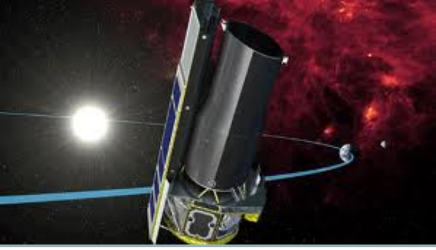


Does the Stellar IMF Evolve with Redshift?

Insights from z>4 Field Galaxies and Gamma-Ray Bursts

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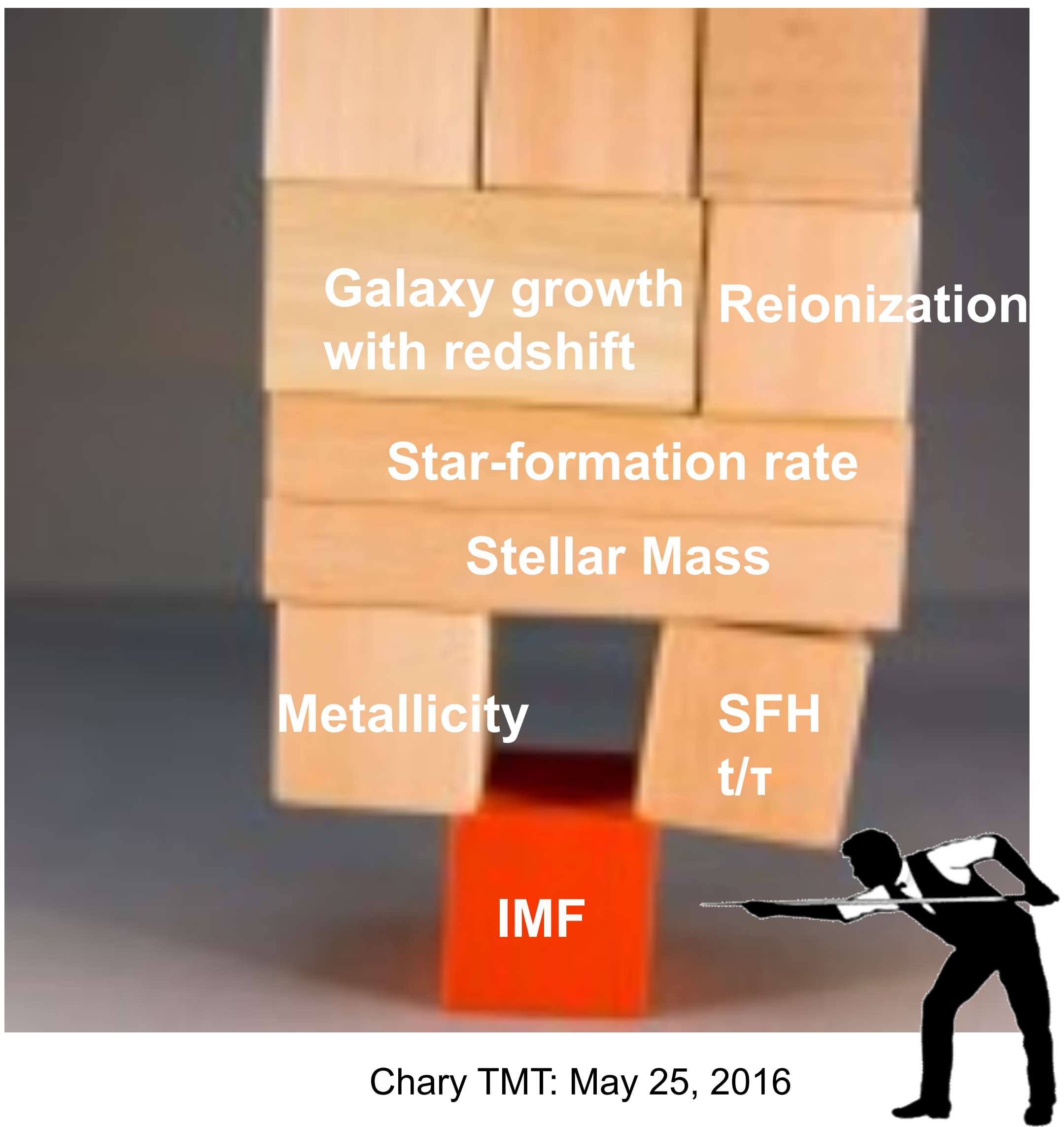
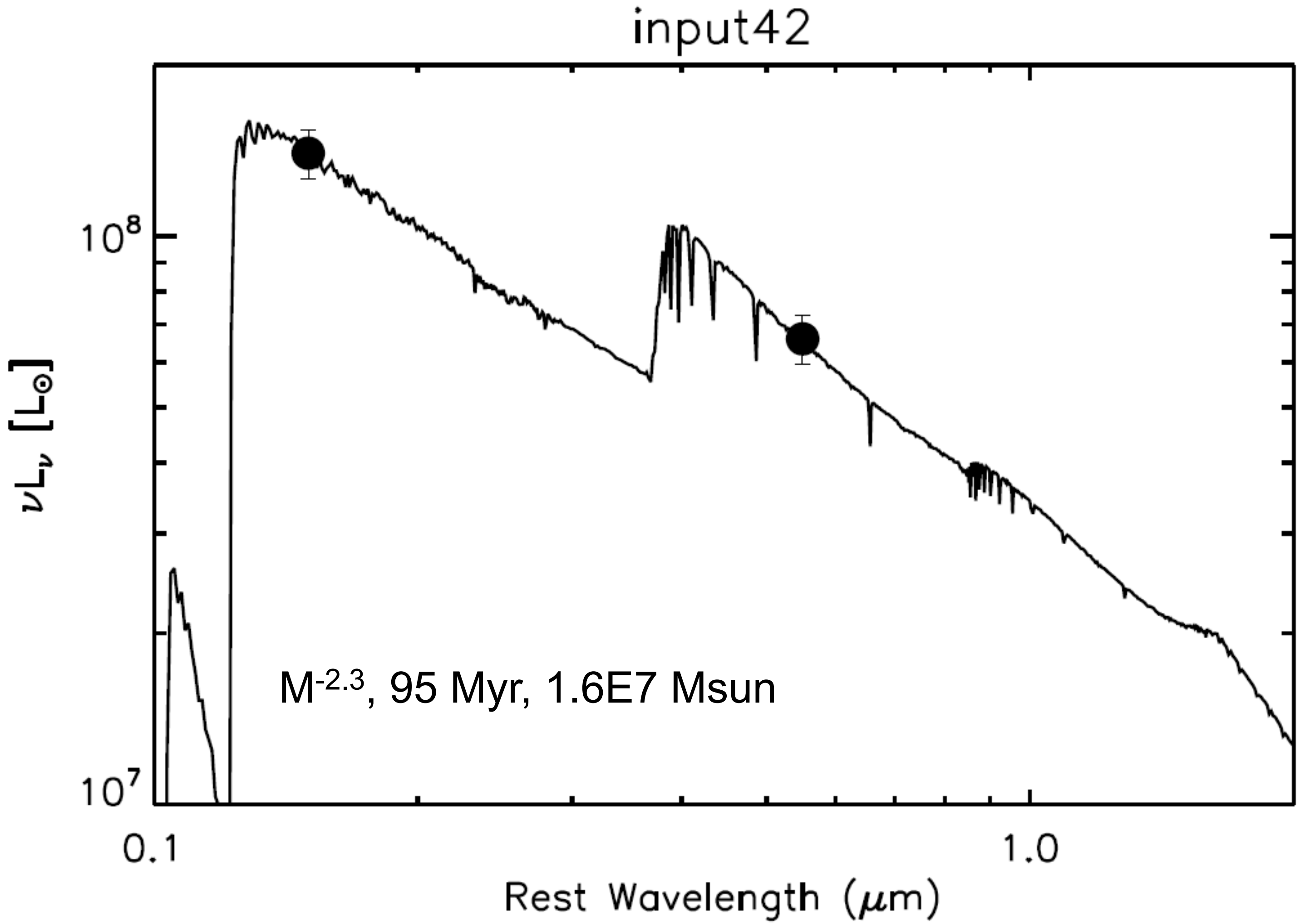
U.S. Planck Data Center/IPAC
California Institute of Technology

IMF: A Fundamental Parameter in Galaxy Evolution

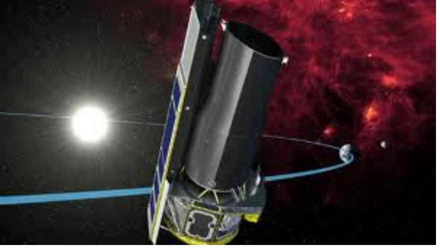


Differences in SED fitting are small

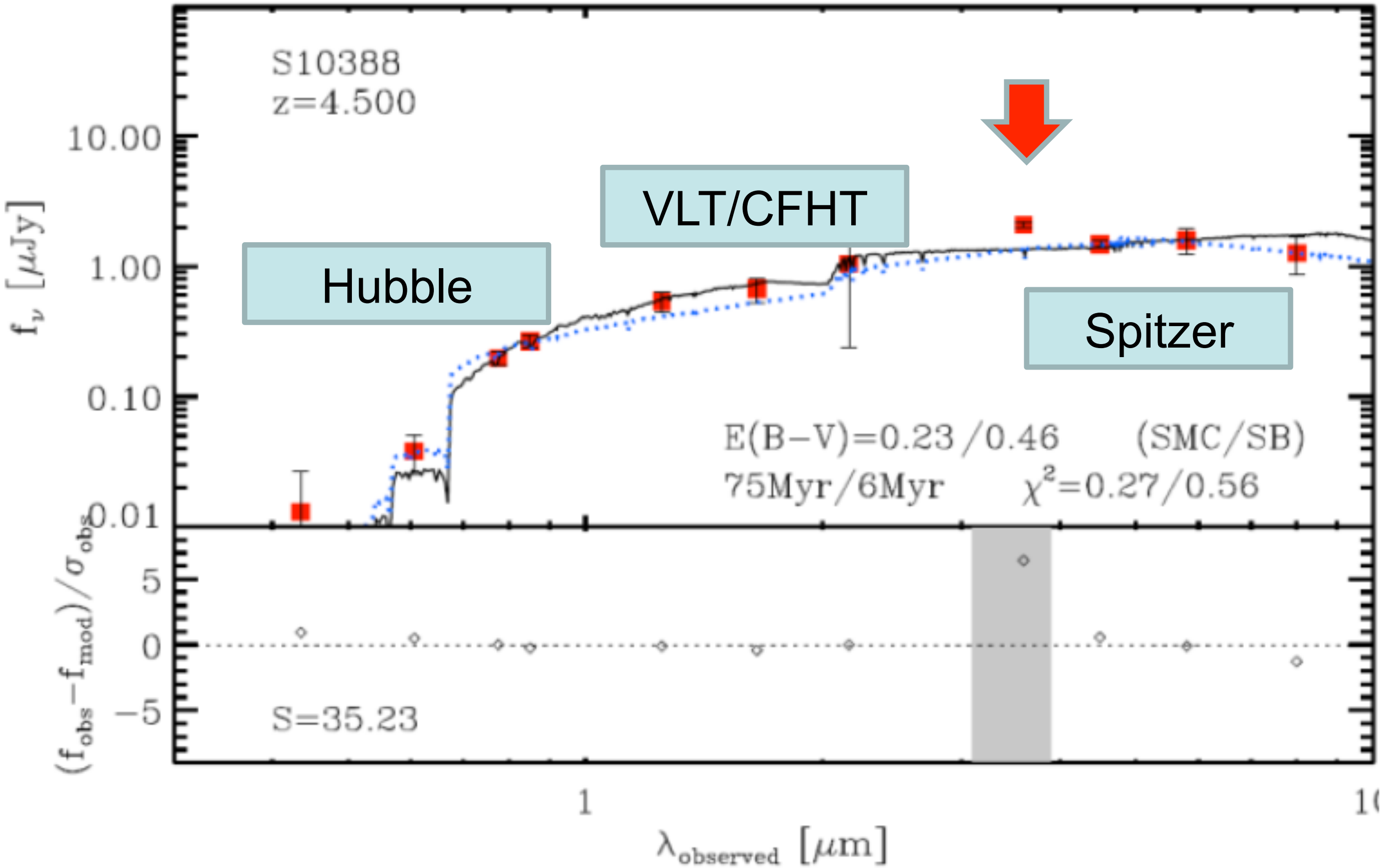


Evidence is clear…

- Results on field galaxies at z~5
- Balancing CMB tau, stellar mass density and UV luminosity functions at z>6
- Long-duration GRB rates at z>3
- How can TMT address this question?



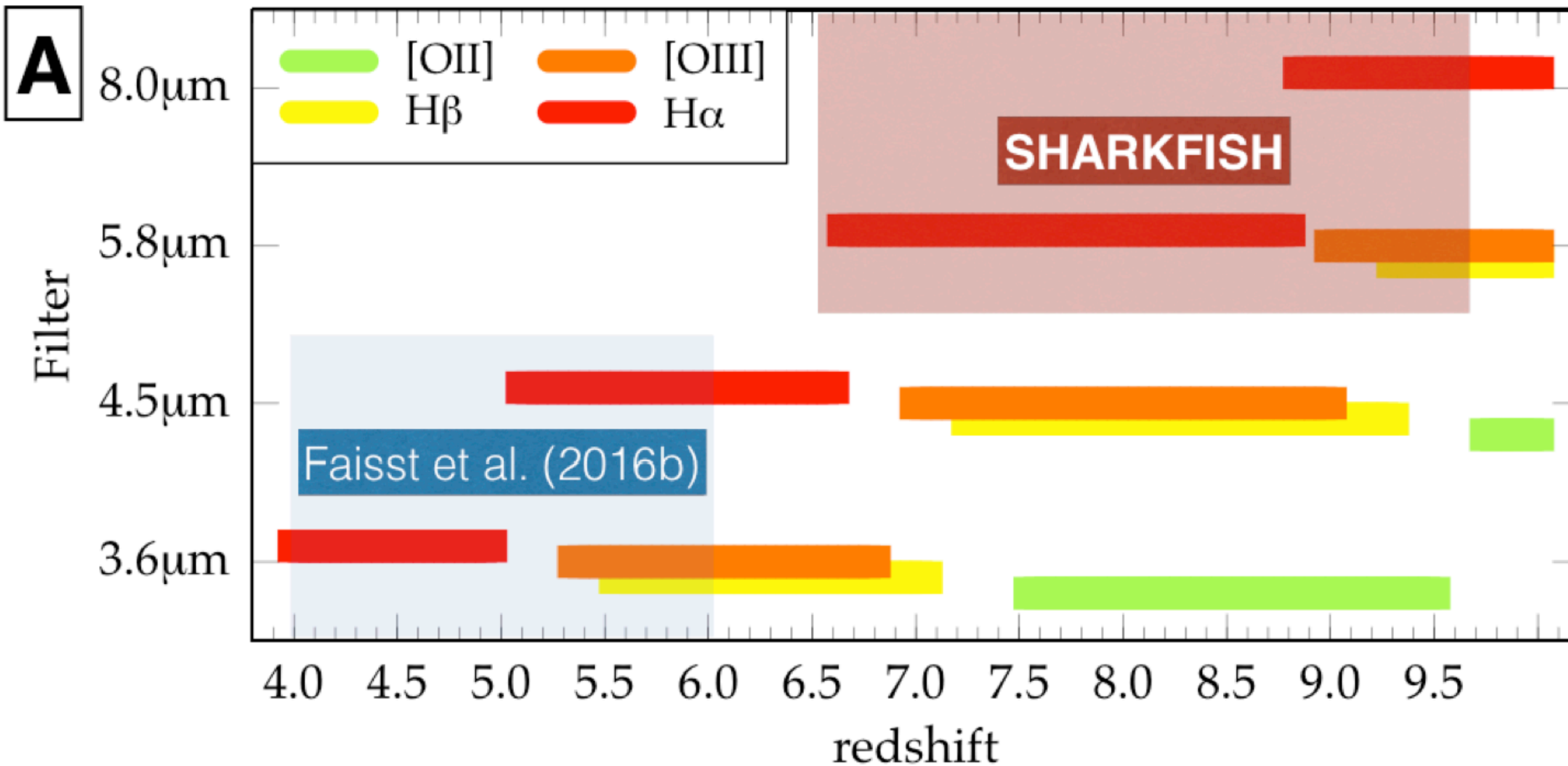
Unexpected surprises in 3.8<z<5 galaxies



Shown by 70% of spectroscopically confirmed 3.8<z<5 galaxies in Spitzer data

Chary et al. 2005
Shim, RC, et al. 2011

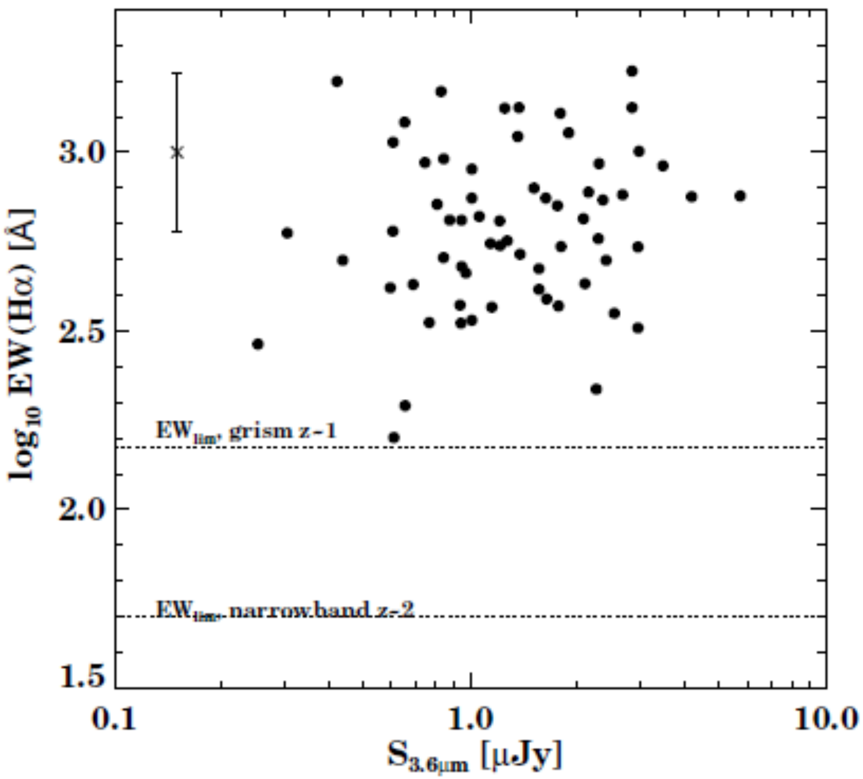
The excess must arise from Hα nebular emission



From A. Faisst

Unusually high EW compared to other star-forming galaxies at lower redshifts

GOODS at 3.8<z<5



HST grism surveys at z<2

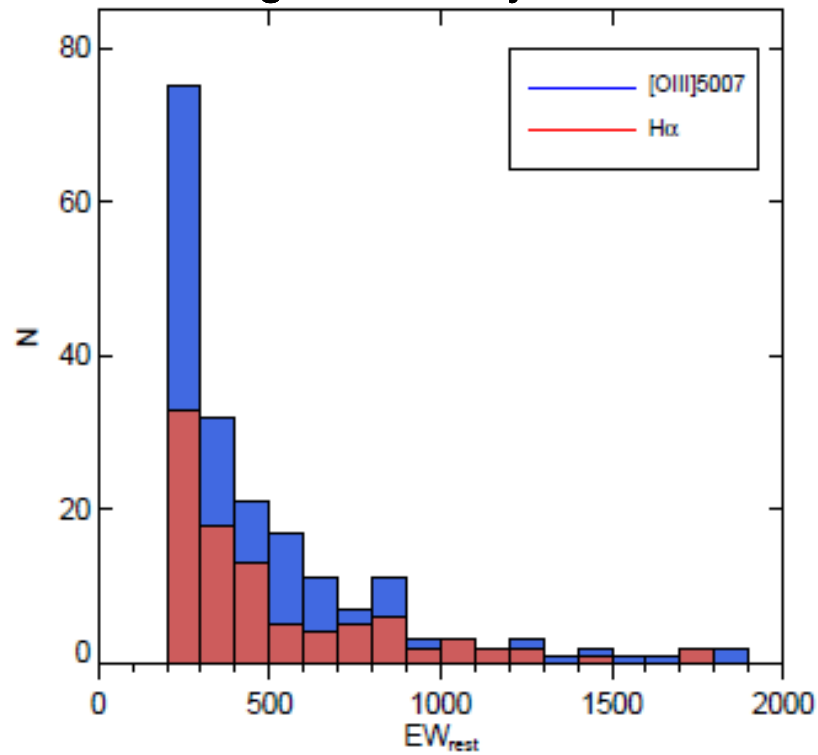
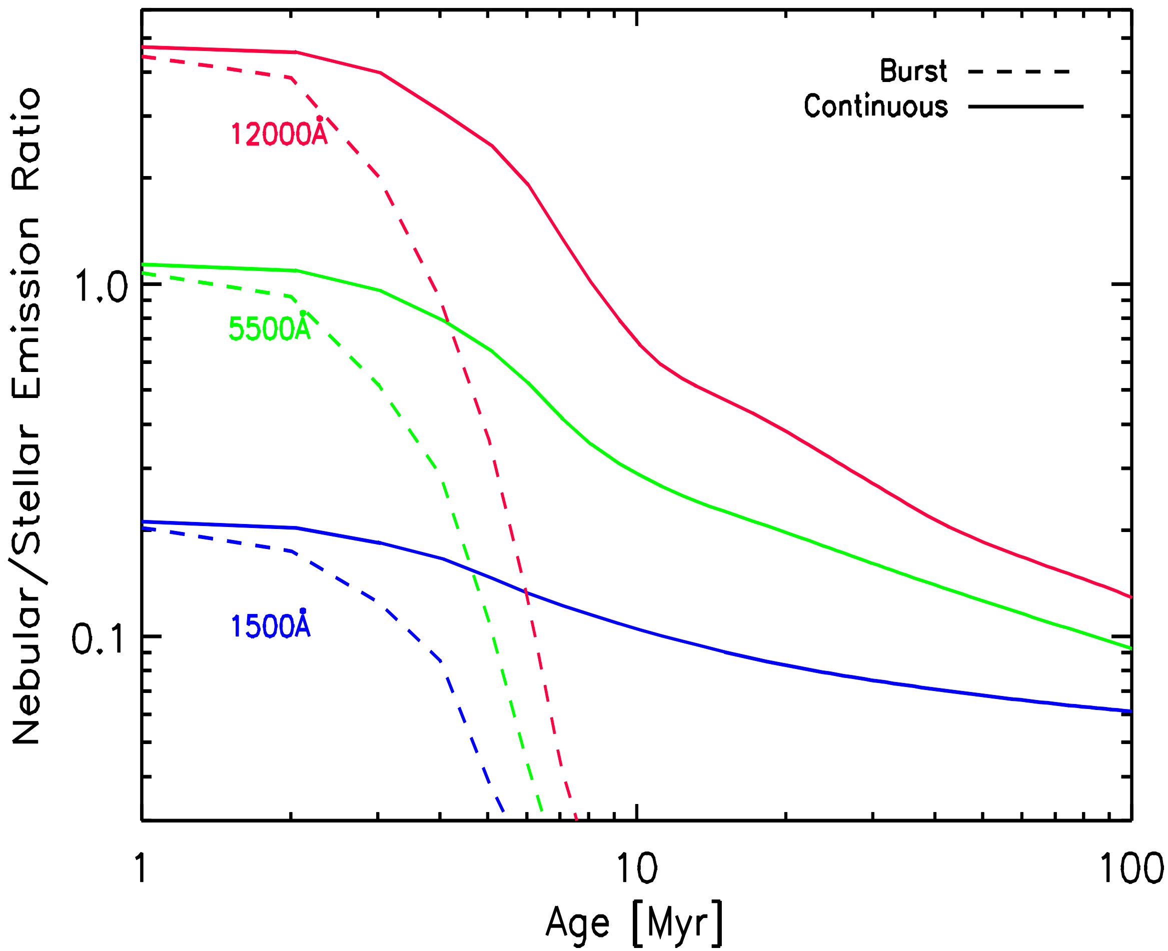


FIG. 2.— Rest-frame equivalent width distribution for objects with EW ≥ 200 Å in the WISP Survey. The total number in each bin is divided into the [OIII] λ5007 line (presented in blue) and the Hα line (presented in red).

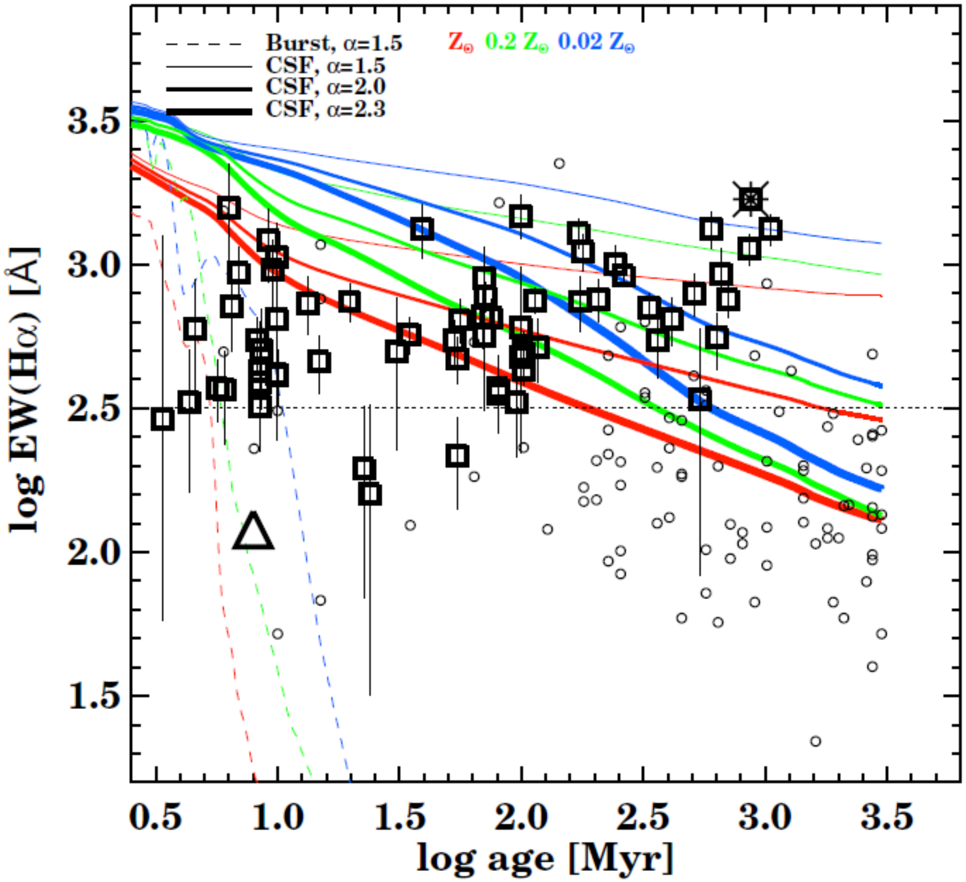
Atek et al. 2011, Fumagalli et al. 2012

Even exist in 0.01% of galaxies at z~0 in the Sloan survey! (Shim & Chary 2013)

Probing Instantaneous SFR: The Boon of Nebular Emission



It is not an age or AGN effect.....

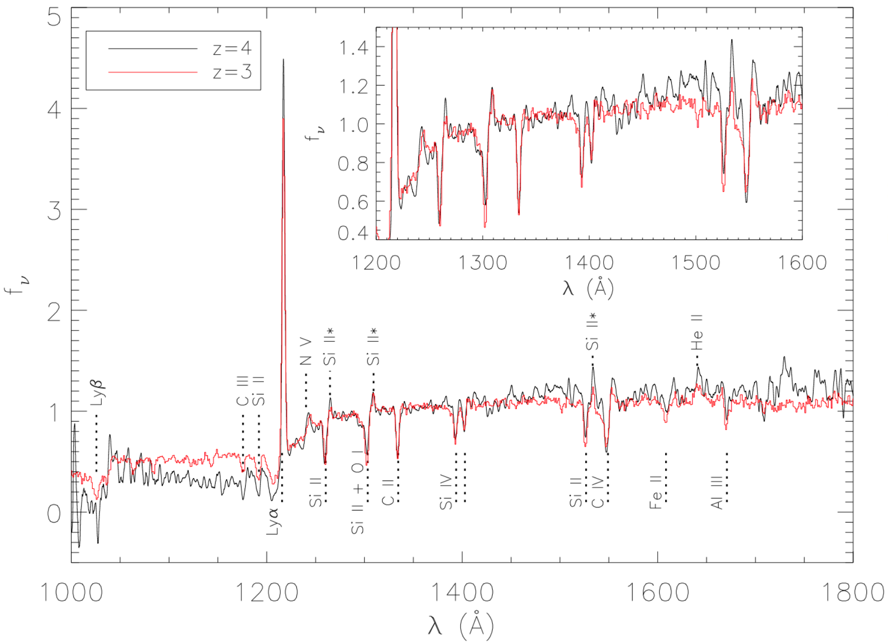


Shim et al. 2011
RC 2008

- If galaxies were undergoing ~10 Myr long bursts, ~1% of galaxies would show strong Halpha.
- Instead 70% do, some with evolved ages of up to 1 Gyr
- Implies constant (or even rising) SF, but with a top-heavy IMF in some cases
- Really need HeII: classic signature of massive stars in local analogs

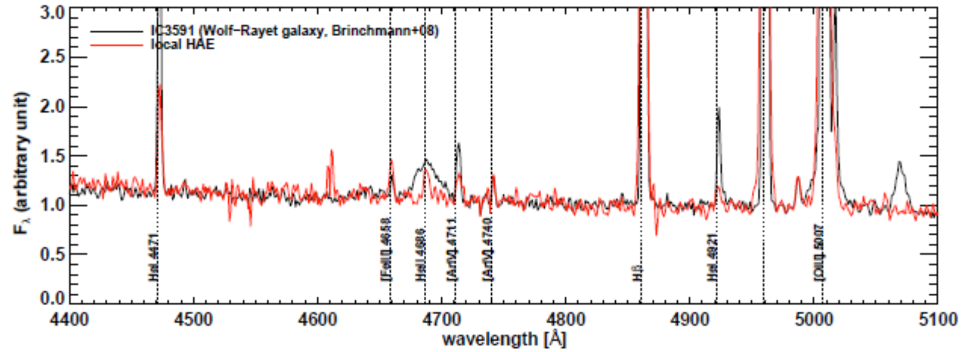
First confirmation of HeII through spectroscopy

HeII 1640 in stack of ~80 z~4 galaxies



T. Jones, R. Ellis et al. 2012

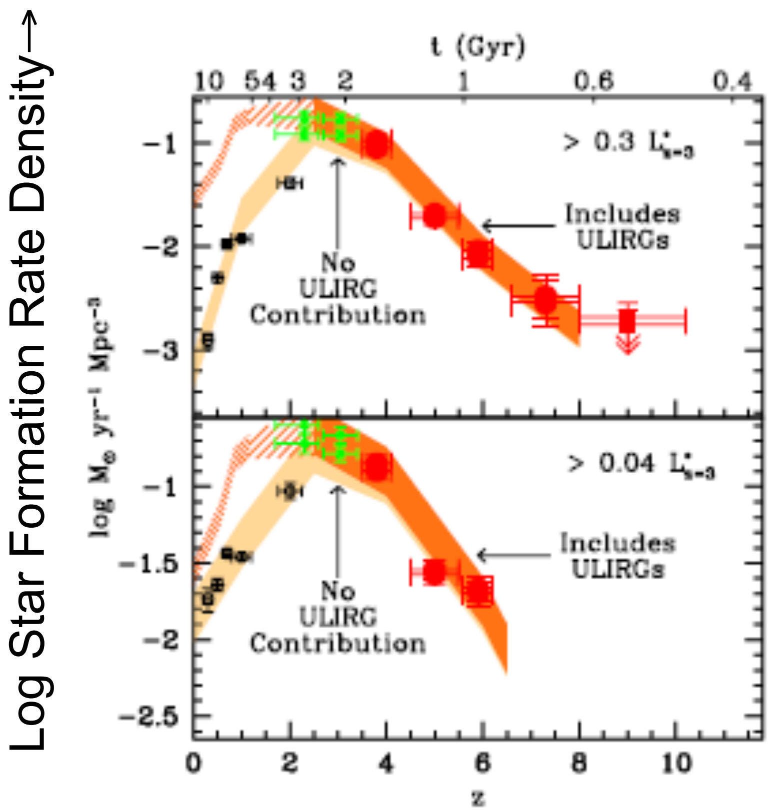
HeII 4686 in stack of ~200 z~0 galaxies



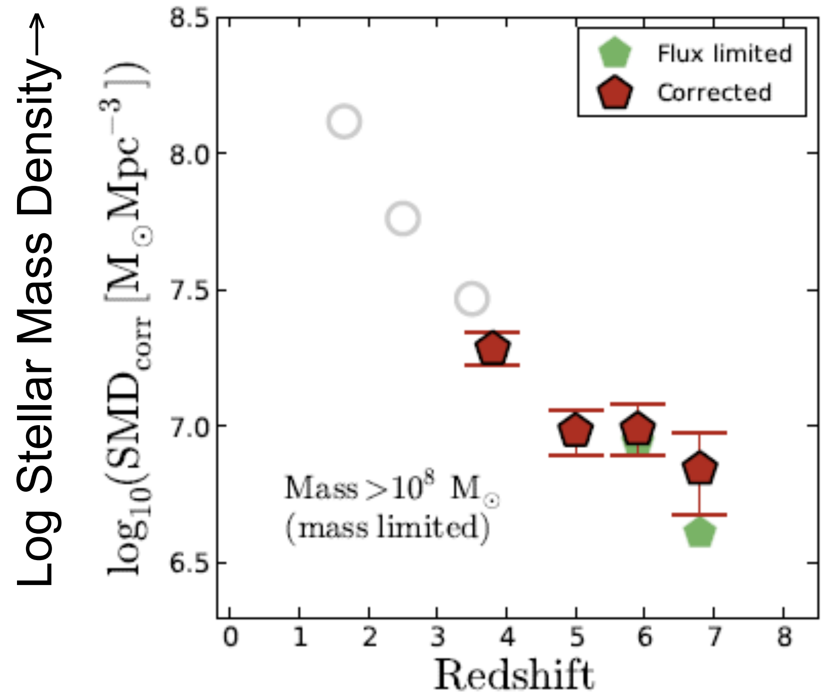
Shim & RC 2013

II. Comparing z>6 UVLF with visible light luminosity density and CMB tau

The Evolution of SFR and SMD with redshift

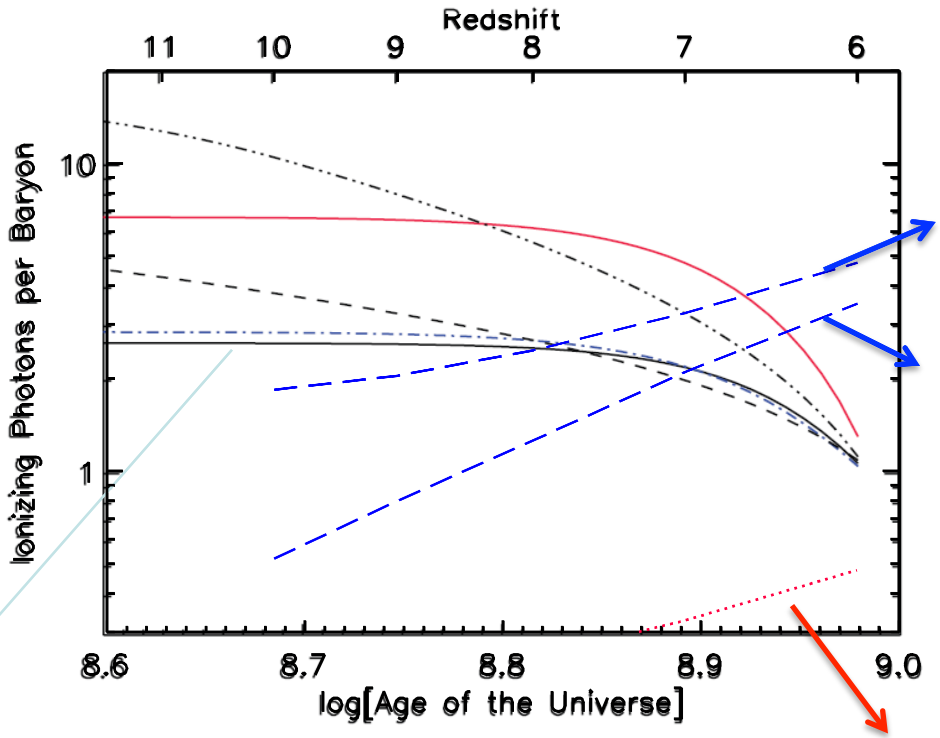


Bouwens et al. 2010



Dickinson et al. 2003
Gonzalez et al. 2011
RC 2008

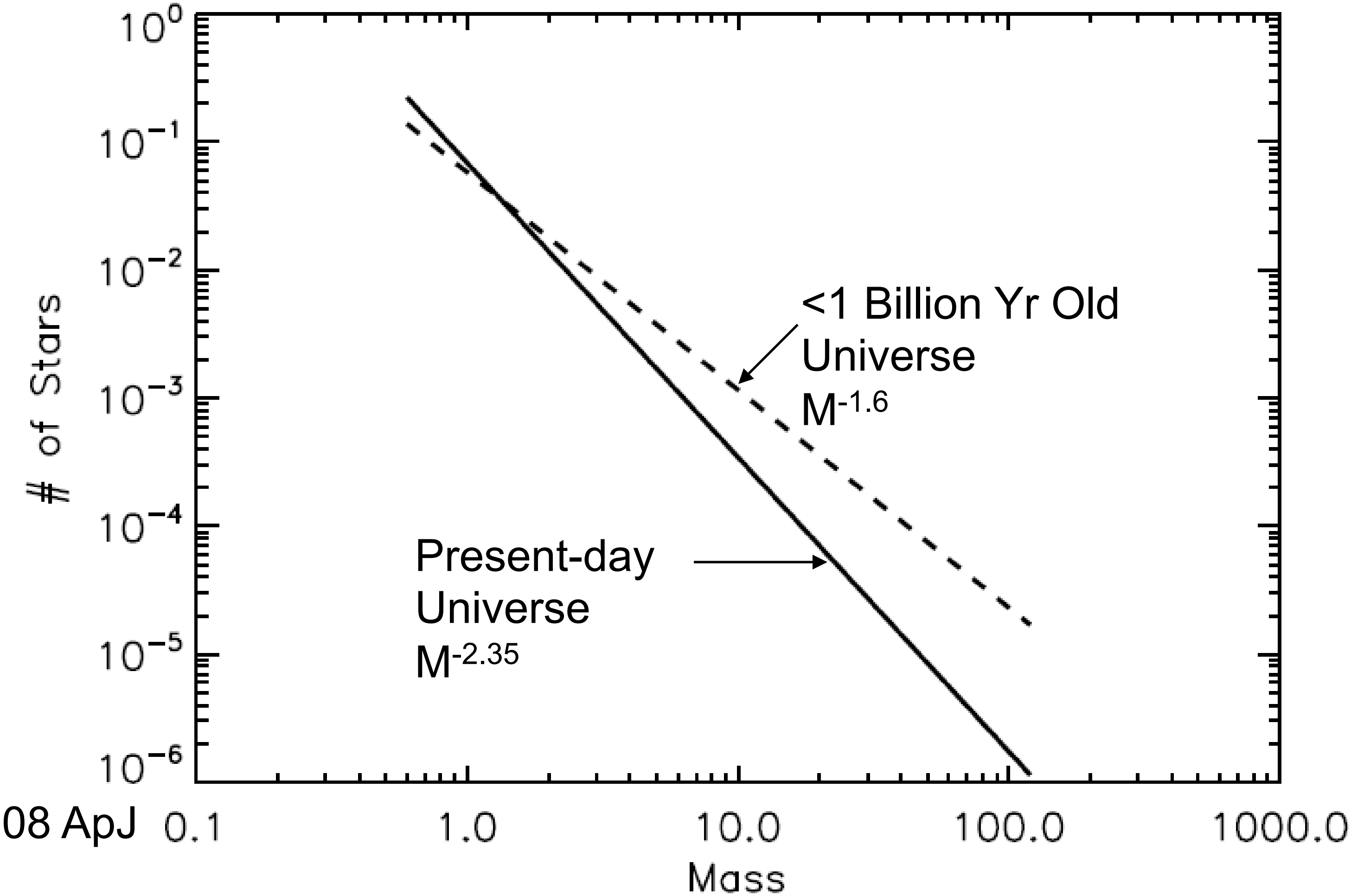
Top-Heavy IMF the Solution to Reionization



- With fesc of >0.02, top-heavy IMF can explain reionization tau and stellar mass density
- Real SFR is declining even faster than claimed at z>6

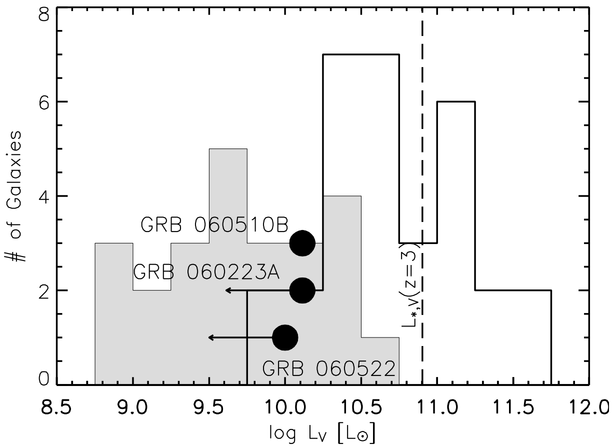
RC 2008

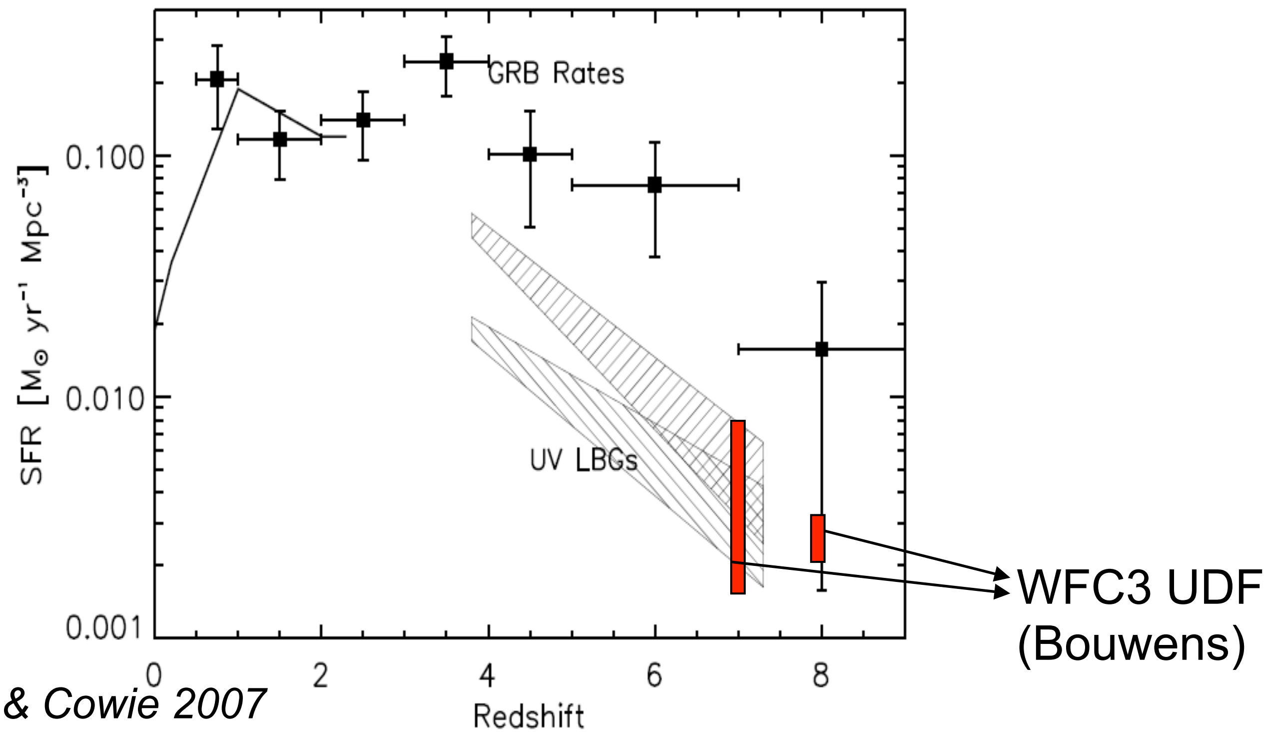
To agree with the stellar mass density at z~6, needs a top-heavy IMF



Chary 2008 ApJ

III. Hint of a higher SFR at z~6 from GRB Hosts





Chary, Berger & Cowie 2007

See also Robertson & Ellis 2012

Caveats

- Uncertainties in high-z GRB rates are substantial: limited by statistics
- Dependence of GRB production on metallicity, angular momentum, turbulence is unclear
- But consistent with the top-heavy IMF derived from field galaxies.

TMT Can Constrain the IMF Robustly [60 Virtual Nights]

- HeII properties in large samples of galaxies as a function of age, metallicity which will constrain the massive end of the IMF
  - WFOS at z<6
  - IRMS at z>6
- Measure weak UV absorption lines to calibrate gas-phase metallicity
  - WFOS at z<7
  - IRMS at z>7
  - Challenging for JWST
- <1day NIR spectroscopy of GRB afterglows to measure spec-z
  - Need SVOM to trigger; IRIS at z>8, WFOS at z<8
    - Cannot be done by JWST
- Metal absorption lines in GRB-DLAs to probe evolution of gas-phase metallicity
- AO+IFU needed for V/sigma in HeII [IRIS+IRMOS; TMT 2nd gen.]
  - Cannot be done by JWST