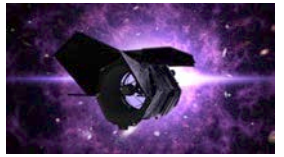
Measurements of Hα Equivalent Width Distributions: The Second Tool to *Roman* Grism Survey Planning

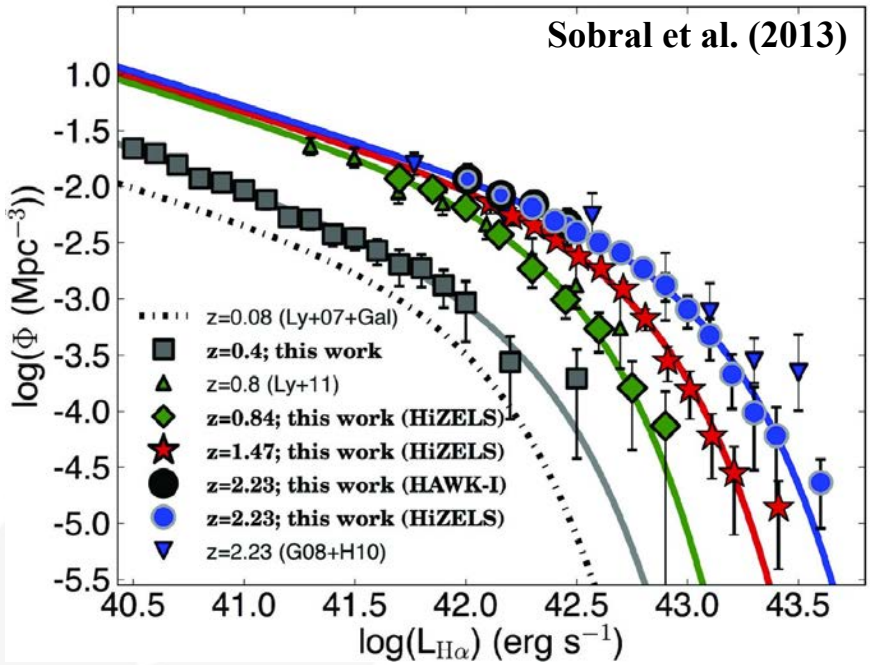
Ali Ahmad Khostovan
Postdoctoral Research Associate
Rochester Institute of Technology

Work done primarily as a NASA Postdoctoral Program Fellow at Goddard Space Flight Center
In-Collaboration with: Sangeeta Malhotra (GSFC), James Rhoads (GSFC), and David Sobral (Lancaster Univ)

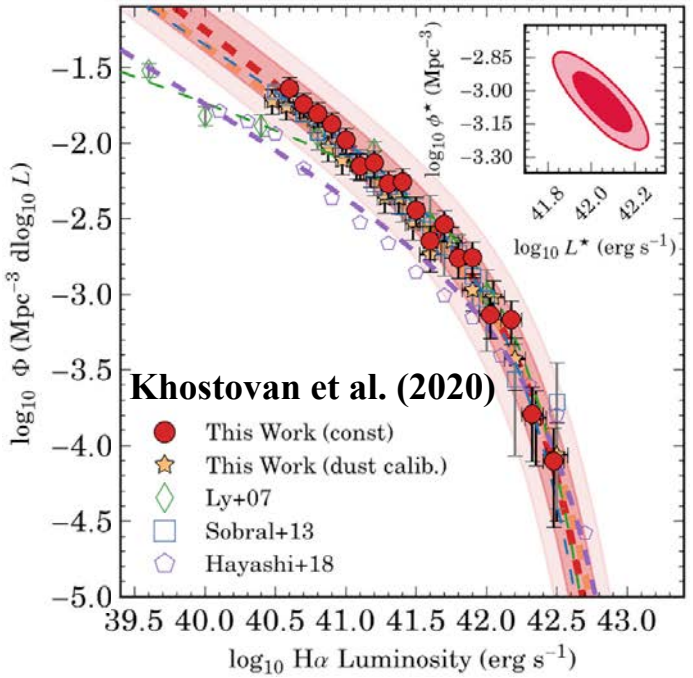
Number Counts for *Roman Space Telescope*



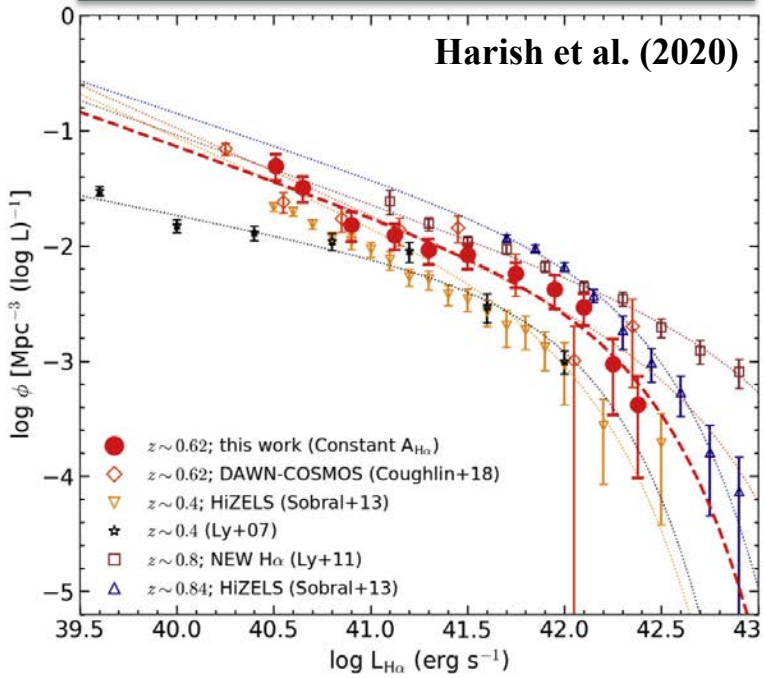
HiZELS ($z \sim 0.4 - 2.2$)



