

Periodic Variations in Muon Flux at Project GRAND



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Introduction



- Overview
 - Project GRAND uses proportional wire chambers (PWC) to detect these muons to find individual events and showers.
 - The muon flux has been shown to exhibit many periodicities
 - Atmospheric Effects
 - Interplanetary Magnetic Field Effects
- Objectives
 - GRAND data has primarily been used to study solar events through cosmic rays. In this analysis we seek to expand the use of this data to time series analysis which can help us better understand the behavior of cosmic ray in the atmosphere and in the solar system.

Project GRAND Experiments



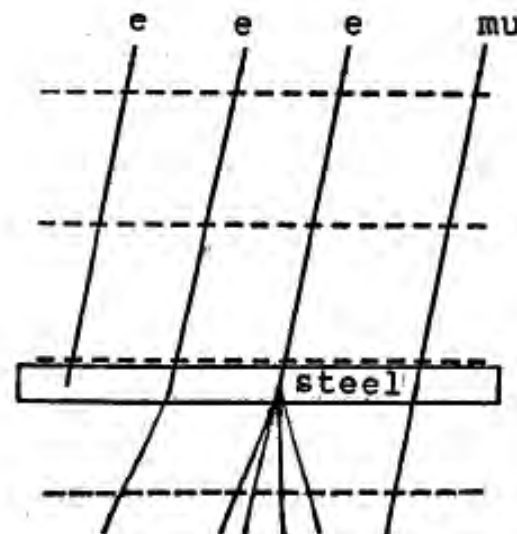
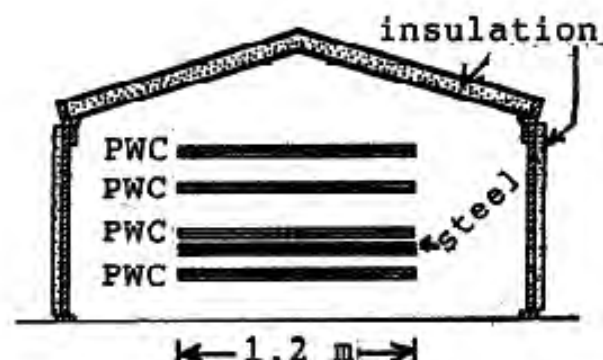
- **Low Energy Experiment**
 - 30 – 300 GeV
 - Single Track Muon Data
 - Looks for variations in individual muon flux
- **High Energy Experiment**
 - 100-100000 TeV
 - Shower Data
 - Analyze high energy cosmic ray events
- **Project Grand Setup**
 - 8x8 array of PWCs with total area of 83 m²
 - Muon threshold of .1 GeV
 - $\pm 63^\circ$ cutoff angle from zenith with greater than $\pm .5^\circ$ precision



Huts for Muon Detection



- **8 Proportional Wire Chambers**
 - 4 x-planes (NS)
 - 4 y-planes (EW)
- **Chamber Details**
 - 1.25 m² in area
 - Uses 80% Argon 20% CO₂ gas mixture
 - .05 m steel plate before the bottom two planes
- **Single Muon Detection**
 - Interactions must form a straight path within the detector

