



QSO project:

Giant Ly α Nebula around the hyper-luminous quasar SDSS-J1538+0855

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Collaborators OAR and more

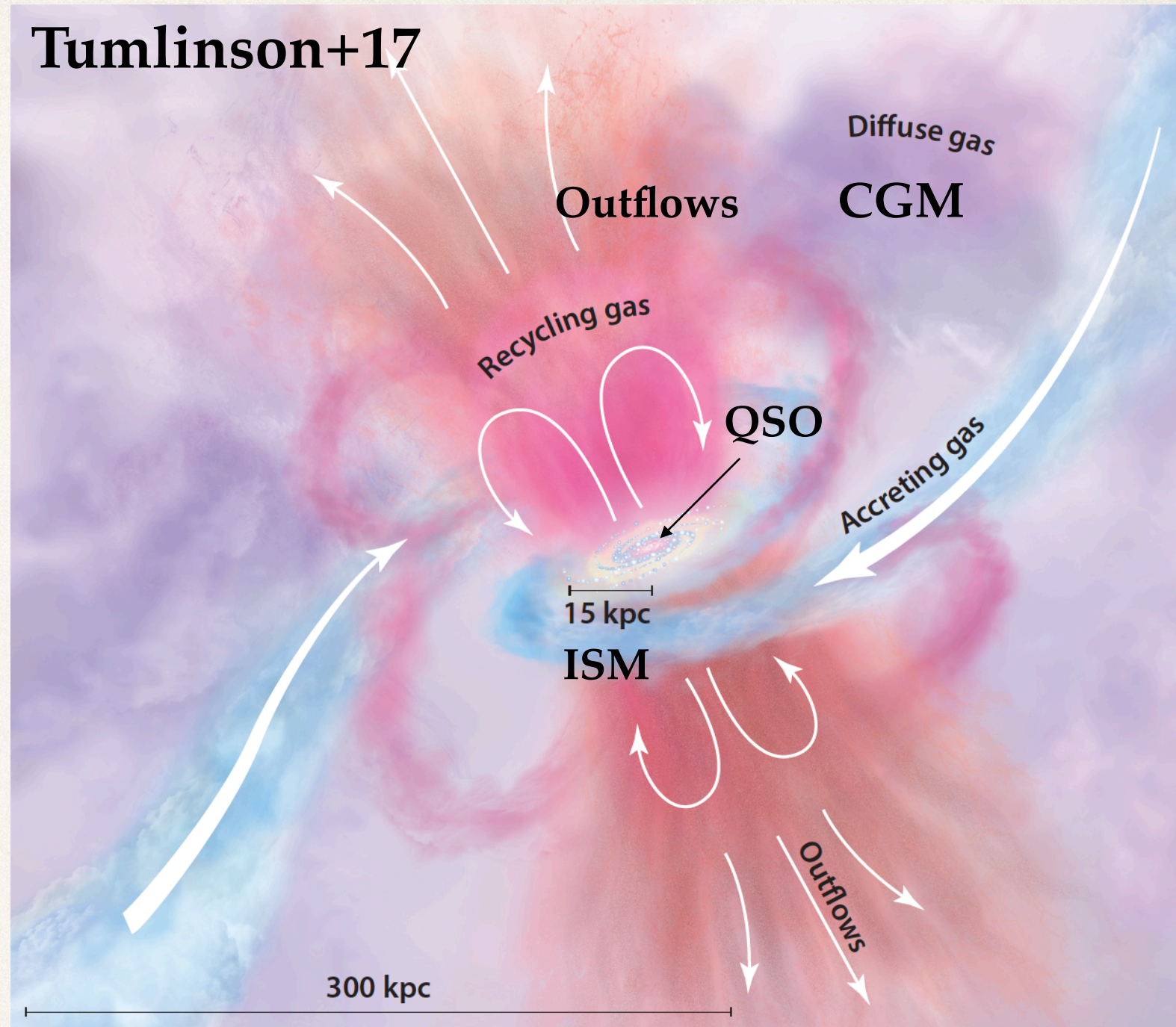
E. Piconcelli, L. Zappacosta, S. Cantalupo*, F. Fiore,
M. Ginolfi, A. Bongiorno, M. Bischetti, G. Vietri, F. Duras, A. Luminari**

AGN13 - 11 Oct 2018



Circum-Galactic Medium (CGM)

- Circum-Galactic Medium (CGM) is the gas surrounding galaxies outside their disks (>15 kpc) and inside their virial radii.
- Observations and simulations indicate that the CGM is
 - ▶ the venue for galactic feedback and recycling
 - ▶ the reserve of galaxies star-forming fuel (Evidences of CGM in inflow?)
 - ▶ the key regulator of the galactic gas supply

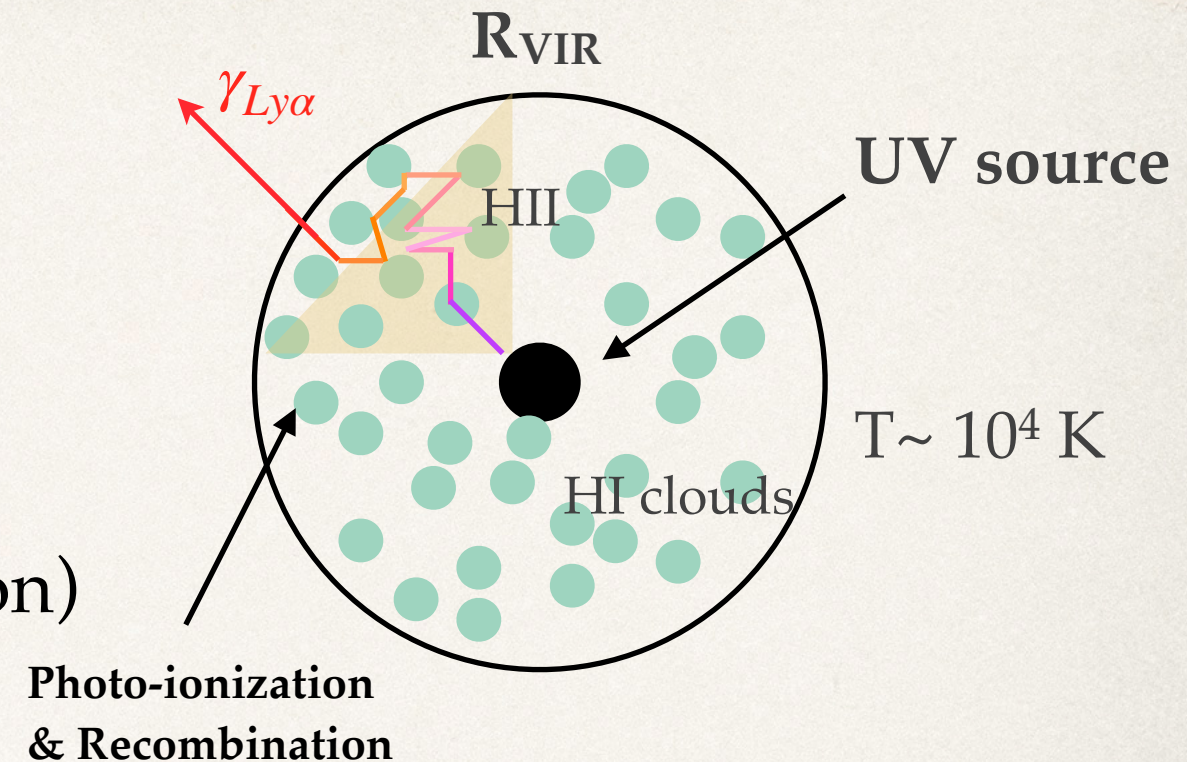


**CGM has a key role in galaxy evolution and in the
AGN feeding & feedback cycle**

Ly α emission

► Mechanisms of emission:

- collisional excitation (Haiman+00)
- resonant scattering from the quasar BLR (Cantalupo+05)
- **fluorescent** (photoionization+recombination) (Hogan & Weymann 1987, Cantalupo+12)

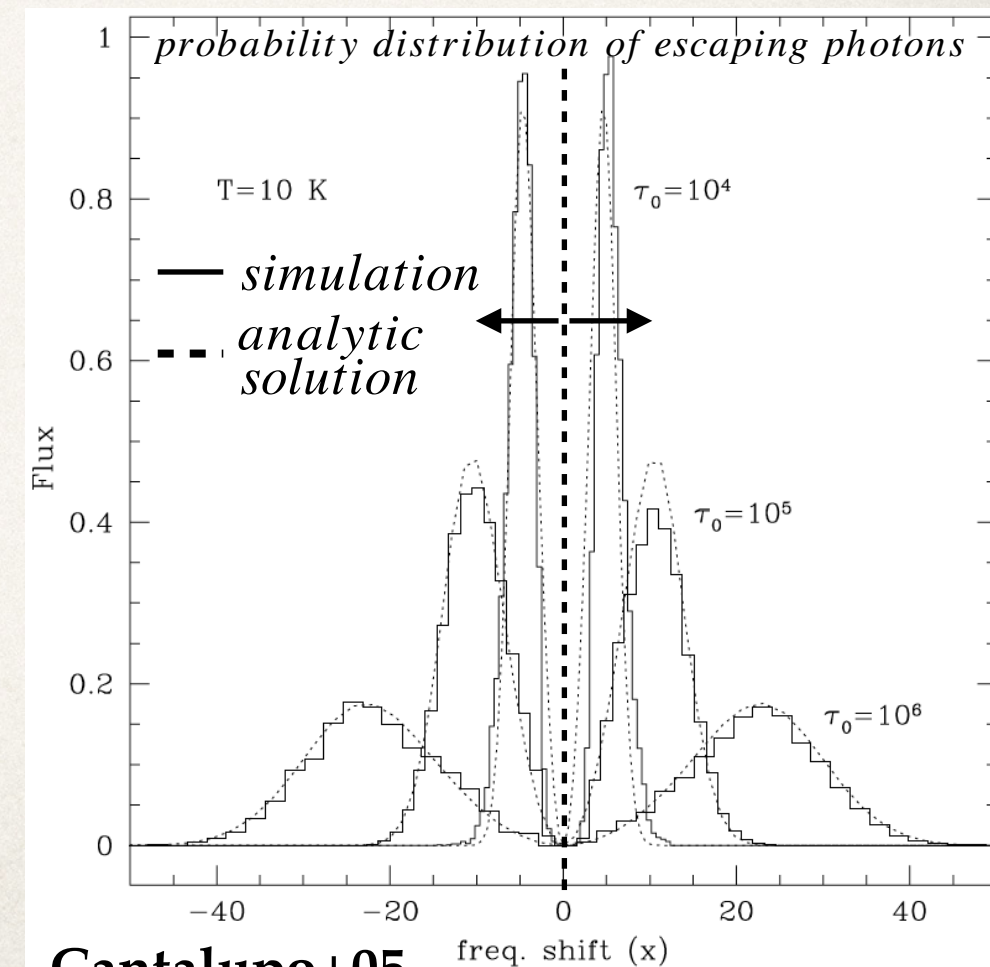


► Ly α line: $\lambda=1215.67$ Å $\tau(\lambda) = \left(\frac{N_{HI}}{10^{17.2} cm^{-2}} \right) \left(\frac{\lambda}{912 \text{ Å}} \right)^3$

