
CALICE
Calorimeter for ILC
SiPM Response Tests
with LED's
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Kobe, May 10, 2007
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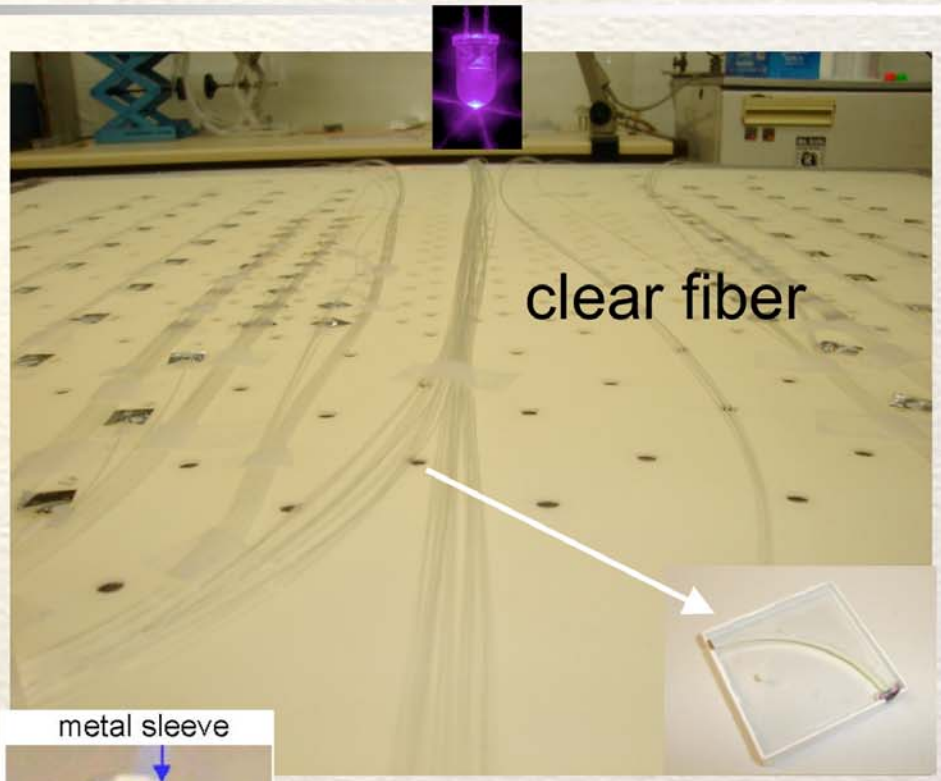
Introduction

- The SiPM response is sensitive to changes in temperature & operating voltage: dG/dT ~ -1.7%/K, dG/dV ~ 2.5%/0.1V
  dQ/dT ~ -4.5%/K, dQ/dV ~ 7%/0.1V
- Thus, we installed an elaborate LED-based monitoring system in which LED light is fed to each tile via a dedicated fiber and we record the temperature in each cassette by 5 sensors
- So we need 1 fiber per tile, 1 LED per 19 fibers 1 PIN diode per LED, electronics to drive LED, ADC for PIN
  ➔ non-negligible costs in a full calorimeter
- The monitoring system allows us to
  - monitor SiPM stability with fixed LED intensities during run
  - Perform gain calibration
  - Measure SiPM response function
  - Determine intercalibration constants

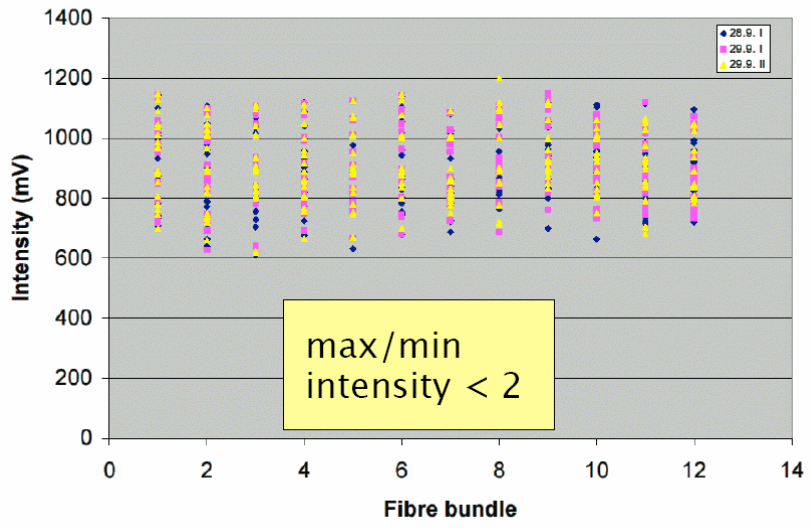
We anticipate a stability of the calorimeter performance of <1%

Calibration-Monitoring System

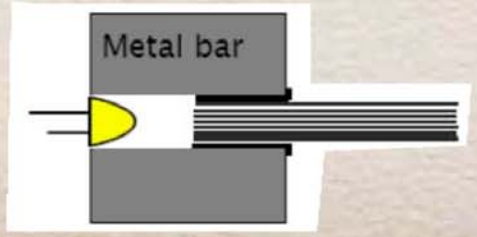
- Provide UV light to each tile via clear fiber
- Monitor each LED with PIN diode
- Record temperature & voltage with slow control system (5 temperature sensors/module)



