

Remarkably Extreme Properties of LyC Leaking Region in the Lensed Sunburst Galaxy

Kim, K. J. et al. 2023 in prep.

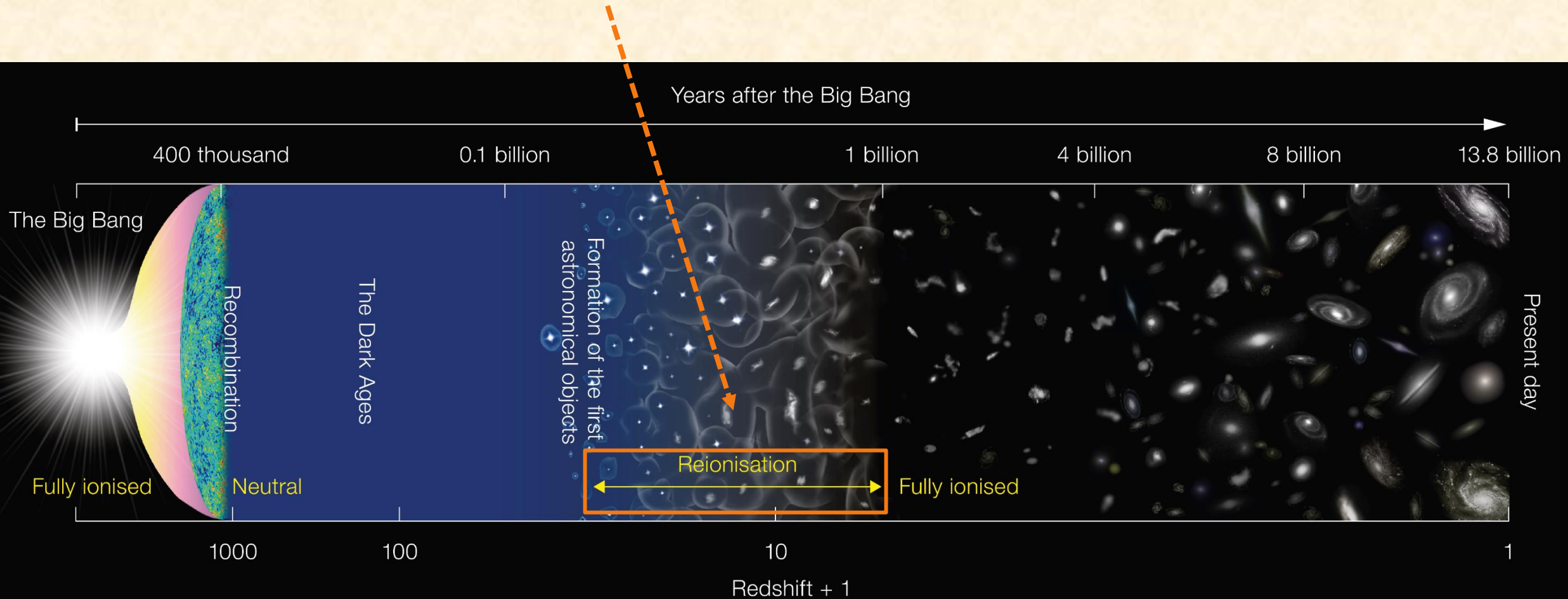
Keunho J. Kim w/ SGAS collaboration

Collaborators:

Matthew Bayliss (U of Cincinnati)	John Chisholm (UT Austin)	Hakon Dahle (U of Oslo),
Michael Florian (U of Arizona)	Mike Gladders (U of Chicago)	Gourav Khullar (U of Pittsburgh)
Guillaume Mahler (Durham Univ.)	Ramesh Mainali (NSAG GFSC)	Kate Napier (U of Michigan)
Alex Navarre (U of Cincinnati)	Riley Owens (U of Cincinnati)	Jane Rigby (NASA GFSC)
Emil Rivera-Thorsen (Stockholm Univ.)	Keren Sharon (U of Michigan)	SGAS collaboration

The Universe was reionized by the first generation of stars and galaxies.

However, the reionization process remains elusive.

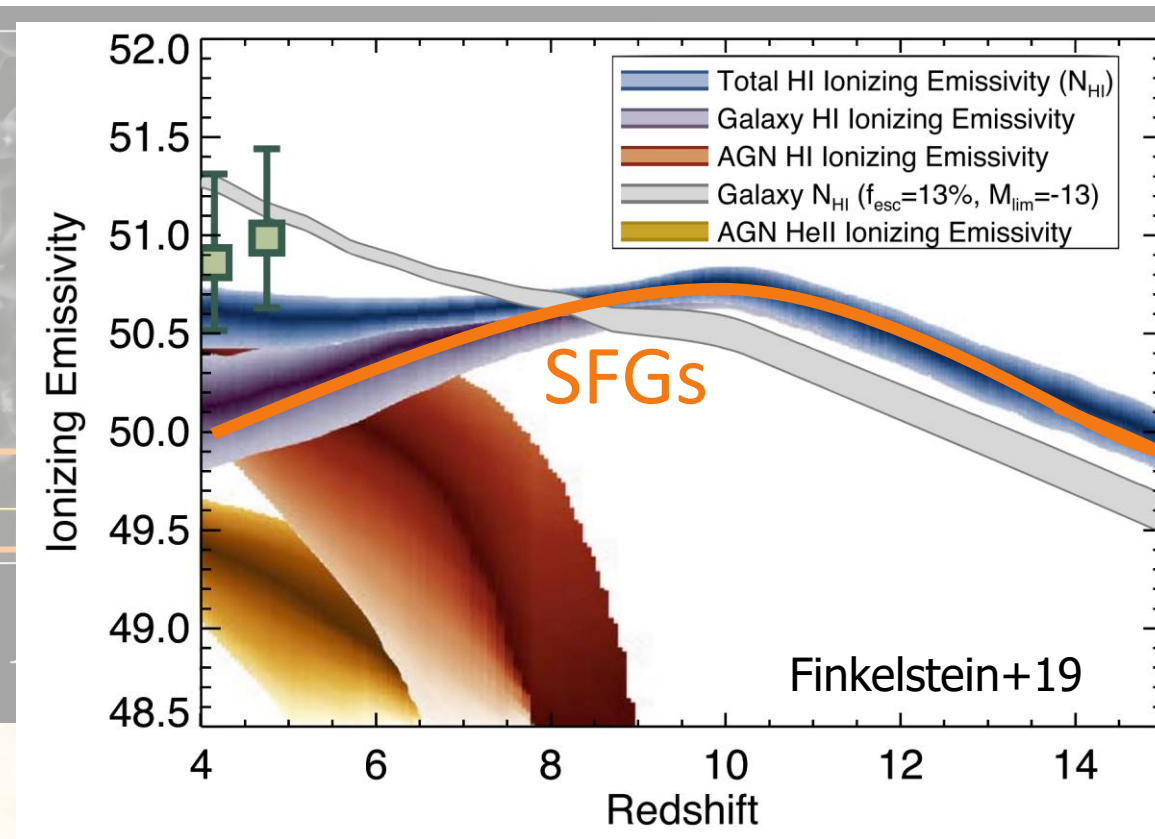
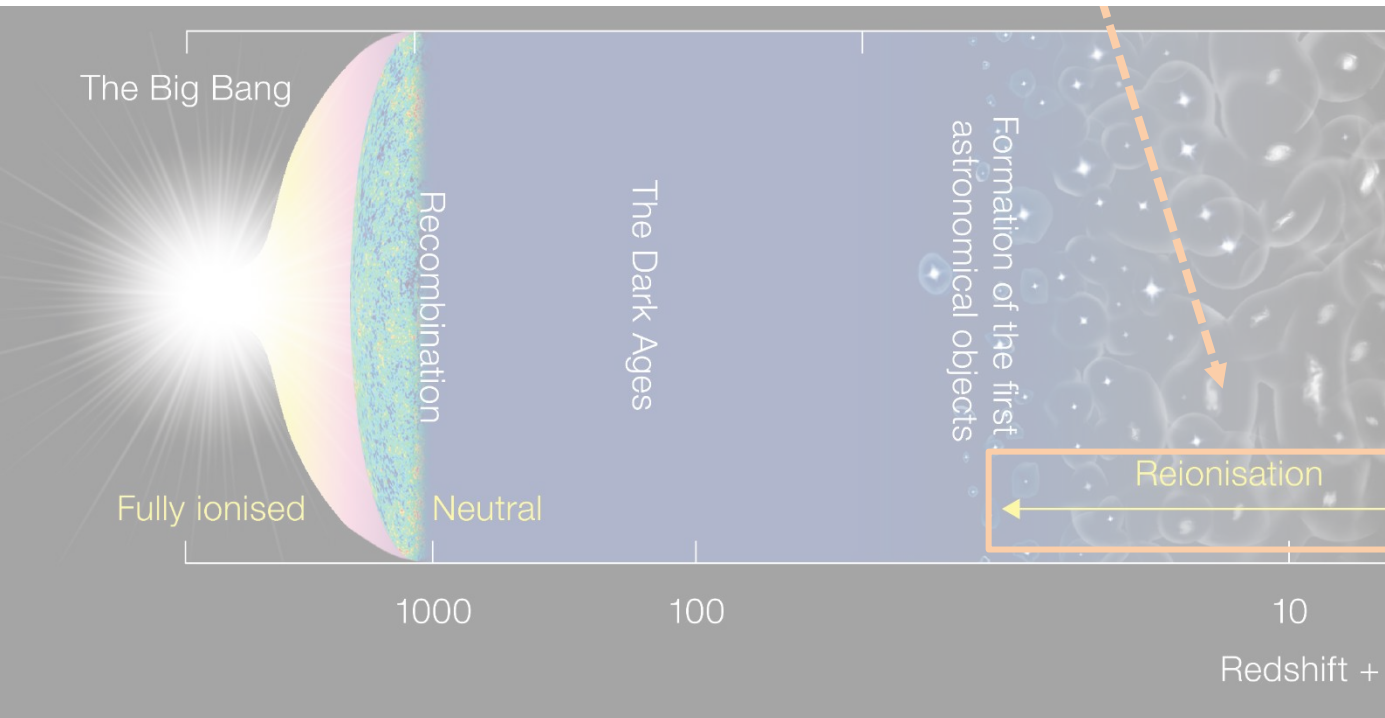


