Physical properties of dust-enshrouded high-redshift galaxies with Data from ALMA and James Webb Space Telescopes

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THE UNIVERSITY OF TOKYO

1. Introduction : What are dusty star-forming galaxies (DSFGs)

2. Previous studies

3. Study of five lensed and high-redshift galaxies : RXCJ0032-ID304/ID127, M0417-ID46, A0102-ID224, R0600-ID67 focusing on R0600-ID67

Introduction or reminder

- Sub-Millimeter Galaxy (SMG) : **high red-shift**, **dust-rich** galaxy that emits most of its energy in the **sub-millimeter range** due to intense star formation hidden by dust.

- Star-Forming Galaxy : galaxy that is actively producing **new stars**, typically characterized by **strong ultraviolet emission** from young, hot stars.

- Lensing cluster : massive galaxy cluster whose gravity bends and **magnifies the light** from background objects, acting like a **natural cosmic lens** (characterized by a magnification value μ)

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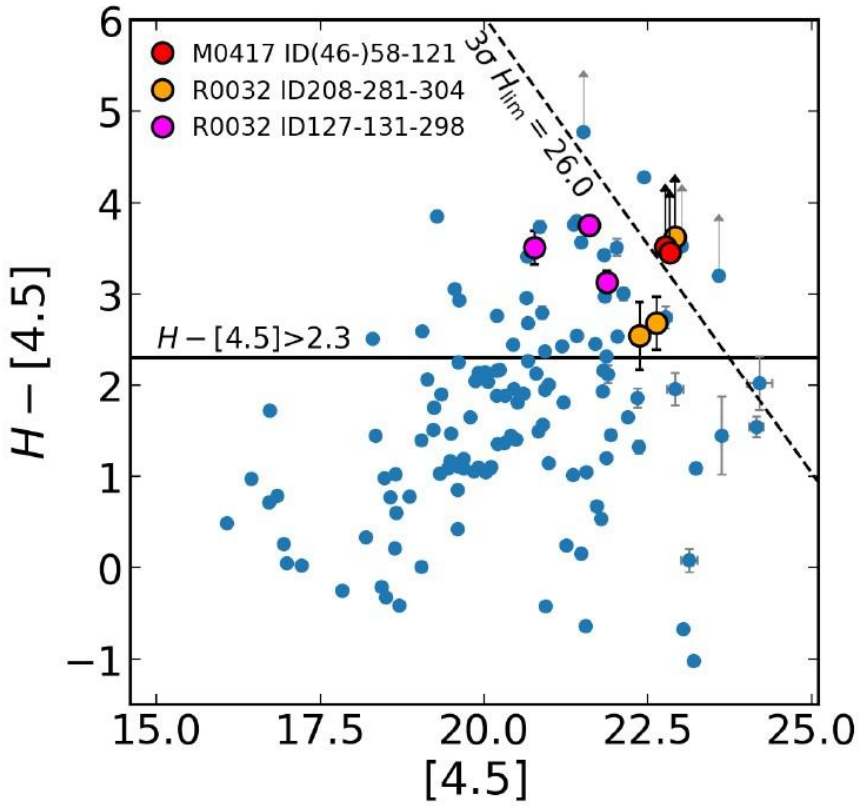

Tsujita et al., 2025,ApJ, inpress (arXiv:2406.09890)

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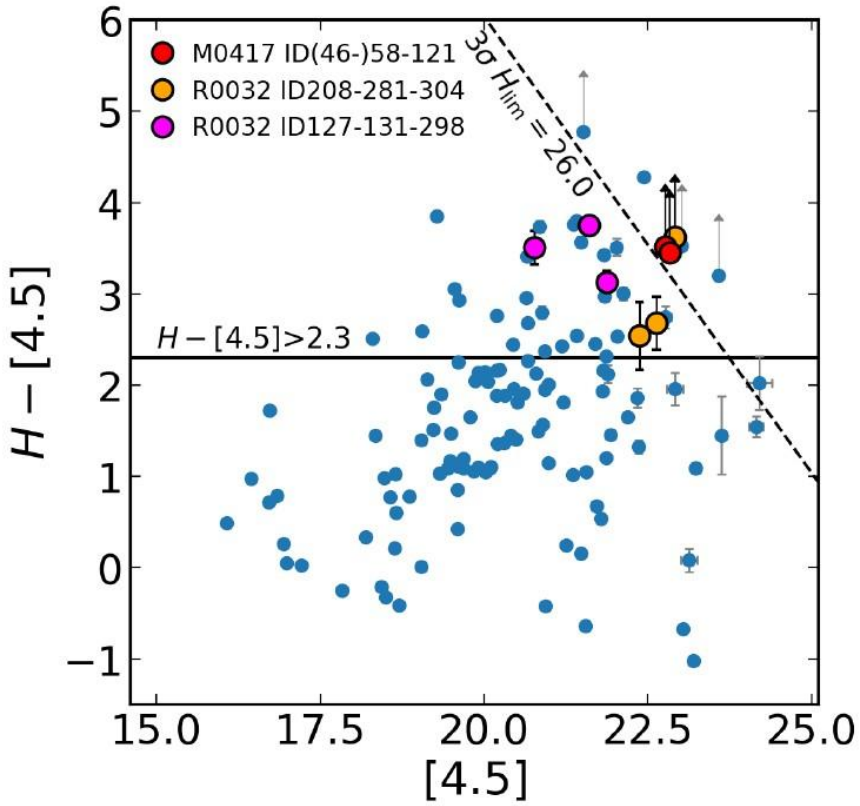

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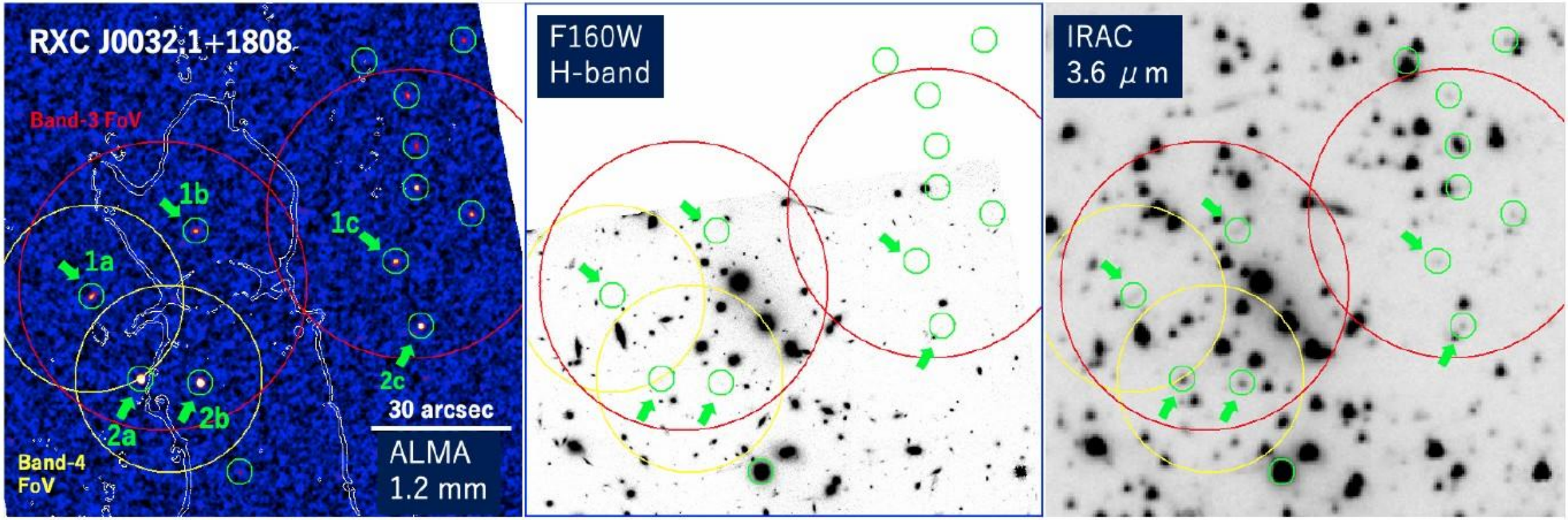
What is the physical origin of heavily obscured galaxies that exhibit a "red" color, as indicated by H–[4.5] > 2.3 ?