LAGER ($z \sim 0.5$)



DAWN ($z \sim 0.6$)



Number Count Predictions: *Model for LF evolution and Integrate down to Flux Limit*

Resolution Limit in Grism sets a minimum EW threshold

In case of G150:

~ 22Å in observer-frame

~ 14Å rest-frame Hα at $z = 0.5$; 1.00 μm

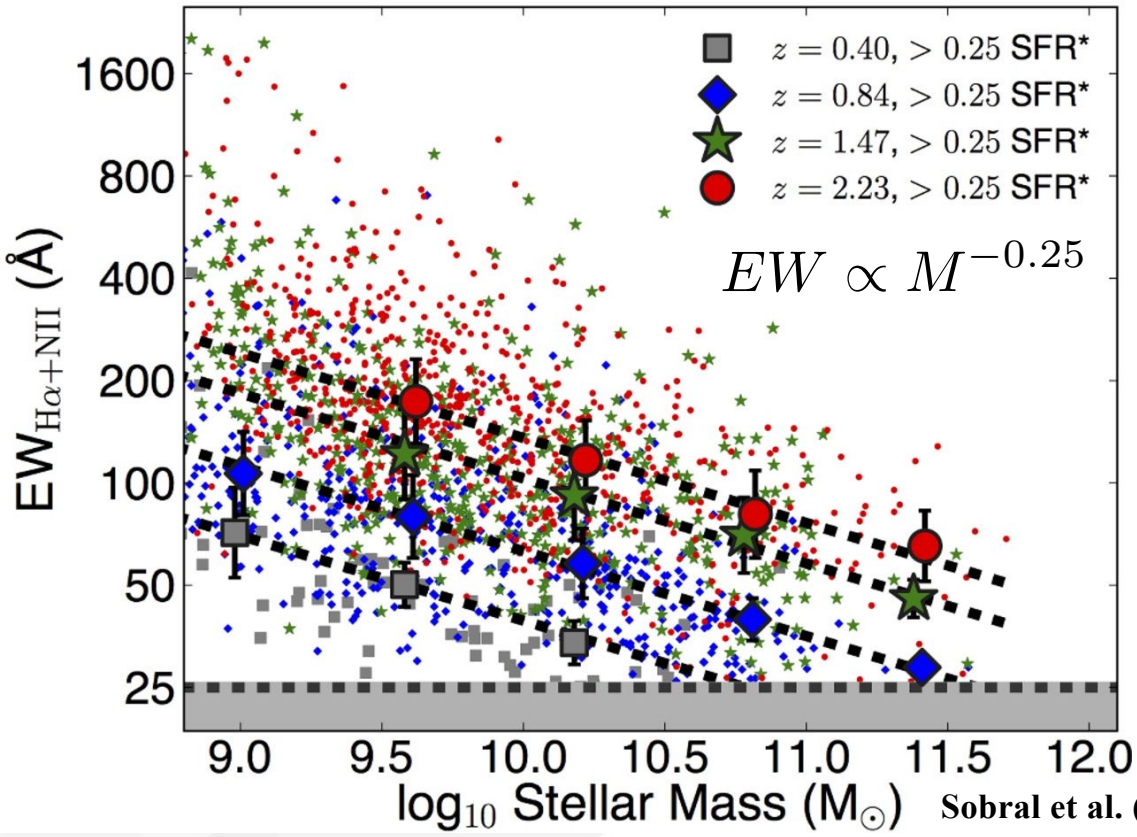
~ 8Å rest-frame Hα at $z = 1.9$; 1.93 μm

Need EW distributions along with well-constrained LFs to measure accurate number count predictions

WFI/G150	
Minimum	1.0 μm
Maximum	1.93 μm
Center	1.465 μm
Width	0.93 μm
R at 1 μm	461

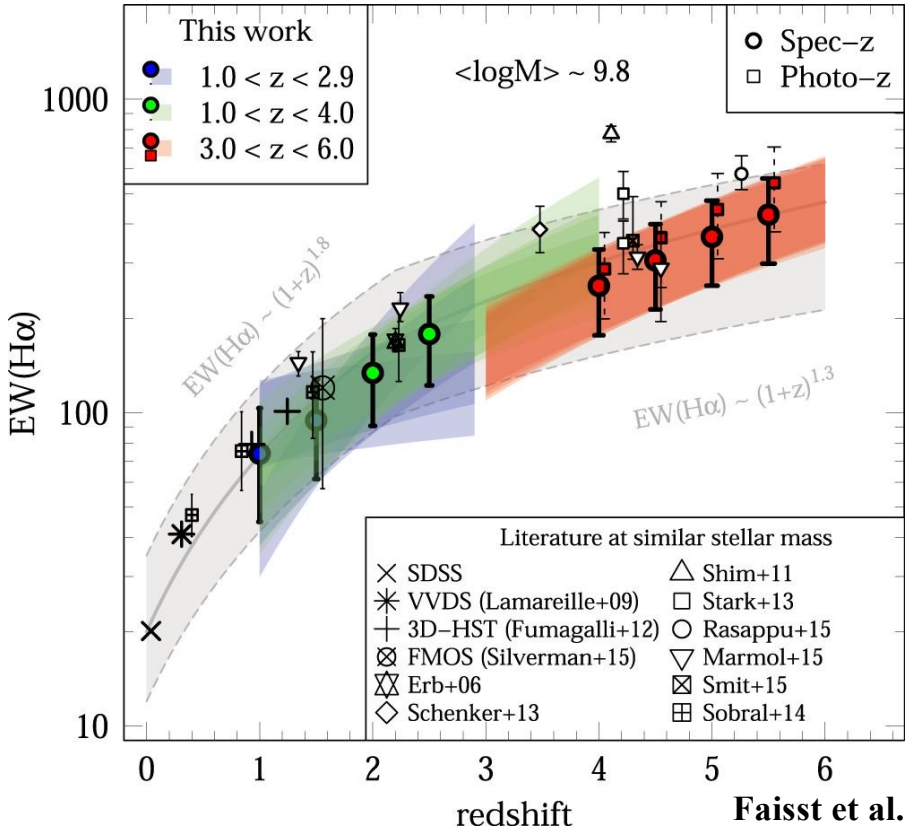
Hα Equivalent Width: Redshift and Mass-Dependent

