

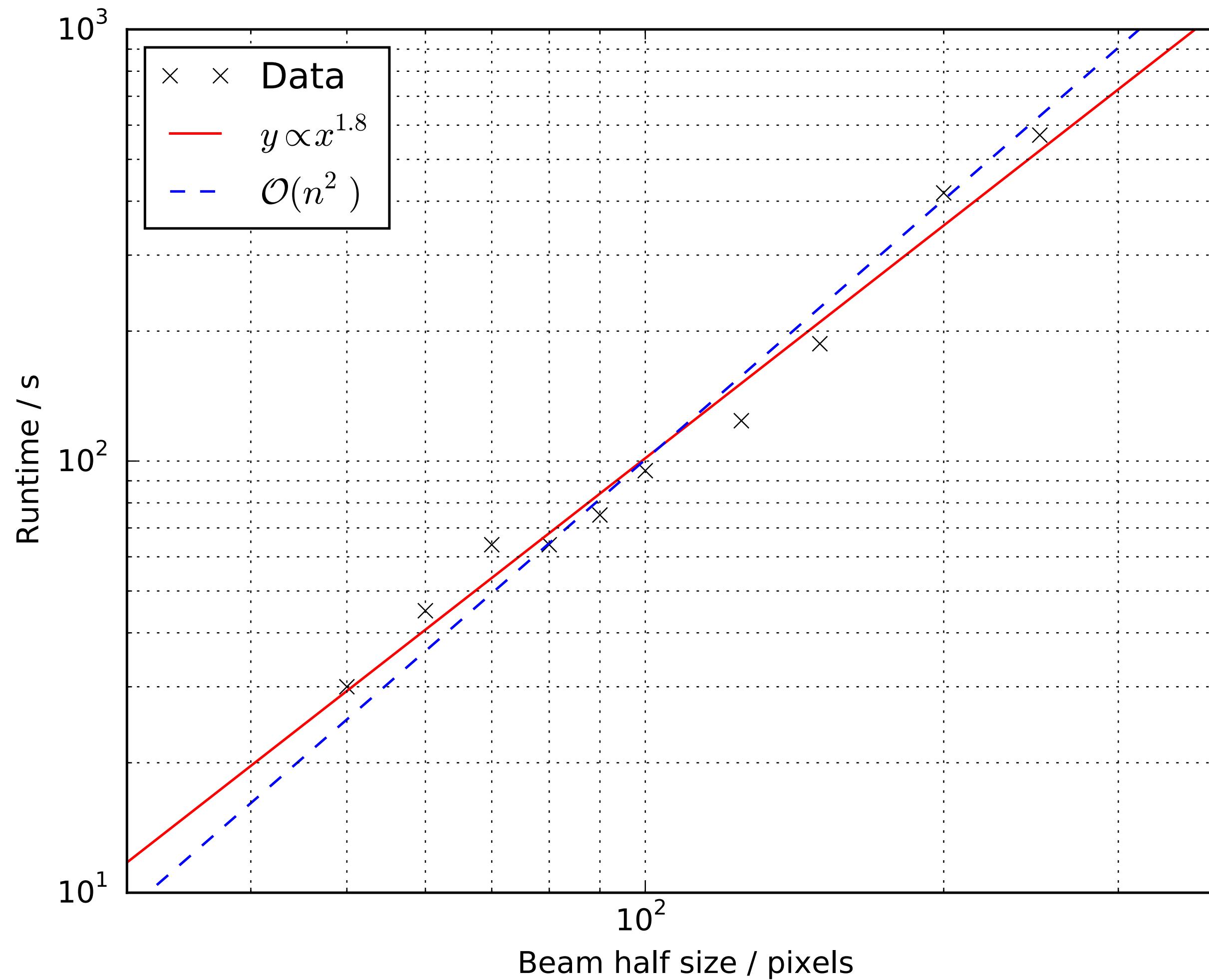
Investigation of HiRes as applied to Herschel SPIRE observations

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Cardiff University

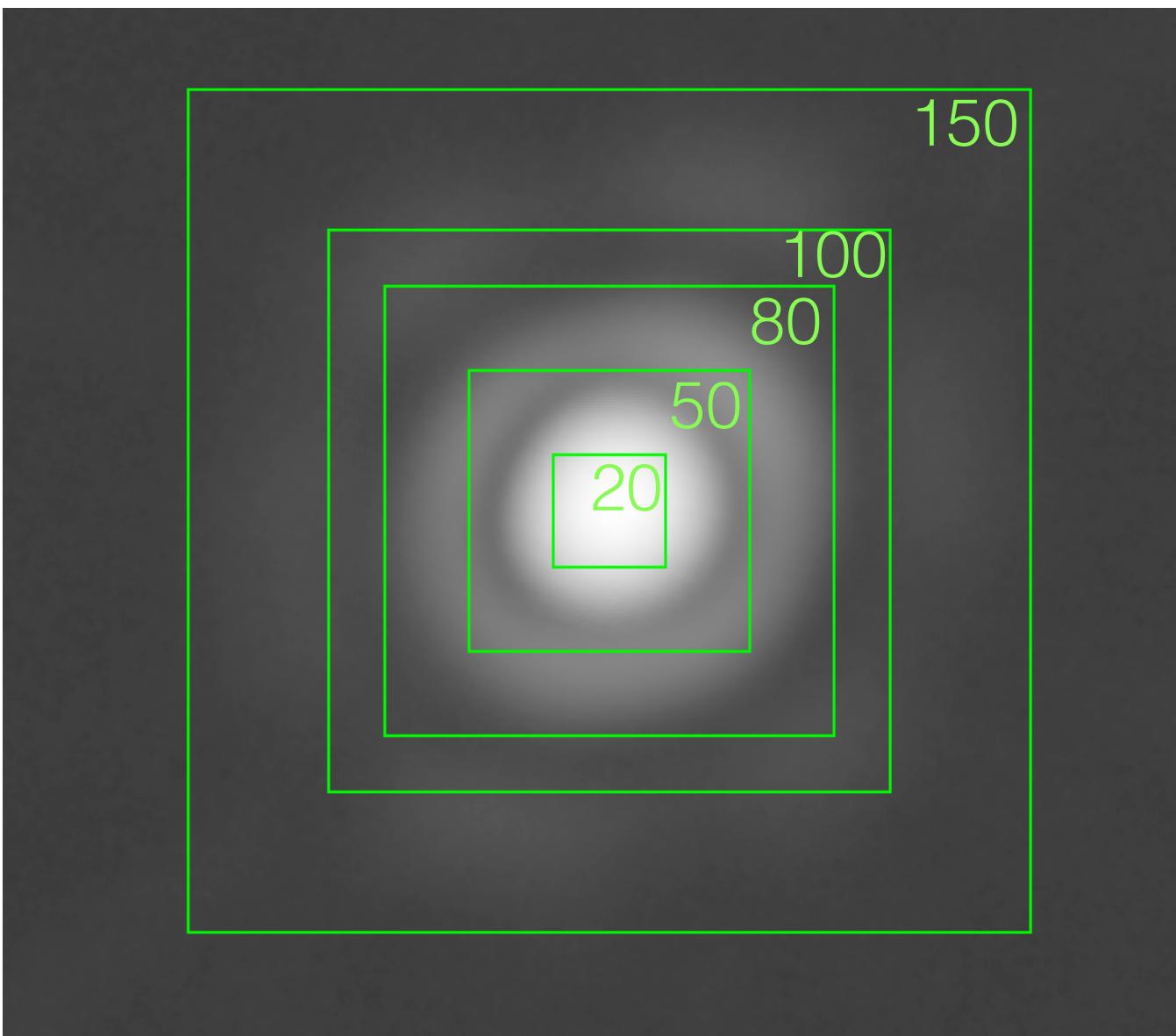
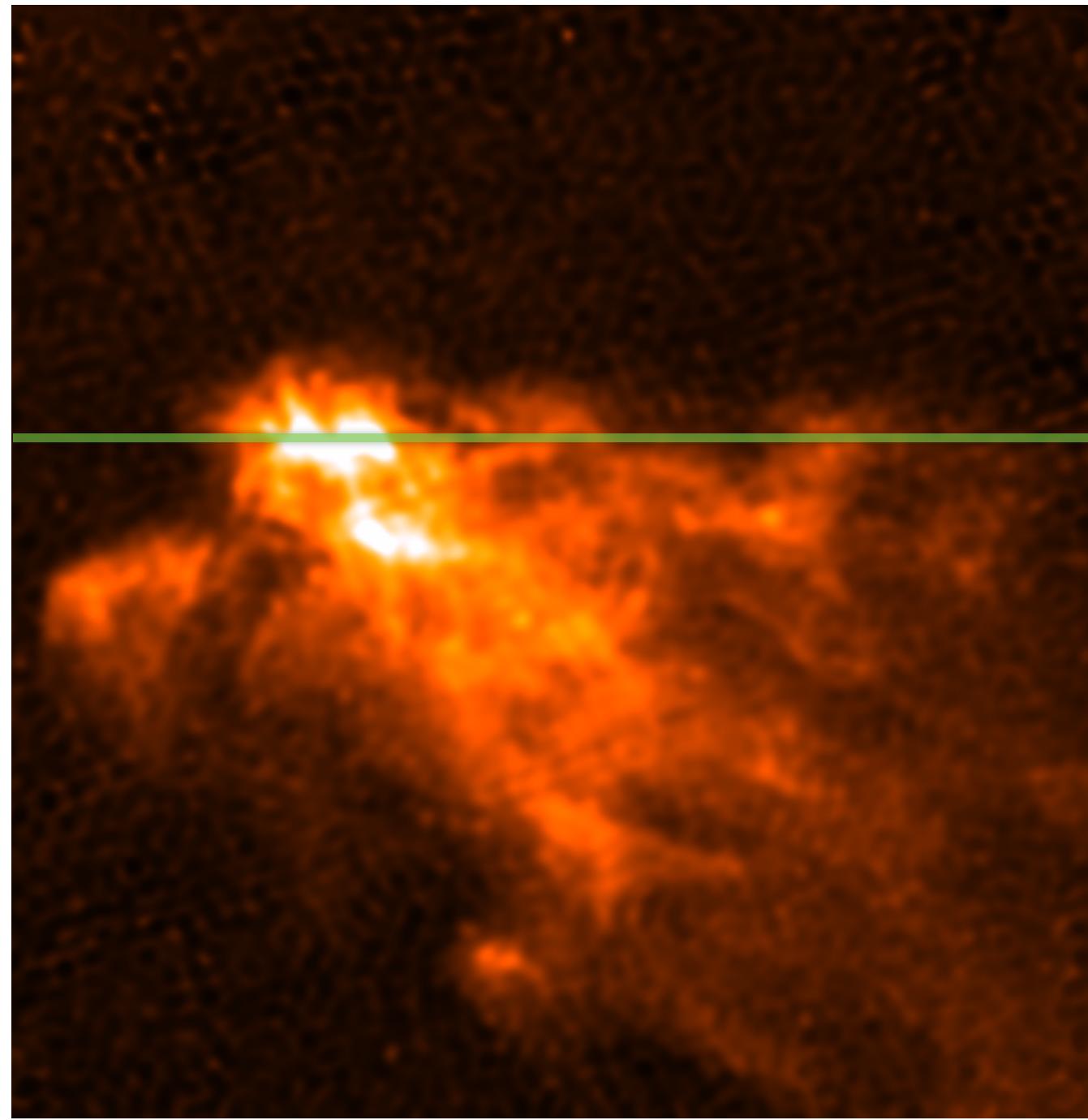
Code

- All code for tests/analysis is at:
- <https://github.com/badders/spire-hires-testing>
- CSV files containing filtered observation lists inside **obs-lists** subdirectory
- Statistics on full archive in **stats** subdirectory