Light Uniformity in Test Module



bundle of 19 fibers
18 → tiles, 1 → PIN diode



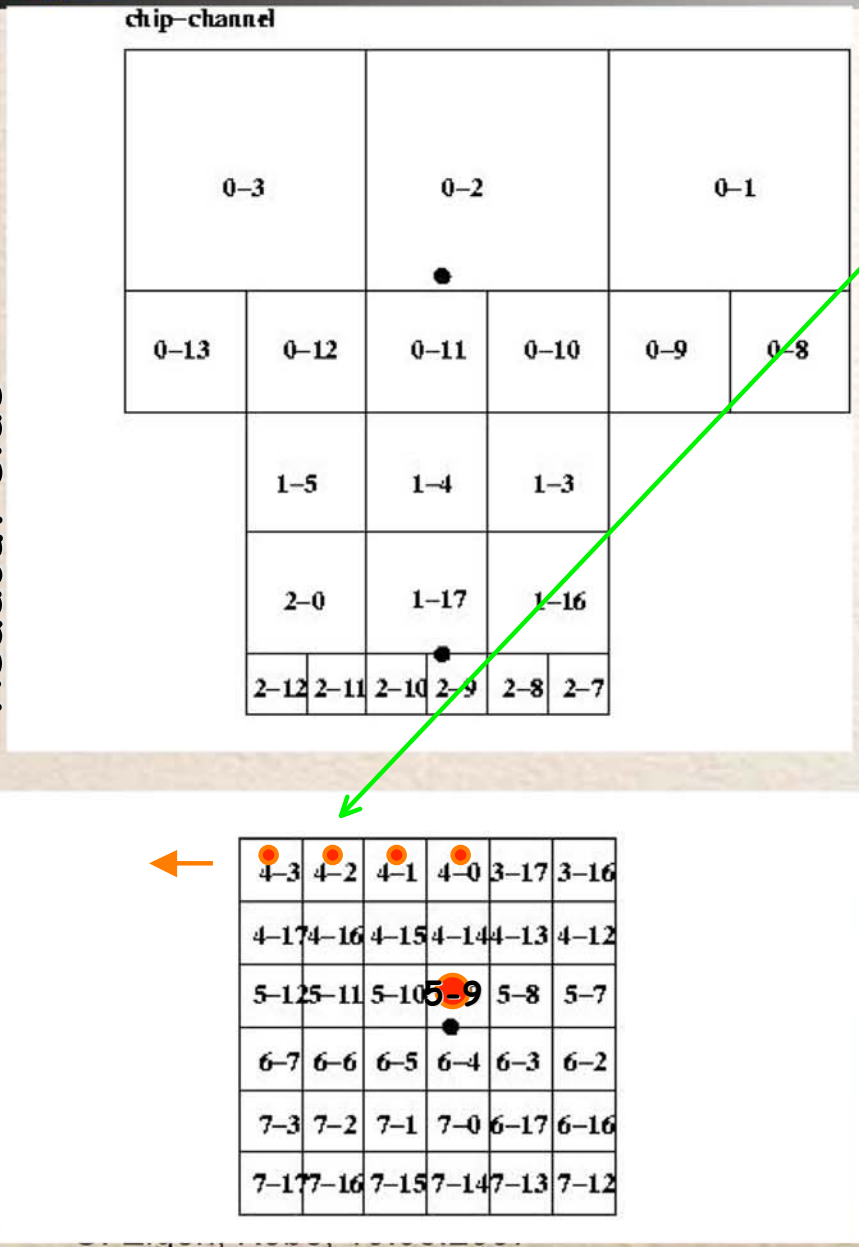
LED fiber coupling

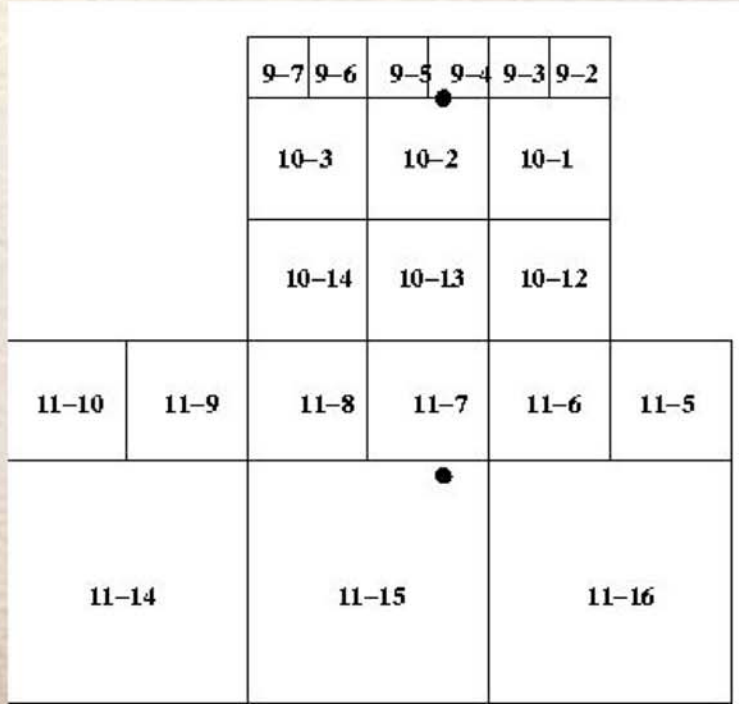
Important Issues

- Can we achieve excellent performance without an LED-based monitoring system?
- Can we achieve stability without measuring full response function?
- Is it sufficient to monitor just one fixed value?
  If so, which one (high or saturation?)
- The test beam data will provide some insight
- But this issue needs to be evaluated very carefully!!
  ↳ Is the detector really stable enough to afford this?
- So here are first studies

Module Layer Layout

- First look at performance of tiles in module 5 chip 4#1-12, chip 5#9, module 3 chip 5#9 chip 6#9, module 3-12,chip5#9
- Look at 2 runs in August & 2 runs in October





Readout side

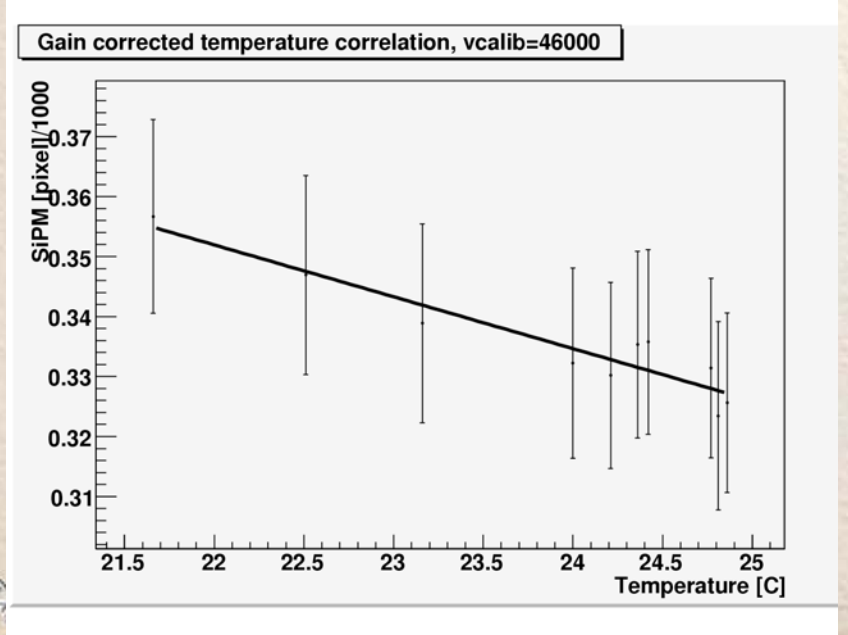
CMB side

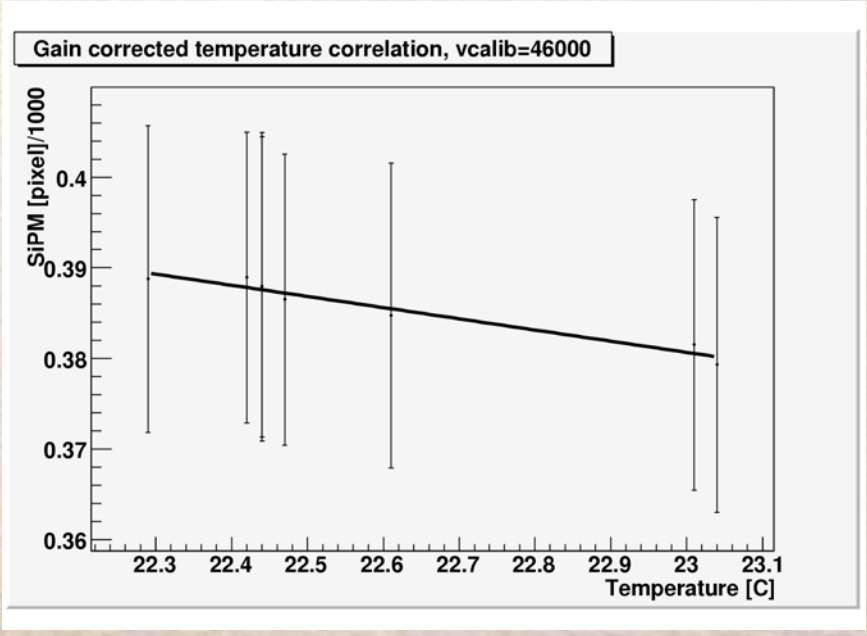
Test under Present Run Conditions

- Note that operating conditions changed between August runs and October runs
- For runs in one test beam period we expect basically only changes in T
- Since this basically affects both SiPM response and the gain a gain correction may take care of this
- In principle this should also apply for V changes
- So can we achieve an understanding of the SiPM response by by a simple gain correction without knowing exactly T and V?

Temperature Dependence

- For August/September runs we observe ~3.5° C temperature variations ➔ this results in ~10% SiPM response variation
- For October runs we controlled temperature variation to < 1°C