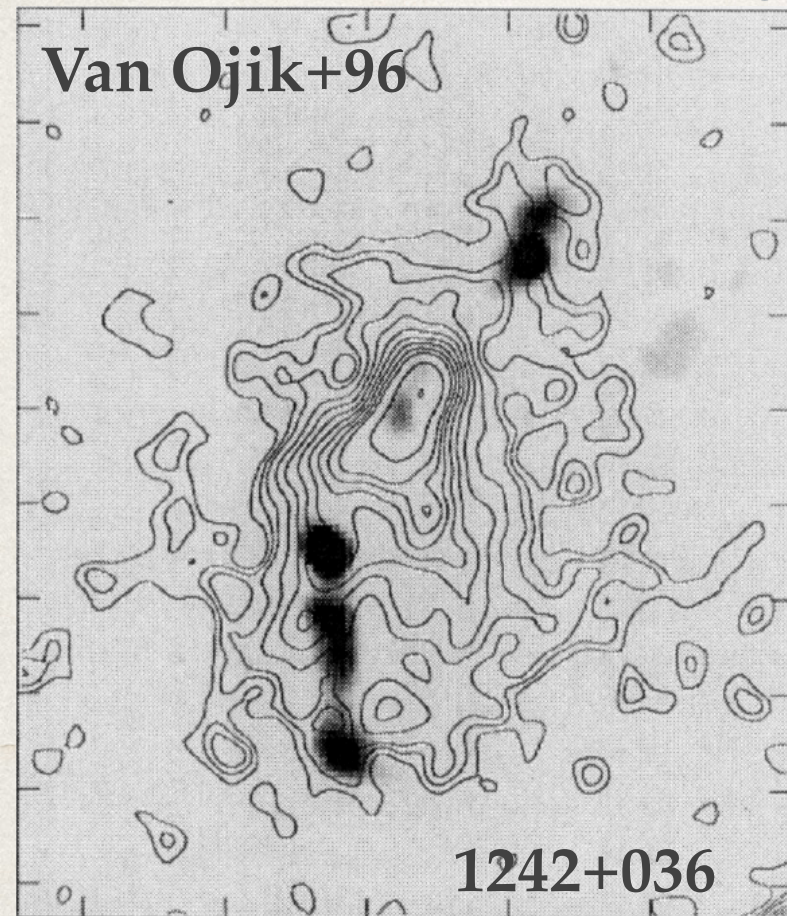
► $h\nu=10.2$ eV, $t=1.59$ ns

► Resonant scattering

► Random walk in frequency and position:
escaping from the system

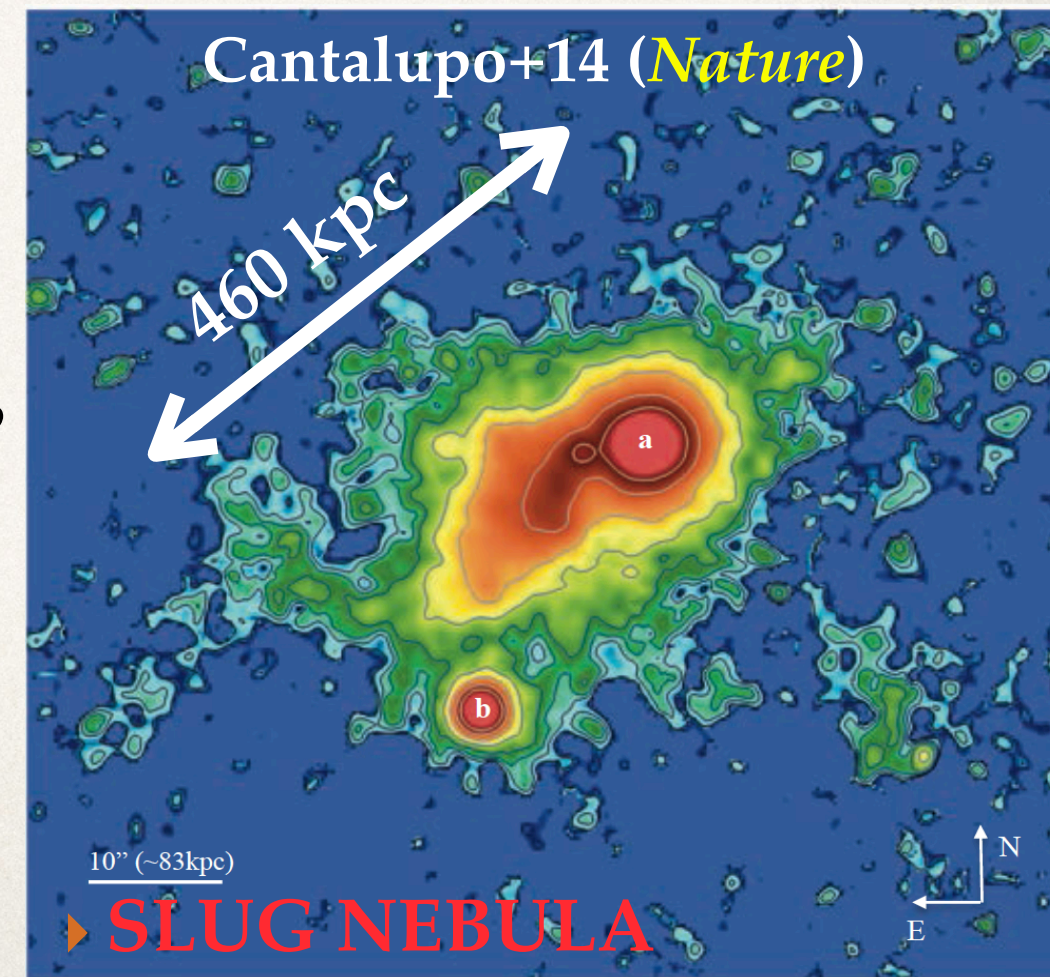


Giant Ly α Nebulae in the past



- ▶ Giant Ly α nebulae around High z Radio Galaxies (HzRGs) (Lilly & Longair 84, Van Ojik+96, Adam+97)
- ▶ $L \sim 10^{45}$ erg/s, size up to ~ 200 kpc
- ▶ Optical/UV and radio emissions spatially correlated (McCarthy+87)
- ▶ photoionization + shock-ionization (Villar Martin+97)

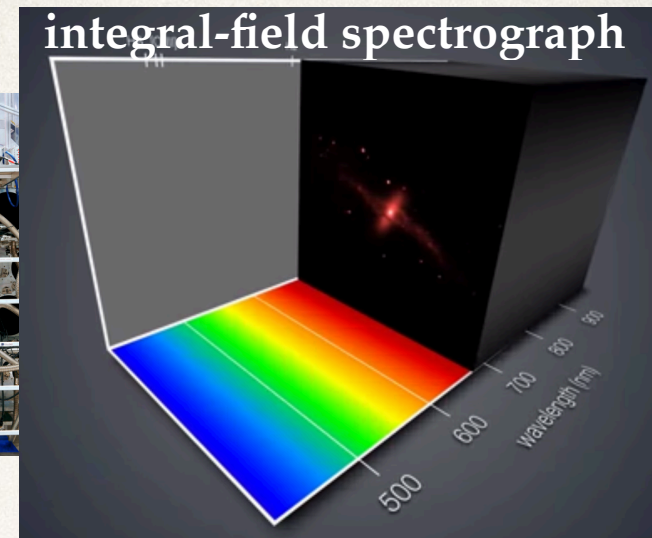
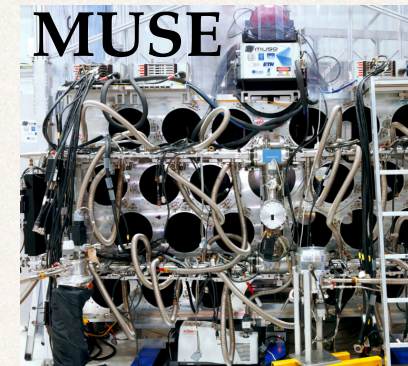
- ▶ Discovered in Narrow Band (NB) imaging a Enormous Lyman-Alpha Nebulae (ELAN) around multiple **radio quiet QSOs** (RQQs) $z \sim 2.3$
- ▶ do not have radio-jets that may power Ly α emission on large scales
- ▶ size **460 kpc** (beyond the virial radius) and $L \sim 2 \times 10^{44}$ erg/s



Giant Ly α Nebulae with MUSE (GLAN)

