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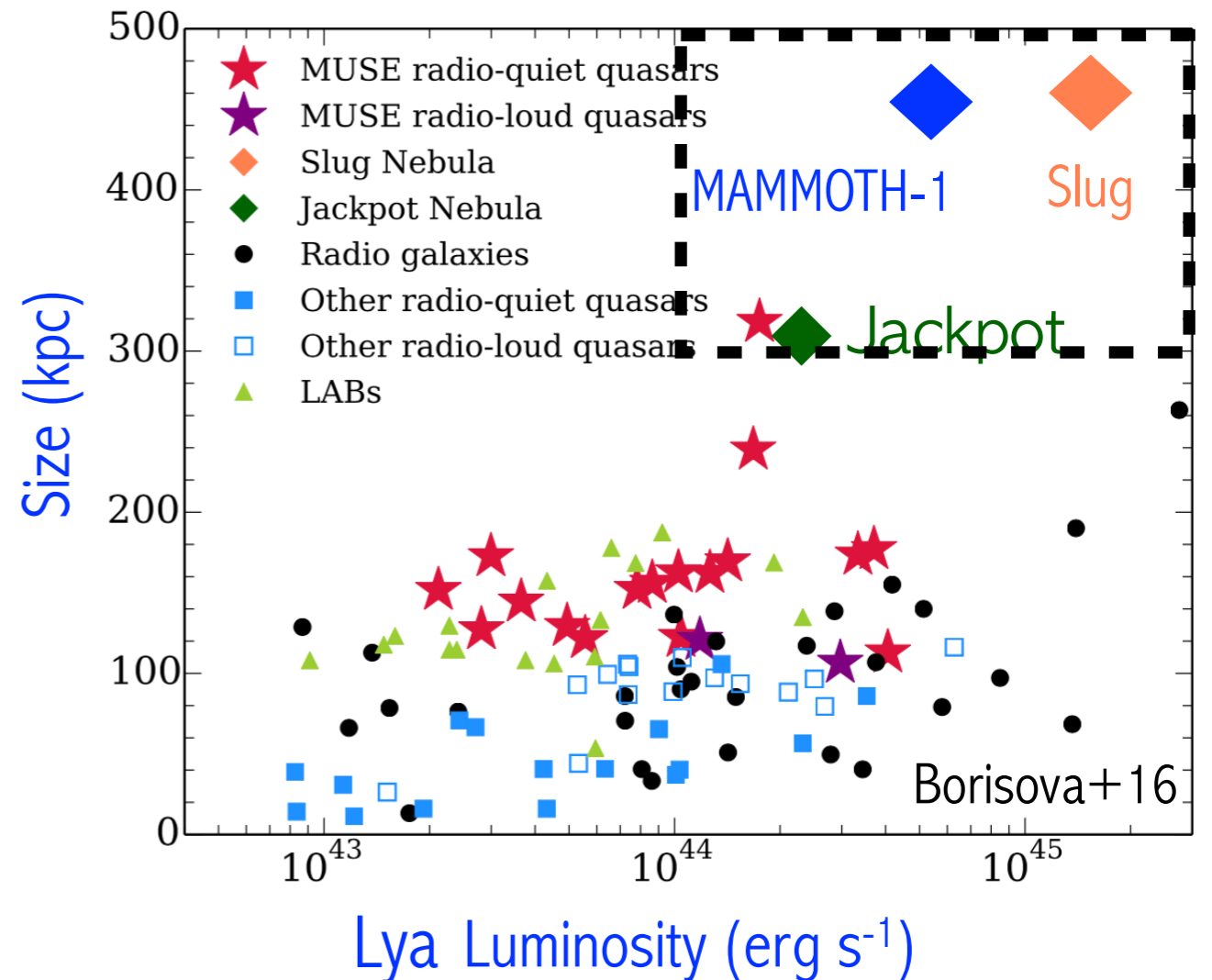
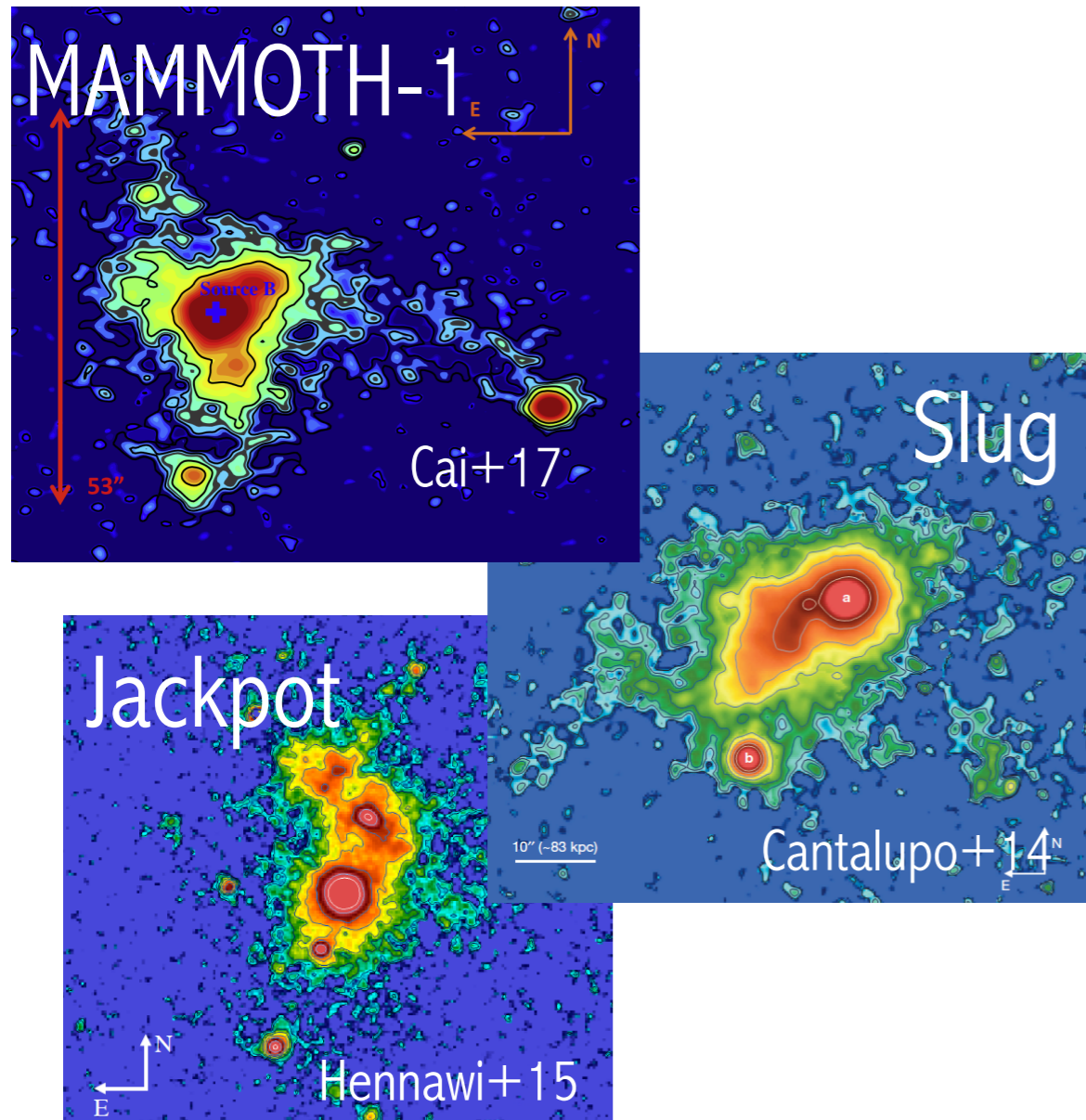
Testing the physical origins of an Enormous Ly α Nebula at $z = 2.3$ by bright background galaxies

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in collaboration with...