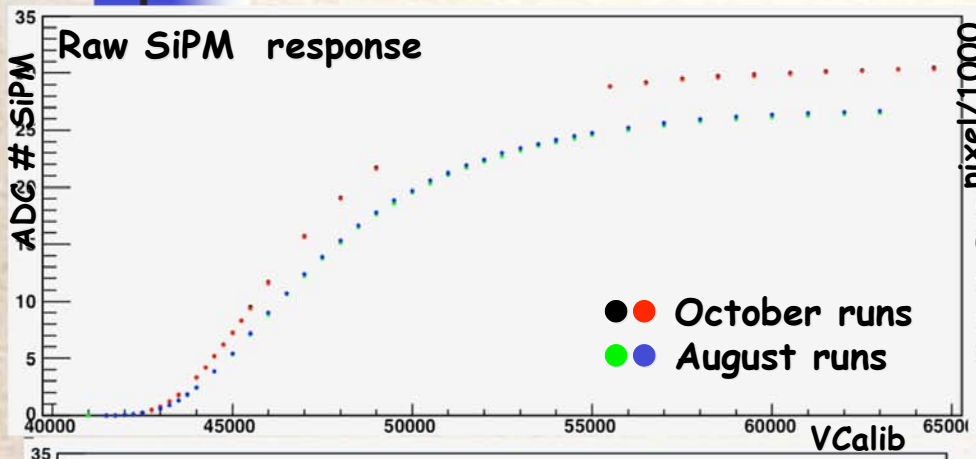


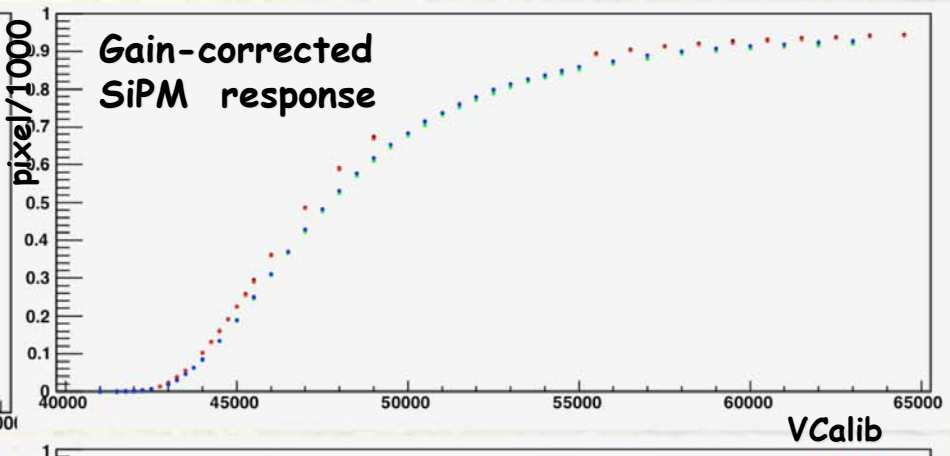


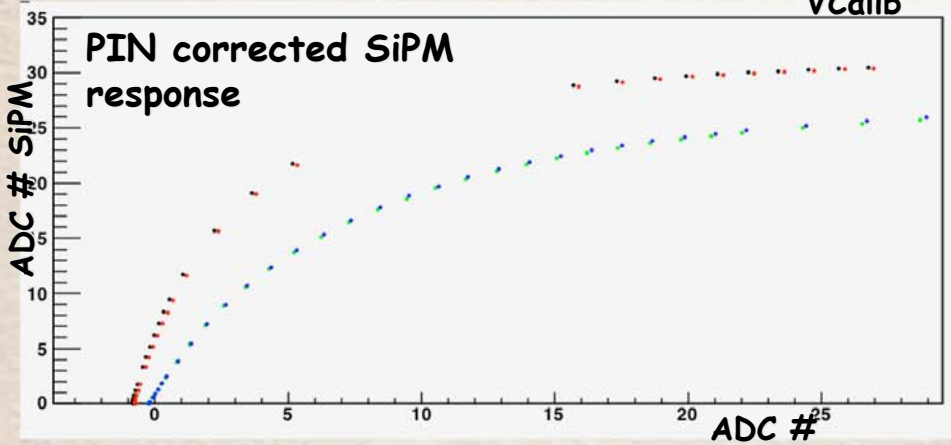
Analysis Procedure

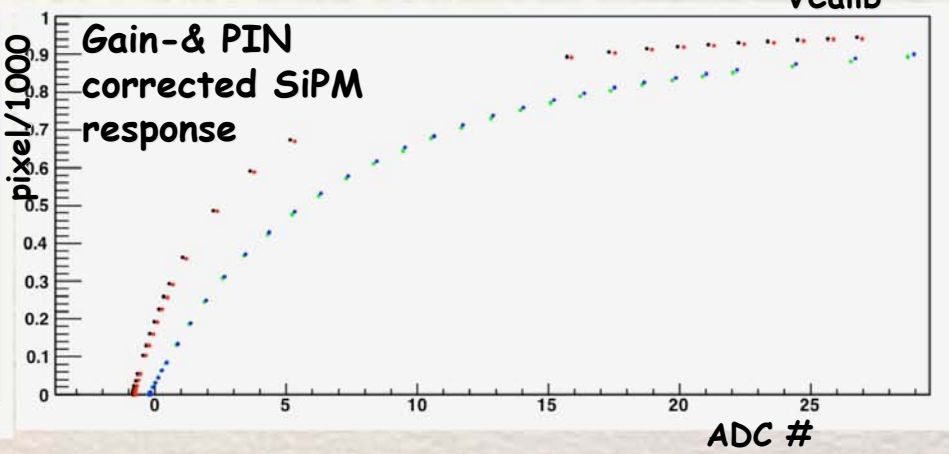
- Record SiPM response in ADC bins vs Vcalib
- Record PIN diode response in ADC bins vs Vcalib
- Determine PIN-corrected SiPM response
- Apply gain correction to measured SiPM response in pixels vs ADC bins
- Determine PIN corrected SiPM response in pixels vs ADC bins
- Both SiPM and PIN response functions are pedestal subtracted!

