The Crown Jewels of the JWST PEARLS Project

Rogier Windhorst (ASU) — Regents' Professor & JWST Interdisciplinary Scientist

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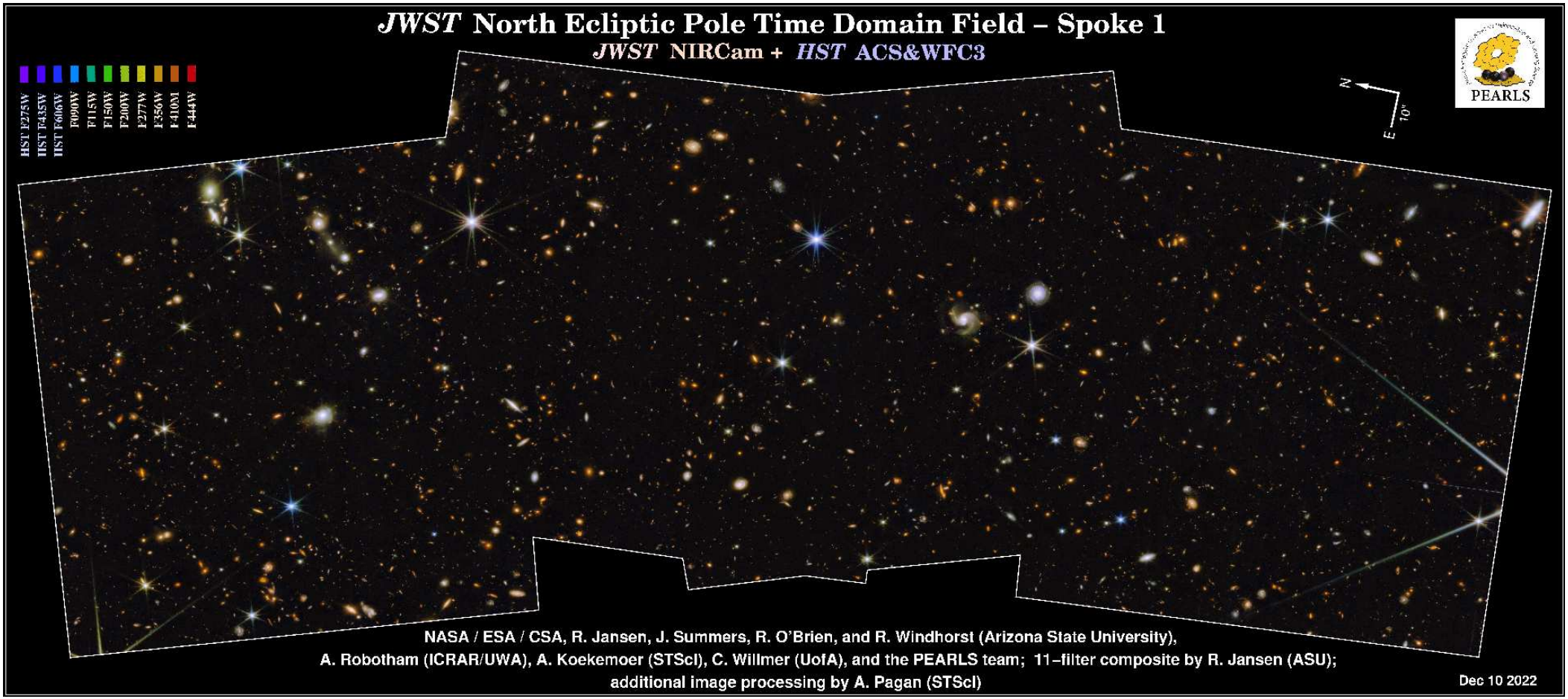
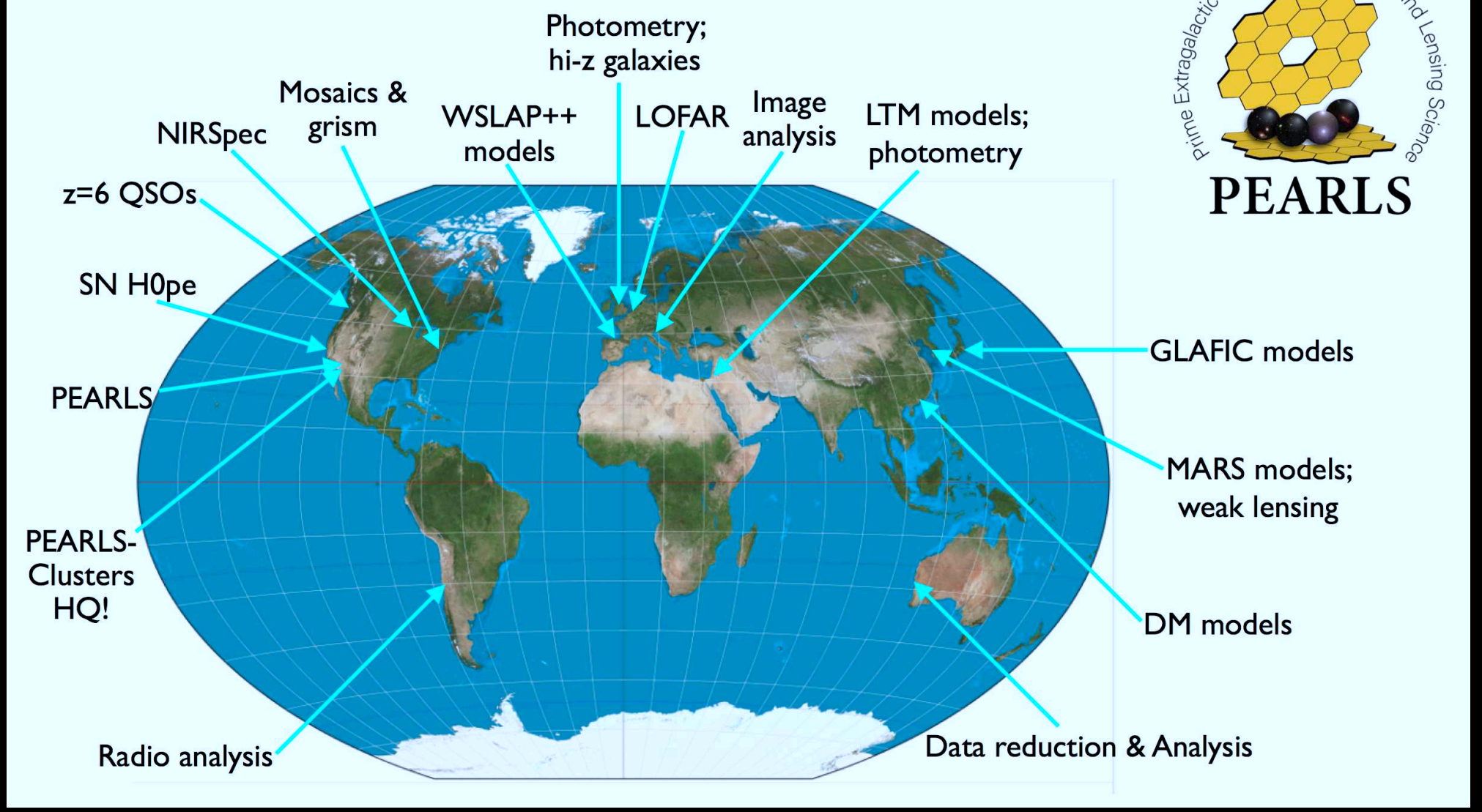


The First Year of JWST Science Conference; Monday Sept. 11, 2023 (STScI, Baltimore, MD)

PEARLS Program



Prime Extragalactic Areas for Reionization and Lensing Science

PEARLS

PEARLS = Prime Extragalactic Areas for Reionization and Lensing Science (Windhorst^{+} 2023, AJ, 165, 13):

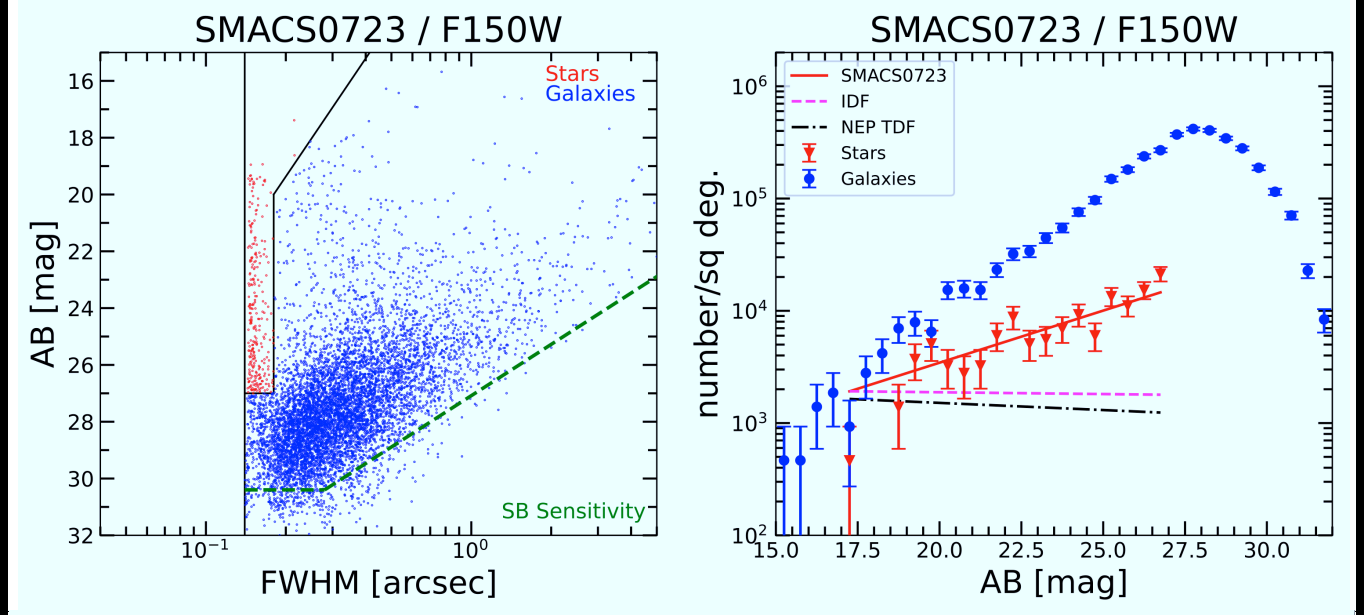
- A mix of medium-deep NIRCam fields (GTO-2738; PIs Windhorst & Hammel), best lensing clusters (GTO-1176 Windhorst & DD-4446 PI Frye), and high-zs QSOs (GTO-1176 & GO-1813 PI Marshall).

