Ly-alpha tomography at cosmic noon

A motivation for hydro sims

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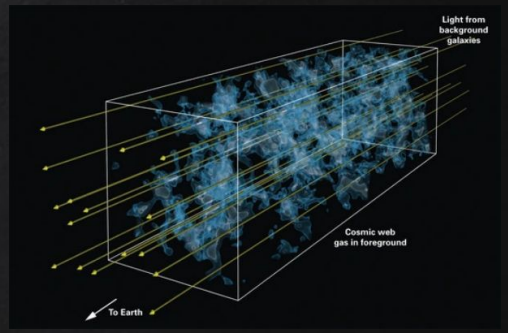
Dense Lya surveys (tomography)

Survey	Background sources	Footprint (degre^2)	Mean sightline seperation (cMpc/h)	Forest redshift	Volume $(cMpc/h)^3$	Instrument
CLAMATO	240	0.157	~ 2.5	2.05 - 2.55	3.15×10^5	LRIS Keck
LATIS	3800	1.7	~2.5	2.20-2.80	4.0×10^6	IMACS Magellan
PFS		12.3	~2.5-3.7	2.5-3.5		
DESI	8.4e5	14,000	~10	z > 2.1	—	
eBOSS Stripe 82	8199	220	~ 13	2.20-2.80	9.4×10^8	SDSS DR 16



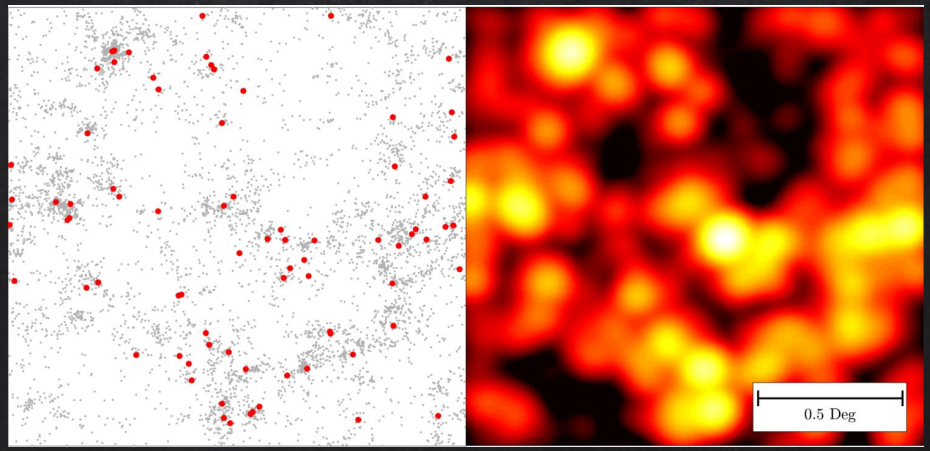
Credit : CLAMATO Collaboration

Making forecast using ASTRID simulation (L=250 cMpc/h, $N=5500^3$).

Helping out the line-intensity maps at cosmic noon (Preliminary results)

What is LIM ?

Measuring aggregate emission in a particular line (or frequency) from galaxies without resolving them individually.