Evidence for EW – Stellar Mass Correlation
Similar to sSFR – Stellar Mass Trend



Sobral et al. (2014)

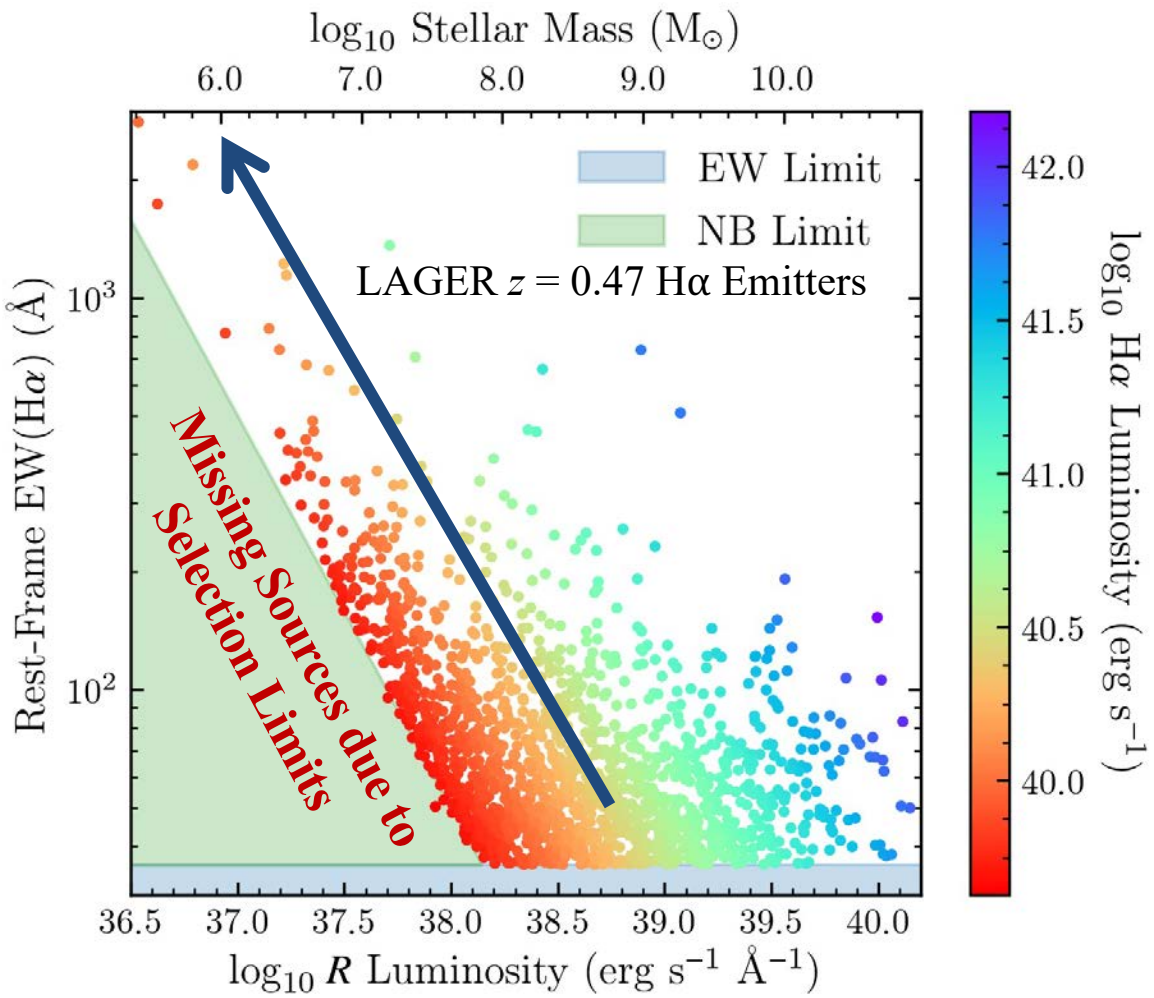
Increasing EW with increasing redshift
Similar to sSFR evolution

