Herschel Observations of the Lupus Star Forming Region

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The star forming regions in Lupus

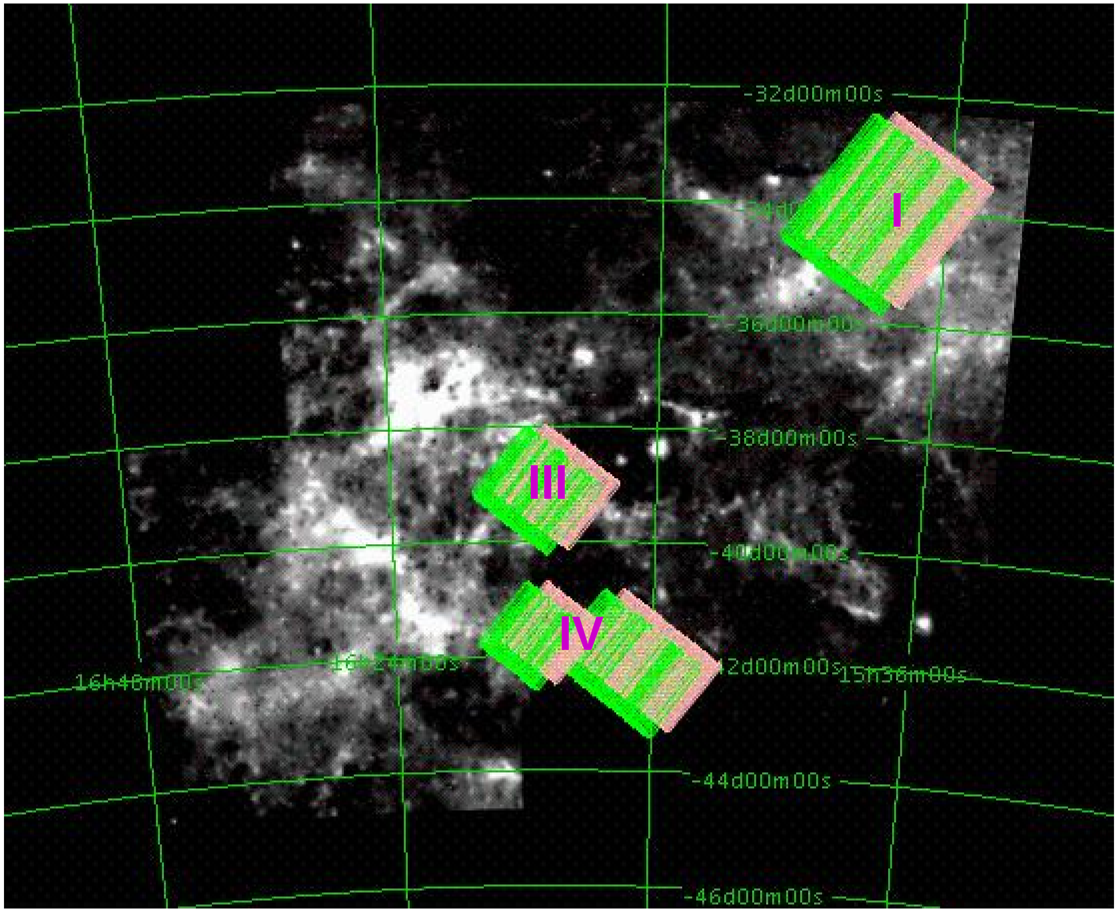
The constellation of Lupus hosts a complex of nearby clouds observed as part of the Gould Belt KP

Probing the origin of the stellar initial mass function
(PI: Andrè & Saraceno)

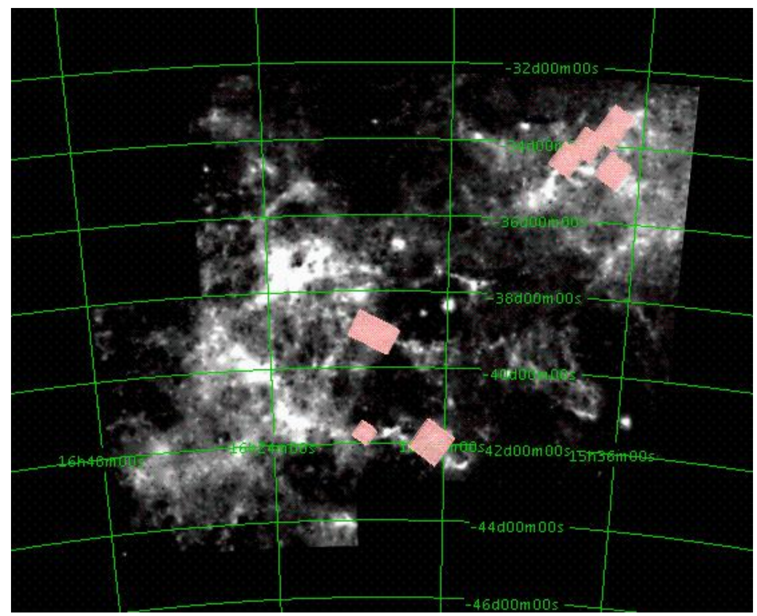
The complex covers about 180 deg^2 at an average distance of 155±8 pc (Lombardi, Lada & Alves 2008) with a thickness of 51 pc (effect of subclouds at different distances)

Regions selected are: Lupus I, III and IV with masses (Cambrésy 1999, assuming d=100 pc) 10^4, 1150 and 630$M_☼$

These regions have been observed with Spitzer (Chapman et al. 2007) as part of c2d program. Number of YSO/deg^2: 12 for Lupus I, 58 for Lupus III and 33 for Lupus IV



Maps in Parallel Mode (PACS 70 & 160µm + 3 SPIRE bands), fast speed, of Lupus I, III and IV



Maps with PACS only (100 & 160µm), medium speed, of more extinct regions

Lupus III observed in Parallel Mode in OD 261 (January 30th)

- *Covered an area of 1.3 deg^2 (60'x80') centred at $16^h09^m56.00^s$ -39°04'41.7"*
- *Two consecutive observations in Nominal and Orthogonal direction (about 1hr 20m each) to reduce 1/f noise effects in the final map*
- *Reduction performed first with the instruments pipeline (HIPE release 2.3.1); then with an internal pipeline:*

