Deblending sub-mm images with TPHOT: lessons from SCUBA-2

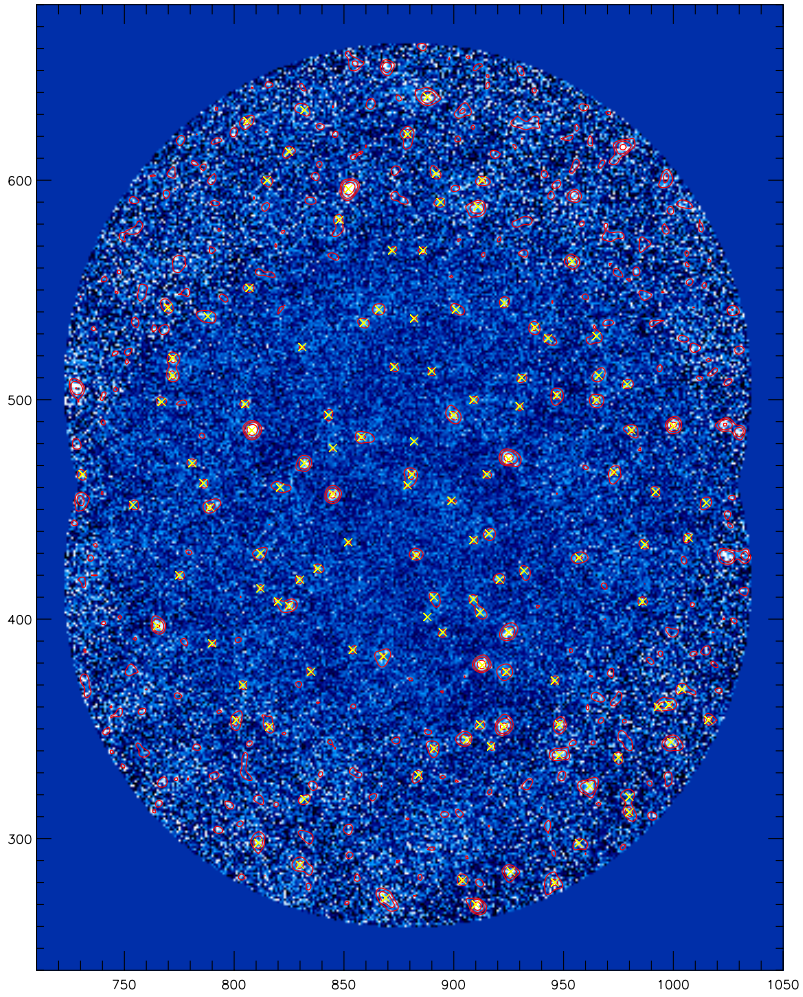
Nathan Bourne

What can we learn from SCUBA-2?

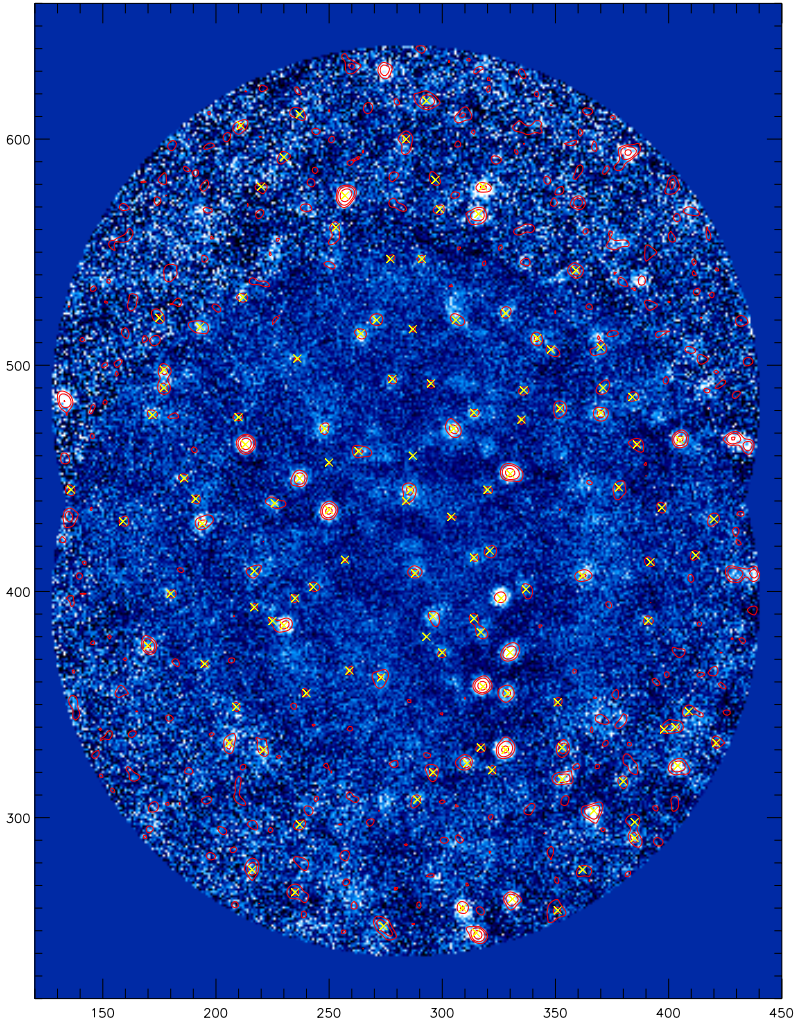
	wavelength / µm	PSF FWHM / arcsec
SCUBA-2	450	7.5
	850	14
Herschel-SPIRE	250	18
	350	24
	500	35

Using TPHOT to deblend a 500µm image should reproduce the fluxes at 450µm

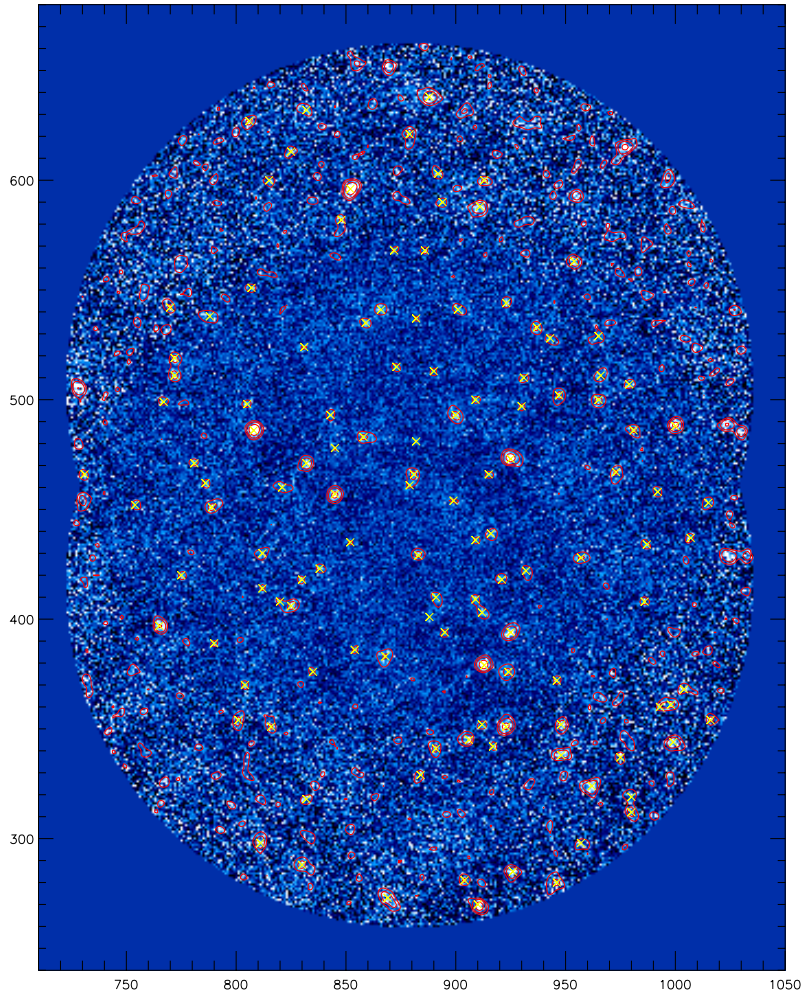
450


600
500
400
300
750
800
850
900
950
1000
1050

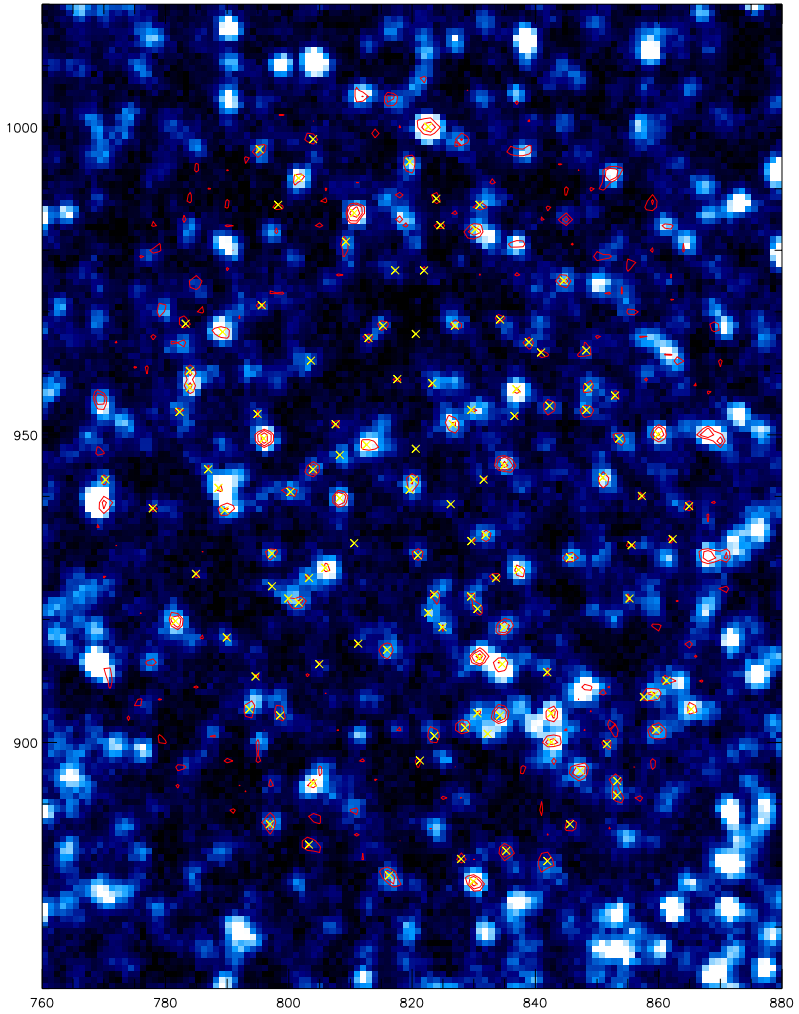
850


600
500
400
300
150
200
250
300
350
400
450

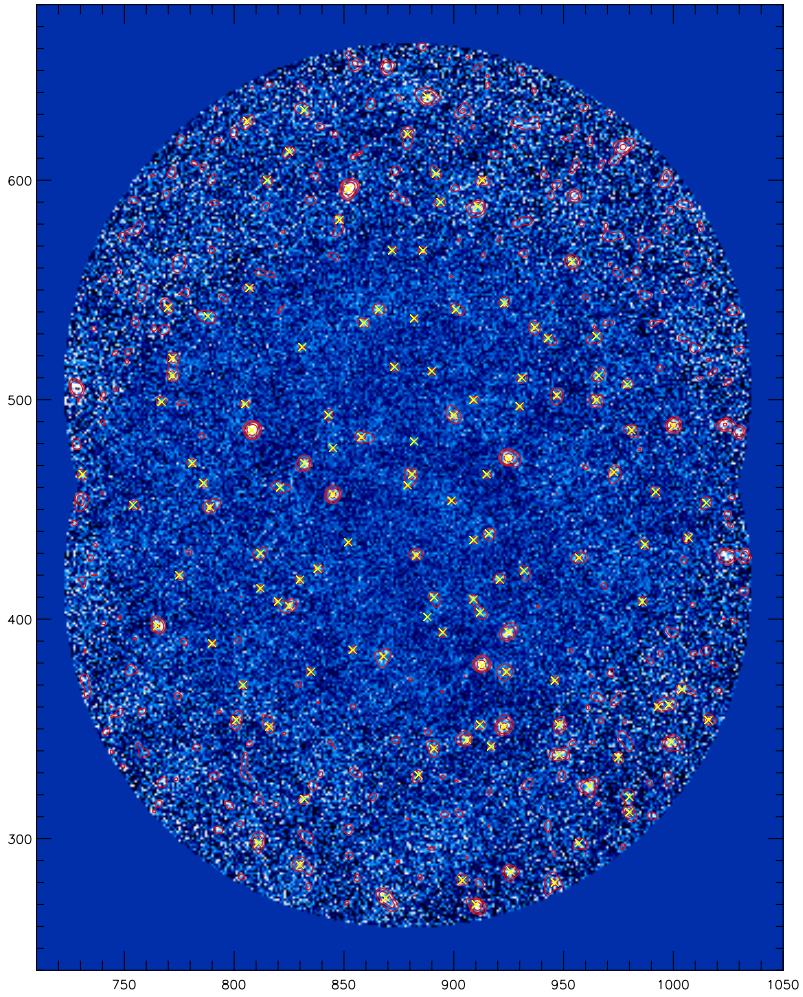
450


600
500
400
300
750
800
850
900
950
1000
1050

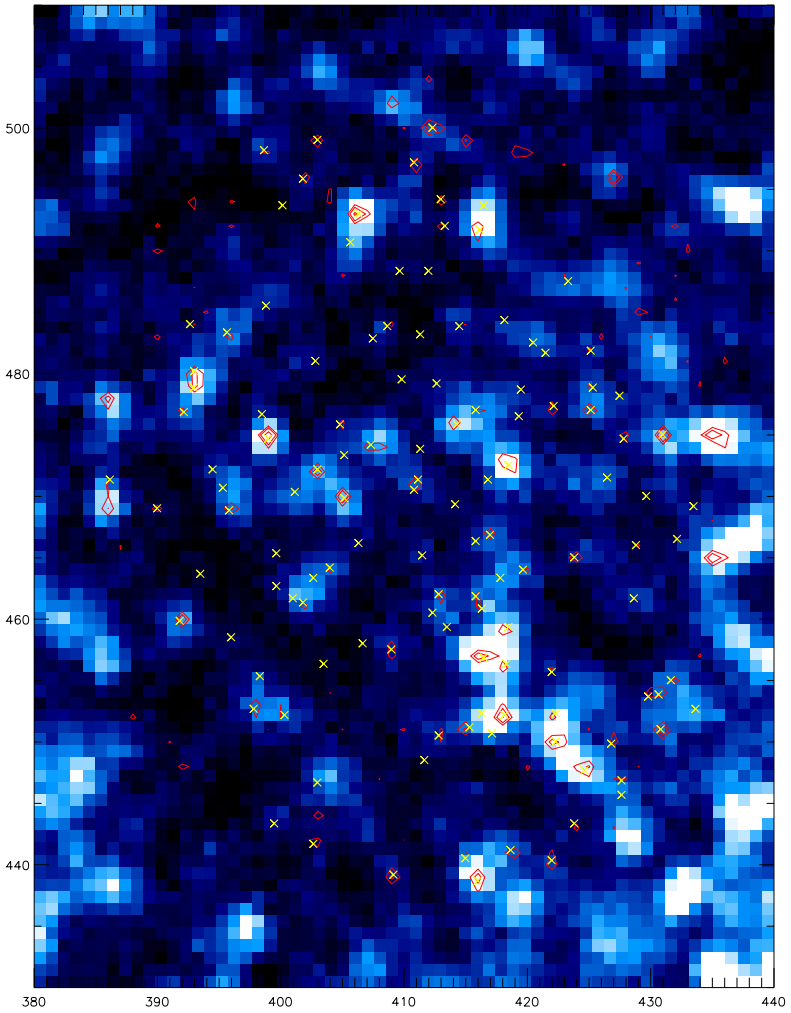
250


1000
950
900
760
780
800
820
840
860
880

450

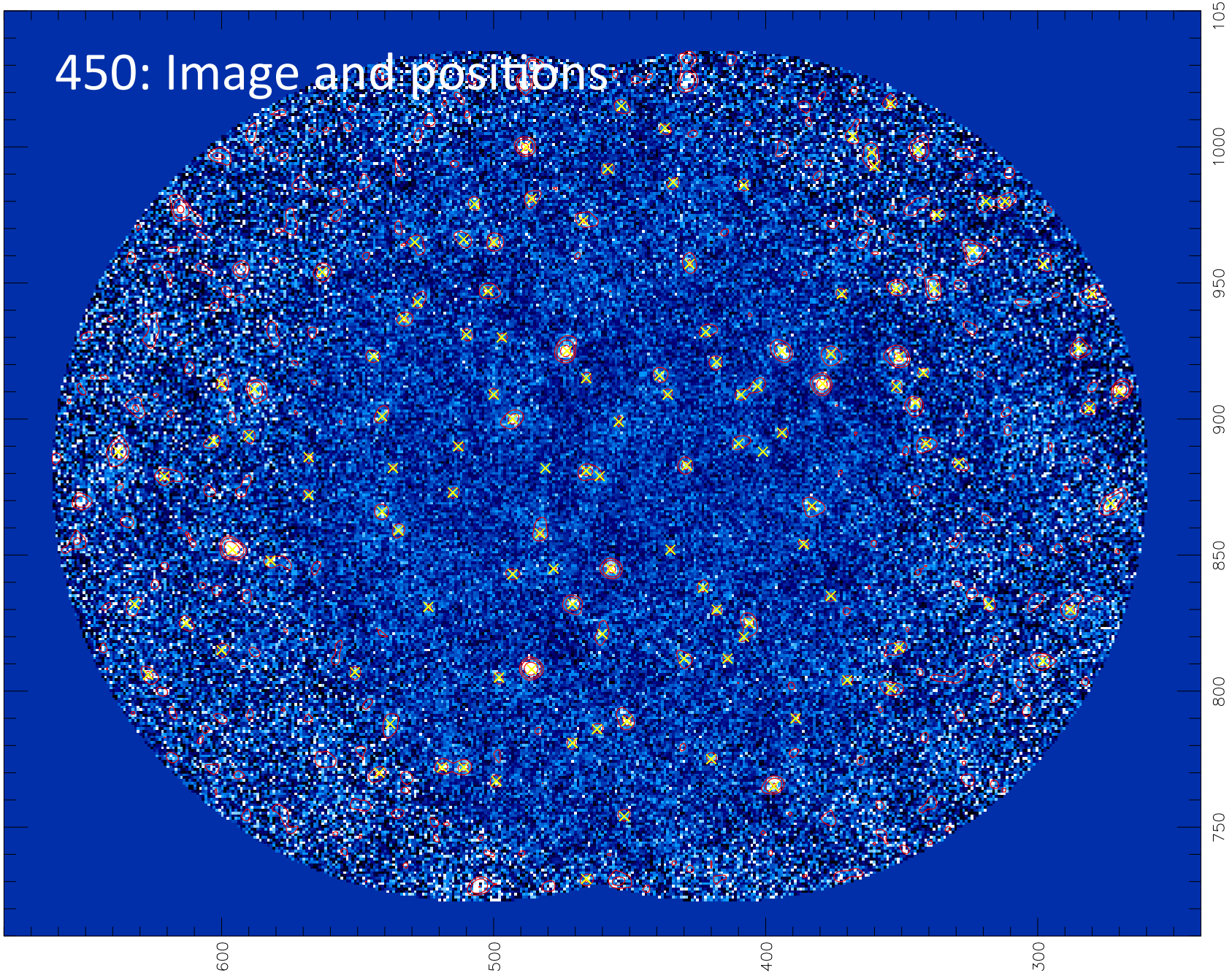

600
500
400
300
750
800
850
900
950
1000
1050

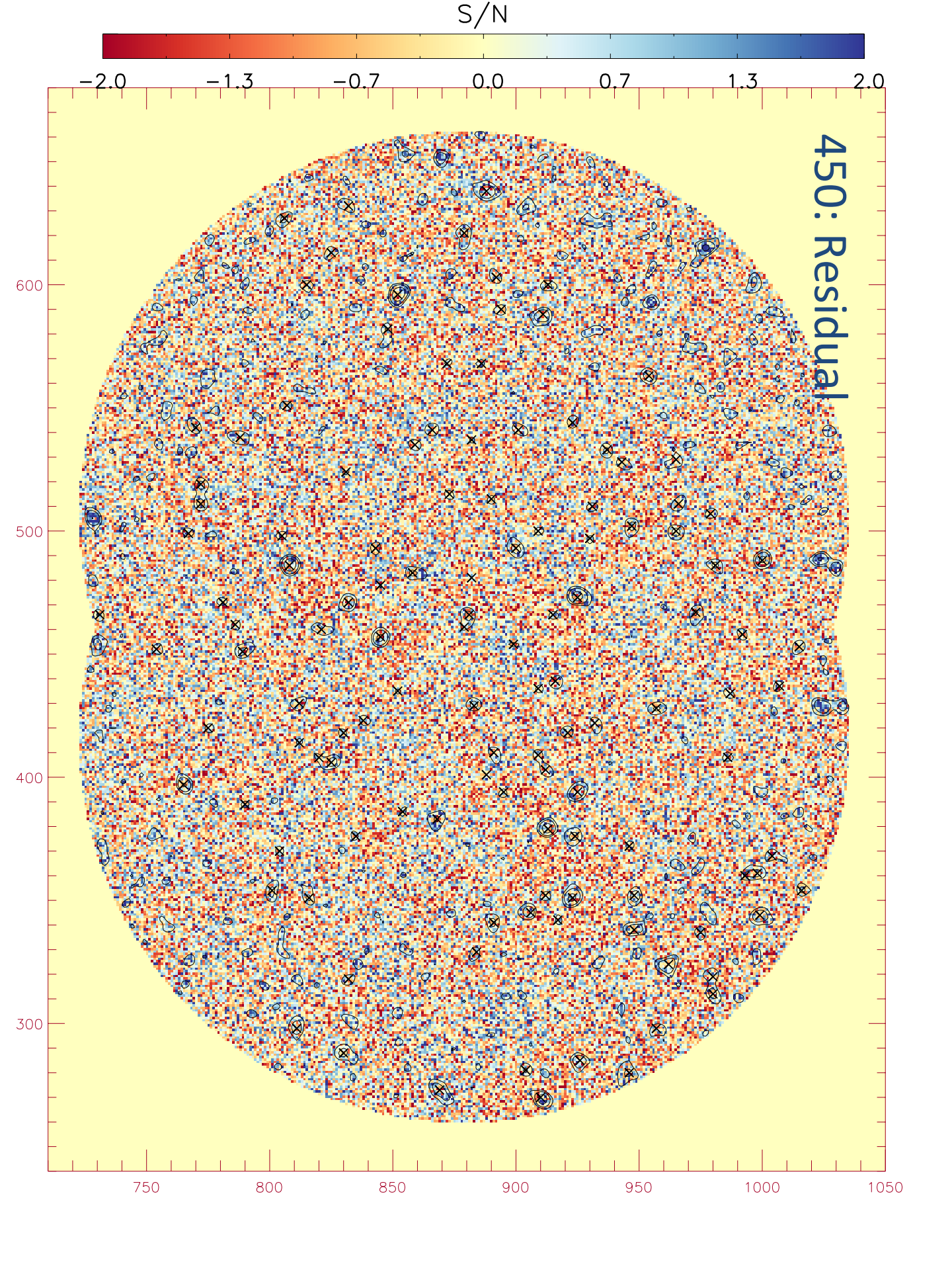
500


500
480
460
440
380
390
400
410
420
430
440

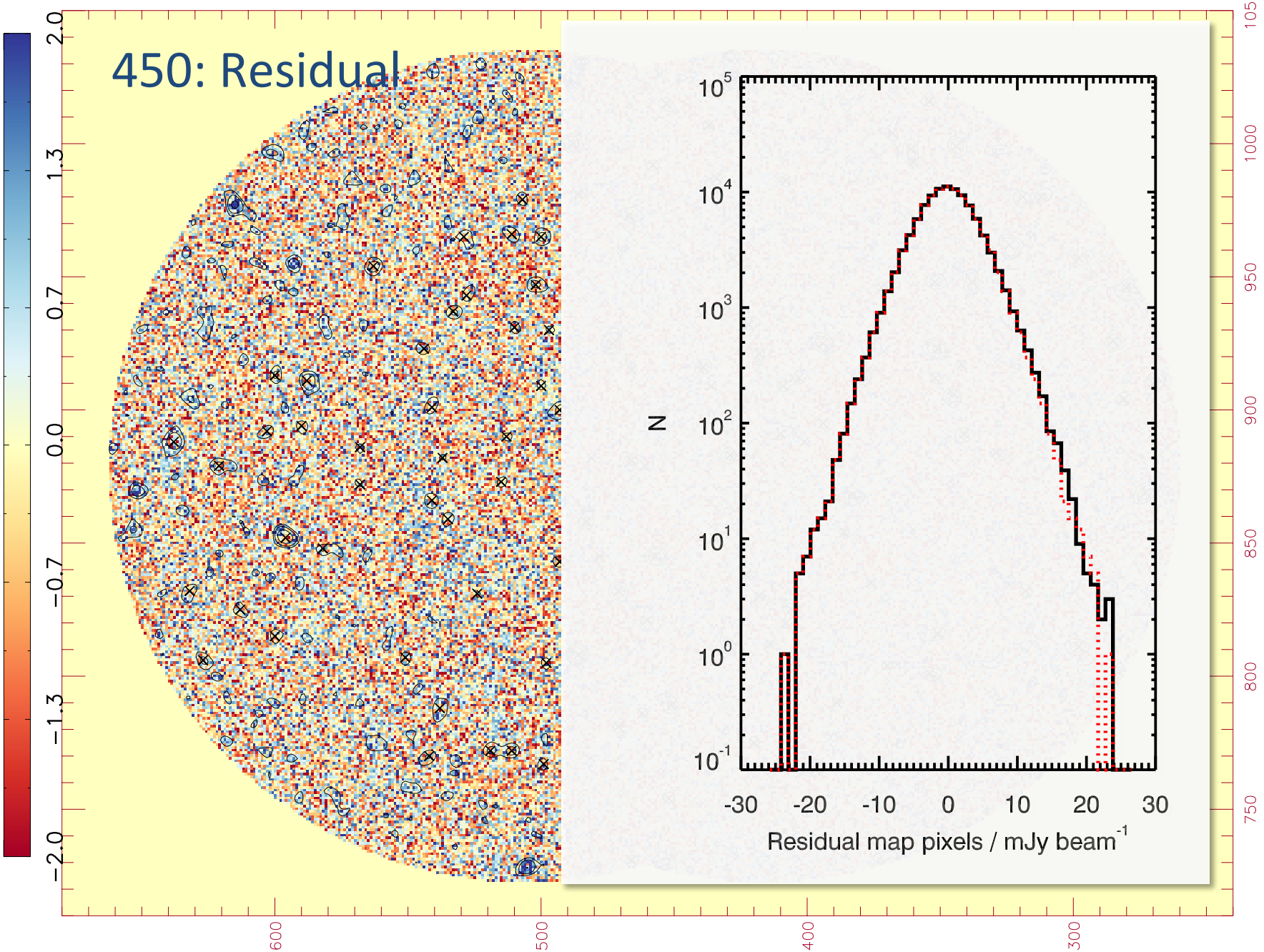
Let’s see how well this works…

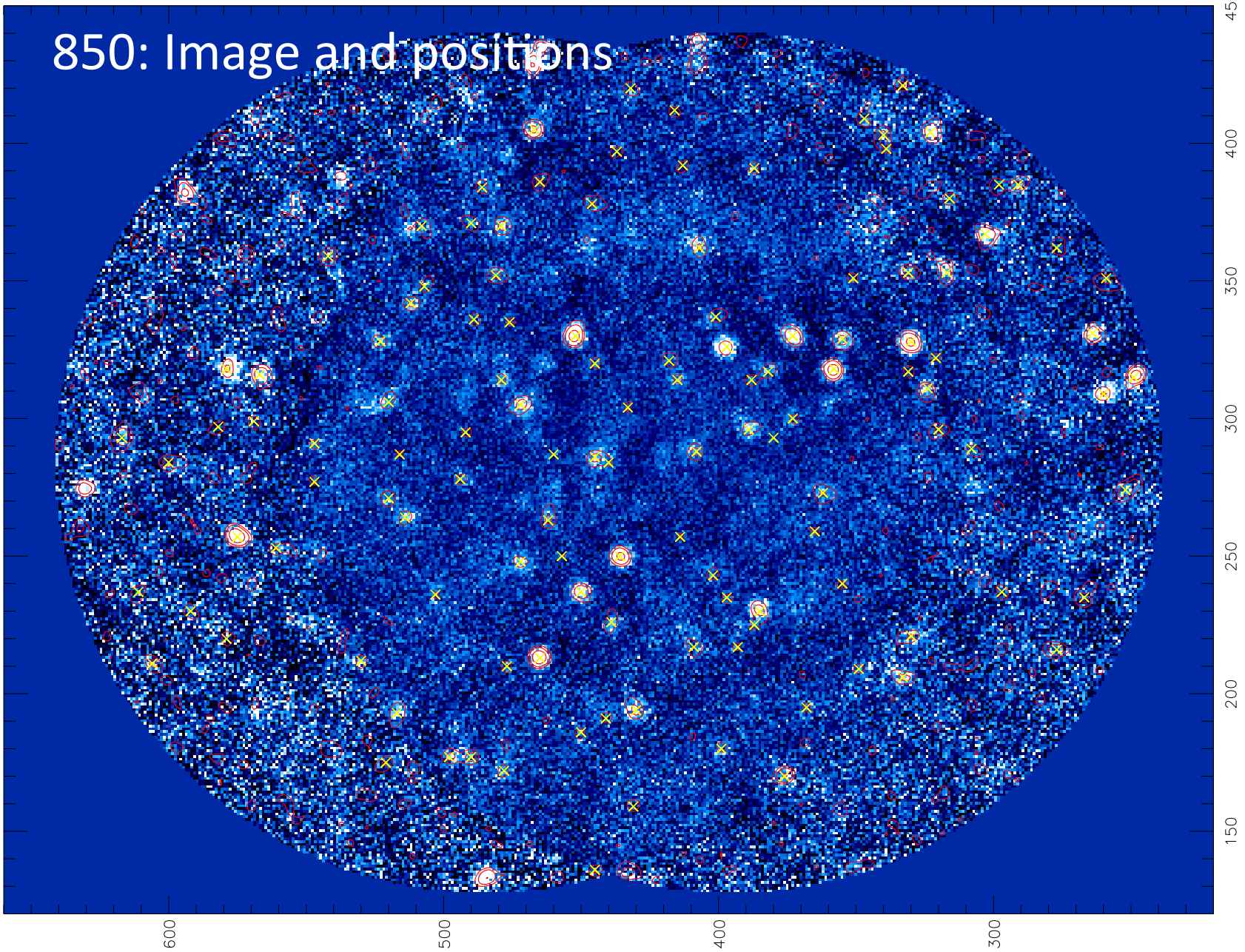
1. Fit each image with TPHOT using the 450µm positions

