The nature of radio-quiet Lyα blobs

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Outline

1. Subaru search for radio-quiet Lya blobs in and around the SSA22 proto-cluster at z=3.1

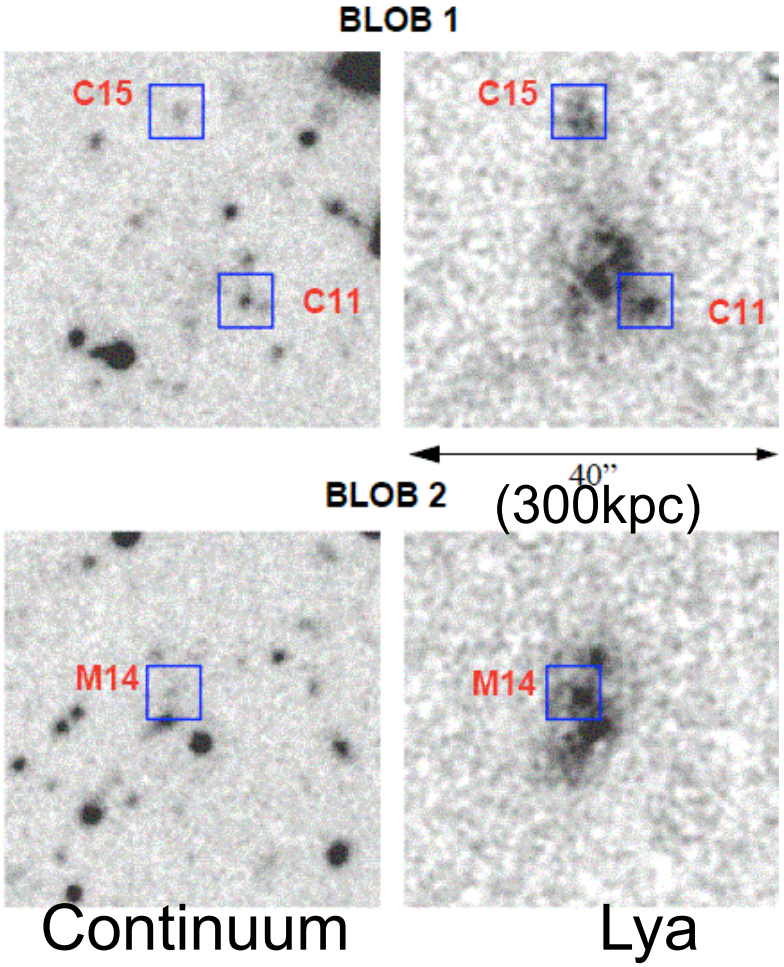
2. High resolution submm observations of a submm bright, radio-quiet Lya blob

Radio-quiet Lya blobs

(e.g. Keel et al. 1999, Steidel et al. 2000, Francis et al. 2001, Palunas et al. 2004, Matsuda et al. 2004, Dey et al. 2005, Nilsson et al. 2006, Smith & Jarvis 2007, Bunker's talk, Dijikstra's talk)

Similar extended Lya halos are often seen around high-z radio galaxies (e.g. McCarthey et al. 1987, van Ojik et al. 1997, Villar-Martin's talk, Humphrey's talks)

Relation between radio-quiet Lya blobs and Lya halos around high-z radio galaxies is unclear!!



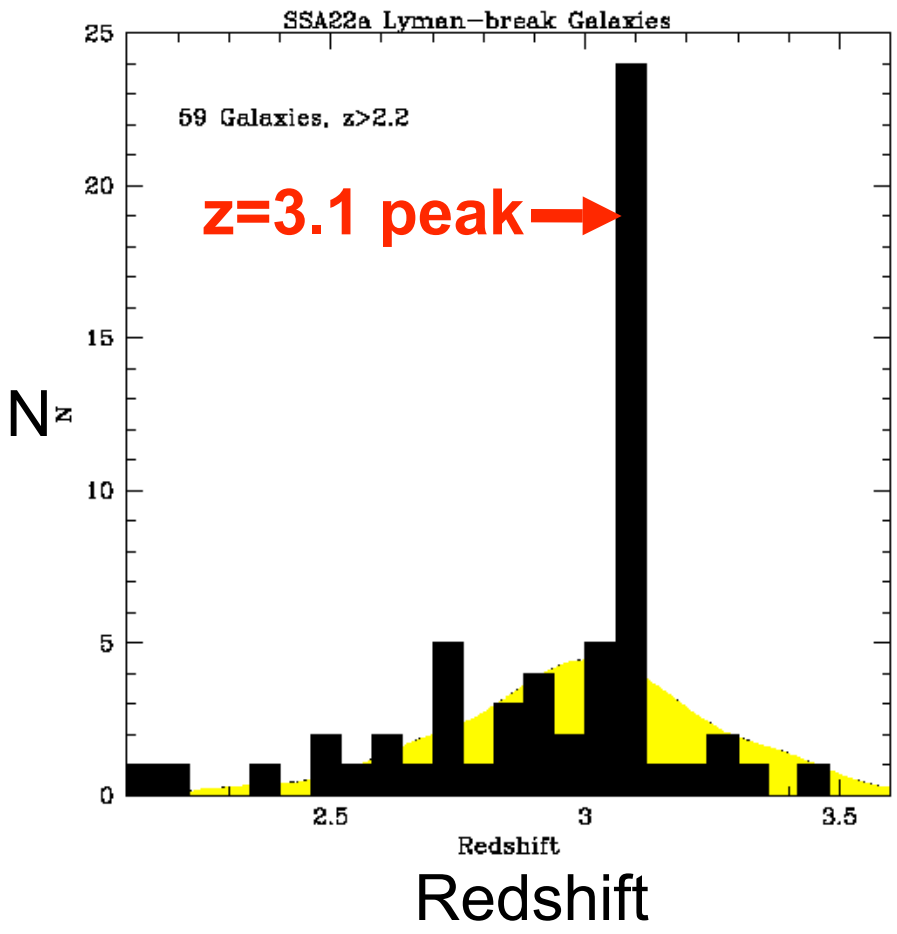
Steidel et al. (2000)

1. Subaru search for radio-quiet Lya blobs in and around the SSA22 proto-cluster at z=3.1

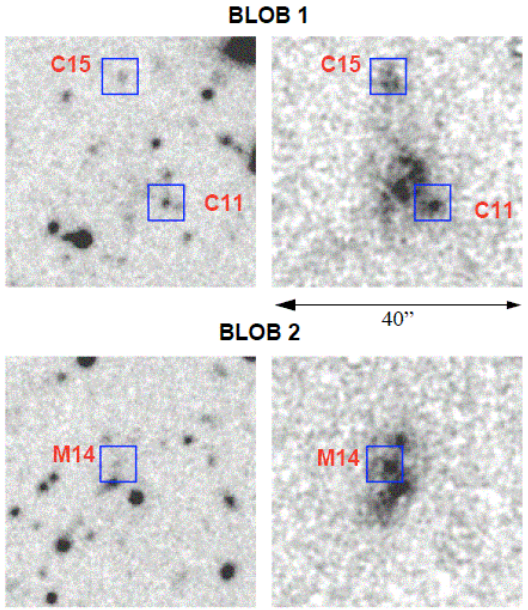
The SSA22 proto-cluster at z=3.1

(Steidel et al. 1998, 2000)

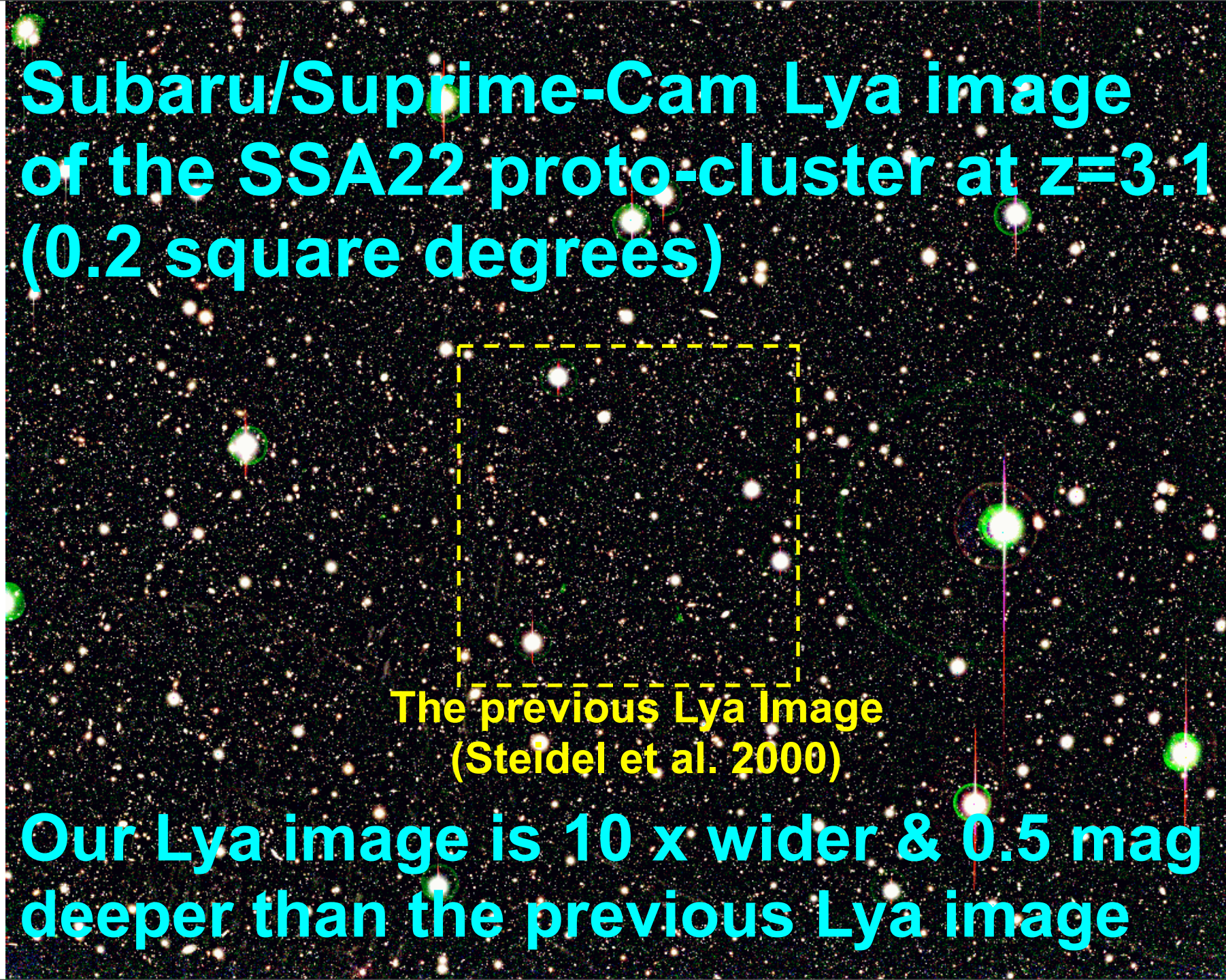
Redshift distribution of Lyman-break galaxies



2 giant radio-quiet Lya blobs



Are there other Lya blobs in and around the proto-cluster?