ALMA Lensing Cluster Survey (ALCS) : RXC J0032.1+1808



Sun, F., et al. 2022, ApJ, 973, 77

- 33 cluster fields
- 96-hr large program

Galaxies are hidden by dust !

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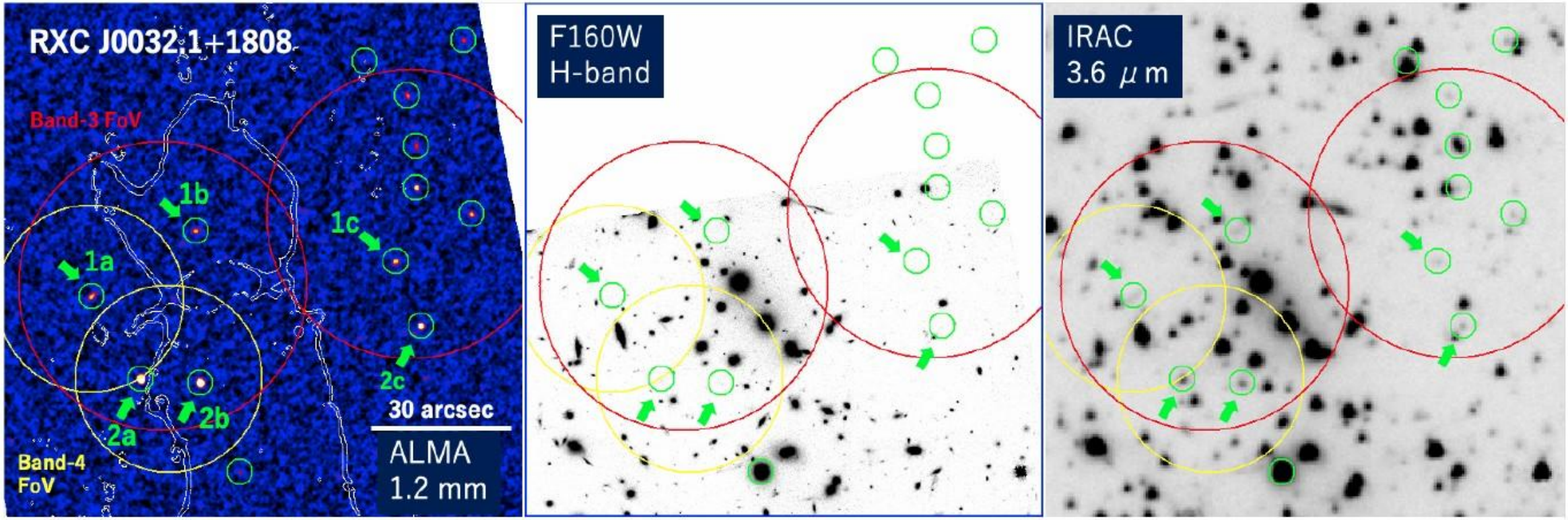

- 33 cluster fields
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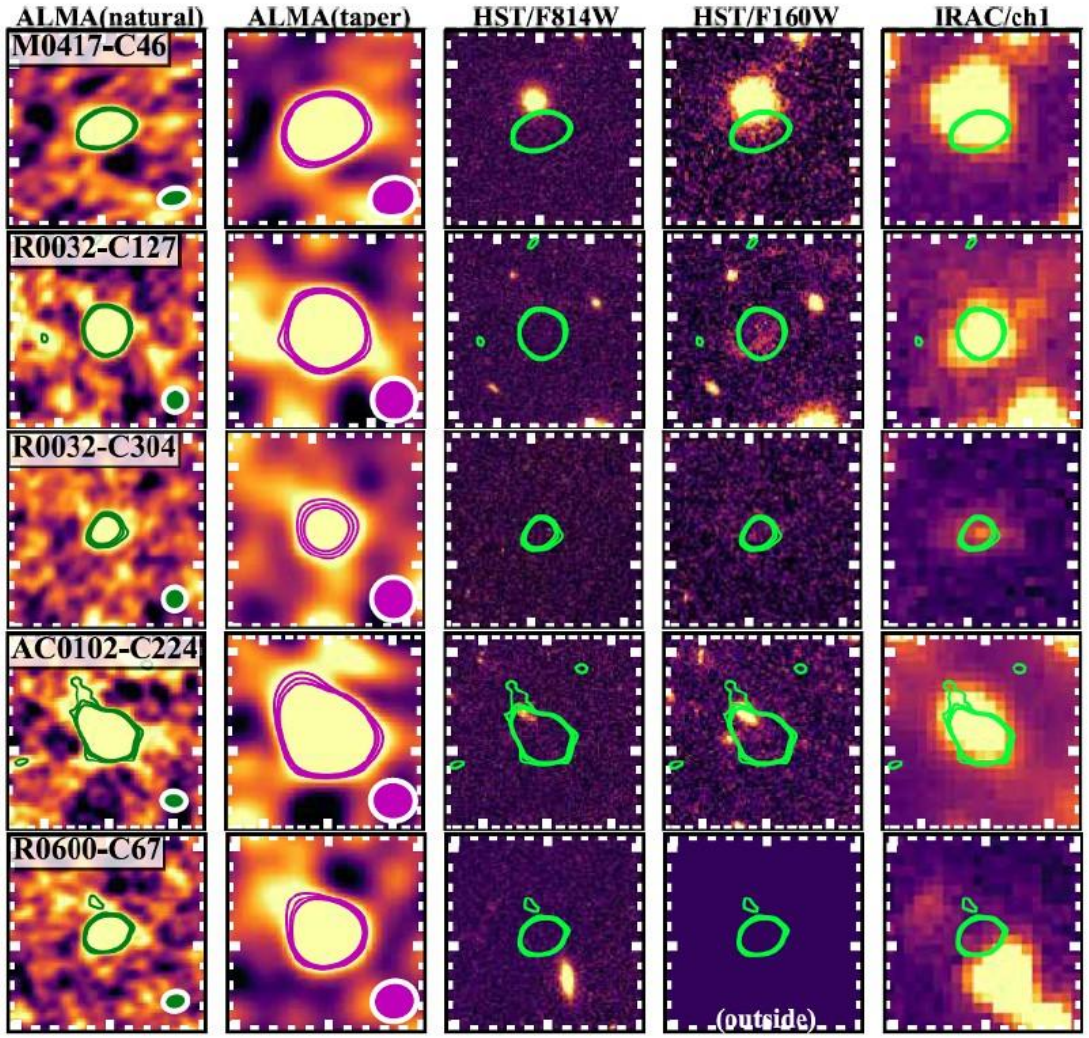
- 1c : RXCJ0032 ID304
- 2a : RXCJ0032 ID127

