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Hannibal vapour cell replaced at Las Campanas in 2018 October

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Abstract

The toroidal transformer power supply in the weather module failed and was replaced. The transformer failure caused the supply fuse for the main electronics rack to blow, additionally removing power from all other modules including the thermocouple sensor amplifiers within the Hannibal spectrometer. Whilst the sensors were without power, the vapour cell oven became overheated and caused damage to the vapour cell. The cell was replaced with the last available spare. The two UPS devices were tested and both found to require new batteries.

Contents

1 Introduction

Steven Hale visited Las Campanas from 2018 October 12 to 22. The most recent previous visit was in 2017 November where the mount controller was replaced due to corrosion around some of the header connectors on the PCB causing erratic behaviour [1]. This visit followed a failure of the power supply in the weather module, with the aim to complete repairs to the module and to investigate the cause of low scattering counts that began while the site was offline due to the fault.

Section 2 first discusses the failure of the weather module, the repairs that were completed prior to the site visit, and repairs finalised during the visit. Section 3 details the installation of a new vapour cell and repairs to the oven temperature sensors that were required due to the oven becoming overheated when the power supply to the thermocouple amplifiers was lost. Finally, Section 4 discusses tests of both UPS units and logs the need for replacement batteries.

2 Weather Module Repairs

On 2018 August 7 the toroidal transformer in the weather module failed. The primary windings were shorted and caused the fuse in the main electronics crate to blow, taking all modules in the crate offline. Many modules have been replaced with newer independent devices. The remaining modules are dome control (positioning and weather monitoring), EOLM control output to the counters, and the Hannibal thermocouple temperature interface to the temperature controller and monitor. Without these modules the entire site was offline.

On 2018 September 13 a new Block RKD 30/2x12 toroidal transformer (RS 752-9356) was installed. All modules came back online, except an ongoing fault with the weather module caused a constant shutter drive UP signal to be output to the relay box. The relevant schematics can be found in the weather and relay box network manuals [2, 3]. During the installation of the transformer, a loose wire was noticed and accidentally reconnected at the wrong point in the circuit. The wire for the shutter UP drive signal was connected to the ground pin of the output line driver transistor, rather than the switched output pin, resulting in the constant UP request. During this visit, the signal wire was moved to the correct output pin. All dome positioning and rain monitoring was tested and confirmed operational.

3 Hannibal Potassium Cell

Whilst the main electronics crate was without power due to the fault with the weather module, an additional failure occurred that caused catastrophic damage to the potassium vapour cell and oven.

In 2015 April the original temperature controller for Hannibal was replaced with one our new digital controllers [4, 5]. The design and construction of Hannibal is described in BTR-105 [6]. The thermally controlled components originally used two temperature sensors per channel. There was a thermistor which was connected via a Wheatstone bridge to produce a temperature error signal, and a thermocouple to log the temperature directly. In the newer instruments we use LM35 and AD590 temperature sensors that are directly connected to the temperature controller. In order to simplify installation of the new controller, the existing thermocouples were used rather than replace and rewire all of the old sensors. The thermocouple amplifiers remain powered via a module in the main rack. If the thermocouples are disconnected then the temperatures go outside expected ranges allowing the controller to detect this as an error condition and disable the drive outputs. However, if the thermocouples remain connected but power to the amplifier board is lost, as during the weather module fault, the temperatures remain stable within expected parameters. The controller cannot detect this as an error condition and simply sees temperatures that are not at the expected set-points, resulting in maximum power eventually being supplied to the heating or cooling elements. The potassium vapour cell oven became massively overheated for several days causing irreparable damage to the vapour cell itself.

There are two spare potassium vapour cells on site, and a third cell that is labelled “Na?” indicating that it may be sodium. The two spare potassium cells are slightly different in size. One has a stem that is slightly thicker and slightly shorter than the other. Both cell cubes are identical. The cell with the thicker stem matches the damaged one that was removed from Hannibal, and so this was used as the replacement. The cell with the thinner stem matches the spares that we have at Birmingham. We no longer have any spare cells that match the thicker stem used in Hannibal.

