



Line intensity mapping with ALMA



Argander-
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für
Astronomie

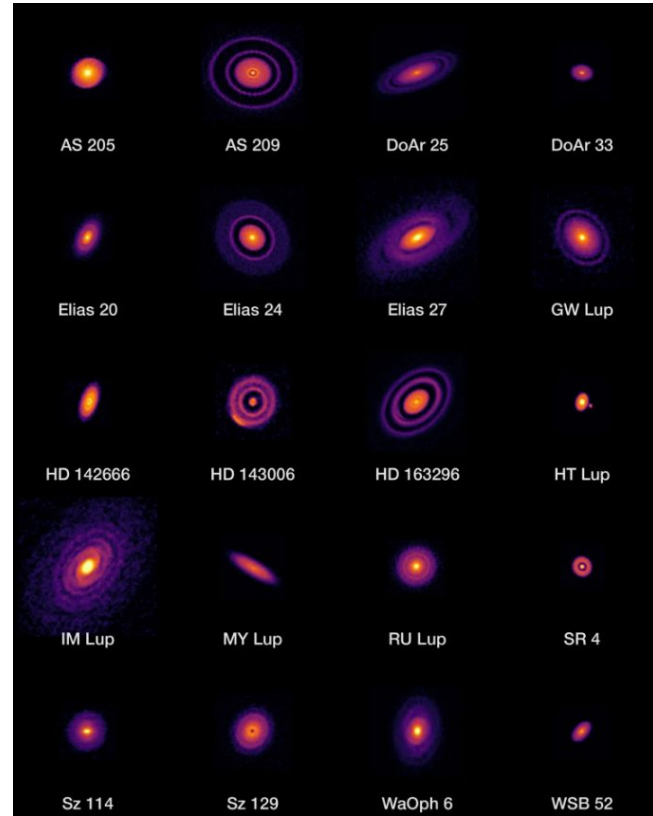


SFB 1601

Christos Karoumpis



Line intensity mapping with ALMA???

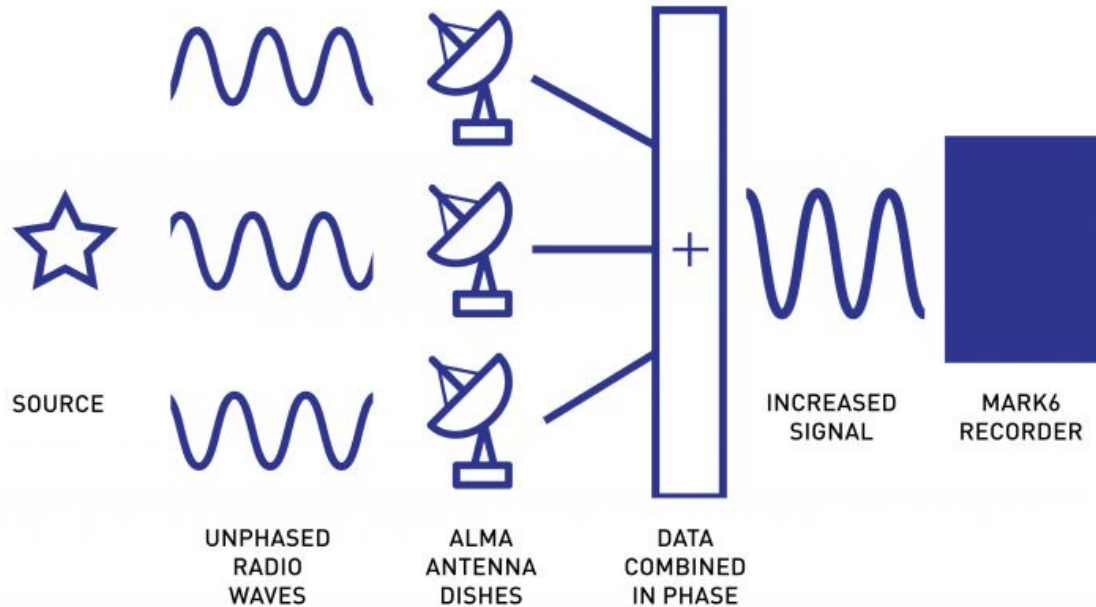


Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira

Phased Array today

- Made for VLBI (since Cycle 4)
- Used for standalone pulsar observations (since Cycle 8)
- Why not for any source/field?
- Why not ACA? (7 meter antennas)

