

SIPM Response Tests with LED'S

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DESY, February 14, 2007





Introduction

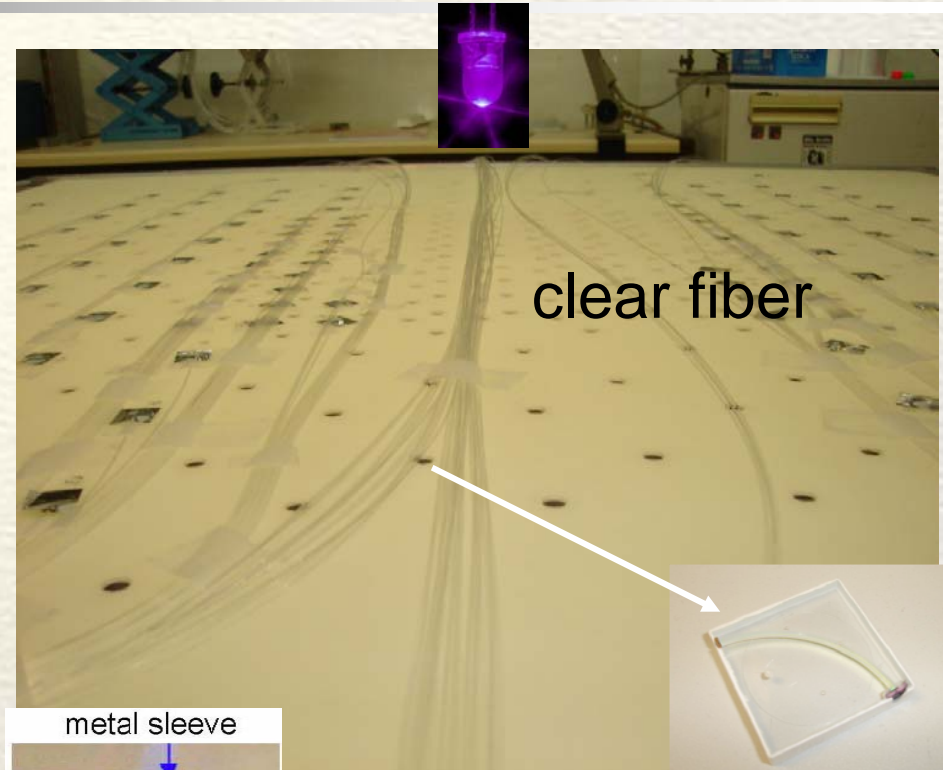
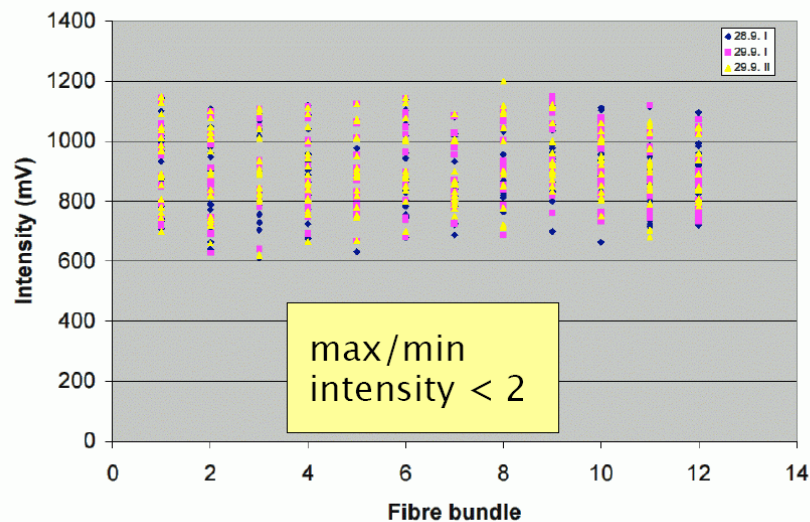
- The SiPM response depends on the temperature and operating voltage → gain change: $dG/dT \sim -1.7\%/K$, $dG/dV \sim 2.5\%/0.1V$
- For light yield of the tile at fixed LED light intensity, the T & U dependences become: $dQ/dT \sim -4.5\%/K$, $dQ/dV \sim 7\%/0.1V$
- Thus, we installed an LED based monitoring system
 - Monitor stability of tile-fiber-SiPM system between MIP calibrations with fixed LED intensities
 - Perform gain calibration
 - Measure SiPM response function
 - Determine intercalibration constants
- We have started to study the SiPM response in different cells using beam test data
 - to determine correction factors
 - to evaluate what measurements are required to achieve a stable system ($< 1\%$)



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

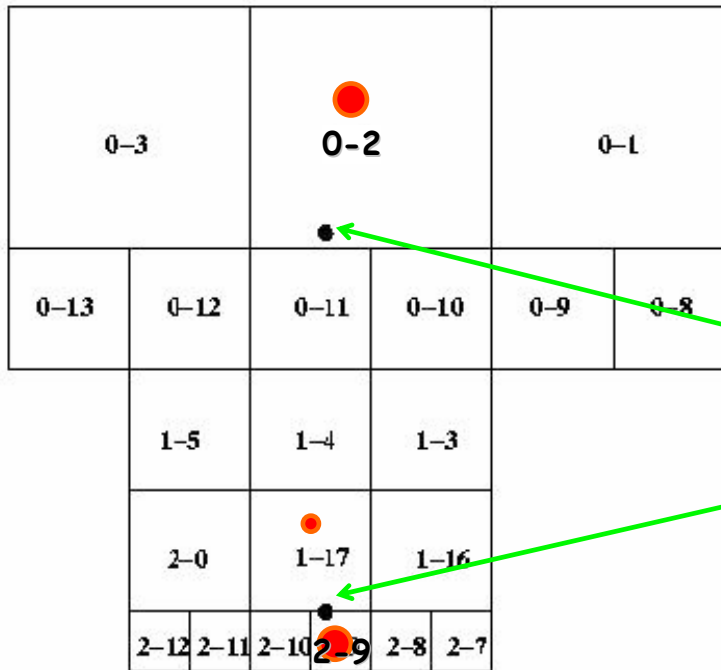


bundle of 19 fibers
18 → tiles, 1 → PIN diode



Temperature Sensors in Module

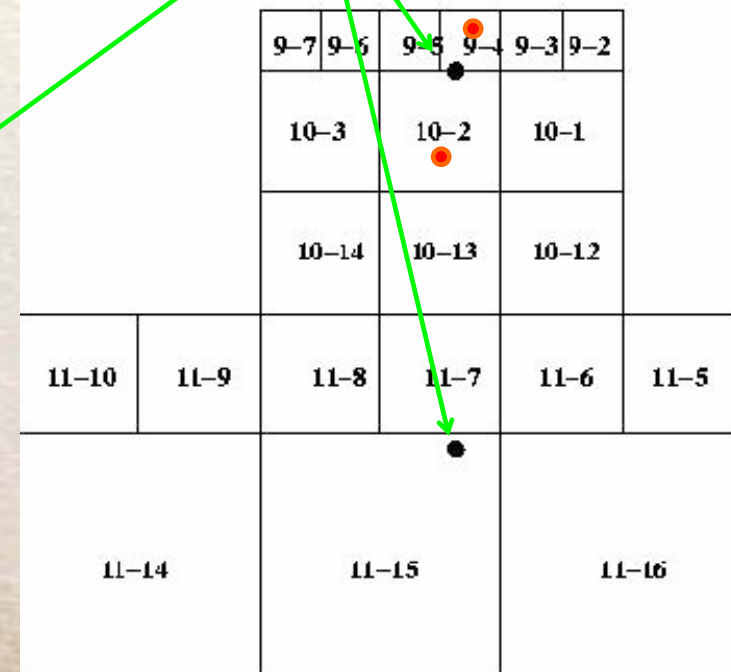
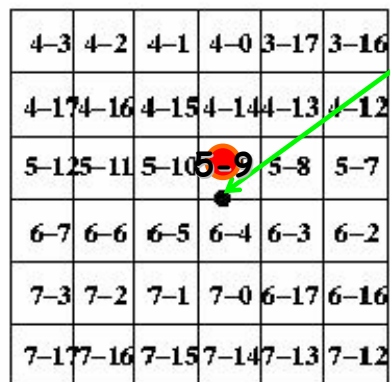
chip-channel



- Look at tiles close to temperature sensors
- We started to look at tiles near a sensor (●)

temperature sensors

Readout side

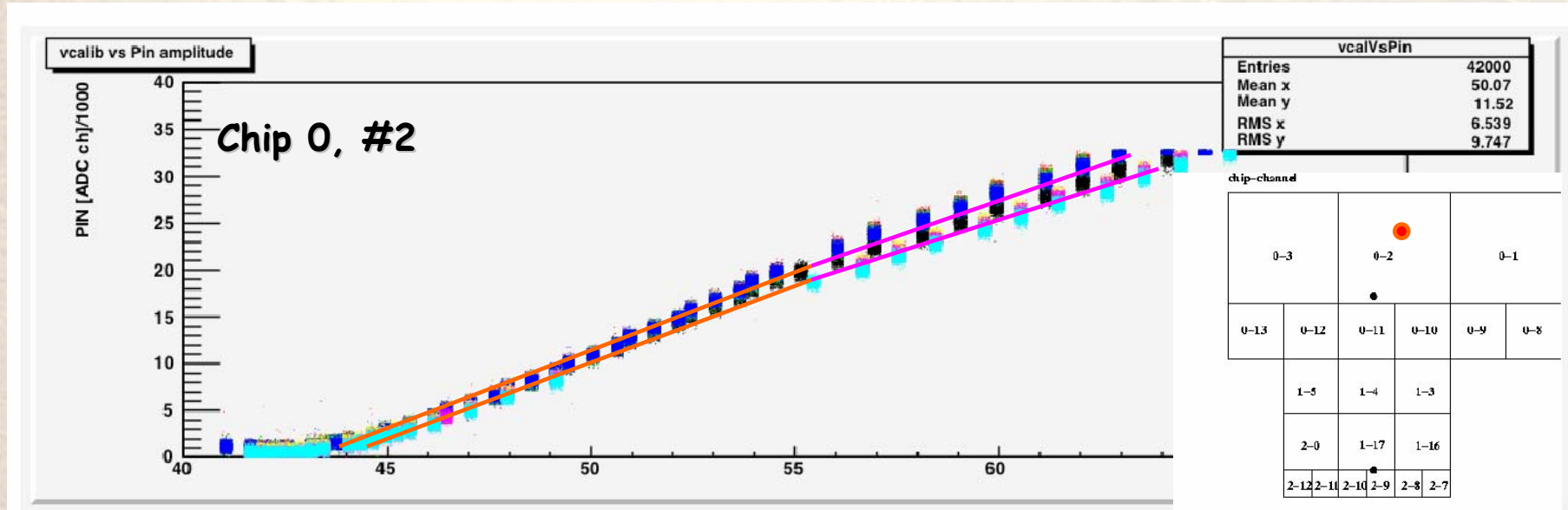


CMB side



PIN Diode Response in Module 8

- PIN diode response for 7 runs between Oct 12 & Oct 21



- PIN vs Vcalib shows 2 slopes, breakpoint at ~55k

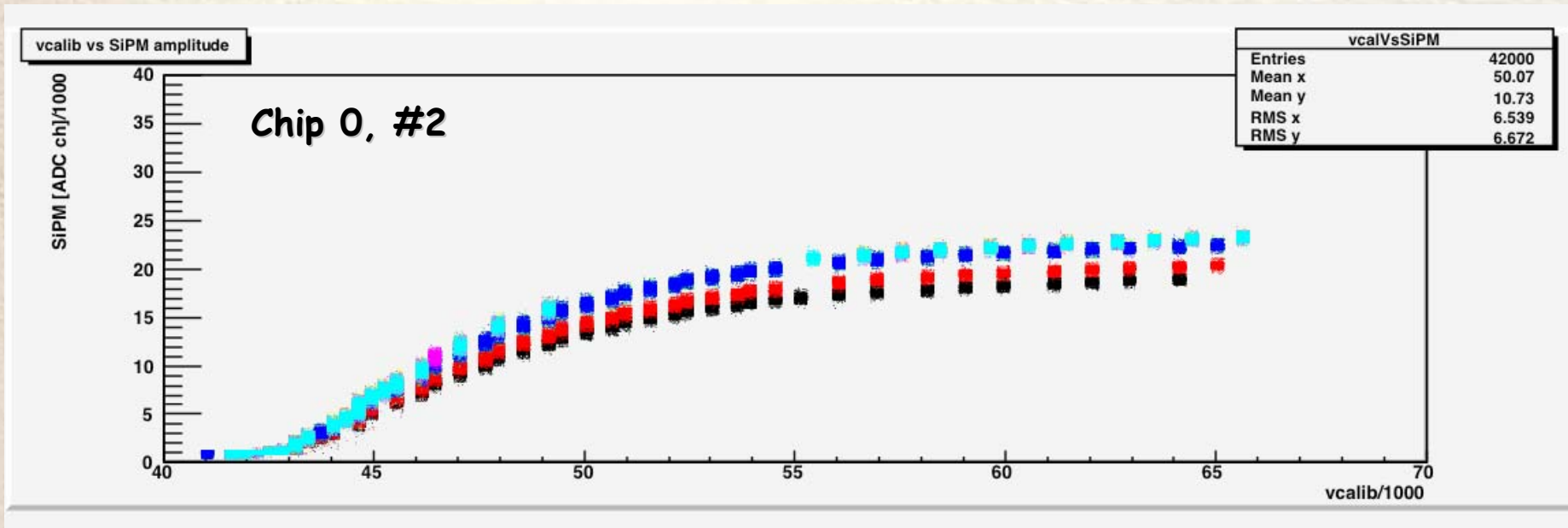
- Runs before & after Oct 15 show different slopes (temp effect in PIN?)

black: Run 300462 (Oct 12)
 red: Run 300521 (Oct 13)
 green: Run 300541 (Oct 14)
 blue: Run 300548 (Oct 15)
 yellow: Run 300622 (Oct 19)
 magenta: Run 300682 (Oct 20)
 cyan: Run 300701 (Oct 21)



SiPM Response vs Vcalib in Module 8

- SiPM response for 7 runs between Oct 12 & Oct 21



- SiPM response curves differ for individual runs (temperature effect)

