電離酸素とSMBH形成の関係
Ionized Oxygen and its relation to the Formation of SMBH

Hiroshi Matsuo (NAOJ)

FIR SED of Starburst galaxies

- OI, OIII
- NII, NIII
- CII

Fischer et al. (1999)

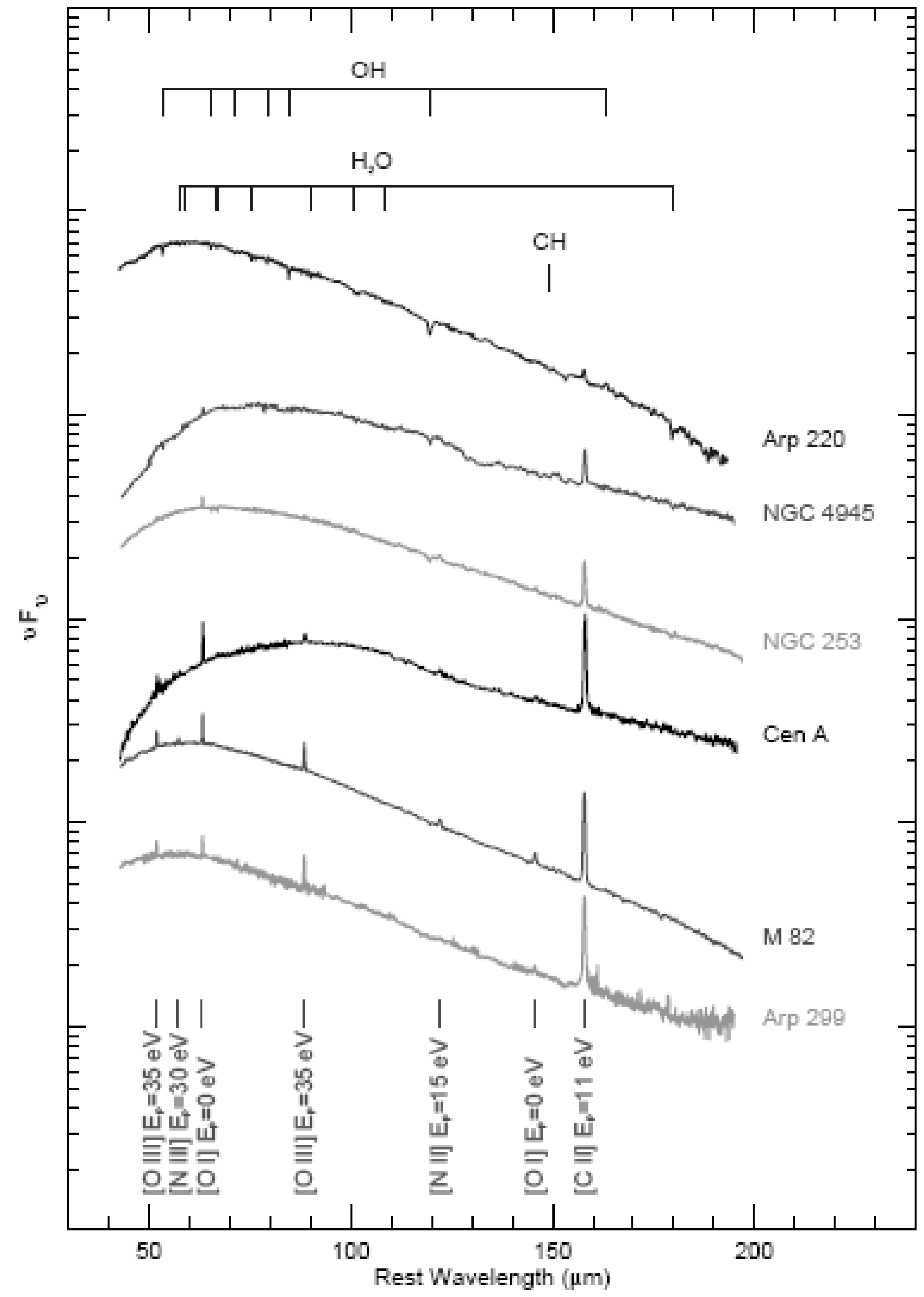
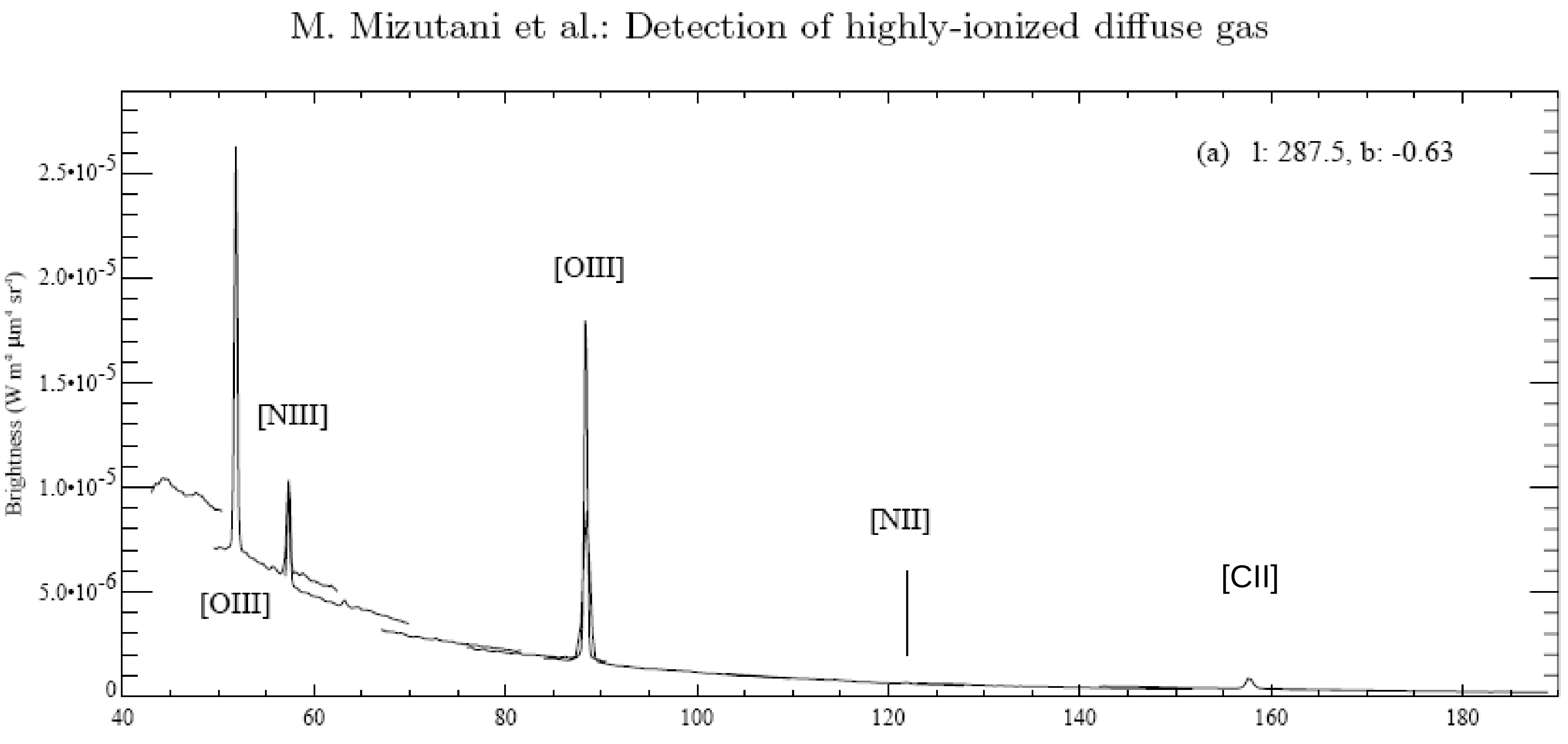


