UNIVERSITY OF BIRMINGHAM | COLLEGE OF ENGINEERING AND PHYSICAL SCIENCES

BiSON ‘mini’ update

Yvonne Elsworth, **Steven Hale**, Bill Chaplin,
Guy Davies, Rachel Howe

Existing Network

BiSON

- International Network of 6 sites observing the Sun
- IAC is a key player (Pere)
- Aim to get near continuous coverage
- Many key results over decades
- Current focus for new data is on the solar cycle
- But instrumentation is old and begins to wear out

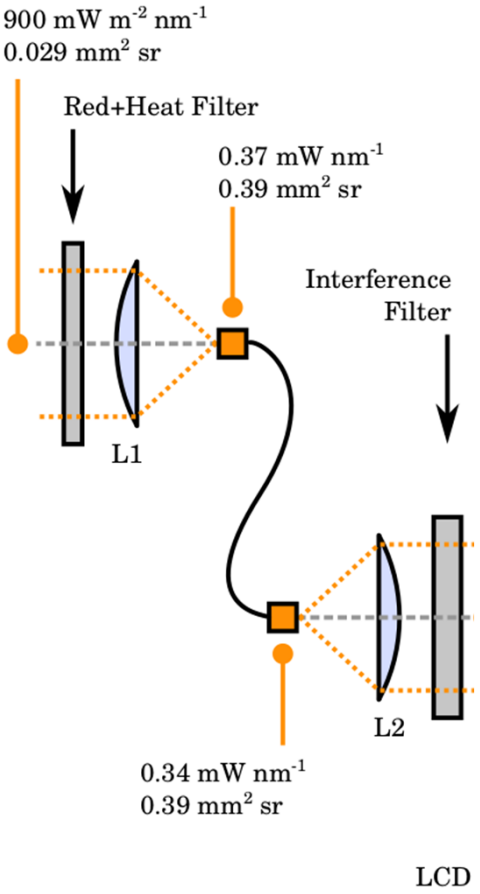
Very brief introduction to instrument

- Measurement of Doppler shift of Potassium Fraunhofer line at 770nm
- Tracks the Sun automatically
- Housed in a building – either something like the Pyramid or a purpose built dome
- Philosophy still appropriate
- New and continuing science
- Want many more sites hence need to make cheaper
- But ……Old equipment & new ideas

Strategy

- Keep the same basic measurement technique
- Reduce the size of the instrument
- Move to off the self components
- Remove the need for purpose built buildings
- Reduce the footprint
- Minimize cost
- This work forms the basis of PhD for Steven Hale and I am grateful to him for many of my data and drawings.

Begin at the beginning



- A telescope to collect enough power from Sun.
- Replace the direct feed with a long length of fibre
- Advantages
  - Allow separation of spectrometer and light collection optics
  - Fibre scrambling reduces sensitivity to guiding errors
- BUT
  - Need fibre that transmits working wavelength
  - Image of Sun formed on fibre hence require relatively large diameter
  - Has to be kept clean

Fibre Feed(technical)

- FT1000EMT multimode fibre from Thorlabs, standard off-the-shelf fibre with a silica core diameter of 1000 µm, a low hydroxyl content for low attenuation at 770nm of 7 dB km−1, and an NA of 0.39 producing an acceptance angle of approximately 22.9°.
- The minimum short term bend radius of the 1000 µm is 50mm, the long term limit is 100mm
- Use fibres of different lengths depending on the need at the particular location (10m to 30m)
- The collector lens has a focal ratio of 1.2, 30mm focal length and a spot size of 0.6 mm (on a fibre of 1mm diameter). This is a smaller aperture than we normally use but we get compensation elsewhere.