HiRes Time Complexity - Beam Size

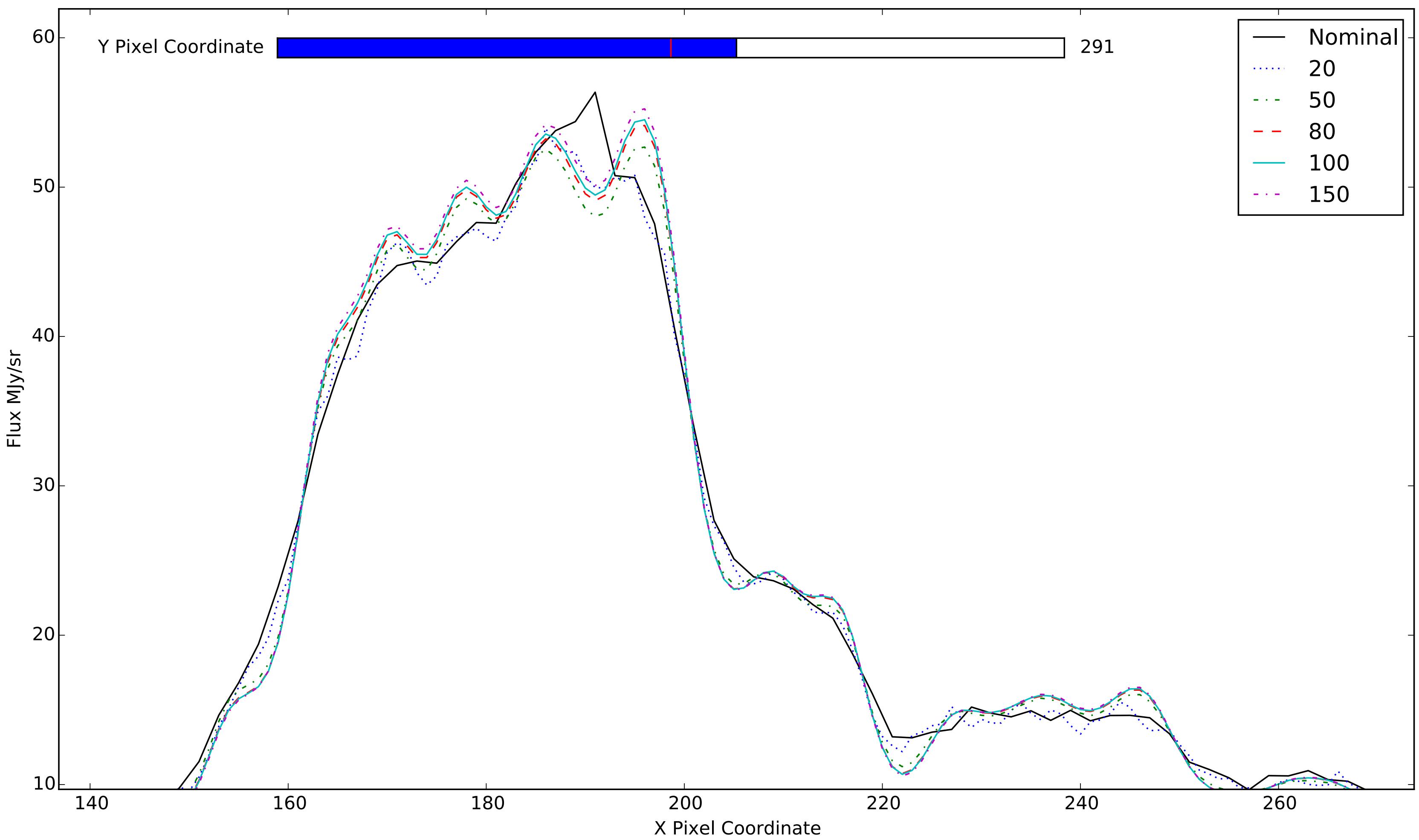


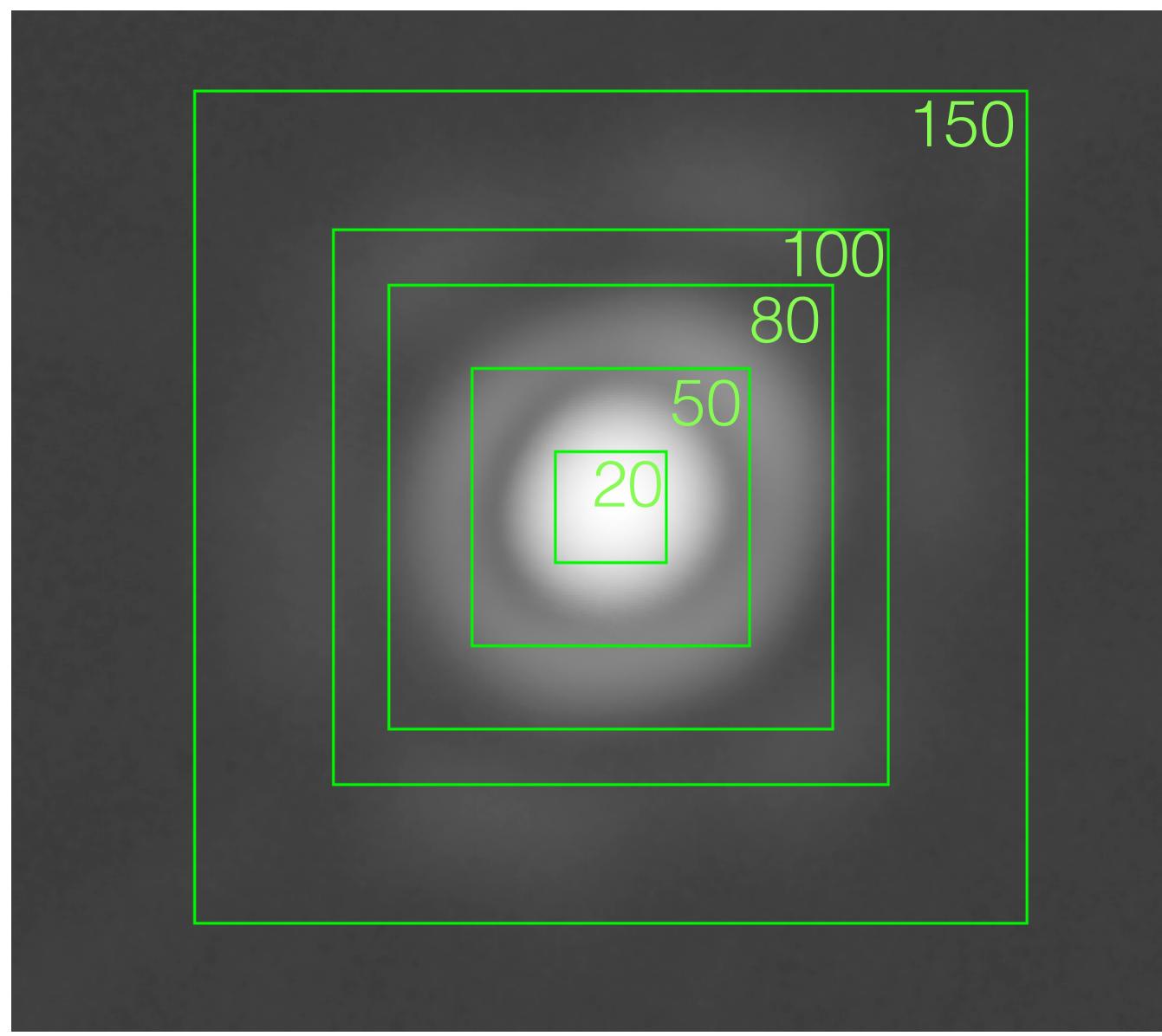
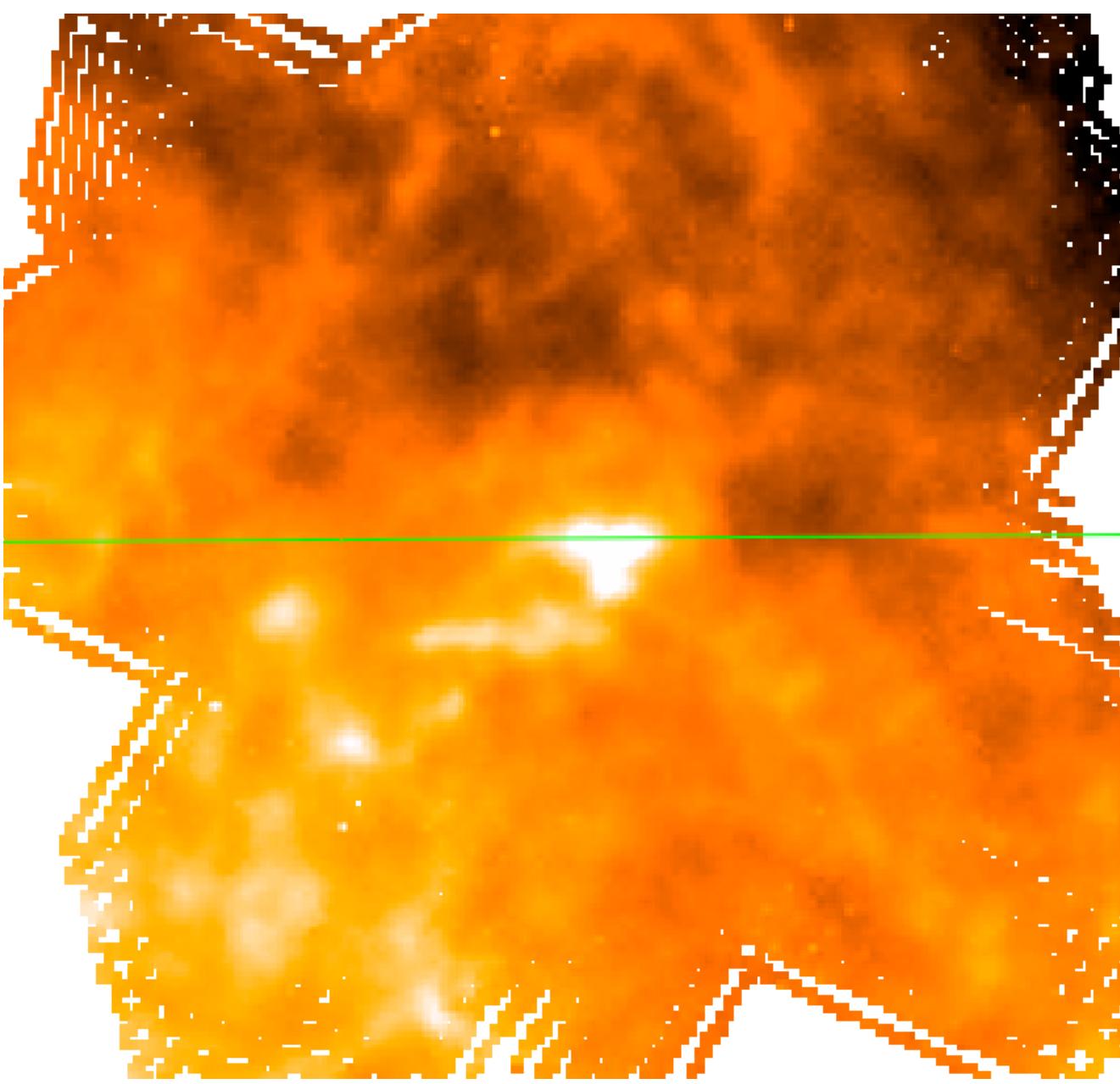
- Approximately quadratic time in terms of beam width
- Approximately linear in terms of beam area



Varying HiRes input beam size

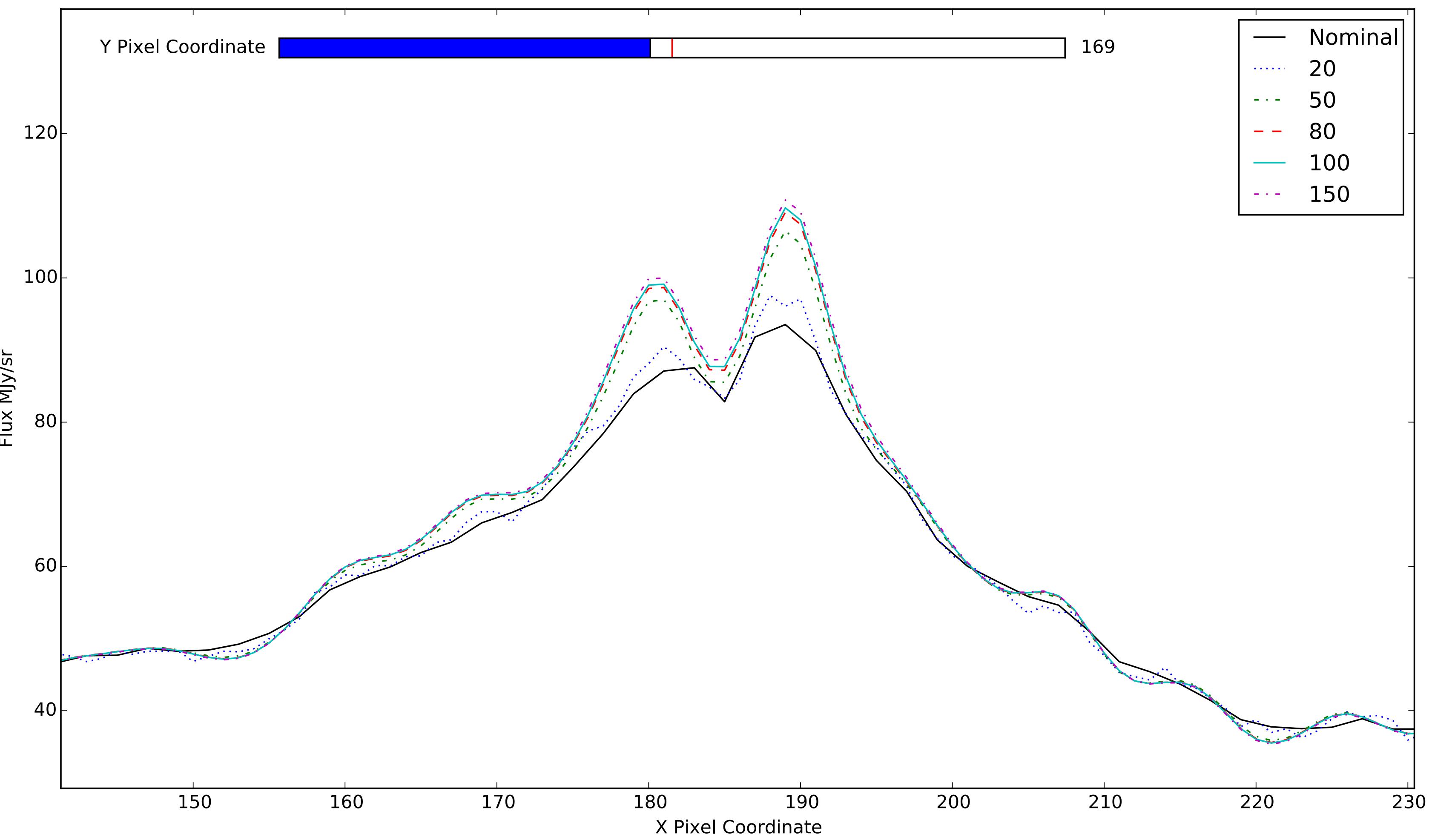
Obsid: 1342249237





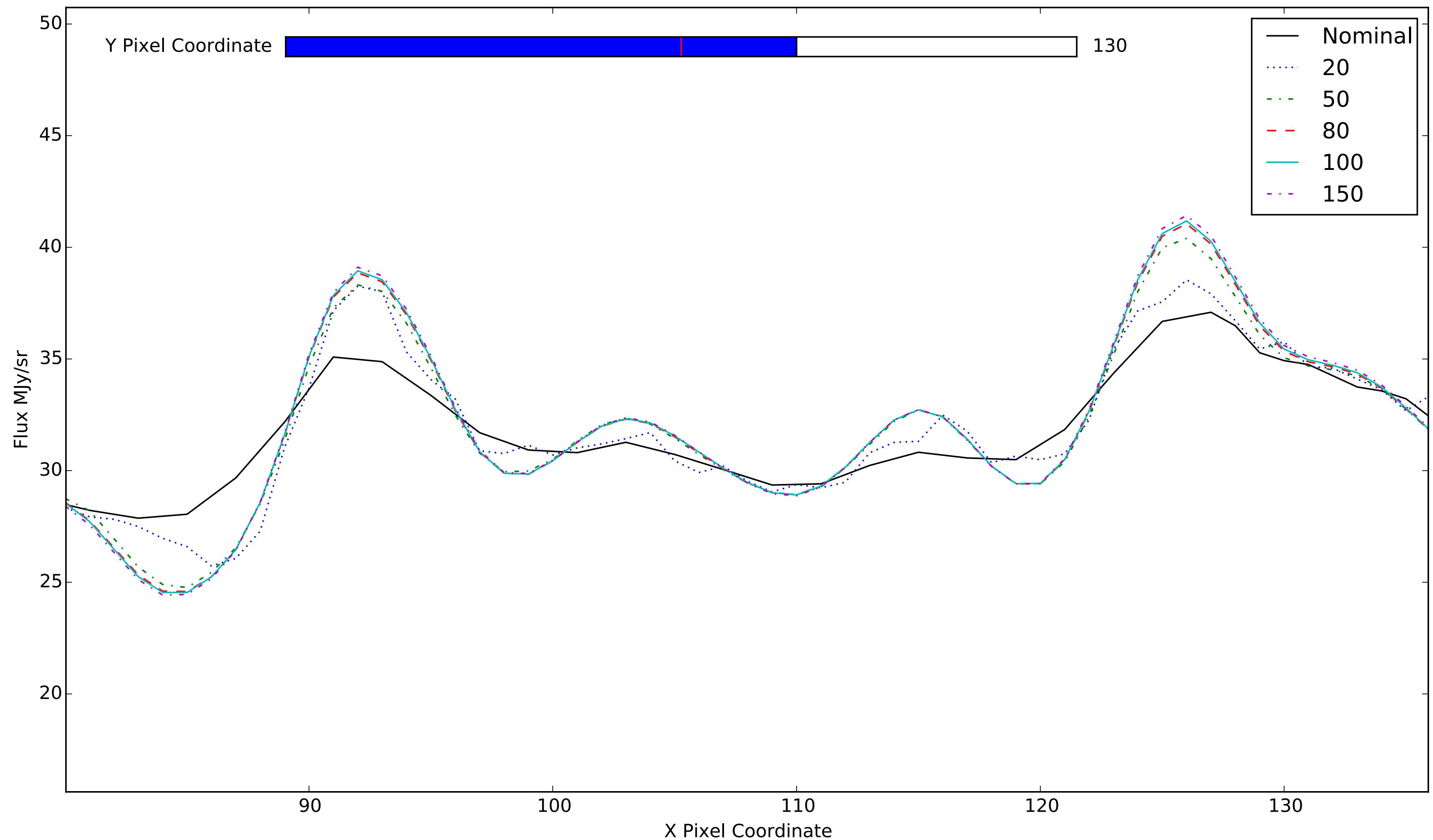
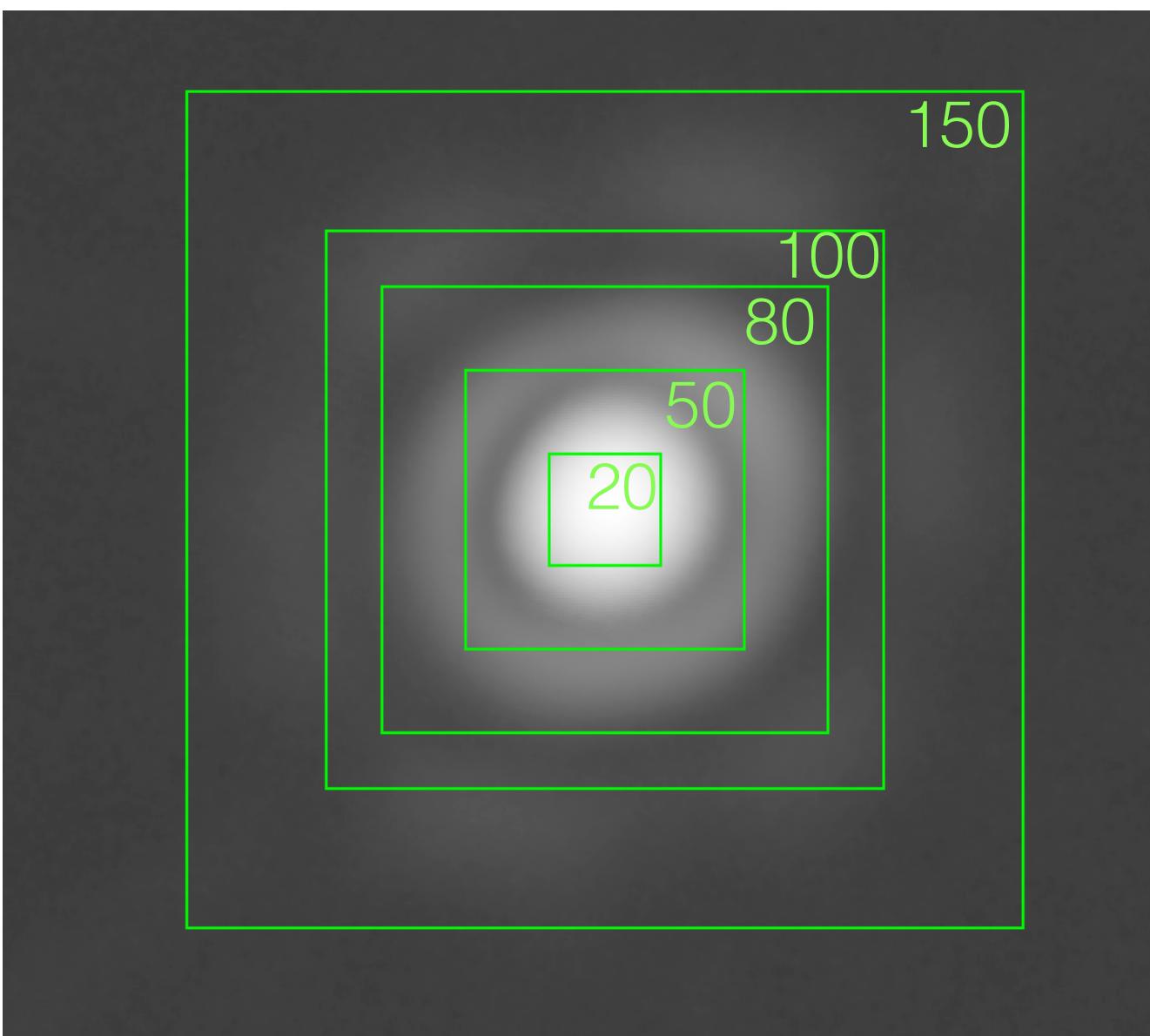
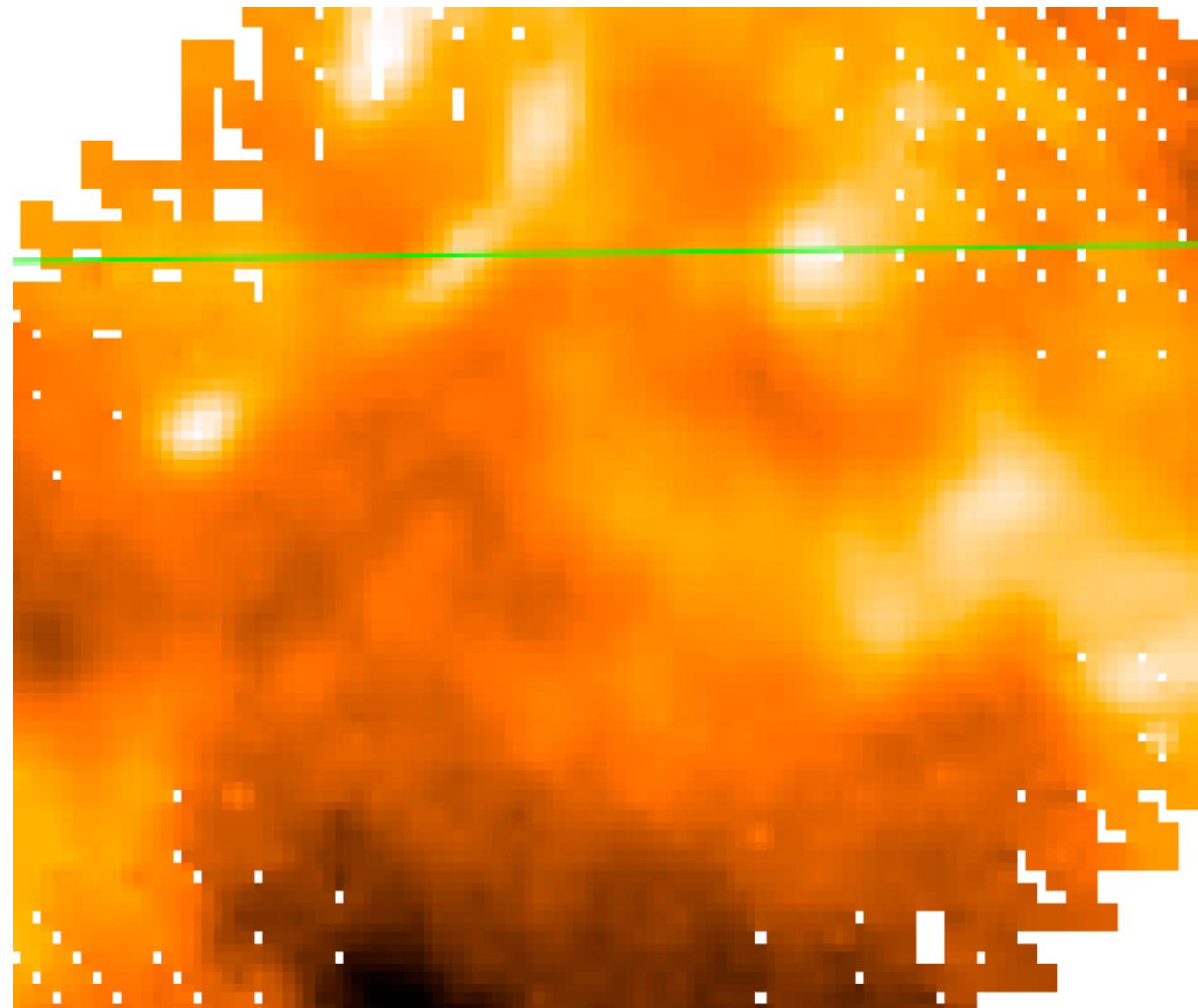
Varying HiRes input beam size

