2008 ECAL MIP Calibration

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Outline

- Introductory Remarks

- Stability of Residual Pedestal

- Muon Selection

- Fitting

- Corrections for Dead Pads and Fitting Failures

- Systematic Errors

- Quality Check: Uniformity and Stability

- Summary

Introductory Remarks

MIP Calibration of ECAL:
> Assign a **standard energy scale** to the electronic readout from the silicon active medium **of each pad**.

The Standard Energy Scale:
> Energy deposition of **minimal ionizing muons**, defined as a **MIP**. A constant for a given the thickness of the material.

Calibration Constants:
> 1 MIP= ? ADC counts, for each pad.
> Extract by a fitting using a convolution of Landau with Gaussian, where the Landau MPV gives the calibration constant.

Following previous works done by:
> Goetz Gaycken, Marcel Reinhard

Data Samples:
Muon data triggered with 20x20 scintillator counter, July 2008 FNAL
About 520k events after reconstruction.

Stability of Residual Pedestal

After Pedestal Subtraction, the **Stabilities of Residual Pedestals and Noise** are checked:

- Taking the signals recorded by each pad without muon hit.
- Fit with a Gaussian function for each pad
  - mean of the Gaussian: the **Residual Pedestal**
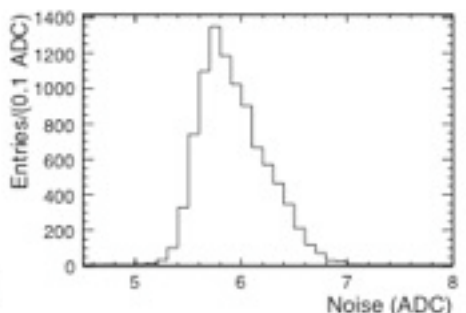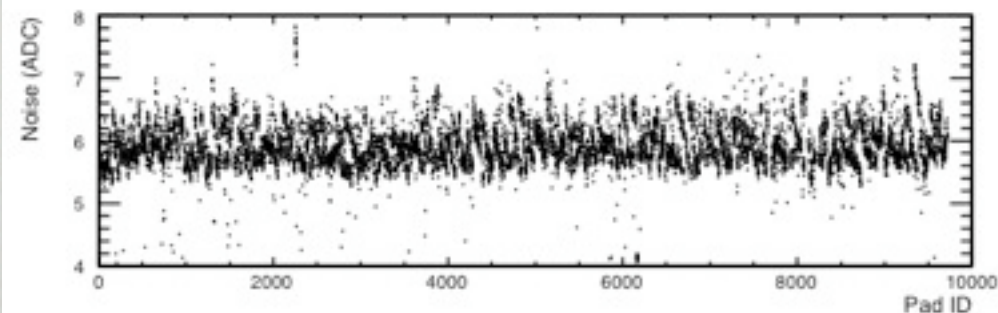 - sigma of the Gaussian: the **Noise**
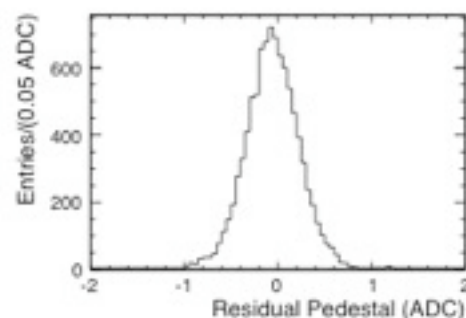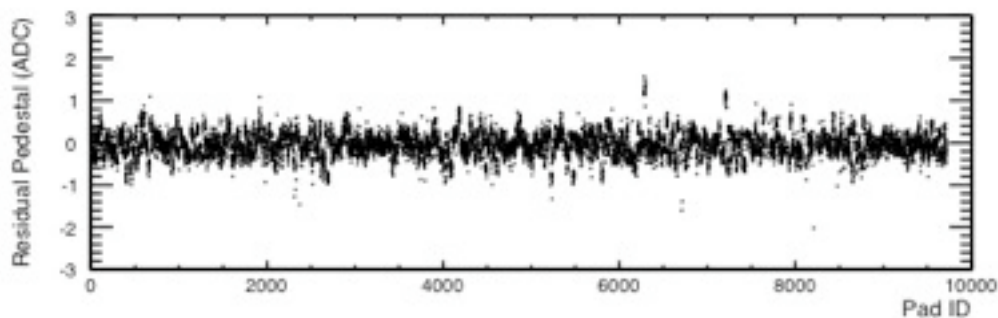
Residual Pedestals

mean:

