ASTRODEEP

Unveiling the power of the deepest images of the Universe

Application of T-PHOT in SCUBA-2 images

Nathan Bourne

Summary

- General procedure for fitting prior-based models in submm maps:

I. Selection of priors

II. Preparing inputs

III. Model fitting choices

IV. Background estimation

- A few science results

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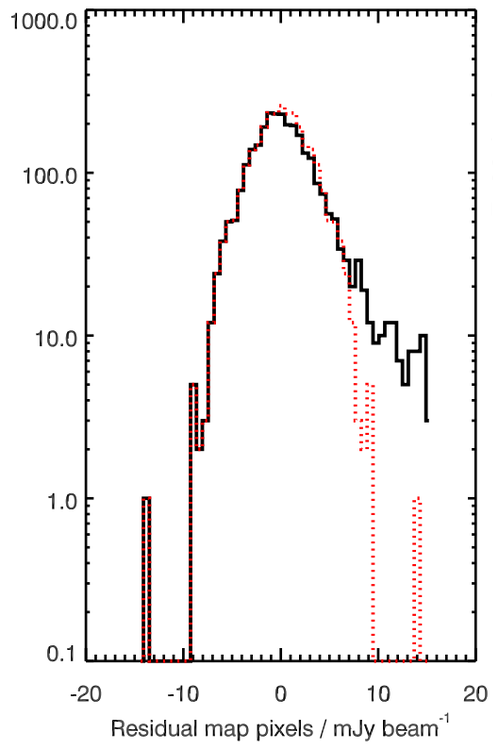
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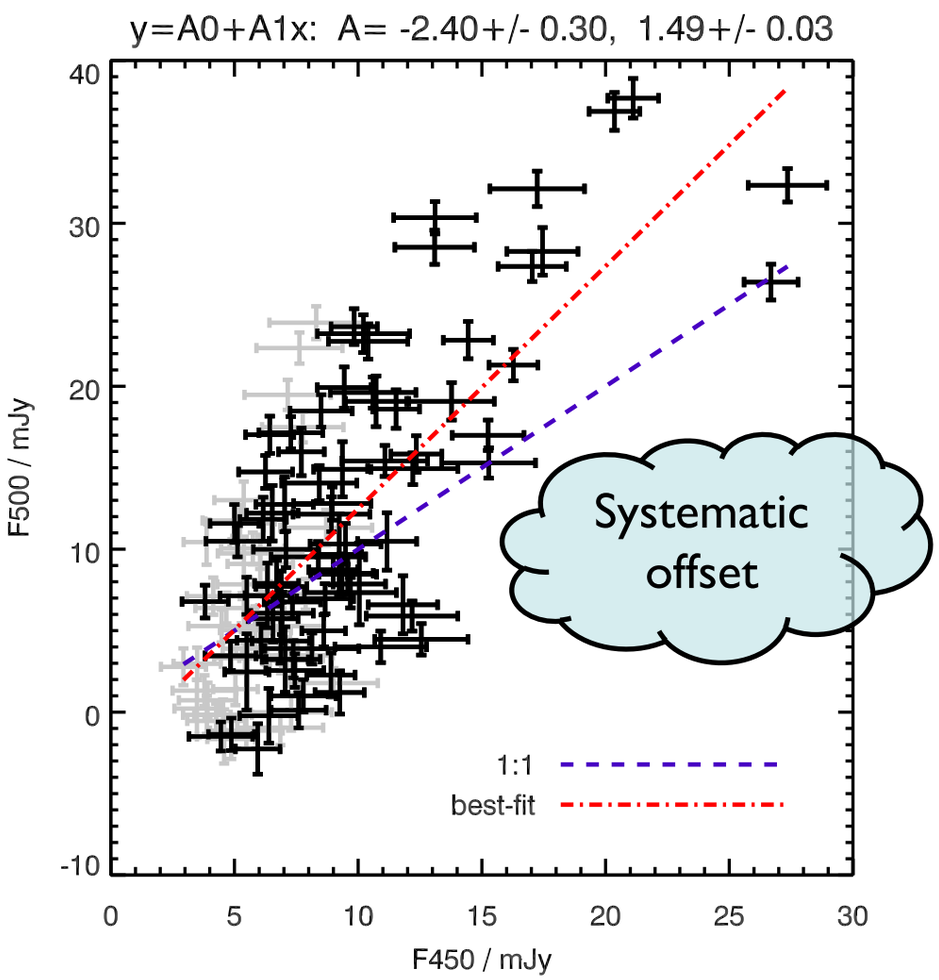
Selection of priors

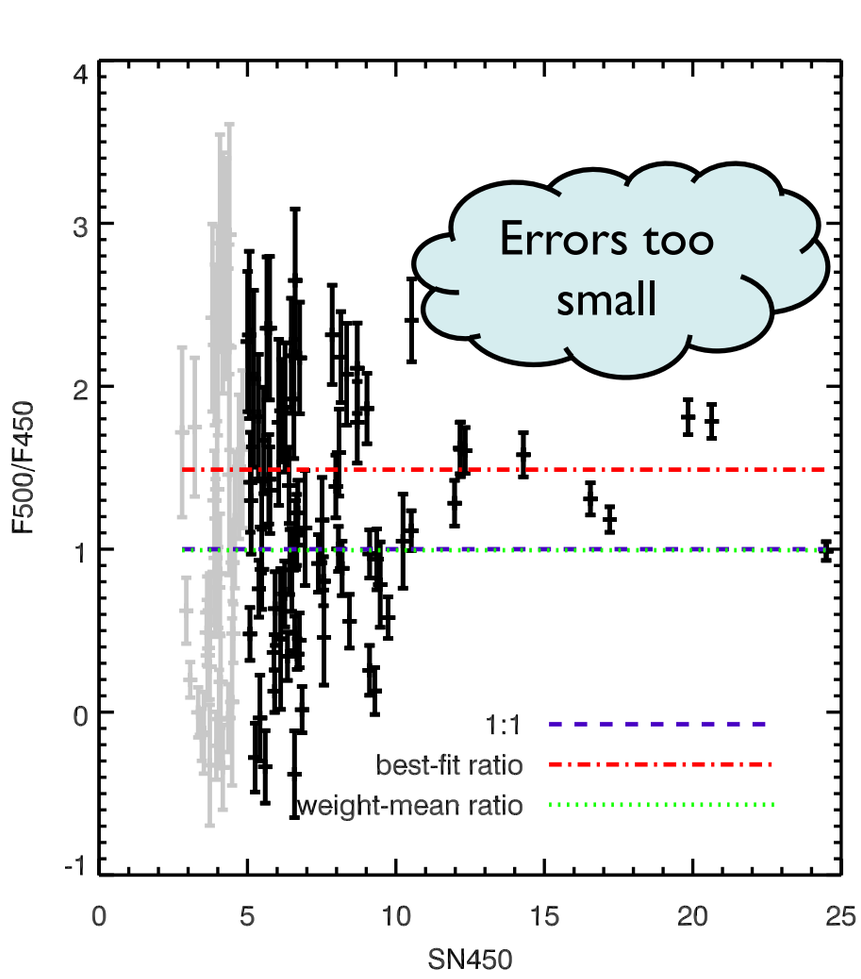
- Priors should be chosen carefully…
  - ➢ To represent all sources in the map
  - ➢ To correctly parameterize the model

Example: comparing T-PHOT fits of 450 and 500μm maps with same prior lists:

450 μm selected priors







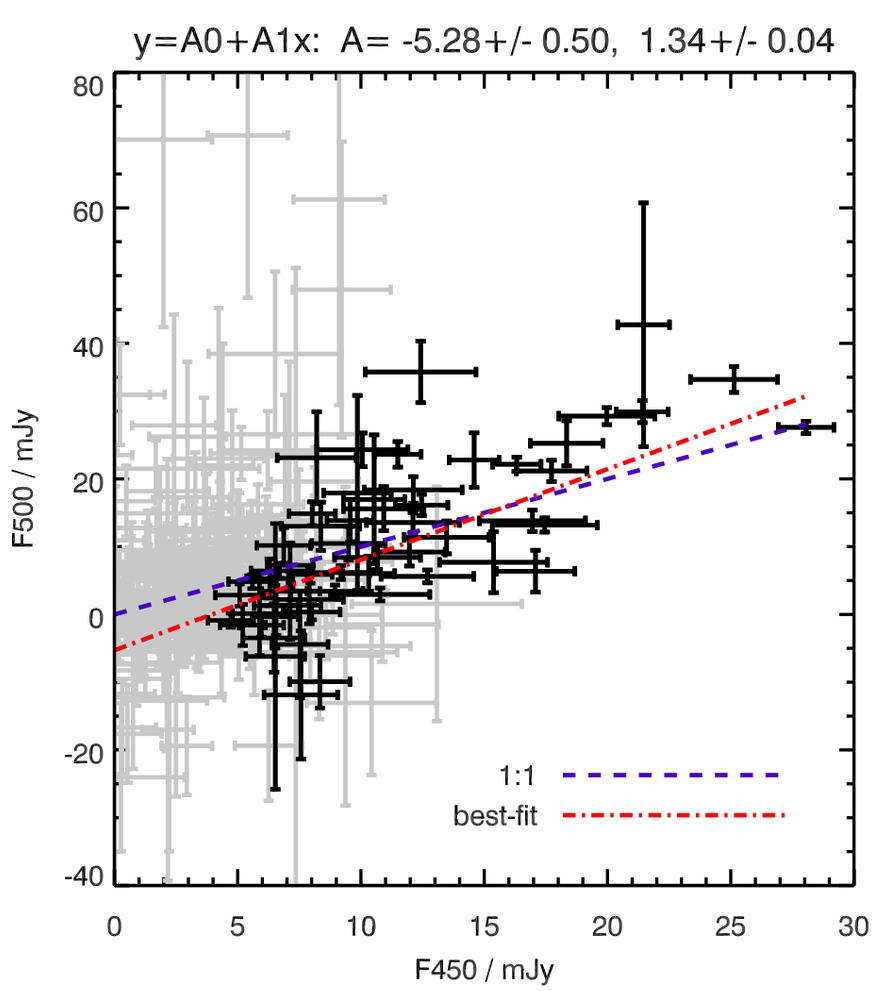
Insufficient prior list: Confusion with "background" sources

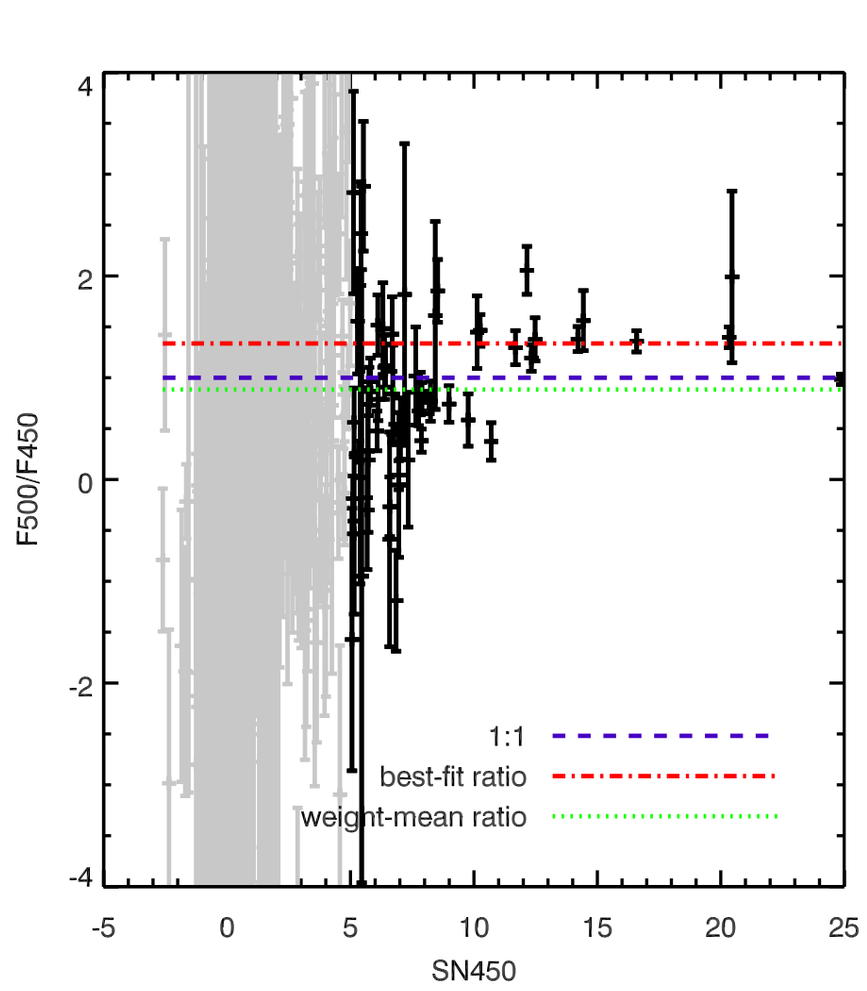
Selection of priors

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Example: comparing T-PHOT fits of 450 and 500μm maps with same prior lists:

24+850 μm selected priors





Error bars more consistent with scatter; fewer outliers

Selection of priors

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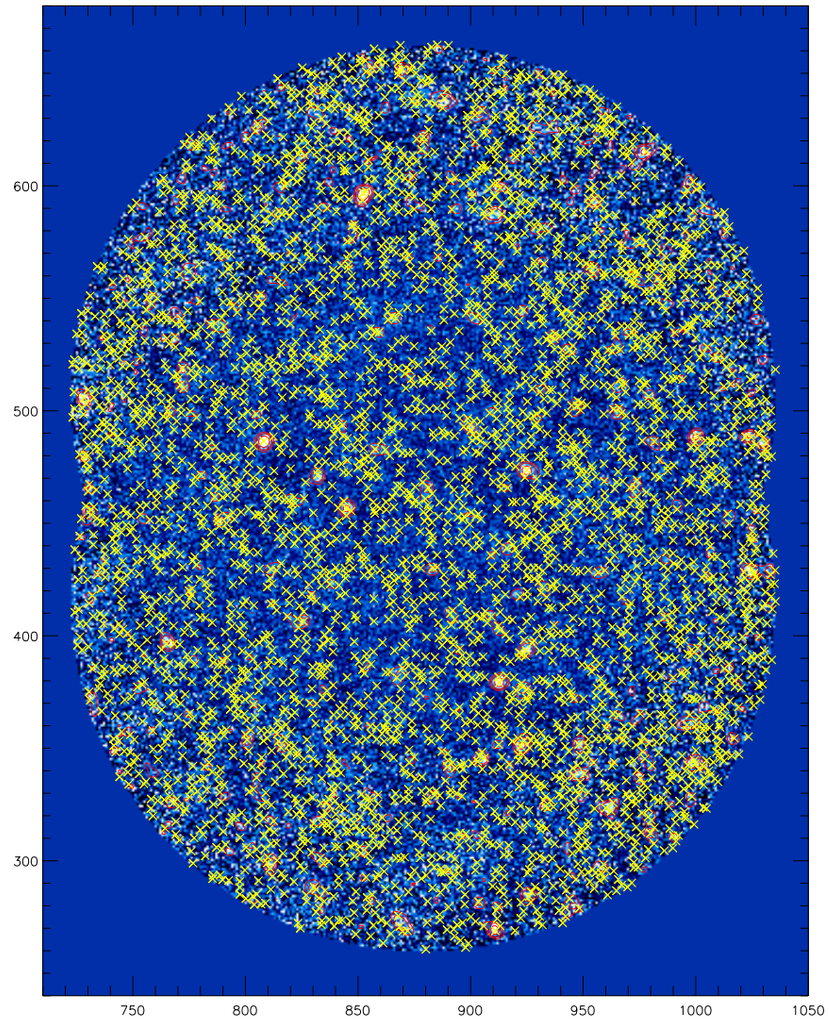
Insufficient priors lead to systematic errors and residual confusion noise

Too many priors leads to degeneracy in the models

Selection of priors

- 450μm map: 7.5 arcsec resolution
- Prior list: 3D-HST photometric catalogue including photo-z and SED-fitting results (Skelton+14):

  [K<24 or IRAC1<24]
  +USE flag
  +logM>9
- Magnitude cuts chosen to obtain good completeness of sample
- Stellar mass cut to reduce crowding at low-z
- But how to model a confused map with very dense priors?

