Galaxy source counts at 7.7 μm, 10 μm and 15 μm with the James Webb Space Telescope

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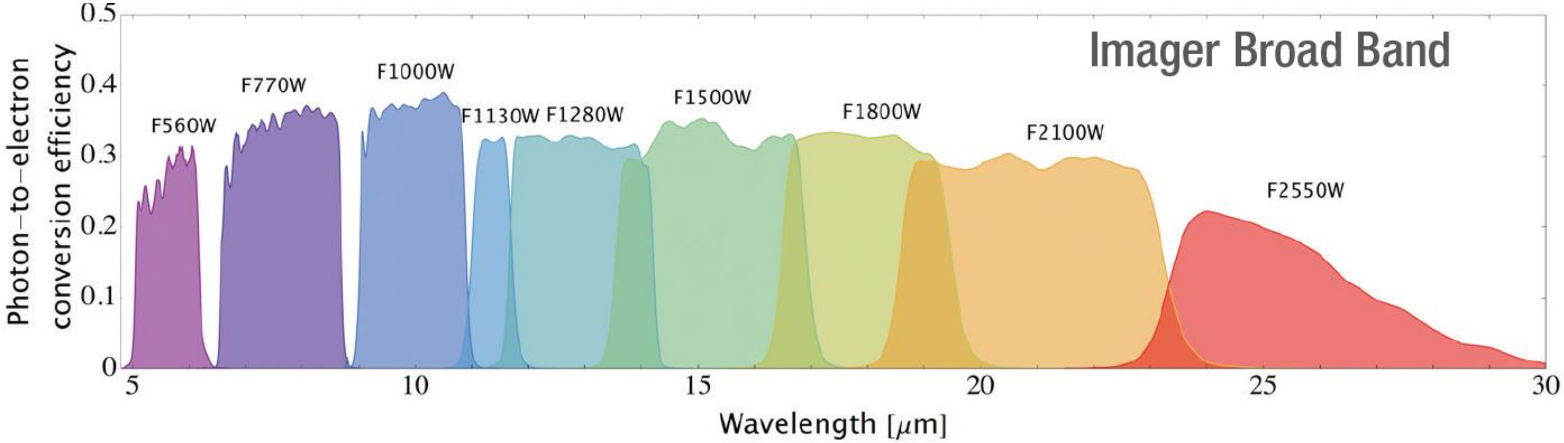
ABSTRACT

We present mid-infrared galaxy number counts based on the Early Release Observations obtained by the James Webb Space Telescope (*JWST*) at 7.7-, 10- and 15-μm (F770W, F1000W and F1500W, respectively) bands of the Mid-Infrared Instrument (MIRI). Due to the superior sensitivity of *JWST*, the 80 percent completeness limits reach 0.32, 0.79 and 2.0 μJy in F770W, F1000W and F1500W filters, respectively, i.e., ~100 times deeper than previous space infrared telescopes such as *Spitzer* or *AKARI*. The number counts reach much deeper than characteristic peaks due to polycyclic aromatic hydrocarbon (PAH) emissions. An extrapolation towards fainter flux from the evolutionary models in the literature agrees amazingly well with the new data, where the extrapolated faint-end of infrared luminosity functions combined with the cosmic star-formation history to higher redshifts can reproduce the deeper number counts by *JWST*. Our understanding of the faint infrared sources has been confirmed by the observed data due to the superb sensitivity of *JWST*.