Source:MIT
Haystack
Observatory



ALMA 2040: Towards a radical upgrade of ALMA

ESO expanding horizons: transforming astronomy in the 2040s

Call for Ideas in Q3/2026 with a deadline of 2027 June 1 (and a deadline of 2026 December 1 for Letters of Intent)



*Contributed by Stefano Facchini,
Jacqueline Hodge, Eva Schinnerer
and Maria Diaz Trigo*



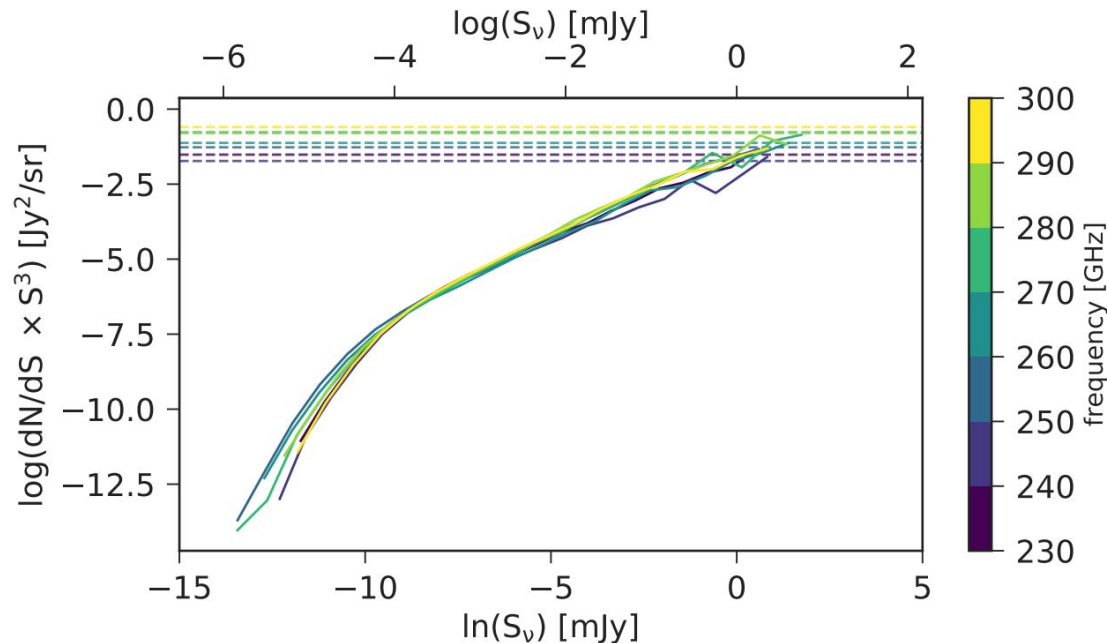
ALMA 2040: Towards a radical upgrade of ALMA

- Phased subarrays for multibeam mapping
- Simultaneous phased and interferometric array
- Combination of phased array with long baselines to remove bright sources



