A high signal to noise spectrum of Beta Cen with CRIRES

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- Beta Cen is a B1 III star with mB=0.38 and mH=1.209

- As part of the CRIRES closeout calibrations we obtained one hour of observation on this very bright target.

- The aim was to see what S/N ratio could be achieved using CRIRES for comparison with CRIRES plus and what are the limiting factors.

Observations

CRIRES slit width 0.4” (spectral resolution about 50,000).

No Adaptive Optics.

Seeing: 0.7” in H-band.

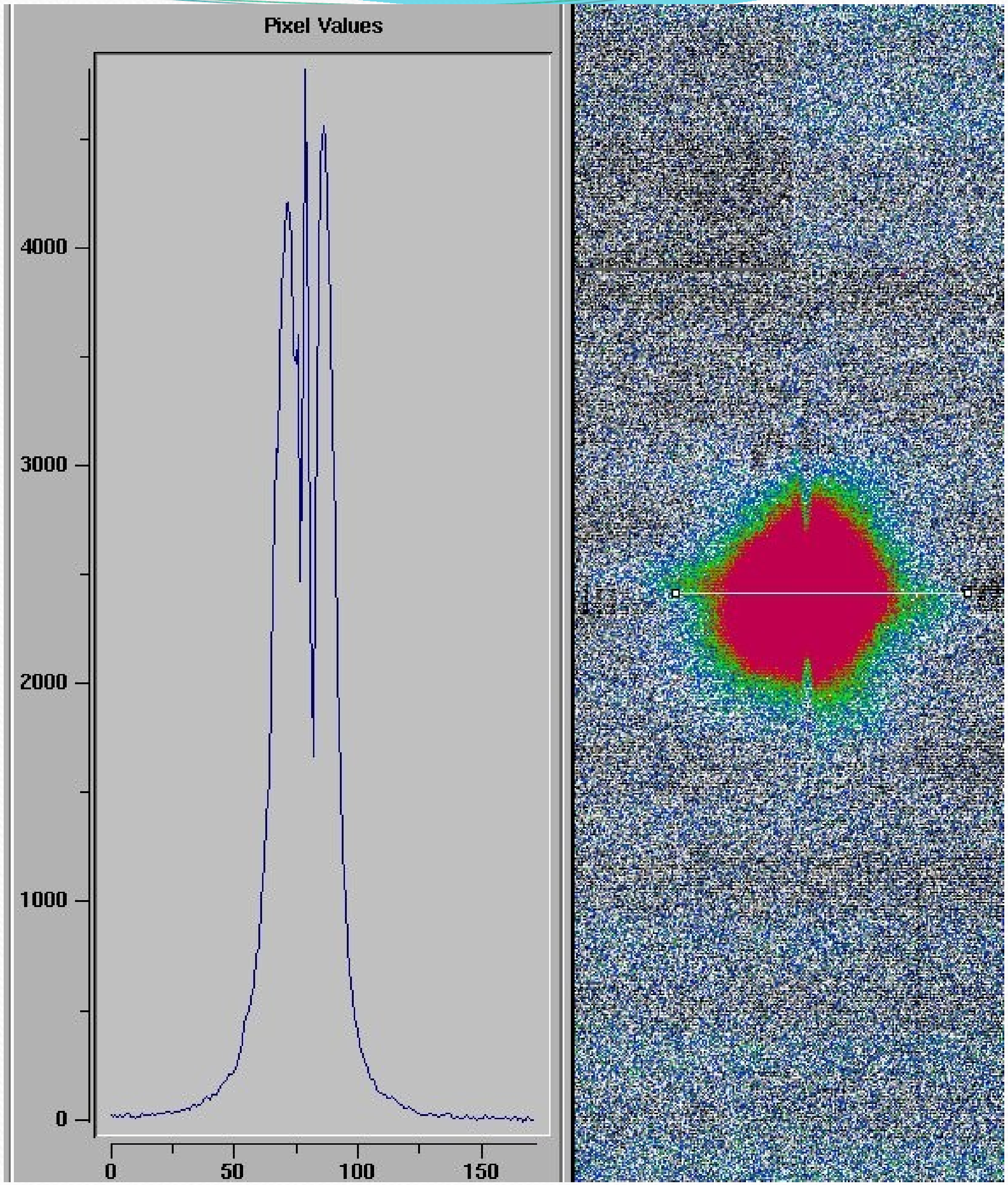
Detector integration time: 5 seconds. Number of DITs per integration: 10.

Number of exposures 30.

Nod of 12” with jitter of 4”.

