The Herschel Virgo Cluster Survey

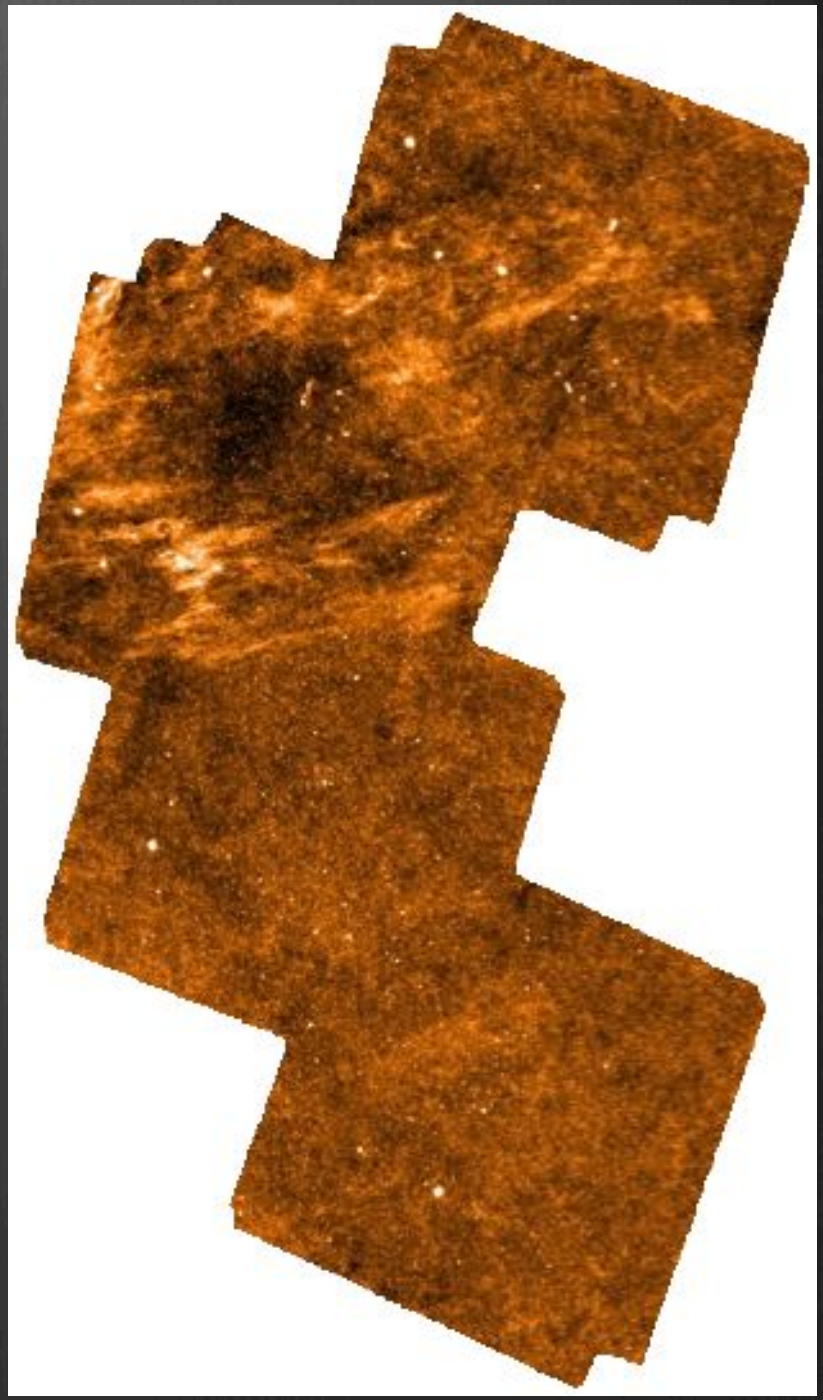
Insight into galaxy evolution from Far Infra Red wavelength

Ciro Pappalardo (CAAUL, OAL) and the HeViCS consortium

HeViCS

Open Time Key Project (Davies et al. 2010)
286 hours
4 field of 4X4 sq deg.
PACS (100 – 160 micron)
SPIRE (250 - 350 - 500 micron)

Science Institutes involved:
CAAUL - OAL, Lisboa Portugal
Universiteit Gent, Belgium
Imperial College London UK
Osservatorio Astrofisico di Arcetri, Firenze Italy
Ruhr-University Bochum Germany
Laboratoire d'Astrophysique de Marseille France
INAF-Osservatorio Astronomico di Padova Italy
Cardiff University UK
NASA Herschel Science Center, Pasadena USA
ESO, Santiago Chile
Universita' di Milano-Bicocca Italy
Institut d'Astrophysique Spatiale (IAS), Paris-Sud France
Laboratoire AIM, CEA/DSM- CNRS France
Max-Planck-Institut fuer extraterrestrische Physik, Garching
INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica, Roma
Leiden Observatory Netherland
National Observatory of Athens Greece
Max-Planck-Institut fuer Astronomie, Heidelberg Germany



HeViCS science goals

1. detection of dust in the inter-galactic medium
2. the extent of cold dust in the outskirts of galaxies
3. the FIR LFs
4. the complete spectral energy distributions of galaxies
5. the dust content of dwarf ellipticals and irregulars
6. analysis of the dust content of early type galaxies

di Serego Alighieri, S. et al. 2013 - XIII. Dust in early-type galaxies
Auld et al. 2013 - XII. FIR properties of optically selected Virgo cluster galaxies
Pappalardo et al. 2012 - XI. Environmental effects on molecular gas and dust in spiral disks
Corbelli et al. 2012 - X. The relationship between cold dust and molecular gas content in Virgo spirals
Magrini et al. 2011 - IX. Dust-to-gas mass ratio and metallicity gradients in four Virgo spiral galaxies
Davies et al. 2012 - VIII. The Bright Galaxy Sample
De Looze et al. 2010 - VII. Dust in cluster dwarf elliptical galaxies
Baes et al. 2010 - VI. The far-infrared view of M 87
Grossi et al. 2010 - V. Star-forming dwarf galaxies - dust in metal-poor environments
Smith et al. 2010 - IV. Resolved dust analysis of spiral galaxies
Clemens et al. 2010 - III. A constraint on dust grain lifetime in early-type galaxies
Cortese et al. 2010 - II. Truncated dust disks in H I-deficient spirals
Davies et al. 2010 - The Herschel Virgo Cluster Survey. I. Luminosity function