An example: Dealing shot noise dominated by few bright sources

Combine
interferometry
with phased
array to remove
them



Gkogkou et al. 23

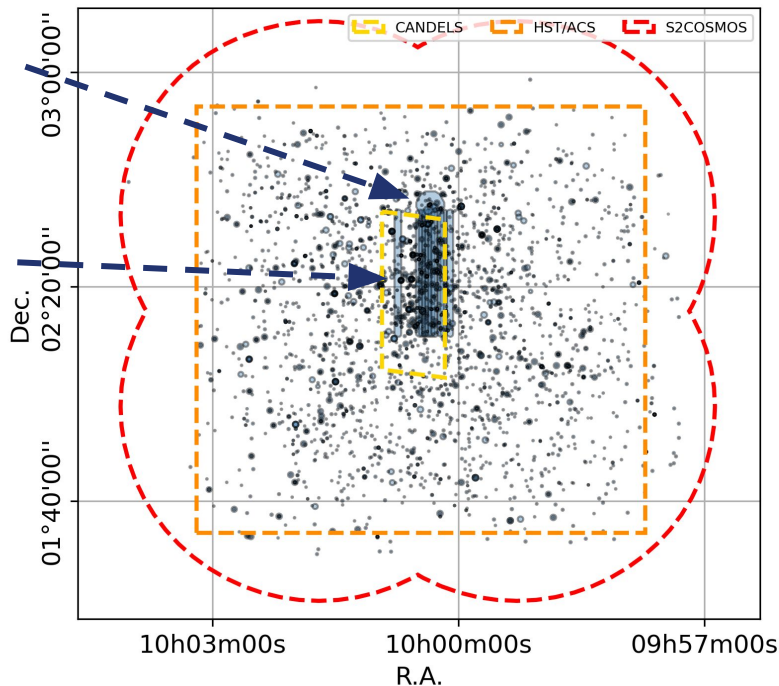


Back to 2020s: A3COSMOS

mmIME (Keating et al. 2023)

MORA (Casey et al. 2021)

Map not up-to-date: there is
now Ex-MORA (Long et al. 2024).
We will come back to this...



Adscheid et al. 2024

ACA or Morita array



source:
nrao

ACA or Morita array

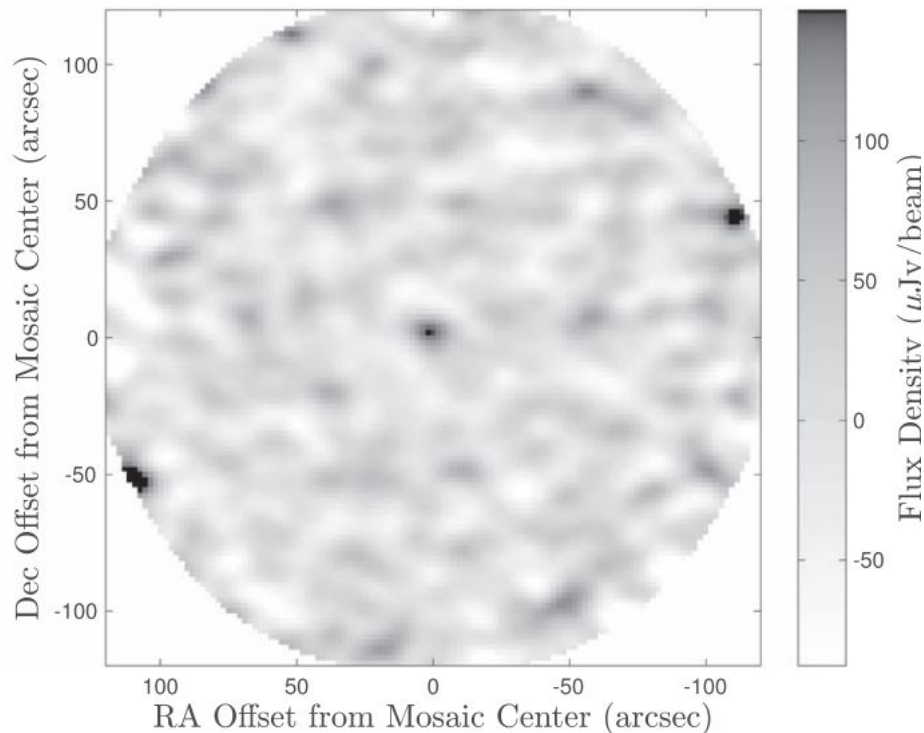


source:
nrao

mmIME

The mmIME dataset is a combination of the ASPECS with ACA observations

Here we will focus on the 200 arcsec x 200 arcsec field located in COSMOS field observed at 3mm (Band 3)



Keating et al. 2020

mmIME

$$\tilde{I}^2(u, v, \eta, \nu_c) = \frac{\sum_i \sum_j [\psi_{i,j} \tilde{\mathcal{V}}_i^* \phi_{i,j} \tilde{\mathcal{V}}_j w_{i,j}] - \mathcal{A}_i}{\sum_i \sum_j [w_{i,j}] - w_{\mathcal{A}_i}}.$$

