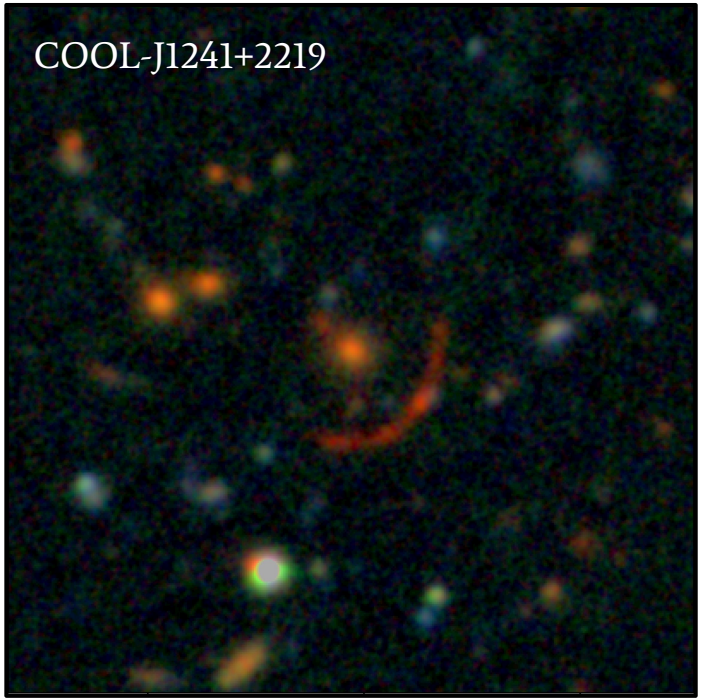
COOL-LAMPS

ChicagO Optically-selected Lenses - Located At the Margins of Public Surveys

THE UNIVERSITY OF CHICAGO

Department of Astronomy and Astrophysics

KICP



The Brightest Galaxy in the z>5 Universe

Observing Distant Lensed Galaxies with Roman Space Telescope

Gourav Khullar

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PhD Candidate, The University of Chicago

on behalf of the COOL-LAMPS collaboration

(PI: Mike Gladders)

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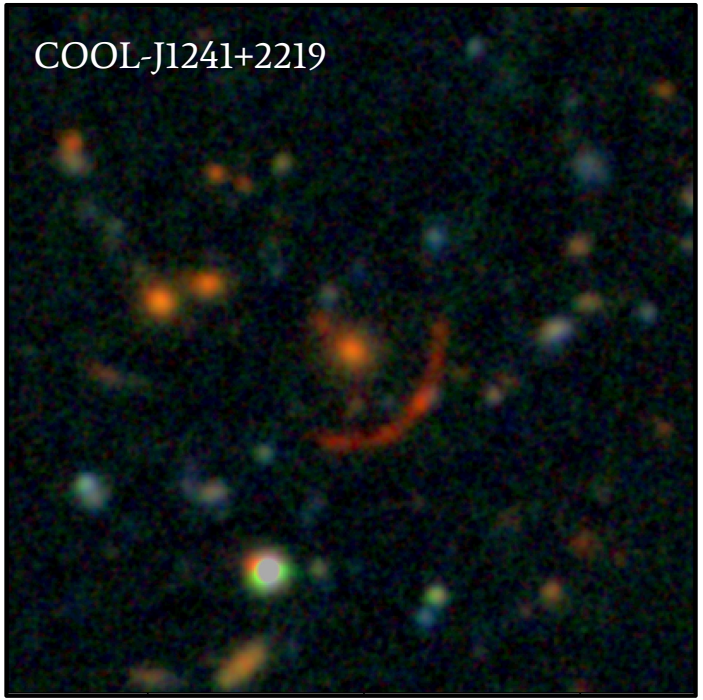


The Brightest Galaxy in the z>5 Universe

Observing Distant Lensed Galaxies with Roman Space Telescope

1. Describing the Project
2. The Physics of COOL-J1241
3. Roman Space Telescope and Distant Lensed Galaxies
   a. Projections: Number of Galaxies
   b. Stellar populations in High-z galaxies w/ photometry
   c. Harnessing RST's spatial resolution

COOL-LAMPS

ChicagO Optically-selected Lenses - Located At the Margins of Public Surveys

Effort to find strong gravitational lenses in recent public imaging data - DECaLS (DR8) and Pan-STARRS (DR2)

Objects that are photometrically at the margins of the distributions of source color and brightness, with visual examinations of 275k lines-of-sight