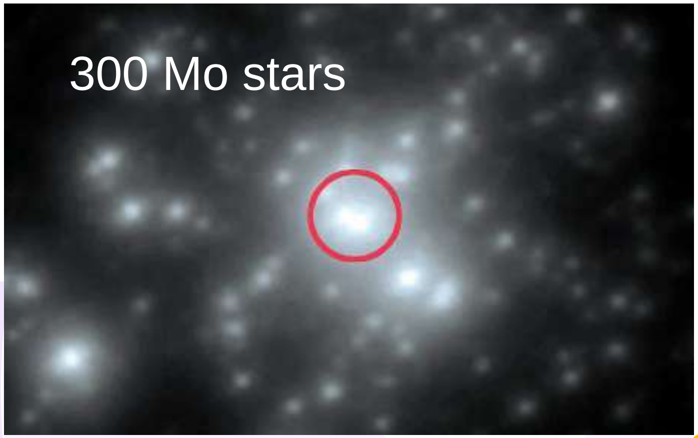
Figure 1. The full ISO Long Wavelength Spectrometer spectra of six IR-bright galaxies. The spectra have been shifted and ordered vertically according to apparent excitation (Fischer et al. 1999) and are not in order of relative luminosity or brightness.

Carina Nebula by ISO LWS



Mizutani, Onaka, Shibai. (2002)

30Dor region and R136



◆ [OIII] 88μm is observed widely distributed around R136

Contour: MIPS 24μm

Kawada et al. (2011)

