Death to IRAF

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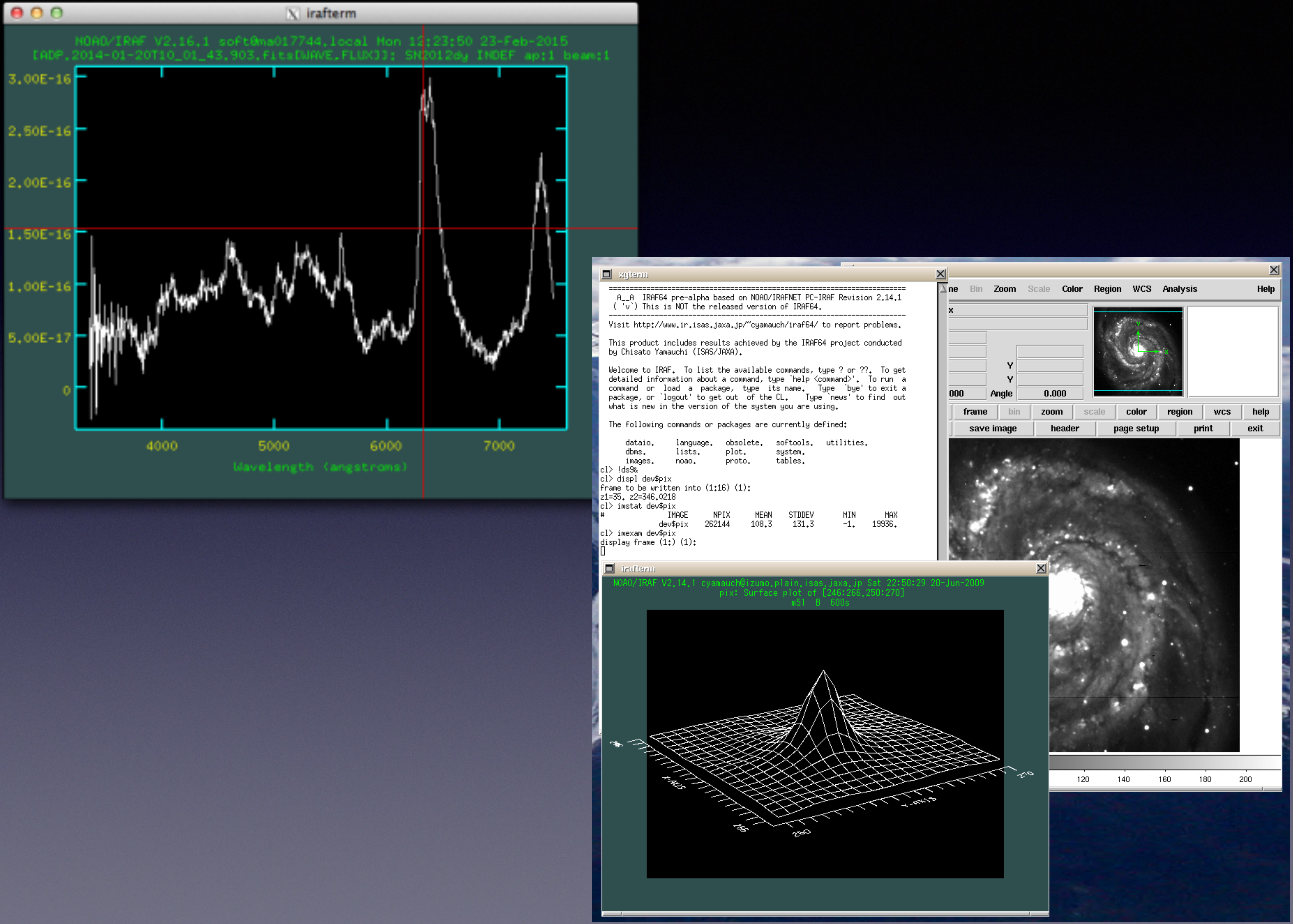
A world about it…

Image Reduction and Analysis Facility, or on short **IRAF**, is a collection of software developed by NOAO geared towards the reduction of astronomical images in pixel array form.



irafterm
NOAO/IRAF V2.16.1 soft@ma017744.local Mon 12:23:50 23-Feb-2015
[ADP.2014-01-20T10_01_43.903.fits[WAVE,FLUX]]: SN2012dy INDEF ap:1 beam:1
3.00E-16
2.50E-16
2.00E-16
1.50E-16
1.00E-16
5.00E-17
0
4000
5000
6000
7000
Wavelength (angstroms)
xgterm
ne Bin Zoom Scale Color Region WCS Analysis Help
x
Y
Y
000
Angle
0.000
frame bin zoom scale color region wcs help
save image header page setup print exit
120
140
160
180
200
irafterm
NOAO/IRAF V2.14.1 cyamauch@izumo.plain.isas.jaxa.jp Sat 22:50:29 20-Jun-2009
pix: Surface plot of [246:266,250:270]
m51 B 600s
X-AXIS
Y-AXIS
266
250
270

```
  ====================================================================
   A__A  IRAF64 pre-alpha based on NOAO/IRAFNET PC-IRAF Revision 2.14.1
  ( 'v`) This is NOT the released version of IRAF64.
  --------------------------------------------------------------------
  Visit http://www.ir.isas.jaxa.jp/~cyamauch/iraf64/ to report problems.

  This product includes results achieved by the IRAF64 project conducted
  by Chisato Yamauchi (ISAS/JAXA).

  Welcome to IRAF.  To list the available commands, type ? or ??.  To get
  detailed information about a command, type `help <command>'.  To run  a
  command  or  load  a  package,  type  its name.   Type  `bye' to exit a
  package, or `logout' to get out  of the CL.    Type `news' to find  out
  what is new in the version of the system you are using.

  The following commands or packages are currently defined:

      dataio.     language.   obsolete.   softools.   utilities.
      dbms.       lists.      plot.       system.
      images.     noao.       proto.      tables.
cl> !ds9&
cl> displ dev$pix
frame to be written into (1:16) (1):
z1=35. z2=346.0218
cl> imstat dev$pix
#               IMAGE      NPIX      MEAN    STDDEV       MIN       MAX
              dev$pix    262144     108.3     131.3       -1.    19936.
cl> imexam dev$pix
display frame (1:) (1):
```

