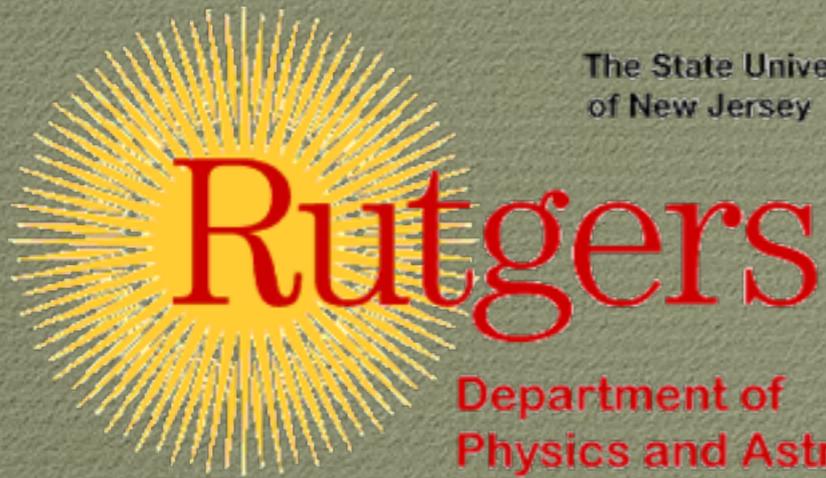


The State University
of New Jersey



Department of
Physics and Astronomy

GALAXY EVOLUTION ACROSS COSMIC AGES AS SEEN BY JWST

ALYSON BROOKS
RUTGERS UNIVERSITY
ASSISTANT PROFESSOR

OUTLINE OF THIS TALK

- High z : the first galaxies and reionization
- Low z : connection to high z star formation
- Mid z : the growth of galaxies

OUTLINE OF THIS TALK

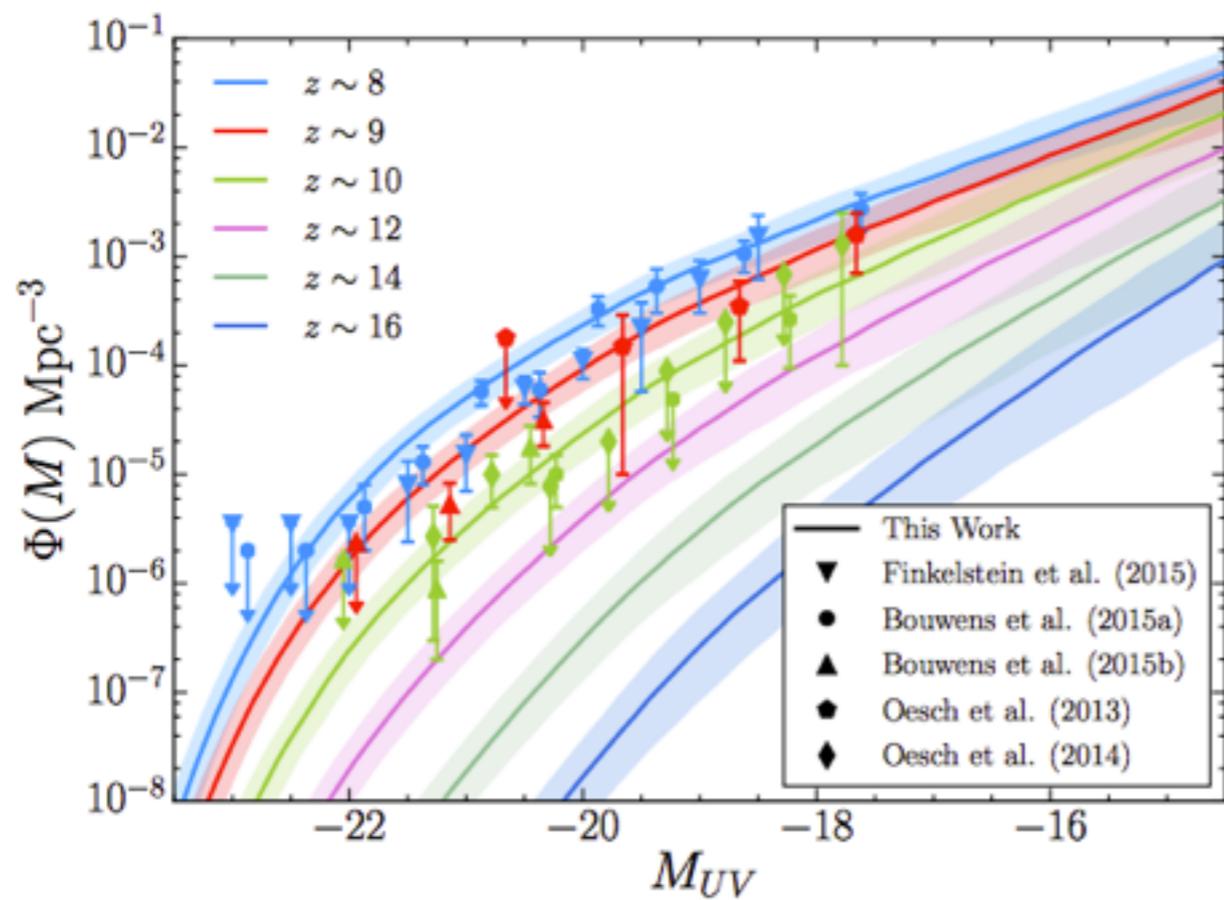
- High z : the first galaxies and reionization

↑
Link: the feedback that allows escaping ionizing radiation in low mass galaxies generates the stellar distribution observed today

- Low z : connection to high z star formation

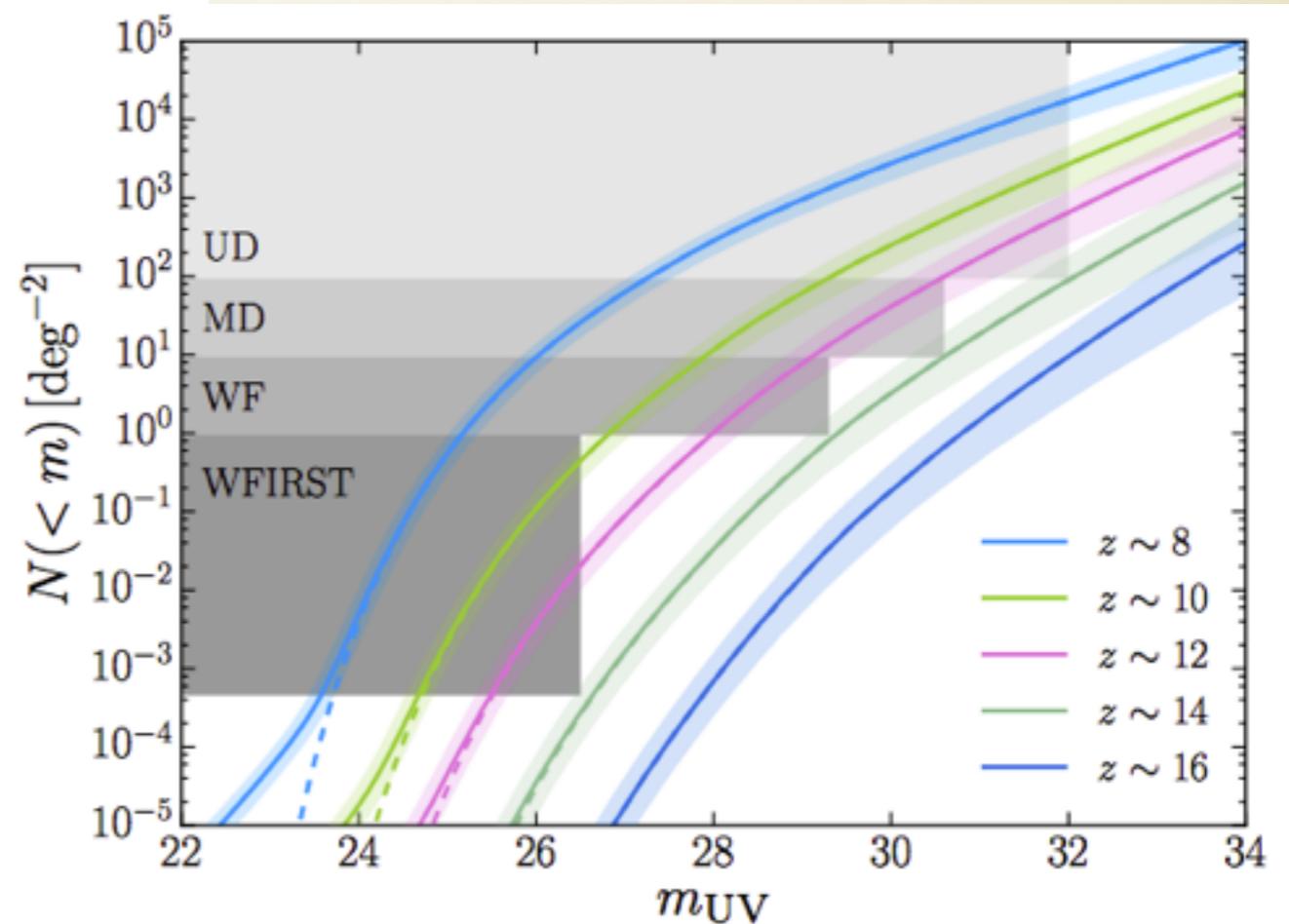
↓
↑
Link: the same feedback sets the distribution of morphologies appearing at $1 < z < 3$

- Mid z : the growth of galaxies

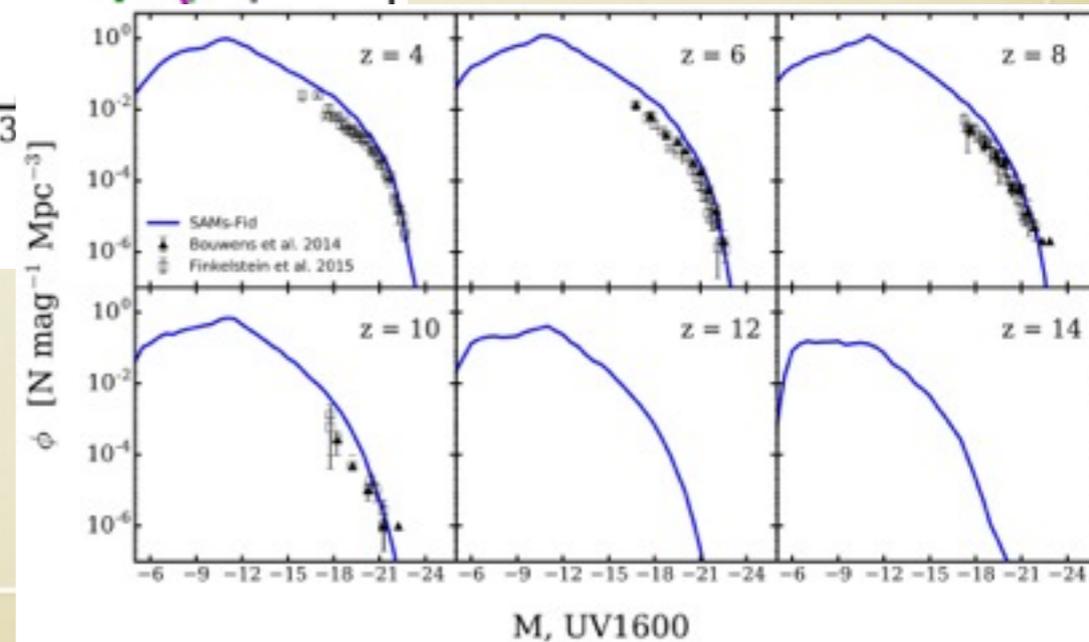
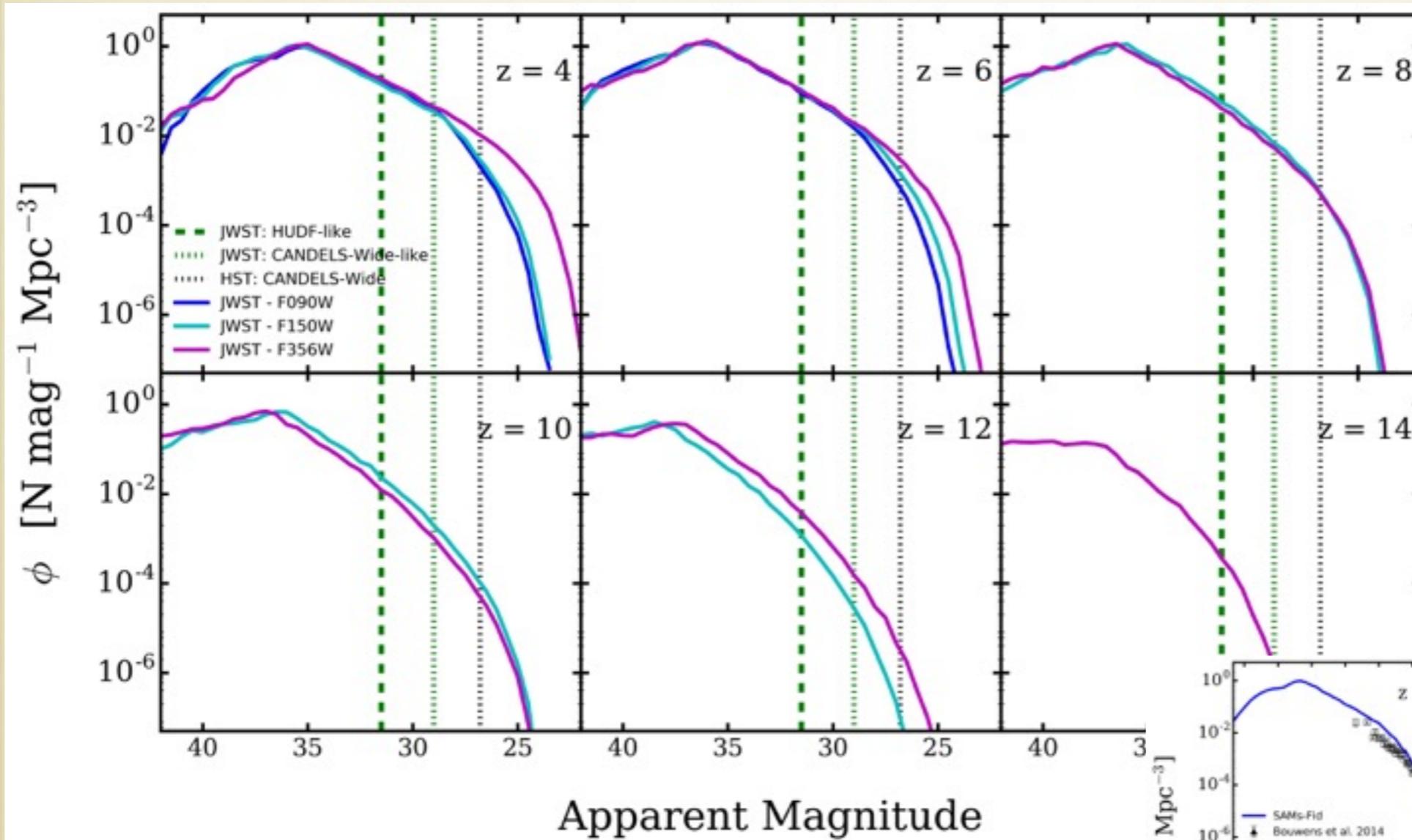


**JWST WILL
PROBE LF TO
 $z > 10$**

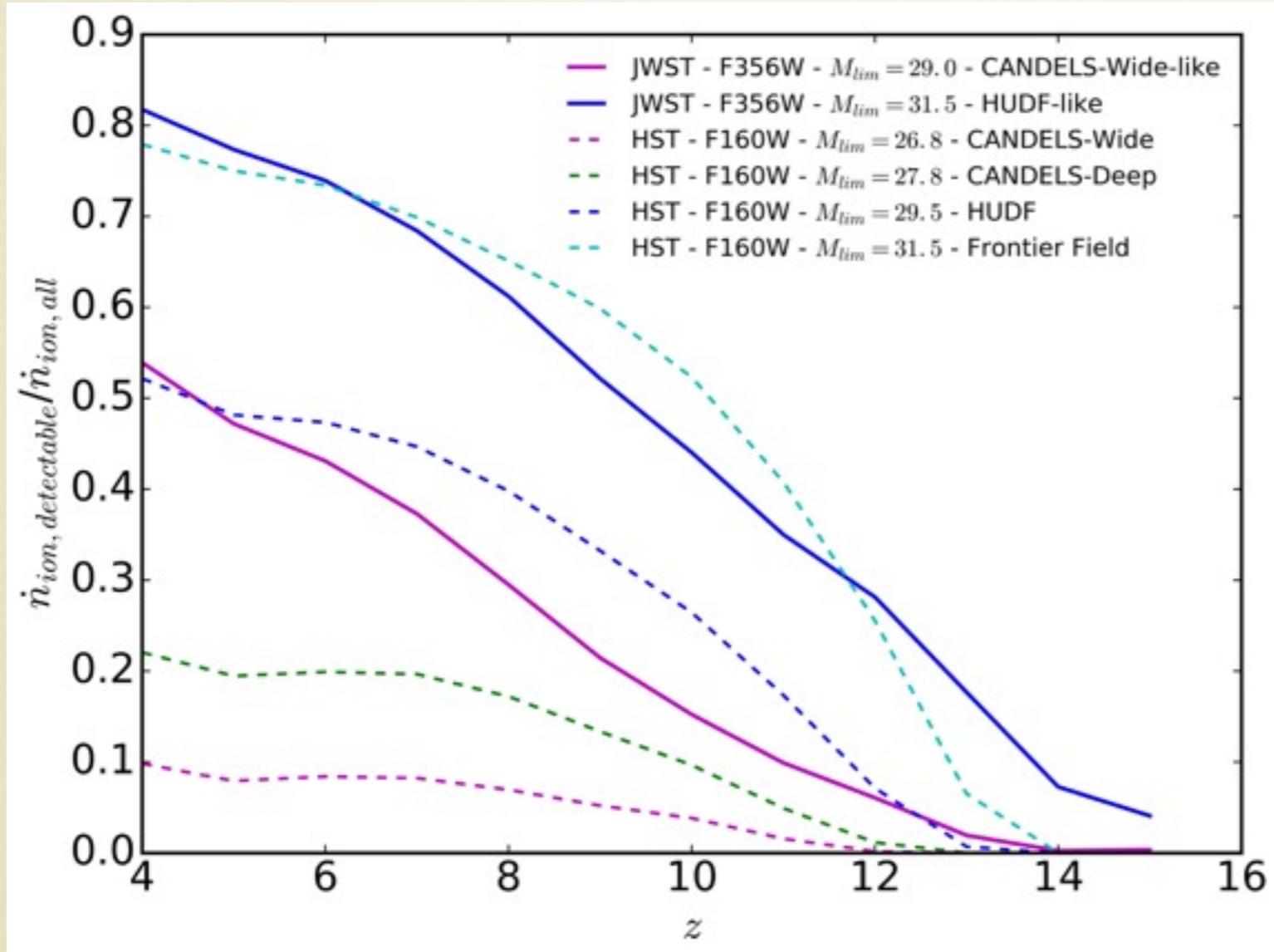
**JWST WILL FIND
GALAXIES AT GIVEN
 z SEVERAL
MAGNITUDES
FAINTER THAN HST**



PREDICTIONS FOR PROBING THE FAINT END OF THE LF

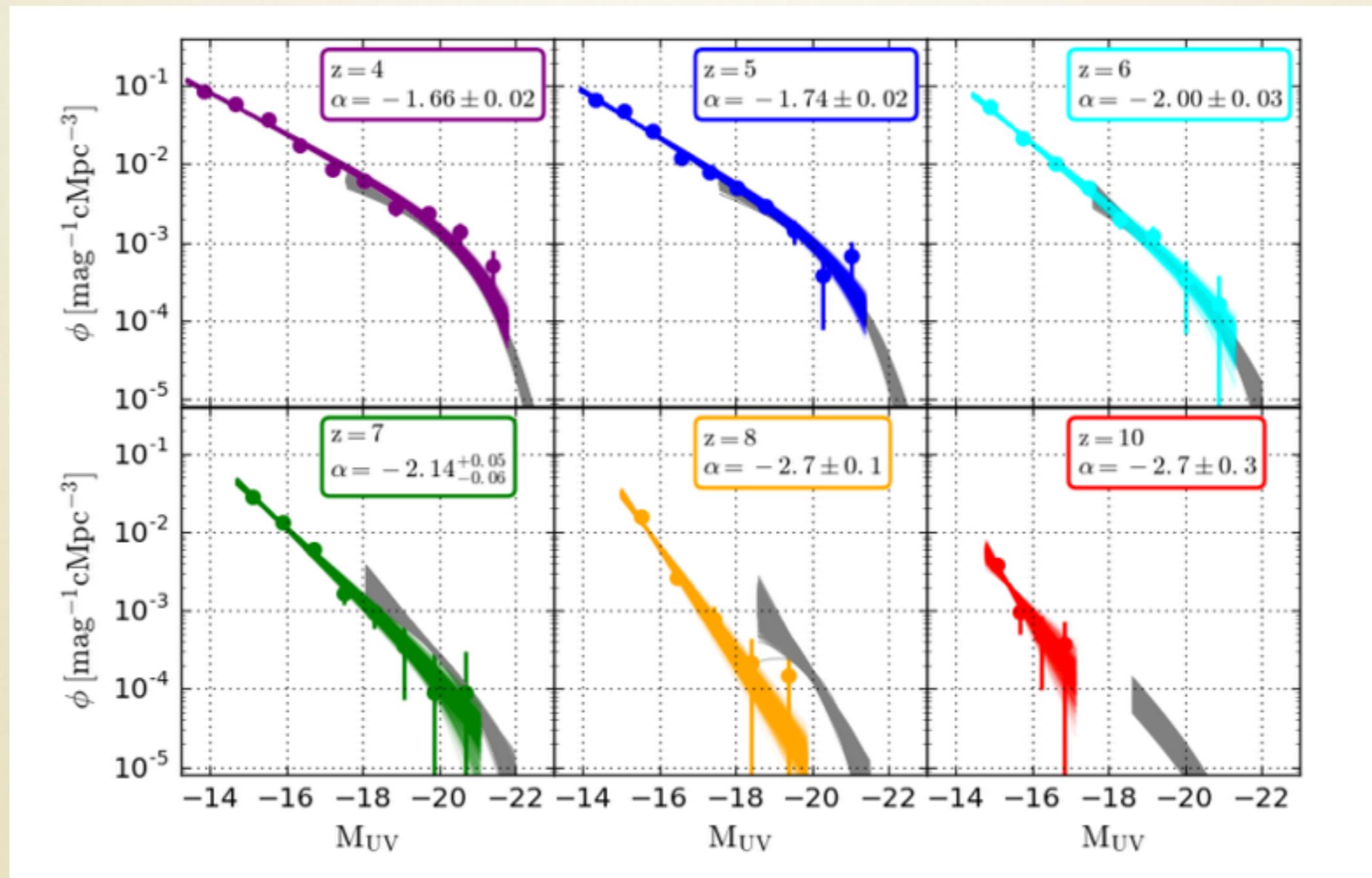


THIS MEANS WE SHOULD BE SEEING THE GALAXIES THAT REIONIZED THE UNIVERSE



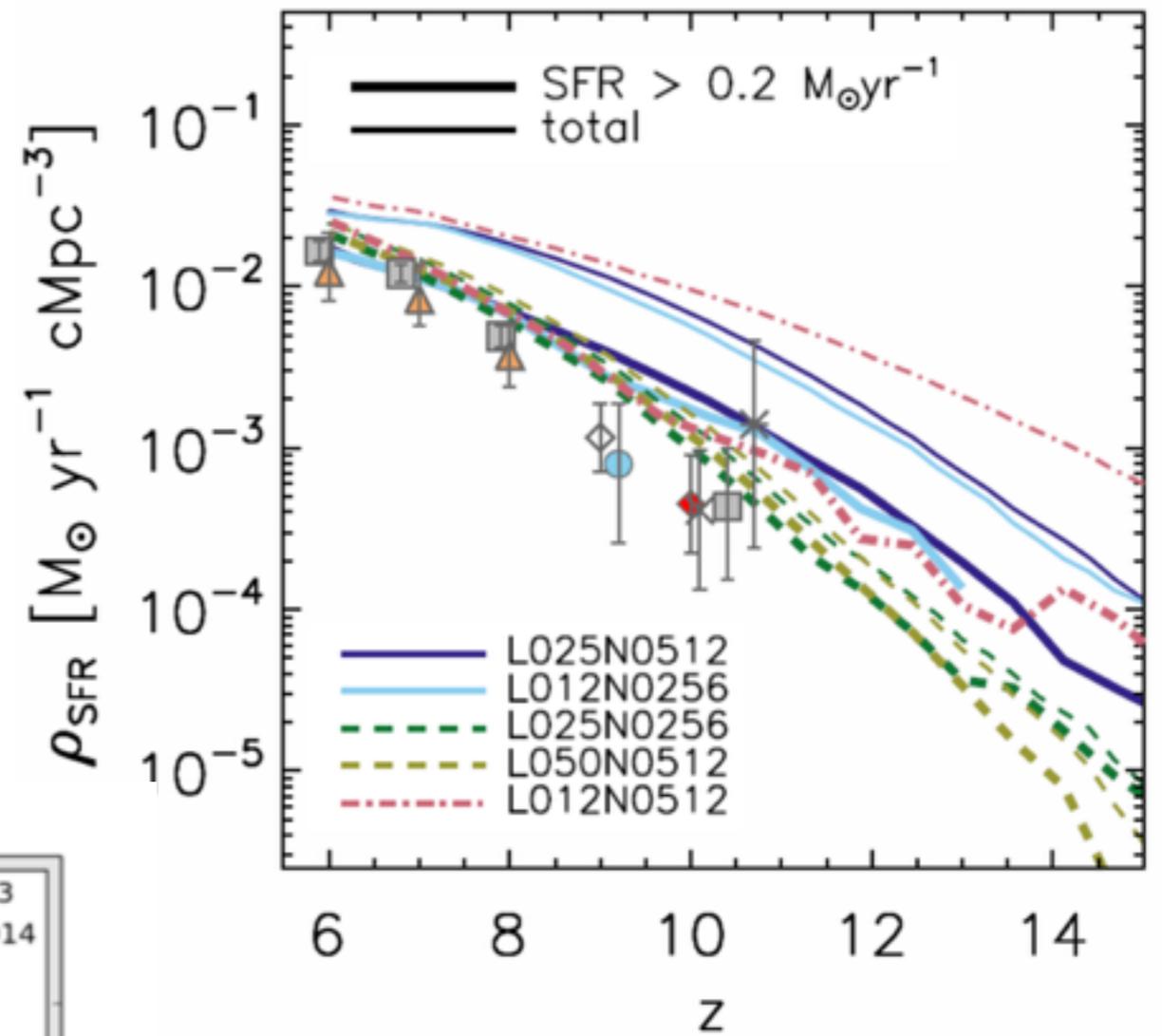
...THOUGH
MAYBE NOT AS
MANY AS WE
MIGHT HAVE
HOPED

BUT (WE PREDICT) THERE WILL BE SIGNIFICANT IMPROVEMENTS

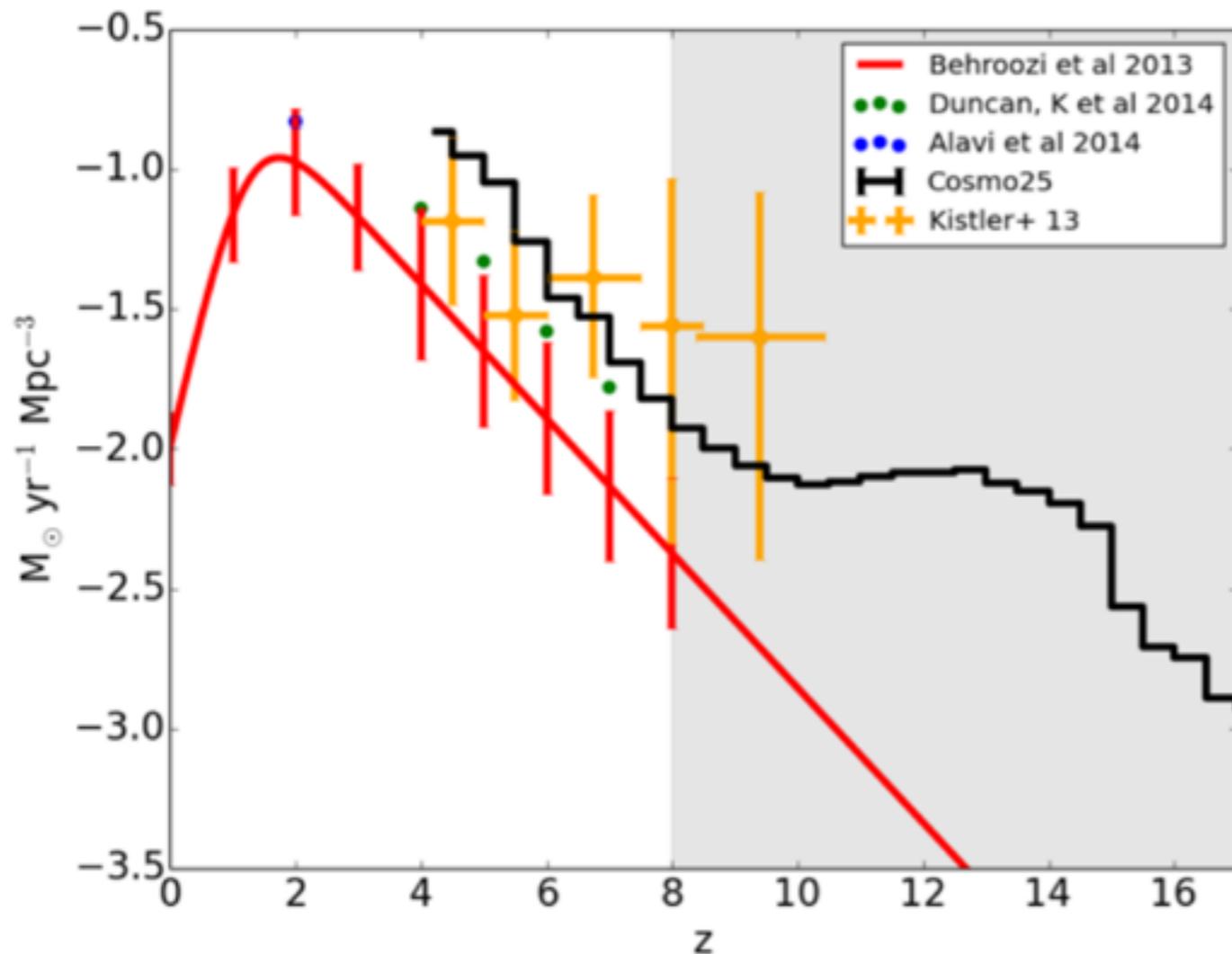


ALSO PREDICT
WE'RE GOING TO
SEE MORE STAR
FORMATION

Anderson et al. (2016)



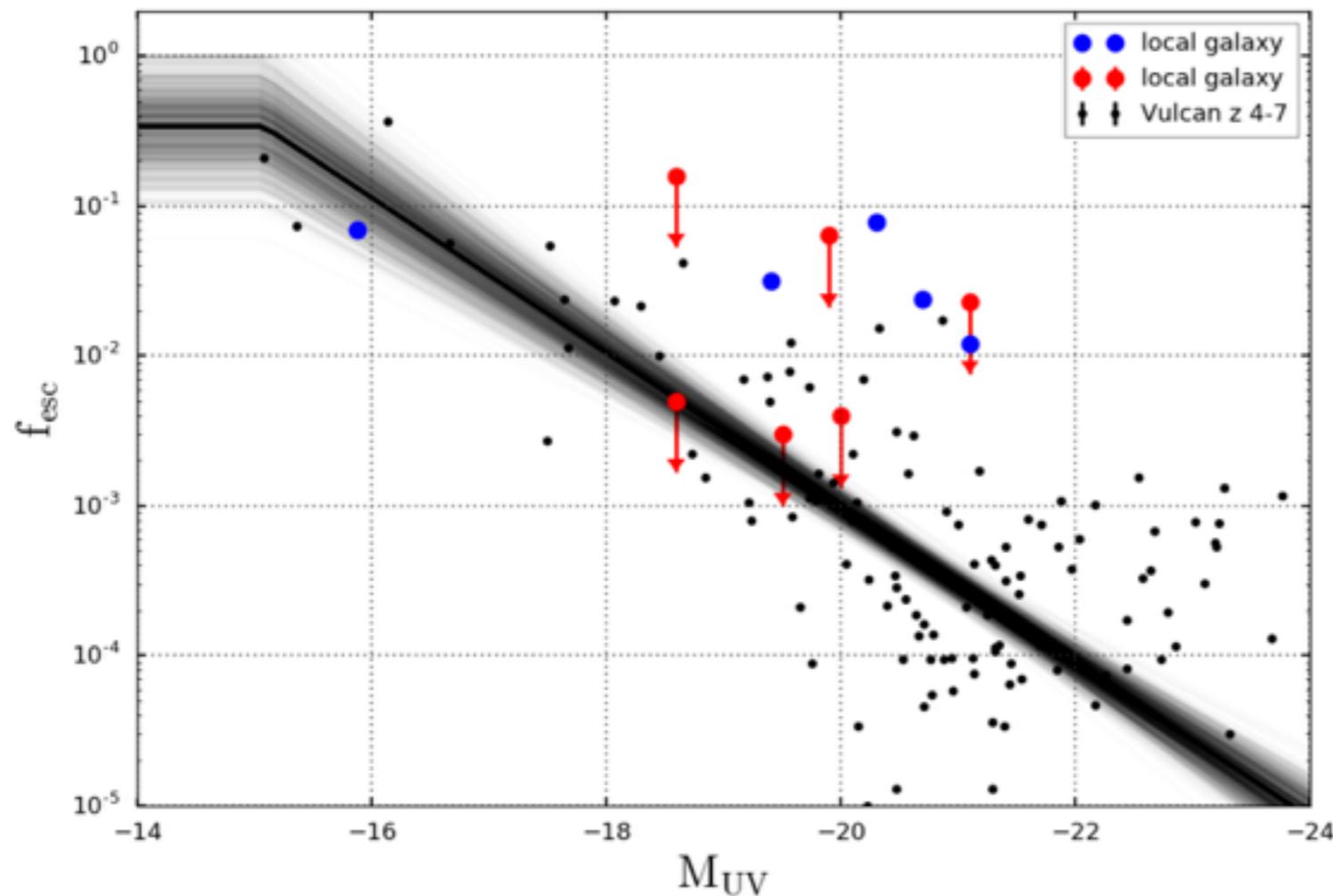
Pawlik et al. (2016)



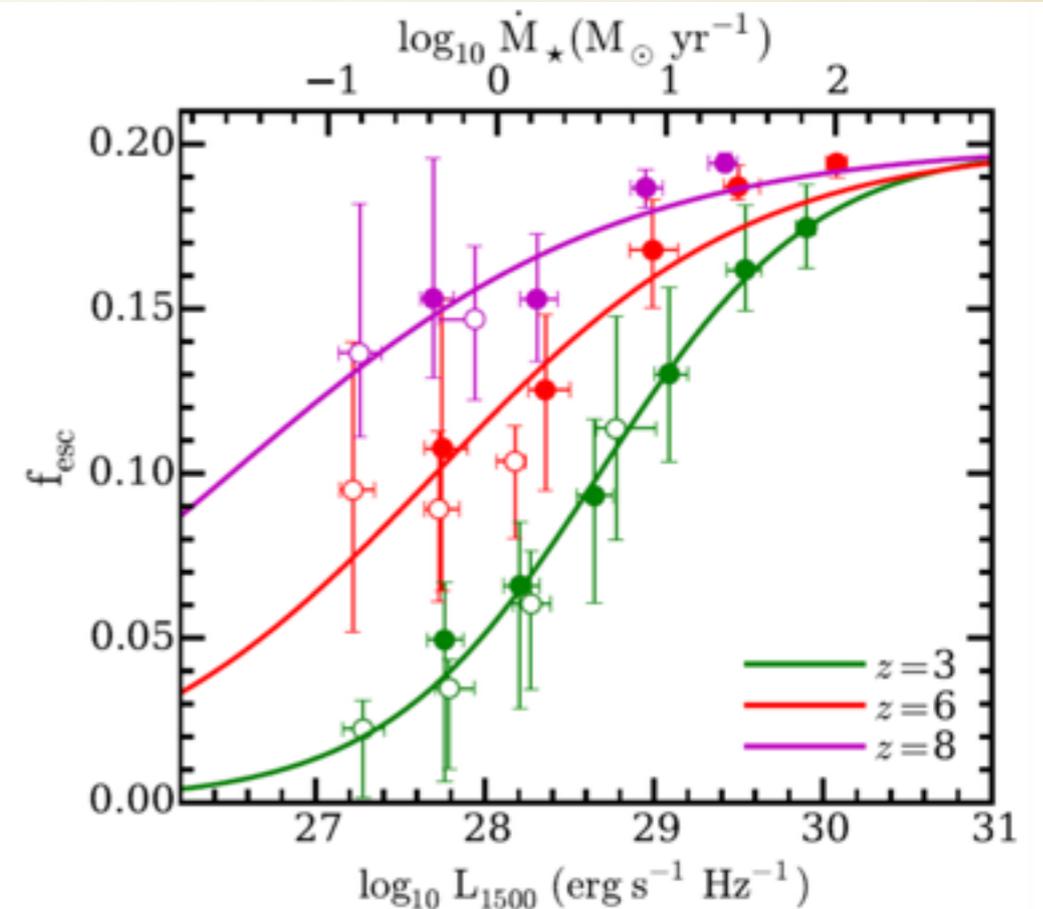
ALSO PREDICT:

F_{ESC} VARIES WITH MASS

...BUT IN WHAT WAY?



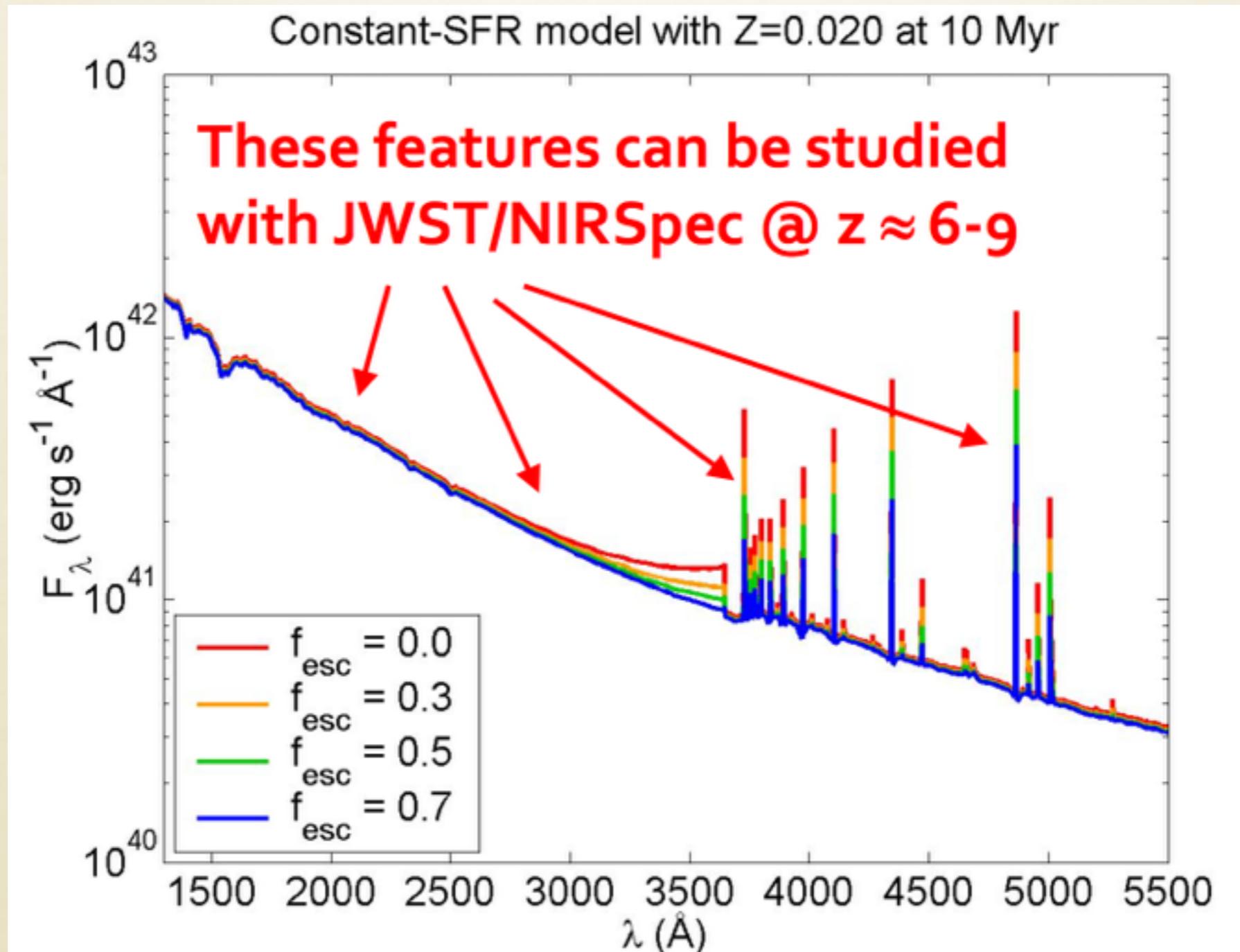
Anderson et al. (2016)

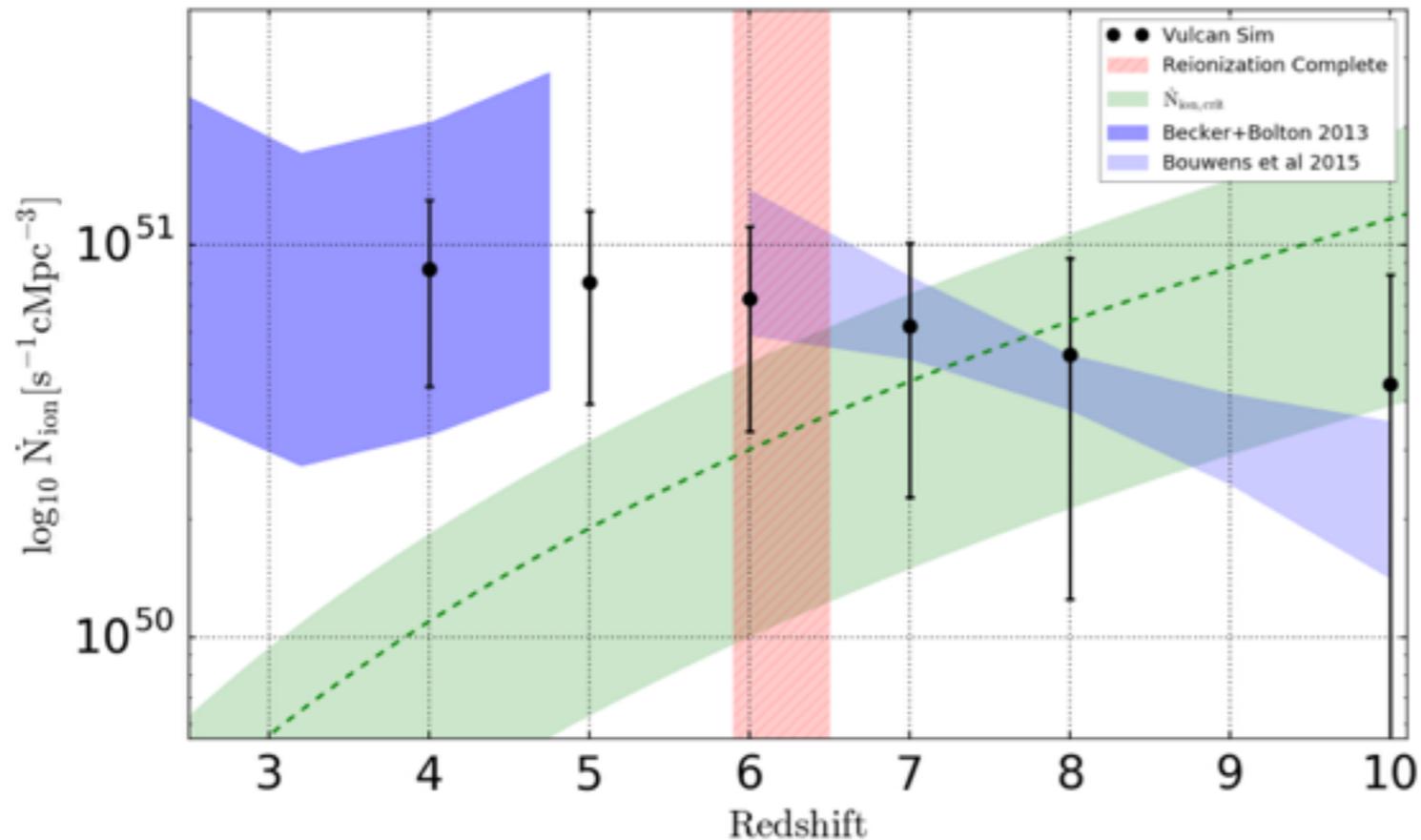


Sharma et al. (2016)

...AND VARY WITH TIME?

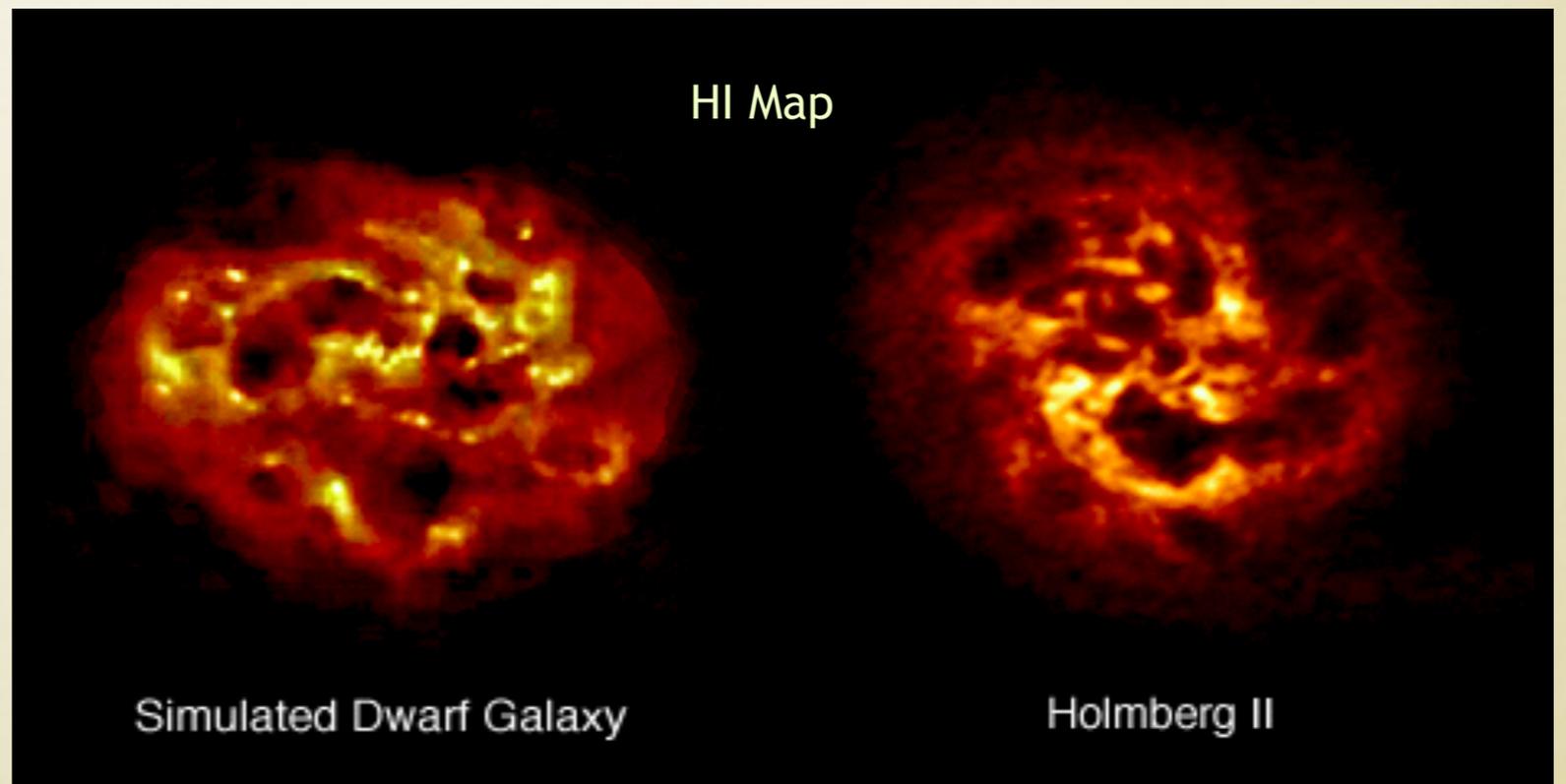
BUT WE'LL RELY ON PROXIES TO ESTIMATE



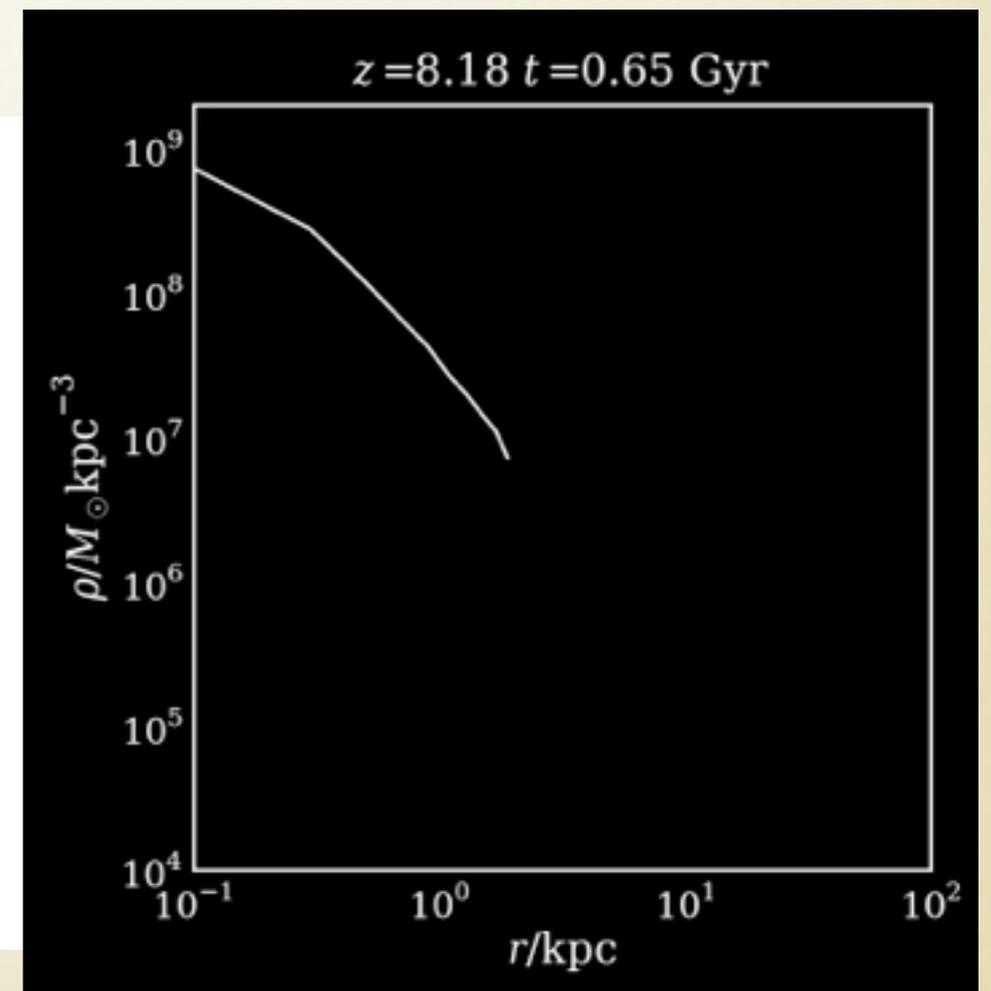
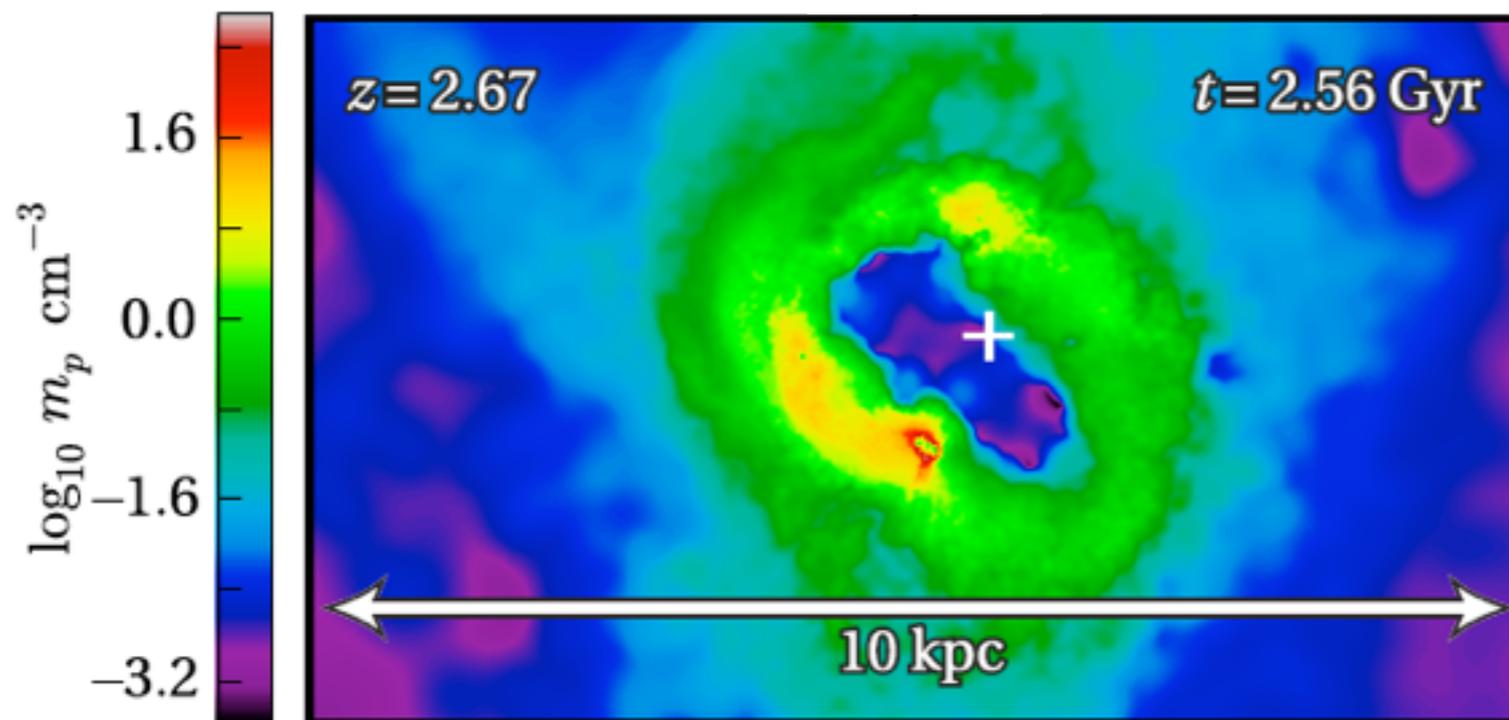


Stellar feedback alone is suggested to be sufficient to reionize and maintain

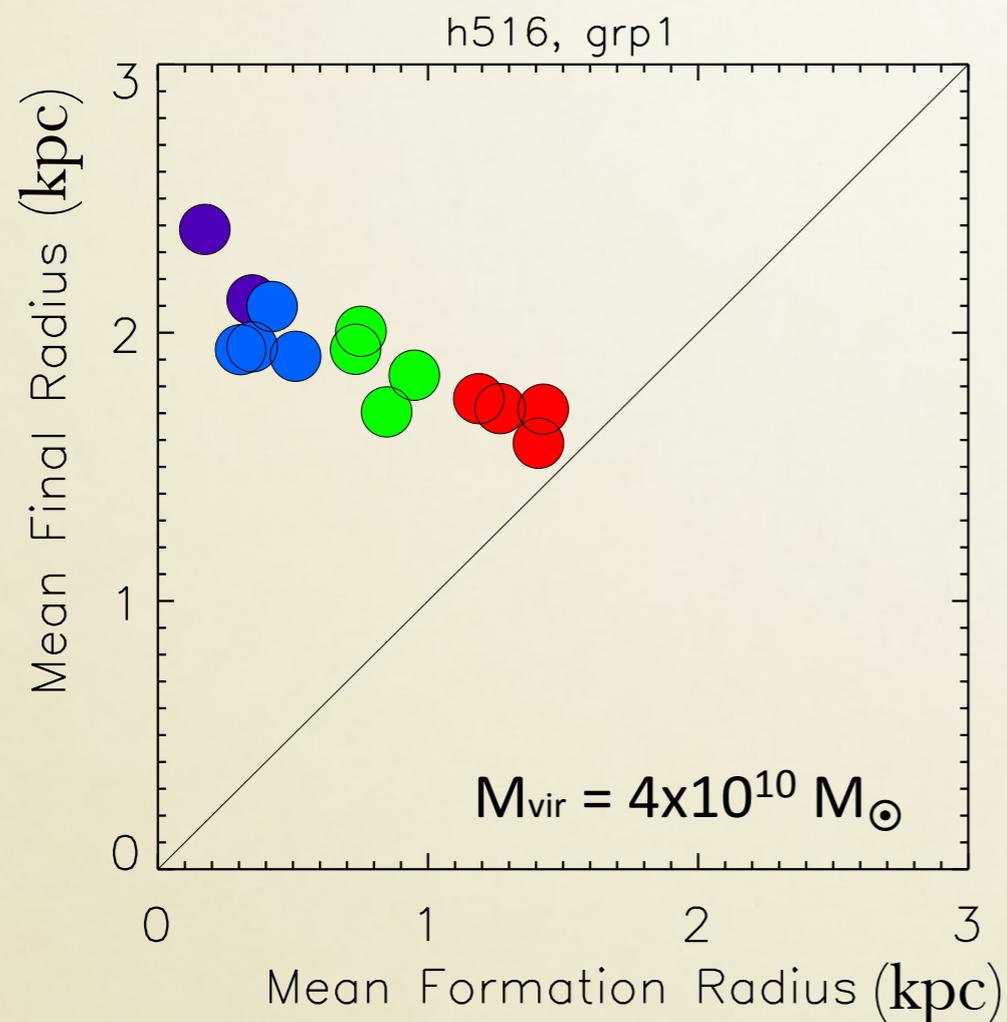
Ionizing radiation thought to escape along “chimneys” created in the neutral gas by feedback.



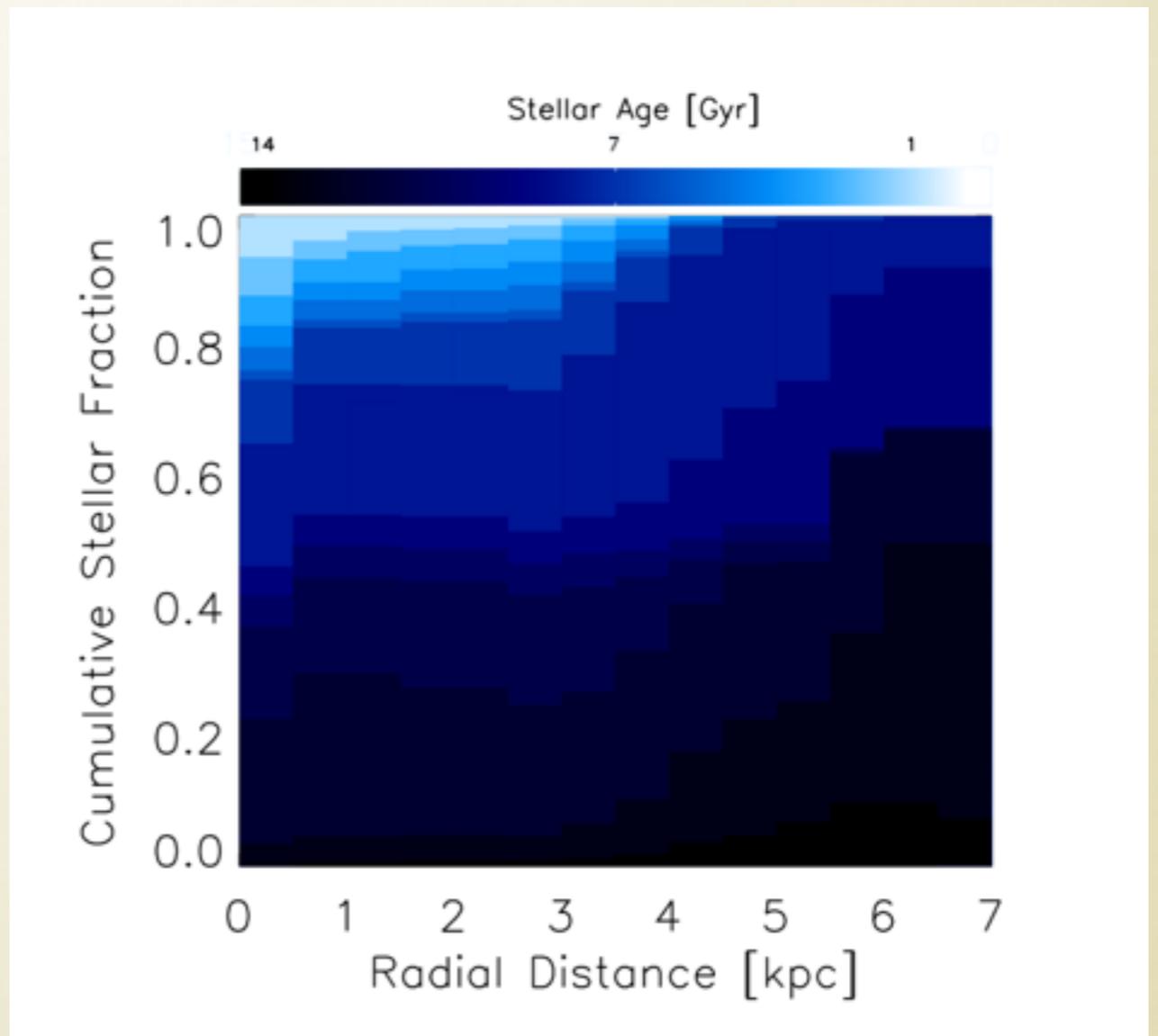
LOW Z:
SAME PROCESS THAT CREATES CHIMNEYS
CREATES DARK MATTER CORES



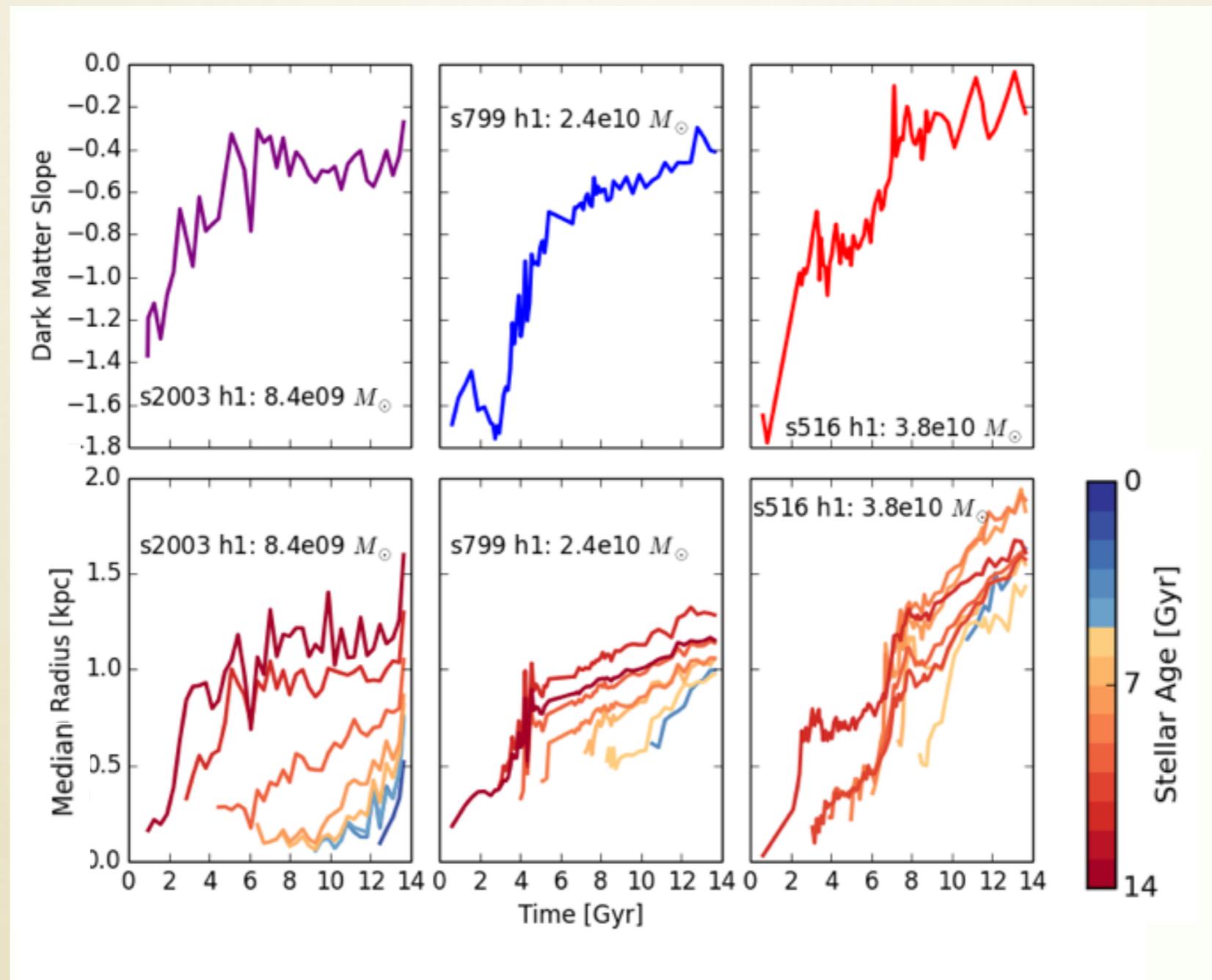
IN DWARFS, THE STARS THAT FORMED CLOSEST TO THE CENTER ARE THE FURTHEST OUT AT Z=0



Purple = oldest stars,
Red = youngest stars



MIGRATION OF STARS TRACKS CHANGING DM SLOPE

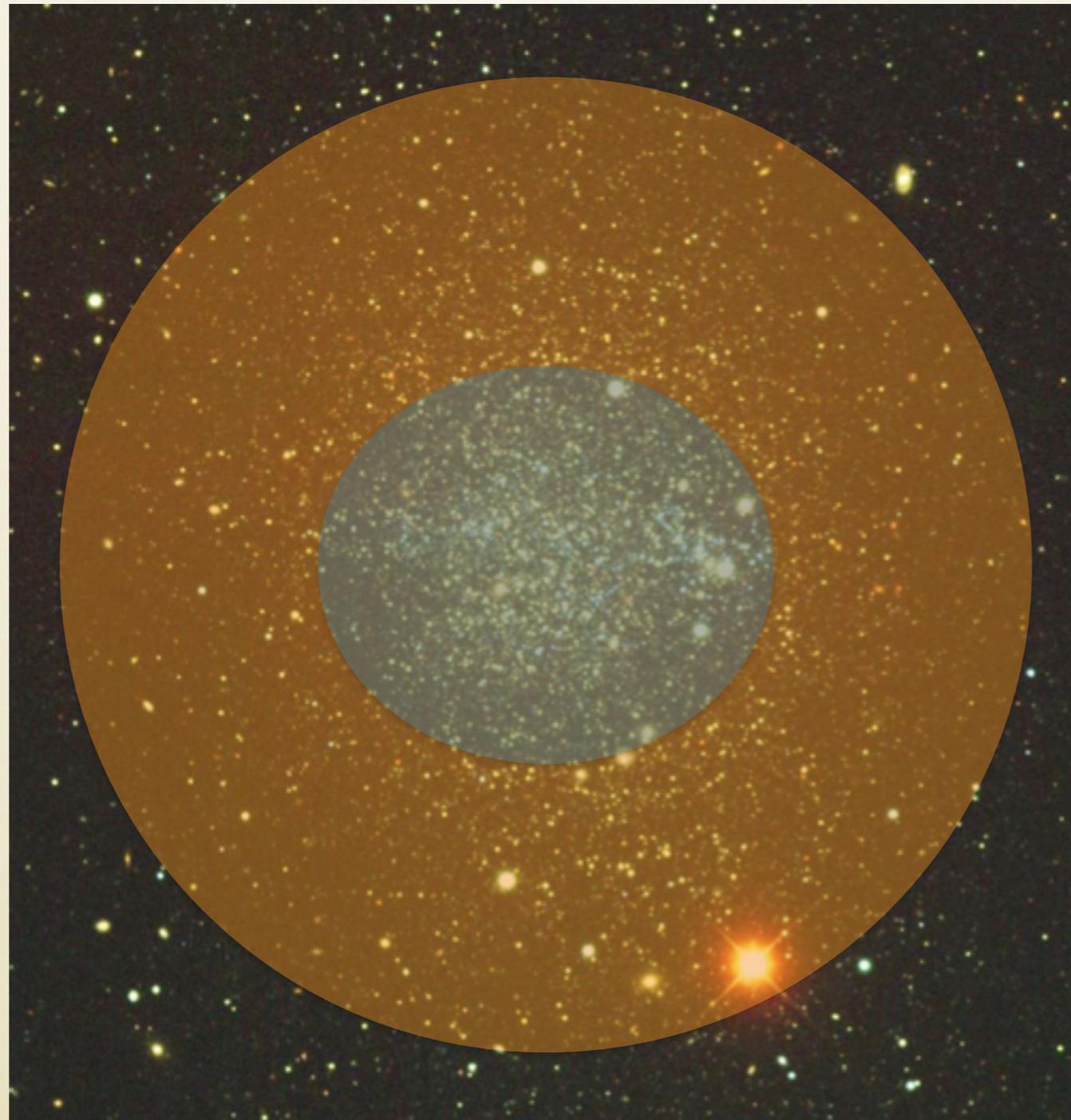


DWARF GALAXIES ARE GENERALLY
YOUNG ON THE INSIDE, OLD ON THE OUTSIDE



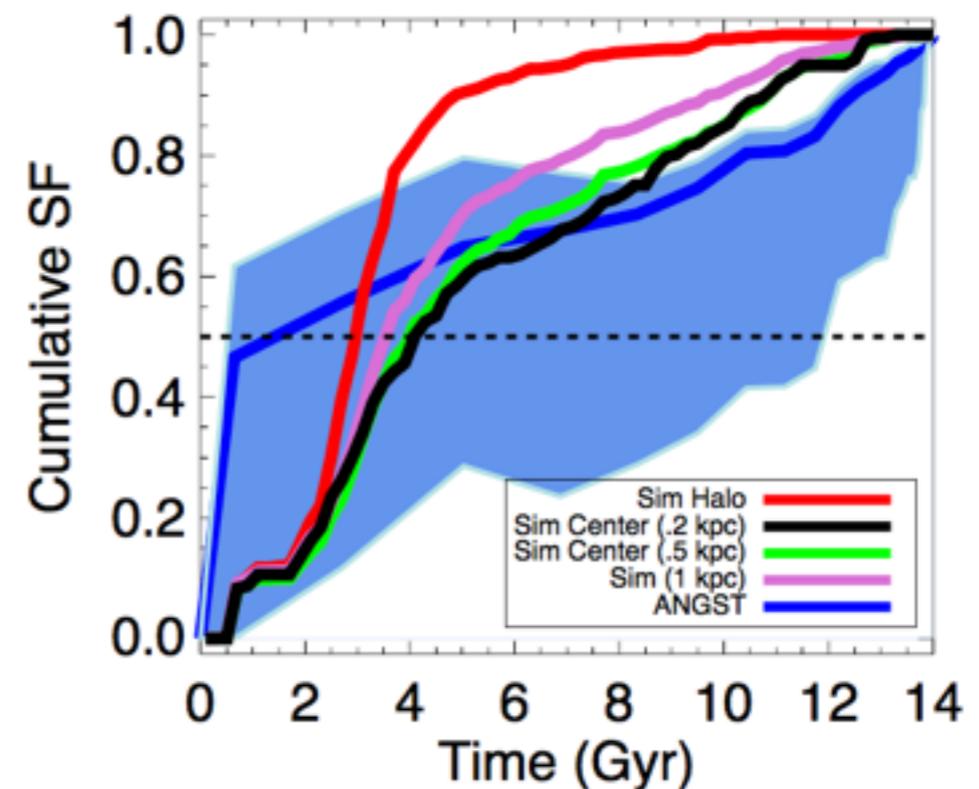
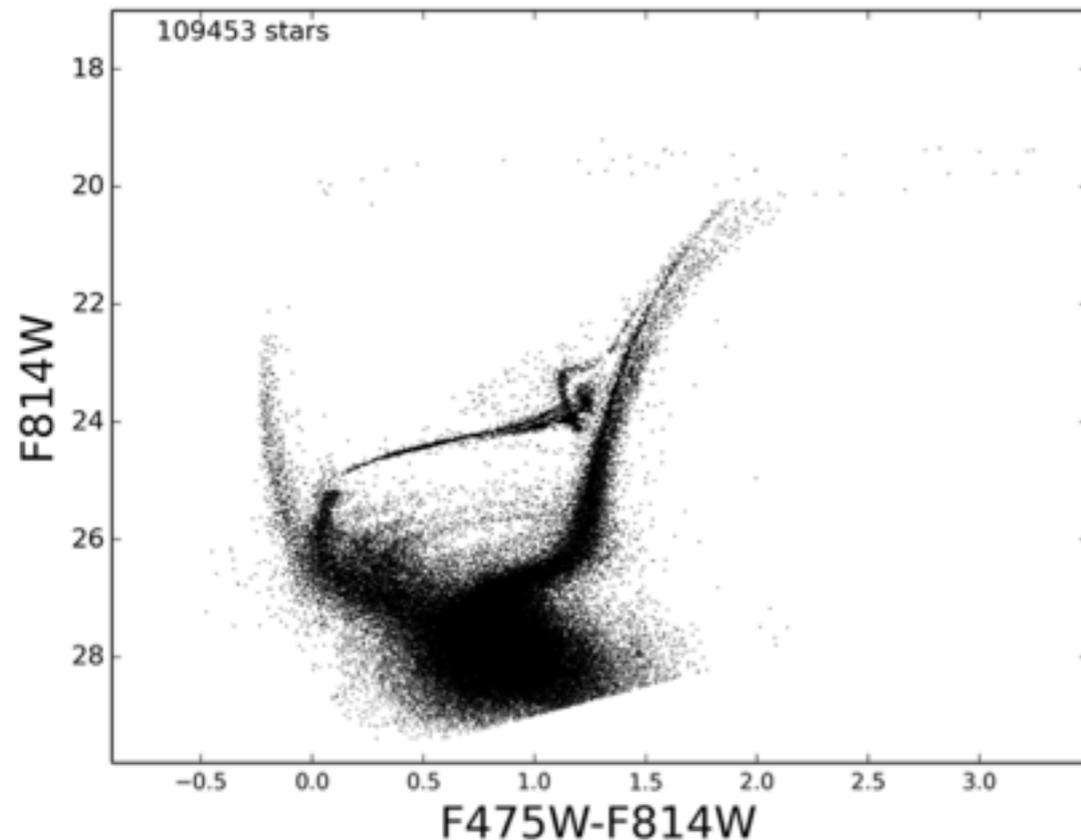
Phoenix Dwarf

DWARF GALAXIES ARE GENERALLY
YOUNG ON THE INSIDE, OLD ON THE OUTSIDE



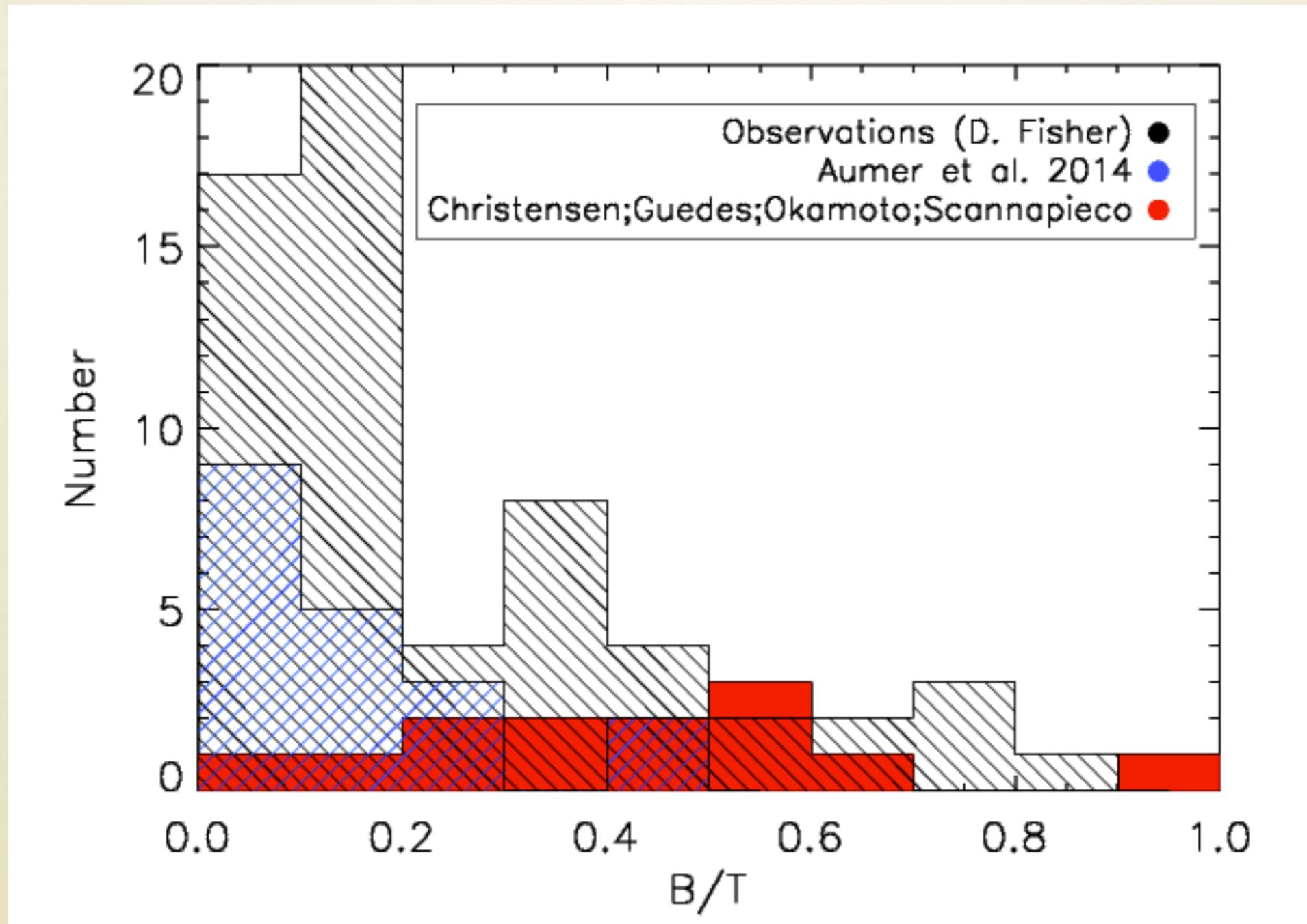
Phoenix Dwarf

**CAVEAT EMPTOR:
TO TRACE THE OLDEST STARS,
DON'T LOOK (JUST) AT THE CENTER!**



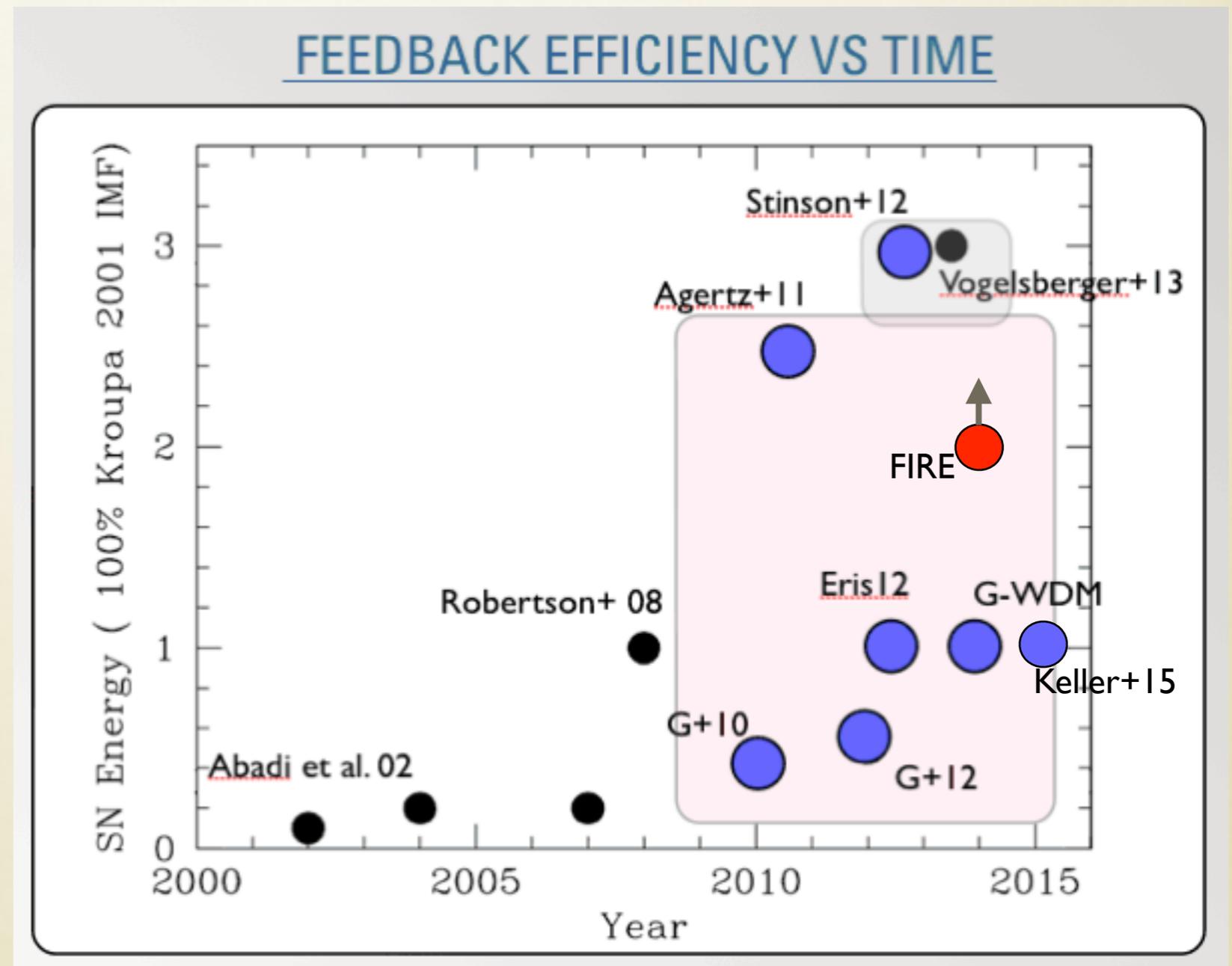
SEE DAN WEISZ'S TALK ON THURSDAY

MID-Z: FEEDBACK THAT CREATES REALISTIC DWARFS FAILS IN MILKY WAY-MASS GALAXIES



HOW TO MATCH EVERYTHING, INCLUDING THE HIGH Z $M_{\text{STAR}}-M_{\text{HALO}}$ RELATION

More feedback,
please

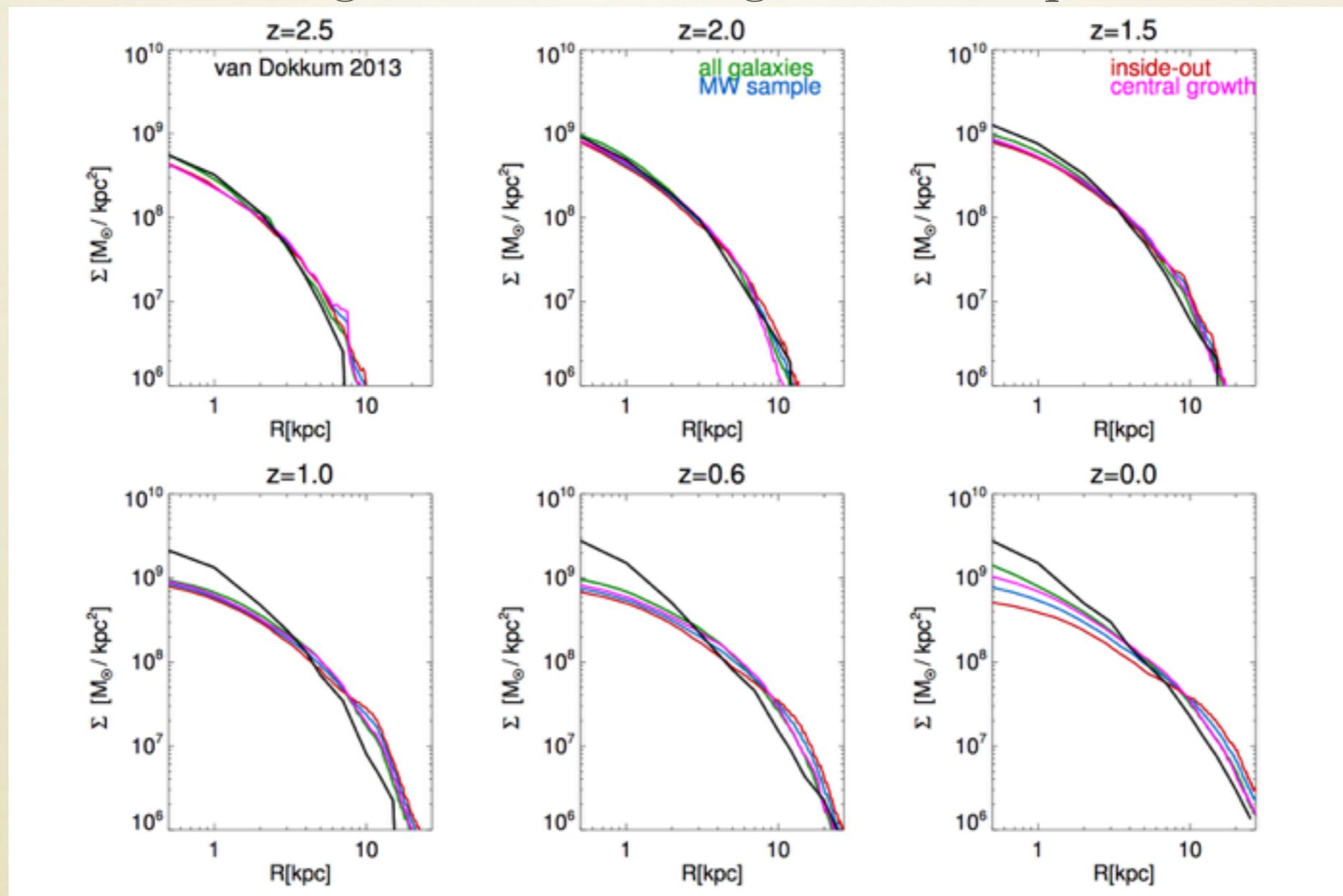


USING THE FULL RANGE OF AVAILABLE FEEDBACK

- Supernovae — they go to since the dawn of feedback, but massive stars don't go SNe until ~ 4 Myr after the star particle is born
- Stellar winds — momentum injection from winds of massive stars (up to 1000 km/s)
- UV ionization — formation of HII regions
- Radiation pressure — momentum injection from scattering off dust grains (*highly debated*)

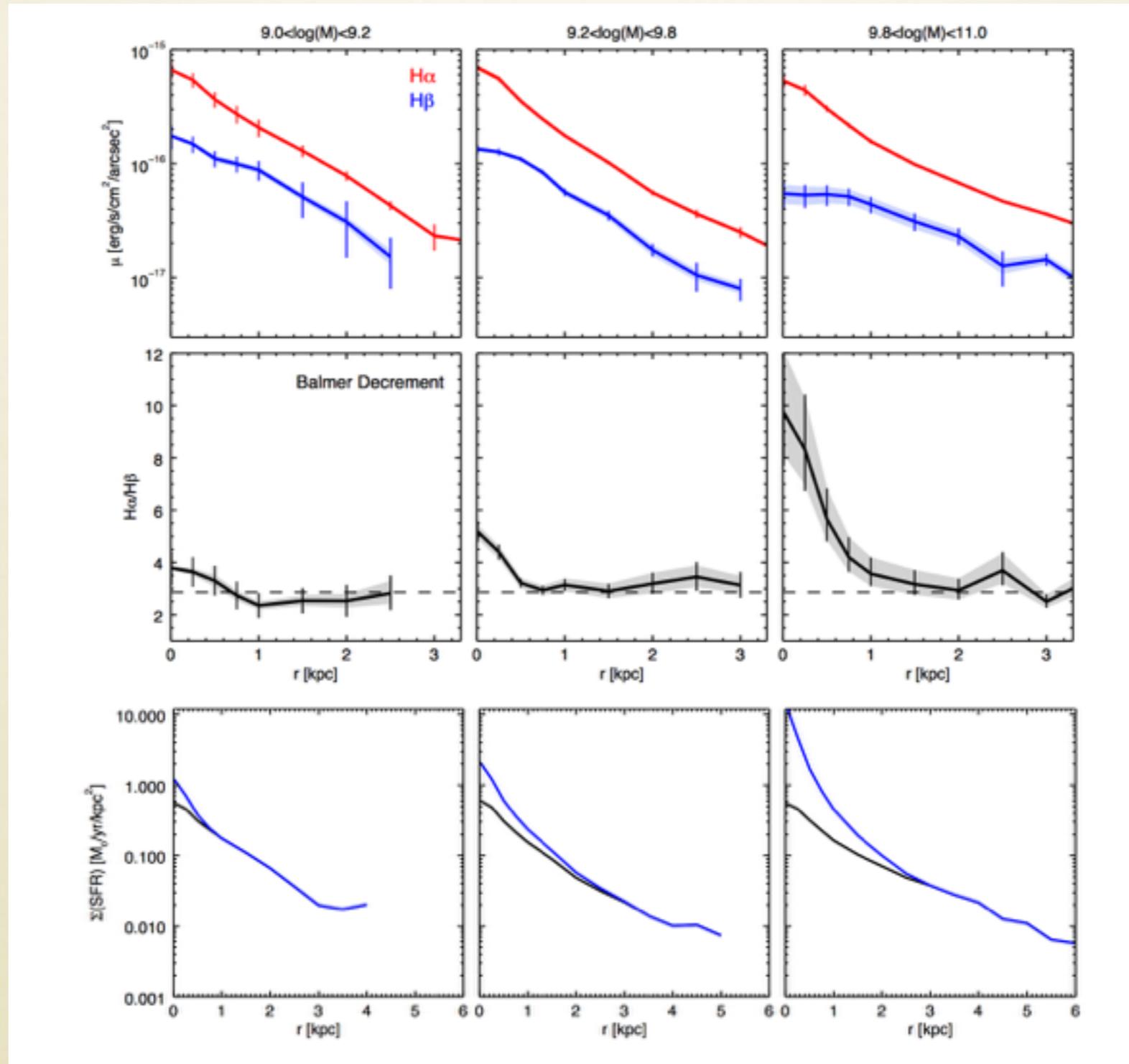
THE DEVIL IS IN THE DETAILS

Simulated MW-mass galaxies with realistic B/T show too much outer disk growth, not enough central mass growth compared to observations



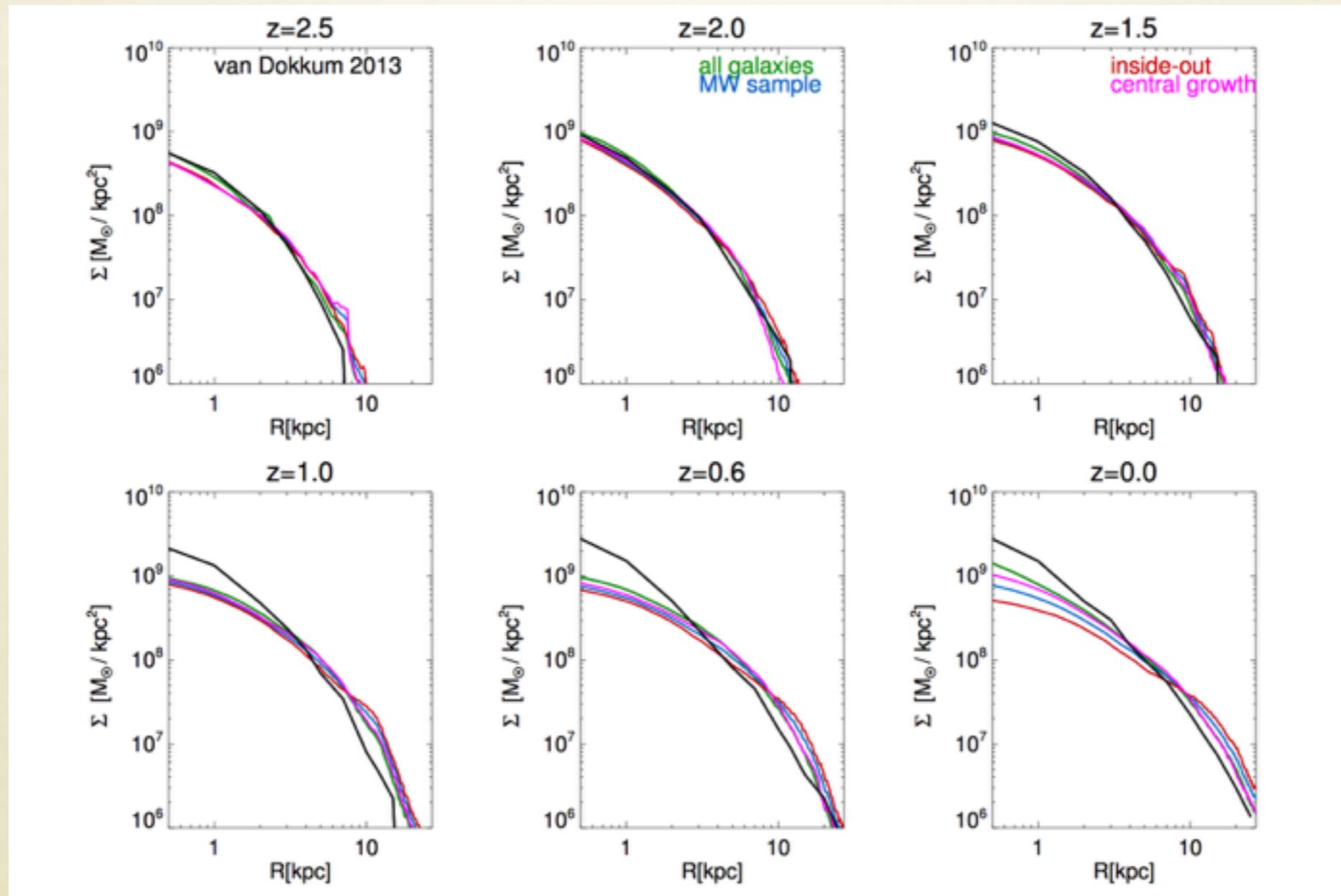
Aumer et al. (2014), data from van Dokkum et al. (2013)

THERE MAY EVEN BE MORE DEVIL IN THE DETAILS

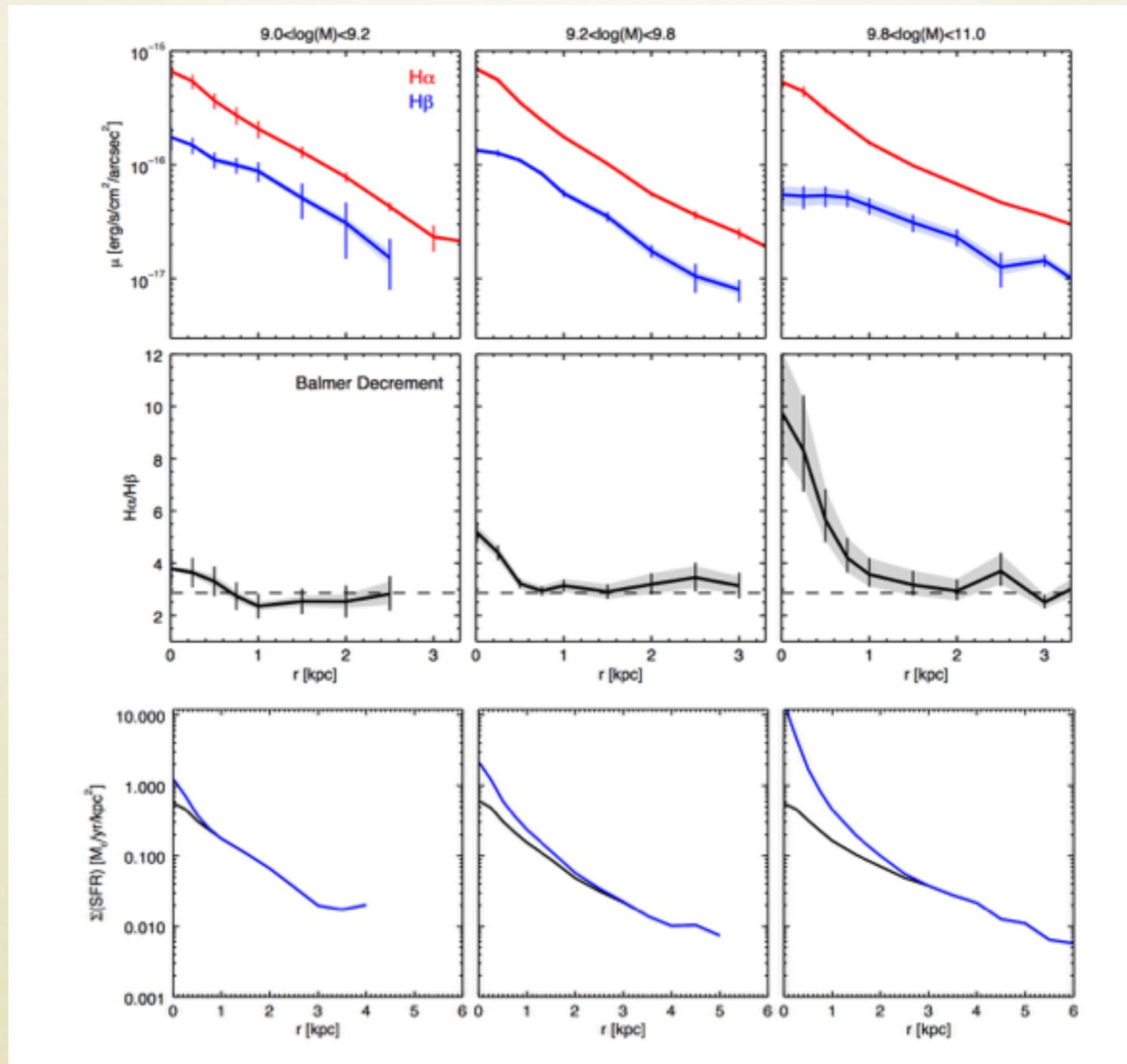


JWST CAN TRACE THIS TO HIGHER Z!

AND POSSIBLY AVOID STACKING AT THESE Z



JWST: LONGER WAVELENGTHS, BETTER TRACER OF TRUST VIA SED



CONCLUSIONS

- High z : JWST will probe LFs to higher z and fainter. Predict will find (1) higher cosmic star formation rate, (2) steeper faint end slopes, (3) some fraction of galaxies with escaping LyC
- Low z : Dan Weisz will show us how to connect low z and high z star formation histories, but be careful to collect all the low z data (age gradients in resolved populations)
- Mid z : Conundrum - strong feedback in simulations that can create realistic B/T ratios can't match the observed evolution in bulge and disk stellar surface density. Situation is even worse if central dust obscuration is real! JWST can provide more/better data, clarify the dust question.