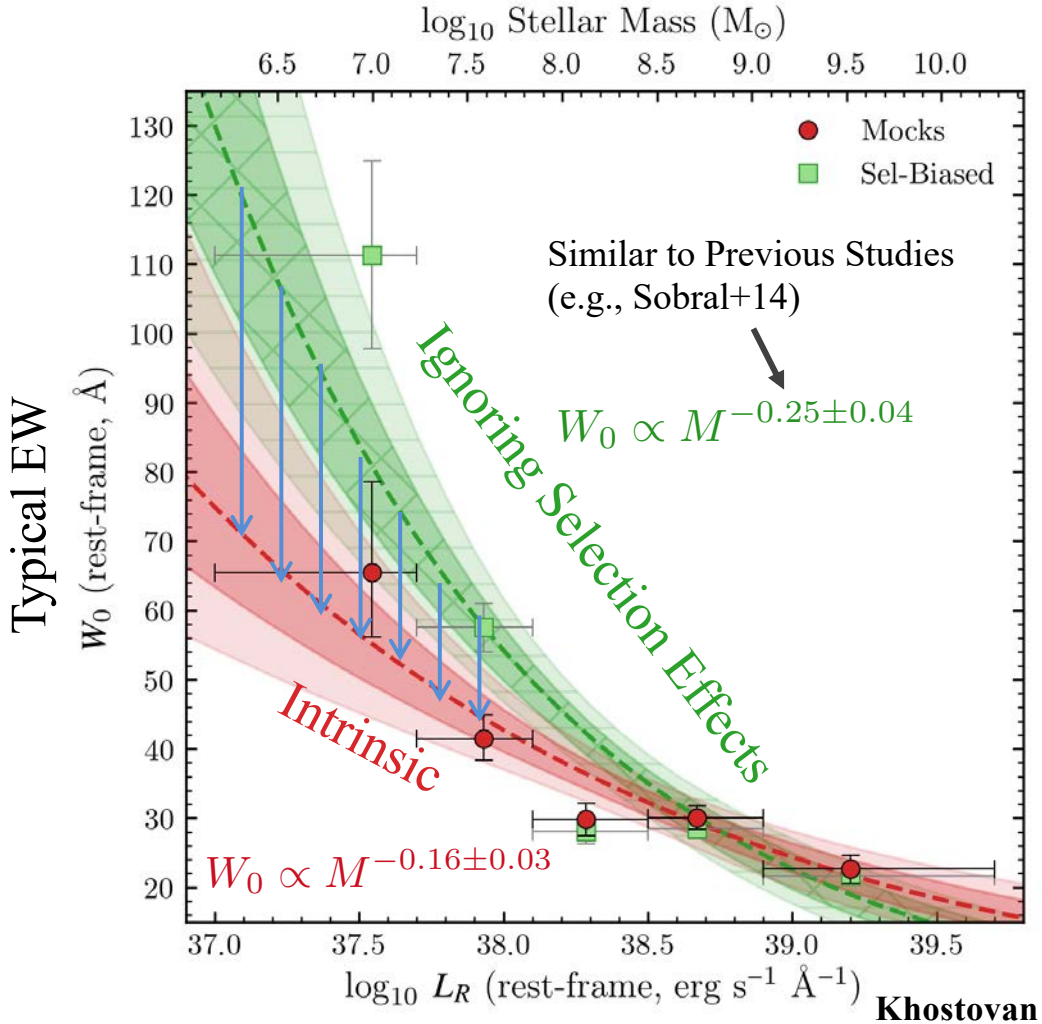


Faisst et al. (2015)

High-mass, star-forming galaxies have low equivalent widths. Could this be missed in *Roman* Grism Surveys?
How well constrained are EW distributions? Are flux limits and other selection effects biasing results?

Selection Effects: Is it a problem? … *Yes*





Khostovan et al. (2021)

Equivalent Width intrinsically correlates with Stellar Mass

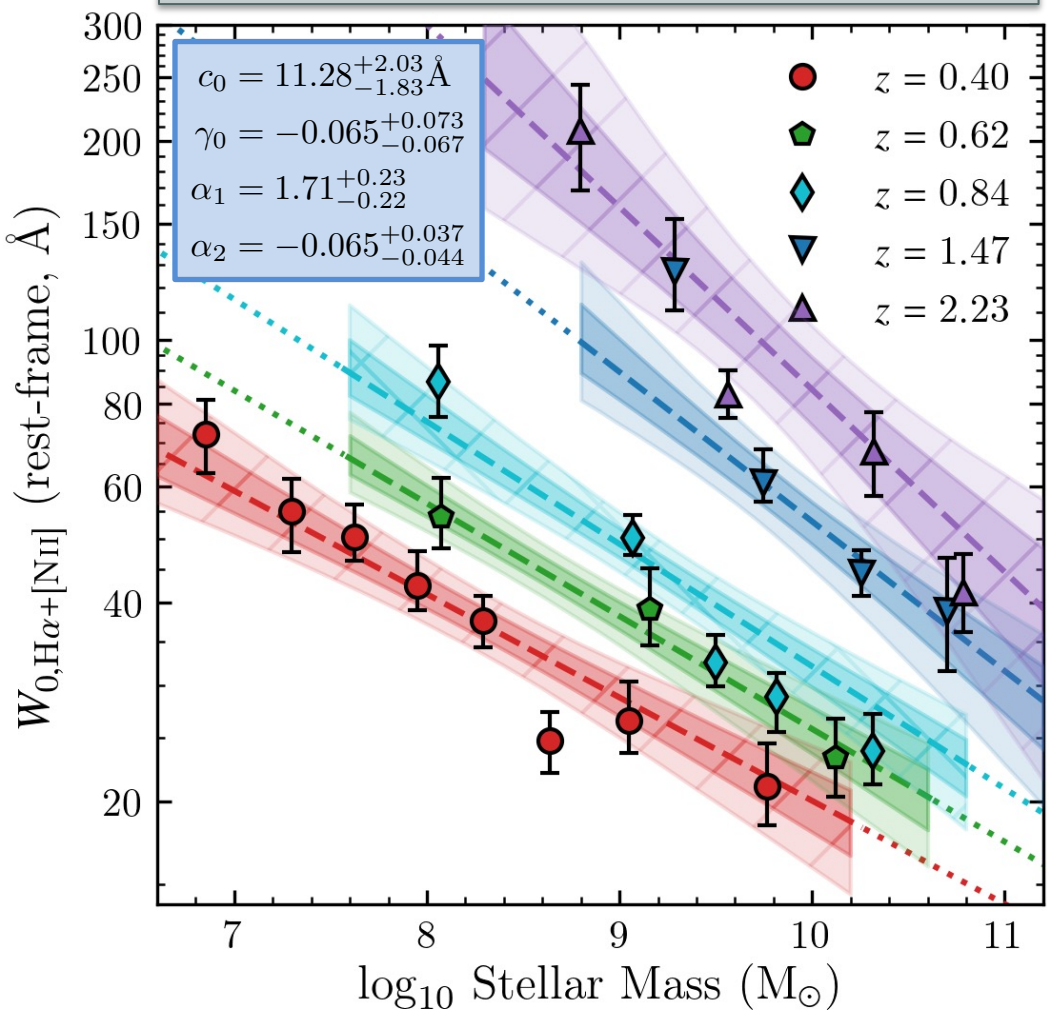
How about at different redshifts?

Equivalent Width Evolution

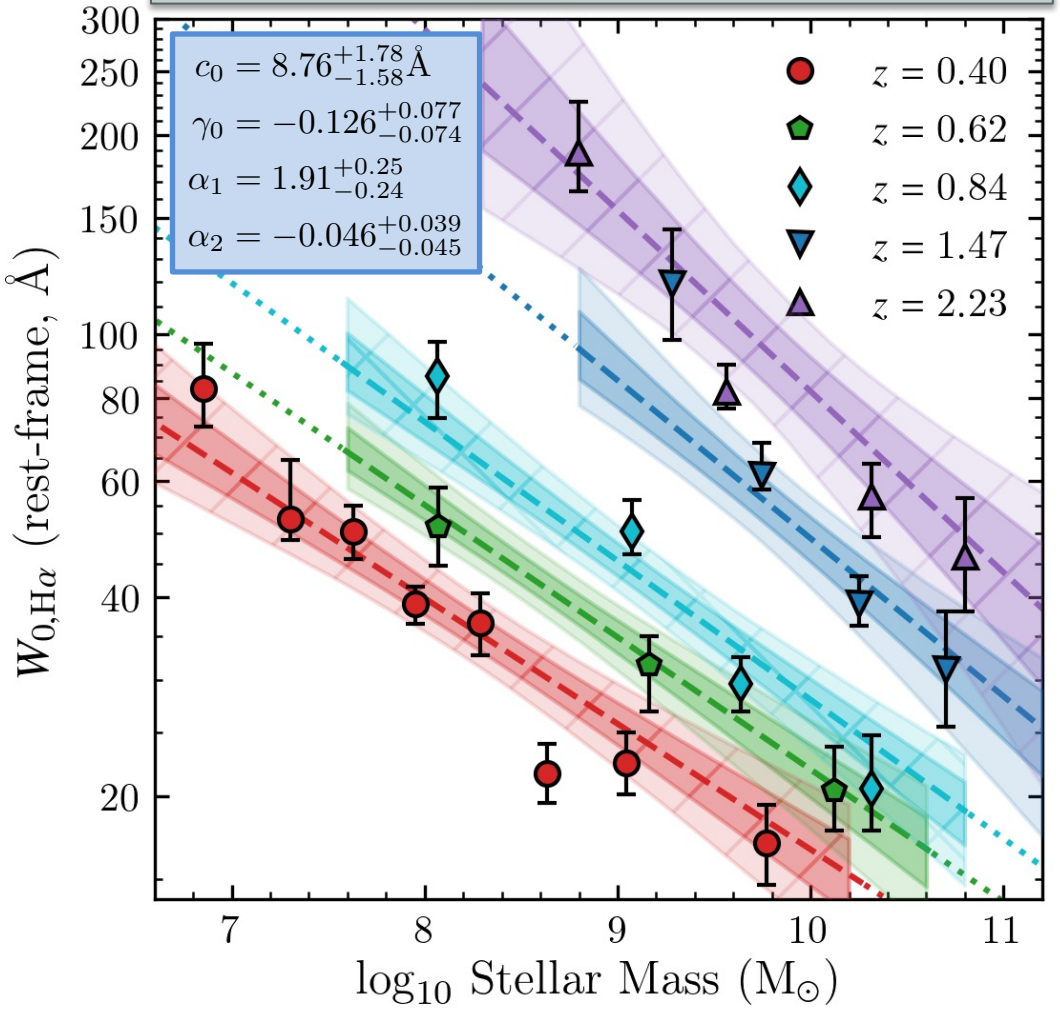
Best Mass and Redshift Dependent Model

$$W_0(M,z) = c_0(1+z)^{\alpha_1}\left(\frac{M}{10^{10}\mathrm{M}_\odot}\right)^{\gamma_0+\alpha_2(1+z)}$$

Hα + [NII] Correlation



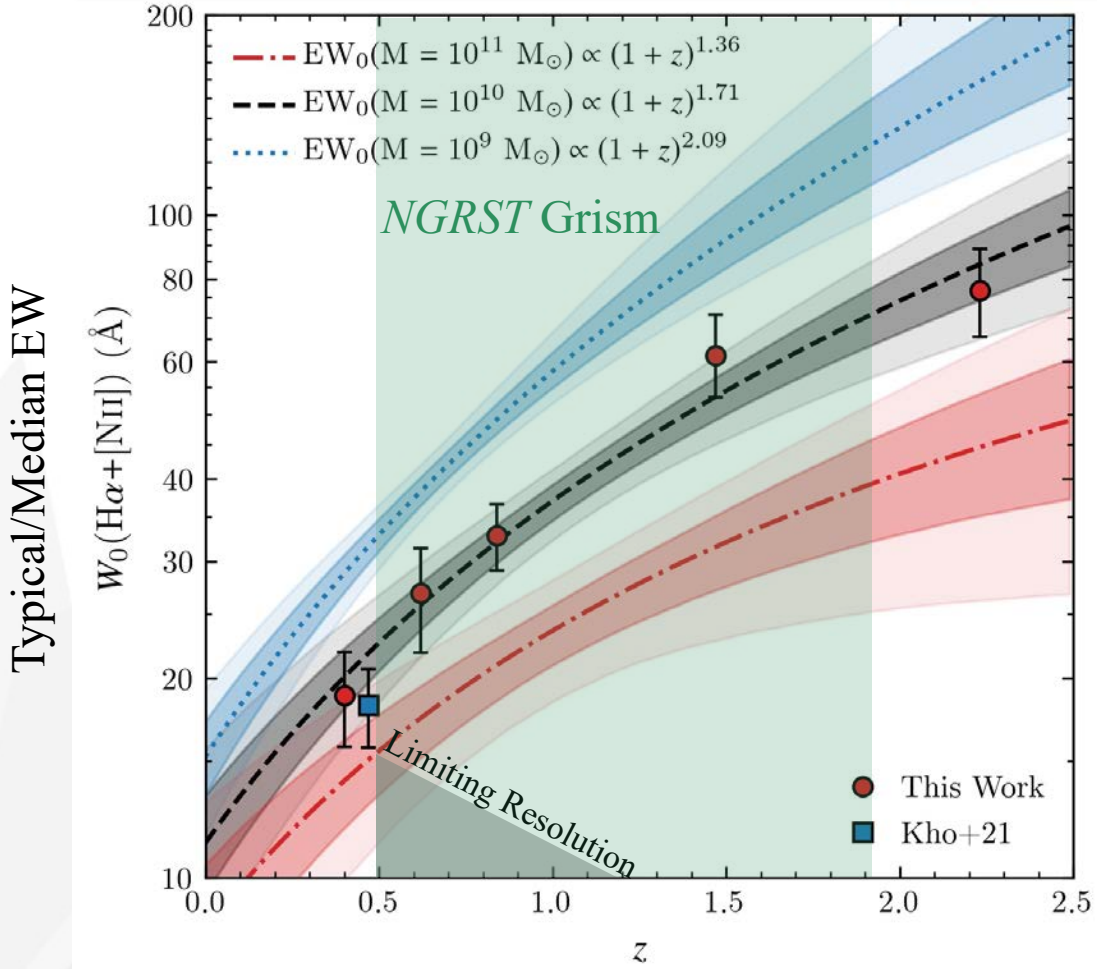
Hα Correlation



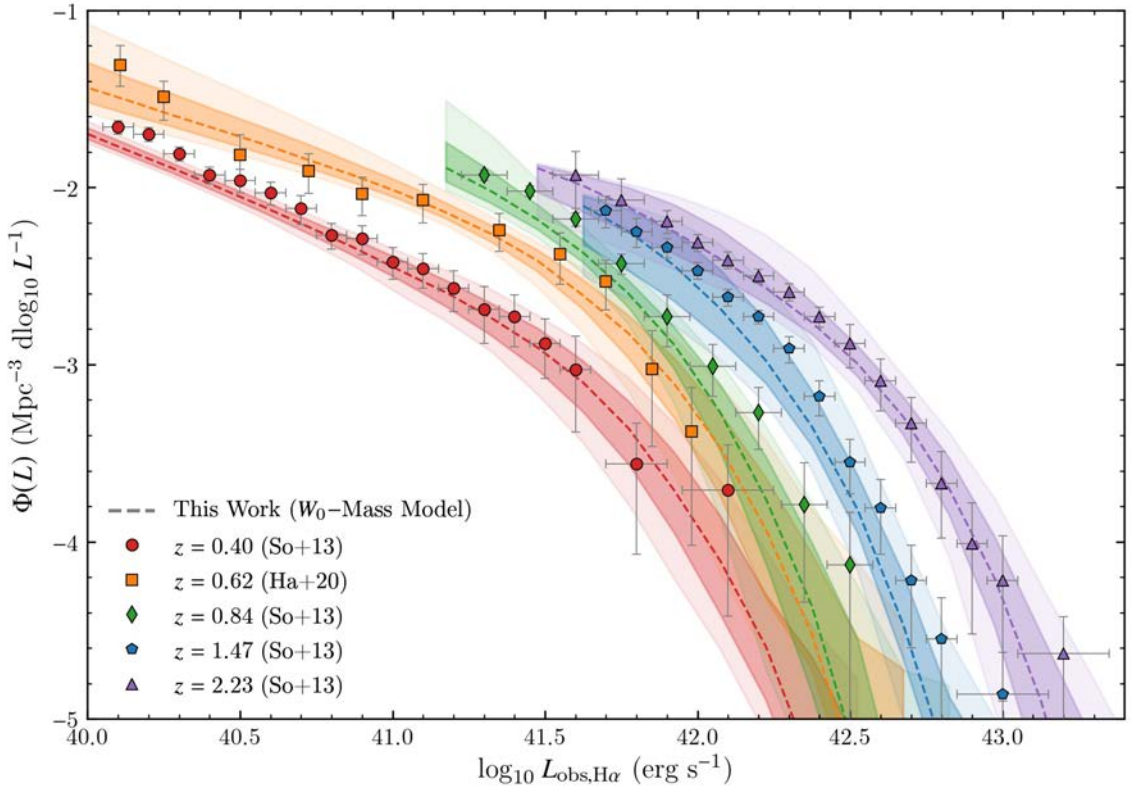
Khostovan et al., *in prep*

Equivalent Width Evolution and Hα LF

Low-Mass Galaxies Have Wider EW distributions with increasing z compared to high-mass galaxies