Credit: ESO

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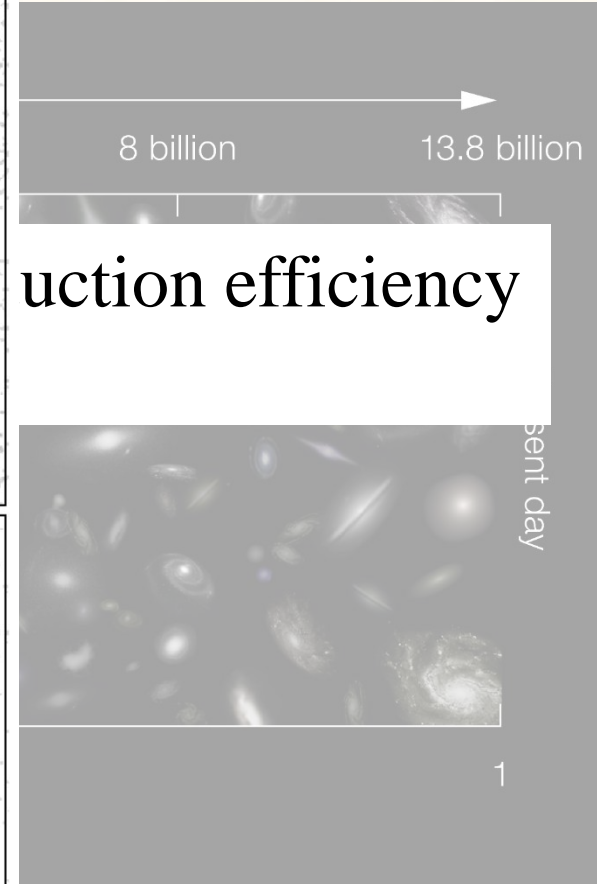
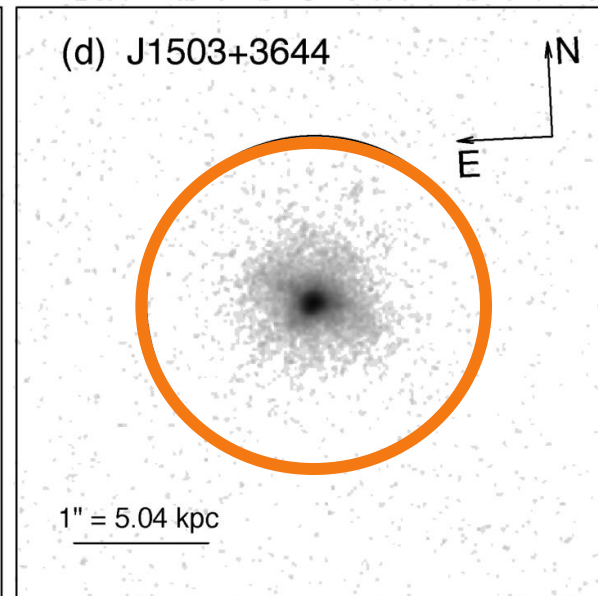
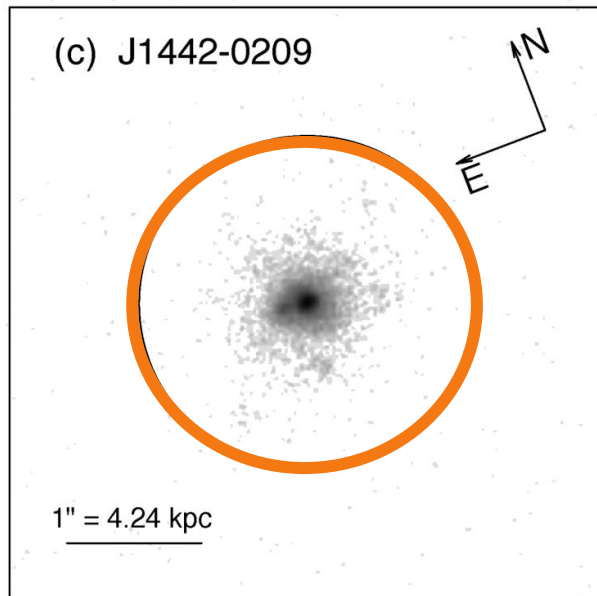
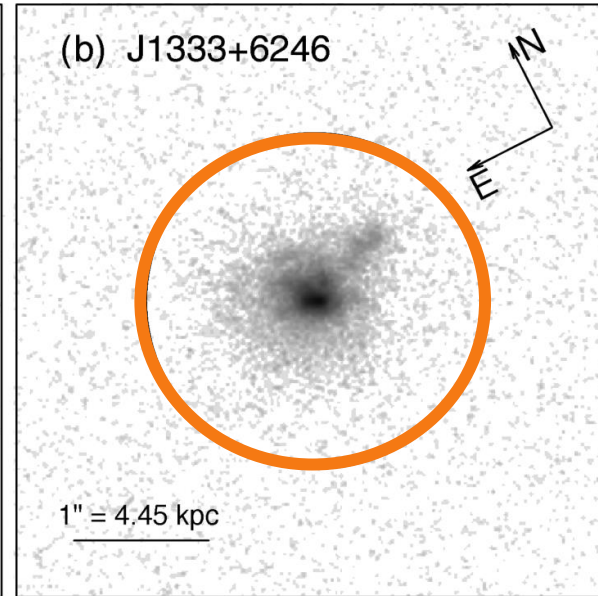
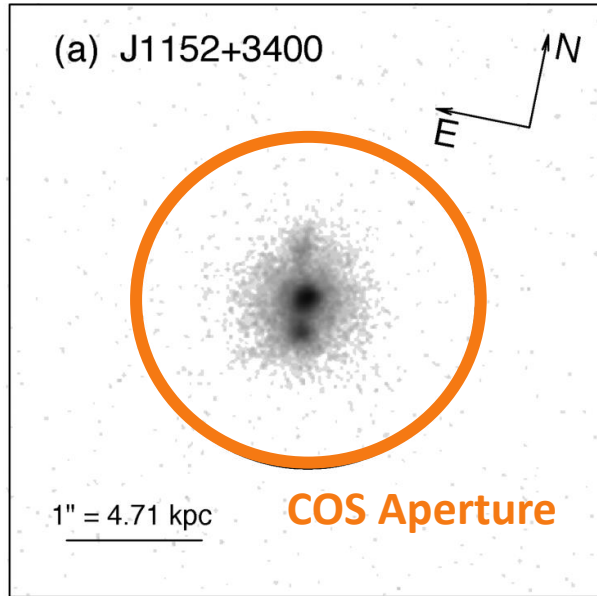
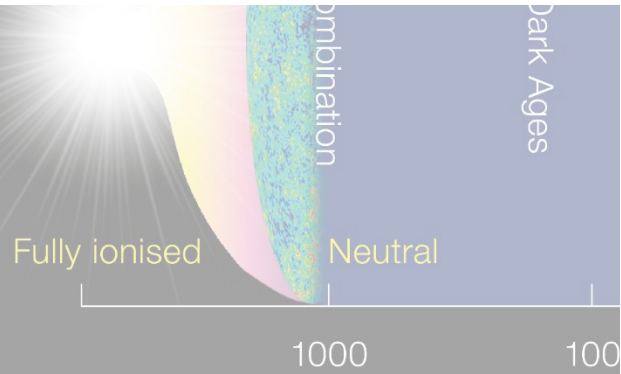
Ionizing emissivity = **Ionizing escape fraction** * Ionizing production efficiency * UV luminosity density



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How? Local LyC-emitting galaxies (Izotov+16)

Ionizing emissivity =
* UV luminosity den

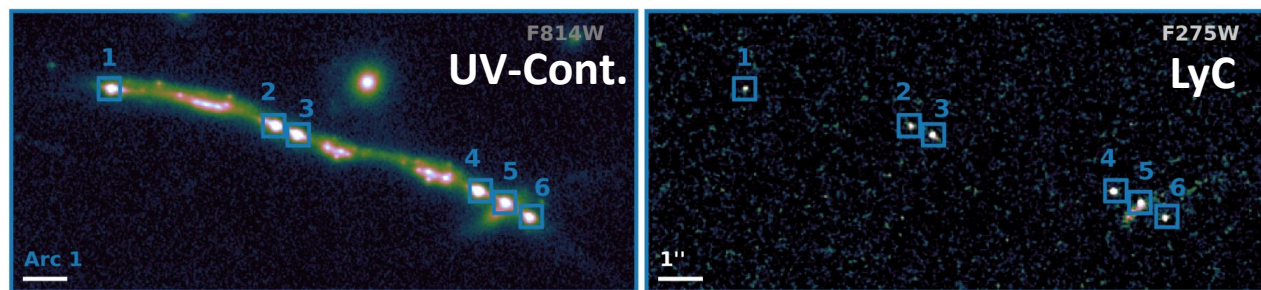


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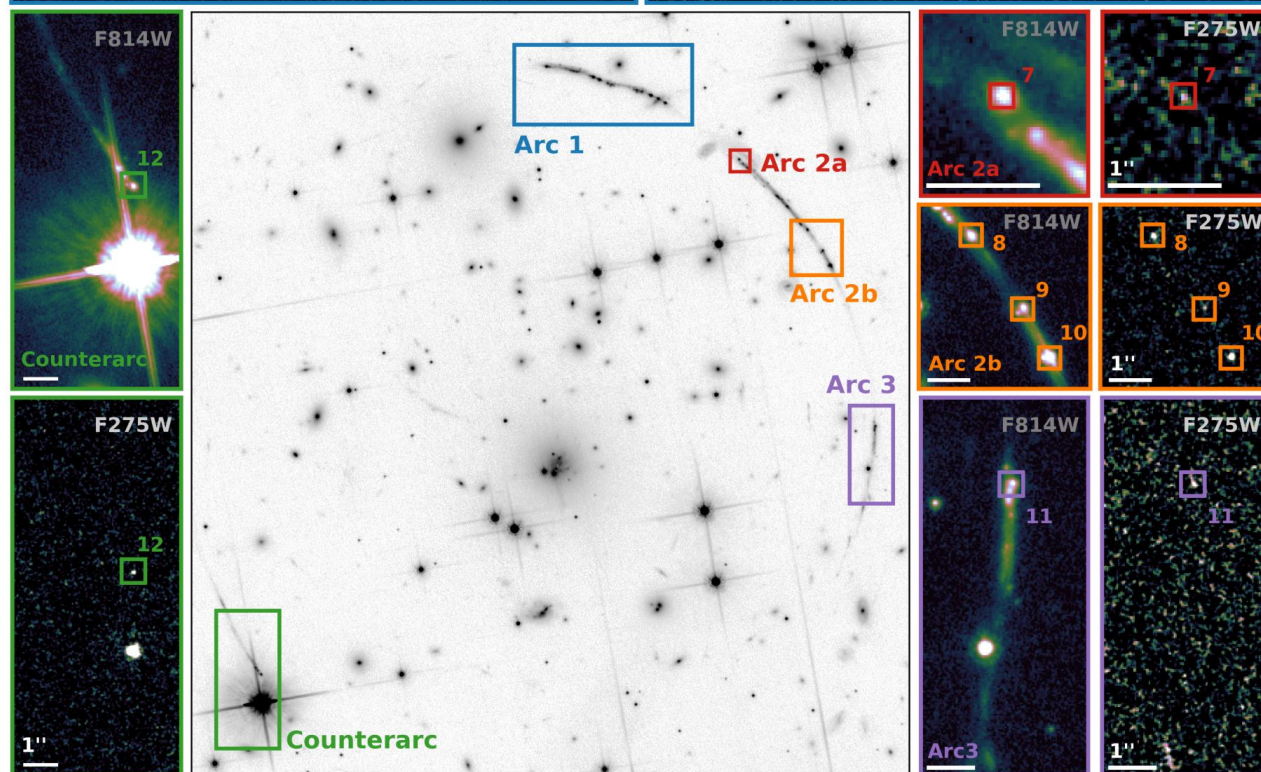
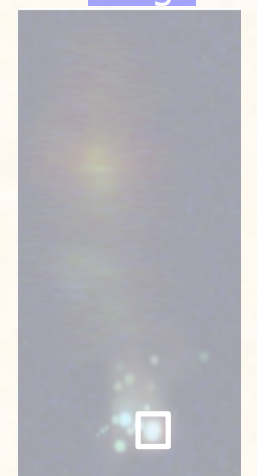
the UV slope in LyC leakage

Sunburst Arc: A gravitationally-lensed star-forming galaxy with **LyC leakage**, serving as a unique laboratory **to zoom-in where LyC is leaking** in the galaxy.

