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Mapping the Morphology and Kinematics of a Lyα-selected Nebula at z=3.15 with MUSE

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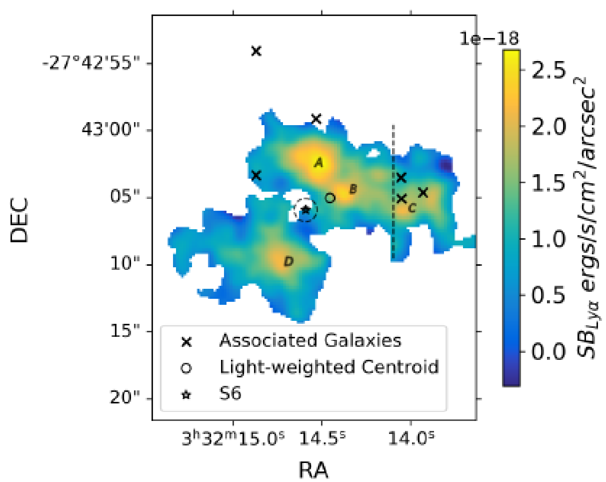
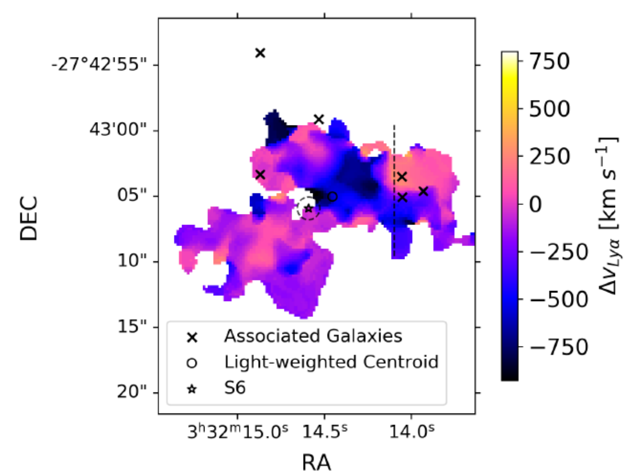




Доклад подготовил: Балашев С.А. (s.balashev@gmail.com) 28 Октября 2021

Введение. Линия Lyα

Lyα (1215 Å) прекрасная линия для **космологии ($z \gtrsim 2$)**:

- Водород – самый распространённый элемент во Вселенной
- Линия резонансная $A_{21} = 6.5 \times 10^{-8}\ \mathrm{s}^{-1}$

Введение. Линия Lya

Lya (1215 Å) прекрасная линия для **космологии ($z \gtrsim 2$)**:

- Водород – самый распространённый элемент во Вселенной
- Линия резонансная $A_{21} = 6.5 \times 10^{-8}\ \mathrm{s}^{-1}$

Но для **абсорбции** (например, Лайман-альфа лес – межгалактическая среда)

Для **эмиссии** эти преимущества не настолько выражены

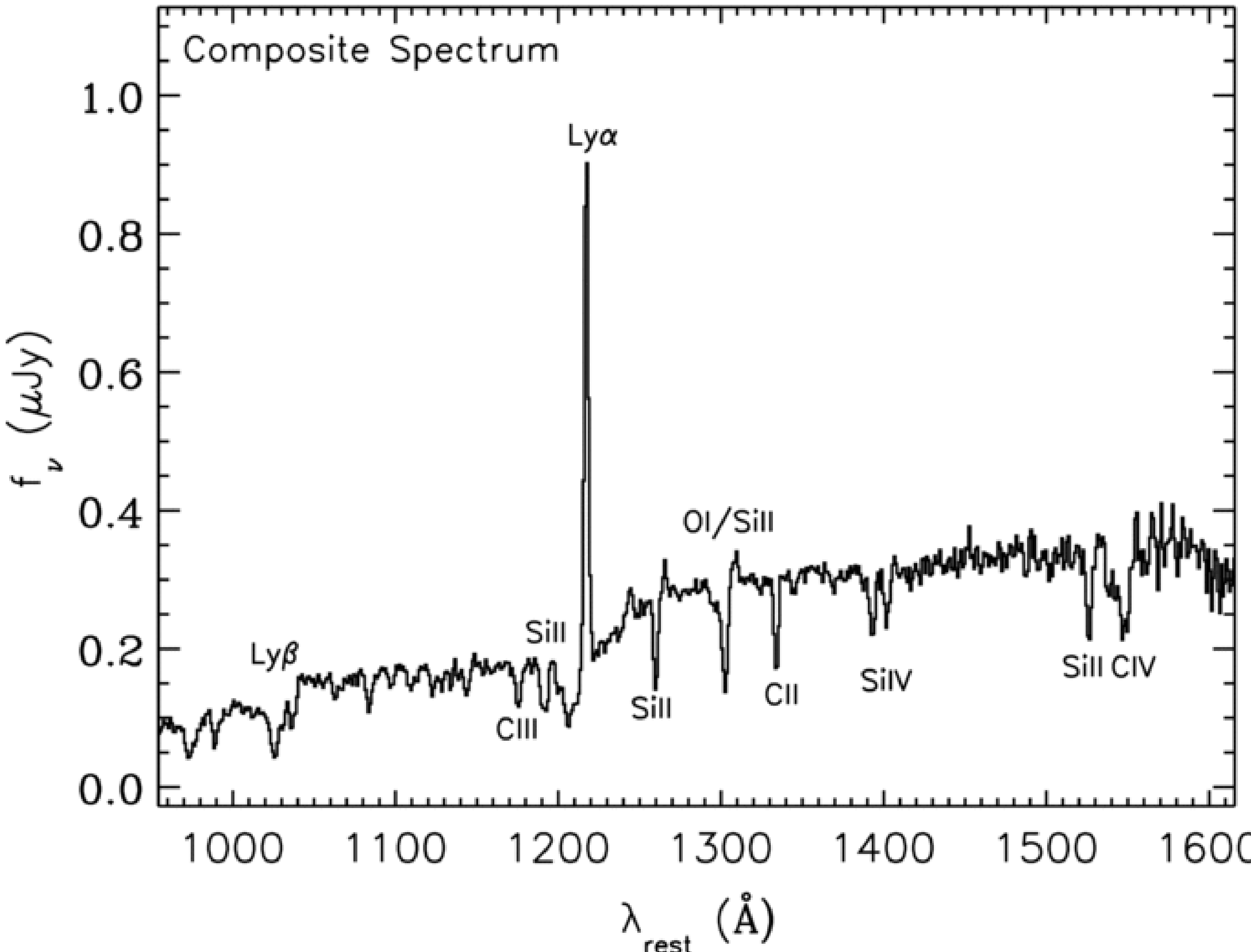
$$\sigma_{Lya}(\nu, T) \approx 5.9 \times 10^{-14} \left(\frac{T}{10^4}\right)^{-\frac{1}{2}} H(a, x) \quad \mathrm{cm}^{-2}$$

