

Superdeblending Manual

(GOODS-North)

December 28, 2015

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1 Abstract

This is the manual for the super-deblending photometry. We describe our method and procedures at each wavelength band, and record the latest notes and unsolved issues.

Hints: black text are our method and procedures, [blue text are notes](#), and [red text are unsolved issues](#).

2 Dashboard

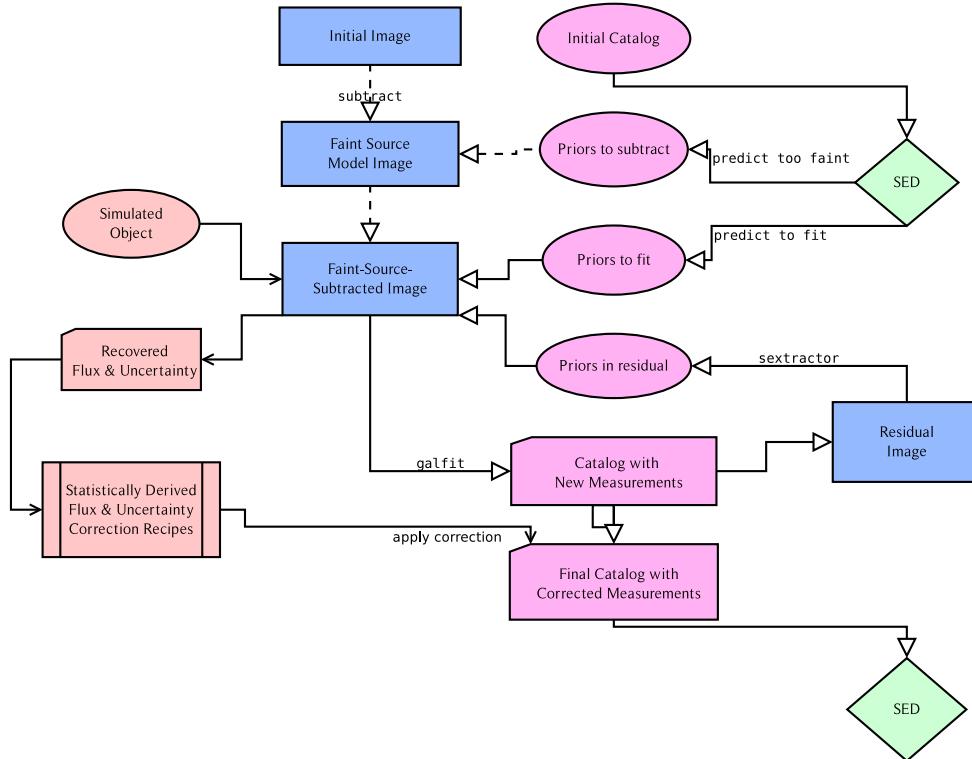


Figure 1: Flow chart diagram

Processing: Initial Catalog → SED → predict → subtract → galfit → residual → simulation → statistical corrections → final catalog and SED.

Band	SED	Predict	Subtract	Galfit	Residual	Galsim	Correct	Final
	1	2	3	4	5	6	7	8
100	[3.1]	[3.2]	[3.3]	[3.4]	[3.5]	[3.6]	[3.7]	[x]
160	[4.1]	[??]	[4.3]	[4.4]	[4.5]	[4.6]	[4.7]	[x]
250	[5.1]	[5.2]	[5.3]	[5.4]	[5.5]	[5.6]	[5.7]	[x]
350	[6.1]	[6.2]	[6.3]	[6.4]	[6.5]	[6.6]	[6.7]	[x]
500	[7.1]	[7.2]	[7.3]	[7.4]	[7.5]	[7.6]	[7.7]	[x]
1160	[8.1]	[8.2]	[8.3]	[8.4]	[8.5]	[8.6]	[8.7]	[x]

Table 1: Status of Processing

3 Band 100

3.1 SED fitting before band 100

The SED fitting at this step includes these bands:

- K_s
- IRAC 3.6, 4.5, 5.8, 8.0
- IRS PUI 16, MIPS 24
- VLA 1.4 GHz (hereafter radio)

The SED fitting uses the following 3 parameters for better fitting of the SEDs:

- Type_AGN: radio loud AGN, $(f_{radio} - f_{SED}) > 3 \times \sqrt{\sigma_{f_{radio}}^2 + \sigma_{f_{SED}}^2}$
- Type_SED: pure starburst, $SFR_{SED} > 6 \times SFR_{MS}$
- Type_FIR: high FIR S/N ratio, $\sqrt{SNR_{100}^2 + \dots + SNR_{1160}^2} > 10$

But at this step, we do not have any prior information about these Type_ parameters. Therefore, we run a trial SED fitting without any Type_ parameter, and use the output to do the Type_AGN and Type_SED classifications:

- Type_AGN: 85 out of 3306 sources are classified as radio loud AGN, for which we will not fit their radio data points.
- Type_SED: 46 out of 3306 sources are classified as pure starburst (hereafter SB), for which we will use only SB type SED templates. 1011 out of 3306 sources are classified as pure main-sequence (hereafter MS), for which we will use only MS type SED templates.

Applying these Type_ parameters, we run the SED fitting again, and use the results for the next step SED prediction. Additionally, we update the Type_ parameters, but do not repeat a third fitting for now.

- Type_AGN: 205 radio AGNs, 3306 in total.
- Type_SED: 41 pure SB, 891 pure MS, 3306 in total.
 - Comparing to the trial step SED fitting: applying Type_AGN leads to lower SED best fitting SFR and S/N ratio for some radio AGNs, therefore their Type_SED changed from pure MS to unclassified.
 - Code update: 2015-12: introduced a new parameter Type_FIR, but this parameter is not determined from SED fitting results but the galfit photometry results. This parameter will be used since the SED fitting before band 160, but not current step before band 100.

3.2 SED prediction for band 100

We use SED best fitting flux and uncertainty at band 100 as the predicted values to flag faint sources. We set a $(f + 2\sigma_f)$ cut f_{cut} , so that brighter or larger uncertainty sources will be kept while fainter and better constrained sources will be flagged and subtracted. A Type_FIT parameter is determined for each source from the SED best fitting results:

- Type_FIT: fit at current band, $(f_{SED} + 2\sigma_{f_{SED}})/crowdiness > f_{cut}$
- DONE: 2015-12: I'm thinking about a crowdiness-dependent way to flag sources, so that if a source is relatively isolated, we can use a lower f_{cut} which tends to keep it for fitting, while a source is in a relatively blended environment, we can use a higher f_{cut} so that it tends to be flagged out. The inequation thus becomes $(f_{SED} + 2\sigma_{f_{SED}})/crowdiness \geq f_{cut}$.
- NOTE: 2015-12: The "crowdiness" property of a prior source is the sum of the Gaussian-type weights of all surrounding sources including the source itself:

$$crowdiness_i = \sum_{j=1}^N e^{-4 \ln 2 \cdot ((RA_j - RA_i)^2 + (Dec_j - Dec_i)^2) / (\text{FWHM})^2}$$
- DONE: 2015-12: I have computed the "crowdiness" values using this equation, and with proper FWHM values as recorded in "goFine.sm" and "astroPhot.sm". Note that the computations before were normalized to arbitrary value and were not using proper FWHM at each band.

With different f_{cut} , the number of faint sources that are flagged out changes, and the number of sources kept for fitting also changes as a function of f_{cut} . Dividing the number of sources by the PSF beam area: $A_{PSF} = \pi / (4 \ln 2) \cdot \text{FWHM}^2$, the density of sources for fitting (ρ_{fit}) can be derived. We decide the best f_{cut} value by ensuring that ρ_{fit} is not larger than 1 source per beam, so that the photometry performance can be improved.

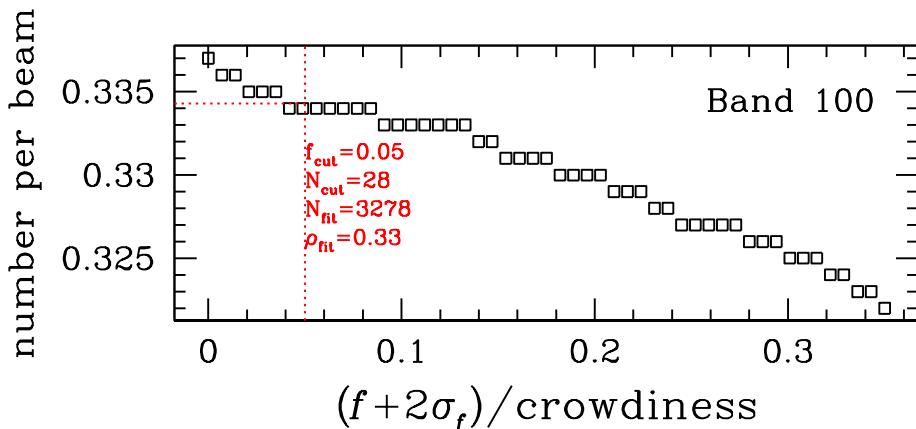


Figure 2: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 100. ρ_{fit} is small at band 100, therefore even without flagging out any sources, the photometry performance can still be good. But we still decide to set a very low f_{cut} to flag out a few sources that are predicted to be too faint or in too crowded environment.

We use a $f_{cut} = 0.05$ at band 100, which leads to:

- Type_FIT: 3280 out of 3306 sources will be used as prior sources at band 100, while 26 out of 3306 sources are flagged out, which will be not used as prior sources but whose flux will be subtracted from the observed image. *obsolete!*
- Type_FIT: 3278 out of 3306 sources will be used as prior sources at band 100, while 28 out of 3306 sources are flagged out, including ID 14834 and 13731.
 - DONE: 2015-12: If crowdiness is used for the flagging $(f_{SED} + 2\sigma_{f_{SED}})/crowdiness \geq f_{cut}$, then we have 28 out of 3306 flagged out, i.e. two more faint sources: ID 14834 (spec-z 0.202) and 13732 (spec-z 0.079). I have checked that 13732 has a very nearby source 13731, whose old version SED had a bad χ^2 , i.e. 100 and 160 measurements were too low while 250 was much higher than the SED best fit. The new flagging will flag out 13732 since band 100, therefore will likely lead to much better SED of 13731.
 - DONE: 2015-12: Now we use $(f_{SED} + 2\sigma_{f_{SED}})/crowdiness > f_{cut}$ as the criterion to flag out too faint sources.

