Unlocking the evolution of star formation with CASTOR

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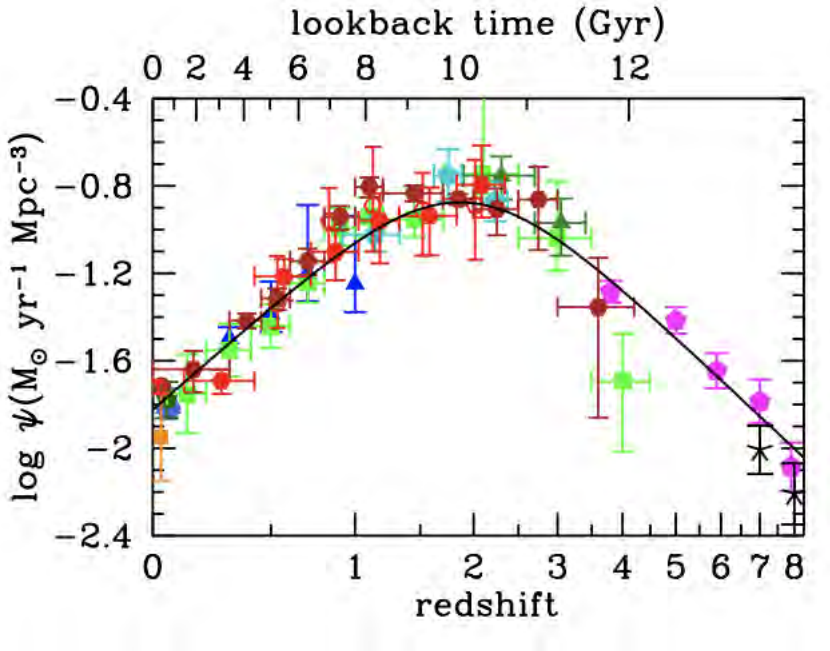
Star Formation and Dwarf Galaxies

- The star formation rate is a fundamental property of galaxies and UV emission is a direct tracer.

- Dwarf galaxies exhibit bursty or stochastic star formation histories (e.g. Seo & Ann 2023; Perry et al. 2025), which affects the accuracy of SFR indicators (e.g. Lee et al. 2009, 2011; Koda et al. 2012).



Madau & Dickinson (2014)

