Unveiling the obscured high-redshift Universe with Millimetron

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Unveiling the obscured Universe: from the first stars and black holes to the dust factory in galactic super-winds

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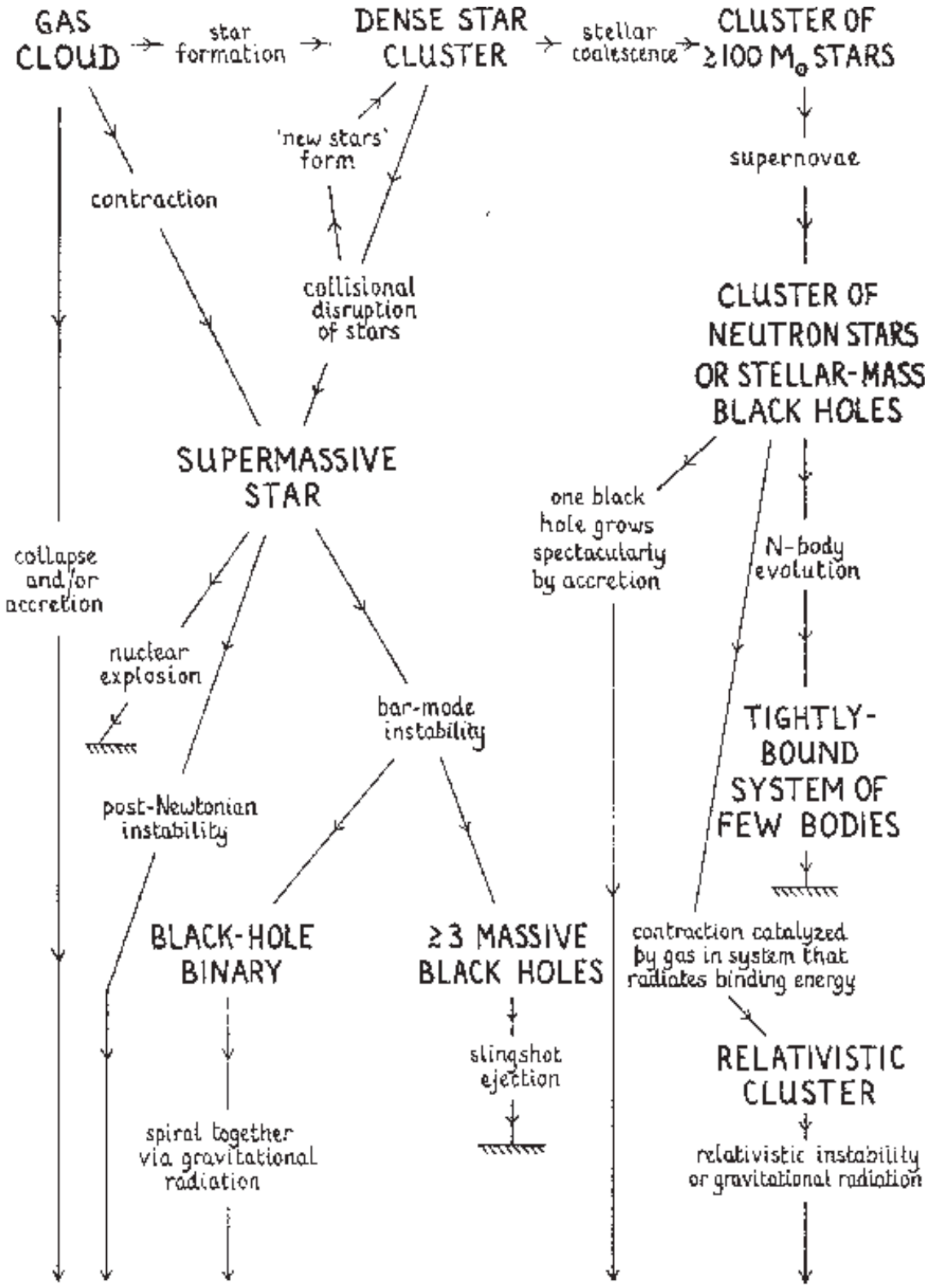
Moscow, 14 April 2021

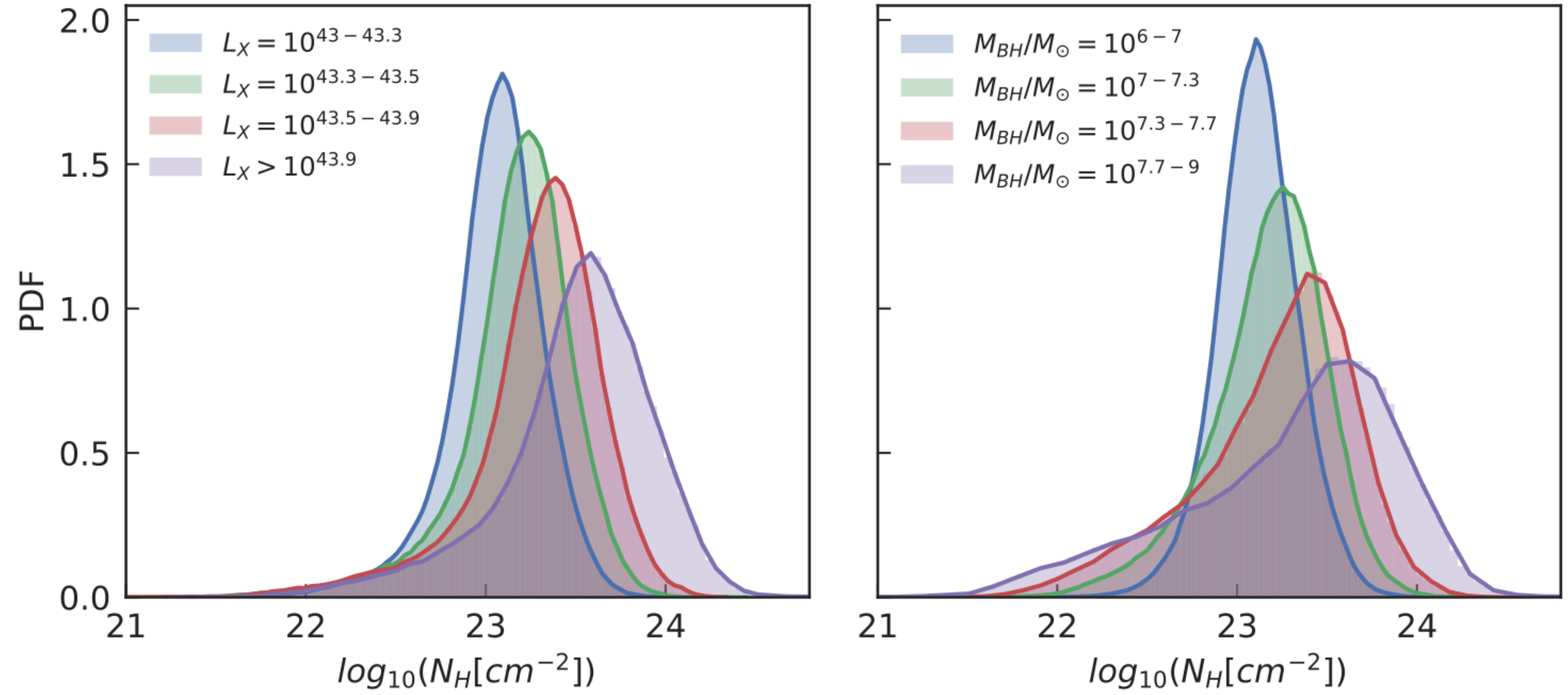
How did SMBHs formed?