- Largest effects between Oct 12, Oct 13 and remaining runs

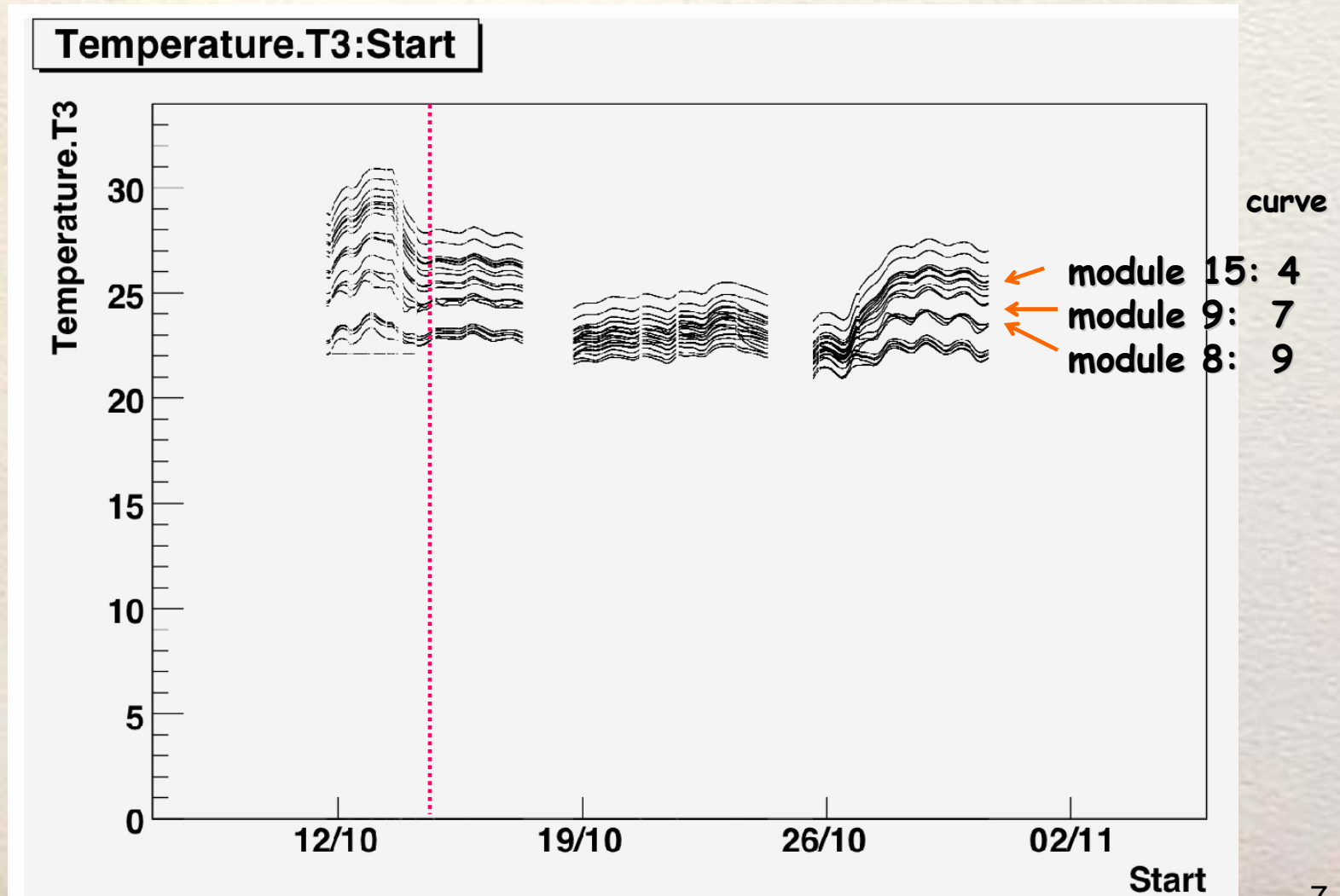
- Temperature decreased due to installation of fans

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)⁶



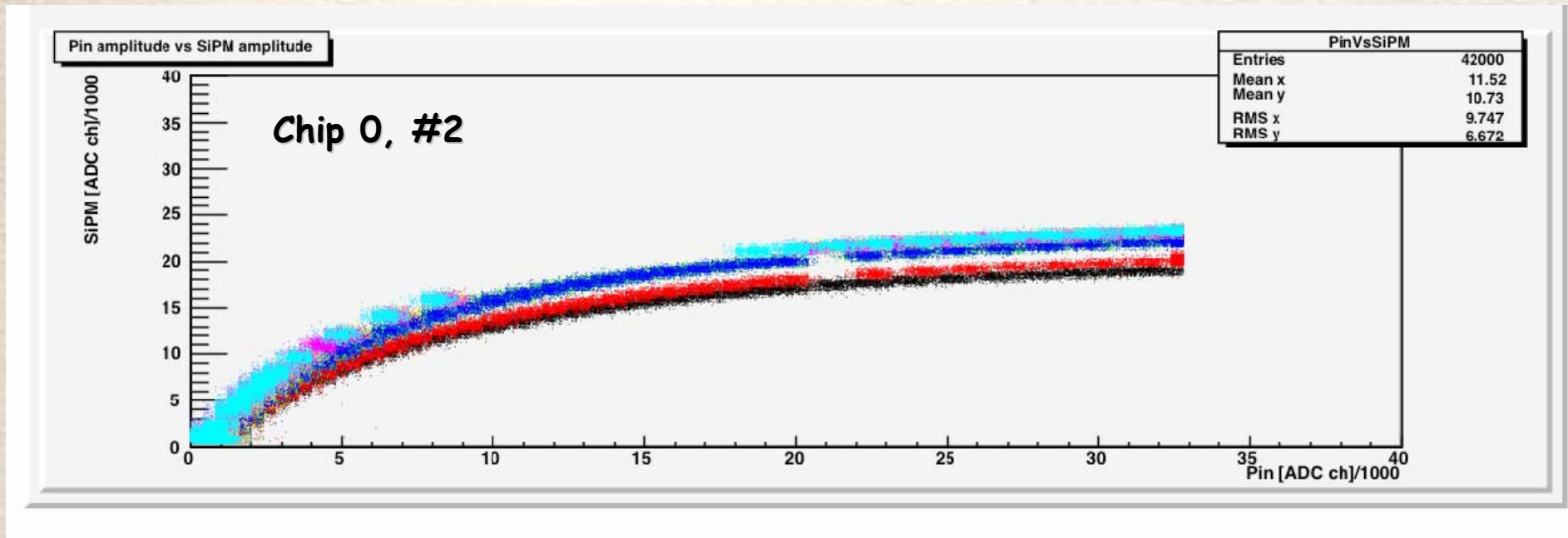
Temperature Measurements

- For runs before October 18, temperature was 3-6° C higher



SiPM Response vs PIN in Module 8

- SiPM response for 7 runs between Oct 12 & Oct 21



- SiPM plateau increases systematically with time from ~ 18k ADC bins to 24k ADC bins

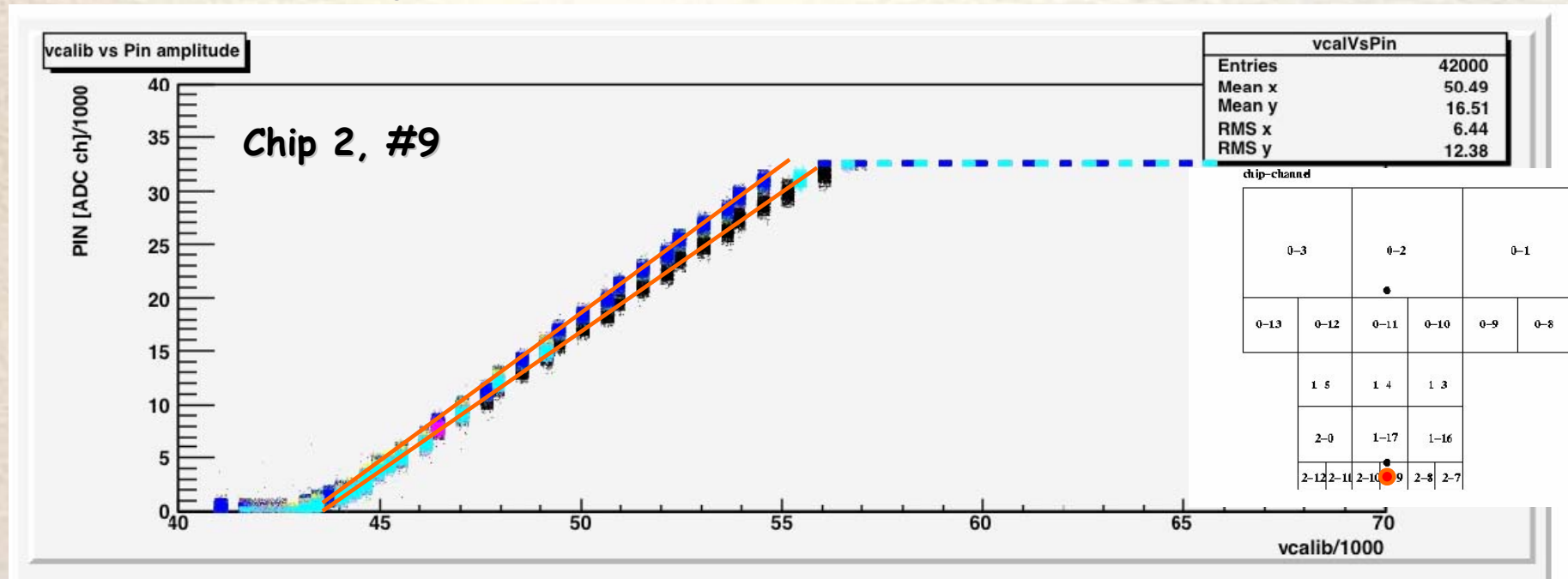
black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
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yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)⁸



This is dominated by temperature changes

PIN Diode Response in Module 8

- PIN diode response for 7 runs between Oct 12 & Oct 21



- PIN vs Vcalib runs into ADC saturation at Vcalib = 55k

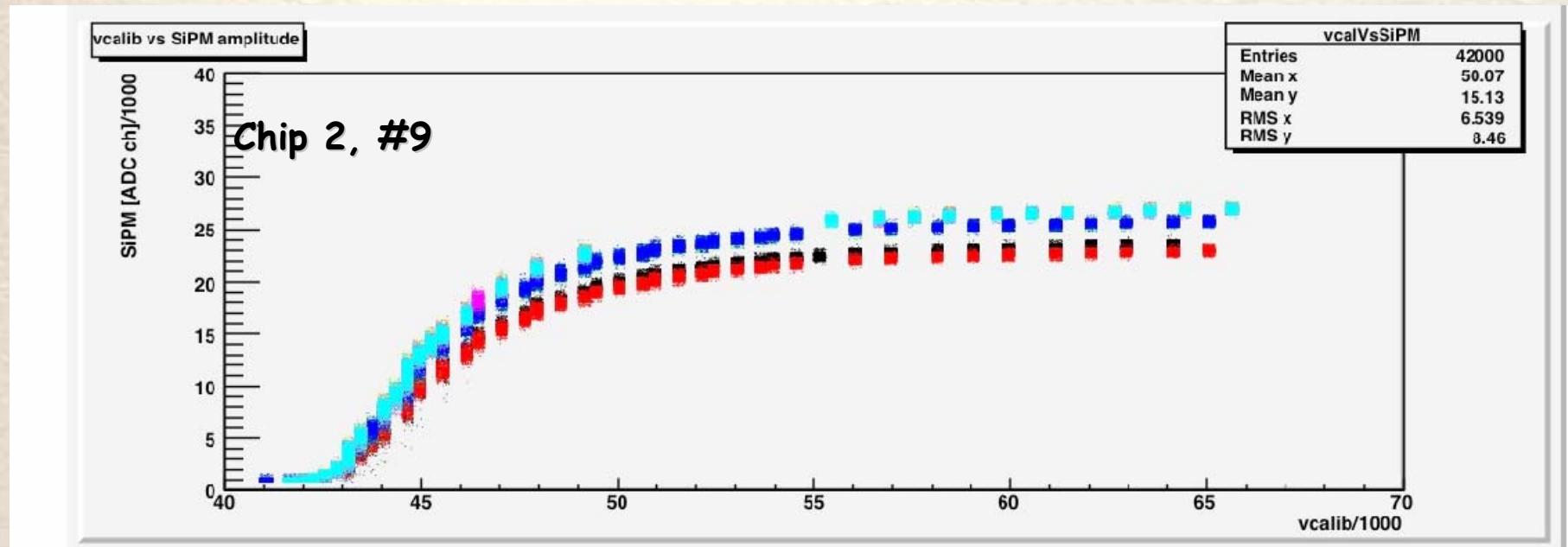
- Data can be parameterized by one slope, however, slope differs for the 7 runs, becomes steeper with time (temperature?)

- black: Run 300462 (Oct 12)
- red: Run 300521 (Oct 13)
- green: Run 300541 (Oct 14)
- blue: Run 300548 (Oct 15)
- yellow: Run 300622 (Oct 19)
- magenta: Run 300682 (Oct 20)
- cyan: Run 300701 (Oct 21)



SiPM Response vs Vcalib in Module 8

- SiPM response for 7 runs between Oct 12 & Oct 21



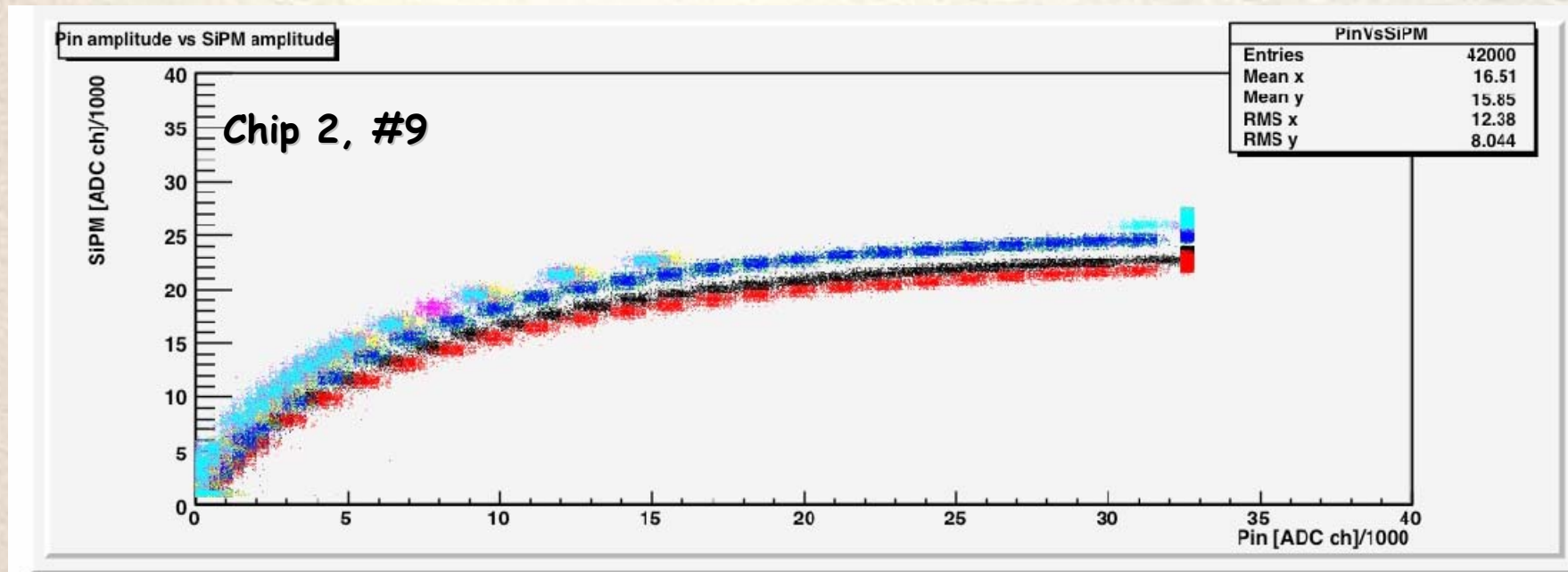
- SiPM response curves differ for individual runs
- Largest effects between Oct 12, Oct 13 and remaining runs

