Theoretical Model of Lyman alpha Emitters and the Relation to Multi-Wavelength Observations

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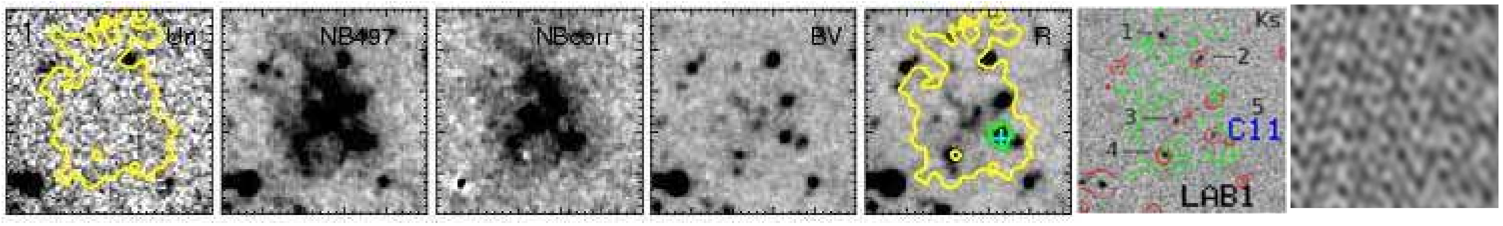
LAB1 in SSA22 region at z=3.1



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Understanding Lyman-alpha emitters conference, Heidelberg, Oct 2008

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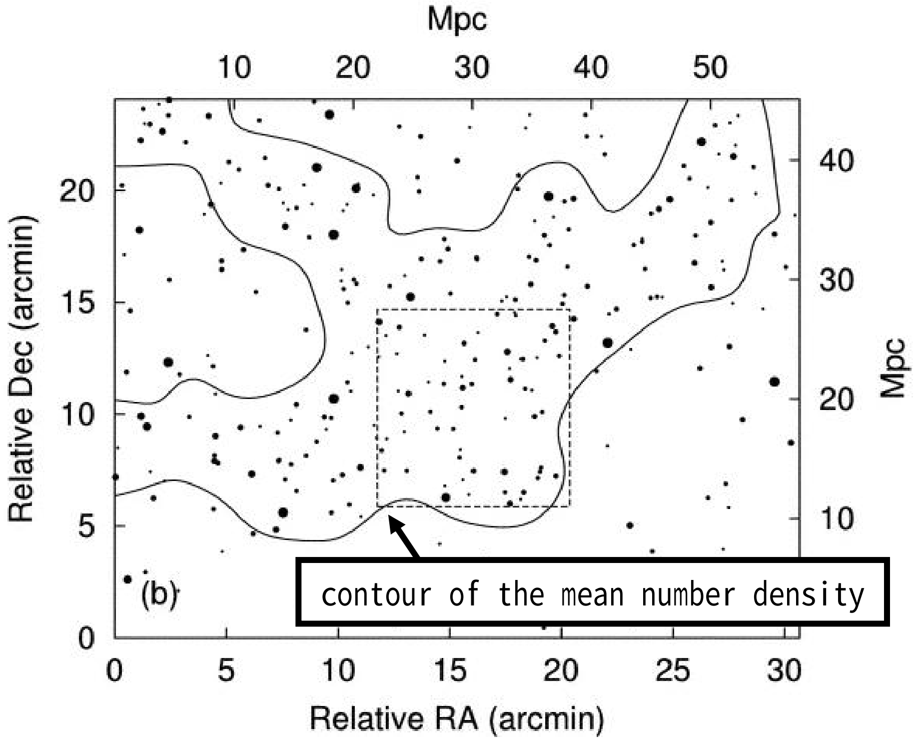
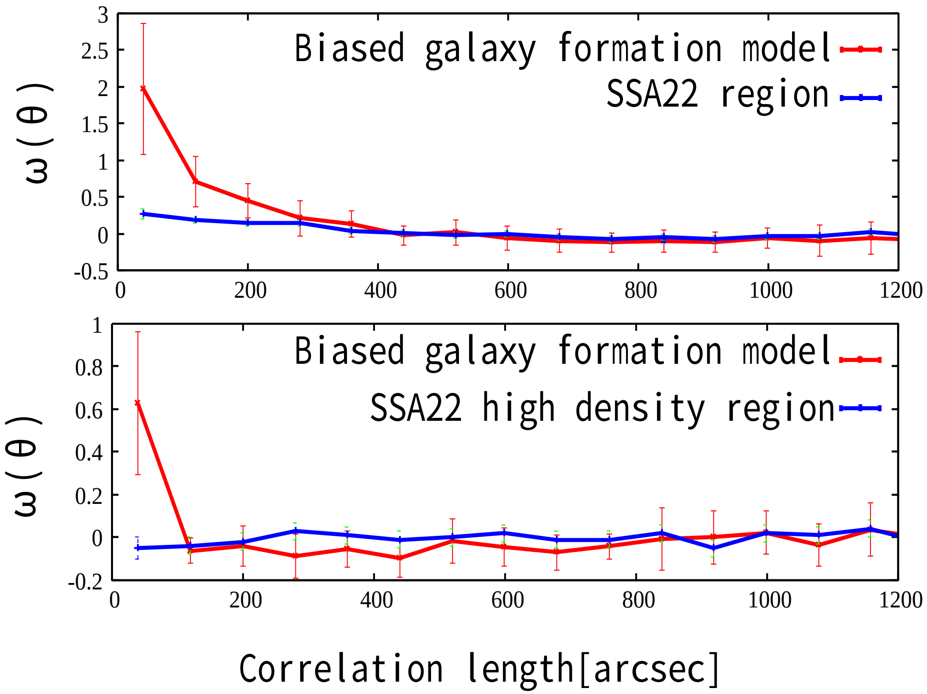
LAEs in SSA22 region at z=3.1

