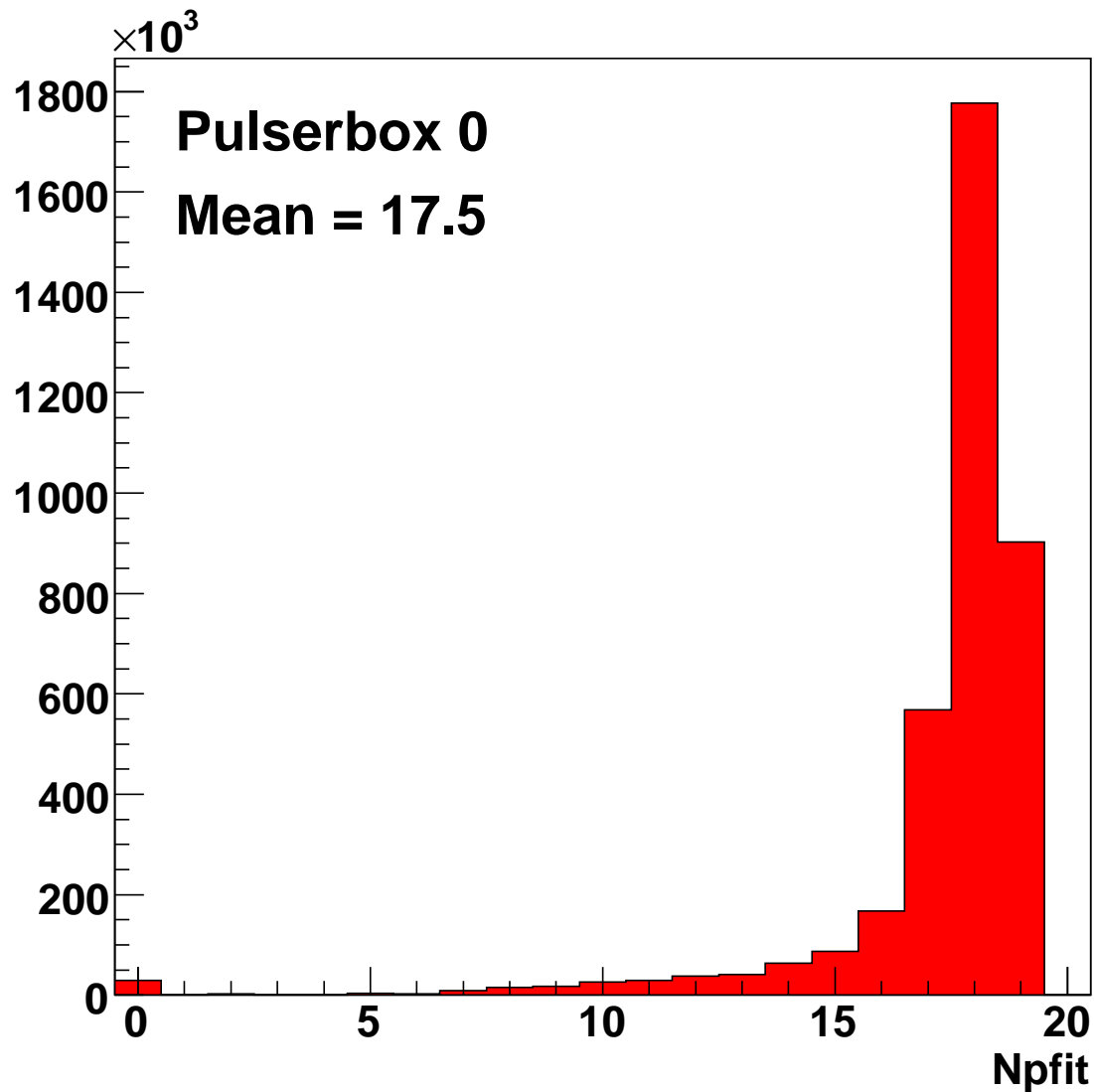
PI1St174vPI13St177



PI1St174vPI13St178



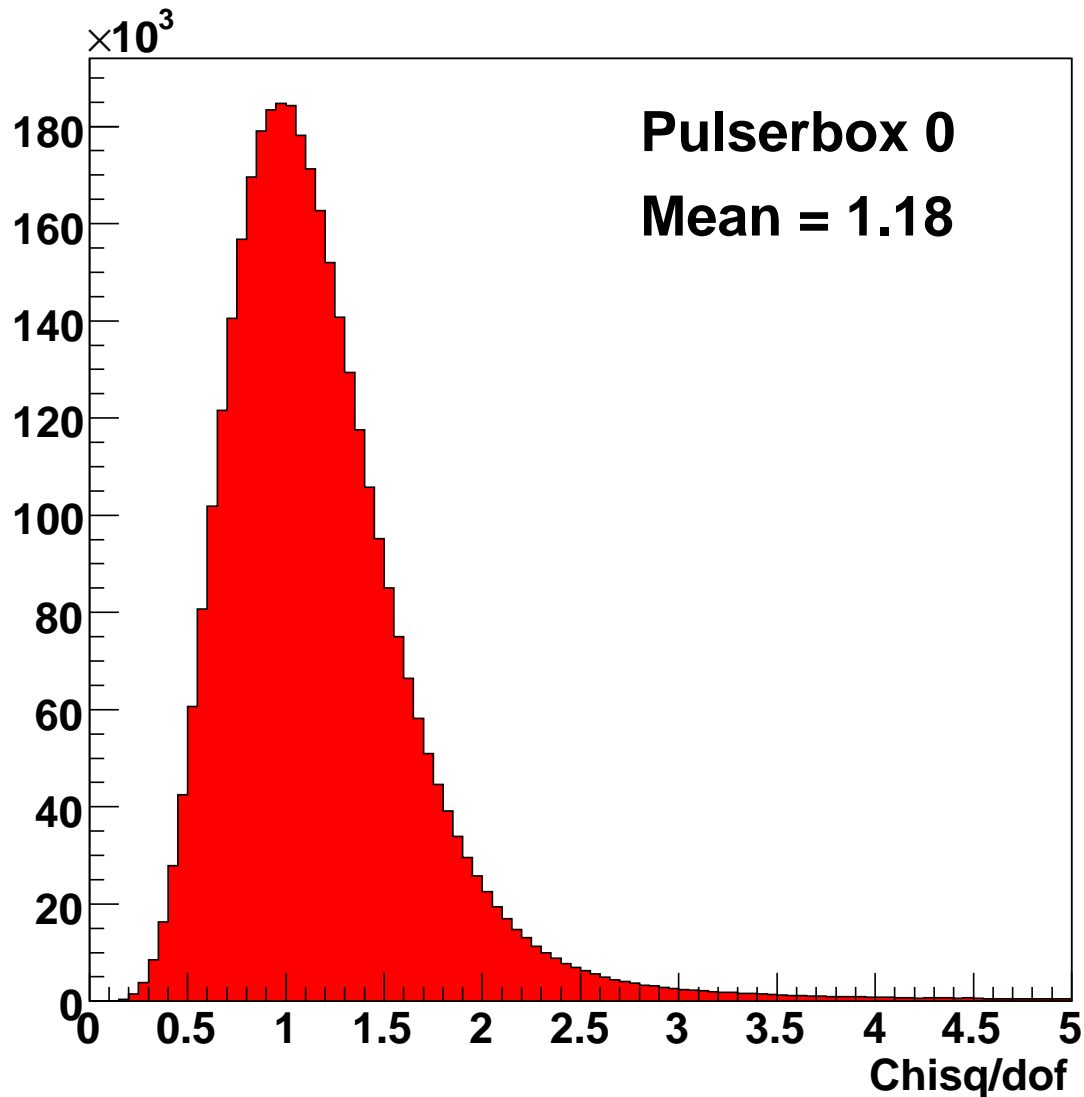
## Far-Far: Number of Points in Fit



- Mean number of points in fit range = 17.3
- 98% of pairs have at least 10 points fitted
- 93% of pairs have at least 15 points



