

The Diffuse Neutral Circum-Galactic Medium around High- z Dusty Galaxies

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AoP Fellow

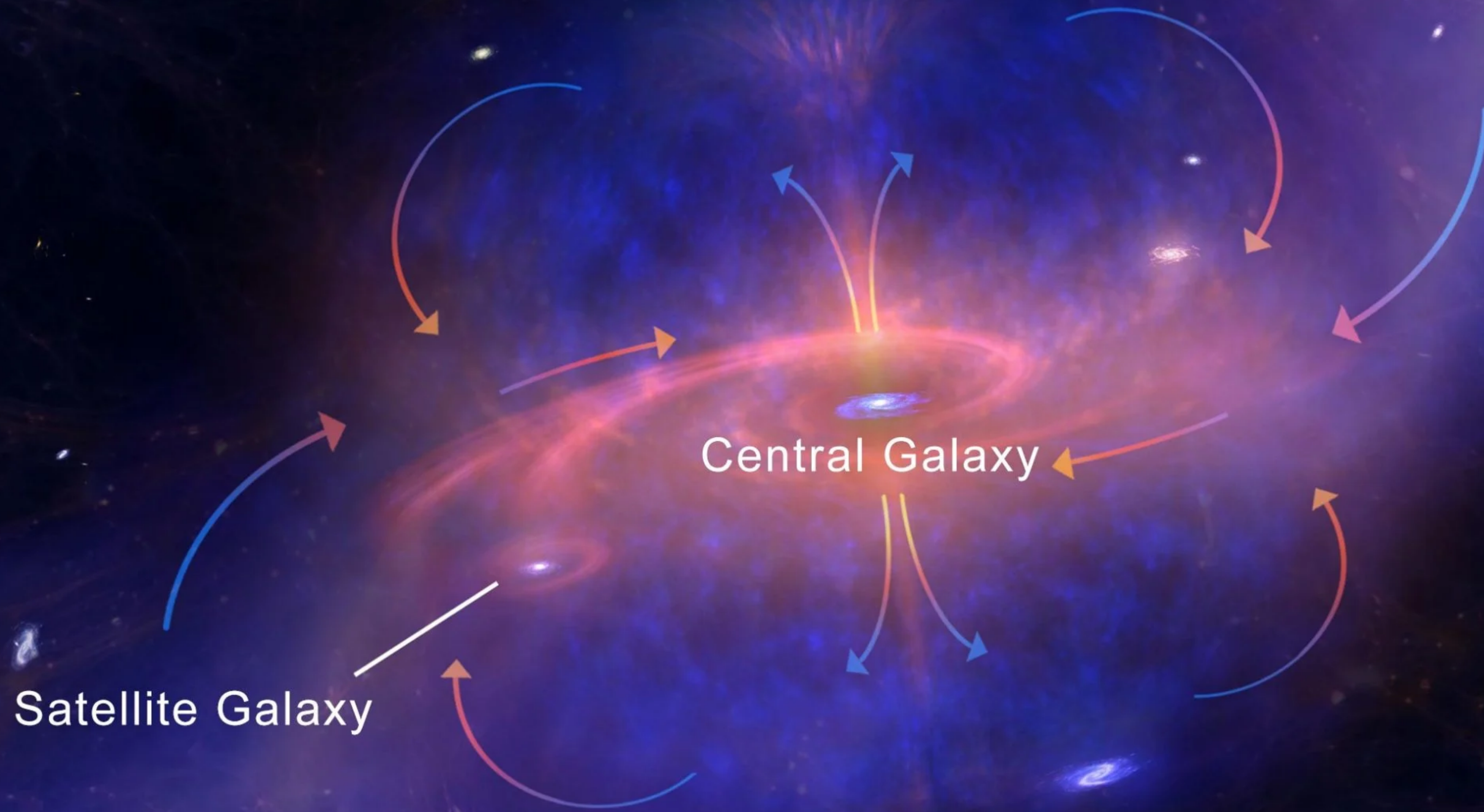


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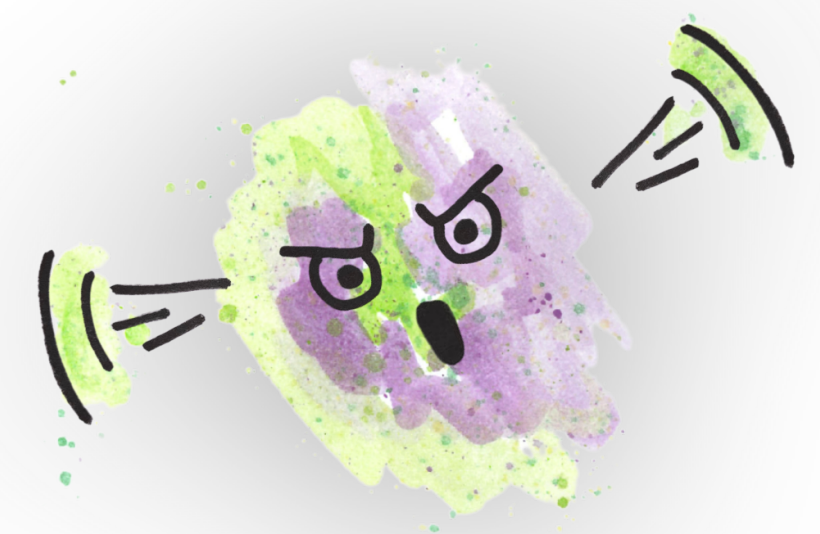
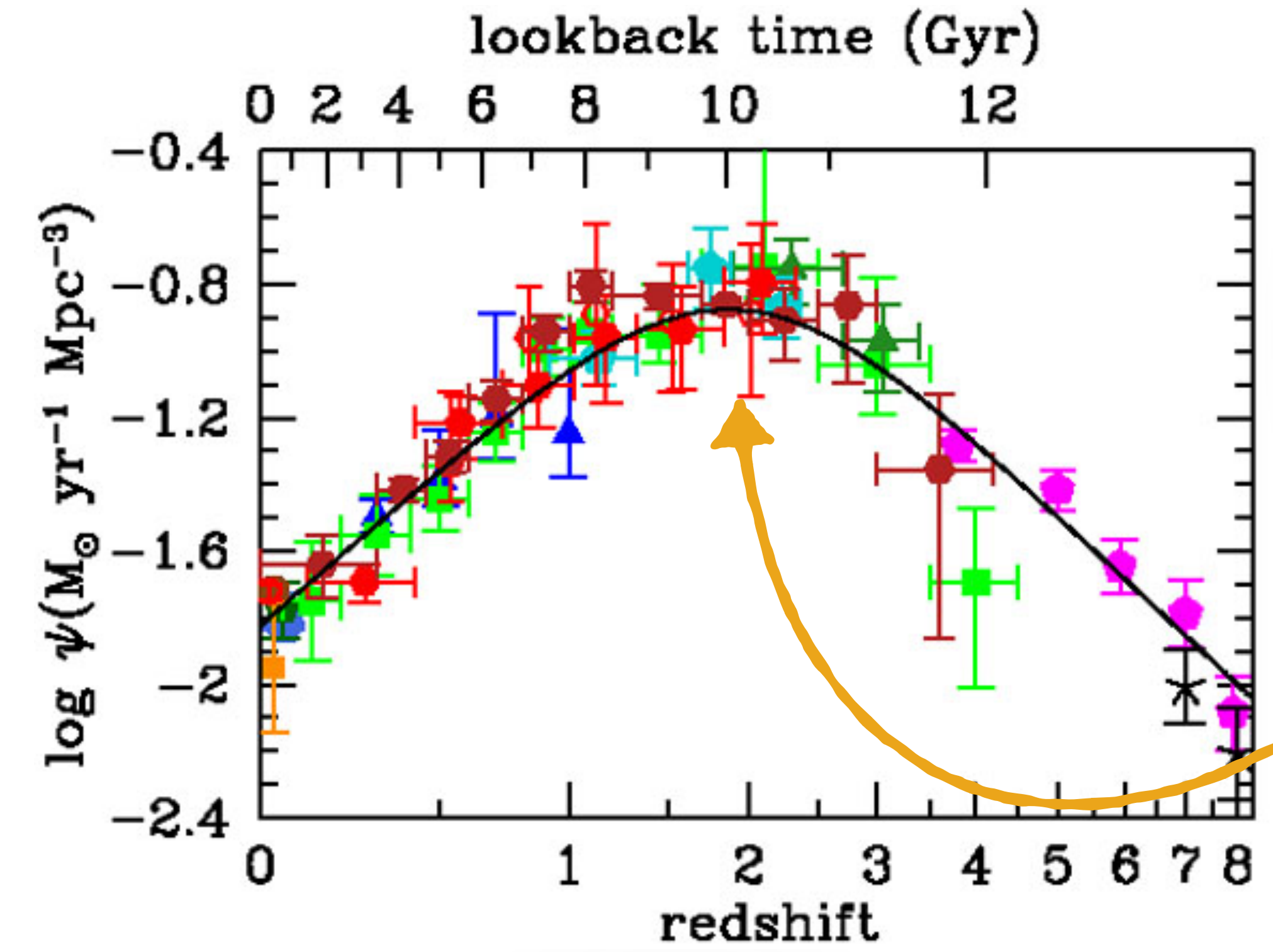
Nordic-Baltic Summit 28/05/2026



