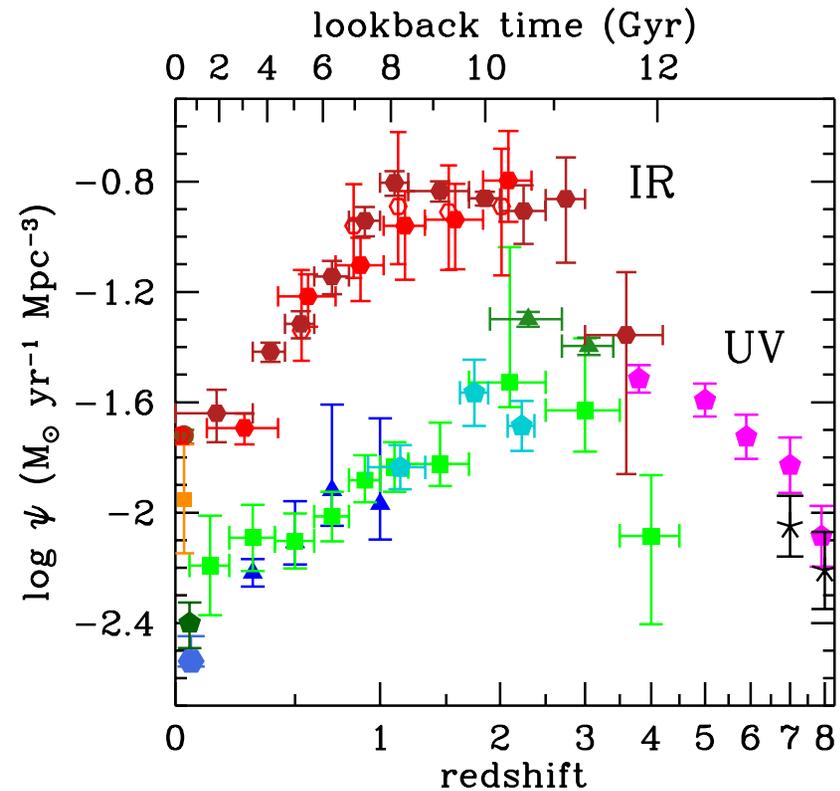
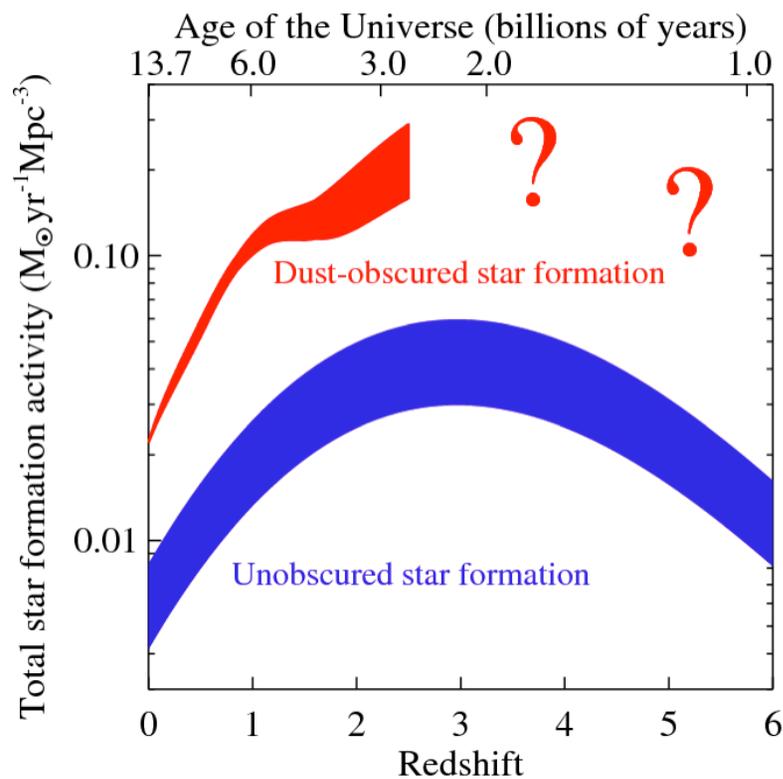


