### Dust Obscured Star Formation Seen in the Far-Infrared

#### Hanae Inami (NOAO)

M. Dickinson, D. Elbaz, J. Kartaltepe, CANDELS/GOODS-Herschel team

### Galaxy Evolution

- The peak era of galaxy growth took place at  $z\sim 1-3$ 
  - Dusty star formation
- SFRD of (U)LIRGs increase dramatically towards higher redshifts.





### The CANDELS project

- Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey (PIs: S. Faber & H. Ferguson)
- HST ACS & WFC3 deep imaging for GOODS-S and N, EGS, UDS, and COSMOS
  - High resolution (galaxy structure)
  - Deep imaging (detect all Herschel counterparts)



### GOODS- & CANDELS-Herschel

- Deepest 100-500µm data
  - Typical star-forming galaxies up to z~1.5
- Covering 4/5 CANDELS fields
  - Improved statistics and good control over cosmic variance
  - Increase accessible fields with ALMA
    - GOODS-S, UDS, & COSMOS









#### **GOODS- & CANDELS-Herschel** COSMOS Deepest 100-500um data **PEP-COSMOS** 10<sup>13</sup> 1000 CANDELS له] (L<sub>©</sub>) لسا 10<sup>12</sup> 100 ° ₩ \* 10<sup>11</sup> SFR $\_$ CANDELS (100 $\mu$ m, 1.4 mJy) -10 $\_$ $\_$ CANDELS (160 $\mu$ m, 3.5 mJy) $\_$ COSMOS (100 $\mu$ m, 5 mJy) 10<sup>10</sup> $\_$ ..... COSMOS (160 $\mu$ m, 11 mJy) 10<sup>9</sup> 2 3 redshift GOODS-N GOODS-S

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![](_page_5_Picture_8.jpeg)

![](_page_5_Figure_9.jpeg)

![](_page_5_Picture_10.jpeg)

### Controlling cosmic variance: Number counts (160µm)

![](_page_6_Figure_1.jpeg)

# IR luminosity functions in the CANDELS fields

![](_page_7_Figure_1.jpeg)

## IR luminosity functions with stacking

![](_page_8_Figure_1.jpeg)

# IR luminosity functions in the CANDELS fields

![](_page_9_Figure_1.jpeg)

**Evolution in LFs** 

![](_page_10_Figure_1.jpeg)

### IR Star Formation and Galaxy Structure

![](_page_11_Figure_1.jpeg)

### Star Formation and Galaxy Structure

![](_page_12_Figure_1.jpeg)

Kartaltepe et al. 2012

![](_page_13_Figure_0.jpeg)

![](_page_14_Figure_0.jpeg)

#### Gini-M20 for Herschel Galaxies

![](_page_15_Figure_1.jpeg)

![](_page_16_Figure_0.jpeg)

### Summary

- The deepest 100-500µm data in 4/5 CANDELS fields
  - GOODS-S, GOODS-N, UDS, and COSMOS
  - Improved statistics and good control over cosmic variance
  - 3x more typical SF galaxies can be observed with ALMA
- Dust-obscured star formation at high redshifts
  - IR luminosity functions
  - Better constrain on IR LF <  $L_{IR}^*$
  - Direct measurement of the faint-end slopes at  $z \le 1$
- Infrared galaxies and their morphologies
  - Lie along a sequence in G-M20
  - Mostly late-type (disk) galaxies