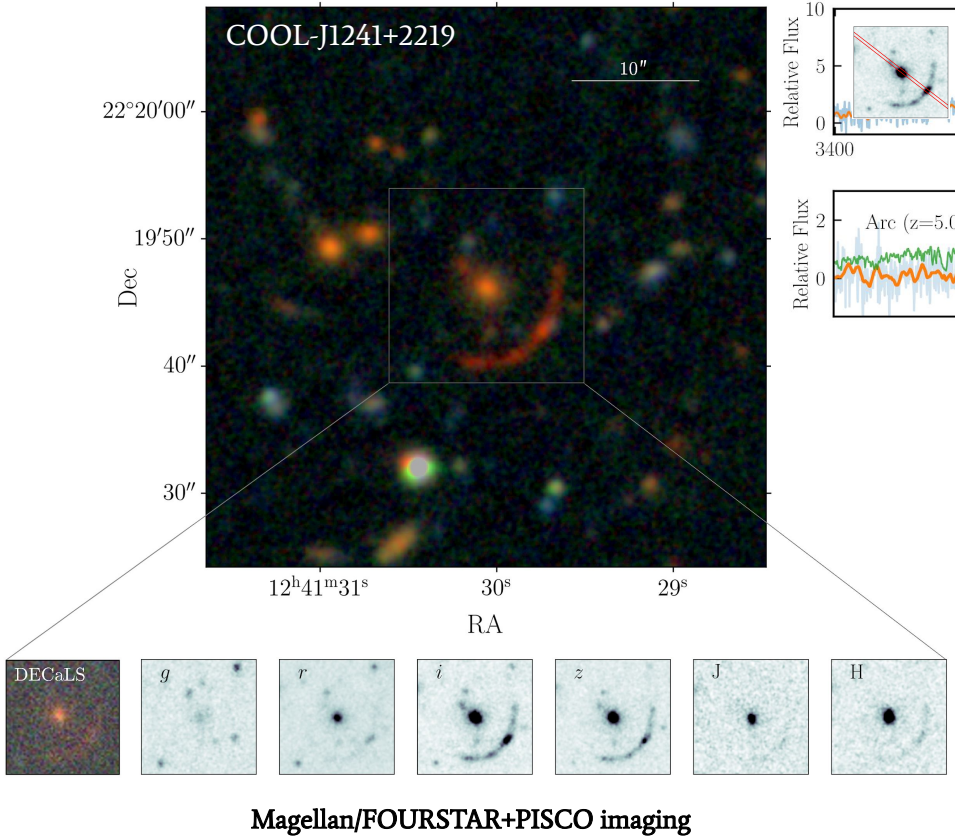
Initiated as the central focus of undergraduate research class at The University of Chicago (December 2019-present)

PI/Instructor: Mike Gladders | TA and lead grad student: Gourav Khullar (me!)

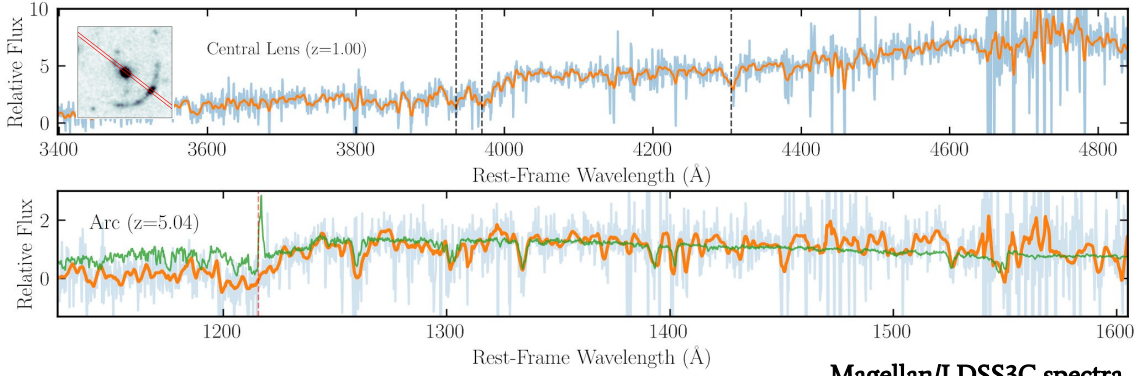
Katya Gozman, Jason Lin, Michael Martinez, Owen S. Matthews Acuna, Elizabeth Medina, Kaiya Merz, Jorge Sanchez, Emily Sisco, Daniel Stein, Ezra Sukay, Kiyan Tavangar

Hakon Dahle, Guillaume Mahler, Keren Sharon, Jane Rigby, Matt Bayliss, Lindsey Bleem, Sasha Brownsberger, Michael Florian, Tony Stark

COOL-LAMPS I. An Extraordinarily Bright Lensed Galaxy at Redshift 5.04; *Khullar et al. 2020 (submitted to ApJ)*



