The Herschel Lensing Survey (HLS)

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HLS Team Members

(Total: 35, US: 14, ESA 21)

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B. Clement	Marseille	R. Pello	Toulouse	M. Zemcov	JPL/Caltech
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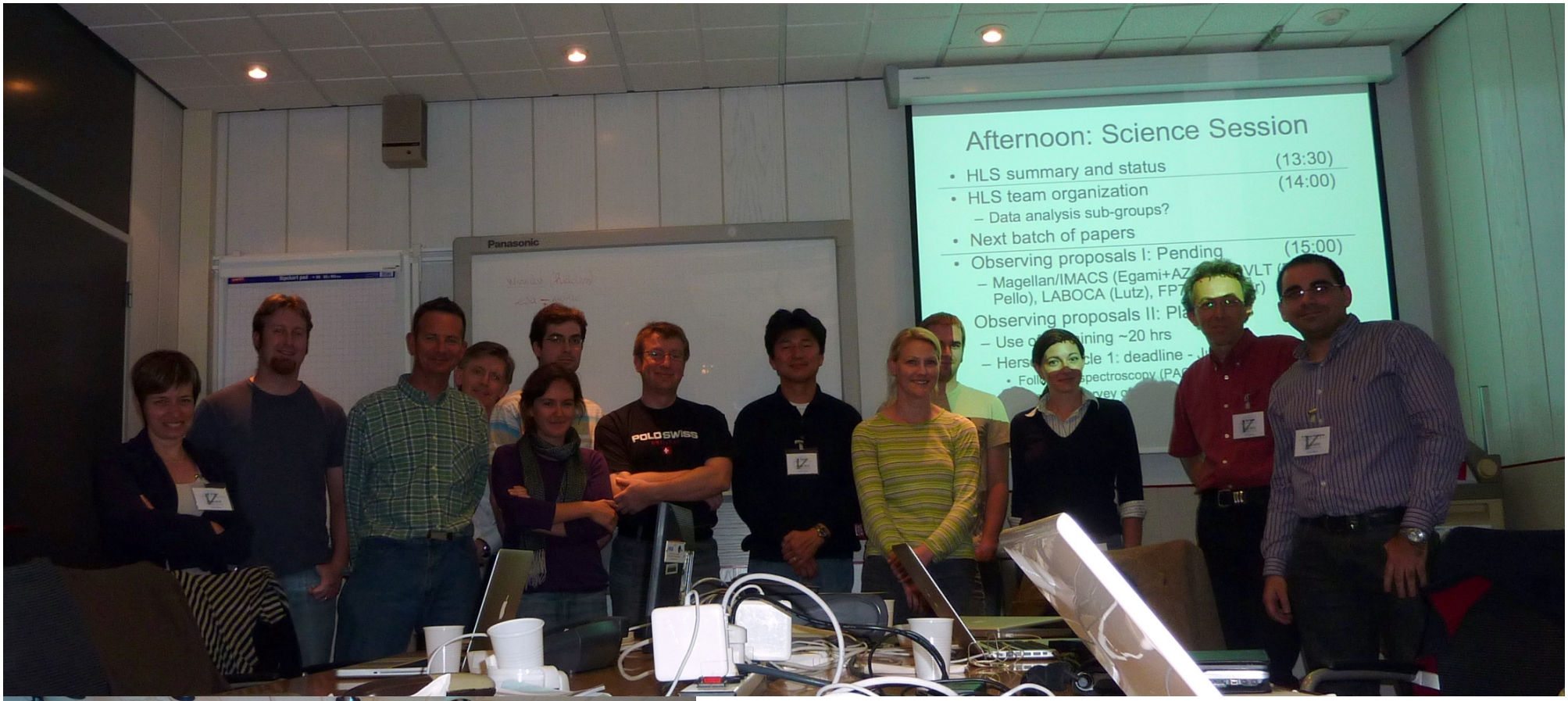


HLS Team Meeting at ESTEC
May 3, 2010

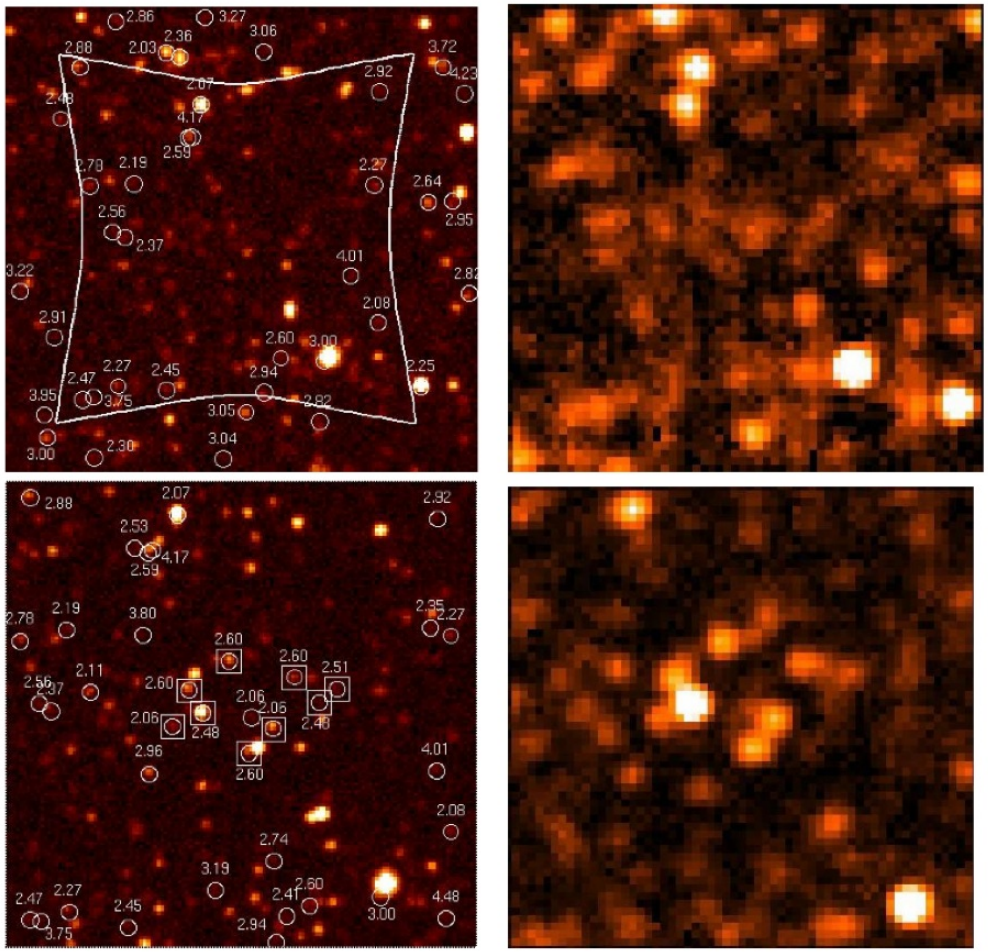
Scientific Goals

1. To detect and study IR/Submm sources that are below the nominal confusion limit of Herschel using the gravitational lensing power of massive galaxy clusters.
2. To study IR/submm properties of galaxies in dense environment (i.e., cluster members).
3. To investigate the Sunyaev-Zel'dovich effect (SPIRE can detect increment at 350/500 um).

Penetrating through the Confusion with Cluster Cosmic Telescopes

Without Lensing

With Lensing



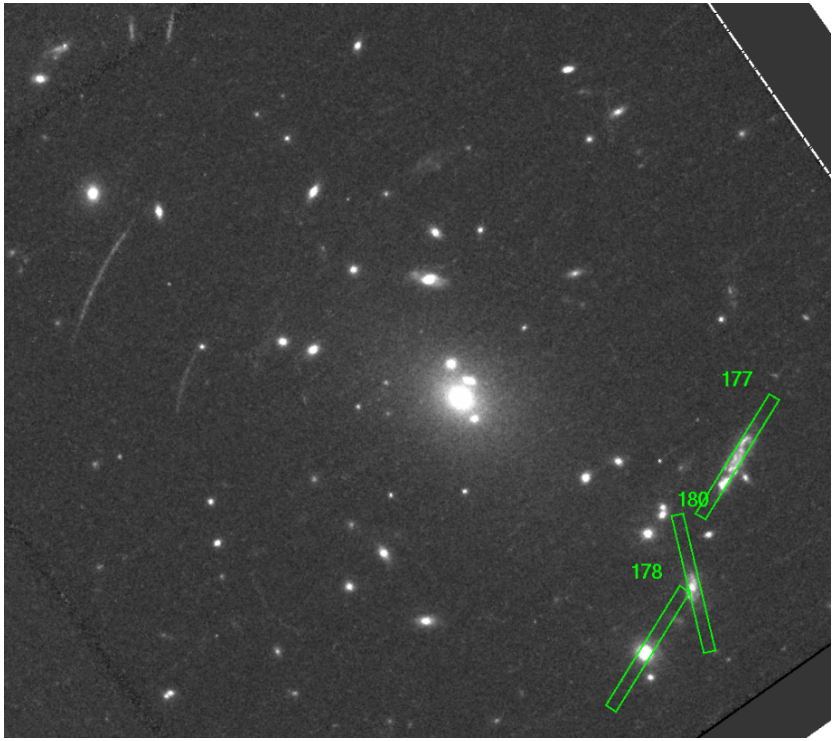
PACS 100 um SPIRE 250 um

7'x7'

Lensing is more Important for SPIRE images, which get confusion-limited quickly.

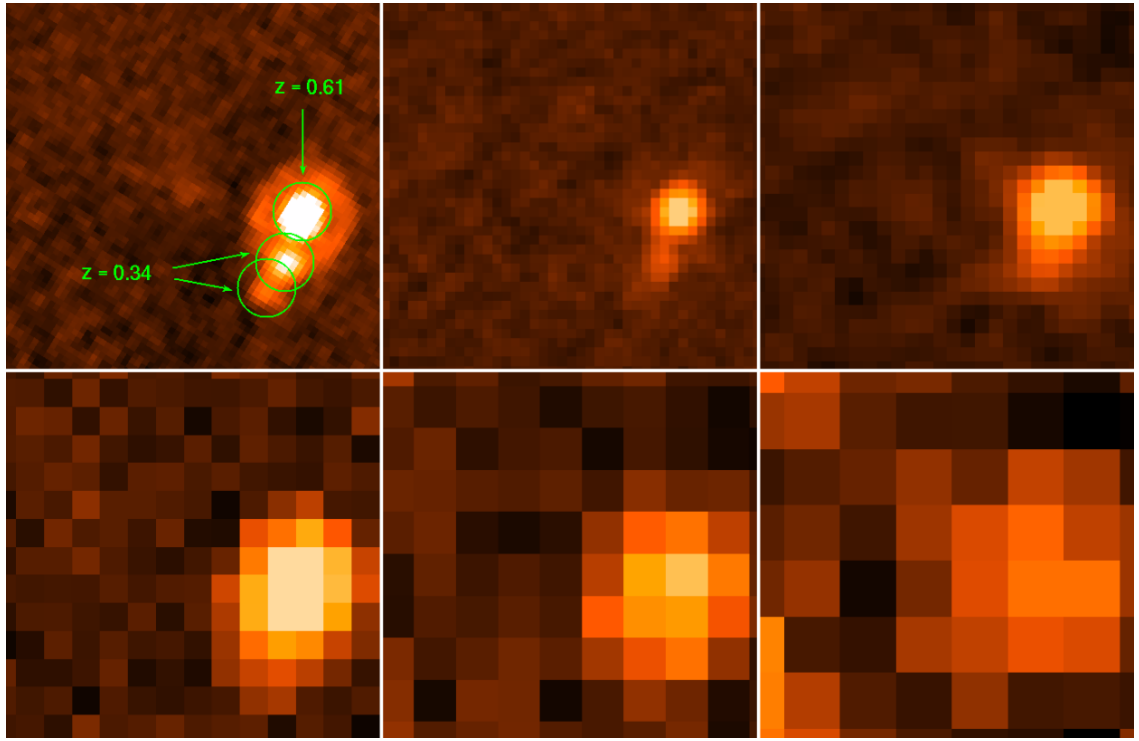
In IR/Submm, massive galaxy clusters act as transparent lenses (well, almost…)

