# IRAF Task

Astrophysical Techniques and Data Reduction

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We built **iraf** and **x11iraf**, and installed **pyraf** on our Ubuntu 24.04 system on WSL. We will now follow the tutorial highlighted in the **IRAF_task.pdf** document.

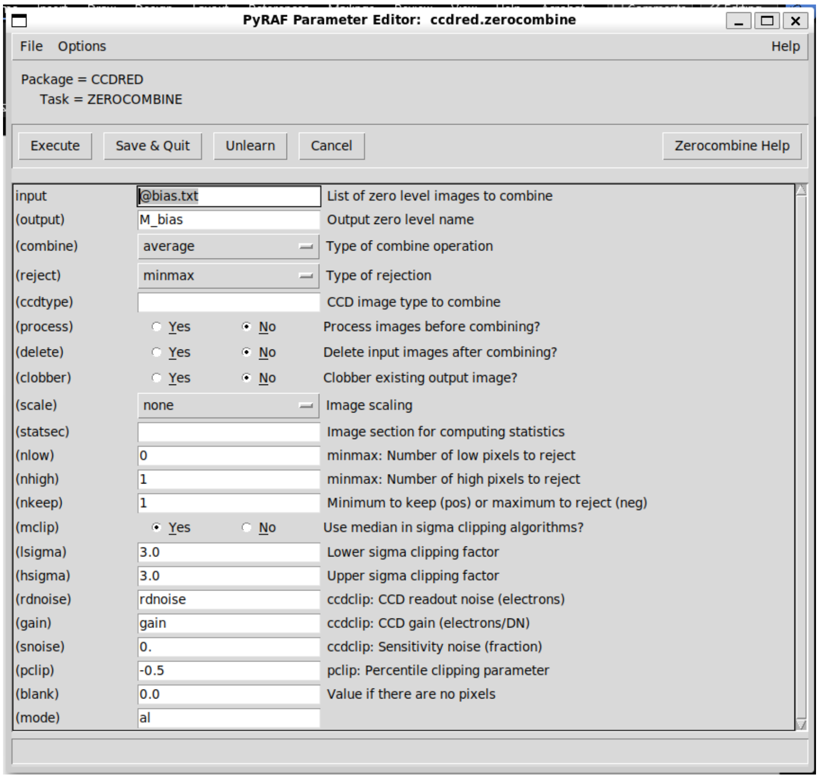
## 5) Data Reduction

### 5.1) Calibration

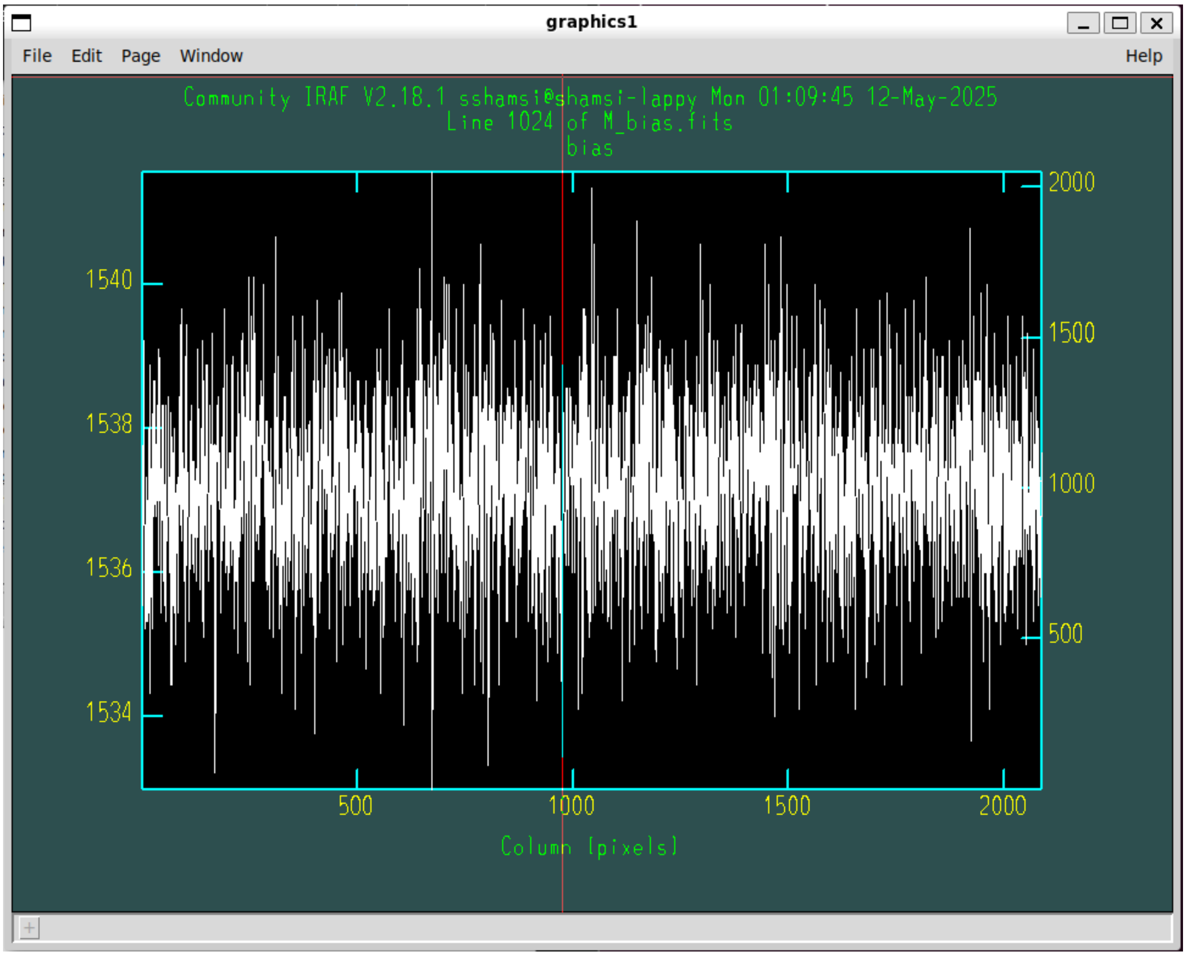
#### *Baias Correction*

i) Combination of the Bias Files

We have some bias FITS files, listed both in the **Copernico_coded.txt** and **bias.txt** files. We will run the **zerocorrection** task:




This outputs the **M_bias file**, which can be seen below:

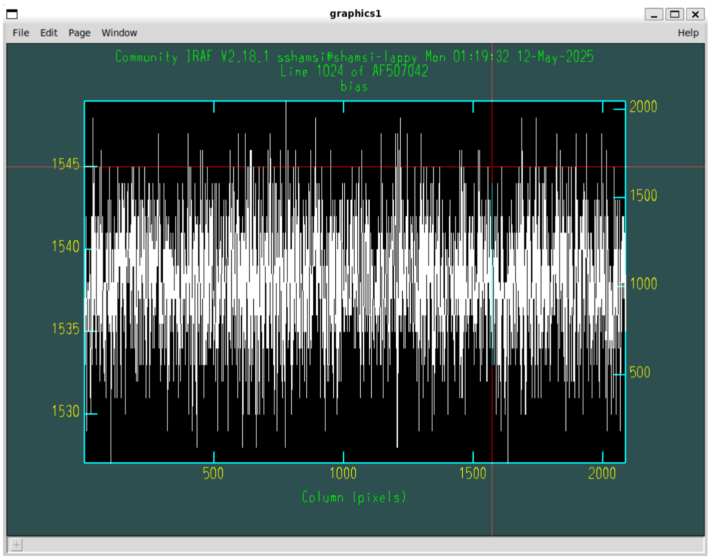


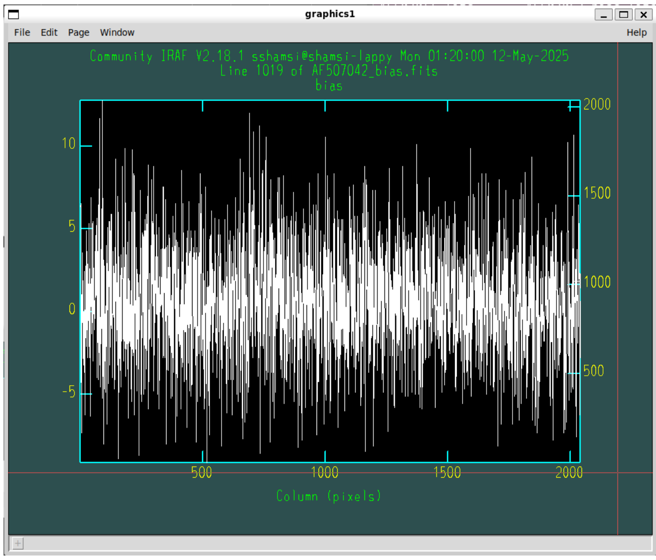

ii) Applying the bias correction and trimming

We can now use the task **ccdproc** to apply bias correction from **M_bias** to all our images, saving the results with '**_bias**' after the filename. We define the new filenames in a separate file called **all_bias.txt**.

```
TASK : ccdproc
PACKAGE : noao -> imred -> ccdred

input = @all.txt Text
output = @all_bias.txt
ccdtype = BLANK
fixpix = no
oversca = no
trim = yes
zerocor = yes
darkcor = no
flatcor = no
trimsec = [26:2065,7:2044]
zero = M_bias
```

The change in an example file and its bias-corrected counterpart can be seen below:

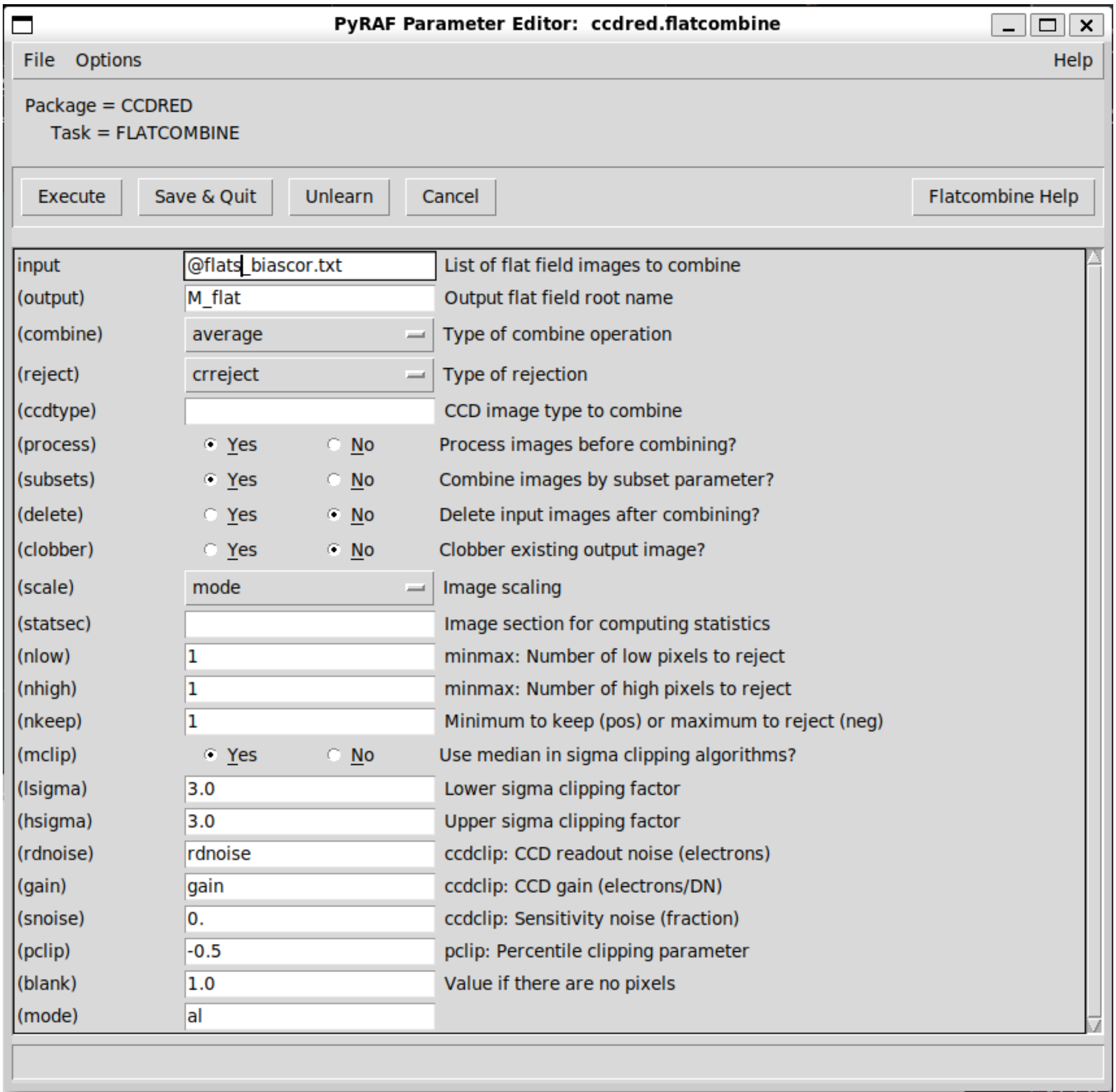


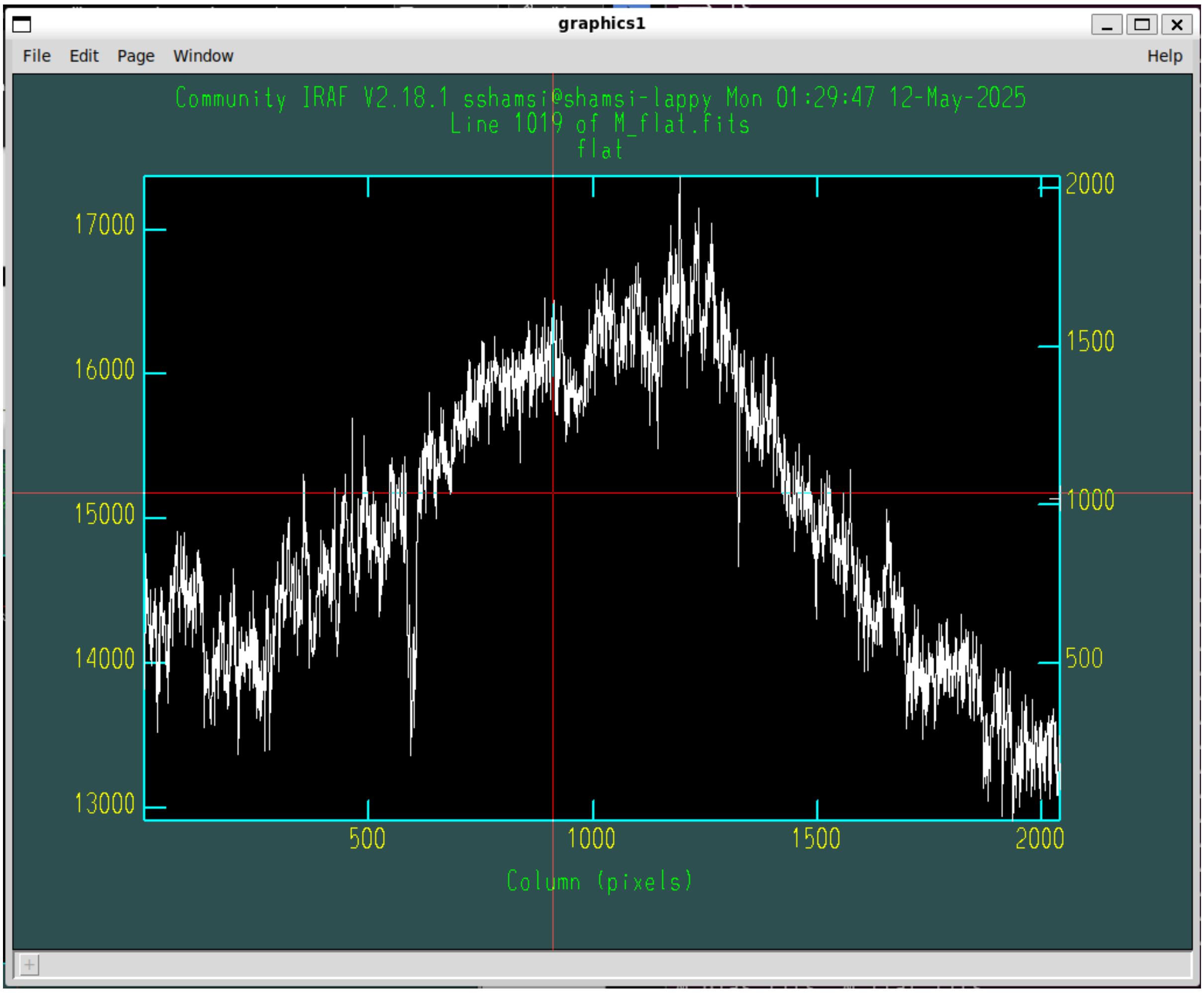

## *Flat Normalisation*

i) Combination of the flat images

We take our bias-corrected flat files, and use the task **flatcombine** to combine them:

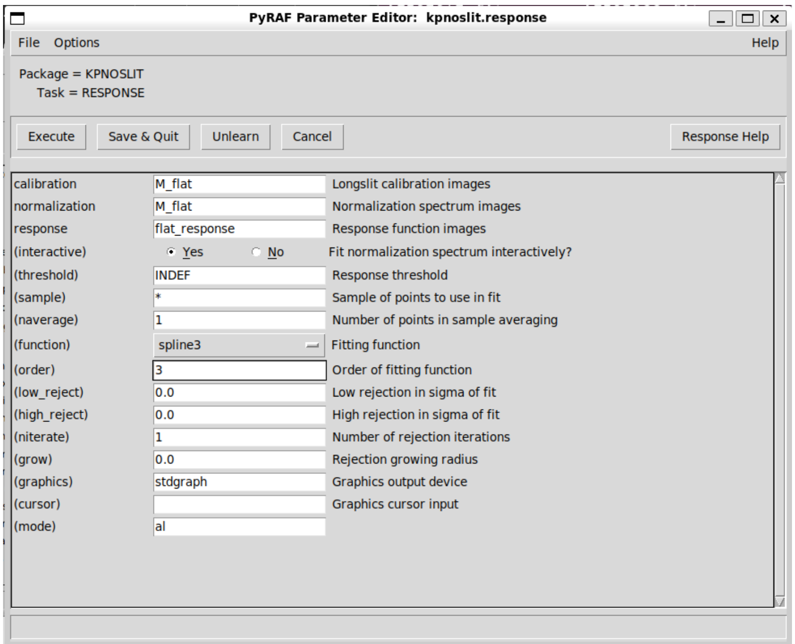


This produces a **M_filat** file for us to do further corrections. It looks like the following:

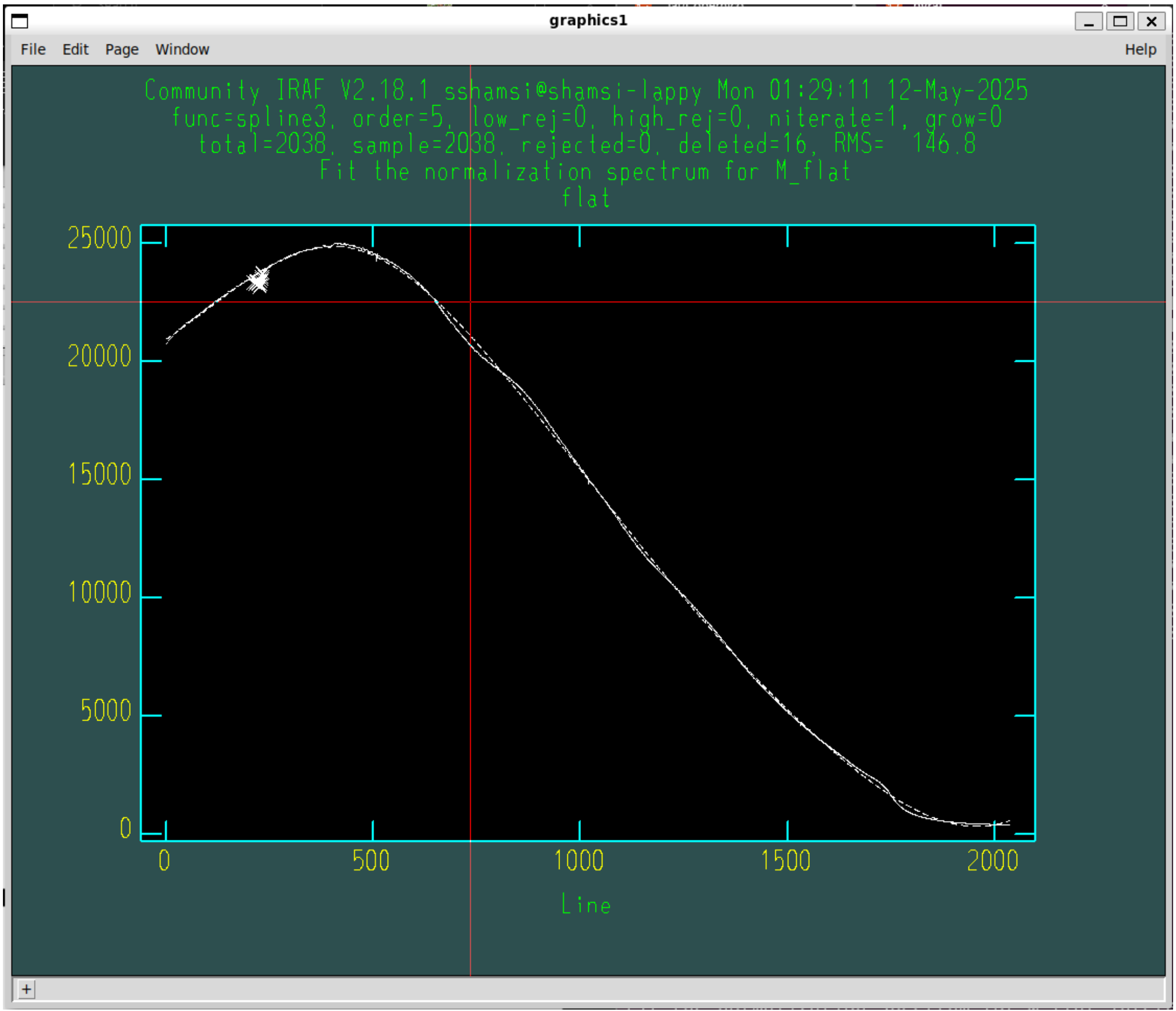



ii) Fitting the flat lamp spectrum

We use the response task to model the flat lamp's spectral response at high frequencies, so that only low frequency variations remain.

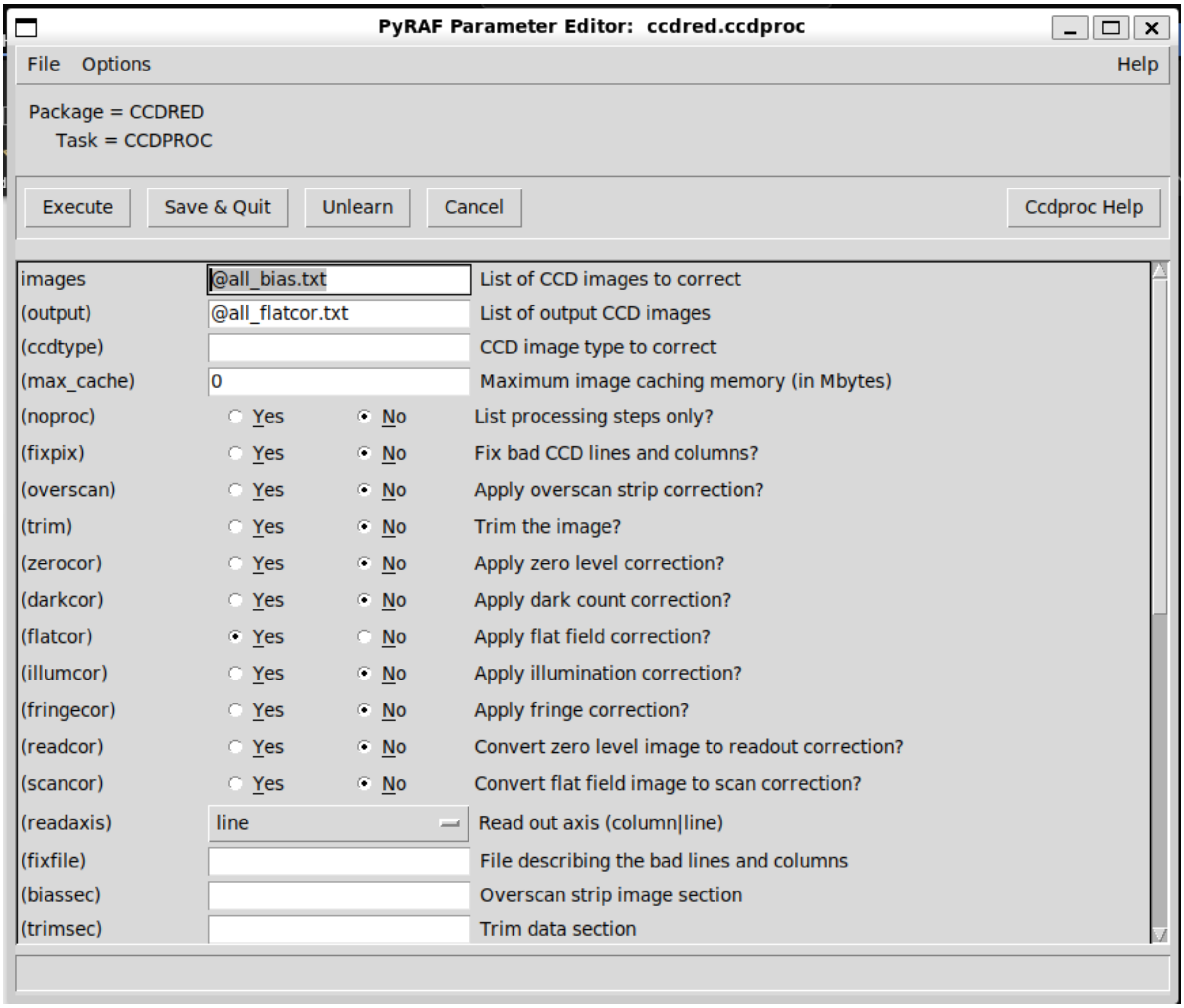


We interactively edit the **spline3** function, removing some datapoint deviations and editing the order of the fit. We find that the order 3 best represents the response function without resorting to frequencies which were too high.

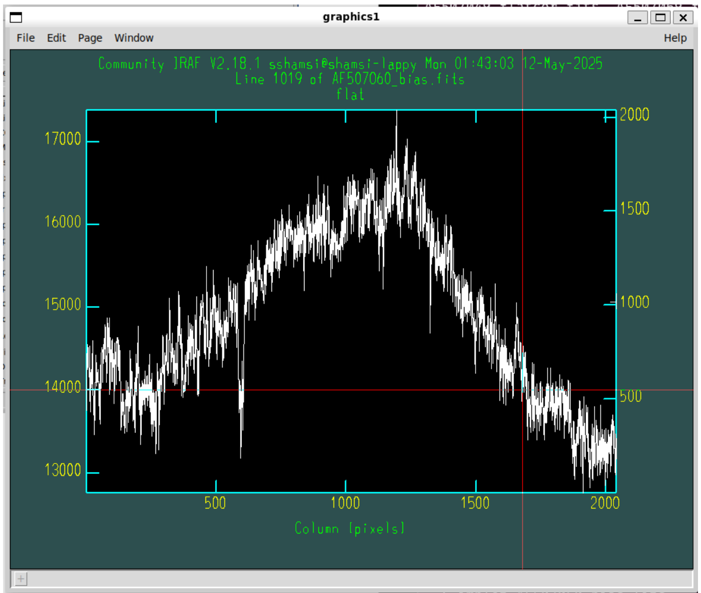


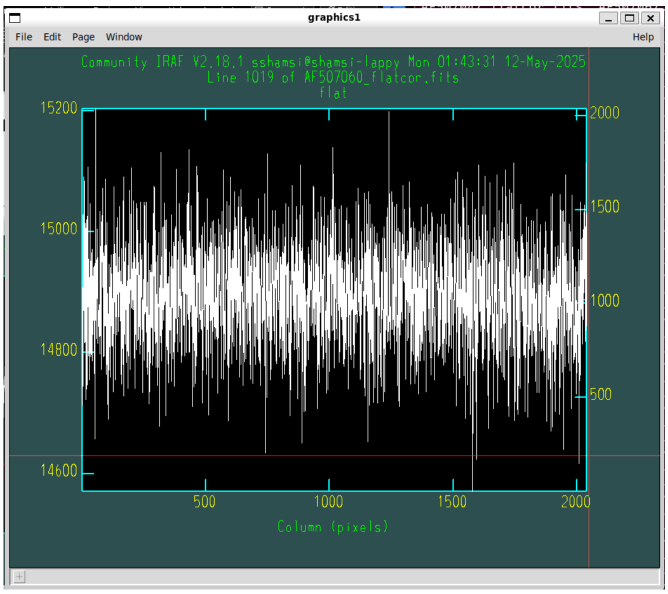

iii) Applying the flat correction

We once again use the **ccdproc** task, this time applying the flat correction to all of our bias corrected files using the **flat_response** file.




The effect of the flat correction can be seen in the following images, before and after the correction:

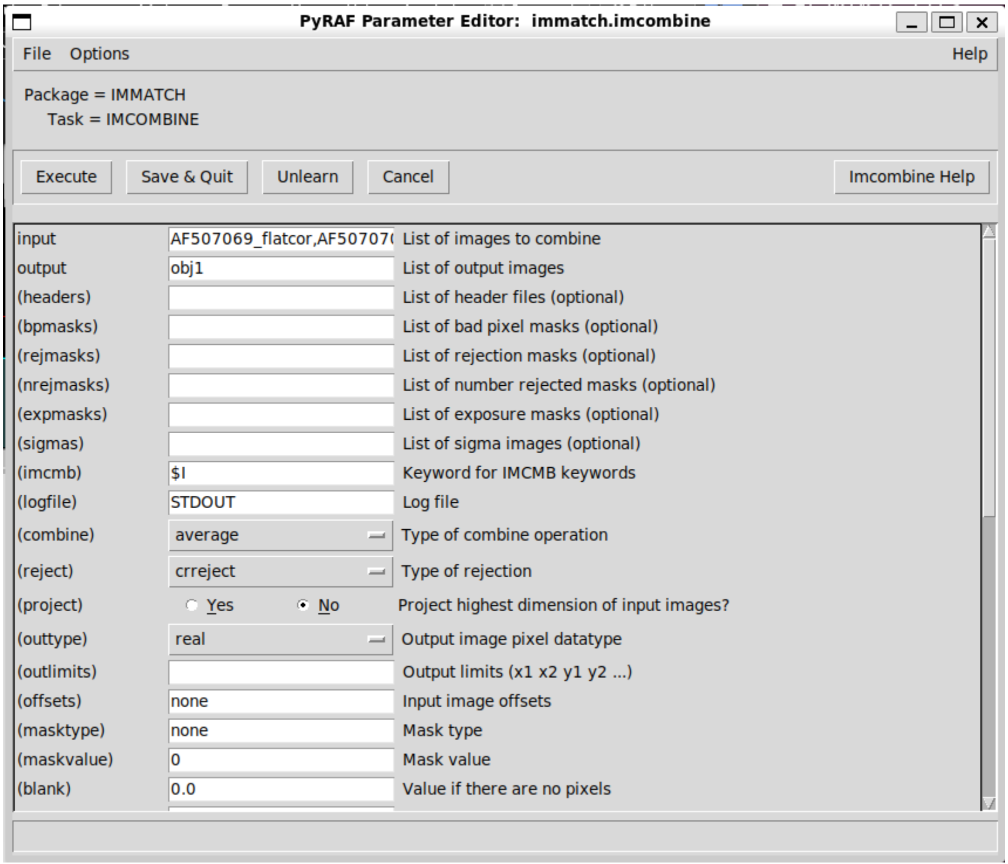


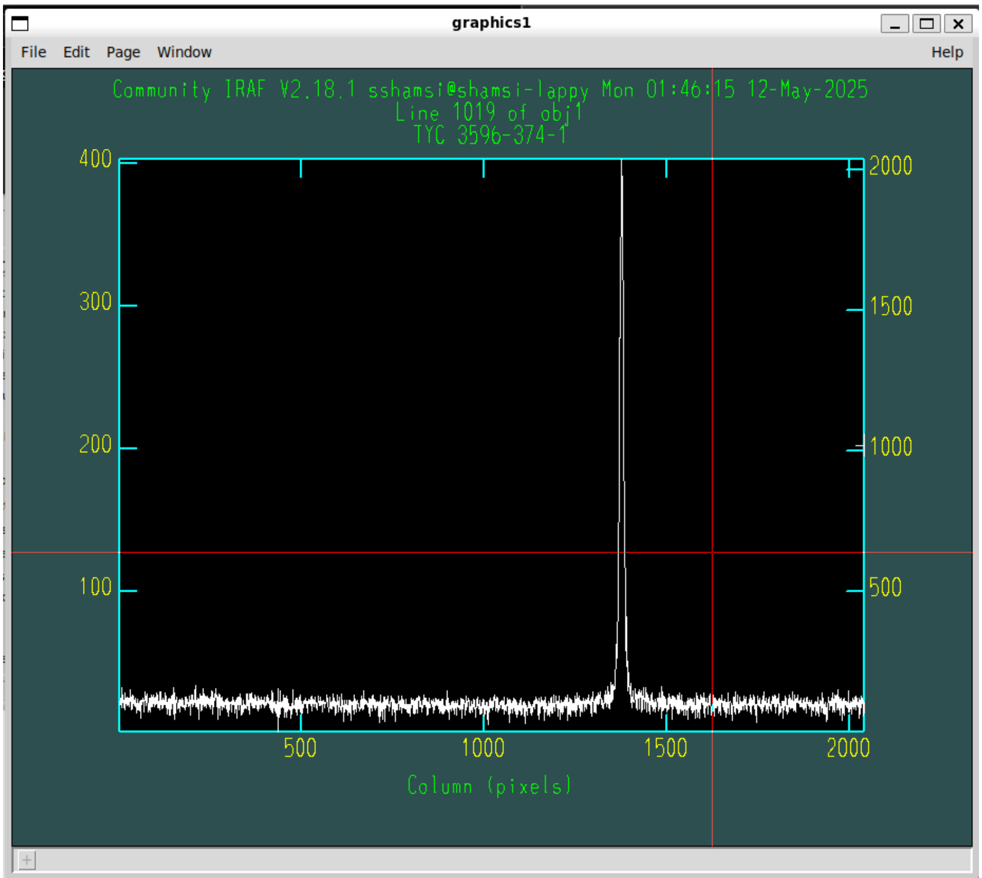

## 5.2) Spectrum Extraction

i) Image Stacking

We use the **imcombine** task to combine the bias and flat corrected images for each of our objects. **Copernico_coded.txt** tells us which images are associated with which target files.



