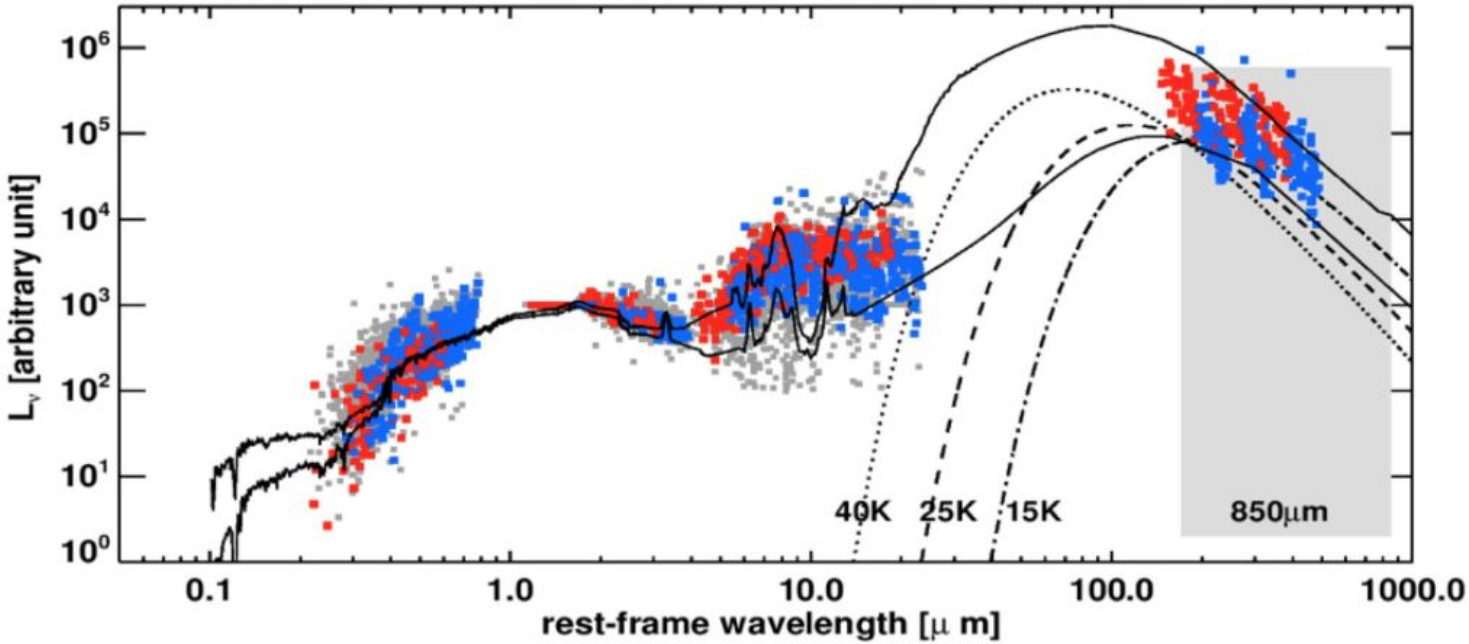
NEPSC2: SCUBA-2 850μm Survey in the North Ecliptic Pole

SSG 2020

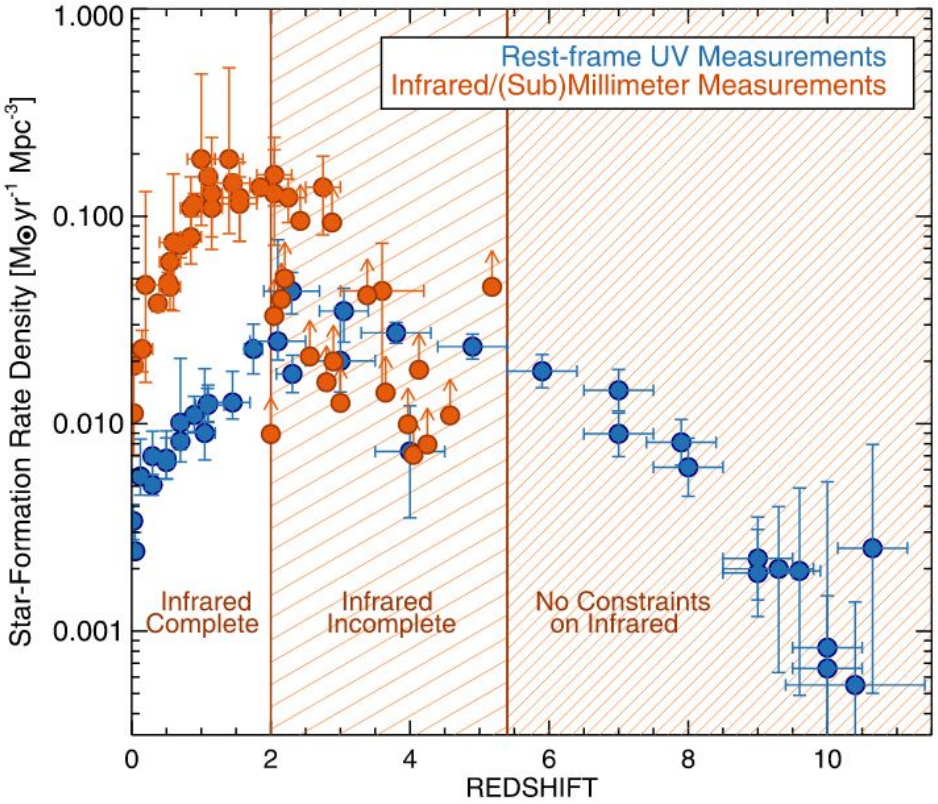
Hyunjin Shim (KNU) on behalf of the NEP team

Need for IR/submm wavelength



FIR/submm observation gives constraints to total dust luminosity and hidden star formation rates; Thanks to the negative K-correction, > 500 μm observation can sample z > 1 bright dusty galaxies (SMGs; DSFGs).

Need for IR/submm wavelength



Casey et al.(2018)

Our understanding on the “dusty” star formation is still limited - large incompleteness at z > 2, and even no constraints for the very early galaxies.

requesting on the large IR/(sub) mm surveys on numerous cosmological deep fields

Existing FIR deep surveys

+ (multi-wavelength) datasets

Why do you need so many “deep fields”? What is unique/special about your proposed field?

low cirrus, deepest, widest, has high spatial resolution optical/NIR images, can be reached by ALMA, ...