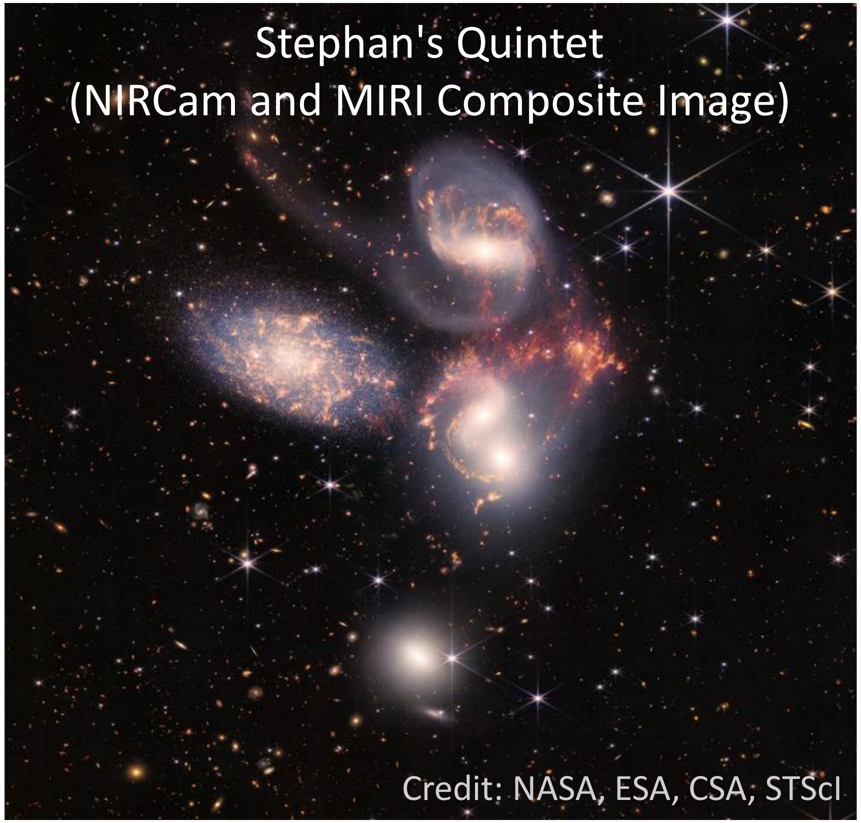
Motivation of This Paper

- The comparison of galaxy formation models with observed number densities of IR galaxies is a very useful method to understand their formation and evolution
- JWST has just opened up a new window to observe the faintest IR sources that have not been observed
- Mid-Infrared Instrument (MIRI)
  - 9 bands covering the 5-28 um
  - ➔ this paper focuses on 7.7, 10, and 15 um



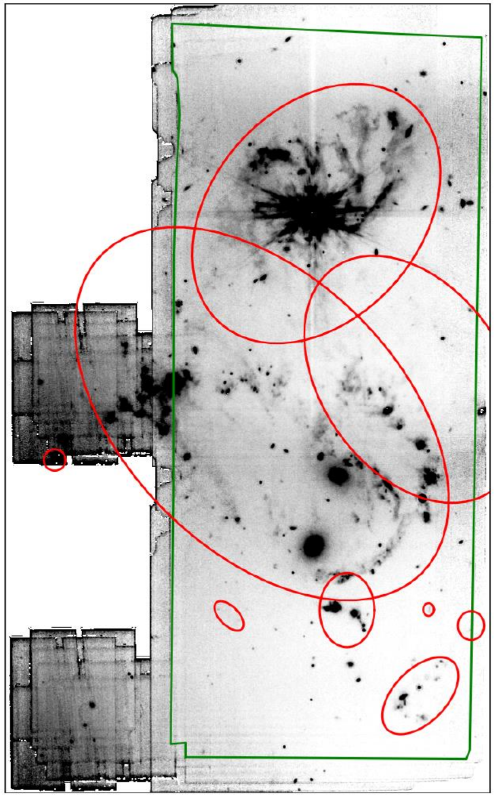
JWST Data

- Early Release Observations
- First images released on Jul. 12, 2022
- Stephan's quintet
  - ID1: jw02732-o002_t001
  - ID2: jw02732-o006_t001
- 3 filters of MIRI
  - F770W
  - F1000W
  - F1500W