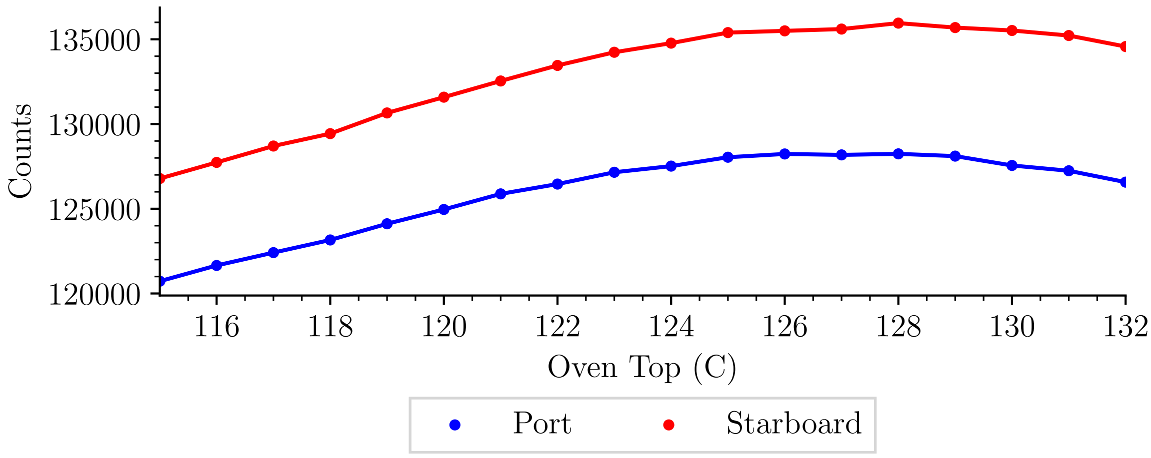

Figure 1: Hannibal oven top temperature scan completed on 2018 October 17.

The new cell was installed and the oven reassembled. There were no spare thermocouples available, and also no stock of LM35 or AD590 sensors to replace them. The oven stem thermocouple was able to be reused. A second thermocouple was recovered from the Hannibal baseplate sensor channel, and used as the oven top sensor. The Hannibal oven is of the older design where only the cell cube top is thermally controlled. The stem of the cell floats with a temperature gradient that is partially determined by a metal collar around the stem that is in contact with the oven base. The thermal gradient across the cell is adjusted by moving the position of the collar; further down and the stem temperature is lower (larger gradient), further up and the the stem temperature is higher (smaller gradient). The process to optimise the gradient is time consuming because the oven has to be removed and everything disassembled to adjust the collar. It then takes an hour or so when reassembled for the oven to heat and come to thermal equilibrium before the new gradient can be determined. The thermal gradient between the cell cube top and the stem is typically of the order of 20 °C. The most critical temperature is the cell stem since this controls the potassium vapour pressure. The cell cube simply needs to be hotter than the stem to ensure the solid potassium remains in the stem and does not undergo deposition onto the cell windows. This means the old style spectrometer design is poor, since the wrong part of the cell is thermally controlled. The newer designs have both top and stem control, meaning it is possible to directly define the desired temperature gradient and obtain better stabilisation of the vapour pressure.

Previously the cell has been operated at 128 °C at the cube, and between 96 °C to 99 °C at the stem varying with ambient temperature. At other sites the cells are typically operated between 110/90 °C and 120/100 °C with the optimum depending on scattering detector aperture size. A scan over a range of temperatures was completed, with the results shown in Figure 1. The scan suggests that 127 °C for the cube, resulting in 97 °C at the stem is the ideal temperature, and this matches what was determined previously with the old cell. The cell cube temperature is higher than usually expected due to the 30 °C thermal gradient between the cube and the stem and the lack of direct stem thermal control. A lower gradient would allow the 97 °C stem temperature to be achieved at a reduced cell top temperature. Many attempts were made at adjusting the stem collar to change the gradient, but 30 °C was the best gradient achieved with all other attempts being either much too low or much too high.