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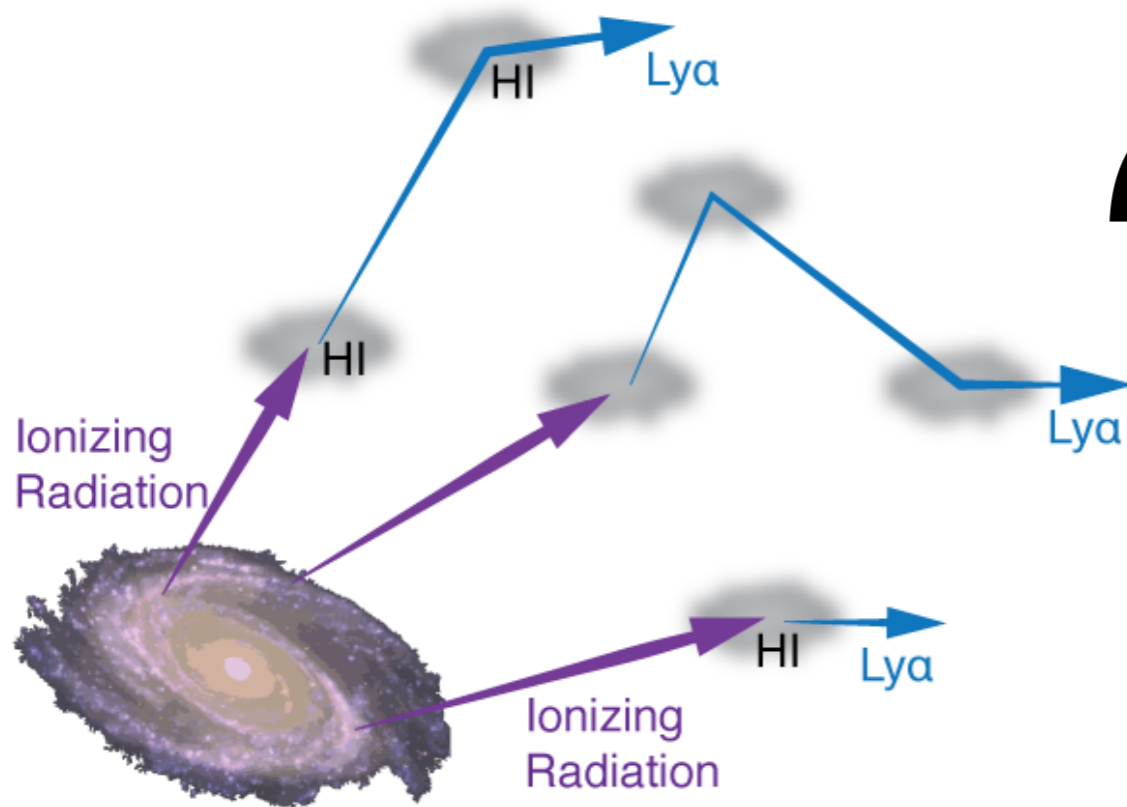
Enormous Ly α Nebulae (ELANe)



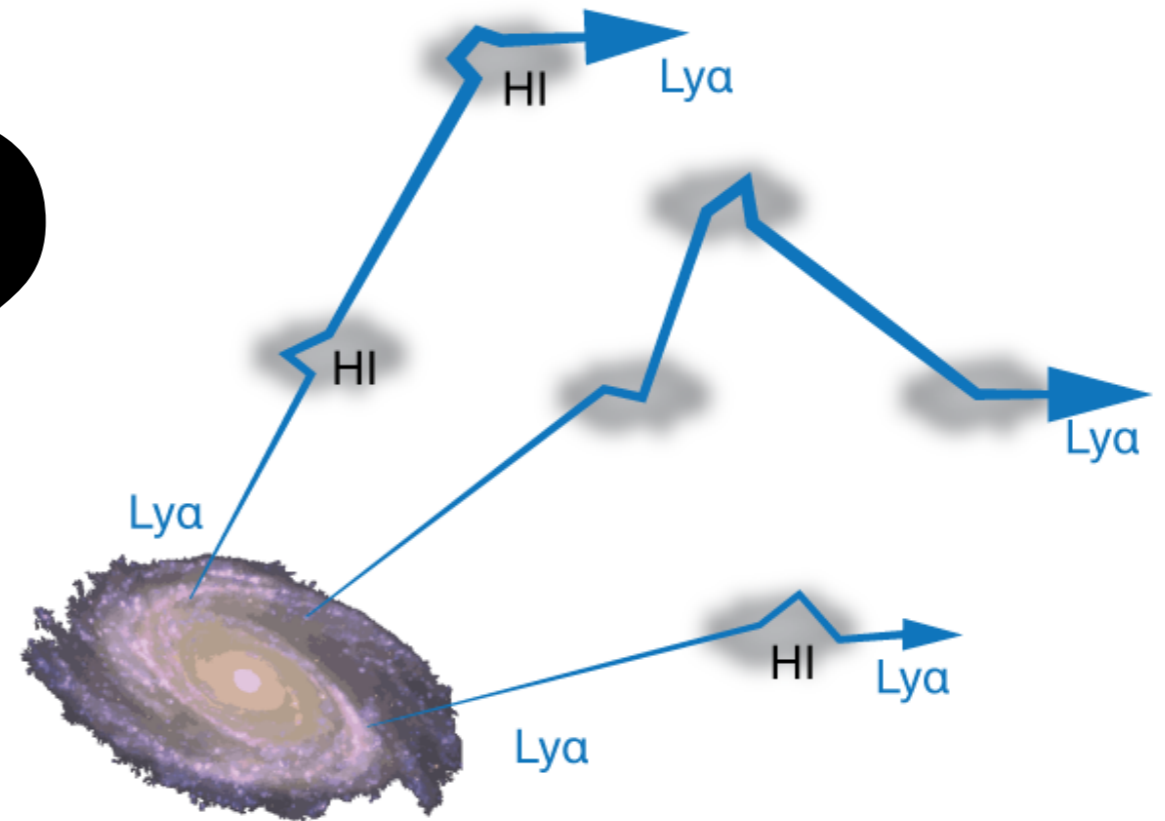
- **extremely** luminous/extended Ly α sources w $L_{\text{Ly}\alpha} > 10^{44} \text{ erg s}^{-1}$
Size $> 300 \text{ pkpc}$
- beyond viral diameter (280 pkpc) of host qso \rightarrow trace IGM filaments

Physical origins

① Fluorescence



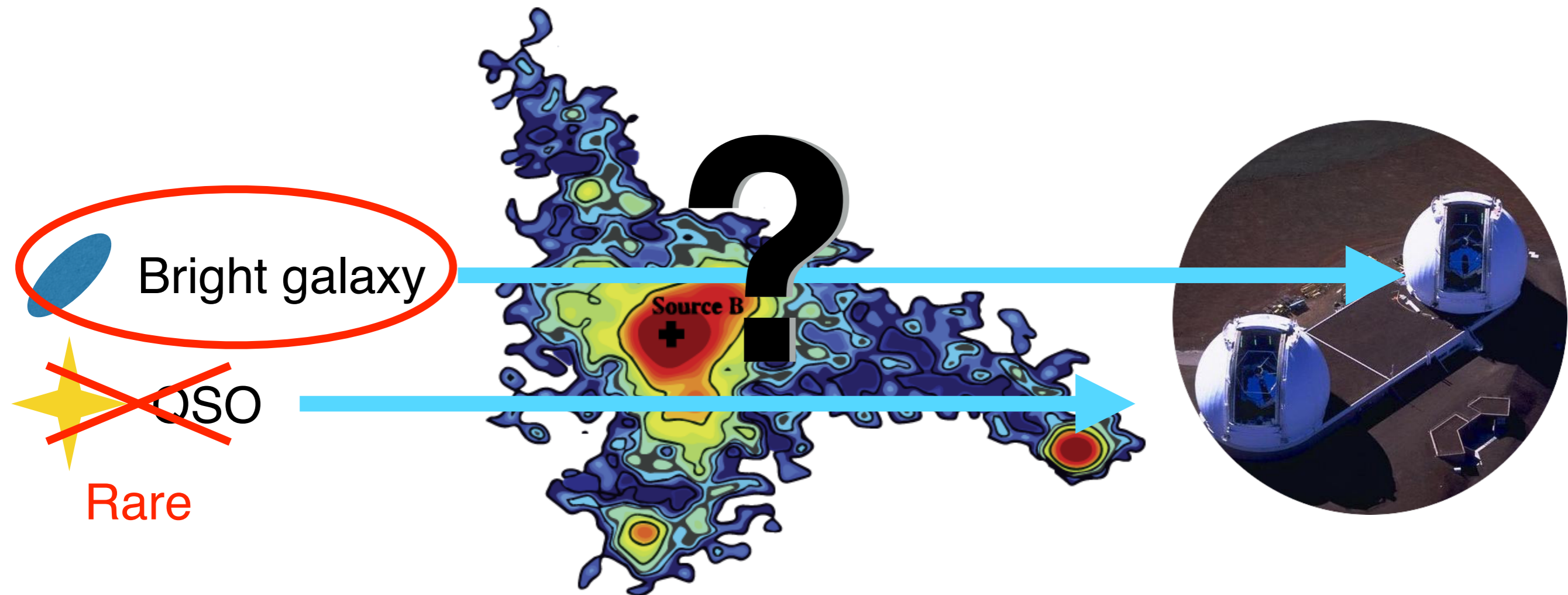
② Scattering



- no strong constraints on the physical origin
- HI property is still unknown—> optically thin? thick?