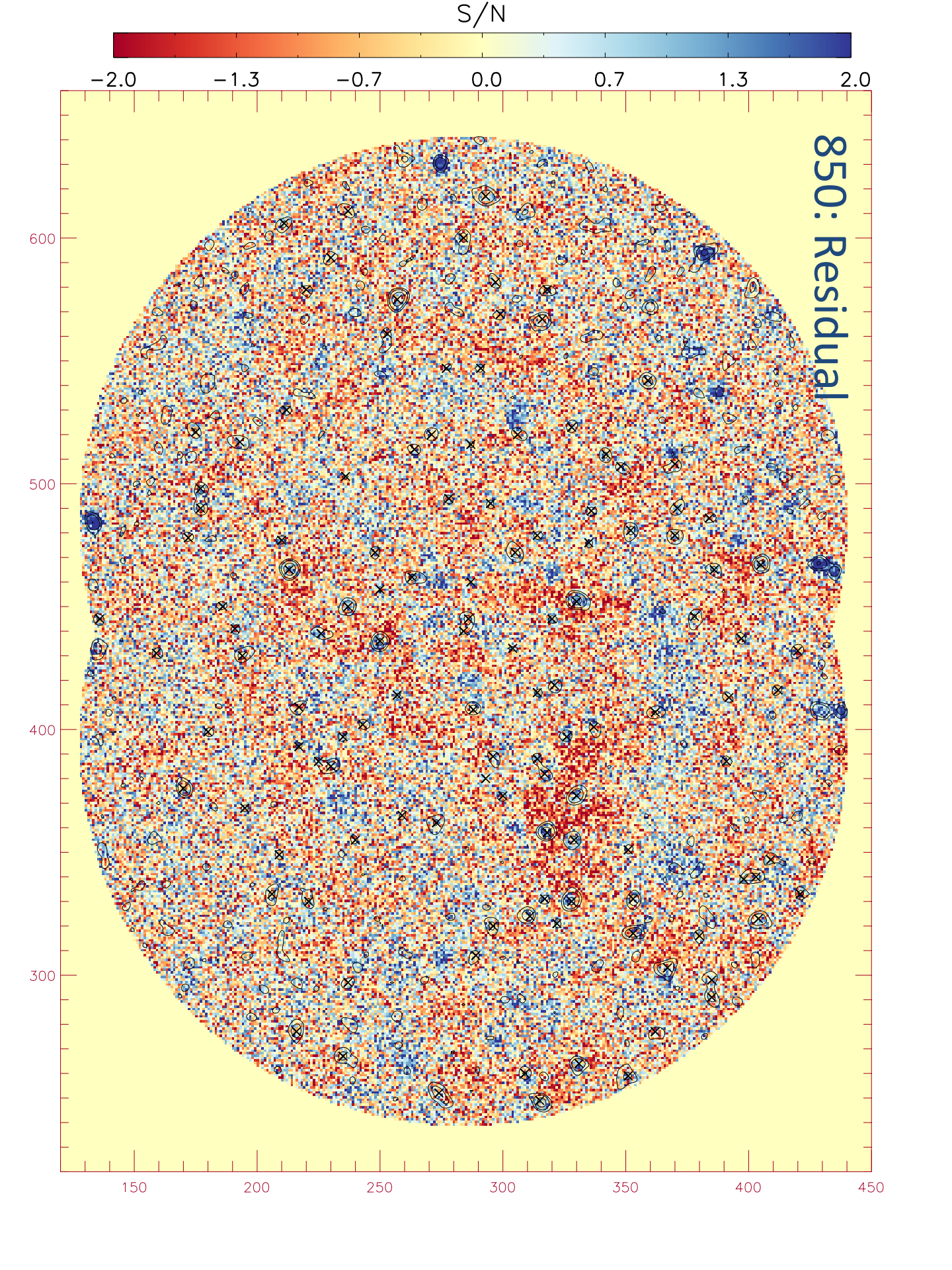

450: Image and positions
1050
1000
950
900
850
800
750
600
500
400
300

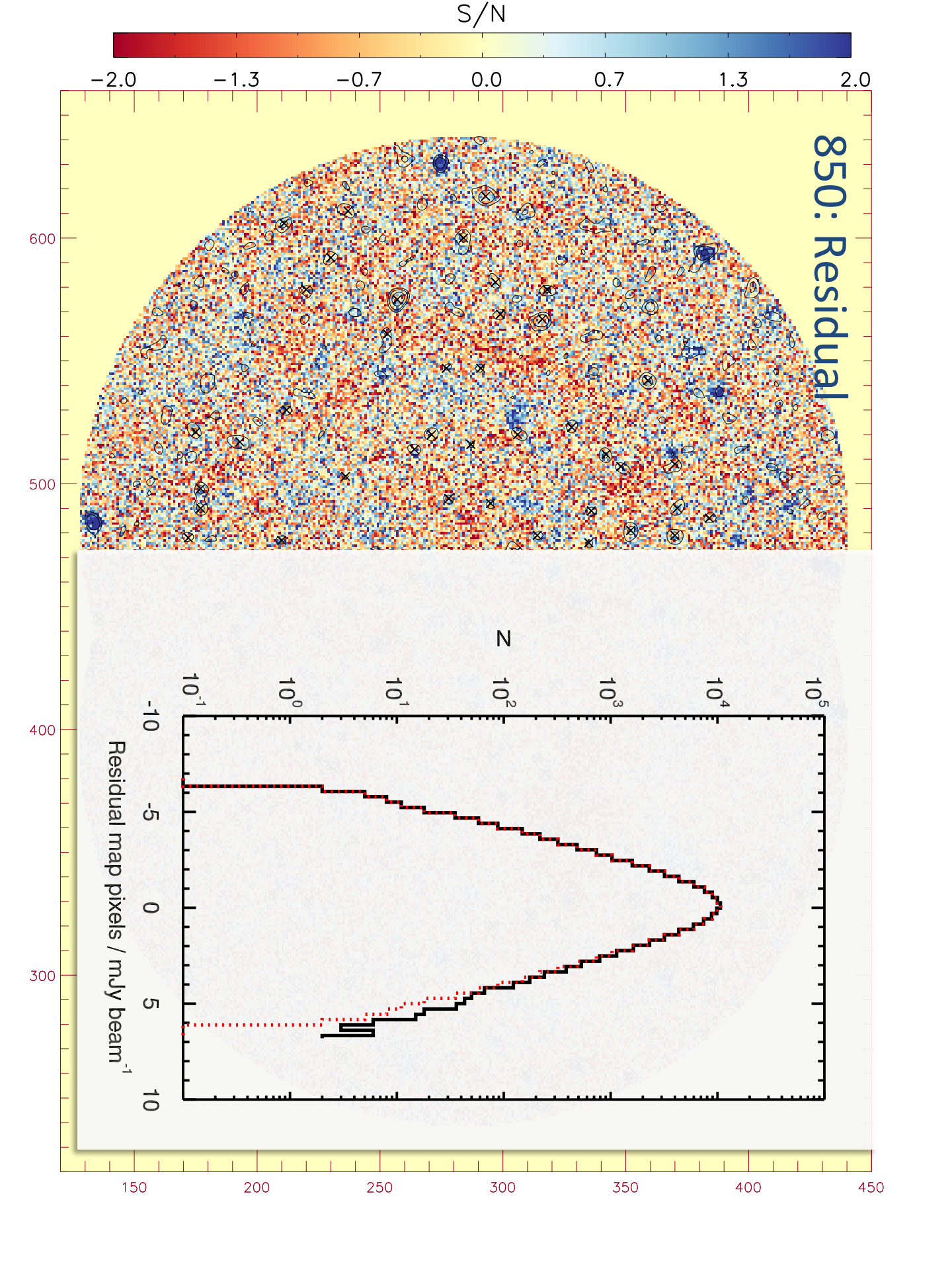

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
450: Residual
600
500
400
300
750
800
850
900
950
1000
1050

450: Residual

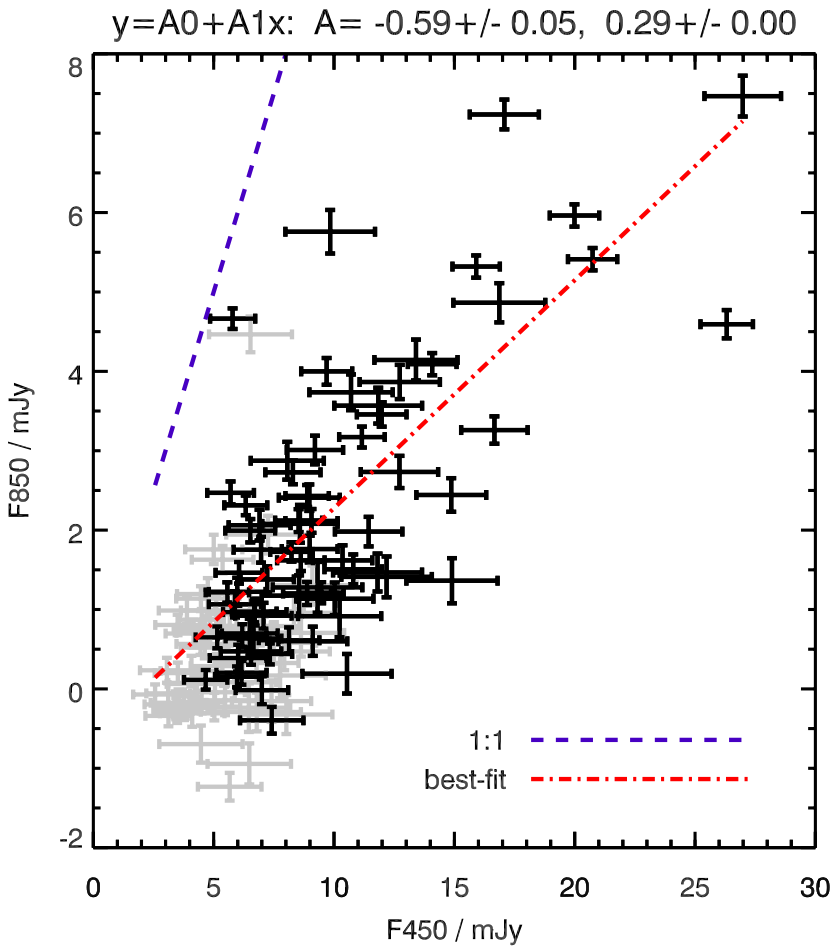


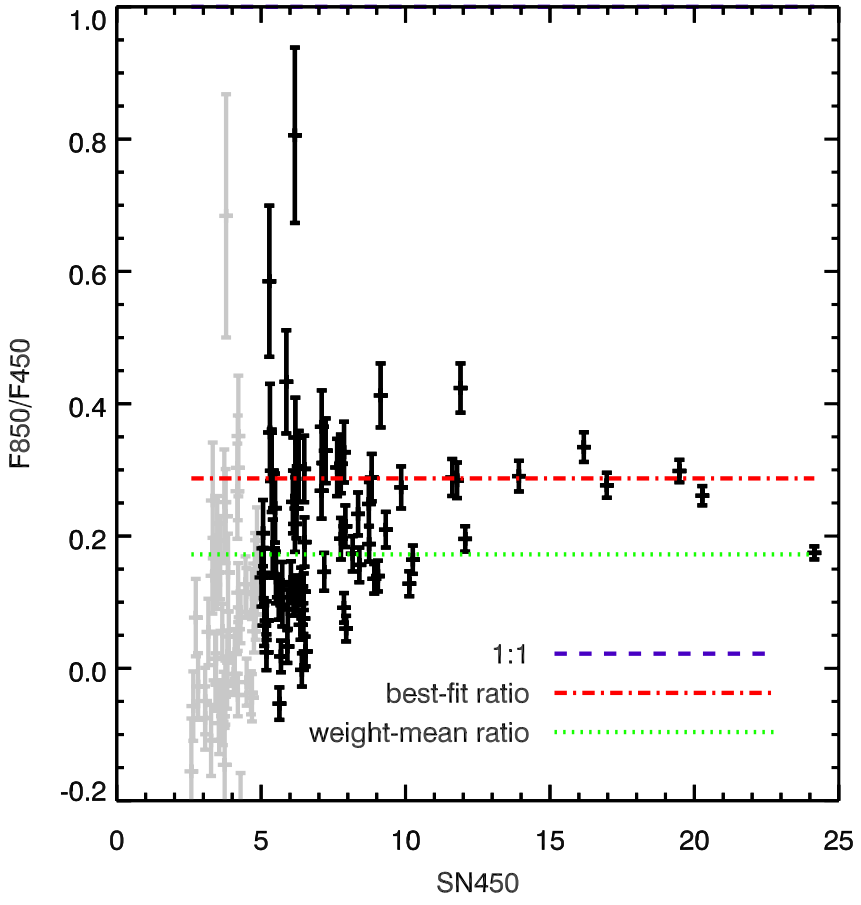

850: Image and positions
600
500
400
300
450
400
350
300
250
200
150


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
600
500
400
300
150
200
250
300
350
400
450

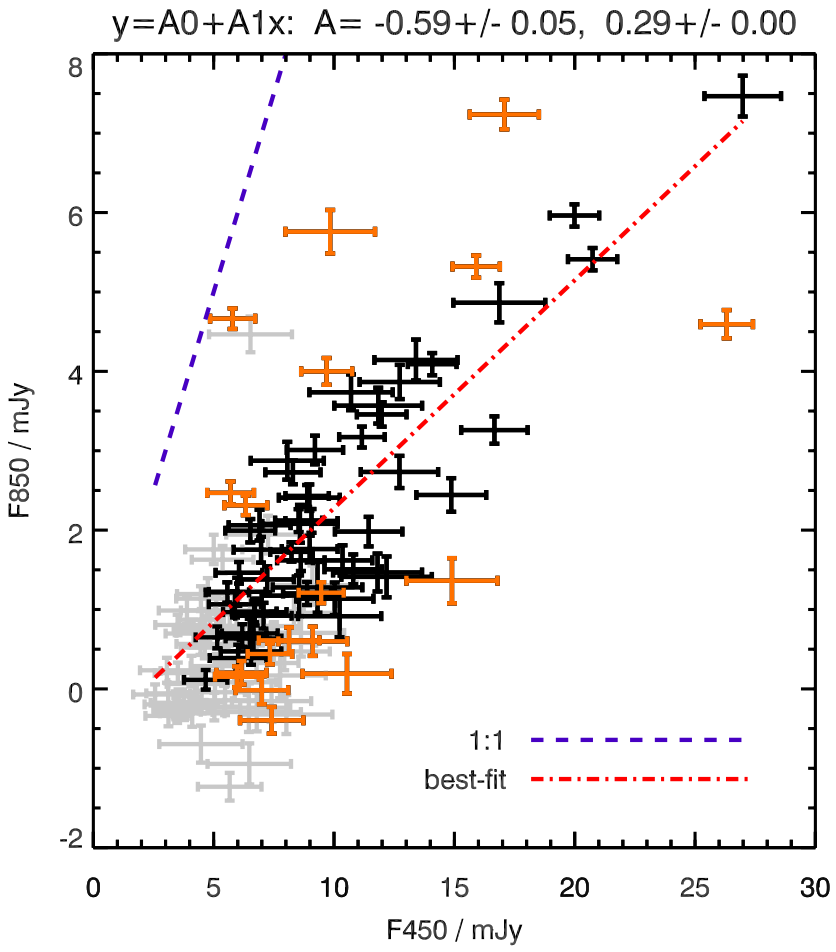

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
600
500
400
300
150
200
250
300
350
400
450
N
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
-10
-5
0
5
10
Residual map pixels / mJy beam^{-1}

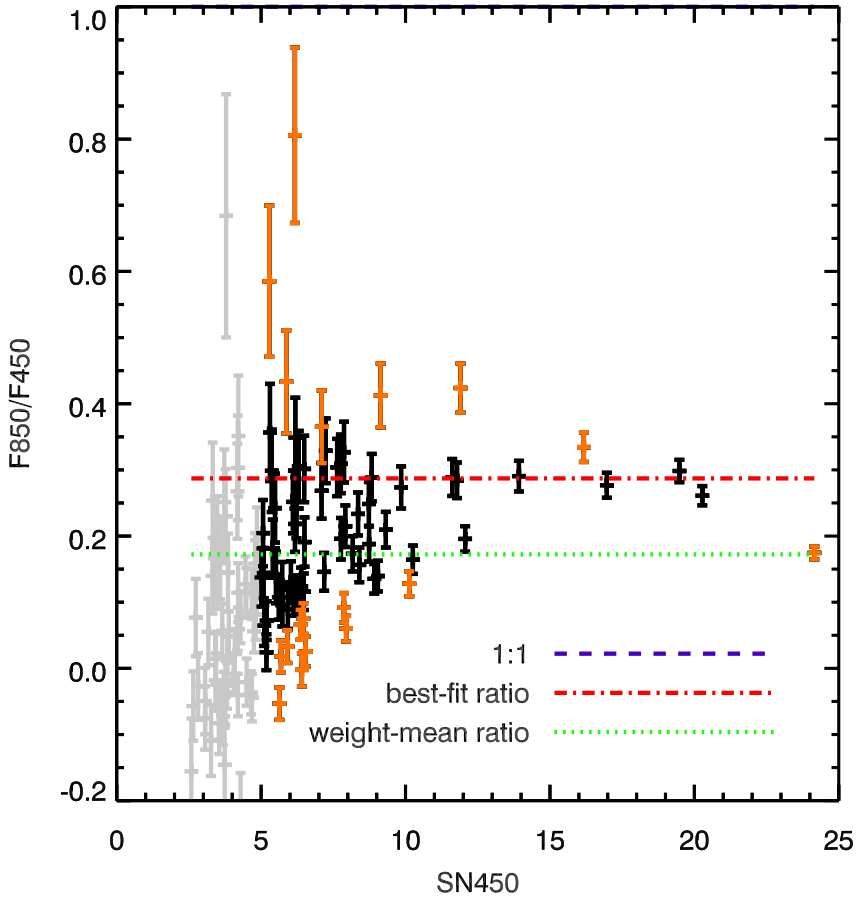
850 vs 450 fluxes



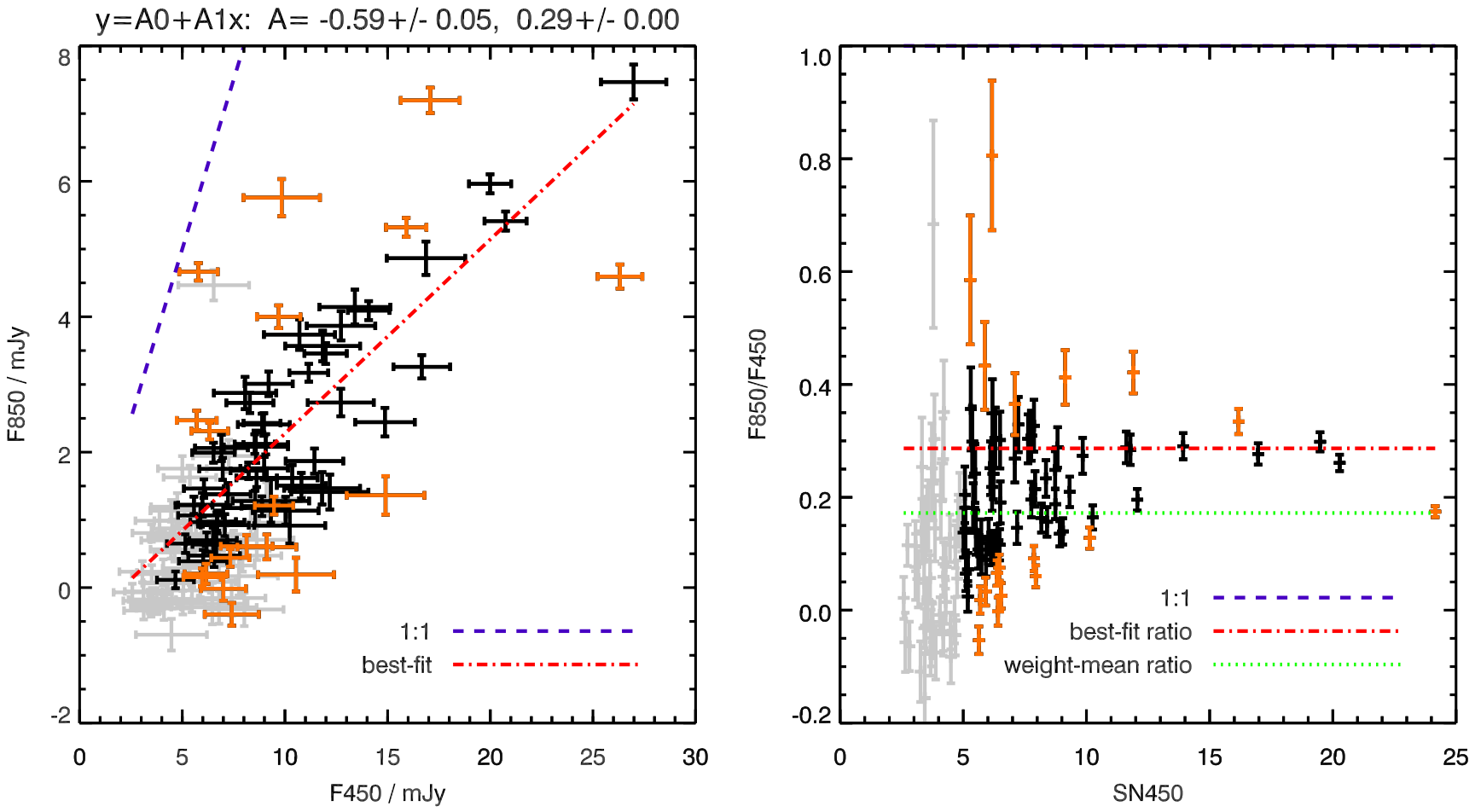


850 vs 450 fluxes

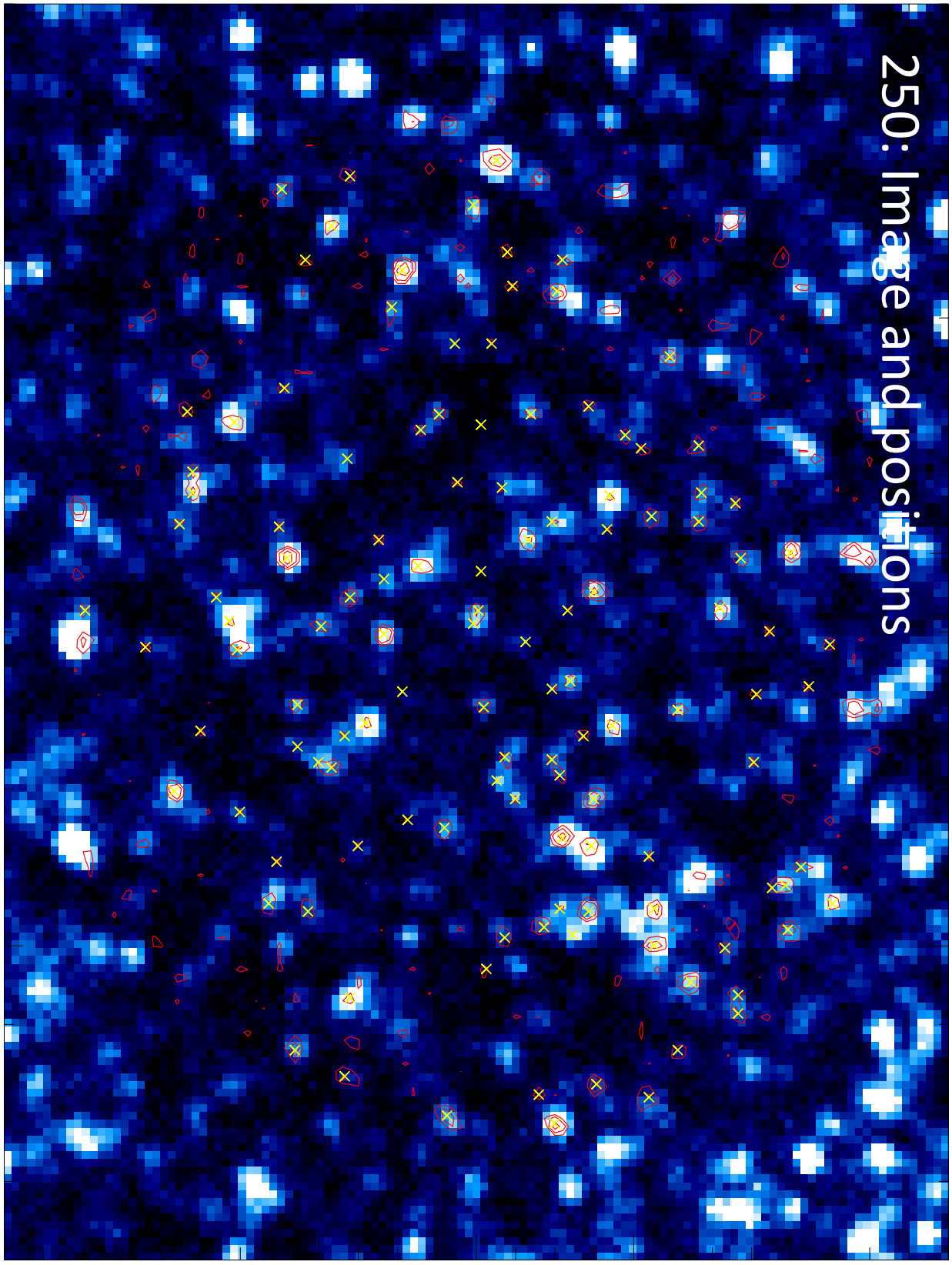


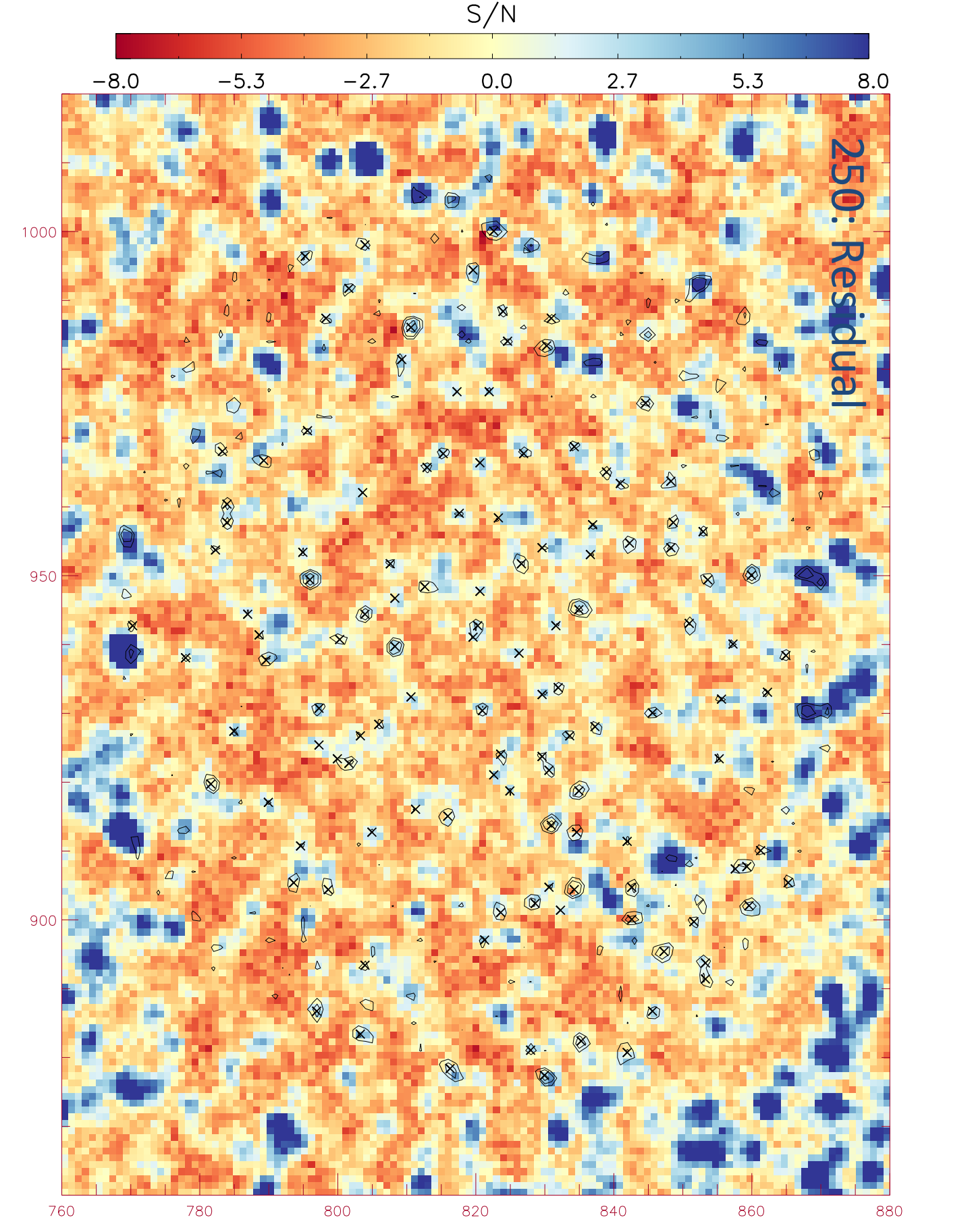


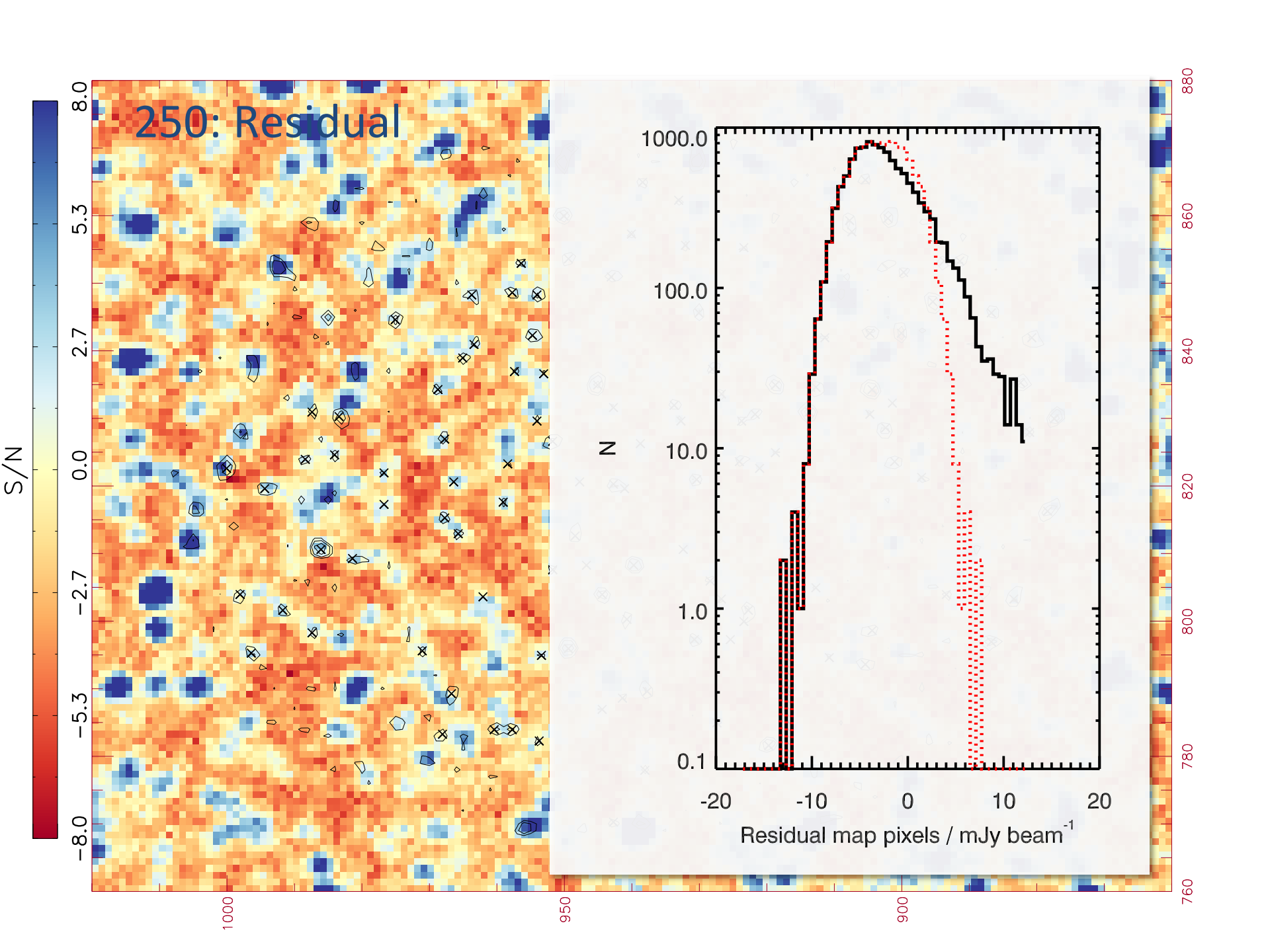
850 vs 450 fluxes



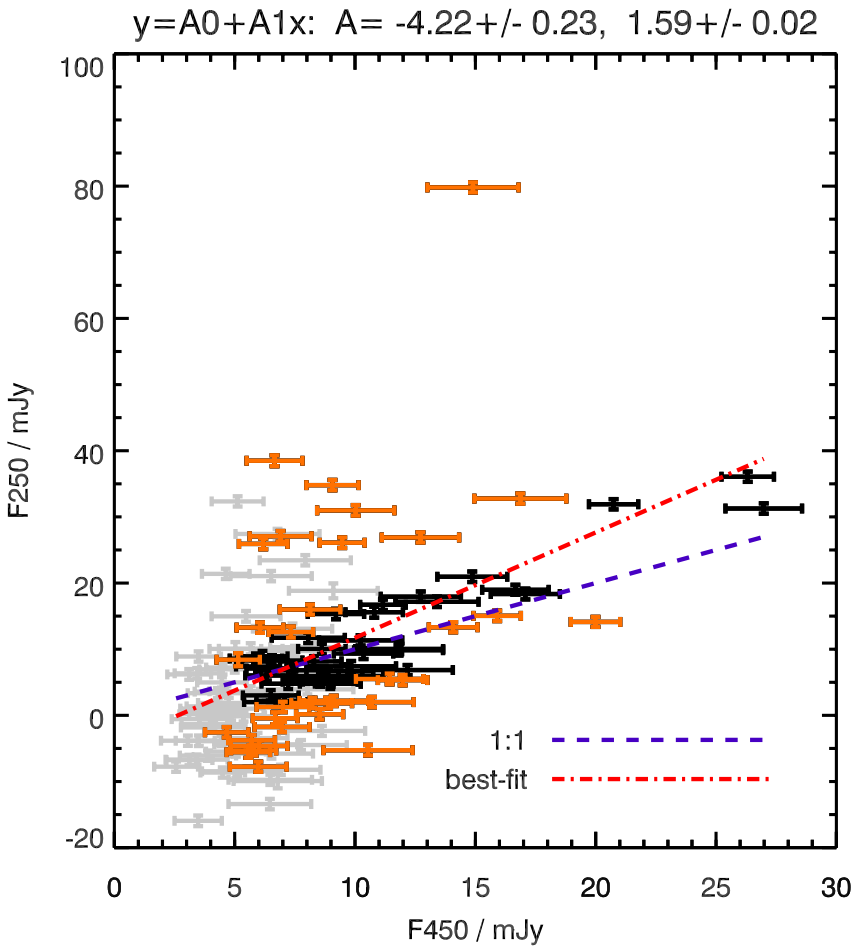
Clip=true

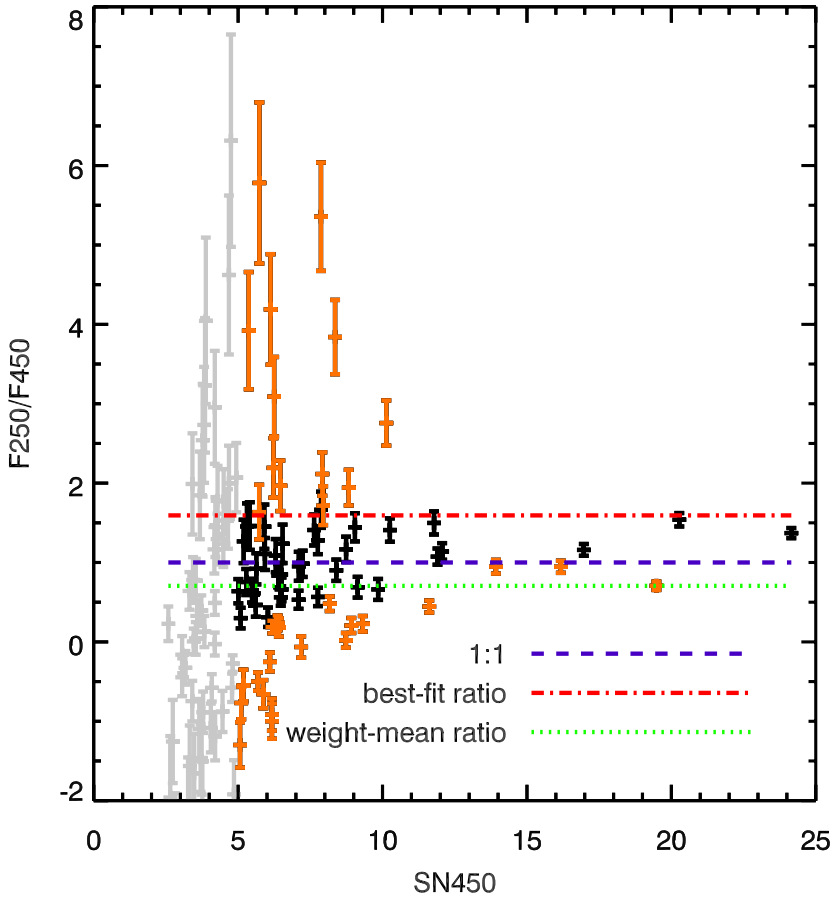

250: Image and positions
1000
950
900
760
780
800
820
840
860
880


S/N
−8.0
−5.3
−2.7
0.0
2.7
5.3
8.0
250: Residual
1000
950
900
760
780
800
820
840
860
880