AS 1063 (z= 0.34)



HST optical

MIPS 24um PACS 100um PACS 160um



SPIRE 250um SPIRE 350um SPIRE 500 um

See the poster by Greg Walth

Survey Strategy & Design

- Target: ~40 massive galaxy clusters (GT surveys observe 10 clusters -> OT+GT~50)
- Selected X-ray-luminous clusters with good ancillary data and cluster mass models.
- Close collaboration with two other cluster OTKPs (LoCuSS – PI: G. Smith; BCGs – PI: A. Edge)
- PACS: 100/160um; FOV 8'x8'; 5/10 mJy (5σ)
- SPIRE: 250/350/500 um; FOV 17'x17'; confusion limit ~30 mJy (5σ)
- Total observing time: 292.3 hrs

Five Herschel Special-Issue Papers on the Bullet Cluster (SDP target)

- The Herschel Lensing Survey: Overview **(Egami et al.)**
- **Sources behind the Cluster:**
  - 1. Far-IR/Submm SED properties **(Rex et al.)**
  - 2. Multi-wavelength source matching/photometry and far-IR/submm phot-z's **(Perez-Gonzalez et al.)**
- **Cluster Galaxies**: 3. Far-IR/Submm properties of galaxies in dense environment **(Rawle et al.)**
- **Sunyaev-Zel'dovich effect**: 4. First detection of SZ increment at < 650 um **(Zemcov et al.)**

The Bullet Cluster: X-ray-luminous merging cluster at z=0.3

Special thanks to,

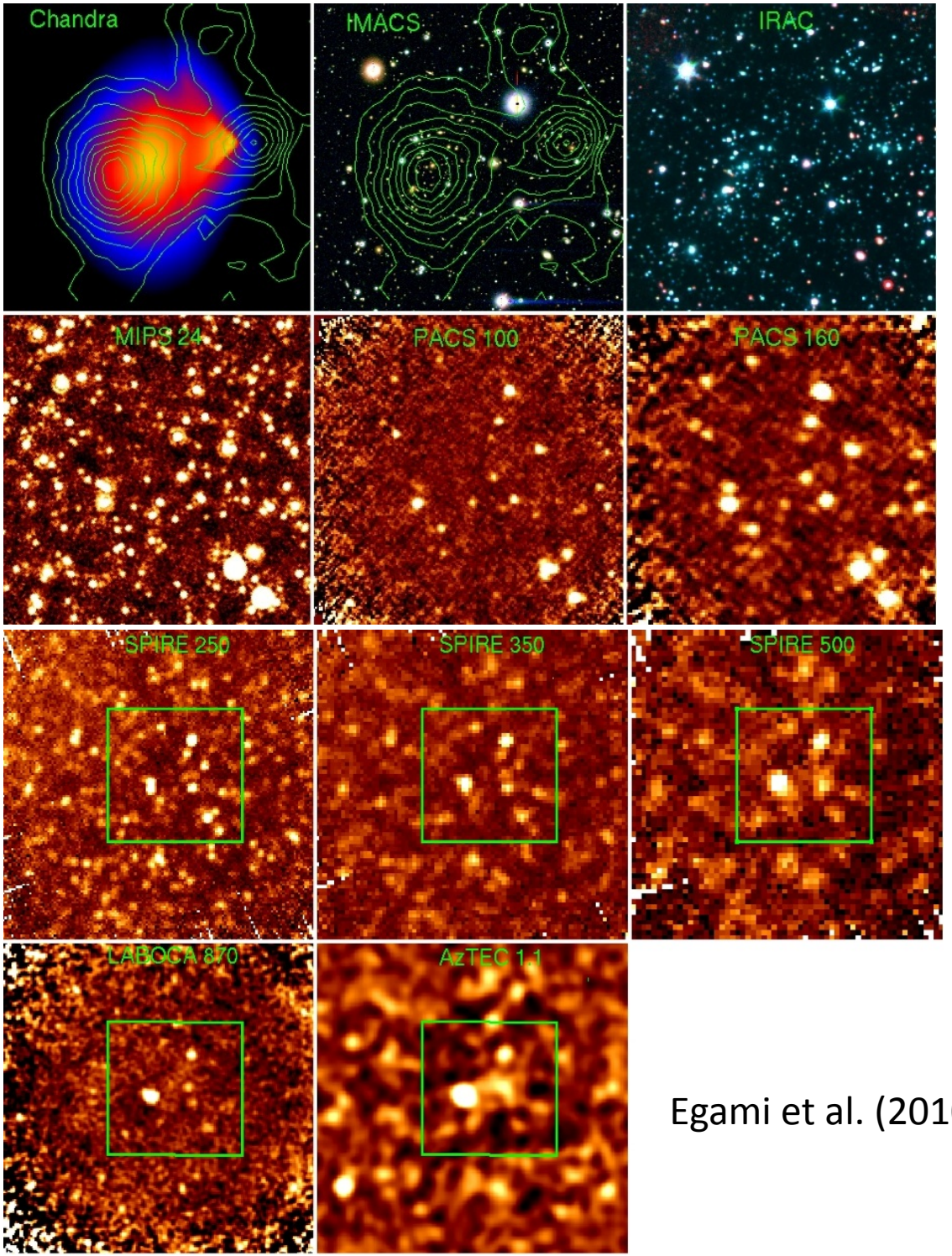
Doug Clowe
(Magellan/IMACS images)

Jean-Gabriel Cuby
(VLT/HAWKI images)

Anthony Gonzalez, Sun Mi Chung
(Magellan/IMACS redshifts)

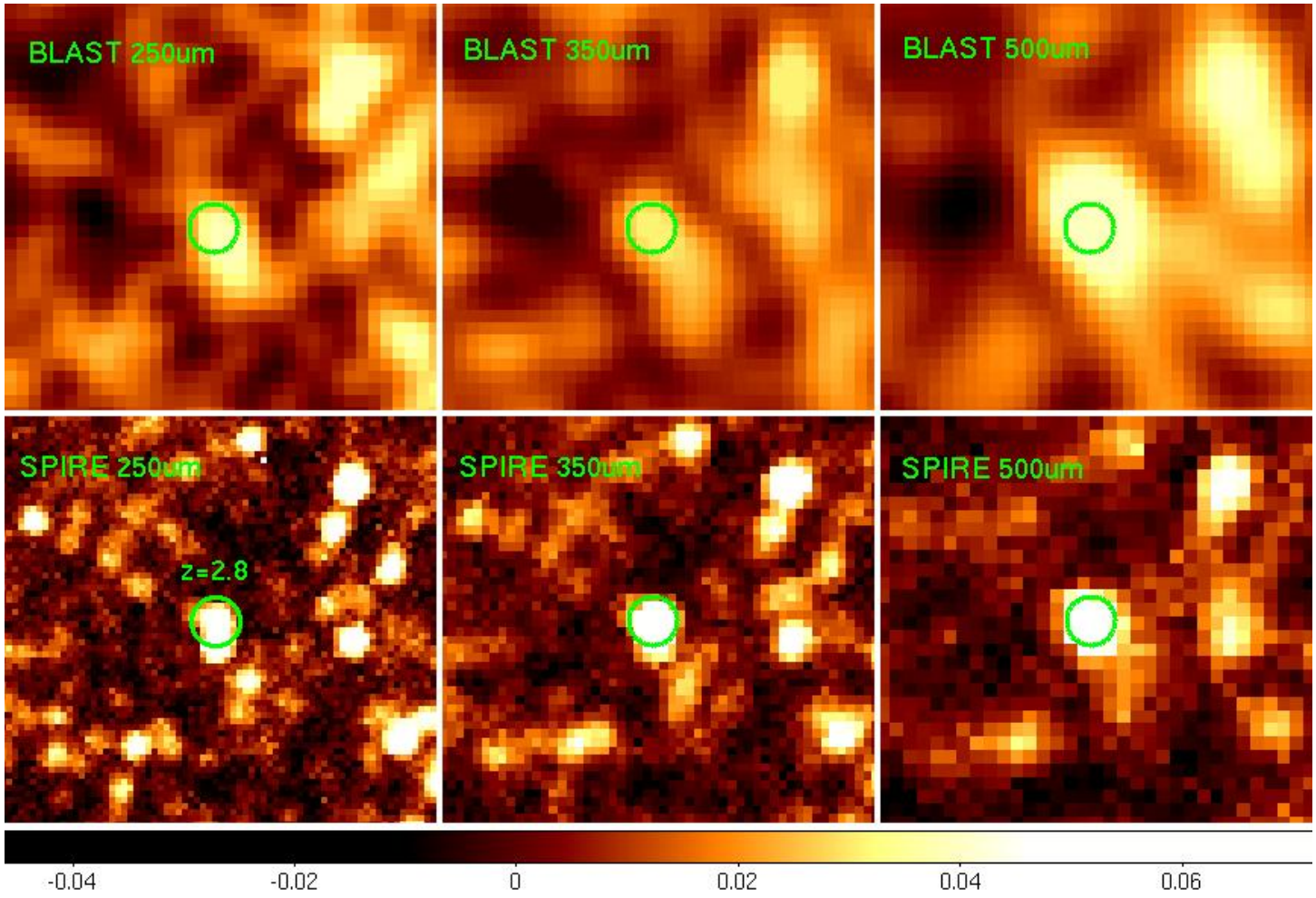
Cathy Horellou, Daniel Johansson and LABOCA team