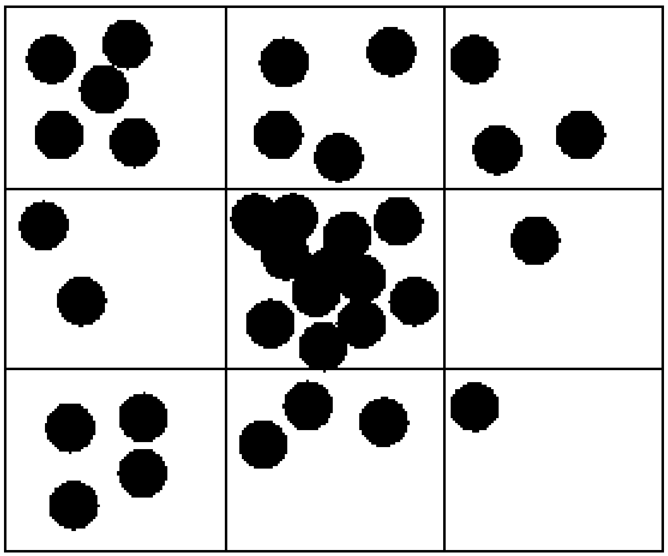
  a) For PACS: offset removal, deglitch and map making

  b) For SPIRE: drift removal and map making

  Internal pipeline based on a combination of HIPE scripts, IDL procedures and Fortran code (see Traficante et al. 2010 for details)
- *Source extraction and photometry: 2nd derivative of the image and Gaussian(s) fitting (see Molinari et al. 2010)*

For PACS deglitching we exploit the spatial redundancy of the bolometers (a technique named IInd level deglitching in the PACS pipeline): signals from bolometers observing the same sky pixel are averaged and outliers are found with sigma clipping method

Sigma clipping uses a fix number of standard deviation: we changed this approach



1) **Project all the bolometers pixels onto the final map**
2) **For each pixel in the map compute the median and the standard deviation σ**
3) **Look for values that differ from the median by more than a number n_σ of σ with**

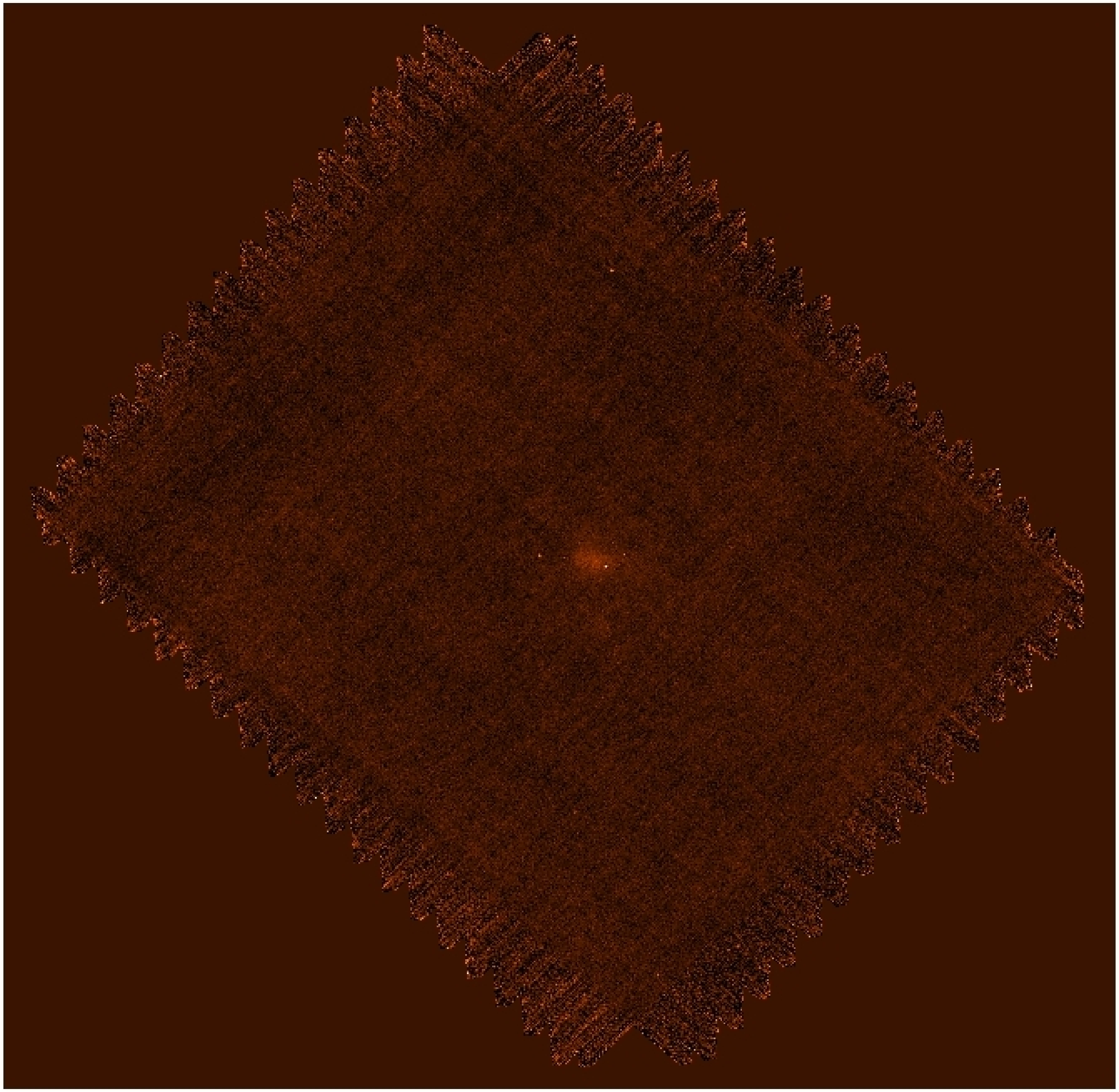
$$n_\sigma = -0.569 + \sqrt{-0.072 + 4.99\,\mathrm{Log}(N)}$$

where N is the size of the sample, ie number of bolometers falling in each pixel

4) **Repeat steps 2) and 3) until no outliers are found**

N (size of the sample)	n_σ (number of σ)
10	1.65
50	2.33
100	2.58
1000	3.29
10000	3.89
100000	4.42
1000000	4.90

Example: if we have 50 values, the number of expected points differing from the mean by more than 2.33σ is less than 1, which means that values above this threshold can be rejected as outliers