3.3 Faint flux subtraction at band 100

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```

1 ./do_Galsub 100 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand100.txt \
3 -fitsname pg_h_goodsn_green_Map_v1.0_sci_DL.fits \
4 -sedpredict SED_predictions_100_201512.txt

```

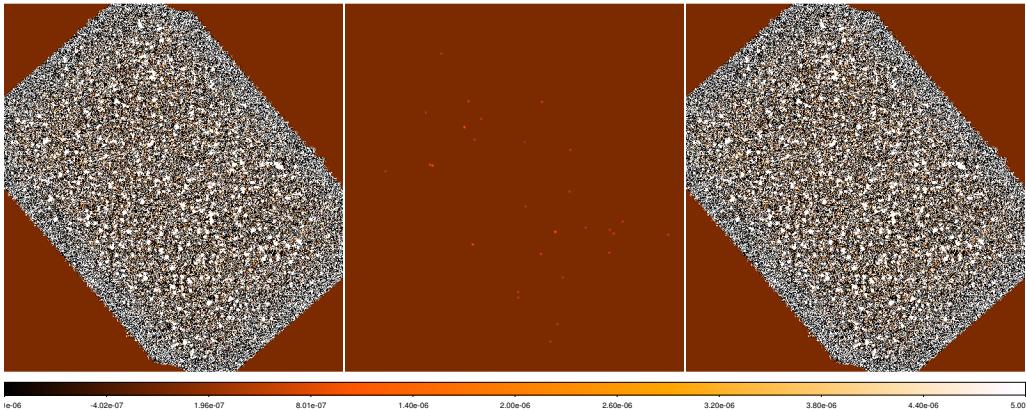


Figure 3: Faint-source subtraction step at band 100. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- Note: Remember to set Xback=0 and fbias=0 while doing the faint-source subtraction.

3.4 Galfit photometry at band 100

We use supermongo code + galfit software to do the prior source fitting photometry.

We use the sky background value based on previous simulation results.

We correct astrometry when needed. For the PACS 100 and 160 images from PEP project, no additional astrometry needs to be corrected.

But for PACS 100 and 160 images, the flux measurements need high-pass filtering correction:

- If $f_{24} > 60$ and $S/N_{24} > 3$, we multiply a factor $\times 1.12$ to the measured flux, otherwise $\times 1.19$.

◦ Note: See "AGN_N.sm".

◦ Note: Flux bias: Previously we were using a constant flux bias at band 100, 160 and 1160, while a non-linear σ_f -dependent flux bias at band 250, 350 and 500. Now we decide to fully use Monte-Carlo simulation to derive non-linear correction recipes for flux bias correction. See next part.

◦ Note: Sky background: we have verified that median input minus measured very close to zero.

◦ Confirmed: For the PACS 100 and 160 images from PEP project, no additional astrometry needs to be corrected.

3.5 Residual image at band 100

We found no obvious additional source from the residual image of band 100.

3.6 Monte-Carlo simulation at band 100

We simulate one source at each time, and add its PSF-modeled image to the real observed image. Then all sources not flagged out (Type_FIT=1) are fitted together with the simulated source, and we record the recovered flux and flux uncertainty for the simulated source. The simulated flux, or the input flux S_{in} , are compared to the recovered flux, or the output flux S_{out} and the recovered flux uncertainty $\sigma_{S_{out}}$.

We repeat the procedure 6000 times, so that we have 6000 pairs of S_{in} , S_{out} , and $\sigma_{S_{out}}$. Statistical analyses are in the following section.

3.7 Flux bias and flux uncertainty correction

In one aspect, statistically, the differences between S_{in} and S_{out} should have a mean of 0. Any non-zero mean of the differences $\langle(S_{in} - S_{out})\rangle$ is indicating that there have flux bias in the photometry procedure.

In another aspect, statistically, the flux uncertainty $\sigma_{S_{out}}$ should be consistent with the dispersion of $(S_{in} - S_{out})$. In another word, $(S_{in} - S_{out})/\sigma_{S_{out}}$ should have a shape of Gaussian distribution and a dispersion (Gaussian width $\sigma_{Gaussian}$) of 1.0.

Based on the above two criterion, we can correct both S_{out} and $\sigma_{S_{out}}$. In the simplest way, we can derive a constant flux bias by taking the mean (TODO: or median?) $S_{bias} = \langle(S_{in} - S_{out})\rangle$, and derive a constant flux uncertainty factor by taking the dispersion $corr_{\sigma_{S_{out}}} = \sigma_{((S_{in}-S_{out})/\sigma_{S_{out}})}$. However, after the simplest corrections, we find that $\sigma_{S_{out}}$ are still not good enough to match the input and output flux $(S_{in} - S_{out})$ in some individual cases, where the simulated sources either have very high $\sigma_{S_{out}}$, or left over imperfect residual, or are in too crowd fields.

Therefore, more sophisticated recipes are analyzed here. (TODO: descriptions.)

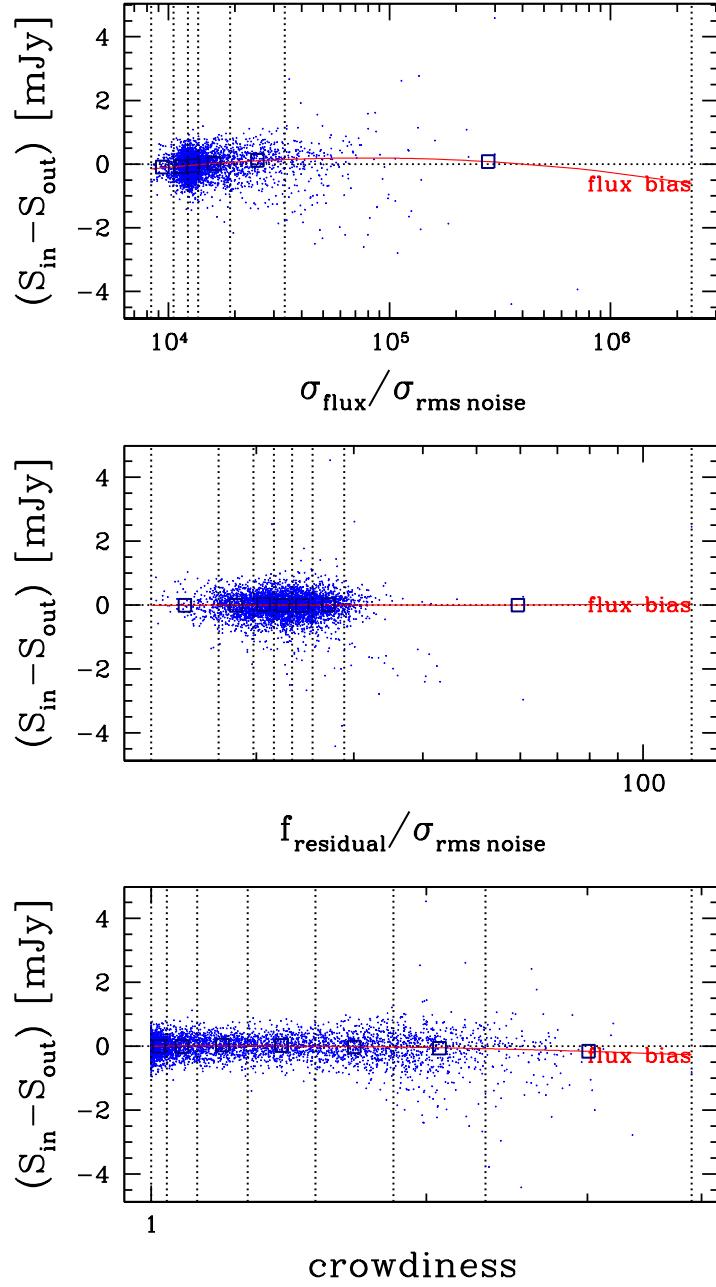


Figure 4: (TODO: Band 100 flux bias correction plots:)

- Note: Flux bias corrections: In the plots, the blue data points are uncorrected, while the red ones are corrected. The dashed curve is the flux bias values, which are around 0. A lower than 0 flux bias means that we correct flux bias to be smaller, vice versa.
- Note: Flux bias corrections: Seems the flux bias are very small at band 100. Slightly non-linear trend can be found correlating to $\sigma_{\text{flux}} / \sigma_{\text{rms noise}}$.

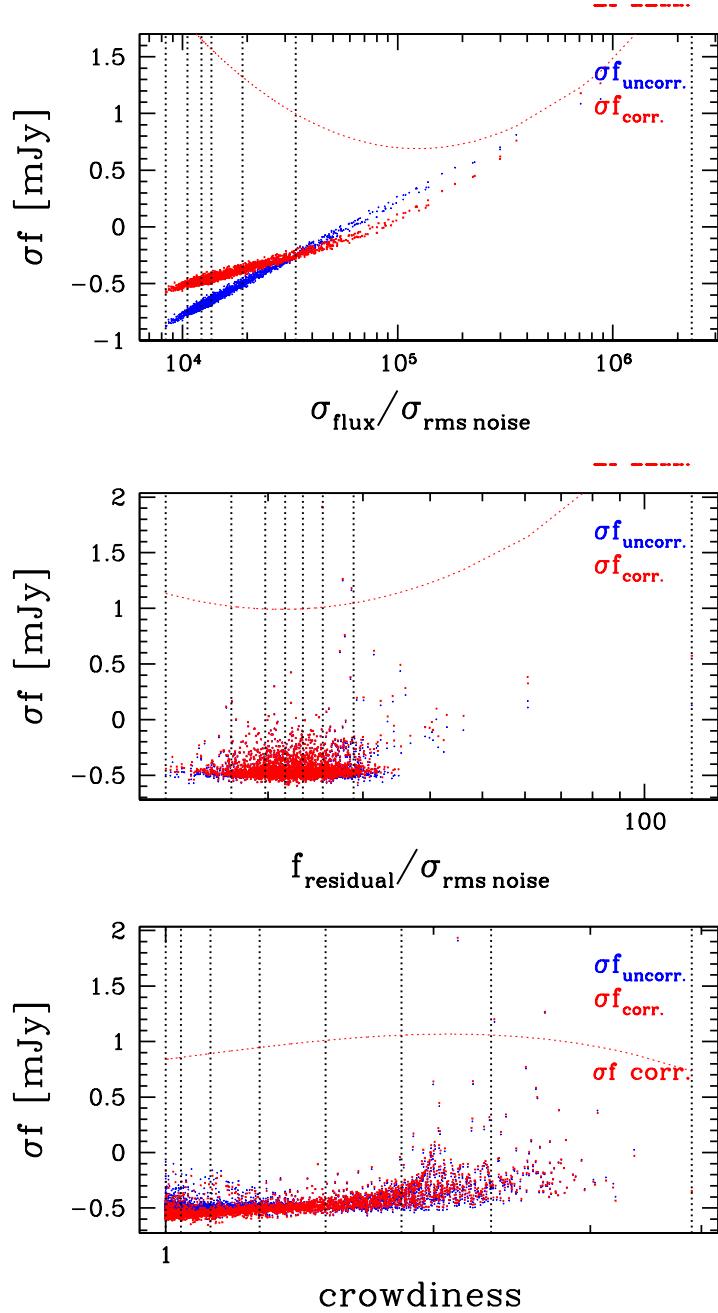


Figure 5: (TODO: Band 100 flux uncertainty correction plots:)

- Note: Flux uncertainty corrections: In the plots, the blue data points are uncorrected, while the red ones are corrected. The dashed curve is the correction factor values, which are around 1. A lower than 1 corr. factor means that we correct flux uncertainty to be smaller, vice versa.
- Note: Flux uncertainty corrections: Seems performing well. The correlation of $\sigma f_{corr.}$ correction factor with $f_{residual}$ is not as prominent as the other two parameters, but it might have stronger correlation at longer wavelength bands.

4 Band 160

4.1 SED fitting before band 160

At this step, we have obtained new flux measurements and flux uncertainty are band 100. Therefore the SED fitting at this step includes:

- K_s
- IRAC 3.6, 4.5, 5.8, 8.0
- IRS PUI 16, MIPS 24
- PACS 100 *new!*
- VLA 1.4 GHz (hereafter radio)

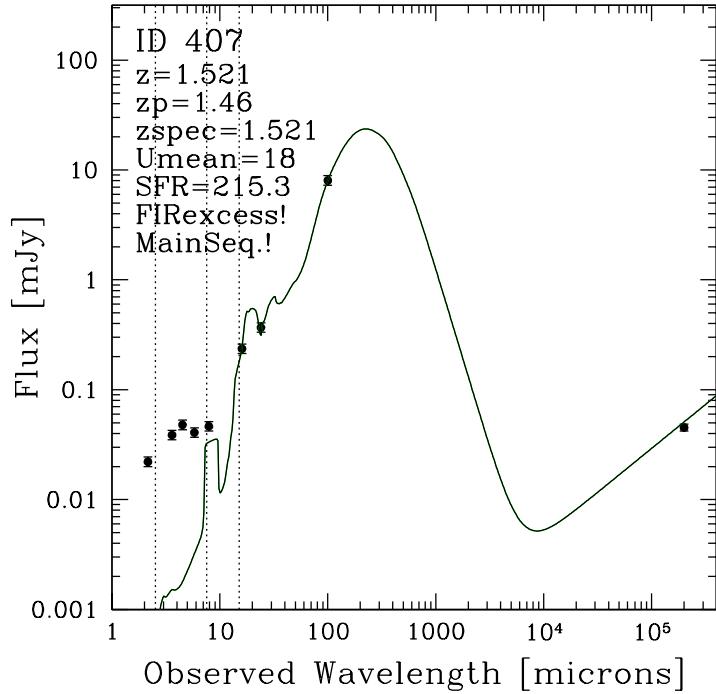
The SED fitting uses the 3 aforementioned parameters, two of which have already been determined in the step ??:

- Type_AGN: 205 radio AGNs, out of 3306 sources in total.
- Type_SED: 41 pure SB, 891 pure MS, out of 3306 sources in total.

The 3rd parameter is Type_FIR, which defines whether the SED will use only FIR (100-1160) data points or not. At this step, the Type_FIR parameter needs band 100 flux measurements to determine:

- Type_FIR: If $SNR_{100} \geq 5$, we fit only FIR data points (i.e. only 100 at this step). While $SNR_{100} < 5$, we fit all data points (but radio depends on Type_AGN).
 - DONE: 2015-12: Implement SED fitting code, that when Type_FIR=1, we mask the non-FIR data points by setting the uncertainty values to 10^{10} , but we still show their measured data points in the SED fitting plot.
 - DONE: 2015-12: edaddi: This might be too stringent. We might use ≥ 5 as a limit, which should be enough to consider the IR as detected by itself.

Following are two examples of Type_FIR=1 SEDs:



- DONE: 2015-12: Found bug in flux residual measuring, which affects the band 100 simulation step. I have redone from that step.
- DONE: 2015-12-21: Found bug in reading the SED prediction file, which affects the band 100 photometry step. I have redone from that step.
- DONE: 2015-12-22: Found bug in supermongo! The supermongo on planer produces different SED best fitting PDF plots, but consistent SED best fitting text files. This is likely because the supermongo on planer was compiled with "float" type, while on my local PC it was compiled with "double" type. Now I have recompiled supermongo on planer, and the new plots look consistent. The SED best fitting text files seem consistent with my PC results, so no need to redo text files. Therefore, we must follow the same compiling procedure for supermongo as listed in Section B.

4.2 SED prediction for band 160

With the best fitting flux at 160um, we can determine which sources to fit and band 160 and which to be flagged out and subtracted:

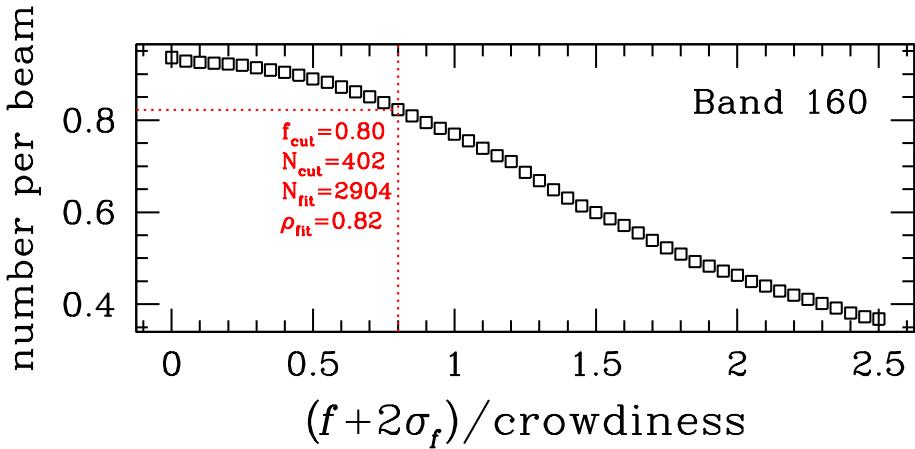


Figure 6: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 160. ρ_{fit} is small at band 160, but we still decide to set a very low f_{cut} to flag out a few sources that are predicted to be too faint or in too crowd environment.

- Type_FIT: $(f_{SED,160} + 2\sigma_{f_{SED,160}}/crowdiness) \geq 0.80$, 2904 sources will be fit while 402 sources be flagged out.

4.3 Faint flux subtraction at band 160

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```

1 ./do_Galsub 160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
3 -fitsname pg_h_goodsn_red_Map_v1.0_sci_DL.fits \
4 -sedpredict SED_predictions_160_201512.txt