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END OF HeViCS ADVERTISING

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last: www.hevics.org

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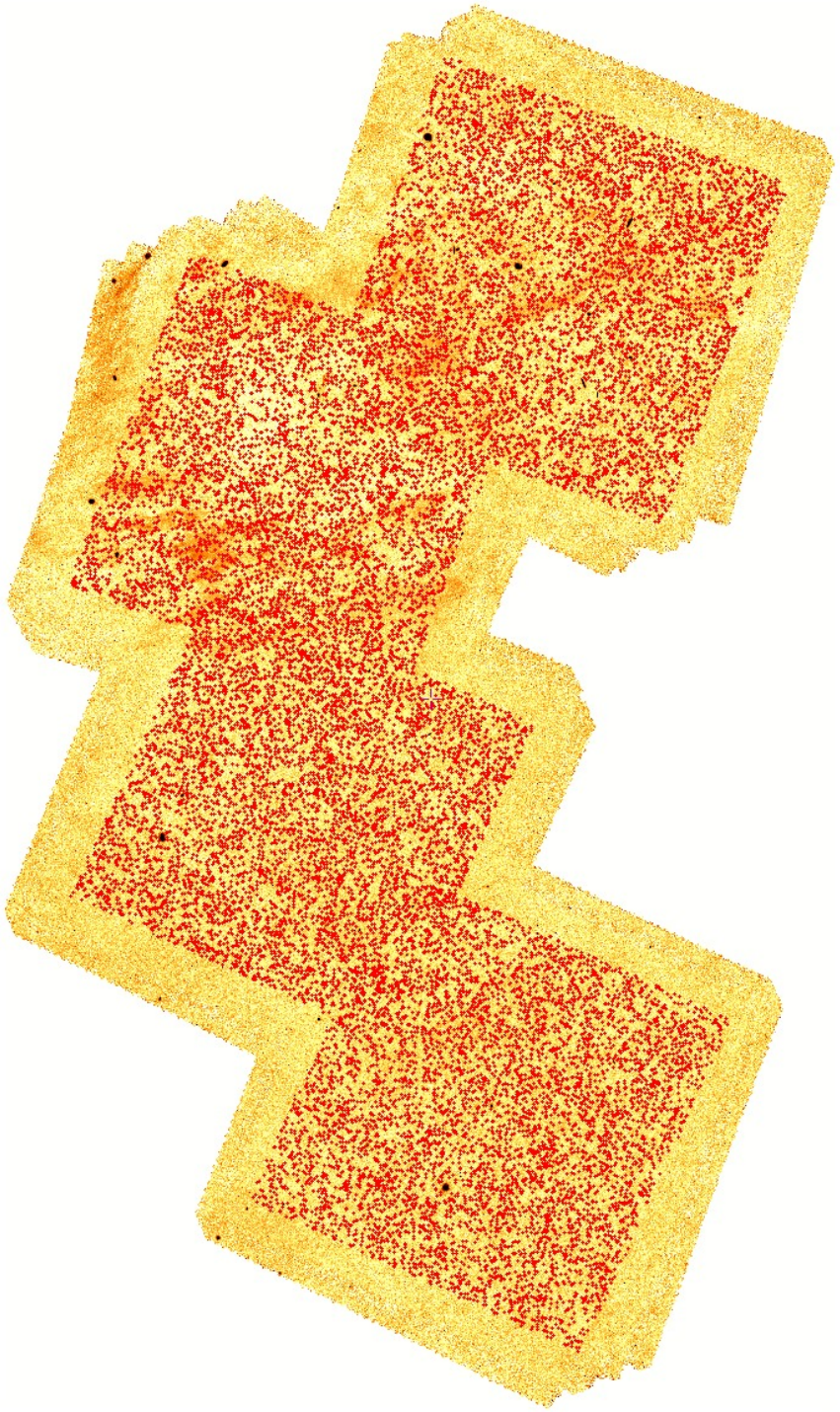
Point Source Catalogue

26638 unique sources selected at 250 micron

POSITION – Sussextractor
FLUX DENSITY - sourceExtractorTimeline

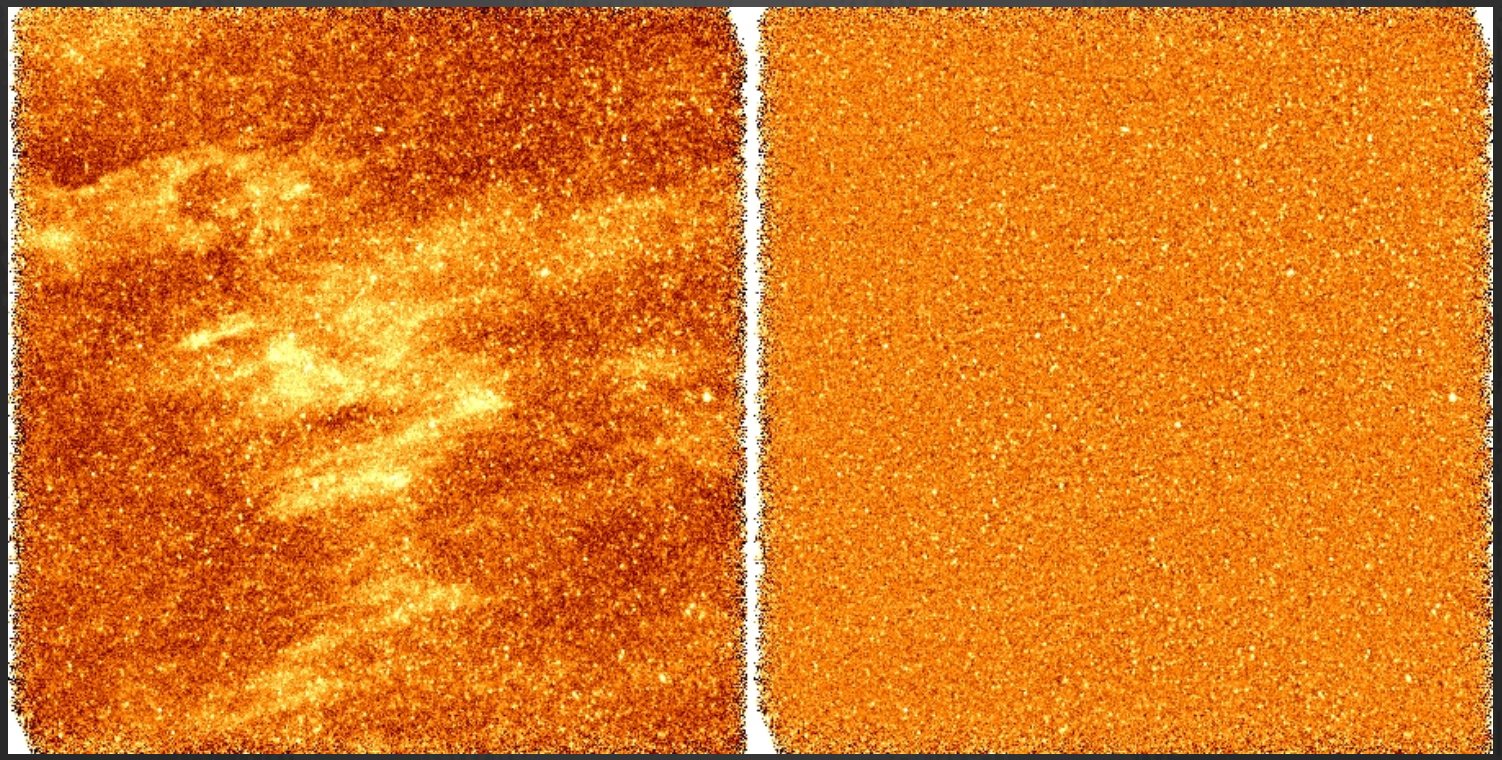
Main Problem:

CIRRUS (above all in the central regions of Virgo)

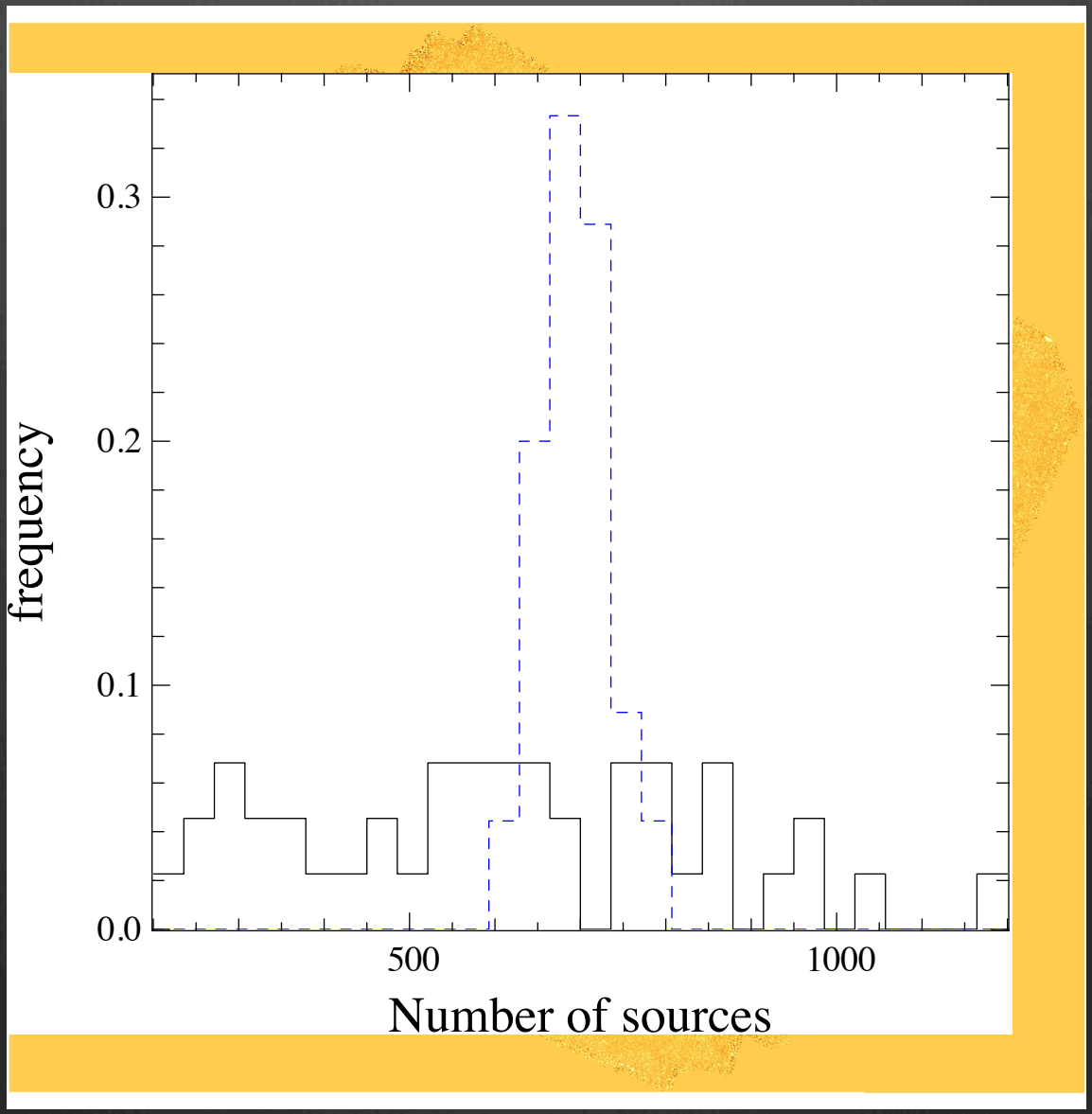


Cirrus

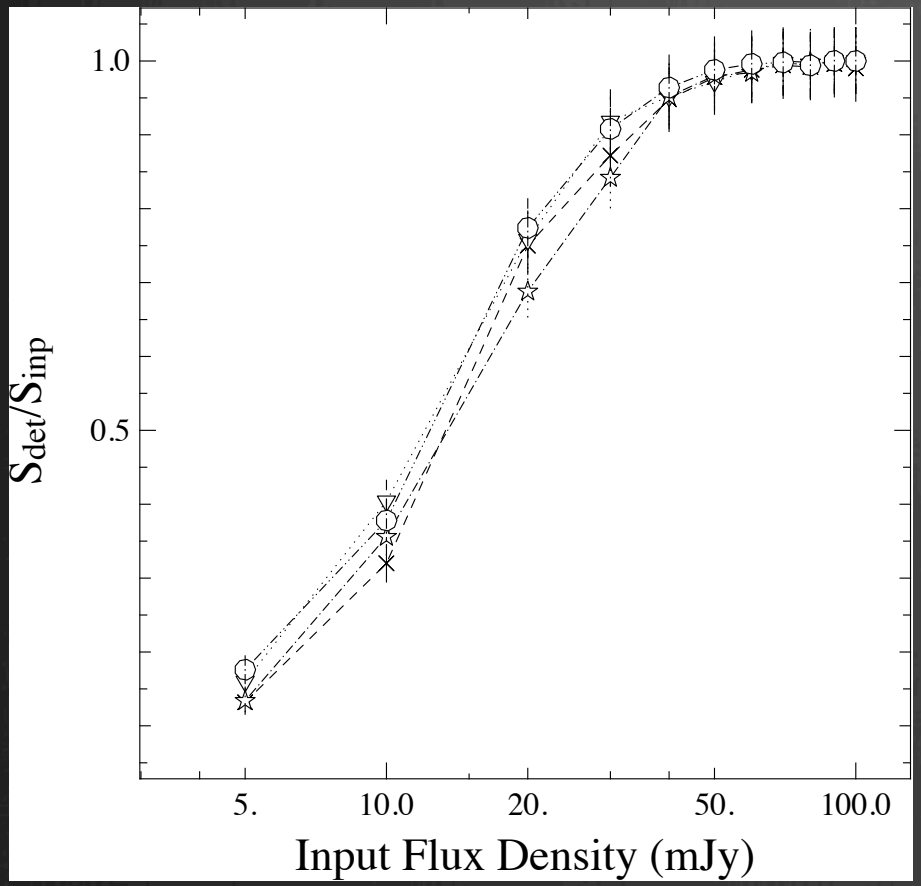
Background estimated using Sextractor (Bertin & Arnouts 1996)
It regrids the map in cells larger than the pixel size and then estimates the mean and the standard deviation of the distribution of pixel values in each cell.
Finally the background map is obtained by interpolating linearly between the cells.