David Hughes, Itziar Aretxaga and AzTEC team



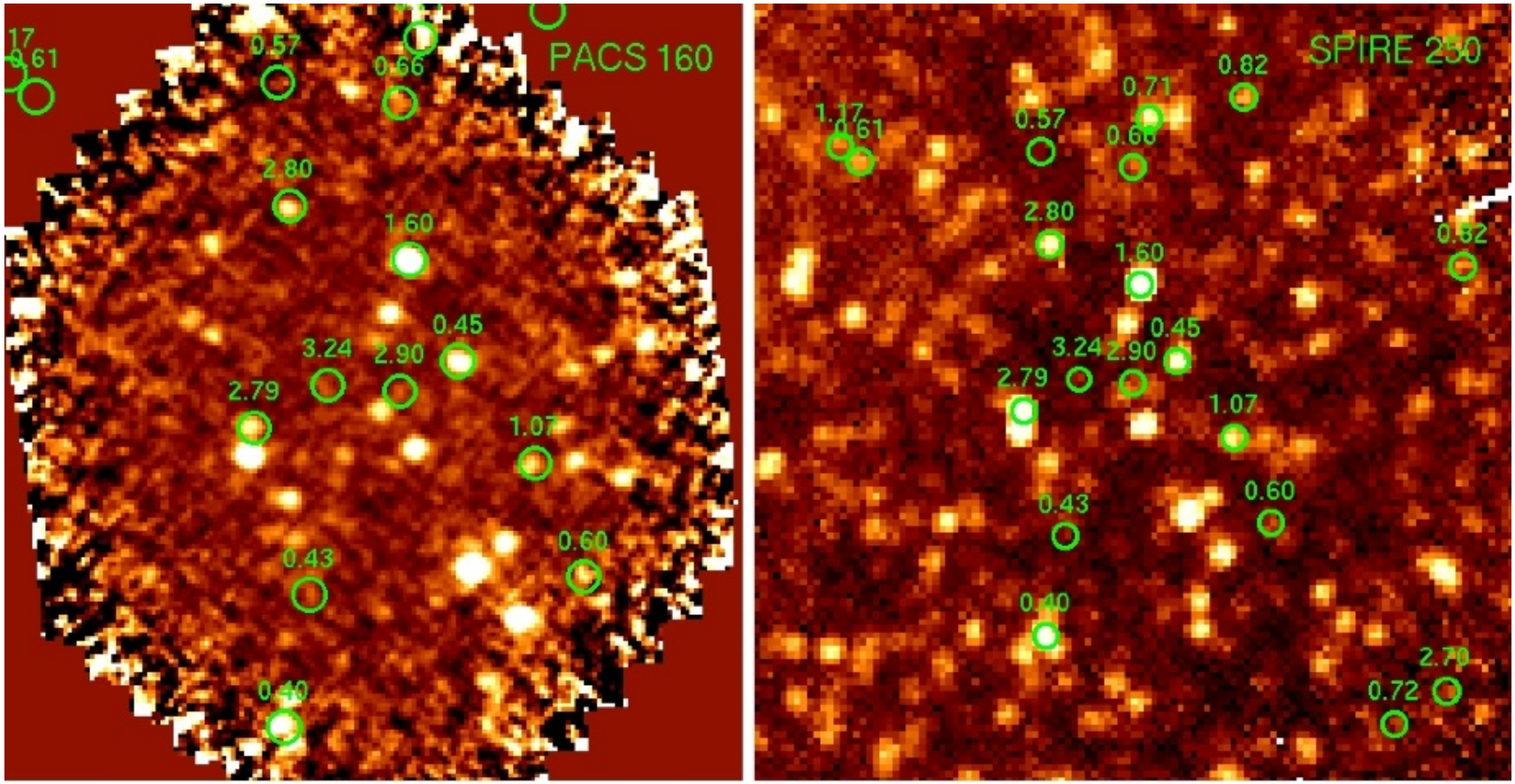
Egami et al. (2010)

BLAST vs. SPIRE



Galaxies behind the Bullet Cluster

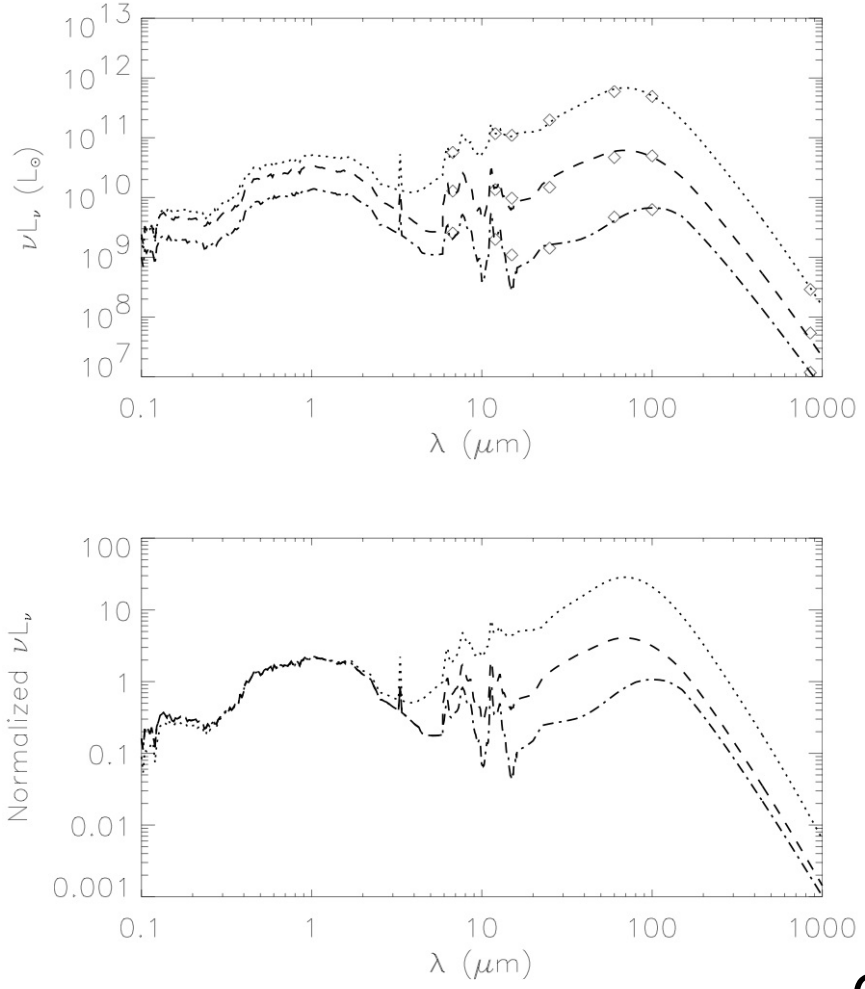
(z>0.4)



For the SDP papers, we limited the analysis to well-isolated,

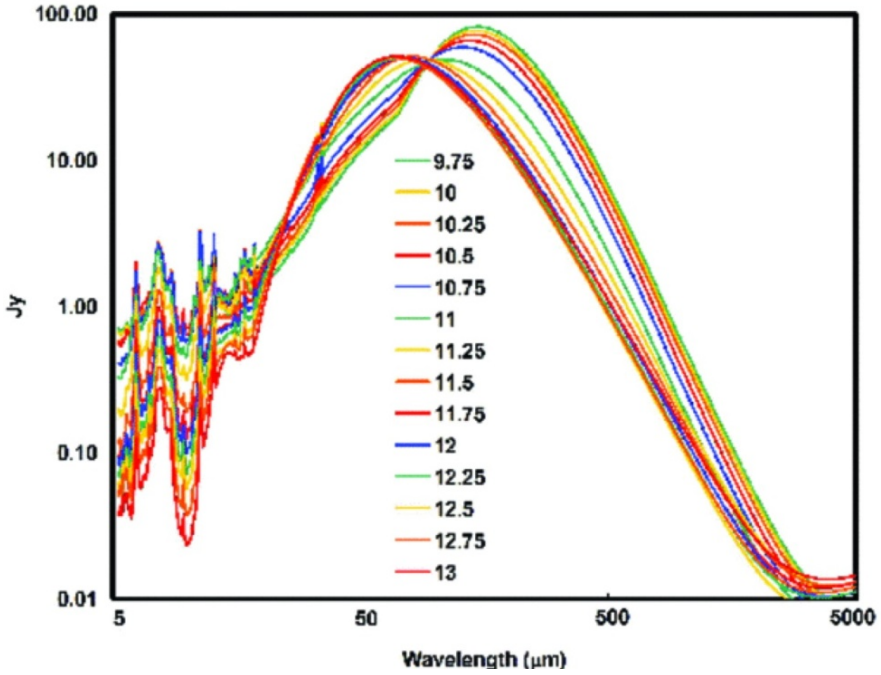
- 15 sources with spectroscopic redshifts
- 4 sources with good photometric redshifts

1. Far-IR/Submm SED Properties



Chary & Elbaz (2001)

Rex et al. (2010); see her poster!

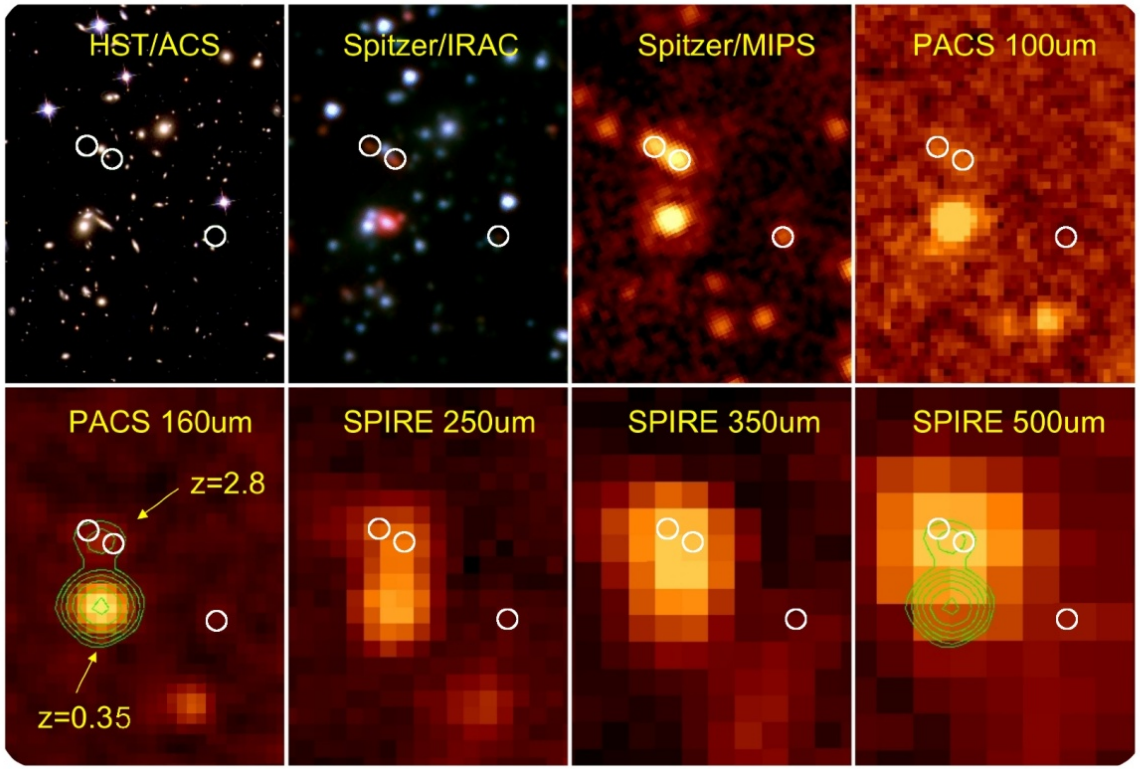


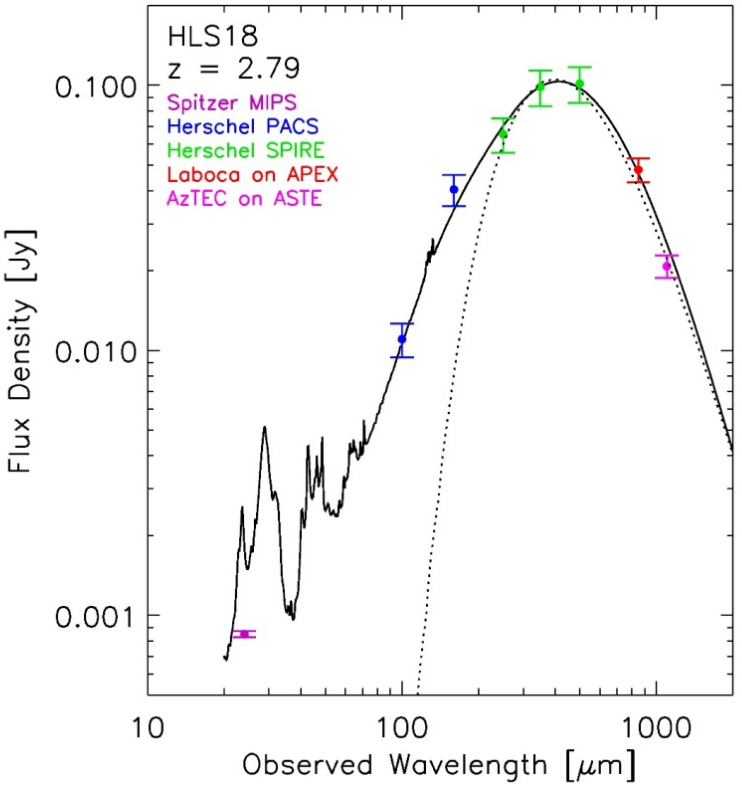
Rieke et al. (2009)

$L_{TIR}\uparrow \longrightarrow T_{dust}\uparrow \longrightarrow L_{FIR}/L_{MIR}\uparrow$

Q: Do the local galaxy SED templates work at high redshift?