```

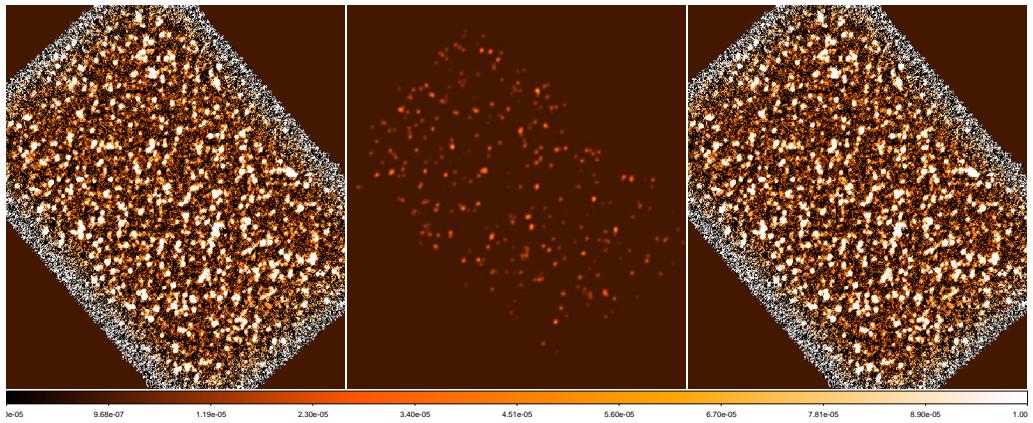


Figure 7: Faint-source subtraction step at band 160. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- Note: Remember to set Xback=0 and fbias=0 while doing the faint-source subtraction.

4.4 Galfit photometry at band 160

```

1 ./do_Galfit 160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
3 -fitsname pgf_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
4 -sedpredict SED_predictions_160_201512.txt
5 # then run scripts in parallel
6 cd boxgalfit; do_GalfitRunqsub
7 cd ..
8 # then run postparallel process
9 ./do_Galfit 160 201512 \
10 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
11 -fitsname pgf_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
12 -sedpredict SED_predictions_160_201512.txt \
13 -postparallel

```

```

1 ./do_Galfit 160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
3 -fitsname pgf_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
4 -sedpredict SED_predictions_160_201512.txt \
5 -vary
6 # then run scripts in parallel
7 cd boxgalfit_vary; do_GalfitRunqsub
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 160 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
12 -fitsname pgf_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
13 -sedpredict SED_predictions_160_201512.txt \
14 -vary -postparallel

```

4.5 Residual image at band 160

```

1 cd run.sextractor_160/
2 idl -e 'do_SExtract_Mask, \
3 FitsFile="FIT_goodsn_160_Map_201512.fits", \
4 RmsFile="pgf_goodsn_red_Map_v1.0_rms_DL.fits"'
5 vim default.sex # set sigma thresholds
6 sex SExtractor_Signal.fits
7 # then write additional residual source catalog
8 # with supermongo code do_sextract_result.sm
9 gedit do_sextract_result.sm
10 ...
11 define band 160
12 set catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt"}
13 set rmsfits24 = {"n_mips_1_s1_v0_37_rms_ED.fits"}
14 set catalogadd = {"Residual_priors_v6_Band160.txt"}
15 ...

```

```

16 print $(catalogadd) '%-9.0f %12.7f %12.7f %9g\n' \
17 {_id _ra _de zp_X f24 df24 f16 df16 f100 df100 \
18 radio eradio _fch1 _dfch1 _fch2 _dfch2 _fch3 _dfch3 _fch4 _dfch4 \
19 KtotX MassX distX spezX zq source distz idz goodArea}
20 ...
21 macro read do.sextract_result.sm go

```

(TODO: Put Residual Images Here!)