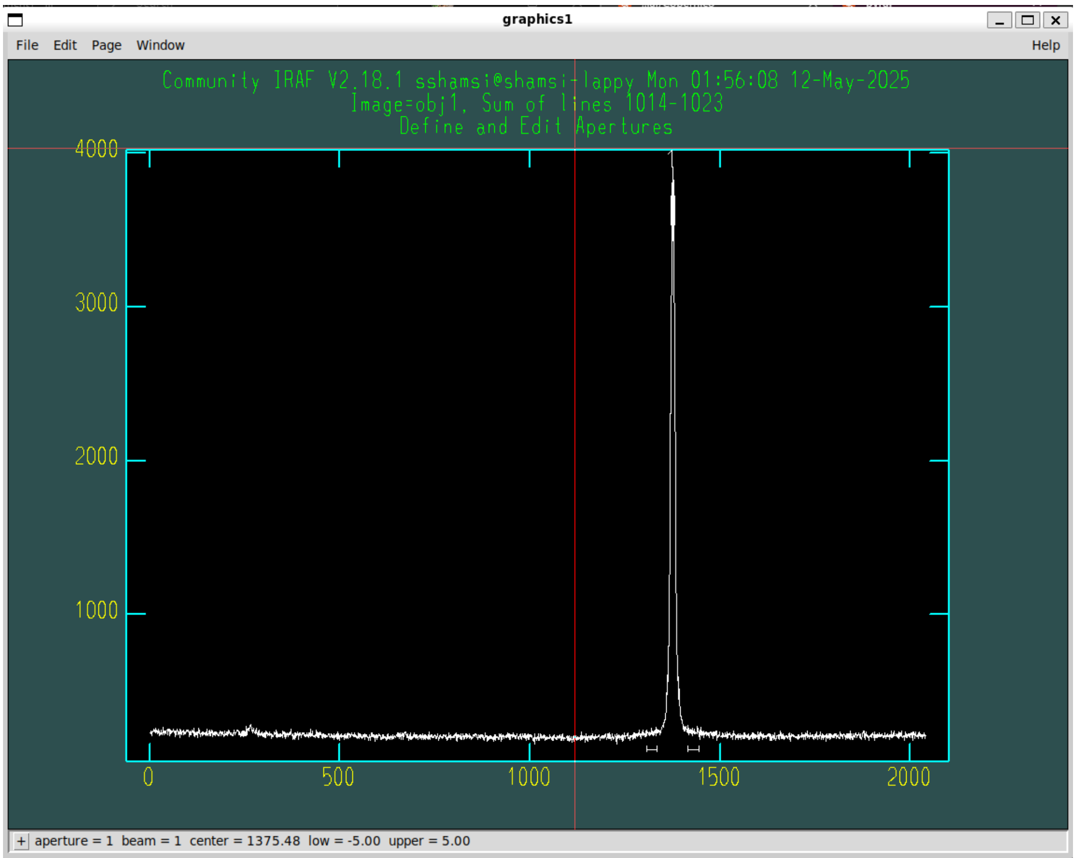

The stacked **obj1** image plotted with **implot** looks like:

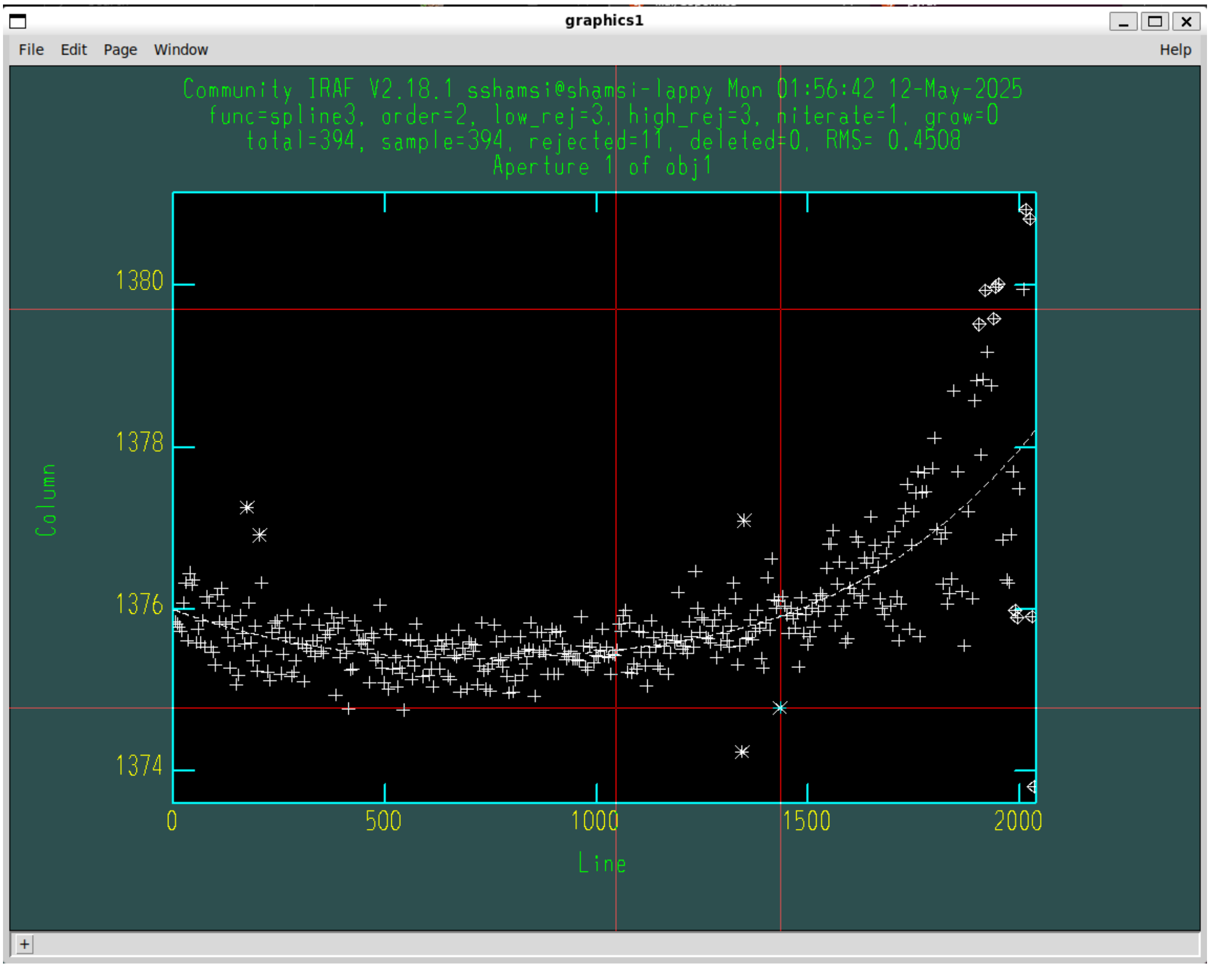


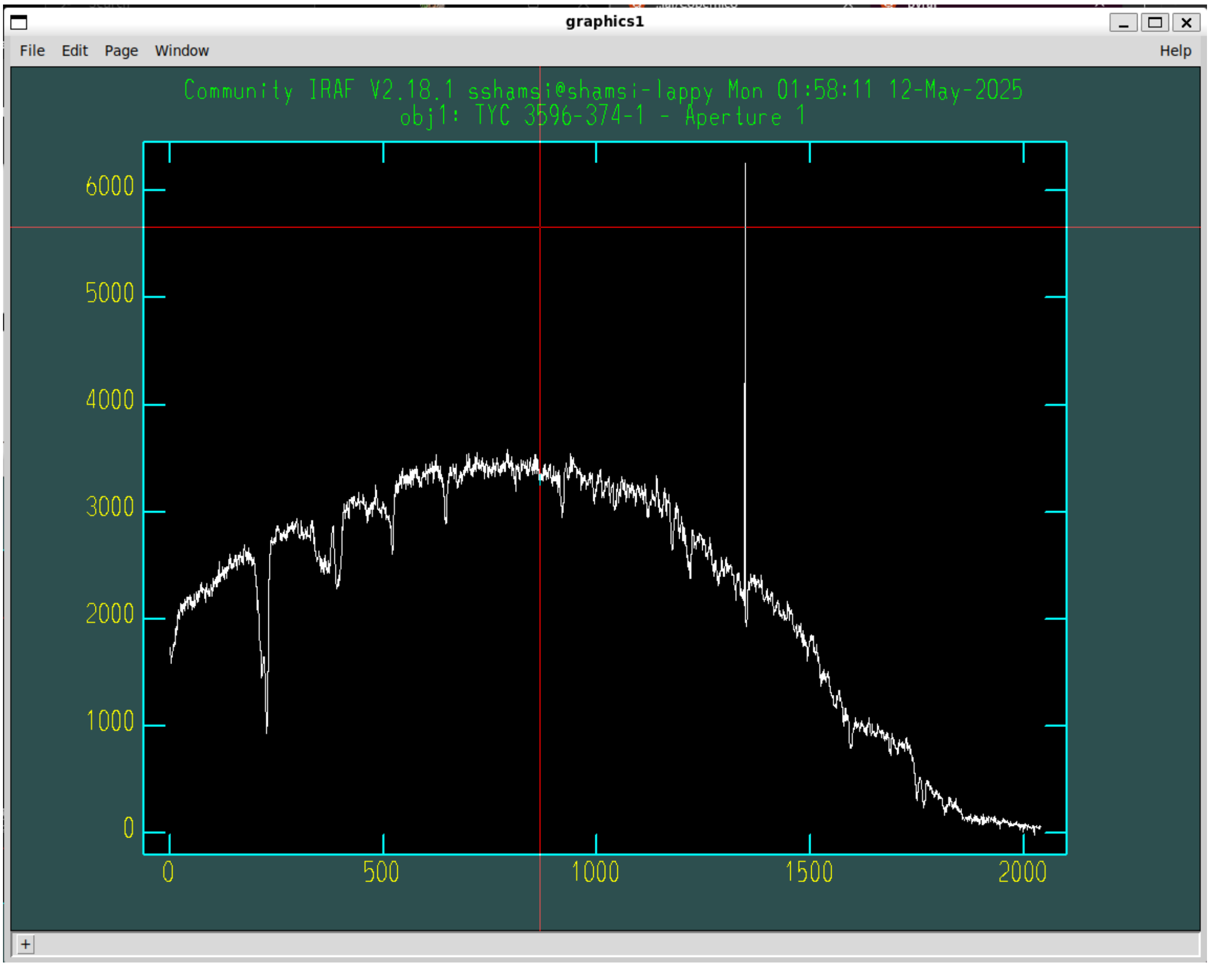
ii) Spectrum extraction

We then use the **apall** task to extract the spectrum, obtaining the following aperture, trace, and extracted spectrum files:

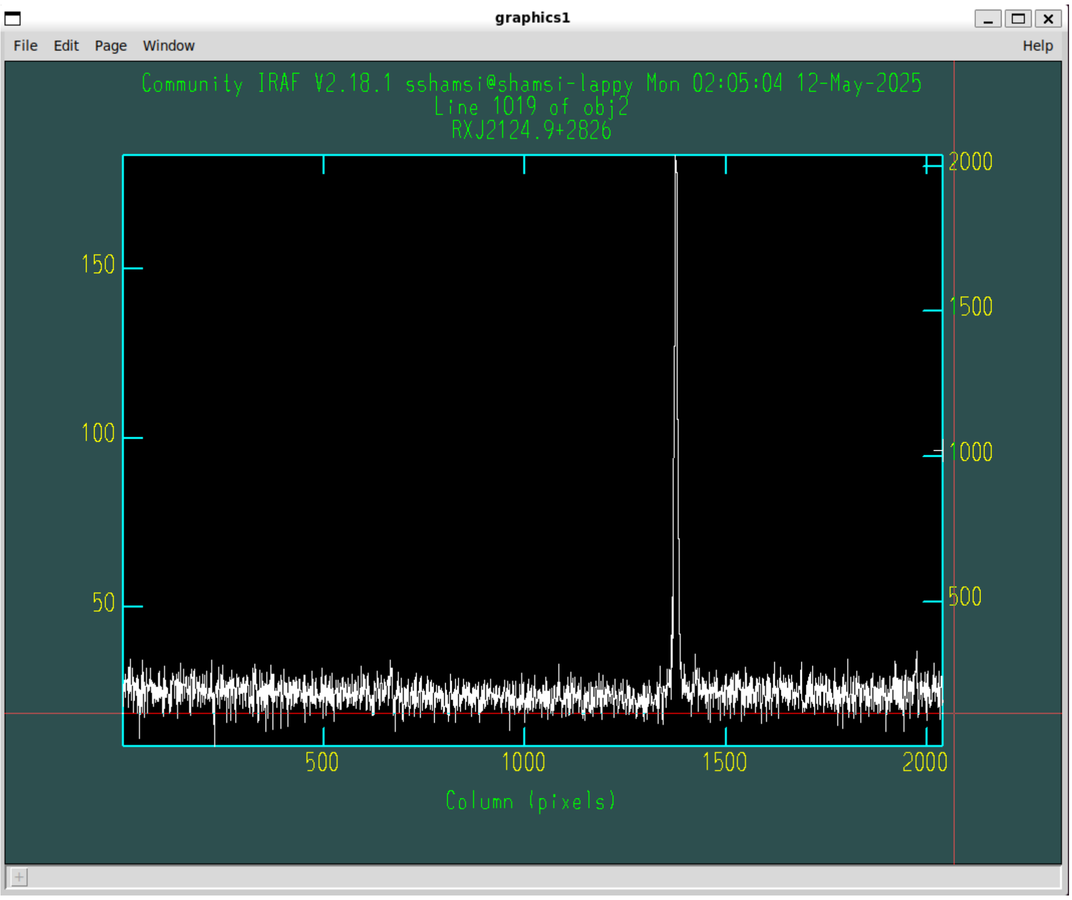
```
TASK : apall
PACKAGE : noao -> imred -> kpnoslit

input = obj1
output = obj1
recente = yes
resize = no
edit = yes
trace = yes
b_funct = chebyshev
b_order = 2
b_sampl = -70:-40,40:70
b_naver = -15
b_niter = 2
width = 5
radius = 5
nfind = 1
bkg = yes
t_nsum = 5
t_step = 5
t_funct = spline3
t_niter = 1
backgro = fit
weights = variance
clean = yes
```



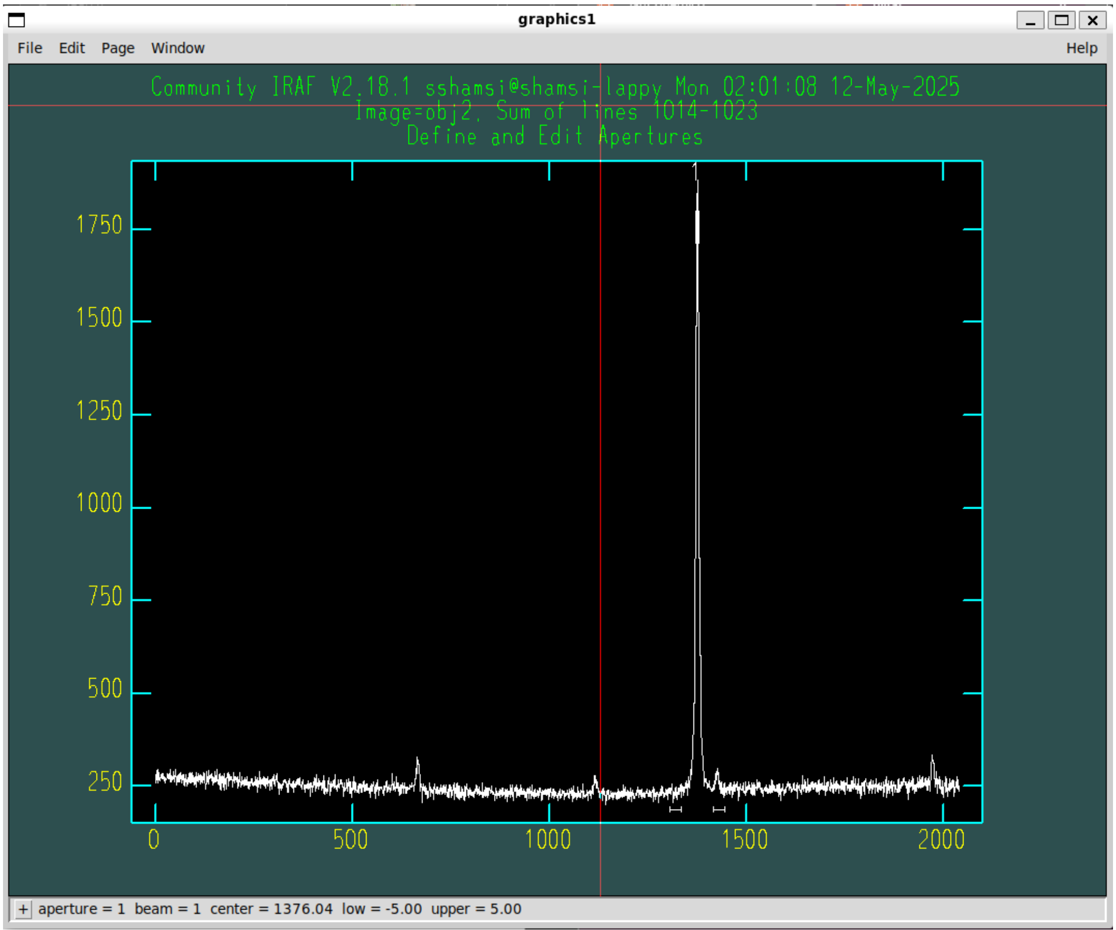

graphics1
File Edit Page Window Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 01:56:42 12-May-2025
func=spline3, order=2, low_rej=3, high_rej=3, niterate=1, grow=0
total=394, sample=394, rejected=11, deleted=0, RMS= 0.4508
Aperture 1 of obj1
Column
1374
1376
1378
1380
0
500
1000
1500
2000
Line

