# 1 Observations

Observations were completed with FRODOSpec (Fibre-fed RObotic Dual-beam Optical Spectrograph), a robotic integral field spectrograph on the Liverpool telescope. Both blue (3900 - 5100Å) and red arm (5900 - 8000 Å) observations were completed. Due to the very low S/N, the blue arm spectra were not considered in the following work. The resolution of the red arm in high resolution mode is $\sim$ 5,300. The integral field covers 9.8" x 9.84", with 12 lenslets of 0.82 arcsec on-sky.

Due to the robotic nature of the telescope, in some of the observations the source is either not within the IFU or is not centred within the IFU. The main result of this appears to be the increase in the noise within the spectrum.

# 2 Comparison between pipeline extracted and self extraction

A comparison was made between those spectra extracted by the pipeline, and a 'home-made' extraction.

- The home made extraction was done by flatting the data cube along the wavelength direction.
- The pixel with the greatest flux value was found.
- The pixels around this greatest flux pixel where then combined one by one, measuring the SN in the resulting spectrum after each step. This was done in each case for up to 50 pixels.
- The turn over in the S/N to pixels was taken to be the best number of pixels to extract.
- The sky spectrum was then extracted from the remaining pixels. This I tried to do in a number of ways. Eventually selecting all pixels in the remained of the cube that were less than or equal to the median of all the remaining pixels. (see plot 2). This is probably not the best cut off, but I wanted to make sure not to get too much signal from the star itself.
- The same number of pixels were taken for each night - 3 separate observations. In most cases it was about 20 pixels.

The results of the normalised 'home-made' and pipeline extraction were very similar. In the majority of the cases the sky background counts were also low and considered not to be an issue.

Very little difference was found when the EW of the pipeline and the home-made extraction.

The biggest issue in the spectra are when the source lies not entirely on the IFU, in particular in the last epochs of the observations. See plot 2

# 3 Cleaning of bad objects

Some fits files were not considered as the the targets were not within the field of view of the IFU (at all). These were removed from the analysis.

# 4 EW of lines and Line profiles

The EWs of the emission lines were measured for H$\alpha$, [OI] and HeI. The errors in the following plots are taken to be the spread in measurements over one night (3 observations).

The mean and variance profiles of a number of epoch selections are given. In this case the split is some what arbitrary, based on the observing blocks.

Also shown below is a timeseries of the H$\alpha$ and OI profiles. In each case the MJD is given beside the mean profile for that night.

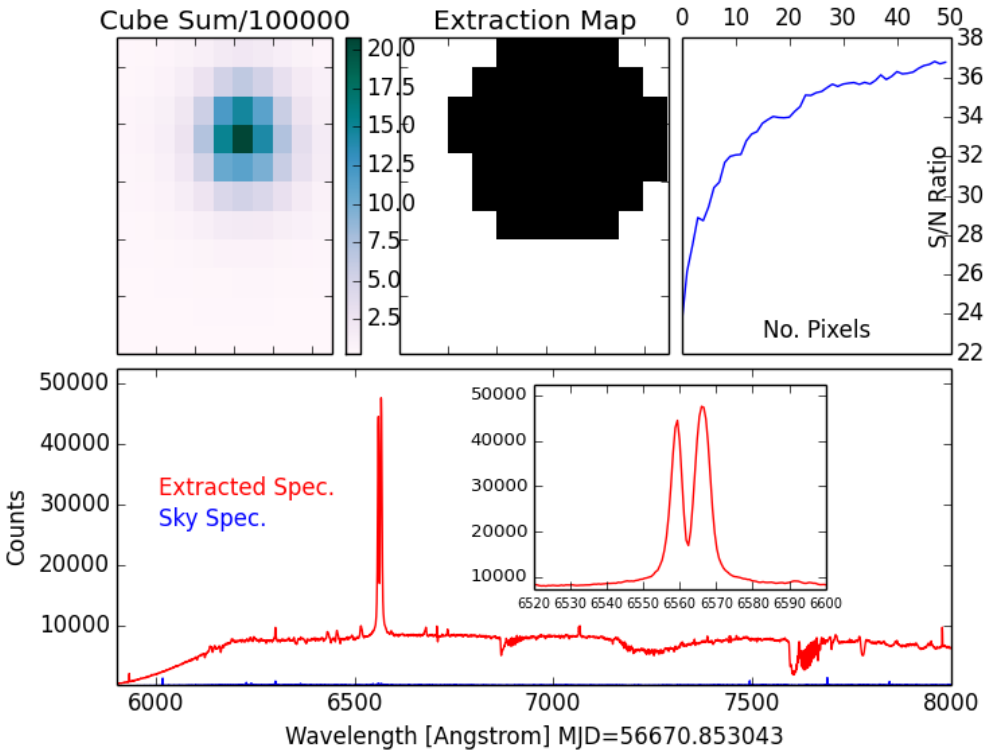


Figure 1: Testing of pipeline extraction. Top left panel shows flatten IFU. Middle top panel shows pixels summed to get spectrum. Top right panel shows the relation between the number of pixels combined versus SN in the resulting spectrum. The bottom panel shows the extracted spectrum.

