Measuring the HE/Co Relative Energy using FD background files

Kenneth Jacks, Jose Bellido and Bruce Dawson

Long Term Performance Teleconference
March 23, 2020

Calculating photon fluxes from background files (BG files record signal variances)

6.2.2 K_v Method

Phong Nguyen (PhD thesis)
GAP-2018-011

The K_v method reduces the reliance on some of the simplifying assumptions outlined in Section 6.2.1, providing a more reliable (on an individual pixel basis) conversion for the measured NSB variance into a photon flux. The following method was adapted from references [132–134].

Firstly, the variance scaling factor K_v is defined as follows

$$K_v = \frac{I_{ADC}}{\sigma^2_{ADC}} \tag{6.10}$$

[132] A. Segreto. Night sky background measurements by the Pierre Auger fluorescence detectors and comparison with simultaneous data from the UVscope instrument. In *Proceedings, 32nd International Cosmic Ray Conference (ICRC 2011): Beijing, China, August 11-18, 2011*, volume 3, page 129, 2011.

[133] M. Kleifges, A. Menshikov, et al. Statistical current monitor for the cosmic ray experiment pierre auger. *IEEE Transactions on Nuclear Science*, 50:1204–1207, August 2003.

[134] A. Menshikov, M. Kleifges, and H. Gemmeke. Fast gain calibration of photomultiplier and electronics. *IEEE Transactions on Nuclear Science*, 50:1208–1213, August 2003.

Calculating photon fluxes from background files (BG files record signal variances)

the complete analogue signal chain [132]. Using information provided by K_v, the photon flux is given by

$$\Phi_\gamma = \frac{[\sigma^2_{ADC}]^{NSB} \times K_v \times C_{FD}}{A \times \Delta t} \qquad [\text{photons}/\text{m}^2/\text{deg}^2/\mu\text{s}] \qquad (6.12)$$

where definitions of $[\sigma^2_{ADC}]^{NSB}$, C_{FD}, A and Δt were provided in Section 6.2.1.

- C_{FD} is the calibration constant and can be thought of as the *inverse gain* of the pixel of interest (see Section 5.1). C_{FD} values are available through the FD Calibration database.
- A is the pixel aperture = 7.68 $\text{m}^2\,\text{deg}^2$ (the telescope aperture multiplied by the square of an FD pixel's angular size).
- Δt is chosen to be 100 ns.

Kv is not explicitly stored in the monitoring database.

Calculating photon fluxes from background files (BG files record signal variances)

The software used to analyse the cal A data (and produce the relevant calibration parameters to be uploaded to the monitoring database) contains the following equation:

$$G = \frac{\sigma^2_{ADC}}{I_{ADC}} \Big/ F \times Sphe_{res} \Big/ 5 \Big/ range_{coeff} \tag{6.13}$$

where $Sphe_{res}$ and $range_{coeff}$ are predefined constants with values of 1.4 and 0.99893, respectively. By substituting in Equation 6.10, this can be rewritten as

$$G = \frac{1}{K_v} \Big/ F \times Sphe_{res} \Big/ 5 \Big/ Range_{coeff} \tag{6.14}$$