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)



SiPM Response vs PIN in Module 8

- Corrected SiPM response for 7 runs between Oct 12 & Oct 21



- Each run reveals different shape due to different temperature

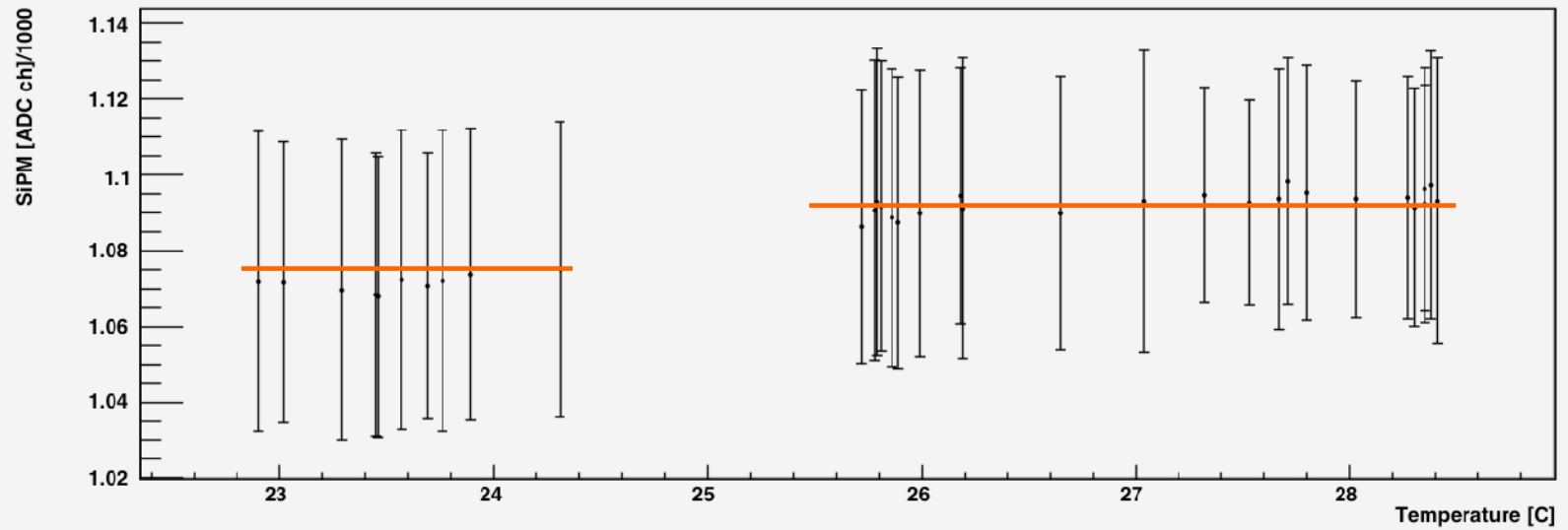
black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)¹



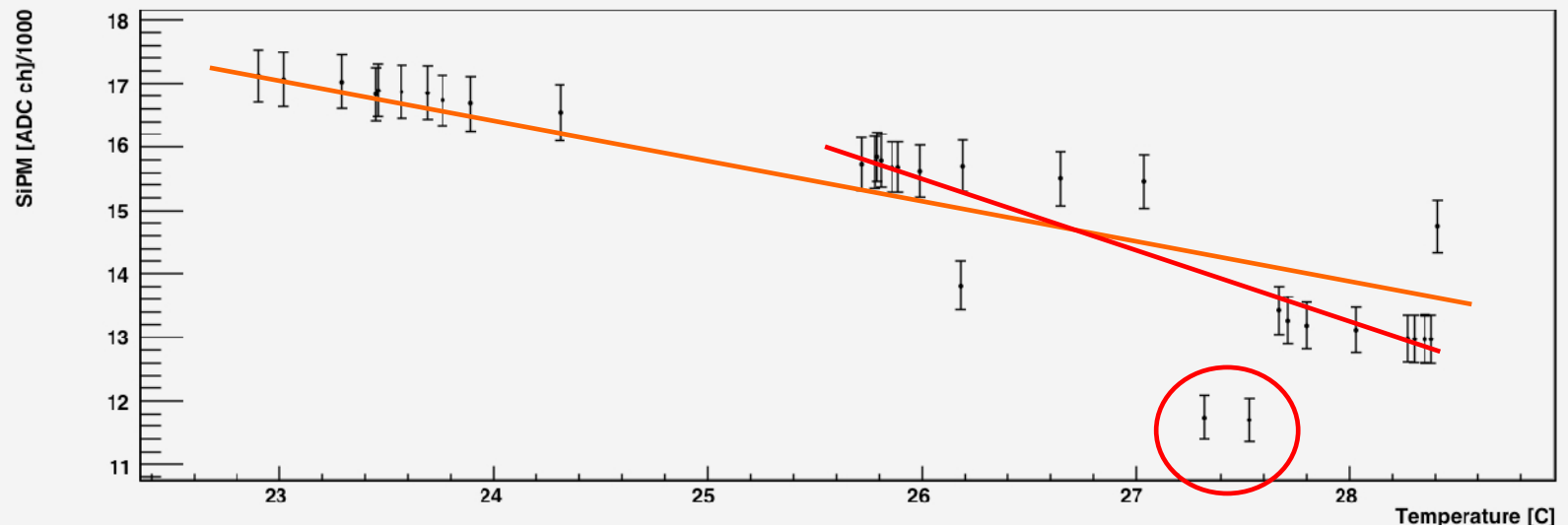
SiPM Temperature Dependence: Module 8

Chip 2
#9

Temperature correlation, pedestal events

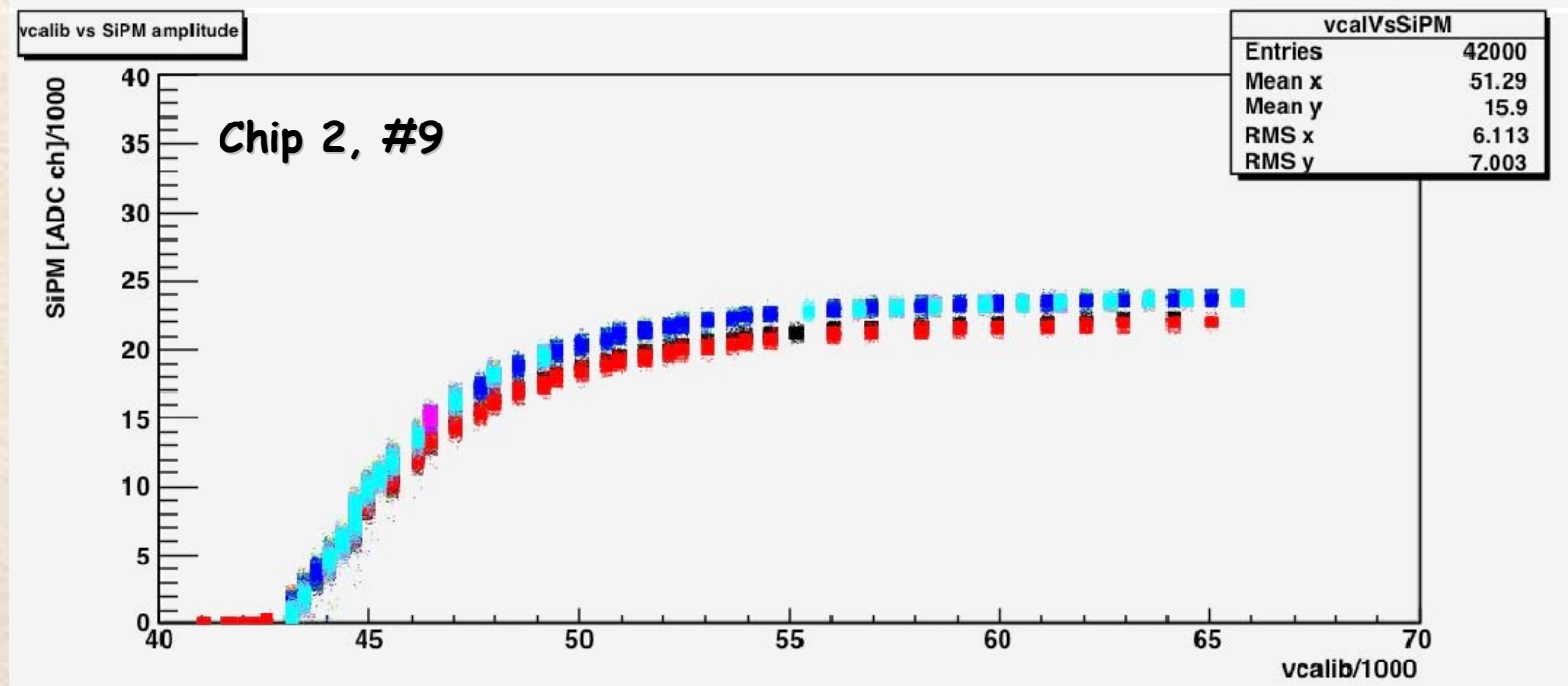


Temperature correlation, vcalib=46000



SiPM Response vs Vcalib in Module 8

- Temperature corrected SiPM response for 7 runs Oct 12-21



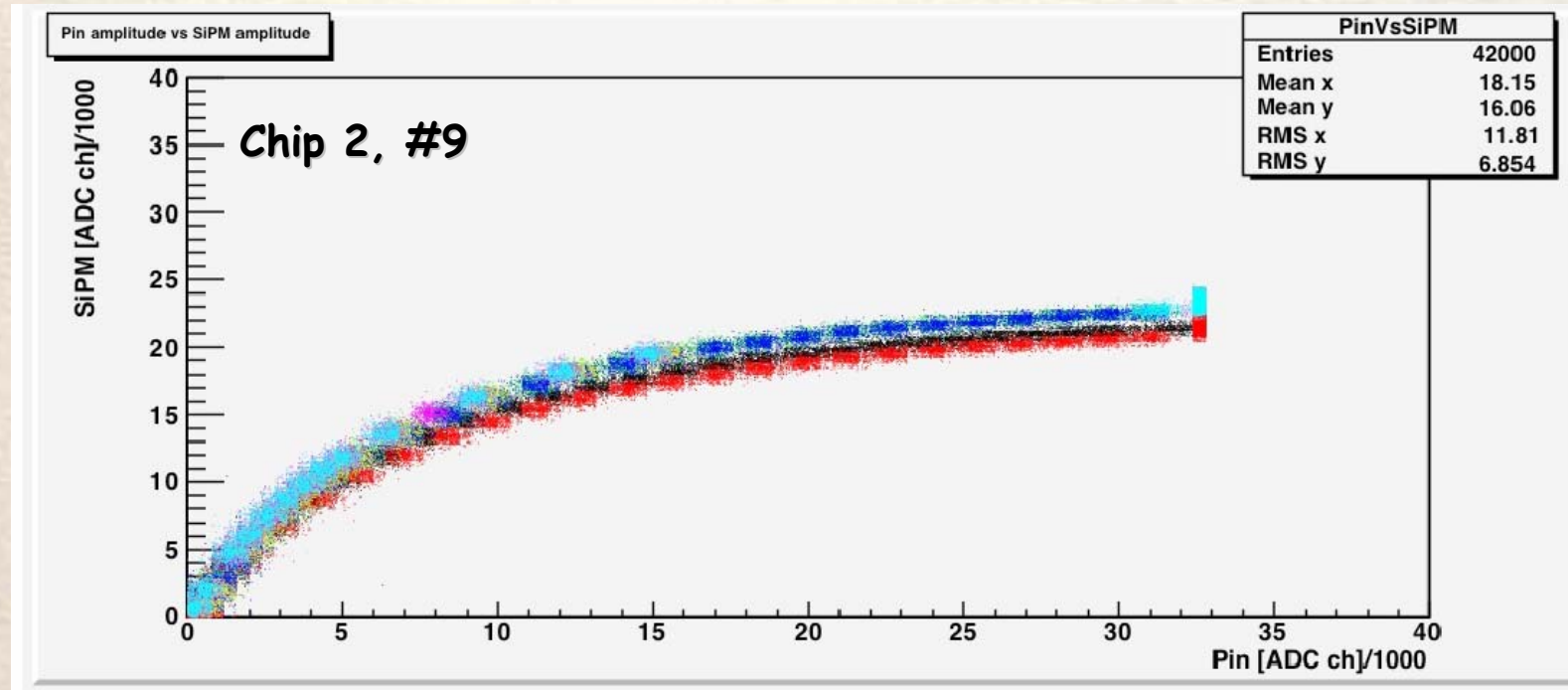
- Shapes fall into 2 groups, before and after Oct 14

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)



SiPM Response vs PIN in Module 8

- T & PIN corrected SiPM response for 7 runs, Oct 12-21



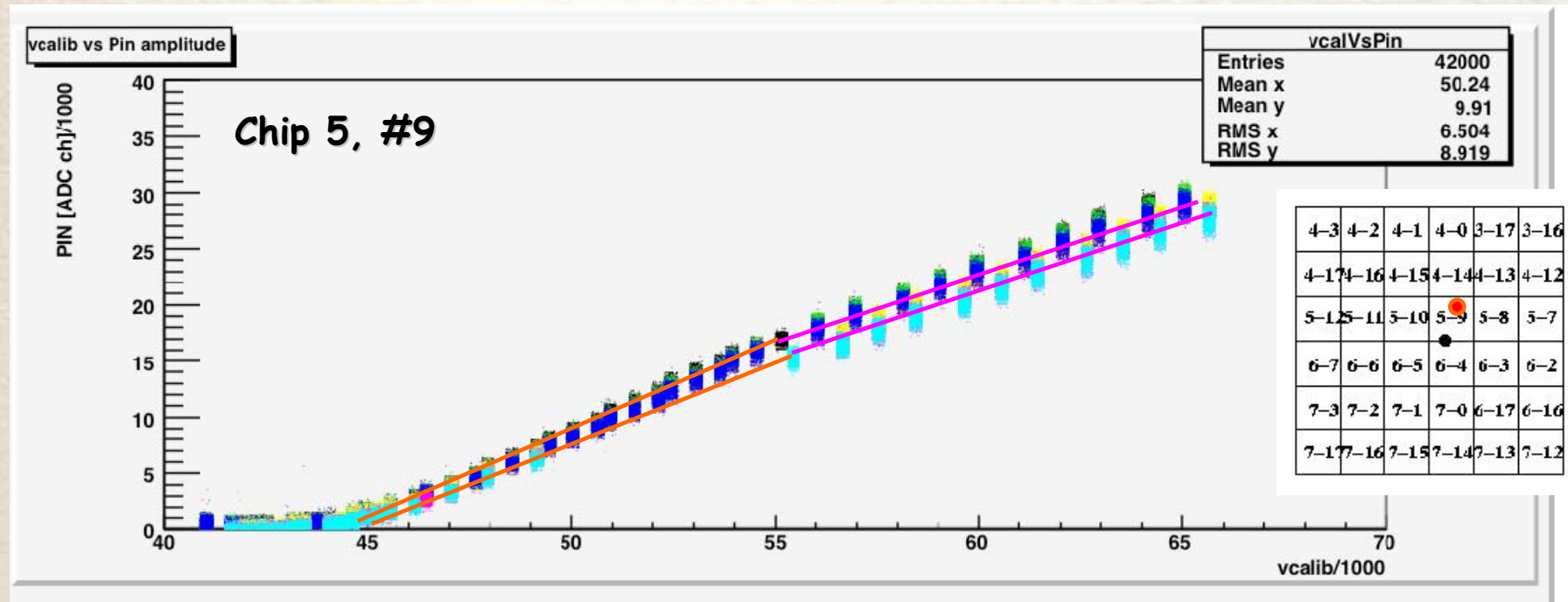
- Runs from Oct 14 and later show same shape
- 2 runs before Oct 14 have lower response and differ from each other