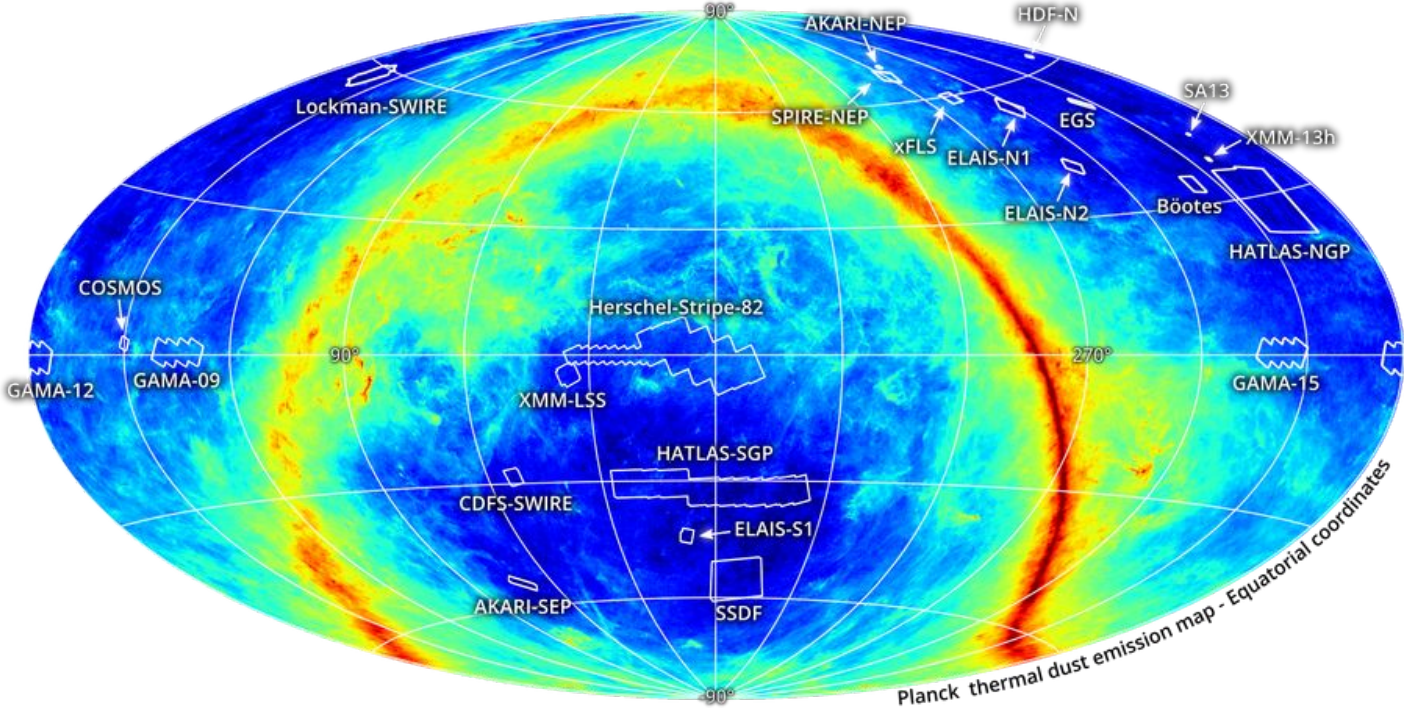
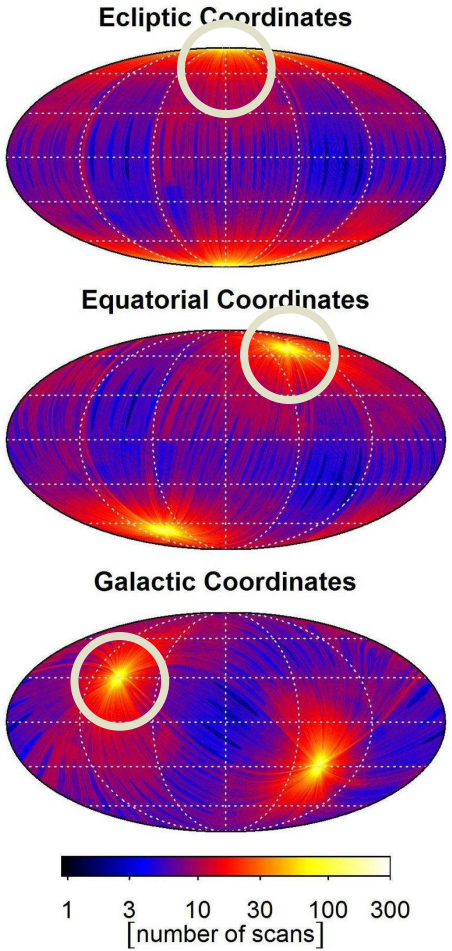


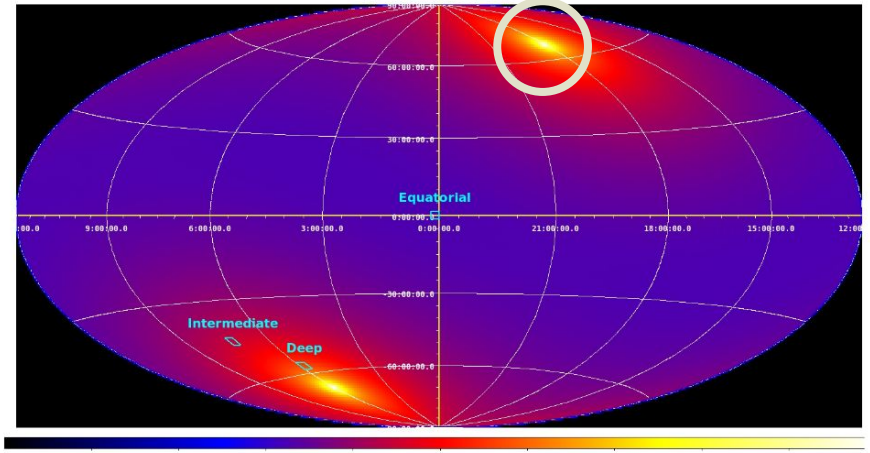
Figure from the Herschel Legacy Project (HELP)

Ecliptic Poles :

