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CMS DP -2014/013

The Compact Muon Solenoid Experiment

CMS Performance Note

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SiPM Property Measurement from HO

CMS Collaboration

Abstract

The results from commissioning data collected by the Outer Hadron Calorimeter of the CMS detector are presented here. Properties of the Silicon Photomultiplier photodetectors were measured and variation of the properties is also monitored over the period of time.

SiPM Property Measurement from HO

The CMS Collaboration

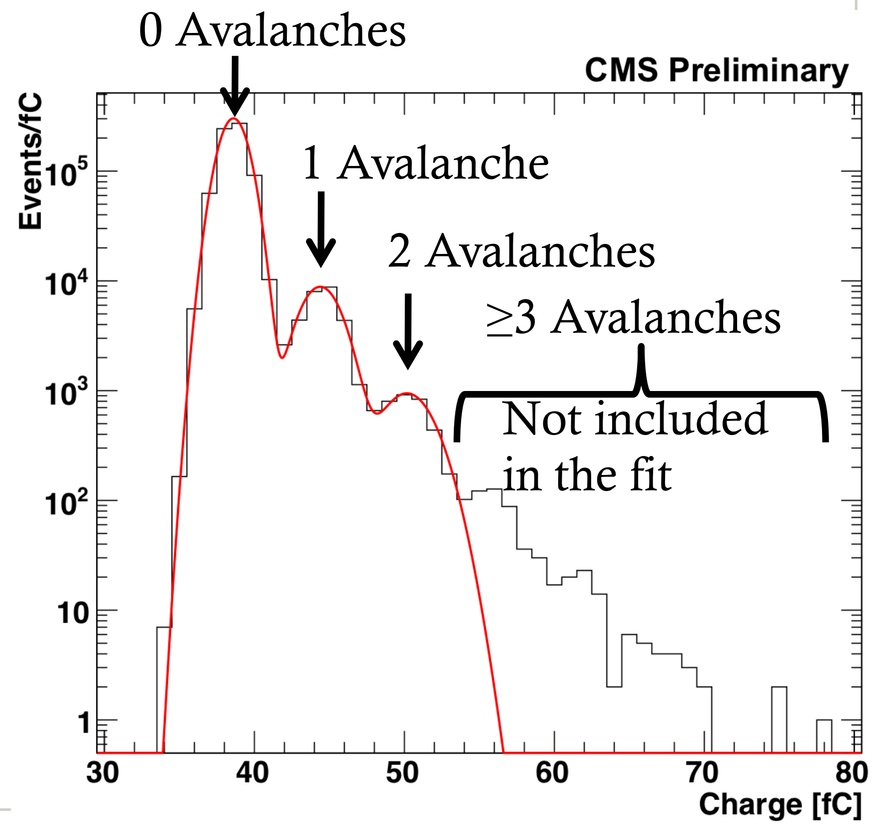
Gain Measurement

Gain determination

- The presence of dark counts allows a fit to the pedestal charge distribution to determine:
  - **Gain:** Difference between the charge of the 0 and 1 avalanche peak
  - **Dark Count Rate:** Average number of avalanches per event
  - **Cross-Talk Rate:** Rate that avalanche in one SiPM causes another avalanche in the same SiPM