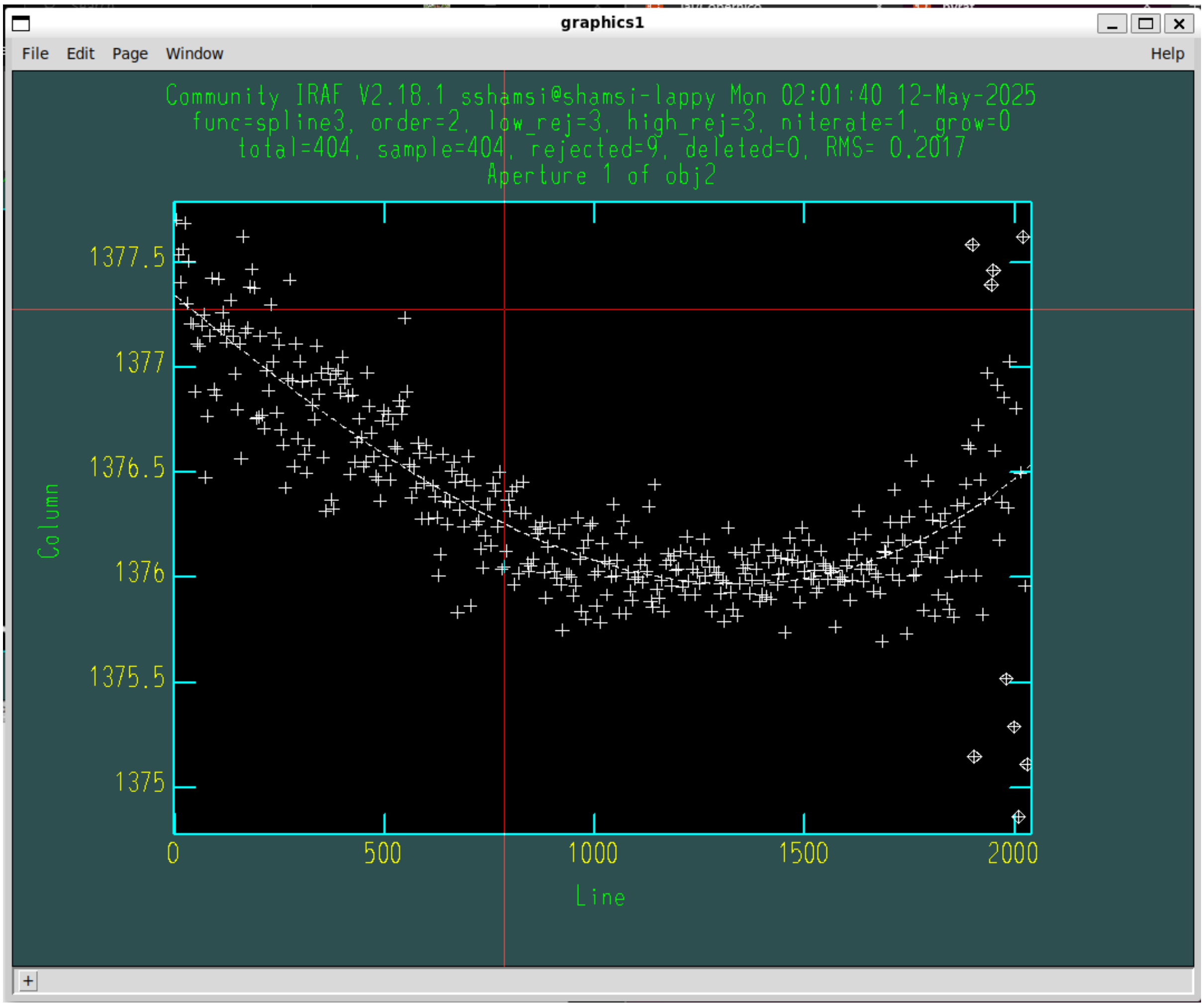

graphics1
File Edit Page Window Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 01:58:11 12-May-2025
obj1: TYC 3596-374-1 - Aperture 1
0
1000
2000
3000
4000
5000
6000
0
500
1000
1500
2000

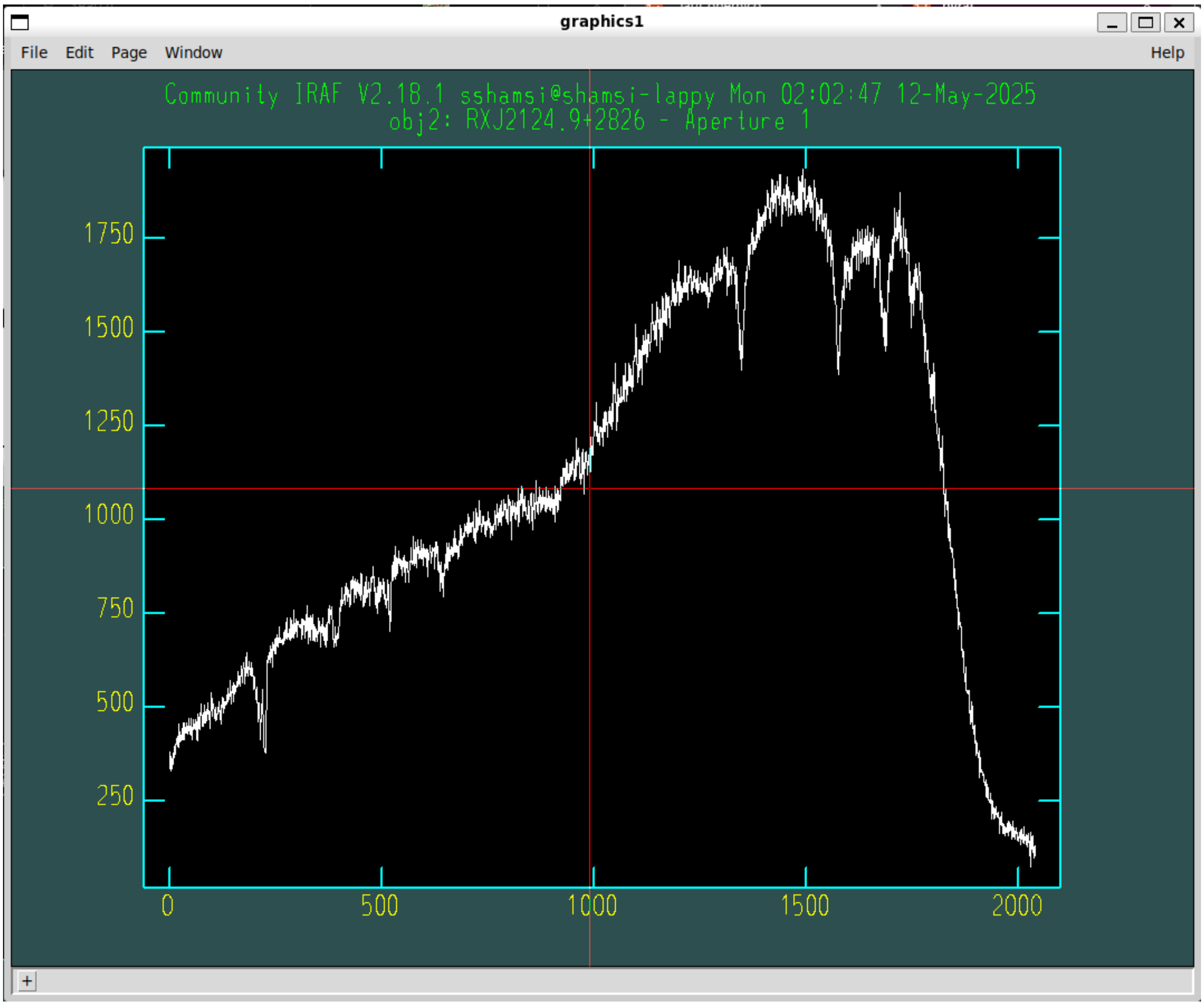
And we'll do the same for **obj2**. The stacked **obj2** image looks like:




The aperture, trace, and extracted spectrum looks like:




graphics1
File Edit Page Window
Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 02:01:40 12-May-2025
func=spline3, order=2, low_rej=3, high_rej=3, niterate=1, grow=0
total=404, sample=404, rejected=9, deleted=0, RMS= 0.2017
Aperture 1 of obj2
Column
Line

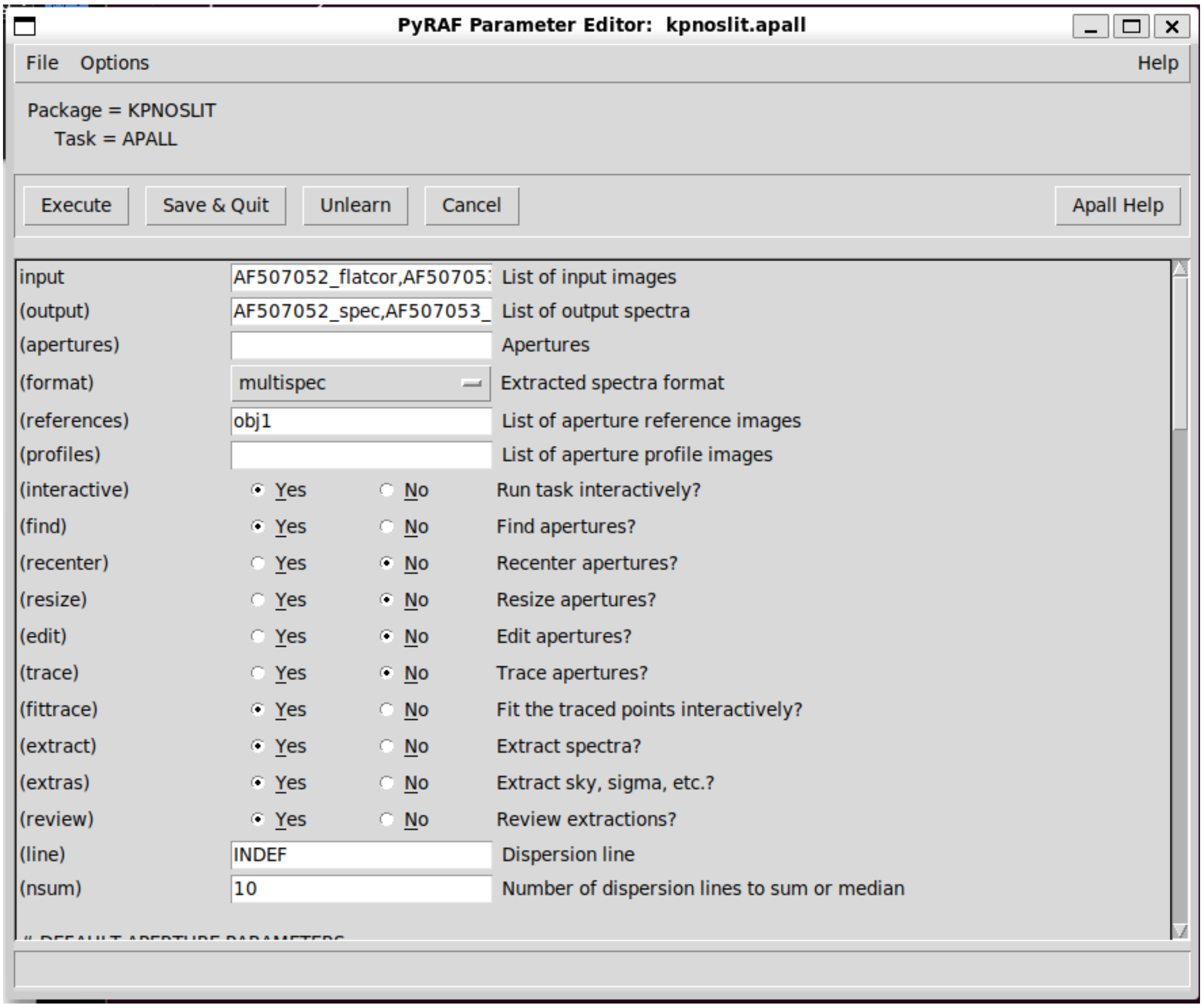

graphics1
File Edit Page Window
Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 02:02:47 12-May-2025
obj2: RXJ2124.9+2826 - Aperture 1

## 5.3 Wavelength Solution

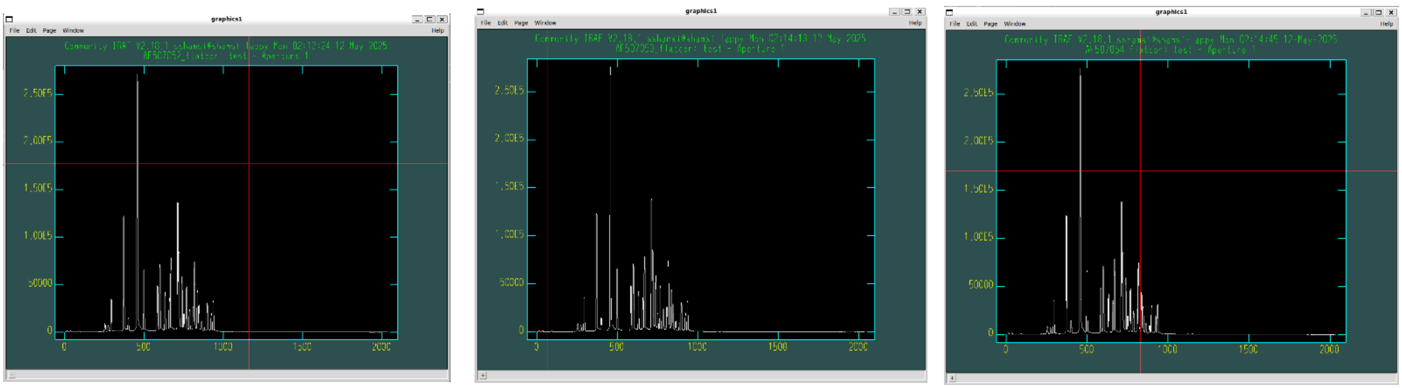
### *Processing emission lamp spectra*

i) Extraction of lamp spectra

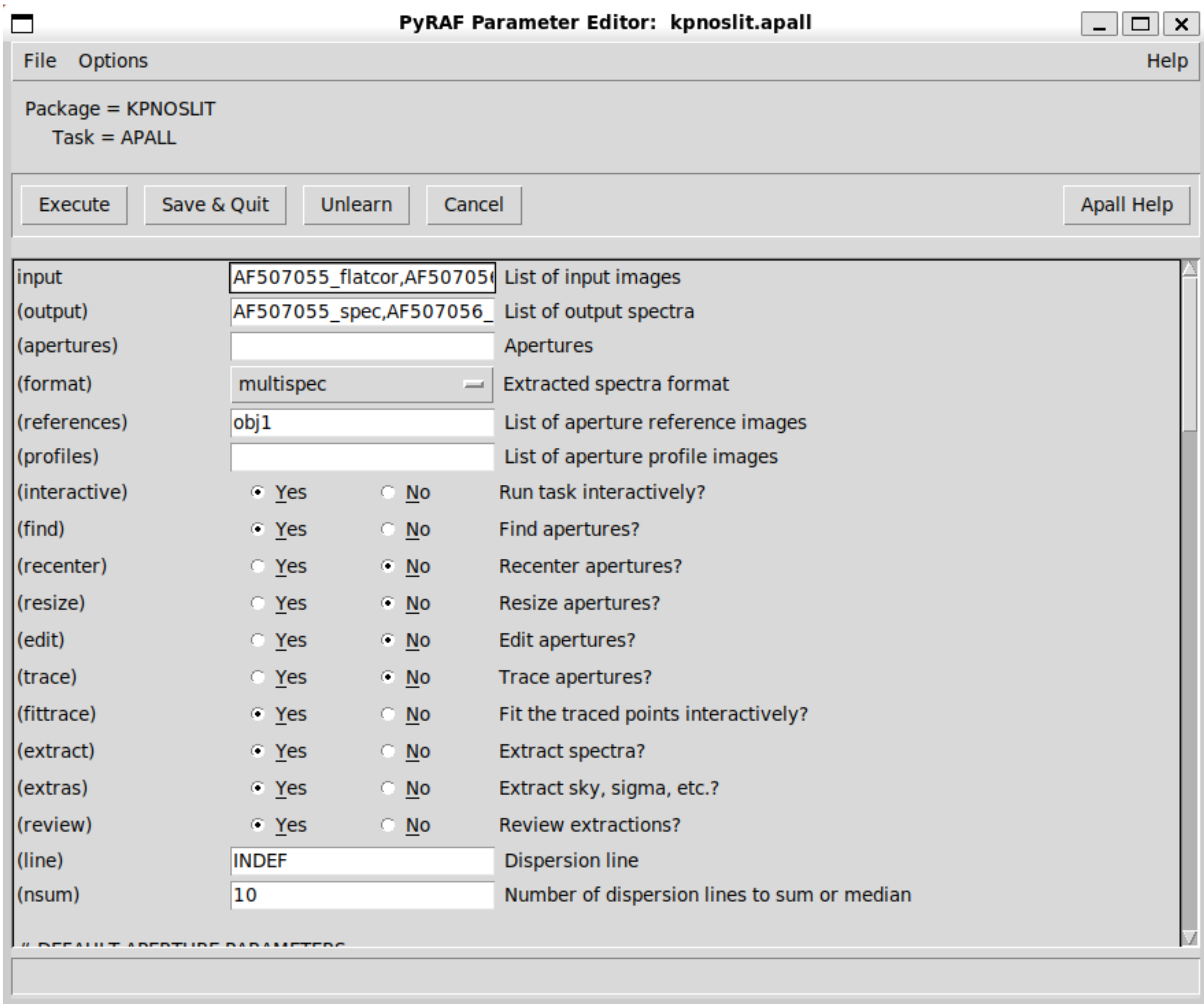
We use the **apall** task to extract the spectra from each of the Ne lamps.



