Lessons learned from Synpipe tests on HSC SSP data

Song Huang (Princeton)
Alexie Leauthaud (UCSC) & HSC Pipeline Team

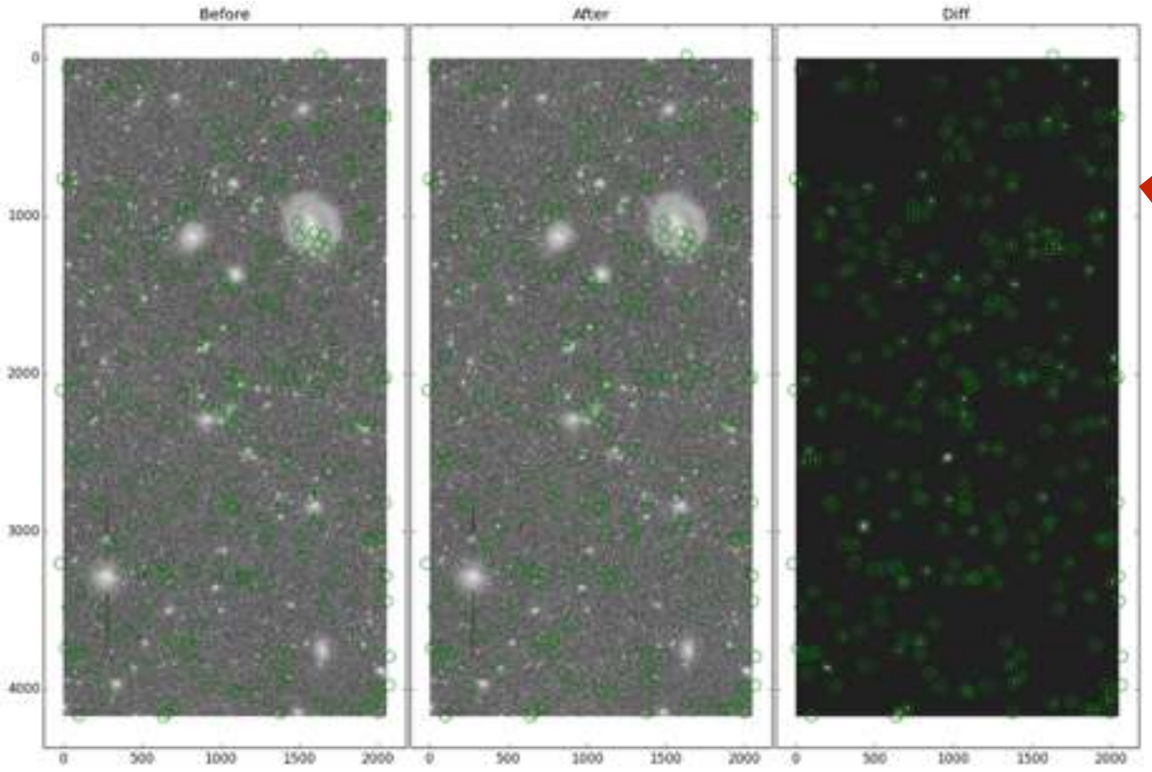
- Background/ Strategy
- Validation of HSC
- Other Applications
- A Few Thoughts

HSC UltraDeep - COSMOS

Basic Steps of Synpipe:

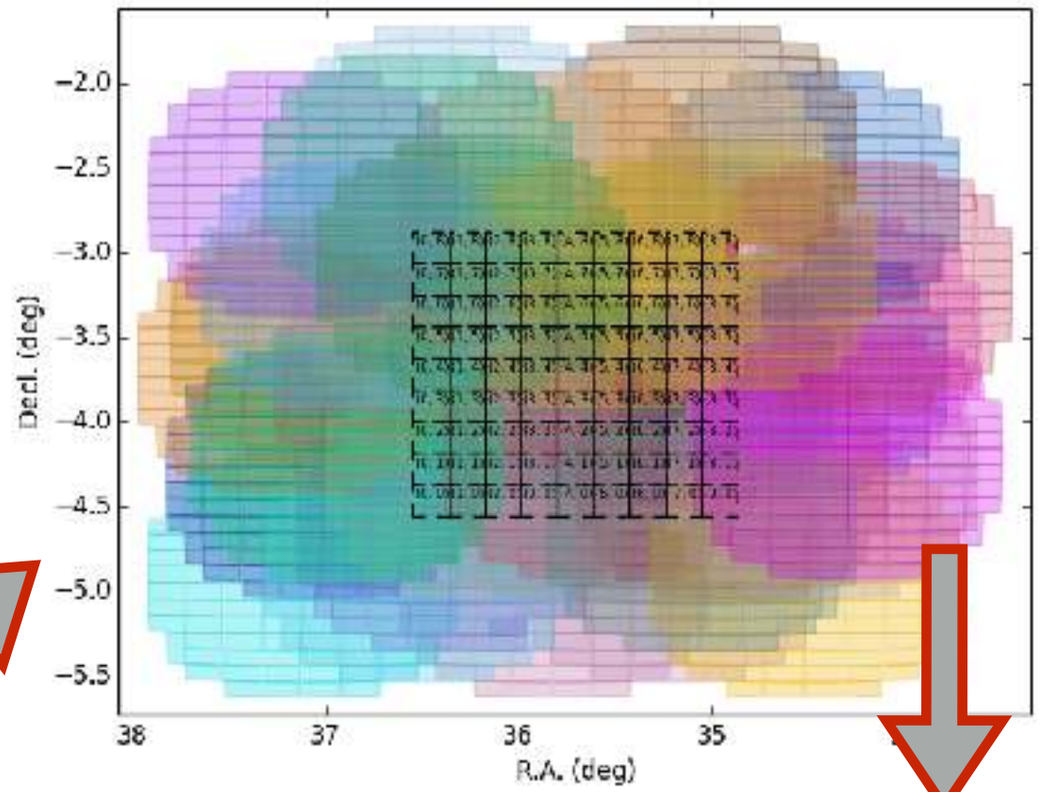
Step 0: Prepare an input catalog

Step 1: Inject fake object to each CCD



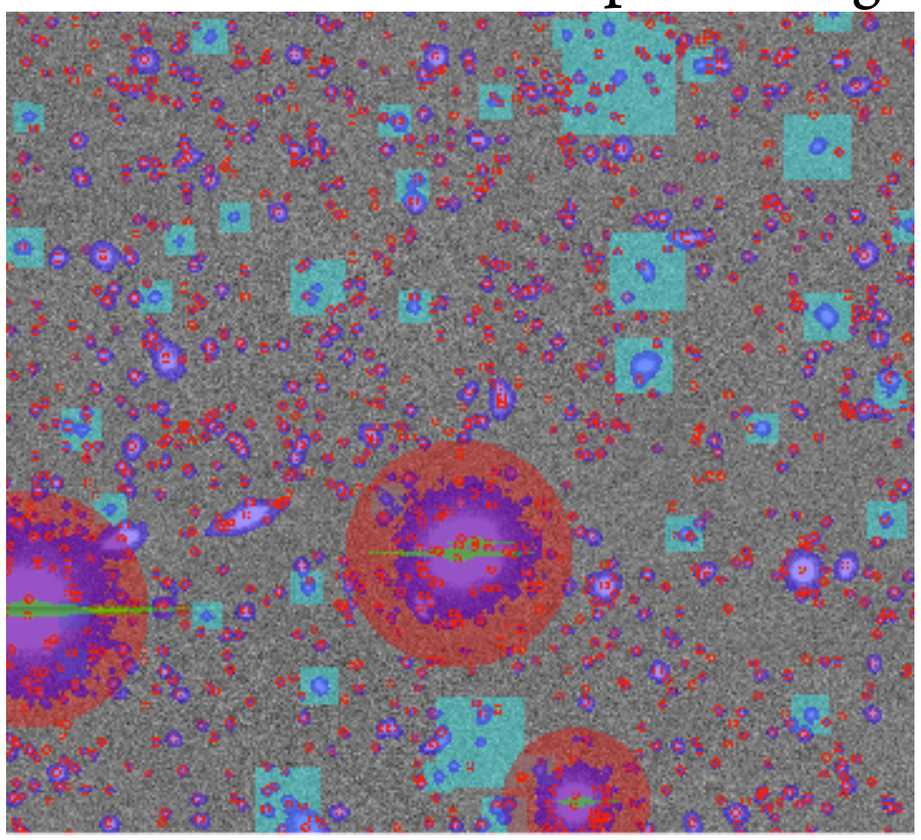
Based on the initial astrometric calibration
Does not mess with background subtraction

