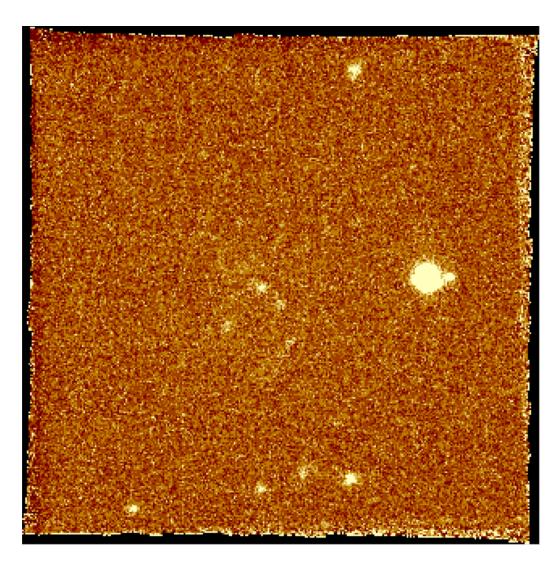
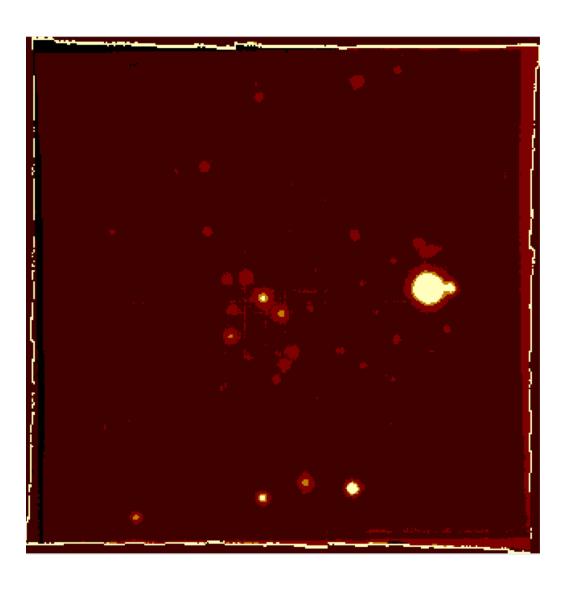
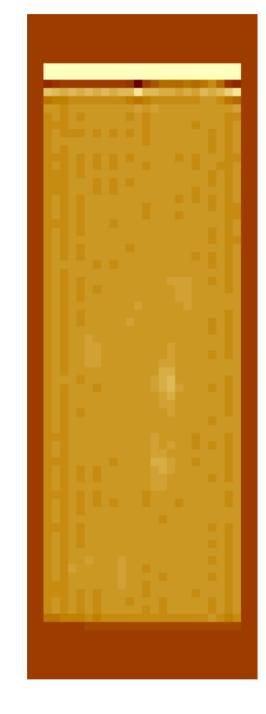
# Spectral Cube Shenanigans

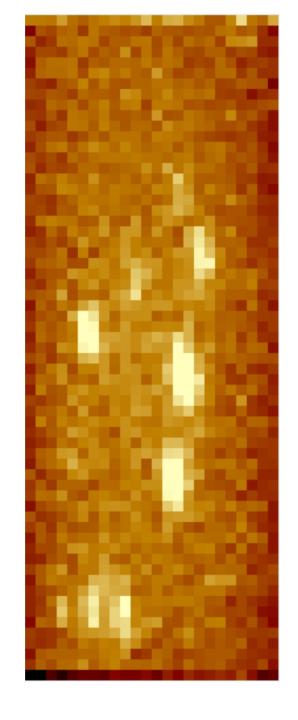
## Examples (MUSE)





## Example (KCWI)





# QFitsView Intermission

(+ quick ds9 remark)

```
WAVALL0 = 4861 / Low inclusive wavelength
WAVALL1 = 5336 / High inclusive wavelength
WAVGOOD0= 4859.751032916362 / Low good wavelength
WAVGOOD1= 5337.463081480892 / High good wavelength
WAVMID = 5098.594534348915 / middle wavelength
```

8.096E-05 / Pixel scale along slice (deg)