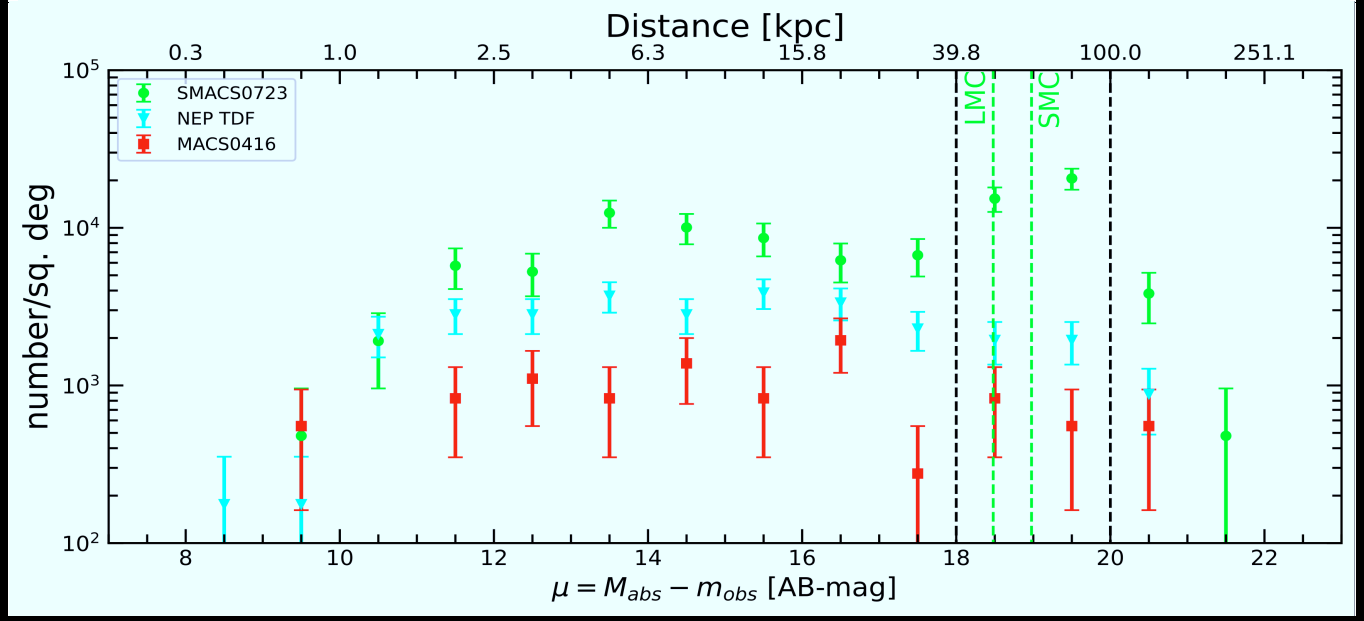
- PEARLS crown jewels today: Extremes in Cosmic SF (low$\rightarrow$high $\sim 10^7\times$)!

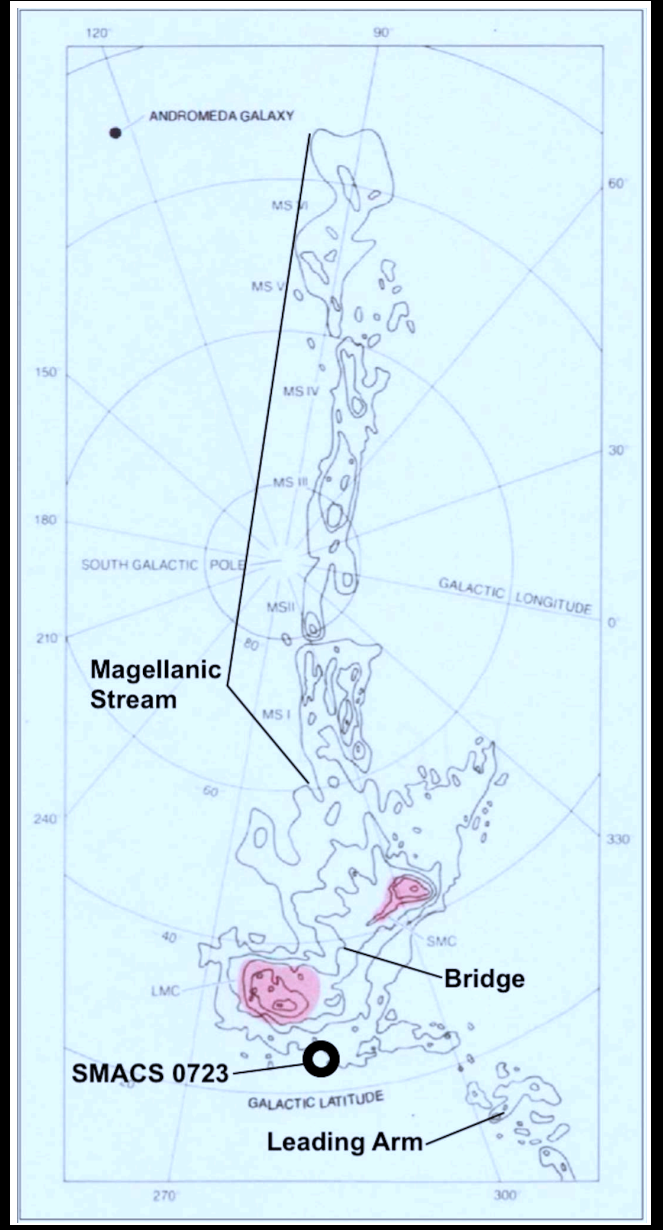
North Ecliptic Pole (NEP) Time Domain Field (TDF) from PEARLS project

— some remarkable results in PEARLS and other JWST projects:

- (Old star) tidal tails everywhere (J. Summers^{+} astro-ph/2306.13037);
- $\lesssim$1% of objects variable: AGN & SNe (R. O'Brien, R. Jansen^{+} 2023);
- Gravitational (galaxy-galaxy) lensing common (Keel^{+} 23, AJ, 165, 166).



