Star-Formation History in Early Universe Revealed by Blind Line-Search using AtLAST and ALMA

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Before moving into the '*AtLAST era*'...

Question : To what extent can we constrain the line luminosity function using existing ALMA archival data?

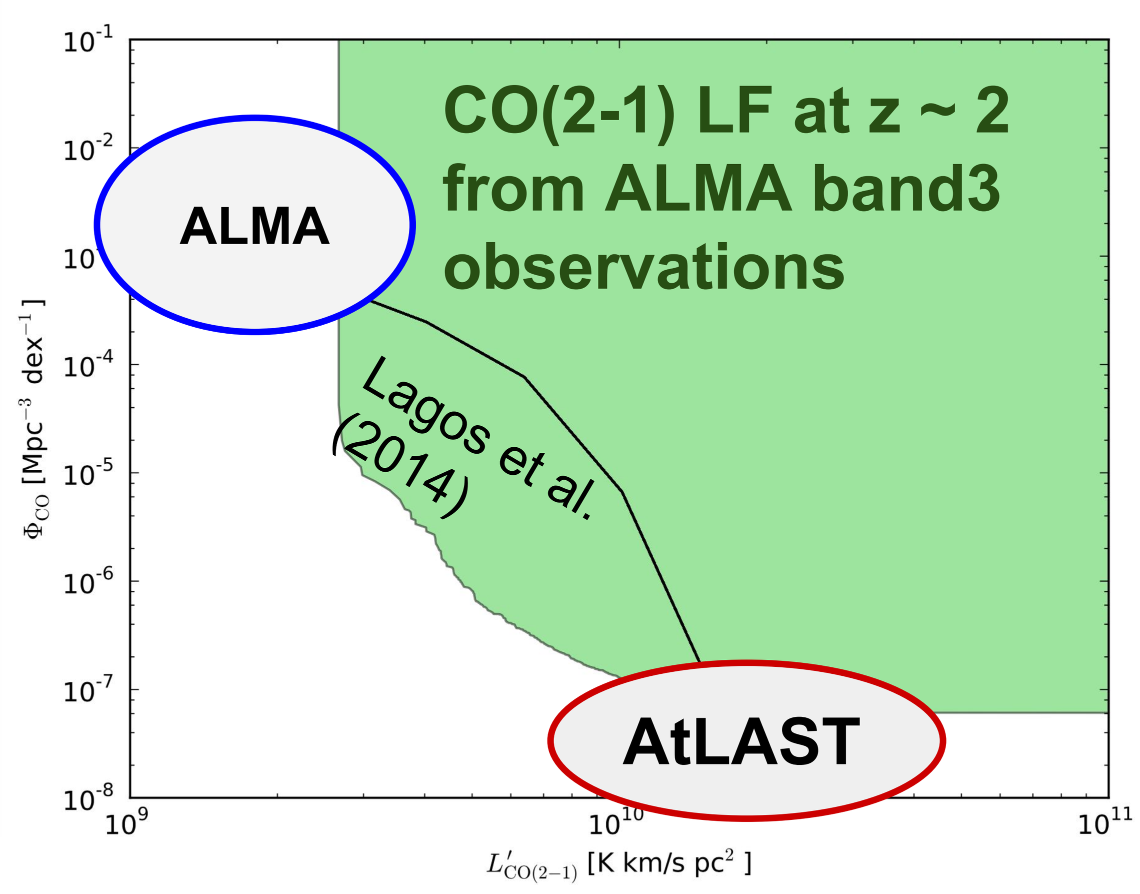
Estimation of Result of Patchy Line Survey using ALMA Archive Query