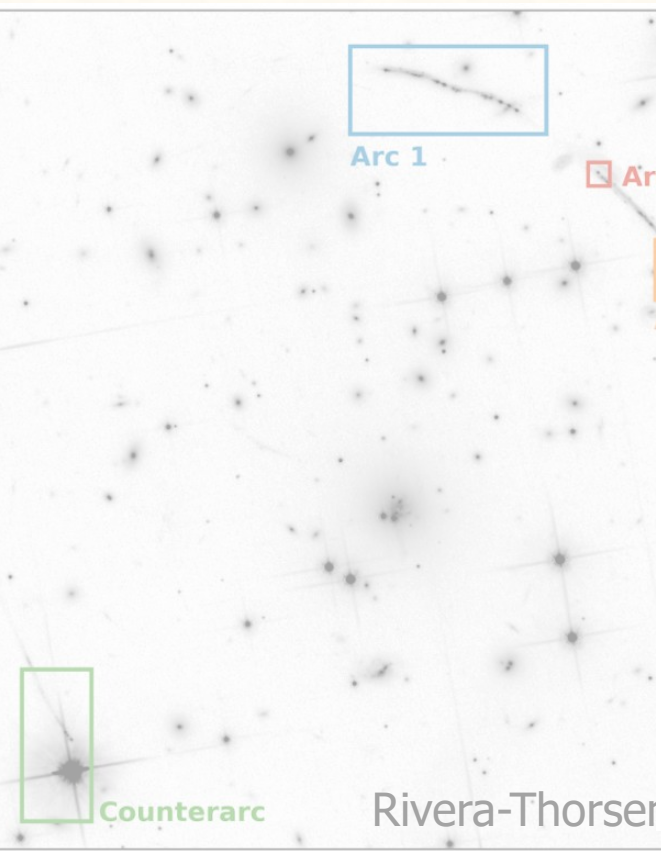
□: The LyC leaking



Source plane image



Sharon+ 22

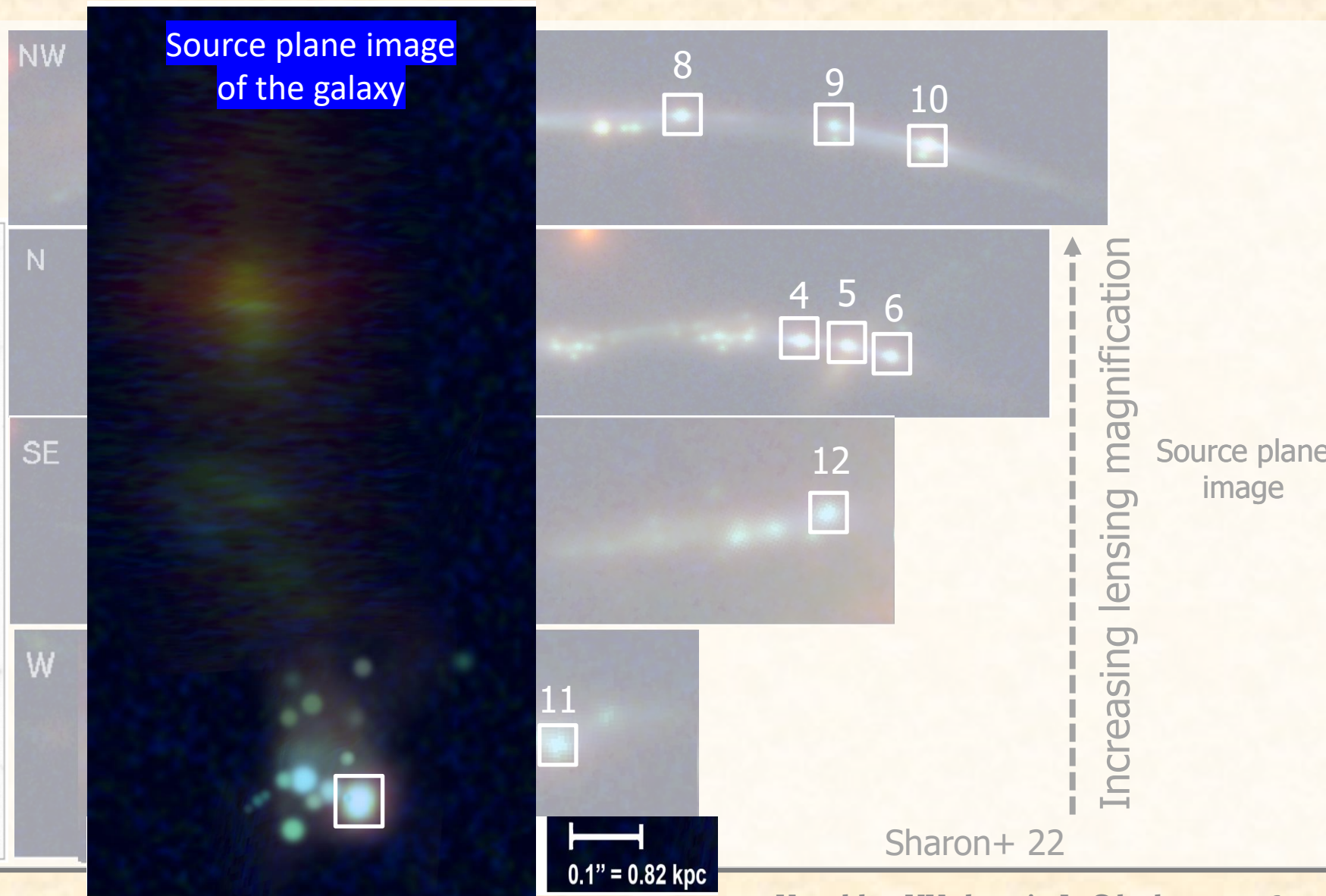
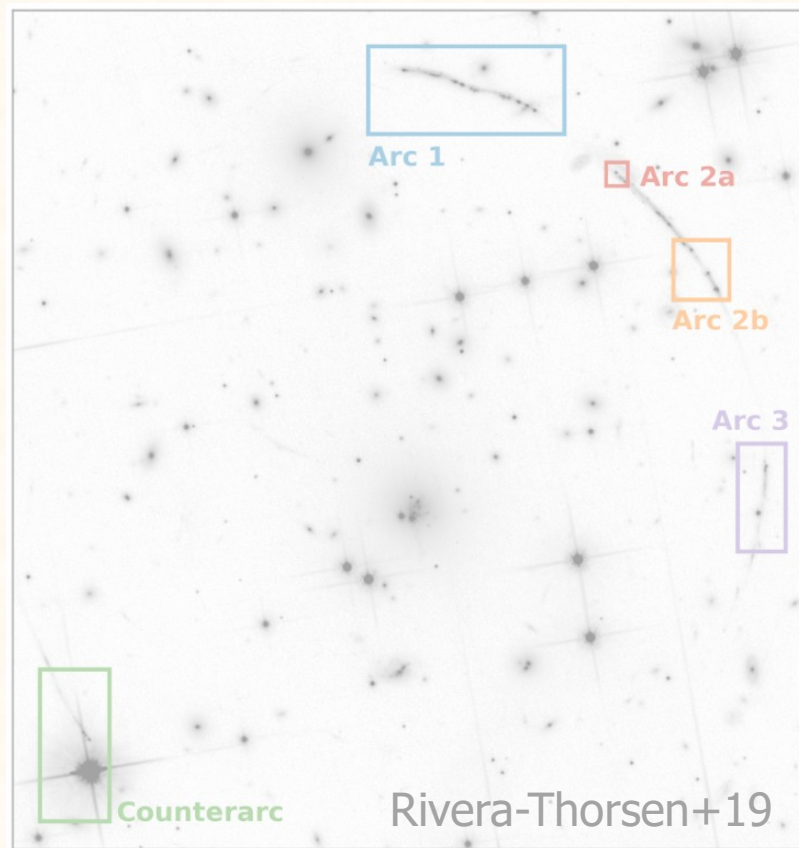