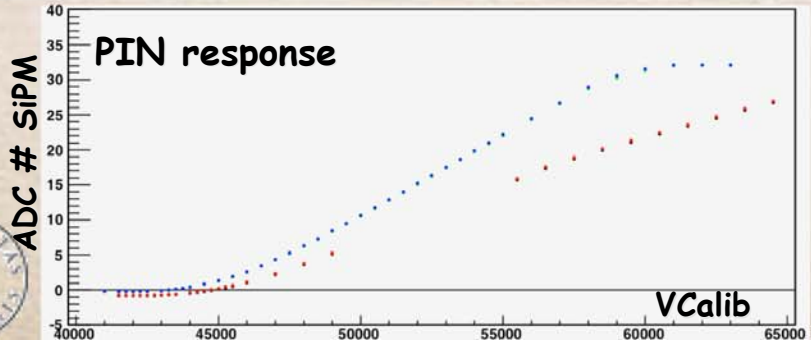
SiPM Response for Module 3 Chip 5#9





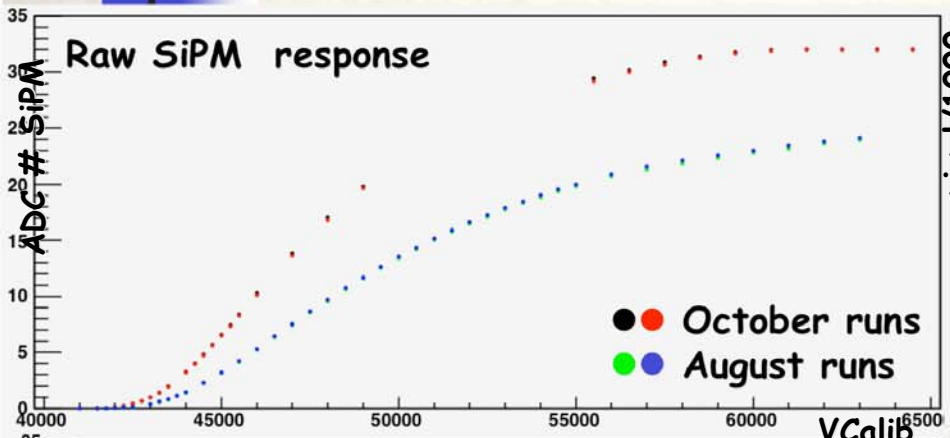


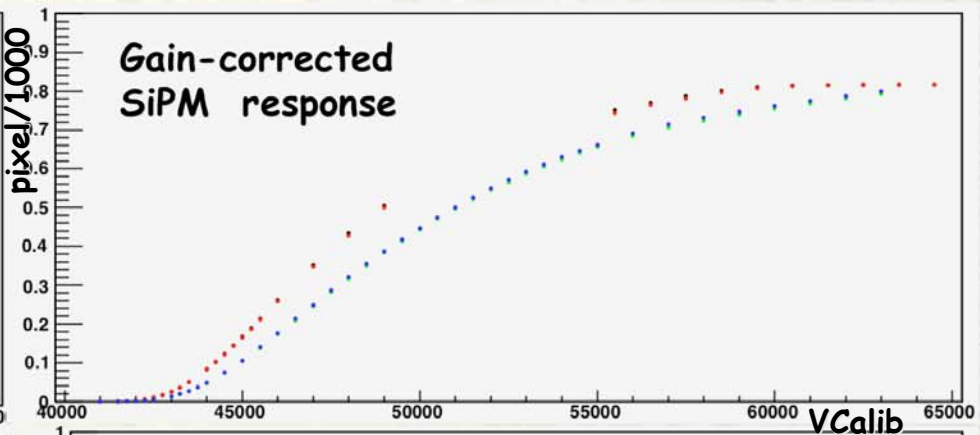


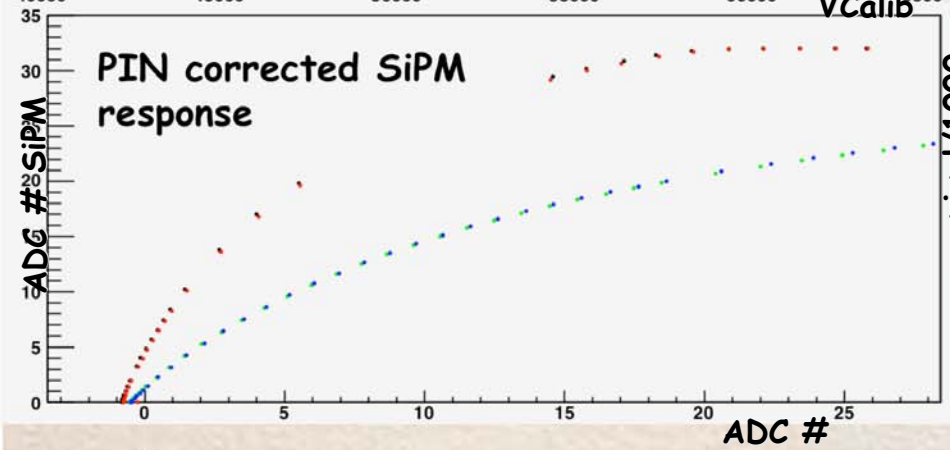


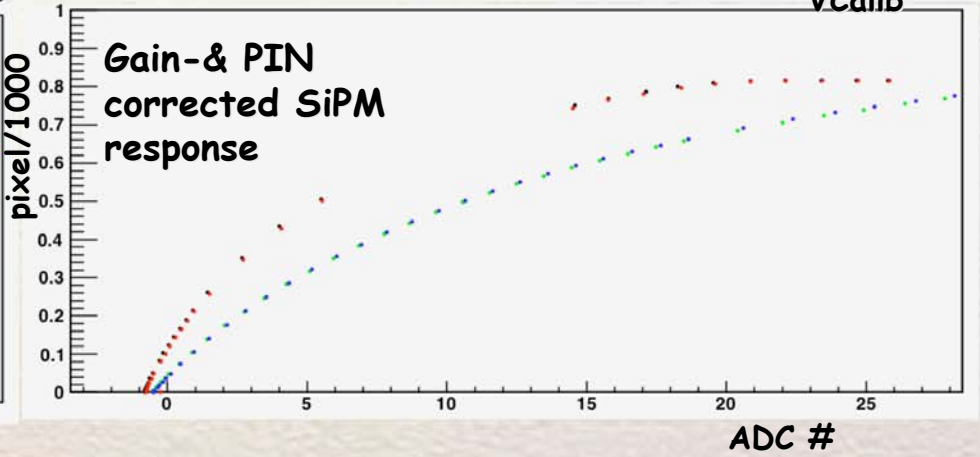
- Runs in each run period agree
- Gain correction does good job
- PIN corrections worsens shape

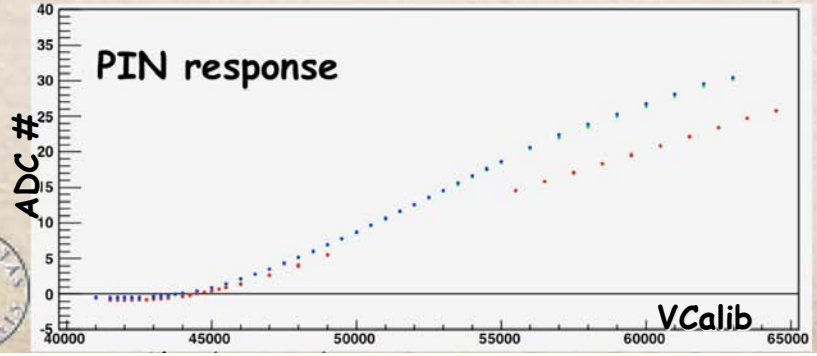
SiPM Response for Module 5 Chip 5#9





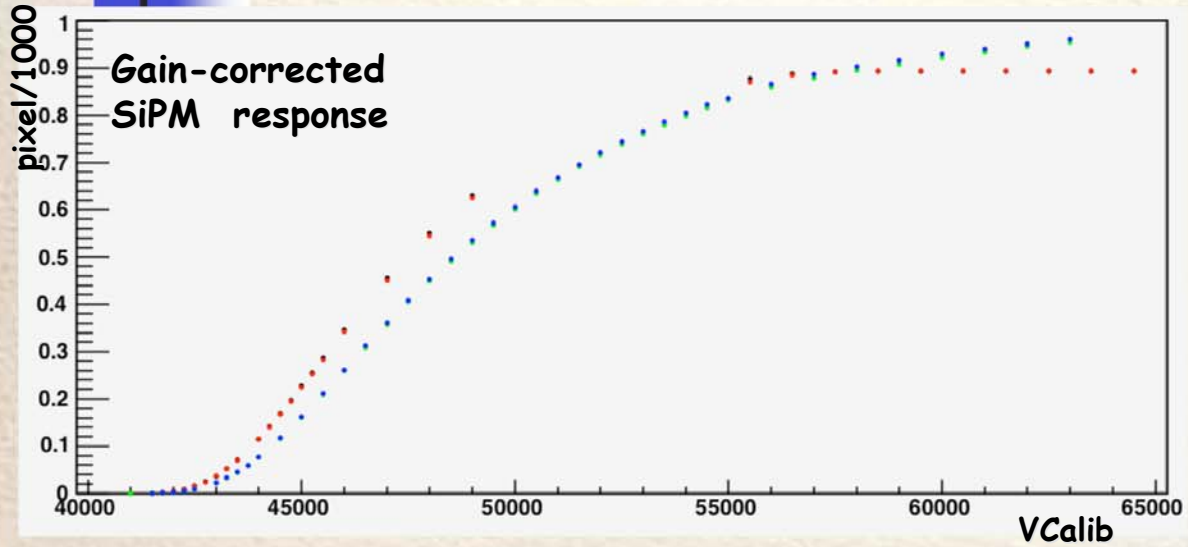


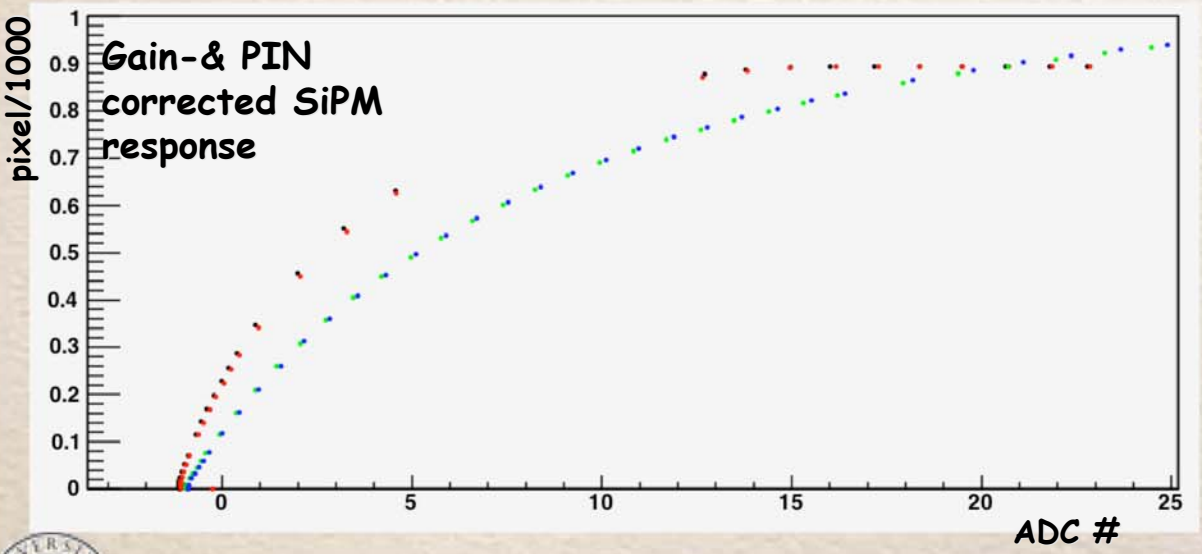




- Runs in each run period agree
- Gain correction does good job
- PIN corrections worsens shape