$\Rightarrow$ Lya очень эффективно рассеивается в практически любой среде

$\Rightarrow$ {
1. Нужны достаточно специфические условия для выхода из среды
2. Светимость уменьшается за счёт двухфот. распадов и пыли

Введение. Эмиссия Lya

Lya наблюдается в основном в двух типах объектов
Lya emitters и Lyman break galaxies

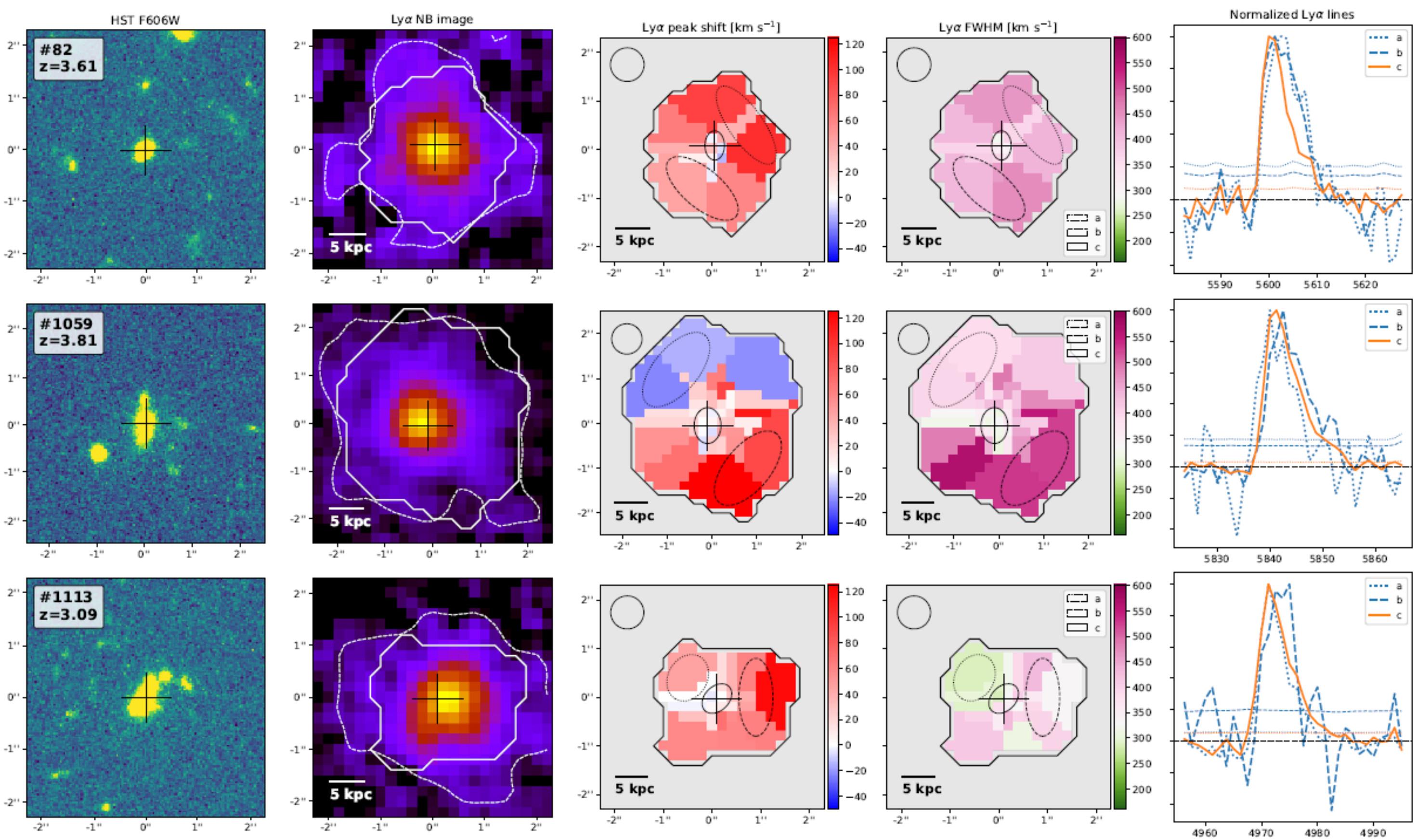


Kornei+2010

Введение. Эмиссия Lya

С развитием IFU (MUSE, KWCI) появилась возможность систематически изучать **протяжённое излучение** в линии Lya

1. **Вокруг галактик** (Steidel+2012, Wisotzki+2018, Leclercq+2020, …)