Subaru/Suprime-Cam Lya image
of the SSA22 proto-cluster at z=3.1
(0.2 square degrees)
The previous Lya Image
(Steidel et al. 2000)
Our Lya image is 10 x wider & 0.5 mag
deeper than the previous Lya image

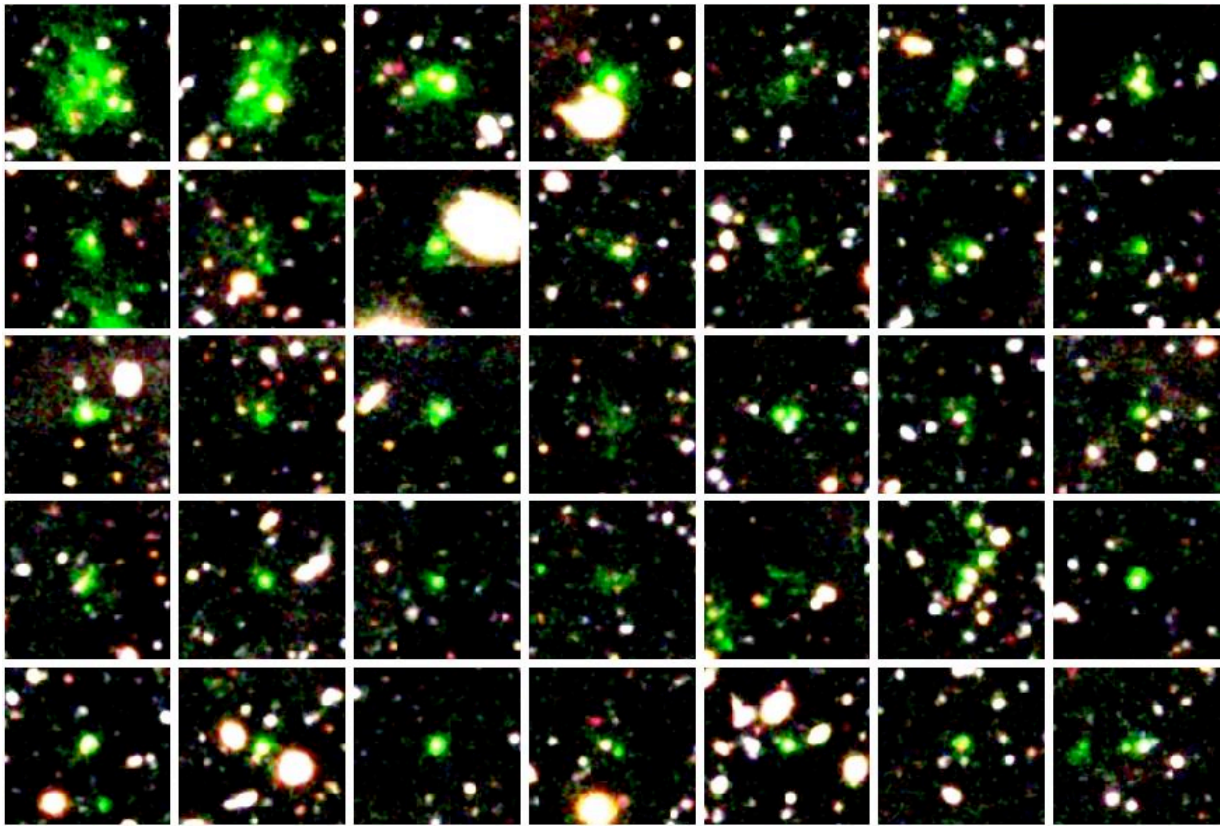
33 (+2) radio-quiet Lya blobs

(Matsuda et al. 2004)

The first large sample of radio-quiet Lyman alpha blobs

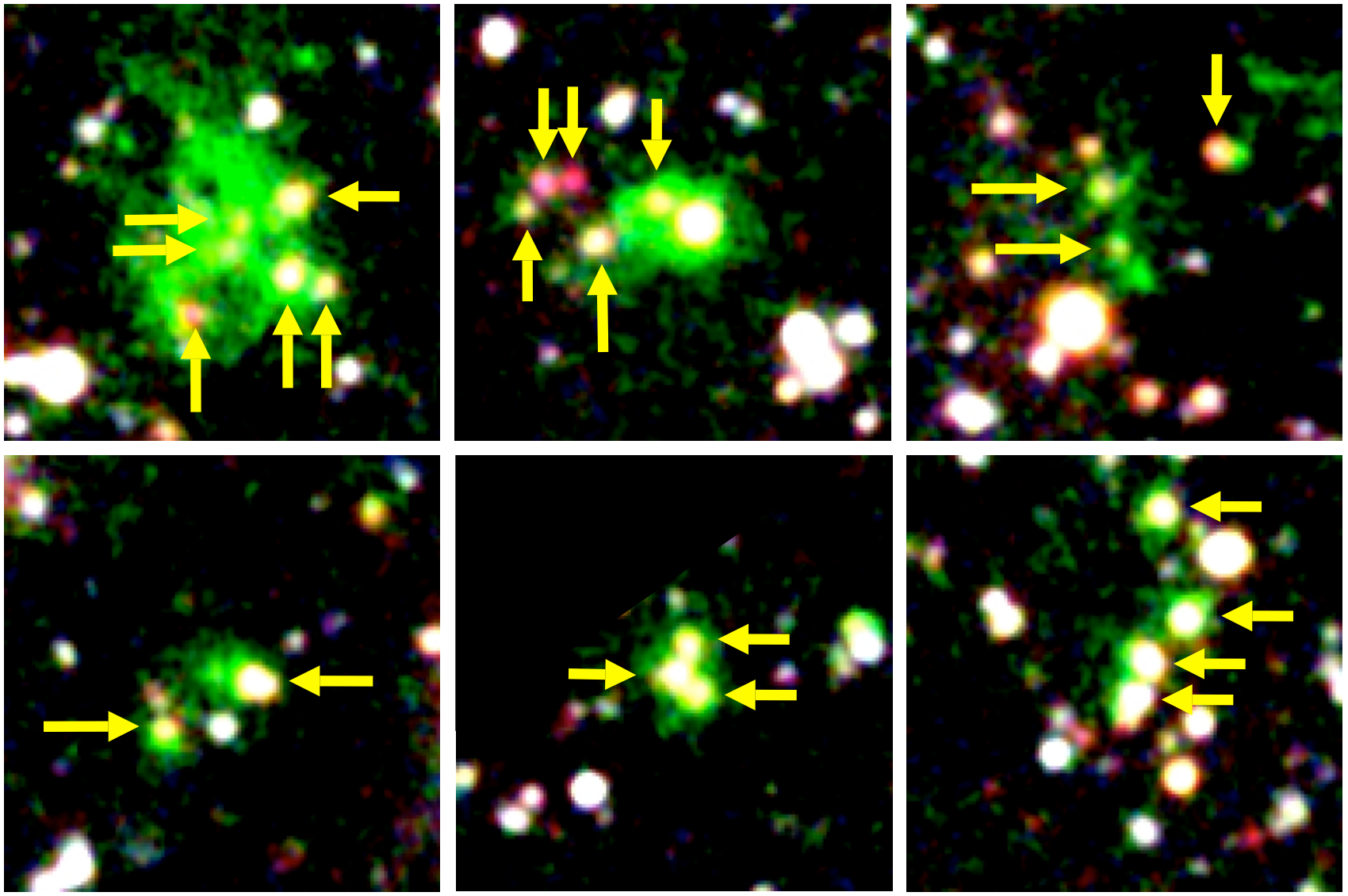
Selection criteria: Lya luminosity > 6 x 10^{42} ergs/s
Lya equivalent width > 80A, Lya size > 30 kpc

25”

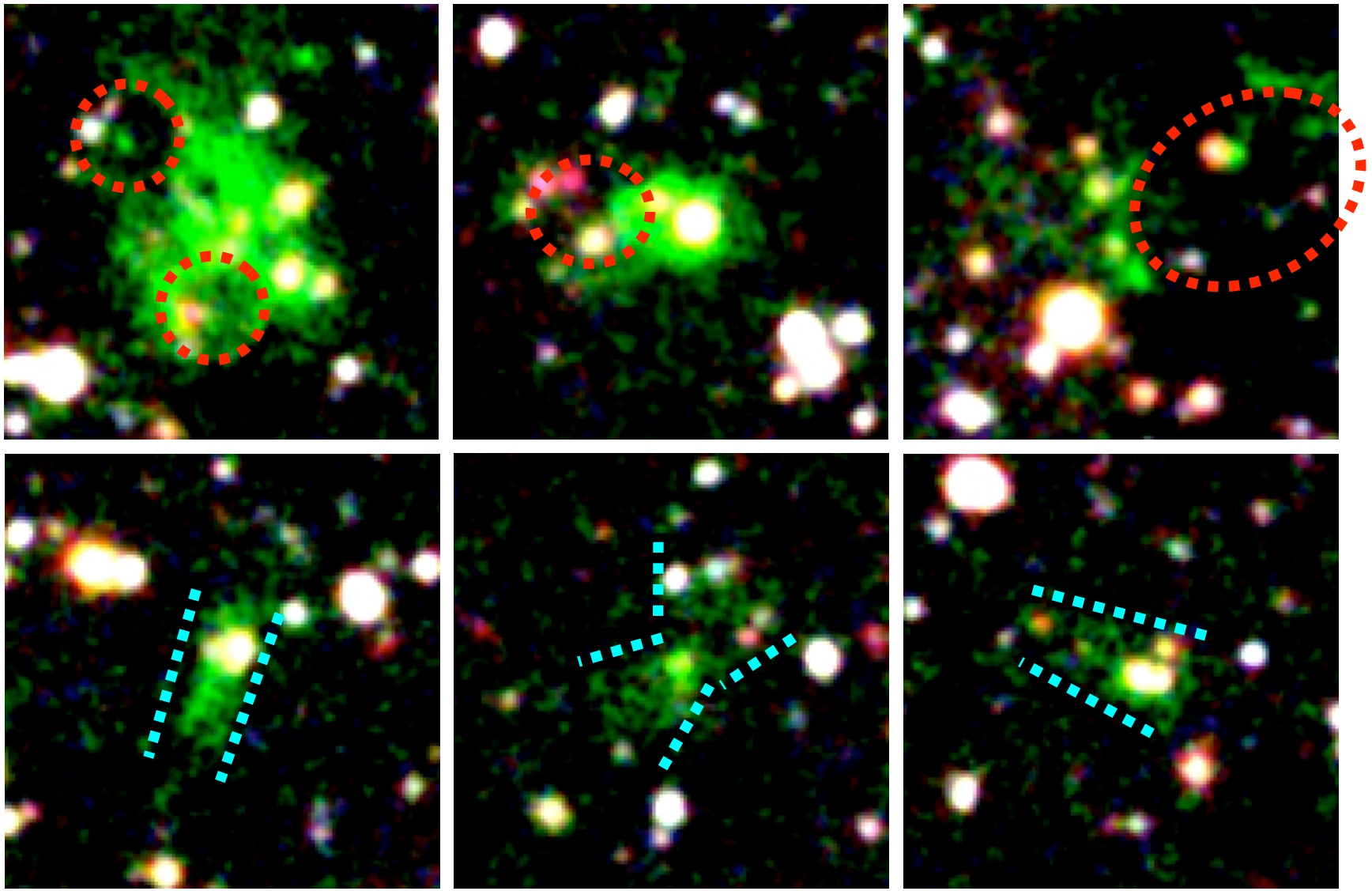


All the objects are radio-quiet f(1.4GHz)<1mJy

Multiple UV continuum sources?



Bubble-like / conical structures?