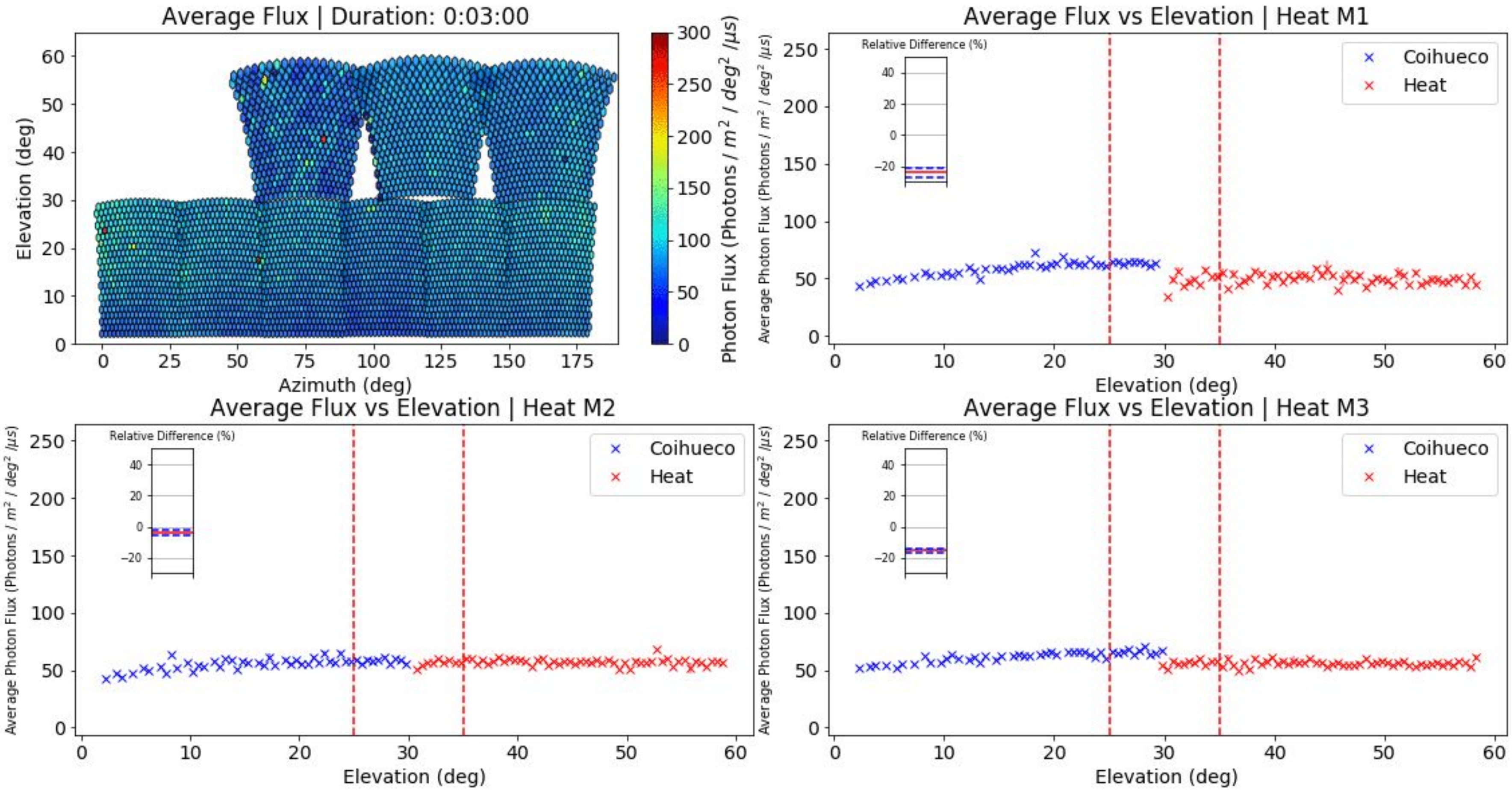
which can be rearranged to give

$$K_v = \frac{5}{G \times F \times Sphe_{res} \times range_{coeff}} \tag{6.15}$$

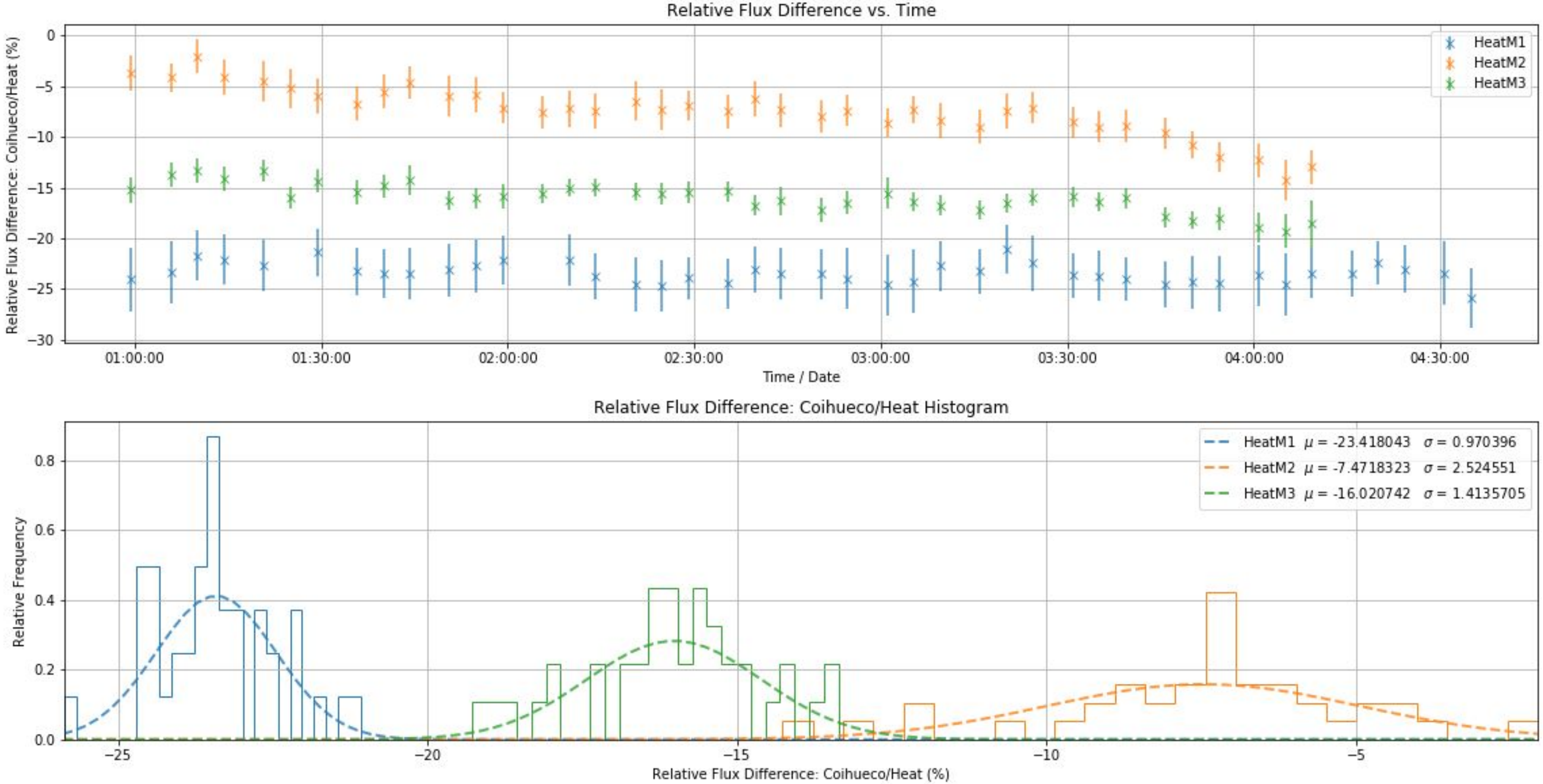
G is the PMT gain (ADC counts per photoelectron)
F is the noise equivalent bandwidth (MHz)

Kv is not explicitly stored in the monitoring database, but G and F are.

