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Constraints on Reionization from z-dropouts

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(largely based on Oesch et al. 2008, arXiv: 0804.4874)

In collaboration with the UDF05 team:

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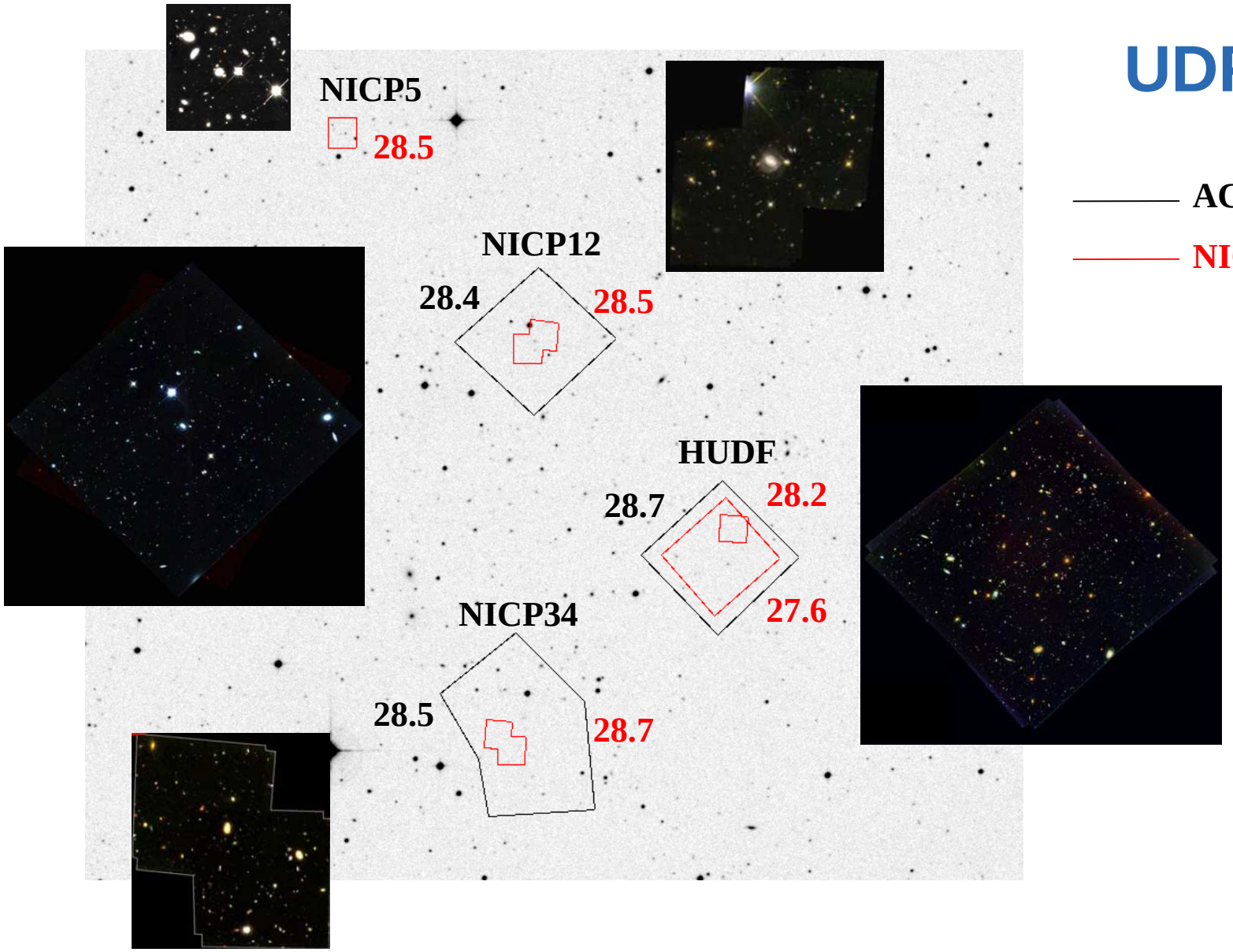
What reionizes the Universe?

- Possible sources
  - QSOs
    - LF found to decrease significantly out to z>6
    - too shallow faint end slope
  - Exotic sources
    - Xray photons from Mini-BHs
    - Decaying sterile neutrinos
  - Star-forming galaxies
    - LBGs / LAEs detected out to z~7 (some candidates out to z~10)
    - space density and its evolution just after reionization (z<6) quite well constrained
- This talk
  - UDF05 data: **LBG** LF to z~7
  - estimate their possible contribution to reionization

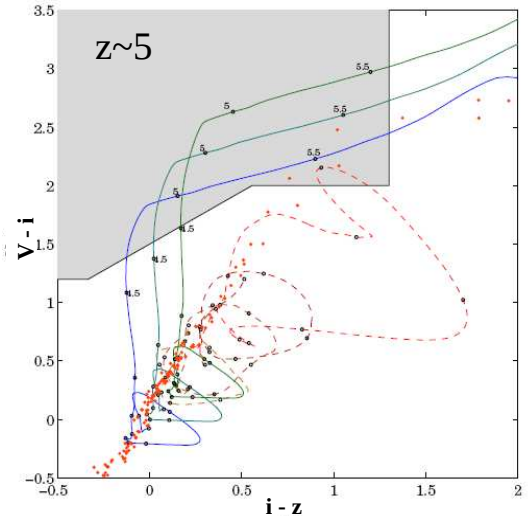