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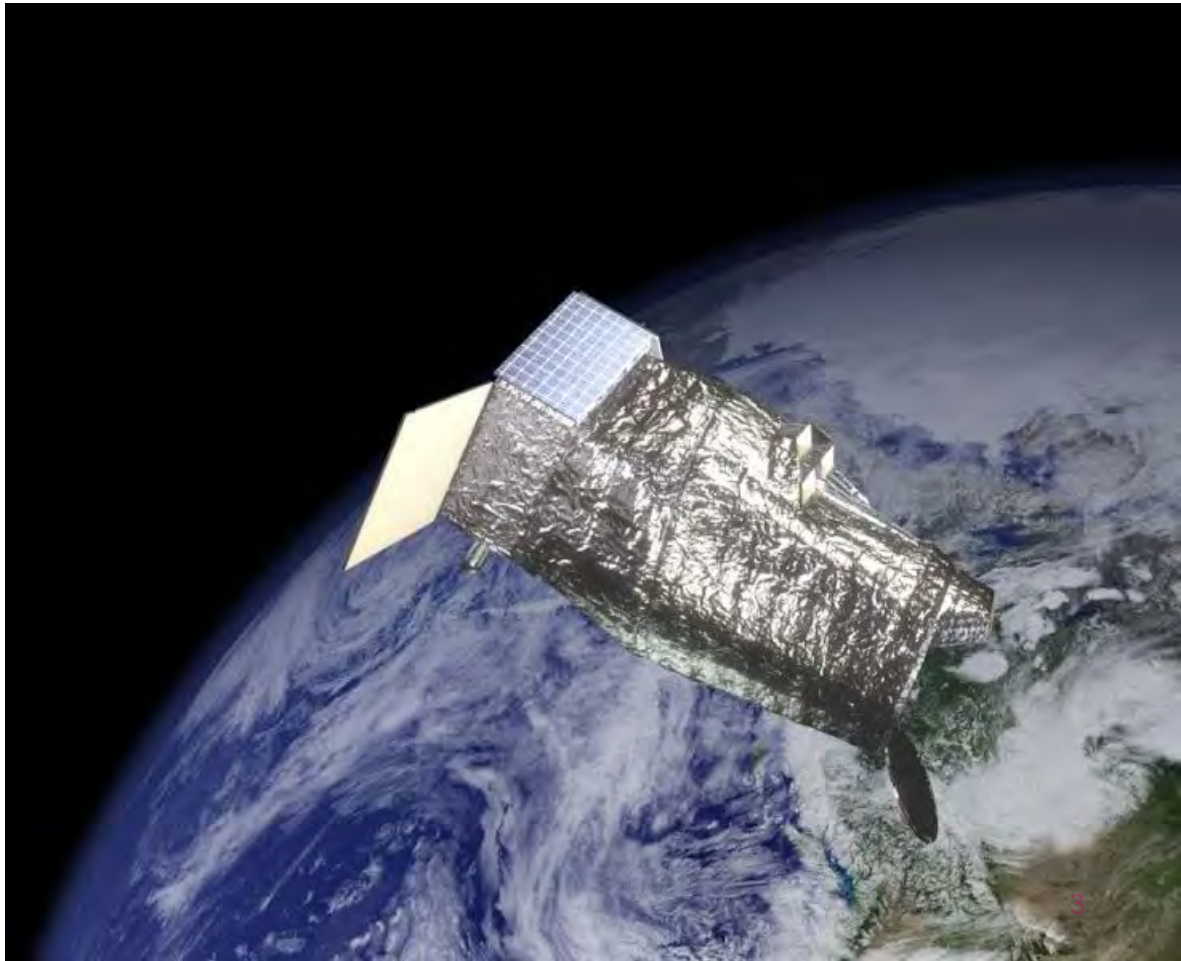
Cosmological Advanced Survey Telescope for Optical & UV Research

- CASTOR is a flagship Canadian-led space telescope that will provide a successor to HST at ultraviolet and optical wavelengths
- Wide field (0.25 deg^2) telescope with Hubble-like resolution (0.15")
- Simultaneous *UV* (150–300nm), *u* (300–400nm), and *g* (400–550nm) photometry, with proposed *UV*- and *u*-split filters.



