The Influence of Shelter Temperature on Gain Stability of LWA1

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1 Introduction

Analyzing 24 hour beam observations pointed at the Northern celestial pole (NCP) and Zenith that were observed on November 22, 2013, revealed a time variable ripple pattern in the observed power levels that resembles the shelter temperature variations due to the air conditioning units cycling. The number of cycles/hour matched (4-5 cycles/hour, ∼12-15 min per cycle), thus a more direct comparison with the various temperature readouts that are recorded from within the shelter was made.

There are a range of temperature sensors at different locations in the shelter. The shelter temperature sensor is located at the rear wall in between the air outtake honey combs. Another set of sensors are located inside the chassis of the digital processor (DP), as well as, sensors for the surface and inside of the power supply units of the analog signal processor (ASP).

Visual comparison of the shelter temperature sensor and the observed power variations do not show to be a very good match, however the DP chassis 1 middle air intake sensor, as well as the surface temperature sensor of one of the ASP power supplies show a clear anti-correlation with the variation of the recorded beam power. Fig. 1 shows a scaled plot of ASP temperatures together with 42 MHz and 74 MHz beam power levels pointing at zenith (bandwidth 1 MHz each, split bandwidth filter).

From this plot dataset a beam power level change of **-0.024 dB/K** was derived. The largest contributor to this frequency dependence are the amplifiers of the ARX from which a temperature dependence of -0.01 dB/K is expected. However, additional contribution of ARX components as well as from the cables on the input side of the ARX and DP itself could be adding to the observed temperature-gain dependence.

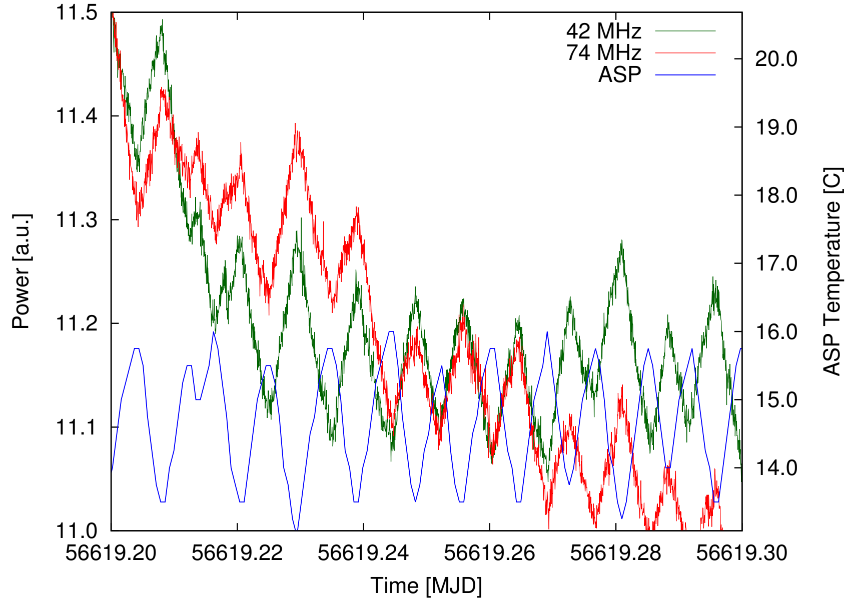

Figure 1: The blue curve, marked ASP, shows the temperature variations of the surface temperature of one of the ASP power supply units powering the frontend electronics. The red and green curves show the power level variation for the same stretch of time for XX polarization at 42 and 74 MHz pointing the beam at NCP.

2 Assessment of Impact from Shelter Temperature Variations

The temperature variations of a typical day are shown in Fig. 2. There are four states that in some cases can be all identified over the cycle of a single day.

1. Low-level HVAC cycling which depends on which of the two HVAC units leads. In this state the typical temperature fluctuations are $\pm 0.4°$ C.
2. High-level HVAC cycling. Then the temperature variations increase to around $\pm 2.0°$ C.
3. Icing-up of one or two of the HVAC units. This typically manifests in a stop of the cycling and a gradual or fast increase in shelter temperature. This can lead to signficant changes in shelter temperature of the order of $5°$ C.
4. When DP and/or ASP are turned off, the typical temperature fluctuations in the shelter are around $\pm 2.5°$ C.

Altogether, during normal operation the short term variations have an impact on observations of the order of ± 0.05 dB ($\sim$1.1%). For times of HVAC icing the influence on signal levels can exceed that of 0.1 dB ($\sim$2.3%).