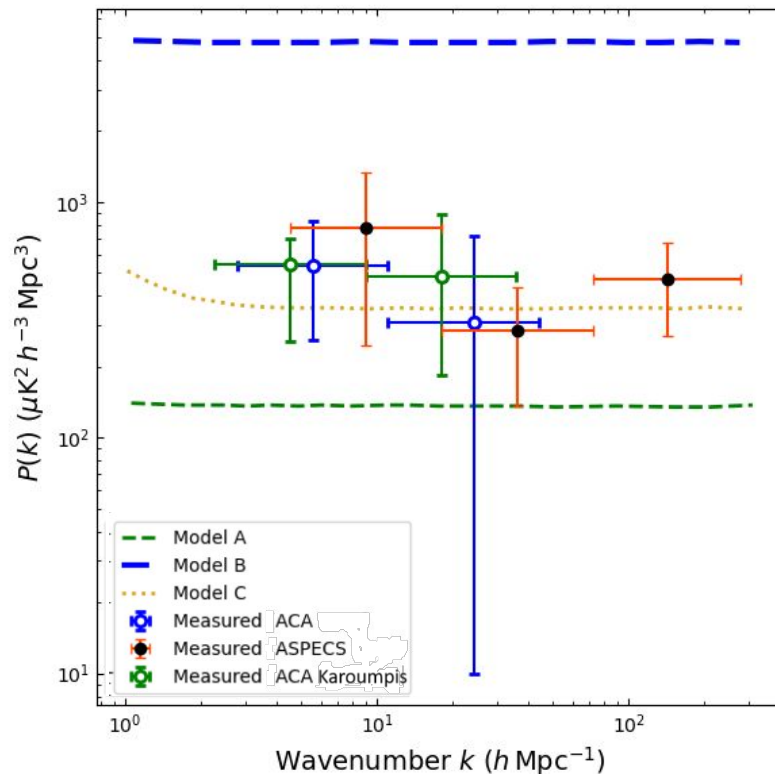
Equation from Keating et al. 2020

At this point we avoid the autocorrelations.
We calculate an estimator of the “spectral shot power”: the weighted sum of delay visibilities cross-multiplied against one another

mmIME

-We tried to recreate the Keating et al. 2020 result to test our pipeline

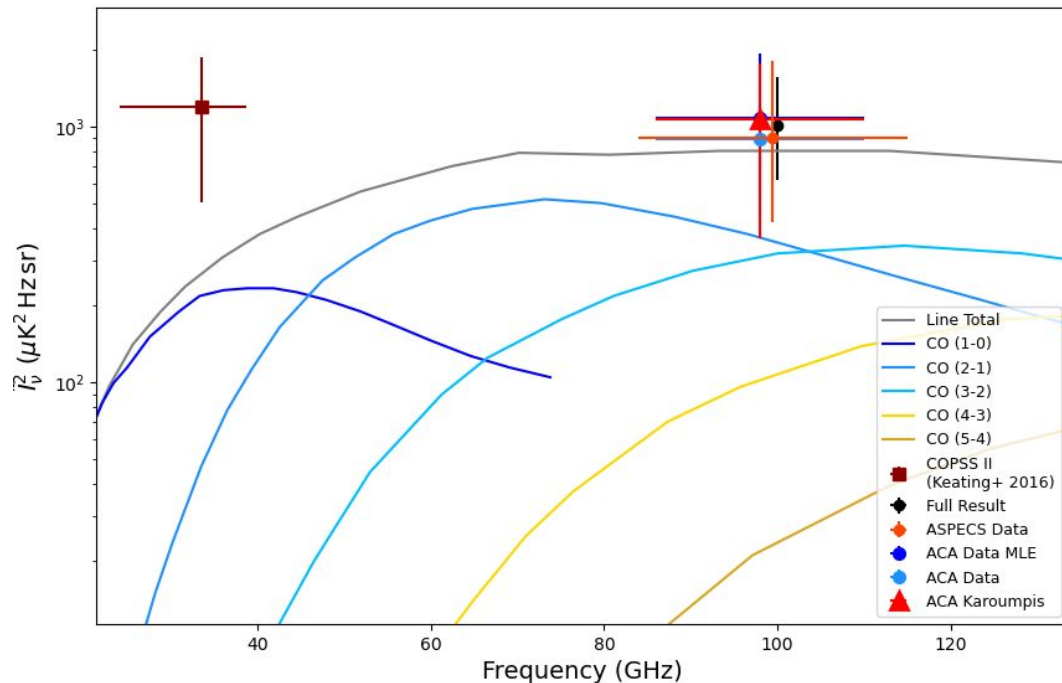
-Small differences probably because of flagging and the way we estimate the noise