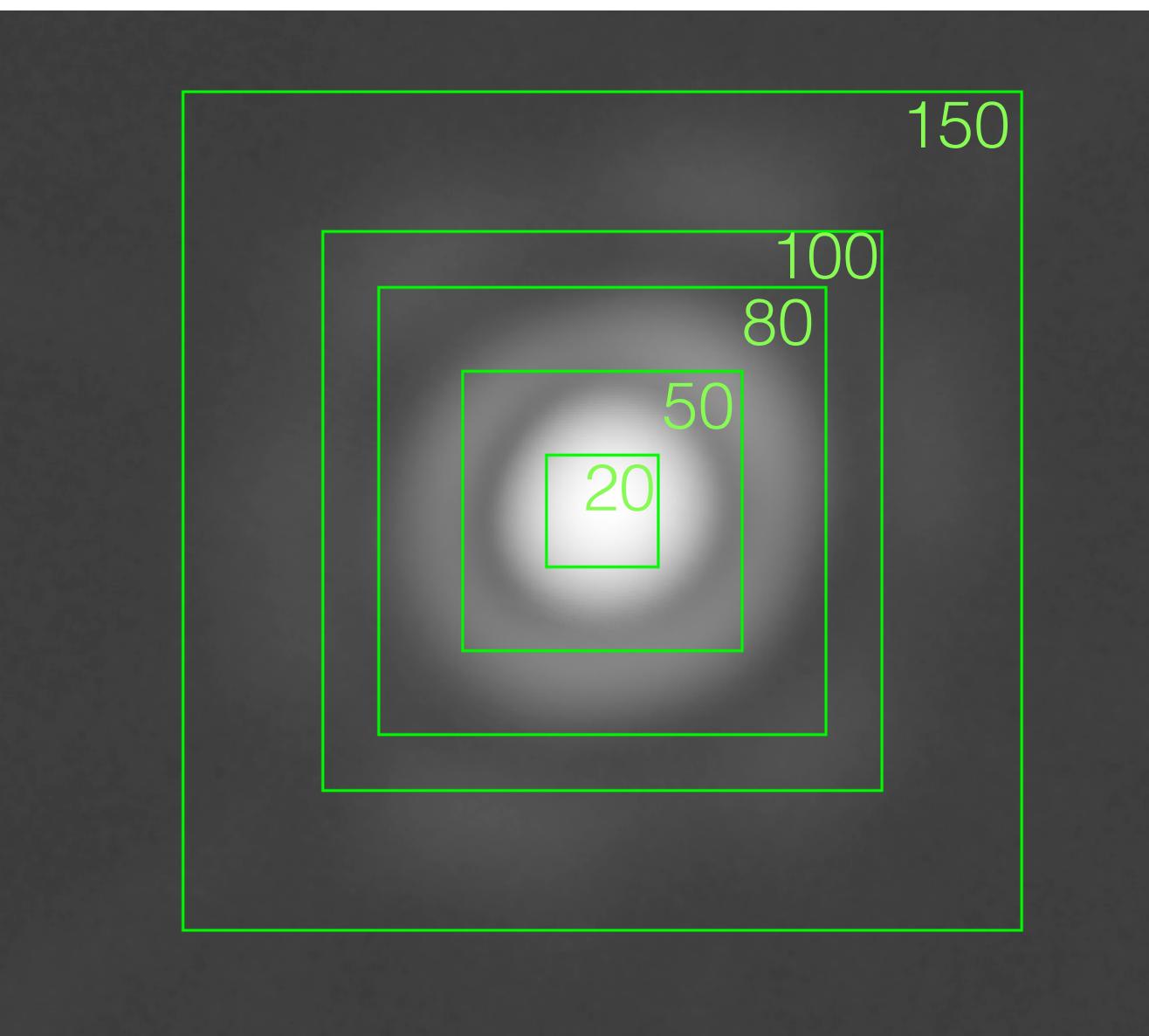
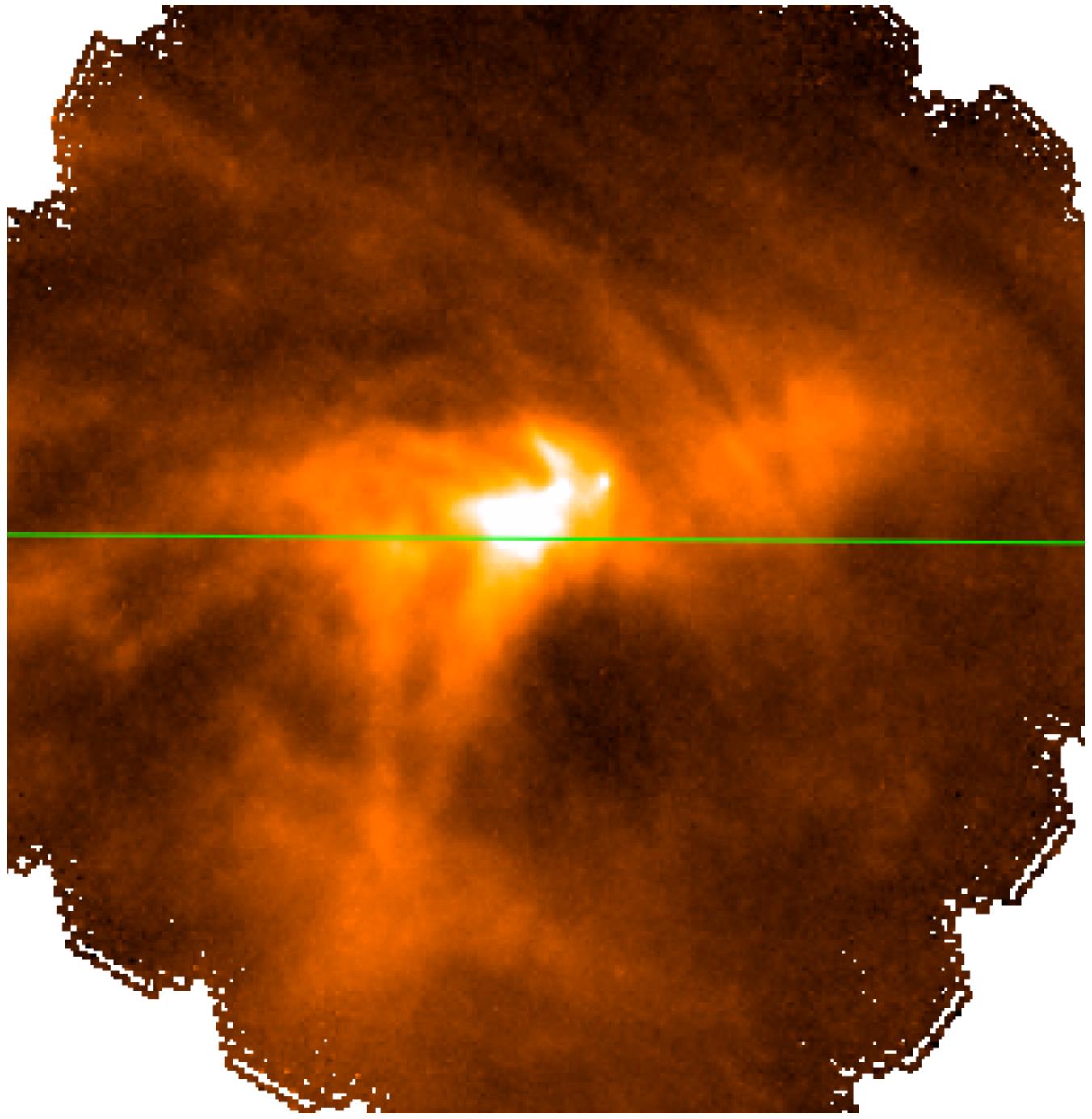
Obsid: 1342227726



Varying HiRes input beam size

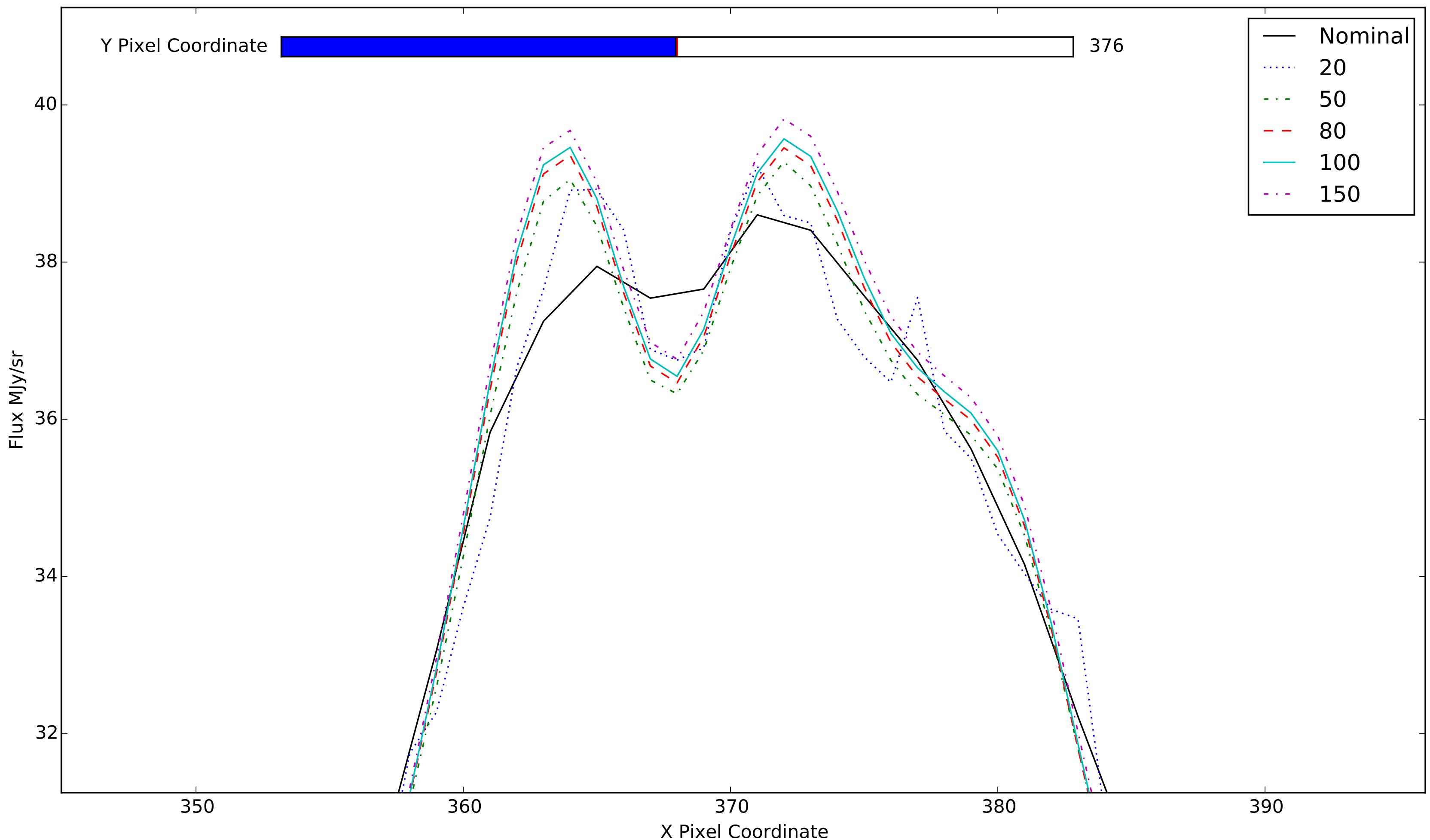
Obsid: 1342210936





Varying HiRes input beam size

Obsid: 1342216940



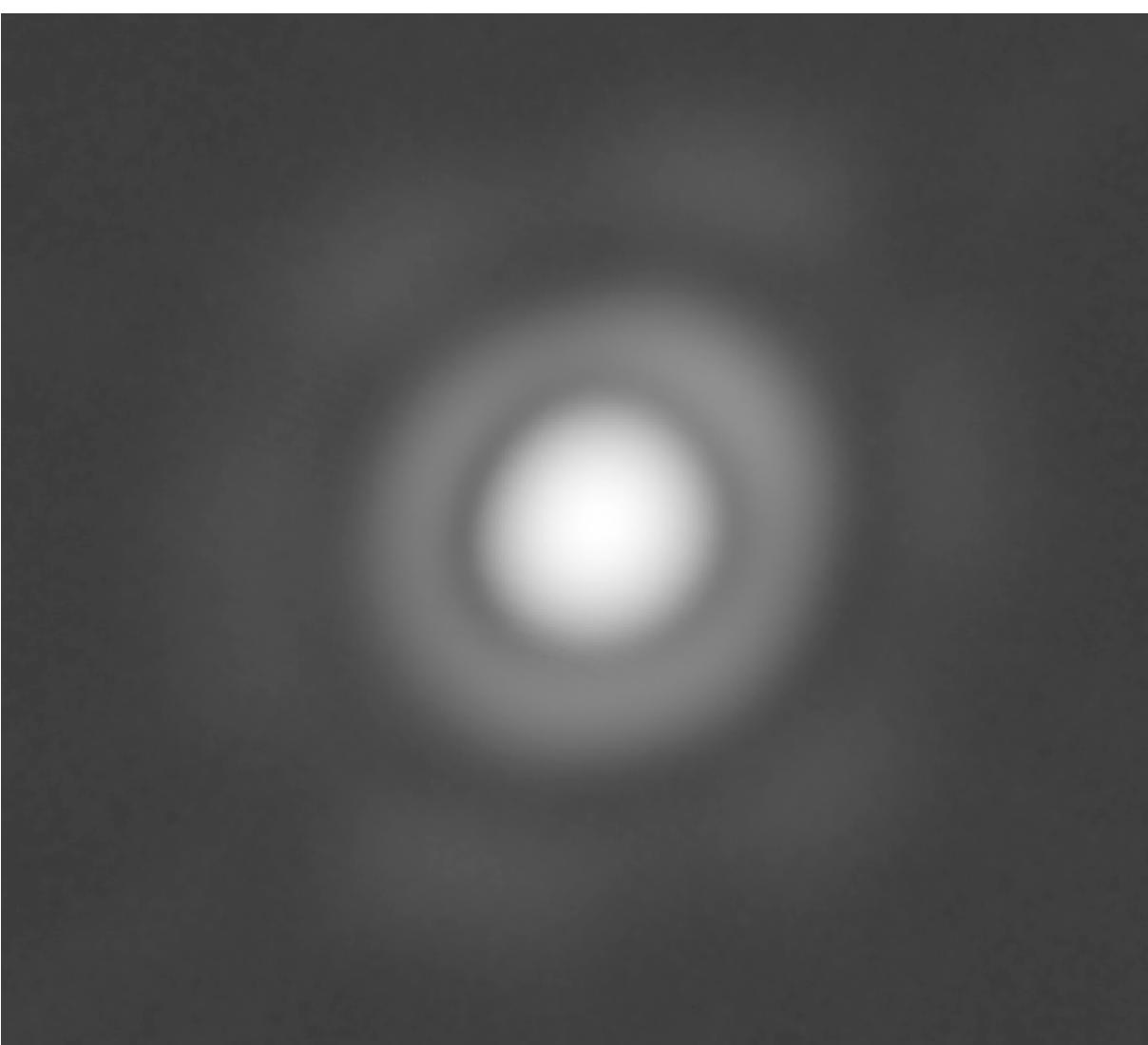
Beam Size affect on Quality

- < 1st minima introduces artefacts (unsurprisingly)
- 2nd Minima seems noticeably better then using 1st minima in ROI, marginally better than 2nd maxima, but very little - very close to converging here
- Current beam sizes are 80, 60, 40 for PLW, PMW, PSW respectively
- Going to 2nd minima would increase processing time by about half, so need to decide if the quality improvement is worth it - probably not, so enclosing first two maxima should be enough

Using the Radial beam Profile

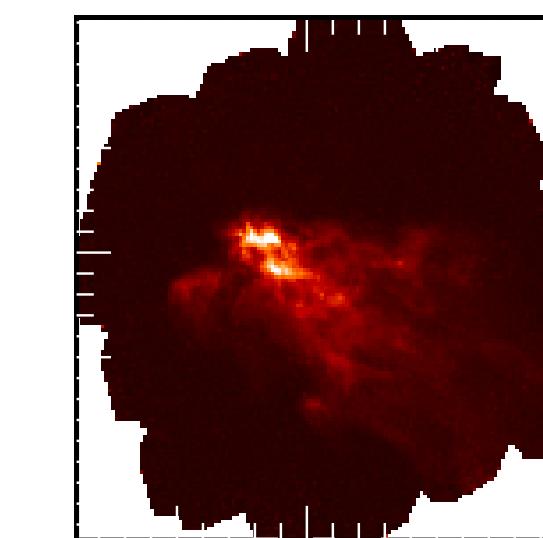
- Does using the radial beam profile to generate the beam image have any significant differences to using the fine beam on the output of HiRes?