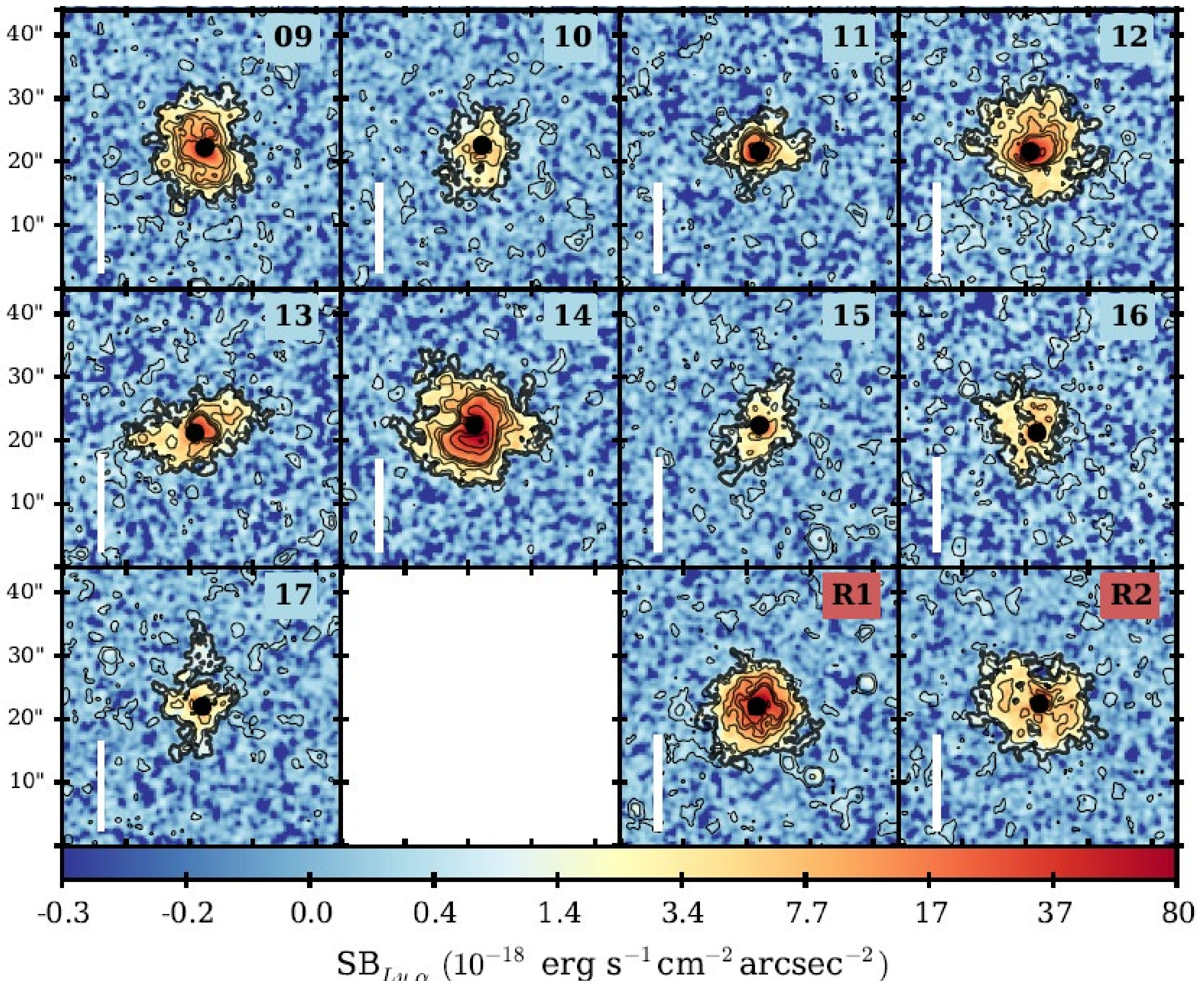


Leclercq+2020

Введение. Эмиссия Lya

С развитием IFU (MUSE, KWCI) появилась возможность систематически изучать **протяжённое излучение** в линии Lya

1. Вокруг галактик (Wisotzki+2018, Leclercq+2020, …)
2. **Вокруг квазаров** (Christensen+2012, Borisova+2016, …)

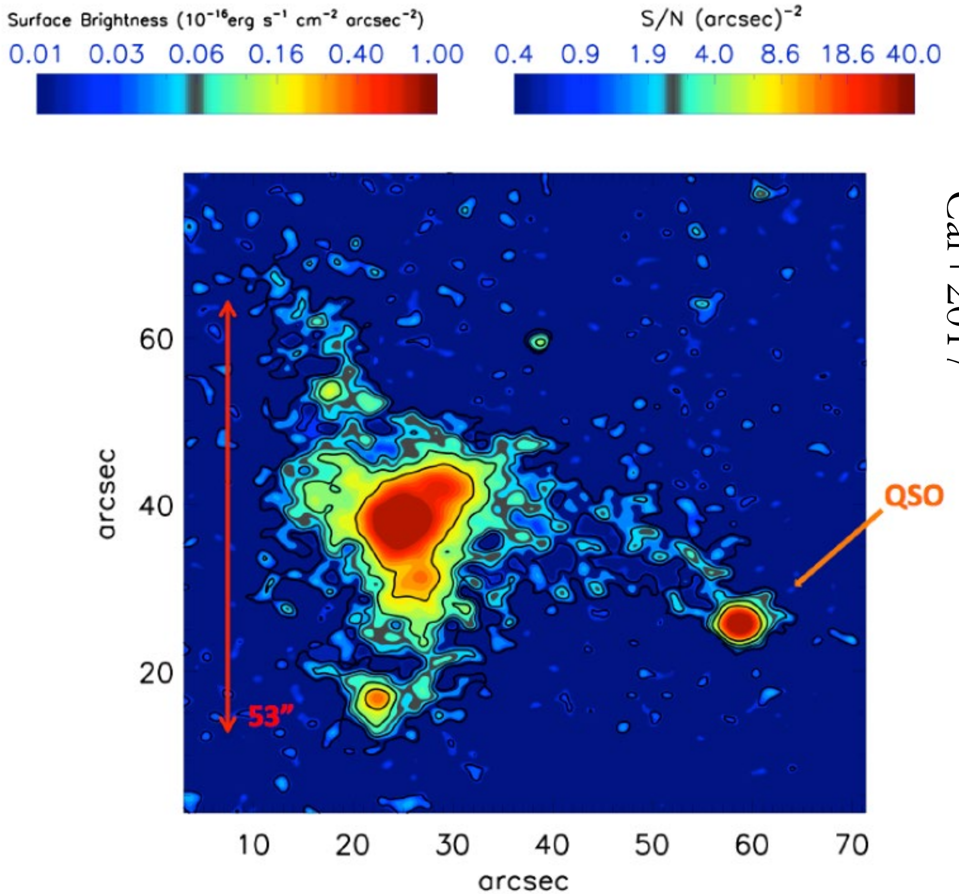


Borisova+2016

Введение. Эмиссия Lya

С развитием IFU (MUSE, KWCI) появилась возможность систематически изучат
протяжённое излучение в линии Lya