Magellan/FOURSTAR+PISCO imaging



Magellan/LDSS3C spectra

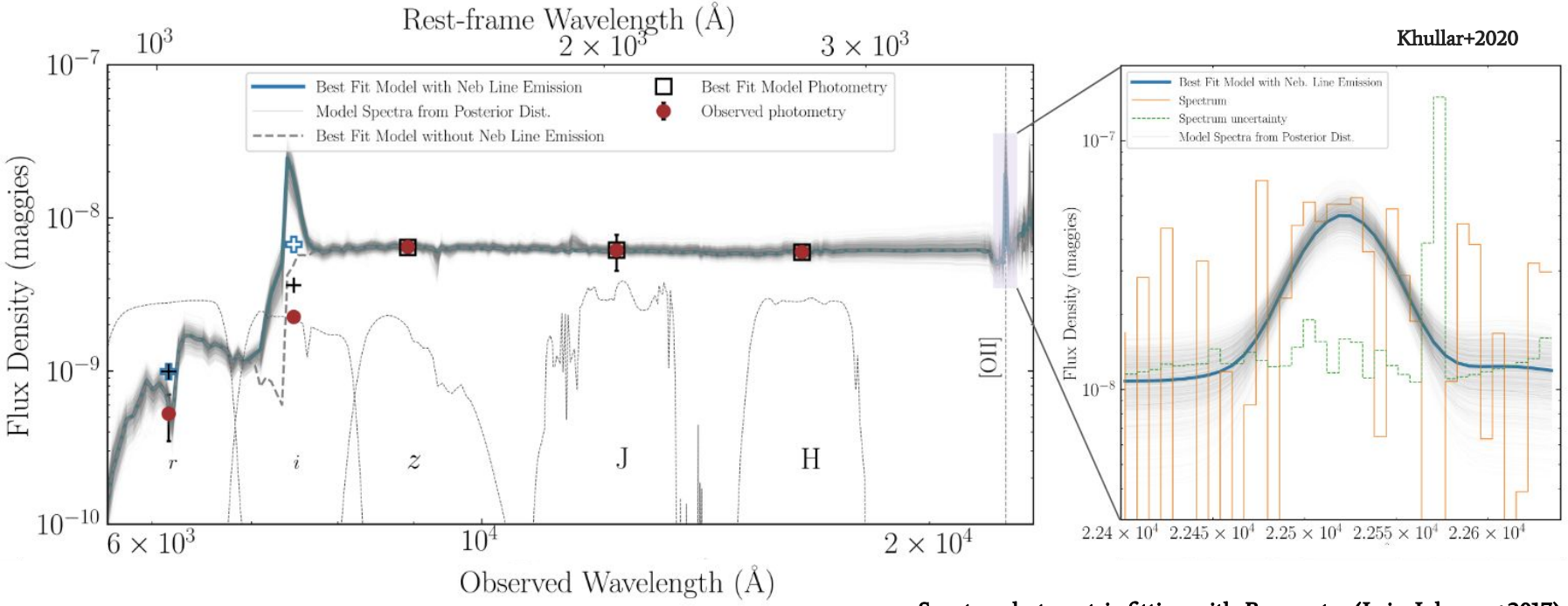
Found in the DECaLS grz DR8

Part of comprehensive visual search of the northern galactic cap portion and looking for potential high-z lenses in ~ 4000 deg^2 .

Photometry: *i*=21.6, *z*=20.5, J=20.5

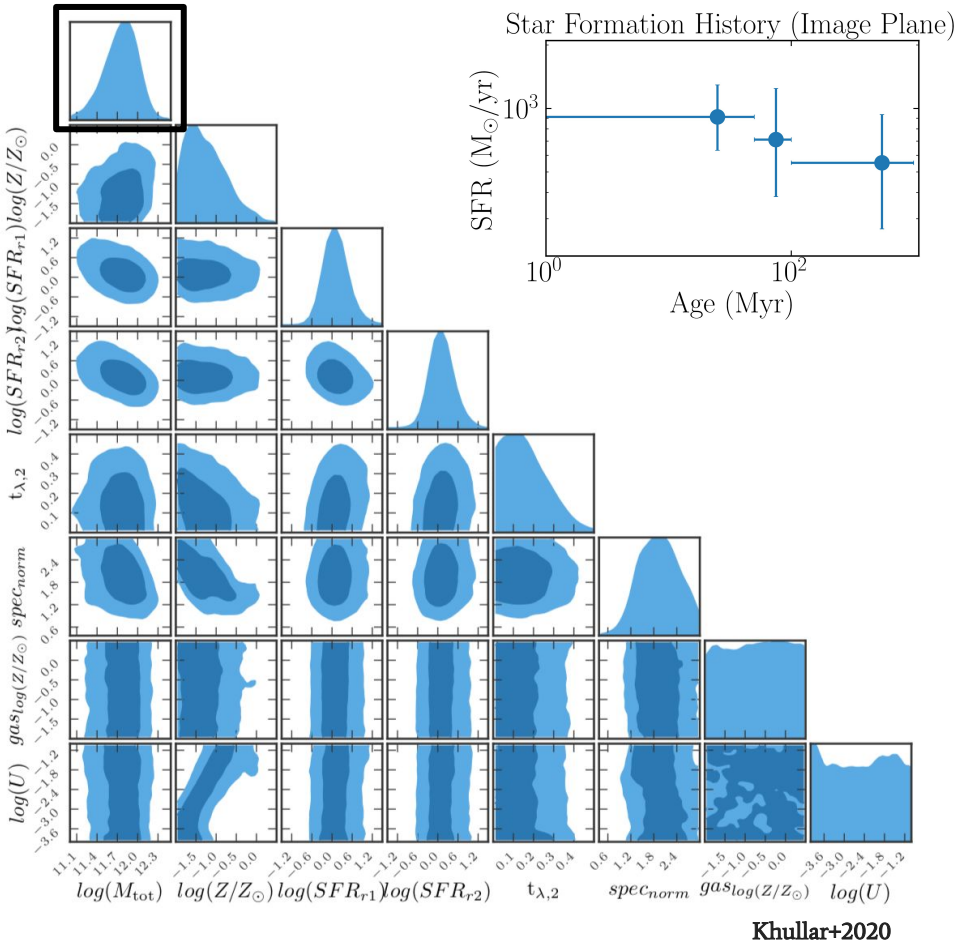
grizJH imaging + rest-frame UV + optical spectrum of the arc

