How to Use Guide for Image Reduction Pipeline

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Before You Run the Code

1. You can run cells by pressing Shift+Enter.
2. Find your directory path.
   Of the form '/content/drive/MyDrive/Colab Notebooks/Research/'
3. Go through the section titled.
   `"#Please run first to download all packages that are required"` change the directory path to yours in this code block. Which should be where main folder where all your research files are located.

```
# Mount Google Drive
from google.colab import drive
drive.mount('/content/drive', force_remount=True)

# Specify the directory path to the FITS files that were processed
dir_path = '/content/drive/MyDrive/Colab Notebooks/Research/Jan20'
```

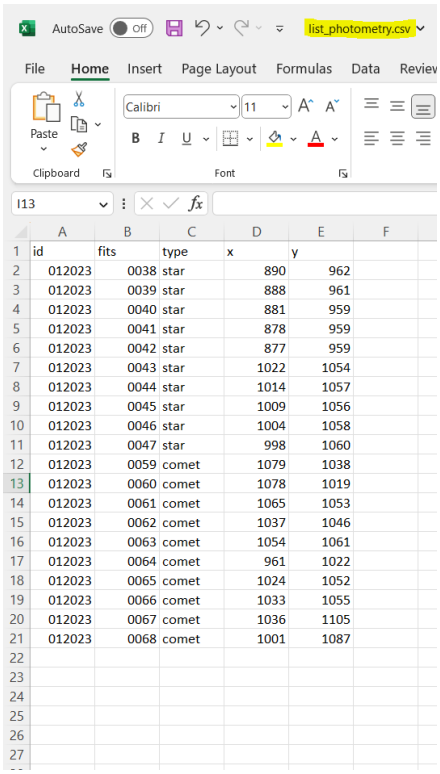
```
Mounted at /content/drive
```

4. Then upload your folder than contains the images from the night in question.

How to Save Files

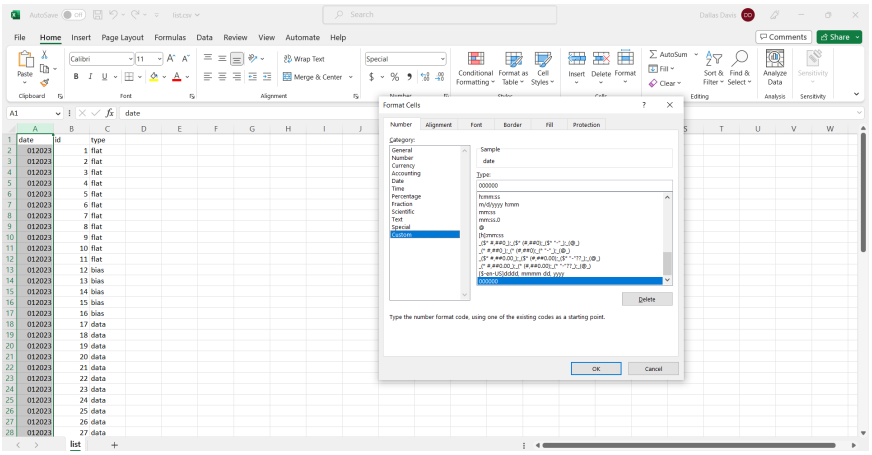
1. You will need two files throughout this code that will be uploaded externally to your google colab folder than contains the night you are analyzing.
2. first item must be named `list.csv` and the second file must be named `list_photometry.csv`
3. To begin right click on your desktop, under new, and create an excel worksheet.
4. Be sure to do this step Format your cells in a way that can be read by the code. So as follows. Select a column and click `Format Cells` in the categories select `number` then `custom` and change them to fit the following format:

   As a note when opening them back up they may appear to have lost the format. However a check into the format cells will show that it is still in that format.
5. Be sure to save the file as a CSV.
6. Upload these files to the night you are currently working on as shown. This can be done by selecting New and going to upload file:

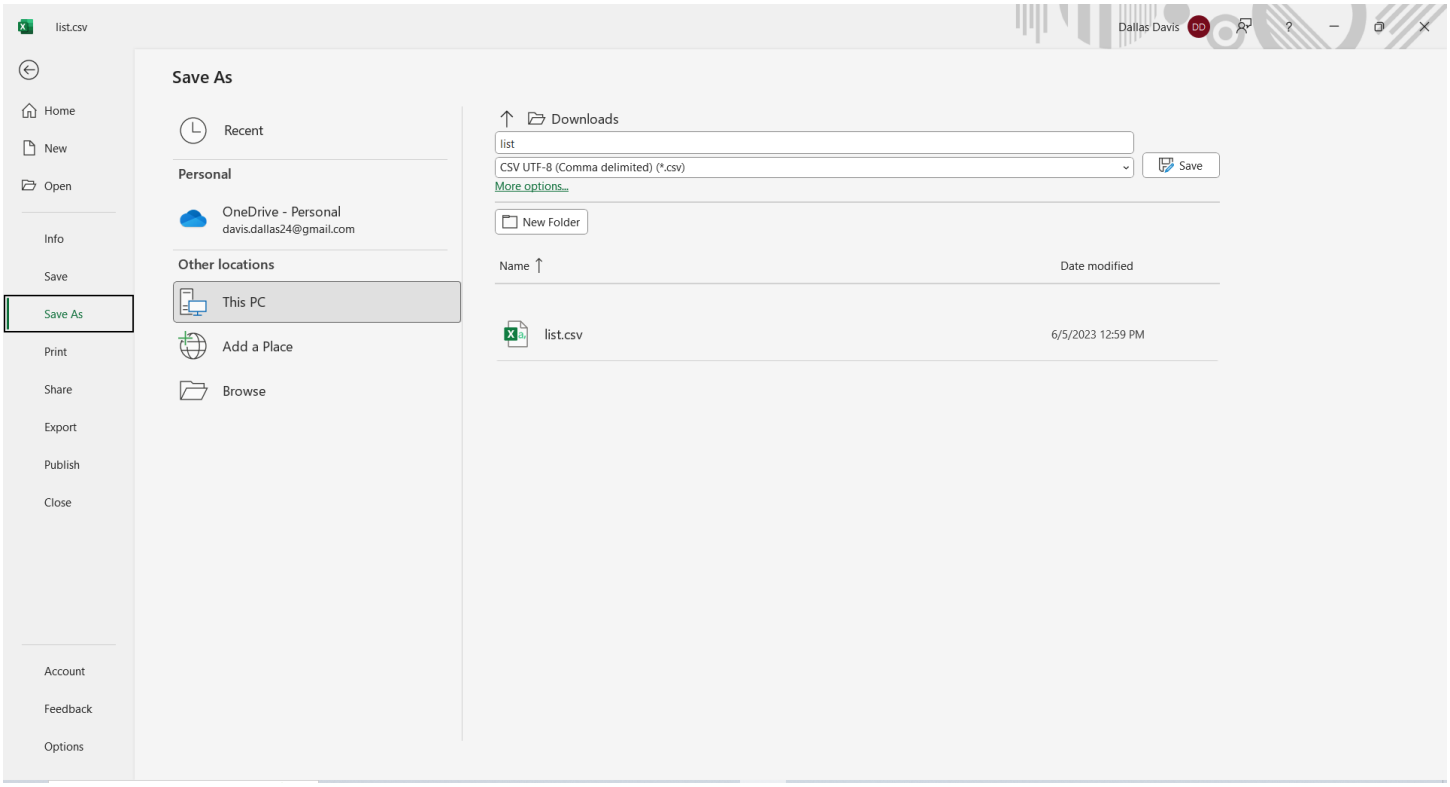


	id	fits	type	x	y
2	012023	0038	star	890	962
3	012023	0039	star	888	961
4	012023	0040	star	881	959
5	012023	0041	star	878	959
6	012023	0042	star	877	959
7	012023	0043	star	1022	1054
8	012023	0044	star	1014	1057
9	012023	0045	star	1009	1056
10	012023	0046	star	1004	1058
11	012023	0047	star	998	1060
12	012023	0059	comet	1079	1038
13	012023	0060	comet	1078	1019
14	012023	0061	comet	1065	1053
15	012023	0062	comet	1037	1046
16	012023	0063	comet	1054	1061
17	012023	0064	comet	961	1022
18	012023	0065	comet	1024	1052
19	012023	0066	comet	1033	1055
20	012023	0067	comet	1036	1105
21	012023	0068	comet	1001	1087