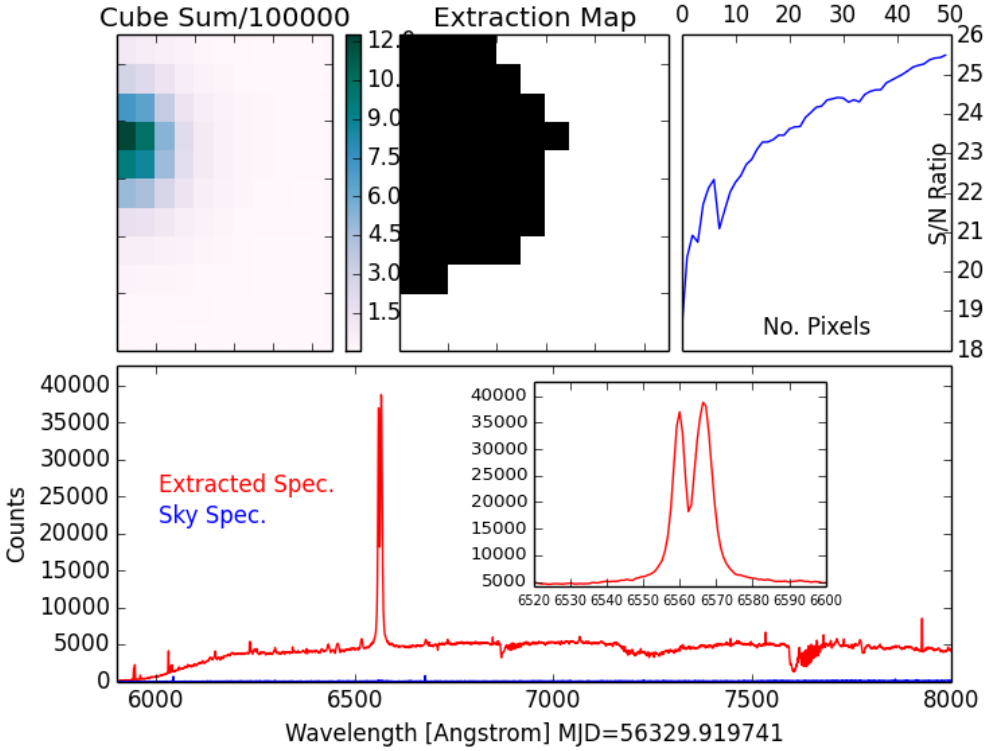


Figure 2: Testing of pipeline extraction. Example in which the source is not entirely on the IFU. This is the first observation in the time-series as plotted below.

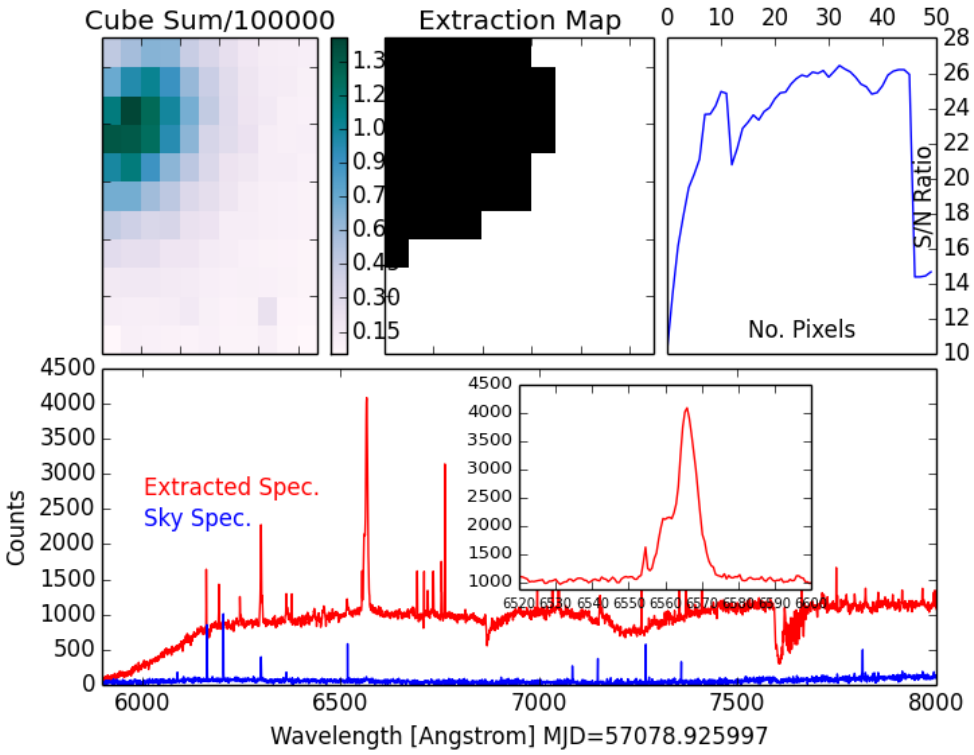


Figure 3: This is one of the final observations in the time-series as plotted below. Here there is also poor seeing.