- It is **unintuitive** to work with.

- Despite its **complexity**, not much is left for us, the students, to grasp from it and make it **our own**.

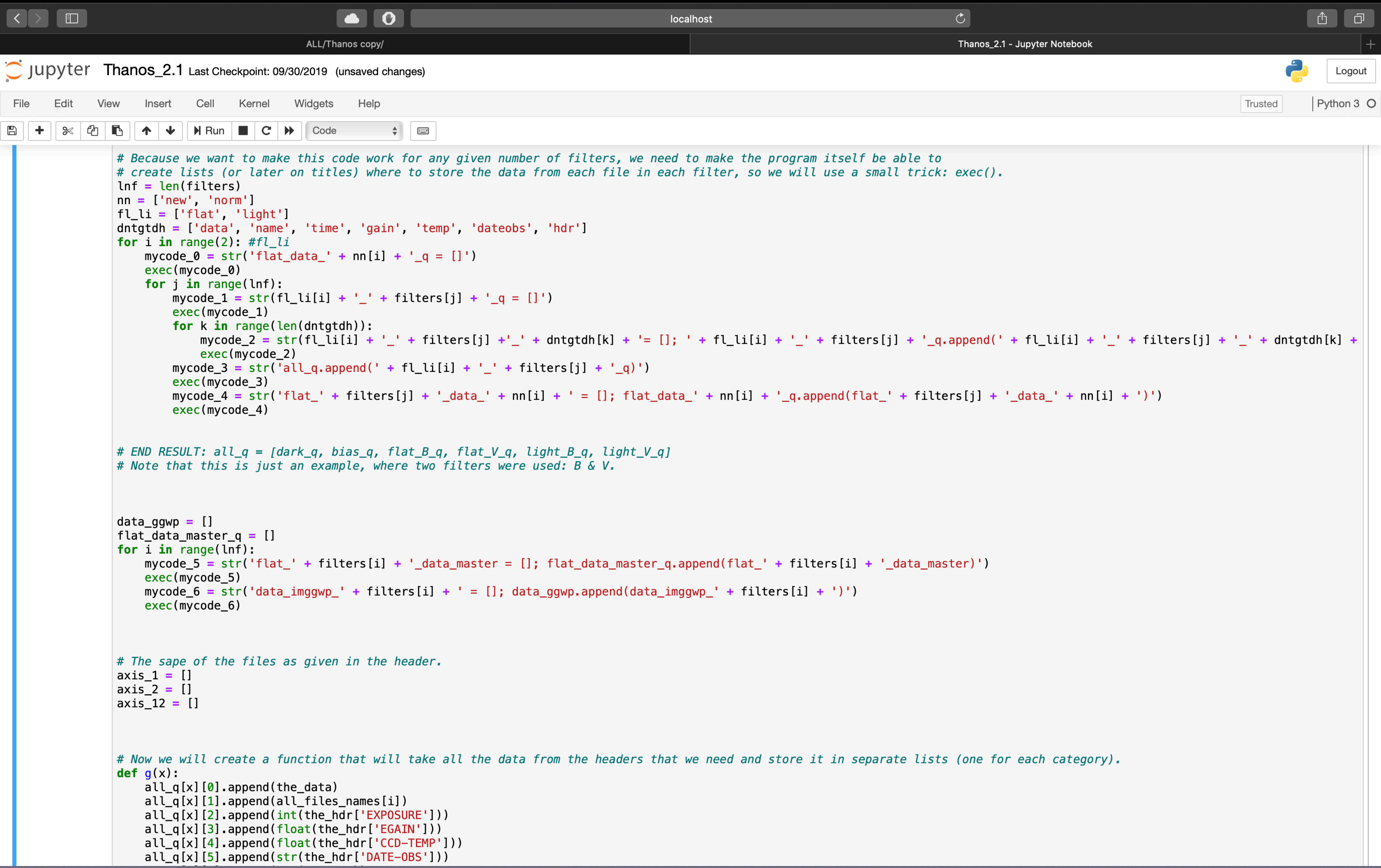
Why bother?