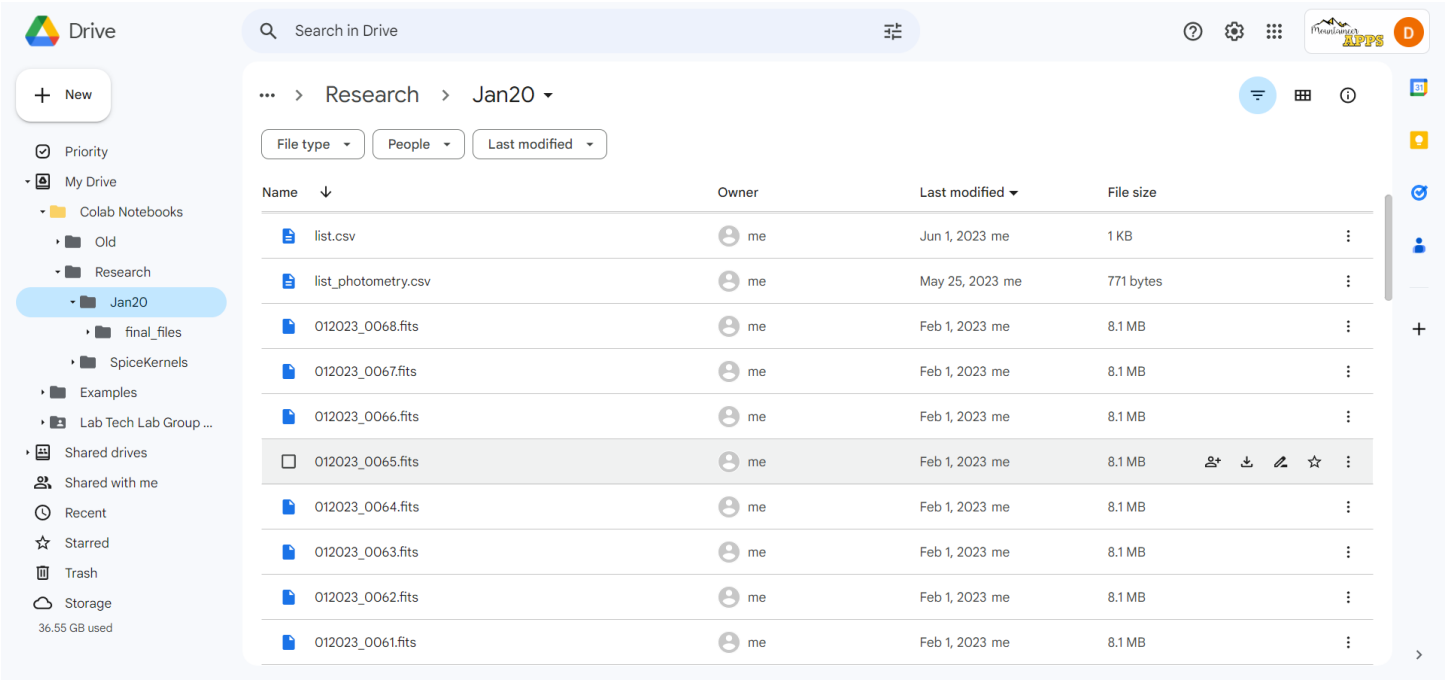
(a) list_photometry.csv format



(b) list.csv format



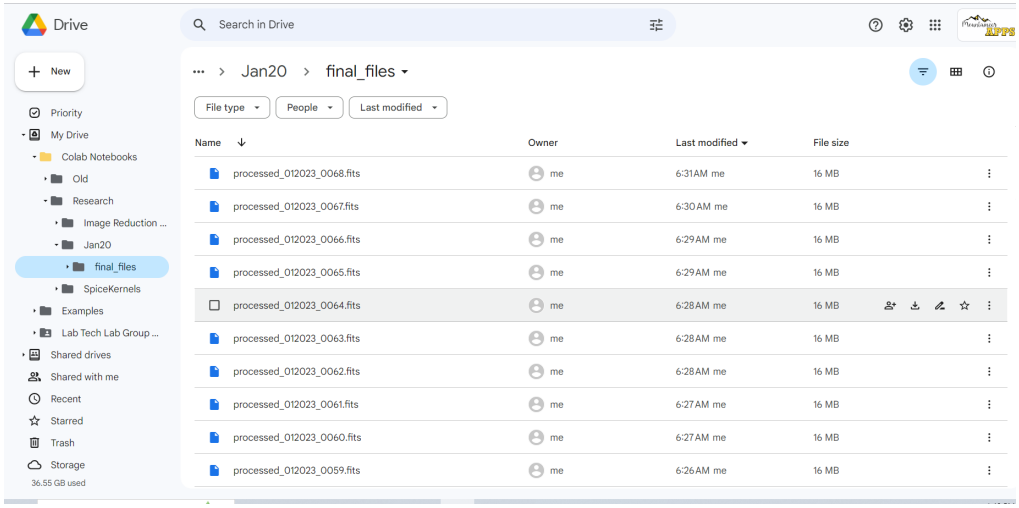
Example of saving "list" as csv



list.csv and list_photometry.csv in google colab

Image Calibration

The Image Calibration saves the processed files in a separate folder called "final_files"



The section that is labeled Comment this section out if there are no streaks is used to remove vertical streaks. Open your processed image in DS9 and use the x coordinates to find the pixels that contain the streaks. If no streak exists then comment the code out with the # in front of the line of code.

Feel free to change sigclip, sigfrac, and objlim if needed for better photometry results. The Parameters for image cropping is used to remove large anomalies caused by the flats and biases. It crops out large issues. Set it to zero if this is not needed. You can find the coords by mousing over in DS9. -35 for instance tells the program 35 pixels FROM the right side of the screen will be cropped. The box size code line tells the program how to smooth out the bad values and what to replace the bad pixels with. Think of it as a window that searches that box to then replace the bad values.

Photometry

Be sure to change the parameters for the star and comet aperture size.

Be sure that you have run the two photometry code cells so that it saves photometry_data_star.csv and photometry_data_comet.csv in final_files folder. It will print the table for you to see.

Make a data frame of star and comet data for the night. Do this by putting in the formation like this:

```
#This code cell is for your convenience. To make doing photometry easier. Please put your star values in the correct spots.
#These will be used by the calibration code.