Then run a second pass 4.4:

```

1 ./do_Galfit 160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
3 -catalog-add Residual_priors_v6_Band160.txt \ # new!
4 -fitsname pg_h_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
5 -sedpredict SED_predictions_160_201512.txt
6 # then run scripts in parallel
7 cd boxgalfit; do_GalfitRunqsub
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 160 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
12 -catalog-add Residual_priors_v6_Band160.txt \ # new!
13 -fitsname pg_h_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
14 -sedpredict SED_predictions_160_201512.txt \
15 -postparallel

```

4.6 Monte-Carlo simulation at band 160

```

1 # first estimate simulating flux or magnitude range
2 sm
3 load astroPhot.sm
4 convert_flux2mag goodsn 160 0.40 1.0 # 1σ 0.43mJy mag=9
5 convert_flux2mag goodsn 160 12.0 1.0 # 30σ 12mJy mag=5.2
6 # then run simulation code
7 ./do_Galsim 160 20151201 \
8 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt \
9 -fitsname pg_h_goodsn_red_Map_v1.0_sci_subfaintDL.fits \
10 -sedpredict SED_predictions_160_201512.txt \
11 -fitincl \
12 -mag0 5.2 -mag1 9 -nsim 6000

```

4.7 Flux bias and flux uncertainty correction

```
1 macro read run_simu_stats_v6.sm run_simu_stats_v6 160
```

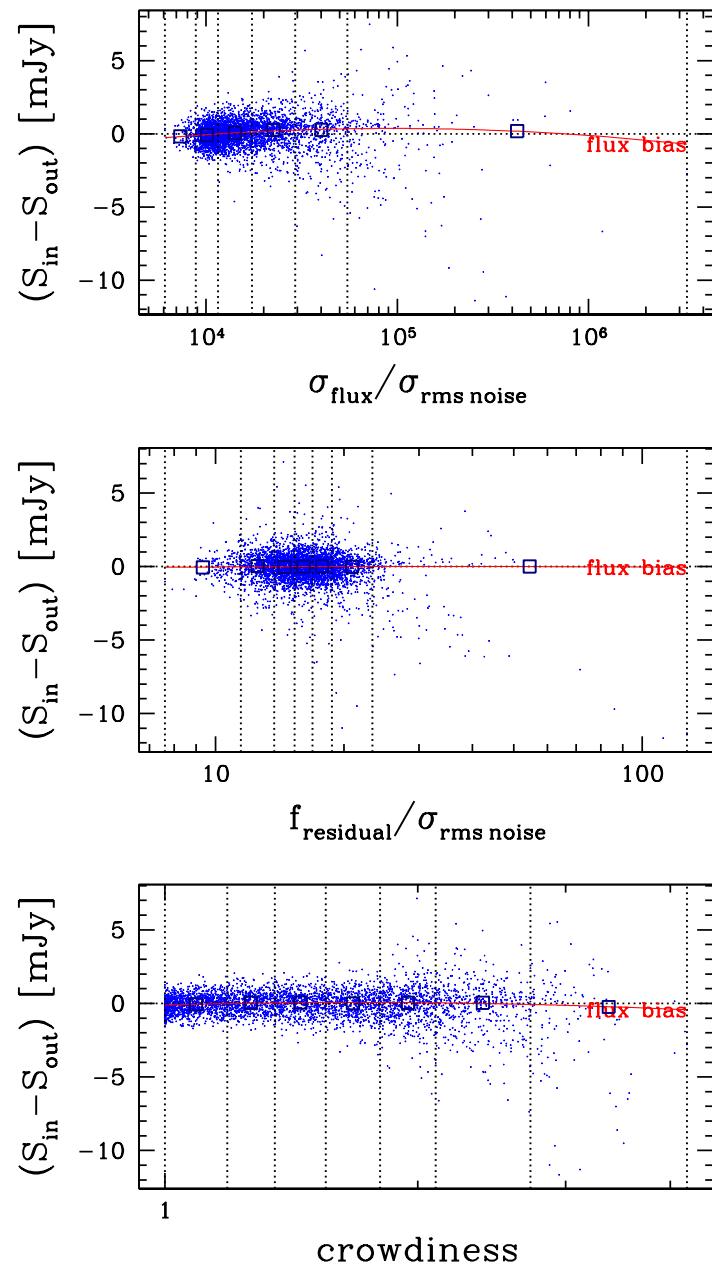


Figure 8: (TODO: Band 160 flux bias correction plots:)

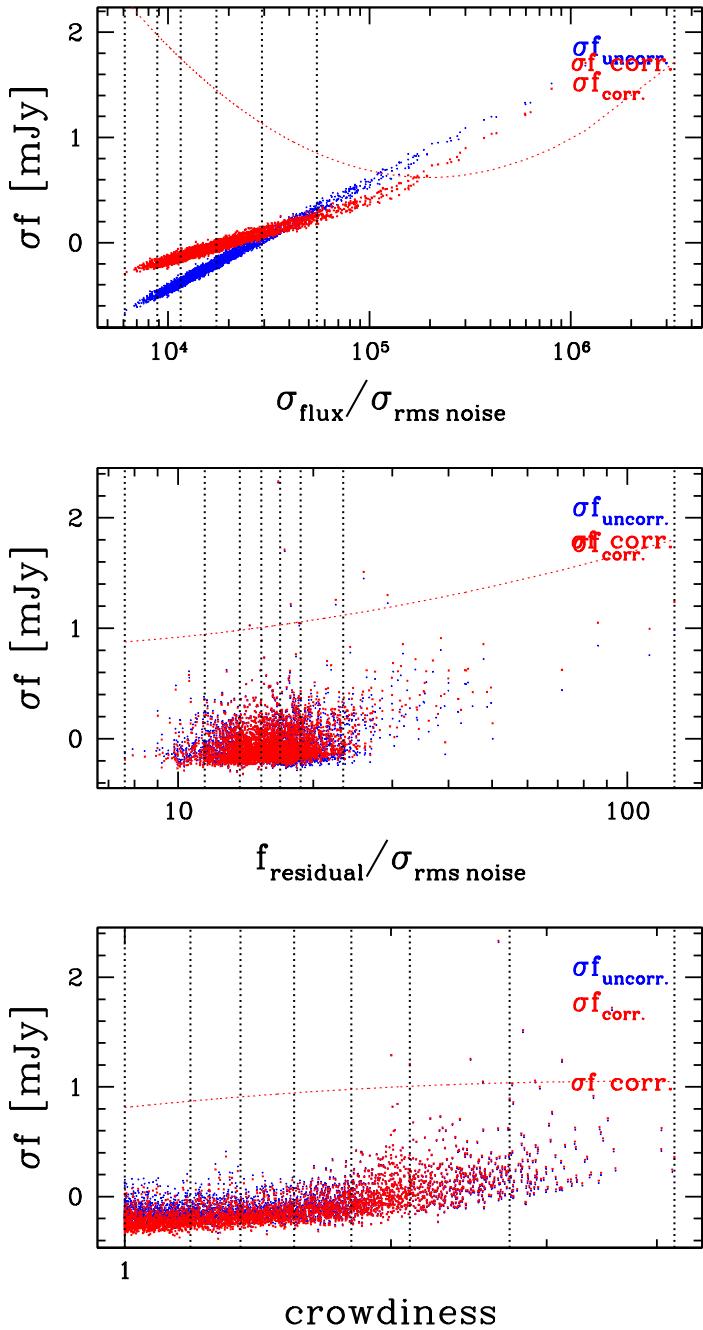


Figure 9: (TODO: Band 160 flux uncertainty correction plots:)

4.8 Update catalog with the measurements of band 160

```

1 gedit run_simu_stats_v6.sm
2 define imax 160
3 define xdate_galsed 201512
4 define xdate_galfit 201512
5 define xdate_galsim 20151201
6 define xpath_galsed "Galsed_BeforeBand$imax"_Pass1"
7 define xpath_galfit "Galfit_Band$imax"_Pass2"

```

```
8 define xpath_galsim "Galsim_Band"$imax"_Pass1"
9 set old_catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand160.txt"}
10 set new_catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt"} \
11 # found fres -- simu.fits[2] error in previous data, \
12 # now corrected to [3]. redone Galsim statistics.
13 set add_catalog = {"Residual_priors_v6_Band160.txt"}
14 sm
15 macro read run_update_catalog_v6.sm run_update_catalog_v6
```

5 Band 250

5.1 SED fitting before band 250

Firstly, we use the Type_AGN and Type_SED determined in 4.1:

- Type_AGN: more radio loud AGNs now. Numbers TODO.
- Type_SED: more MS now. Numbers TODO.

Then we determine Type_FIR with the latest 160 measurements:

- Type_FIR: $\sqrt{SNR_{100}^2 + SNR_{160}^2} \geq 5$: 940 out of 3320 sources will be fit with only FIR data points. This includes 1 additional residual source.

Then, **do not forget** to append zeros to coo_AGN and coo_SED files for those additional residual sources! Here we have 14 of them, and we set all of their Type_AGN and Type_SED to 0, because they do not have radio data point, nor stellar mass measurement.

5.2 SED prediction for band 250

```

1 cd Galsed_BeforeBand250_Pass2/do_Type_FIT
2 gedit do_Type_FIT.sm
3 define band 250
4 define fcut$band 1.63
5 define fmax$band 6.0
6 set catalog = {"./RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt"}
7 set sedpredict = {"./ResLMTfluxes_priors_v6_20151221_BeforeBand250.txt"}
8 macro read do_Type_FIT.sm go
9 Total source number: 3320
10 Fitting source number: 1528
11 Subtract source number: 1792

```

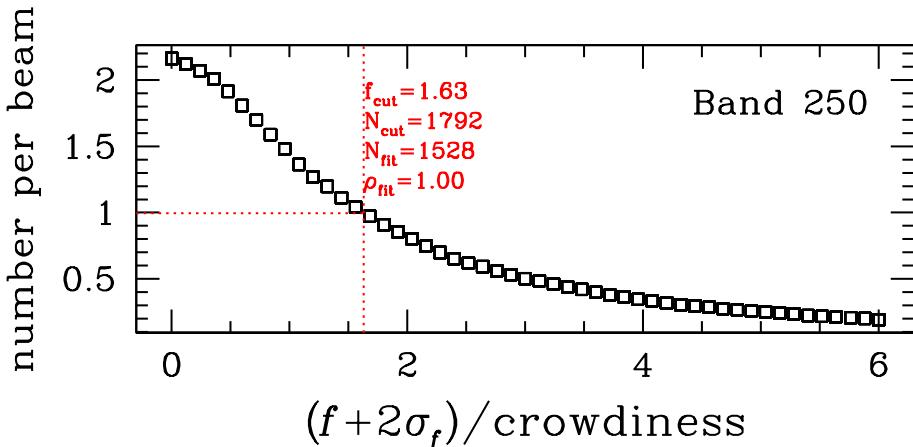


Figure 10: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 250.