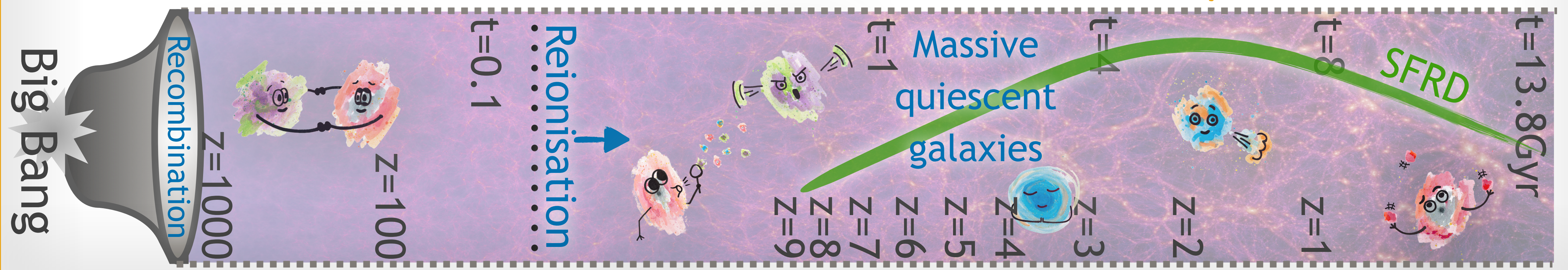
Circum-Galactic Medium



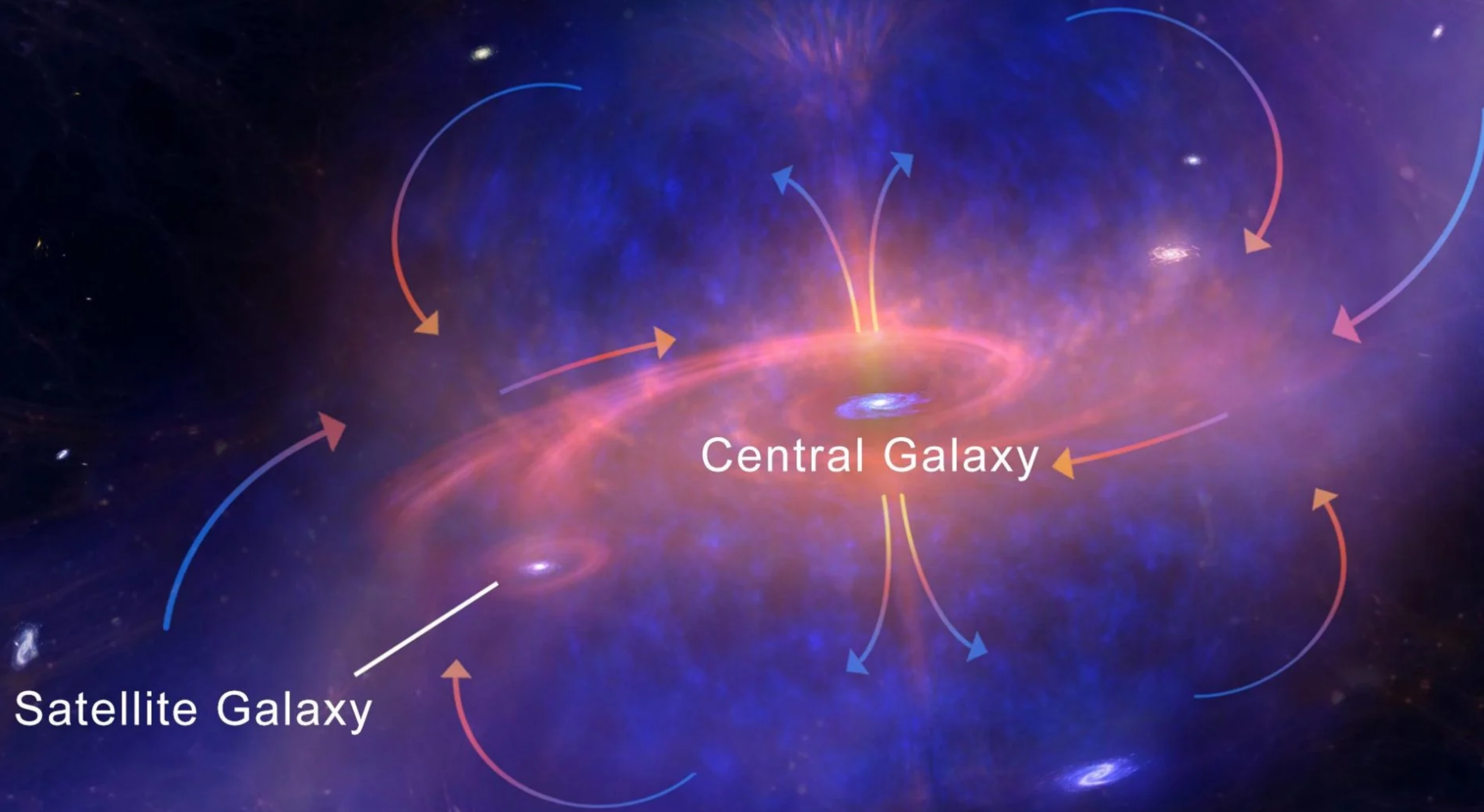
The CGM at High-z



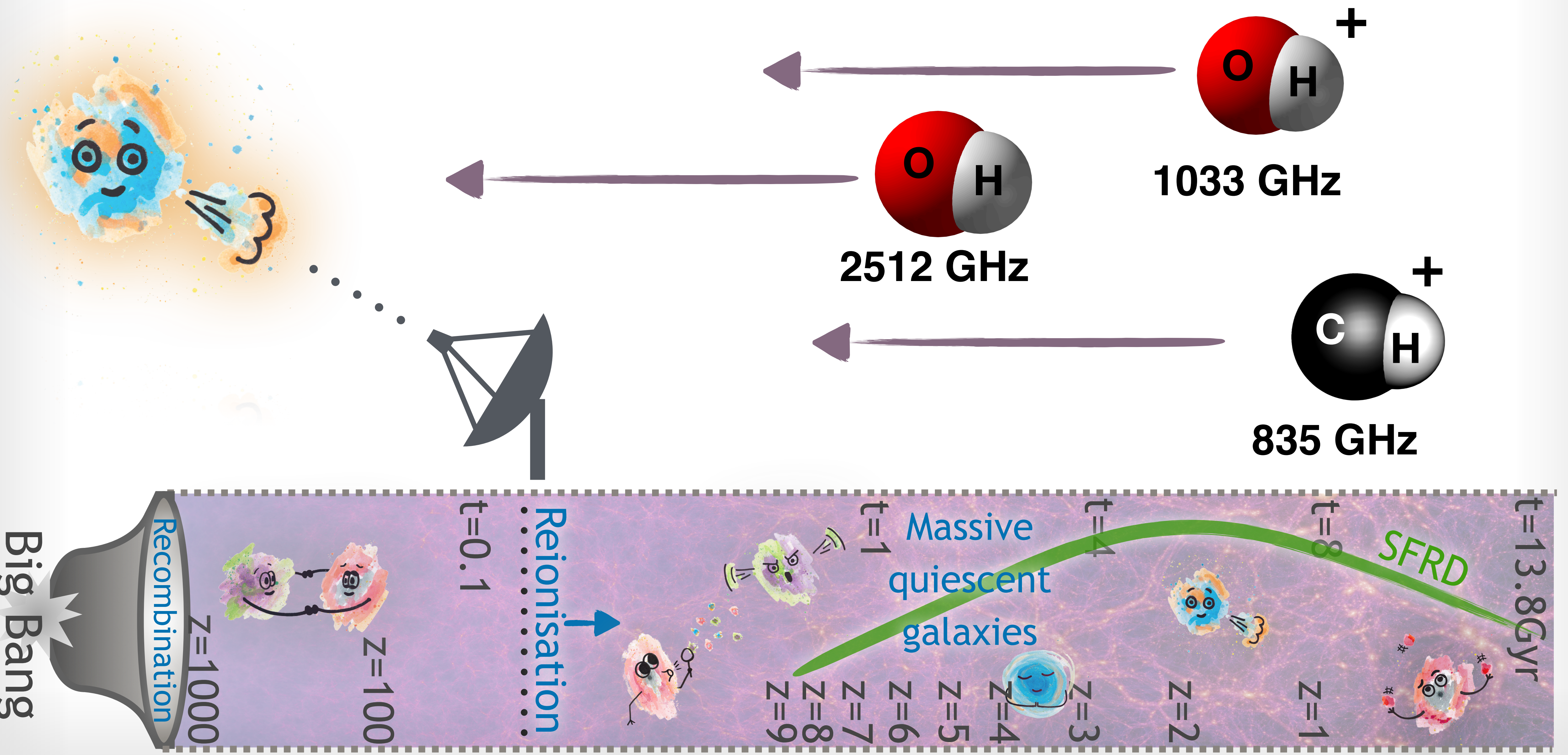
Cosmic Noon



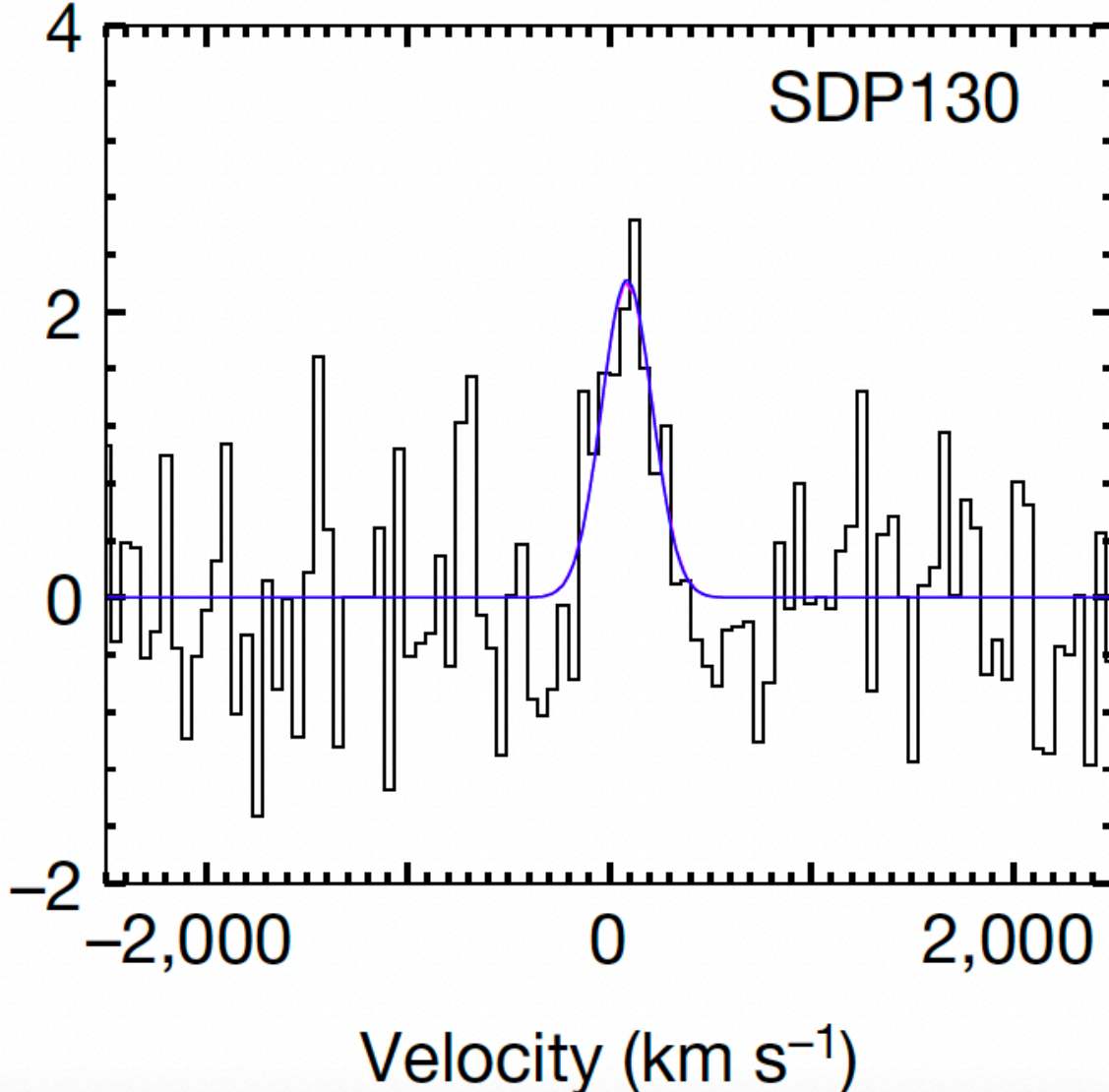
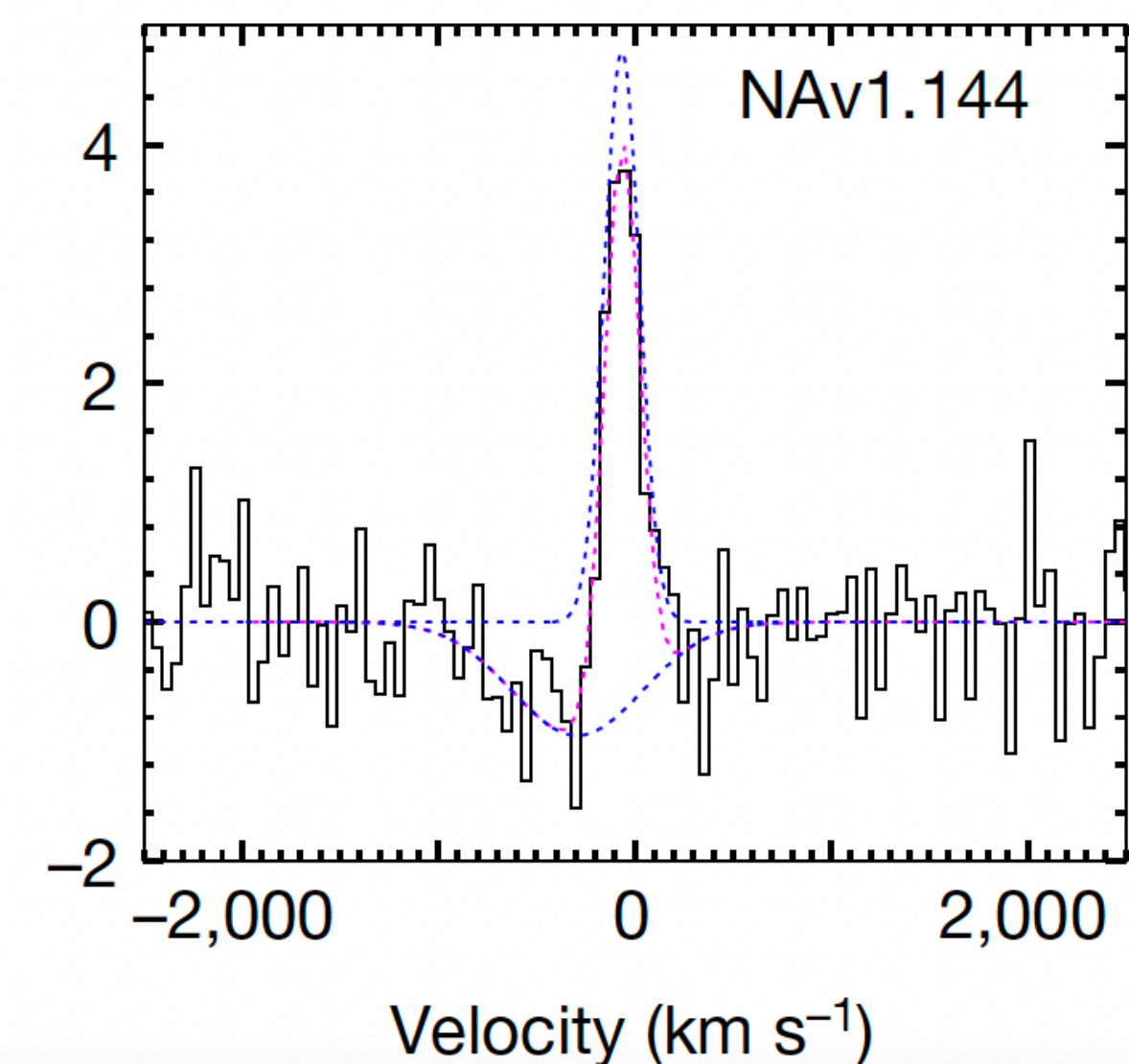
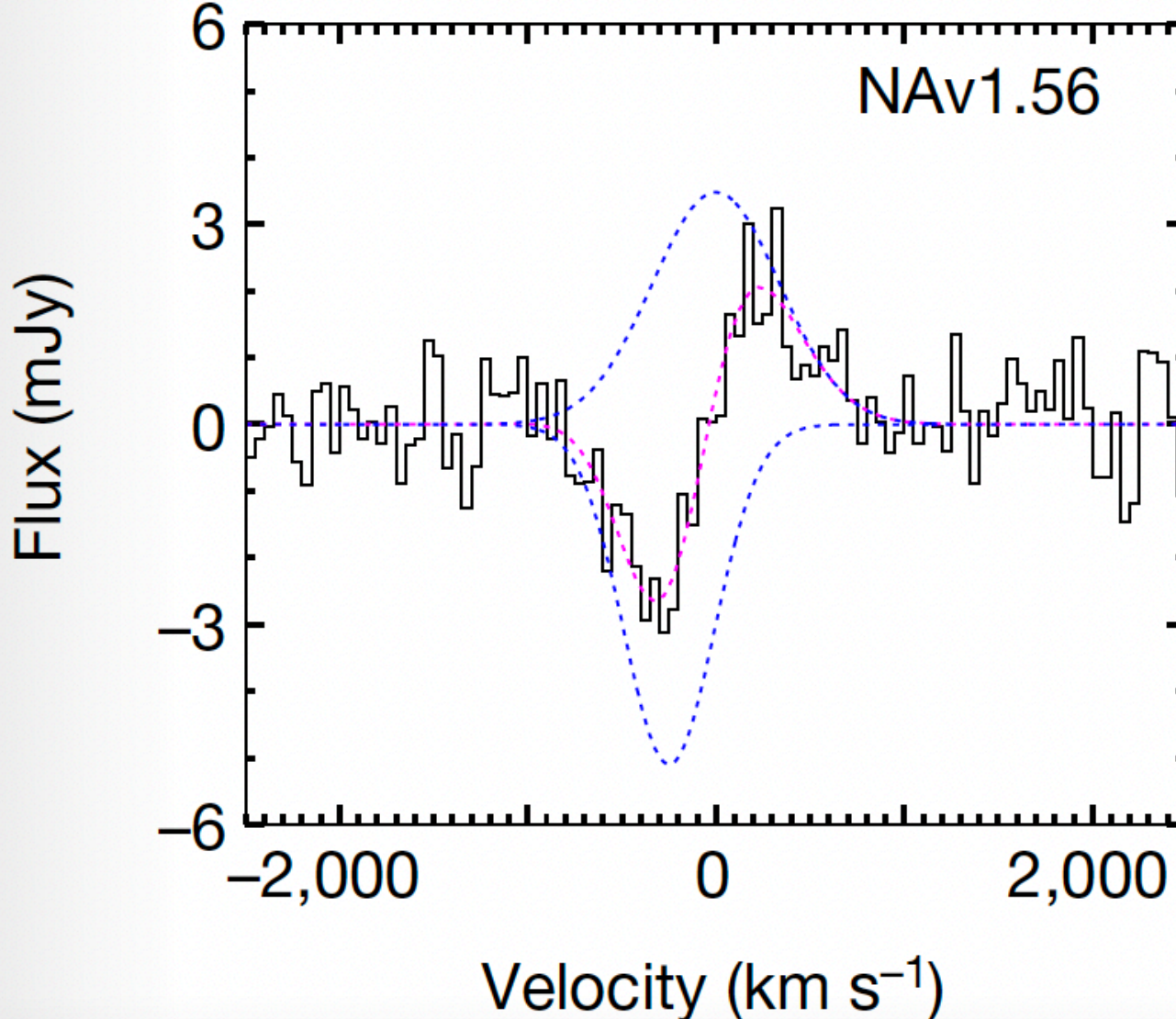
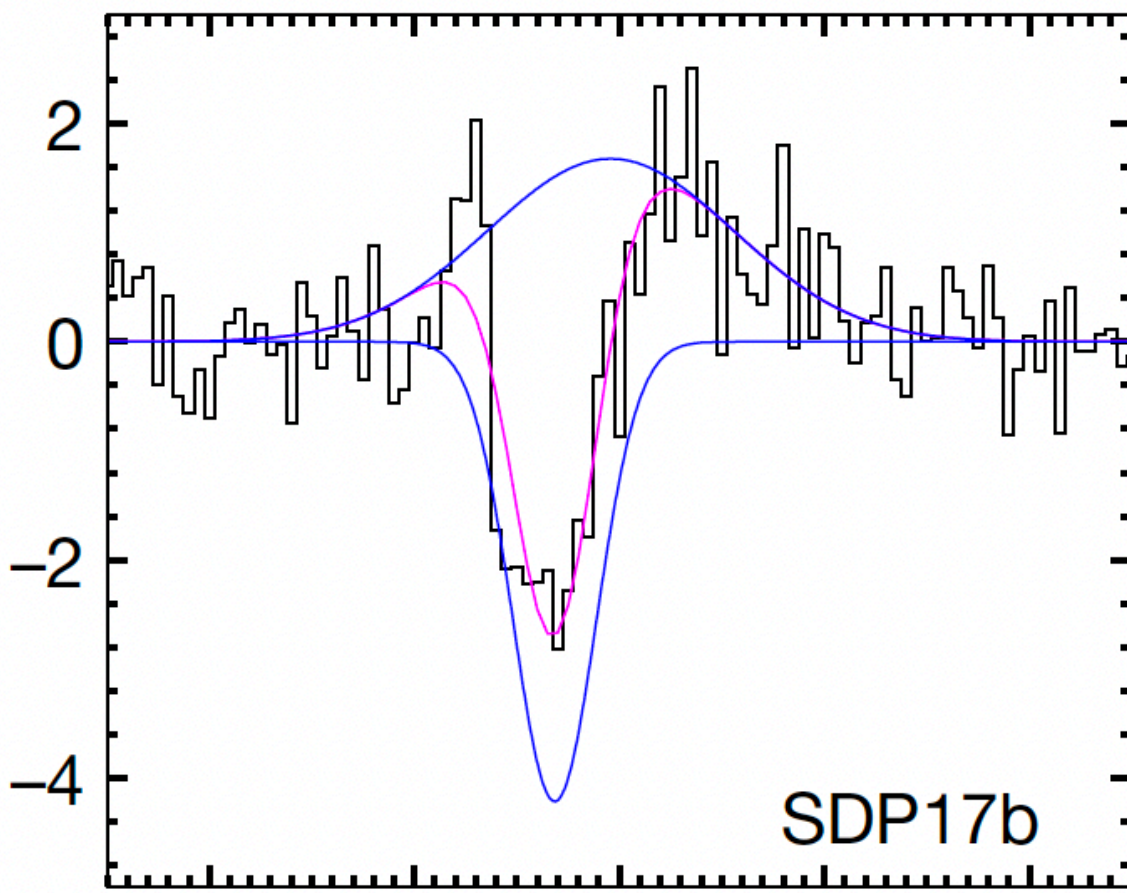
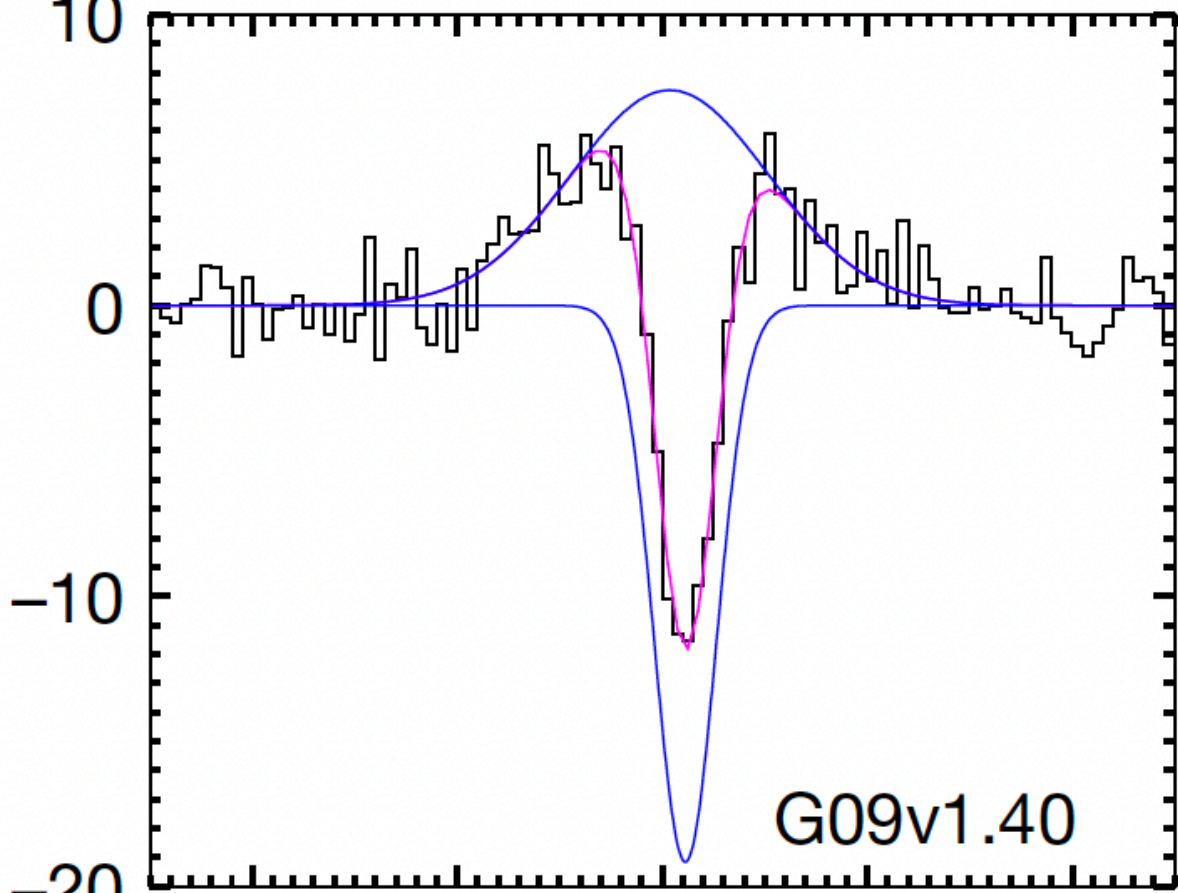
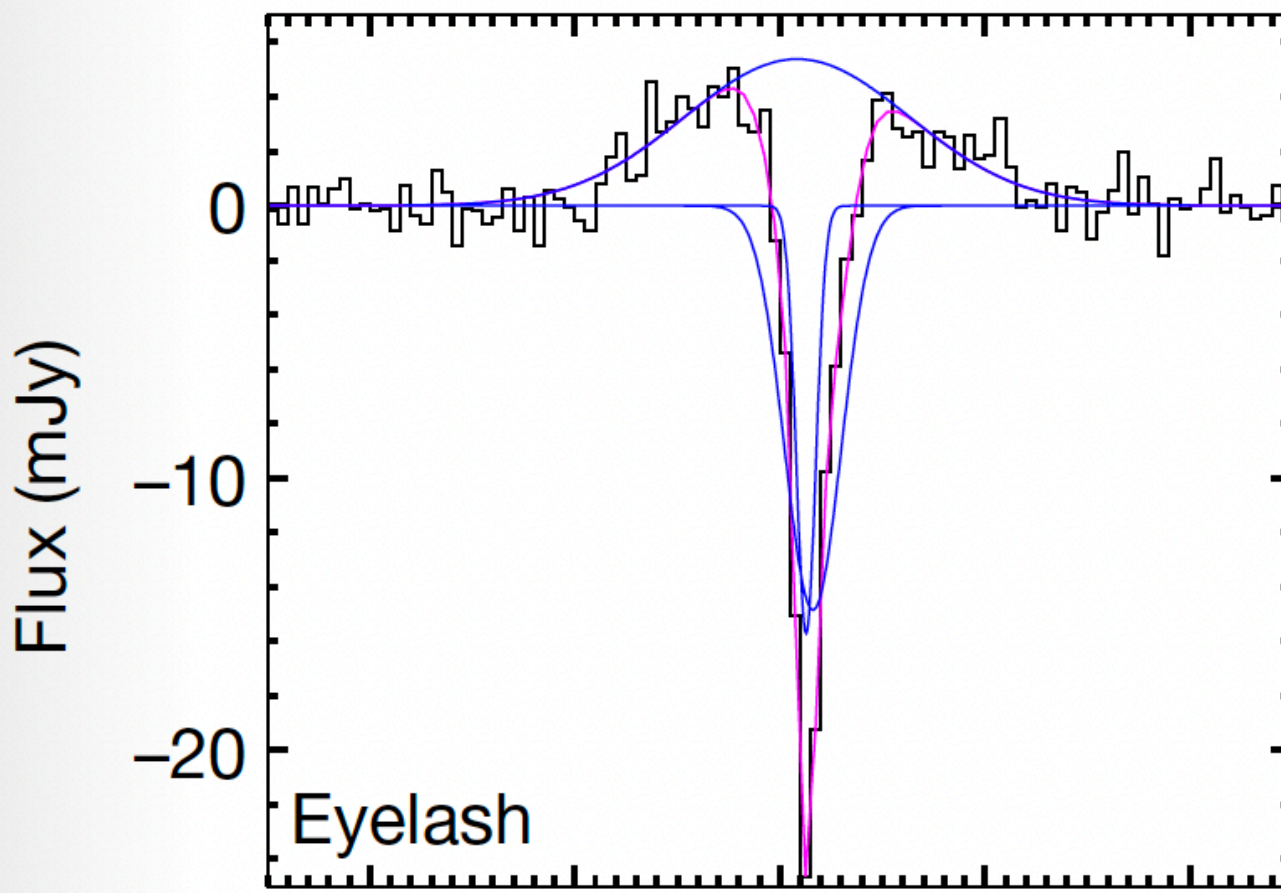
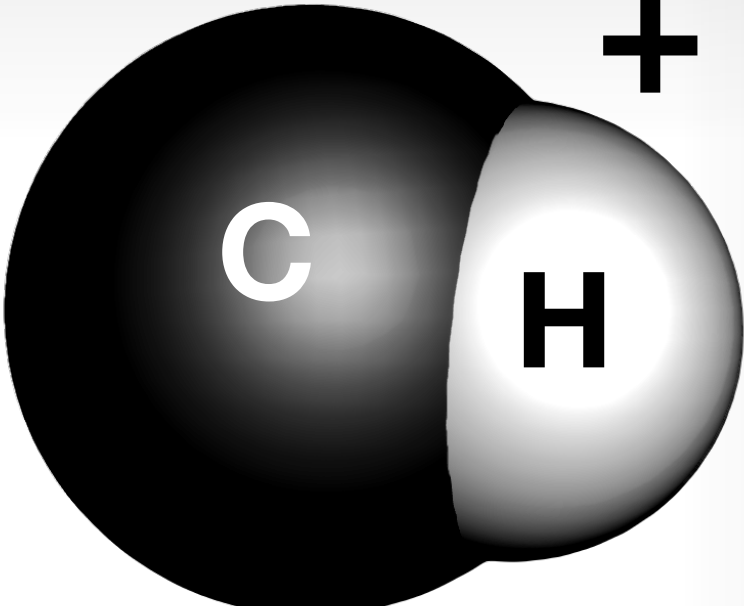
Circum-Galactic Medium