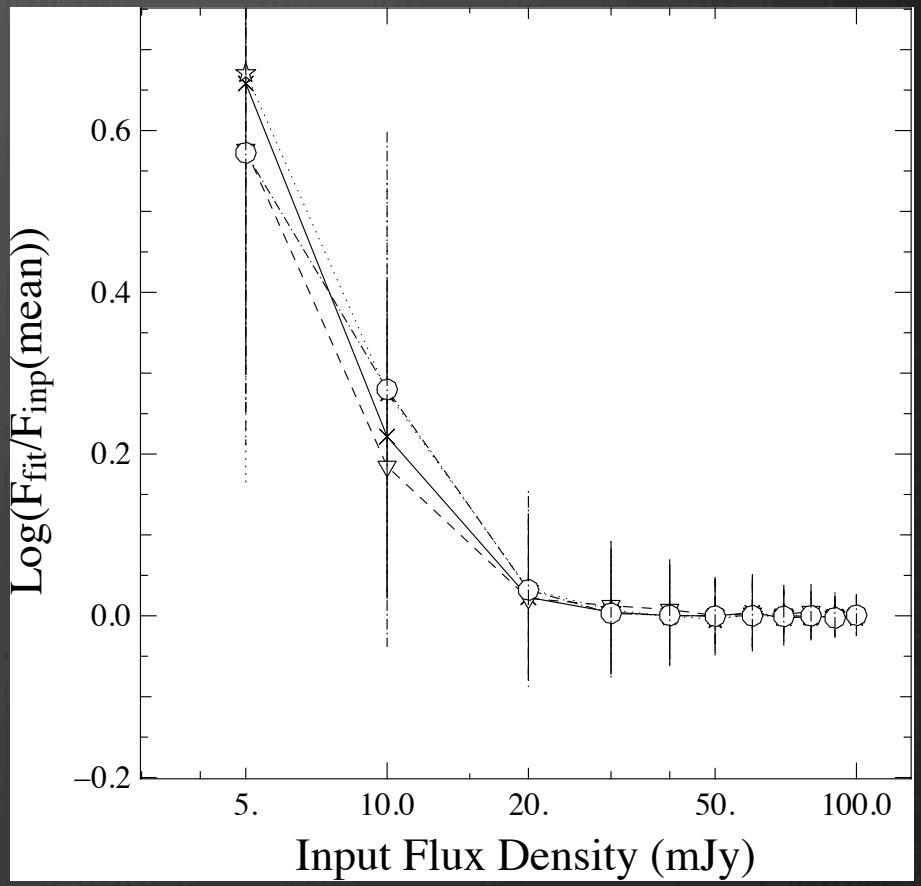


Cirrus



Completeness and Flux accuracy



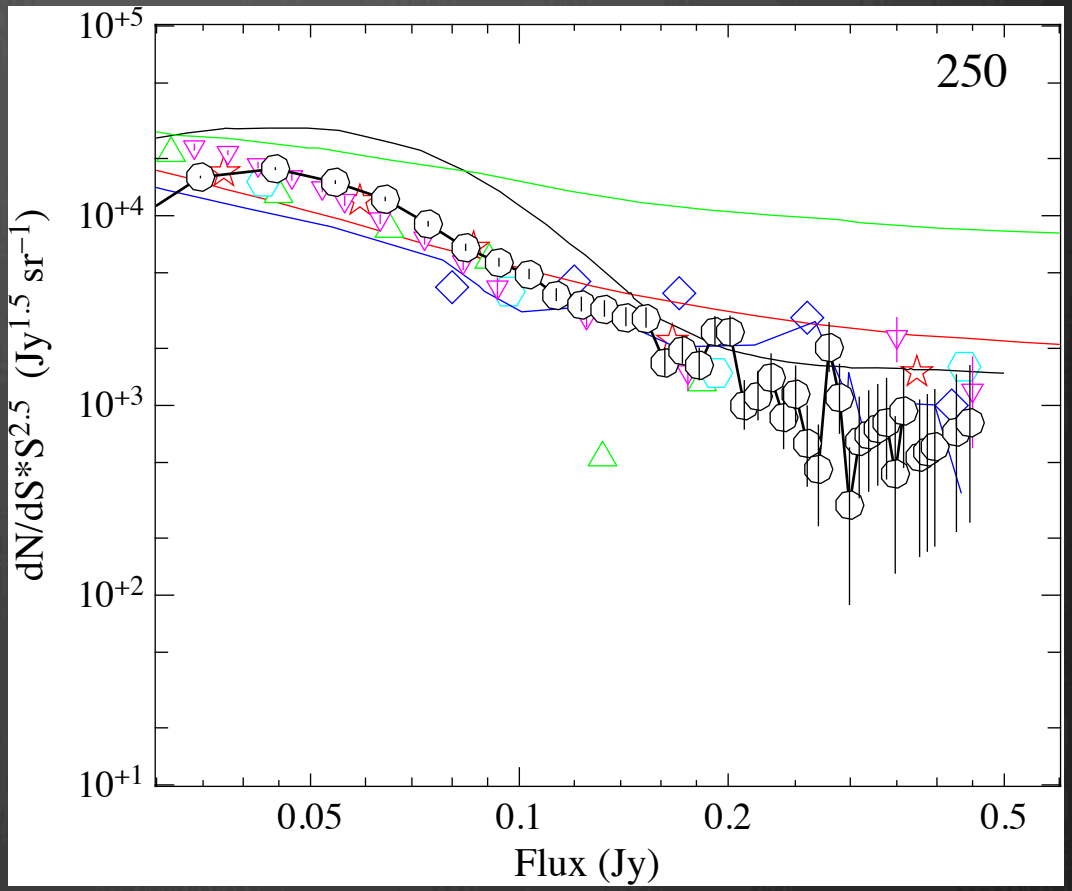


The catalogue at 250 micron is 95% complete at 40 mJy and the completeness decreases to 74% at 20 mJy

Number Counts

Magenta triangles H-ATLAS
Red stars, HerMES SDP
Blue diamonds BLAST
Cyan hexagons HERMES DR1
Green triangles P(D) analysis

SOLID LINES
Green Lacey et al 2010
Black Negrello et al. 2007
Blue Valiante et al. 2009
Red Bethermin et al. 2012



A characteristic feature at all the wavelengths is an increase of the number counts at F < 200 mJy indicating a strong evolution for the galaxy populations at faint fluxes