Sun, F., et al. 2022, ApJ, 973, 77

5 galaxies : RXCJ0032-ID304/ID127, M0417-ID46, A0102-ID224, R0600-ID67



- 10” × 10”
- from left to right :
  - **ALMA** 1.2 mm (native and tapered)
  - **HST/ACS** F814W
  - **WFC3- IR** F160W
  - **Spitzer/IRAC** 3.6 μm

2023.1.01689.S Proposal : ALMA Lensing Cluster Survey; Fujimoto et al. 2023), Herschel (Herschel Lensing Survey; Egami et al. 2010), and HST/Spitzer (RELICS; Coe et al. 2019

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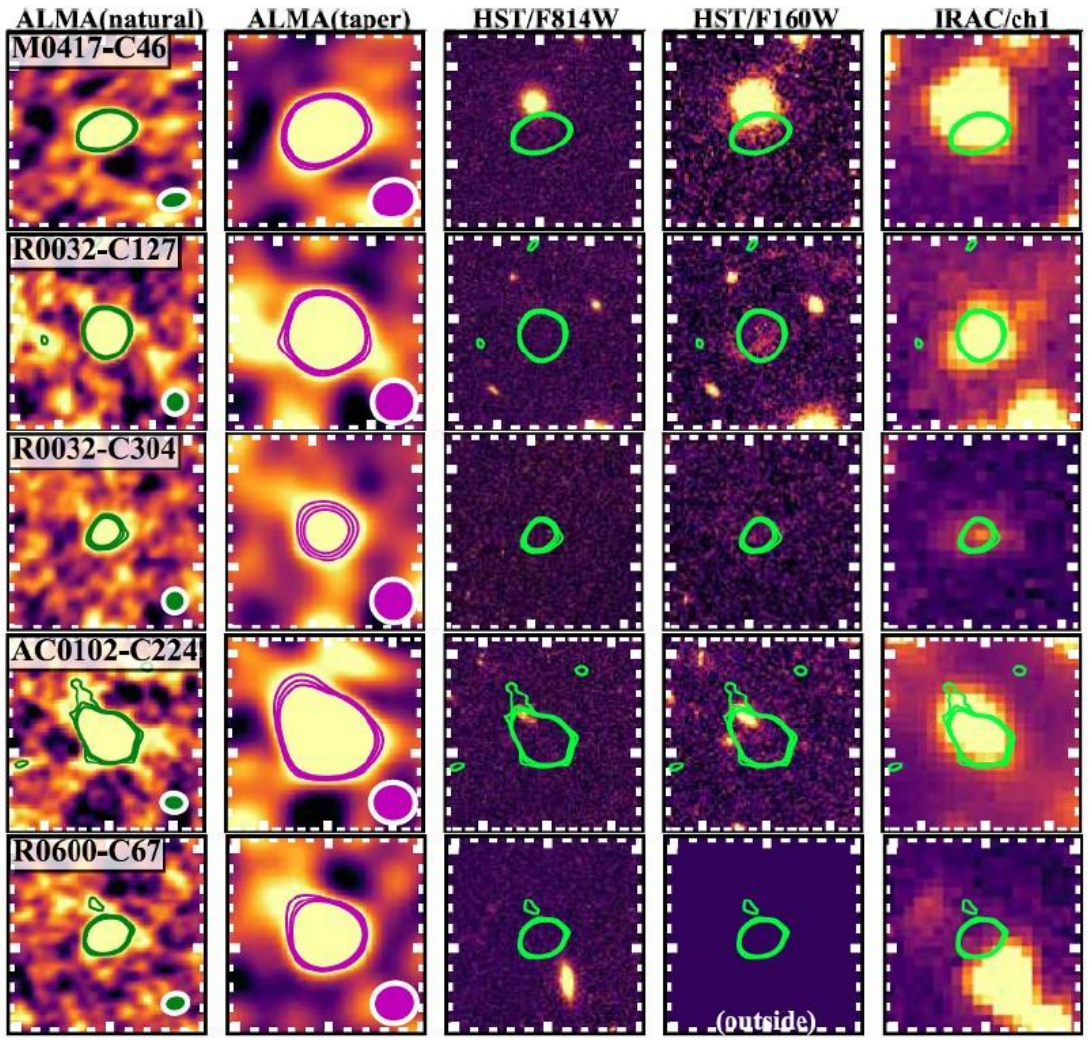

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Dusty star-forming galaxies (DSFGs) important because :

- Might represent the majority of massive galaxies ($M_* \geq 10^{10}\ M_\odot$) of the MS with $3 < z < 6$
- The claimed high abundance of the mm-faint NIR-dark sources at $3 < z < 6$ cannot be reproduced by current semi-analytical models.

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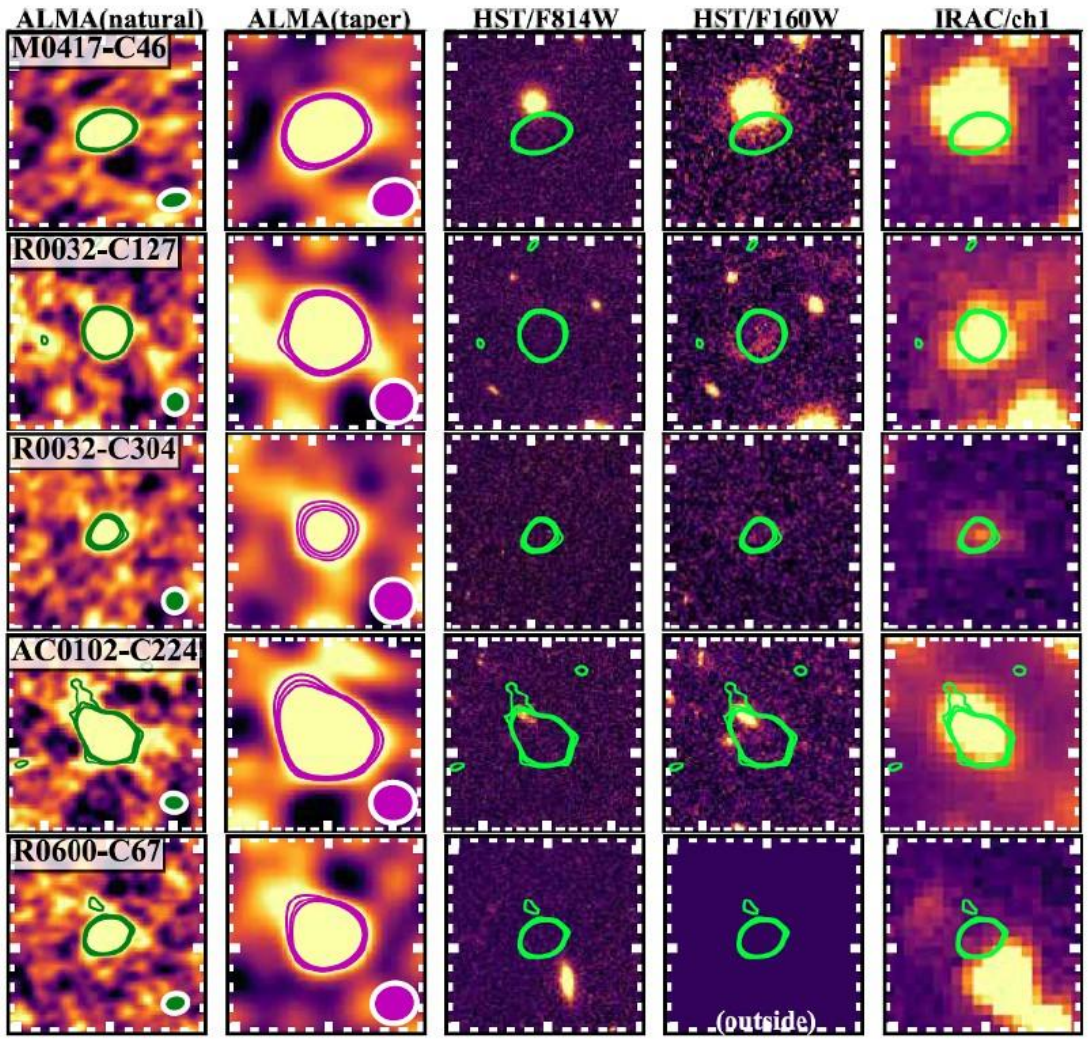
Why theses five galaxies ?