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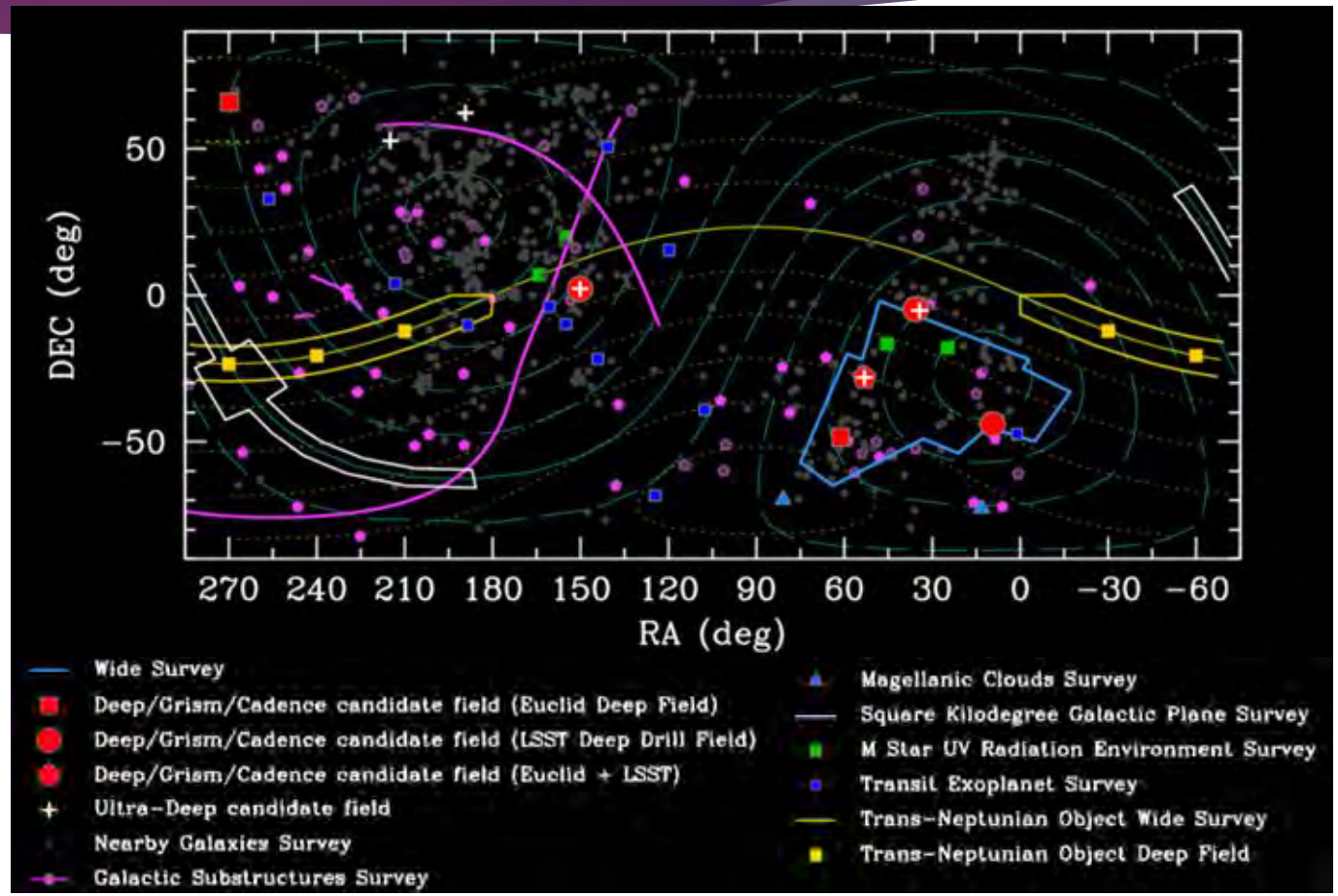
CASTOR Legacy Surveys

- Total of 16 proposed legacy surveys.
- For galaxy survey studies, there are three key surveys:
  - The Wide Survey, covering 2 227 deg^2 with 1 000s exposure time per pointing.
  - The Deep Survey, covering 83 deg^2 with 18 000s exposure time per pointing.
  - The Ultra-Deep Survey, covering 1 deg^2 with 180 000s exposure time per pointing.