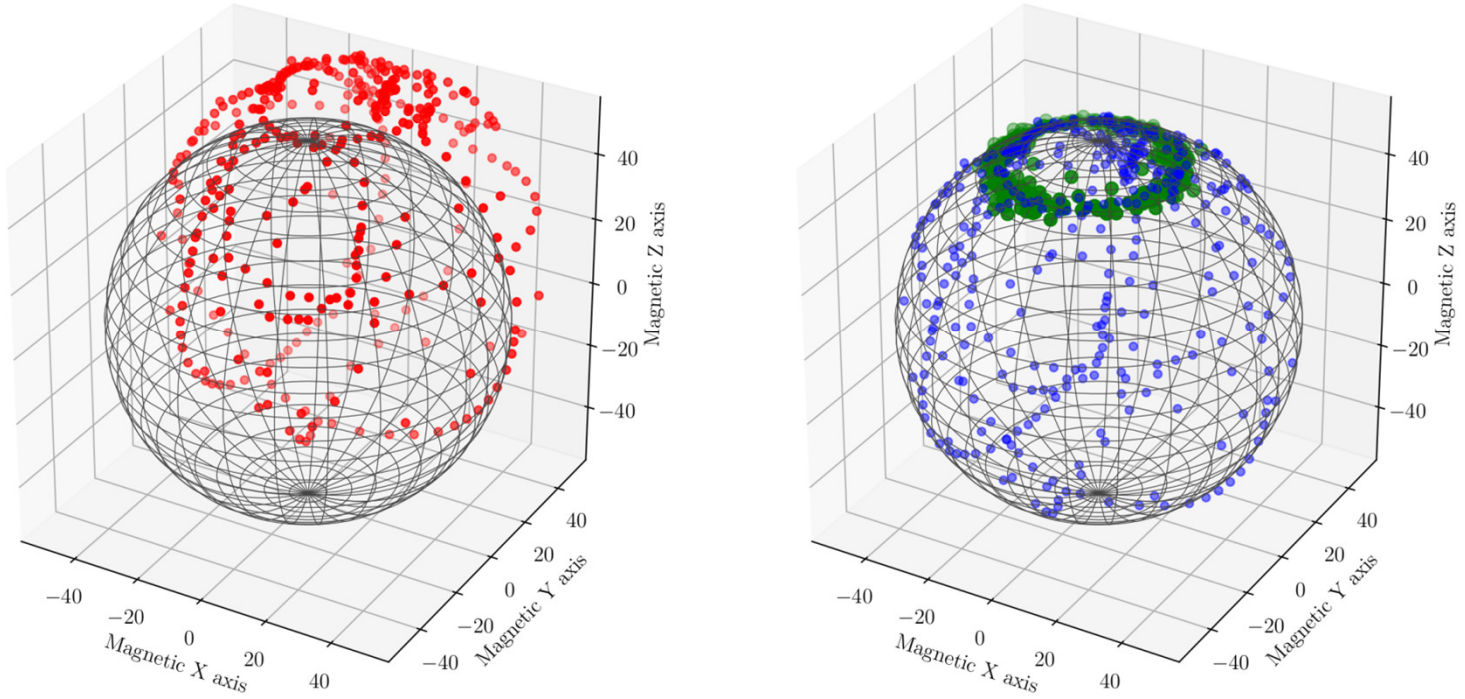
Filters

- Isolate the working wavelength range to cut stray light and reduce thermal load
- Broadband filters + narrow-band interference filters.
- Can no longer get KG4 to remove the IR – discontinued by Schott
- Astrodon in the United States have developed new filters for both the UVBRI and SDSS
- SDSS i’2 filter selected and an improvement over the original Schott KG4/RG9 filters
- We make no change to the choice of a 1.5nm interference filter centred on our working wavelength