Taking Census of Dust-obscured Star Formation in all Galaxies over Cosmic Time



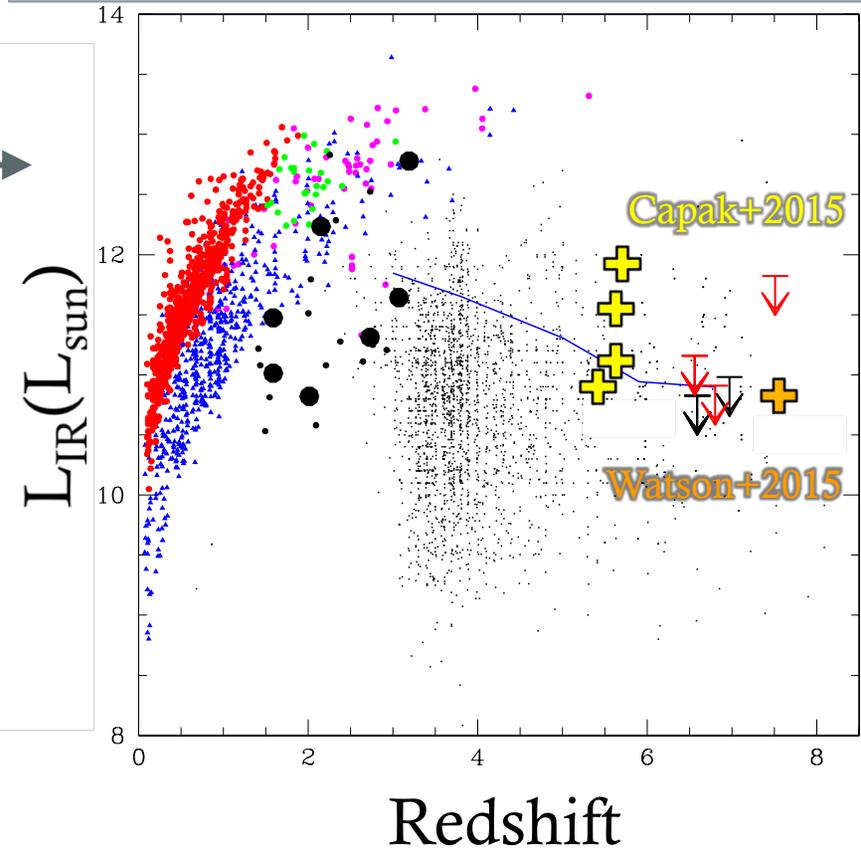
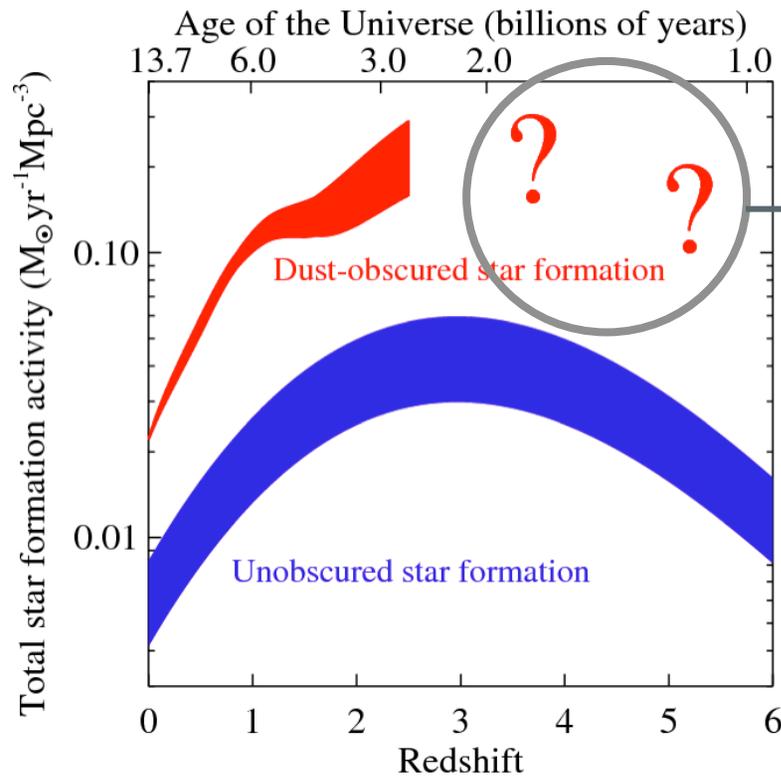
Alexandra Pope (UMass Amherst)
RMS Science Futures in the 2020s meeting
Chicago - December 16, 2015

Dust-obscured activity dominates the build-up of stars (and black holes) in galaxies



Dust-obscured activity dominates the build-up of stars (and black holes) in galaxies

