

# The Herschel Lensing Survey: SDP Observations of the Bullet Cluster at z=0.297

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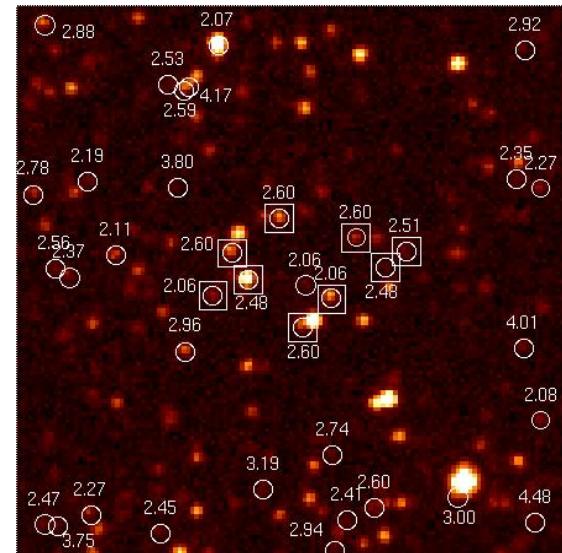
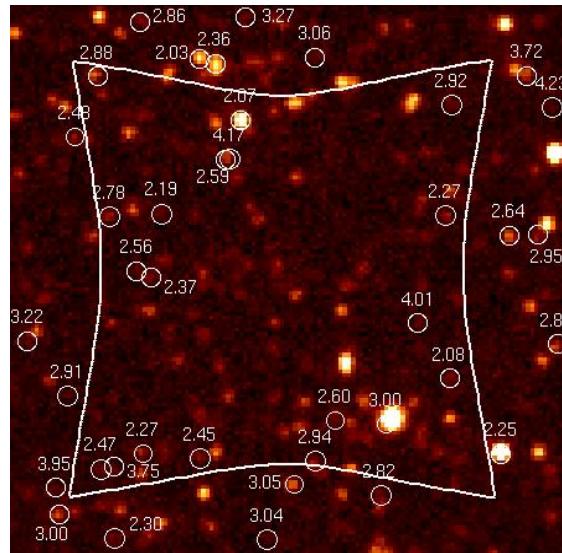
# HLS: Science Goal

- To detect sources that are **below the nominal confusion limits of Herschel** using the gravitational lensing power of massive galaxy clusters.

# Herschel Simulated Images of massive cluster cores

PACS  
100μm

Without  
lensing

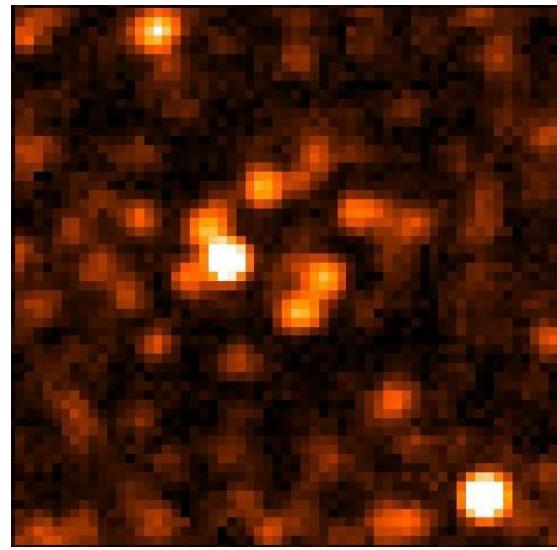
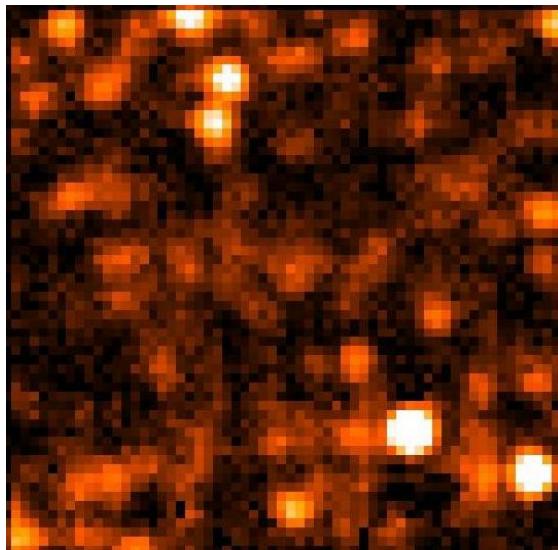


7'x7'