Mounting for Input Optics

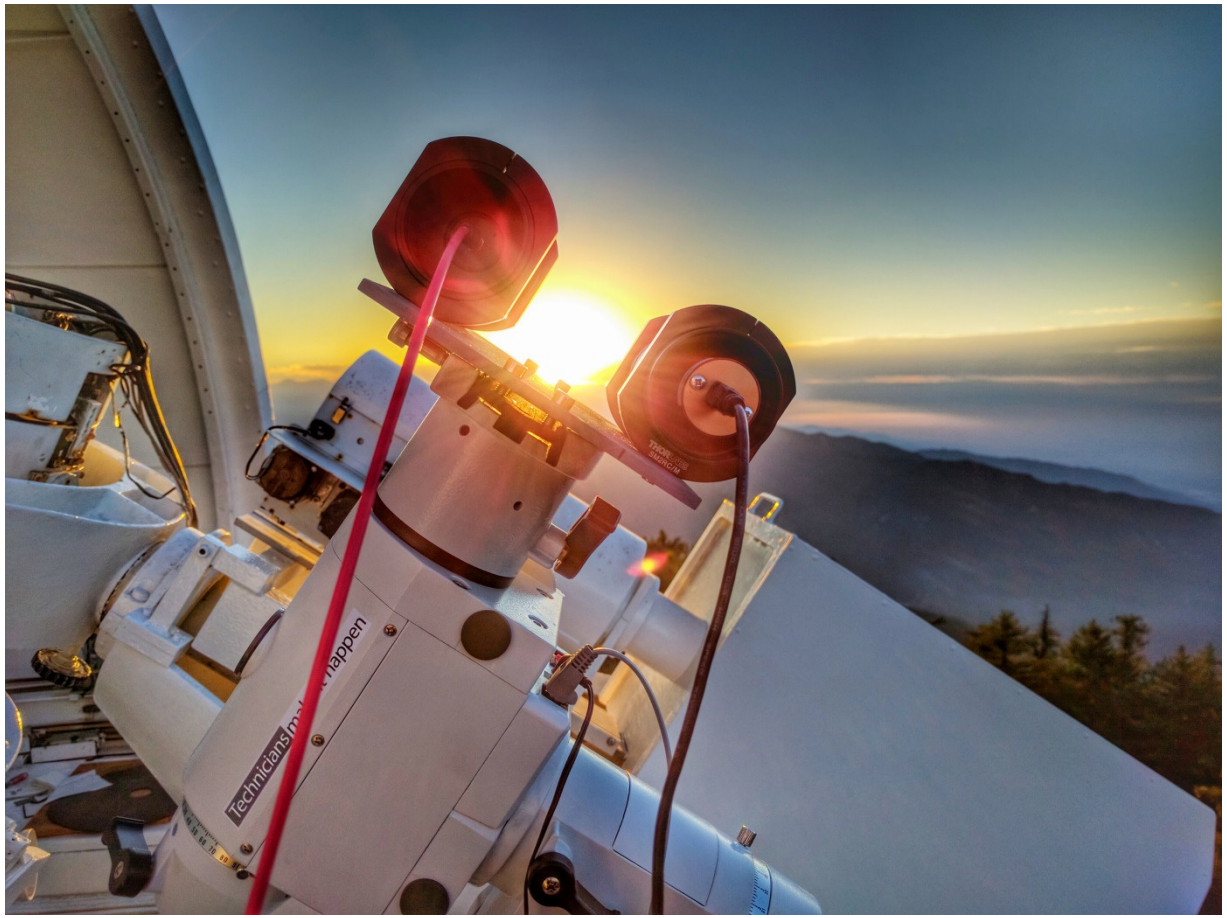
- No need for a big dome given separation of collection optics from spectrometer
- Use commercial mounts
- Two key issues to automate a COTS telescope mount are access to a communications protocol with a published application programming interface (API), and the ability to keep track of where the mount is pointing when power is lost
- Open-source and publish their control API
- Use microelectromechanical systems (MEMS), such as the accelerometers used to control screen orientation in devices such as smartphones and tablets, to track the position of a telescope

Recalibrate 3-axis magnetometer



- Work by Steve
- Note RHS on sphere
- Bottom line – can get precision of a few degrees

