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ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

Simulating LAEs around EOR – focusing on IGM structure

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&

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arxiv:1204.2554

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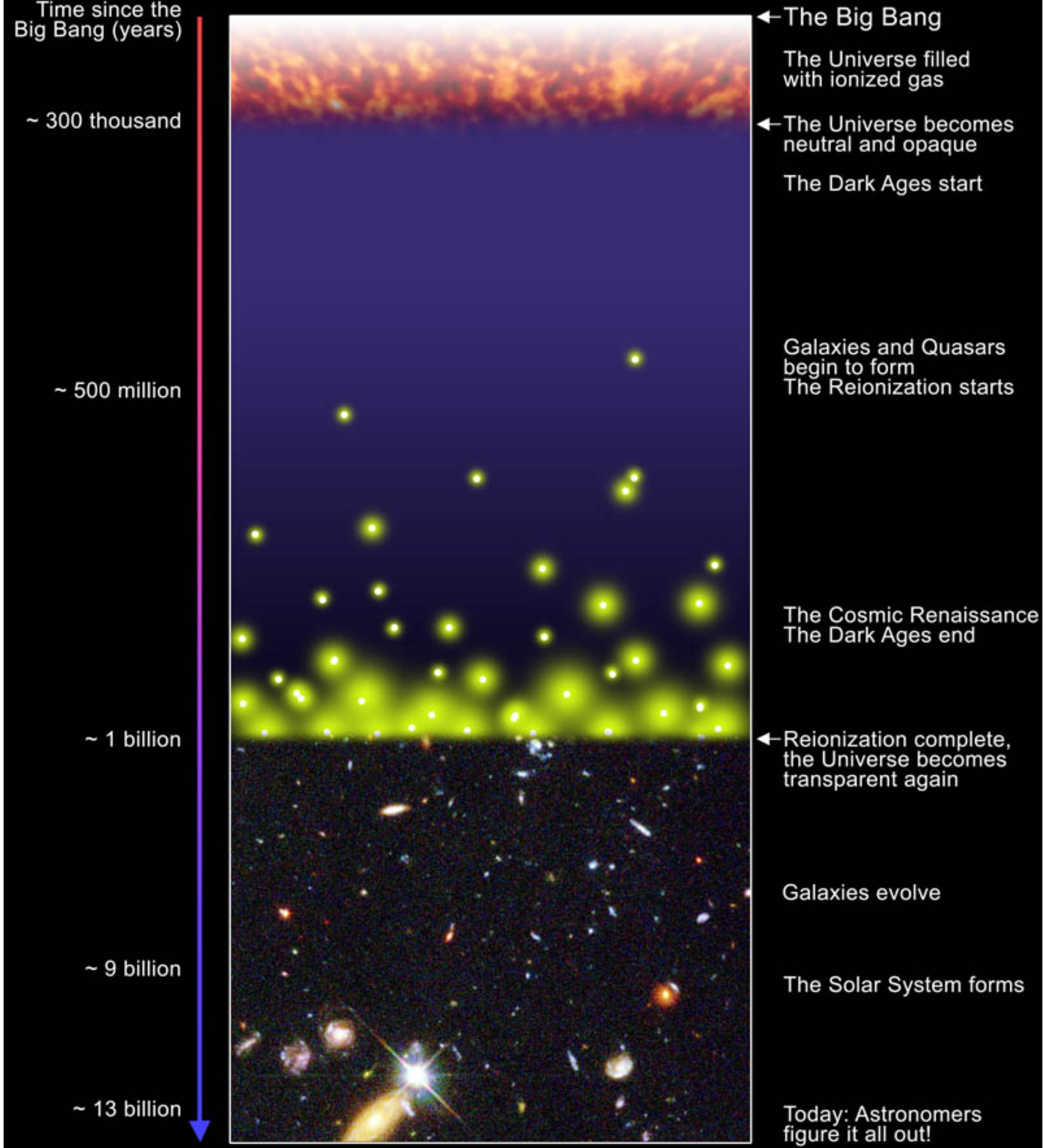
What is the Reionization Era?