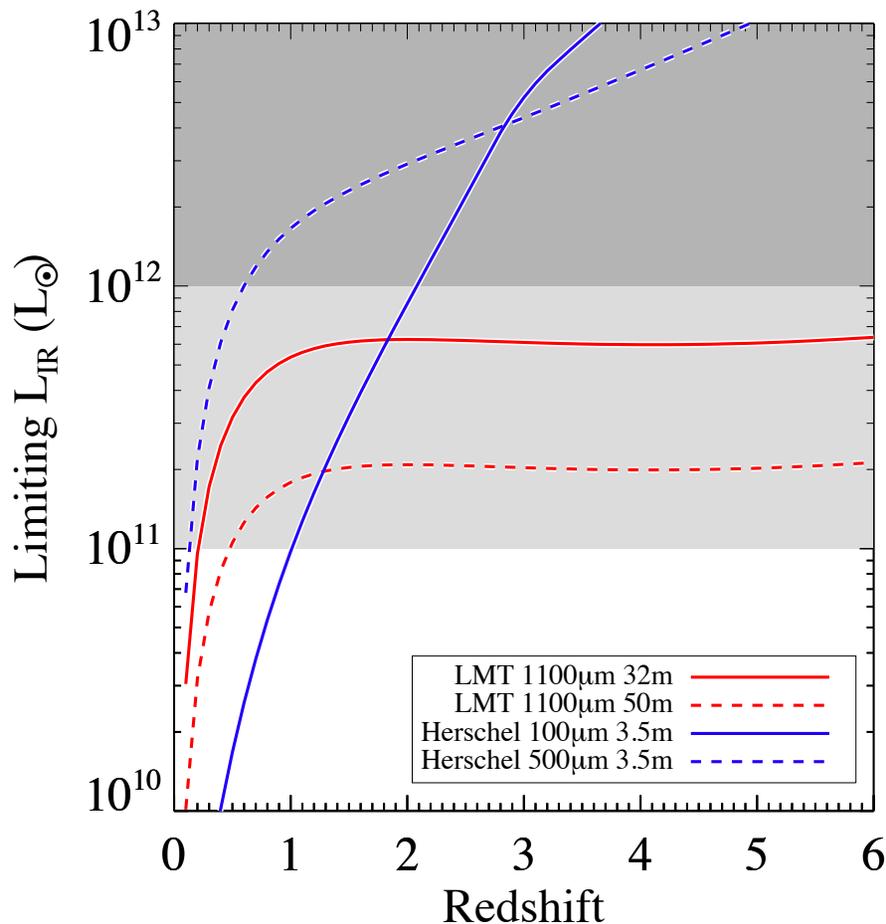
BUT we have only detected dust in a handful of *normal* galaxies at $z > 3$



Using data from Bouwens+2009 and Murphy+2011

Adapted from Schaerer et al. 2015

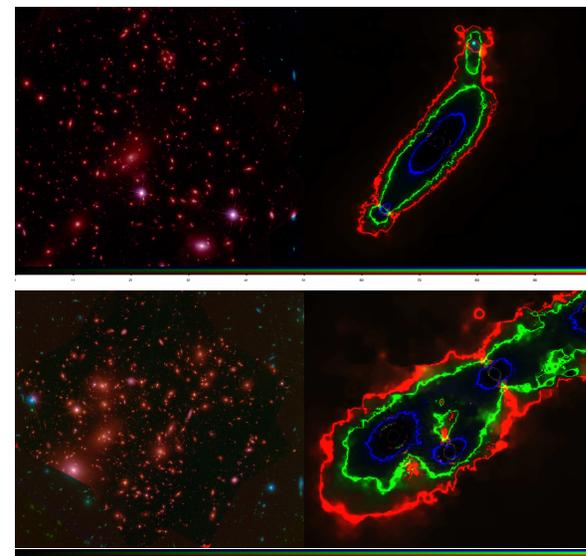
How can we reach the depths needed to detect dust in normal galaxies at $z > 3$?



NOW:

Low redshift clusters = Cosmic telescopes

The *HST* Frontier Fields Program



LMT Frontier Fields (FF) Program

<http://www.astro.umass.edu/~pope/FF/>

PIs: **Alexandra Pope (UMass)**, Alfredo Montaña (INAOE, Mexico)

Team:

Umass/FCAD: Daniela Calzetti, Mauro Giavalisco, James Lowenthal, **Grant Wilson (AzTEC PI)**, Kate Whitaker, **Min Yun**, Adam Battista, Joe Burchett, Ryan Cybulski, Mihwa Han, Allison Kirkpatrick, Chris Thibodeau

INAOE: Itziar Aretxaga, Daniel Ferrusca, **David Hughes**, Jonathan León Tavares, Manolis Plionis, Daniel Rosa Gonzalez, Elena Terlevich, Roberto Terlevich, Olga Vega, Miguel Velázquez, Milagros Zeballos, Emmaly Aguilar, David Sánchez, Jorge Zavala