In agreement with Glenn et al. (2010) we found a bump for F > 400 mJy

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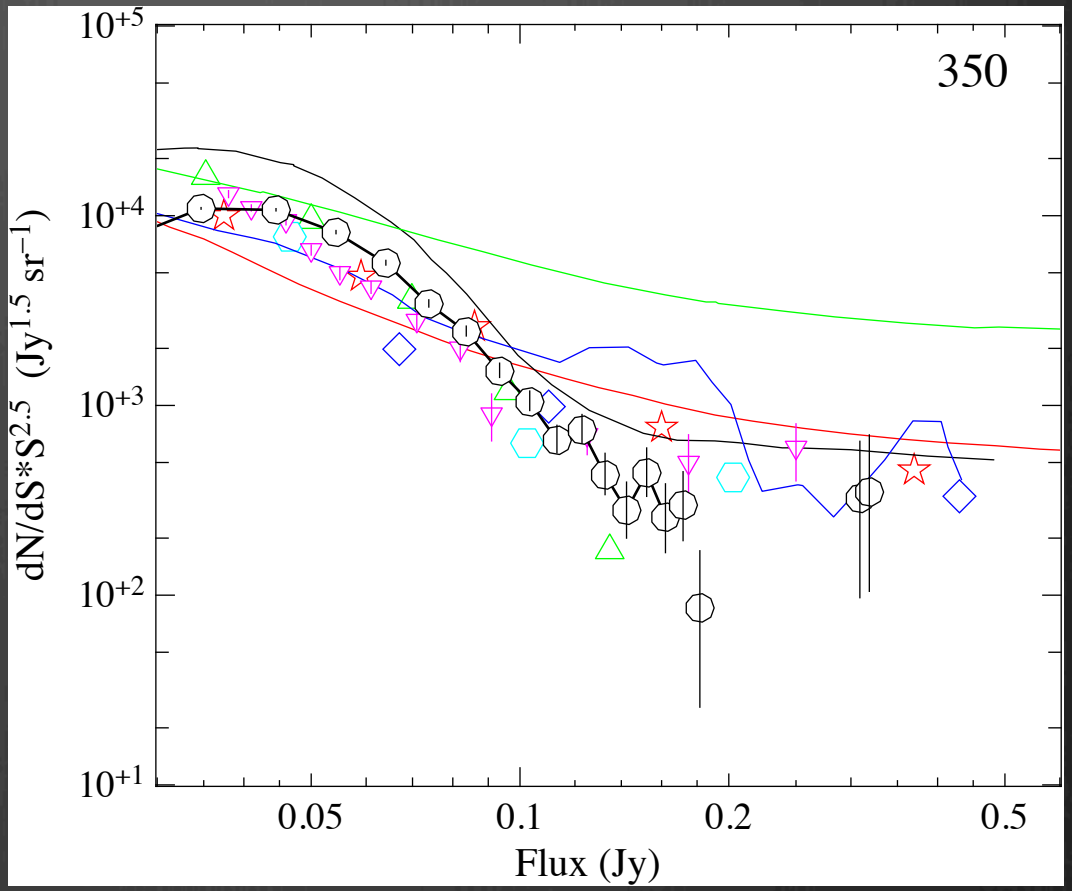

A characteristic feature at all the wavelengths is an increase of the number counts at F < 200 mJy indicating a strong evolution for the galaxy populations at faint fluxes

In agreement with Glenn et al. (2010) we found an increase in the number of counts for fluxes of ~ 300 mJy, that is reproduced in the semi-analytical models of Niemi et al. (2012), independently of the dust template.

Number Counts

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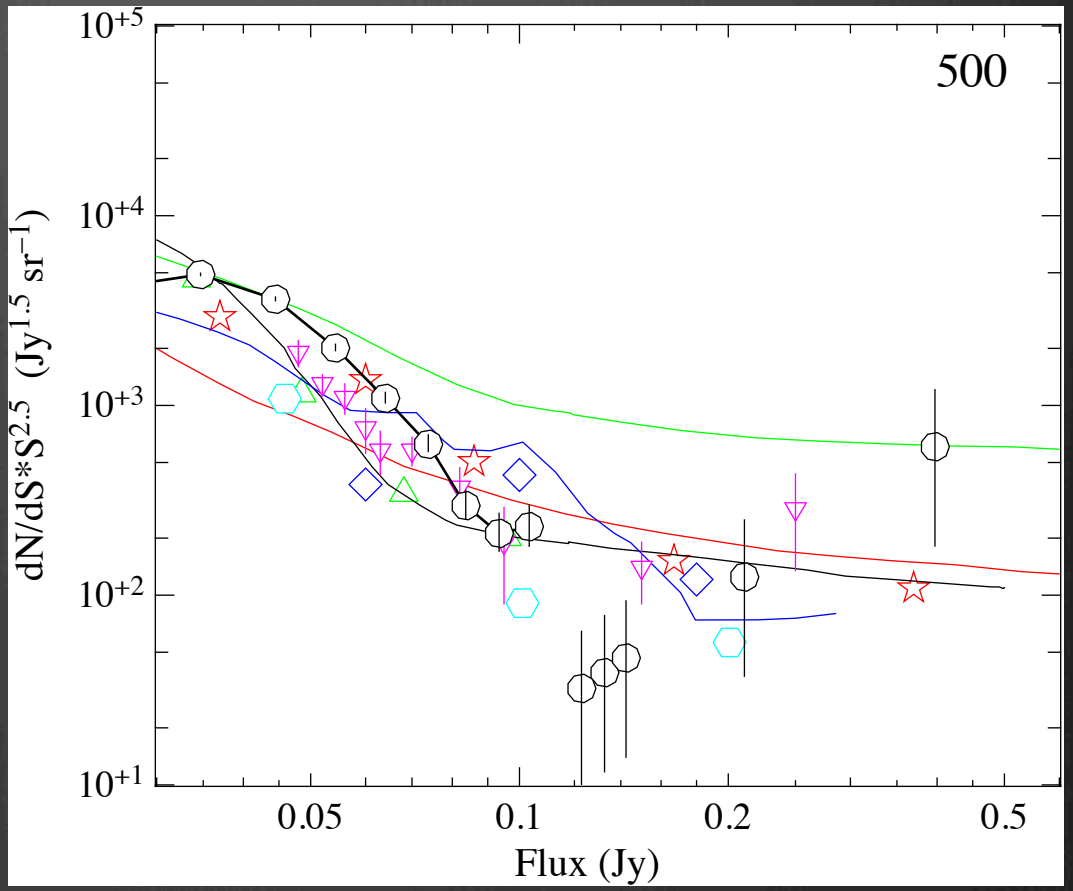
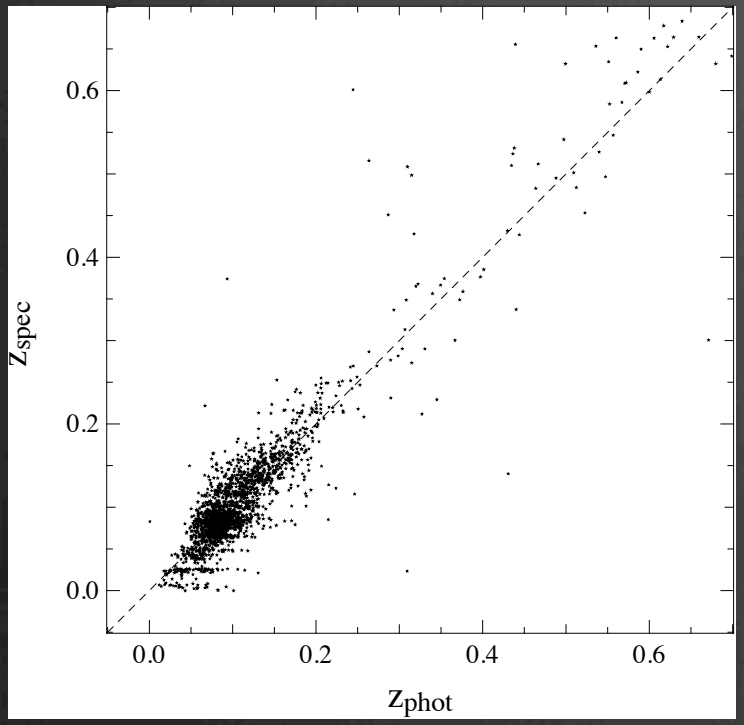


