Test on LUCIFER calibrator science frames

Marco Fumana, Bianca Garilli, Marco Scodeggio

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1. Introduction

In order to find the best way to combine together telluric spectra and compute a sensitivity function, we observed different scientific frames of telluric stars. During this exploration we detected strange changes in spectra obtained from consecutive frame, this variability prevents us to compute a suitable sensitivity function, so we need to investigate better these frames.

We focus our attention on telluric acquisition in the same pointing with the same configuration during 3 different night: HDFN 210zJHK, K filter, M075 mask, acquired on 12 April, 04 May and 18 June.[1]
The acquisition script puts the star in reddest slit (slit number 11) and bluest slit (slit number 3) and for each list it acquires n frames in A (centered) and B (offset) position.
After script ran we obtain the following files (in this order):

- acquisition images of the star in the reddest slit (note: blue image miss)
- a family of n red spectra in A position (red A)
- a family of n red spectra in B position (red B)
- a family of n blue spectra in B position (blue B)
- a family of n blue spectra in A position (blue A)

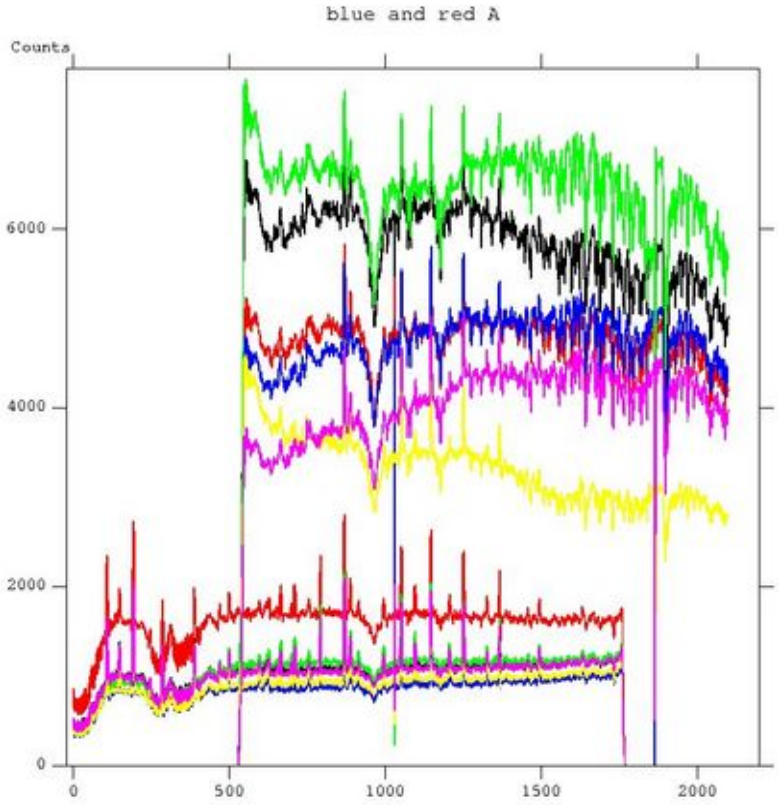

Figure 1: Spectra extracted from red and blue (A position) files. Time sequence is: black, red, blue, green, purple and yellow

Figure 1 plots red and blue spectra in A position obtained on the 18 June; this figure shows 2 unexpected spectra features:

1 Examined files are:
from luci.20100412.0119.fits to luci.20100412.0126.fits (2 frame for family)
from luci.20100504.0246.fits to luci.20100504.0253.fits (2 frame for family)
from luci.20100618.0132.fits to luci.20100618.0155.fits (6 frame for family)

- there are 2 big groups of spectra, blue and red family have different intensities
- inside each family (red A or blue A) objects have different shapes and intensities each other

Since these strange features had been detected in both A and B position over all the examined nights, we performed a set of tests to find an explanation to these strange features.

2. Performed tests

In the first test, we manually extracted from reduced bi-dimensional files, 2 different regions of the slit number 11: a region where star is located and another where not. Then we performed this extraction in 2 different red frames (0132 and 0133) obtaining the 4 spectra plotted in the figure 2.
This picture show how intensity differences of the star spectra are not relevant in the relative sky spectra.

