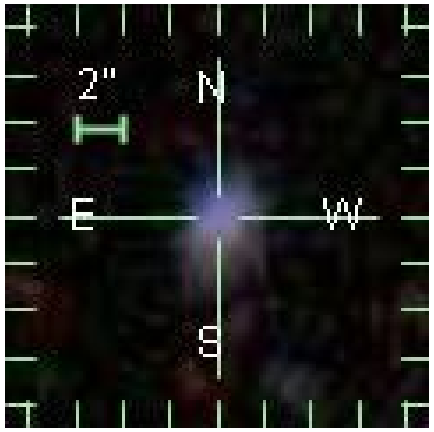
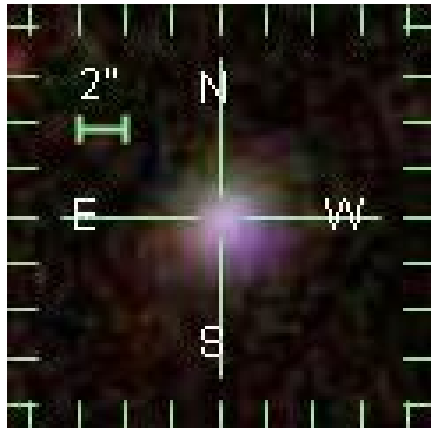
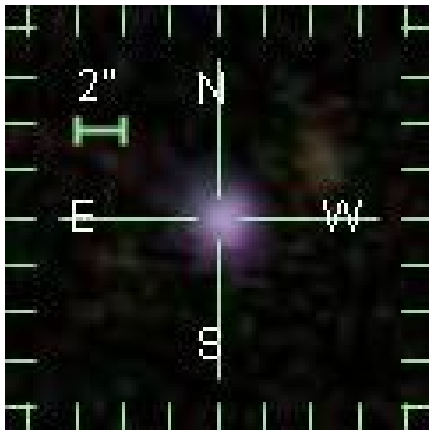


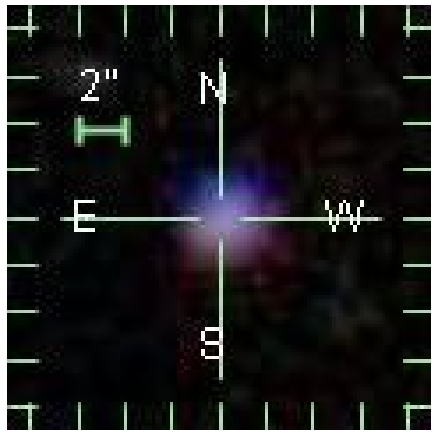


Local Analogues to z~5 Lyman Break Galaxies



Stephanie Greis

with
Elizabeth Stanway & Luke Davies



What are Lyman Break Galaxies?

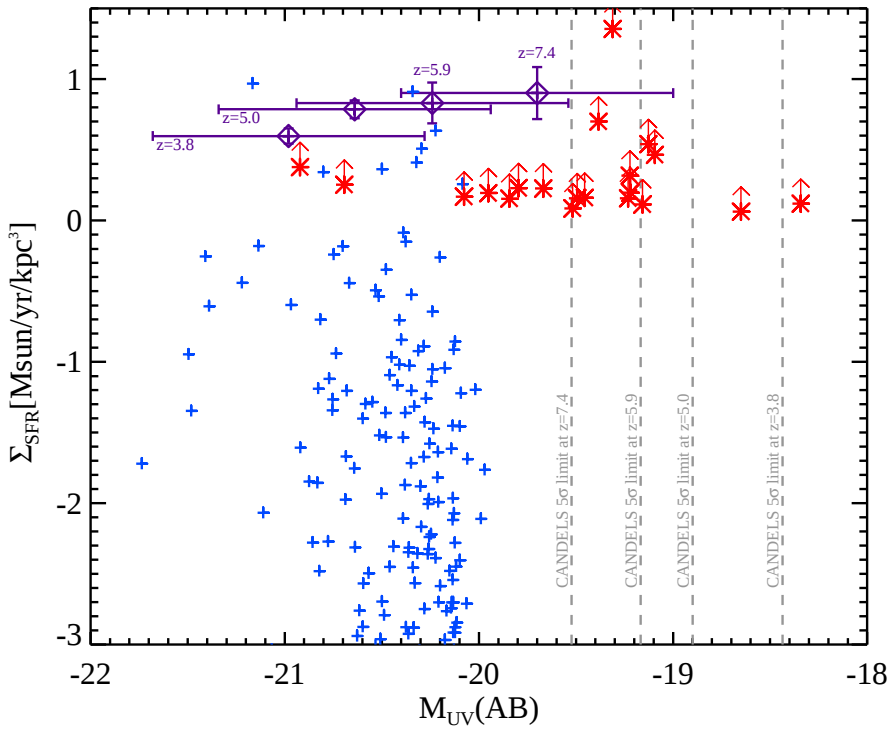
- UV-luminous, spatially compact objects
- Characterised by Lyman break at rest-frame 912A (or Ly alpha break at 1216A) due to neutral H absorption
- Constitute the normal galaxy population at high redshifts (z~5)
- Aid understanding of: Galaxy formation & evolution
- From them: can infer properties of galaxies involved in Epoch of Reionization

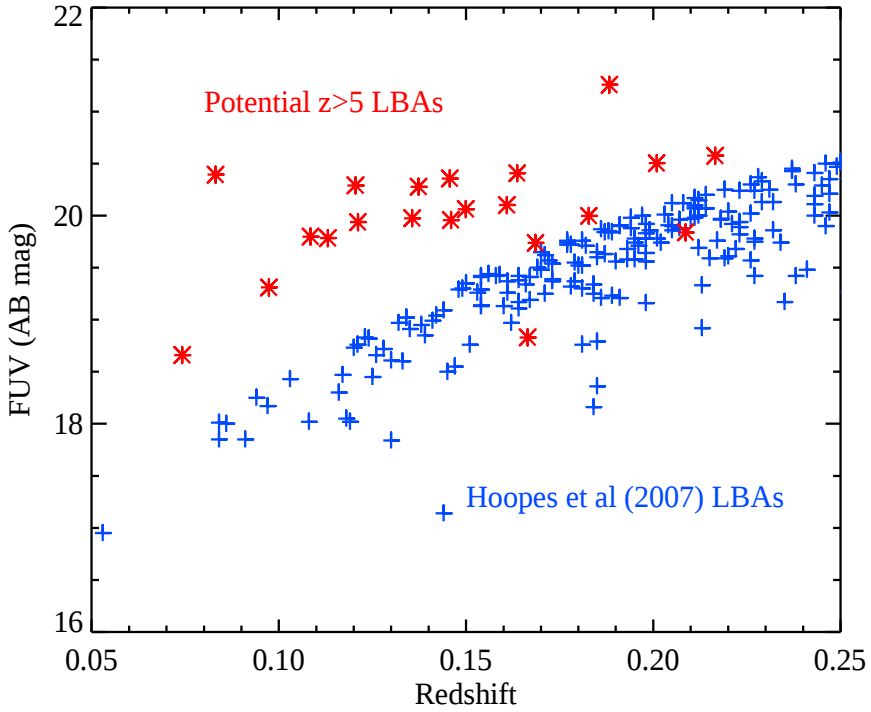
Need for Local Analogues

- High-z LBGs: faint apparent magnitudes & small projected sizes → difficult to study

- Hence: need more nearby analogue sample
  - can be studied in greater detail
  - can help interpret the more distant population

Difference to z~2/3 LBGs

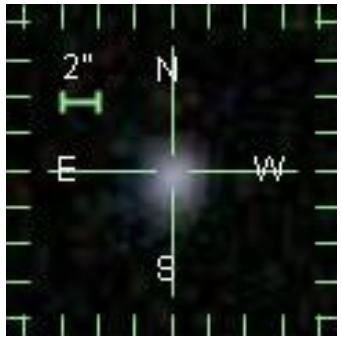


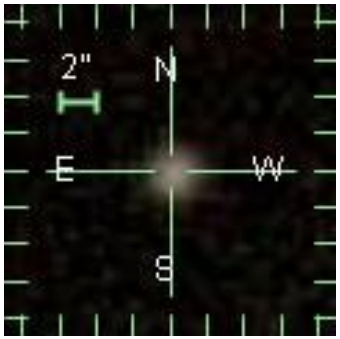


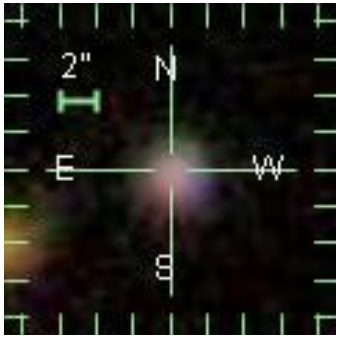
	z~3 LBGs	z~5 LBGs	z~8 LBGs
log(age)	<9	~8	~8.3
log(mass)	9.5 - 11.0	~9	~7
Dust E(B-V)	~ 0.13	~0.15	0.0 – 0.4
SFR [Msun/yr]	3 - 300	~10	~ few

Sample

- Established a UV-selected pilot sample of 29 objects
  - Redshifts 0.05<z<0.25
  - Southern decs
  - FUV abs mags: -17 to -21
  - Spatially compact ($r_{0.5}$ < 2kpc)
  - Detections from GALEX, SDSS, 2MASS, and WISE







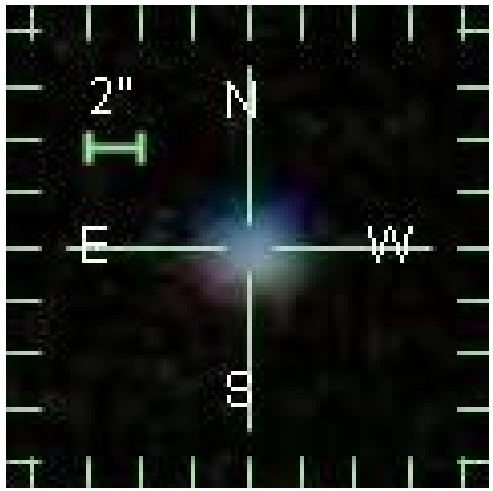
SED Fitting

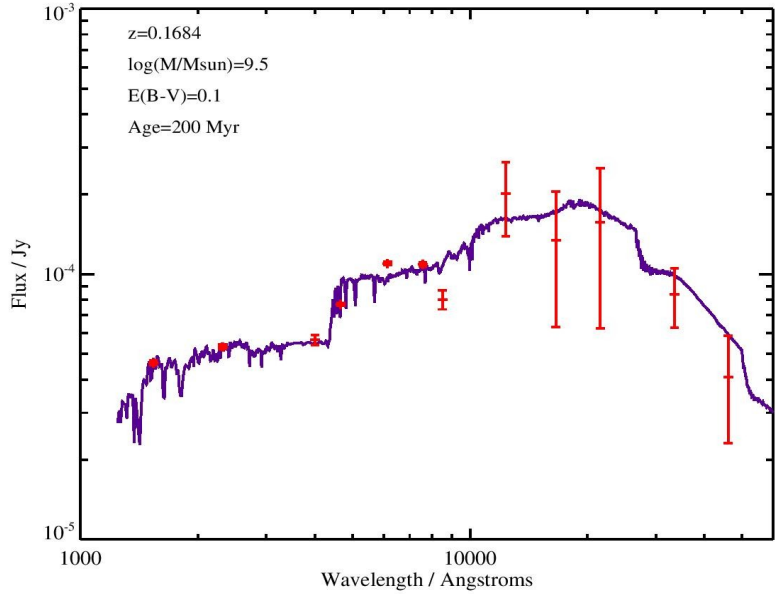
M05	BPASS	MPA - comparison
- starburst model - exp declining tau model: SFH ∝ exp(-t/τ)	- starburst model - exp declining and rising tau models: SFH ∝ exp(±t/τ) - includes binary evolution	- uses only SDSS data - variety of stellar population synthesis models

Dust modelling: Calzetti dust absorption, and da Cunha+2008 & Smith+2007 dust emission features

SED Fitting

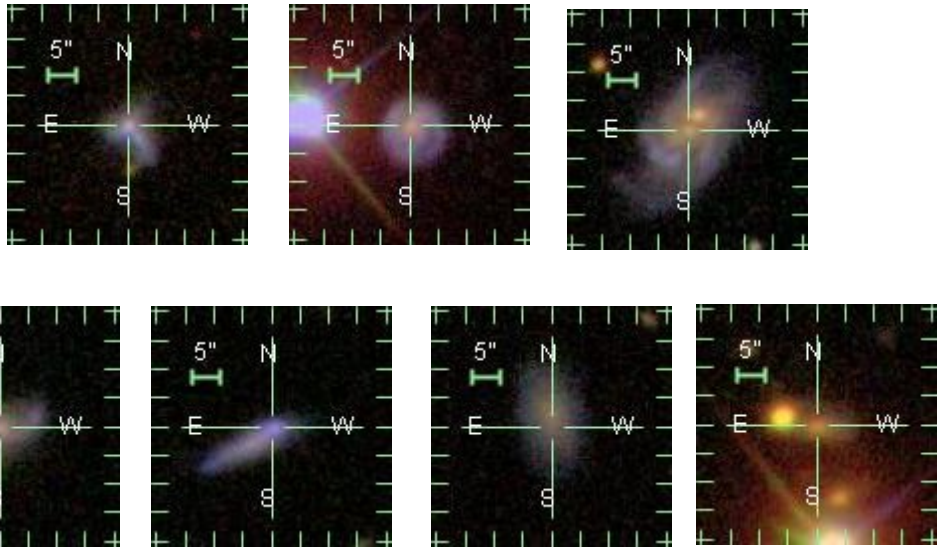
- Using chi-squared fitting, the best-fit models are determined for each galaxy

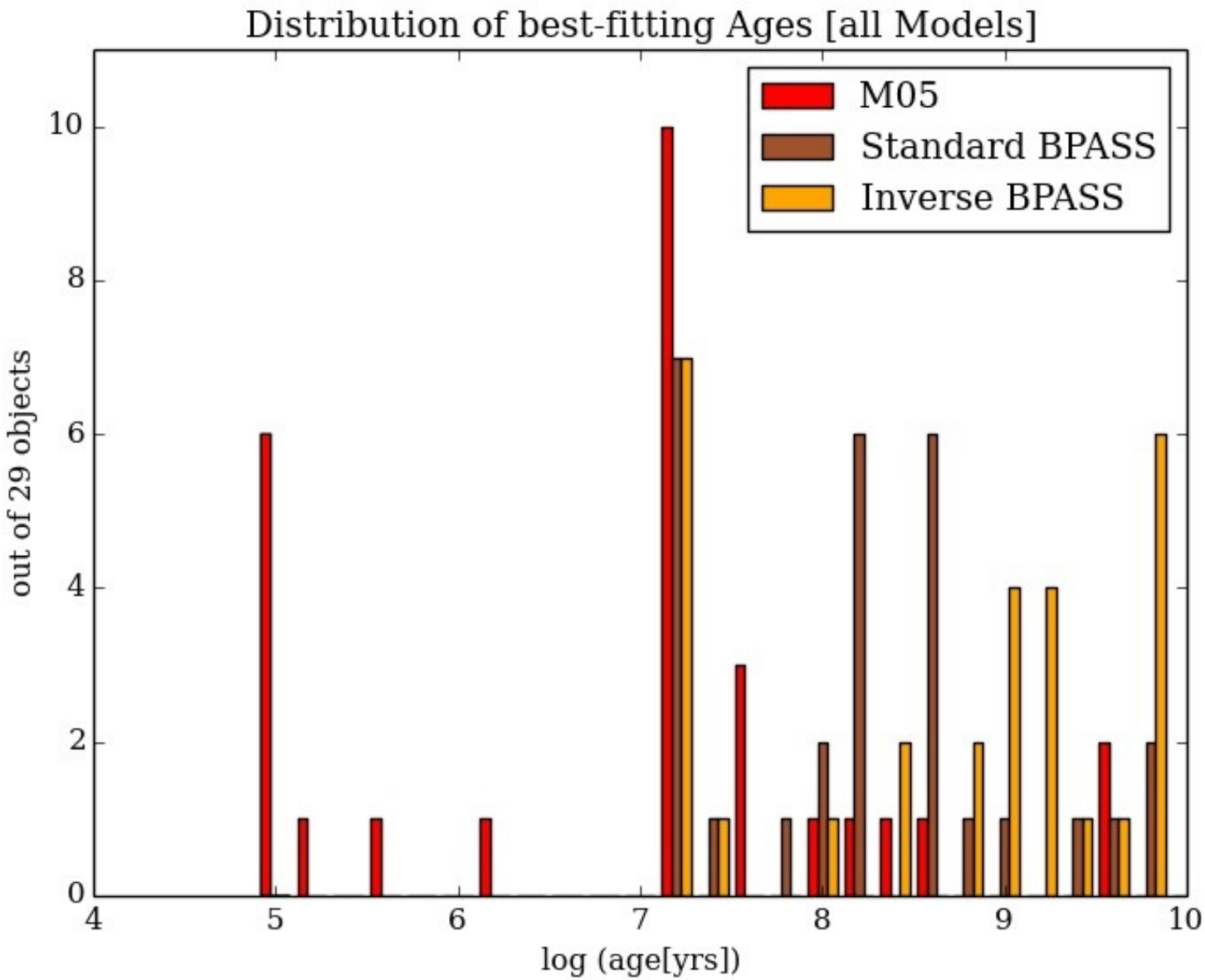


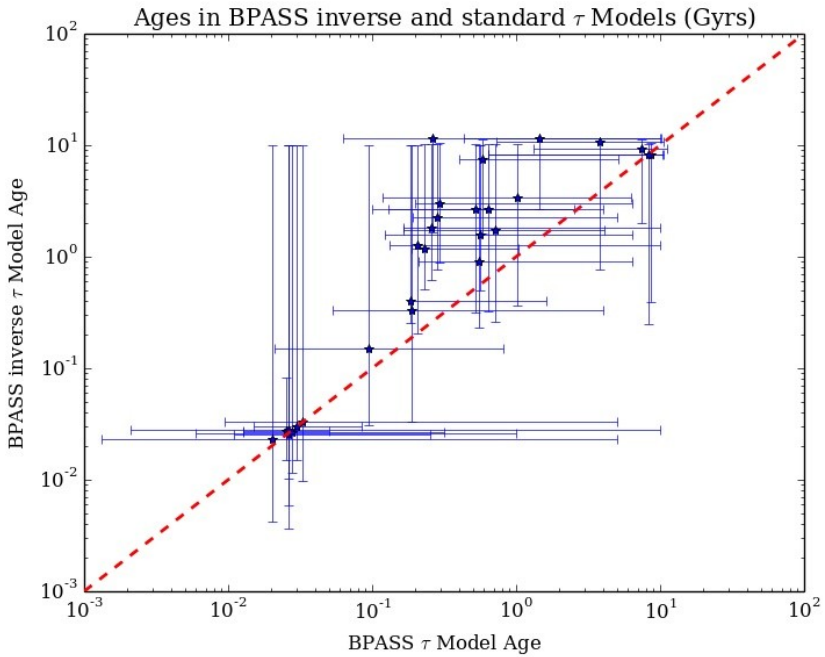


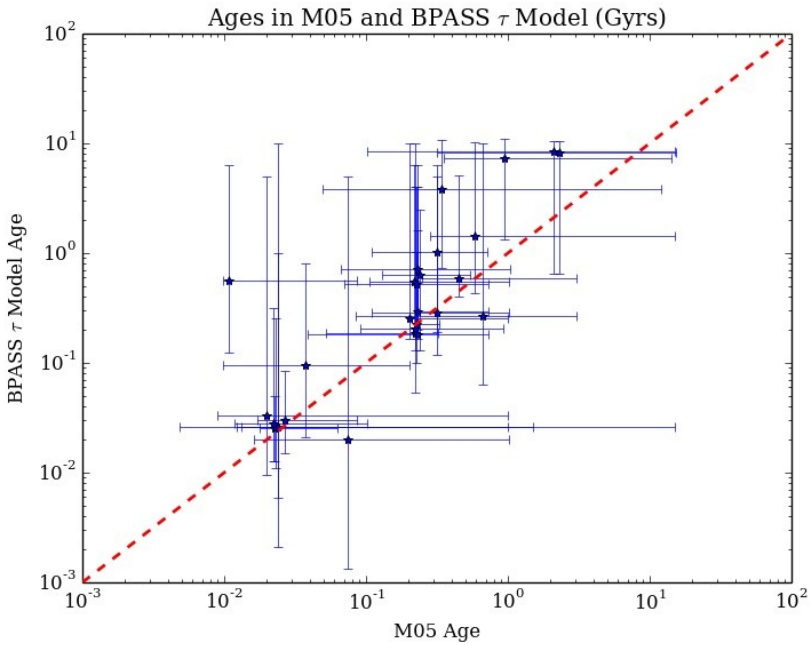
Outliers

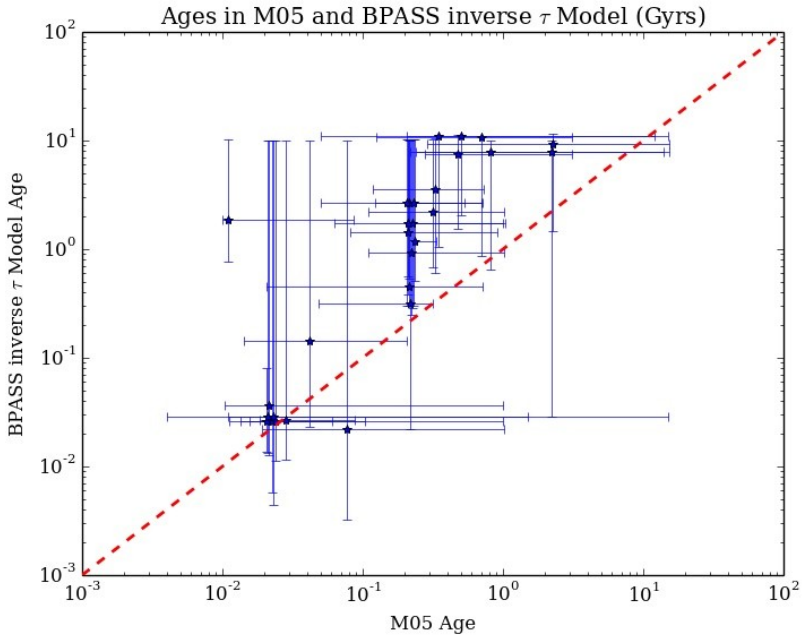
- Identified 7 such outliers
- Not well fit by simple stellar population model
- They satisfy LBA photometric selection criteria
- Visual inspection confirms that they are bad LBA candidates

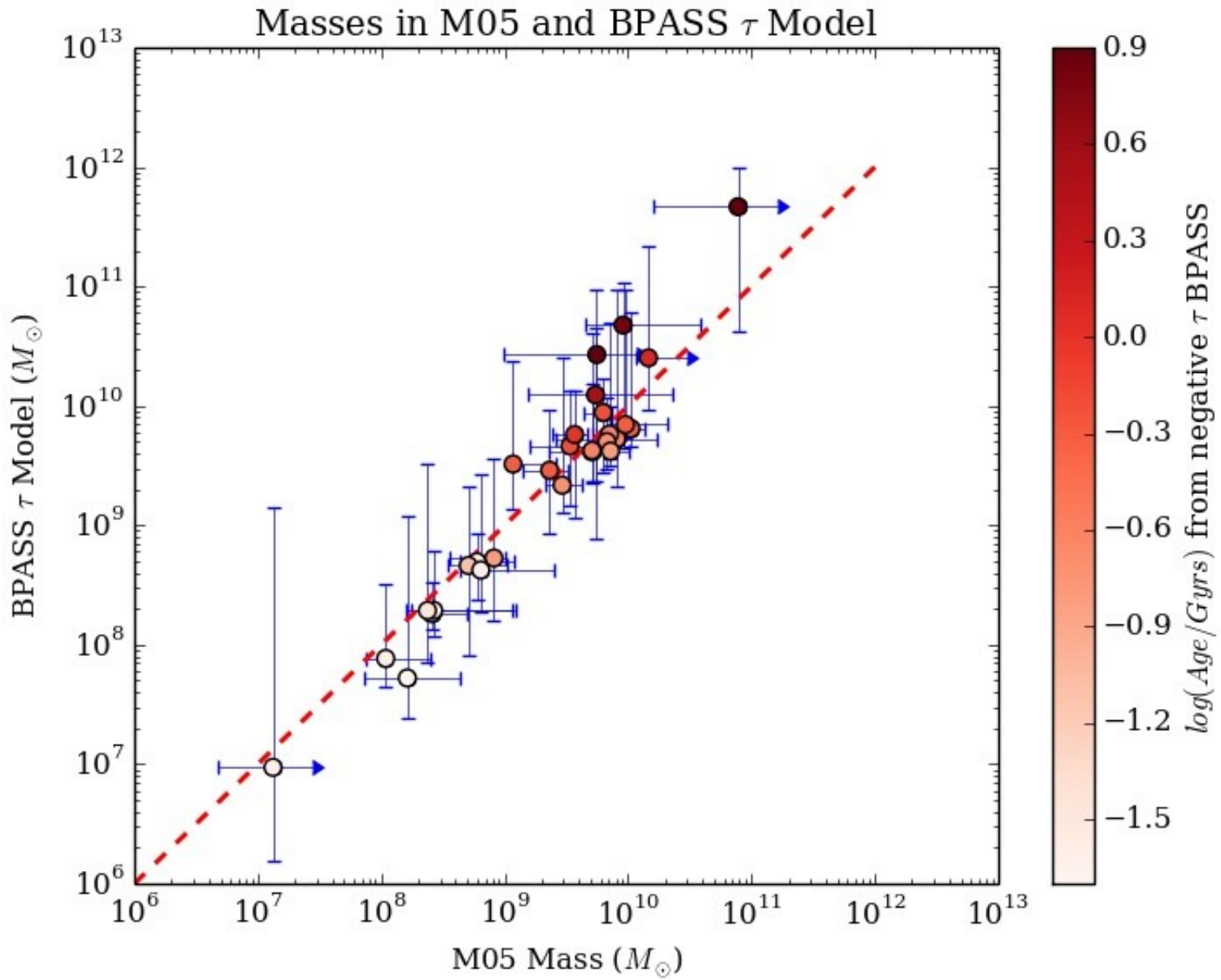


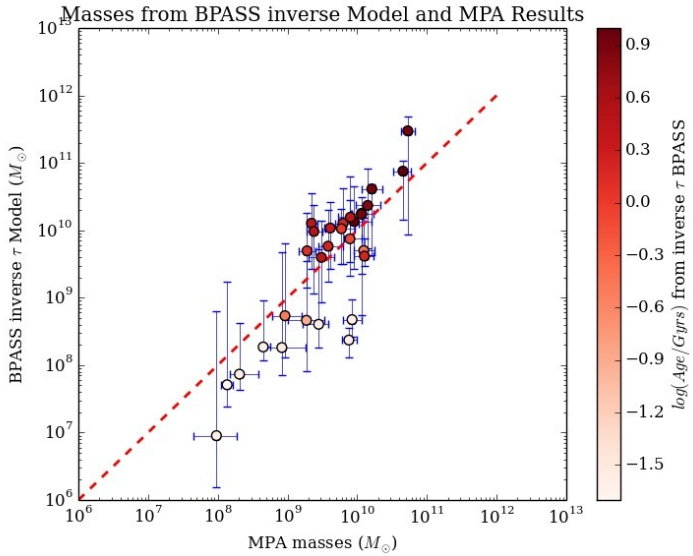

Distribution of best-fitting Ages [all Models]
M05
Standard BPASS
Inverse BPASS
out of 29 objects
log (age[yrs])
0
2
4
6
8
10
4
5
6
7
8
9
10


Ages in BPASS inverse and standard τ Models (Gyrs)
BPASS inverse τ Model Age
BPASS τ Model Age


Ages in M05 and BPASS τ Model (Gyrs)
BPASS τ Model Age
M05 Age

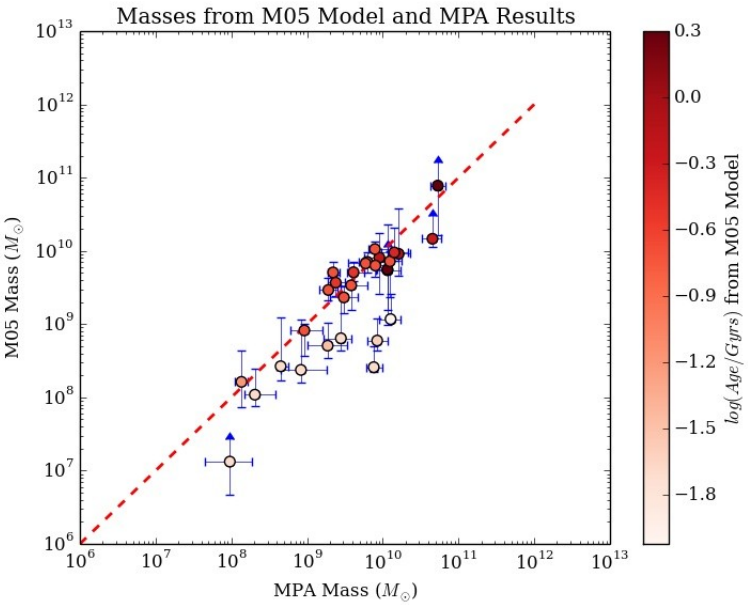

Ages in M05 and BPASS inverse τ Model (Gyrs)
BPASS inverse τ Model Age
M05 Age

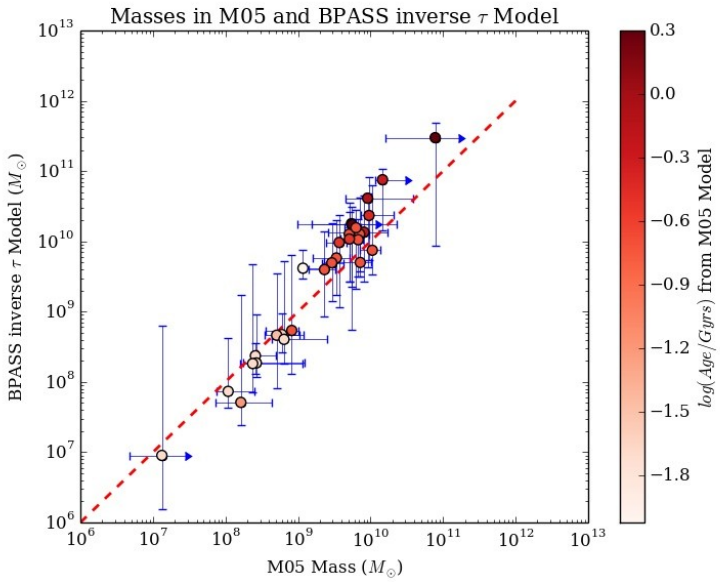

Masses in M05 and BPASS τ Model
BPASS τ Model ($M_\odot$)
M05 Mass ($M_\odot$)
10^{6}
10^{7}
10^{8}
10^{9}
10^{10}
10^{11}
10^{12}
10^{13}
0.9
0.6
0.3
0.0
−0.3
−0.6
−0.9
−1.2
−1.5
log(Age/Gyrs) from negative τ BPASS

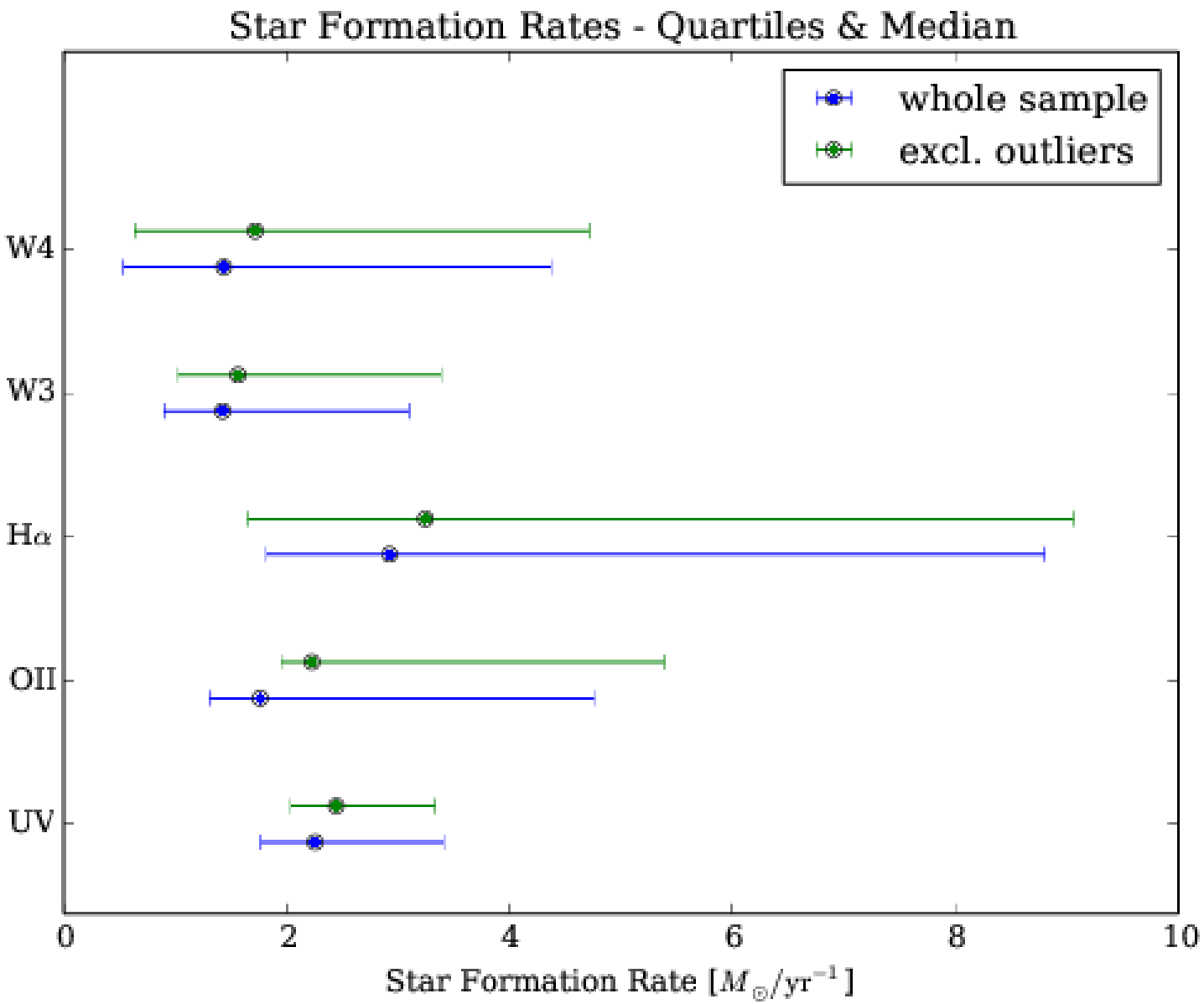


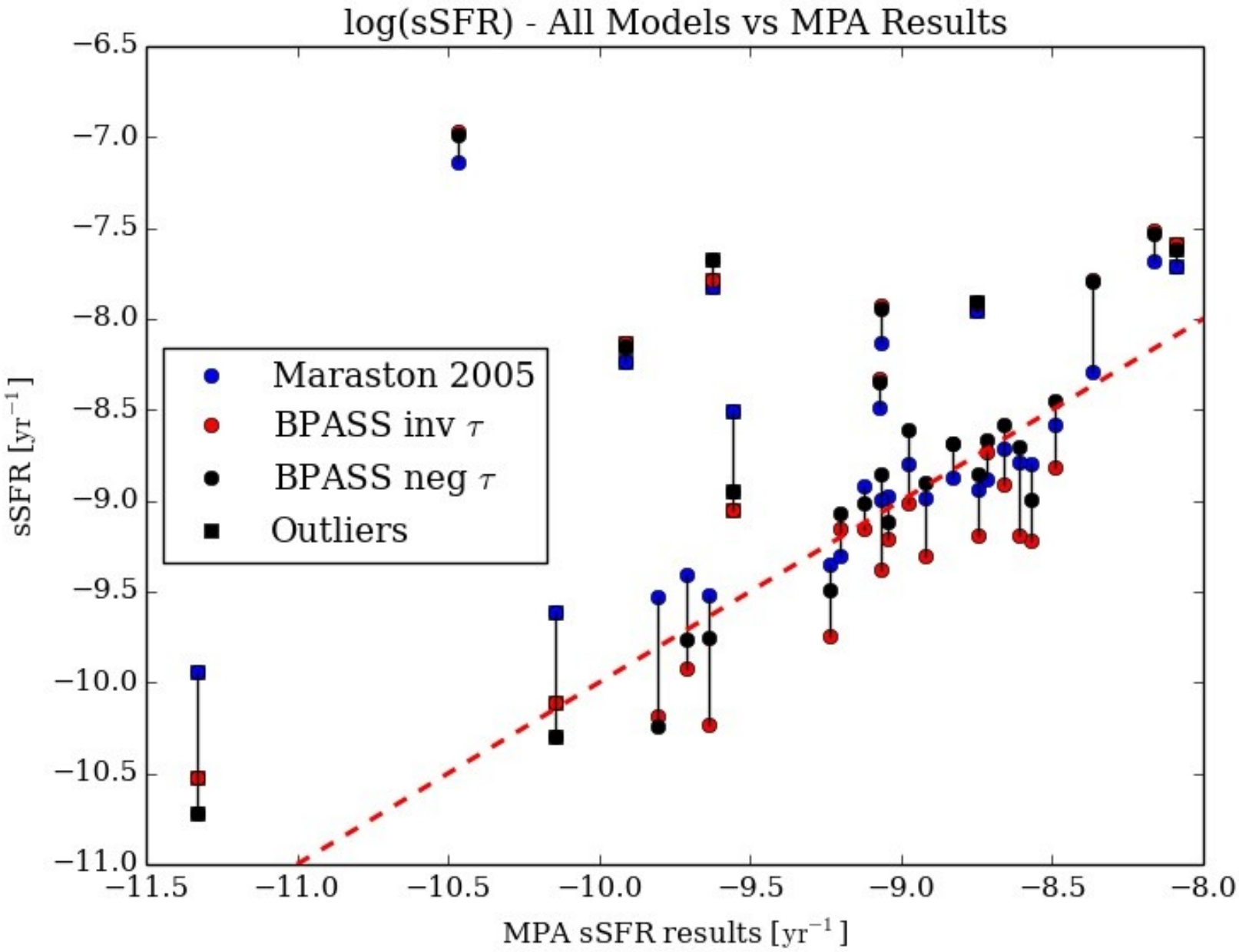
Mass results appear to be model-independent

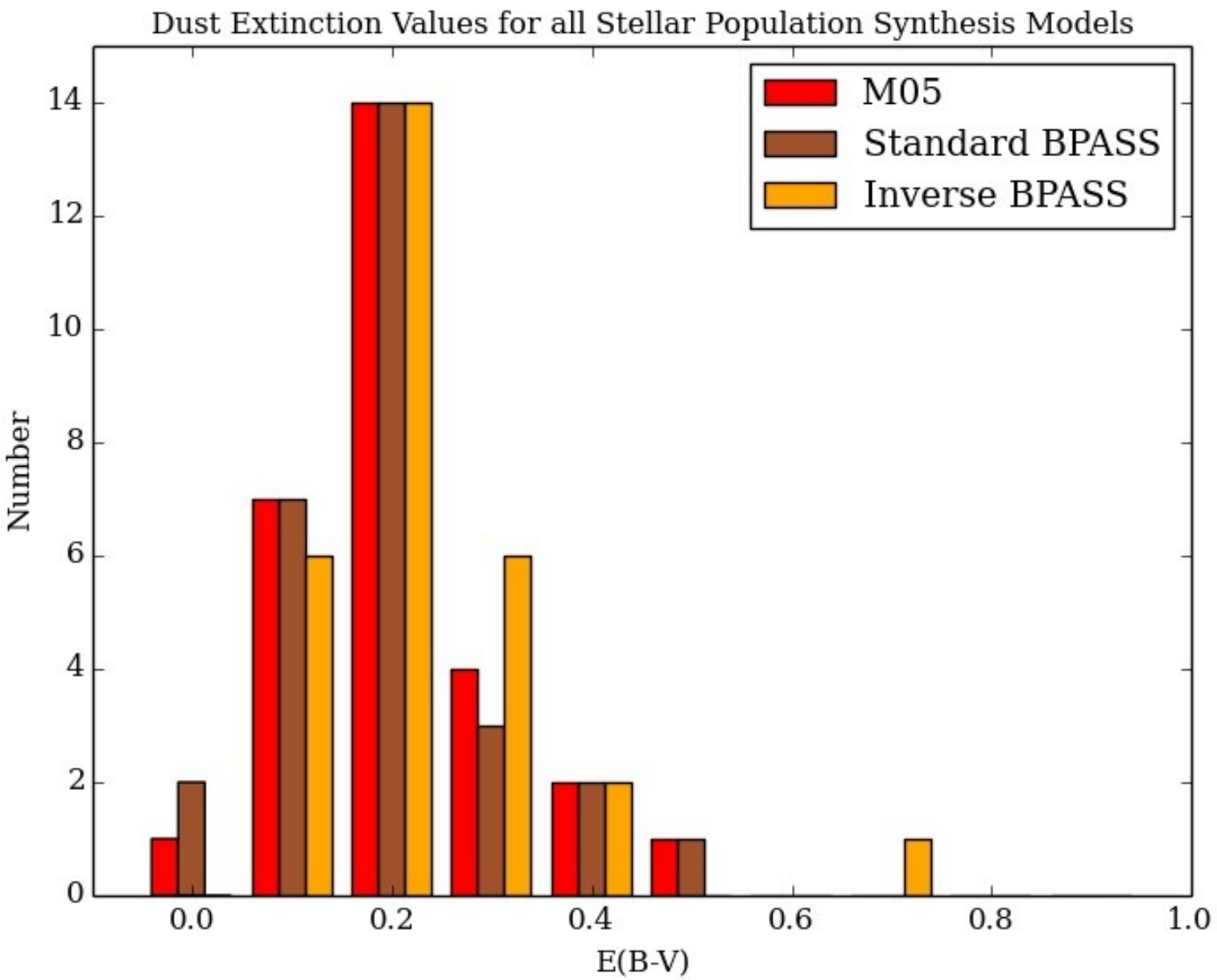
MPA appears to preferentially fit higher masses than BPASS/M05 due to different emission line models






Star Formation Rates - Quartiles & Median
whole sample
excl. outliers
W4
W3
Hα
OII
UV
0
2
4
6
8
10
Star Formation Rate [$M_\odot/\mathrm{yr}^{-1}$]


log(sSFR) - All Models vs MPA Results
Maraston 2005
BPASS inv τ
BPASS neg τ
Outliers
sSFR [yr^{-1}]
MPA sSFR results [yr^{-1}]
−6.5
−7.0
−7.5
−8.0
−8.5
−9.0
−9.5
−10.0
−10.5
−11.0
−11.5
−11.0
−10.5
−10.0
−9.5
−9.0
−8.5
−8.0


Dust Extinction Values for all Stellar Population Synthesis Models
M05
Standard BPASS
Inverse BPASS
Number
E(B-V)
0
2
4
6
8
10
12
14
0.0
0.2
0.4
0.6
0.8
1.0

How do These Galaxies Compare?

	z~3 LBGs	Our Sample	z~5 LBGs	z~8 LBGs
log(age)	<9	7.5 - 9.5	~8	~8.3
log(mass)	9.5 - 11.0	8.5 - 10.5	~9	~7
Dust E(B-V)	~ 0.13	0.2	~0.15	0.0 – 0.4
SFR [Msun/yr]	3 - 300	0.5 - 10	~10	~ few

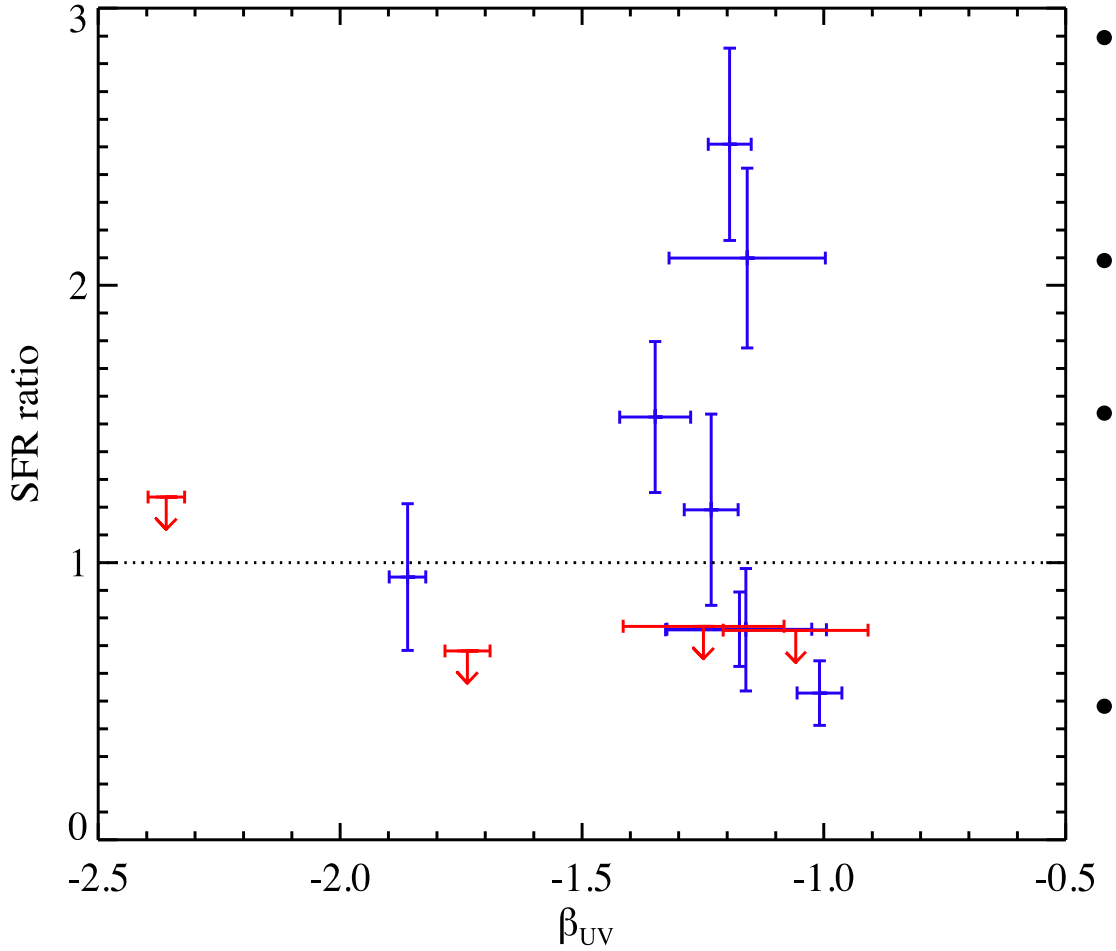
Hoopes+2007, Bunker+2010, Finkelstein+2010, Verma+2007, Hathi+2013

How do These Galaxies Compare to Other Populations?