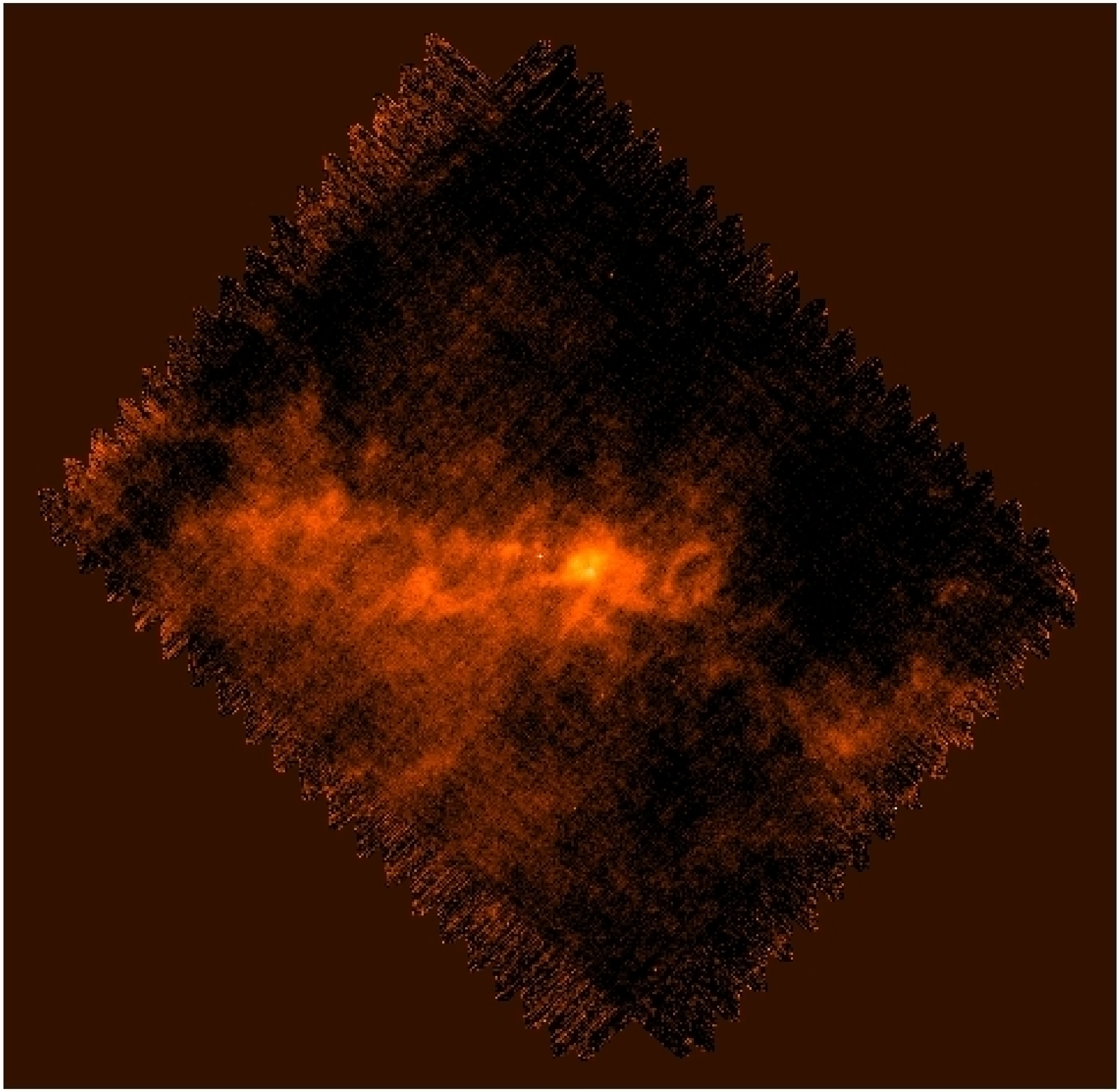


PACS 70µm

Diffuse emission in the central part only

rms (20 MJy/sr in HSPOT estimate): as low as 19 MJy/sr in the central region, increasing to 30-40 MJy/sr in the outskirt