Credit : Patrick Breysse

Kovetz et al. 2017

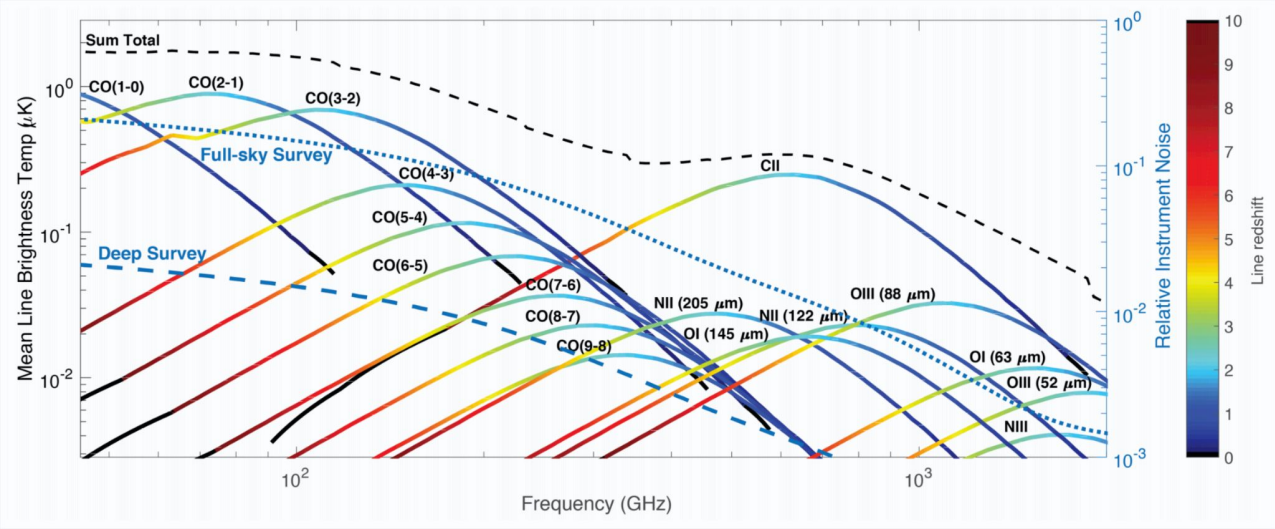
Left : CO emitting galaxies detected with 4500 hours of VLA, Right : CO intensity mapping instrument (COMAP) for 1500 hours

Modeling the signal requires large galaxy catalogs. So hydro or SAM can help with this.

LIM is challenging

Detection sensitivity: The instrumental noise is significant.

Contamination is an important challenge :
Foreground/background Line emissions in other frequencies redshifted to the target frequency, a.k.a Line interlopers



Kovetz et al. 2017

Helping out LIM at cosmic noon

Cross-correlation with known tracers of line-emission and large-scale density helps :

- Enhance the detection sensitivity
- Constrain the line emission models (clustering vs shot noise terms)
- Remove the interlopers

Galaxy surveys have been extensively studied :

E.g. Spherically averaged Power-spectrum model in CO $\times$ Galaxy surveys

(G.Sun et al. 2020, TIME collaboration,
Chung et al. 2018, COMAP Collaboration)

$$P_{\rm CO}(k,z) = \bar{I}^2_{\rm CO}(z)\bar{b}^2_{\rm CO}(z)P_{\delta\delta}(k,z) + P^{\rm shot}_{\rm CO}(z)$$

$$P_{\rm CO\times gal}(k,z) = \bar{b}_{\rm gal}(z)\bar{b}_{\rm CO}(z)\bar{I}_{\rm CO}(z)P_{\delta\delta}(k,z) + \frac{\bar{I}_{\rm CO,gal}(z)}{n_{\rm gal}(z)}$$

Breaking the degeneracy between the clustering and shot noise term.

How about Lya forest:
(Preliminary results)
A multifield observation

Qezlou et al.
In prep.

Why should we use Lya tomography :

Galaxy surveys are limited :

- to larger galaxies while the abundant small galaxies also contribute to the line emission
- by uncertainties in the redshift estimation, i.e. coarser spatial resolution

However, Lya tomography :

- provides the information on the continuum underlying density
- has high spatial resolution
- is easier to model Lya forest's statistics (e.g. no shot-noise term in the P(k) formalism)

How about Lya forest: (Preliminary results)

