HST ACS/grism spectra of SuF02-12 & SuF02-60

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In this memo I describe shortly the work I have done on the *HST* ACS/grism spectra of SuF02-12 and SuF02-60, and Riess' SN 2002fw.

The reduction started with combining the images and cleaning the cosmic rays. This was simultaneously done in IRAF with IMCOMBINE. During the two visits of SuF02-12 the SN was placed at the same position on the chip and with the same orientation. I have combined all the images from the two visits. For SuF02-60 the images of the two visits were combined separately because the SN was at slightly different position and orientation. Contrary to our observations when on all the images of a given visit the SN was on the same position, A. Riess dither the telescope while keeping the same orientation. It seems that on each orbit they took two dithered 1200 s long exposures, with the dithering pattern #12. Each such pattern also dithered, thus ending up with 16 dithered images. Thus, in the case of SN 2002fw the images were first shifted and then combined. So obtained 2D images are shown on Fig. 1. The 1D spectra were extracted from these images. Judging from the 2D images, our observations seem better than those of Riess.

Dithering is a very efficient way to combat the bad (cold, hot, etc.) pixels. The bright pixels on the images of SuF02-12 and SuF02-60 are namely such bad pixels. These are absent from the images of SN 2002fw. However, #12 is a 1/2 sub-pixel dithering pattern and after the image combination this introduces pixel-to-pixel correlation. My opinion is that for the grism spectra we should follow a similar dithering scheme but using dithering pattern #14. This is a two-image integer pixel dithering by 5 pixels in each direction. Each such two-image pattern should be started from slightly different pixels (integer).

The extraction of the spectra was done with aXe and IRAF with additional work in IDL. I will not go into detail of the extraction scheme. Briefly, aXe was used for flat-fielding and wavelength calibration. I did the background subtraction and flux calibration in IDL. IRAF was used to extract the spectra. I used a simple summing of the flux along the trace. This proved superior to the weighted extraction. The extracted spectra are shown in Fig. 2. For comparison, it is also shown the VLT spectrum of SuF02-60. As seen the general shape of the VLT and ACS/grism spectra is the same with the spectrum being red and showing SN-like humps. The ACS/grism spectrum of SuF02-12 shows the same features. Figures 3 & 4 show the result of running SUPERFIT on the spectra. The SUPERFIT was restricted to only the SNe Ia templates, and for redshifts 0.9–1.2 in the case of SuF02-60 and 1.0-1.6 for SuF02-12. For both SNe (including the VLT spectrum) the program gives best match with spectra around maximum as expected. The redshifts obtained are $\sim$ 1.05 for SuF02-60 and $\sim$ 1.28 for SuF02-12. Note also the significant host galaxy contribution in SuF02-60.

The results on SN 2002fw are presented in Fig. 5 along with the spectrum as presented by Riess. For comparison I also show both, the pure aXe and the "mixed" extraction spectra. The two spectra coincide reasonably well, although the "mixed" looks less noisy. Comparing with the spectrum of Riess, the spectra look the same in the sense that all the SN features are there. But apparently there is a problem with the flux calibration – in my reduction the spectrum is much bluer, or more precisely, there is a flux deficit in the red. Looking at Fig. 2, it is seen that the flux calibration I did on the ACS/grism spectrum of SuF02-60 is quite consistent with Chris' VLT calibration, thus giving additional confidence in my reduction.

In conclusion, *HST* ACS/grism spectra we have seem to be useful for typing the high-redshift SN candidates and estimating the redshift. I would suggest for future observations to use integer pixels dithering scheme. However, to get useful results careful reduction is need. Because the objects are faint special attention should be paid on the background subtraction. Unfortunately, aXe is not very flexible in doing this and this step should be done outside it.

