BiSON Birmingham Solar-Oscillations Network

TECHNICAL REPORT NO. 384

Fibre-feed tests at Izaña in 2017 May

Steven J. Hale
The University of Birmingham, Edgbaston, Birmingham B15 2TT

2017 September 29

This technical report series is published by:

THE UNIVERSITY OF BIRMINGHAM

High-Resolution Optical-Spectroscopy Group

School of Physics and Astronomy
The University of Birmingham
Edgbaston, Birmingham B15 2TT, United Kingdom
Telephone: +44-121-414-4551

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Abstract

A new fibre-based spectrometer was commissioned from 2017 May 8 to May 26. The system was initially commissioned using the light feed from the secondary cœlostat on the lower-level platform in the main observing room of the solar pyramid building. Limited operational time was achieved in this phase due to bad weather. At the end of the site visit the whole system was moved into the apex of the pyramid sharing light from the primary cœlostat with the Mark-I spectrometer, and remains running in this configuration. Data from the spectrometer suffers from poor low- and high-frequency noise that are thought to be caused by the size of the solar image formed on the end of the fibre.

The guiding performance of the Skywatcher mount was tested when operating via a Raspberry Pi single-board computer, and results are consistent with earlier tests at Mount Wilson. No issues are expected with the use of the low-power system.

Contents

1 Introduction

This is the first of a two-part report on a two-stage visit to Izaña. Steven Hale visited Izaña from 2017 May 8 to May 26. The second-stage visit was completed in 2017 September and is reported in BTR385 [1]. Prior to this site visit, the last visit to Izaña was in 2012 October to replace a failed data acquisition computer for Mark-I [2].

The purpose of this visit was to begin the initial testing of a prototype optical-fibre based spectrometer. Some fibre testing was carried out at Mount Wilson during 2016 September, where spectrometer-K ("Klaus") was temporarily modified to accept a fibre input and run with fibre collection optics fitted on a consumer-grade Skywatcher HEQ5-Pro motorised mount [3]. On this visit the testing included the commissioning of a new spectrometer designed specifically for use with fibre-feed input, in addition to the use of the inexpensive Skywatcher mount.

Much of the first half of the site visit was spent on hardware commissioning, and marred by bad weather. Initial setup of the spectrometer was in the main observing room of the solar pyramid building, making use of the light feed from the secondary cœlostat on the lower-level platform. The Skywatcher mount and control electronics arrived at the end of the first week, and were set up outside whilst continuing to run via the cœlostat. Due to delays in manufacturing a weather-proof housing for the mount, at the end of the visit the new spectrometer was moved up to the pyramid apex and continues to operate sharing light from the Mark-I cœlostat.

It is not intended that this technical report provide significant detail on the hardware design or the software controlling the new data acquisition system — this will be published in later reports. The intention of this trip report is only to log the work completed and to present the initial results of the performance tests. Section 2 provides a log of events and configuration information, and discusses performance problems. Section 3 discusses performance of the Skywatcher mount when running on the Raspberry Pi including comparison with expectations from previous tests.

2 Trip Log and Data Quality

The spectrometer and mount were sent out to Izaña via DHL in two separate shipments, approximately one week apart. The first shipment was on site at arrival, and the mount arrived about a week later as expected. The spectrometer was initially setup in the main observing room of the solar pyramid building, making use of the light feed from the secondary cœlostat on the lower-level platform, whilst waiting for the dedicated mount to arrive. Whilst setup took only a few days, cloud and strong wind prevented observing until May 13.

The cœlostat on the lower platform sometimes has trouble guiding and requires the system to be aligned and reset. The primary mirror also vibrates in strong wind with approximately an arcminute of oscillation which is large in comparison to our typical guiding accuracy of a few arcseconds [3, 4]. Since the fibre-feed makes use of an 80 mm focal length lens to focus a 1 mm image of the Sun onto the end of the 1 mm fibre, it was considered that the wind-induced oscillation was causing some noise issues experienced in the data. The fibre-feed was moved from the cœlostat onto the more-stable Skywatcher mount on May 19.