Tracing the CGM at High-z



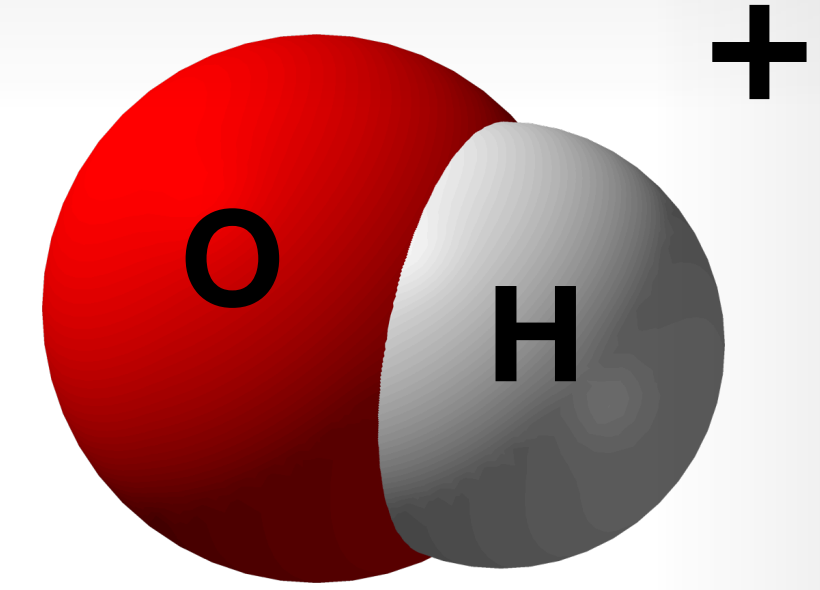
CH⁺ in Cosmic Noon DFSGs



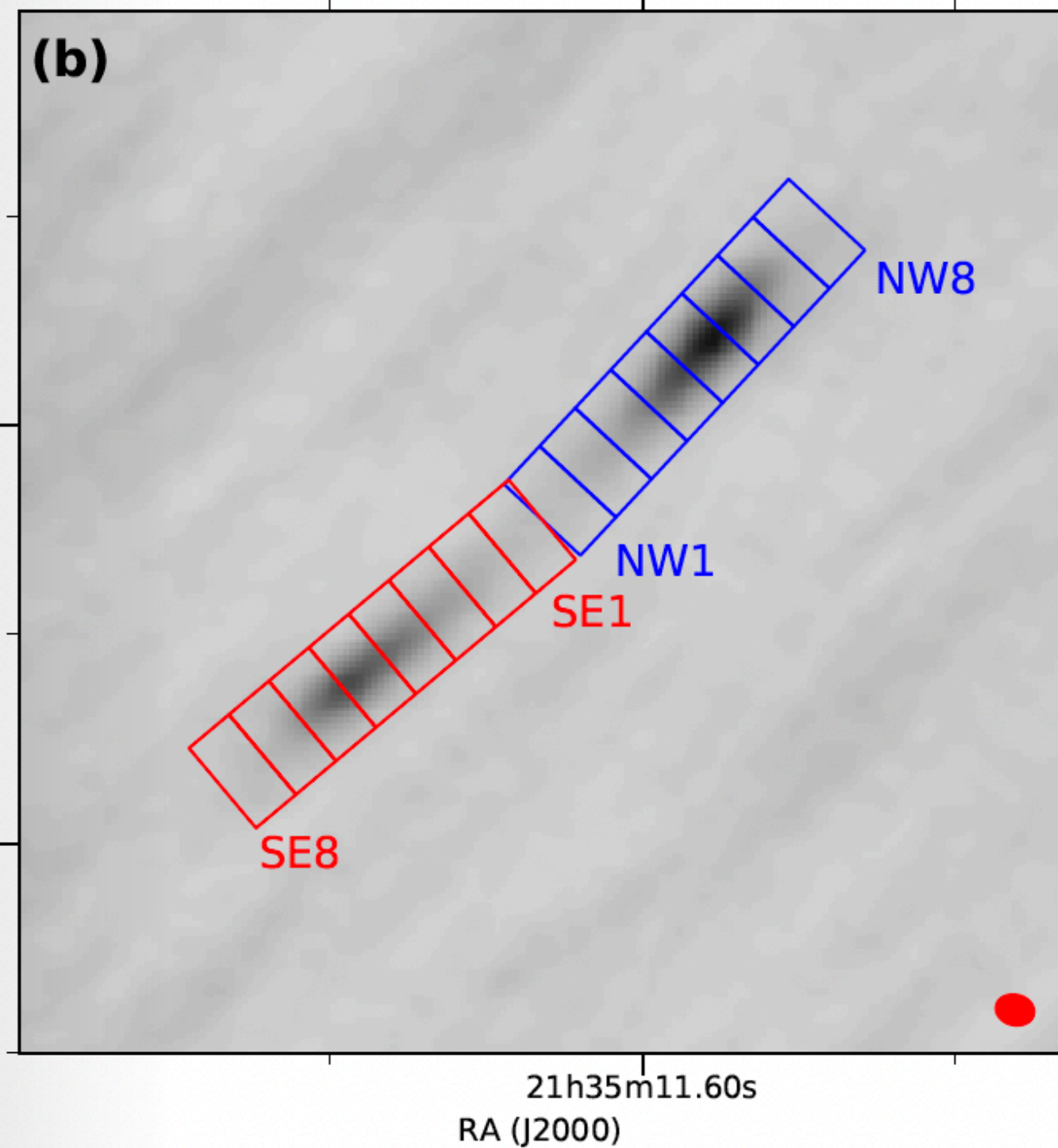
In absorption, CH⁺ traces the dissipation of mechanical energy in low-density gas

$$R_{TR} = 8-20 \text{ kpc}$$

OH⁺ in Cosmic Noon DFSGs

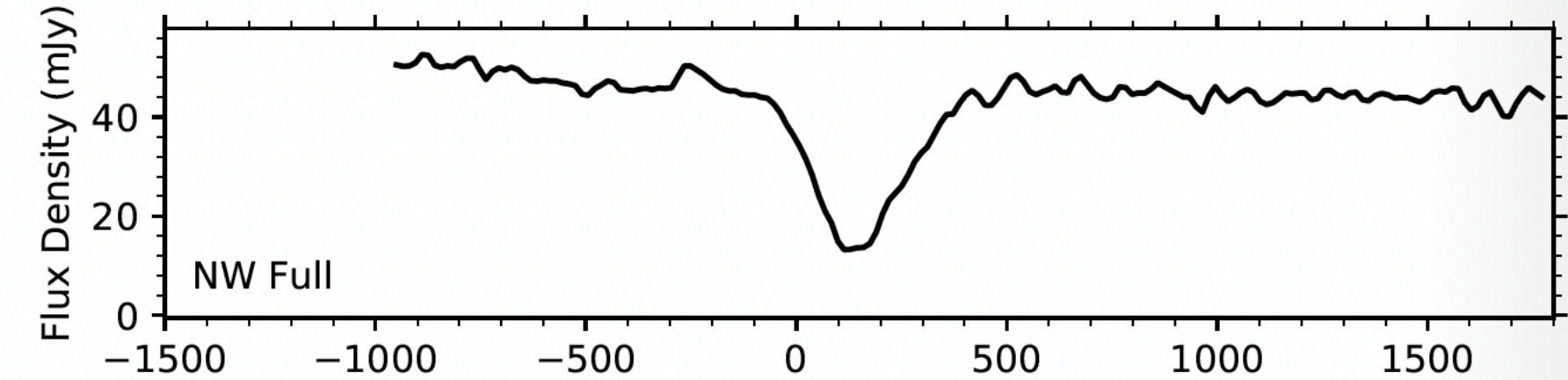
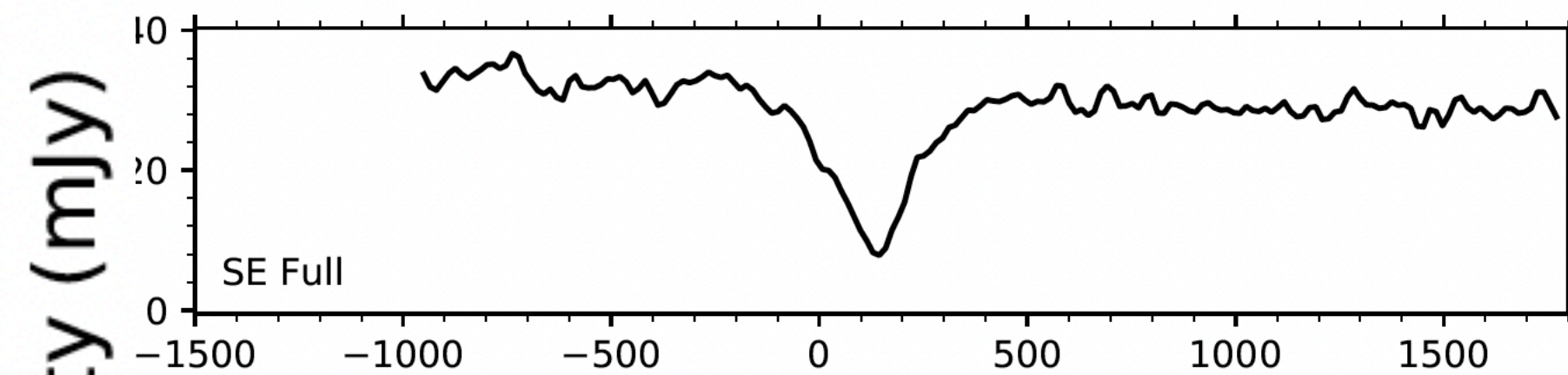


SMM J2135-0102
1033 GHz Continuum Moment 0

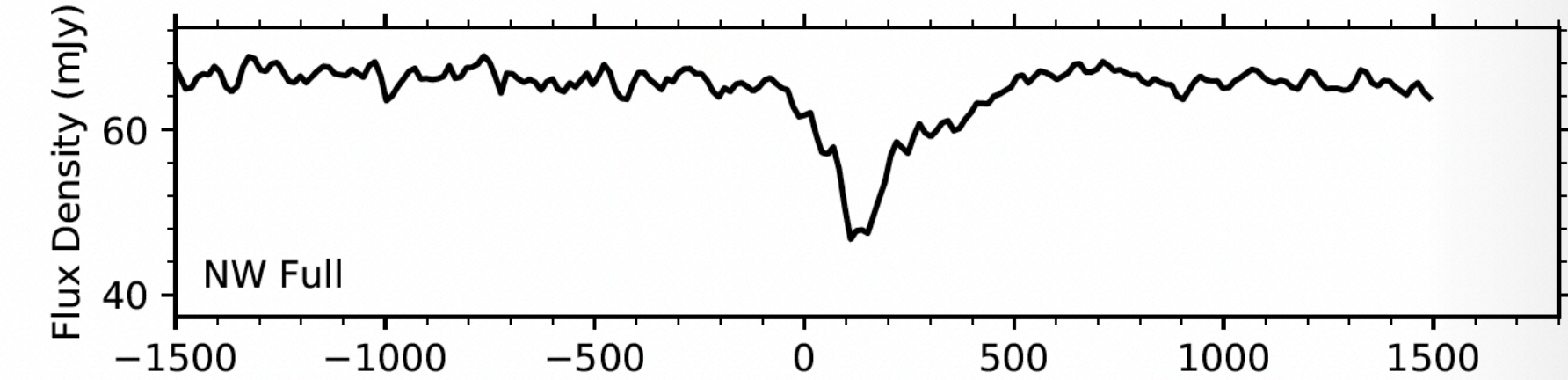
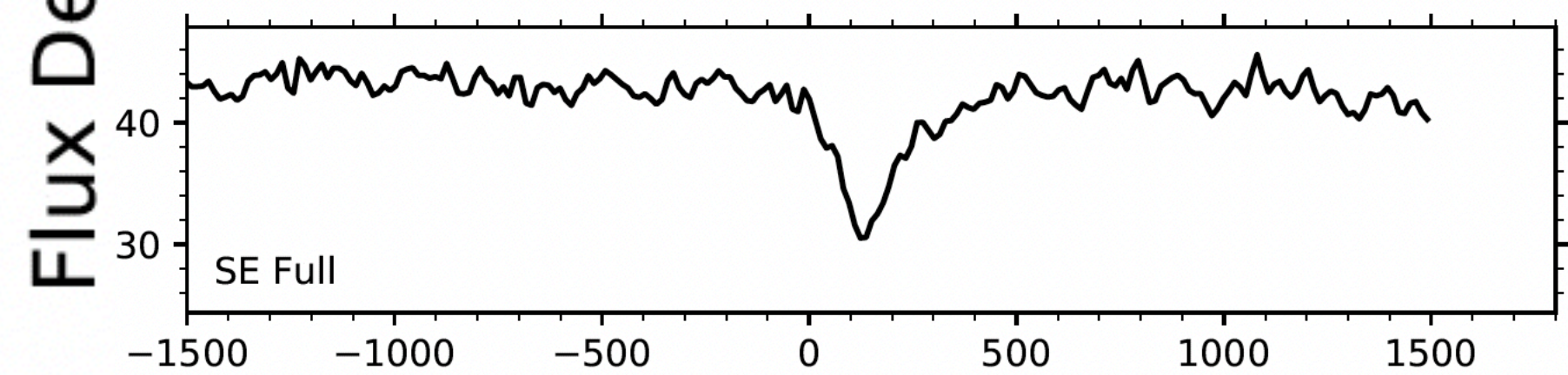


Indriolo et al. 2018

1033 GHz OH⁺ Spectra of SMM J2135-0102



1139 GHz H₂O⁺ Spectra of SMM J2135-0102

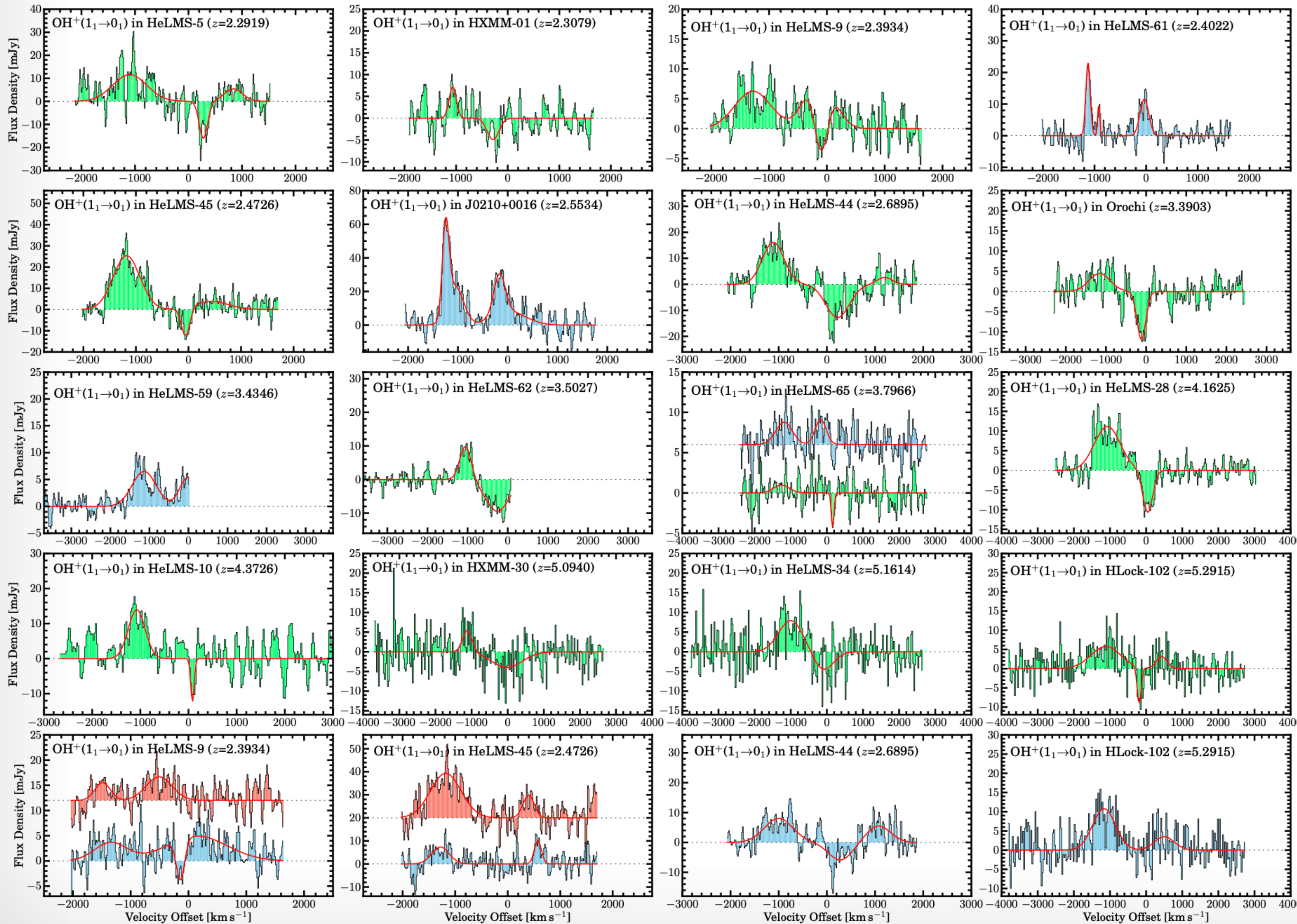
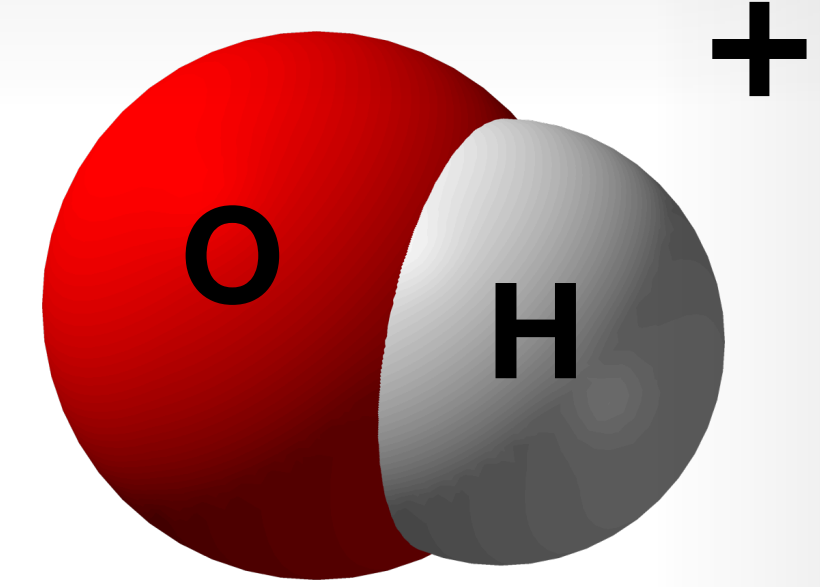


Velocity (km s⁻¹)

Velocity (km s⁻¹)

*Cosmic-ray ionisation rates on the order of 10^{-16} – 10^{-14} s⁻¹
Orders of magnitude lower than inside the galaxy*

OH⁺ in Cosmic Noon DFSGs



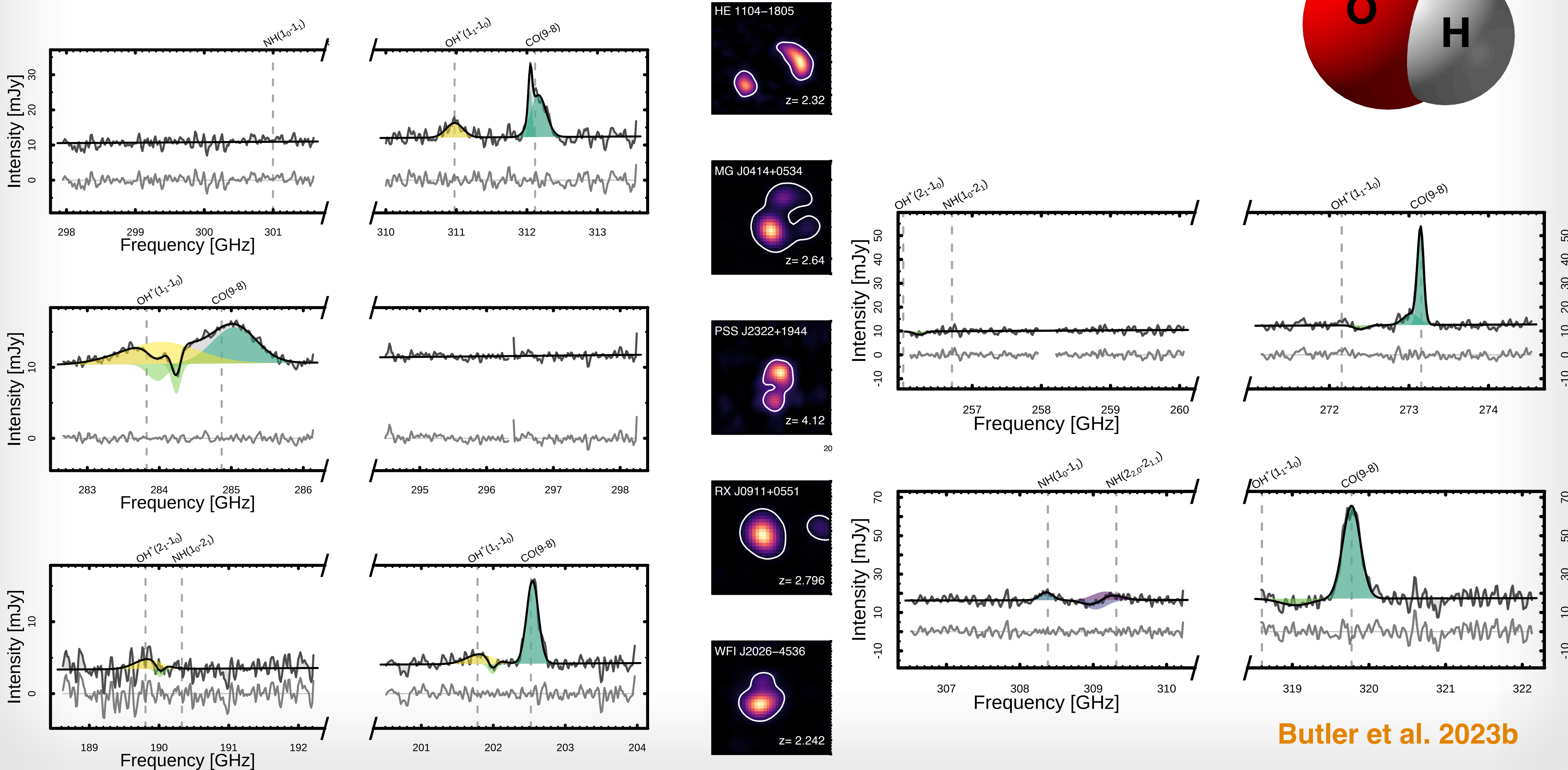
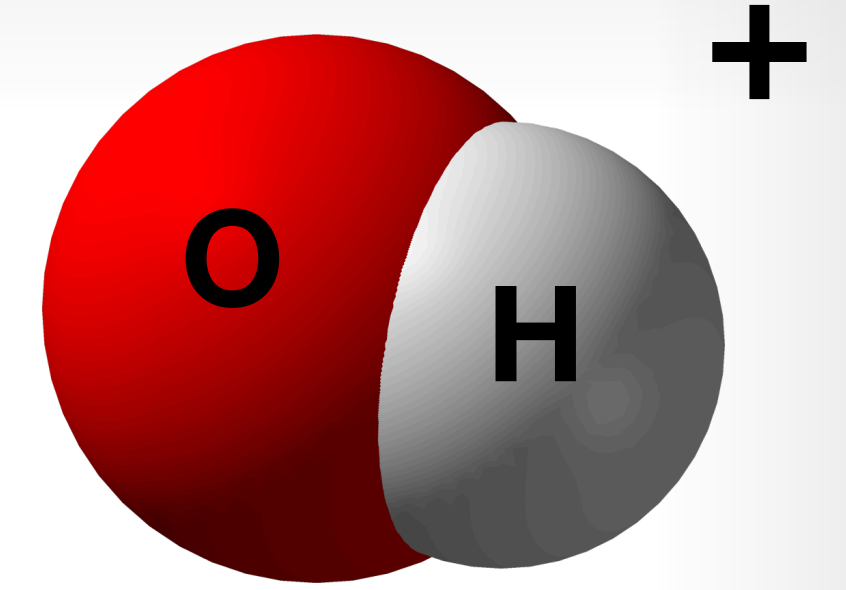
● 89% detection rate of OH⁺ abs.