Fine Beam

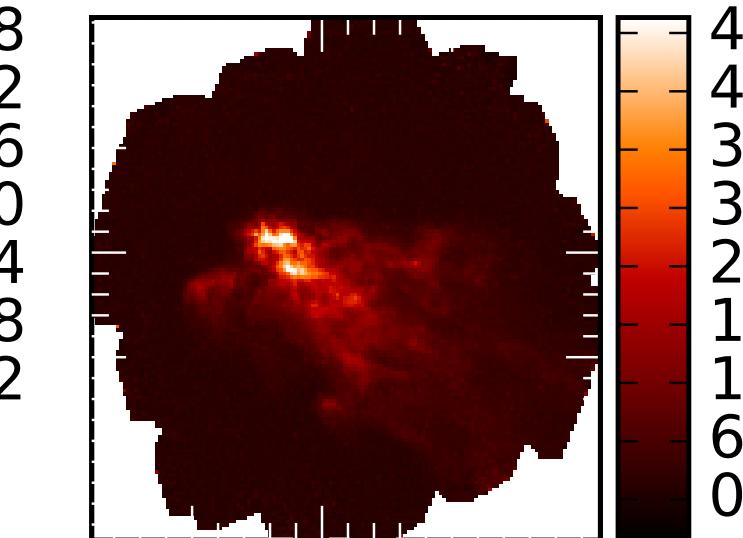


Obsid: 1342249237

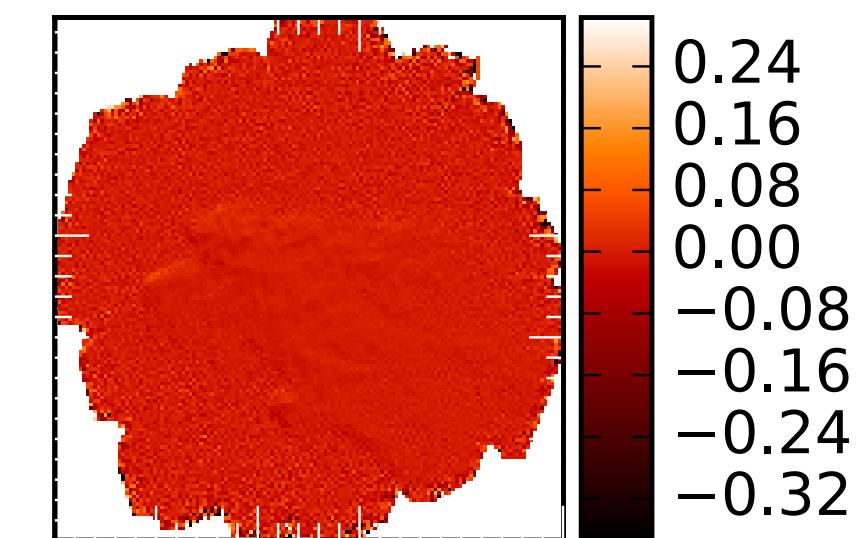
Hires Fine Beam



Hires Radial Beam



Normalised Difference

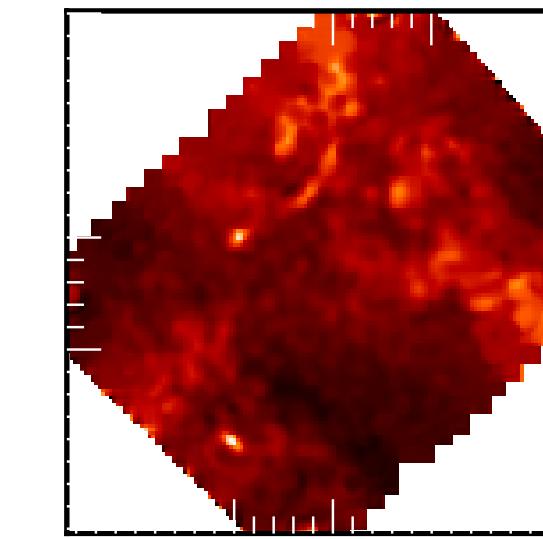


Radial Beam

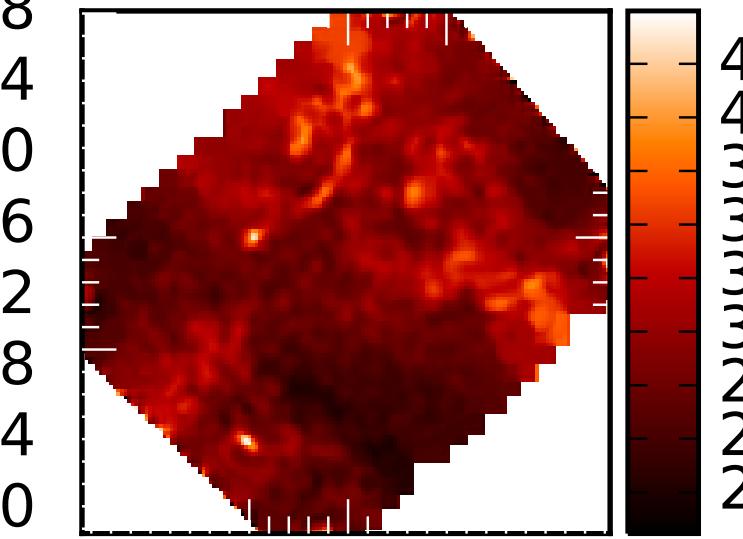


Obsid: 1342210936

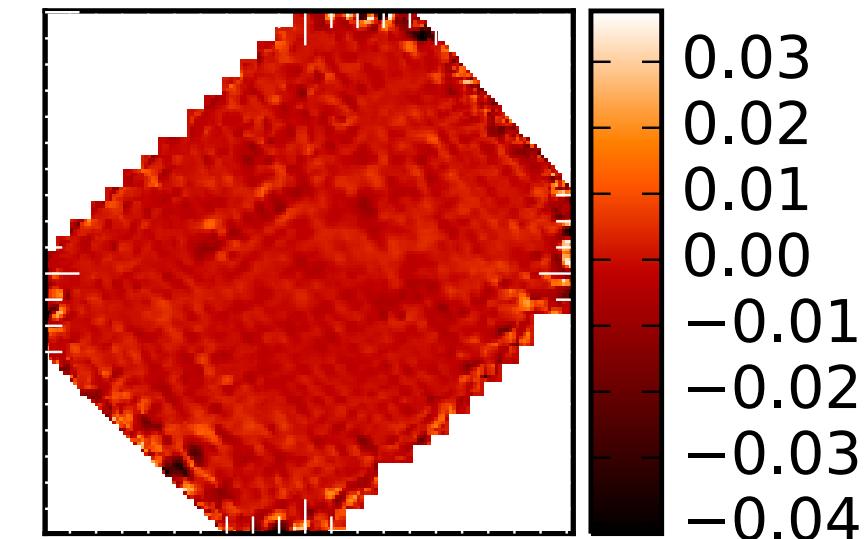
Hires Fine Beam



Hires Radial Beam

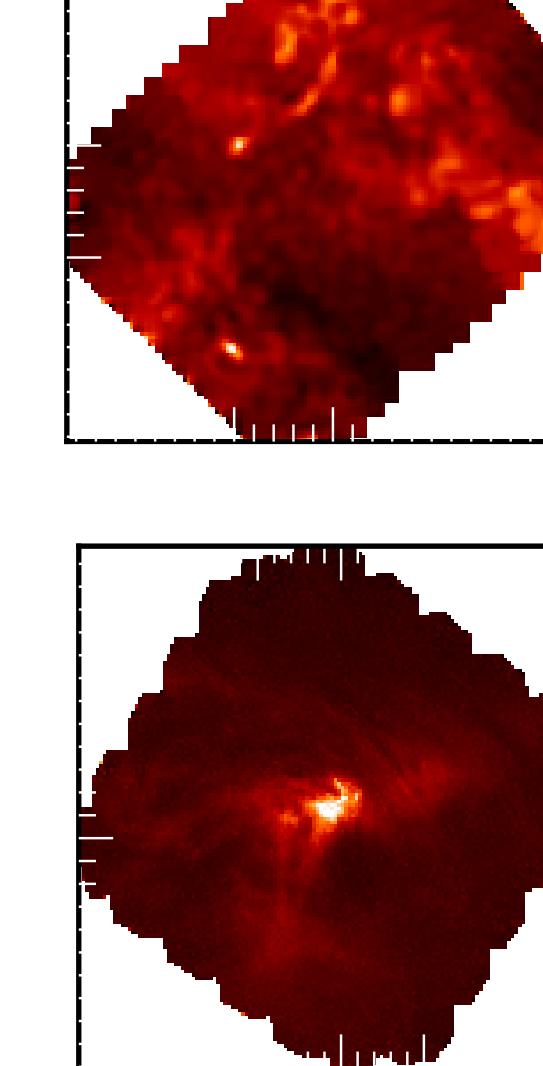


Normalised Difference

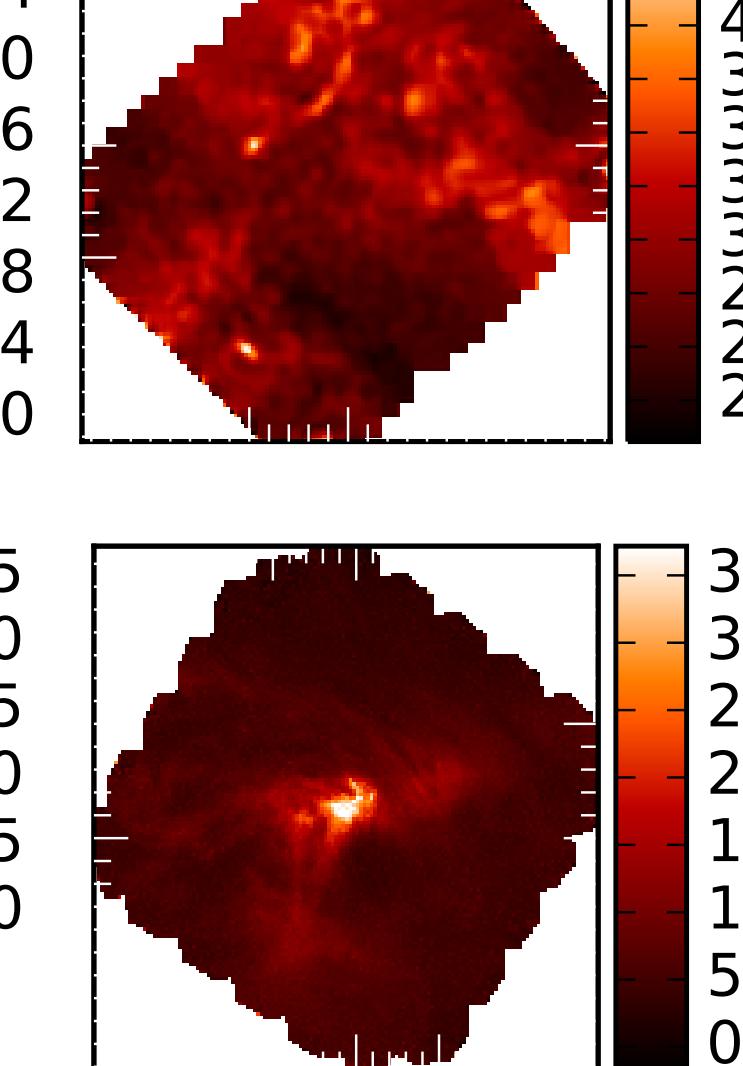


Obsid: 1342216940

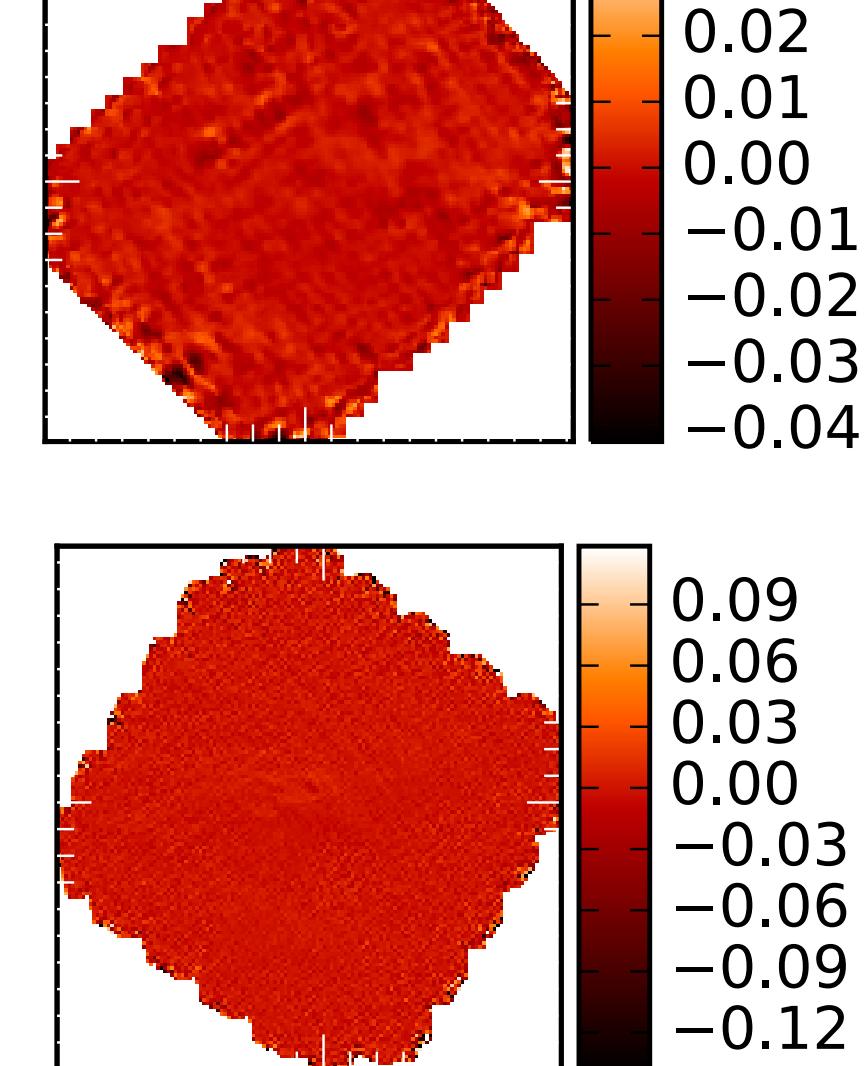
Hires Fine Beam



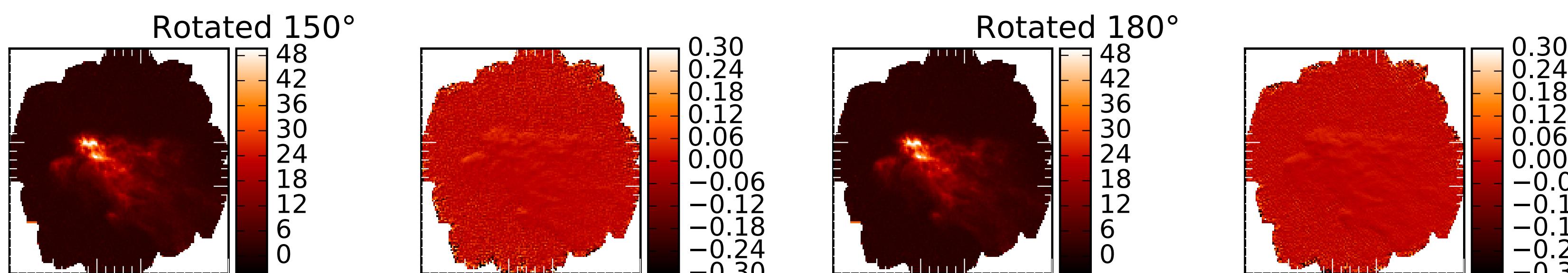
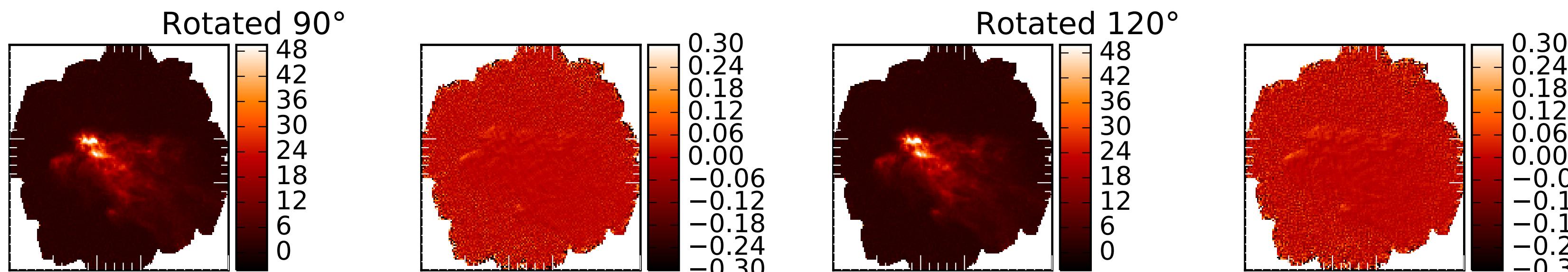
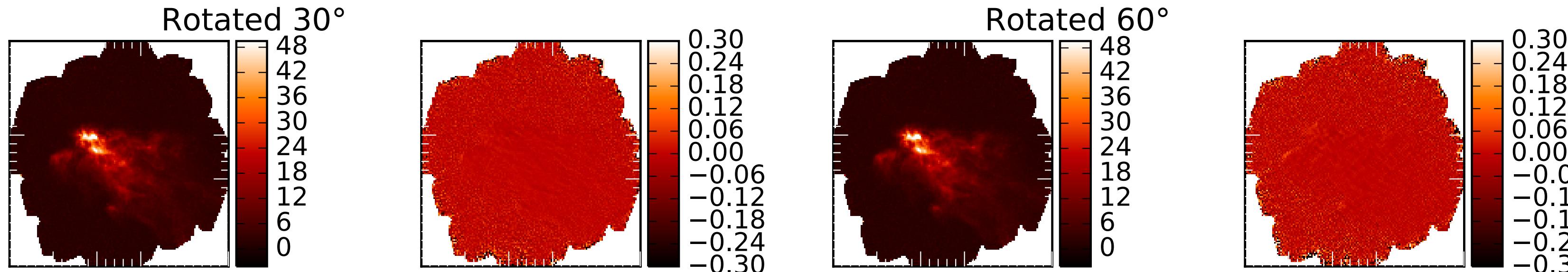
Hires Radial Beam



Normalised Difference



Comparison to Rotated Beam



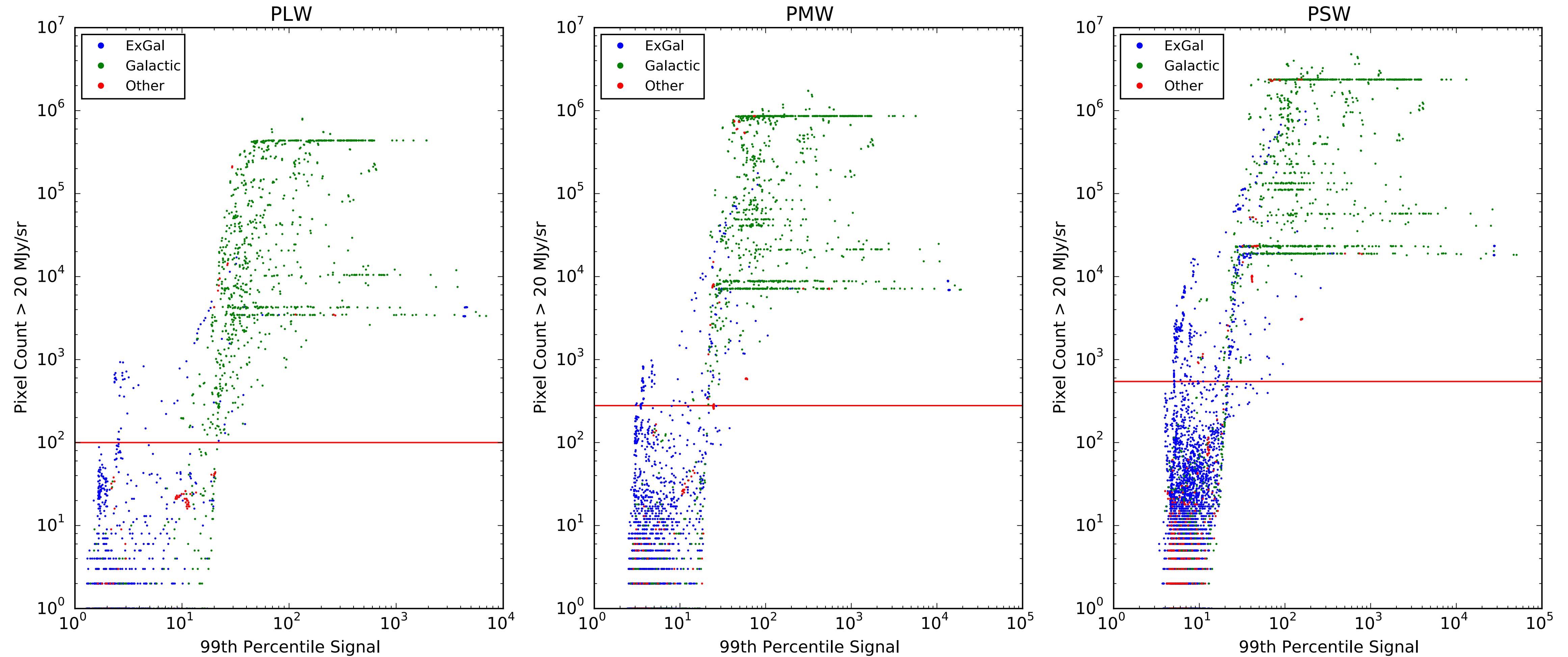
Obsid: 1342249237

Generated by rotating the fine beam and performing HiRes.