5.3 Faint flux subtraction at band 250

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```
1 ./do_Galsub 250 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
3 -fitsname spire250_ima_3p6_v0_100615.fits \
4 -sedpredict SED_predictions_250_201512.txt
```

Figure 11: Faint-source subtraction step at band 250. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- Note: Remember to set `Xback=0` and `fbias=0` while doing the faint-source subtraction.

5.4 Galfit photometry at band 250

```
1 ./do_Galfit 250 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
3 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
4 -sedpredict SED_predictions_250_201512.txt
5 # then run scripts in parallel
6 cd boxgalfit; do_GalFitRunqsub
7 cd ..
8 # then run postparallel process
9 ./do_Galfit 250 201512 \
10 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
11 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
12 -sedpredict SED_predictions_250_201512.txt \
13 -postparallel
```

5.5 Residual image at band 250

```
1 cd run.sextractor_250/
2 idl -e 'do_SExtract_Mask, \
3 FitsFile="FIT_goodsn_250_Map_201512.fits", \
4 RmsFile="spire250_rms_3p6_v0_100615.fits"'
5 vim default.sex # set sigma thresholds
6 sex SExtractor_Signal.fits
7 # then write additional residual source catalog
8 # with supermongo code do_sextract_result.sm
9 gedit do_sextract_result.sm
10 ...
11 define band 250
12 set catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt"}
13 set rmsfits24 = {"n_mips_1_s1_v0_37_rms_ED.fits"}
14 set catalogadd = {"Residual_priors_v6_Band250.txt"}
```

```

15 ...
16 print $(catalogadd) '%-9.0f %12.7f %12.7f %9g\n' \
17 {_id _ra _de zp_X f24 df24 f16 df16 f100 df100 f160 df160 \
18 radio eradio _fch1 _dfch1 _fch2 _dfch2 _fch3 _dfch3 _fch4 _dfch4 \
19 KtotX MassX distX spezX zq source distz idz goodArea}
20 ...
21 macro read do_sextract_result.sm go

```

(TODO: Put Residual Images Here!)

Then run a second pass 5.4:

```

1 ./do_Galfit 250 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
3 -catalog-add Residual_priors_v6_Band250.txt \ # new!
4 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
5 -sedpredict SED_predictions_250_201512.txt \
6 # then run scripts in parallel
7 cd boxgalfit; do_GalfitRunqsub
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 250 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
12 -catalog-add Residual_priors_v6_Band250.txt \ # new!
13 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
14 -sedpredict SED_predictions_250_201512.txt \
15 -postparallel

```

5.6 Monte-Carlo simulation at band 250

```

1 # first estimate simulating flux or magnitude range
2 sm
3 load astroPhot.sm
4 convert_flux2mag goodsn 250 1.90 1.0 # 250um 1-sigma 1.98mJy -> mag=3.069
5 convert_flux2mag goodsn 250 57.0 1.0 # -> mag=-0.62
6 # then run the simulation code
7 ./do_Galsim 250 20151201 \
8 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
9 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
10 -sedpredict SED_predictions_250_201512.txt \
11 -fitincl -mag0 -0.62 -mag1 3.07 -nsim 6000
12 ./do_Galsim 250 20151201 \
13 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt \
14 -fitsname spire250_ima_3p6_v0_100615_subfaintDL.fits \
15 -sedpredict SED_predictions_250_201512.txt \
16 -fitincl -mag0 -0.62 -mag1 3.07 -nsim 6000 \
17 -postparallel

```

5.7 Flux bias and flux uncertainty correction

```

1 gedit run_simu_stats_v6.sm
2 sm
3 macro read run_simu_stats_v6.sm run_simu_stats_v6 250

```

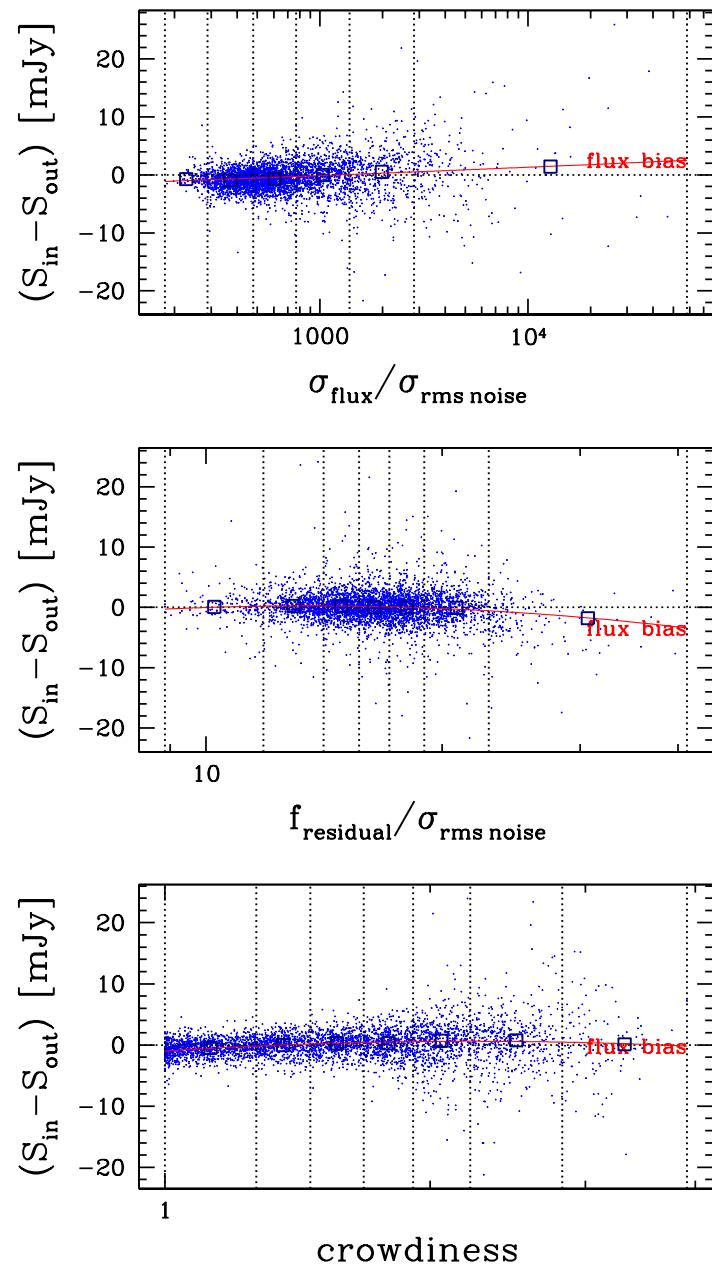


Figure 12: (TODO: Band 250 flux bias correction plots:)

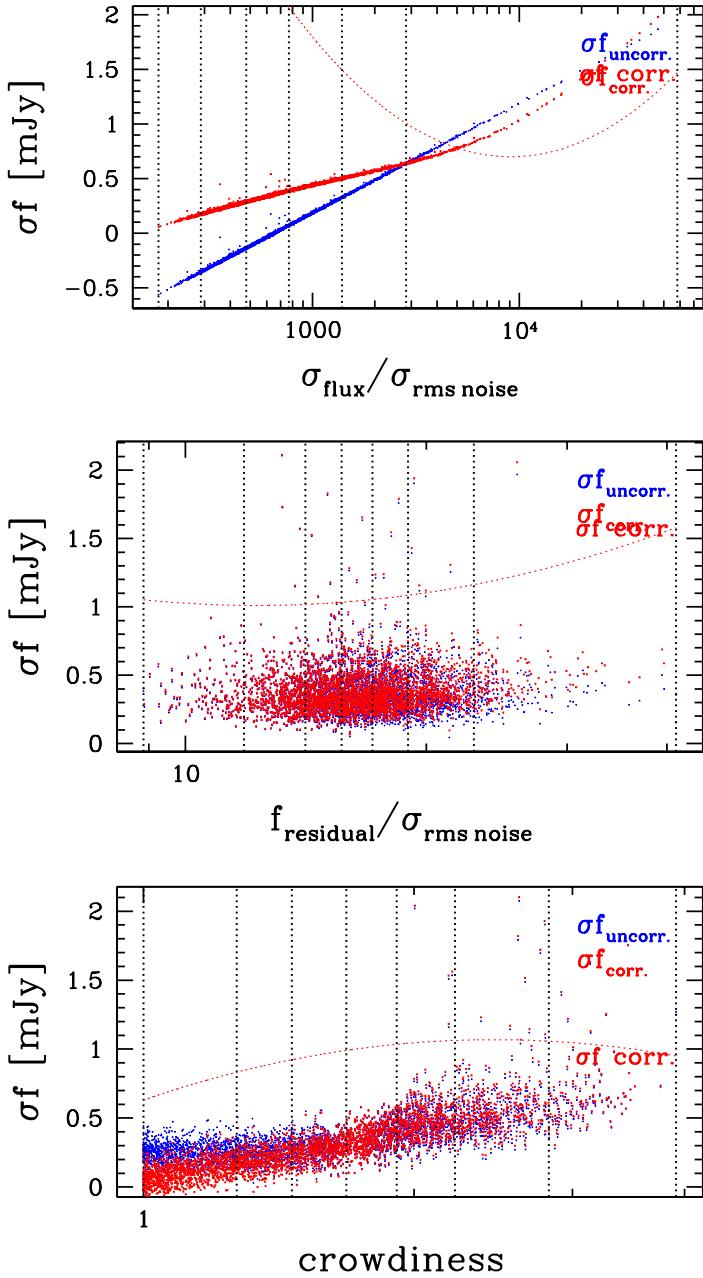


Figure 13: (TODO: Band 250 flux uncertainty correction plots:)

5.8 Update catalog with new corrected measurements

```

1 gedit run_update_catalog_v6.sm
2 define xdate_galsed 201512
3 define xdate_galfit 201512
4 define xdate_galsim 20151201
5 define xpath_galsed "Galsed_BeforeBand"$imax"_Pass2"
6 define xpath_galfit "Galfit_Band"$imax"_Pass2"
7 define xpath_galsim "Galsim_Band"$imax"_Pass1"
8 set old_catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand250.txt"}
9 set new_catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt"} 
```