● 10/16 no significant velocity shift

● 3/16 show significant redshifts

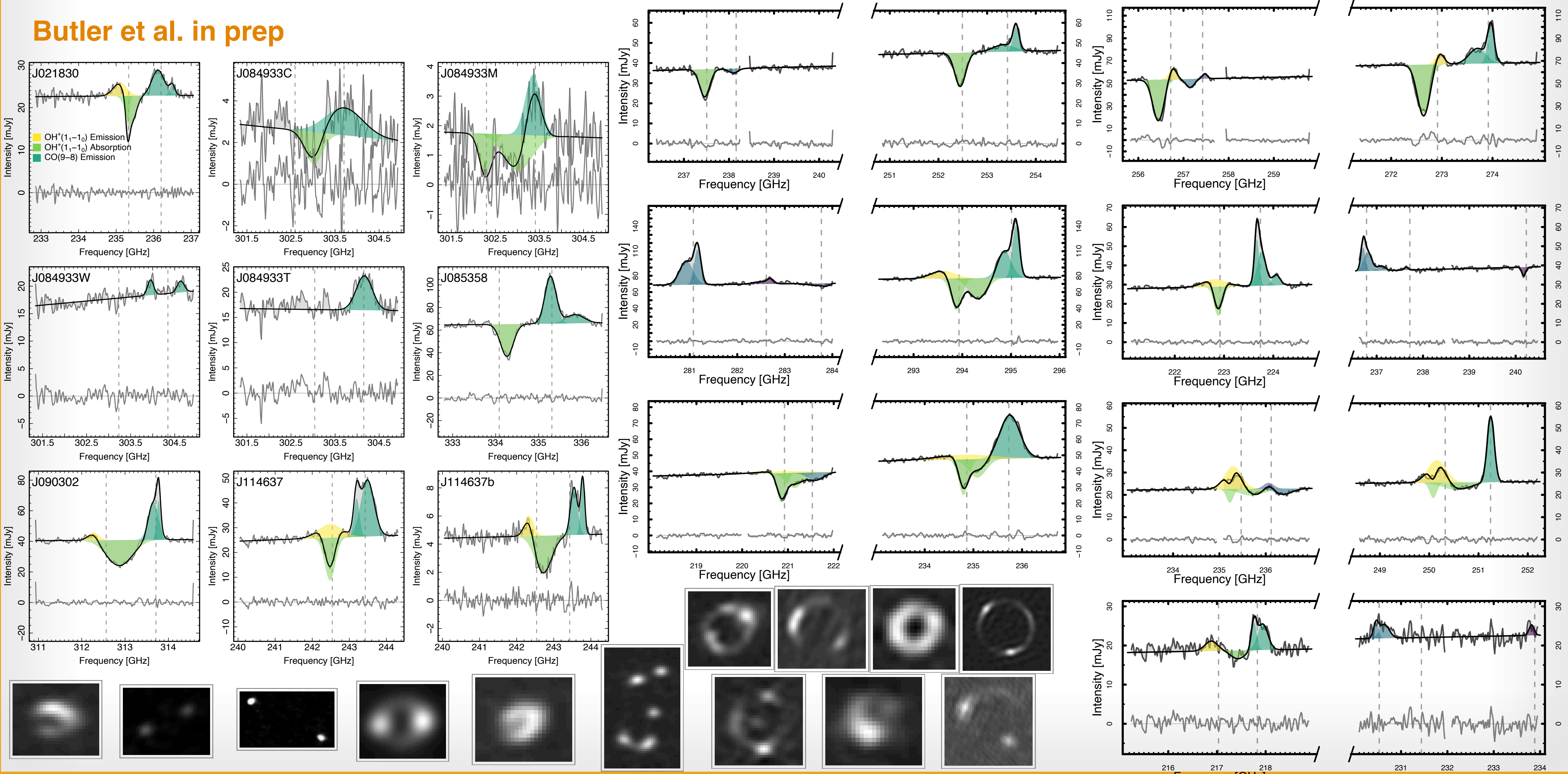
● 3/16 show significant blueshift

OH⁺ in Cosmic Noon QSOs



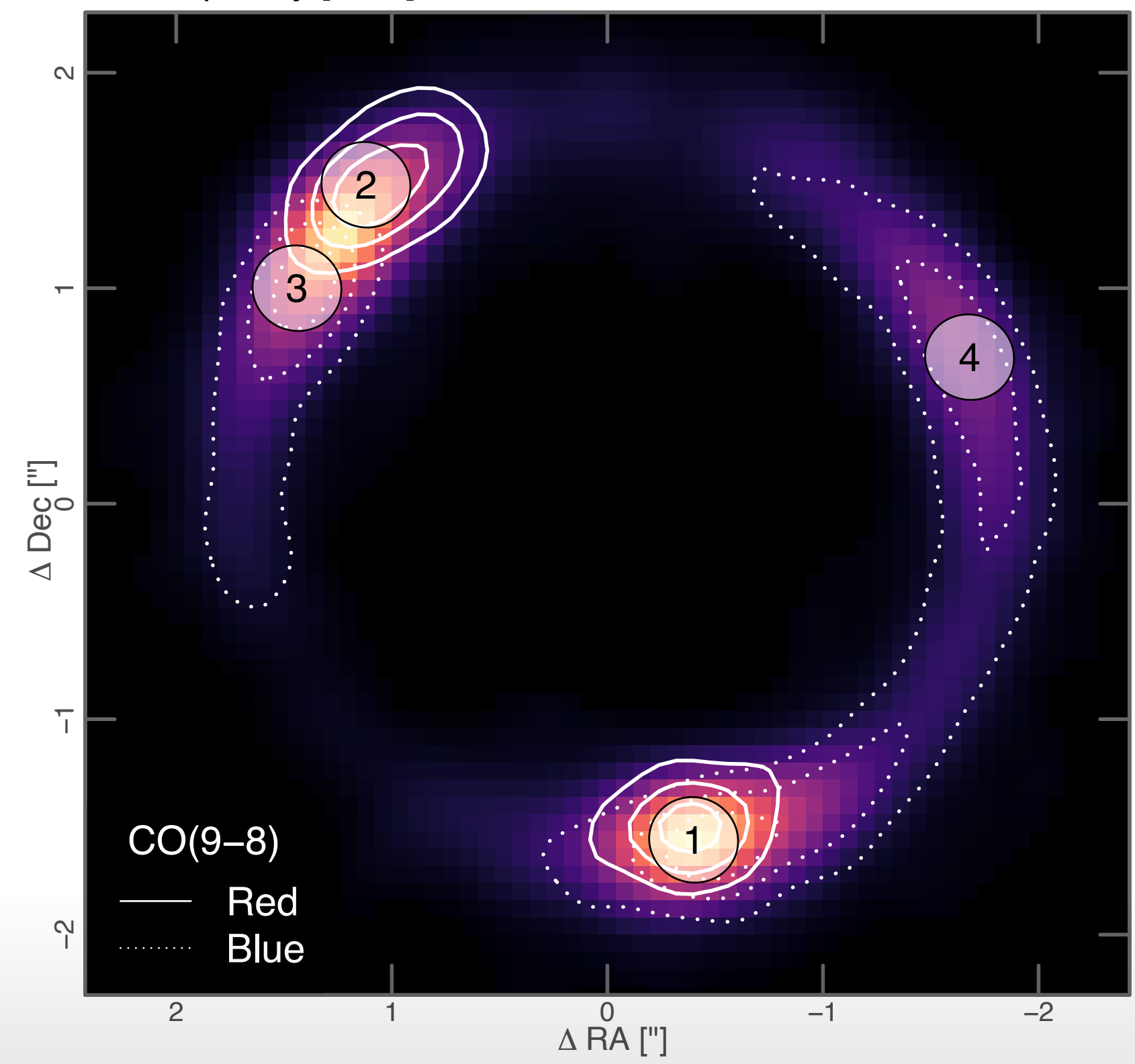
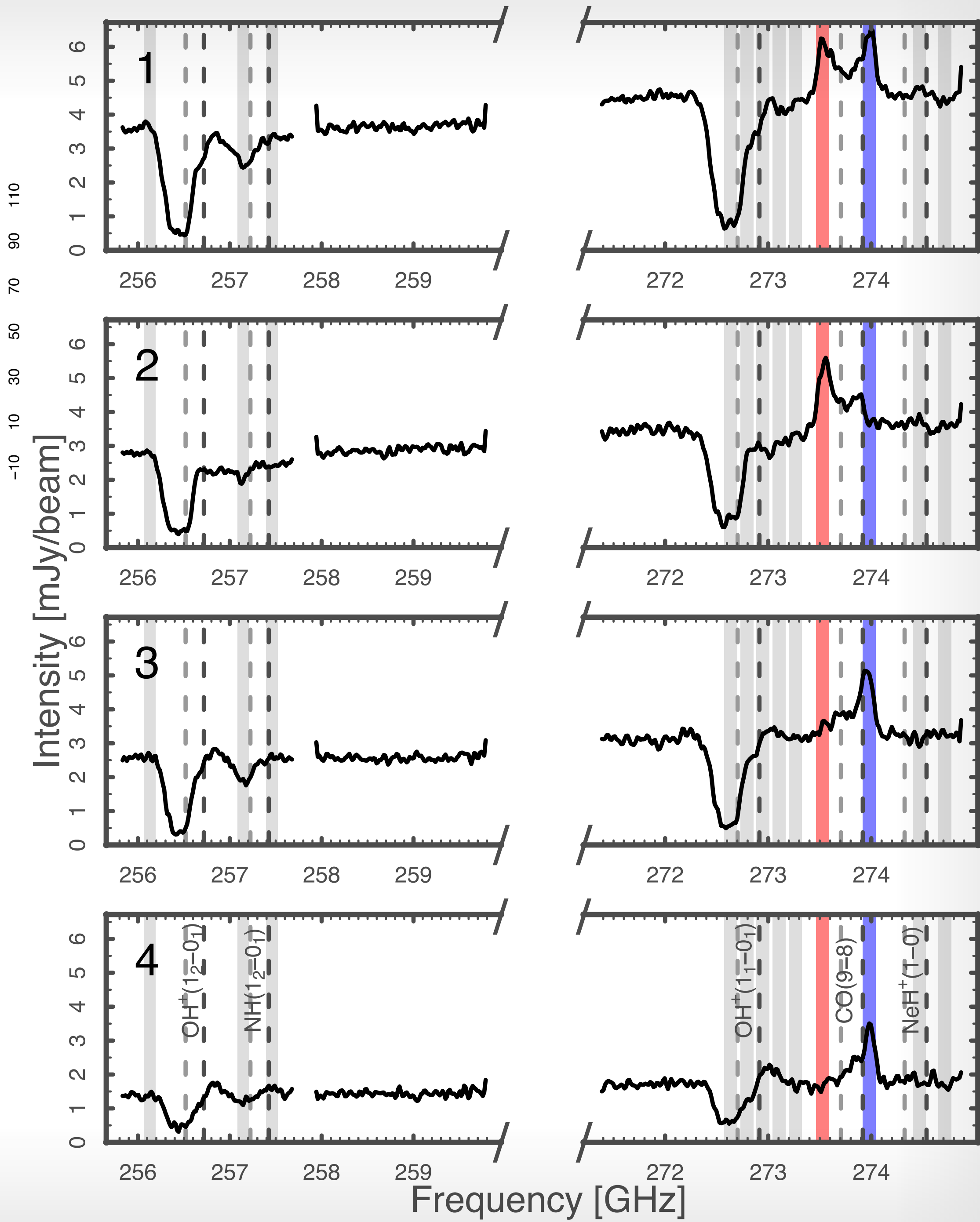
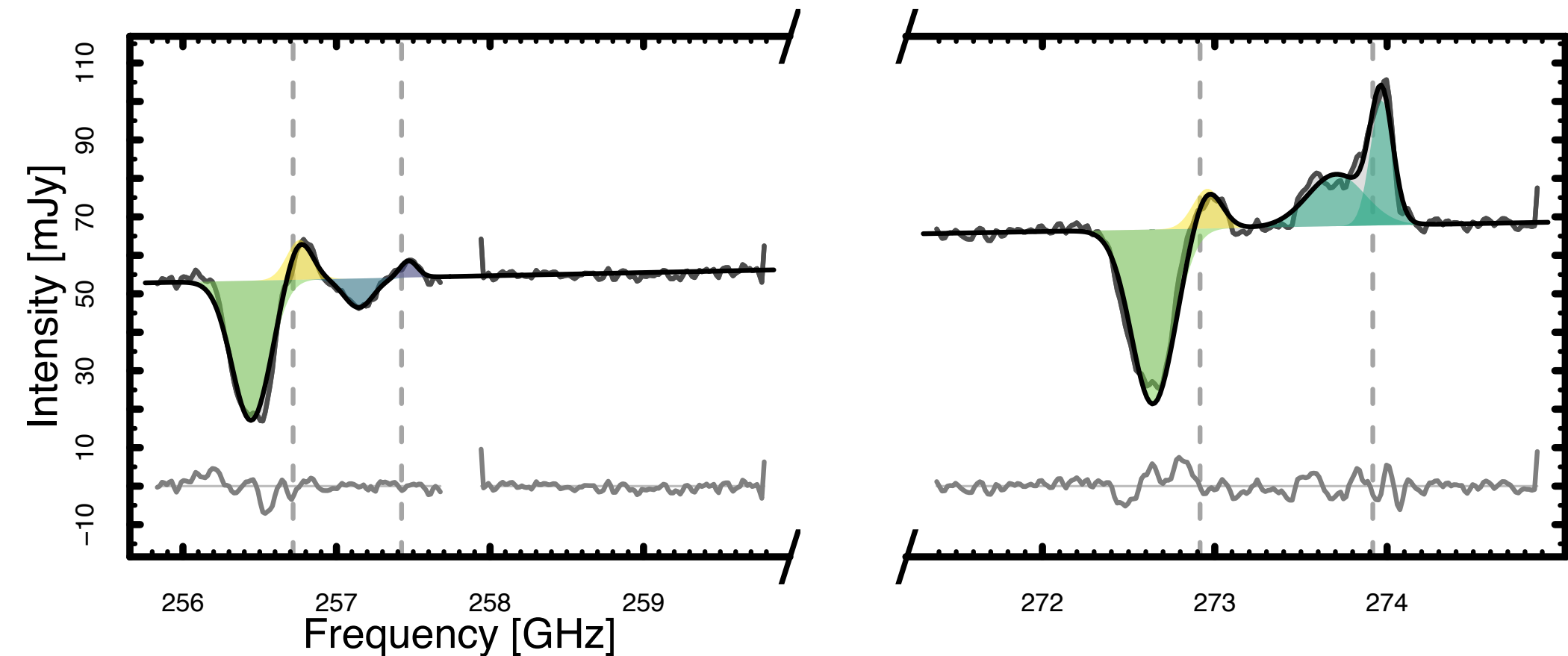
OH⁺ in Cosmic Noon DFSGs

Butler et al. in prep



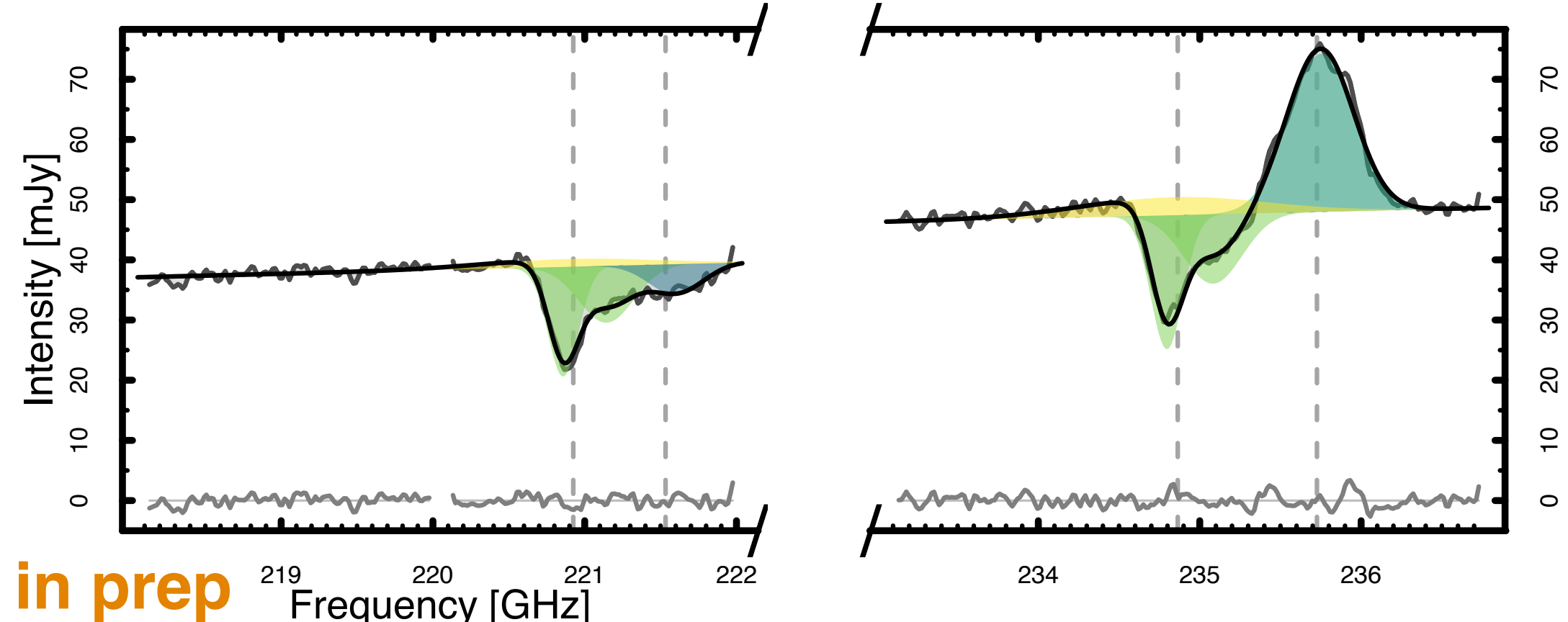
False Inflows

- J053816**
- OH⁺(1₁-1₀) Emission
 - OH⁺(1₁-1₀) Absorption
 - CO(9-8) Emission
 - NH(1₀-1₁) Absorption
 - NH(1₀-1₁) Emission

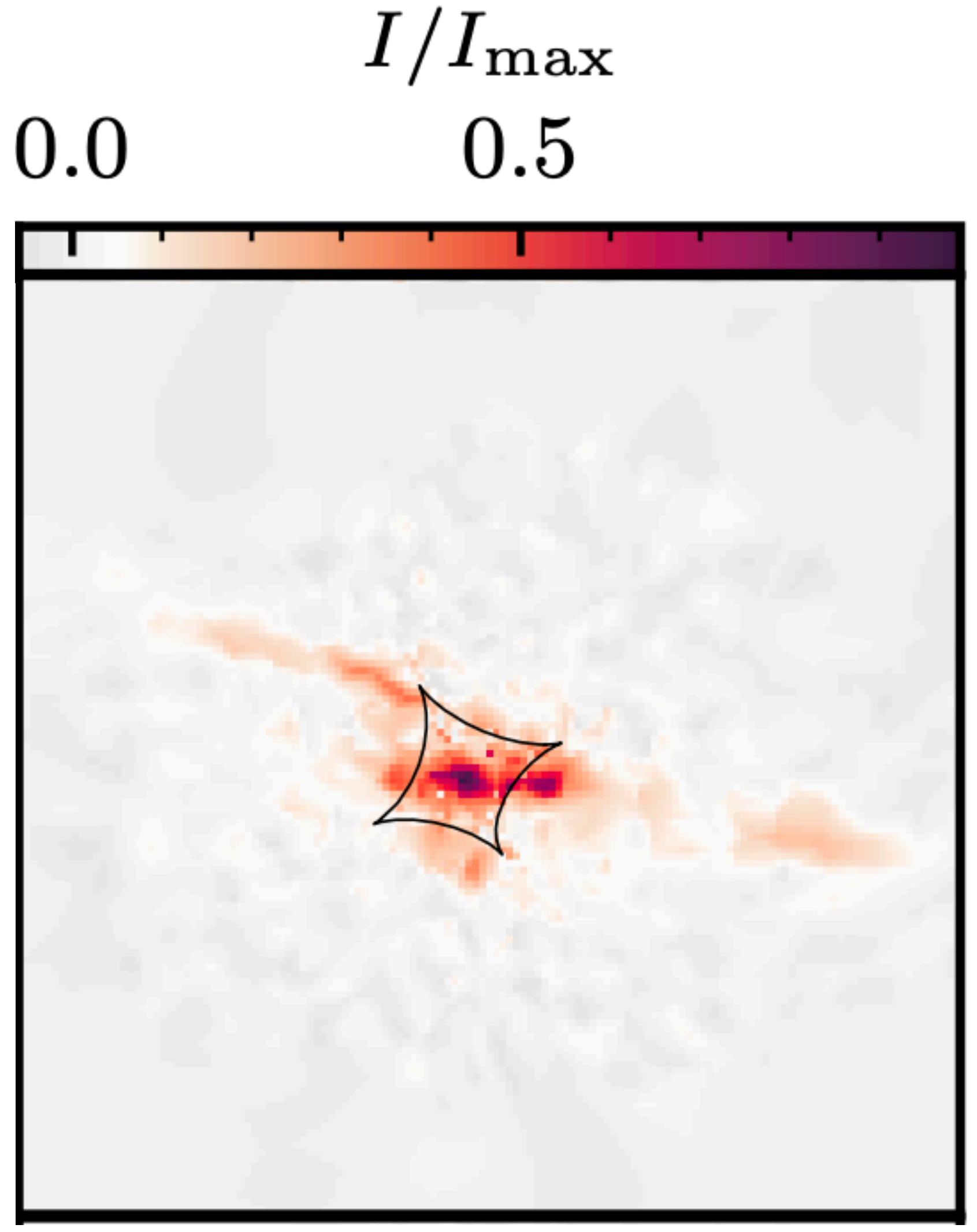
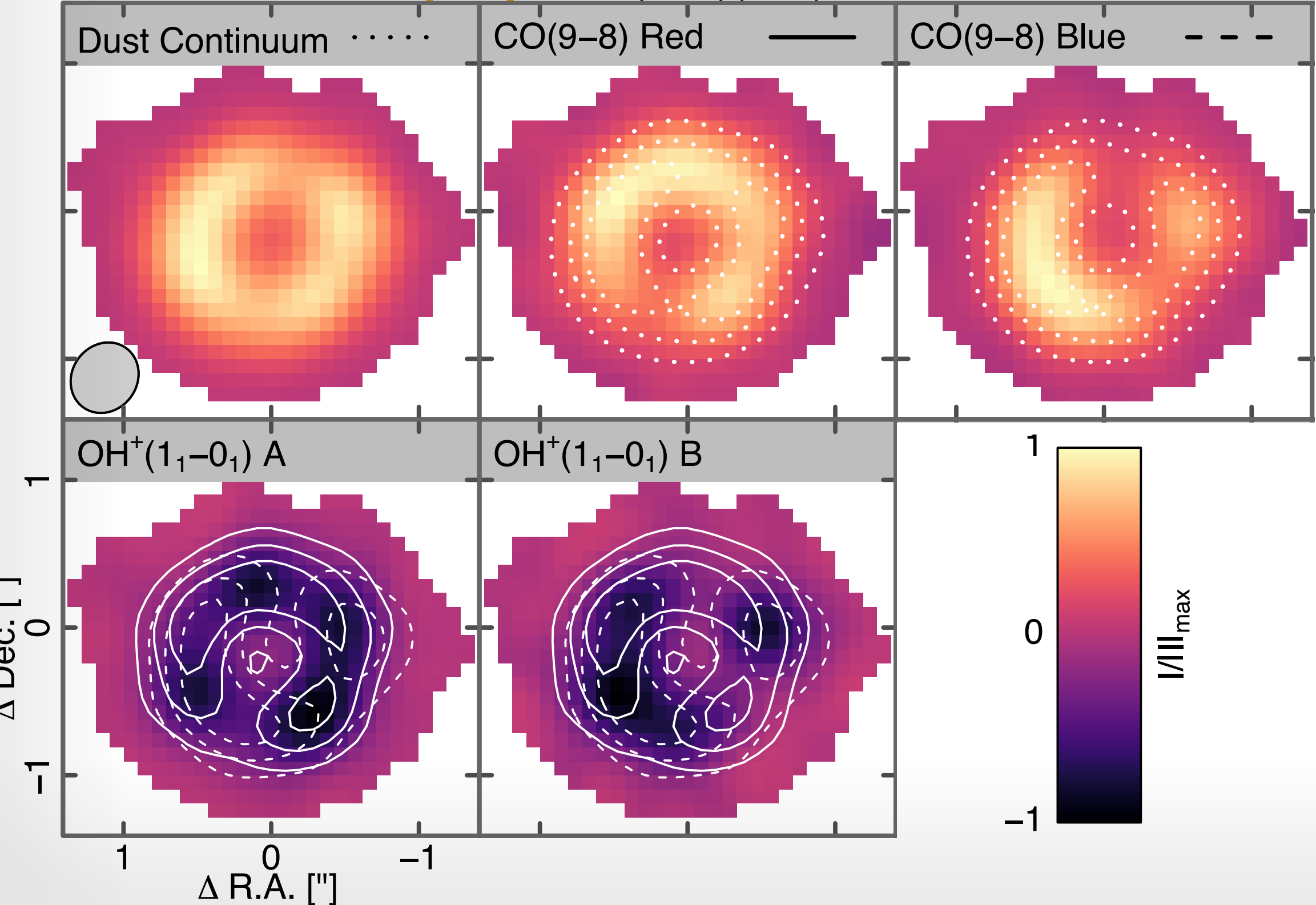


False Outflows

- J053250
- OH⁺(1₁-0₁) Emission
 - OH⁺(1₁-0₁) Absorption
 - CO(9-8) Emission
 - NH(1₀-1₁) Absorption