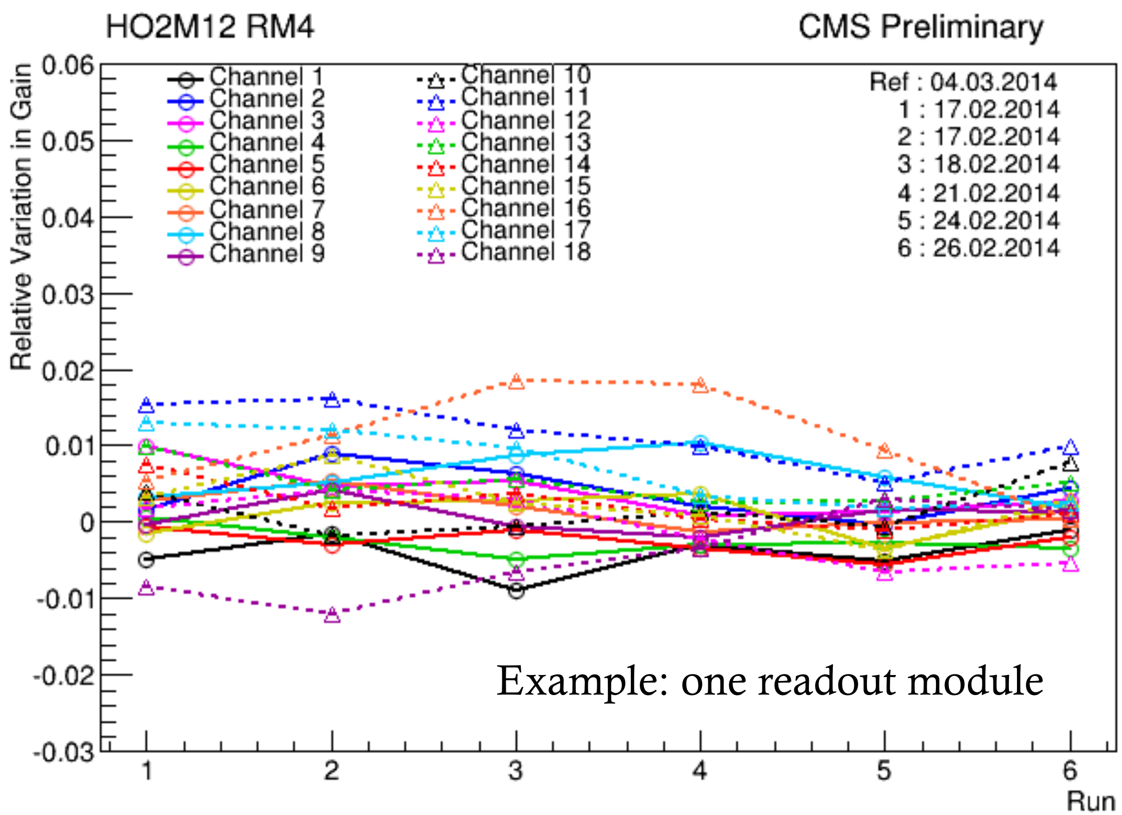
[The fit details can be found in backup]

SiPM Pedestal Charge Distribution



Relative Gain Variation vs. Time

- Stability of gain is monitored over the period of time
  - Example:
    Relative gain variation for 18 channels of one of the readout modules