## Far-Far: Fit $\chi^2$ Values



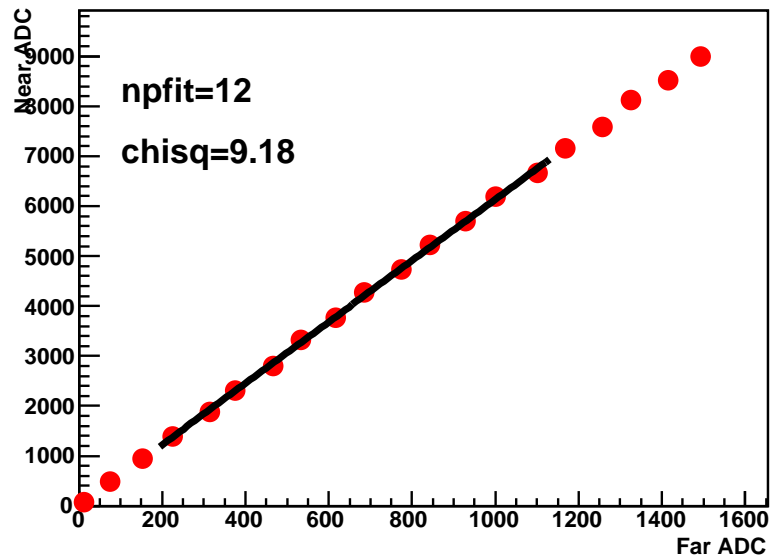
- Fits generally good
- 98% of pairs have  $\chi^2/dof < 10$
- 90% of pairs have  $\chi^2/dof < 3$
- $\langle \chi^2 \rangle = 1.17$  (excluding values  $> 10$ )
- Looks promising:  
PMTs are linear

## Towards a Linearity Correction

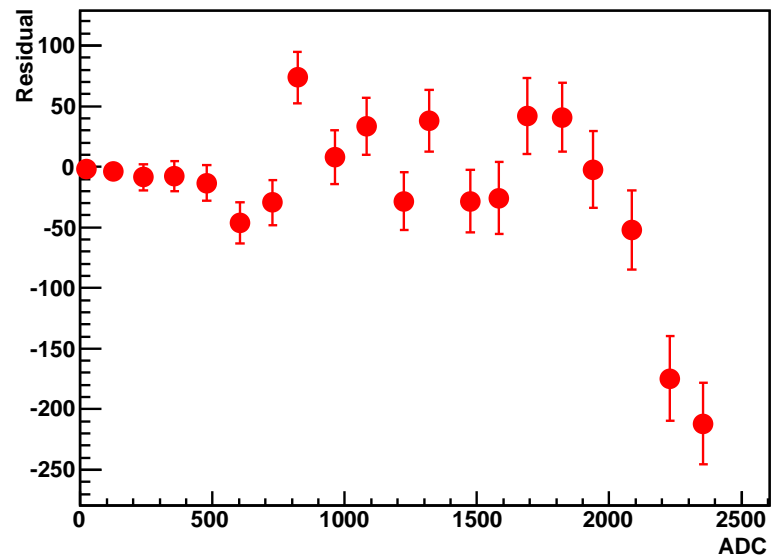
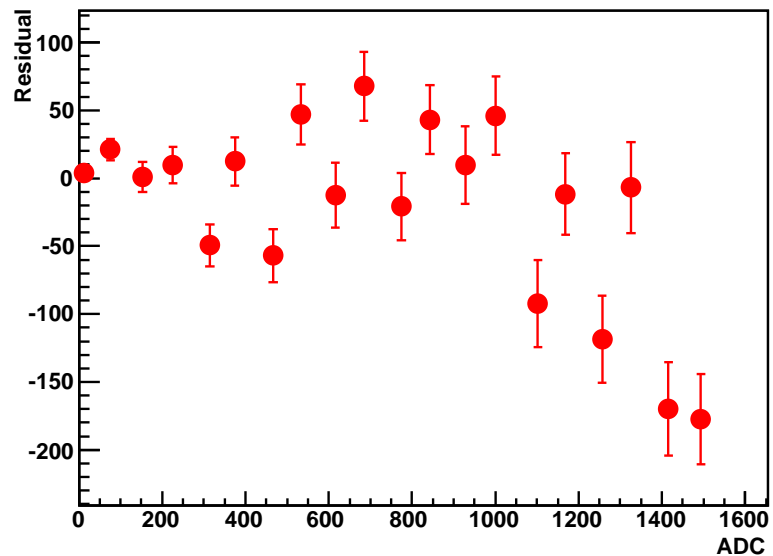
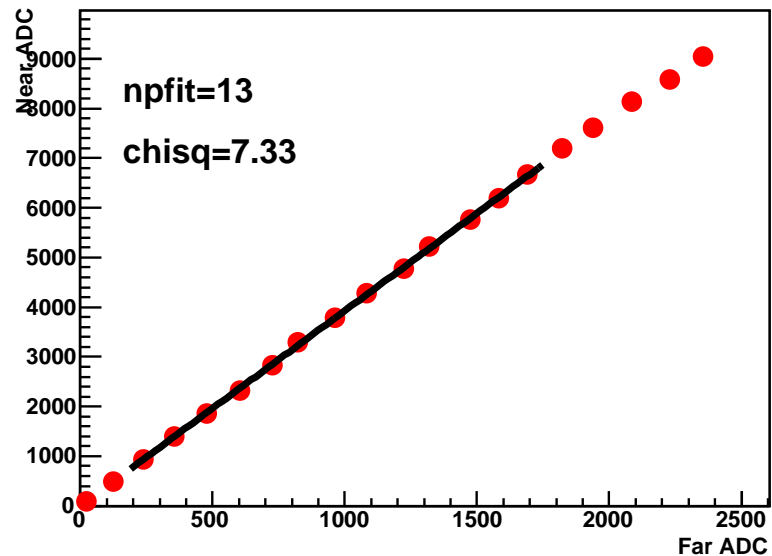
- Far-Far linearity plots show PMTs are generally linear (in  $200 < ADC < 7000$ )
- 97.7% of channels (strip-ends) are good:
  - At least 90% of fits have  $\geq 10$  points;
  - At least 80% of fits have  $\chi^2/dof < 3$  and mean  $\chi^2/dof < 2$
- Plot Near v Far data for a strip to obtain linearity correction for Near strip-end
  - What to do about 2.3% of channels not shown to be good from Far-Far study?
- Results for June 2005 gain curve, fits in  $200 < ADC < 7000$  again