The hot to cold ratio is 14 for the starboard detector and 13.6 for the port detector, which is exceptionally good. Figures 2, 3, 4, and 5 show data from the last four days of the site visit. The five-minute Figure-of-Merit (FOM) is greater than 100 and this is better than has typically been achieved since 2012, producing a noticeable improvement in data quality.

To try to prevent this happening again if the thermocouple amplifier fails, the current limit for the oven has been set to just 20 %. At equilibrium at 127 °C the oven runs at approximately 16 % power, and so even if operated continuously at 20 % it would not become significantly overheated. A disadvantage to this lower power limit is that the oven takes longer to heat and stabilise from cold, since it does not have access to higher power during the heating phase. On the next visit, all five temperature sensors should be replaced with new LM35 and AD590 sensors and the thermocouple amplifiers removed. It would also be a good time to install the second oven channel heater to directly control the cell stem temperature, and so provide an improvement in low frequency stability.

4 UPS Batteries

Both UPS units were tested and found to provide zero seconds of backup power, and both need replacement batteries as a matter of urgency. The smaller 1000VA unit that supplies the computer has turned itself off twice despite continuous mains supply. This could be due to the failed battery, or could indicate a fault with the UPS itself. The computer has been moved to the normal mains supply until the UPS is functional again. The dome remains operational without a backup supply to close the shutter during a power failure.

References

[1] Hale, S. J. Mount controller repairs at Las Campanas in 2017 November. *BiSON Technical Report Series,* Number 386, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2017. URL `http://epapers.bham.ac.uk/3137/`. [page 1]

[2] McLeod, C. P. Weather. *BiSON Network Manual*, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 1990. [page 2]

[3] McLeod, C. P. Relay Box A. *BiSON Network Manual*, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 1990. [page 2]

[4] Hale, S. J. The Hannibal Temperature Controllers. *BiSON Technical Report Series,* Number 372, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2015. URL `http://epapers.bham.ac.uk/2067/`. [page 2]

[5] Hale, S. J. New temperature controller for Hannibal in Las Campanas in 2015 April. *BiSON Technical Report Series,* Number 373, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2015. URL `http://epapers.bham.ac.uk/2068/`. [page 2]

[6] Wheeler, S. J. All You (n)Ever Wanted to Know About the Chile Spectrometer. *BiSON Technical Report Series,* Number 105, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 1999. [page 2]