on and Analysis Fa

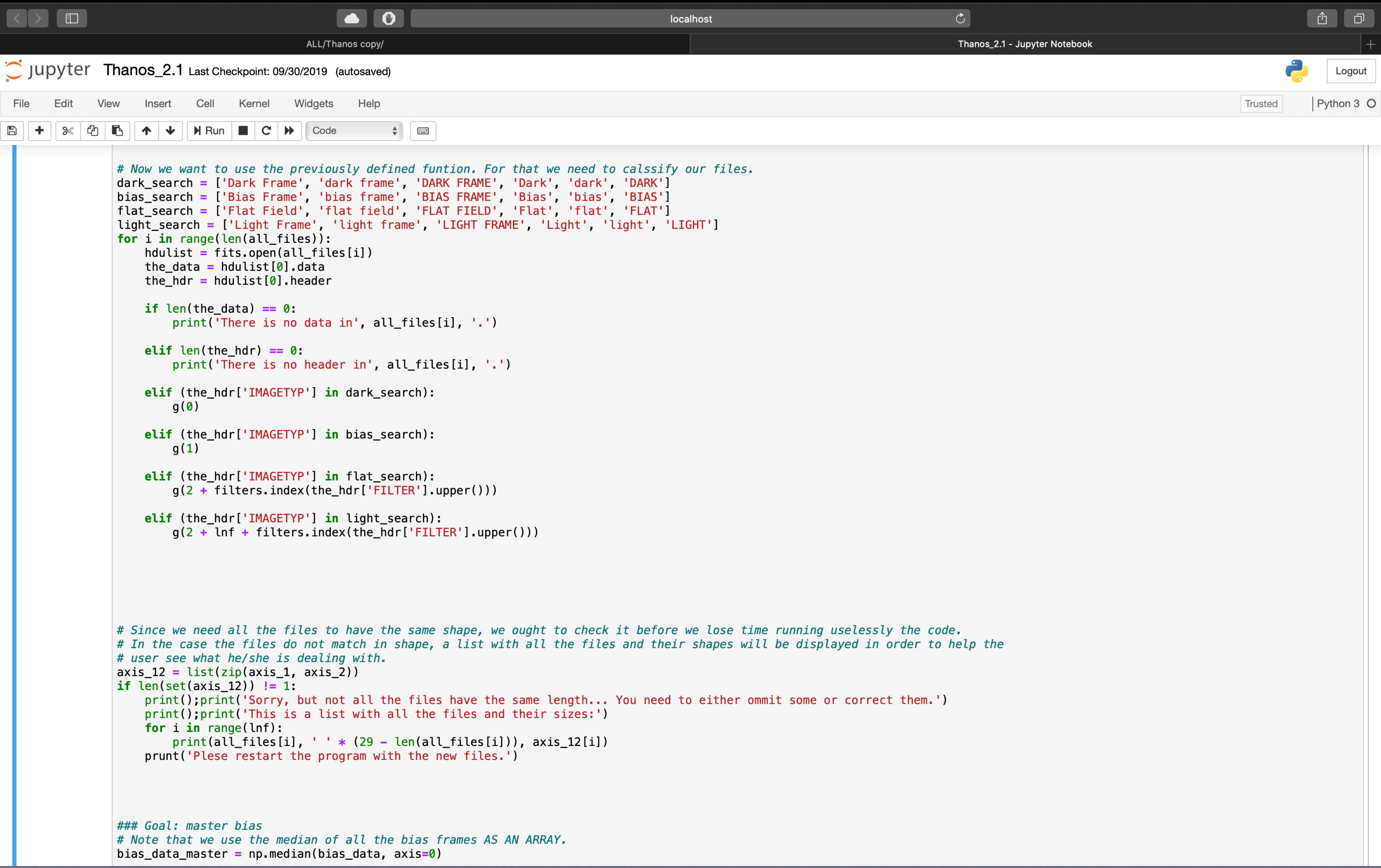
an end-of-support state, an

nstallations during this revie

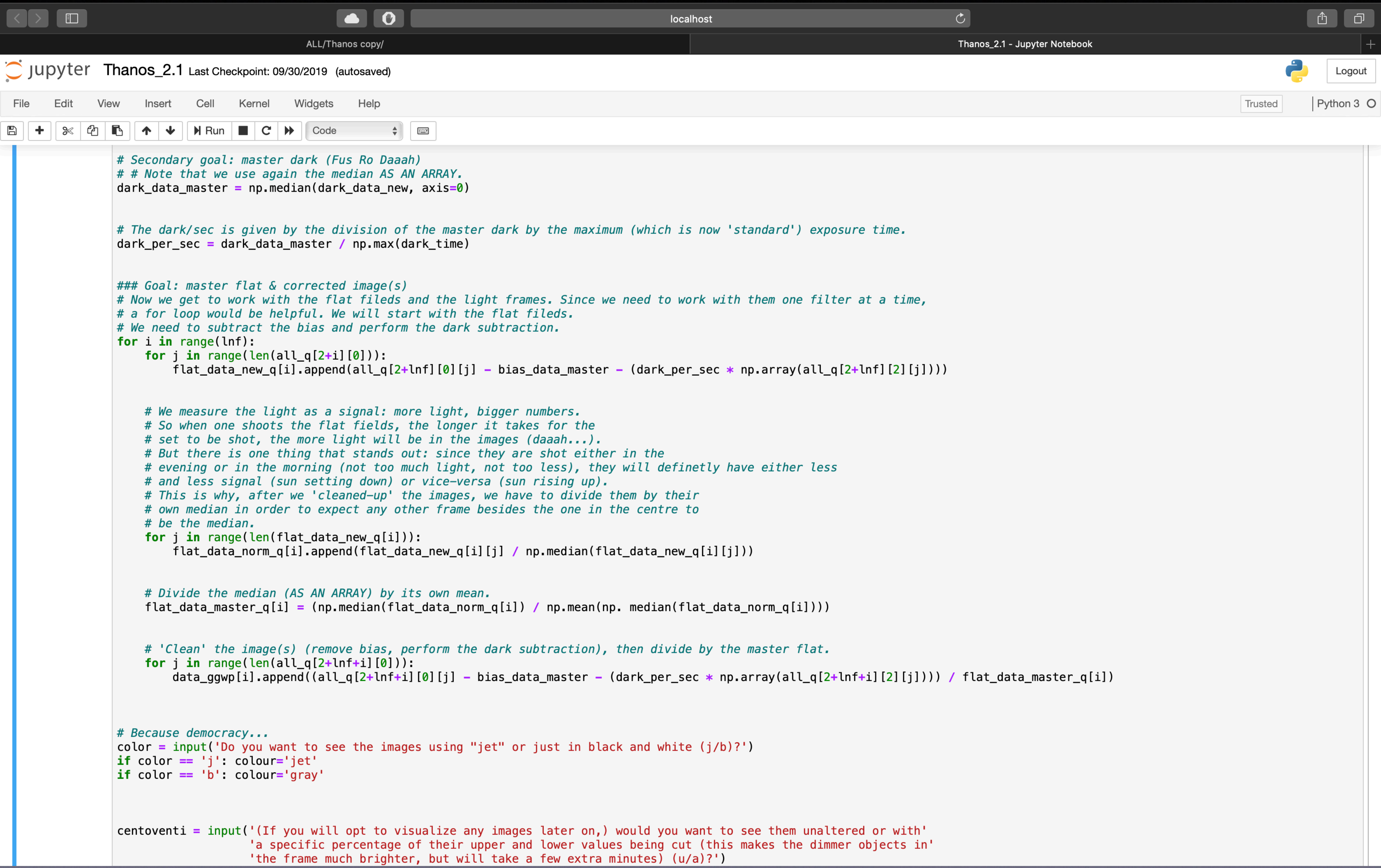
y – Community-based Python astronomy software proje



```
# Because we want to make this code work for any given number of filters, we need to make the program itself be able to
# create lists (or later on titles) where to store the data from each file in each filter, so we will use a small trick: exec().
lnf = len(filters)
nn = ['new', 'norm']
fl_li = ['flat', 'light']
dntgtdh = ['data', 'name', 'time', 'gain', 'temp', 'dateobs', 'hdr']
for i in range(2): #fl_li
    mycode_0 = str('flat_data_' + nn[i] + '_q = []')
    exec(mycode_0)
    for j in range(lnf):
        mycode_1 = str(fl_li[i] + '_' + filters[j] + '_q = []')
        exec(mycode_1)
        for k in range(len(dntgtdh)):
            mycode_2 = str(fl_li[i] + '_' + filters[j] +'_' + dntgtdh[k] + '= []; ' + fl_li[i] + '_' + filters[j] + '_q.append(' + fl_li[i] + '_' + filters[j] + '_' + dntgtdh[k] +
            exec(mycode_2)
        mycode_3 = str('all_q.append(' + fl_li[i] + '_' + filters[j] + '_q)')
        exec(mycode_3)