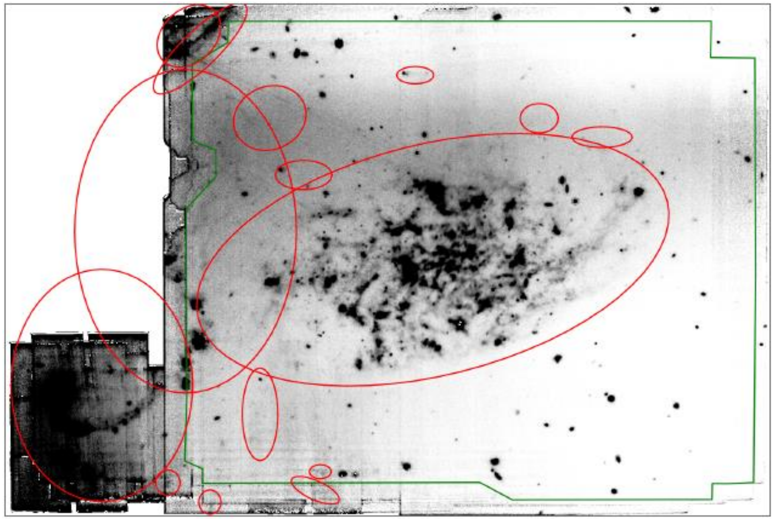


Source Extraction

- Mask Stephan's quintet in the center of the images and foreground extended objects
- Source-Extractor

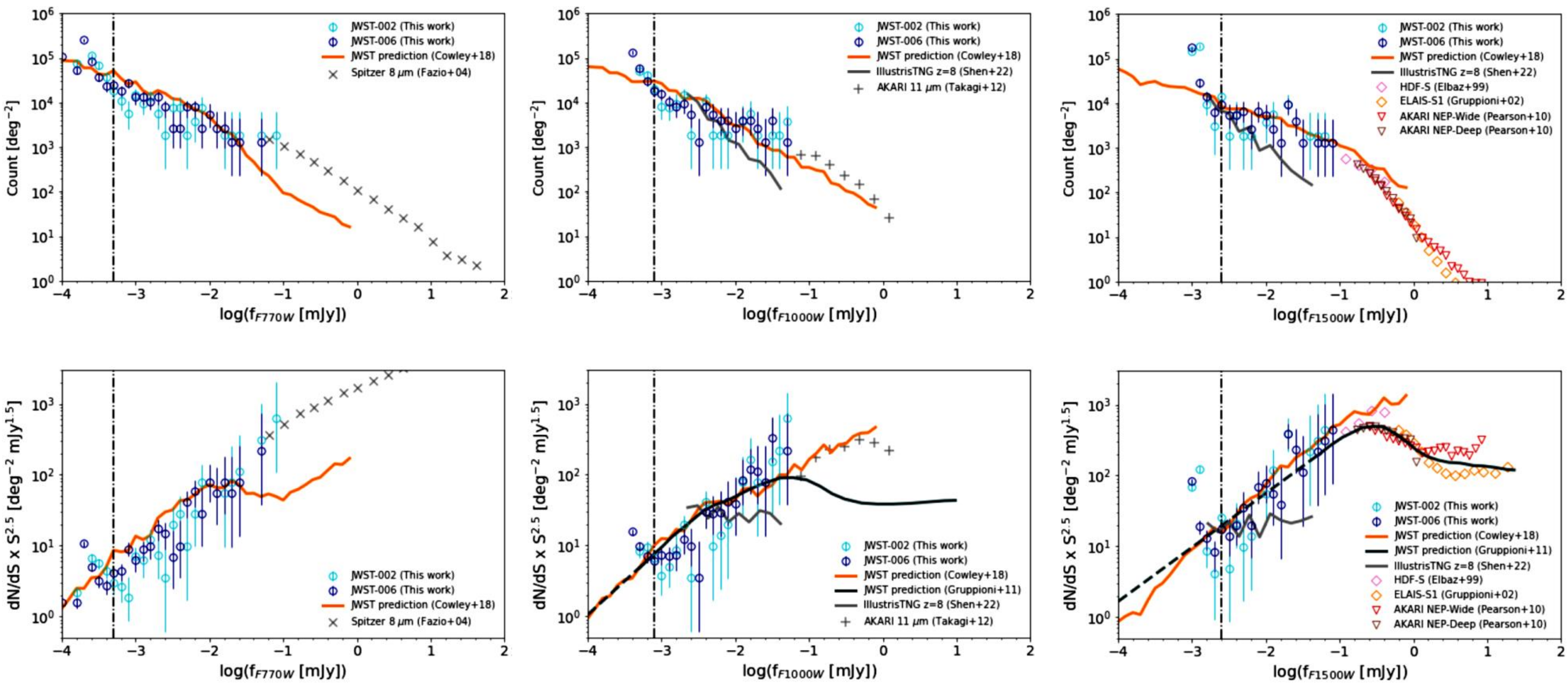


Mask images at 15-um band (F1500W). Regions within red ellipses and outside green boxes are masked.