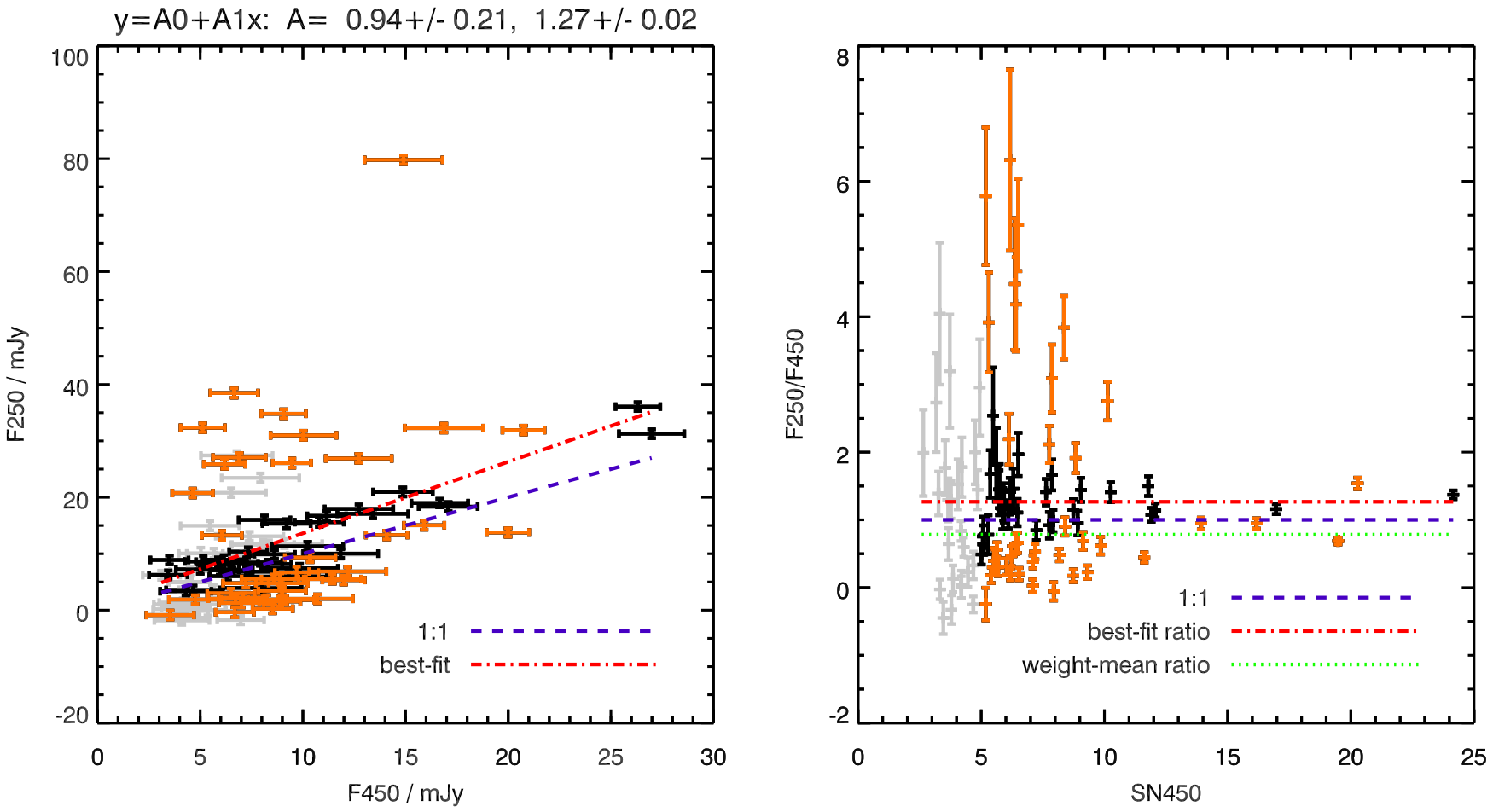

250: Residual
S/N
8.0
5.3
2.7
0.0
−2.7
−5.3
−8.0
1000
950
900
880
860
840
820
800
780
760
1000.0
100.0
10.0
1.0
0.1
N
-20
-10
0
10
20
Residual map pixels / mJy beam-1

250 vs 450 fluxes



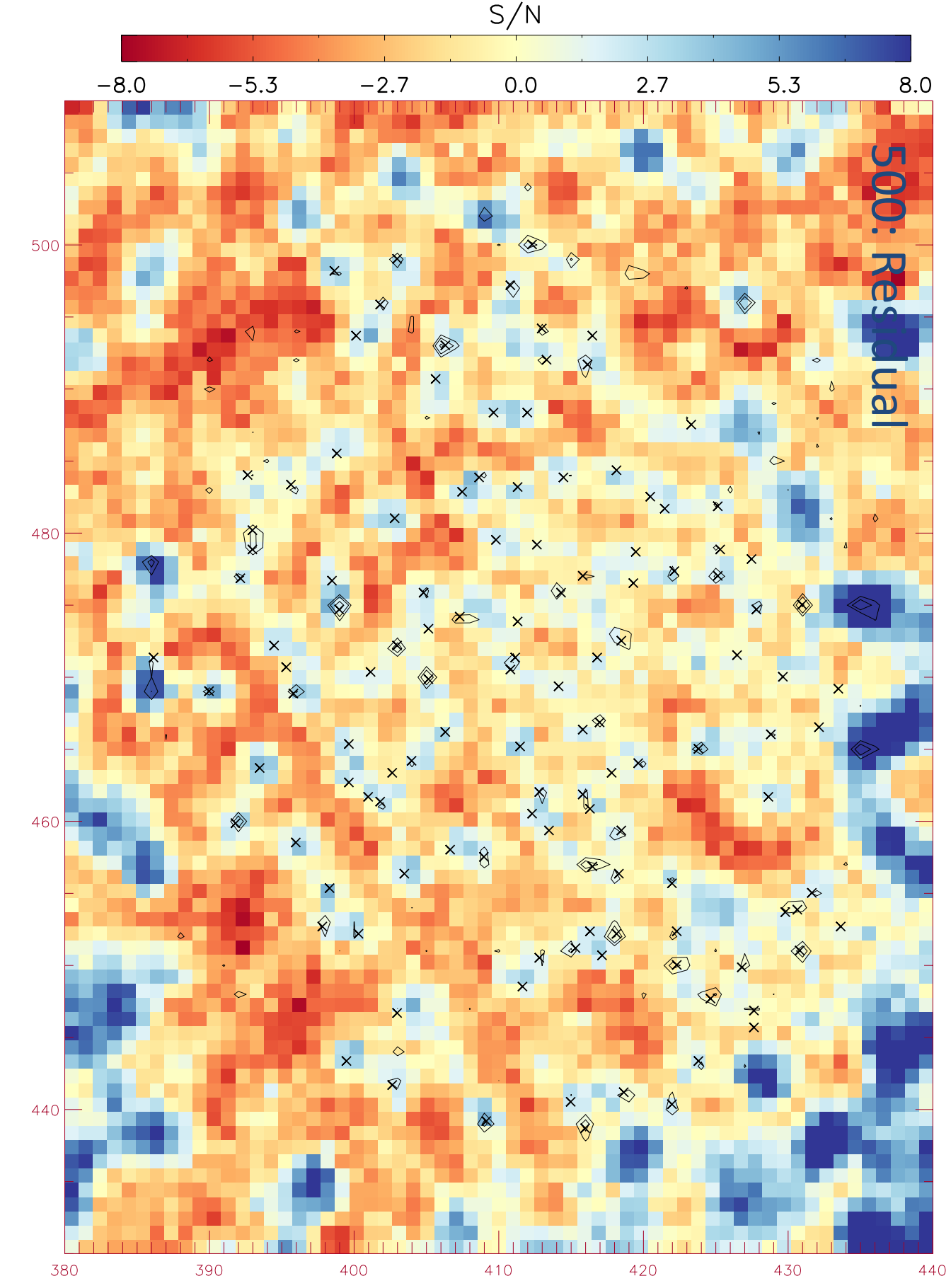


250 vs 450 fluxes



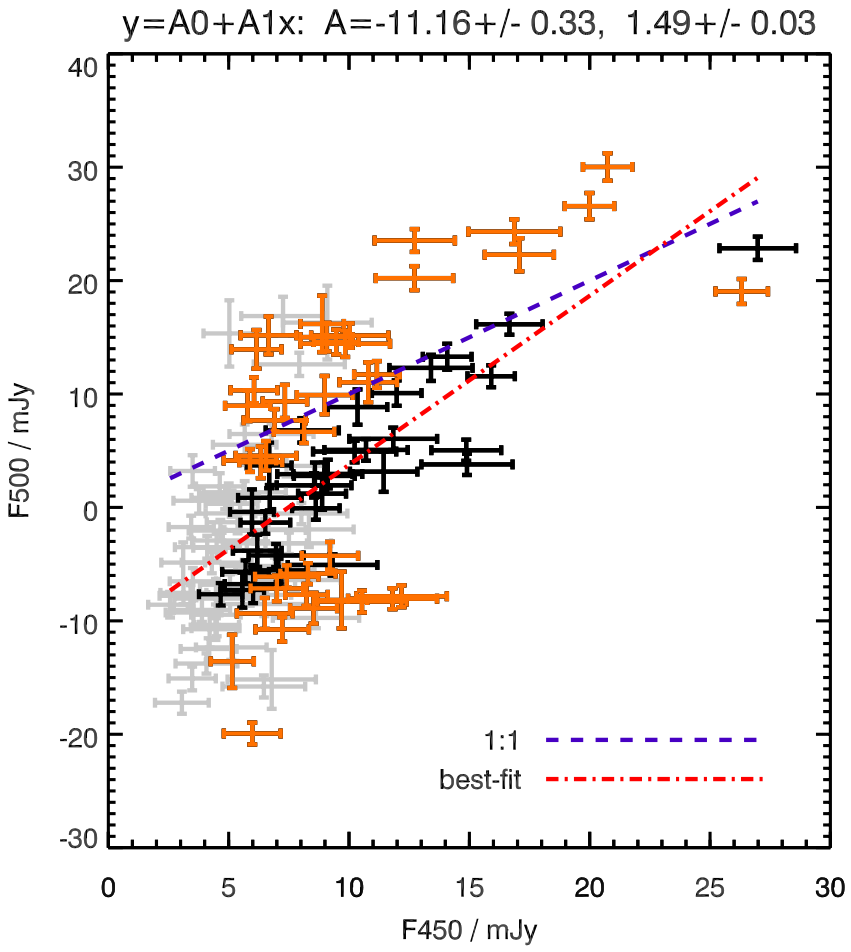
Clip=true

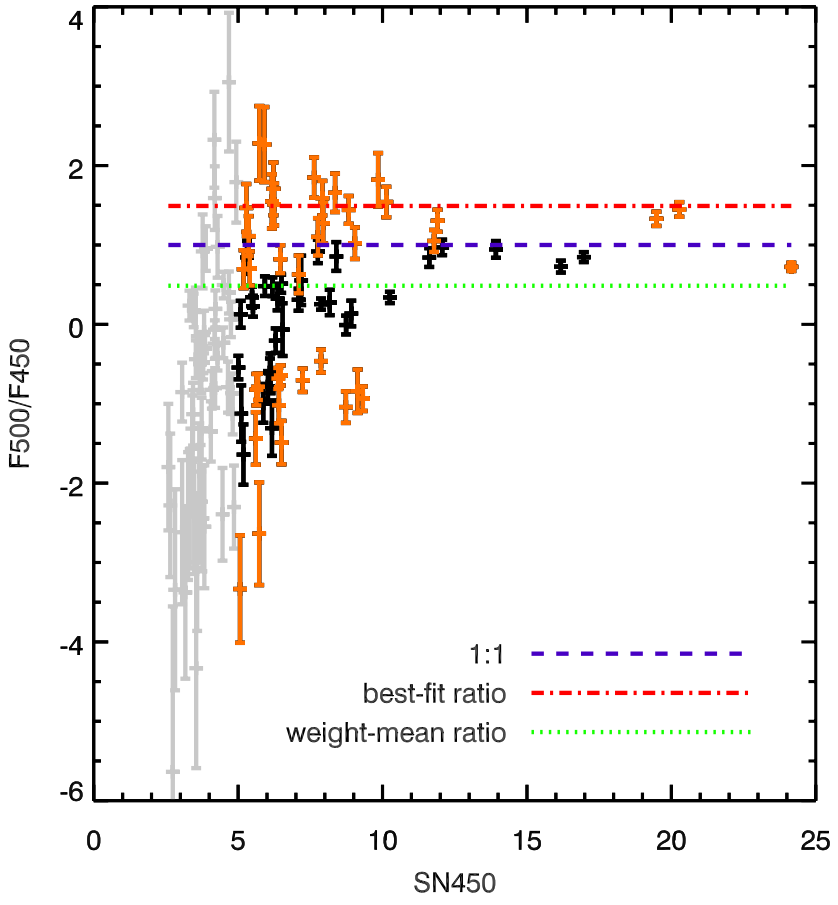
500: Image and positions


S/N
−8.0
−5.3
−2.7
0.0
2.7
5.3
8.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440

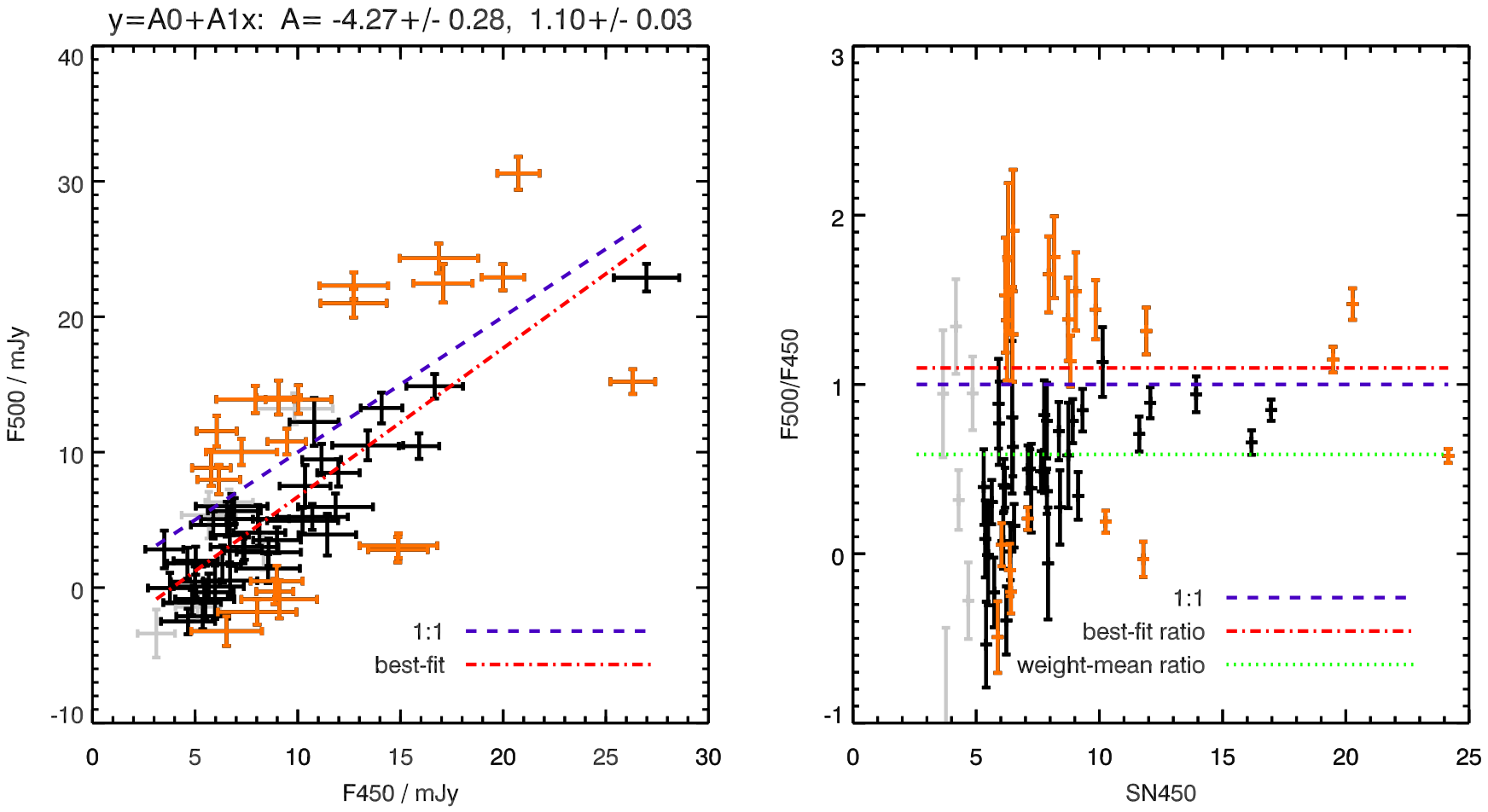
500: Residual

500 vs 450 fluxes





500 vs 450 fluxes



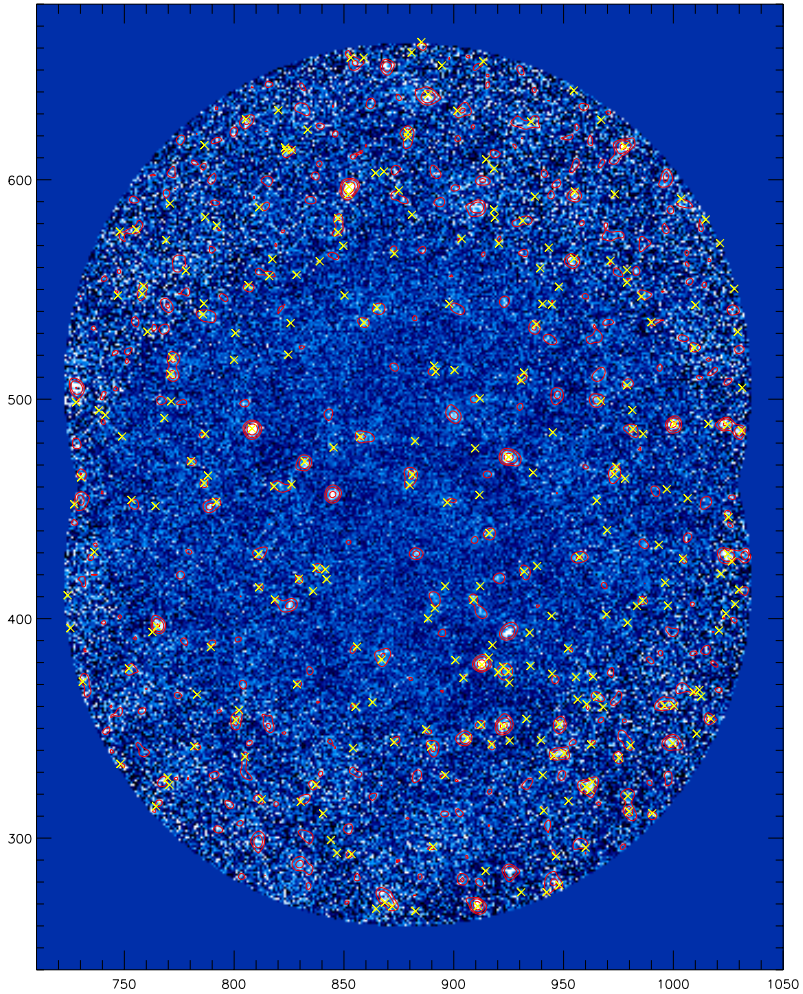
Clip=true

So we need a catalogue that better describes all the sources in the map…

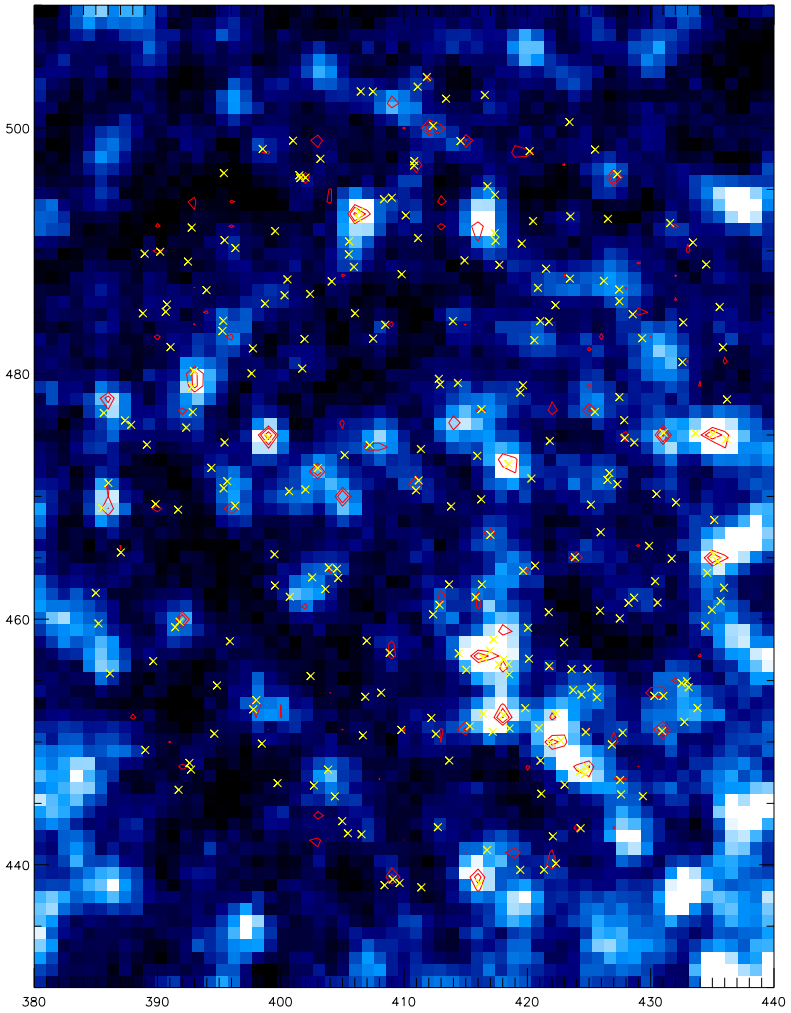
2. Do things improve with larger catalogues from other wavebands?