# Near-Far Fit: example 1

Plane1Strip174E

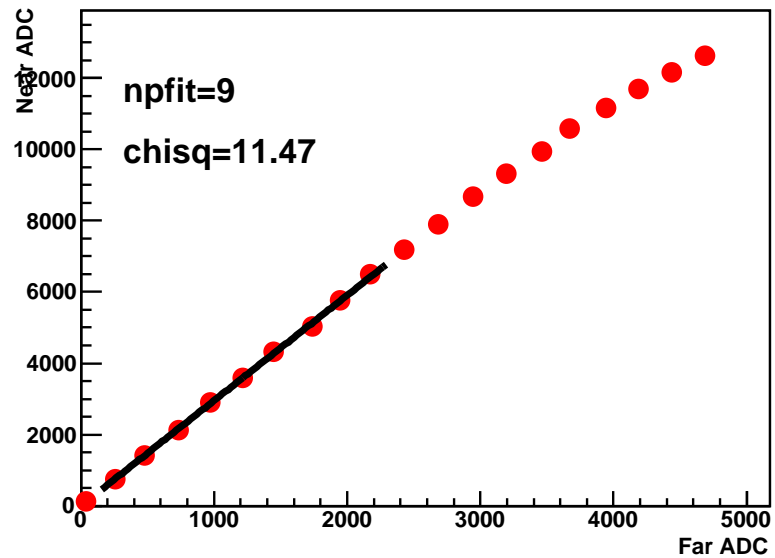


Plane1Strip175E

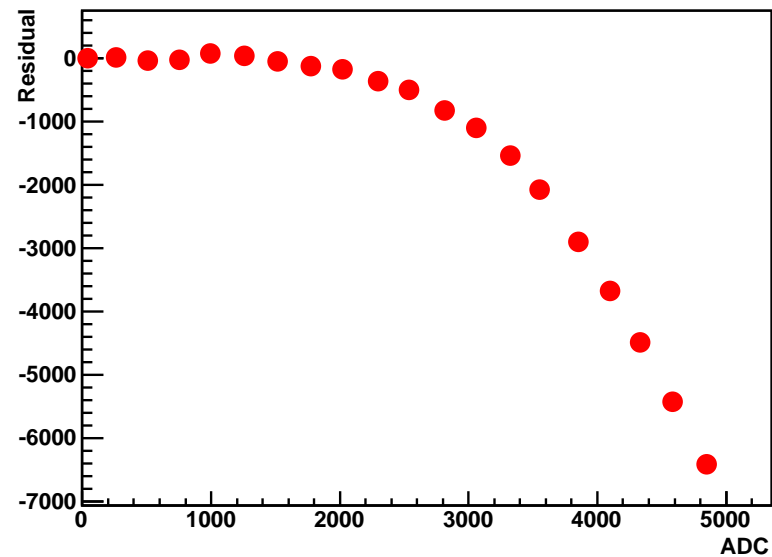
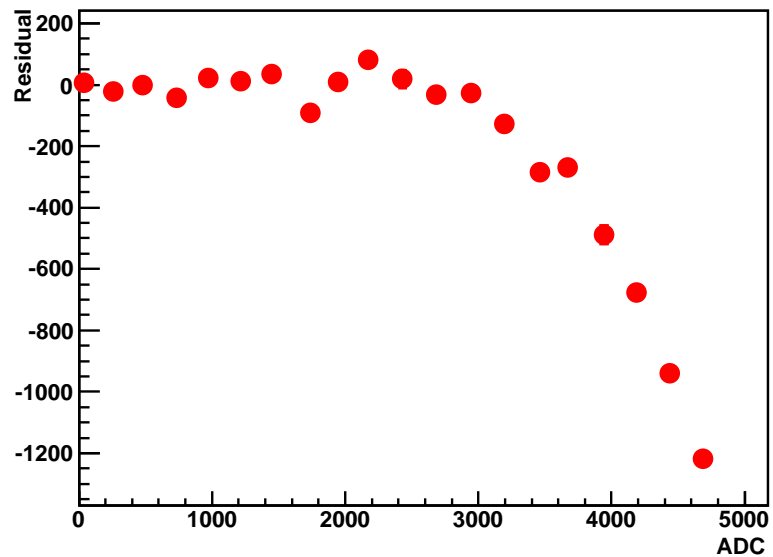
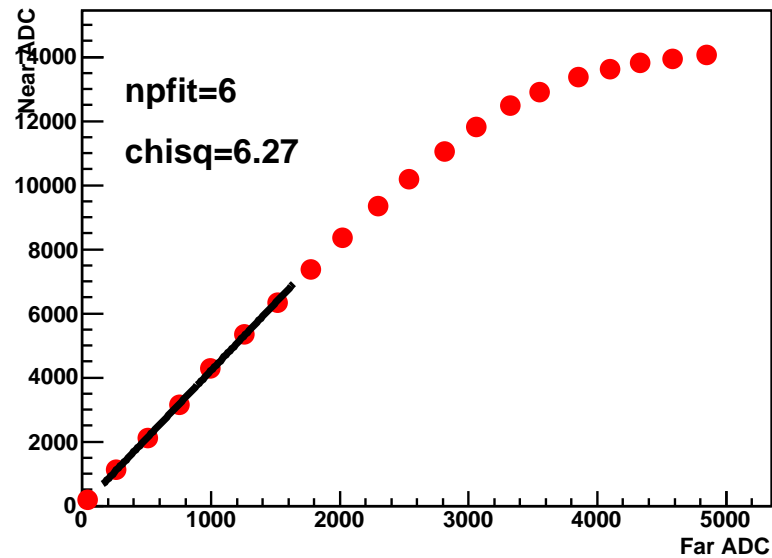