Squares  
-  $m > 5$

With  
lensing

SPIRE  
250μm



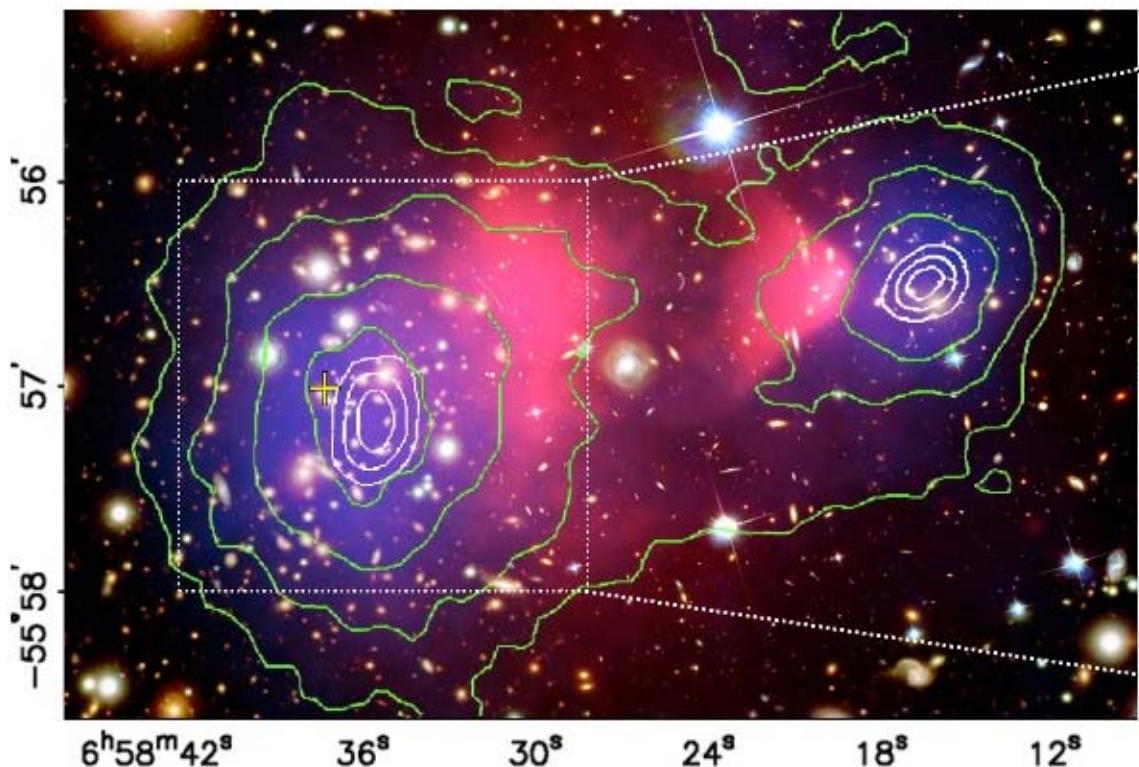
Clusters  
act as  
transparent  
lens

# Observing Parameters

- Total observing time: 292.3 hours
- 40 clusters (GT survey: 10 clusters)
- PACS (100/160 um, slow → medium scan,  
5.4hr/cl → ?)
- SPIRE (250/350/500 um; large map, 1.9hr/cl)
- Nominal FOV: 4'x4'
- 5 $\sigma$  sensitivity : 3.9/5.5/10/14/13 mJy
- 5 $\sigma$  (confusion): 2.9/ 11/25/29/25 mJy

# SDP: The Bullet Cluster

Original data from Clowe et al. (2006)