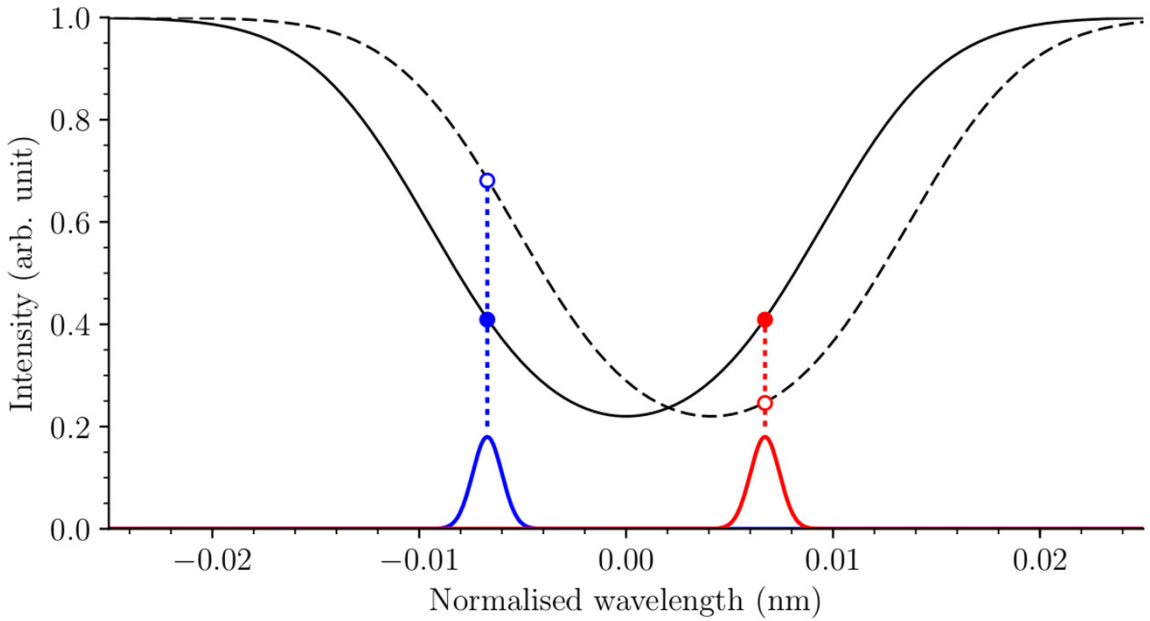
Trial at Mount Wilson (California)



- September 2016
- One telescope for guiding and one for data
- Image won prize for Steve

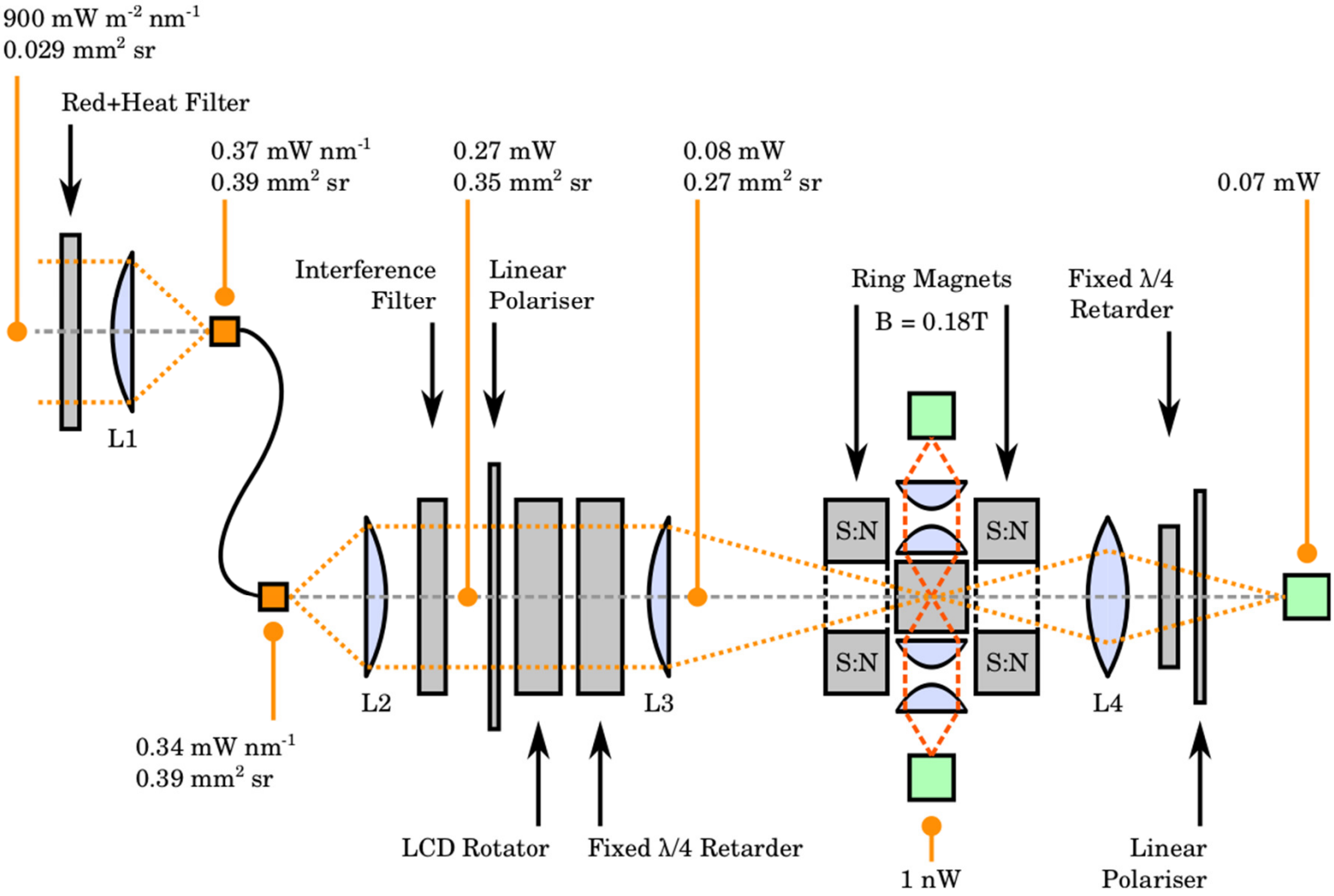
- Guided with image on CCD with precision of about 6 arc sec (over many hours) in RA and DEC

