

```
In [1]: from pathlib import Path
import os

from astropy.nddata import CCDData
from astropy.stats import mad_std
from astropy.visualization import hist
import ccdproc as ccdp
import matplotlib.pyplot as plt
import numpy as np
```

```
In [2]: reduced_data = Path('c:\\Users\\micha\\vfilter\\reduced_data')
unreduced_data = Path('c:\\Users\\micha\\vfilter\\unreduced_data')
```

```
In [3]: all_unreduced = ccdp.ImageFileCollection(unreduced_data)
all_reduced = ccdp.ImageFileCollection(reduced_data)
```

```
In [4]: all_unreduced.summary['file', 'object', 'exptime', 'naxis1', 'naxis2']
```

Out[4]: *Table length=33*

file	object	exptime	naxis1	naxis2
str11	str8	float64	int32	int32
bias10.fits	BIAS	0.0	2060	2060
bias11.fits	BIAS	0.0	2060	2060
bias12.fits	BIAS	0.0	2060	2060
bias13.fits	BIAS	0.0	2060	2060
bias14.fits	BIAS	0.0	2060	2060
bias15.fits	BIAS	0.0	2060	2060
bias16.fits	BIAS	0.0	2060	2060
bias17.fits	BIAS	0.0	2060	2060
bias18.fits	BIAS	0.0	2060	2060
bias19.fits	BIAS	0.0	2060	2060
...
vflat5.fits	SKY,FLAT	45.2058	2060	2060
vraw1.fits	BWST	40.0092	2060	2060
vraw10.fits	BWST	40.0091	2060	2060
vraw2.fits	BWST	40.0096	2060	2060
vraw3.fits	BWST	40.0093	2060	2060
vraw4.fits	BWST	40.0088	2060	2060
vraw5.fits	BWST	40.0094	2060	2060

file	object	exptime	naxis1	naxis2
vraw6.fits	BWST	40.011	2060	2060
vraw8.fits	BWST	40.0106	2060	2060
vraw9.fits	BWST	40.0088	2060	2060

In [5]:

```

for ccd, file_name in all_unreduced.ccds(object='BIAS',
                                         ccd_kwargs={'unit': 'adu'}, # CCDData requires a unit
                                                         # it is not in the header
                                         return_fname=True           # Provide the file name to
                                         ):
    # Subtract the overscan
    subtract_overscan_bias = ccdp.subtract_overscan(ccd, overscan=ccd[:, 2055:], median

    # Trim the overscan
    trimmed_bias = ccdp.trim_image(subtract_overscan_bias[:, 2048, :2048])

    # Save the result
    trimmed_bias.write(reduced_data / file_name, overwrite = True)

```

```
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the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
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```

```
In [6]: calibrated_biases = all_reduced.files.filtered(object='bias', include_path=True)
```

```
In [7]: master_bias = ccdp.combine(calibrated_biases,  
                                   method='average',  
                                   sigma_clip=True, sigma_clip_low_thresh=5, sigma_clip_high=  
                                   sigma_clip_func=np.ma.median, sigma_clip_dev_func=mad_std,  
                                   mem_limit=350e6  
                                   )  
  