BLAST/AzTEC data

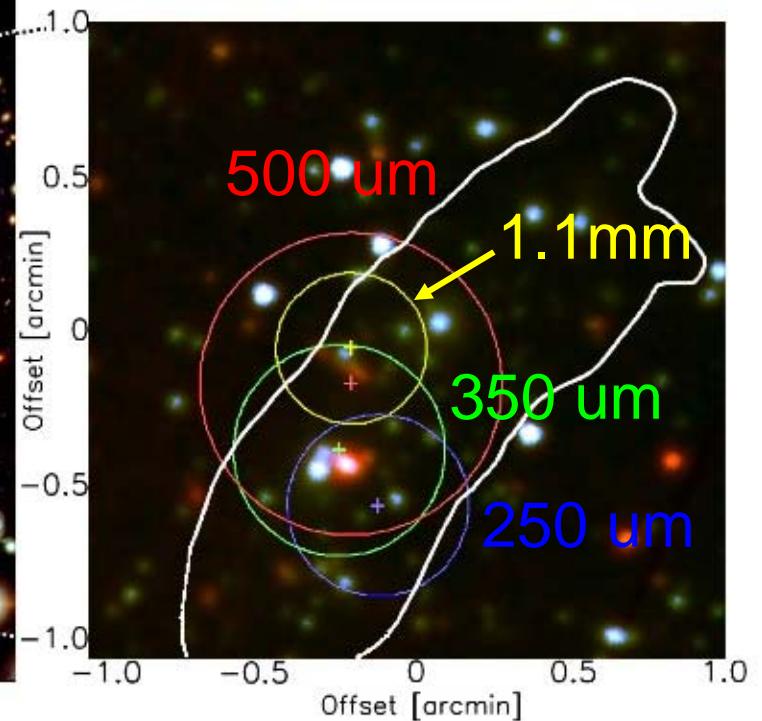
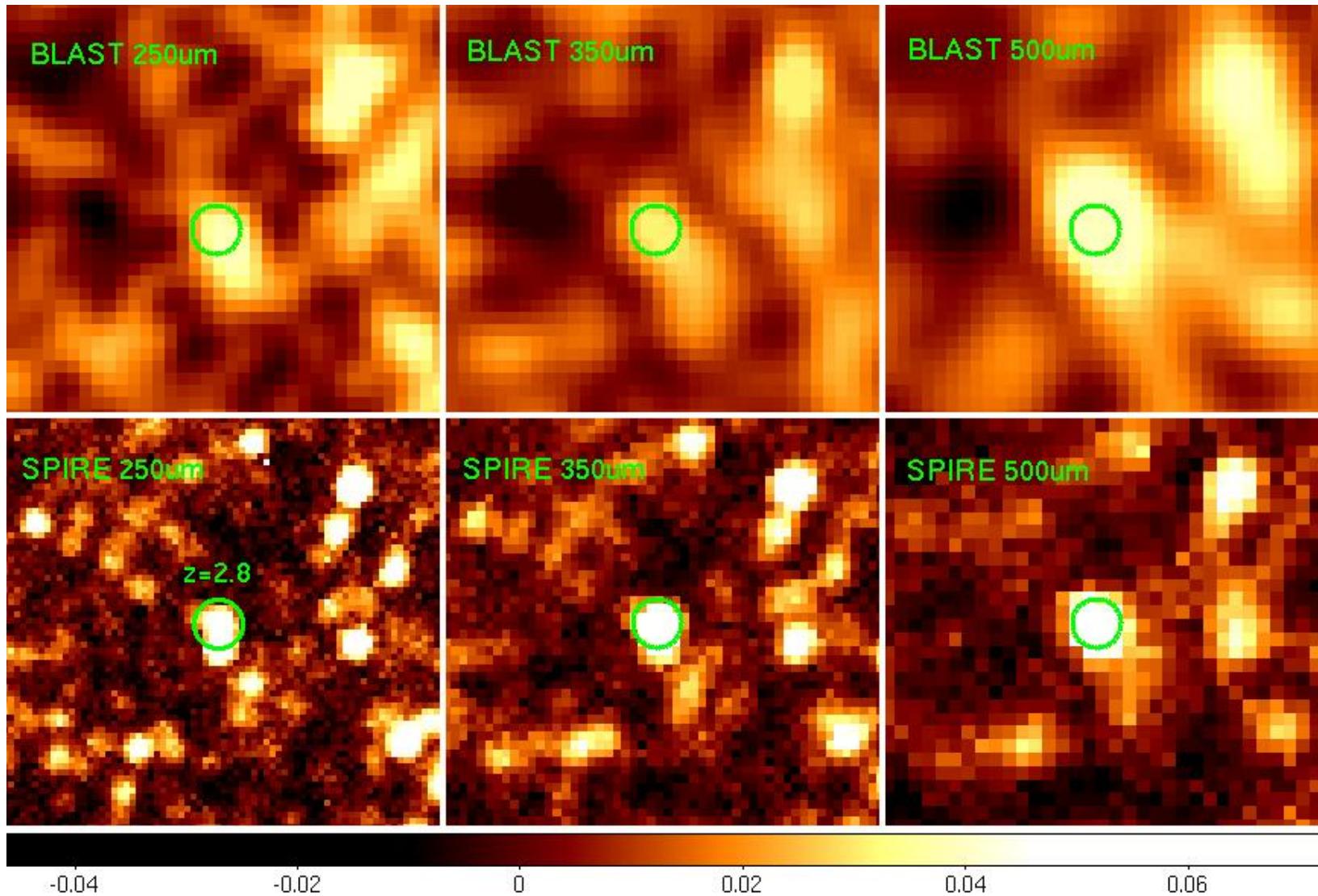