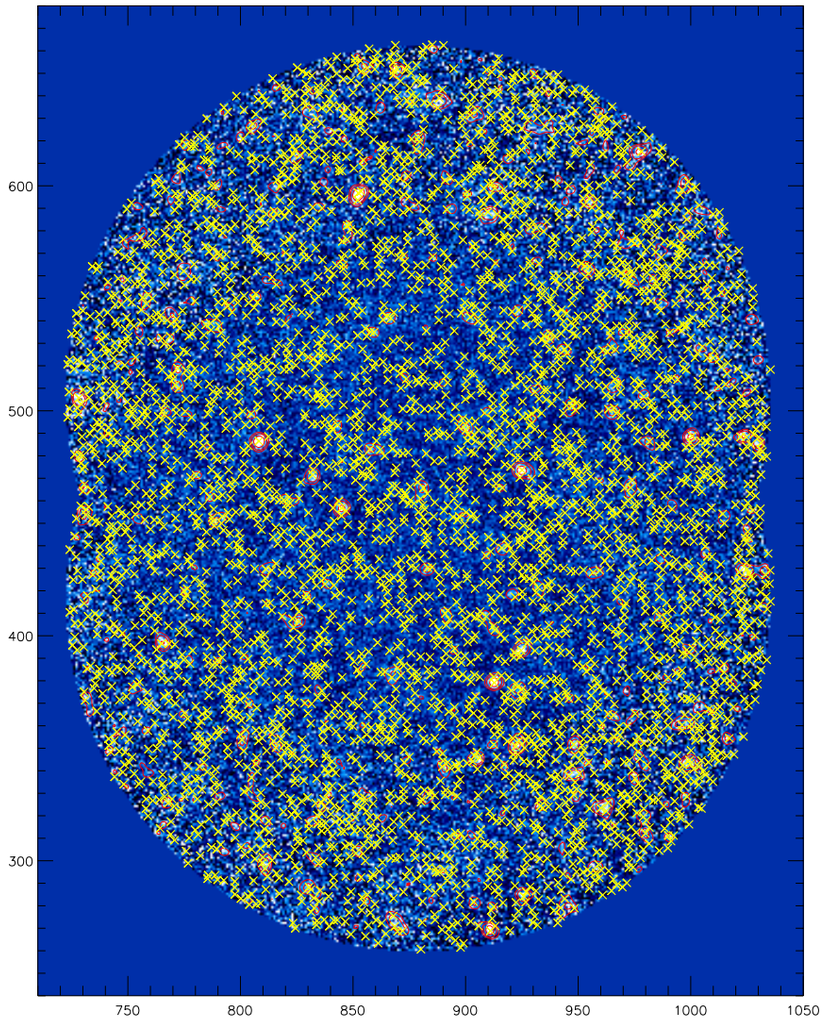


Denser priors, Deeper deconfusion…

- Want to model as many sources as possible
- Number of objects in the model is limited by the number of independent beams in the map:

$$N_{dof} < N_{data}$$

- Anything we can't model becomes part of the background and is assumed to be uncorrelated
- We can model more objects by splitting the prior list into uncorrelated slices and fitting each independently to the image

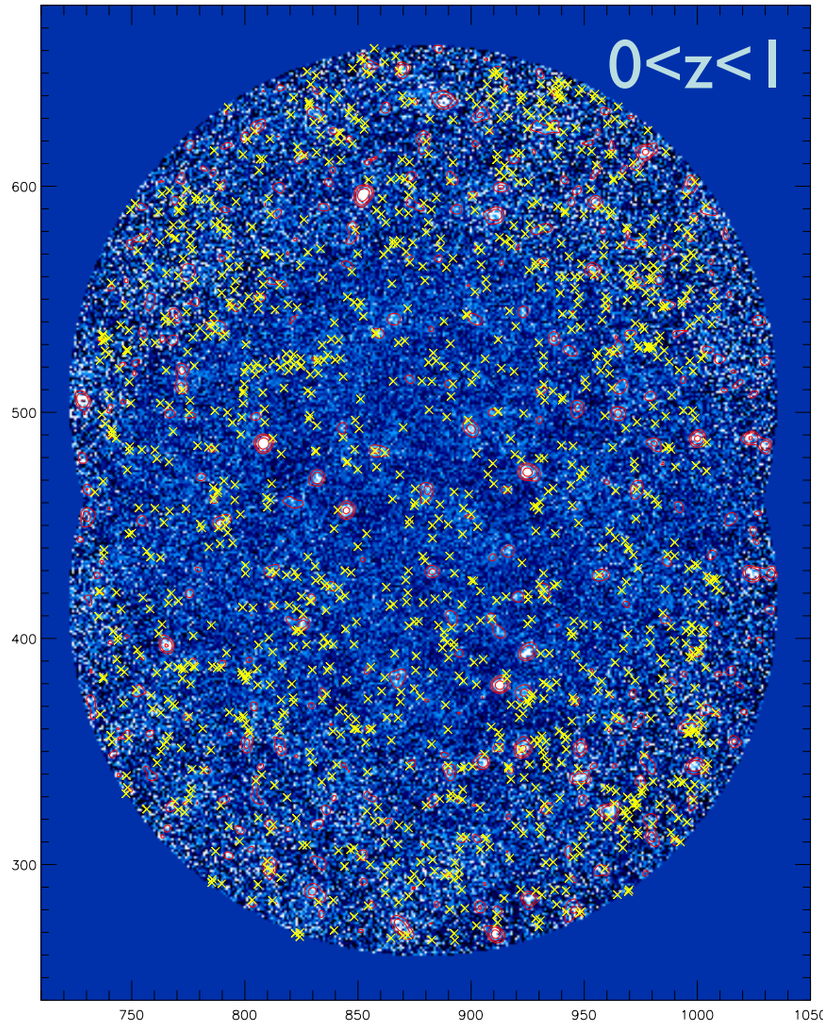


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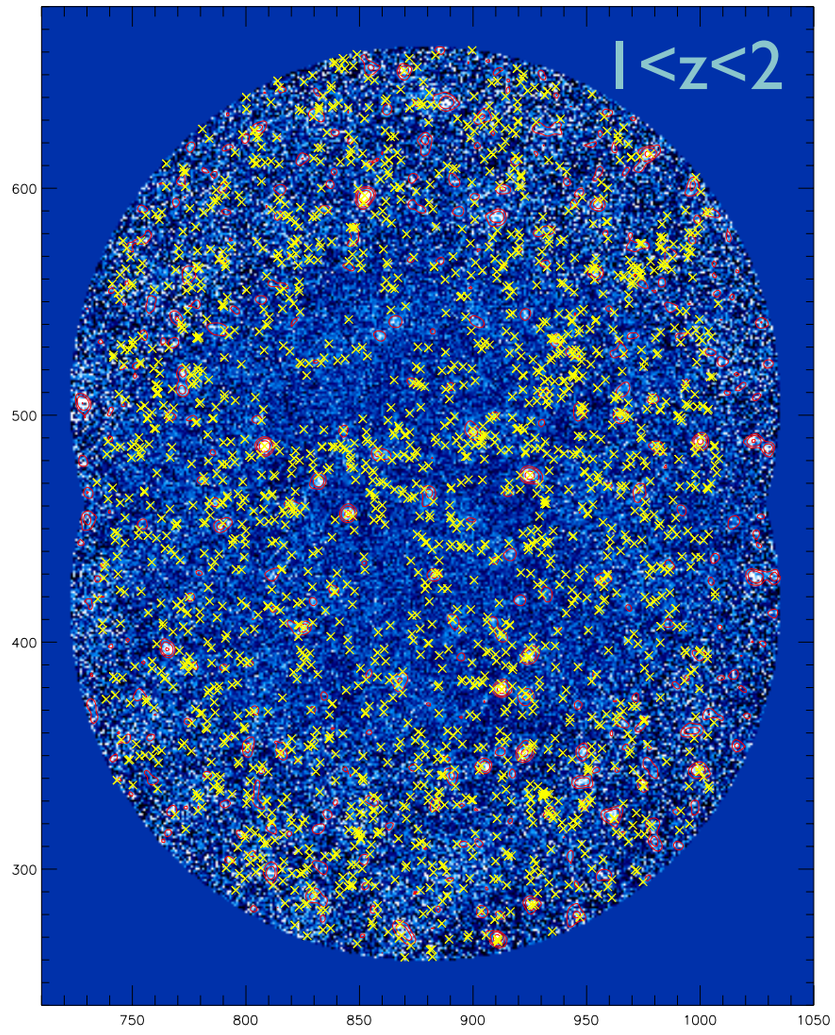