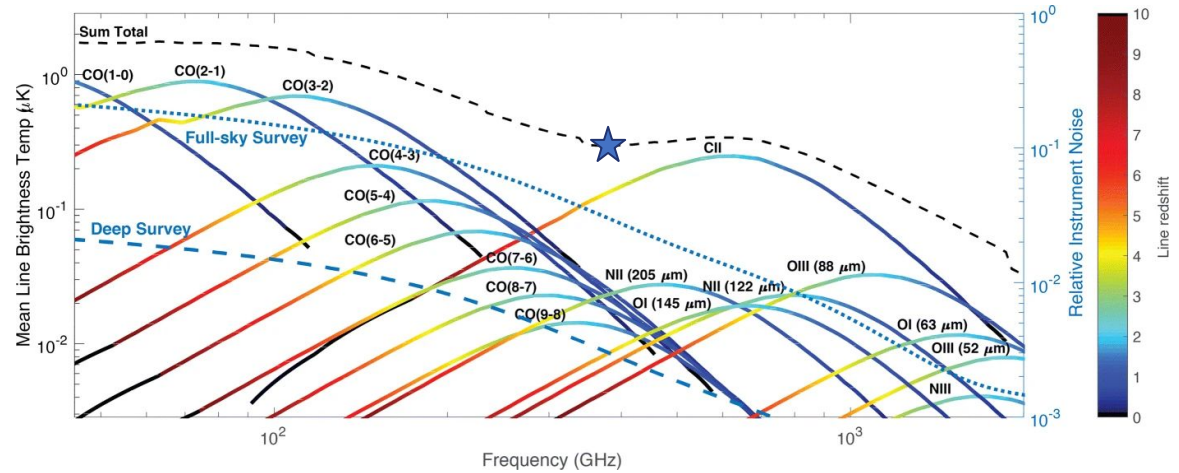
mmIME

The challenge with
100 GHz is that many
CO lines contribute.

That makes it difficult
to model...



ACA Band 8 observations



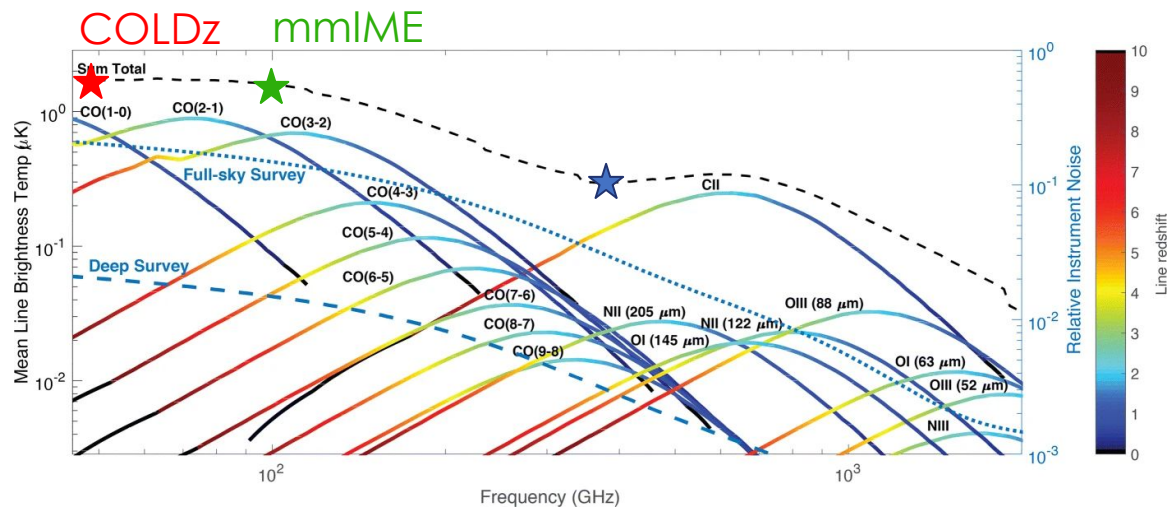
~ 40% of ~80 hours

Source: Silva et al. 2021

ACA Band 8 observations

Riechers et al. 2019

Same field!

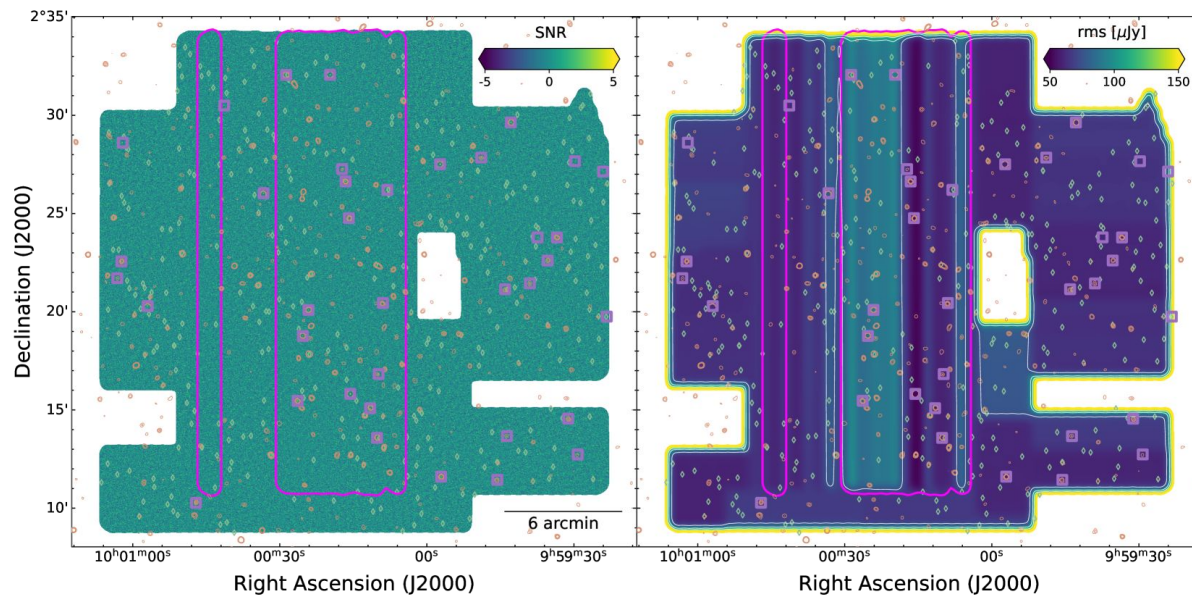


~ 40% of 80 hours

Source: Silva et al. 2021

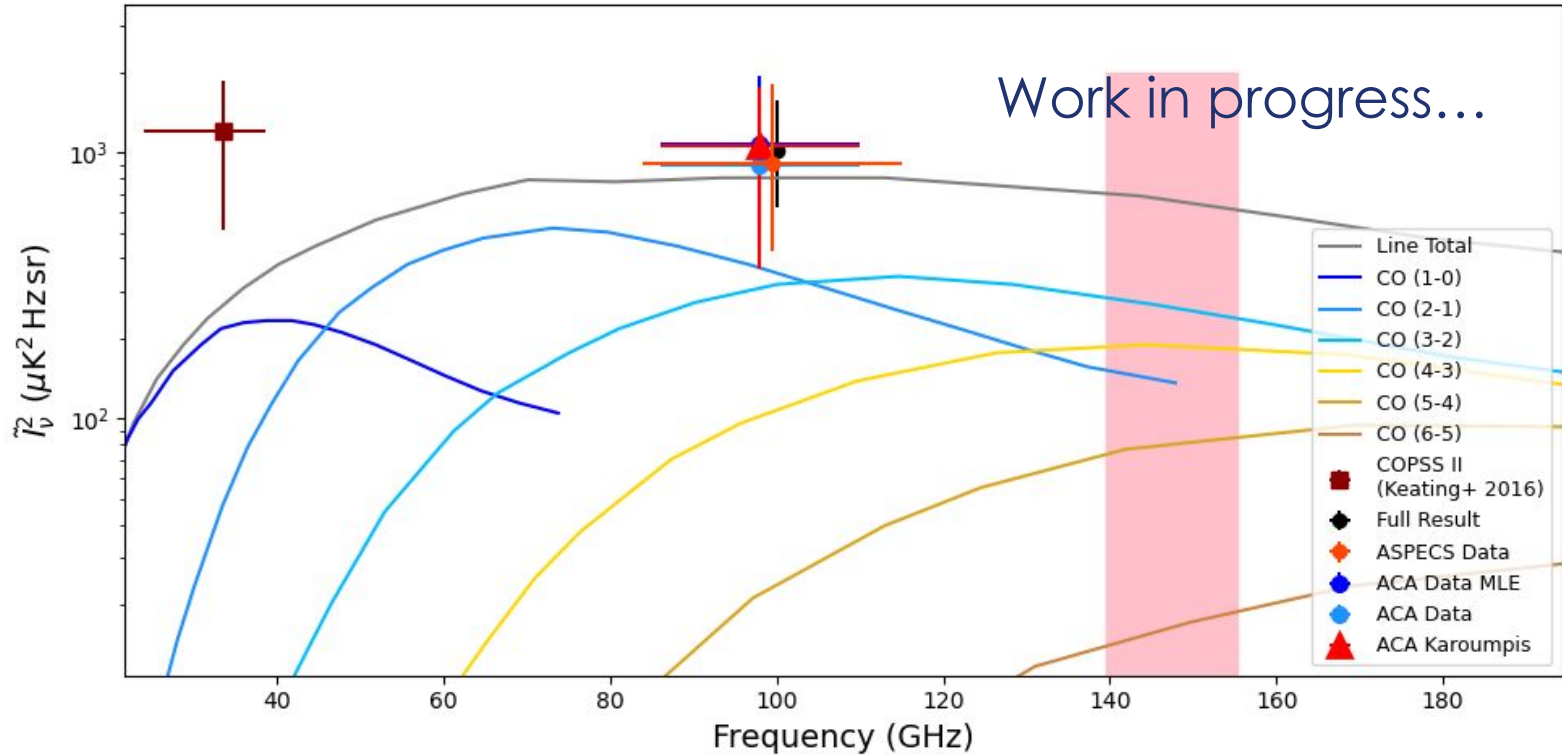
The extended MORA

Also in
A3COSMOS:
the largest
ever ALMA
blank-field
survey to-date
covering 577 arcmin^2 at
2mm



Source: Long et al. 2024

Use Keating+2020 methodology on Ex-MORA

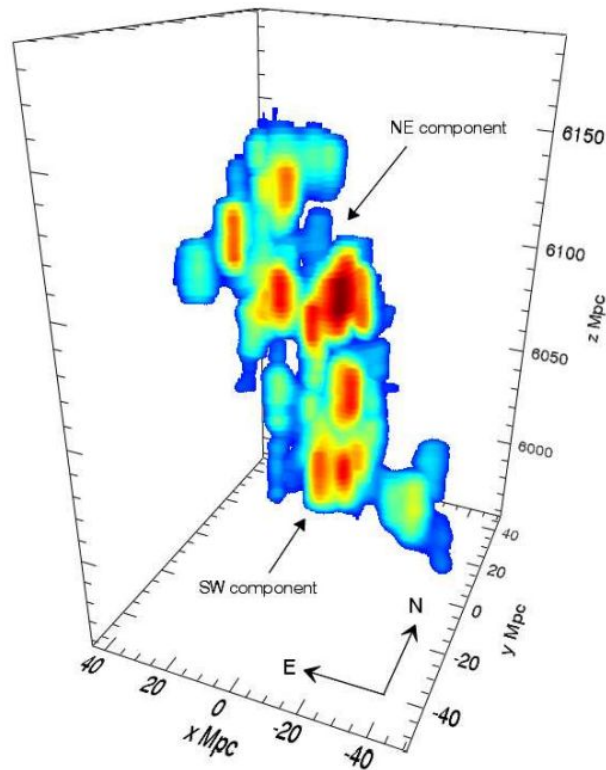


Hyperion proto-supercluster

Source Cucciati et al. 2018

Something to investigate: Ex-MORA is not your average field!

Known overdensity at $z=2.45$. Does this mean boosted CO(4-3)?



Take away message

- We make use of archival to calculate the shot-noise dominated PS of the small scale CO lines fluctuations.
- We are using ACA to observe the frequencies where (probably) the [CII] line starts to dominate.
- We can combine this dataset with CO dominated ALMA Band 8 and VLA observations of the same field
- Join us in drafting a white paper to advocate for phased array capabilities in a transformative ALMA upgrade.