-0.058±0.003 ADC

RMS:

0.281±0.002 ADC

Noise

mean:

5.930±0.003 ADC

RMS:

0.330±0.002 ADC

$$Pad\ ID = 9 \times 36 \times K + 36 \times (3 \times W_x + W_y) + (6 \times P_x + P_y)$$
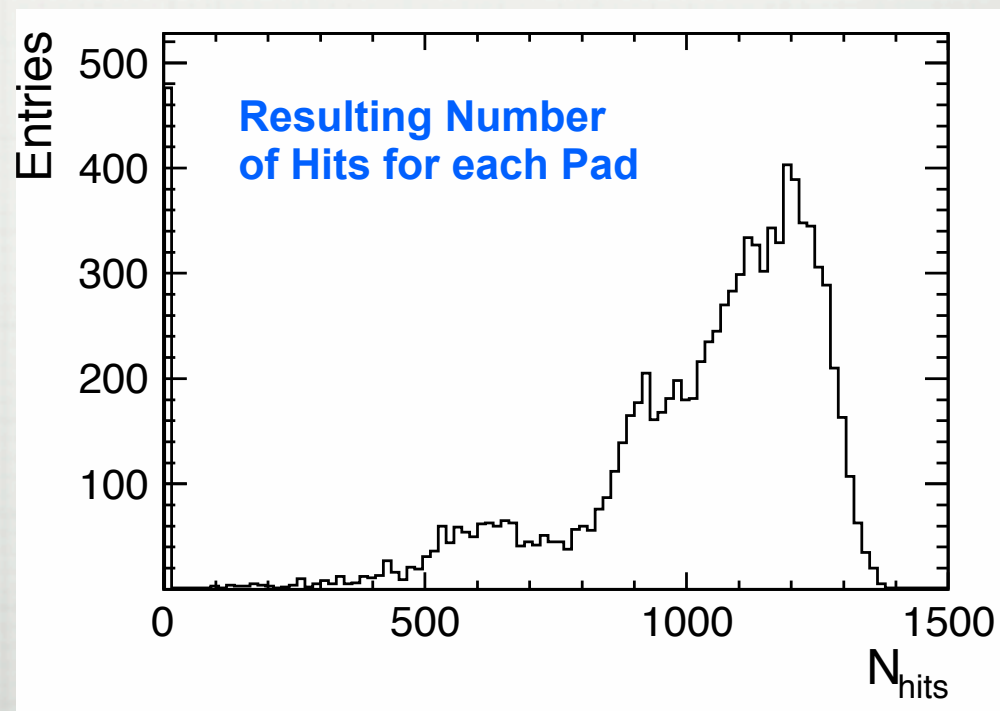
Muon Selection

Muon Selection:

1) Fit to the hits as a straight line

2) Number of hits in the straight line must be greater than 10

3) Distance between two hits in consecutive layers must be less than 2 cm

Statistics

Dead Pads: 476 (4.9%)
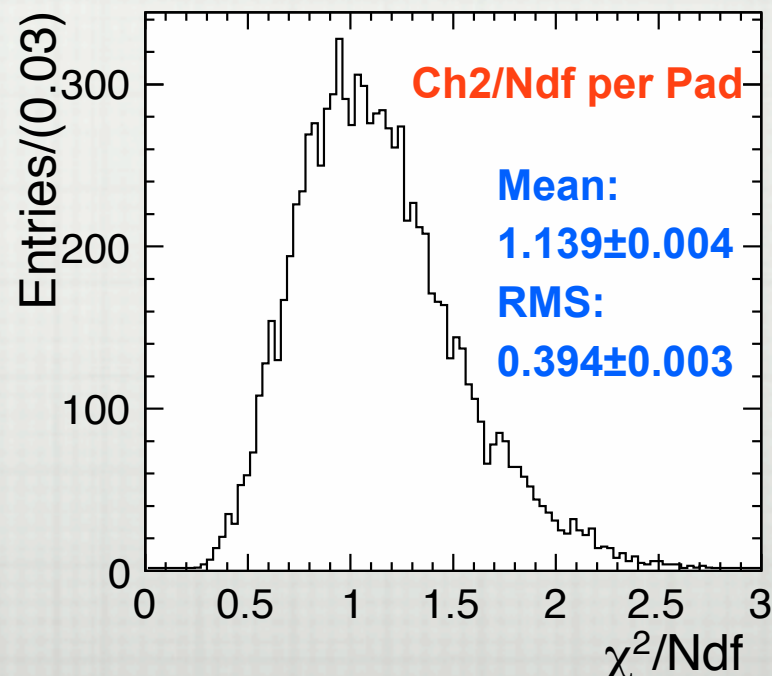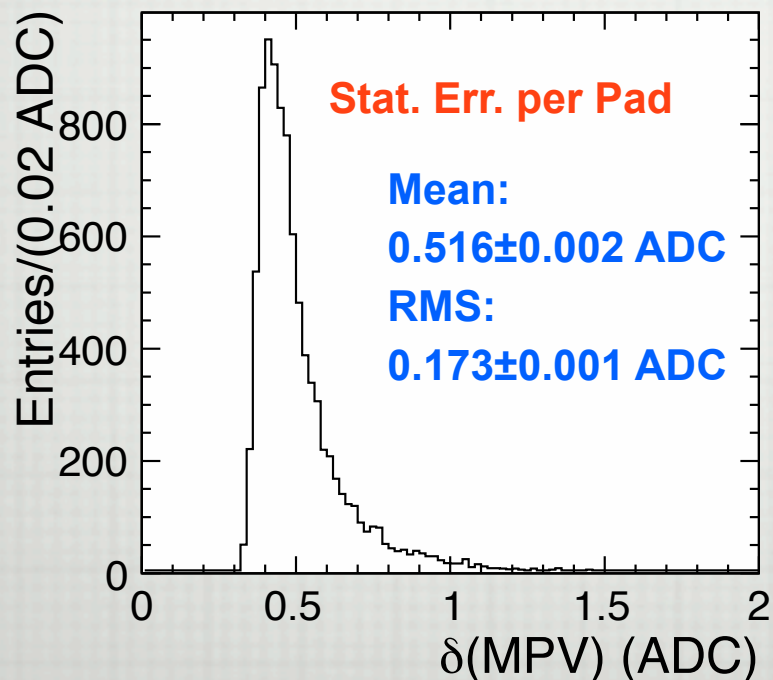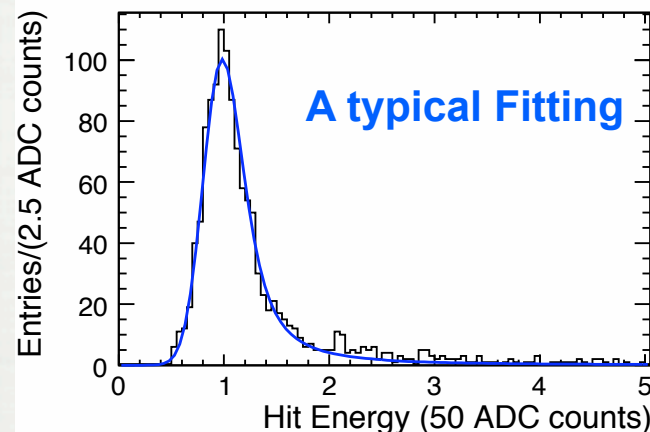
N hits less than 800: 1250 (12.9%)

N hits greater than 800: 7992 (82.2%)

Resulting Number of Hits for each Pad

Entries/(2...)

40

20

0

Hit Energy (50 ADC counts)

Fitting for each pad with a Convolution of Landau with Gaussian:

- Landau MPV: the calibration constant

- Gaussian Sigma: the Noise (signal induced)

- Fitting Range: 25 to 78.5 ADC

A typical Fitting

Entries/(2.5 ADC counts)

Hit Energy (50 ADC counts)

Stat. Err. per Pad

Mean:
0.516±0.002 ADC
RMS:
0.173±0.001 ADC

Entries/(0.02 ADC)

δ(MPV) (ADC)

Ch2/Ndf per Pad

Mean:
1.139±0.004
RMS:
0.394±0.003

Entries/(0.03)

χ^2/Ndf

Corrections for Dead Pads and Fitting Failures

Number of Dead Pads: 476

Map of Dead Pads, for all 30 layers

Number of Fitting Failures: 47

A fitting failure, if any one of the following criteria is **not** satisfied:

1) MPV within (37.5, 53.5) ADC

2) Stat. Err. less than 2 ADC

3) Noise within (2, 14) ADC

4) Chi2/ndf within (0.5, 3)

Corrections for fitting failures:

1) Due to abnormal residual pedestal:

- Refit together with another Gaussian to account for the residual pedestals

- 14 pads are recovered.