###To create the table below, enter the filter, the magnitude (m) of your standard in that filter (from Farnham et al.),
#and the airmass of for all your flux star observations on a given night. z is the zenith angle, which is just arccos(1/airmass).
#It seems that Mike used a more precise formula for z, I can find out what he used, but the difference is very small.
#Then you also need to convert your counts to an instrumental magnitude, which we discussed before.
import pandas as pd
import numpy as np

# Get 'Background-Subtracted Flux' and 'Aperture Sum Err' columns as lists from fluxcal_df
counts = fluxcal_df['Background-Subtracted Flux'].tolist()
counts_unc = fluxcal_df['Aperture Sum Err'].tolist()

# Define exposure time, air mass, and m values as lists
exposure_time = [5,2,180,20,10,10,5,2,180,20]
Air_Mass = [1.73,1.76,1.80,1.88,1.93,1.08,1.08,1.08,1.08,1.09]
m = [5.838,5.837,6.018,6.004,5.875,5.986,5.921,5.931,6.366,6.325]

# Create a dictionary containing the data NIGHT OF JAN 20
data = {
    'Number': [38,39,40,41,42,43,44,45,46,47],
    'Object': ['HD31331','HD31331','HD31331','HD31331','HD31331','HD68099','HD68099','HD68099','HD68099','HD68099'],
    'filter': ['BC','C2','OH','NH','CN','CN','BC','C2','OH','NH'],
    'airmass': Air_Mass,
    'exptime': exposure_time,
    'counts': counts,
    'counts_unc': counts_unc,
    'm': m,
    'm_inst': -2.5 * np.log10(np.array(counts) / np.array(exposure_time)),
    'm_inst unc': 2.5 * 0.434 * np.array(counts_unc) / np.array(counts),
    'z': np.degrees(np.arccos(1 / np.array(Air_Mass)))
}

# Create a DataFrame using the data dictionary
df_star = pd.DataFrame(data)

# Specify the directory path to save the file
save_dir = dir_path_final_files

# Save the DataFrame to a CSV file
df_star.to_csv(save_dir + '/photometry_data_star.csv', index=False)

# Optional: Print the DataFrame
df_star
```