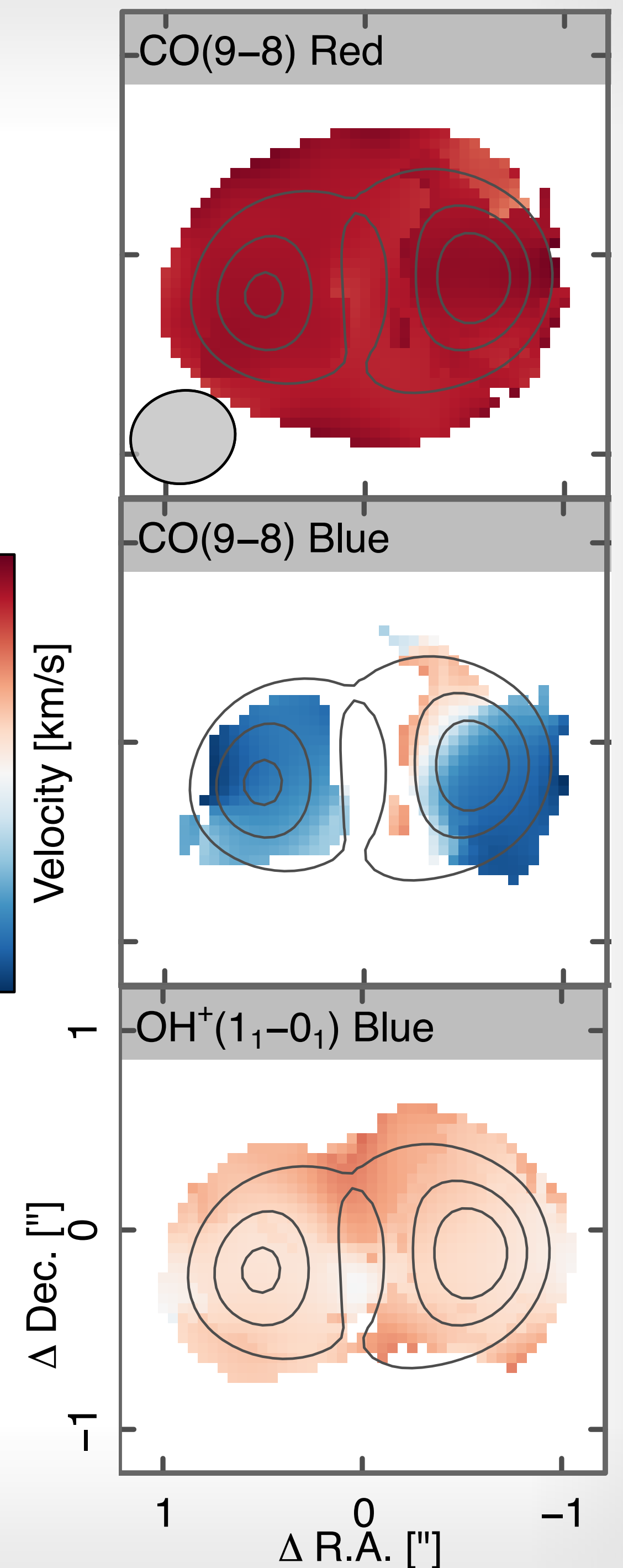
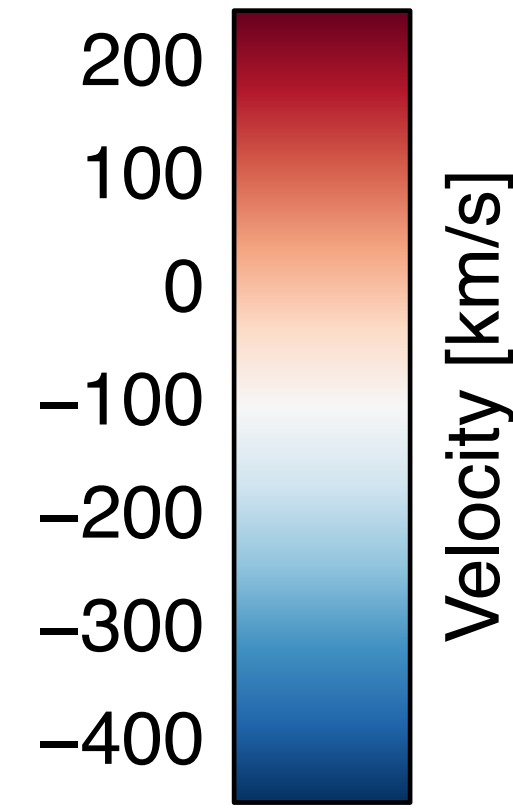
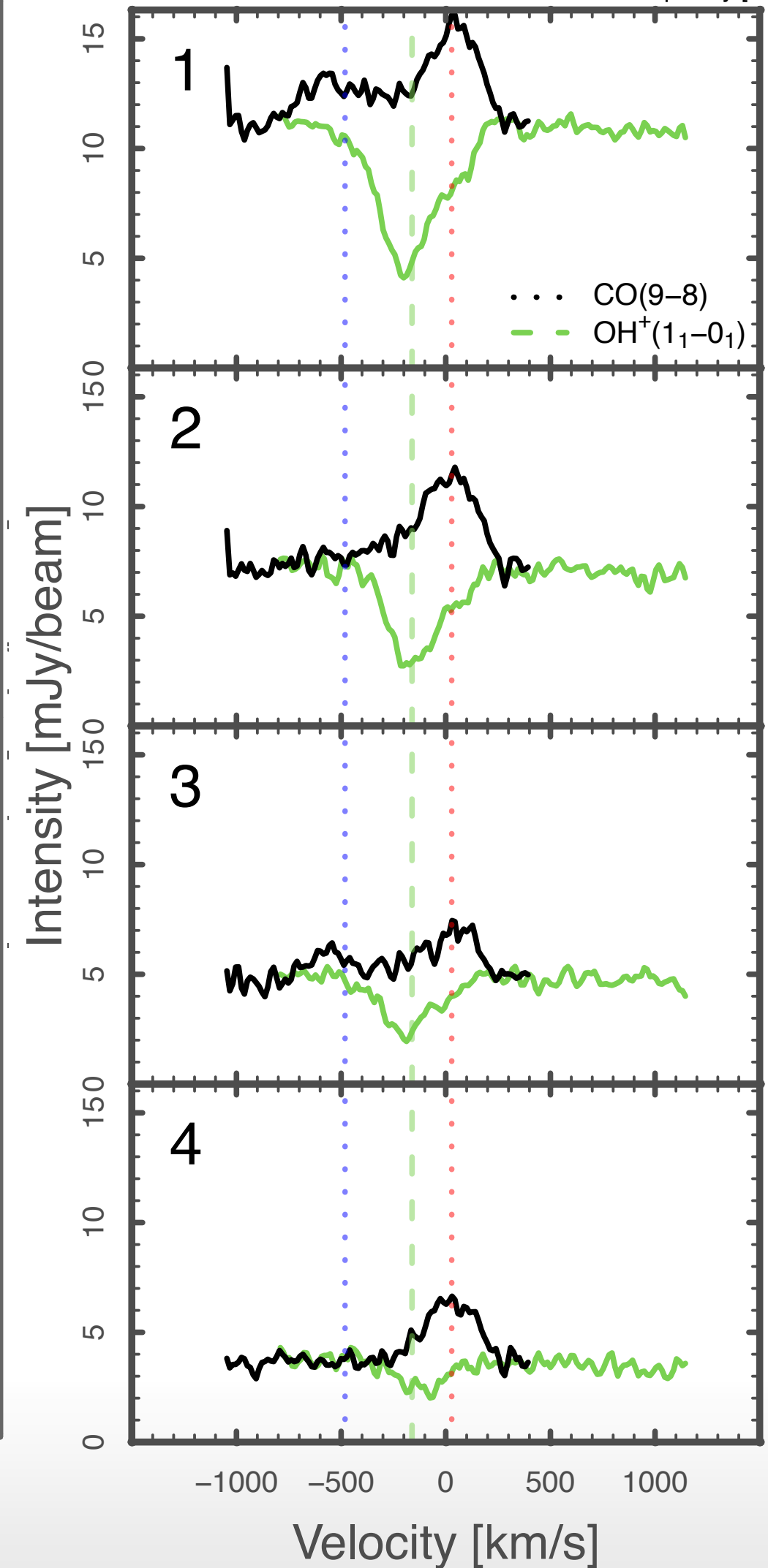
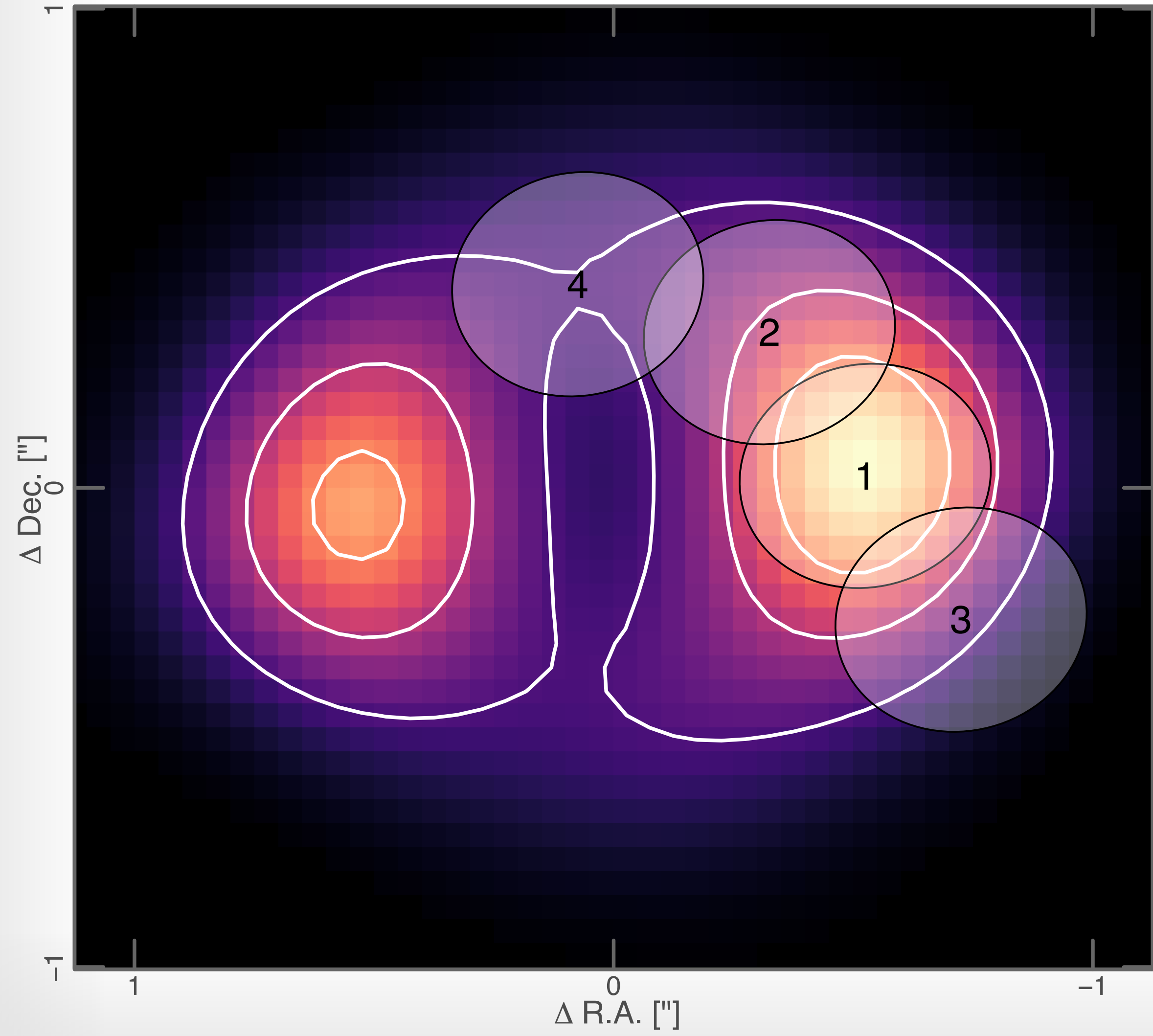
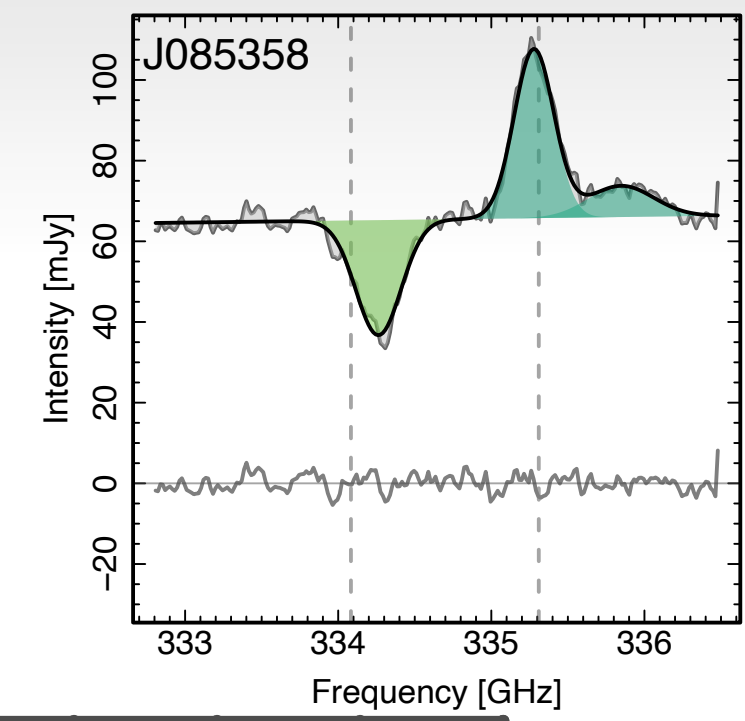
Butler et al. in prep