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)⁴



PIN Diode Response in Module 5

- PIN diode response for 7 runs between Oct 12 & Oct 21



- PIN vs Vcalib shows 2 slopes, breakpoint at ~55k

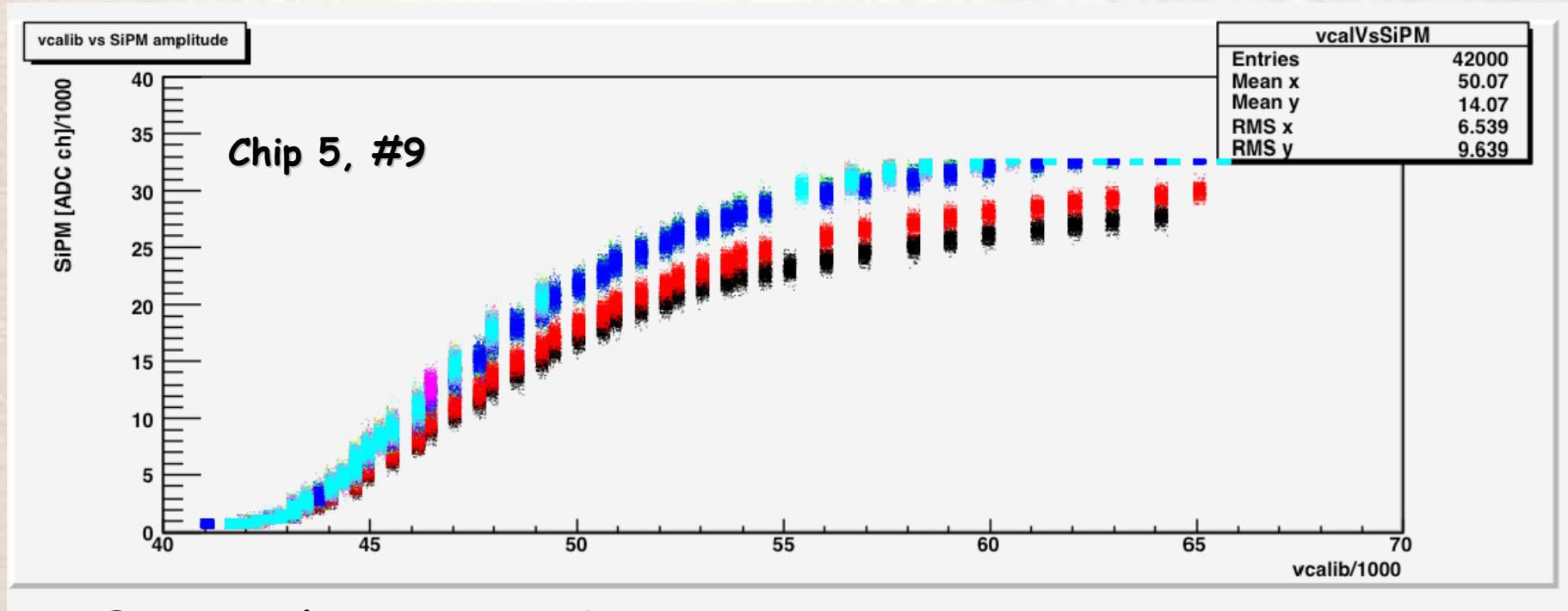
- Again dependence varies for runs before & after Oct 15

black: Run 300462 (Oct 12)
 red: Run 300521 (Oct 13)
 green: Run 300541 (Oct 14)
 blue: Run 300548 (Oct 15)
 yellow: Run 300622 (Oct 19)
 magenta: Run 300682 (Oct 20)
 cyan: Run 300701 (Oct 21)



SiPM Response vs Vcalib in Module 5

- SiPM response for 7 runs between Oct 12 & Oct 21



- SiPM signal runs into ADC saturation for $V_{calib} > 58k$ for runs after Oct 13 → temperature effect

- SiPM signals are rather broad

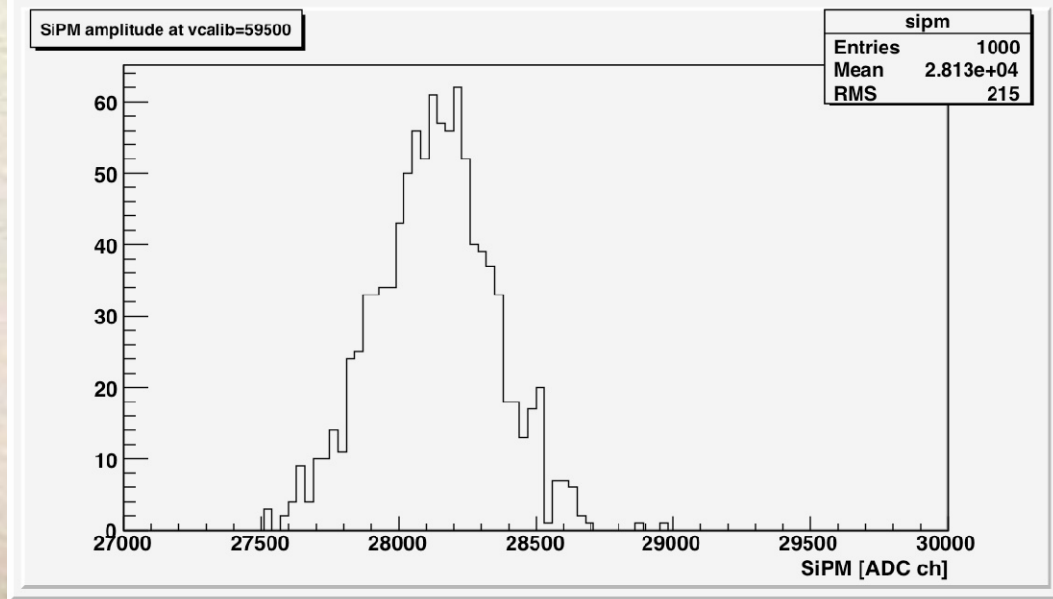
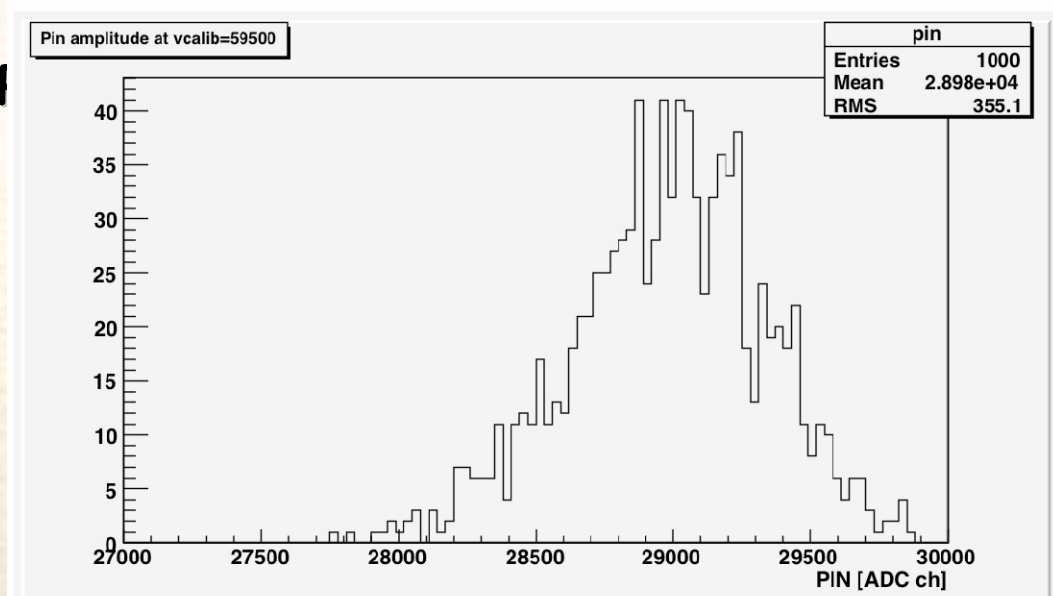
Curves differ for the 7 runs, plateau increases for later runs

black: Run 300462 (Oct 12)
 red: Run 300521 (Oct 13)
 green: Run 300541 (Oct 14)
 blue: Run 300548 (Oct 15)
 yellow: Run 300622 (Oct 19)
 magenta: Run 300682 (Oct 20)
 cyan: Run 300701 (Oct 21)¹⁶



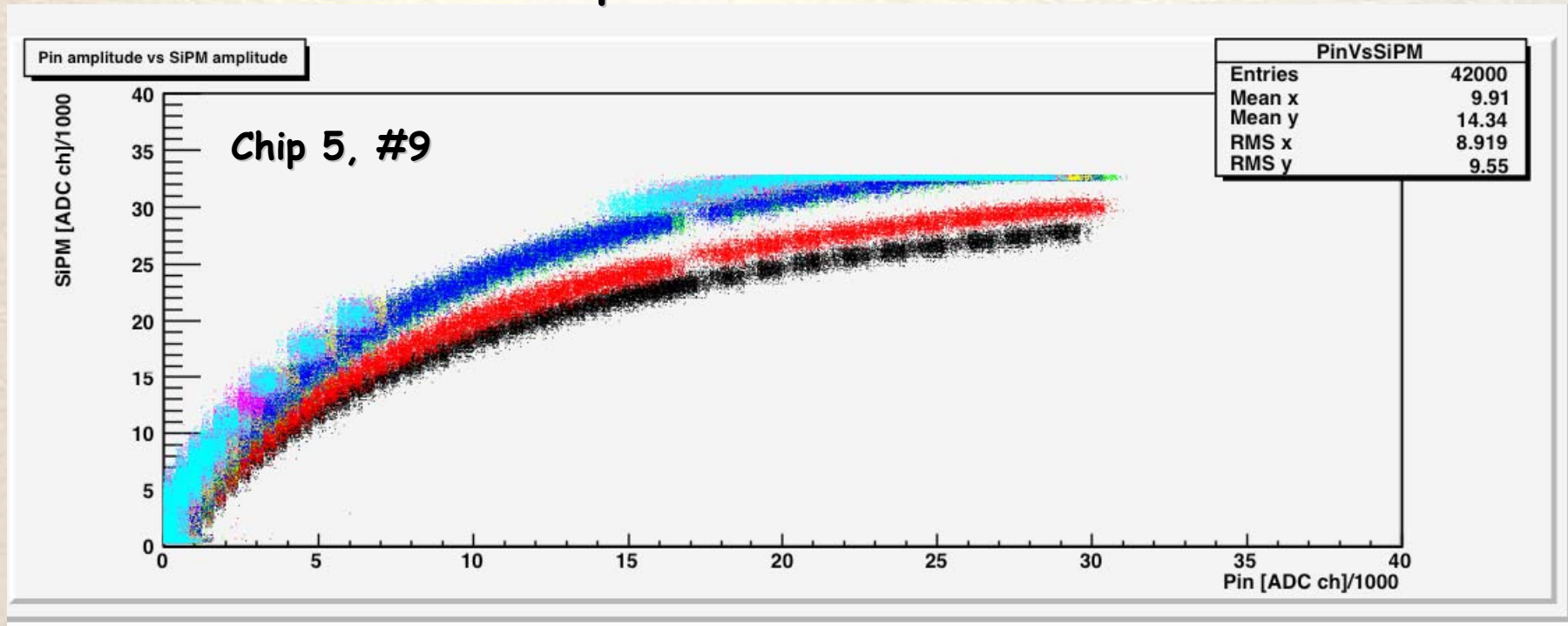
Pulse Height Distributions

- Look at PIN diode and SiPM pulse height distribution in module 8 chip 5 #9 for Vcalib=59500
- PIN diode distribution is rather broad, rms = 355 ADC bins
- SiPM distribution is a bit narrower, rms=215 ADC bins