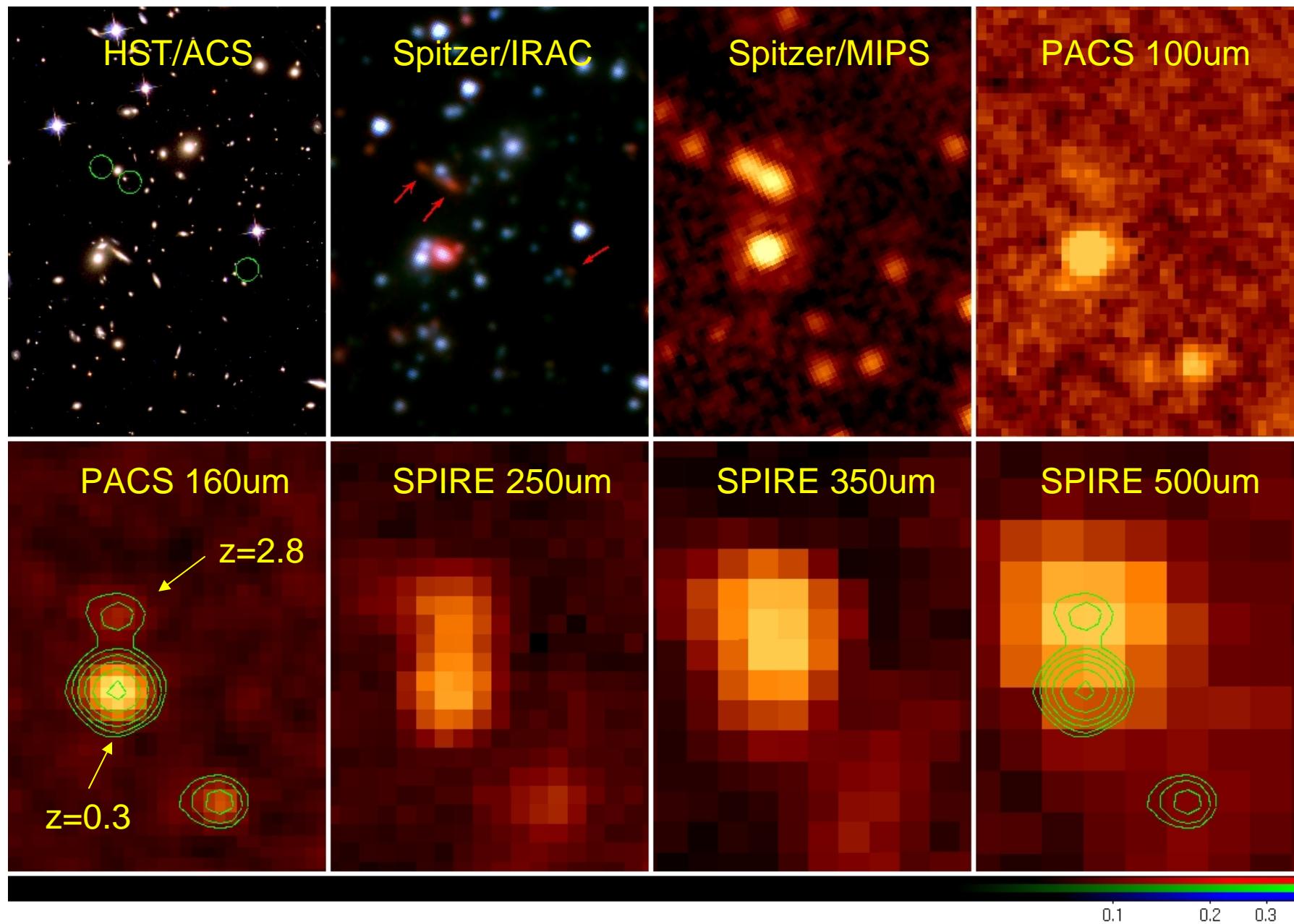
Figure from Rex et al. (2009)

Bright (13.5 mJy) strongly lensed ( $>x20$ ) mm galaxy at  $z=2.8$  (Wilson et al. 2008) detected by BLAST (Rex et al. 2009).