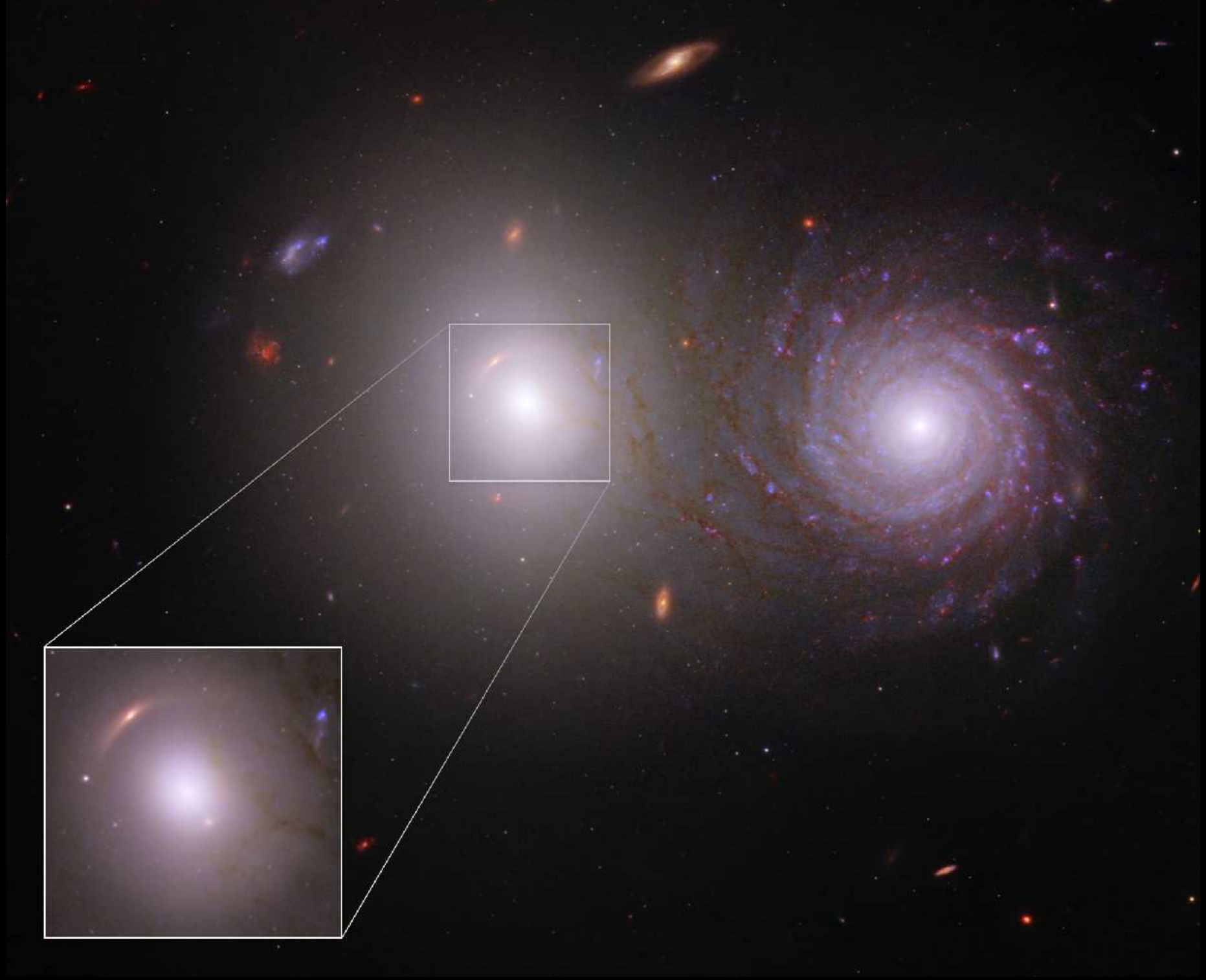




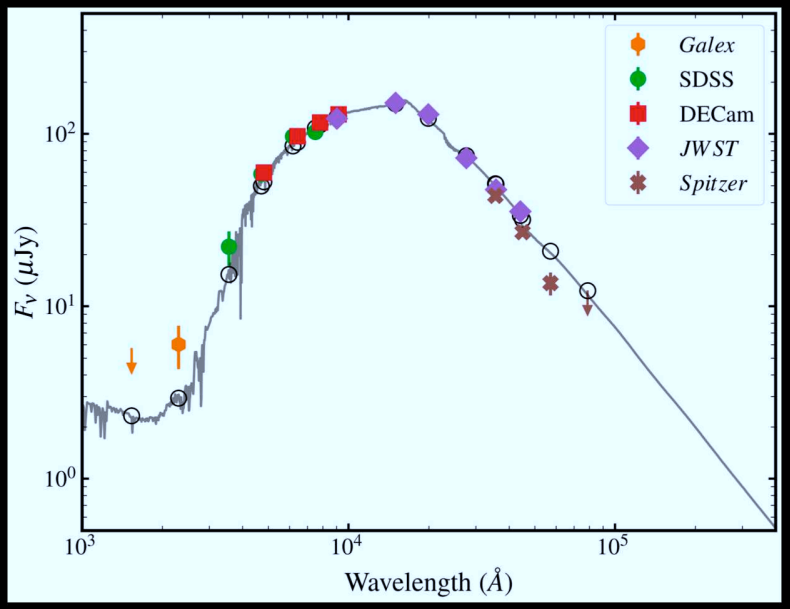
Summers, J., et al. (astro-ph/2306.13037):

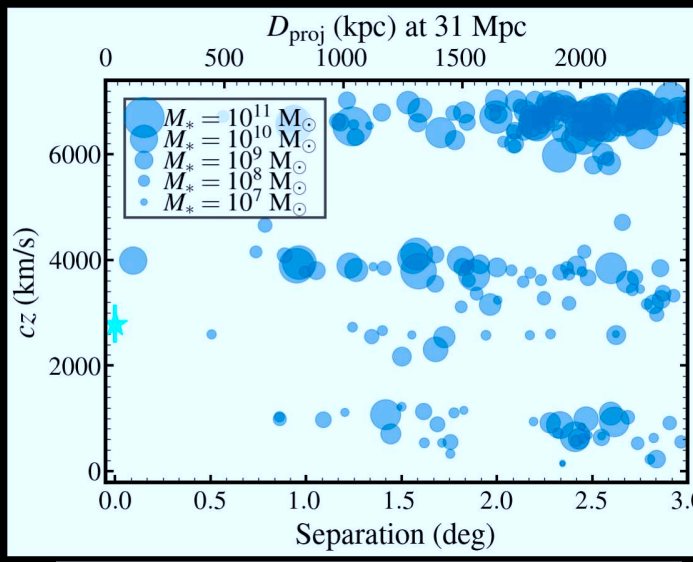
- SMACS0723 star counts show excess near LMC/SMC compared to NEP;
- 71 stars (AB$\lesssim$27) with $D_{SpecType}\simeq$40–100 kpc about 10° from LMC;
- Part of Leading Arm between LMC and MW: 10 mag fainter than Gaia!

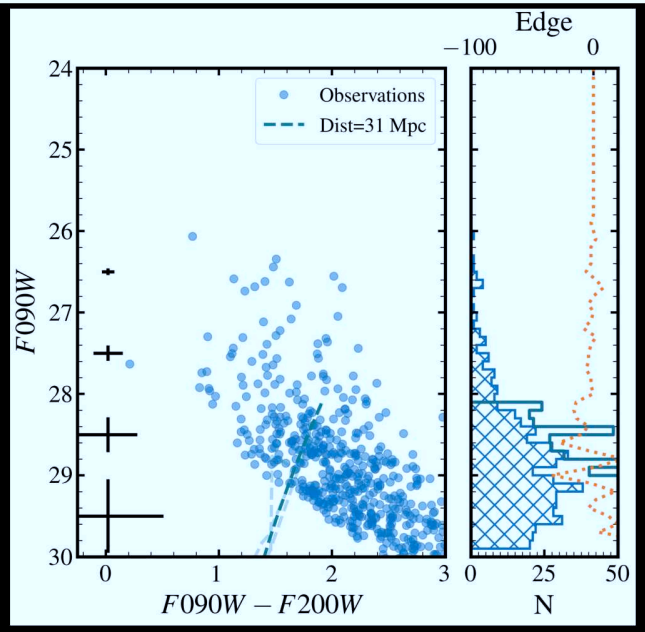
- Spiral overlapping Elliptical: Trace cosmic dust: small grains! (Keel^{+} 2023).
- 100's of Globular Clusters in Elliptical at z=0.0513 (J. Berkheimer^{+} 2023).



... and the z=0.0513 Elliptical also lenses a background galaxy at z∼1 (Keel, et al. 2023, AJ, 165, 16)!