SiPM Response vs PIN in Module 5

- PIN corrected SiPM response for 7 runs between Oct 12 & Oct 21



- ADC saturation is visible for runs after Oct 13

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)¹⁸

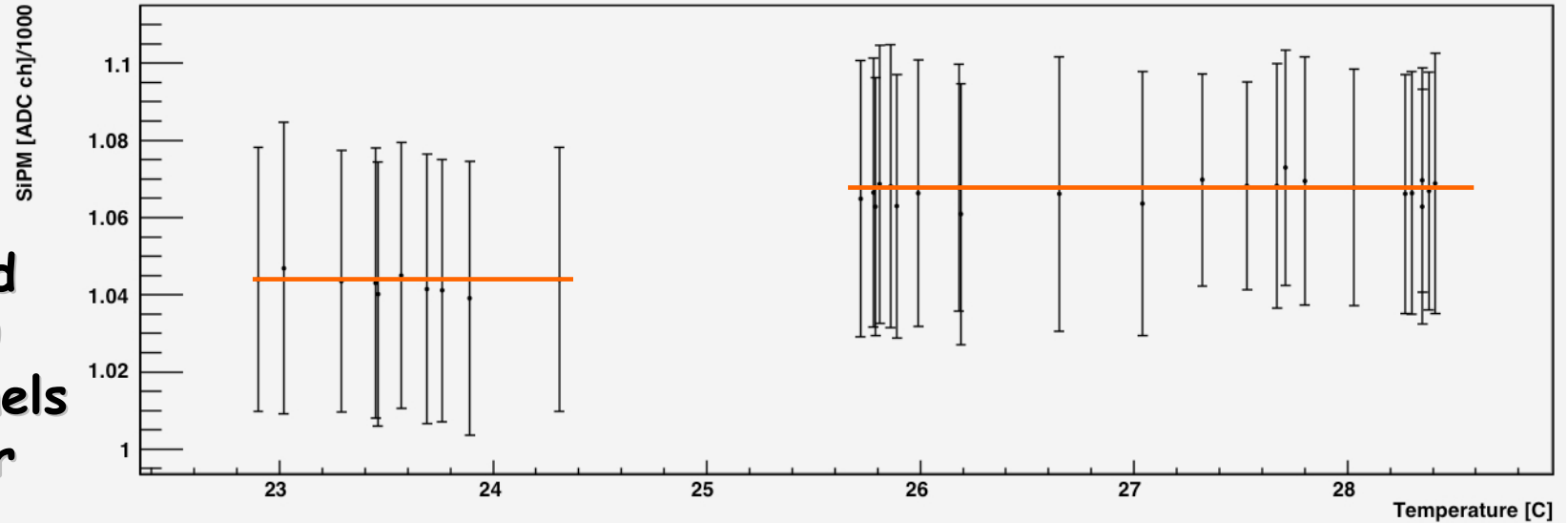


SiPM Temperature Dependence: Module 15

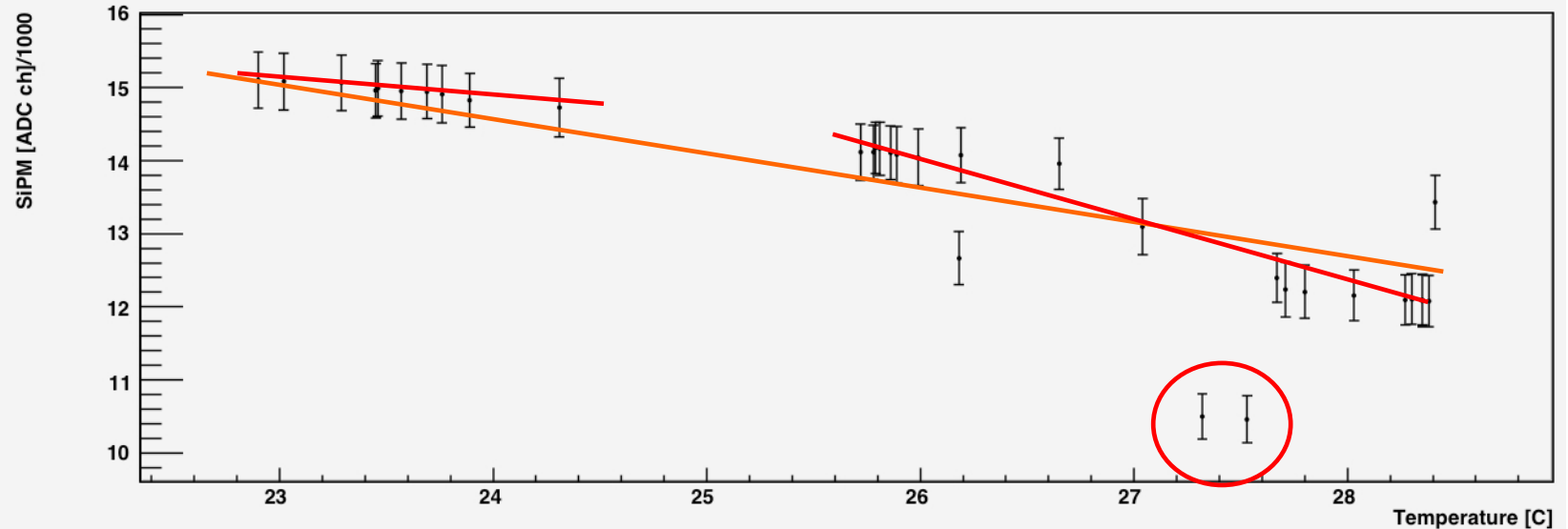
Chip 5
#9

● We looked at 10 channels so far

Temperature correlation, pedestal events



Temperature correlation, vcalib=46000





Temperature Measurements

- Observe offset between pedestals for runs at low temperatures and runs at high temperatures
→ this is probably caused by change of conditions after Oct 18
- The slopes for runs before Oct 18 (high temperature) and after Oct 18 look differently (due to modification of conditions)
- Two low points at high temperature (present in each channel) are flawed and should be omitted





Conclusion and Outlook

- The SiPM response functions taken at the beginning of each run provide a useful diagnostic tool in the test beam analysis
- The data need to be corrected for temperature effects
→ corrections factors are derived from measurements of sensors
- The correction will be tested with the SiPM response function
→ After corrections for temperature and PIN diode effects the SiPM response function of different runs should be identical
- This will allow us to refine the procedure and compare the response function of different SiPMs
- From this exercise we will learn what measurements are crucial for the ILC calorimeter
- We have just started this effort (plots for 4 channels) and need to do it for all channels





Conclusion and Outlook

- Trygve has determined the pedestal-subtracted mean values for all SiPM channels and PIN diodes in the Vcalib runs
- We also need to understand the shapes of the individual distributions that enter the SiPM response curves
- For future beam tests the LED intensity needs to be tuned to avoid ADC saturation effects



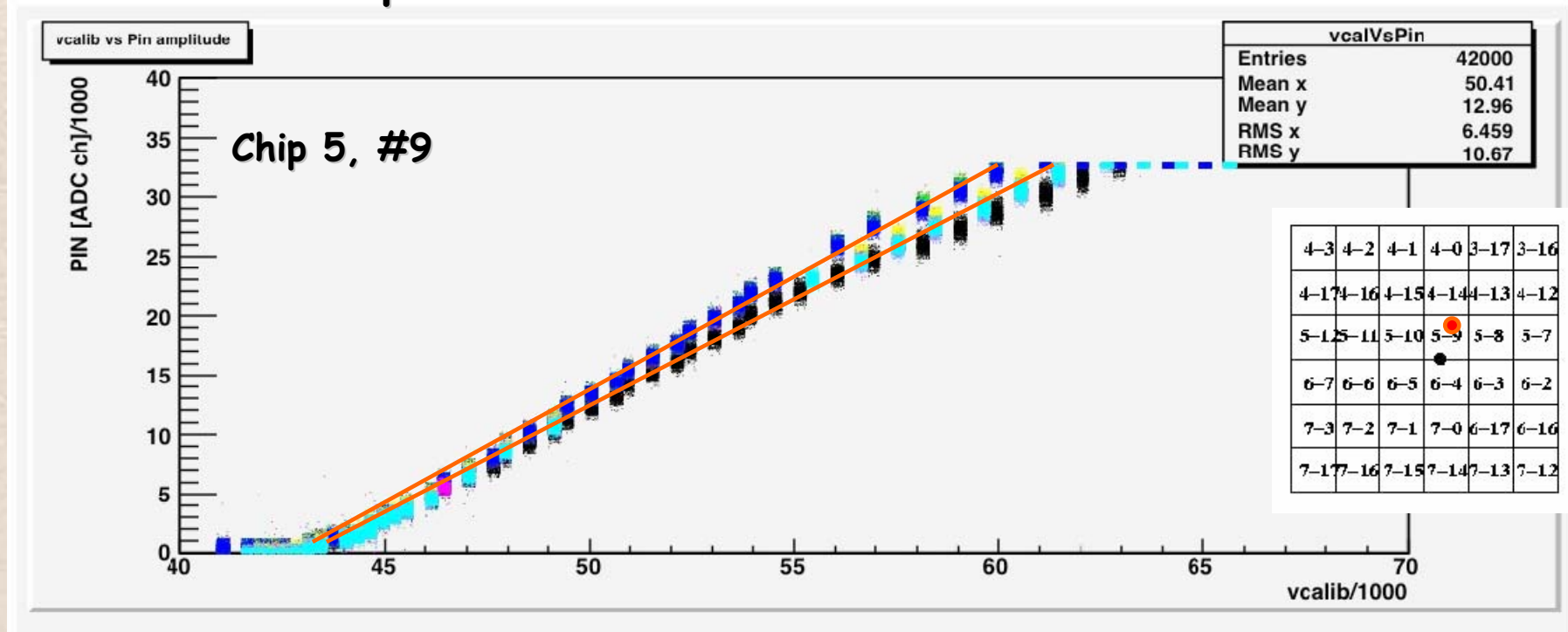


Backup Slides



PIN Diode Response in Module 8

- PIN diode response for 7 runs between Oct 12 & Oct 21



- PIN vs Vcalib shows 2 slopes, breakpoint at ~55

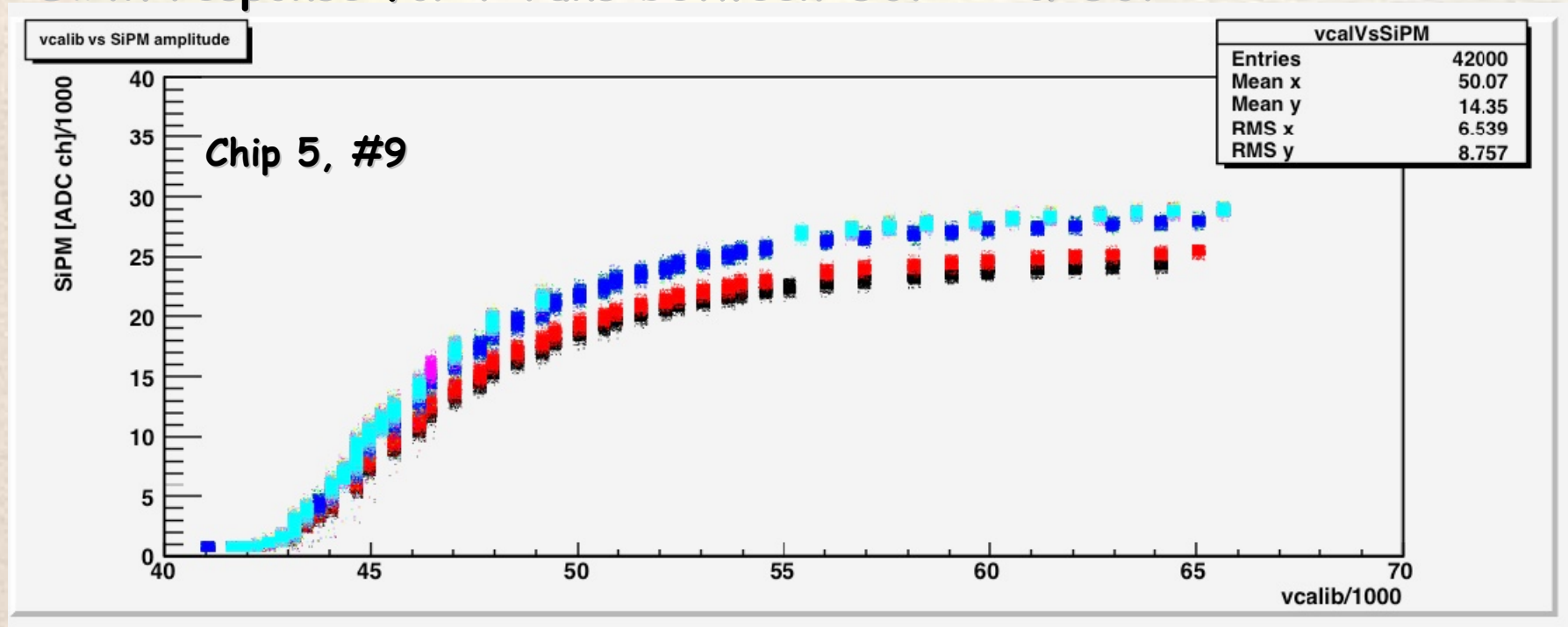
- Runs before & after Oct 15 show additional offset for slope for Vcalib > 55

black: Run 300462 (Oct 12)
 red: Run 300521 (Oct 13)
 green: Run 300541 (Oct 14)
 blue: Run 300548 (Oct 15)
 yellow: Run 300622 (Oct 19)
 magenta: Run 300682 (Oct 20)
 cyan: Run 300701 (Oct 21)²⁴



SiPM Response vs Vcalib in Module 8

- SiPM response for 7 runs between Oct 12 & Oct 21



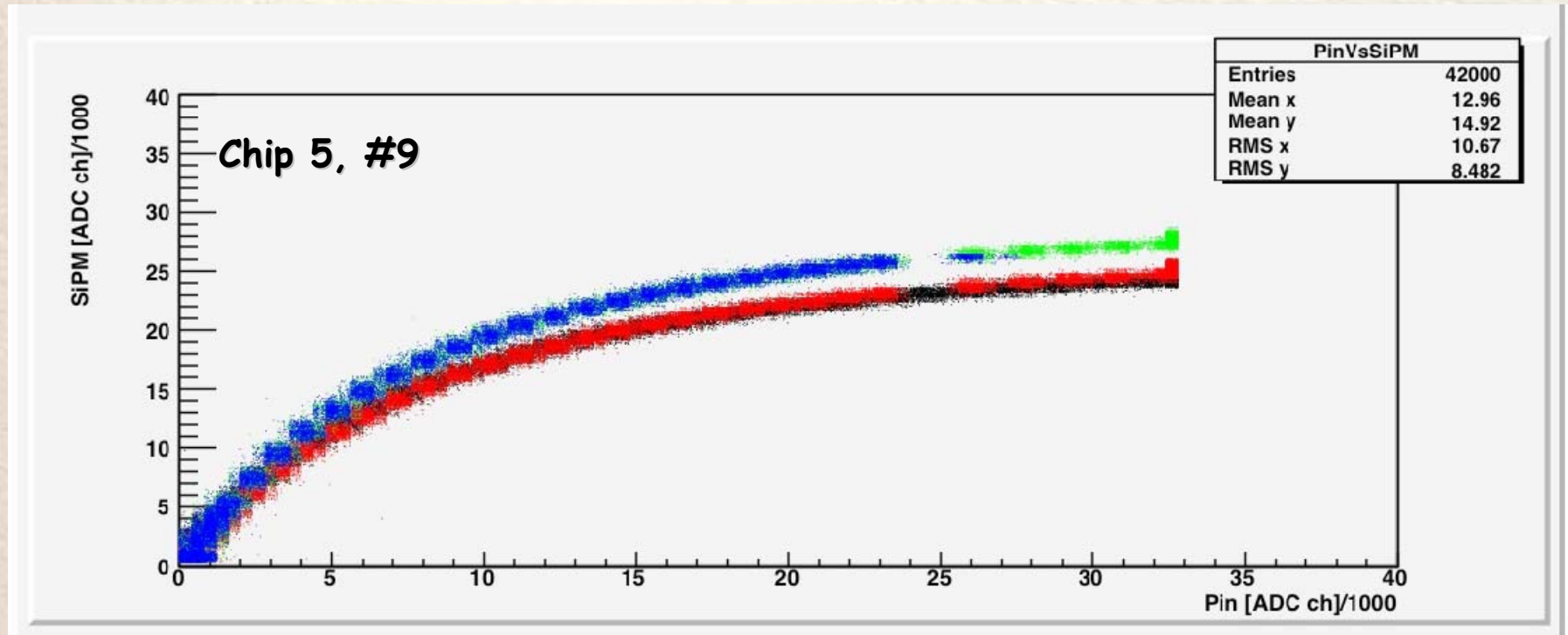
- No ADC saturation seen
- Curves look similar as those for chip 2 #9

black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
blue: Run 300548 (Oct 15)
yellow: Run 300622 (Oct 19)
magenta: Run 300682 (Oct 20)
cyan: Run 300701 (Oct 21)



SiPM Response vs PIN in Module 8

- Compare PIN diode response for 7 runs between Oct 12 & Oct 21



- Two sets of curves before Oct 14, after Oct 14 (temperature effects)