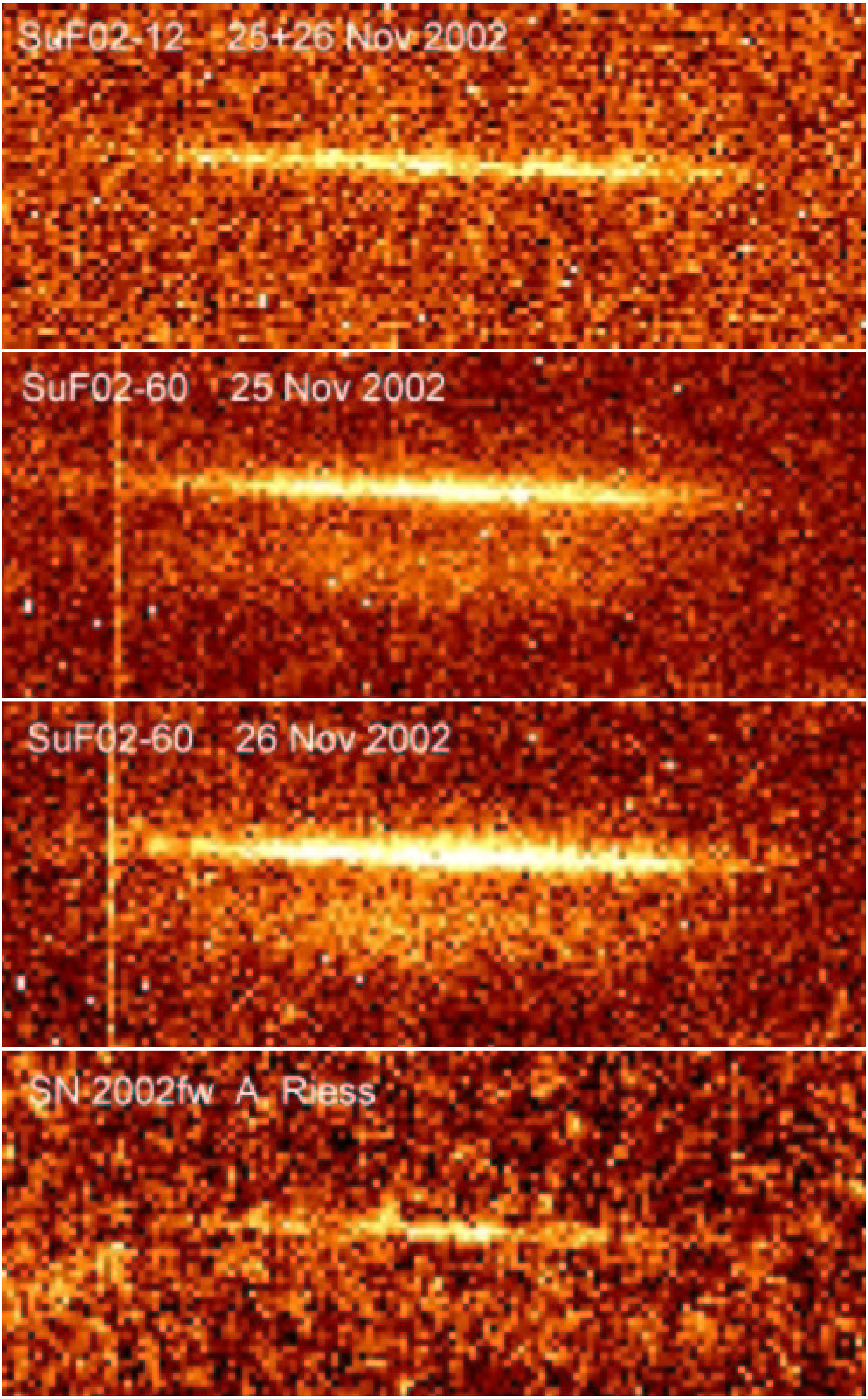

Figure 1: Summed 2D images.