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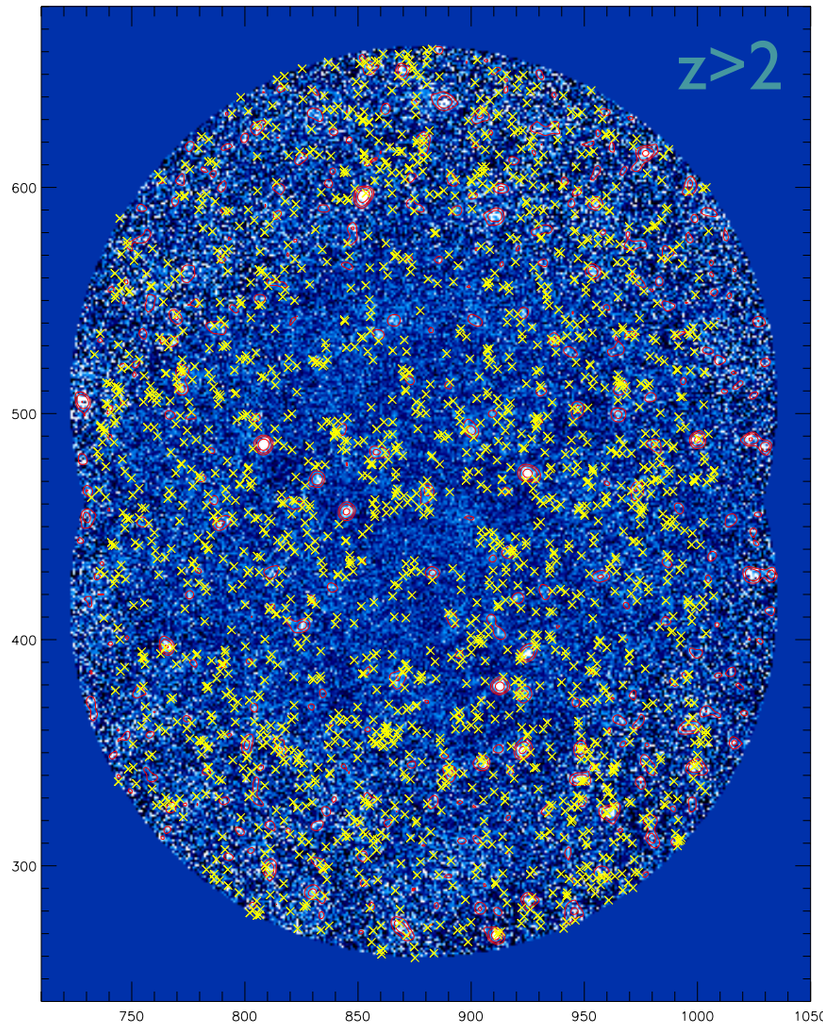


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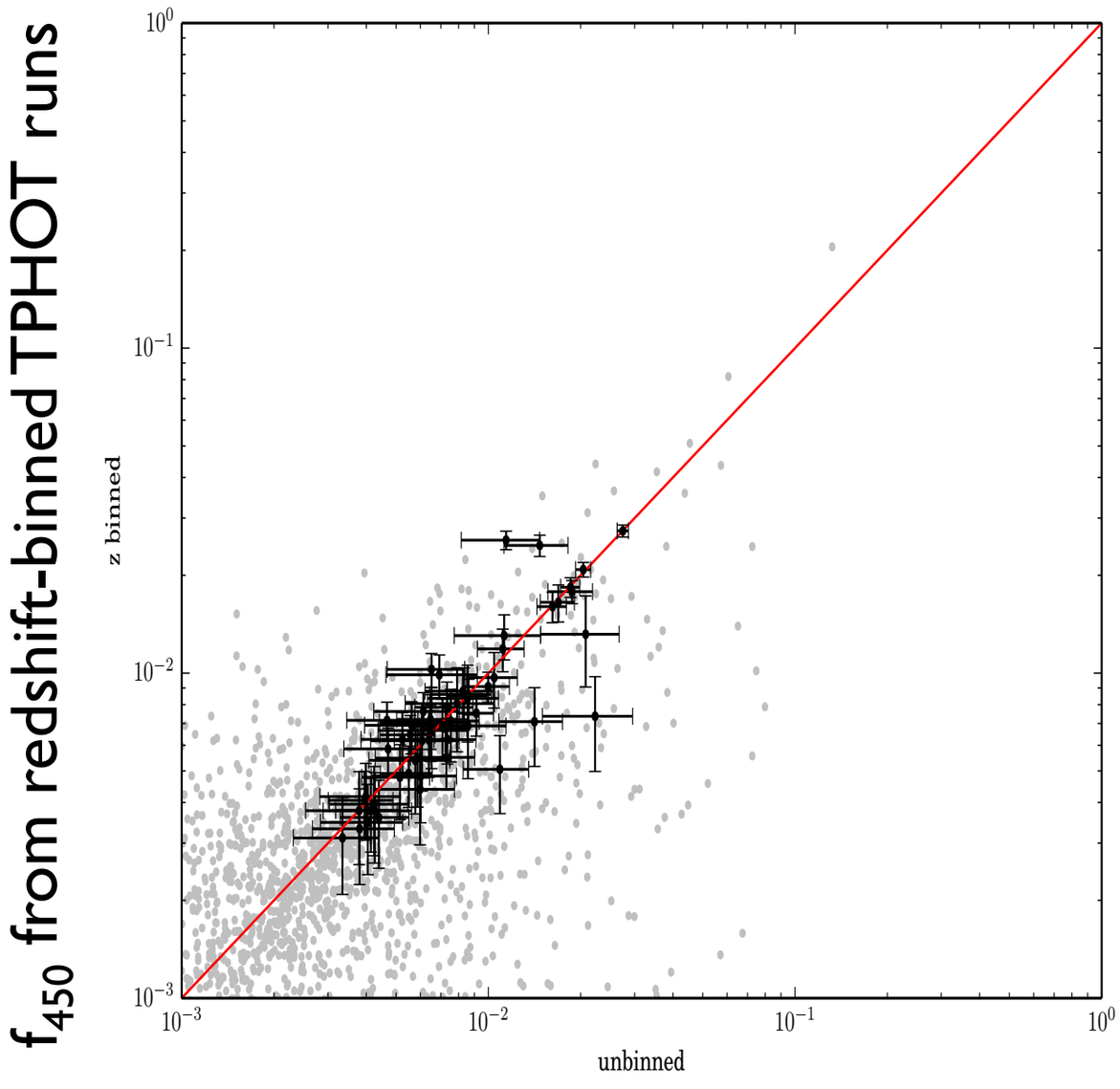
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Denser priors, Deeper deconfusion…

- Individual fluxes can be biased by blending with objects in different redshift bins
- Assuming no correlations between objects in different bins, average (stacked) fluxes within a bin will be accurate
- c.f. SIMSTACK, Viero et al. 2013.

To obtain average fluxes in bins we are simply taking the cross-correlation between each bin and the map



- General procedure for fitting prior-based models in submm maps:

I. Selection of priors

II. Preparing inputs

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IV. Background estimation

- A few science results

TPHOT Inputs

- Select the prior catalogue
- Low-resolution images and RMS maps:
  - No PSF-filtering
  - Subtract large-scale variations in the background
  - Mask LRI to match coverage of prior catalogue
- TPHOT parameter files:
  - Fit whole image as Single Cell (mode=single)
  - Include single-valued background as a free parameter (fit_background=true)
  - No clipping of priors (clip=false)