        mycode_4 = str('flat_' + filters[j] + '_data_' + nn[i] + ' = []; flat_data_' + nn[i] + '_q.append(flat_' + filters[j] + '_data_' + nn[i] + ')')
        exec(mycode_4)


# END RESULT: all_q = [dark_q, bias_q, flat_B_q, flat_V_q, light_B_q, light_V_q]
# Note that this is just an example, where two filters were used: B & V.



data_ggwp = []
flat_data_master_q = []
for i in range(lnf):
    mycode_5 = str('flat_' + filters[i] + '_data_master = []; flat_data_master_q.append(flat_' + filters[i] + '_data_master)')
    exec(mycode_5)
    mycode_6 = str('data_imggwp_' + filters[i] + ' = []; data_ggwp.append(data_imggwp_' + filters[i] + ')')
    exec(mycode_6)



# The sape of the files as given in the header.
axis_1 = []
axis_2 = []
axis_12 = []



# Now we will create a function that will take all the data from the headers that we need and store it in separate lists (one for each category).
def g(x):
    all_q[x][0].append(the_data)
    all_q[x][1].append(all_files_names[i])
    all_q[x][2].append(int(the_hdr['EXPOSURE']))
    all_q[x][3].append(float(the_hdr['EGAIN']))
    all_q[x][4].append(float(the_hdr['CCD-TEMP']))
    all_q[x][5].append(str(the_hdr['DATE-OBS']))
```