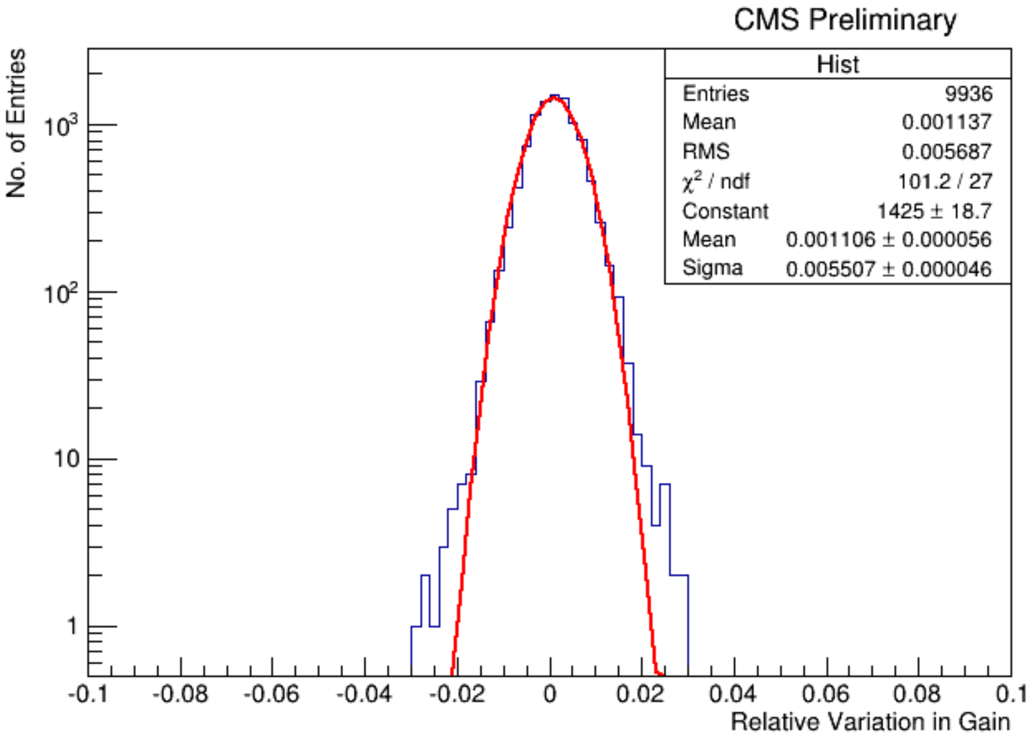


Relative variation in Gain:

$$\frac{Gain - Gain_{ref}}{Gain_{ref}}$$

Relative Gain Variation vs. Time

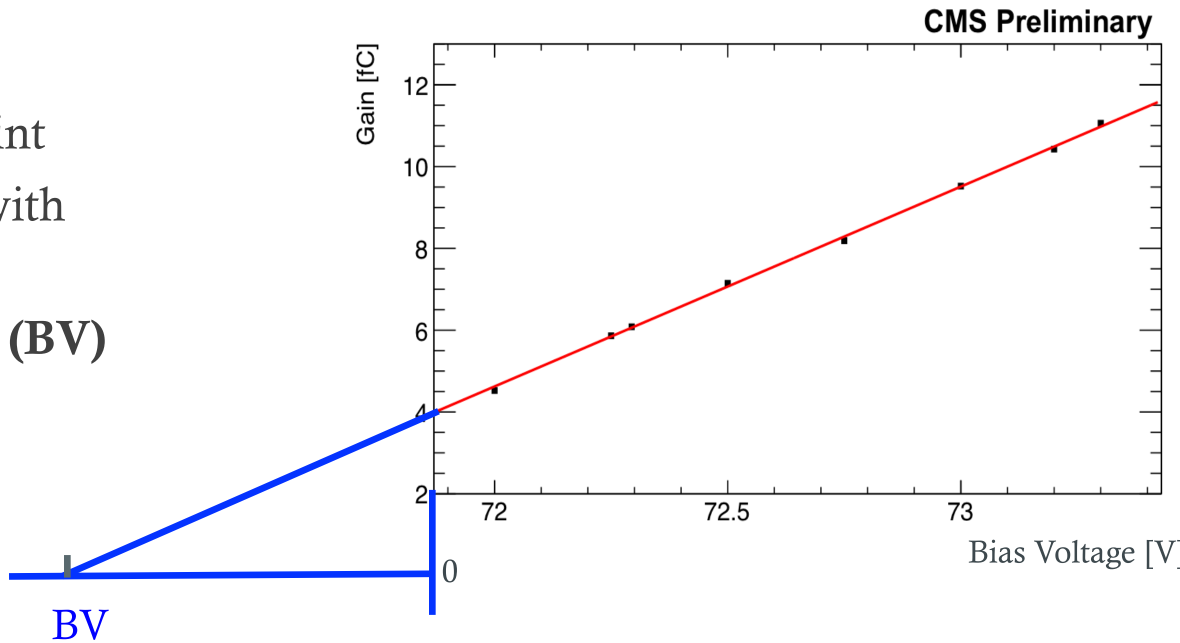
- Relative gain variation over the period 17.02.2014 – 04.03.2014
  - Entries correspond to measurements from all installed and commissioned channels at six different times described on previous slide
  - Variation for all channels is within 3%