A multifield observation

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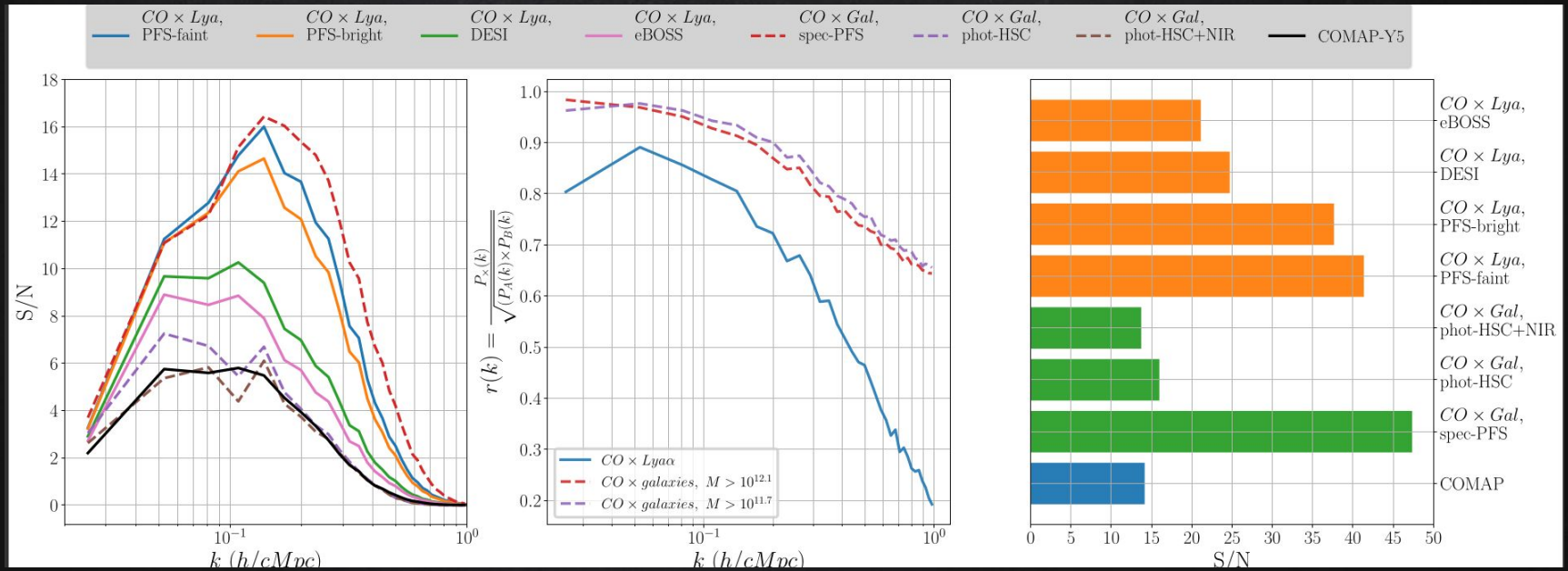
Enhance the detection sensitivity of the line emission.



How about Lya forest: (Preliminary results)

A multifield observation

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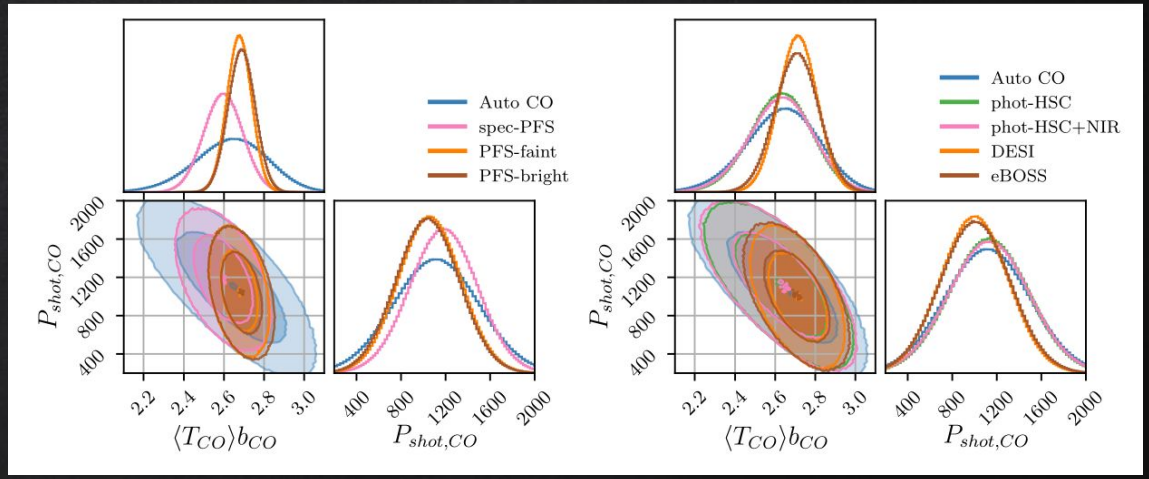
Cosmology :

Tighter constraints on the emission clustering due to:

1. high S/N
2. easier to model

Breaking the degeneracies



Summary :

Application of the Lya tomography :

- Helping out the upcoming line intensity map experiments at cosmic noon
  - Improve the detection sensitivity
  - Provide tighter constraints on the emission models
- We need :
  - large hydro simulations to consistently model the IGM and galaxies: ~ 3 × of ASTRID's volume.
  - better ML tools to infer cosmology/astrophysics from this synergy (we are working on this)

Thank you for listening !!