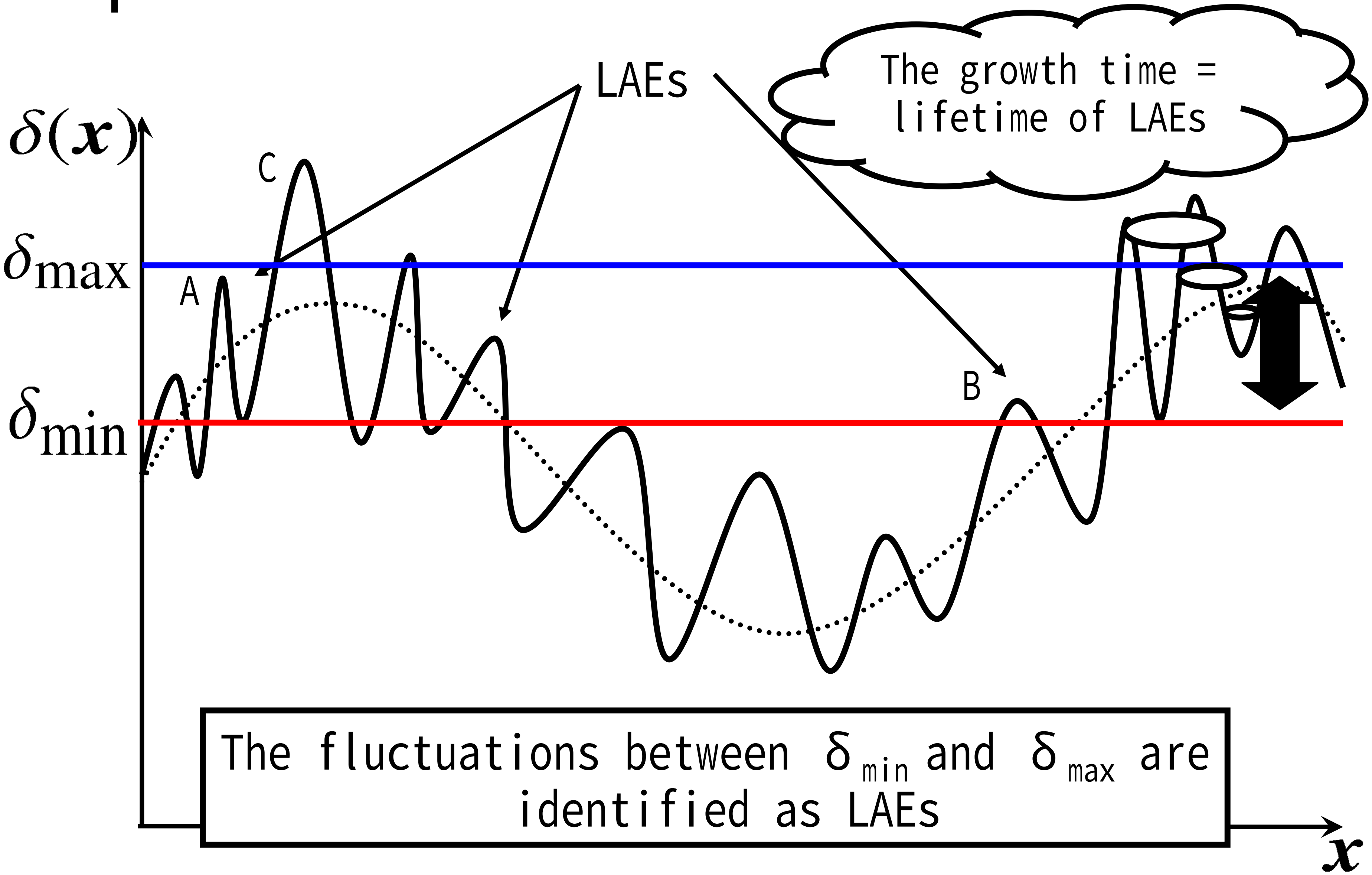


Hayashino et al. 2004

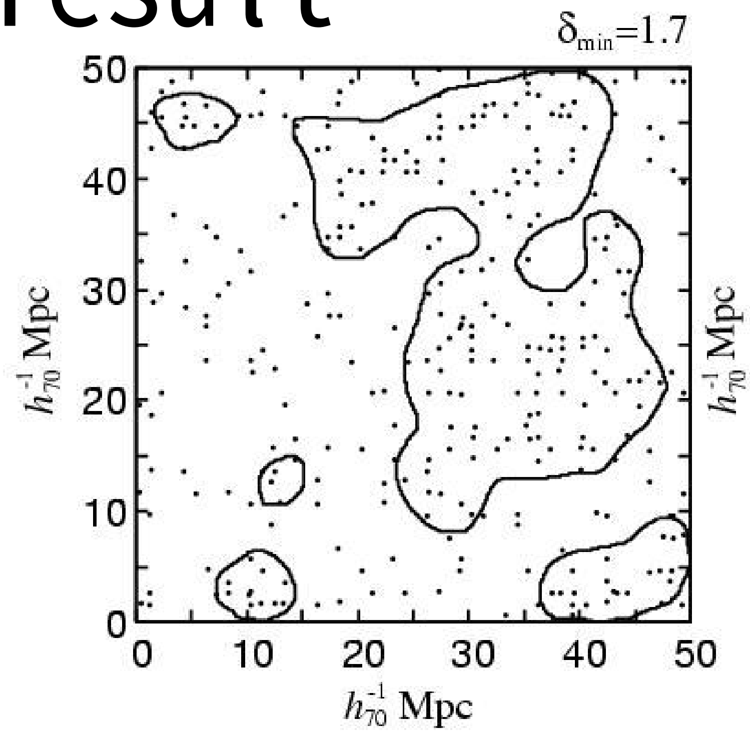


●This region have very large (～50Mpc) belt-like structure.
●If the spatial distribution of observed LAEs is real,
this structure is corresponding to 6σ density fluctuation!.
●Correlation function of observed LAEs is weaker than
the biased galaxy formation model.

picture of evolution of LAEs



result



●The model with δ_{min} = 1.7 remarkably agrees with the observation (Hayashino et al.,2004).

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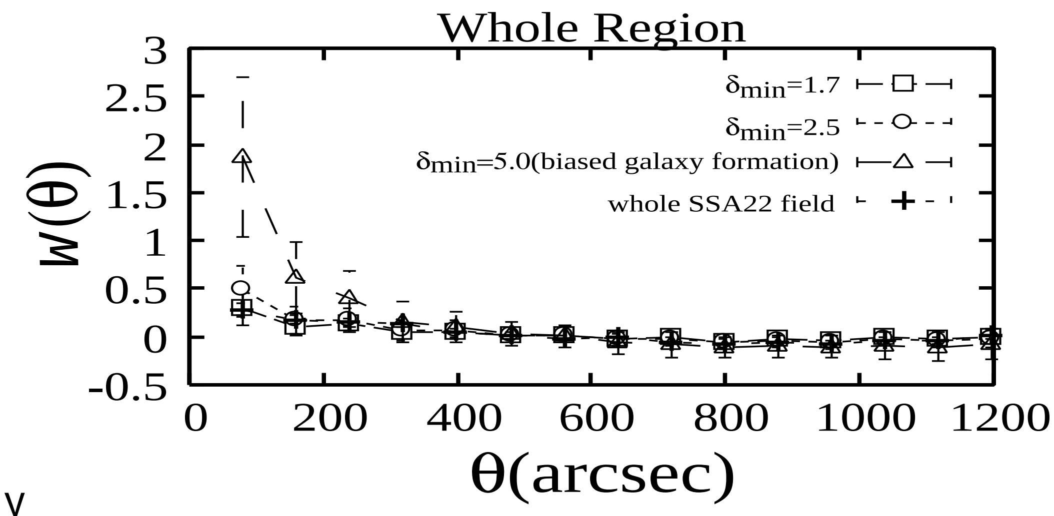
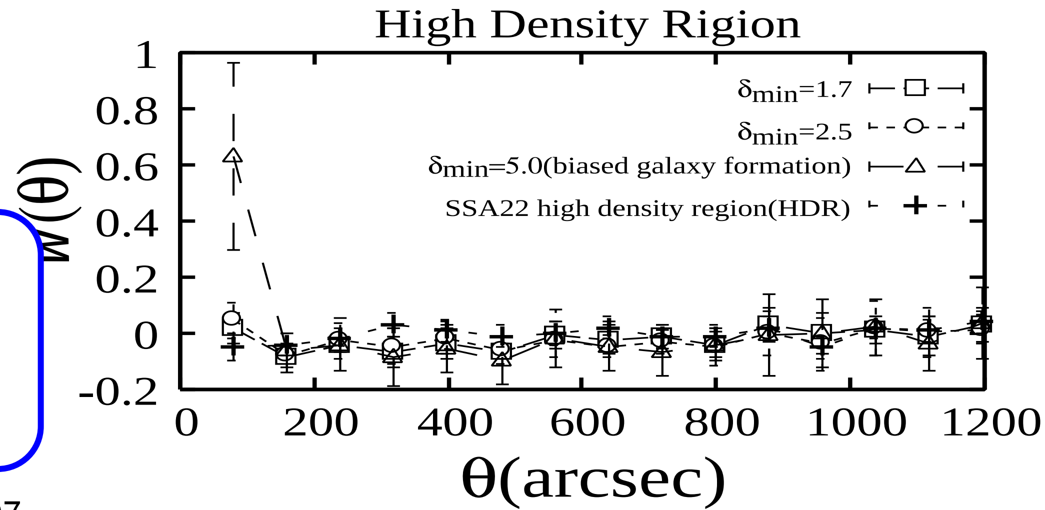
●LAEs are thought to be in the early evolutionary phase of galaxies

●Lifetime of LAE is ～10^8 yr

Zeldovich approximation
•Simulation box：$(50h_{70}Mpc)^3$
•particle number ：8000000
⇒1 particle mass：$5.6\times10^8 M_{sun}$





Shimizu et al., 2007

Age of observed LAEs

Result of SED fitting of observed LAEs

refrence	z	stellar mass $[M_\odot]$	Age [Myr]
Gawiser2006, 2007	3.1	5×10^8	90
Lai2007b1	3.1	3×10^8	160
Nilsson2007	3.15	4.7×10^8	850
Lai2007b2	3.1	9×10^8	1600
Finkelstein2007	4.4	$(3.0 \sim 65) \times 10^8$	$3 \sim 800$
Pirzkal2007	5	$(0.07 \sim 18) \times 10^8$	$1.0 \sim 200$
Lai2007a	5.7	$(4.5 \sim 11) \times 10^9$	$4.8 \sim 720$

The age of some observed LAEs exceed our model($\sim 10^8$yr).

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LAEs are only young objects??

Formation of LAEs by Delayed Gas Accretion

The early phase of the star formation is bright in Lyα emission (Mori & Umemura.2006)

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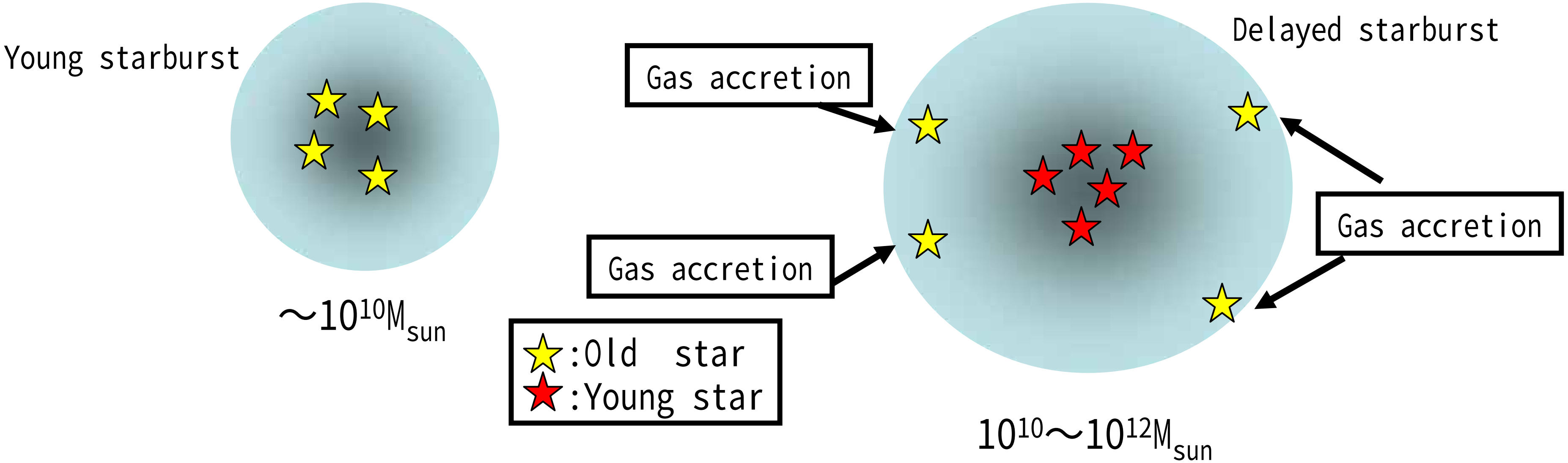
Aged galaxies also can be LAEs if starburst occurs.

Young object ⇒ Type I LAE   Aged galaxy ⇒ Type II LAE



In this study, we explore whether the object where gas accretes onto aged galaxy (Type II LAEs) can be LAEs

Method

- Cosmology： ΛCDM
- N-body simulation：P3M method
- Halo identify：FOF method

•Simulation box：$(50h_{70}^{-1}\mathrm{Mpc})^3$
•particle number ：16777216
⇒1 particle mass：$2.7\times10^{8}M_{sun}$
•Initial z：z=51
•periodic boundary condition

Model

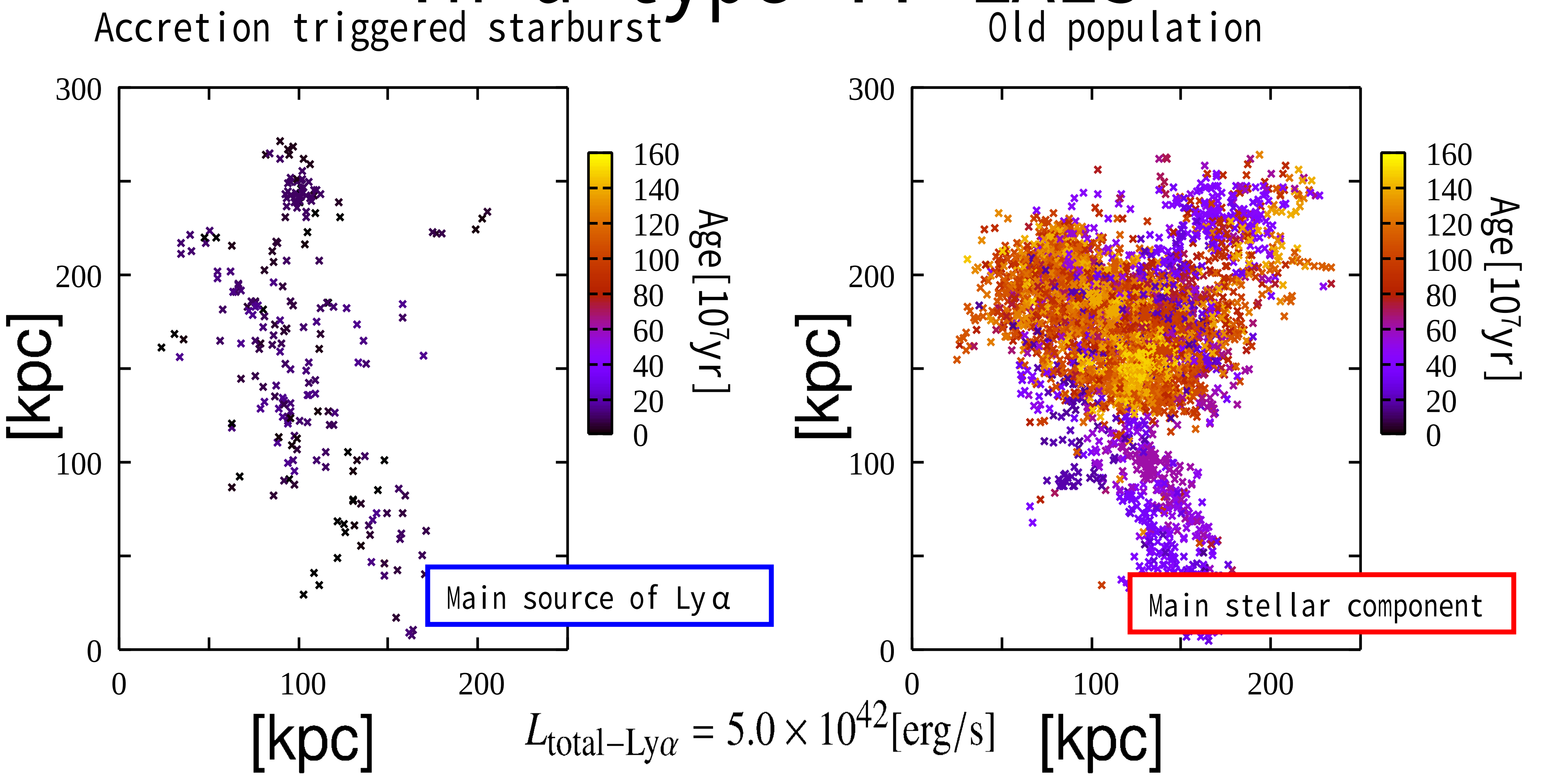
- The star formation is triggered, when a dark matter particle is trapped in a halo.
- SED is calculated with PEGASE
- The dust extinction is included.

$$L_{\mathrm{Ly}\alpha,\mathrm{obs}} = f_{\mathrm{esc}} L_{\mathrm{Ly}\alpha,\mathrm{int}}$$
$$f_{\mathrm{esc}} = \exp\left(-a\tau_{\mathrm{dust}}\right)$$

$L_{\mathrm{Ly}\alpha,obs}$：The observed Lyα luminosity
$L_{\mathrm{Ly}\alpha,int}$：intrinsic Lyα luminosity
τ_{dust}：optical depth of dust in each halo

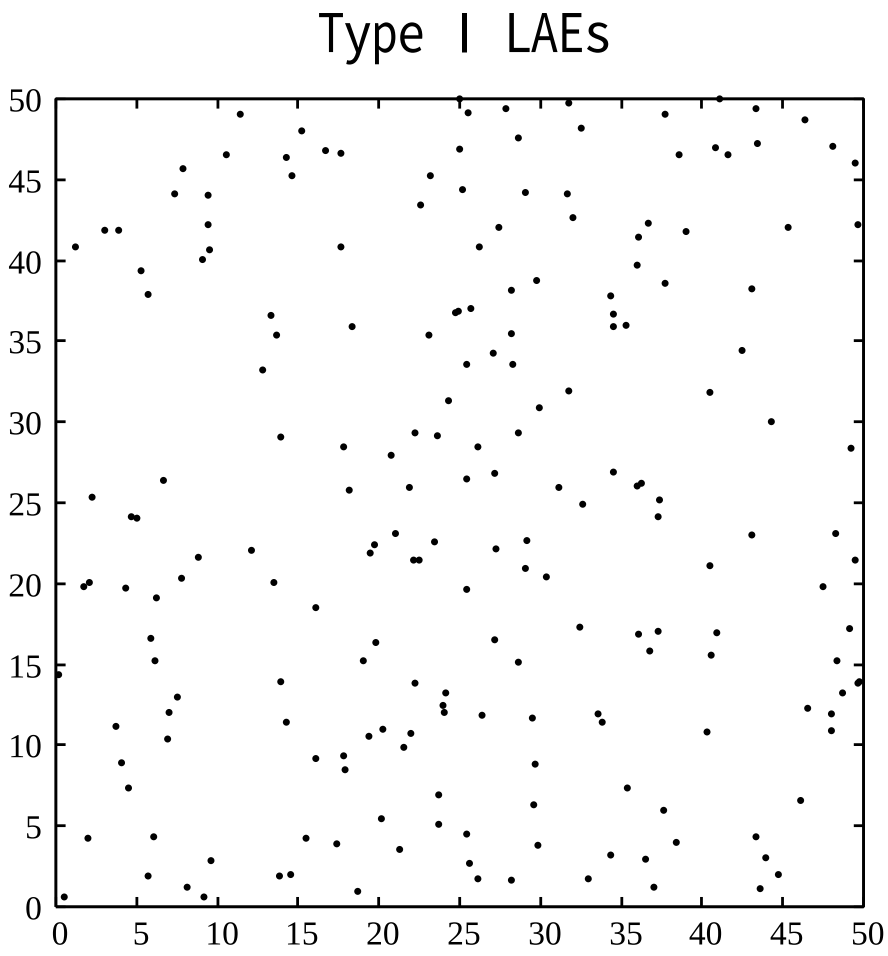
- LAEs are identified under the conditions as $L_{\mathrm{Ly}\alpha}>1.4\times10^{42}$[erg/s], $EW_{\mathrm{Ly}\alpha}>30$Å

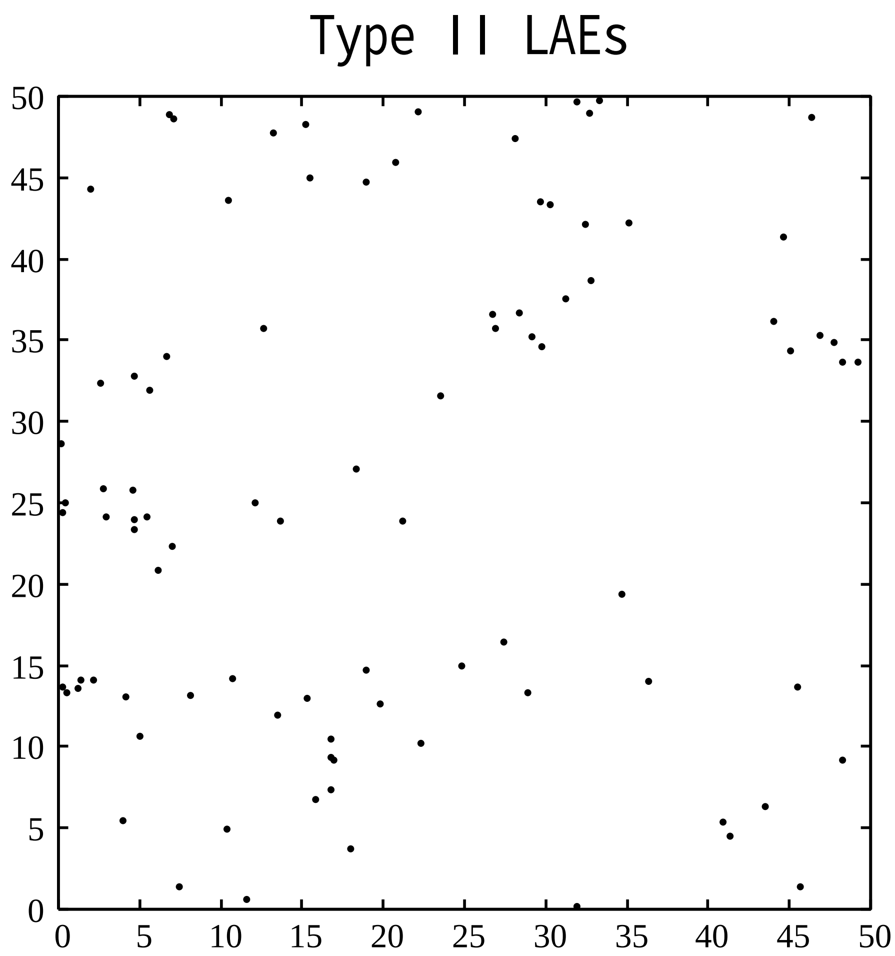
Stellar population distribution in a type II LAEs



The region where gas accretion triggered starburst occurs is distributed to surround old population. Its spatial distribution are different from that of old population.

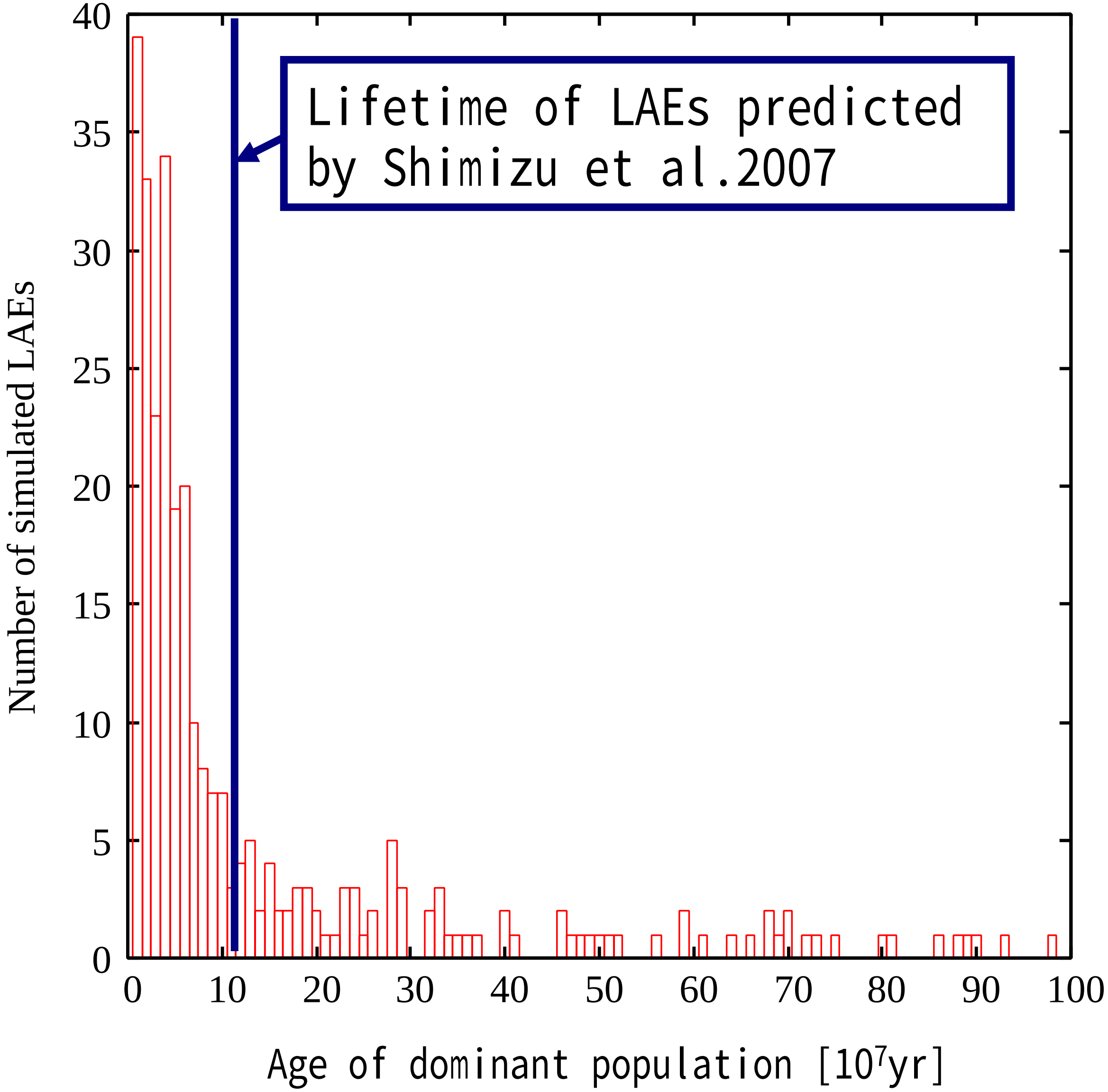
Spatial distribution of LAEs



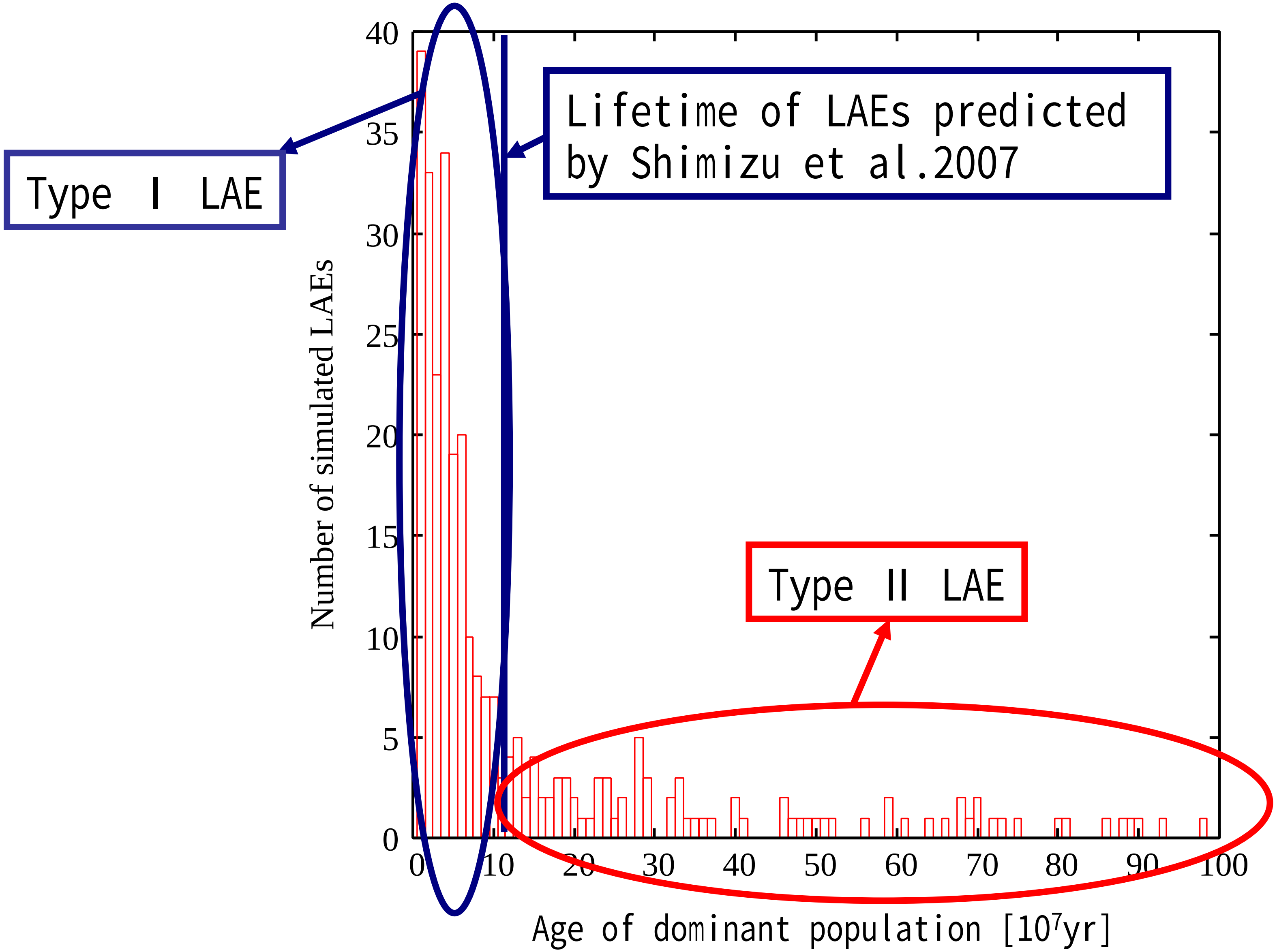


The spatial distribution of Type II LAEs exhibit a stronger contrast.

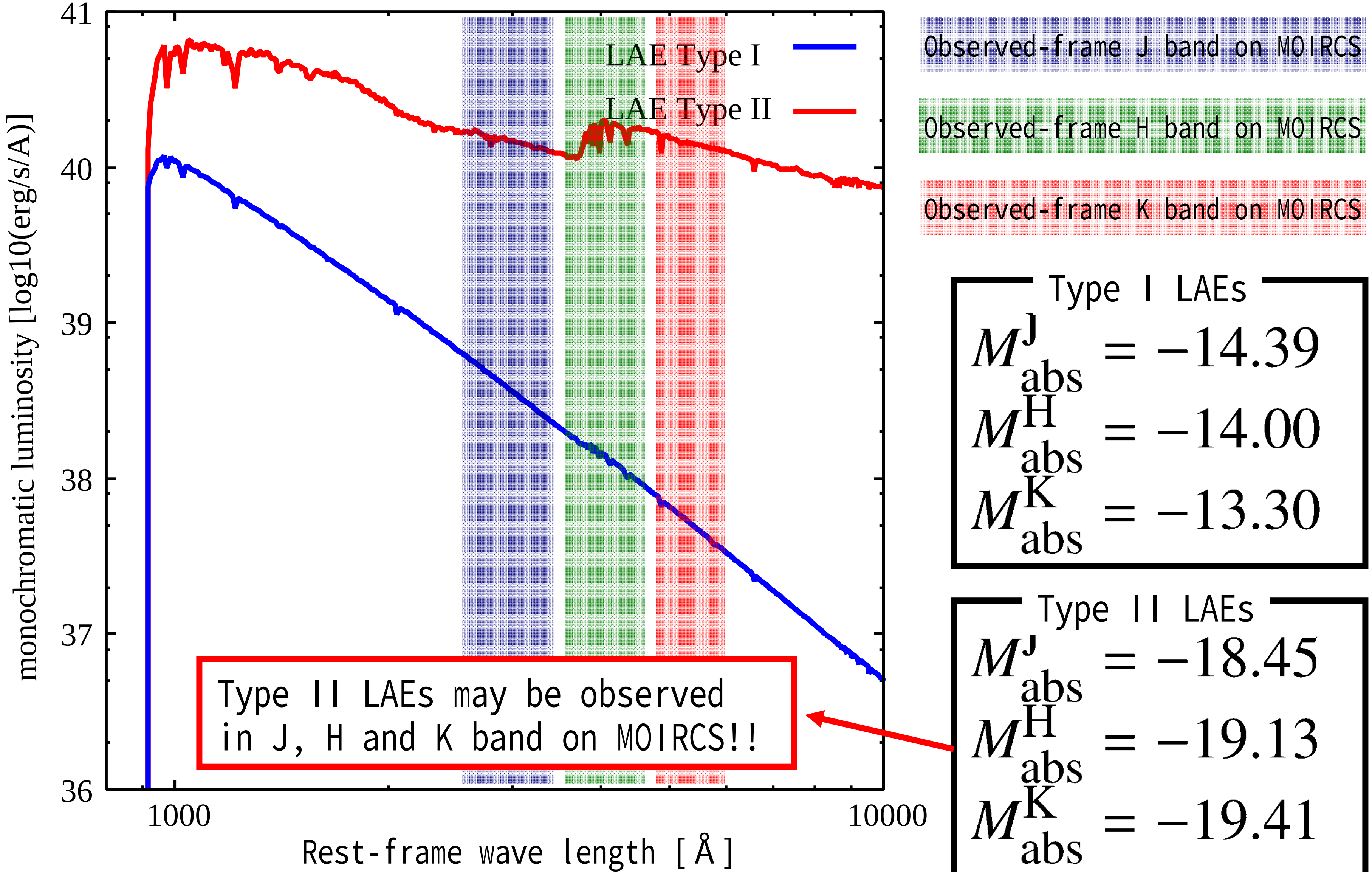
Age distribution of simulated galaxies



Age distribution of simulated galaxies



SED of simulated LAEs



Type I LAEs

$$M^{J}_{abs} = -14.39$$
$$M^{H}_{abs} = -14.00$$
$$M^{K}_{abs} = -13.30$$

Type II LAEs

$$M^{J}_{abs} = -18.45$$
$$M^{H}_{abs} = -19.13$$
$$M^{K}_{abs} = -19.41$$

Summary

To explore whether LAEs are only young object,
we consider gas accretion onto aged galaxy induced starburst (Type II LAE).

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- We find that there may be at least two type LAE,

  I. Very young object (Type I LAE)
  II. Object where accretion onto aged galaxy (Type II LAE)

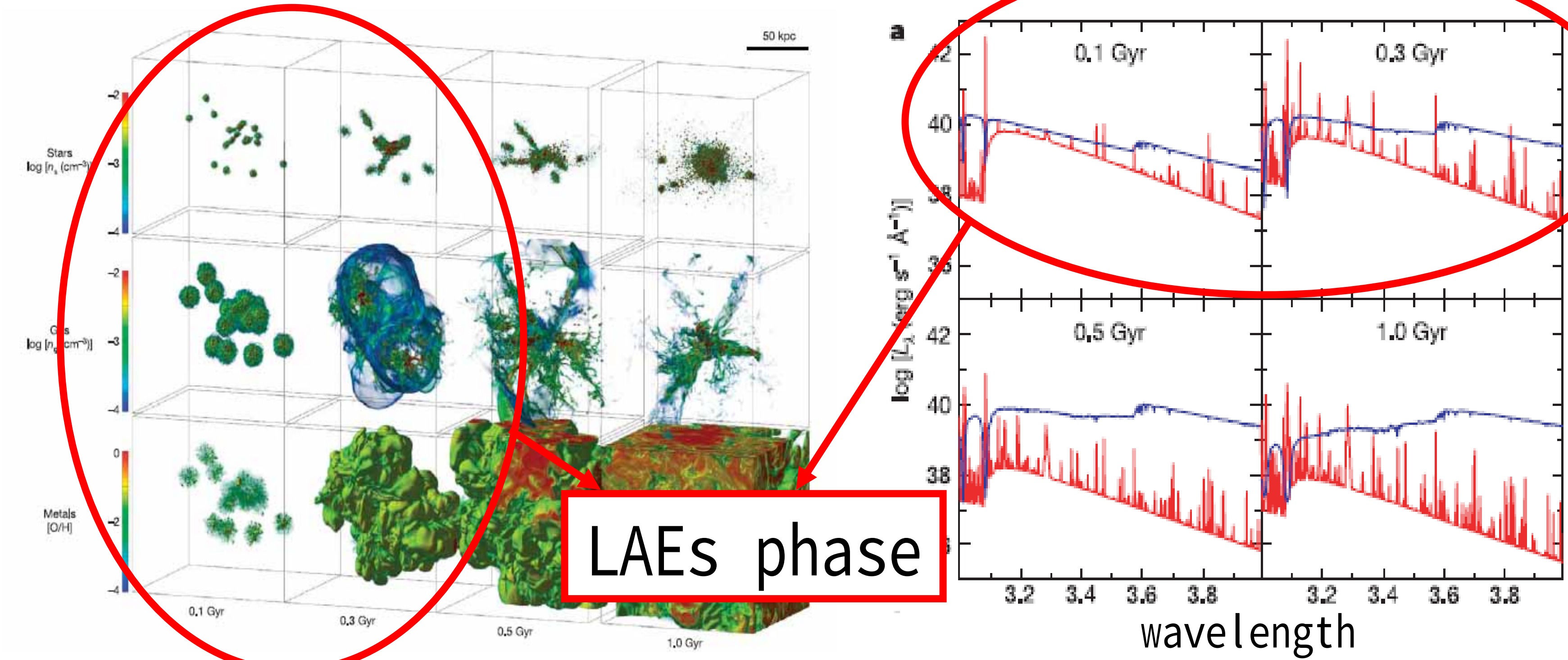
- The spatial distribution of young stellar population are different old stellar population in a Type II LAE.
- The spatial distribution of Type II LAEs shows a stronger contrast
- Type II LAE at z=3.1 can be observed at J, H and K band on MOIRCS

To confirm our new picture of LAEs,
we need to perform more detailed hydrodynamics simulation.

Appendix

Theoretical approach to LAEs

Mori & Umemura.,(2006a,b)
← ultra high resolution simulation on the dynamical and chemical evolution of galaxy



●multiple supernova explosions at an early phase of < 3 × 10^8 yr result in forming high density cooling shells, which emit so strong Lyα as to account for the luminosity of LAE.

Effect of dust absorption of Lyα emission

Absorption of Lyα emission by the dust

$$L_{Ly\alpha,obs} = f_{esc} L_{Ly\alpha,int}$$

$$f_{esc} = \exp(-aN)$$

$L_{Ly\alpha,obs}$: The observed Lyα luminosity
$L_{Ly\alpha,int}$: intrinsic Lyα luminosity
N : column density of heavy element in each halo

A parameter a is constrained so that the number of simulated LAEs should match the observed number of LAEs at z = 3.1

Star formation history

$$\mathrm{SFR}(t) = f_{\mathrm{SFR}} \exp\left(-t/10^8\mathrm{yr}\right)$$

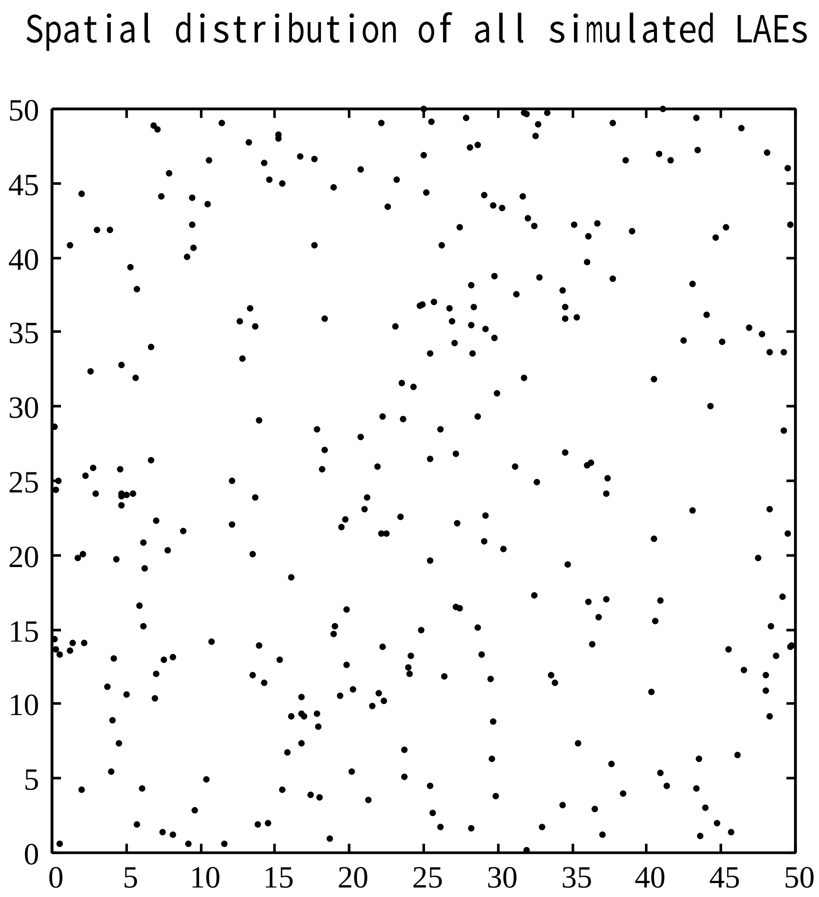
We set f_{SFR} to finally convert 10% of the gas into star

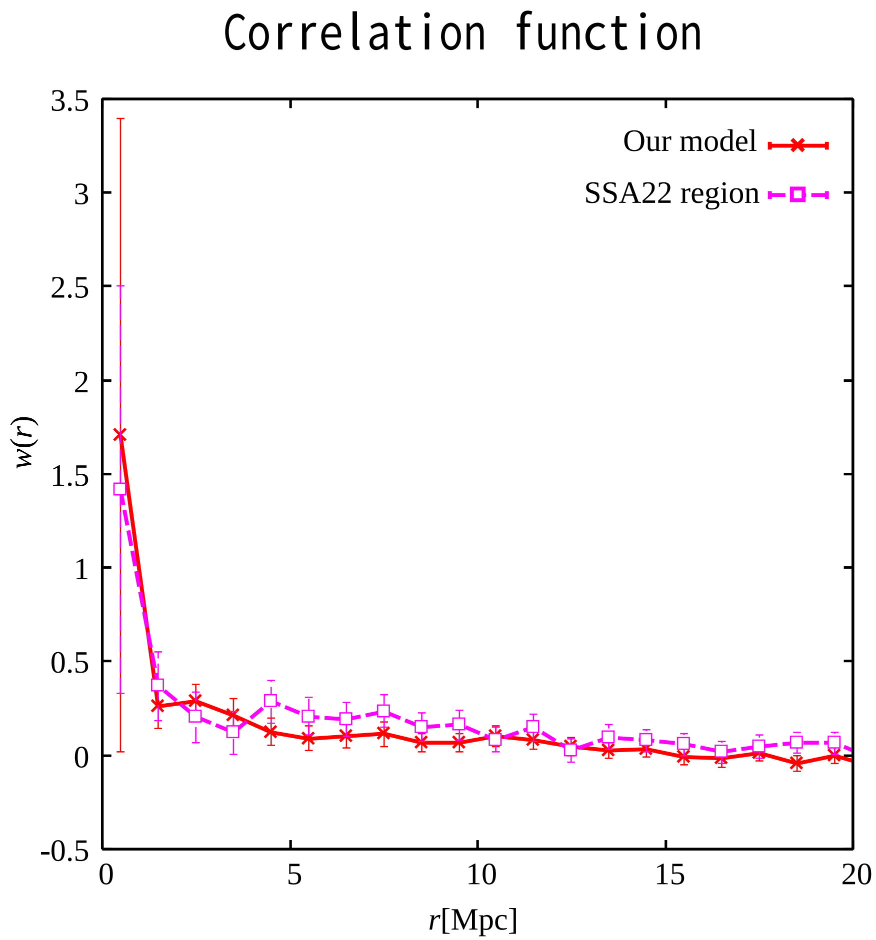
Detection limit of observation

We identify LAEs with the same condition of observation (Hayashino et al. 2004)

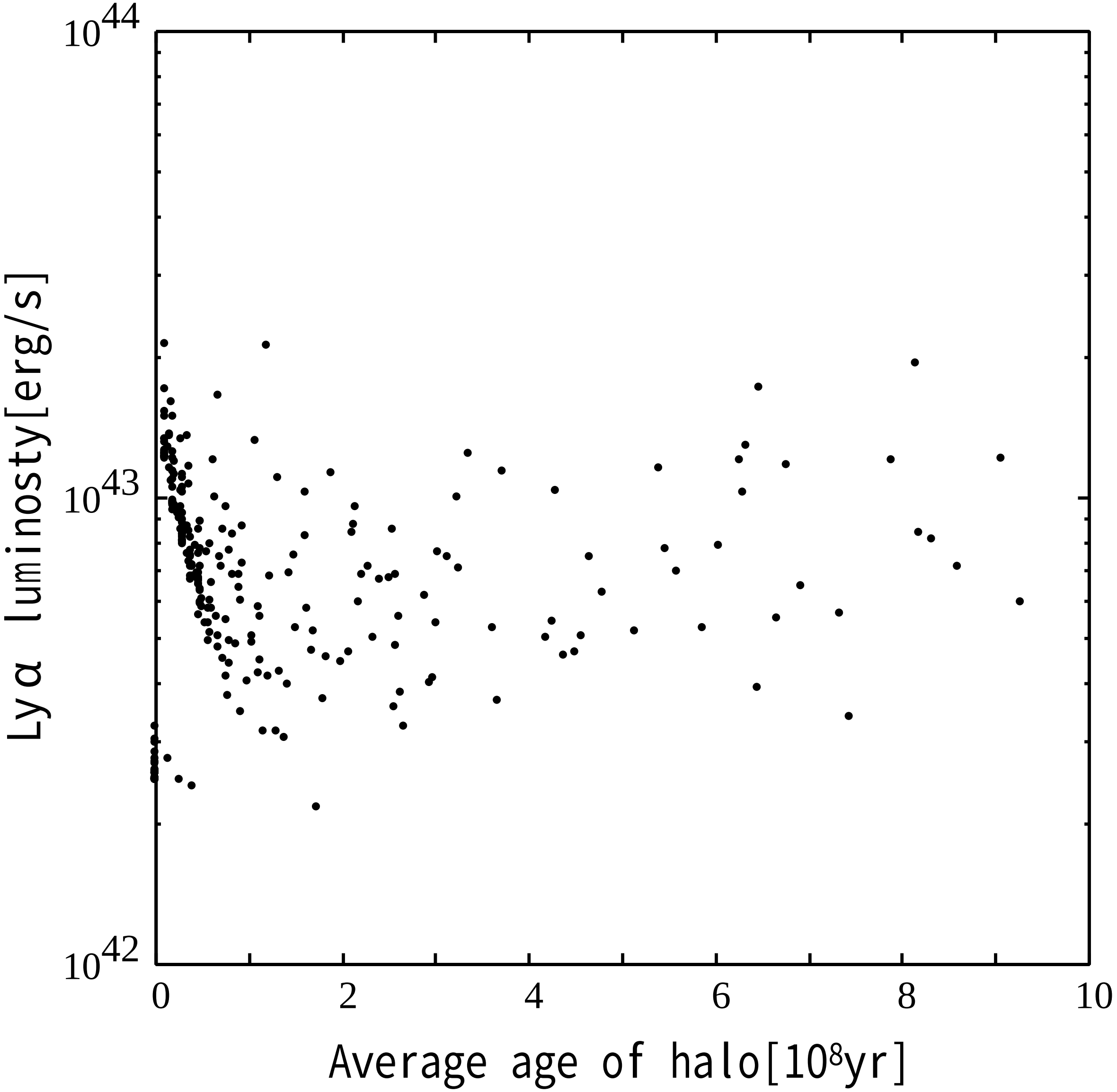
$L_{Ly\alpha} > 1.4 \times 10^{42}$ [erg/s]
$EW_{Ly\alpha} > 30$ Å

Correlation function of simulated LAEs

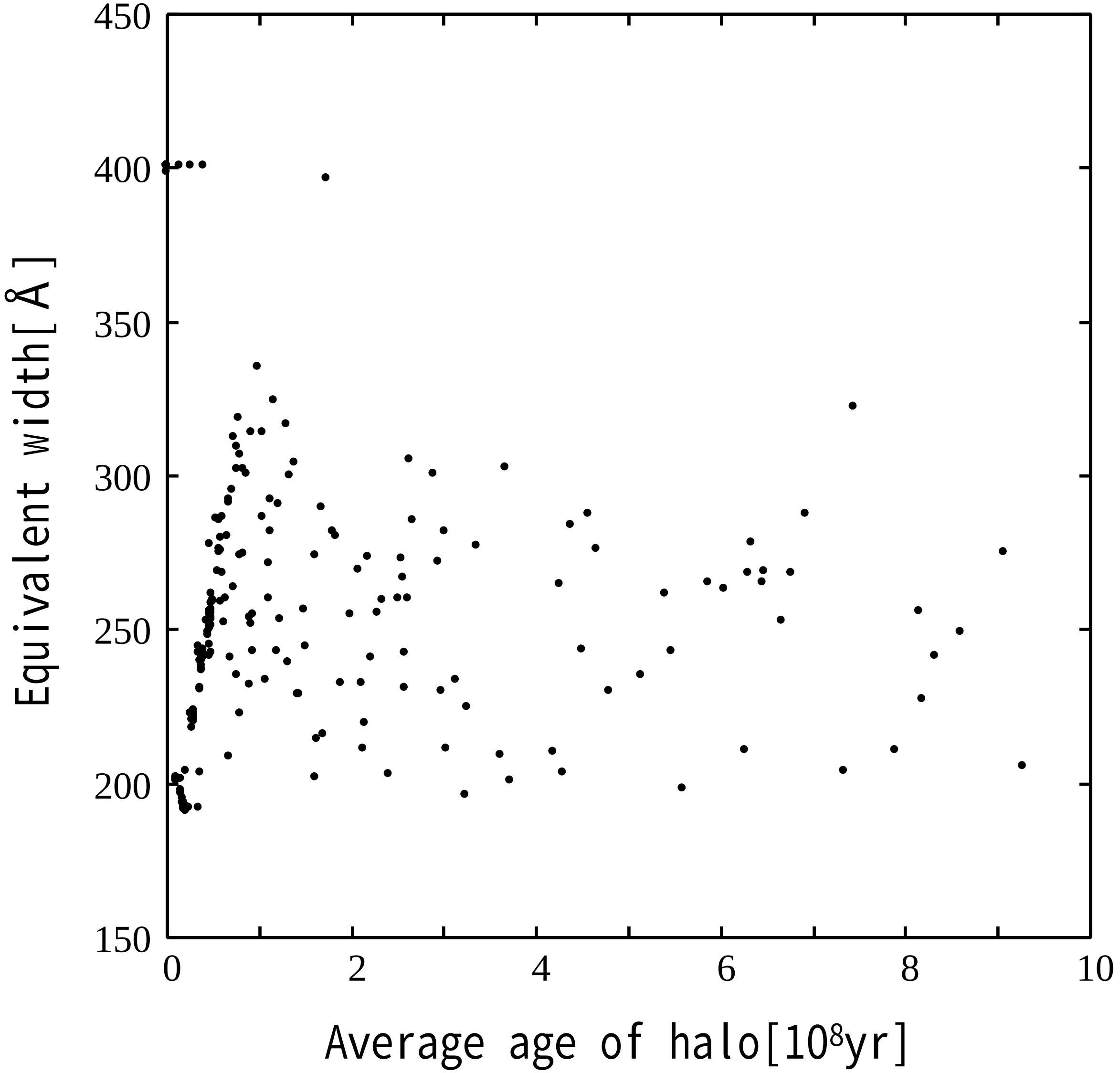




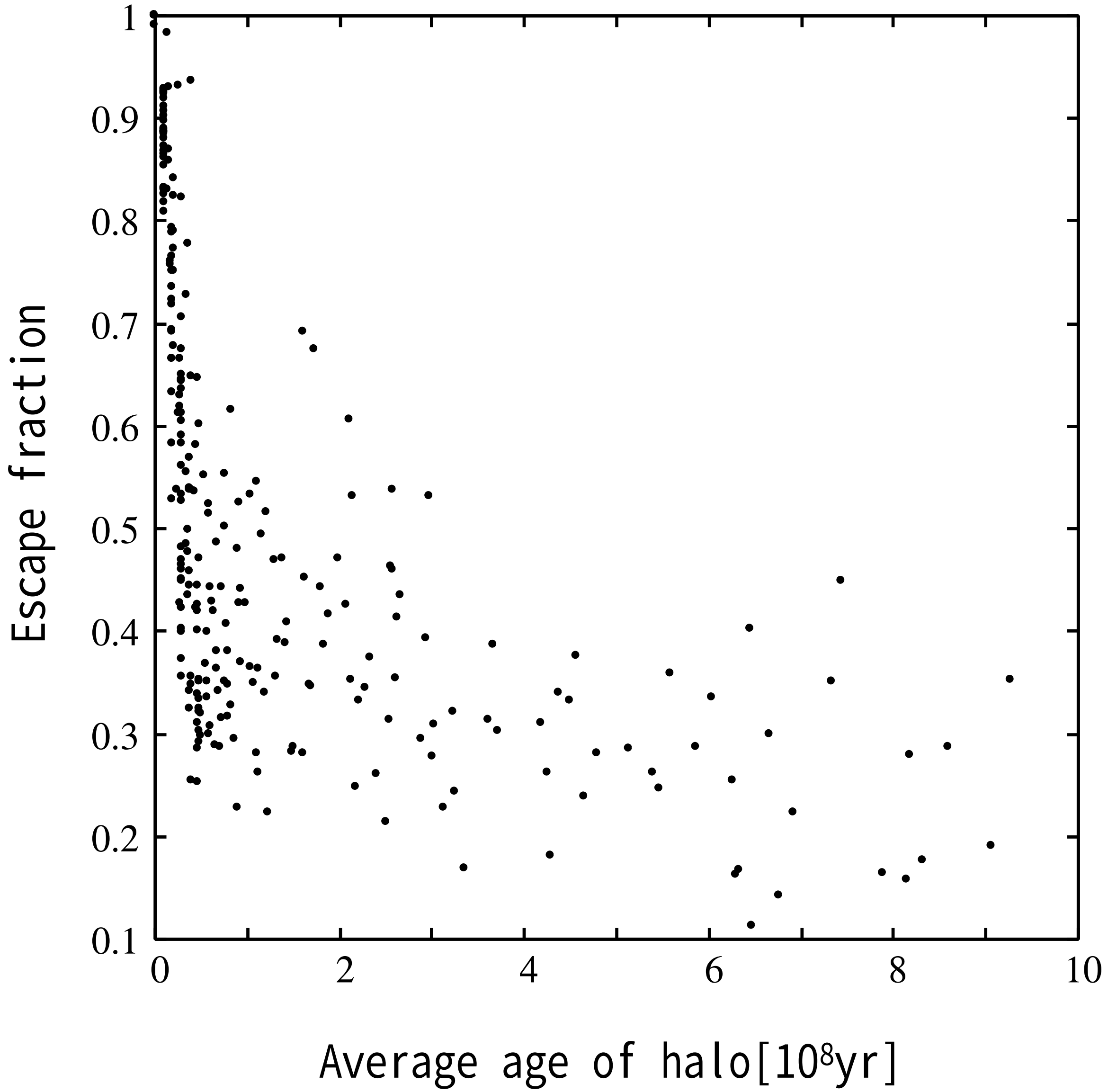
Lyα luminosity against halo age



EW of Lyα against halo age

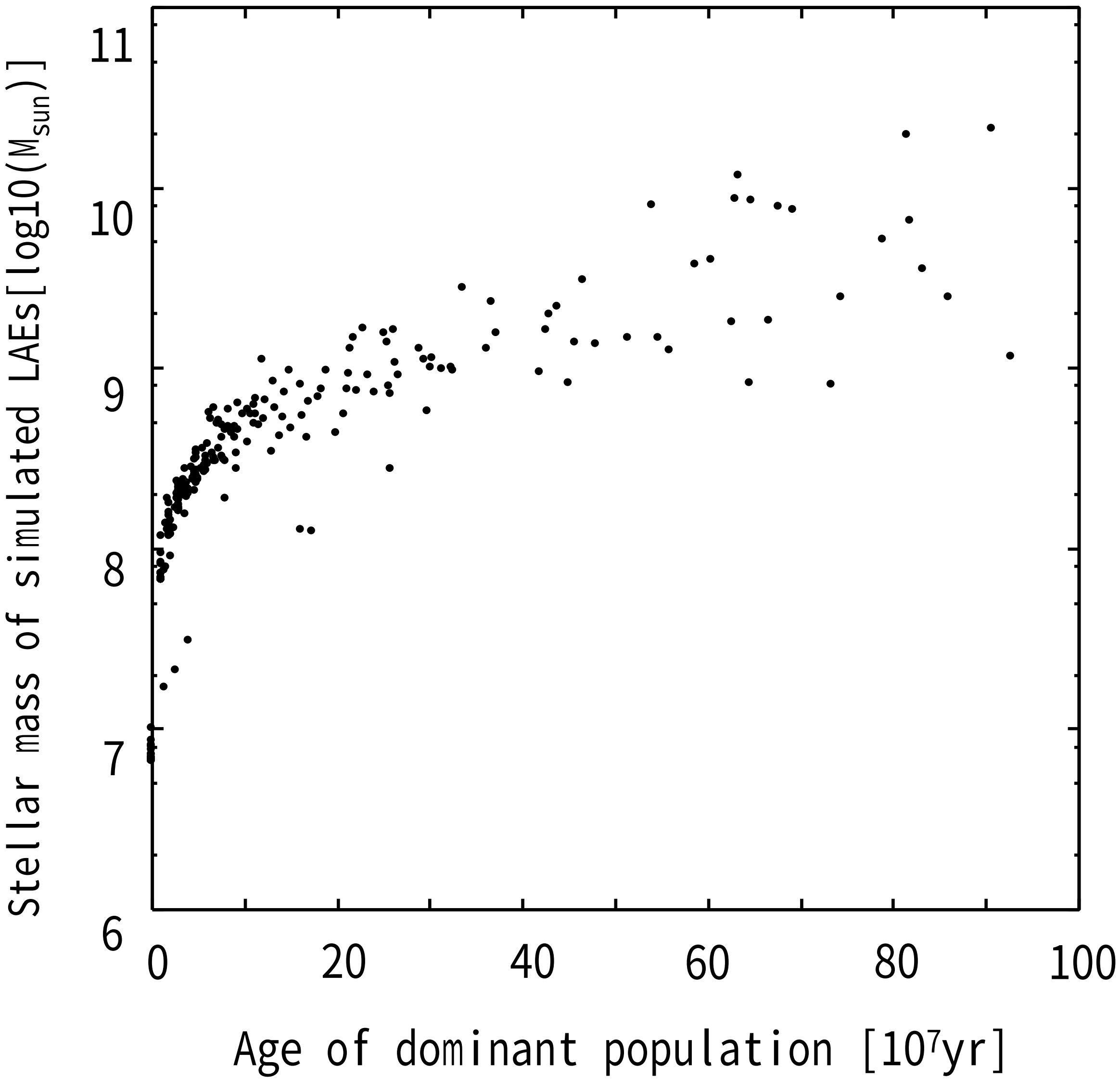


Escape fraction of Lyα luminosity

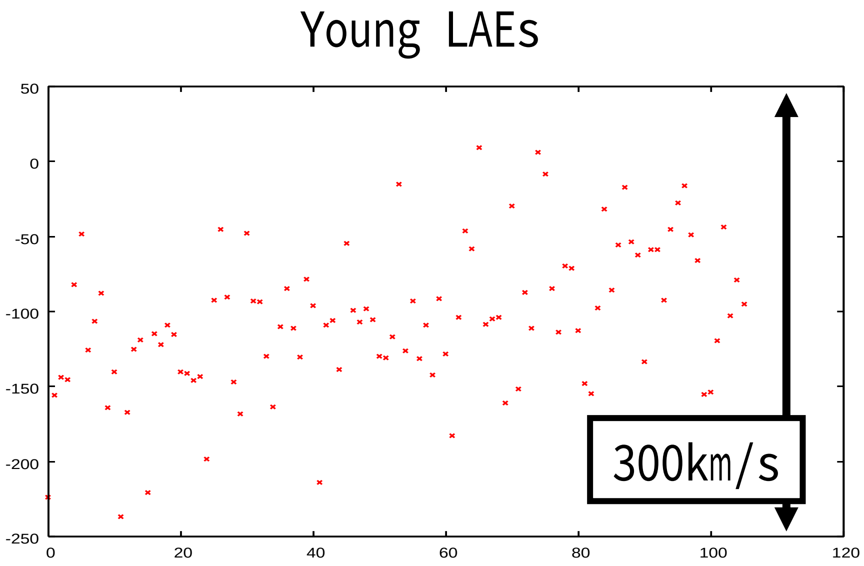


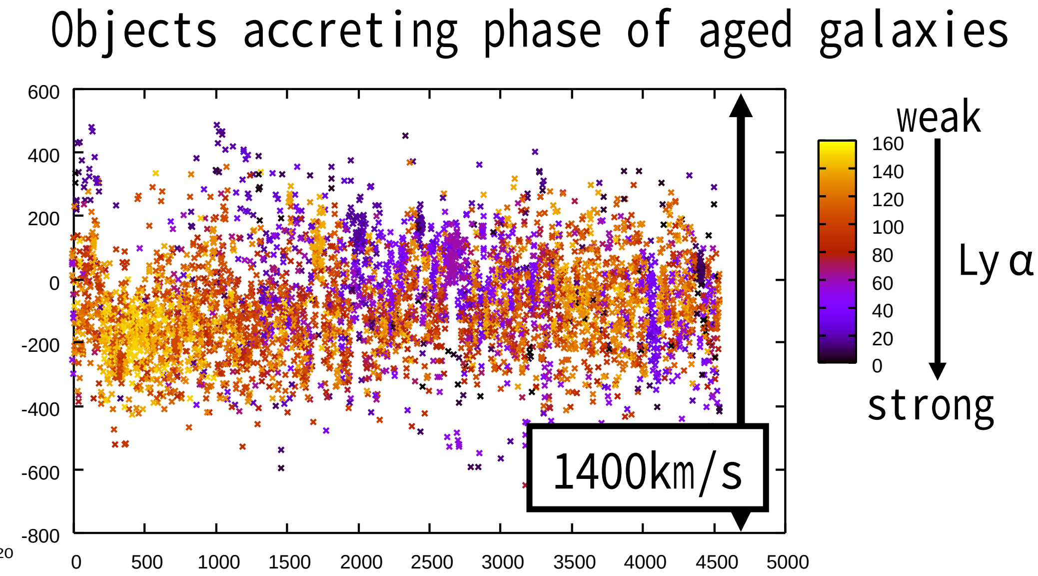
Stellar mass of simulated LAEs

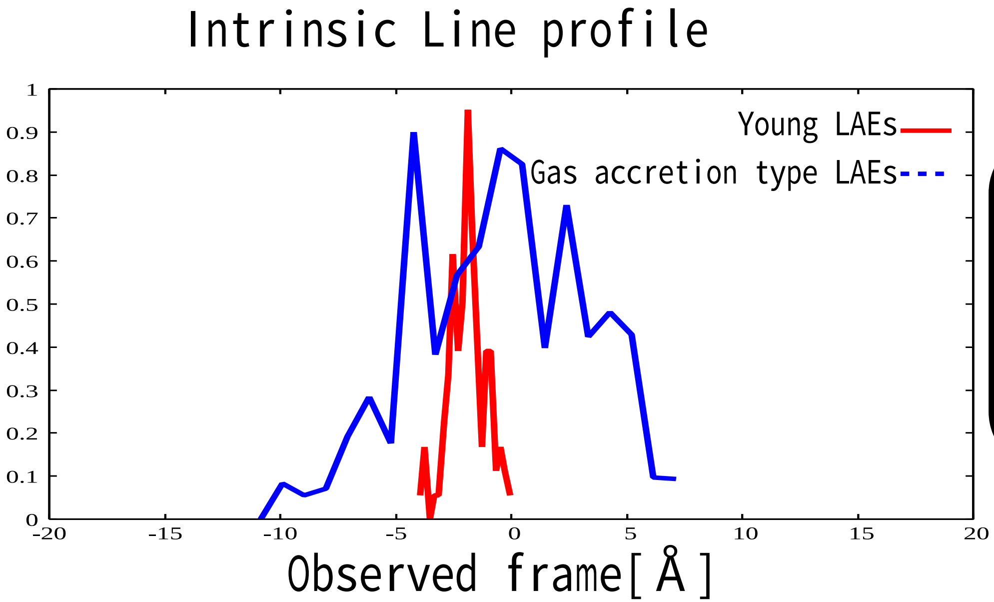
stellar mass of simulated LAEs against age of each halo



Line width of each type of LAEs







Latter type LAEs
may explain
observed LAEs
with large line width.