Step 2: Image Coaddition



Step 3: Photometric Measurements

Match results to the input catalog

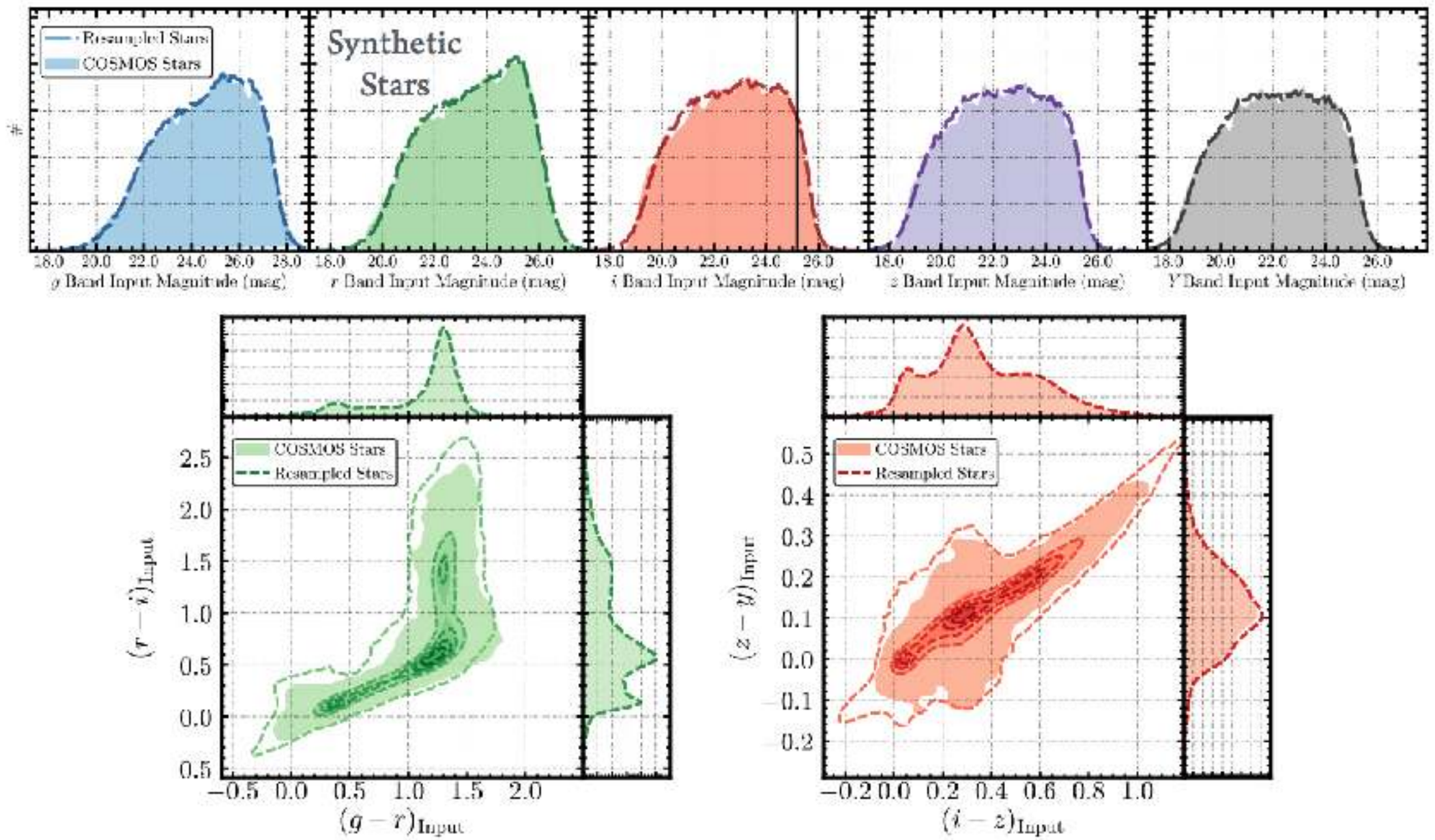


Mask Planes: Cyan boxes are for fake objects

Default Catalog of Fake Stars

Based on COSMOS star catalog from Leauthaud et al. 2010; Matched to HSC UltraDeep catalog

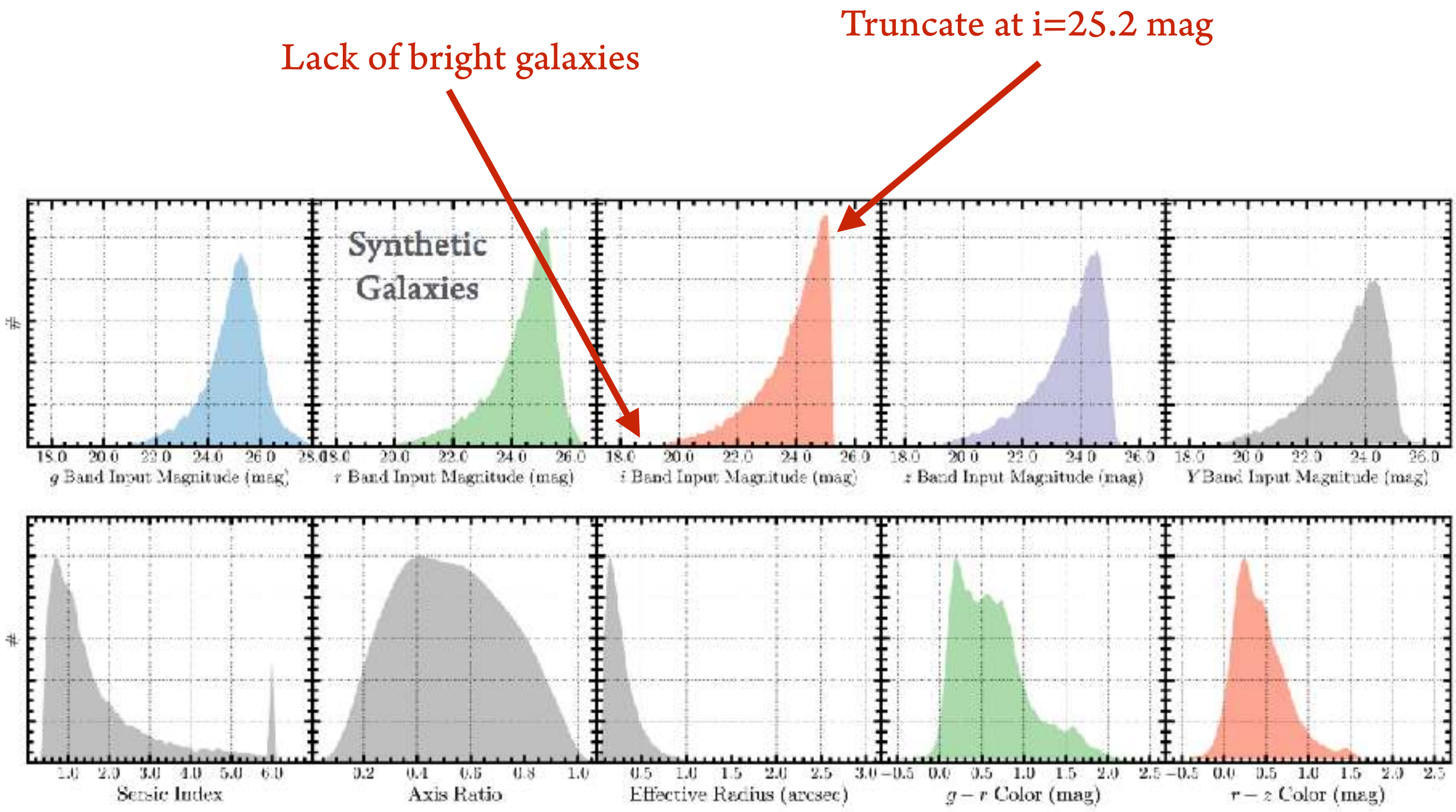
Resample large number of fake stars from the GMM model of 5-band photometry



Huang, Leauthaud et al. 2018

Default Catalog of Fake Galaxies

Also based on Claire Lackner's Sersic models of COSMOS galaxies



Huang, Leauthaud et al. 2018

Validation of HSC SSP data reduction

Huang et al. 2018: PDR1 hscPipe v4.0.5 Two tracts: good/bad seeing

PDR2 hscPipe v7.0.1

S20A hscPipe v8.5.0

Publ. Astron. Soc. Japan (2018) 70 (SP1), S6 (1–28)
doi: 10.1093/pasj/psx126
Advance Access Publication Date: 2017 December 22

Characterization and photometric performance of the Hyper Suprime-Cam Software Pipeline

Song Huang,[1,2,*] Alexie Leauthaud,[1,2] Ryoma Murata,[2,3] James Bosch,[4] Paul Price,[4] Robert Lupton,[4] Rachel Mandelbaum,[5] Claire Lackner,[2] Steven Bickerton,[2] Satoshi Miyazaki,[6,7] Jean Coupon,[8] and Masayuki Tanaka[6]

[1]Department of Astronomy and Astrophysics, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, USA
[2]Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo Institutes for Advanced Study, The University of Tokyo (Kavli IPMU, WPI), 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan
[3]Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
[4]Department of Astrophysical Sciences, Princeton University, 4 Ivy Lane, Princeton, NJ 08544, USA
[5]McWilliams Center for Cosmology, Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[6]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[7]SOKENDAI (The Graduate University for Advanced Studies), 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[8]Department of Astronomy, University of Geneva, ch. d'Écogia 16, 1290 Versoix, Switzerland