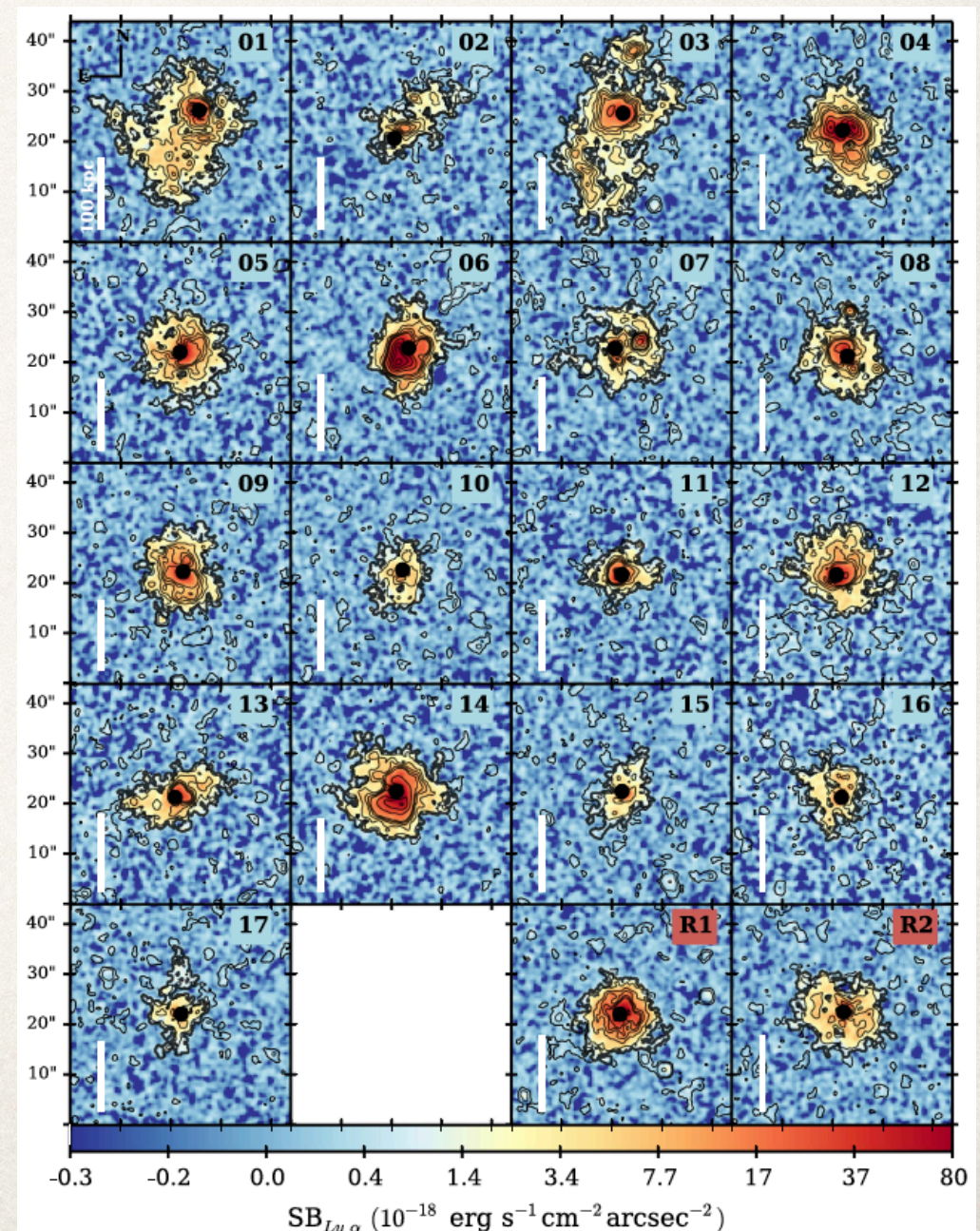
★ Advent of Multi Unit Spectroscopic Explorer (MUSE)

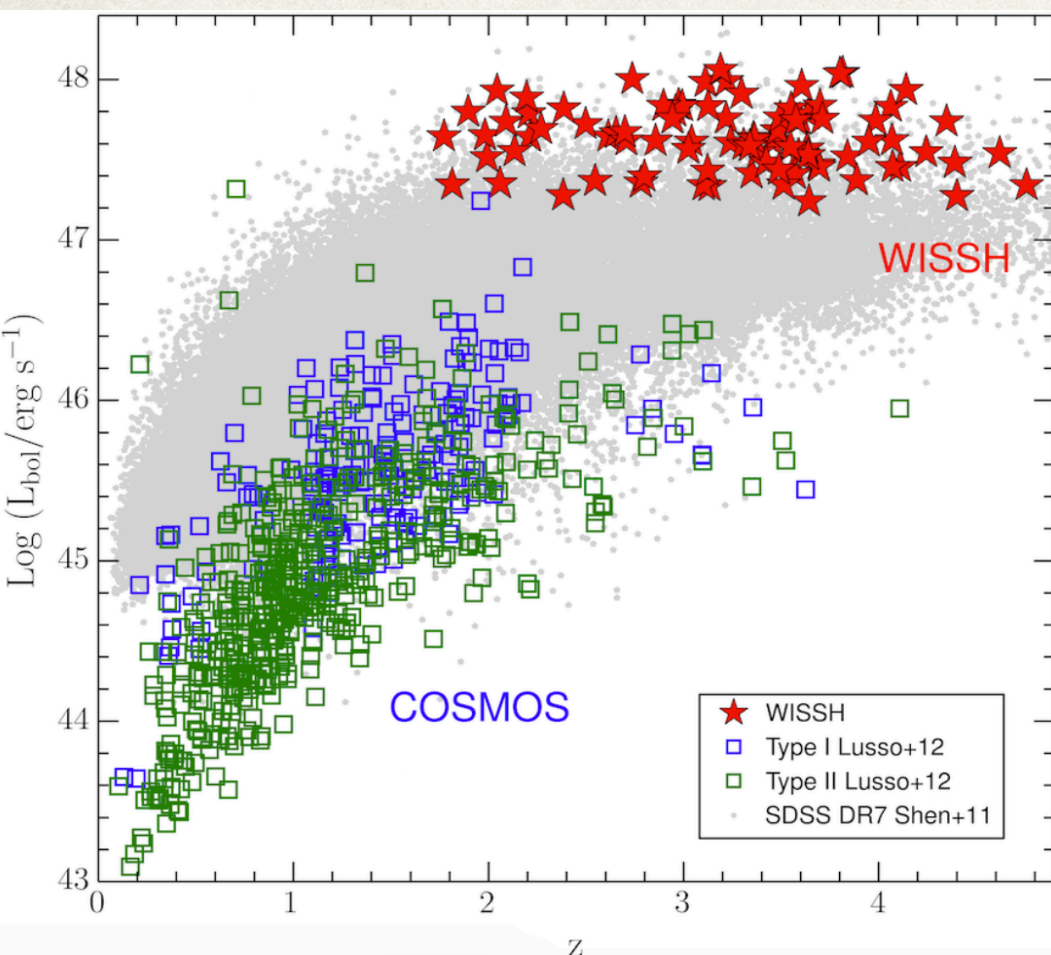
- ▶ MUSE Optical integral-field spectrograph
 - No filter and slit losses
- ▶ FoV 1'x1', pixel scale 0.2 "/pixel
 - at redshift $z=3.5$: FoV (450x450 kpc²), pixel scale (1.5 kpc/pixel)
 - High sensitivity



★ GLAN today

- ▶ GLAN are ubiquitous (detection rate 100%) around RQQs at $z\sim 3-4$ within at least 50 kpc (Borisova+16)
- ▶ see also Ginolfi+18, Arrigoni-Battaia+18





- ▶ Sample of ~ 86 broad-line **WISE/SDSS Selected Hyper-luminous (WISSH)** quasars
- ▶ Bolometric Luminosity $\log(L_{\text{bol}}) > 47.2$, $z > 1.5$ and $\text{WISE}(22\mu\text{m}) > 3$ mJy
- ▶ Aims: *AGN feedback in the most luminous quasars of the Universe*
- ▶ see Vietri's, Duras's, Bischetti's talk

Bischetti+17,+18, Martocchia+17, Duras+17, Vietri+18, Bruni+ in prep

★ WISSH MUSE PROJECT

- ▶ 7 WISSH QSOs targeted by MUSE
- ▶ 2 are proprietary data (PI Fiore) (J1538+08, J2238-08)

★ Aims:

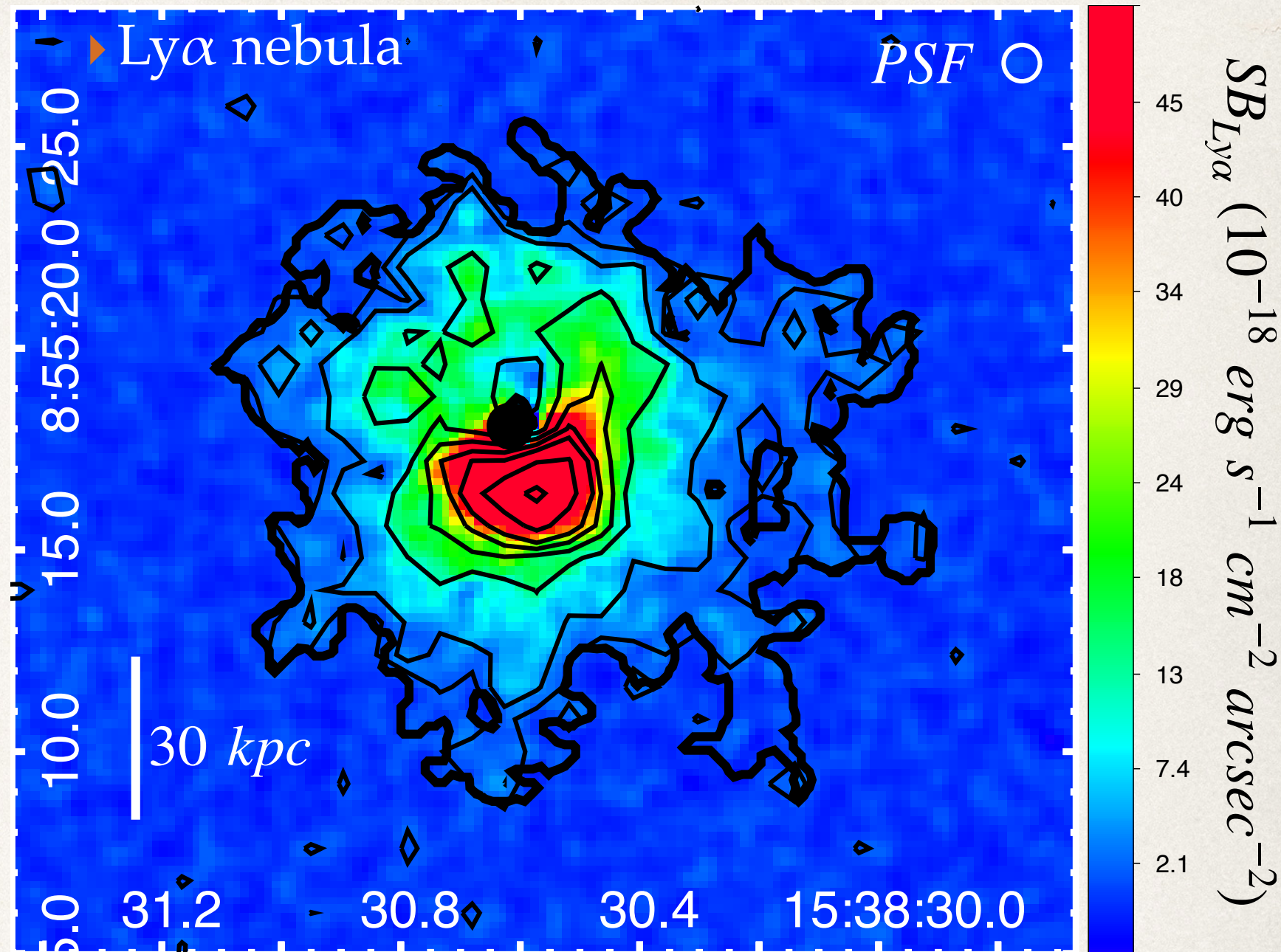
- ▶ *Studying the CGM around the most luminous quasars of the Universe with powerful outflows*
- ▶ probe presence of possible AGN driven winds beyond host galaxy
- ▶ shedding light on AGN feeding and feedback

Giant Ly α nebula around J1538

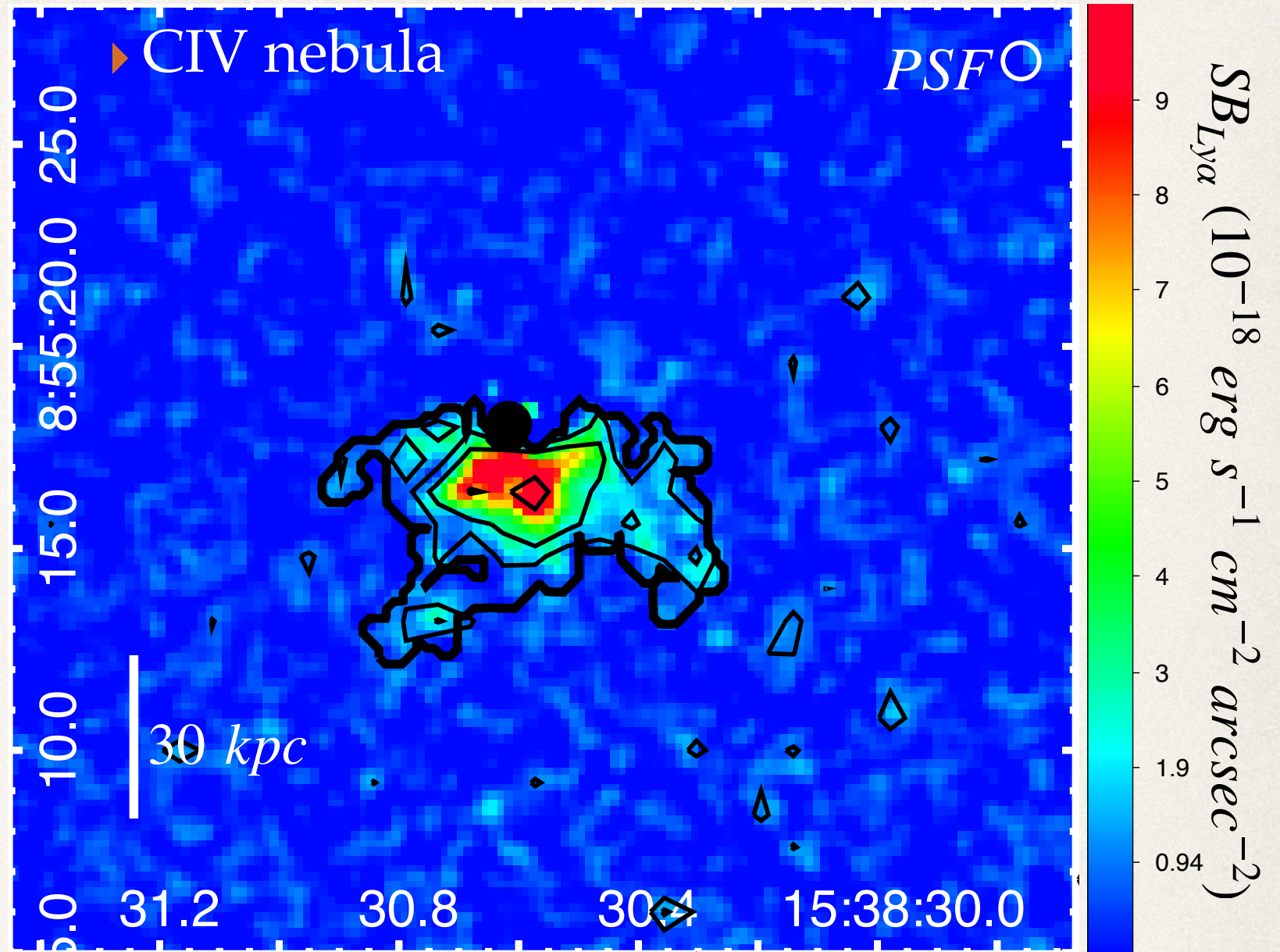
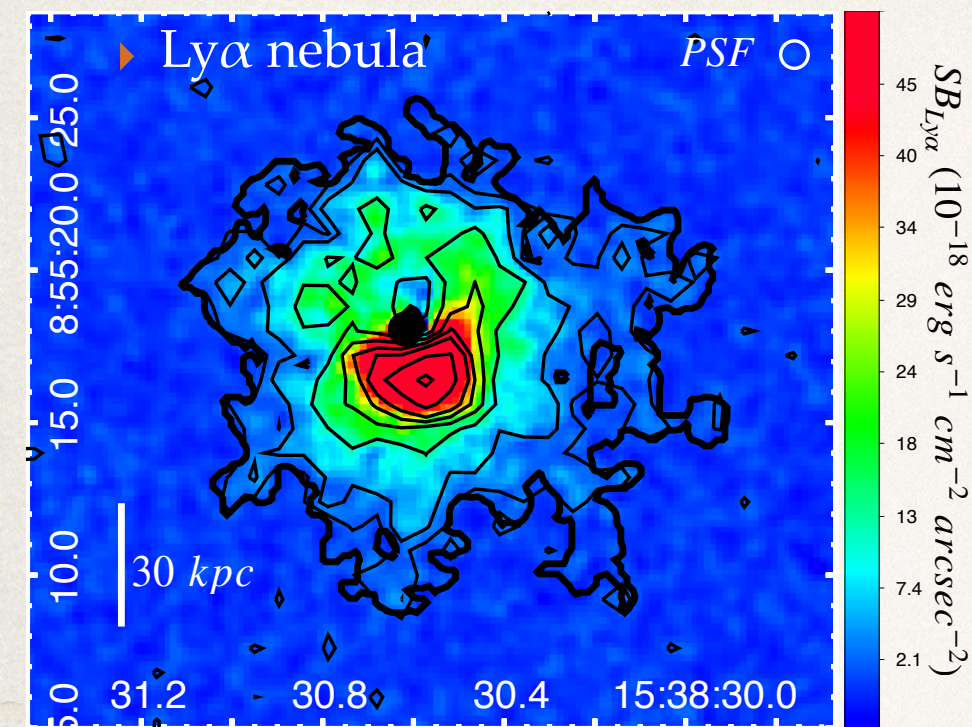
- SNR >2.5
- propagated SNR levels
- QSO (1 x 1 arcsec²)

- ▶ Obtained with **CubExtractor**, a tool to perform PSF-subtraction and low surface brightness detection/analysis (Cantalupo+in prep)
- ▶ Maximum size **144 kpc**
- ▶ Integrated SNR(Ly α)~30
- ▶ $z_{\text{QSO}}=3.567$, $z_{\text{Ly}\alpha}=3.563$
- ▶ $L_{\text{Ly}\alpha}=\mathbf{2.04 \times 10^{44} \text{ erg/s}}$

★ SB peak in the south region of the nebula (UV radiation cone)