UNAM: Vladimir Ávila Reese, Víctor de la Luz, Octavio Valenzuela

U. Guanajuato: Héctor Bravo Alfaro

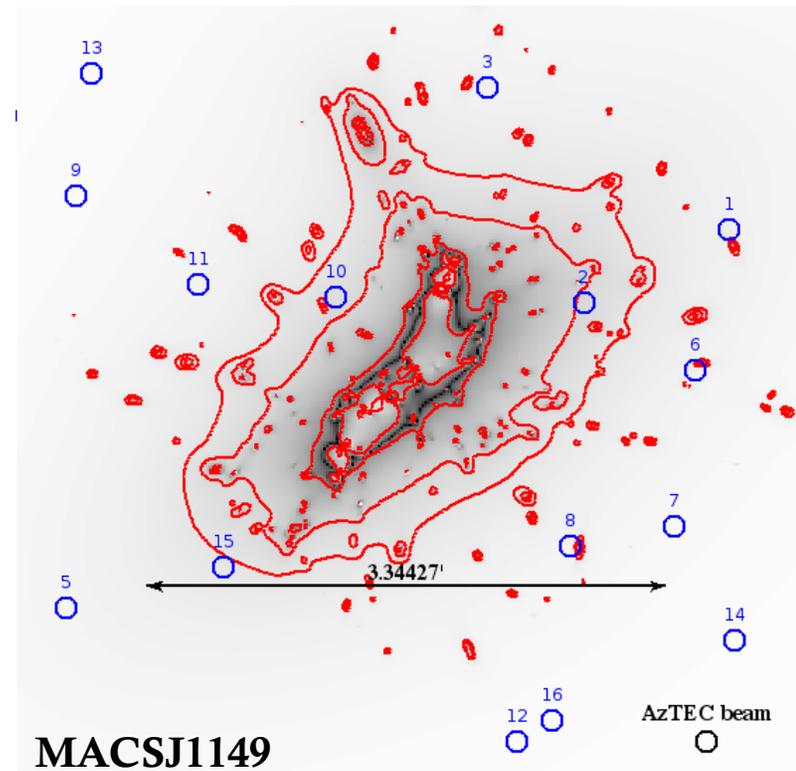
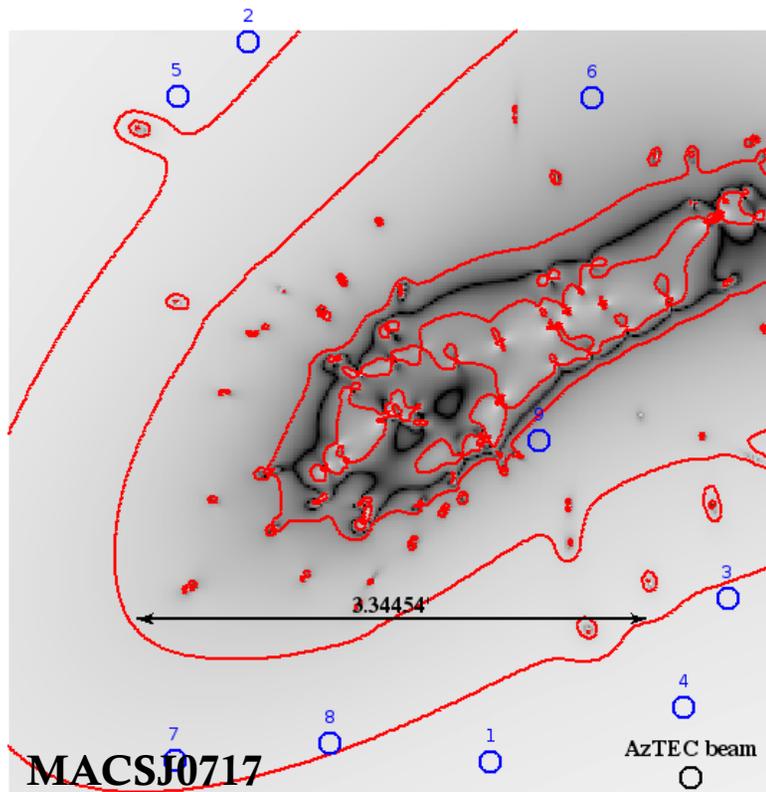
External: Erica Keller (NRAO), Danilo Marchesini (Tufts), **Phil Maukopf (ASU)**, **Eric Murphy (IPAC)**, Brian Siana (UCR), Jennifer Lotz (STScI), Stacey Alberts (UAz), Christina Williams (UAz)

Observations:

2014-2015: AzTEC 1.1mm imaging of the primary *HST* field (20 sq arcmin) around two northern FF clusters: MACS J0717.5+3745 ($z=0.545$) and MACS J1149.5+2223 ($z=0.543$)

<u>Cluster</u>	<u>Hours observed</u>	<u>1 σ depth (mJy)</u>
MACSJ0717	21.1	0.22
MACSJ1149	25.4	0.25