The first few days of observation were taken at high-cadence in an attempt to measure atmospheric scintillation noise. The data acquisition system is based on a Raspberry Pi single-board computer and three Texas Instruments ADS1210 24-bit ADCs. These were configured to run at a 1 kHz sampling rate and used our normal 4-second period for logging, which resulted in 3000 samples taken over 3-seconds followed by almost 1 second to write out to disk. The polarisation state is switched using an LCD retarder at 5 Hz. Unfortunately the polarisation switching and dead time proved to add complications to the scintillation noise measurement making it unreliable. A second more successful attempt at measuring scintillation noise is described in BTR385 [1]. The data acquisition was re-configured and finalised to the normal 4-second cadence on May 20, and only May 20 onward is presented here. The following is a log of the key events during the last third of the site visit.

2.1 2017 May 20

Shown in Figure 1. At 09:00UT the hot-to-cold ratio was measured to be 7.7 for scattering detector-1 and 8.5 for scattering detector-2. This is very good. At approximately 12:00UT the transmission monitor was covered up and so removed from the optical path. The scattering counts dropped a little, indicating that some back reflections are making it into the cell, and the ratio changed significantly. Unfortunately neither the low frequency or high frequency noise improved, and so while back reflection is clearly an issue it is not causing the noise problems.

2.2 2017 May 21

Shown in Figure 2. At the beginning of the day an attempt was made to improve the focus of the objective lens onto the end of the fibre, and also to improve the alignment onto the fibre. The high frequency noise appears to have improved a little but the low frequency issues are still present. The image appears very slightly larger than the 1 mm diameter fibre, and this is causing vignetting of the solar disc which is almost certainly the cause of the low frequency problems.

2.3 2017 May 22

Shown in Figure 3. Pere visited and discussed the design and the noise problems. The mount was operating for only a hour in the afternoon.

2.4 2017 May 23

Shown in Figure 4. No data due to clouds.

2.5 2017 May 24

Shown in Figure 5. All the hardware was moved up into the apex of the pyramid. Due to delays in manufacturing a weather-proof housing for the Skywatcher mount, the option of sharing light from the Mark-I cœlostat is the only way to allow the system to continue operating past the end of this site visit. The Mark-I cœlostat is smaller than the cœlostat on the lower platform which means that it has better mirror stability in windy conditions. The guider system is also better, and due to being positioned at the top of the pyramid has a wider field of view than the lower cœlostat.

2.6 2017 May 25

Shown in Figure 6. At approximately 09:30UT the isolation of the transmission monitor was improved by pushing some blackout material into the exit aperture of the oven/magnet. This made things worse and appeared to increase the back reflections into the cell.

2.7 2017 May 26

Shown in Figure 7. At approximately 07:30UT the material was removed from the oven/magnet and the transmission monitor covered separately with a strip of blackout material.

2.8 Summary

The measured velocity ratios appear to be slightly lower than measured by Mark-I, and this lower sensitivity is expected due to using a 0.3 T magnet rather than the ideal 0.18 T normally used for the scattering cells. The system remained operating after the site visit in the configuration as of May 26. The low and high frequency noise problems are almost certainly due to issues with the solar image size on the end of the fibre, and this was addressed in the second stage site visit in 2017 September reported in BTR385 [1].

