Going Wide and Deep with Roman
The z~6-8 UV Luminosity Function

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Roman Science Team Community Briefing, Nov 15-19, 2021

Roman Deep Field Surveys

Goals

- **Accuracy of the faint-end slope of the UV luminosity function**
- **Accuracy of the integrated luminosity density**
  - → galactic contribution to reionization
  - → constraints on the cosmic star formation rate density
- **Abundance of very bright galaxies**
  - → constraints on feedback processes; star formation efficiencies, etc.
HST Surveys

![Graph showing the relationship between area and H 5σ Limiting Mag for different surveys.](image-url)
HST Surveys

JWST Surveys
We consider a 500hr Roman Deep field survey.
Roman Deep Field Surveys

We consider 16 possible Roman Deep Field Surveys

- Four areas:
  1. Roman pointing, ~0.28 deg$^2$
  2. 2 Roman pointings, ~0.56 deg$^2$
  3. 4 Roman pointings, ~1.12 deg$^2$
  4. 7 Roman pointings, ~2 deg$^2$

- Four filter sets:
  - ‘Base survey’ – $z, Y, J, H$ (F087, F106, F129, F158)
  - Base+r
  - Base+F184
  - Base+r+F184

- For a total exposure time of ~500 hours
Roman Deep Field Surveys

We consider 16 possible Roman Deep Field Surveys

- Four areas:
  - 1 Roman pointing, \( \sim 0.28 \text{ deg}^2 \)
  - 2 Roman pointings, \( \sim 0.56 \text{ deg}^2 \)
  - 4 Roman pointings, \( \sim 1.12 \text{ deg}^2 \)
  - 7 Roman pointings, \( \sim 2 \text{ deg}^2 \)

- Four filter sets:
  - ‘Base survey’
  - Base+r – \( r, z, Y, J, H \) (F062, F087, F106, F129, F158)
  - Base+F184
  - Base+r+F184

- For a total exposure time of \( \sim 500 \) hours
Semi-analytic model (SAM) for galaxy formation

Mock observed "lightcone"
- DM halos sourced from the Multi-Dark suite (SMDPL; Klypin et al. 2016)
  400 Mpc/h on a side, resolving $\sim 10^{10}$ M☉ halos
- Construction of a 2 sq deg lightcone up to $z \sim 10$ (Yang et al. 2021, Somerville et al. 2021, Yung et al. in prep)
  using UniverseMachine (Behroozi et al. 2019)
- DM halo merger histories constructed using extended Press-Schechter (Somerville & Primack 1999)

Santa Cruz SAM
- Standard recipes for physical processes that shape galaxy evolution
- Predicted physical properties are forward modeled and reflected in synthetic SEDs and mock photometry
- Model performance at high redshift has been extensively tested (Yung et al. 2019a, 2019b, 2020a, 2020b)
Cosmic Variance — Roman vs. HST
Cosmic Variance — Roman vs. HST

$6.5 < z < 7.5$

$0.5^\circ$

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Measuring the ‘observed’ LF

Apply photometric scatter
- 1 Roman pointing, Base+r
  F062, F087 5σ = 30.39, F106, F129, F158 5σ = 29.89
- 4 Roman pointings, Base+r
  F062, F087 5σ = 29.64, F106, F129, F158 5σ = 29.14

Calculate effective volume via catalog-level completeness

Calculate low-z contamination from SAM sources (accurate number densities)

Extract non-overlapping fields from mock lightcone
- 4 RST WFI fields, 0.75° × 0.375° (0.28 sq. deg.)

Fit a Schechter function via parametric maximum-likelihood analysis

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Schechter function fits — $z \sim 6-9$
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Schechter fit parameters $- 6.7 < z < 7.7$

$\phi^*(N \text{ mag}^{-1} \text{ Mpc}^{-3})$

$M_{1500} \text{ (mag)}$

$\phi(M < -21)$

$\alpha$

$\phi^*$

$M^*$

1.12 deg$^2$

Full lightcone

Binned counts

- Roman 0.28 deg$^2$
- Roman 1.12 deg$^2$
- HUDF+ 42 arcmin$^2$
Schechter fit parameters $- 6.7 < z < 7.7$

Accuracy on the faint end slope:

- ~2-6% for a single, deep pointing covering 0.28 deg$^2$
- ~1.5% for an area of 1.12 deg$^2$
UV Luminosity density — \( z \sim 6-9 \)
### Number counts per survey

<table>
<thead>
<tr>
<th>$z$</th>
<th>N in full lightcone ($M_{1500} \leq -17$)</th>
<th>N in ~42 arcmin$^2$, HUDF + 8 Parallel fields ($5\sigma m \leq 29.5, 29.0$)</th>
<th>N in 0.28 deg$^2$, 1 Roman pointing ($5\sigma m \leq 29.89$)</th>
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<tr>
<td>6</td>
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<td>688 ± 92</td>
<td>29,798 ± 3152</td>
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Conclusions

- 16 Roman Deep Field survey designs, 0.28 - 2 deg²
- Photometric scatter for a 500hr survey
- Full sample selection, completeness and contamination for z ~ 6-9
- UV luminosity function, accuracy on the faint end slope ~1-6% (see Drakos et al. 2021)
- UV luminosity density

Number counts per survey

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Thank you!