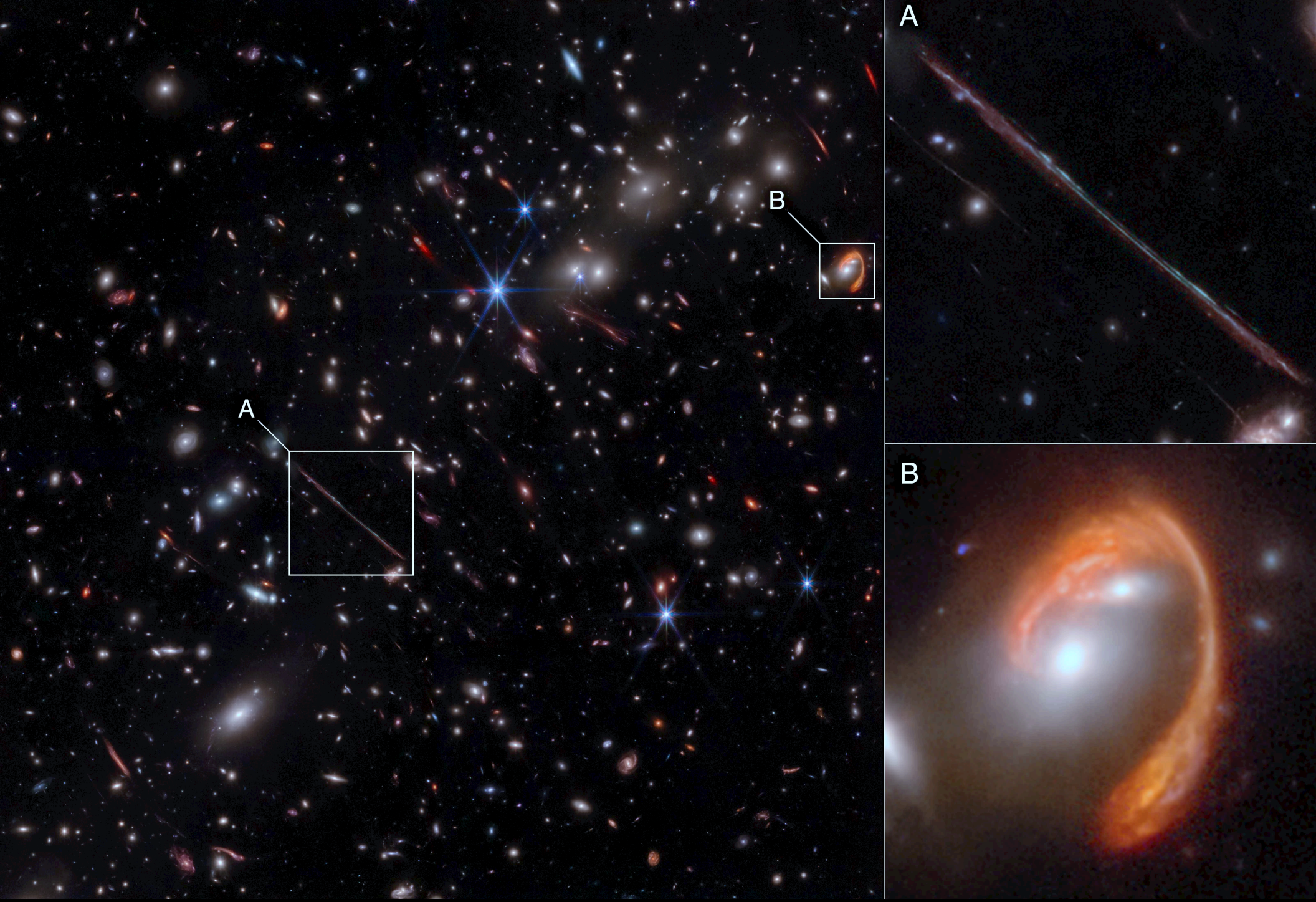




PEARLSDG - an isolated quiescent dwarf galaxy with a TRGB distance of 31 Mpc

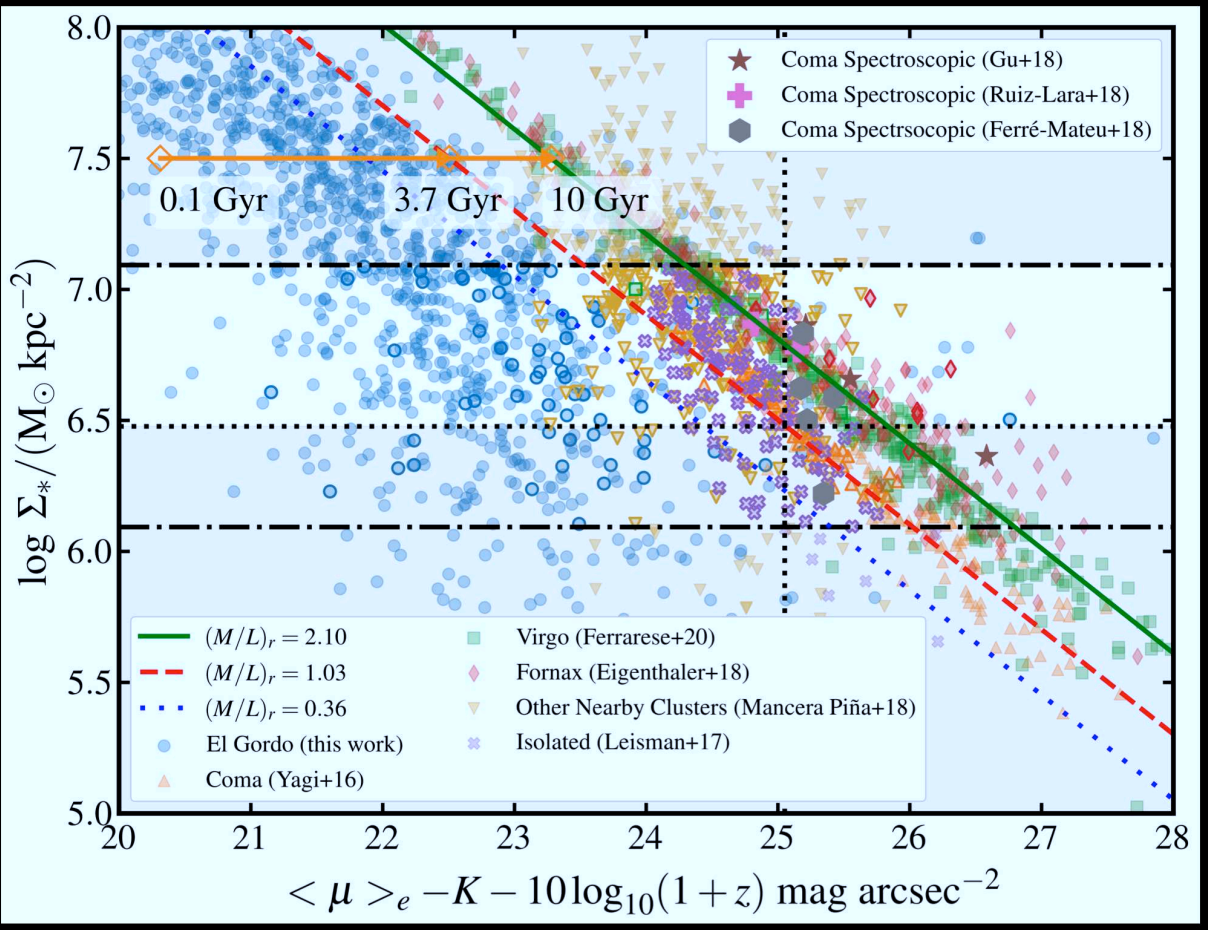
The Carleton$^+$ 2023 NIRCam image of A1489 (LTM cluster CLG1212) revealed:

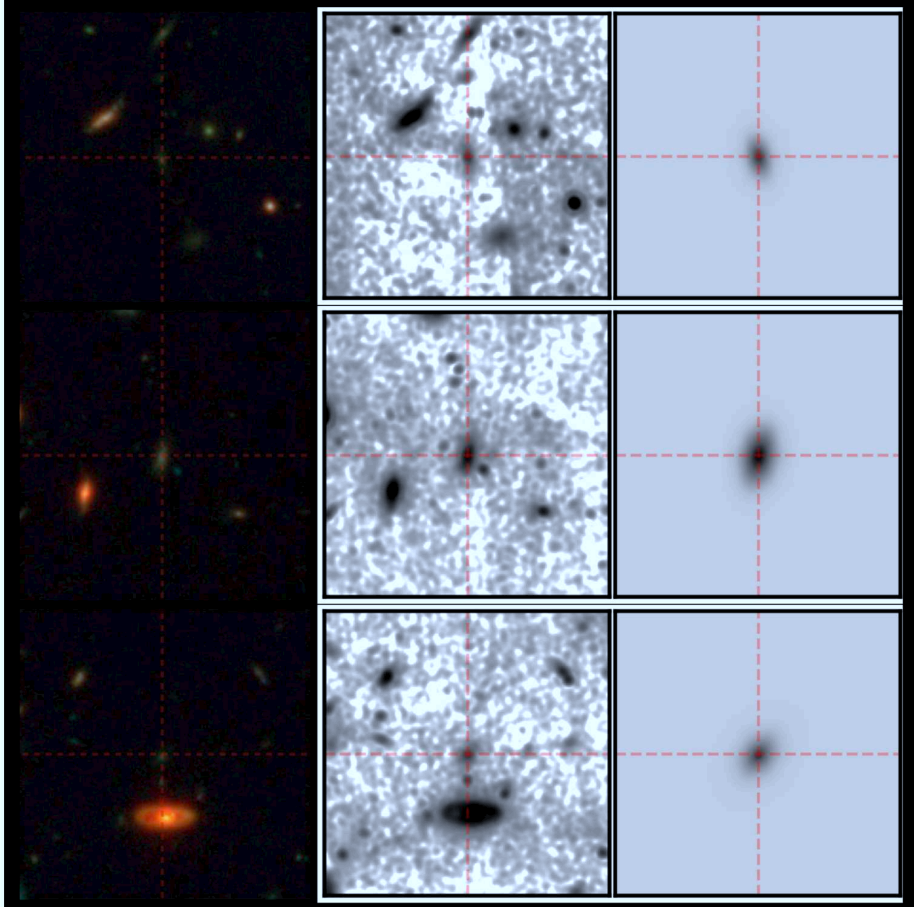
- Isolated Low-SB dwarf at z_{spec}=0.010 between Virgo and Coma LSS;
- TRGB distance of 31.0±1.6 Mpc, ≳800 km/s from nearest neighbor;
- Rather red & old, with extremely low SFR $\simeq 10^{-4}$ $M_\odot$/yr!



8-filter JWST/NIRCam of massive El Gordo cluster at redshift $z \simeq 0.87$

T. Carleton^{+} (2023, ApJ, 953, 83); P. Kamieneski^{+} 23 (astro-ph/2303.05054); J. Diego^{+} (2023; A&A, 672, A3); B. Frye, N. Foo^{+} (2023, ApJ, 952, 81).





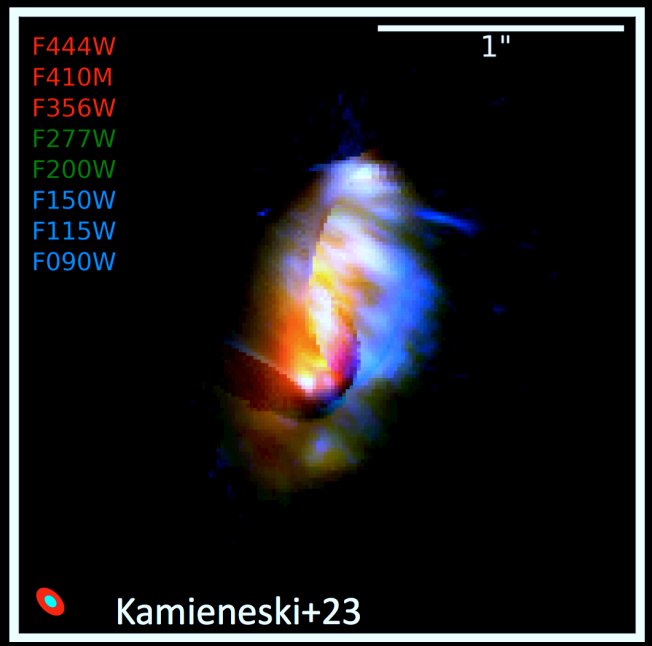
We find low stellar density galaxies in imaging of the El-Gordo cluster.
These objects are younger than local UDGs, suggesting that they were more recently accreted onto the cluster.

Carleton$^+$ (2023, ApJ, 953, 83; astro-ph/2205.06347) NIRCam:

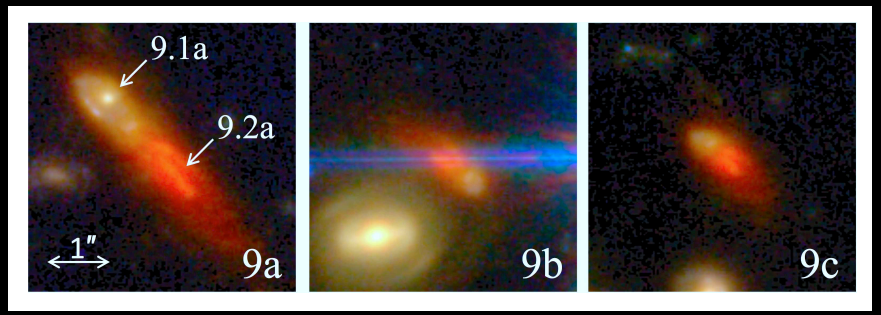
- El Gordo's Low Density Galaxies at z=0.87 have SFR$\simeq$0.1 $M_\odot$/yr.
- $i.e.$, SFR higher than Local Dwarfs, but of course much lower than the upcoming higher-z extremes ...