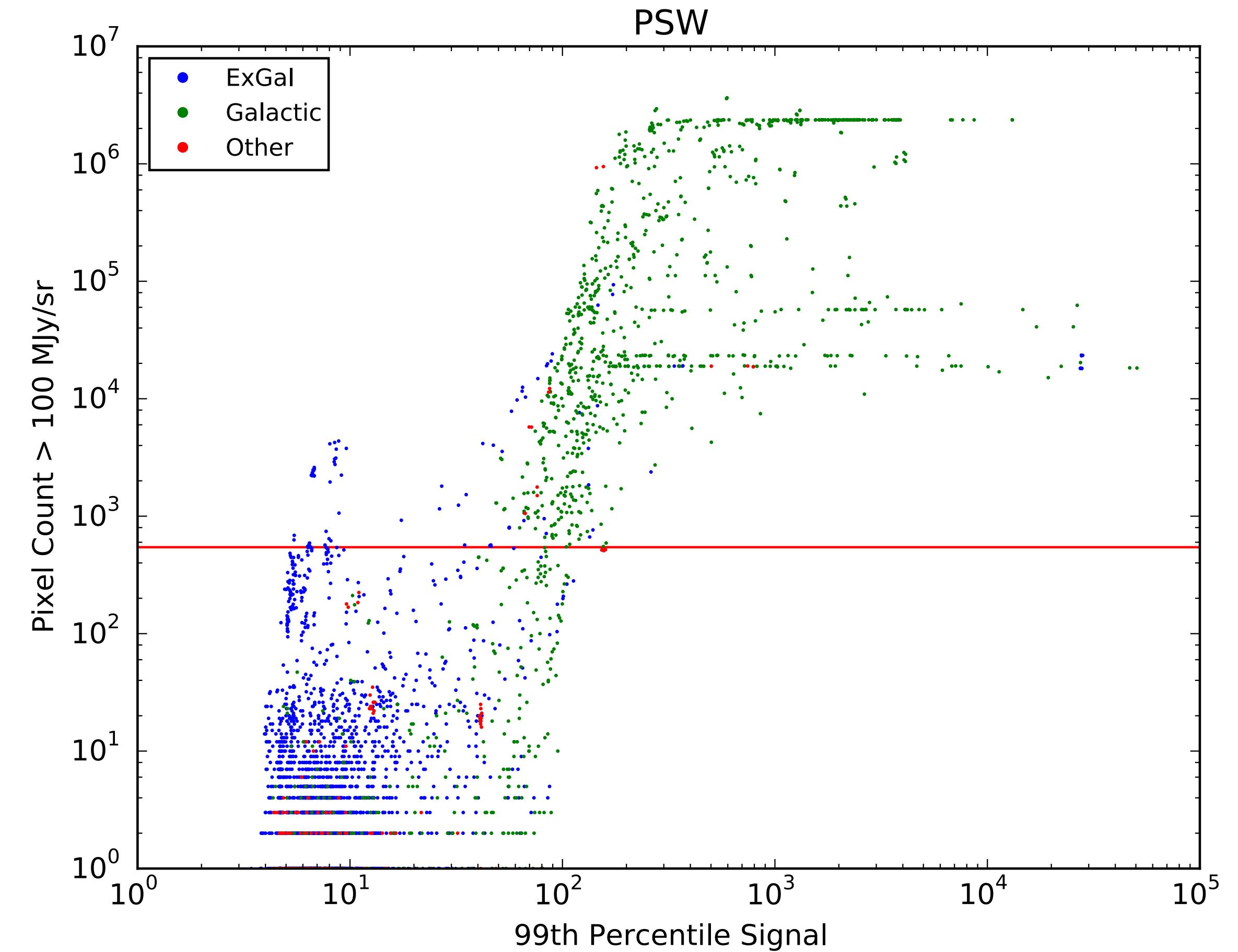
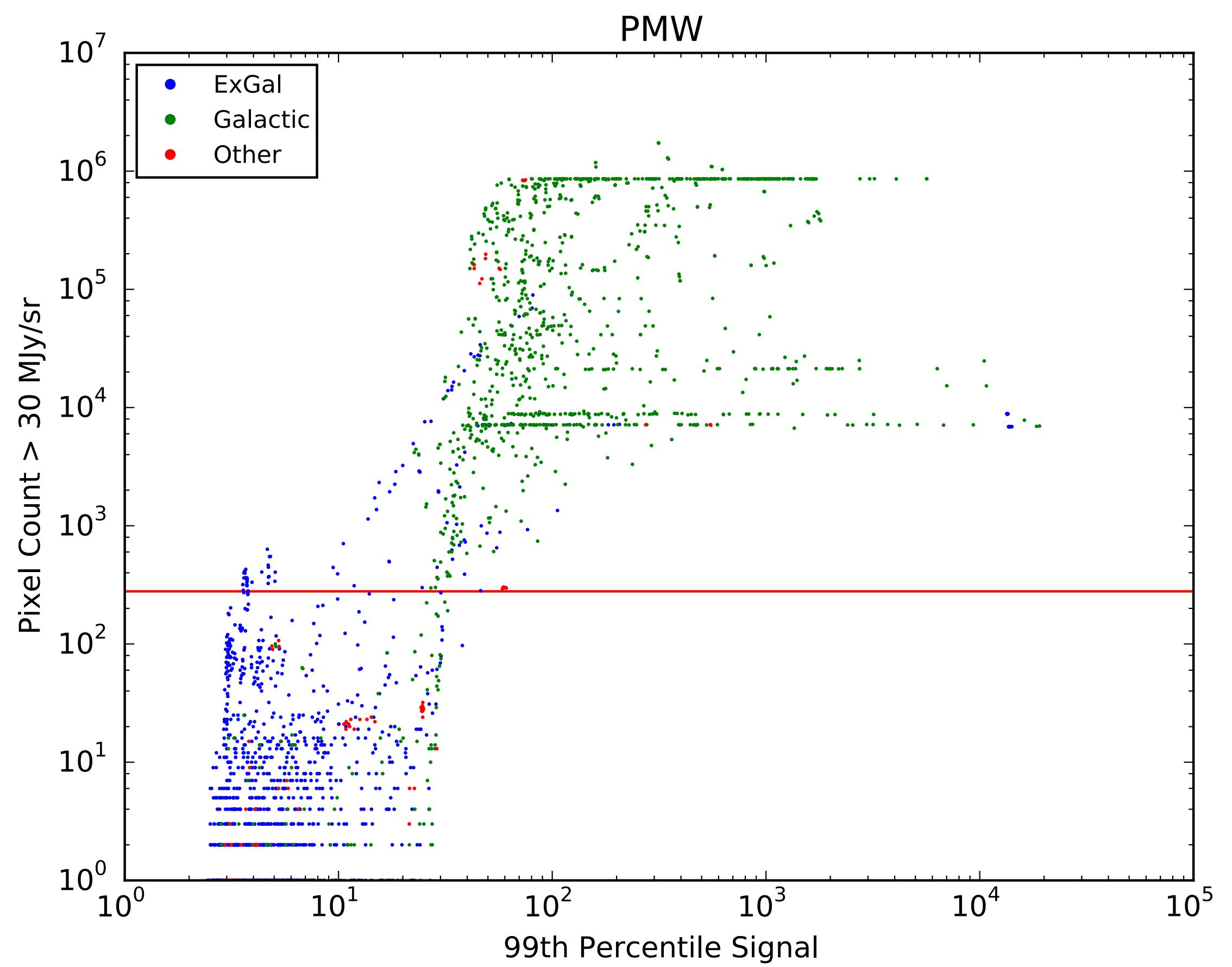
Difference is output using rotated beam vs output with no rotation, normalised by non rotated hires.

Differences of the same order as using the radial beam instead of fine beam.

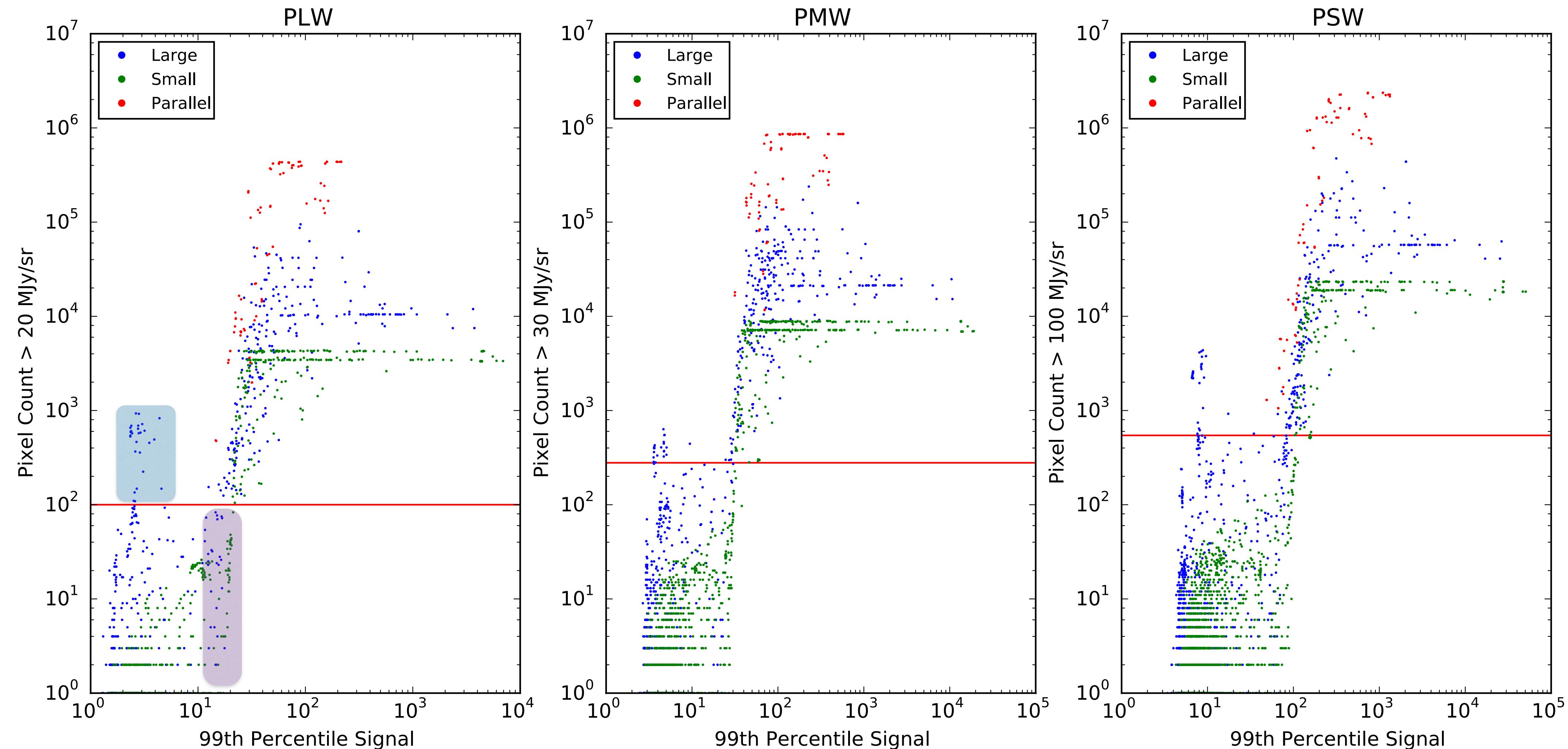
Thresholds for HiRes



Updated Brightness thresholds for PMW/PSW



Thresholds for HiRes



- From previous work by Chris and my own undergraduate project work suggests that HiRes starts to make sense around a 99th percentile SNR of 20
- Statistics on entire archive suggest this correlates roughly with around 100 pixels (PLW) being greater than 20 MJy/sr
- Area scaled for PMW/PSW but also need a different threshold - from statistics this looks to be 30 MJy/sr and 100 MJy/sr respectively for PMW/PSW

Below threshold but high SNR ($\text{pix_gr_20} < 100$ and $\text{SNR} > 17$)

Obs Ids (Right then down)

1342268378

1342255087

1342254493

1342266693

1342237513

1342224023

1342210935

1342240284

1342224973

1342239913

1342210542

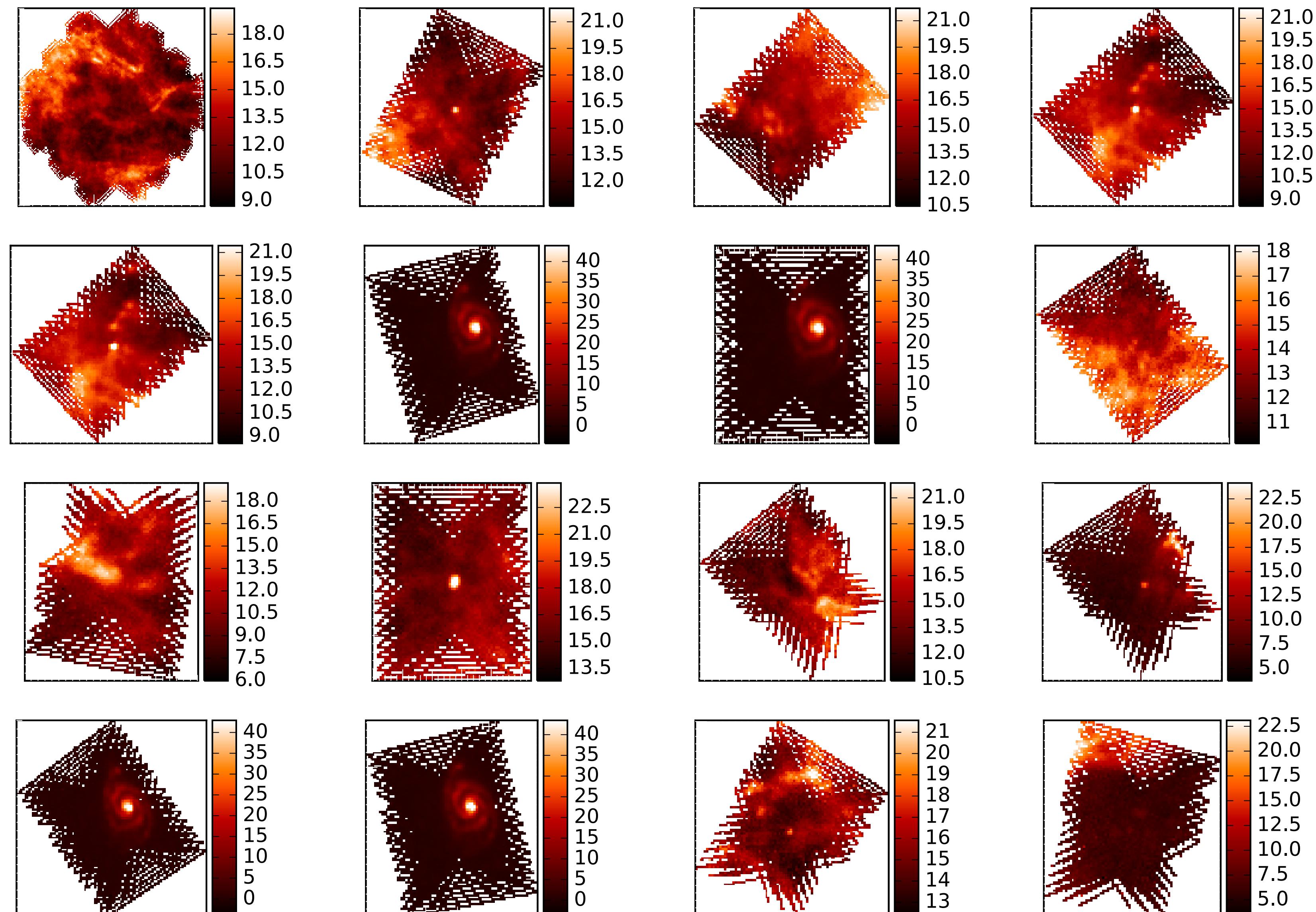
1342247978

1342265305

1342229204

1342268390

1342239795



- Observations are very low brightness and/or very small FOV
- Kepler SN observation is large, but very dim (top left) with an SNR of only about 2
- M51 observations are short exposure and small FOV, very dim apart from galactic center (these are actually supernova observations)
- Visual inspections suggests only on areas with per pixel brightness of around 20 MJy/sr benefit from HiRes (PLW)
- OK to ignore, HiRes can still always be applied by the user, or specific observations can be added to the list where appropriate