Mapping the Full Far-IR/Submm SED of a ULIRG ($2x10^{12}$ $L_{\odot}$) at z=2.8!





Also, see Rex et al. (2009) for BLAST

Magnification factor ~x50-100

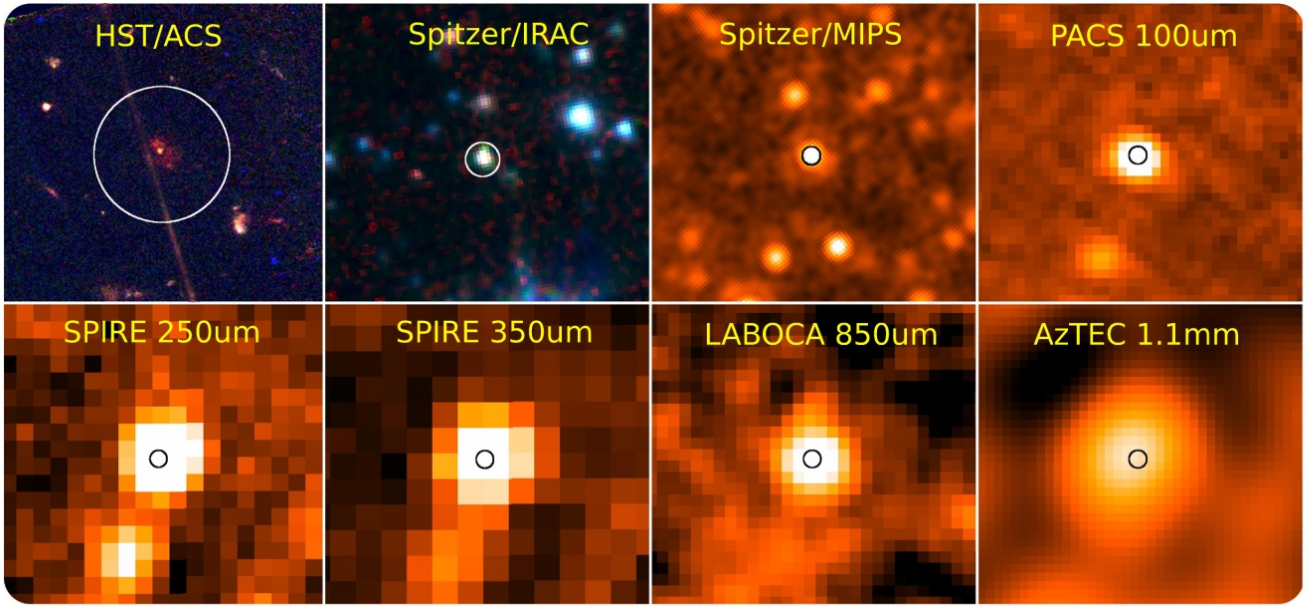
Observed flux densities : 7.0, 24.5, 65.3, 98.6, 101.4 mJy

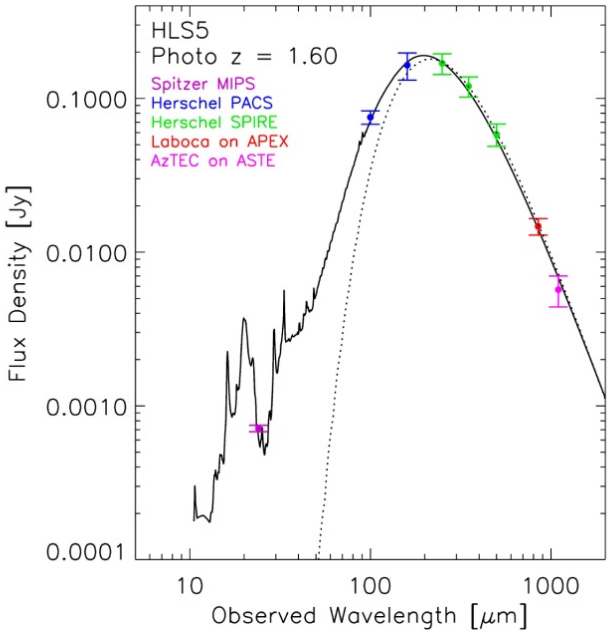
Corrected for lensing (x75): 0.09, 0.3, 0.9, 1.3, 1.4 mJy

Impossible to detect without lensing!!

HyLIRG (4.4×10^{13} $L_{\odot}$) at z=1.6

(But not significantly lensed…more like a typical SMG)