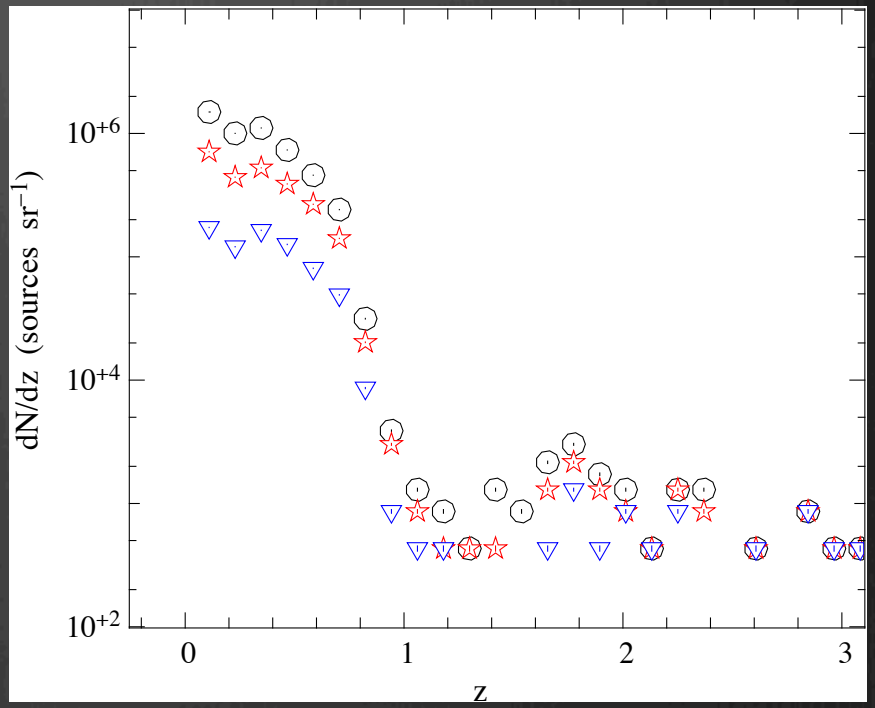
A characteristic feature at all the wavelengths is an increase of the number counts at F < 200 mJy indicating a strong evolution for the galaxy populations at faint fluxes

Comparison of the number counts at different wavelengths shows that the slope of the faint end where the statistics are good (60 <~ F <~150 mJy) steepens going from 250 micron to the longer wavelengths.

Cross correlation with SDSS DR7

Maximum radial distance allowed, 1.5 pixel, 9”
SDSS threshold in r-band magnitude of $m_r < 22.2$
SPIRE sources with flux densities above 30 mJy and a SNR ≥ 5 at all wavelengths.
About half of the sources detected at all SPIRE wavelengths have an optical counterpart

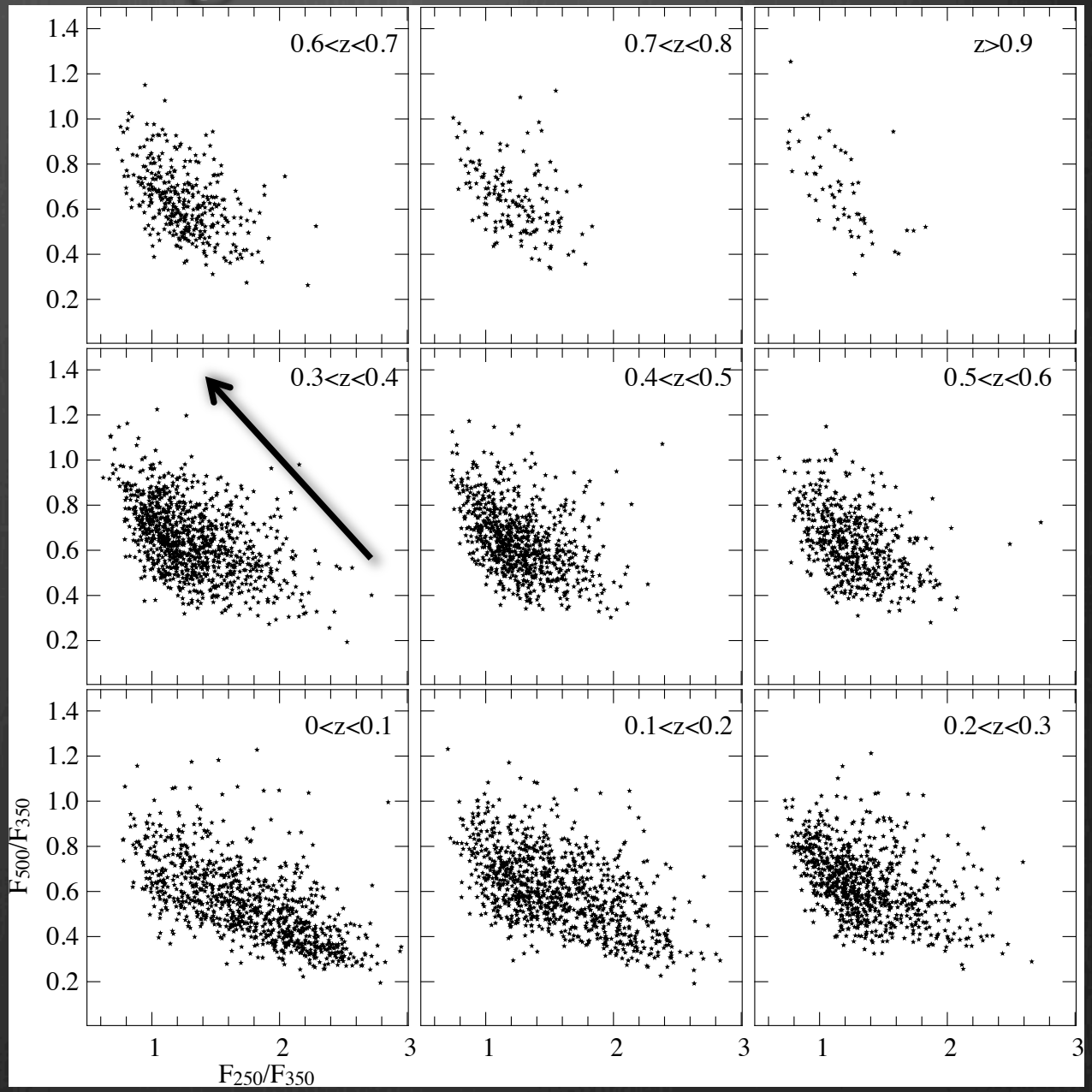




Steep decrease at z = 1, because the SDSS catalogue is biased toward low redshift sources. At z > 1 we have an increase in the number of sources at z ~ 2 consistent with the statistical redshift distribution of H-ATLAS SDP sources in Amblard et al. (2010) z = 2.2±0.6, and SCUBA Half Degree Extragalactic Survey, that determined photometrically an average redshift range for sub-mm galaxies between 1.8 and 3.1 (Aretxaga et al. 2007).