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Source	z_{spec}	coordinates	μ	Angular resolution (ALMA)	Physical length
M0417 ID46	3.65	04:17:33.2880, -11:55:03.922	7.2	0.1″	~0.3 kpc
R0032 ID127	2.39	00:32:13.1600, 18:08:14.255	6.2	0.1″	~0.2 kpc
R0032 ID304	2.99	00:32:08.9526, 18:08:41.771	2.7	0.2″	~0.8 kpc
A0102 ID224	4.33	01:02:55.6832, -49:15:09.068	9.0	0.1″	~0.2 kpc
R0600 ID67	4.80	06:00:05.0099, -20:09:24.326	4.5	0.1″	~0.2 kpc

Adapted from 2023.1.01689.S Proposal

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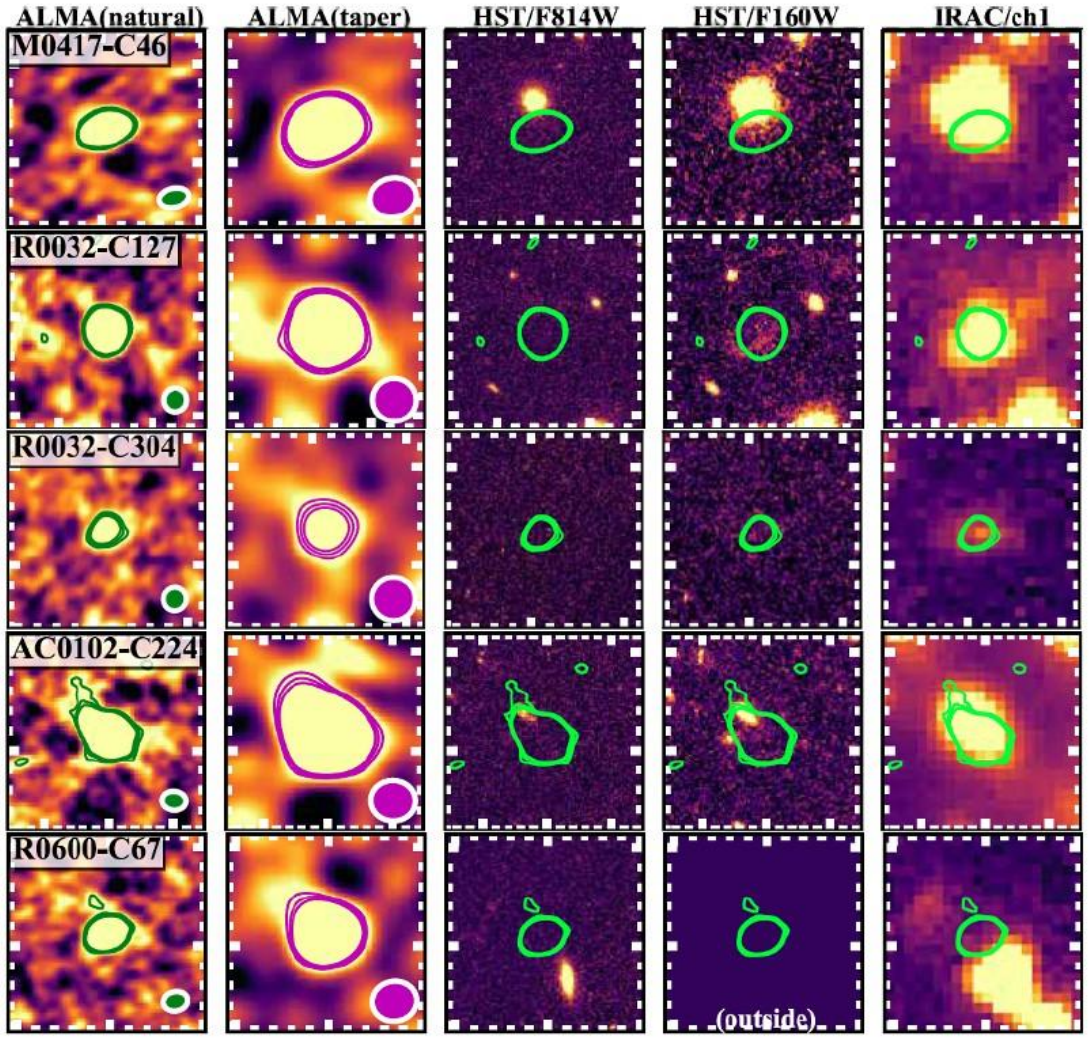

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Need to have high resolution images (similar to 0.1” ALMA) focused on **near-infrared spectra**

