European Town Meeting and Workshop on an M4 ESA Microwave/Far-infrared Polarization Satellite Bid

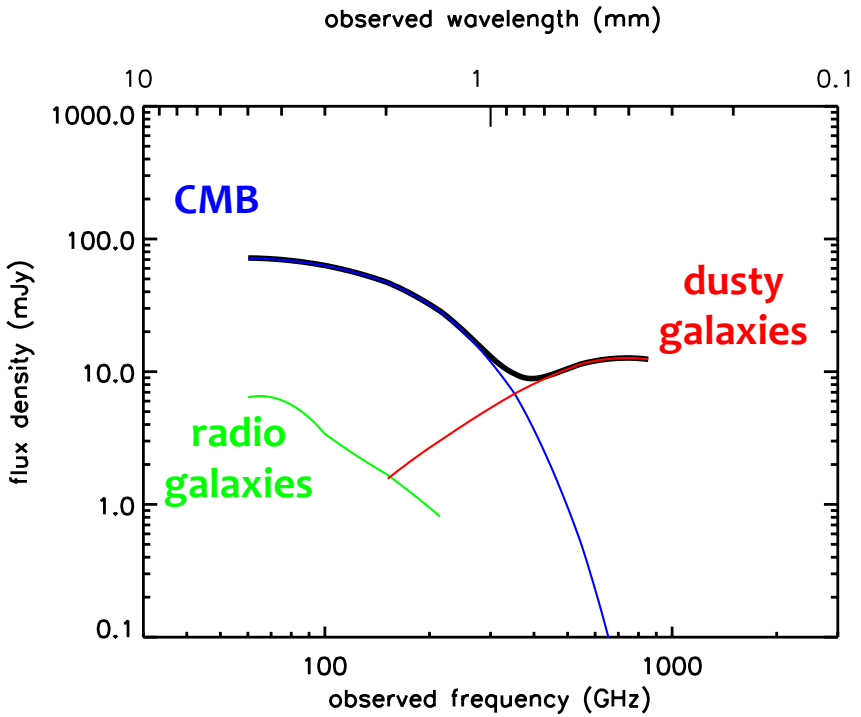
Laboratoire Astroparticule et Cosmologie (APC)
Paris, 10-11 Feb. 2014

Dusty galaxies

Presented by **Mattia Negrello**
INAF - Osservatorio Astronomico di Padova

with contribution from
G. De Zotti, Z.-Y. Cai, G. Castex

Sub-mm/mm confusion noise



D_{mirror} = 2.5 m

ν (Ghz)	FWHM (arcmin)	σ_{CMB} (mJy)	$\sigma_{P,radio}$ (mJy)	$\sigma_{P,dusty}$ (mJy)	$\sigma_{Clus,dusty}$ (mJy)	σ_{conf} (mJy)
60	8.40	72	6.4	-	-	**72**
75	6.74	70	6.1	-	-	**70**
100	5.04	63	3.4	0.25	0.54	**63**
150	3.36	47	1.7	0.88	1.2	**48**
217	2.33	28	0.8	2.1	2.3	**28**
353	1.46	6.7	-	5.2	4.5	**9.6**
545	0.92	0.52	-	9.3	6.6	**11**
857	0.59	0	-	11	5.9	**12**

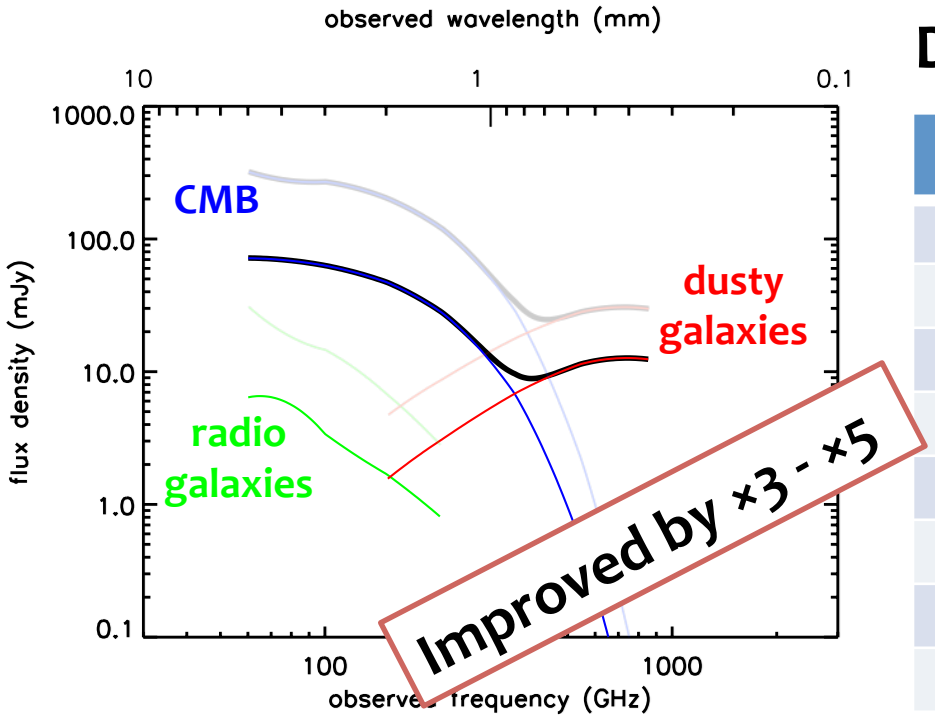
Calculations made by G. De Zotti (galaxies) and G. Castex (CMB)

The confusion noise is dominated by

- **CMB @ ν <~ 350 GHz**
- **Dusty galaxies @ ν >~ 350 GHz**

The contribution of **radiosources** is negligible

Sub-mm/mm confusion noise



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The contribution of **radiosources** is negligible

Detection limits

Planck versus **2.5m**

ν (Ghz)	$\sigma_{CMB,\ Planck}$ (mJy) [**]	$\sigma_{CMB,\ 2.5m}$ (mJy)	$S_{d,\ Planck}$ (mJy) [**]	$S_{d,\ 2.5m}$ (mJy)
70	228	**70**	1000	**175**
100	225	**63**	500	**160**
143	202	**47**	300	**120**
217	124	**28**	300	**70**
353	70	**7**	500	**45**
545	-	**-**	1200	**57**
857	-	**-**	1900	**62**

$S_d = \mathbf{2.5} \times \sigma_{CMB}$ (*)

$S_d = \mathbf{5} \times \sigma_{dusty\text{-}gal}$

(*) CMB noise can be filtered out to some extent with appropriate source detection algorithms

=> Adopted detection limits of **2.5 × σ** @ ν < 300GHz

[**] Planck estimates are from Planck early results XIII (2011) and Planck intermediate results VII (2013)

Detection limits

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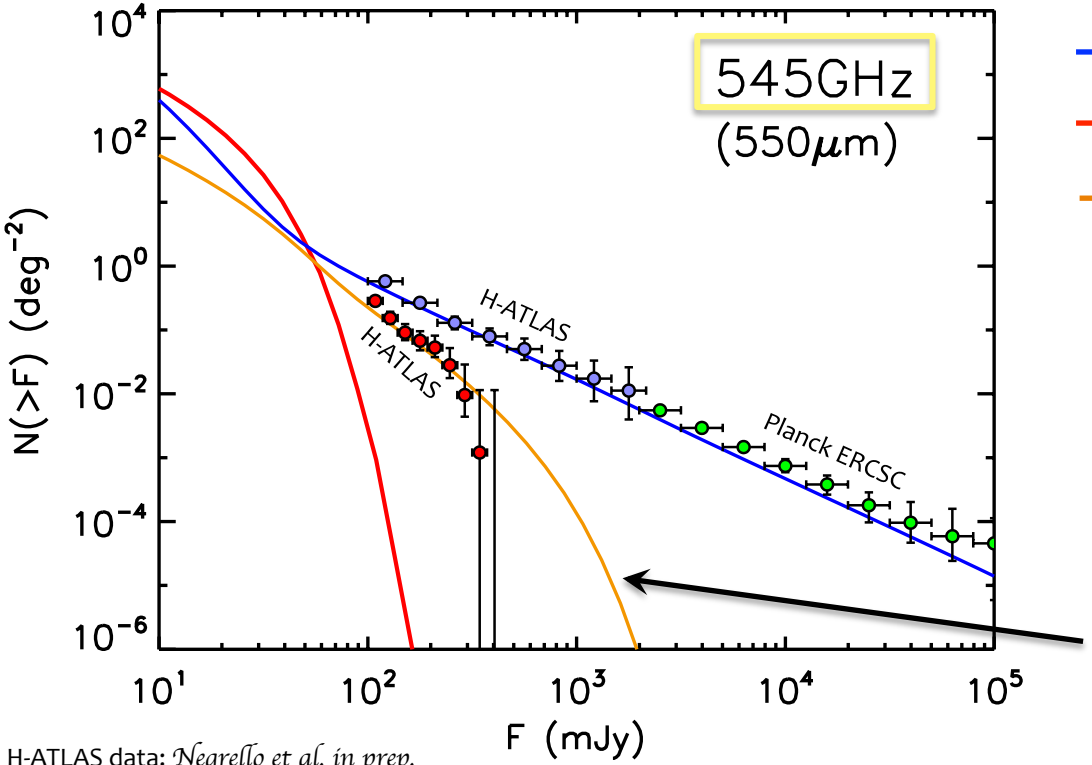
$S_d = \mathbf{5} \times \sigma_{dusty\text{-}gal}$

Frequencies of interest for the detection and the study of **(high-z) dusty galaxies**

Dusty galaxies

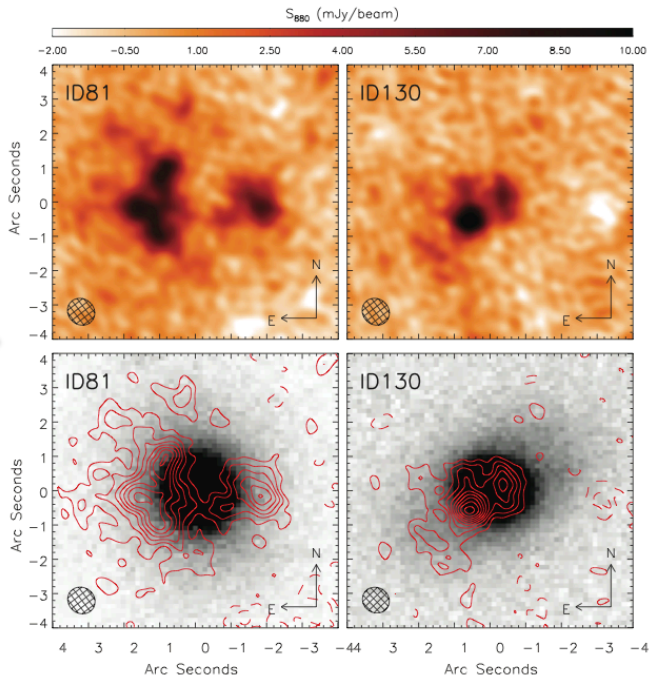


H-ATLAS data: *Negrello et al. in prep.*
Planck data: *Negrello+13*
Number count model: *Cai+13*

late-type galaxies

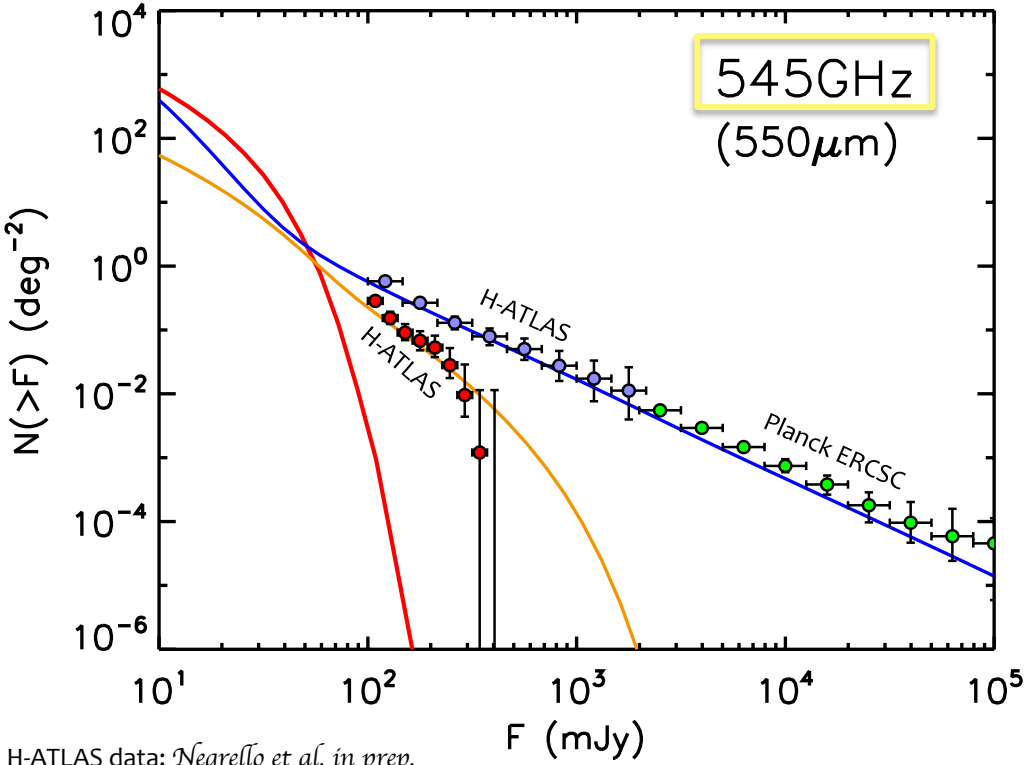
un-lensed **proto-spheroids**

lensed **proto-spheroids**



Negrello+10, Science

Strongly lensed dusty galaxies



H-ATLAS data: *Negrello et al. in prep.*
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Number count model: *Cai+13*

late-type galaxies
un-lensed **proto-spheroids**
lensed **proto-spheroids**

2.5m: **S_d = 57 mJy**

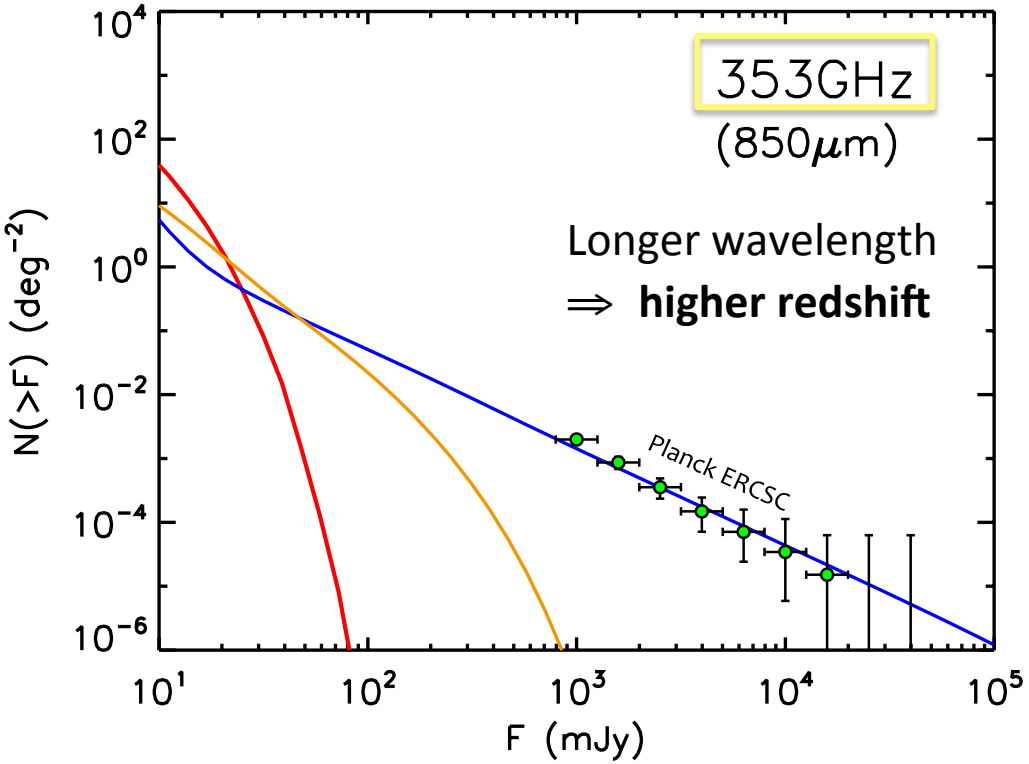
Over **Area = 20,000 deg²**:

- **N_{lensed} = 21500 (!!)**
- $N_{un\text{-}lensed}$ = 16000
- **N_{lensed} = 4500 if S_d = 100 mJy**

Excellent sample for astrophysical and cosmological studies!

- Foreground lens characterized by **Euclid**
- Background source imaged by **ALMA**

Strongly lensed dusty galaxies



Planck data: *Negrello+13*
Number count model: *Cai+13*

late-type galaxies
un-lensed **proto-spheroids**
lensed **proto-spheroids**

Planck: **S_d = 500 mJy**

Over **Area = 20,000 deg²**:

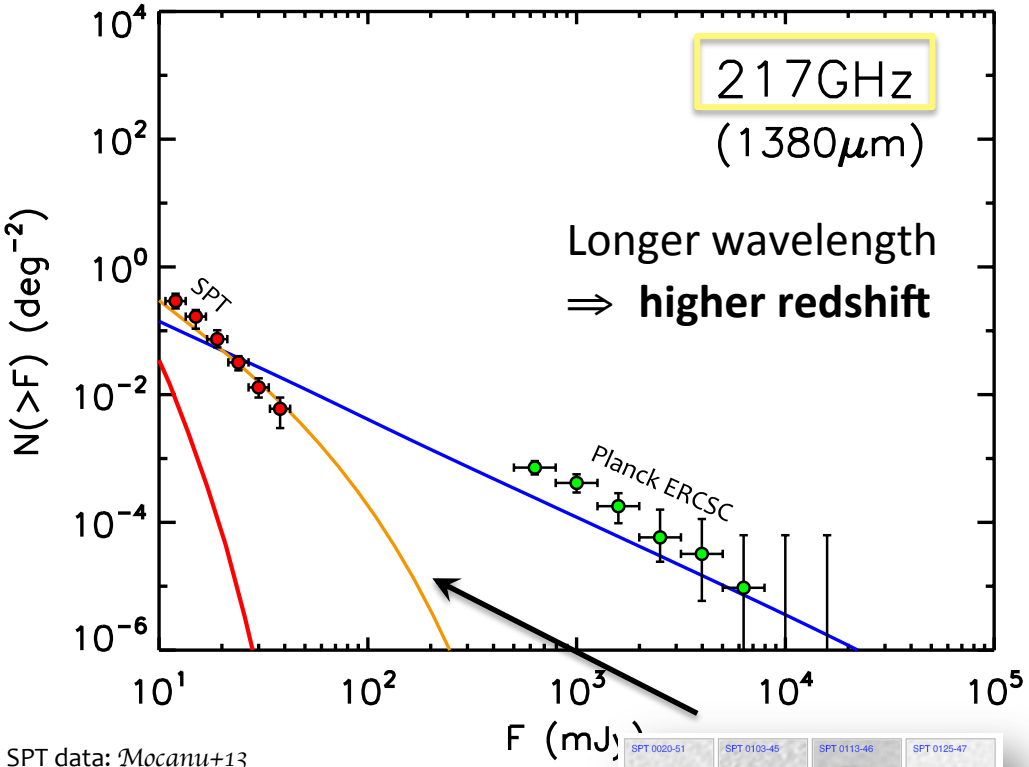
- **N_{lensed} = 0**

2.5m: **S_d = 45 mJy**

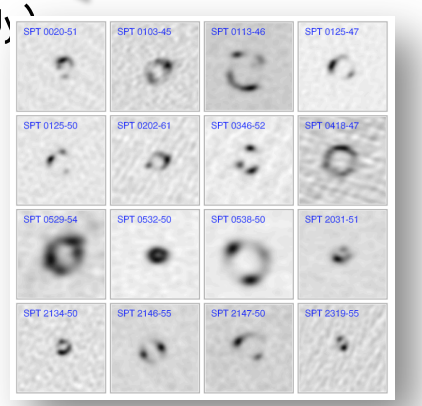
Over **Area = 20,000 deg²**:

- **N_{lensed} = 3500**

Strongly lensed dusty galaxies



SPT data: *Mocanu+13*
Planck data: *Negrello+13*
Number count model: *Cai+13*



ALMA imaging of
SPT brightest galaxies
Vieira+13, Nature

late-type galaxies
un-lensed **proto-spheroids**
lensed **proto-spheroids**

Planck: S_d = 300 mJy

Over **Area = 20,000 deg²**:

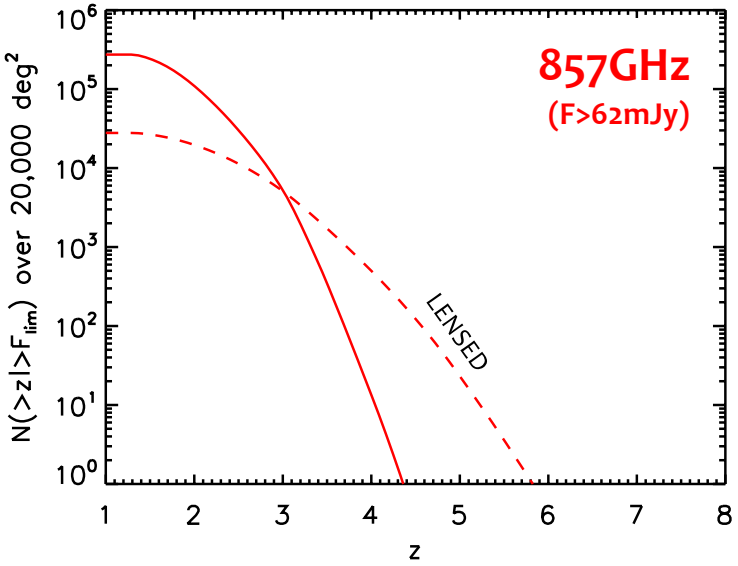
- N_{lensed} = 0

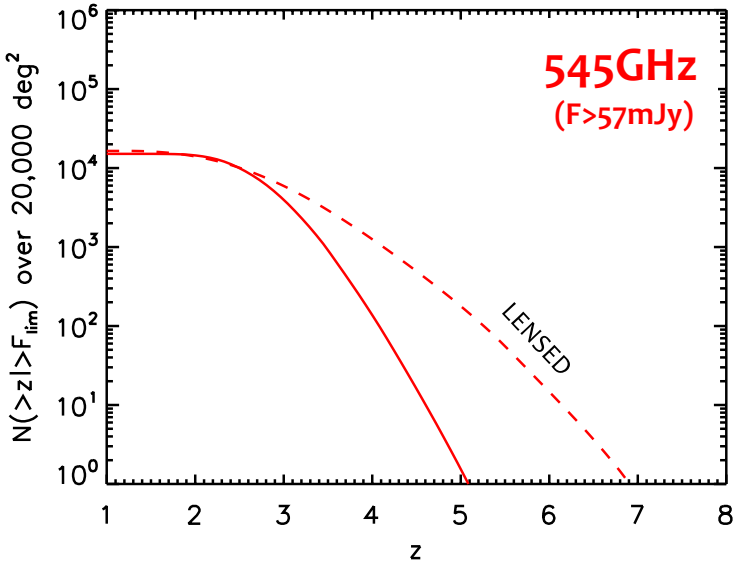
2.5*m*: S_d = 70 mJy

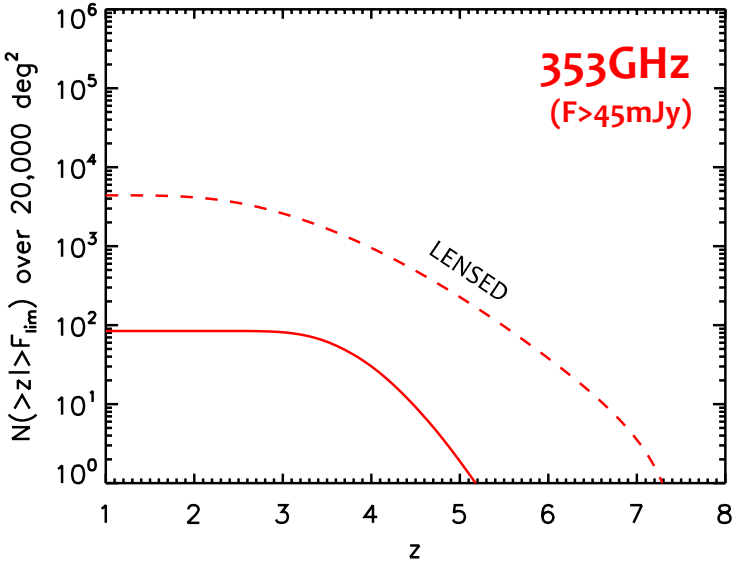
Over **Area = 20,000 deg²**:

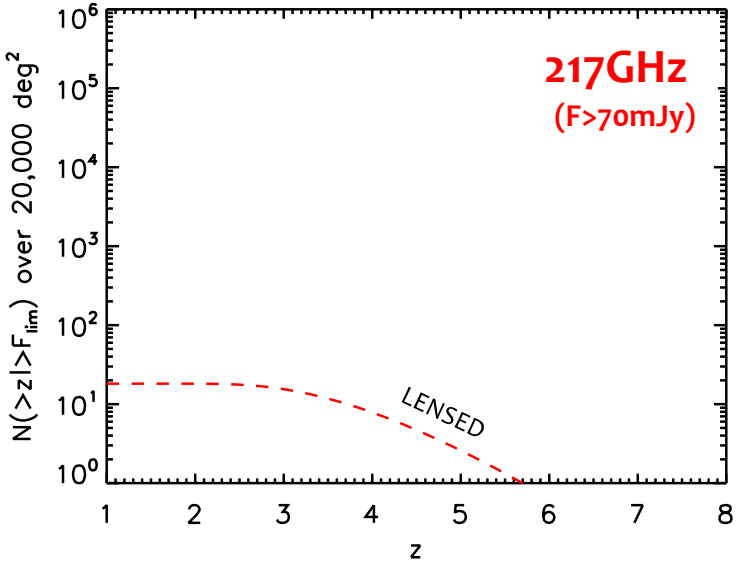
- N_{lensed} = 17

Cumulative Redshift distributions

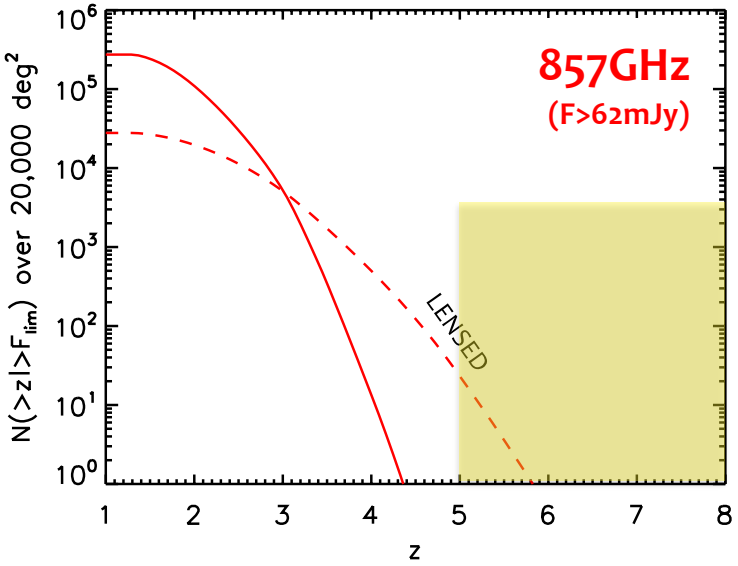


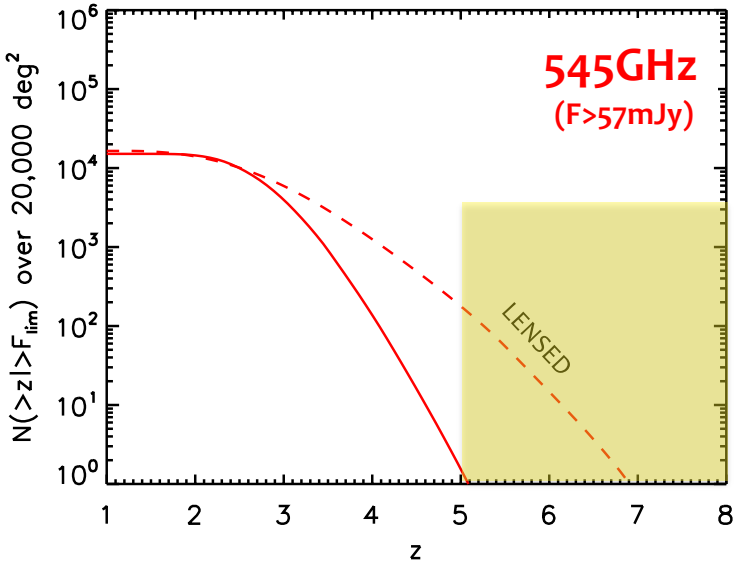


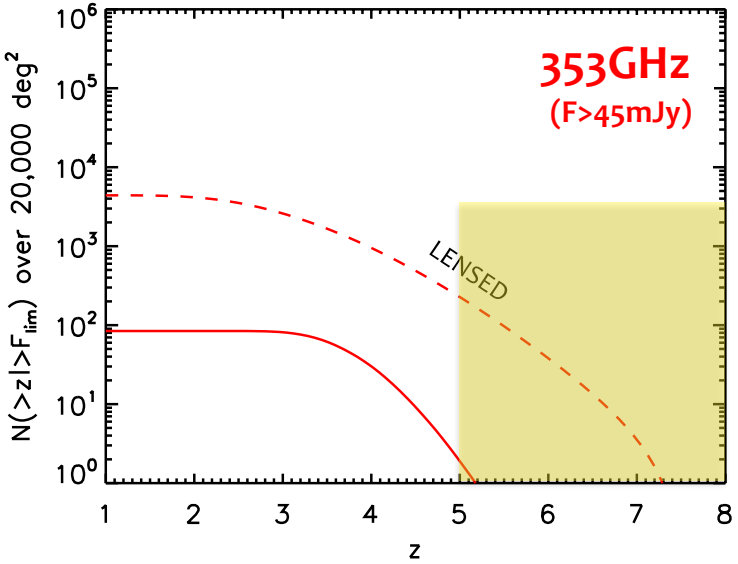


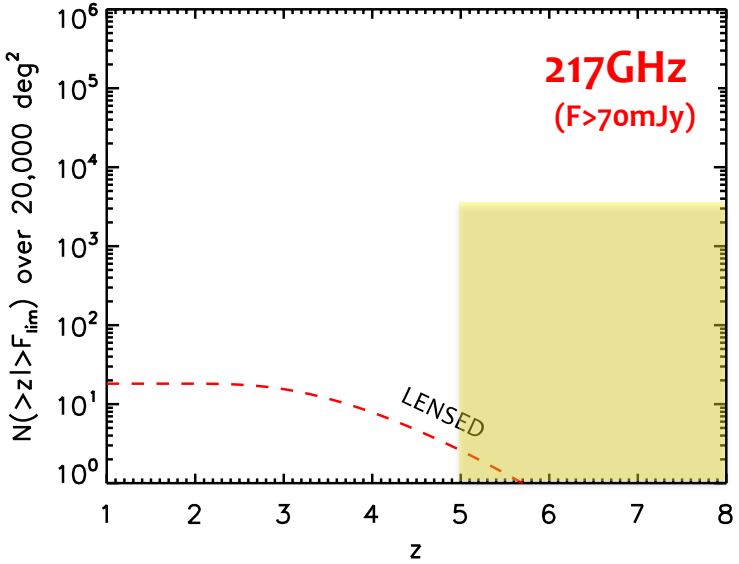


Cumulative Redshift distributions

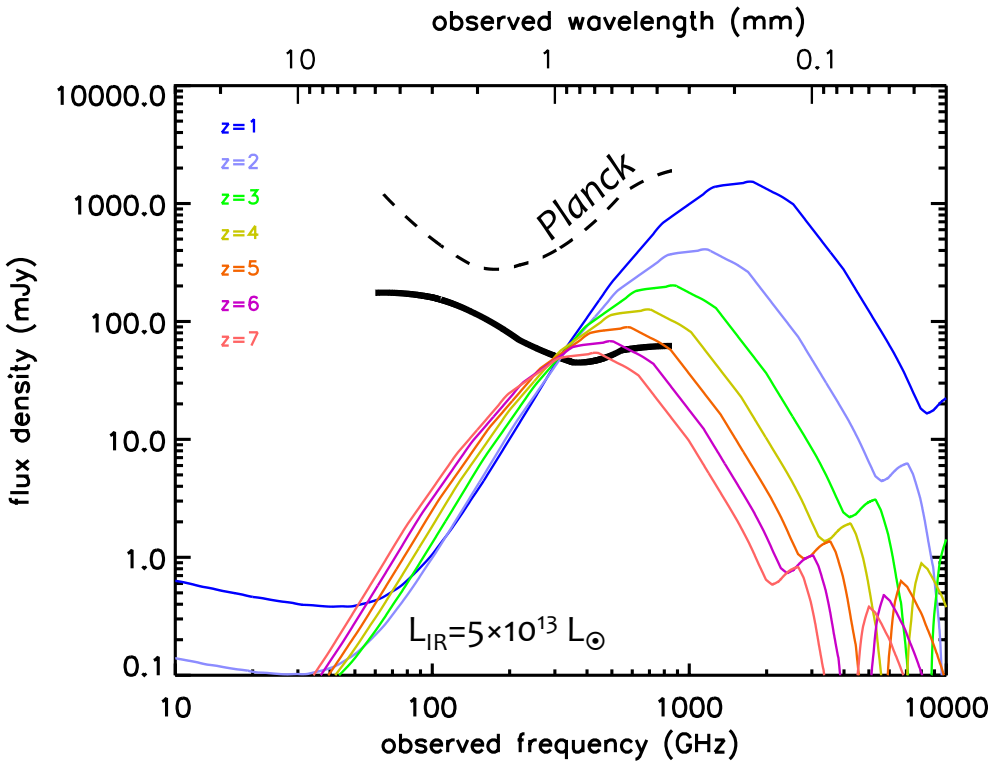


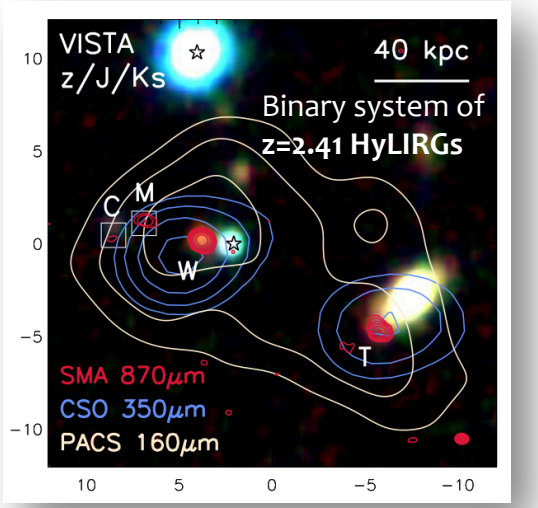




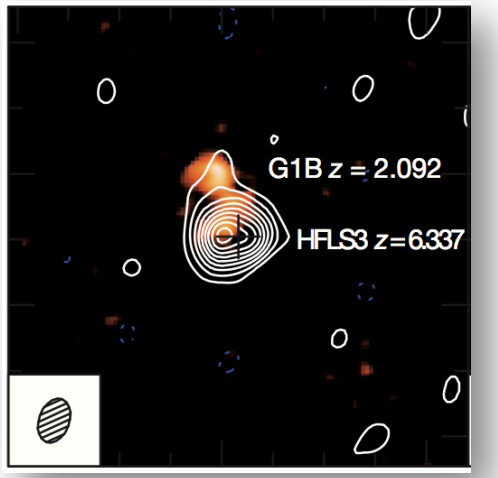


“Extreme” unlensed dusty galaxies





Ivison+13

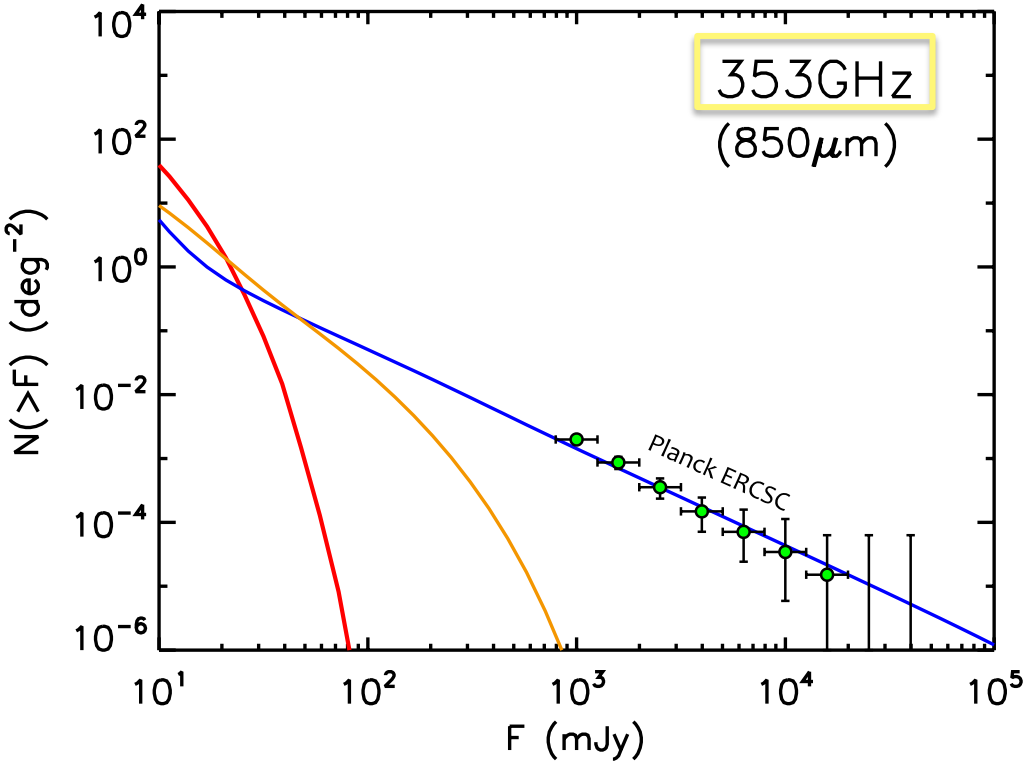


Riechers+13, Nature

Surface density: ~< 0.01 deg^{-2}

⇒ >~ 100 them to be discovered!

Local dusty galaxies



Planck data: *Negrello+13*
Number count model: *Cai+13*

- Luminosity functions
- Dust mass function
- SED & free-free emission,
- . . .

in the ***local*** **Universe**

late-type galaxies
un-lensed **proto-spheroids**
lensed **proto-spheroids**

Planck: **S_d = 500 mJy**

Over **Area = 20,000 deg²**:

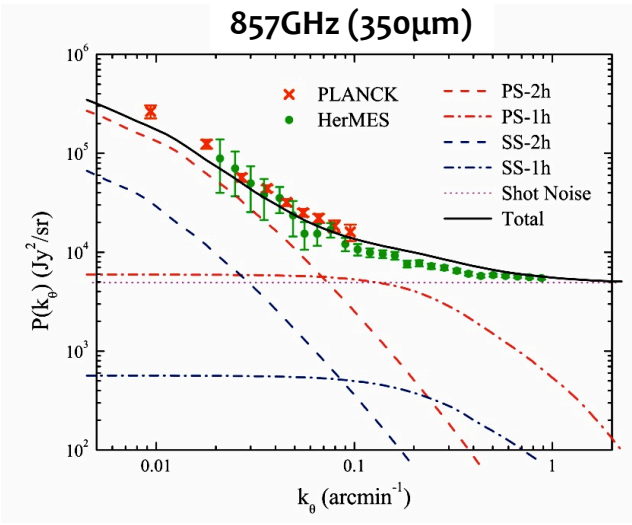
➢ **$N_{late\text{-}type}$ = 85**

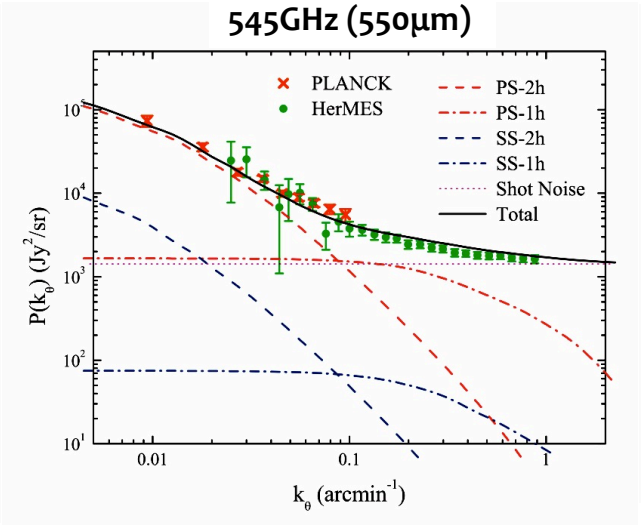
2.5m: **S_d = 45 mJy**

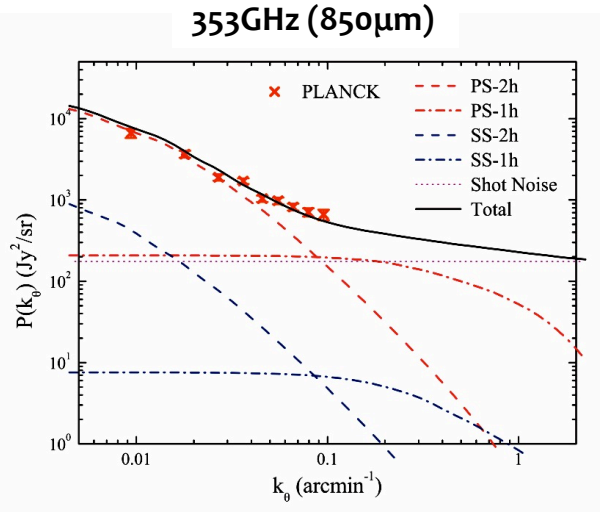
Over **Area = 20,000 deg²**:

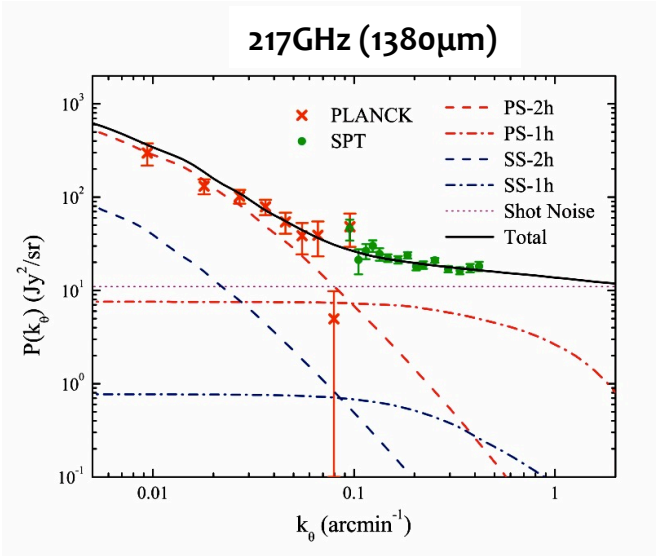
➢ **$N_{late\text{-}type}$ = 3400**

P(k) of correlated anisotropies









CREDITS: *Xia+12*

- Homogeneous estimate of *P(k)* from small to large scales
- Measure of shot noise & 1-halo @ ν >= 353 GHz and 217 GHz

Conclusions

- > 10,000 sub-mm selected lensed galaxies out to z=7
- Best study of the local Universe in the sub-mm
- Improved measurement of P(k) of correlated anisotropies
- Cross-correlation (see Paolo Serra's talk tomorrow)