2) Short in statistics:

- 33 pads, treat as dead pads
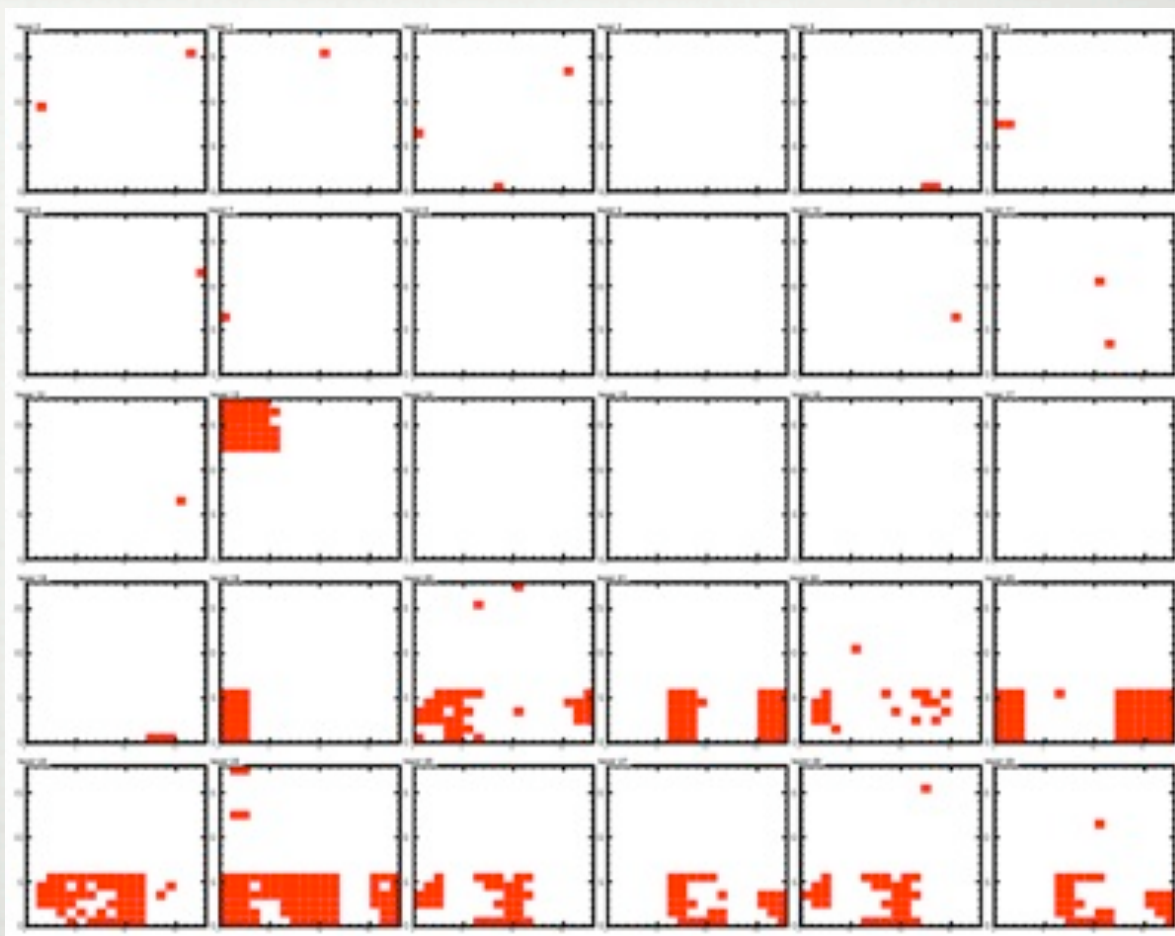
Corrections for Dead Pads and Fitting Failures

Corrections for Dead Pads:

1) If they behave at random:

- calibration constant: replaced by the mean of the same chip.

- error on calibration constant: the corresponding RMS. (on average for all chips: 1.31±0.03 ADC)

2) If they behave as a whole dead chip:

- calibration constant: replaced by the mean of the same PCB

- error on calibration constant: the corresponding RMS. (on average for all PCBs: 1.57±0.03 ADC)

3) In case more than half the pads in a PCB are dead:

- calibration constant: replaced by the mean of the other PCB in the same slab.