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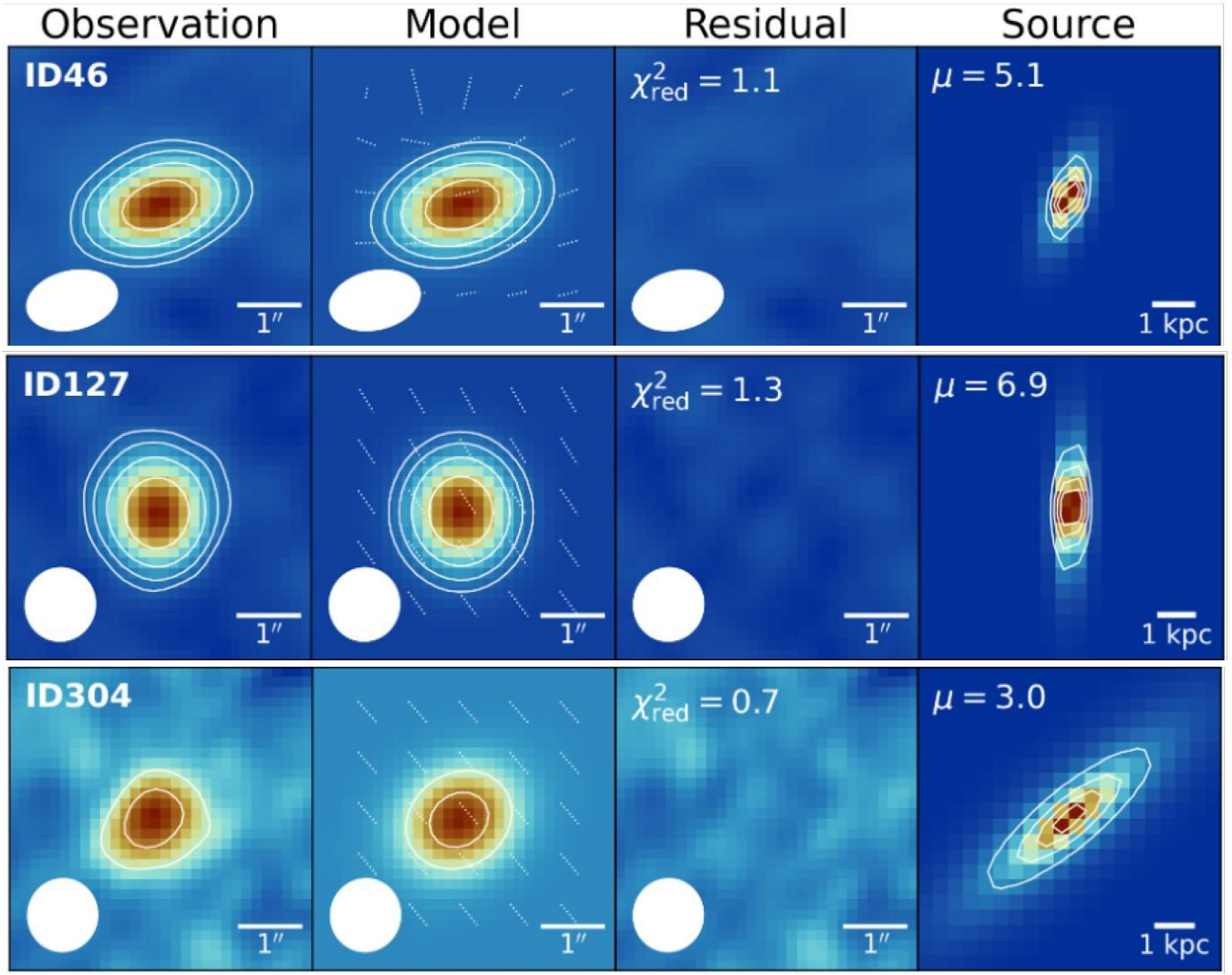
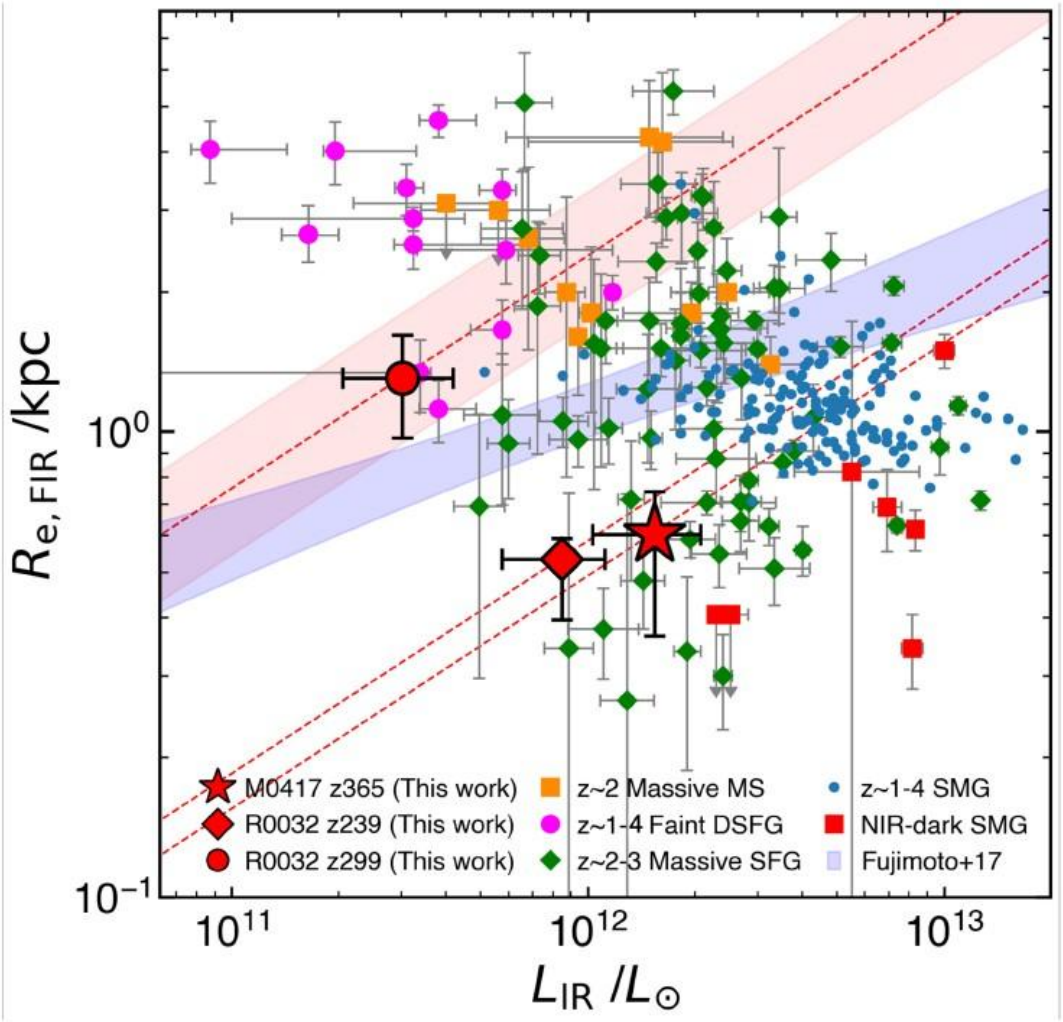
Previous studies : spatial distribution of dust emission via gravitational lensing



Last studies : Tsujita and al., 2025



Why R0032 ID304 so attenuated ?

- Edge-on configuration ?
- Dust compactness ?