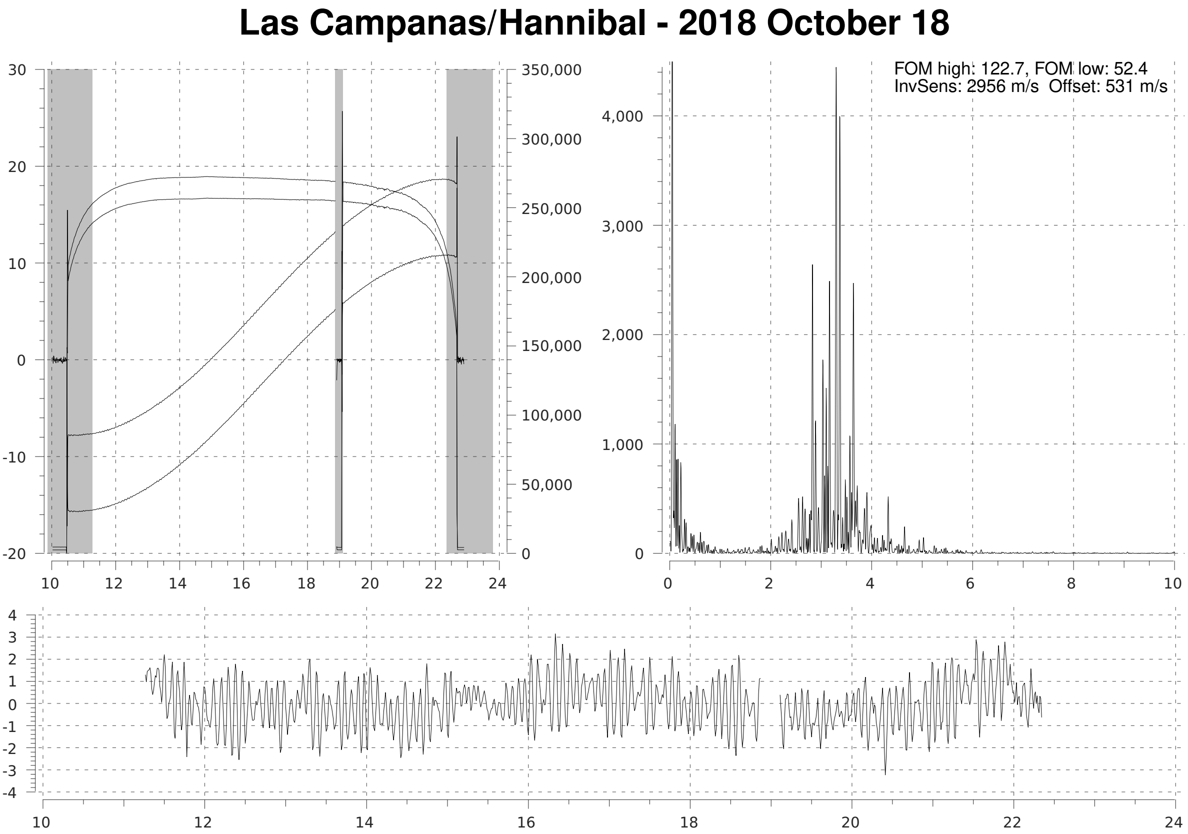

Figure 2: Data from Hannibal for 2018 October 18.