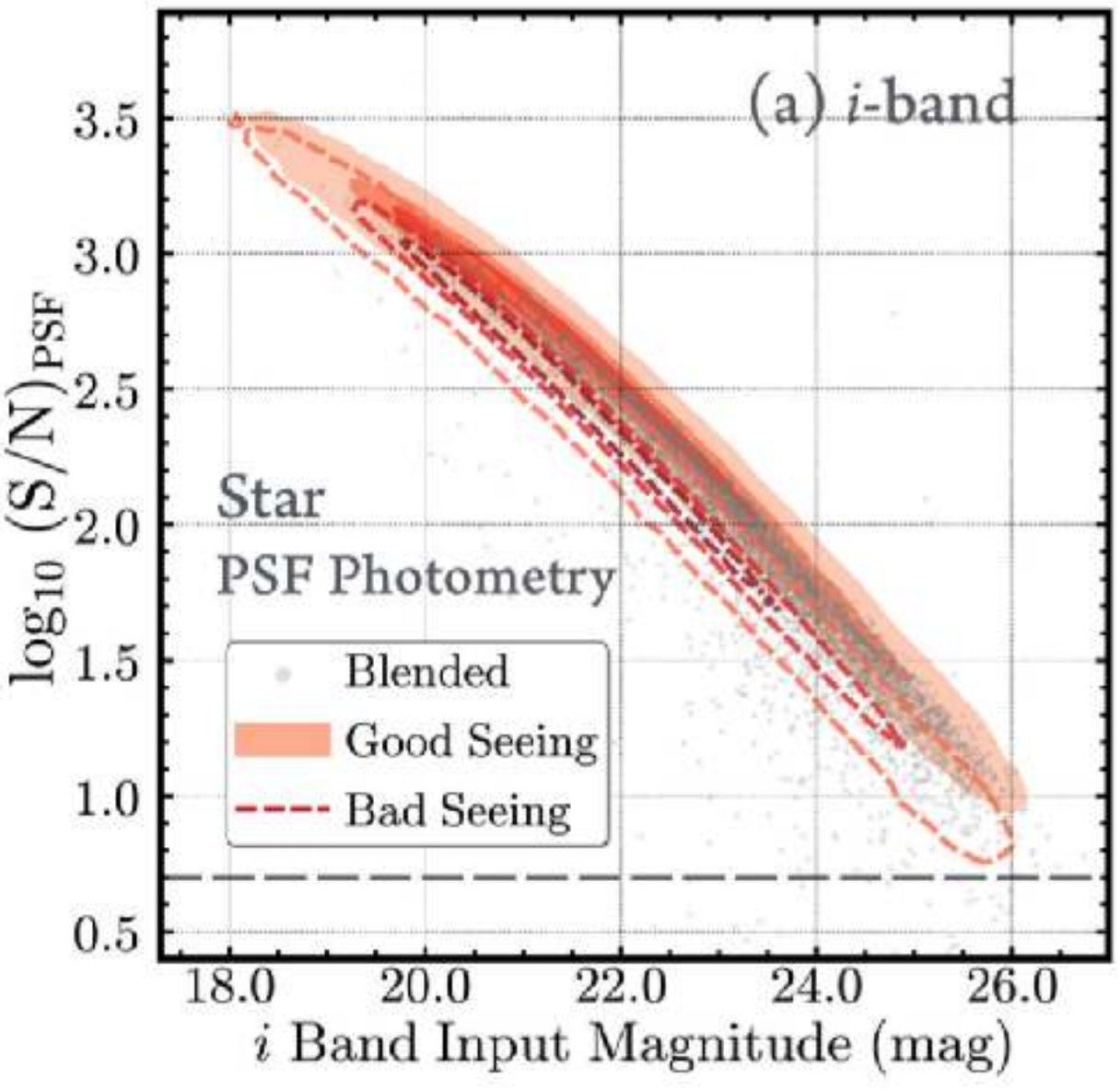
*E-mail: song.huang@ipmu.jp

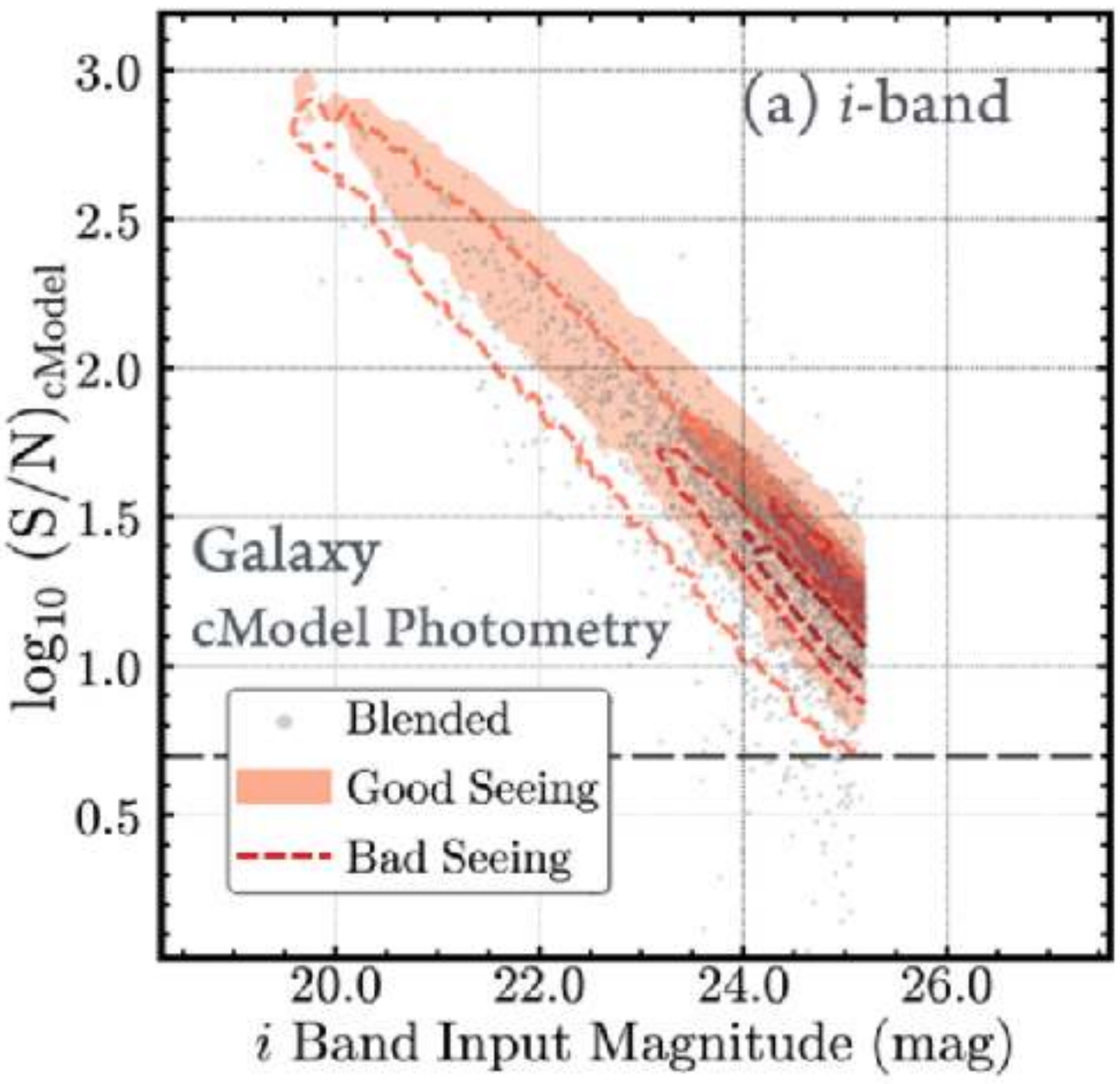
Received 2017 May 2; Accepted 2017 October 9

- Impact from seeing
- Impact from blendedness

Basic Validation of HSC Photometry of Stars and Galaxies

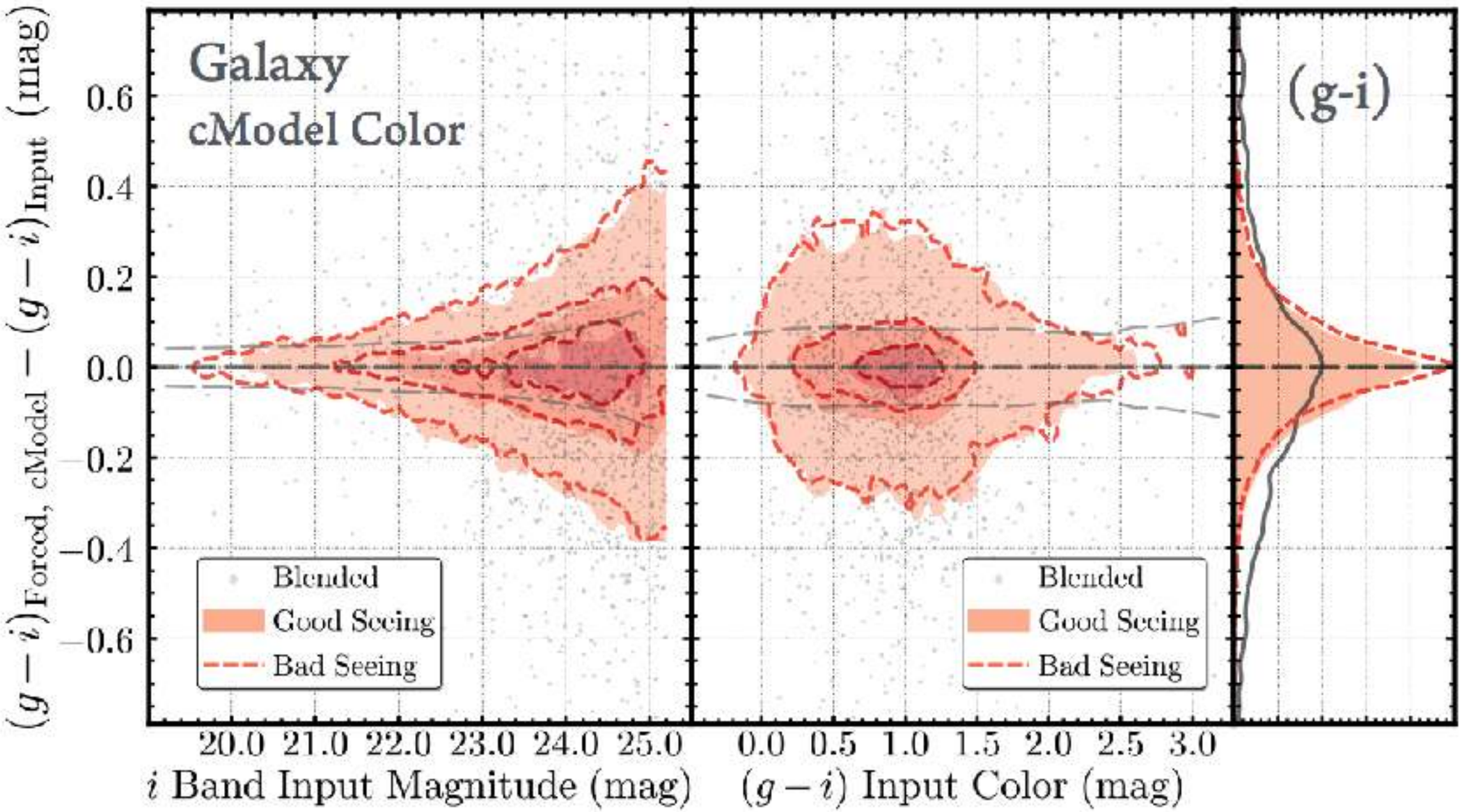
S/N difference between 0.5” and 0.7” seeing