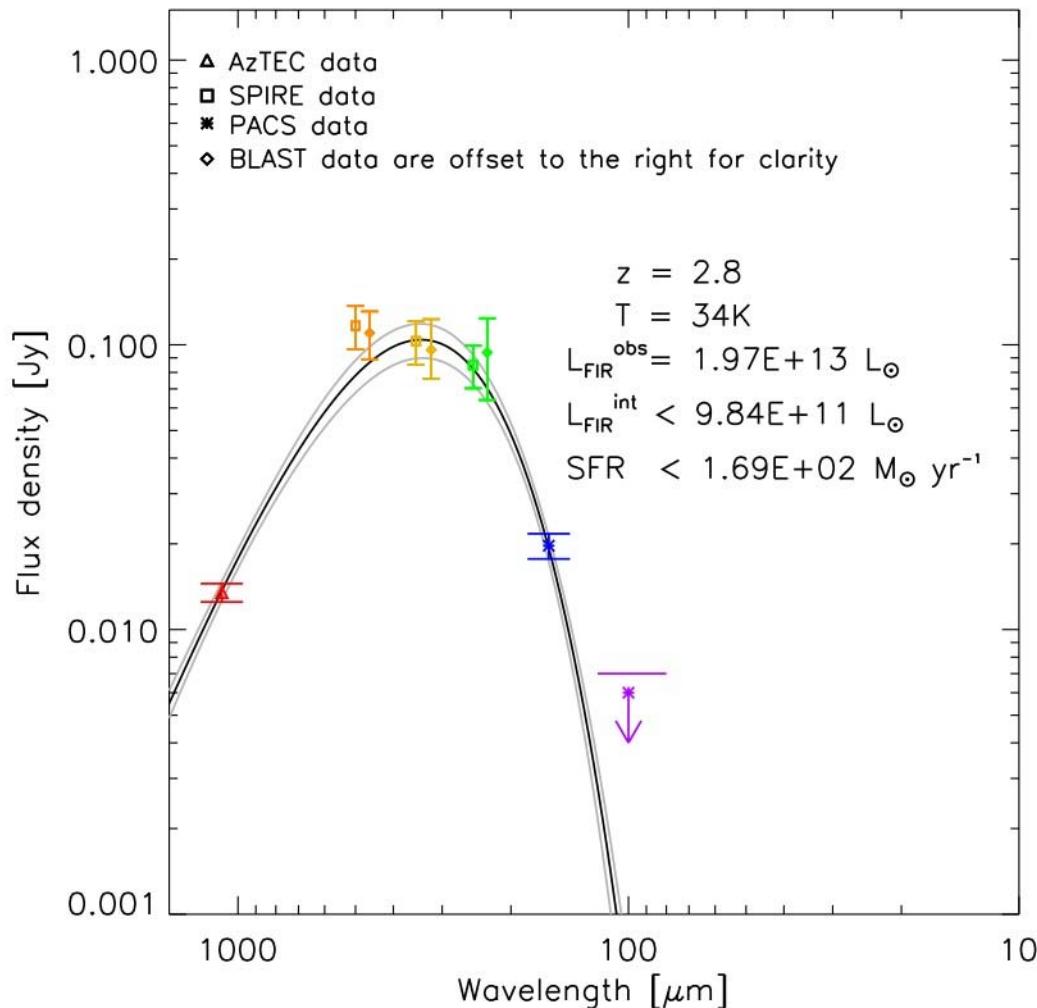
# BLAST vs. SPIRE



# Triply lensed IR-luminous galaxy at $z=2.8$



# Herschel+AzTEC SED

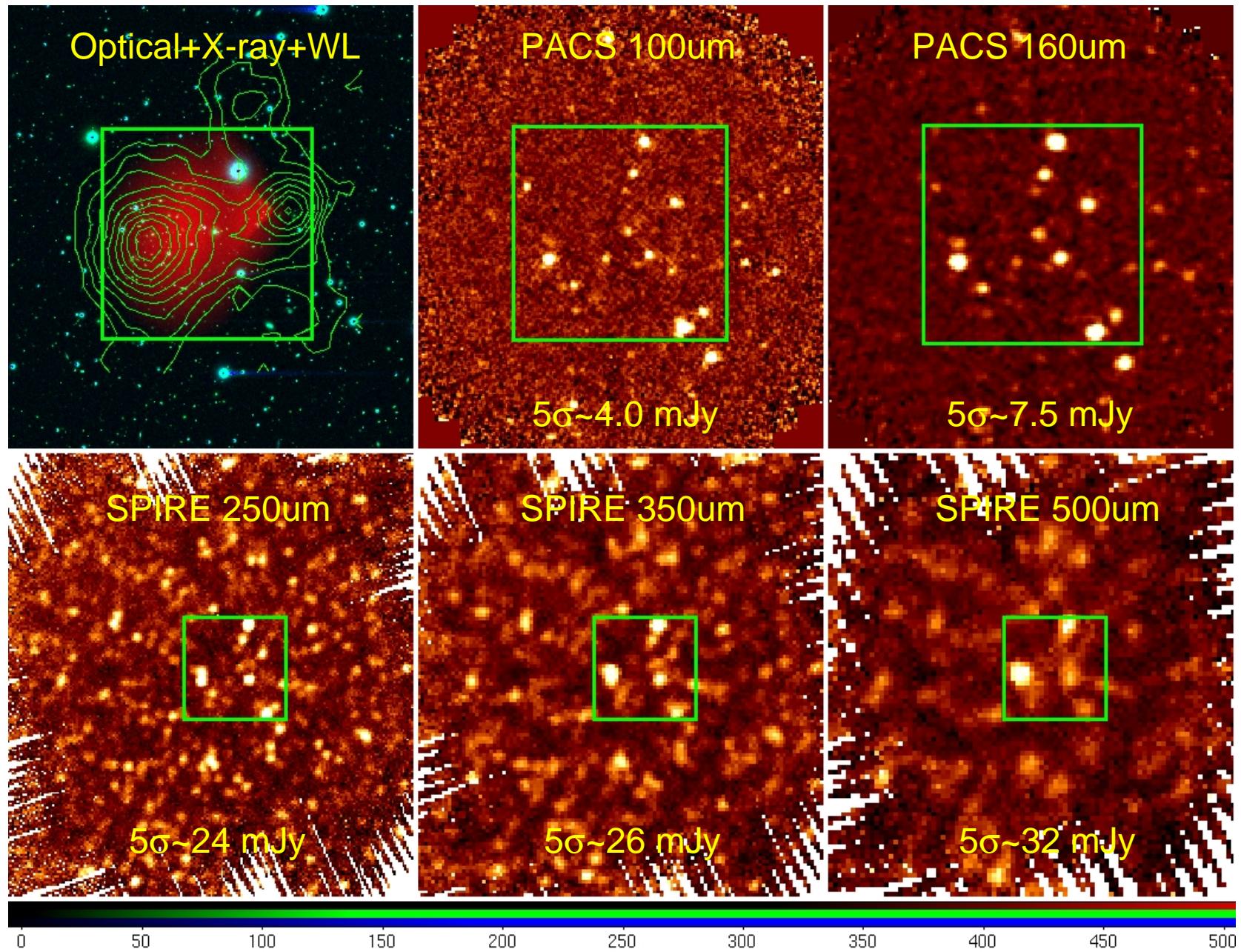


~100 mJy in the SPIRE Bands ( $L_{\text{IR}}=2\times10^{13} L_{\odot}$ )