<u>47 sources detected</u>

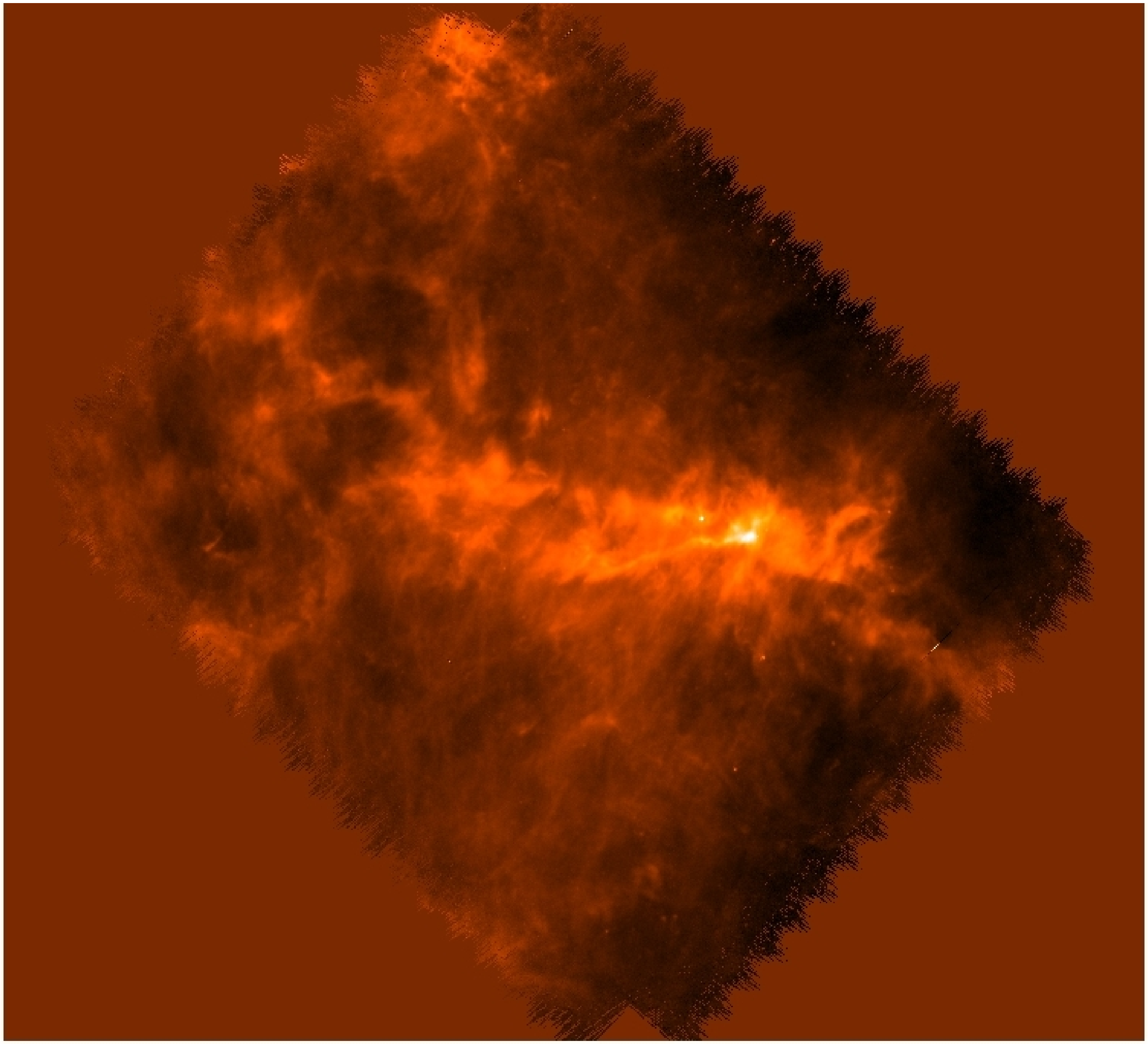


PACS 160μm

Diffuse emission more prominent

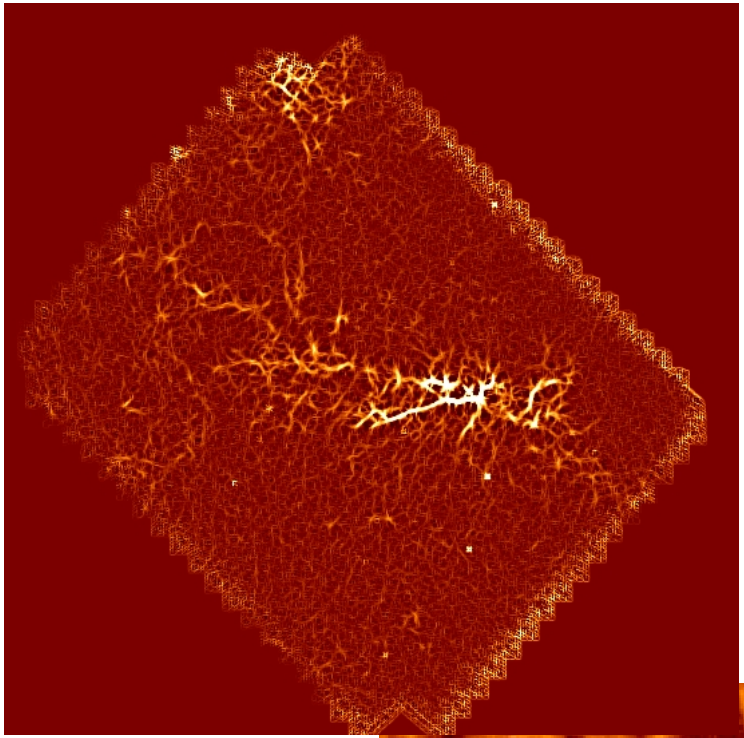
rms (9.2 MJy/sr in HSPOT):
17 – 24 MJy/sr