```
10 set add_catalog = {"Residual_priors_v6_Band250.txt"}  
11 sm  
12 macro read run_update_catalog_v6.sm run_update_catalog_v6 250
```

6 Band 350

6.1 SED fitting before band 350

Firstly, we use the Type_AGN and Type_SED determined in 5.1:

- Type_AGN: more radio loud AGNs now. Numbers TODO.
 - Type_SED: more MS now. Numbers TODO.
- Note: do not forget to append zeros for additional sources found in the residual image of 250.

Then we determine Type_FIR with the latest 250 measurements:

- Type_FIR: $\sqrt{SNR_{100}^2 + SNR_{160}^2 + SNR_{250}^2} \geq 5$: 1047 out of 3334 sources will be fit with only FIR data points. This includes the additional residual sources found on 160 and 250 residual images.

Run SED fitting code on planer:

```
1 scp Galsed_BeforeBand350_Pass1_BeforeFitting_20151223.tar.gz \
2 dliu@hubble.extra.cea.fr:/dsm/upgal/data/dliu/daddi_goodsn_2015/
3 cd /dsm/upgal/data/dliu/daddi_goodsn_2015/Galsed_BeforeBand350_Pass1/
4 ./do_GalsedRunqsub
```

6.2 SED prediction for band 350

```
1 cd Galsed_BeforeBand350_Pass2/do_Type_FIT
2 gedit do_Type_FIT.sm
3 define band 350
4 define fcut$band 1.55
5 define fmax$band 6.0
6 set catalog = {"./RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt"}
7 set sedpredict = {"./ResLMTfluxes_priors_v6_20151221_BeforeBand350.txt"}
8 macro read do_Type_FIT.sm go
9 Total source number: 3334
10 Fitting source number: 817
11 Subtract source number: 2517
```

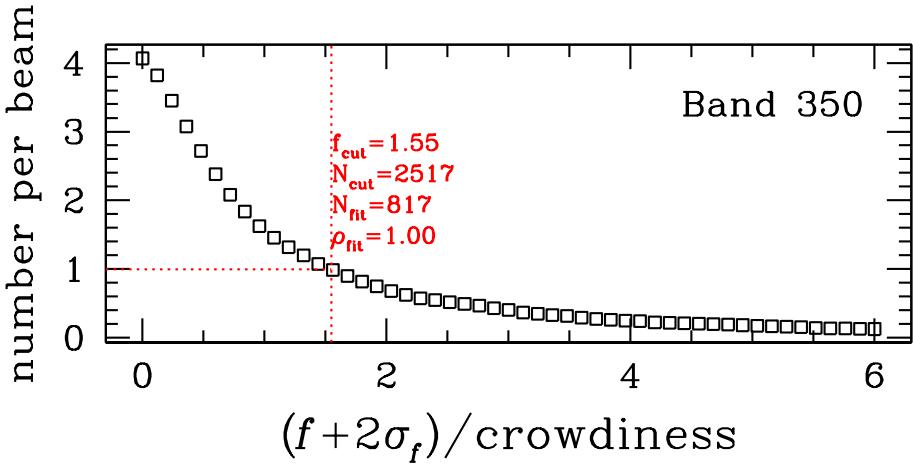


Figure 14: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 350.

6.3 Faint flux subtraction at band 350

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```

1 ./do_Galsub 350 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt \
3 -fitsname spire350_ima_4p8_v0_100615.fits \
4 -sedpredict SED_predictions_350_201512.txt

```

Figure 15: Faint-source subtraction step at band 350. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- Note: Remember to set Xback=0 and fbias=0 while doing the faint-source subtraction.

6.4 Galfit photometry at band 350

```

1 ./do_Galfit 350 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt \
3 -fitsname spire350_ima_4p8_v0_100615_subfaintDL.fits \
4 -sedpredict SED_predictions_350_201512.txt
5 # then run scripts in parallel
6 cd boxgalfit; do_GalfitRunqsub
7 cd ..
8 # then run postparallel process
9 ./do_Galfit 350 201512 \
10 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt \

```

```

11 -fitsname spire350_ima_4p8_v0_100615_subfaintDL.fits \
12 -sedpredict SED_predictions_350_201512.txt \
13 -postparallel

```

6.5 Residual image at band 350

```

1 cd run.sextractor_350/
2 idl -e 'do_SExtract_Mask, \
3 FitsFile="FIT_goodsn_350_Map_201512.fits", \
4 RmsFile="spire350_rms_4p8_v0_100615.fits"' \
5 vim default.sex # set sigma thresholds
6 sex SExtractor_Signal.fits
7 # then write additional residual source catalog
8 # with supermongo code do_sextract_result.sm
9 gedit do_sextract_result.sm
10 ...
11 define band 350
12 set catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt"}
13 set rmsfits24 = {"n_mips_1_s1_v0_37_rms_ED.fits"}
14 set catalogadd = {"Residual_priors_v6_Band350.txt"}
15 ...
16 print $(catalogadd) '%-9.0f %12.7f %12.7f %9g\n' \
17 {_id _ra _de zp_X f24 df24 f16 df16 f100 df100 f160 df160 f250 df250 \
18 radio eradio _fch1 _dfch1 _fch2 _dfch2 _fch3 _dfch3 _fch4 _dfch4 \
19 KtotX MassX distX spezX zq source distz idz goodArea}
20 ...
21 macro read do_sextract_result.sm go

```

(TODO: Put Residual Images Here!)

Then run a second pass 6.4:

```

1 ./do_Galfit 350 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt \
3 -catalog-add Residual_priors_v6_Band350.txt \ # new!
4 -fitsname spire350_ima_4p8_v0_100615_subfaintDL.fits \
5 -sedpredict SED_predictions_350_201512.txt \
6 # then run scripts in parallel
7 cd boxgalfit; do_GalfitRunqsub
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 350 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand350.txt \
12 -catalog-add Residual_priors_v6_Band350.txt \ # new!
13 -fitsname spire350_ima_4p8_v0_100615_subfaintDL.fits \
14 -sedpredict SED_predictions_350_201512.txt \
15 -postparallel

```

6.6 Monte-Carlo simulation at band 350

6.7 Flux bias and flux uncertainty correction

```

1 gedit run_simu_stats_v6.sm
2 sm

```

```
3 | macro read run_simu_stats_v6.sm run_simu_stats_v6 350
```

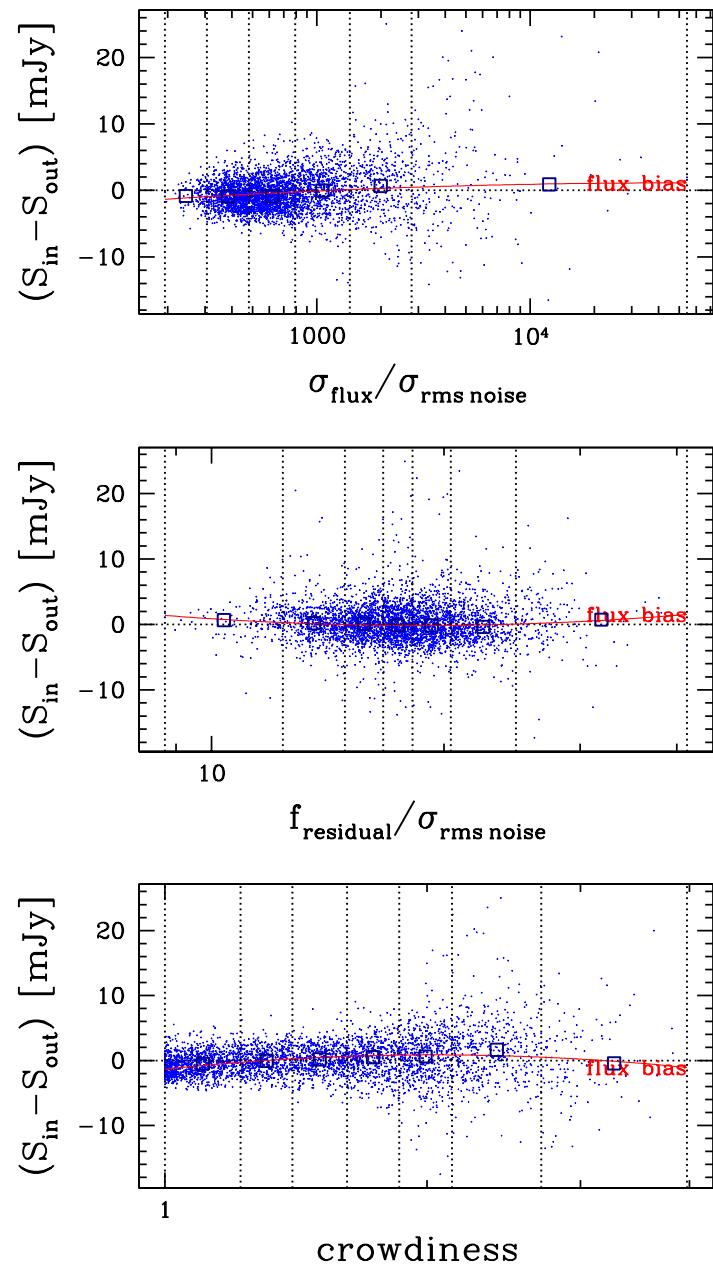


Figure 16: (TODO: Band 350 flux bias correction plots:)