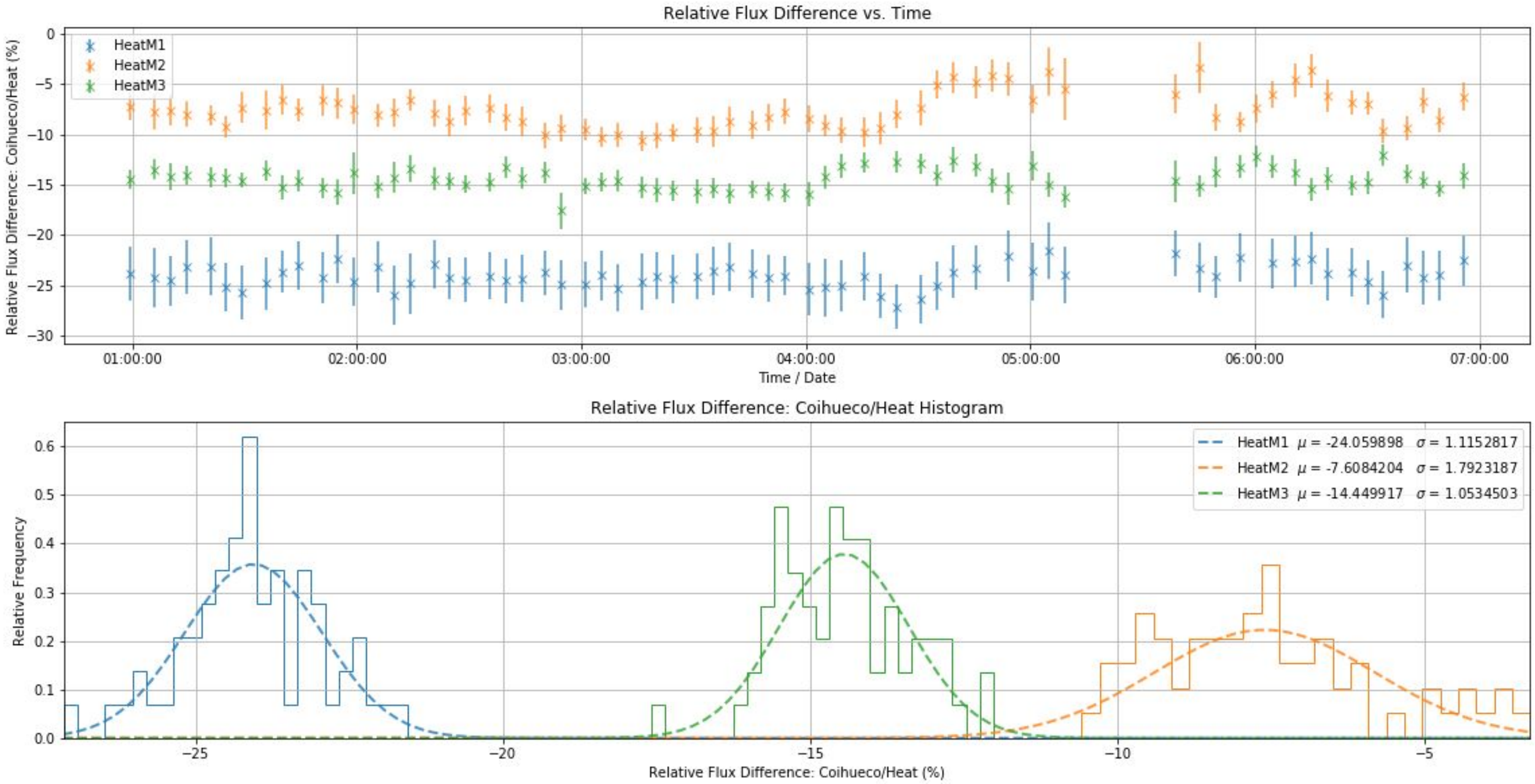
Time: 16/08/2014 01:00:00



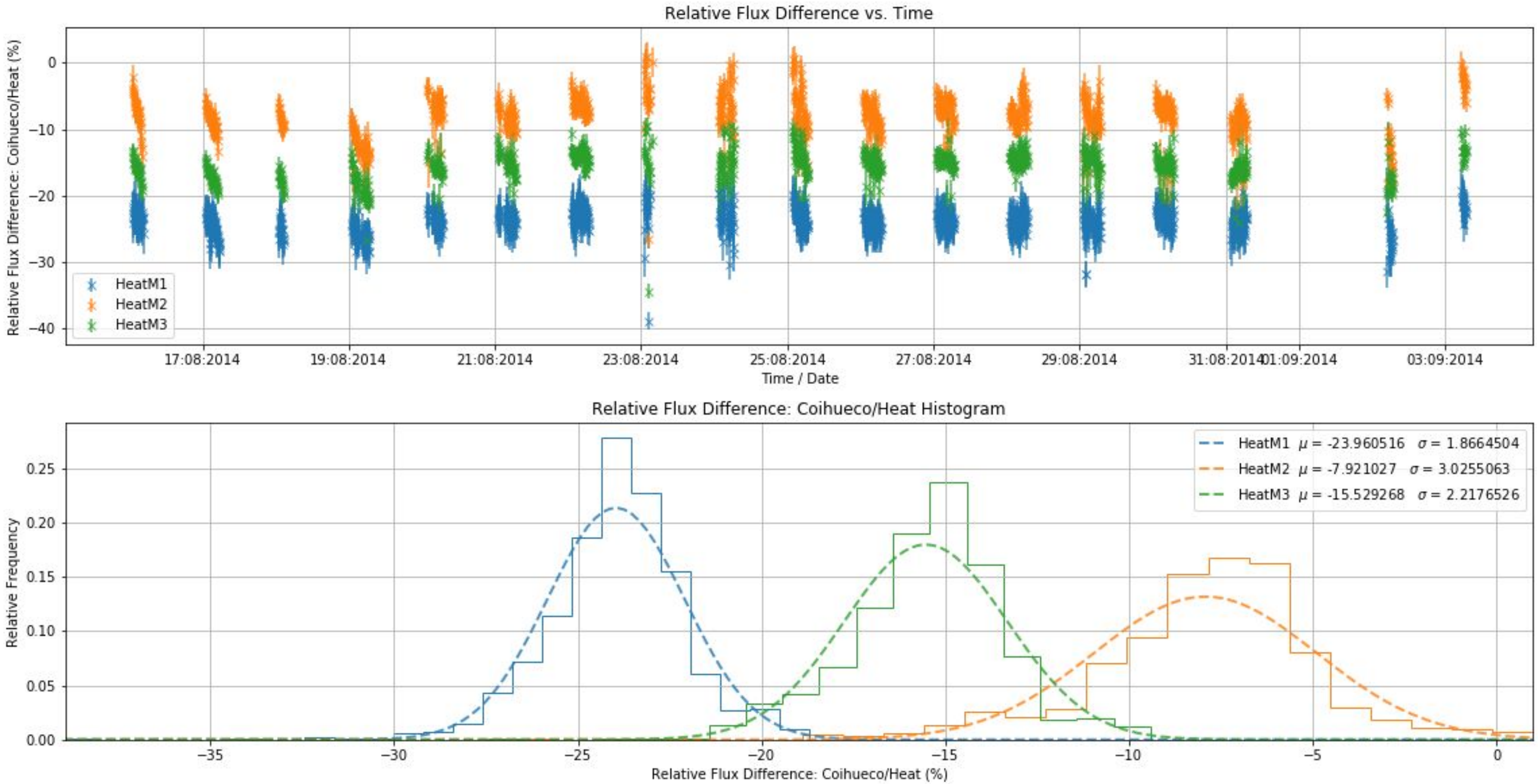
Relative Flux Analysis: 16/08/2014

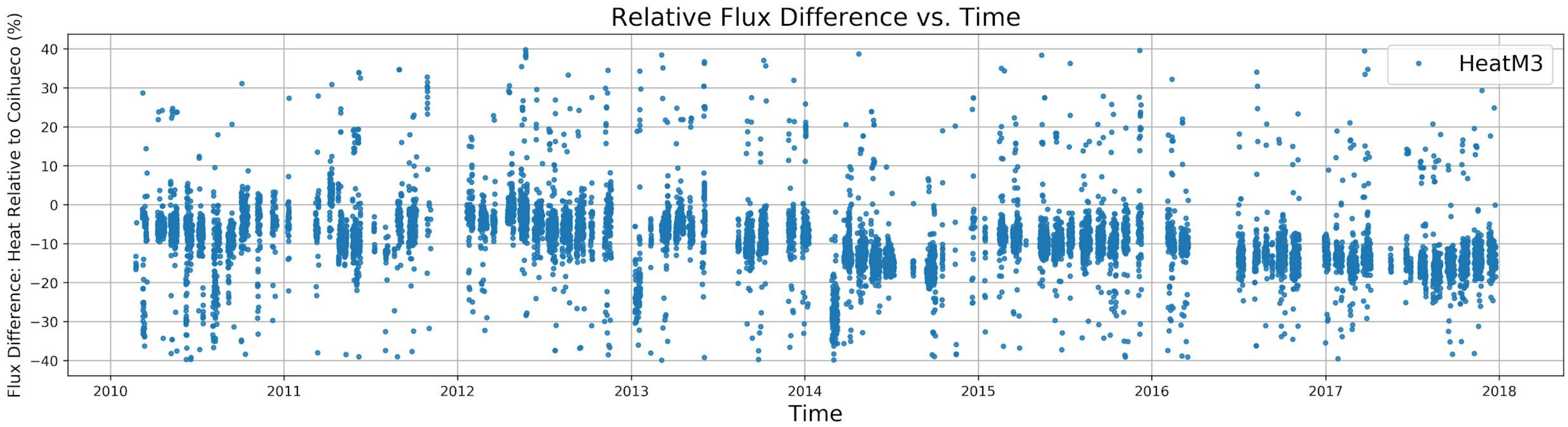


Relative Flux Analysis: 28/08/2014

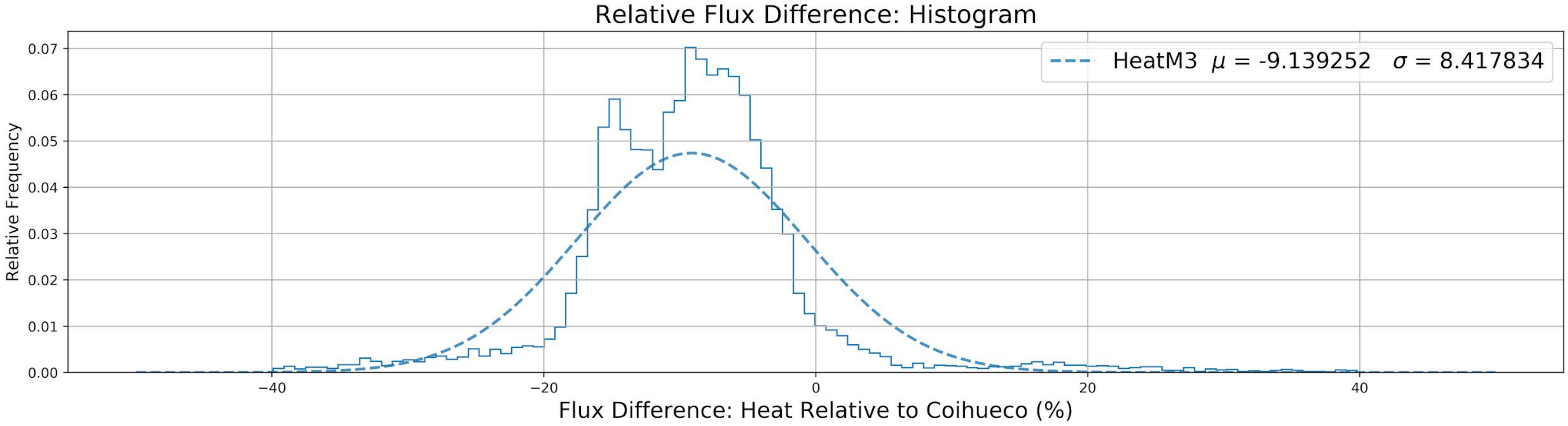


All Relative Flux - Run: 16/08/2014 - 03/09/2014



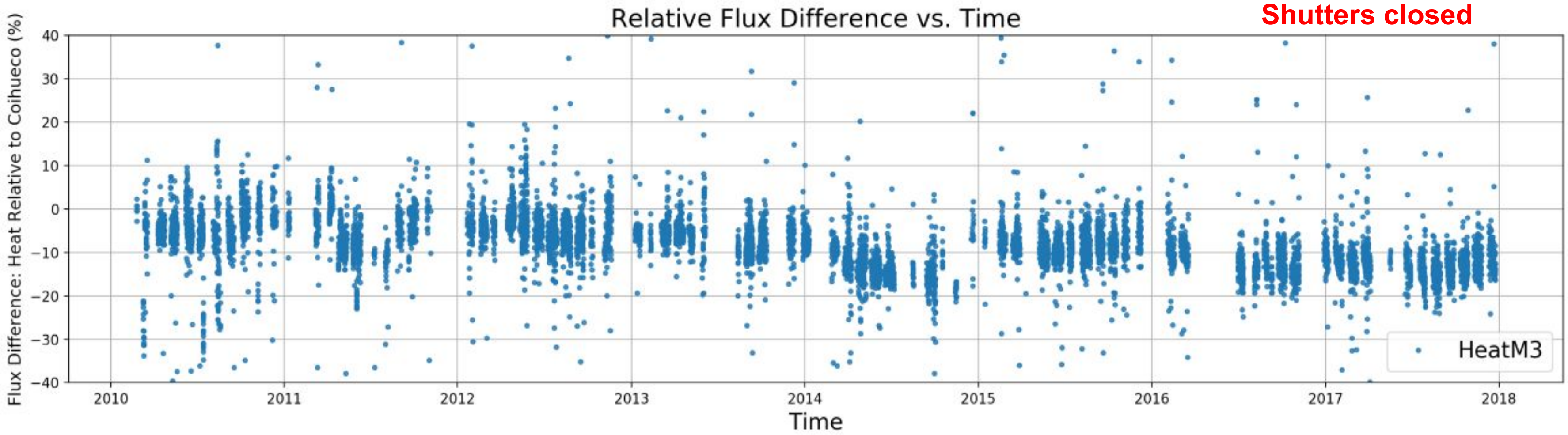


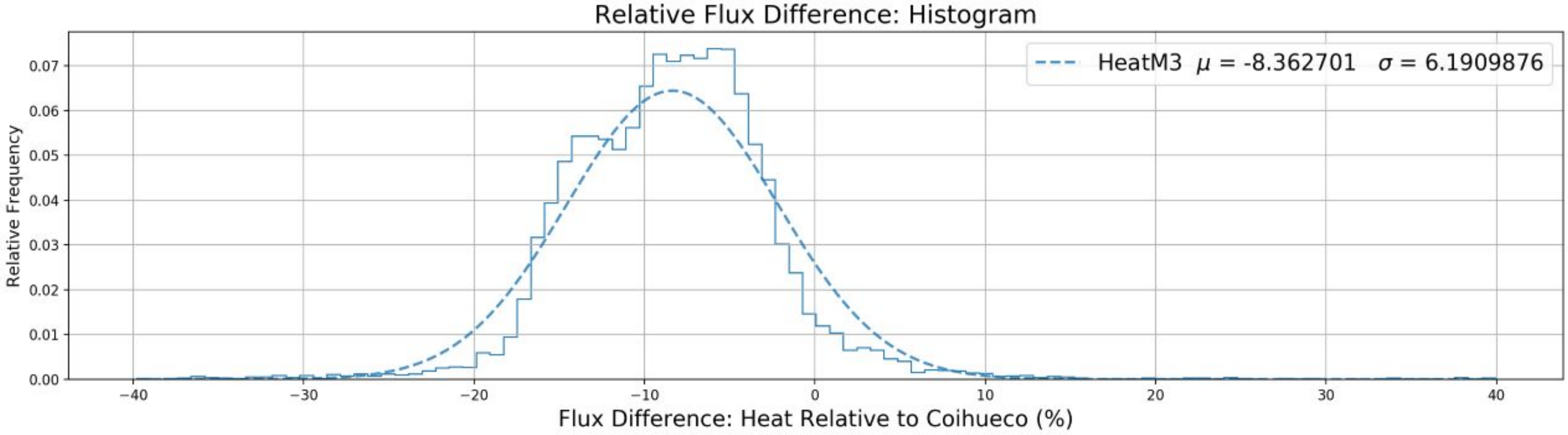
Relative Flux Difference vs. Time
HeatM3
Flux Difference: Heat Relative to Coihueco (%)
Time
2010
2011
2012
2013
2014
2015
2016
2017
2018



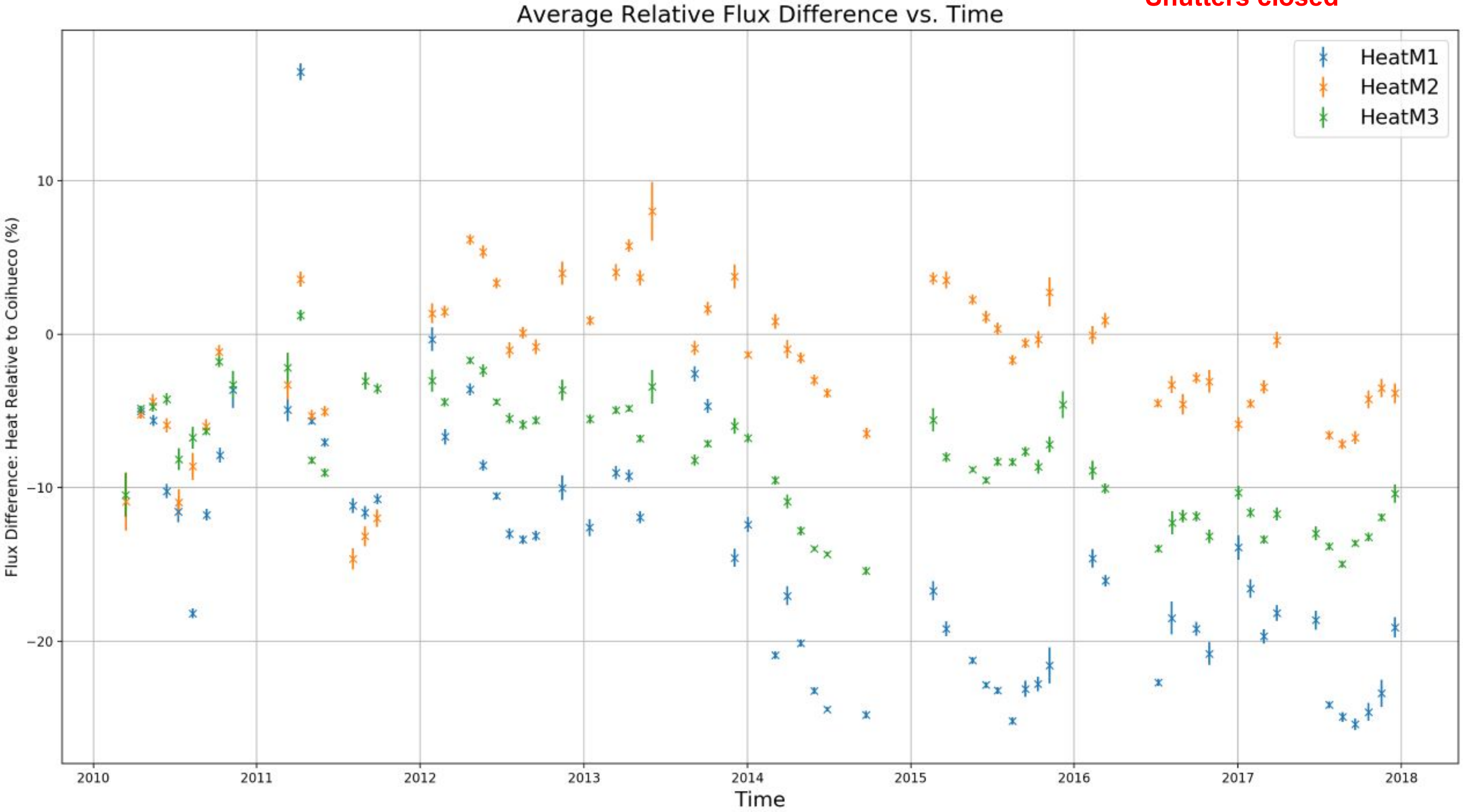
Relative Flux Difference: Histogram
HeatM3 μ = -9.139252 σ = 8.417834
Relative Frequency
Flux Difference: Heat Relative to Coihueco (%)

Correcting for: HEAT in downwards position
Shutters closed

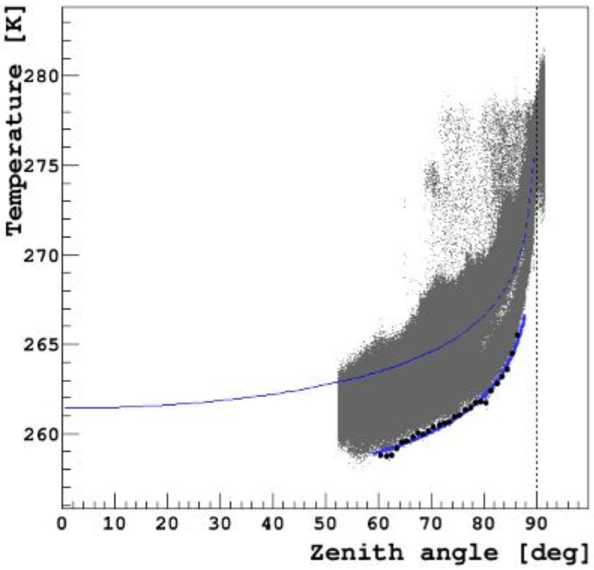




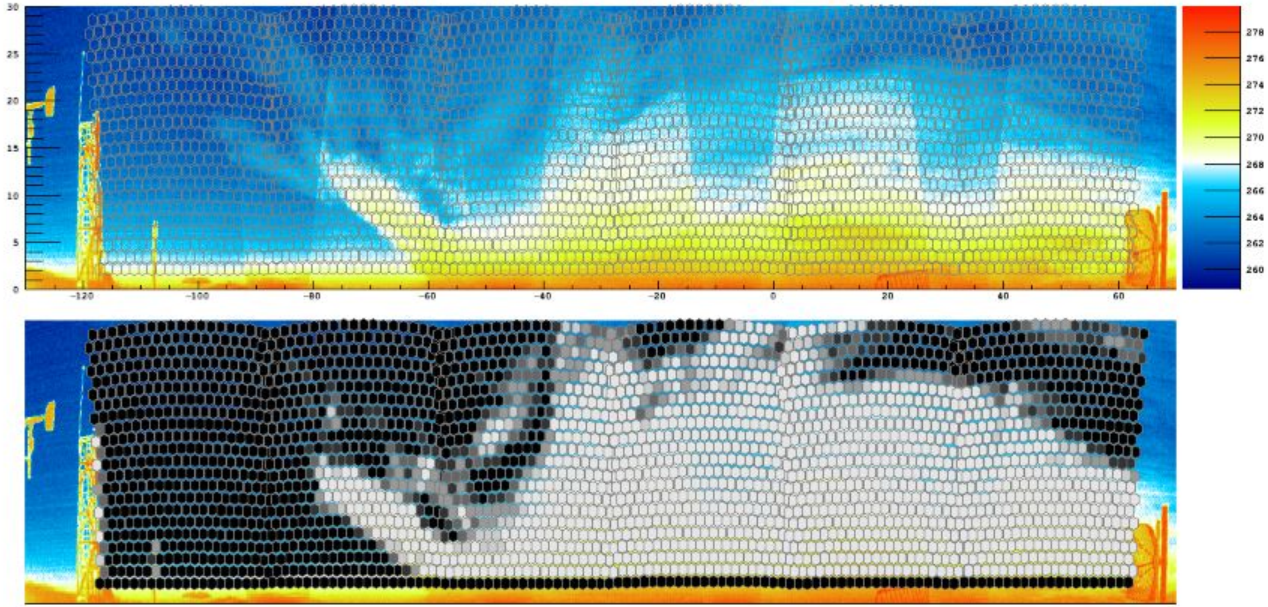
Correcting for: HEAT in downwards position
Shutters closed