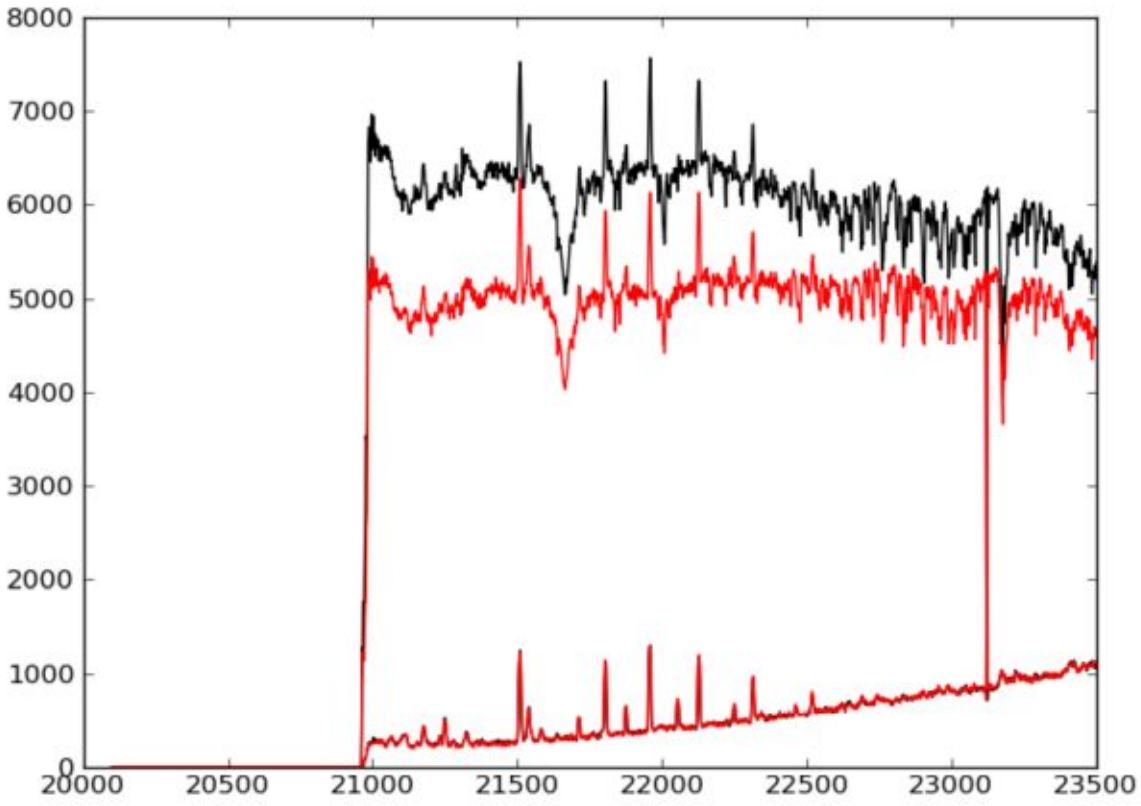

Figure 2: Sky and object extracted from 2 different frame: black line from 0132 and red line from 0133

In another test (always using reduced bi-dimensional file) we used red a blue files (0134 and 0152). From the blue file (0152) we extracted a star spectrum from the slit 3 and a sky spectrum from slit 11 (where star miss), and from the red file (0134) we extracted a star spectrum from the slit 11 and a sky from slit 3 (where star miss).
Also this figure shows that differences in star spectra disappear in the relative sky spectra[2]

2 The slight difference in the slope tail of the sky spectra should be explained by flat field correction

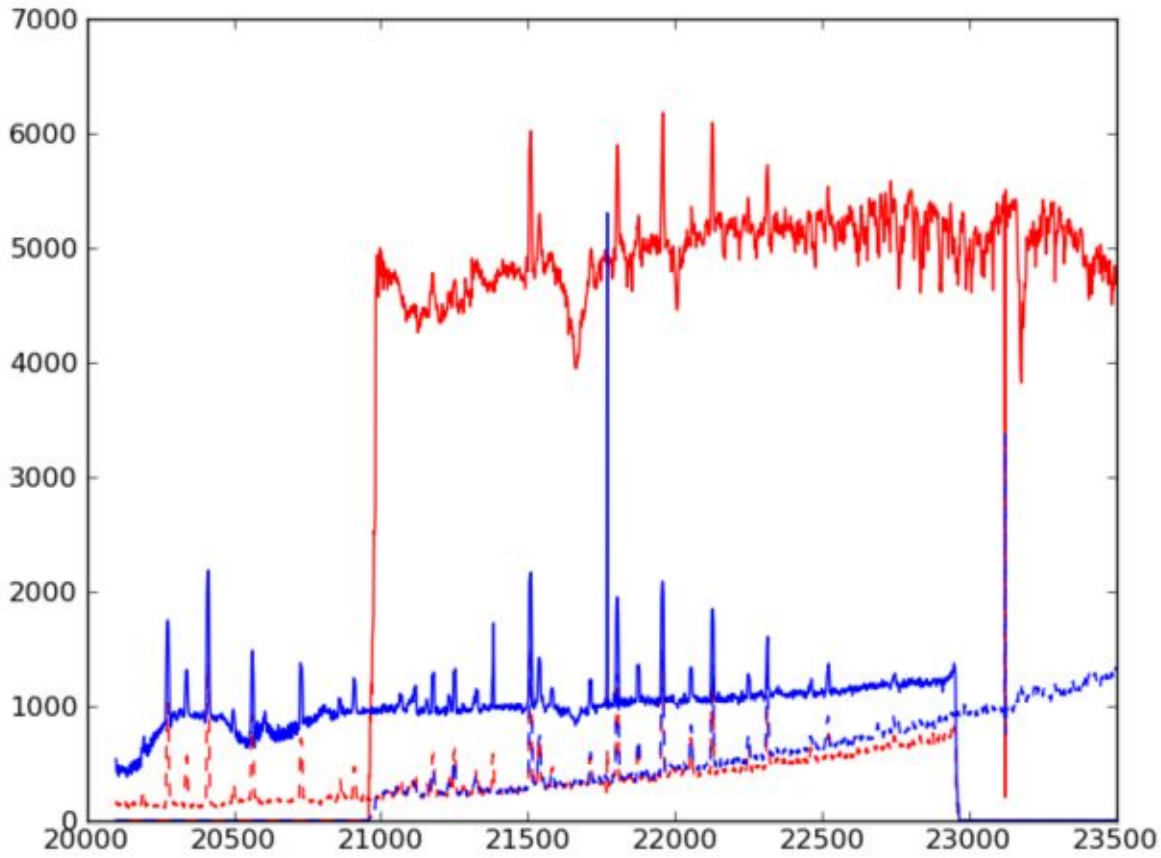

Figure 3: *blue solid line: star extracted from 0152, slit 3*
blue dot line: sky extracted from 0152, slit 11
red solid line: star extracted from 0134, slit 11
red dot line: sky extracted from 0134, slit 3.

The previous tests drive us to exclude problems such as: not uniform detector illumination, different exposures from a frame to another and different response of the array sensors.

In order to exclude errors introduced by our reduction pipeline, we executed a trivial spectra extraction on the raw data: we detect manually regions where objects are located and regions where not, then sum columns in these regions to obtain respectively star and sky spectra.
Obviously no lambda calibration and distortion corrections are applied, we just focus our attention on spectra counts.

Reproducing plots of figure 3 with spectra extracted from the raw data, we obtained the figure 4 which shows the same behavior of the previous figure.

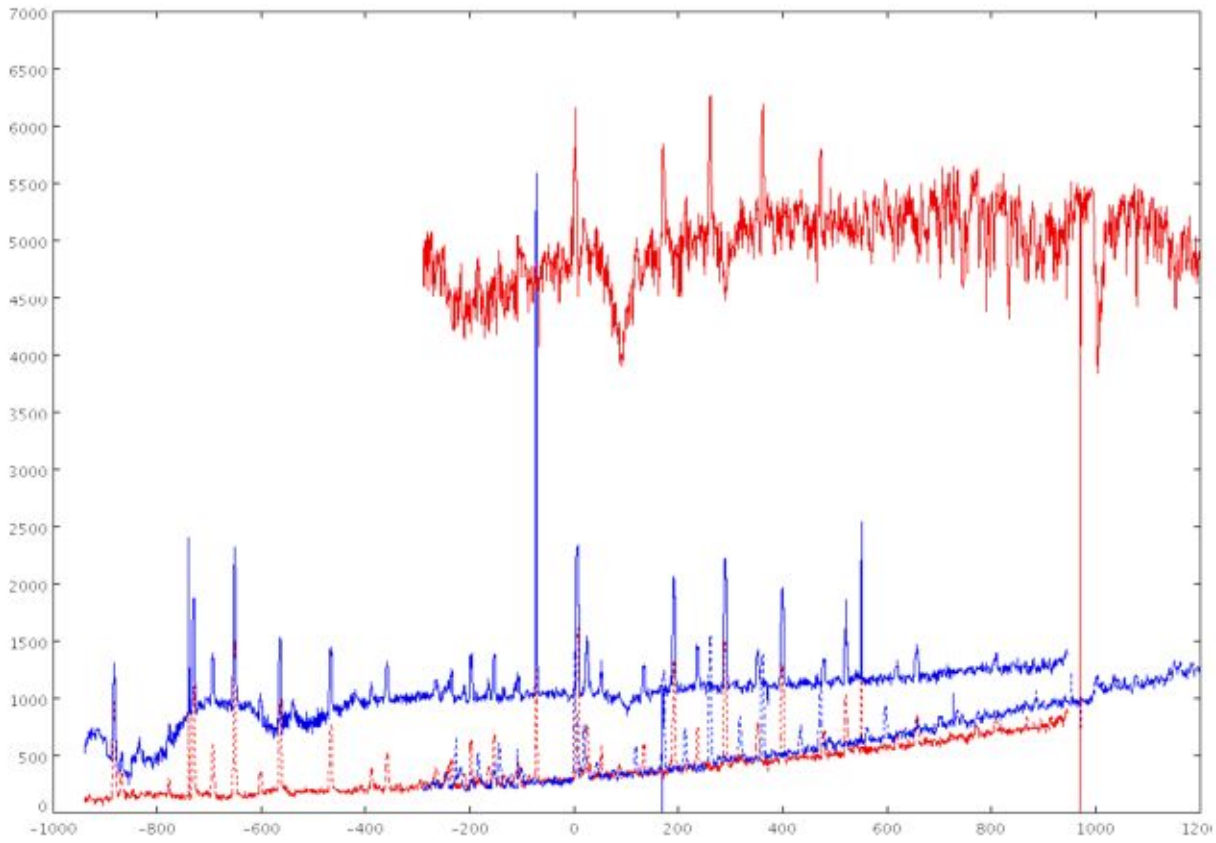

Figure 4: *blue solid line: start extracted from 0152 (raw), slit 3*
blue dot line sky extracted from 0152 (raw), list 11
red solid line star extracted from 0134 (raw), slit 11
red dot line sky extracted from 0134 (raw), slit 3

By this test we can also exclude that the strange behavior of the red and blue families depend on the reduction pipeline.

Resuming: changes of star spectra aren't observable in the sky spectra, i. e. sky intensities appear uniform in each list and in each frame. This sounds like the blue slit picks just a small percentage of star light, so we investigate this hypothesis.

Since blue acquisition image miss, we used a red and blue scientific frames, and the red acquisition image to compute if star is fully contained the blue split or not.
Using 0132 and 0150 we obtain telescope coordinates
ra_{0132} = 13:50:18.2505 dec_{0132} = 58:32:22.1518
ra_{0150} = 13:50:35.8233 dec_{0150} = 58:31:29.5374
and so we can compute telescope offset.
Looking acquisition image[3] we compute star position in center of the reddest slit
ra_{red} = 13:50:27.331 dec_{red} = 58:32:19.02
and we apply the same offset performed by the telescope
ra_{blue} = 13:50:9.758 dec_{blue} = 58:33:11.634

The blue coordinates computed are no more in the center of the blue slit, we deduce that the star in bluest slit is no more in the center, but it falls on its border (wasting a good percentage of counts).

3 luci.20100412.0131.fits

3. Conclusions and future actions

After these checks we suppose that the difference of intensities from red and blue family is due to a problem in the offset telescope, i. e. when telescope moves star from red to blue slit, the star falls out of the list center.
We suggest to pick a blue acquisition image after offset to verify if the blue star is or not in the slit.

At the moment we are developing a pipeline task which compute sensitivity function according with this recipe :

- it uses only frames in the A position
- it obtains a unique (median) spectrum from the red family and another for the blue family
- it normalizes blue spectrum on the red to obtain an unique spectrum calibrator, which covers all lambda range
- it uses these merged spectrum to compute sensitivity function

We have no explanation for the variability of shape and intensity of the spectra in the same family, our test cannot explain these anomalies. We guess that this problem requires further tests.