# Near-Far Fit: example 2

Plane6Strip174E

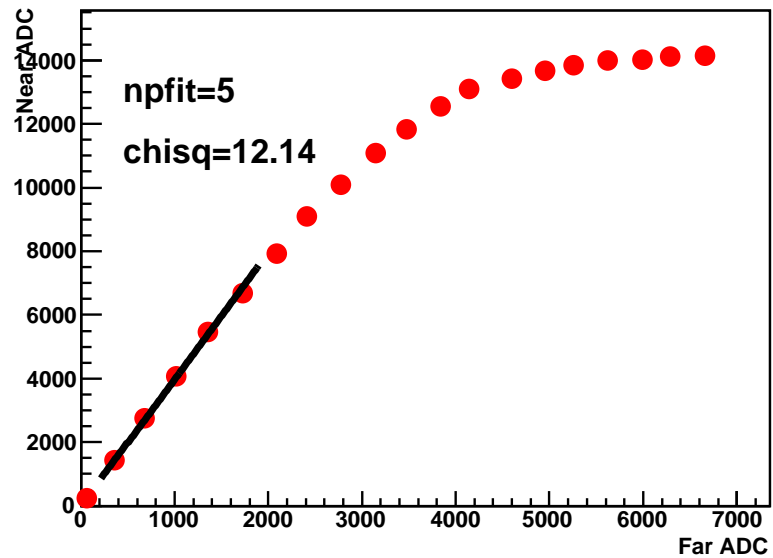


Plane6Strip175E

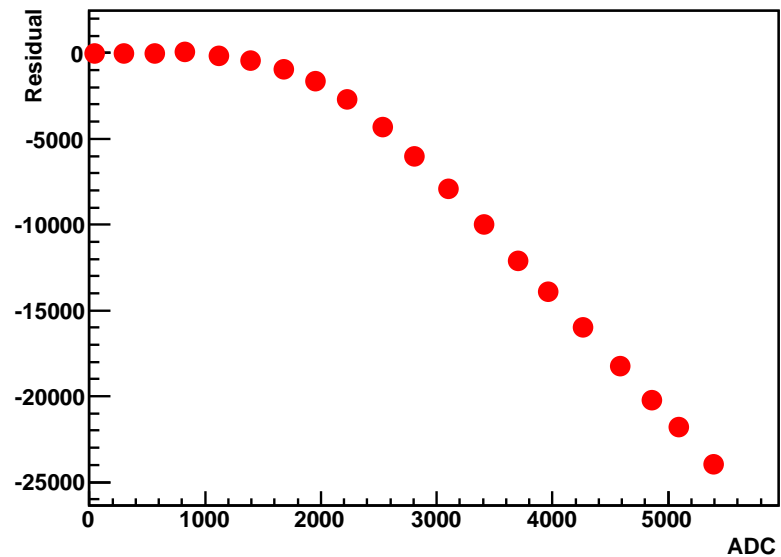
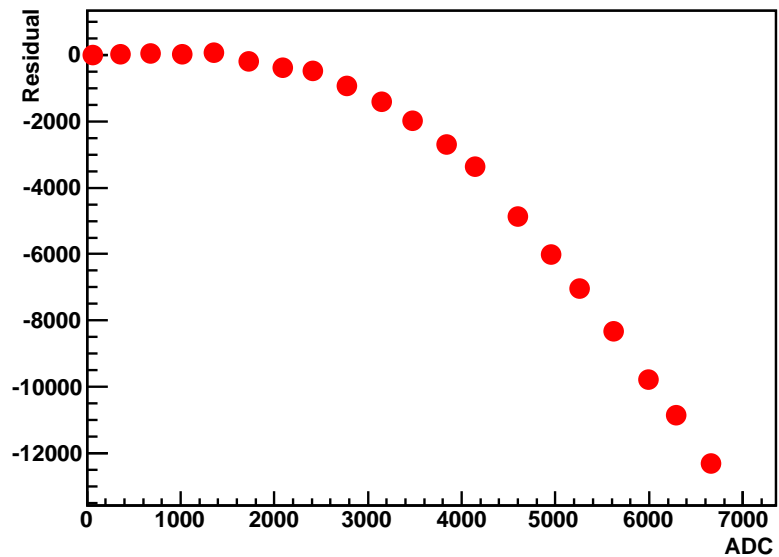
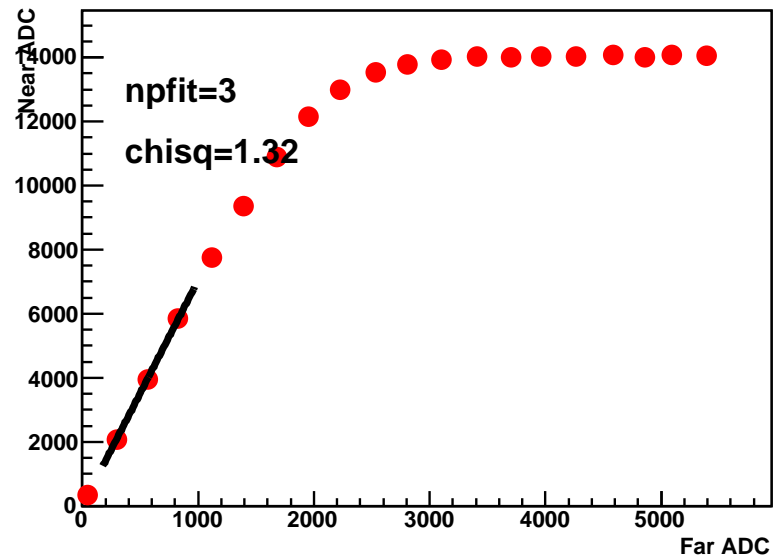