Source Counts

- extend source counts to the low flux limit of 0.4 uJy, about two orders deeper than the literature
- well connect to the result from previous observations



Source Count Models

- Gruppioni+2011
  - employed local luminosity functions and backward evolution
  - parameters determined for representative populations of IR galaxies:
    - spiral, starburst, low-luminosity AGNs, type 1 and type 2 AGNs
  - based on the previous Spitzer and Hershel data

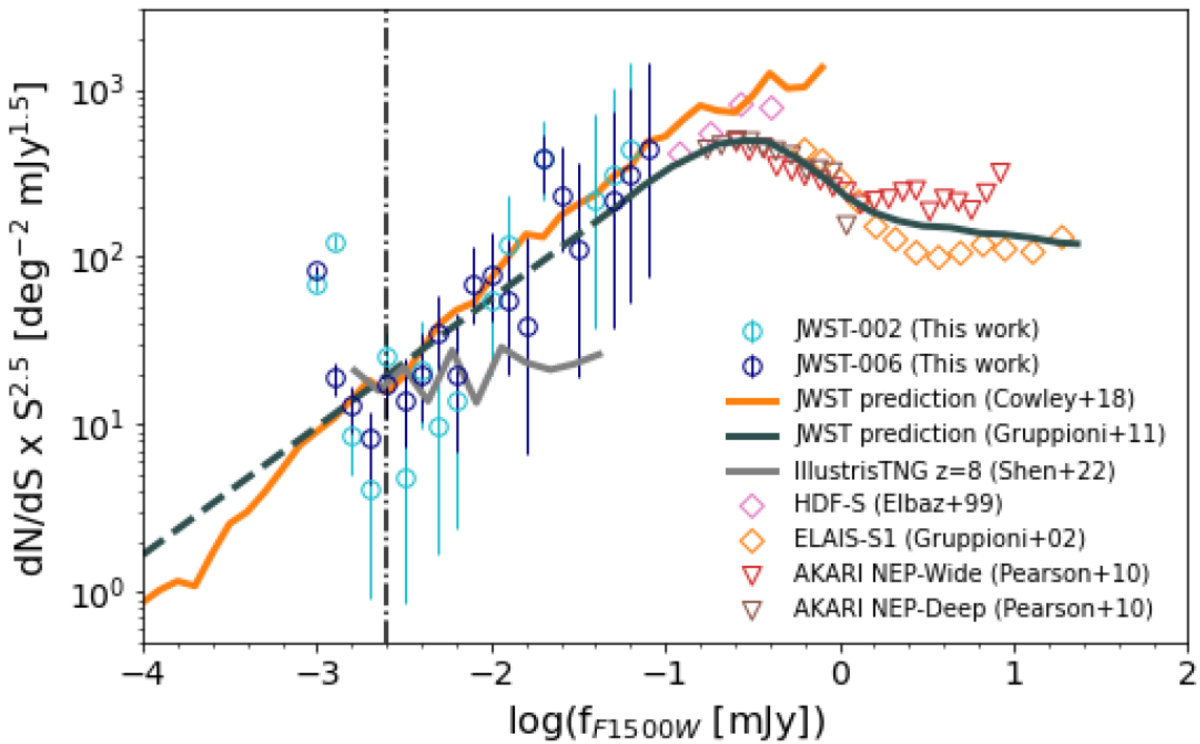
- Cowley+2018
  - GALFORM model, embedded within a dark matter simulation
  - SEDs from radiative transfer code GRASIL

- Shen+2022
  - based on simulated galaxies in IllustrisTNG (cosmological MHD simulations)
  - with SKIRT radiative transfer computation process