37 sources detected



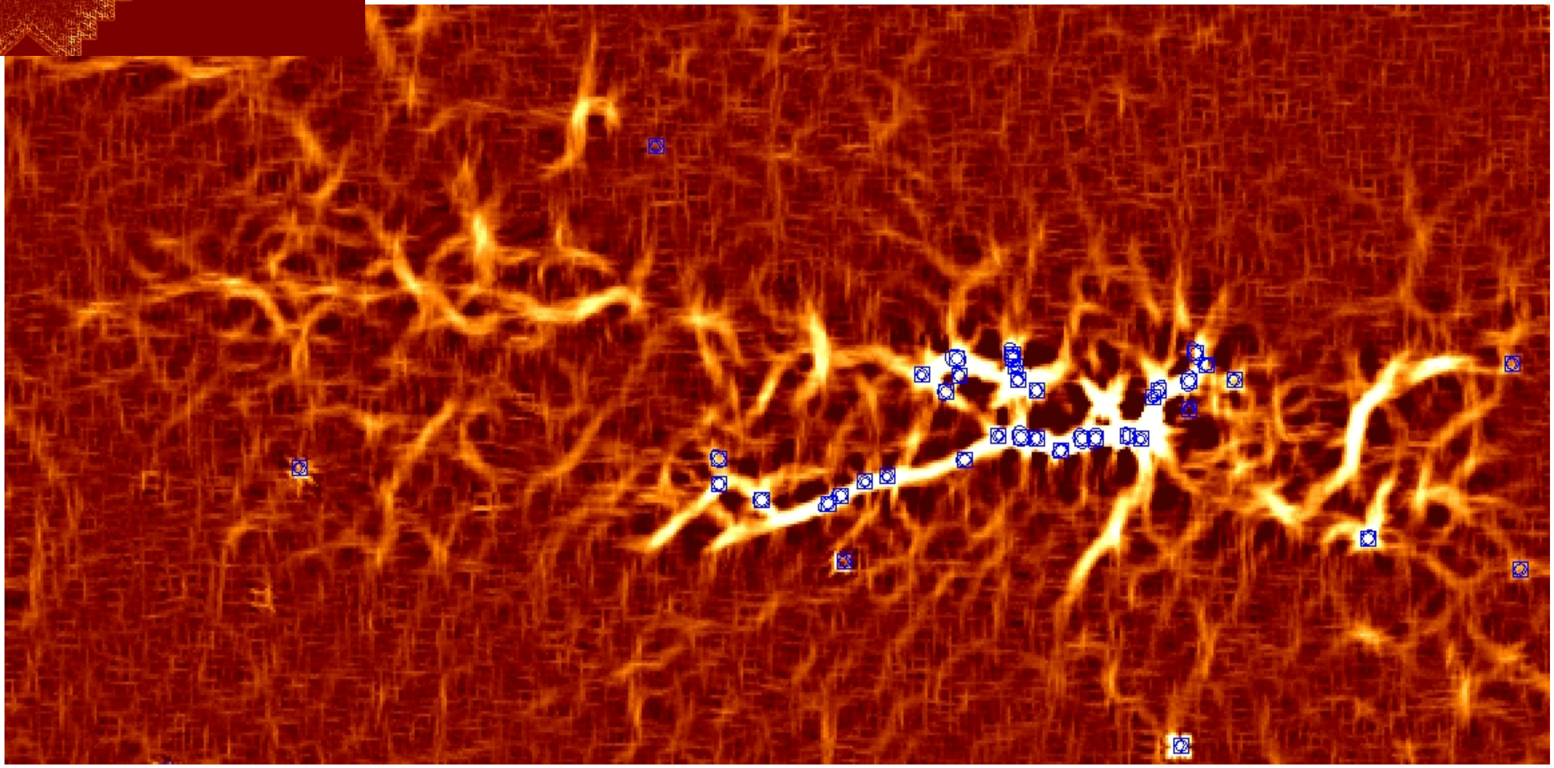
*SPIRE 250**μm***

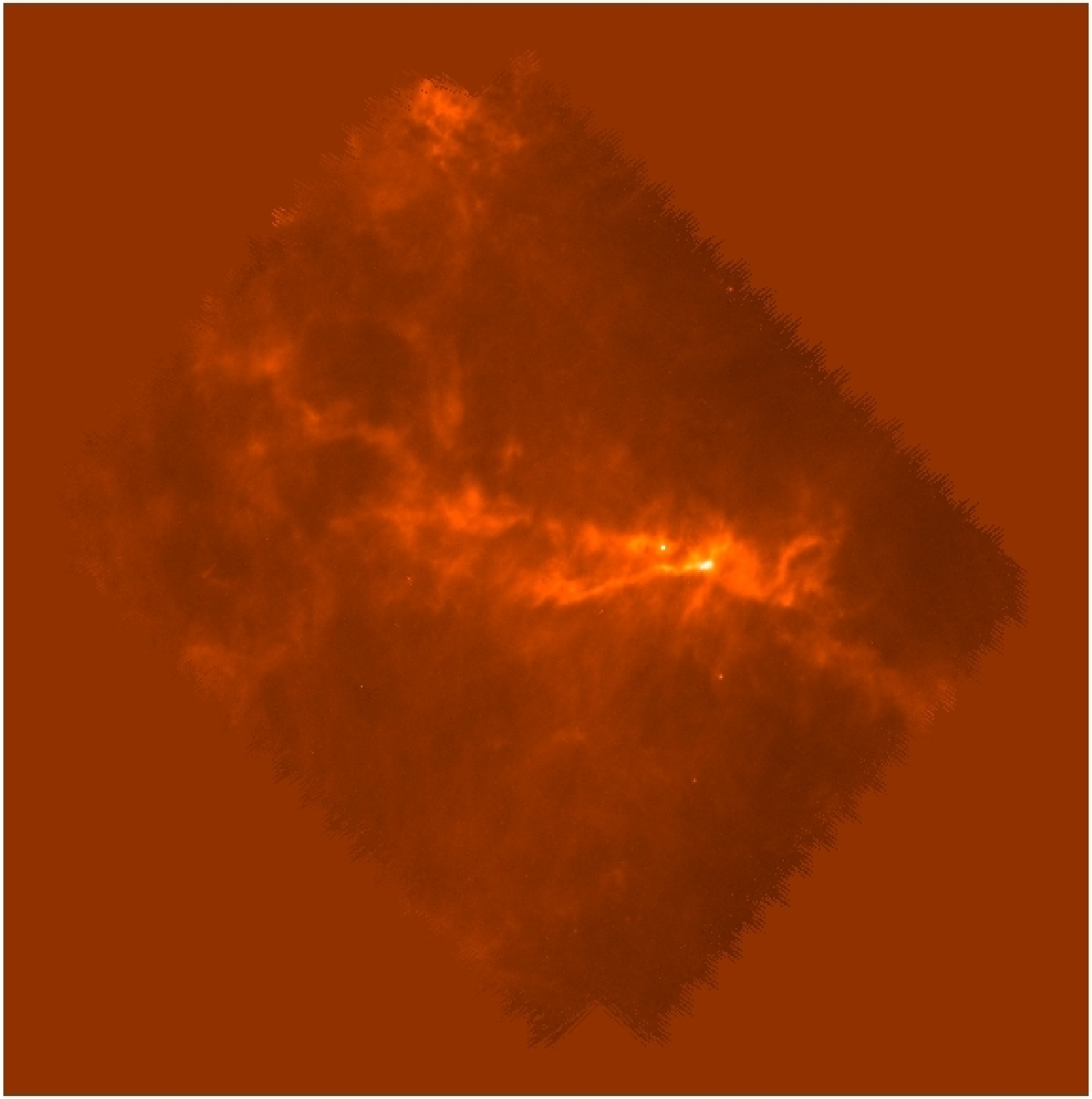
117 sources detected



Map of curvature at 250 µm

with position of detected sources