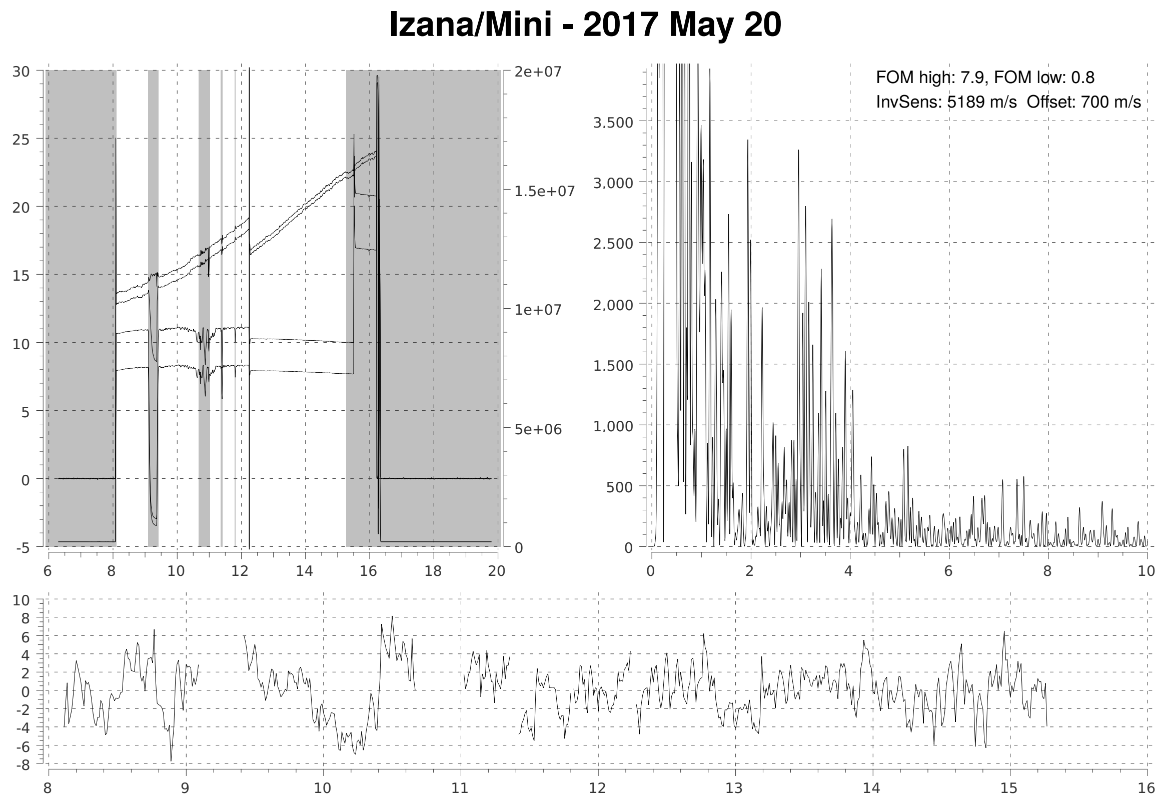

Figure 1: 2017 May 20 running on the Skywatcher mount. The step-change at approximately 12:00UT was due to the transmission monitor being covered up and removed from the optical path.