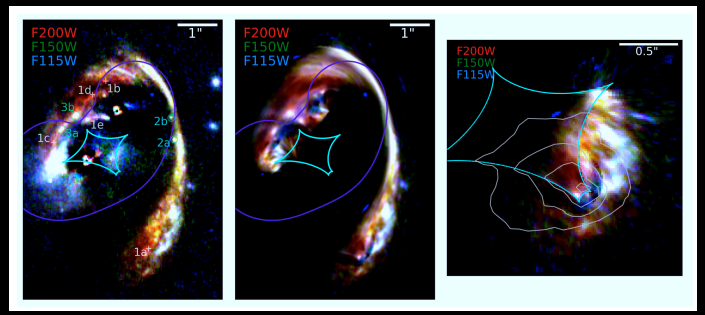
El Anzuelo
"The Fish Hook"

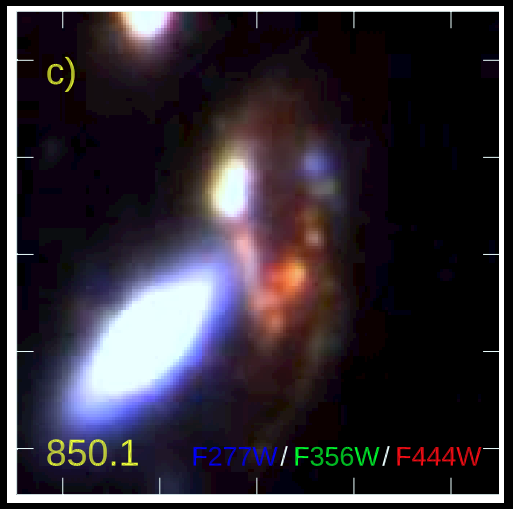
- SFR ~ 80 Msun/yr
- A_V ~ 2
- Source plane:

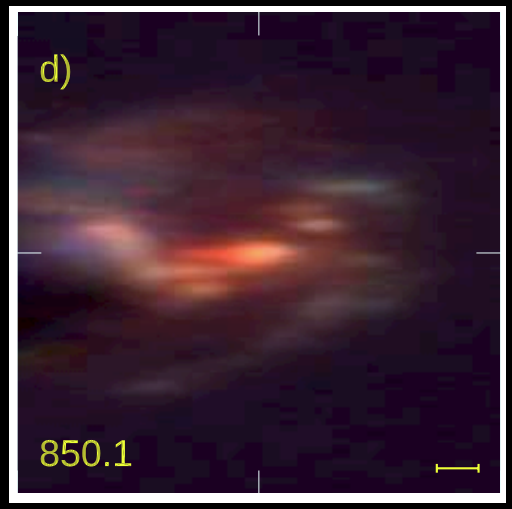


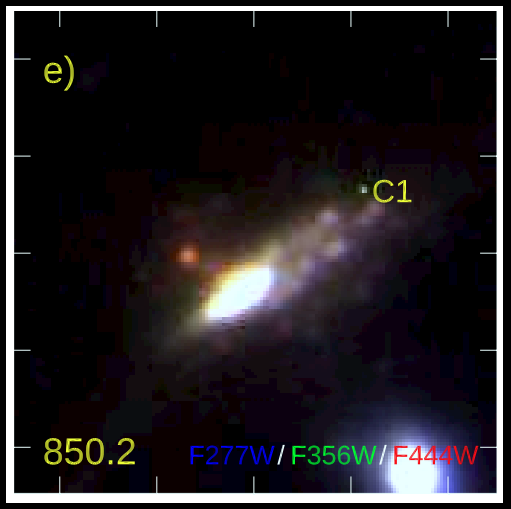
Dusty "El Anzuelo" has a high de-magnified total SFR≃80 $M_\odot$/yr (P. Kamieneski+ 23; astro-ph/2303.05054):