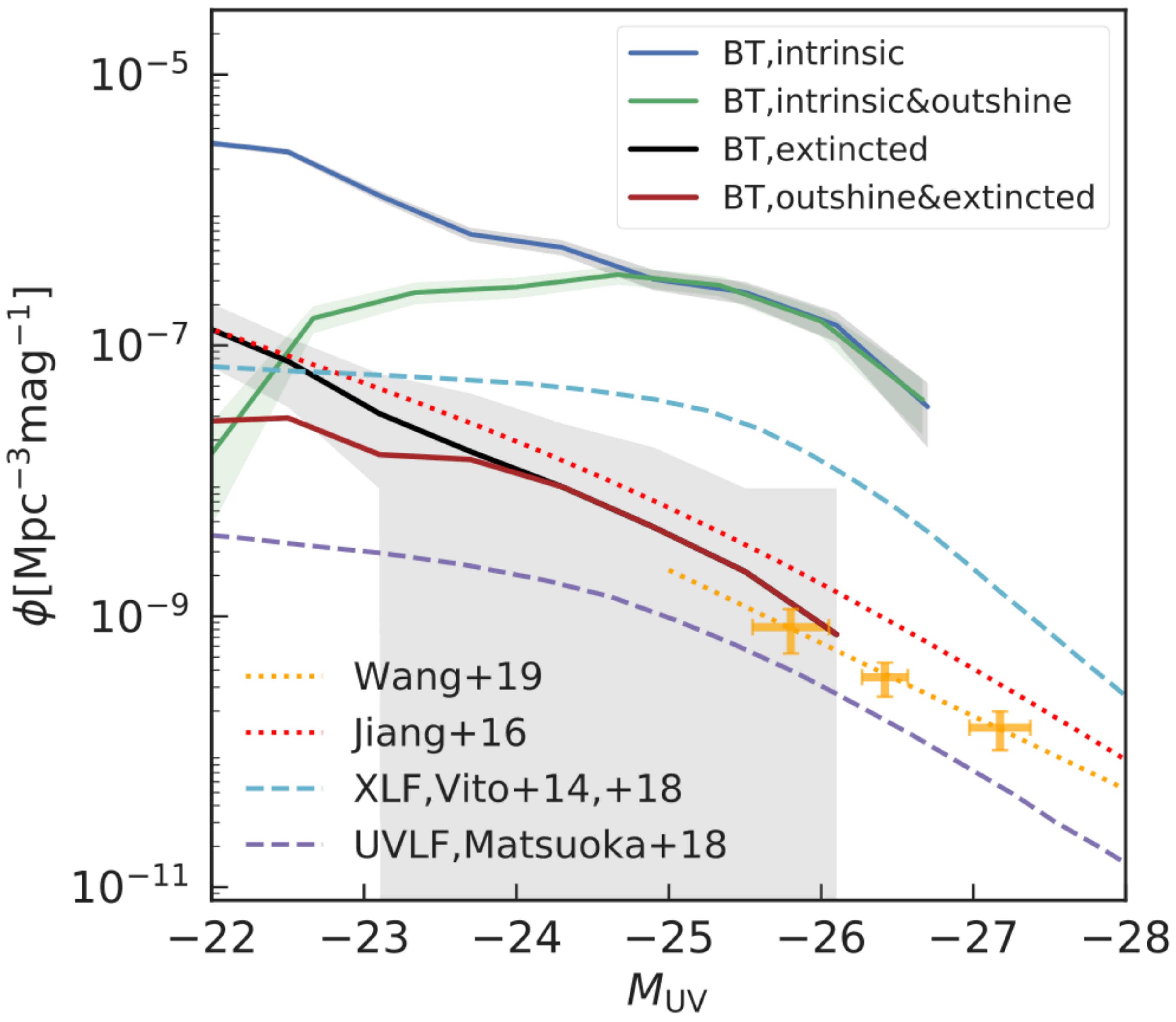
Obscured AGNs at high redshifts

Ref.	Mass	Redshift	t
Mortlock+ 2011	$2 \times 10^9 M_\odot$	7,1	0.77 Gyr
Wu+ 2015	$1.2 \times 10^{10} M_\odot$	6,3	0.84 Gyr
Banados+ 2018	$8 \times 10^8 M_\odot$	7,54	0.7 Gyr
Yang+ 2020	$1.5 \times 10^9 M_\odot$	7,52	0.7 Gyr



Most of high-z AGNs can be obscured!