Schematic Spectral Line



- Zeeman split the line with magnetic field
- Polarisation switching between the two sides of the Potassium line is fundamental to our design
- Resolution……

Compare Potassium on ground to Potassium on Sun



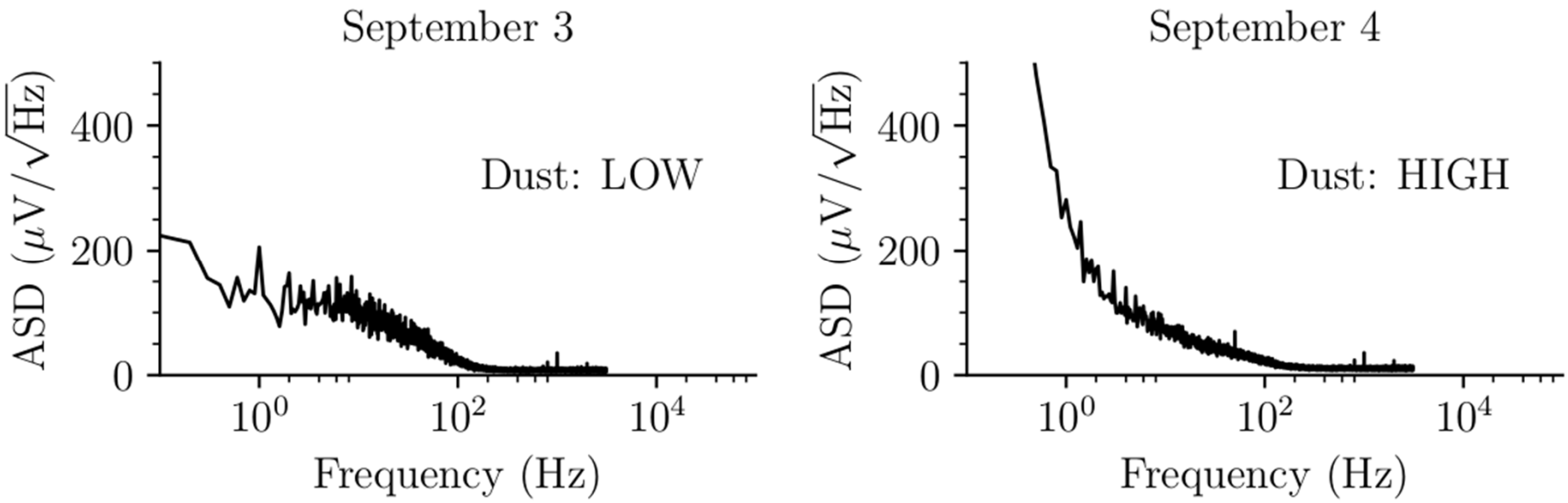
Polarisation Switching

- Traditionally use Pockels cells to switch from one side of line to other
- High switching rate and effective
- BUT…….
  - Expensive
  - Fragile
  - Small field of view
  - Limited life unless doubled up – bespoke design
- Try liquid crystals

Liquid Crystals

- They do work but big down side is the switching rate.
- Pockels cells are fast
- Liquid crystal are much slower
- Why do we care?
- Atmosphere – at 1Hz quite a bit of scintillation at 100Hz it is insignificant
- Whether it matters depends on other noise sources and science goal.