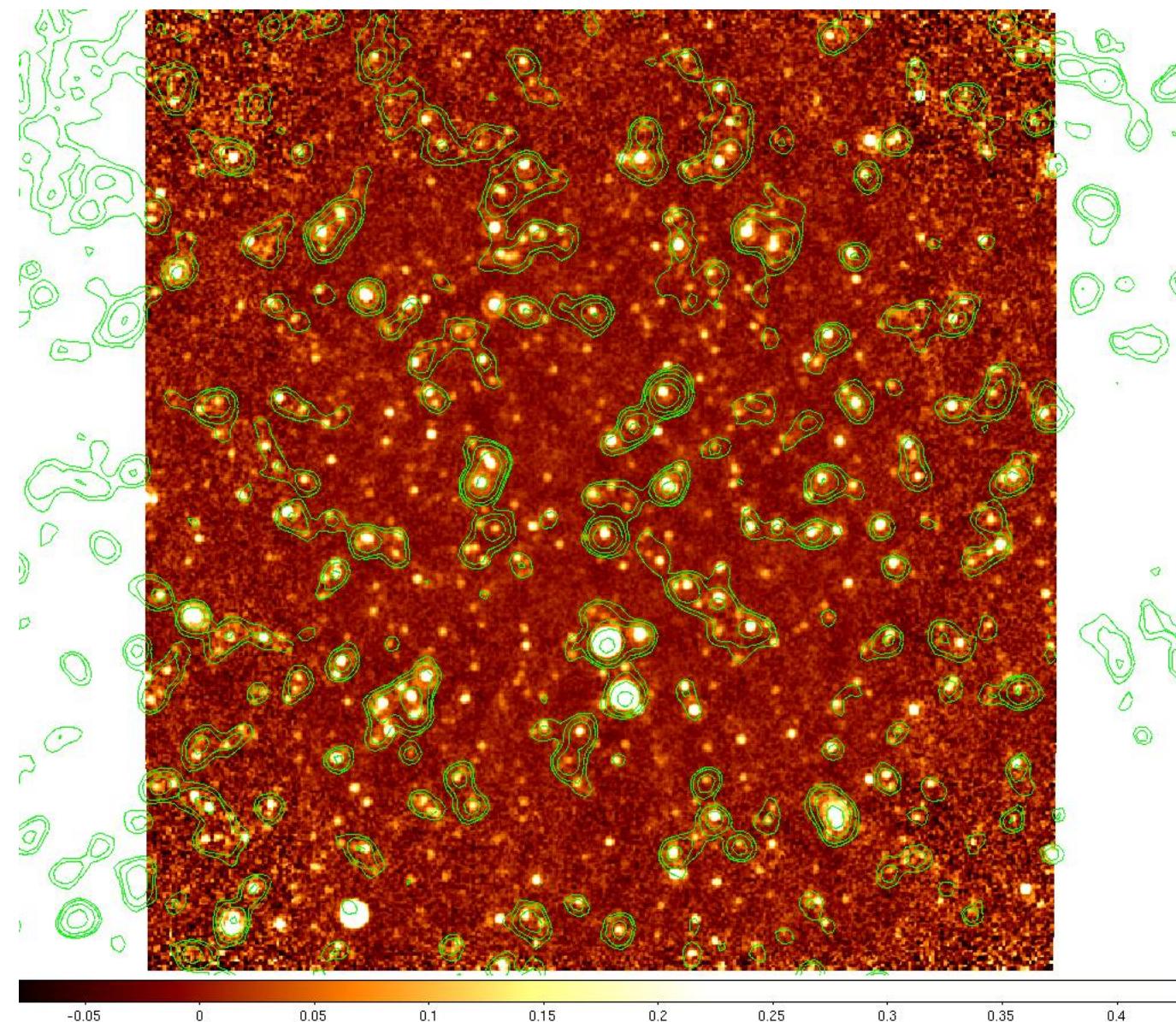


- (1) If mag = x20,  
~5 mJy without mag  
 $L_{\text{IR}} \sim 10^{12} L_{\odot}$
- (2) If mag = x75,  
~1.3 mJy without mag  
 $L_{\text{IR}} \sim 3\times10^{11} L_{\odot}$