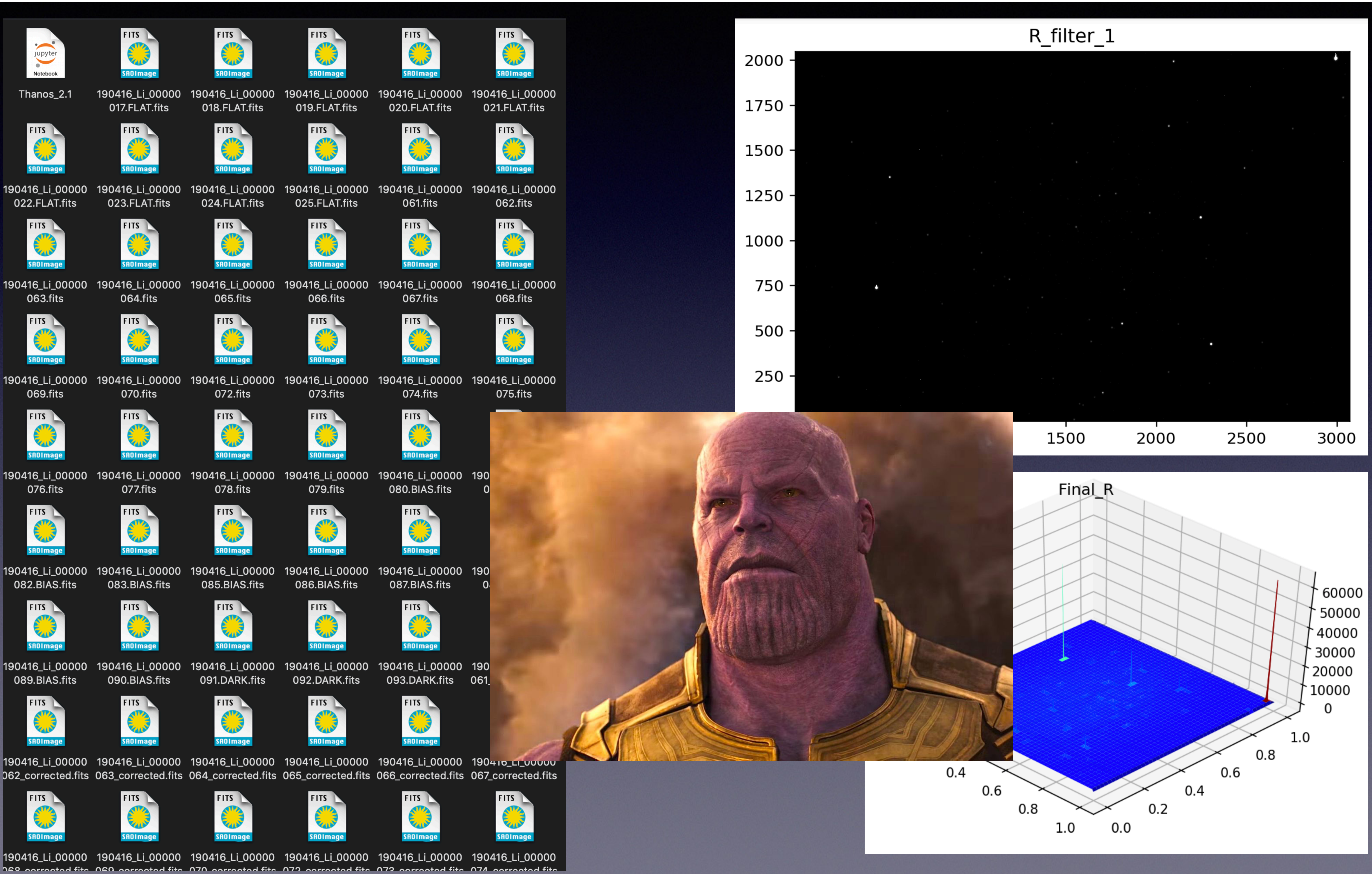


```
# Now we want to use the previously defined funtion. For that we need to calssify our files.
dark_search = ['Dark Frame', 'dark frame', 'DARK FRAME', 'Dark', 'dark', 'DARK']
bias_search = ['Bias Frame', 'bias frame', 'BIAS FRAME', 'Bias', 'bias', 'BIAS']
flat_search = ['Flat Field', 'flat field', 'FLAT FIELD', 'Flat', 'flat', 'FLAT']
light_search = ['Light Frame', 'light frame', 'LIGHT FRAME', 'Light', 'light', 'LIGHT']
for i in range(len(all_files)):
    hdulist = fits.open(all_files[i])
    the_data = hdulist[0].data
    the_hdr = hdulist[0].header

    if len(the_data) == 0:
        print('There is no data in', all_files[i], '.')

    elif len(the_hdr) == 0:
        print('There is no header in', all_files[i], '.')

    elif (the_hdr['IMAGETYP'] in dark_search):
        g(0)

    elif (the_hdr['IMAGETYP'] in bias_search):
        g(1)

    elif (the_hdr['IMAGETYP'] in flat_search):
        g(2 + filters.index(the_hdr['FILTER'].upper()))

    elif (the_hdr['IMAGETYP'] in light_search):
        g(2 + lnf + filters.index(the_hdr['FILTER'].upper()))





# Since we need all the files to have the same shape, we ought to check it before we lose time running uselessly the code.
# In the case the files do not match in shape, a list with all the files and their shapes will be displayed in order to help the
# user see what he/she is dealing with.
axis_12 = list(zip(axis_1, axis_2))
if len(set(axis_12)) != 1:
    print();print('Sorry, but not all the files have the same length... You need to either ommit some or correct them.')
    print();print('This is a list with all the files and their sizes:')
    for i in range(lnf):
        print(all_files[i], ' ' * (29 - len(all_files[i])), axis_12[i])
    prunt('Plese restart the program with the new files.')




### Goal: master bias
# Note that we use the median of all the bias frames AS AN ARRAY.
bias_data_master = np.median(bias_data, axis=0)
```



```python
# Secondary goal: master dark (Fus Ro Daaah)
# # Note that we use again the median AS AN ARRAY.
dark_data_master = np.median(dark_data_new, axis=0)


# The dark/sec is given by the division of the master dark by the maximum (which is now 'standard') exposure time.
dark_per_sec = dark_data_master / np.max(dark_time)


### Goal: master flat & corrected image(s)
# Now we get to work with the flat fileds and the light frames. Since we need to work with them one filter at a time,
# a for loop would be helpful. We will start with the flat fileds.
# We need to subtract the bias and perform the dark subtraction.
for i in range(lnf):
    for j in range(len(all_q[2+i][0])):
        flat_data_new_q[i].append(all_q[2+lnf][0][j] - bias_data_master - (dark_per_sec * np.array(all_q[2+lnf][2][j])))


    # We measure the light as a signal: more light, bigger numbers.
    # So when one shoots the flat fields, the longer it takes for the
    # set to be shot, the more light will be in the images (daaah...).
    # But there is one thing that stands out: since they are shot either in the
    # evening or in the morning (not too much light, not too less), they will definetly have either less
    # and less signal (sun setting down) or vice-versa (sun rising up).
    # This is why, after we 'cleaned-up' the images, we have to divide them by their
    # own median in order to expect any other frame besides the one in the centre to
    # be the median.
    for j in range(len(flat_data_new_q[i])):
        flat_data_norm_q[i].append(flat_data_new_q[i][j] / np.median(flat_data_new_q[i][j]))


    # Divide the median (AS AN ARRAY) by its own mean.
    flat_data_master_q[i] = (np.median(flat_data_norm_q[i]) / np.mean(np. median(flat_data_norm_q[i])))


    # 'Clean' the image(s) (remove bias, perform the dark subtraction), then divide by the master flat.
    for j in range(len(all_q[2+lnf+i][0])):
        data_ggwp[i].append((all_q[2+lnf+i][0][j] - bias_data_master - (dark_per_sec * np.array(all_q[2+lnf+i][2][j]))) / flat_data_master_q[i])



# Because democracy...
color = input('Do you want to see the images using "jet" or just in black and white (j/b)?')
if color == 'j': colour='jet'
if color == 'b': colour='gray'



centoventi = input('(If you will opt to visualize any images later on,) would you want to see them unaltered or with'
                   'a specific percentage of their upper and lower values being cut (this makes the dimmer objects in'
                   'the frame much brighter, but will take a few extra minutes) (u/a)?')
```