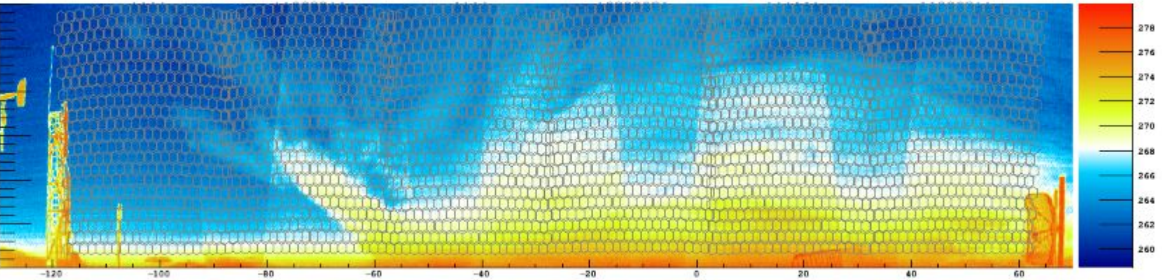


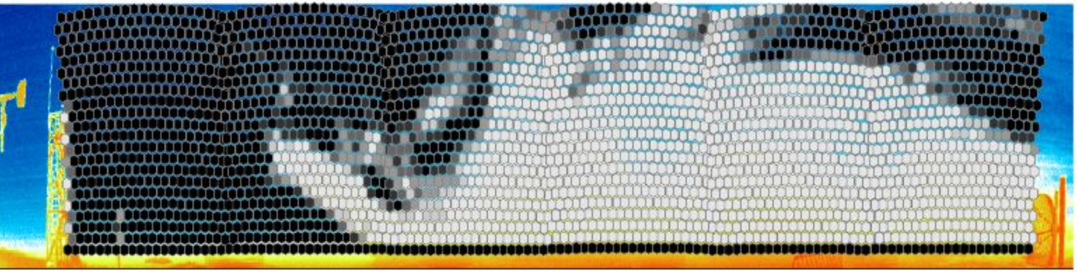
Example of a cloudy moment



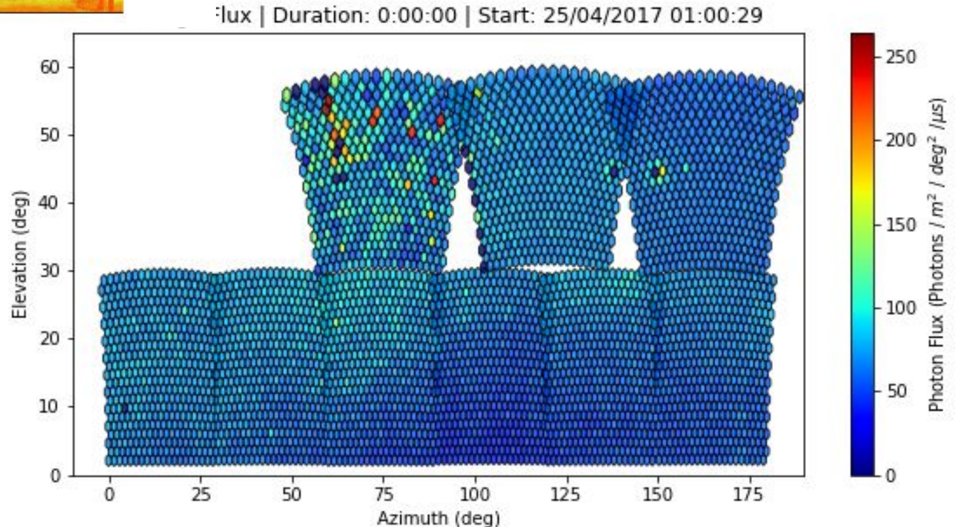
Cloud camera



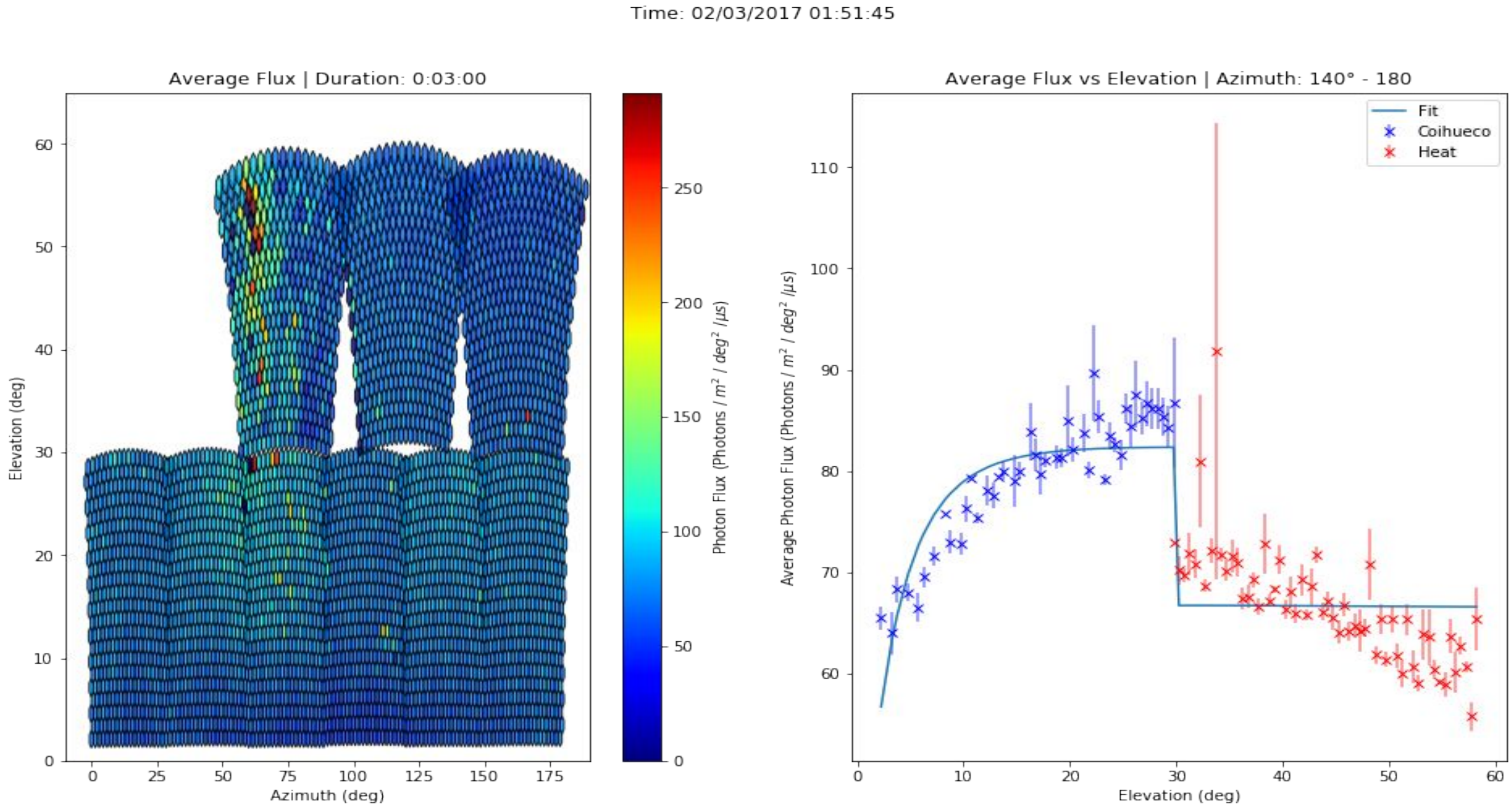




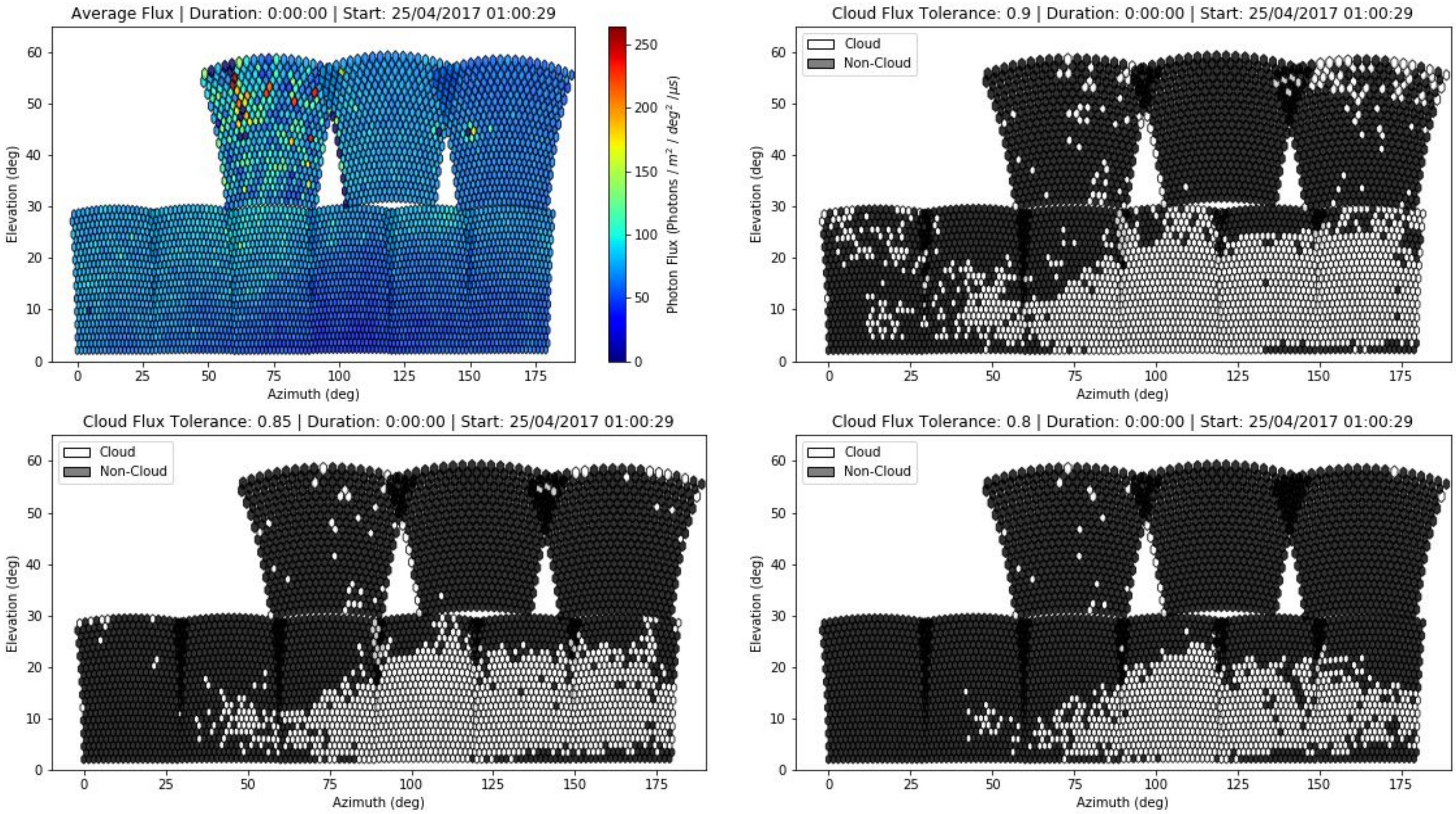
BG light for the same moment



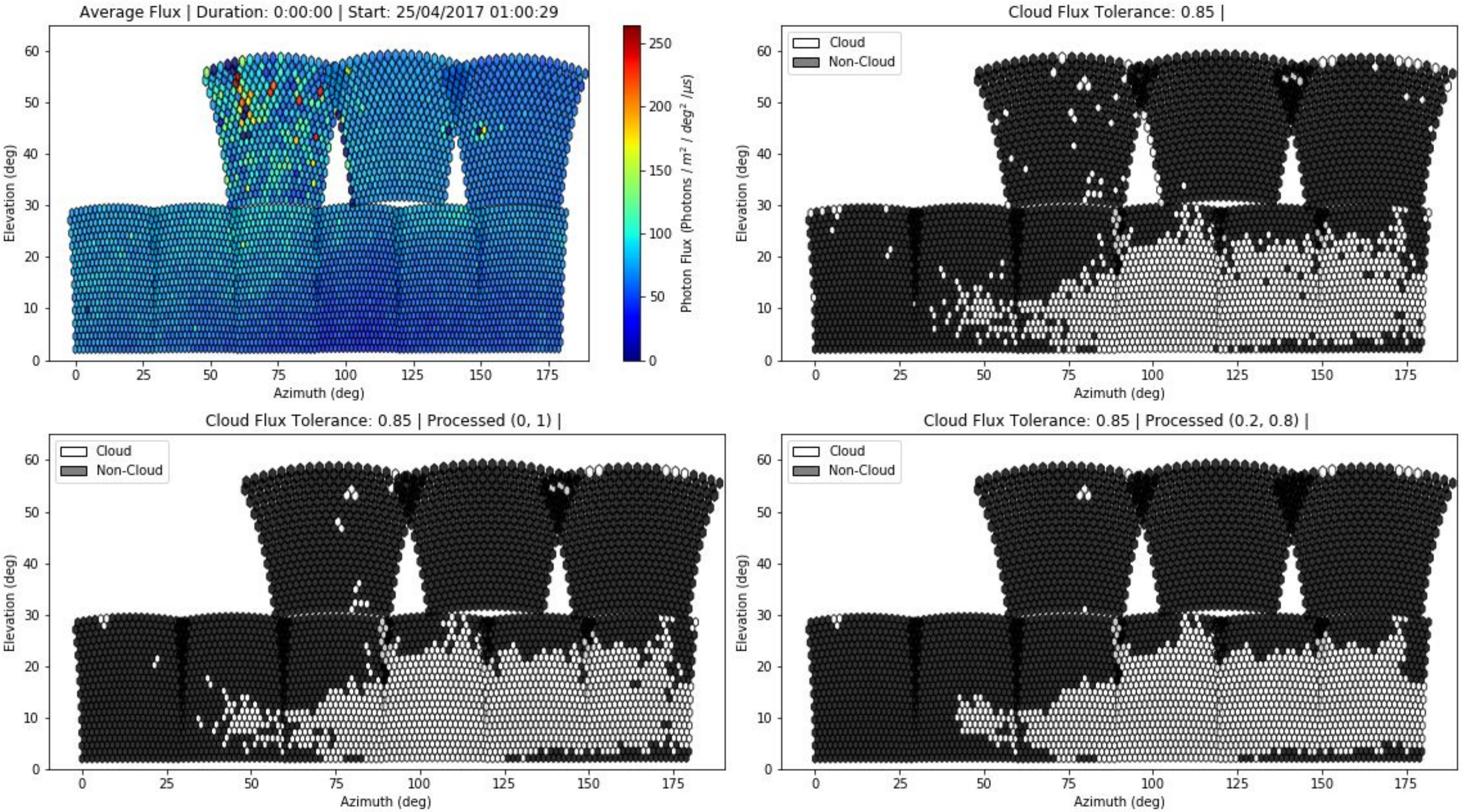
BG light as a function of elevation for a clear night for the same sidereal time

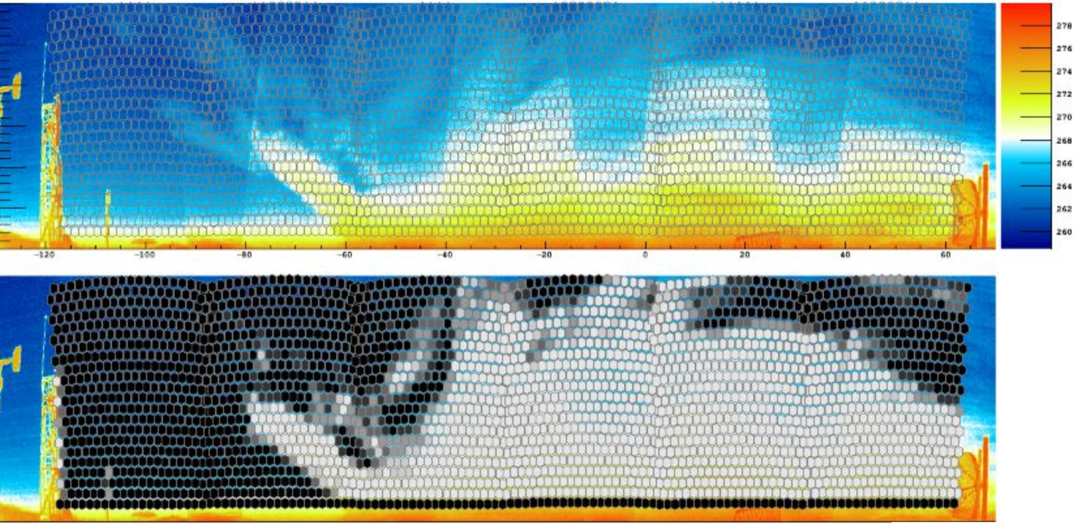