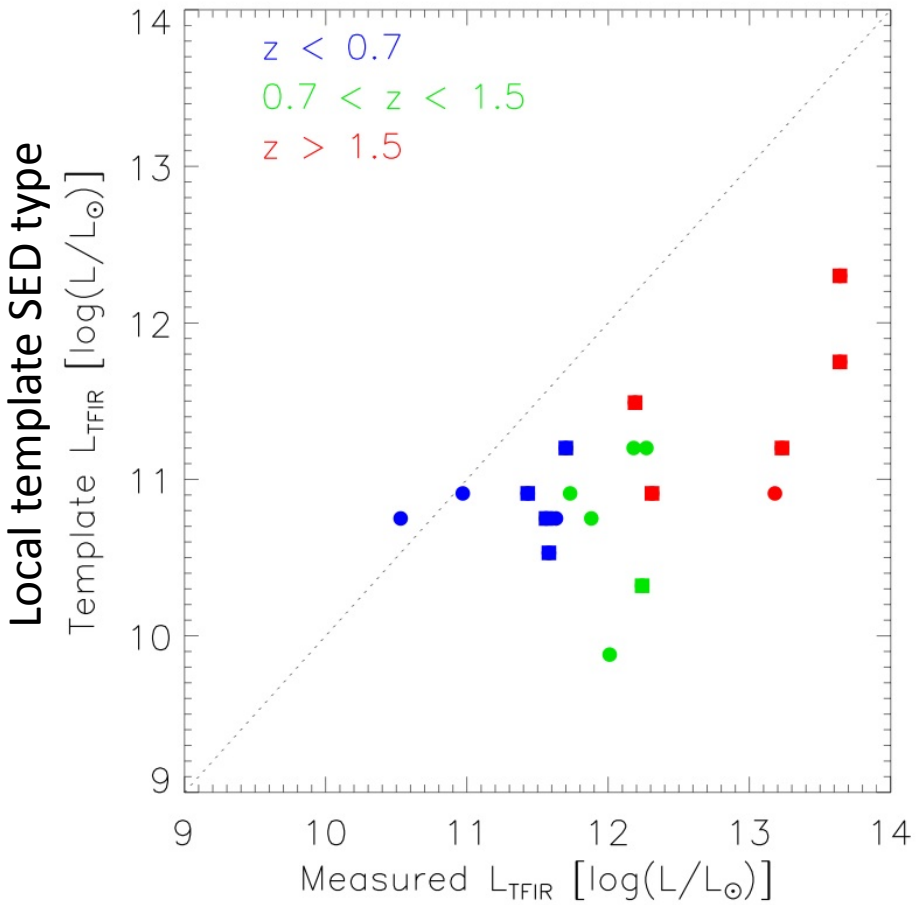


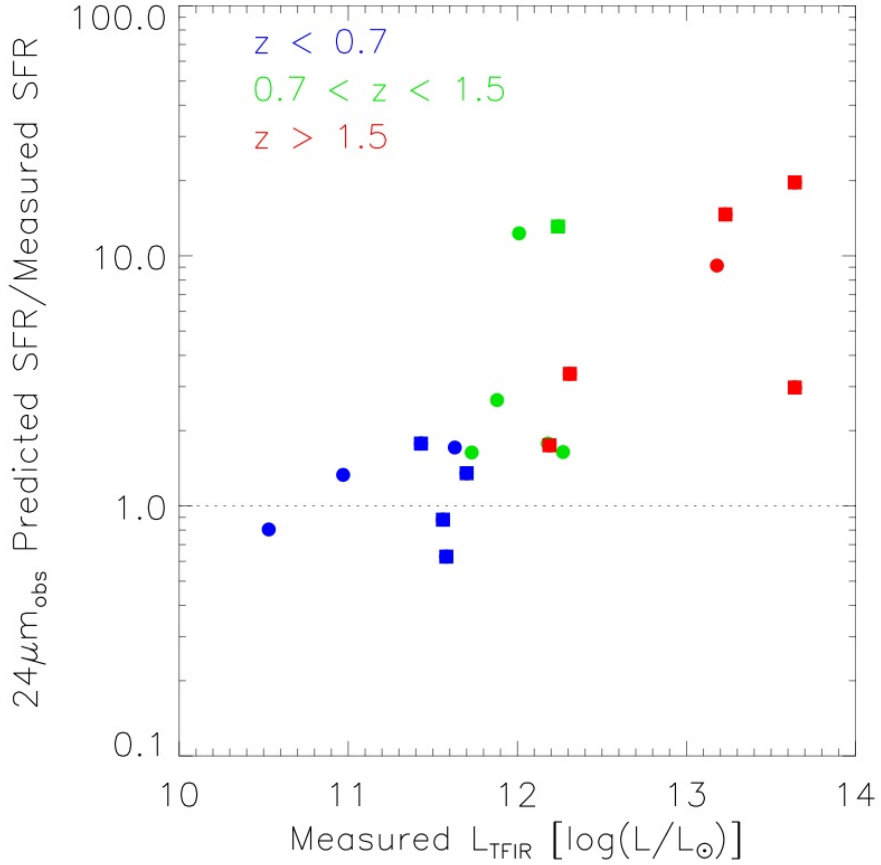
Magnification factor ~x1.2

Observed flux densities : 75.4, 164.4, 168.9, 120.0, 58.4 mJy

Star-forming galaxy SED

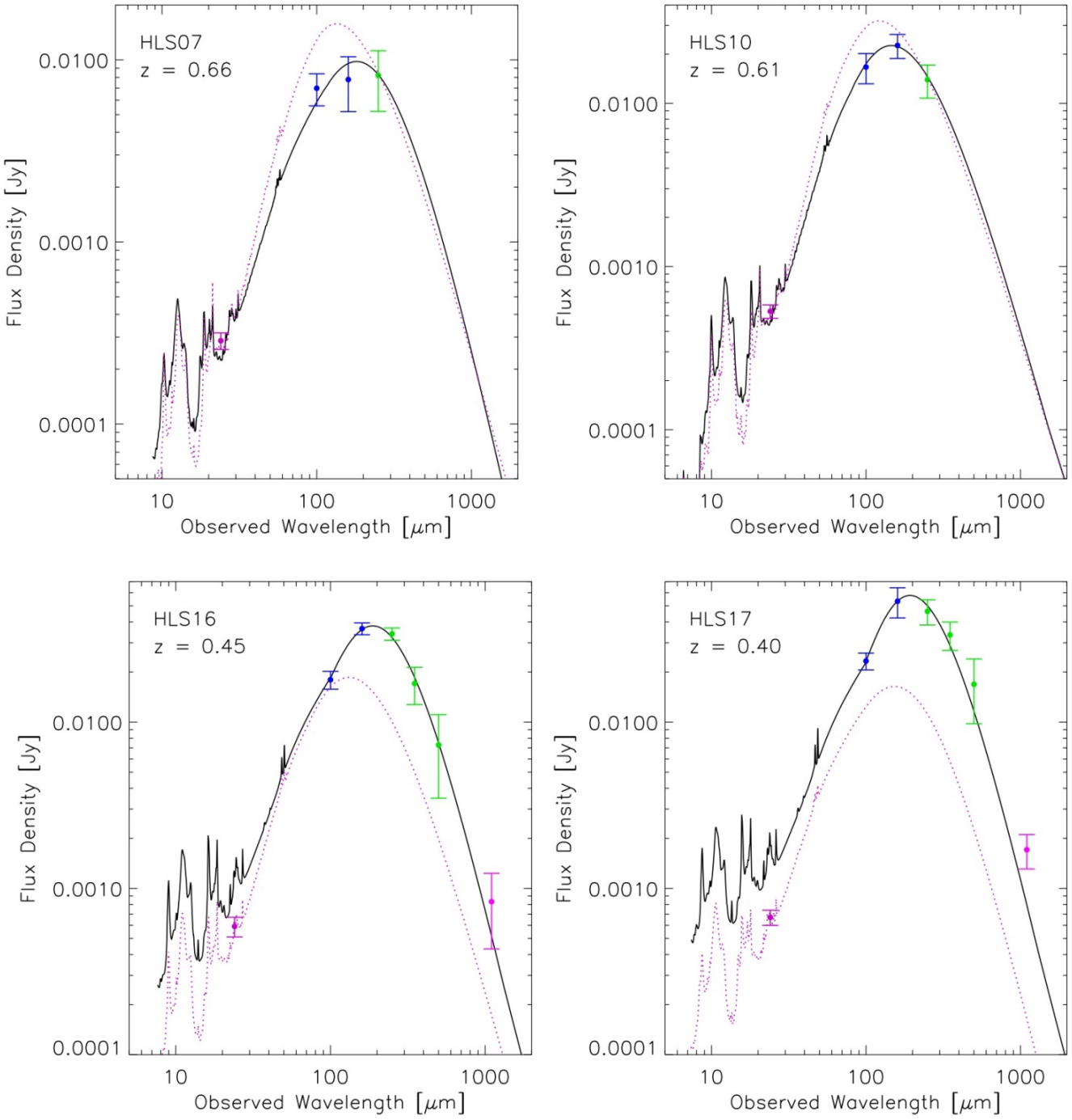
Properties of High-z Galaxy SEDs





IR/Submm SEDs of high-redshift galaxies appear colder than their local galaxies with Similar IR luminosities.

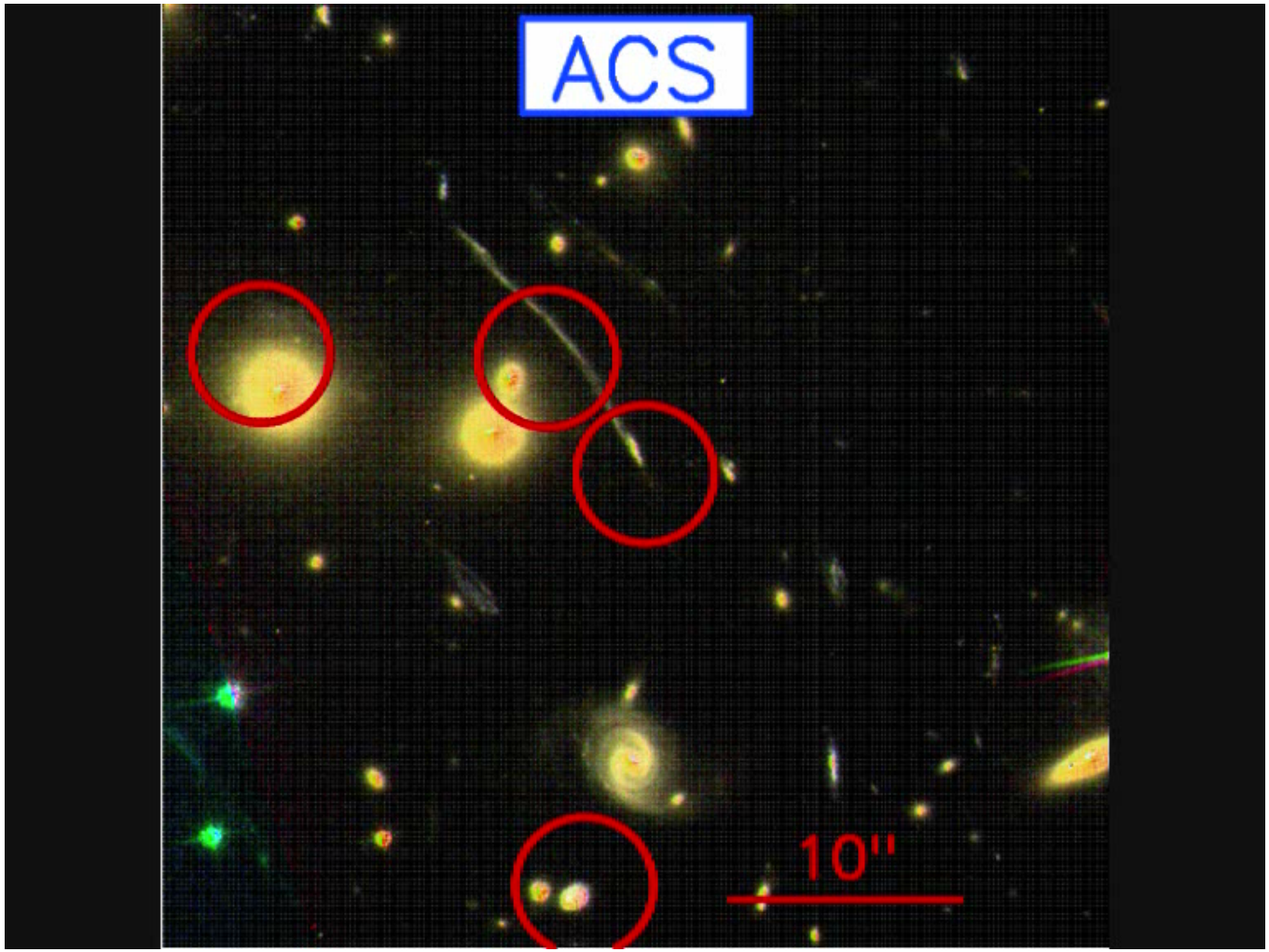
24um-derived SFRs/L_{TIR} tend to overestimate the true values.



Suggest that there's still a lot to learn about the properties of Far-IR/Submm galaxy SEDs.

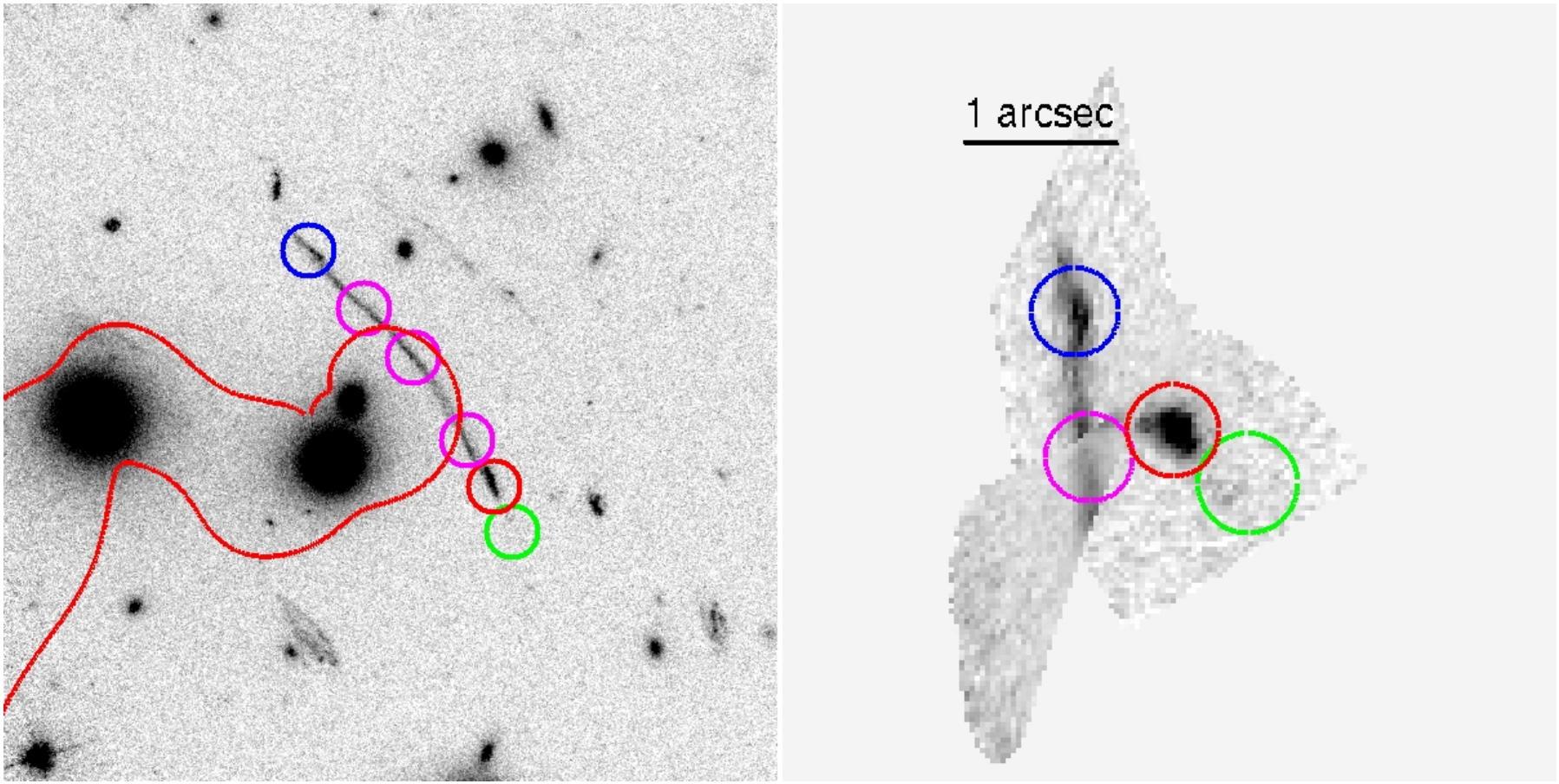
2. Multi-Wavelength Source Matching, Photometry & Far-IR/Submm Phot-z's

Perez-Gonzalez et al. (2010)