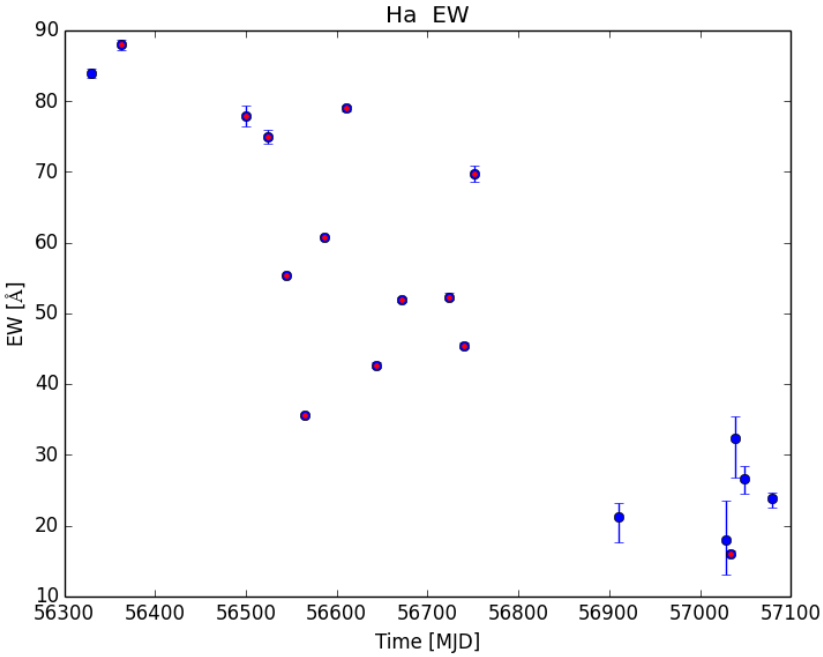


Figure 4: Mean EW versus MJD. Here the mean EW is taken from the 3 observations each night. The error bars represent the differences between the 3 observations that night. The points marked with a red dot are those observations with the source centred on the IFU (see Table 1).

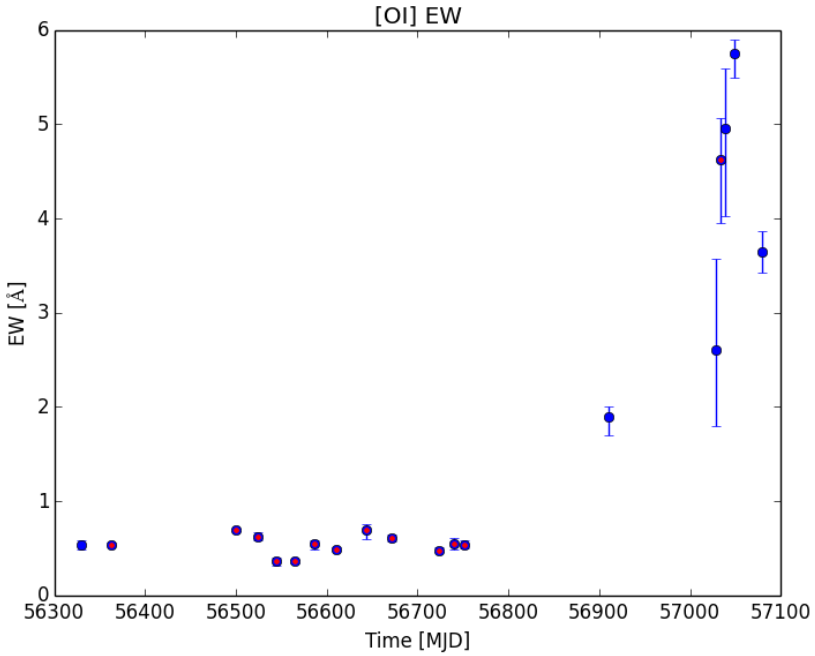


Figure 5: OI: Mean EW versus MJD. Here the mean EW is taken from the 3 observations each night. The error bars represent the differences between the 3 observations that night. The points marked with a red dot are those observations with the source centred on the IFU

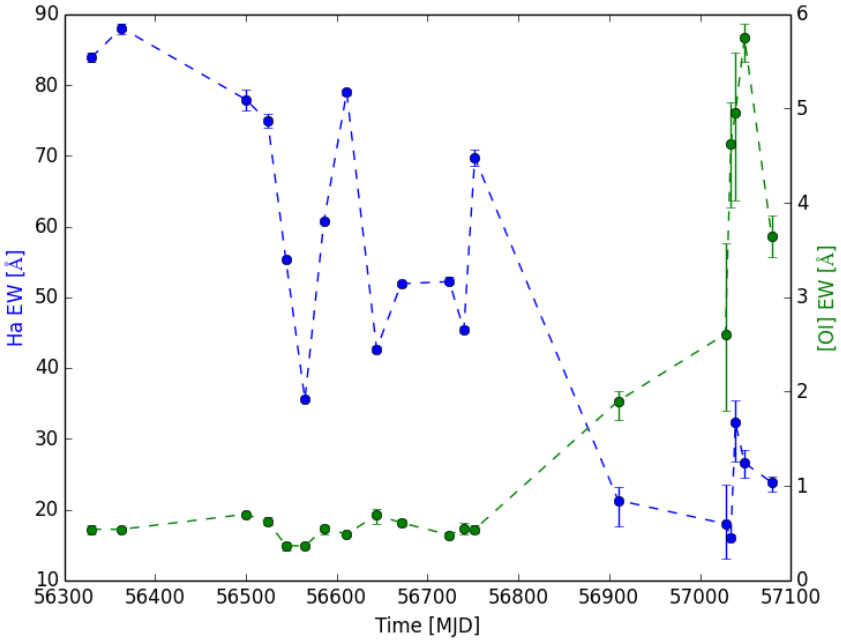


Figure 6: Mean EW versus MJD for both H$\alpha$ and OI.