Key quantity: HI Optical depth of extended Lya components

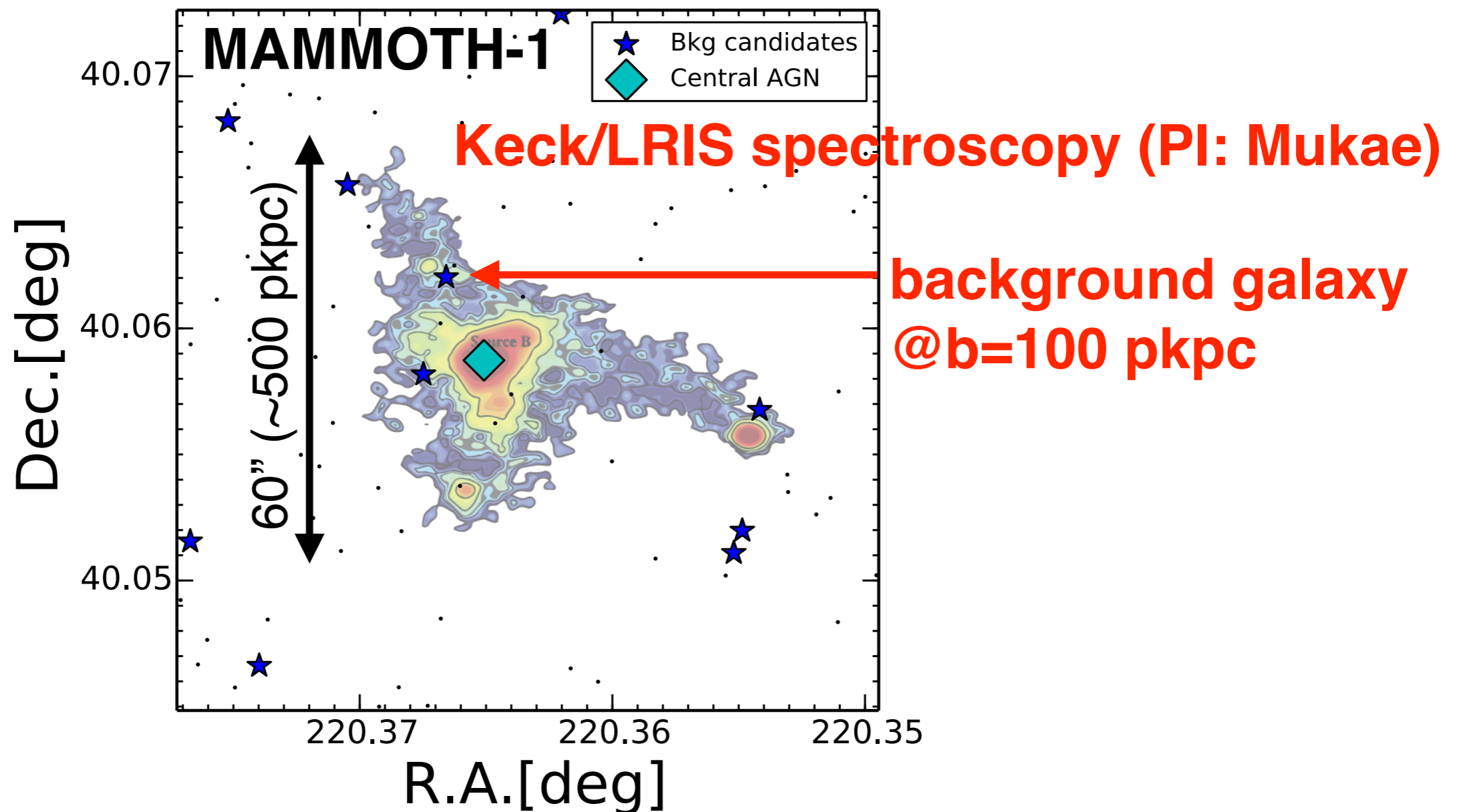
Background sources



- to constrain HI optical depth of extended Ly α components,
—> **HI absorptions** in background galaxy spectra