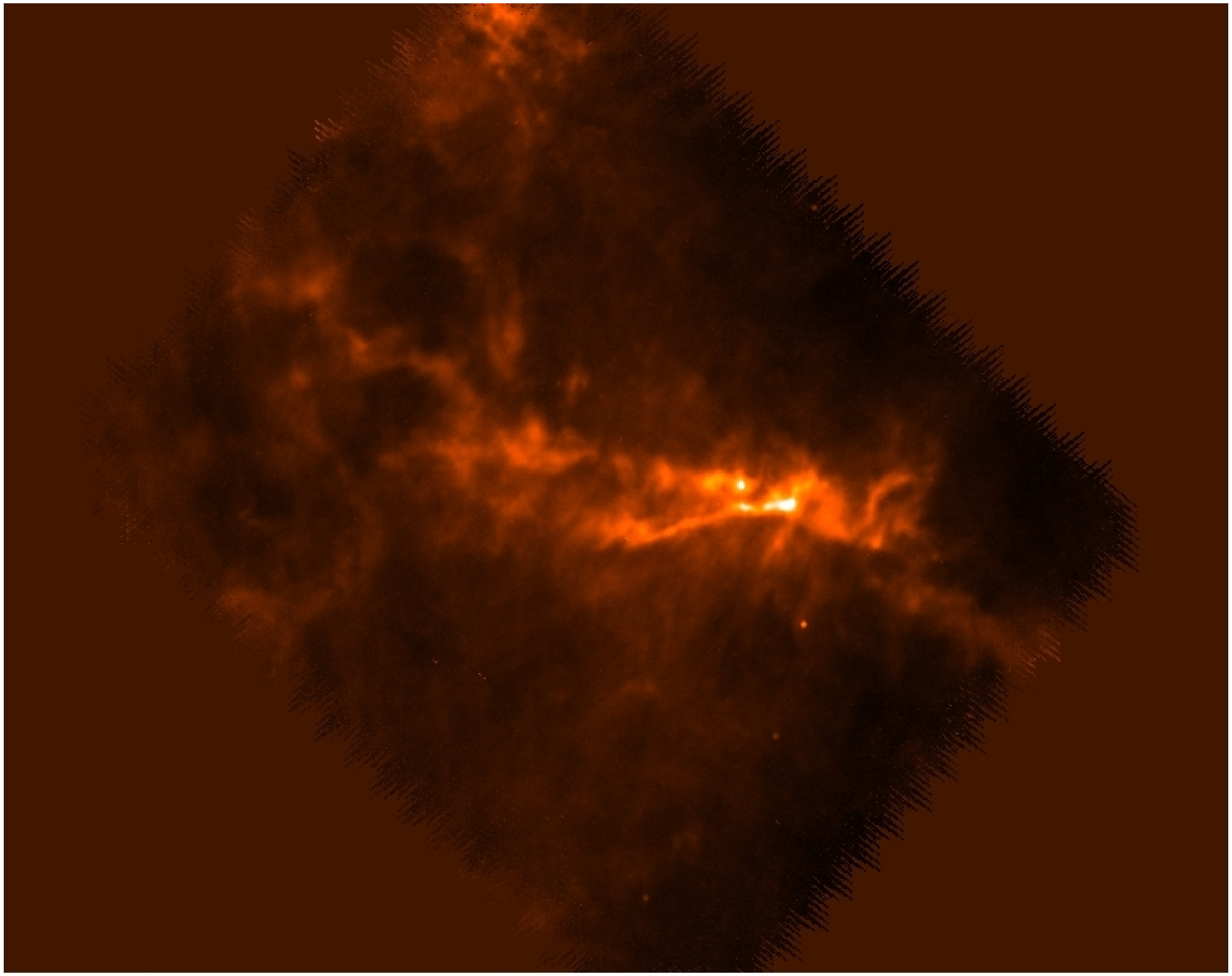




SPIRE 350μm

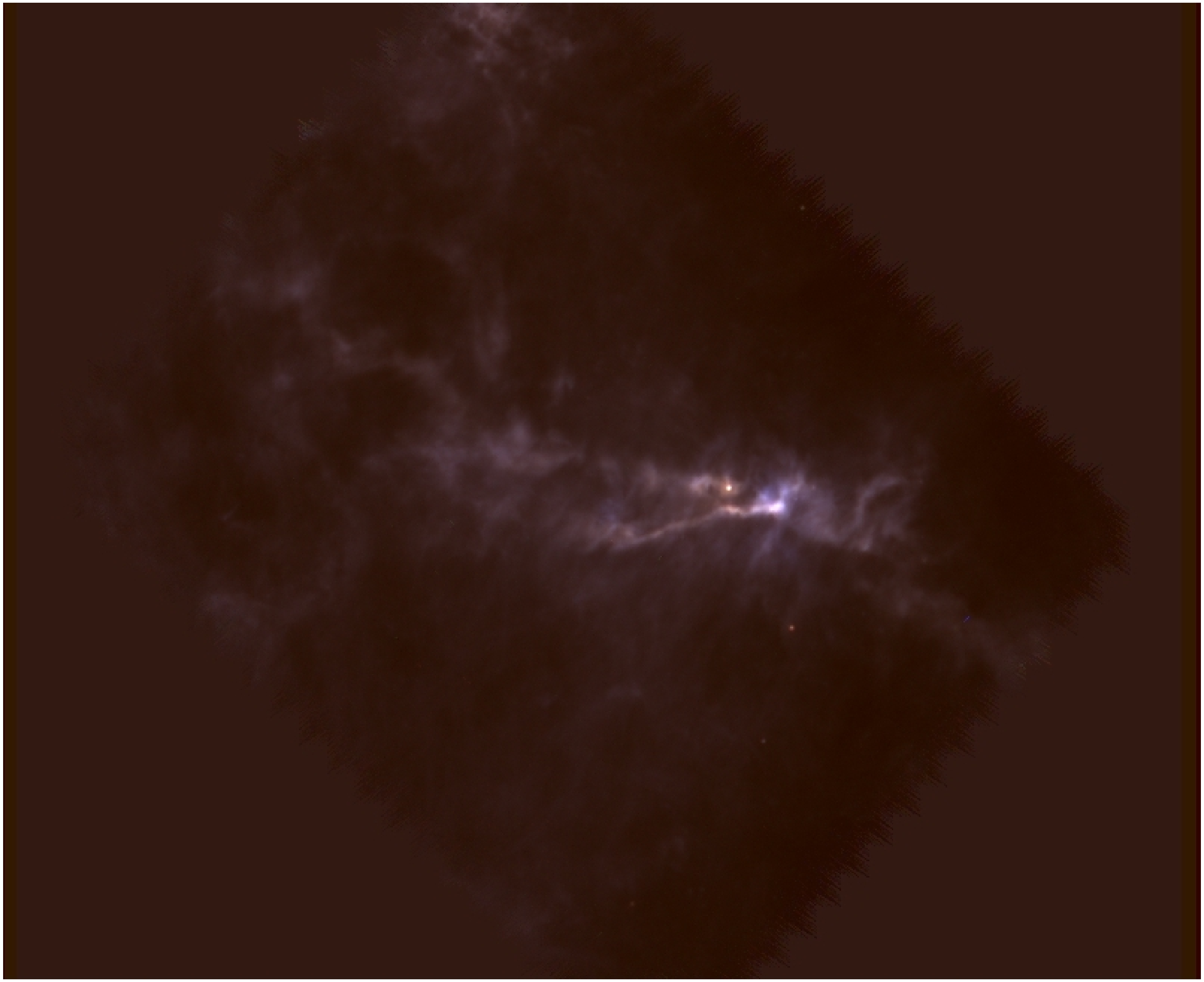
41 sources detected

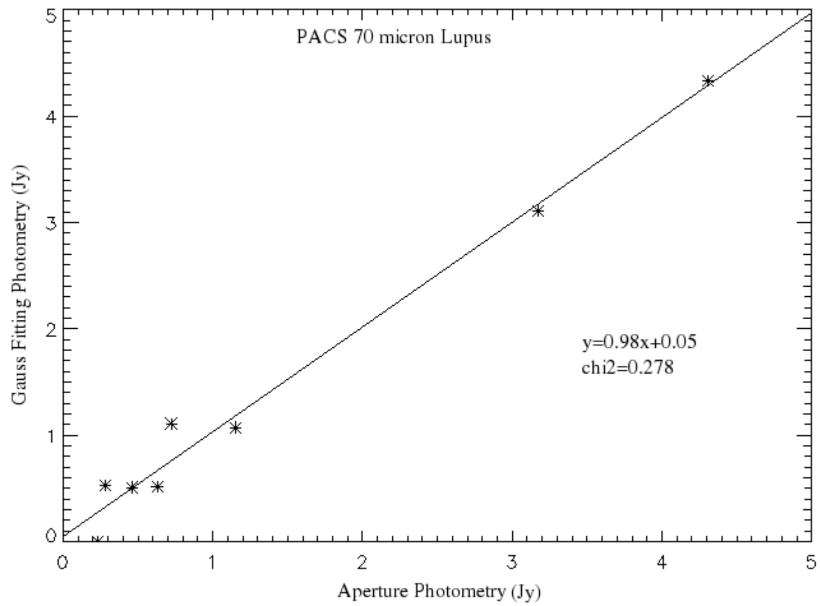
SPIRE 500μm