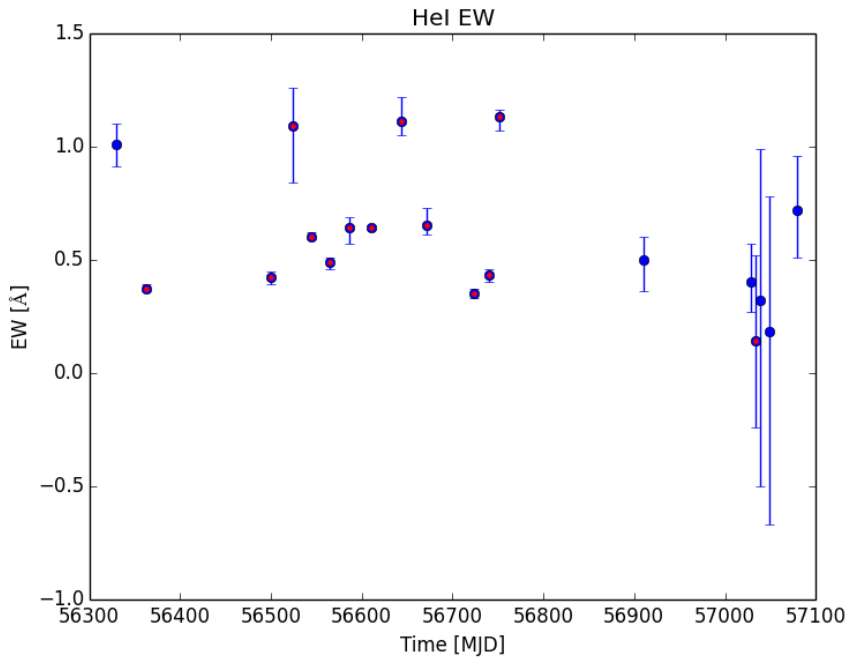


Figure 7: Mean EW versus MJD. Here the mean EW is taken from the 3 observations each night. The error bars represent the differences between the 3 observations that night. The points marked with a red dot are those observations with the source centred on the IFU

| MJD | Mean EW | Min EW | Max. EW | No. Of Obs. | IFU coverage |
|---|---|---|---|---|---|
| 56330 | 83.88 | 83.2 | 84.52 | 3 | Partial |
| 56363 | 88.07 | 87.21 | 88.59 | 3 | |
| 56500 | 77.94 | 76.35 | 79.35 | 3 | |
| 56524 | 74.87 | 73.93 | 75.88 | 3 | |
| 56544 | 55.39 | 55.32 | 55.42 | 3 | |
| 56565 | 35.53 | 35.35 | 35.69 | 3 | |
| 56586 | 60.79 | 60.75 | 60.86 | 3 | |
| 56611 | 78.96 | 78.56 | 79.31 | 3 | |
| 56644 | 42.68 | 42.21 | 43.03 | 3 | |
| 56671 | 51.9 | 51.56 | 52.21 | 3 | |
| 56724 | 52.21 | 51.88 | 52.84 | 3 | |
| 56740 | 45.39 | 45.03 | 45.82 | 3 | |
| 56752 | 69.7 | 68.58 | 70.91 | 3 | |
| 56910 | 21.29 | 17.59 | 23.18 | 3 | Partial |
| 57028 | 17.97 | 13.1 | 23.59 | 3 | Partial |
| 57034 | 16.05 | 15.8 | 16.55 | 3 | |
| 57039 | 32.25 | 26.77 | 35.41 | 3 | Partial |
| 57049 | 26.59 | 24.57 | 28.35 | 3 | Partial |
| 57079 | 23.81 | 22.48 | 24.72 | 3 | Partial |

Table 1: Measurements of the H$\alpha$ Emission Line. Those epochs in which the target was not centred in the IFU i.e. was not completely covered, are indicated in the last column.

| MJD | Mean EW | Min EW | Max. EW | No. Of Obs. | |
|---|---|---|---|---|---|
| 56330 | 0.54 | 0.49 | 0.59 | 3 | Partial |
| 56363 | 0.54 | 0.53 | 0.56 | 3 | |
| 56500 | 0.7 | 0.68 | 0.71 | 3 | |
| 56524 | 0.62 | 0.59 | 0.67 | 3 | |
| 56544 | 0.37 | 0.32 | 0.4 | 3 | |
| 56565 | 0.36 | 0.34 | 0.38 | 3 | |
| 56586 | 0.55 | 0.49 | 0.59 | 3 | |
| 56611 | 0.49 | 0.48 | 0.51 | 3 | |
| 56644 | 0.69 | 0.6 | 0.76 | 3 | |
| 56671 | 0.61 | 0.57 | 0.64 | 3 | |
| 56724 | 0.48 | 0.46 | 0.51 | 3 | |
| 56740 | 0.55 | 0.49 | 0.61 | 3 | |
| 56752 | 0.54 | 0.5 | 0.59 | 3 | |
| 56910 | 1.9 | 1.7 | 2.0 | 3 | Partial |
| 57028 | 2.61 | 1.8 | 3.57 | 3 | Partial |
| 57034 | 4.63 | 3.95 | 5.07 | 3 | |
| 57039 | 4.96 | 4.03 | 5.59 | 3 | Partial |
| 57049 | 5.75 | 5.49 | 5.9 | 3 | Partial |
| 57079 | 3.64 | 3.43 | 3.87 | 3 | Partial |