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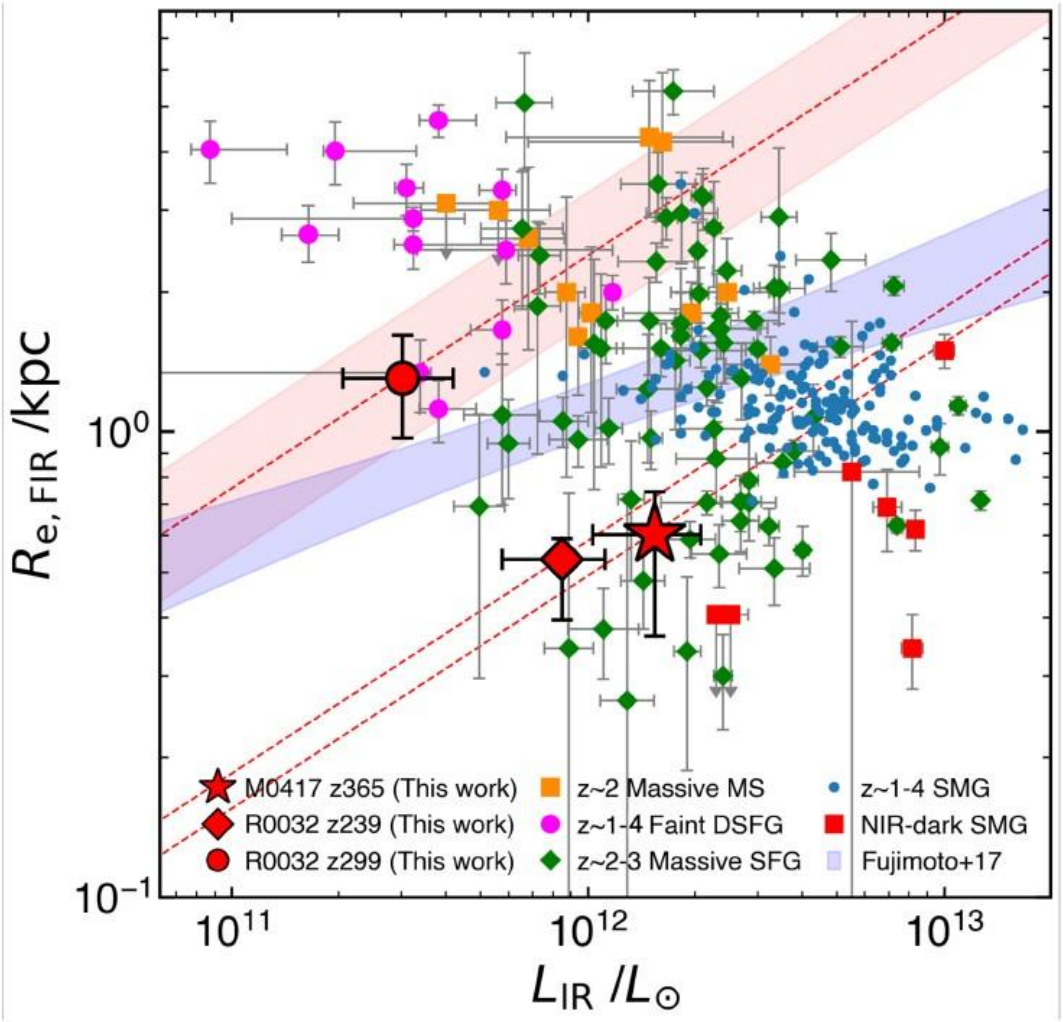

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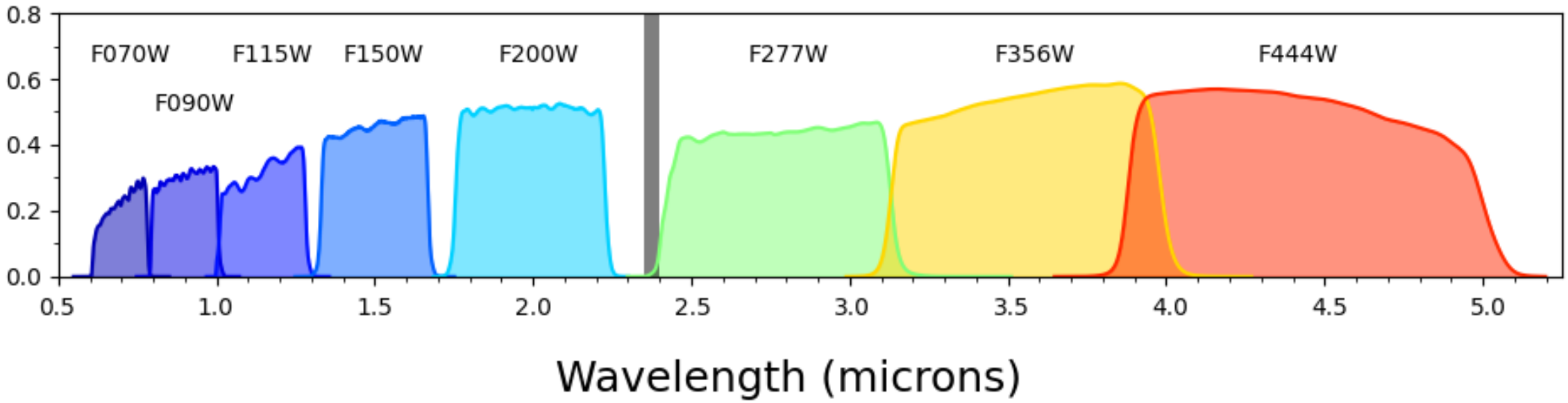
What is the spatial distribution of stellar light in these dust-enshrouded galaxies ?

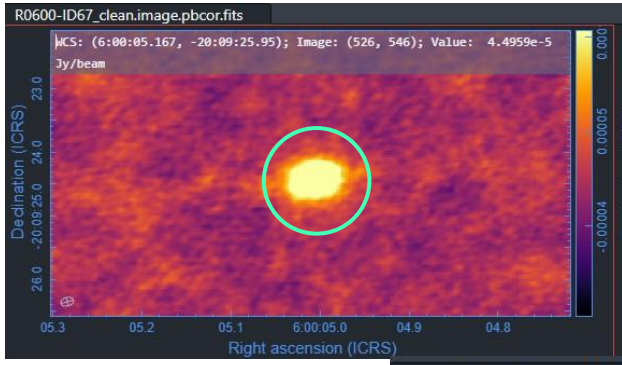
Recent JWST data of 4 lensing clusters



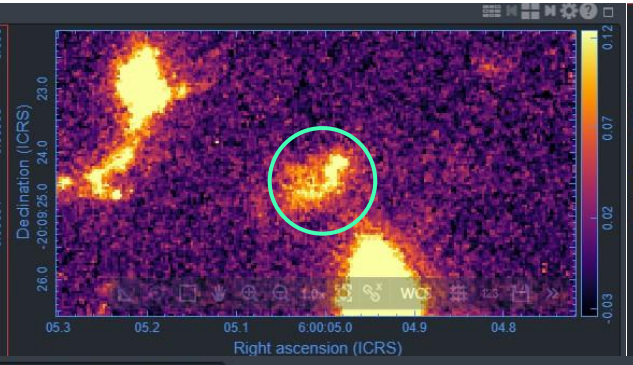
NIRCam Filters - JWST User Documentation