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                              3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                        = 'RA---TAN'
OBJECT = 'NGC5846-UDG1'
                              Object name
                                                                          'DEC--TAN'
                                                               CTYPE2
OBSERVER= 'Various
                              Observer name
                                                               CTYPE3
                                                                       = 'AWAV
                                                                                                 / Air Wavelengths
INSTRUME= 'KCWI
                              Instrument
                              Camera (blue, red, fpc)
CAMERA = 'BLUE
                                                                         'deg
                                                                                                  RA units
                                                               CUNIT1
                              Image type
IMTYPE = 'OBJECT
                                                                                                  DEC units
                                                               CUNIT2
                                                                       = 'deg
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                                                  Wavelength units
                                                                          'Angstrom'
                                                               CNAME1
                                                                       "KCWI RA
                                                                                                  RA name
                                                               CNAME 2
                                                                       = 'KCWI DEC'
                                                                                                  DEC name
                               DCS Instrument
CURRINST= 'KCWI
                                                               CNAME3
                                                                                                  Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                                                                       = 'KCWI Wavelength'
PONAME = 'IFU
                               DCS Point origin name
                                                               CRVAL1
                                                                                    226.334625 / RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                                             1.813611111111111 / DEC zeropoint
                                                               CRVAL2
       = '+01:48:49.0'
                               DCS Dec
                                                                                        4808.25 / Wavelength zeropoint
                                                               CRVAL3
                               DCS Target RA
TARGRA = '15:05:20.46'
                                                                                           14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                           43.0 / DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                       = -9.4237983519361E-05 / RA degrees per column pixel
IMGRECT =
                           T / Image rectified?
                                                                       = 0.000163356636113151 / DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                           F / master dark subtracted?
                                                               CD1 2
                                                                       = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                       = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                           T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
         'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                               63
                                                                                              3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3 =
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                        = 'RA---TAN'
OBJECT = 'NGC5846-UDG1'
                              Object name
                                                               CTYPE2
                                                                          'DEC--TAN'
OBSERVER= 'Various
                               Observer name
                                                               CTYPE3
                                                                       = 'AWAV
                                                                                                 / Air Wavelengths
                              Instrument
INSTRUME= 'KCWI
CAMERA = 'BLUE
                              Camera (blue, red, fpc)
                                                                                                  RA units
                                                               CUNIT1
                                                                          'dea
                              Image type
IMTYPE = 'OBJECT
                                                                                                  DEC units
                                                               CUNIT2
                                                                        = 'dea
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                           Angstrom
                                                                                                  Wavelength units
                                                               CNAME1
                                                                       = 'KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                       = 'KCWI DEC'
                                                                                                  DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME3
                                                                                                  Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                                                                       = 'KCWI Wavelength'
PONAME = 'IFU
                               DCS Point origin name
                                                               CRVAL1
                                                                                    226.334625 / RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                                             1.813611111111111 / DEC zeropoint
                                                               CRVAL2
        = '+01:48:49.0'
                               DCS Dec
                                                               CRVAL3
                                                                                        4808.25 / Wavelength zeropoint
                               DCS Target RA
TARGRA = '15:05:20.46'
                                                                                           14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                           43.0 / DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                       = -9.4237983519361E-05 / RA degrees per column pixel
                           T / Image rectified?
IMGRECT =
                                                                       = 0.000163356636113151 / DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                            F / master dark subtracted?
                                                               CD1 2
                                                                       = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                       = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
         'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
                                                                         8.096E-05 / Pixel scale along slice (deg)
                                                   PXSCL
```

SLSCL

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                              3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                        = 'RA---TAN'
OBJECT =
          'NGC5846-UDG1'
                              Object name
                                                                        = 'DEC--TAN'
                                                               CTYPE2
OBSERVER=
         'Various
                               Observer name
                                                               CTYPE3
                                                                       = 'AWAV
                                                                                                 / Air Wavelengths
                               Instrument
INSTRUME= 'KCWI
CAMERA = 'BLUE
                              Camera (blue, red, fpc)
                                                                       = 'deg
                                                                                                  RA units
                                                               CUNIT1
                              Image type
      = 'OBJECT
                                                                                                  DEC units
                                                               CUNIT2
                                                                       = 'deg
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                                                  Wavelength units
                                                                          'Angstrom'
                                                               CNAME1
                                                                       = 'KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                       = 'KCWI DEC'
                                                                                                   DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME3
                                                                                                  Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                                                                       = 'KCWI Wavelength'
PONAME = 'IFU
                               DCS Point origin name
                                                                                    226.334625 /
                                                               CRVAL1
                                                                                                  RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                                             1.813611111111111 / DEC zeropoint
                                                               CRVAL2
       = '+01:48:49.0'
                               DCS Dec
                                                               CRVAL3
                                                                                        4808.25 / Wavelength zeropoint
TARGRA = '15:05:20.46'
                               DCS Target RA
                                                                                           14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                           43.0 / DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                       = -9.4237983519361E-05 / RA degrees per column pixel
IMGRECT =
                           T / Image rectified?
                                                                       = 0.000163356636113151 / DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                            F / master dark subtracted?
                                                               CD1 2
                                                                       = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                       = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
                                                                         8.096E-05 / Pixel scale along slice (deg)
                                                   PXSCL
                                                   SLSCL
                                                                        0.00018859 / Pixel scale perp. to slices (deg)
```

NAXIS

GEOMCOR =

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

```
NAXIS1
                                  24
NAXIS2
NAXIS3
                               1901
        = 'NGC5846-UDG1'
                                 Object name
                                 Observer name
OBSERVER= 'Various
                                 Instrument
INSTRUME= 'KCWI
                                 Camera (blue, red, fpc)
CAMERA = 'BLUE
                                 Image type
IMTYPE = 'OBJECT
                                 Group ID
GROUPID = '2019-03-31-52
CURRINST= 'KCWI
                                  DCS Instrument
TARGNAME= 'NGC5846-UDG1'
                                  DCS Target name
PONAME = 'IFU
                                  DCS Point origin name
RA
                                  DCS RA
        = '15:05:20.31'
DEC
        = '+01:48:49.0'
                                  DCS Dec
TARGRA = '15:05:20.46'
                                  DCS Target RA
TARGDEC = '+01:48:45.6'
                                  DCS Target Dec
                                 stddev uncertainty created?
UNCSTD
IMGRECT =
                             T / Image rectified?
DARKSUB =
                                 master dark subtracted?
                              T / was scattered light subtracted?
SCATSUB =
                              T / flat corrected?
FLATCOR =
           'kb190331 00040 mflat.fits' / Master flat filename
MFFILE
                             F / sky corrected?
SKYCOR
```

T / Geometry corrected?

```
60.02 / IFU position angle (degrees)
IFUPA
                           0.0 / IFU-SKYPA offset (degrees)
IFUROFF =
                              3 / number of dimensions in WCS
WCSDIM
WCSNAME =
          'KCWI
RADESYS
          'FK5
CTYPE1
          'RA---TAN'
CTYPE2
          'DEC--TAN'
CTYPE3
                                / Air Wavelengths
        = 'AWAV
          'deg
                                 RA units
CUNIT1
                                 DEC units
CUNIT2
        = 'deg
CUNIT3
                                 Wavelength units
           Angstrom
CNAME1
        "KCWI RA
                                 RA name
CNAME 2
        = 'KCWI DEC'
                                 DEC name
CNAME3
                                 Wavelength name
        = 'KCWI Wavelength'
                    226.334625 /
CRVAL1
                                 RA zeropoint
CRVAL2
             1.813611111111111 /
                                 DEC zeropoint
CRVAL3
                                 Wavelength zeropoint
                          14.5 / RA reference pixel
CRPIX1
                          43.0 / DEC reference pixel
CRPIX2
                        -210.0 / Wavelength reference pixel
CRPIX3
CD1 1
        = -9.4237983519361E-05 / RA degrees per column pixel
        = 0.000163356636113151 / DEC degrees per column pixel
CD2 1
CD1 2
        = 7.01275426041717E-05 / RA degrees per row pixel
        = 4.04555233348930E-05 / DEC degrees per row pixel
CD2 2
                          0.25 / Wavelength Angstroms per pixel
CD3 3
```

```
PXSCL = 8.096E-05 / Pixel scale along slice (deg)
SLSCL = 0.00018859 / Pixel scale perp. to slices (deg)
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

```
NAXIS
NAXIS1
                                 24
NAXIS2
NAXIS3
                               1901
       = 'NGC5846-UDG1'
                                 Object name
                                 Observer name
OBSERVER= 'Various
                                 Instrument
INSTRUME= 'KCWI
                                Camera (blue, red, fpc)
CAMERA = 'BLUE
                                 Image type
IMTYPE = 'OBJECT
                                Group ID
GROUPID = '2019-03-31-52
                                 DCS Instrument
CURRINST= 'KCWI
TARGNAME= 'NGC5846-UDG1'
                                 DCS Target name
PONAME = 'IFU
                                 DCS Point origin name
                                 DCS RA
        = '15:05:20.31'
        = '+01:48:49.0'
                                 DCS Dec
TARGRA = '15:05:20.46'
                                  DCS Target RA
TARGDEC = '+01:48:45.6'
                                 DCS Target Dec
UNCSTD =
                                 stddev uncertainty created?
IMGRECT =
                                 Image rectified?
DARKSUB =
                              F / master dark subtracted?
                             T / was scattered light subtracted?
SCATSUB =
FLATCOR =
                              T / flat corrected?
           'kb190331 00040 mflat.fits' / Master flat filename
MFFILE
                              F / sky corrected?
SKYCOR
GEOMCOR =
                             T / Geometry corrected?
```

```
60.02 / IFU position angle (degrees)
IFUPA
                           0.0 / IFU-SKYPA offset (degrees)
IFUROFF =
                              3 / number of dimensions in WCS
WCSDIM
WCSNAME =
          'KCWI
RADESYS
          'FK5
CTYPE1
          'RA---TAN'
          'DEC--TAN'
CTYPE2
CTYPE3
        = 'AWAV
                                / Air Wavelengths
          'deg
                                 RA units
CUNIT1
                                 DEC units
CUNIT2
        = 'deg
CUNIT3
           Angstrom
                                 Wavelength units
CNAME1
        "KCWI RA
                                 RA name
CNAME 2
        = 'KCWI DEC'
                                 DEC name
CNAME3
                                 Wavelength name
        = 'KCWI Wavelength'
                    226.334625 /
CRVAL1
                                 RA zeropoint
CRVAL2
             1.813611111111111 /
                                 DEC zeropoint
                                 Wavelength zeropoint
CRVAL3
                          14.5 / RA reference pixel
CRPIX1
                          43.0 / DEC reference pixel
CRPIX2
                        -210.0 / Wavelength reference pixel
CRPIX3
CD1 1
        = -9.4237983519361E-05 / RA degrees per column pixel
        = 0.000163356636113151 / DEC degrees per column pixel
CD2 1
CD1 2
        = 7.01275426041717E-05 / RA degrees per row pixel
CD2 2
        = 4.04555233348930E-05 / DEC degrees per row pixel
CD3 3
                          0.25 / Wavelength Angstroms per pixel
```

```
PXSCL = 8.096E-05 / Pixel scale along slice (deg)
SLSCL = 0.00018859 / Pixel scale perp. to slices (deg)
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                               3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                          'RA---TAN'
       = 'NGC5846-UDG1'
                              Object name
                                                               CTYPE2
                                                                          'DEC--TAN'
                               Observer name
OBSERVER= 'Various
                                                               CTYPE3
                                                                        = 'AWAV
                                                                                                 / Air Wavelengths
                              Instrument
INSTRUME= 'KCWI
CAMERA = 'BLUE
                              Camera (blue, red, fpc)
                                                                          'deg
                                                                                                  RA units
                                                               CUNIT1
                              Image type
IMTYPE = 'OBJECT
                                                                                                  DEC units
                                                               CUNIT2
                                                                        = 'dea
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                           Angstrom
                                                                                                   Wavelength units
                                                               CNAME1
                                                                        = 'KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                        = 'KCWI DEC'
                                                                                                   DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME3
                                                                                                  Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                                                                        = 'KCWI Wavelength'
PONAME = 'IFU
                               DCS Point origin name
                                                                                     226.334625 /
                                                                                                  RA zeropoint
                                                               CRVAL1
                               DCS RA
RA
        = '15:05:20.31'
                                                               CRVAL2
                                                                             1.813611111111111 /
                                                                                                  DEC zeropoint
       = '+01:48:49.0'
                               DCS Dec
                                                                                                  Wavelength zeropoint
                                                               CRVAL3
                               DCS Target RA
TARGRA = '15:05:20.46'
                                                                                           14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                                  DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                        = -9.4237983519361E-05 / RA degrees per column pixel
IMGRECT =
                           T / Image rectified?
                                                                        = 0.000163356636113151 / DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                            F / master dark subtracted?
                                                               CD1 2
                                                                        = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                        = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
                                                                         8.096E-05 / Pixel scale along slice (deg)
                                                   PXSCL
```

SLSCL

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

```
NAXIS
NAXIS1
                                 24
NAXIS2
NAXIS3
                               1901
      = 'NGC5846-UDG1'
                                 Object name
OBSERVER= 'Various
                                 Observer name
INSTRUME= 'KCWI
                                 Instrument
                                Camera (blue, red, fpc)
CAMERA = 'BLUE
                                Image type
IMTYPE = 'OBJECT
                                Group ID
GROUPID = '2019-03-31-52
CURRINST= 'KCWI
                                 DCS Instrument
TARGNAME= 'NGC5846-UDG1'
                                 DCS Target name
PONAME = 'IFU
                                 DCS Point origin name
                                 DCS RA
RA
        = '15:05:20.31'
        = '+01:48:49.0'
                                 DCS Dec
TARGRA = '15:05:20.46'
                                  DCS Target RA
TARGDEC = '+01:48:45.6'
                                 DCS Target Dec
                                 stddev uncertainty created?
UNCSTD =
IMGRECT =
                             T / Image rectified?
DARKSUB =
                             F / master dark subtracted?
                             T / was scattered light subtracted?
SCATSUB =
                             T / flat corrected?
FLATCOR =
          'kb190331 00040 mflat.fits' / Master flat filename
MFFILE
                             F / sky corrected?
SKYCOR
GEOMCOR =
                             T / Geometry corrected?
```