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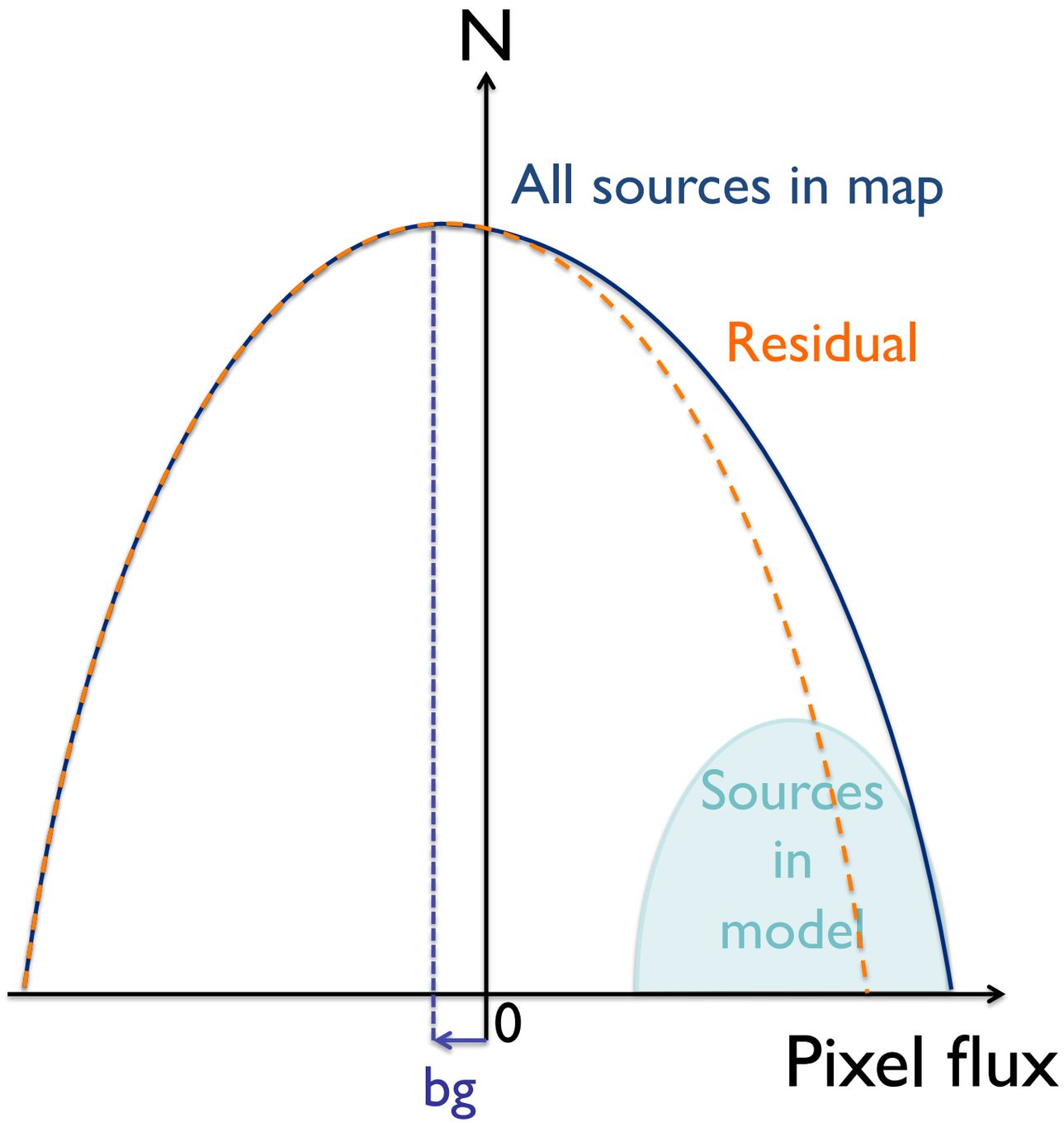
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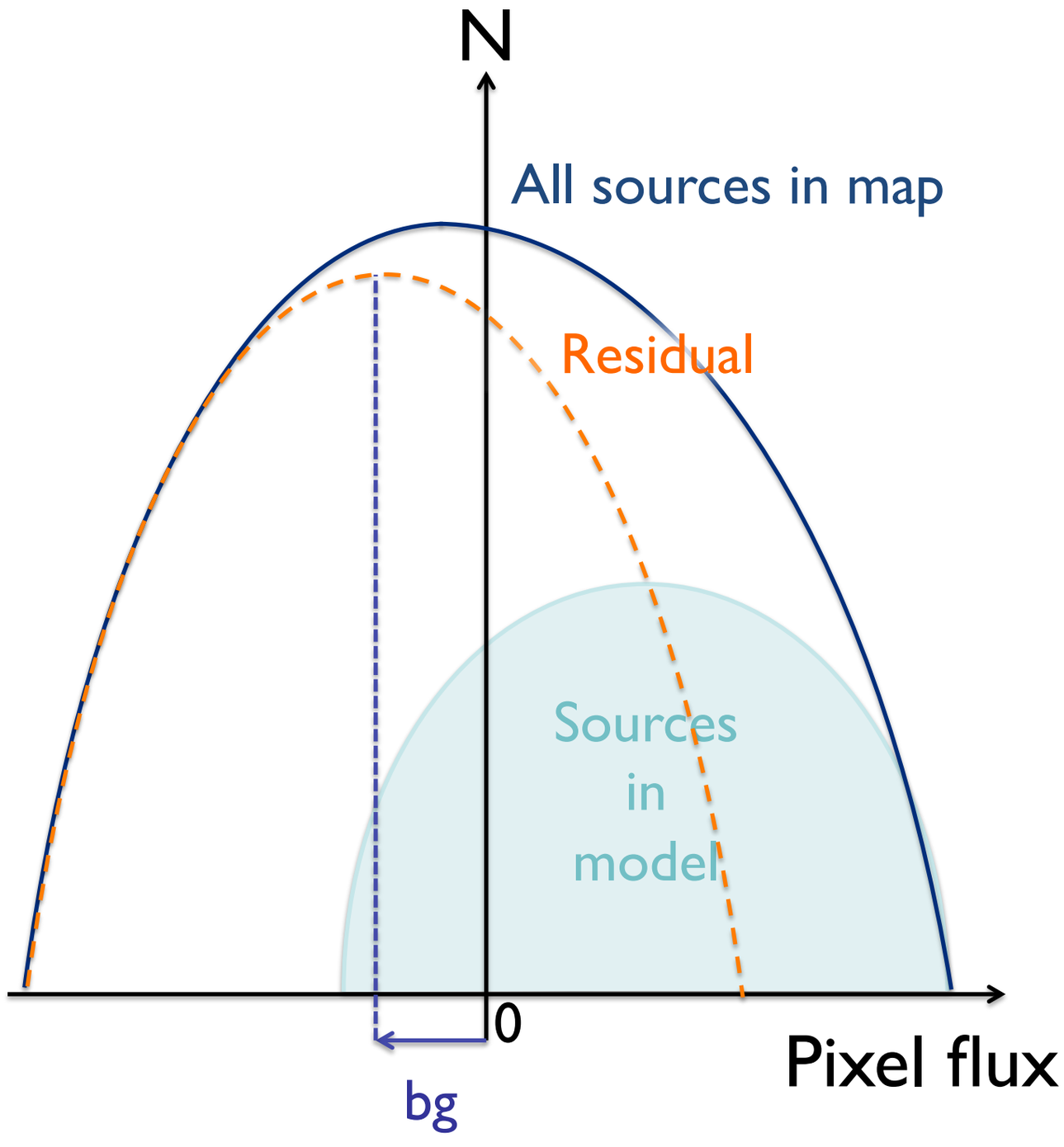
Background subtraction

- Submm images have an arbitrary background offset
- This depends on the properties of the image and the catalogue we want to extract
- Image is made up of a population of sources: those we do not model make up the background
- TPHOT fits background as another free parameter within the model
- Is this sufficiently accurate for us to measure unbiased properties of faint sources?