Table 2: Measurements of the [OI] Emission Line.

| MJD | Mean EW | Min EW | Max. EW | No. Of Obs. |
|---|---|---|---|---|
| 56330 | 1.01 | 0.91 | 1.1 | 3 |
| 56363 | 0.37 | 0.36 | 0.39 | 3 |
| 56500 | 0.42 | 0.39 | 0.45 | 3 |
| 56524 | 1.09 | 0.84 | 1.26 | 3 |
| 56544 | 0.6 | 0.59 | 0.62 | 3 |
| 56565 | 0.49 | 0.46 | 0.51 | 3 |
| 56586 | 0.64 | 0.57 | 0.69 | 3 |
| 56611 | 0.64 | 0.63 | 0.65 | 3 |
| 56644 | 1.11 | 1.05 | 1.22 | 3 |
| 56671 | 0.65 | 0.61 | 0.73 | 3 |
| 56724 | 0.35 | 0.33 | 0.37 | 3 |
| 56740 | 0.43 | 0.4 | 0.46 | 3 |
| 56752 | 1.13 | 1.07 | 1.16 | 3 |
| 56910 | 0.5 | 0.36 | 0.6 | 3 |
| 57028 | 0.4 | 0.27 | 0.57 | 3 |
| 57034 | 0.14 | -0.24 | 0.52 | 3 |
| 57039 | 0.32 | -0.5 | 0.99 | 3 |
| 57049 | 0.18 | -0.67 | 0.78 | 3 |
| 57079 | 0.72 | 0.51 | 0.96 | 3 |

Table 3: Measurements of the HeI Emission Line.