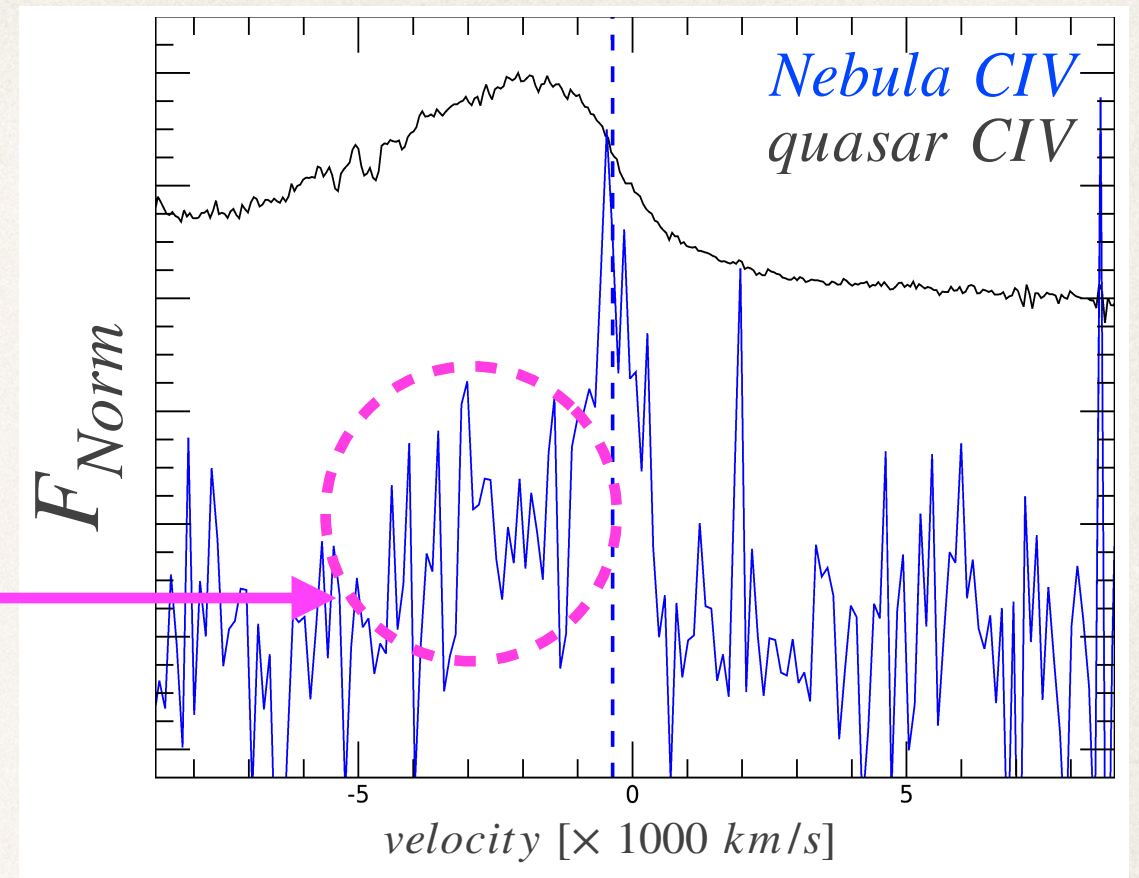
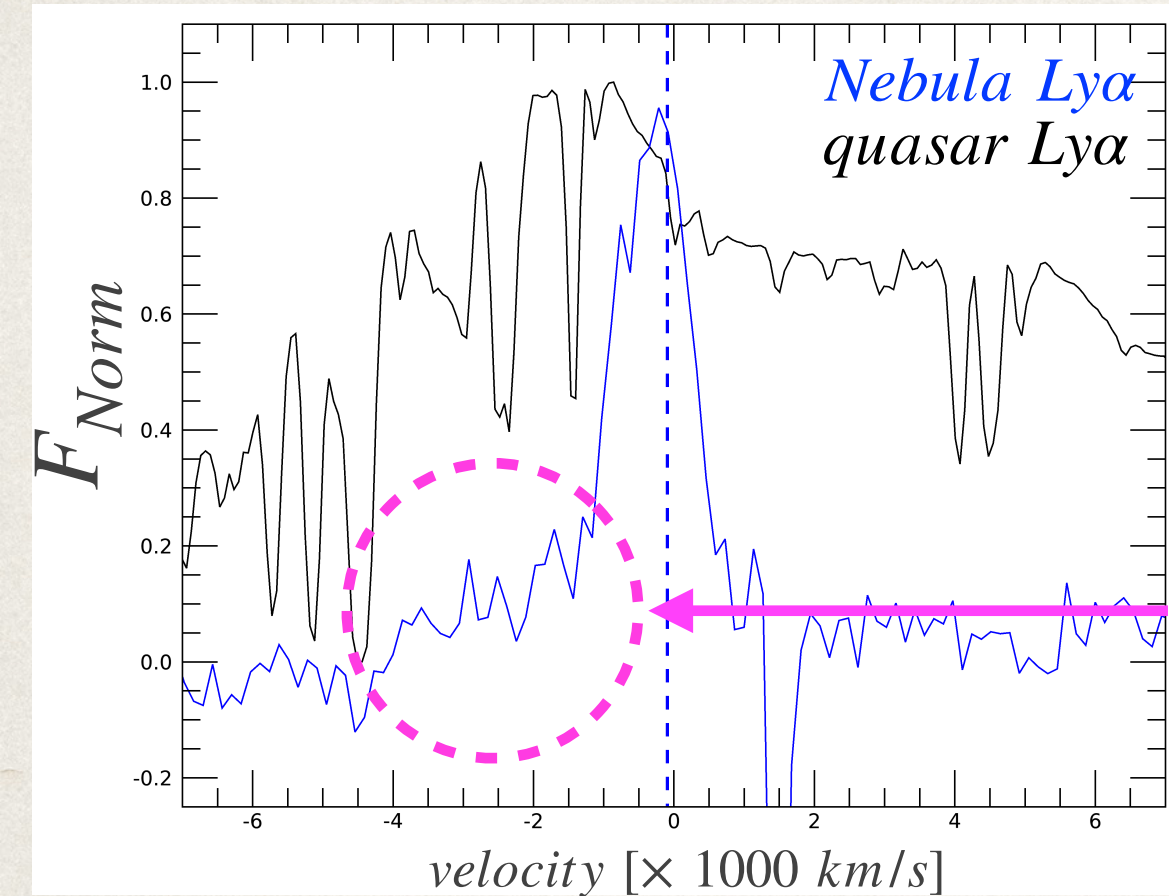
Surprise: discovery of giant CIV nebula



- ▶ Maximum size **60 kpc**
- ▶ Integrated SNR(Ly α) \sim 5
- ▶ $z_{\text{QSO}}=3.567$, $z_{\text{CIV}}=3.562$
- ▶ $L_{\text{CIV}}=\mathbf{9.63 \times 10^{42} \text{ erg/s}}$

- ★ Discovery a CIV nebula in the same south region
- ★ CGM metal-rich
- ★ Which mechanism has transported the CIV up to here?
- ▶ Outflow? Stellar feedback?

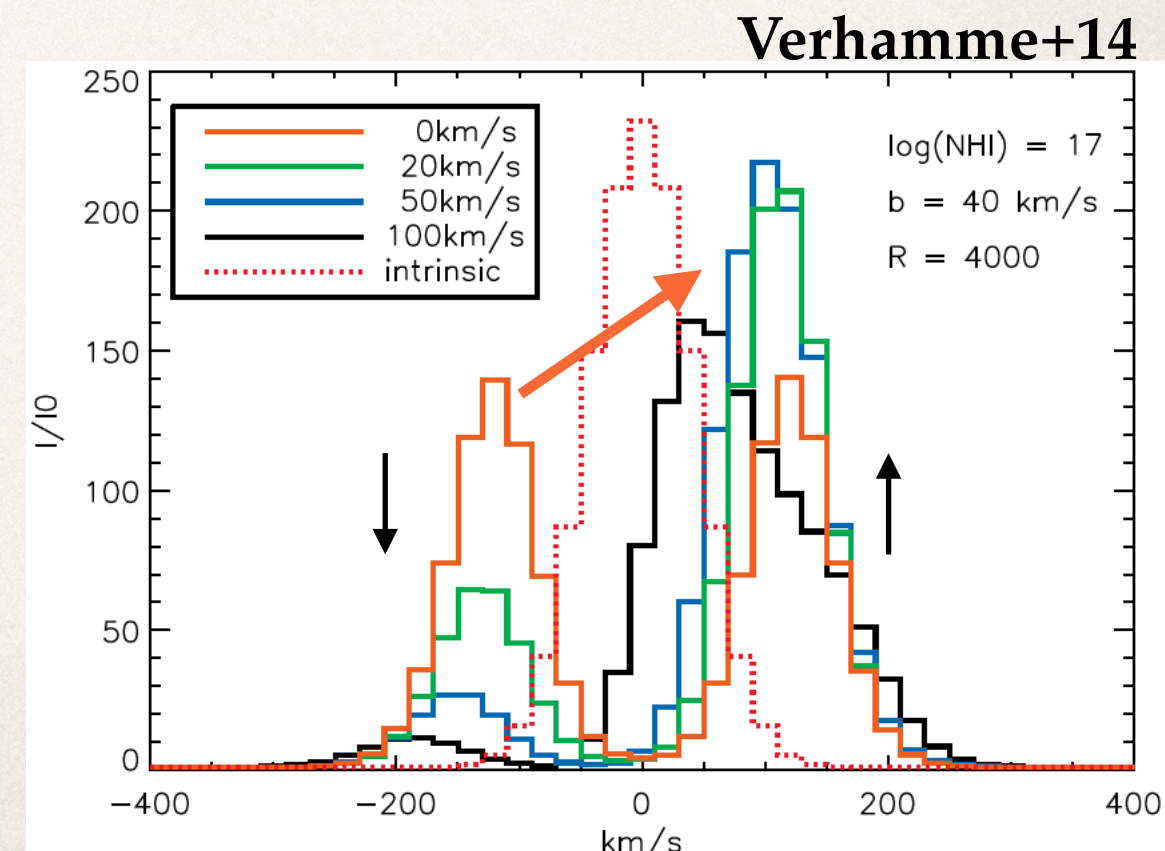
Ly α line profile: blue tail = outflow?