Data and observations

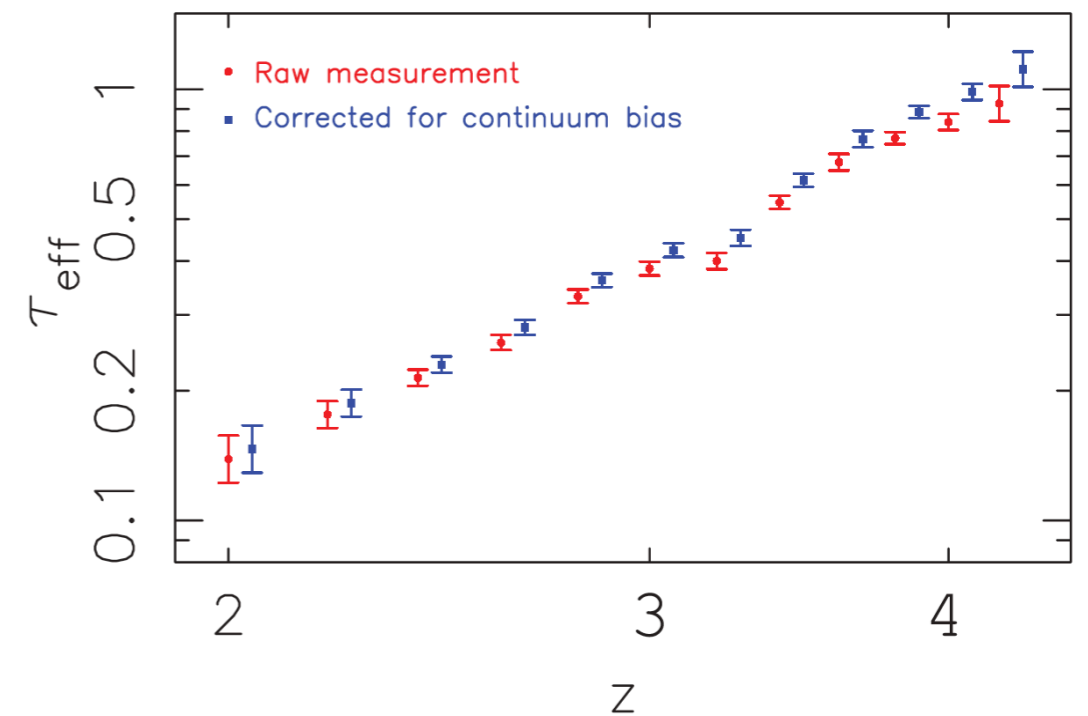
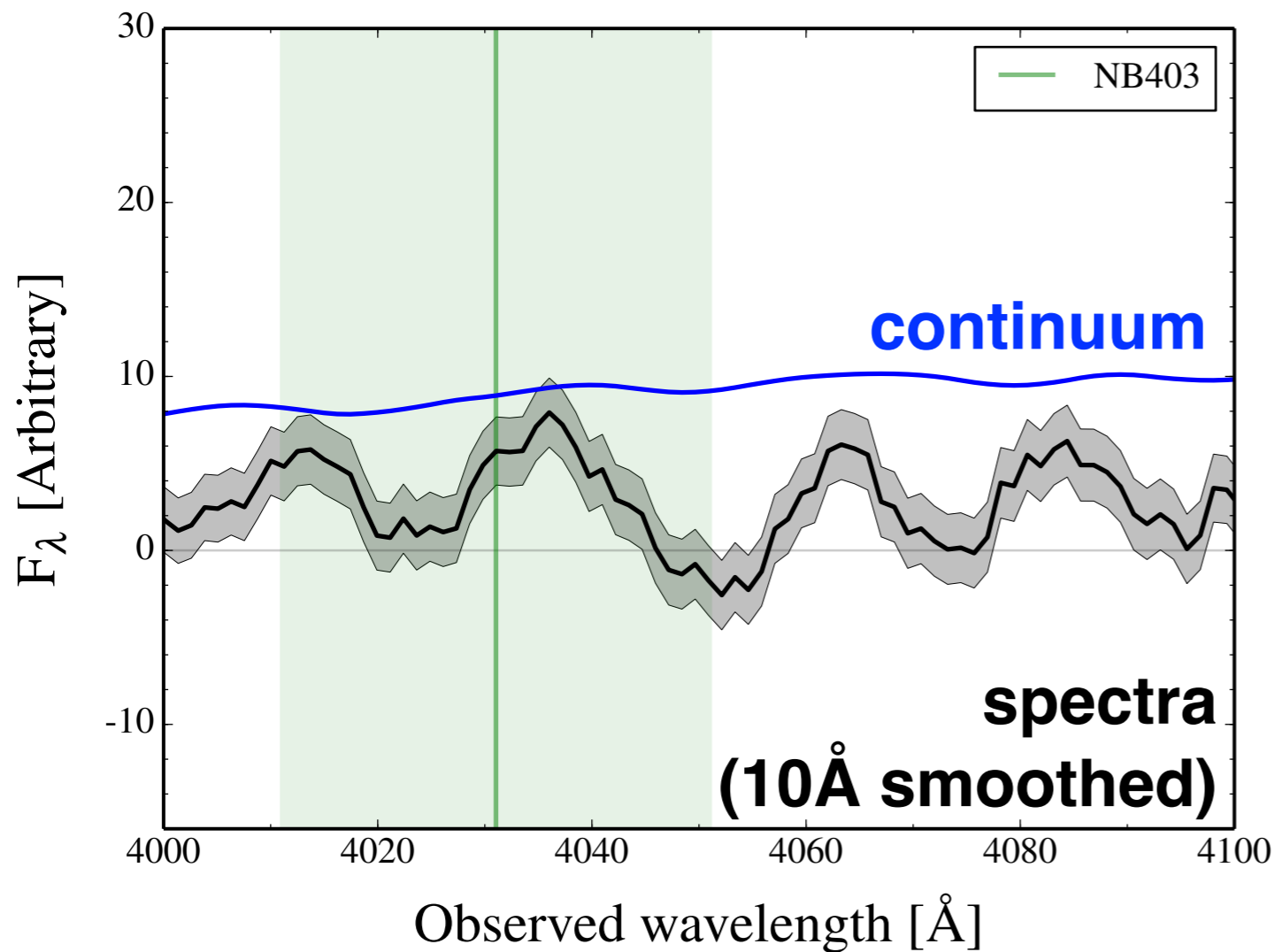
- **ELAN:** MAMMOTH-1 at $z = 2.32$ (Cai+17)
- **Background:** star-forming galaxies ($V_{AB}=23.8-24.6$) at $z=2.4-2.8$
- BX selection (Steidel+04) + Photo-z (EAZY; Brammer+08)
<— imaging data: LBT/LBC (U, V, i) & UKIRT/WFCAM (J, H)



Analysis – Background galaxy

Background galaxy at $z = 2.52$ ($V_{AB} = 24.5$)

- inspected with **Shapley+03 template** (chi-square)
- Mean flux-regulated continuum fit with **Berry+12 template** (Lee+12)

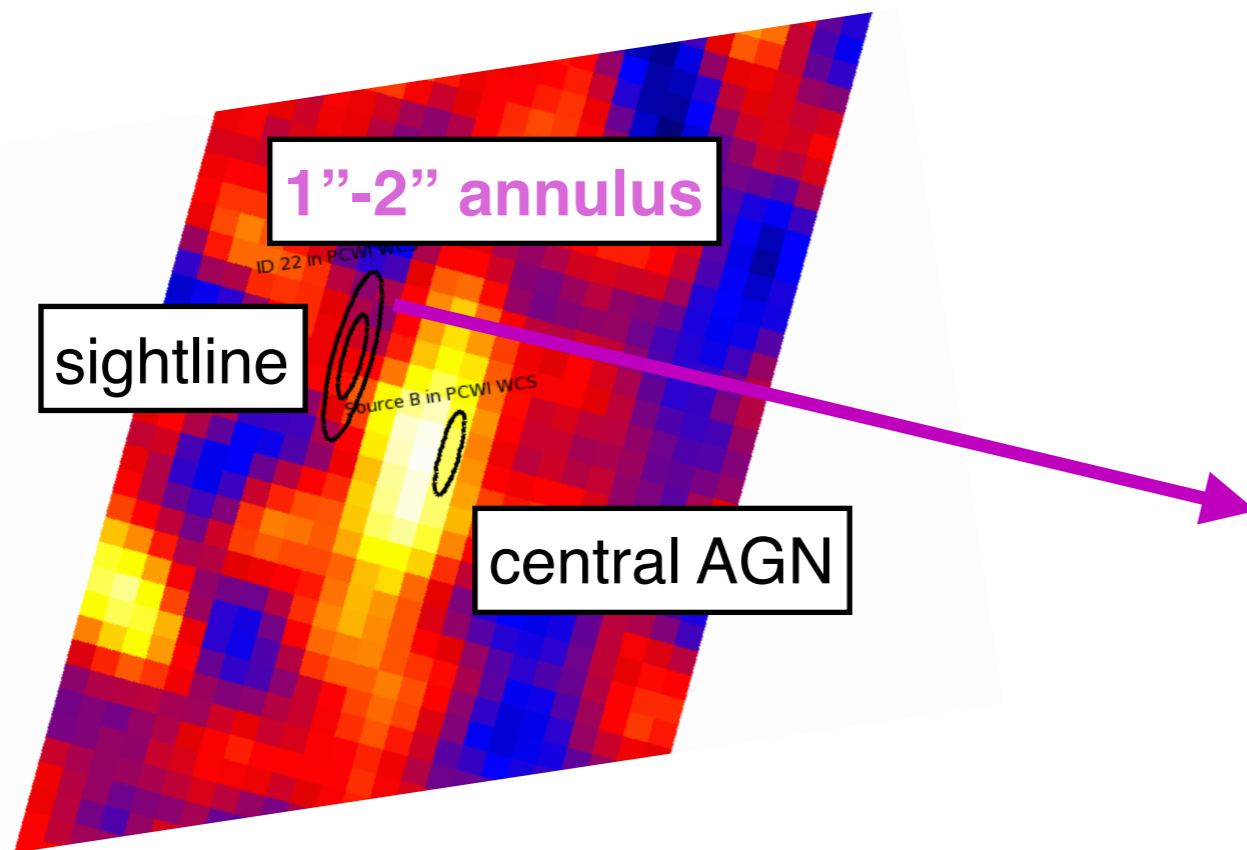


Cosmic mean flux
(Faucher-Giguère+08)