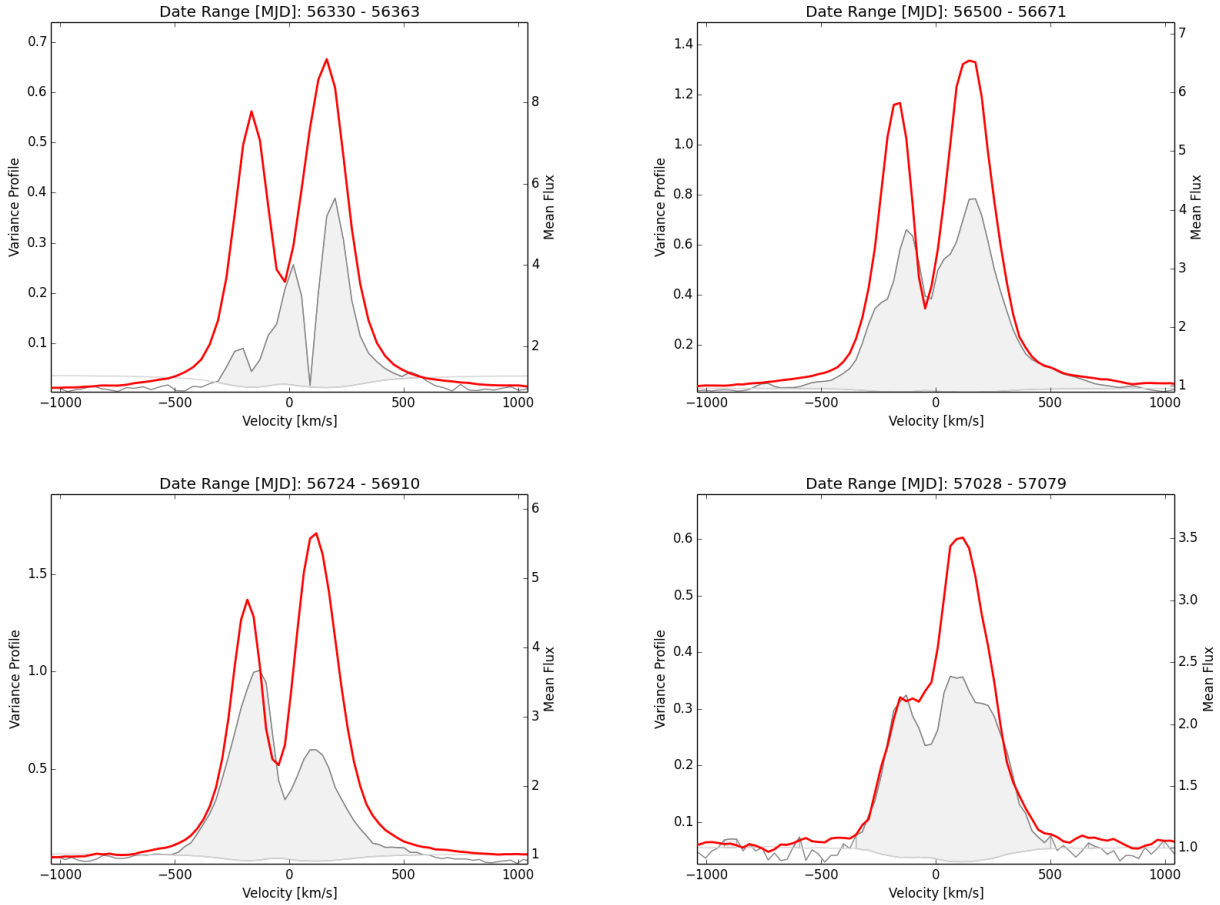


Figure 8: H$\alpha$: Mean and Variance profiles for difference divisions within the sample.Variance profile is given in grey. That part of the variance profile that lies above the continuum is shaded in grey.

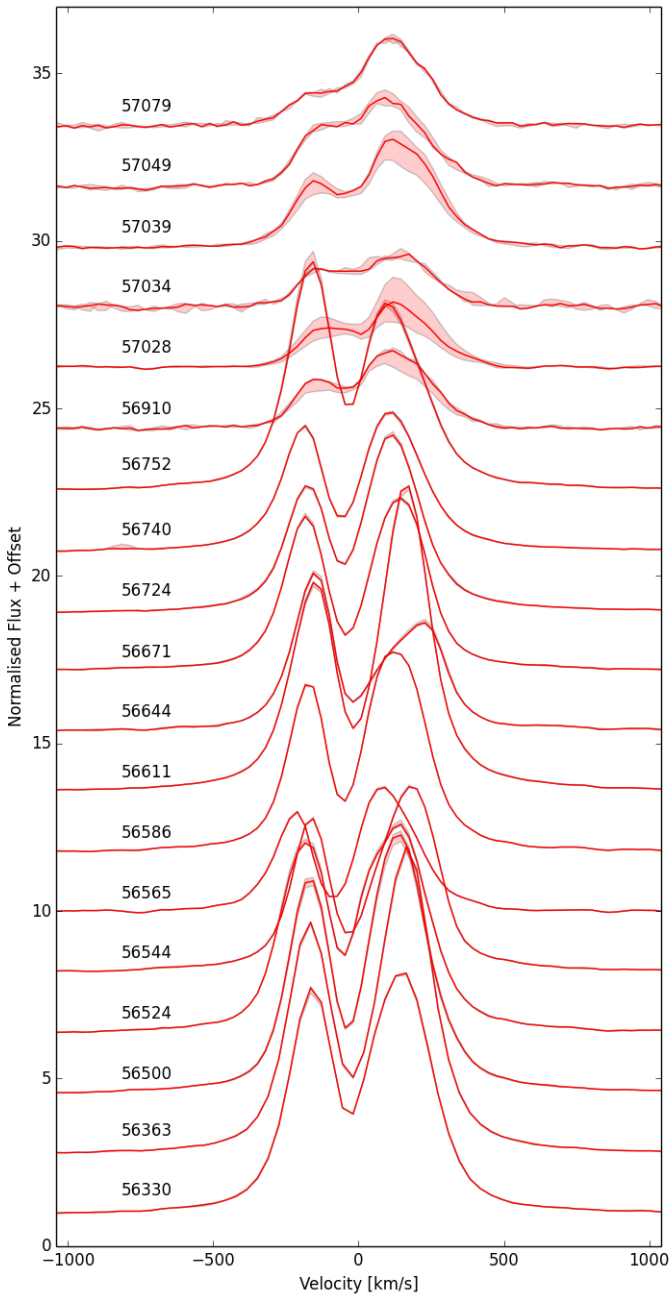


Figure 9: Full time-series of all H$\alpha$ profiles. The red lines indicate the mean profile for that night's observation. While the red shading indicates the spread between the individual 3 spectra for that night.