Comparison with Models

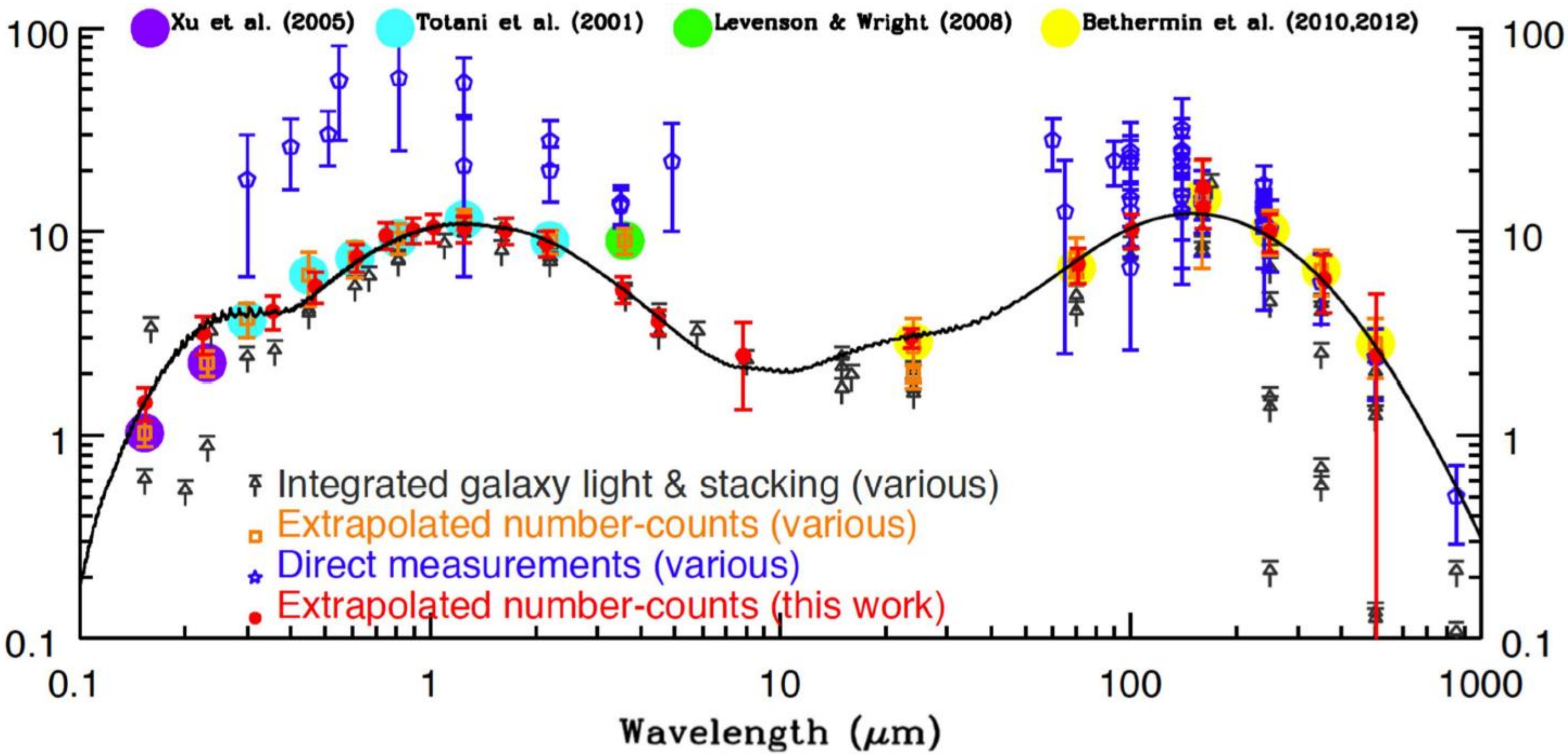
- source counts agree well with the model predictions
- JWST confirms models by directly detecting faint population undetectable with previous telescopes (<0.1 mJy)

➔ our understanding of faint IR galaxies population is correct



Supplement

- JWST has sensitivity, spatial resolution, and continuous wavelength coverage that overwhelm Spitzer



Extragalactic background light and integrated galaxy light (Driver+2016)