1. Вокруг галактик (Wisotzki+2018, Leclercq+2020, …)
2. Вокруг AGN и квазаров (Borisova+2016, Arrigoni Battaia+2018, …)
3. **Без ассоциации с “источником” – Lya nebulae (Lya Blobs)**



Cai+2017

Введение. Источник Lya

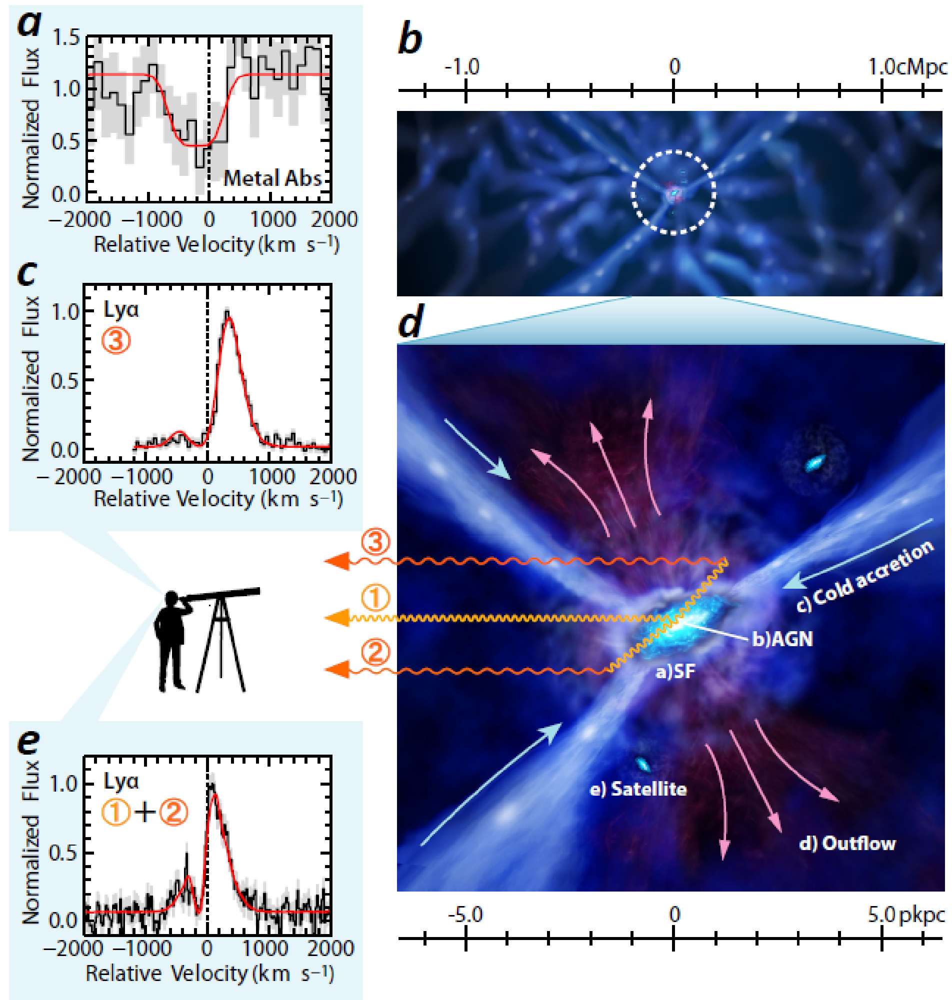
До сих пор не всегда понятно физический механизм формирования протяжённого излучение в Lya:

1. Резонансное рассеяние фотонов от центрального источника

2. Вследствие рекомбинации (флюорисценция)

3. Столкновительная накачка (например, за счёт ударных волн в истечениях)

4. Гравитационное охлаждение аккрецирующего газа.



Ouchi+2020

LABn06

A Lyman-α blob in the GOODS South field: evidence for cold accretion onto a dark matter halo ⋆