Sky map of radio-quiet Lya blobs

(Matsuda et al. 2004)

~90% of the blobs are located in the overdense region

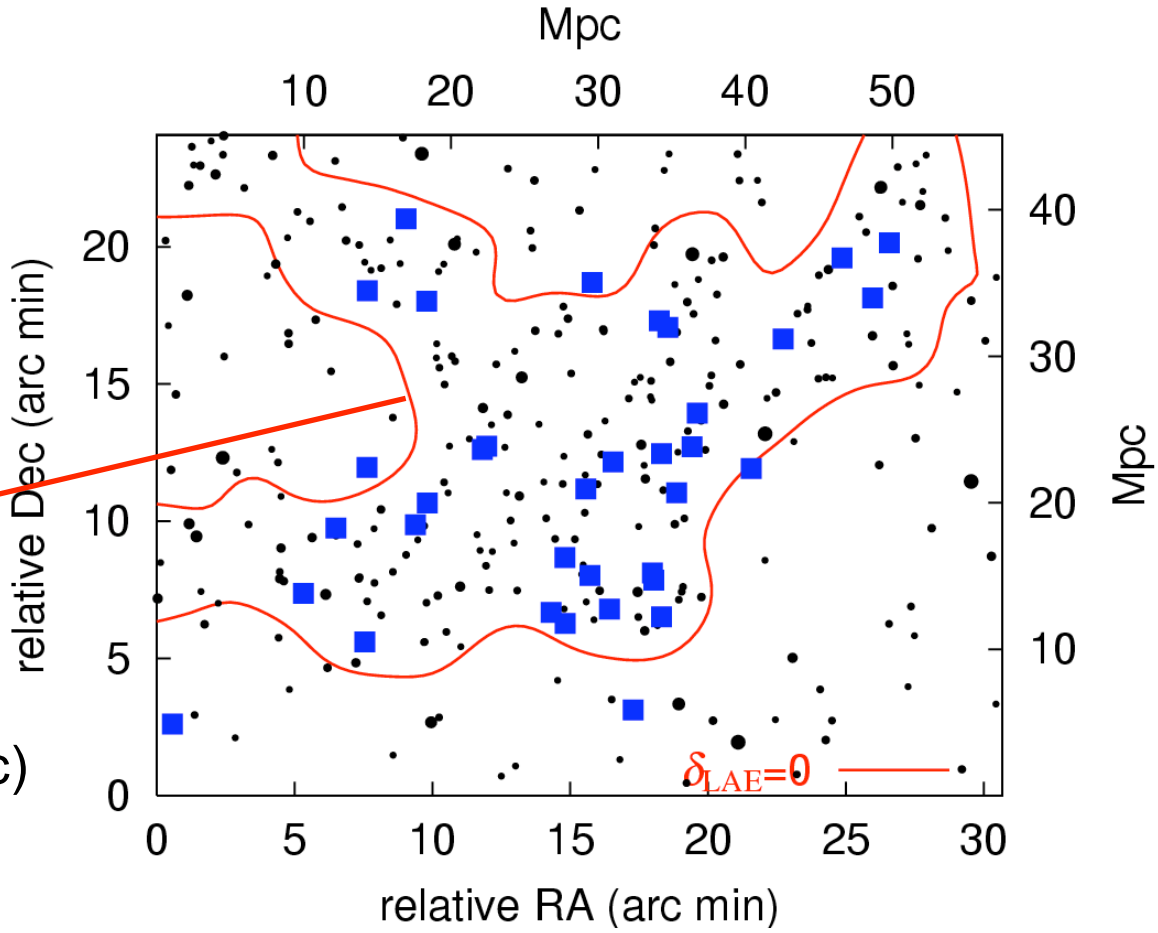
→ **Radio-quiet Lya blobs are characteristic phenomena in overdense environments!!**

■ radio-quiet Lya blobs

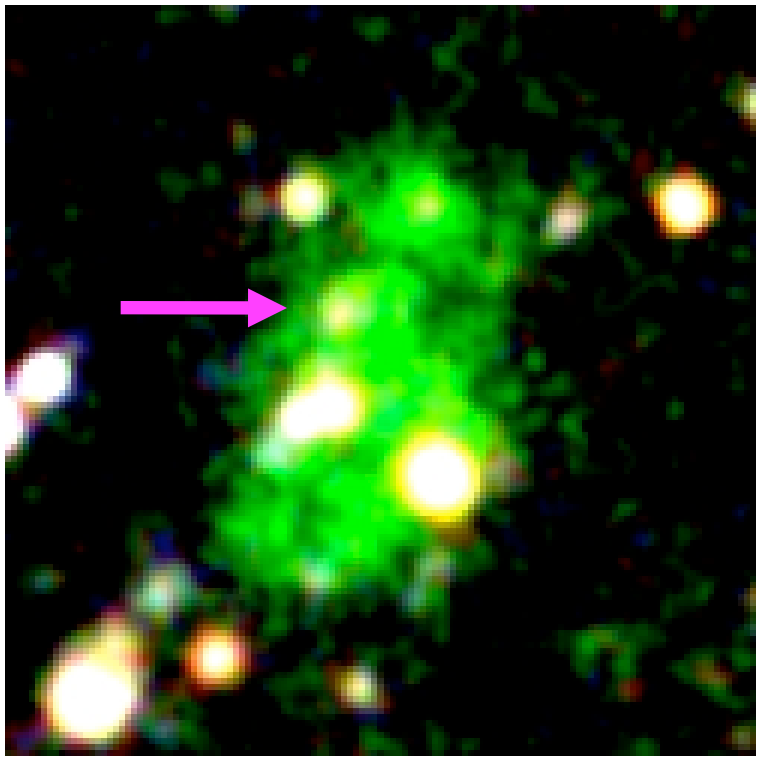
● compact star-forming (Lya emitting) galaxies

overdense region of compact star-forming galaxies

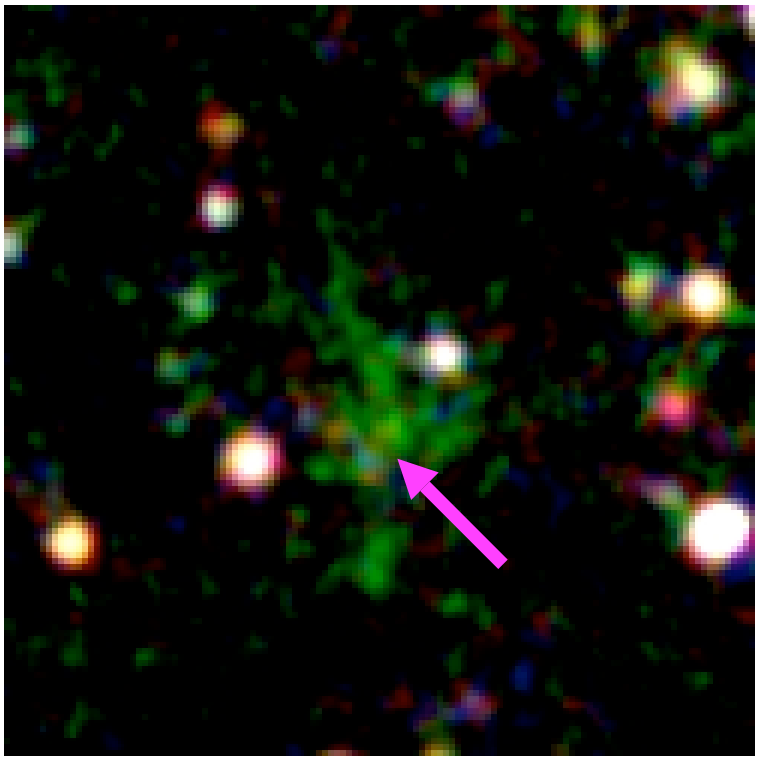
redshift range
z=3.05-3.12 (width~60Mpc)



X-ray detected Lya blobs (2/35)



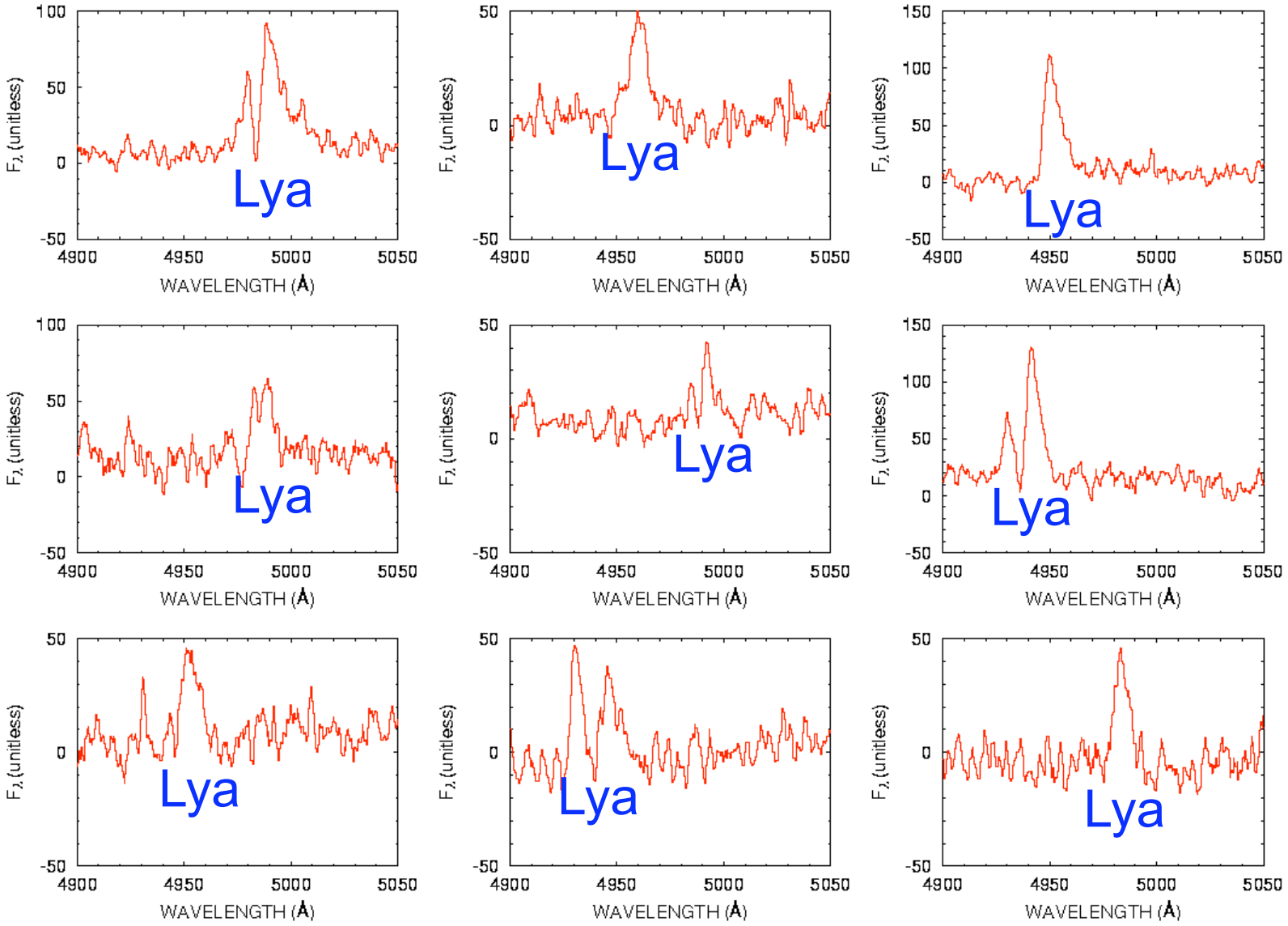
Detected in 78 ks Chandra data
0.3-8 keV flux ~ 3 x 10^{-15} ergs/s/cm^2
Unabsorbed X-ray luminosity
~ 10^{44} ergs/s
(Basu-Zych & Scharf 2004)



Detected in 400 ks XMM data
(O. Almaini, private communication)

Stacking analysis is required for undetected objects!!