Above threshold but Low SNR ($\text{pix_gr_20} > 100$ and $\text{SNR} < 5$)

Obs Ids (Right then down)

1342247216

1342236240

1342245412

1342245510

1342246580

1342238251

1342236234

1342237553

1342237550

1342234749

1342246632

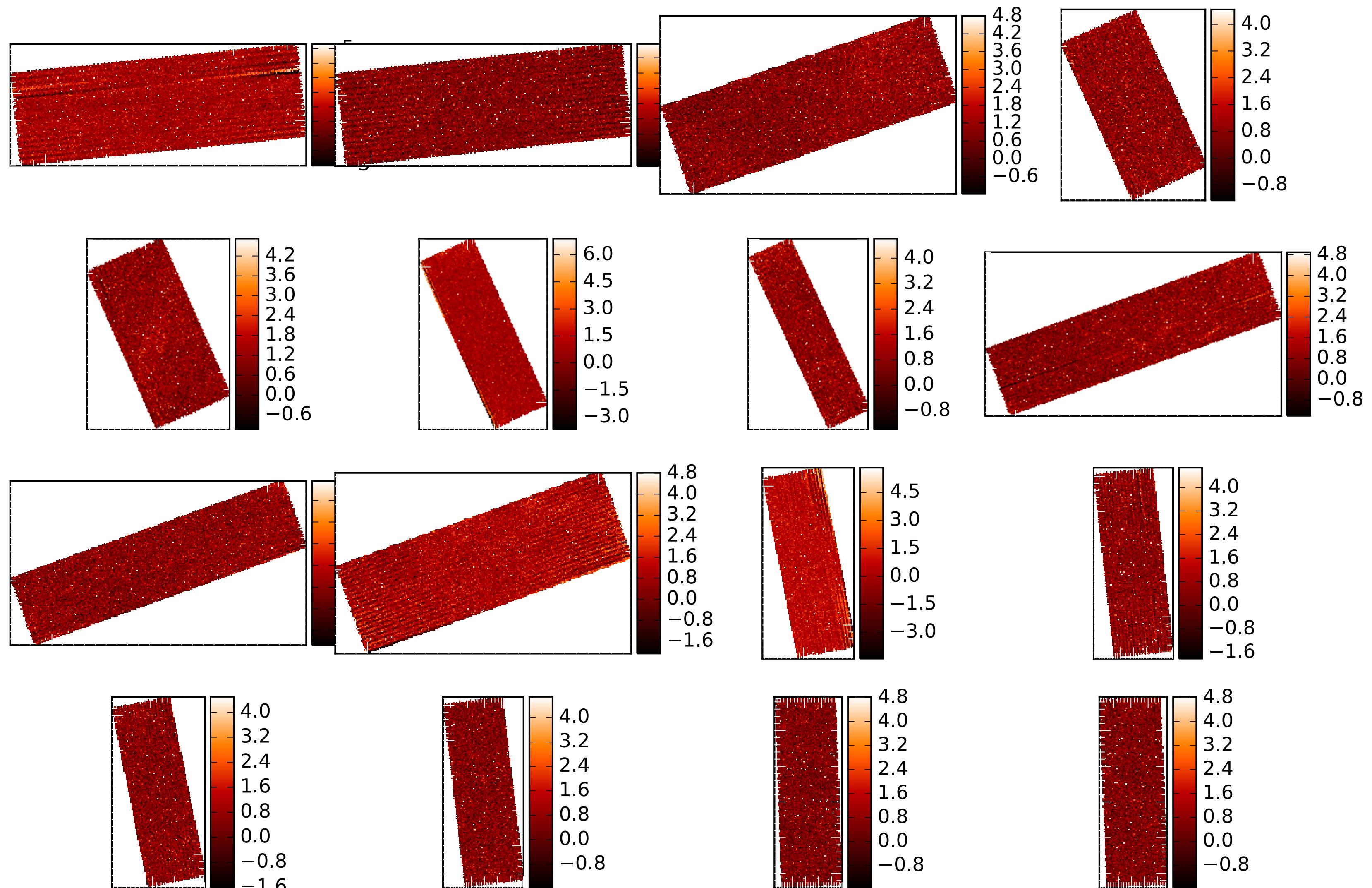
1342237563

1342236232

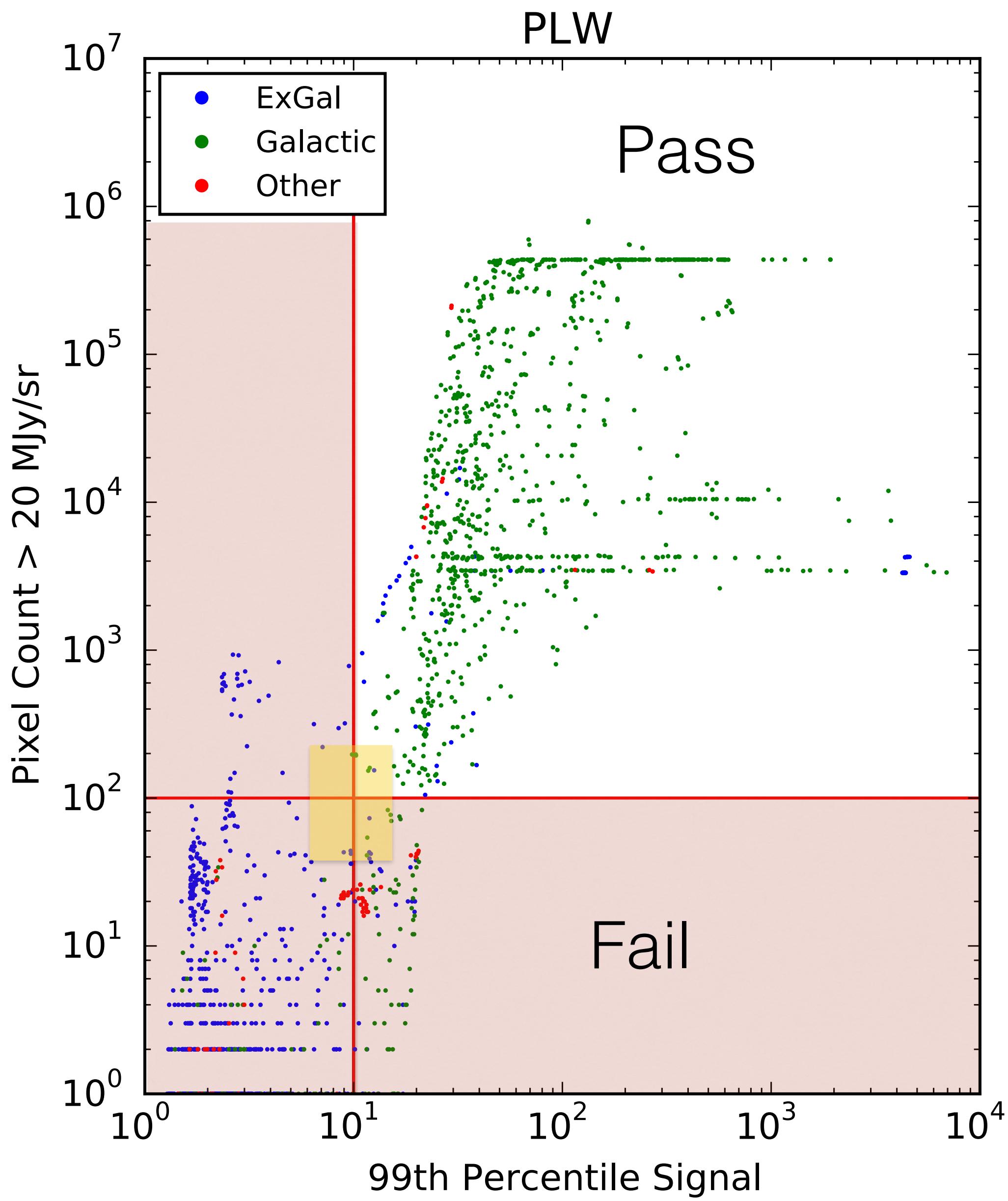
1342245413

1342232365

1342245512



- Observations are very large FOV but dim, but as we are counting the pixels they just rise above our threshold test
- Don't want more complicated testing such as bright pixel proximity etc, suggest adding a second threshold of 99th percentile SNR as both this and the pixel count tests are both computationally very quick. Suggest 99th percentile signal of 10, 15, and 30 for PLW, PMW, PSW

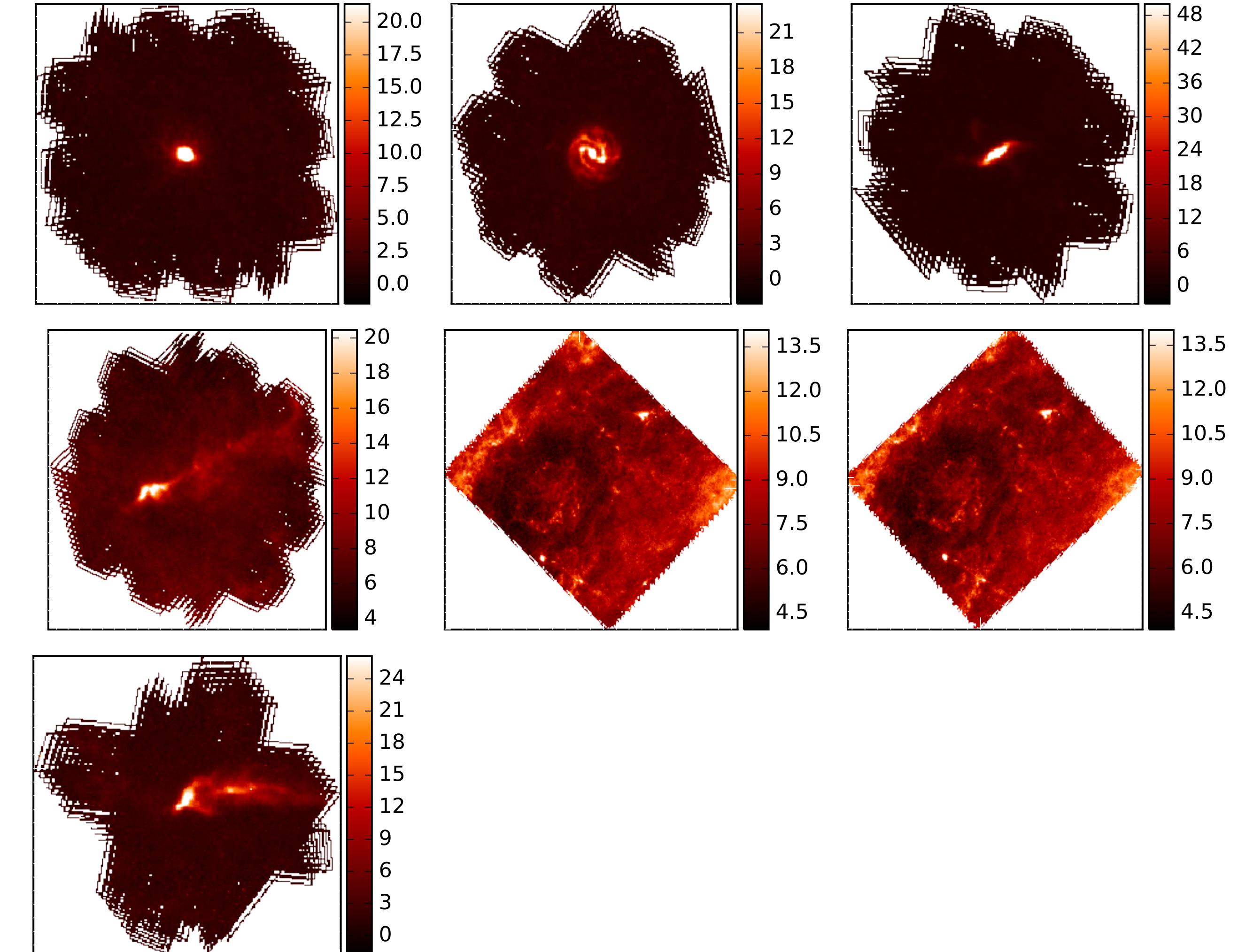
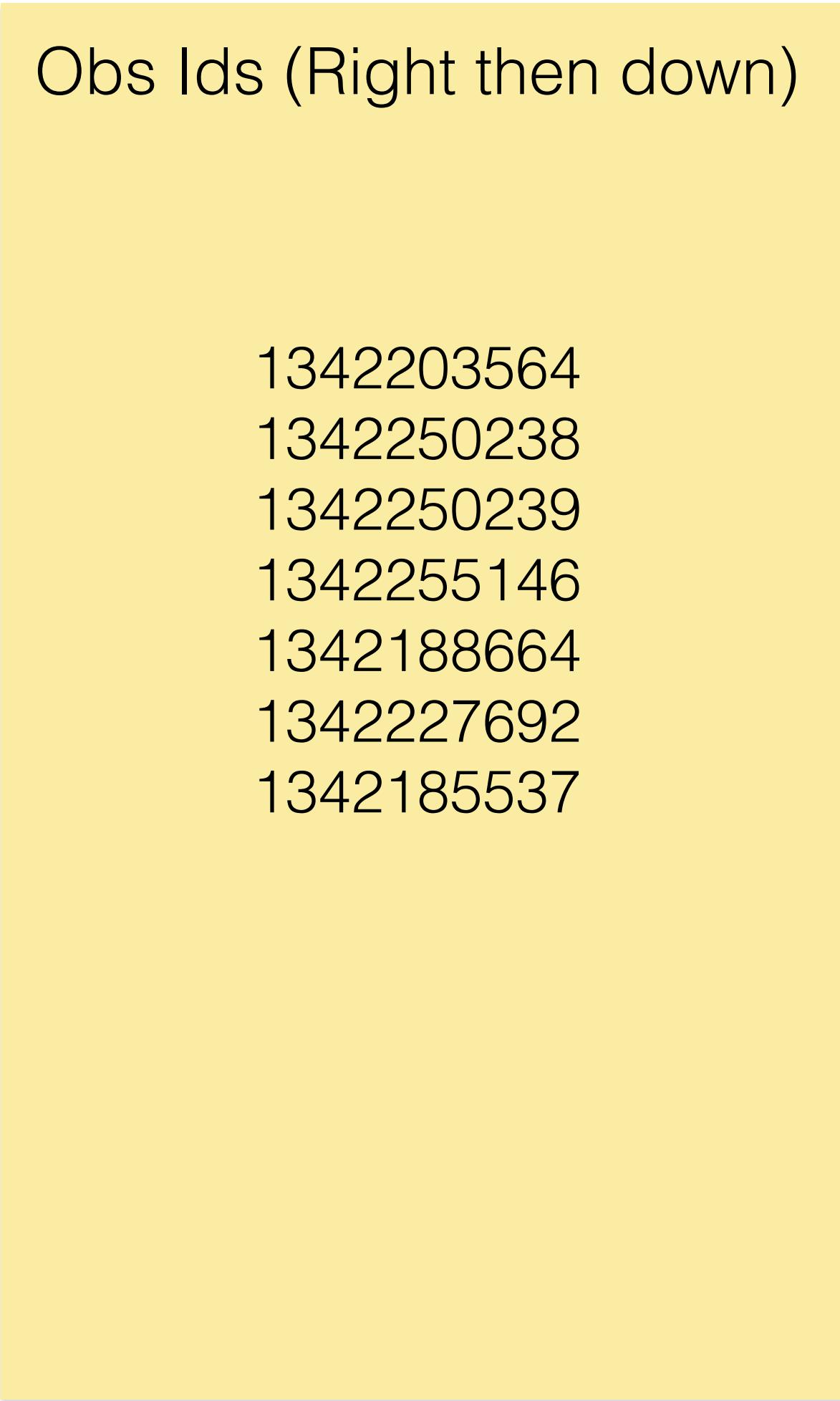


With suggested thresholds:

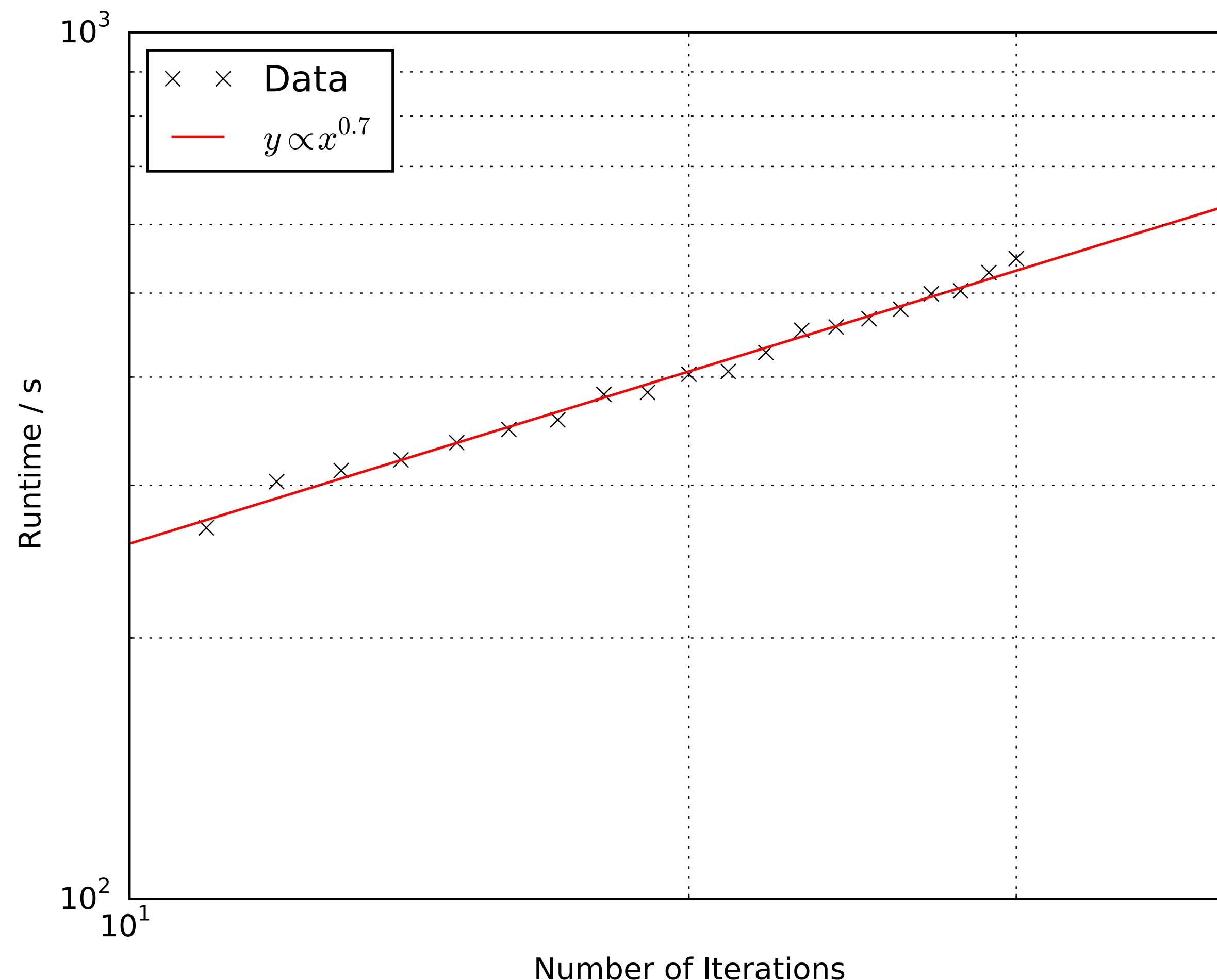
Band	Pass	Fail
PLW	1012	4873
PMW	1132	4753
PSW	972	4913