K. K. Nilsson[1,2], J. P. U. Fynbo[2], P. Møller[1], J. Sommer-Larsen[2], and C. Ledoux[3]

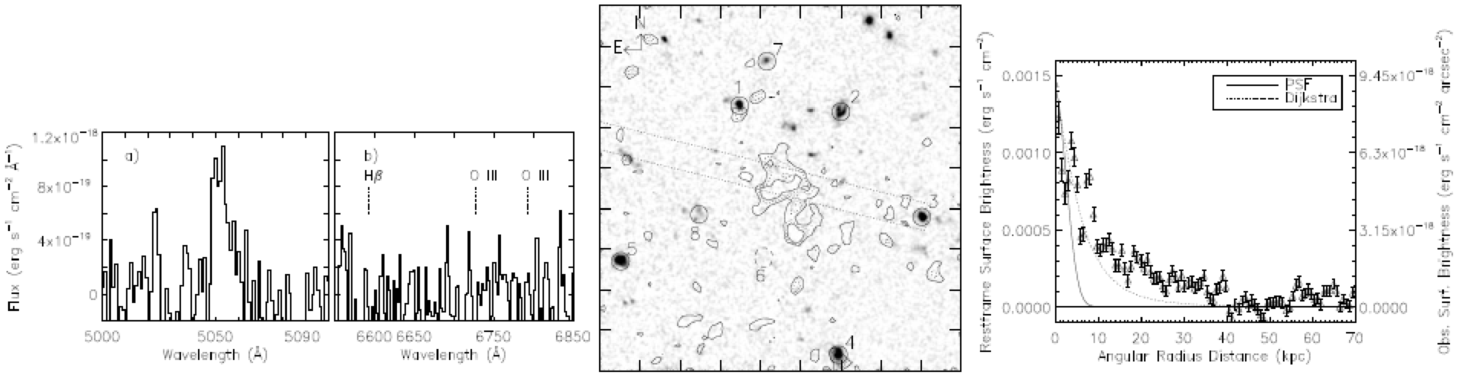
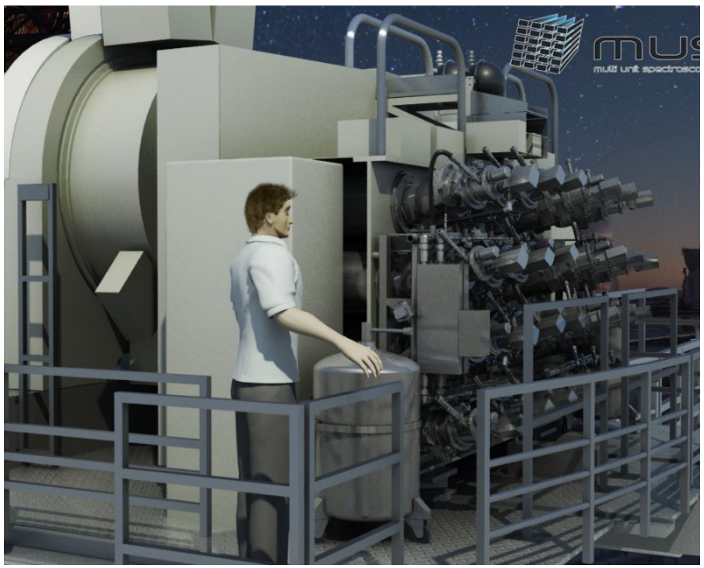


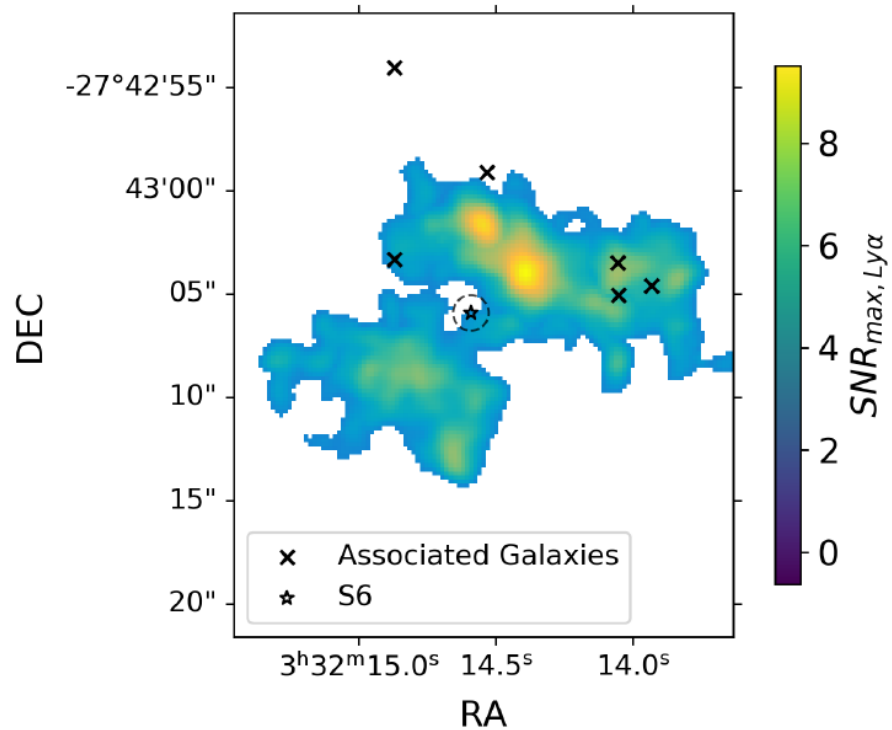
Fig. 1. *Left a)* Flux calibrated spectrum of the blob emission line. The line has the characteristic blue side absorption, indicating high redshift. *b)* The part of the spectrum (binned with a binsize equal to half the resolution (1.1 Å)) where Hβ and [OIII] should have been observed if the emission line was [OII] at a redshift of $z \approx 0.36$. These lines are not observed and therefore we conclude the observed line is due to Lyα at $z = 3.16$. *Middle* Contour-plot of narrow-band emission from the Lyα blob overlaid the HST V-band image. The narrow-band image has been continuum subtracted by subtracting the re-binned, smoothed and scaled HST/V-band image. Contour levels are $2 \cdot 10^{-4}$, $4 \cdot 10^{-4}$ and $6 \cdot 10^{-4}$ erg s^{-1} cm^{-2} in restframe flux (corresponding to $1.2 \cdot 10^{-18}$, $2.5 \cdot 10^{-18}$ and $3.7 \cdot 10^{-18}$ in observed flux). The image is $18'' \times 18''$ ($18''$ corresponds to a physical size of ~ 133 kpc). Numbers refer to those used in section 3. The dotted lines indicate the slitlet position for our follow-up spectroscopy. *Right* Plot of surface brightness as function of radius. The flux is the sky subtracted narrow-band flux. The PSF of the image is illustrated by the solid line, and the dotted line is the best fit model of Dijkstra et al. 2006. The deficit at ~ 45 kpc is due to the asymmetric appearance of the blob.

LABn06. Sanderson+2021

Sanderson+2021 получили одну их самых глубоких наблюдений Lya nebula на MUSE:

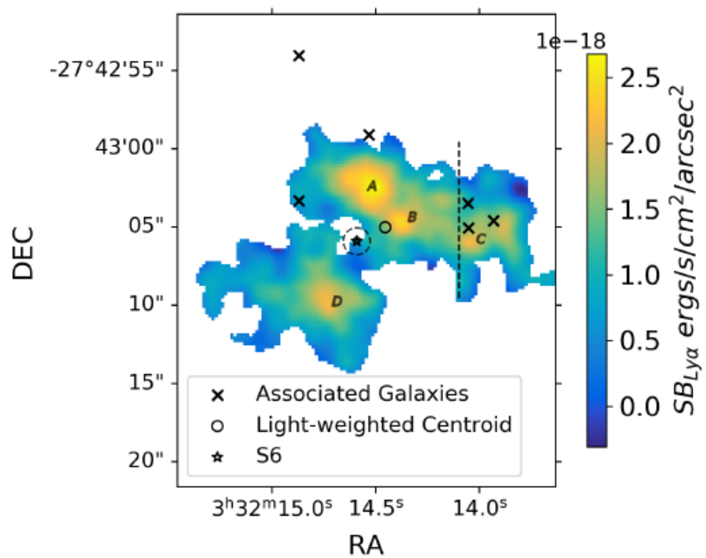
~ 12 часов MUSE (2019-2021)



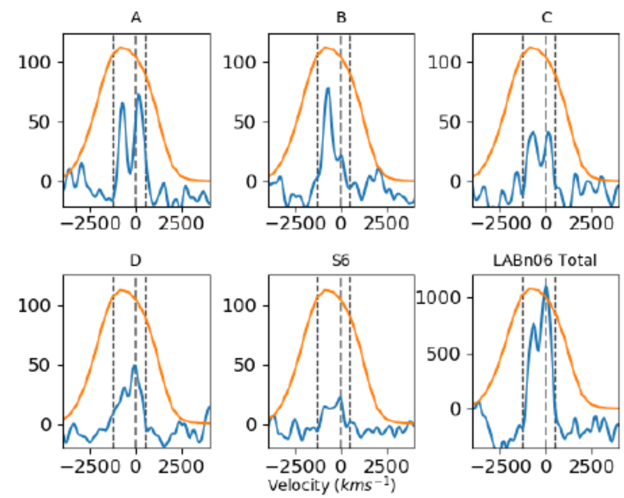


LABn06. Sanderson+2021

Наблюдения Sanderson+2021 подтверждают наличие Lya nebula с размером ~ 170 pkpc (4×10^{-19} erg s^{-1} cm^{-2}arcsec^{-2})



(a)

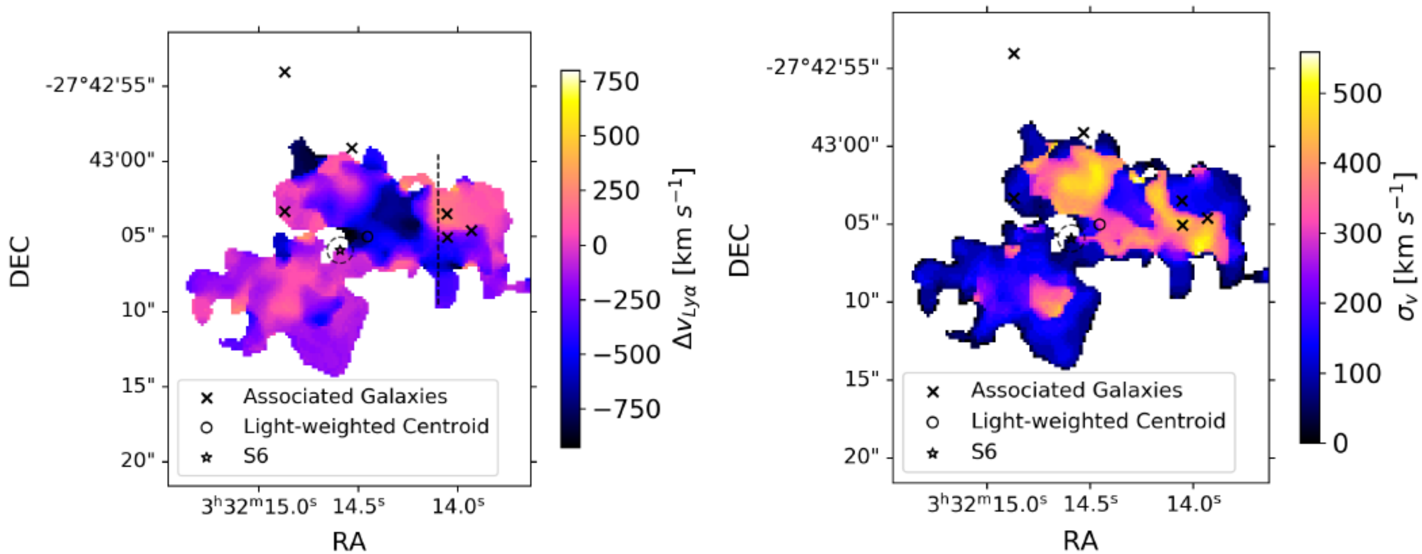


(b)

Figure 3. Regions of interest within the nebula (A-D and the location of S6). (a) 0th moment map with regions of interest labeled. The vertical dashed line marks a dip in Lyα surface brightness between region B and the western lobe as discussed in Section 4.1. (b) Spectra extracted from the labeled regions in panel (a) using a diameter aperture of 12 native MUSE pixels (2.4 arcsec) and from the entire nebula. The gray long-dashed vertical line marks the systemic velocity defined as the central wavelength slice (5048.48Å), and the two black short-dashed vertical lines mark the widest wavelength range of the 3D Lyα mask. Each spectrum is plotted over 8000 km s^{-1} and over arbitrary flux units on the y-axis. The transmission curve for the narrowband filter used in the discovery paper by Nilsson et al. (2006) is over-plotted (orange). The Lyα line profiles across the nebula are varied and complex, showing multiple peaks or asymmetric line shapes.

LABn06. Sanderson+2021

Кинематическая структура указывает на сложную морфологию, которая включает область похожую на биконическое истечение из источника S6 (type II AGN):

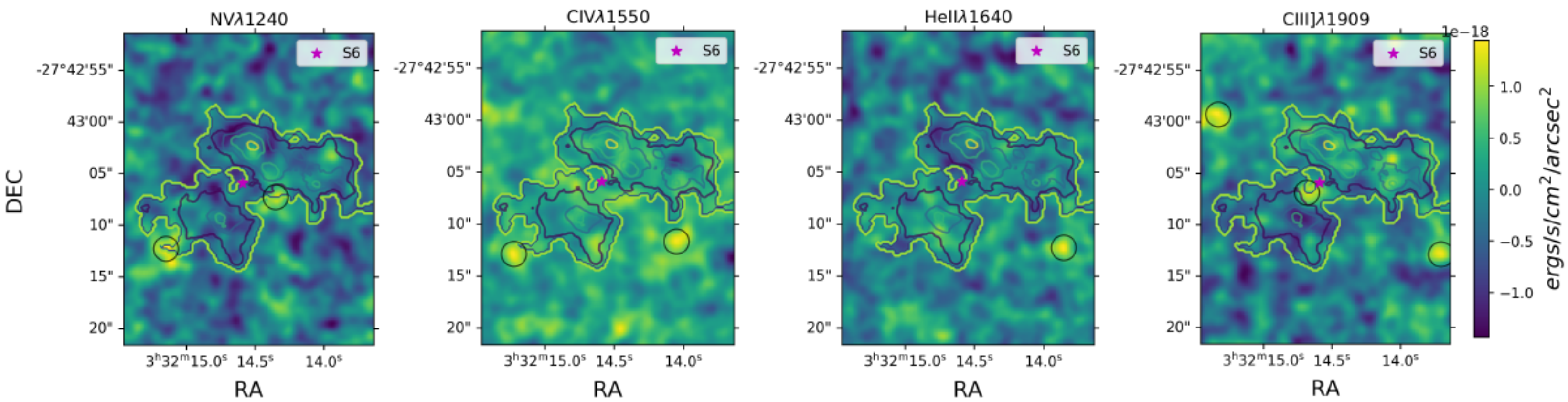


(a) (b)

Figure 4. First and second image moment maps. In each case, the systemic velocity was defined to be the wavelength layer with the largest connected region of voxels with SNR≥ 2 (5048.48Å). (a) The velocity map derived from the first moment of the flux data cube. The kinematics of the gas in LABn06 show hints of ordered motion around the location of S6. There is also a steep North-South velocity gradient seen across the western lobe (see Section 4.1) of the nebula near three of the associated galaxies (Prescott et al. 2015b). The vertical dashed line marks a dip in Lyα surface brightness between region B and the western lobe as discussed in Section 4.1. (b) The apparent velocity dispersion map (σ_V) derived from the second moment of the Lyα emission. The gas to the South-East of S6 shows lower velocity dispersions. Larger velocity dispersions are seen to the North-West of S6, but these higher σ_v values are likely caused by the double-peaked nature of the Lyα emission in this region.

LABn06. Sanderson+2021

Другие линии, которые могут ассоциироваться с LAB не найдены:

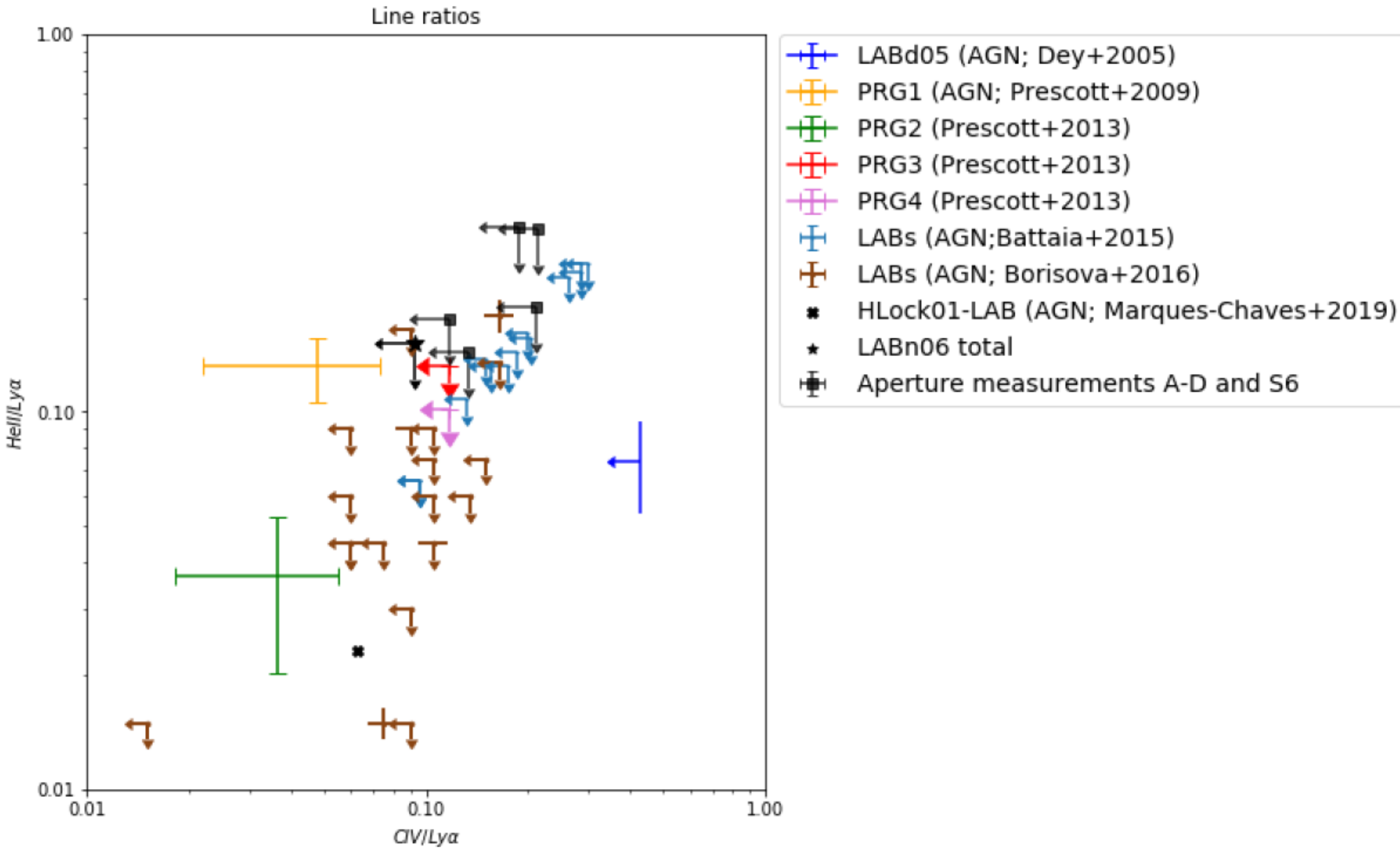


(a) (b) (c) (d)

Figure 7. Flattened 2D images centered on the expected wavelength for each UV metal line assuming a source redshift of $z_{Ly\alpha} = 3.15$. Contours of the Lyα emission are plotted at arbitrary levels. We also indicate S6 (purple star) and the locations of some of the largest peaks in these images (black circles; 1.2″radius apertures). S6 seems to lie close to a peak in the NVλ1240 image and one of the peaks in the CIII]λ1909 image.

LABn06. Sanderson+2021

Но пределы достаточно высокие, что не противоречит источнику AGN:



LABn06. Sanderson+2021

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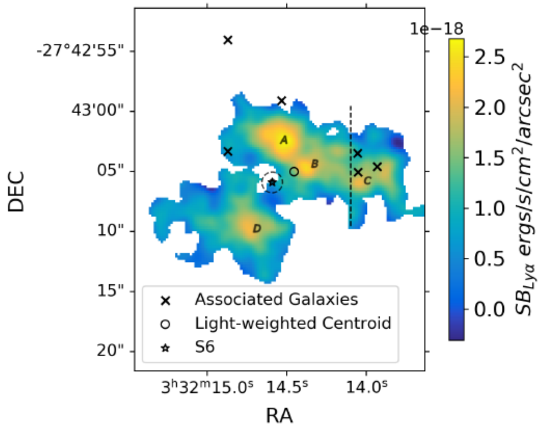
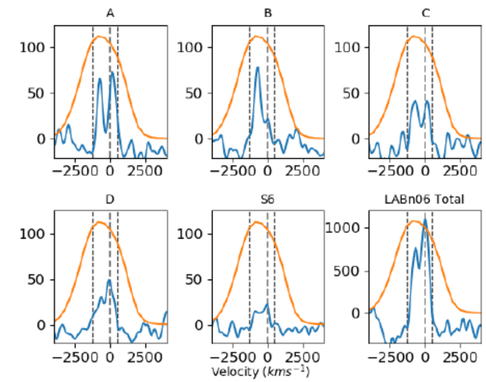
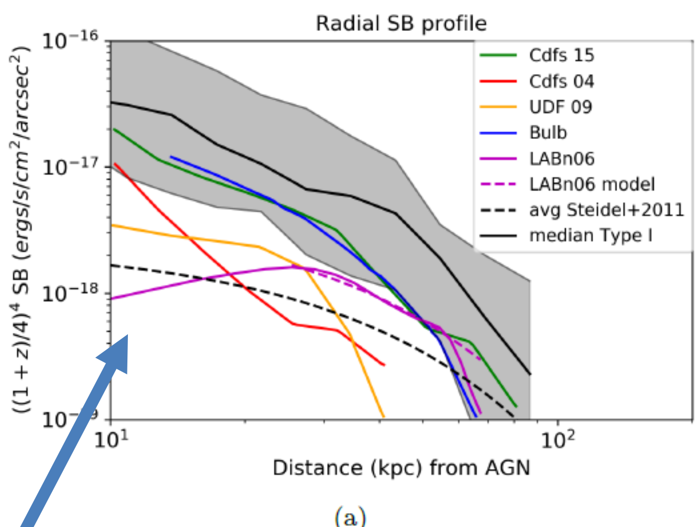
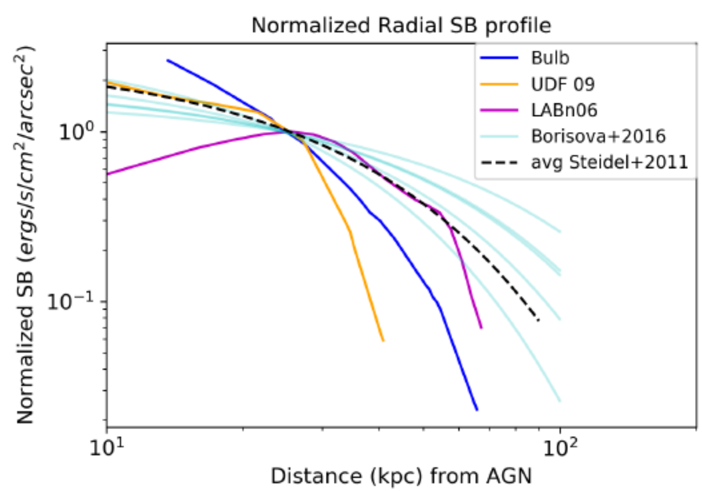




Профиль на расстояниях >30 кпк – экспоненциальный и согласуется с профилями LBG



(a)



(b)

Нетипичное падение яркости около S6