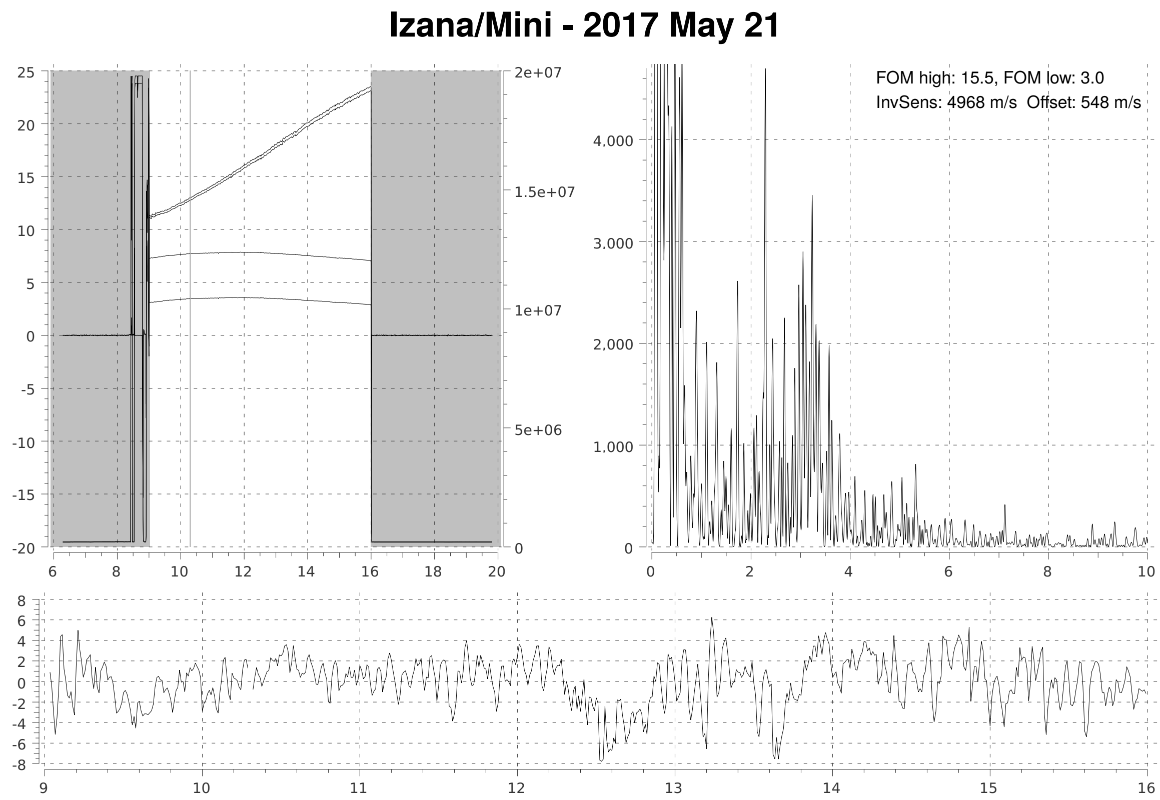

Figure 2: 2017 May 21. Data from the Skywatcher mount.