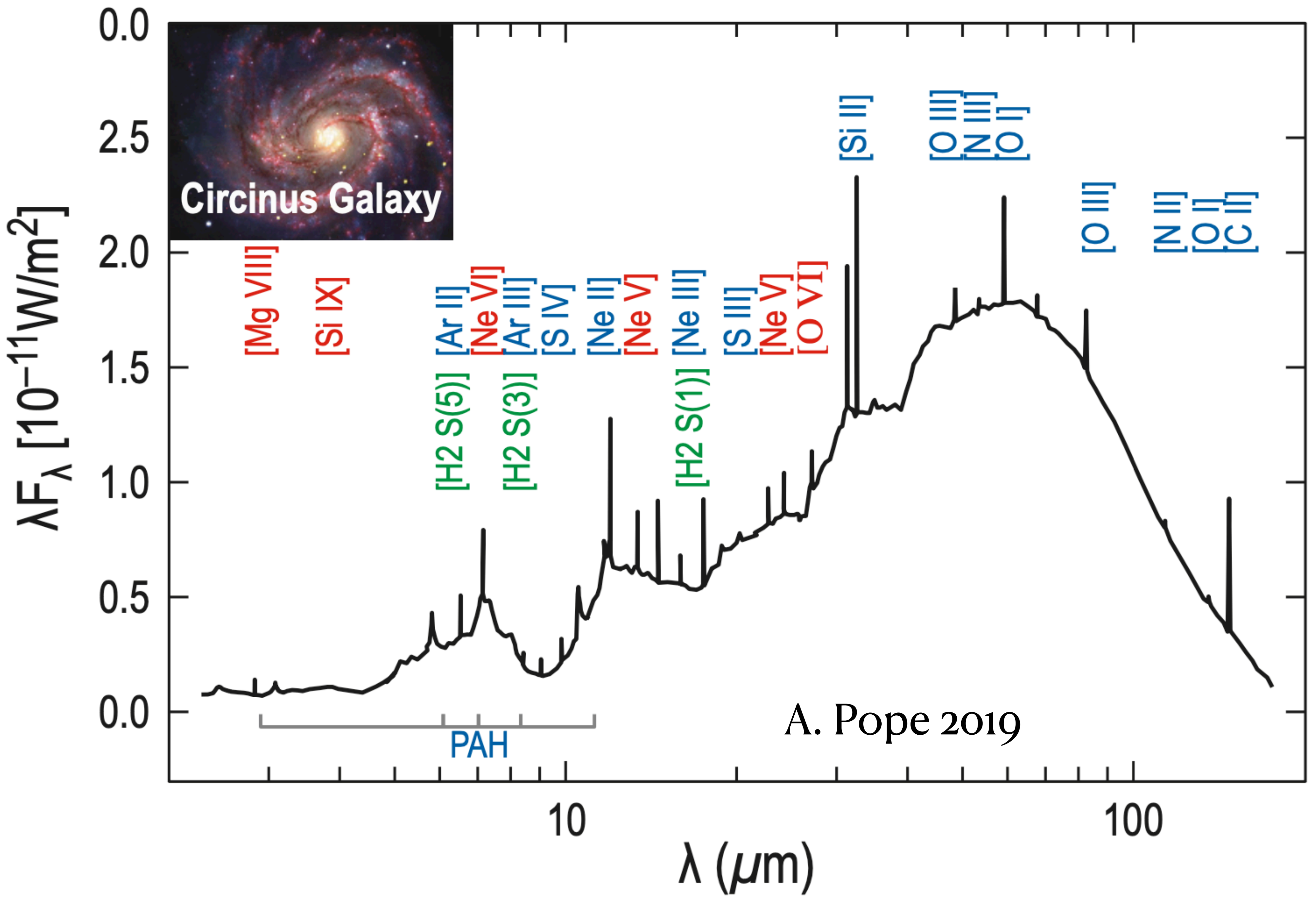


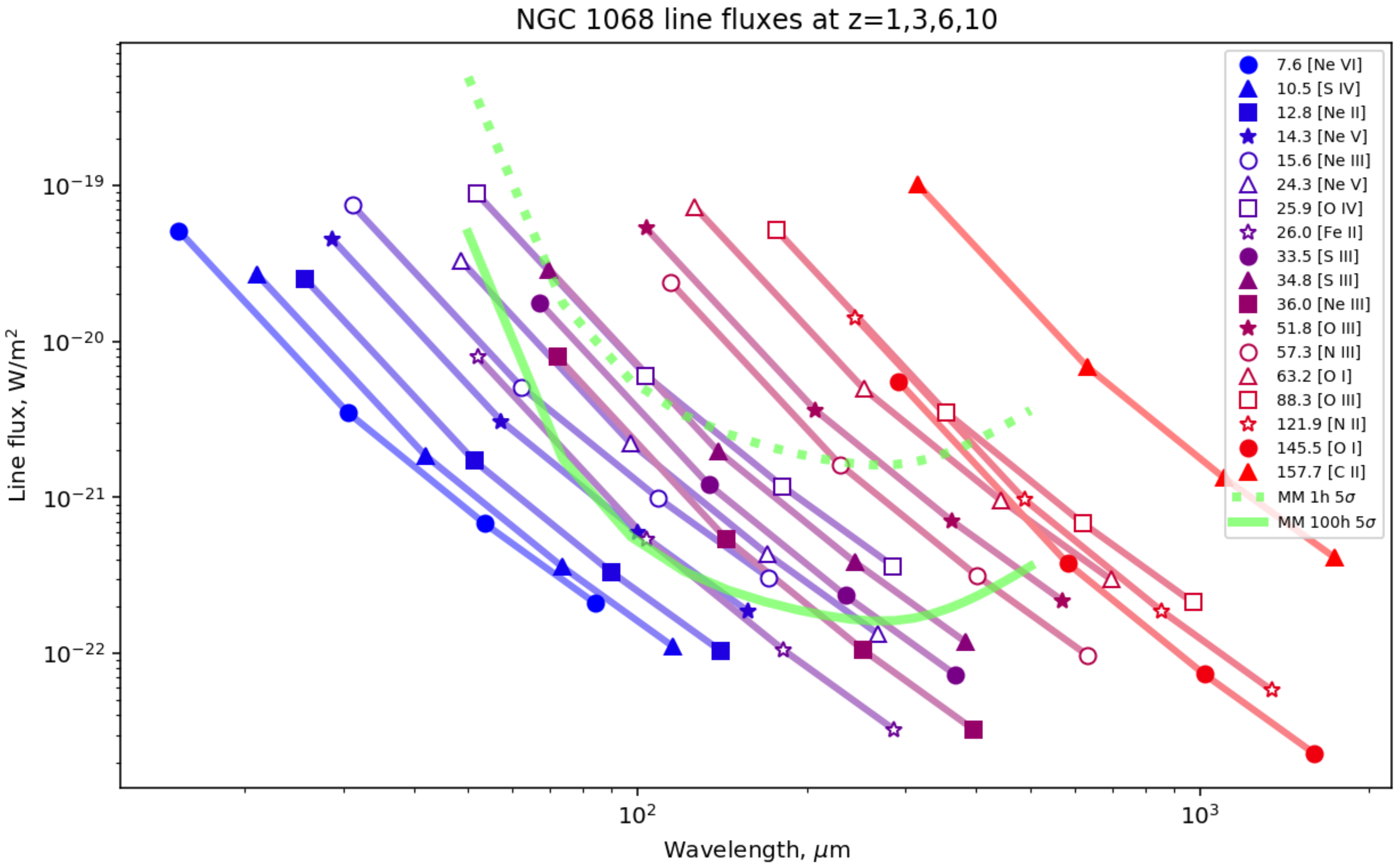


Obscuration is known to depend on L and z!

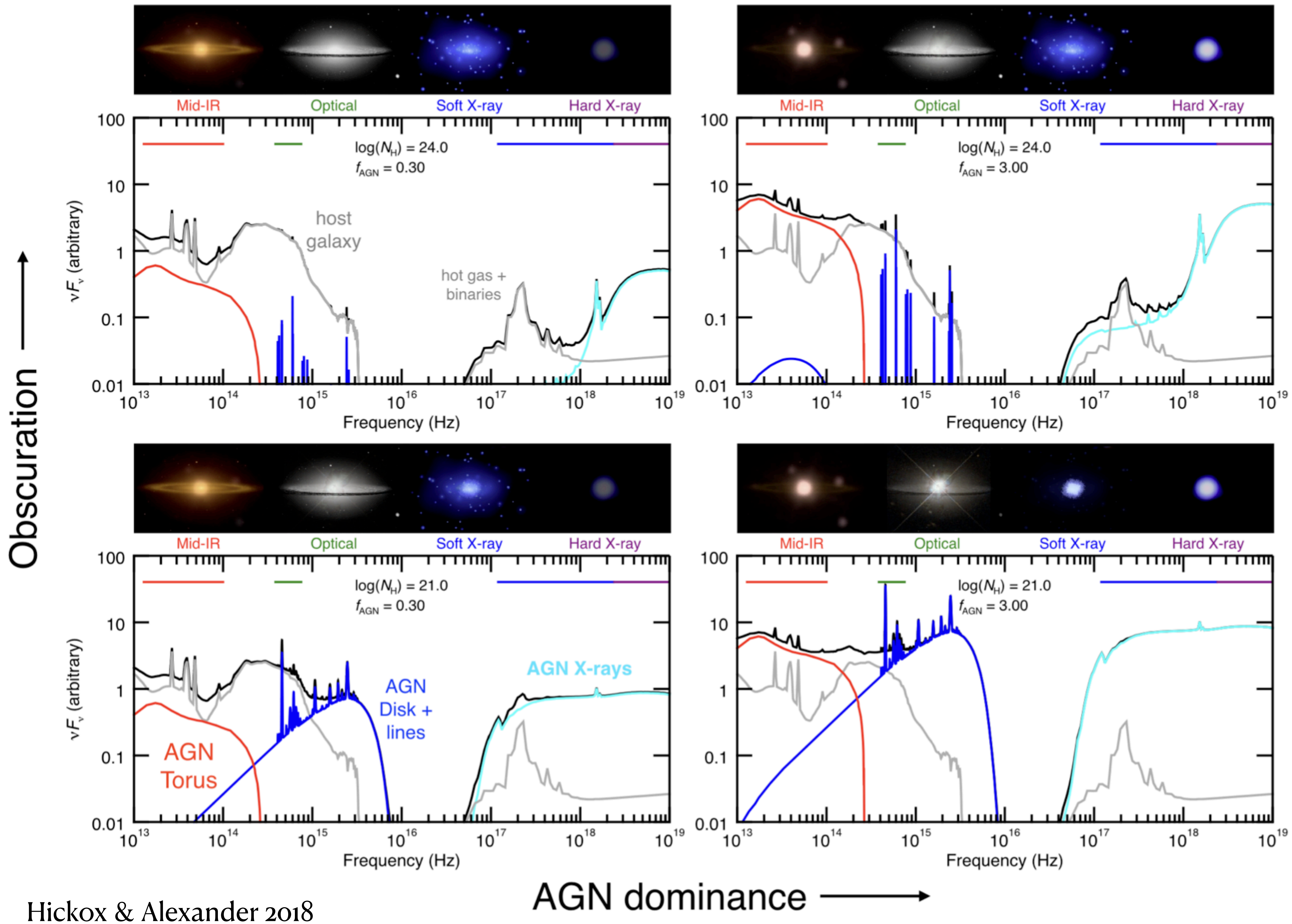
Ni et al. 2020

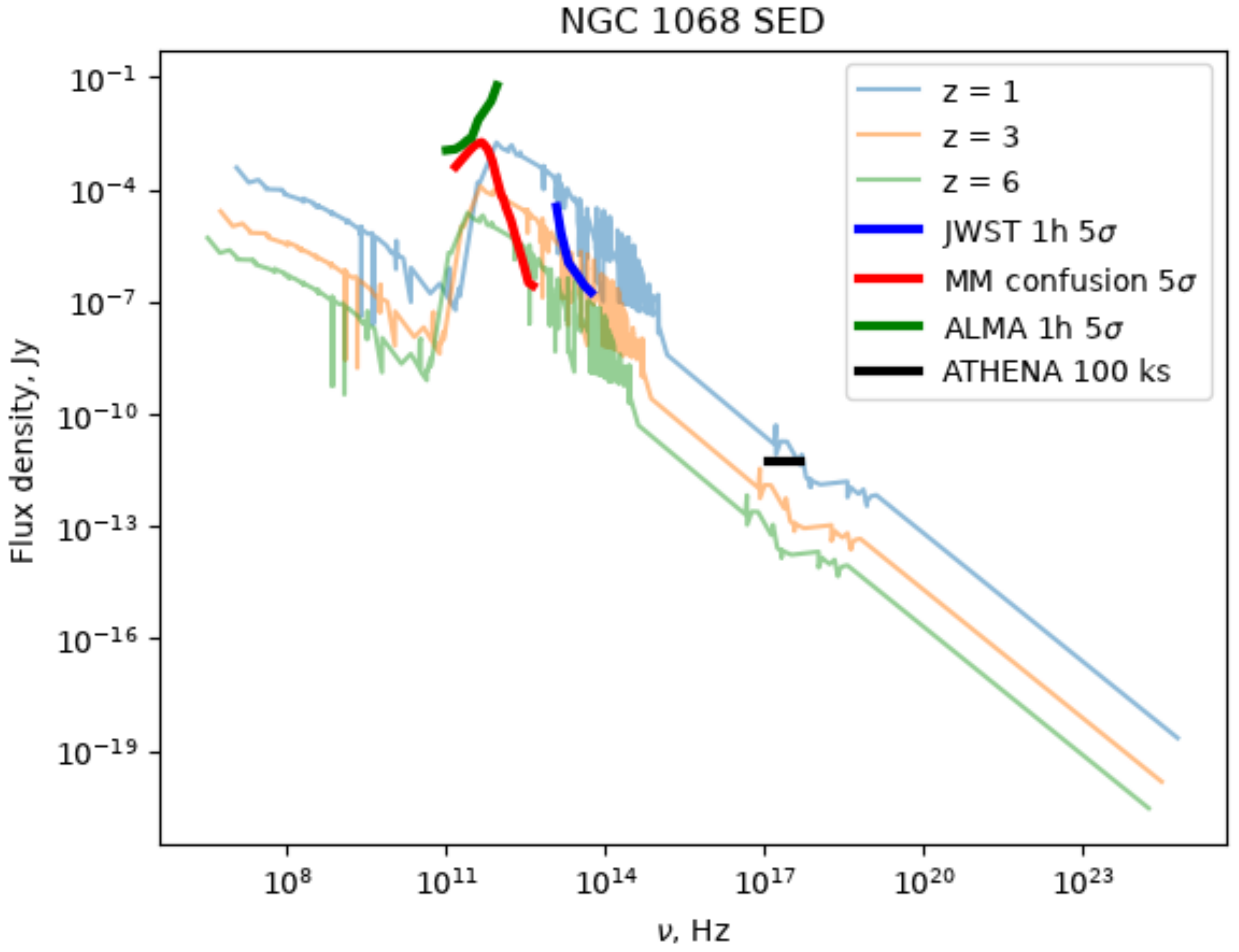
Power of FIR photometry and spectroscopy





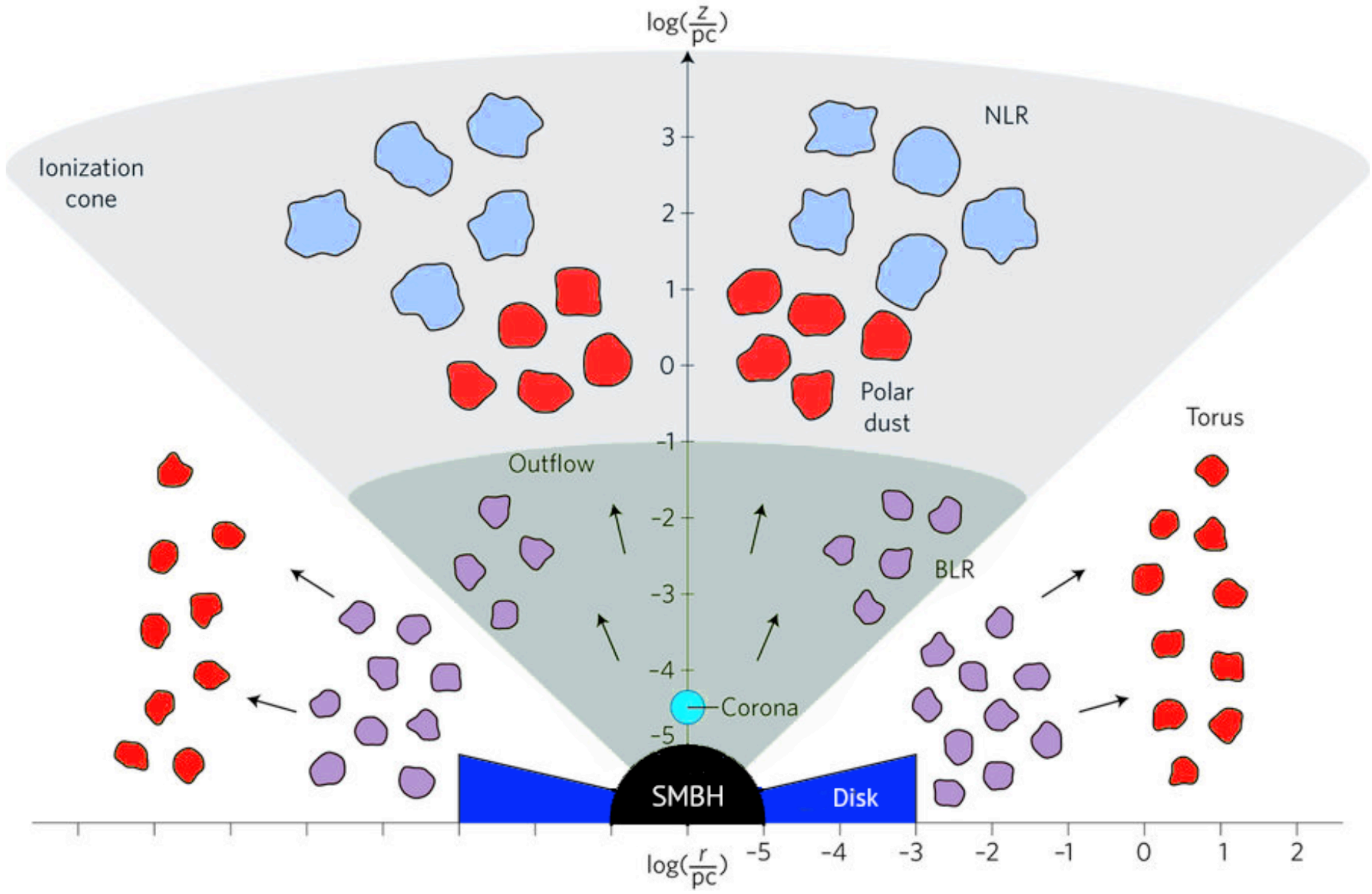
Power of FIR photometry and spectroscopy

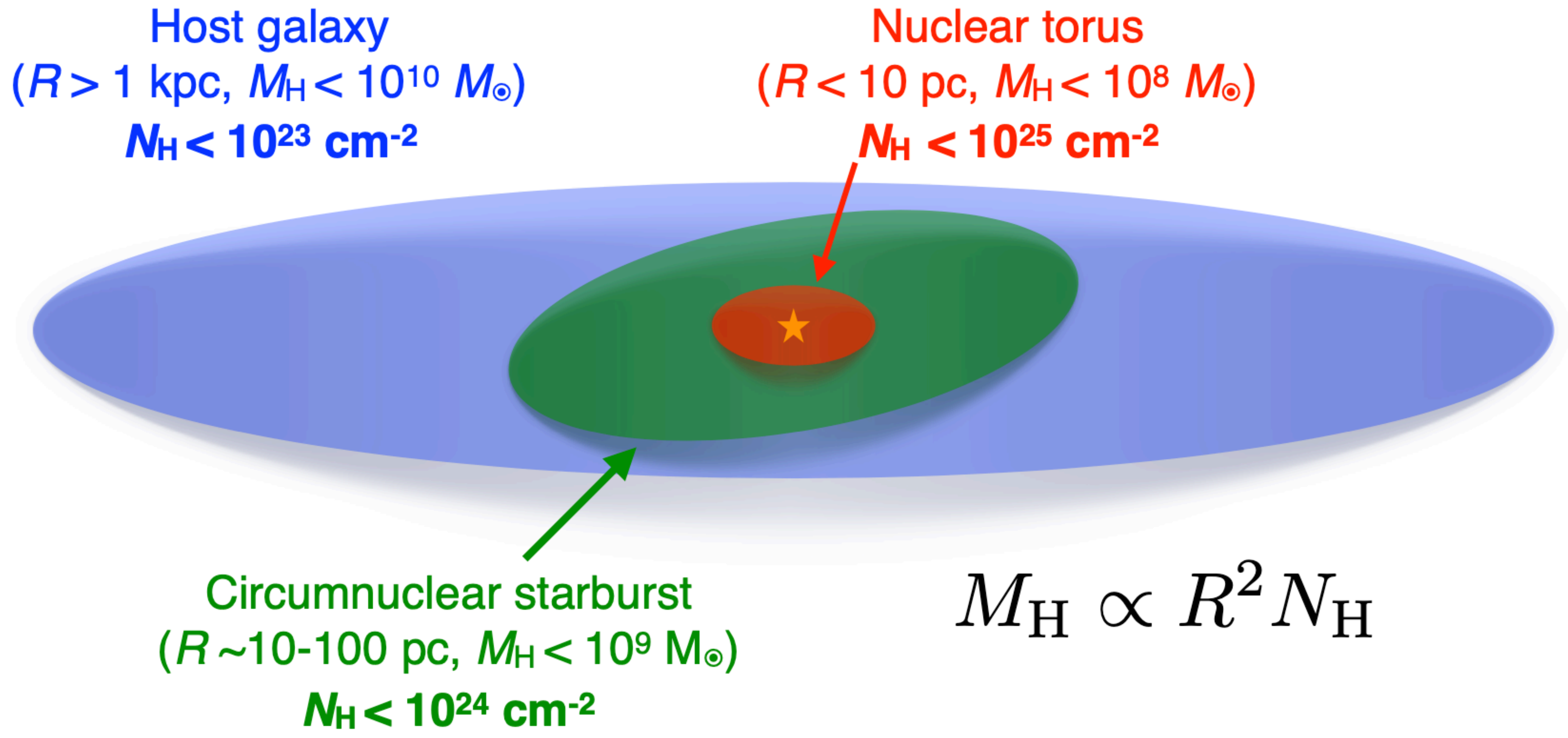


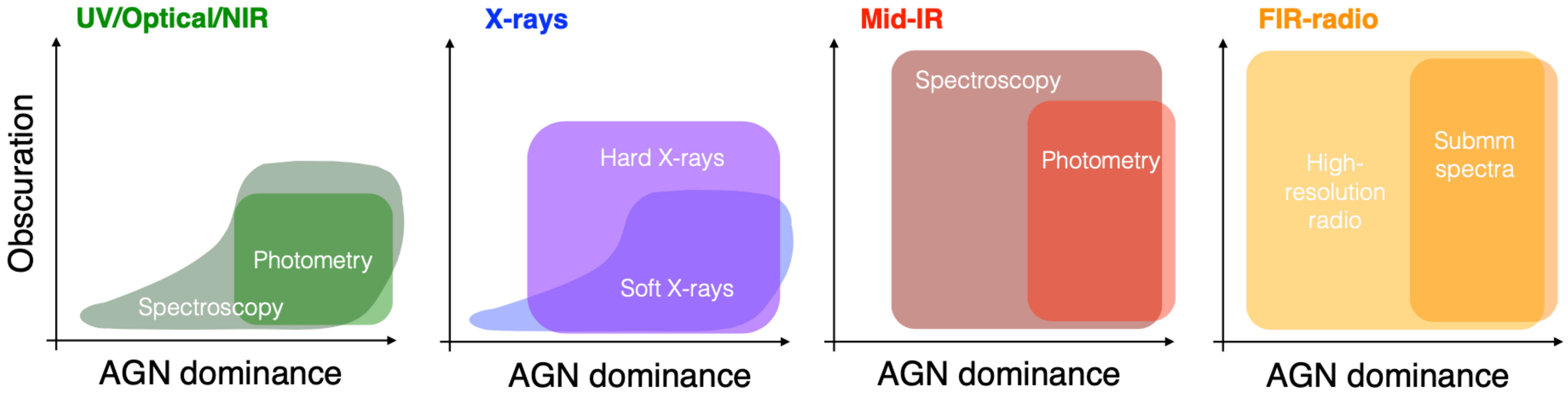


Hickox & Alexander 2018

Low-z obscured AGNs

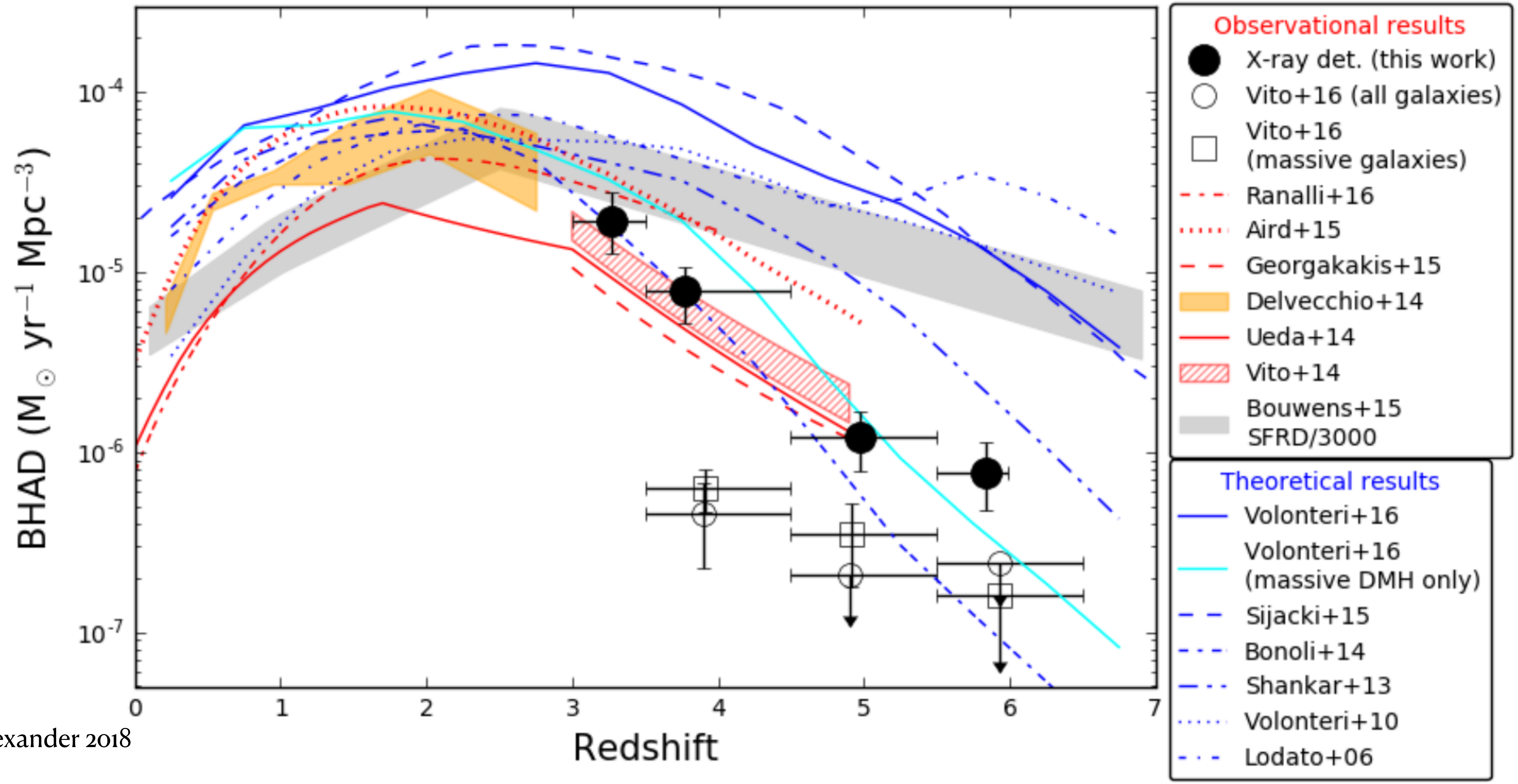






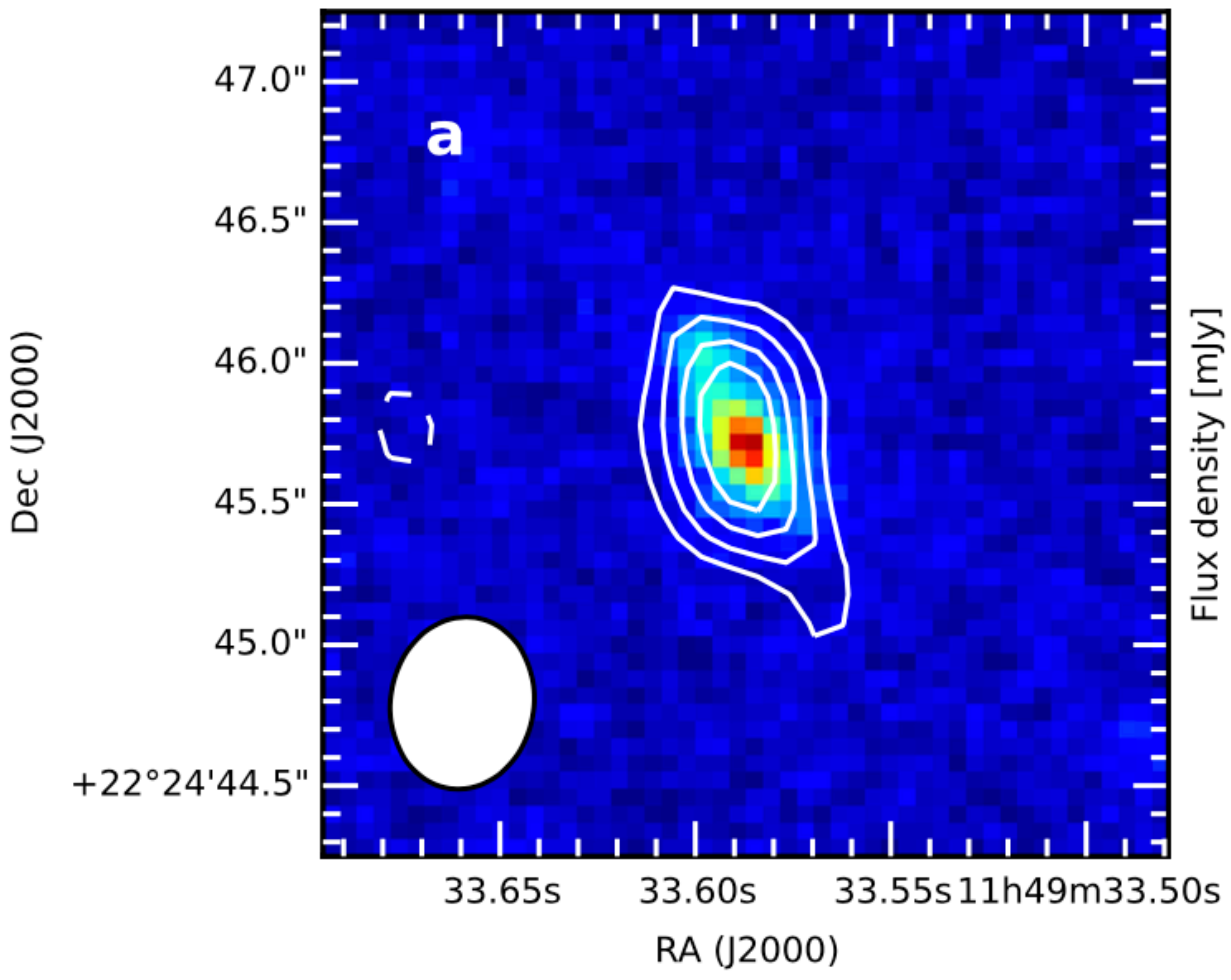