Stacey et al. 2024

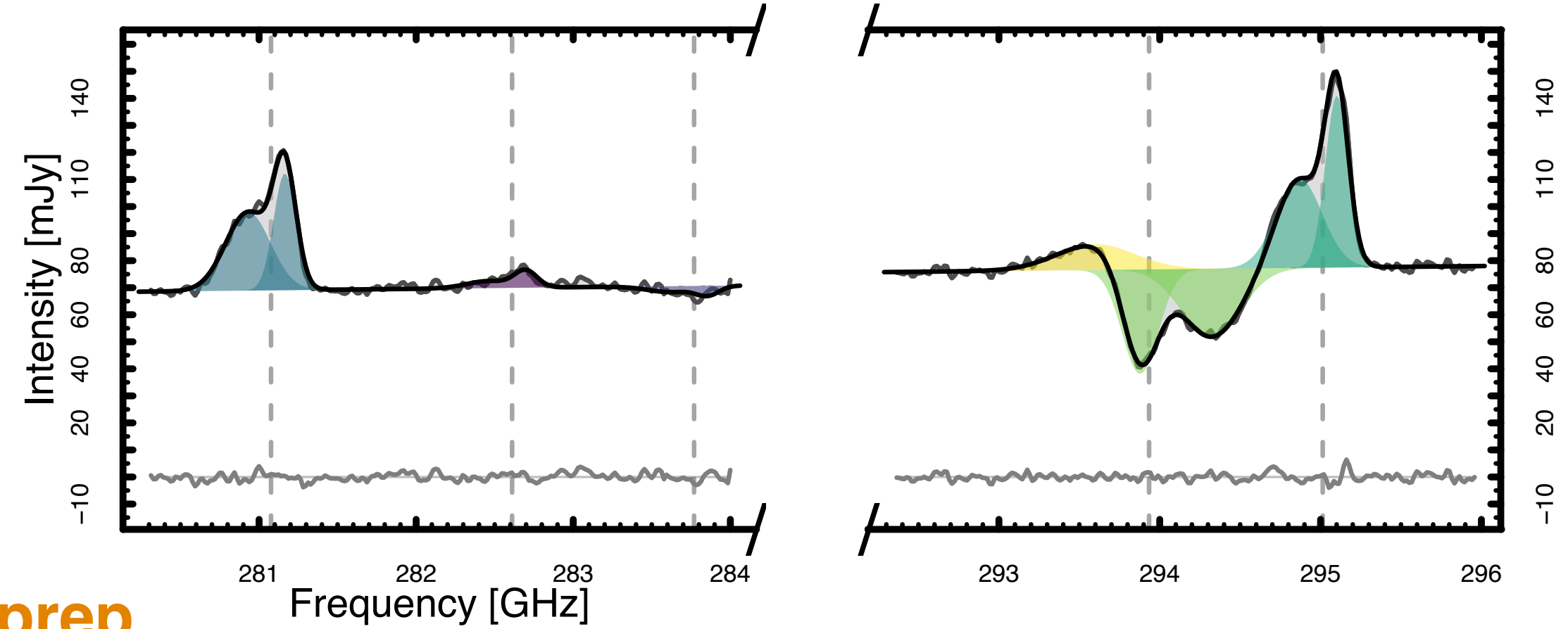
ISM Contributions

Butler et al. in prep

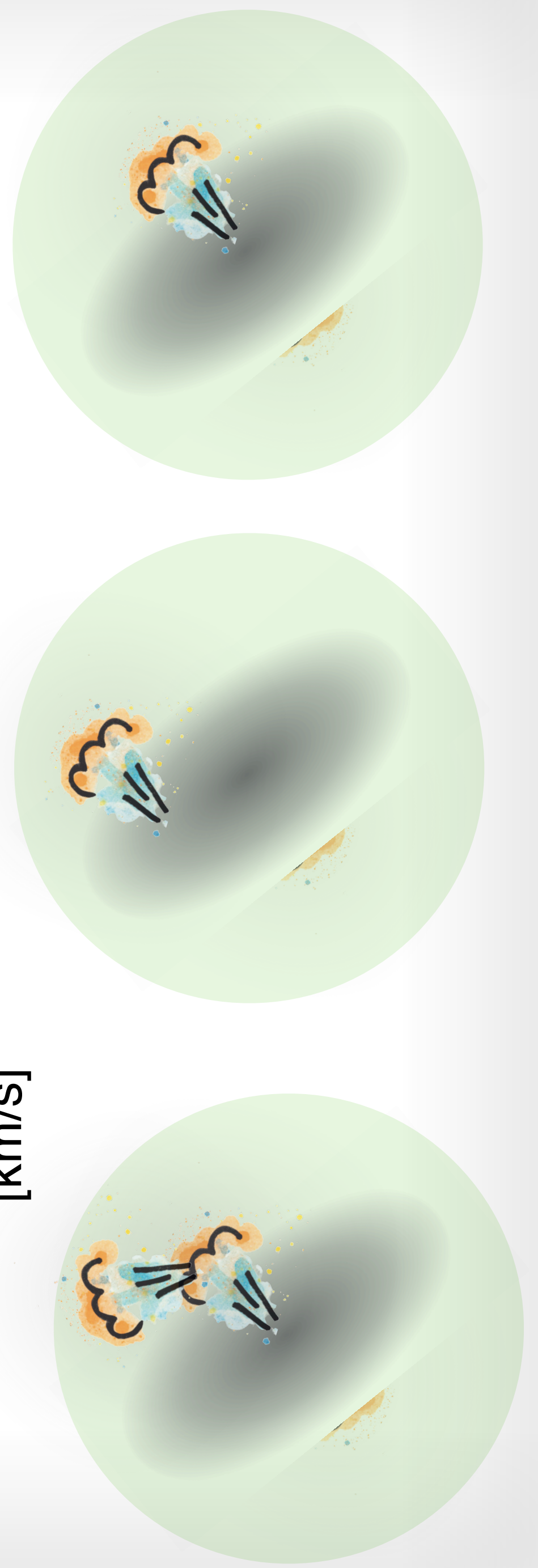
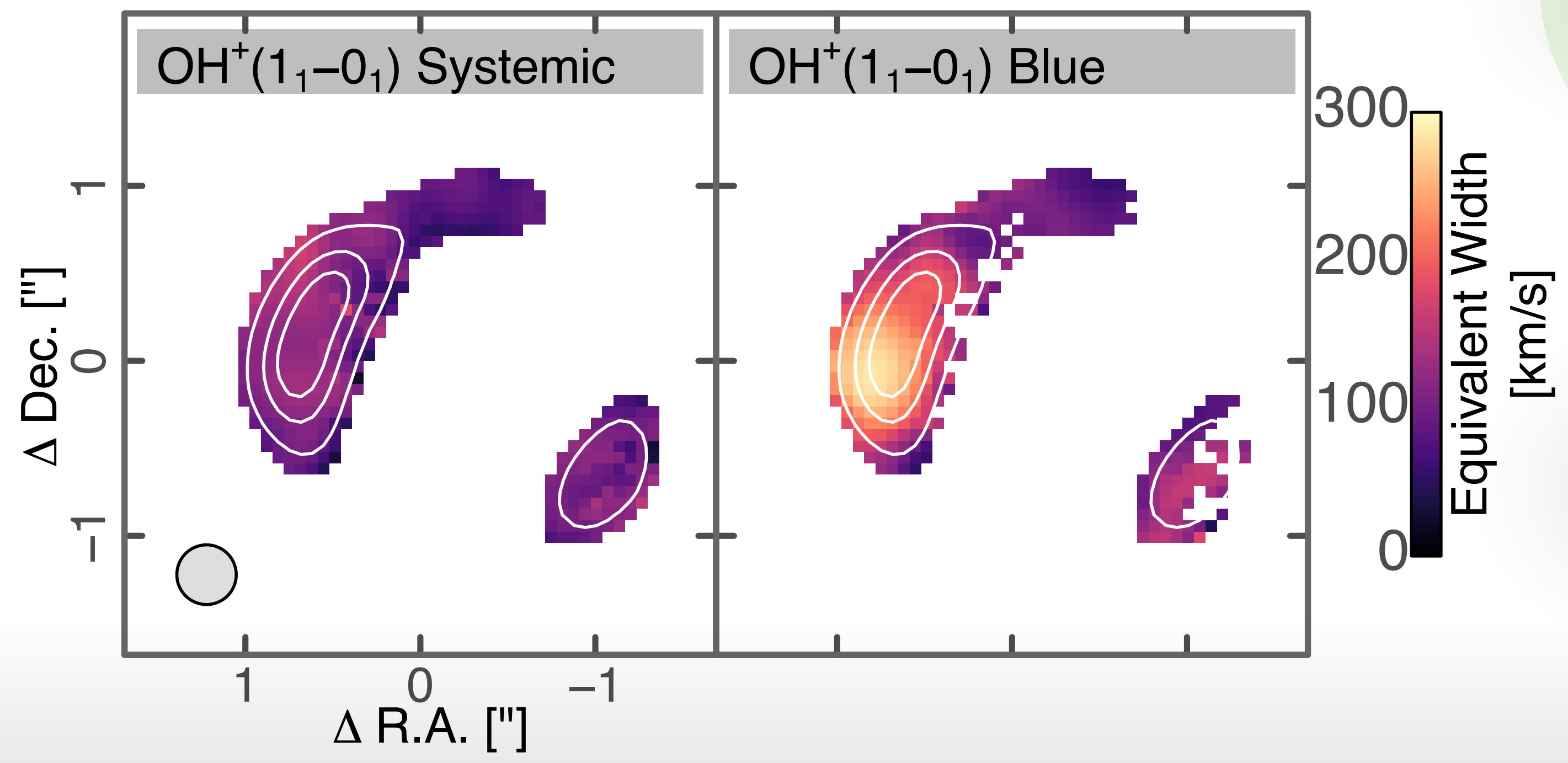
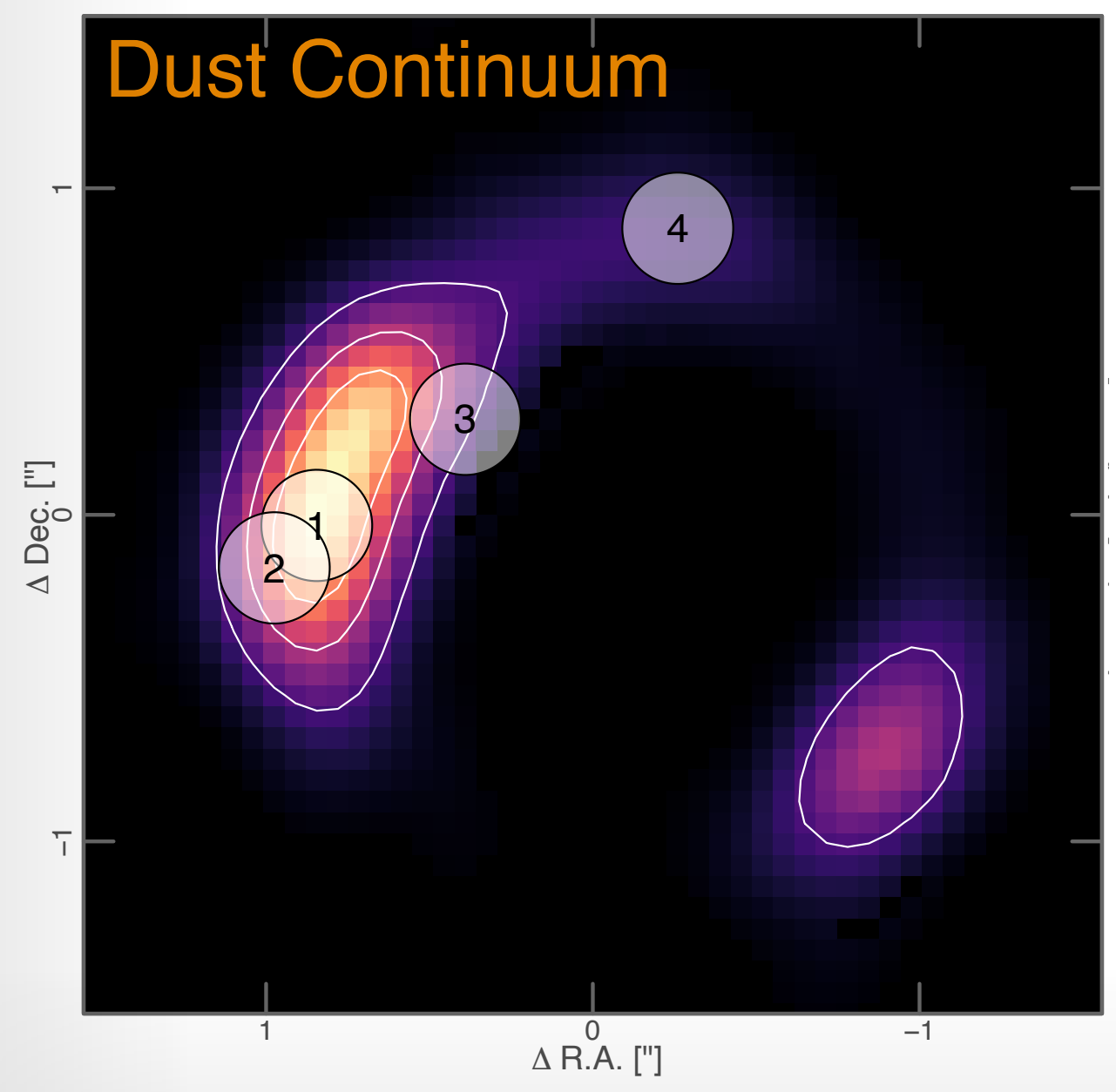


Real Outflows

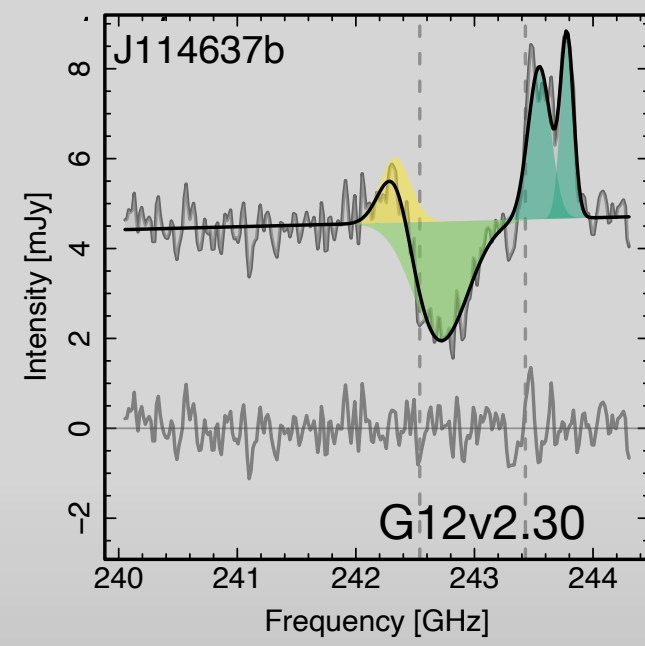
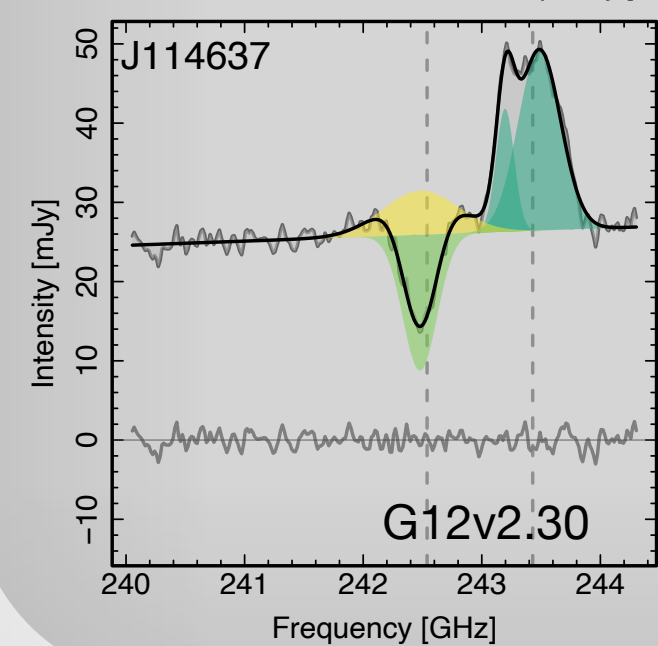
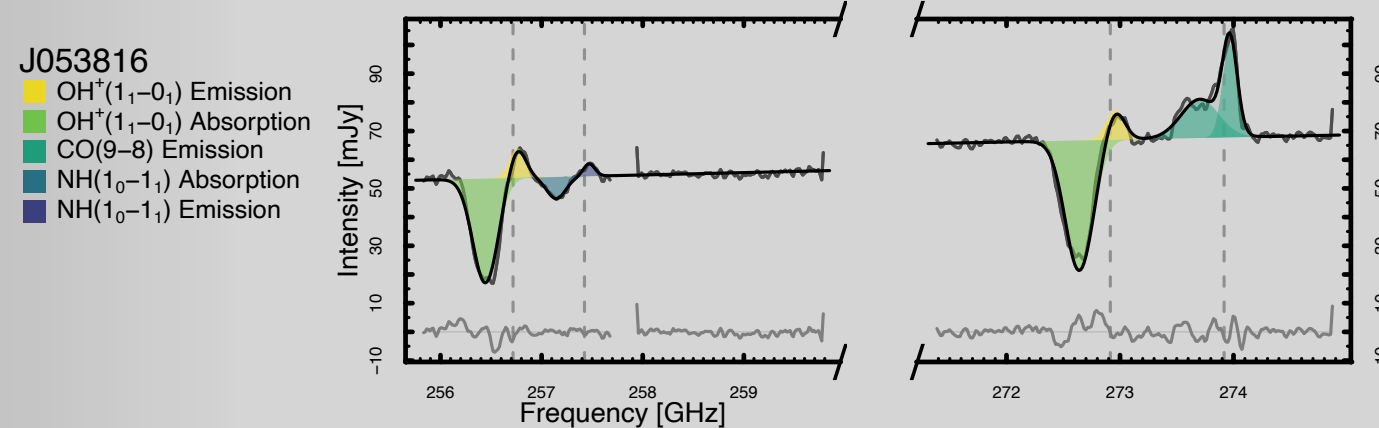
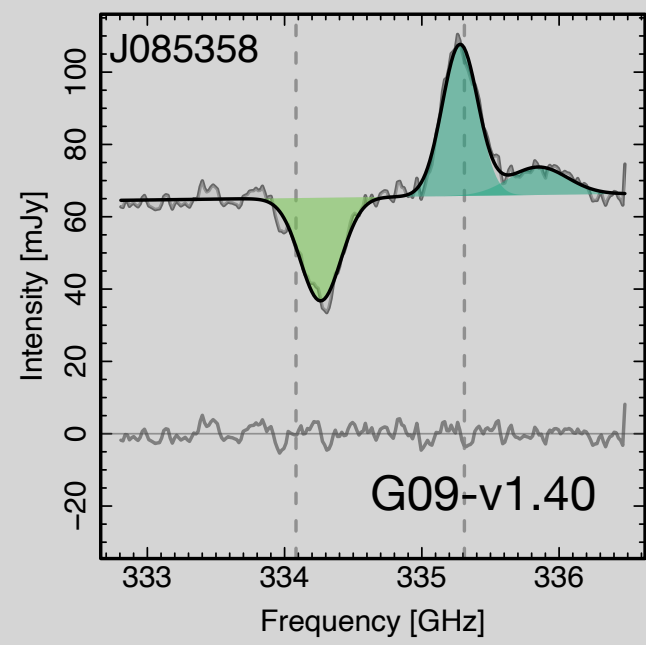
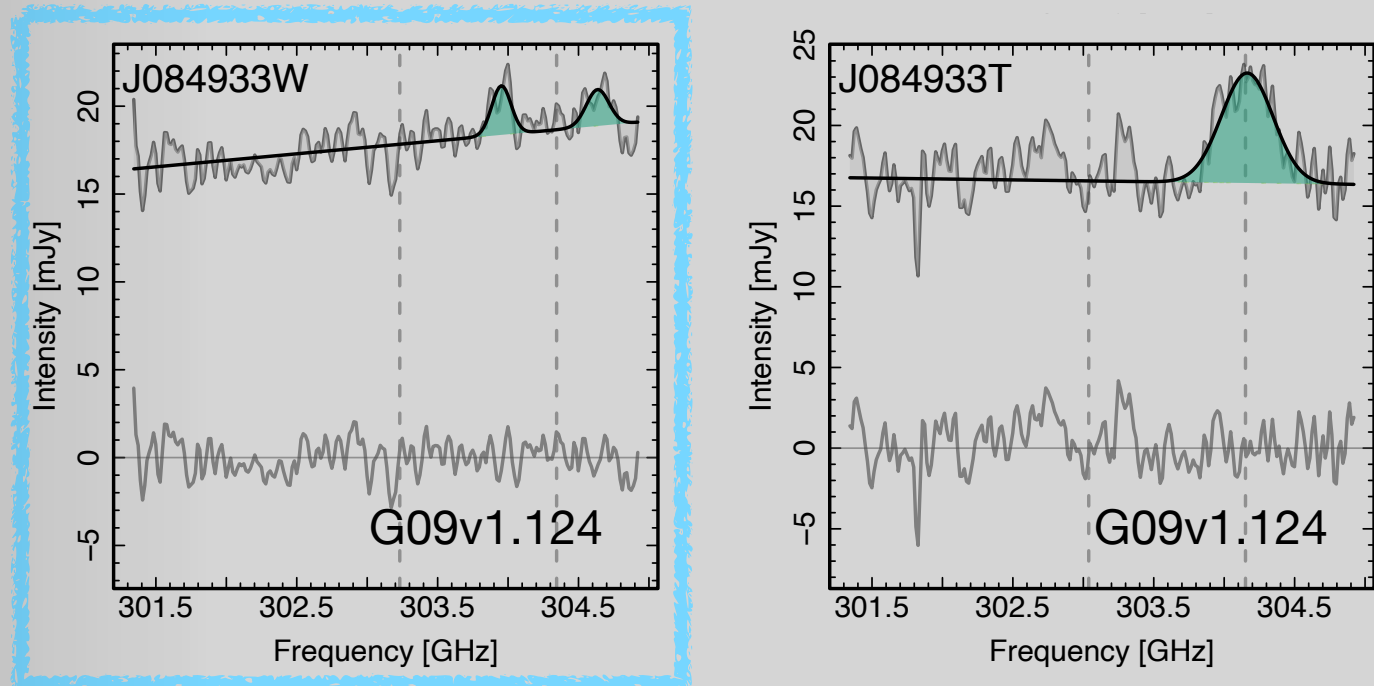
- J012507
- OH⁺(1₁-1₀) Emission
 - OH⁺(1₁-1₀) Absorption
 - CO(9-8) Emission
 - H₂O(2_{0,2}-1_{1,1}) Emission
 - CH₃NH₂ Absorption
 - NH₂(2_{2,0}-2_{1,1}) Emission