jupyter Thanos_2.1 Last Checkpoint: 09/30/2019 (autosaved)



Thanos_2.1
190416_Li_00000017.FLAT.fits
190416_Li_00000018.FLAT.fits
190416_Li_00000019.FLAT.fits
190416_Li_00000020.FLAT.fits
190416_Li_00000021.FLAT.fits
190416_Li_00000022.FLAT.fits
190416_Li_00000023.FLAT.fits
190416_Li_00000024.FLAT.fits
190416_Li_00000025.FLAT.fits
190416_Li_00000061.fits
190416_Li_00000062.fits
190416_Li_00000063.fits
190416_Li_00000064.fits
190416_Li_00000065.fits
190416_Li_00000066.fits
190416_Li_00000067.fits
190416_Li_00000068.fits
190416_Li_00000069.fits
190416_Li_00000070.fits
190416_Li_00000072.fits
190416_Li_00000073.fits
190416_Li_00000074.fits
190416_Li_00000075.fits
190416_Li_00000076.fits
190416_Li_00000077.fits
190416_Li_00000078.fits
190416_Li_00000079.fits
190416_Li_00000080.BIAS.fits
190 0
190416_Li_00000082.BIAS.fits
190416_Li_00000083.BIAS.fits
190416_Li_00000085.BIAS.fits
190416_Li_00000086.BIAS.fits
190416_Li_00000087.BIAS.fits
190 0
190416_Li_00000089.BIAS.fits
190416_Li_00000090.BIAS.fits
190416_Li_00000091.DARK.fits
190416_Li_00000092.DARK.fits
190416_Li_00000093.DARK.fits
190 061_
190416_Li_00000062_corrected.fits
190416_Li_00000063_corrected.fits
190416_Li_00000064_corrected.fits
190416_Li_00000065_corrected.fits
190416_Li_00000066_corrected.fits
190416_Li_00000067_corrected.fits
190416_Li_00000068_corrected.fits
190416_Li_00000069_corrected.fits
190416_Li_00000070_corrected.fits
190416_Li_00000072_corrected.fits
190416_Li_00000073_corrected.fits
190416_Li_00000074_corrected.fits

- the ability to use files from different folders and auto-select those that are viable

- the ability to work with any filters, regardless of their type or number, **by creating individual, specially named lists** containing the respective data sets, thus making easy for the user to search through them

