The WFC3 (UV) Early Release Science program: Brief Science Summary and Lessons Learned

Rogier Windhorst (ASU) — JWST Interdisciplinary Scientist

Collaborators: S. Cohen, R. Jansen (ASU), S. Driver (OZ), & H. Yan (U. MO)

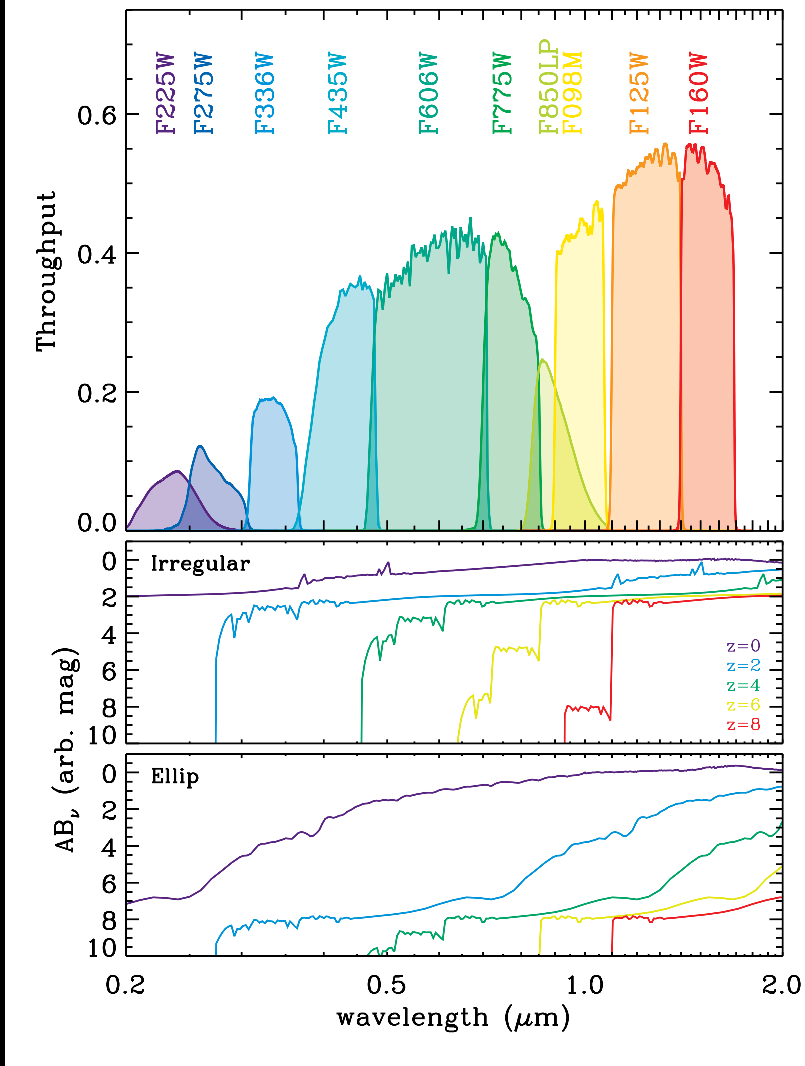
(Ex) ASU Grads: N. Hathi, H. Kim, M. Mechtley, R. Ryan, M. Rutkowski, A. Straughn

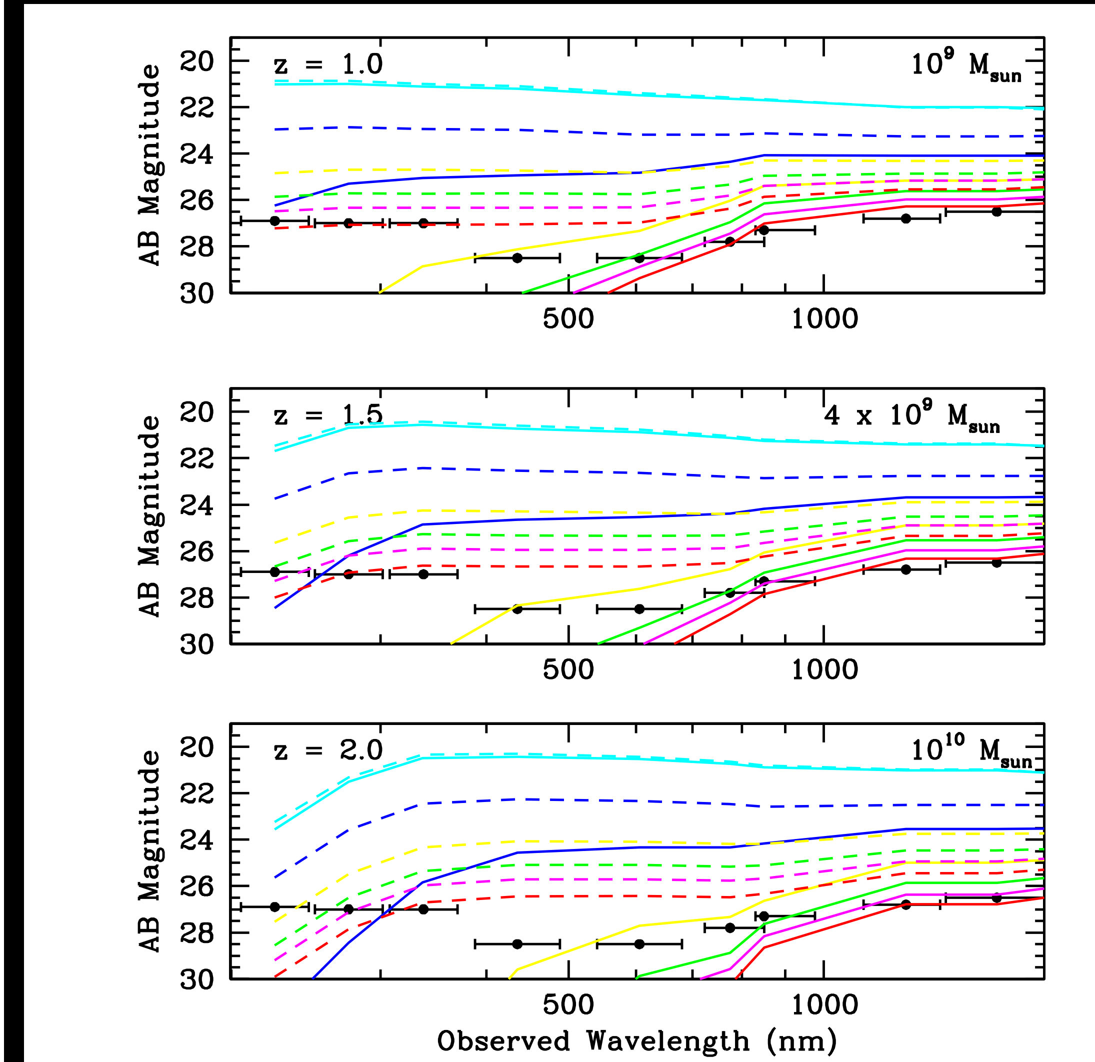
Talk at the GOODS UV Cycle 21 planning meeting, Fr. Dec. 7, Baltimore, MD

Outline:

- (1) The WFC3 ERS UV: Technical Lessons Learned
- (2) The WFC3 ERS: Summary of UV Science
- (3) Conclusions: What Cy 21 GOODS UV needs to do

Sponsored by NASA/HST WFC3





WFC3/UVIS channel unprecedented UV–blue throughput & areal coverage:

- QE$\gtrsim$70%, 4k$\times$4k array of $0''.04$ pixel, FOV $\simeq$ $2'.67 \times 2'.67$.

WFC3/IR channel unprecedented near–IR throughput & areal coverage:

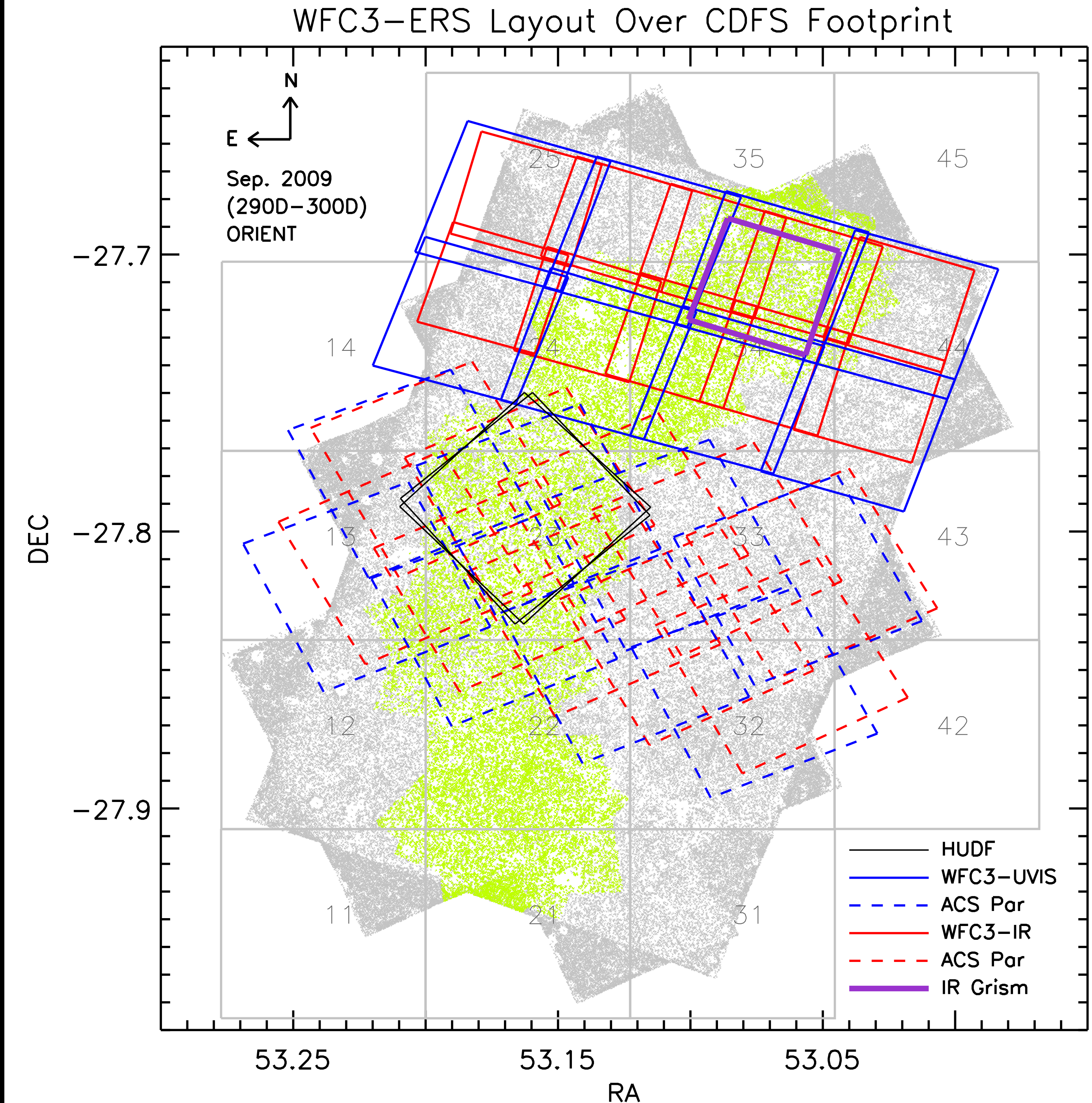
- QE$\gtrsim$70%, 1k$\times$1k array of $0''.13$ pixel, FOV $\simeq$ $2'.25 \times 2'.25$.

WFC3 filters designed for star-formation and galaxy assembly at z$\simeq$0–8.

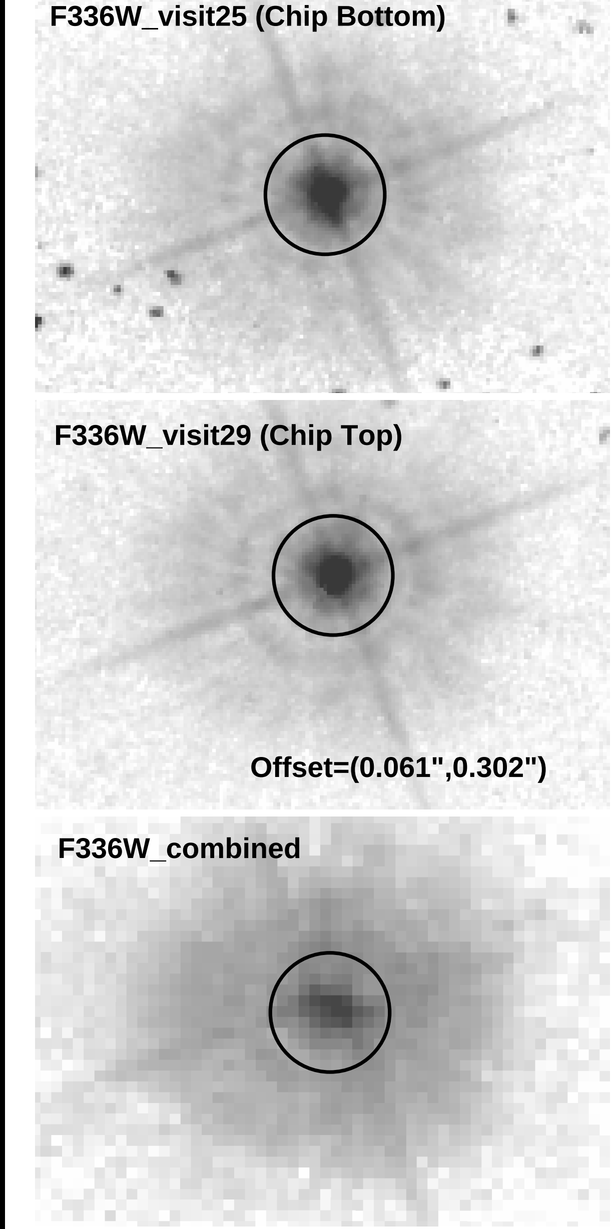
• (1) What is the WFC3 ERS and Technical Lessons Learned?

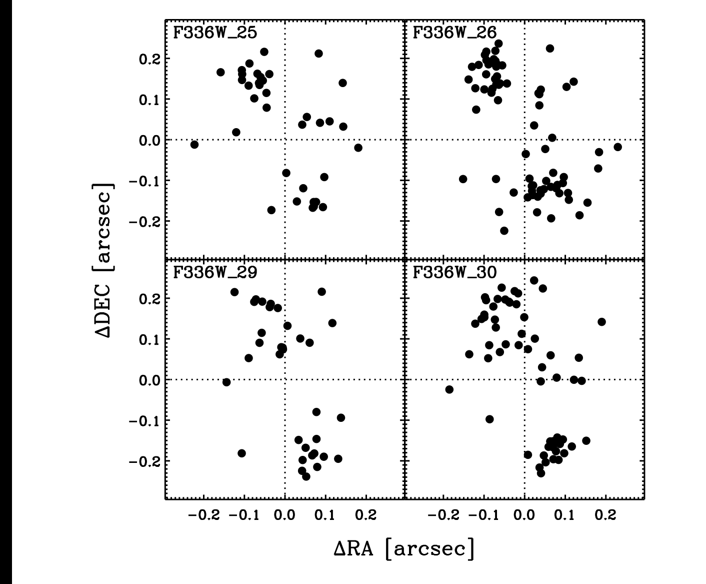
10 filters with HST/WFC3 & ACS reaching AB=26.5-27.0 mag (10-σ) over 40 arcmin^2 at 0.07–0.15" FWHM from 0.2–1.7μm (UVUBVizYJH).

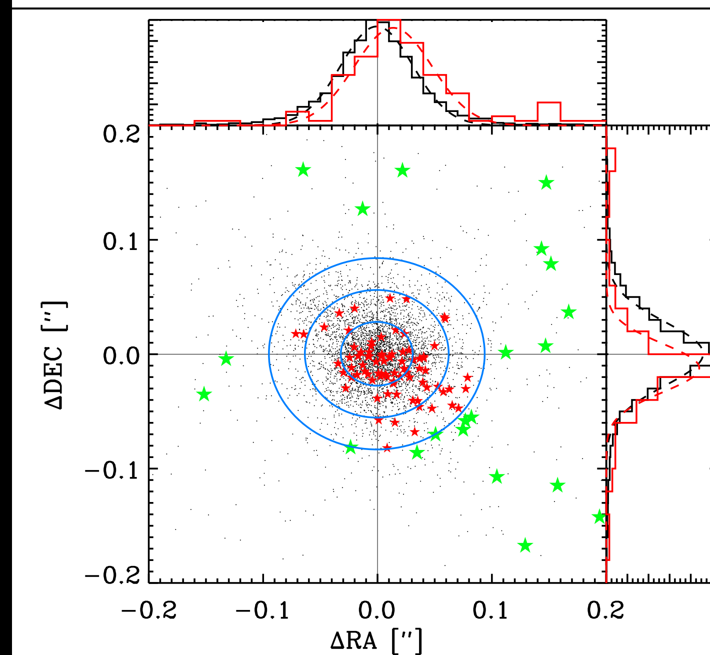
• ERS in GOODS-S v2: using WFC3 for what it was designed to do.



The ERS field in GOODS-S: WFC3/UV+ WFC3/IR: By design, ERS left majority of FOV to be covered by CANDELS & Cycle 21 GOODS UV.

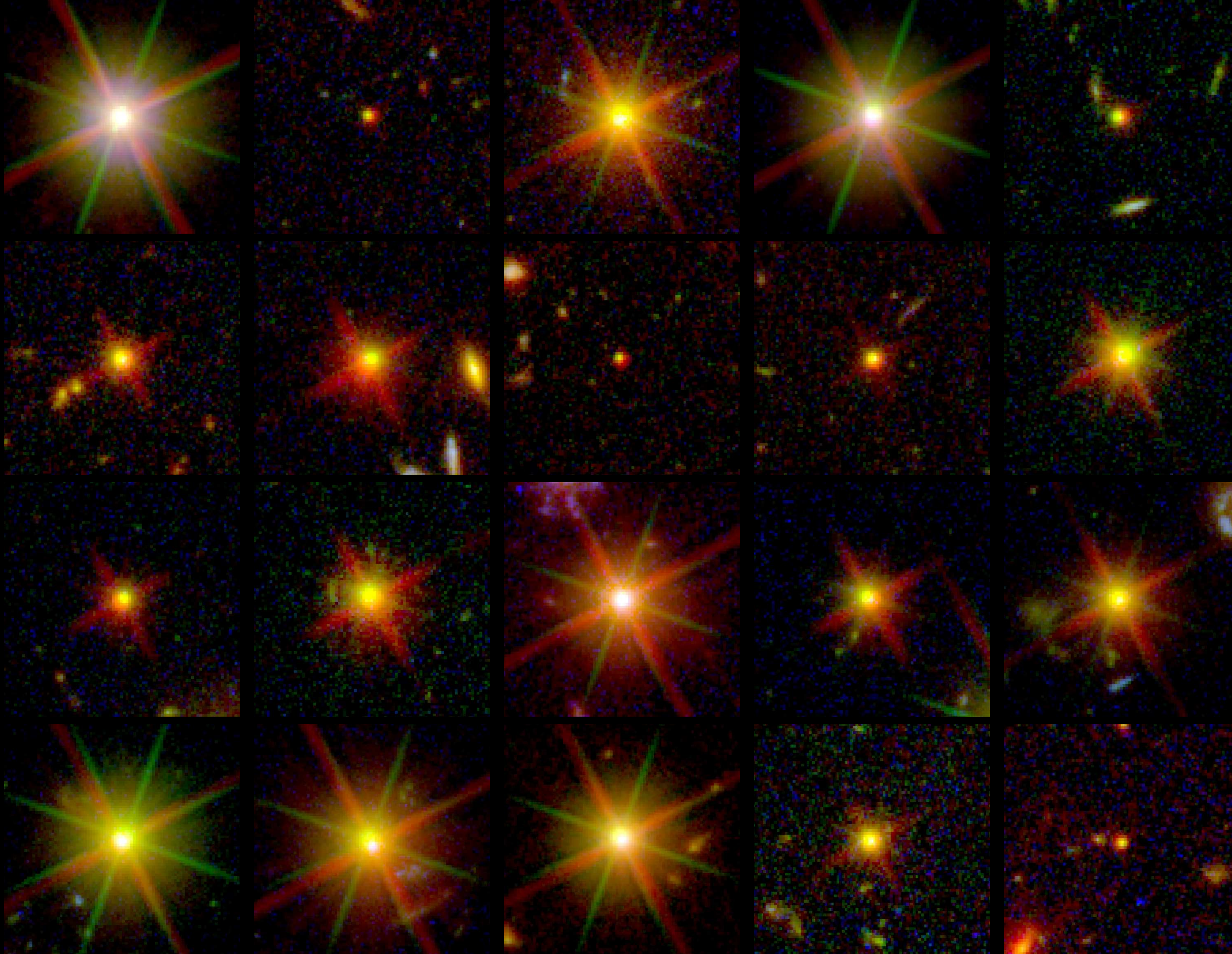






Stellar Images and 6-year Proper Motion in the ERS v1/GOODS-S v2:

- Stellar p.m.$\simeq$3.06$\pm$0.66 m.a.s./yr, $\lesssim$0.5 m.a.s. for background galaxies.
- Stars in corners stretched over few pixels: v2 GeoDistort will do better.



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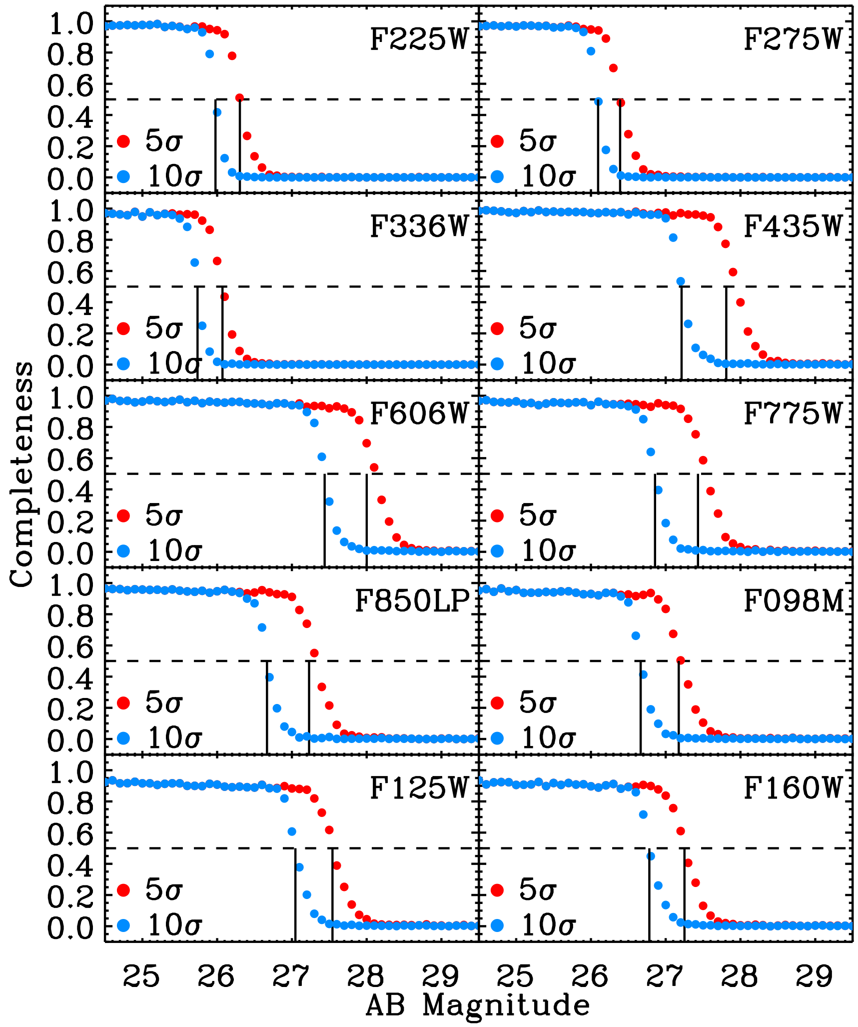
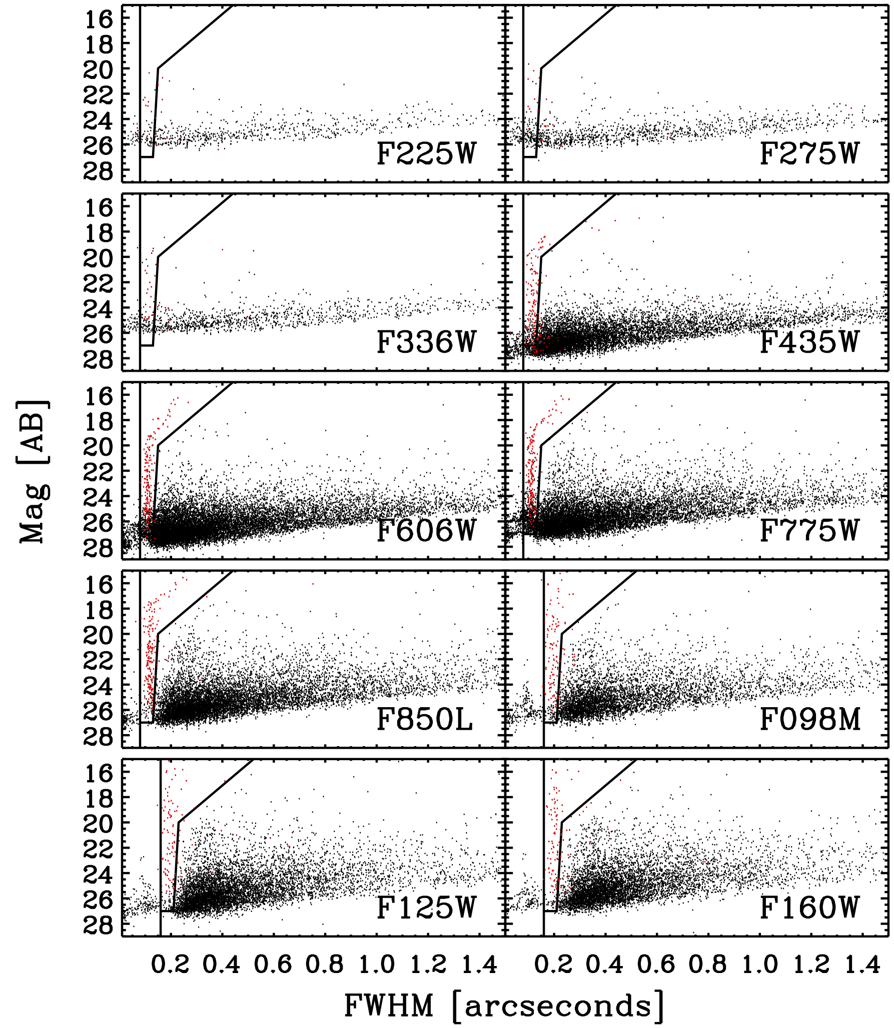
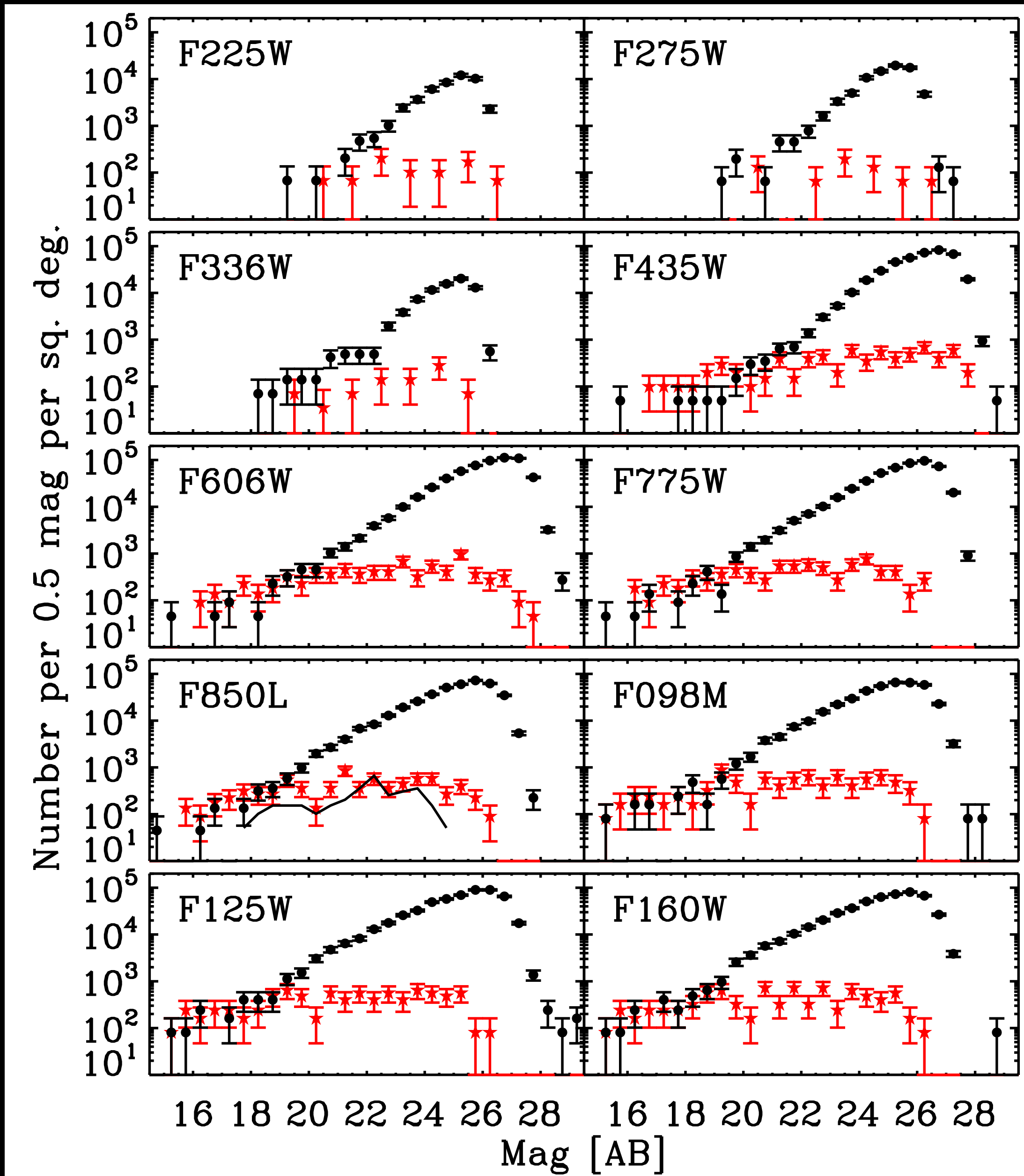
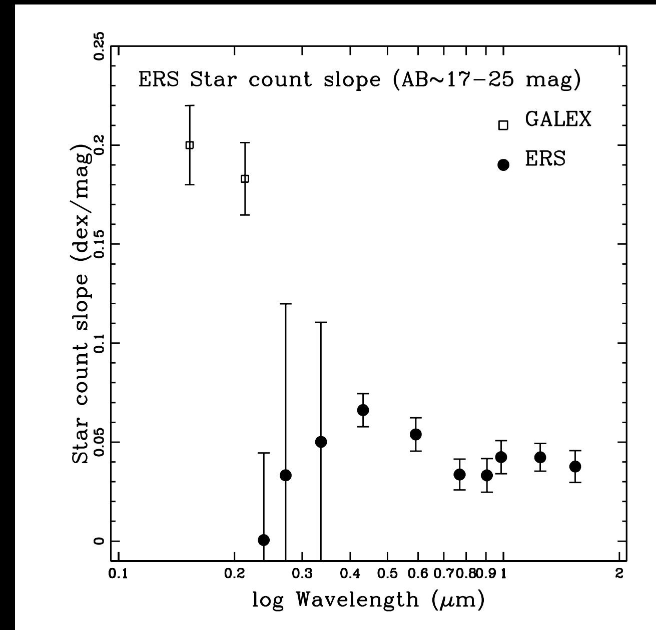


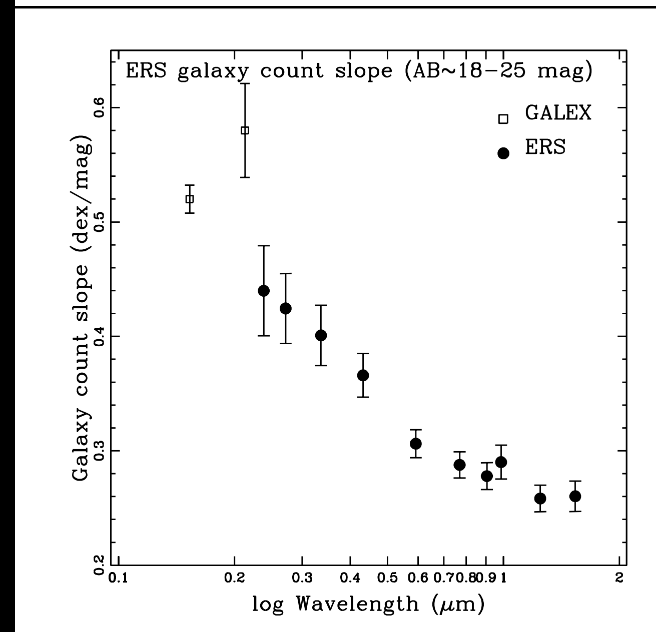


10-band ERS point source completeness limits & Star-Galaxy separation:

- ERS v1 UV: 5-σ AB(UV)$\lesssim$26.3 mag. Star-Gal separation of high quality.
- Need CTE & post-flash correction to do better in recent WFC3 UV images.
- Both must be discussed in our Cycle 21 proposal Technical Section!



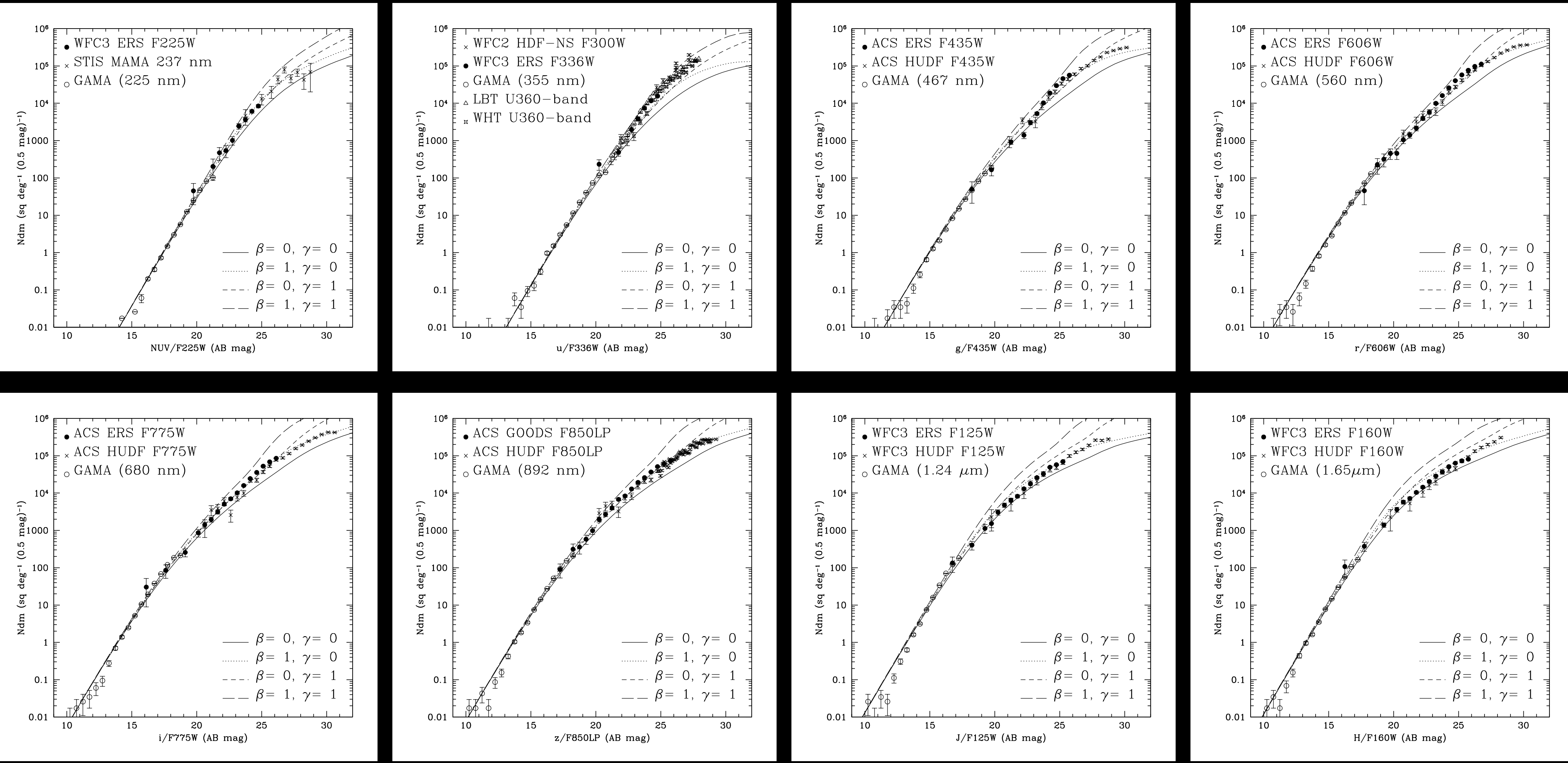




Panchromatic 10-band ERS star-counts and galaxy counts:

- Star-counts flat at all wavelengths, slope ∼declines with wavelength.
- Galaxy counts steeper at all wavelengths, slope declines with λ!

Panchromatic Galaxy Counts from $\lambda \simeq$0.2–2μm for AB$\simeq$10–30 mag

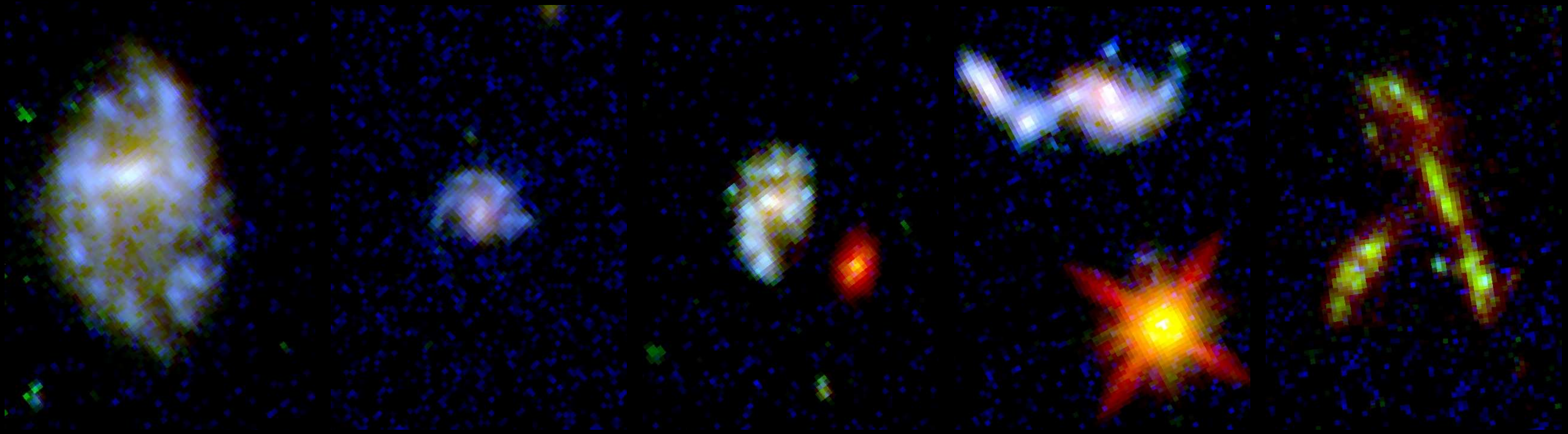


Data: GALEX, ground-based GAMA, HST ERS ACS+WFC3 + HUDF ACS+WFC3 (*e.g.*, Windhorst et al. 2011, ApJS 193, 27):

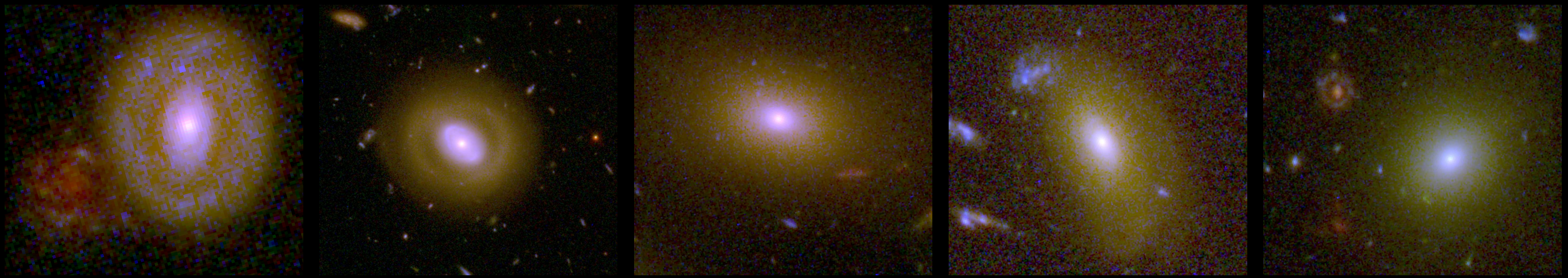
Filters: F225W, F275W, F336W, F435W, F606W, F775W, F850LP, F098M/F105W, F125W, F160W.

- No single Lum.+Dens evol model fits over 1 dex in λ and 8 dex in flux.

(2) Summary of Science results from WFC3 Early Release Science data:



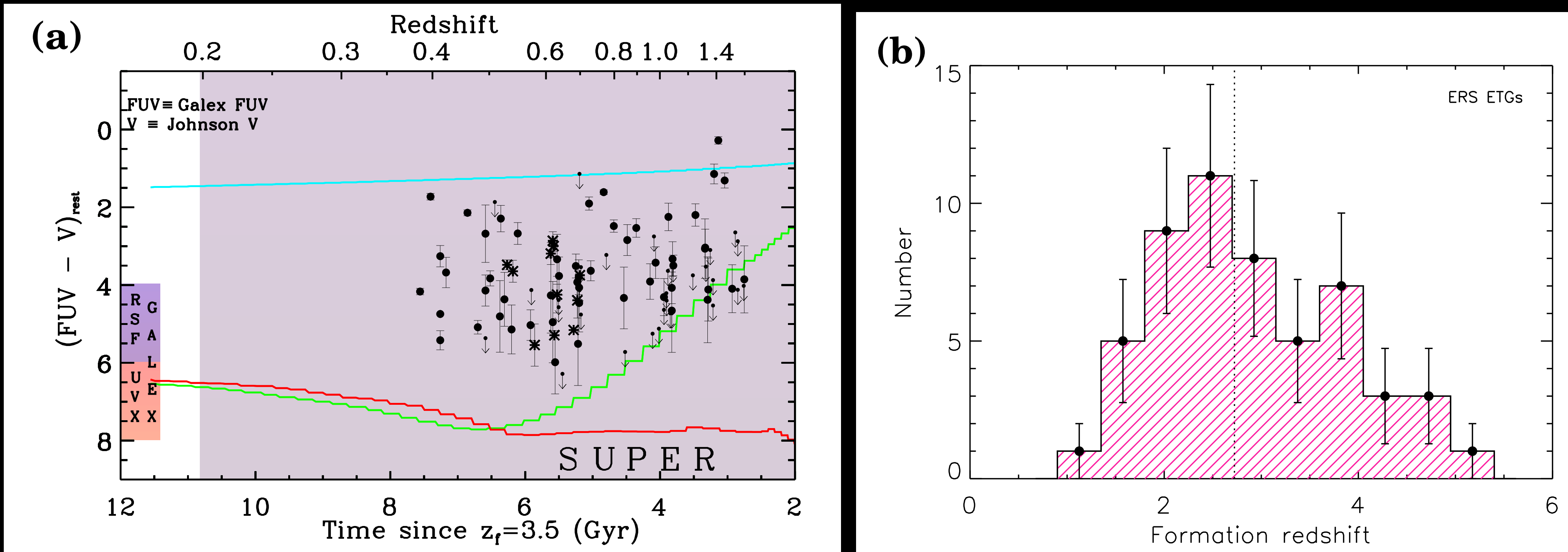
Galaxy structure at the peak of the merging epoch (z$\simeq$1–2) is very rich: some resemble the cosmological parameters $\boldsymbol{H_0}$, $\boldsymbol{\Omega}$, $\boldsymbol{\rho_o}$, $\boldsymbol{w}$, and $\boldsymbol{\Lambda}$, resp.



Panchromatic WFC3 ERS images of early-type galaxies with nuclear star-forming rings, bars, weak AGN, or other interesting nuclear structure.

(Rutkowski ea. 2012 ApJS 199, 4) $\Longrightarrow$ "Red & dead" galaxies aren't dead!

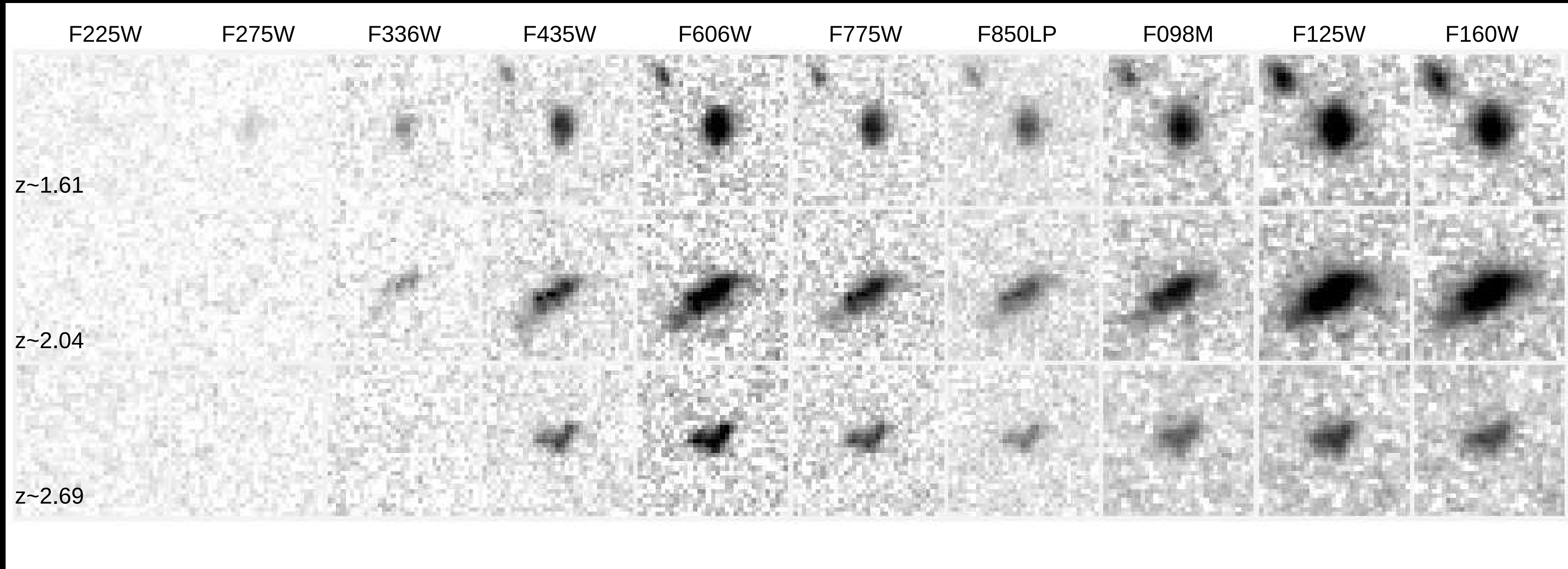
HST WFC3: Rest-frame UV-evolution of Early Type Galaxies since z$\lesssim$1.5.



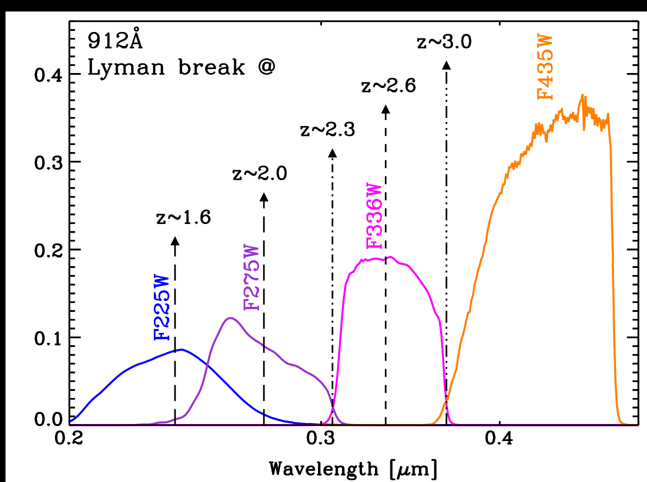
- 10-band WFC3 ERS data measured rest-frame UV-light in nearly all early-type galaxies at 0.3$\lesssim$z$\lesssim$1.5 (Rutkowski et al. 2012, ApJS, 199, 4).

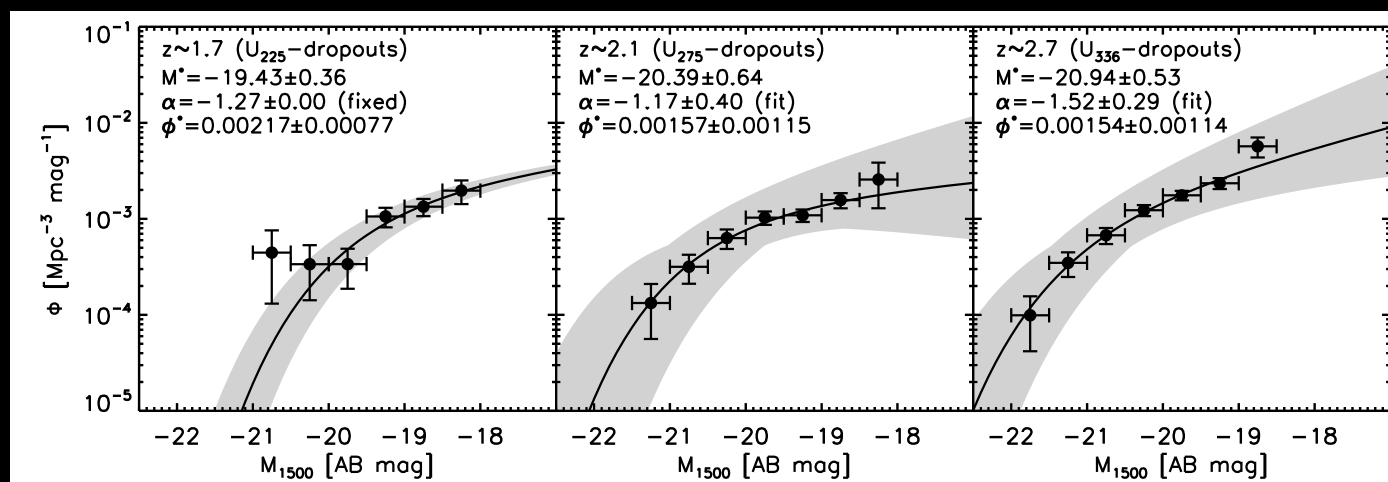
$\Longrightarrow$ Most ETGs have continued residual star-formation after they form.

- Can determine their N(z_{form}), which resembles the cosmic SFH diagram (*e.g.*, Madau et al. 1996). This can directly constrain the process of galaxy assembly and down-sizing (Kaviraj et al. 2012, MNRAS, astro-ph/1206.2360).



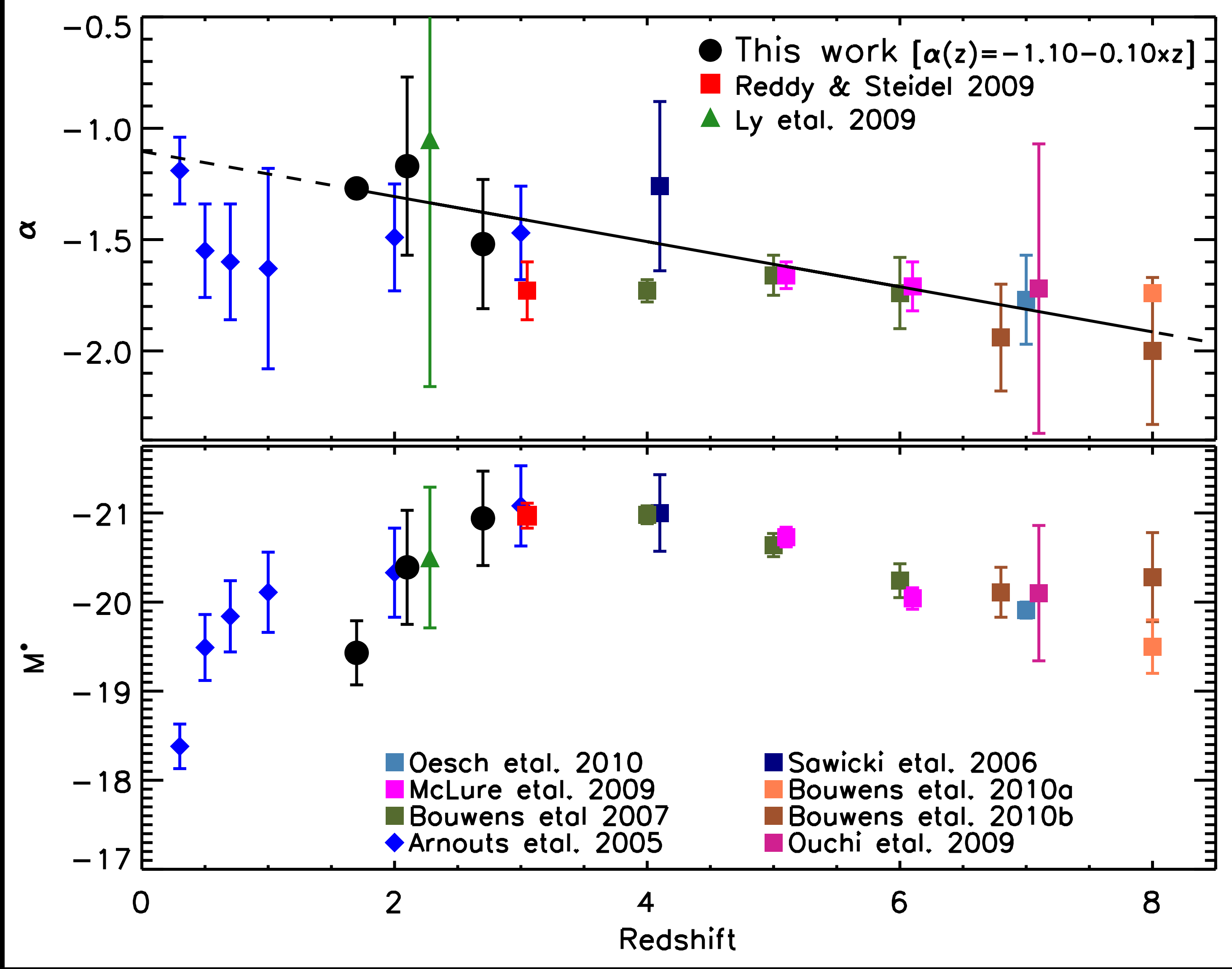
Lyman break galaxies at the peak of cosmic SF (z≃1-3; Hathi ea. 2010)





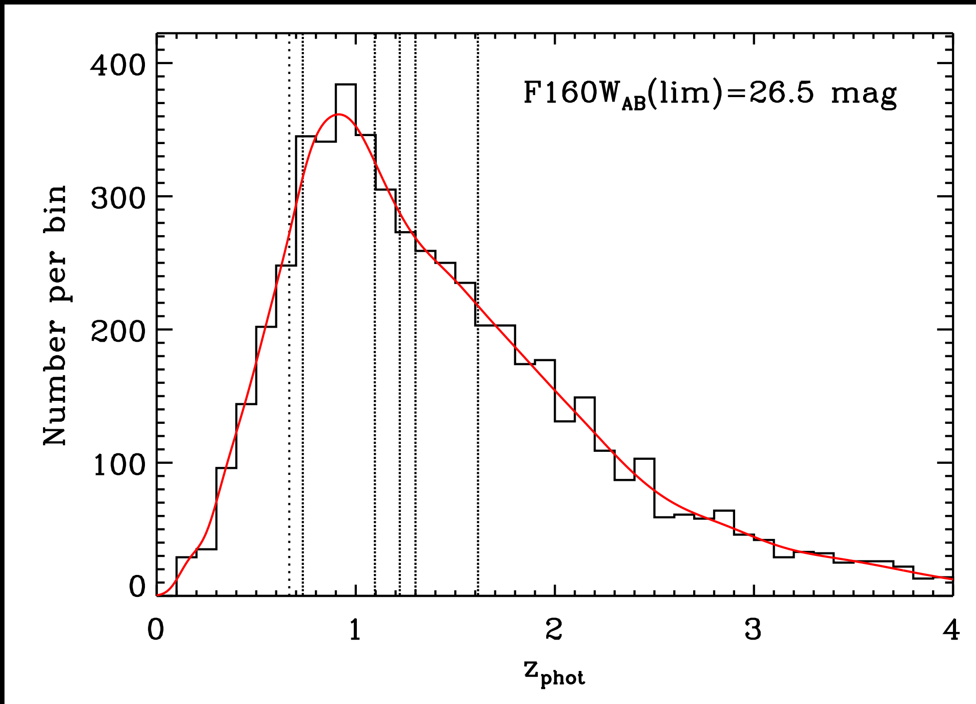
- Good UV LF's over z-range that is hard to do from ground.
- Limited flux-range as yet, which limits the M^* , ϕ^* , α-accuracy.

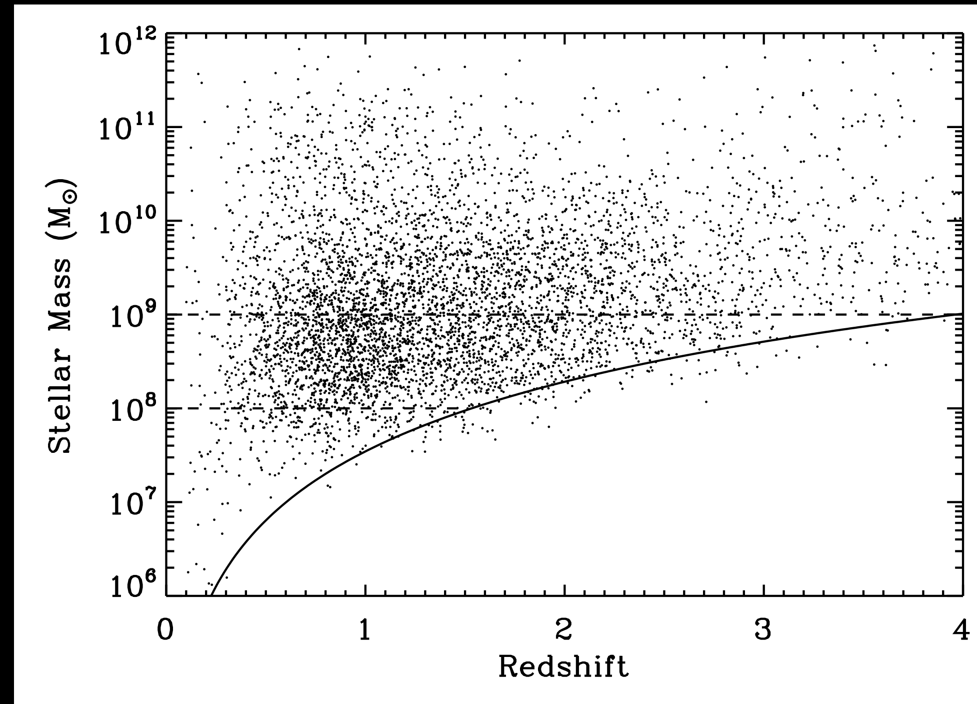
Cycle 21 GOODS-UV will significantly improve on bright-end, M^* & ϕ^* .



Measured faint-end LF slope evolution (α; top) and characteristic luminosity evolution (M^* ; bottom) from Hathi et al. 2010 (ApJ, 720, 1708).

- Still significantly poorly determined LF parameters at $1 \lesssim z \lesssim 3$, when most stars are born: Cycle 21 GOODS-UV will vastly improve on this.





WFC3 ERS 10-band redshift estimates accurate to $\lesssim$4% with small systematic errors (Hathi et al. 2010, 2012), resulting in a reliable N(z):

• Measure masses of faint galaxies to AB=26.5 mag, tracing the process of galaxy assembly: downsizing, merging, (& weak AGN growth?).

ERS shows WFC3's new panchromatic capabilities on galaxies at z$\simeq$0–8:

• Cycle 21 GOODS UV will significantly improve SED-fits & photo-z's, both in rms and catastrophic failures (Cohen et al. 2012).

(3) Conclusions: What Cycle 21 GOODS UV needs to do:

(1) ERS set stage to measure galaxy assembly in the last 12.7-13.0 Gyrs.

(2) WFC3 UV images key to SF in epoch when most stars form: $1 \lesssim z \lesssim 3$.

(3) ERS UV+IR area covered very small: $\lesssim$40 arcmin^{2}

$\Longrightarrow$ Must expand with GOODS UV in at least F275W+F336W.

(4) GOODS UV will complete the limited UV coverage from ERS+CANDELS:

- GOODS UV has the highest priority and must be done in Cycle 21.
- Will consider SUPER-2 for Cycle 22, based on GOODS UV lessons.

Both are unique and essential to do before HST dies & before JWST flies.