Star Data

```python
#This code cell is for your convenience. To make doing photometry easier. Please put your comet values in the correct spots.
import pandas as pd
import numpy as np

#comet C/2022 E3

# Get the 'Background-Subtracted Flux' and 'Aperture Sum Err' columns from comet_df as lists
counts = comet_df['Background-Subtracted Flux'].tolist()
counts_unc = comet_df['Aperture Sum Err'].tolist()

# Define exposure time, air mass, and file_id values as lists
exposure_time = [60,60,300,300,60,300,300,300,900,600]
Air_Mass = [1.31,1.29,1.27,1.25,1.23,1.22,1.20,1.18,1.16,1.13]
file_id = [59,60,61,62,63,64,65,66,67,68]

# Create a dictionary to store the data for the comet NIGHT OF JAN 20
data_comet = {
    'Number': file_id,
    'filter': ['BC','C2','OH','NH','CN','CN','BC','C2','OH','NH'],
    'airmass': Air_Mass,
    'exptime': exposure_time,
    'counts': counts,
    'counts_unc': counts_unc,
}

# Create a DataFrame using the comet data
df_comet = pd.DataFrame(data_comet)

# Specify the directory path to save the file
save_dir = dir_path_final_files

# Save the DataFrame to a CSV file
df_comet.to_csv(save_dir + '/photometry_data_comet.csv', index=False)

# Optional: Print the DataFrame
df_comet
```

	Number	filter	airmass	exptime	counts	counts_unc
0	59	BC	1.31	60	3.667609e+04	258.535354
1	60	C2	1.29	60	3.406449e+05	635.386574
2	61	OH	1.27	300	3.735563e+04	265.898386
3	62	NH	1.25	300	7.195559e+04	343.134663
4	63	CN	1.23	60	1.522531e+05	443.596641
5	64	CN	1.22	300	1.184432e+05	468.689042
6	65	BC	1.20	300	7.348194e+04	336.263713
7	66	C2	1.18	300	1.911034e+06	1455.628403
8	67	OH	1.16	900	1.059912e+05	394.080851
9	68	NH	1.13	600	1.533462e+05	477.310892

Comet Data

Calibration

Be sure to that you have ran the photometry code so that it saves photometry_data_star.csv and photometry_data_comet.csv in final_files folder

Change the range() to meet the number of filters in order of NH,CN,BC, and C2. Keep in mind that the index of range starts at zero So if you had two NH filters it would be range(0,2). If this is confusing you can always do:

```
for i in range(0,2):
    print(i)
```

to see how this works. Think of it as storing the filters starting at the index 0. So it would go 0,1,2,3,4,5,6....

Production Rate

1. Change the epoch date to UT which is one day ahead of our EST date.
2. Change the next line to the name of your comet
3. Find the gfactor from the website in the code by plugging in the Heliocentric Velocity and make sure to use the value from 1AU.
4. Run the code again and then plug in the phase angle correction. Found from either the website or the code cell below the production rate code. By plugging in the angle.
5. After that you are done!
6. A file will be saved called Production_Rate.txt to the final_files folder for that night.

Common Errors and Fixes

Please make sure the dirpath is defined correctly. As this is propagated throughout the code for convenience. It is defined in the "Please run first section" this folder should be your night Ex: Jan20 and that folder must contain the list.csv and list_photometry.csv. There will be a final_files folder created by the code. The code will store the processed images, Tables of anything created. Such as the photometry, star photometry/data and so on. This is so that you can use them later if needed. Or refer to them later.