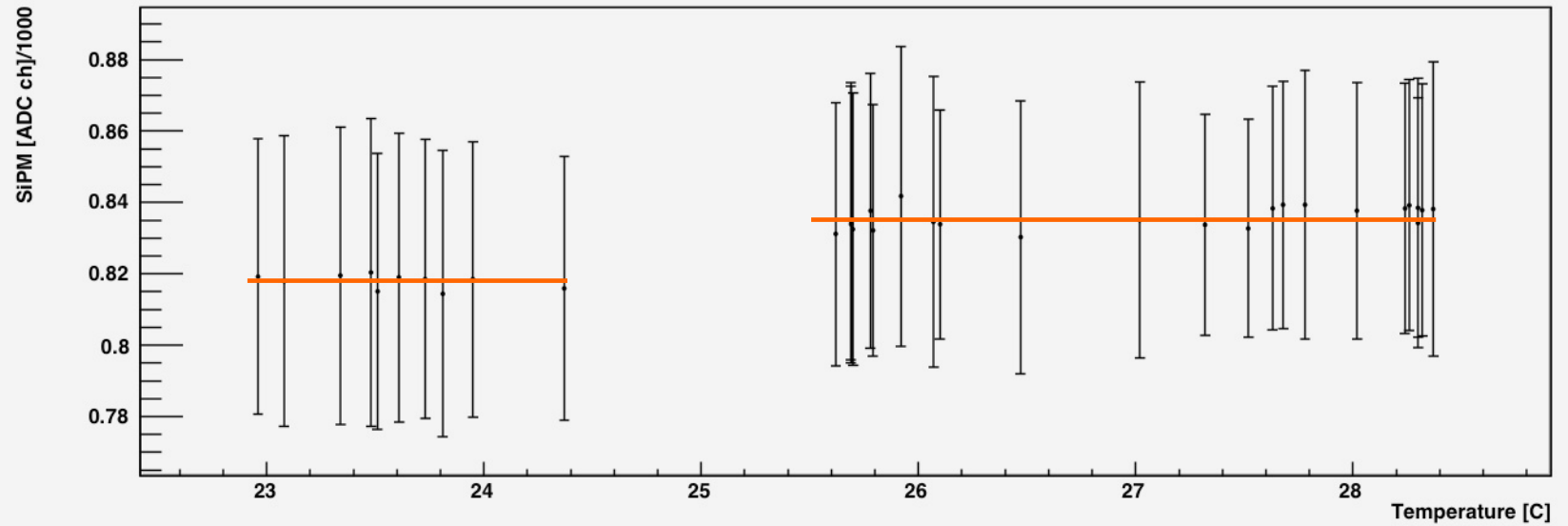
black: Run 300462 (Oct 12)
red: Run 300521 (Oct 13)
green: Run 300541 (Oct 14)
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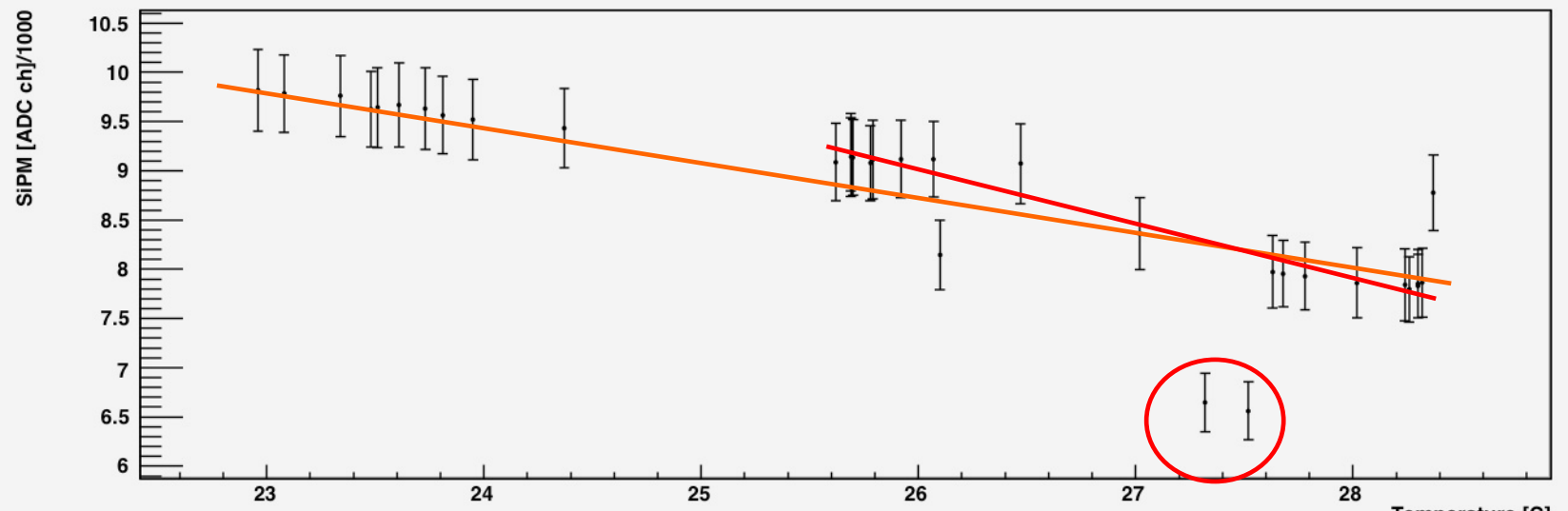
SiPM Temperature Dependence: Module 15

Chip 2
#9

Temperature correlation, pedestal events



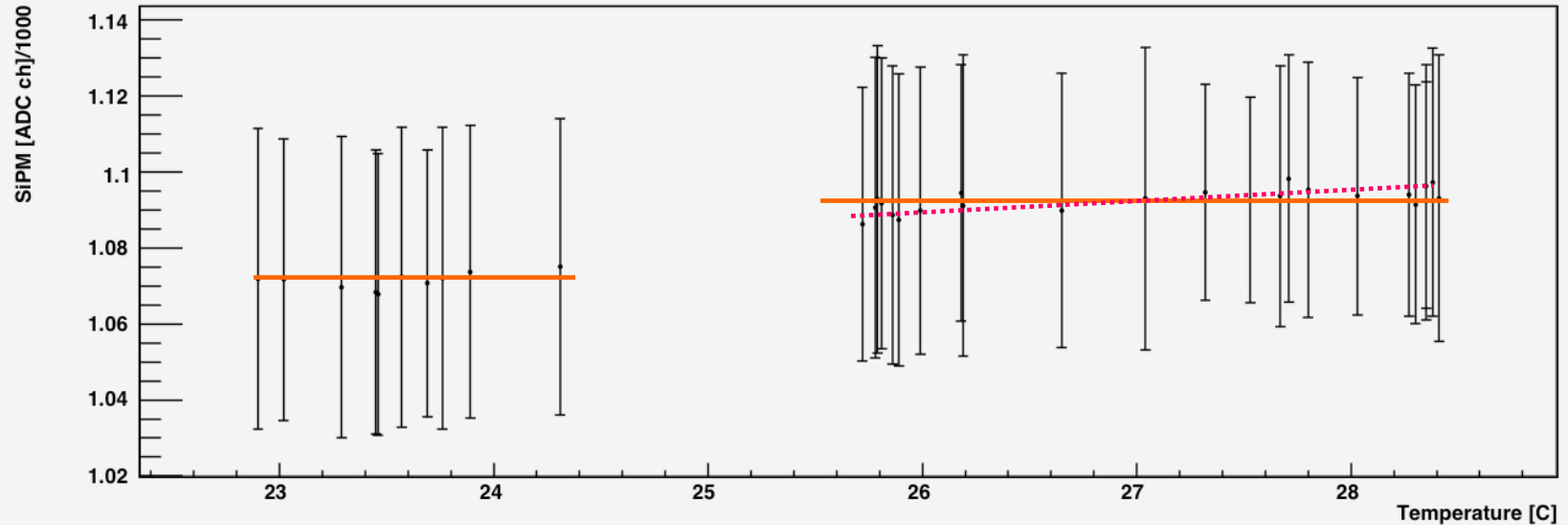
Temperature correlation, vcalib=46000



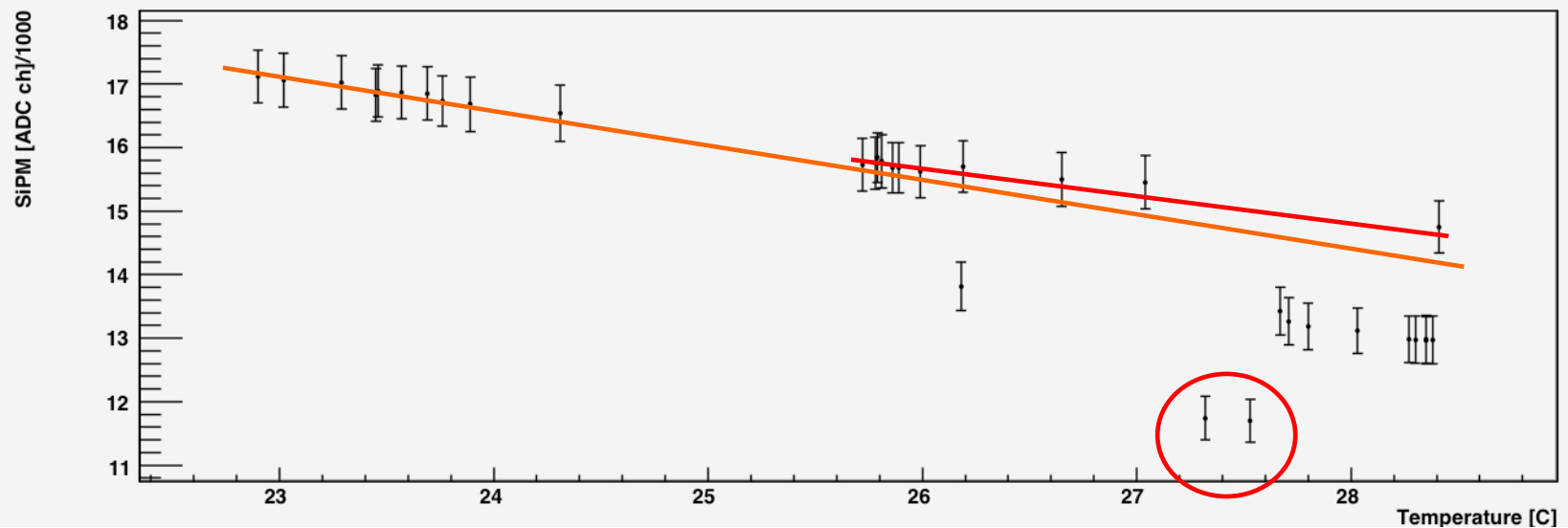
SiPM Temperature Dependence: Module 8

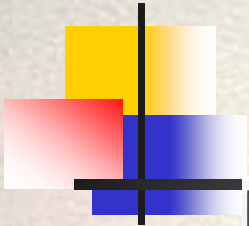
Chip 0
#2

Temperature correlation, pedestal events



Temperature correlation, vcalib=46000

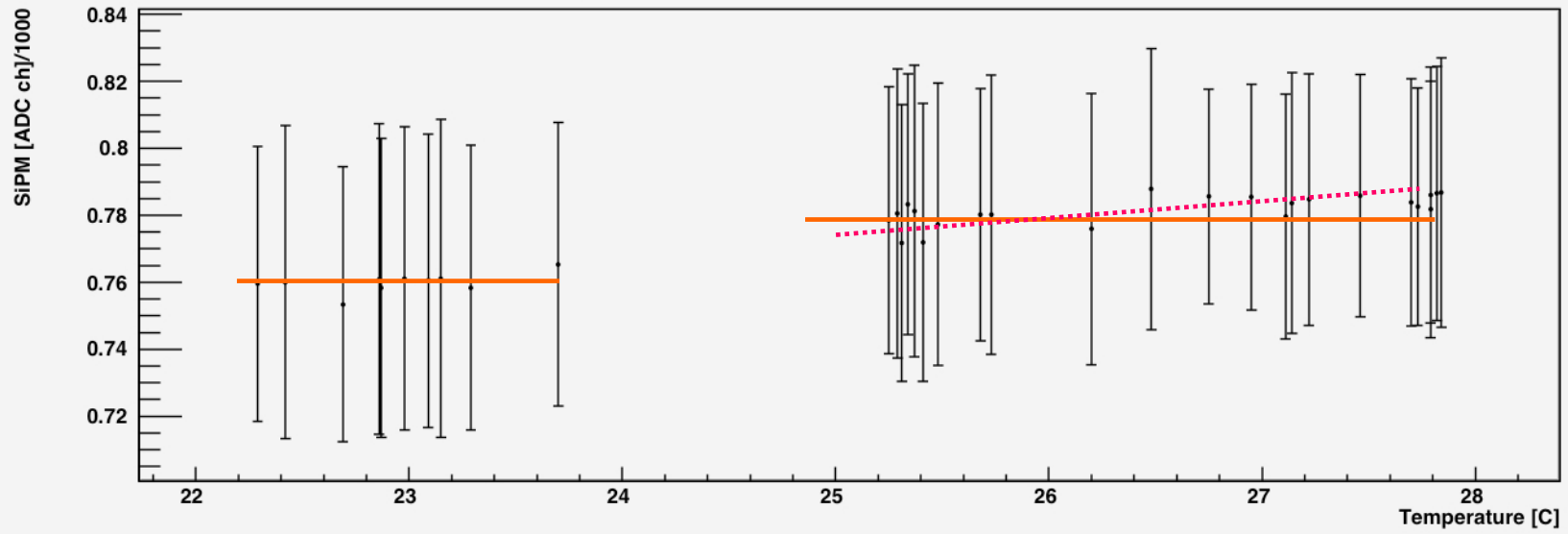




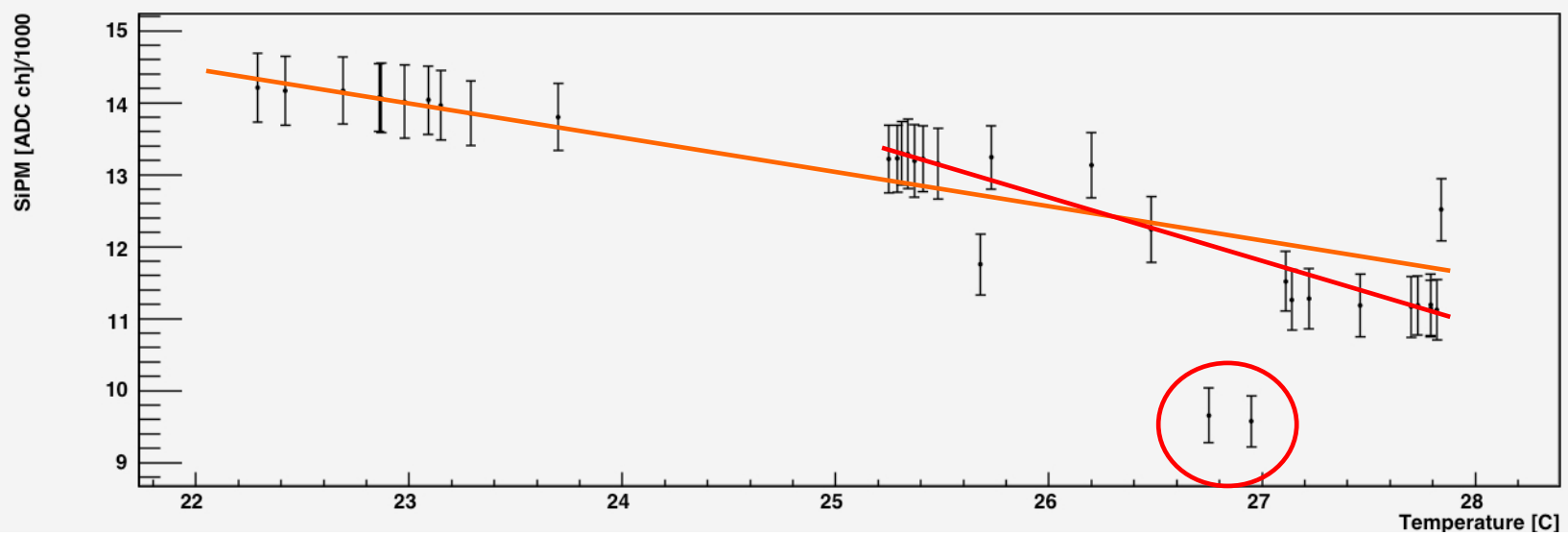
SiPM Temperature Dependence: Module 8

Chip 1C
#2

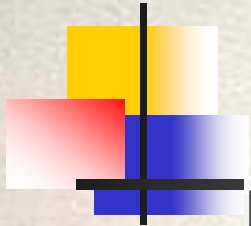
Temperature correlation, pedestal events