- error on calibration constant: The RMS of the difference between the mean of one PCB
and each pad of the other PCB in the same slab.
This RMS is 1.81±0.01 ADC, measured using all slabs.
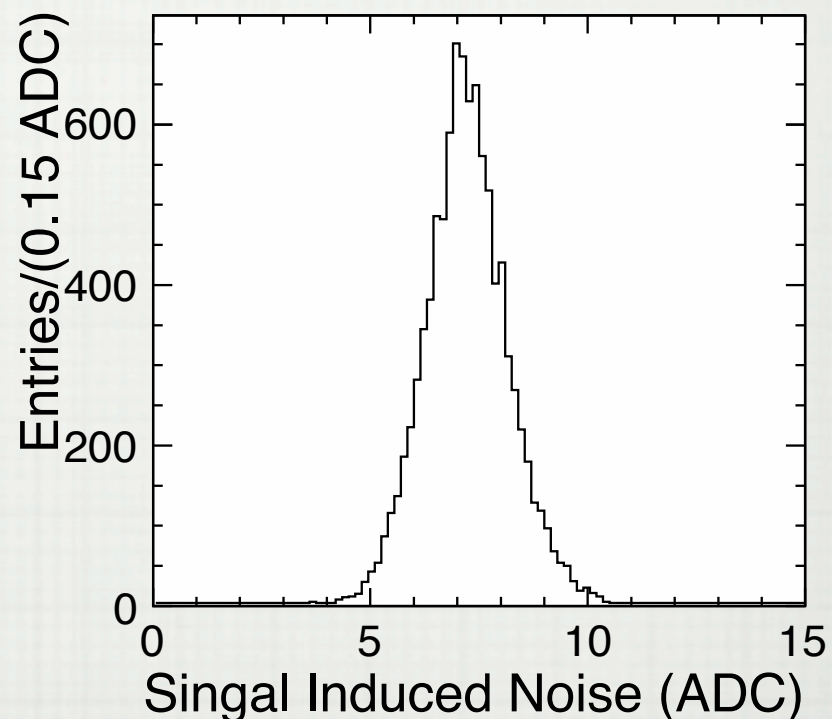
Resulting Calibration Constants and Noise
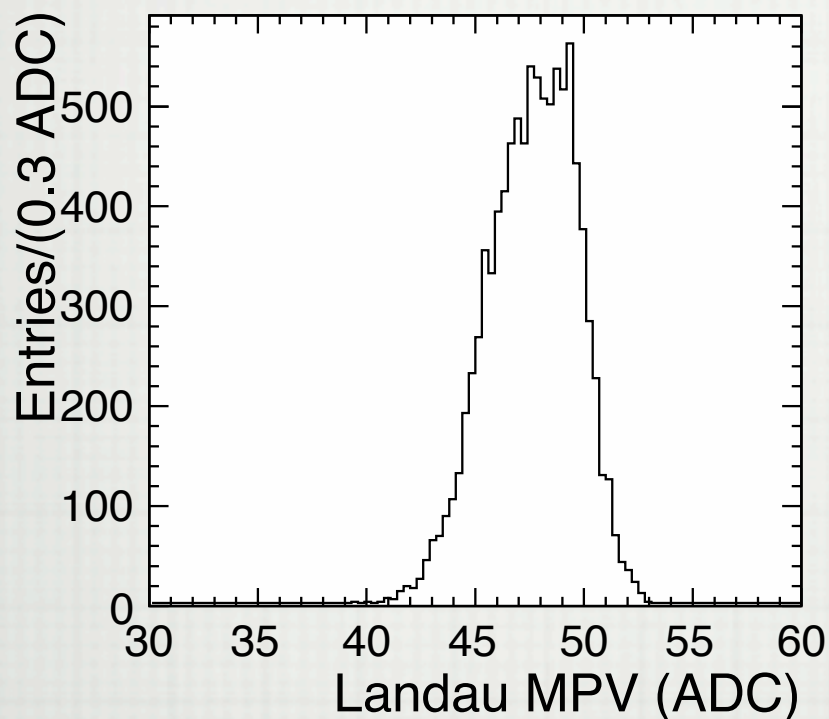
Calibration Constants:

Mean:

47.61±0.02 ADC

RMS:

2.06±0.01 ADC

Signal Induced Noise:

Mean:

7.22±0.01 ADC

RMS:

1.00±0.01 ADC

Systematic Errors

1) Due to Residual Pedestals:
- mean of residual pedestals over all pads:

<p style="text-align:center">-0.058±0.003 ADC</p>

2) Due to Different Fitting Ranges:
- Comparing the results with that using the entire range.
- difference for each pad: mean: 0.258±0.004 ADC

<p style="text-align:center">RMS : 0.366±0.003 ADC</p>
<p style="text-align:center">(systematic error)</p>

3) Due to Timing Offsets between Different Triggers:

- Reason:
  - Difference in Trigger response time
  - Difference in Hold Value

- Systematic Error:

  When apply the calibration constants obtained with 20x20 trigger, to the data triggered with 10x10&Cerenkov.