High visibility for space-based telescopes on the sun-synchronous polar orbit



Doi et al.(2015) AKARI FIR all-sky maps

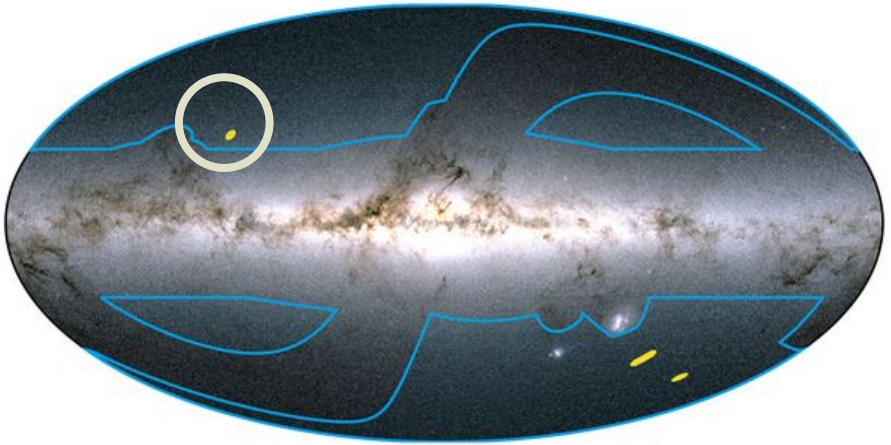


Clerc et al.(2018) eROSITA simulations

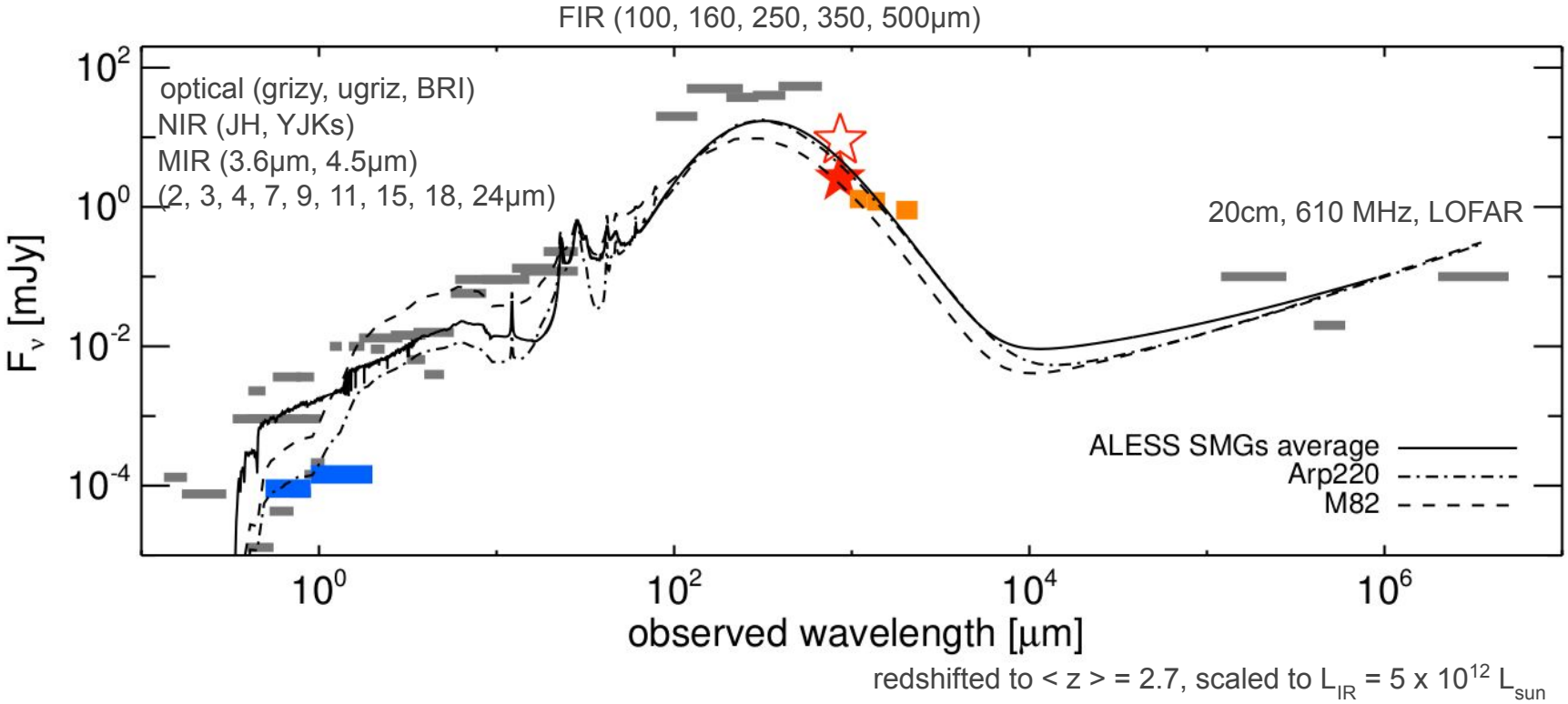
X-ray, 3 times deeper than all sky survey

THE EUCLID WIDE AND DEEP SURVEYS

imaging + spectroscopy 0.9-2µm

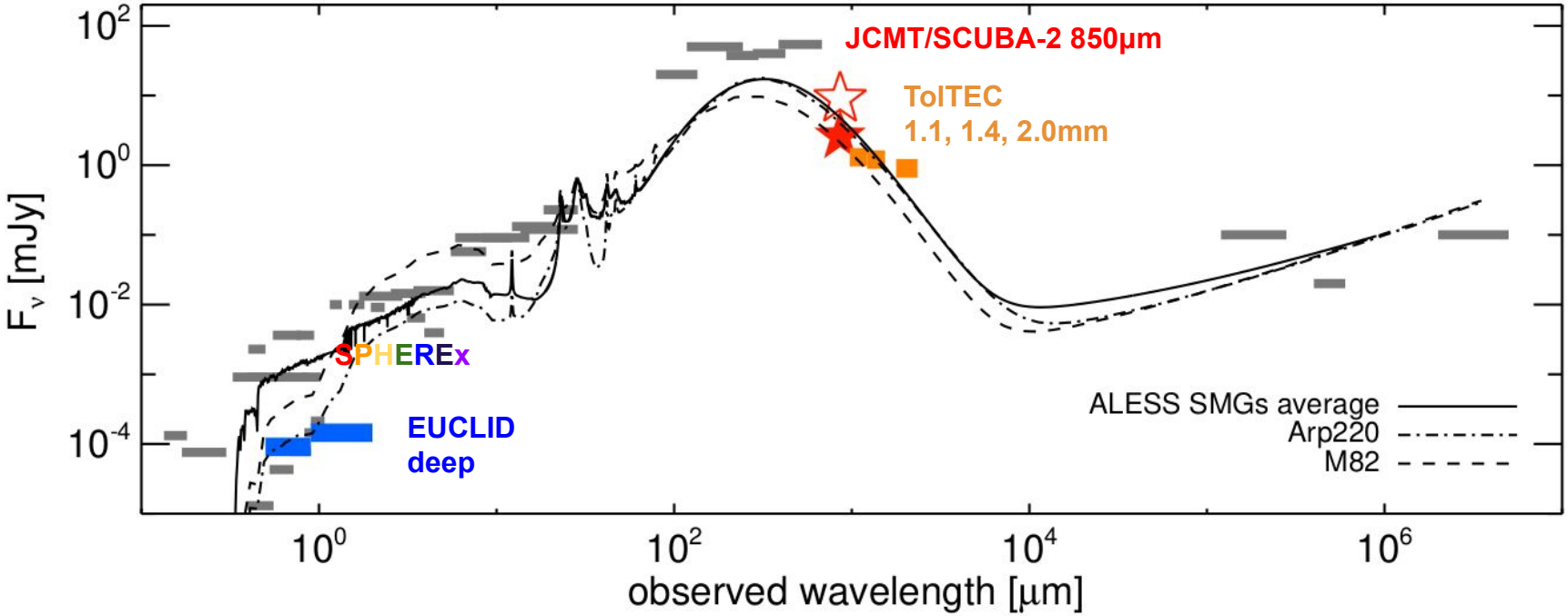


North Ecliptic Pole region



Existing FIR data are too shallow to study MIR-selected galaxies - initial motivation, but …

North Ecliptic Pole region



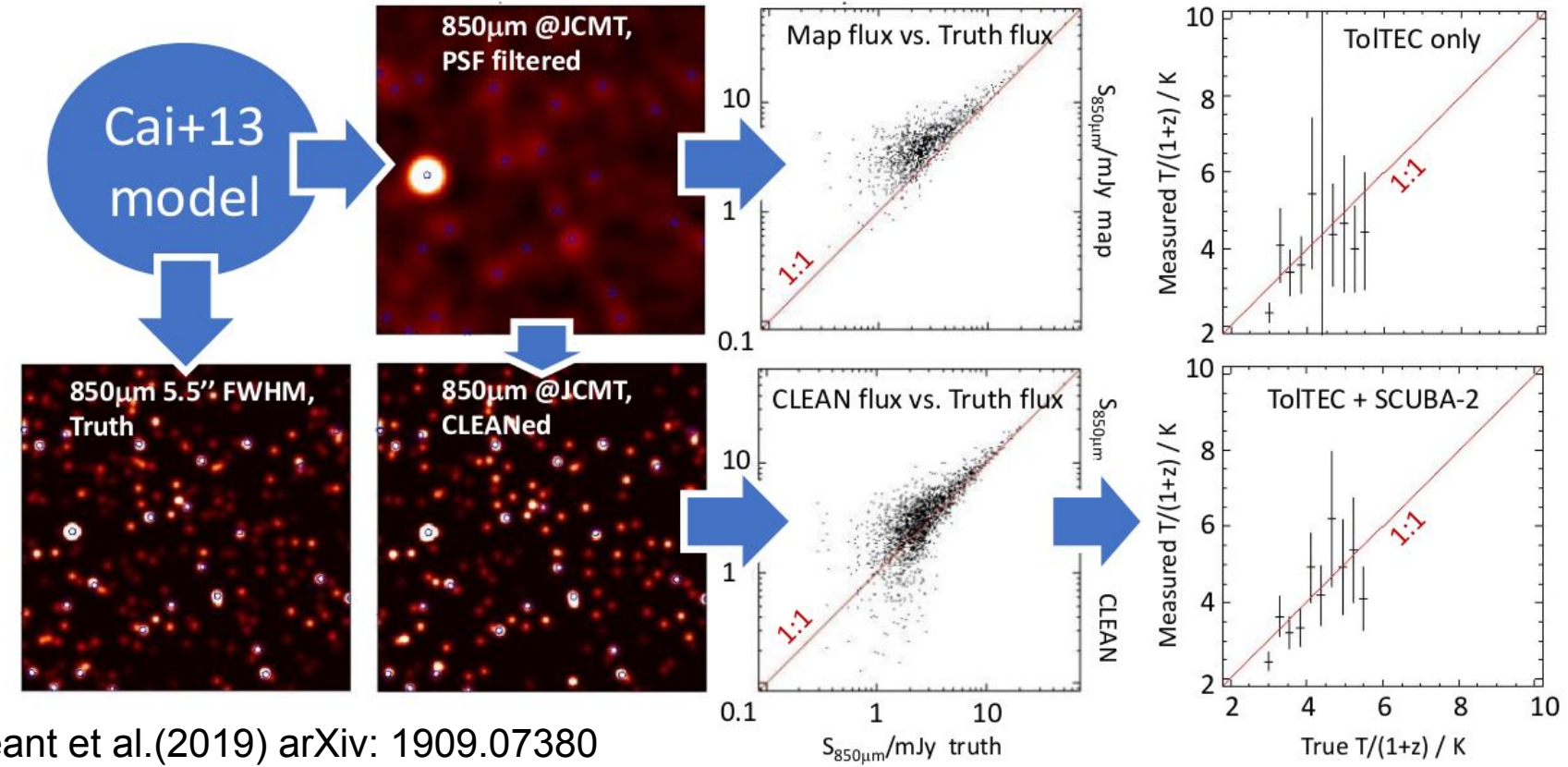
… there are upcoming surveys. Wouldn't it be nice to prepare these in this wavelength?

North Ecliptic Pole region

	JCMT/SCUBA-2	LMT/TolTEC (expected) (start observation soon?)
wavelength	450 μm, 850 μm	1.1mm, 1.4mm, 2.0mm
beamsize (FWHM)	7.9 arcsec, 13 arcsec	5 arcsec, 6.3 arcsec, 9.5 arcsec
mapping speed to reach 1 mJy rms, 1 deg^2	~ 200 hrs (850 μm)	< 1 hr (1.1 mm)

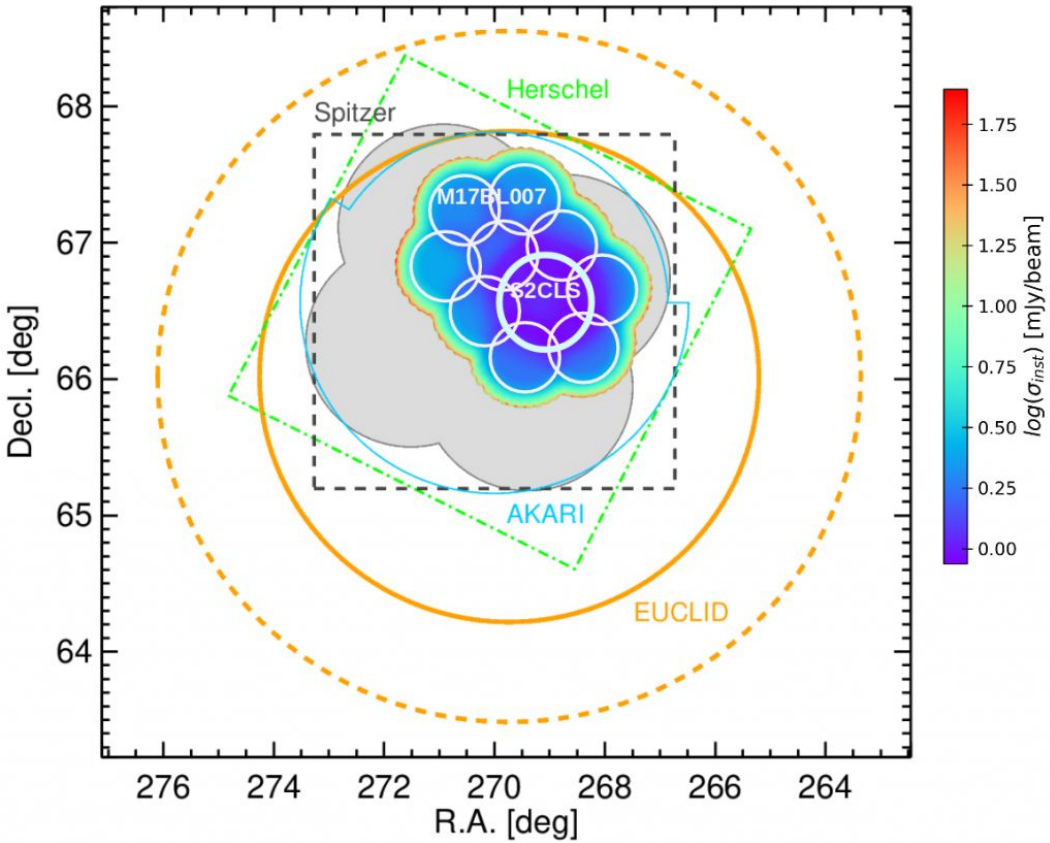
surveys	S2CLS completed (~5 deg^2, ~1.2 mJy rms)	large scale surveys (~4-60 deg^2, ~0.2 mJy rms)	ECDFS XMM COSMOS NEP Bootes
if finished...	S2COSMOS (2deg^2, 1 mJy) S2LXS (3deg^2, 2 mJy) NEP (4deg^2, 2.2 mJy)	ultra-deep survey (~0.8 deg^2, ~0.02 mJy rms)	CANDELS

The role of 850μm in combination w/ 1 mm



Serjeant et al.(2019) arXiv: 1909.07380

Survey progress until 2019 (Jan. 2020)

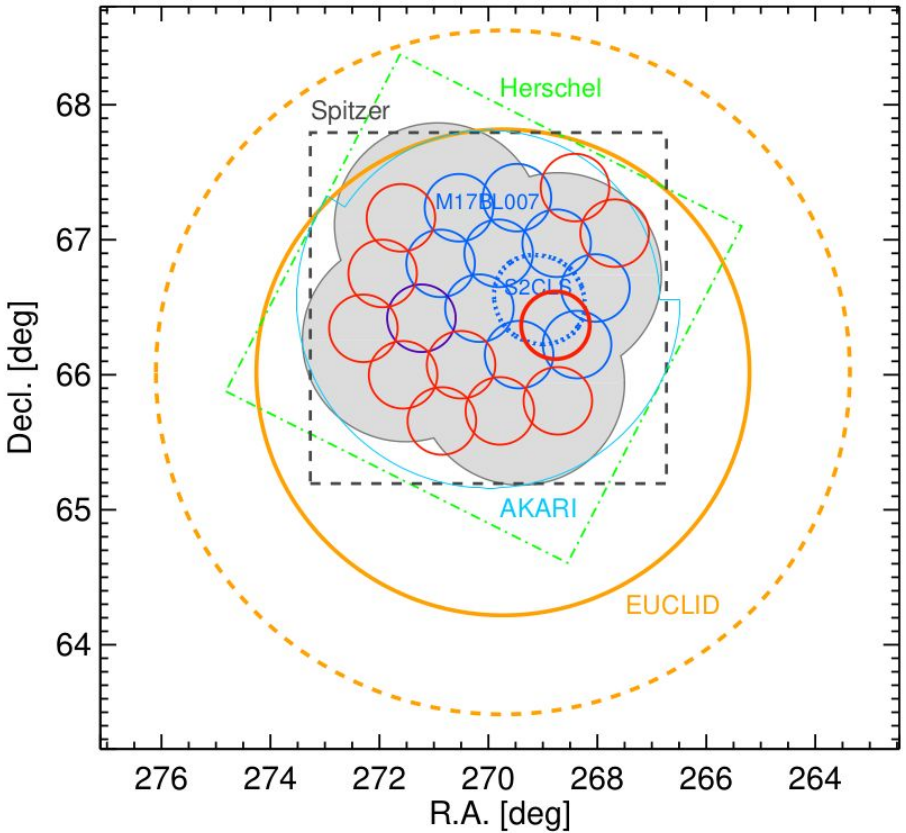


9 PONG1800 pointings are completed.

200 hrs observed (~50% complete in terms of the proposed observing time).

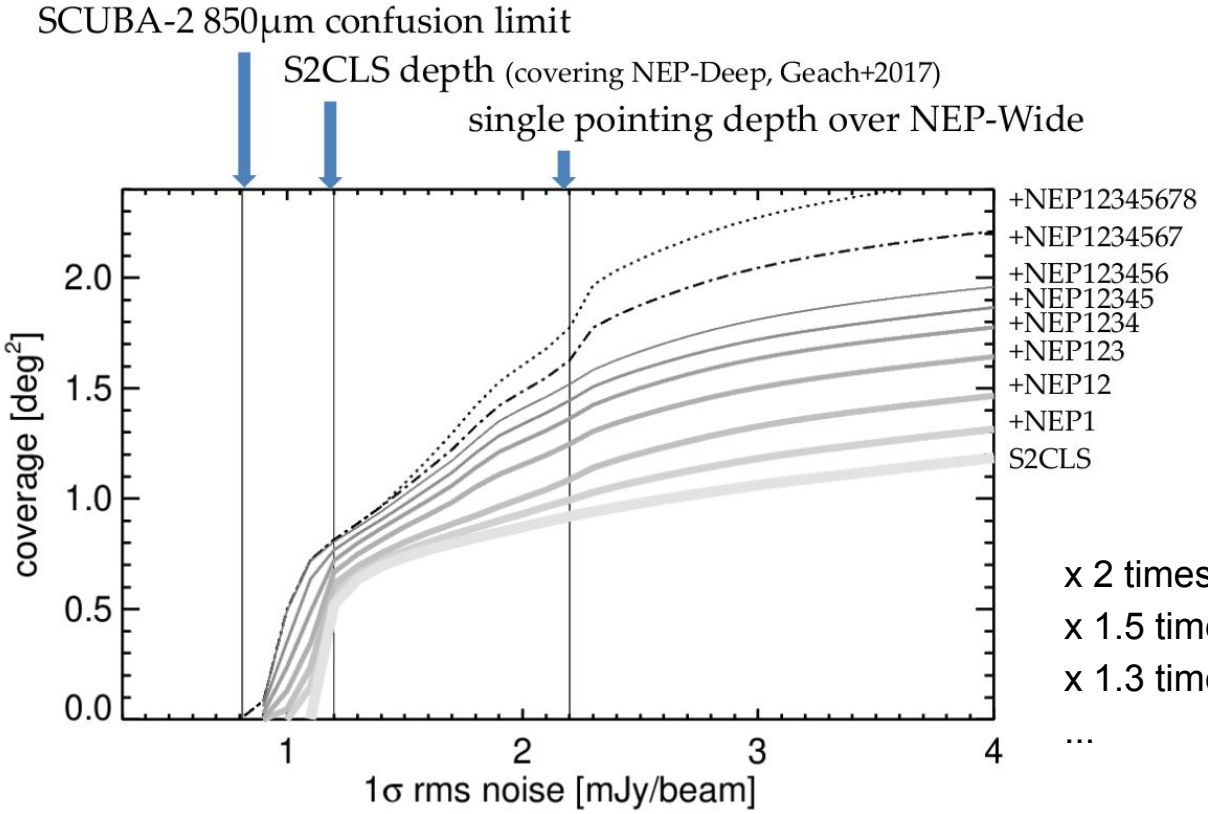
Instrumental noise of a single field ranges 1.7 - 2.2 mJy rms.

Extension approved as (new) JCMT LP



~200 hrs were to complete the previously planned survey. (though we initially asked for the survey extension to go **deeper** and wider, the deeper part was not approved. Band 3 weather only, therefore cannot expect much new science such as finding z > 5 DSFGs in combination with TolTEC.)

Survey progress until 2019 (Jan. 2020)



x 2 times wider 2.2 mJy rms

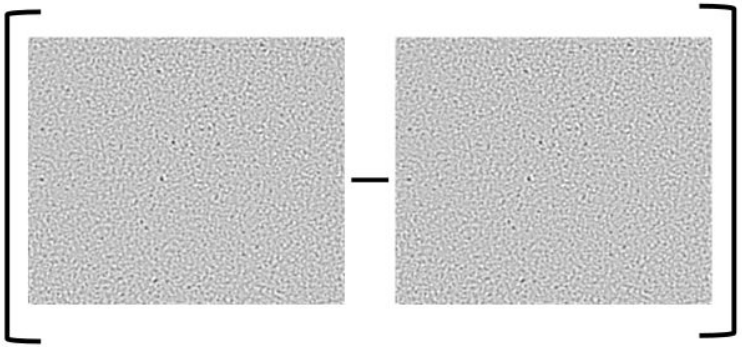
x 1.5 times wider 1.2 mJy rms

x 1.3 times deeper in the deepest region

...

Data reduction

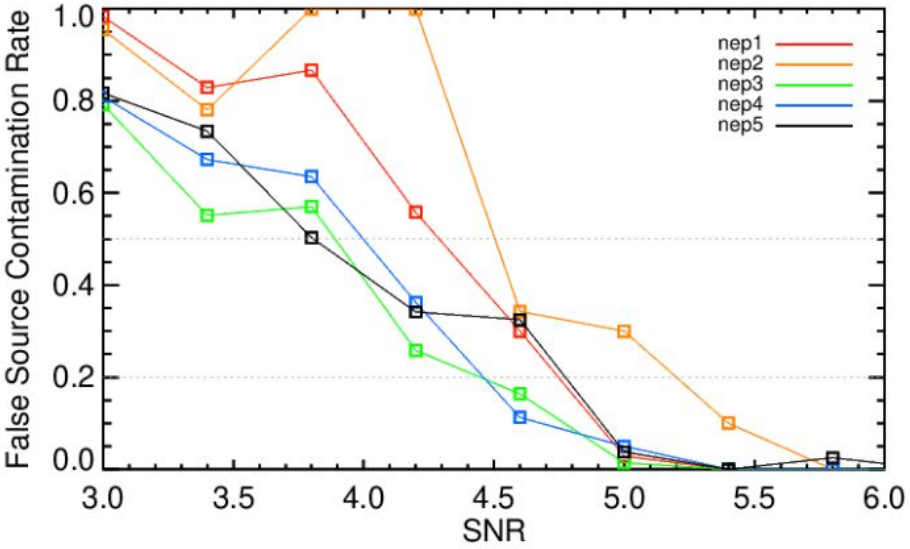
- Map-making using blank-field recipe for faint source extraction, matched filtering to enhance the faint source detection
- Monte Carlo simulation of images using Jackknife noise map + artificial source injection (based on the matched-filtered PSF) to estimate completeness, false detection rate, flux deboost factor, positional uncertainty, ...

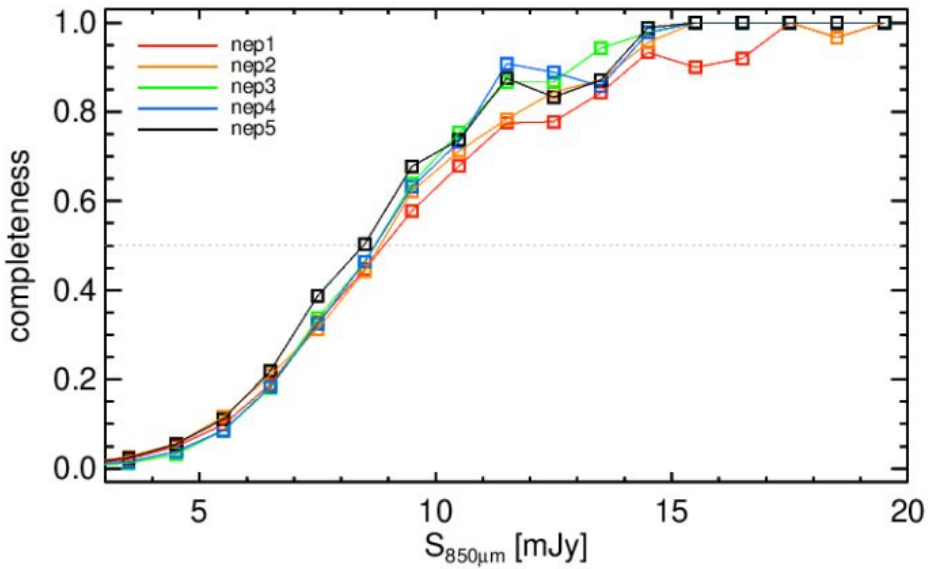


$$\times \frac{1}{\sqrt{t_1+t_2}} + \text{Sources with known flux density distribution}$$

Source detection, compare the result with the input

Data reduction





Source extraction

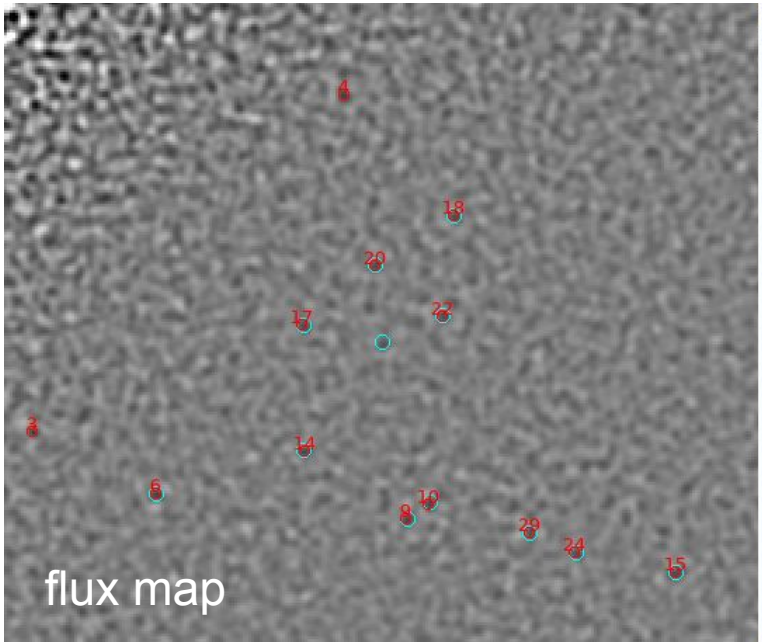
1. find the most significant peak in the SNR map (“peak finding”)
2. store the peak flux, noise, and position
3. remove the source from both SNR and flux map by subtracting a scaled version of the model PSF…

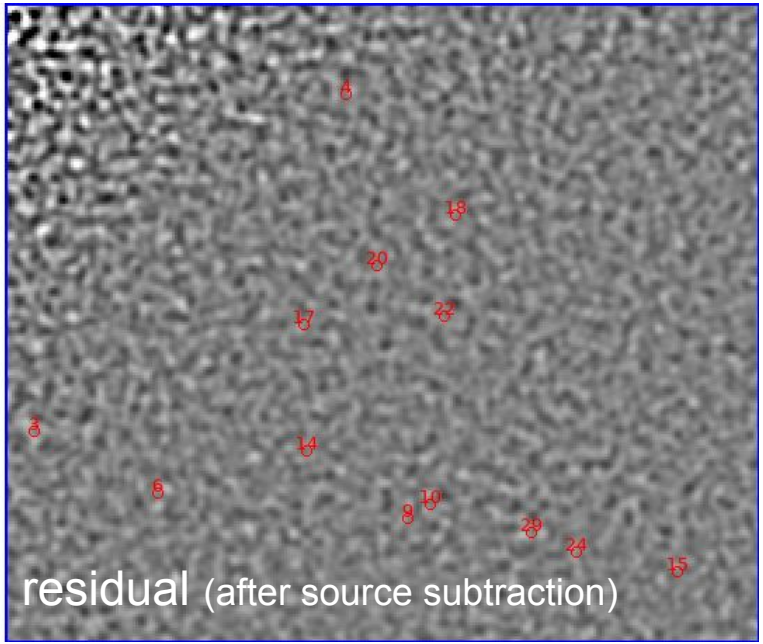
   iterates these procedure to reach down to the floor detection limit (where the detection is not reliable anymore).

At SNR > 4, number of the extracted sources are

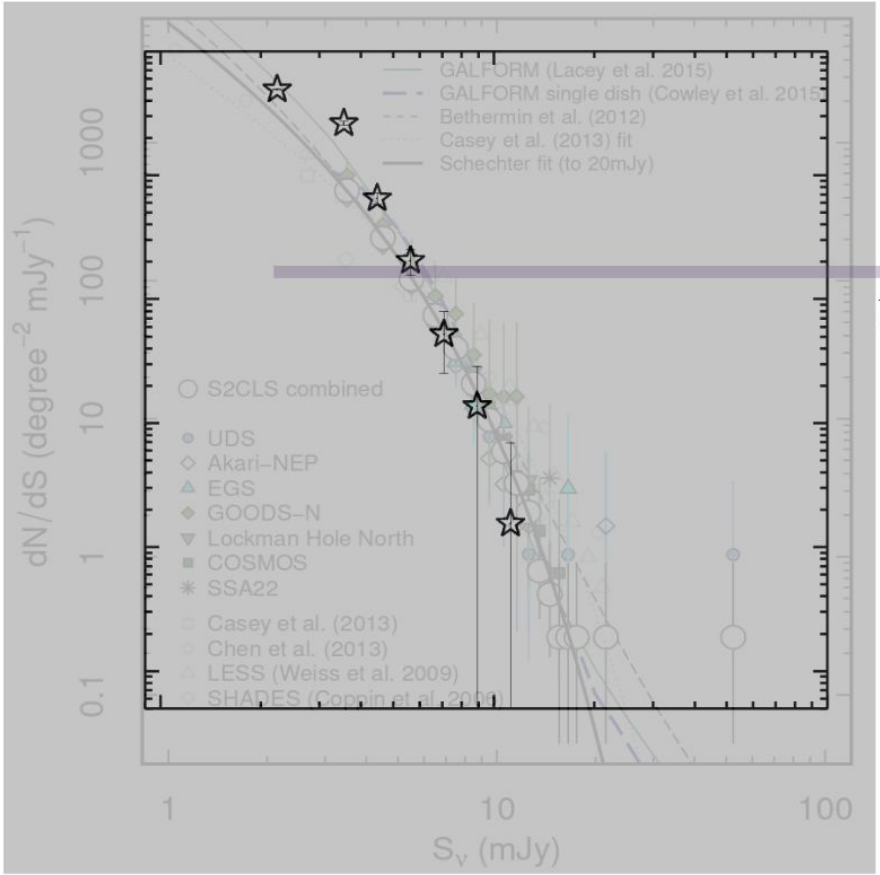
NEP1	NEP2	NEP3	NEP4	NEP5	NEP6	NEP7	NEP8	NEP9	total
22	13	33	37	35	29	25	25	14	233

Source extraction





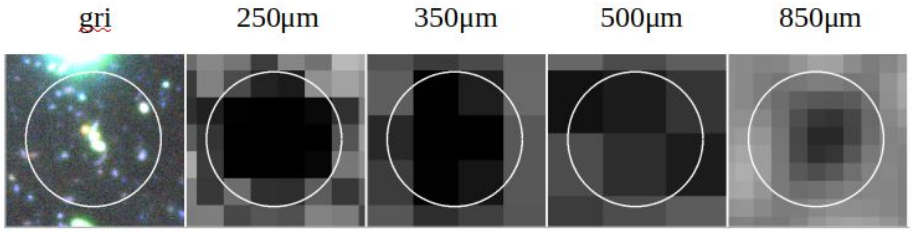
850μm number counts

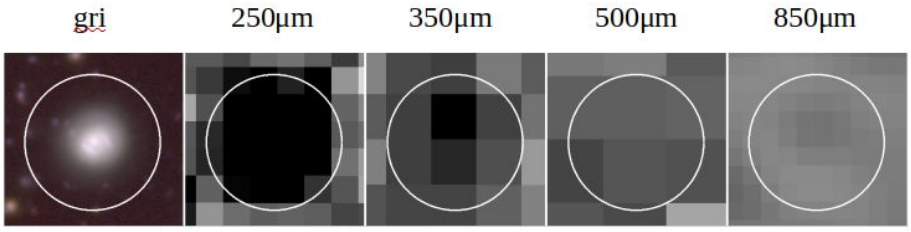


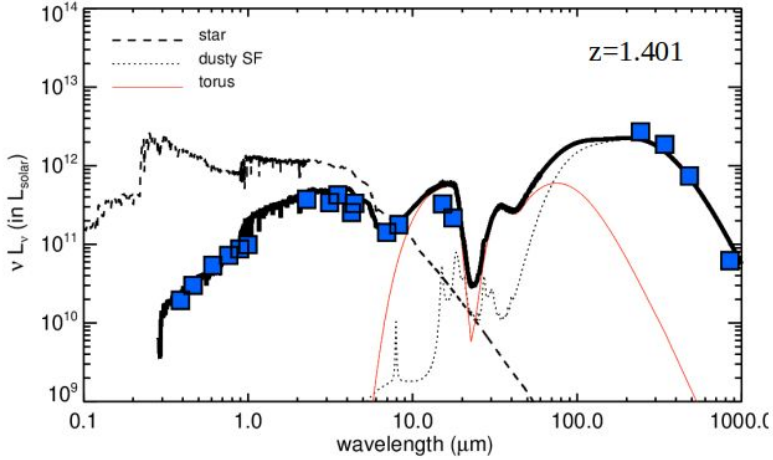
Differential number counts are consistent with other cosmological survey fields.

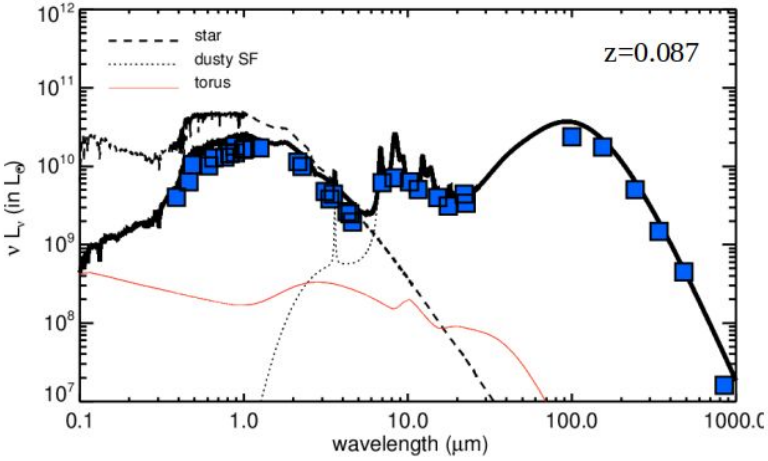
$L(IR) > 10^{12} L_{sun}$ galaxies at $0.8 < z < 3.5$

Multi-wavelength identification of SMGs









JCMT Newsletter, September 2019

Multi-wavelength identification of SMGs

Ongoing work based on the likelihood analysis method, using the magnitude ([3.6], stellar mass) distribution and color ([3.6]-[4.5]) distribution.

$$L = \frac{q(m)}{n(m)} f(r)$$

$$q(m) = \frac{excess(m)}{\sum_m excess(m)} \times Q_0 \qquad Q_0 = \frac{N_{candidates} - N_{background}}{N_{sources}} \qquad f(r) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left(-\frac{r^2}{2\sigma^2}\right)}$$

$n(m)$: normalized distribution of objects in background (out of matching radius).
$excess(m)$: magnitude distribution of difference between objects within matching radius and objects in background.
$N_{candidates}$: the number of objects within matching radius.
$N_{background}$: the number of objects in background.
r : distance between a submillimeter source and a object
σ : positional error

Future plans - publication

- Data release paper (ASAP, submission required to resume the observation)

Mostly applicable to the old NEP friends working on -

- AGN census paper (optical - submm SED fitting)
- MIR-selected galaxies with no optical counterparts paper
- band-merged catalog release paper
- ...

Now is the open enrollment period (~March 13), and there is a need to re-arrange the membership within the team. Any ideas from the (current) team members and suggestions from the (new) members are welcomed.