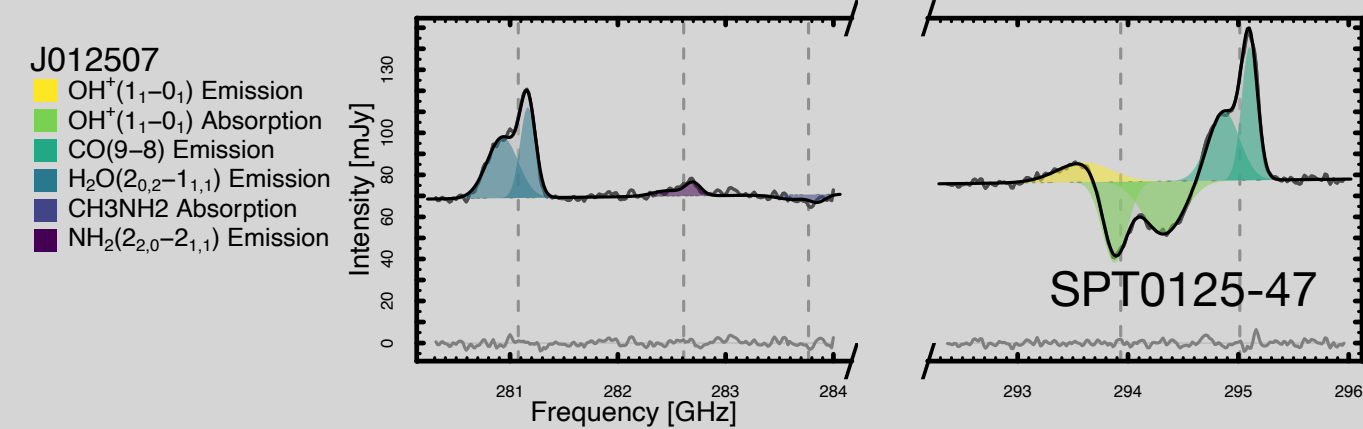
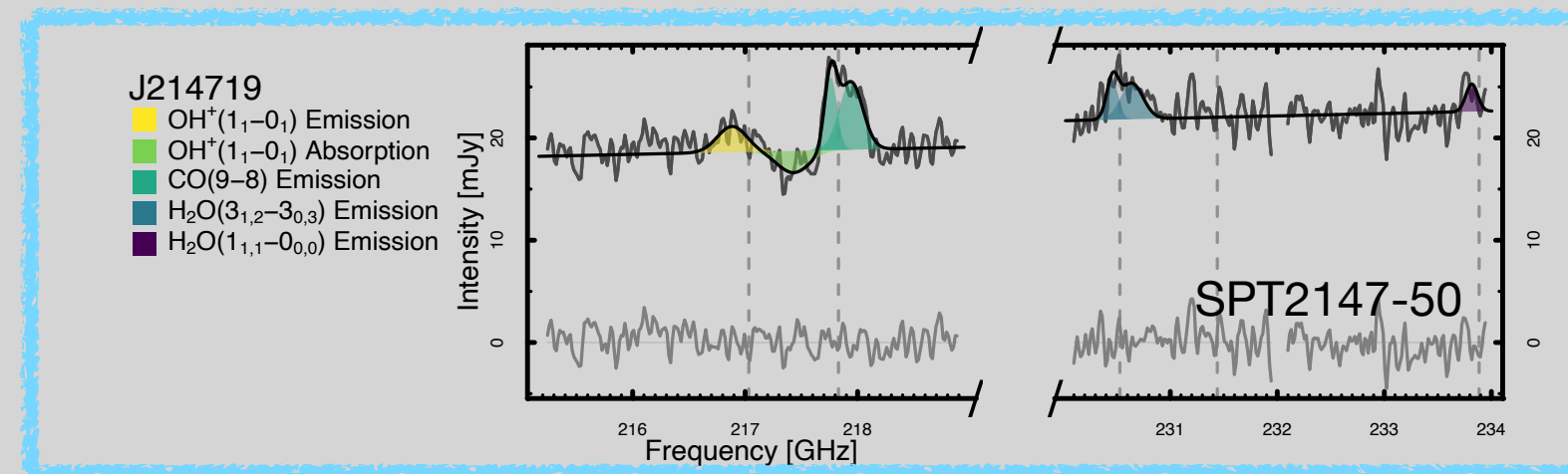
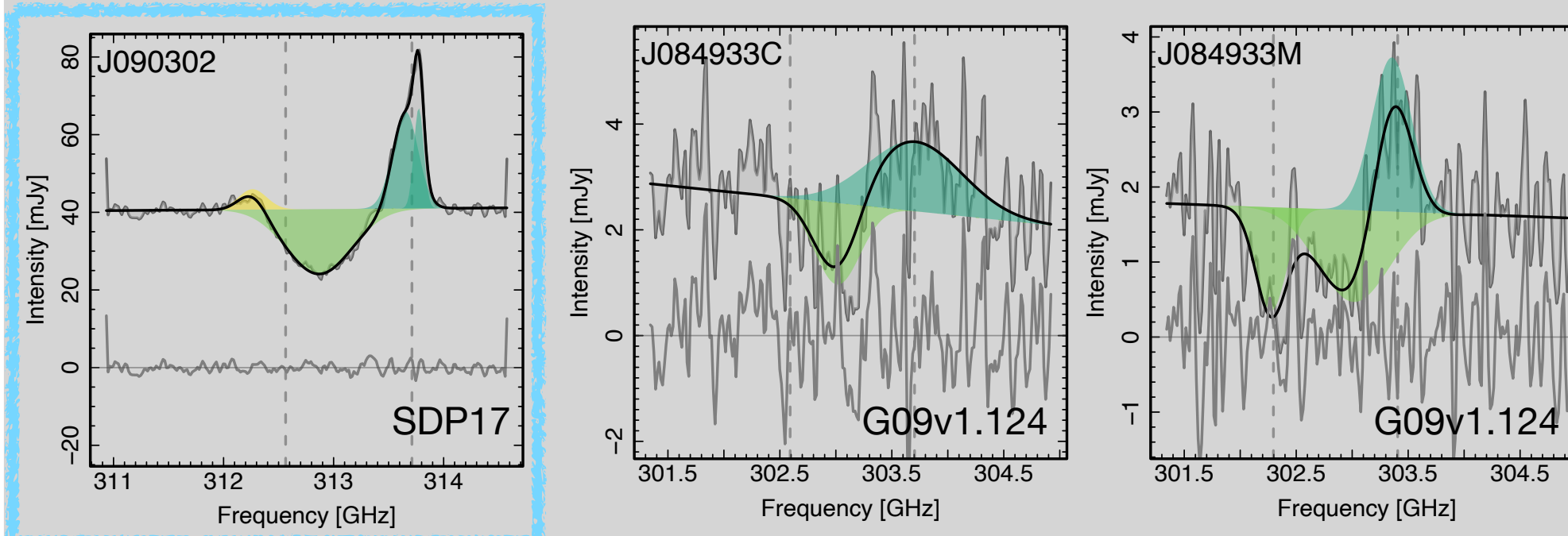
Butler et al. in prep



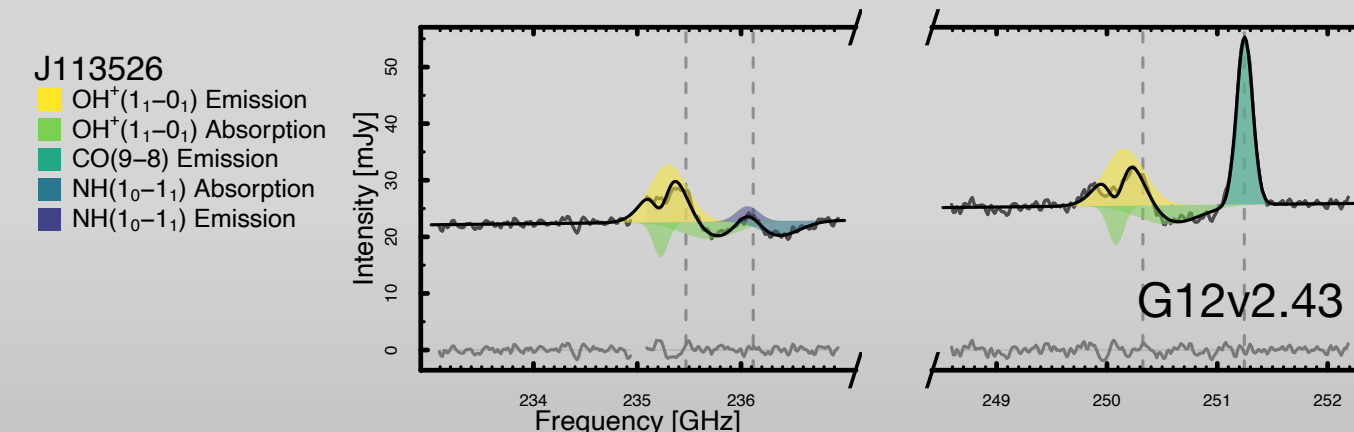
Rotating, no OF:



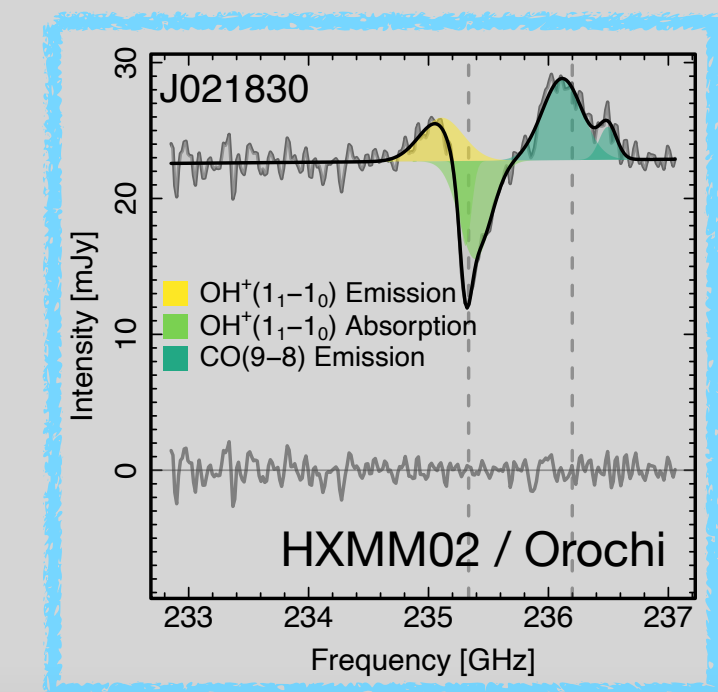
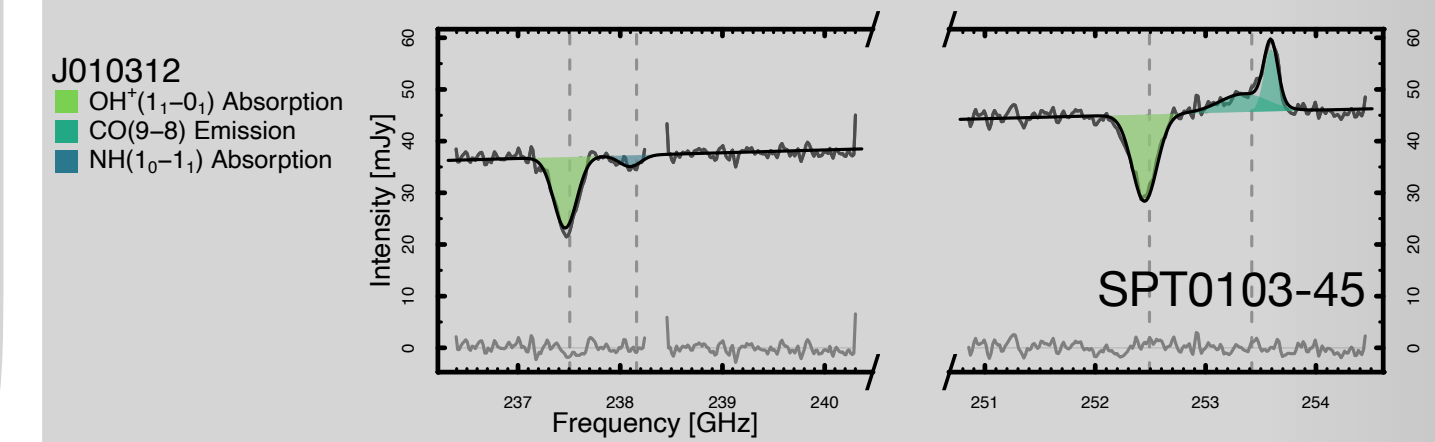
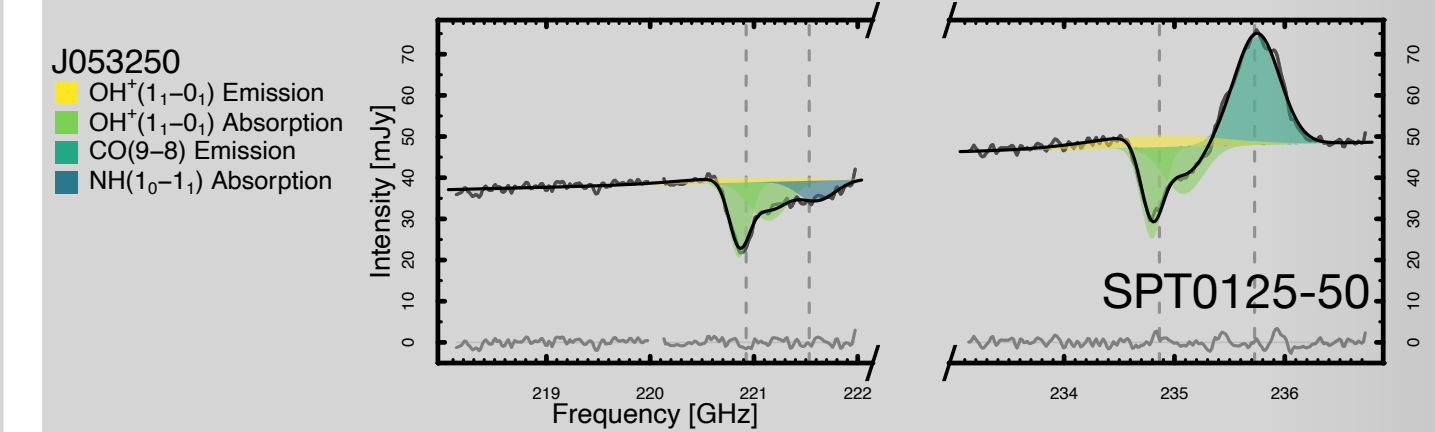
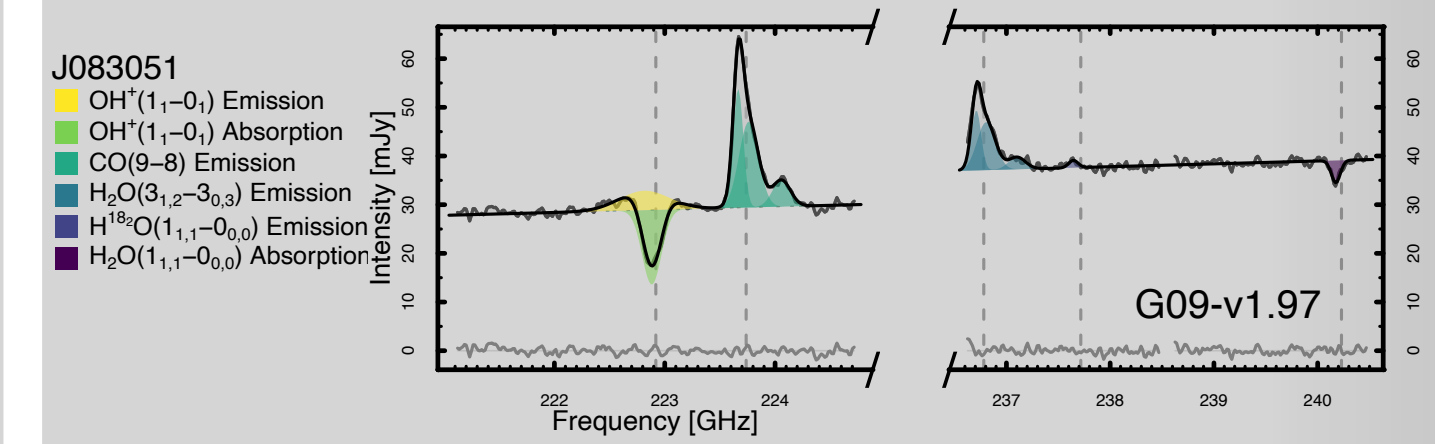
Rotating + OF:



Non rot./ face on + OF + IF



Mergers



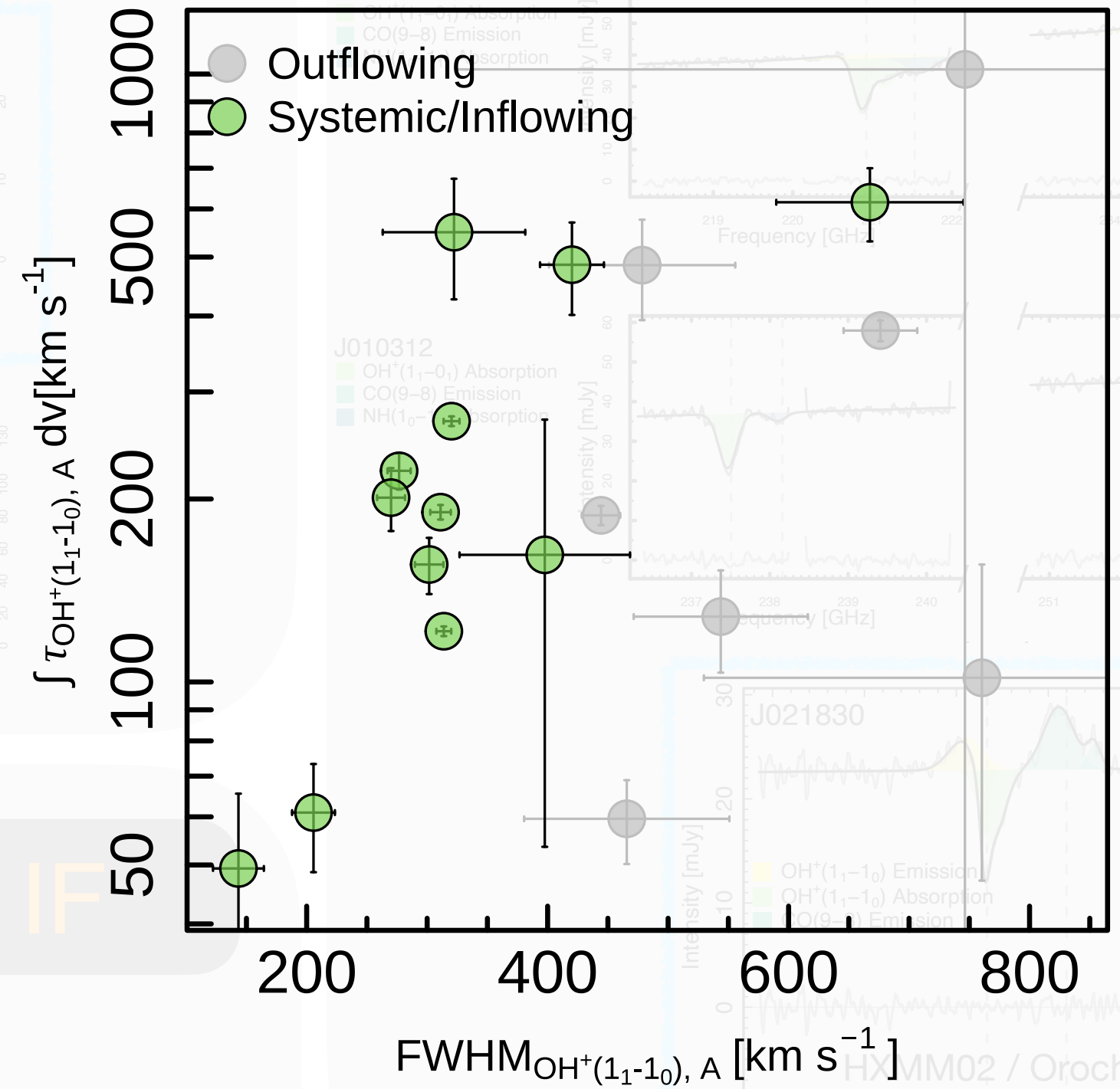
Rotating, no OF:

Rotating + OF:

Mergers

Takeaways

- Differential Lensing can have huge impacts on line interpretations
- Redshifted/ inflowing structures are likely much rarer than previously inferred
- High spatial resolution observations are needed to fish out mergers.
- High S/N spectra allow direct science of the gas flows, and general CGM components



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