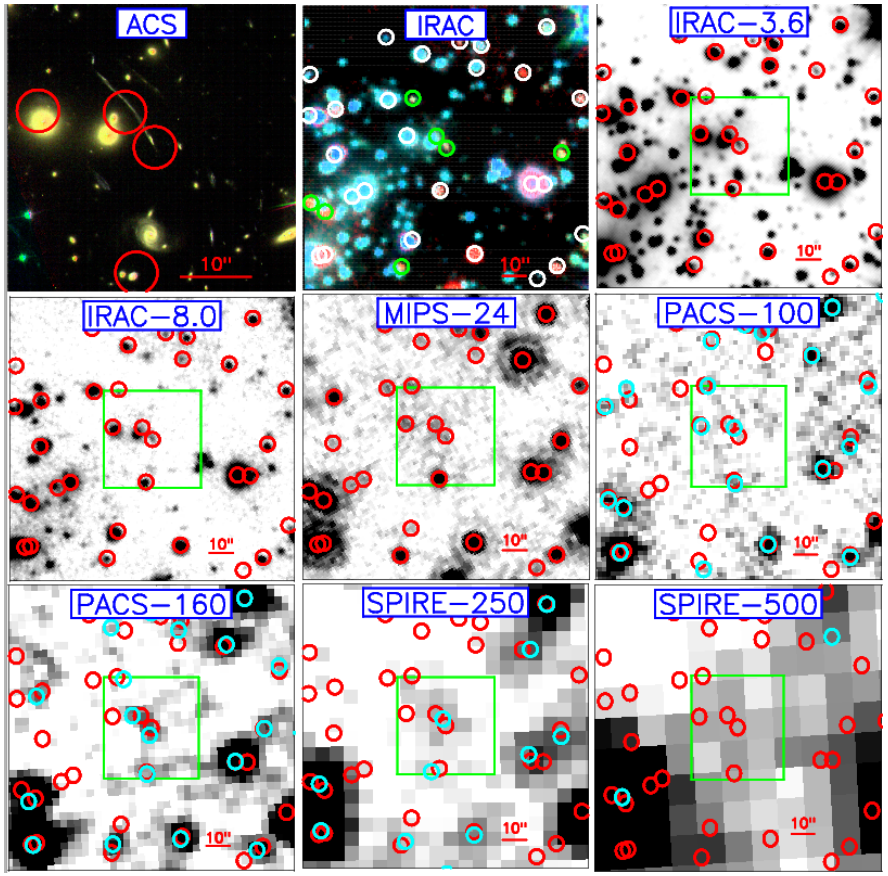


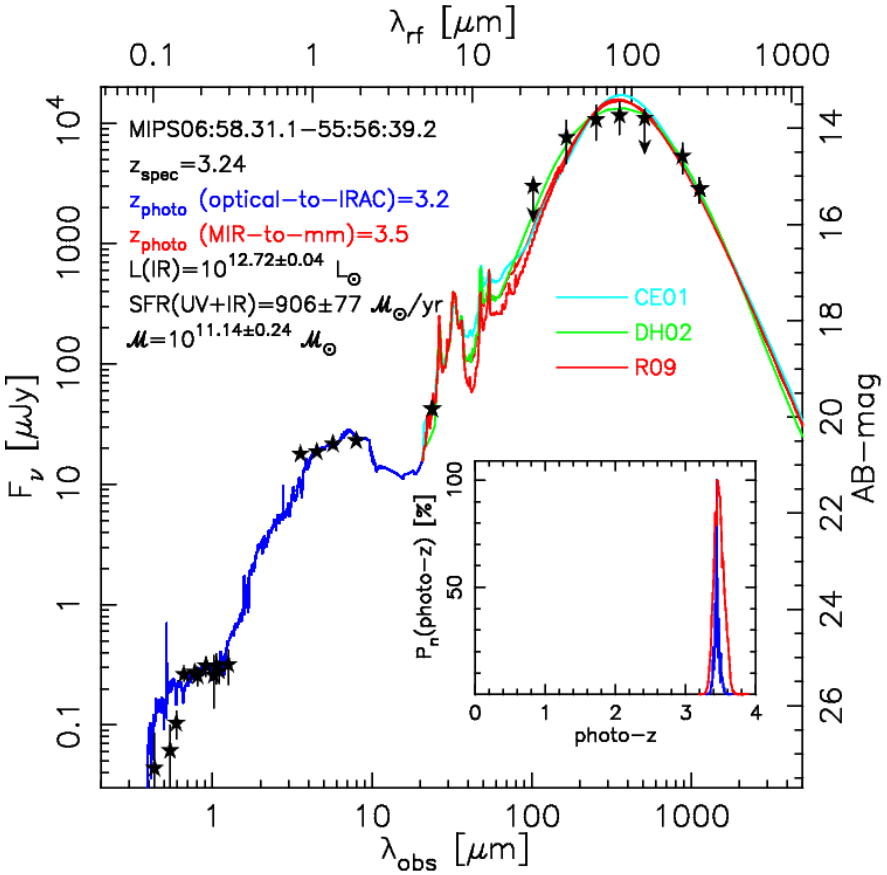
Z=3.24 giant lensed arc

HST Image Reconstruction in the Source Plane at z=3.24

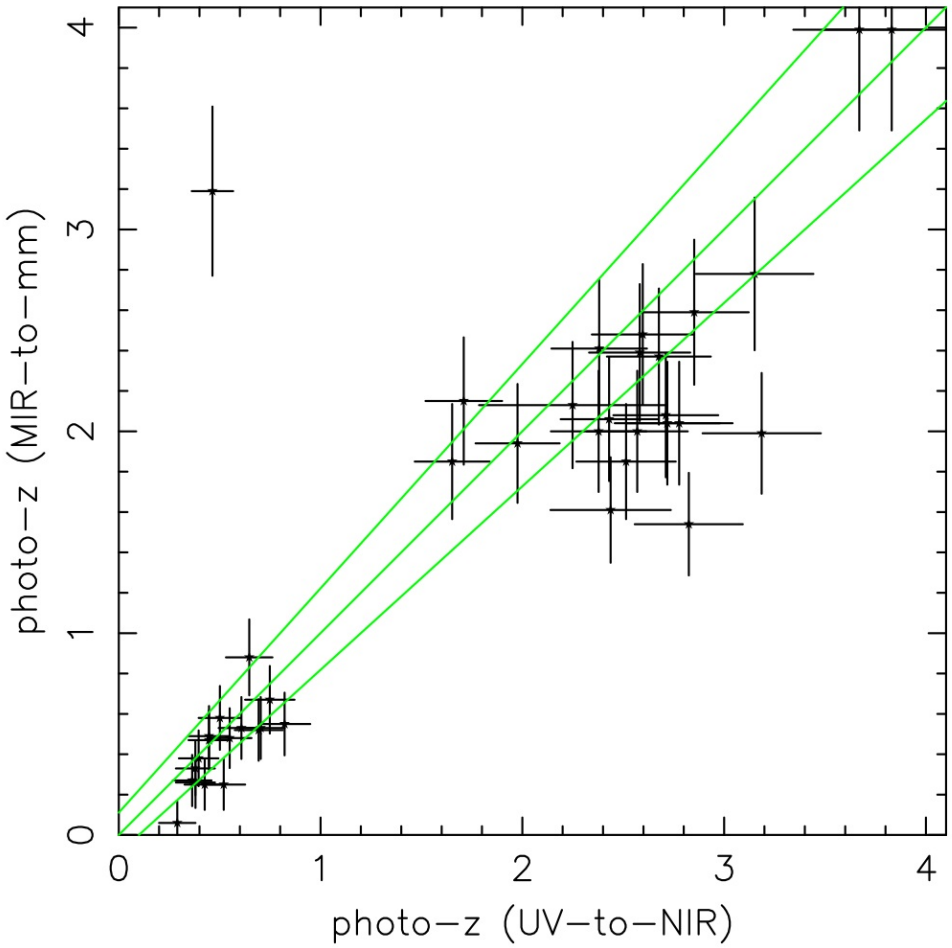


Full SED of the z=3.24 Lensed Galaxy





IR/Submm Phot-z's



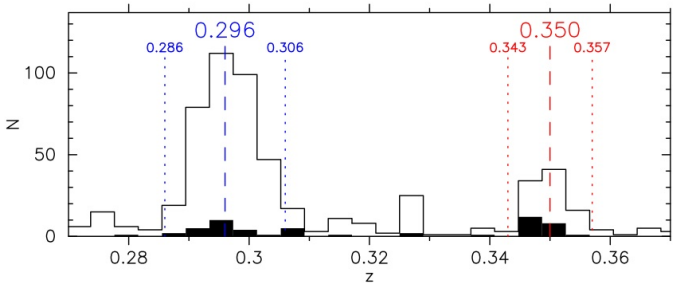
Preliminary results

Perez-Gonzalez, in prep

3. IR/Submm Properties of Galxaies in Dense Cluster Environment

Rawle et al. 2010; See his poster!

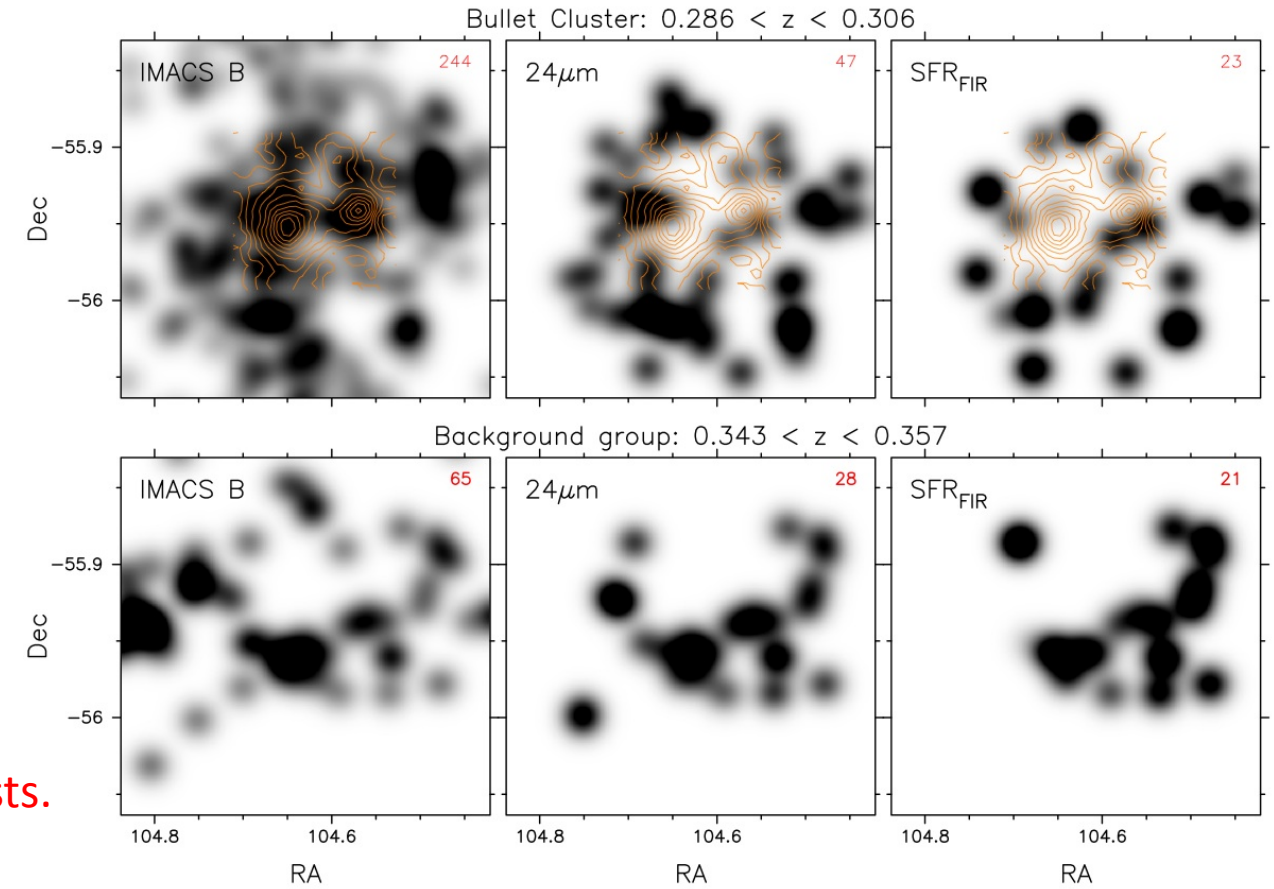
Comparing the Bullet Cluster (z=0.3) and the z=0.35 background system