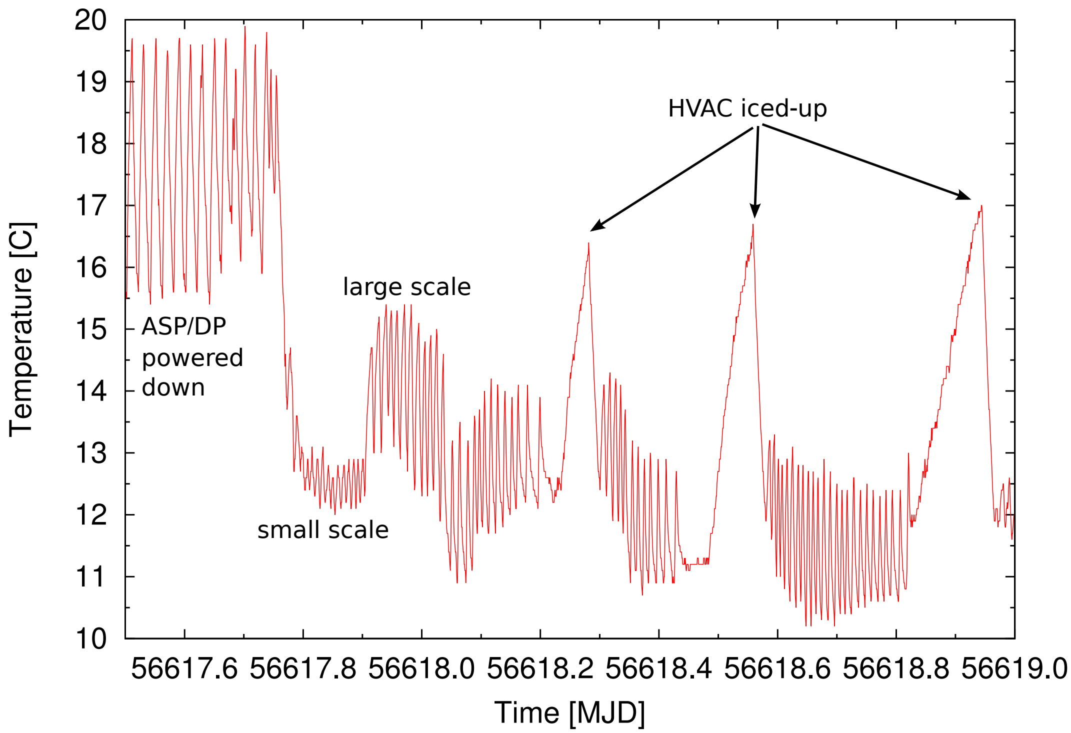

Figure 2: Example shelter temperature variation around November 22, 2013.

3 Correcting for Shelter Temperature Variations

Although, this temperature dependence might not be a significant concern for observers, however some high sensitivity projects might benefit from correcting for this power fluctuation in particular for long-term integrations. Comparing the different sensors present in DP and ASP shows almost the same temperature dependence with very little variation between them. For simplicity the ASP PSU 0x1E (powering the frontend electronics) case temperature was selected in order to use this information to remove the trend in temperature variations from the beam formed data. The temperature information for all sensors can be found at the LWA archive server[1].

The temperature sensor data was normalized and multiplied by -1 due to it being anti-correlated with the gain change and a value of 1 was added in order to make the net contribution zero:

$$Normalized\ T = \left(\left(\frac{T}{mean(T)}\right) \cdot -1\right) + 1 \tag{1}$$

After this the temperature data was resampled to match the sampling of the beam dataset. Then the resulting temperature data was subtracted from the beam data. Fig. 3

[1]url: http://lda10g.alliance.unm.edu/metadata/subsystem/

shows a plot of before and after the correction of the beam data. The correction reduced the signal fluctuations significantly. However, depending on the scientific requirements of some experiments one might want to evaluate the goodness of this correction and might try to apply a more sophisticated approach to correct for shelter temperature variations.

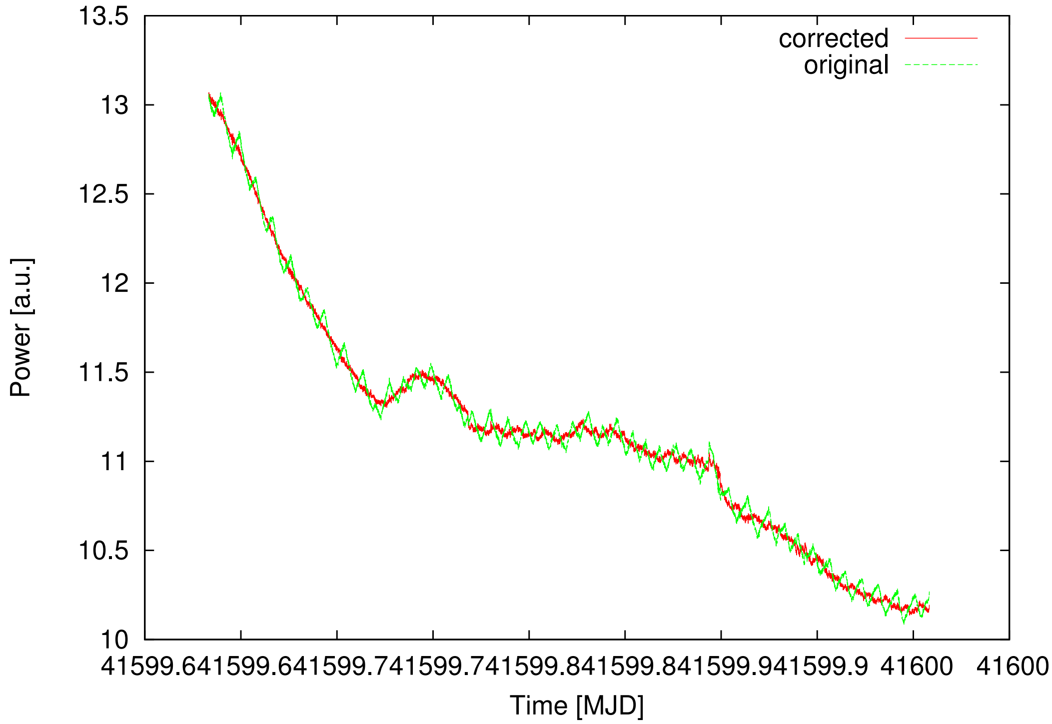

Figure 3: Example time variability of beam data for 42 MHz averaged over 1 MHz bandwidth for XX polarization pointing at zenith. The green line shows the original data, the red line is the data with the temperature variation measured by ASP subtracted.

4 Summary

It was shown the shelter temperature has a noticable influence on the measured power levels of the LWA1 beam data and presumably also other data products such as TBN and TBW captures. Although the influence is small, typically on the level of a few percent of the total power, some science experiments might require to take this effect into account. With the captured temperature sensor data from one of the ASP power supplies it was shown that most of the gain fluctuations introduced by the temperature changes in the shelter can be easily removed.