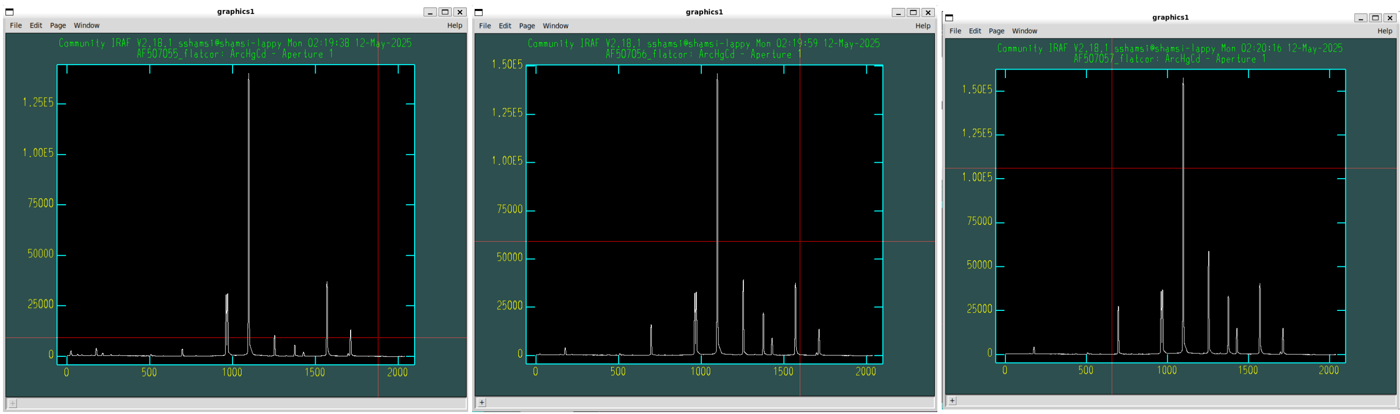

This yields the following spectra files:



And we repeat the same procedure for the HgCd files:

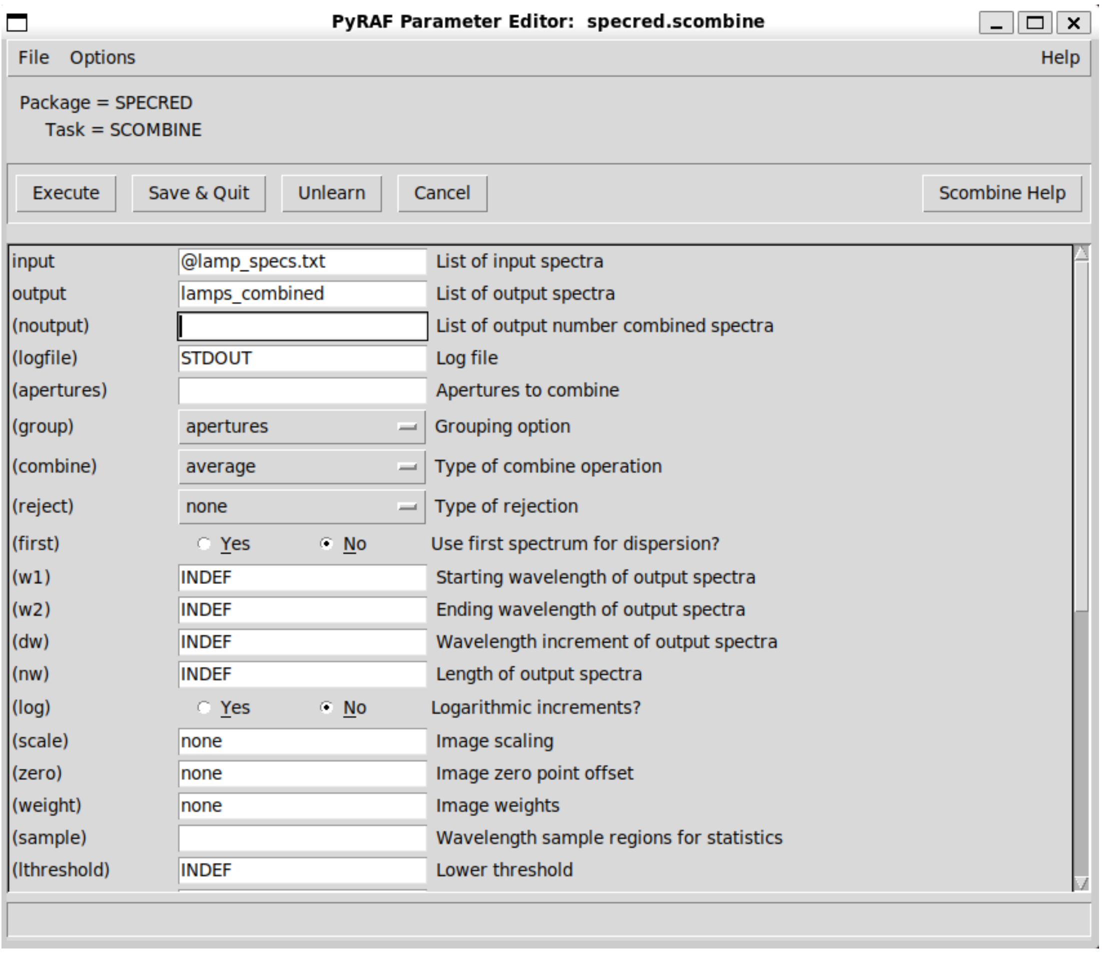



Which yields the following spectra files:

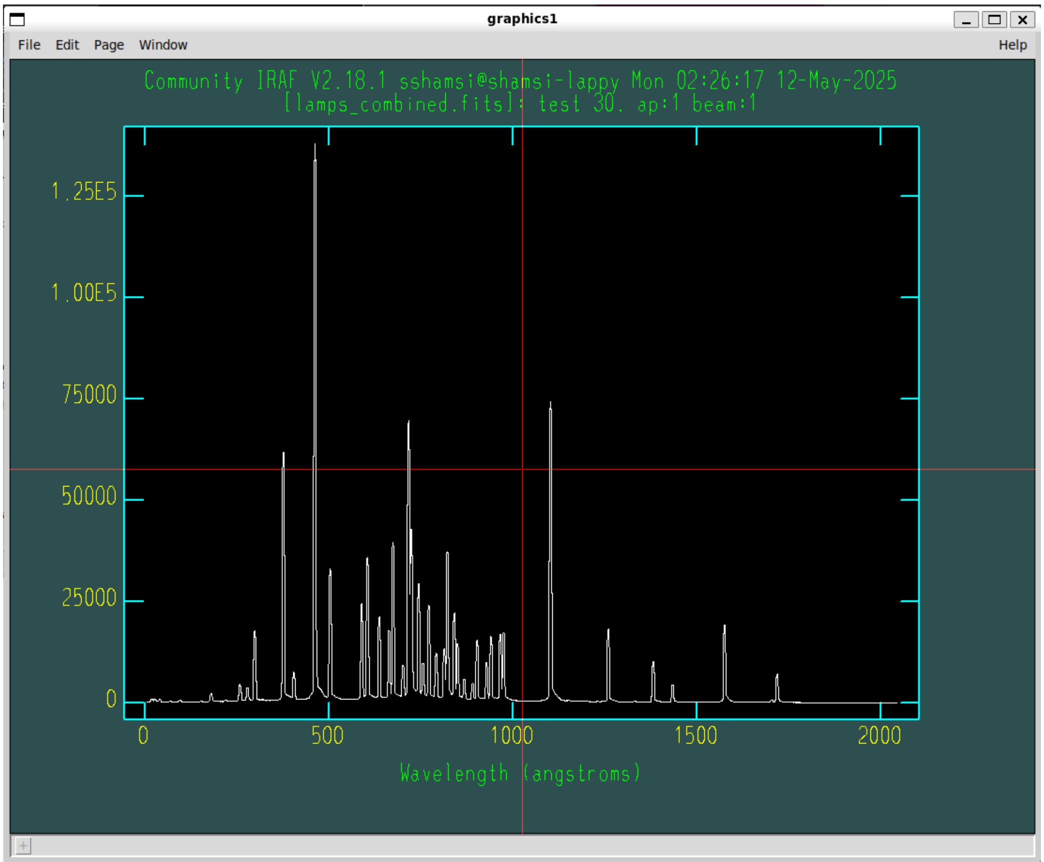



ii) Combining lamp spectra

We then combine all these spectra into a single **lamps_combined** file with the **scombine** task.

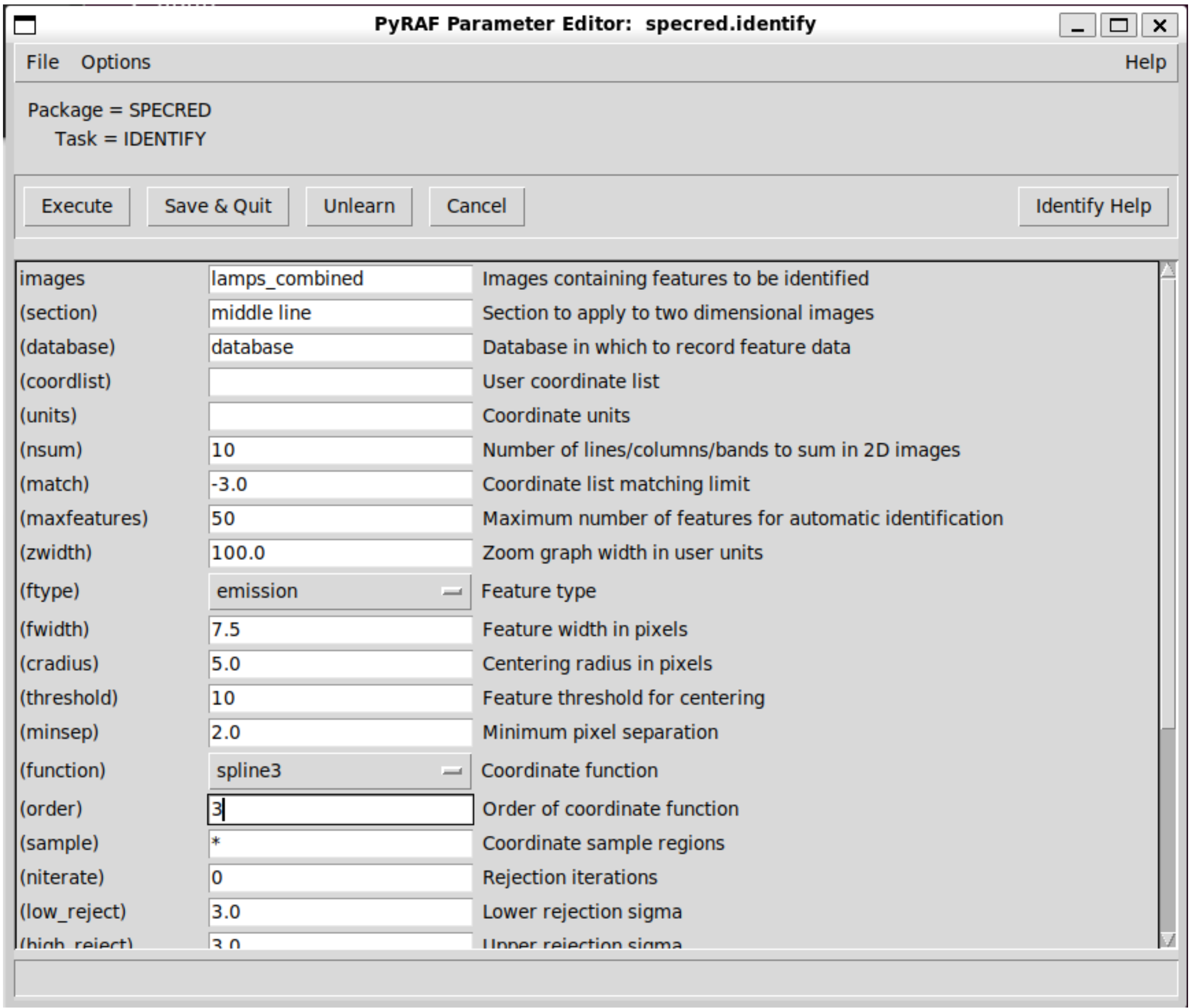



The combined file then looks like:

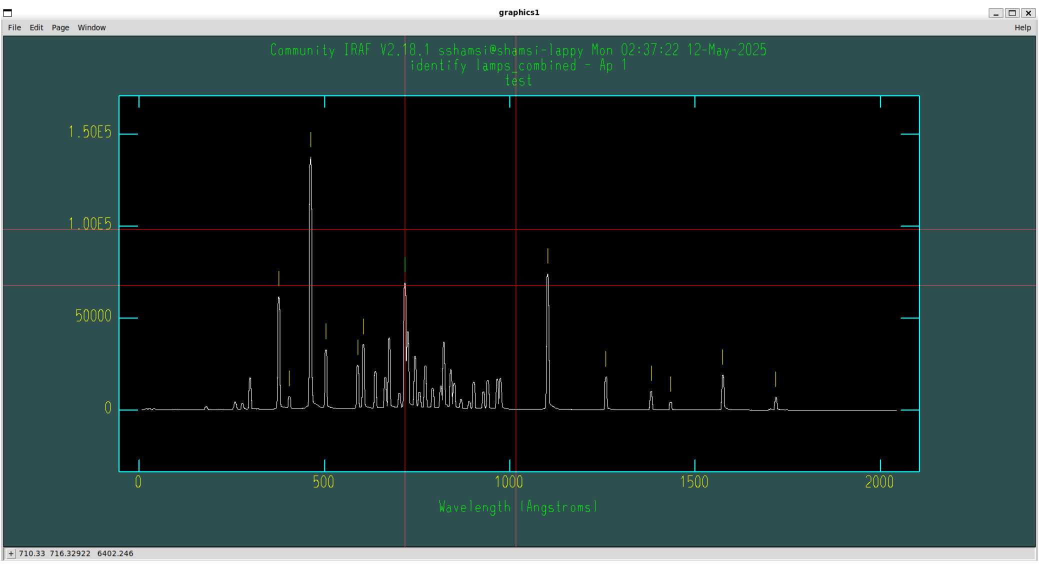


iii) Line identification and wavelength fitting:

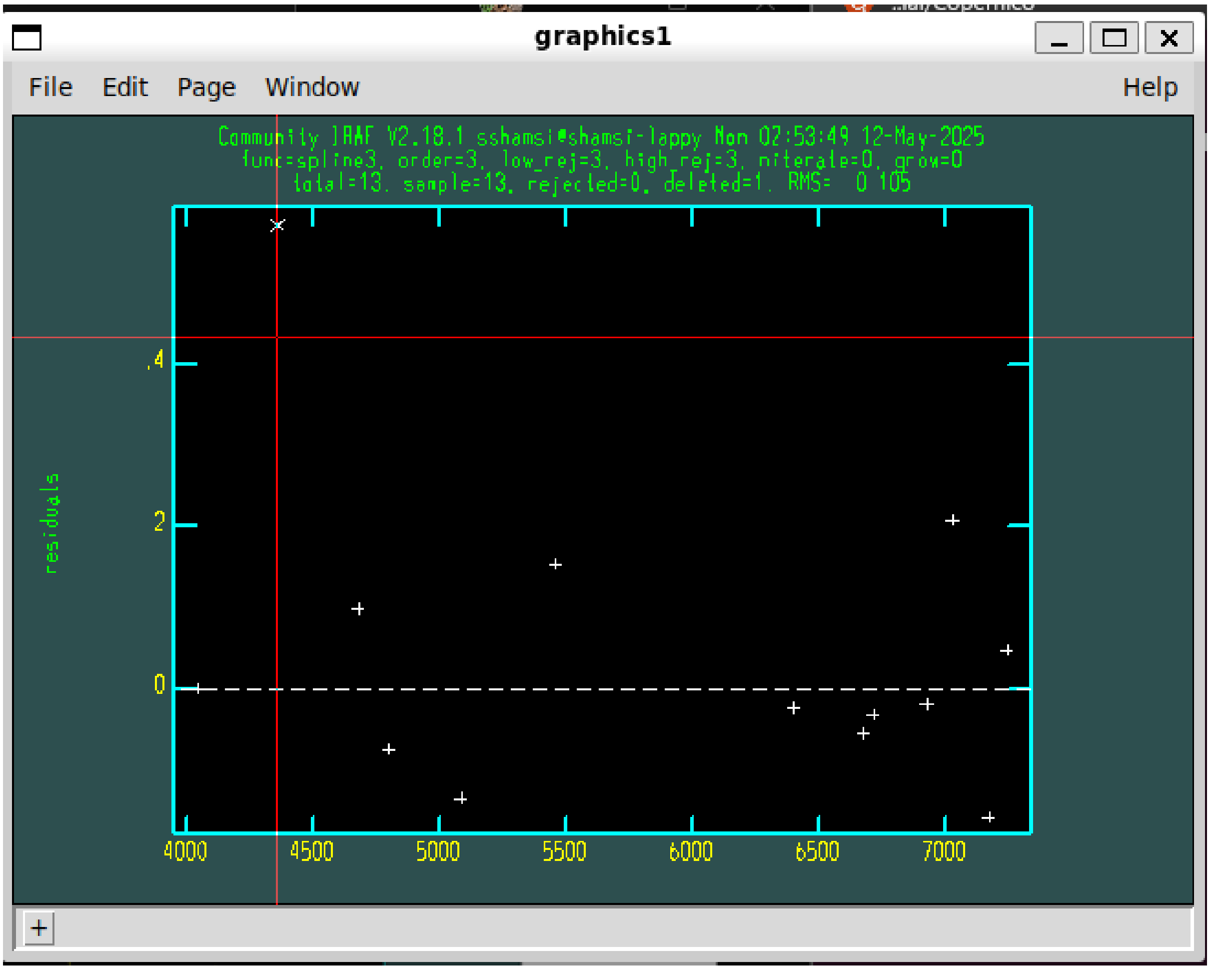
Now we can use the identify task to identify and mark lines. We make sure to identify a healthy number of lines (~13) across the wavelength range, using the Ne and MgCd emission lines presented in the task.



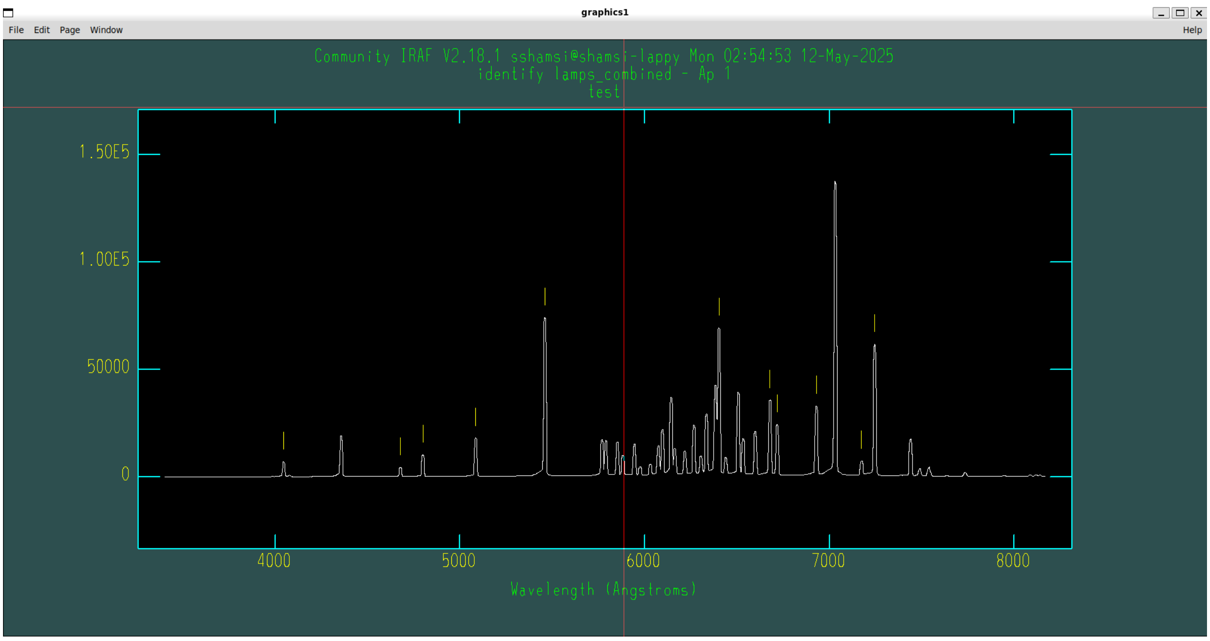

The identified lines are shown below. We note that the **lamps_combined** file is initially plotted with the wavelength on the x-axis in a descending order. We take care to flip our reference images before identifying the lines.



The following file shows the residuals after fitting. We remove one point which had a higher than usual residual.



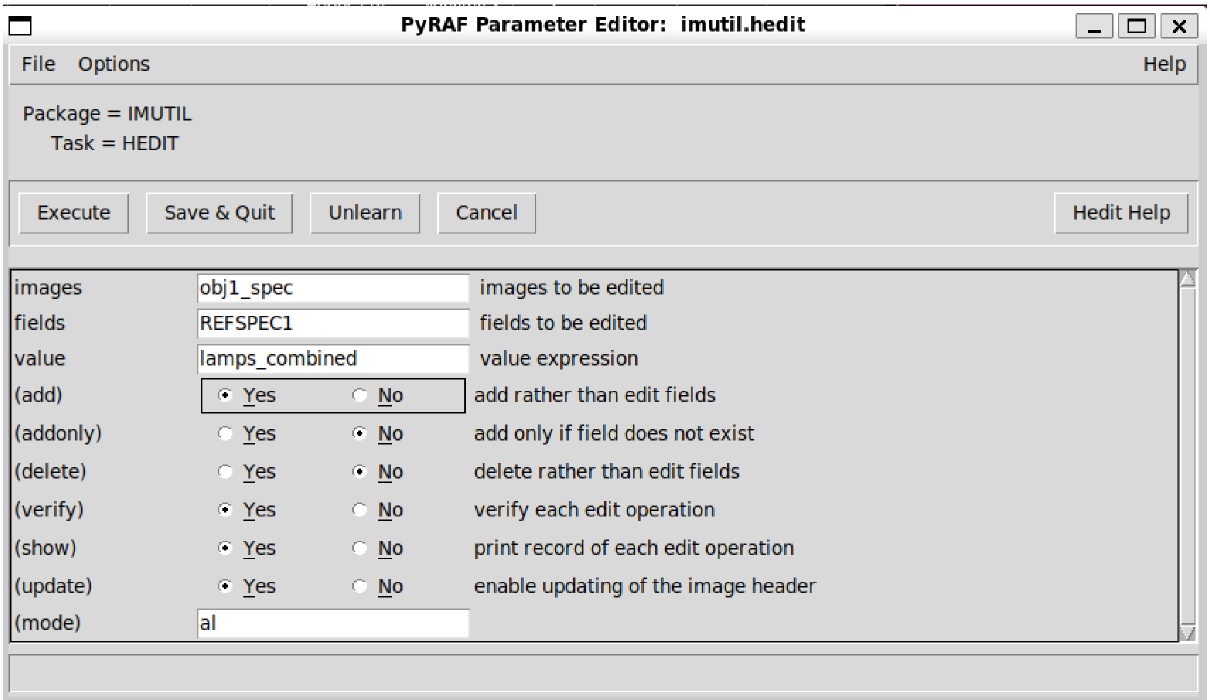

After identification, the **lamps_combined** file is flipped the right way around. We save this.




### *Wavelength mapping in science spectra*

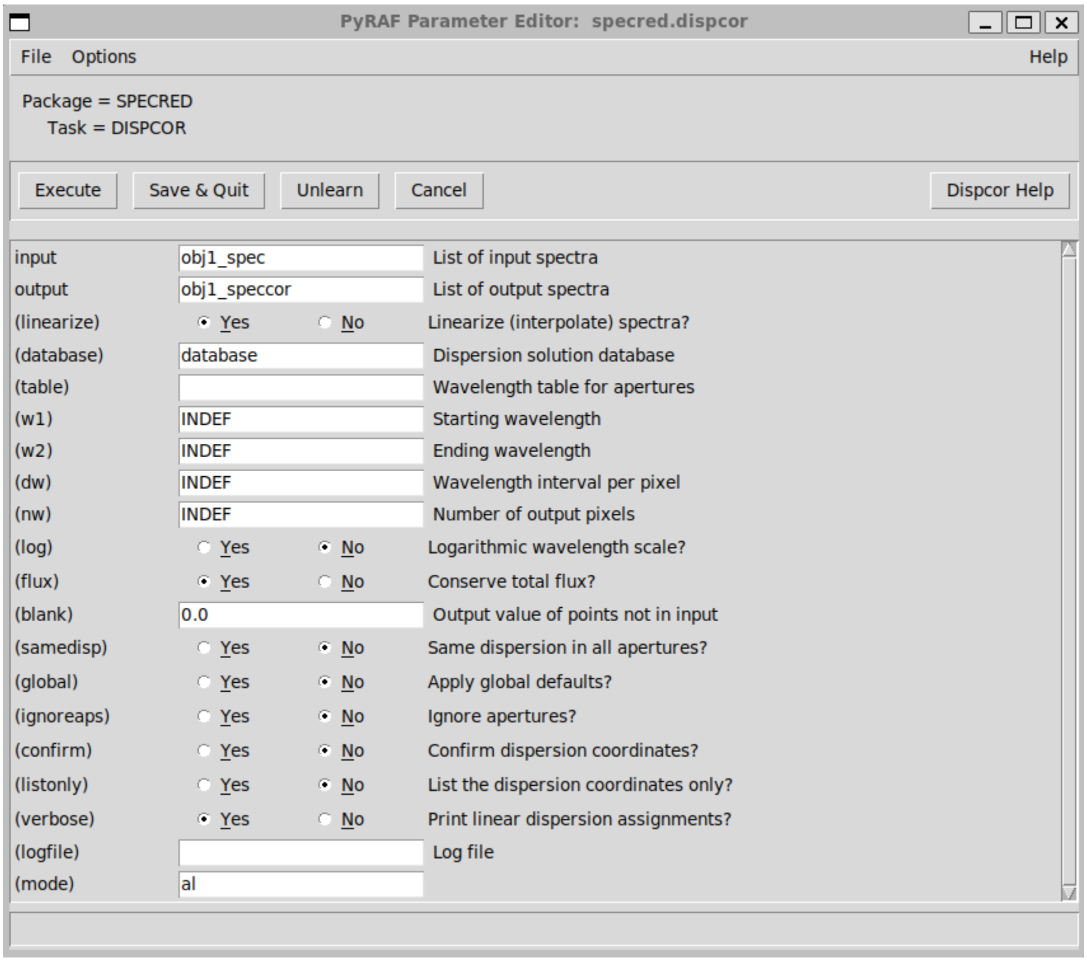
### i) Editing file header

It is now time to apply this spectrum reference to our **obj1** spectrum file.

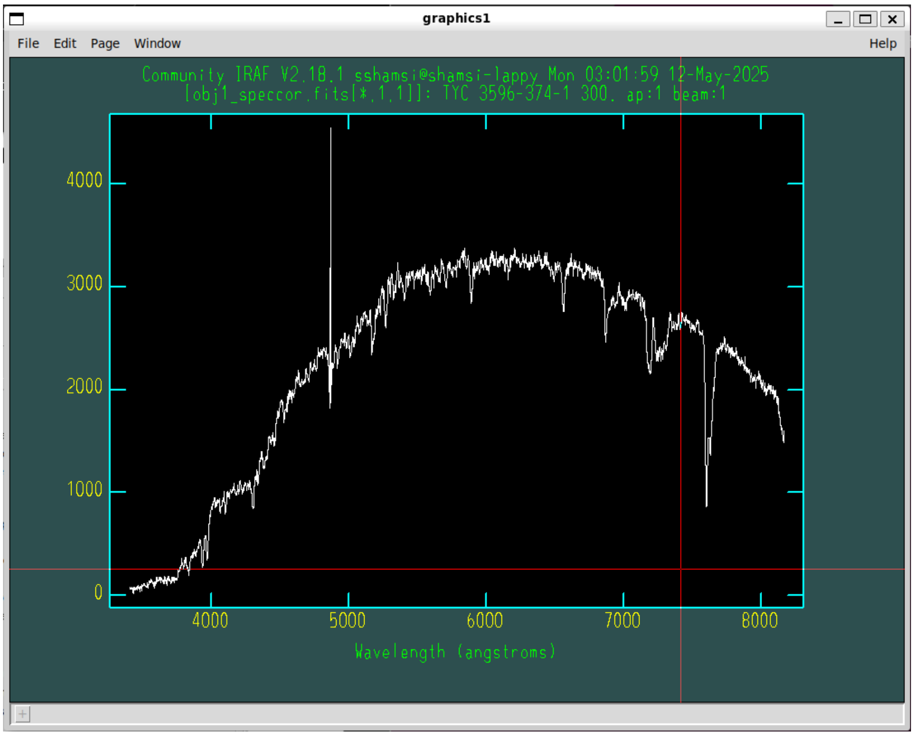



### ii) Apply the wavelength solution

With the information in the header, we can now apply the wavelength solution using the **dispcor** task.



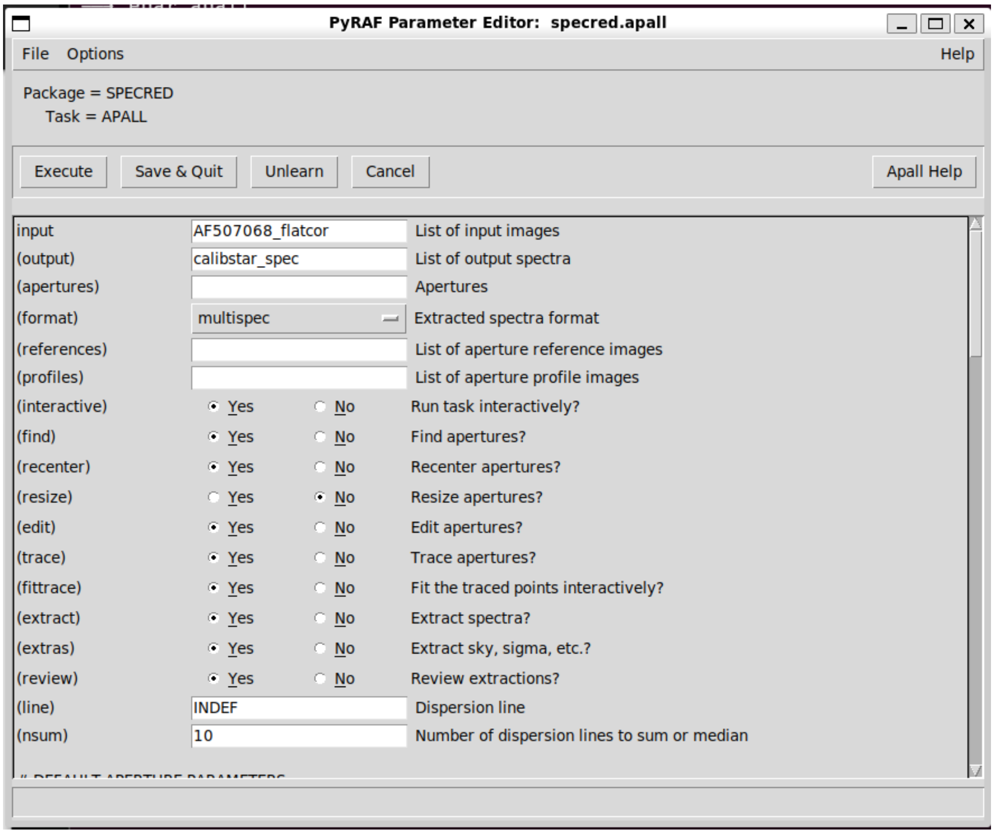
Finally, plotting **obj1_speccor** using **splot** gives us the following graph:



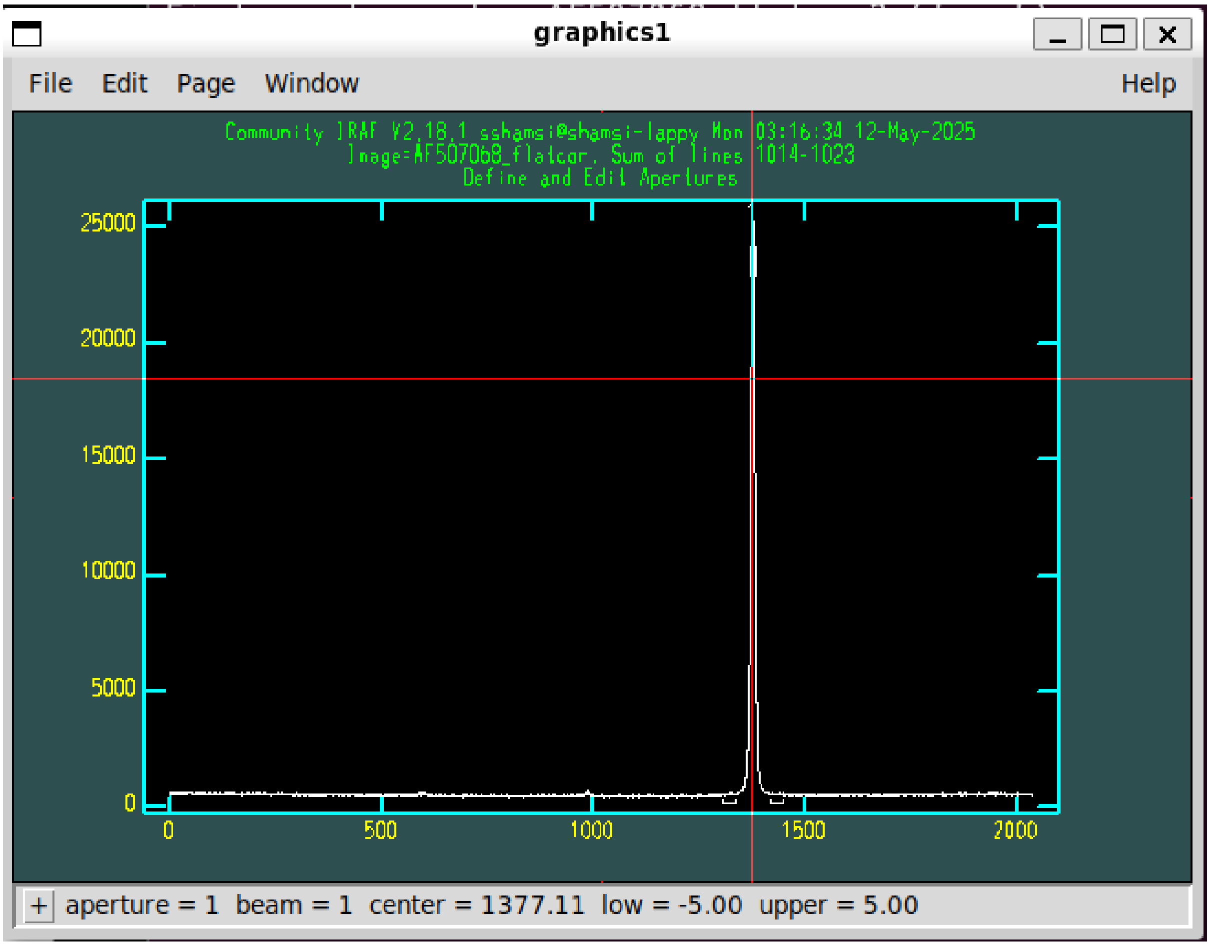

## 5.4) Flux Calibrations

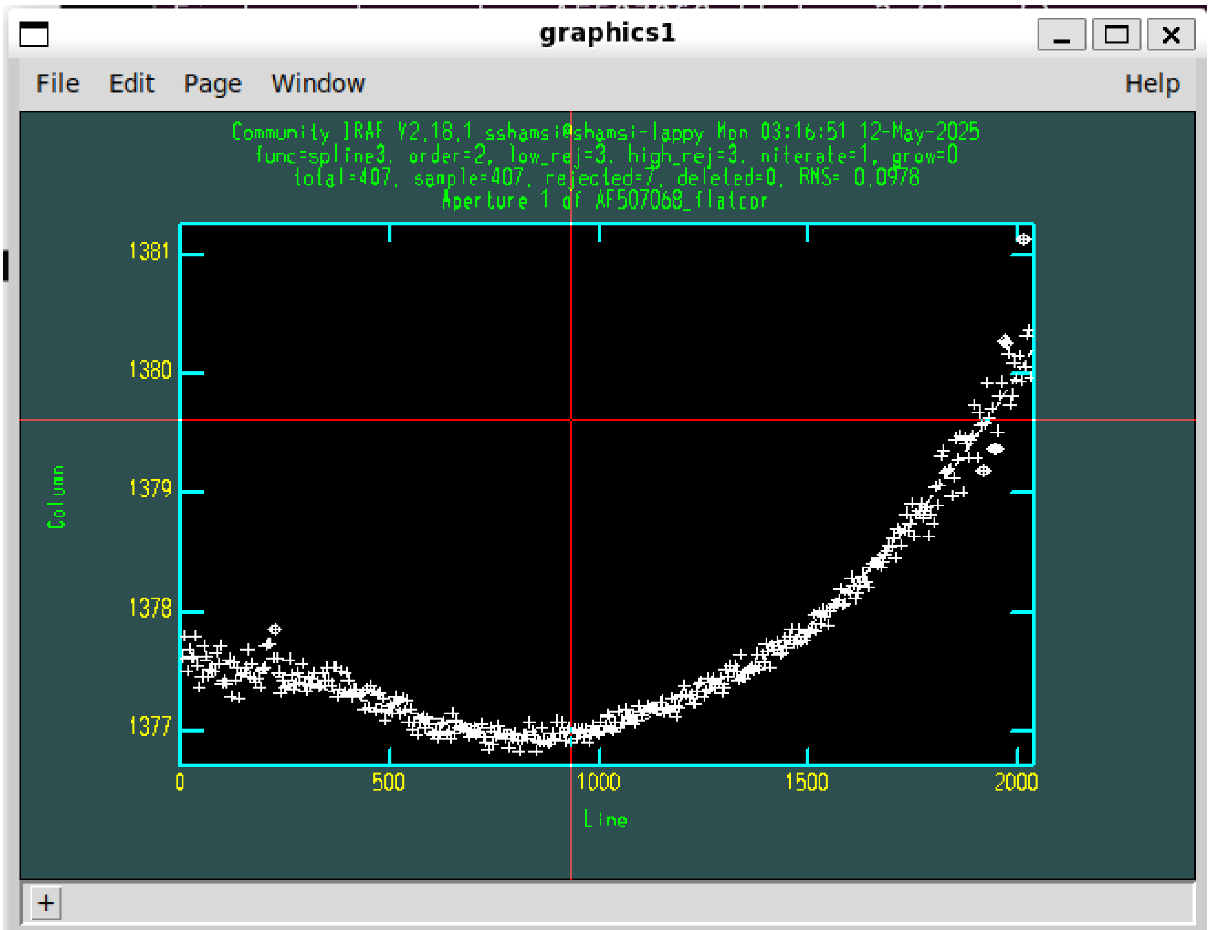
### *Instrumental response*

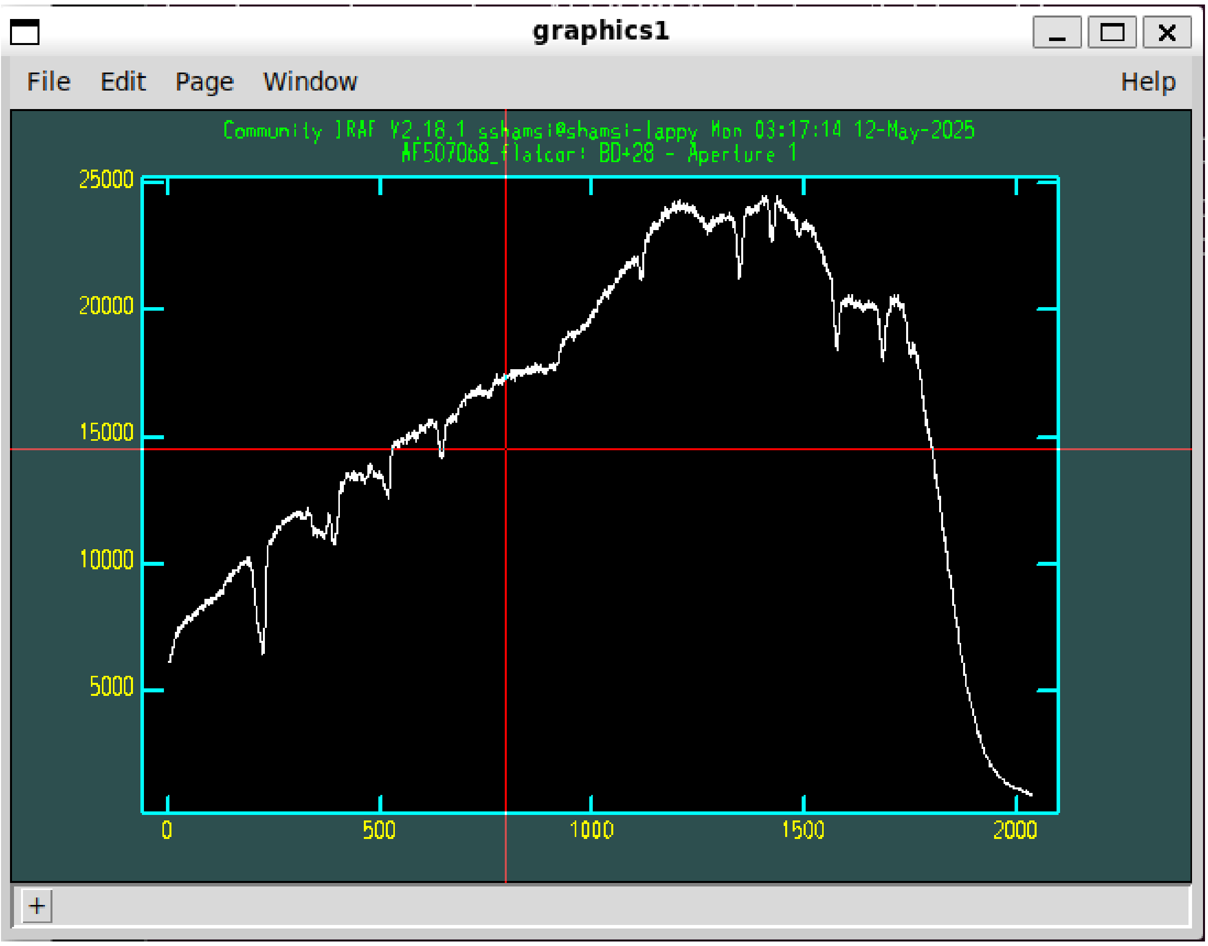
Let's extract the spectrum for the calibration star BD284211 with **apall** as before.



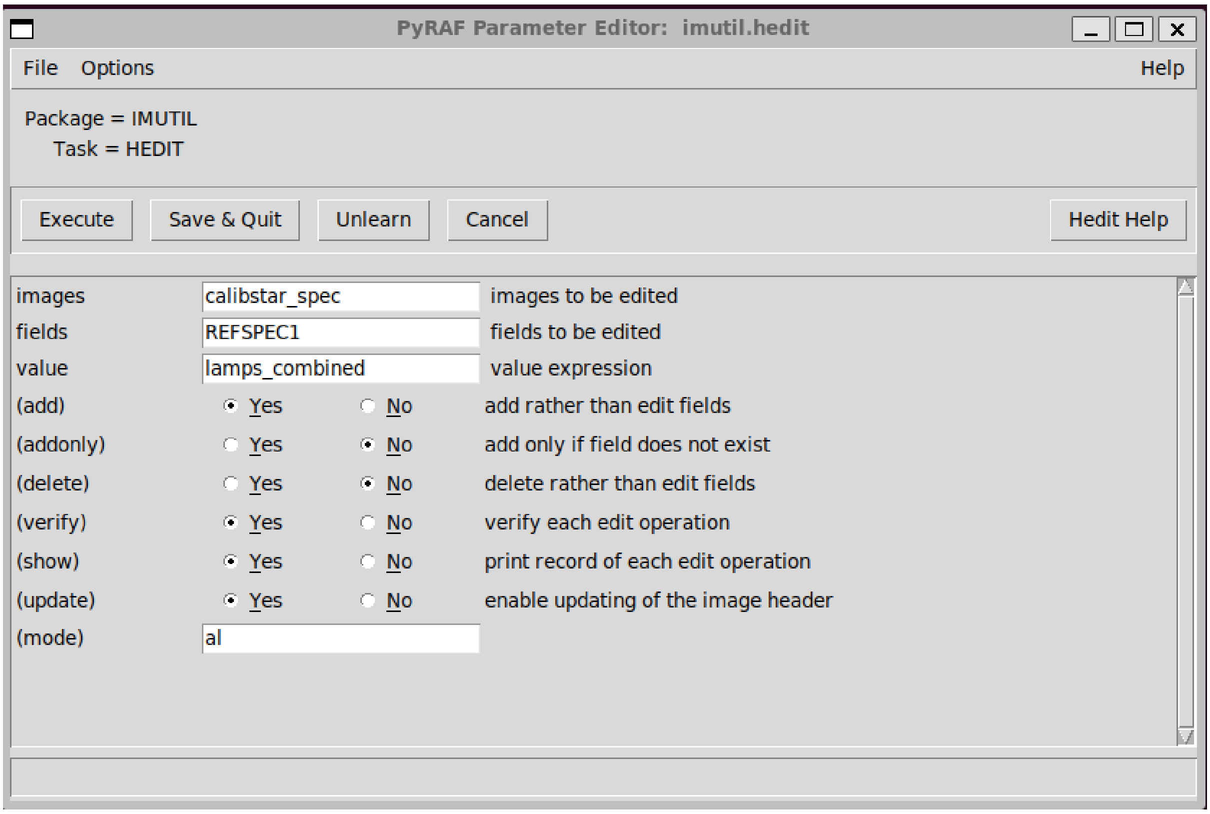

The aperture, trace and spectrum for the calibration star are as follows:


graphics1
File Edit Page Window Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 03:16:34 12-May-2025
Image=AF507068_flatcor, Sum of lines 1014-1023
Define and Edit Apertures
25000
20000
15000
10000
5000
0
0
500
1000
1500
2000
aperture = 1 beam = 1 center = 1377.11 low = -5.00 upper = 5.00

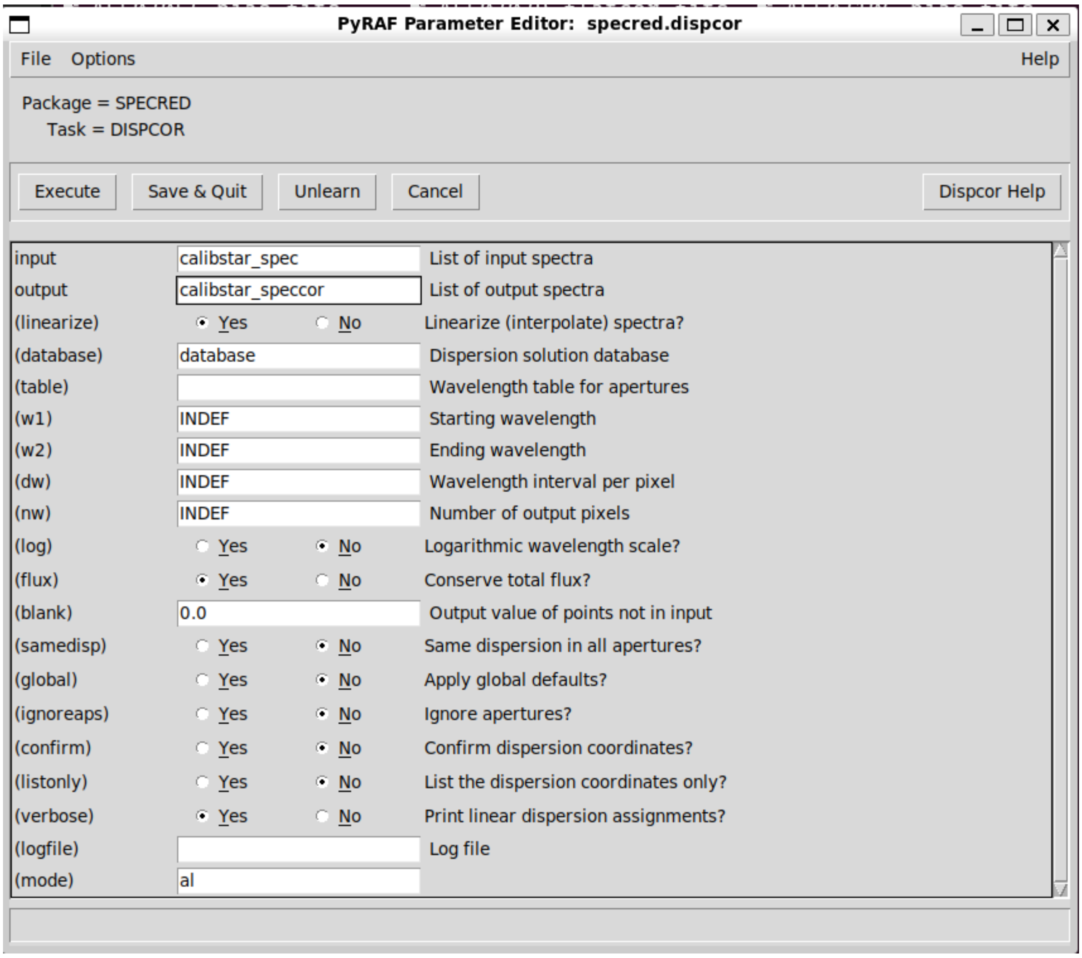

graphics1
File Edit Page Window Help
Community IRAF V2.18.1 sshamsi@shamsi-lappy Mon 03:16:51 12-May-2025
func=spline3, order=2, low_rej=3, high_rej=3, niterate=1, grow=0
total=407, sample=407, rejected=7, deleted=0, RMS= 0.0978
Aperture 1 of AF507068_flatcor
Column
1381
1380
1379
1378
1377
0
500
1000
1500
2000
Line



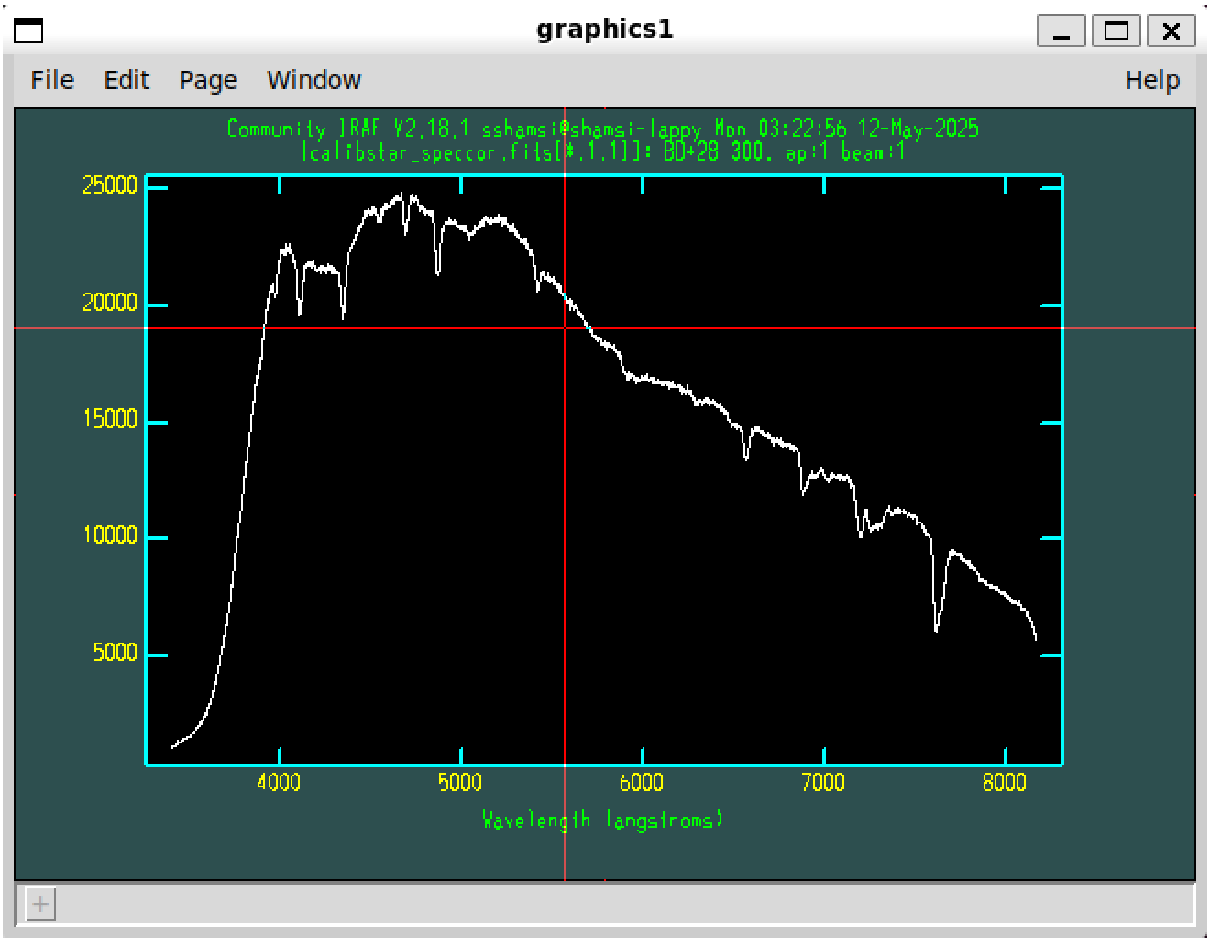

We'll add the reference spectrum information to the calibration star header:




And then apply the wavelength solution to the calibration star from its header:

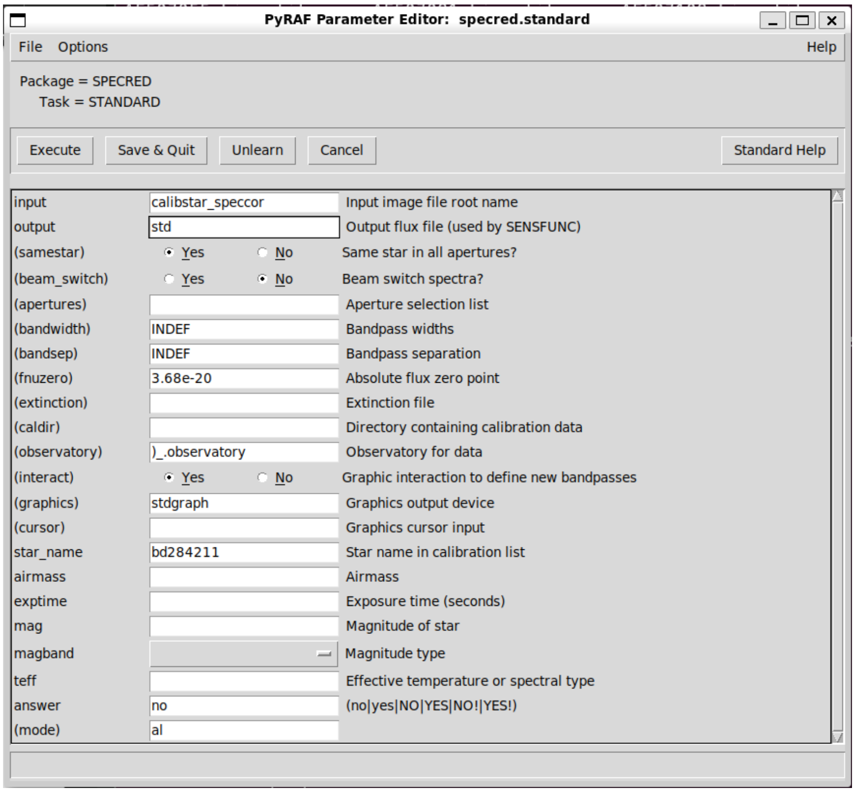



The resulting calibration star spectrum looks like:



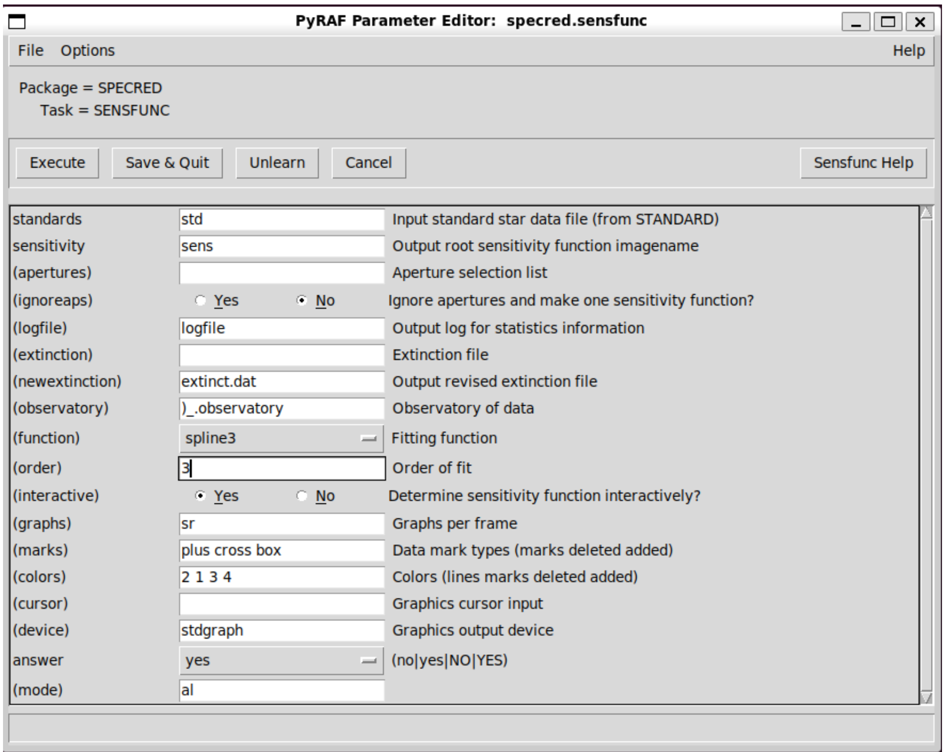
## i) Setting up flux calibration

Iraf has this information in its database and will find the flux calibration using the **standard** task.

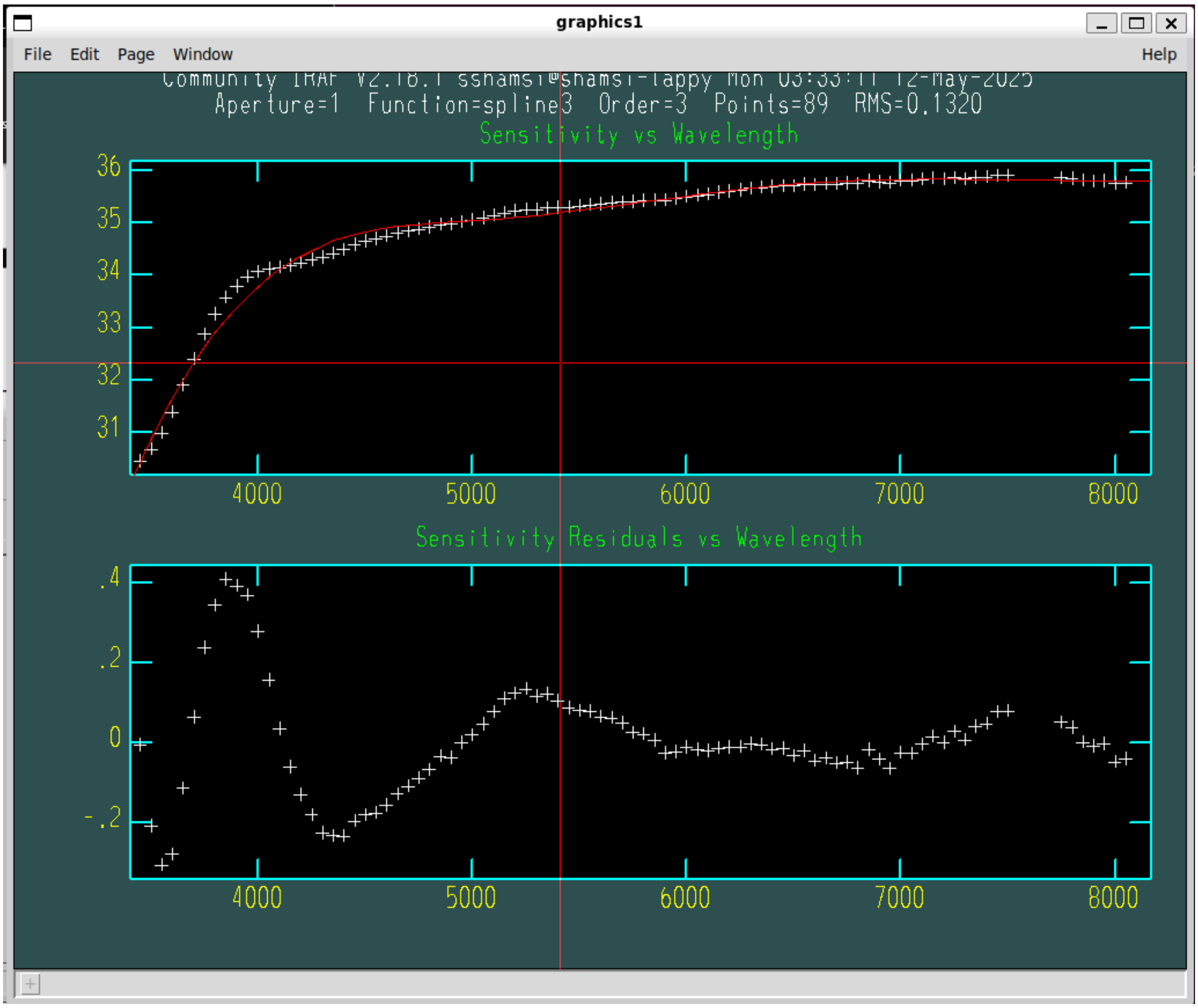



## ii) Fitting the sensitivity function

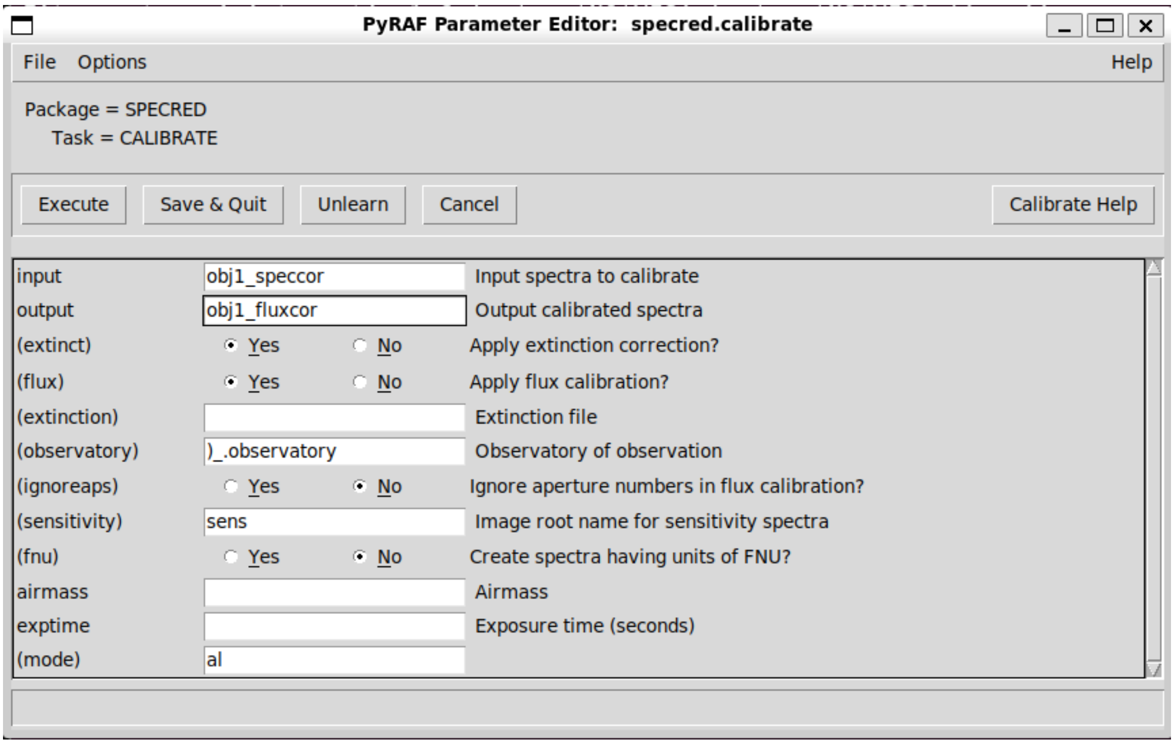
Using the **sensfunc** task, we'll fit the sensitivity function:



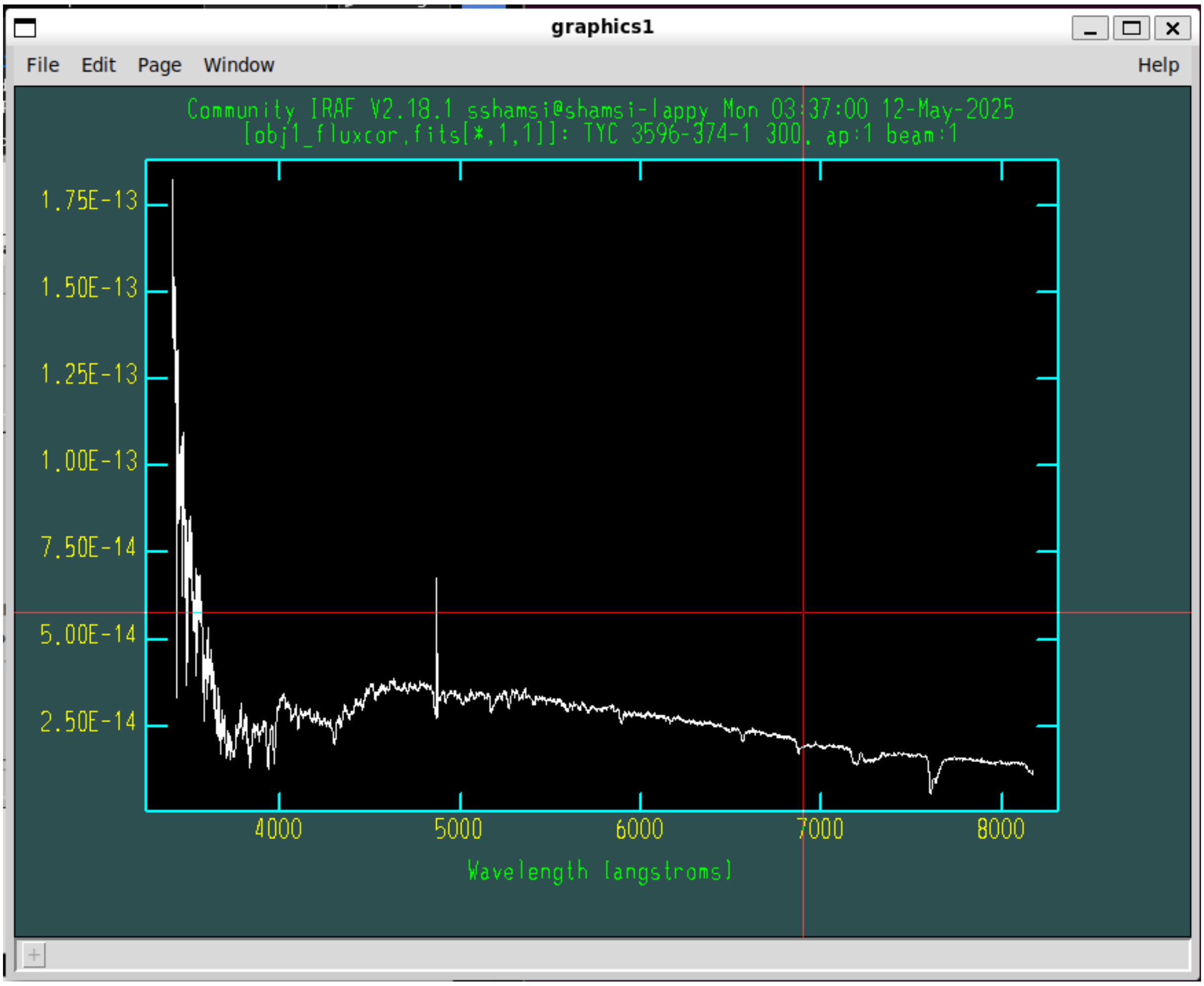
This yields the following plot, which we accept:




iii) Applying the flux correction using the **calibrate** task:

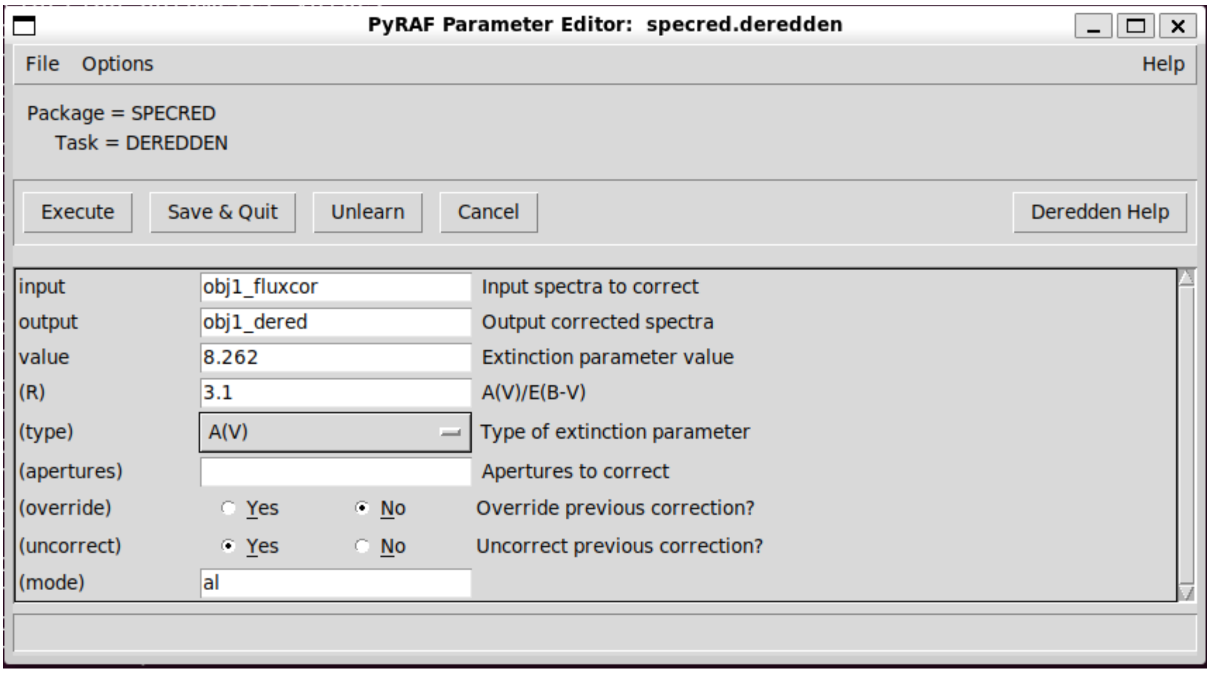


This gives us the following flux corrected spectrum for **obj1:**




*Correction for interstellar extinction*

We use the **deredden** task as follows:



Finally, we can plot the dereddened spectrum: