####AU Mic Research Notes: Feb 2017

To Do

- Boccaletti plots
  - also, use all three dates!

- do imfit without flare time
- just show combined image
- reclean with robust=0.5, uniform

Papers:

- Thebault 2009

For Meredith:

- Evan's model has ctrpix 256.5, while I have 257?

6/13/17: Position fixing: imfit on non-flare component of June date

A different method to fix the June flare offset problem: if the flare is indeed asymmetric and pulled the imfit position away from the true star position, this can be remedied by calling imfit on the non-flare part of the June observation. First, I will use March and August as controls.

Methods: Concatenate all four pre-fixvis and -uvsub spws (i.e. before phase shifting and stellar component subtraction), use this to fit. Make sure region around star is a very small circle, so that any irregularities at the edges of the smeared point source don't affect fit position

March:

```
ra:   20:45:09.84238 +/- 0.00033 s (0.00426 arcsec along great circle)
dec: -31.20.32.35898 +/- 0.00223 arcsec
Peak: 771.3 +/- 4.7 uJy/beam
```

Compare to previously used imfit values:

```
All times
ra:   20:45:09.843230 +/- 0.000062 s (0.000800 arcsec along great circle)
dec: -31.20.32.358302 +/- 0.000378 arcsec
Peak: 755.40 +/- 0.82 uJy/beam
```

```
Fixvis phase center:
J2000 20h45m09.8443s −031d20m32.36s
```

August:

```
ra:   20:45:09.85274 +/− 0.00016 s (0.00200 arcsec along great circle)
dec: −31.20.32.50258 +/− 0.00182 arcsec
Peak: 226.5 +/− 2.5 uJy/beam
```

Compare to previously used imfit values:

```
ra:   20:45:09.85471 +/− 0.00077 s (0.00984 arcsec along great circle)
dec: −31.20.32.52039 +/− 0.00717 arcsec
Peak: 225.1 +/− 10.0 uJy/beam

Fixvis phase center:
J2000 20h45m09.85471s −031d20m32.52034s
```

June:

```
ra:   20:45:09.871593 +/− 0.000061 s (0.000778 arcsec along great circle)
dec: −31.20.32.838199 +/− 0.000479 arcsec
Peak: 378.9 +/− 1.3 uJy/beam
```

Compare to previously used imfit values:

```
All times
ra:   20:45:09.86765 +/− 0.00016 s (0.00203 arcsec along great circle)
dec: −31.20.32.88803 +/− 0.00128 arcsec
Peak: 862.3 +/− 7.7 uJy/beam

Fixvis phase center:
J2000 20h45m09.8677s −031d20m32.89s
```

For all dates, the imfit coordinates are just about exactly at the stellar emission (by visual inspection). For June, the previously used coordinates are significantly below and to the right of the star position.

####5/31/17: First day of summer research

- Relative position uncertainty (per synthesized beam) = $\frac{\theta_{sb}}{SNR}$
- $\to$ Fixvis phasecenter

####5/28/17: Star position Sooo it's been a while since I've written any notes. In the last month and a half, I have:

1. Cutting out the last observation window for **(just spw3? all spws?)** fixed the flare date.
2. While concatenating the different dates before cleaning may have helped with the star offset from the image center, this effect remains. Meredith and I wonder if the flare could have been asymmetric, so that the point source fit to the flaring star that defines the image center is offset from the star itself. This would also explain the asymmetric gap/hole by the star in the June observation.
3. To fix this issue, I hope to find some metric of determining the center/star position of the disk that gives good agreement with august and march dates and apply it to the June date.

Approaches:

- `pixel_mean:` take the mean position of all pixels with values above 6.2 σ
  - mar offset from image center: $(0.0, 0.03)$
  - aug offset from image cenger: $(0.0, 0.0)$
  - jun offset from image center: $(0.06, -0.18)$
    - visual inspection shows that this is on the wrong side of the disk...

- `single_gauss:` fit a Gaussian to the whole disk
  - mar offset from image center: $(-0.04, 0.02)$
  - aug offset from image center: $(0.07, -0.03)$
  - jun offset from image center: $(0.25, -0.10)$

- `double_gauss:` fit a Gaussian to each side of the disk
  - mar offset from image center: $(0.01, -0.06)$
  - aug offset from image center: $(0, 0.06)$
  - jun offset from image center: $(0.13, 0.09)$

- `clean_pixels:` run clean with a low number of iterations, select the brightest pixel on each side of the disk from the clean component map
  - March:
    - NW side: `20:45:09.682 -31.20.30.767`, (6.77×10^{-5}) Jy
    - SE side: `20:45:10.012 -31.20.34.047`, (6.78×10^{-5}) Jy
    - Mean: $\to$ `20:45:9.847 -31.20.32.407`;
    - Pointing center: `20:45:09.84 -31:20:32.36`
    - Offset: `0.01 -0.05` arcsec
  - August:
    - NW side: `20:45:09.68 -31.20.30.75`, (3.69×10^{-5}) Jy
    - SE side: `20:45:10.03 -31.20.34.29`, (3.24×10^{-5}) Jy
    - Mean: $\to$ `20:45:9.855 -31.20.32.52`;
    - Pointing center: `20:45:09.85 -31:20:32.52`
    - Offset: `0.01 0.00` arcsec
  - June:
    - NW side: `20:45:09.702 -31.20.31.099`, (1.03×10^{-4}) Jy
    - SE side: `20:45:10.036 -31.20.34.504`, (6.70×10^{-4}) Jy

  - Mean: $\to$ `20:45:09.869 -31.20.32.802` ;
  - Pointing center: `20:45:09.87 -31:20:32.89`
  - Offset: `0.00 0.09` arcsec

The 'clean pixel' method gives the best agreement for the March and August dates, and we will use this method going forward. The coordinates calculated above will be used as the new phasecenters (`fixvis` will be applied to all three dates for consistency).