- Comparison of LBAs with
  - UVLGs: UVLGs are too massive and old to provide good comparisons to 5<z<8 samples
    (Bouwens et al 2012, Verma et al 2007, Douglas et al 2010)
  - BCDs (such as Haro 11, VV114) probe the other extreme, more akin to the first generation of primordial galaxies;
    v. low metallicity, v. high SFRs

ESO/ESA/Hubble and NASA

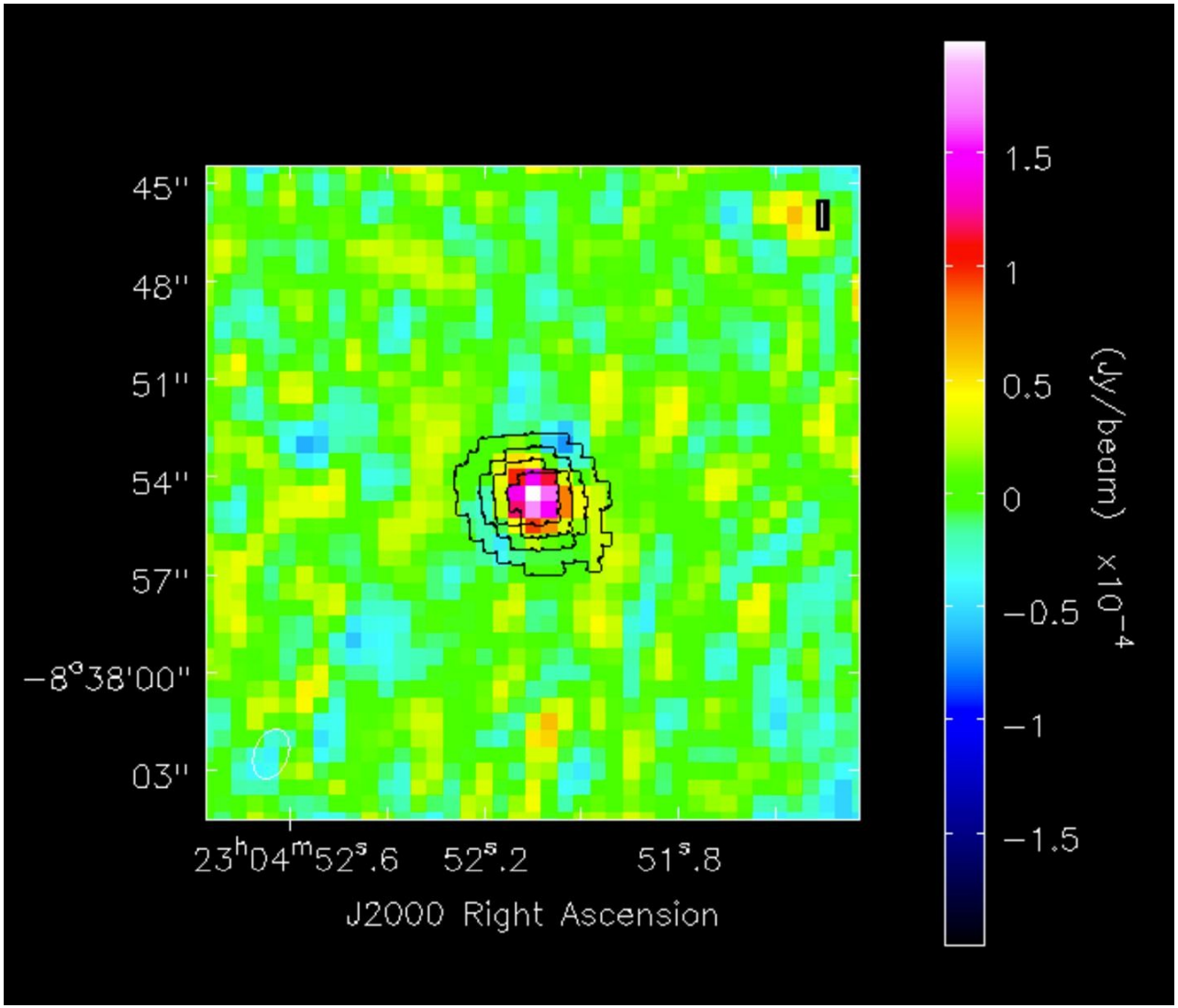
What do Lyman Break Analogues tell us? - Radio



- Observations of 13 sources at 5.5 GHz using the ATCA
- None host heavily obscured starbursts/AGN
- About half the sources have radio flux deficient relative to the UV at the 3σ level
- If supported by future observations, this may indicate very young star formation

These genuinely appear to be young, compact, low mass starbursts

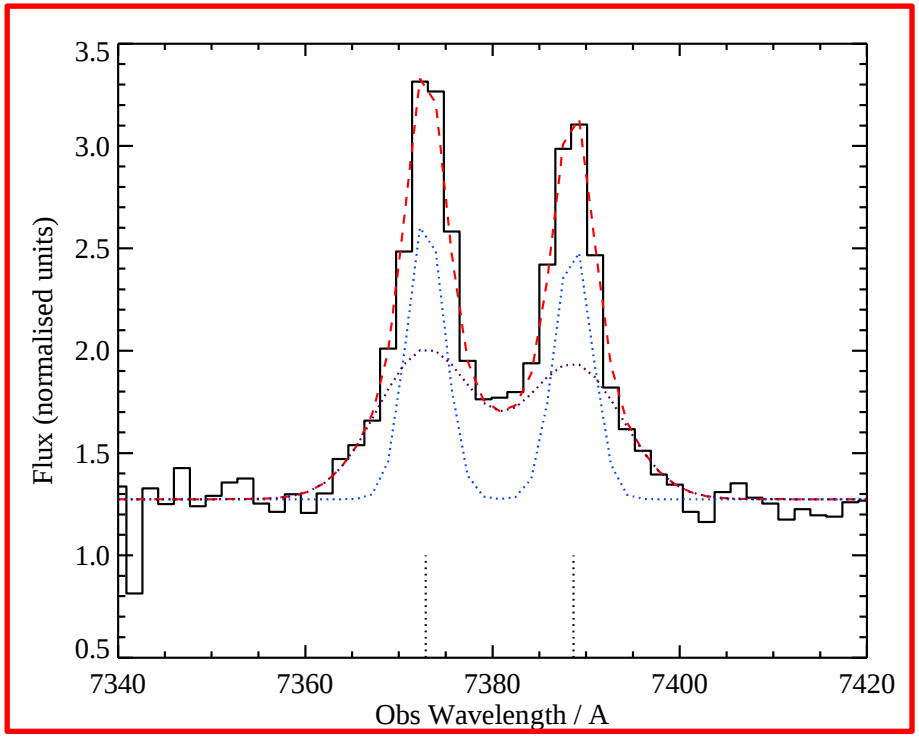
What do Lyman Break Analogues tell us? - Radio



What do Lyman Break Analogues tell us? - Spectroscopy

- Outflows in [S II]
  - Present in about 1/8 of photometrically selected (extended) sample

→ What volume of surroundings is affected by these galaxies?



Future Work

- Spectroscopy & Reliability of Selection Criteria
  - AAOmega 2dF; ~200 objs; based on photometric selection
  - Number density of LBA candidates
  - How reliable are our selection criteria?
- Radio follow-up
  - VLA: 21cm & continuum (5 in hand, expecting more this year, aiming for 50)
  - APEX: explore dust component (probably non-detection) → ALMA
  - Have applied for IRAM time: molecular gas → ALMA
- This work is ongoing

Conclusions

- UV-selected objects reasonably reproduce characteristics of z~5 LBG population:
  - Genuinely young, star-forming systems, low dust extinction, log(mass) ~8.5-10.5

- Enable us to study their properties in greater detail than possible for high-redshift objects
  - starting to constrain physical properties, outflows, radio emission

See Greis et al, in prep.