the TAO of SAGE

(part I)

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SAGE:

Semi-**A**nalytic **G**alaxy **E**volution

Croton et al., ApJS, 2016

https://github.com/darrencroton/sage

Primary goal:

Release a publicly available semi-analytic codebase that is ...

... fast, clean, modular

... easy to install and use

... can run on multiple simulations

darrencroton / sage

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Home of the Semi-Analytic Galaxy Evolution (SAGE) galaxy formation model

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darrencroton Merge pull request #9 from jacobseiler/HDF5_reader ... Latest commit 5be5505 13 days ago

code	Initialized output_galaxy.	18 days ago
extra/CoolFunctions	Initial version of SAGE. This is a working version that will be devel...	6 years ago
input	Initialized output_galaxy.	18 days ago
output	Models are now properly bitwise identical.	19 days ago
.gitignore	Hdf5 writer (#1)	26 days ago
LICENSE.txt	Added MIT license file	3 years ago
Makefile	Models are now properly bitwise identical.	19 days ago
README.md	Update README.md	a year ago

README.md

Semi-Analytic Galaxy Evolution (SAGE)

DOI 10.5281/zenodo.45010

SAGE is a publicly available code-base for modelling galaxy formation in a cosmological context. A description of the model and its default calibration results can be found in Croton et al. (2016). These calibration results can also be explored in an iPython notebook showcasing the key figures here. SAGE is a significant update to that previously used in Croton et al. (2006).

Compared to Croton et al. 2006...