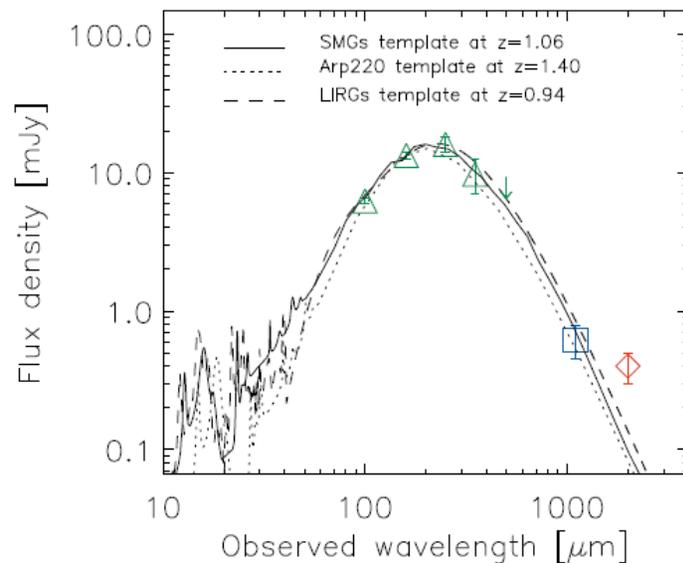
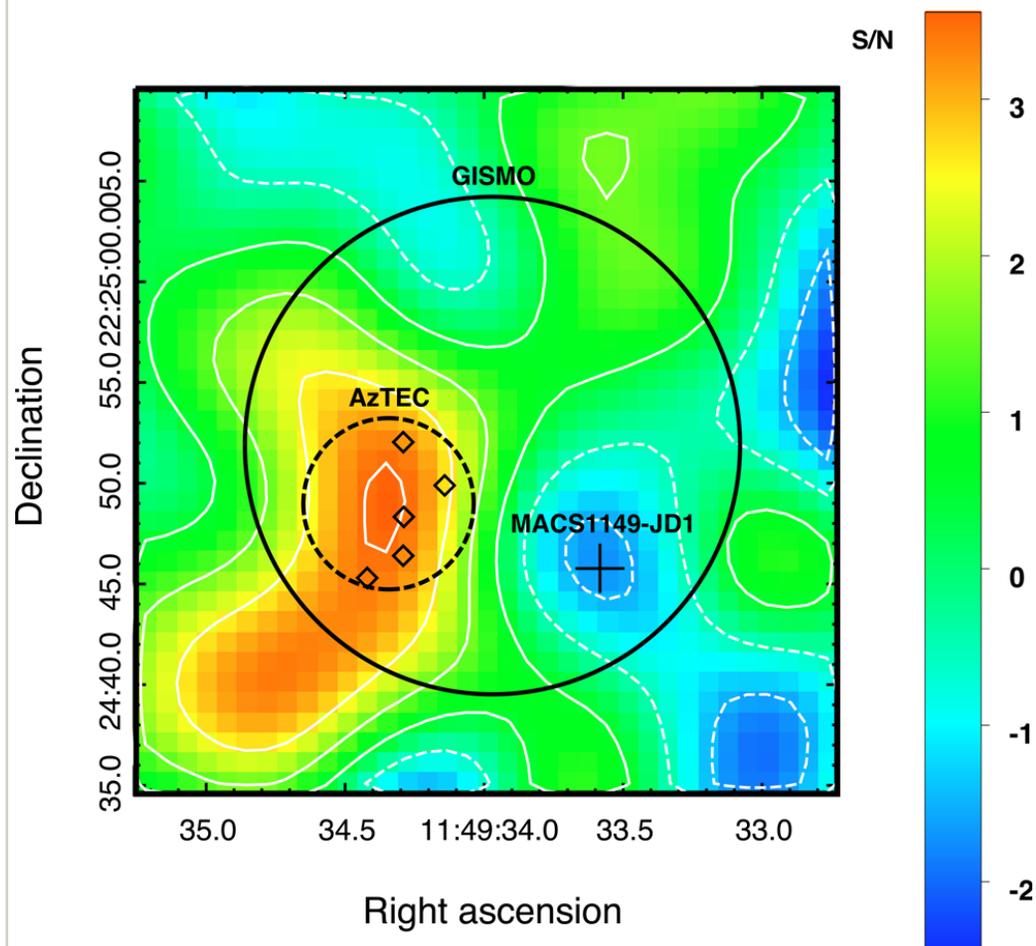
LMT FF Results: Millimeter detections



1 mm detections ($>3.5 \sigma$) have magnifications from 1.1-10

LMT FF Results:

Detection of dust from MACS1149-JD1 at $z \sim 9.6$ - NO!