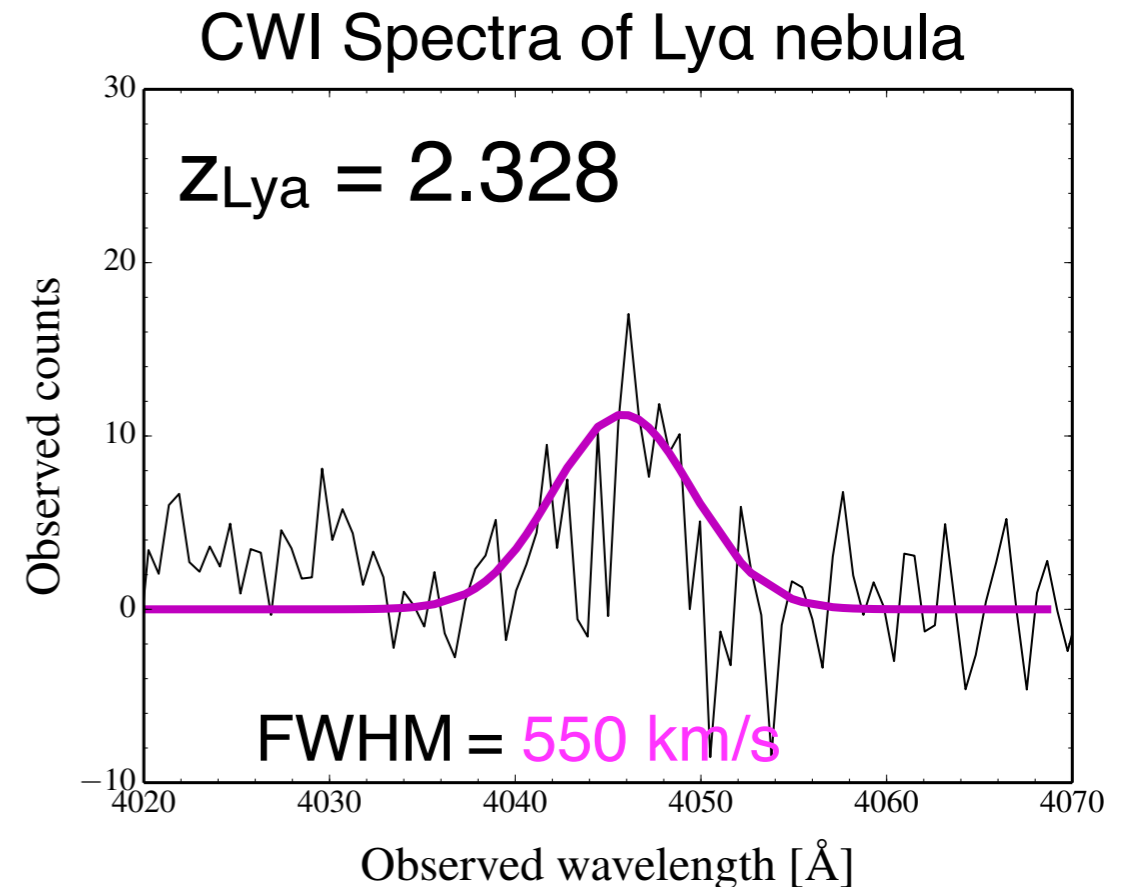
NB403 width is large ($\pm 1500\text{km/s}$) \rightarrow Where is the Ly α nebula??

Analysis – Ly α component

Ly α investigated with Palomar/CWI observations (PI: Zheng Cai)



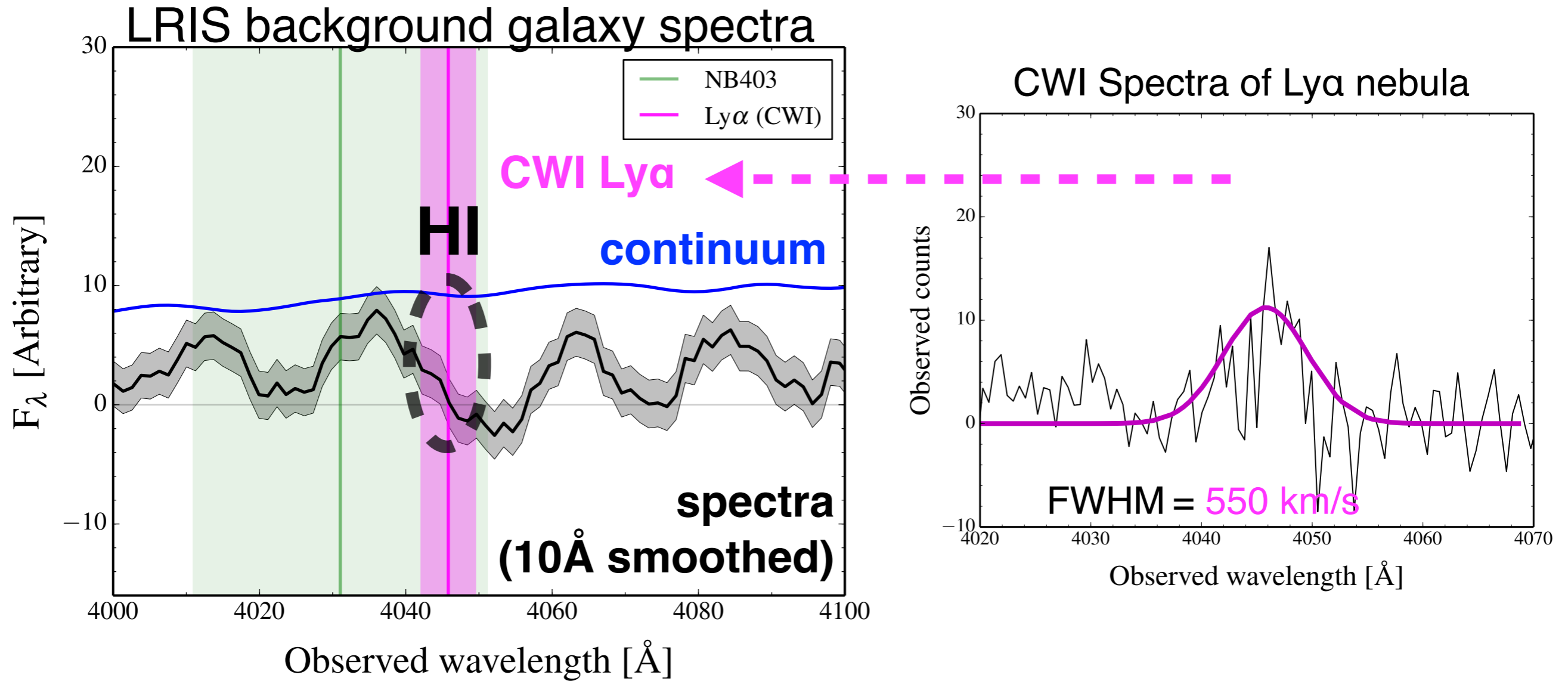
Datacube: 3800-4200Å (R~4000)



Ly α nebula emission around 1-2 arcsec

—> measure the wavelength range of the Ly α emission

Results – HI absorption



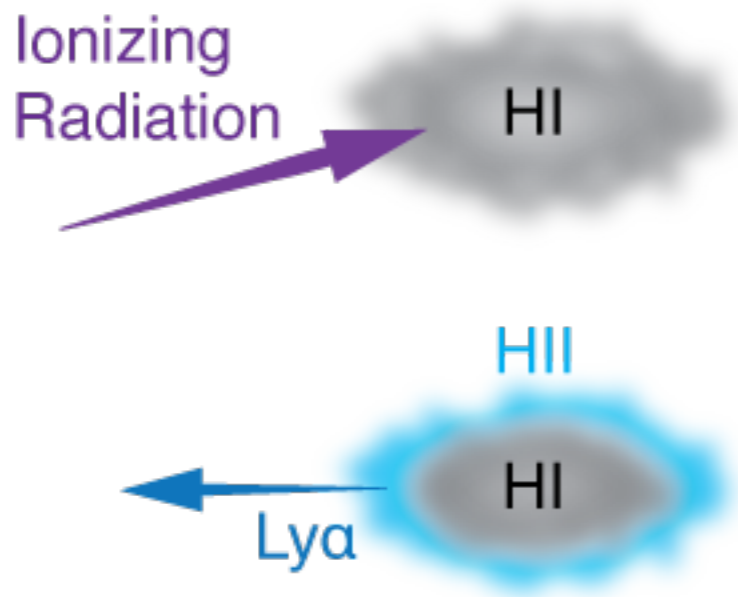
transmission $0.09 \pm 0.01 \rightarrow \tau = 2.36^{+2.99}_{-0.67}$

\rightarrow **HI is optically thick** @ bright Ly α nebula components ($b=100$ pkpc)