24μm positions

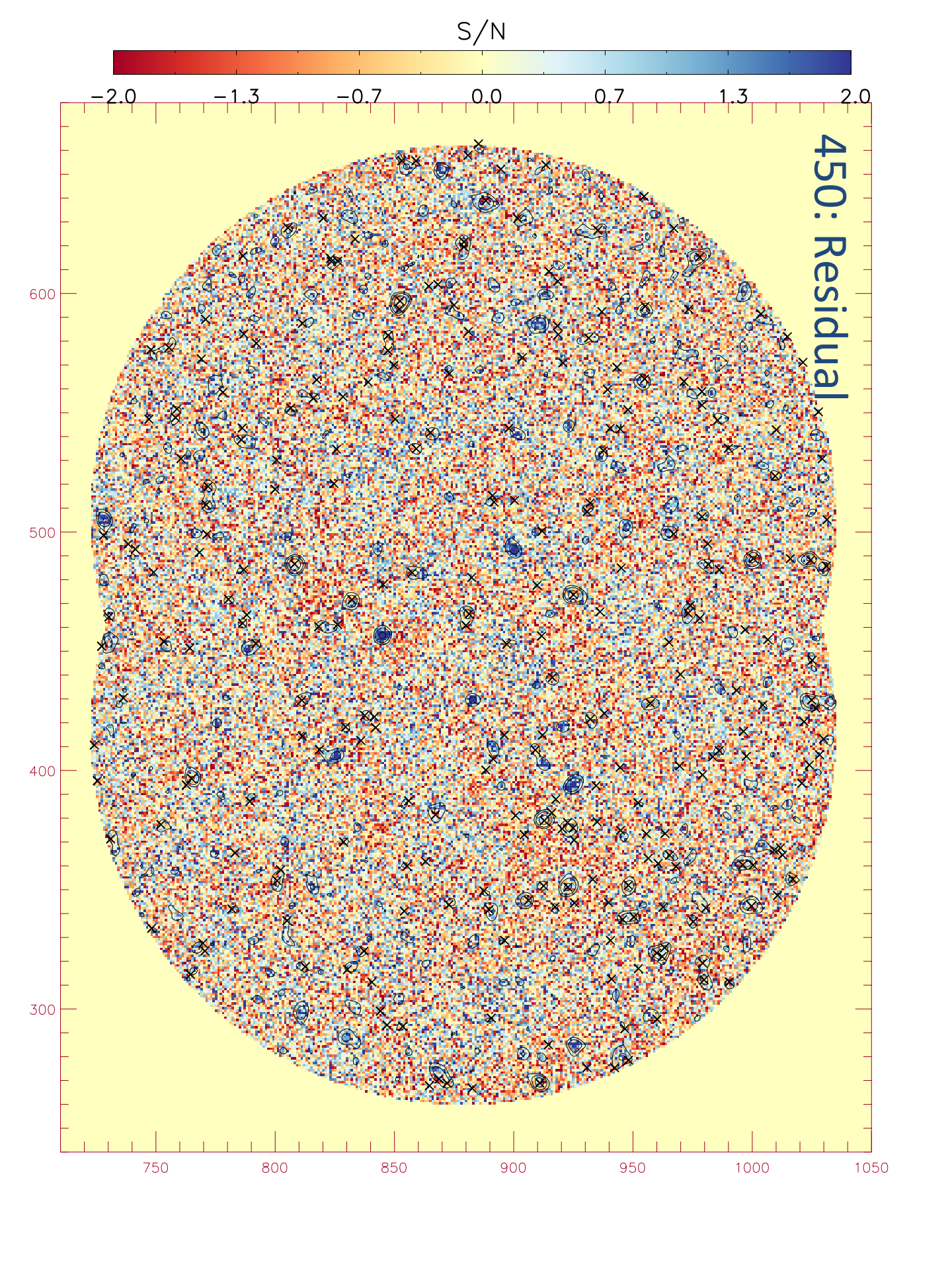
450

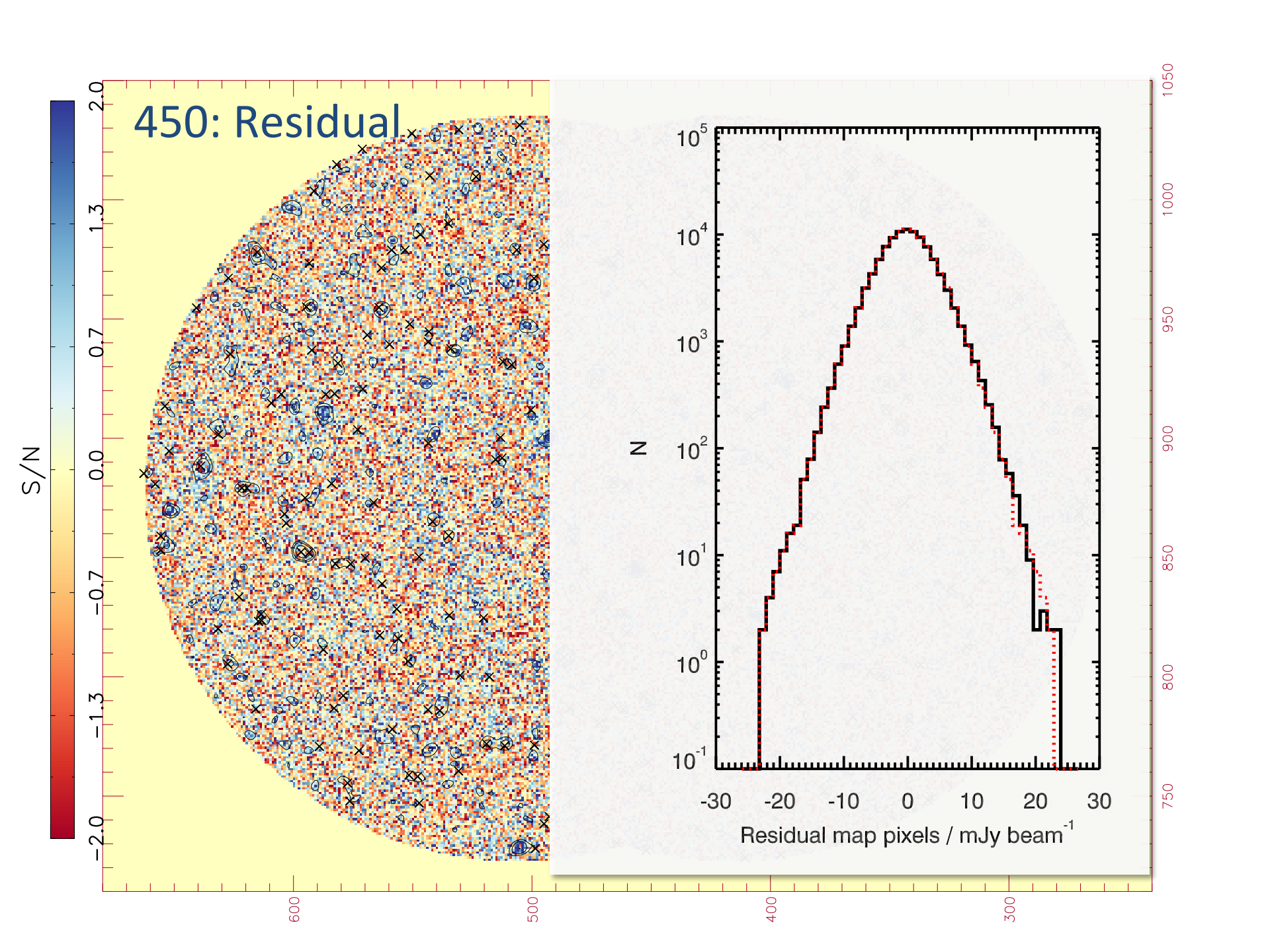


500

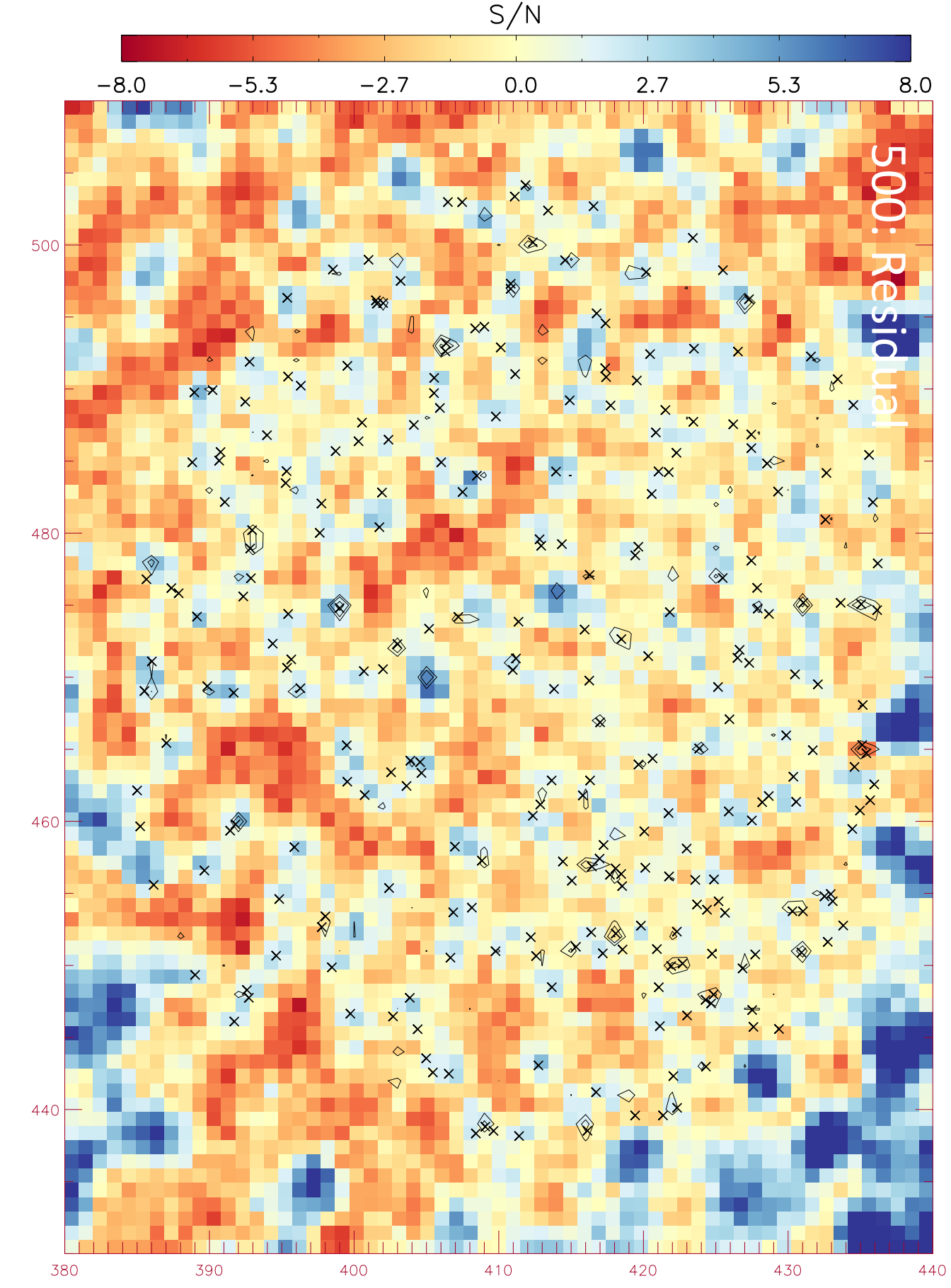


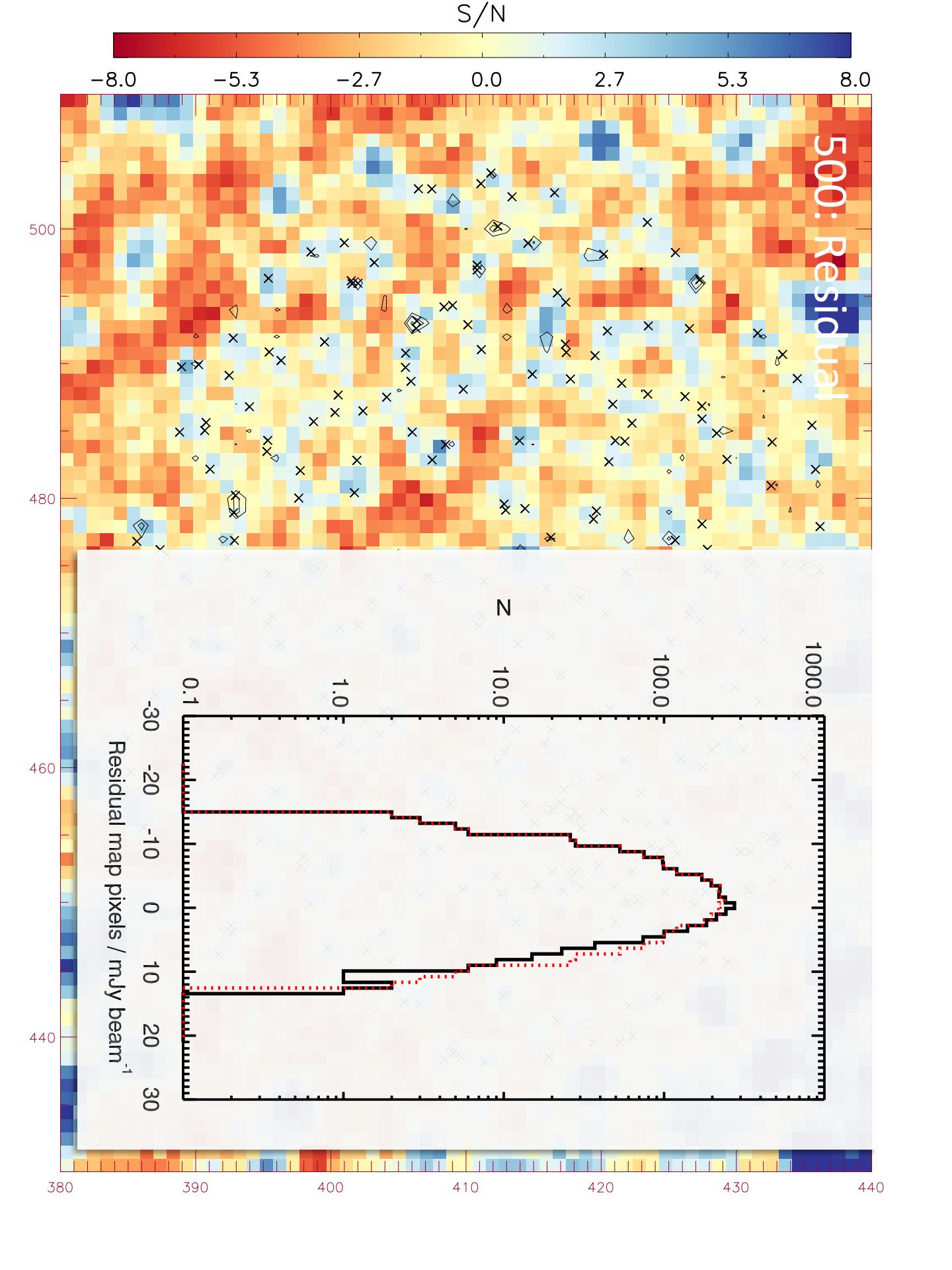
450: Image and positions


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
450: Residual
600
500
400
300
750
800
850
900
950
1000
1050

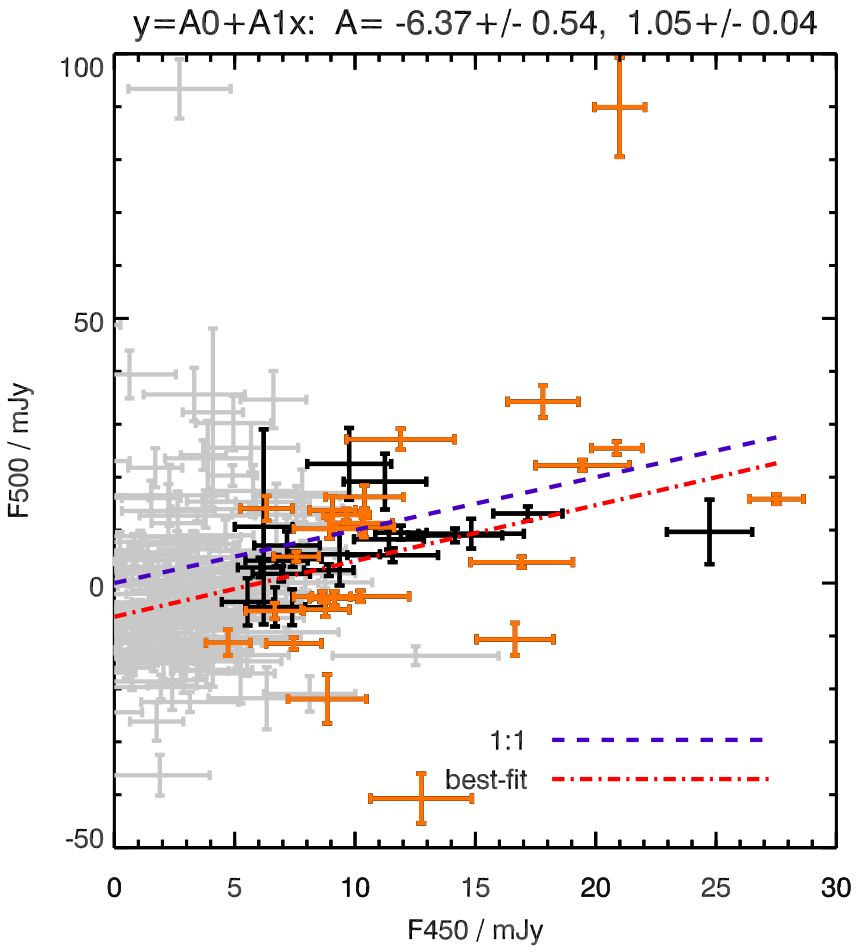

450: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
600
500
400
300
1050
1000
950
900
850
800
750
N
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam^{-1}

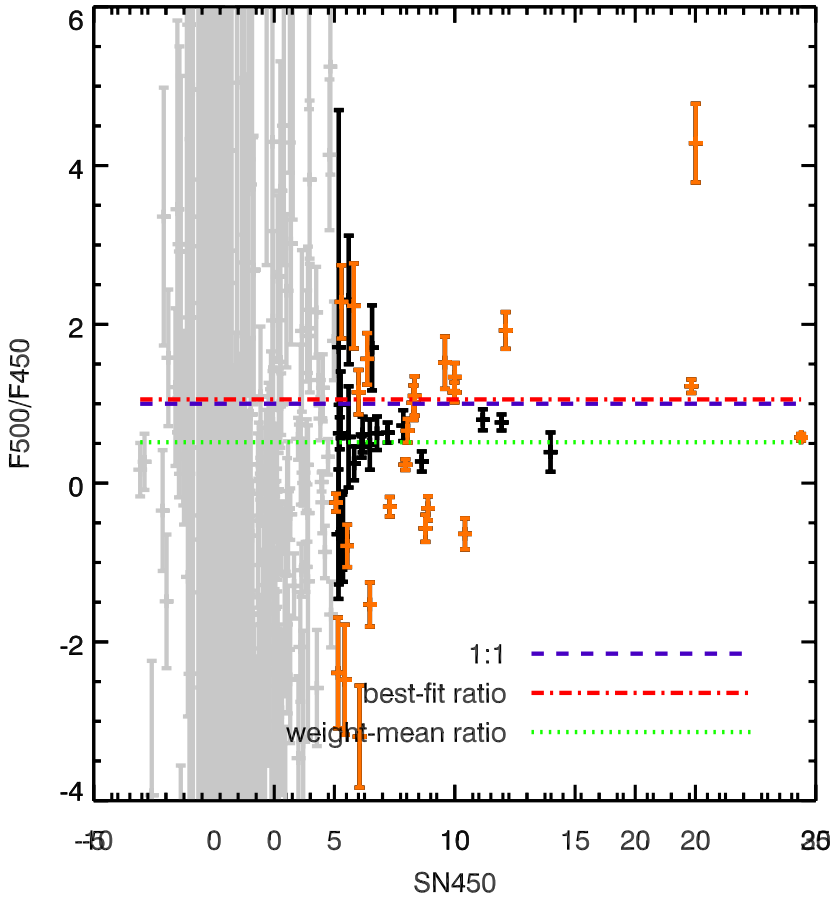
500: Image and positions


S/N
−8.0
−5.3
−2.7
0.0
2.7
5.3
8.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440

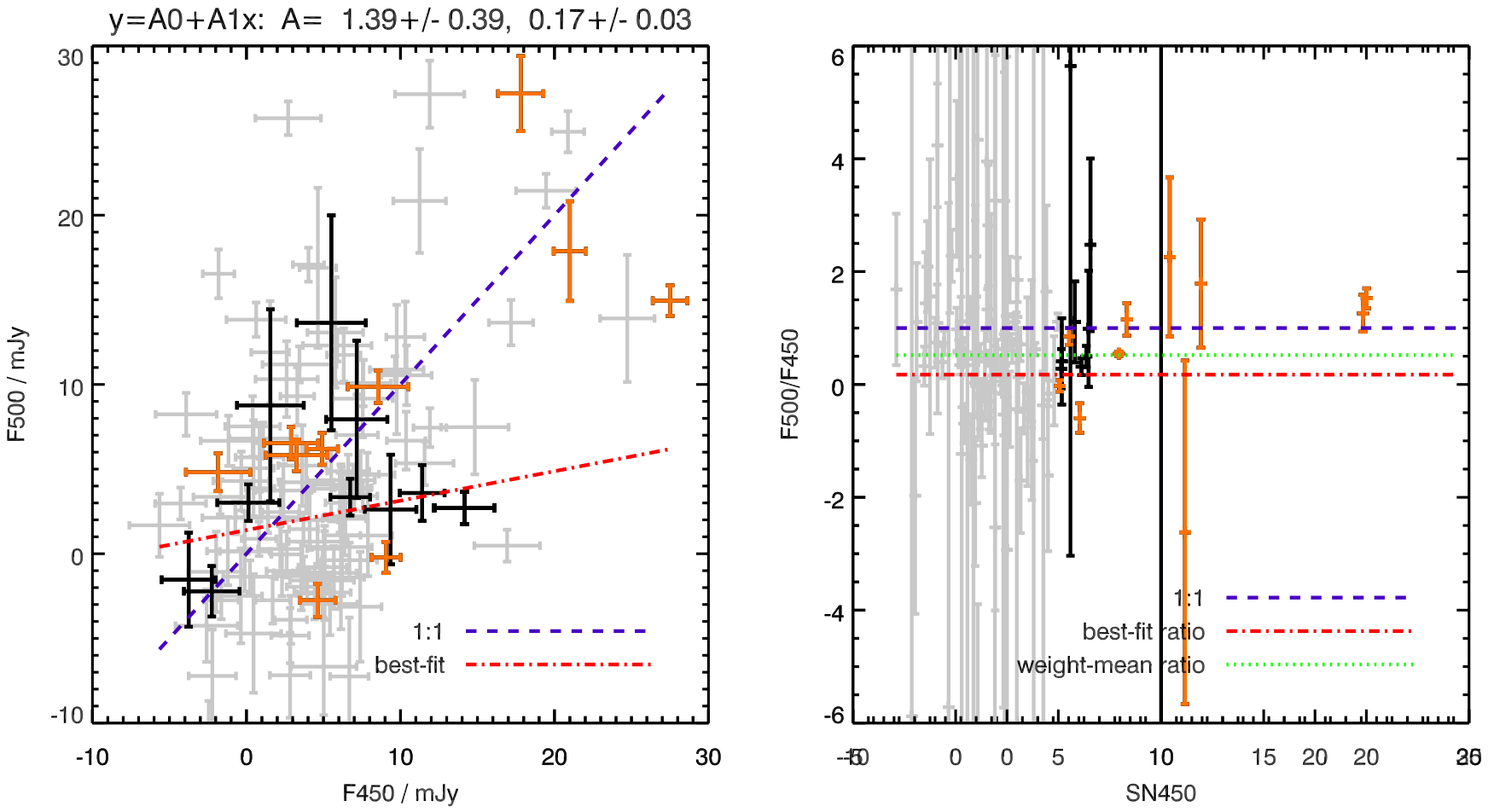

S/N
−8.0
−5.3
−2.7
0.0
2.7
5.3
8.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440
N
0.1
1.0
10.0
100.0
1000.0
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam^{-1}