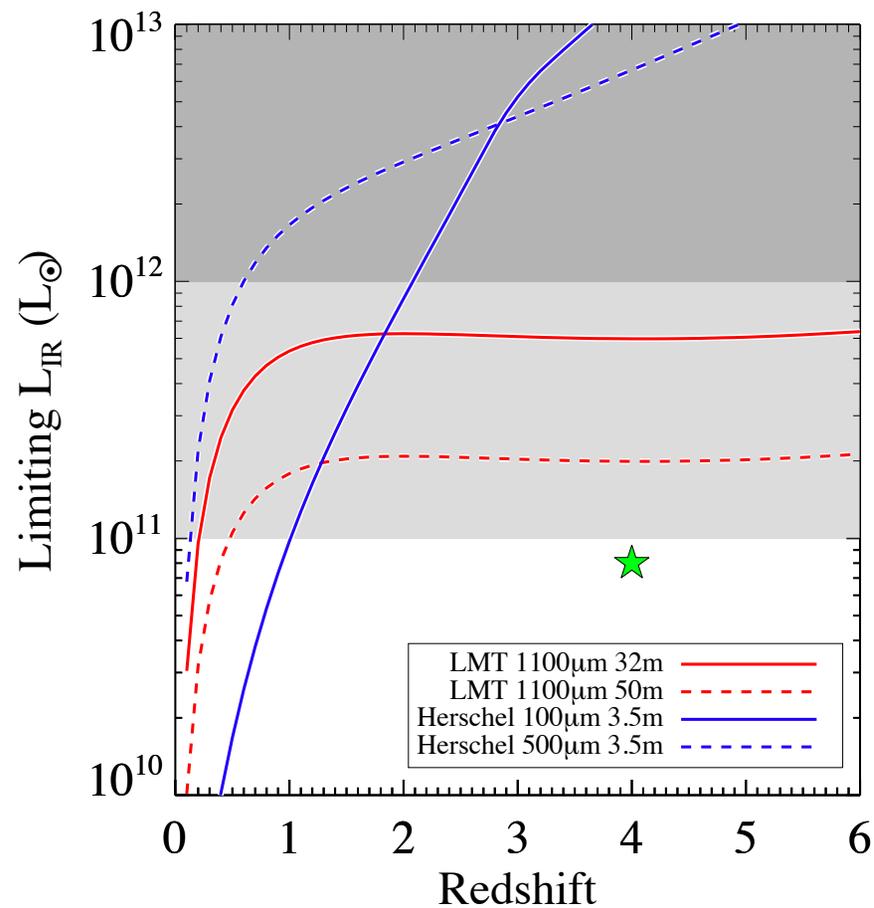
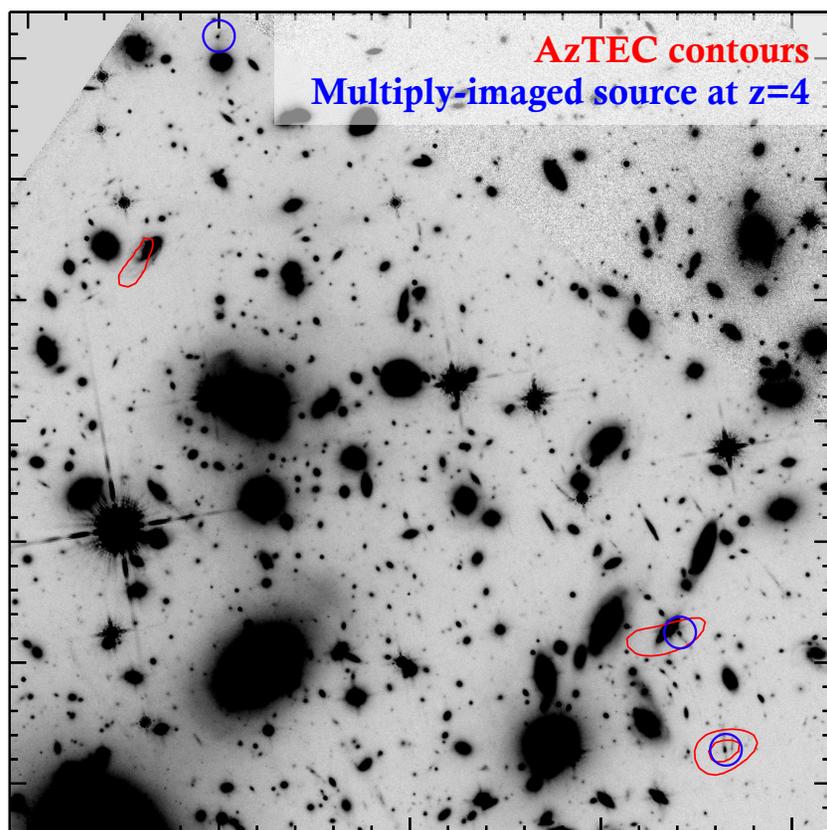