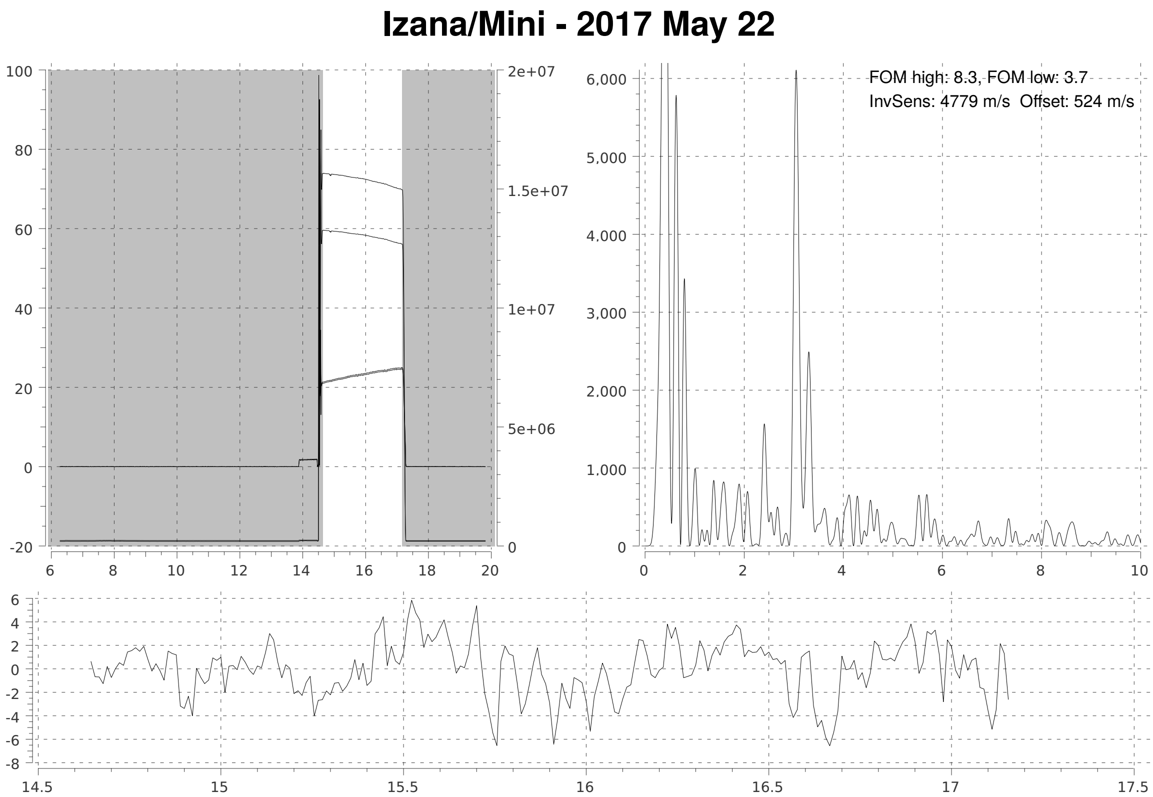

Figure 3: 2017 May 22. Data from the Skywatcher mount.

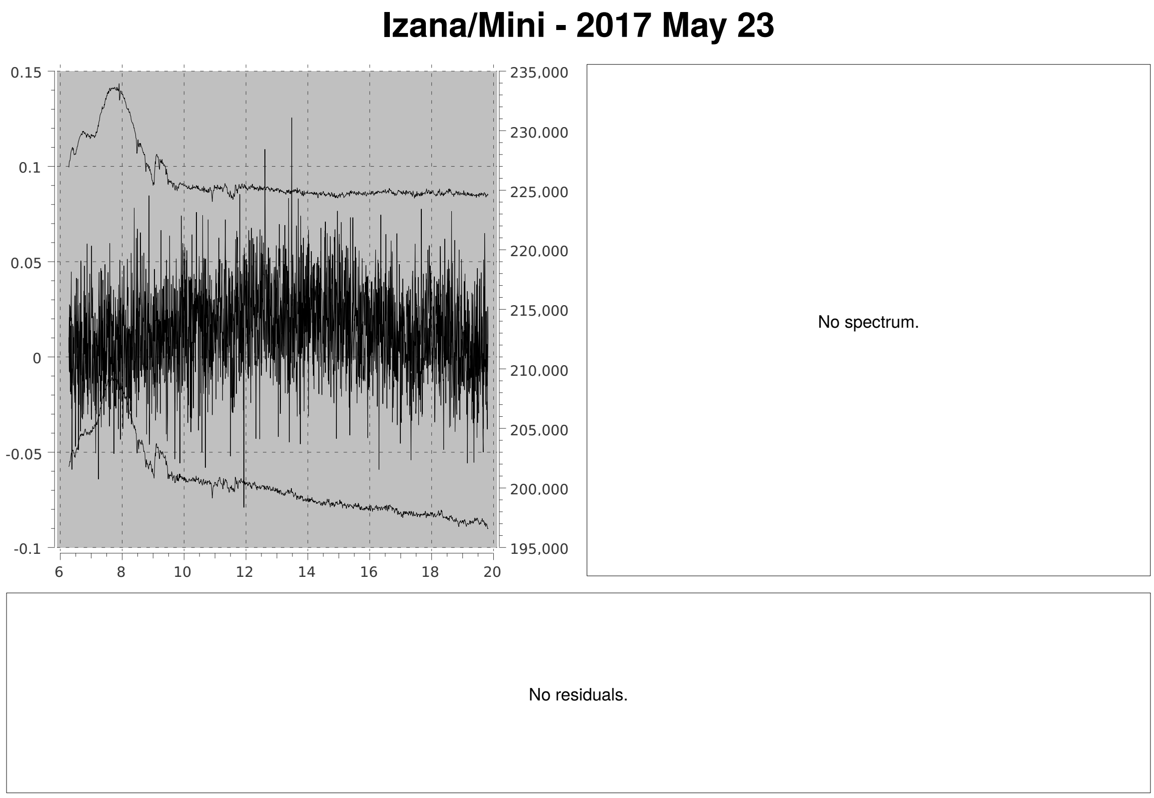

Figure 4: 2017 May 23. Cloudy.

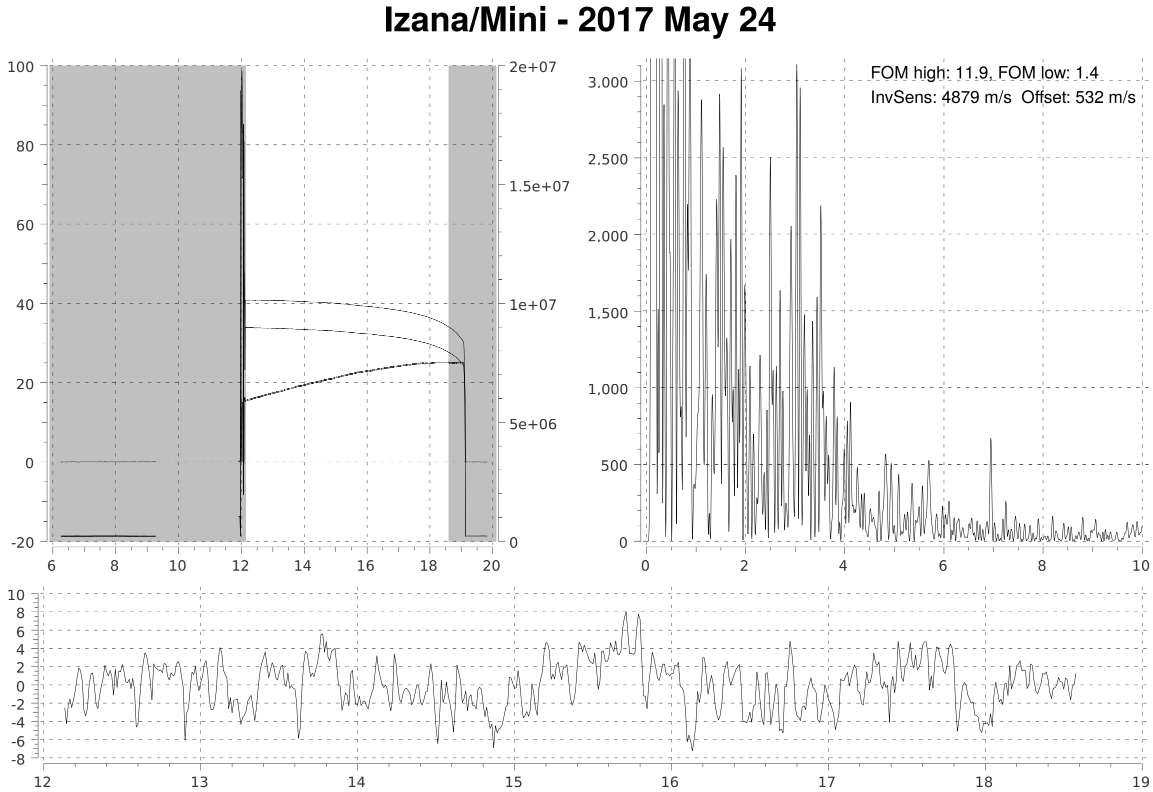

Figure 5: 2017 May 24. The spectrometer was moved to the apex of the pyramid, sharing the beam with Mark-I.