Temperature correlation, vcalib=46000

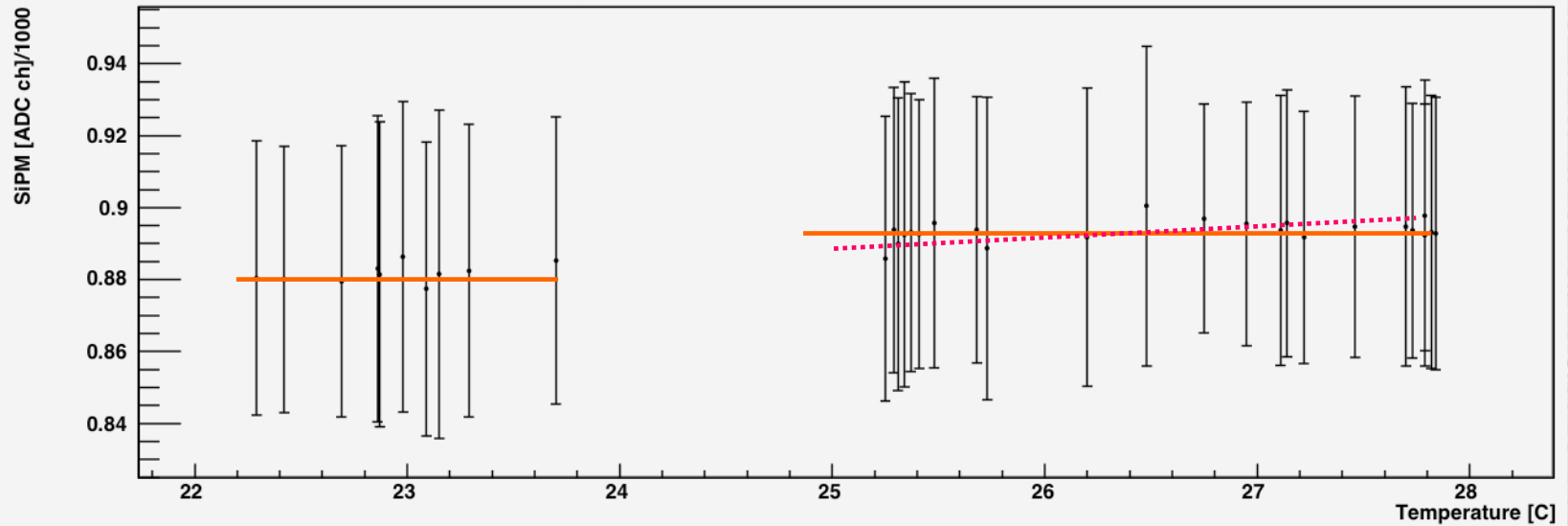


SiPM Temperature Dependence: Module 8

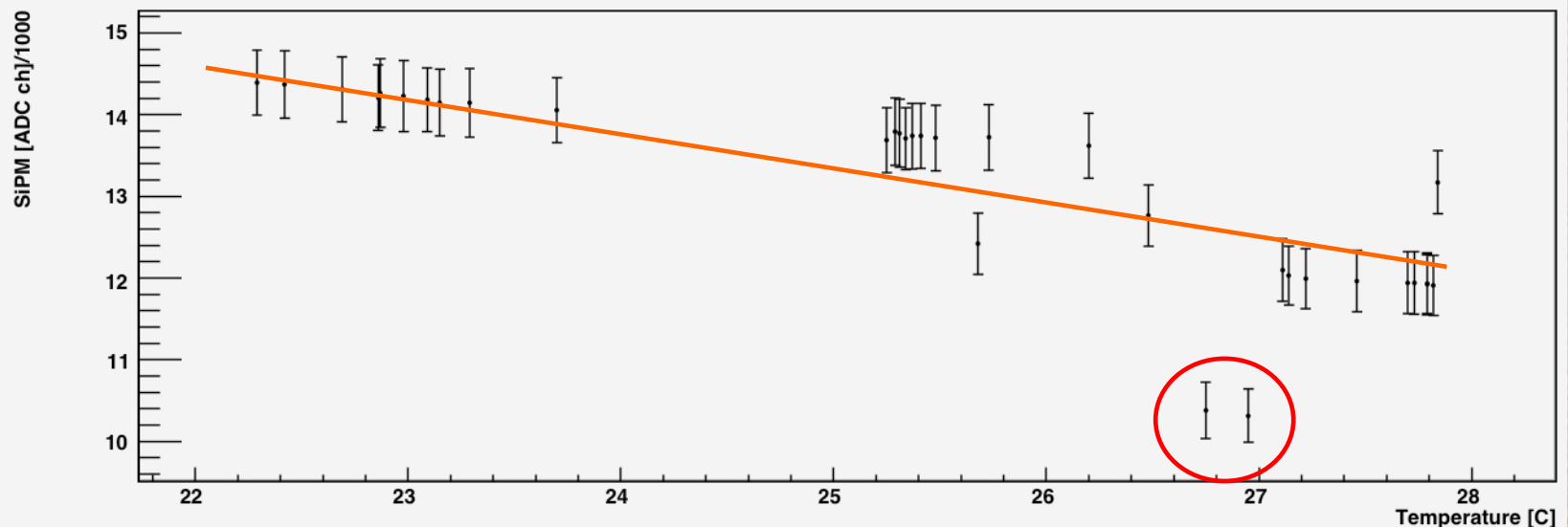


Chip 11
#15

Temperature correlation, pedestal events



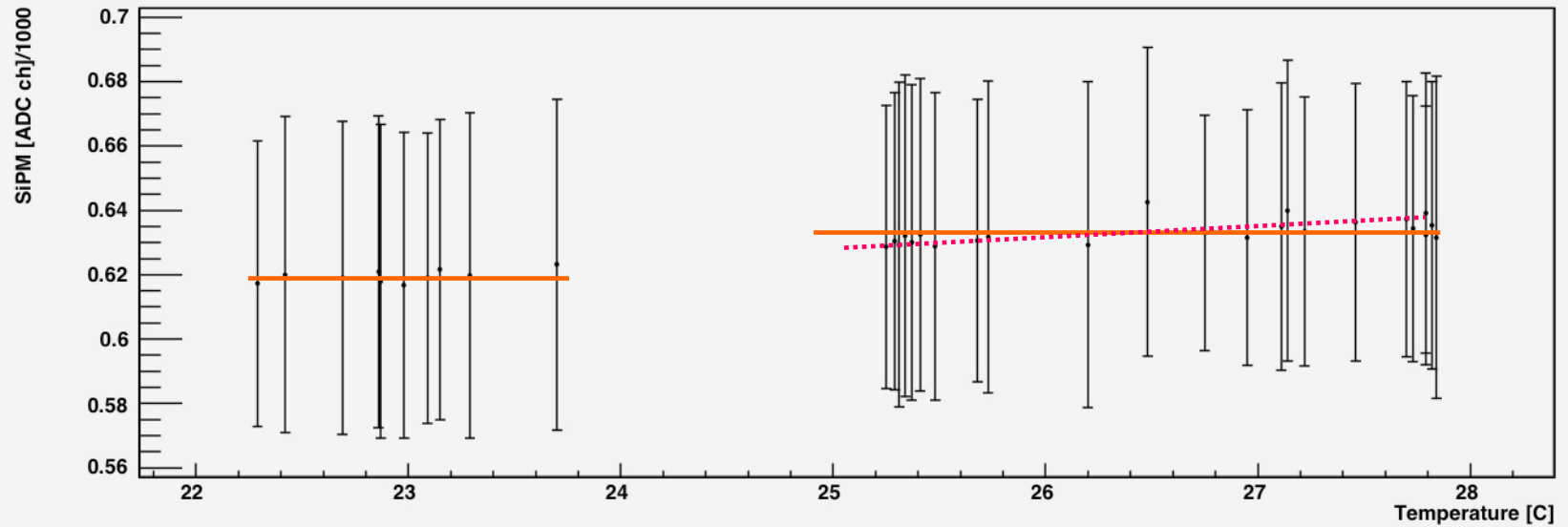
Temperature correlation, vcalib=46000



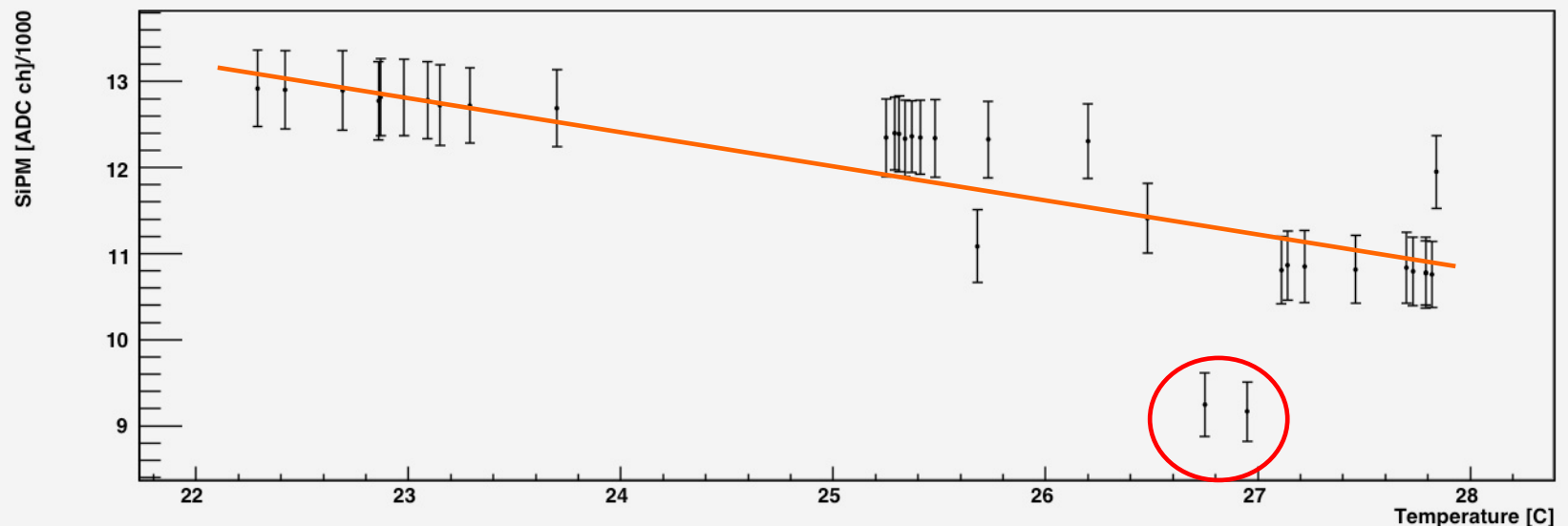
SiPM Temperature Dependence: Module 8

Chip 1
#17

Temperature correlation, pedestal events



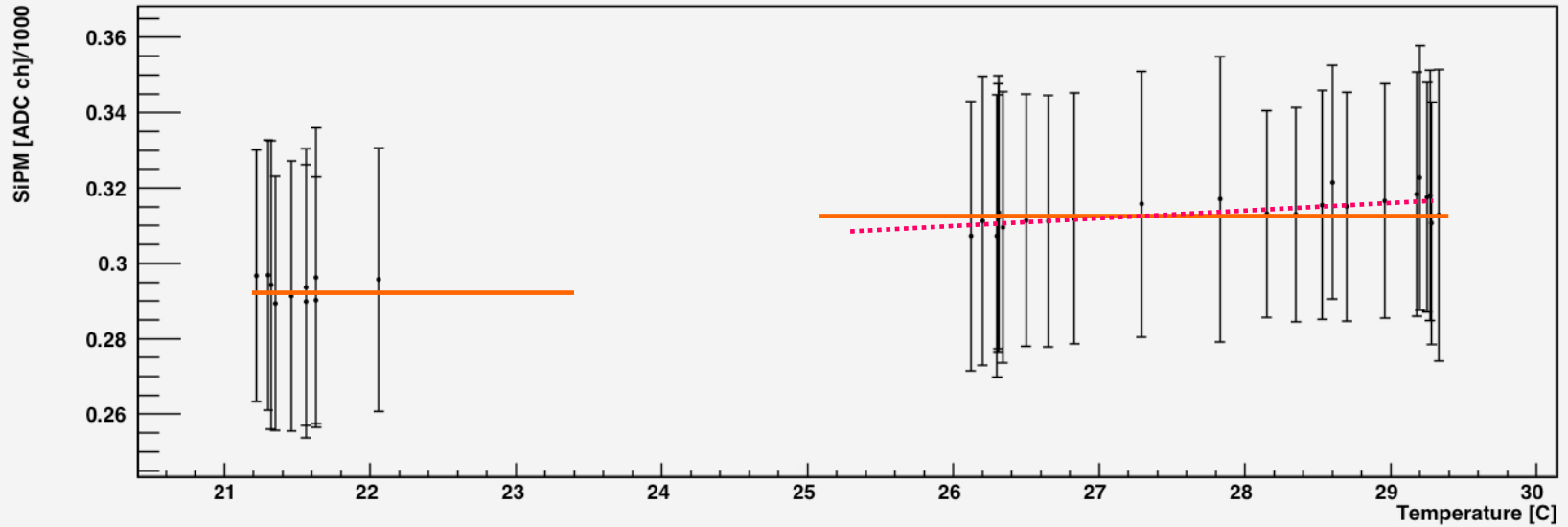
Temperature correlation, vcalib=46000



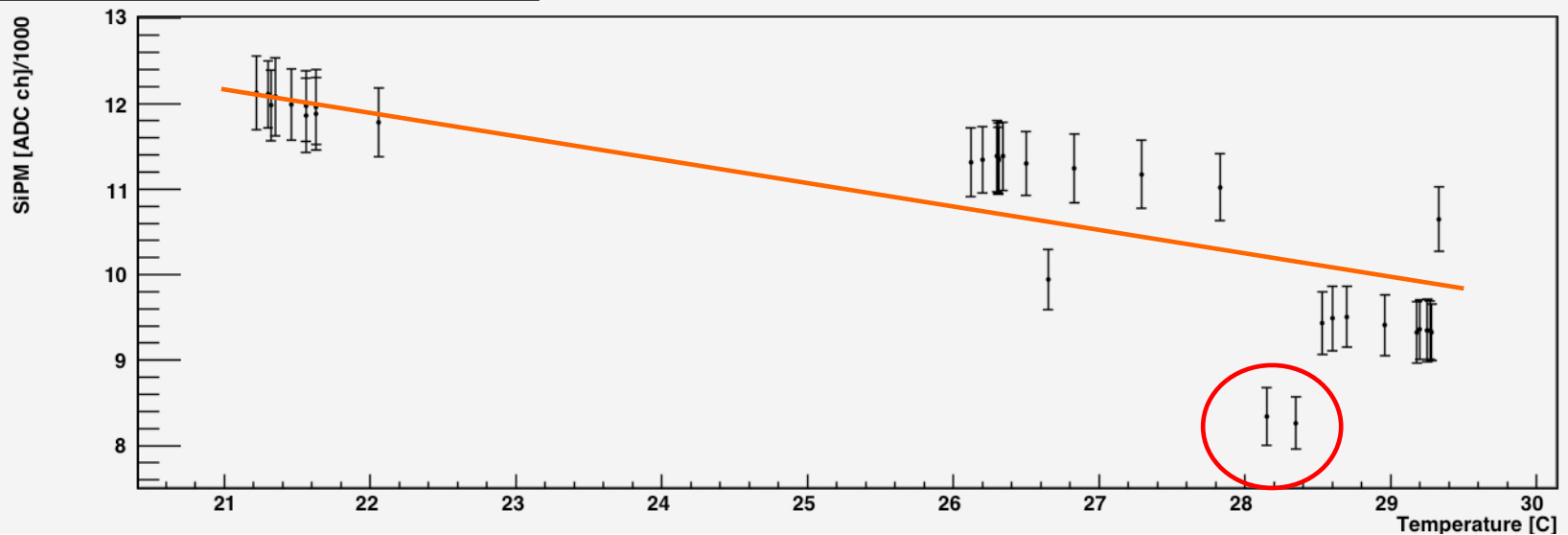
SiPM Temperature Dependence: Module 8

Chip 1
#17

Temperature correlation, pedestal events