NEW! Gas cooling and AGN heating

NEW! Quasar mode feedback

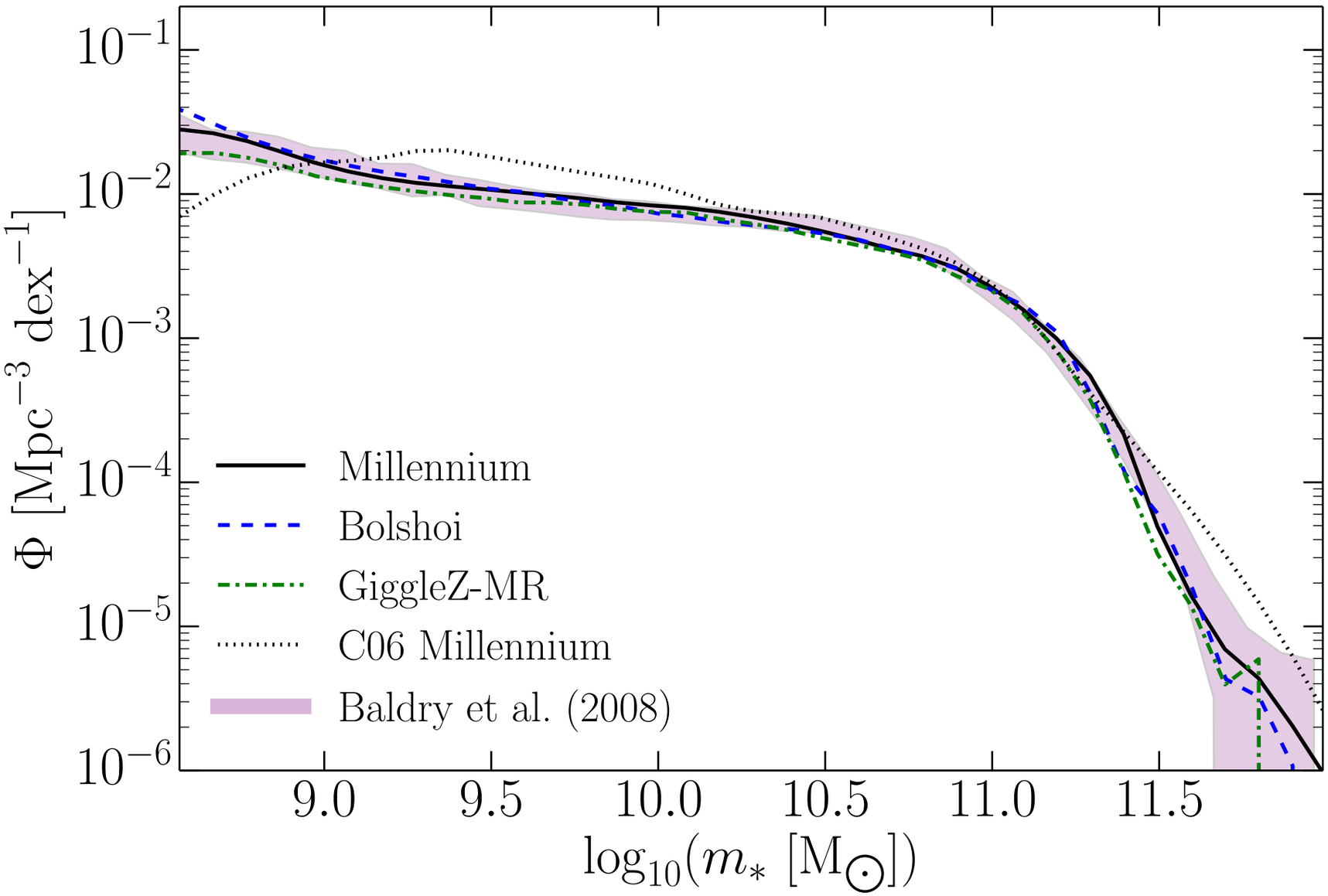
NEW! Ejected gas reincorporation

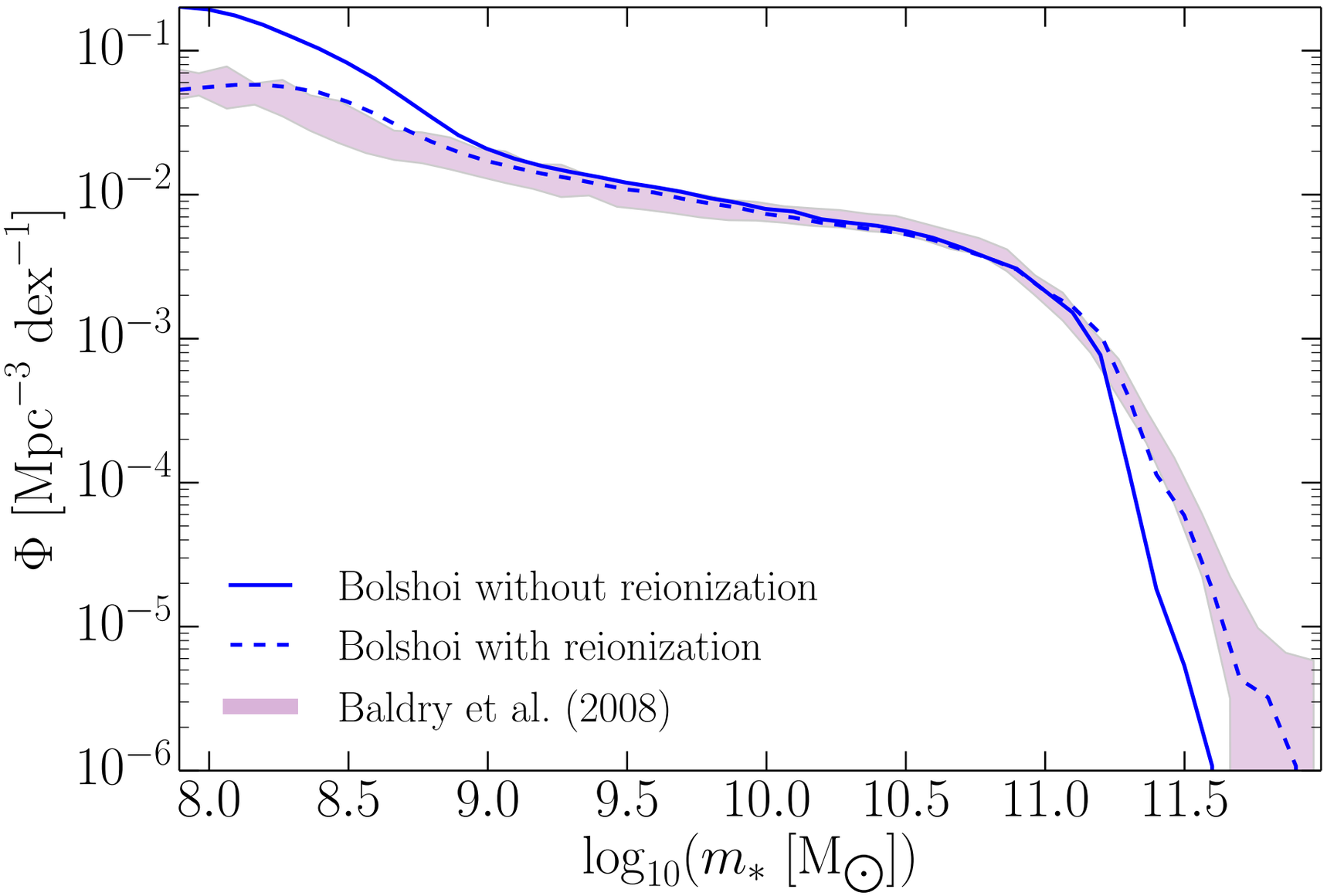
NEW! Satellite galaxies prescription

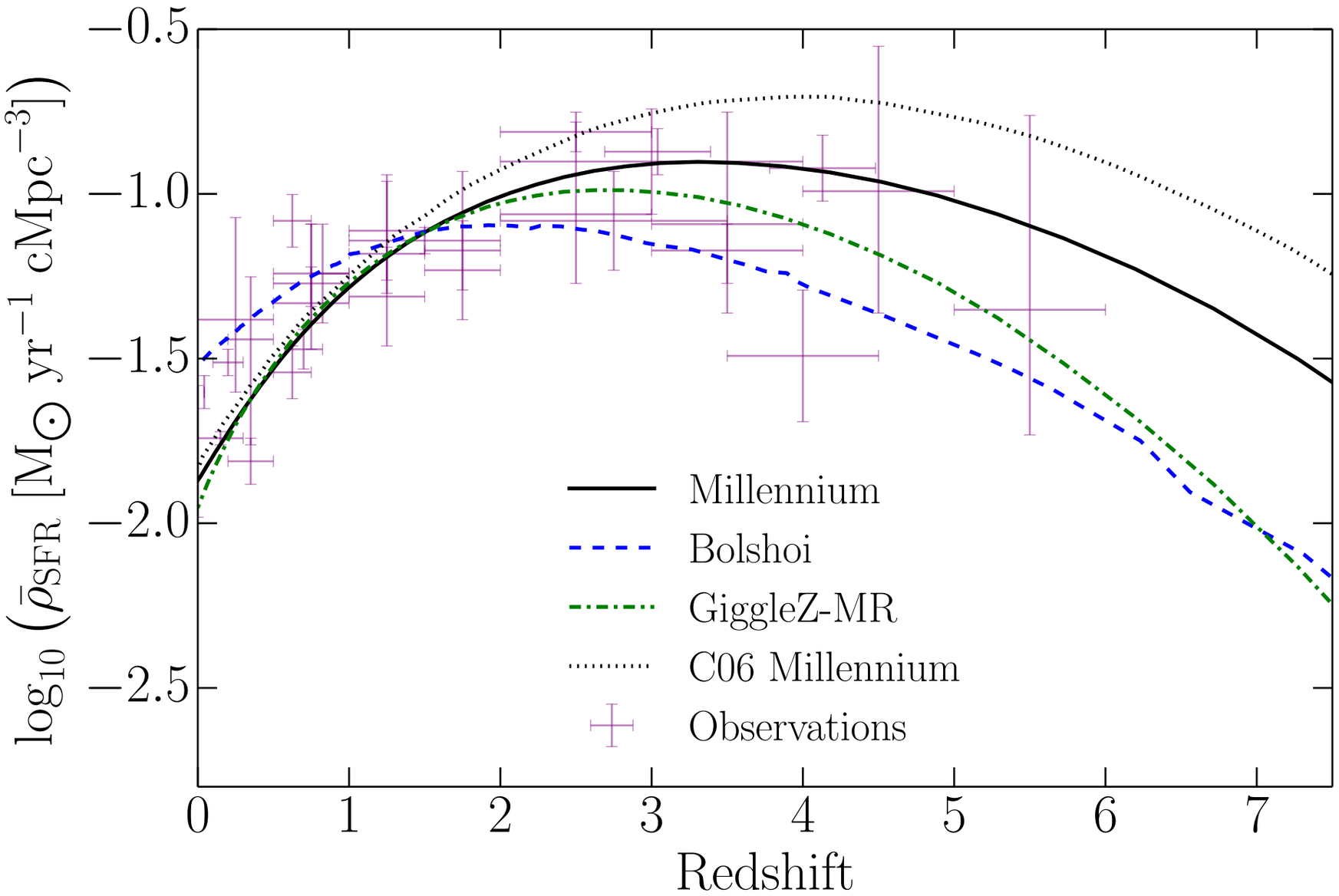
NEW! Mergers and intra-cluster stars

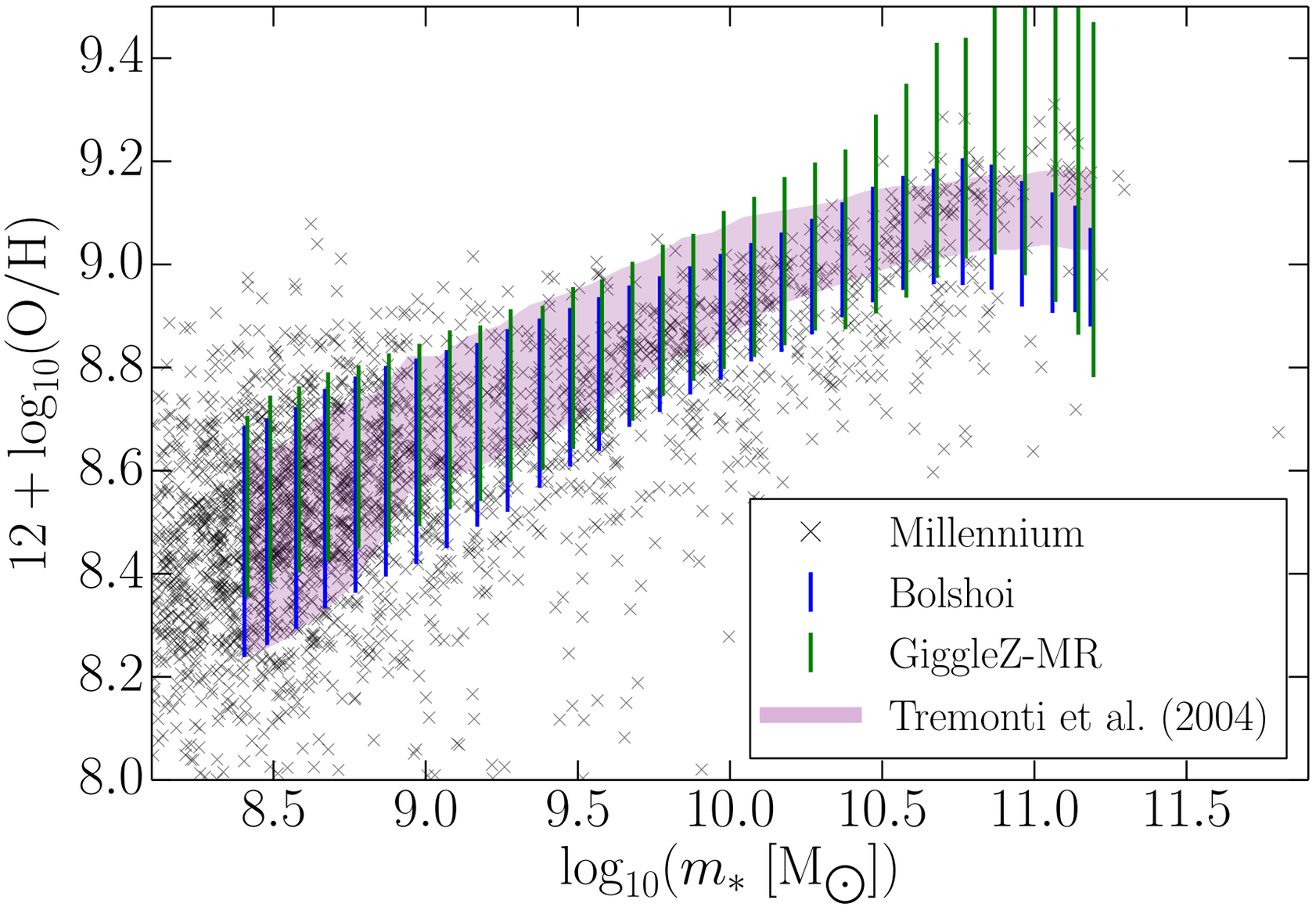
Simulation	$N_{\rm part}$	$M_{\rm part}h$ ($M_\odot$)	$l_{\rm box}h$ (cMpc)	Ω_M	σ_8	Code	Subhalo finder	Tree constructor
Millennium	2160^3	8.60×10^8	500	0.250	0.900	GADGET-2	SUBFIND	L-HALOTREE
Bolshoi	2048^3	1.35×10^8	250	0.270	0.820	ART	ROCKSTAR	CONSISTENT-TREES
GiggleZ-MR	520^3	9.50×10^8	125	0.273	0.812	GADGET-2	SUBFIND	Poole et al. (in prep.)

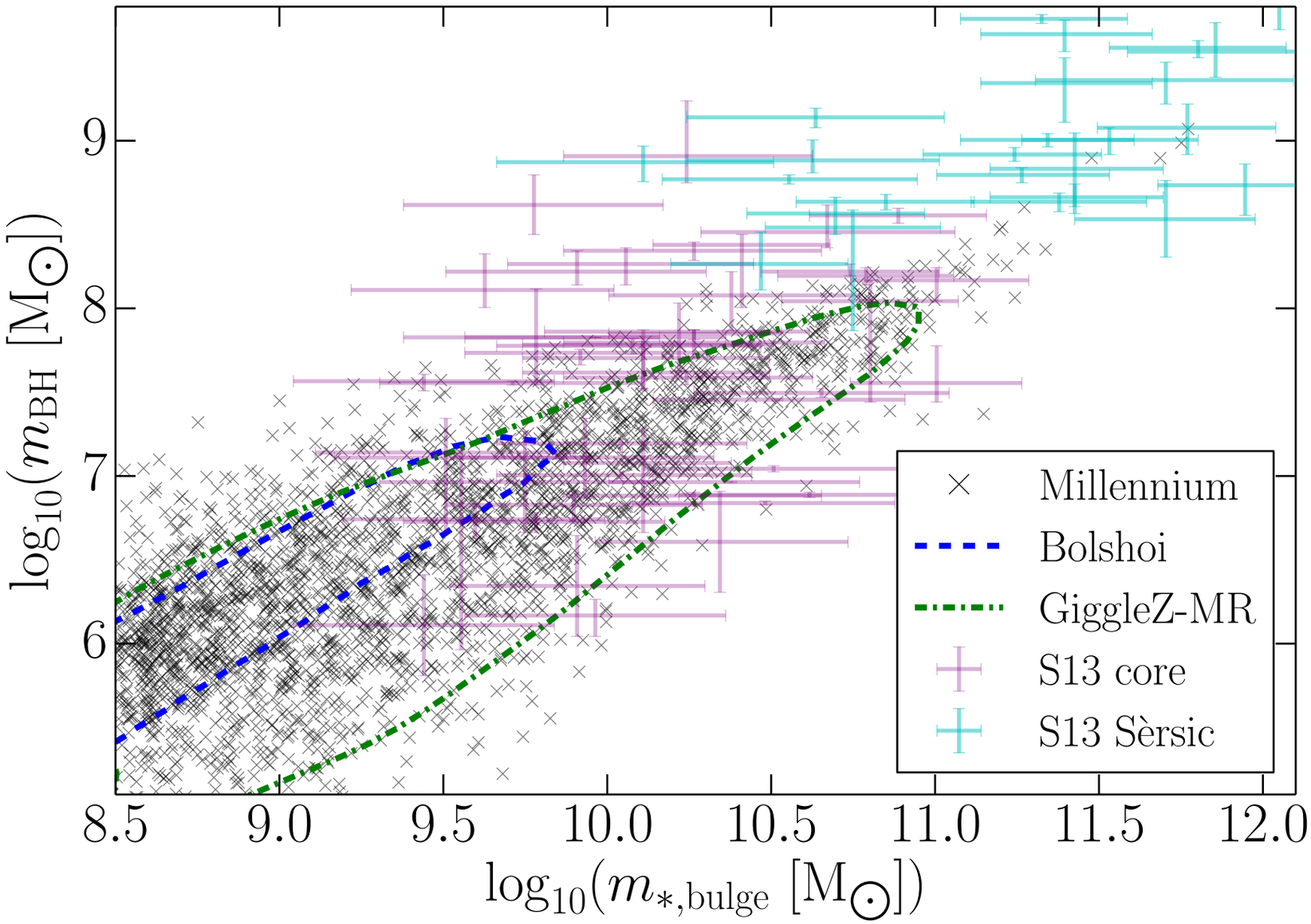
Parameter	Description	Value	C06 value	Fixed	Section(s)
$f_b^{(\rm cosmic)}$	(Cosmic) baryon fraction	0.17, 0.13	0.17	No	4, 5
z_0	Redshift when H II regions overlap	8.0	8.0	Yes	5
z_r	Redshift when the intergalactic medium is fully reionized	7.0	7.0	Yes	5
$\alpha_{\rm SF}$	Star formation efficiency	0.05	0.07	No	7
Y	Yield of metals from new stars	0.025	0.03	No	7
$\mathcal{R}$	Instantaneous recycling fraction	0.43	0.30	Yes	7, 8
$\epsilon_{\rm disc}$	Mass-loading factor due to supernovae	3.0	3.5	No	8
$\epsilon_{\rm halo}$	Efficiency of supernovae to unbind gas from the hot halo	0.3	0.35	No	8
$k_{\rm reinc}$	Sets velocity scale for gas reincorporation	0.15	N/A	Yes	8
$\kappa_{\rm R}$	Radio mode feedback efficiency	0.08	N/A	No	9.1
$\kappa_{\rm Q}$	Quasar mode feedback efficiency	0.005	N/A	No	9.2
$f_{\rm BH}$	Rate of black hole growth during quasar mode	0.015	0.03	No	9.2
$f_{\rm friction}$	Threshold subhalo-to-baryonic mass for satellite disruption or merging	1.0	N/A	Yes	10
$f_{\rm major}$	Threshold mass ratio for merger to be major	0.3	0.3	Yes	10


10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Φ [Mpc^{-3} dex^{-1}]
Millennium
Bolshoi
GiggleZ-MR
C06 Millennium
Baldry et al. (2008)
9.0
9.5
10.0
10.5
11.0
11.5
$\log_{10}(m_*$ [M$_\odot$])


10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Φ [Mpc^{-3} dex^{-1}]
Bolshoi without reionization
Bolshoi with reionization
Baldry et al. (2008)
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
$\log_{10}(m_*$ [M$_\odot$])


−0.5
−1.0
−1.5
−2.0
−2.5
$\log_{10}\left(\bar{\rho}_{\rm SFR}\ [{\rm M}_\odot\ {\rm yr}^{-1}\ {\rm cMpc}^{-3}]\right)$
0
1
2
3
4
5
6
7
Redshift
Millennium
Bolshoi
GiggleZ-MR
C06 Millennium
Observations


9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
$12 + \log_{10}(\mathrm{O/H})$
8.5
9.0
9.5
10.0
10.5
11.0
11.5
$\log_{10}(m_* \ [\mathrm{M}_\odot])$
Millennium
Bolshoi
GiggleZ-MR
Tremonti et al. (2004)


Millennium
Bolshoi
GiggleZ-MR
S13 core
S13 Sèrsic
$\log_{10}(m_{\rm BH}\ [{\rm M}_\odot])$
$\log_{10}(m_{*,\rm bulge}\ [{\rm M}_\odot])$
6
7
8
9
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0

Branches under development…

Tonini et al: Bulge formation and demographics

Stevens et al: Angular momentum in disks (DarkSAGE)

Raouf et al: Radio jets and radio AGN (RadioSAGE)

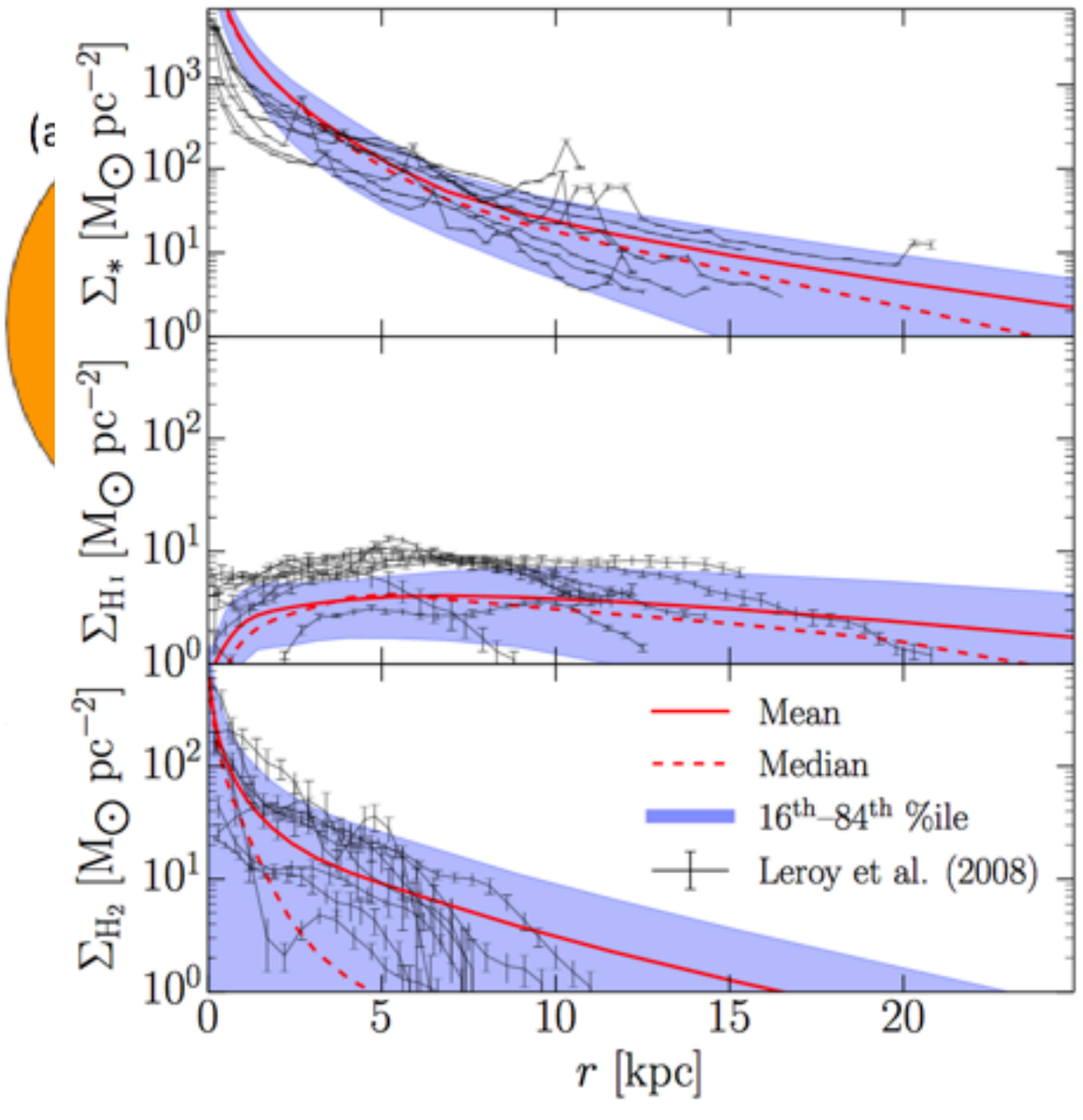
Seiler et al: Diffuse gas and reionization