R0600-ID67 : images from carta

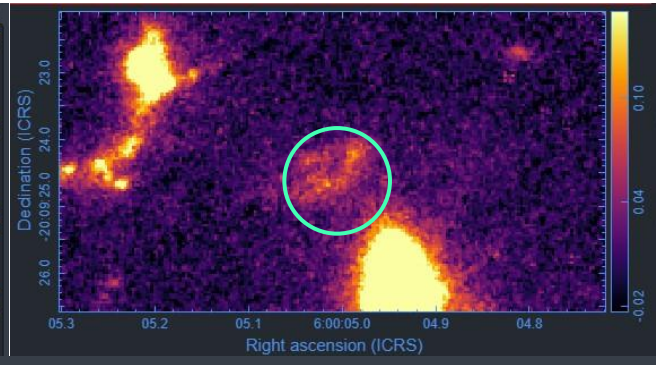
1.2 mm



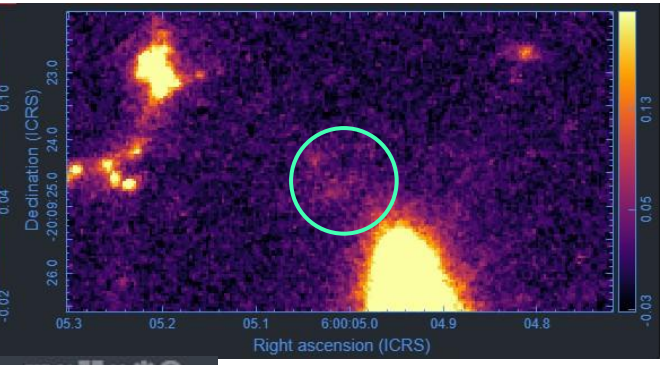
4.44 μm

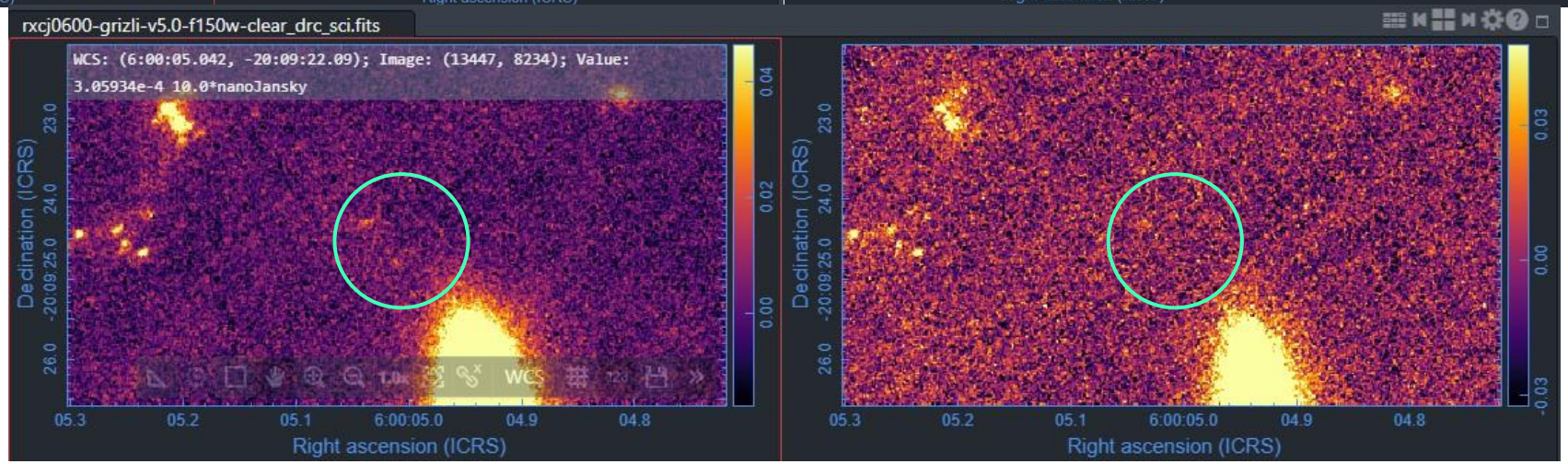


3.57 μm



2.77 μm

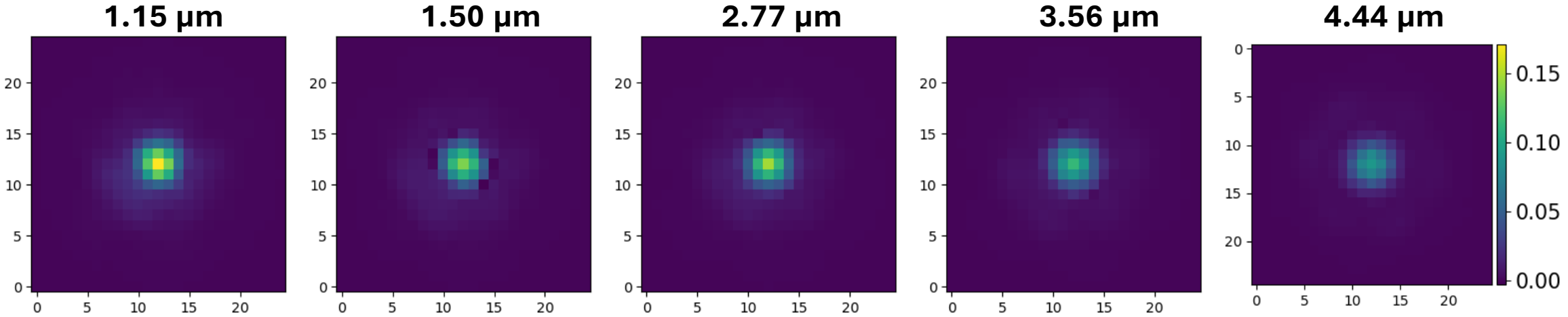




1.50 μm

1.15 μm

Image processing of R0600-ID67 : PSF models for PSF matching



Extract objects data using **Sextractor**

→

Create **PSF models** for each images with **PSFex**

→

Create **convolution kernels** from the worst PSF model

↓ **PSF MATCHING**

Create **convolution kernels** from the worst PSF model

←

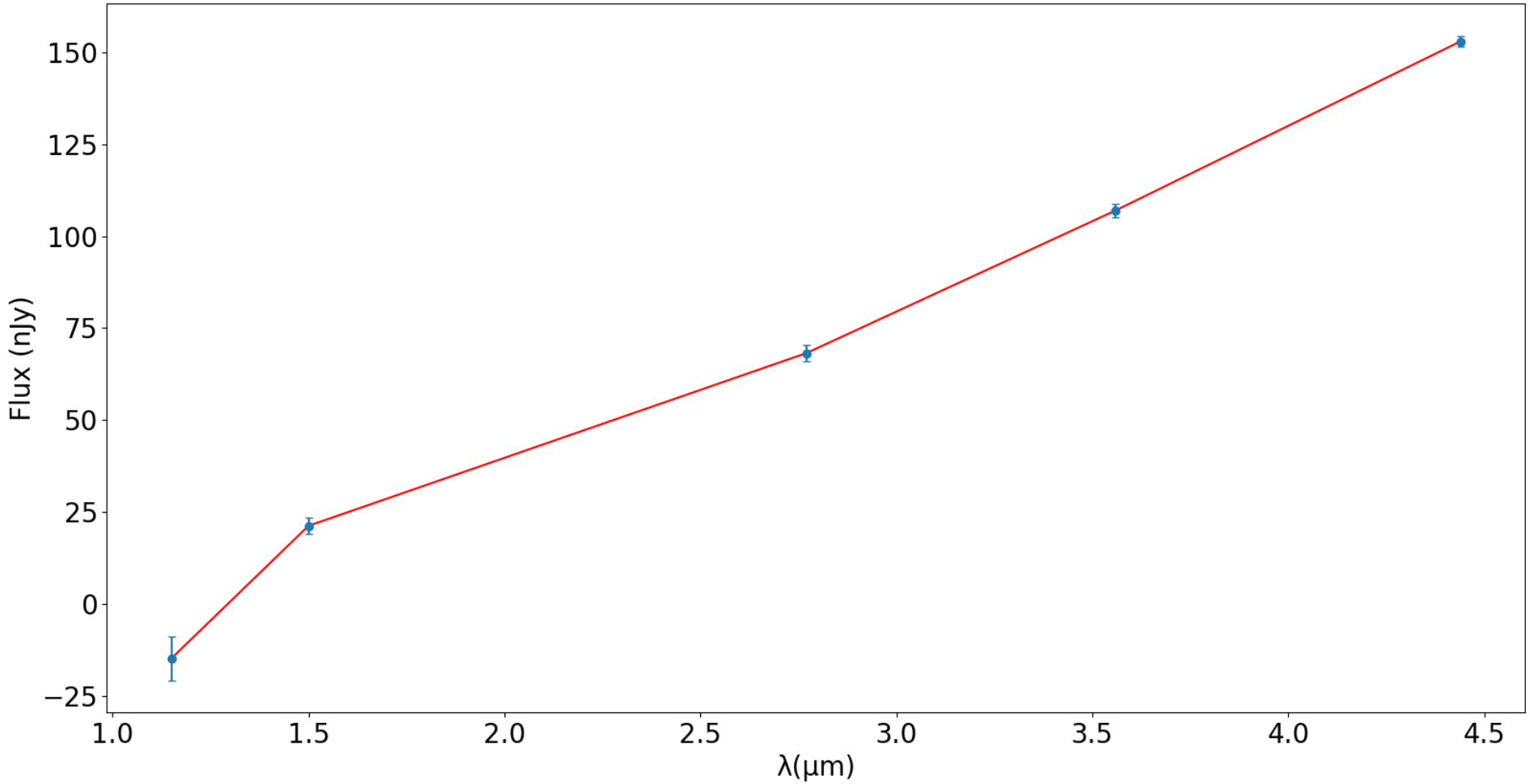
Project high resolution images on **the lowest resolution** image