Rivera-Thorser

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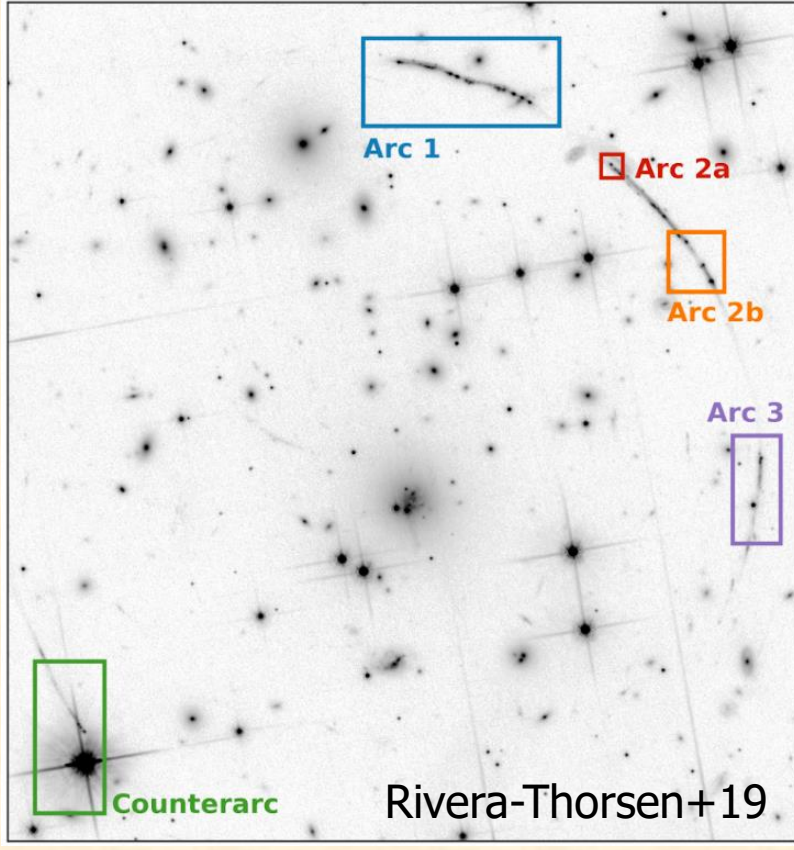
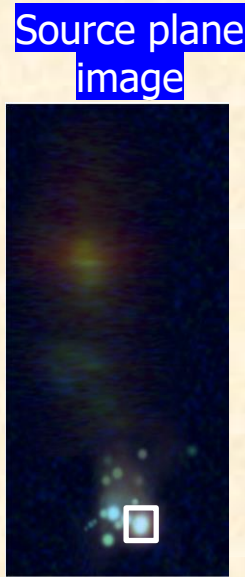
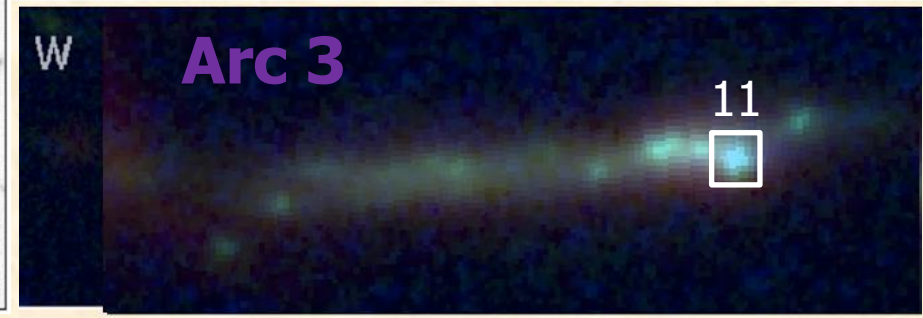
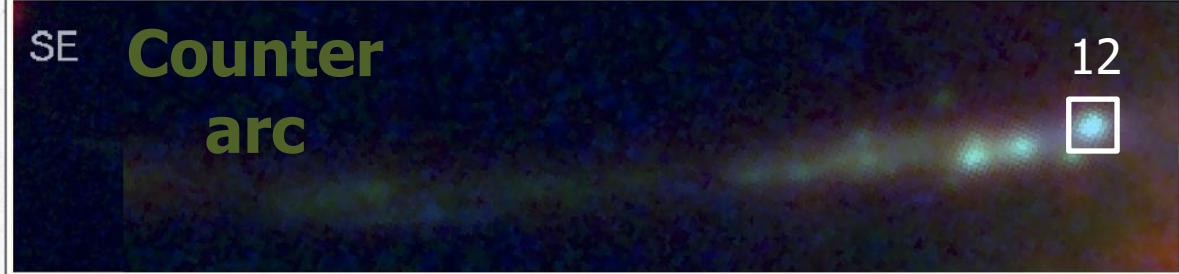
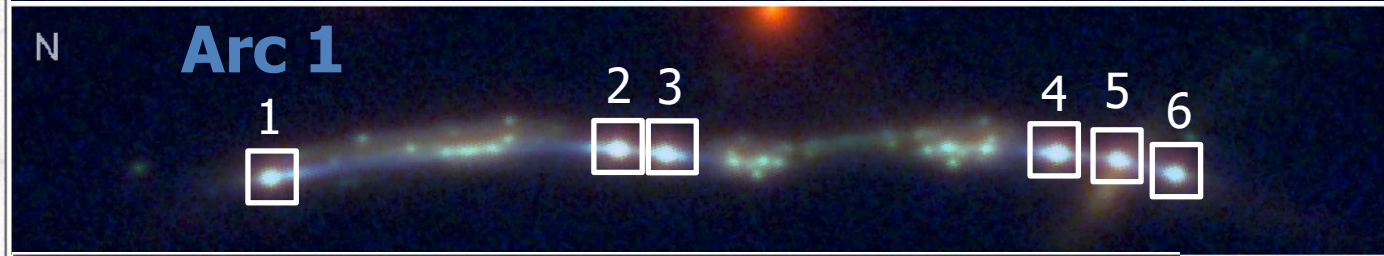
☐: The LyC leaking knot

Source plane image of the galaxy



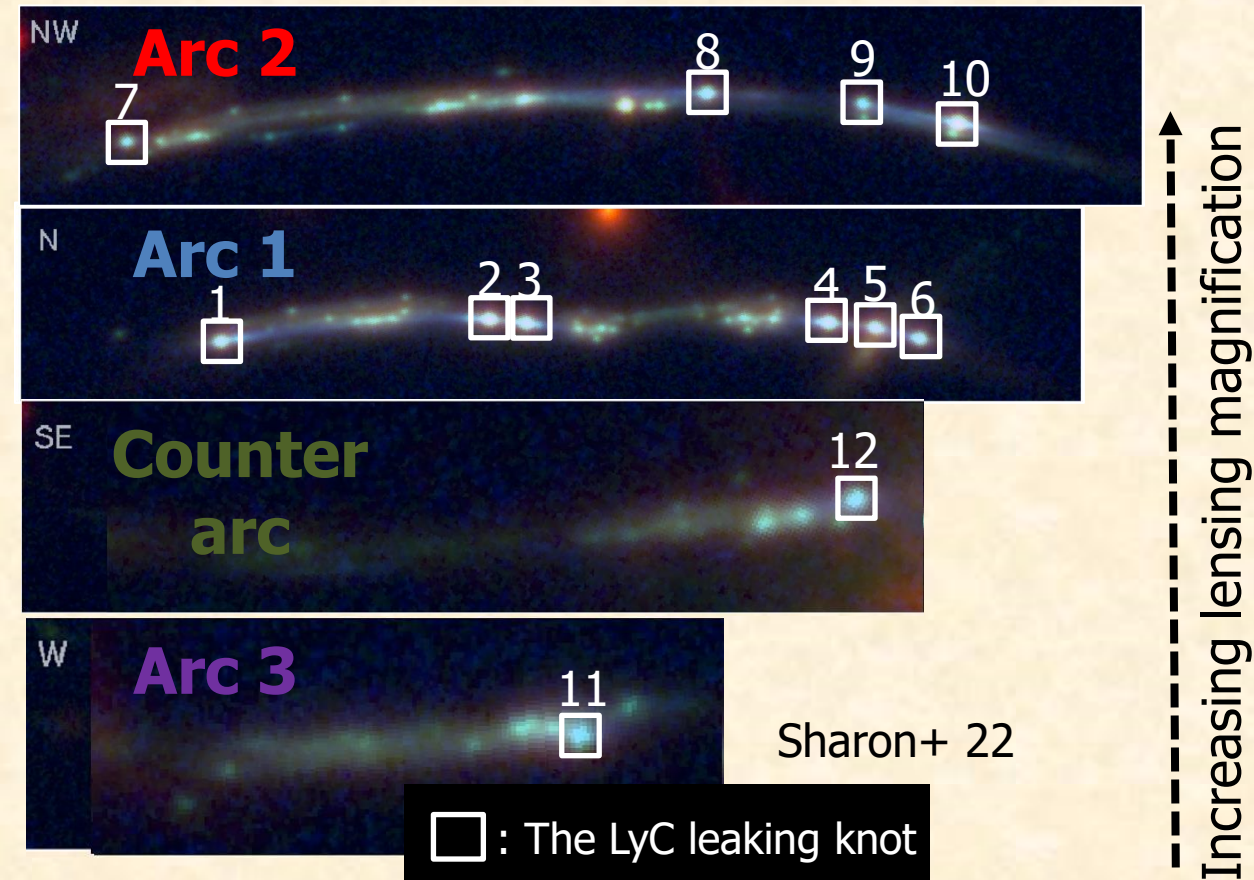
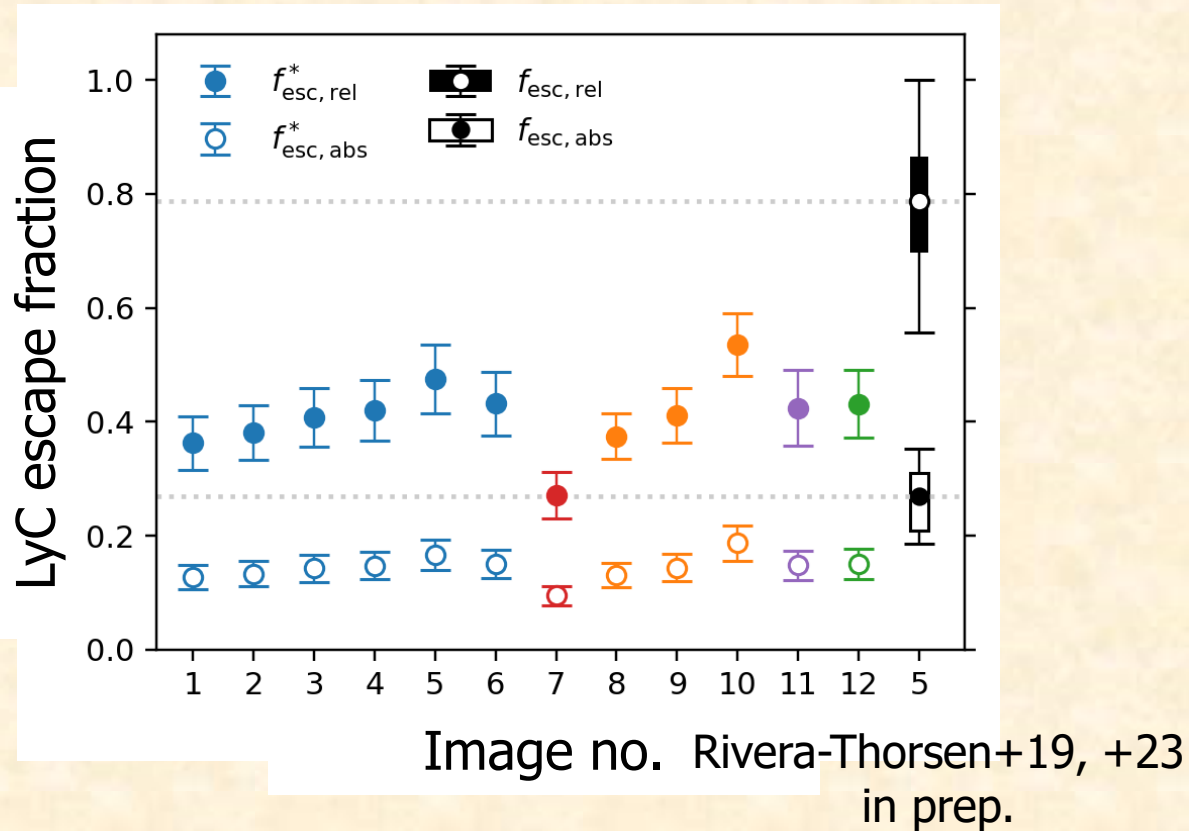
Sunburst Arc: A gravitationally-lensed star-forming galaxy with **LyC leakage**, serving as a unique laboratory **to zoom-in where LyC is leaking** in the galaxy.