Number Bands	Pass
3	956
2	71
1	106

thumbnails of Observations closest to thresholds (pix_gr_20 within 50 to 200 and SNR within 5 to 15)

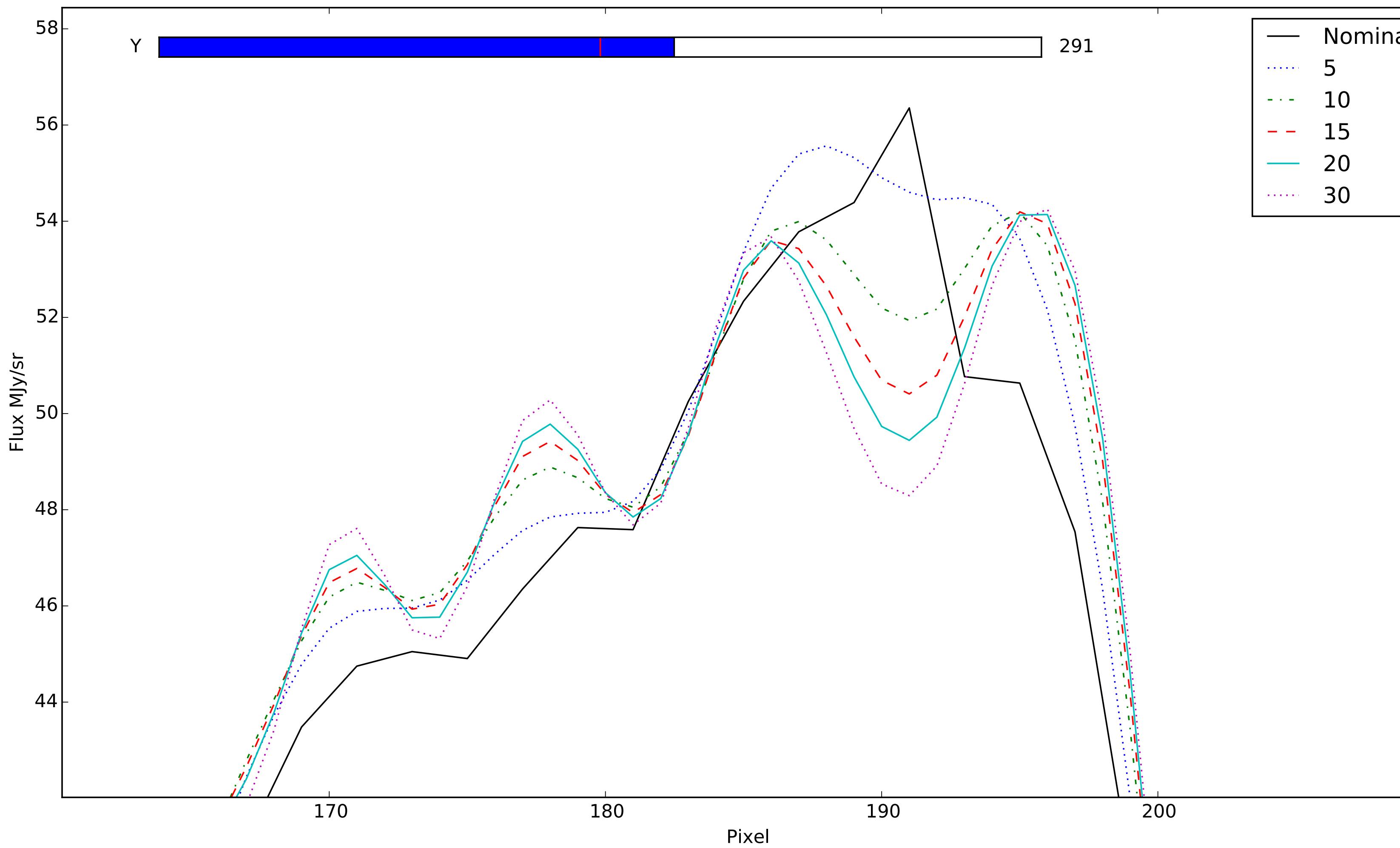


HiRes Time Complexity - Iterations

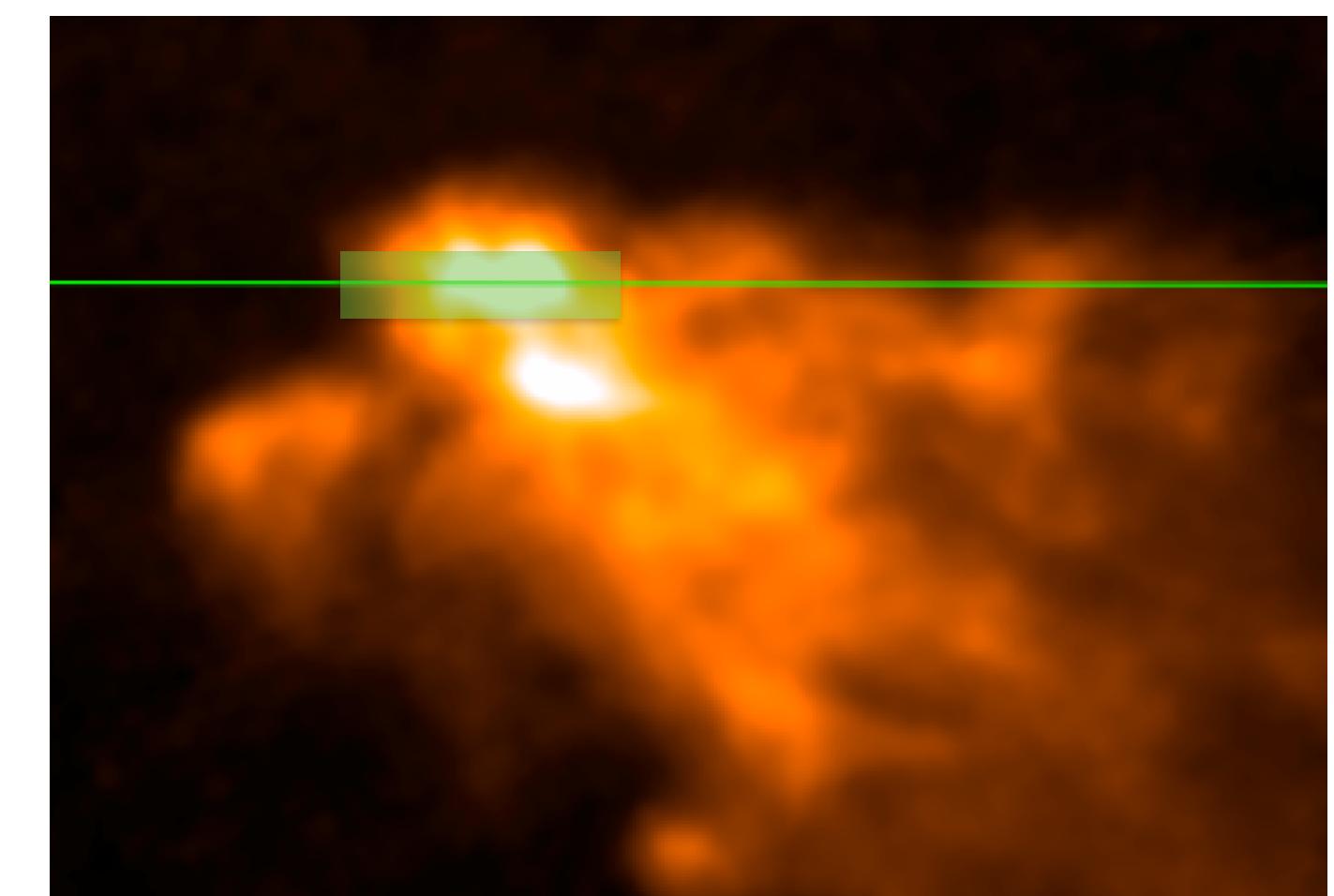


Slightly better
than linear

Number of HiRes Iterations



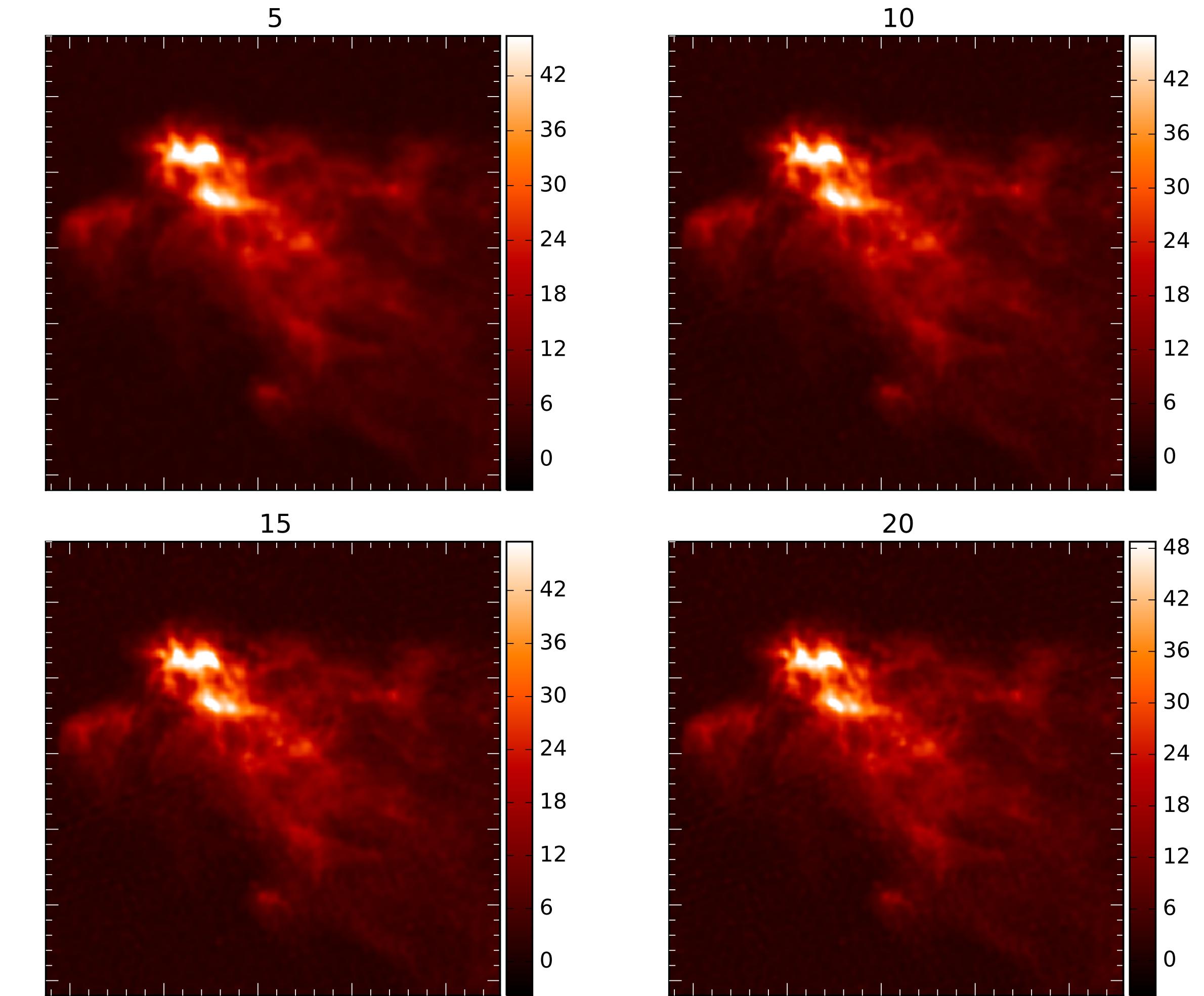
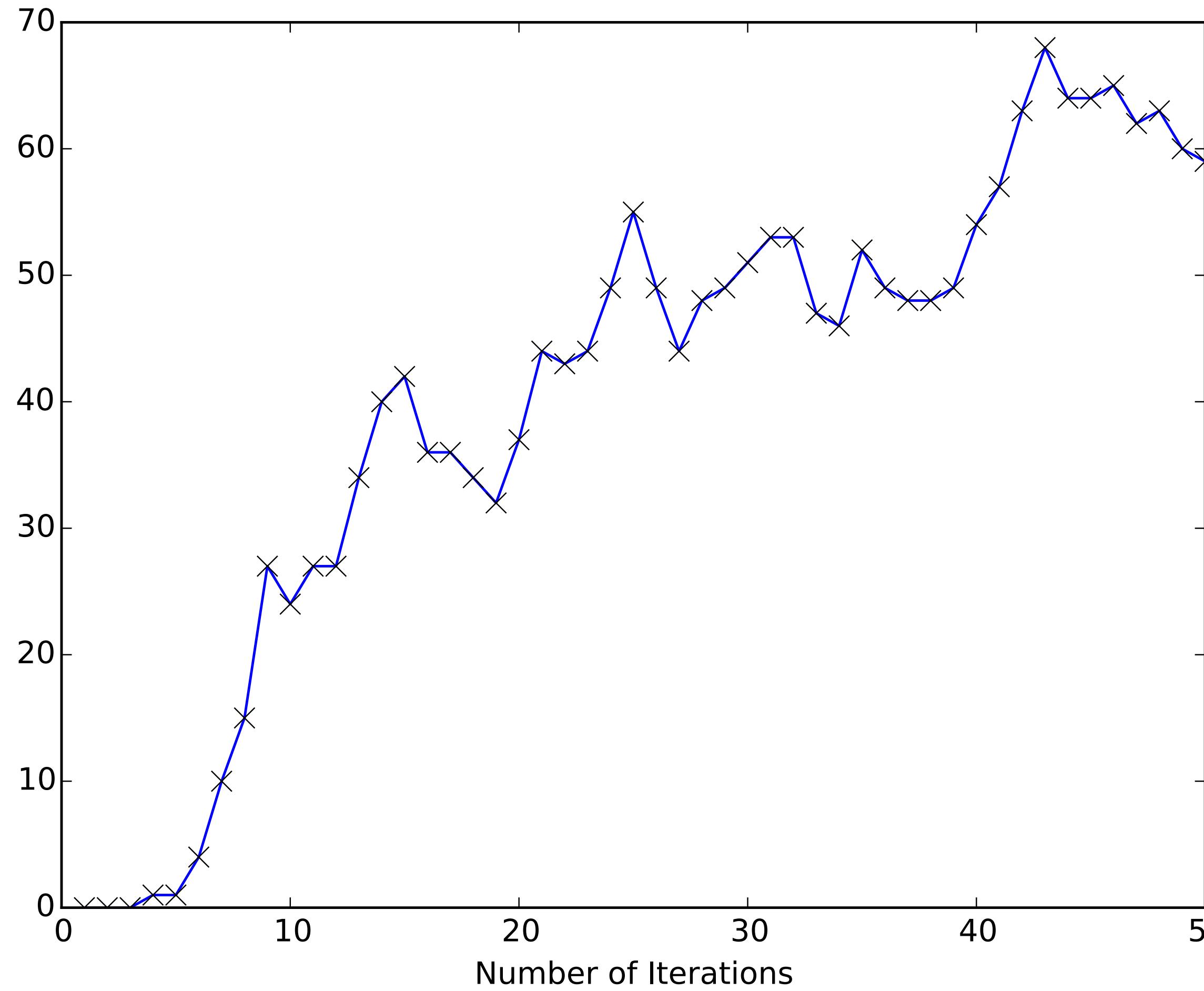
Obsid: 1342249237