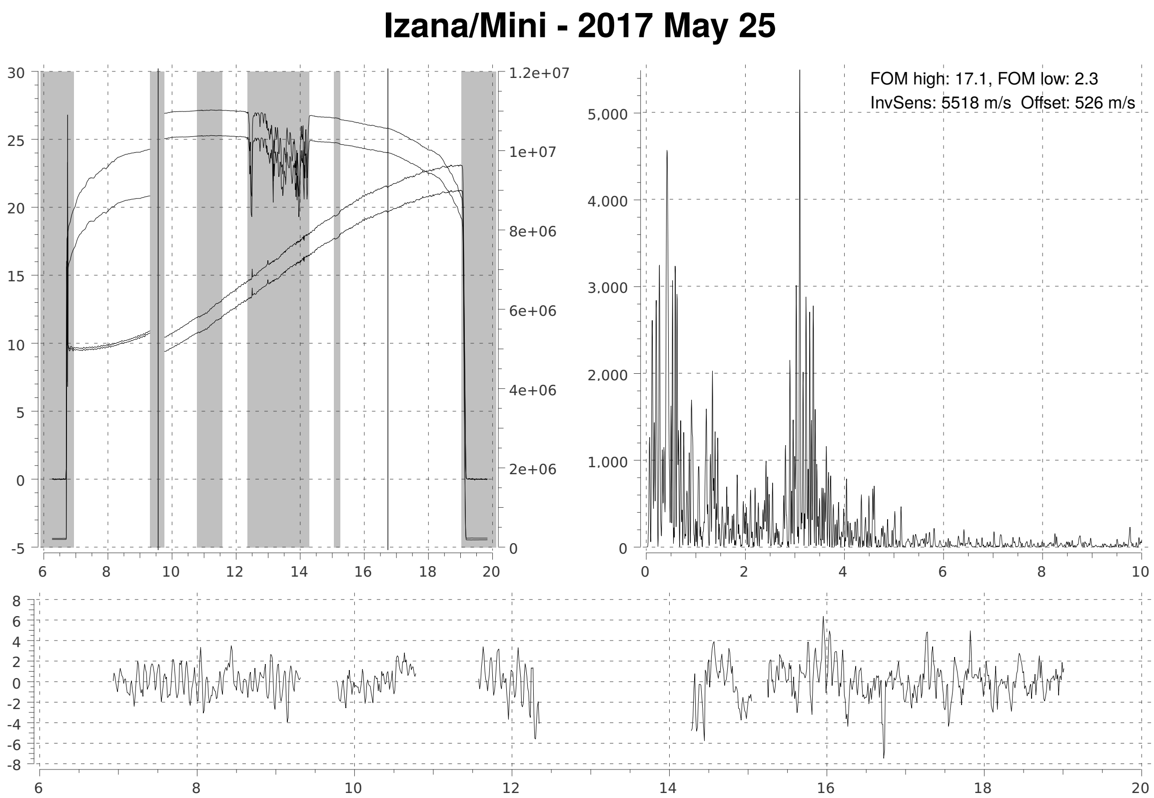

Figure 6: 2017 May 25. Data from the primary cœlostat. The step-change at approximately 09:30UT is due to trying to improve the isolation of the transmission monitor, but actually making the back reflections into the cell worse.