UDF05

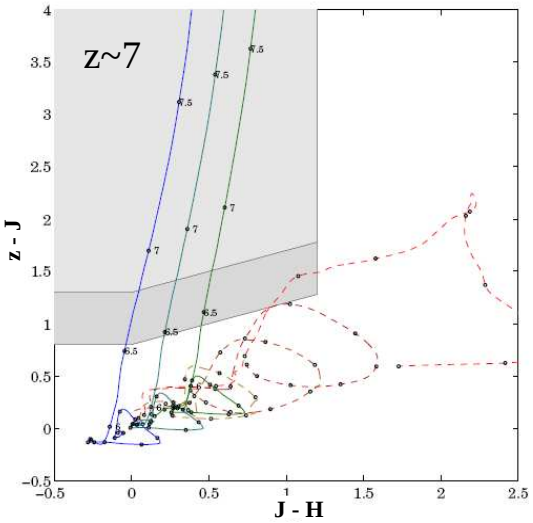


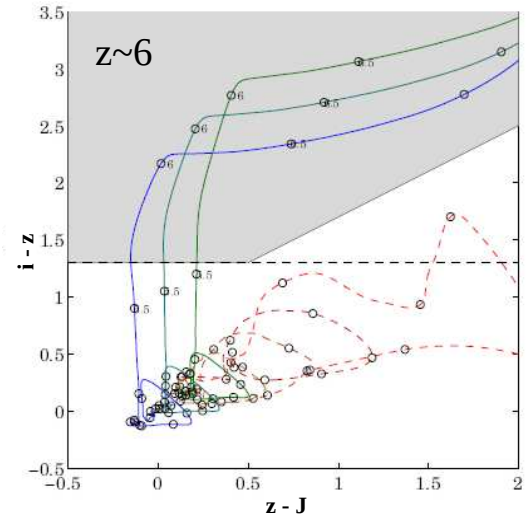
ACS (B), V, i, z

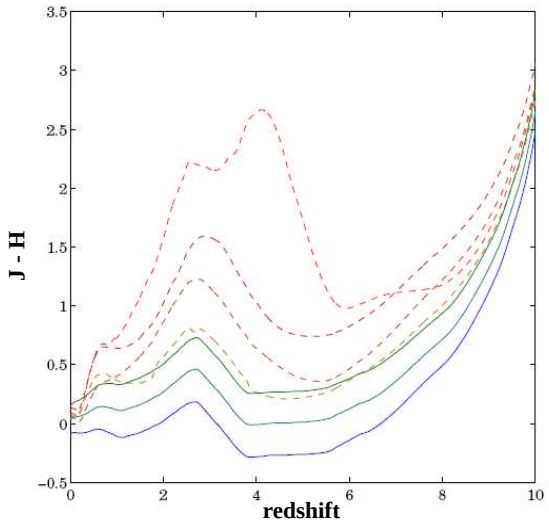
NICMOS J, H

The Lyman Break Technique in the UDF05



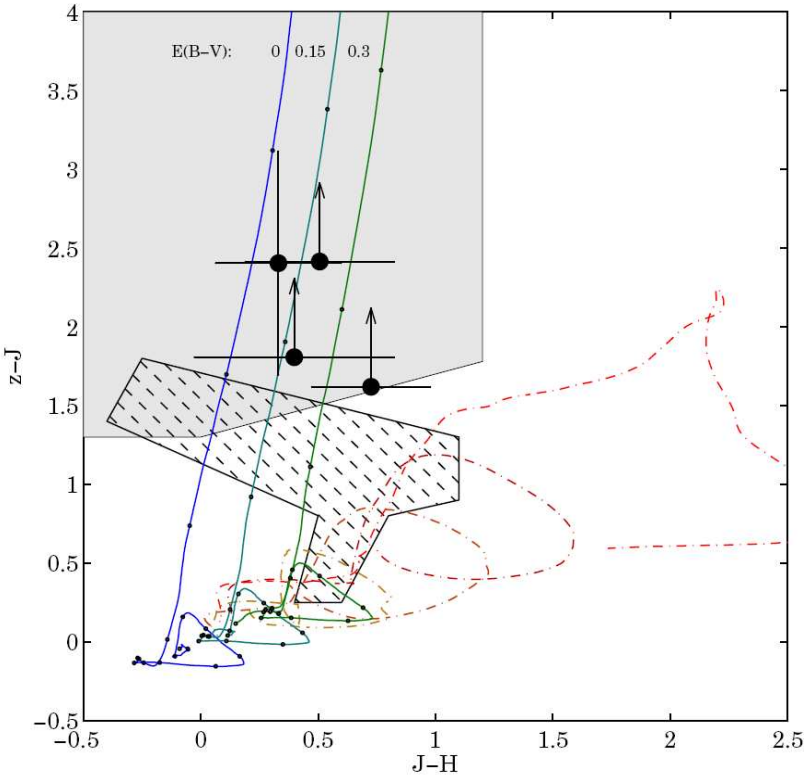




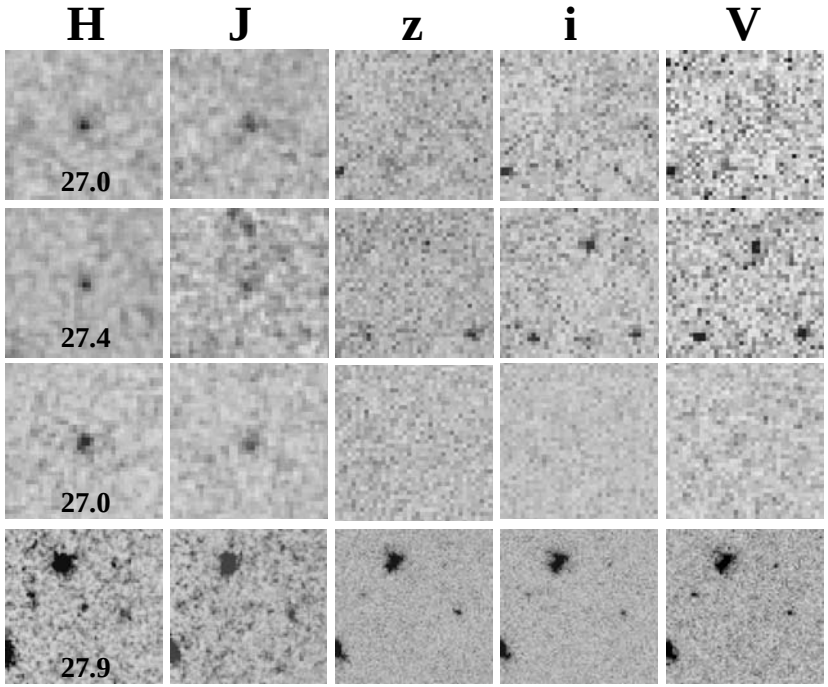


- 5 band photometry: V, i, z, J, H
- Selection of galaxies from z = 5 – 10
- Interlopers:
  - Faint stars
  - Passive galaxies around z~1-2
- GOODS FORS2 spectroscopy contamination < 10% for V- and i-dropouts (Vanzella et al. 2006)

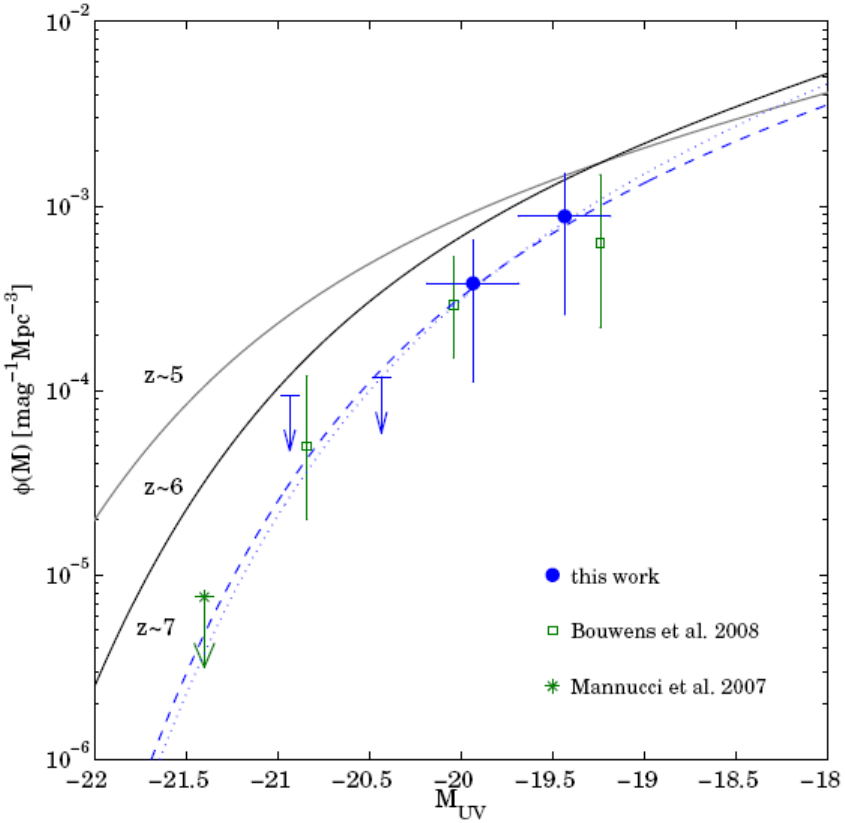
The z~7 Universe: z-dropouts in the UDF05+HUDF



- Search 7.9 arcmin^2 NICMOS imaging
- H-selected catalogs
- results in 4 candidates



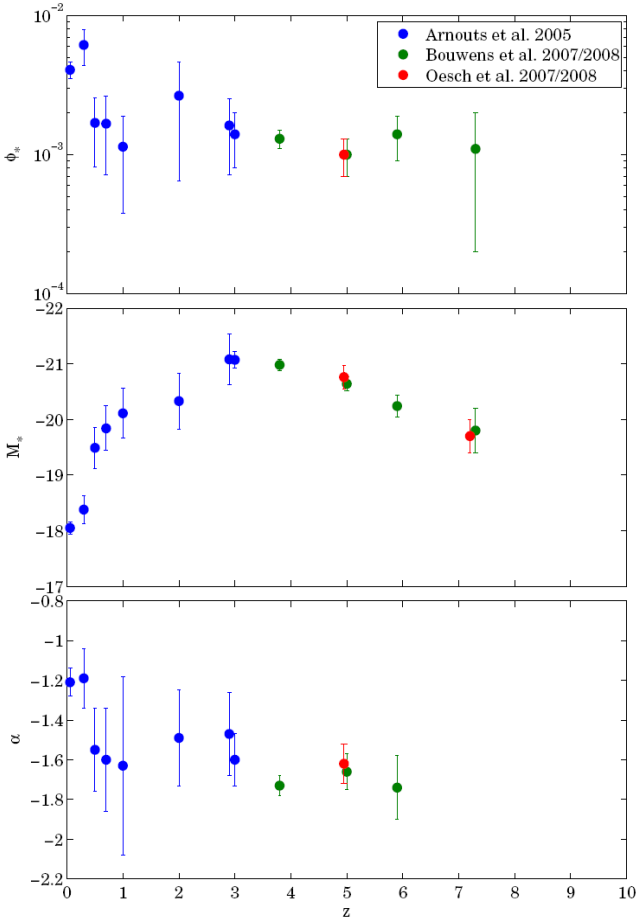
Evolution of the LBG LF to z~7



- Use candidates to construct LF at z~7
- No bright (H<26.5) galaxies found (4 expected)
- z~6 LF would over predict the number of galaxies by factor of 3
- $M_* = -19.7 \pm 0.3$

UV LF: Schechter Function Modeling

- Evolution of the UV LF is found to be remarkably smooth at z>1
- Fixing phi* and alpha is well motivated
- Dimming in M* found to continue steadily (z~3-7)



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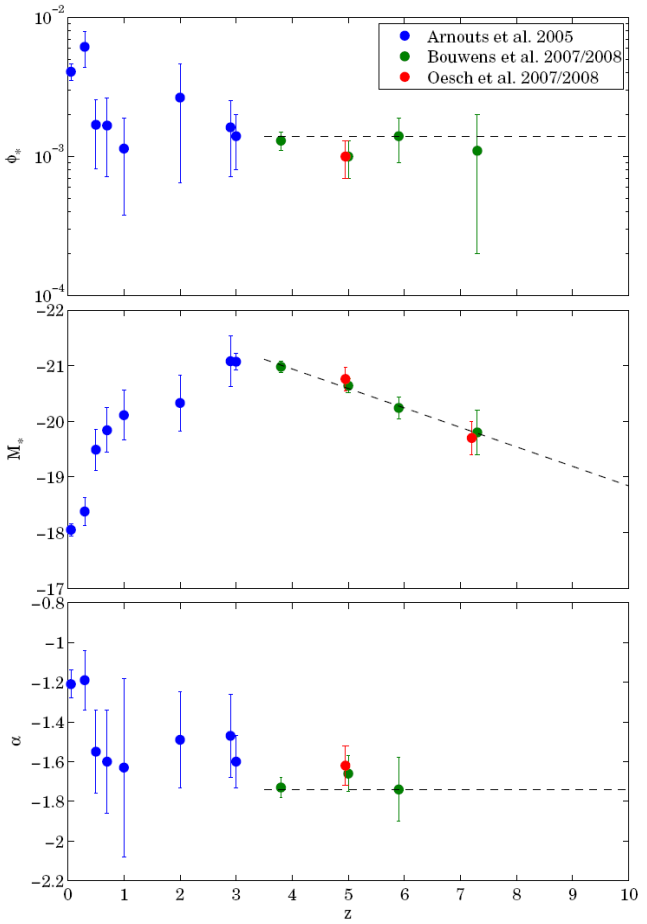
→ **Extrapolate to z>7**

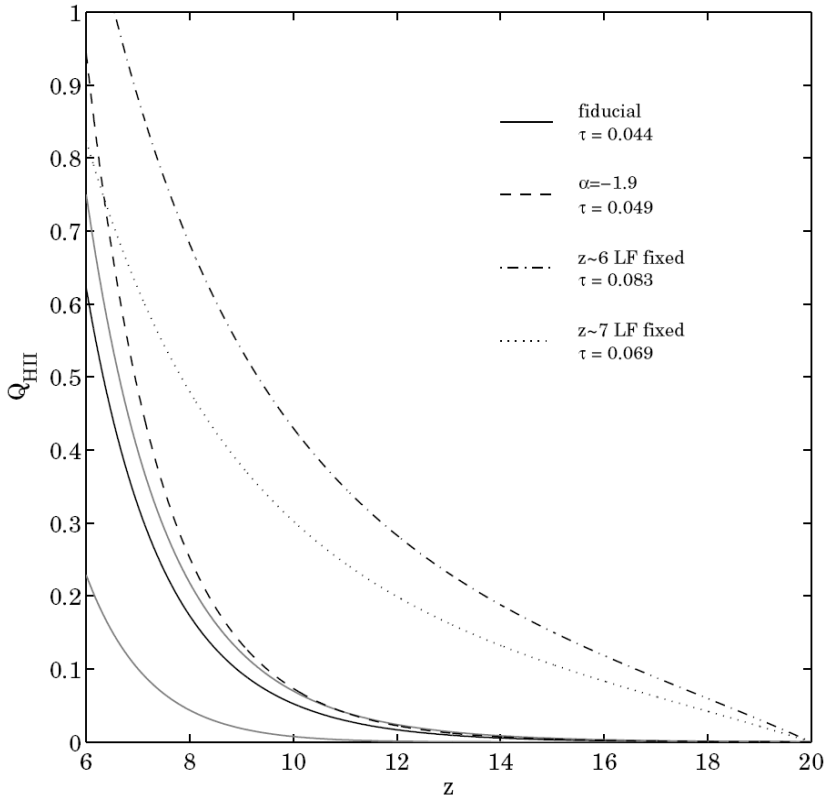


The Contribution of LBGs to Reionization

- Diagnostic: volume filling factor of ionized hydrogen Q_{HII}
  - require percolation (Q_{HII}=1) for end of reionization (z~6)
  - calculation of Q_{HII} (following Bolton & Haehnelt 2007)
    - balance between ionizing photons emitted and recombinations
    - biggest uncertainties
      - clumping factor, C = 2
      - escape fraction of ionizing photons relative to NUV continuum radiation, f_{esc} = 20%

- Constraint: optical depth of CMB photons to electron scattering
  - measured by WMAP: $\tau = 0.087 \pm 0.017$ (Dunkley et al. 2008)
  - for instantaneous reionization scenario this implies: z(reion) = 11.0 ± 1.4

Results: Evolution of the HII filling factor

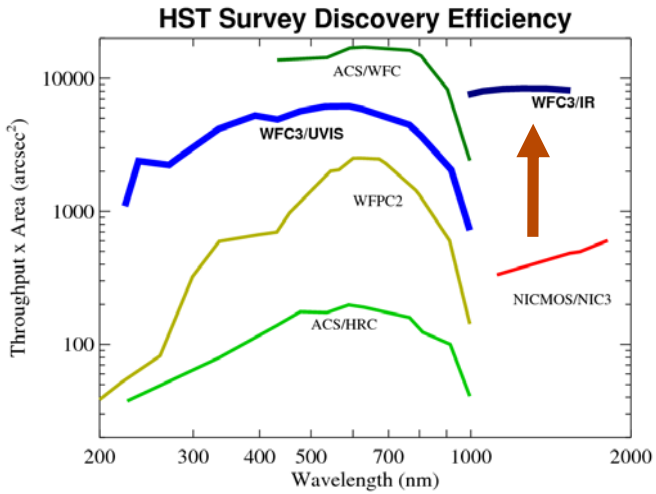


- faint galaxies provide the bulk of the ionizing photons required for reionization
- too few atoms ionized at high redshift (in fiducial model)
- population with non-evolving z~7 LF does not ionize the universe by z~6

So what is really going on?

- Evolution of LF slowing down or inverted?
  - Higher SFR density predicted before reionization due to SF in minihalos
    - Jeans mass increased in ionized IGM (e.g. Barkana & Loeb 2000)
  - massive, post-SB galaxies at z~6
    - ~40% of bright i-dropouts show strong Balmer breaks: old stellar populations (e.g. Eyles et al. 2007)
    - Bulk of these stars must have formed at z>7
- Are LBGs more efficient ionizers at higher redshifts?
  - low metallicities
  - top heavy IMF
- Undetected sources?
  - Pre-ionization from first stars, mini-QSOs, …
    - points towards an extended EoR

Our WFC3 program



- Current limitations
  - Resolution & sensitivity of ground based NIR
  - FoV & sensitivity of space-based NIR

- Ultra-deep WFC3 survey around the HUDF
  (PI: Illingworth, CoIs: Bouwens, Carollo, Franx, Labbe, Magee, PO, Stiavelli, Trenti, vanDokkum)
  - Firm constraints on SEDs of LBGs
  - Consolidate z ~ 4 - 7 LF
  - New LF at z ~ 8 → 10
    - Evolution of SFRD from z ~ 4 → 10
    - Further constraints on reionization from LBGs

The END