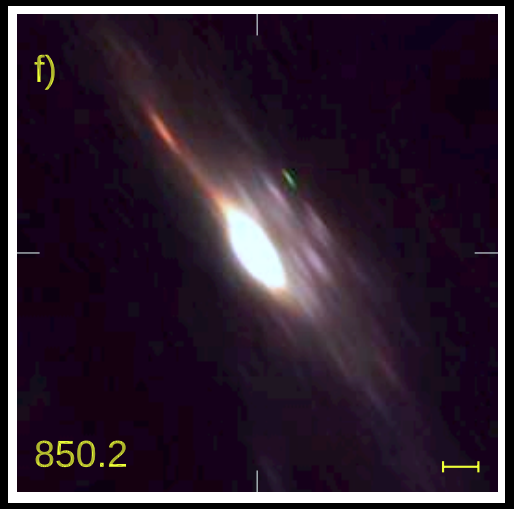


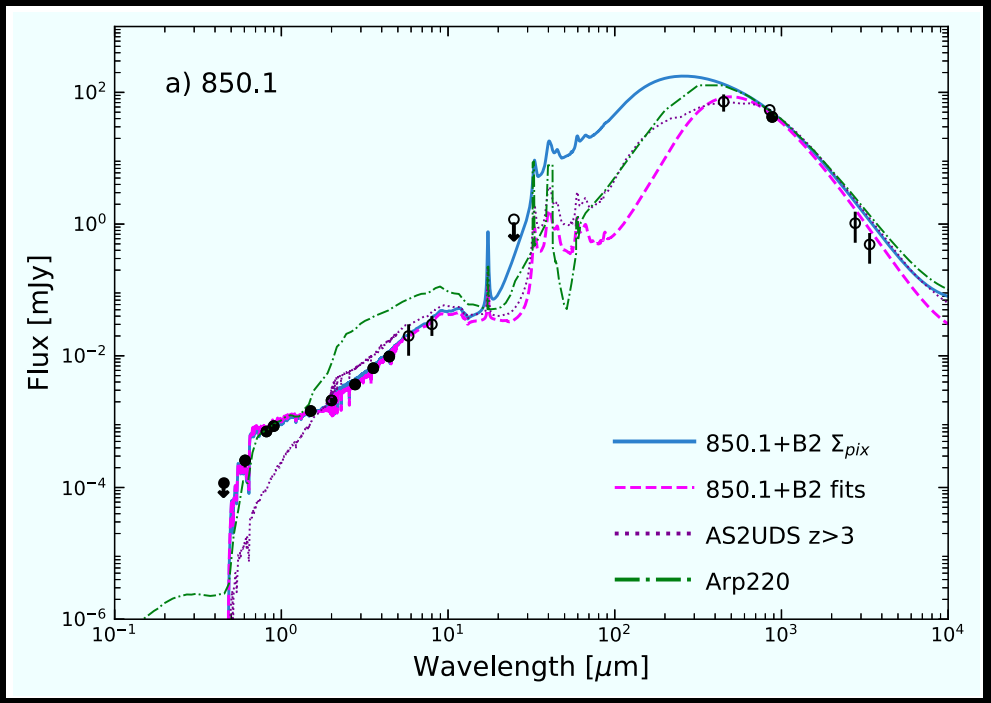


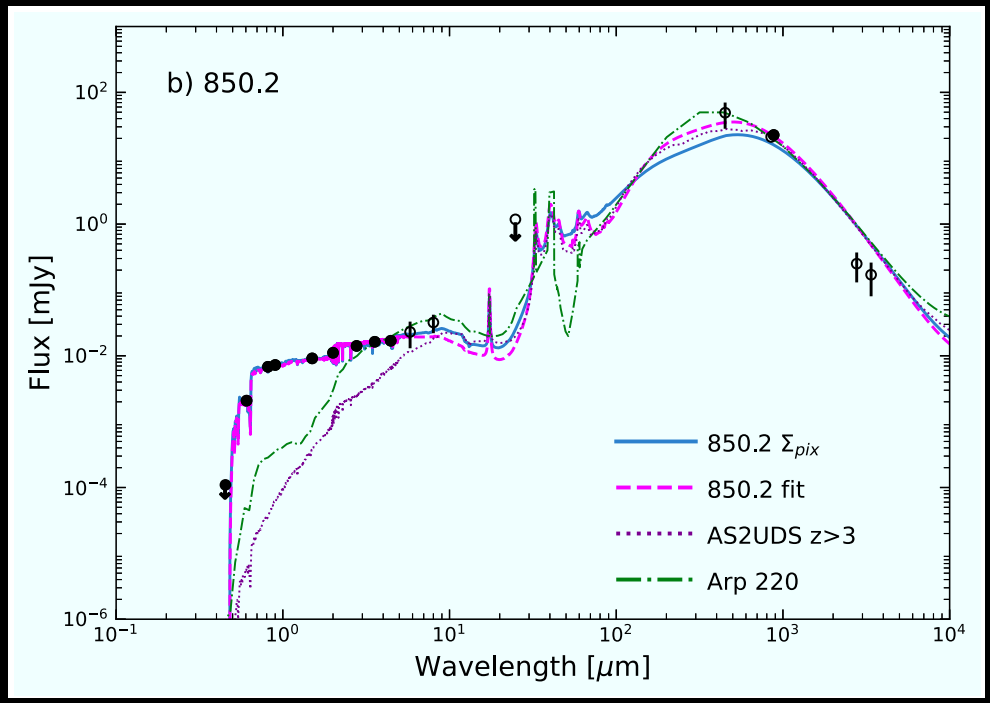






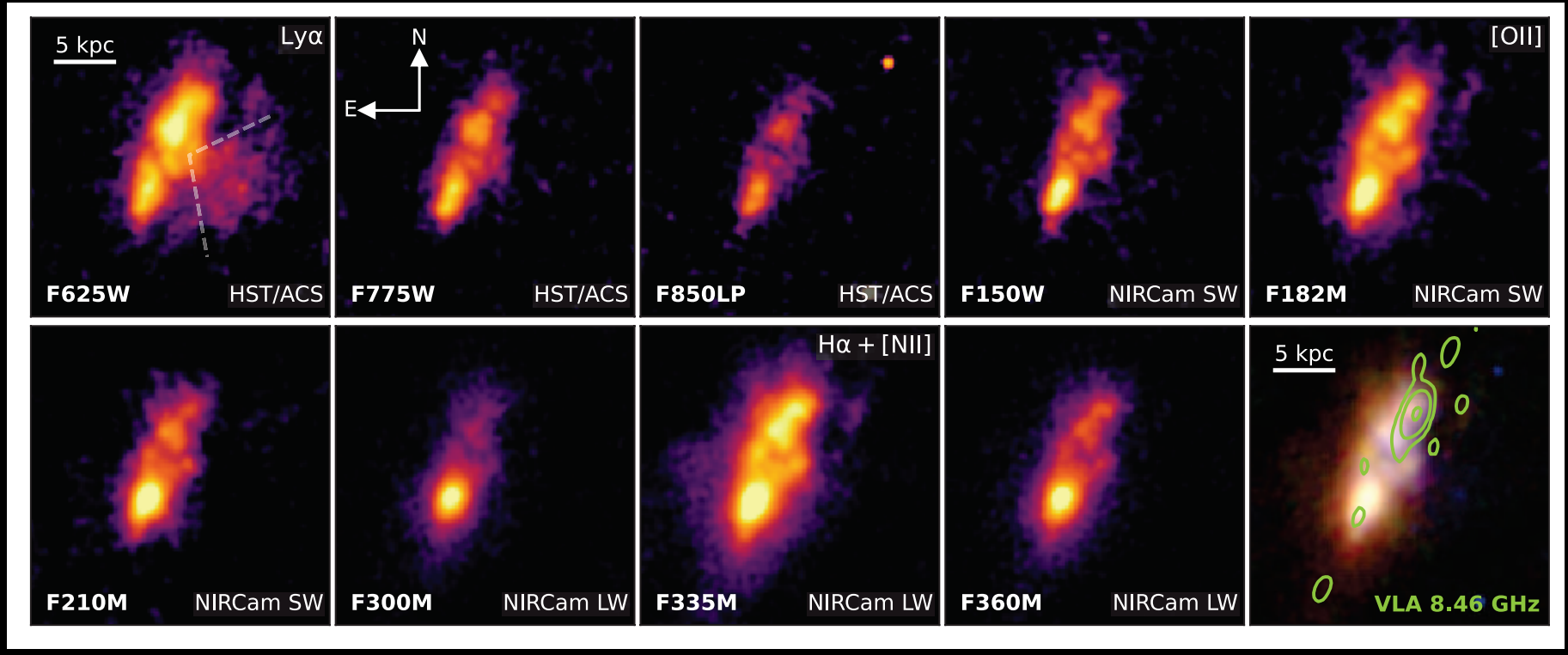


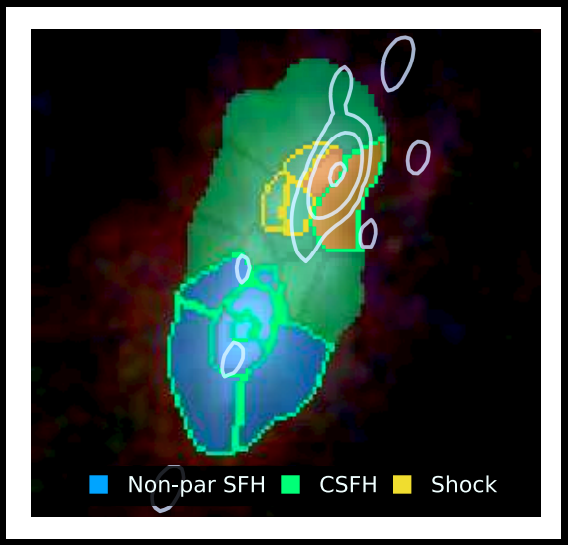


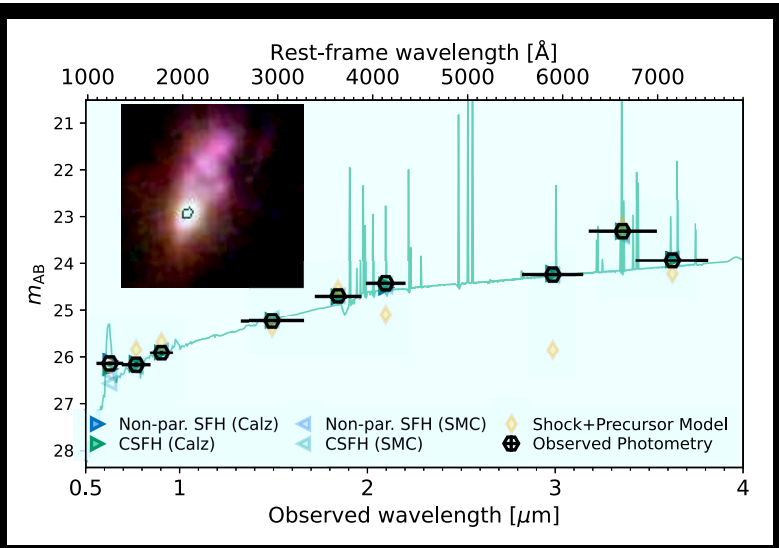


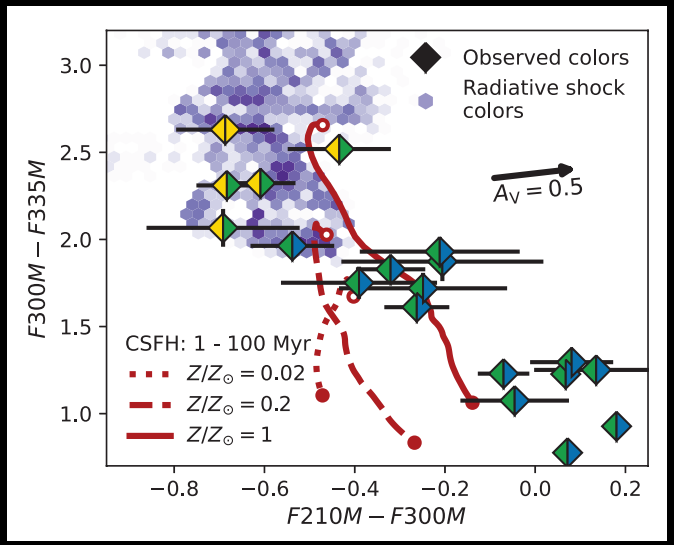
Smail^{+} (astro-ph/2306.16039): Two bright lensed sub-mm galaxies at z≃4.26 behind A1489 (LTM cluster CLG1212) could not be more different:

- 850.1: $\sim 10^{11.8}$ $M_\odot$, $\tau \sim$450 Myr, 1400 $M_\odot$/yr, $A_V \sim$5 mag!
- 850.2: $\sim 10^{10.3}$ $M_\odot$, $\tau \sim$50 Myr, 400 $M_\odot$/yr, $A_V \sim$1.2 mag!





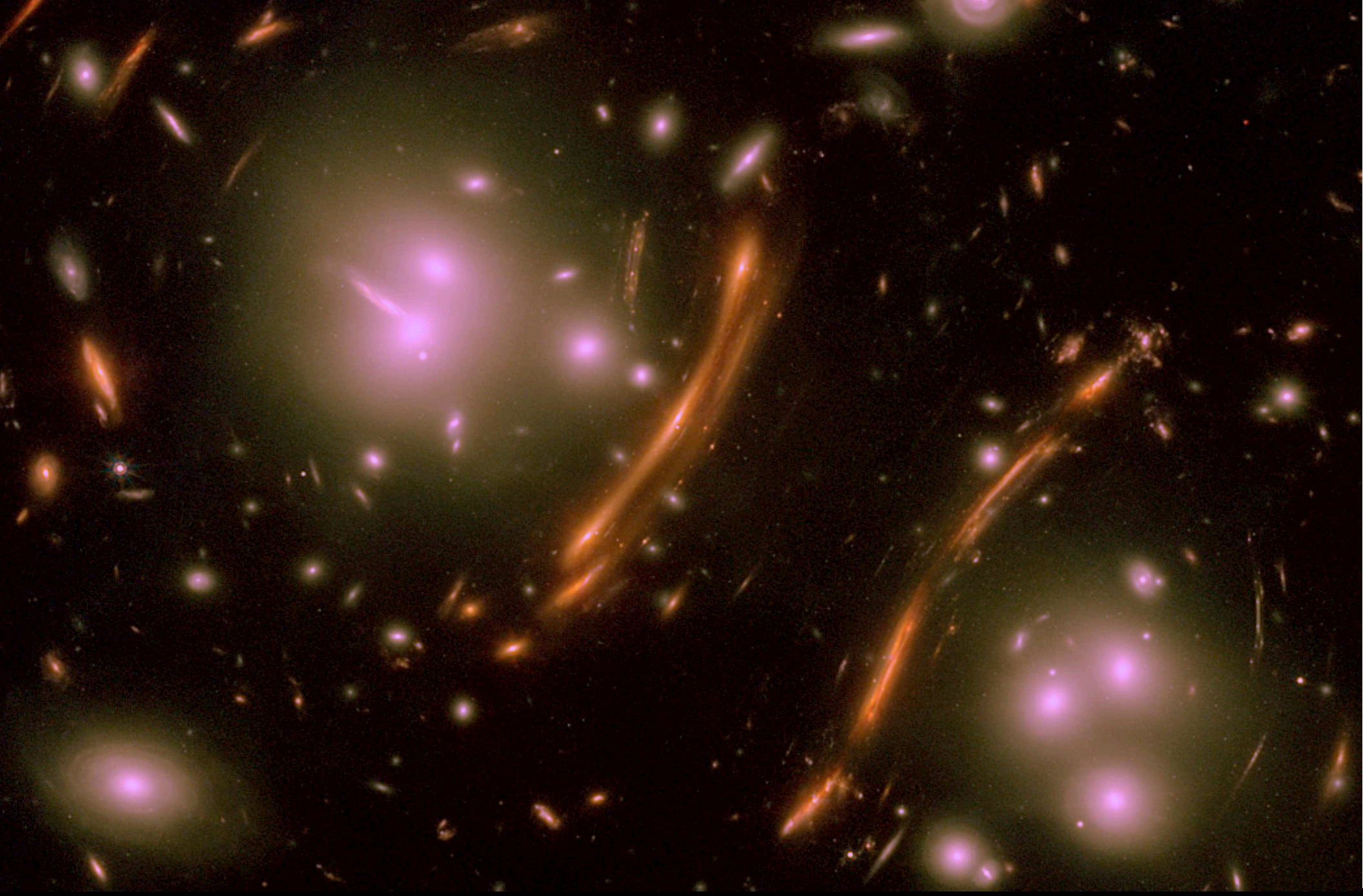




The most massive ($10^{10.9}$ $M_\odot$) high-z radio galaxy TNJ1338 at z=4.11:

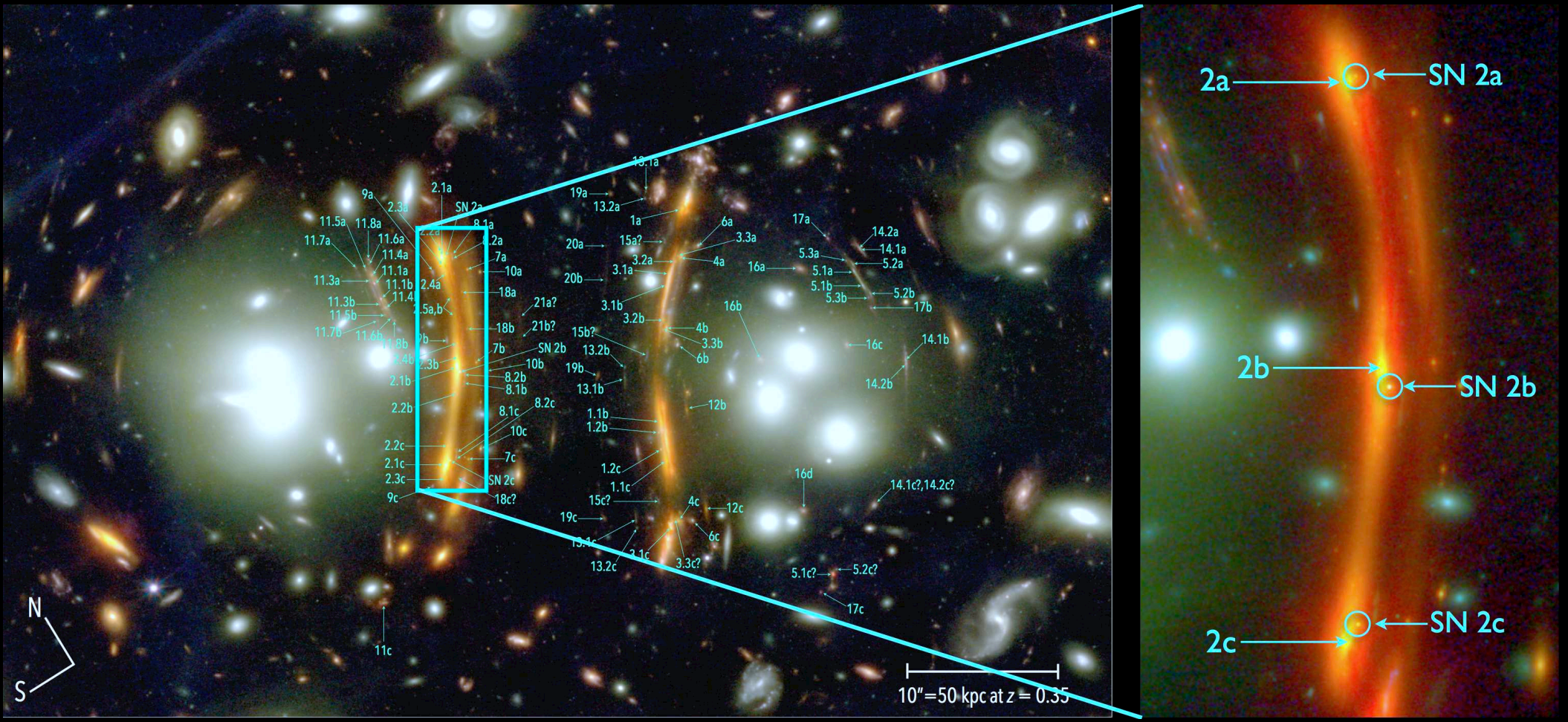
Total medium-band SFR≃1600 $M_\odot$/yr (Duncan+23, MNRAS, 522, 4548)

- Extreme jet-induced SFR≳500 $M_\odot$/yr and t_{SFR}≃4 Myr.



NIRCam image of most luminous far-IR Planck cluster G165 at z=0.35:

- Frye^{+} 23: Very high *de-magnified total* SFR$\simeq$200–350 $M_{\odot}$/yr.

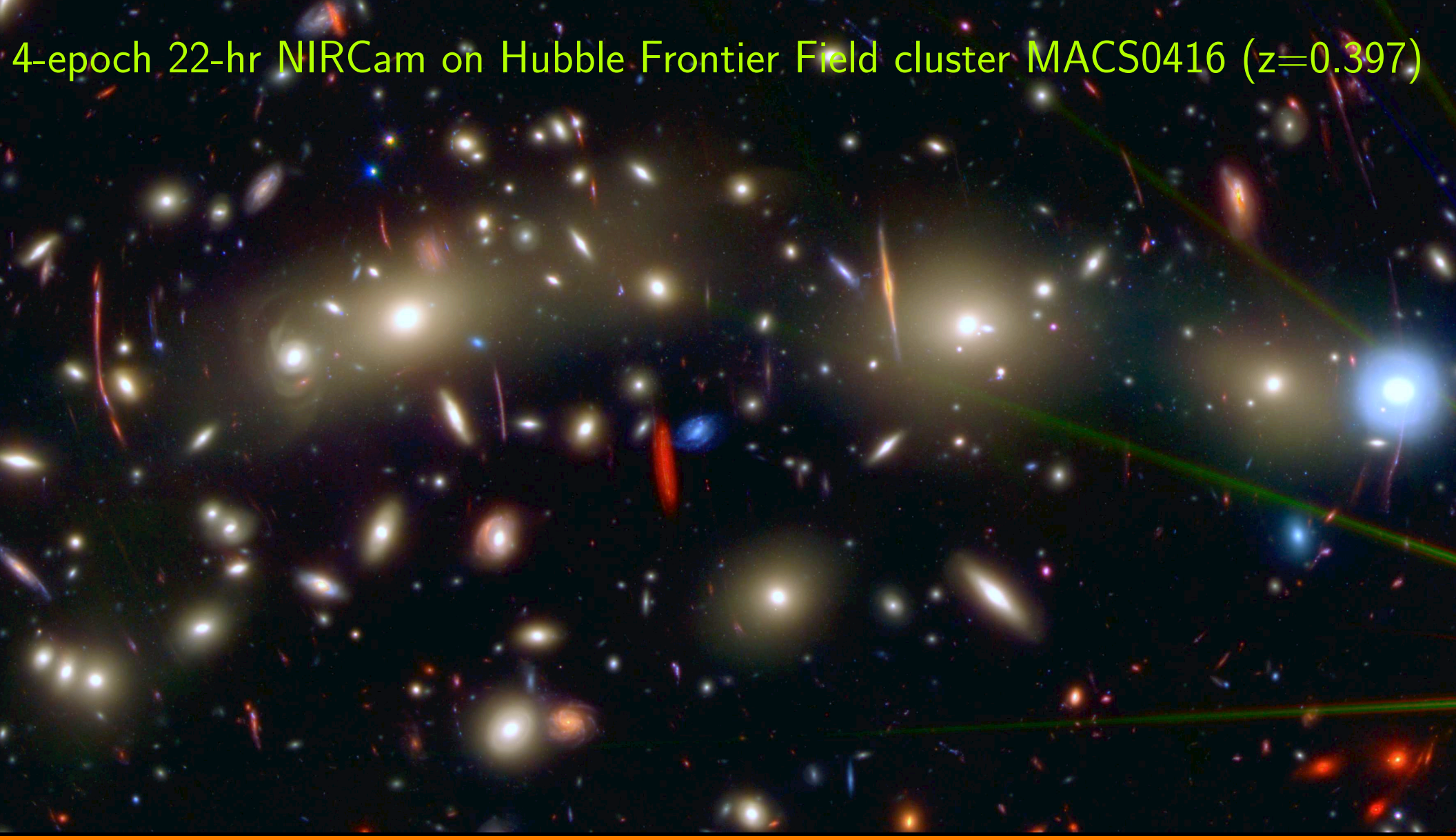


NIRCam in G165 shows: 3 bright point sources parity-flipped w.r.t. Arc-2:

- Clear SN-Ia at z=1.783! (LBT, NIRSpec; Polletta^{+}, 2023, A&AL, 675, L4; astro-ph/2306.12385);
  - 3-epoch G165: 9 data-point light-curve! $\longrightarrow$ suitable to measure H_0 at z=1.783 (Frye^{+}23; Chen^{+}23; Foo^{+}23; Pascale^{+}23; Pierel^{+}23);

$\rightarrow$ Regular monitoring of clusters with extreme SF can yield more lensed SNe!

- Total SFR$\simeq$200–350 $M_{\odot}$/yr should give a lensed SN every few years.



- Yan, H.$^{+}$ (2307.07579): 12 new caustic transits at z$\simeq$1–2 from 4 epochs!
- Diego, J.$^{+}$ (2307.10363): extremely magnified z=2.091 binary star!

$\Longrightarrow$ Regular monitoring of several clusters can yield IMF's at z$\gtrsim$1 directly!

References and other sources of material

Talk: http://www.asu.edu/clas/hst/www/jwst/stsci23_JWST_1stYr_Windhorst.pdf Data: https://sites.google.com/view/jwstpearls