####4/8/17: Final iteration of data files?

Aug χ^2	Jun χ^2	Mar χ^2
0.96209719	2.77836548	1.9568517
0.96680418	2.52863844	1.96150345
0.97191927	2.59185666	1.97182168
1.02544892	**1.74236074**	1.97257757

Aug χ^2	Jun χ^2	Mar χ^2
0.96209719	2.77836548	1.9568517
0.96680418	2.52863844	1.96150345
0.97191927	2.59185666	1.97182168
1.02544892	**2.29280139**	1.97257757

####3/21/17: Pixel location:

- ctrpix remains the same if I make image 257 pixels
- `interpolate.rotate` works on arrays, and does not mention a rotation centroid--I assume it must choose the float center point of the array

CRPIXn from FITS standard:

> The value field shall contain a floating point number, identifying the location of a reference point along axis n, in units of the axis index. This value is based upon a counter that runs from 1 to NAXISn with an increment of 1 per pixel. The reference point value need not be that for the center of a pixel nor lie

> within the actual data array. Use comments to indicate the location of the index point relative to the pixel.

From STSCI:

> When the data matrix represents a digital image, transformation between the data matrix and the physical picture requires knowledge of where in the pixel -- center or corner -- the data point is. Historically, astronomers have generally assumed that the index point in a FITS file represents the center of a pixel. This interpretation is endorsed by GC. It differs from the common practice in computer graphics of treating the center of a pixel as a half-integral point. GC note that the pixel in a FITS file is commonly regarded as a volume element in physical space, which might be viewed from different perspectives via transposition and rotation. Under such operations, only the center of an element remains invariant. Pending adoption of a standard convention by the astronomical community, FITS writers should use appropriate comments in the comment field of the card image or the COMMENT keyword to inform readers of the file which convention is being used. Once the community has accepted a convention, a single comment noting that the convention is being used will be sufficient.

3/21/17: Flare date and bad spws

Recently I realized that the time window we split out to fix the bad spw in the June date was exactly the time window of the flare. This makes me somewhat suspicious, and Meredith and I decided I should do some more digging, espcially considering all the work we put into making the flare data useable.

The `plotms` of amp vs. time for spw3 (the bad one) and spw1 (well behaved) are roughly the same--both show a huge spike in the last (flare) time window. This leads me to believe that it's not the flare itself that's messing up spw3; if this were the case, we should see the same thing for spw1.

- Antenna 1 and 2 are almost constantly 'on' in last time window, as opposed to dashed in previous windows?
- same for baseline, phase
- weights get very low for in flare window for both spws
- everything I tried seems to match for both spws...

This is a little confusing, since spw1 had a pretty nice χ^2; but we did remove that flare time window for *all* spws...

2/26/17---3/20/17: Image Centering

While comparing images made with different date combinations (i.e. removing August date because of poor quality), I noticed that the disk was offset from the image center for certain combinations. We have decided that this is caused by the non-homogeneous pointing centers (due to proper motion) of the three datasets. When `tclean` is called on a collection of datasets with different pointing centers, the pointing center of the first of the datasets is chosen as the origin of the image, and all datasets are combined in the *uv*-domain, with their phase offsets preserved. The resulting sky-domain image is both offset from the image center and a false representation of the disk.

To fix this issue, I tried using `contcat` with its *dirtol* parameter set to a high value (2"). As long as the pointing/phase

centers of the datasets do not differ from each other by more than *dirtol*, the datasets are combined as if they all share the pointing center of the first dataset and all is well. A quick test indicates that this method is succesful.

However, I ran into another problem while attempting the `concat` method. The `26mar2014_aumic_spw0.corrected_weights.ms` dataset is missing `table.f8_TSM1` (all other datasets have this table), and because of this `concat` fails when applied to this dataset. However, recreating the `.ms` file from the corresponding `.uvf` file seems to have fixed this problem. I'm starting over with a `cleans` directory, and have added the suffix `_old` to the originals.

My troubleshooting notes:

Fixvis:

```
If the phase center is changed, the corresponding modifications are applied to the visibility
columns given by the parameter "datacolumn" which is by default set to "all" (DATA, CORRECTED,
and MODEL).
```

- All dates have 257, 257 `CRPIX`

  - 24 June: 311.291115417 -31.3424694444

- 24 June fixvis: `phasecenter = J2000 20h45m09.8677s −031d20m32.89s`

  - not many precision points?
  - 311.2911154166666 -31.342469444444443 in deg... essentially the same as the image center

- Center pixel info for all dates:

  - aumic_18aug_usermask_natural:

    - 311.2910612917 -31.34236676111

  - aumic_26mar_usermask_natural

    - 311.2910179167 -31.34232222222

  - aumic_24jun_usermask_natural

    - 311.291115417 -31.3424694444

  - aumic_usermask_natural

    - 311.2910612917 -31.34236676111

  - aumic_marjune_usermask_natural

    - 311.291115417 -31.3424694444 March + June (the culprit):

  - 311.291115417 -31.3424694444

  - 257 257 center pixel