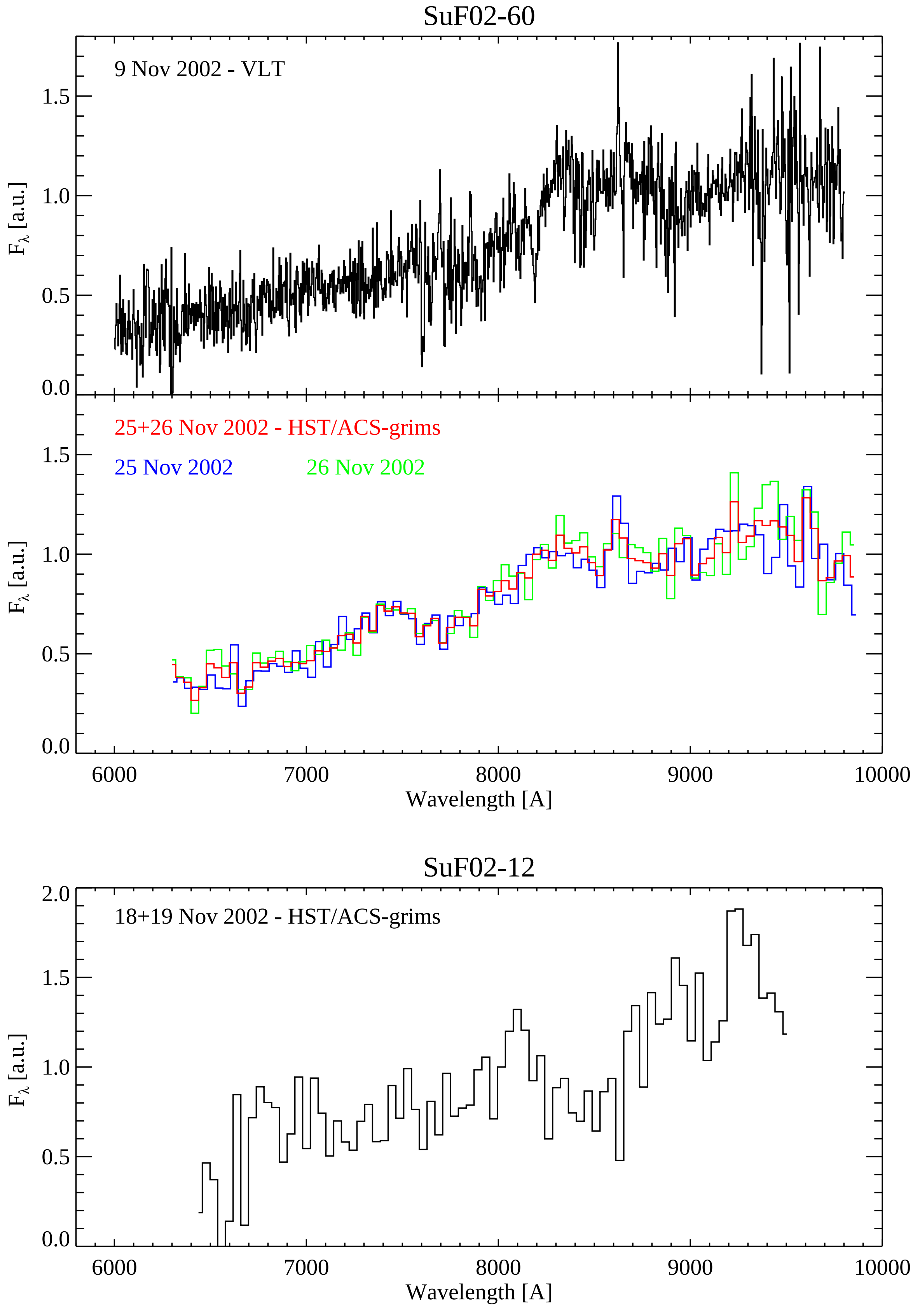

Figure 2: The extracted spectra. Also shown is the VLT spectrum of SuF02-12 as reduced by Chris.