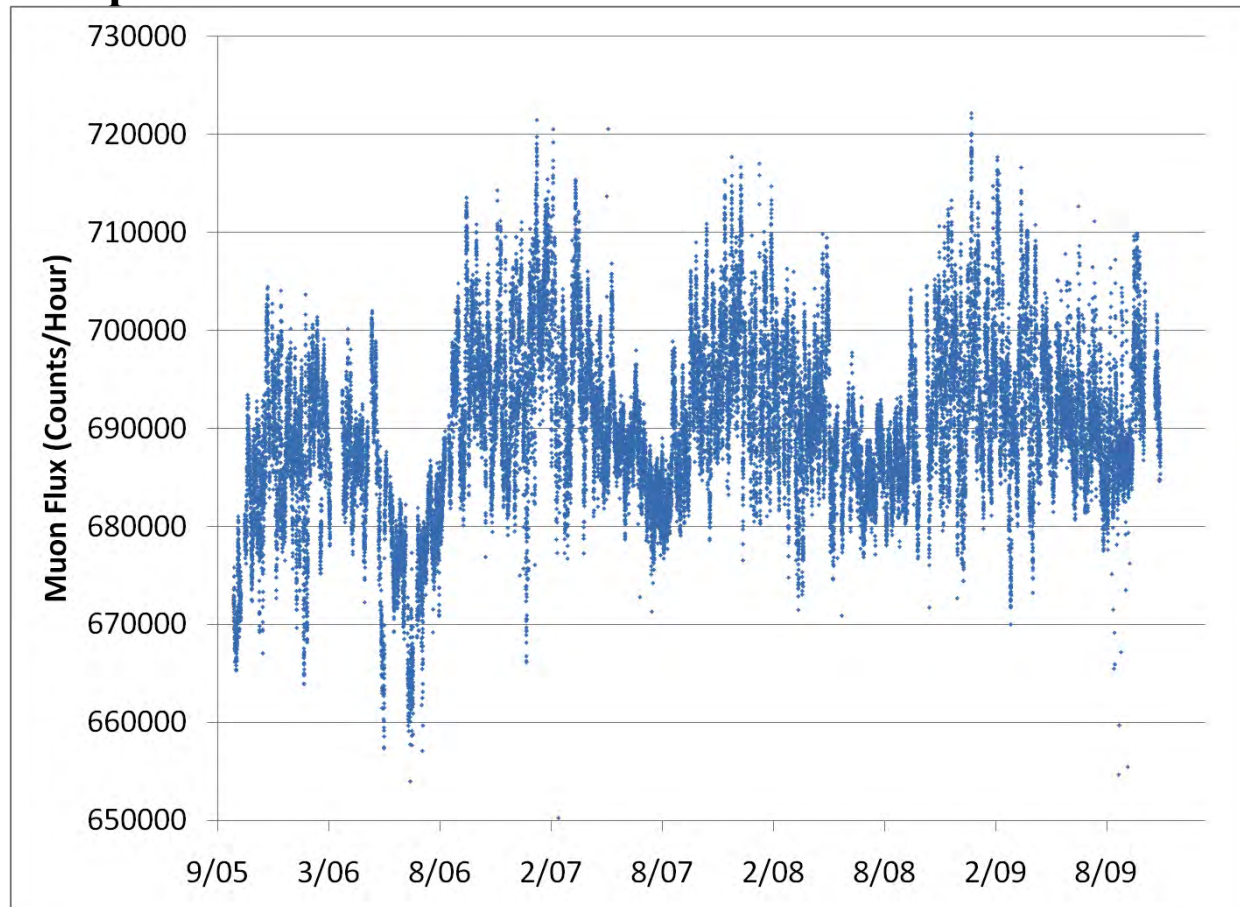


Datasets: Muon Flux



- **GRAND (10 Min)**

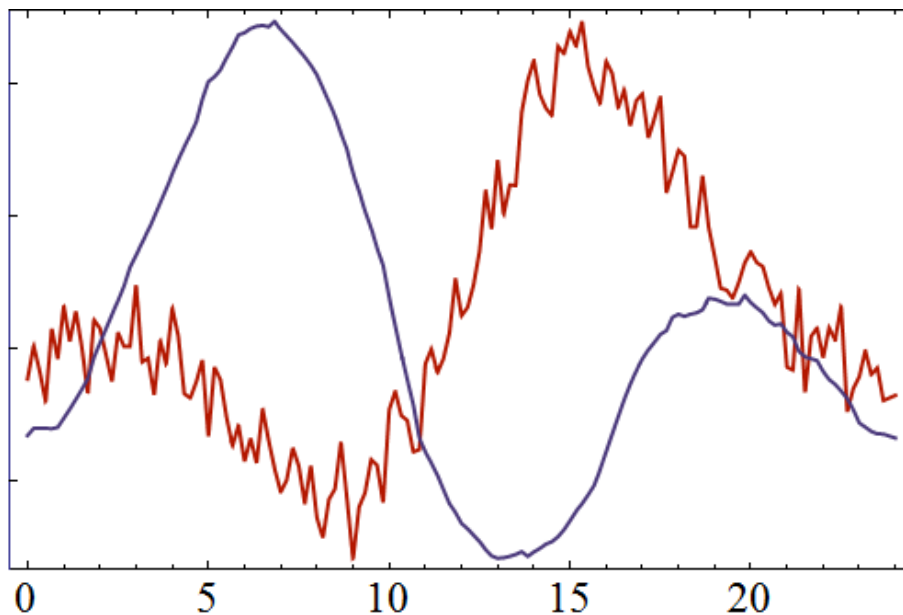
- **Top 4**



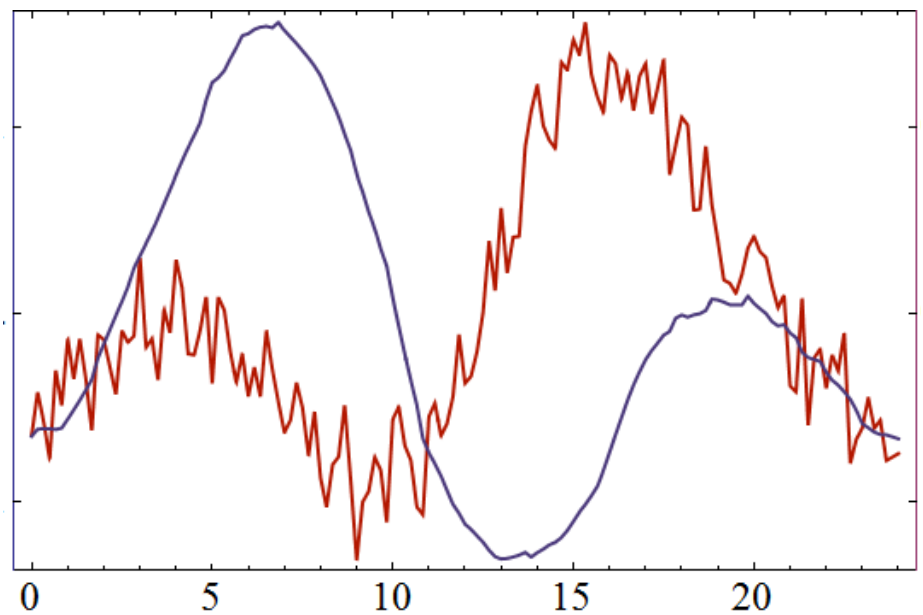
Atmospheric Pressure Effects



- **Atmospheric Pressure is inversely proportional to muon flux**
- **Pressure exhibits a periodic behavior at 1 and 2 cycles/day which is also seen in Muon data**



Uncorrected Muon Flux

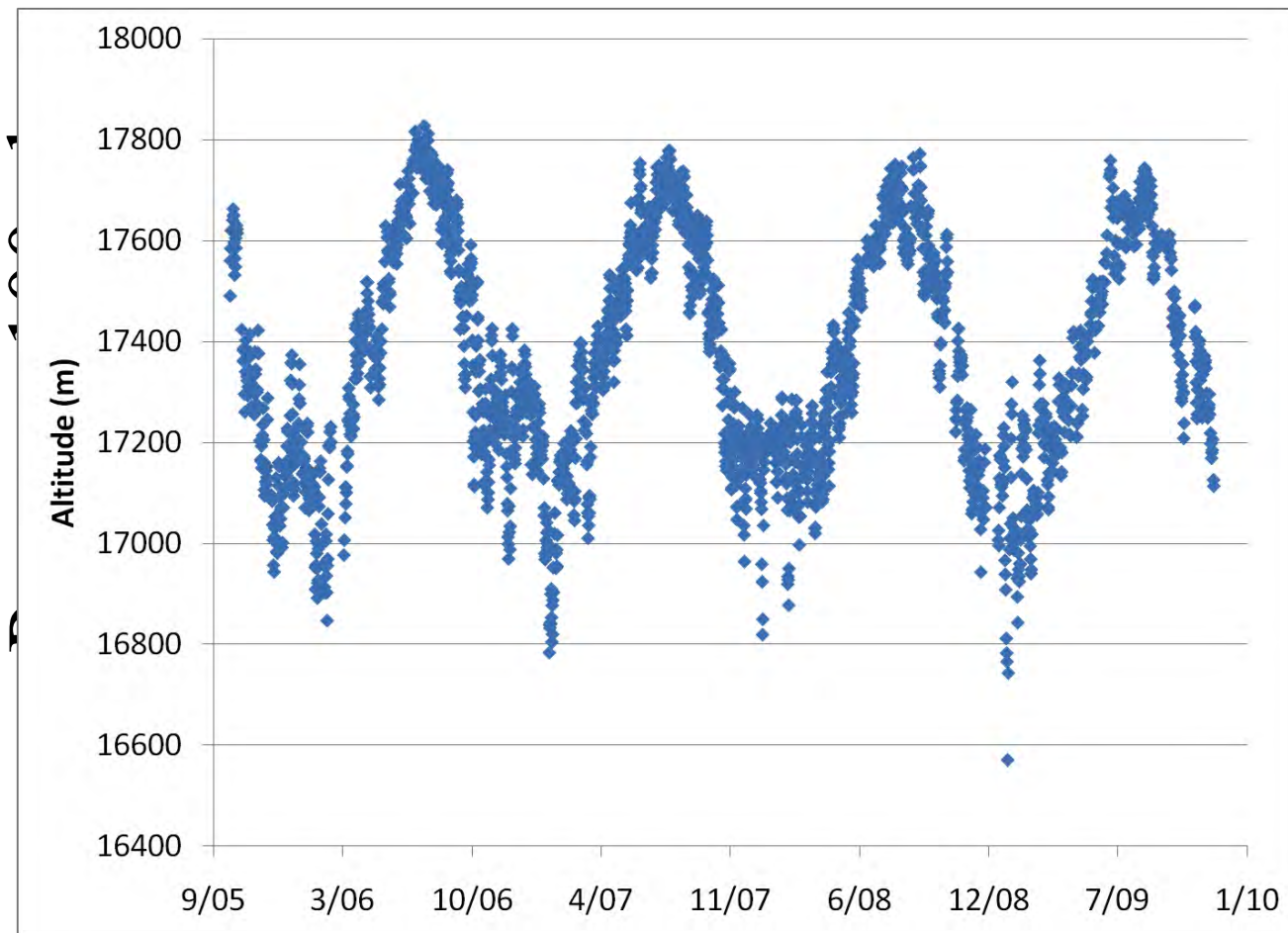


Corrected Muon Flux

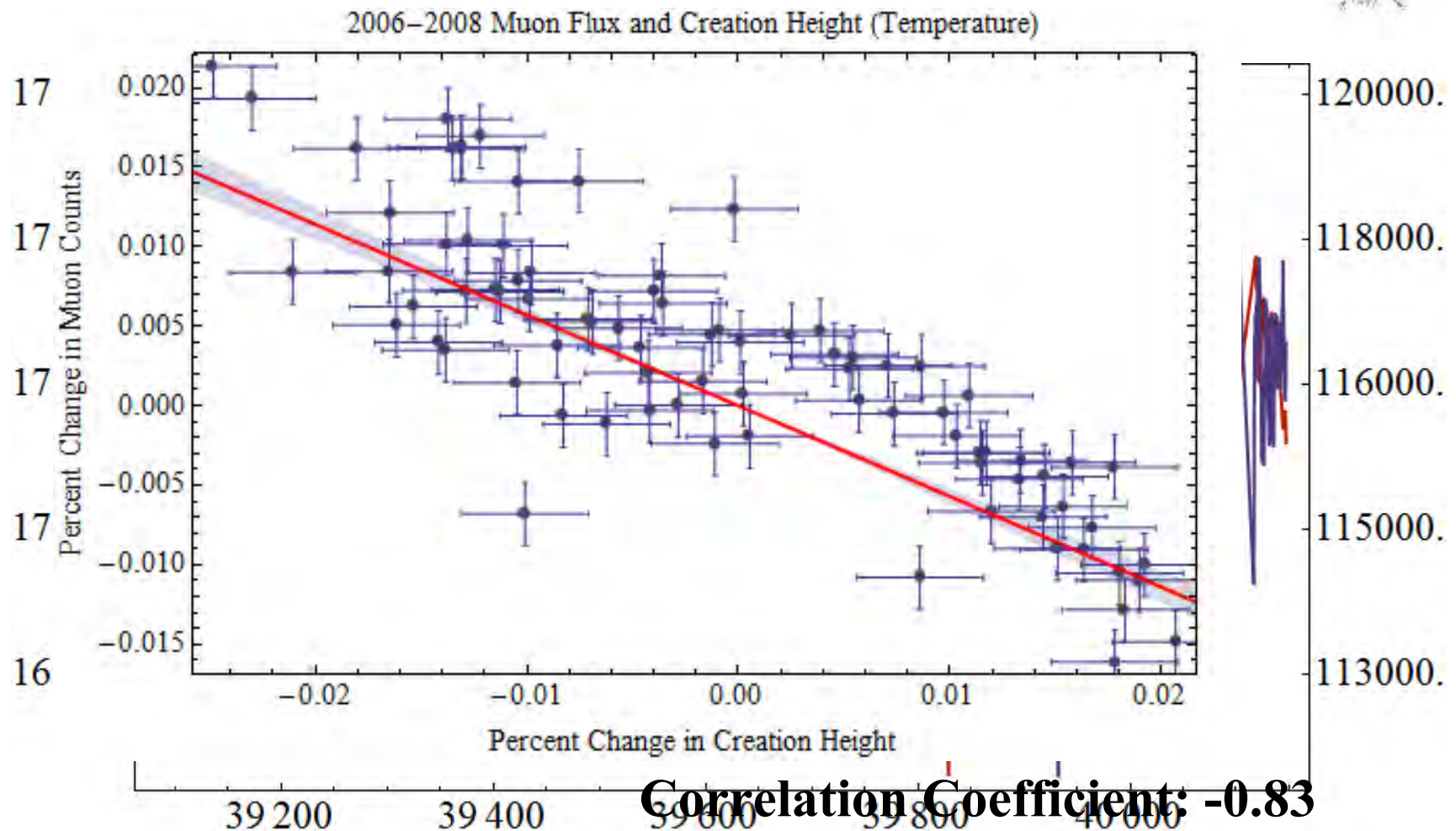
Atmospheric Temperature



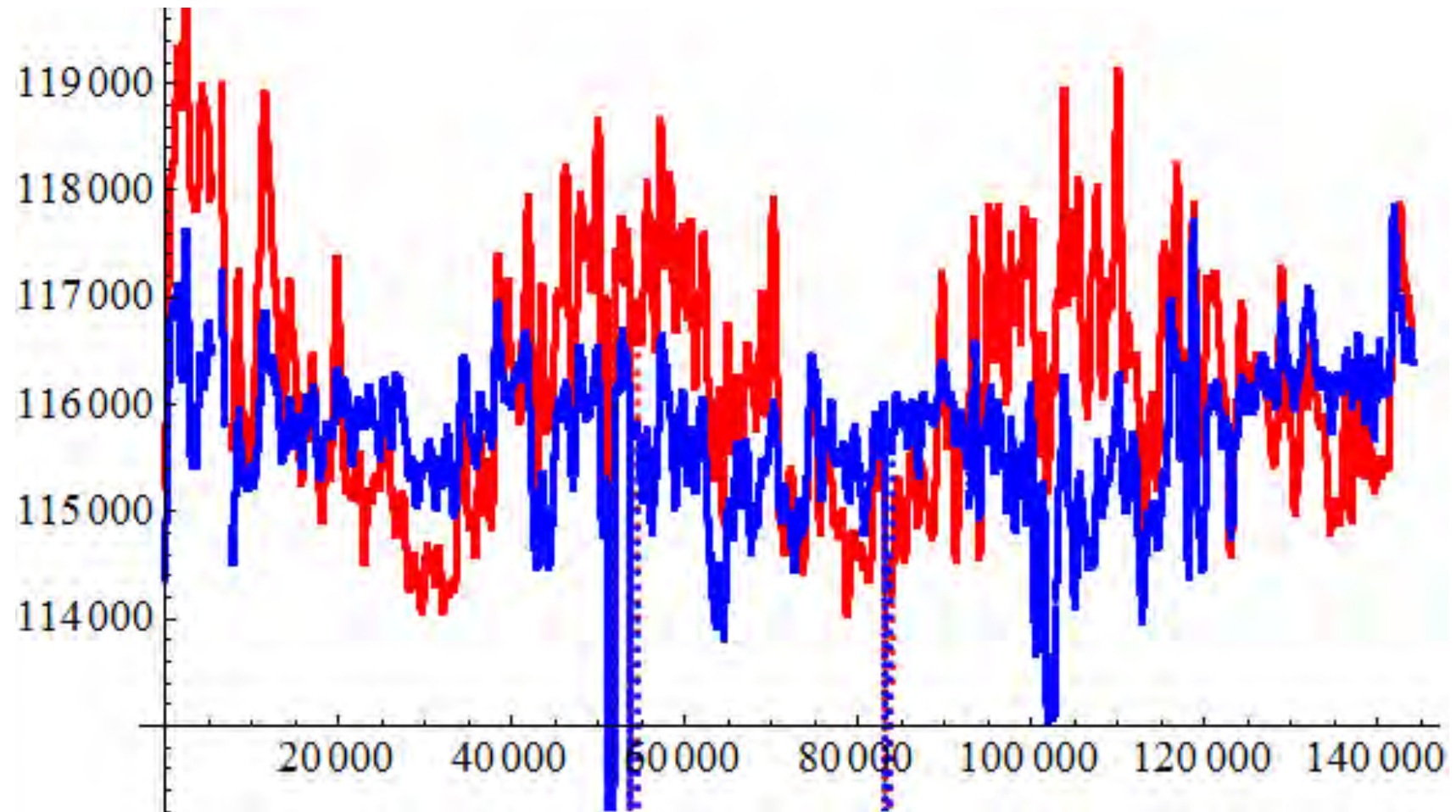
**Combine Atmospheric Profiles to form a
Pion creation height time series**