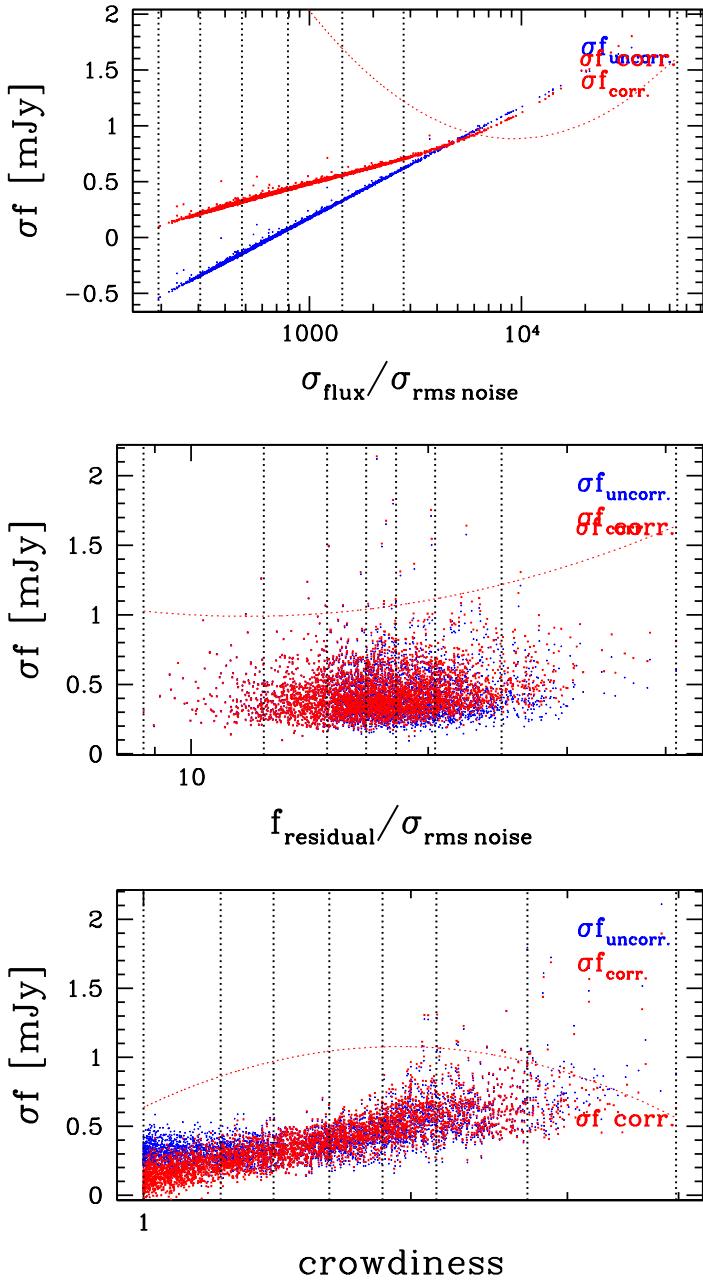


Figure 17: (TODO: Band 350 flux uncertainty correction plots:)

7 Band 500

7.1 SED fitting before band 500

Firstly, we use the Type_AGN and Type_SED determined in 6.1:

- Type_AGN: Numbers TODO.
- Type_SED: Numbers TODO.
- Note: do not forget to append zeros for additional sources found in the residual image

of 350.

Then we determine Type_FIR with the latest 350 measurements:

- Type_FIR: $\sqrt{SNR_{100}^2 + SNR_{160}^2 + SNR_{250}^2 + SNR_{350}^2} \geq 5$: 1092 out of 3361 sources will be fit with only FIR data points.

7.2 SED prediction for band 500

```

1 cd Galsed_BeforeBand500_Pass2/do_Type_FIT
2 gedit do_Type_FIT.sm
3 define band 500
4 define fcut$band 1.02
5 define fmax$band 3.0
6 set catalog = {"./RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt"}
7 set sedpredict = {"./ResLMTfluxes_priors_v6_20151221_BeforeBand500.txt"}
8 macro read do_Type_FIT.sm go
9 Total source number: 3361
10 Fitting source number: 386
11 Subtract source number: 2975

```

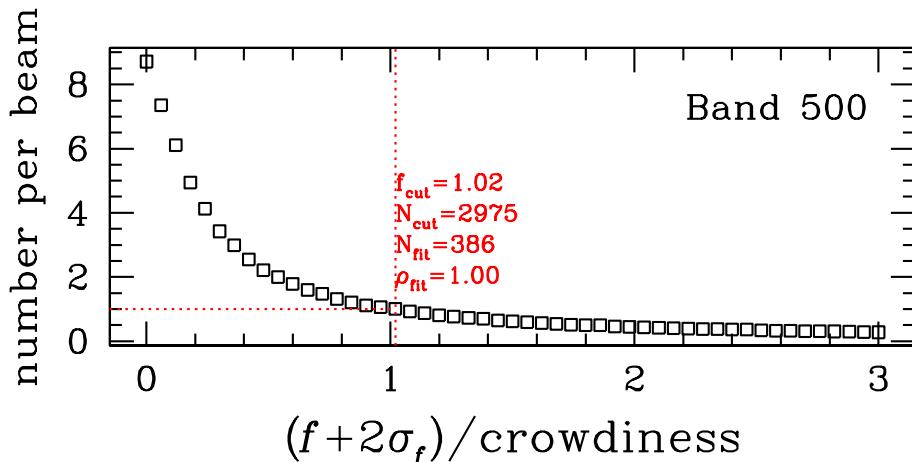


Figure 18: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 500.

7.3 Faint flux subtraction at band 500

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```

1 ./do_Galsub 500 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt \
3 -fitsname spire500_ima_7p2_v0_100615.fits \
4 -sedpredict SED_predictions_500_201512.txt

```

Figure 19: Faint-source subtraction step at band 500. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- o Note: Remember to set Xback=0 and fbias=0 while doing the faint-source subtraction.

7.4 Galfit photometry at band 500

```

1 ./do_Galfit 500 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt \
3 -fitsname spire500_ima_7p2_v0_100615_subfaintDL.fits \
4 -sedpredict SED_predictions_500_201512.txt
5 # then run scripts in parallel
6 cd boxgalfit; do_GalfitRunqsub
7 cd ..
8 # then run postparallel process
9 ./do_Galfit 500 201512 \
10 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt \
11 -fitsname spire500_ima_7p2_v0_100615_subfaintDL.fits \
12 -sedpredict SED_predictions_500_201512.txt \
13 -postparallel

```

7.5 Residual image at band 500

```

1 cd run.sextractor_500/
2 idl -e 'do_SExtract_Mask, \
3 FitsFile="FIT_goodsn_500_Map_201512.fits", \
4 RmsFile="spire500_rms_7p2_v0_100615.fits"'
5 vim default.sex # set sigma thresholds
6 sex SExtractor_Signal.fits
7 # then write additional residual source catalog
8 # with supermongo code do_sextract_result.sm
9 gedit do_sextract_result.sm
10 ...
11 define band 500
12 set catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt"}
13 set rmsfits24 = {"n_mips_1_s1_v0_37_rms_ED.fits"}
14 set catalogadd = {"Residual_priors_v6_Band500.txt"}
15 ...
16 print $(catalogadd) '%-9.0f %12.7f %12.7f %9g\n' \
17 {_id _ra _de zp_X f24 df24 f16 df16 f100 df100 \
18 f160 df160 f250 df250 f350 df350 radio eradio \
19 _fch1 _dfch1 _fch2 _dfch2 _fch3 _dfch3 _fch4 _dfch4 \
20 KtotX MassX distX spezX zq source distz idz goodArea}
21 ...
22 macro read do_sextract_result.sm go

```

(TODO: Put Residual Images Here!)

Then run a second pass 7.4:

```
1 ./do_Galfit 500 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt \
3 -catalog-add Residual_priors_v6_Band500.txt \ # new!
4 -fitsname spire500_ima_7p2_v0_100615_subfaintDL.fits \
5 -sedpredict SED_predictions_500_201512.txt
6 # then run scripts in parallel
7 cd boxgalfit; do_GalfitRunqsub
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 500 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand500.txt \
12 -catalog-add Residual_priors_v6_Band500.txt \ # new!
13 -fitsname spire500_ima_7p2_v0_100615_subfaintDL.fits \
14 -sedpredict SED_predictions_500_201512.txt \
15 -postparallel
```

7.6 Monte-Carlo simulation at band 500

7.7 Flux bias and flux uncertainty correction