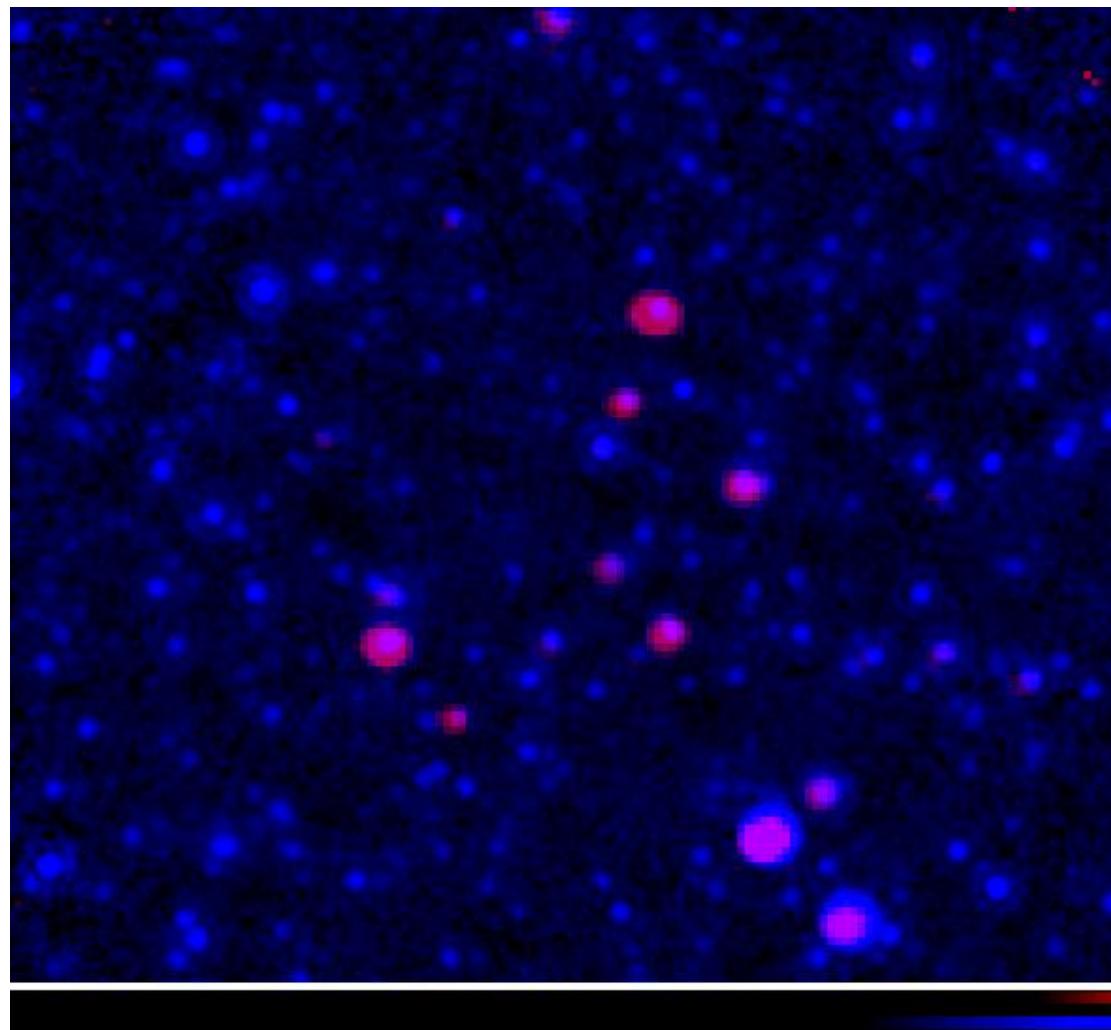
# The Bullet Cluster Herschel Maps



# MIPS 24um vs. SPIRE 250 um



# MIPS 24um vs. PACS 160 um

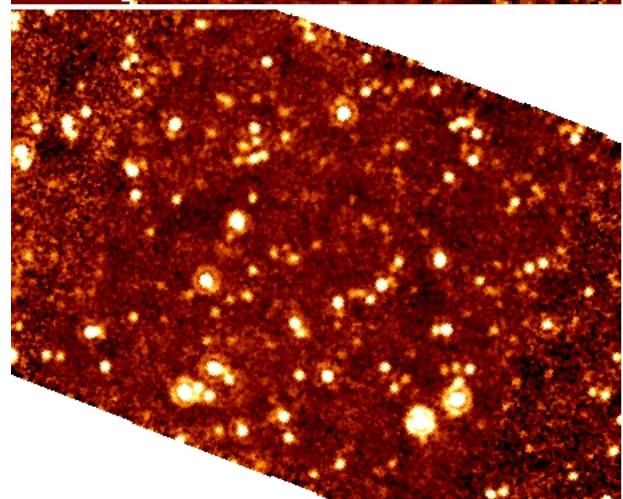
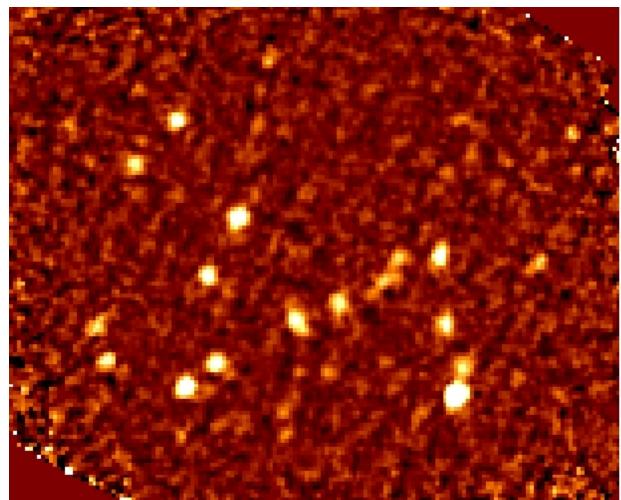