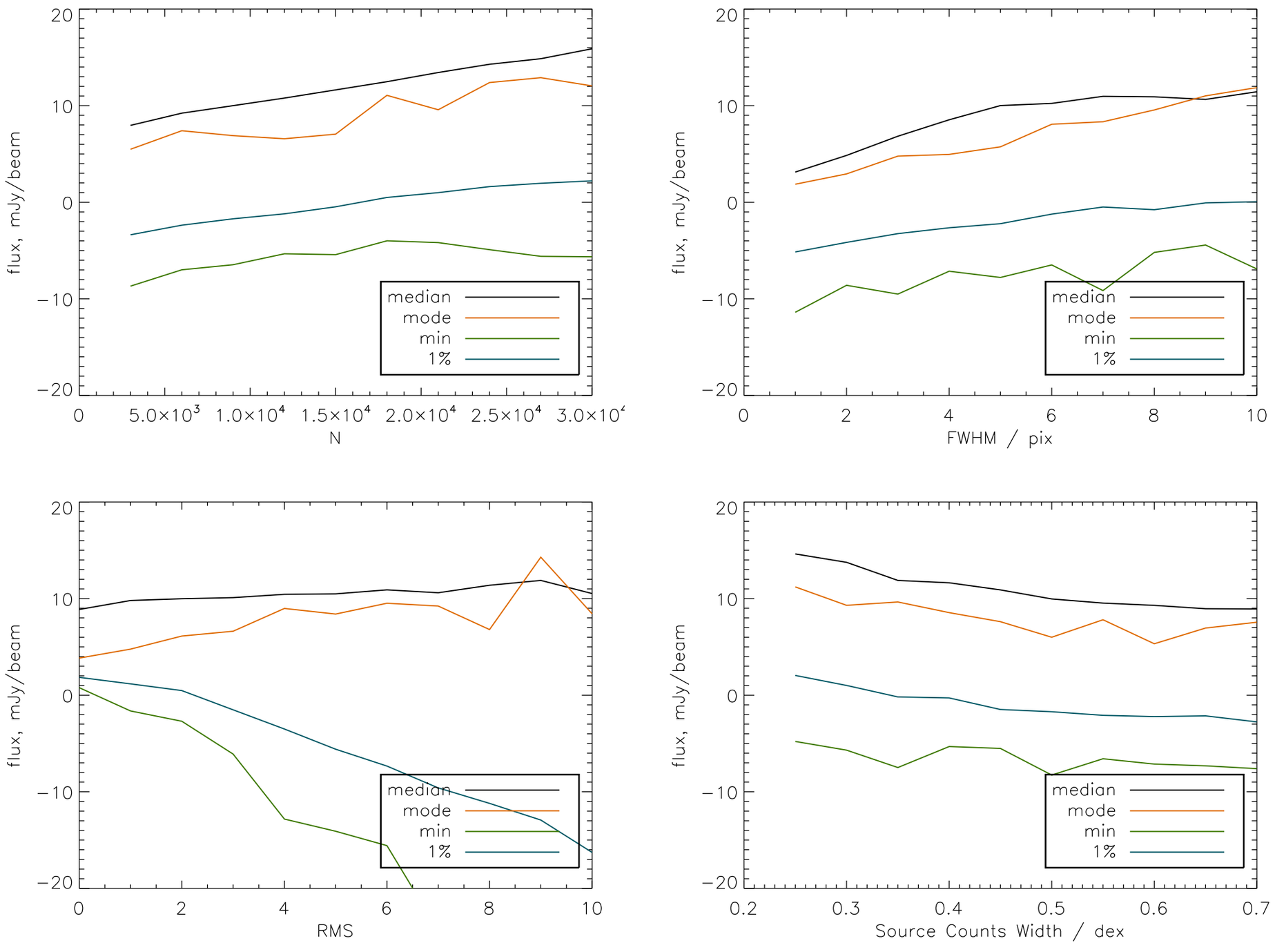
Background subtraction



Background subtraction

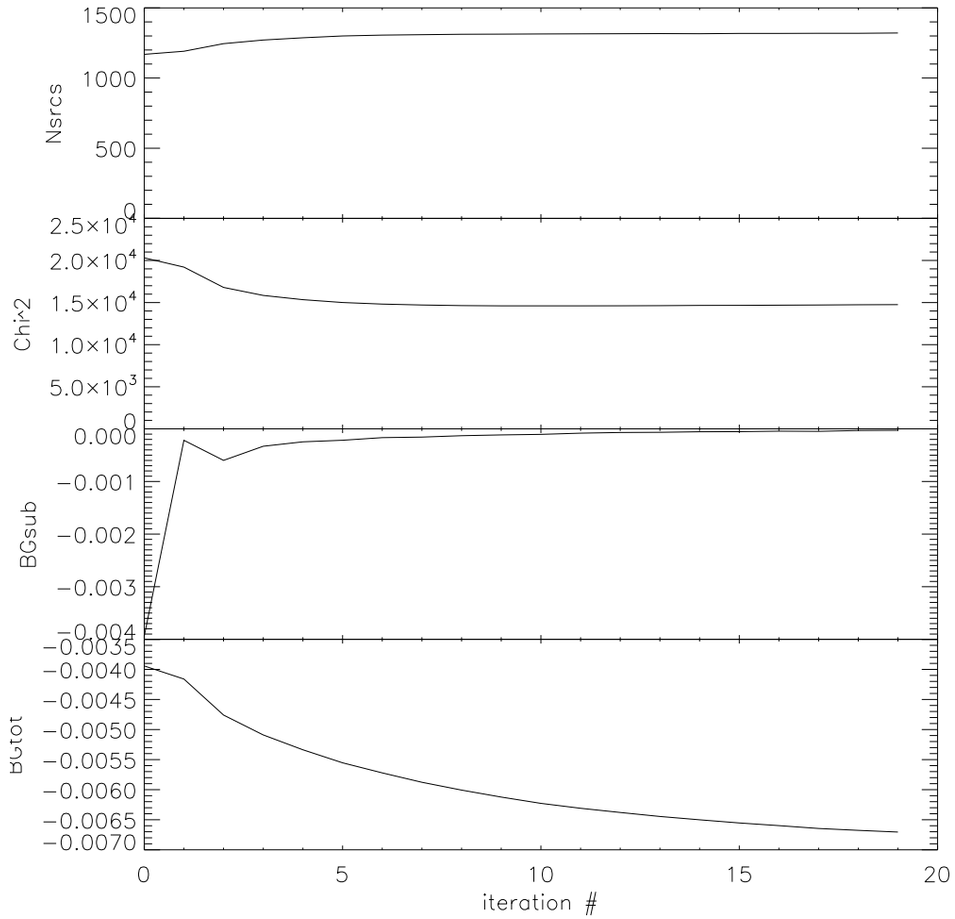


Statistics of a zero-background map



Background subtraction

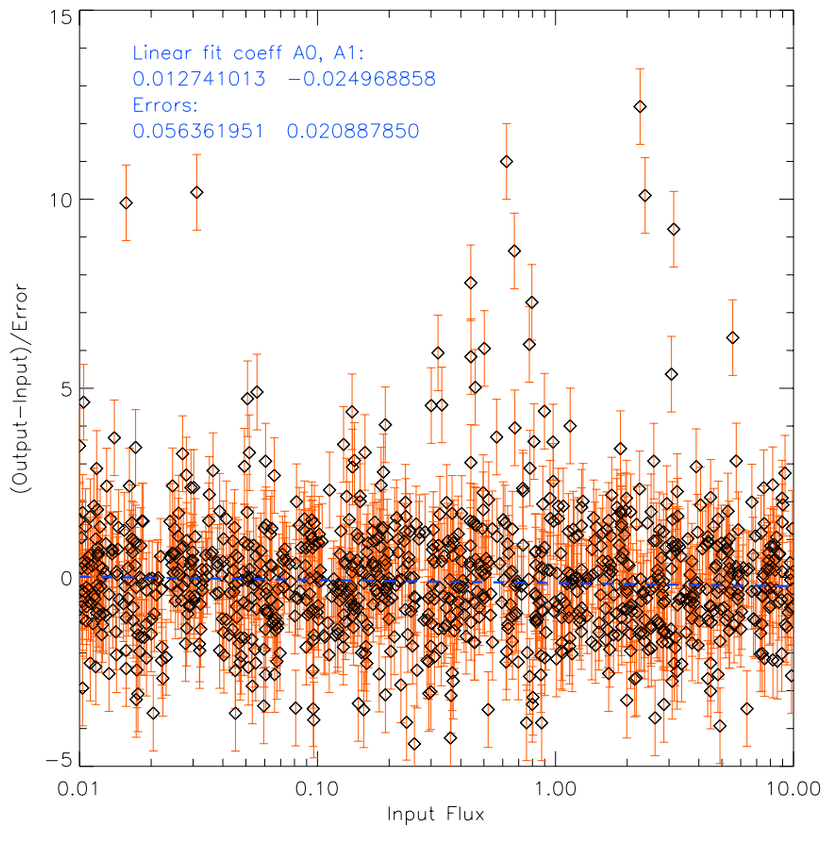
- 1st Test: compare against alternative method
- E.g. Iterative method:
  - Measure BG = peak (mode) of pixel histogram in raw map
  - Subtract BG from map
  - Run TPHOT with BG=0 *fixed*
  - Create residual (LRI – model)
  - Measure BG = peak of pixel histogram in residual

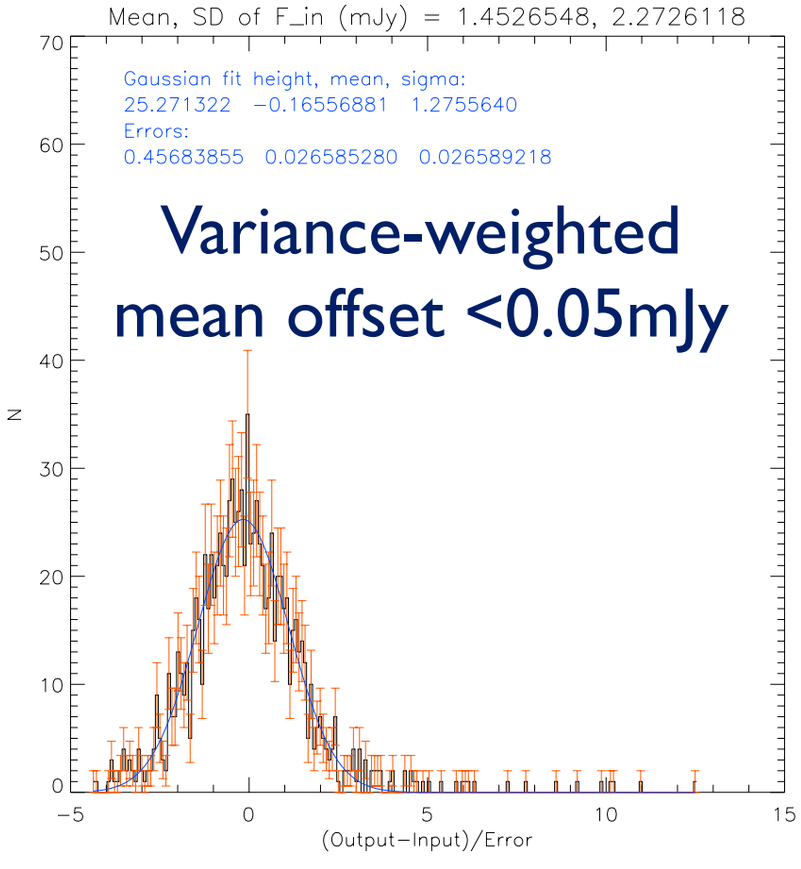


- This BG agrees with the TPHOT fit within a tolerance of 0.1mJy

Background subtraction

- 2nd test: Source injection simulation:
  - Add simulated point source to a real map at a random position
  - Fit the resulting map with TPHOT, including the simulated position along with the usual prior list
- Repeat over 1000 realizations and measure (output – input) flux offsets