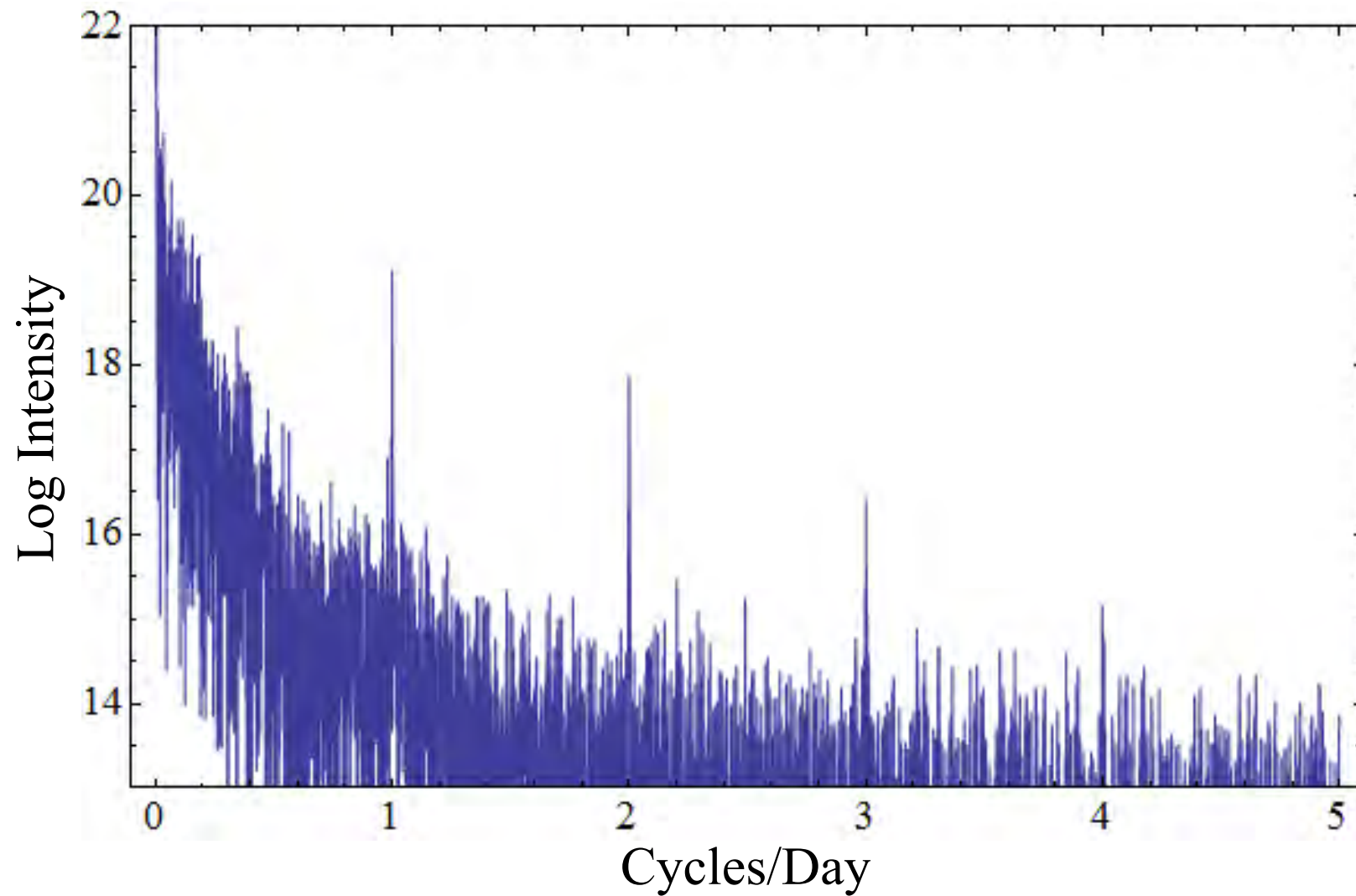
Temperature Effects



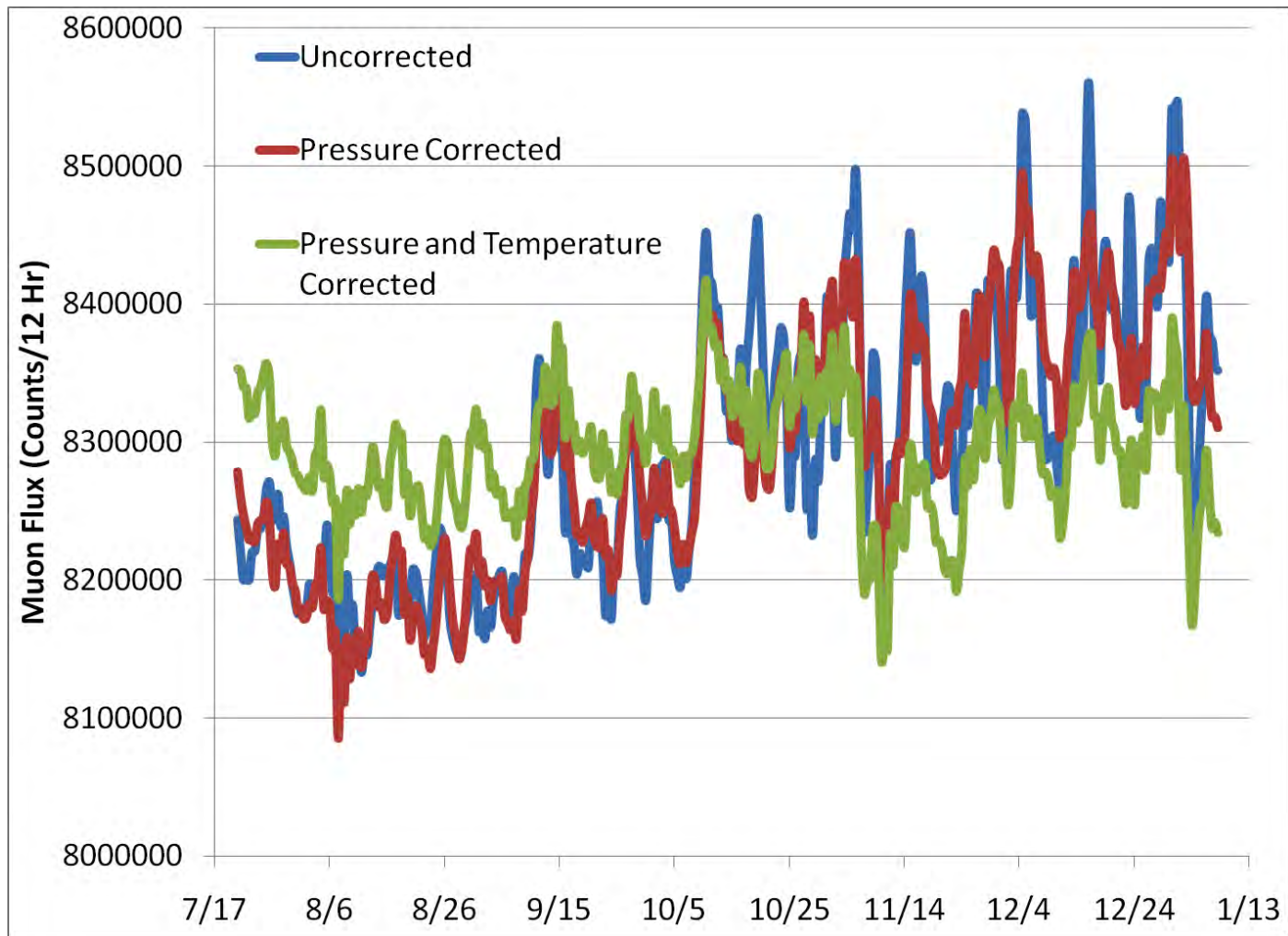
Corrected Data Set



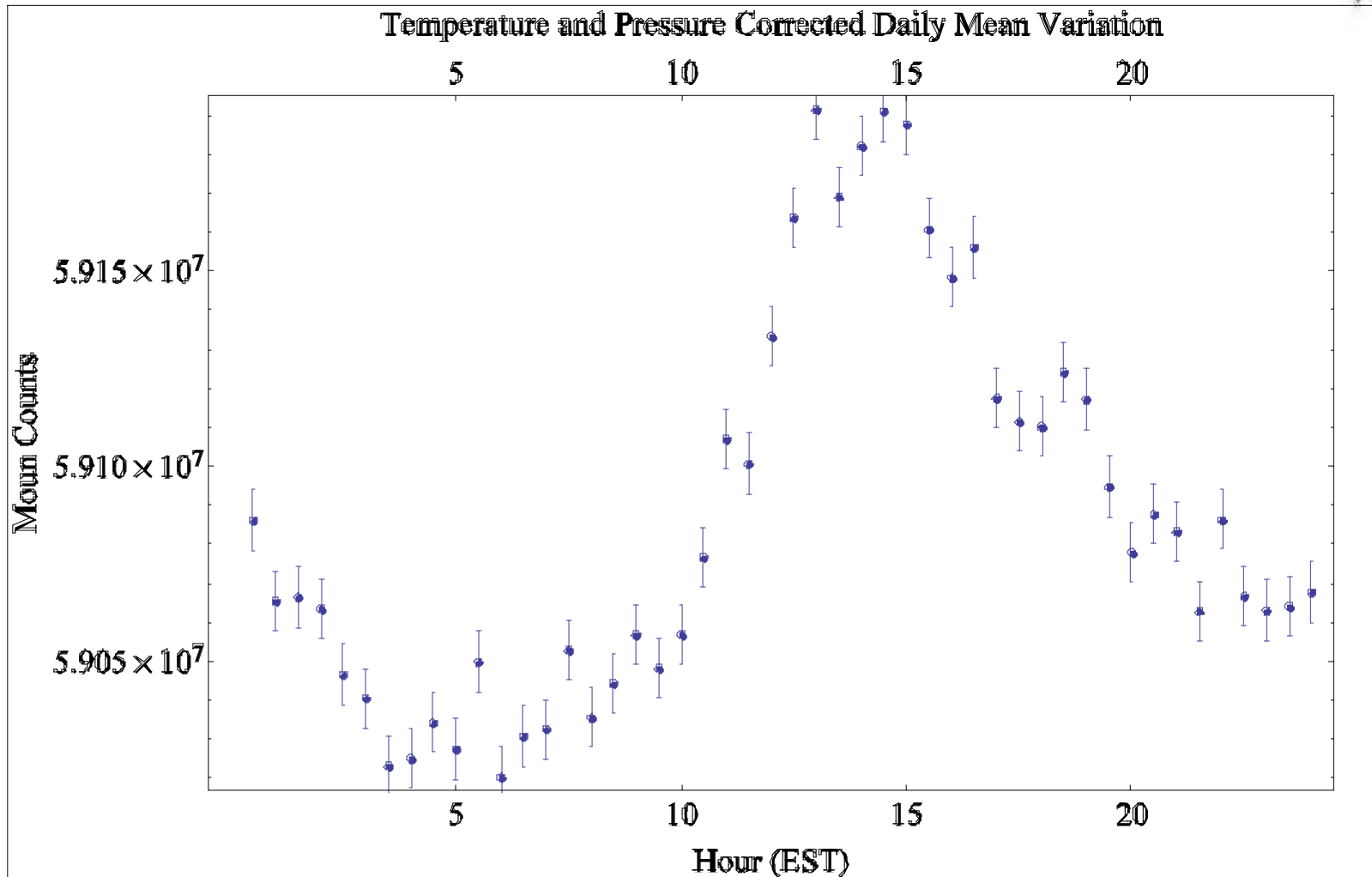
Flux Power Spectrum



July 2007 – January 2008



Daily Variation