★ Blue tail of the Ly α emission line in the nebula spectrum: could it suggest the presence of an outflow? (Verhamme+14)

- ▶ Is it a simple Ly α blue component?
- ▶ Is it the second peak that we would observe typical for a resonant line?

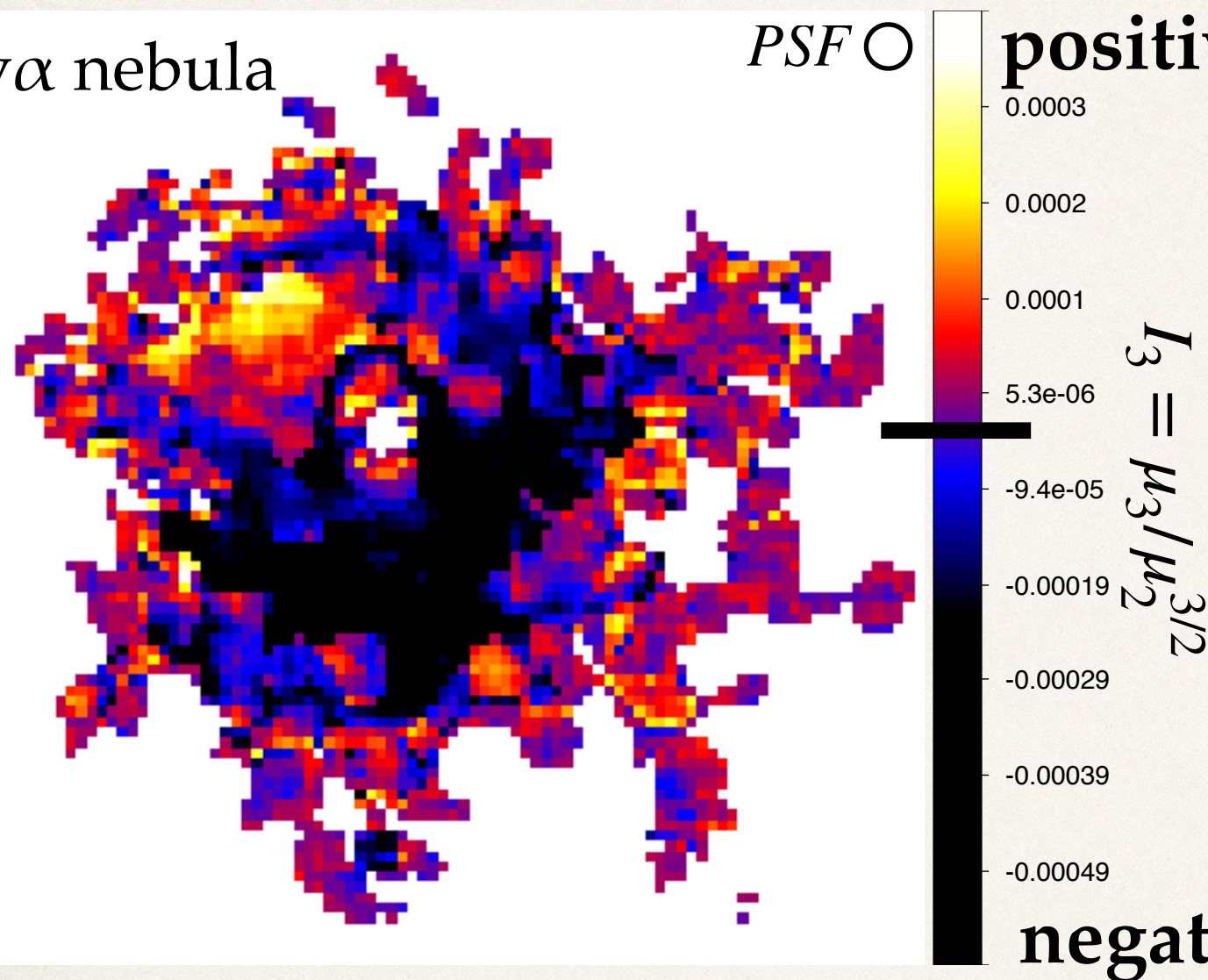
★ What is the spatial distribution of this blue tail?



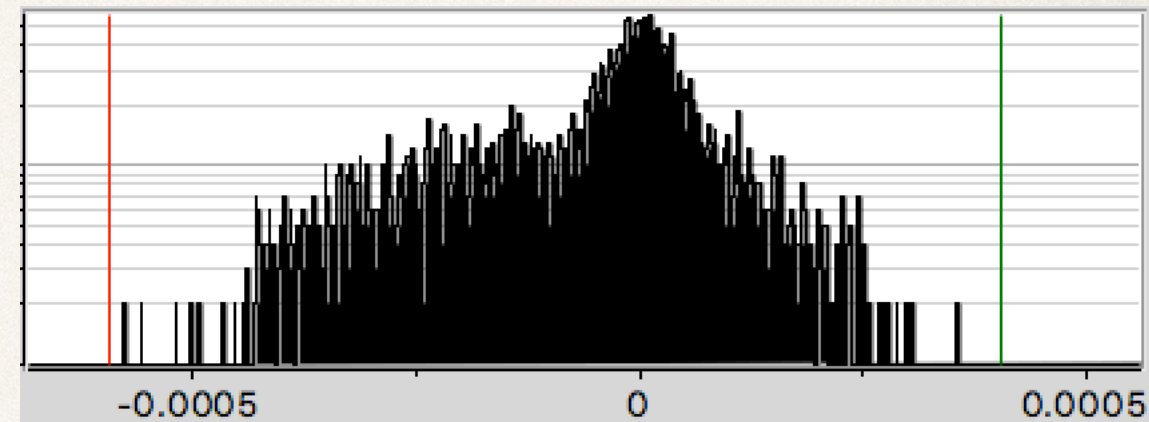
blue tail spatially resolved

► Skewness map

► Ly α nebula



► pixel value distribution



► It gives an indication of the Ly α emission line asymmetry and its spatial distribution

★ The Ly a profile is more skewed towards negative values in the SB peak of the nebula. Why?

► Can we just resolve the blue tail with an higher SNR?

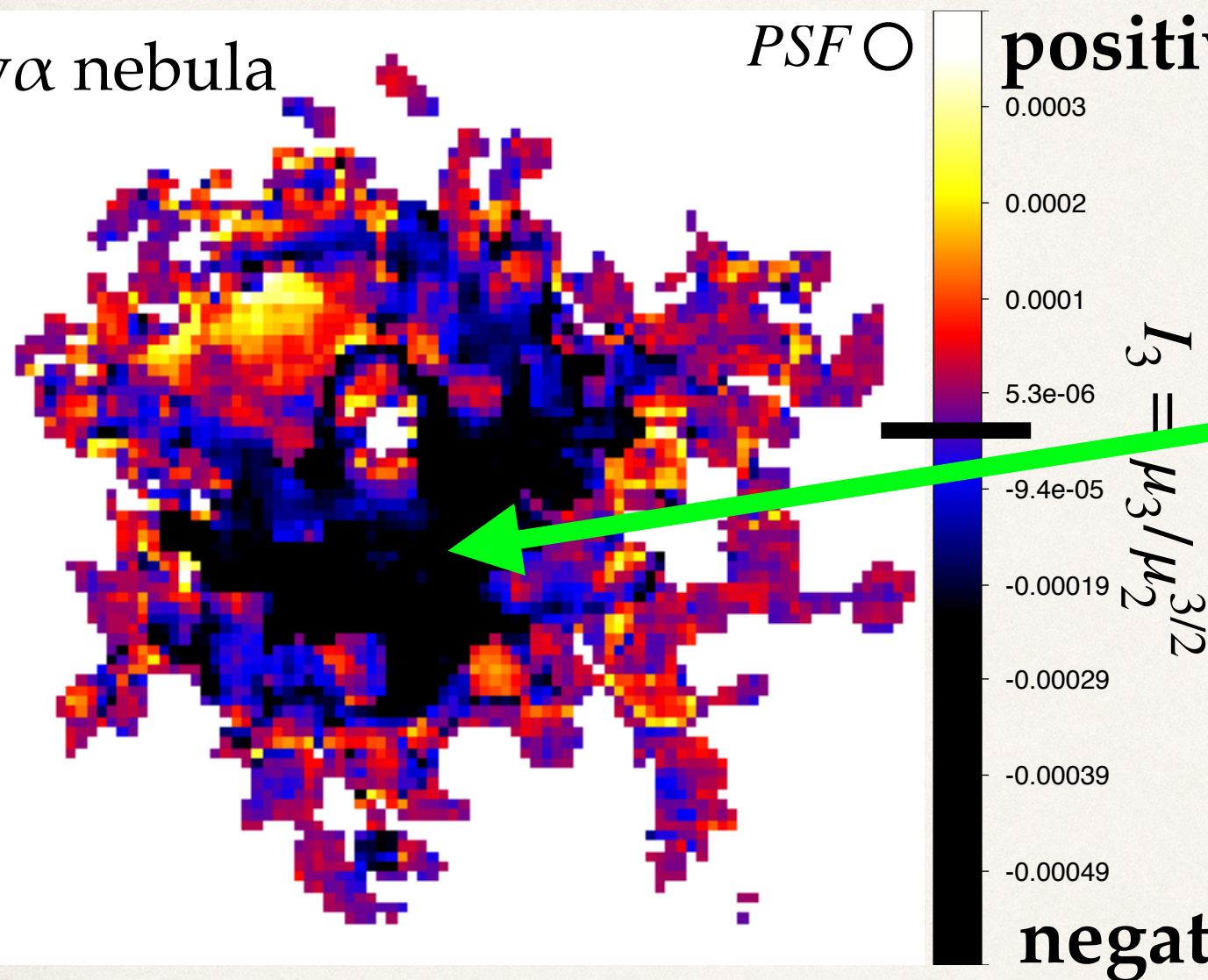
► Is it indicating the presence of an outflow?