500 vs 450 fluxes @ 24µm positions





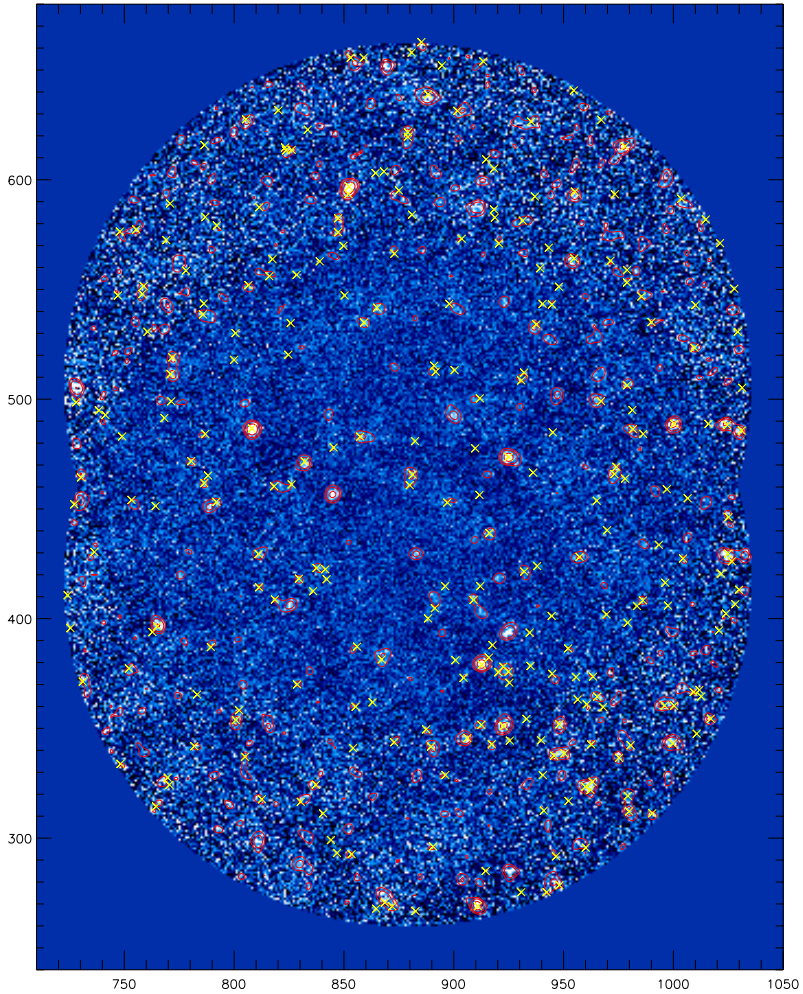
500 vs 450 fluxes @ 24µm positions



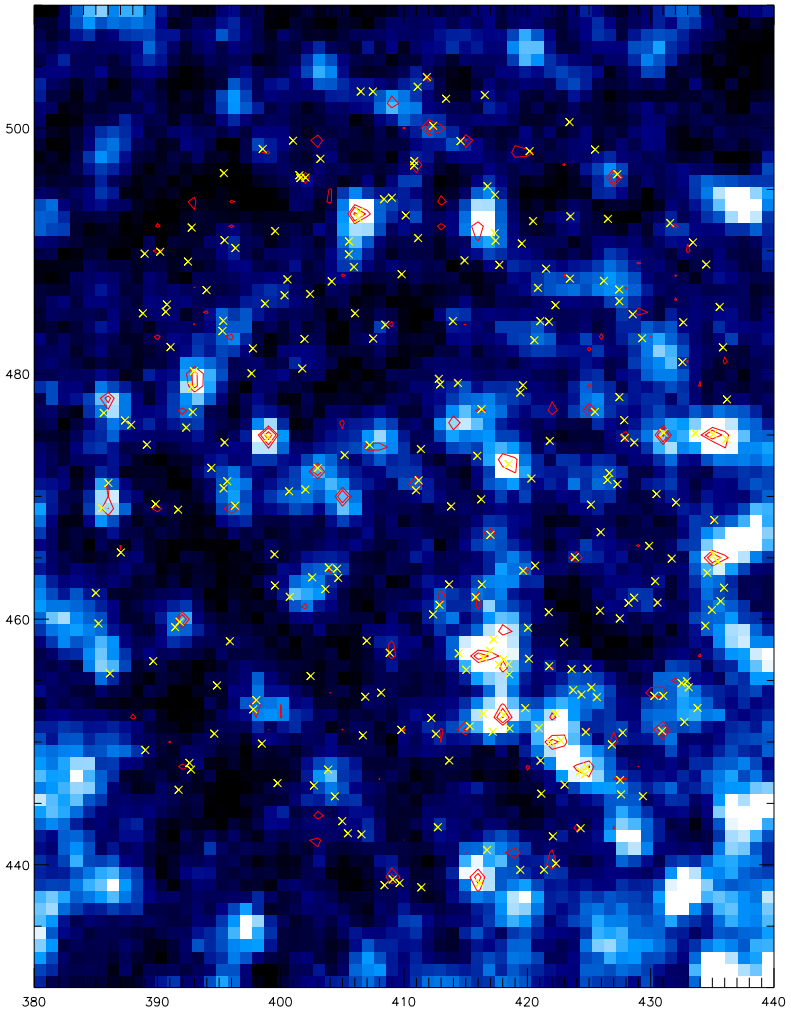
Clip=true

24μm positions

450

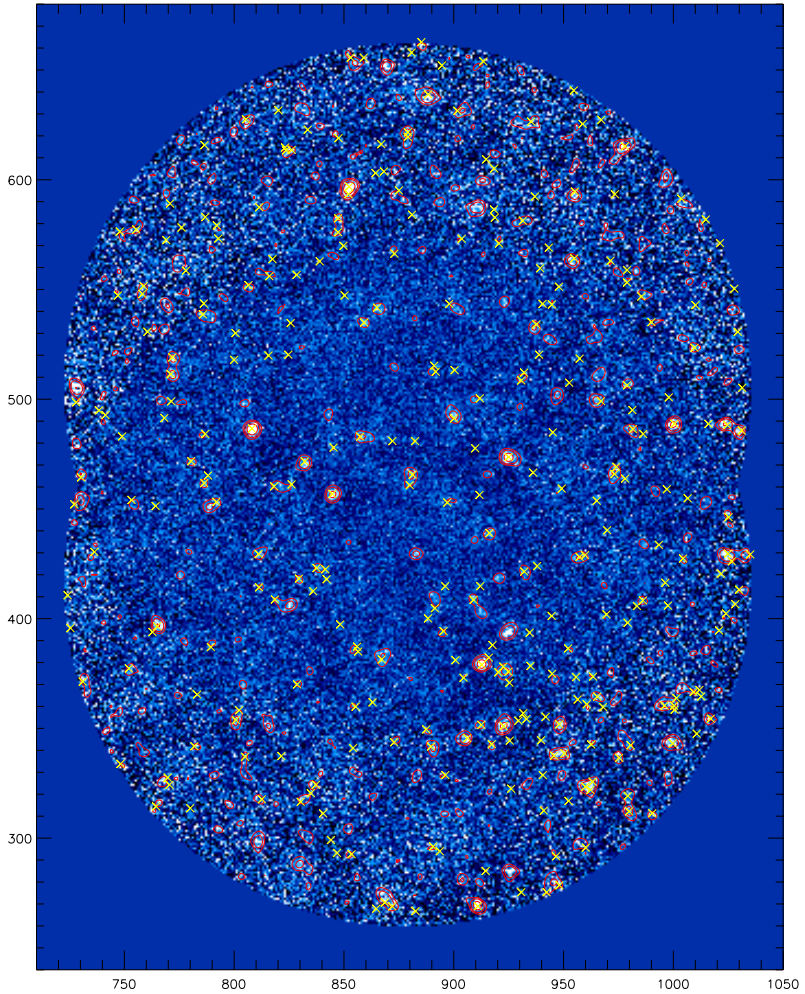


500

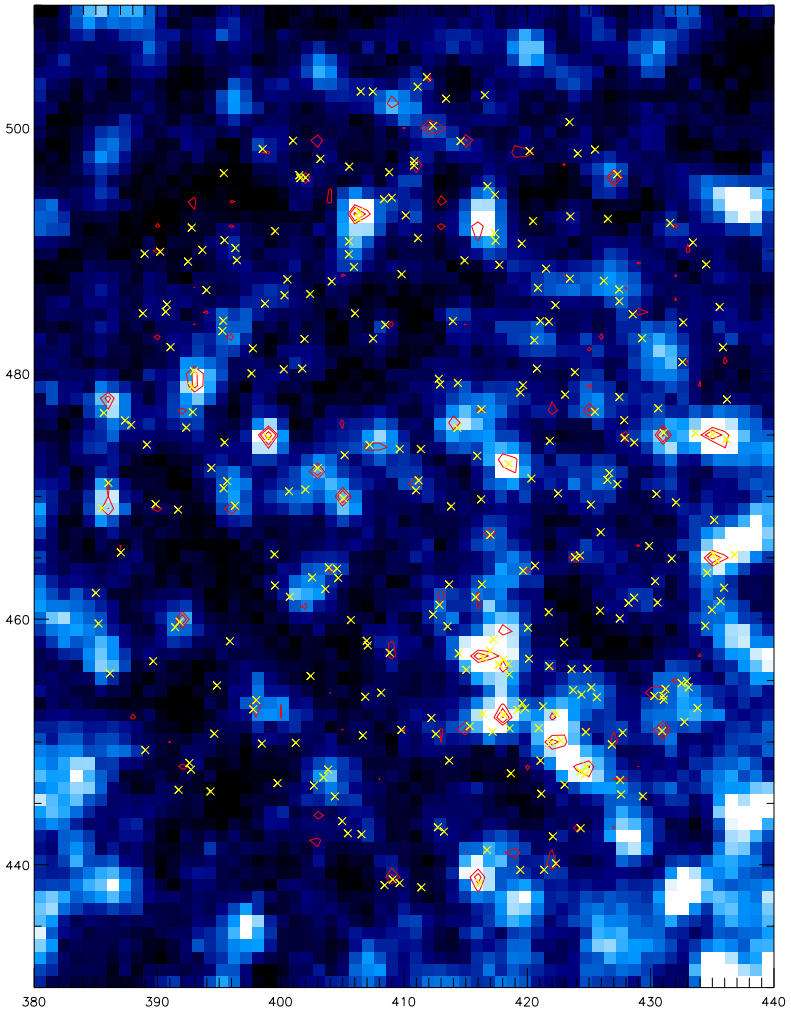


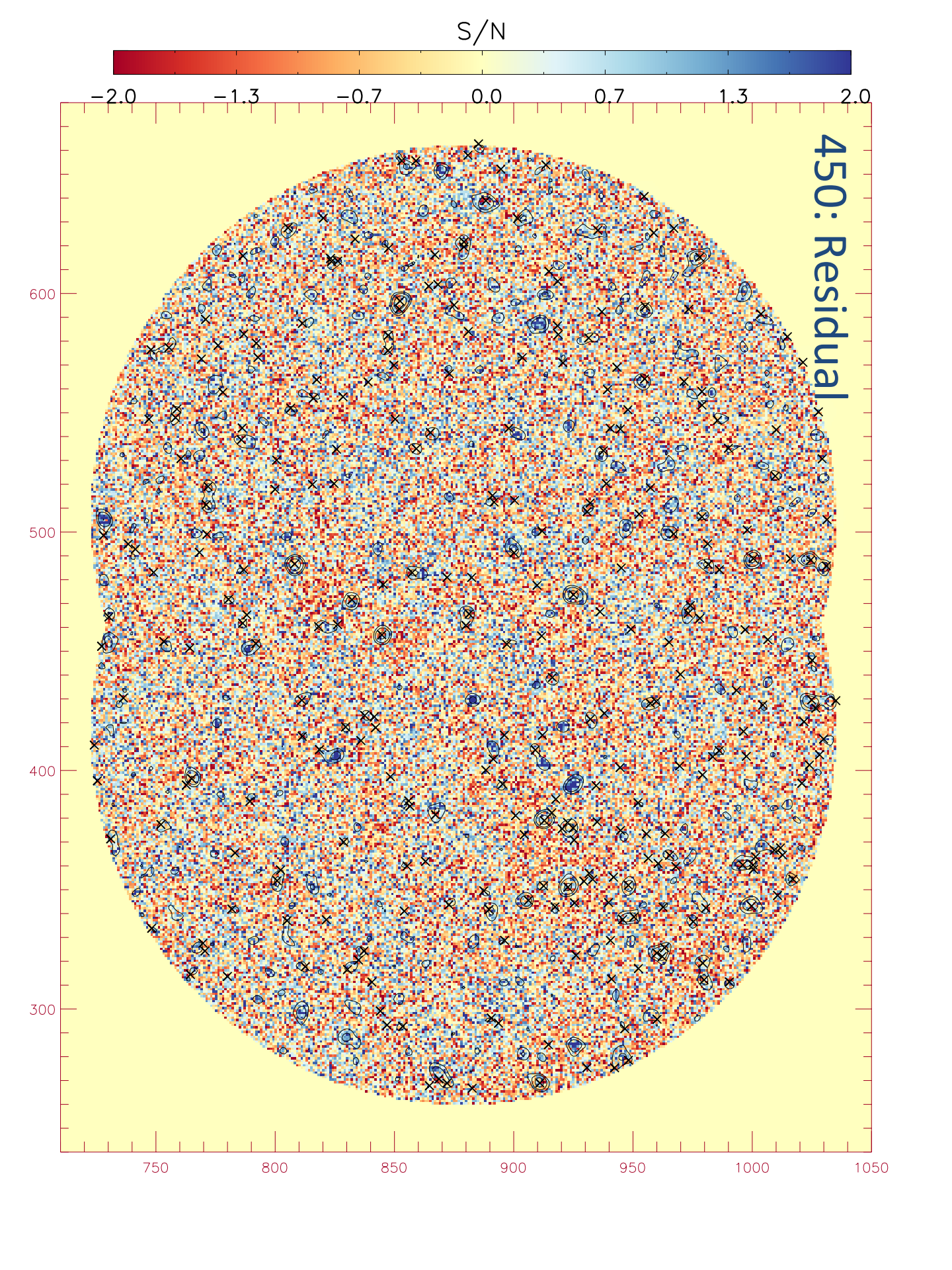
24μm+1.4GHz positions

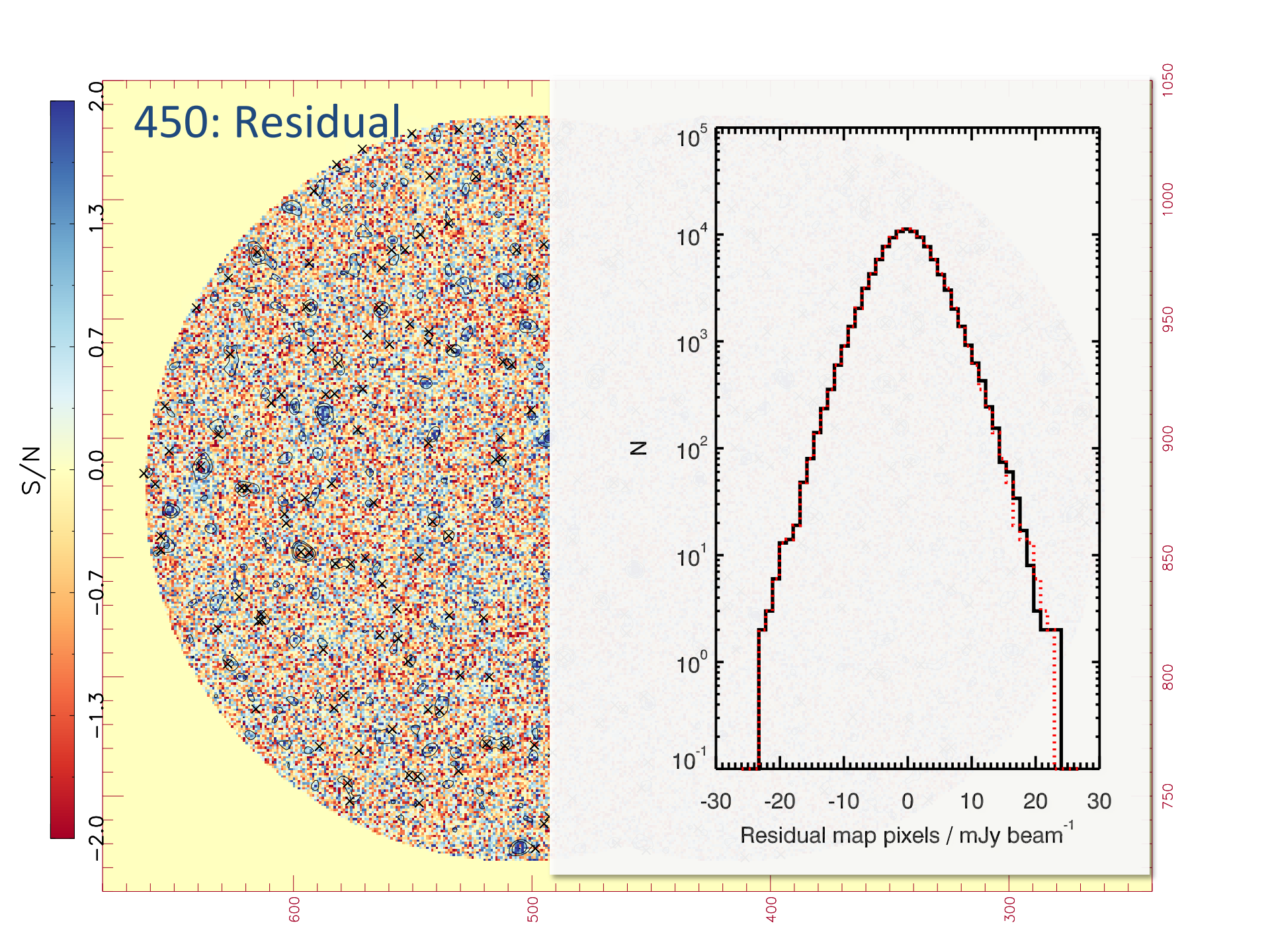
450

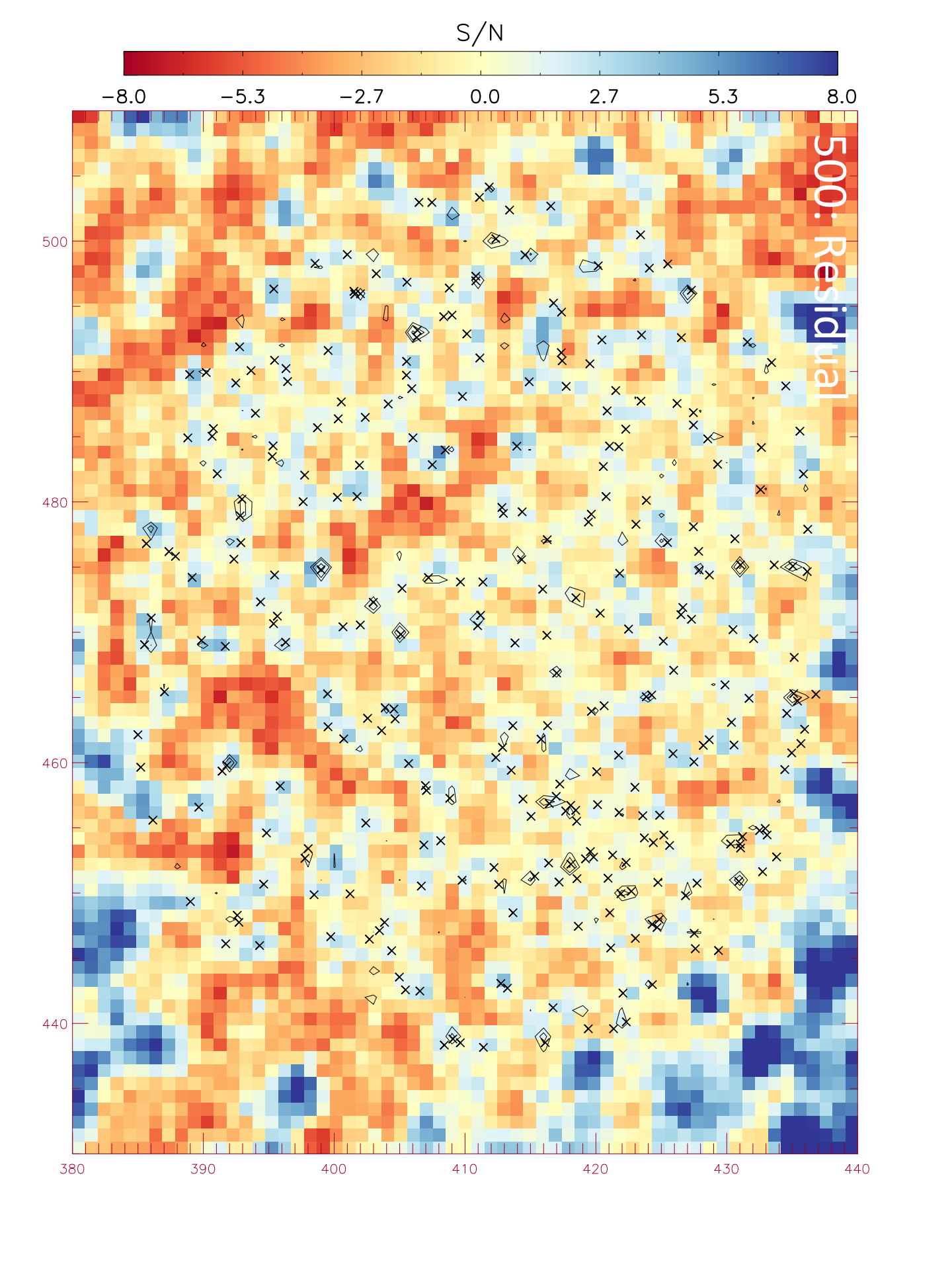


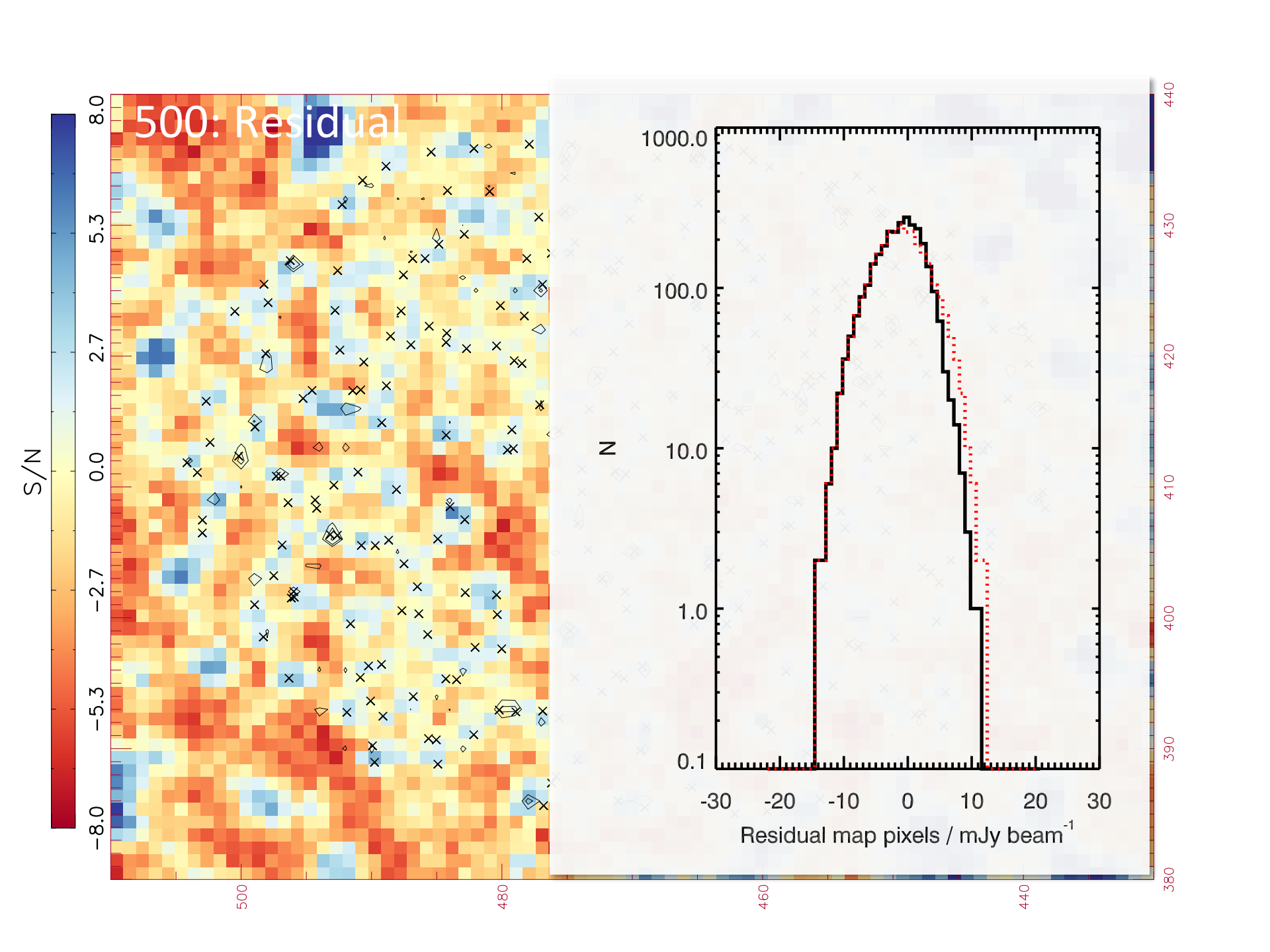
500




S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
450: Residual
600
500
400
300
750
800
850
900
950
1000
1050

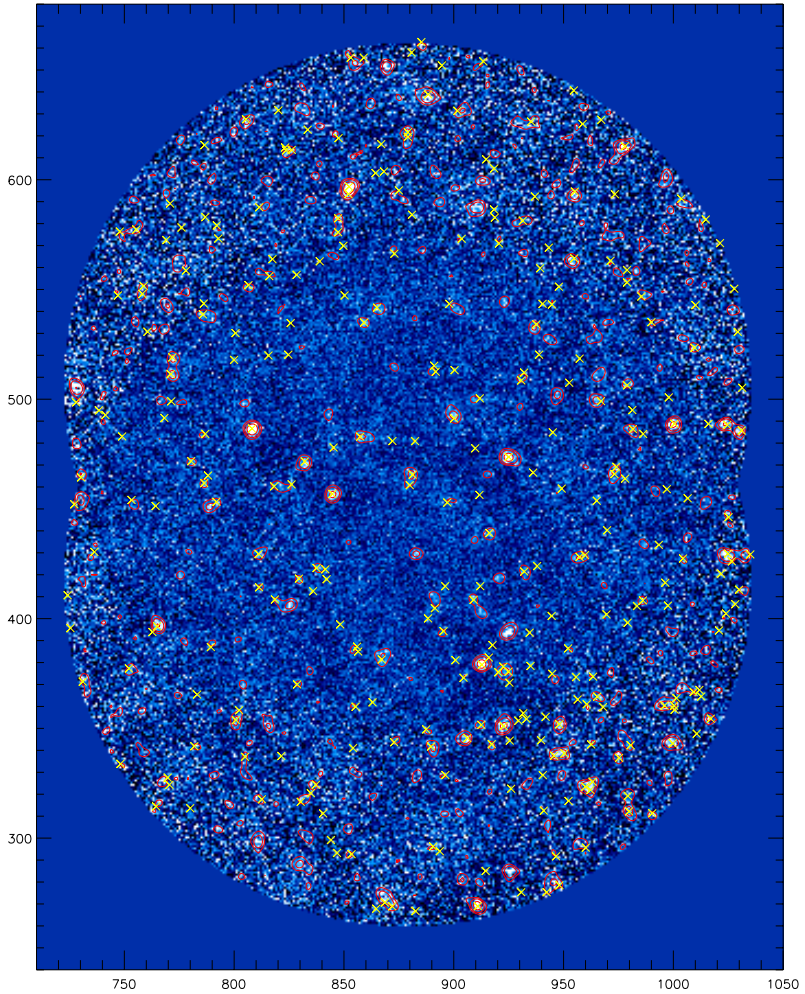

450: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
600
500
400
300
1050
1000
950
900
850
800
750
N
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam^{-1}


S/N
−8.0
−5.3
−2.7
0.0
2.7
5.3
8.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440

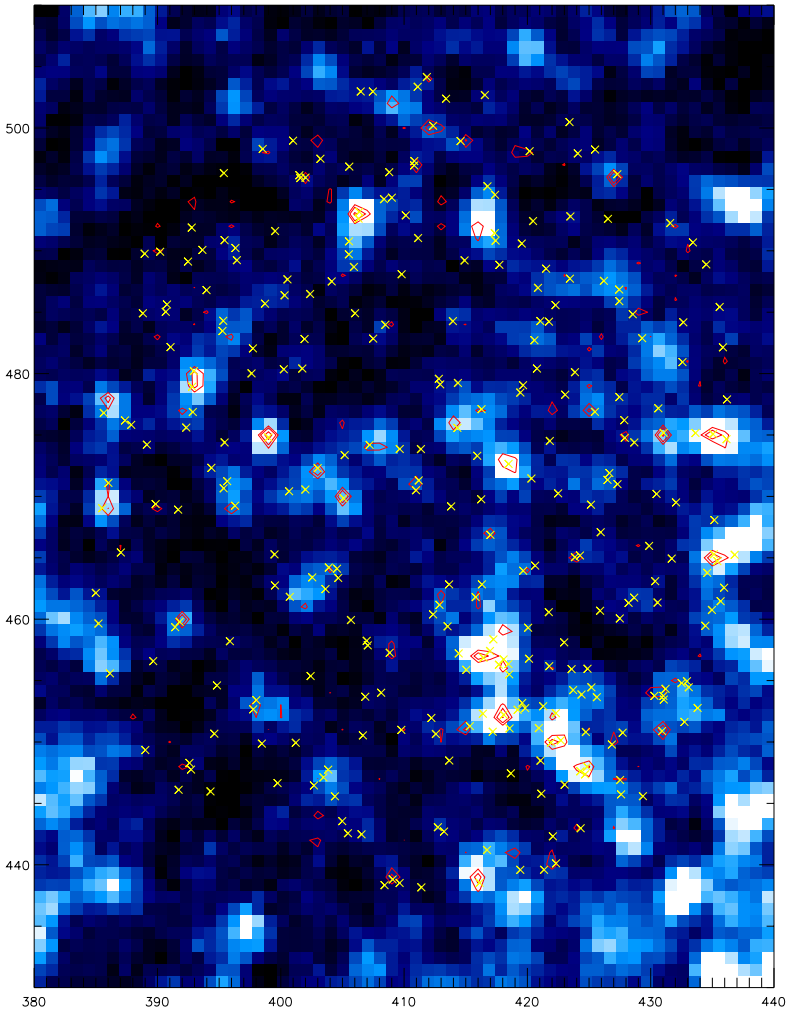

500: Residual
S/N
8.0
5.3
2.7
0.0
−2.7
−5.3
−8.0
500
480
460
440
380
390
400
410
420
430
440
N
1000.0
100.0
10.0
1.0
0.1
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam-1

24μm+1.4GHz positions

450

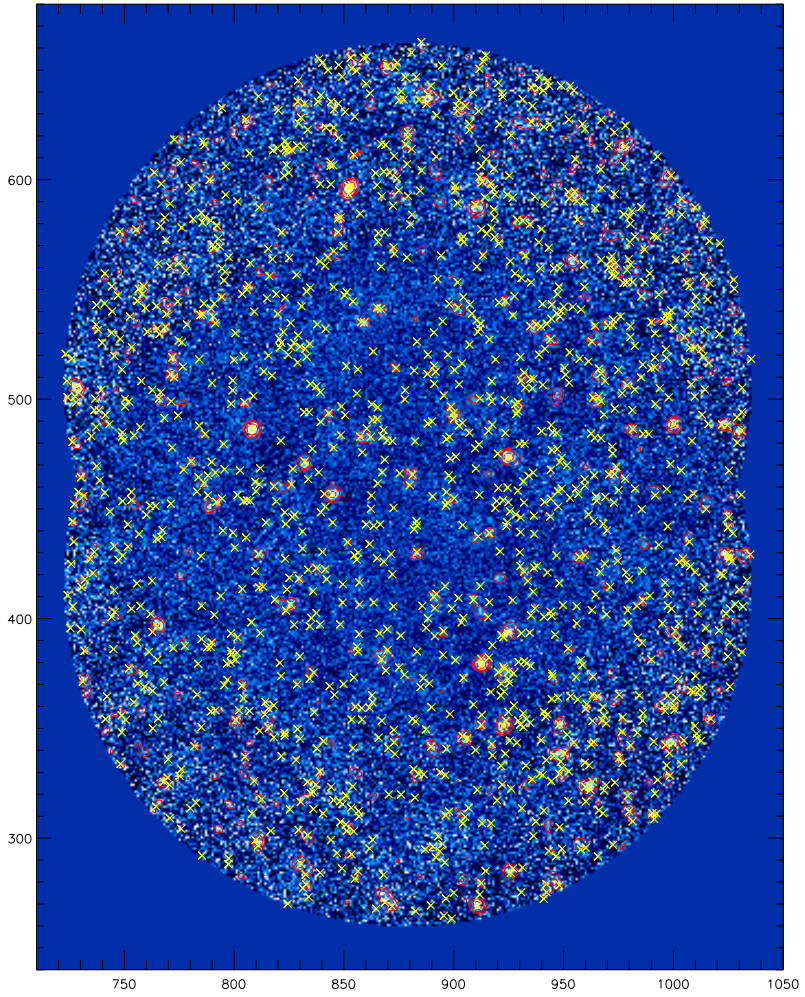


500

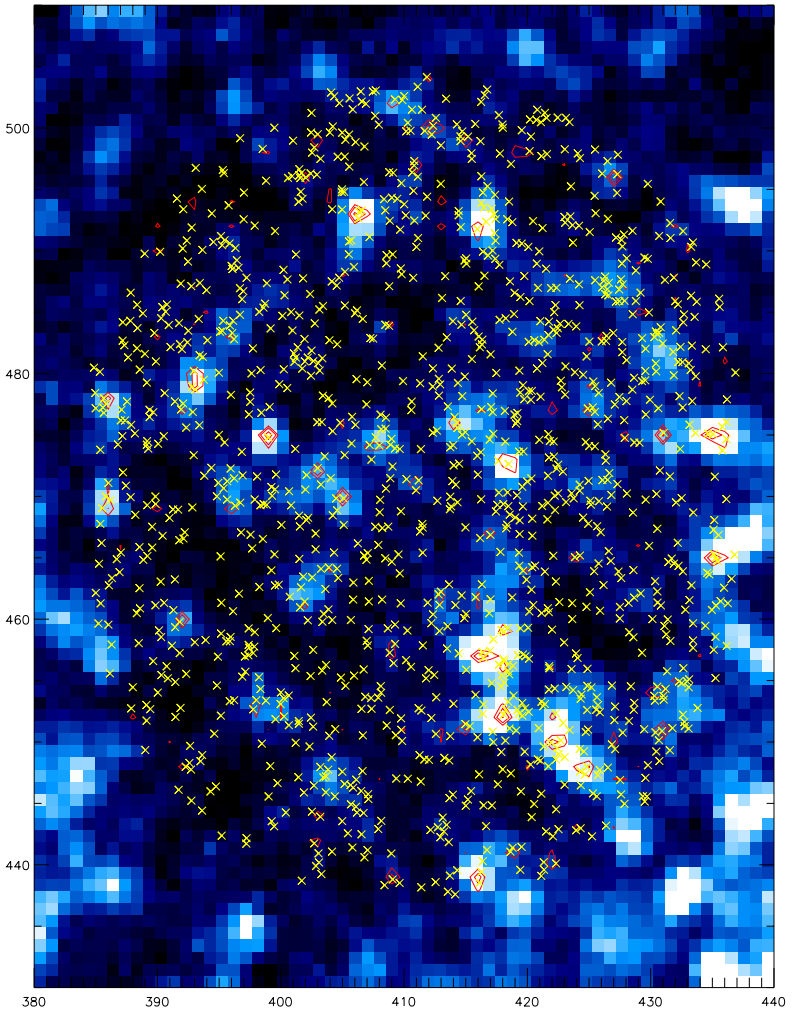


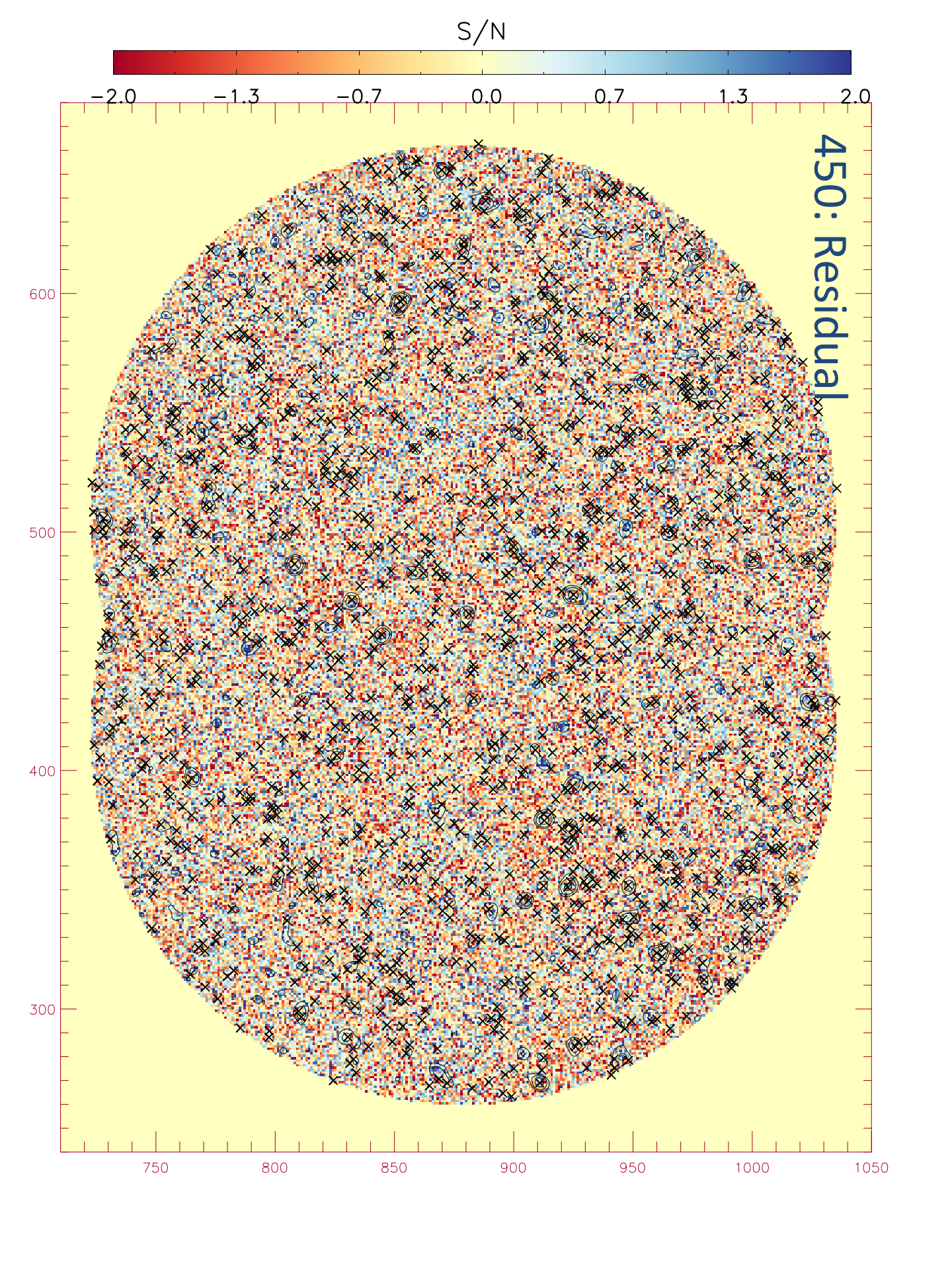
8μm+24μm+1.4GHz positions

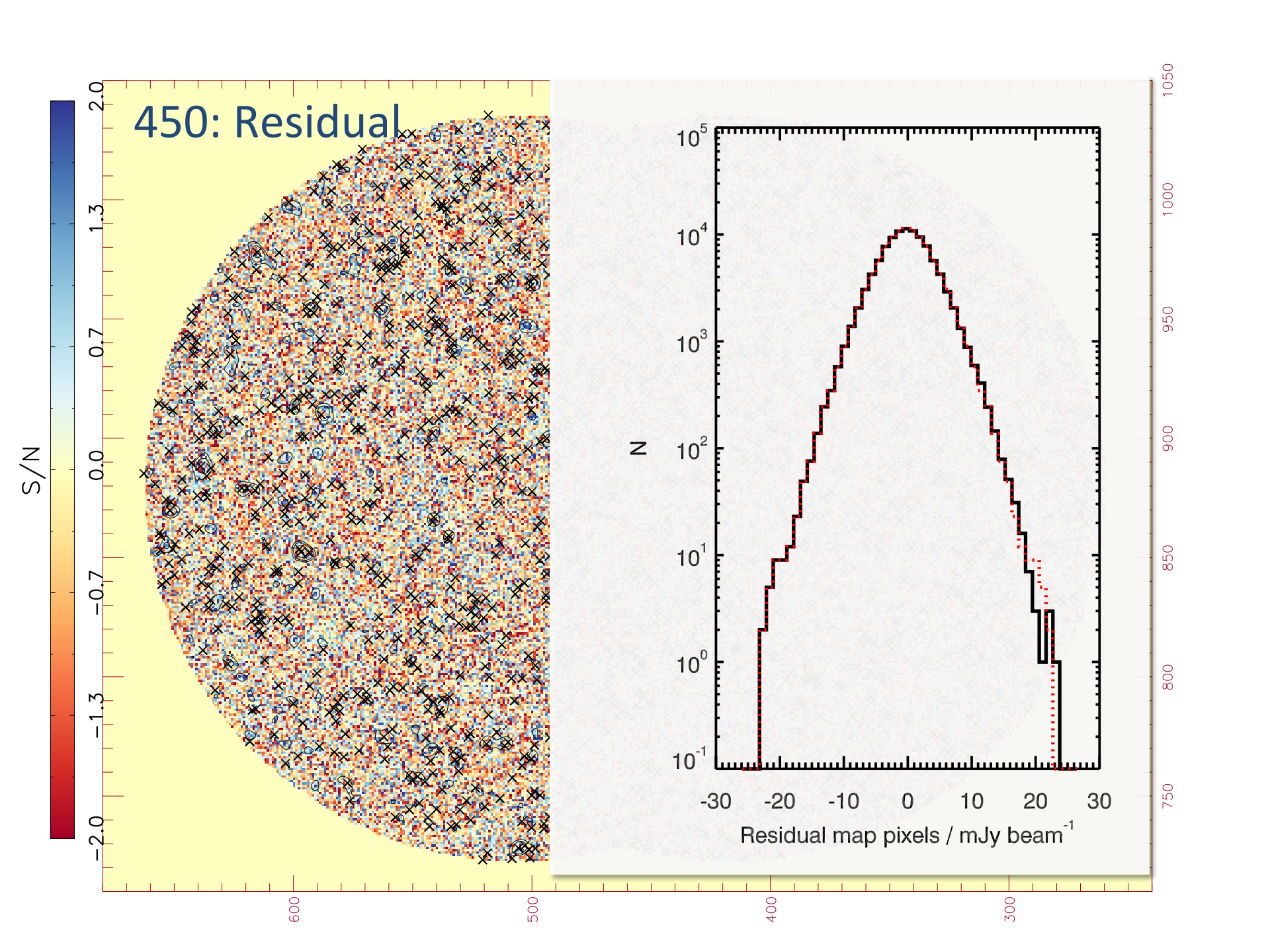
450

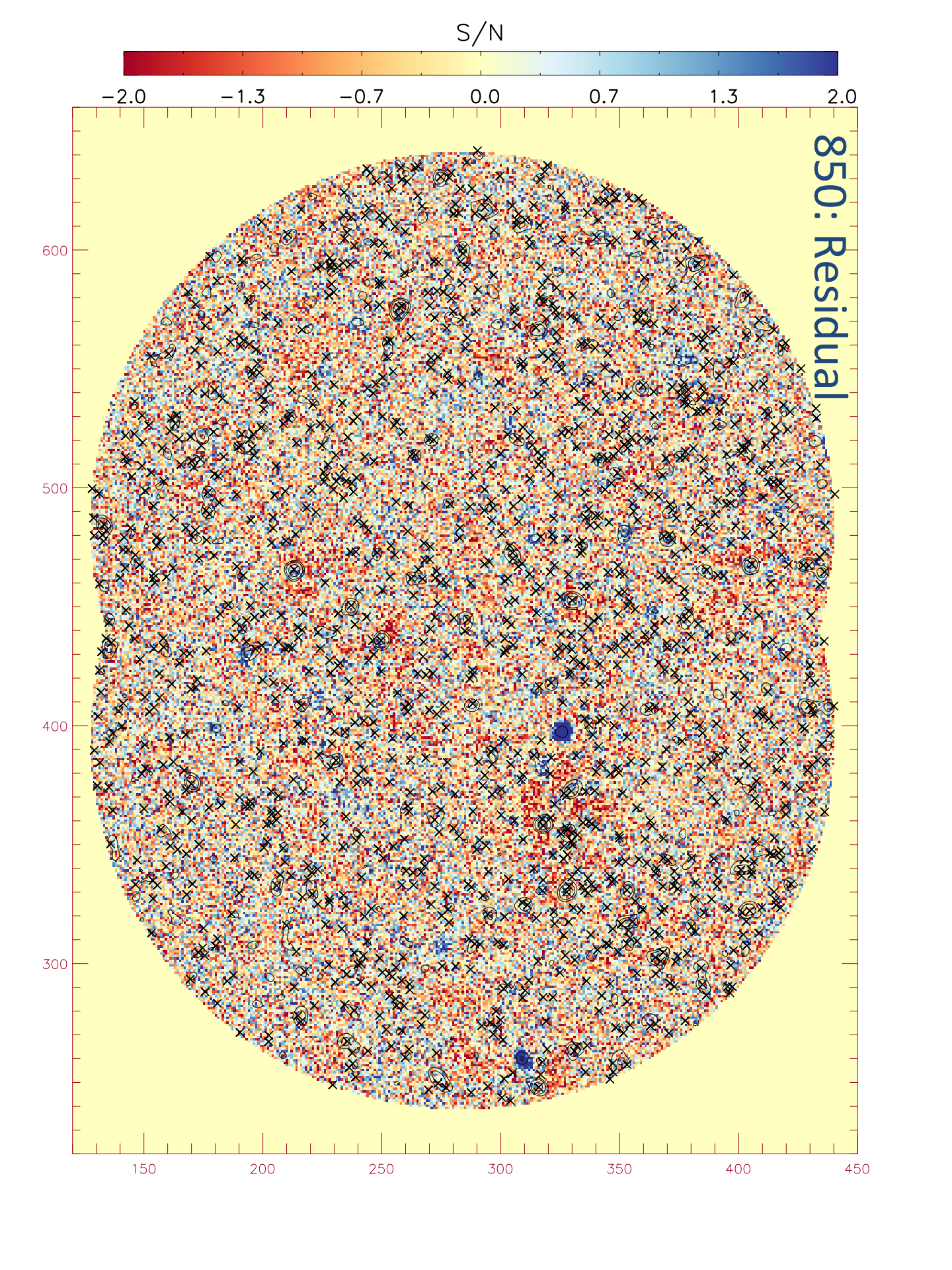


500

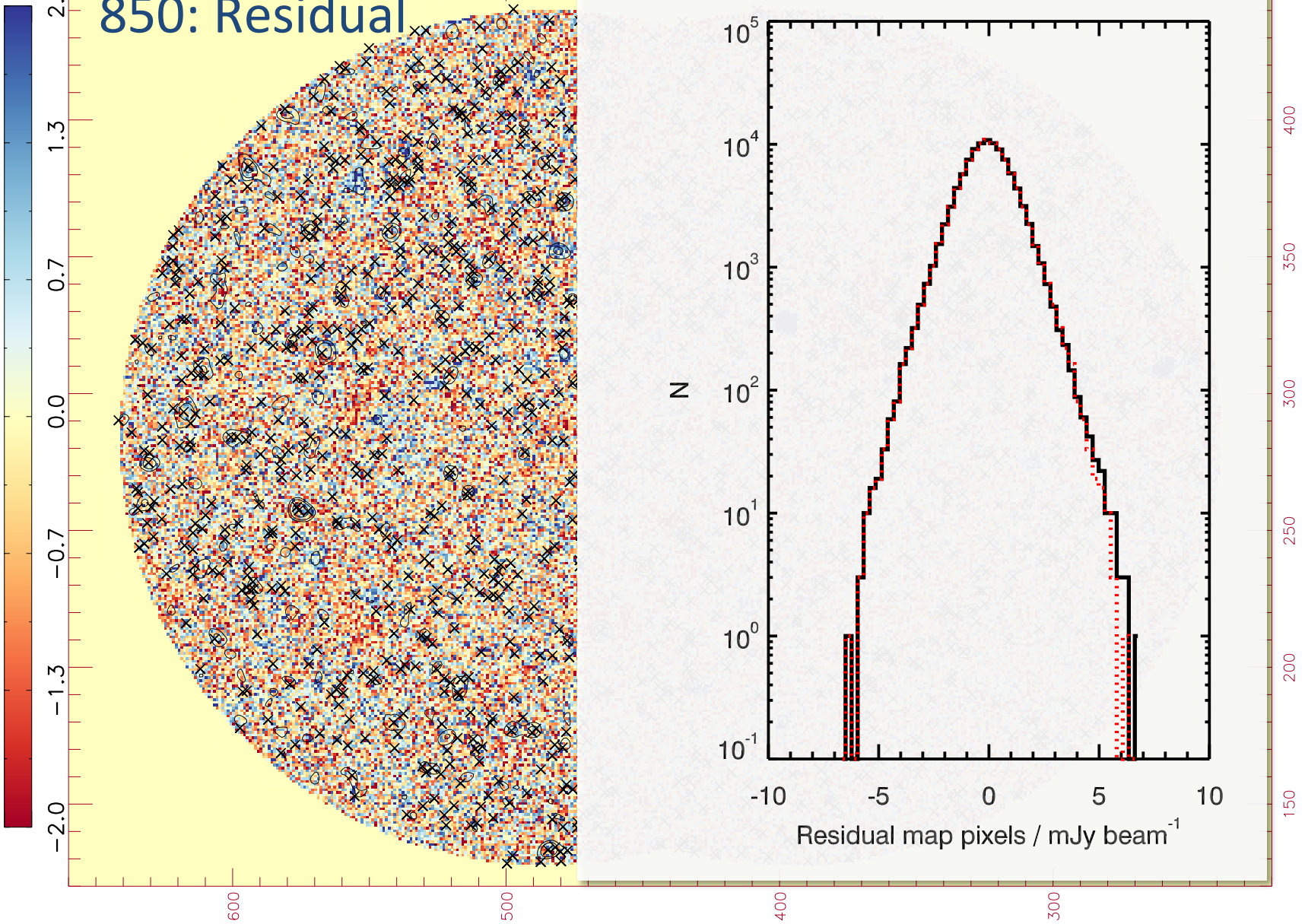



S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
450: Residual
600
500
400
300
750
800
850
900
950
1000
1050

