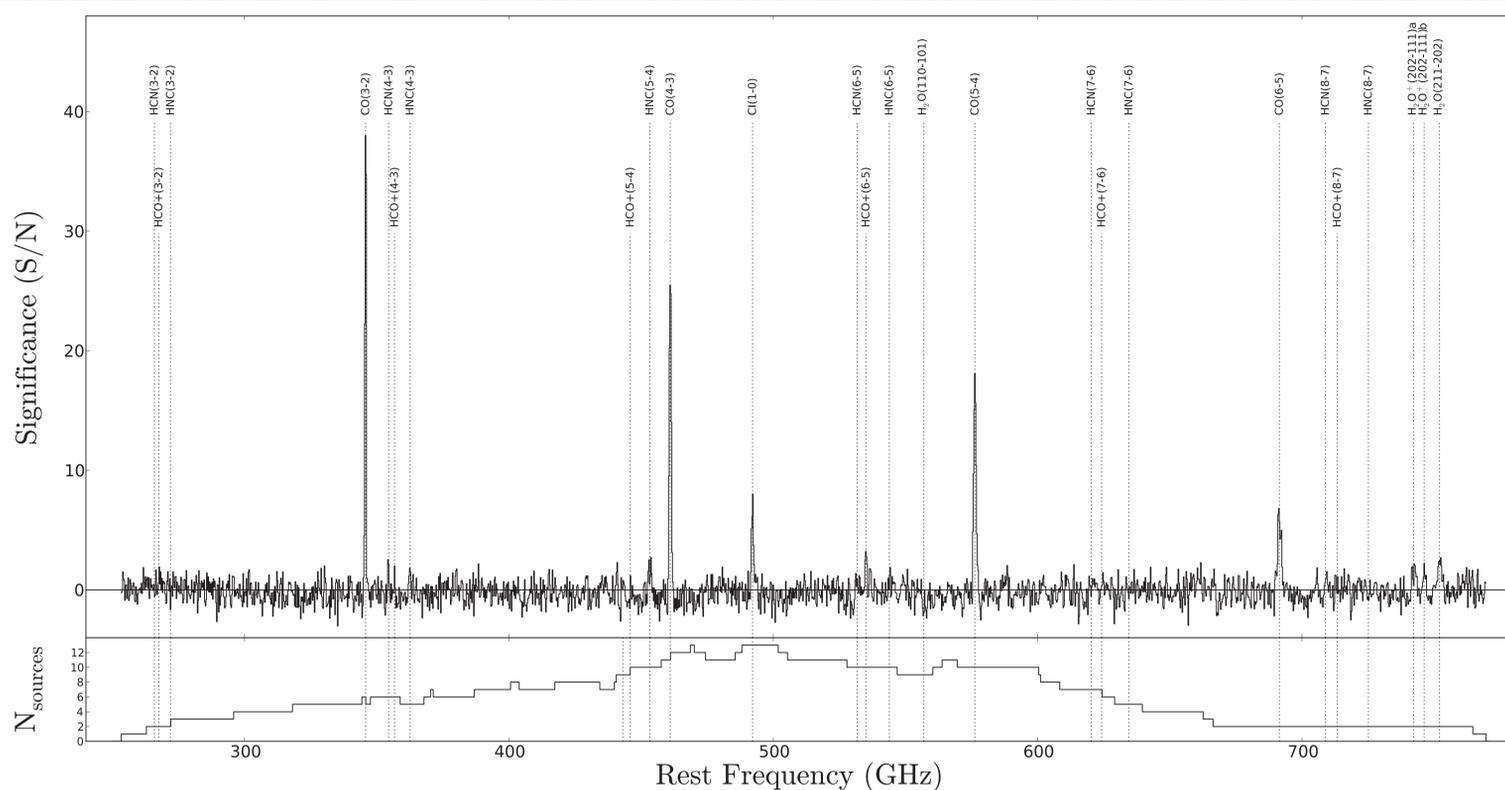


Dense Gas in High-Redshift Star-Forming Galaxies in the SPT-ALMA Survey

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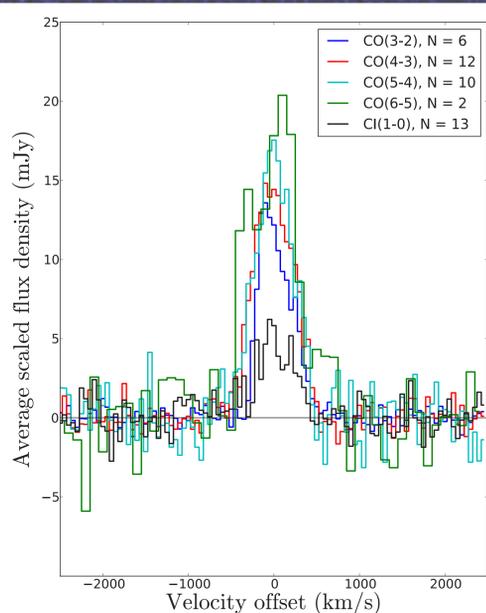
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SPT SMG Collaboration