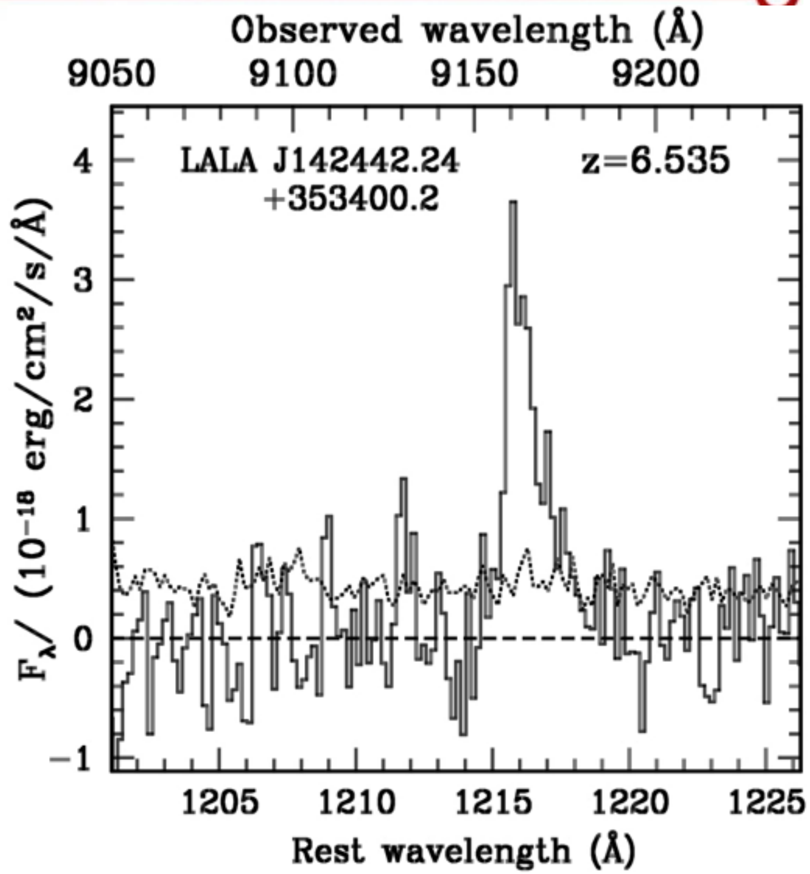
A Schematic Outline of the Cosmic History



S.G. Djorgovski et al. & Digital Media Center, Caltech

Lyman Alpha Emitters

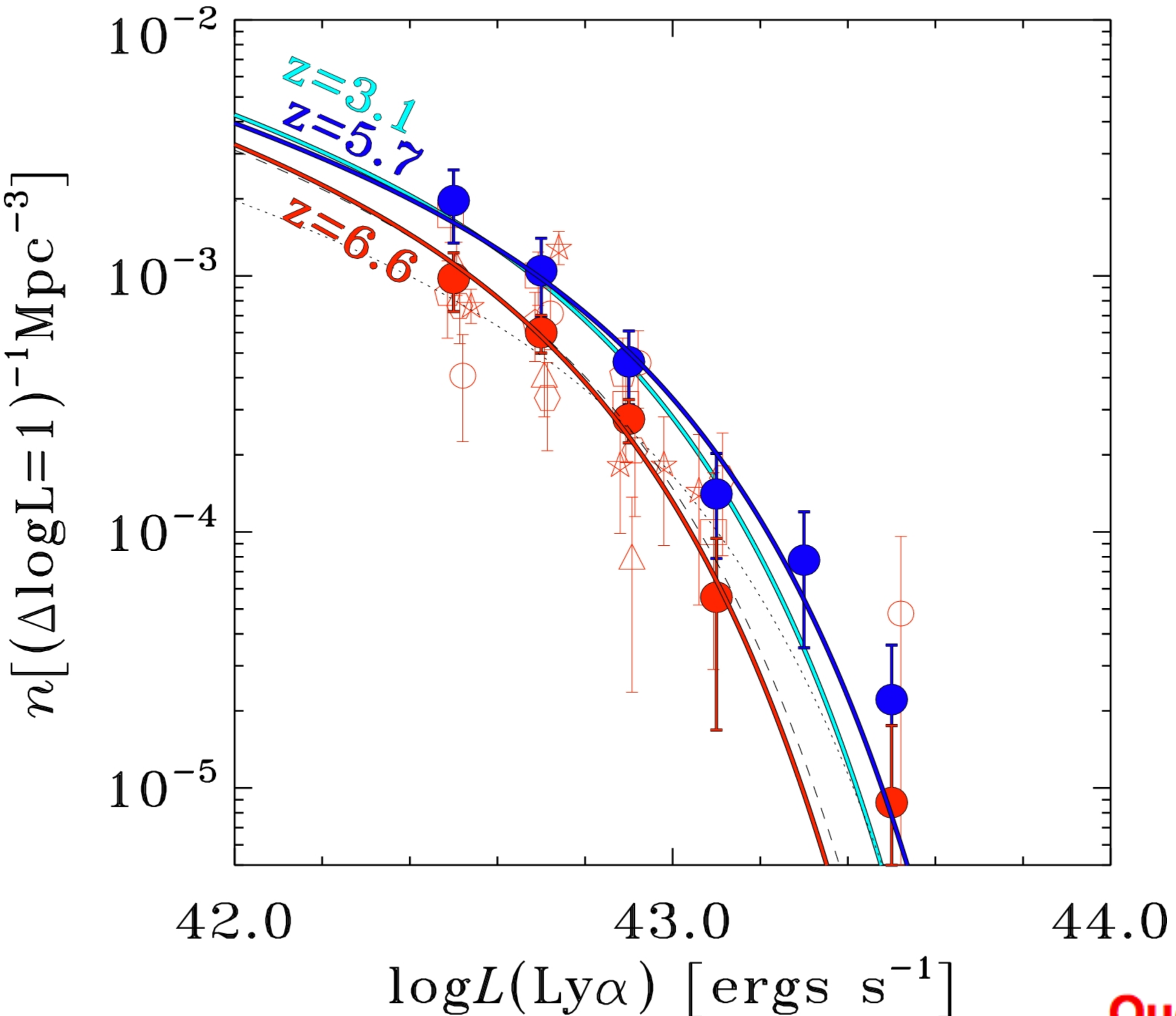
- Definition of a LAE – strong line at Lyα rest wavelength
- Where does it come from? - ionizing photons from stars → ISM => Lyα emission.
- What affects it? - neutral H gas (scattering), dust (absorption).



Rhoads et. al 2004

Good for observing galaxies at high redshifts

Using LAEs to study EOR



Ouchi et. al 2010

Simulating LAEs

Our Aim:

To study the effect of **inhomogeneities in the IGM close to the galaxy**, on the observability of LAEs around EOR.

Cosmological Simulations

- Gadget-2 simulations with primordial and metal chemistry included.
- IMF changes from 100-500 $M_\odot$ to 0.1-100 $M_\odot$ Salpeter at the critical metallicity ($Z \sim 10^{-4} Z_\odot$).
- Supernova and wind feedback.

Simulation box sizes of 5-30 Mpc/h with 320^3 particles resolving DM haloes > 10^9 solar masses.

Maio et al.,2007, 2008 & 2009

CRASHα

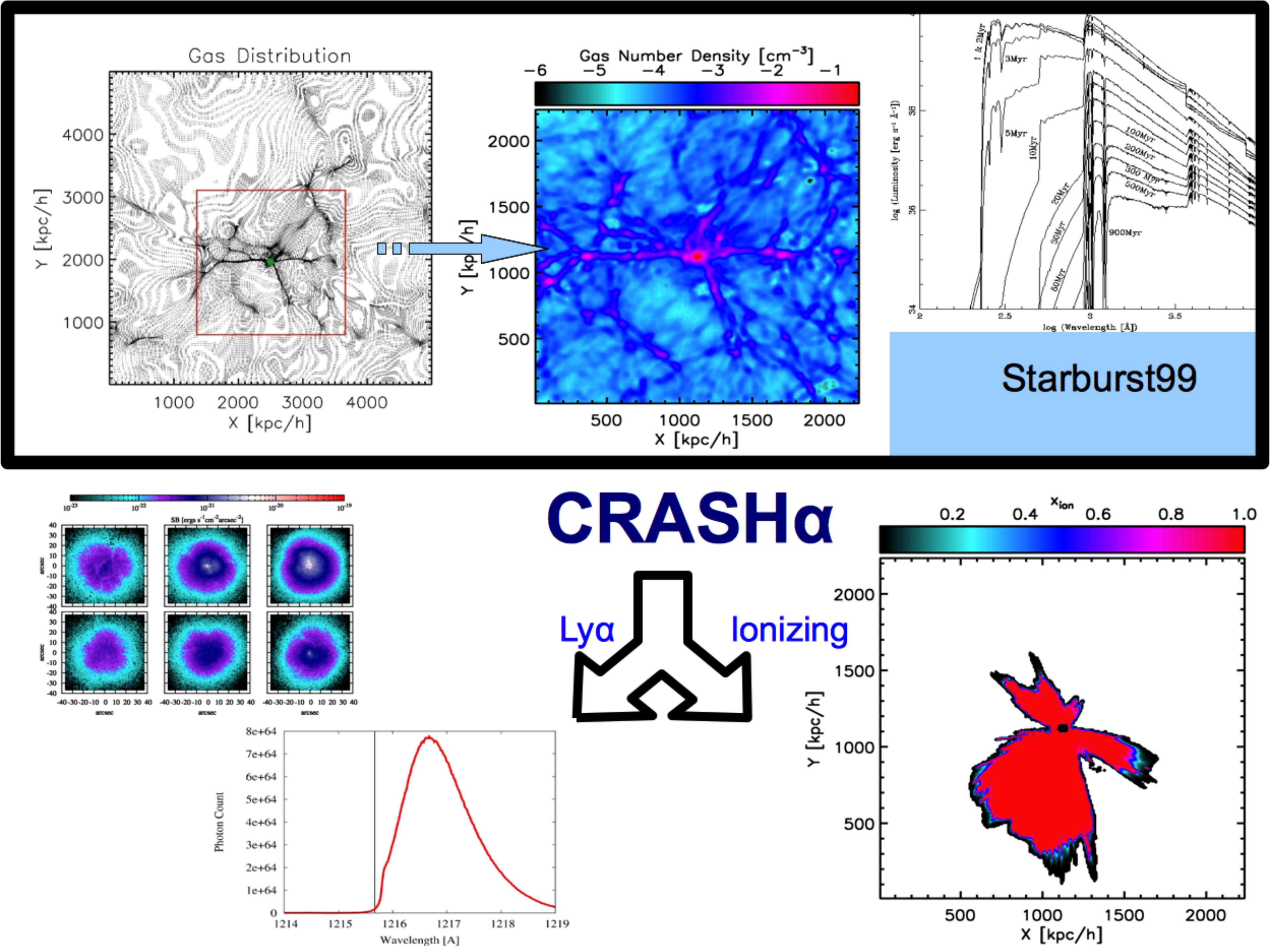
- CRASHα is a 3D grid based radiative transfer code for cosmological simulations with ***the parallel propagation of Lyα and ionizing photons*** using ray-tracing and Monte-Carlo techniques.

  - Ionizing radiation propagated at each time step, changes the temperature and ionization structure.

  - Lyα photons propagated through this taking into account the velocity fields as well.

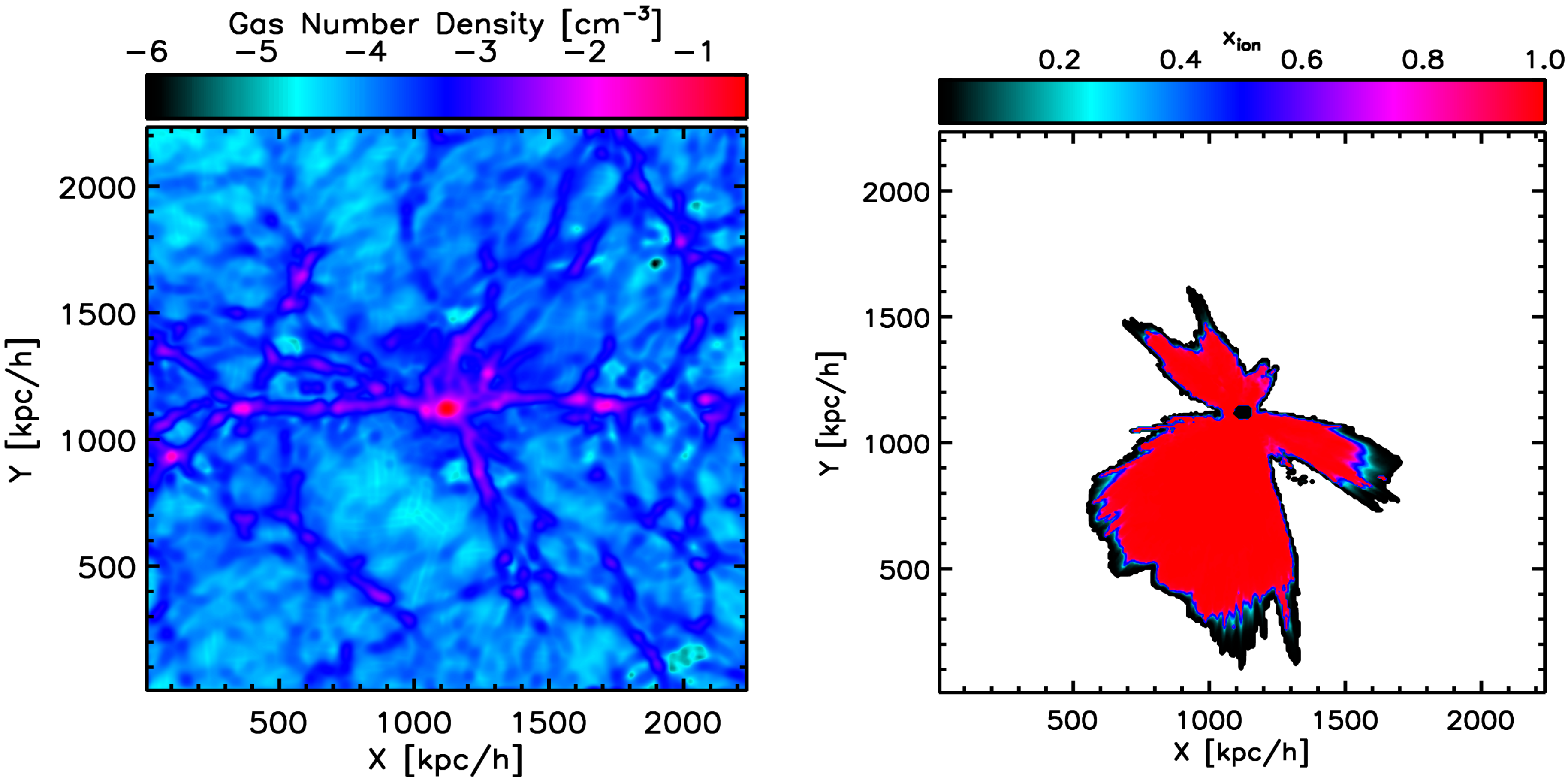
  - Diffuse radiation are taken into account.

Pierleoni et al.,2009

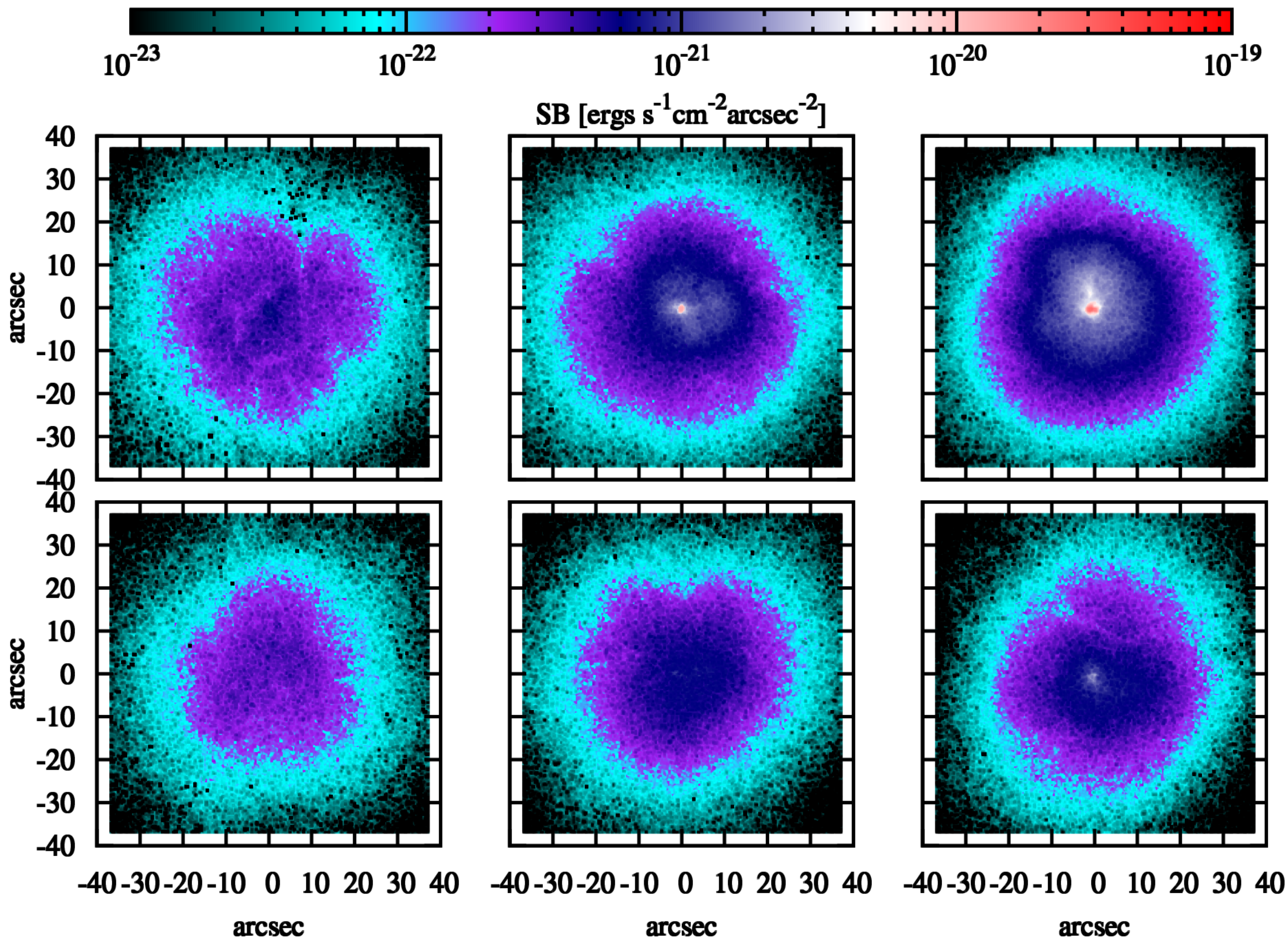


Gas Distribution
Y [kpc/h]
X [kpc/h]
Gas Number Density [cm^{-3}]
Y [kpc/h]
X [kpc/h]
log (Luminosity [erg s^{-1} Å^{-1}])
log (Wavelength [Å])
1 & 2Myr
3Myr
5Myr
10Myr
20Myr
30Myr
50Myr
100Myr
200Myr
300 Myr
500Myr
900Myr
Starburst99
SB [ergs s^{-1}cm^{-2}arcsec^{-2}]
arcsec
Photon Count
Wavelength [A]
CRASHα
Lyα
Ionizing
x_{ion}
Y [kpc/h]
X [kpc/h]

Non-Spherical Ionization Structure



Lyman-alpha Surface Brightness Maps



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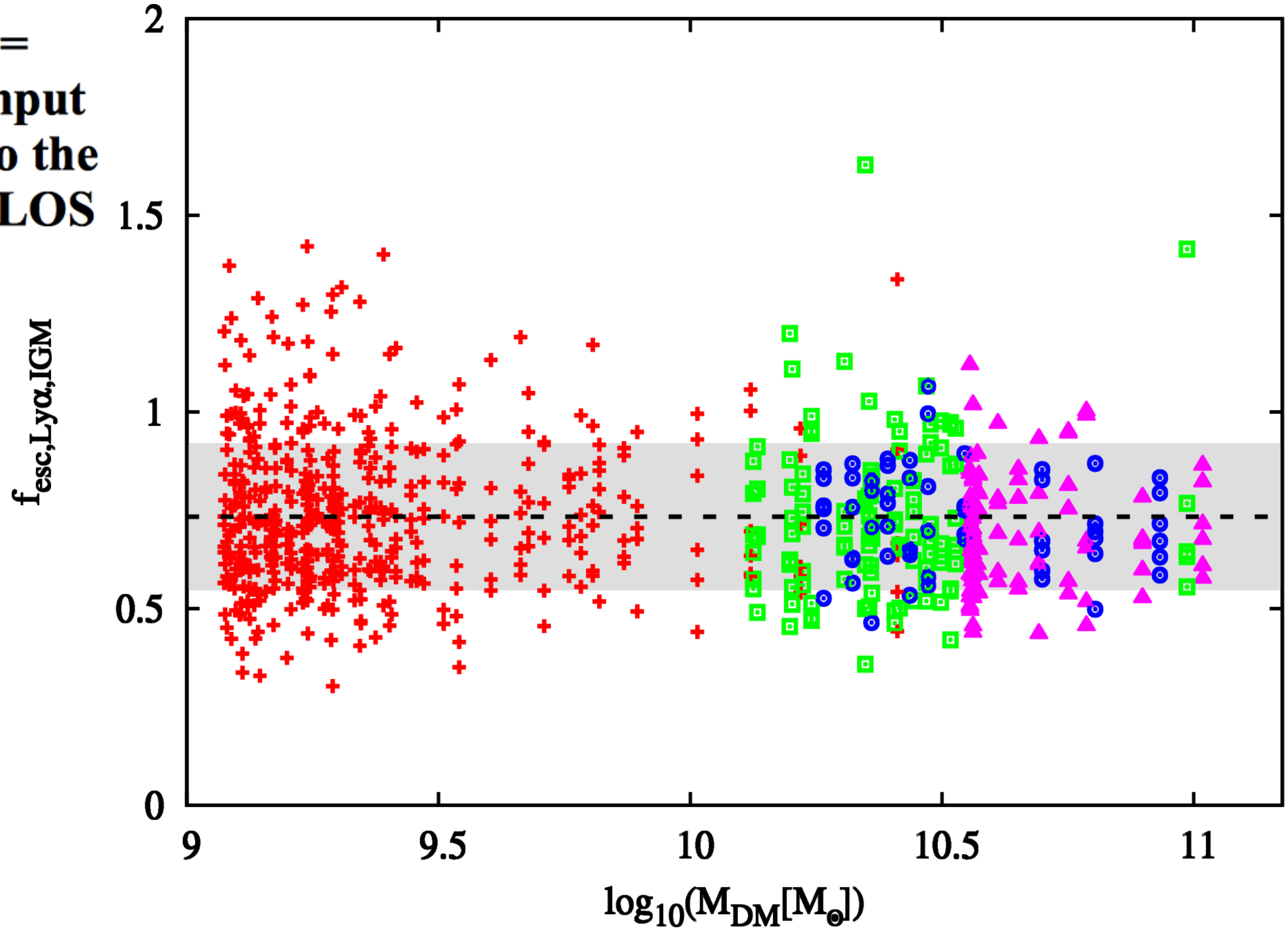
IGM Escape fraction

fesc,Lya,IGM = Output flux/Input flux of Lyα into the IGM for each LOS

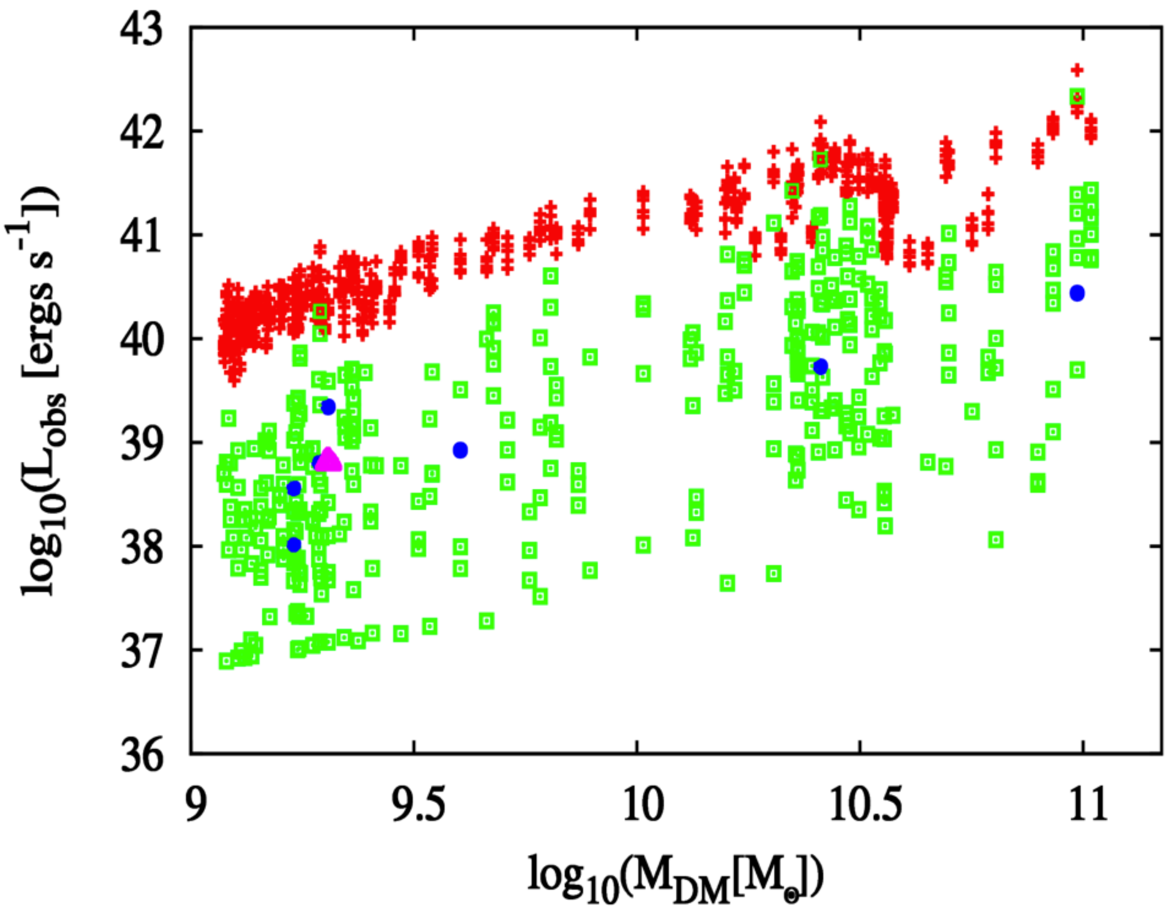
5 cMpc/h
10 cMpc/h
20 cMpc/h
30 cMpc/h



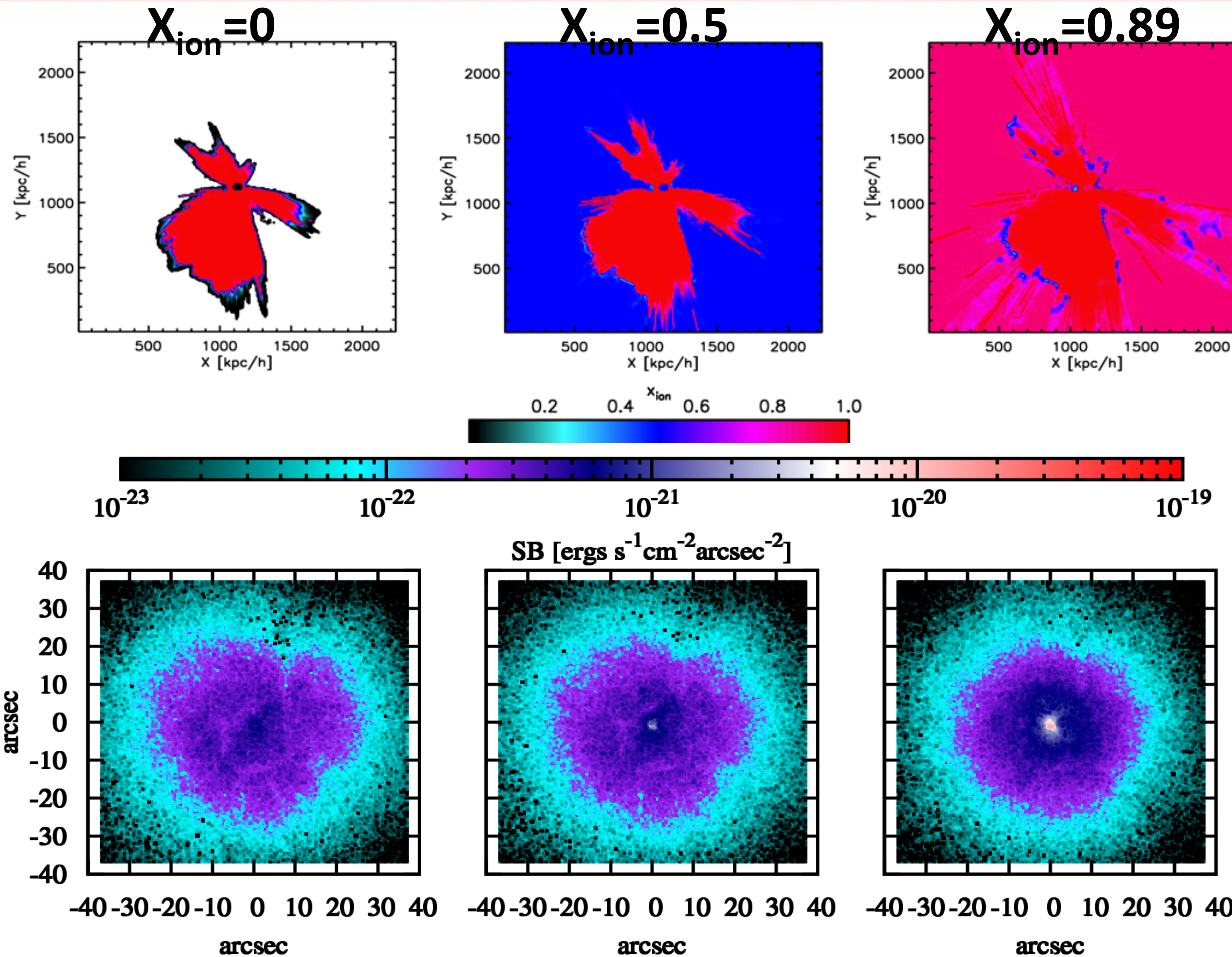
Surface Brightness Thresholds and Luminosity

Surface Brightness Thresholds in ergs/s/sq. cm/sq. arcsec

> 5e-20
> 1e-20
>1e-21
>1e-23



Initial Ionization Level



Luminosity functions

Initial Background Ionization

$x_{ion} = 0$

$x_{ion} = 0.5$

$x_{ion} = 0.89$

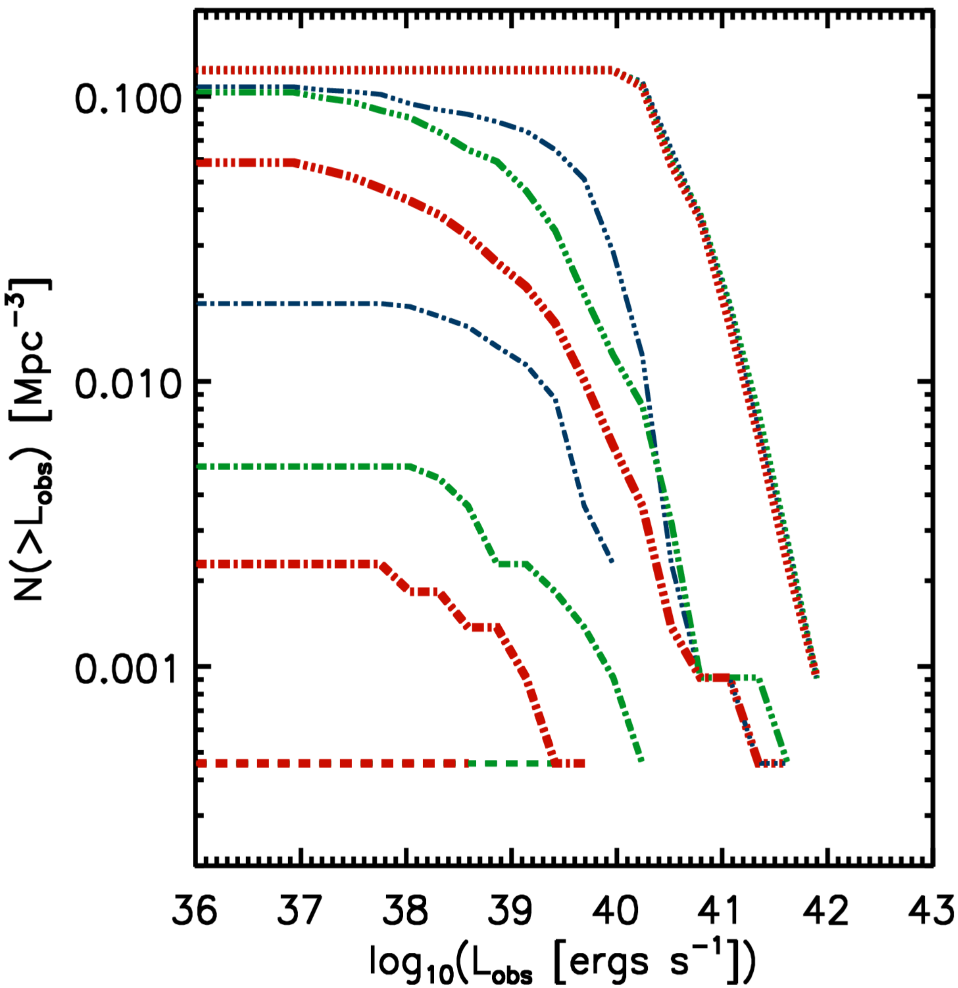
Surface Brightness Thresholds (ergs/s/cm²/arcsec²)

> 5e-20 — — — — —

> 1e-20 — · — · — ·

>1e-21 —— · · —— ·

>1e-23 · · · · · · · · ·



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Story at Low Redshifts

Environment effects on LAEs at z=3 (with Stuart and Edoardo)

- LAE Environment - Lyman Limit Systems, large scale velocity gradients, local ionization enhancement.
- See if it affects LAE clustering measurements in HETDEX.
- Edoardo's cosmo simulations
    – 18 cMpc/h box with 2 ckpc/h spatial resolution.

WORK in PROGRESS

Conclusions

- IGM inhomogeneities leads to special lines of sight (through voids) where LAE observability is higher especially in high neutral fraction Universe.
- LAE surface brightness profiles could give information on the galaxy outflows and IGM around them.
- Surface brightness thresholds need to be taken into account while using LAE LFs to study EOR.
- Detecting high redshift LAEs – need deeper observations to catch the tip of the flatter and fainter surface brightness profiles (unless they have strong outflows).