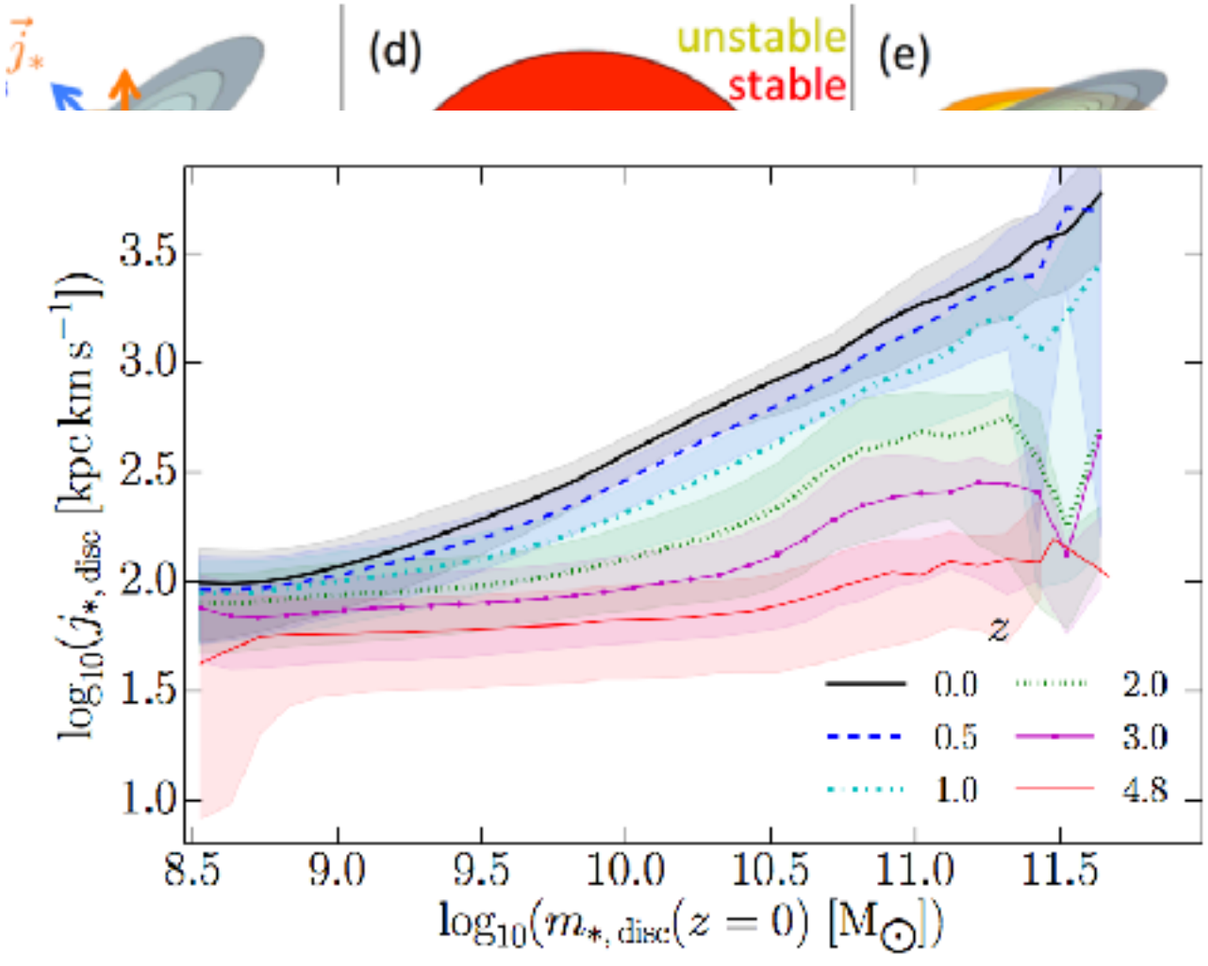
Triani et al: Composite SED modelling

https://github.com/darrencroton/sage

Building disc structure and galaxy properties through angular momentum: The DARK SAGE semi-analytic model

Adam R. H. Stevens,[1⋆] Darren J. Croton[1] and Simon J. Mutch[2]
[1] *Centre for Astrophysics & Supercomputing, Swinburne University of Technology, Hawthorn, VIC 3122, Australia*
[2] *School of Physics, The University of Melbourne, Parkville, VIC 3010, Australia*

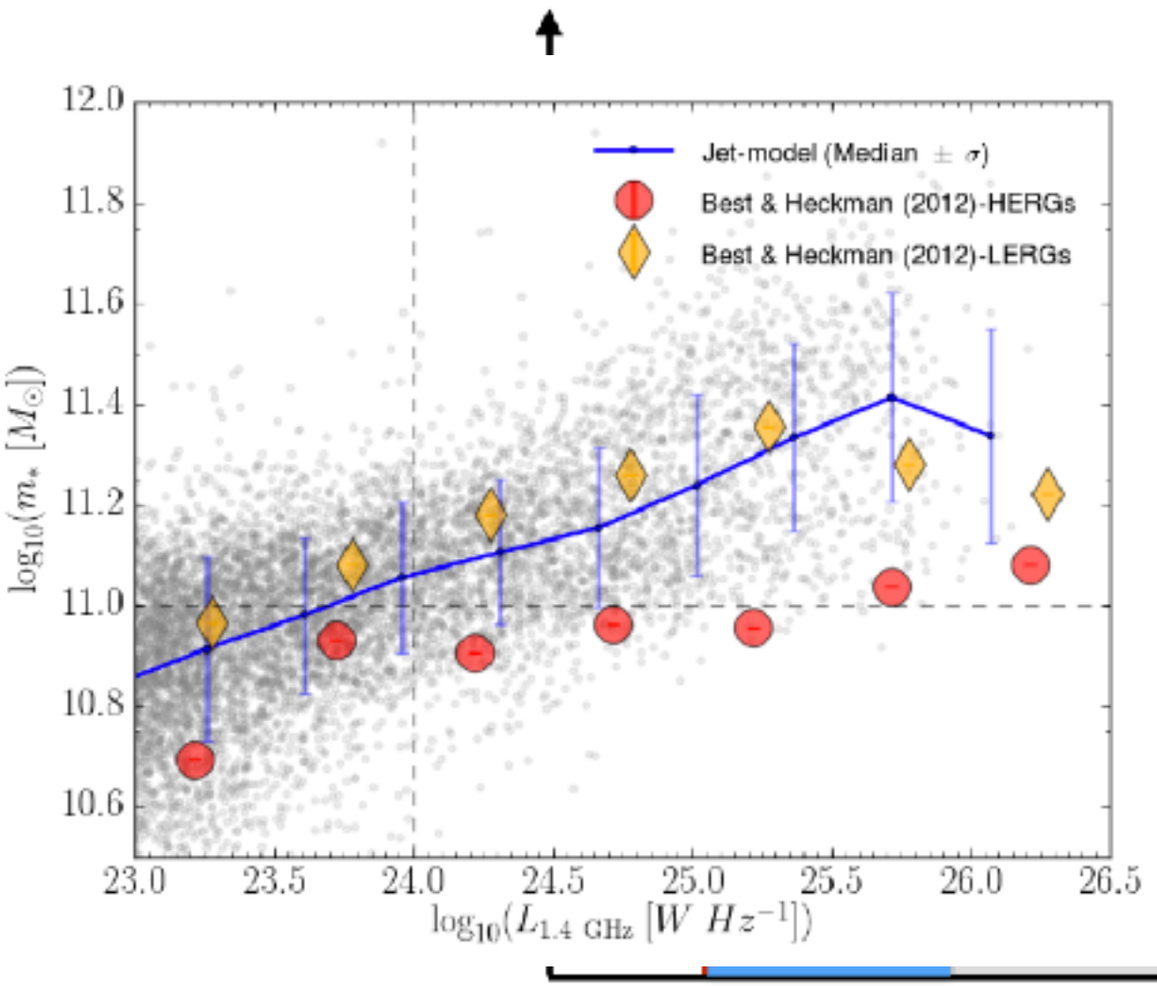


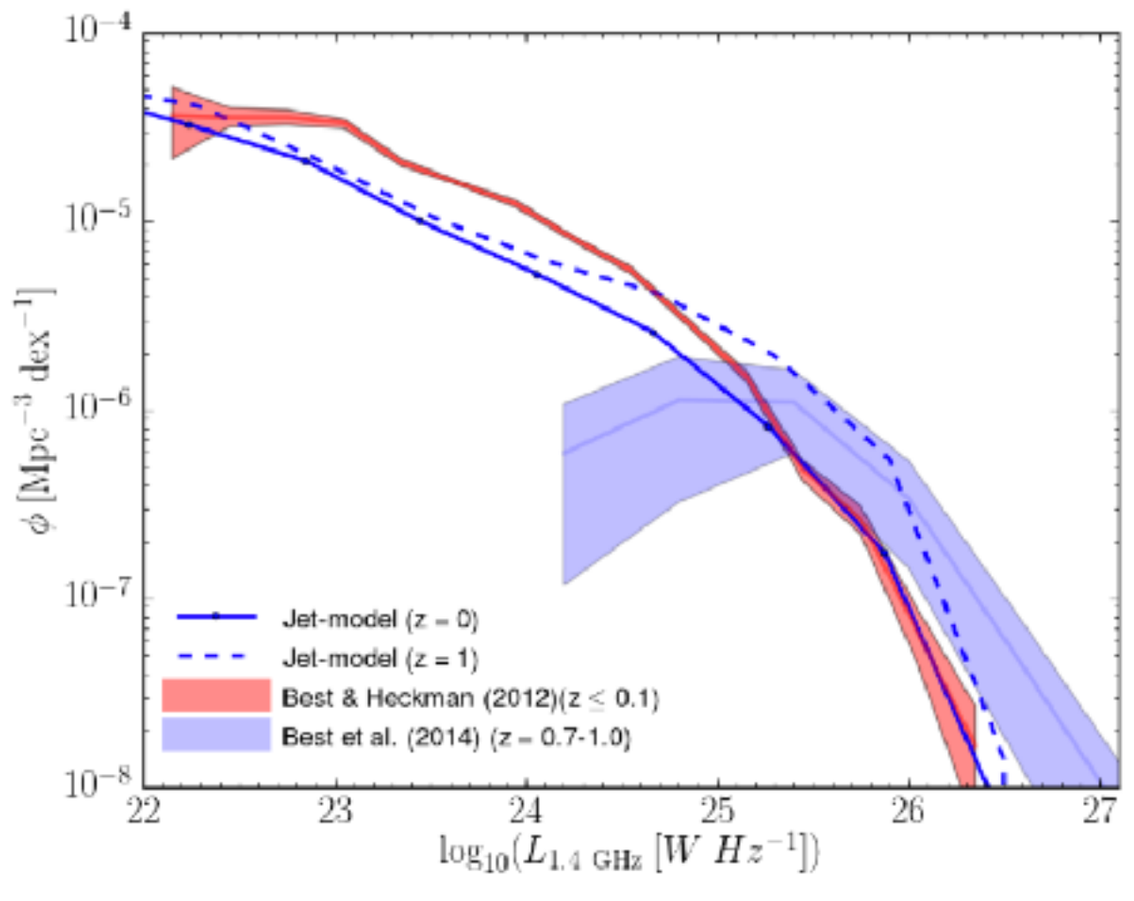


The many lives of active galactic nuclei-II: The formation and evolution of radio jets and their impact on galaxy evolution

Mojtaba Raouf [1,2⋆], Stanislav S. Shabala [3], Darren J. Croton [2], Habib G. Khosroshahi [1], Maksym Bernyk [2].

[1] *School of Astronomy, Institute for Research in Fundamental Sciences (IPM), Tehran, 19395-5531, Iran*
[2] *Centre for Astrophysics & Supercomputing, Swinburne University of Technology, PO Box 218, Hawthorn, Victoria 3122, Australia*
[3] *School of Physical Sciences, Private Bag 37, University of Tasmania, Hobart, TAS 7001, Australia*



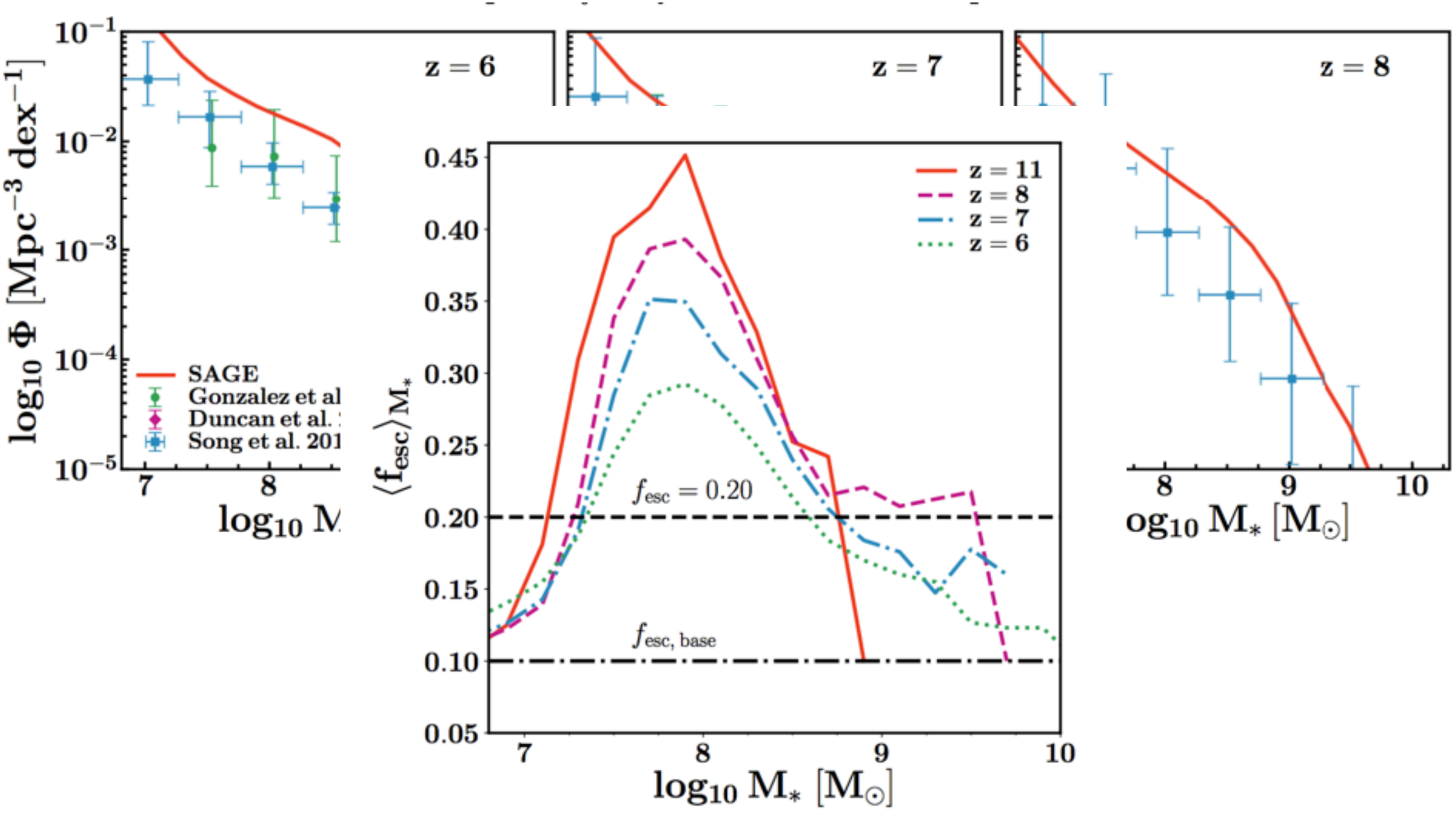


time

The Indirect Influence of Quasars on Reionization

Jacob Seiler[1], Darren Croton[1], Anne Hutter[1], Manodeep Sinha[1⋆]

[1] *Centre for Astrophysics & Supercomputing, Swinburne University of Technology, PO Box 218, Hawthorn, Victoria 3122, Australia*



SAGE in Github

https://github.com/darrencroton/sage

Croton et al. 2016

Models in TAO

https://tao.asvo.org.au

Bernyk et al. 2016