● **Work in progress! Any comments or suggestions please? :)**

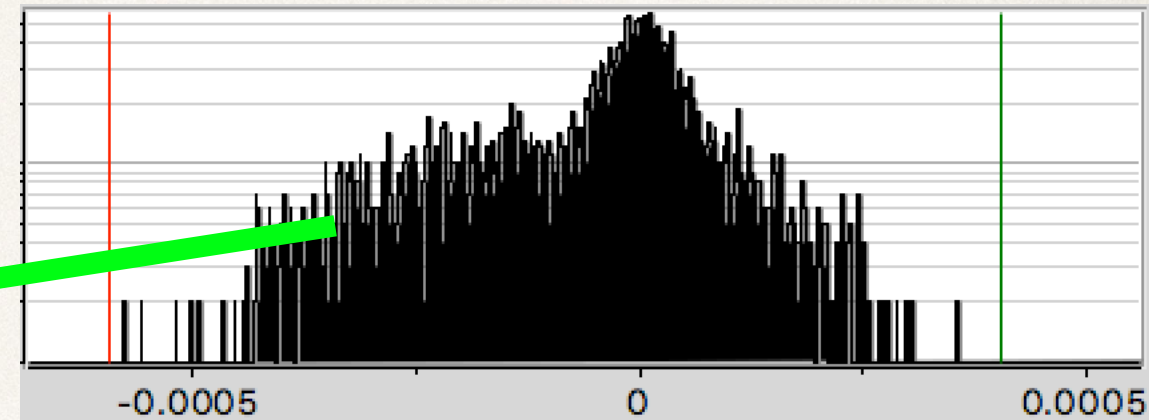
blue tail spatially resolved

► Skewness map

► Ly α nebula



► pixel value distribution



► It gives an indication of the Ly α emission line asymmetry and its spatial distribution

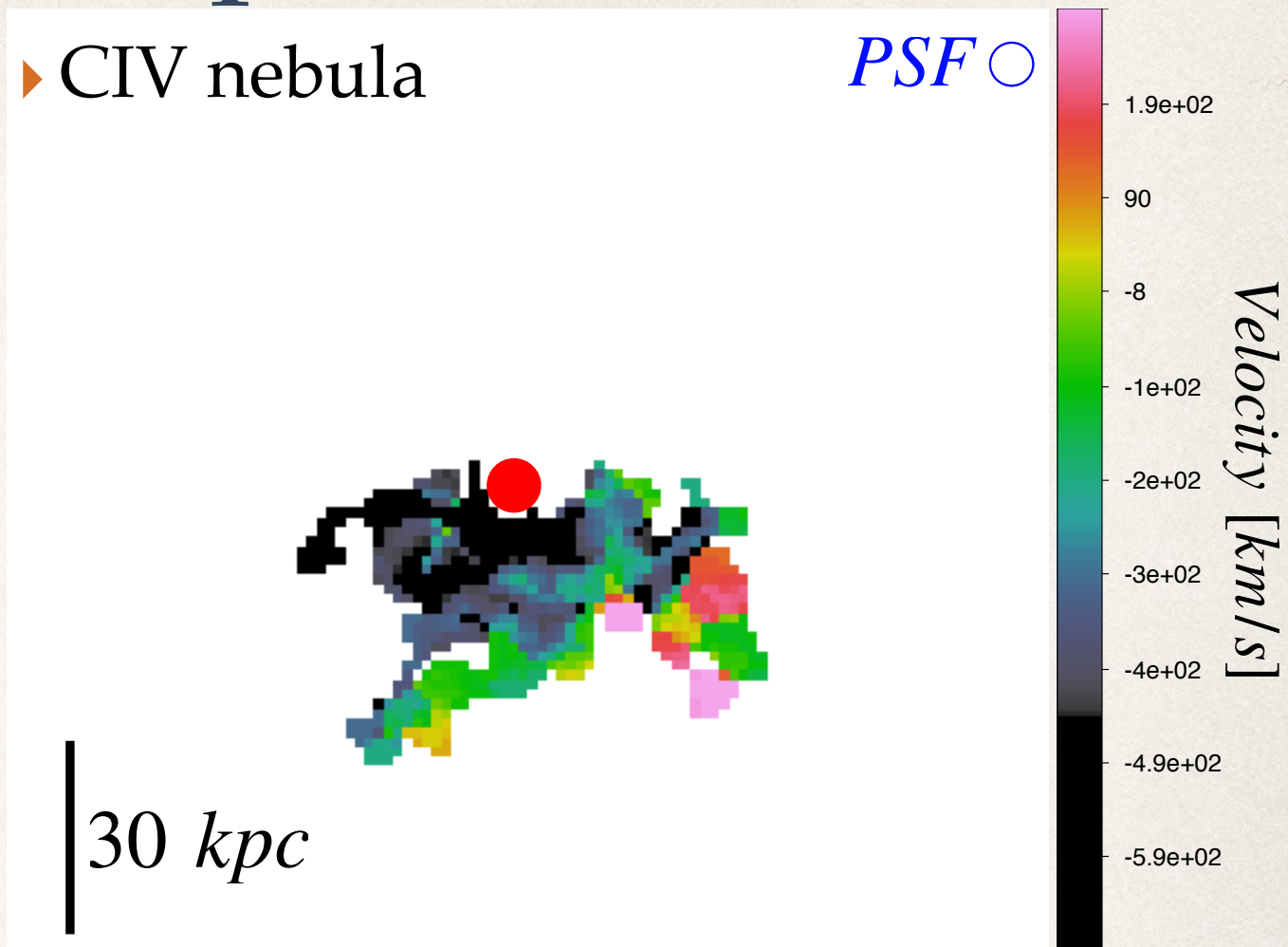
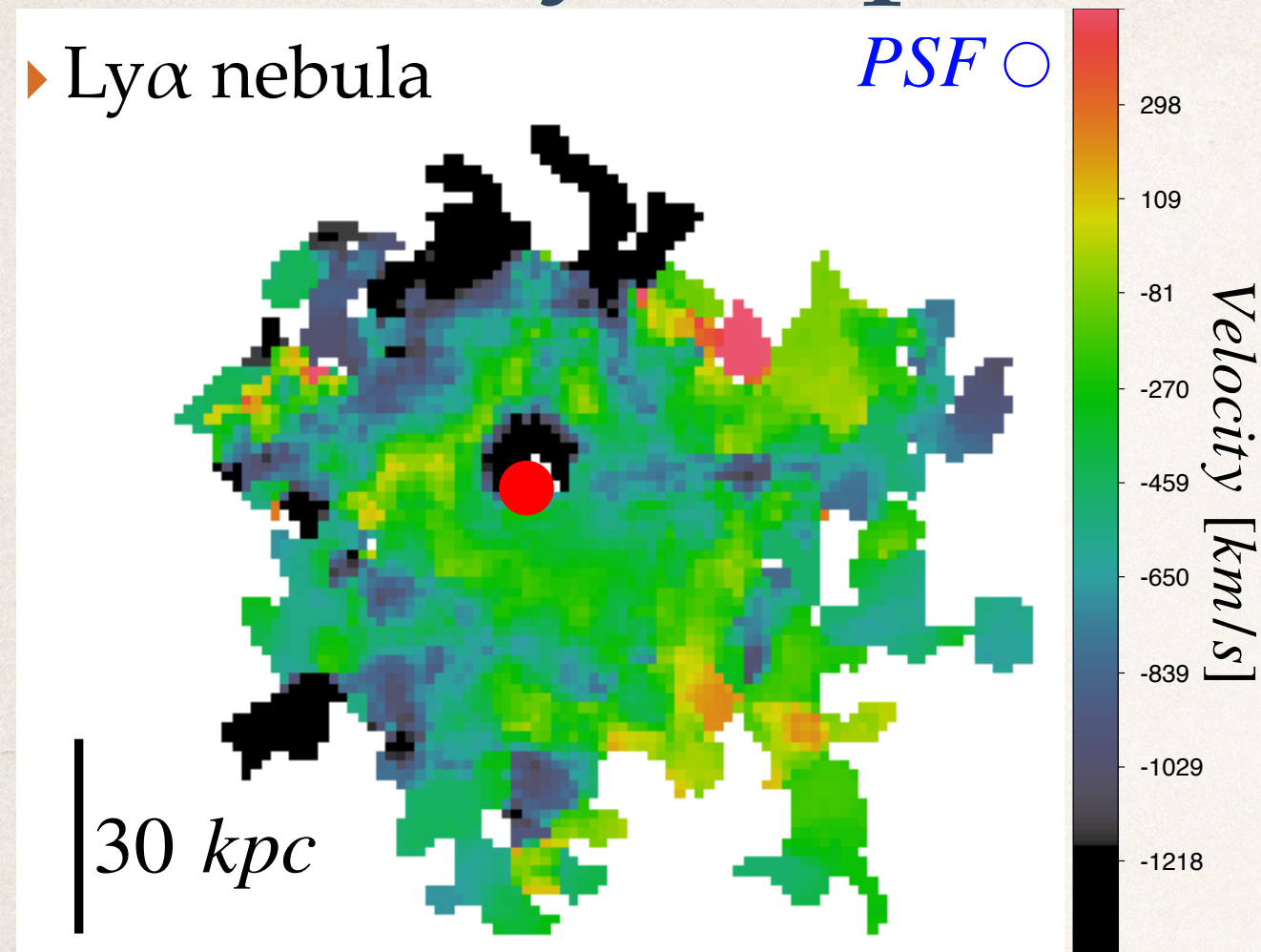
★ The Ly a profile is more skewed towards negative values in the SB peak of the nebula. Why?