master_bias.meta['combined'] = True
```

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INFO:astropy:splitting each image into 11 chunks to limit memory usage to 350000000.0 by
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```

[illegible]

localhost:8888/nbconvert/html/vfilter/vfilter good hopefully.ipynb?download=false

[illegible]

[illegible]

8/25

[illegible]

localhost:8888/nbconvert/html/vfilter/vfilter good hopefully.ipynb?download=false

[illegible]

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[illegible]

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[illegible]

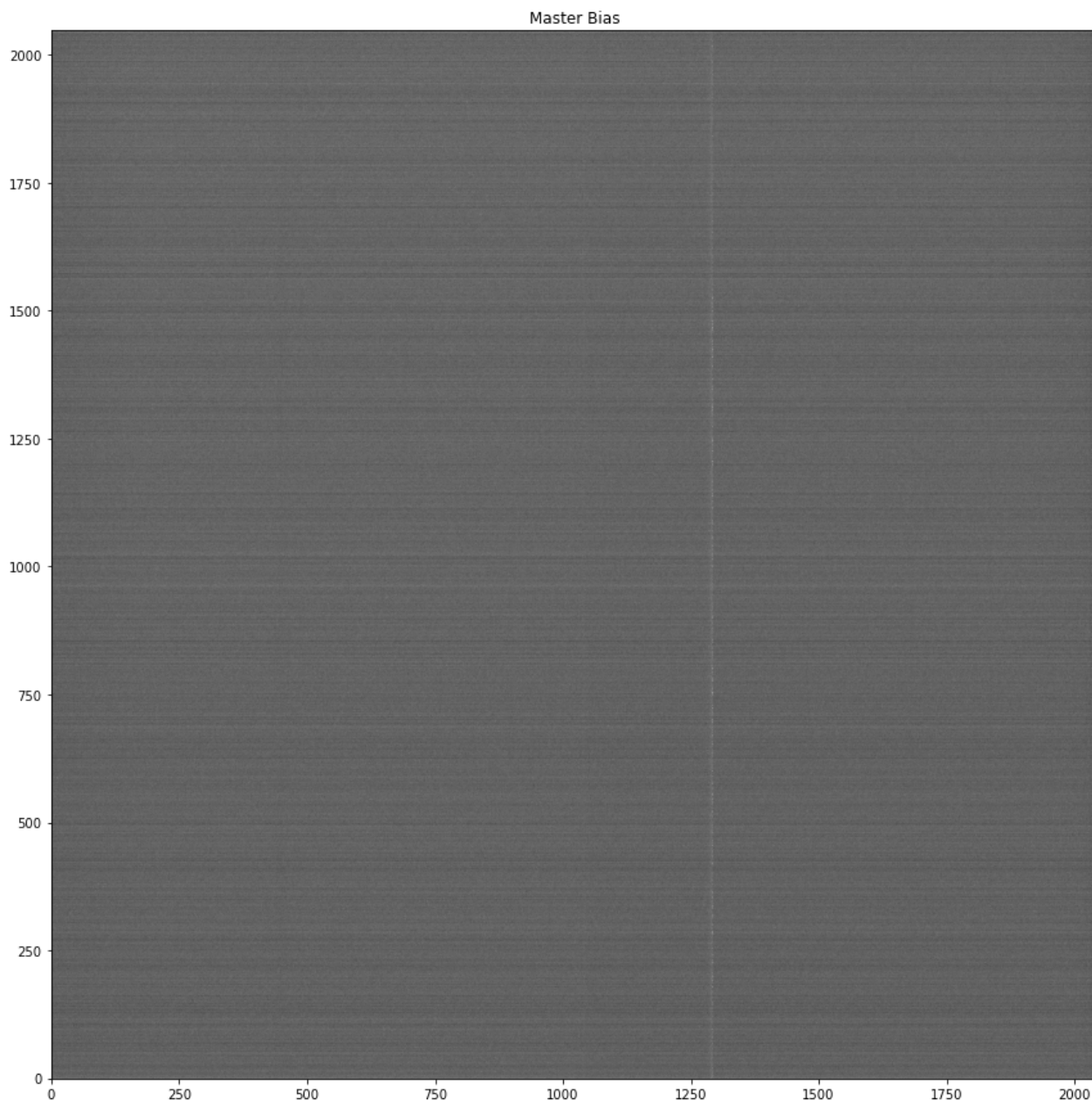
[illegible]

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```
In [8]: plt.figure(figsize=(15,15))
plt.imshow((master_bias), origin='lower', cmap='gray');
plt.title('Master Bias')
```

```
Out[8]: Text(0.5, 1.0, 'Master Bias')
```



```
In [10]: for ccd, file_name in all_unreduced.ccds(object='sky,flat', # Just get the f
          ccd_kwargs={'unit': 'adu'}, # CCDData requires
```

```

# it is not in the
# Provide the file
return_fname=True
):

# Subtract the overscan
subtract_overscan_flat = ccdp.subtract_overscan(ccd, overscan=ccd[:, 2055:], median

# Trim the overscan
trimmed_flat = ccdp.trim_image(subtract_overscan_flat[:,2048, :2048])

# Save the result; there are some duplicate file names so pre-pend "flat"
trimmed_flat.write(reduced_data / file_name, overwrite = True)

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```

```

In [11]: calibrated_flats = all_reduced.files_filtered(object='sky,flat', include_path=True)

```

```

In [12]: master_flat = ccdp.combine(calibrated_flats,
                                     method='average',
                                     sigma_clip=True, sigma_clip_low_thresh=5, sigma_clip_high_
                                     sigma_clip_func=np.ma.median, sigma_clip_dev_func=mad_std,
                                     mem_limit=350e6
                                     )