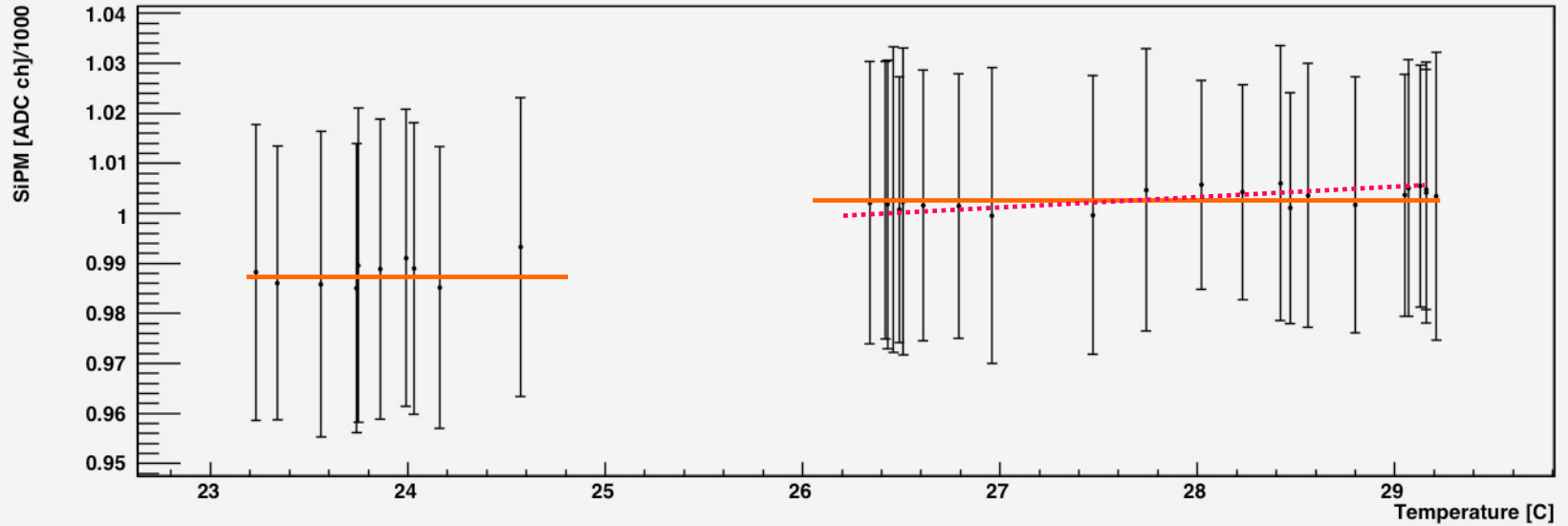
Temperature correlation, vcalib=46000



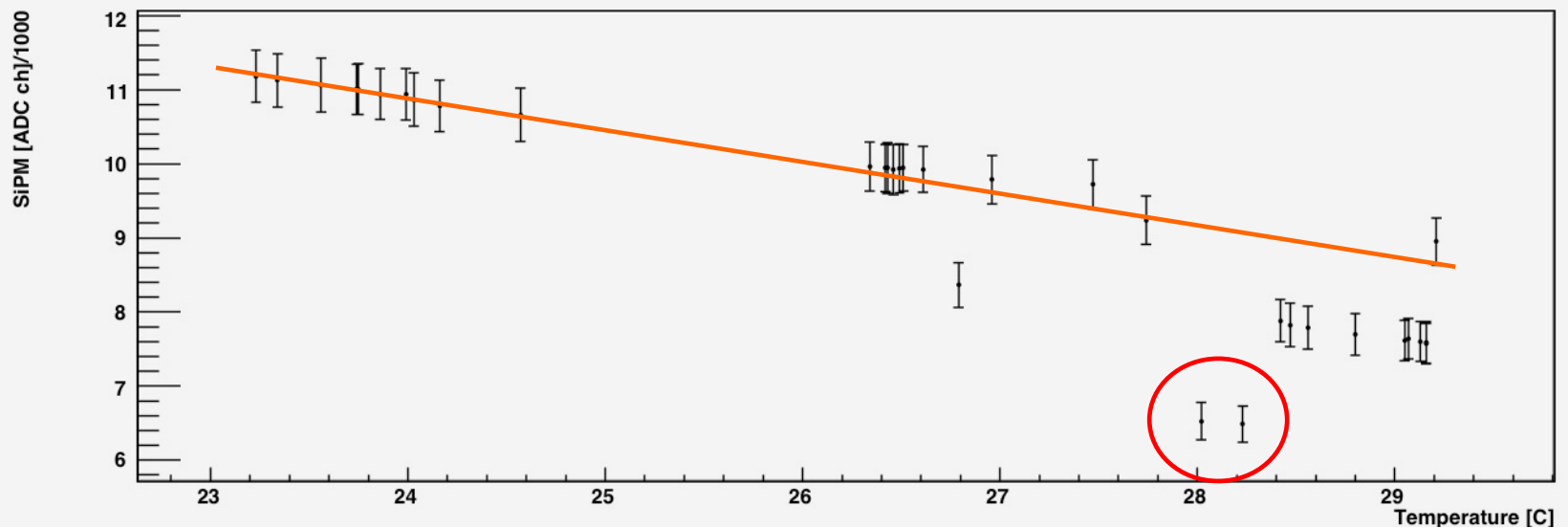
SiPM Temperature Dependence: Module 8

Chip 5
#9

Temperature correlation, pedestal events



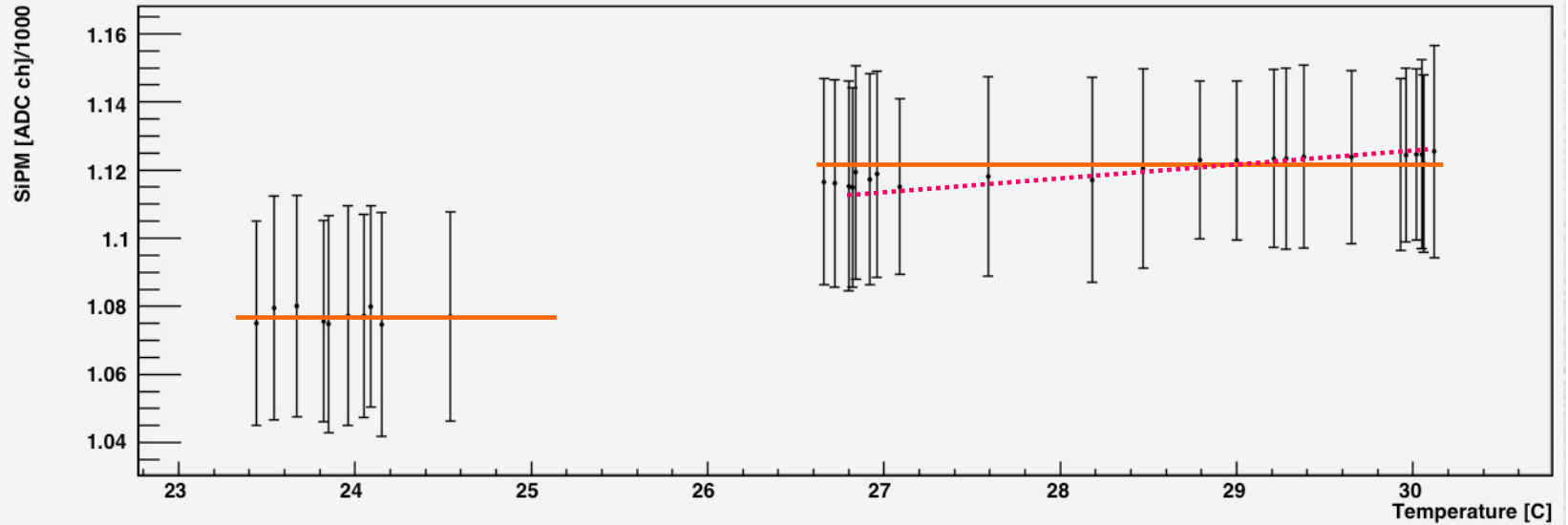
Temperature correlation, vcalib=46000



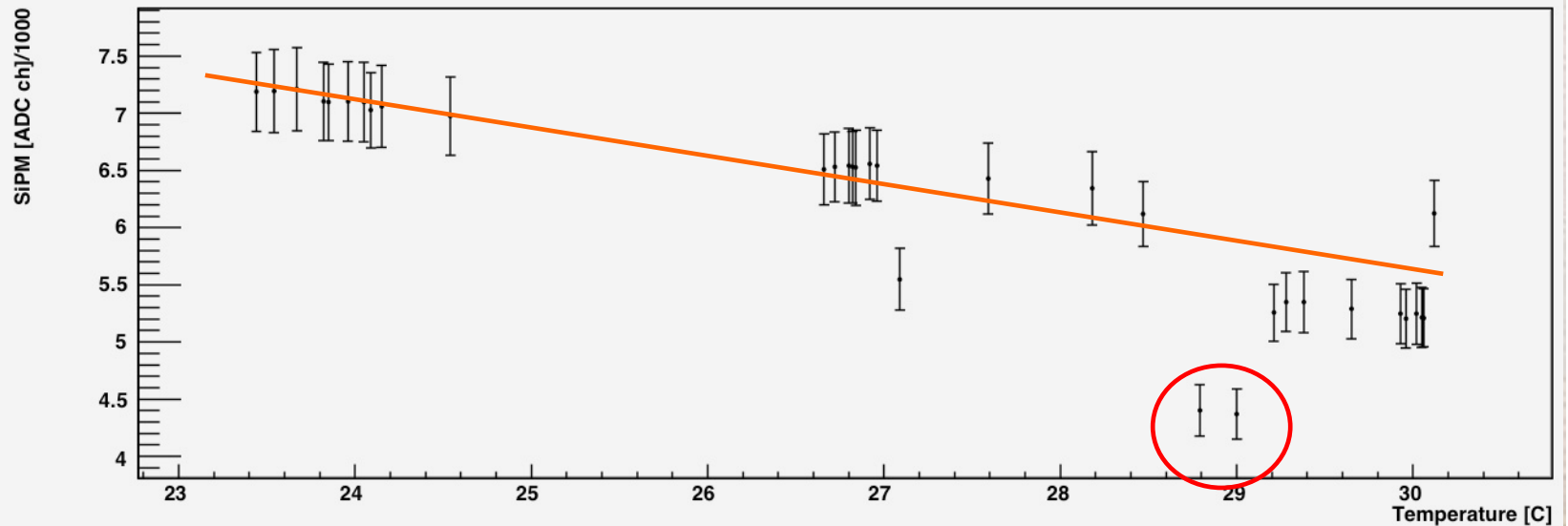
SiPM Temperature Dependence: Module 8

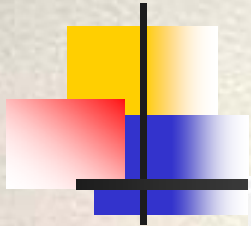
Chip 9
#4

Temperature correlation, pedestal events



Temperature correlation, vcalib=46000

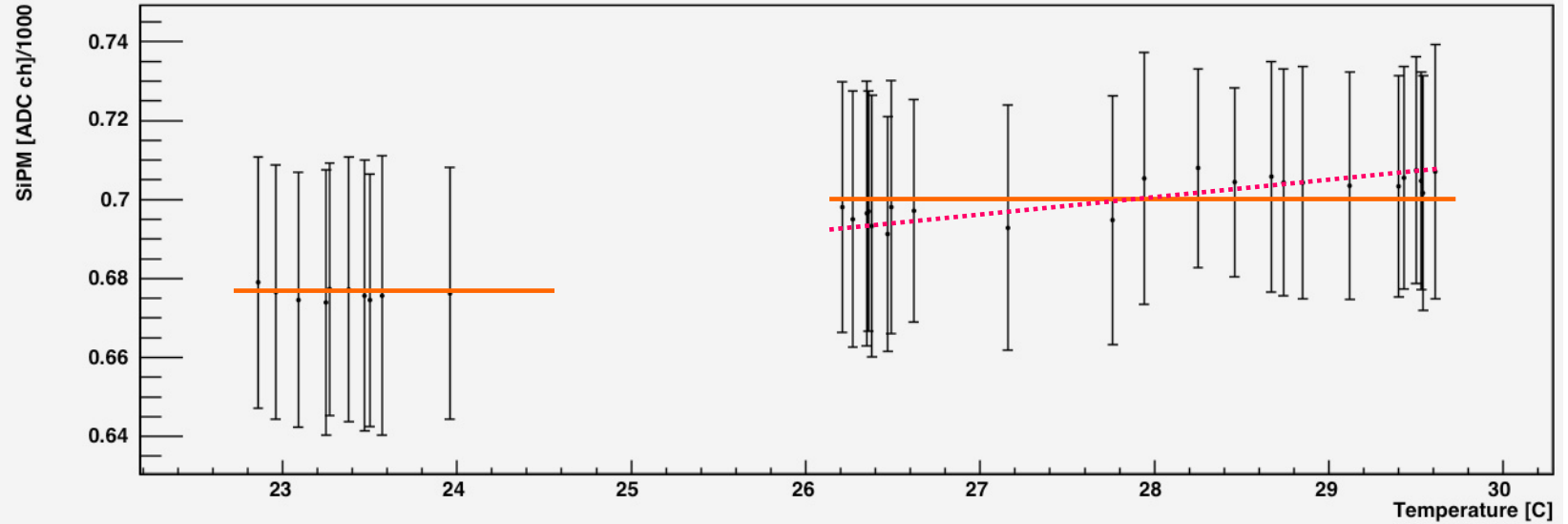




SiPM Temperature Dependence: Module 9

Chip 5
#9

Temperature correlation, pedestal events



Temperature correlation, vcalib=46000