A z=5 galaxy with a flat UV SED (blue spectrum), little dust attenuation, and weak [OII] 3727A emission

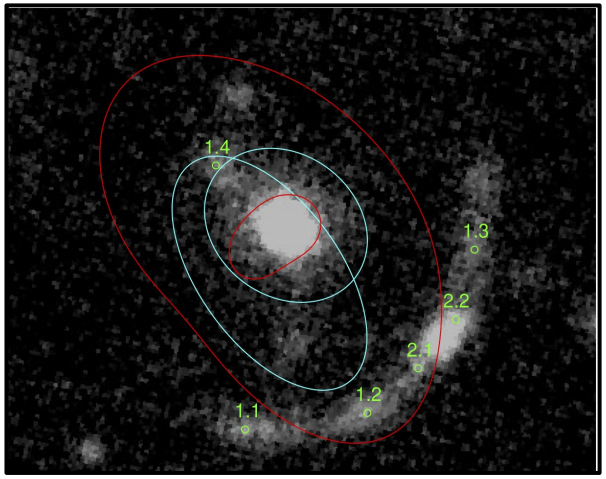


Khullar+2020

Spectro-photometric fitting with *Prospector* (Leja, Johnson+2017)



Khullar+2020



Source plane properties (from a PISCO *i* imaging based lens model):

$\log M_* \text{ (in } M_\odot) = 10.1 \pm 0.2$

$\text{SFR (0-50 Myr, in } M_\odot yr^{-1}) = 27_{-9}^{+13}$

Roman Space Telescope and Distant Galaxies

The Roman Space Telescope (RST) → **wide area NIR coverage**, **HST-like spatial resolution**

Will be a unique resource for the discovery *and* characterization of strongly-lensed galaxies in the early universe.

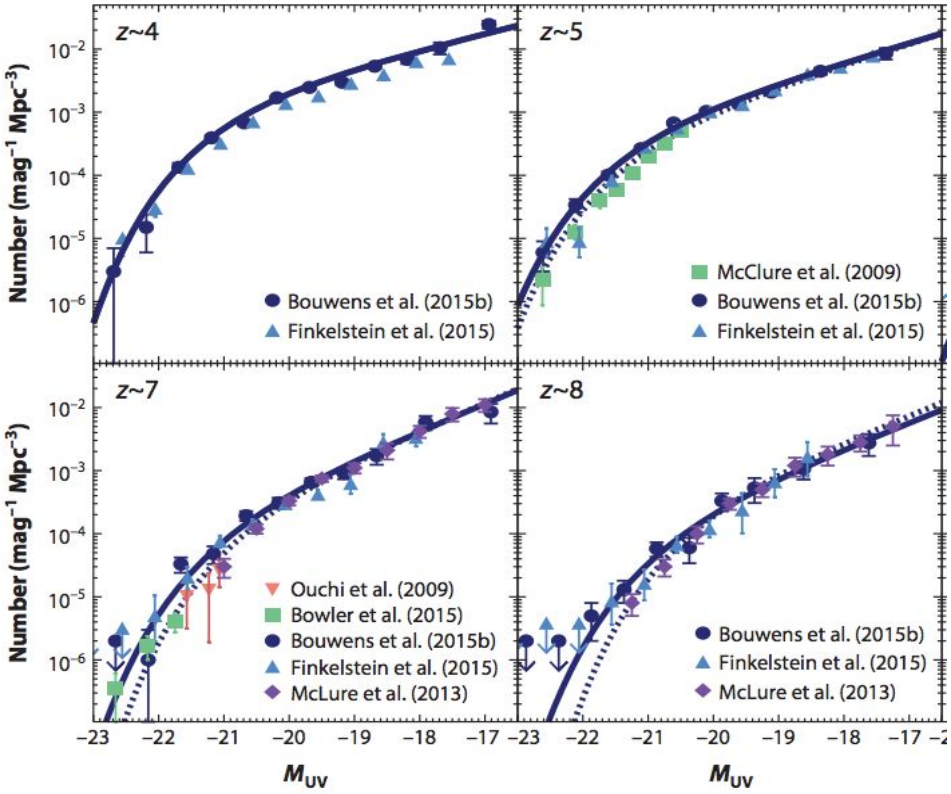
It will fill the broad gap in discovery space between:

1. Brightest systems found in all-sky shallower data, and
2. Faintest lensed systems found already in the Frontier Fields and expected from JWST.

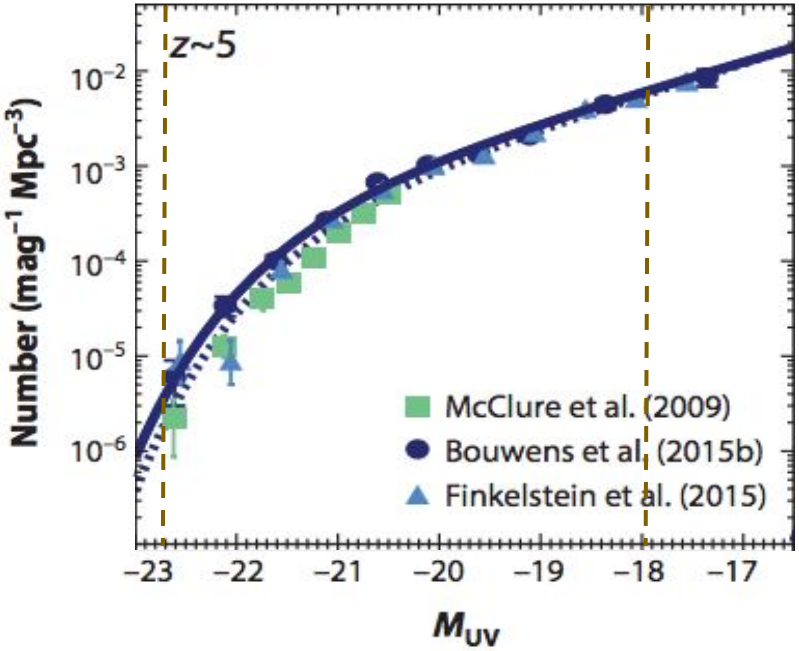
Enormous benefits of RST's features, **combined with the resolving power of strong gravitational lensing**:

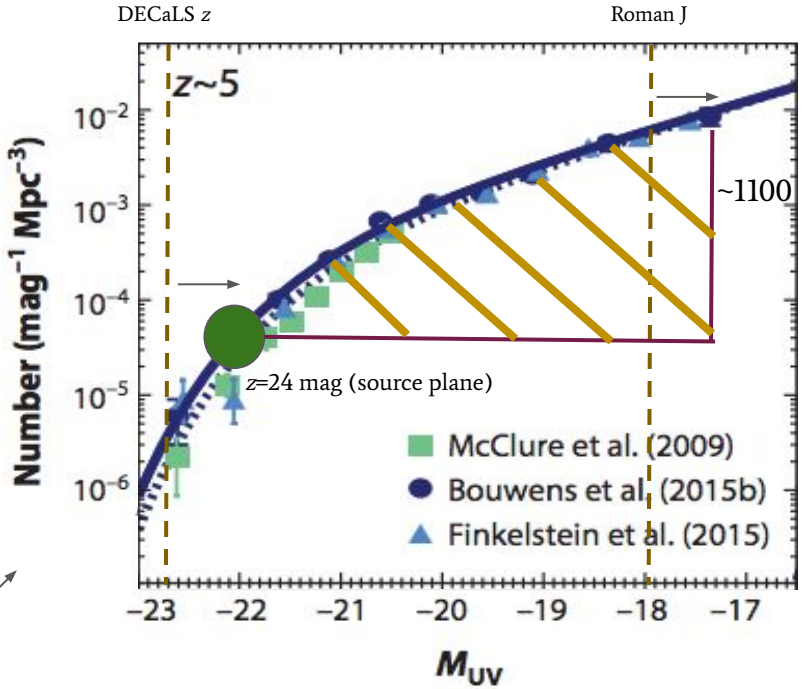
- Capturing and analysing rest-frame UV and optical signatures from stellar populations in high-redshift galaxies systematically.
- Observing the interiors of distant galaxies → < 1 kpc scale clumps

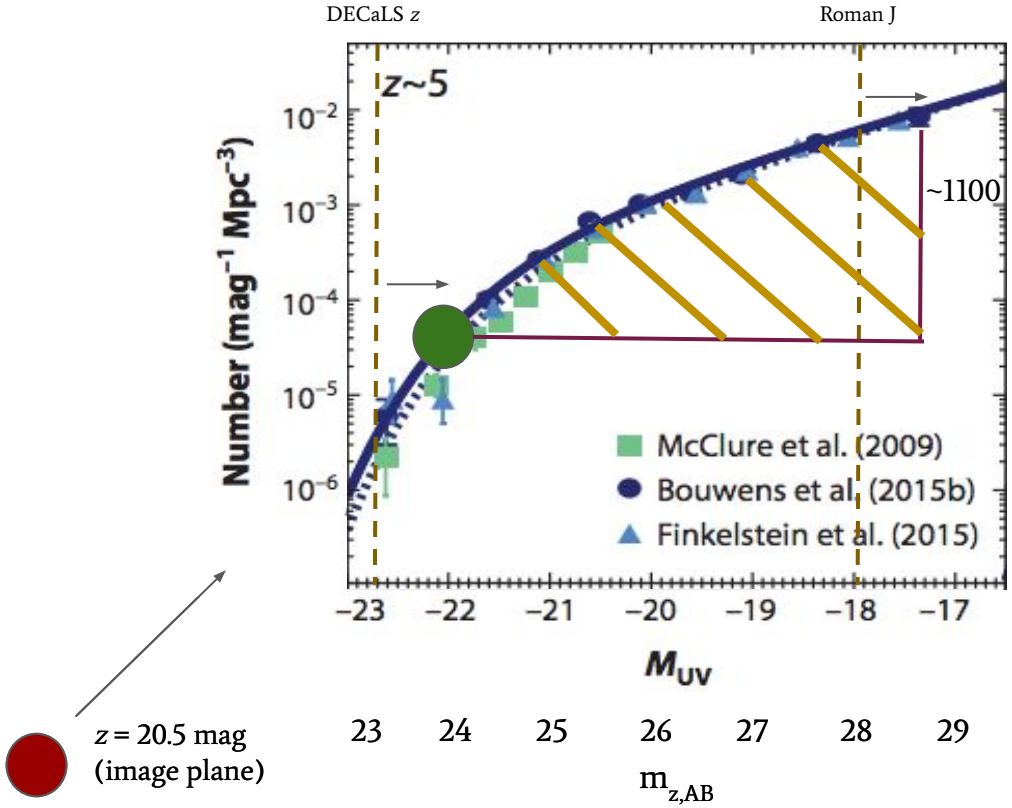
How many lensed galaxies will the RST find at z>5 ?



Galaxies in the First Billion Years After the Big Bang; Stark 2016


z~5
Number (mag^{-1} Mpc^{-3})
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
−23
−22
−21
−20
−19
−18
−17
M_{UV}
McClure et al. (2009)
Bouwens et al. (2015b)
Finkelstein et al. (2015)


DECaLS z
Roman J
z~5
~1100
z=24 mag (source plane)
McClure et al. (2009)
Bouwens et al. (2015b)
Finkelstein et al. (2015)
Number (mag^{-1} Mpc^{-3})
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
−23
−22
−21
−20
−19
−18
−17
M_{UV}
z = 20.5 mag
(image plane)
23
24
25
26
27
28
29
$m_{z,AB}$



DECALS DR8 Surveyed by COOLLAMPS → 4000 deg^2
Roman High Latitude Survey → 2000 deg^2

Expected number of objects ~ (0.5 x 500 x 4.5) x 2000/4000

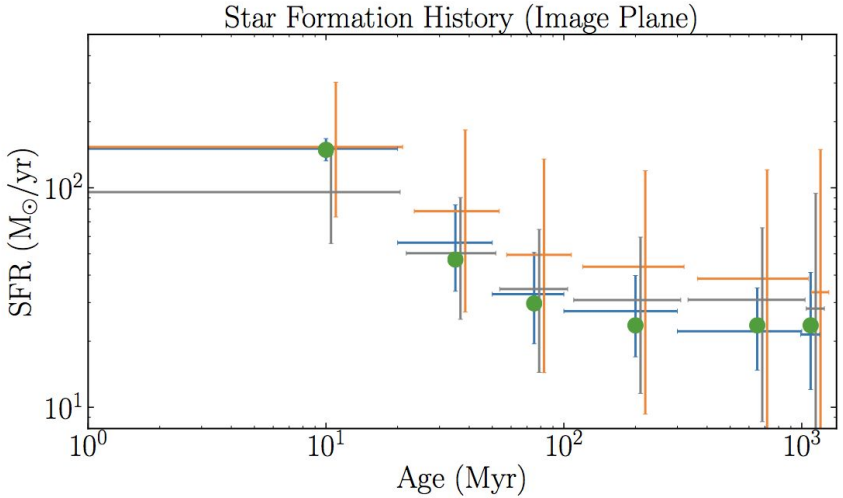
at least ~ 500 galaxies @ z ~5-6 !

A sample of distant strongly lensed galaxies with
1. **YJH+F184W imaging**
2. **1-2μm spectra**

How well can we characterize the physical properties of such galaxies?