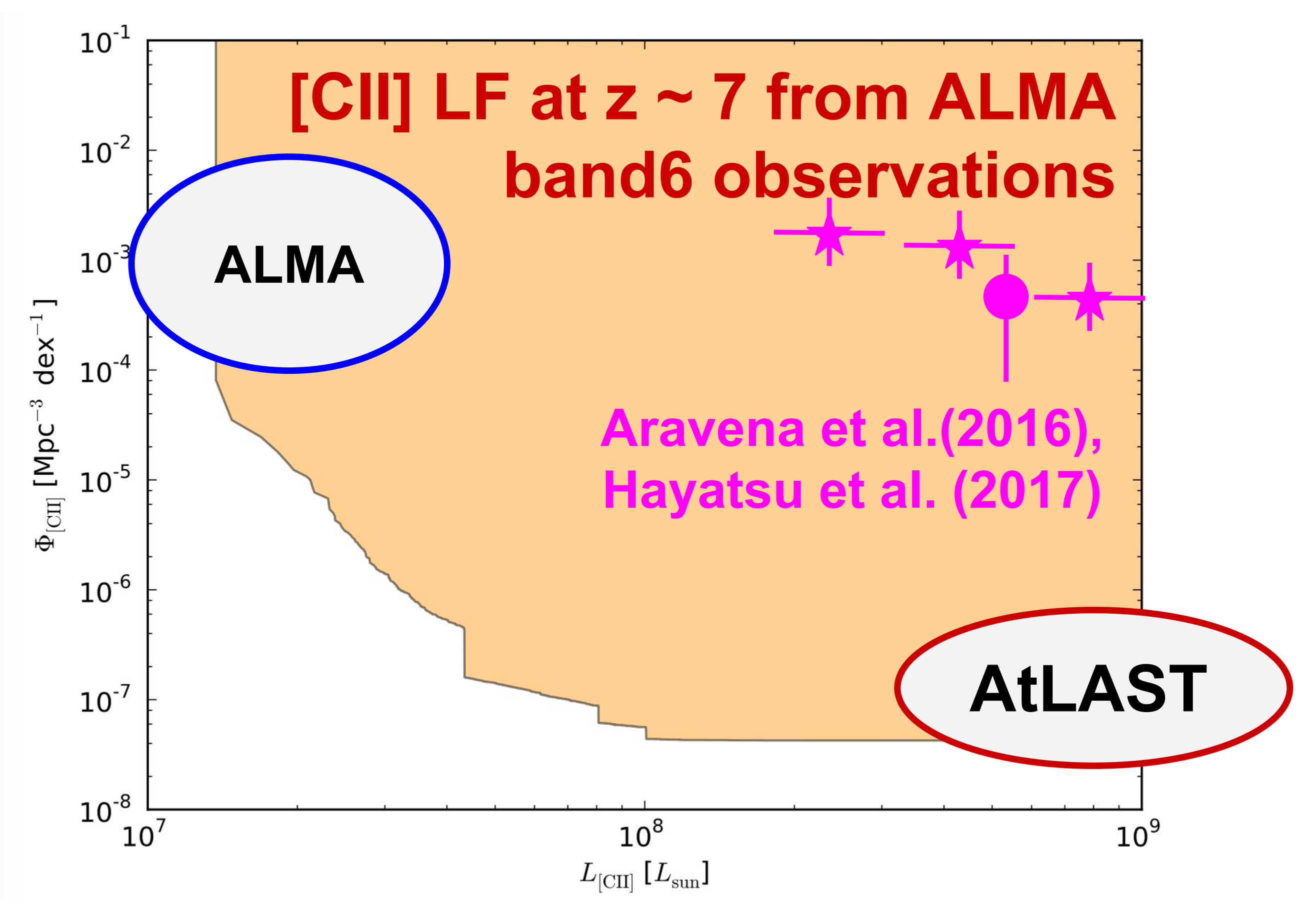
Selection Criteria

band 3, 6 (for CO/[CII] search)
+ observation date >01-07-2012 (>Cy.0)
+ integration time (s) > 900
+ spectral resolution (kHz) < 10000
+ 12m array
+ scientific data only
+ public data only
+ not use data of Field of view > 8 arcmin^2

= **total 612x8** [arcmin^2 GHz] for band3,
350x8 [arcmin^2 GHz] for band6.