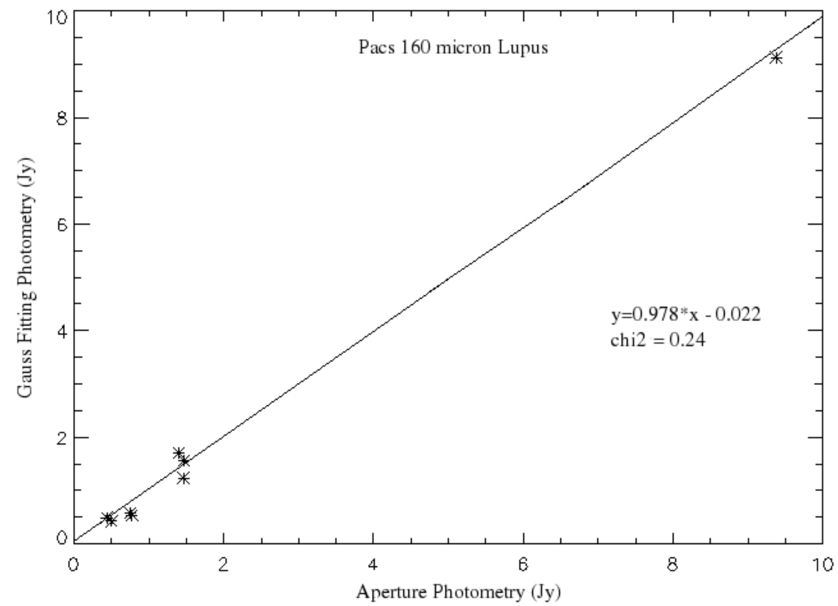


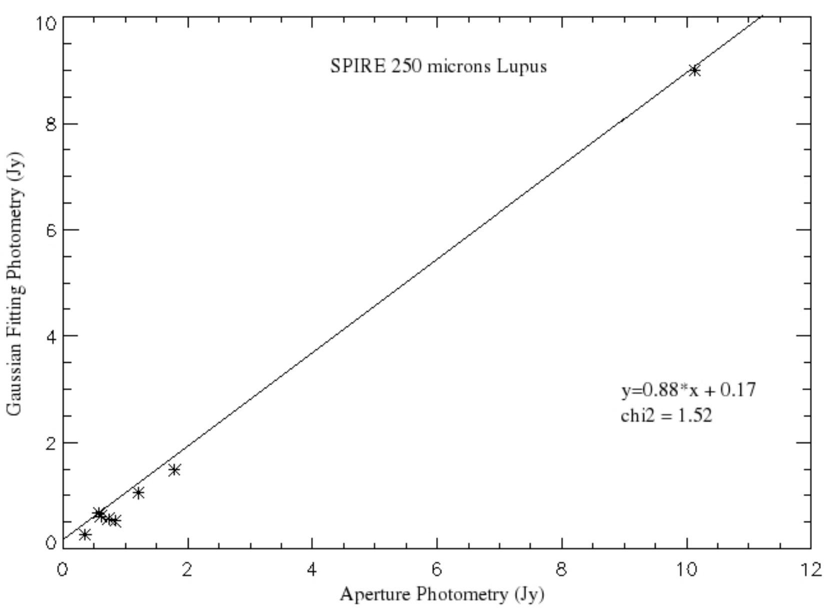
23 sources detected

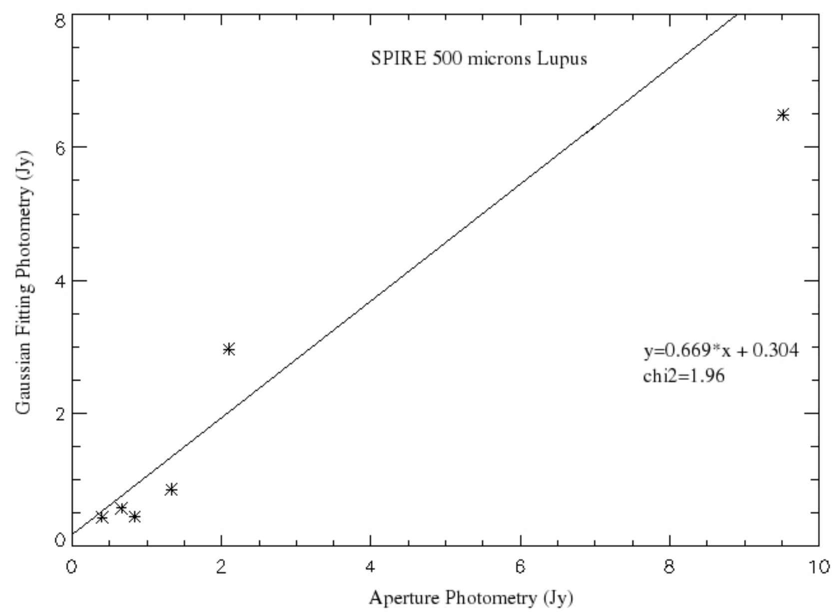
Composite RGB image with SPIRE 250, 350, and 500µm