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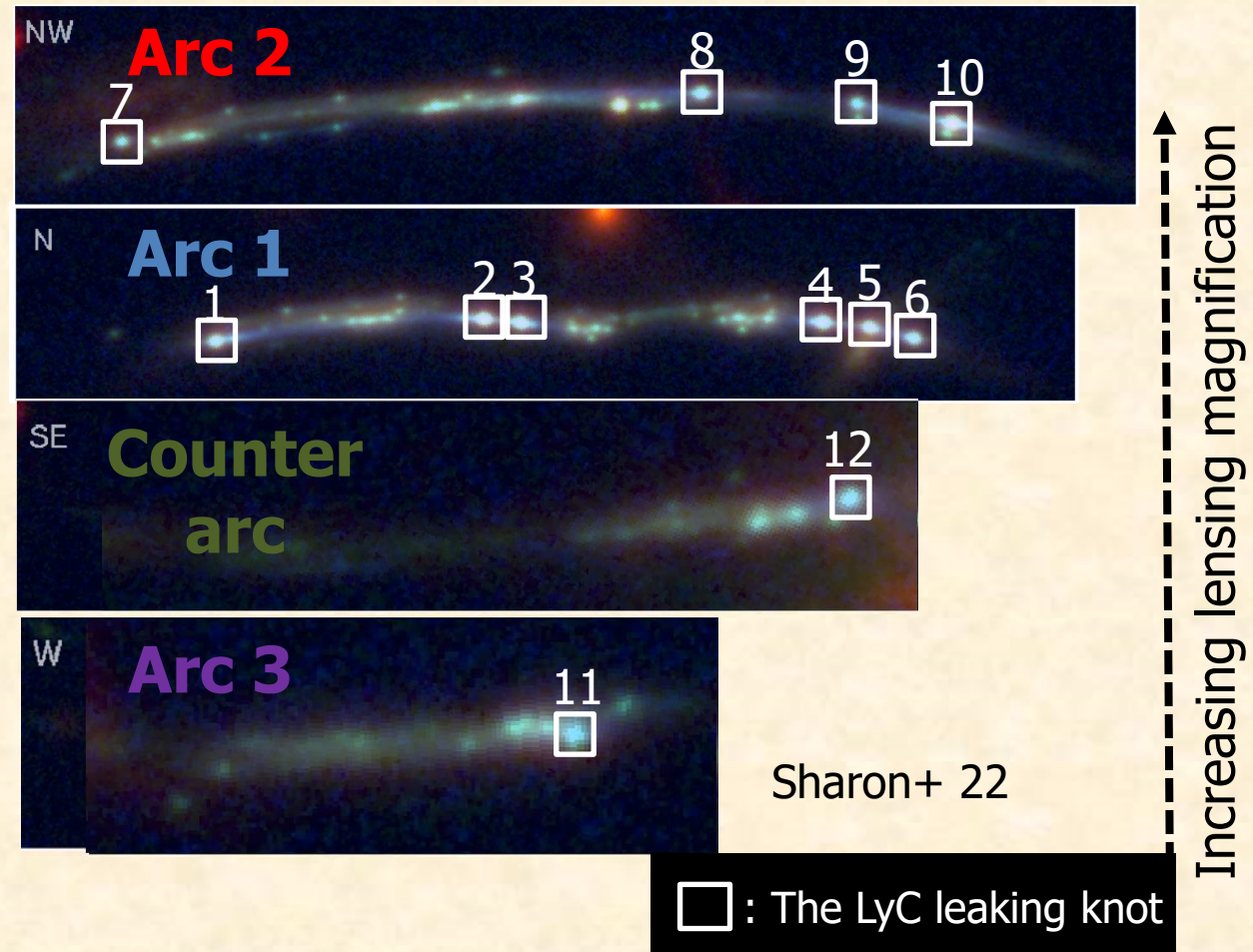
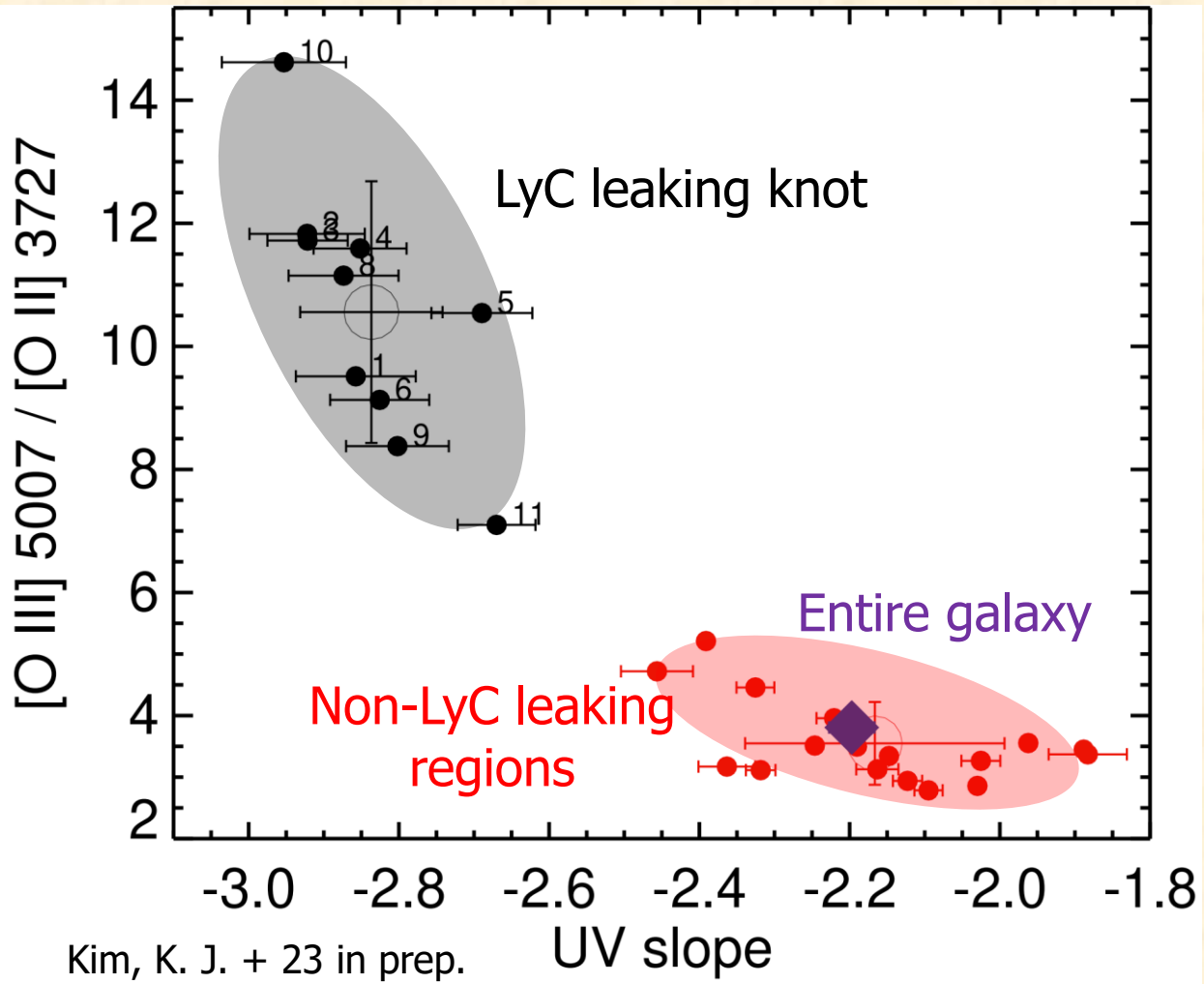


* **LyC escape fraction:** 78 % (relative) and 27 % (absolute)