```
IFUPA
                         60.02 / IFU position angle (degrees)
                           0.0 / IFU-SKYPA offset (degrees)
IFUROFF =
                              3 / number of dimensions in WCS
WCSDIM
WCSNAME =
          'KCWI
RADESYS
          'FK5
CTYPE1
        = 'RA---TAN'
CTYPE2
          'DEC--TAN'
CTYPE3
                                / Air Wavelengths
        = 'AWAV
                                 RA units
CUNIT1
          'dea
                                 DEC units
CUNIT2
        = 'deg
CUNIT3
                                 Wavelength units
           Angstrom
CNAME1
        "KCWI RA
                                 RA name
CNAME 2
        = 'KCWI DEC'
                                 DEC name
CNAME3
        = 'KCWI Wavelength'
                                 Wavelength name
CRVAL1
                    226.334625 /
                                 RA zeropoint
CRVAL2
             1.813611111111111 /
                                 DEC zeropoint
                       4808.25 / Wavelength zeropoint
CRVAL3
                          14.5 / RA reference pixel
CRPIX1
                          43.0 / DEC reference pixel
CRPIX2
                        -210.0 / Wavelength reference pixel
CRPIX3
CD1 1
        = -9.4237983519361E-05 / RA degrees per column pixel
        = 0.000163356636113151 / DEC degrees per column pixel
CD2 1
CD1 2
        = 7.01275426041717E-05 / RA degrees per row pixel
        = 4.04555233348930E-05 / DEC degrees per row pixel
CD2 2
                          0.25 / Wavelength Angstroms per pixel
CD3 3
```

```
PXSCL = 8.096E-05 / Pixel scale along slice (deg)
SLSCL = 0.00018859 / Pixel scale perp. to slices (deg)
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

8.096E-05 / Pixel scale along slice (deg)

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                           60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                             0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                               3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME = 'KCWI
                                                                          'RA---TAN'
                                                               CTYPE1
       = 'NGC5846-UDG1'
                               Object name
                                                               CTYPE2
                                                                          'DEC--TAN'
OBSERVER= 'Various
                               Observer name
                                                                        = 'AWAV
                                                                                                  / Air Wavelengths
                               Instrument
                                                               CTYPE3
INSTRUME= 'KCWI
                              Camera (blue, red, fpc)
CAMERA = 'BLUE
                                                                                                   RA units
                                                               CUNIT1
                                                                           dea
                              Image type
IMTYPE = 'OBJECT
                                                               CUNIT2
                                                                           dea
                                                                                                   DEC units
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                           Angstrom
                                                                                                   Wavelength units
                                                               CNAME1
                                                                        = 'KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                        = 'KCWI DEC'
                                                                                                   DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME 3
                                                                          'KCWI Wavelength'
                                                                                                   Wavelength name
TARGNAME= 'NGC5846-UDG1'
                                DCS Target name
PONAME = 'IFU
                               DCS Point origin name
                                                               CRVAL1
                                                                                     226.334625 /
                                                                                                   RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                               CRVAL2
                                                                              1.813611111111111 /
                                                                                                   DEC zeropoint
        = '+01:48:49.0'
                               DCS Dec
                                                                                                   Wavelength zeropoint
                                                               CRVAL3
TARGRA = '15:05:20.46'
                                DCS Target RA
                                                                                            14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                                   DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                        = -9.4237983519361E-05 /
                                                                                                   RA degrees per column pixel
IMGRECT =
                           T / Image rectified?
                                                                        = 0.000163356636113151 /
                                                                                                   DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                               master dark subtracted?
                                                               CD1 2
                                                                        = 7.01275426041717E-05 / RA degrees per row pixel
                            T / was scattered light subtracted?
SCATSUB =
                                                                        = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                            0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                            F / sky corrected?
SKYCOR
GEOMCOR =
                            T / Geometry corrected?
```

```
WAVALL0 = 4861 / Low inclusive wavelength
WAVALL1 = 5336 / High inclusive wavelength
WAVGOOD0= 4859.751032916362 / Low good wavelength
WAVGOOD1= 5337.463081480892 / High good wavelength
WAVMID = 5098.594534348915 / middle wavelength
```

8.096E-05 / Pixel scale along slice (deg)

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                               3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                          'RA---TAN'
       = 'NGC5846-UDG1'
                               Object name
                                                                          'DEC--TAN
                                                               CTYPE2
                               Observer name
OBSERVER= 'Various
                                                                                                 / Air Wavelengths
                               Instrument
                                                               CTYPE3
                                                                        = 'AWAV
INSTRUME= 'KCWI
                              Camera (blue, red, fpc)
CAMERA = 'BLUE
                                                                                                   RA units
                                                               CUNIT1
                                                                        = 'dea
                              Image type
IMTYPE = 'OBJECT
                                                               CUNIT2
                                                                          'dea
                                                                                                   DEC units
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                                                   Wavelength units
                                                                        = 'Angstrom'
                                                               CNAME1
                                                                           KCWI RA
                                                                                                   RA name
                                                                          'KCWI DEC'
                                                               CNAME 2
                                                                                                   DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME3
                                                                                                   Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                                                                        = 'KCWI Wavelength'
PONAME = 'IFU
                               DCS Point origin name
                                                               CRVAL1
                                                                                     226.334625 /
                                                                                                   RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                               CRVAL2
                                                                             1.813611111111111 /
                                                                                                   DEC zeropoint
       = '+01:48:49.0'
                               DCS Dec
                                                                                                   Wavelength zeropoint
                                                               CRVAL3
TARGRA = '15:05:20.46'
                               DCS Target RA
                                                                                           14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                                   DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                        = -9.4237983519361E-05 /
                                                                                                   RA degrees per column pixel
IMGRECT =
                           T / Image rectified?
                                                                        = 0.000163356636113151 /
                                                                                                   DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                               master dark subtracted?
                                                               CD1 2
                                                                        = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                        = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

8.096E-05 / Pixel scale along slice (deg)

0.00018859 / Pixel scale perp. to slices (deg)