Breakdown voltage measurement

Breakdown Voltage from Pedestal runs

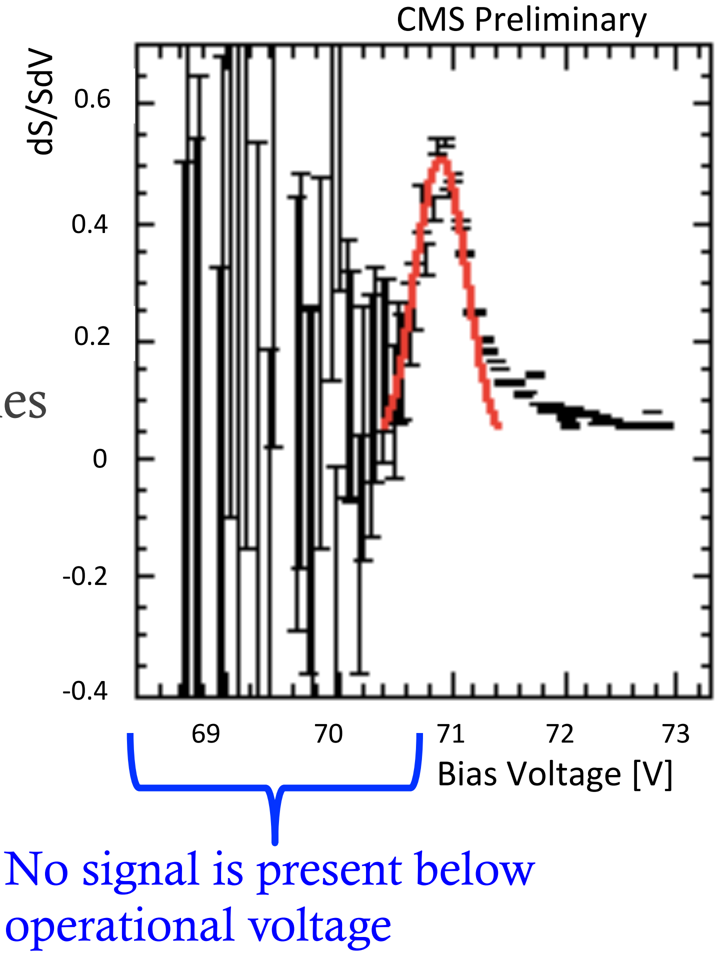
- Breakdown voltage is measured for each SiPM in order to achieve desired gain for all SiPM; The target gain (6 ADC) is chosen such that to be in optimal region of charge integration electronics
  - Scan over bias voltage and fit pedestal charge distribution at each point
  - Gain vs. voltage is fit with a line to obtain:
    - **Breakdown Voltage (BV) --** Voltage at which extrapolated fit line reaches zero gain
    - **Gain/Voltage Slope**



Breakdown Voltage from LED Runs

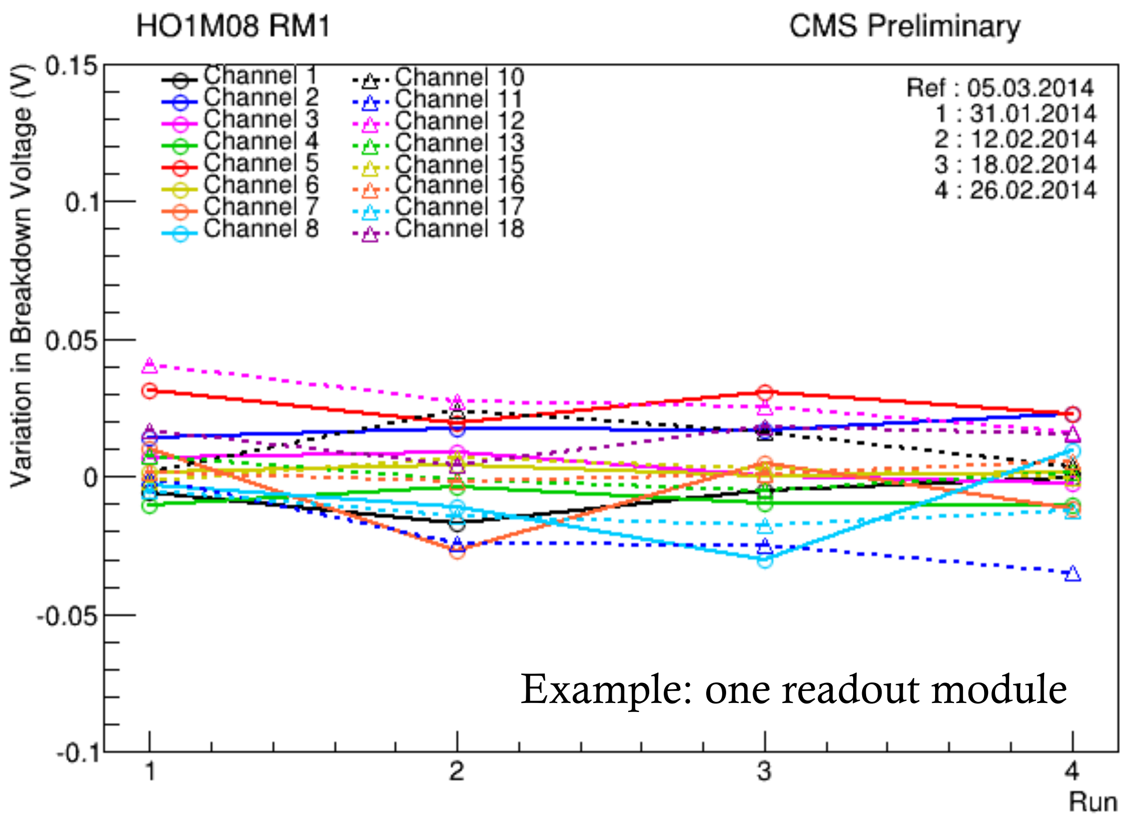
- Signal from each channel is measured at different applied bias voltage configuration
- Variation of the slope of the collected mean charge is measured as a function of voltage (dS/SdV). This quantity reaches maximum at breakdown voltage
- The BV is obtained by fitting the distribution with a simple Gaussian function