# Bullet Cluster Ancillary Data

- HST images
- Spitzer images (IRAC + MIPS 24um)
- IMACS images (D. Clowe et al.)
- IMACS spectra (A. Gonzalez et al.)
- ASTE/AzTEC 1.1 mm map
- APEX/LABOCA 870um map

# HLS vs. LoCuSS

HLS PACS 160um



-0.0006

-0.0004

-0.0002

0

0.0002

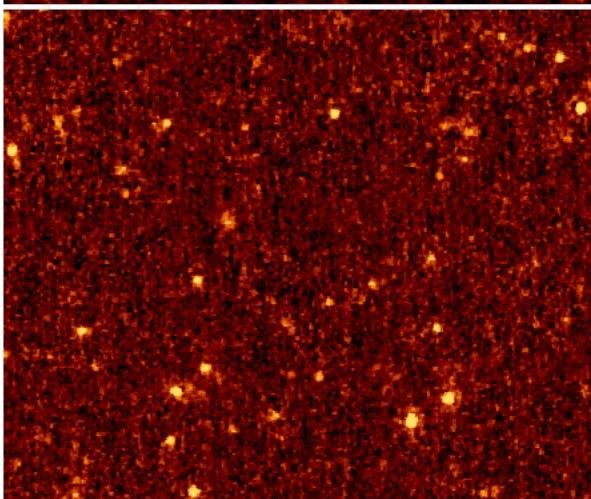
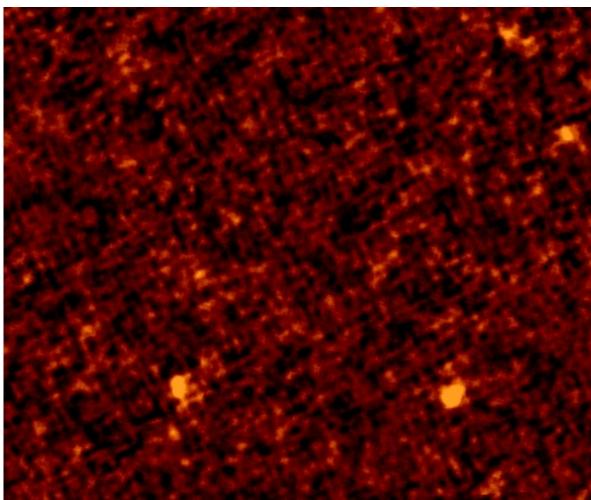
0.0004

0.0006

0.0008

Deep MIPS 24um

LoCuSS PACS 160um



-0.0002

-0.0001

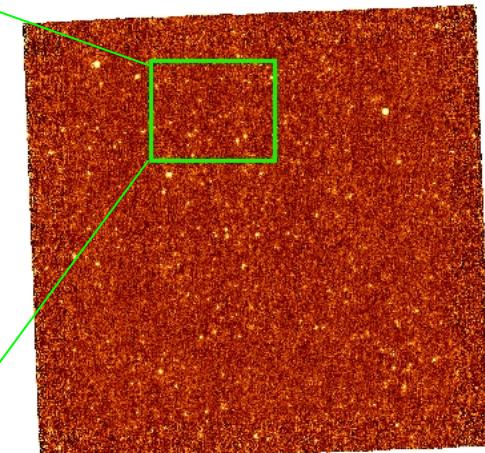
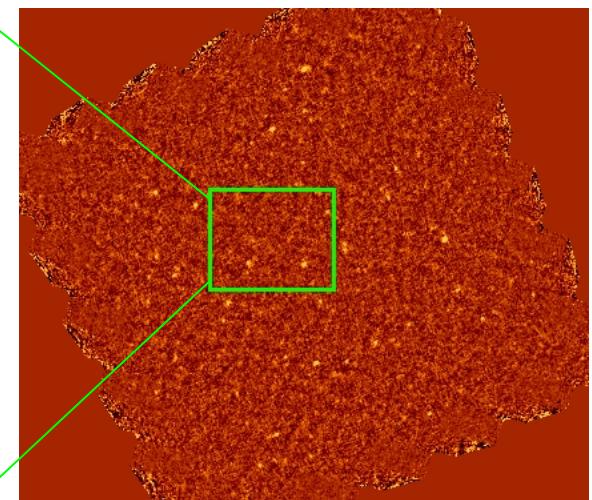
0

0.0001

0.0002

Wide MIPS 24um

LoCuSS PACS 160um



-0.0002

-0.0001

0

0.0001

0.0002

Wide MIPS 24um

# Summary & Current Status

- Herschel data are as **high-quality** as promised, and HIPE is already producing **science-grade maps!**
- The Bullet Cluster SDP observations have demonstrated **the power of our lensing survey approach.**
- 23 out of 40 targets will be observed by the end of this month.
- Now the main question is whether we can keep up with the data inflow rate....

*We would like to thank,*

*- the Herschel project office and instrument teams  
for creating this great observatory, and  
- HSC, NHSC for the excellent user support !*