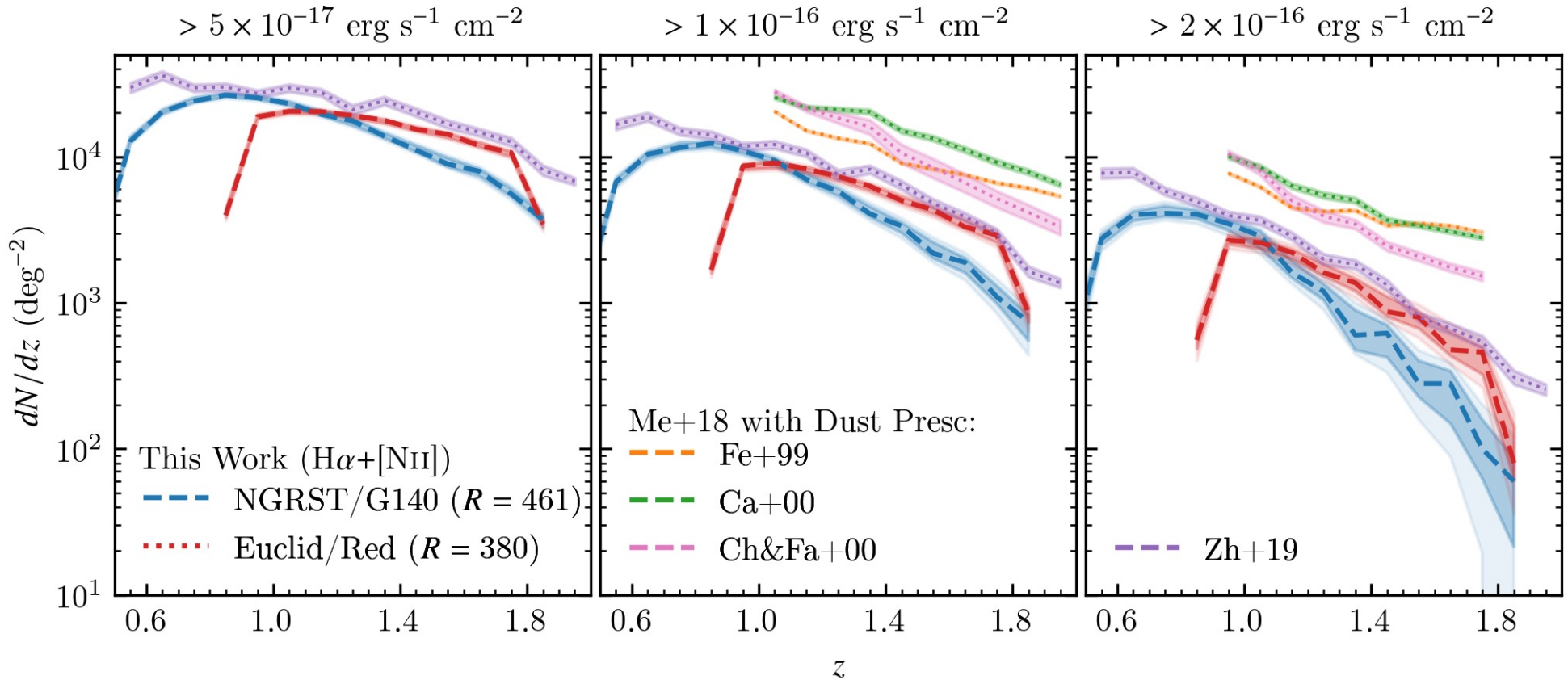
Predicting Hα LF using our $W_0(M,z)$ model
Strong Agreement with Observations – $LF(EW_{limit},z)$



Khostovan et al., *in prep*

***Roman* may miss Low EW, high-mass Hα emitters -- mostly towards lower z. At z = 0.5 half of Hα emitters have $EW_0 < 15$Å for 10^{11} $M_\odot$**