Cloud detection using three different threshold levels

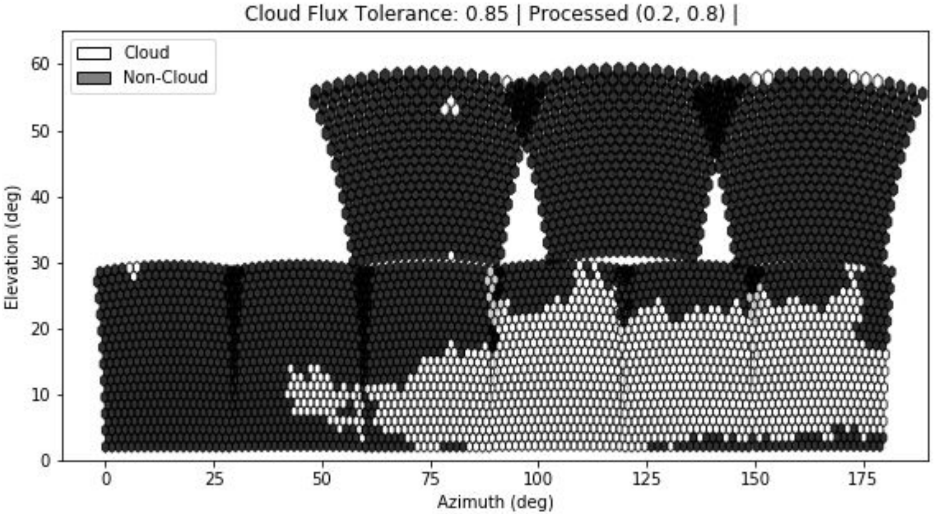


Cloud detection using three three levels of image processing





278
276
274
272
270
268
266
264
262
260
-120
-100
-80
-60
-40
-20
0
20
40
60



Cloud Flux Tolerance: 0.85 | Processed (0.2, 0.8) |
Cloud
Non-Cloud
Elevation (deg)
Azimuth (deg)
0
10
20
30
40
50
60
0
25
50
75
100
125
150
175

Conclusions

- BG files have been used to monitor the Heat/Coihueco relative energy scale with a precision of about 2% (in each HEAT mirror!) for the period from 2010 to 2018.
- We need to create a relative calibration DB for each HEAT mirror to account for the variability.

BG files as cloud detectors

- BG files can be used as good cloud detectors.
- Further work is needed to optimize the measurement the BG light as a function of elevation for a clear night (templates).