```
1 gedit run_simu_stats_v6.sm
2 sm
3 macro read run_simu_stats_v6.sm run_simu_stats_v6 500
```

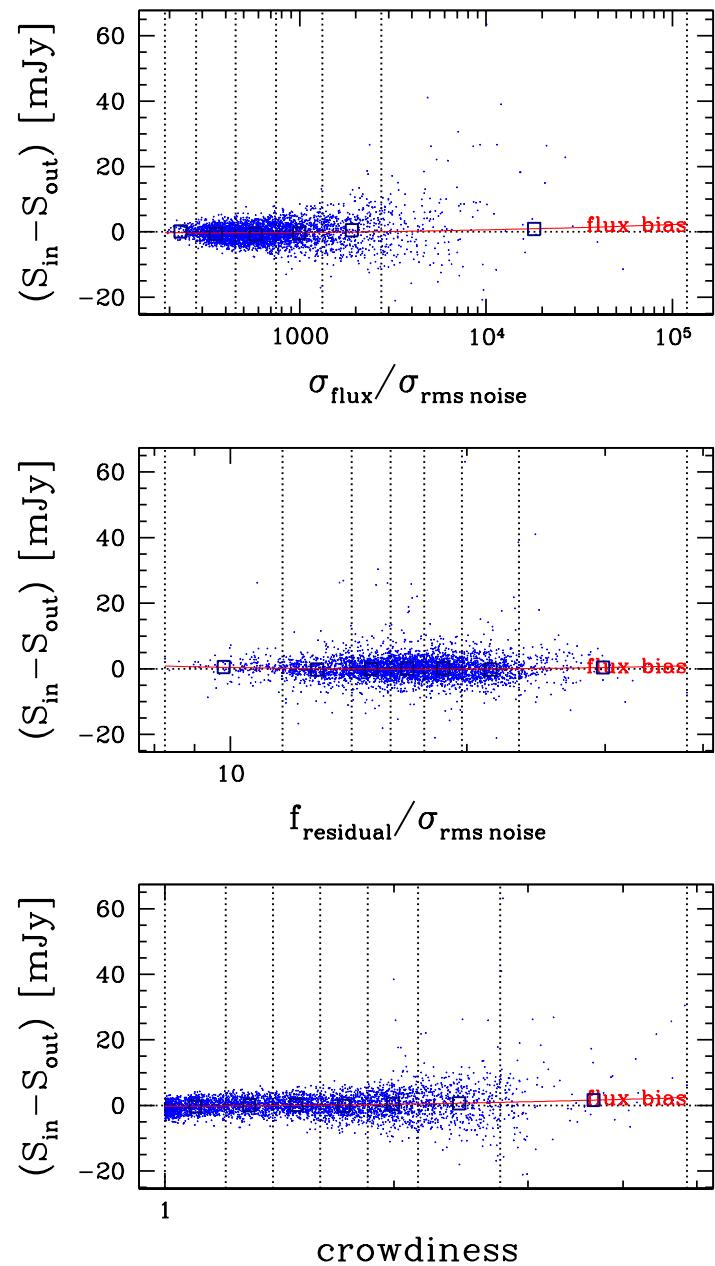


Figure 20: (TODO: Band 500 flux bias correction plots:)

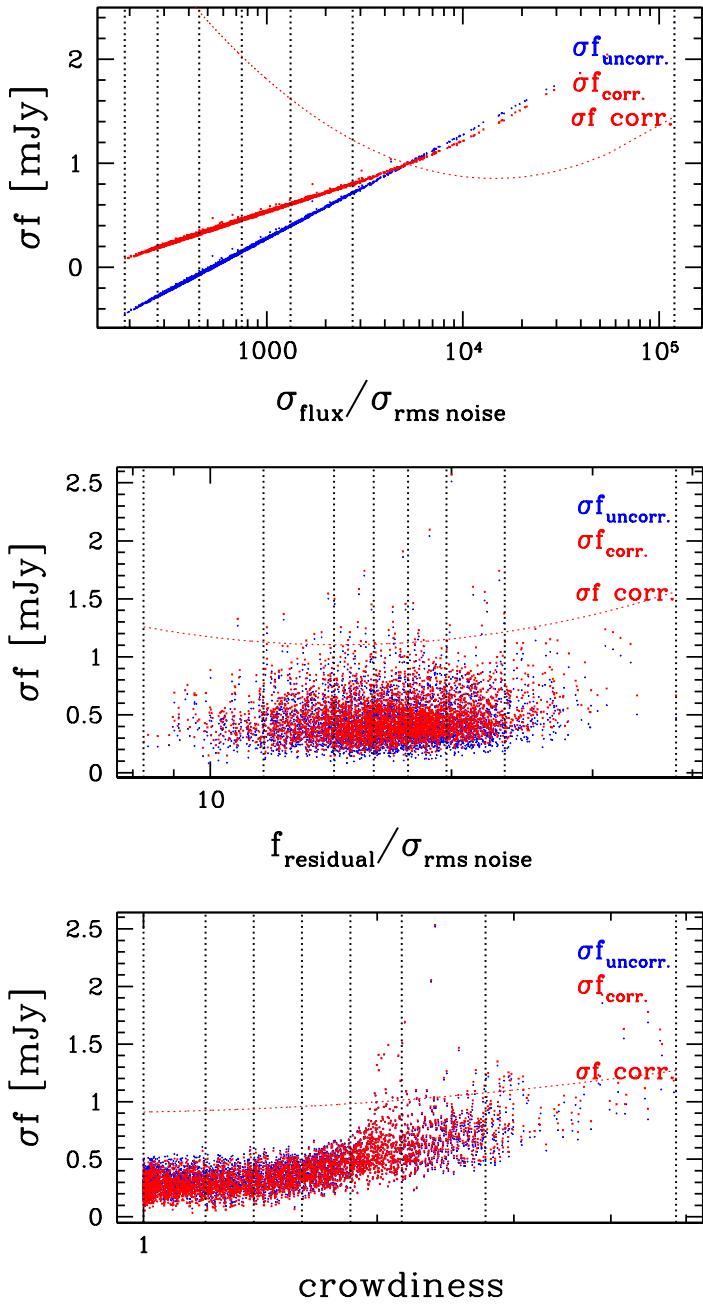


Figure 21: (TODO: Band 500 flux uncertainty correction plots:)

8 Band 1160

8.1 SED fitting before band 1160

Firstly, we use the Type_AGN and Type_SED determined in 7.1:

- Type_AGN: Numbers TODO.
- Type_SED: Numbers TODO.

- Note: do not forget to append zeros for additional sources found in the residual image of 500.

Then we determine Type_FIR with the latest 500 measurements:

- Type_FIR: $\sqrt{SNR_{100}^2 + SNR_{160}^2 + SNR_{250}^2 + SNR_{350}^2 + SNR_{500}^2} \geq 5$: 1114 out of 3386 sources will be fit with only FIR data points.

8.2 SED prediction for band 1160

```

1 cd Galsed_BeforeBand1160_Pass2/do_Type_FIT
2 gedit do_Type_FIT.sm
3 define band 1160
4 define fcut$band 0.205
5 define fmax$band 0.75
6 set catalog = {"../RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt"}
7 set sedpredict = {"../ResLMTfluxes_priors_v6_20151221_BeforeBand1160.txt"}
8 macro read do_Type_FIT.sm go
9 Total source number: 3386
10 Fitting source number: 651
11 Subtract source number: 2735

```

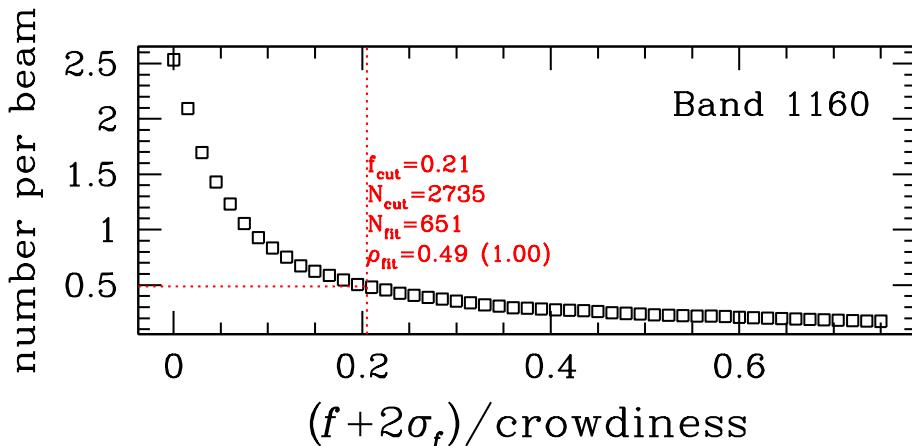


Figure 22: Number of sources kept for fitting per PSF beam area (ρ_{fit}) as a function of different f_{cut} at band 1160.

8.3 Faint flux subtraction at band 1160

We use the SED flux of the flagged faint sources to construct a PSF-modeled image, then subtract it from the original observed image.

```

1 ./do_Galsub 1160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt \
3 -fitsname combined_maw0_4_azw0_5_sig_astro.fits \

```

```
4 | -sedpredict SED_predictions_1160_201512.txt
```

Figure 23: Faint-source subtraction step at band 1160. From left to right: original image, faint-source model image, and faint-source-subtracted image.

Using the faint-sources-subtracted image, we perform prior source fitting photometry in the next step.

- Note: Remember to set Xback=0 and fbias=0 while doing the faint-source subtraction.

8.4 Galfit photometry at band 1160

```
1 ./do_Galfit 1160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt \
3 -fitsname combined_maw0_4_azw0_5_sig_subfaintDL.fits \
4 -sedpredict SED_predictions_1160_201512.txt
5 # then run scripts in parallel
6 cd boxgalfit; do_GalfitRunqsub255
7 cd ..
8 # then run postparallel process
9 ./do_Galfit 1160 201512 \
10 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt \
11 -fitsname combined_maw0_4_azw0_5_sig_subfaintDL.fits \
12 -sedpredict SED_predictions_1160_201512.txt \
13 -postparallel
```

8.5 Residual image at band 1160

```
1 cd run.sextractor_1160/
2 idl -e 'do_SExtract_Mask, \
3 FitsFile="FIT_goodsn_1160_Map_201512.fits", \
4 RmsFile="combined_maw0_4_azw0_5_rms.fits"'
5 vim default.sex # set sigma thresholds
6 sex SExtractor_Signal.fits
7 # then write additional residual source catalog
8 # with supermongo code do_sextract_result.sm
9 gedit do_sextract_result.sm
10 ...
11 define band 1160
12 set catalog = {"RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt"}
13 set rmsfits24 = {"n_mips_1_s1_v0_37_rms_ED.fits"}
14 set catalogadd = {"Residual_priors_v6_Band1160.txt"}
15 ...
16 print ${catalogadd} '%-9.0f %12.7f %12.7f %9g\n' \
17 {_id _ra _de zp_X f24 df24 f16 df16 f100 df100 f160 \
18 df160 f250 df250 f350 df350 f500 df500 radio eradio \
19 _fch1 _dfch1 _fch2 _dfch2 _fch3 _dfch3 _fch4 _dfch4 \
20 KtotX MassX distX spezX zq source distz idz goodArea}
21 ...
22 macro read do_sextract_result.sm go
```

(TODO: Put Residual Images Here!)

Then run a second pass 8.4:

```
1 ./do_Galfit 1160 201512 \
2 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt \
3 -catalog-add Residual_priors_v6_Band1160.txt \ # new!
4 -fitsname combined_maw0_4_azw0_5_sig_subfaintDL.fits \
5 -sedpredict SED_predictions_1160_201512.txt
6 # then run scripts in parallel
7 cd boxgalfit; do_GalfitRunqsub255
8 cd ..
9 # then run postparallel process
10 ./do_Galfit 1160 201512 \
11 -catalog RadioOwenMIPS24_priors_v6_20151221_BeforeBand1160.txt \
12 -catalog-add Residual_priors_v6_Band1160.txt \ # new!
13 -fitsname combined_maw0_4_azw0_5_sig_subfaintDL.fits \
14 -sedpredict SED_predictions_1160_201512.txt \
15 -postparallel
```

8.6 Monte-Carlo simulation at band 1160

8.7 Flux bias and flux uncertainty correction

```
1 gedit run_simu_stats_v6.sm
2 sm
3 macro read run_simu_stats_v6.sm run_simu_stats_v6 1160
```

A Setup supermongo in planer

```
1 IRAF
2 supermongo
3 wcstools
4 galfit
5 ds9
6 XPA
7 CrabPhotAperPhot
8 CrabTableReadColumn
9 CrabTable2ds9reg
```

B Setup supermongo in planer

Here are the code for configuring, compiling and installing supermongo:

```
1 cd /dsm/upgal/data/dliu/Software/sm2_4_30/
2 ./set_opts
3 We can help you configure things for which the defaults are usually OK
4 Do you want to do so? [n|y|list] y
5 Choose data type for vectors, "float" or "double"? [float] double
6 Choose length of longest macro [10000] 50000
7 Choose length for string-valued-vectors' elements [40] 80
8 Top level path to install things? [/usr/local] /dsm/upgal/data/dliu/supermongo
9 vim src/options.h
10 :d7
11 :wq
12 make
13 make install
14 cd
15 cd /home/dliu/.local/lib/sm/macro
16 rsyncdir /usr/local/lib/sm/macro \
    dliu@hubble.extra.cea.fr:/dsm/upgal/data/dliu/supermongo/lib/sm/macro "*.sm"
17 It should be OK now!
18 echo PATH=/home/dliu/.local/bin:$PATH
19 type sm
20 # Note:
21 # additionally, if sm does not work,
22 # try to modify "/home/dliu/.local/lib/sm/.sm"
```