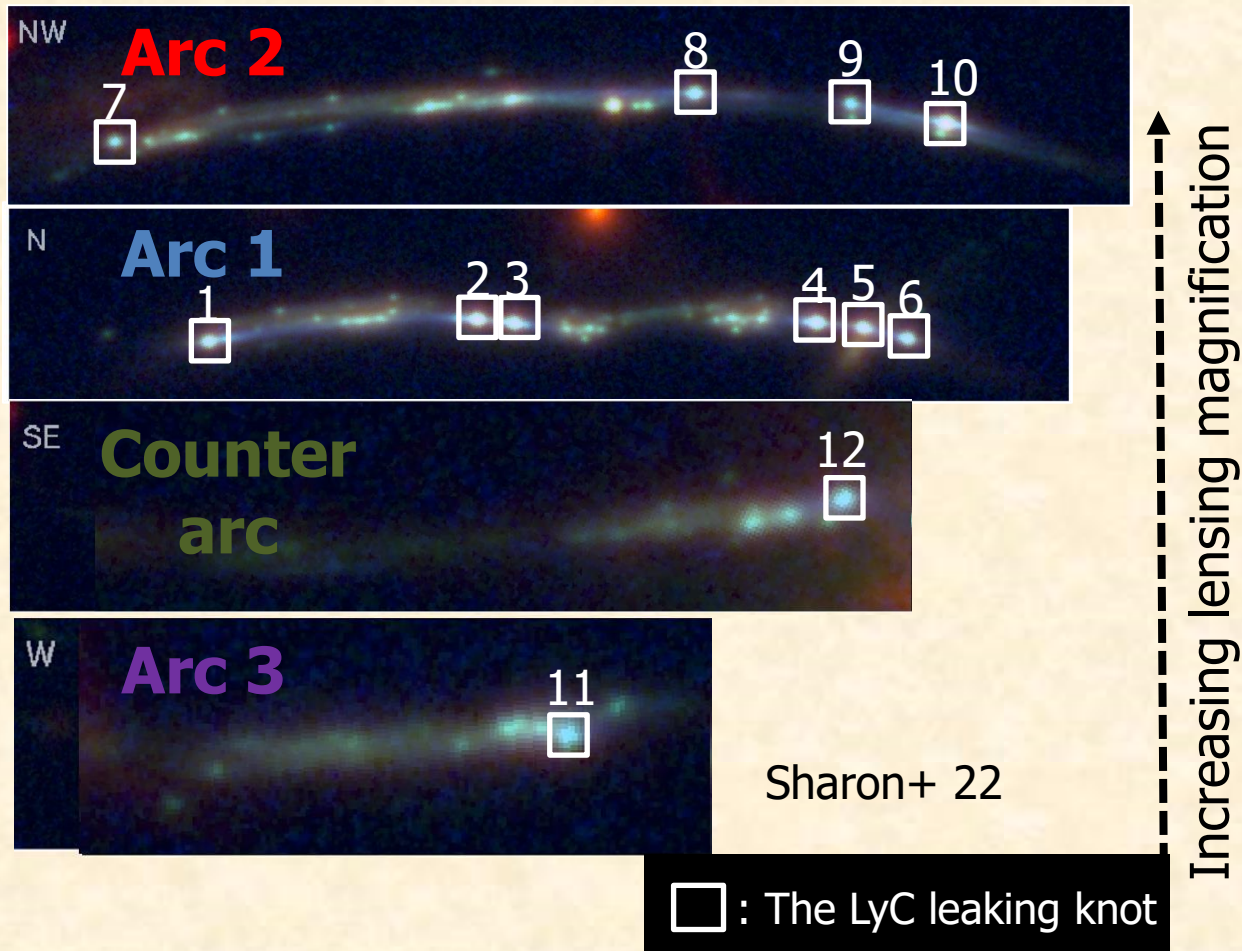
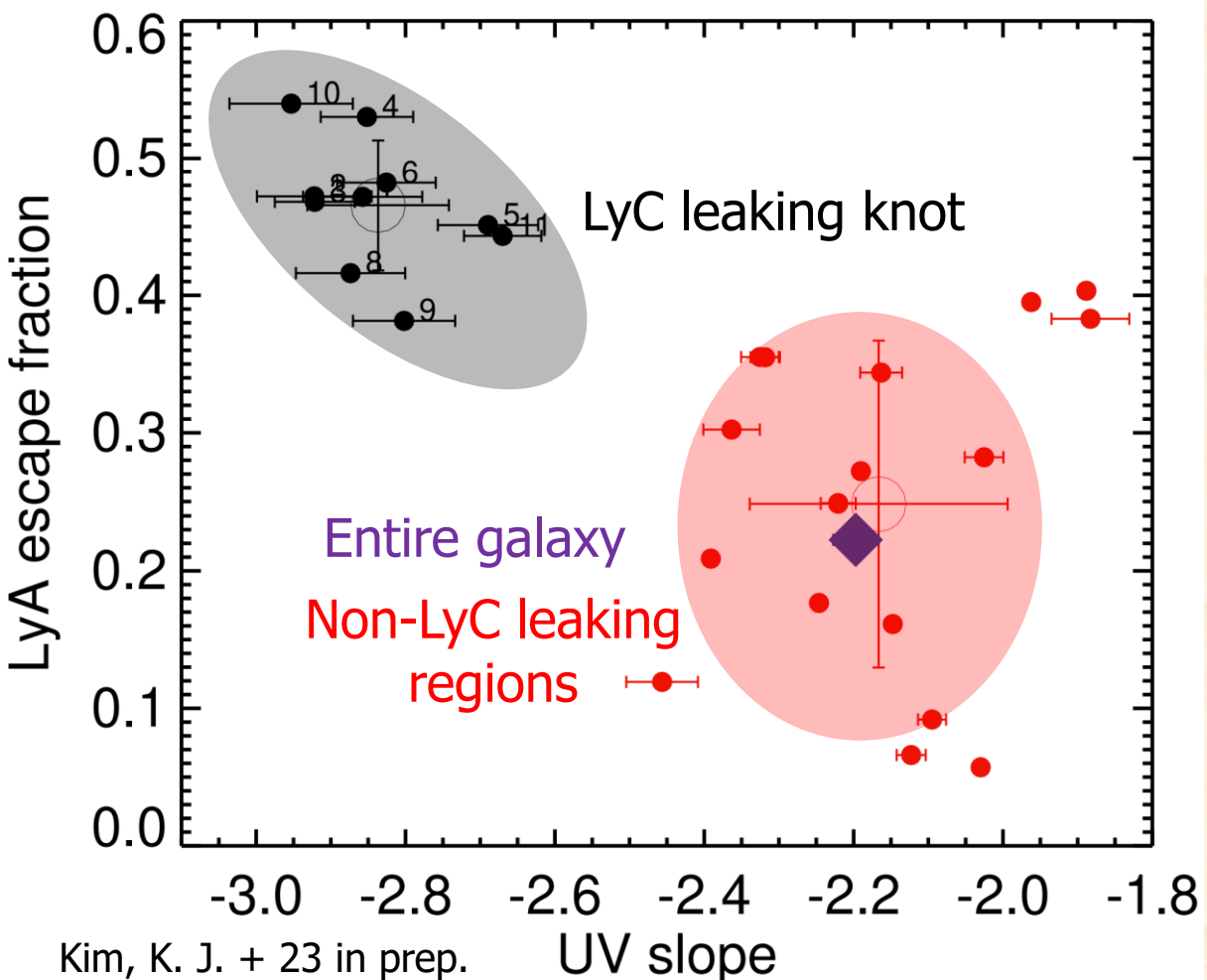
* Far-UV SED modelling shows a **very young (3 Myr) age** and **sub-solar ($0.55 Z_{\odot}$) metallicity** of the leaking region (Chisholm+19).

* Also, Triple-peaked LyA profile (Rivera-Thorsen+17), star cluster formation (Vanzella+22) *Galactic outflow (Mainali+23)

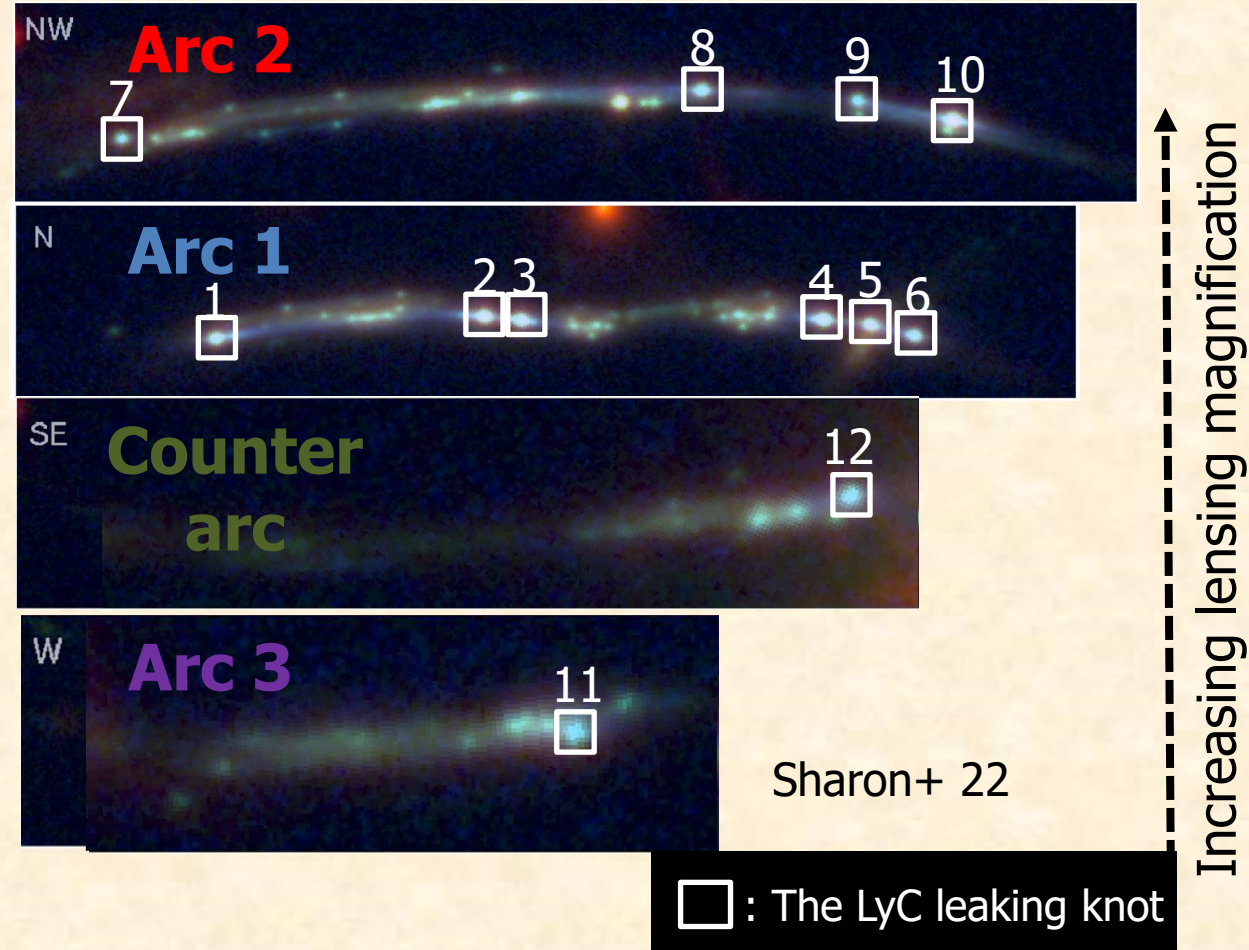
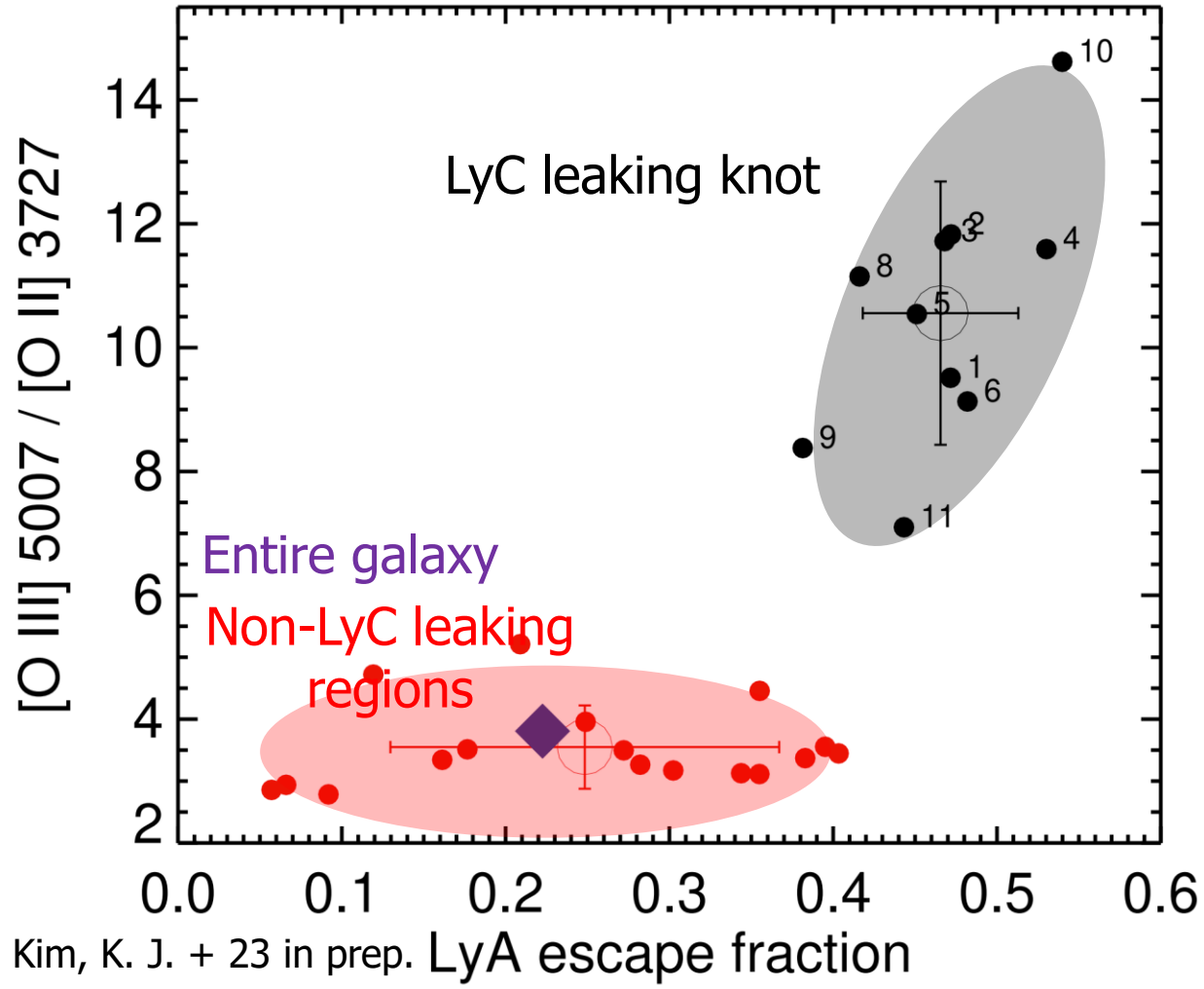
Spatially-resolved UV slope and Oxygen line ratio analysis reveals **very blue UV-continuum slope ($\beta \sim -2.9$)** and **high O32 ratio of the LyC leaking region.**