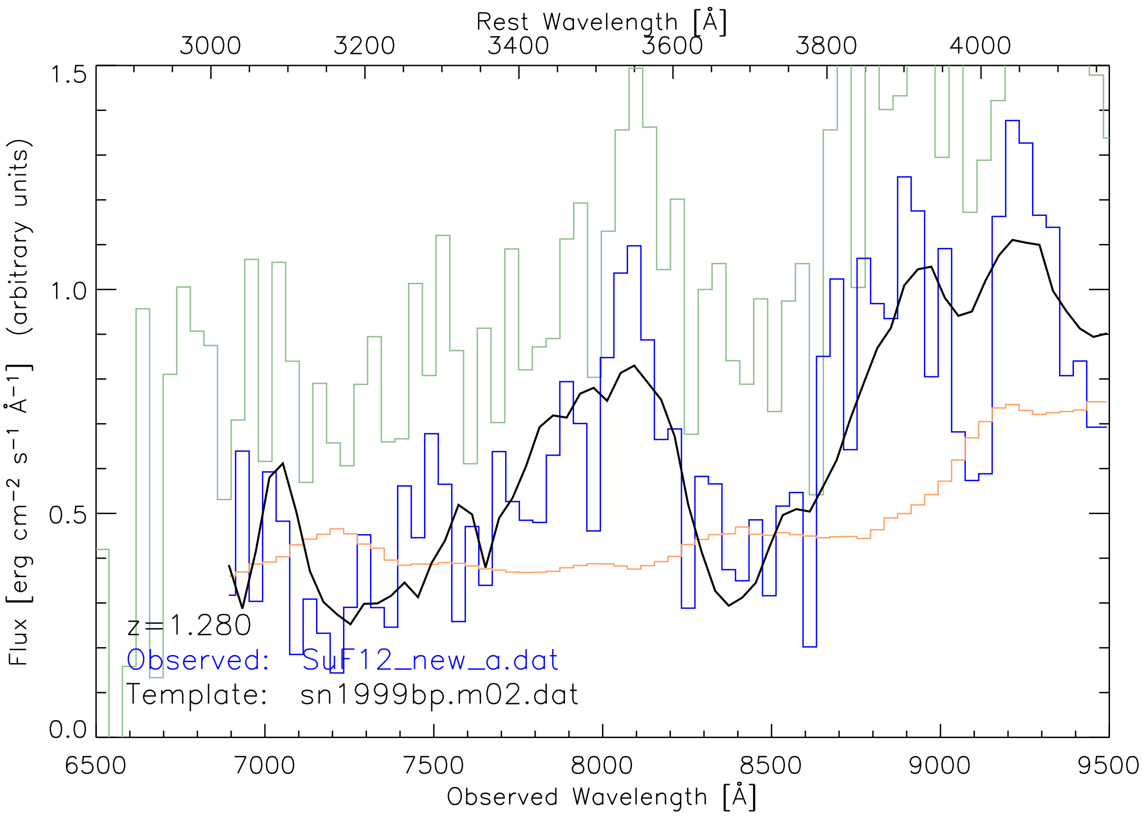

Figure 3: Best match by SUPERFIT.

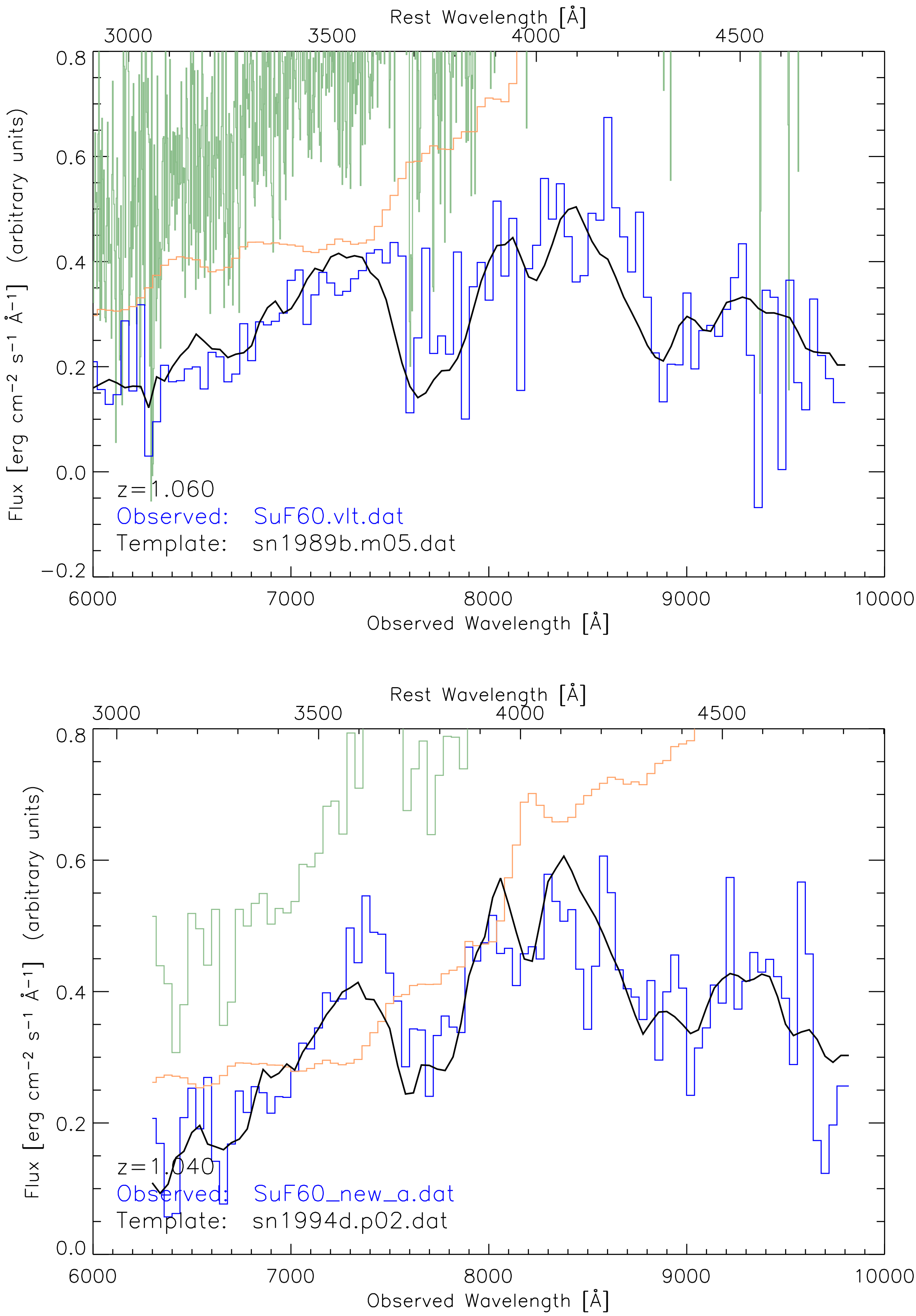

Figure 4: Best match by SUPERFIT.**up** – the VLT spectrum; **down** – *HST* ACS/grism.

