IFUs: Disentangling the Light from Neighbour Fibers

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Integral Field Unit (IFU) spectrographs allow continuous space coverage of a small part of the sky by using a microlens array at the telescope focal plane. Each microlens images the telescope pupil onto an optical fiber, which is in turn taken to a bench spectrograph. A larger number of microlenses allows for higher spatial coverage and/or spatial resolution.

A larger number of fibers also implies in larger spectrographs, this means higher costs and higher telescope payloads. As the fibers are brought closer together at the spectrograph slit, the smaller the spectrograph becomes, and bigger becomes the contamination problem.

We have been working to determine how close together can be the fibers at the slit plane of a spectrograph, and yet have an acceptable amount of contamination. To separate the signal of a fiber from its neighbor, we devised the following strategy: a- measure the width and position of the spectrum of every fiber at all wavelengths as part of our calibration process, using non-linear Gaussian fits (see Figure 1); b- when observing our science objects we use the already determined positions and widths and solve only for intensity, using a linear Gaussian fit. This is currently done for Gaussian profiles (spatially), but could be implemented for other shapes, including numerical tables. We note that the mask procedure is always used, whether we extract our spectra using profile fitting or simple aperture extraction.

We have tested our method by running simulations changing fiber spacing from 1 to 5 pixels and FWHM of the spatial profile from 1 to 5 pixels. Our tests roughly show that for equal values of spacing and FWHM simple aperture extraction gives a contamination of 15% between neighbors, while this number falls to 0.1% for Gaussian fits. The quality of the Gaussian fits depend on SN and we conclude that one can easily push as far as 1 pixel separation and 2 pixels FWHM at a SN=5, or equivalently to 2 pixels separation and 4 pixels FWHM also for SN=5. Simple aperture extraction at the same parameters produces a 50% contamination, while Gaussian fits produce 2% contamination. Figure 2 presents contour lines of contamination

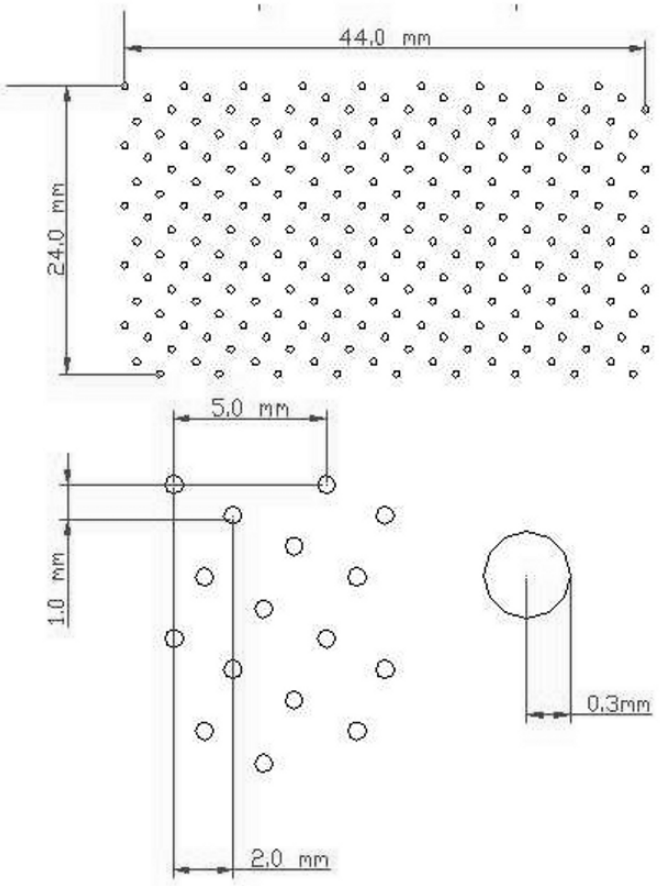

Fig. 1. This figure shows the current mask used with the Eucalyptus spectrograph at the 1.6m telescope in Brazil. The holes are arranged in a way that we need to move the mask to 5 successive positions and take one spectrum at each position in order to have one spectrum of each and every fiber. The mask holes are 0.3mm in diameter, compared to 1mm of the microlens size. The hole size being much smaller than the microlens insures that we don't contaminate a neighbor microlens thanks to bad alignment.

as a function of fiber separation and spectrum FWHM for Gaussian fits. Figure 3 is the same as Figure 2 for aperture extraction.

We have validated our results analyzing data obtained with the Eucalyptus spectrograph (in use at the 1.6m telescope in Brazil) at two samplings, spacing=FWHM=3 pixels and spacing=FWHM=5 pixels.

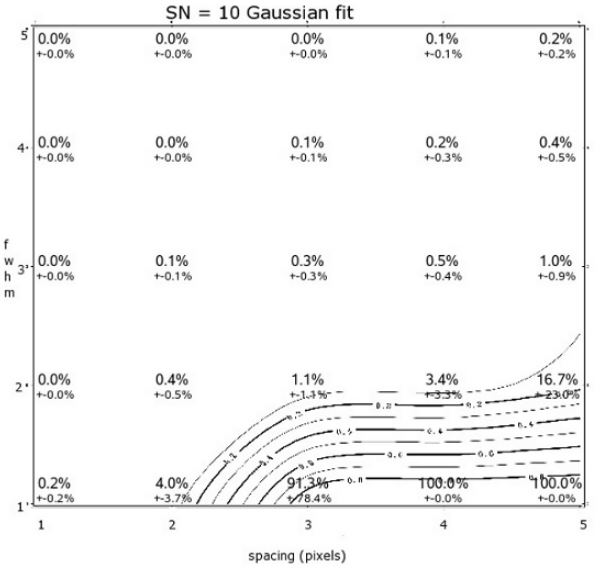

Fig. 2. This figure shows contour lines of contamination. The iso-contamination lines are equally spaced in intervals of 20%. In the x-axis is the spacing between fibers. In the y-axis the FWHM. The numbers superposed to the plot show the average contamination. The smaller numbers below are the scatter in contamination measured in Monte-Carlo simulations.

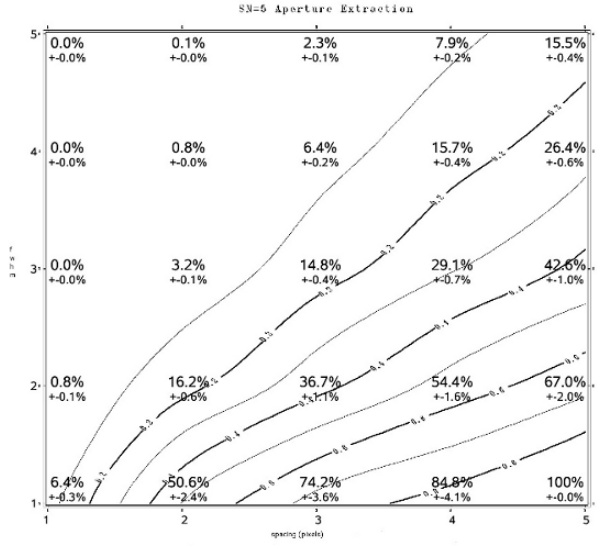

Fig. 3. Same as previous figure for aperture extractions. Note how contamination is much higher.