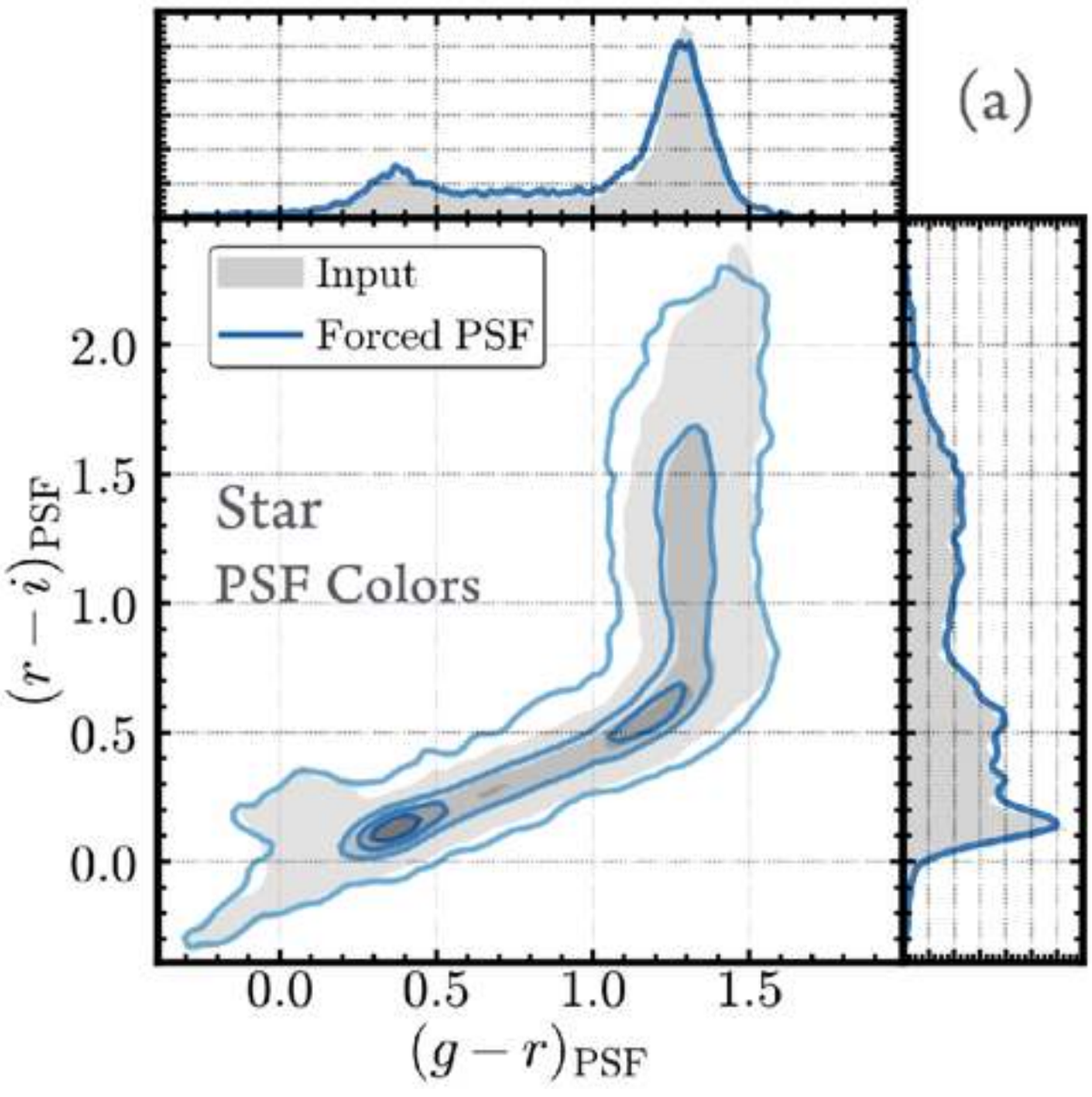


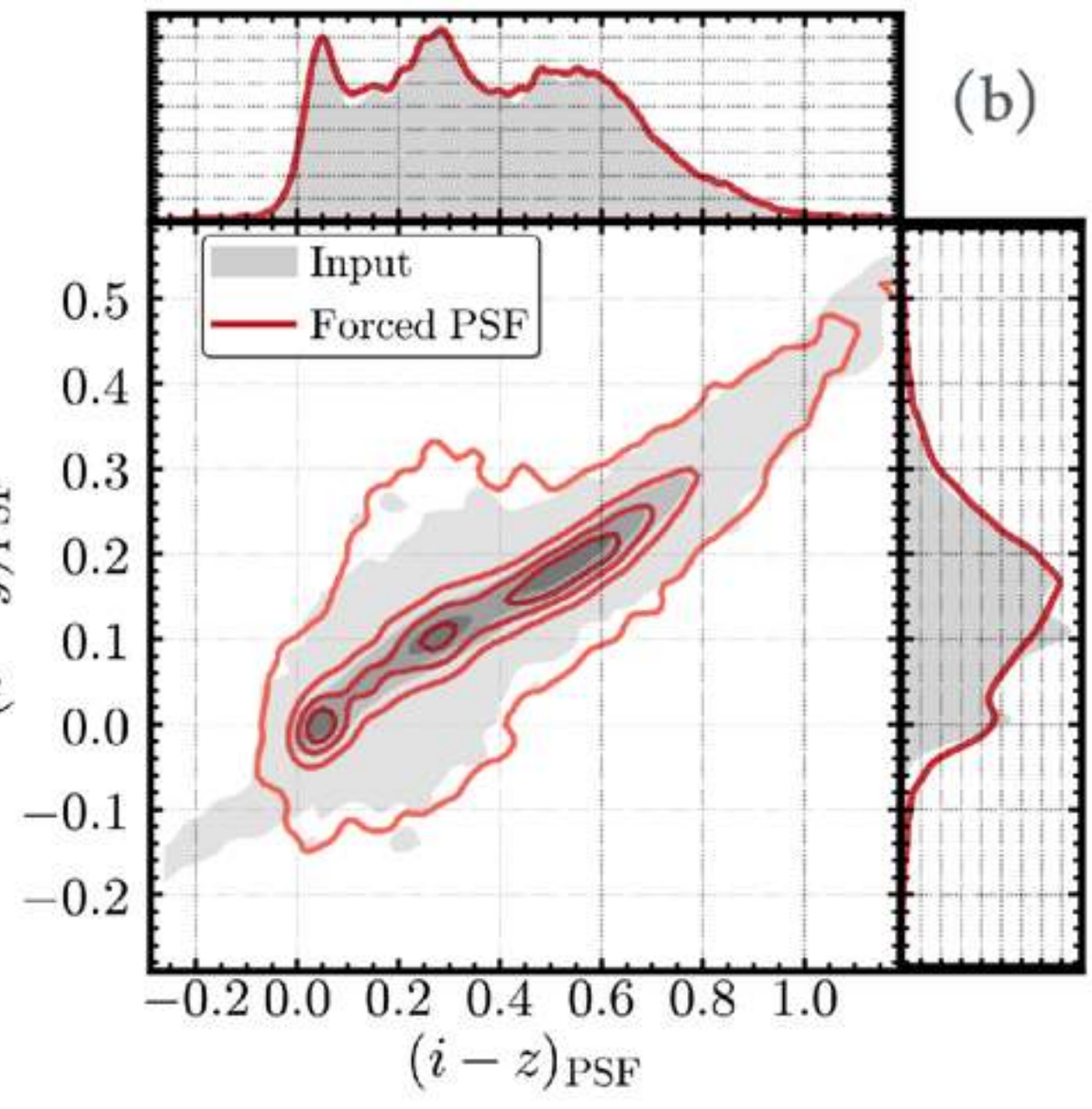
Basic Validation of HSC Photometry of Stars and Galaxies

CModel color is pretty accurate!

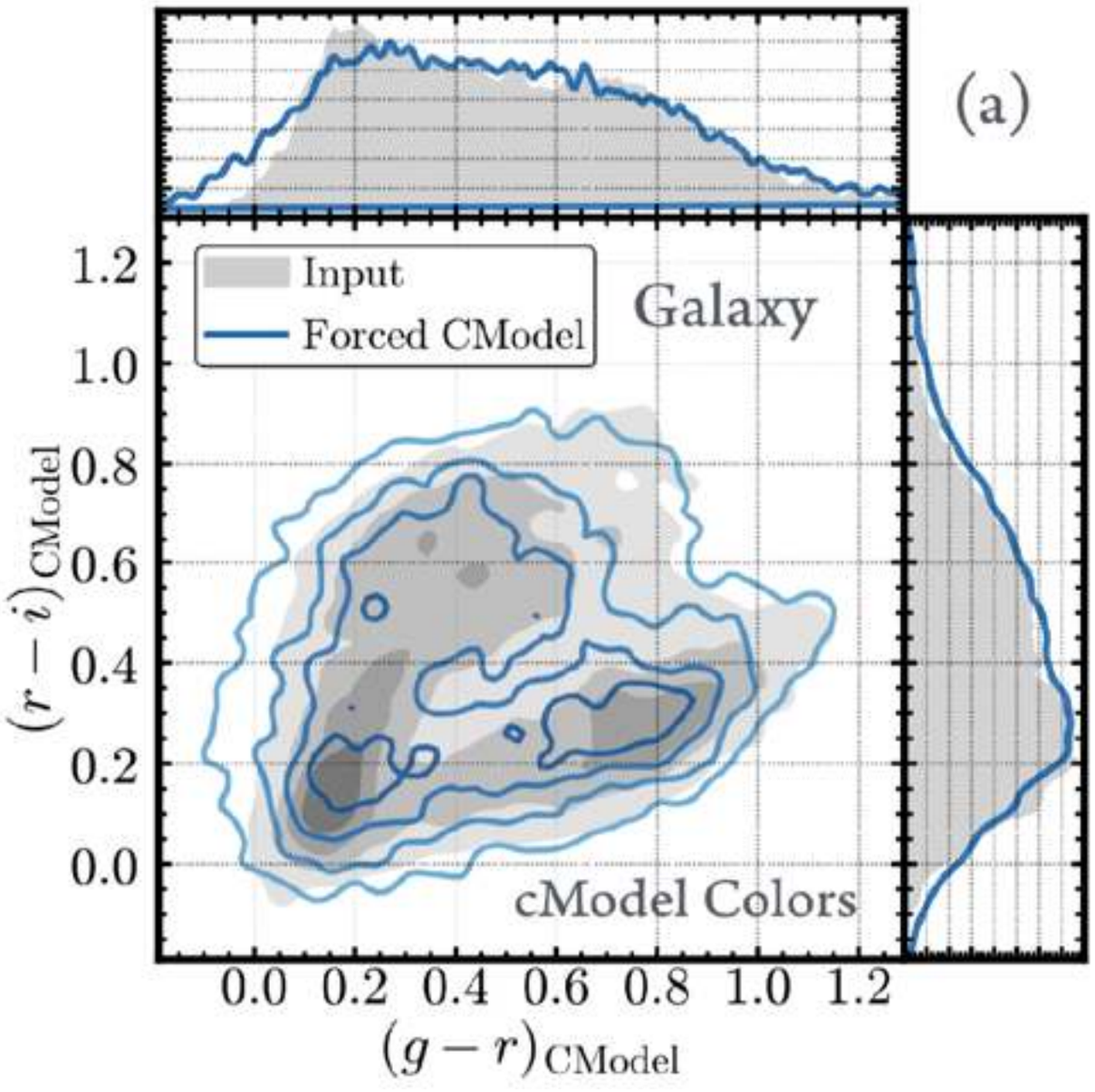


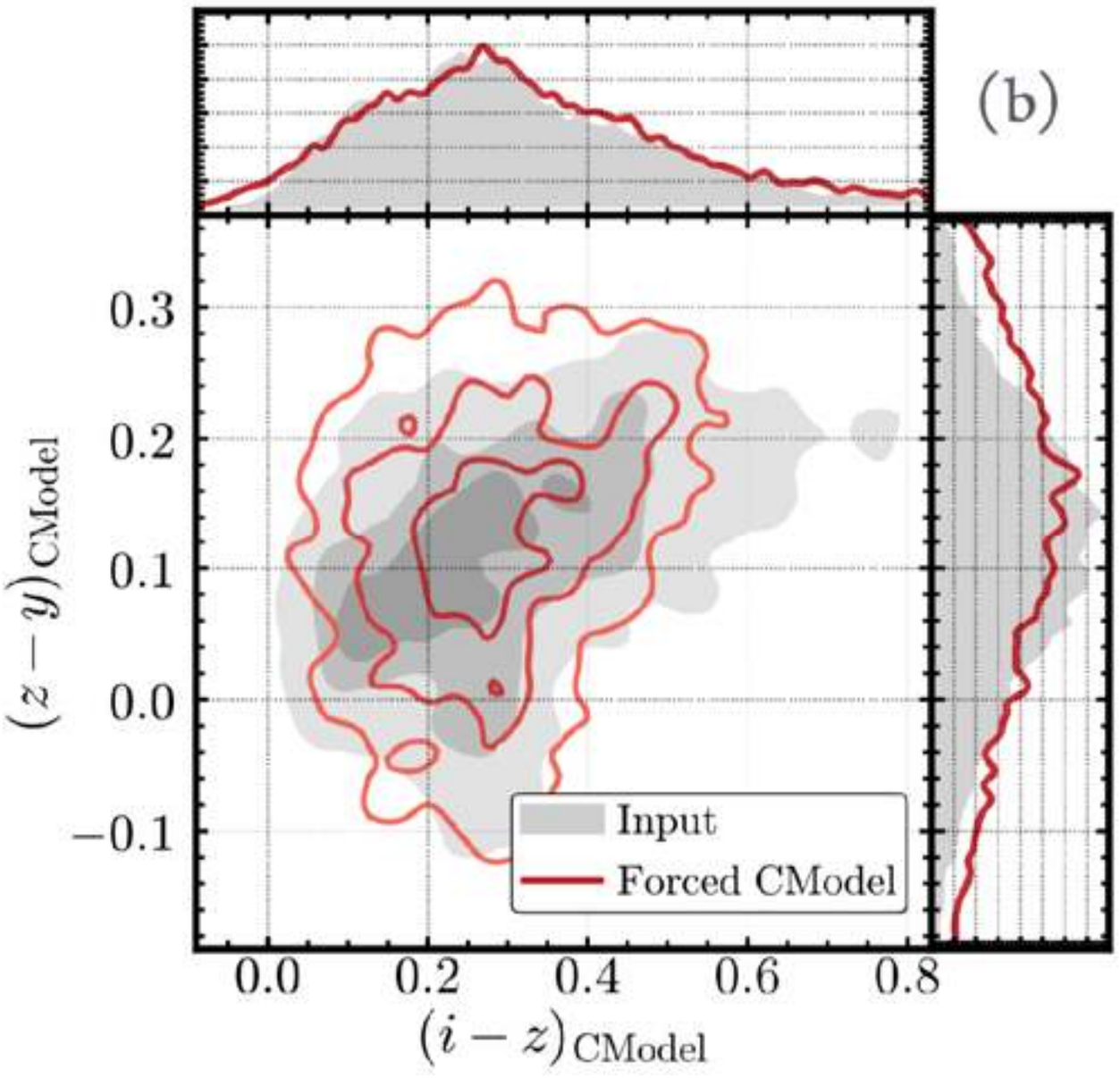
Recover the color-color distributions of stars and galaxies





Recover the color-color distributions of stars and galaxies





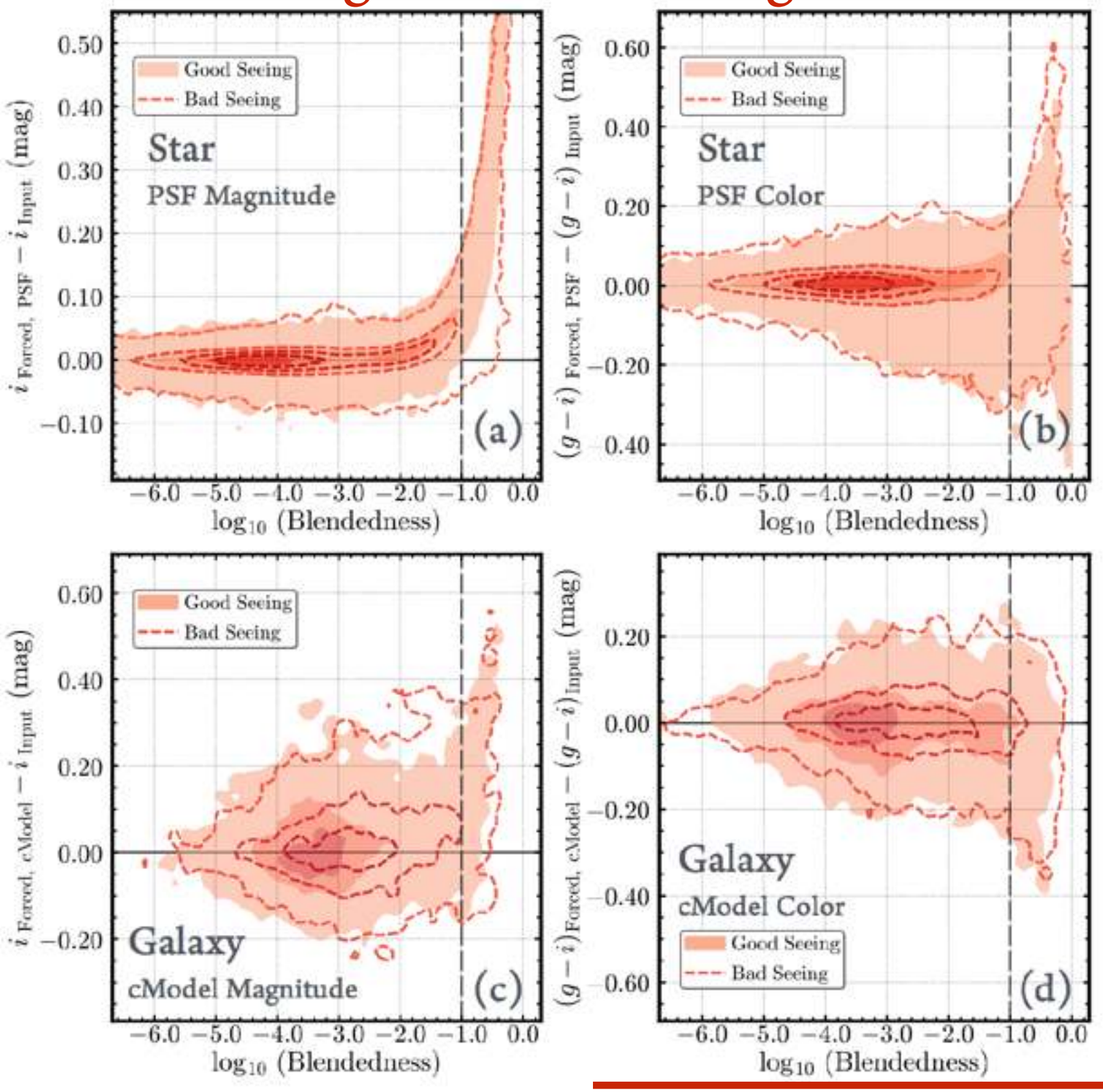
Synpipe can reveal interesting insight of photometry

i-band Magnitude

g-i Color

Star

Galaxy

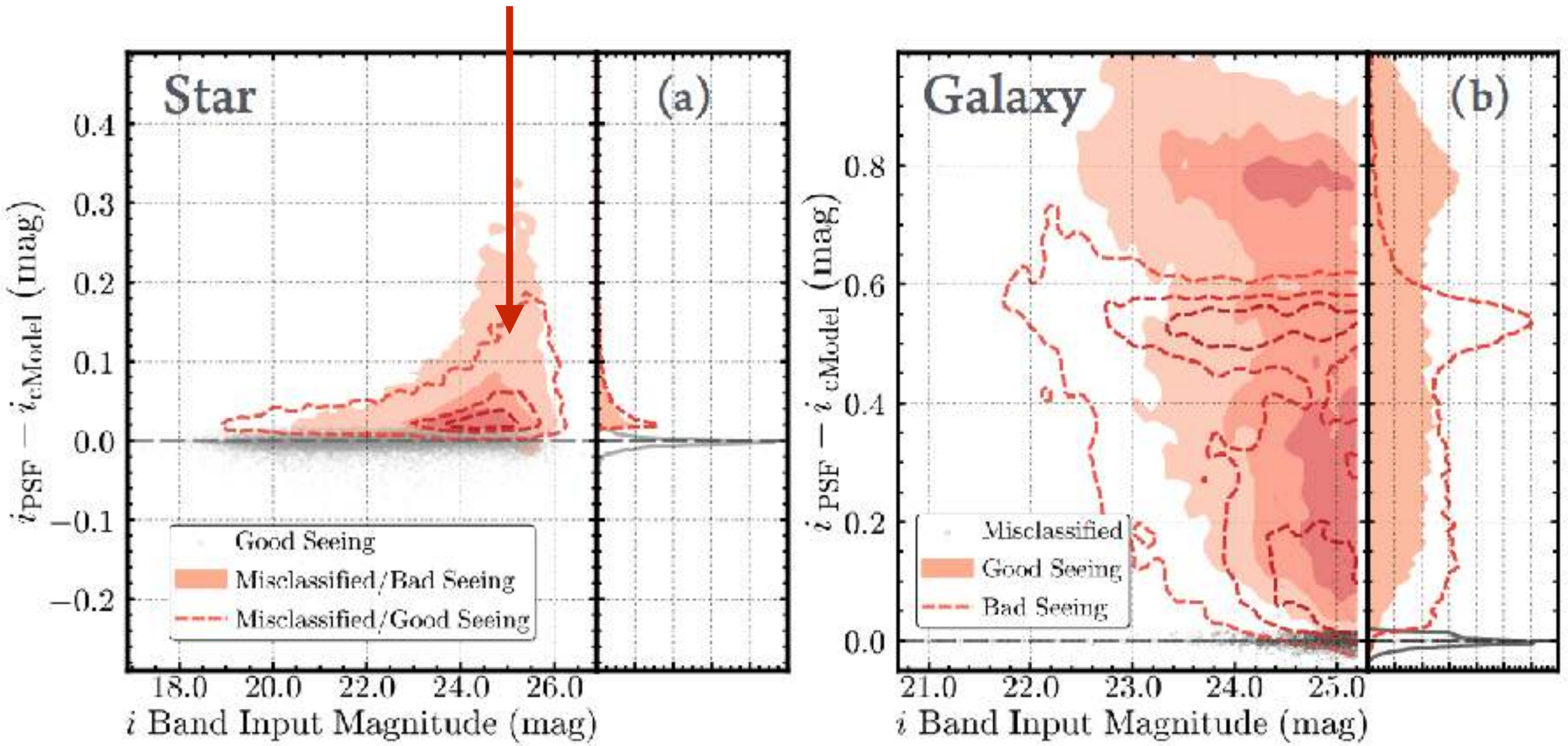


Isolated → Heavily blended

Synpipe can reveal potential problem of the pipeline

e.g. Star-Galaxy separation

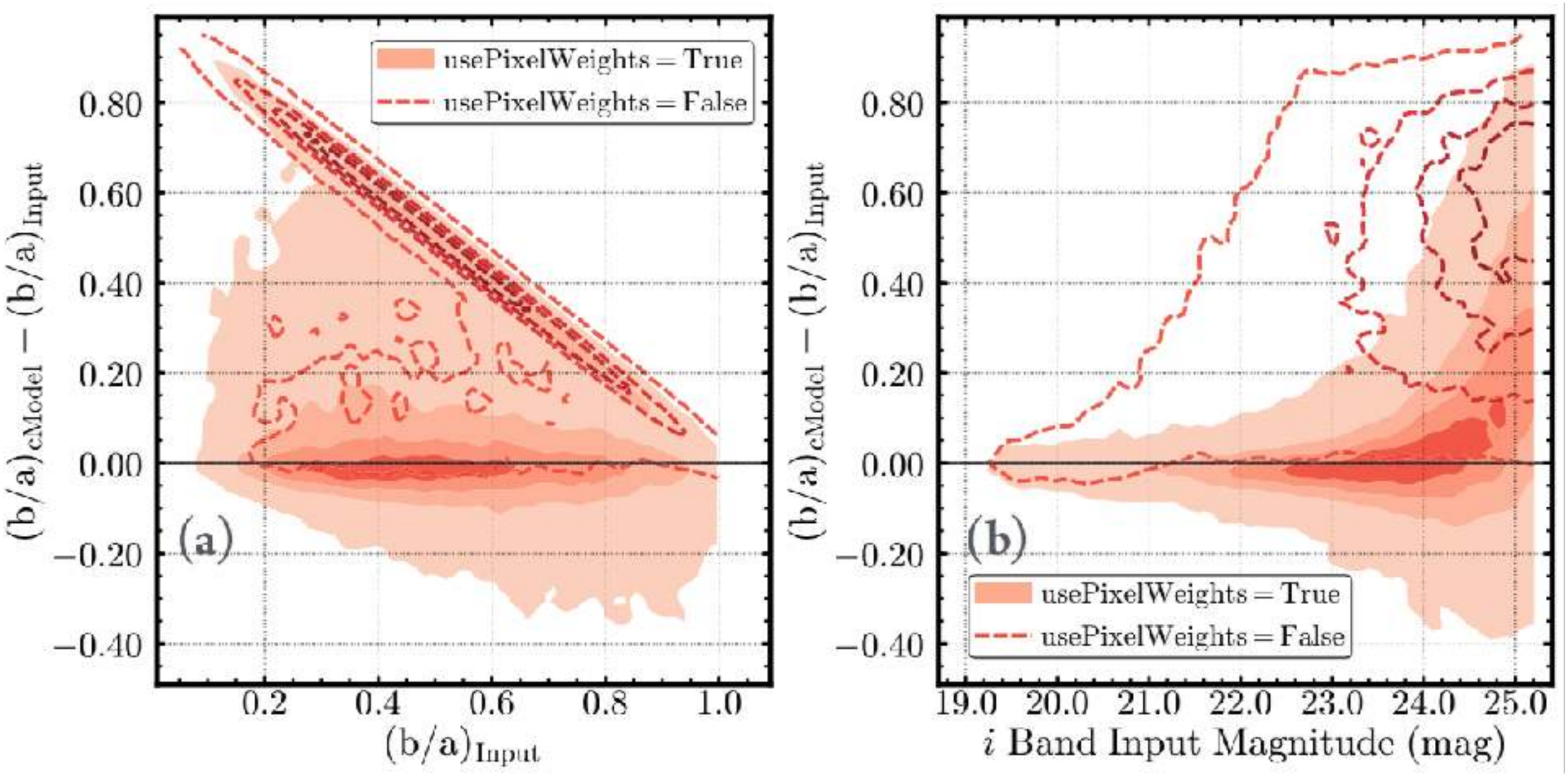
hscPipe used to misclassify lots of faint stars as galaxies



Synpipe can reveal potential problem of the pipeline

e.g. Galaxy shape/size in CModel

The combination of CModel priors and whether to use per-pixel variance information makes hscPipe think all faint galaxies are small and round



Applications of Synpipe:

Validation of photometry: for HSC or for testing the algorithm

Huang et al. 2019; Portillo, Speagle, & Finkbeiner 2019

Impact of blended galaxies on the WL shape catalog

Murata et al. in prep.

Detection and completeness of LAE or dropout galaxies

Ono et al. 2018, Harikane et al. 2018, Konno et al. 2018, Hayashi et al. 2018

Itoh et al. 2018, Matsuoka et al. 2018

Microlensing events in M31 (single epoch)

Niikura et al. 2019

Impact of blending on photo-z measurements

Under discussion

PSF Photometry by P.S.F

https://arxiv.org/abs/1902.02374

Based on Huang et al. 2018

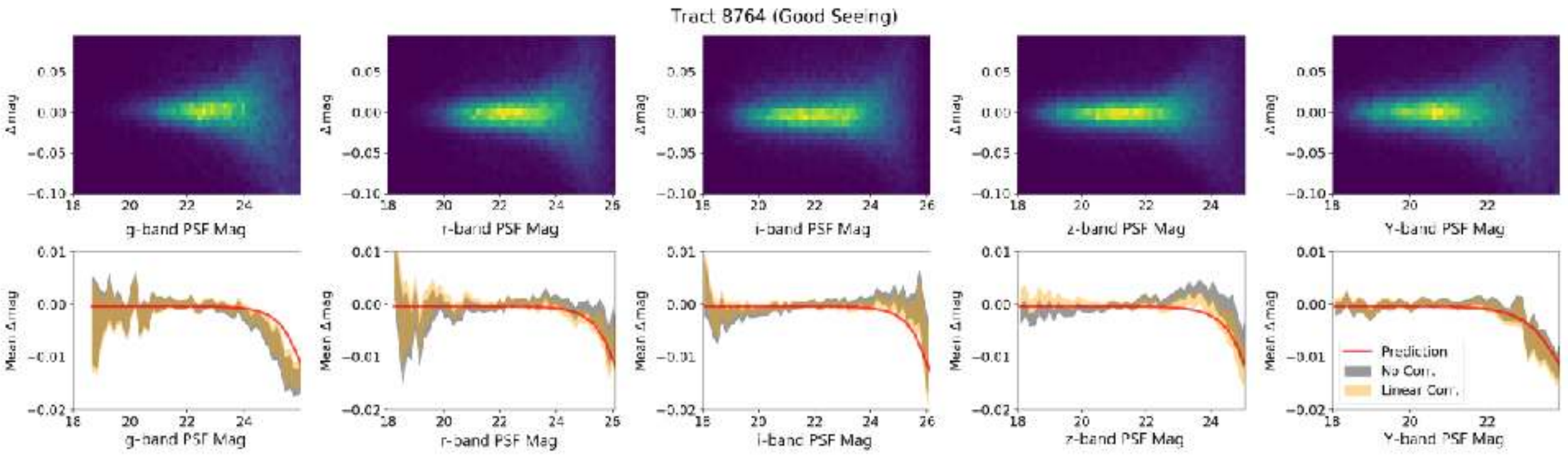
Photometric Biases in Modern Surveys

STEPHEN K. N. PORTILLO,[1,*] JOSHUA S. SPEAGLE,[2,*] AND DOUGLAS P. FINKBEINER[2]

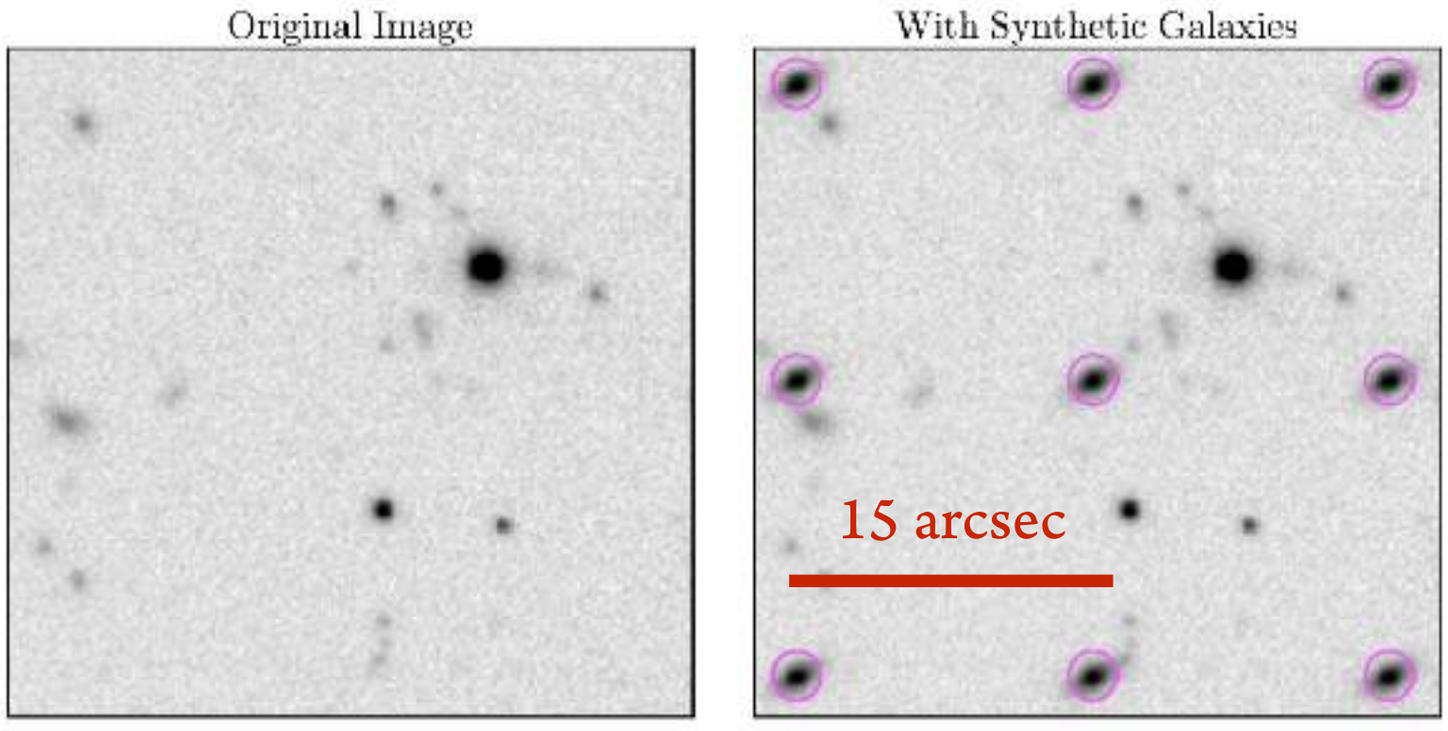
[1] *DIRAC Institute, Department of Astronomy*
University of Washington
3910 15th Ave NE
Seattle, WA 98195, USA
[2] *Harvard-Smithsonian Center for Astrophysics*
60 Garden St, MS-10
Cambridge, MA 02138, USA

ABSTRACT

Most surveys use maximum-likelihood (ML) methods to fit models when extracting photometry from images. We show these ML estimators systematically *overestimate* the flux as a function of the signal-to-noise ratio (SNR) and the number of model parameters involved in the fit. This bias is substantially worse for galaxies: while a 1% bias is expected for a 10σ point source, a 10σ galaxy with a simplified Gaussian profile suffers a 2.5% bias. This bias also behaves differently depending how multiple bands are used in the fit: simultaneously fitting all bands leads the flux bias to become roughly evenly distributed between them, while fixing the position in "non-detection" bands (i.e. forced photometry) gives flux estimates in those bands that are biased *low*, compounding a bias in derived colors. We show that these effects are present in idealized simulations, outputs from the HSC fake object pipeline (SynPipe), and observations from SDSS Stripe 82. Prescriptions to correct for these biases are provided along with more detailed results related to biases in ML error estimation.



Fraction of blended galaxies in the WL shape catalog



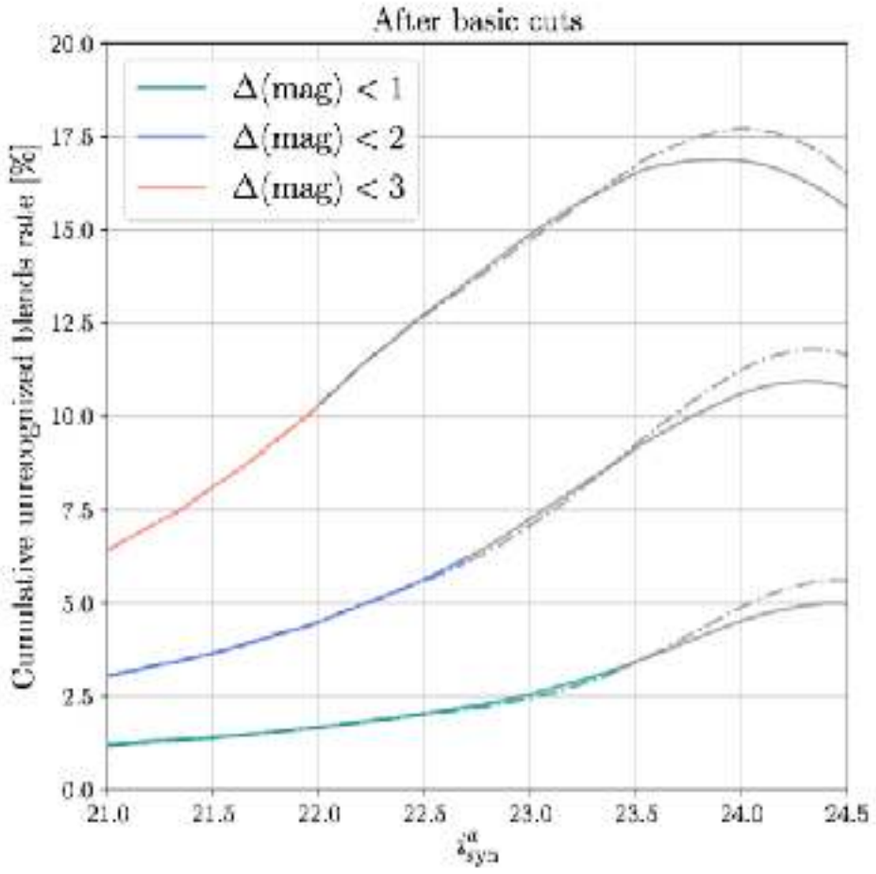
Murata et al. in prep.

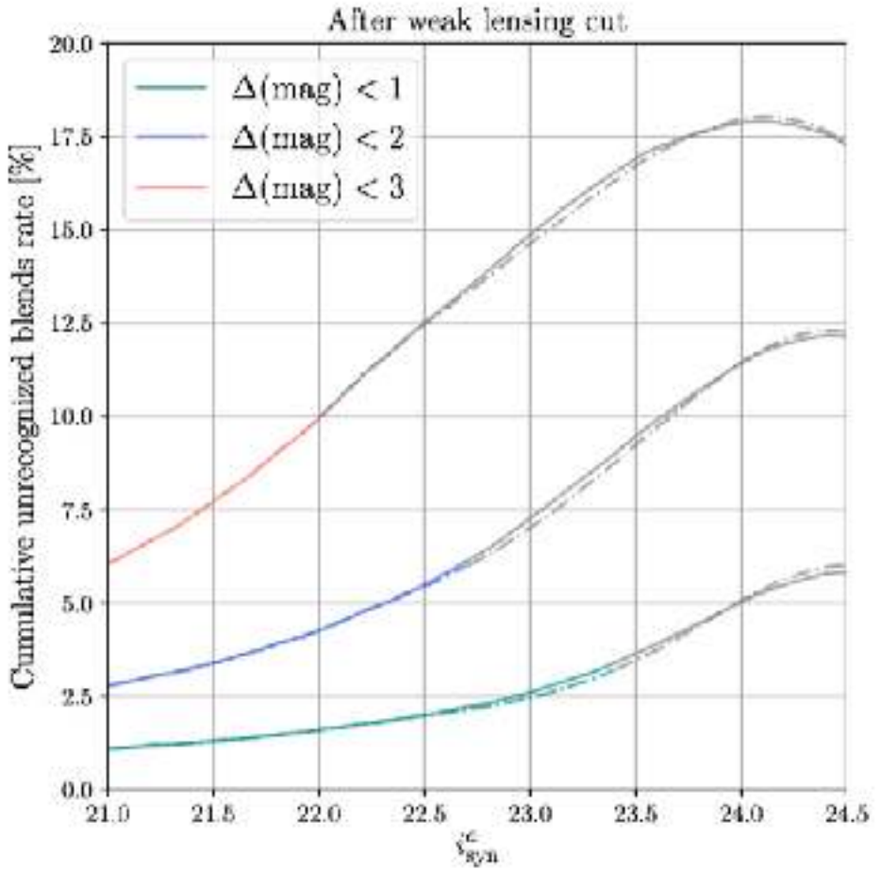
Unfortunately the student left the field with the project unfinished…