master_flat.meta['combined'] = True

```

```

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WARNING:astropy:FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
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INFO:astropy:splitting each image into 3 chunks to limit memory usage to 350000000.0 byt
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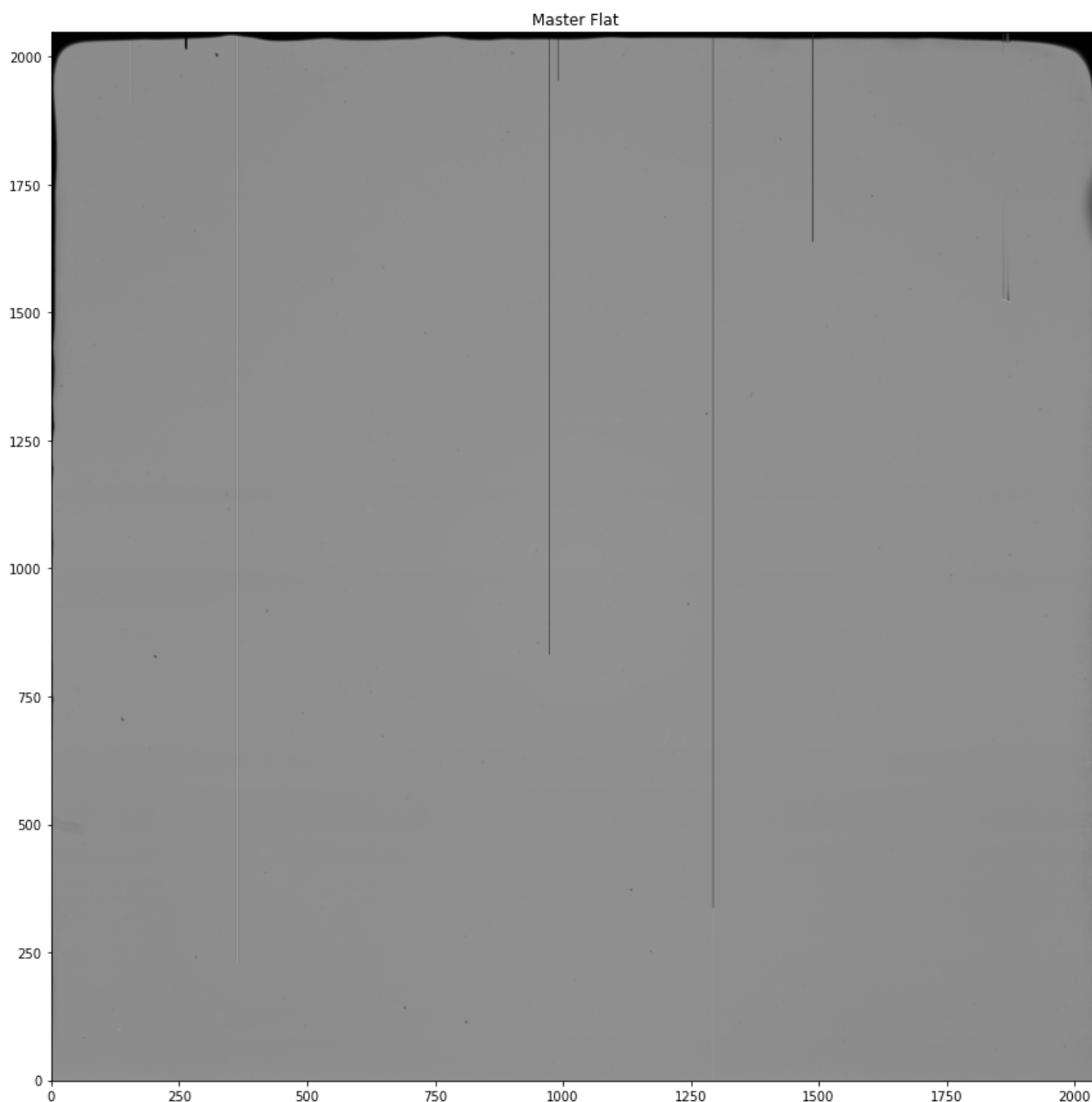
```

```
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INFO: splitting each image into 3 chunks to limit memory usage to 350000000.0 bytes. [cc
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```
In [13]: plt.figure(figsize=(15,15))  
plt.imshow((master_flat), origin='lower', cmap='gray');  
plt.title('Master Flat')
```

```
Out[13]: Text(0.5, 1.0, 'Master Flat')
```



```
In [14]: for ccd, file_name in all_unreduced.ccds(object='bwst',
                                                ccd_kwargs={'unit': 'adu'},
                                                return_fname=True):

    # Subtract the overscan
    subtract_overscan_rows = ccdp.subtract_overscan(ccd, overscan=ccd[:, 2055:], median

    # Trim the image
    trimmed_rows = ccdp.trim_image(subtract_overscan_rows[:, 2048, :2048])

    # Subtract the bias
    bias_subtracted_rows = ccdp.subtract_bias(trimmed_rows, master_bias)

    # Flat correct it
    flat_corrected_rows = ccdp.flat_correct(bias_subtracted_rows, master_flat)

    # Save the images
    flat_corrected_rows.write(reduced_data / file_name, overwrite=True)
```

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g: divide by zero encountered in true_divide
    result = super().__array_ufunc__(function, method, *arrays, **kwargs)
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```



```
C:\Users\micha\anaconda3\lib\site-packages\astropy\nddata\nduncertainty.py:650: RuntimeWarning: divide by zero encountered in true_divide
    return from_variance((left + right + correlation_sign * corr) /
C:\Users\micha\anaconda3\lib\site-packages\astropy\nddata\nduncertainty.py:650: RuntimeWarning: invalid value encountered in true_divide
    return from_variance((left + right + correlation_sign * corr) /
WARNING: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
WARNING: astropy: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa.
C:\Users\micha\anaconda3\lib\site-packages\astropy\units\quantity.py:486: RuntimeWarning: divide by zero encountered in true_divide
    result = super().__array_ufunc__(function, method, *arrays, **kwargs)
C:\Users\micha\anaconda3\lib\site-packages\astropy\nddata\nduncertainty.py:650: RuntimeWarning: divide by zero encountered in true_divide
    return from_variance((left + right + correlation_sign * corr) /
C:\Users\micha\anaconda3\lib\site-packages\astropy\nddata\nduncertainty.py:650: RuntimeWarning: invalid value encountered in true_divide
    return from_variance((left + right + correlation_sign * corr) /
```

In []: