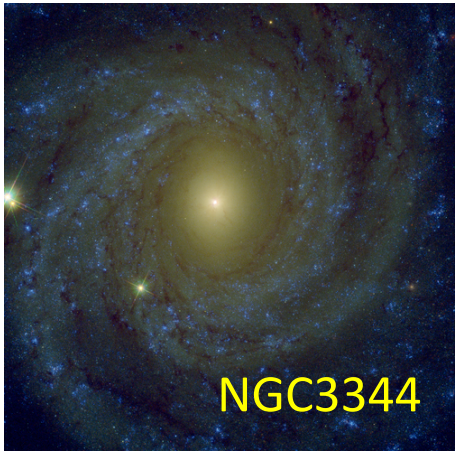
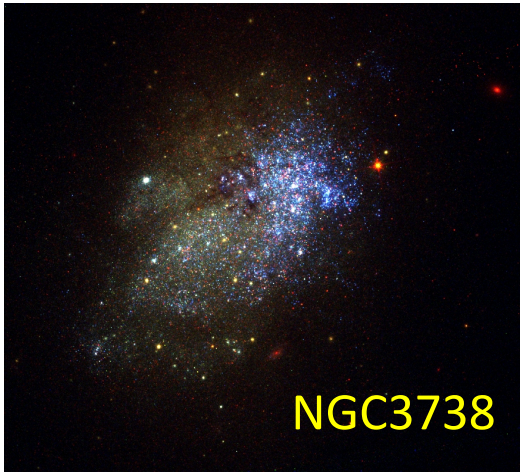
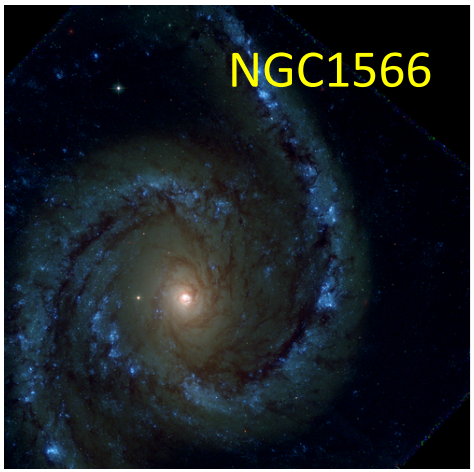




Nearby Galaxies under Magnification: New Science with a Future UV-Optical Telescope

D. Calzetti (Univ. of Massachusetts)



Science Contribution to:

Finding the UV-Visible Path Forward:

A Community Workshop to Plan

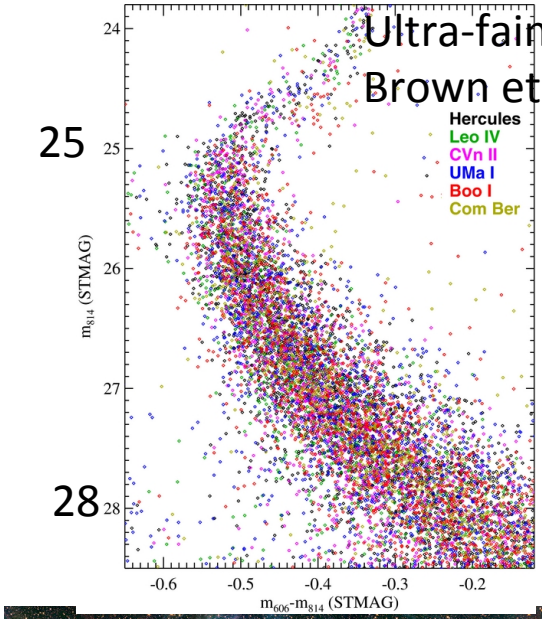
the Future of UV/Visible Space Astrophysics

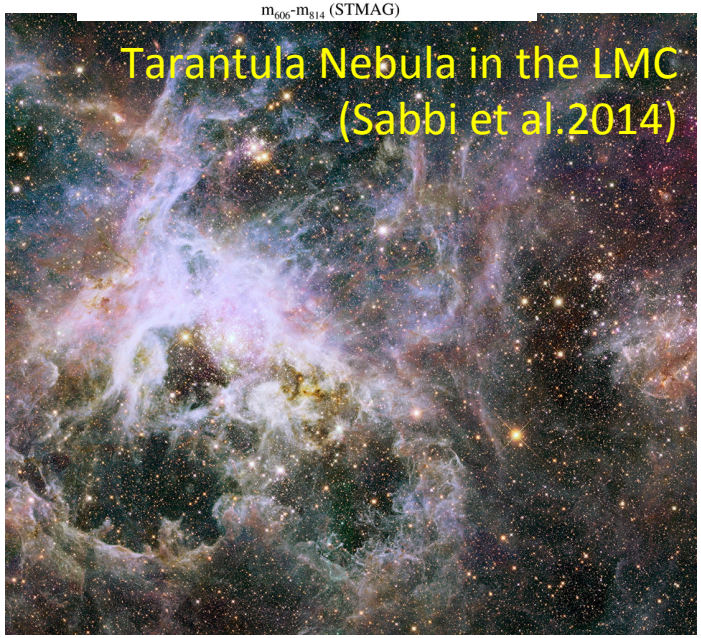
GSFC, Maryland, June 25-26, 2015

Nearby Galaxies: The Hubble Revolution

(a biased view)

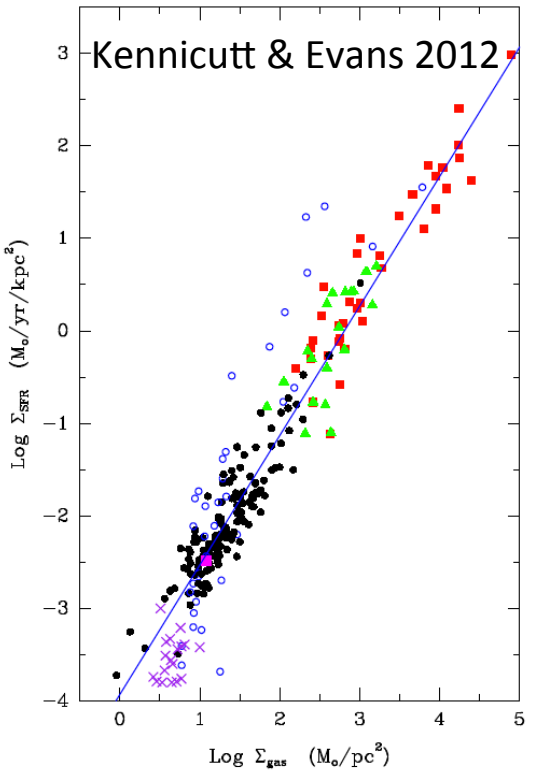
- **Enabled** resolution and accurate measurements of individual stars in galaxies beyond the MCs and in otherwise crowded environments (MW GCs, MC star forming regions, etc.) -> SFHs (3-4 Mpc), our window into the past
- **Enabled** UV measurements of the young structures in external galaxies (stars, clusters, associations, etc.) -> SFRs (~10-20 Mpc), our window into the present
- **Enabled** detecting the ionized gas component and its complex interrelation with the young stars -> SF feedback and chemical enrichment (range of distances), our window into the physics

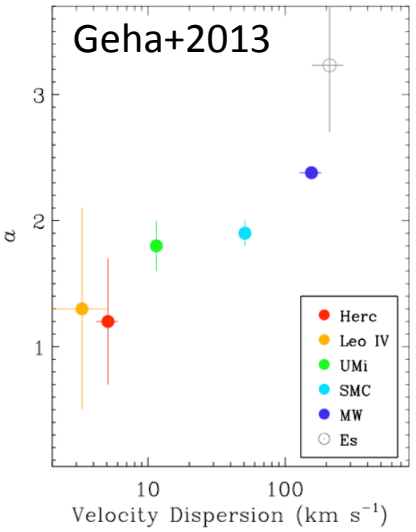




The Realm of JWST

- Address the **physical foundation** of the Schmidt-Kennicutt Law (scaling between SFR and gas) via YSOs within 1 Mpc and dust-enshrouded HII regions within ~10 Mpc.
- Investigate the low-end of the IMF via resolved counts out to ~0.5 Mpc. Current evidence gives **2x mass variations** for galaxies.
- SF Histories of galaxies between 200 Myr and 10 Gyr, out to ~6-8 Mpc for `fossil record' studies (~a dozen giant spirals, and at most 1 giant elliptical).
- **Physics** of the Bulge mass – BH mass relation
- **Physics** of dust processing (e.g., PAHs) out to ~10 Mpc and of dust formation (e.g., CCSNe) out to larger distances





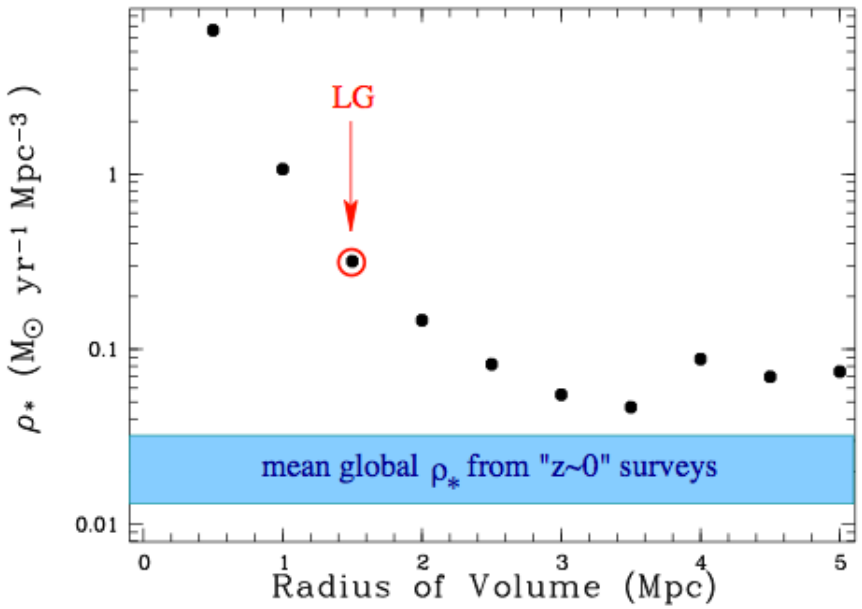
Science Cases for a ~12-m UVO Telescope

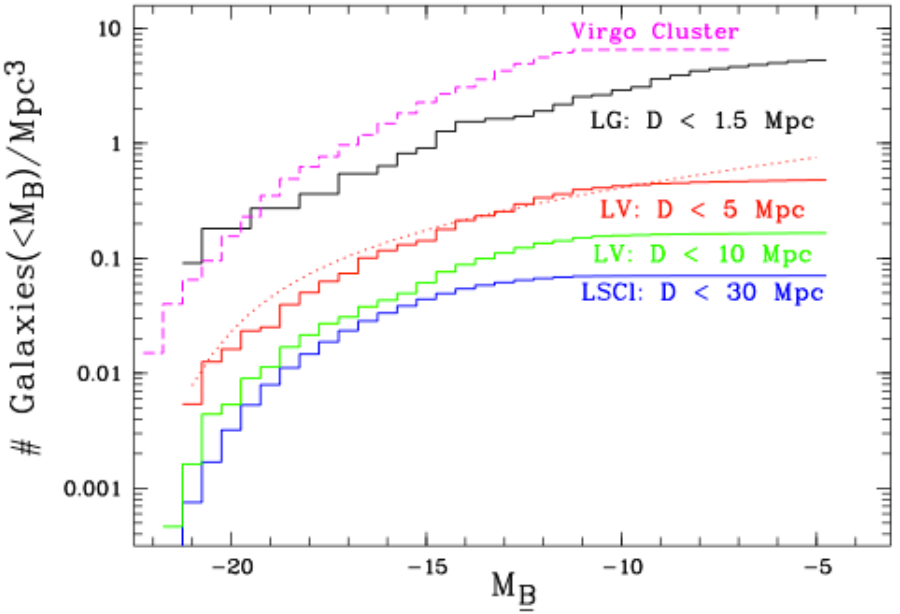
(5x the FoV, 5x the Angular resolution, 25x the sensitivity of HST)

- Galaxy Growth
- The Physical Underpinning of IMF Variations
- Reconciling the Local and Cosmic Star Formation Histories

Know Thy Neighborhood - 1

Drozdovsky+2008

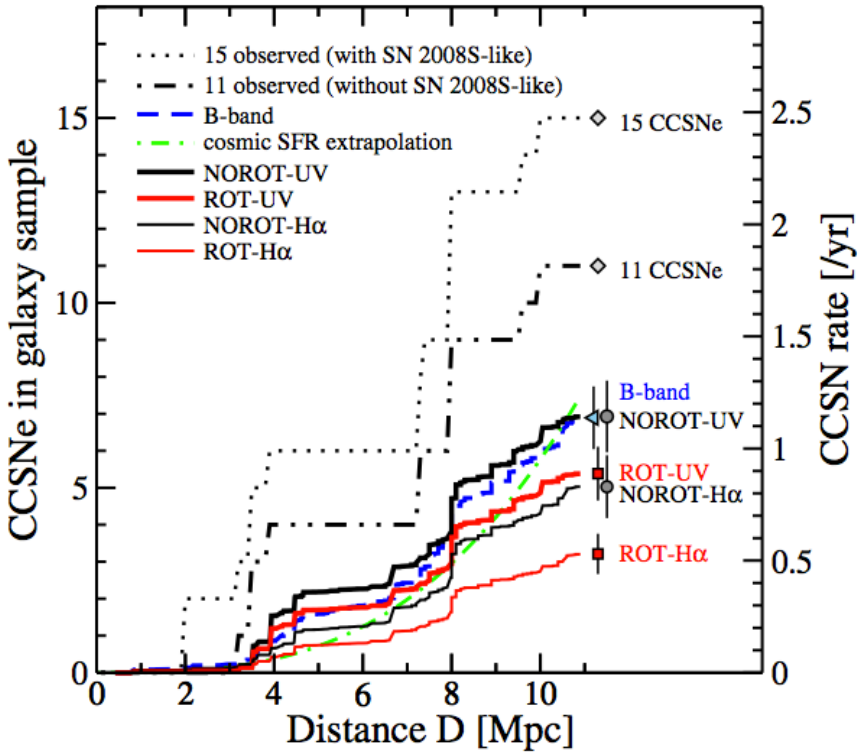




- The Local Universe is over-dense relative to the cosmic average, by a factor of a few, up to at least ~10 Mpc.
- The discrepancy is more noticeable for the LG (local ~1.5 Mpc), which departs from the cosmic SFR for the most recent 4-6 Gyr (Drozdovsky +2008, Williams+2011)

Know Thy Neighborhood - 2

Horiuchi+2013



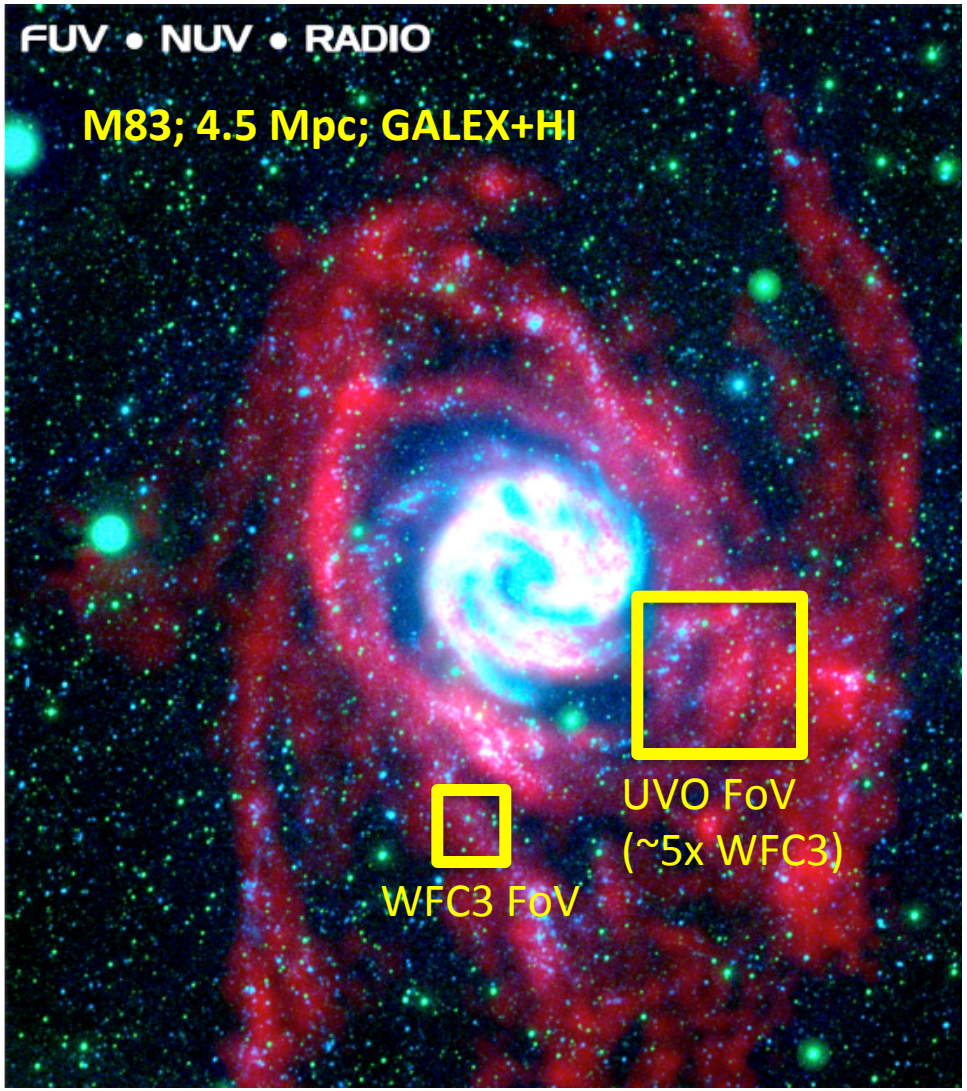
- Within the local 11 Mpc, the CCSNe is higher than predicted by the UV, and even higher than predicted by Hα (Horiuchi+2013, Botticella +2012).
- Within uncertainties, no such discrepancy is observed on cosmic scales (0<z<1, Dahlen+2012).
- The most consistent result is the UV-Hα discrepancy. Three causes:
  - Upper IMF variations
  - Recent (<200 Myr) SFH issues
  - Ionizing photon escape

Within the local 11 Mpc, 85% of the SFR is within the 80 galaxies more massive than the MCs (out of almost 500), and 45% of SFR is within the 10 most massive.

This volume includes only a couple of LIRGs (M82, NGC253), and no ULIRGs; i.e., it does not reflect the high-z Universe, where LIRGs and ULIRGs are common.

Galaxy Growth - 1

- Galaxies are far more extended than their bright disks, in stellar populations and gas content.
- Regions with extreme conditions of density, pressure, metal enrichment, dust content, response to feedback.
- Outskirts are dynamically `quiet': imprints of structures persist for many Gyrs – testbeds for:
  - Modes of star formation
  - Upper IMF universality
  - Star cluster evolution
- Virtually no HST data. Key requirements: UV (SFH<200 Myr) +efficiency (FoV+sensitiv.)



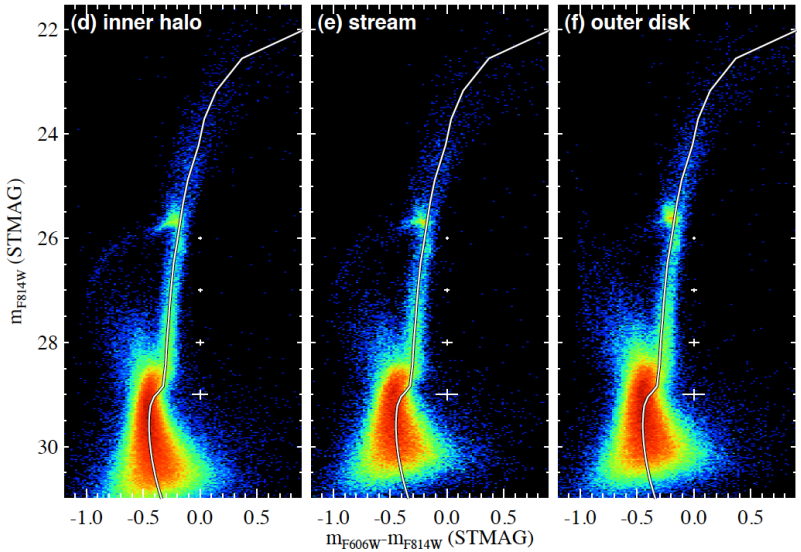
Thilker et al. 2007

Galaxy Growth - 2

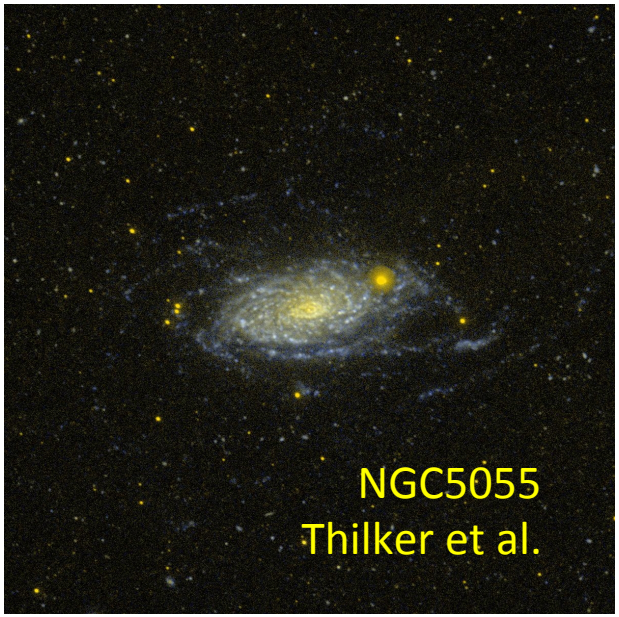
- ΛCDM models = galaxy growth through multiple minor mergers (Penarrubia et al. 2006). Imprints remain in the outskirts of galaxies (Bullock & Johnston 2005). Outer disk of M31 consistent with this picture (Brown et al. 2008; Martin-Delgado et al. 2008).

- Inside-out star formation (Roskar et al. 2008) observed in: breaks in exponential profiles and blue outskirts of HI-rich disk galaxies (Wang et al. 2011). About 20% of local galaxies have XUV disks (Lemonias et al. 2011).

- Minor mergers and inside-out star formation predict different outskirts population mixes. Key requirements: efficiency (FoV+sensitiv.) @ optical (Brown+2012, astroph1209.4141)

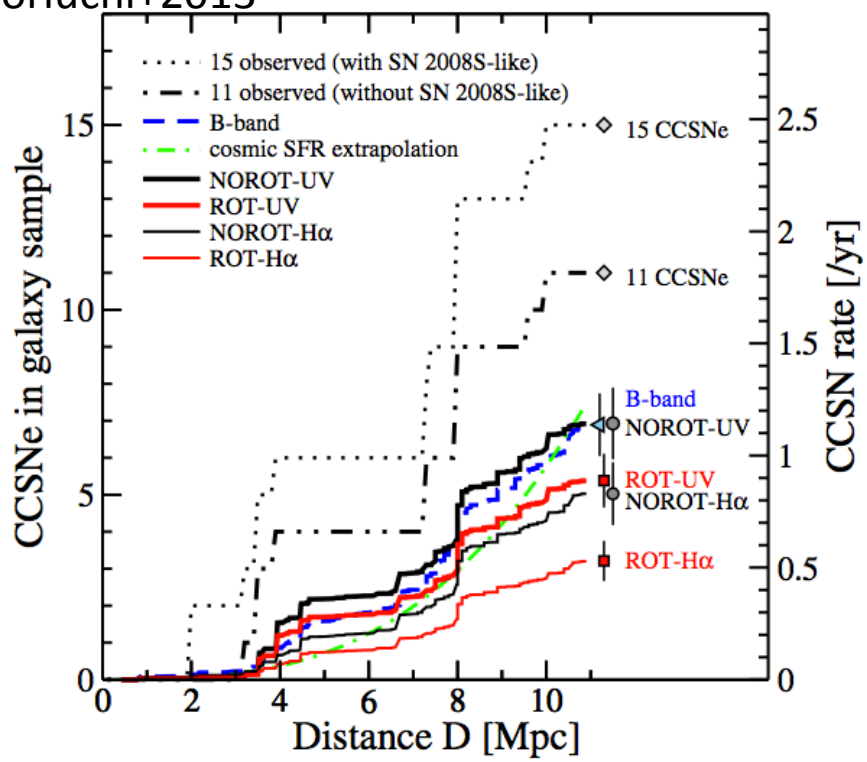


M31 CMDs; Brown et al. 2008



High-End IMF

Horiuchi+2013



To the extent that it has been possible to test so far (HST; C+2010; Andrews +2013,2014) , there is no evidence for a variation of the upper end of the IMF

- The upper end of the stellar IMF impacts:
  - SFRs at all cosmic distances
  - Energy input into the ISM/IGM (feedback/outflows)
  - Metal enrichment

Discrepancy between UV and Hα driven by the dwarfs ($M^* < 10^8$ Mo; Lee +2009, Botticella+2012)

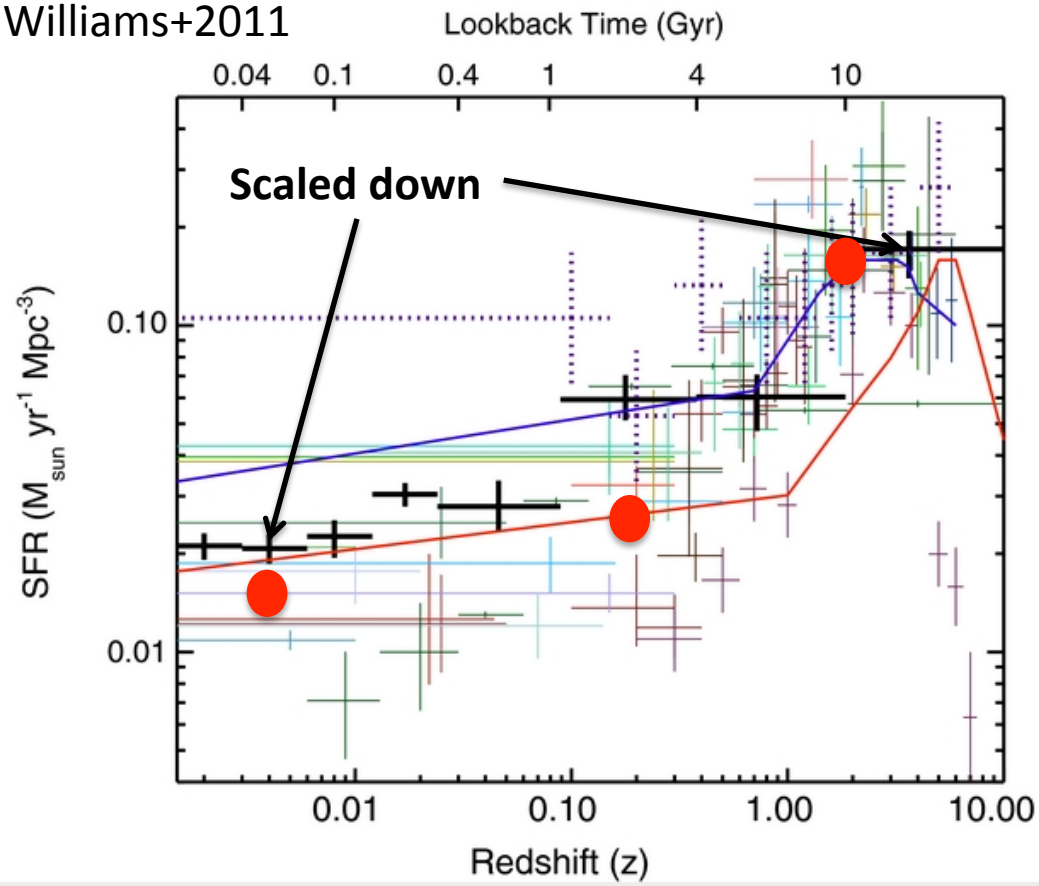
Problems:

1. Recent SFH/IMF degeneracy
2. Loss of ionizing photons

Key requirements: UV (IMF stochasticity+recent SFH), optical narrow bands (ionizing photon counts), angular resolution (~5x HST, to reach 5 Mpc with same resolution as M31)

Local and Cosmic SFH

Williams+2011



- Even after rescaling:
  - discrepancy (~1.5-2x) between the Local (<4 Mpc) SFH and the Cosmic SFH, over the most recent ~4 Gyr (Drozdovsky+2008; Williams+2011)

● From Madau&Dickinson2014

- Tension exists between standard models of galaxy evolution and the Local fossil record:
  - Dwarfs should have formed 50% of their mass before z=2 (Weisz+2011)

Key requirements for reconciliation: angular resolution (5X HST, to resolve crowding at 15-20 Mpc) @ optical

Conclusions

- There are at least three, non-exclusive, science areas that will enable understanding galaxy evolution via nearby galaxies investigations:
  - Outer disk regions for galaxy growth – UV, large FoV, sensitivity
  - Upper end of the IMF – UV, optical narrow-band, high angular resolution, sensitivity
  - Local-to-Cosmic SFH – high angular resolution, sensitivity