9 realizations of the same galaxy under similar noise and seeing condition

Preliminary

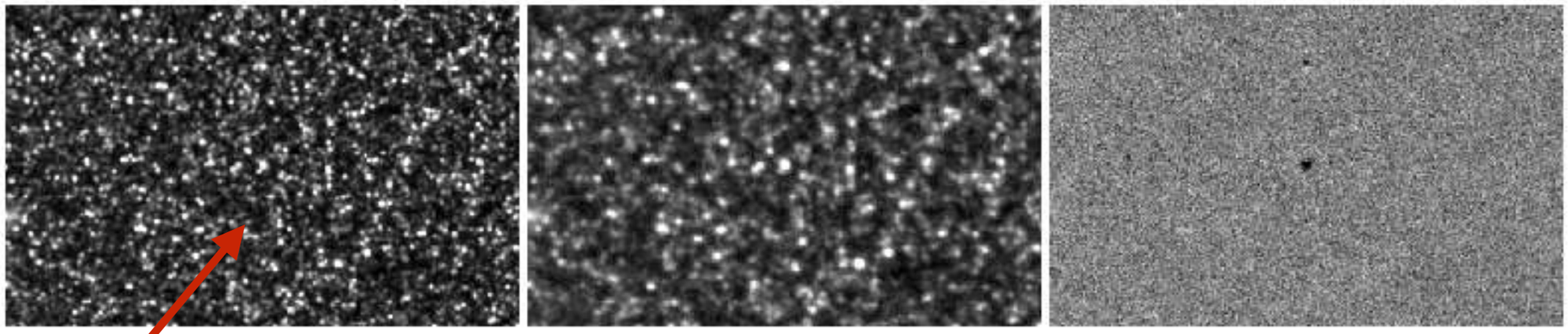
Classify into different scenarios: recovered, lost, unrecognized blends

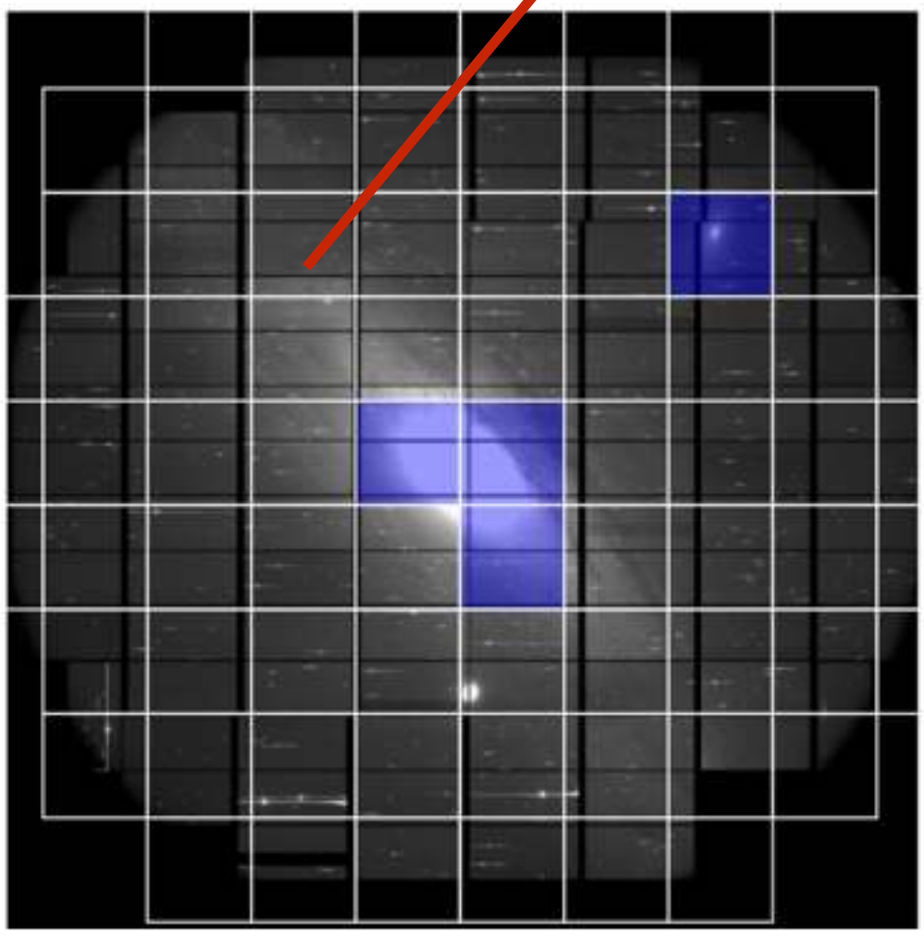


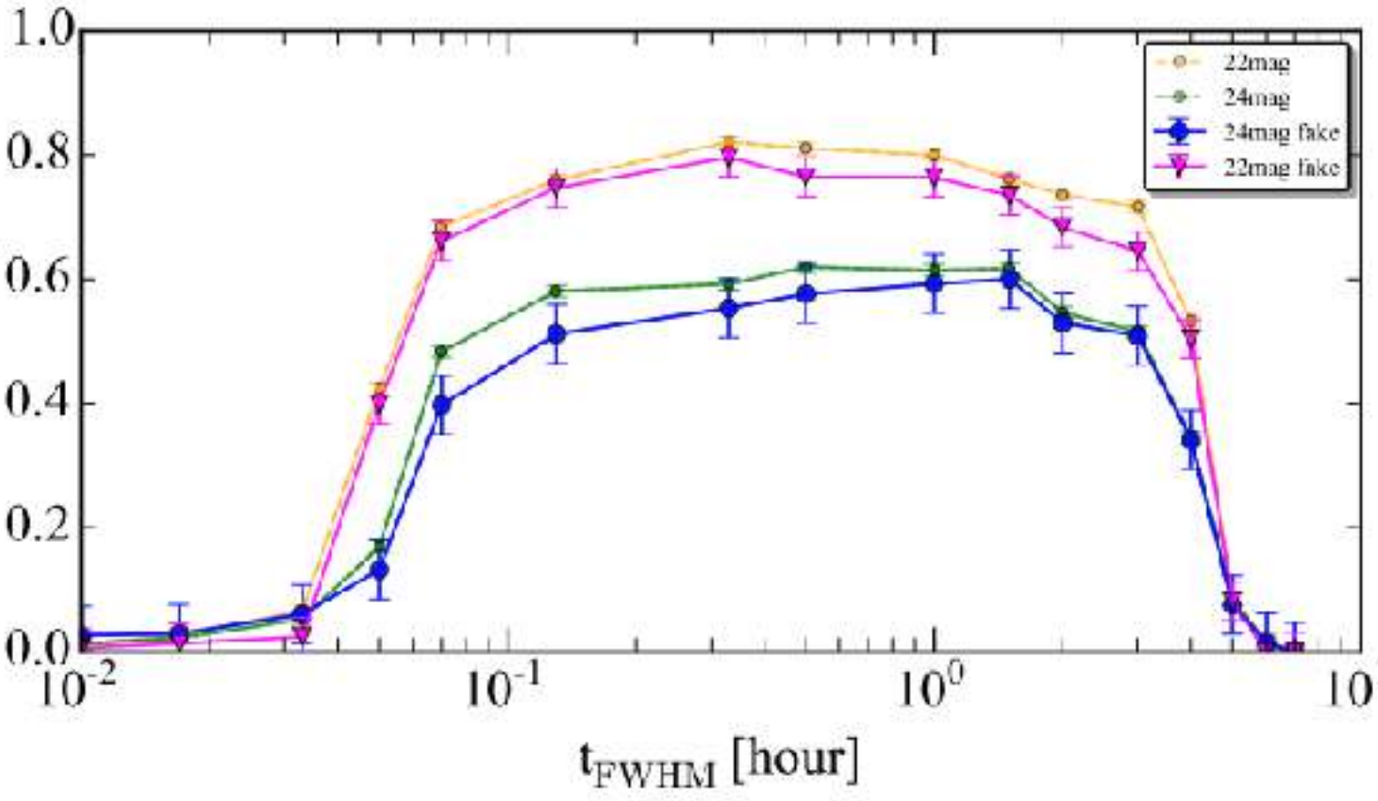


Constraints of Primordial Black Hole as candidate of DM
Using microlensing events in M31

Niikura et al. 2019







A Few Lessons / Thoughts:

Mock tests should happen along with the development of the pipeline

- Not after the data reduction. It could help avoid a lot of problems…

Need to advocate more about the importance of mock tests to the community

- The user should know their science always depends on the performance of the data reduction pipeline in some way. We need to make it clear that they can benefit from mock tests.

- We should have done better for HSC… In the HSC DR3 forced photometry catalog, every object has 747 columns….The number will double when independent measurements are included. Should be similar for LSST.
- A lot of information there has never been carefully evaluated…and there could be problems…

A Few Lessons / Thoughts:

hscPipe/LSST Pipe are not exactly "user friendly" by design

- In my experience, one of the main reasons that people avoid mock tests is they can't run pipeline by themselves

And…no single mock test / mock catalog can satisfy all scientific goals

- The pipeline team cannot cover everything. Need to coordinate with the community better.
- What we really need is an interface that allows users to easily run customized mock test on a small/tiny piece of sky, to help them understand the data.

Realistic galaxy images with "truth label" will be very useful!

- So far, all the mock tests we have done are just "sanity checks". They do not reflect the true complexity of real objects and do not account for all systematics.
- Rendered images from hydro-sims or machine learning can help

e.g., galaxy2galaxy; Lanusse et al. 2020

Thank You !