Keck/DEIMOS Spectroscopy of radio-quiet Lya blobs (Matsuda et al. 2006)



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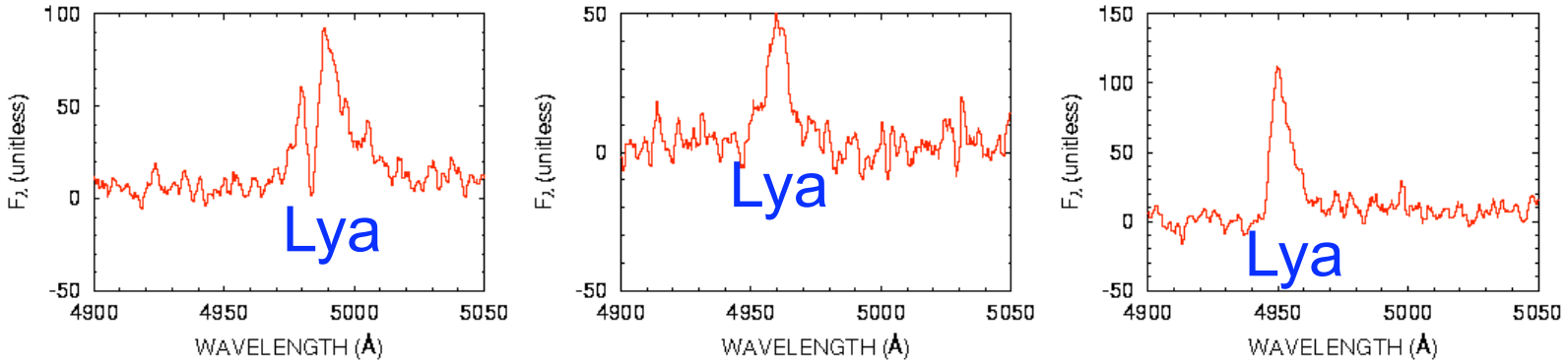
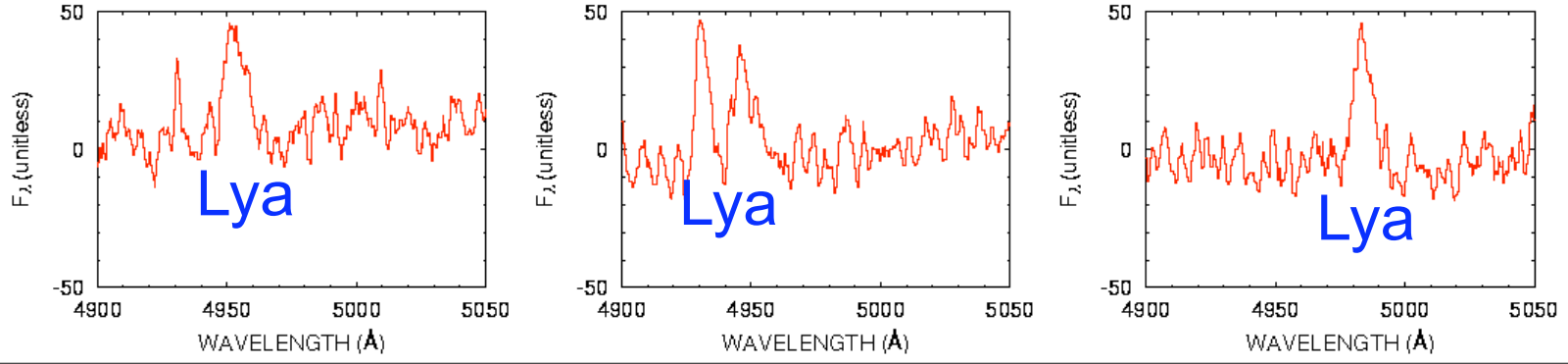


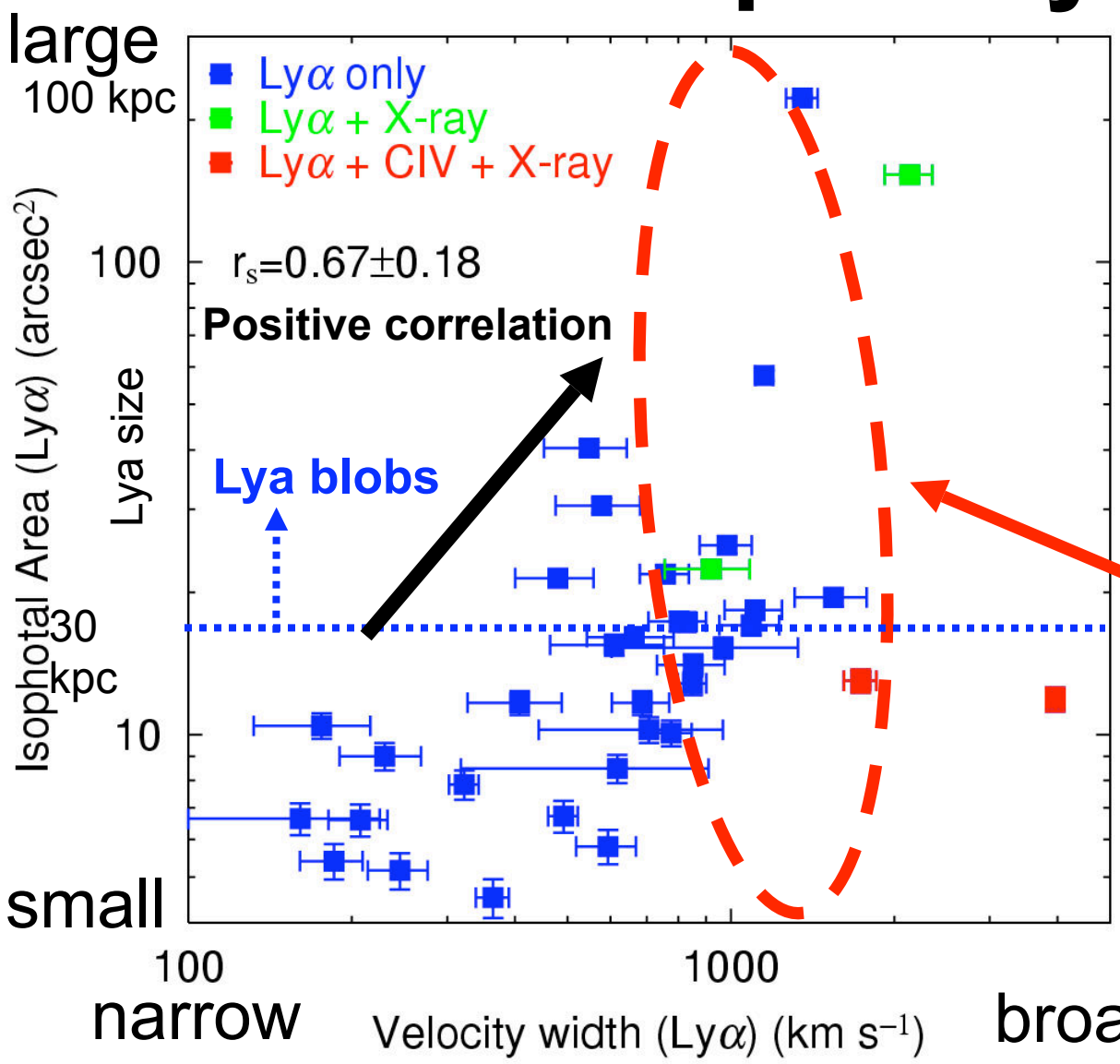
Lya velocity width FWHM ~ 500-1700km/s

No CIV line is detected



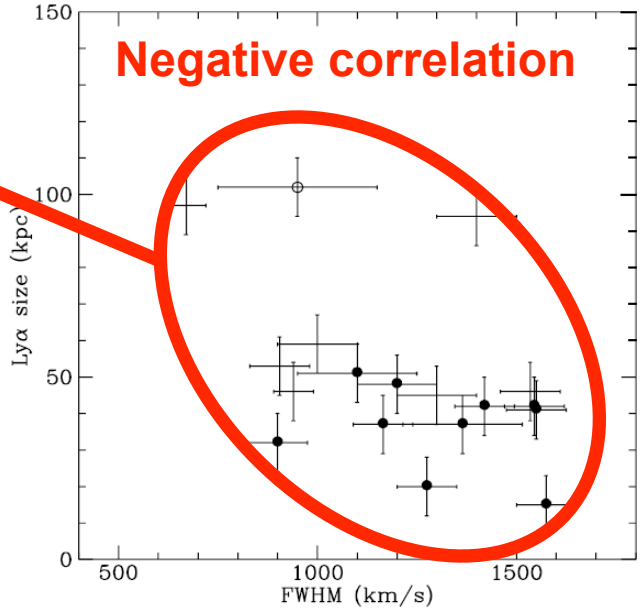
Lya size and Lya velocity width of radio-quiet Lyα blobs

(Matsuda et al. 2006)



Lya halos around high-z radio galaxies

(van Ojik et al. 1997)



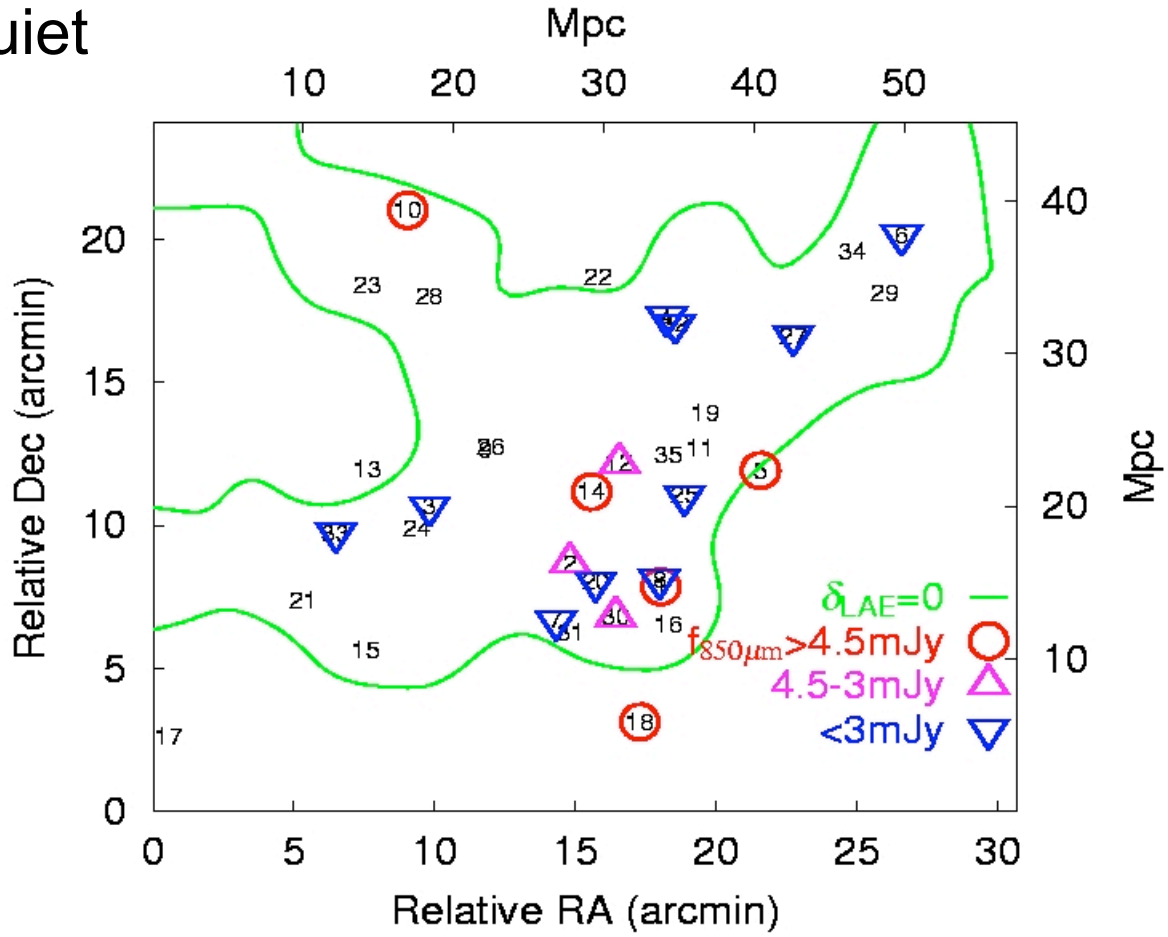
Submm photometry of radio-quiet Lya blobs

(Geach, Matsuda, Smail et al. 2005)

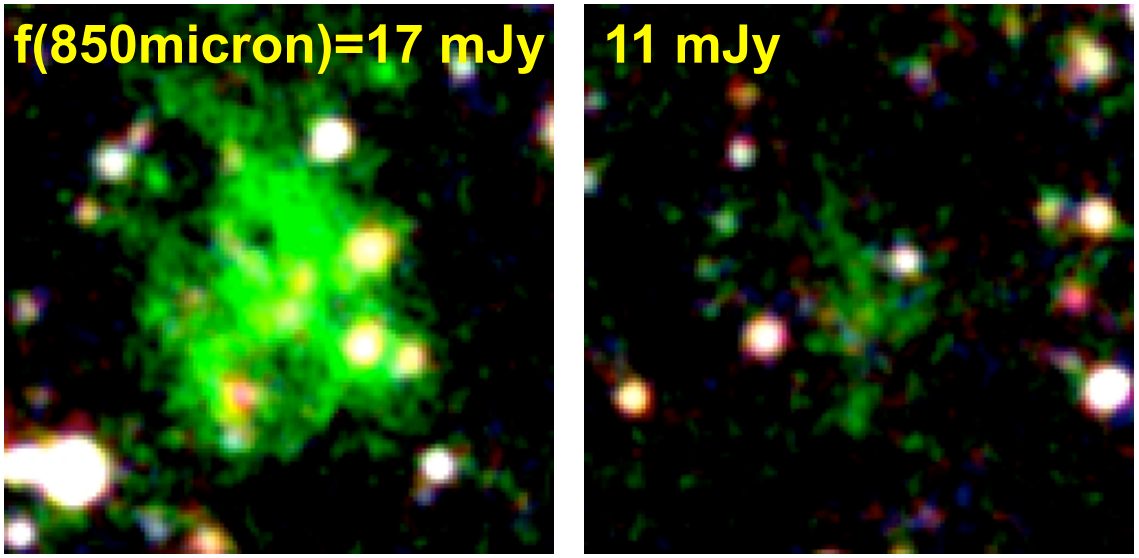
~30% (5/18) of radio-quiet Lya blobs are detected (≥5 mJy) at 850um

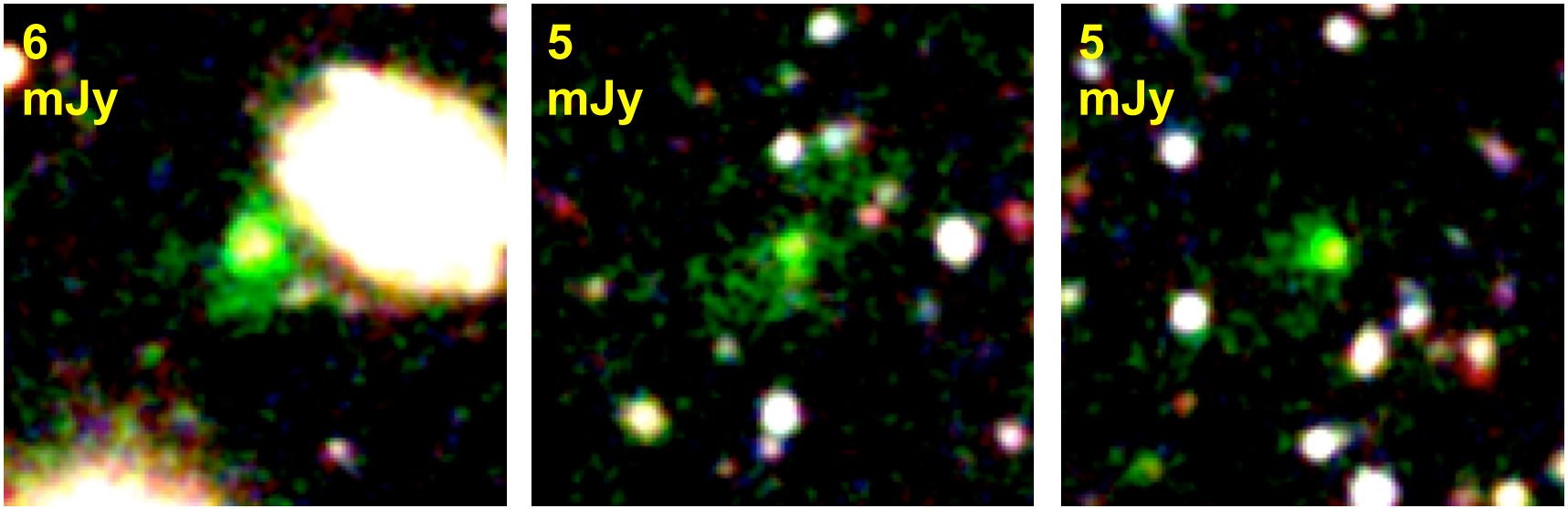
>75% detection for radio galaxies at z>2.5 (Archibald et al. 2001)

The average (stacked) 850um flux is ~3 mJy (L(FIR)~5x10^{12} Lsun)

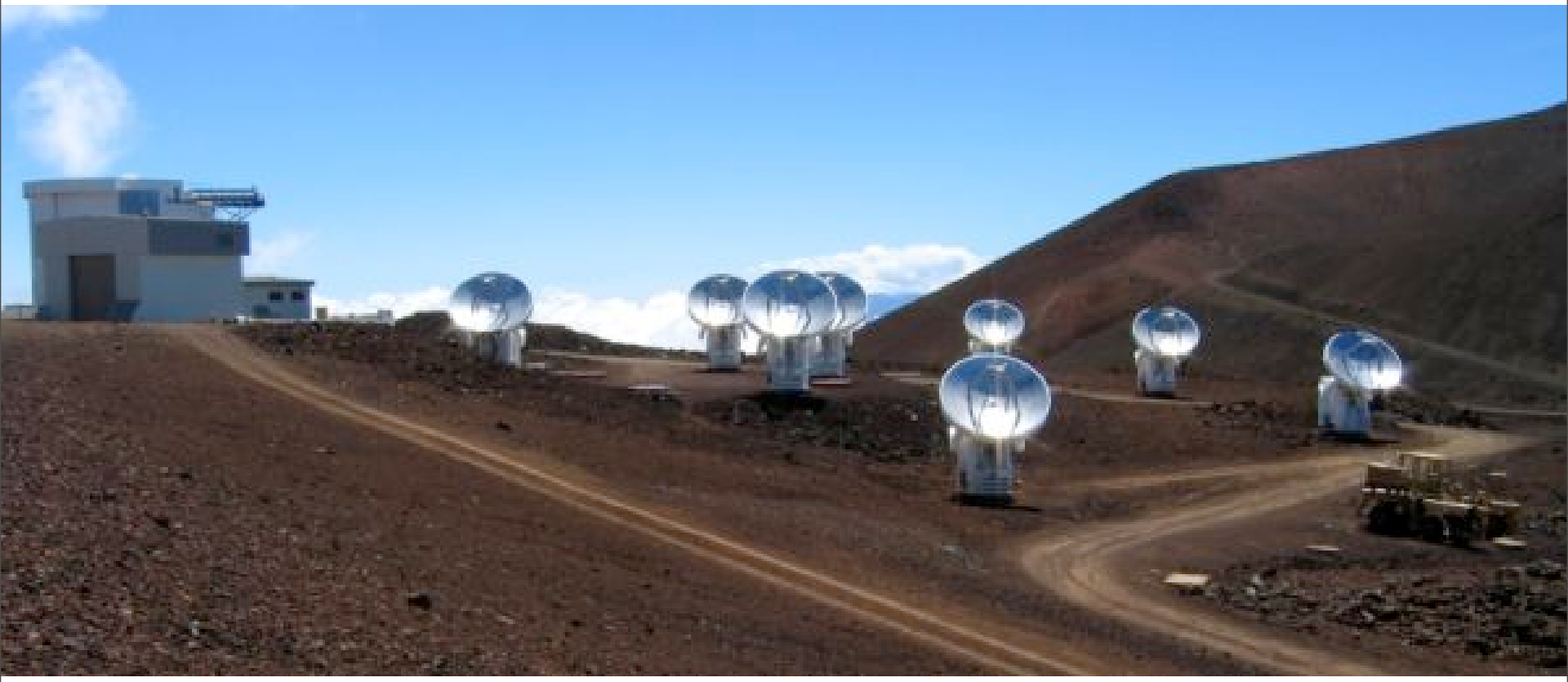


Submm bright Lya blobs





2. High resolution submm observations of a submm bright, radio-quiet Lya blob

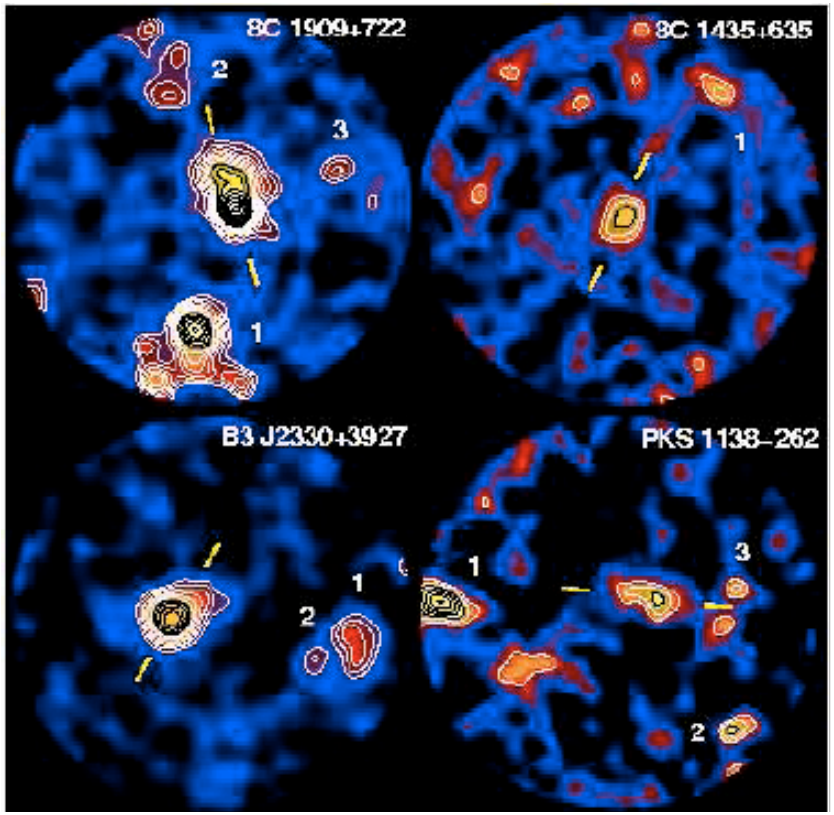


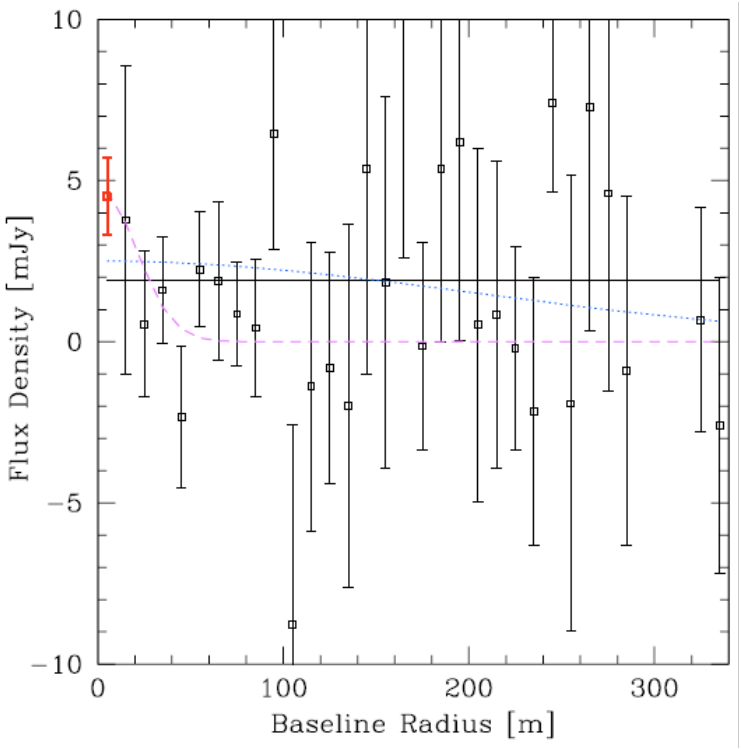
Submillimeter Array

High-z radio galaxies have spatially extended dust emission!!

Submm/mm source size of ~30-250 kpc

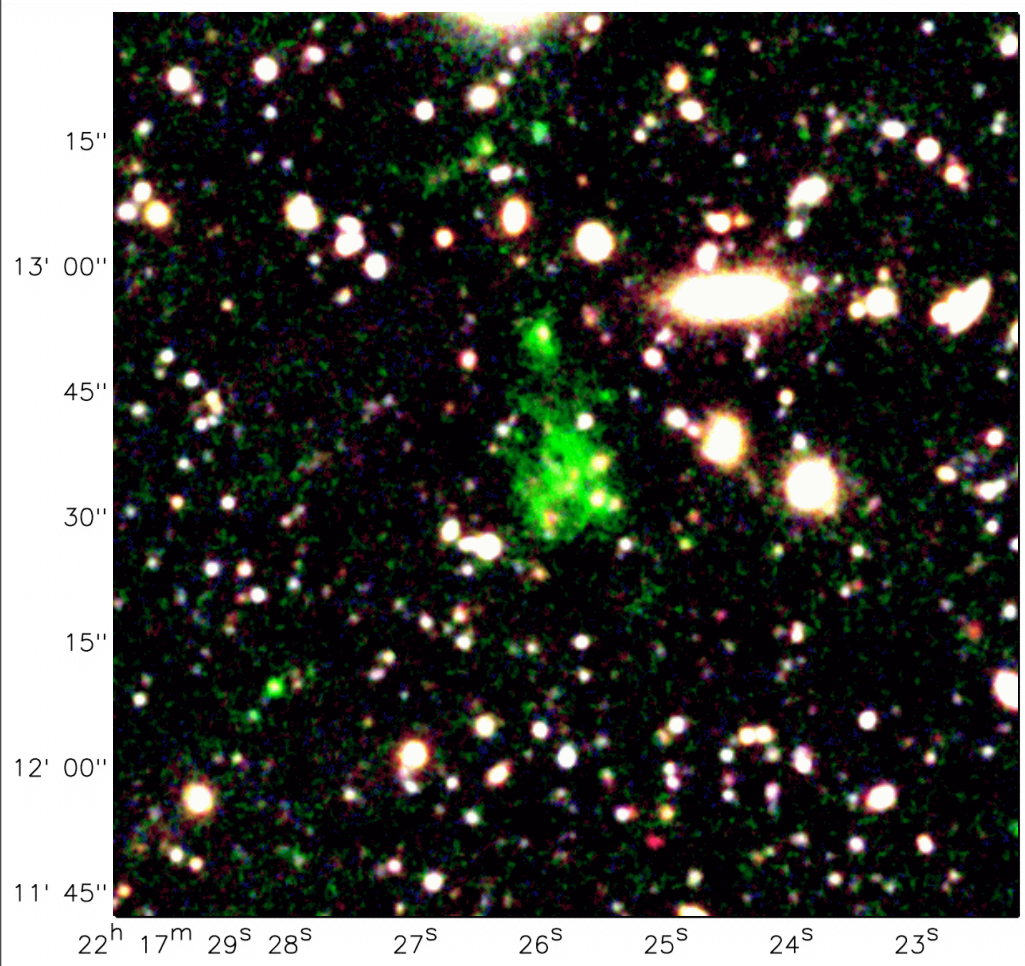
(Papadopoulos et al. 2000, Stevens et al. 2003, De Breuck et al. 2003)





SSA22 Lya blob1

- A submm bright, radio-quiet Lya blob



Lya size ~ 150 kpc
Lya luminosity
~ 10^{44} ergs/s
850um flux density ~17mJy
(Chapman et al. 2001)

The submm source is ***unresolved*** with SCUBA 15" beam (~110kpc).

But we don't know whether the submm source is **compact (<10 kpc)** or **extended (>10 kpc)**.

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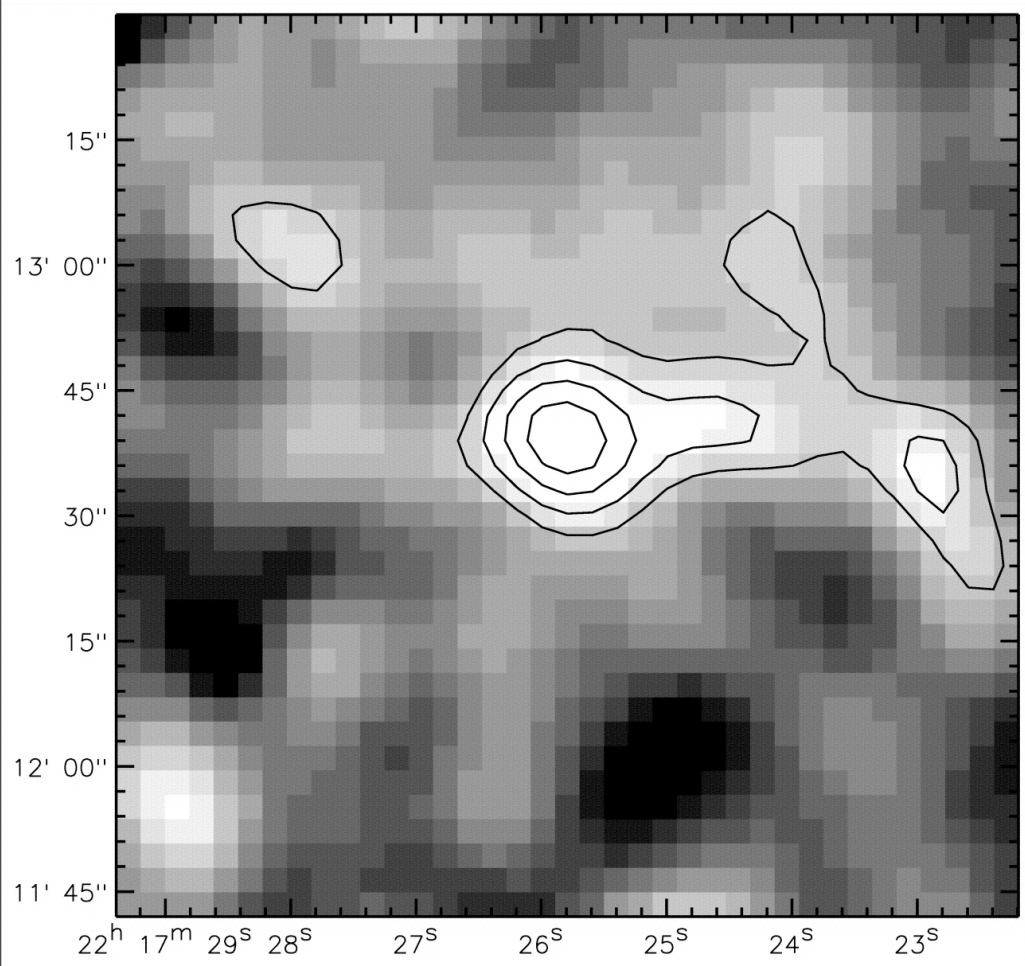

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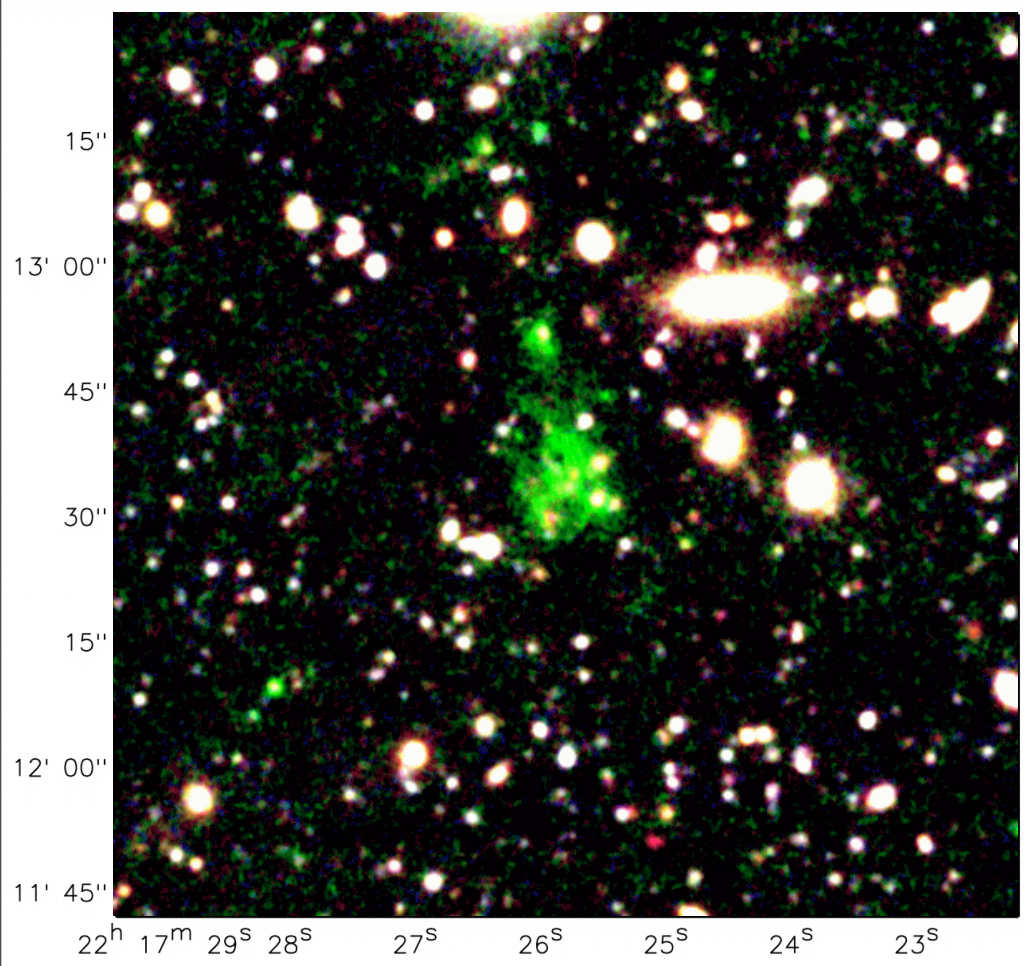

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SMA 880um observation

(Matsuda et al. ApJ, submitted)

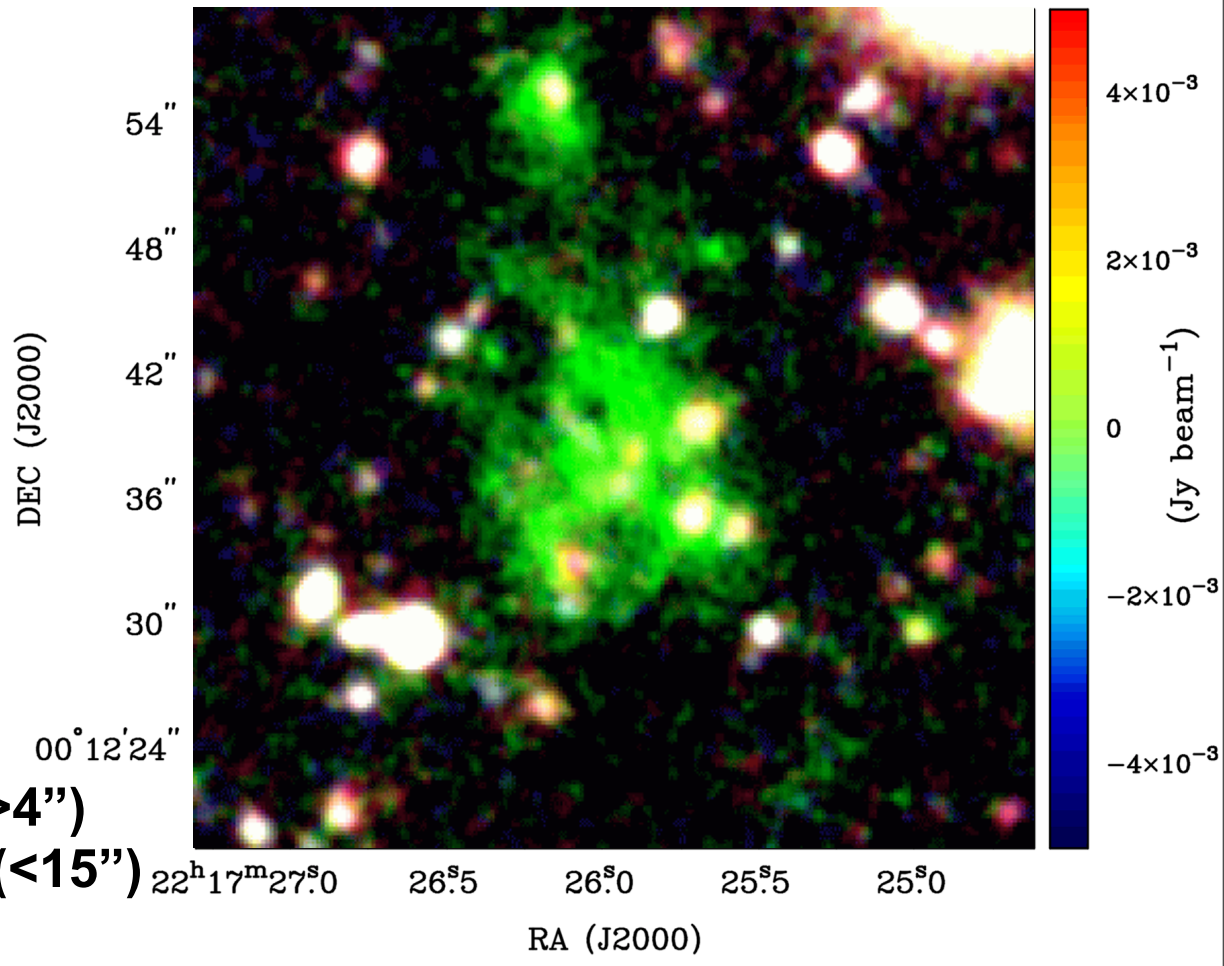
Submm (~16 mJy) emission is resolved out

→ Spatially extended!!

beam size ~2”
rms ~1.4 mJy / beam

Source size
~ 4 - 15”
(30 - 110 kpc)

Resolved out with SMA (>4”)
Unresolved with SCUBA (<15”)



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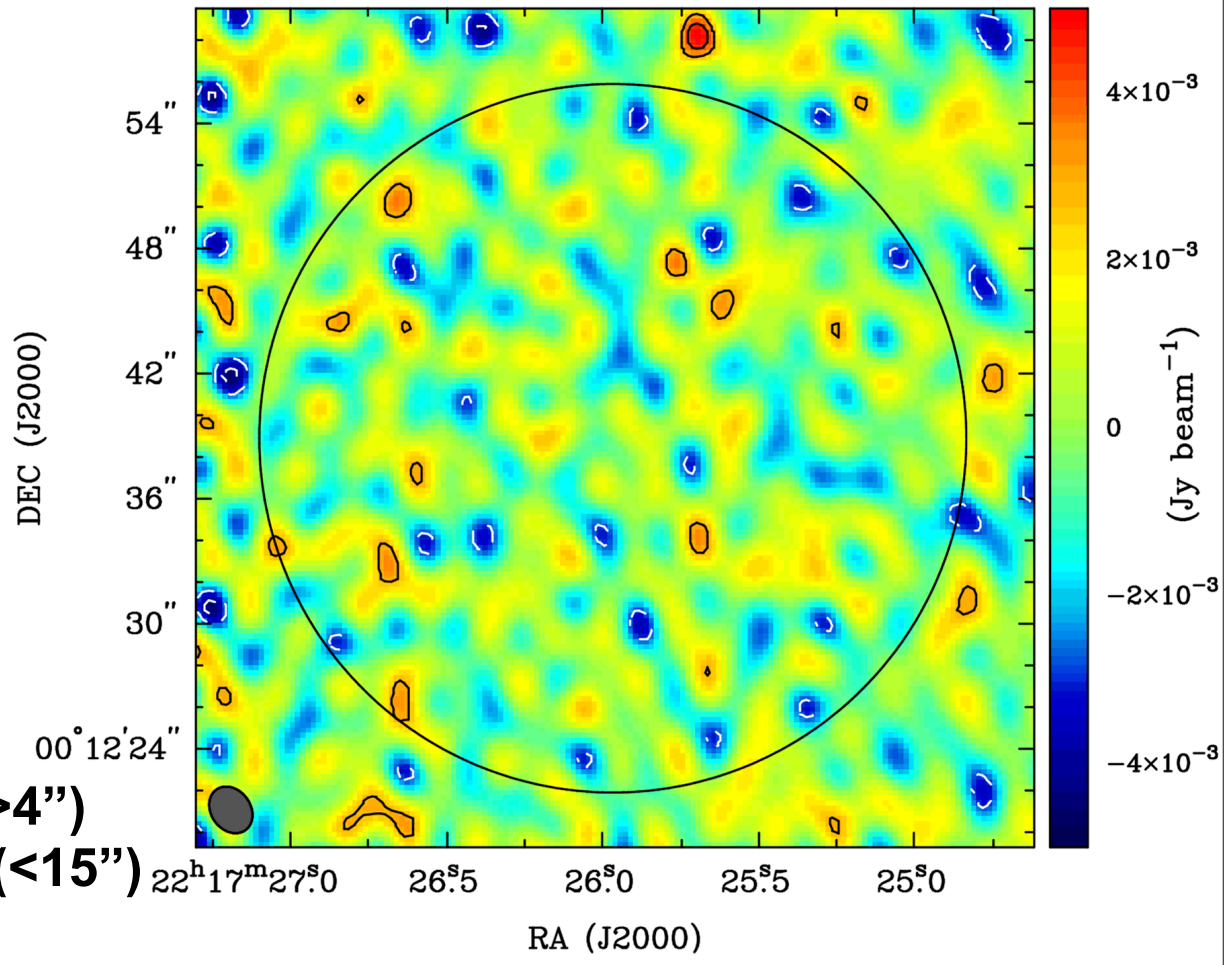
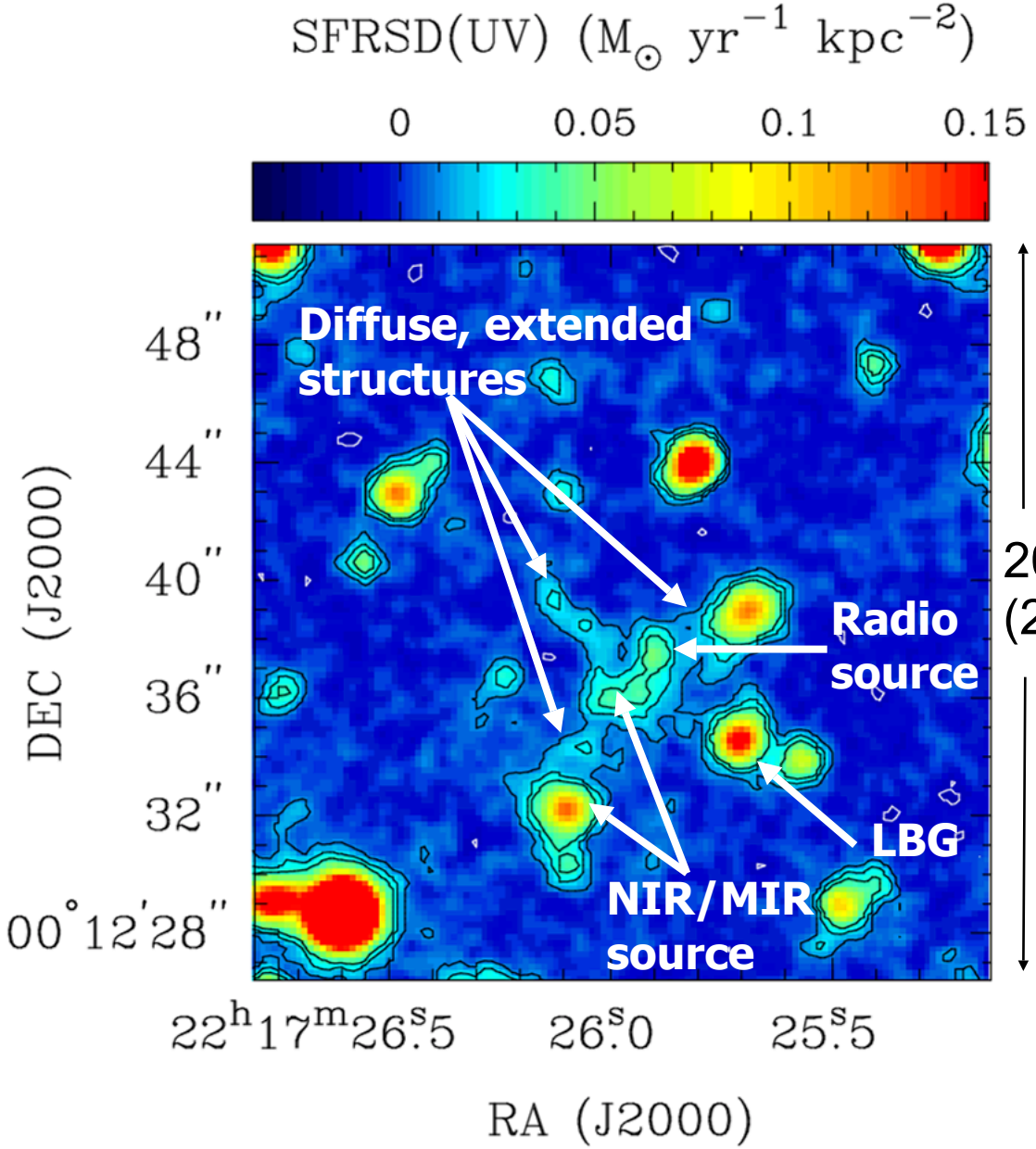


Spatially extended starbursts?

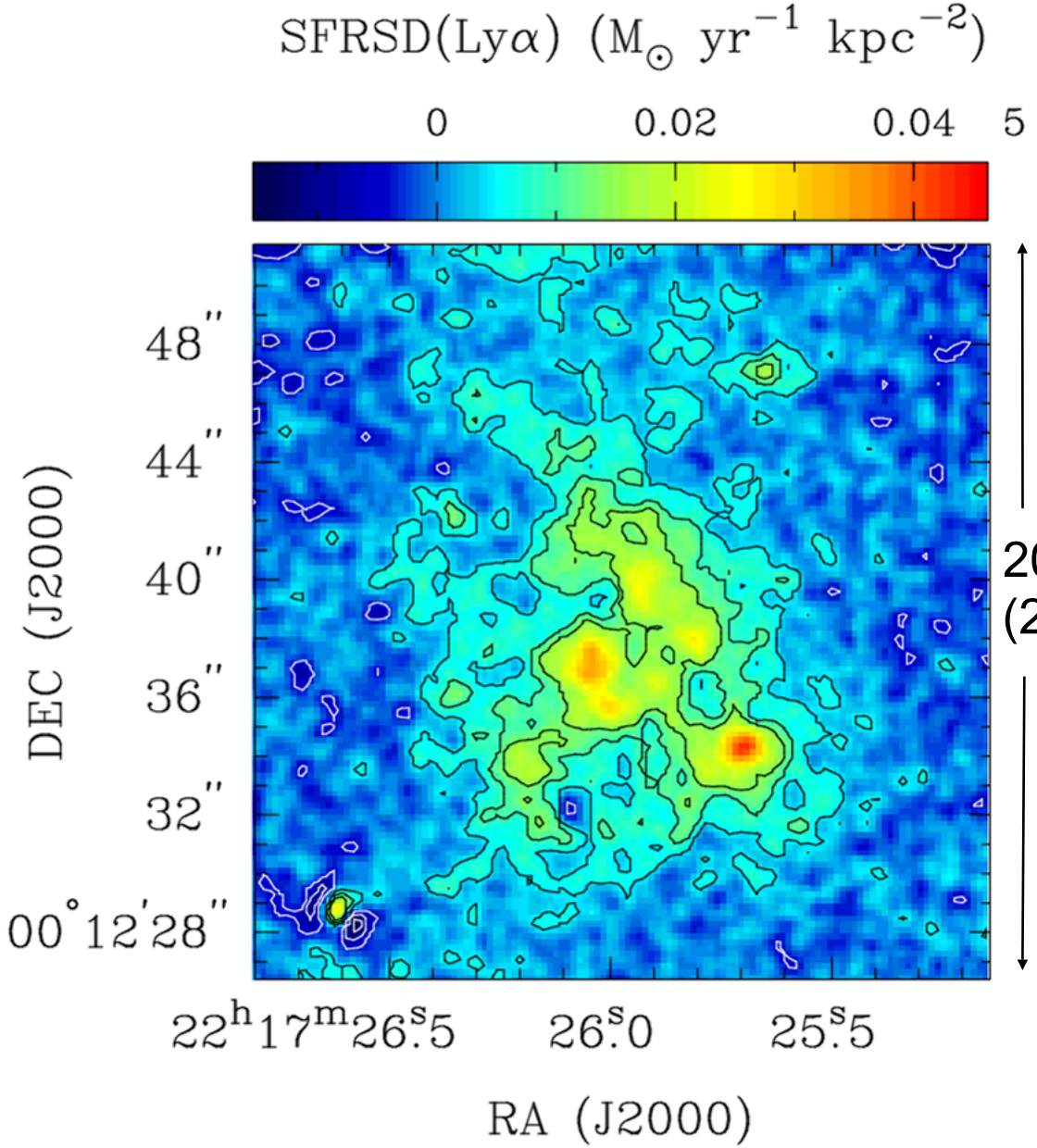


UV continuum image of SSA22 Lya blob1

UV continuum emission shows multiple sources & diffuse, extended structures.

Evidence for spatially extended starbursts!!

Spatially extended starbursts?



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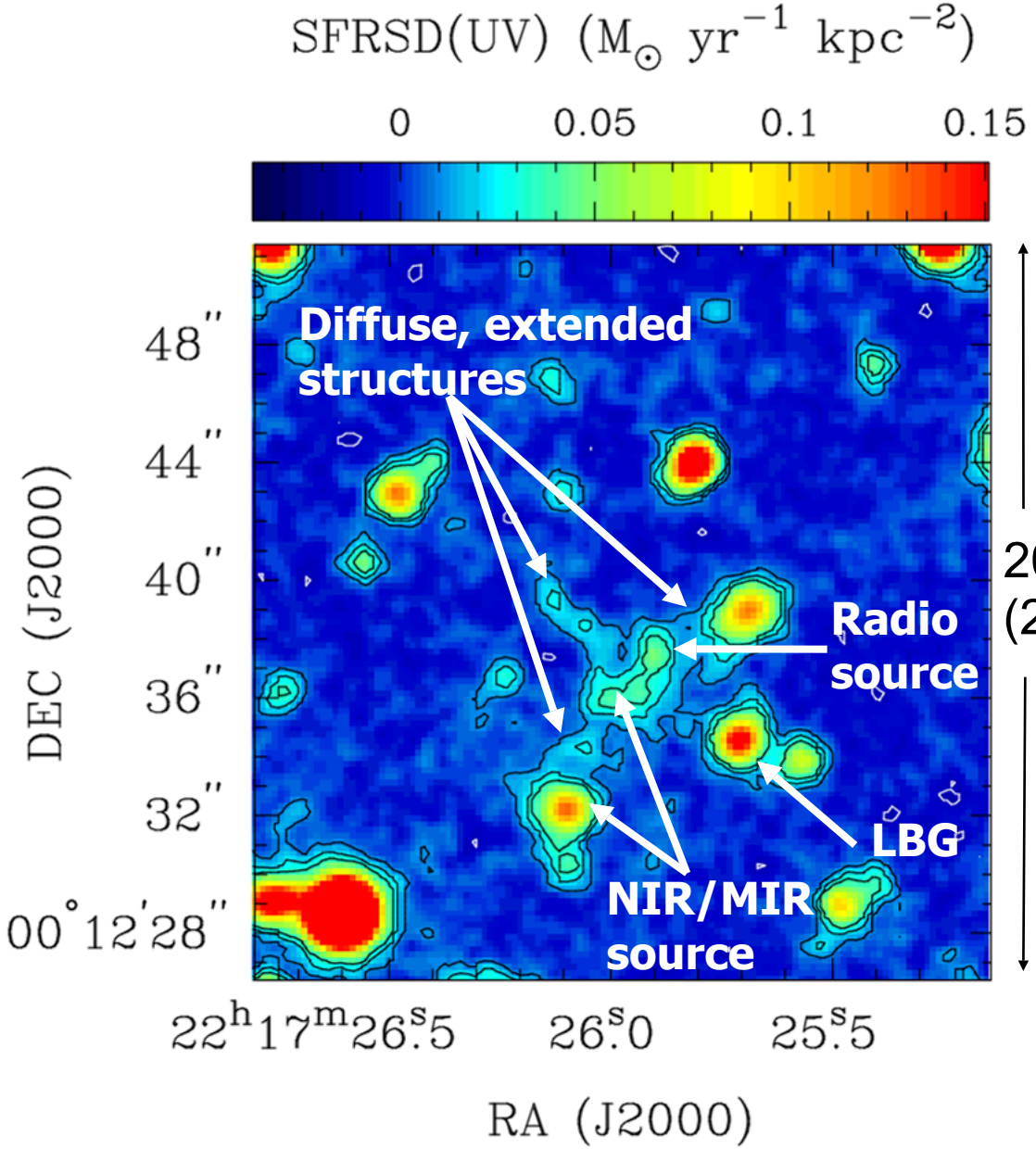

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Evidence for spatially extended starbursts!!

Summary & Conclusion

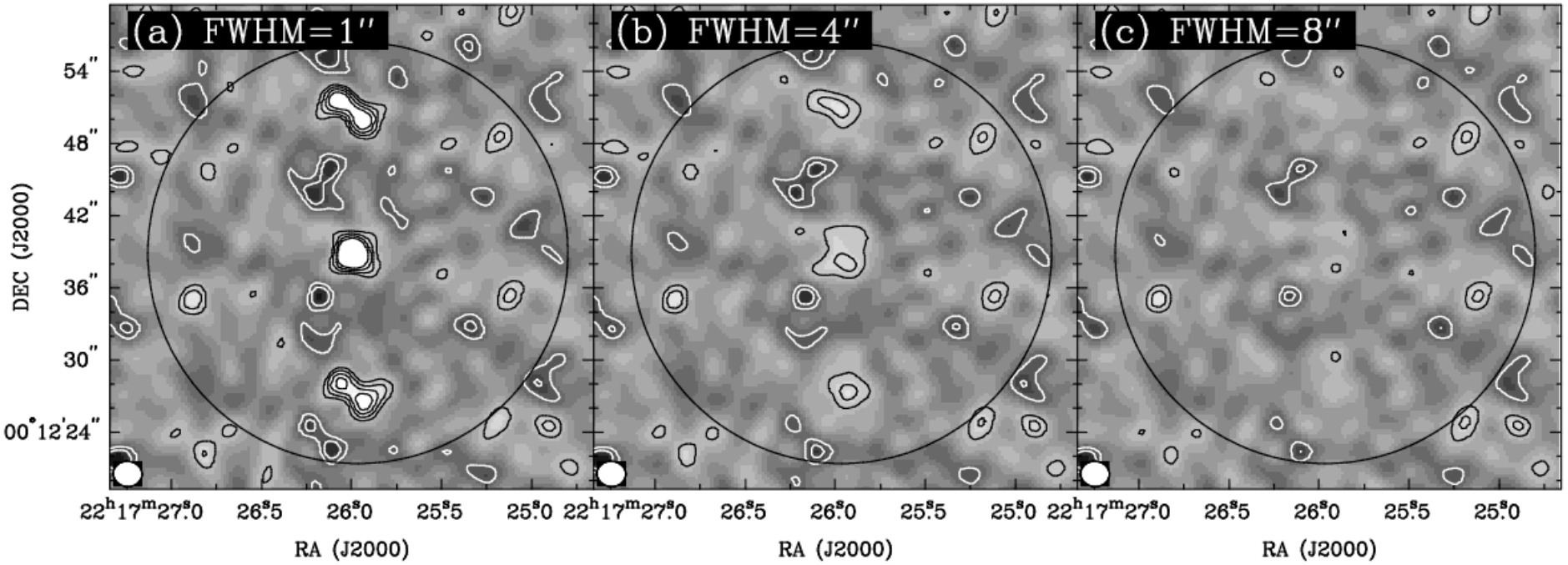
The properties of radio-quiet Lya blobs:

1. Characteristic phenomena in overdense environments
2. A significant fraction have bright submm emission
3. The largest blob has spatially extended submm emission

Spatially extended Lya nebulae of radio-quiet Lya blobs & high-z radio galaxies

Spatially extended starbursts induced by interactions or mergers of gas clumps in overdense environments?
(+ galactic winds? + scattering?)

Simulation of the SMA observation



FWHM=1”
10 σ

FWHM=4”
3 σ

FWHM=8”
1σ

Visibility amplitude

The best fit model is a Gaussian with FWHM=5”.2±1”.3 (40±10 kpc)