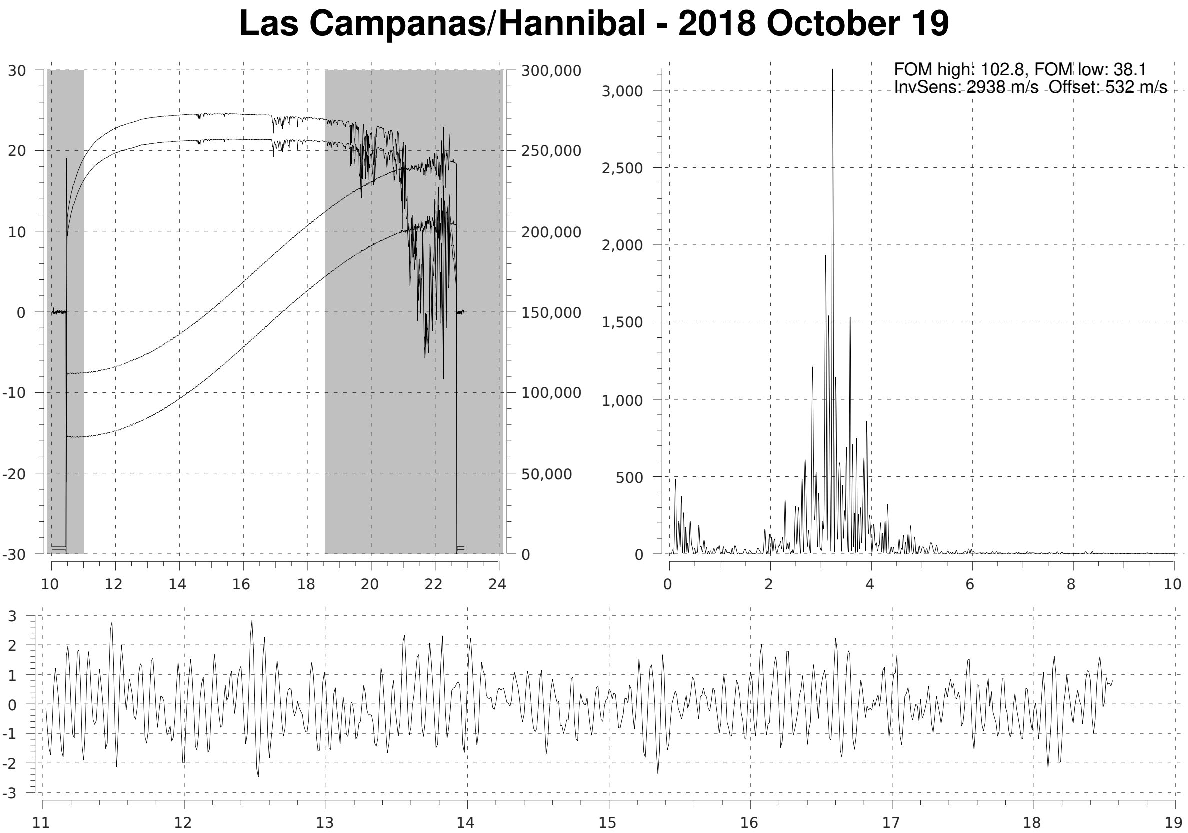

Figure 3: Data from Hannibal for 2018 October 19.