Example: HO1M06 RM3 SiPM11



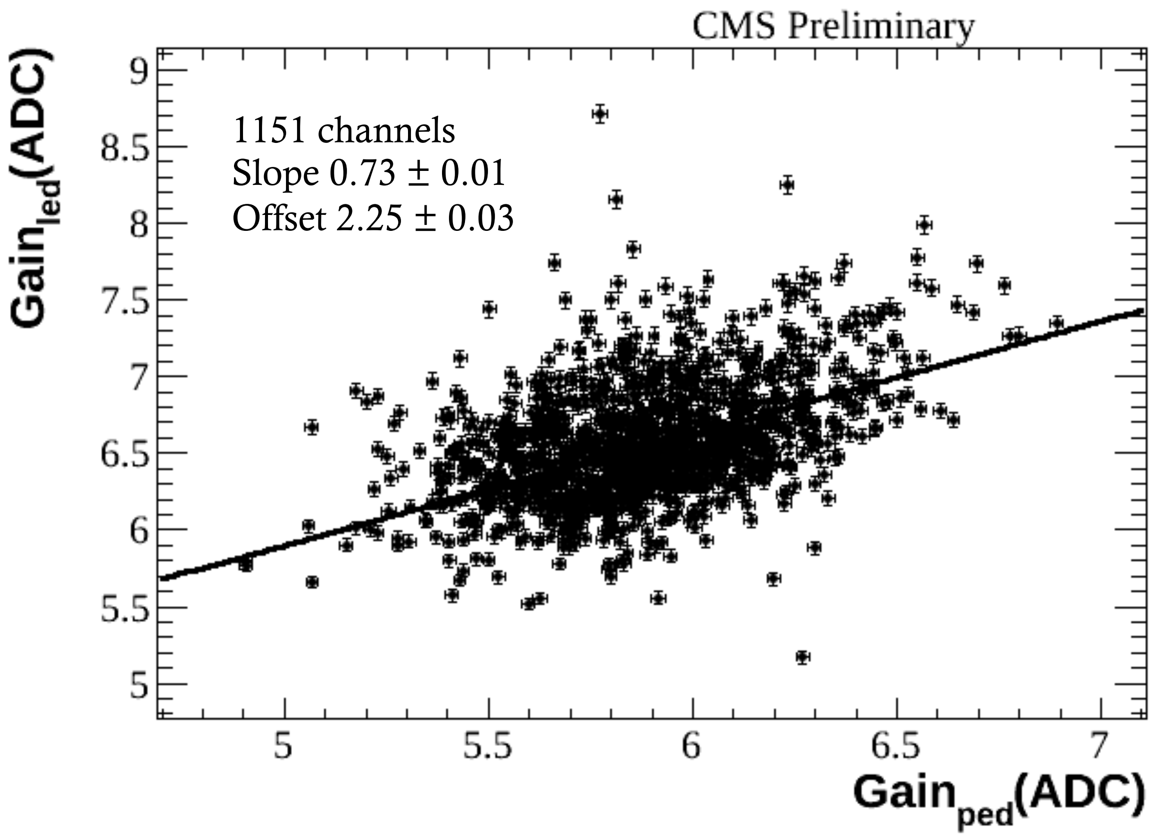
Breakdown Voltage Variation vs. Time

- Breakdown voltage stability is monitored over the period 31.01.2014-05.03.2014
  - BV variation for 18 channels of one of the readout modules