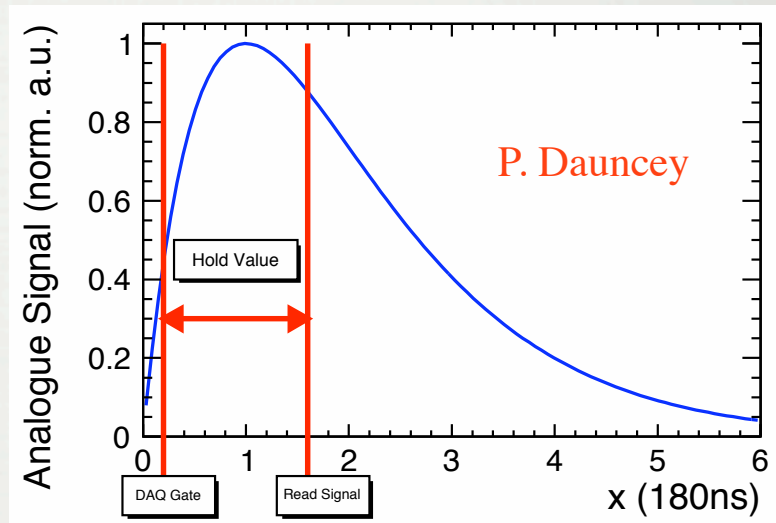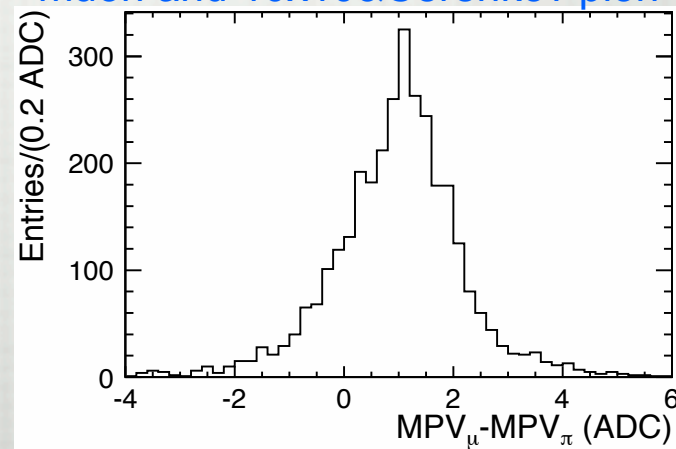- Examine using minimal ionizing pions triggered with 10x10&Cerenkov:
  - Difference:

    Mean: 0.97±0.02 ADC

    RMS : 1.19±0.02 ADC
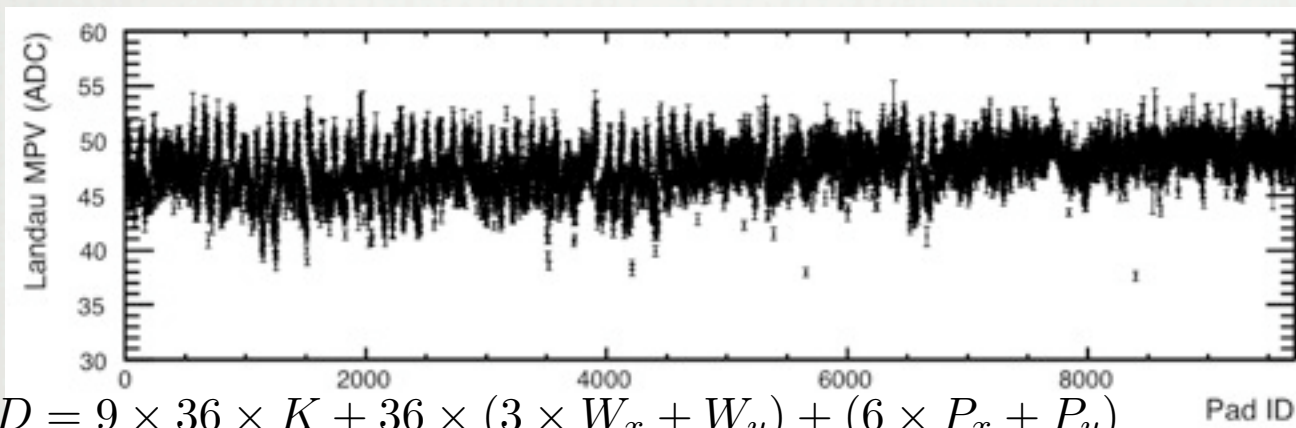 - Take the mean as the systematic error.