# Near-Far Fit: example 3

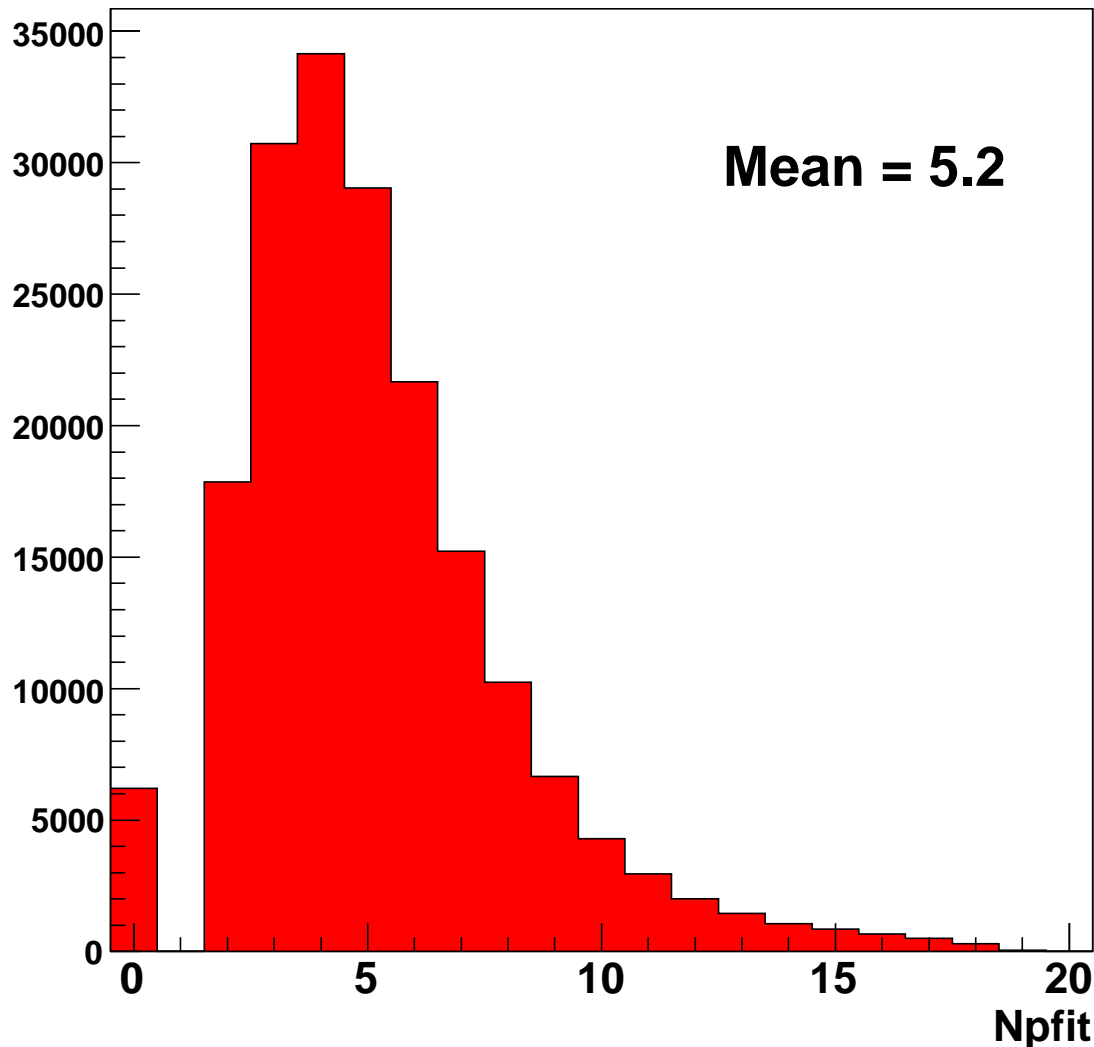
Plane16Strip164E



Plane16Strip165E

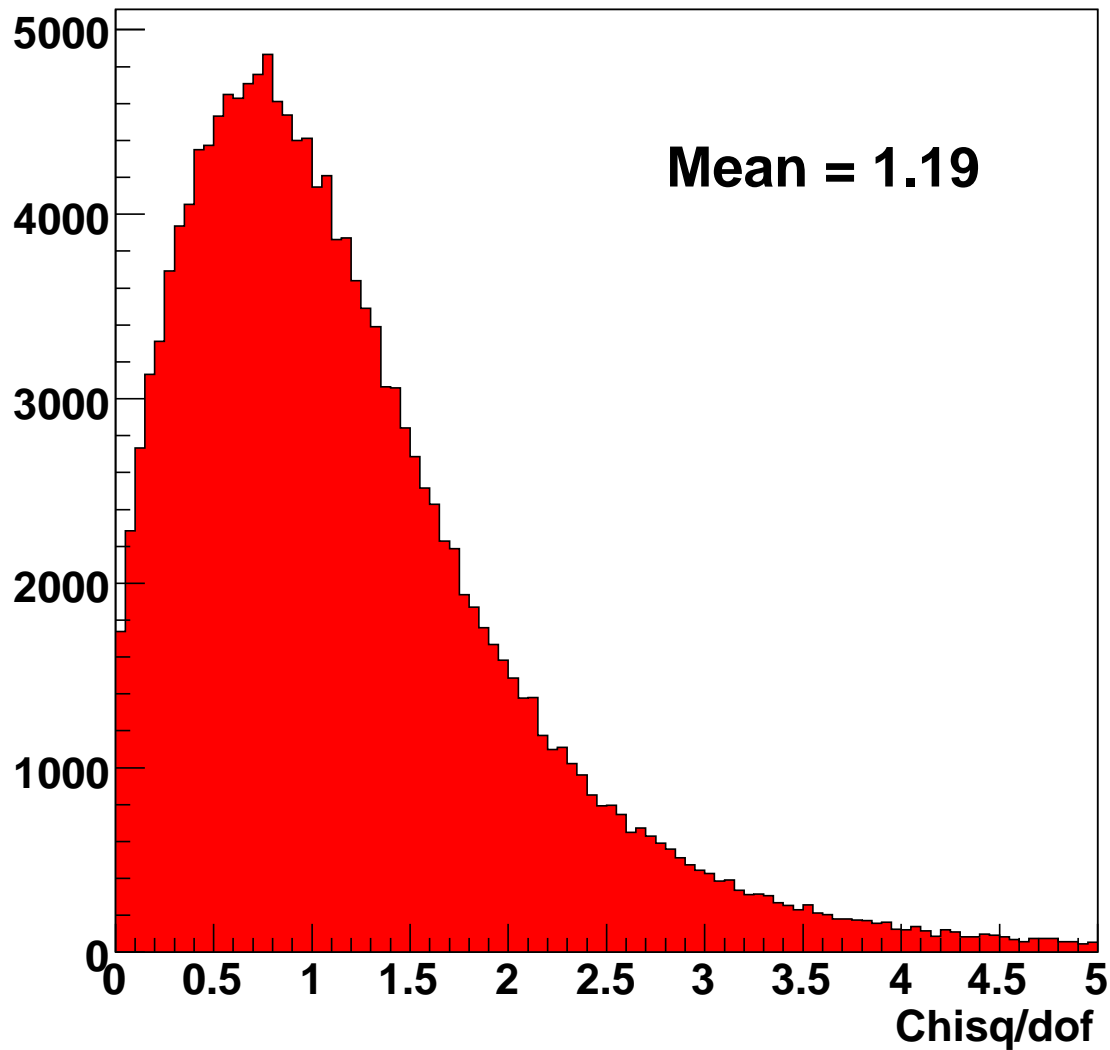


## Near-Far: Number of Points in Fit



- Number of points in fit range is generally low
- Mean number of points in fit range = 5.2
- 13% of strip-ends have fewer than 3 points fitted
- Too many points at high ADC, in PMT saturation region  $\Rightarrow$  change gain curve to put more points at lower ADC?

## Near-Far: Fit $\chi^2$ Values



- Fits generally good
- 99.8% of strip-ends with  $\geq 3$  points fitted have  $\chi^2/dof < 10$
- For these,  $\langle \chi^2 \rangle = 1.23$
- Looks promising

## Conclusions

- PMTs are linear in region  $200 < ADC < 7000$  as shown by fitting a strip-end against other strip-ends for the same LED using Far data
- Linearity correction could be done by fitting Near v Far data for each strip, but
- For most strips there are too few points in the linear region in the Near data
- At present 13% of strip-ends have  $< 3$  points in linear region  $\Rightarrow$  cannot do linearity calibration by any method