  - Variation for all channels is within ±60mV



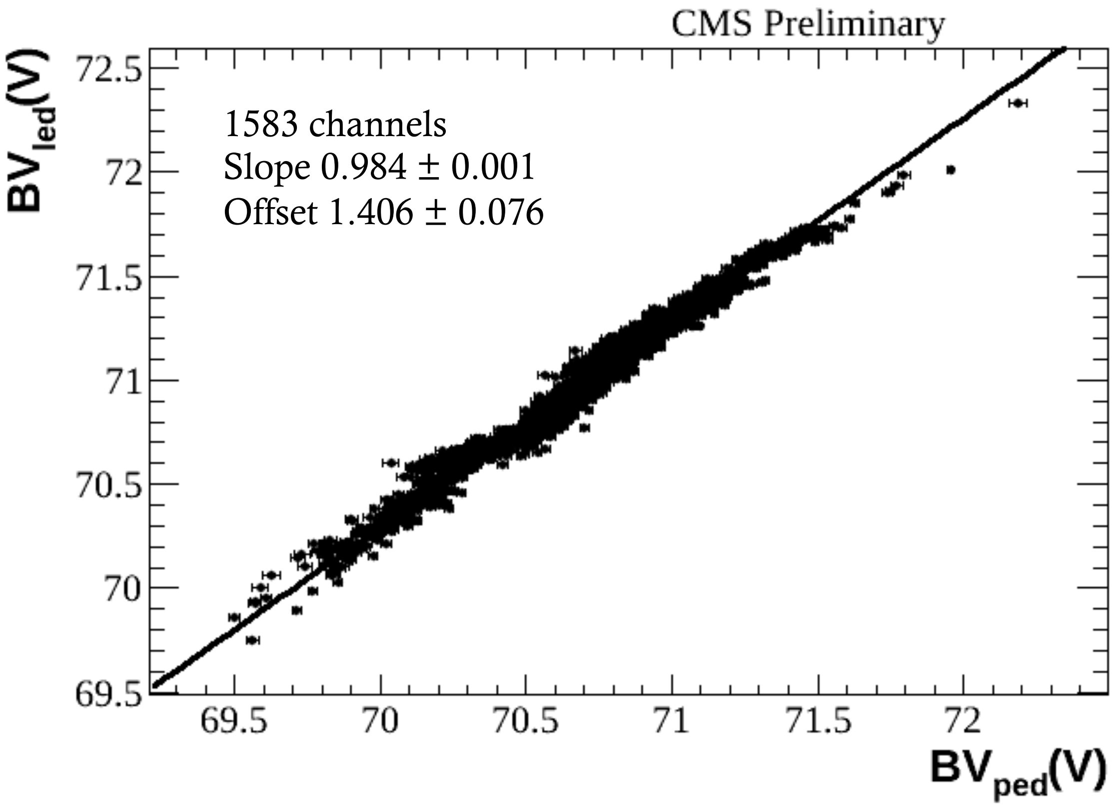
Gain Correlations

- Gain is optimized for all channels to the same target value within the resolution of the gain measurement methods



