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Accretion powered Lyα blobs using radiation hydrodynamics

observatoire de Lyon

ELIXIR

Lyα blobs - LABs

Extended Lyα nebulae at high redshifts (z=2-3)

The LAB craze started in 2000

Usually found in overdense regions

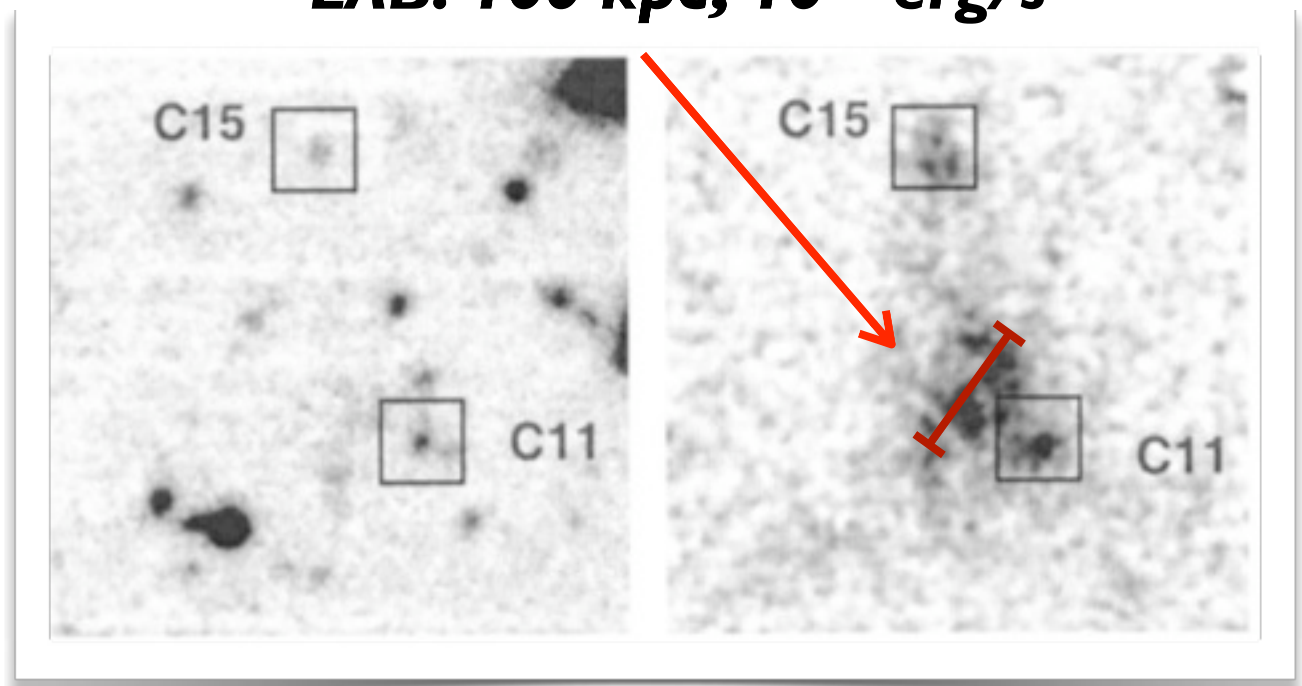
They're not so many - yet
~15 giant LABs (>100 kpc)
~200 LABs (>30 kpc)

Space density is 10^{-4}-10^{-5} comoving Mpc^{-3}

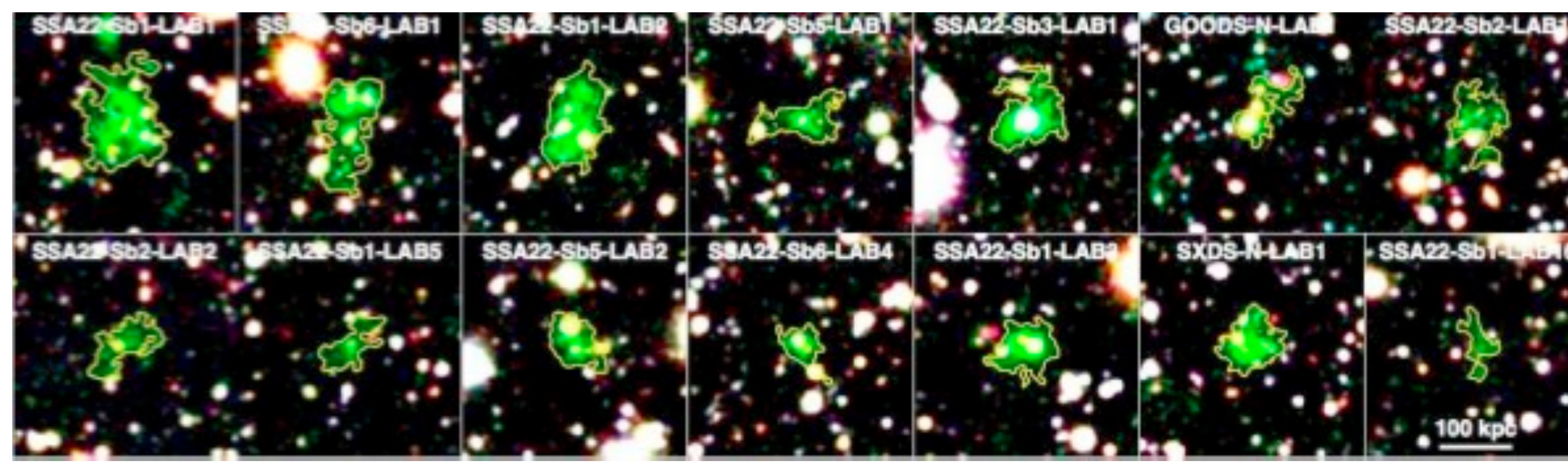
Some of them are really mysterious - they contain no visible galaxies

The mystery is:
What drives the emission?

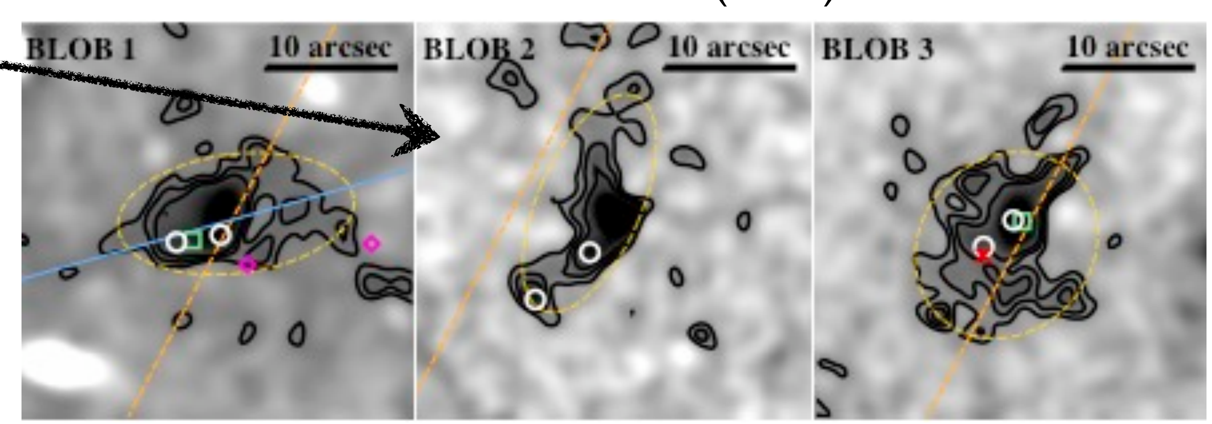
LAB: 100 kpc, 10^{44} erg/s



Steidel et. al. (2000)



Matsuda et. al. (2010)



Erb et. al. (2011)

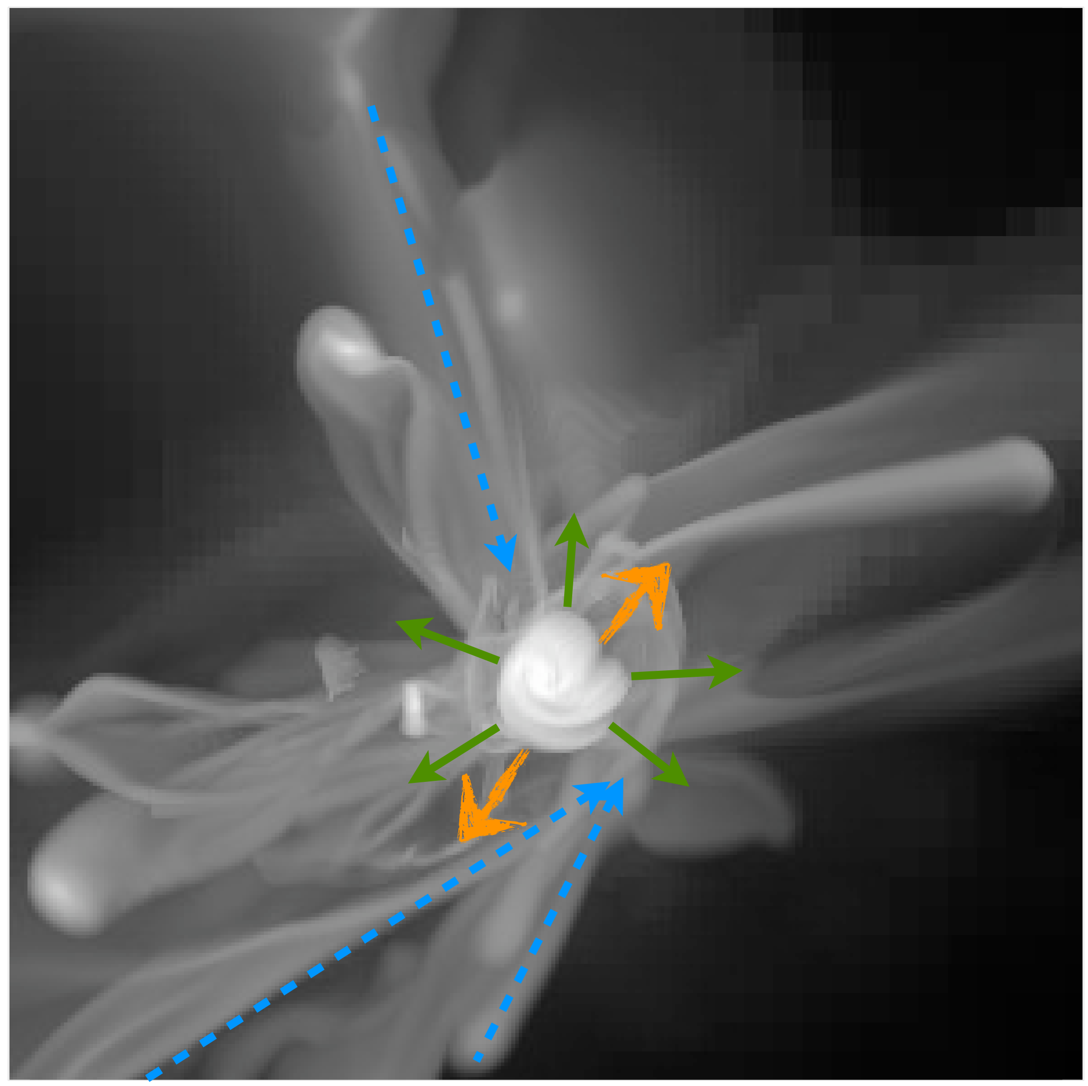
What drives Lyα blobs?

Theories and simulations

A lot of work has been done on models and simulations of LABs, yet their nature remains elusive

1:
Lya scattering
(Zheng, Laursen, Steidel)

2:
UV fluorescence
(Kollmeier, Cantalupo)



3:
SNe winds
(Taniguchi&Shioya, Ohyama, Mori)

4:
Cold accretion
(Fardal, Dijkstra, Faucher-Giguere, Goerdt, us)

Cold streams are predicted by simulations but never detected

Streams heat by gravitational dissipation and cool via Lyα emission

To simulate Lyα emission from cold accretion, one should resolve the competition between gravitational heating and Lyα cooling in the presence of an inhomogeneous UV field.

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Using state-of-the-art RHD simulations, we investigate:

- **Are cold flows responsible for LABs?**
- **The observability of cold streams?**
- **How deep do we need to go to detect those streams?**

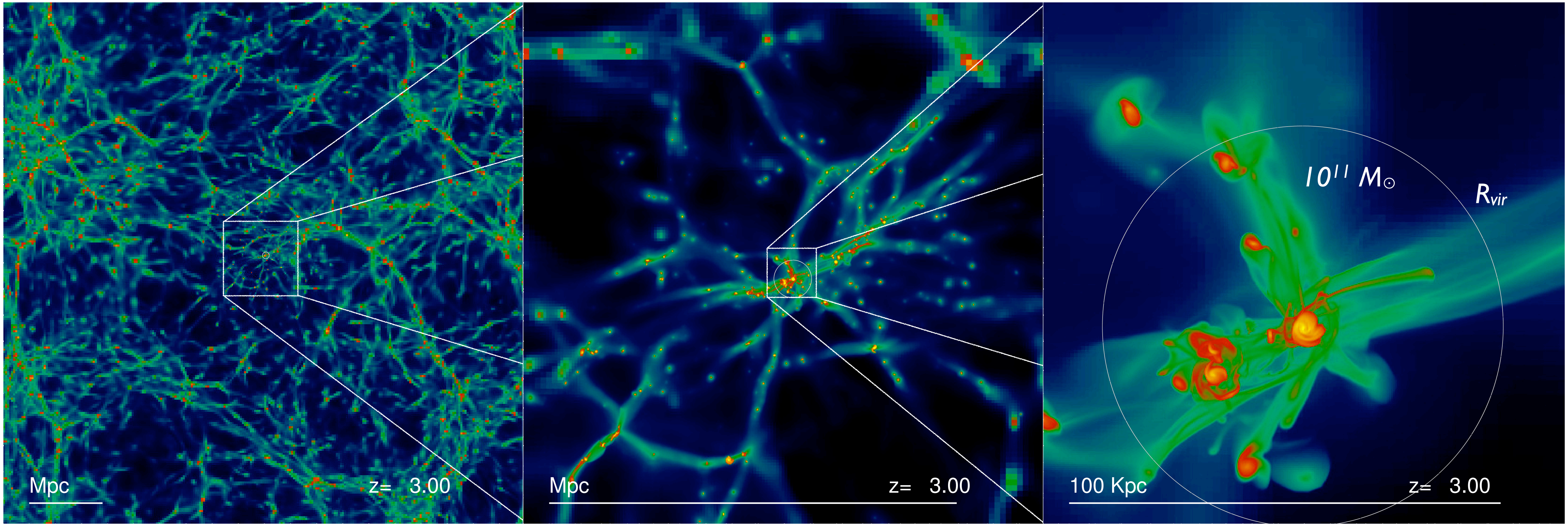
Layout

I. Setup of simulations

II. Accretion properties of 3 targeted halos of very different masses

III. Observational predictions for 3 halos

IV. Comparison to observations



Simulation setup

- **RAMSES-RT code: Radiation-hydrodynamics**

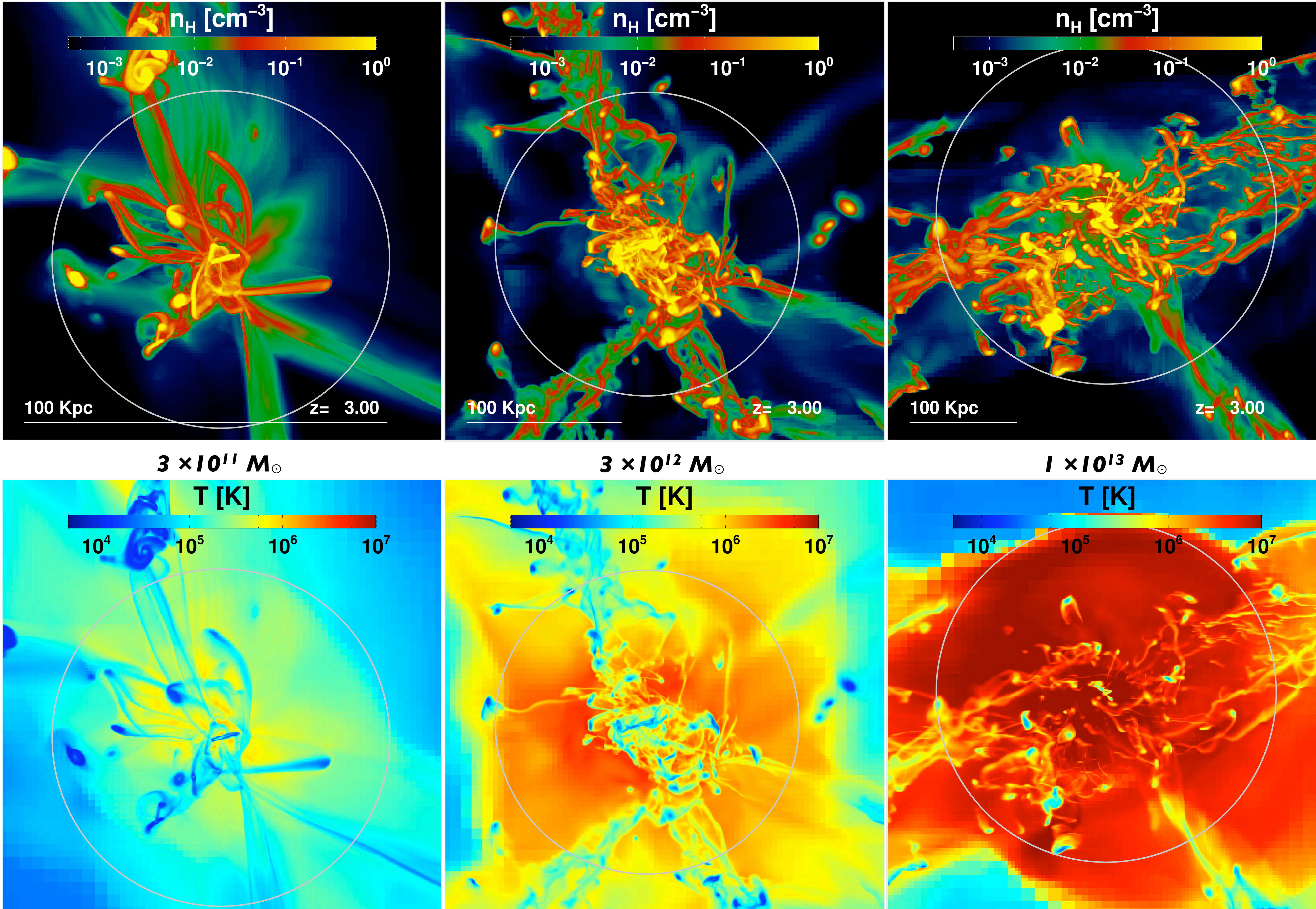
- **3 cosmological zoom simulations, focusing on 3 halos at redshift 3**
  - **Halo masses:** 10^{11} / 10^{12} / 10^{13} $M_\odot$
  - **DM mass resolution:** 10^{6} / 10^{7} / 5×10^{7} $M_\odot$
  - **Cell resolution:** *200 / 400 pc / 800 pc*

  - **Refinement strategy resolves streams to unprecedented levels**

- **Star formation: $n_H > 1$ *H/cc* - ISM is exluded from Lyα analysis**
- **No stellar feedback, no metals - not important in the cold streams**

- **RT: Propagation of the UV background - proper modelling of stream cooling for the first time**

3 halos - a mass study



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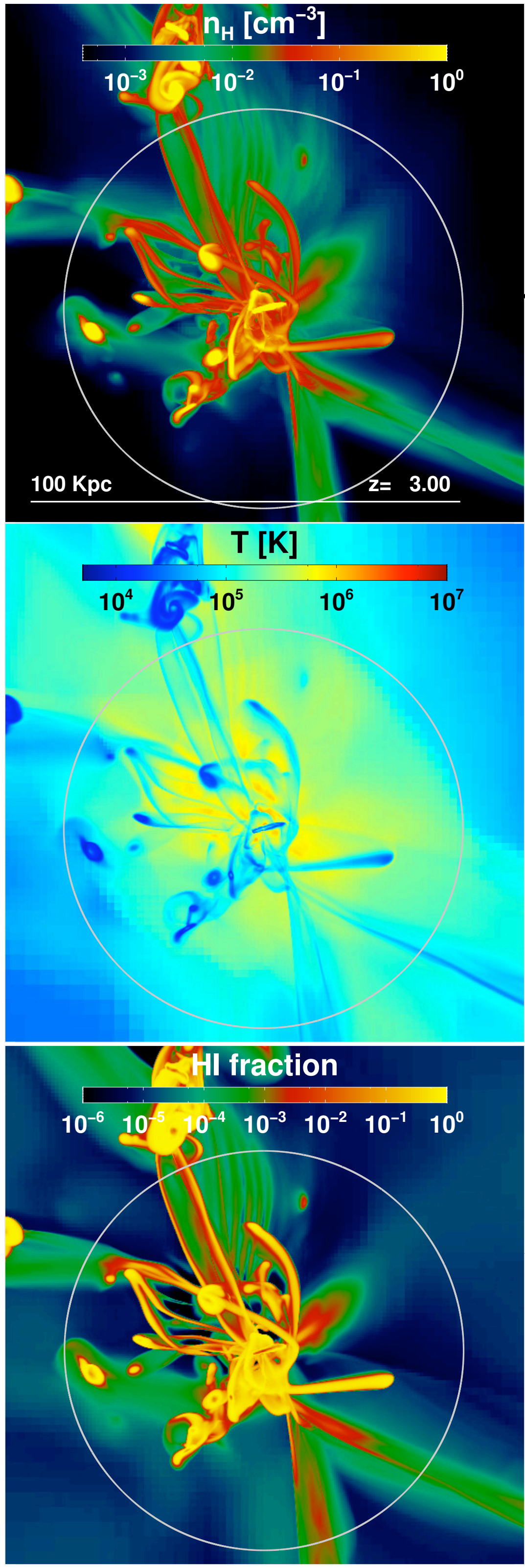
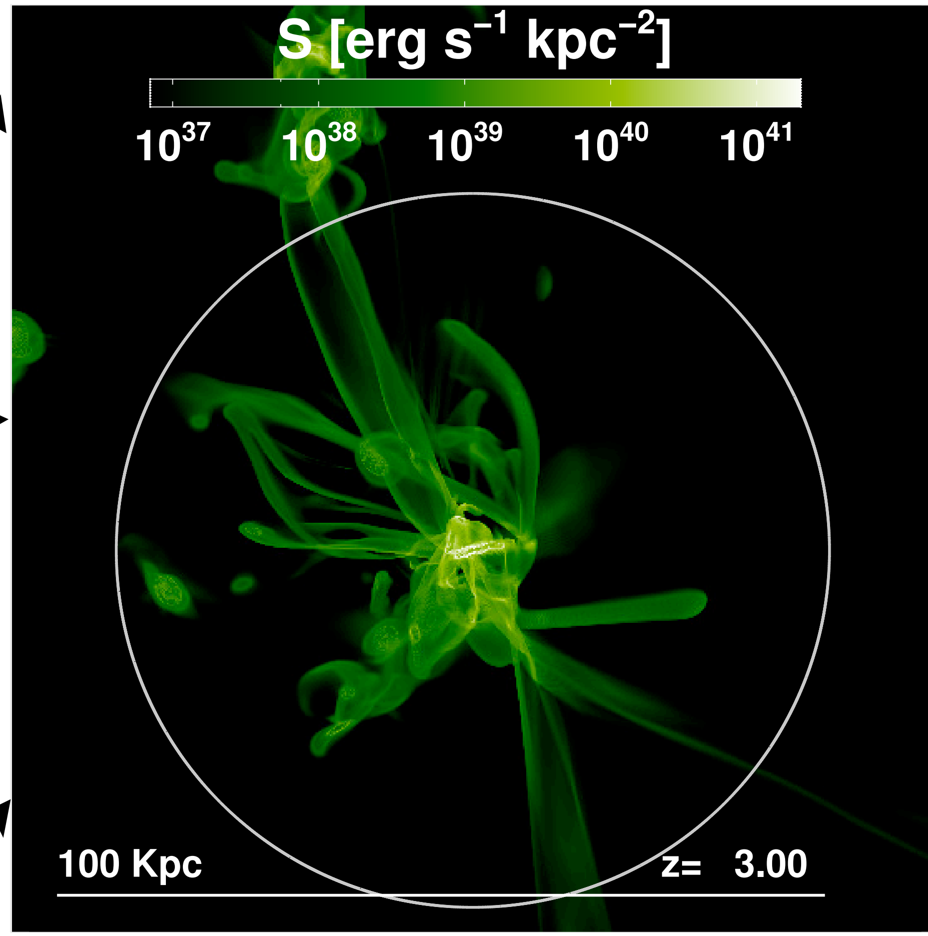
Lyα ‘observations’



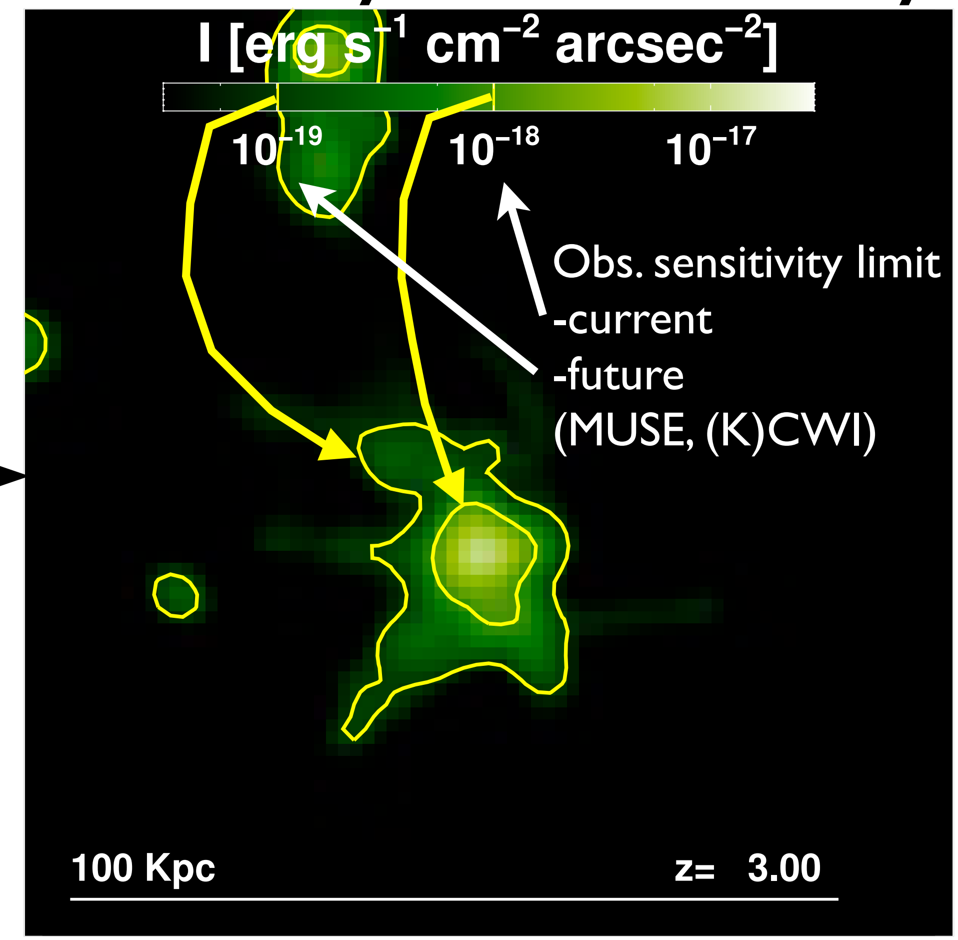
Rest-frame Lyα surface emissivity



$$\varepsilon_{coll} = C_{Ly\alpha}(T)\, n_e\, n_{HI}\, \epsilon_{Ly\alpha}$$

$$\varepsilon_{rec} = 0.68\, \alpha^{B}_{HI}(T)\, n_e\, n_{HII}\, \epsilon_{Ly\alpha}$$

Observed Lyα surface emissivity



- **Luminosity distance**
- **Convolution with PSF of FWHM=0.8 arcsec**
- **Cosmic transmission f_{α}=0.66**

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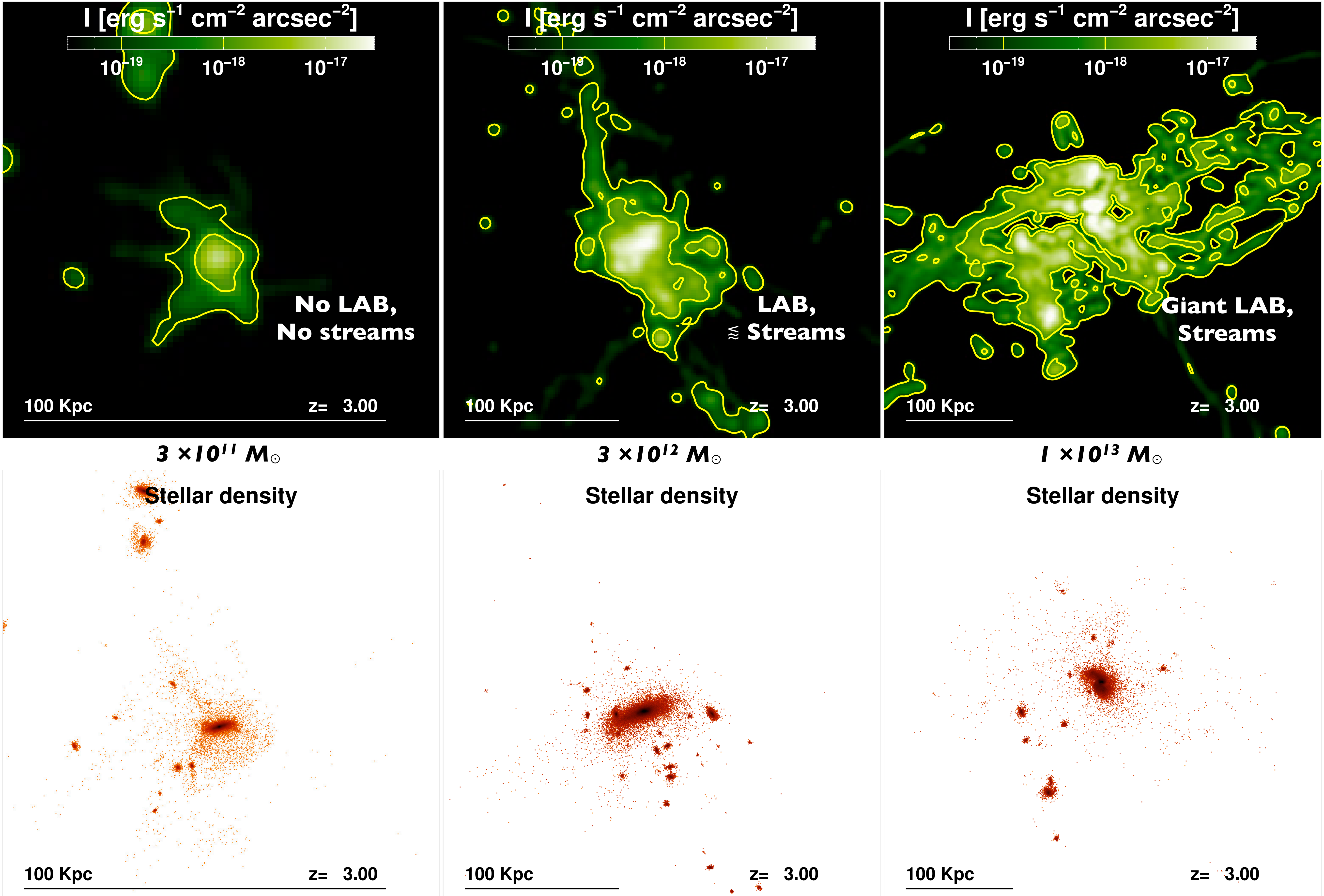
Observational predictions

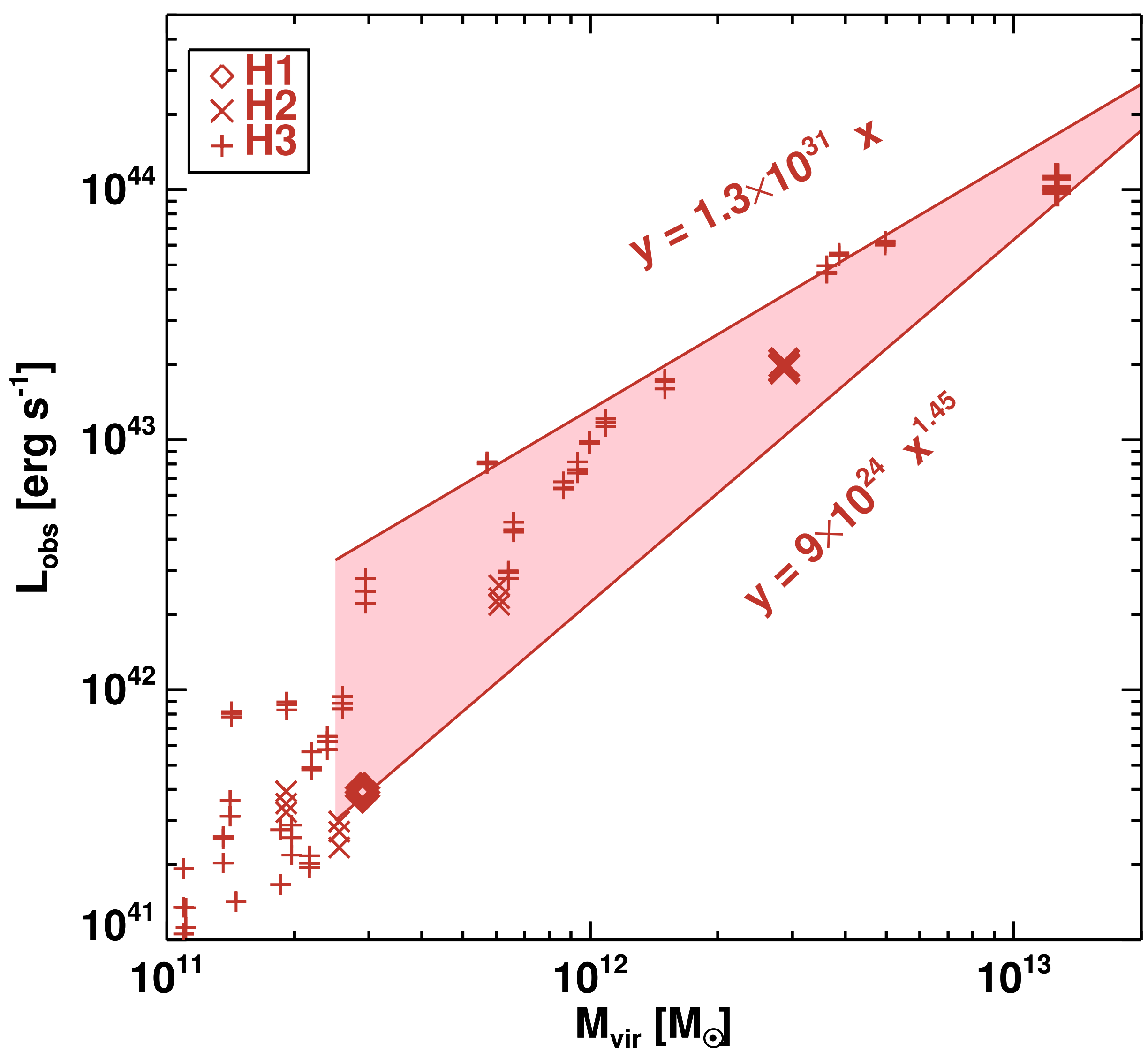
'There is a massive galaxy at the heart of each LAB' (Fardal et al. 2001)

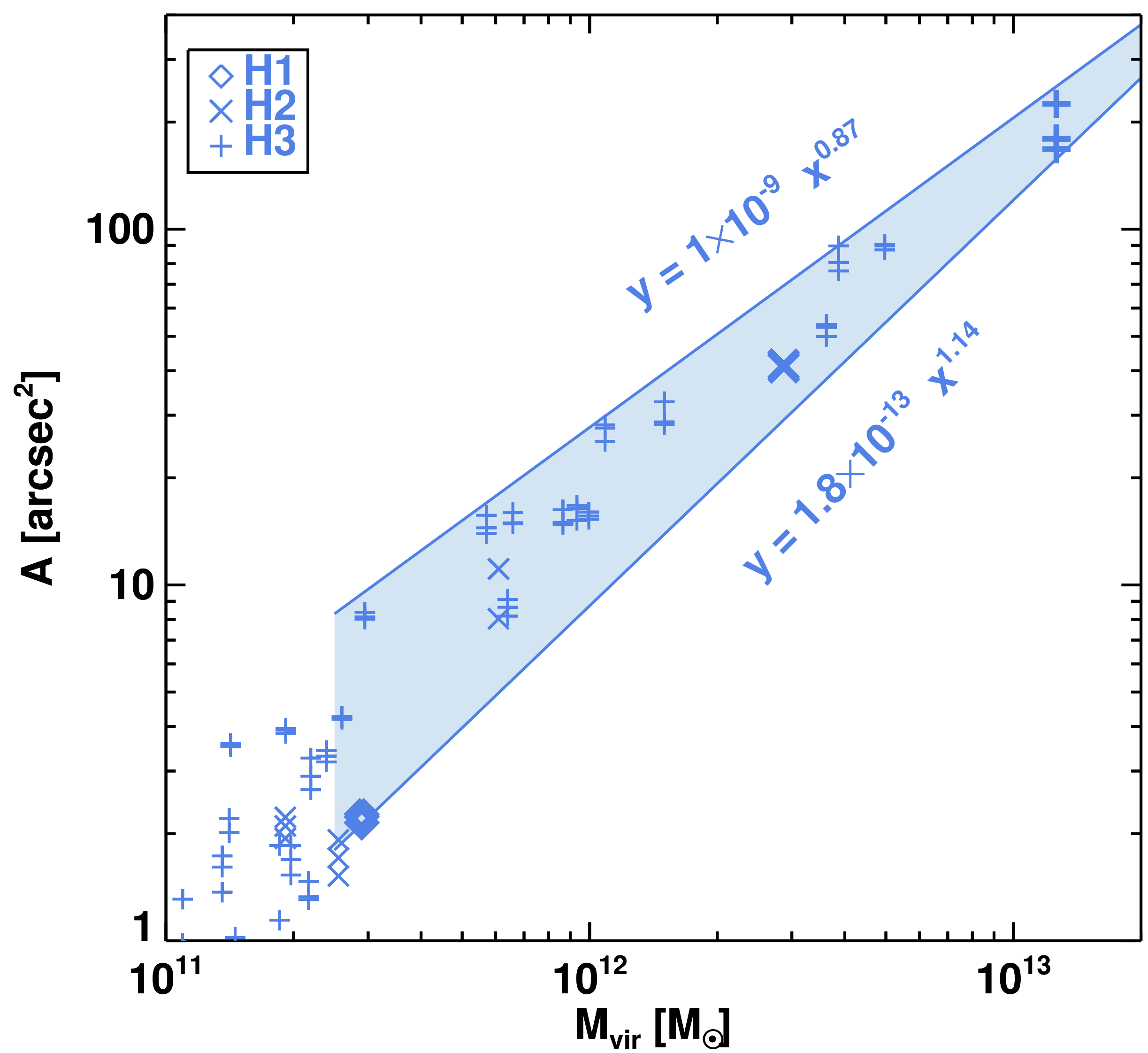


Observational predictions

Luminosity and area

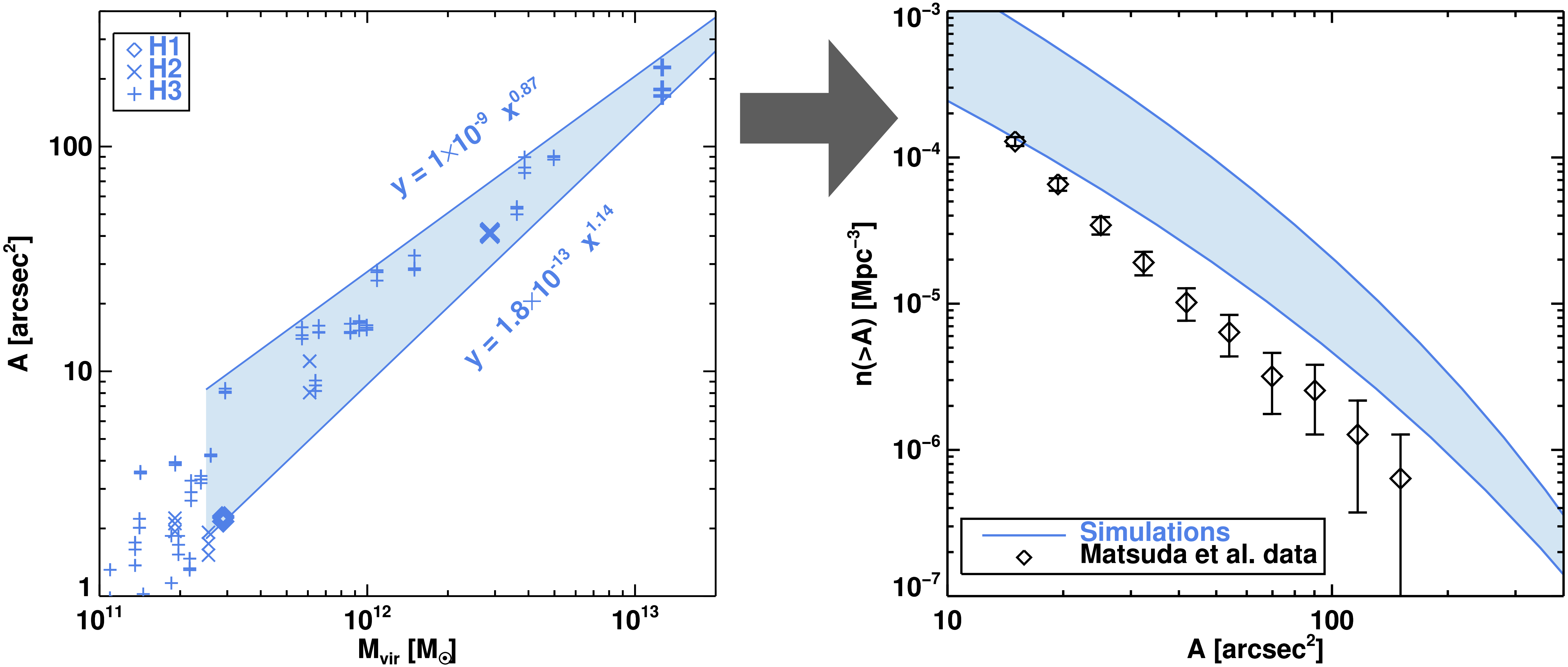
- Lumiosity/Area vs. mass function from our simulations
- $z=3.1$, $f_\alpha=0.66$, FWHM=1.4, $I_{lim}=1.4\times10^{-18}$ erg s^{-1} cm^{-2} arcsec^{-2}
  - to imitate Matsuda observations
- Decent trends in both plots, roughly following power laws
- So LAB properties appear to be largely determined by mass
- Area vs. mass should be more dependable in this case since it is not affected by (lack of) ISM modelling





Comparison to observations

Are the statistics consistent?

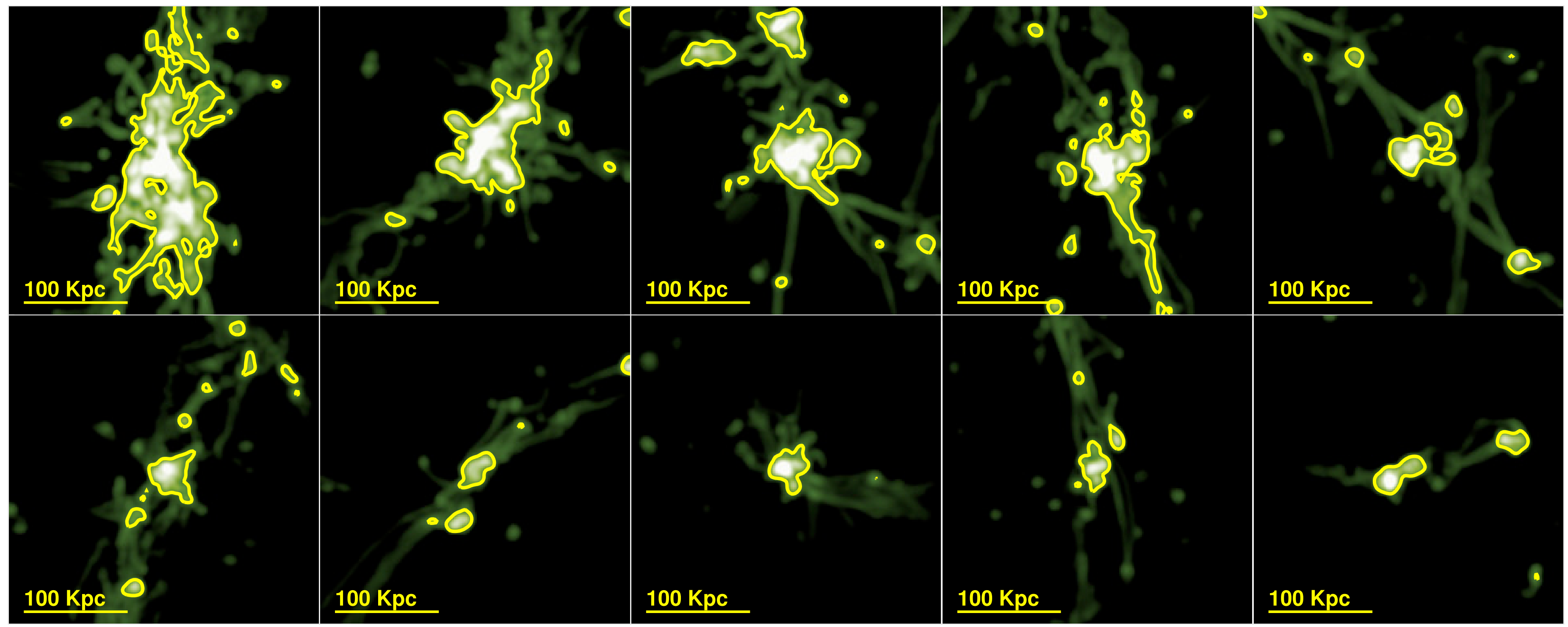


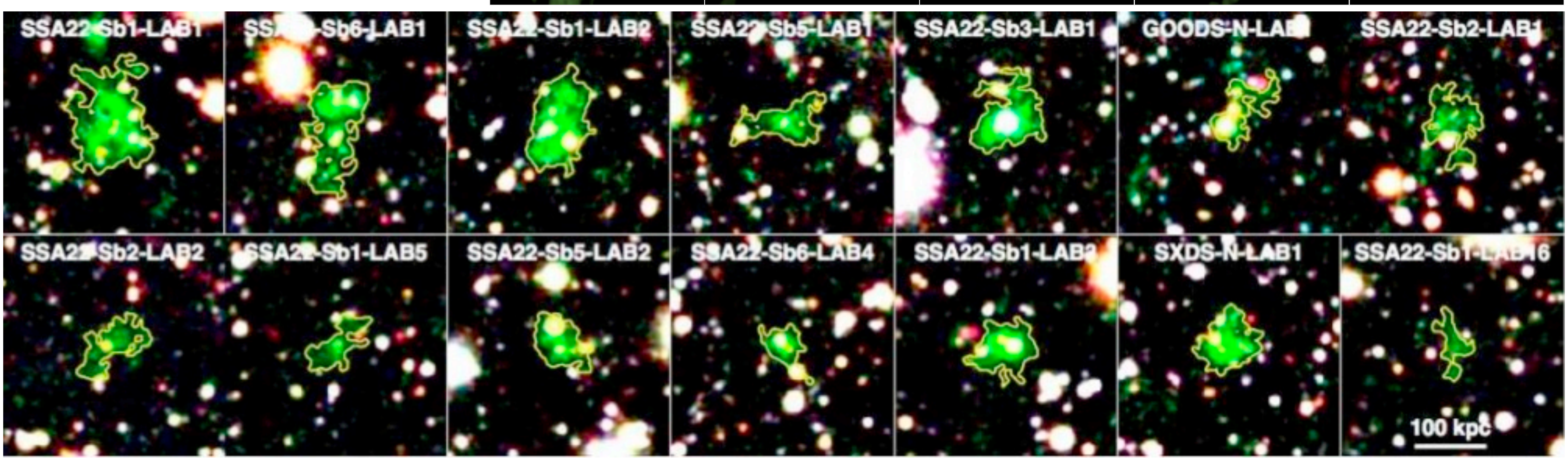
- A(M) convolved with halo mass function
- Compared to 202 halos from Matsuda et al.
- We overproduce LABs - or overestimate their areas, by a factor of 2-3
  - Bad statistics, environmental effects, cosmic extinction
  - Observational uncertainties: Noise, continuum subtraction, Lyα absorbers
  - Physics: Effects of winds, metals, local UV enhancement - can all be negative
- Effects are uncertain - our results leave some room for factor ~2 extinction

Comparison to observations

Do our LABs look like the real thing?

- **Same redshift z≈3**
- **Contours at same sensitivity**
- **Us**
- **Observations of the 14 biggest LABs from Matsuda et al. 2010**





Summary and conclusions

- First fully consistent RHD simulations of accretion streams
- Cold streams are *on-the-verge* Lyα observable in massive halos
- Cold accretion is probably sufficient to explain *most* LABs
  - We overpredict LAB abundance by a factor of 2, but a number of systematic effects may dig us out of that hole
  - Can't explain LABs without galactic counterparts - except by resorting to 'hidden from view' galaxies

Prospectives

- Other models for the drivers of LABs:
  - Lyα transfer in simulation outputs
    - Compare line profiles with observations
    - Scattering in streams
  - Stellar UV feedback - can be a source of Lyα fluorescence
  - SNe Feedback?
- Also, maybe the subject of my PhD...