The Subaru Lyα Blob Survey:
Morphology-Density Relation of Lyα Blobs at z=3?

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- **Lyα blobs (LABs) are ideal laboratories to study large-scale gas circulation processes between galaxies and the surrounding IGM during the peak epoch of galaxy formation.**
- **We obtained Lyα imaging at z=3.1 in wide range of environment from blank field to protocluster.**
- **We construct a sample of 14 LAB candidates with major-axis diameters larger than 100 kpc.**
- **The giant LAB sample shows a "morphology-density relation"**
  - **Filamentary LABs tend to reside in lower galaxy density regions**
  - **Circular LABs tend to reside in higher galaxy density regions**
- **One possible interpretation is:**
  - **Filamentary LABs may remain gas filaments made form cold streams**
  - **Circular LABs may relate to gas outflows from intense starburst/AGN induced by more frequent galaxy interactions in galaxy over-dense regions**
- **Our survey highlights the potential usefulness of giant LABs to investigate the interactions between galaxies and the surrounding IGM as a function of environment at high-redshift.**

Table 1. Summary of narrow-band observations

Field	RA (J2000)	Dec (J2000)	Date (mm/yyyy)	Exposure (hours)	Area (arcmin^2)	FWHM (arcsec)	Depth (cgs)[a]	Depth (ABmag)[b]
SXDS-C	02:18:00.0	−05:00:00	08, 09, 10/2005	5.2	682	1.0	0.81	26.3
SXDS-N	02:18:00.0	−04:35:00	10/2005	4.8	740	1.0	0.94	26.2
SXDS-S	02:18:00.0	−05:25:00	08, 10/2005	4.8	737	1.0	0.82	26.3
GOODS-N	12:37:23.6	+62:11:31	04/2005	10.0	869	1.1	0.69	26.6
SDF	13:24:39.0	+27:29:26	04/2004, 04/2005	7.2	805	1.0	0.67	26.5
SSA22-Sb1	22:17:34.0	+00:17:01	09/2002	7.2	633	1.0	0.92	26.3
SSA22-Sb2	22:16:36.7	+00:36:52	08/2004	5.5	487	1.0	0.96	26.3
SSA22-Sb3	22:18:36.3	+00:36:52	08, 09/2005	5.5	537	1.0	0.89	26.3
SSA22-Sb4	22:19:40.0	+00:17:00	08, 09, 10/2005	5.5	529	1.1	1.15	25.9
SSA22-Sb5	22:15:28.0	+00:17:00	09/2005	5.5	565	1.0	1.06	26.1
SSA22-Sb6	22:14:30.7	+00:33:52	10/2005	5.5	572	1.0	0.92	26.3
SSA22-Sb7	22:17:42.7	+00:56:52	09, 10/2005	5.5	480	1.0	1.02	26.2

[a]The 1-σ surface brightness limit (10^{-18} erg s^{-1} cm^{-2} arcsec^{-2}).
[b]The 5-σ limiting magnitude calculated with 2 arcsec diameter aperture photometry.

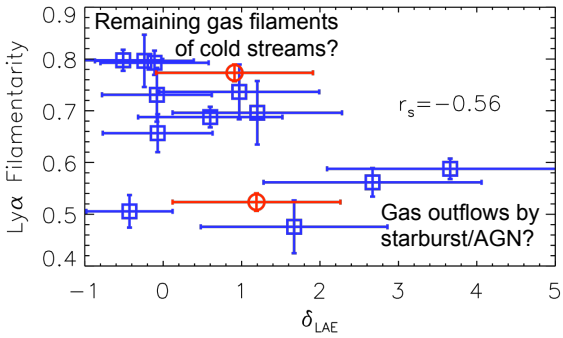

Figure 1. - Filamentarity of the 14 giant LABs as a function of the overdensity of Lyα emitters (LAEs). The blue squares and red circles indicate giant LABs without QSO and with QSO, respectively. The error bars show 1σ uncertainties. The filamentarity of the LABs shows a weak anti-correlation with the overdensity of LAEs. The definition of the filamentarity is

$$F \equiv 1 - ((\text{isophotal area})/(\pi \times (a/2)^2))$$

Where ***a*** is the major-axis diameter of the LABs. For example, a circle has F = 0 and an extremely thin filament has F = 1.

Table 2. Properties of the 14 giant LAB candidates

ID	RA (J2000)	Dec (J2000)	a[a] (kpc)	Area (arcsec^2)	$L_{Ly\alpha}$ (10^{43} erg s^{-1})	F^b	δ_{LAE}	z_{spec}	Note
SSA22-Sb1-LAB1	22:17:25.95	+00:12:37.7	175	181 ± 14	8.1 ± 0.6	0.56	2.7	3.099[c]	8μm[j]/submm[j]
SSA22-Sb6-LAB1	22:13:48.30	+00:31:32.8	166	116 ± 9	5.8 ± 0.4	0.69	0.6	3.094[d]	—
SSA22-Sb1-LAB2	22:17:38.99	+00:13:27.8	157	137 ± 8	6.8 ± 0.3	0.59	3.7	3.091[c]	X-ray[k]/8μm[k]
SSA22-Sb5-LAB1	22:15:33.56	+00:25:16.9	147	59 ± 7	3.8 ± 0.4	0.80	-0.5	—	—
SSA22-Sb3-LAB1	22:17:59.45	+00:30:55.7	126	102 ± 8	20.4 ± 0.3	0.52	1.2	3.099[c]	QSO[c]/Radio[l]
GOODS-N-LAB1	12:35:57.54	+62:10:24.9	124	47 ± 7	5.4 ± 0.5	0.77	0.9	3.075[f]	QSO[f]/X-ray[m]
SSA22-Sb2-LAB1	22:16:58.37	+00:34:32.0	121	60 ± 15	2.0 ± 0.6	0.70	1.2	—	—
SSA22-Sb2-LAB2	22:16:56.40	+00:27:53.3	115	48 ± 11	1.4 ± 0.2	0.73	-0.1	—	—
SSA22-Sb1-LAB5	22:17:11.66	+00:16:44.4	110	43 ± 11	1.3 ± 0.3	0.74	1.0	—	8μm[i]/submm[n]
SSA22-Sb5-LAB2	22:15:30.27	+00:27:43.6	107	53 ± 7	2.1 ± 0.3	0.66	-0.1	—	—
SSA22-Sb6-LAB4	22:14:09.58	+00:40:54.6	107	32 ± 4	2.0 ± 0.2	0.79	-0.1	3.116[d]	—
SSA22-Sb1-LAB3	22:17:59.14	+00:15:28.7	103	75 ± 9	5.2 ± 0.2	0.48	1.7	3.096[g]	X-ray[i]
SXDS-N-LAB1	02:18:21.31	−04:42:33.1	101	68 ± 5	3.3 ± 0.2	0.51	-0.4	—	—
SSA22-Sb1-LAB16	22:17:29.01	+00:07:50.2	101	28 ± 8	0.8 ± 0.2	0.80	-0.2	3.104[h]	X-ray[i]/8μm[i]/submm[n]

[a] Major-axis diameter, [b] Filamentarity ($F = 0$ for a circle, $F = 1$ for a filament, see text for more detail), [c]Steidel et al. (2003), [d]this work, [e]Shen et al. (2007), [f]Barger et al. (2002), [g]Matsuda et al. (2005), [h]Matsuda et al. (2006), [i]Webb et al. (2009), [j]Chapman et al. (2001), [k]Basu-Zych & Scharf (2004), [l]Condon et al. (1998), [m]Alexander et al. (2003), [n]Geach et al. (2005), [o]Geach et al. (2009)

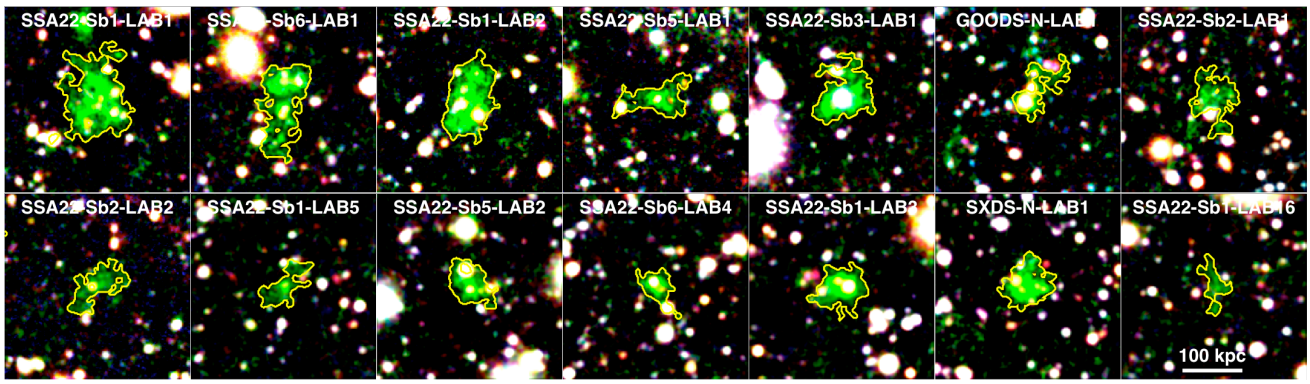

Figure 2. Colour images (B for blue, N B497 for green, V for red) of the 14 giant LABs. The size of the images is 40 × 40 arcsec^2 (300 × 300 kpc^2). The yellow contours indicate isophotal apertures with a threshold of 1.4 × 10^{-18} erg s^{-1} cm^{-2} arcsec^{-2}. The white horizontal bar in the lower right image represents the angular scale of 100 kpc (physical scale) at z = 3.1.

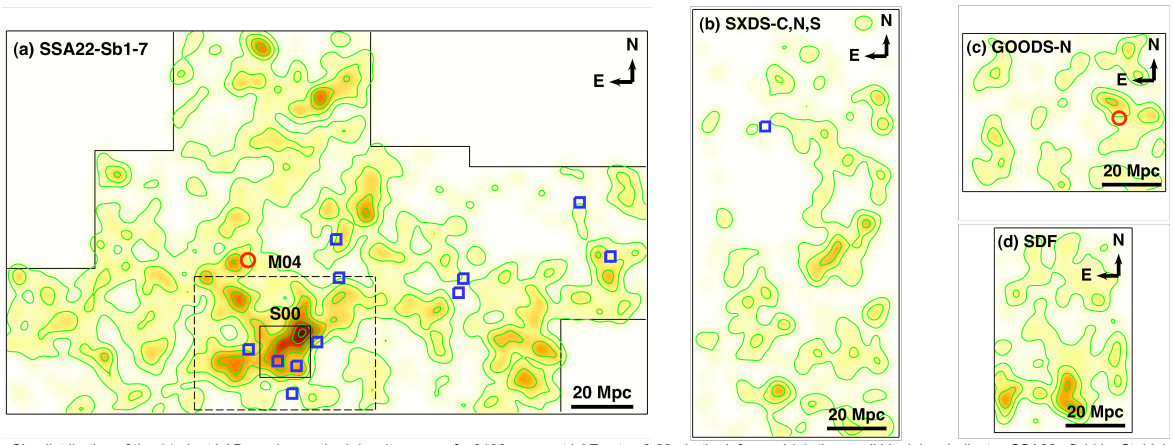

Figure 3. - Sky distribution of the 14 giant LABs and smoothed density maps of ~ 2100 compact LAEs at z=3.09. In the left panel (a), the small black box indicates SSA22a field by Steidel et al. (2000, S00) and the dashed box indicates SSA22-Sb1 by Matsuda et al. (2004, M04). The thick bars show the angular scale of 20 comoving Mpc at z = 3.1. The blue squares and red circles indicate the giant LABs without QSO and with QSO, respectively. The contours represent LAE overdensity, δ=0, 1, 2, 3, 4, 5, and 6.