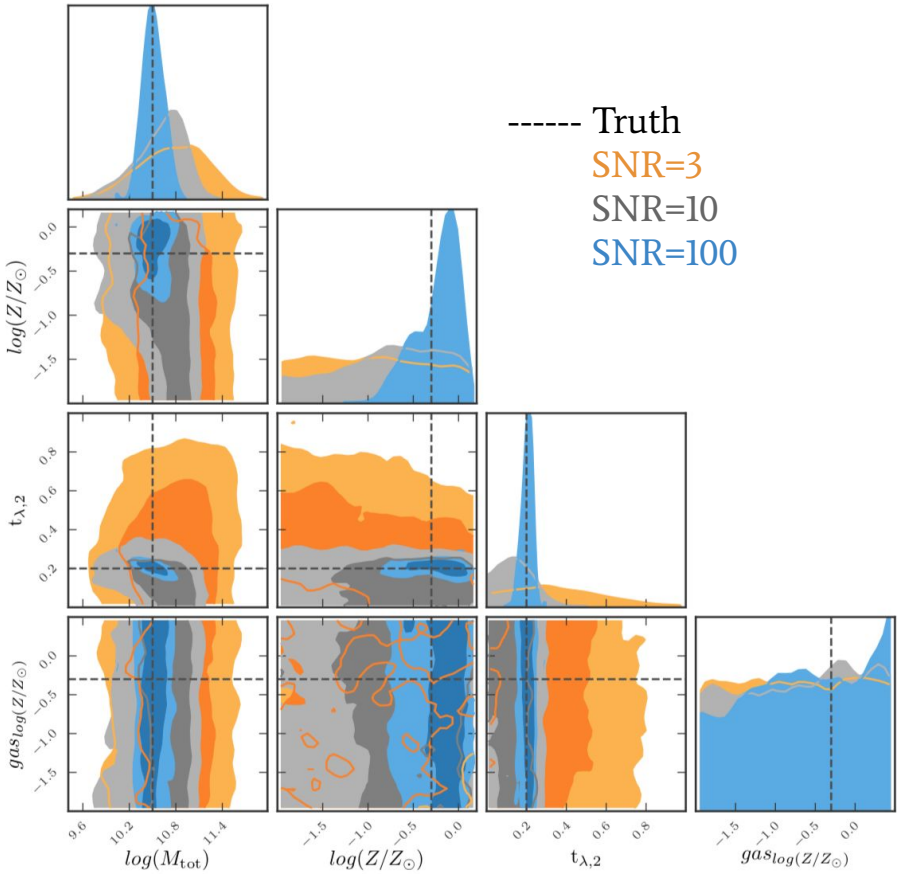
Galaxy with SED similar to COOLJ1241-2219

- Sampled gals → SNR=3 (a faint galaxy), 10, 100 (a bright galaxy)
- Imaging:
  - *riz* (Rubin Observatory)
  - YJH+F184W (Roman Space Telescope)