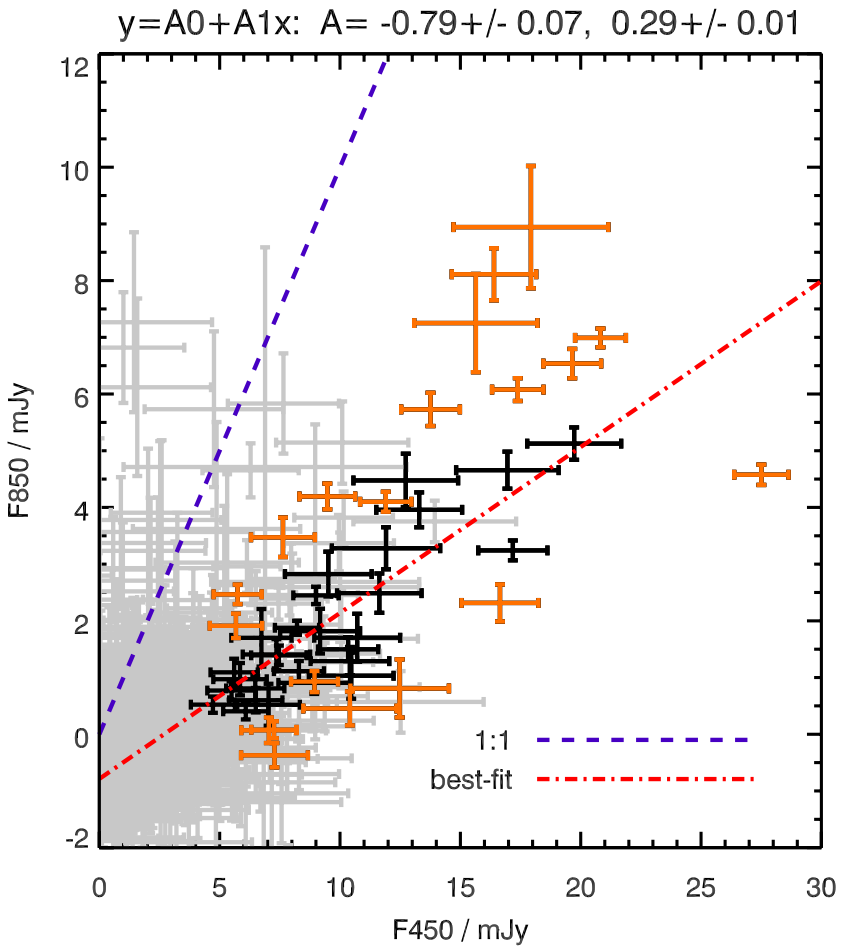

450: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
600
500
400
300
1050
1000
950
900
850
800
750
N
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam^{-1}

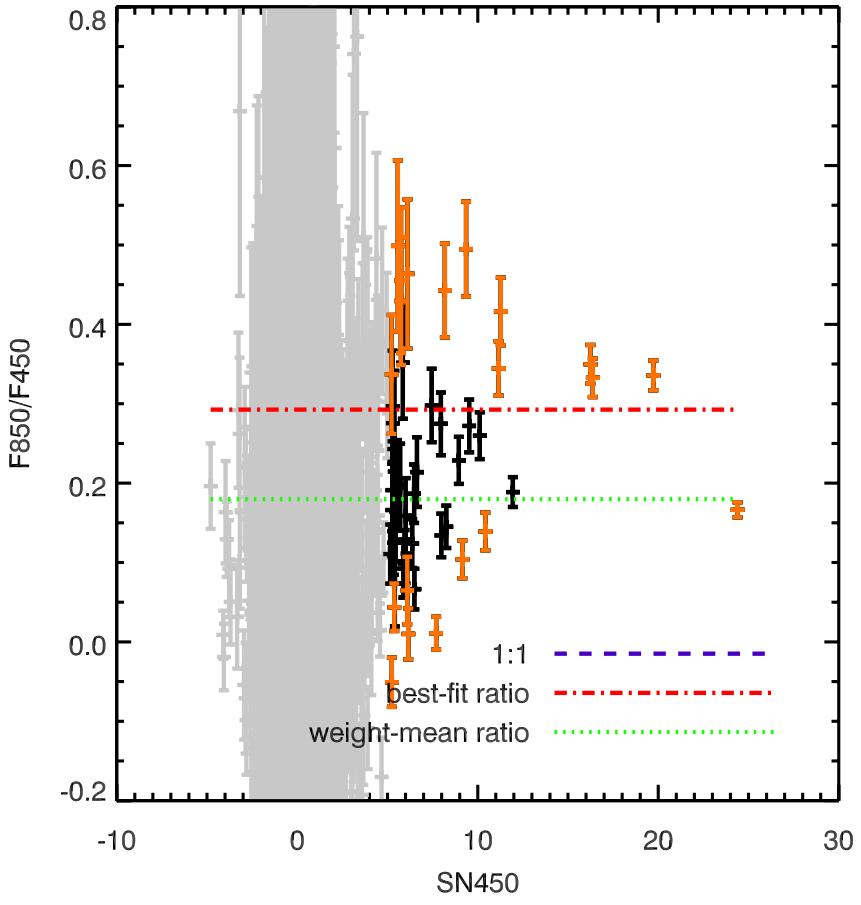

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
600
500
400
300
150
200
250
300
350
400
450

850: Residual

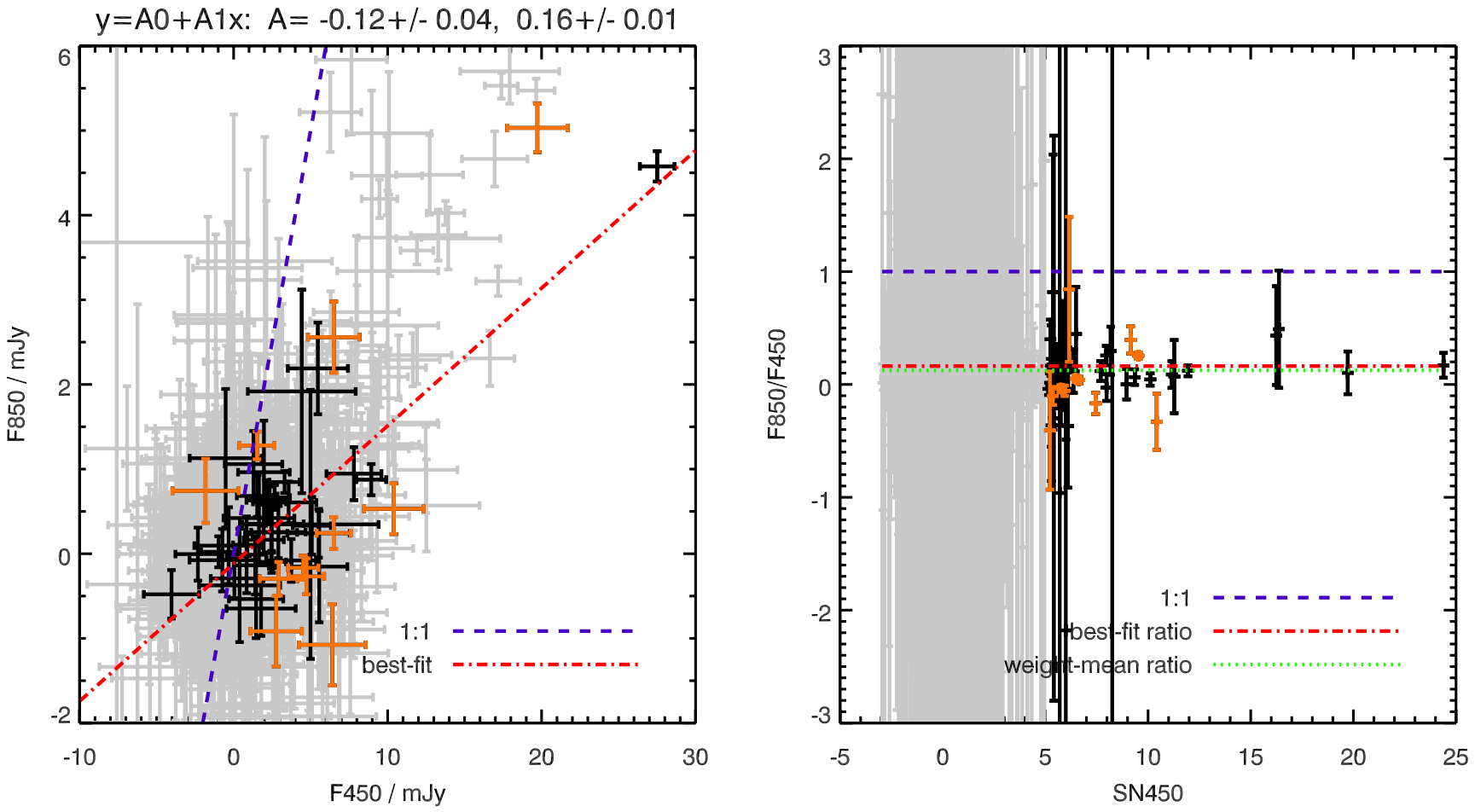


850 vs 450 fluxes @ combined pos.

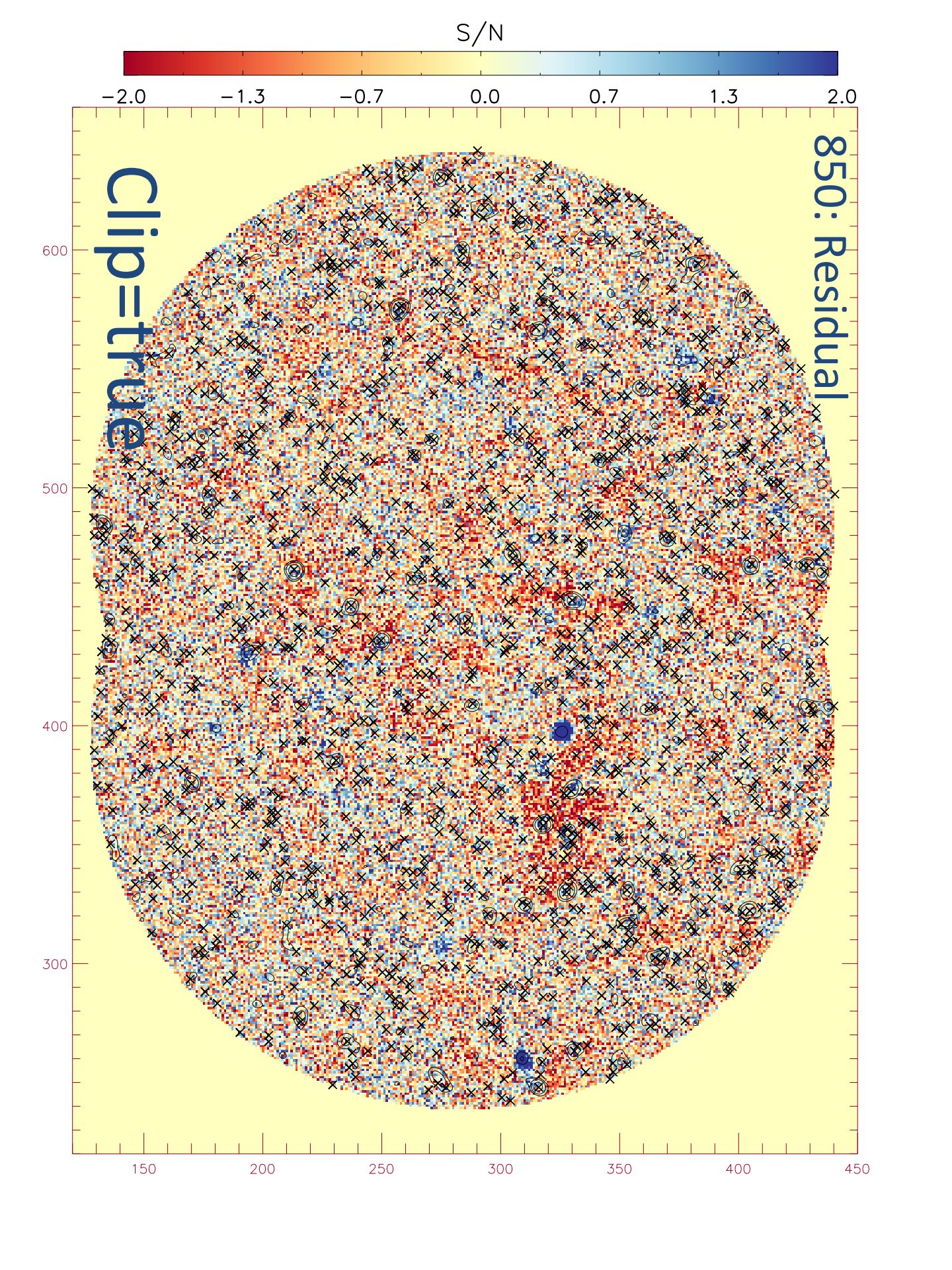


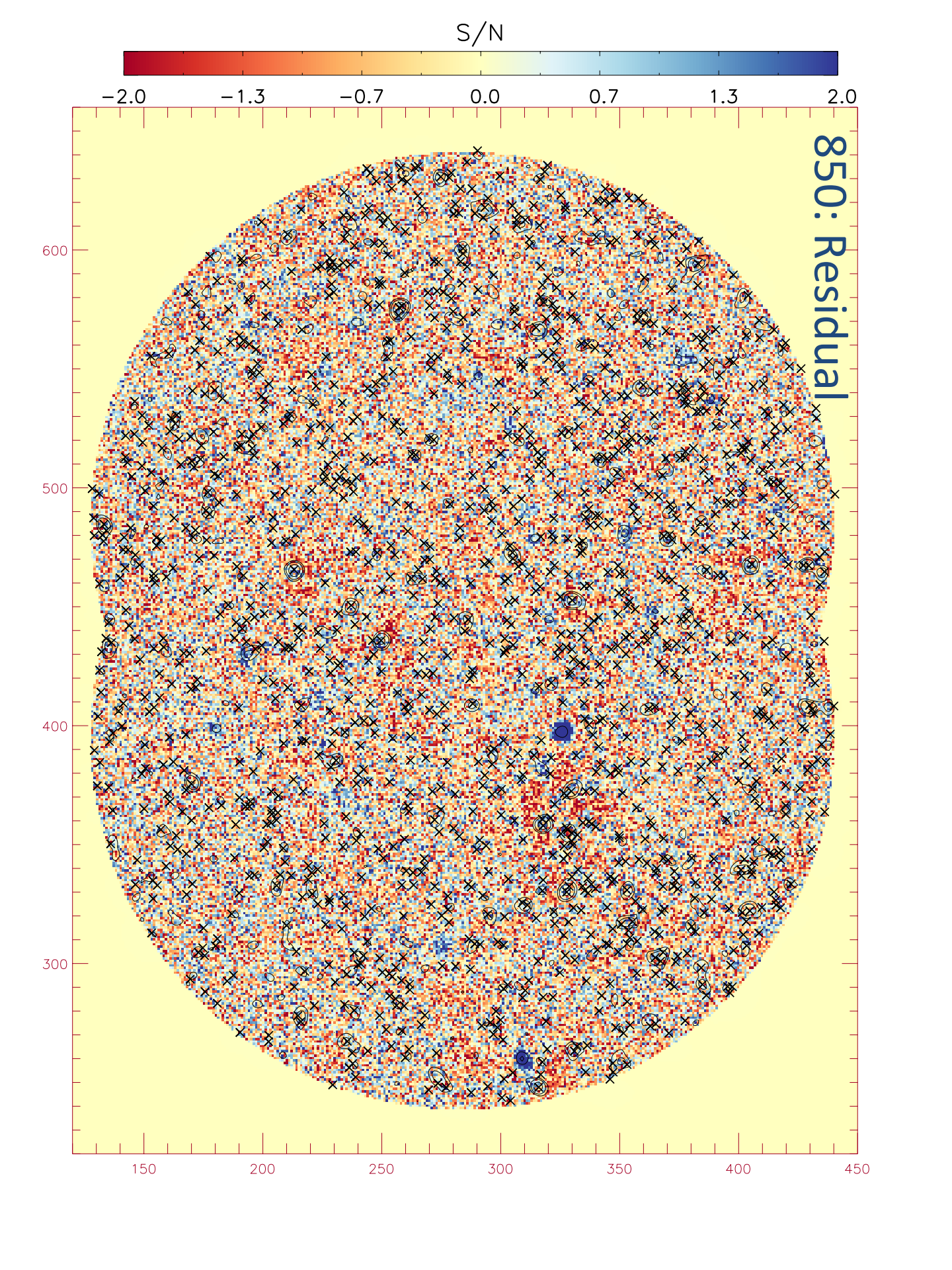


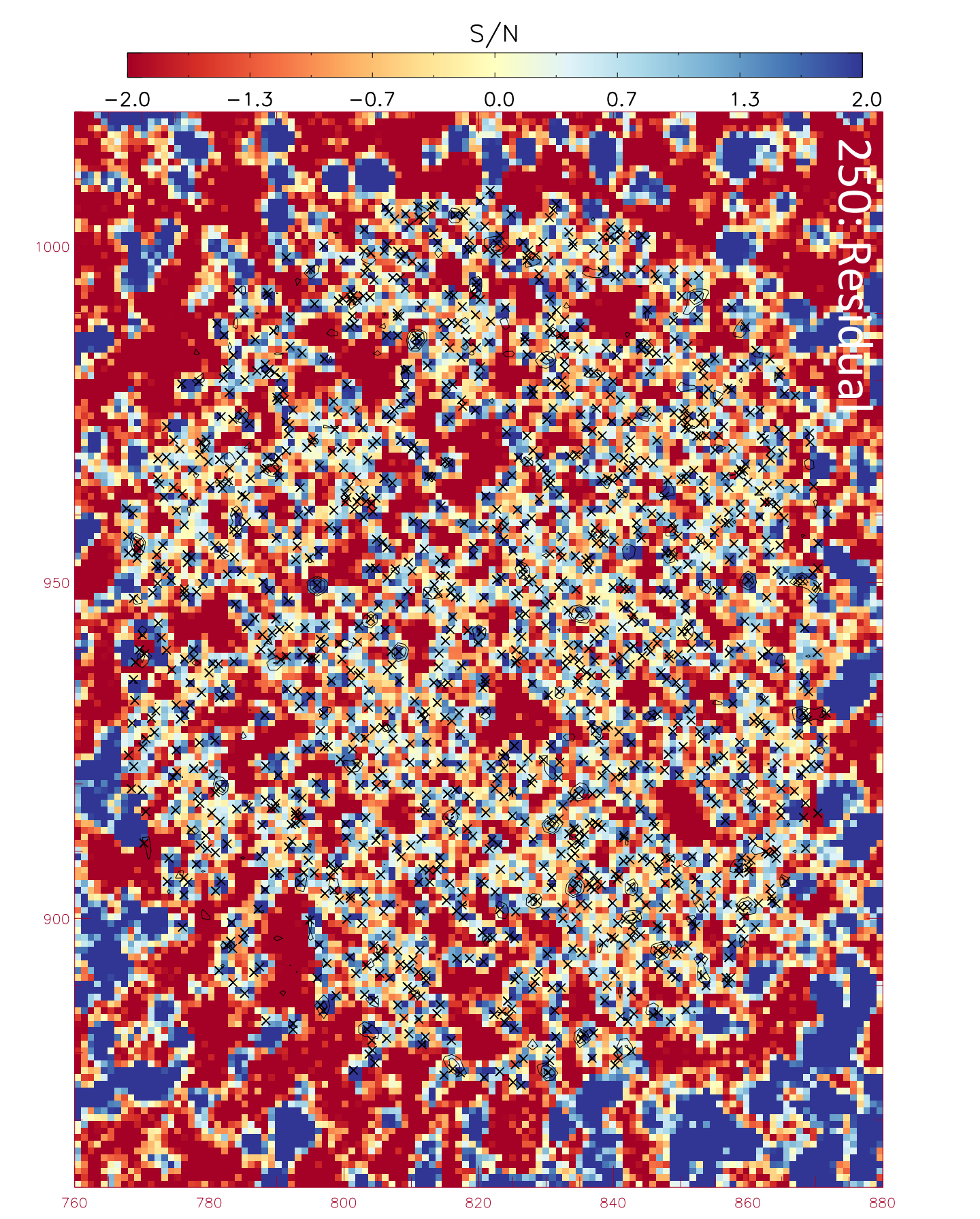
850 vs 450 fluxes @ combined pos.

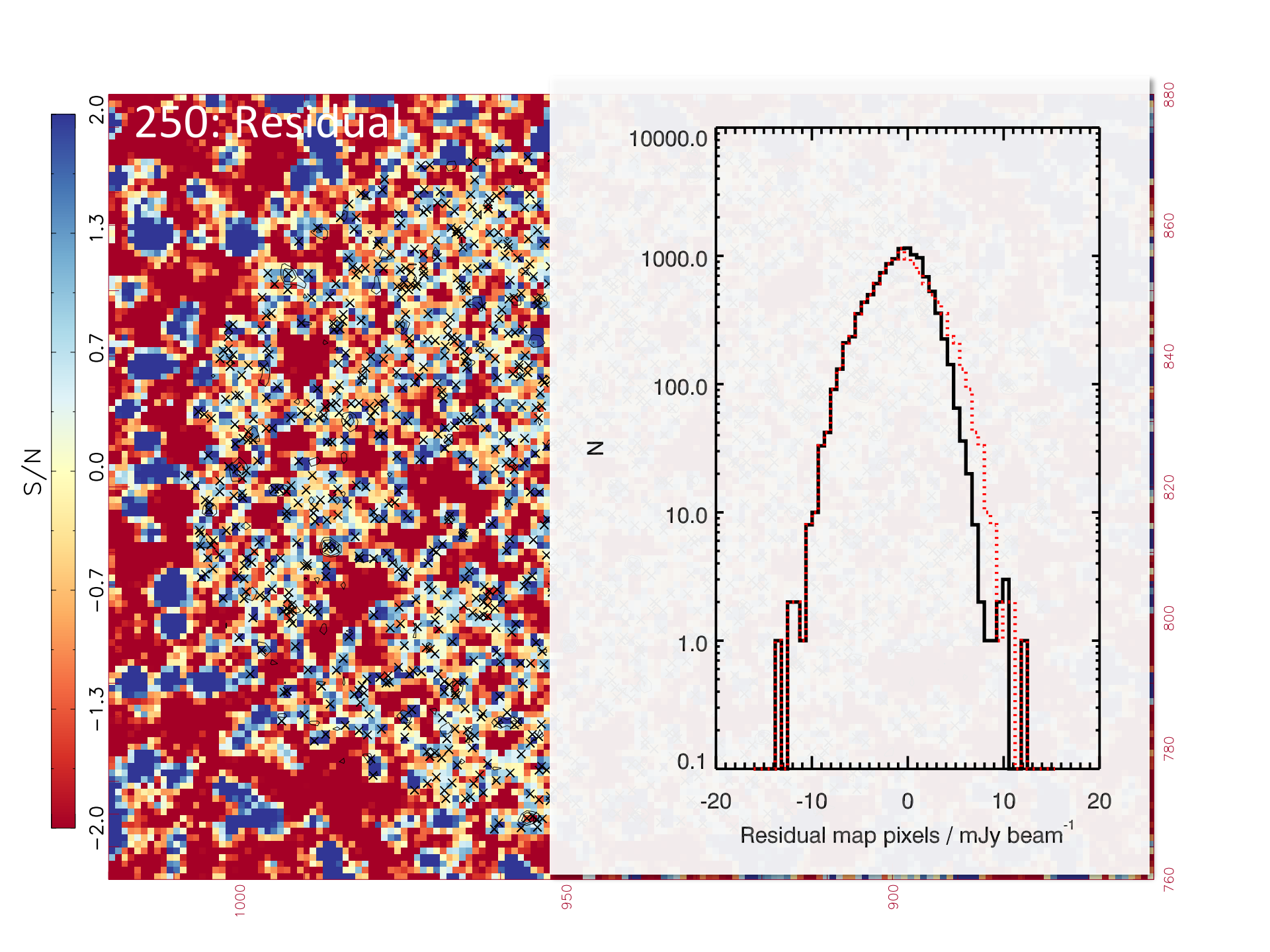


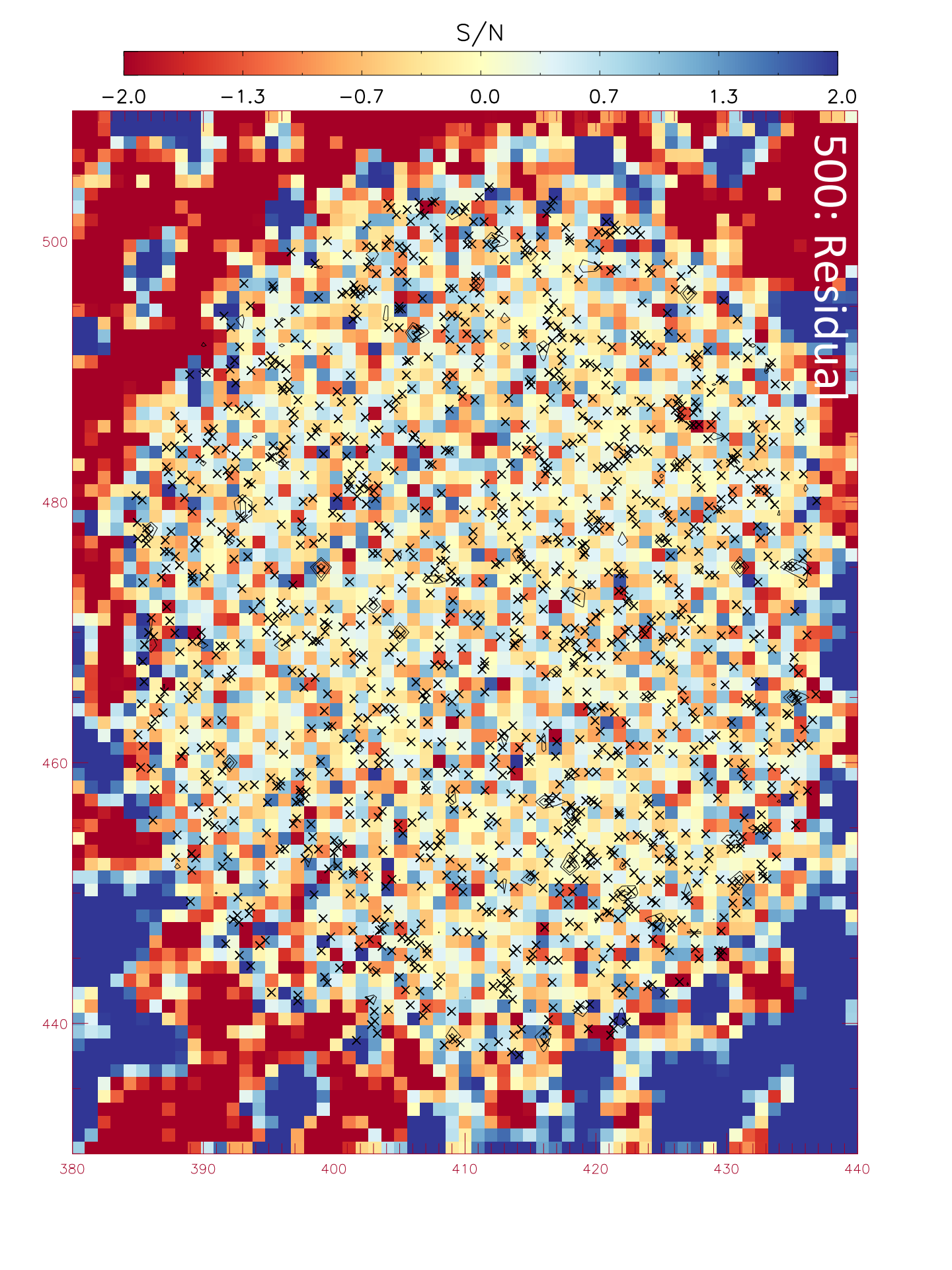
Clip=true

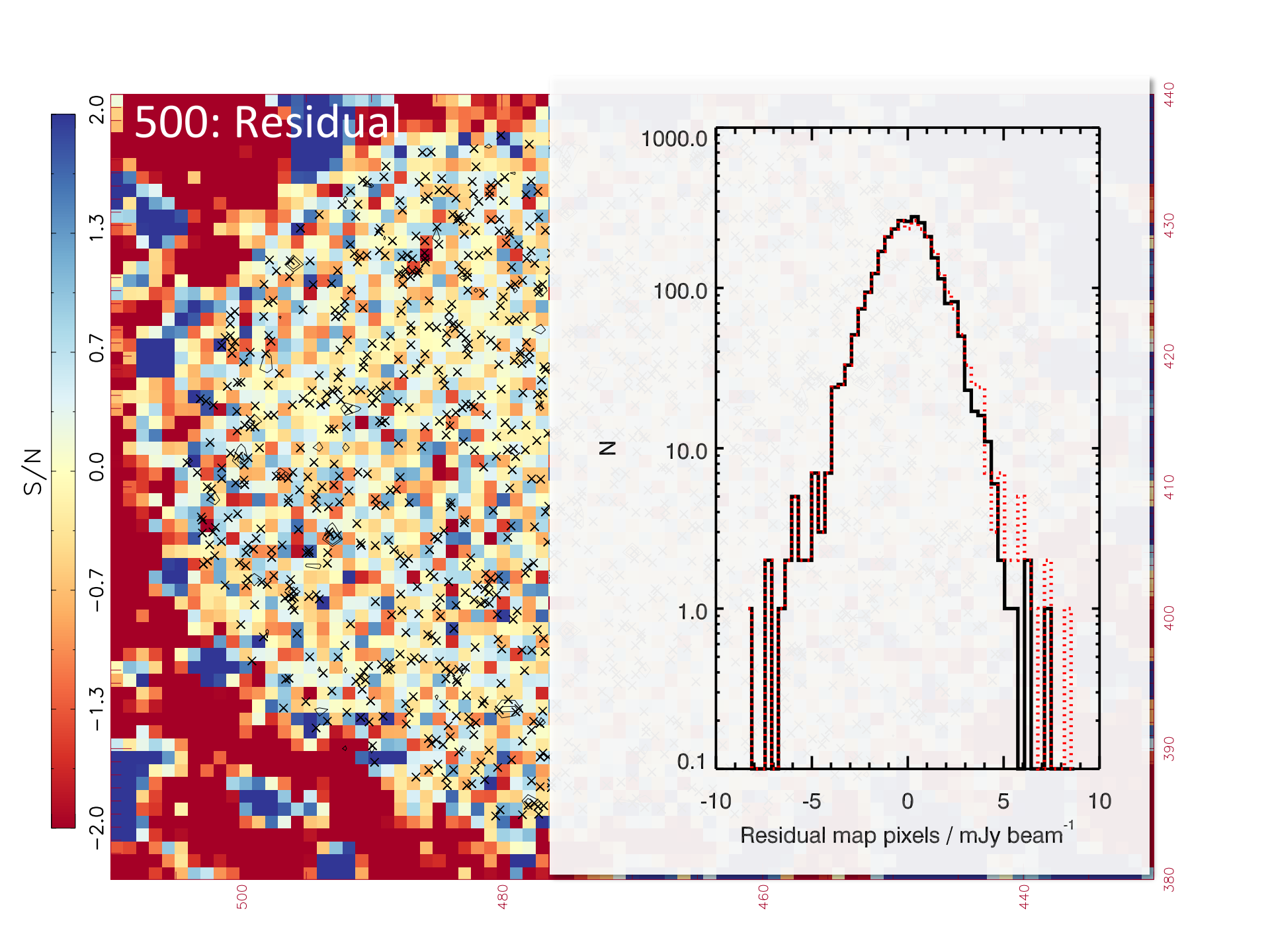

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
Clip=true
600
500
400
300
150
200
250
300
350
400
450