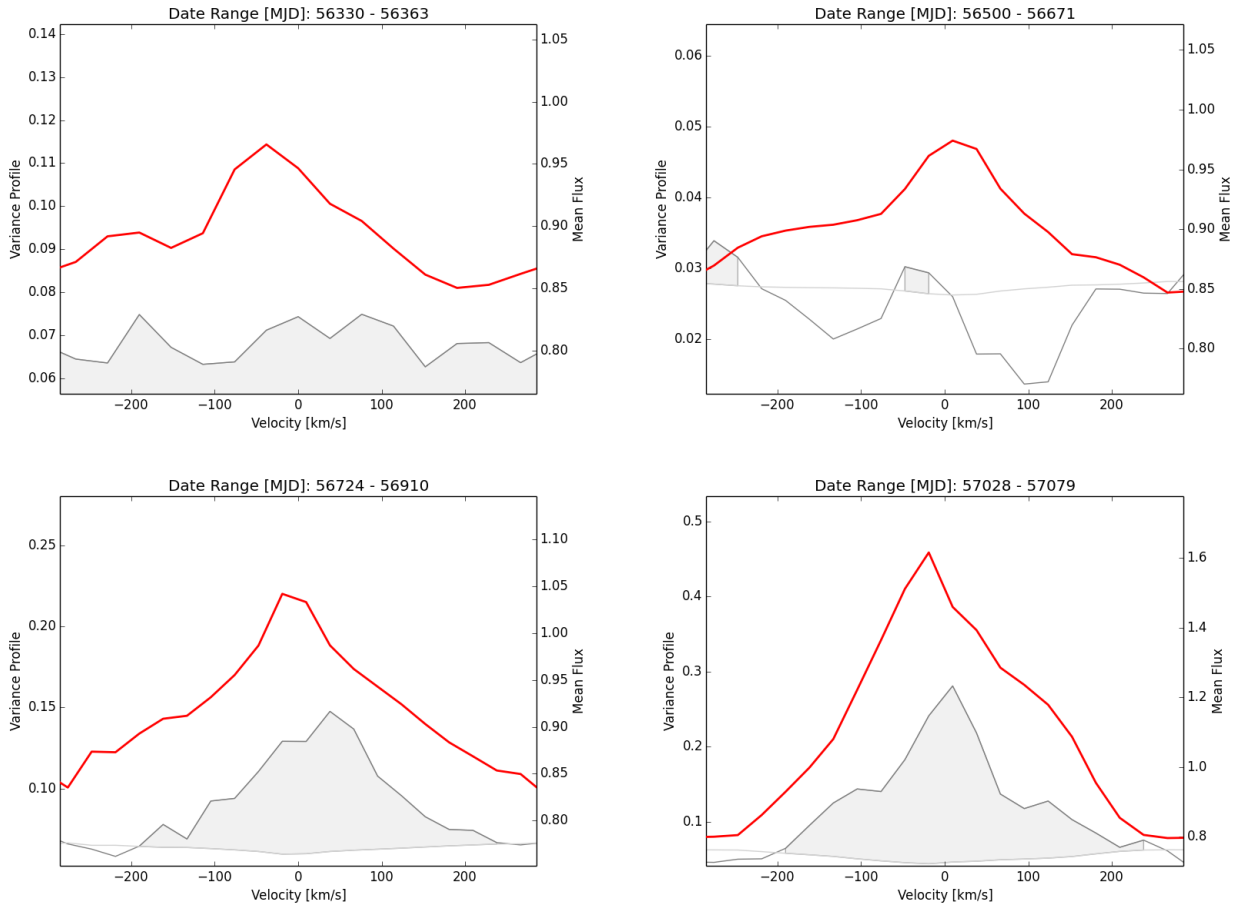


Figure 10: [OI] 6300Å. Mean and Variance profiles for difference divisions within the sample. Mean profile is in red. Variance profile is given in grey. That part of the variance profile that lies above the continuum is shaded in grey.