```
NAXIS
                                                                                          60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                            0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
NAXIS2
                                                                                               3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                                          'RA---TAN'
                                                               CTYPE1
       = 'NGC5846-UDG1'
                               Object name
                                                               CTYPE2
                                                                          'DEC--TAN'
OBSERVER= 'Various
                               Observer name
                                                               CTYPE3
                                                                                                 / Air Wavelengths
INSTRUME= 'KCWI
                               Instrument
                                                                        = 'AWAV
                              Camera (blue, red, fpc)
CAMERA = 'BLUE
                                                                          'deg
                                                                                                   RA units
                                                               CUNIT1
                              Image type
IMTYPE = 'OBJECT
                                                                                                   DEC units
                                                               CUNIT2
                                                                        = 'dea
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                           Angstrom
                                                                                                   Wavelength units
                                                               CNAME1
                                                                        "KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                        = 'KCWI DEC'
                                                                                                   DEC name
CURRINST= 'KCWI
                               DCS Instrument
                                                               CNAME 3
                                                                        = 'KCWI Wavelength'
                                                                                                   Wavelength name
TARGNAME= 'NGC5846-UDG1'
                               DCS Target name
                               DCS Point origin name
PONAME = 'IFU
                                                               CRVAL1
                                                                                     226.334625 / RA zeropoint
       = '15:05:20.31'
                               DCS RA
                                                               CRVAL2
                                                                             1.813611111111111 / DEC zeropoint
       = '+01:48:49.0'
                               DCS Dec
                                                                                        4808.25 / Wavelength zeropoint
                                                               CRVAL3
TARGRA = '15:05:20.46'
                               DCS Target RA
                                                               CRPIX1 =
                                                                                           14.5 / RA reference pixel
                               DCS Target Dec
TARGDEC = '+01:48:45.6'
                                                               CRPIX2
                                                                                           43.0 / DEC reference pixel
                                                               CRPIX3
                                                                                         -210.0 / Wavelength reference pixel
                               stddev uncertainty created?
UNCSTD =
                                                                        = -9.423/983519361E-05 / KA degrees per column pixel
                                                               CDII
IMGRECT =
                           T / Image rectified?
                                                                        = 0.000163356636113151 / DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                            F / master dark subtracted?
                                                               CD1 2
                                                                        = 7.01275426041717E-05 / RA degrees per row pixel
                           T / was scattered light subtracted?
SCATSUB =
                                                                        = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                           0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
                           F / sky corrected?
SKYCOR
GEOMCOR =
                           T / Geometry corrected?
```

```
WAVALL0 = 4861 / Low inclusive wavelength

WAVALL1 = 5336 / High inclusive wavelength

WAVGOOD0 = 4859.751032916362 / Low good wavelength

WAVGOOD1 = 5337.463081480892 / High good wavelength

WAVMID = 5098.594534348915 / middle wavelength
```

```
NAXIS
NAXIS1
                                 24
NAXIS2
NAXIS3
                               1901
       = 'NGC5846-UDG1'
                                 Object name
OBSERVER= 'Various
                                 Observer name
INSTRUME= 'KCWI
                                 Instrument
                                Camera (blue, red, fpc)
CAMERA = 'BLUE
                                Image type
IMTYPE = 'OBJECT
                                Group ID
GROUPID = '2019-03-31-52
CURRINST= 'KCWI
                                 DCS Instrument
TARGNAME= 'NGC5846-UDG1'
                                 DCS Target name
PONAME = 'IFU
                                 DCS Point origin name
                                 DCS RA
RA
        = '15:05:20.31'
        = '+01:48:49.0'
                                 DCS Dec
TARGRA = '15:05:20.46'
                                  DCS Target RA
TARGDEC = '+01:48:45.6'
                                 DCS Target Dec
                                 stddev uncertainty created?
UNCSTD =
IMGRECT =
                             T / Image rectified?
DARKSUB =
                                 master dark subtracted?
                             T / was scattered light subtracted?
SCATSUB =
                             T / flat corrected?
FLATCOR =
          'kb190331 00040 mflat.fits' / Master flat filename
MFFILE
                             F / sky corrected?
SKYCOR
GEOMCOR =
                             T / Geometry corrected?
```