$z \sim 9.6$ source: $S_{1.1} < 0.51$ mJy

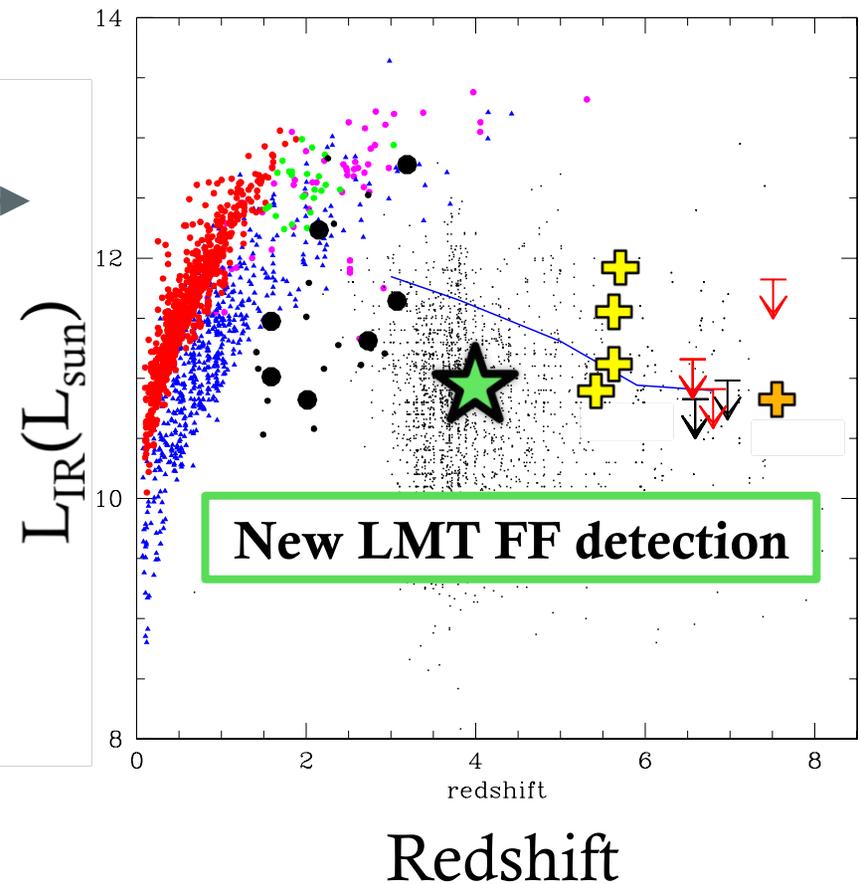
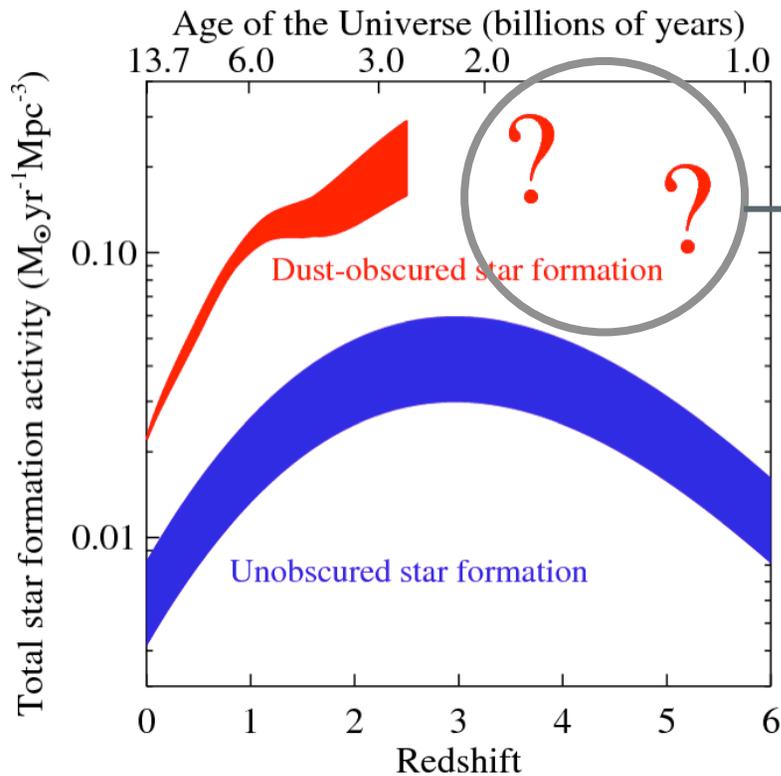
$M_{\text{dust}} < 3 \times 10^7 - 2.4 \times 10^8 M_{\odot} / \mu$

LMT FF Results:

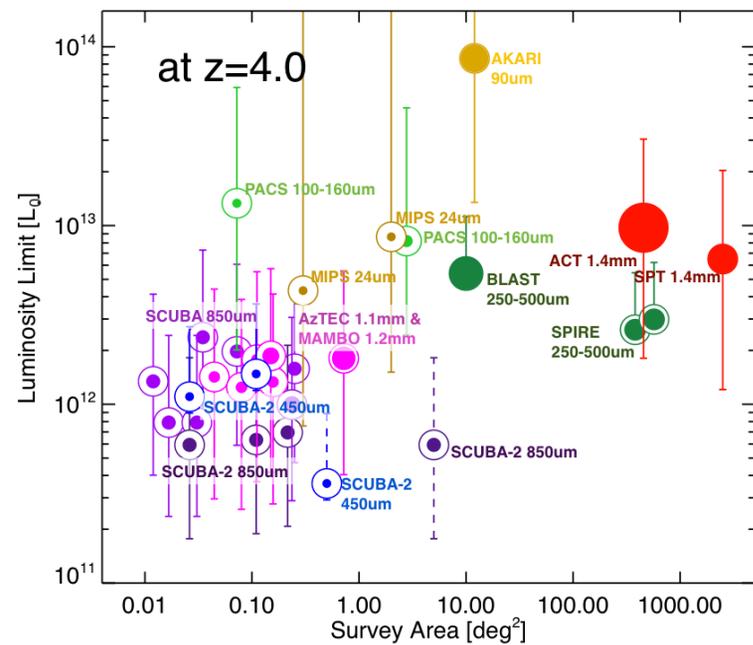
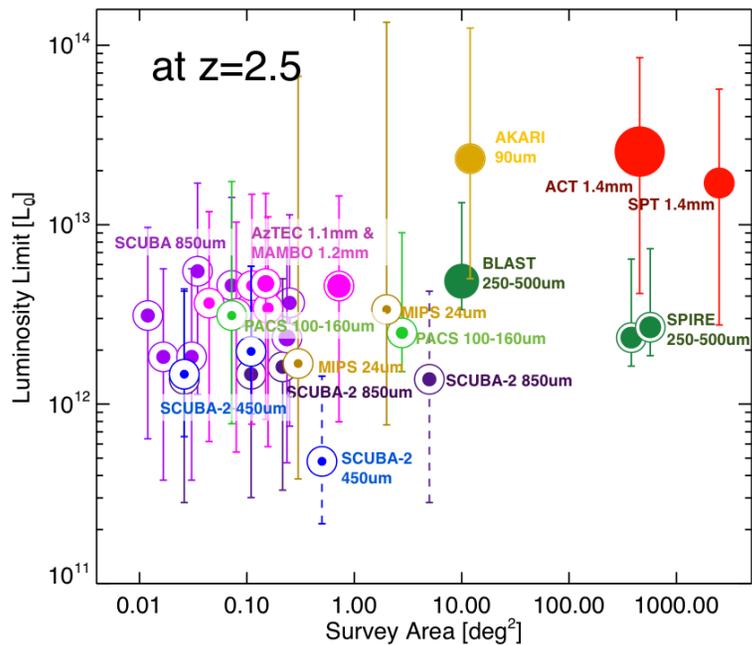
Dust emission in a multiply-imaged *normal* galaxy at $z \sim 4$



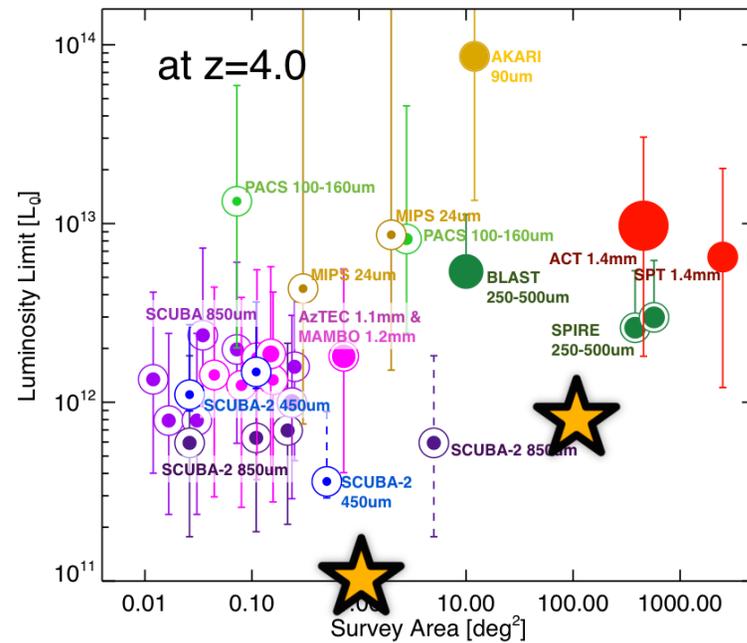
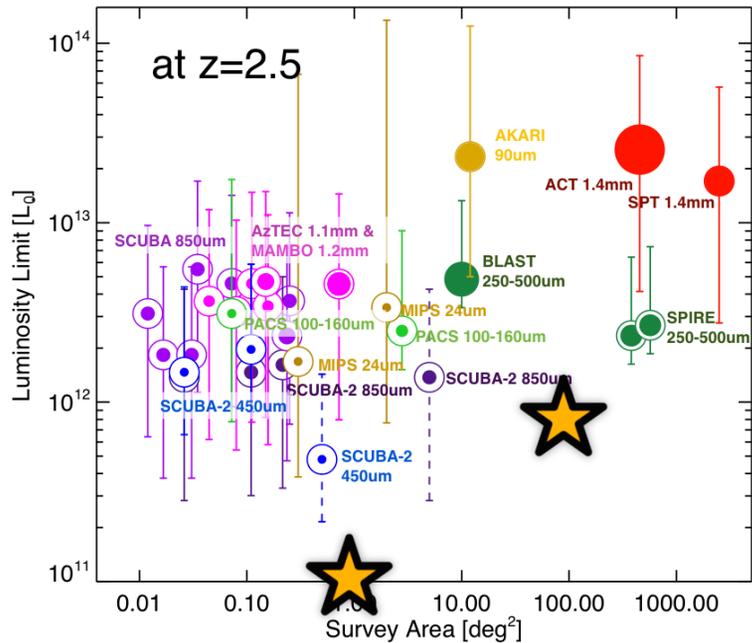
We have begun to directly detect dust-obscured activity in *normal* galaxies at $z > 3$..
how can we ramp this up?



IR luminosity depth – survey area: CURRENT



IR luminosity depth – survey area: FUTURE



LMT/TolTEC 100 hour surveys

MSIP program

http://www.astro.umass.edu/~wilson/TolTEC_website/index.html

LMT/ToI TEC Surveys in Context