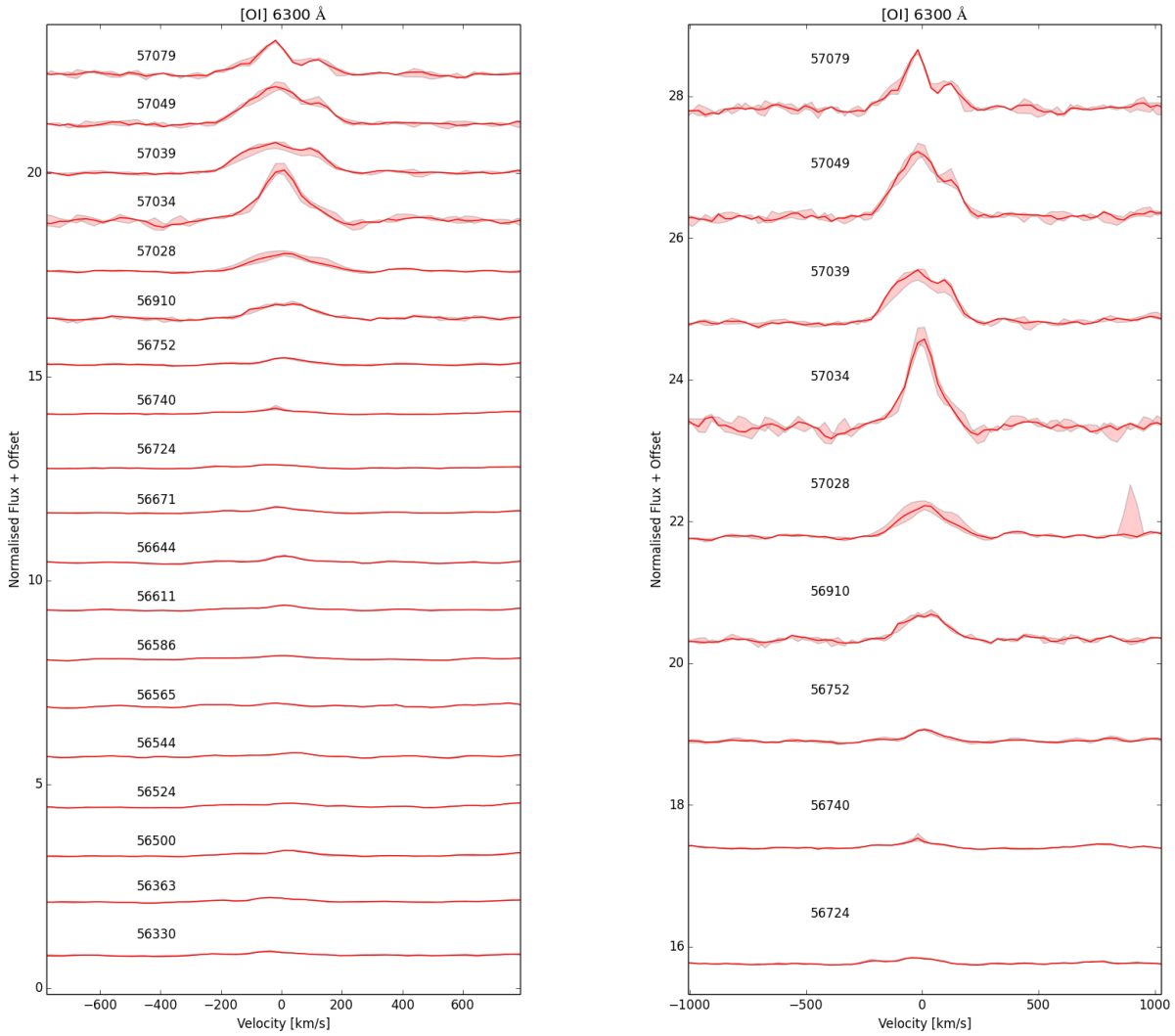


Figure 11: Partial time series of the OI profiles. First panel shows the mean profile for each night, the second panel has the individual observations overplotted as well. Numbers here indicate the days after the first observation.

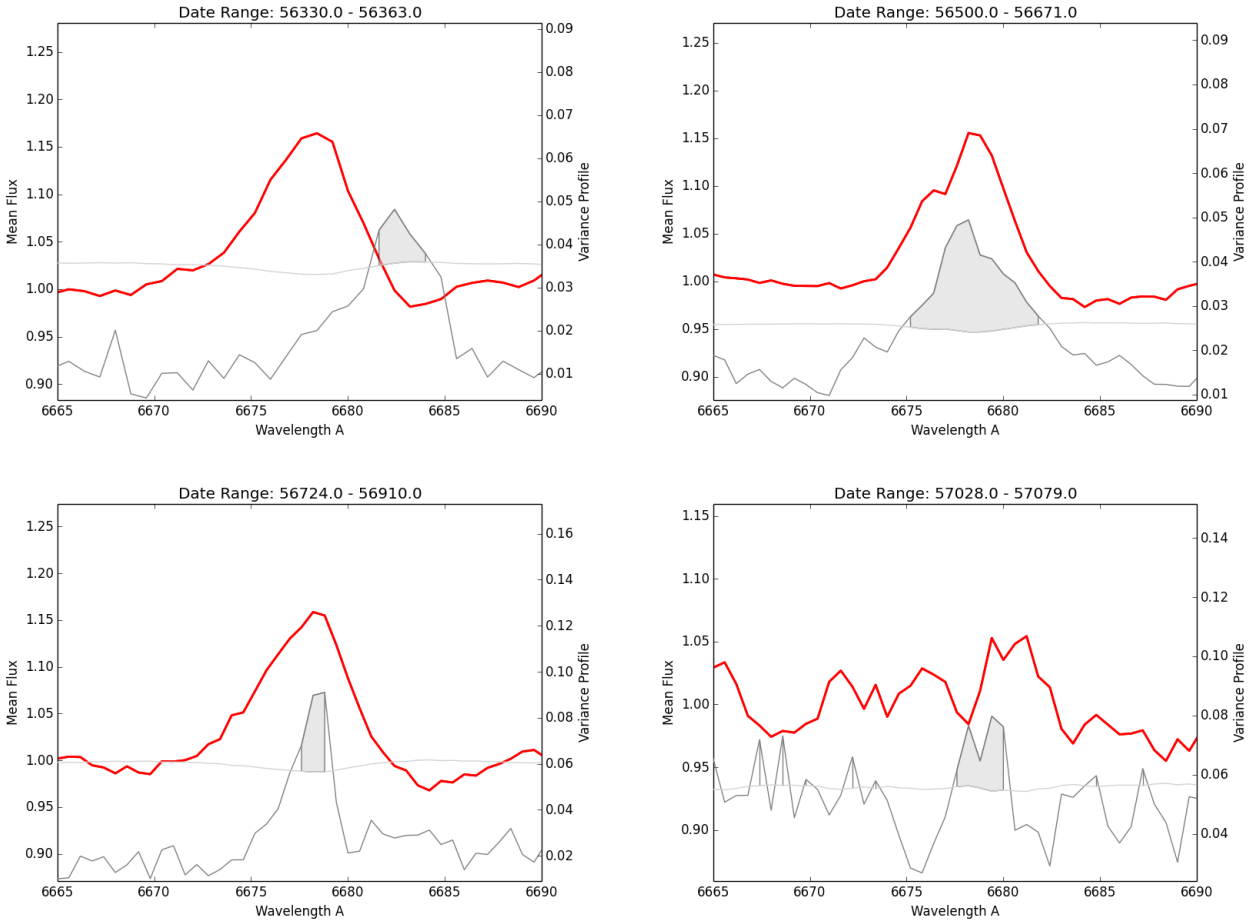


Figure 12: HeI: Mean and Variance profiles for difference divisions within the sample. Variance profile is given in grey. That part of the variance profile that lies above the continuum is shaded in grey.