- performing data reduction

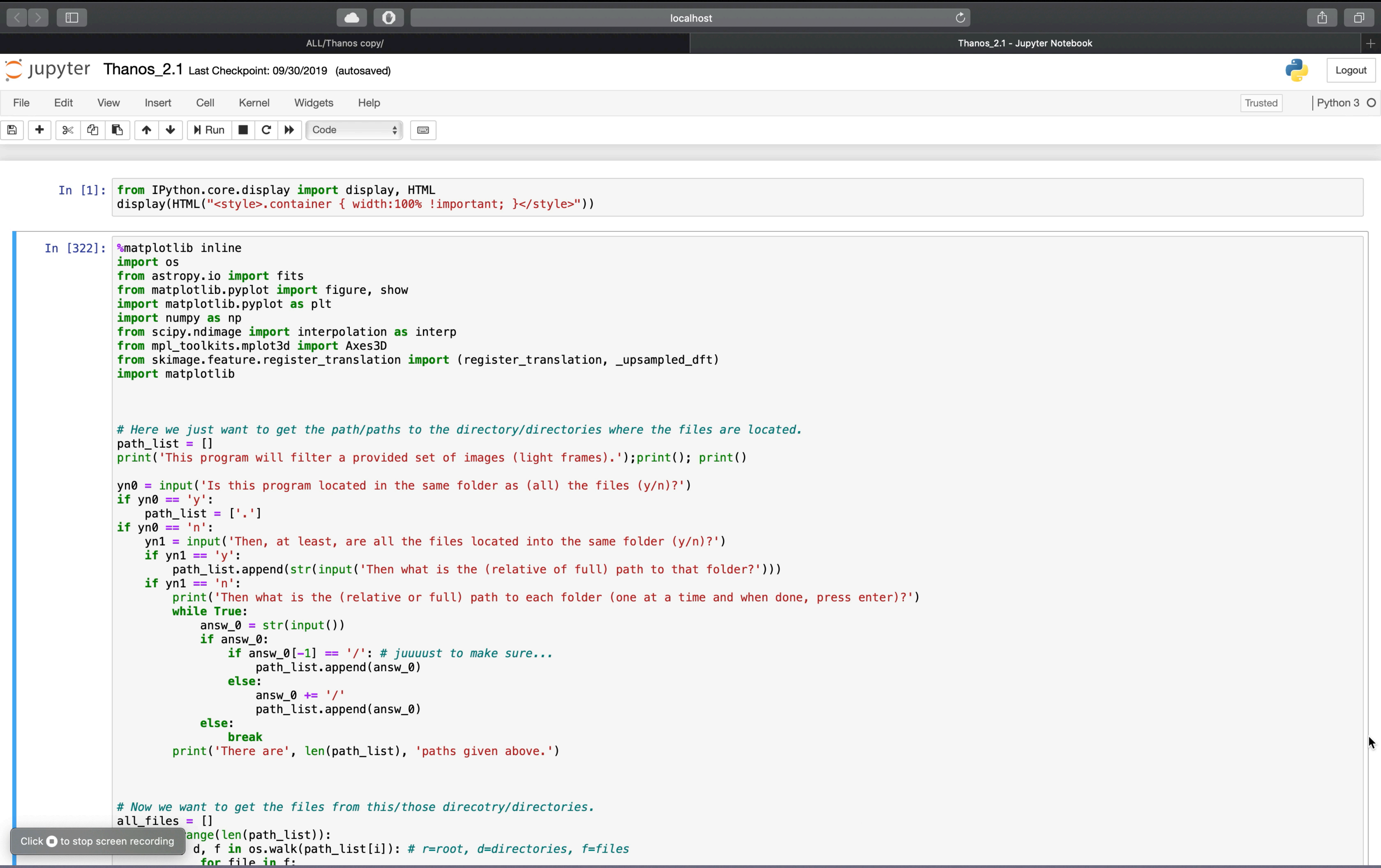
- **sorting them based on the their type** (bias frames, dark frames, flat fields or light frames) and (for the last three ones) also on the filters used when capturing them

- viewing the obtained frames with the option to cut a percentage of the top/lower values in each, thus making the analyzing process easier by not occupying a range of the colors that can be displayed with unimportant values (counts)

- **shifting** the obtained frames and (after letting the user chose one for reference) compiling them into a single one

- repeating the above procedure for the resulted shifted frames and obtaining **a single, final, frame**