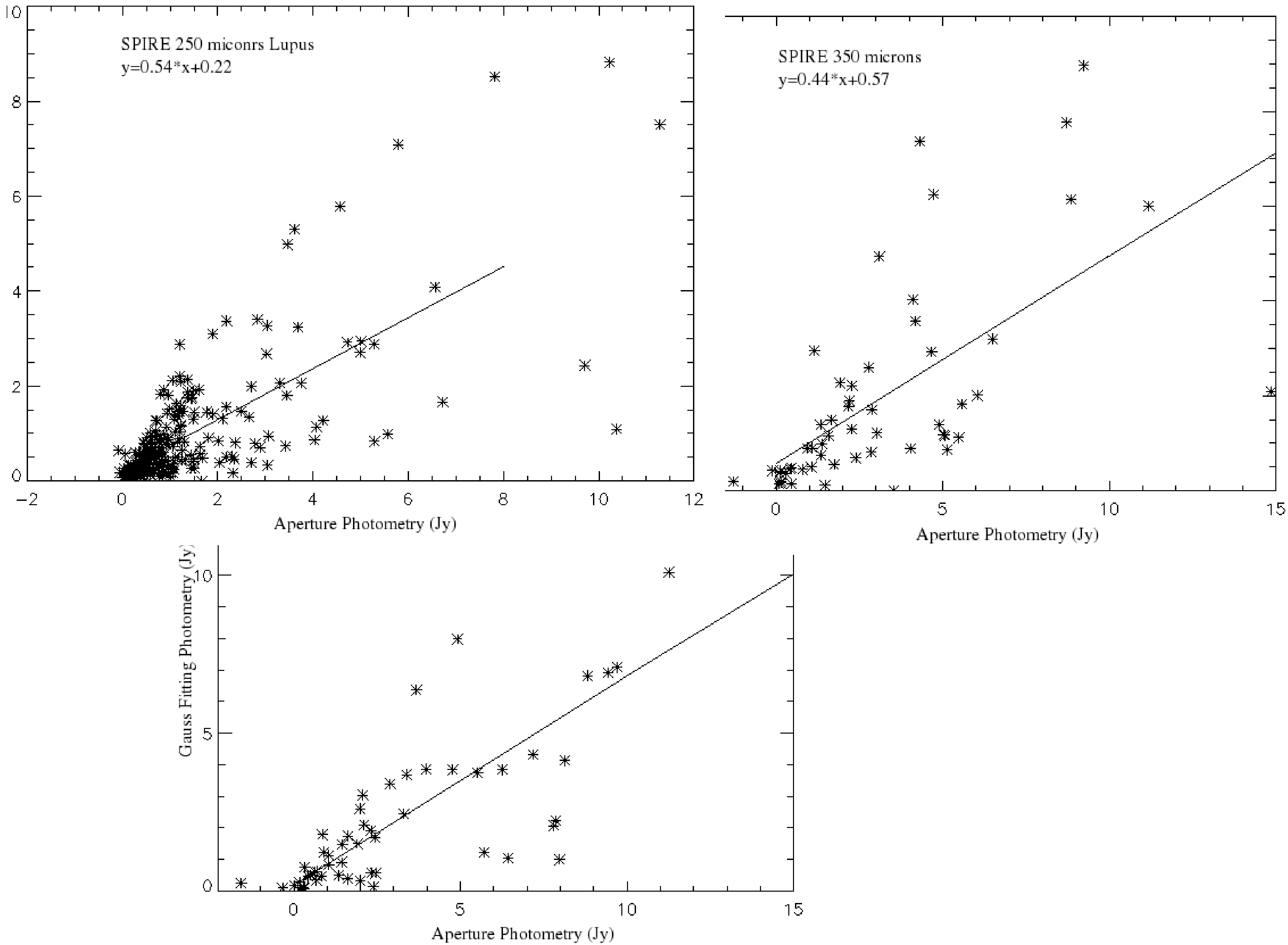



PACS 70 micron Lupus
y=0.98x+0.05
chi2=0.278
Gauss Fitting Photometry (Jy)
Aperture Photometry (Jy)
0
1
2
3
4
5


Pacs 160 micron Lupus
y=0.978*x - 0.022
chi2 = 0.24
Gauss Fitting Photometry (Jy)
Aperture Photometry (Jy)
0
2
4
6
8
10


SPIRE 250 microns Lupus
y=0.88*x + 0.17
chi2 = 1.52
Gaussian Fitting Photometry (Jy)
Aperture Photometry (Jy)
0
2
4
6
8
10
12


SPIRE 500 microns Lupus
y=0.669*x + 0.304
chi2=1.96
Gaussian Fitting Photometry (Jy)
Aperture Photometry (Jy)
0
2
4
6
8
10


SPIRE 250 miconrs Lupus
y=0.54*x+0.22
Aperture Photometry (Jy)
SPIRE 350 microns
y=0.44*x+0.57
Aperture Photometry (Jy)
Gauss Fitting Photometry (Jy)
Aperture Photometry (Jy)

Summary

1) *Lupus III shows a complex filamentous structure visible at all wavelengths but 70* ***µm*** *where diffuse emission is marginally detected*
2) *Sources position appears associated with the filaments (eg Molinari et al 2010, Andrè et al. 2010)*
3) *8 sources detected in all PACS & SPIRE bands*
4) *The most prominent source in all images is a Class 0 (Tachihara et al. 2007): it seems colder than previously reported*
5) *Another interesting source is V1094 Sco classified as T Tauri: not detected at 70* ***µm,*** *faint at 160* ***µm,*** *bright in SPIRE bands (cold companion?)*
6) *Photometry extraction requires caution: number of detected sources allows an object by object measurement*