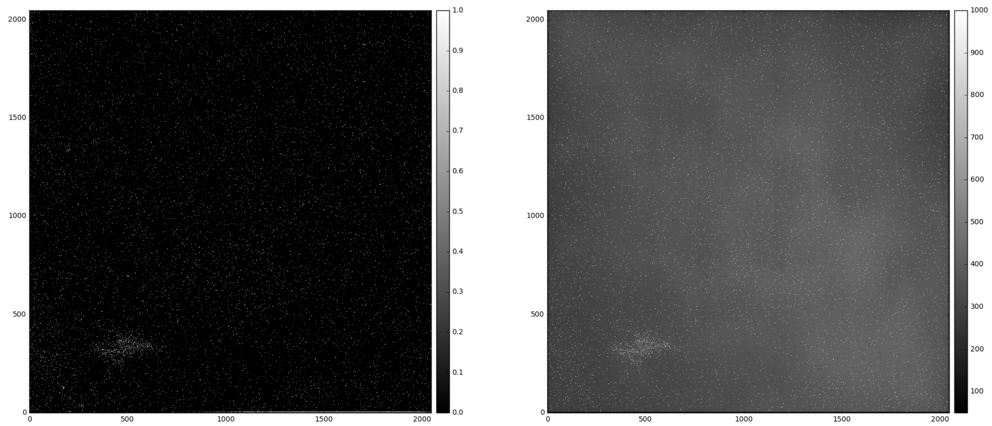
## 3.1 Basic reduction steps

### 3.1.1 Masterdark

The masterdark recipe median combines multiple raw dark frames into one master dark. This recipe determines from the master dark the position of pixels that give strange results in all measurements, which are called static bad pixels. It returns both a file that contains a master dark frame, consisting of the image, badpixels, the rms and the weightmap and a file that contains a static bad pixel map, which has the same content as the second extension in the master dark frame. This master dark is showed in figure 3.1 and can be used to correct for fixed-pattern noise that is caused by dark current and bad pixels for instance. Notice that the lower right corner of the master dark is relative bright. This is true for all used master darks, but the reason for this is yet unknown.



***(a)*** *bad pixel map* ***(b)*** *master dark*

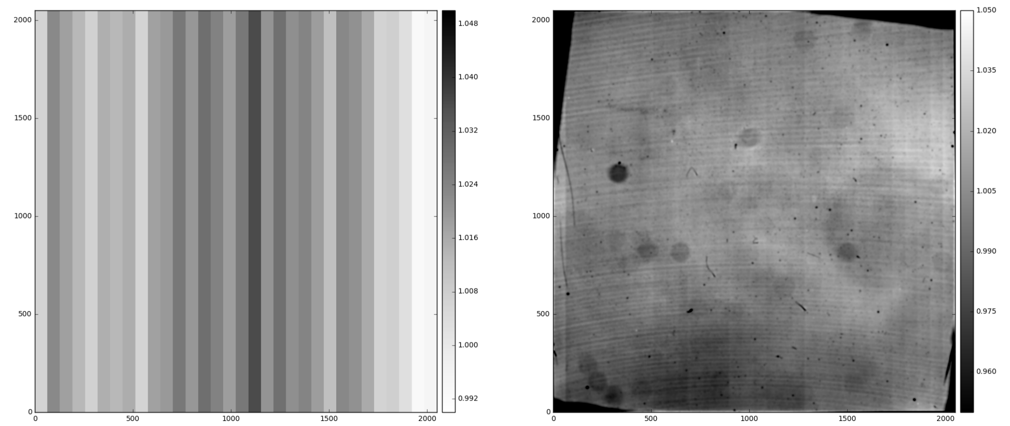
***Figure 3.1:*** *result of the masterdark recipe*

### 3.1.2 Detector flat

At this step, the variation in sensitivity of the different pixels are measured. This can be done by using the extreme useful ability of the IFS to obtain flats with the shutter of the instrument closed and one of its internal calibration sources turned on. This means that the detector can be illuminated directly, which enables us to correct better for the distortions of the detector itself. The distortions in the optical path are measured in the recipe that produces the instrument flat, described in the next paragraph.

Before starting the actual detector flat recipe, it is useful to make a preamp flat, which is a largescale flat field that corrects for the stripe structure caused by the pre amplifiers, as showed in figure 3.2a. The best way to do this, is by putting only the broad band flat field in the recipe and switch the additional output files on. This flat can be used to improve the masterflats and can be used along the masterflats in other calibrations and the final science calibration recipe.

Since the IFS uses a range of wavelengths, different detector flats are needed, taken in different wavelengths to calibrate all pixels properly. The recipe returns the combined master flat frames for the different lamps that are used. The best flat to use in the rest of the recipes are the large scale flat. One of the large scale flats is shown in figure 3.2b

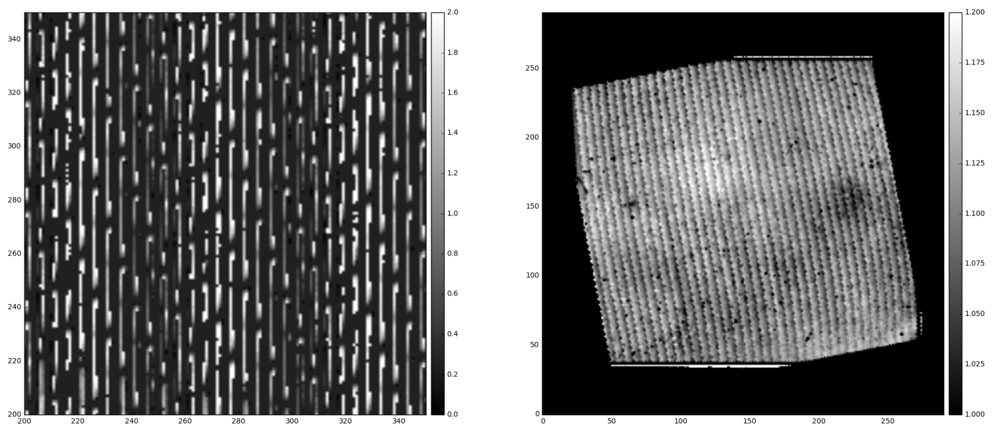


***(a)*** *pre-amplier flat* ***(b)*** *large scale flat*

***Figure 3.2:*** *result of the detectorflat recipe*

### 3.1.3 Instrument flat

This raw data is obtained by taking a flat with three or four of the external calibration lamps on. After the reduction, the flat field is divided by the detector flat, what has the effect of removing the detector response. This recipe returns both an instrument master flat which is the combined and reduced flat field before removing the detector response and the IFU, which is the flat field after removing the detector response. The first can only be used for calibrating other calibration data, the latter can be used to reduce science data. The IFU does not give all pixels a sensitivity value, but gives the response of each individual lenslet, so it gives for all pixels in the same spectrum a median value. Since this causes currently a stripelike feature in the reduced science images, I left it out of the procedure. Both the IFU flat and the instrument flat are shown in figure 3.3

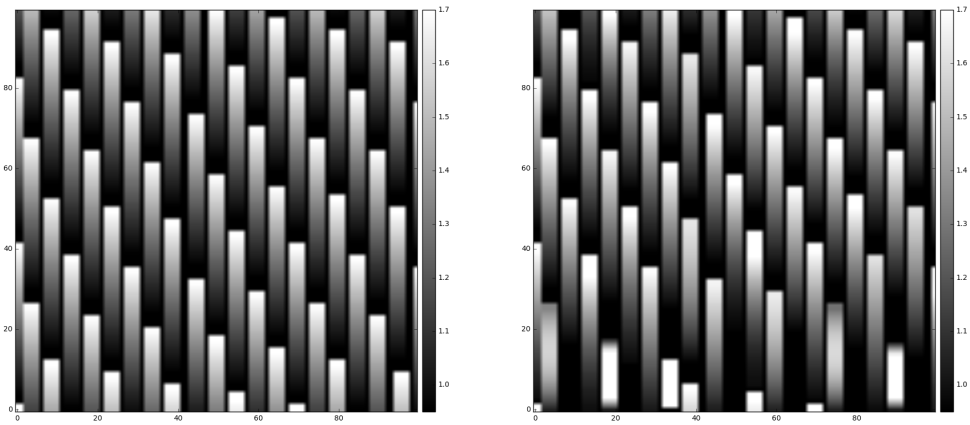


***(a)*** *zoomed instrument flat* ***(b)*** *IFUflat*

***Figure 3.3:*** *result of the instrumentflat recipe*

### 3.1.4 Spectra positioning

The spectra positioning recipe determines the exact position of the different spectra on the ccd. It associates pixels with wavelengths according to a lenslet model. Each pixel in this image has the value of the corresponding wavelength in micron. This model is just a good guess, the exact wavelength can be obtained by running the wavelength calibration. The seperation between the positioning of the spectra and the wavelength calibration makes the positioning of the spectra much better, which is the reason why they have split this step in two. The raw calibration data for the spectra positioning recipe is obtained by illuminating the instrument with an external white calibration light source that is uniformly scattered by use of an integrating sphere that diffuses the incoming light, but preserves the power. A zoomed piece of the spectra positioning file is showed in figure 3.5



***(a)*** *zoomed position of spectra* ***(b)*** *zoomed wavelength calibration*

***Figure 3.4***

### 3.1.5 Wavelength calibration

The wavelength calibration recipe refines the wavelength of the different pixels, by using data that is obtained by illuminating te instrument with three or four external lasers, emitting at 0.9877, 1.1237, 1.3094 and 1.5451($\mu m$). These lasers have been uniformly scattered with the same integrating sphere as mentioned in the section about the spectra positioning. The recipe tries to fit a spectrum on the positions that are determined in the spectra positioning recipe. Note that if a part of the spectrum does not fit on the ccd, the recipe is unable to fit a spectrum, which is visible in figure 3.4b

### 3.1.6 Distortion map

The distortion map is a calibration file that gives the distortion of the lenslet grids. This distortion is a large scale distortion that is caused by a small error in the position of the lenslet grid. This map is made by comparing the expected positions of hundred point sources, with the detected positions of these point sources in the input data file with raw data. If

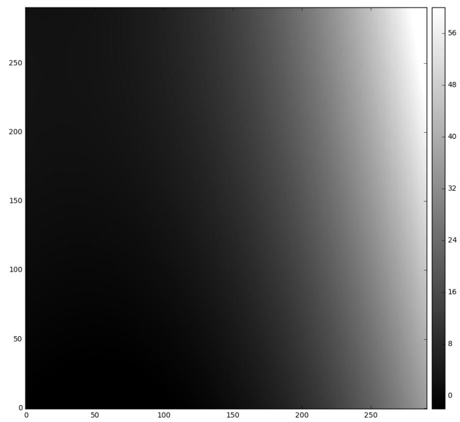


***Figure 3.5:*** *distortion map*

there is no point pattern provided as input, the recipe constructs his own out of the point sources in the reduced images. Since this calibration is much less important, and not noticable in the reduced data, it is currently left out.

### 3.1.7 Background calibration

I am still not complete sure what this does. It uses dark frames, but with much longer exposure times. Since it subtracts the masterdark, it feels like a dark with a subtile bias subtraction.