Spatially-resolved UV slope and LyA analysis reveals **very blue UV-continuum slope ($\beta \sim -2.9$)** and **high LyA escape fraction of the LyC leaking region.**



Spatially-resolved LyA emission and Oxygen line ratio analysis reveals **high O32 ratio** and **high LyA escape fraction of the LyC leaking region.**

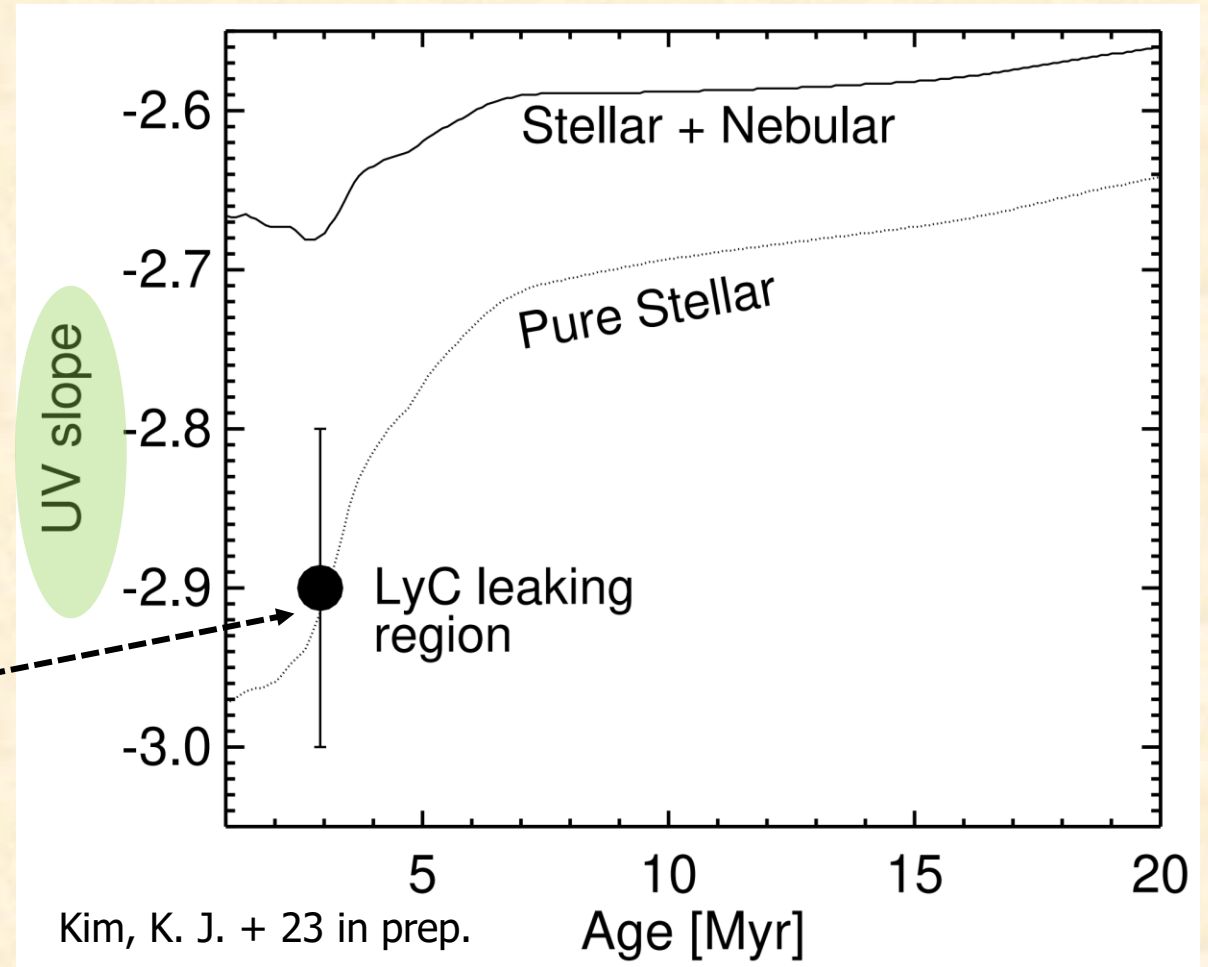
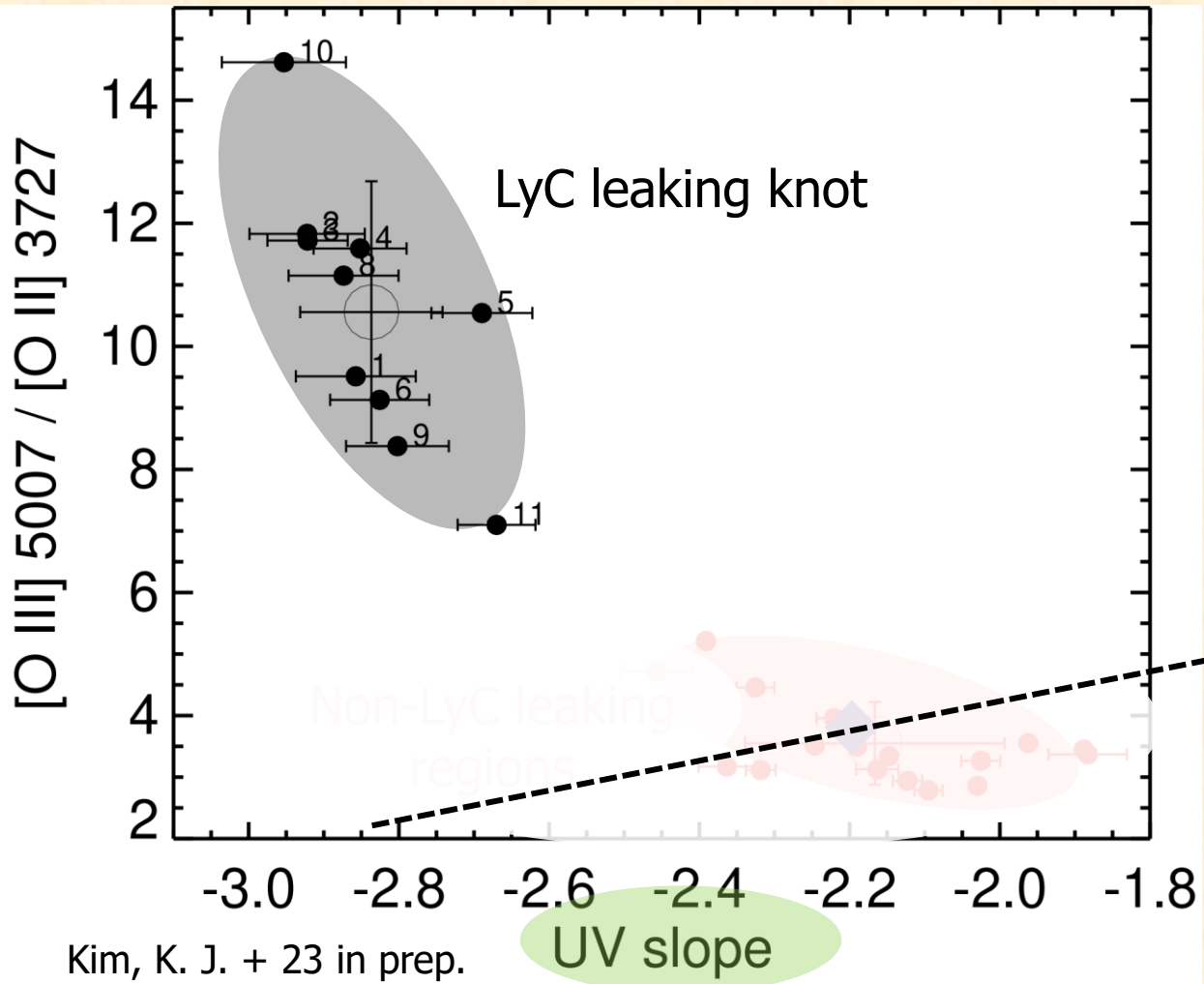