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
600
500
400
300
150
200
250
300
350
400
450

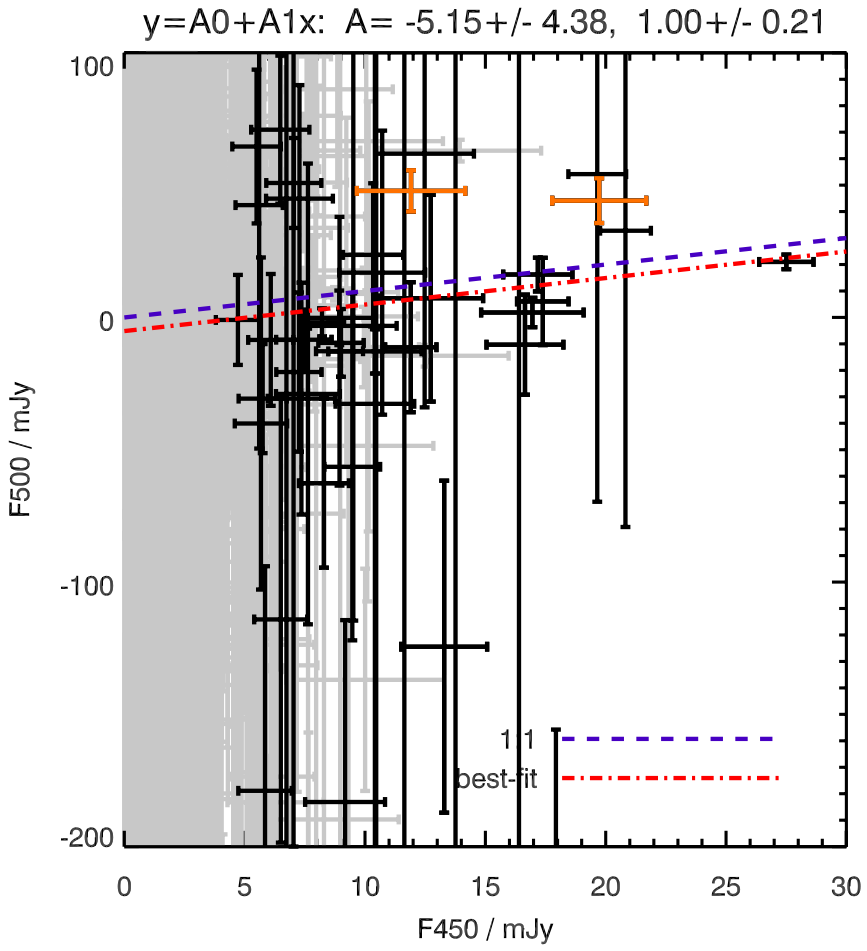

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
250: Residual
1000
950
900
760
780
800
820
840
860
880

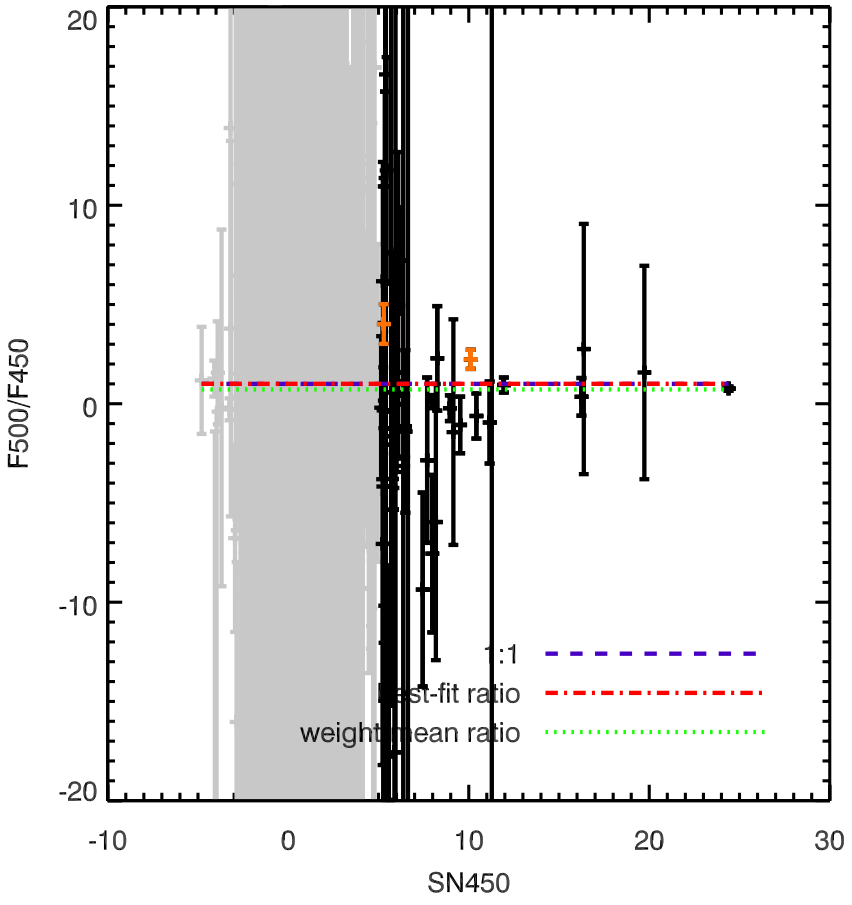

250: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
1000
950
900
880
860
840
820
800
780
760
10000.0
1000.0
100.0
10.0
1.0
0.1
N
-20
-10
0
10
20
Residual map pixels / mJy beam-1


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440

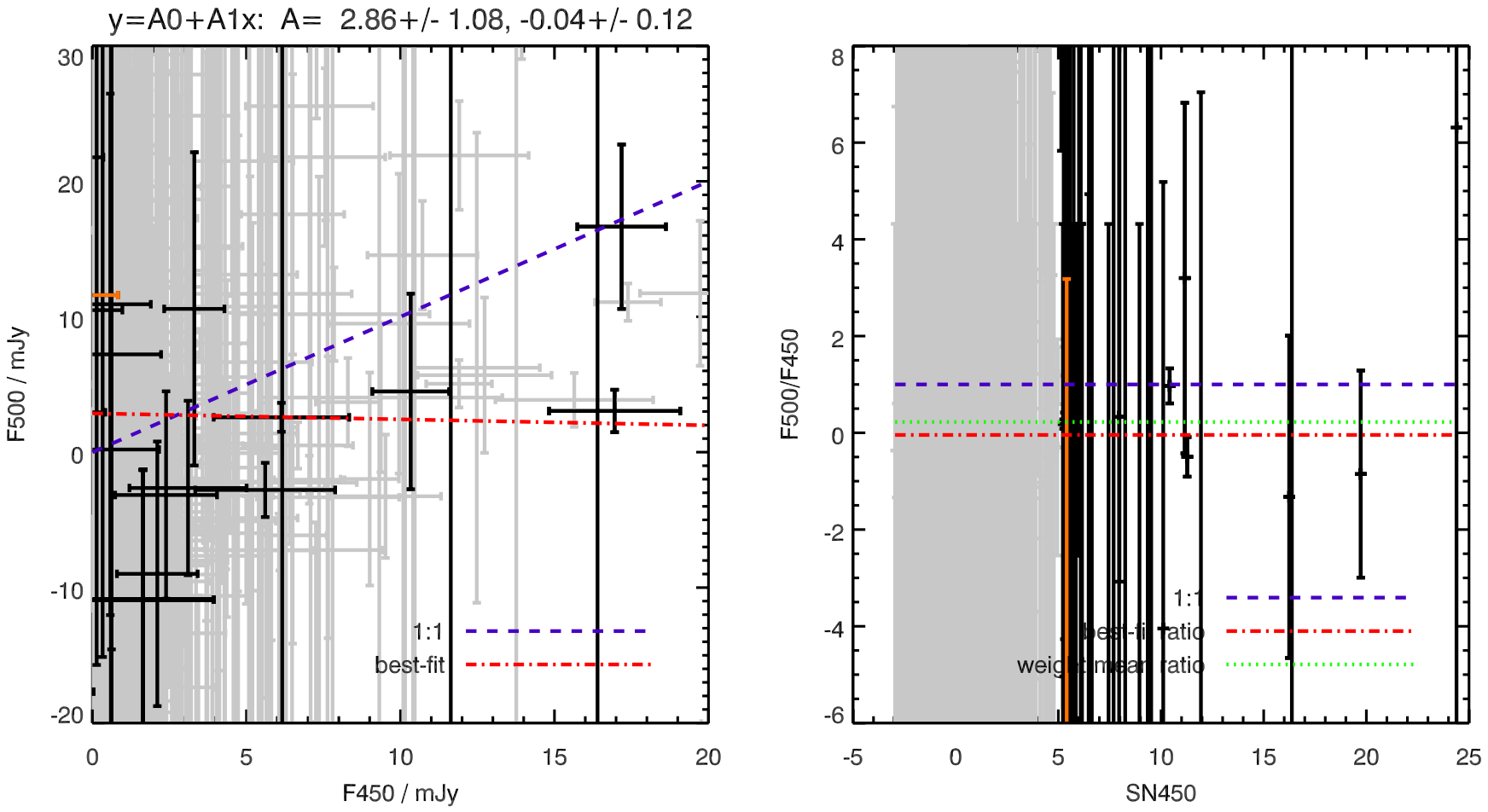

500: Residua
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
500
480
460
440
380
390
400
410
420
430
440
1000.0
100.0
10.0
1.0
0.1
N
-10
-5
0
5
10
Residual map pixels / mJy beam-1

500 vs 450 fluxes @ combined pos.

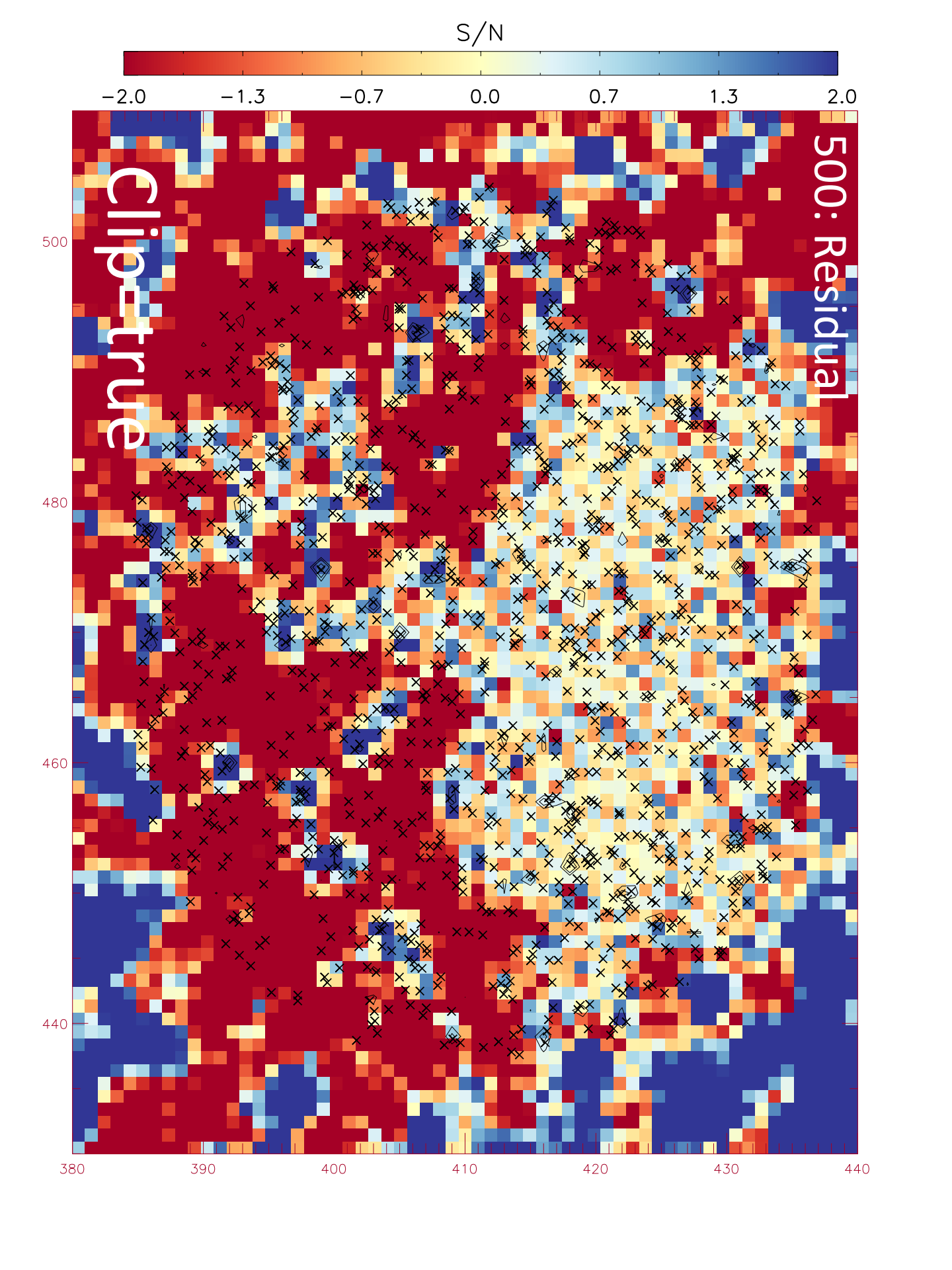


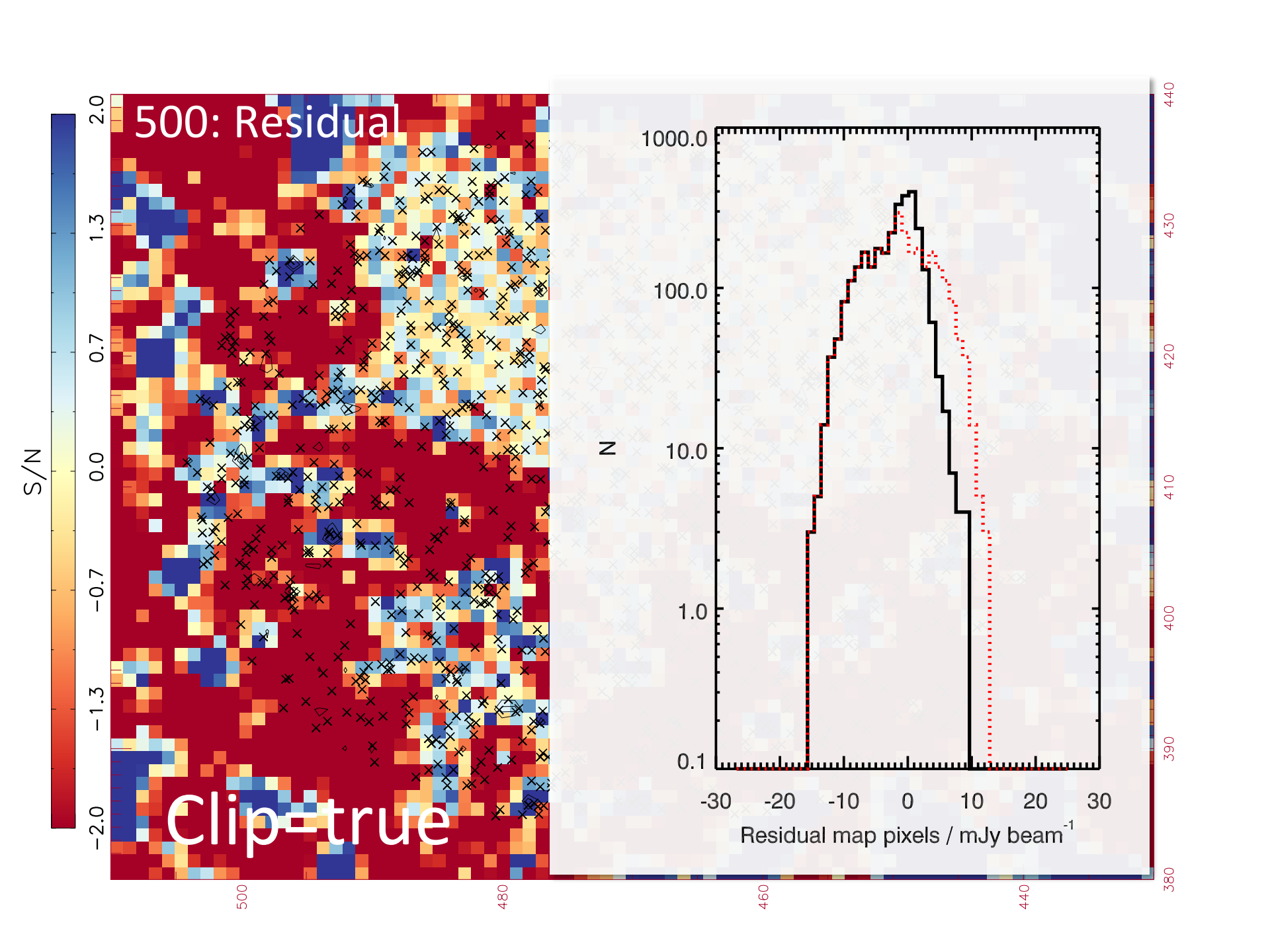


500 vs 450 fluxes @ combined pos.



Clip=true


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
500: Residual
Clip=true
500
480
460
440
380
390
400
410
420
430
440

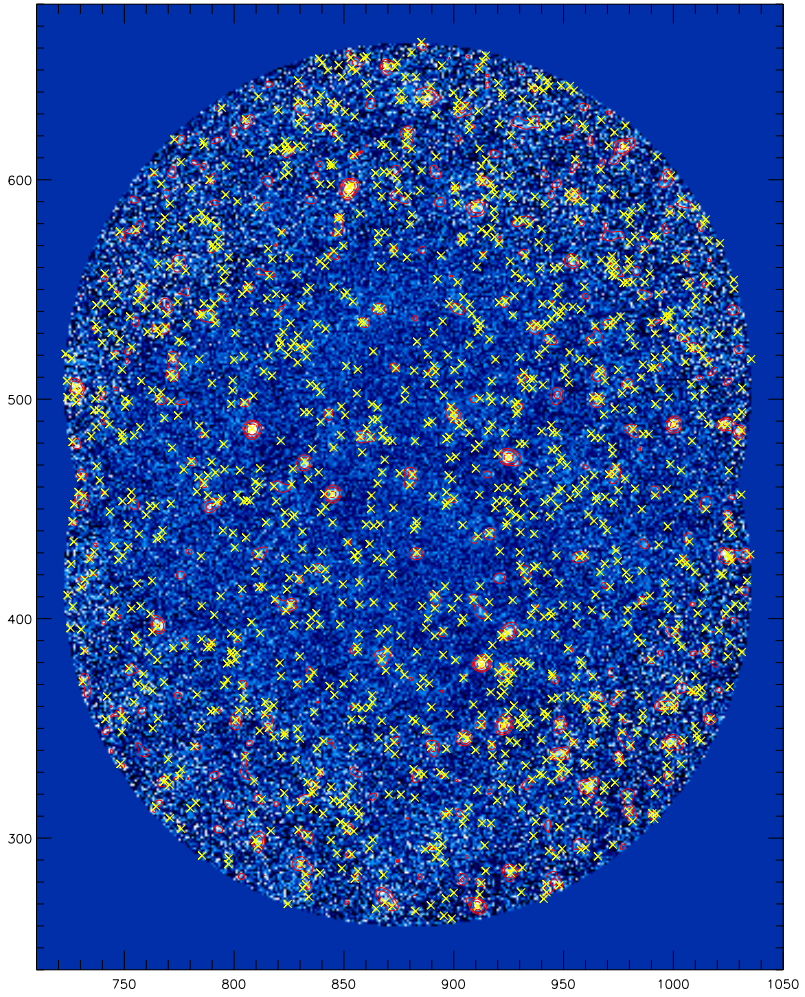

500: Residual
Clip=true
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
500
480
460
440
380
390
400
410
420
430
440
1000.0
100.0
10.0
1.0
0.1
N
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam-1

What if we try and account for every source in the sky?

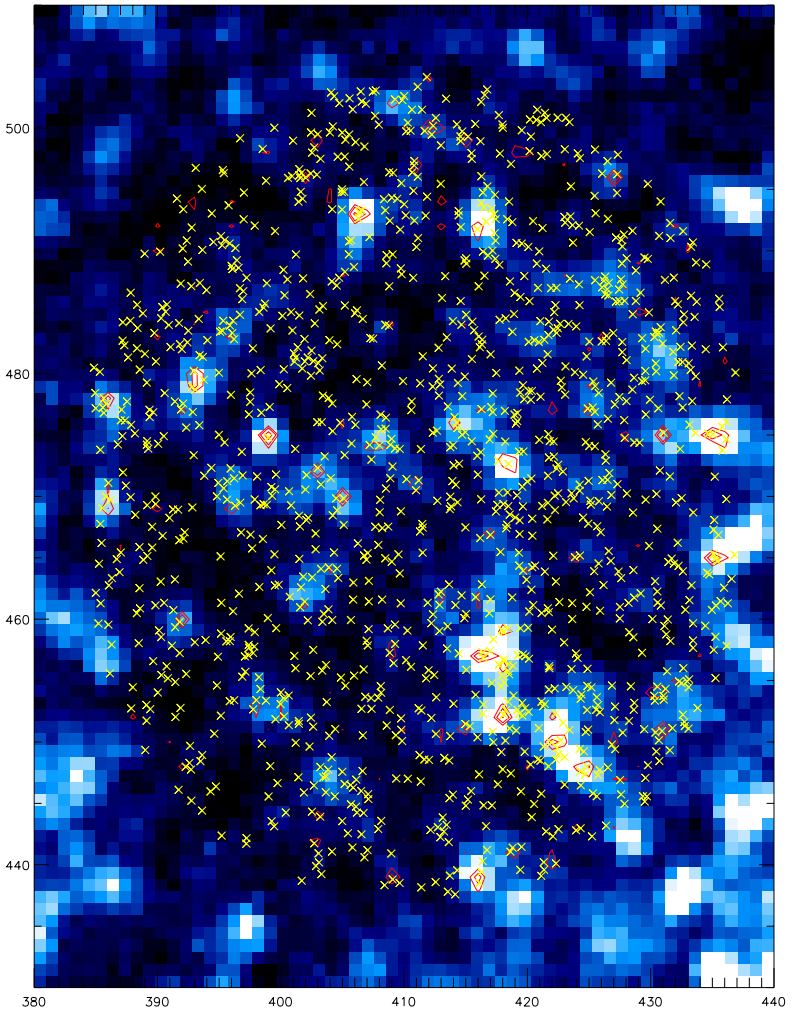
3. Try a much denser catalogue from IRAC 3.6µm