Wavelength range 14830 to 15163 Angstroms with gaps.

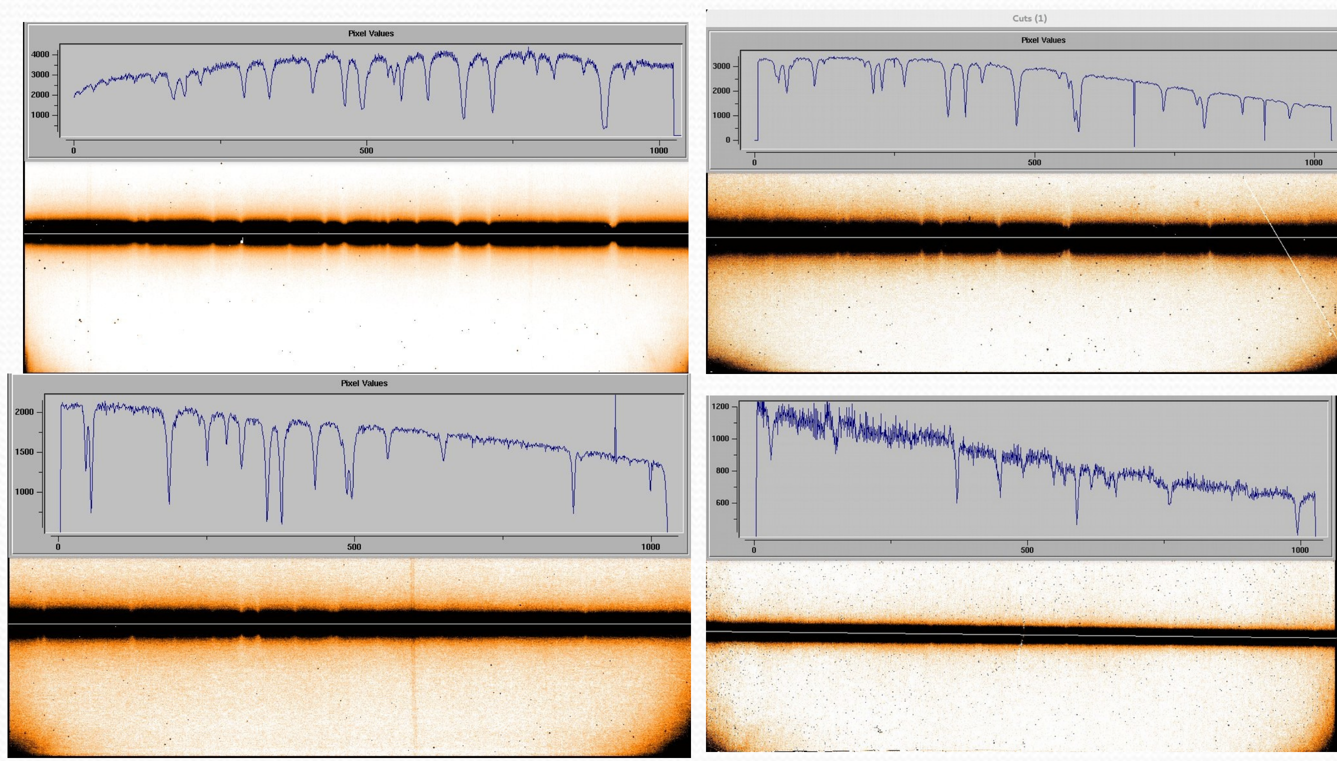
Right figure shows the slit viewer image.



Raw data

The maximum counts were 4200 ADU on detector 1 decreasing to 1200 ADU on detector 4. Total counts in electrons for 30 exposures was around 75 million electrons for detector 1 falling to 20 million counts for detector 4 (FWHM=8 pixels with gain around 7 electrons per ADU)..

Directly after the observations a wavelength calibration and 100 flatfields were taken with object counts from 8500 to 1700 ADU peak on detectors one to 4.



Raw data for CRIRES detectors one (top left) to four (bottom right).

Data reduction

The ESO CRIRES pipeline was used with the default values for data reduction parameters.

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The reduction was also performed using the standard number of flatfields (3), then 6, 12, 25, 50 and 100 flats.

The reduction was performed using the nearest non-linearity coefficient map and an average of the two closest in time. There was little difference between the two reductions.

Finally, we reduced 2, 4, 8, 16, 30 frames separately to see how the S/N ratio increased with number of exposures.

Results (1)

Table showing S/N ratios for spectra for a wavelength range from 15058 to 15060 Angstroms. This is detector 3 where the peak was typically 1670 ADU with FWHM of 7.5 pixels for 2 million electrons per A-B pair (2 exposures) or a precicted S/N of around 1320 for perfect data reduction. This compares to a S/N from the pipeline-reduced data of around 1100 which is encouraging.

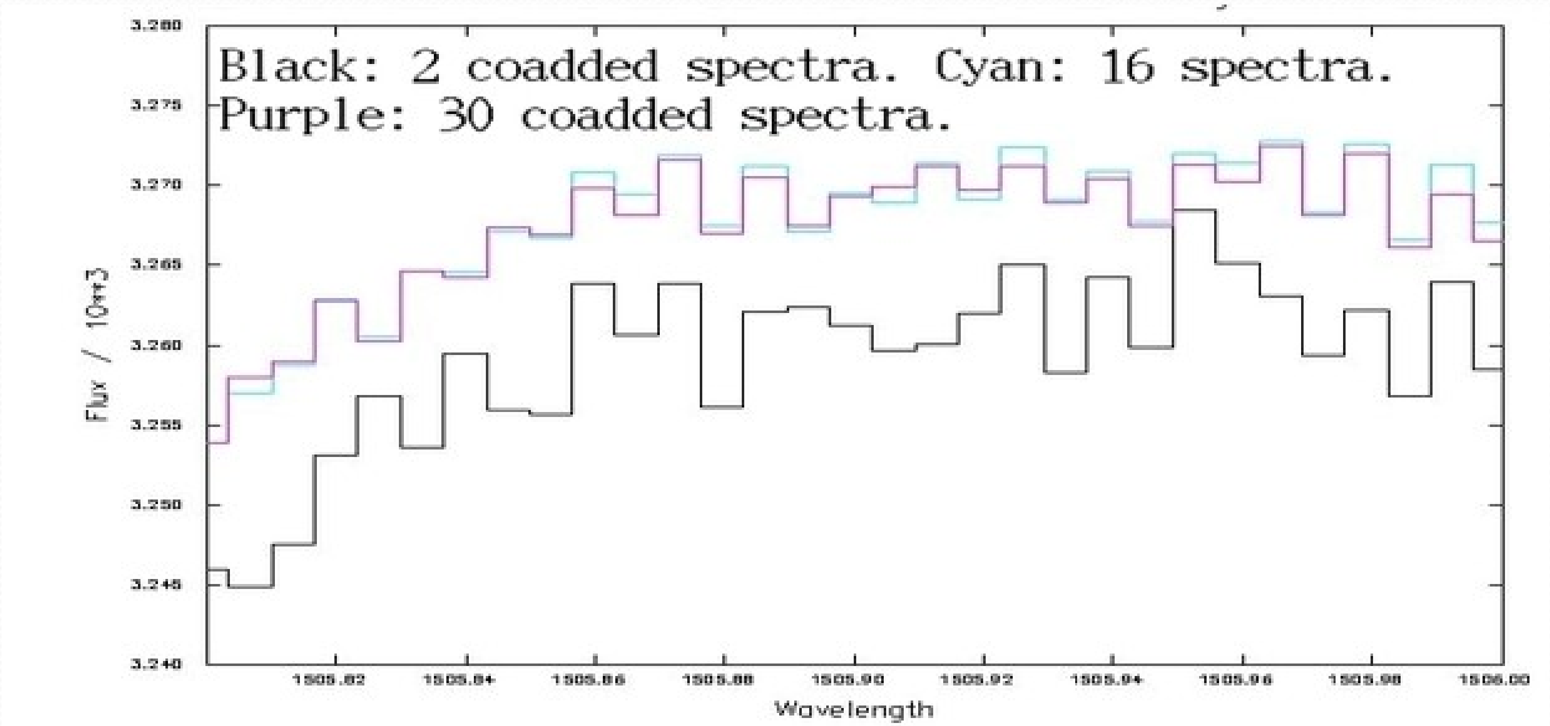
Number of exposures	S/N ratio in reduced spectra
2	1100
4	1420
8	1670
16	2000
30	2000

Derived S/N ratio per pixel for different number of exposures.