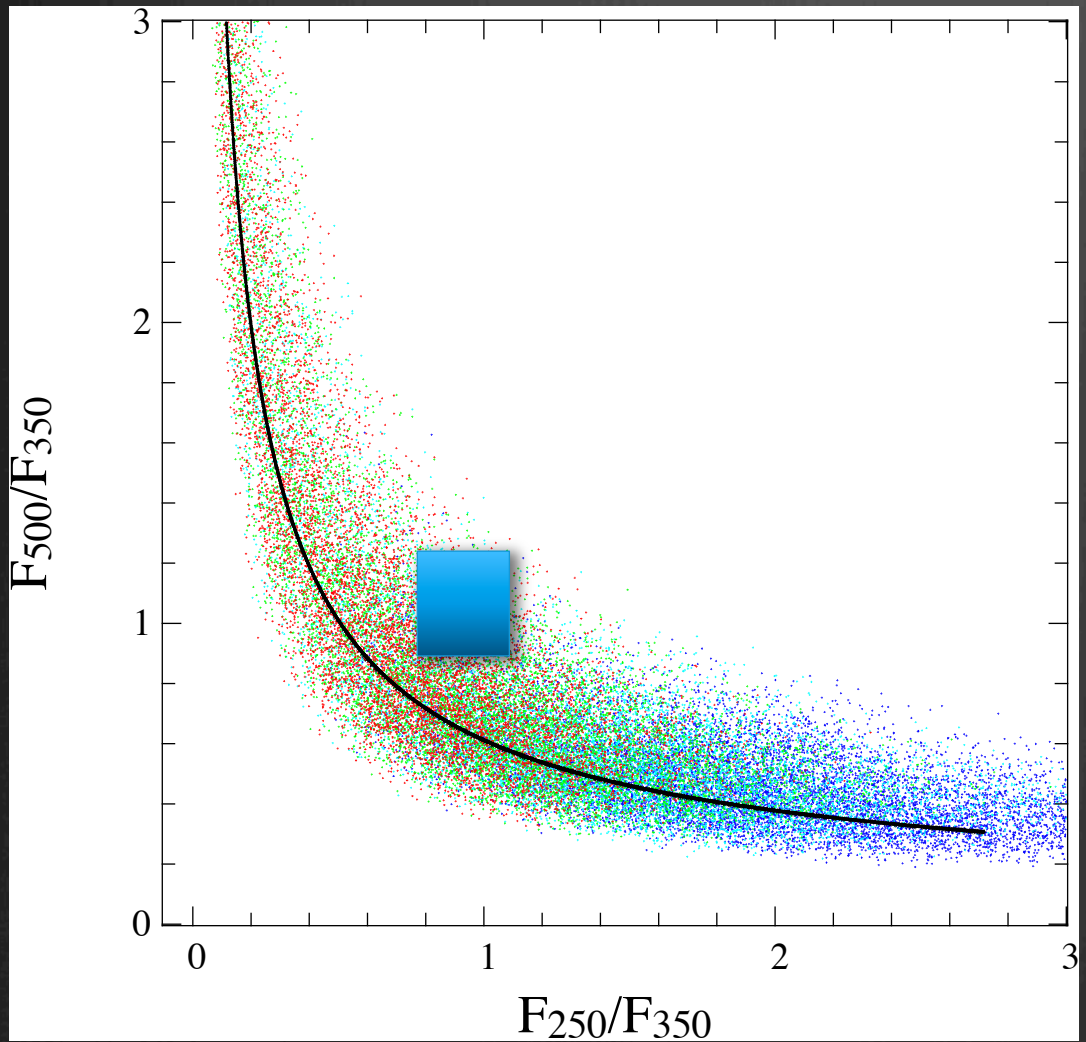
Color Color diagram

Galaxies tends to move in the color-color diagram toward the top left corner of the diagram as redshift increases



Color Color diagram: statistical analysis

Sub-mm photometric redshifts can be determined by calculating the probability that the colours of an observed sub-mm galaxy are consistent with the colours of every galaxy in the mock catalogue.



$$F_\nu = \frac{2h \cdot \nu^{3+\beta}}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$