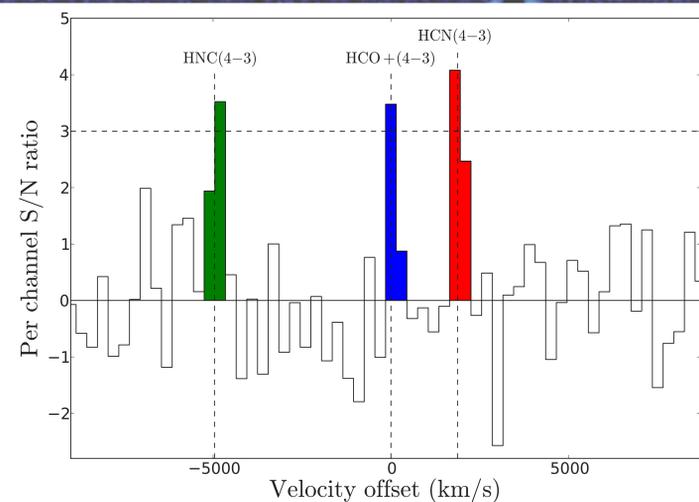
- Detailed studies of high- z dusty galaxies are difficult due to their faintness, but the South Pole Telescope has discovered a large sample of strongly-lensed objects whose magnification allows easier characterization (lower left image; Vieira+ 2013; Hezaveh+ 2013)
- In Cycle 0, we picked out spectral features in $\sim 90\%$ of a sample of 26 lensed starburst galaxies discovered by the South Pole Telescope - in only 10 minutes per source over 30GHz bandwidth (Weiss+ 2013)
- By combining many objects, we can create a “template spectrum” to characterize average properties or look for weak spectral features
- We detect several dense gas tracers (HCN, HNC, HCO+) in the composite spectrum, with detections ~ 10 - $20x$ weaker than CO at similar excitation

Composite signal-to-noise continuum-subtracted spectrum from rest-frame 250 - 750GHz. Such a spectrum lets us pick out features which were low S/N in the spectra of the individual sources and find the properties of a “typical” object.

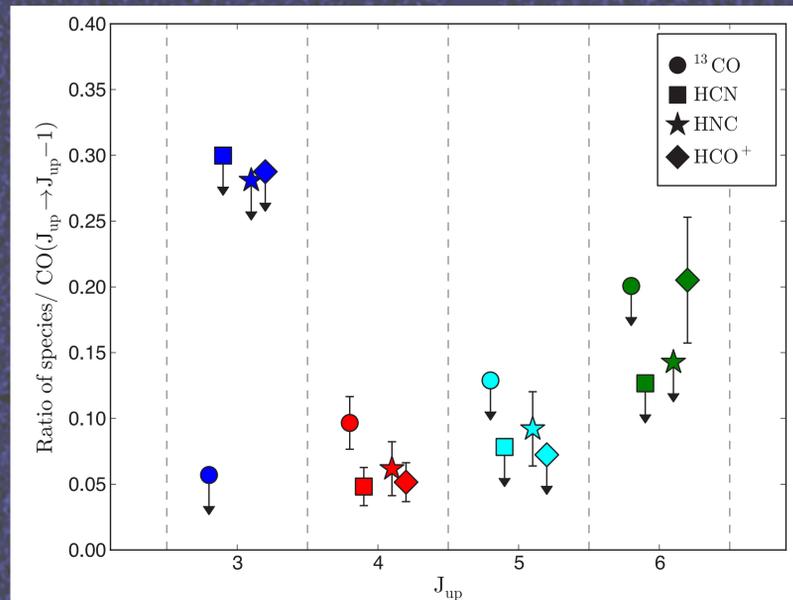
SPT0418-47 at $z = 4.22$, with ALMA 870 μ m image in red and VLT K-band in blue. ALMA detects only the dusty background source, VLT only the foreground lens



Composite CO and Cl lines of all sources; all fluxes have been scaled to $z = 3$.



Example detection of three dense gas tracer molecules in their $J=4-3$ transitions from a composite of 6 sources. Observations with the completed ALMA will require less than 10 minutes to reach the sensitivity achieved in this stack (~ 0.2 mJy in 300km/s channels).



Ratio of composite observed CO line luminosities to those of ^{13}CO , HCN, HNC, and HCO+. In each case, matching- J lines are plotted (e.g., HCN(4-3)/CO(4-3)). The weak constraint on the $J=3-2$ transitions is due, amusingly, to a lack of low redshift sources.

References: Vieira, J.D. et al., 2013, Nature 495
Hezaveh, Y. et al., arXiv:1303:2722
Weiss, A. et al., arXiv:1303:2726

Background: Point-source filtered SPT survey image (Vieira et al., 2010)