```
60.02 / IFU position angle (degrees)
IFUPA
                            0.0 / IFU-SKYPA offset (degrees)
IFUROFF =
                              3 / number of dimensions in WCS
WCSDIM
WCSNAME =
          'KCWI
RADESYS
          'FK5
CTYPE1
          'RA---TAN'
CTYPE2
          'DEC--TAN'
CTYPE3
                                / Air Wavelengths
        = 'AWAV
          'deg
                                  RA units
CUNIT1
                                  DEC units
CUNIT2
        = 'deg
CUNIT3
           Angstrom
                                  Wavelength units
CNAME1
        "KCWI RA
                                  RA name
CNAME 2
        = 'KCWI DEC'
                                  DEC name
CNAME3
        = 'KCWI Wavelength'
                                  Wavelength name
CRVAL1
                    226.334625 /
                                  RA zeropoint
CRVAL2
             1.813611111111111 /
                                  DEC zeropoint
                        4808.25 / Wavelength zeropoint
CRVAL3
                           14.5 / RA reference pixel
CRPIX1
                           43.0 / DEC reference pixel
CRPIX2
                         -210.0 / Wavelength reference pixel
CRPIX3 =
CD1 1
        = -9.4237983519361E-05 /
                                  RA degrees per column pixel
CD2<sup>1</sup>
        = 0.000163356636113151 / DEC degrees per column pixel
CD1 2
        = 7.01275426041717E-05 / RA degrees per row pixel
        = 4.04555233348930E-05 / DEC degrees per row pixel
CD2 2
CD3 3
                           0.25 / Wavelength Angstroms per pixel
```

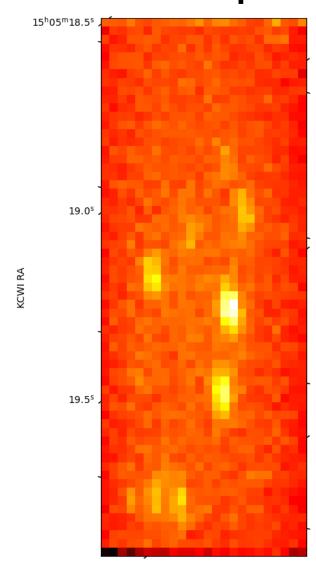
```
PXSCL = 8.096E-05 / Pixel scale along slice (deg)
SLSCL = 0.00018859 / Pixel scale perp. to slices (deg)
```

```
WAVALL0 = 4861 / Low inclusive wavelength
WAVALL1 = 5336 / High inclusive wavelength
WAVGOOD0= 4859.751032916362 / Low good wavelength
WAVGOOD1= 5337.463081480892 / High good wavelength
WAVMID = 5098.594534348915 / middle wavelength
```

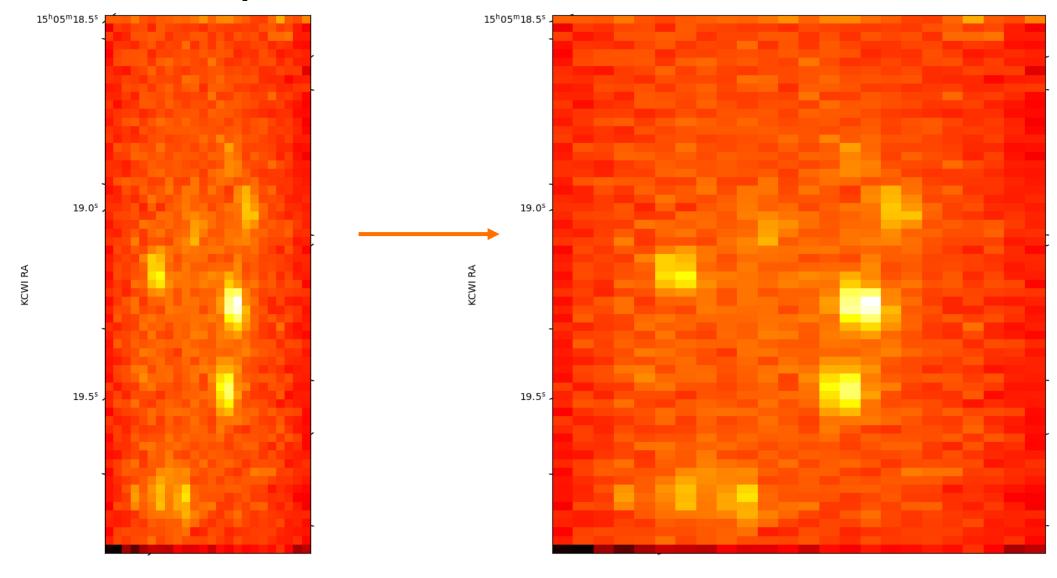
```
NAXIS
                                                                                           60.02 / IFU position angle (degrees)
                                                               IFUPA
NAXIS1
                               24
                                                                                             0.0 / IFU-SKYPA offset (degrees)
                                                               IFUROFF =
                               63
NAXIS2
                                                                                               3 / number of dimensions in WCS
                                                               WCSDIM
NAXIS3
                             1901
                                                               WCSNAME =
                                                                          'KCWI
                                                               RADESYS
                                                                          'FK5
                                                               CTYPE1
                                                                          'RA---TAN'
       = 'NGC5846-UDG1'
                               Object name
                                                                          'DEC--TAN'
                                                               CTYPE2
OBSERVER= 'Various
                               Observer name
                                                               CTYPE3
                                                                          'AWAV
                                                                                                  / Air Wavelengths
INSTRUME= 'KCWI
                               Instrument
                              Camera (blue, red, fpc)
CAMERA = 'BLUE
                                                                                                   RA units
                                                               CUNIT1
                                                                          'dea
IMTYPE = 'OBJECT
                               Image type
                                                                                                   DEC units
                                                               CUNIT2
                                                                          'deq
                              Group ID
GROUPID = '2019-03-31-52
                                                               CUNIT3
                                                                                                   Wavelength units
                                                                           Angstrom
                                                               CNAME1
                                                                        = 'KCWI RA
                                                                                                   RA name
                                                               CNAME 2
                                                                        = 'KCWI DEC'
                                                                                                   DEC name
CURRINST= 'KCWI
                                DCS Instrument
                                                               CNAME3
                                                                        = 'KCWI Wavelength'
                                                                                                   Wavelength name
TARGNAME= 'NGC5846-UDG1'
                                DCS Target name
PONAME = 'IFU
                               DCS Point origin name
                                                               CRVAL1
                                                                                     226.334625 /
                                                                                                   RA zeropoint
                               DCS RA
RA
        = '15:05:20.31'
                                                               CRVAL2
                                                                              1.813611111111111 /
                                                                                                   DEC zeropoint
        = '+01:48:49.0'
                               DCS Dec
                                                               CRVAL3
                                                                                                   Wavelength zeropoint
TARGRA = '15:05:20.46'
                                DCS Target RA
                                                                                            14.5 / RA reference pixel
                                                               CRPIX1
TARGDEC = '+01:48:45.6'
                               DCS Target Dec
                                                                                                   DEC reference pixel
                                                               CRPIX2
                                                                                         -210.0 / Wavelength reference pixel
                                                               CRPIX3
                               stddev uncertainty created?
UNCSTD =
                                                               CD1 1
                                                                        = -9.4237983519361E-05 /
                                                                                                   RA degrees per column pixel
IMGRECT =
                               Image rectified?
                                                                        = 0.000163356636113151 /
                                                                                                   DEC degrees per column pixel
                                                               CD2 1
DARKSUB =
                               master dark subtracted?
                                                               CD1 2
                                                                        = 7.01275426041717E-05 / RA degrees per row pixel
                               was scattered light subtracted?
SCATSUB =
                                                                        = 4.04555233348930E-05 / DEC degrees per row pixel
                                                               CD2 2
                            T / flat corrected?
FLATCOR =
                                                                                            0.25 / Wavelength Angstroms per pixel
          'kb190331 00040 mflat.fits' / Master flat filename
                                                               CD3 3
MFFILE
                            F / sky corrected?
SKYCOR
GEOMCOR =
                            T / Geometry corrected?
```