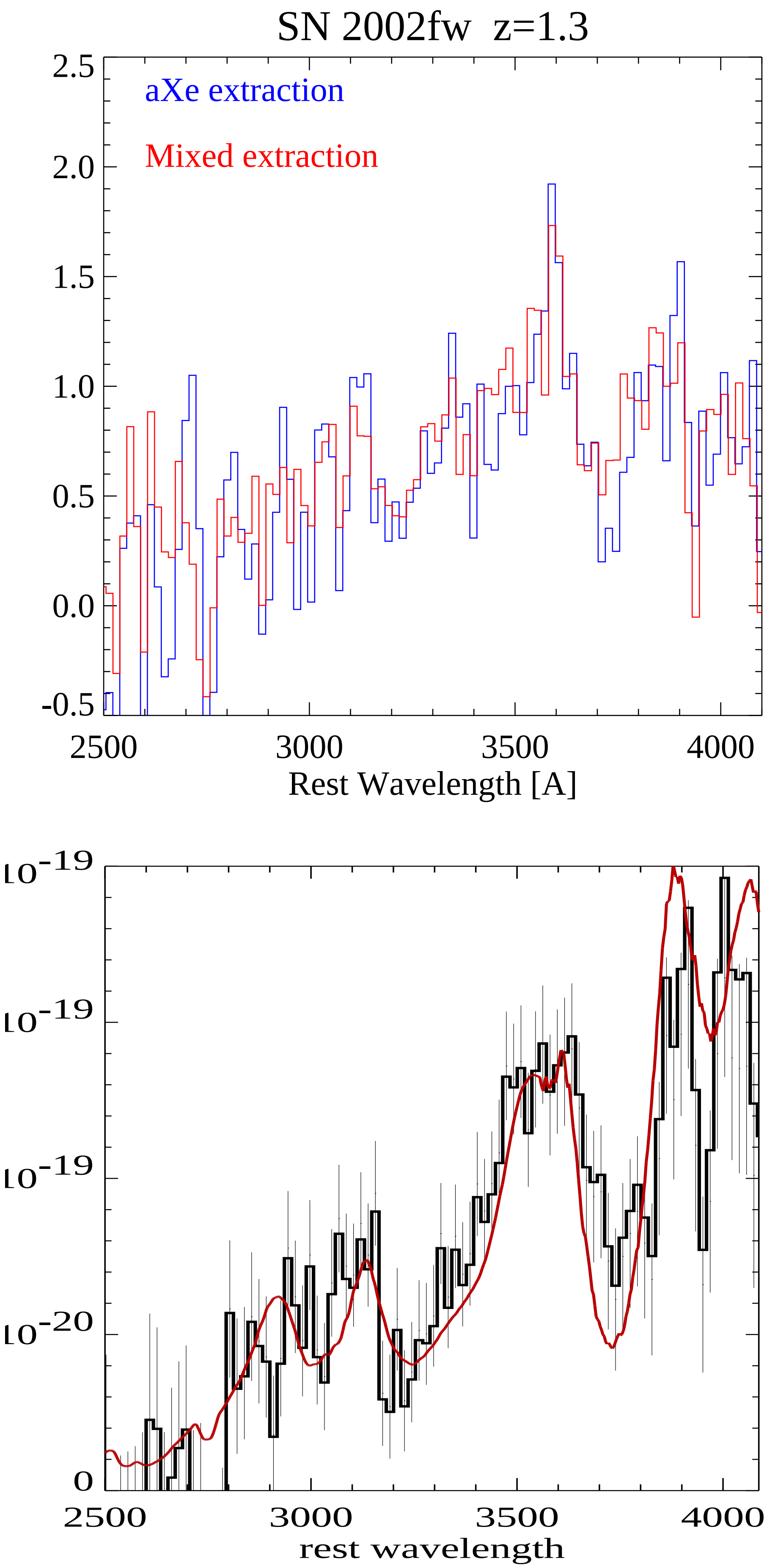

Figure 5: SN 2002fw: **up** – my reduction; **down** – as presented by Riess.