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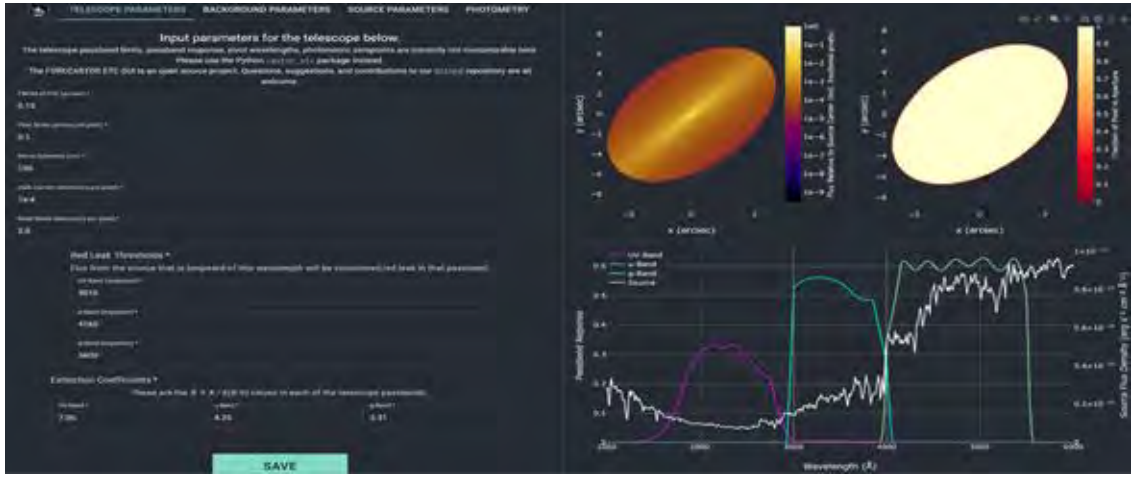
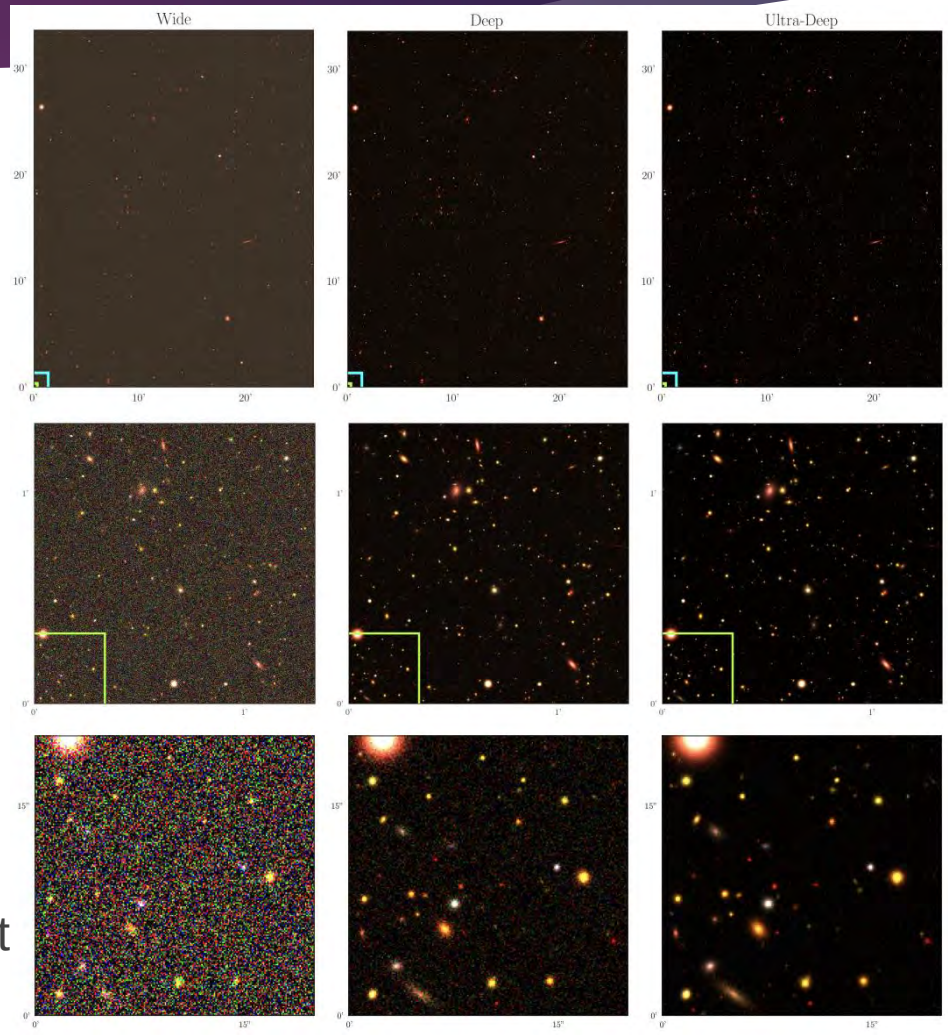
FORECASTOR: Finding Optic Requirements and Exposure times for CASTOR

- A suite of tools for observational preparation, data reduction, and analysis for the CASTOR mission.
- Available: GitHub.com/castor-telescope



Photometric Exposure Time Calculator (Cheng et al. 2024)



Deep field image simulations (Marshall et al. 2025)

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Generating Mock Galaxy Photometry

