

The near-infrared universe
as shown by UltraVISTA

Space Telescope Science Institute
Nancy Grace Roman Telescope | October 2020

COSMOS2020

a stepping stone for the next generation of galaxy surveys

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@astroweave

with Olivier Kauffmann, Marko Shuntov, Iary Davidzon,
Olivier Ilbert, Gabe Brammer, Paul Hsieh, Peter Capak
Andrea Moneti, Henry J. McCracken, & Sune Toft



DAWN

the cosmic evolution survey

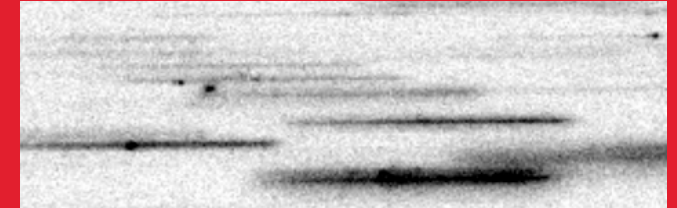
20 years of extensive multi-wavelength observations...



- The deepest “wide” survey on the sky
- Extraordinarily rich spectroscopic sample
{~50,000; Salvato et al., in prep}
- Uniquely suited to explore large scale structure
{Scoville et al. 2013, Darvish et al. 2017, Laigle et al. 2018}
- Pioneered weak lensing methods to map dark matter
{Massey et al. 2007}
- Selected as a deep/calibration field for the next-generation of surveys
{Euclid, Rubin, JWST-WIDE, ToItec, MOONS, PFS...}

Coming in HST Cycle 28!

3D-DASH
drift and shift



1.7 deg² of COSMOS
NIR imaging + grism survey

HST Large Program
PI: Momcheva

COSMOS

cosmic evolution
survey

{10:00:28.6 +02:12:21.0}

2020 CATALOG

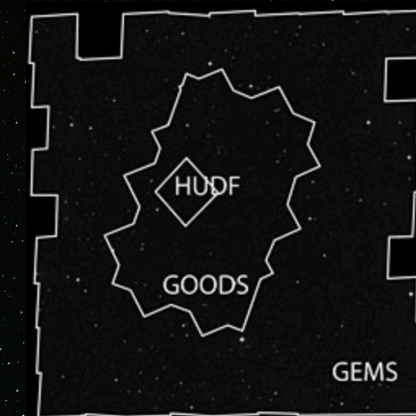
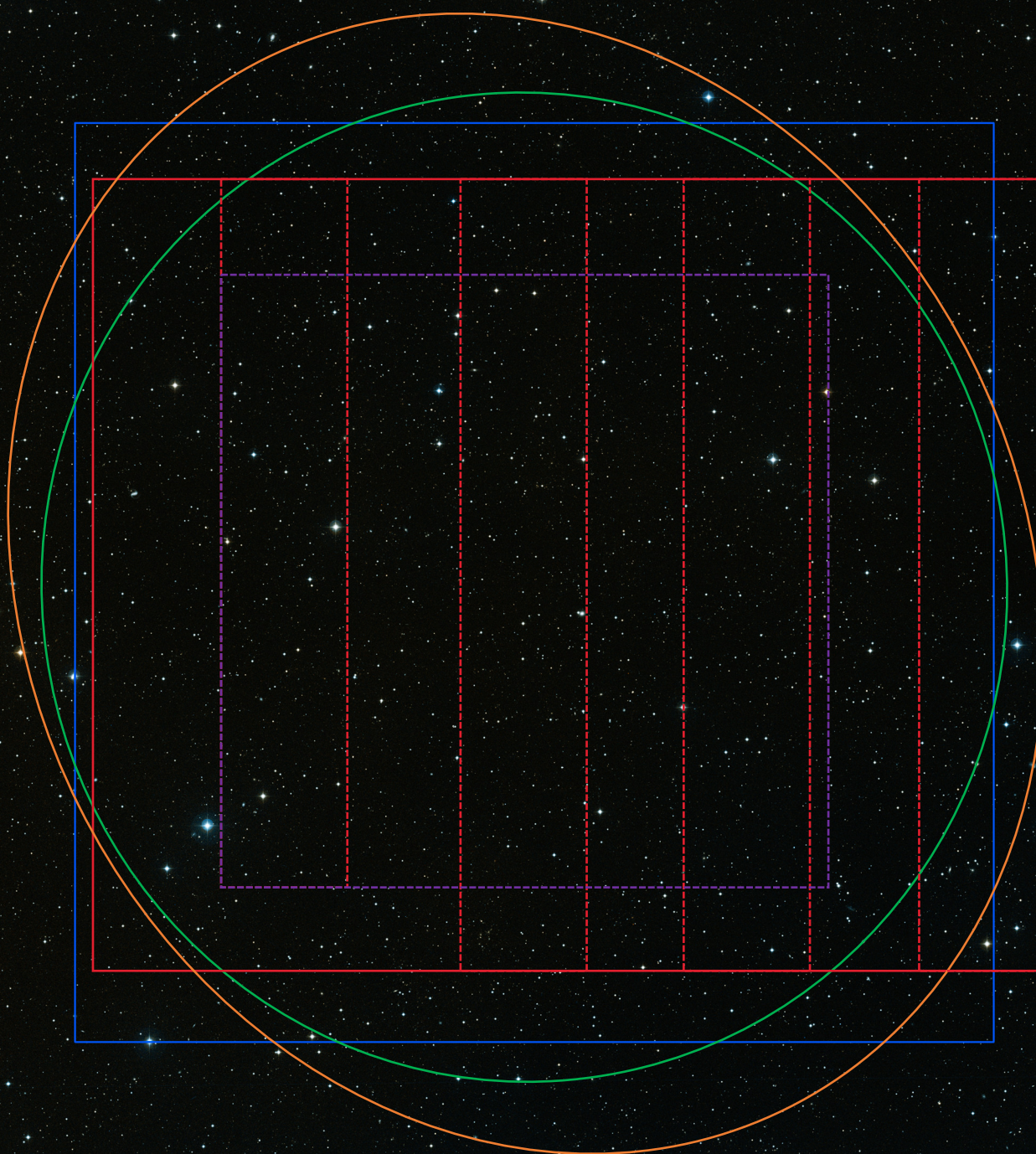
CFHT/CLAUDS

Subaru/HSC SSP

Subaru/SuprimeCam

UltraVISTA DR4

Spitzer/IRAC



COSMOS2020 is **BIG DATA**

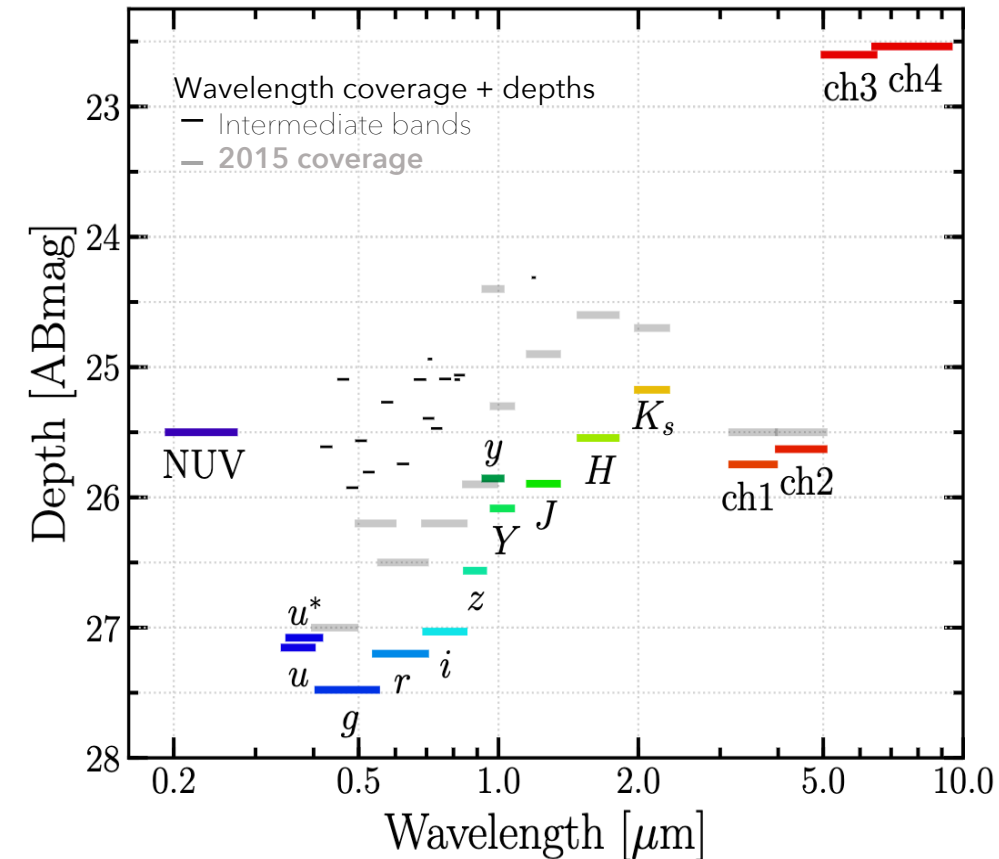
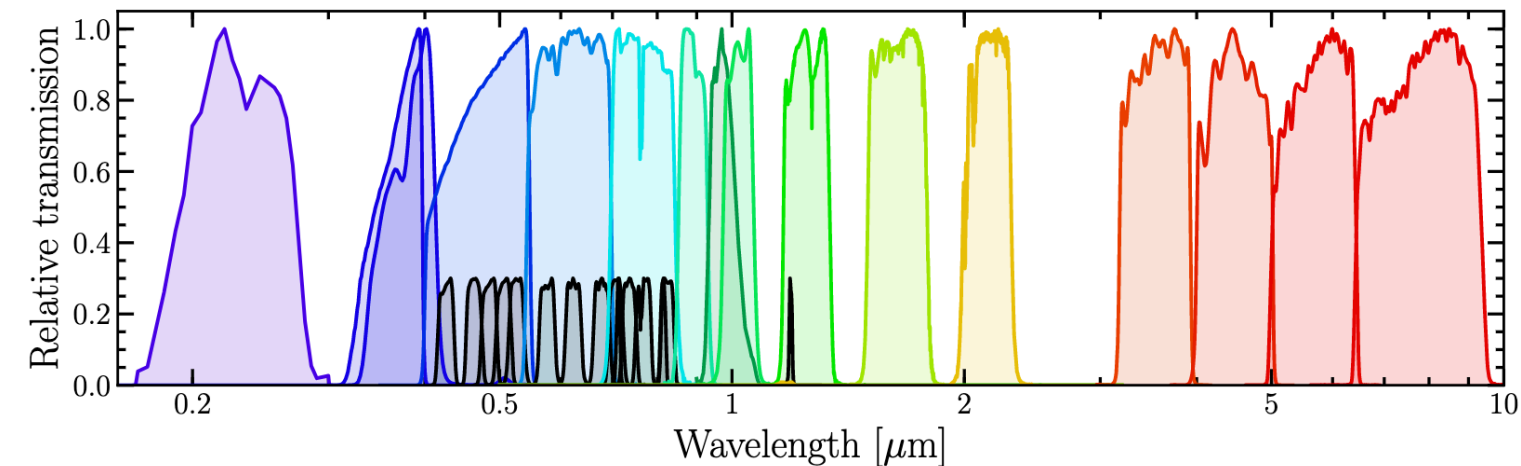
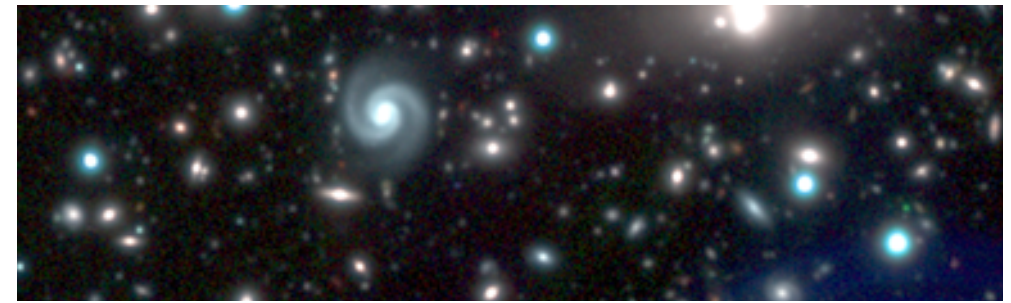
NIR-selected catalog of $\sim 1\text{M}$ galaxies over 2 deg^2

{Weaver, Kauffmann et al., in prep}

➤ ~ 1 Billion pixels of image data alone

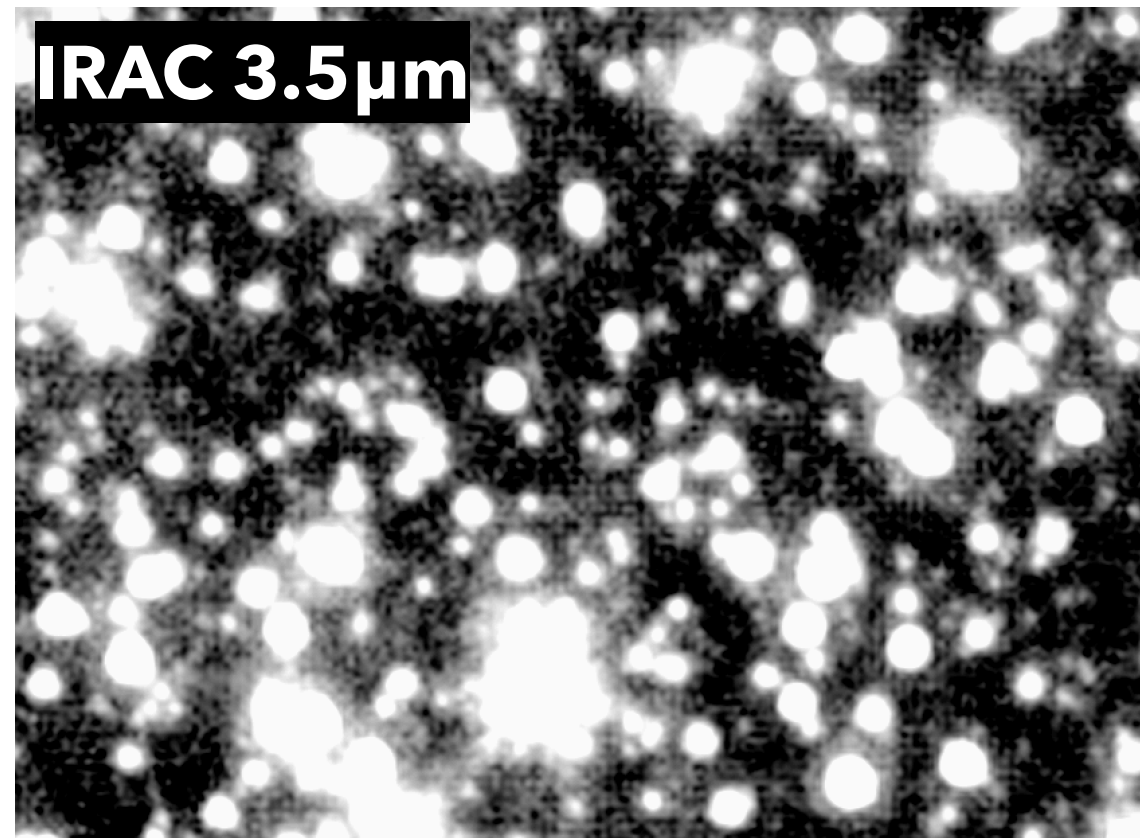
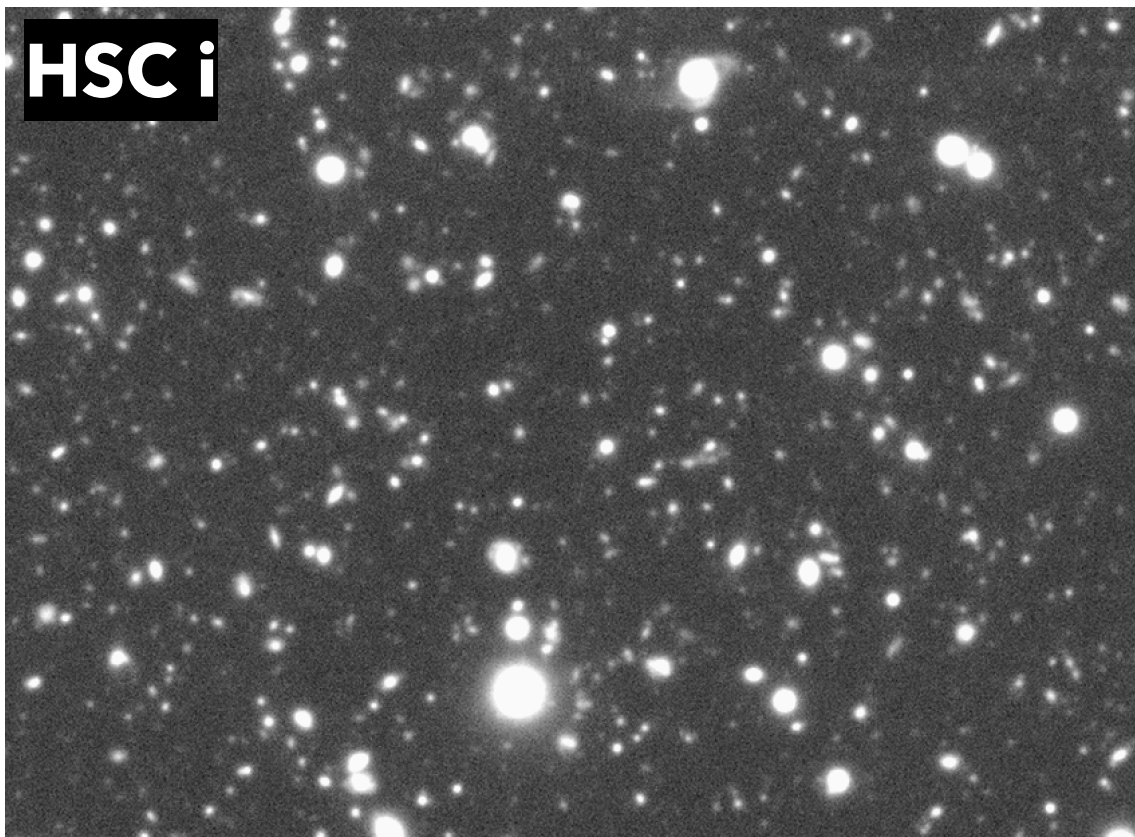
van der Marel - *both catalogs and pixel level datasets provide unique science opportunities*

➤ Unprecedented depths \rightarrow extreme source density



Ultra-deep surveys are pushing traditional methods to their breaking point...

We must develop new tools **with greater de-blending** and **supporting diagnostics**,
or we will **forfeit** our ability to robustly measure **the faintest and most distant galaxies**.



Lotz - we can do better in the era of 'Big Data'

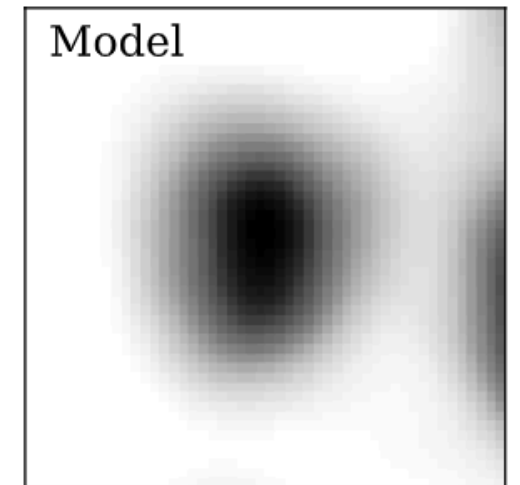
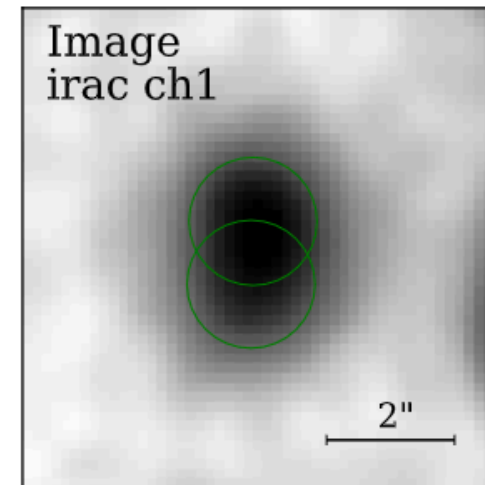
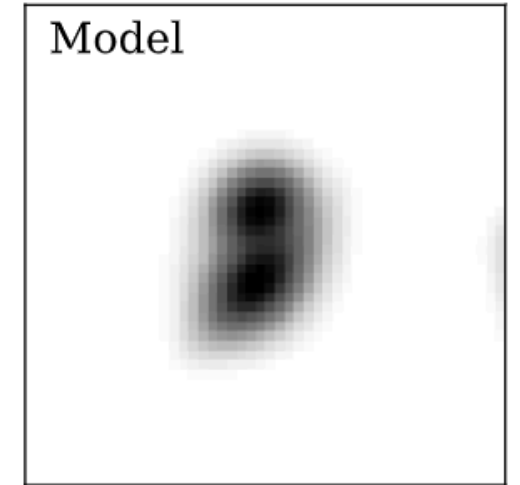
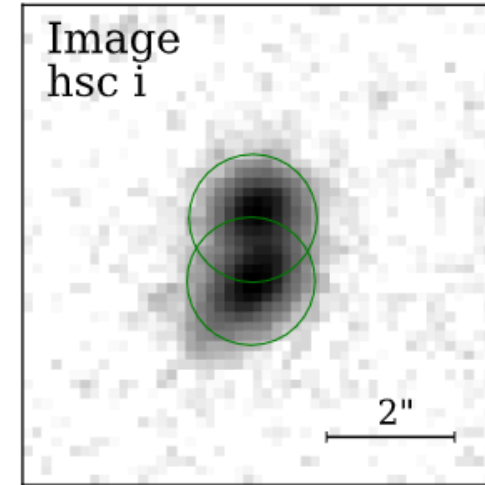
innovating the next decade

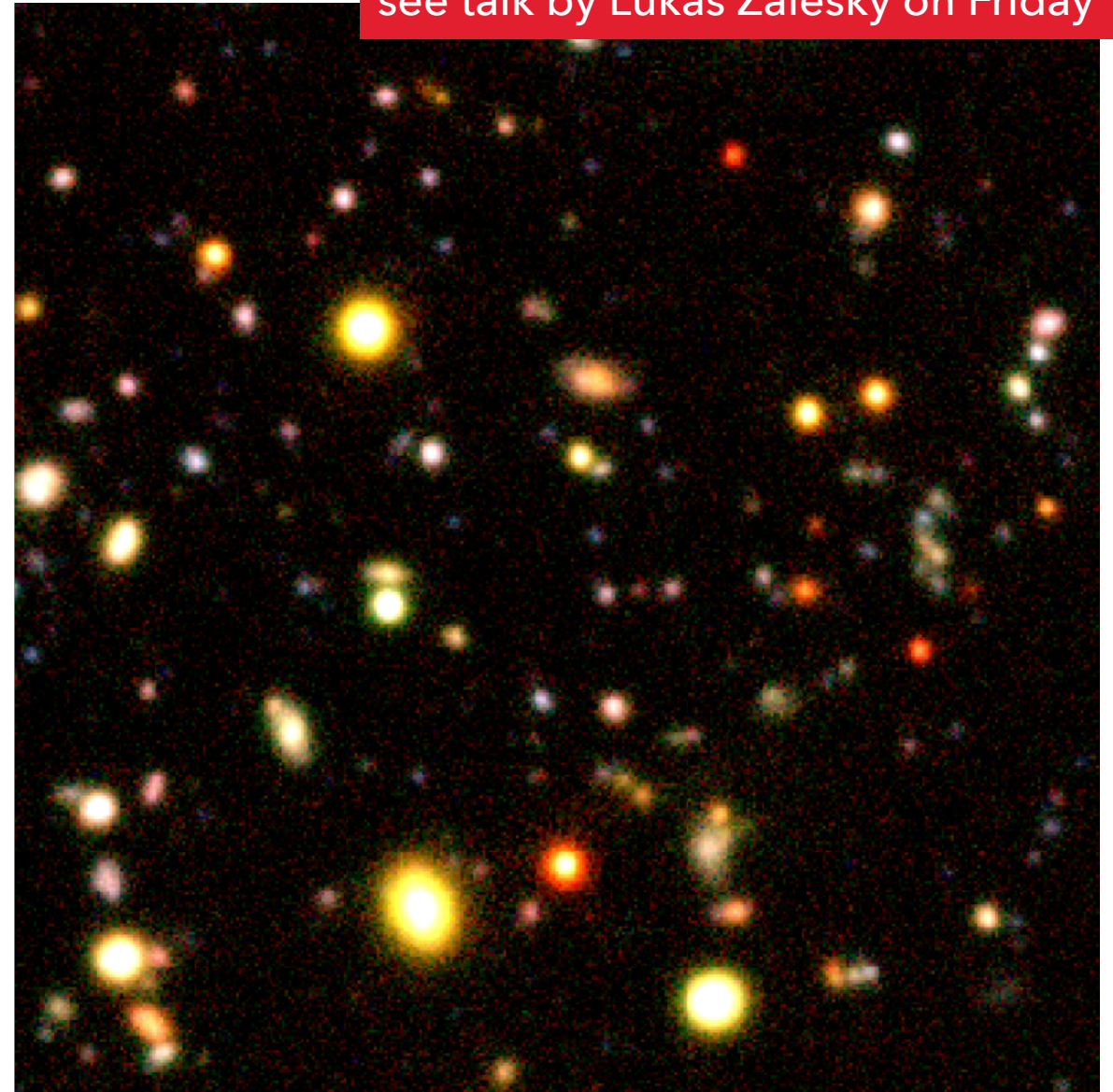
We must confront these challenges now

- Utilize parametric models to fit sources: **The Tractor**
{Lang & Hogg 2016}
- Flux and position are now *model parameters*
 - ✓ Sensitivity to ultra-faint sources
 - ✓ Superior de-blending in NIR/IRAC
 - ✓ Free fitting + residual statistics, shapes, sizes

But model fitting is slow going...

- Developed a scalable framework for HPC: **The Farmer**
{Weaver et al. in prep}
- Provides detection, modelling, and catalog creation





see talk by Lukas Zalesky on Friday

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MODEL

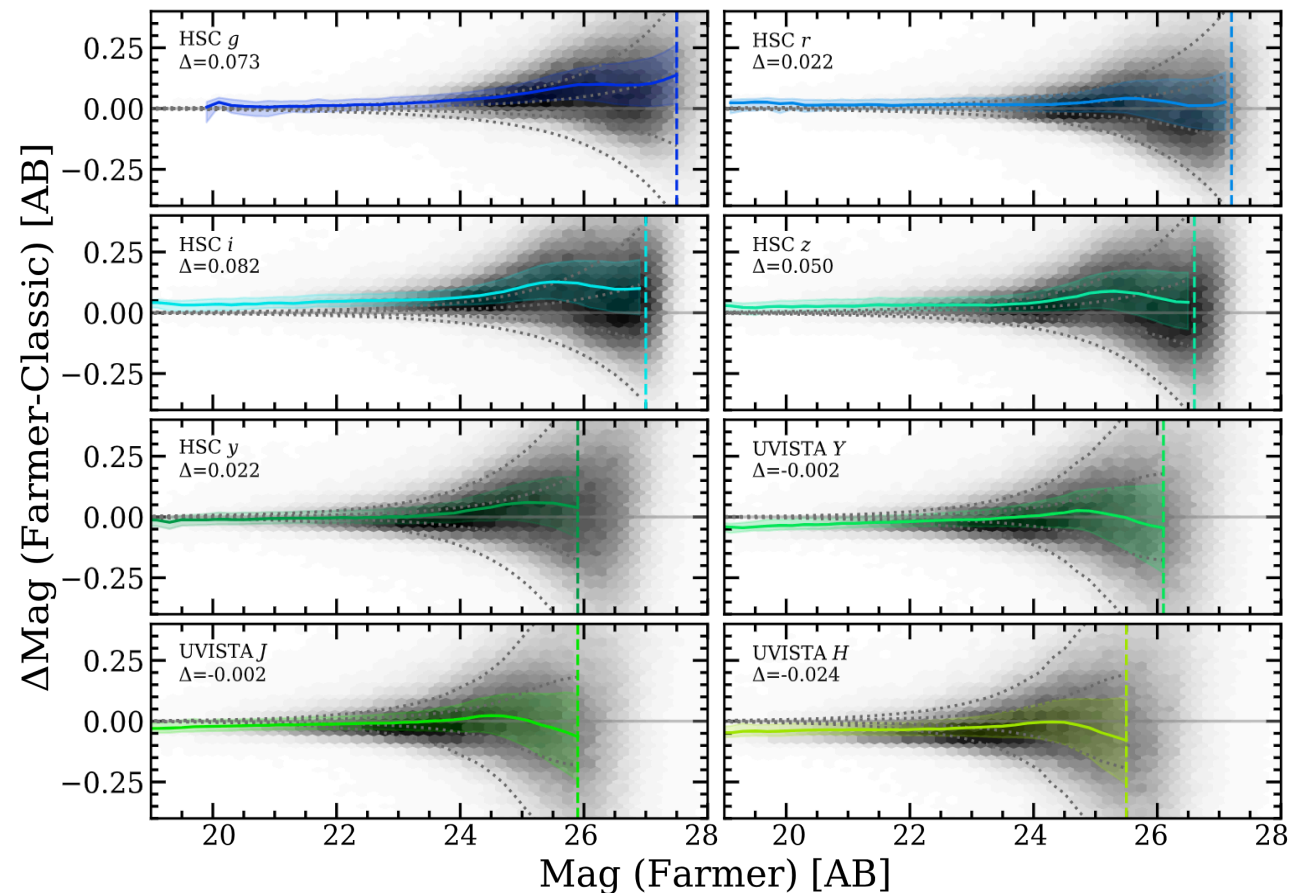
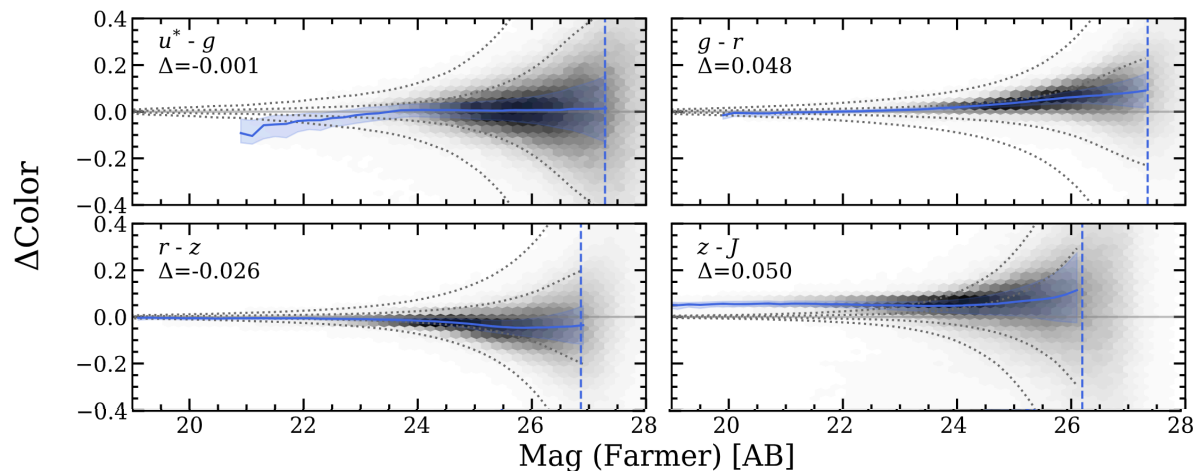


REAL

validation

Benchmark The Farmer against SExtractor

- Prepared an aperture catalog: **Classic**
- We find *excellent* agreement
 - ✓ Magnitudes are consistent < 10%
 - ✓ Colors are consistent < 5%



photometric redshifts

2 sets of photometry - 2 redshift codes

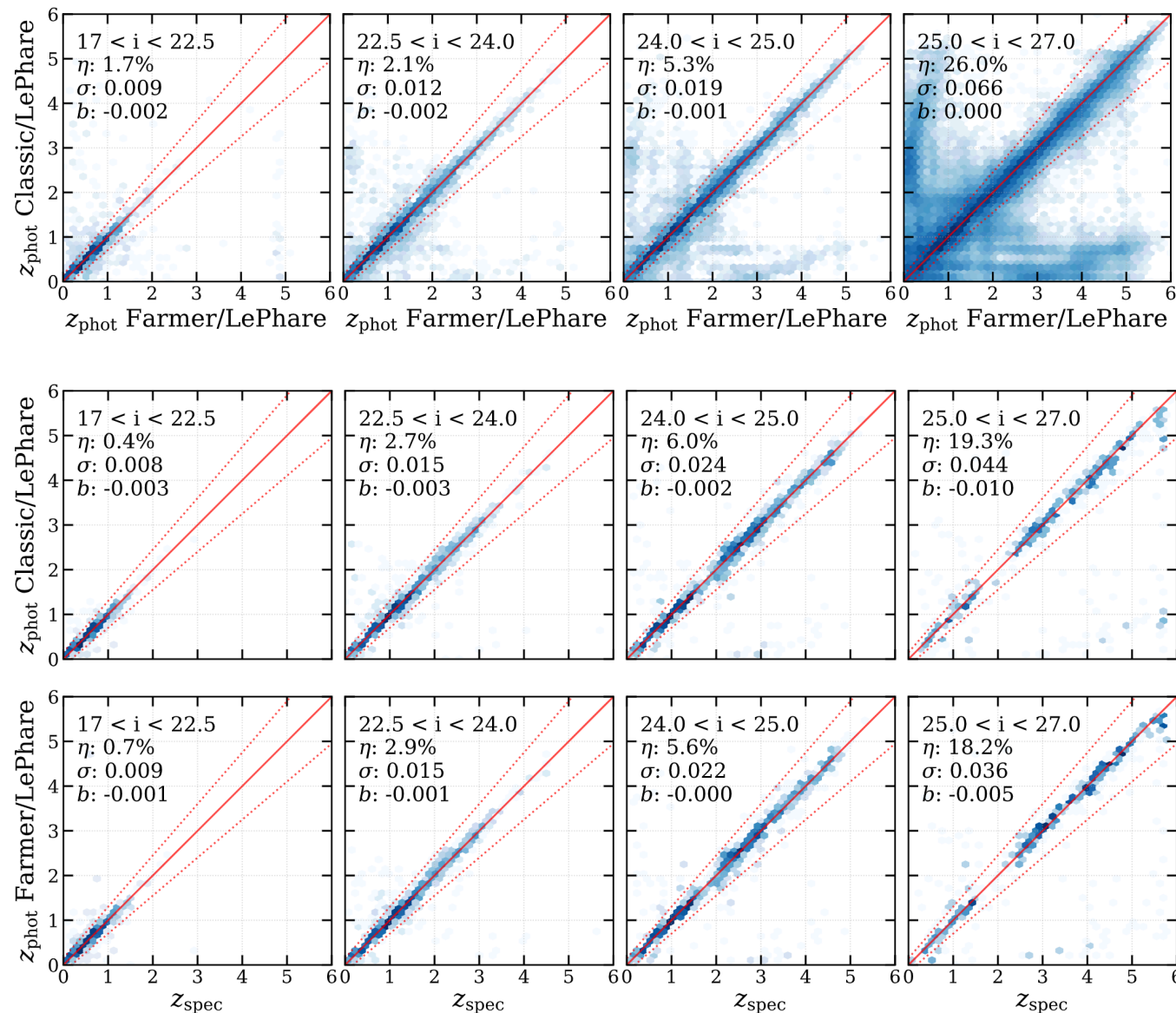
- Obtain z_{phot} with LePhare & EAZY

{Ilbert et al. 2006, Brammer et al. 2008}

- Photometry produces similar results
- z_{phot} codes produce similar results
- Unprecedented photometric accuracy
 - $\sigma < 1\%$ at $i < 22.5$ AB; $< 5\%$ at ~ 26 AB
- Low bias, low failure rate

Classic - fluxes summed in apertures
Farmer - fluxes as model parameters
LePhare/EAZY - z_{phot} fitting codes

η - outlier fraction
 σ - standard deviation
 b - median bias



where we will go...

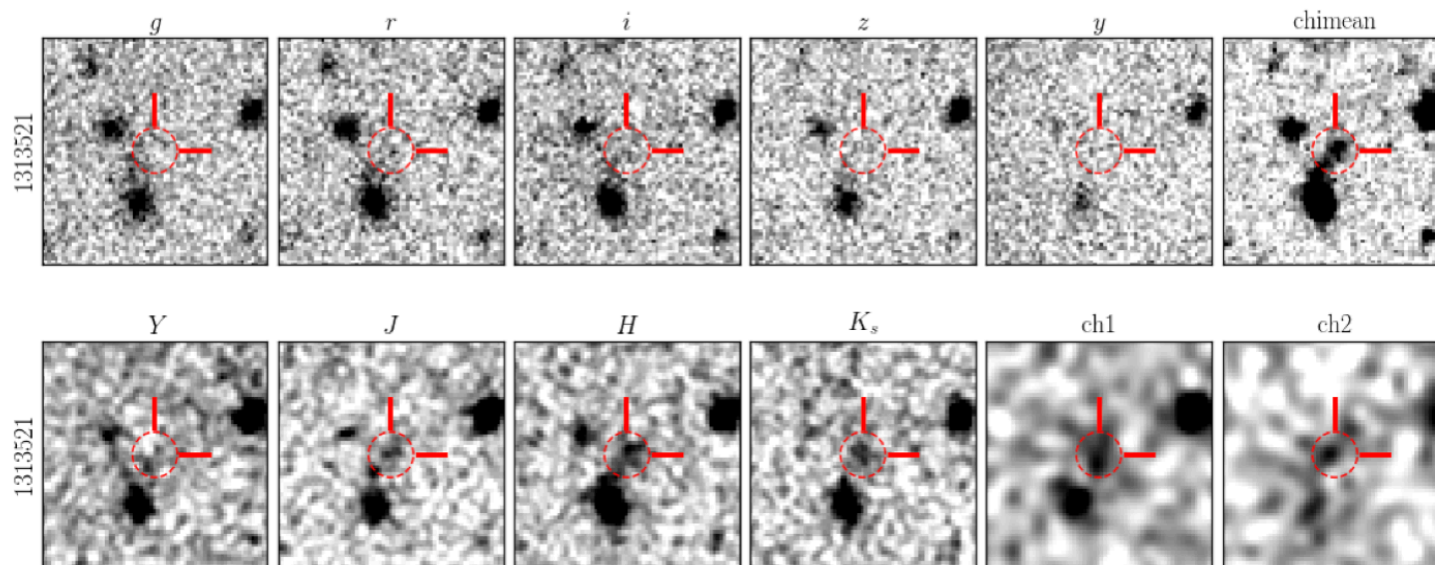
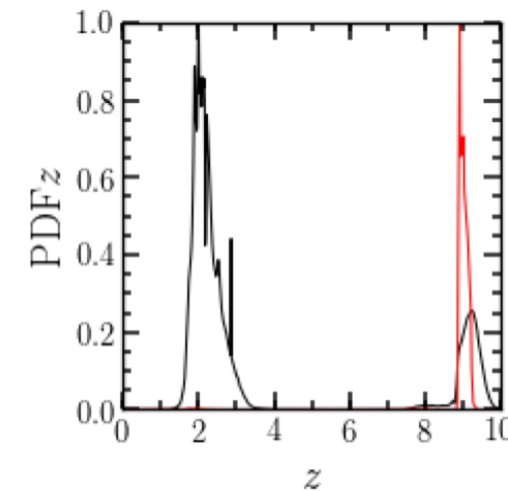
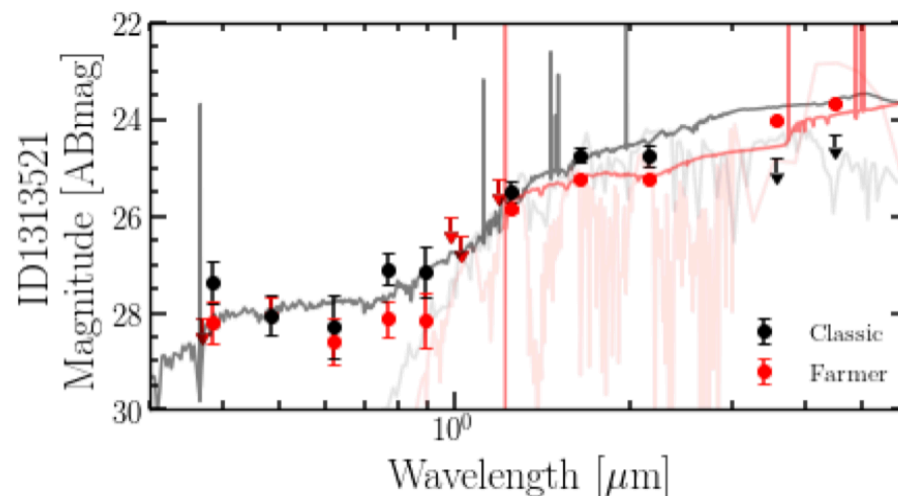
There are 4x COSMOS2020 catalogs!

➤ Multiple independent measurements

- ✓ photometry
- ✓ z_{phot}
- ✓ stellar masses & SFR
- ✓ rest-frame magnitudes

➤ Access many more high-z sources

Model-based photometry is critical
for reaching the high-z universe in
the era of ultra-deep, wide surveys



{Kauffmann et al., in prep.}

Catalog slated to be released in early 2021

{Weaver, Kauffmann et al., in prep.}

- ~1M NIR-selected sources measured in 39 bands
- Innovative model-based photometry with The Farmer
- Excellent agreement with classic aperture techniques
- Can understand our systematics with multiple measurements
- Unprecedented redshift accuracy, scatter, and bias

COSMOS is the stepping stone towards the next decade of surveys



John R. **Weaver**

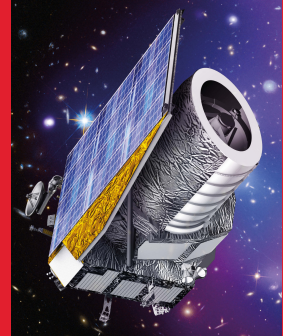
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john.weaver@nbi.ku.dk | astroweaver@github.io | @astroweave

COSMOS2025

Rubin



Euclid



Roman?

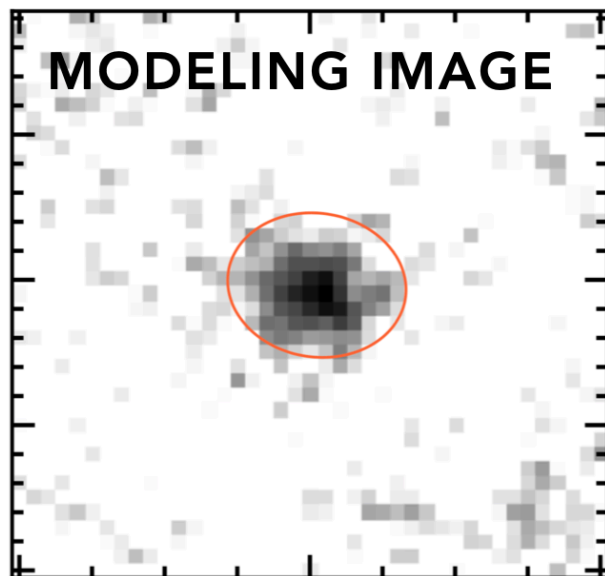


DAWN

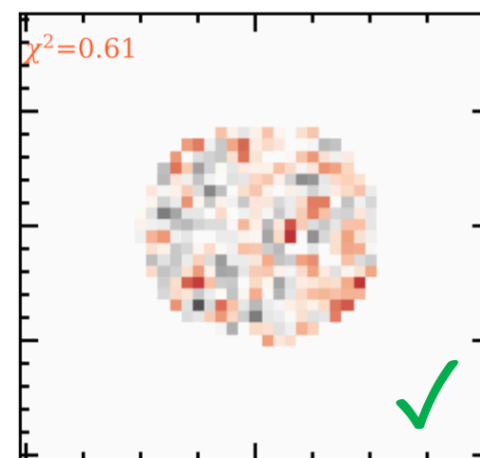
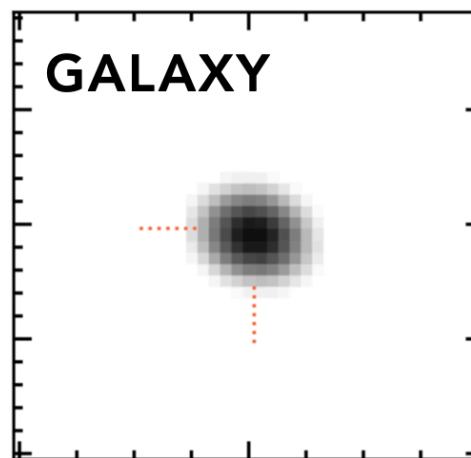
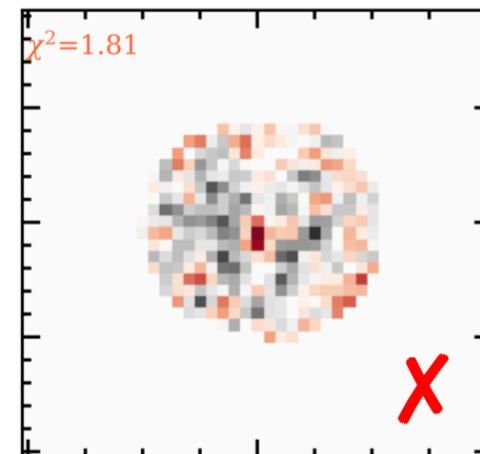
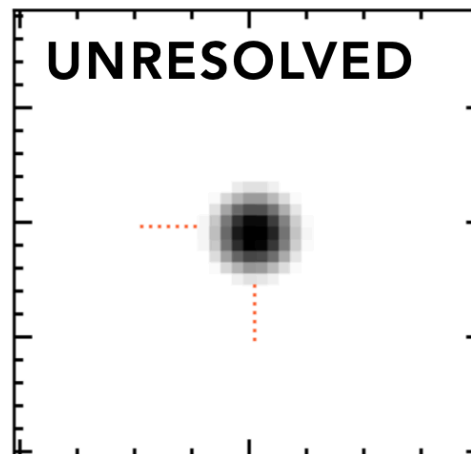
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supp: how farmer works

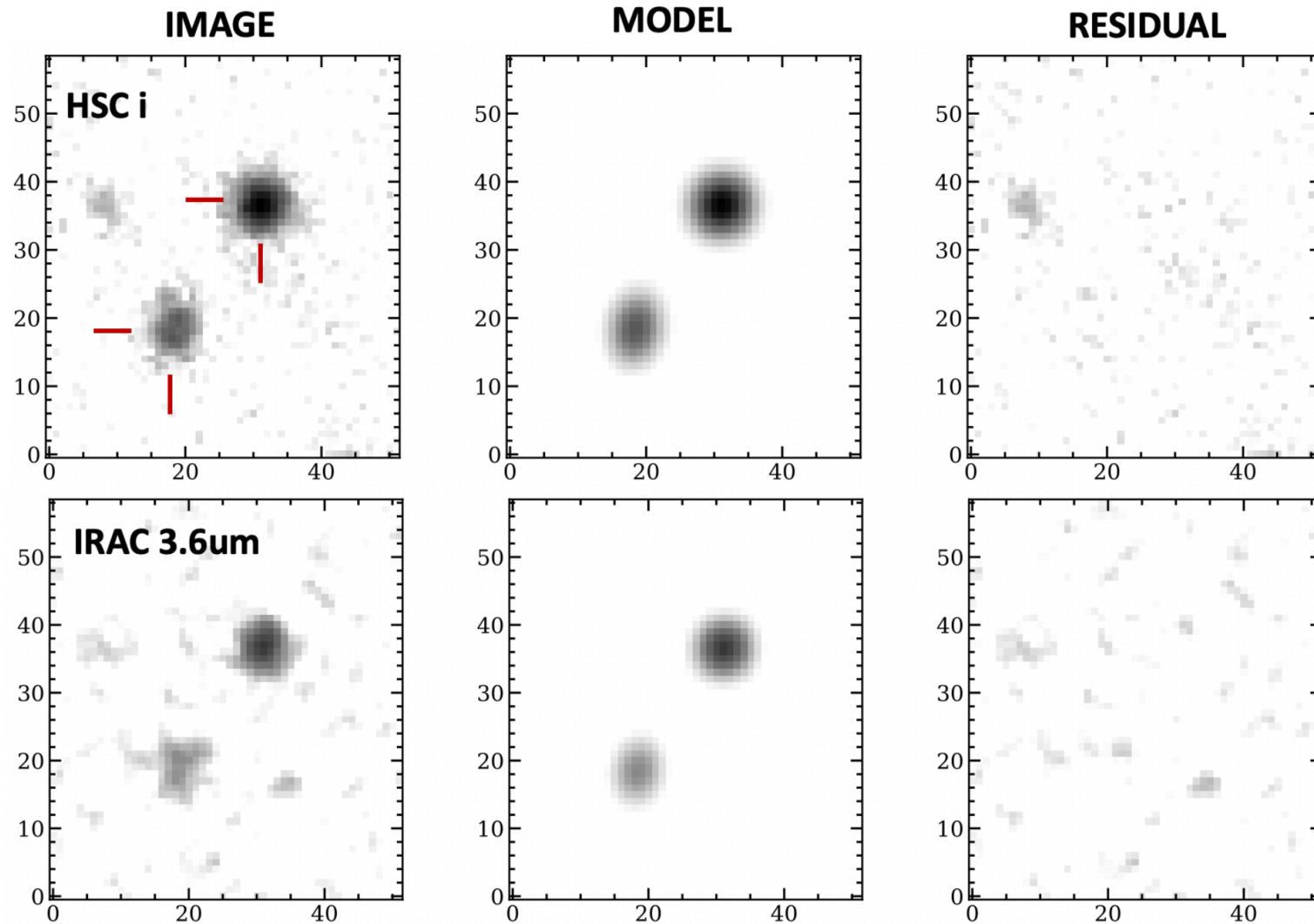


DECIDE



3 TIERS: Unresolved -> Sérsic Galaxy -> 2-Component Galaxy

supp: how farmer works



supp: how farmer works

SOURCE DETECTION

SExtractor/SEP

Initial conditions for modelling

Determine blobs and
number of sources to model

FIT MODELS

Model-type decision tree

Optimize model parameters
(RA, Dec, R_{eff} , b/a, θ)

FORCED PHOTOMETRY

Convolve with PSF

Freeze model type and shape

Optimize for fluxes

supp: how farmer works