```
PXSCL = 8.096E-05 / Pixel scale along slice (deg)
SLSCL = 0.00018859 / Pixel scale perp. to slices (deg)
```

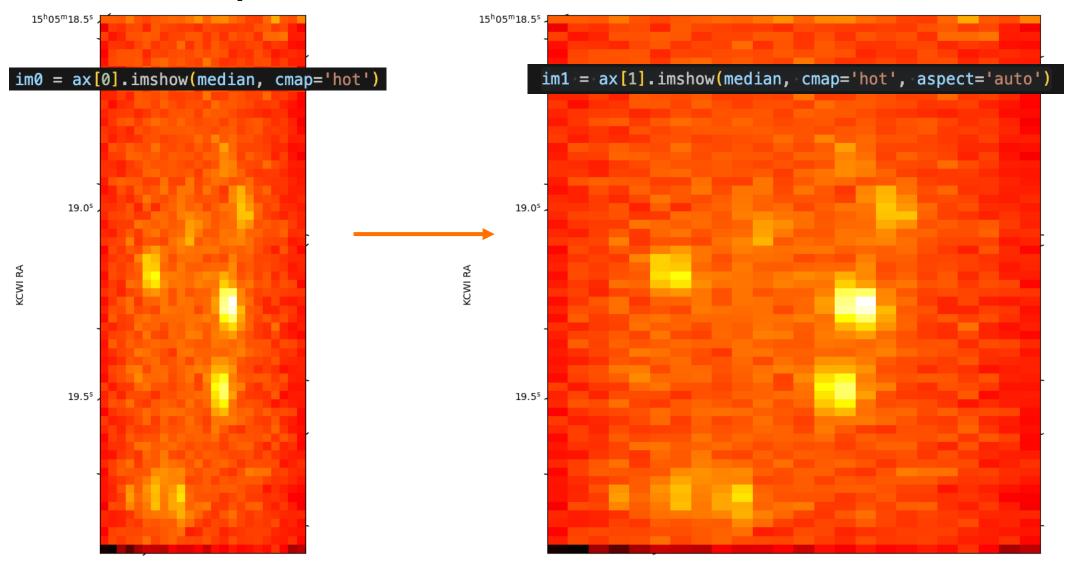
## Pixel Shape



## Pixel Shape



### Pixel Shape



### MontagePy

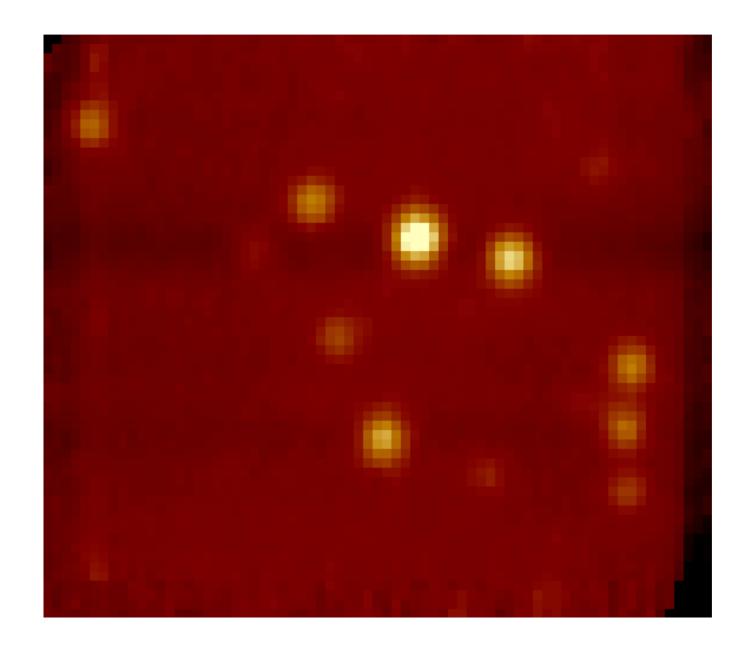
- Rebins cube shaped data
- Steps to take before applying
  - Cut overhang pixel and bad wavelengths
  - Ensure there is no instrument specific artefacts in your cubes (i.e. correct KCWI gradient)
  - Ensure central wavelengths & coordinates of your cubes match & are correct (i.e. correct KCWI cubes for offset RA)
- Good idea to clear everything that is not needed out of the directories you work with

# MontagePy Intermission

(+ some complaining about KCWI peculiarities)

### MontagePy Result

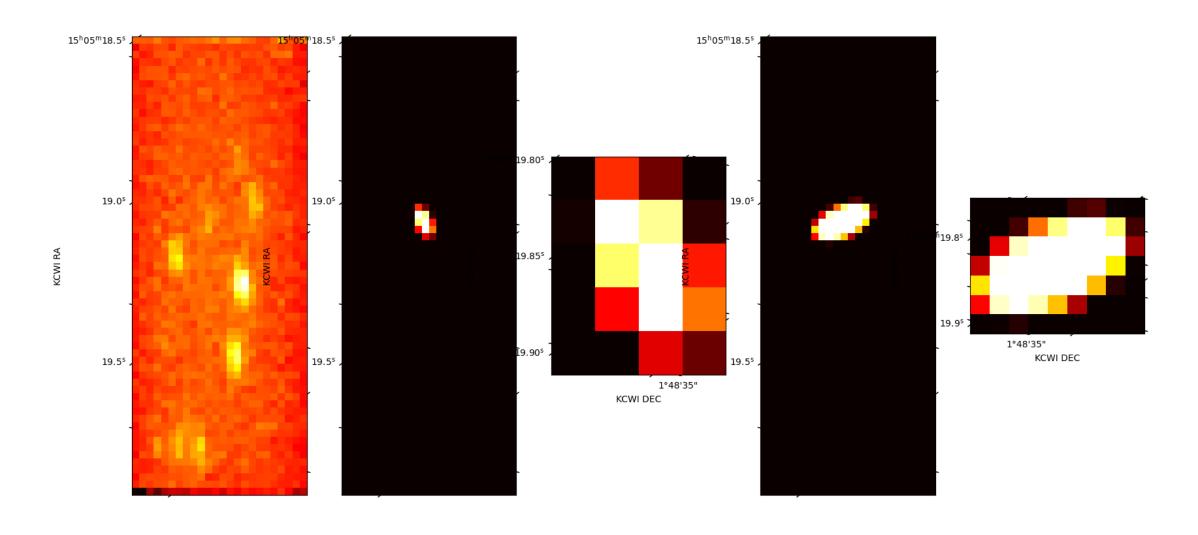
- Pixels are actually square
- Flux conserved



### Extracting Spectra (+Packages)

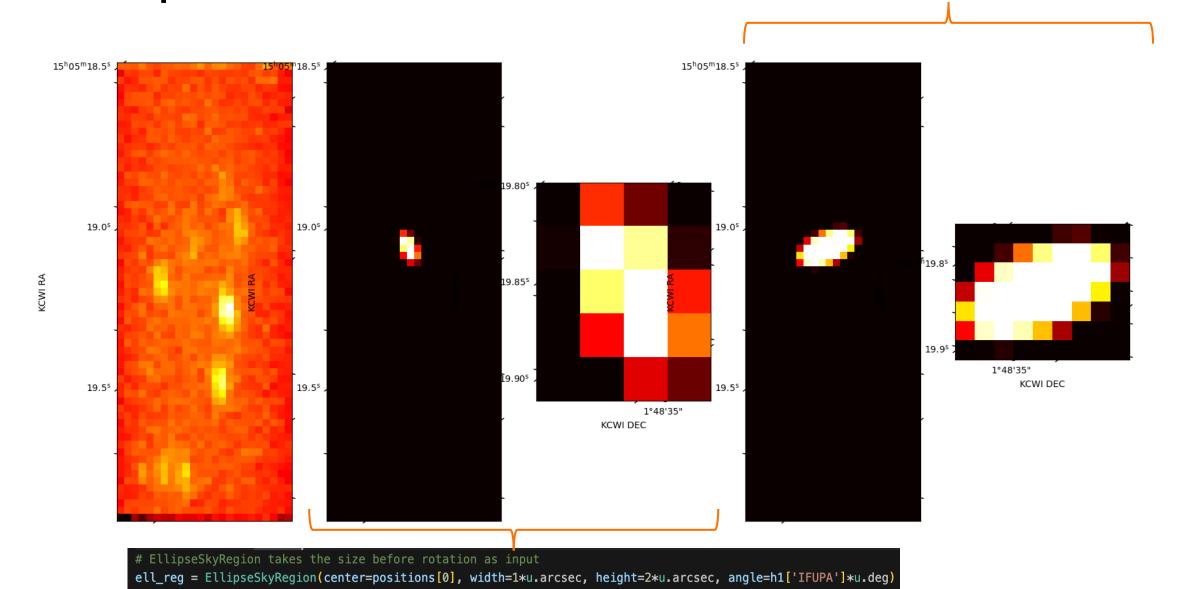
- Create a regions file with regions you want spectra of (this can be easier to do in ds9 than automatically)
- Packages needed
  - from astropy.wcs import WCS
  - from astropy.coordinates import SkyCoord
  - from regions import Regions
  - from photutils.aperture import SkyElliptical Aperture

## On Apertures



### On Apertures

# SkyElliptical aperture takes the size after rotation as input
aper = SkyEllipticalAperture(positions, 1\*u.arcsec, 2\*u.arcsec, theta=h1['IFUPA']\*u.deg)



### Extracting Spectra (+Packages)

Read masks from regions

'exact' allows for fractional pixels