8μm+24μm+1.4GHz positions

450

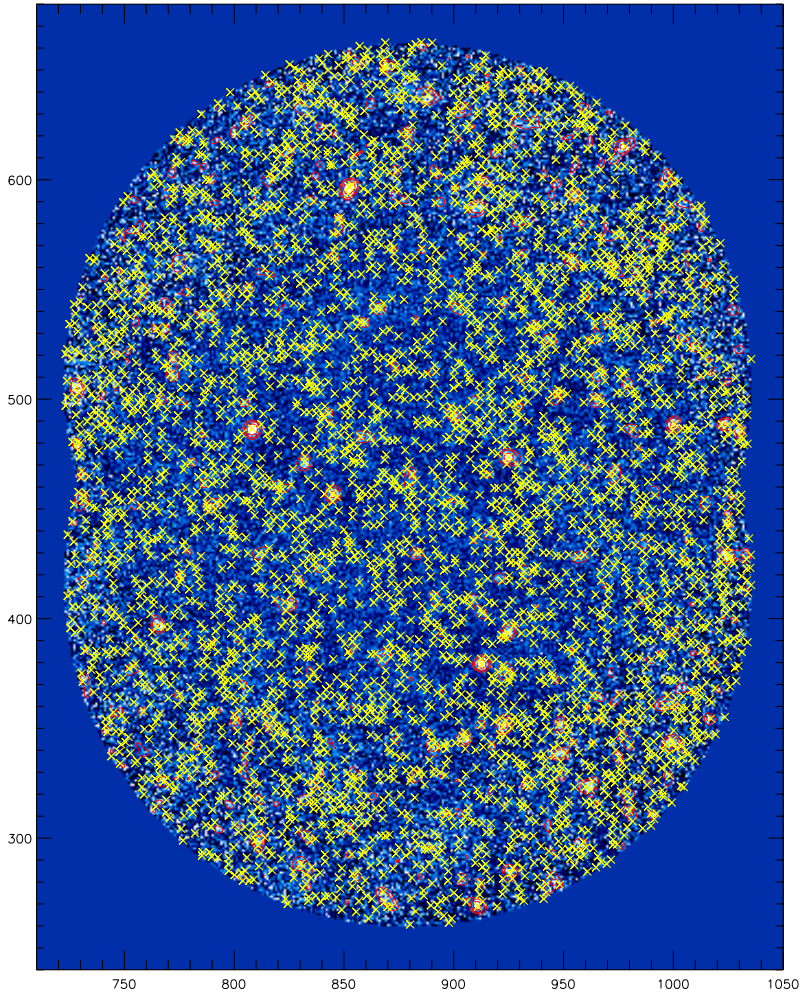


500

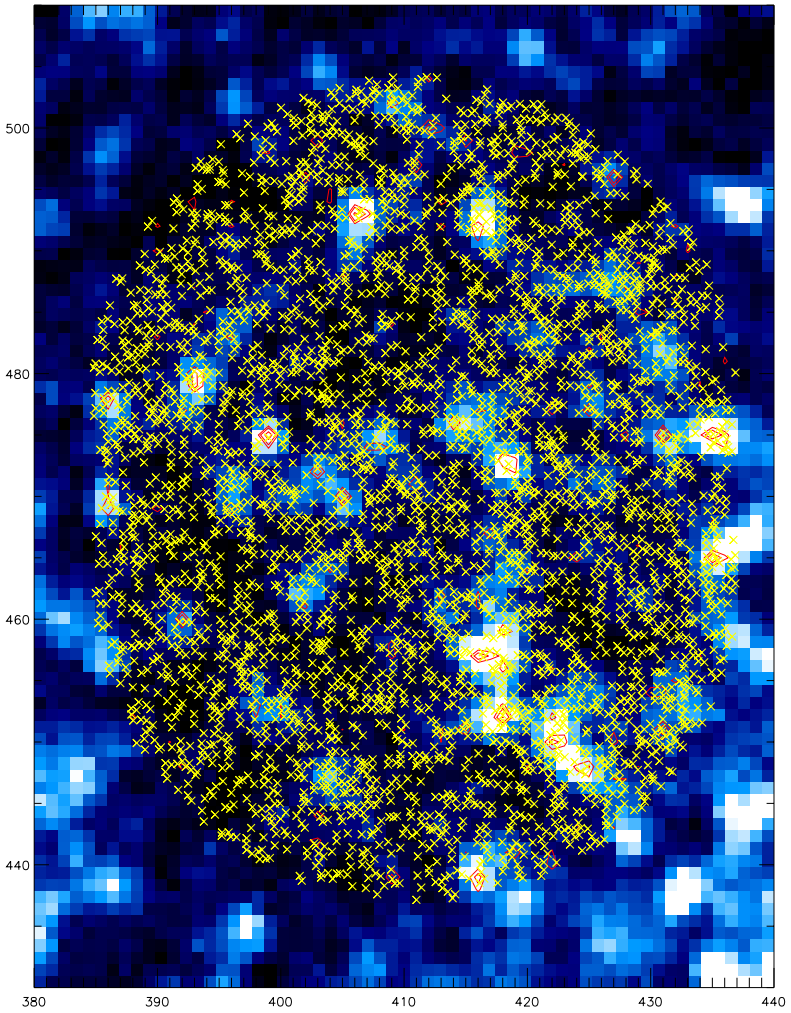


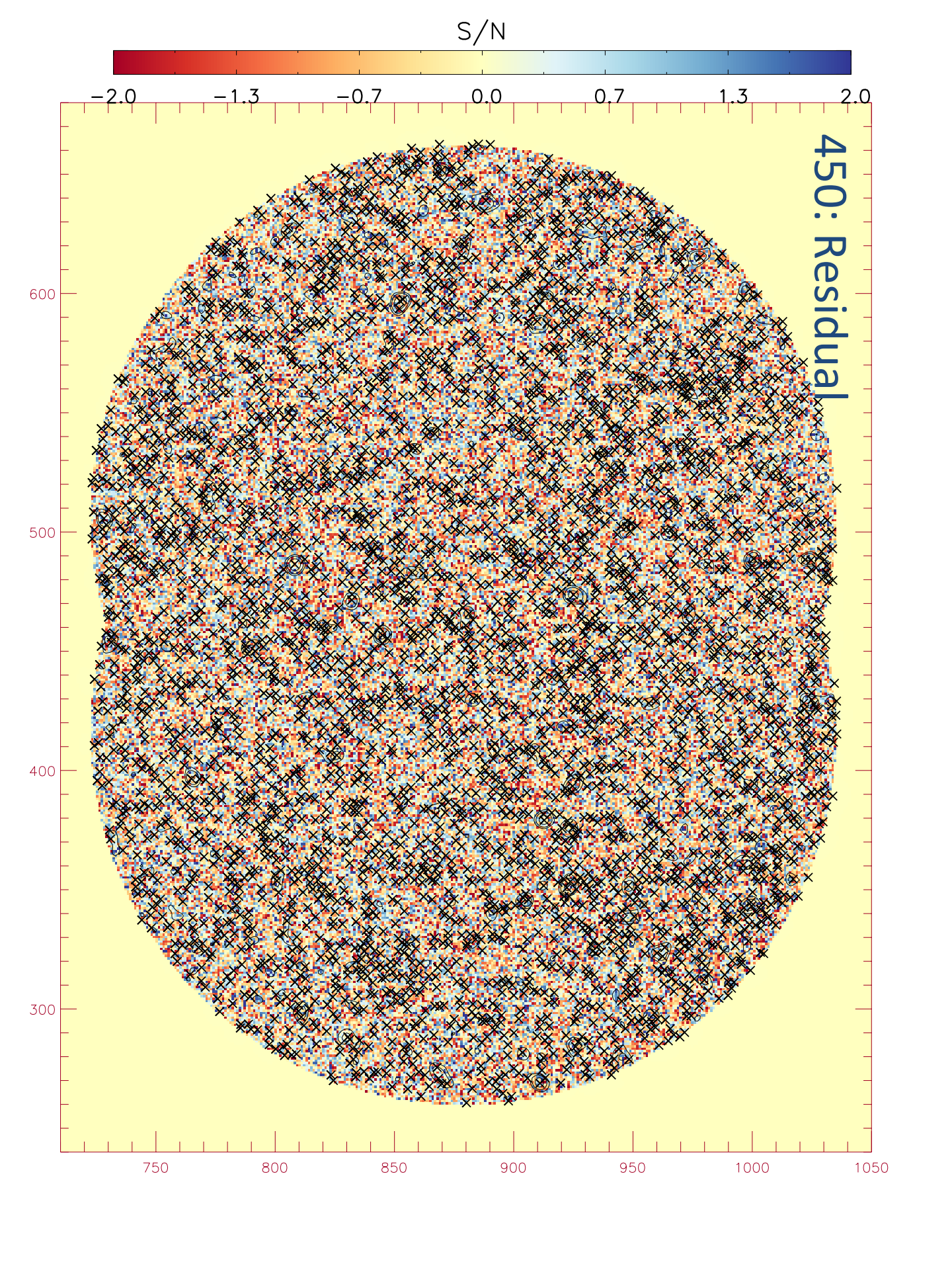
3.6µm positions

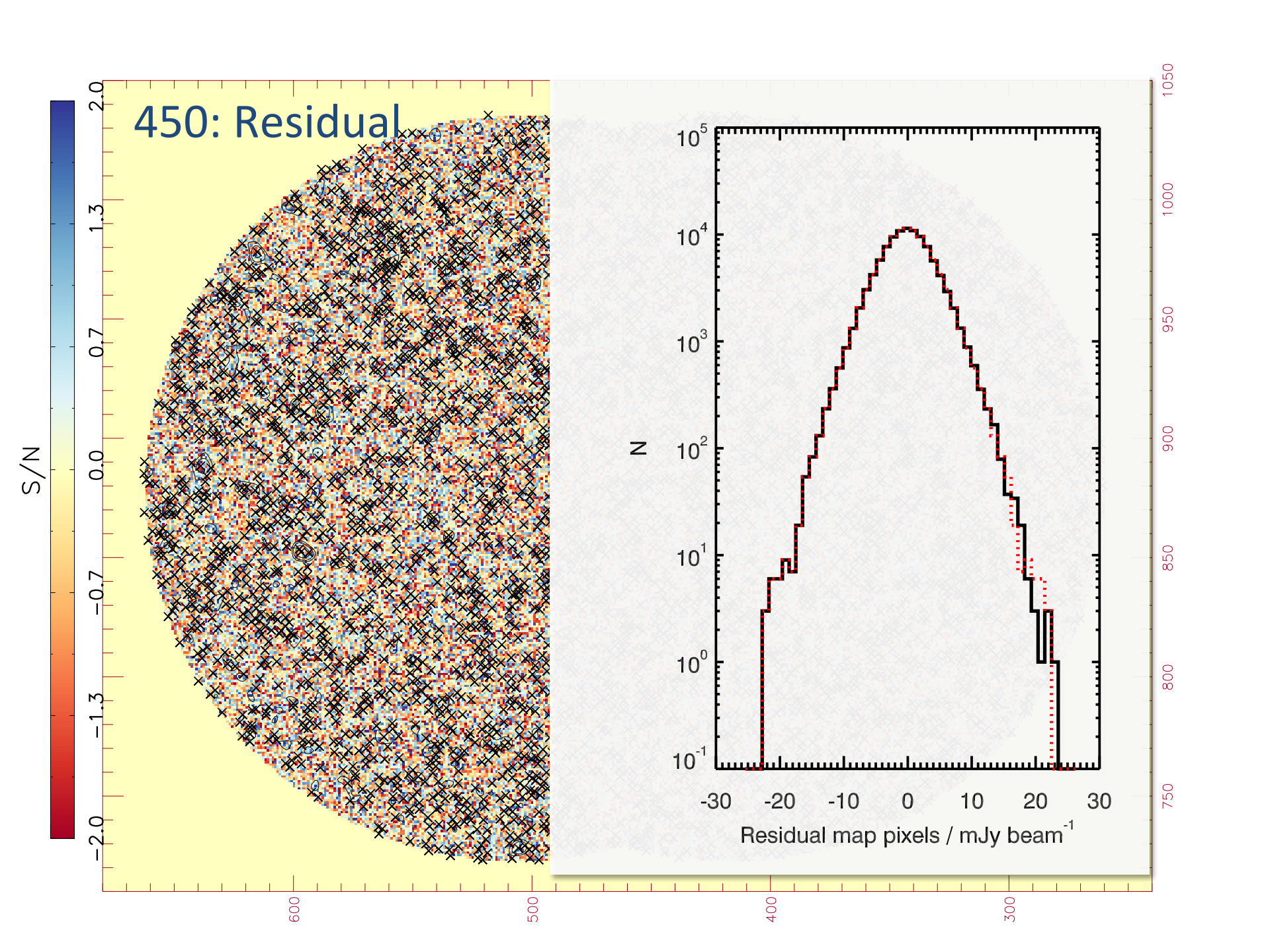
450

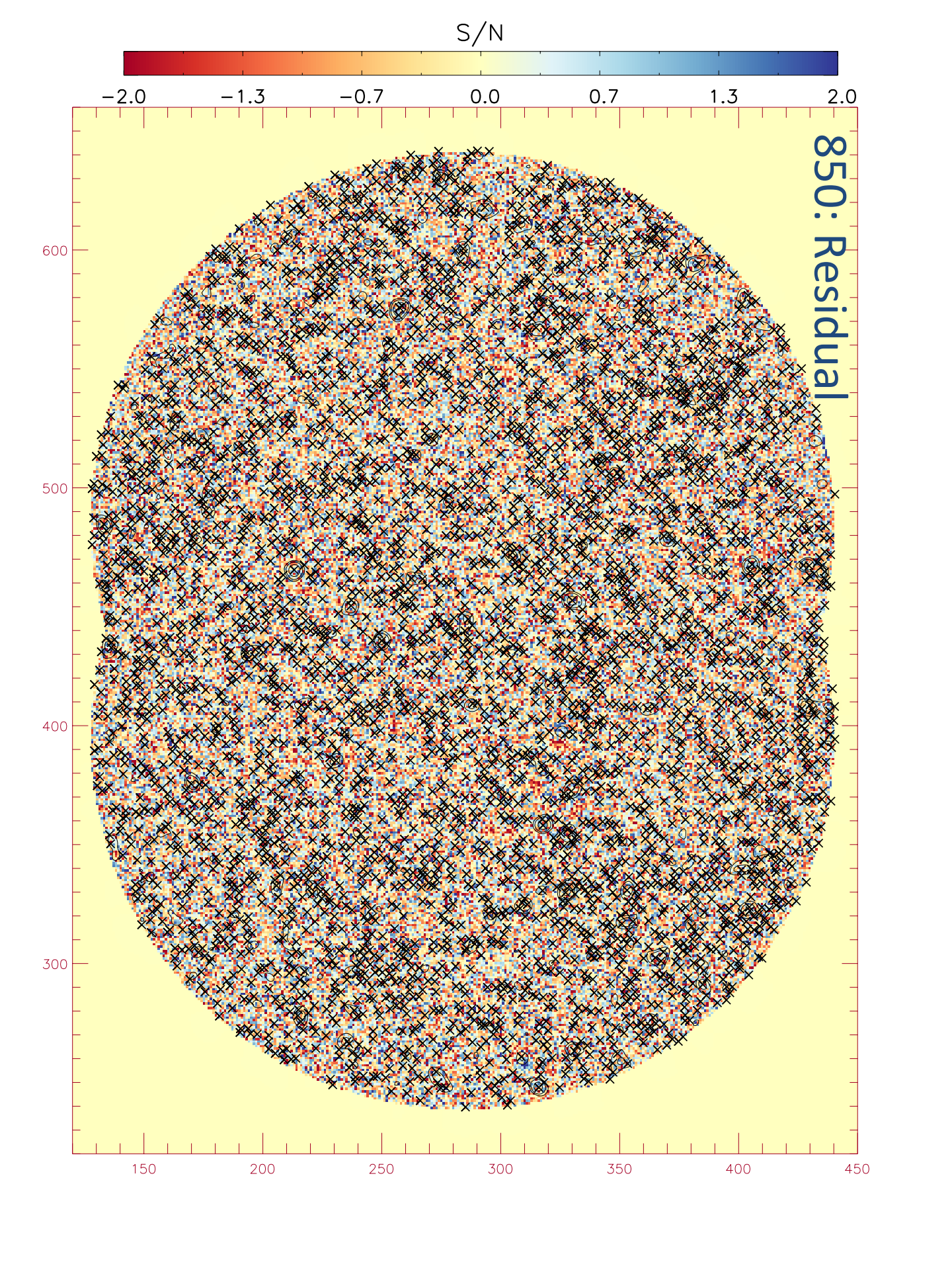


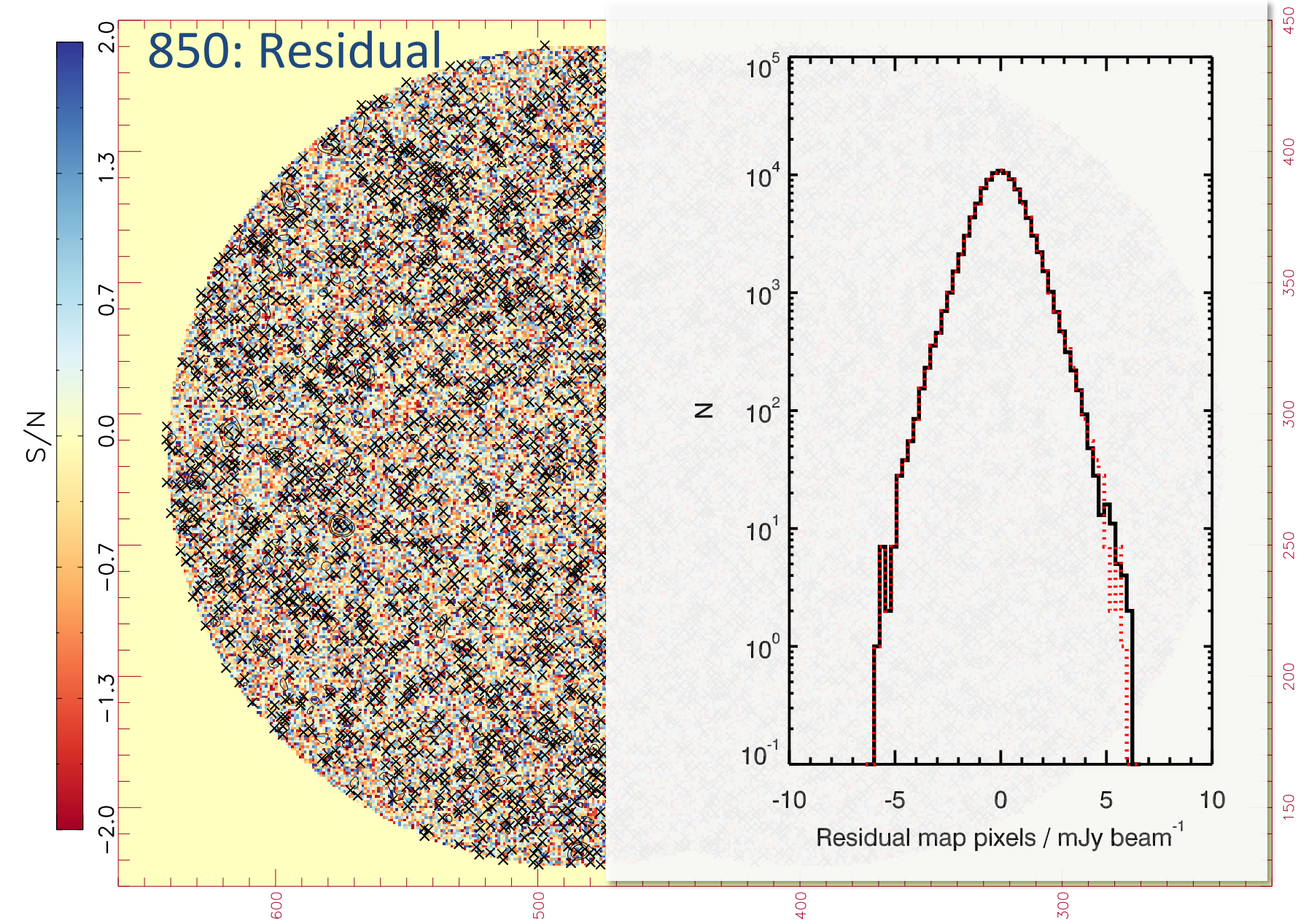
500

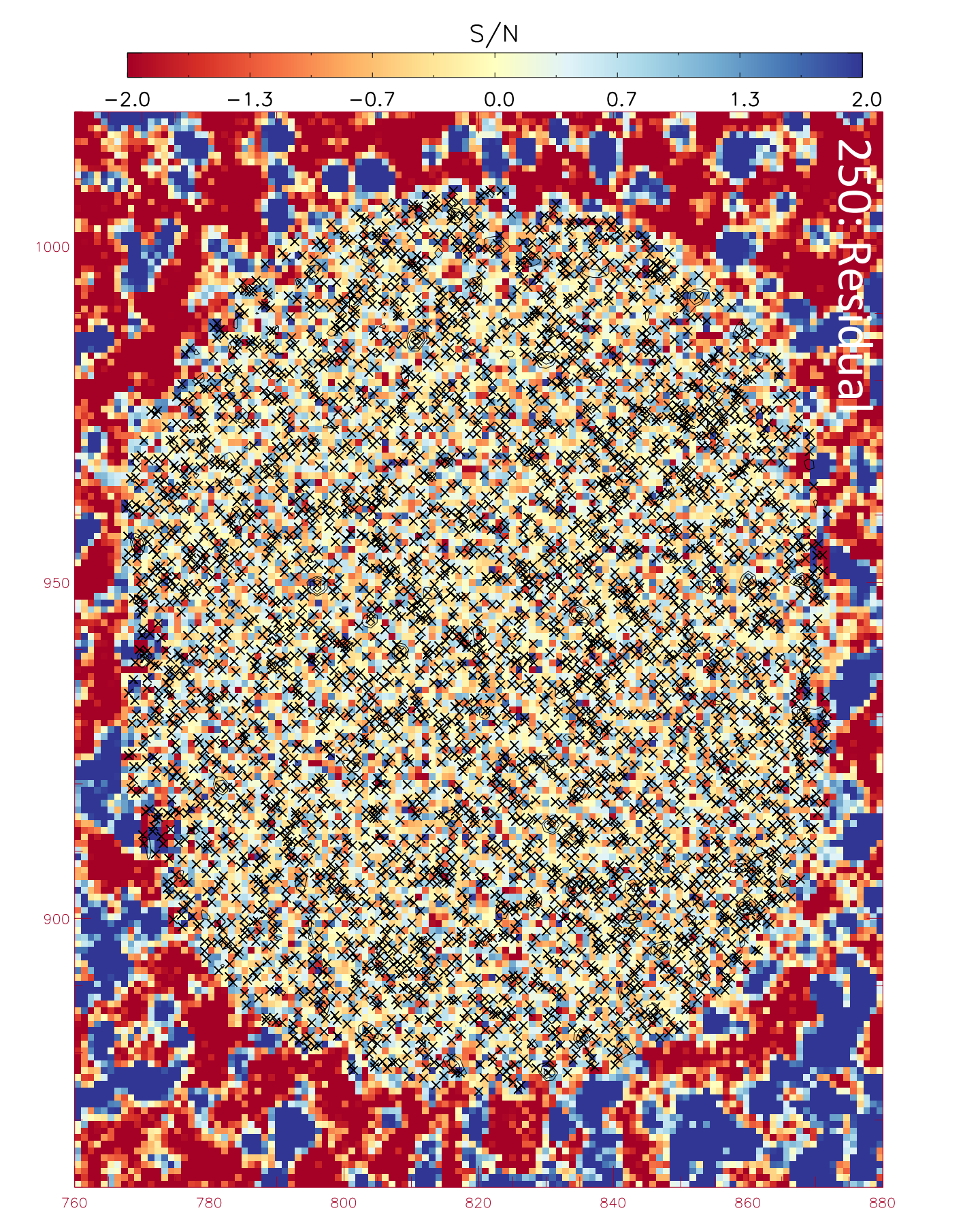


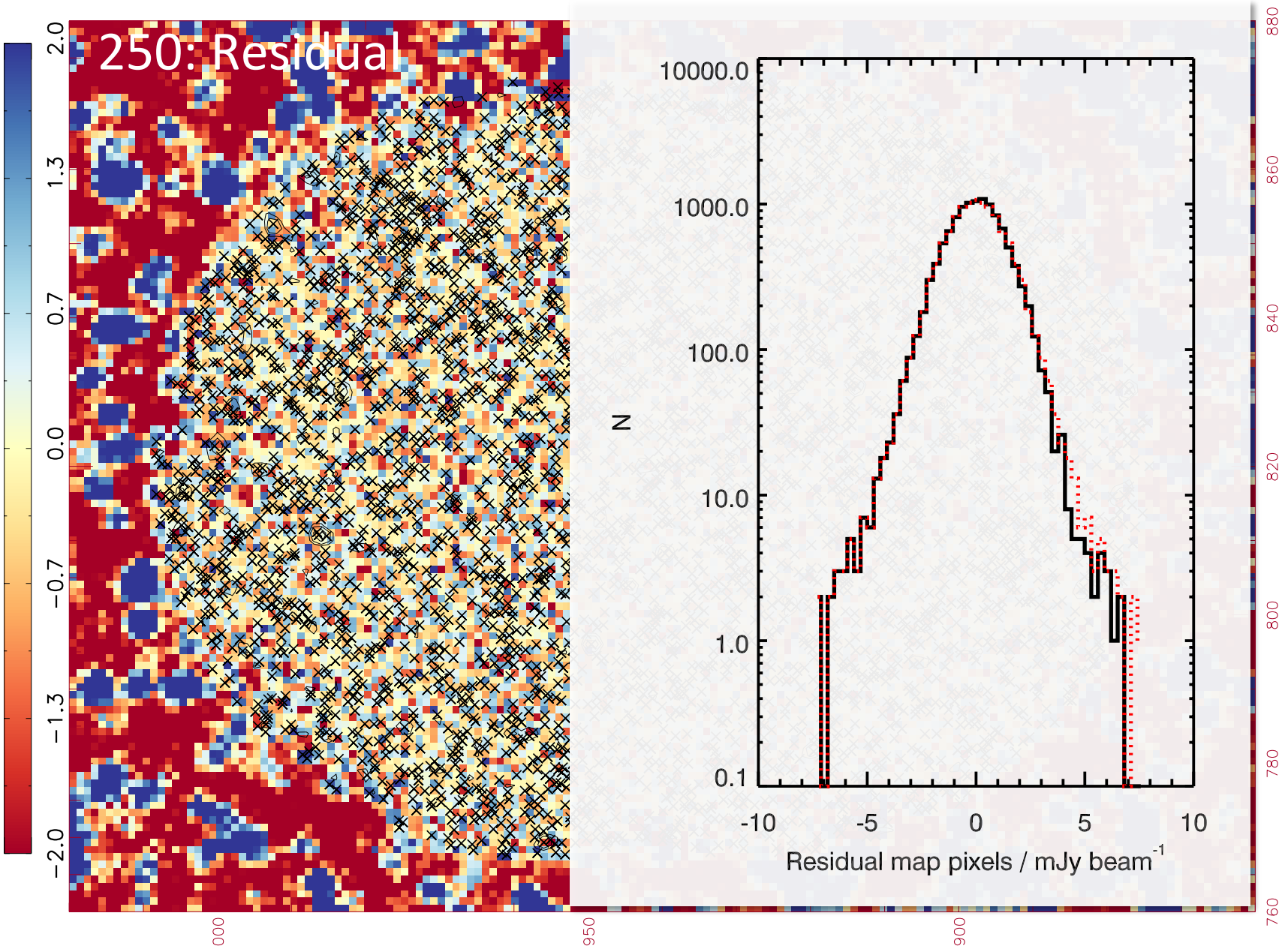

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
450: Residual
600
500
400
300
750
800
850
900
950
1000
1050

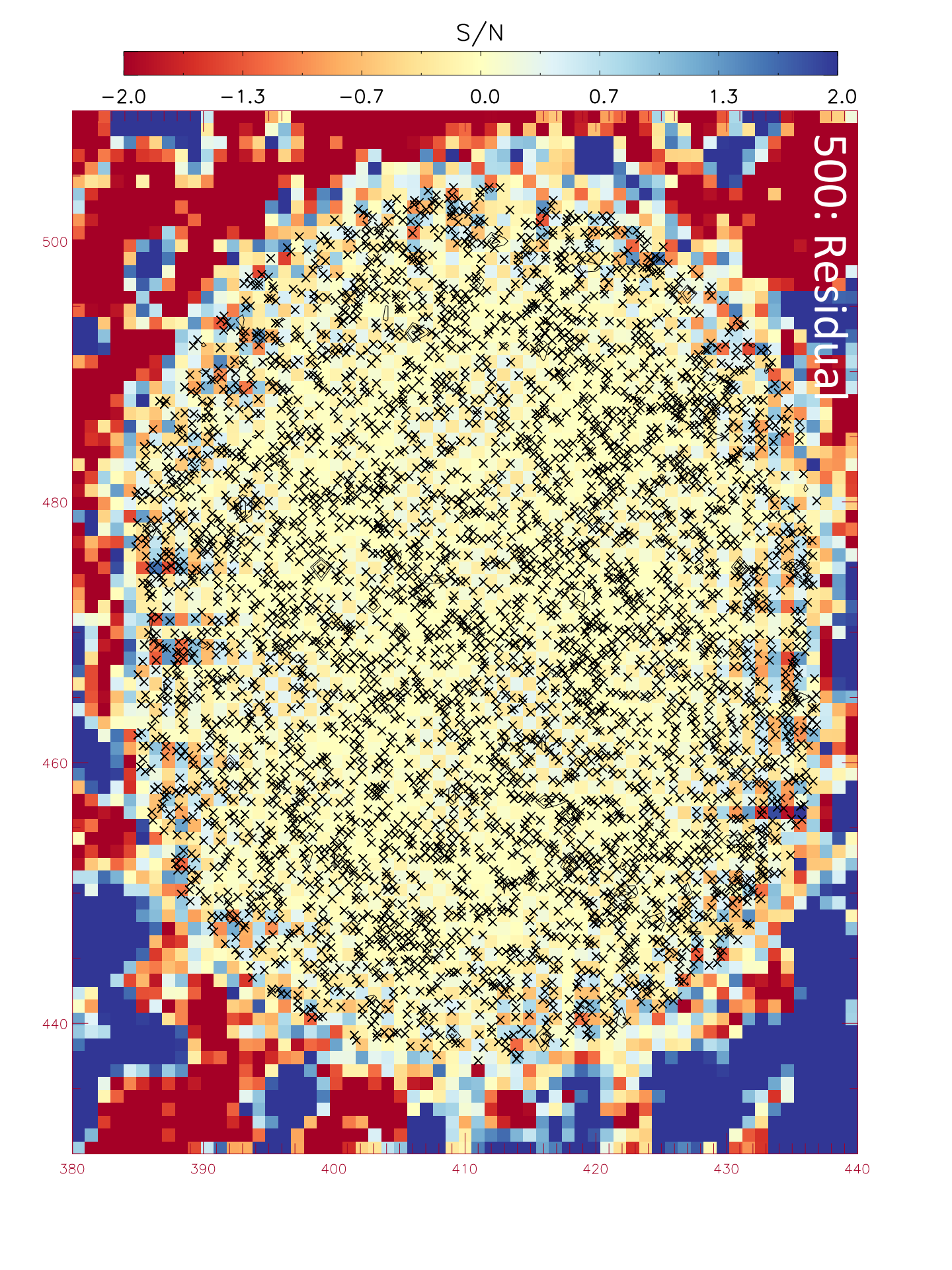

450: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
600
500
400
300
1050
1000
950
900
850
800
750
N
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
-30
-20
-10
0
10
20
30
Residual map pixels / mJy beam^{-1}


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
850: Residual
600
500
400
300
150
200
250
300
350
400
450


850: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
600
500
400
300
450
400
350
300
250
200
150
N
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
-10
-5
0
5
10
Residual map pixels / mJy beam^{-1}

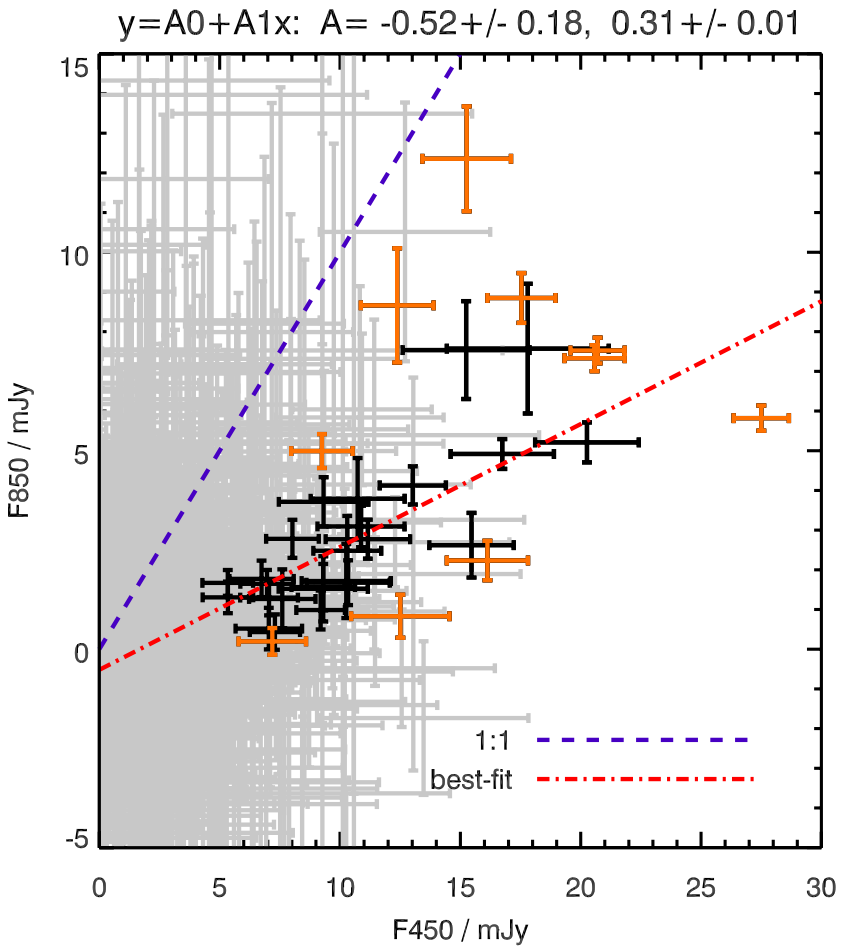

S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
250: Residual
1000
950
900
760
780
800
820
840
860
880

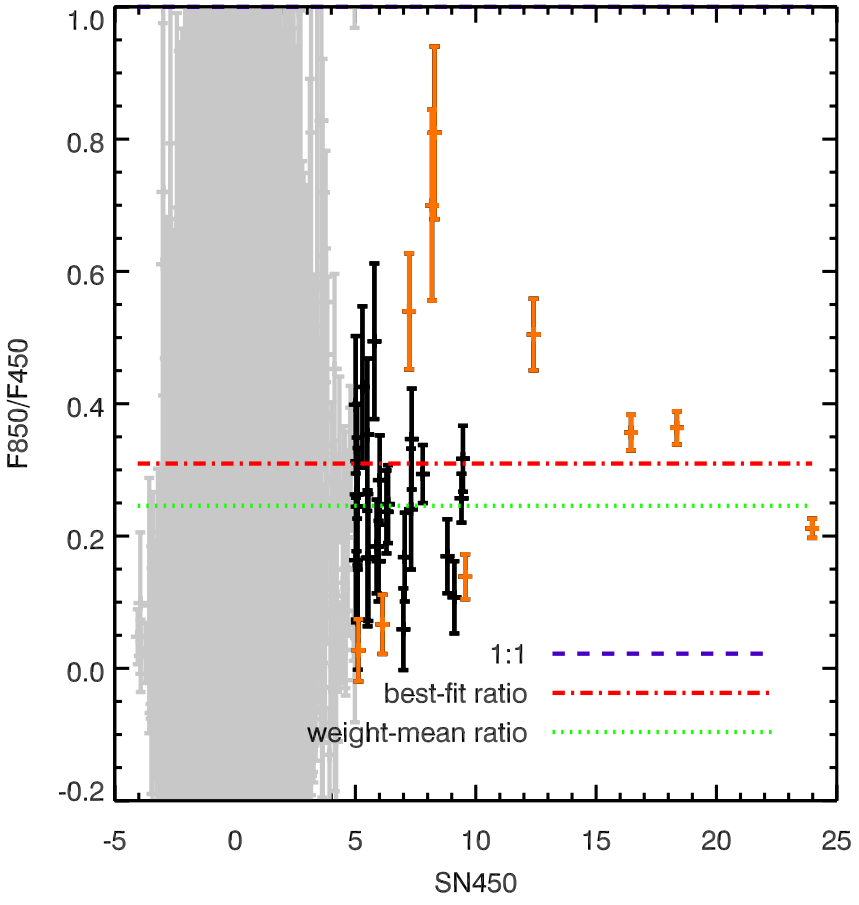

250: Residual
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
1000
950
900
880
860
840
820
800
780
760
N
10000.0
1000.0
100.0
10.0
1.0
0.1
-10
-5
0
5
10
Residual map pixels / mJy beam-1


S/N
−2.0
−1.3
−0.7
0.0
0.7
1.3
2.0
500: Residual
500
480
460
440
380
390
400
410
420
430
440

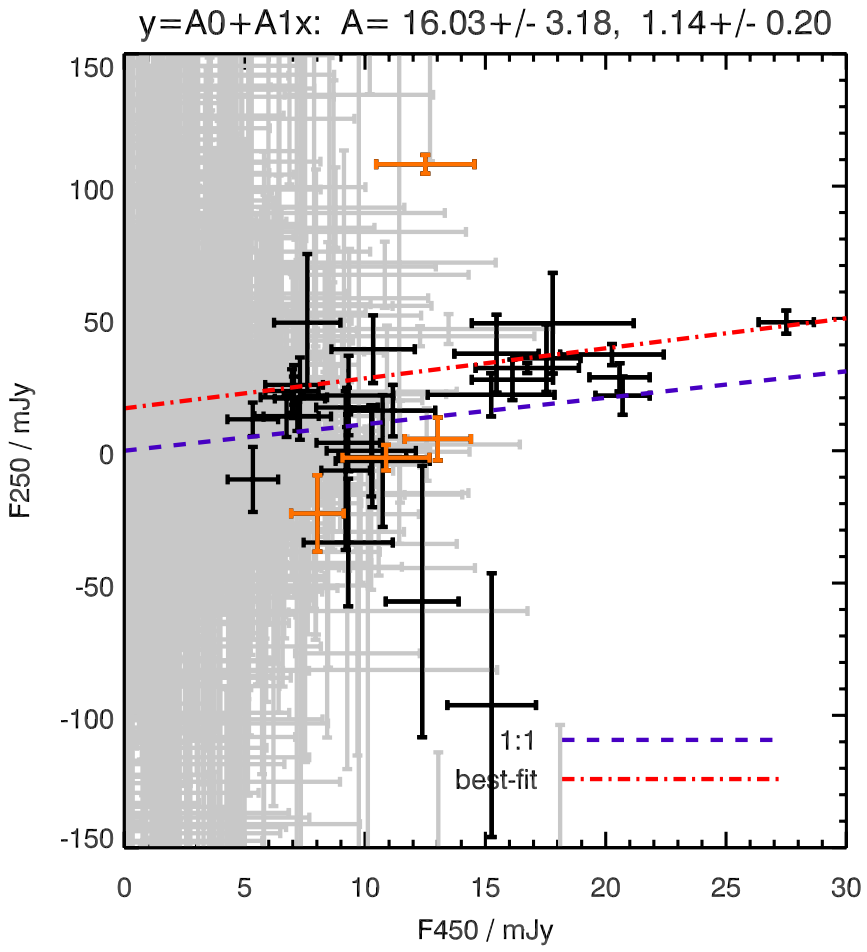
500: Residua
S/N
2.0
1.3
0.7
0.0
−0.7
−1.3
−2.0
500
480
460
440
380
390
400
410
420
430
440
N
1000.0
100.0
10.0
1.0
0.1
-4
-2
0
2
4
Residual map pixels / mJy beam-1

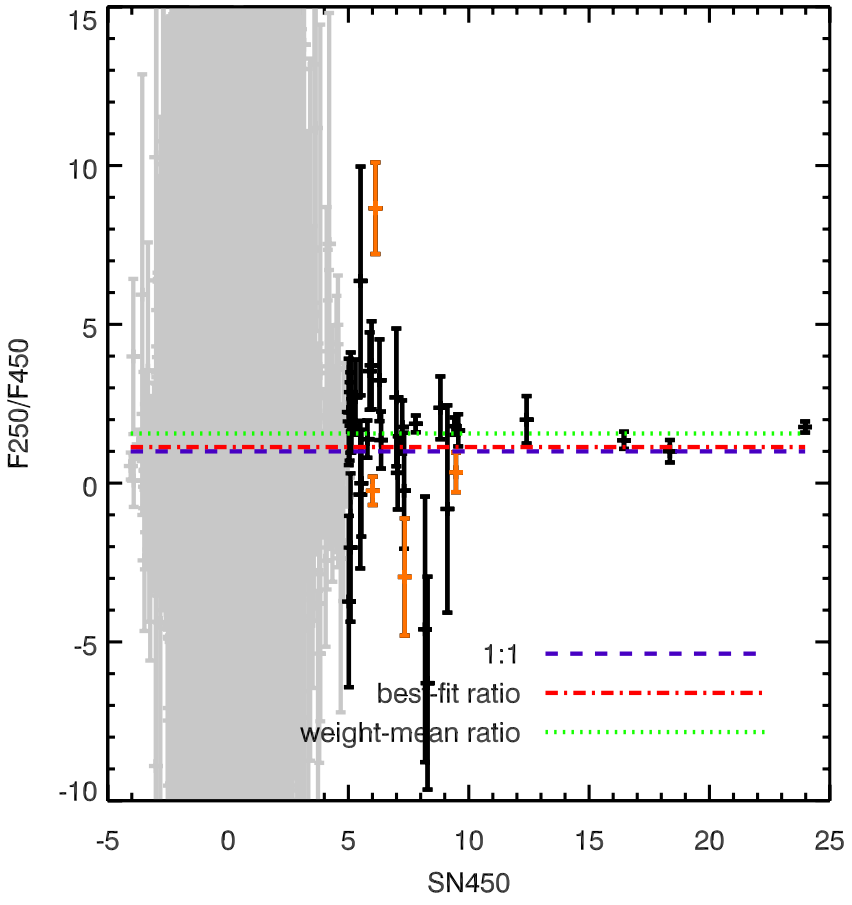
850 vs 450 fluxes @ IRAC pos.





250 vs 450 fluxes @ IRAC pos.





500 vs 450 fluxes @ IRAC pos.

- Nothing detected at 500μm above 1-sigma
- free parameters in the catalogue > independent data points in the map
- The model perfectly describes the map but tells us nothing!

Conclusions (1)

- Obtain good fits to the 450μm map and reproduce fluxes and errors correctly
- Deblending the lower-resolution 850μm map:
  - good residuals can be obtained and some sources reasonably modelled, but there are still significant outliers
  - Perhaps this can be explained by confusion noise, although as you increase the density of the input catalogue you begin to account for this

Conclusions (2)

- Deblending the lower-resolution SPIRE maps:
  - If the catalogue is too sparse, errors seem to be underestimated (confusion noise not accounted for) and the background may need to be varied too
  - If the catalogue is denser, errors are larger but the residual is flatter, and fluxes are more consistent with the higher-resolution 450µm results
  - However, too many sources and the model becomes useless
  - Allowing TPHOT to clip negative sources appears to worsen the fit considerably