(at 16 Jan. 2018; not corrected overwrap etc.)





Answer : We can constrain 'normal' luminosity range using existing ALMA archival data. For brighter luminosity range, sub-square degree observation taken from AtLAST would enable us to constrain it.

In our previous study ***(Hayatsu et al. 2017)****, we blindly detected two CO emitters at z = 0.7 and 3.1 and two [CII] emitter candidates at z = 6.2.*
We plan to release our code as a CASA task.

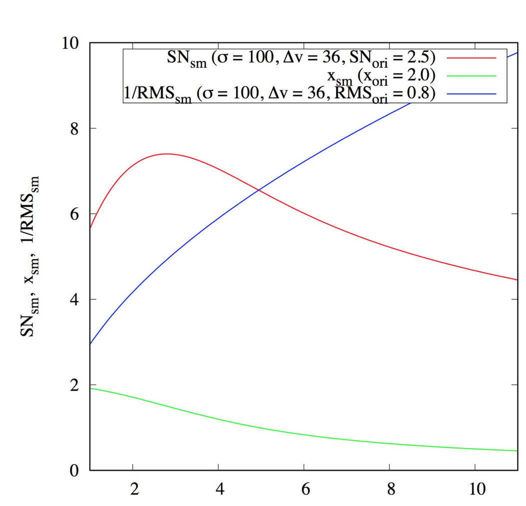
Tests using a blind line-searching method (Hayatsu et al. in prep.)

It is essential to develop a method to efficiently detect faint sources considering the **completeness** of source detection and **contamination** by false detections.

FOUR STEPS to detect faint sources:

1. Spectral Smoothing

To obtain high S/N ratio, we spectrally smooth the data. If original S/N ratio of a target is 2.5σ, **we can obtain > 6σ by spectral smoothing.**



2. Generating 'MAX S/N cube'

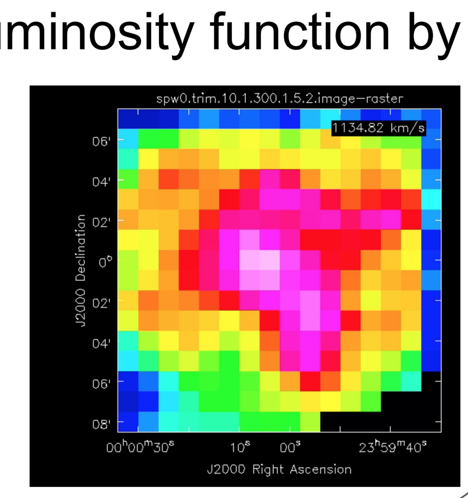
To set detection-threshold by S/N ratio, we normalize each spectral channel by its RMS. To find candidates in the data sets with multiple smoothing parameters, we combine the '**S/N cubes**' **by retaining the maximum pixel values at each 3-dim. position**. (This process is an application of mathematical morphology (erosion and dilation)).

3. Contamination check

To statistically exclude a possibility of a spurious source, we estimate the false-positive rate by comparing the number of detection of the max S/N cube from inverted one (minimum S/Ncube). Note that the noise distribution is assumed to be Gaussian, but the interferometric data often have non-gaussian noise. The use of 'minimum S/N cube' is efficient to avoid underestimation of contamination rate.