Number Count and Redshift Distribution Predictions

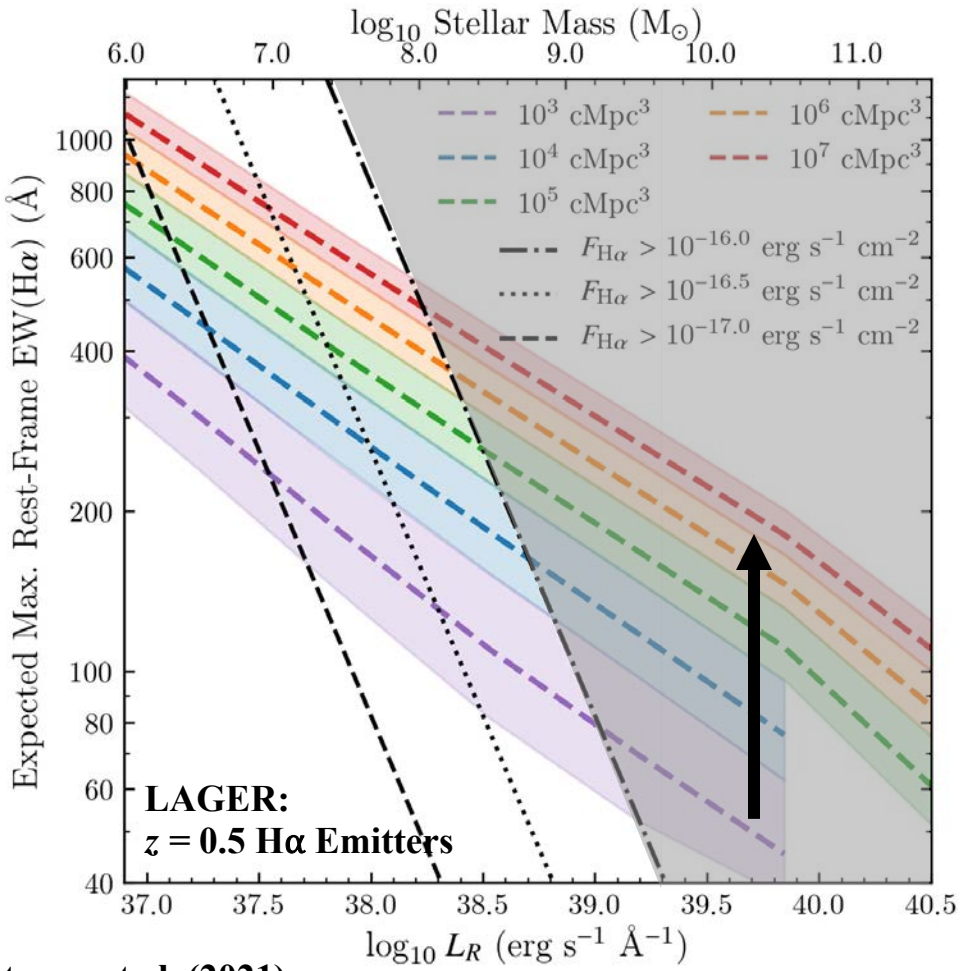


Hα + [NII] Flux Limit (10^{-16} erg s^{-1} cm^{-2})	dN/dz (deg^{-2})	Single *NGRST* Pointing (~0.28 deg^2)	HLSS (~2200 deg^2)
> 0.5	22090±776	6185±218	(48.6±1.7) million
> 1	8833±531	2473±149	(19.4±1.2) million
> 2	2635±292	738±82	(5.8±0.6) million

Khostovan et al., *in prep*

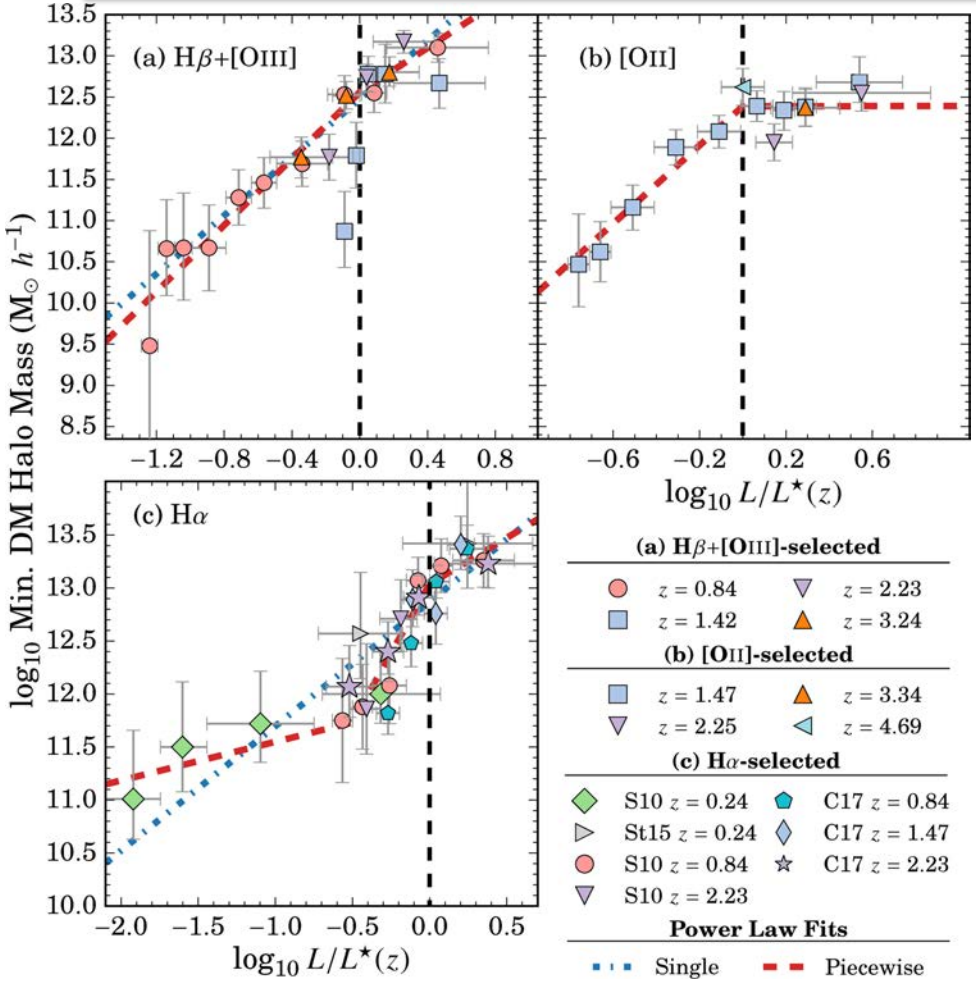
Prospects for *Nancy Grace Roman Space Telescope*

Expected Maximum EW at $z = 0.5$



Khostovan et al. (2021)

Probe Range of Dark Matter Halos



Khostovan et al. (2018)

Can tap into bright, rare, high EW emitters residing in massive dark matter halos to faint, numerous emitters residing in low-mass halos

Investigate Role of Environment on Star Formation Activity at varying cosmic times

Summary

- Selection Effects have two major effects:
  - Steeper EW – Stellar Mass anti-correlations
  - Higher Normalization in the typical Hα EW redshift evolution

- Forward Modeling approach to measure Intrinsic, Selection-corrected Hα EW distributions

- Observationally-constrained, empirical model of Typical Hα EW as dependent on stellar mass and z
  - Matches with past EW evolution assessment when selection limits included
  - Reproduces Hα Luminosity Functions at $0.4 < z < 2.2$

- Model used to assess number counts for *NGRST* Grism Surveys:
  - Number Counts as a function of EW and Line Flux limits

- **Limiting EW threshold may cause us to miss high-mass, low-EW systems mostly at low-z**

- **Can except ~ 2600, ~8900, and ~22000 Hα + [NII] emitters per deg^2 down to R ~ 461 (observed EW > 22Å) for 5x10^{-17} erg s^{-1} cm^{-2}, 1x10^{-16} erg s^{-1} cm^{-2}, and 2x10^{-16} erg s^{-1} cm^{-2}, respectively.**

- *NGRST* will be able to probe wide ranges of Dark Matter Halos enabling environmental studies.
  - Important in the scope of high EW systems, SFHs, and the role of environment