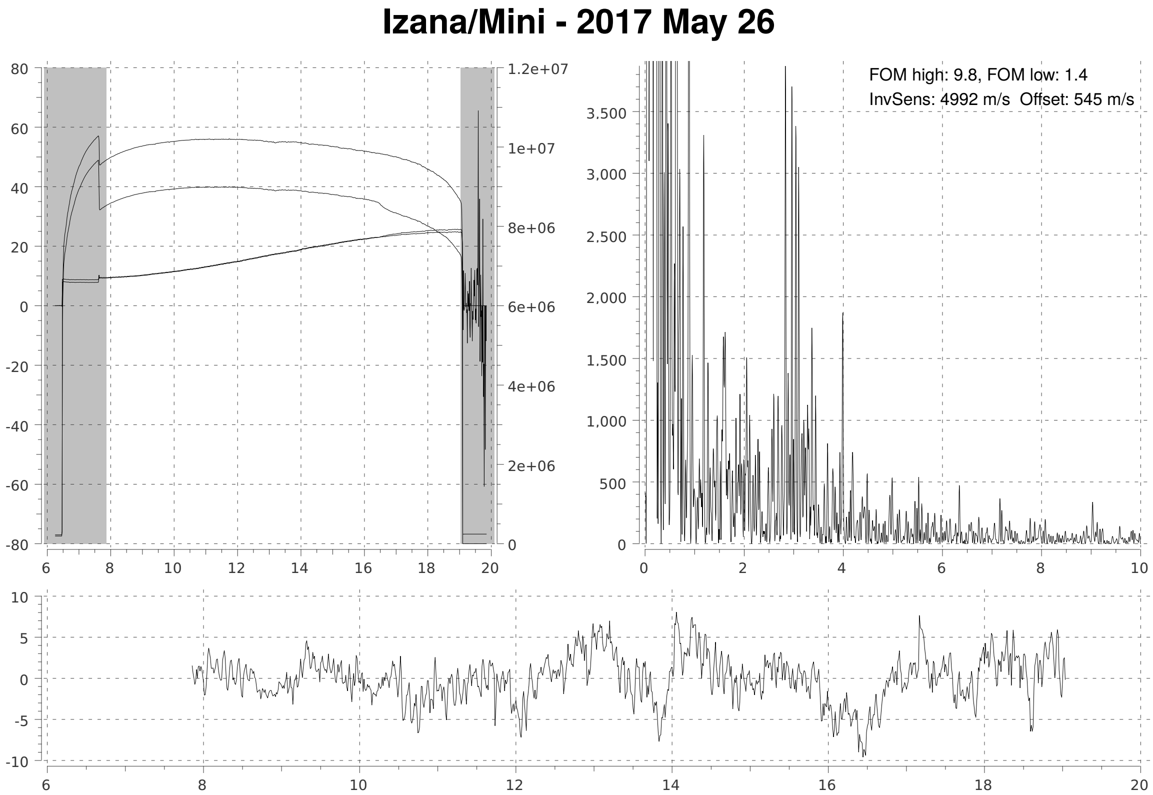

Figure 7: 2017 May 26. Data from the primary cœlostat. The step-change at approximately 07:30UT is where the isolation of the transmission monitor was improved with some blackout material covering the lens at the exit aperture of the oven/magnet.

3 Skywatcher Mount

The Skywatcher HEQ5-Pro has already been tested at Mount Wilson running from a laptop [3]. The aim is to condense all control systems down to a small number of Raspberry Pi single-board computers. Since these are of somewhat limited power compared to full-size systems, it is important to test the image processing and guiding performance.

Images are captured from a CCD camera using the Instrument Neutral Distributed Interface library (INDIlib [5]), and processed using the Open Source Computer Vision library (OpenCV [6]). Both of these projects had to be compiled from source on the Raspberry Pi in order to obtain the most recent versions. Once installed, the mount control and guiding performance was as expected based on the tests at Mount Wilson. There appear to be no issues and the Raspberry Pi is more than capable of powering our control systems.

Some minor issues were experienced. Although the fibre-collection optics are small, at certain times of year it is possible for the optics to hit the telescope pier. This is a known problem with equatorial mounts, and requires a meridian-flip at local-noon in order to keep the telescope optics on the top of the mount. This makes an equatorial mount more difficult to fully automate. It would be easier to automate an altaz mount, although this may create problems due to image rotation on the end of the fibre, and would also involve a slightly more complicate guiding algorithm. Alternative mounts should be considered before going forward with the current design. Also, a solid-state DC relay was included in the mount controller chassis in order to control power to the mount. However, this does not appear to switch off properly under control of the Raspberry Pi. It is not clear if the relay is faulty or if a different component is required.

References

[1] Hale, S. J. Fibre-feed tests at Izaña in 2017 September. *BiSON Technical Report Series,* Number 385, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2017. URL `http://epapers.bham.ac.uk/3136/`. [page 1, 2, 3]

[2] Hale, S. J. PC replaced in Izana in 2012 October. *BiSON Technical Report Series,* Number 359, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2012. URL `http://epapers.bham.ac.uk/2054/`. [page 1]

[3] Hale, S. J. Fibre-feed tests at Mount Wilson in 2016 September. *BiSON Technical Report Series,* Number 382, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2016. URL `http://epapers.bham.ac.uk/3134/`. [page 1, 2, 7]

[4] Hale, S. J. Repairs to Jabba at Carnarvon in 2016 August. *BiSON Technical Report Series,* Number 381, High-Resolution Optical-Spectroscopy Group, University of Birmingham, UK, 2016. URL `http://epapers.bham.ac.uk/3133/`. [page 2]

[5] INDILib. Instrument Neutral Distributed Interface. URL `http://indilib.org`. [page 7]

[6] Itseez. Open Source Computer Vision Library. URL `http://opencv.org/`. [page 7]