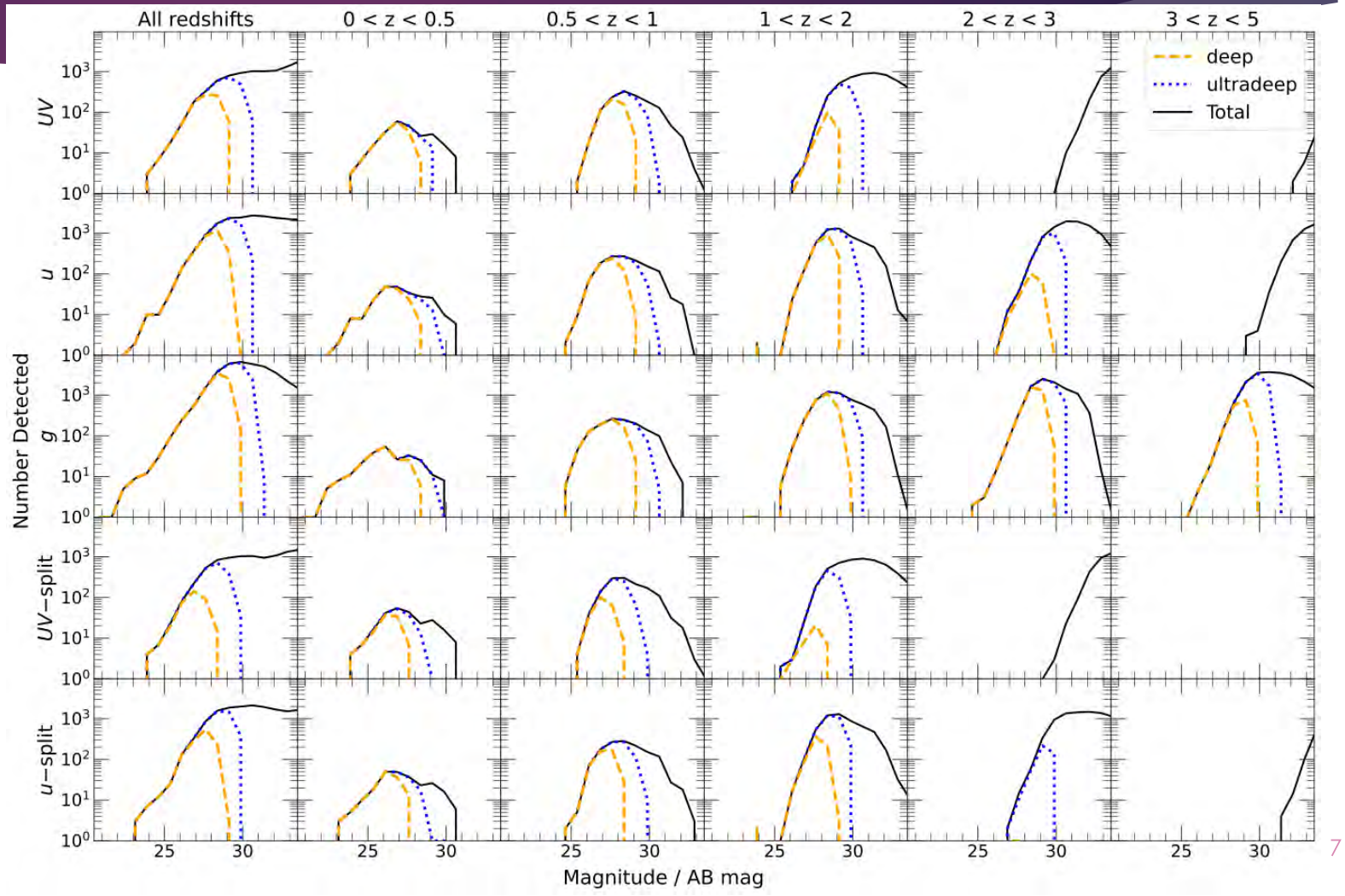
- A sample of mock galaxies is taken from the Santa Cruz semi-analytic model (Yung et al. 2023), selecting a sample of bulgeless galaxies at $0 < z < 5$ with M $> 10^7 \boldsymbol{M}_{\odot}$.