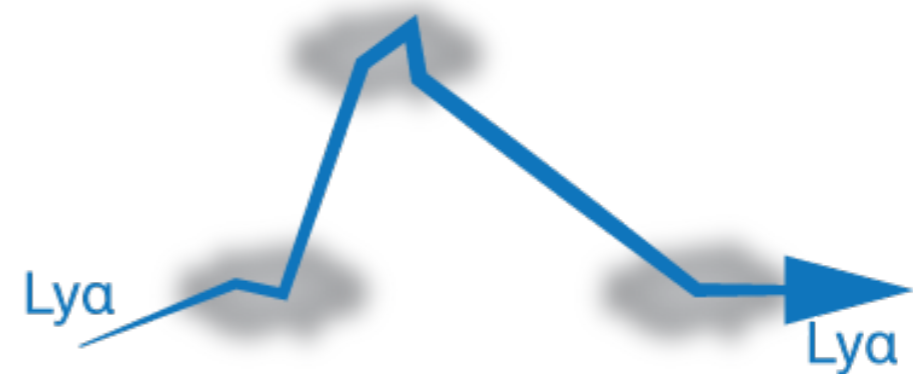
Discussion1 – physical origins

The optical depth indicates that the HI gas is optically thick cloud whose ionized(neutral) skin contributes to Fluorescence(Scattering)

① Optically thick Fluorescence



② Scattering

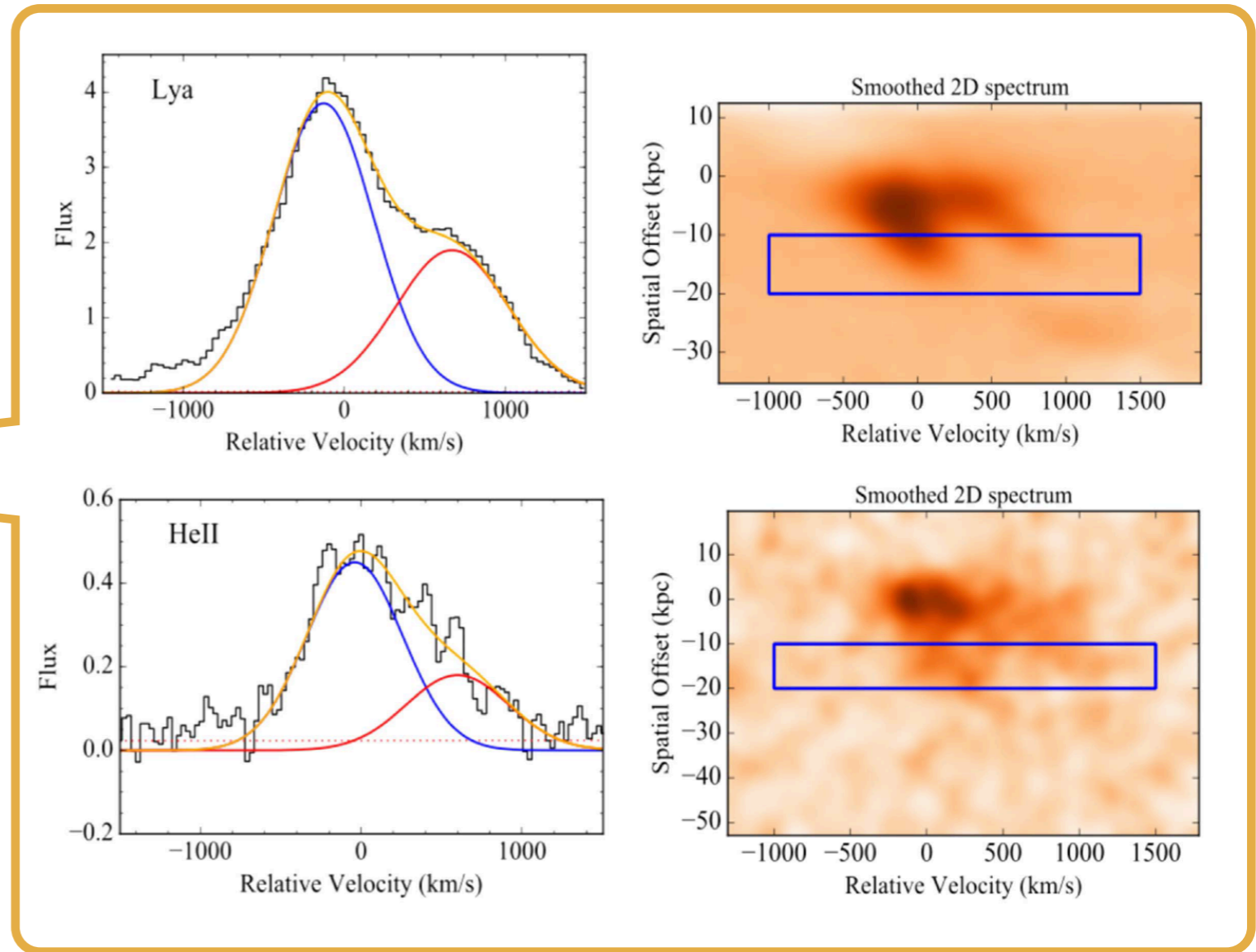
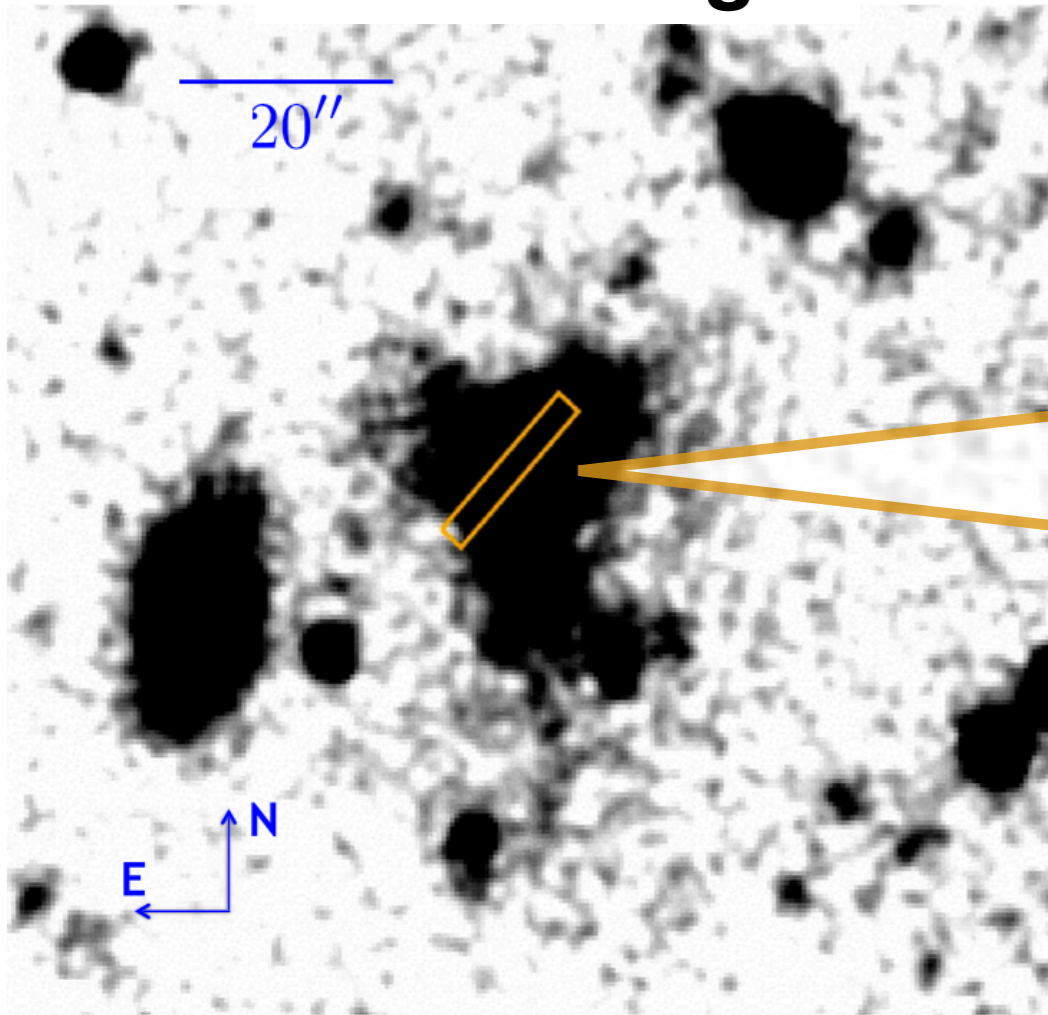