Truth values

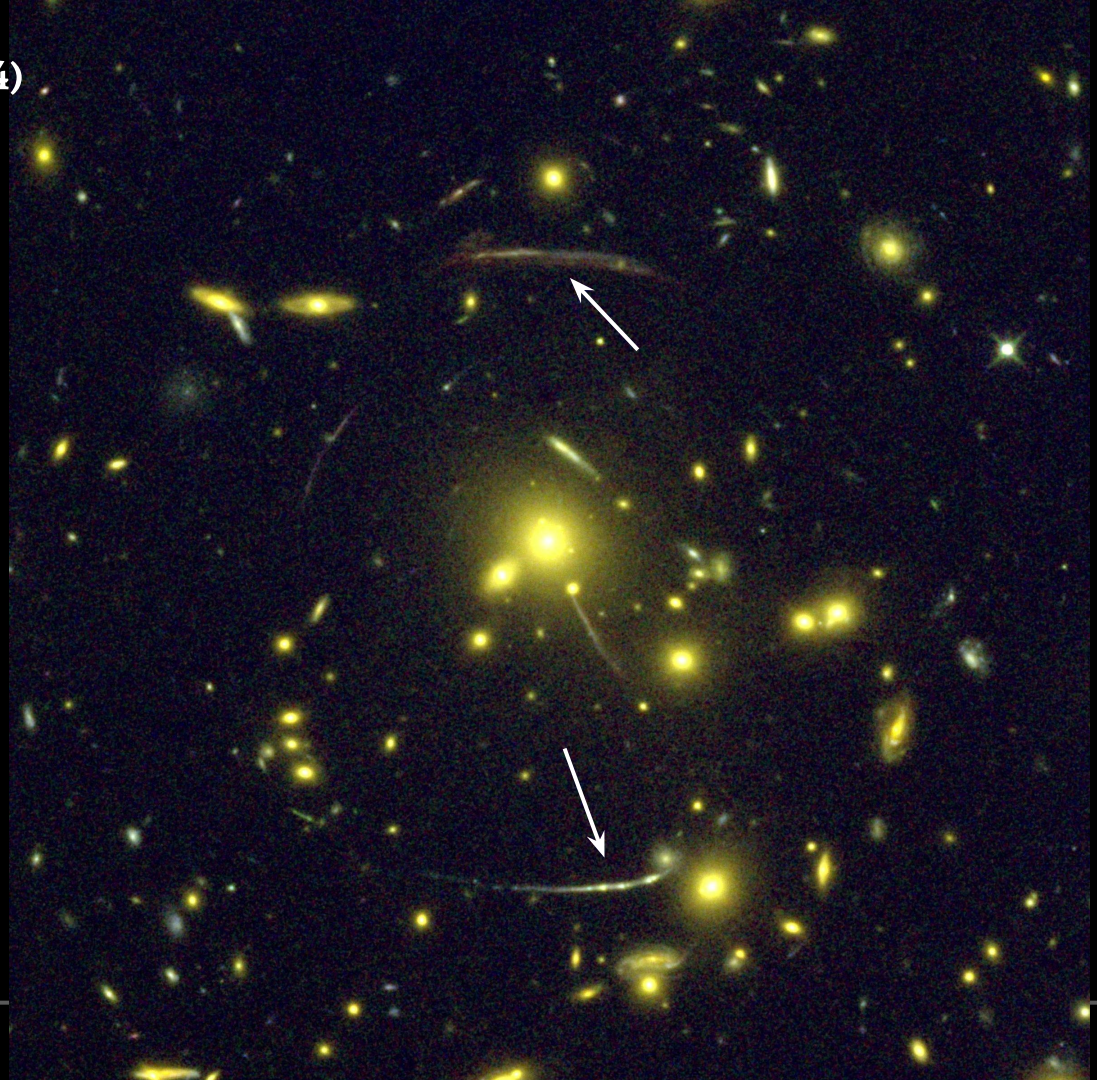
SED analysis: SNR=3, SNR=10, SNR=100

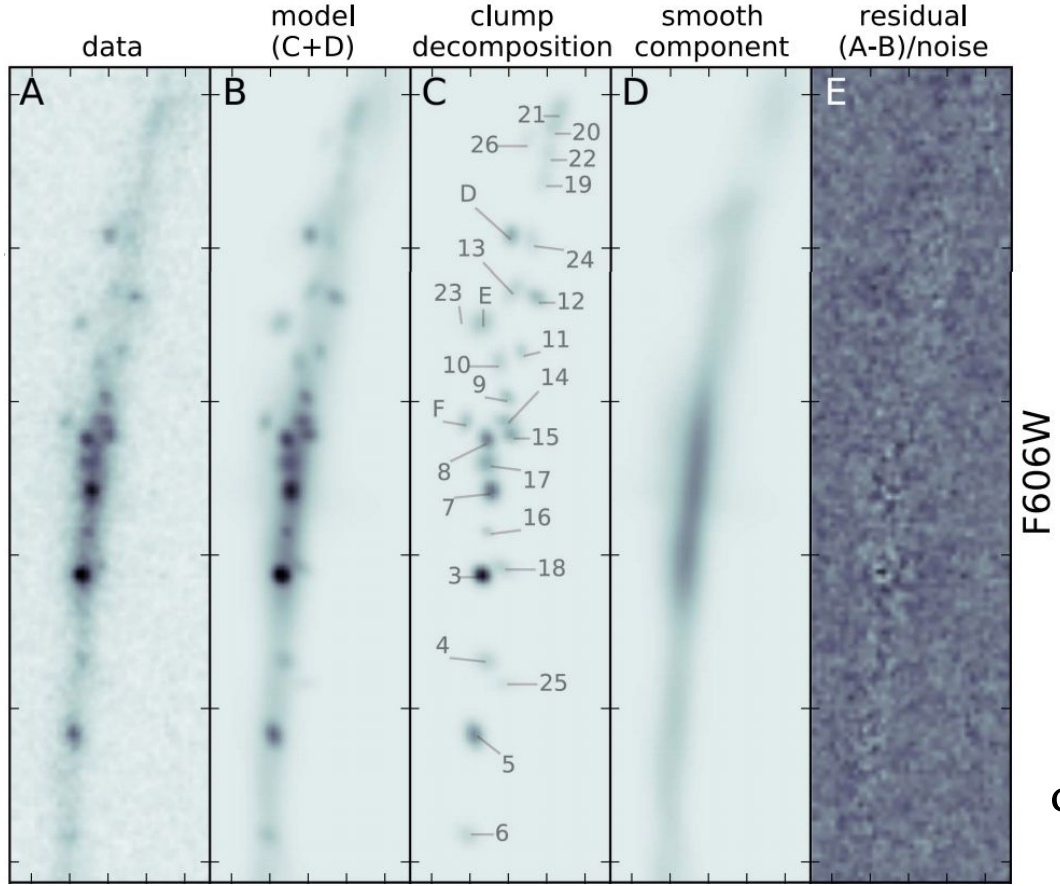


HST- like spatial resolution of the Roman Space Telescope

SGAS1050 (Bayliss+2014)
Subaru/*gri*

SGAS1050 (Bayliss+2014)
NASA/HST - WFC3/IR





Roman Space Telescope's spatial resolution will allow study of the internal structure of galaxies

GALFIT clump decomposition in HST/F606W imaging of the arc in SGAS J1110+6459
(Johnson+2017)

Summary

A large sample of z = 5-6 distant strongly lensed galaxies with YJH+F184W imaging and 1-2μm spectra

RST's Near IR coverage + HST-like spatial resolution + strong gravitational lensing gives us:

- Rest-frame UV and optical signatures from stellar pops in high-z galaxies
- Interiors of distant galaxies → < 1 kpc scale clumps

Please find me on Slack if you'd like to chat about

1. COOL-LAMPS and its wide variety of projects!
2. My work on constraining SFHs of member galaxies in South Pole Telescope galaxy clusters with optical/IR spectrophotometry across cosmic time (0.3<z<1.5)
3. Exciting new developments in synthesizing stellar populations in galaxies

Thank you! Questions?