P. Dauncey

MPV difference between 20x20 muon and 10x10&Cerenkov pion

Uniformity and Stability

Uniformity: Calibration Constants as a function of Pad Index, with error bar.

$$Pad\ ID = 9 \times 36 \times K + 36 \times (3 \times W_x + W_y) + (6 \times P_x + P_y)$$

Calibration Constants:

Mean:

47.61±0.02 ADC

RMS:

2.06±0.01 ADC

Stability is checked by comparing with 2006 CERN Aug. and Oct. ones.

Correlation with Aug. 2006 CERN

Correlation Coefficient: 80.30%
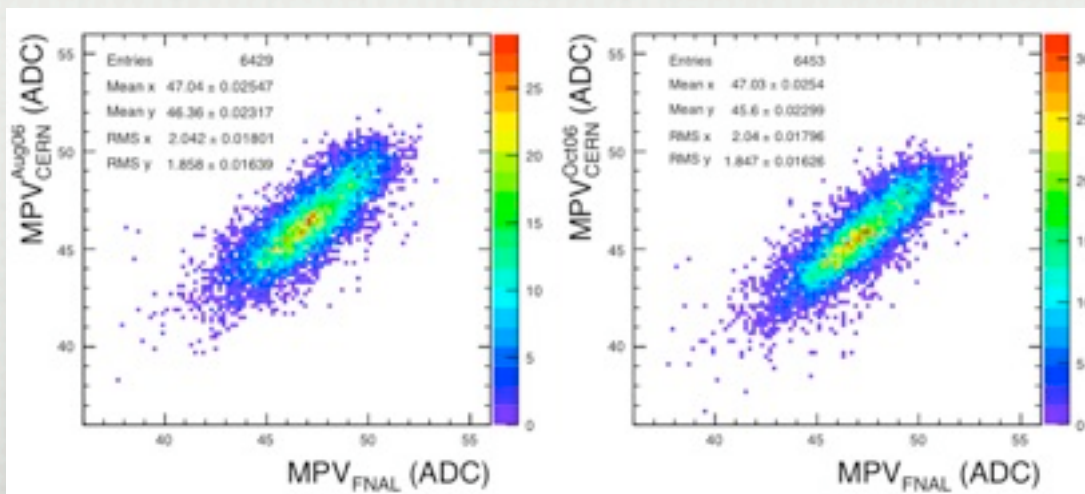
Correlation with Oct. 2006 CERN

Correlation Coefficient: 83.76%
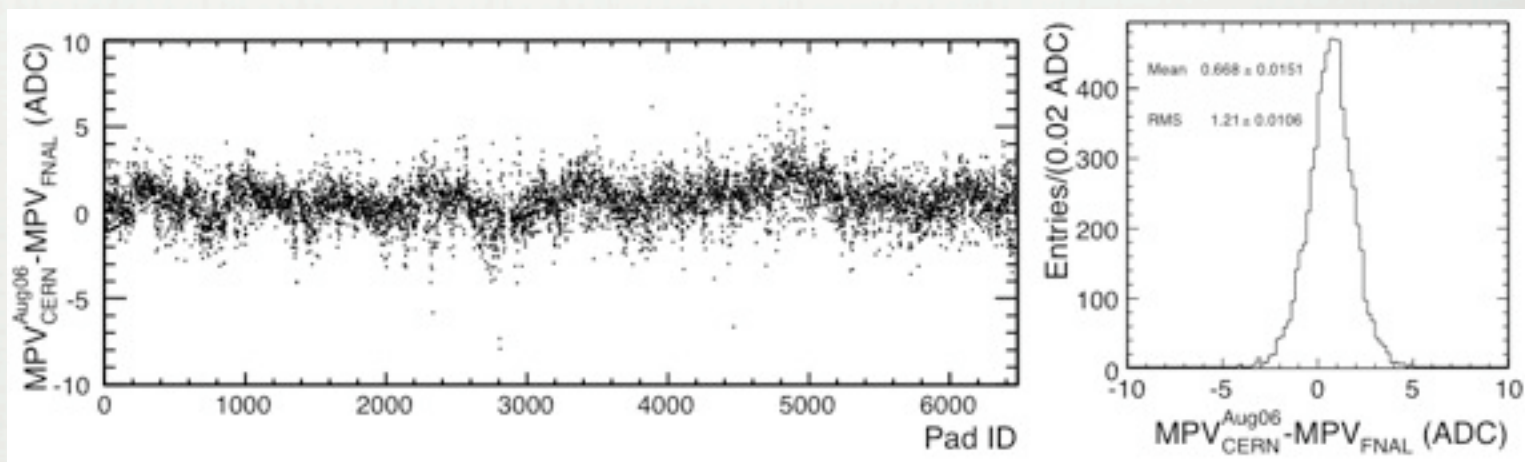
Uniformity and Stability