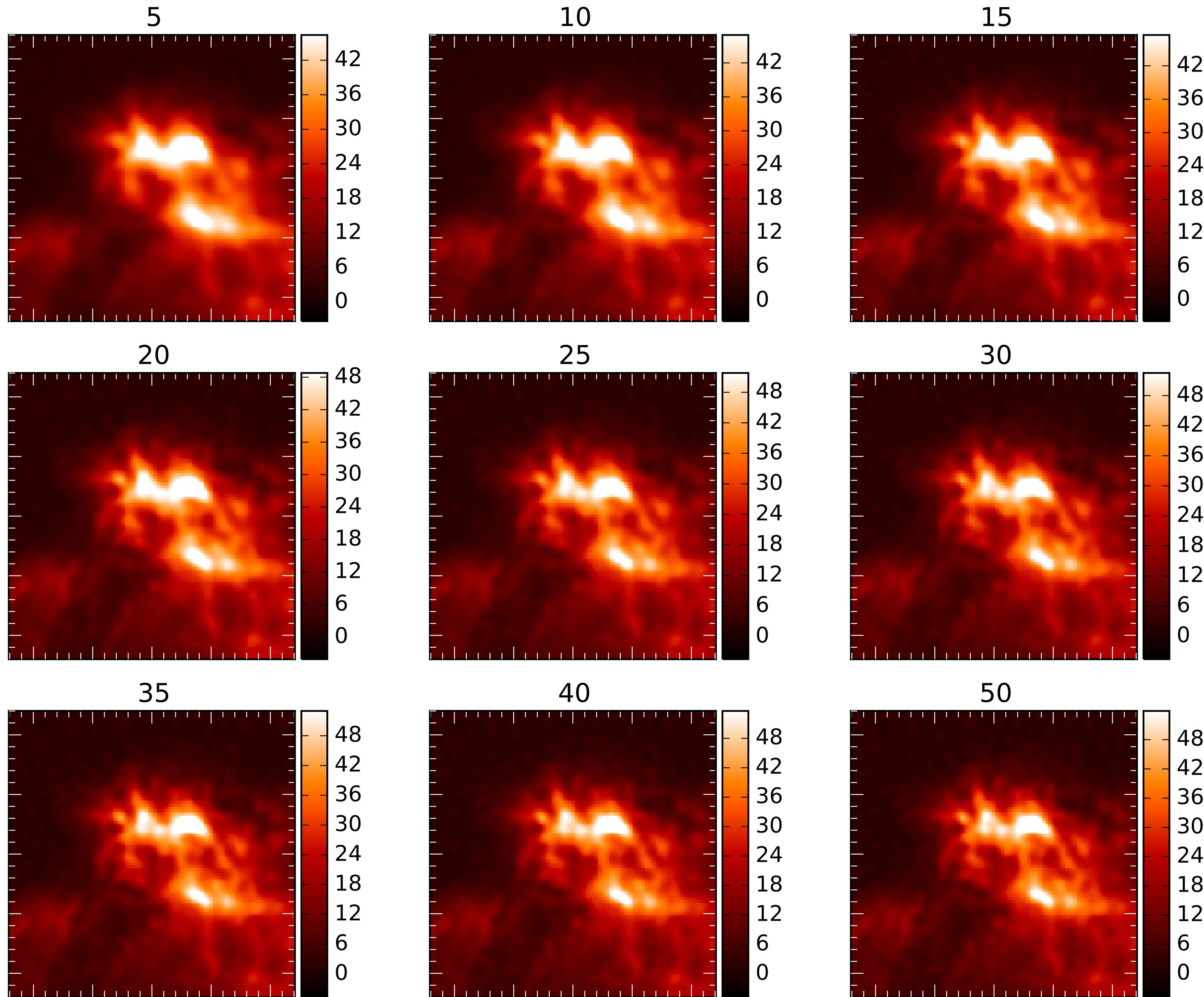


Number of HiRes Iterations

Obsid: 1342249237

RMS Pixel Difference from nominal





Obsid: 1342249237
Zoomed to 0.25 degree
region

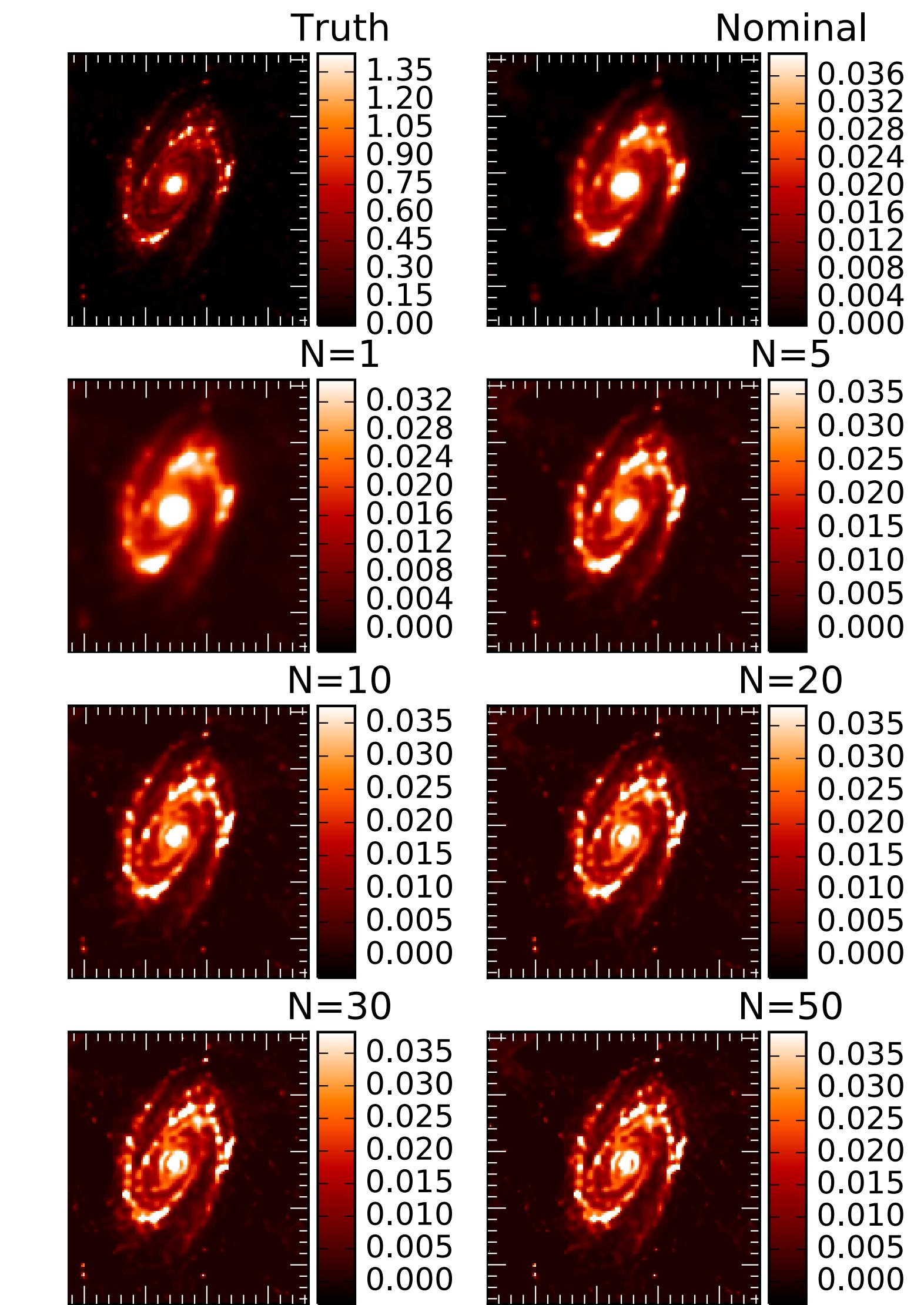
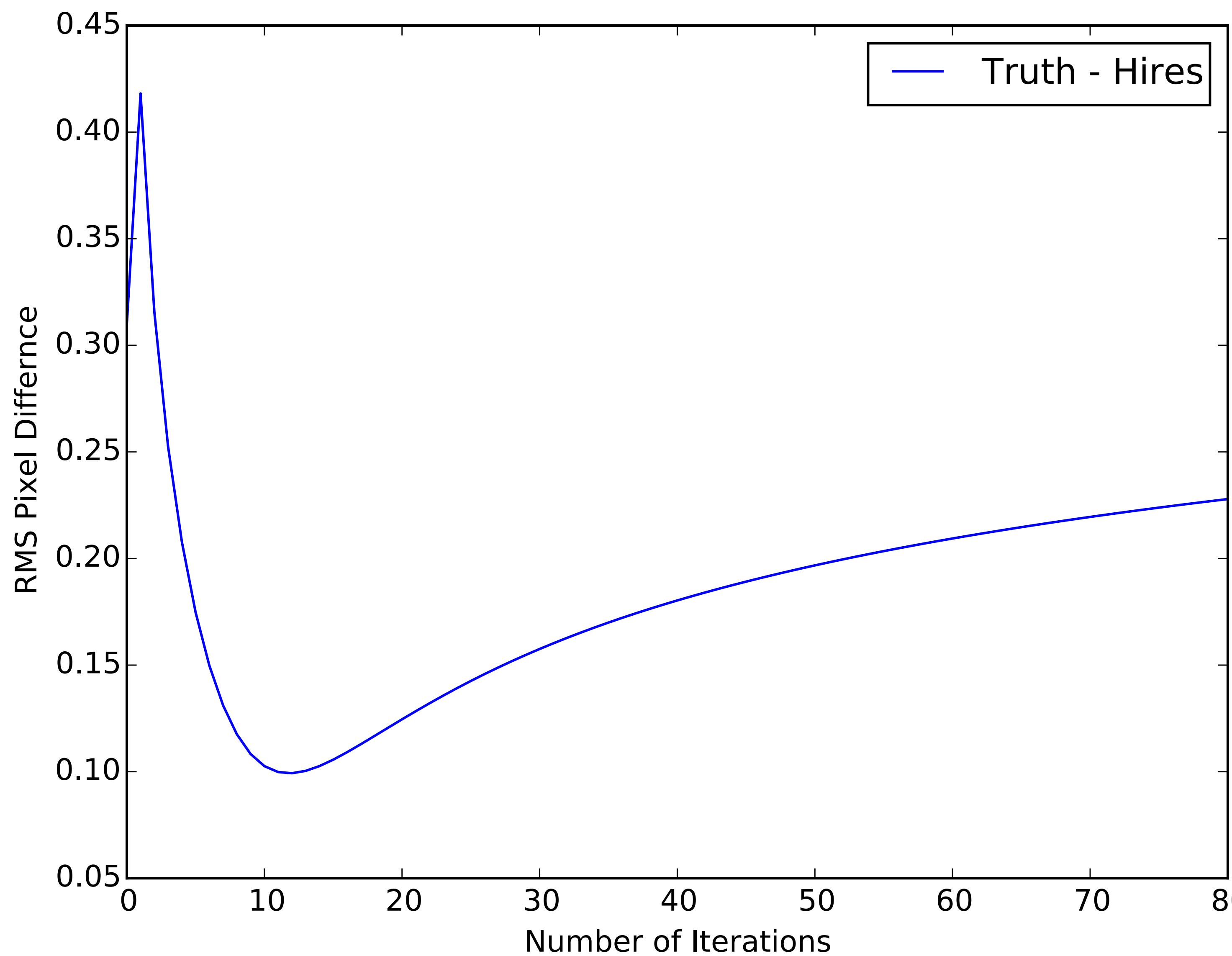
At 20 iterations it appears that some detail is introduced that wasn't shown at 15 iterations (although is apparent on the profile - might be due to scaling on these images), and is further visible at higher iterations.

- Difference rapidly increases from 5-15 iterations, but then rate of change of image differences becomes small
- Small difference from 15-20 iterations (20 current default) but doesn't appear to be adding structure, just enhancing that which is already clear at 15 iterations - previous work in the map making report needs to be checked to see if this is useful or not.
- Time complexity suggests we can save around 1/4 to 1/5th of the processing time by dropping down to 15 iterations.

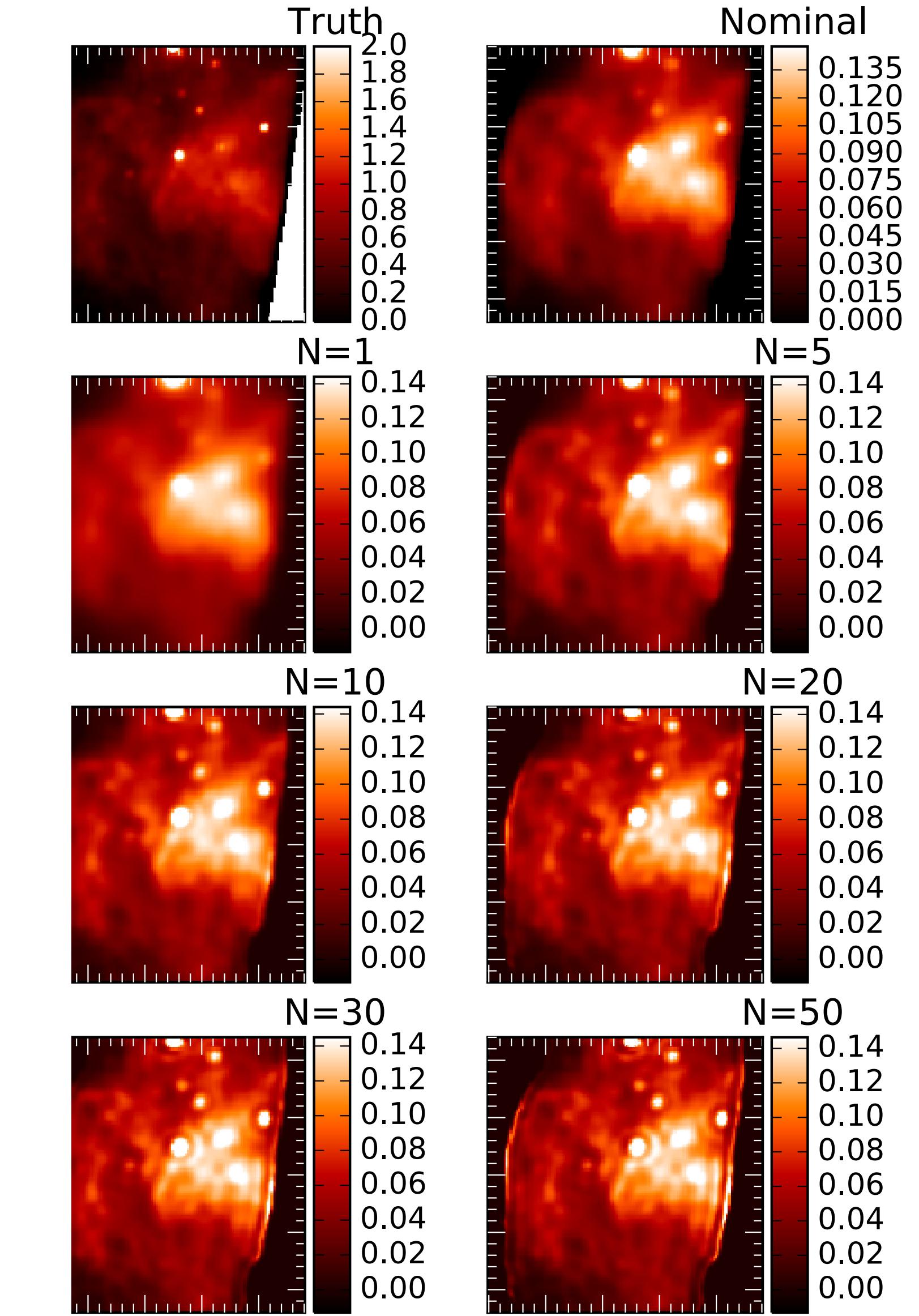
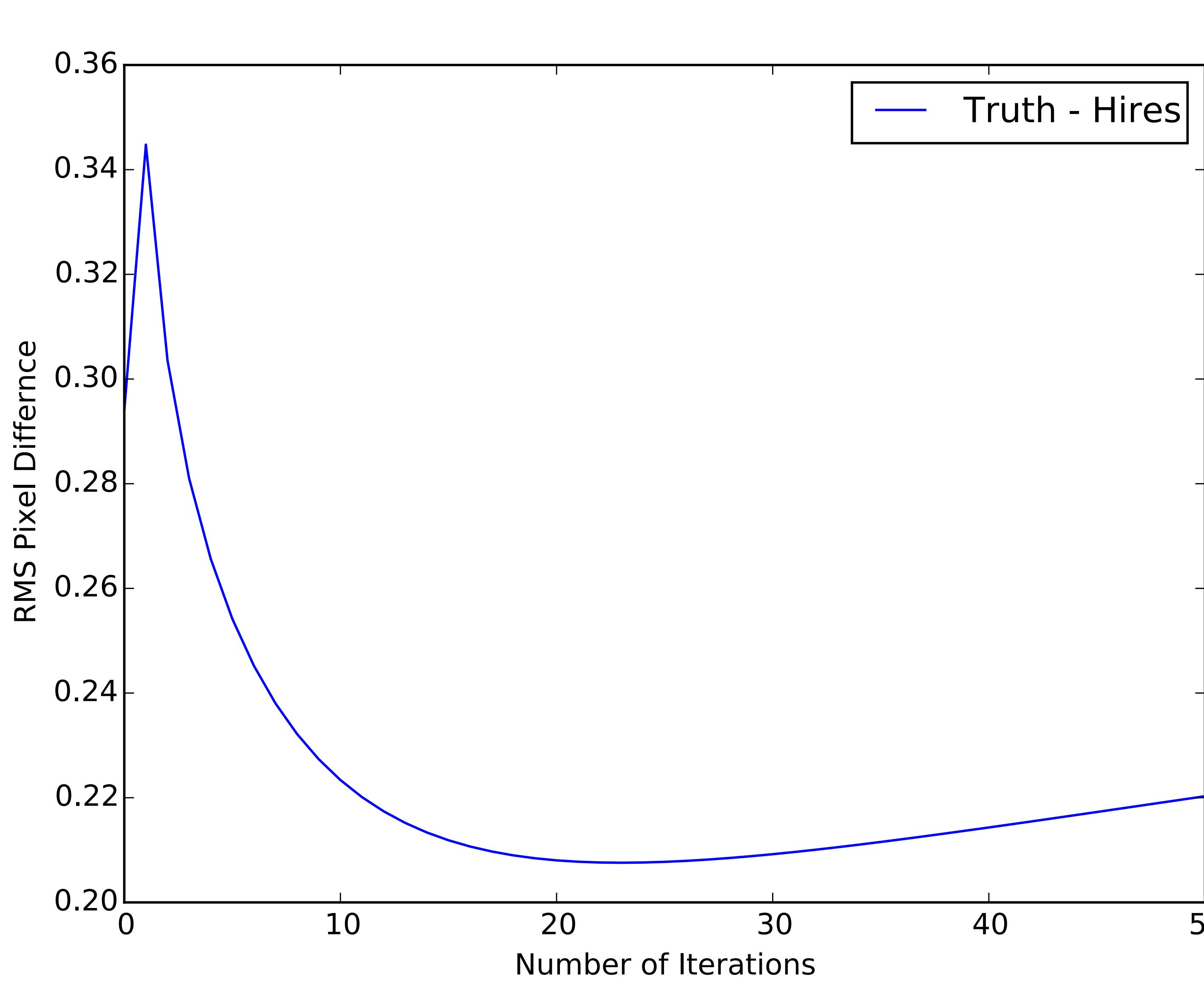
Testing against a Truth Image

- Uses Spitzer 24um data as truth source (convolved with theoretical 2x resolution SPIRE beam)
- Same procedure as my project work
- Looking at RMS pixel difference from a truth image as a function of number of iterations
- Expect to see a minima at the best number of iterations to use

Obsid: 1342185538 (Just fails Threshold Test - Low SNR)



Obsid: 1342249237 (Passes Threshold Test - High SNR)



- Current default is 20 iterations
- For the low SNR this seems to be too high, but as these are excluded from HiRes anyway then not a problem
- For higher SNR maps the minima is at about 21-22, so 20 seems like a sensible iteration number that wont introduce too many artefacts.
- There is a large stable region from about 15-30 iterations where there is no significant difference to the image
- Starting to see visible ringing at high iterations

Recommendations

- The default beam sizes seem appropriate, going smaller could be risky but using larger beams gives no benefit at the expense of significant processing time increase
- There is no significant difference between using the fine beam or one created by linearly interpolating the radial beam profile - could also go to a cubic spline interpolation for slight improvement
- The current default iterations is reasonable. It may be that for very high signal maps this will want to be increased, and it could be possible to include other lower signal observations simply by running HiRes with a lower iteration count
- Using the thresholds picked here a list of observation ids will be generated that can be used in the pipeline. This list can then be altered for edge cases where appropriate