- saving by choice any of the obtained frame with a conclusive name

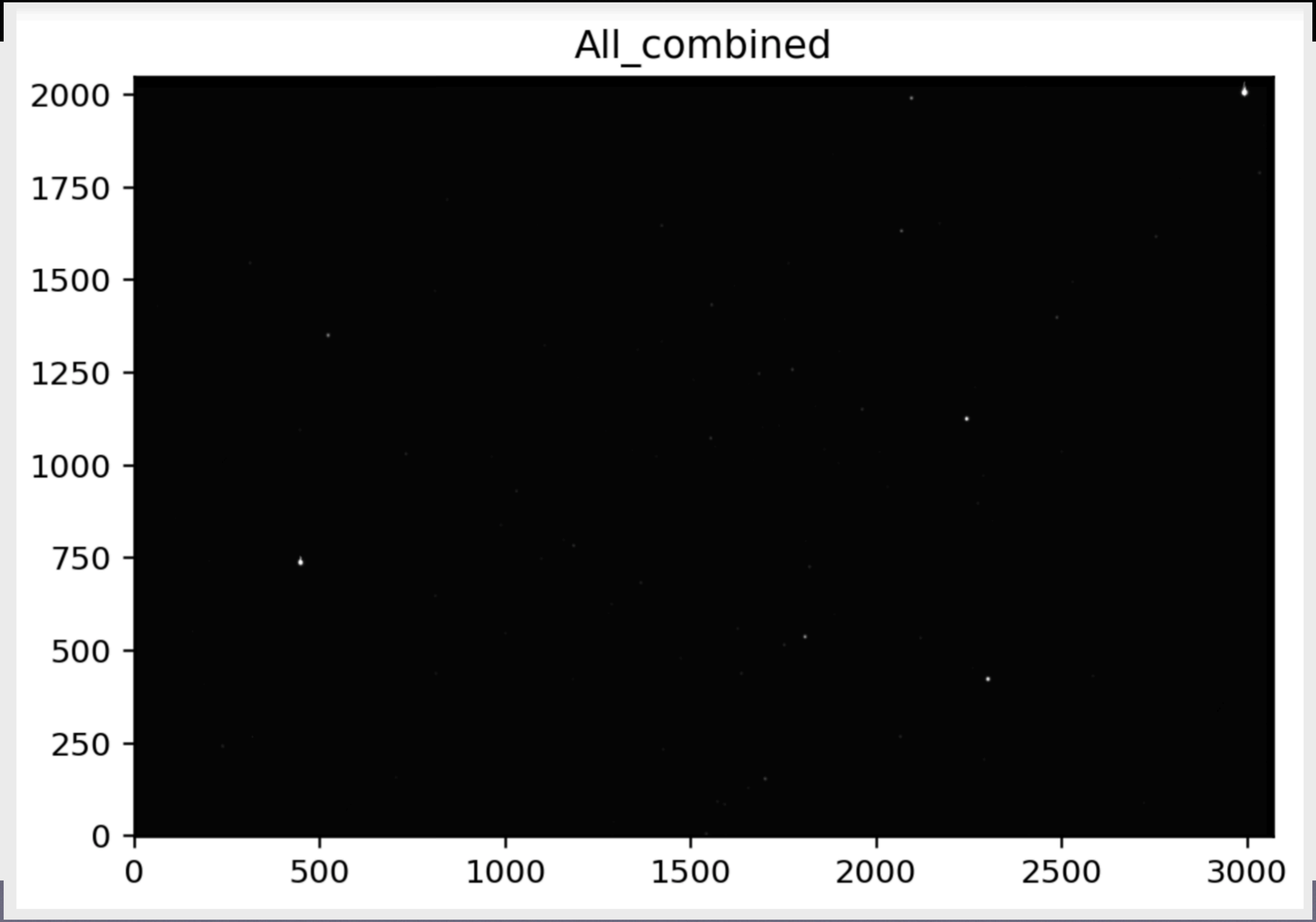

localhost
ALL/Thanos copy/
Thanos_2.1 - Jupyter Notebook
jupyter
Thanos_2.1 Last Checkpoint: 09/30/2019 (autosaved)
Logout
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Trusted
Python 3
Run
Code
Click to stop screen recording

In [1]:

```
from IPython.core.display import display, HTML
display(HTML("<style>.container { width:100% !important; }</style>"))
```

In [322]:

```
%matplotlib inline
import os
from astropy.io import fits
from matplotlib.pyplot import figure, show
import matplotlib.pyplot as plt
import numpy as np
from scipy.ndimage import interpolation as interp
from mpl_toolkits.mplot3d import Axes3D
from skimage.feature.register_translation import (register_translation, _upsampled_dft)
import matplotlib



# Here we just want to get the path/paths to the directory/directories where the files are located.
path_list = []
print('This program will filter a provided set of images (light frames).');print(); print()

yn0 = input('Is this program located in the same folder as (all) the files (y/n)?')
if yn0 == 'y':
    path_list = ['.']
if yn0 == 'n':
    yn1 = input('Then, at least, are all the files located into the same folder (y/n)?')
    if yn1 == 'y':
        path_list.append(str(input('Then what is the (relative of full) path to that folder?')))
    if yn1 == 'n':
        print('Then what is the (relative or full) path to each folder (one at a time and when done, press enter)?')
        while True:
            answ_0 = str(input())
            if answ_0:
                if answ_0[-1] == '/': # juuuust to make sure...
                    path_list.append(answ_0)
                else:
                    answ_0 += '/'
                    path_list.append(answ_0)
            else:
                break
        print('There are', len(path_list), 'paths given above.')



# Now we want to get the files from this/those direcotry/directories.
all_files = []
          ange(len(path_list)):
           d, f in os.walk(path_list[i]): # r=root, d=directories, f=files
            for file in f:
```


All_combined
2000
1750
1500
1250
1000
750
500
250
0
0
500
1000
1500
2000
2500
3000

Thanos - the show must go on

- a more complete description of the individual files in their headers

- the ability to perform photometry

- the addition of other correcting techniques

Thank you… ^^