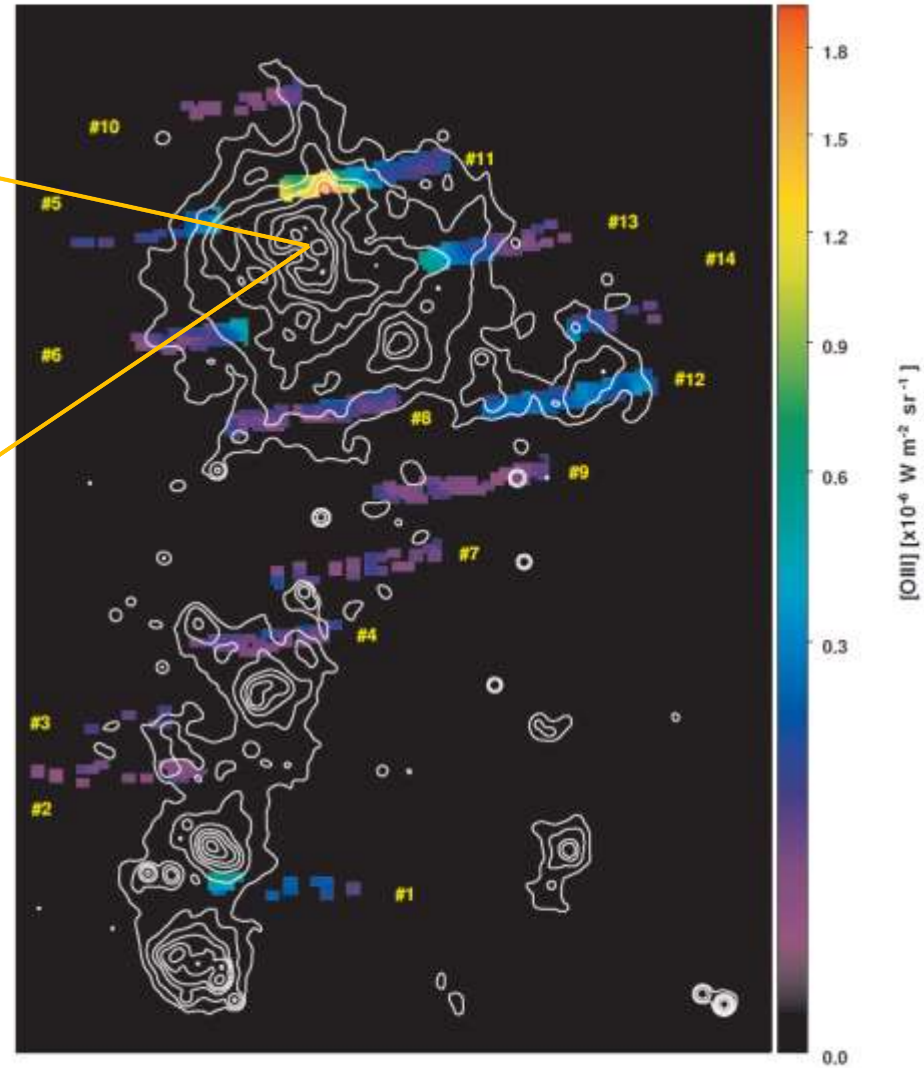
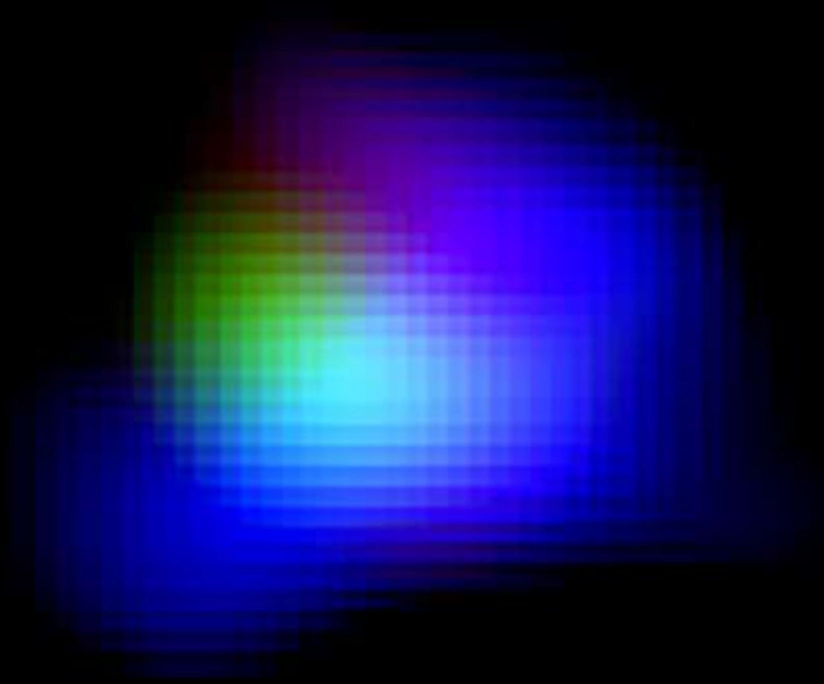


Fig. 3. [OIII] 88μm line intensity map, shown together with the MIPS 24μm contour map

ALMA observed [OIII] 88μm from z=7.2 SXDF-NB1006-2

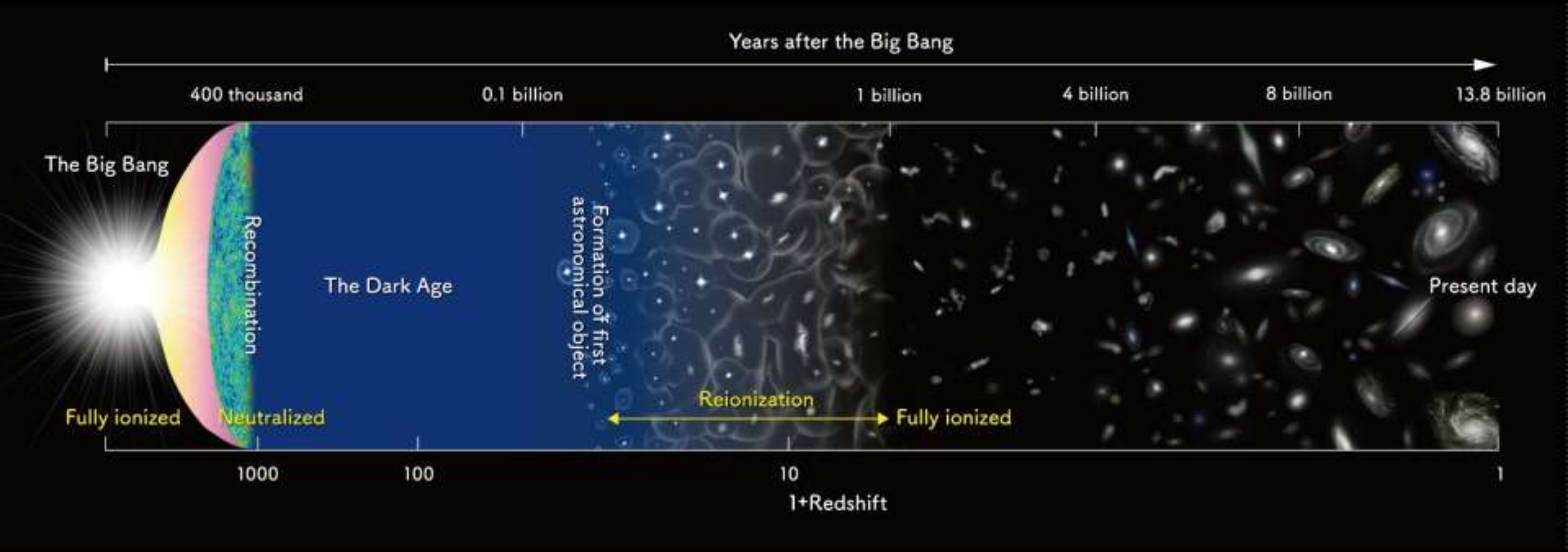


Observational Data

Artist's Imagination

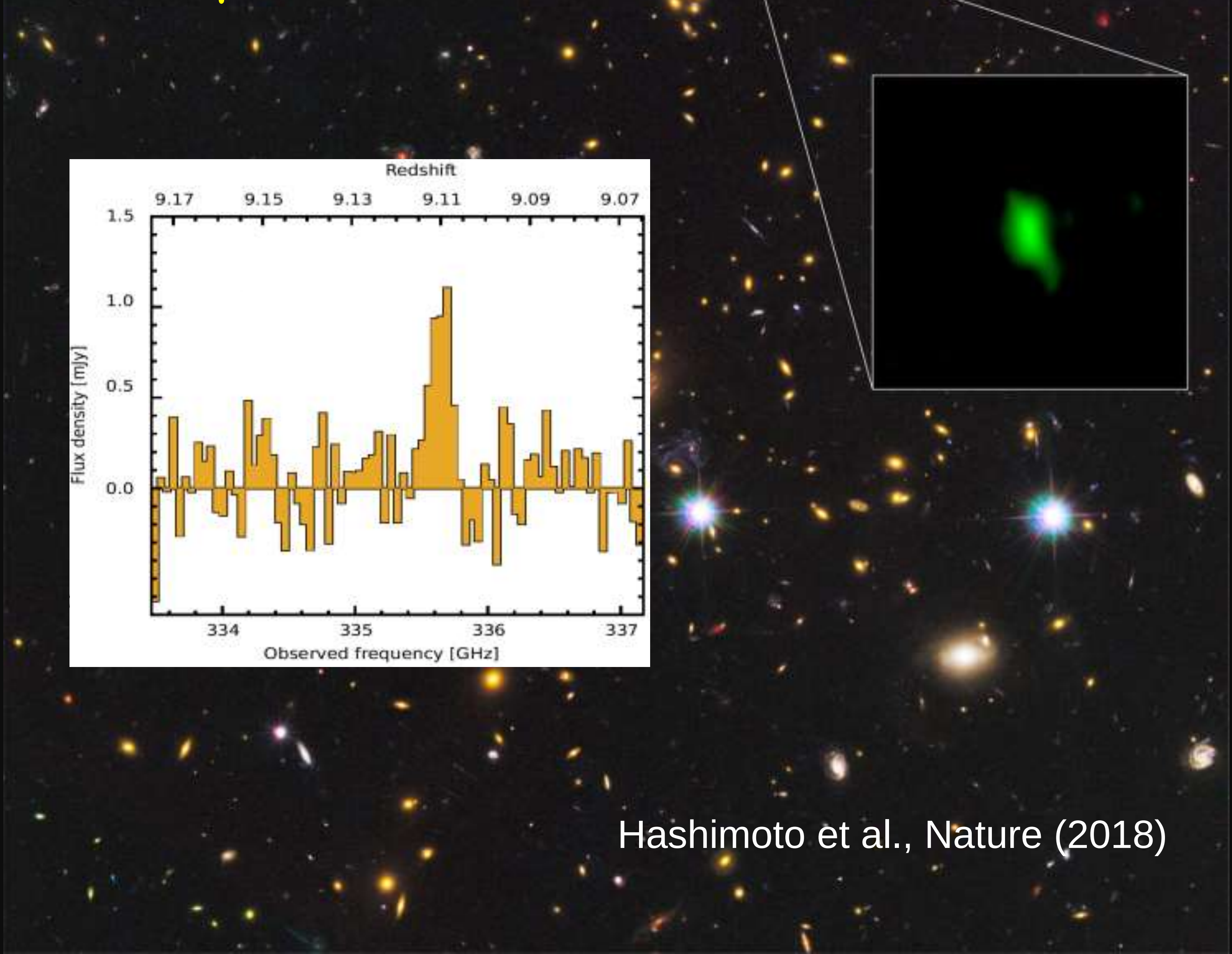
From NAOJ press release
Inoue, Tamura, Matsuo et al., Science 352, 1559 (2016)

Cosmic Reionization



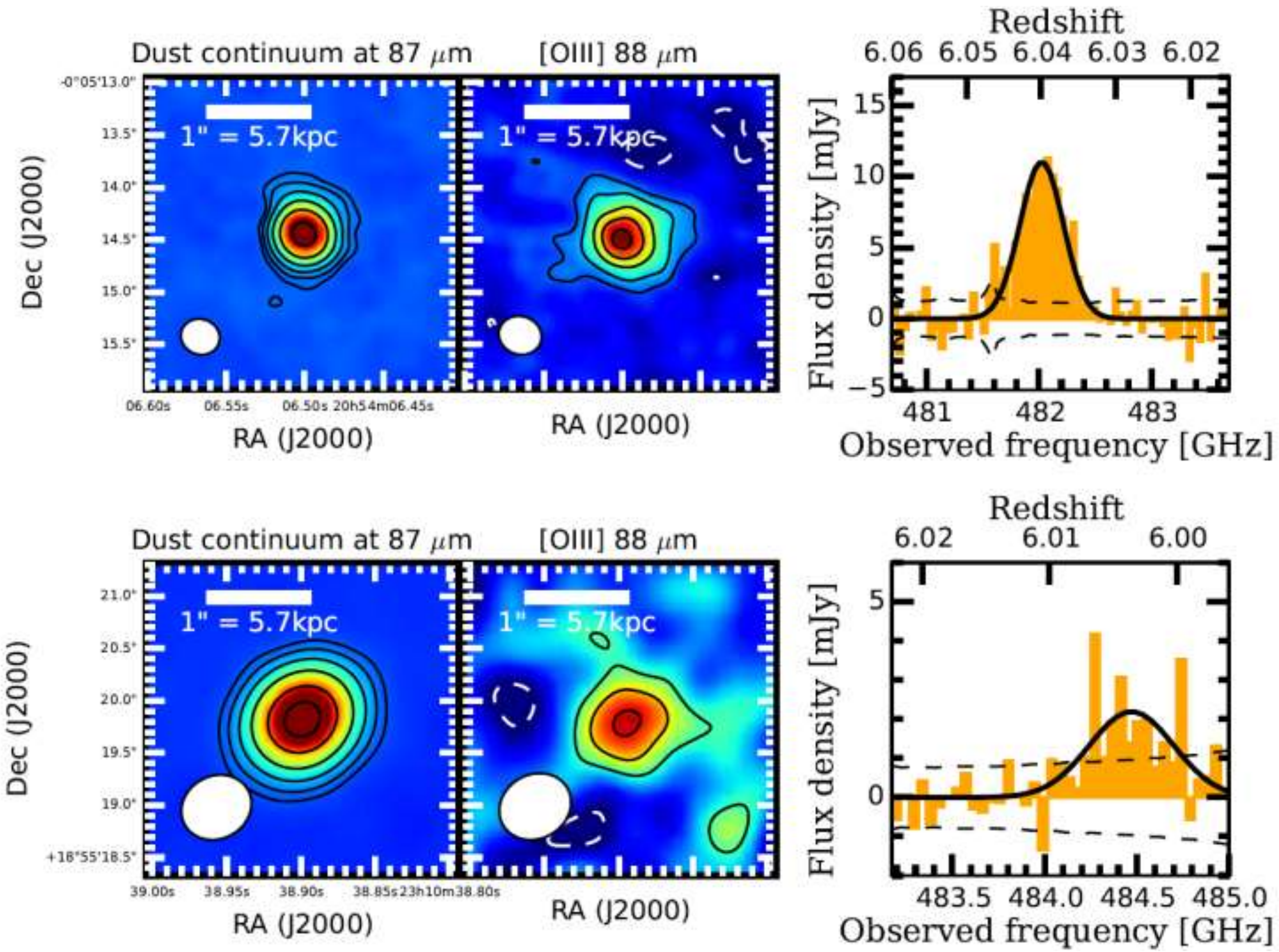
From NAOJ press release
Inoue, Tamura, Matsuo et al., Science 352, 1559 (2016)

The Most Distant z=9.11 Spectroscopic Identification with [OIII] 88 μm



Hashimoto et al., Nature (2018)