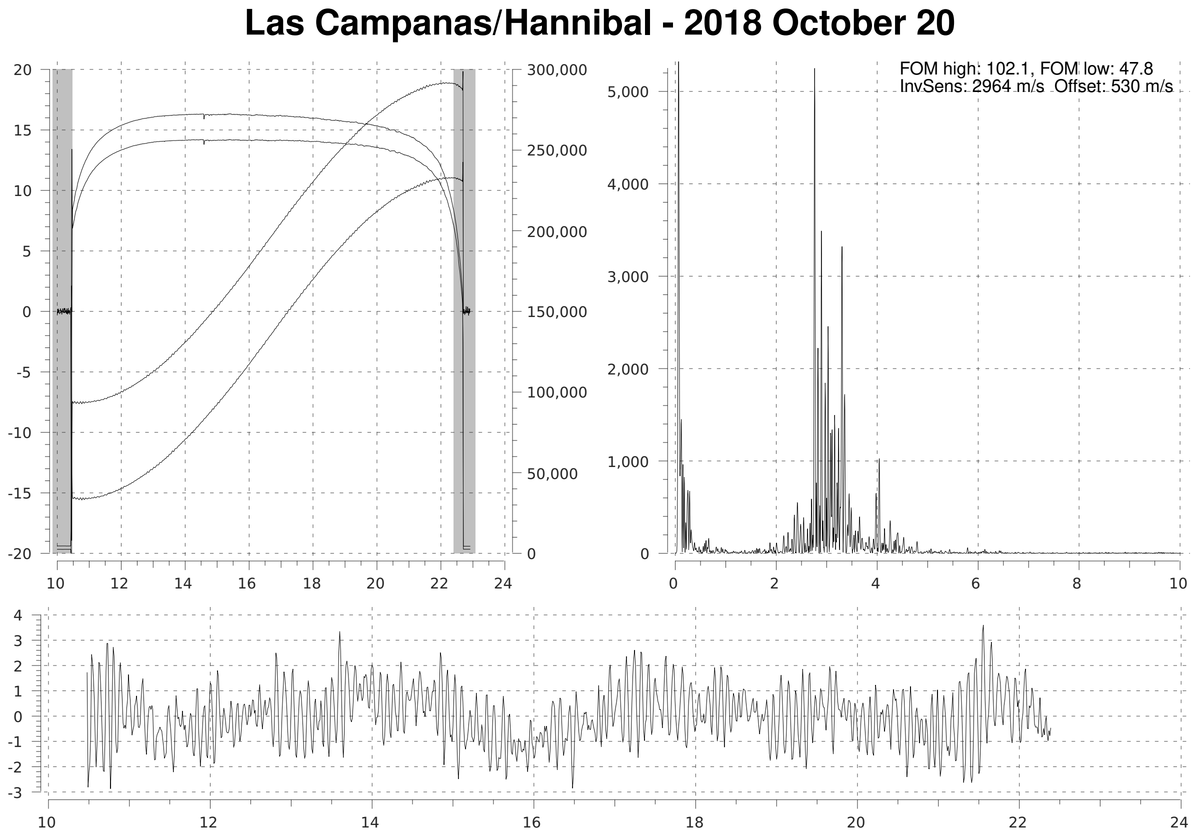

Figure 4: Data from Hannibal for 2018 October 20.

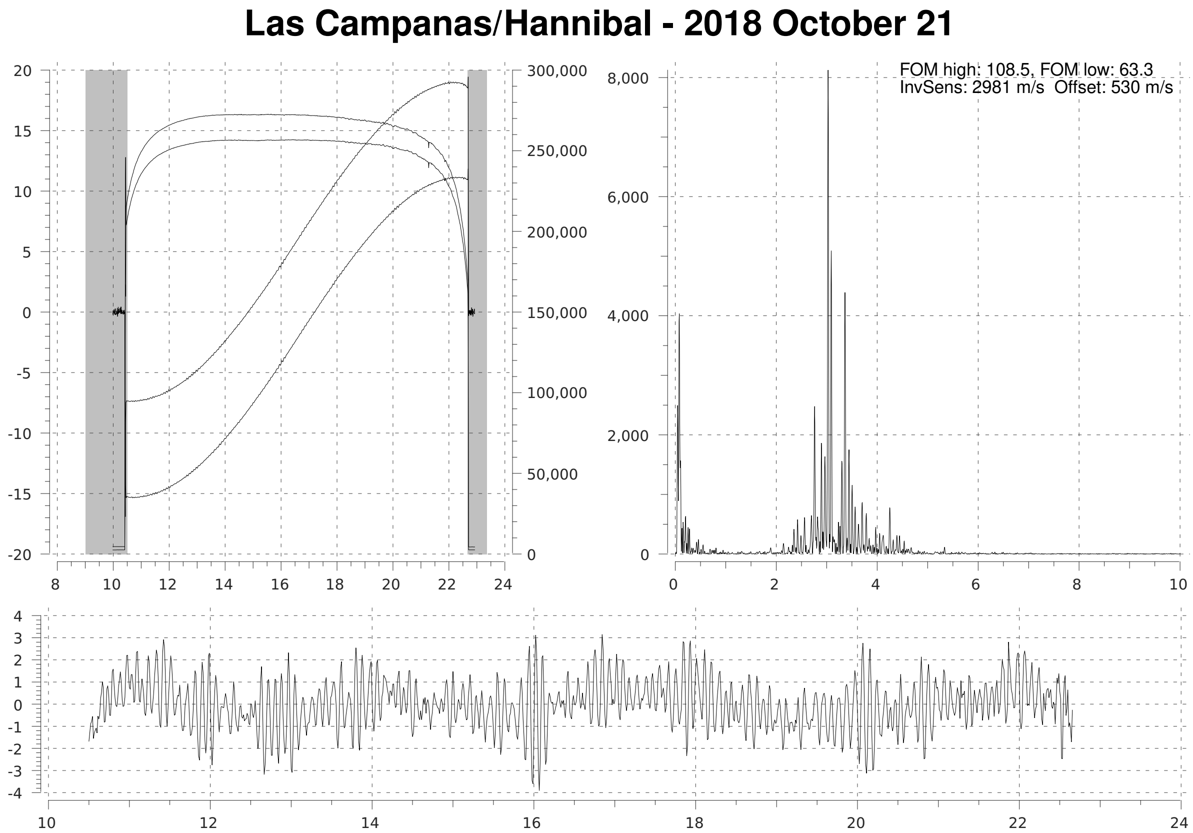

Figure 5: Data from Hannibal for 2018 October 21.