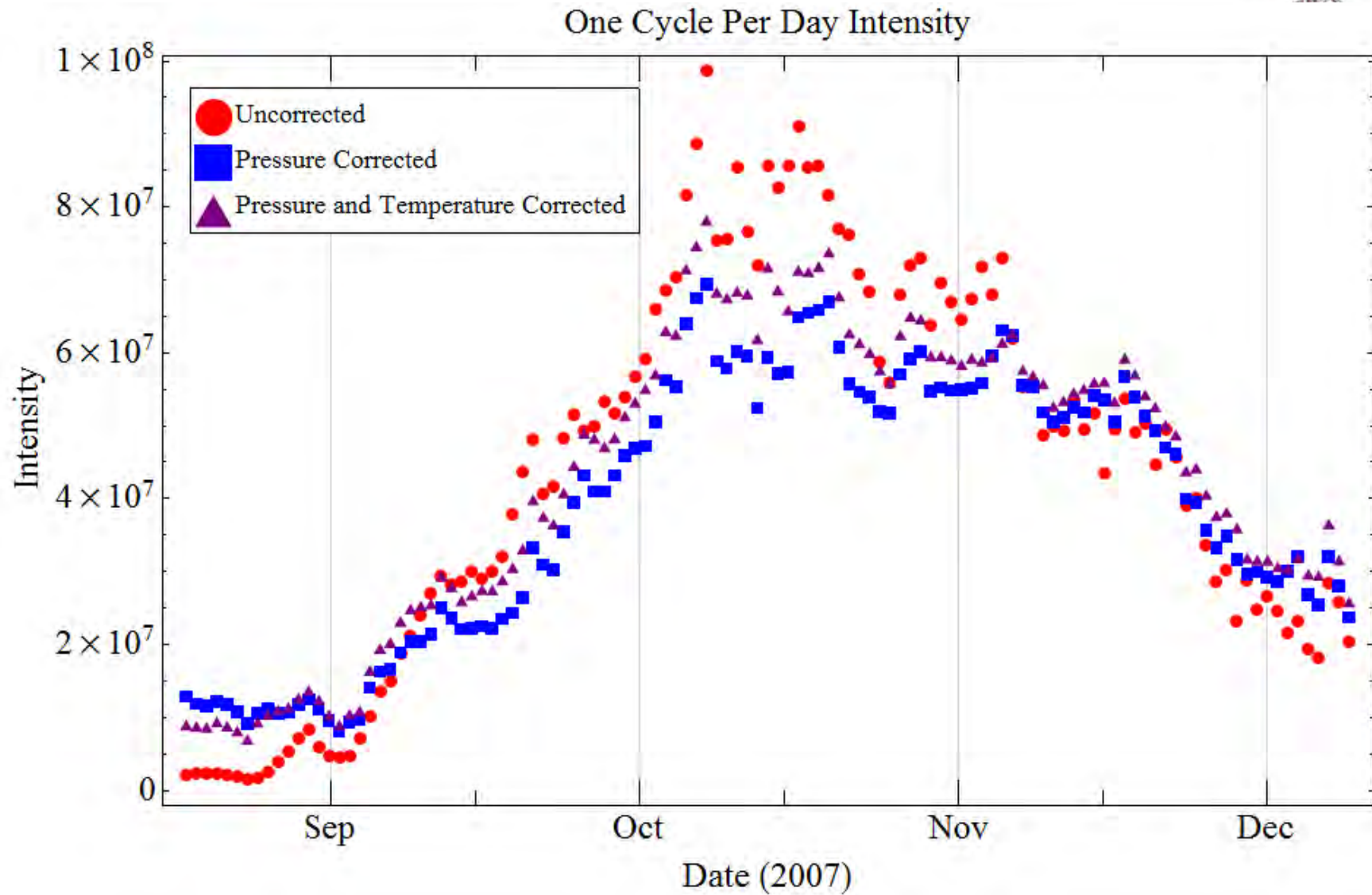


Observation of Seasonal Variations

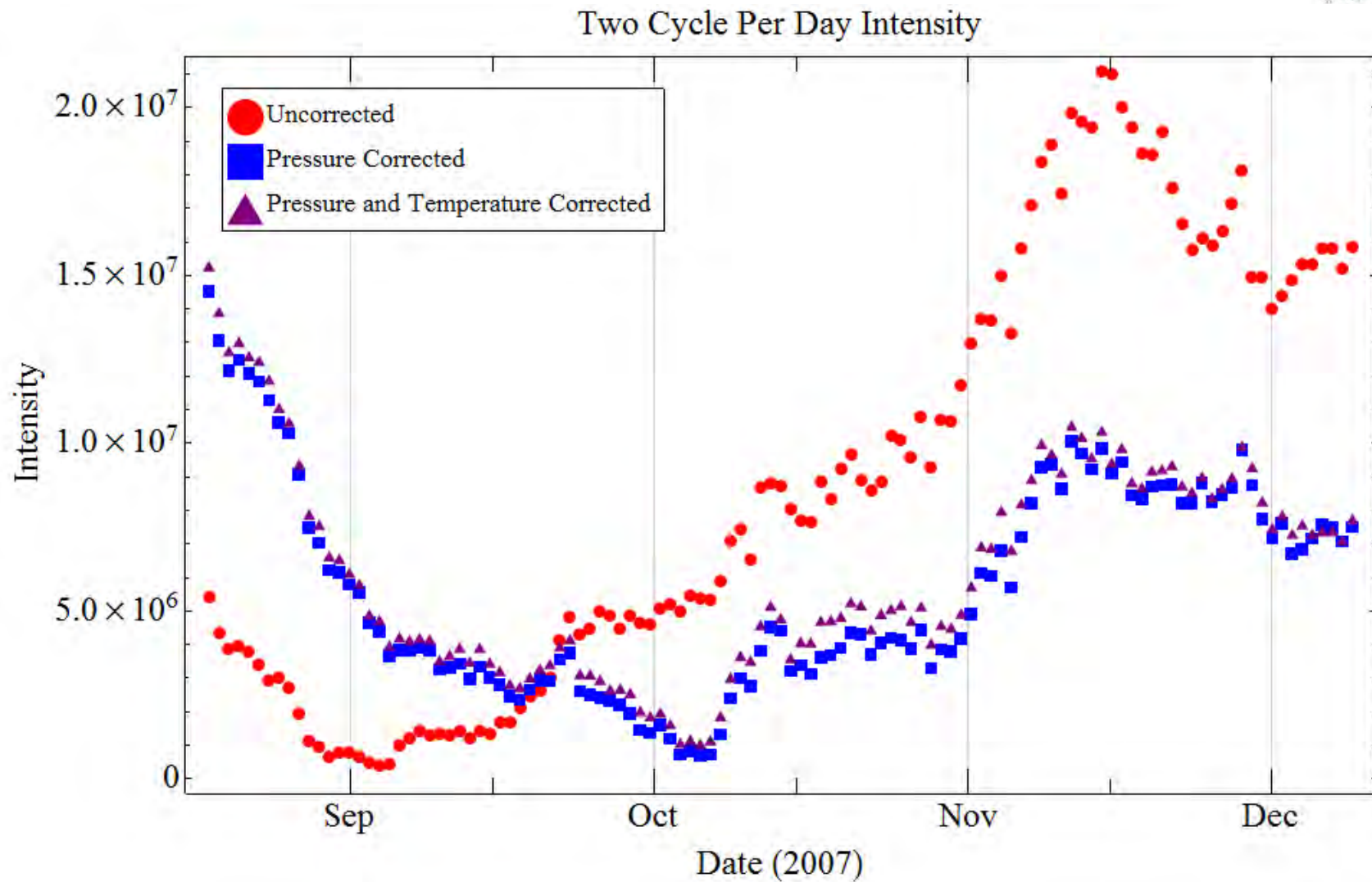


- **Fourier Series**
- **Show movie**

Observations of Season Variations



Observations of Season Variations



Conclusions



- **Conclusions**
 - Atmospheric trends can be observed and corrected for
 - A very small diurnal variations are easily observed in the dataset which also seem to evolve in time
- **Future Work**
 - Seasonal trends in the 1 and 2 cycle per day variations must be further quantified
 - Investigate the correlation with solar weather such as the Interplanetary Magnetic Field and Solar rotation
 - Explore atmospheric effects at high energy

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