144 $M_\odot$ yr^{-1} 207 $M_\odot$ yr^{-1}

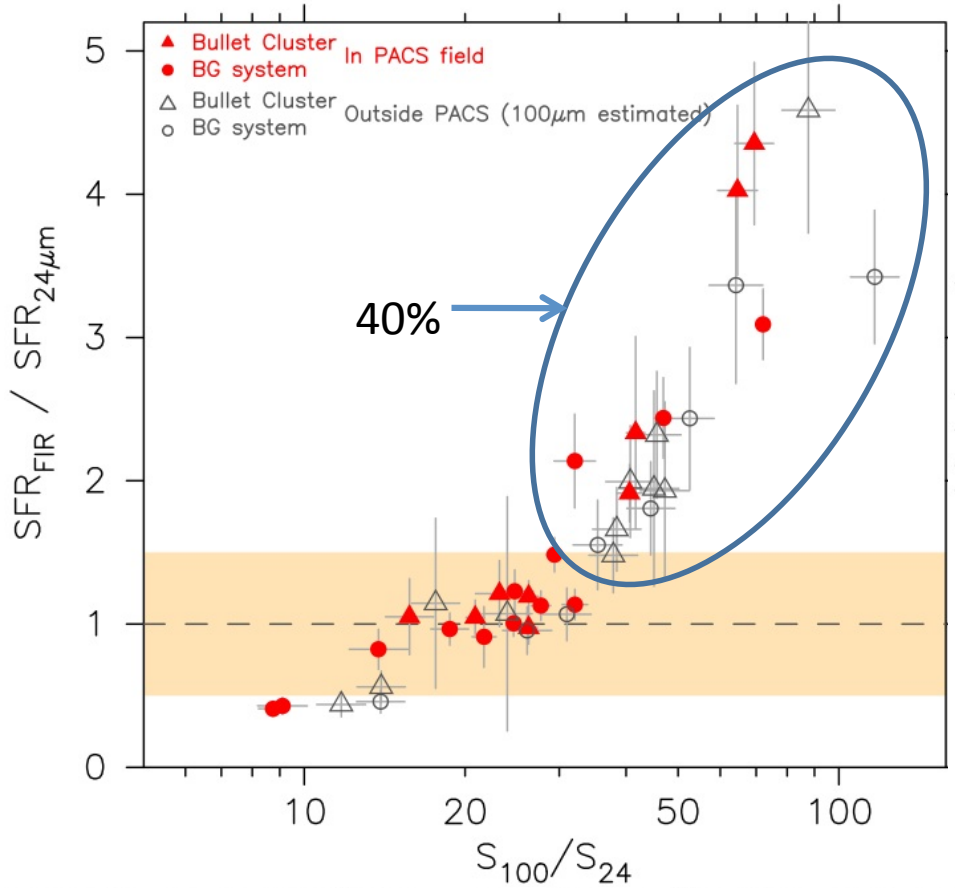
IR-derived total SFRs

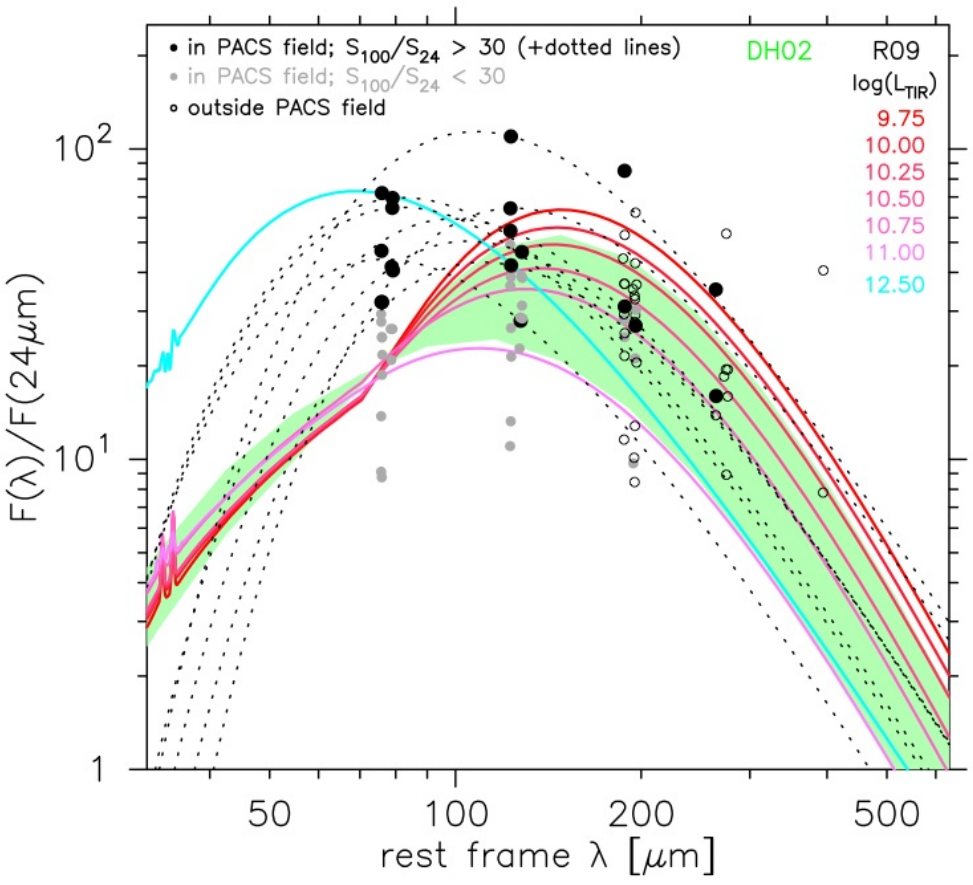
Cluster-cluster mergers may not be important for triggering IR-luminous starbursts.

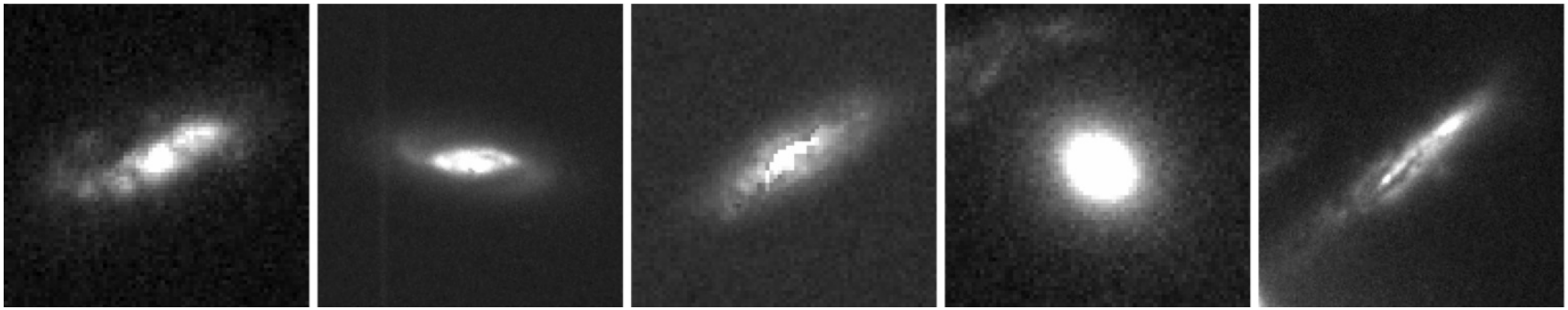


Discovery of 100 um-Excess Galaxies

Does the dense cluster environment modify the far-IR/Submm SED properties?



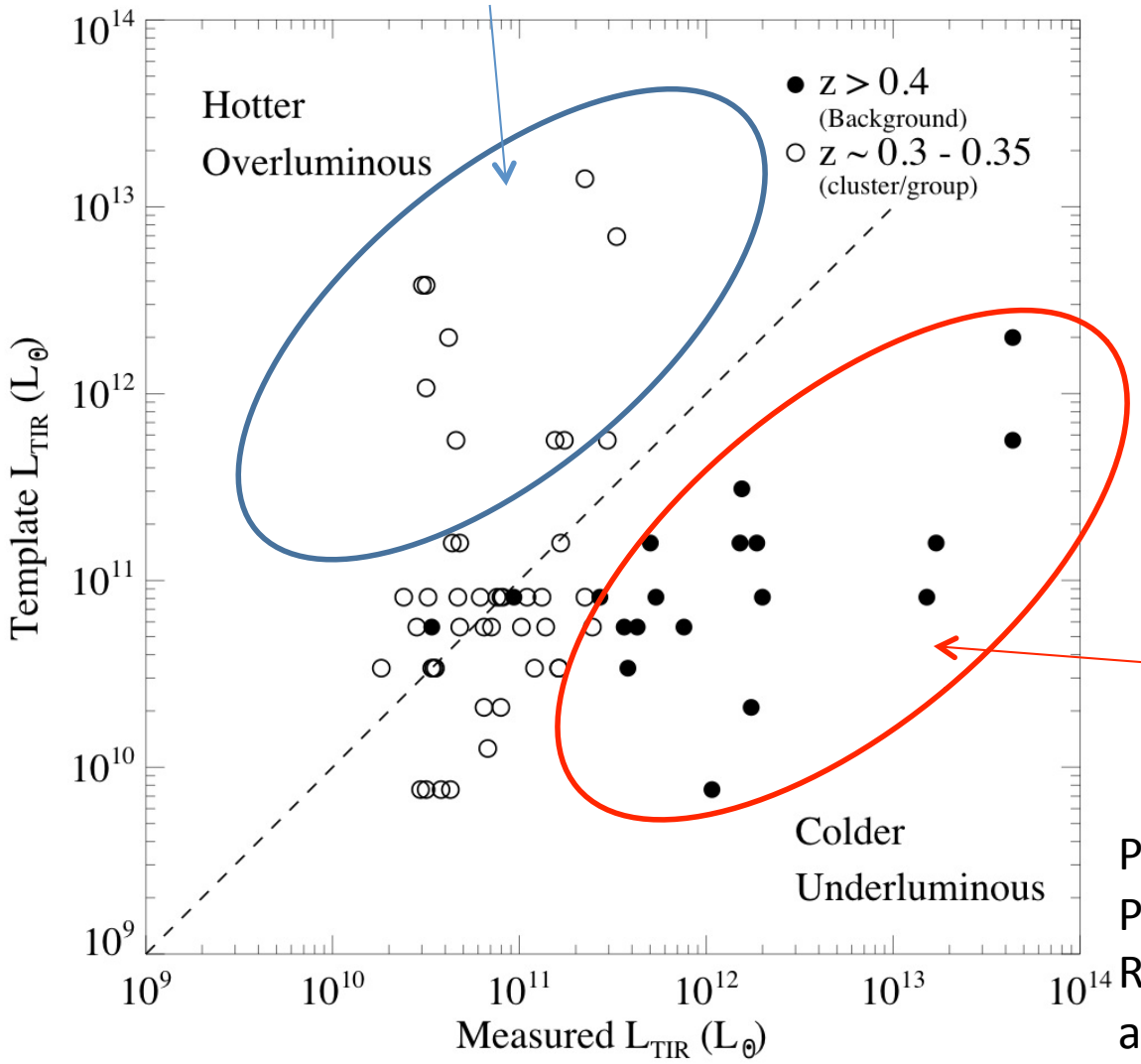




Diverse morphology

IR/Submm SED Properties: Summary

Surprise!!