Scintillation noise

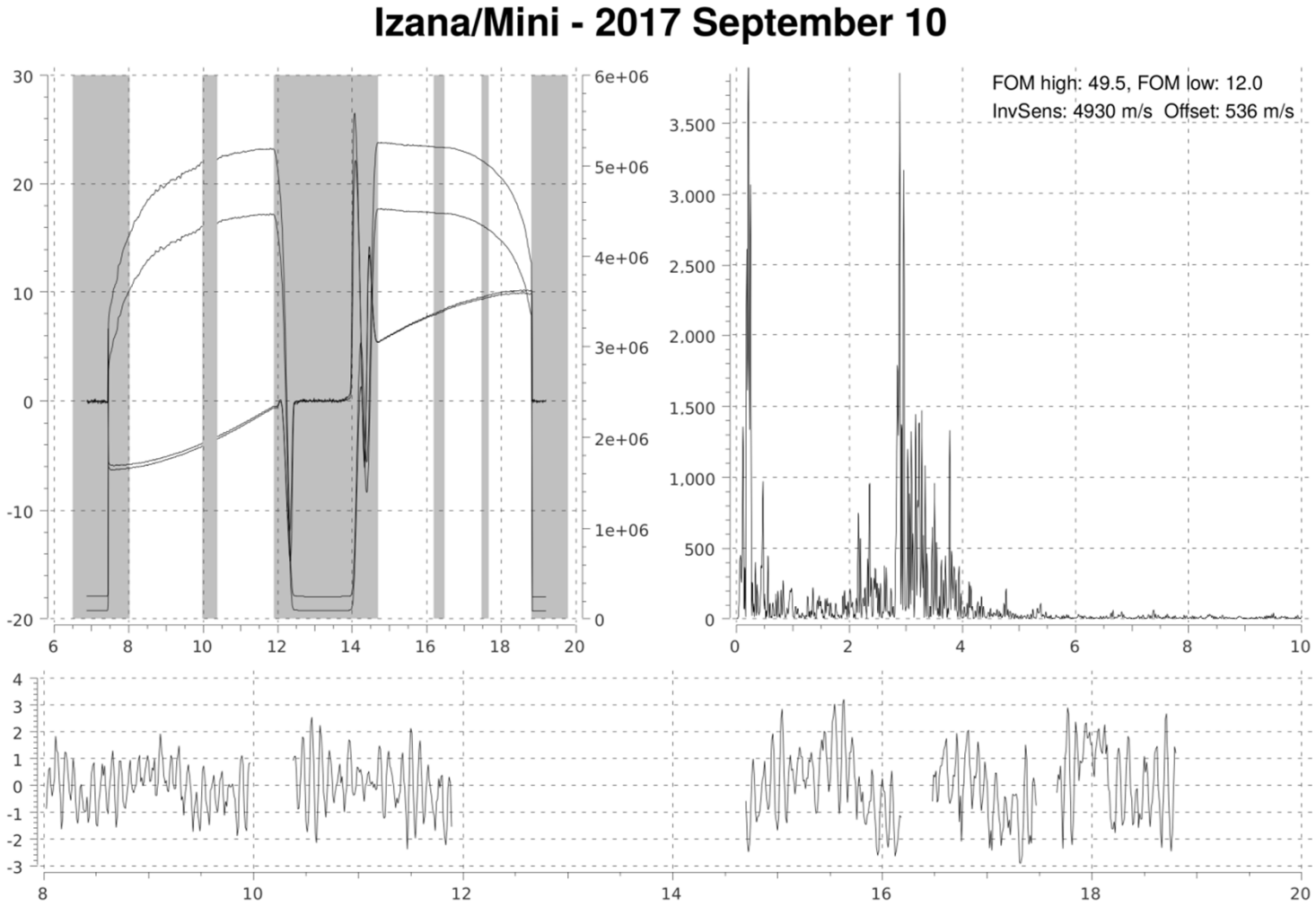


- Short term scintillation noise spectra with different dust levels.
- Measured by Steve at Izana