Key observation

HeII&CIV emissions @ bright Ly α nebula component

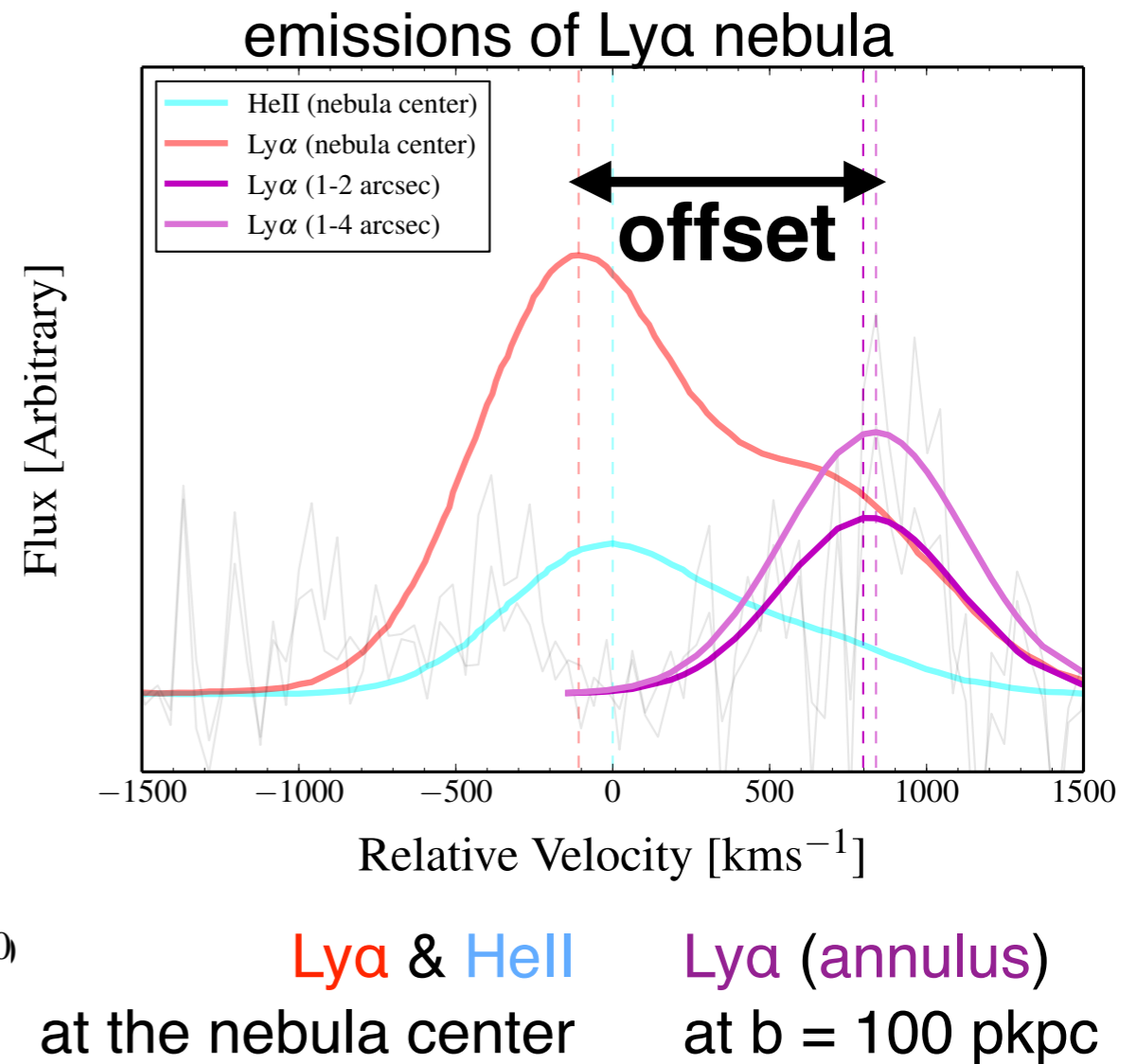
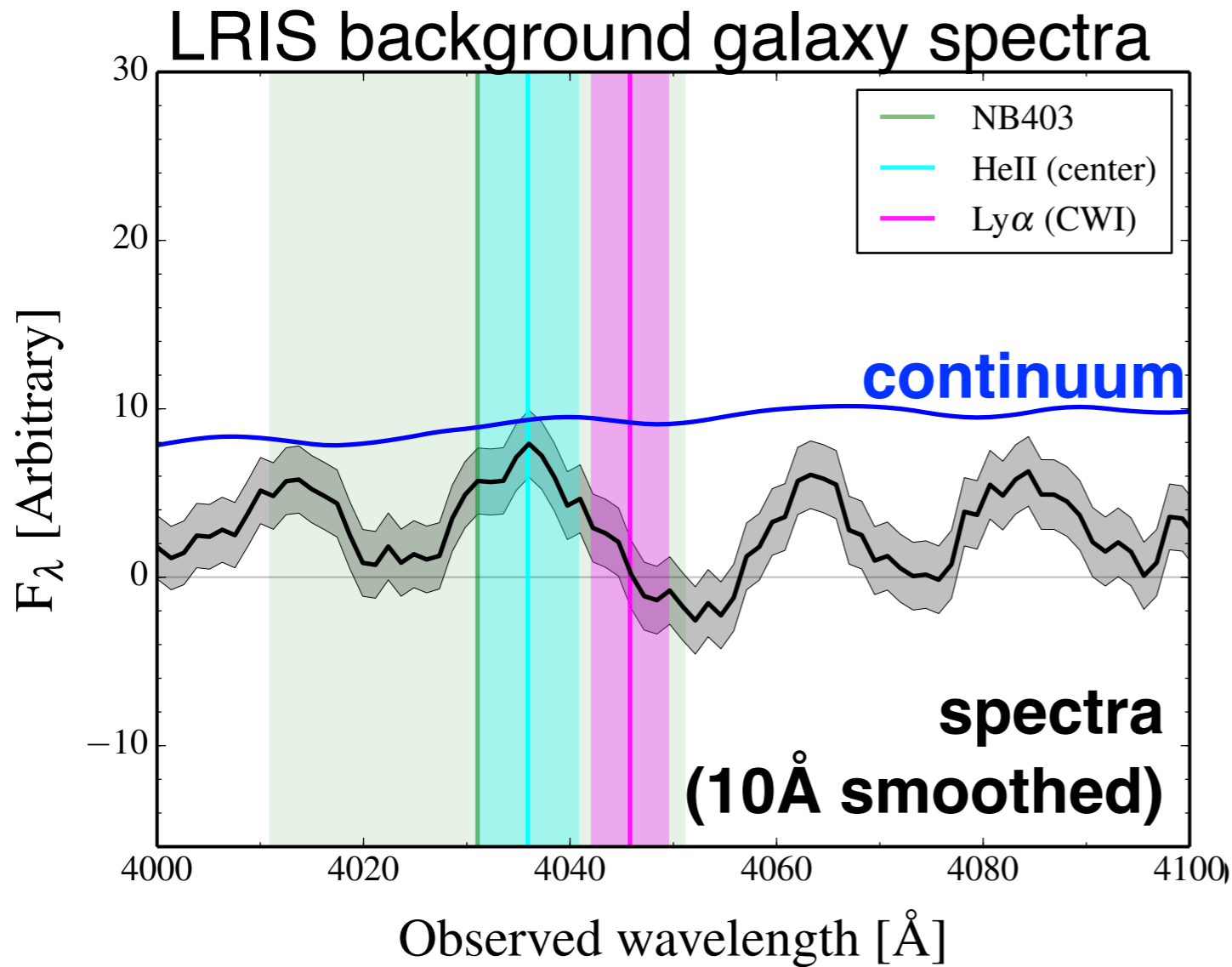
Discussion2—AGN proximity