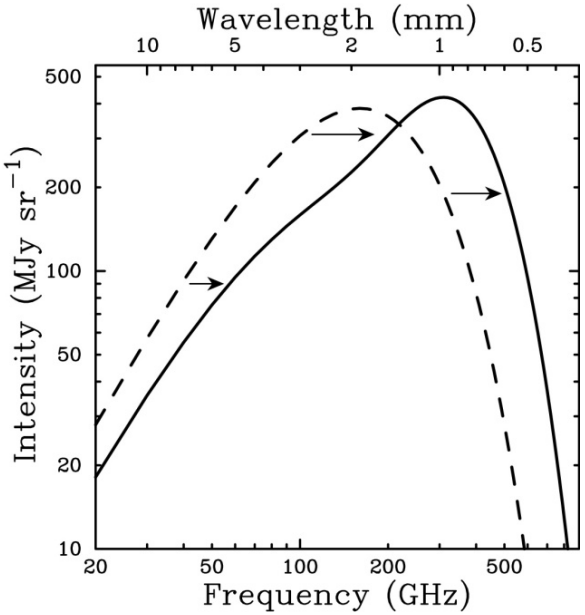
Consistent with Spitzer results.

Pope et al. (2006)
Papovich et al. (2007)
Rigby et al. (2008)
and etc…

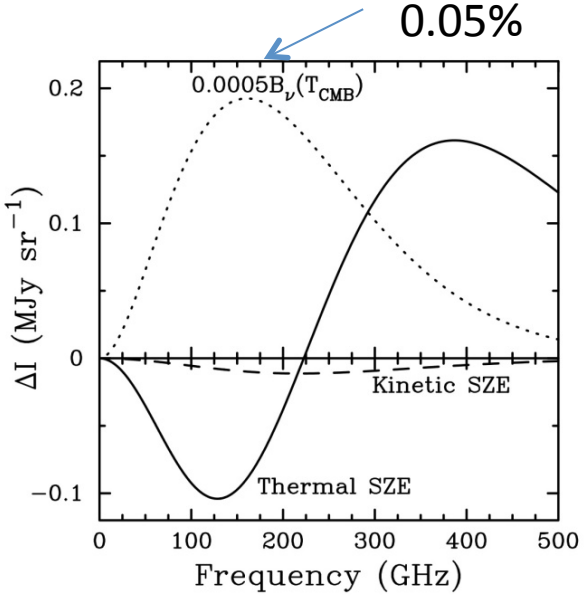
4. First Detection of the Sunyaev-Zel'dovich Effect Increment at < 650 um

Zemcov et al. (2010)

First, some introduction….

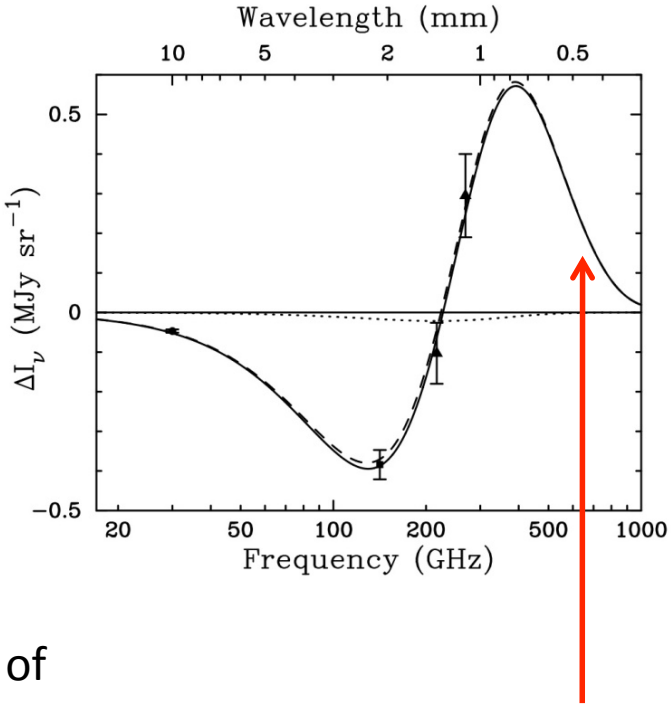


CMB photons gain energy when scattered by high energy electrons in ICM. (The effect exaggerated in the figure above.)



Resultant spectral distortion of the CMB due to the SZ effect.

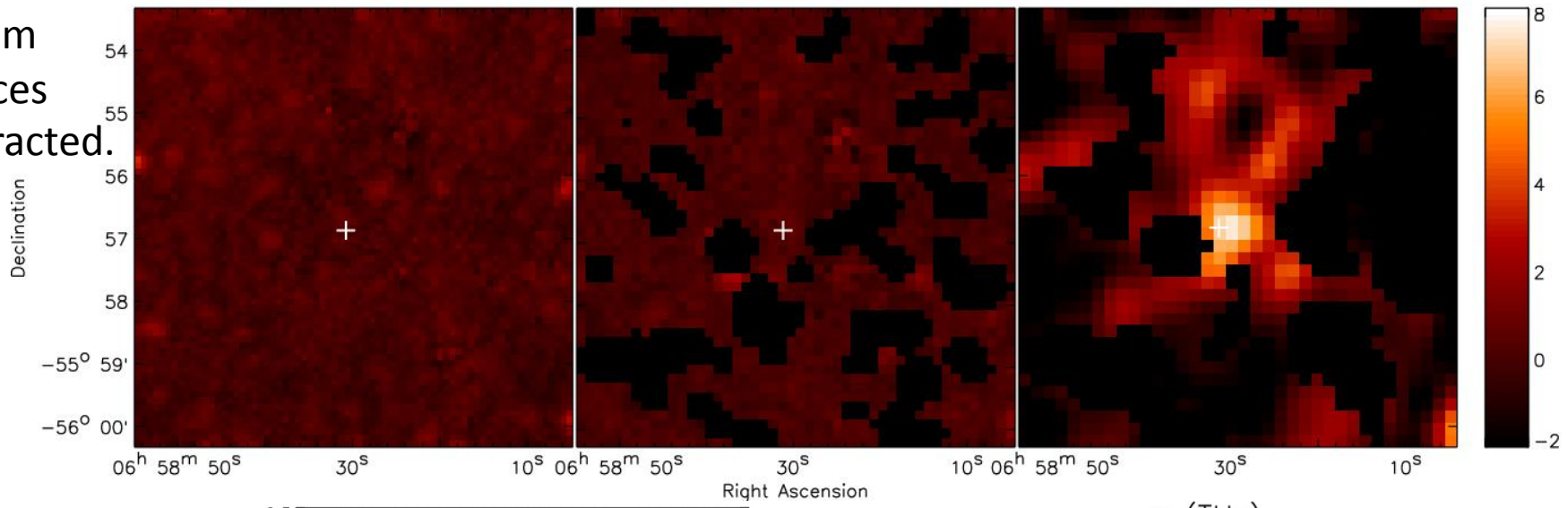
(from Carlstrom et al. 2002)



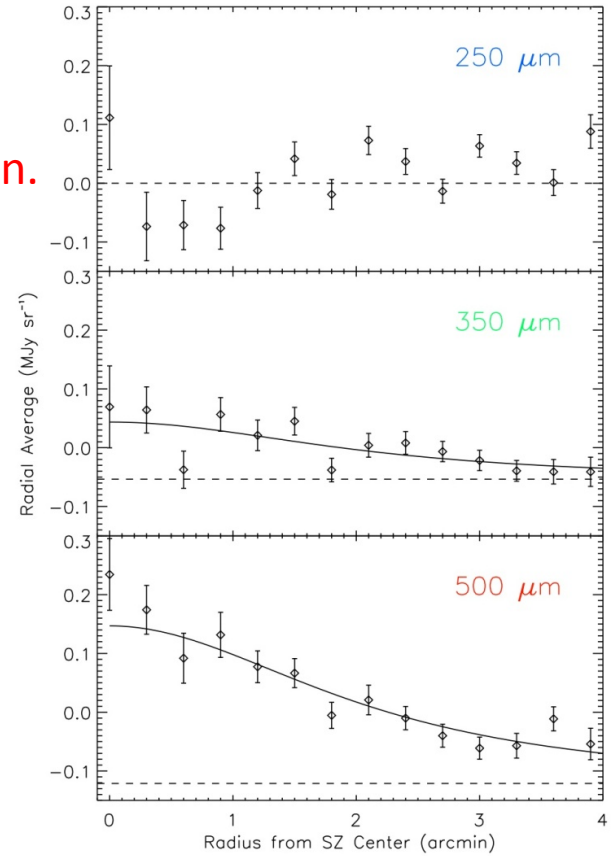
SPIRE will see this part of the SZ signal.

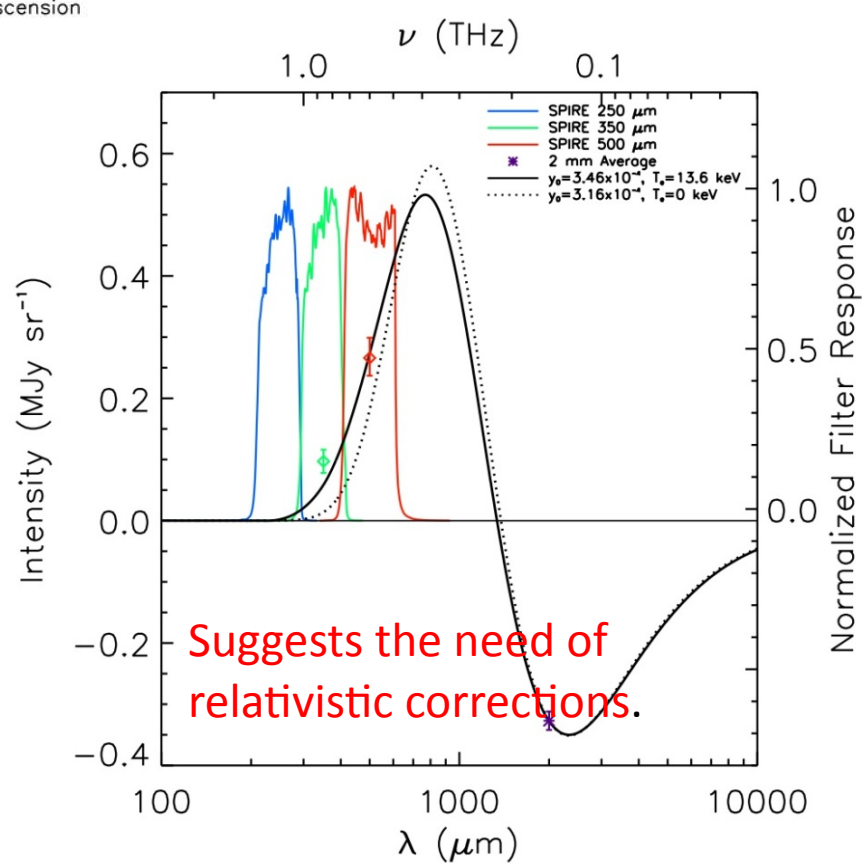
SPIRE 250 um SPIRE 350 um SPIRE 500 um

250um sources subtracted.



But no cluster diffuse emission.





Suggests the need of relativistic corrections.

Summary

- The Herschel Lensing Survey (HLS) is delivering what it promised (lensed high-z galaxies)…and more (cluster members, SZ effect)!
- SEDs of high-redshift IR-bright galaxies → colder (F_{24um} overpredicts L_{TIR} with local SEDs)
- SEDs of 100um-excess cluster-member galaxies → hotter (F_{24um} underpredicts L_{TIR} with local SEDs)
- SZ-effect increment clearly detected at 350/500um
  → Fits the expected SZ spectrum, but suggests relativistic corrections due to fast-moving electrons.
- Road ahead:
  - 39 more clusters to analyze in detail!
  - LABOCA, SCUBA2, LMT and various optical/near-IR observations proposed/planned for the near future.