- Mock spectra are generated using the BPASS v2.2.1 stellar population synthesis models (Stanway & Eldridge 2018), from which mock photometry is calculated in the five CASTOR, three Euclid NISP, and five SDSS filter bandpasses.

- SED fitting is performed using BAGPIPES (Carnall et al. 2018) when both incorporating CASTOR (all-band run) and excluding the CASTOR filters (Euclid+SDSS run).

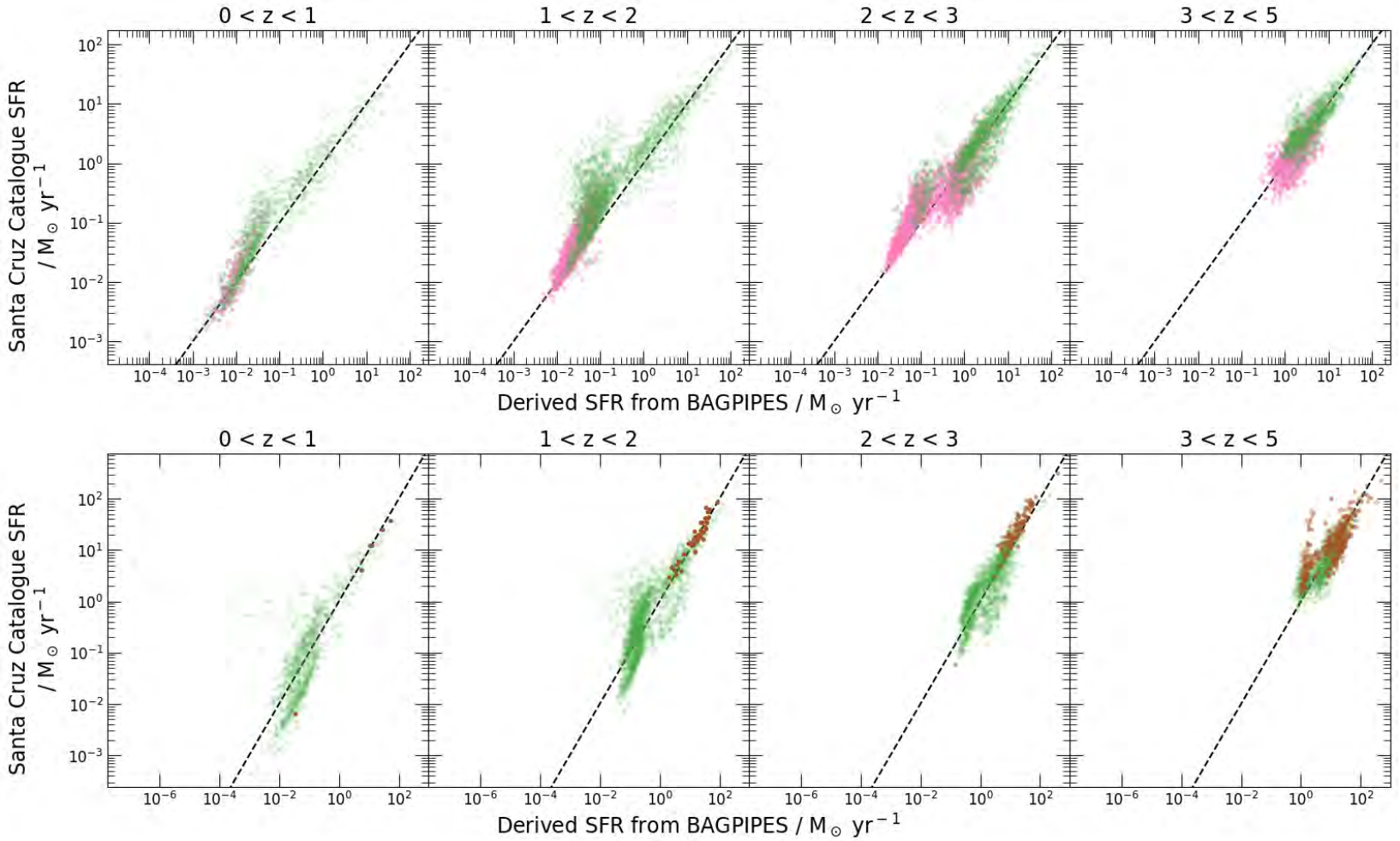
CASTOR Detection Statistics

- In the same observational area, the Ultra-Deep survey will detect 2.5 times as many galaxies as the Deep survey.
- The faintest detectable galaxy is 28.65-30.06 and 30.07-31.29 mag for the Deep and Ultra-Deep surveys, respectively.