[OIII] 88μm from two QSOs

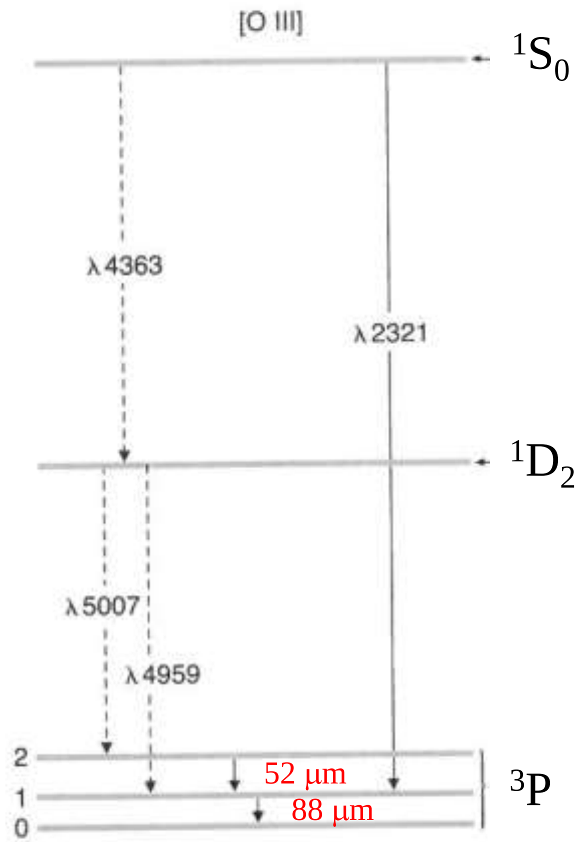


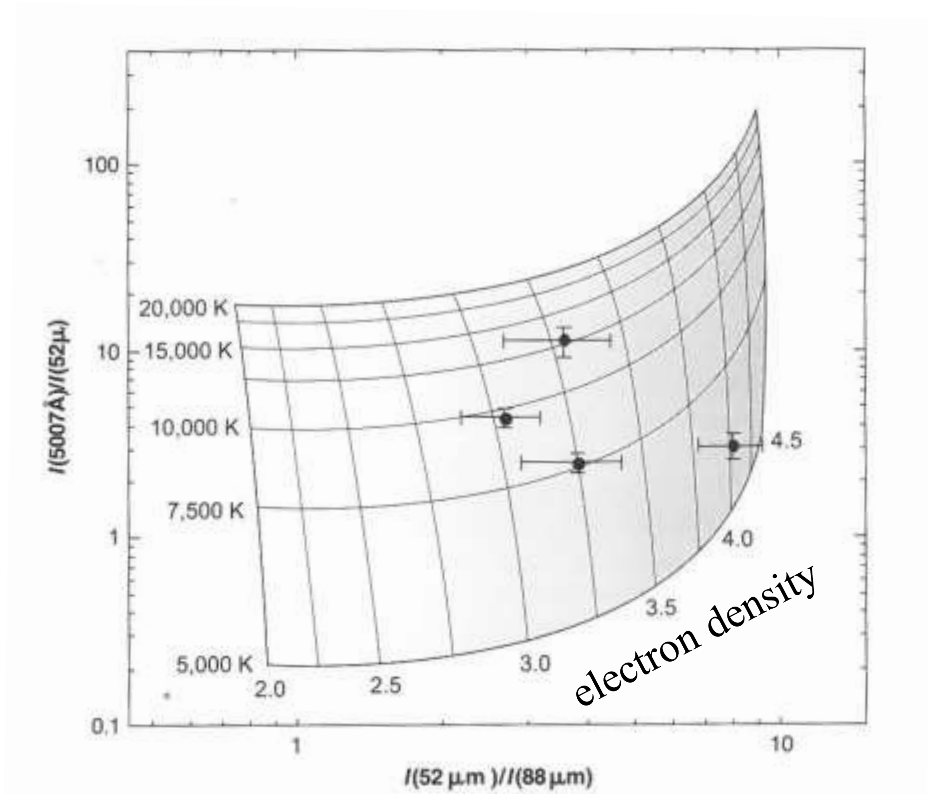
Hashimoto et al., submitted to PASJ

FIR atomic fine structure lines

		Critical Densities
OI		
– 63.185μm	4.745THz	5.0×10^5 cm^{-3}
– 145.54μm	2.060THz	1.5×10^5 cm^{-3}
OIII 35.1eV		
– 51.815μm	5.786THz	3.4×10^3 cm^{-3}
– 88.356μm	3.393THz	5.0×10^2 cm^{-3}
NII 14.5eV		
– 121.80μm	2.461THz	2.8×10^2 cm^{-3}
– 205.30μm	1.460THz	4.5×10^1 cm^{-3}
NIII 29.6eV		
– 57.330μm	5.229THz	3×10^3 cm^{-3}
CII 11.3eV		
– 157.68μm	1.901THz	2.7×10^3 cm^{-3}

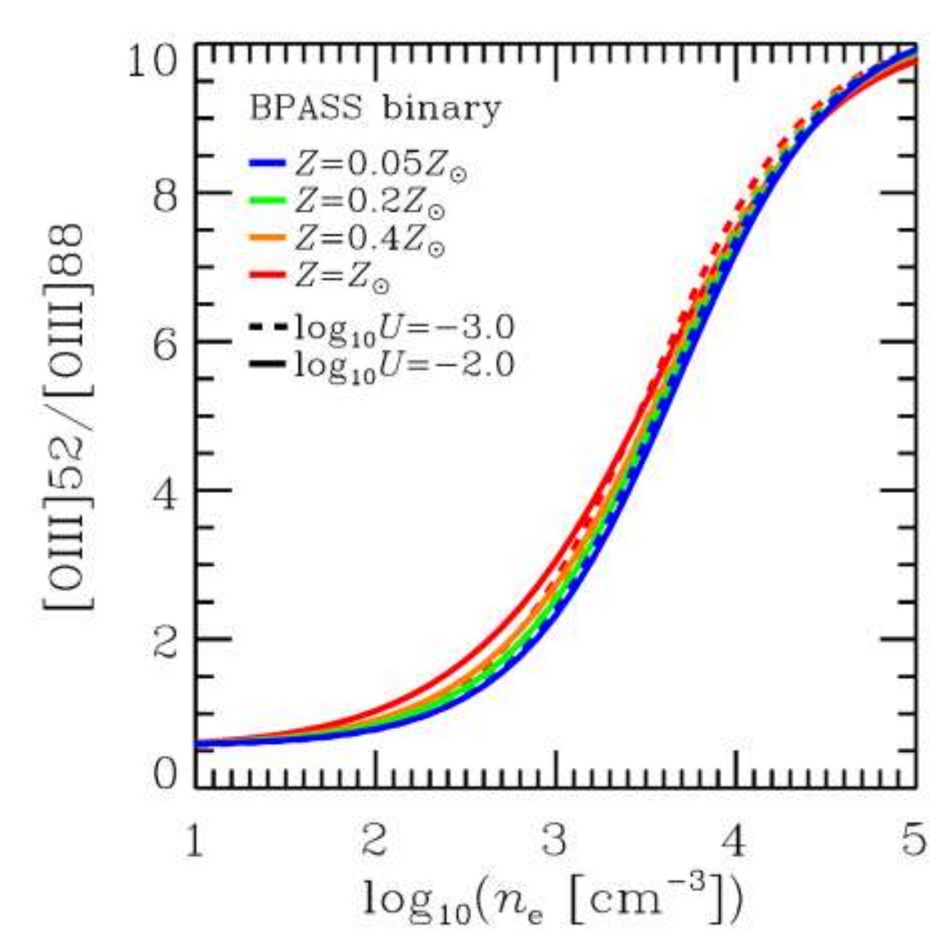
[OIII] energy level and physical conditions





From "Astrophysics of Gaseous Nebulae and Active Galactic Nuclei", Osterbrock and Ferland

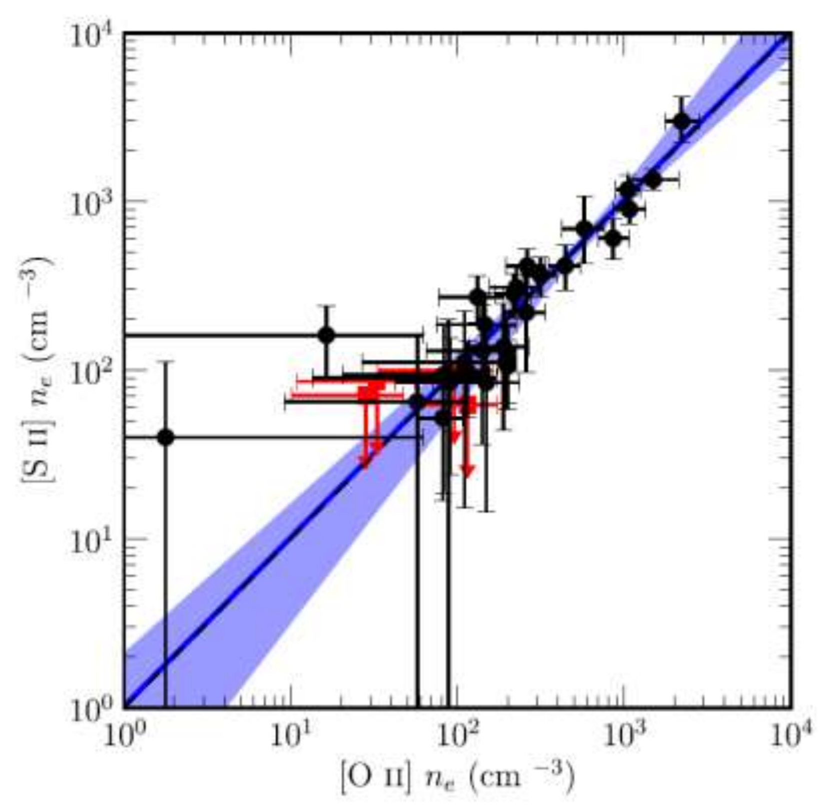
Dependence of the [OIII]52/88 on electron density



A. Inoue (private comm.)

Electron Density of Ionized Gas

at z ~ 2.3



Based on MOSFIRE observation on Keck telescope (Sanders et al. 2016).

Simulation

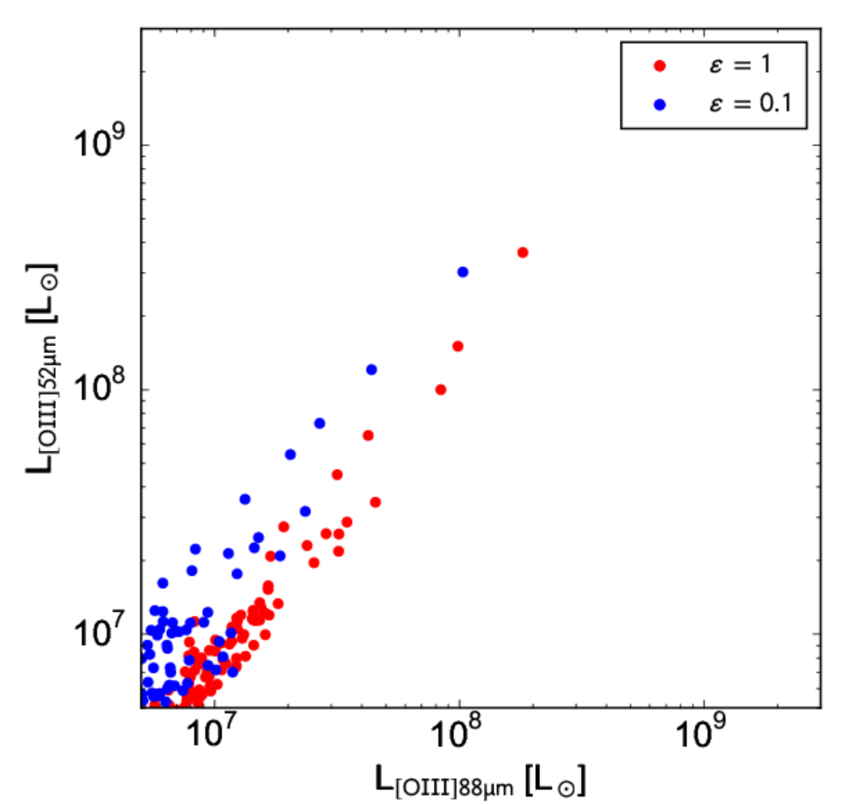
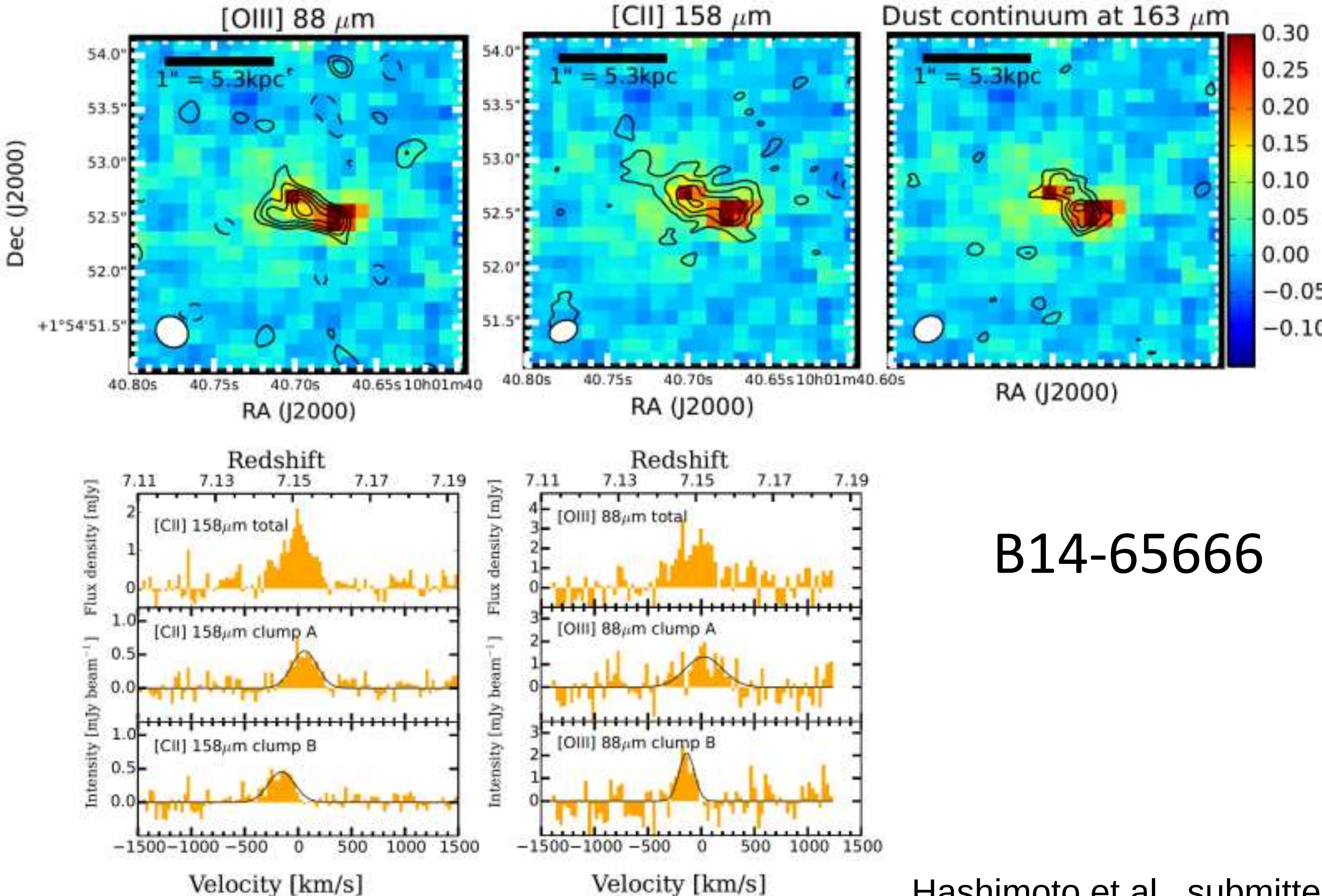


Fig. 4. [OIII] 52 and 88 μm luminosities obtained from cosmological simulation, where ε is a volume filling factor (analysis by Moriwaki).

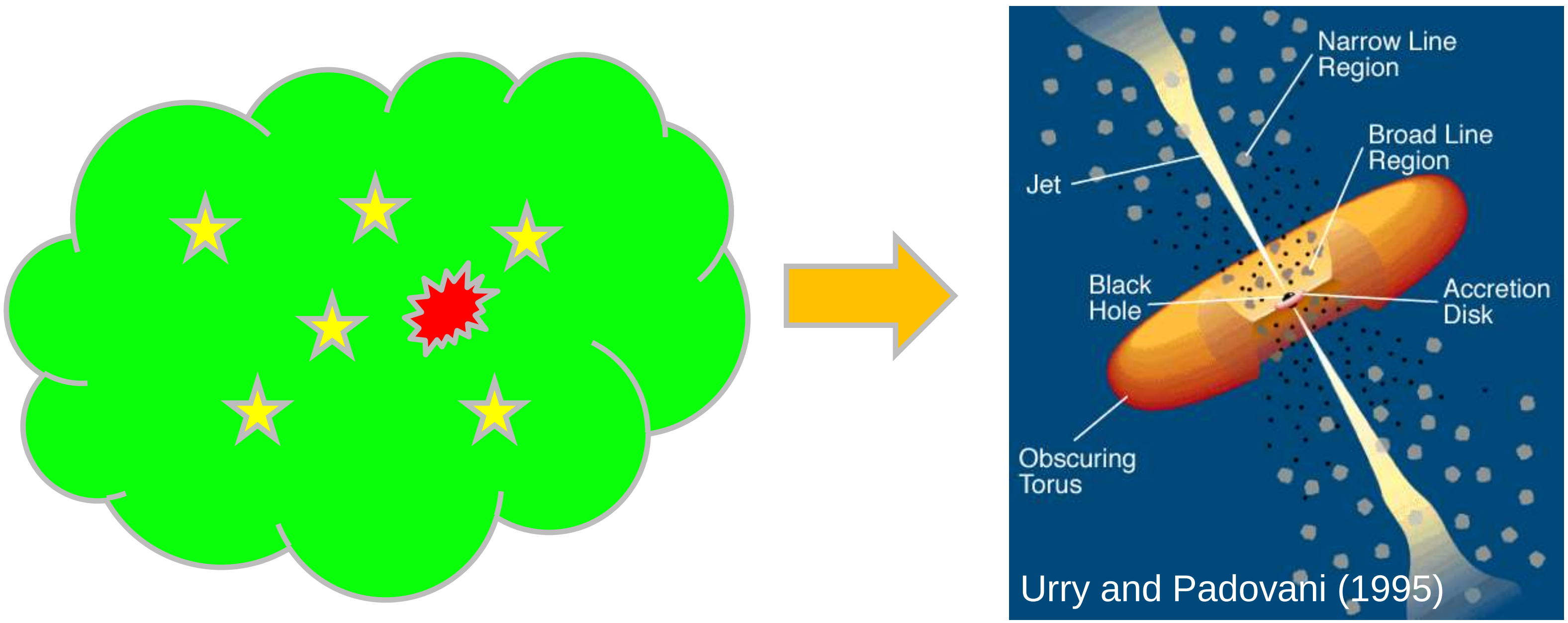
ALMA Cyc6 Target of [OIII] 52μm observation



B14-65666

Hashimoto et al., submitted to PASJ

Massive Star Cluster to AGN ?



Urry and Padovani (1995)

Massive Star Cluster to AGN ?

- Direct Collapse ?
- Fragmentation ?
- Cooling by Metal ?
- Cooling by Dust ?
- Cooling by [CII] ?
- Cooling by [OIII] ?

Parameters of Interest

Total mass	10^9 Mo
Size	1 kpc
Ionized gas temperature	10^4 K
Ionized gas density	10^3 cm^{-1}
Jeans mass	10^6 Mo
Free-fall time	1 Myr
Stellar time scale	1 Myr