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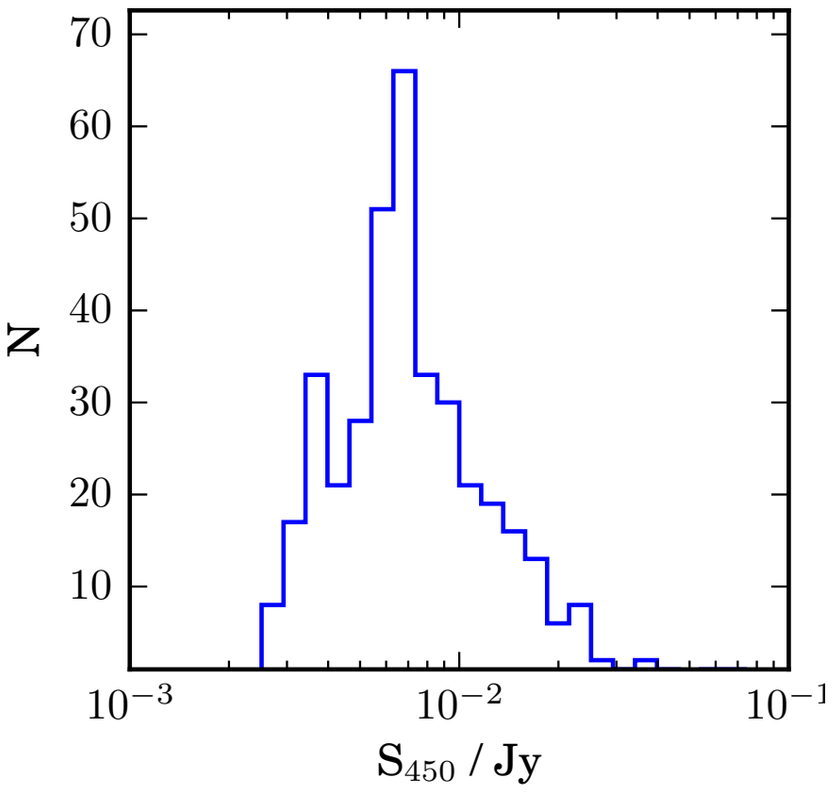
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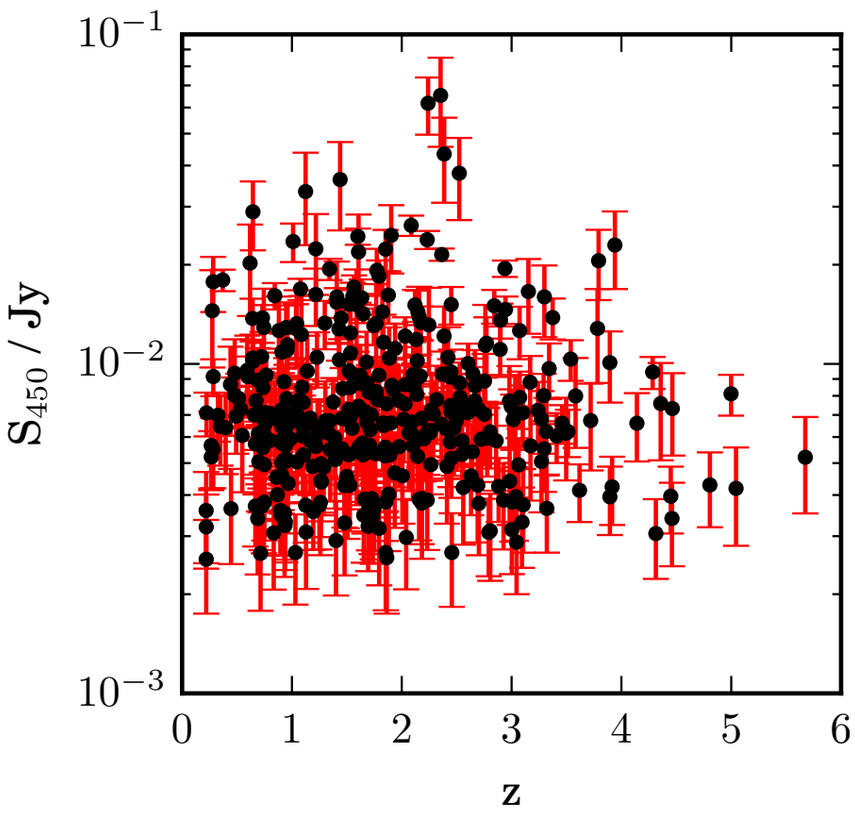
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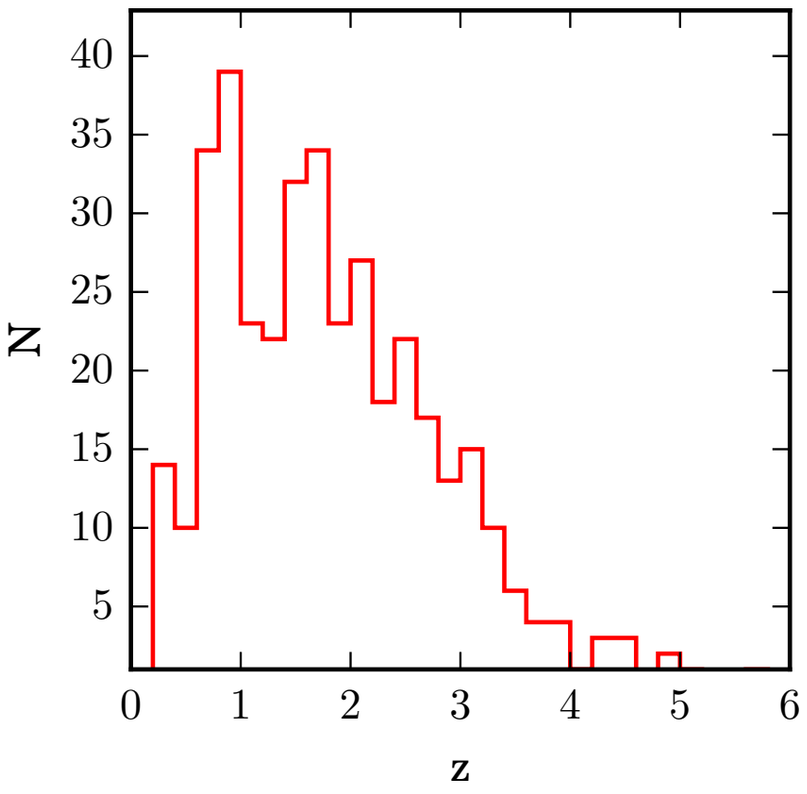
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Results

- Use TPHOT to measure 450um fluxes of galaxies from CANDELS survey over a range of redshifts (0<z<6) as a function of stellar mass and UV luminosity
- TPHOT detects similar numbers of sources as a standard blind source-extraction technique, with consistent results