SFR Recovery Results

- Green points are galaxies included in both fitting runs.
- Pink points are galaxies exclusively in the all-band run.
- Brown points are galaxies exclusively in the Euclid+SDSS run.



Catalogued Galaxy Parameters

- Euclid+SDSS exclusive galaxies are extreme dusty systems (consistently $A_V > 3$ at $z < 2$), attenuating and scattering UV and blue-optical emission.

- All-band exclusive galaxies are faint, low-mass, low-dust systems, requiring very deep observations to be detected.

Group	SFR $M_\odot$ yr $^{-1}$	$\log_{10}$(Mass) $\log_{10}(M_\odot)$	Extinction A_V	m_g^{CASTOR} AB mag	m_H^{Euclid} AB mag
All galaxies	3.49	8.38	0.48	28.71	26.49
All-band fit	0.58	7.86	0.26	29.20	27.64
Euclid+SDSS fit	23.85	9.38	1.17	31.00	26.06

Impact of CASTOR

- Incorporating CASTOR observations does not simply shift the typical SED-derived SFR closer to the catalogue value but substantially improves the consistency of SFR recovery between individual galaxies.

- CASTOR is most impactful as low-redshifts (i.e. $z < 1$), reducing the mean offset by 0.26 dex and the scatter by 0.55 dex.

Redshift	With CASTOR (dex)	Without CASTOR (dex)
All	0.28±0.26	0.34±0.45
$0 < z < 1$	0.28±0.25	0.54±0.80
$1 < z < 2$	0.35±0.32	0.39±0.46
$2 < z < 3$	0.26±0.20	0.27±0.20
$3 < z < 5$	0.18±0.16	0.24±0.19

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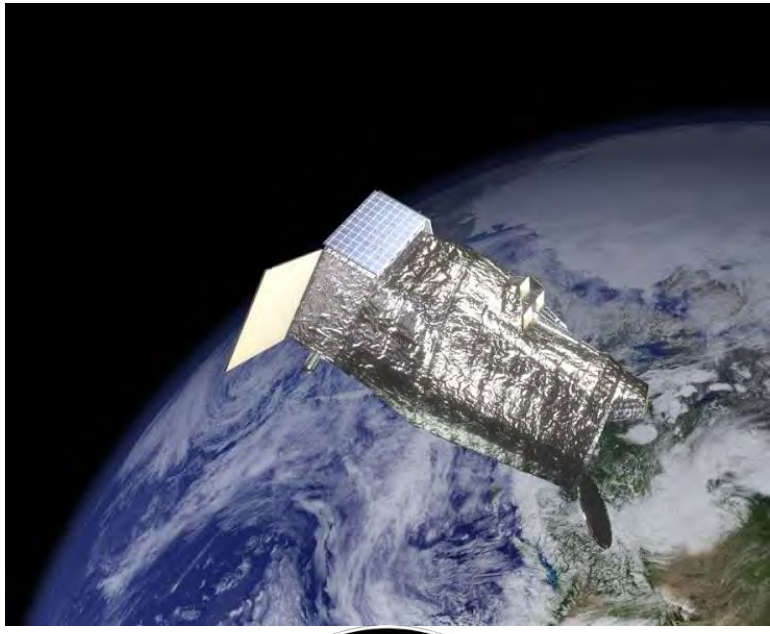
Conclusions

- UV observations are crucial for tracing star formation in galaxies, and CASTOR will extend these studies to faint, low-mass galaxies.
- CASTOR's Ultra-Deep survey will reach ~31 mag, obtaining large statistical samples of faint, low-mass galaxies.
- CASTOR improves SFR recovery and robustness, particularly at low-z and low-masses.



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