Difference on the calibration constants compared with 2006 CERN Aug. and Oct. ones.

$$Pad\ ID = 6 \times 36 \times K + 36 \times (2 \times W_x + W_y - 1) + (6 \times P_x + P_y)$$

Difference with Aug. 2006 CERN
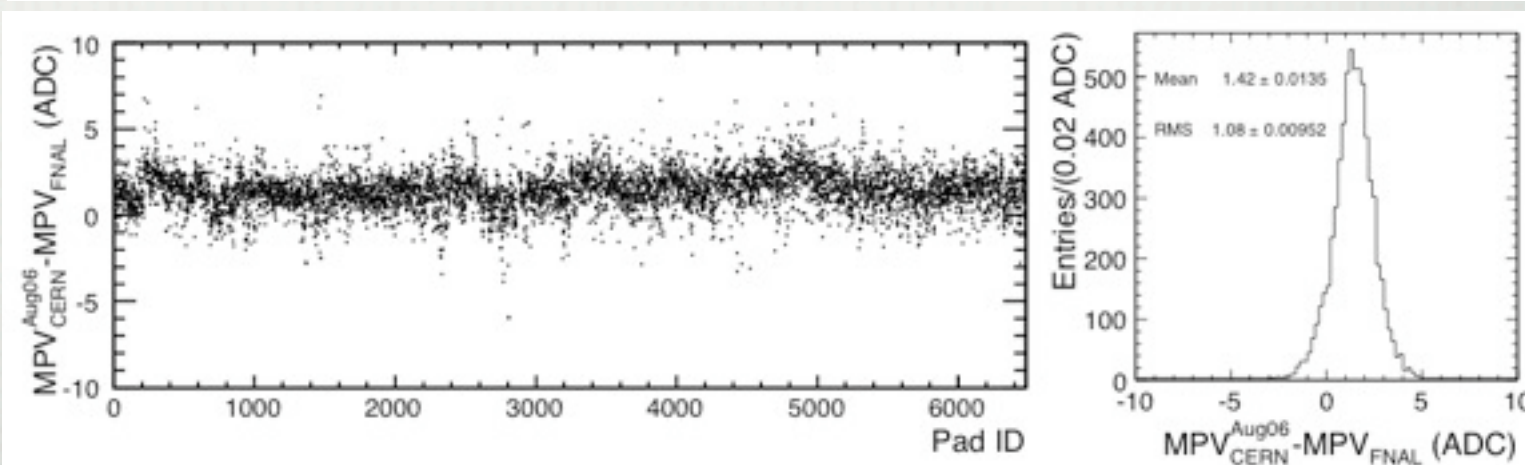
Mean Difference:

0.67±0.01 ADC

RMS:

1.21±0.01 ADC

Difference with Oct. 2006 CERN

Mean Difference:

1.42±0.01 ADC

RMS:

1.08±0.01 ADC

Reason for the difference: Timing offset between different triggers

Summary

☐ MIP Calibration for 2008 FNAL July period is finished.

    ☐ 9211 out of 9720 pads are calibrated

    ☐ 476 dead pads and 33 fitting failures: calibration constants are replaced.

☐ Calibration Constants on average: 47.61 ±0.52(stat.) ±0.37(sys.) ADC

    ☐ if apply on 10x10&Cerenkov, total systematic error : ±1.04(sys.) ADC

☐ Uniformity and Stability are checked

☐ Higher statistical error compared with 2006 CERN (two times higher), due to lower statistics