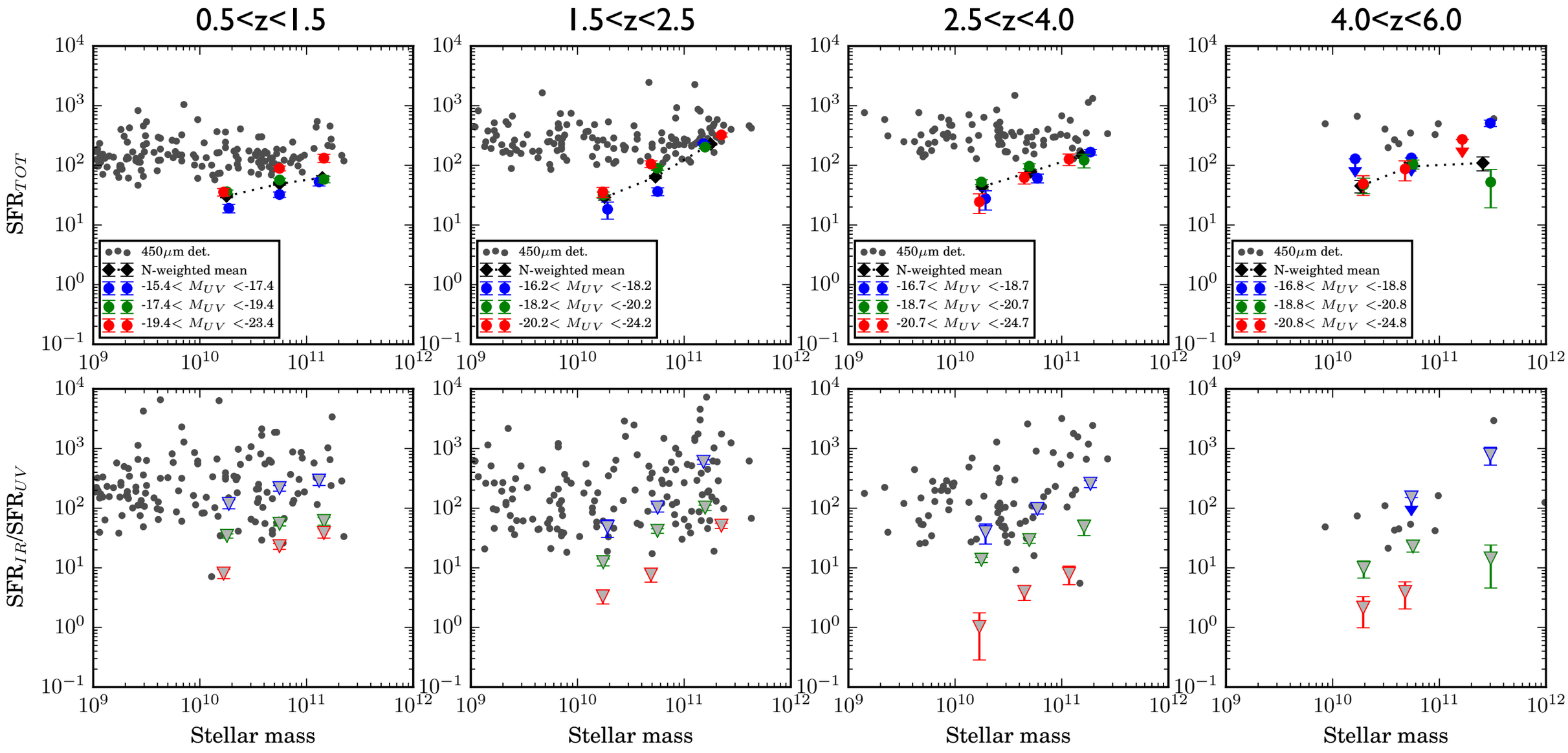




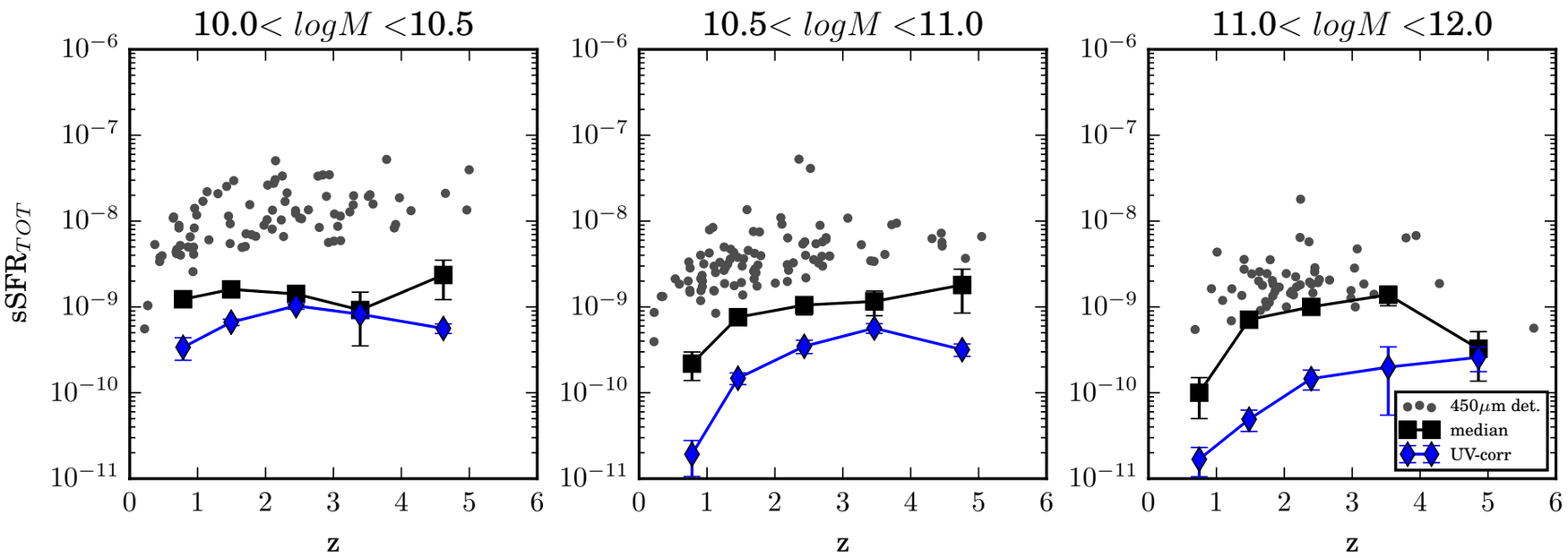


Results

- Stacked fluxes → LIR → obscured SFR(M_{st}, M_{UV})
- SFR correlated with mass but not M_{UV}
- M_{UV} depends on obscuration (IR/UV)



Results

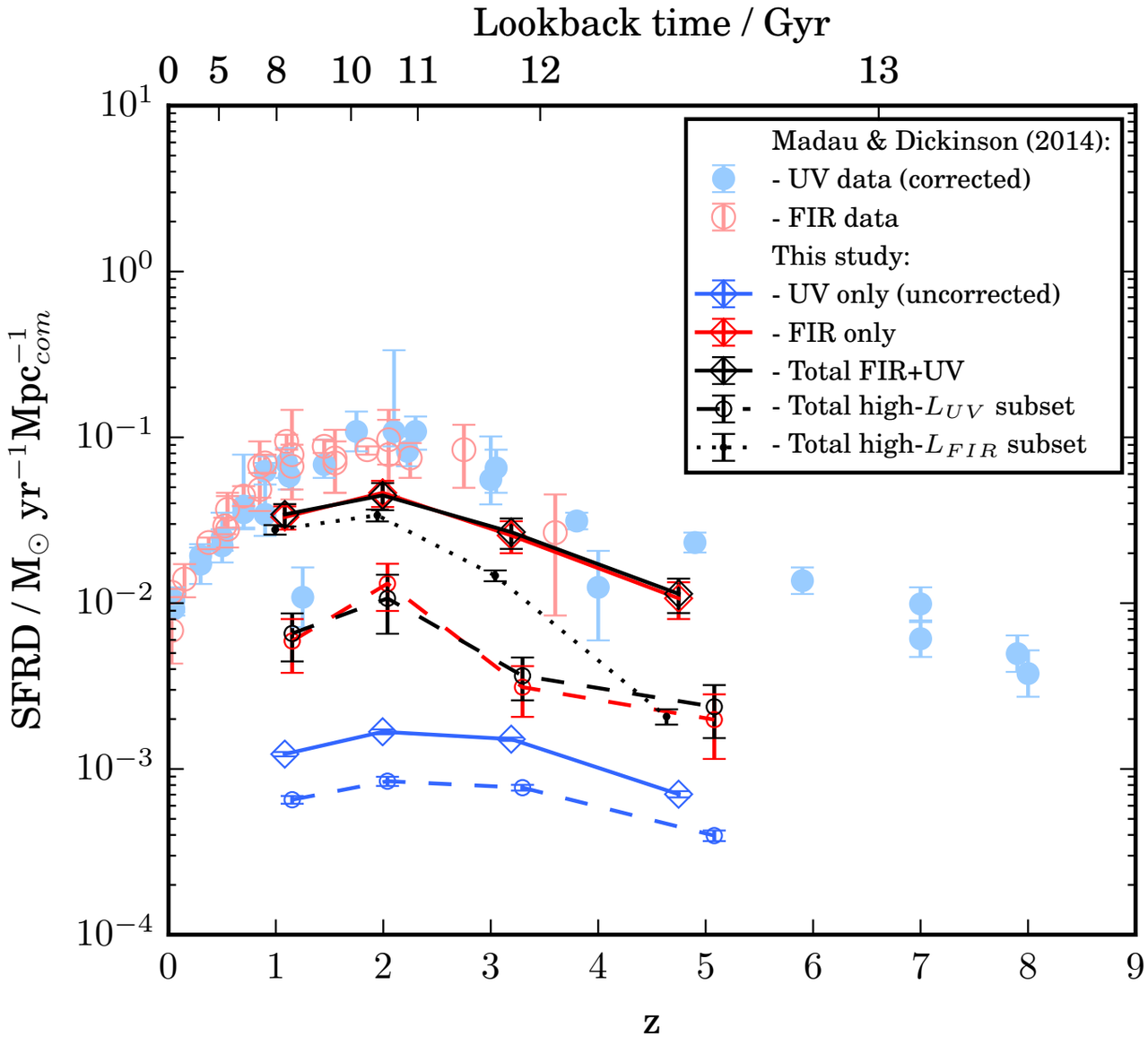


- SSFR(z,M):
  - Gradual increase with redshift
  - Fairly constant with mass except at z<1 (massive galaxies become passive)
  - Poor agreement with dust-corrected UV - need further investigation of IR/UV vs UV slope…

Results

SFRD(z):

- logM>10 (complete sample)
- Dominated by obscured SFR
- FIR detections account for significant fraction at z<3
- UV-luminous (M_{UV}<M*) galaxies account for small but similar fraction at all z
- Trend as f(z) traces existing literature data, but lower normalization
  - Due to mass limit?
  - Cosmic variance?



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The end!