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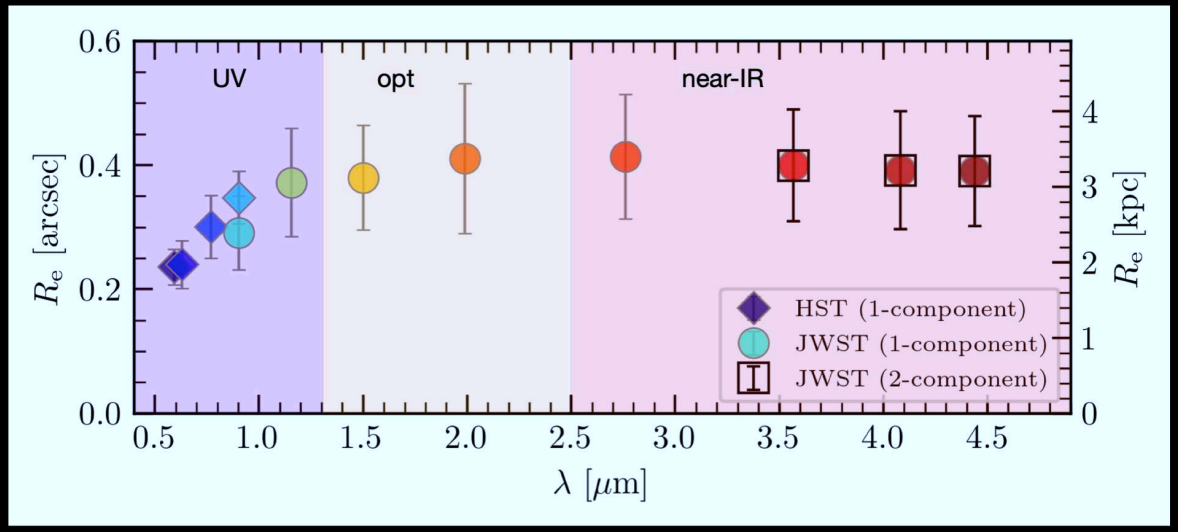
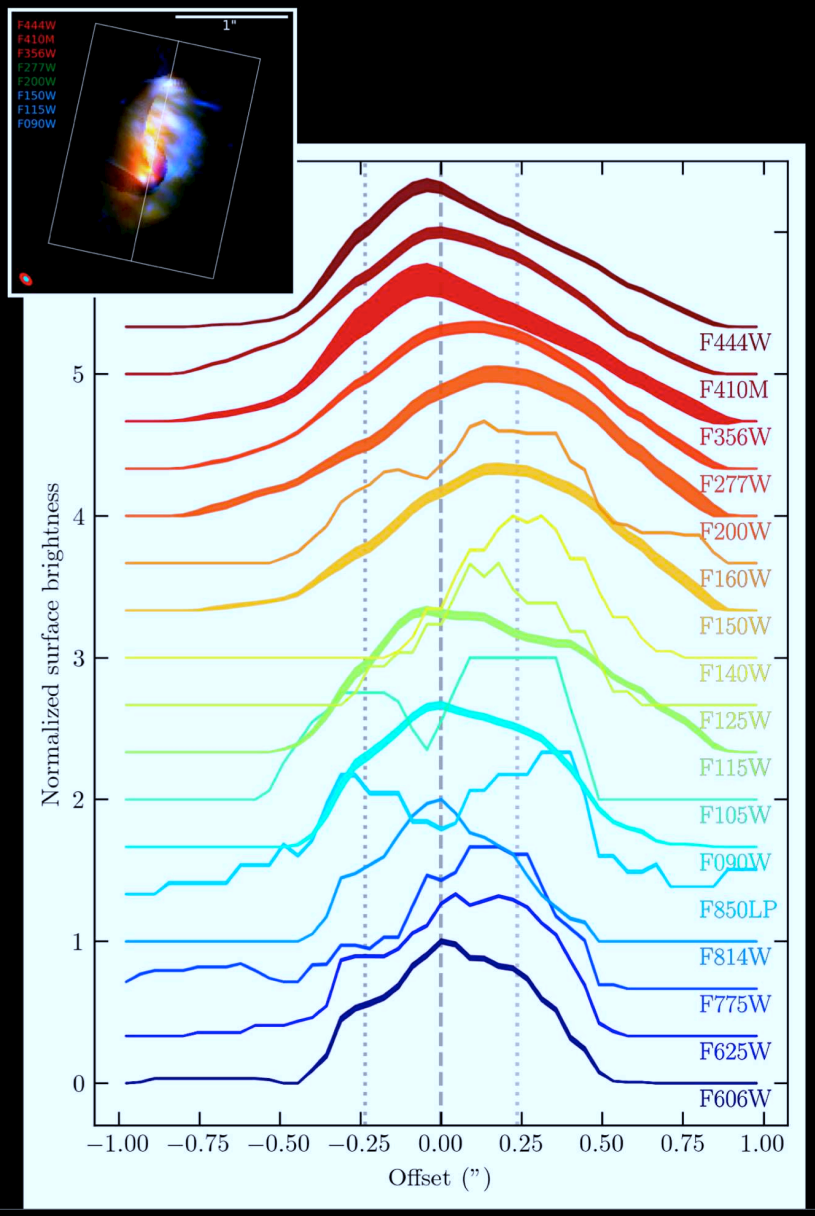
https://news.asu.edu/20230801-jwsts-gravitational-lens-reveals-distant-objects-behind-el-gordo-galaxy-cluster

SPARE CHARTS

How does its size vary from UV to IR?

- Effective radius is nearly *constant* from rest-frame blue optical through near-IR, despite a redder center
- Larger sSFR in galaxy outskirts --> Inside-out quenching?
- Both variations in sSFR and in dust attenuation are likely responsible for the complex color gradients

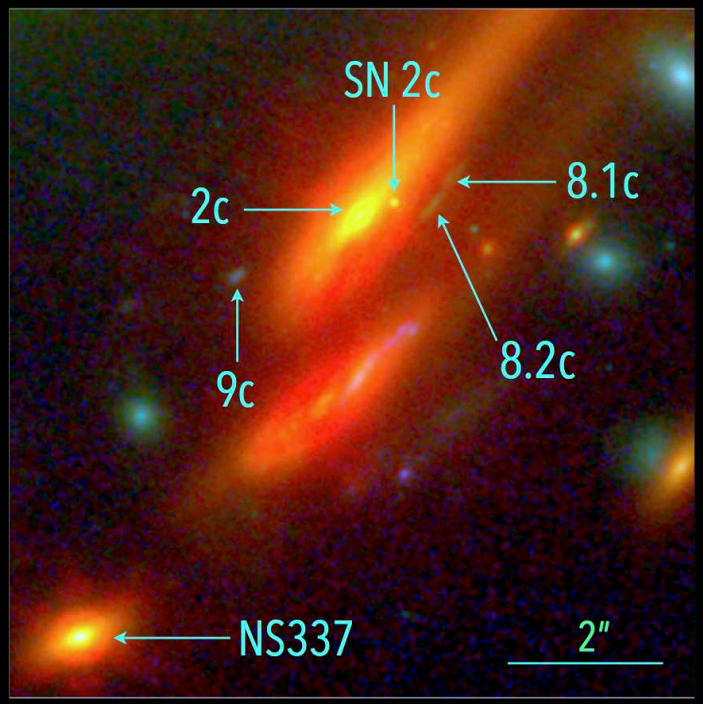




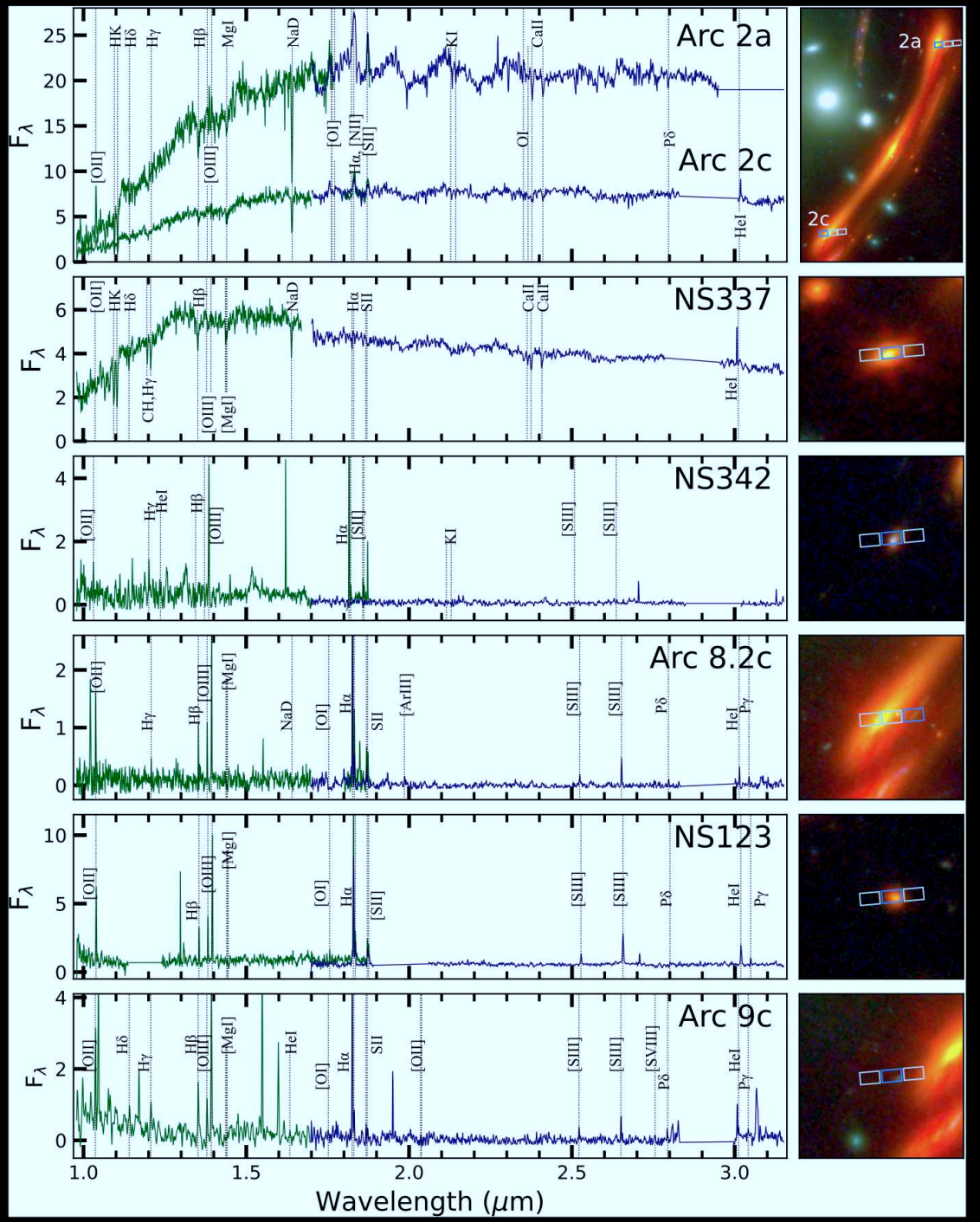
Kamieneski et al. (2023, ApJ, in press; astro-ph/2303.05054):

- Dusty "El Anzuelo" has a high de-magnified total SFR$\simeq$80 $M_\odot$/yr.
- Larger sSFR in delensed outskirts $\Longrightarrow$ inside–out quenching?

JWST/NIRSpec



- SN 2c and its host galaxy (2c) are depicted with 4 *close* galaxy neighbors ($\Delta v<900$ km/s, source plane separation <34 kpc)
- Spectroscopy/SED fits find Arc 2 to be quiescent & massive & its friends to be SFGs/SBGs
- This picture is potentially consistent with galaxy downsizing
- Look for upcoming papers **(Frye+23b; Pierel+23; Chen+23; Pascale+23b)**
-



- Frye$^+$ 23: Very high *de-magnified total* SFR$\simeq$200–350 $M_\odot$/yr.