Results (2)

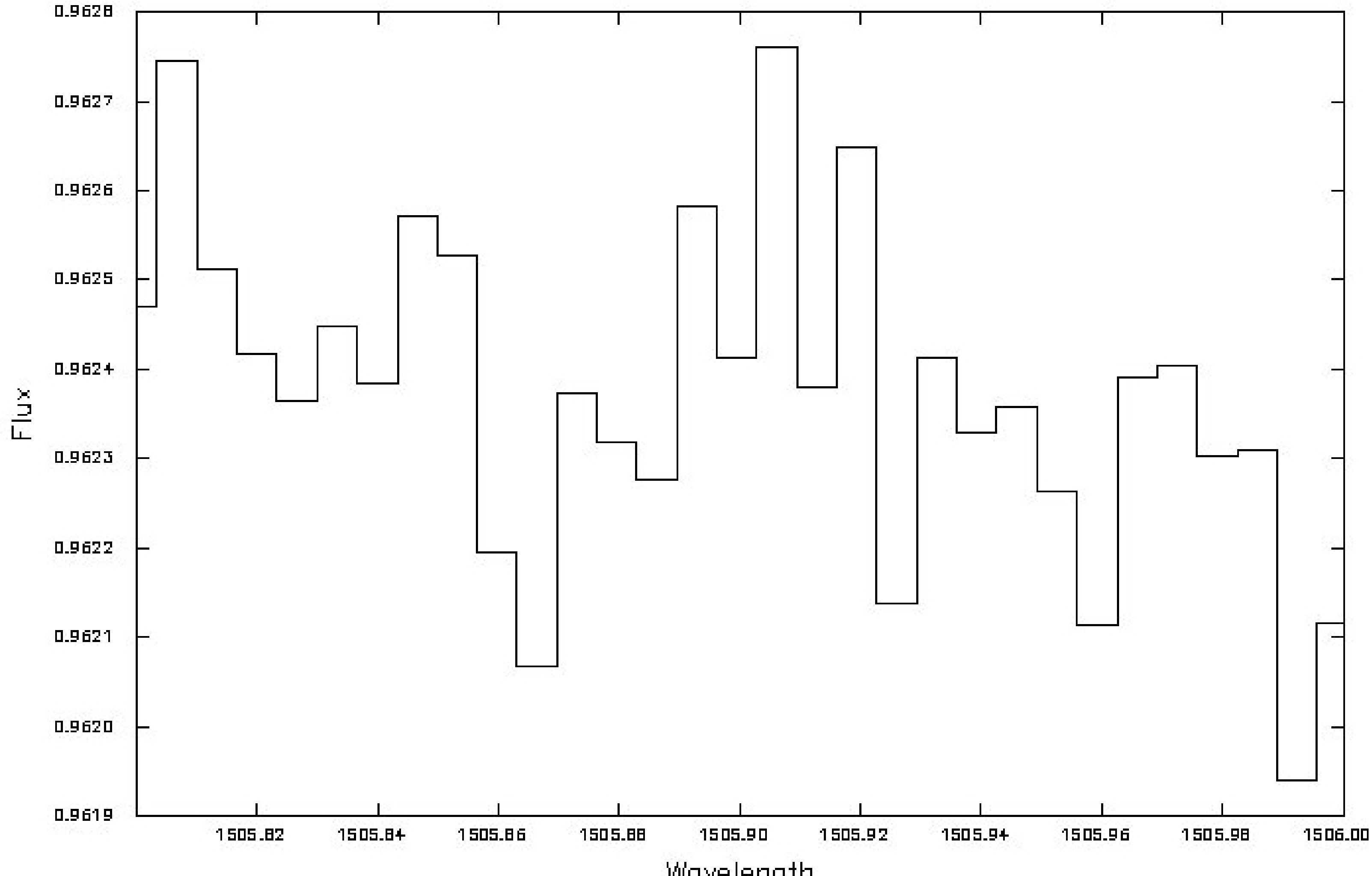
Increasing the number of exposures from 2 to 16 yields and increase in the S/N ratio of 1.8 compared to an expected increase of 2.

However, increasing from 16 to 30 exposures shows no measurable increase in S/N ratio. The figure below shows a zoom on a small spectral range on detector 3 for 2, 16 and 30 coadded spectra.



Results (3)

The figure below shows the extracted spectrum for 16 exposures divided by the same spectra for 30 exposures. The S/N ratio of this is around 5000, indicating correlated noise, clearly visible in the previous figure.



Conclusions

The current data have a maximum extracted S/N ratio per pixel of around 2000 on detector 3, obtained with 16 exposures. Nearly doubling the number of exposures does not increase the S/N as was expected a-priori.

To improve the reduction we aim to:

- Double check how the non-linearity correction is applied.
- Reduce the individual “nods” separately before coadding.

We also plan to use molecfit to check how well telluric correction works for such high S/N data.

In the future the same star will be observed with CRIRES plus and a similar analysis undertaken.

– See www.eso.org/sci/facilities/develop/instruments/crires_up.html