NB403 image



Extended HeII at the center of MAMMOTH-1 (HeII/Ly α ~0.1; Cai+17)
—> assume z_{HeII} as the systemic redshift of MAMMOTH-1

Discussion2—AGN proximity



Bright Ly α nebula components @ $b=100$ pkpc: **spatially offset to the center**

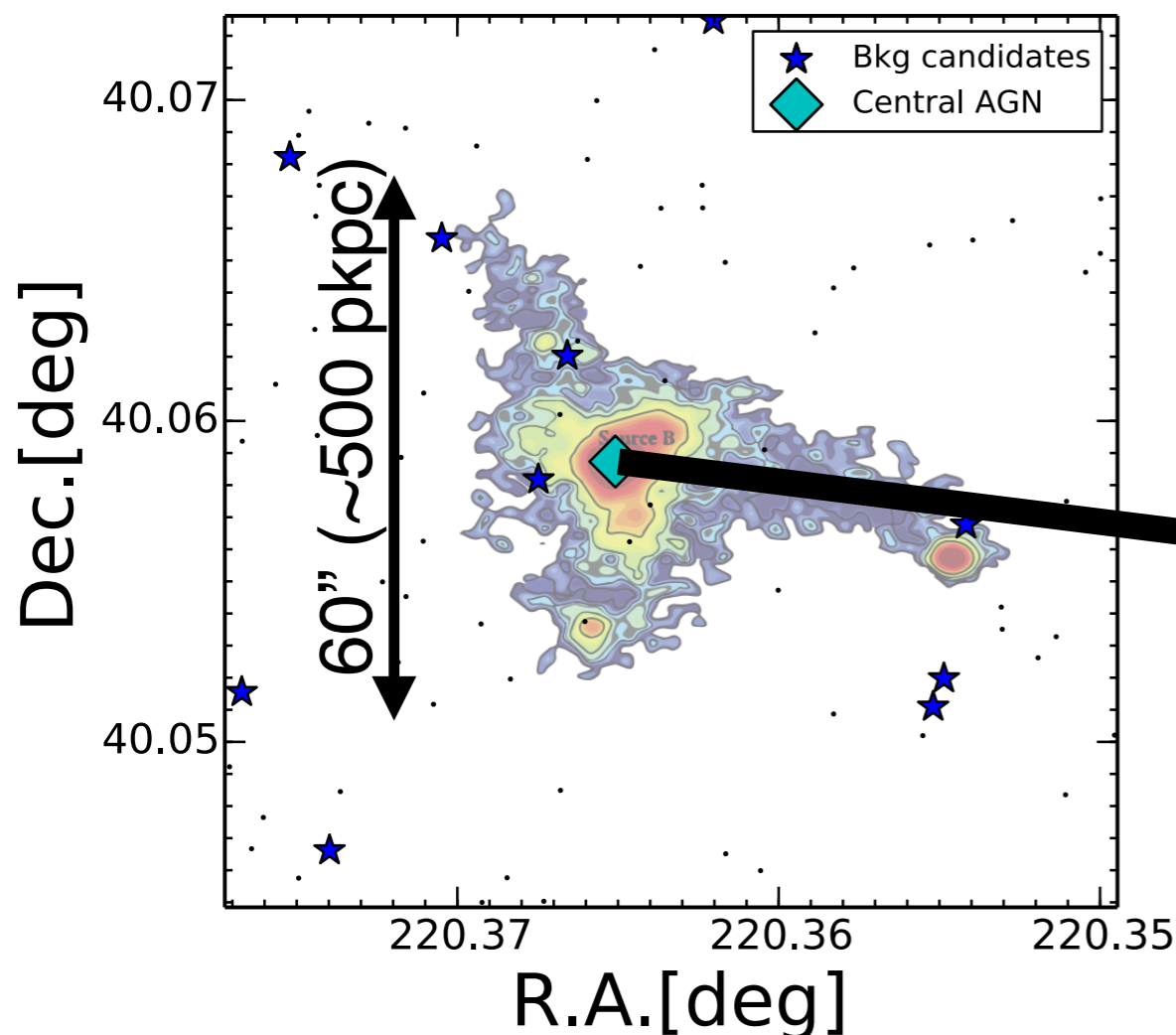
—> AGN proximity: transmission 0.67 ± 0.10 —> $\tau = 0.40^{+0.16}_{-0.14}$

—> **optically thin** (ionized/heated by the central AGN?)

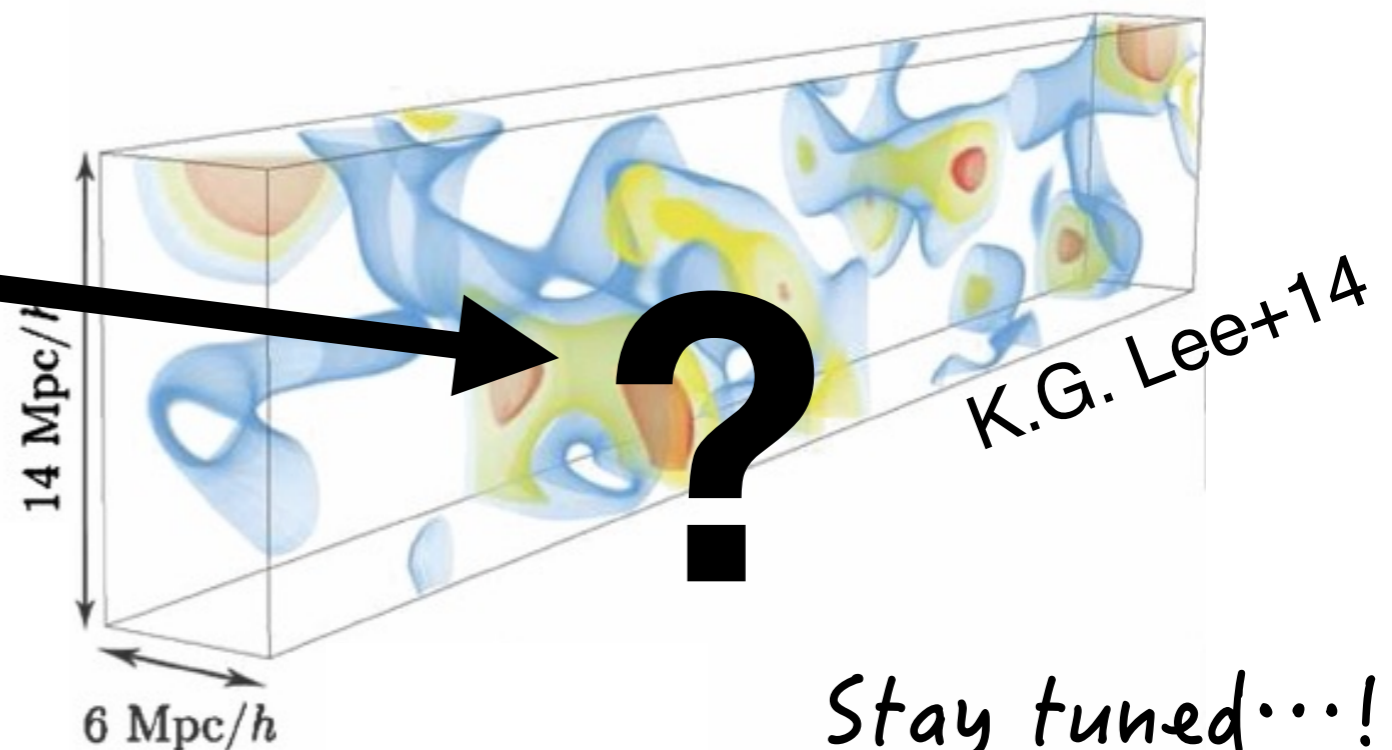
Key observation HeII emissions @ bright Ly α component

Conclusions

- We obtain deep LRIS spectra of background galaxies whose sightlines penetrate MAMMOTH-1 (one is $b=100$ pkpc)
- HI absorption analysis combining with CWI spectra indicates... optically thick gas in the bright Ly α components
- physical origins?: fluorescence vs. scattering
 - > Key observations: HeII & CIV



KCWI: emissions and absorptions
+ IGM tomography of ELANe



Stay tuned...!