Blue -> $0 < z \leq 1$

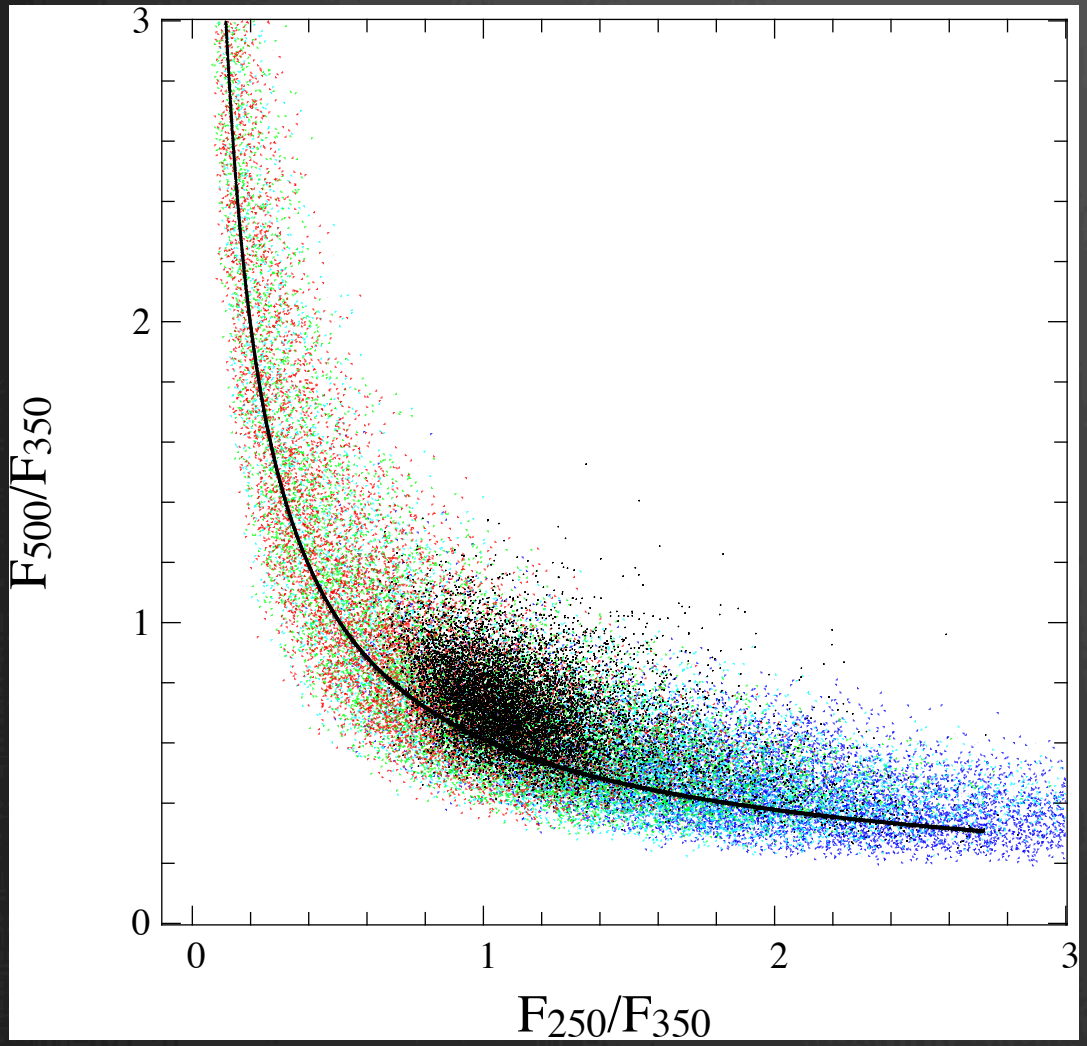
Cyan -> $1 < z \leq 2$

Green -> $2 < z \leq 3$

Red -> $3 < z \leq 4$

Color Color diagram: statistical analysis

Most of the sources occupy a region with F250/F350 > 0.6 and F500/F350 < 1.
This is consistent with the fact that sources at lower redshift are in average detected at lower SPIRE wavelengths, higher redshift sources have statistically higher flux values at longer wavelengths



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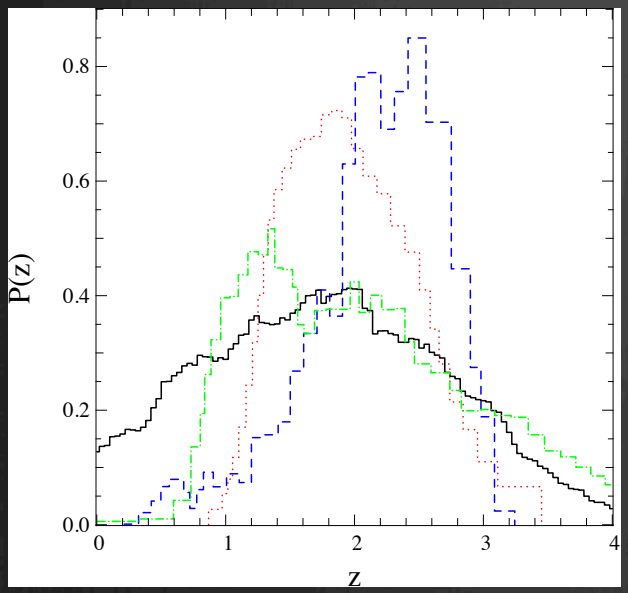
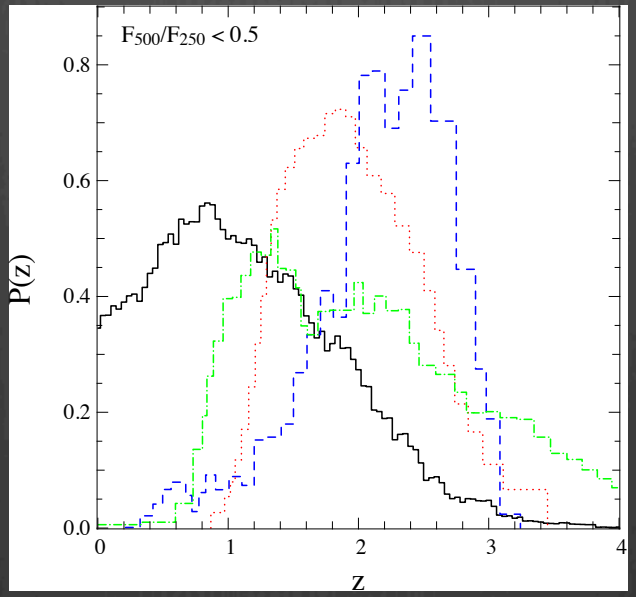
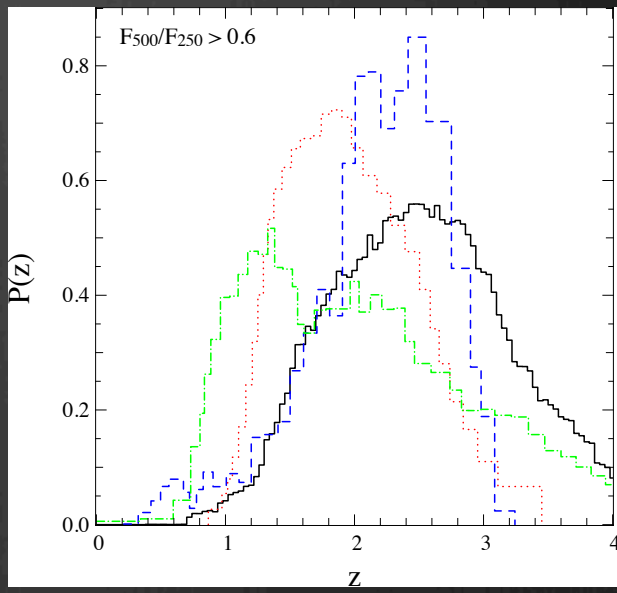
Color Color diagram: statistical analysis

Statistically a selection based on SPIRE colors can divide the galaxy population of our sample in a high redshift ”red” component and a ”bluer” low redshift component







Blue - Amblard et al 2010 Red - Negrello et al. 2007 Green - Lagache et al. 2004

Conclusions

1. There is a catalogue of point sources selected at 250 micron of Virgo background galaxies

2. We find an increase of the slope of the number counts at F < 200 mJy at all SPIRE wavelengths indicating a strong evolution for these galaxies, in agreement with previous observations. This increase in slope might be due to the presence of actively star-forming galaxies at $z \geq 1.5$, that are passive at low redshift.

3. We find a bump for F > 400 mJy at 250 micron, trend that is not reproduced by all the models, showing the importance of Rayleigh-Jeans side of the SED to characterize the evolution of FIR galaxies population

4. We use the color color diagram to constrain in a statistical sense our sample, showing that sources with lower redshift populate larger regions with an overdensity toward the bottom right corner of the diagram (F250/F350 > 1.7), and sources with high redshift occupy the top left region of the diagram (F250/F350 < 0.8)

OPEN ISSUE

A point to be better addressed in future modeling efforts is the contamination by gravitational lensing in the number counts, mostly relevant at 500 micron, and the possibility of an evolving SEDs for FIR galaxies with redshift, as found by Magnelli et al. (2011).

THANK YOU