```
aper = SkyEllipticalAperture(region.center, region.width, region.height, theta=region.angle)
aper_pix = aper.to_pixel(wcs=self.wcs.dropaxis(dropax=2))
aper_mask = aper_pix.to_mask(method='exact')
masks.append(aper_mask)
```

Weigh cubes by mask values

```
# initialise arrays for mask-weighted cubes
mask_weighted_data = np.zeros(shape=self.data_cube_data.shape)
mask_weighted_var = np.zeros(shape=self.var_cube_data.shape)

# get mask images
mask_im = mask.to_image(shape=(self.data_cube_header['NAXIS2'], self.data_cube_header['NAXIS1']))
sky_mask_im = sky_mask.to_image(shape=(self.data_cube_header['NAXIS2'], self.data_cube_header['NAXIS1']))

for j in range(self.data_cube_header['NAXIS3']):
    data_spec_med[j] = np.median(mask.get_values(self.data_cube_data[j,:,:]))
    data_spec_sum[j] = np.sum(mask.get_values(self.data_cube_data[j,:,:]))
    mask_weighted_data[j,:,:] *= mask_im

var_spec_med[j] = np.sum(mask.get_values(self.var_cube_data[j,:,:]))
    var_spec_sum[j] = np.sum(mask.get_values(self.var_cube_data[j,:,:]))
    mask_weighted_var[j,:,:] *= mask_im
```

'median' combining vs 'sum' combining: median better for spikes on singular pixels