SiPM Response for Module 5 Chip 4#2

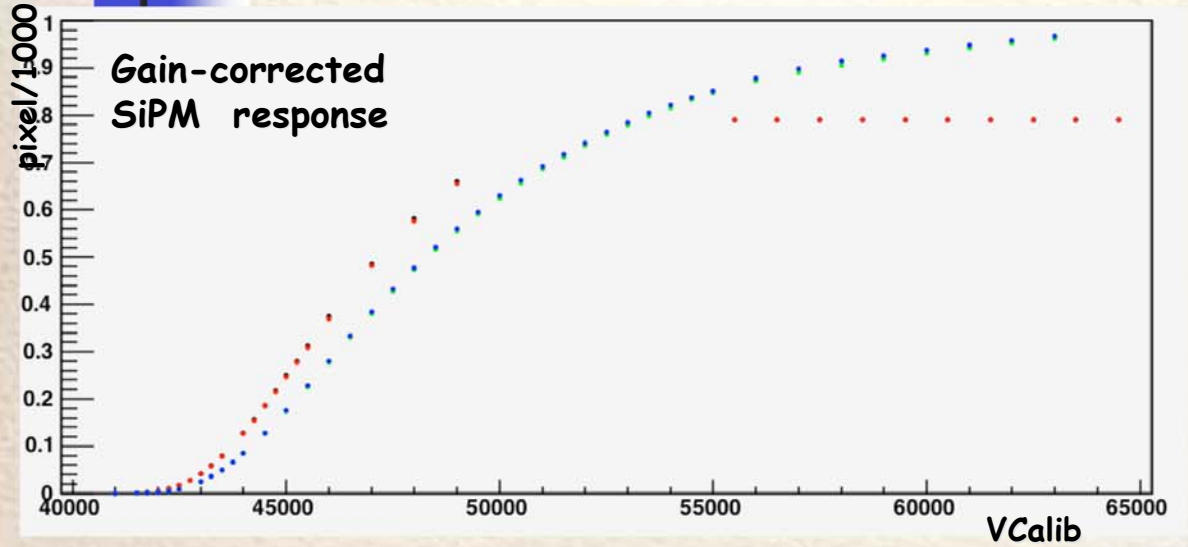


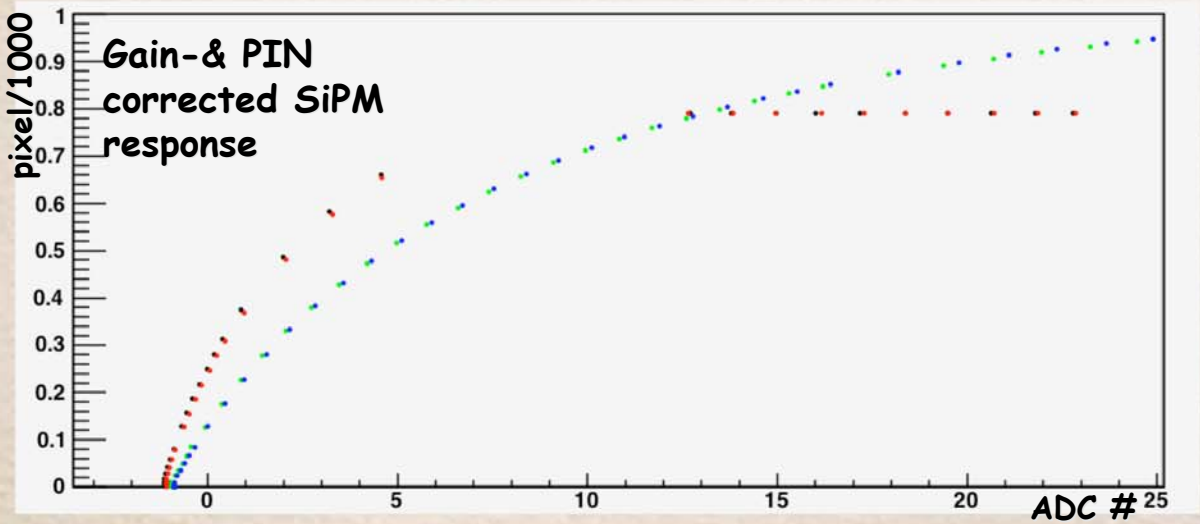


- Gain corrected SiPM response curves are similar in shape but not identical
- PIN correction improves asymptotic limit but deteriorates the shape
- But this is different for other channels

● ● October runs
● ● August runs

SiPM Response for Module 5 Chip 4#4

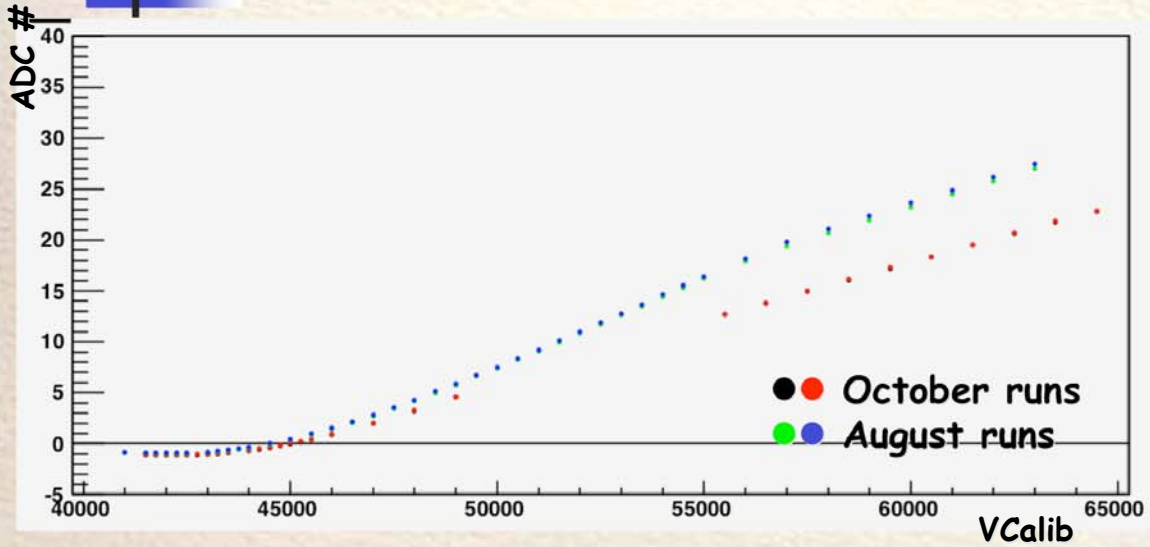


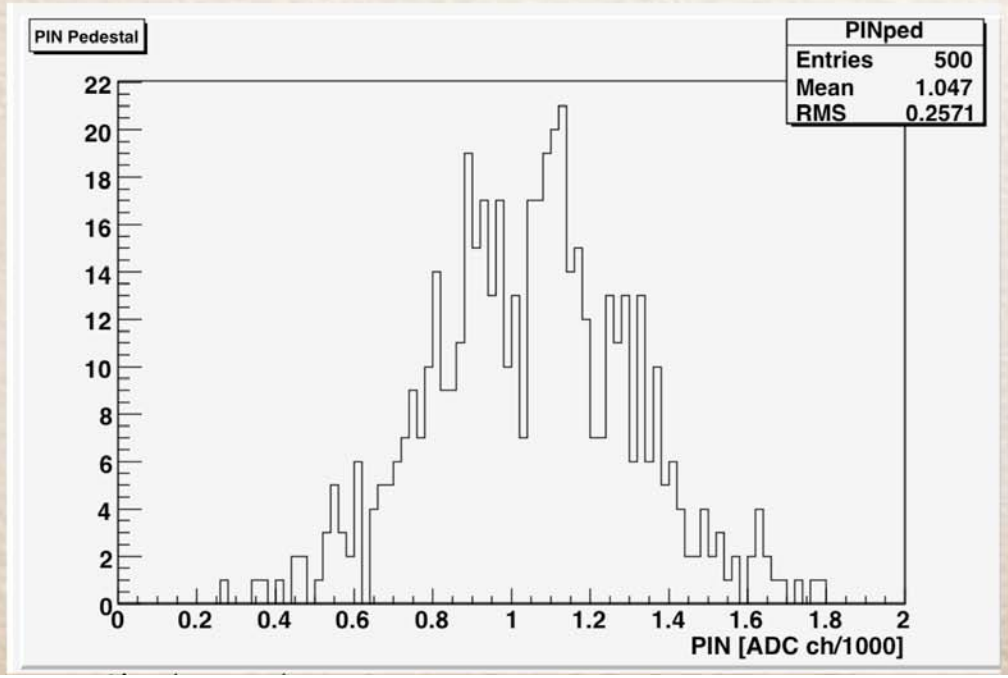


- Gain corrected SiPM response curves differ
- PIN correction does not help either on the asymptotic limit nor on the shape

October runs
August runs

Problems in Pedestal Distributions

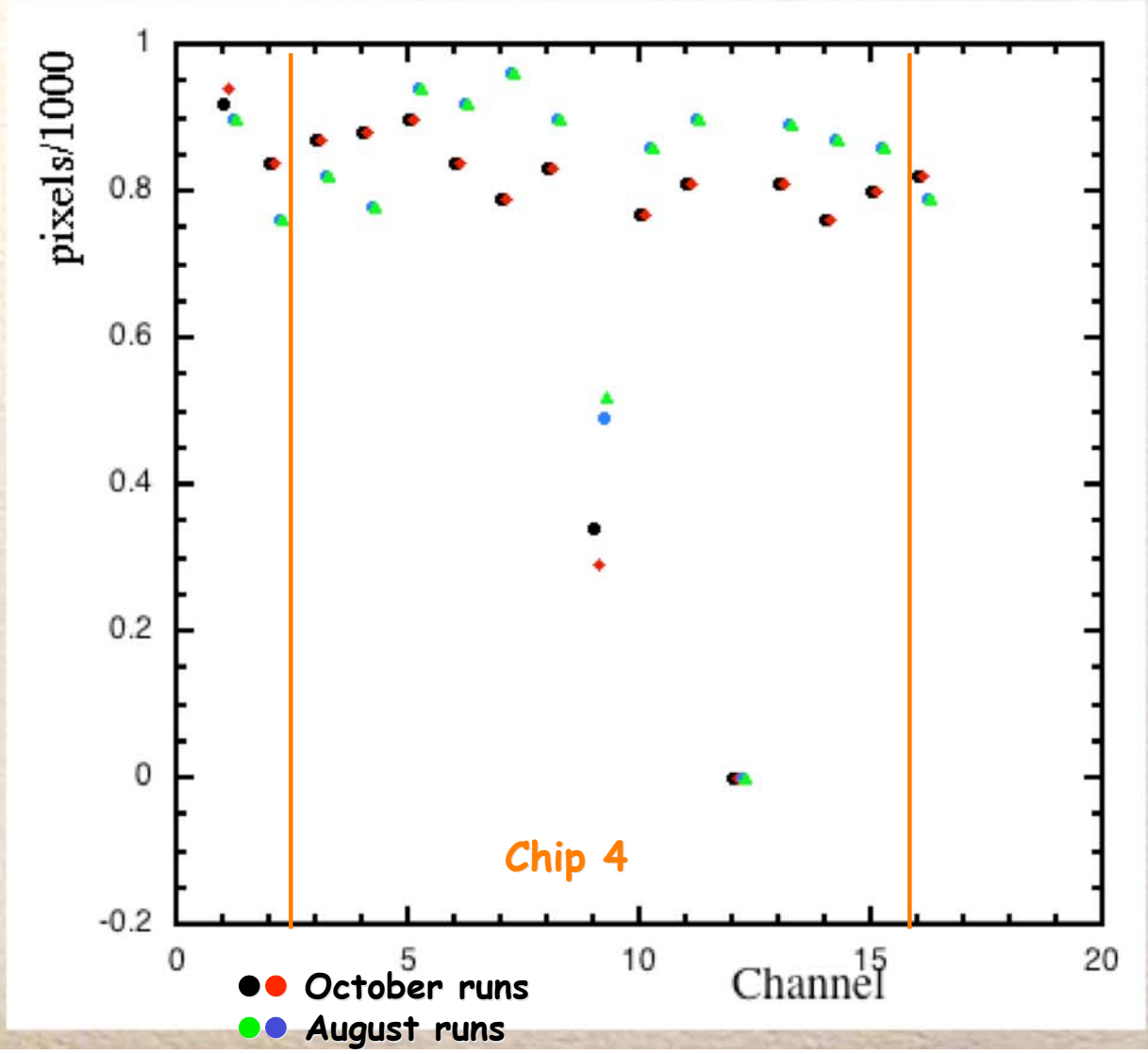




- Pedestal subtraction has a problem in some cases
- Subtracted distribution is negative in some cases
- Reason the distribution is rather broad?
- This may cause a problem
- We need to think how to fix this

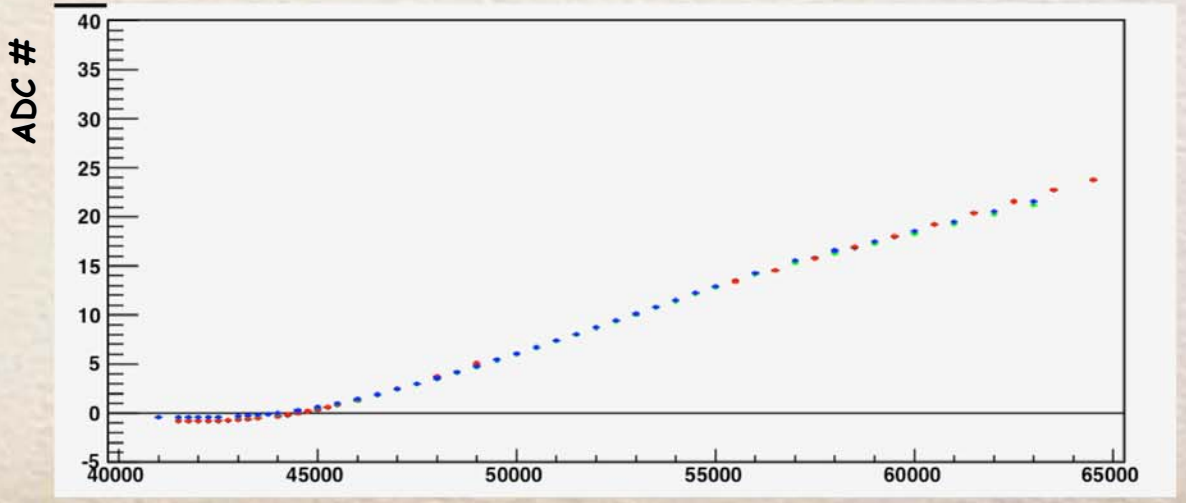
Summary of corrected SiPM Response

- Use simple graphical method to get asymptotic value as fits to selected functions cause problems
- August runs show different responses than October runs (are higher)
- We suspect that main reason is due to PIN calibration
- Thus we try to improve PIN response by simple model

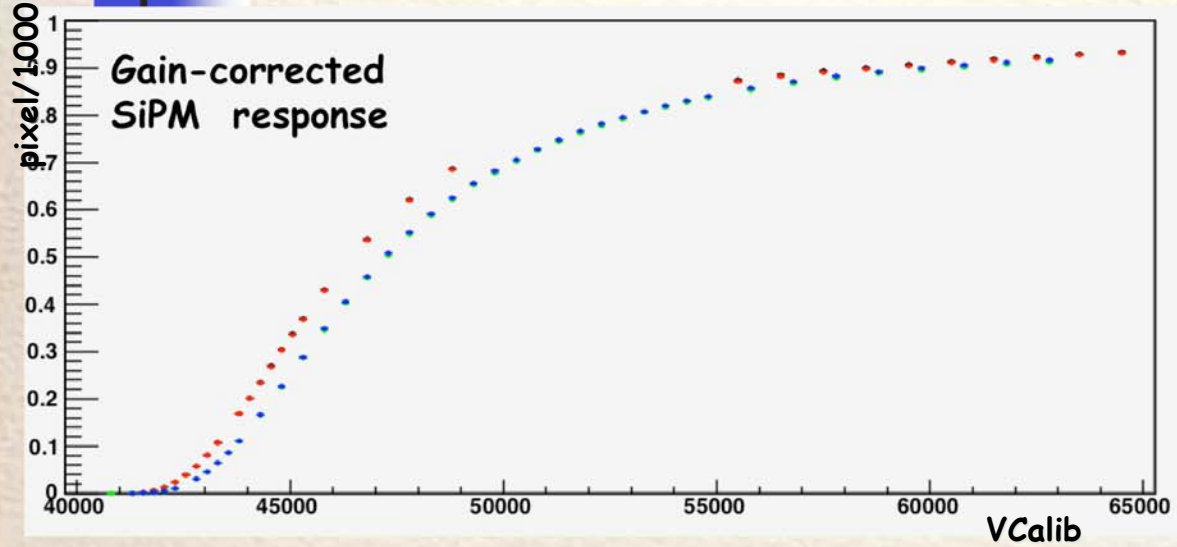


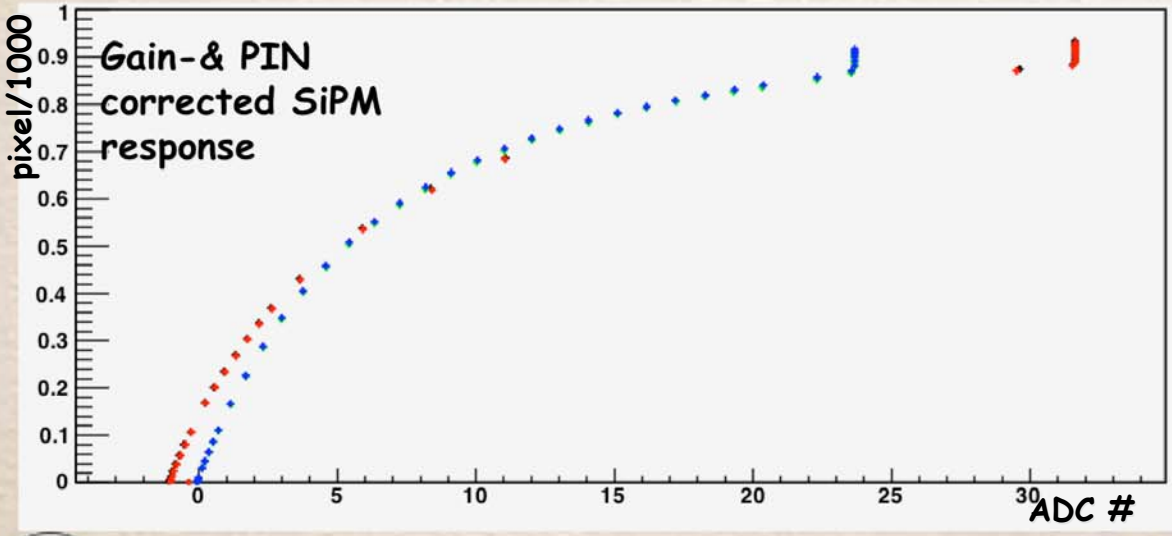
Try Improvement for PIN Correction

- Model: Use PIN distribution from run in November and run in August
- Determine ratio from the two PIN distribution
- Multiply October PIN distributions by this factor to serve as a model for PIN distributions of August runs
- Try channels that are fed by different PINs, i.e module 3-12 chip 5#9

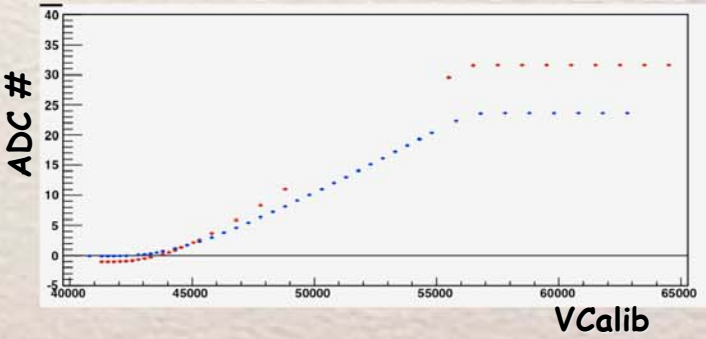


SiPM Response for Module 12 Chip 5#9



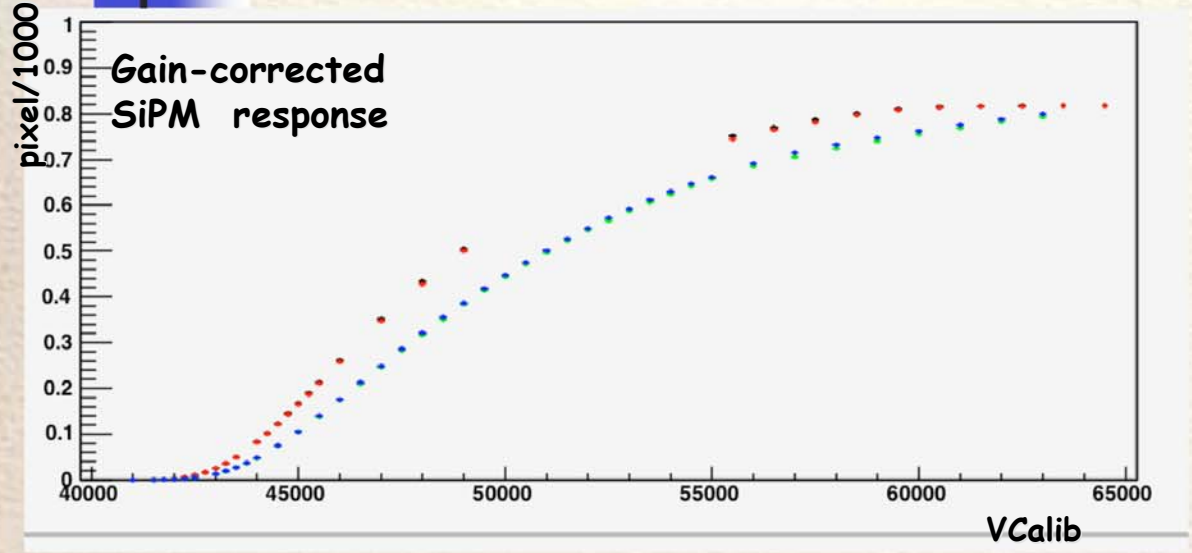


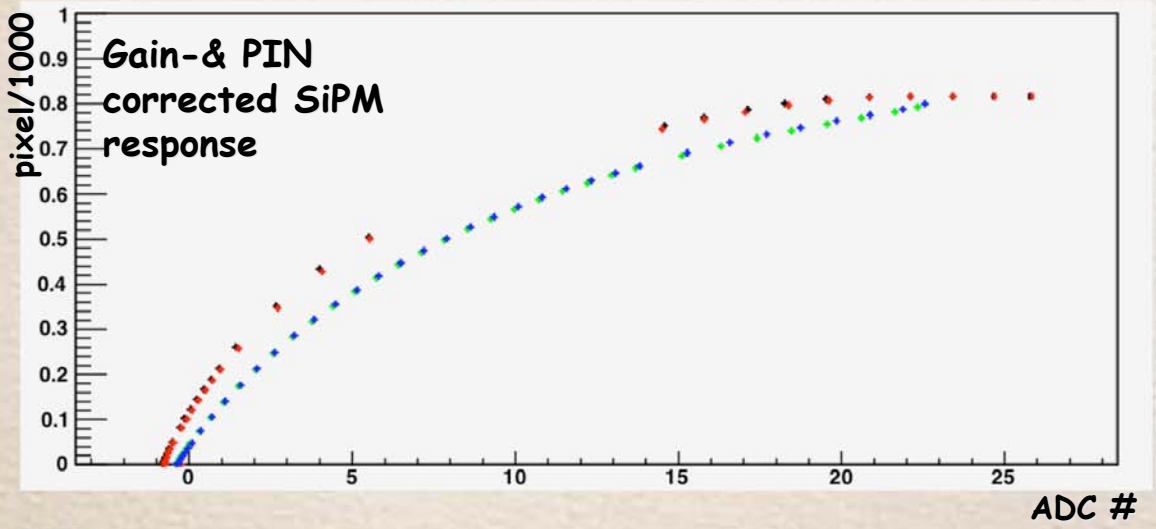
- Model works well in some cases
- SiPM response function for the 2 run periods have similar shapes
- However, for both run periods the PIN diode saturated



October runs
August runs

SiPM Response for Module 5 Chip 5#9

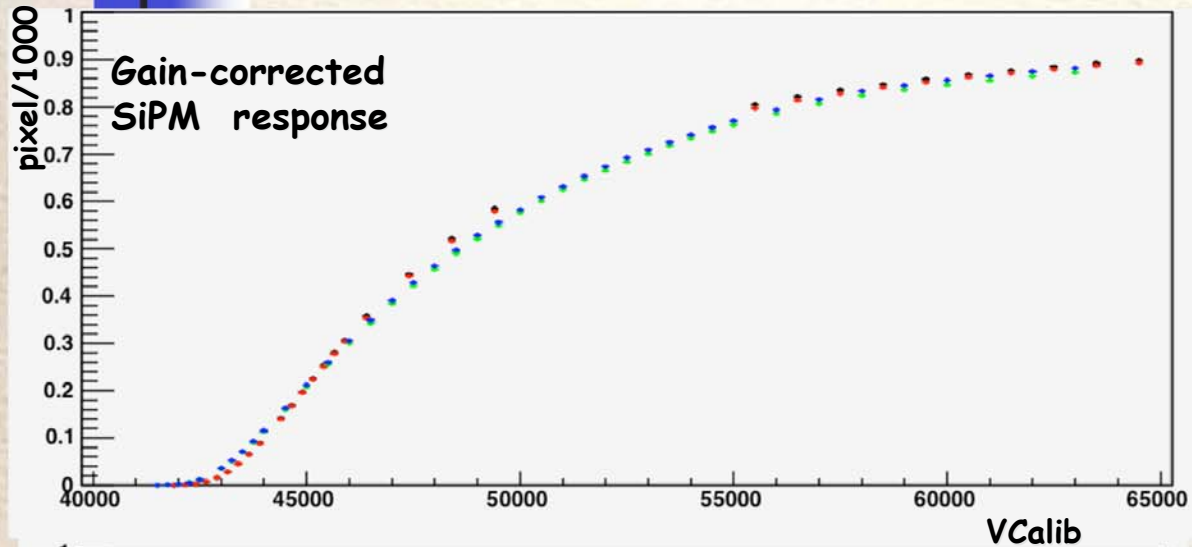


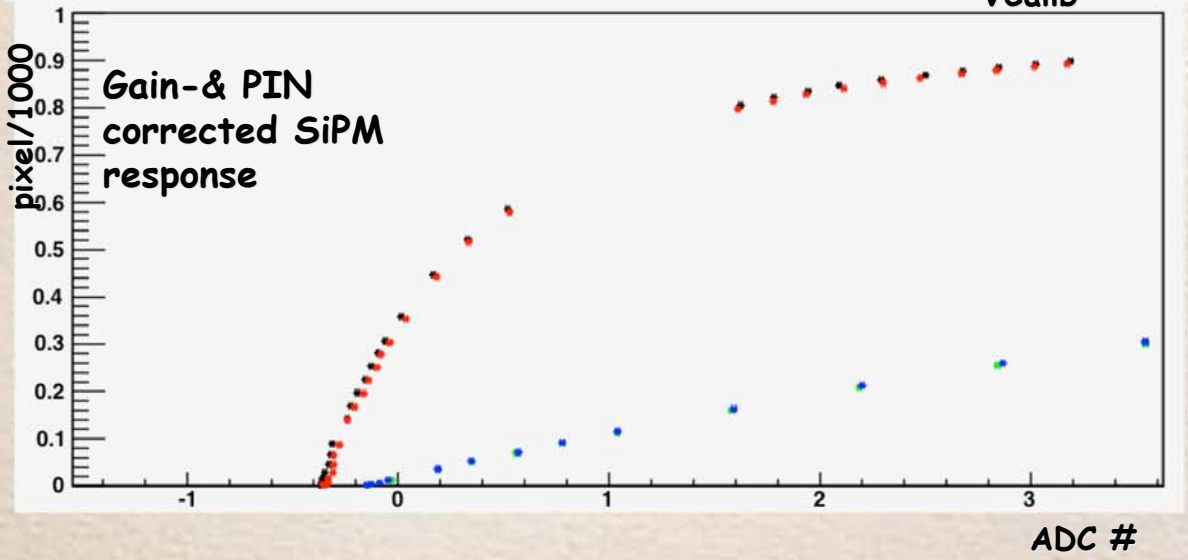


- Model works less well here
- Saturation points are similar but shapes differ

October runs
August runs

SiPM Response for Module 4 Chip 5#9



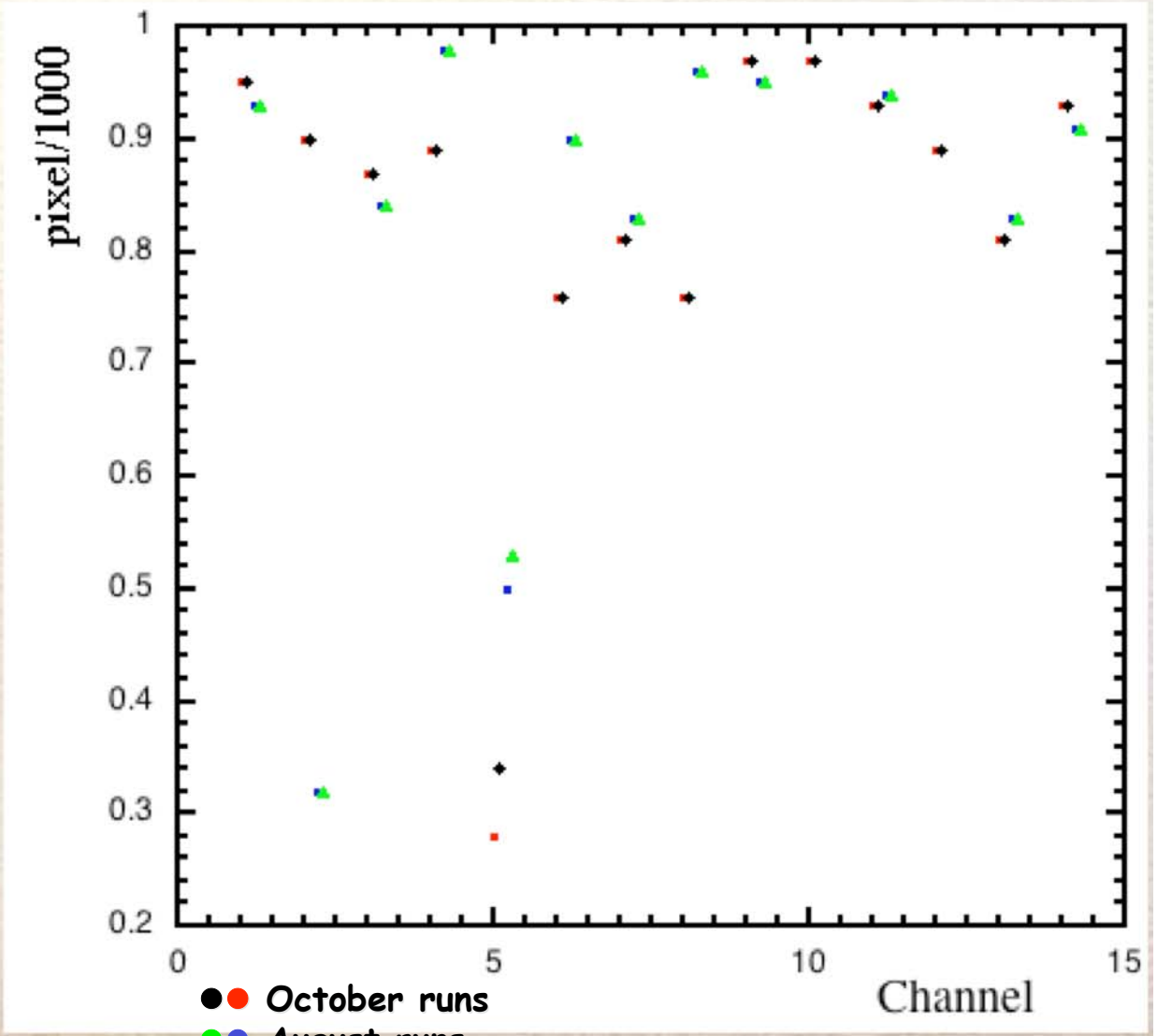


- Gain-corrected SiPM response functions agree well between 2 run periods
- However, the PIN diode correction does work here at all

October runs
August runs

Summary of Model-Corrected Response

- Look at different modules but the same chip and channel
- The model improves performance but is not perfect & fails in some cases
- We need to investigate what other corrections can be made
- Note, we get a considerable spread in the saturation values ➔ can we resolve this?



Conclusion

- We have studied the SiPM response function of different channels after pedestal subtraction, gain corrections and PIN diode corrections for runs in August and October
- SiPM response functions for each run period agree well, while they typically differ for the 2 run periods
- Using PIN corrections derived from a well-behaved PIN diode improves agreement, but we need to do better
  ➔ maybe we need temperature corrections for August runs
  ➔ we should test procedures in upcoming run periods
- At the moment I think that we need a monitoring system and need the capability to measure SiPM response functions as too many things can go wrong and redundancy helps
- However, the final decision will come from future studies

Acknowledgments

- This work was conducted in collaboration with the DESY AHCAL group, in particular I would like to thank S. Schaetzel for his help in setting us up to performing these studies