4. Completeness check

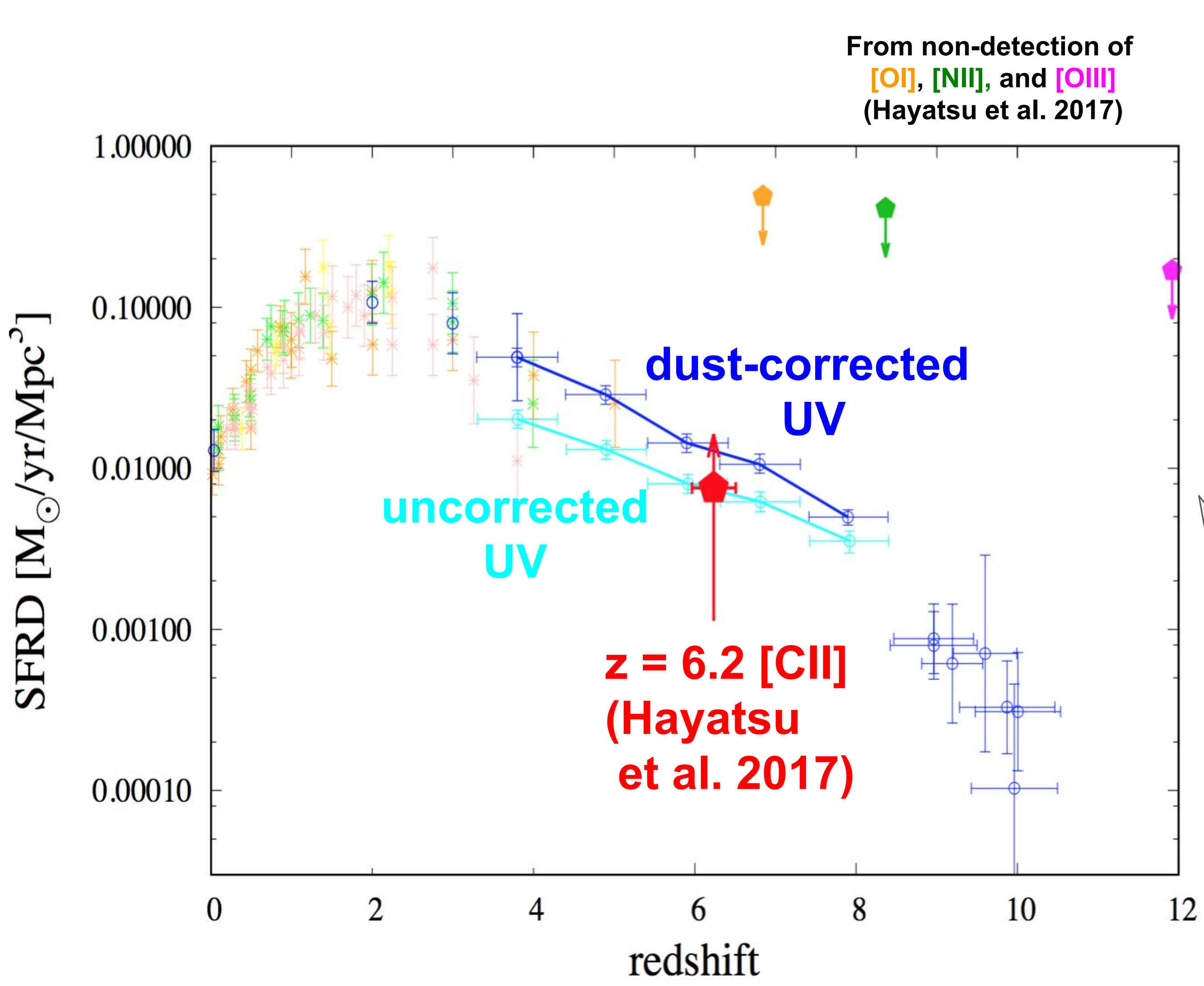
We also estimate the false-negative rate by putting spurious sources of 3-dim. Gaussian with various velocity width, size, peak flux into the datacube and check if it is detected or not. We correct luminosity function by considering contamination and completeness.



Question : How can we apply these results for future AtLAST observations?

Answer :

- From wide-field spectroscopic surveys, cross-checking the luminosity density using an intensity-mapping technique.
- Estimating the redshift evolution of Cosmic star-formation rate density, ionization state, metallicity, or size by combining with JWST or SPICA data.



We might have missed dominant SFRD component at z = 6. :
Upper limit of [CII] SFRD is already close to the dust-uncorrected UV SFRD. To confirm this, we should obtain integrated [CII] luminosity density from blind line-search using ALMA, and upcoming AtLAST observations.