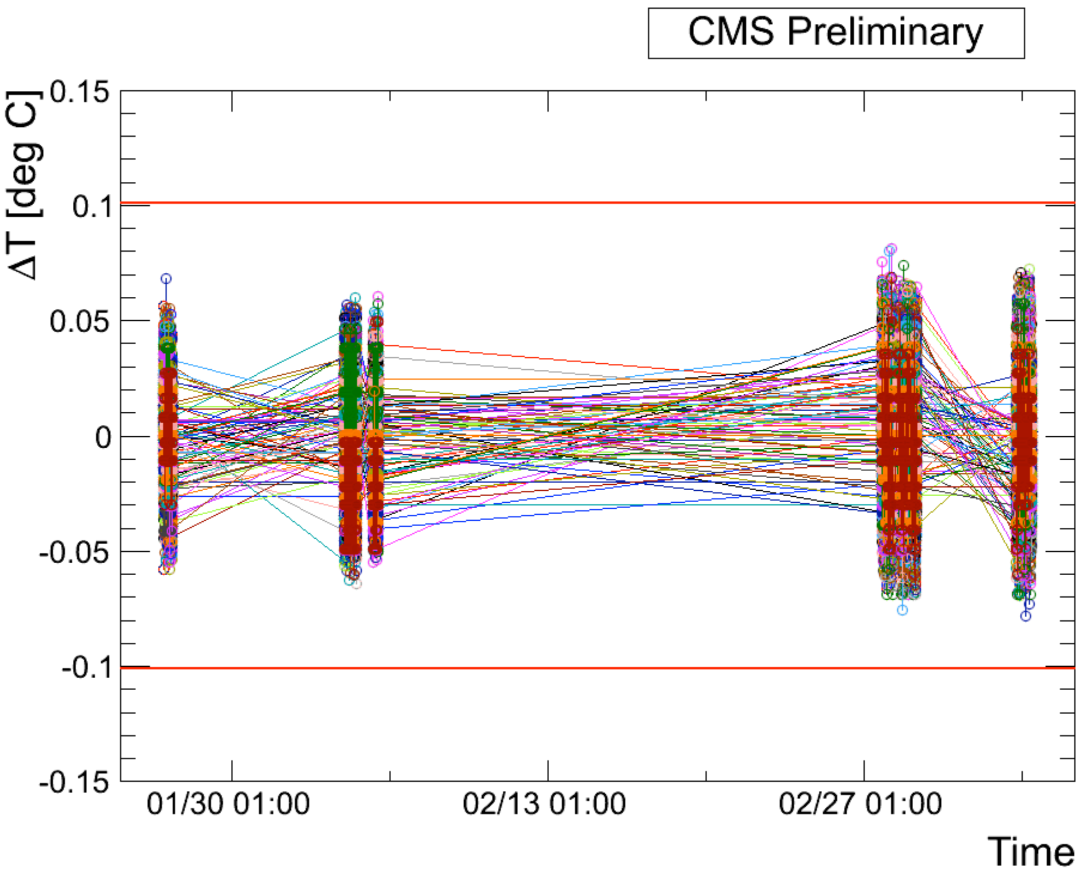
Gain and Breakdown Voltage Correlations

- Good correlation between the two measurements
  - Linear correlation of BV indicates good agreement between the two measurements



Temperature Stability

- The SiPM properties are temperature sensitive and Peltier cooling is used to stabilize temperature for each readout module
  - Desired goal for thermal conditions for optimal SiPM operation is achieved: within ±0.1 deg C



BACKUP

Cross Talk Calculation

- From pedestal fits, use the excess of 2 photoelectron (p.e.) peak over Poisson statistics to determine Cross-Talk between pixels within a channel
  - $N_{1(2)}$ = Normalization of 1(2) p.e. peak
  - R_{12Pois} = Poisson ratio of 1p.e. to 2p.e. according to ratio of 0p.e. to 1p.e.
  - R_{xtalk} = Rate that avalanche in 1 pixel starts an avalanche in neighboring pixel
  - Normalization of 1p.e. peak if no x-talk is approximately: $N_1/(1-R_{xtalk})$
  - So $N_2 \cong N_1/(1-R_{xtalk})*R_{12Pois} + N_1/(1-R_{xtalk})*R_{xtalk}$
- Rearranging and solving: $R_{xtalk} \cong (N_2/N_1 - R_{12Pois}) / (1+N_2/N_1)$
- From Fit parameters:
  - R_{12Pois} = (Mean #p.e.)/2
  - N_2/N_1 = (2p.e. Peak normalization multiplicative factor) * R_{12Pois}