Distinctly Extreme properties of the leaking region

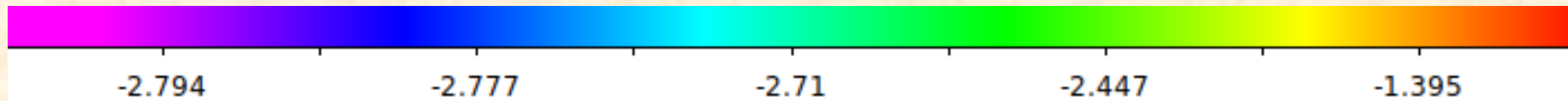
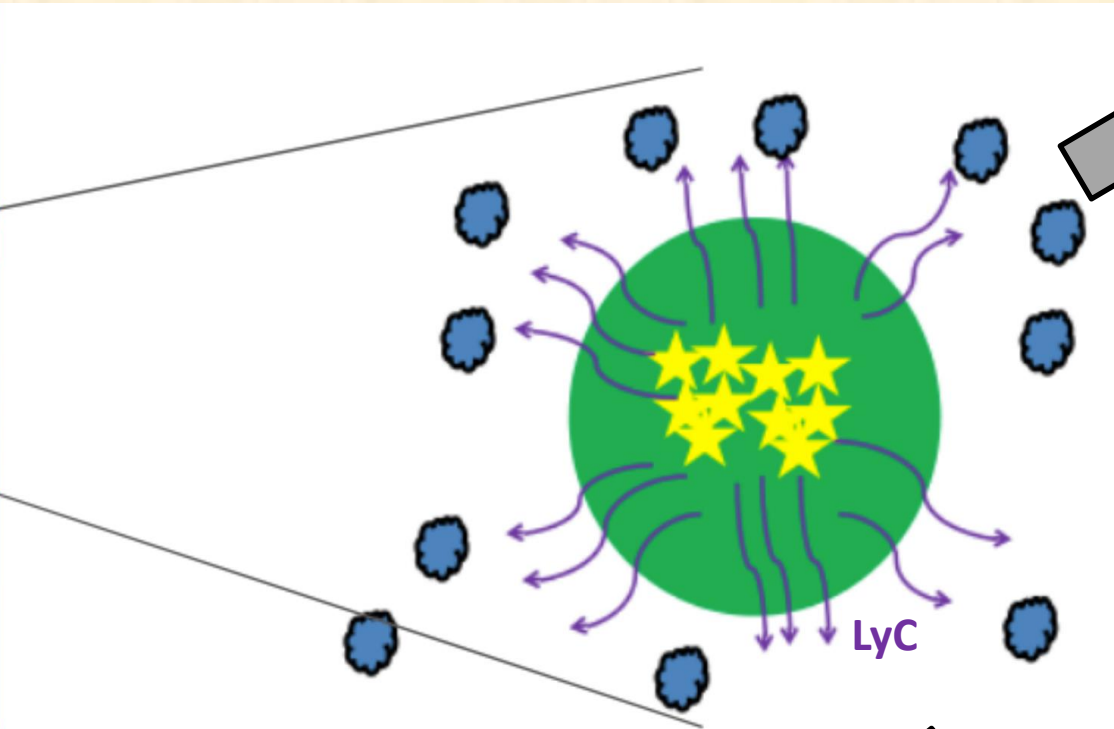
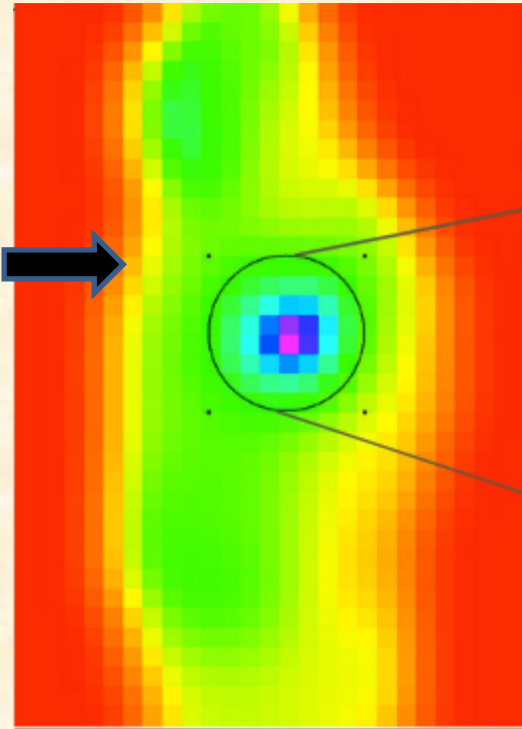
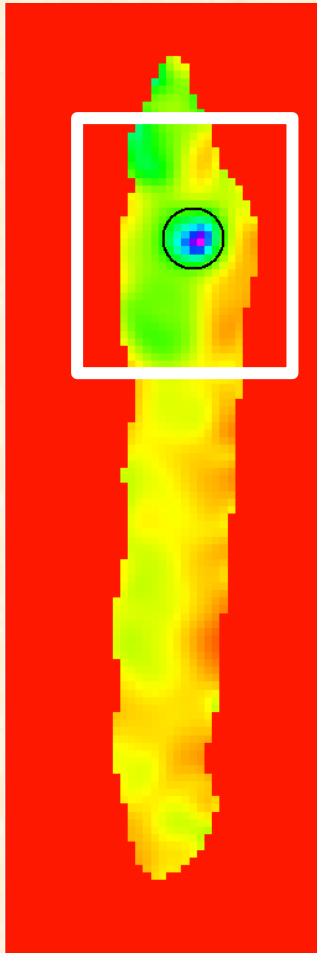
Region	UV slope (β) 1600–2400 Å	[O III]/[O II] 5007/3726,3729	[O III]/H β 5007/4861	$f_{\text{esc}}^{\text{Ly}\alpha}$	EW(Ly α) [Å]	EW(H β) [Å]	EW([O III]) [Å]	EW([O II]) [Å]
LyC leaking region	-2.9 ± 0.03	10.6 ± 0.7	10.4 ± 0.2	0.47 ± 0.02	42 ± 1.3	96 ± 3.6	1034 ± 41	39 ± 2.8
Non-leaking regions	-2.2 ± 0.04	3.5 ± 0.16	7.0 ± 0.22	0.25 ± 0.03	24 ± 5.9	45 ± 6.9	334 ± 54	47 ± 8.1
Entire galaxy	-2.2	3.8	7.7	0.22	33	65	503	56

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Spatially-resolved UV slope and Oxygen line ratio analysis reveals **very blue UV-continuum slope ($\beta \sim -2.9$)** and **high O32 ratio of the LyC leaking region.**



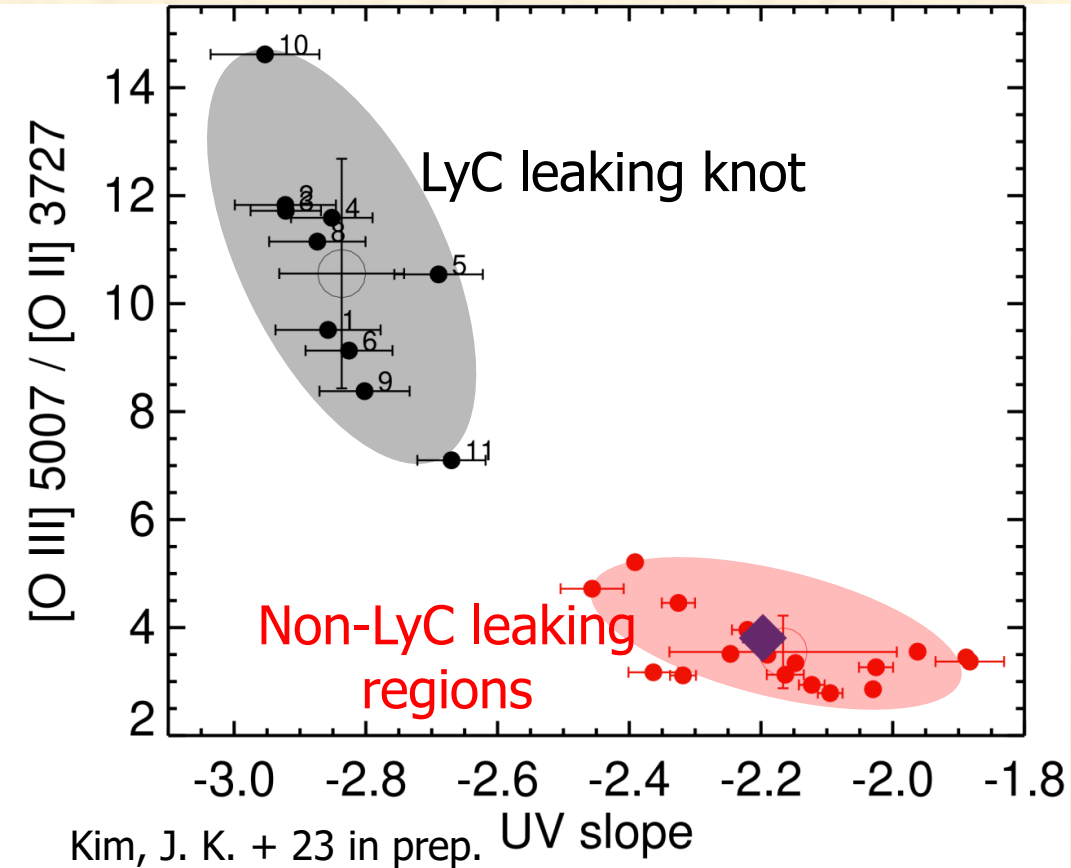
UV Slope map of the Sunburst Arc: Distinctly very blue UV slope of the leaking region suggesting highly **local, directional** escape process of LyC radiation



UV Slope β

Very blue UV slope in LyC leakage 14

Summary and Conclusions



* The Sunburst galaxy is a gravitationally-lensed LyC-leaking galaxy at $z = 2.37$, providing unique opportunities to investigate **the physical characteristics of the leaking region in a spatially-resolved manner (< 100 pc)**.

* The UV slope of the leaking knots show **very blue slope ($\beta \sim -2.9$)**.
→ The leaking knot's UV spectrum is dominated by pristine massive stellar light with little nebular continuum emission.

* **The blue UV slope is closely related to high $[O III]/[O II]$ and high LyA escape fraction.**

→ The highly ionized star-forming region is dominated by young and massive stars, getting close to resolving a “pure” young starburst region with LyC leakage.

* **Distinctly extreme properties of the leaking region suggest the highly localized, directional continuum escape process, rather than the isotropic escape.**

UV slope, Ly α , and nebular ionization: Kim, K. J. et al. 2022 in prep.

LyA profiles: Owens, M. R. et al. 2023 in prep

Ionizing structure metallicity R23: Rigby, J. R. et al. 2022 in prep.

Improved LyC escape fraction: Rivera-Thorsen, E. et al. 2022 in prep.

kim2k8@ucmail.uc.edu <https://sites.google.com/view/astrokeunhokim>

Backup Slide: UV Slope vs. Relative lensing magnification of the LyC leaking knots

