

Probing Faint Ly α Escape Fractions at $z \sim 1$

Brian Siana - Caltech

Harry Teplitz, Carrie Bridge, Harry Ferguson, Mark Dickinson, Mauro
Giavalisco, James Colbert, Tom Brown, Jon Gardner, Duilia de Mello,
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LyC

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Why do you care?

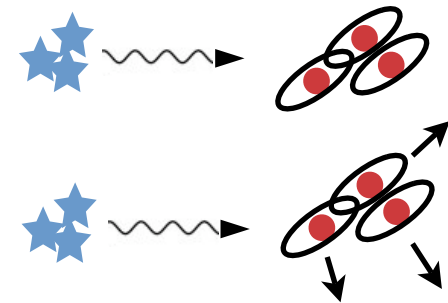
- Evolution of the ionizing background / reionization
 - f_{esc} least understood of reionization parameters

$$\dot{\rho}_{\text{SFR}} \approx \frac{0.026 M_{\odot} \text{ yr}^{-1} \text{ Mpc}^{-3}}{f_{\text{esc}}} \left(\frac{1+z}{7} \right)^3 \left(\frac{\Omega_b h_{70}^2}{0.0457} \right)^2 \left(\frac{C}{30} \right)$$

- $f_{\text{esc}}(\text{LyC})$ affects estimates of $f_{\text{esc}}(\text{Ly}\alpha)$

SFR \Rightarrow L(Ly α)

- Unique probe of ISM
 - $f_{\text{esc}}(\text{LyC}) = f(\text{HI geometry, dust})$
 - $f_{\text{esc}}(\text{Ly}\alpha) = f(\text{HI geometry, dust, kinematics})$



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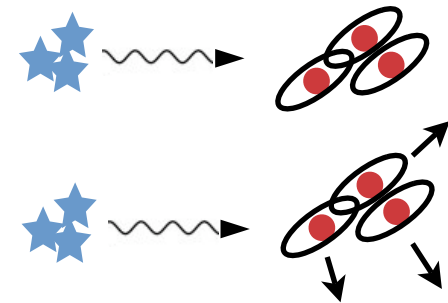
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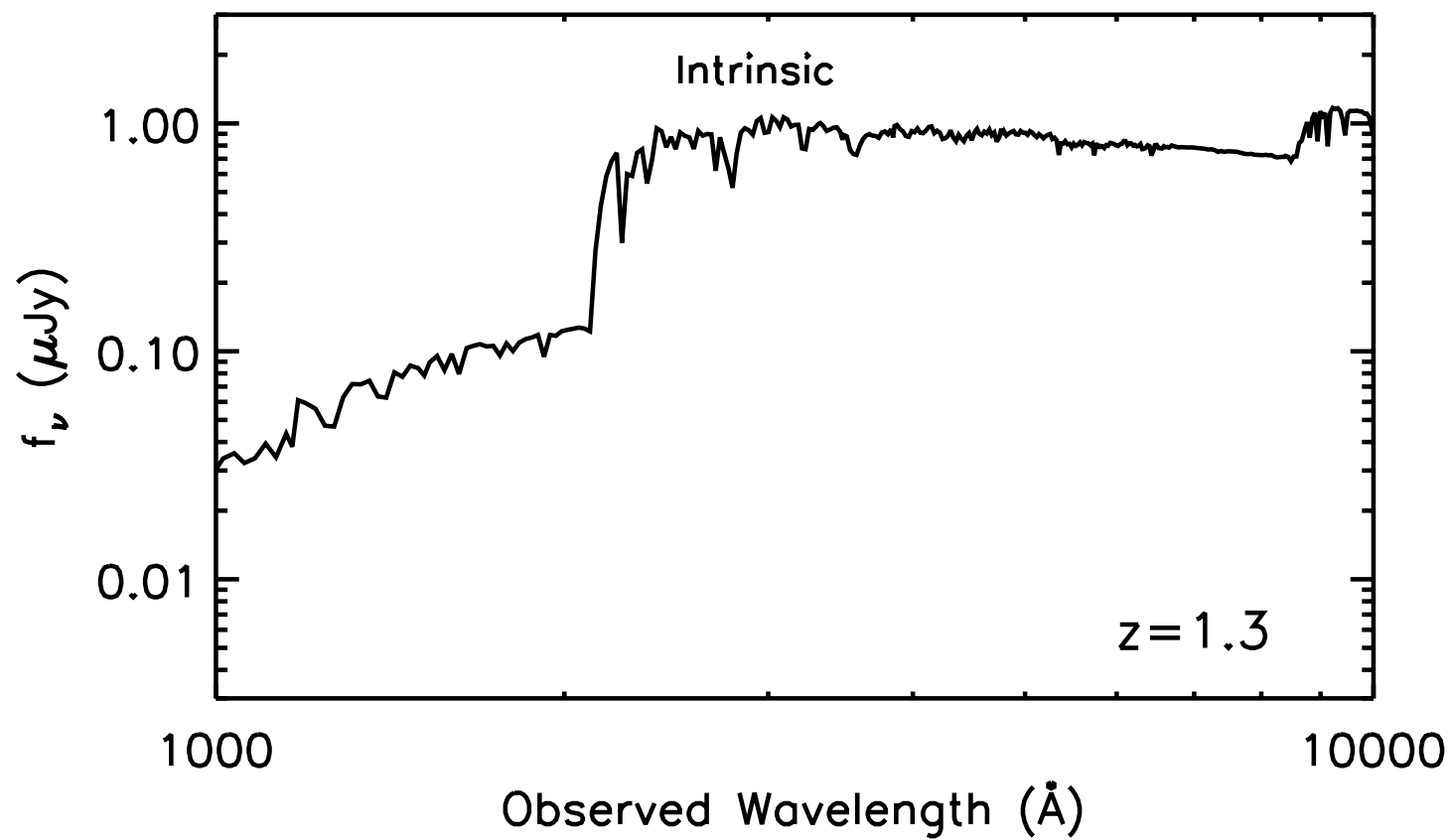
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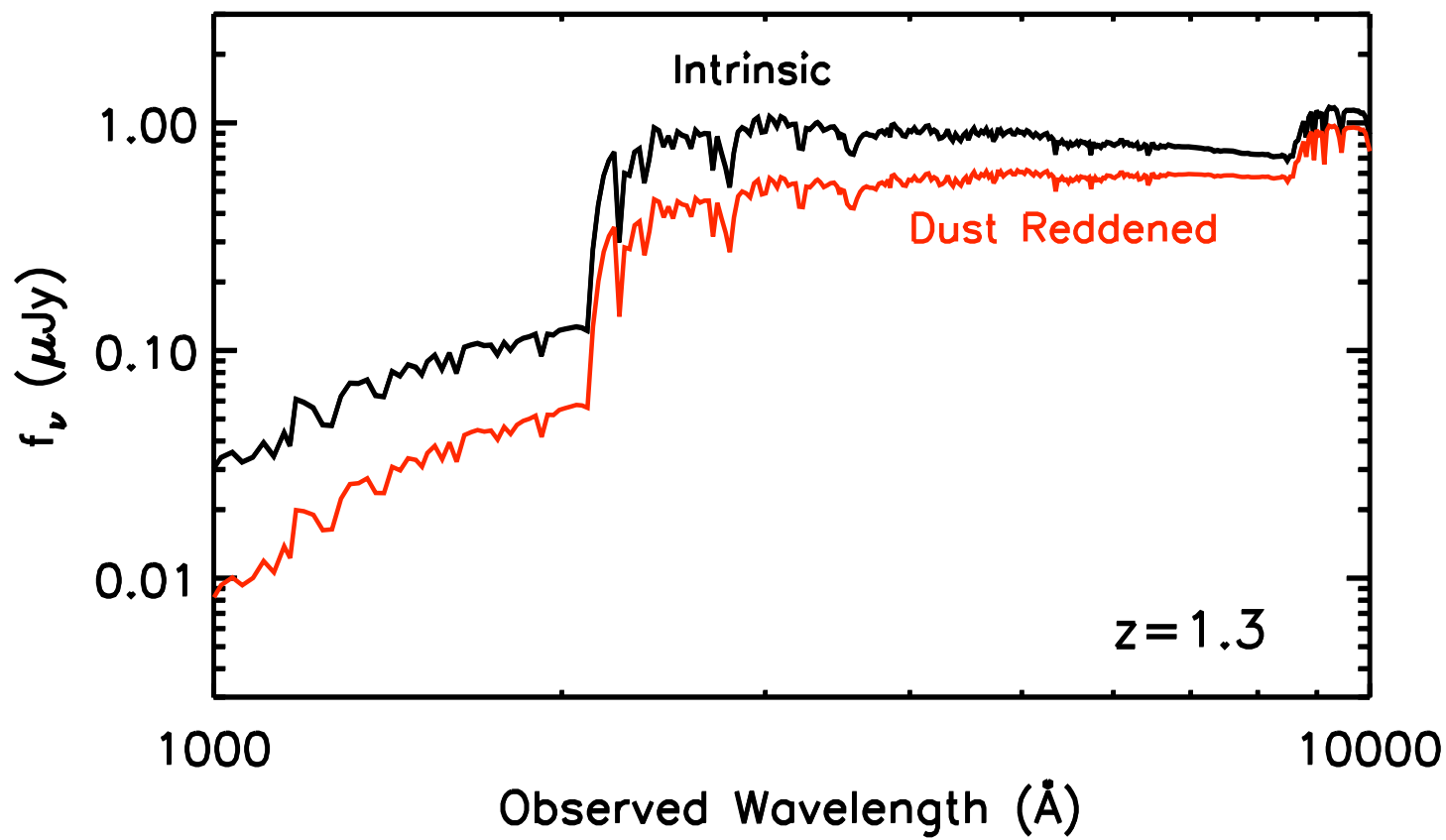
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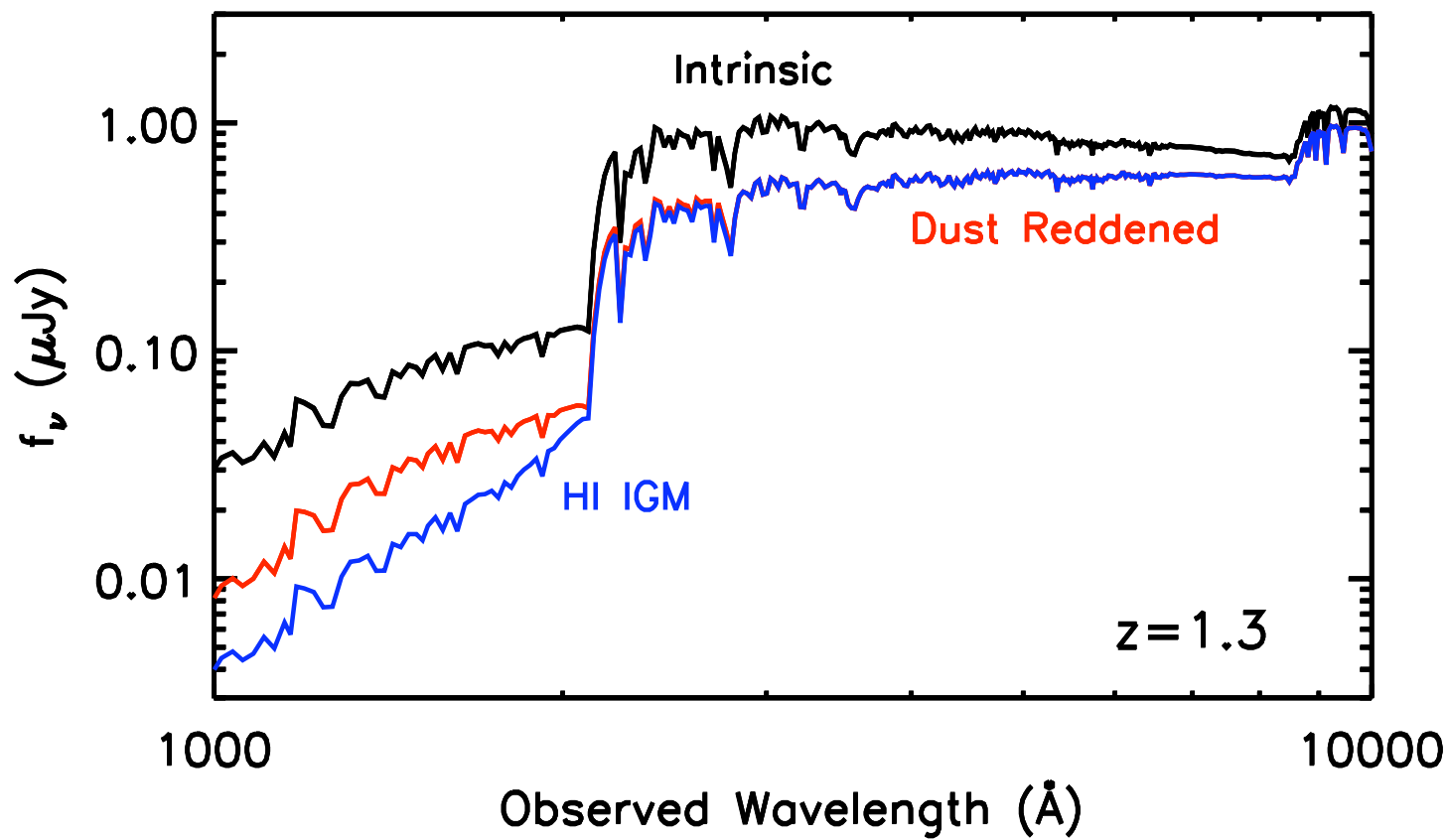
LyC at $z=1.3$



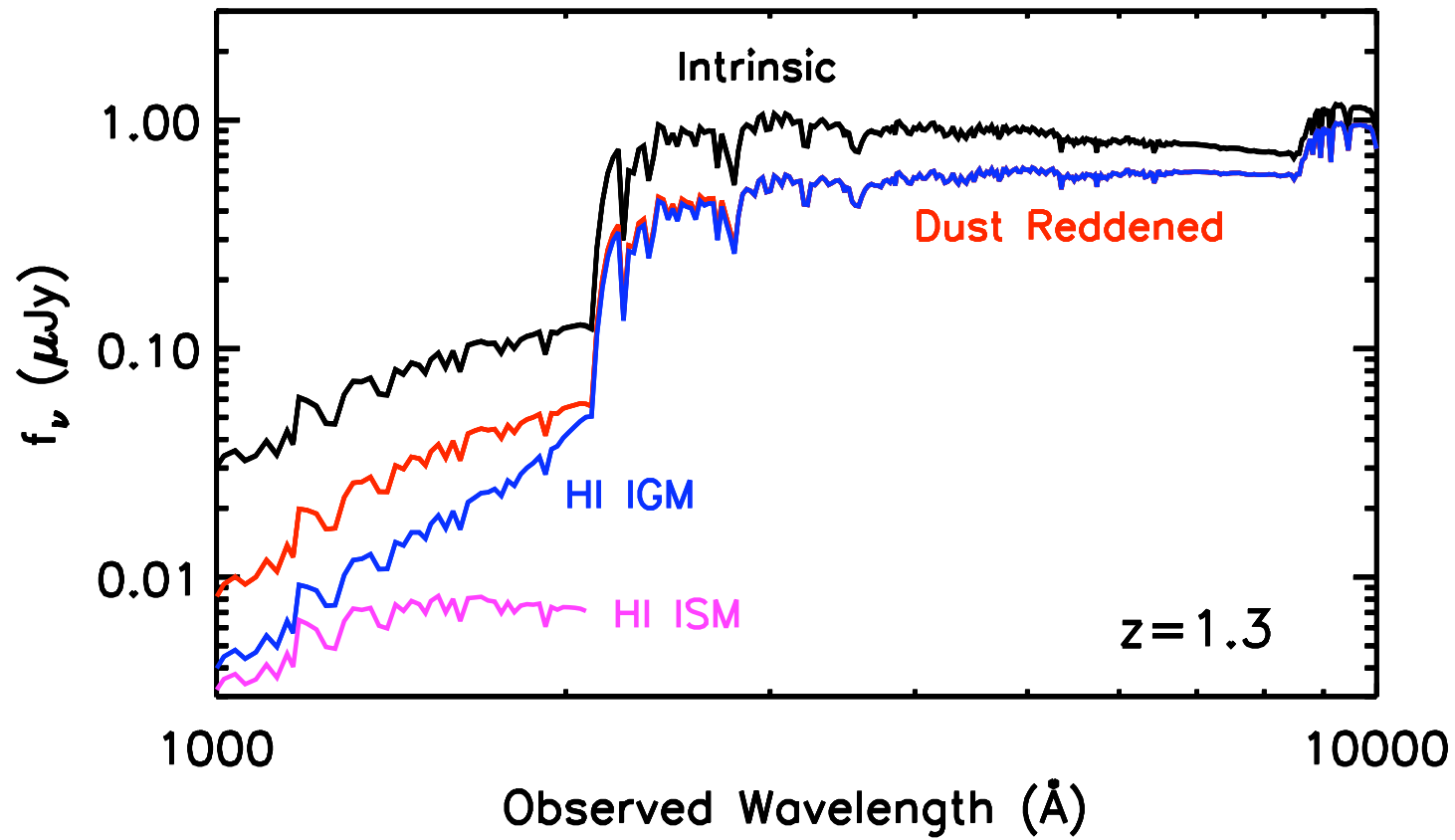
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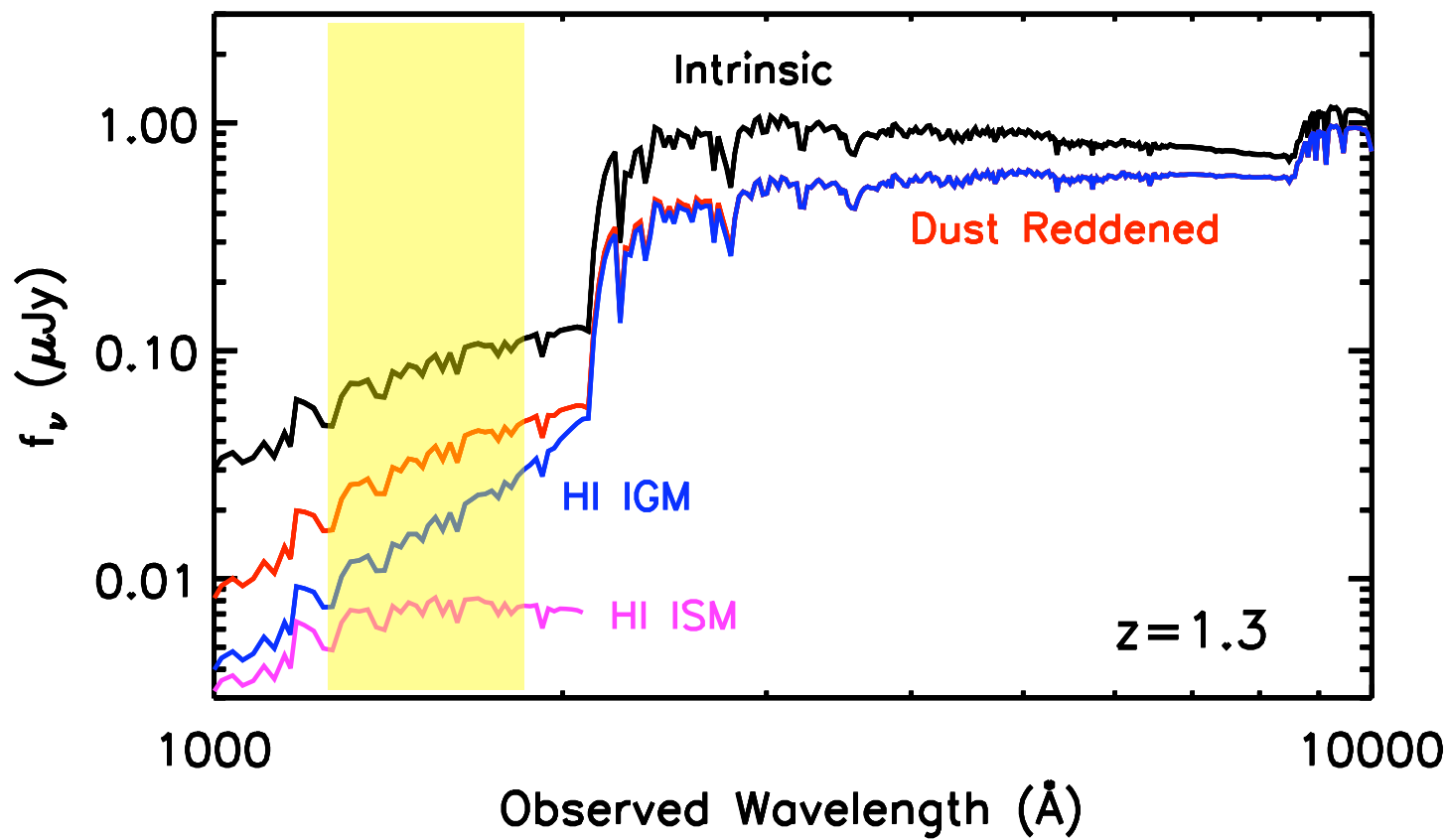
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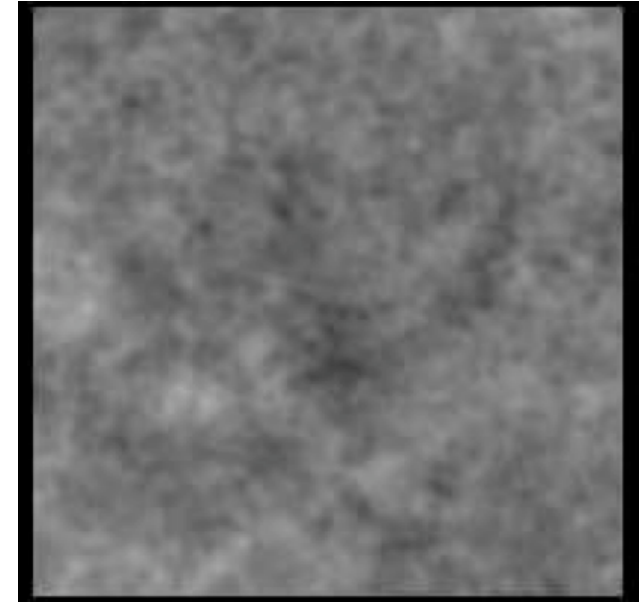
LyC at $z=1.3$



What do we know so far?

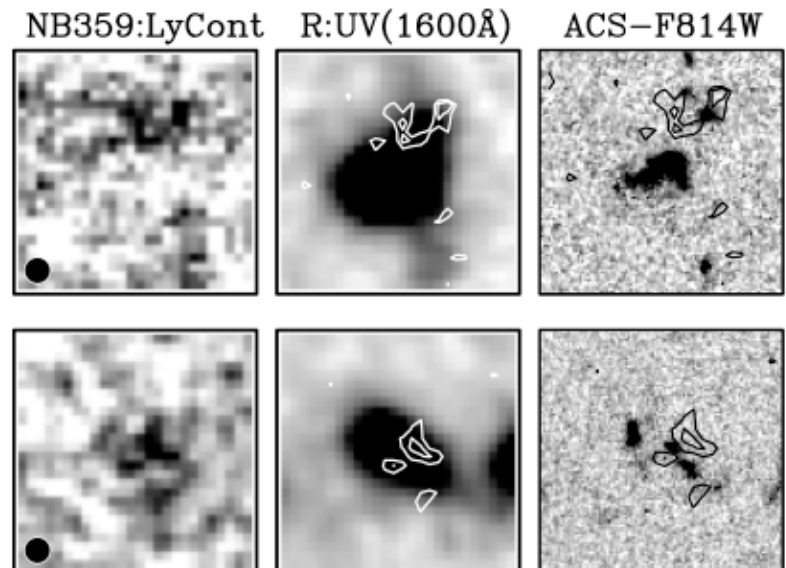
- $z \sim 1$ (HST/GALEX)
 - Malkan+03, Siana+07
 - 30 deep non detections!
 - Cowie+09
 - 600 gal. stack (GALEX) => No detection!

Cowie+ '09



- $z \sim 3$
 - Shapley+06 (Keck spectra)
 - 2/14 individual detections
 - Iwata+09 (NB imaging)
 - 17 detections (1 in 10)

Iwata+ '09



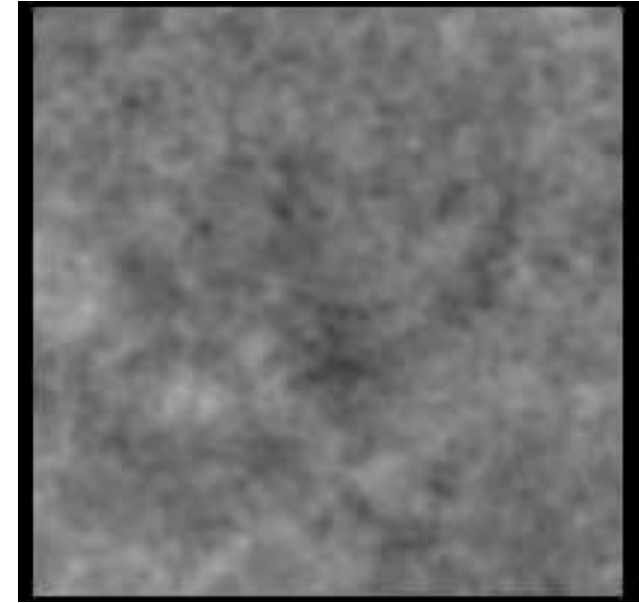
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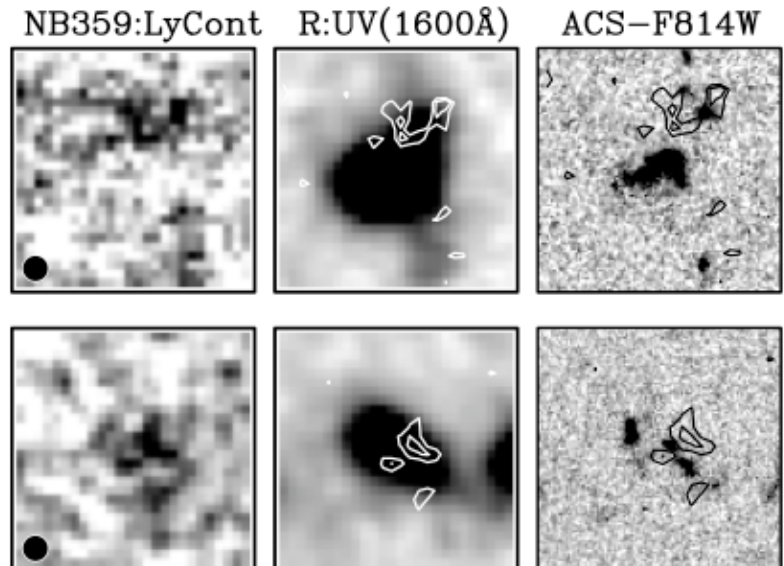
fesc EVOLUTION?

- $z \sim 3$
 - Shapley+06 (Keck spectra)
 - 2/14 individual detections
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Cowie+ '09

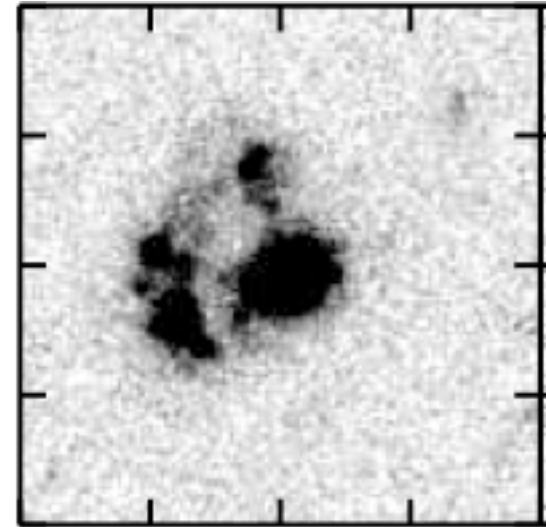


Iwata+ '09



Why deeper constraints?

- Most f_{esc} limits not deep $f_{\text{esc,rel}} < 0.25$
- Only $\sim 1/10$ are detected.
 - If all galaxies have $f_{\text{esc,rel}} \sim 0.1$, they dominate background
- Probe individual regions
 - Causes of high f_{esc}

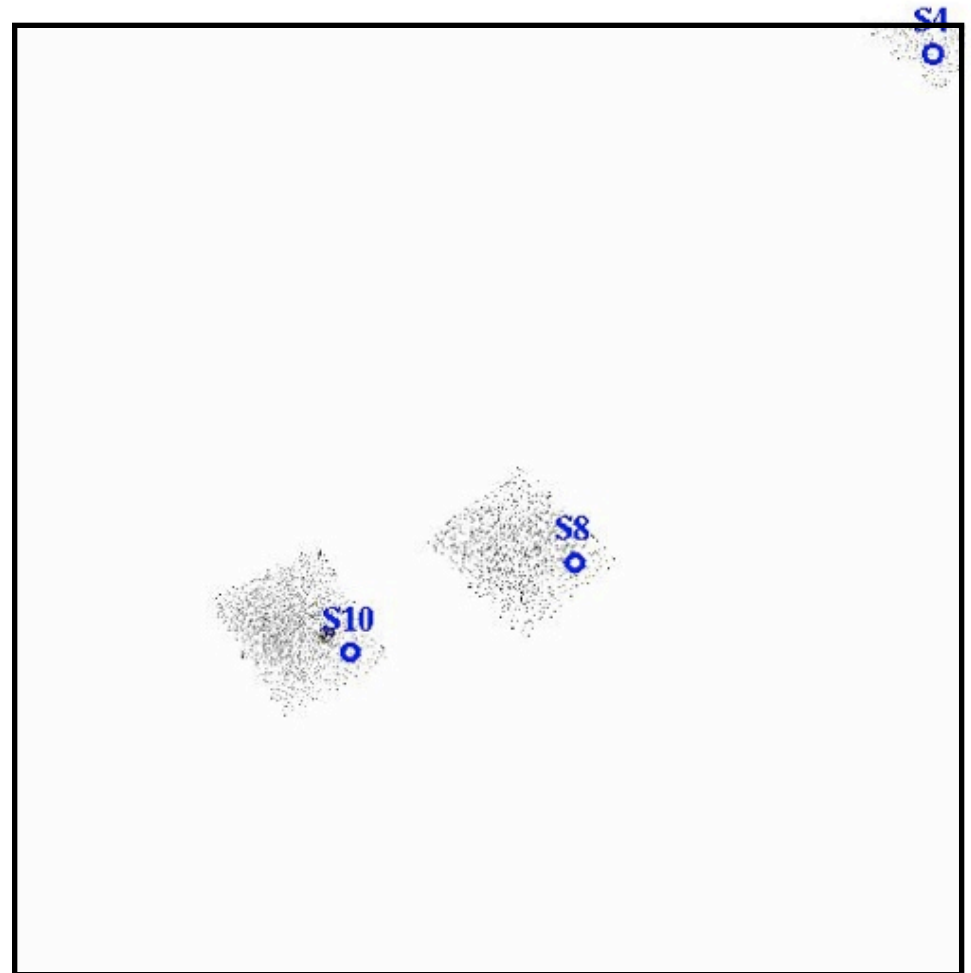
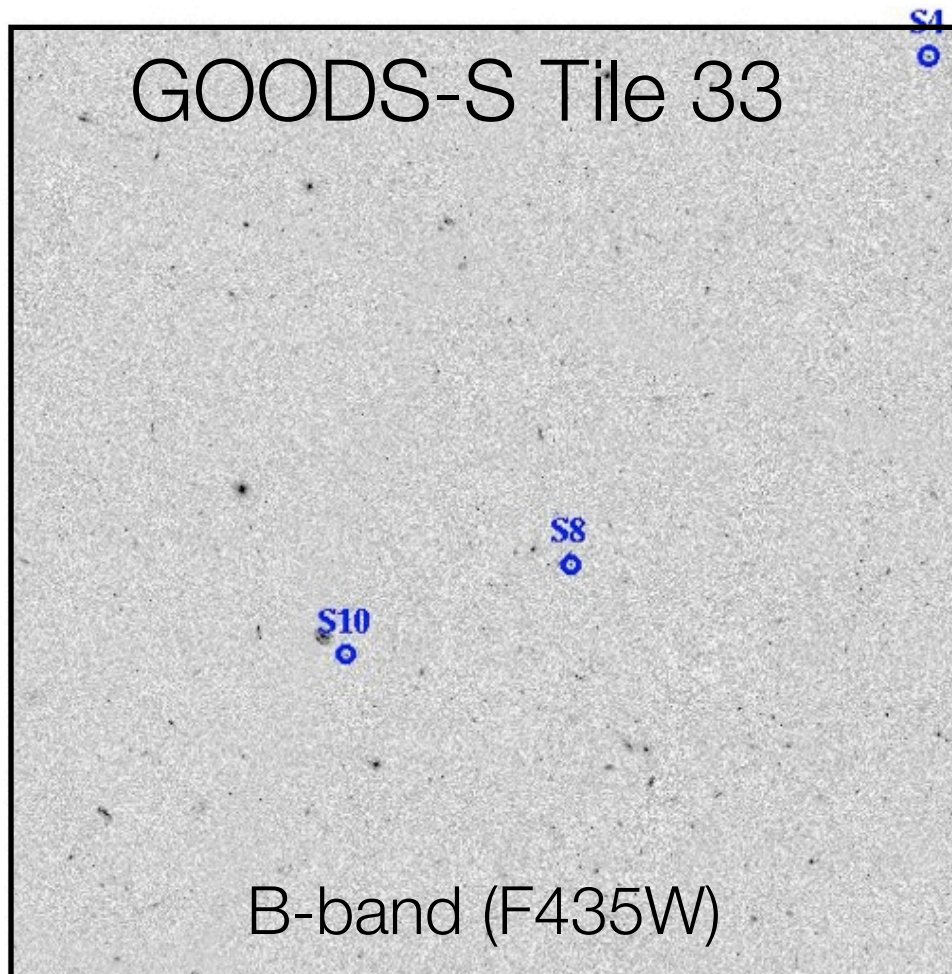


Why $z \sim 1$?

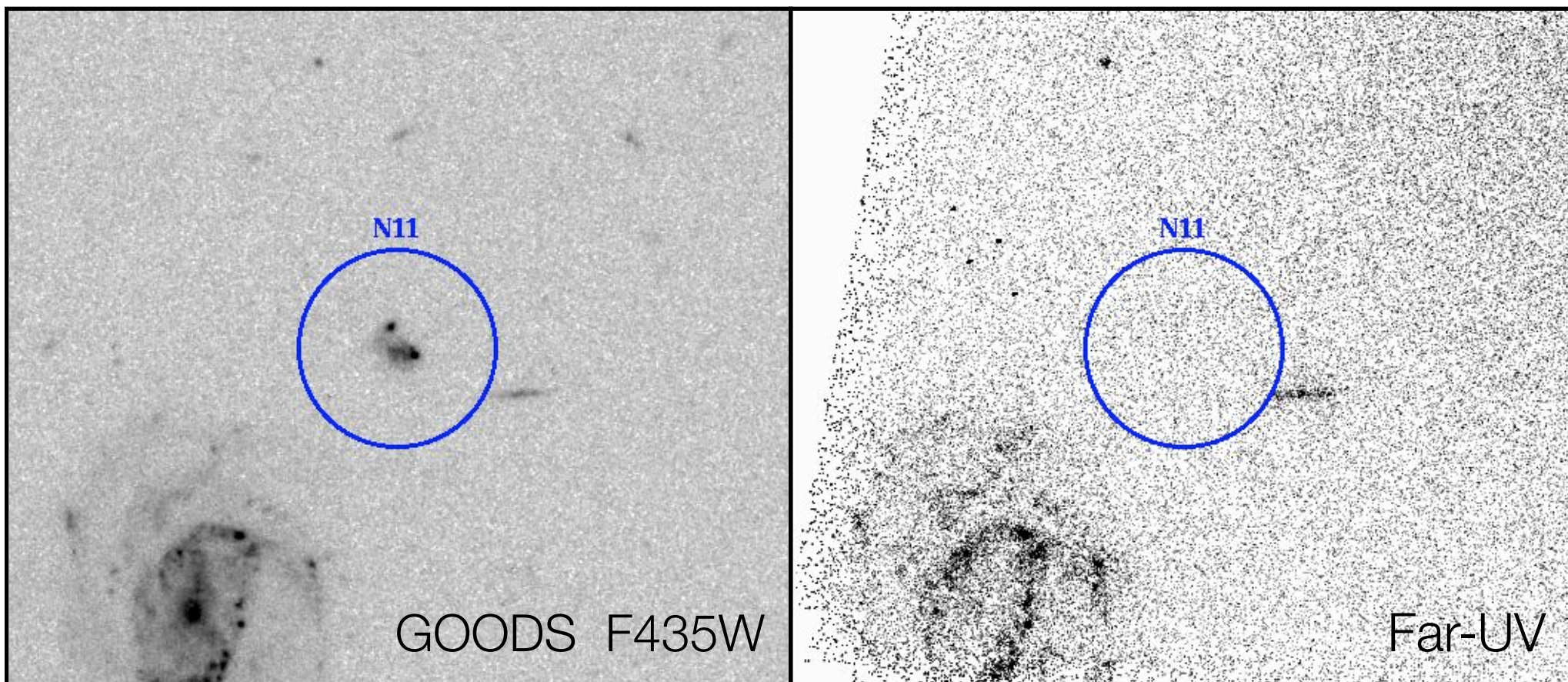
- Easy to follow up
- Determine redshift evolution

The Survey

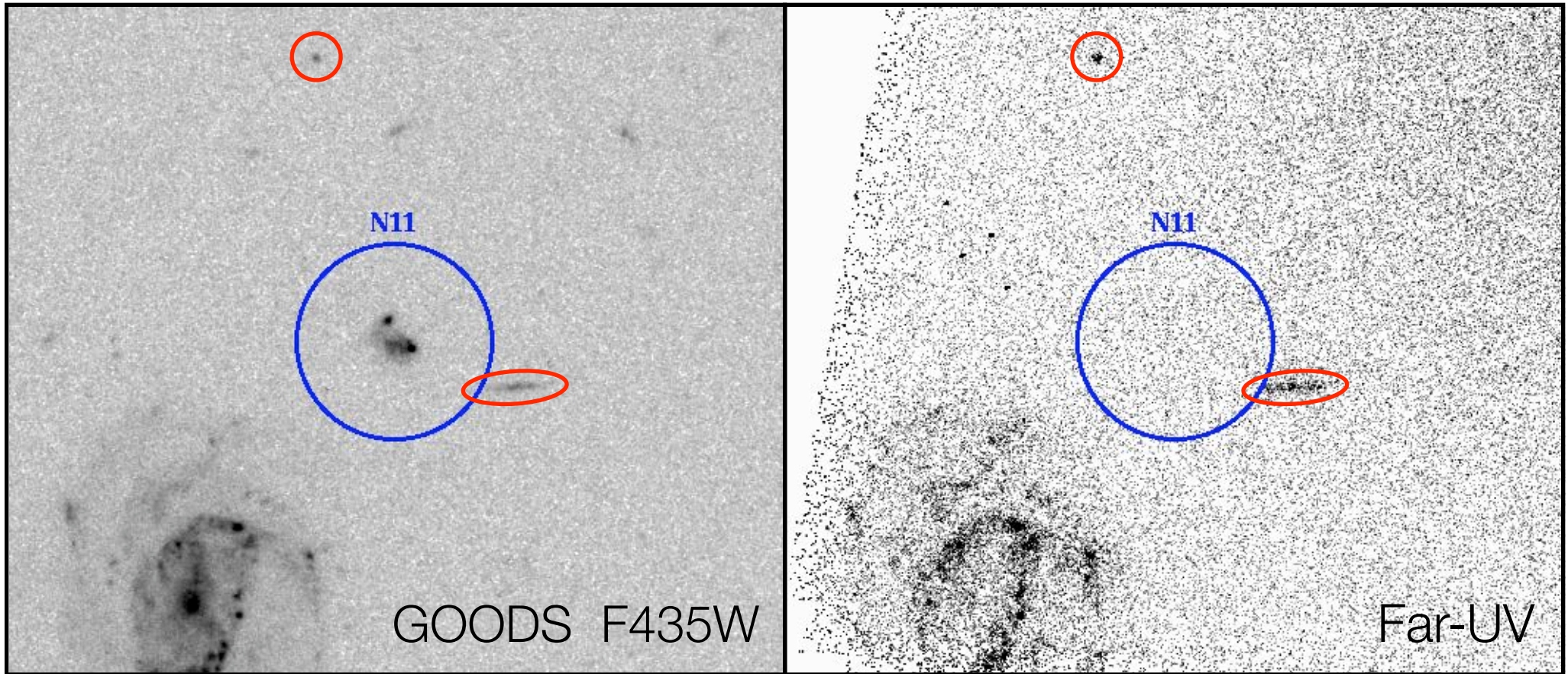
- ACS/SBC 1600 Å ($\lambda_{\text{rest}} < 912 \text{ \AA}$ at $z > 1.2$)
- 15 UV-luminous galaxies in GOODS (B \sim 23.5)
- 5 orbits / galaxy $m_{\text{AB}}(1\sigma) < 30$ 1" diameter



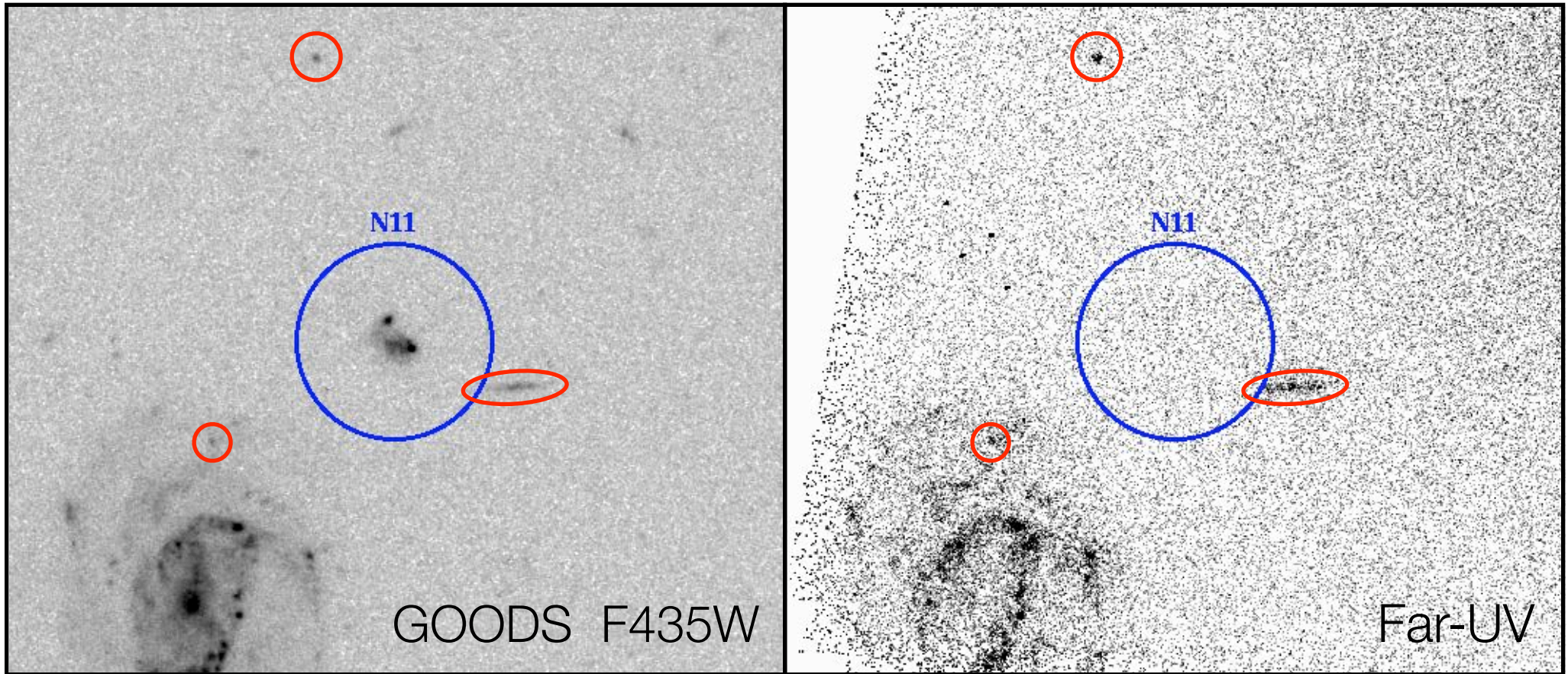
Close-Up



Close-Up

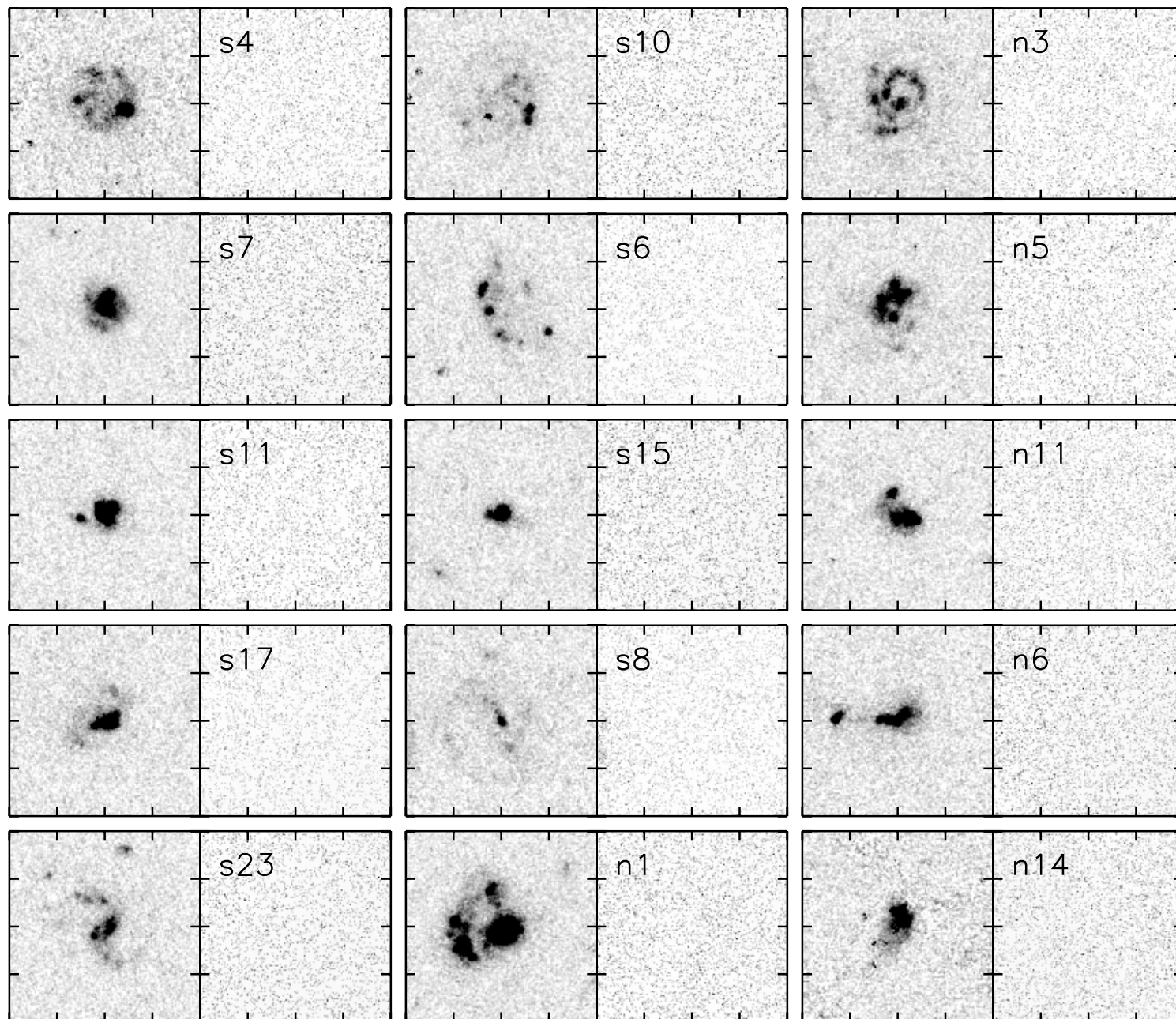


Close-Up

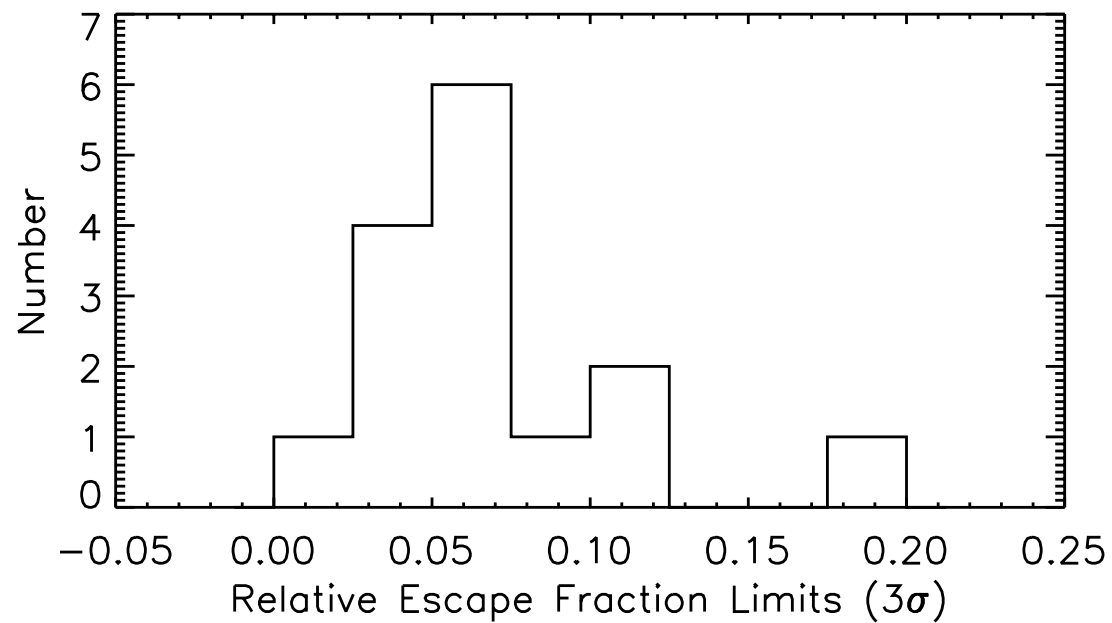
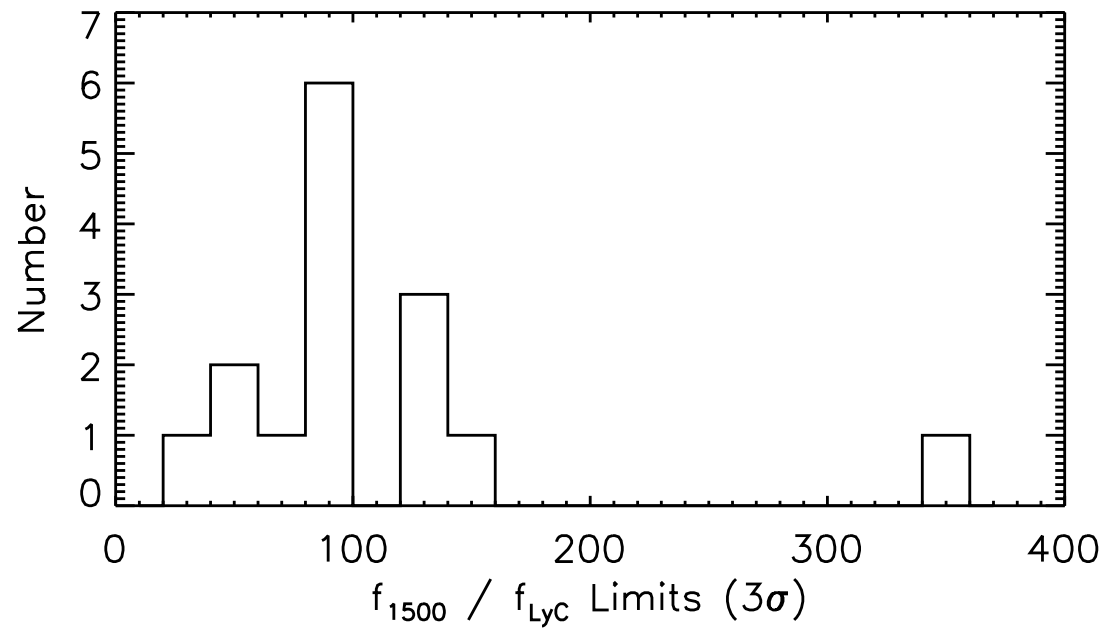


GOODS
F435W
 $\lambda_{\text{rest}} \sim 1900 \text{ \AA}$

far-UV
 $\lambda_{\text{rest}} \sim 700 \text{ \AA}$

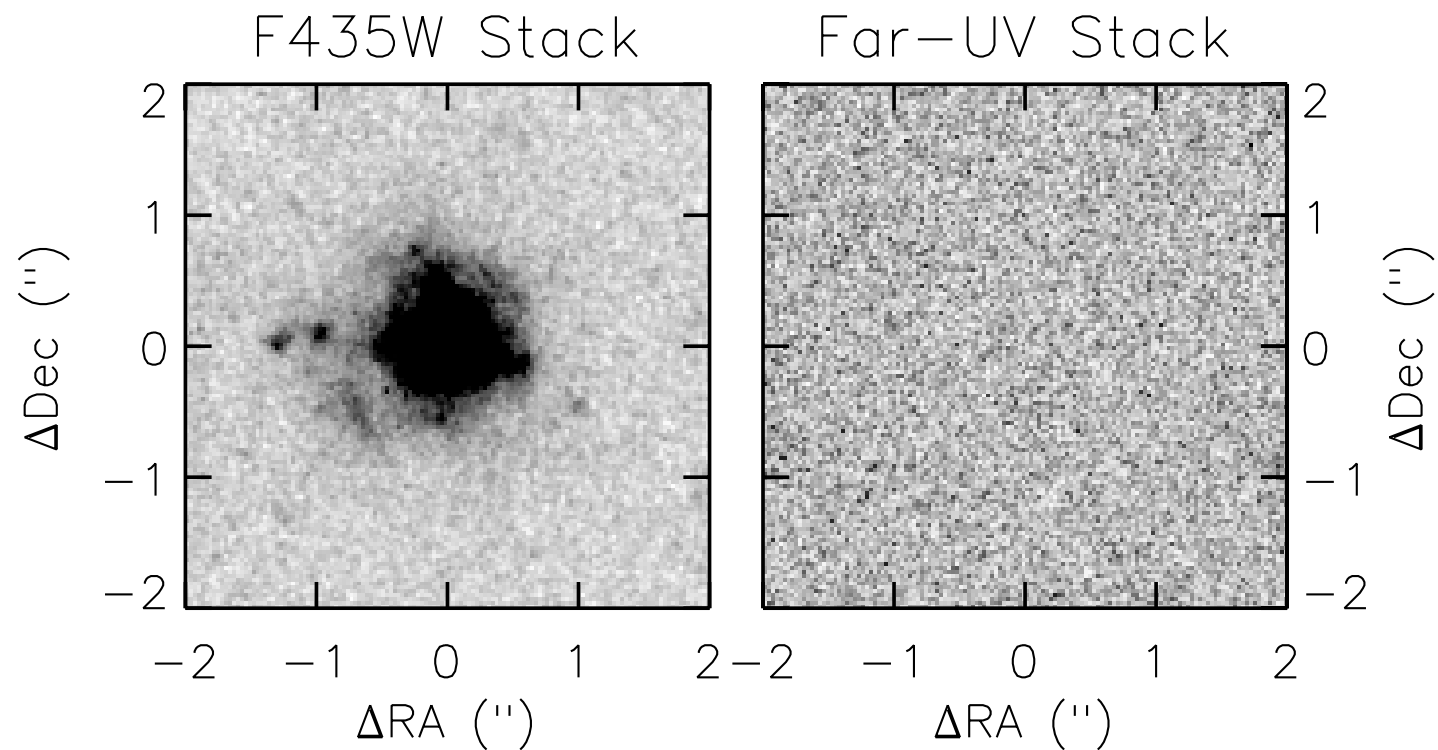


Escape Fraction Limits



Stacked Image

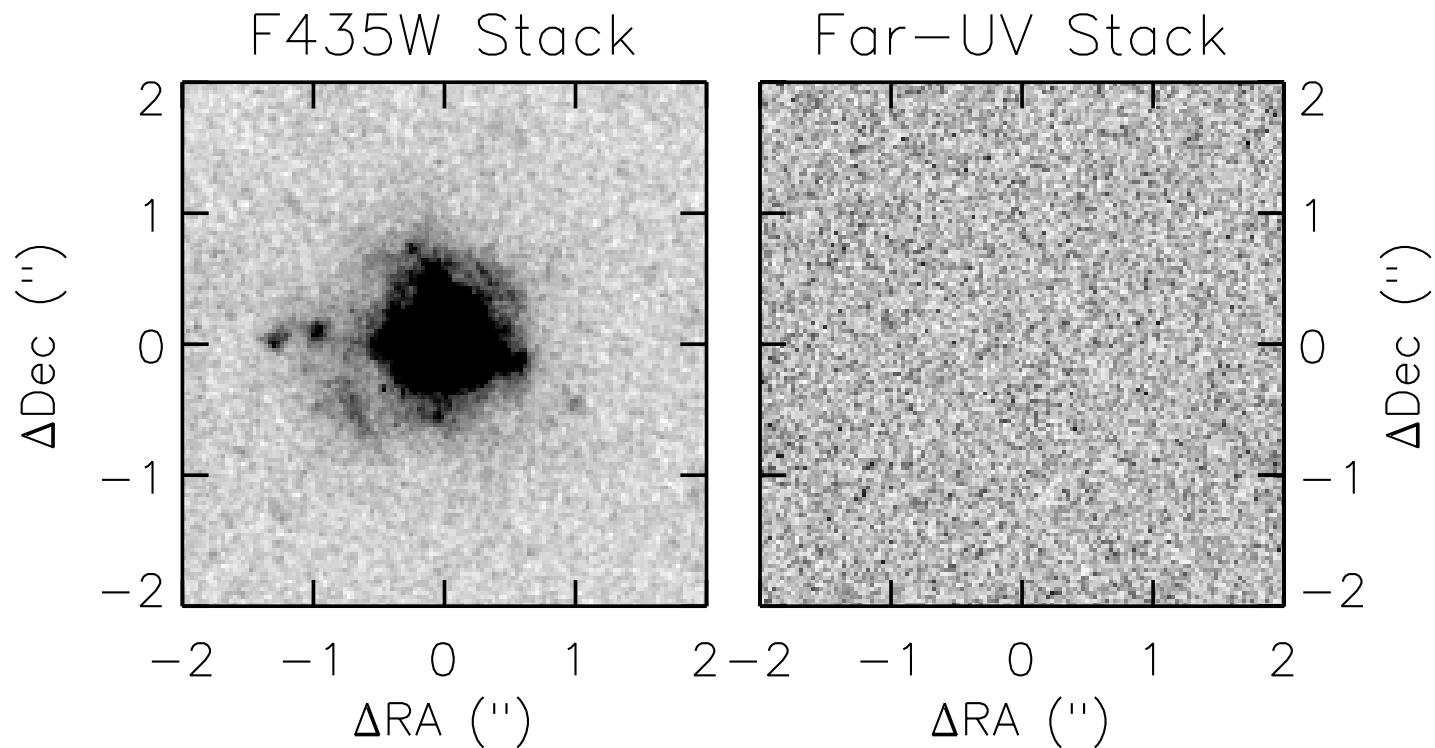
$$f_{\text{LyC}}(3\sigma) < f_{\text{F435W}} / 400$$



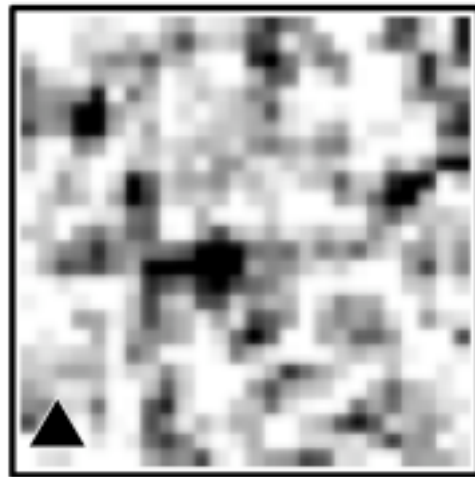
Stacked Image

- $f_{\text{esc,rel}} < 0.02$ in stack!

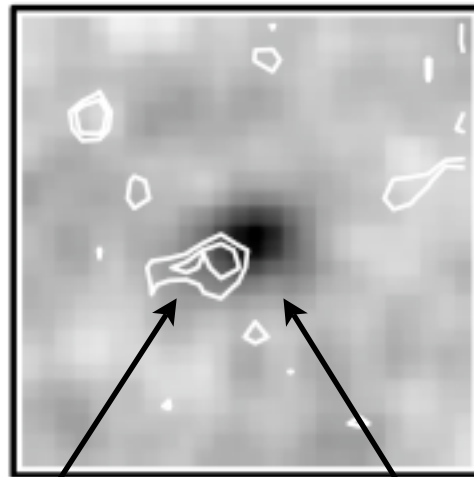
$$f_{\text{LyC}}(3\sigma) < f_{\text{F435W}} / 400$$



Stack by Surface Brightness

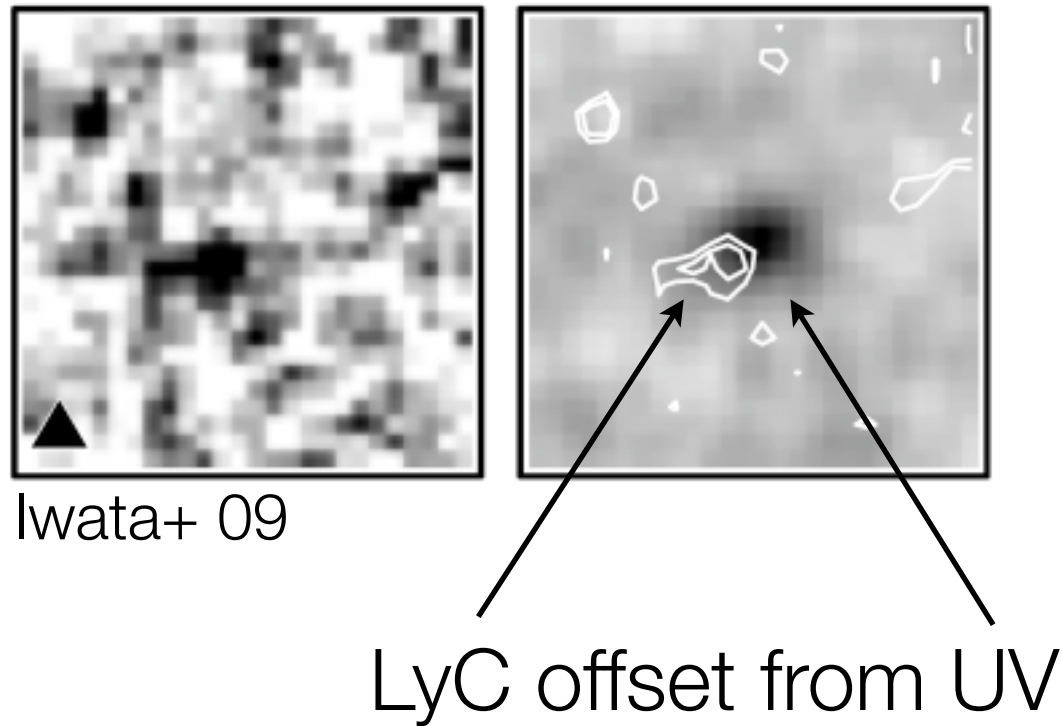


Iwata+ 09



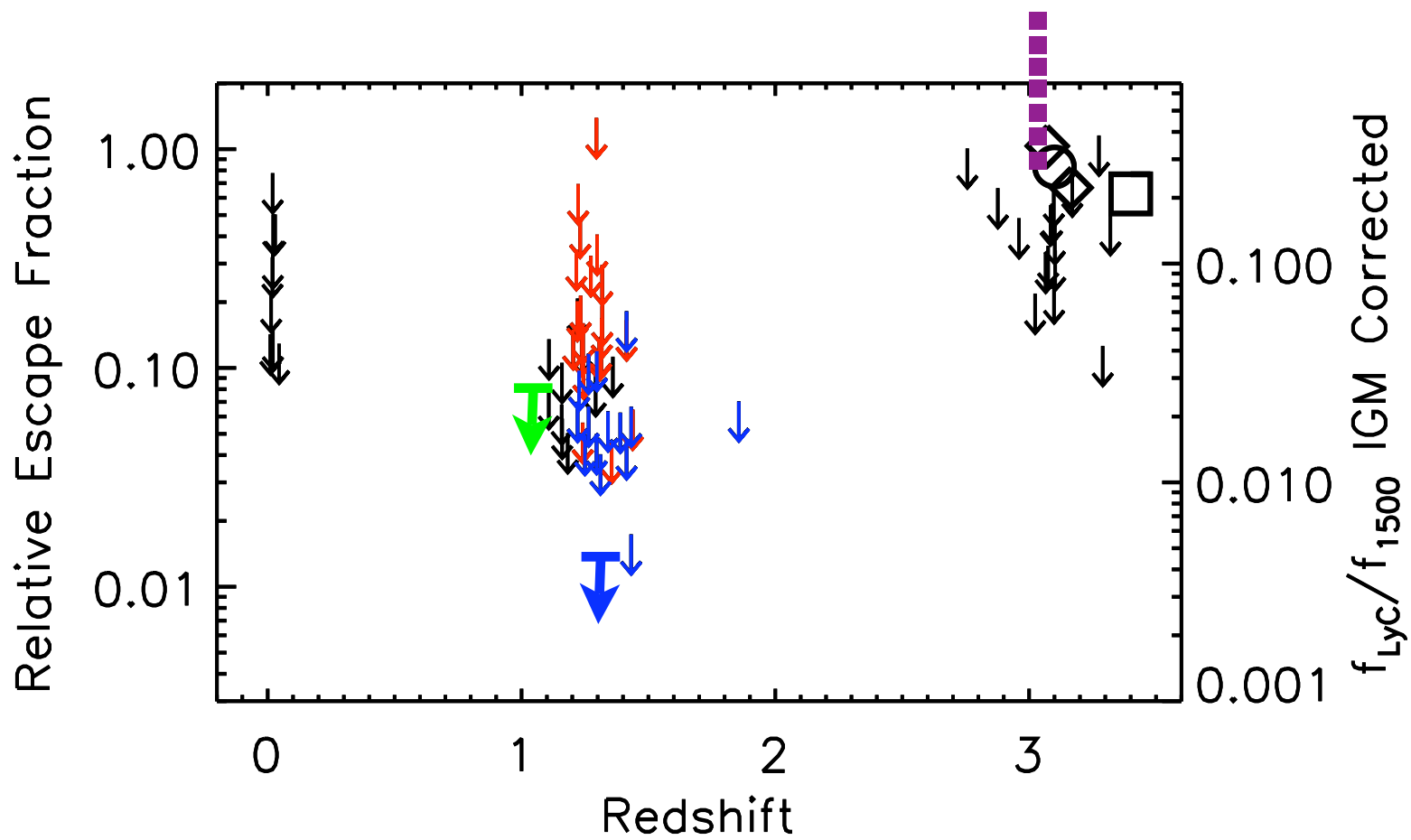
LyC offset from UV

Stack by Surface Brightness



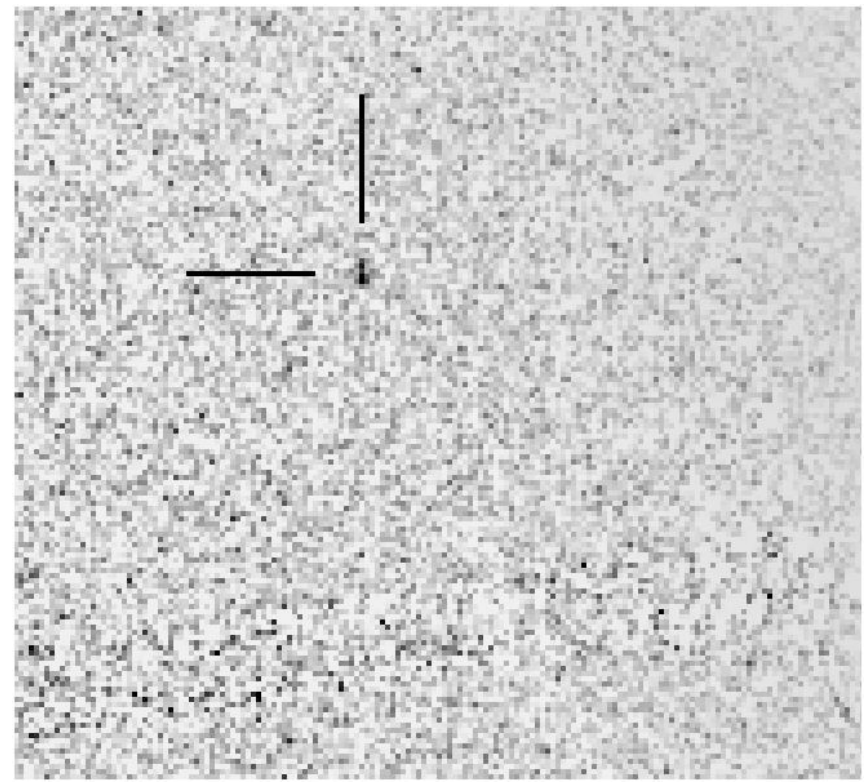
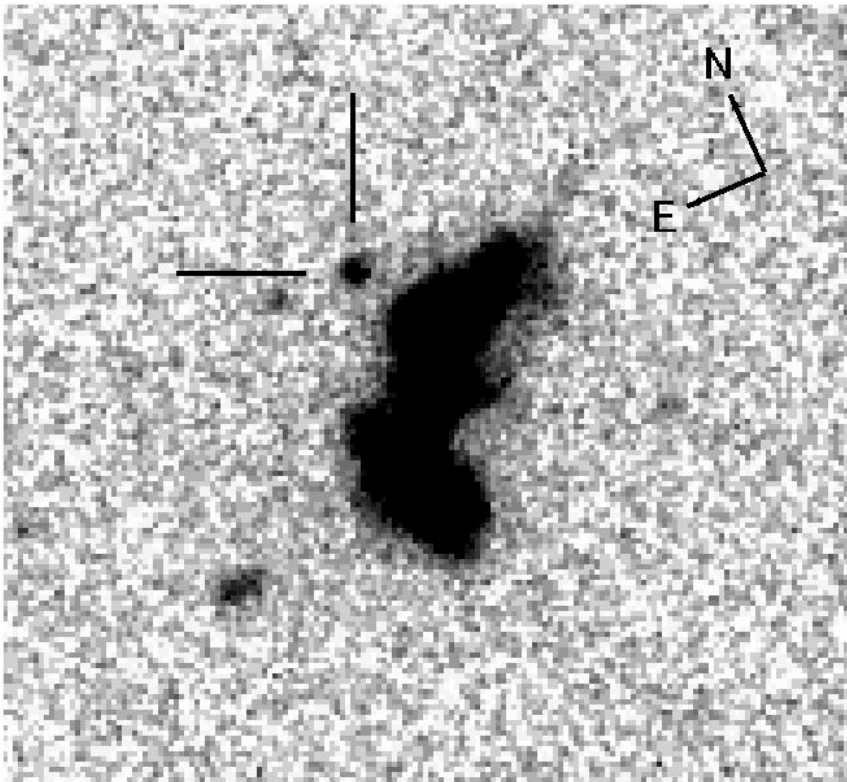
- Split galaxy regions by UV SB
 - Non-detections ($f_{\text{esc}} < 0.07$) in low and high SB regions

f_{esc} Evolves!



Warning!

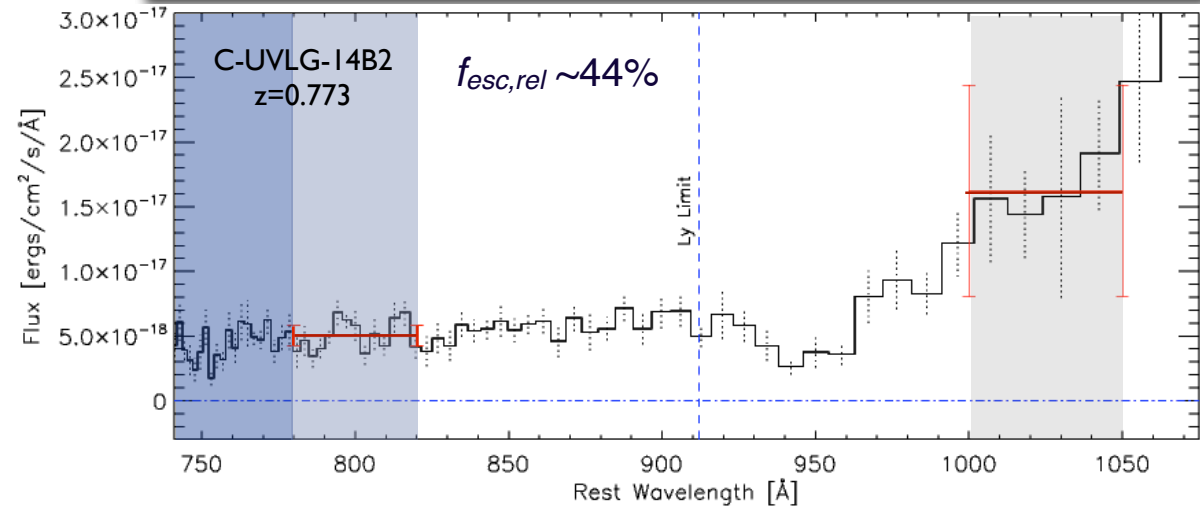
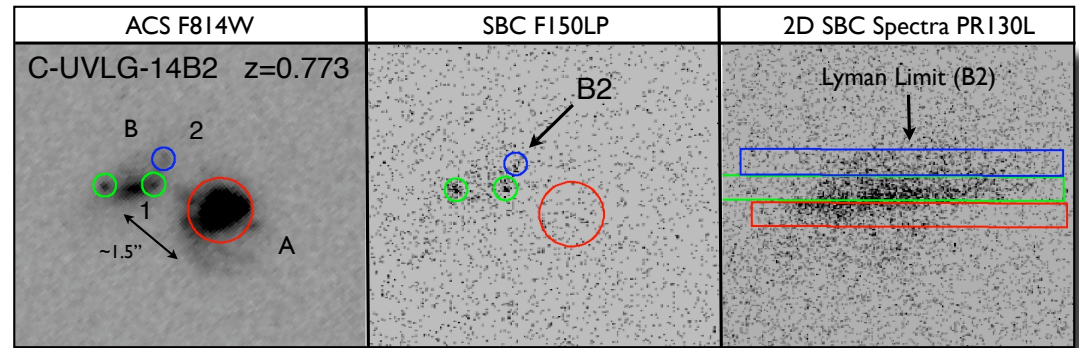
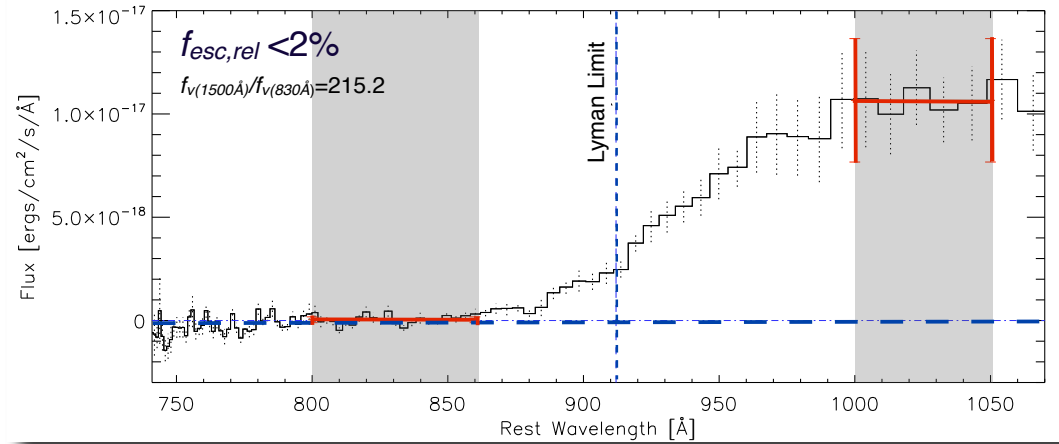
- I have a detection!



Siana et al. (2007)

Poster #36 by C. Bridge

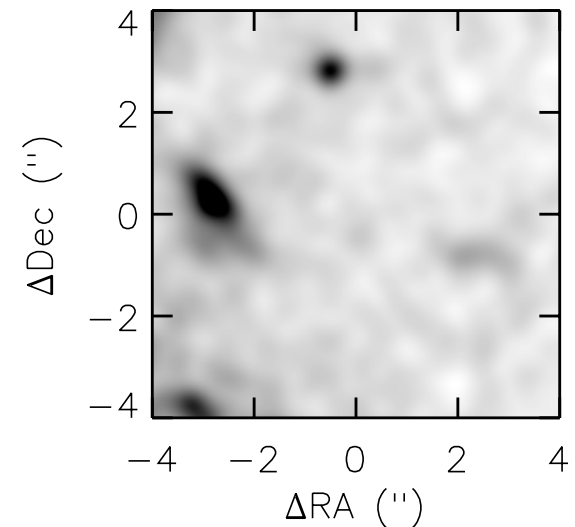
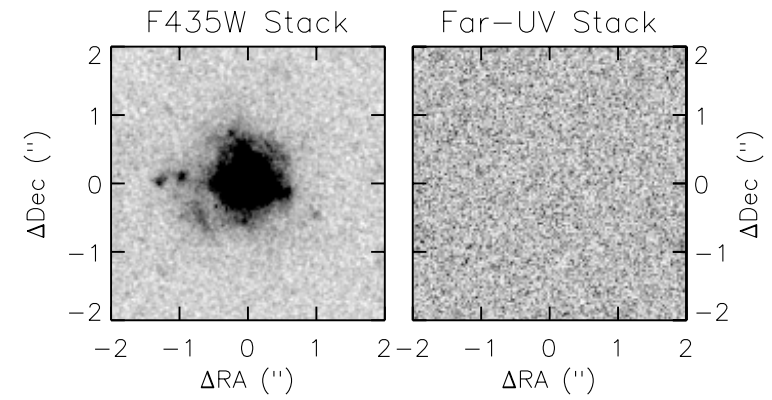
Stacked Spectra of Non-Detections



- Emily Wisnioski Poster
- Elizabet Leitert

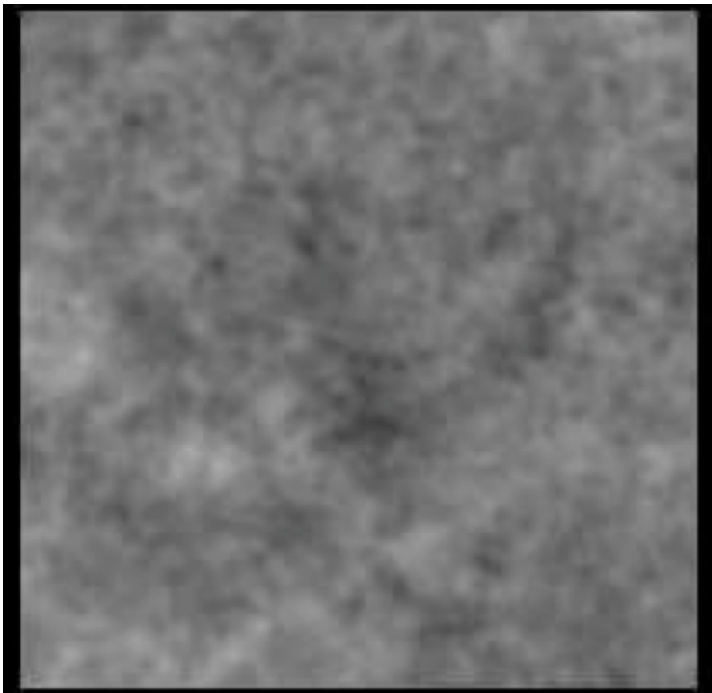
Summary

- 75 orbits deep HST far-UV imaging of 15 galaxies
- No detections $f_{\text{esc}}(3\sigma) < 0.05$
- Stack $f_{\text{esc}}(3\sigma) < 0.02$
- Stack (low/high SB) $f_{\text{esc}}(3\sigma) < 0.05$
 - **Numbers/Depths indicate f_{esc} evolves!**
- No shadowing of ionizing background (~ 20 kpc)
- See poster by Carrie Bridge for possible detection!



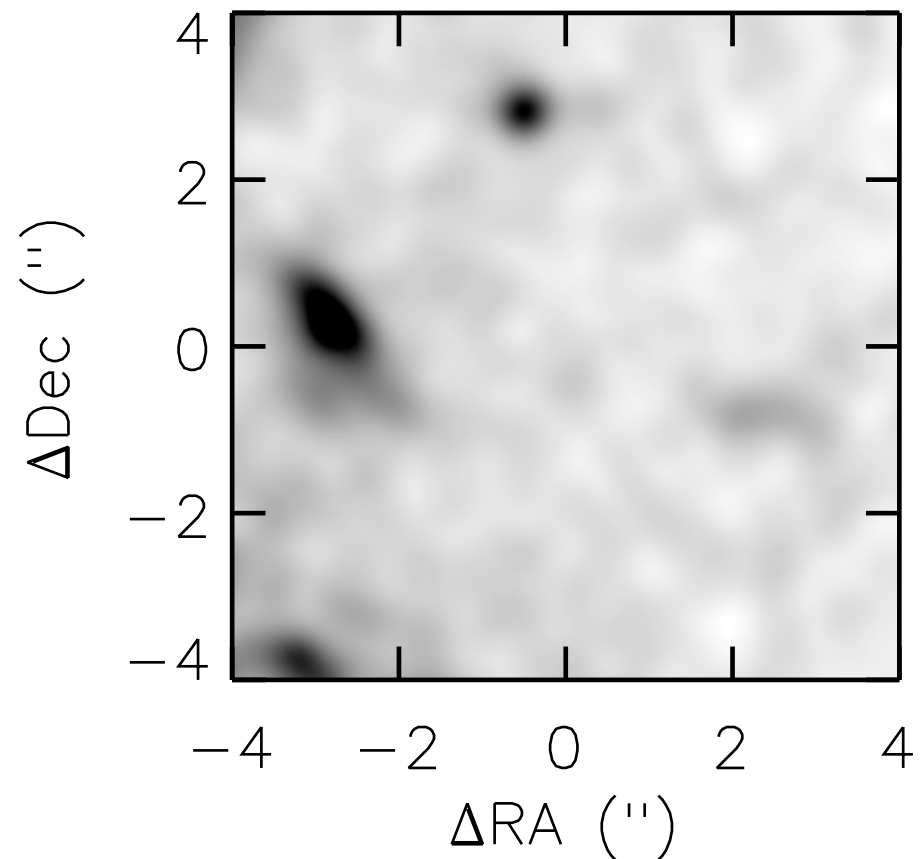
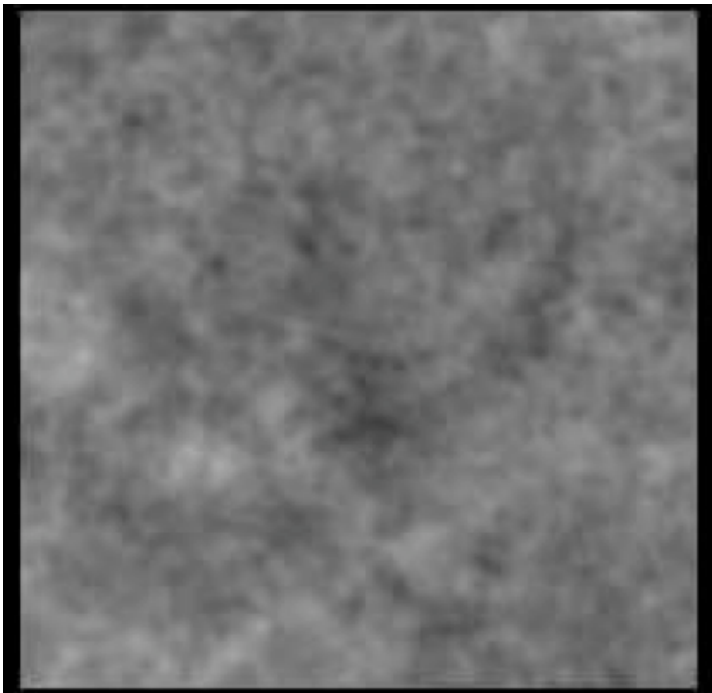
UV Background Shadowing?

- Cowie+09 -
 - $\sim 2\sigma$ negative GALEX stack
 - Shadowing of background by DLAs?



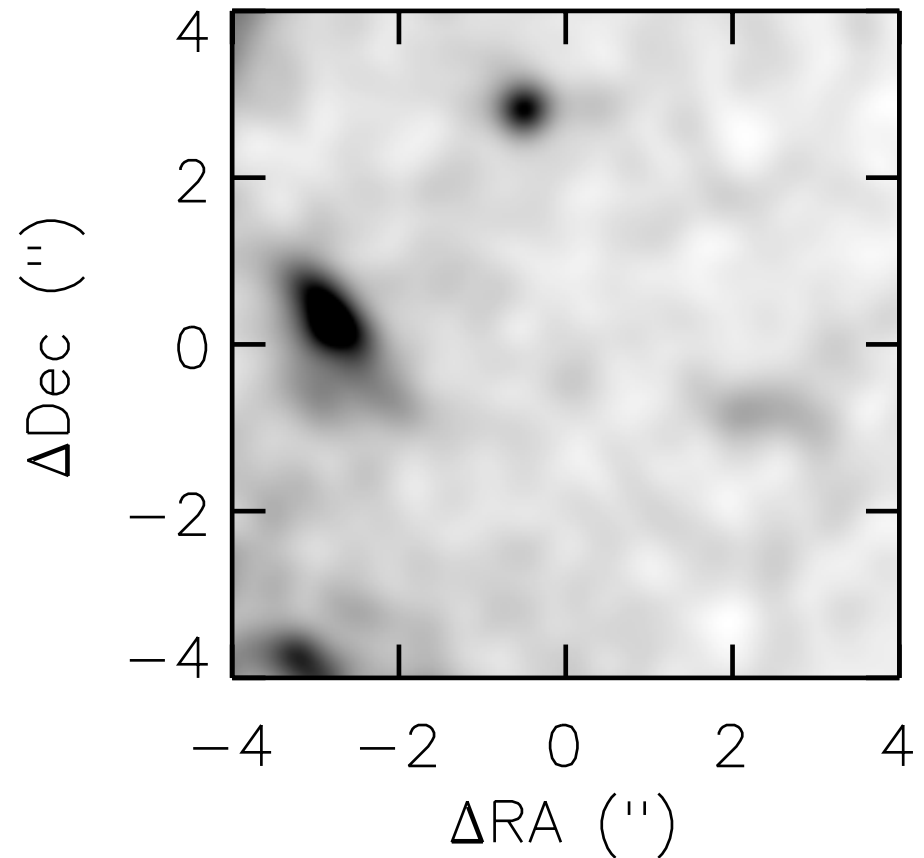
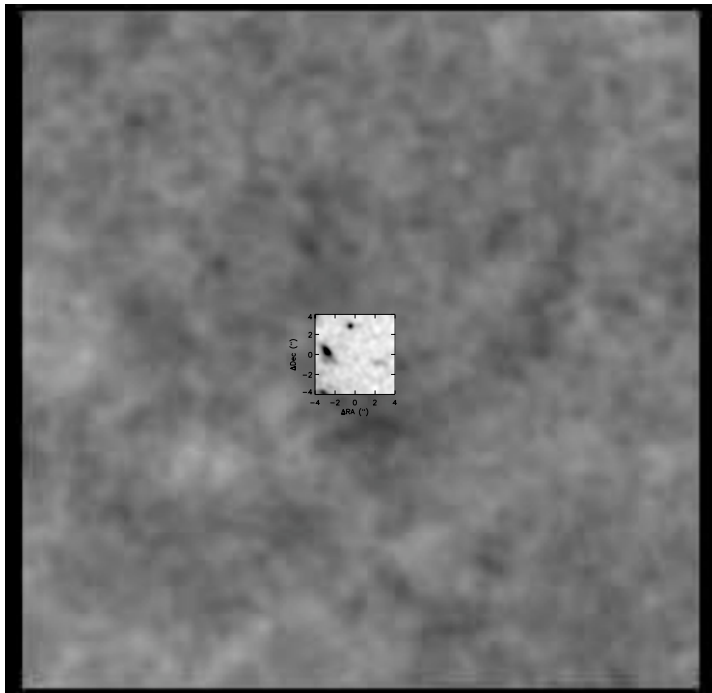
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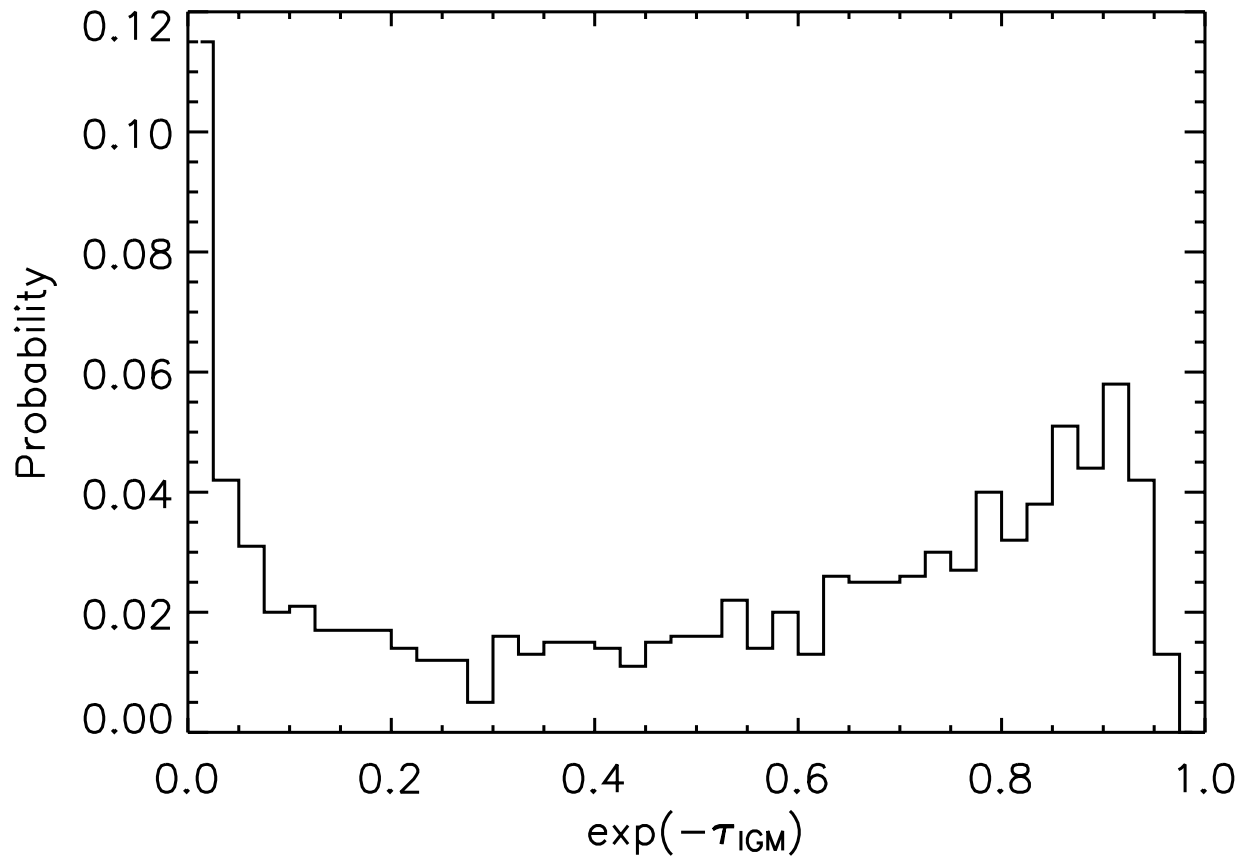


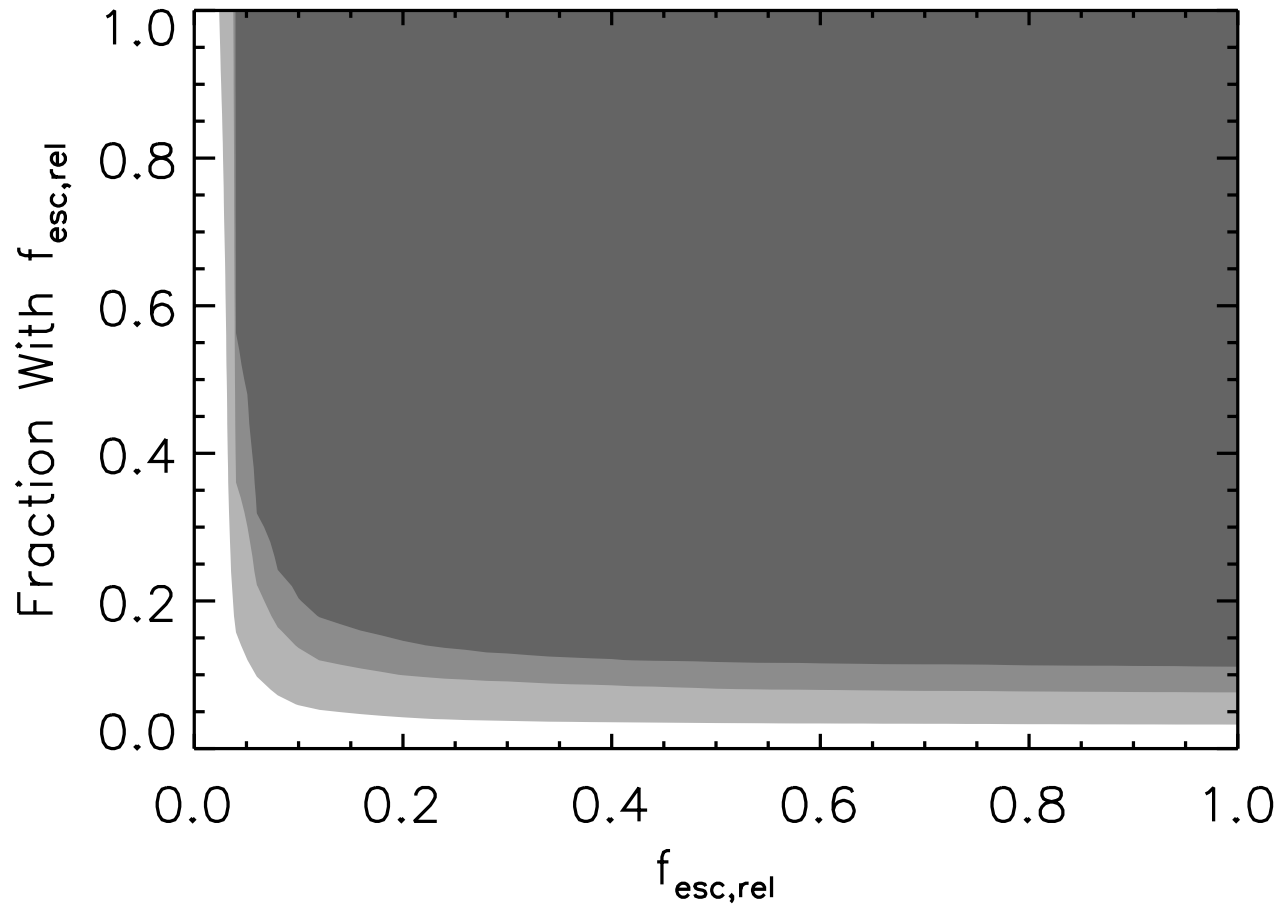
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IGM Transmission Distribution (through filter)





f_{esc} Evolving?

- Many detections at $z \sim 3$
- No detections at $z \sim 1$
- Numbers at $z \sim 1$ not large (only $\sim 1/10$ at $z \sim 3$ have high f_{esc})
- Need larger numbers at $z \sim 1$ to confirm evolution
- Add plot with all previous escape fraction limits