Hickox & Alexander 2018

BH Accretion rate Density and SFRD



Hickox & Alexander 2018

Origin of dust



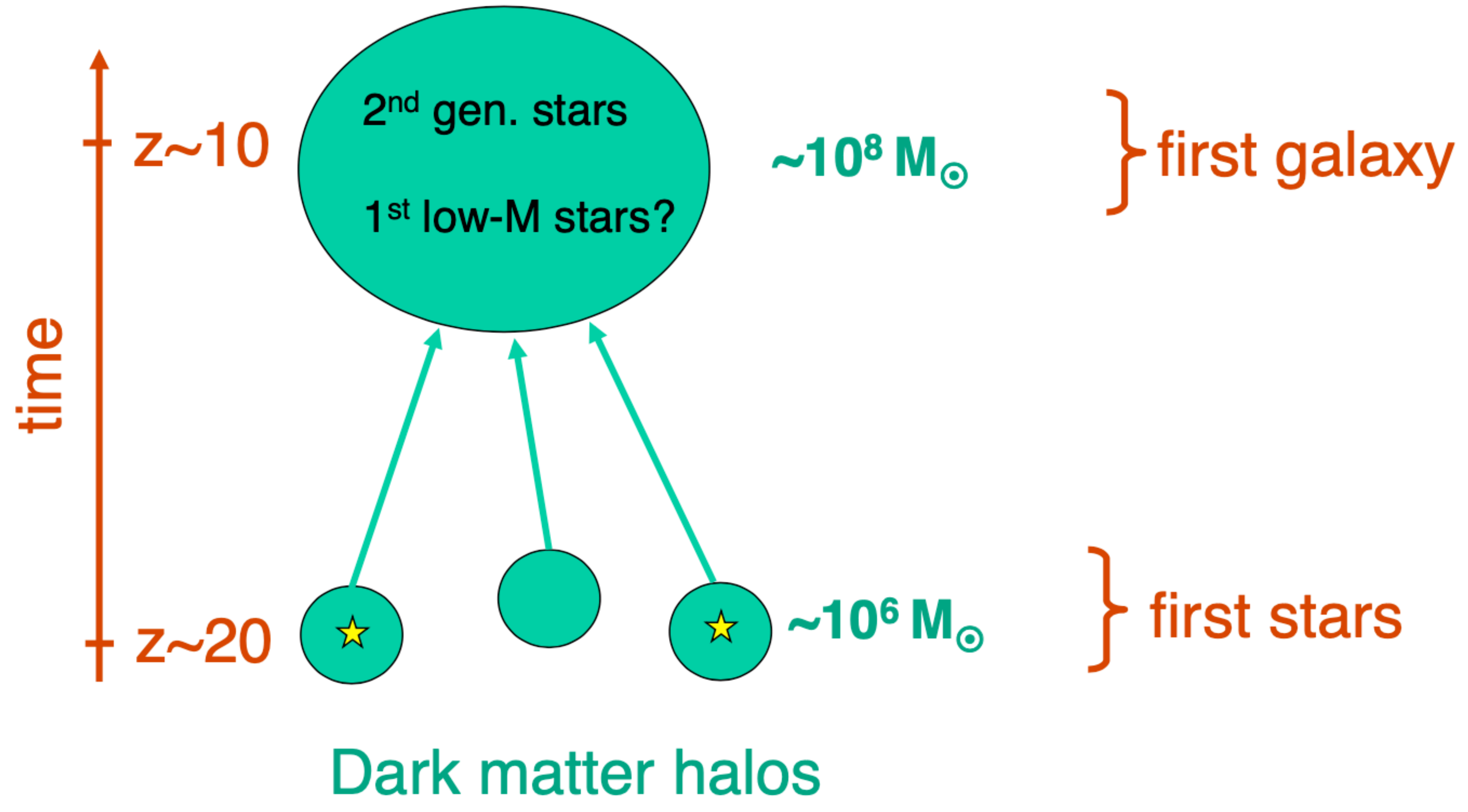
ALMA [OIII] contours of MACS1149-JD1 at z=9.1
Hashimoto et al. 2019

Table 2
Summary of Measurements for GN-z11

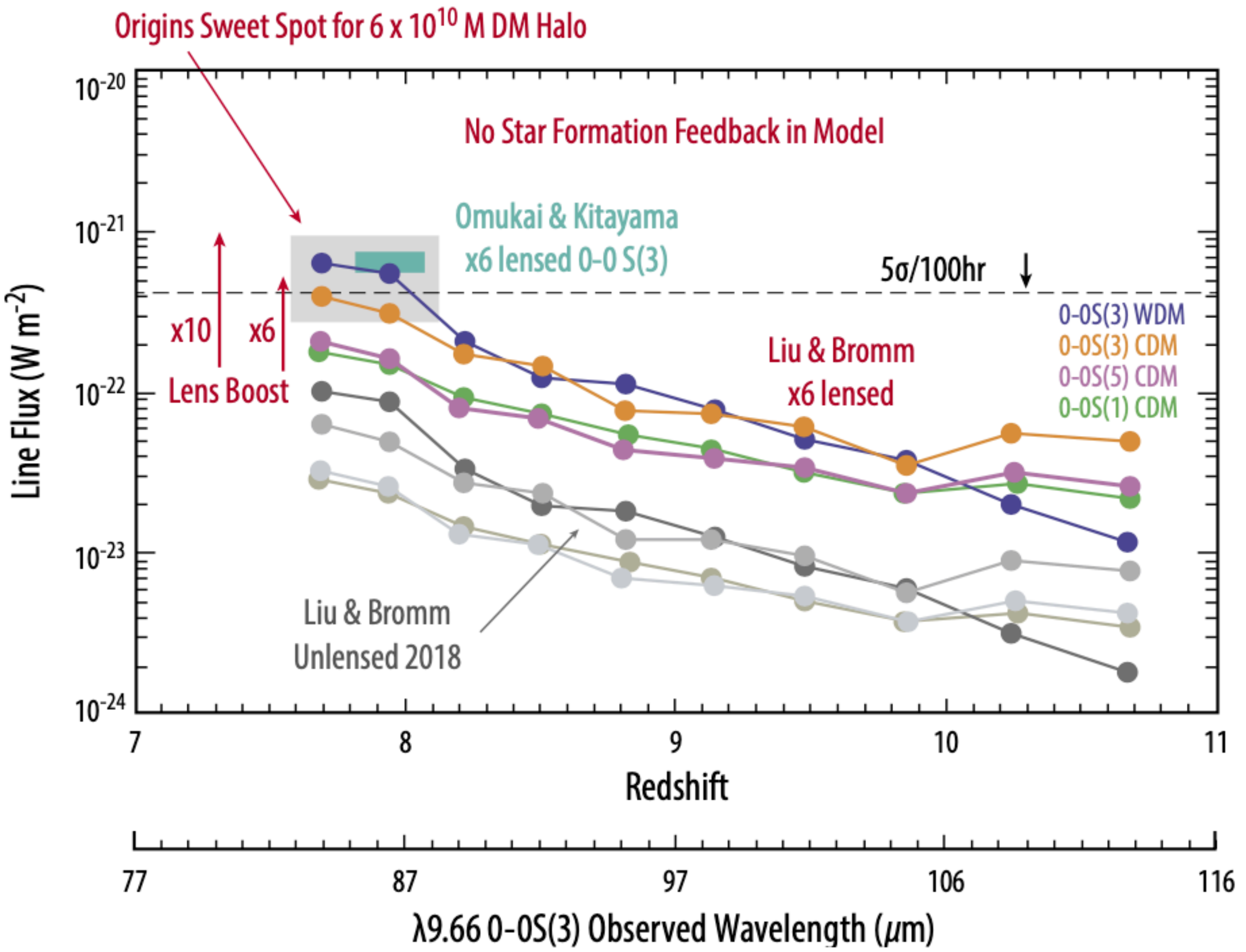
R.A.	12:36:25.46
Decl.	+62:14:31.4
Redshift z_{grism}	$11.09^{+0.08}_{-0.12}$ [a]
UV Luminosity M_{UV}	-22.1 ± 0.2
Half–Light Radius[b]	0.6 ± 0.3 kpc
$\log M_{gal}/M_{\odot}$ [c]	9.0 ± 0.4
log age yr^{-1} [c]	7.6 ± 0.4
SFR	$24 \pm 10\ M_{\odot}\ yr^{-1}$
A_{UV}	<0.2 mag
UV slope β $(f_{\lambda} \propto \lambda^{\beta})$	-2.5 ± 0.2[d]

Oesch et al. 2016

First galaxies

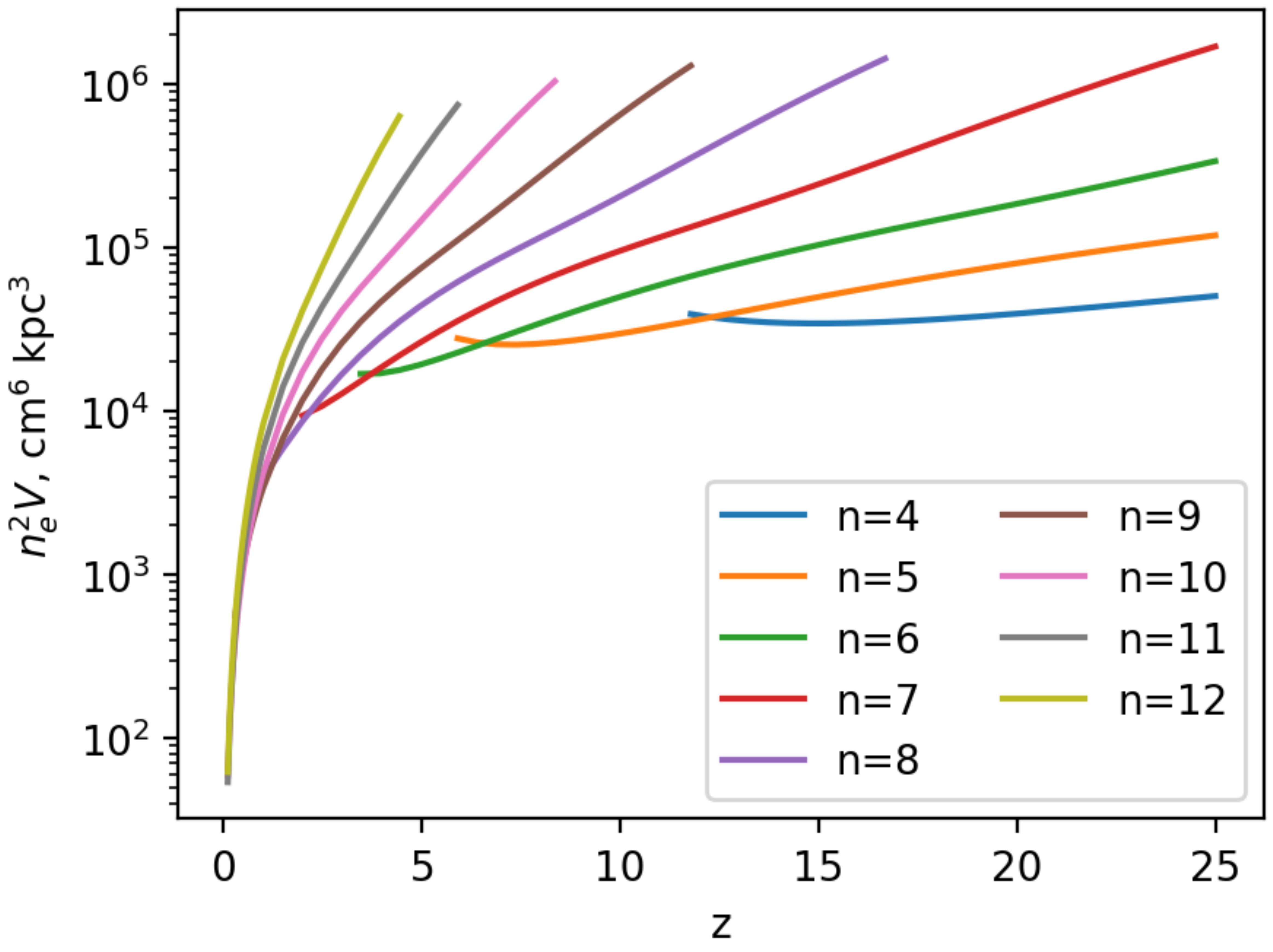


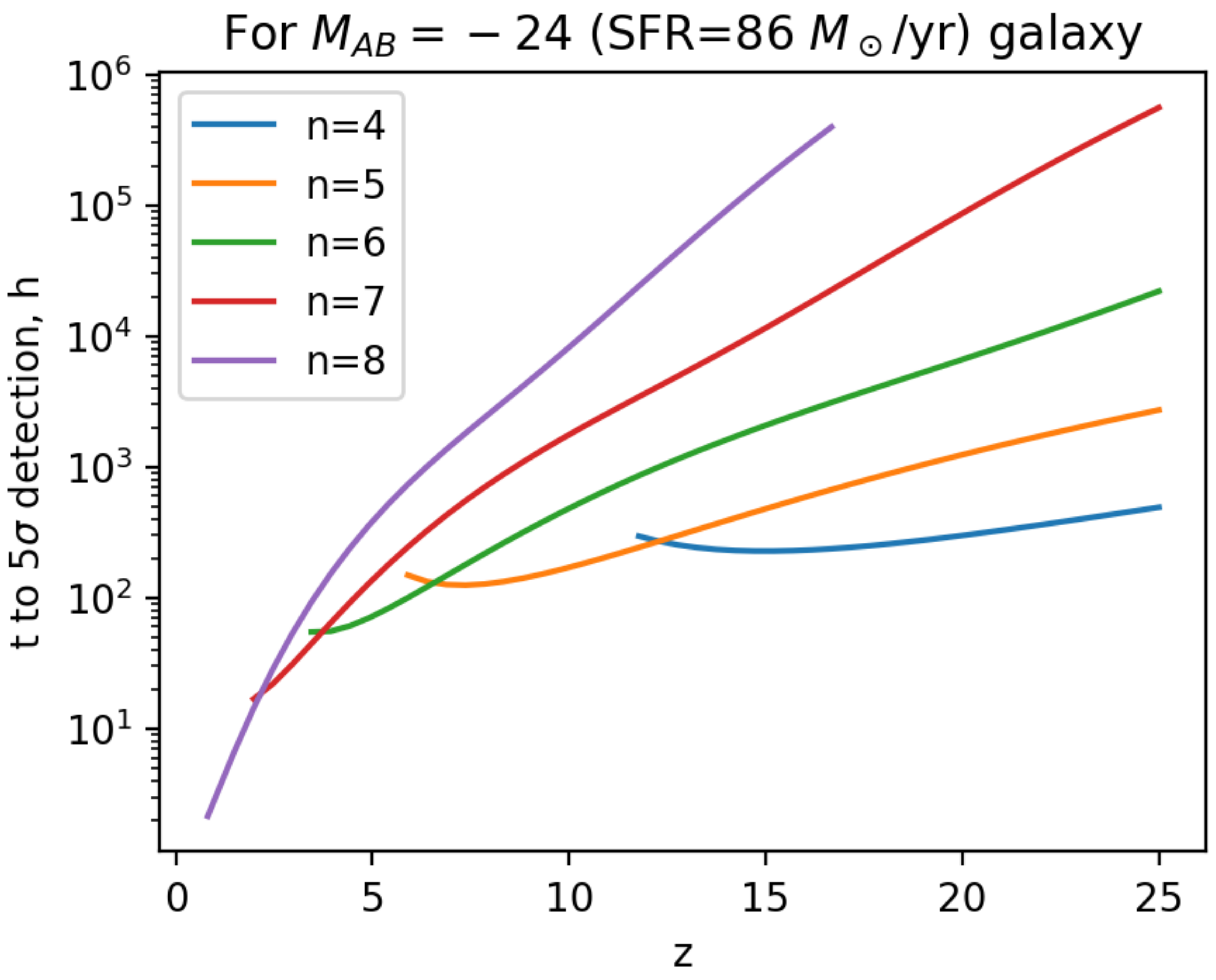
H_2, HD



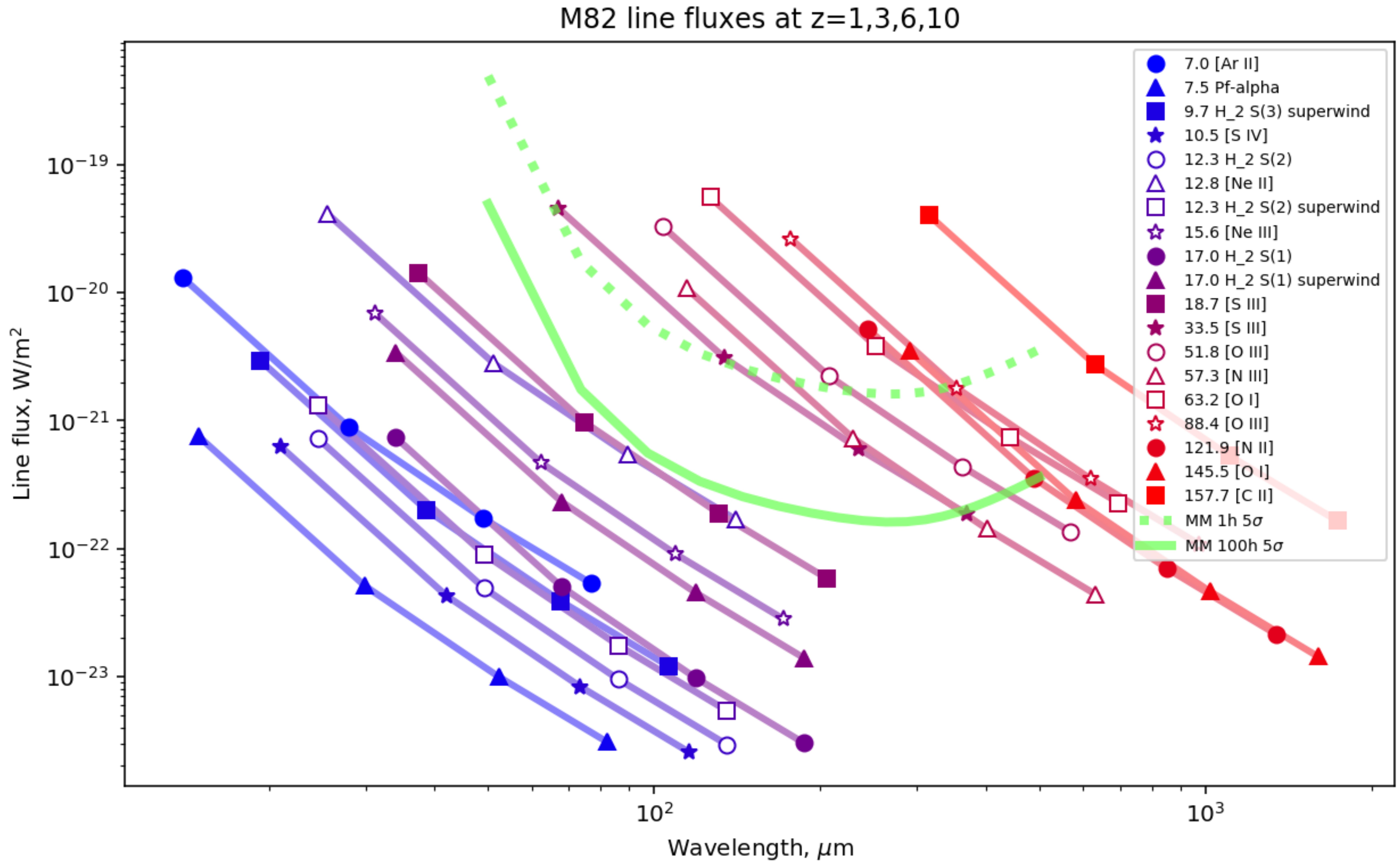
Origins Sweet Spot for 6 x 10^10 M DM Halo
No Star Formation Feedback in Model
Omukai & Kitayama
x6 lensed 0-0 S(3)
5σ/100hr
x10
x6
Lens Boost
Liu & Bromm
x6 lensed
0-0S(3) WDM
0-0S(3) CDM
0-0S(5) CDM
0-0S(1) CDM
Liu & Bromm
Unlensed 2018
Line Flux (W m^-2)
10^-20
10^-21
10^-22
10^-23
10^-24
7
8
9
10
11
Redshift
77
87
97
106
116
λ9.66 0-0S(3) Observed Wavelength (μm)

Recombination lines





Indirect studies of first galaxies



Summary

Millimetron can become a unique tool, unveiling the mystery of SMBH and dust origin.

Key requirements are:

1. Wide-band photometry
2. High sensitivity spectrometry (a grating spectrometer)