► Can we just resolve the blue tail with an higher SNR?

► Is it indicating the presence of an outflow?

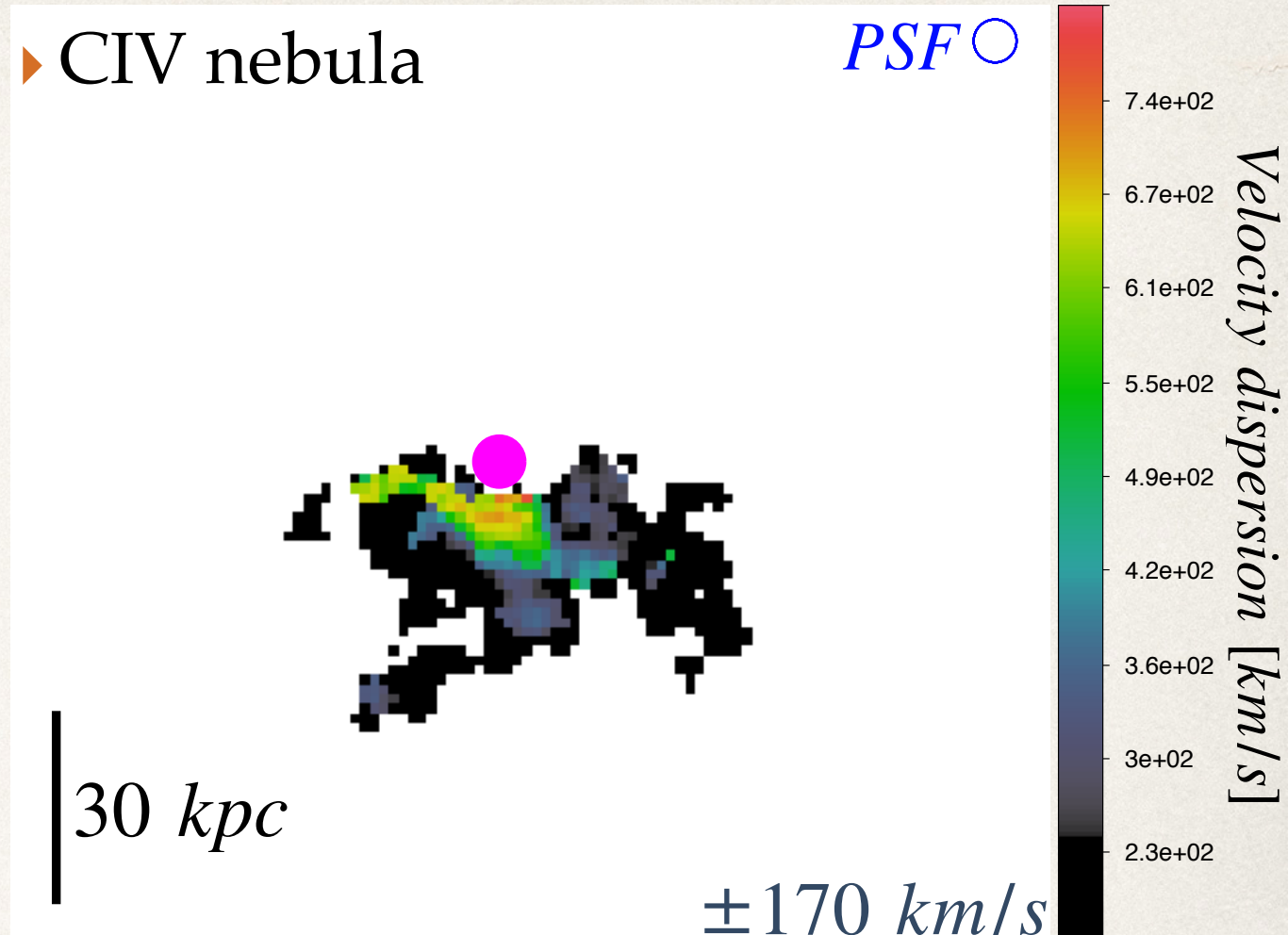
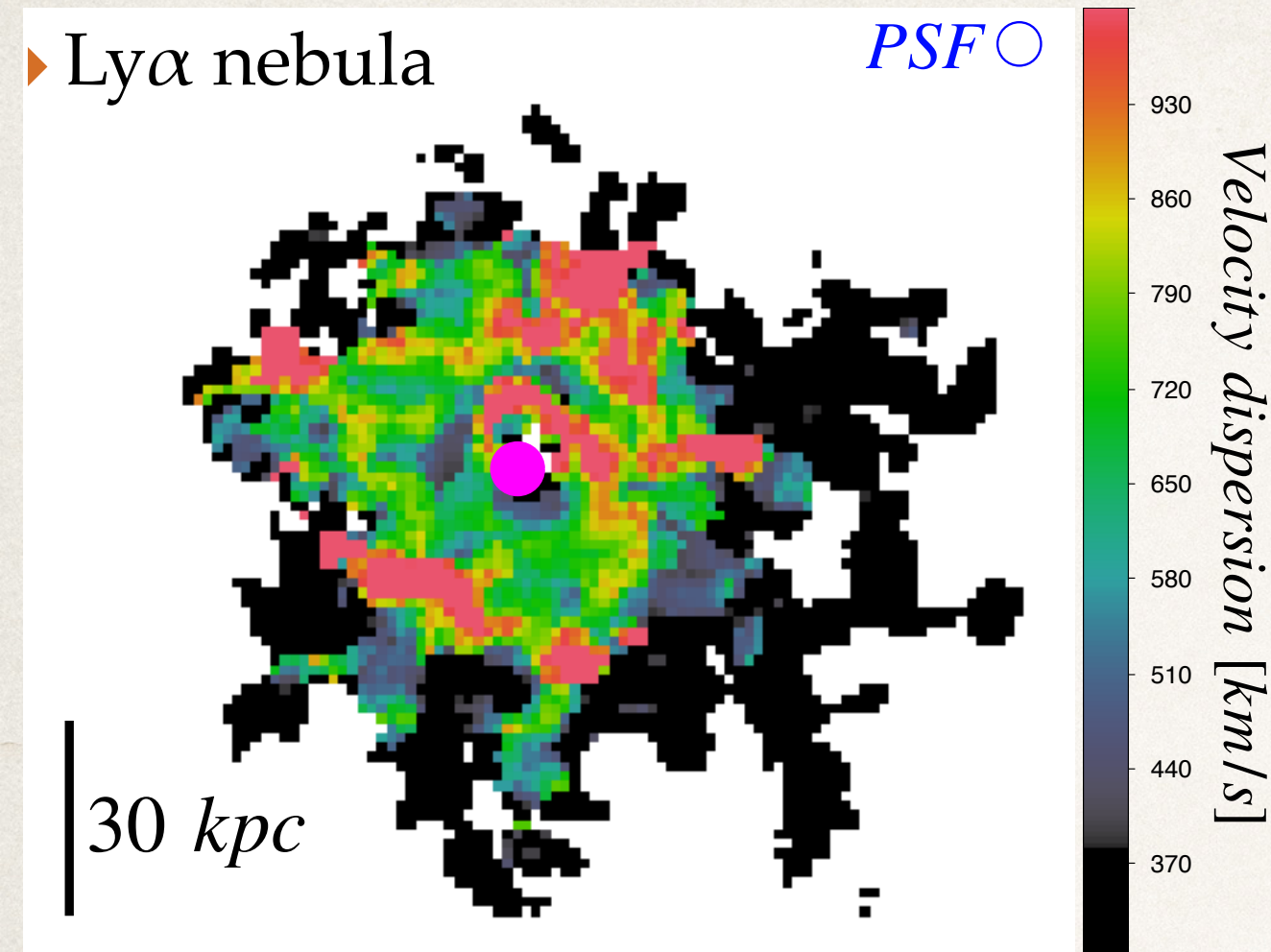
● **Work in progress! Any comments or suggestions please? :)**

Velocity map with respect to the z_{QSO}



- problem to find the systemic redshift of the QSO
- complex radiative transfer effects = complex kinematic interpretation
- ★ blue-shifted bulk motion of the Ly α Nebula relative to the systemic z as determined from the H β \rightarrow hint of an outflow?
- ✓ We need to have molecular lines from the host galaxy in order to a reliable systemic redshift of the QSO and constrain the nebula kinematic
- ✓ We need to have non-resonant line (H α , HeII etc...)

Velocity dispersion map



- Velocity dispersion marks the turbulence of the gas in the CGM
- GLAN around HzRGs: FWHM > 1000 km/s (jet), FWHM < 500 km/s (no jet)

★ high turbulence in the central region of the nebula

$$FWHM_{Ly\alpha}^{max} \sim 1300 \text{ km/s}$$

$$FWHM_{CIV}^{max} \sim 700 \text{ km/s}$$

$$\langle FWHM_{Ly\alpha} \rangle \sim 700 \text{ km/s}$$

$$\langle FWHM_{CIV} \rangle \sim 400 \text{ km/s}$$

SUMMARY

- ✓ We detected Ly α and CIV giant nebulae around a WISSH QSO which shows outflows in the BLR and NLR (Vietri+18)
 - ▶ Ly α nebula has size ~ 144 kpc with $L_{\text{Ly}\alpha} \sim 10^{44}$ erg/s
 - ▶ CIV nebula shows size ~ 60 kpc with $L_{\text{CIV}} \sim 10^{43}$ erg/s
- ✓ The line profiles and the velocity maps suggest that we are witnessing outflowing CGM. In order to confirm this theory we need to:
 - ▶ estimate the systemic redshift of the quasar through a line that surely belongs to the host galaxy
 - ▶ look for a non resonant emission line (e.g. H α , HeII..)
- ✓ Powerful outflows are a plausible mechanism capable of bringing metals into the CGM, by explaining the presence of a giant CIV nebula
 - ▶ AGN feedback on the CGM?

Thanks