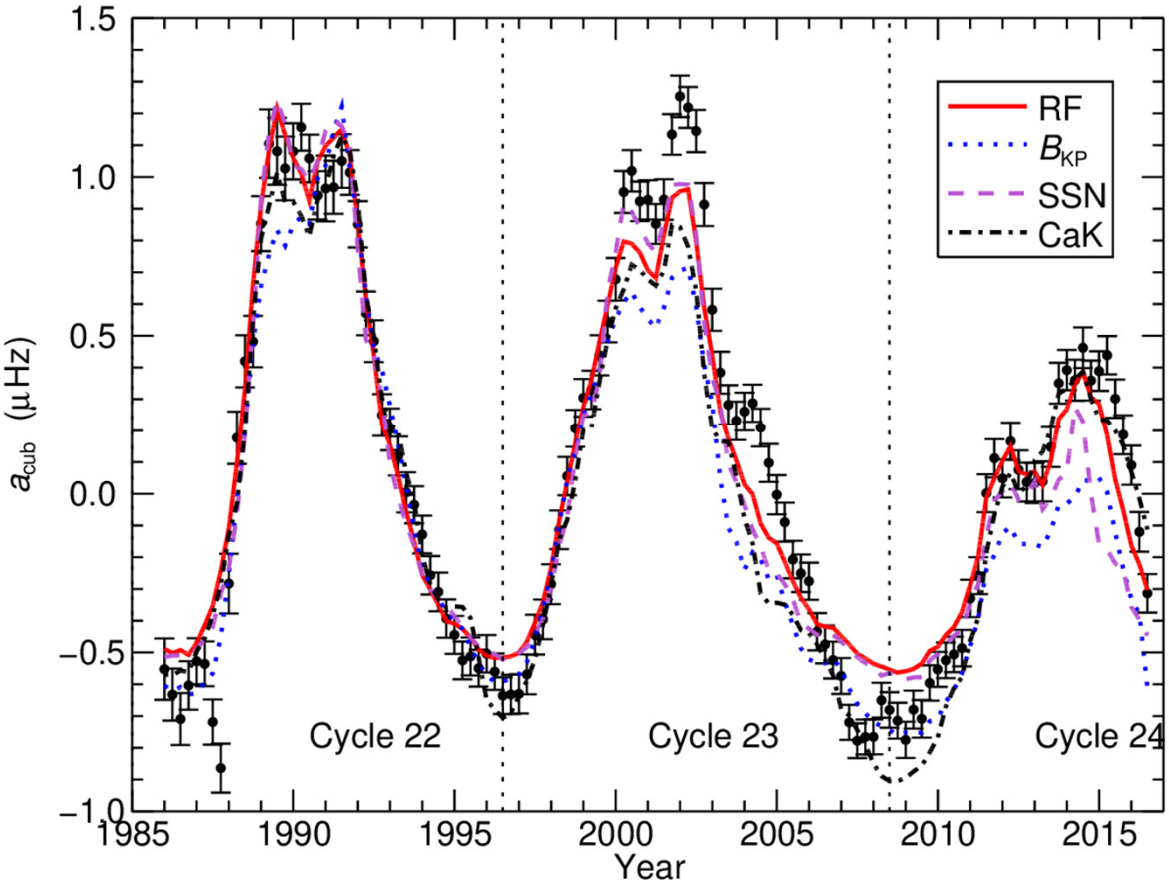
Distributed control

- Instead of one computer controlling everything we have distributed the control.
- Much easier to write the software and to make changes and updates.
- Raspberry Pi

BiSON-Izana - Use light from coelostat plus fibre to feed new mini spectrometer. Very good quality.



Solar cycle data – what will happen at the minimum?



Howe et al. 2017 ‘Sun in Transition’

SONG synergies

- Currently working on cycle dependence of numax values from solar SONG Doppler and BiSON Doppler data.

- Height-dependence/coherence work, and the BiSON paper that Mikkel Lund led, and the potential to utilize different combinations of spectral lines for SONG

Where we are with new setups

- Tenerife
- Carnarvon (WA)
- Mount Wilson

- Skywatcher star discovery

Summary

- PhD Steve
- For the first time we have a proper analysis of where noise in the system comes from
- Considerable progress on new format
- More work needed for an enclosure
- Cells filled with Potassium and magnetic field provision still bespoke