Photometry

←

SED (Spectral energy distribution)

On-working SED of R0600-ID67 : JWST DATA



Observed wavelength

All S/N > 3σ except 1.15μm

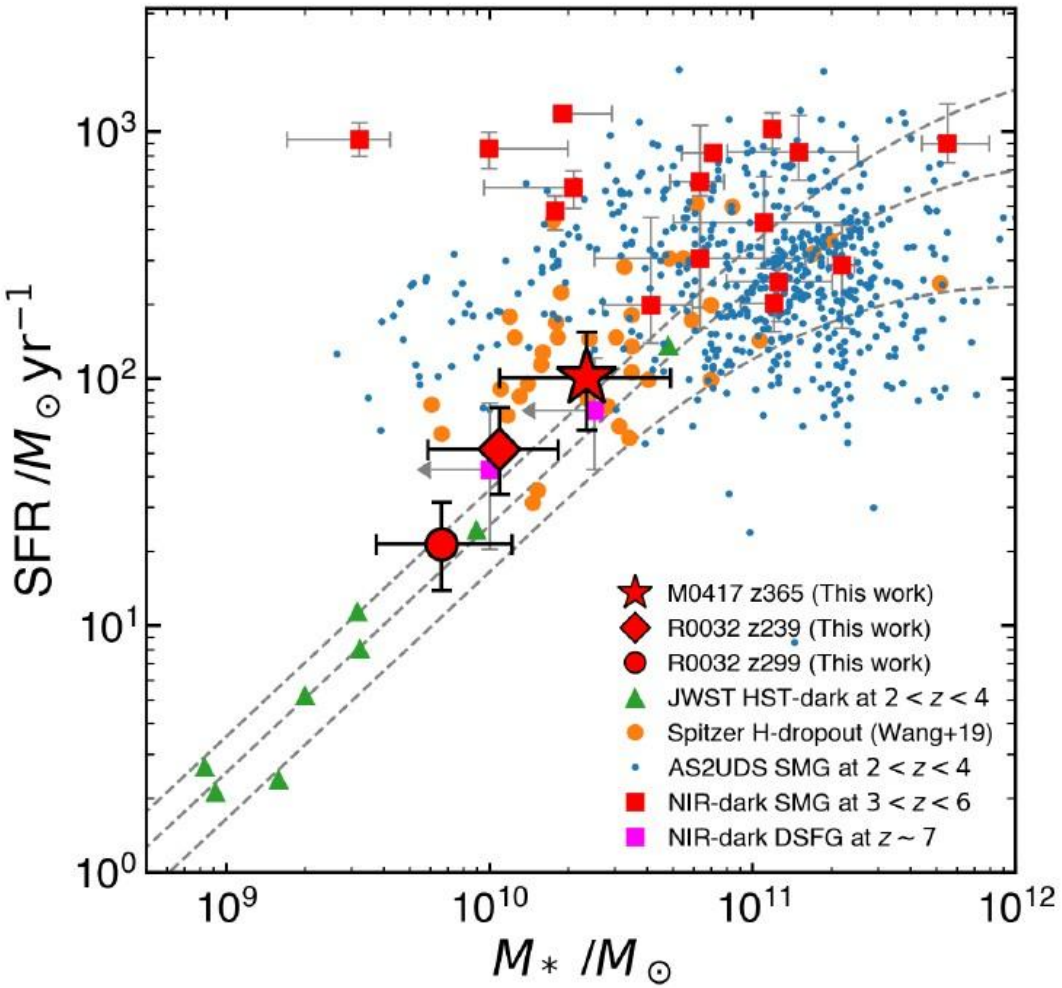
Conclusion and perspectives

- Conclusions after studying certain DSFGs, attenuation might come from:
  - Dust compactness
  - Edge-on observation

- Perspectives :
  - SED fitting with CIGALE
  - Spatially resolved SED analysis
  - Re-imaging ALMA data with JWST data


Thank you for
your attention

Annexes



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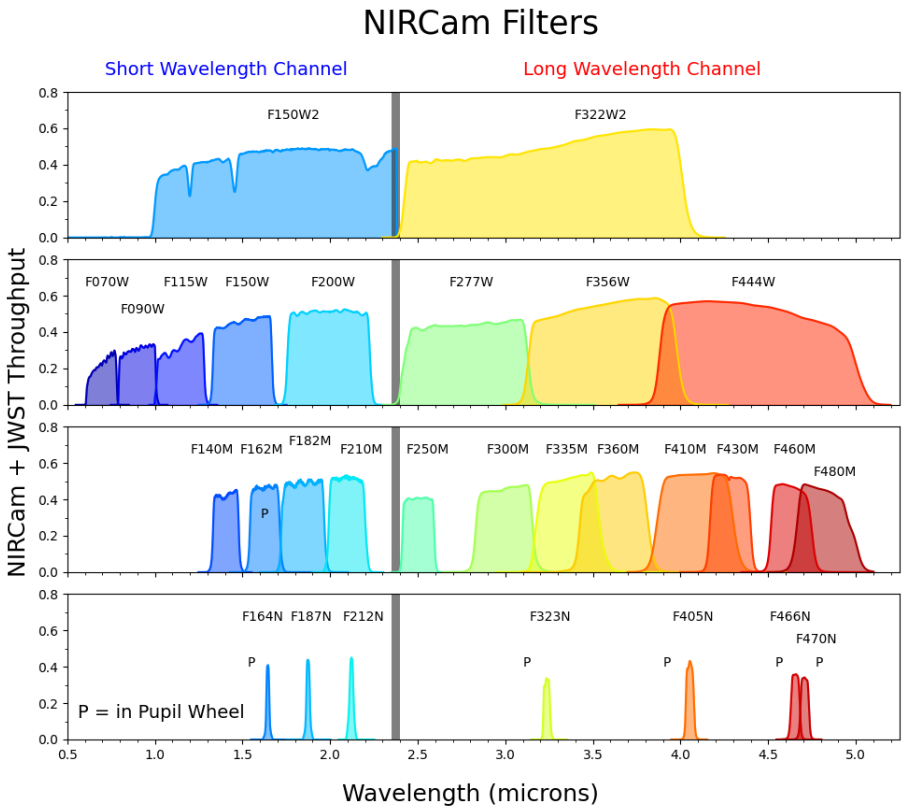

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