The Cosmic Expansion History from Line-Intensity Mapping

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arXiv:1907.10065
JLB, P. Breysse, E. D. Kovetz
"Cosmic Expansion History with Line-Intensity Mapping"

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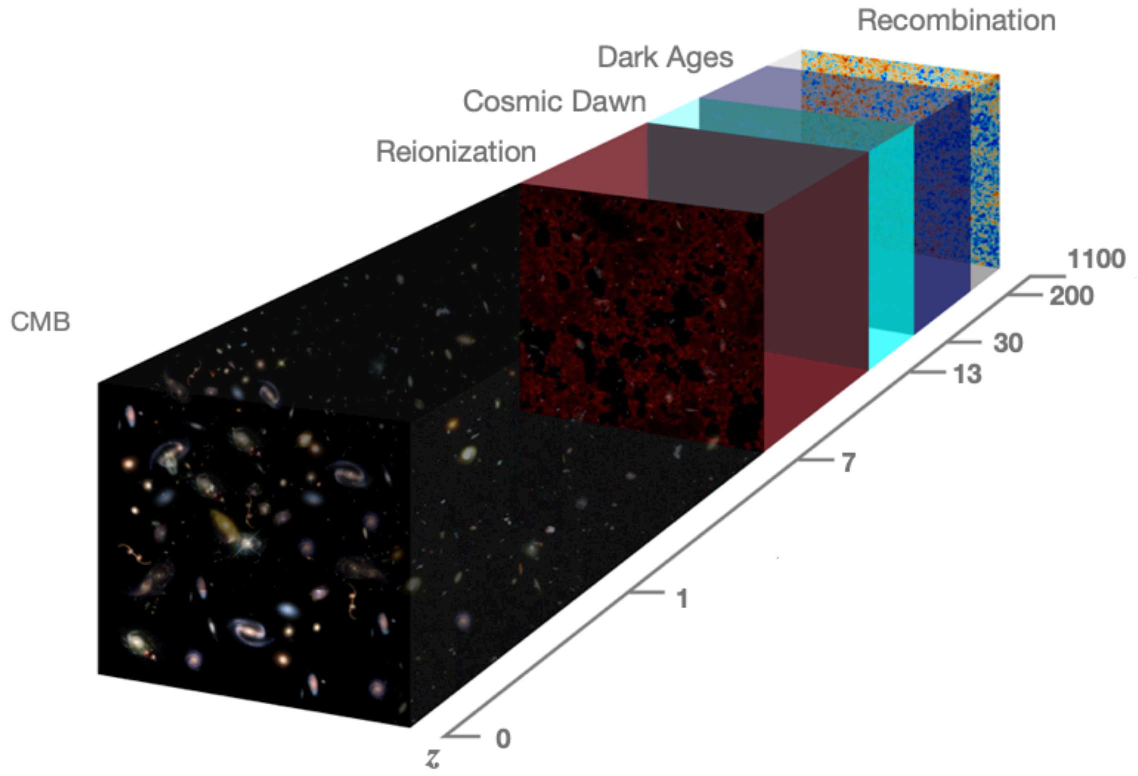
"A User's Guide to Extracting Cosmological Information from Line-Intensity Map"

Cosmic Controversies

10/05/2019

What happens at $2 \lesssim z \lesssim 1000$?



E. D. Kovetz

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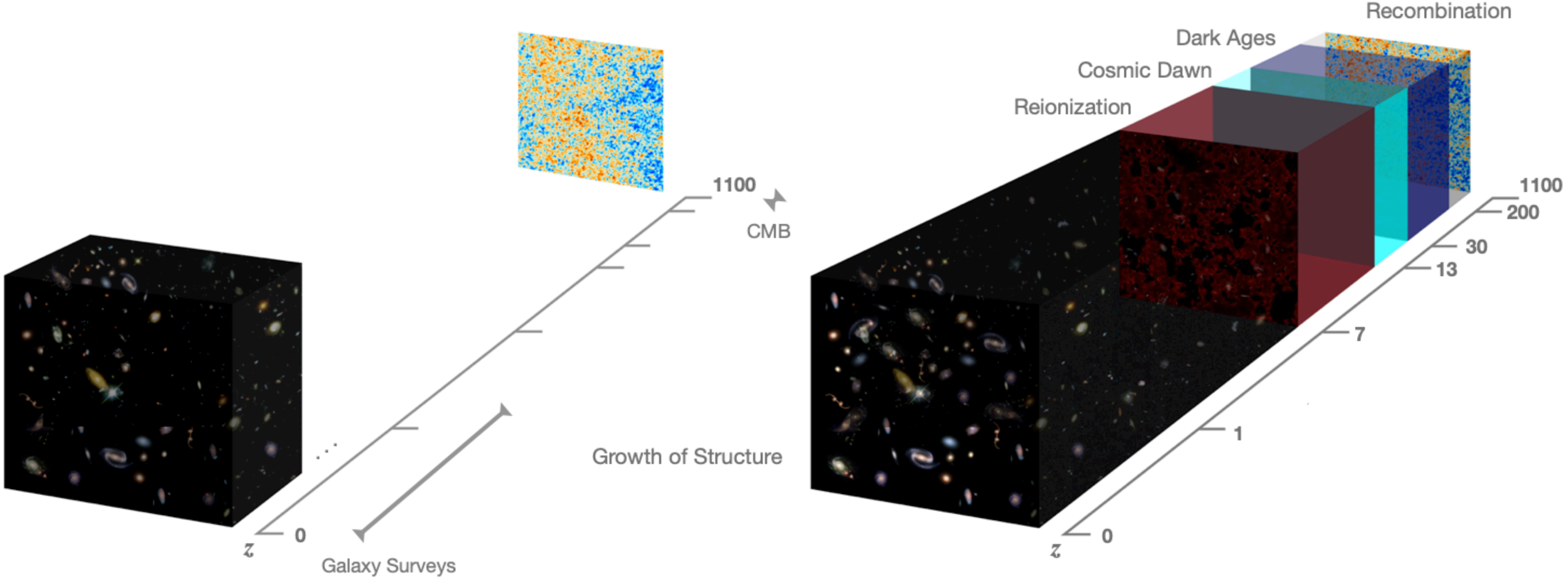

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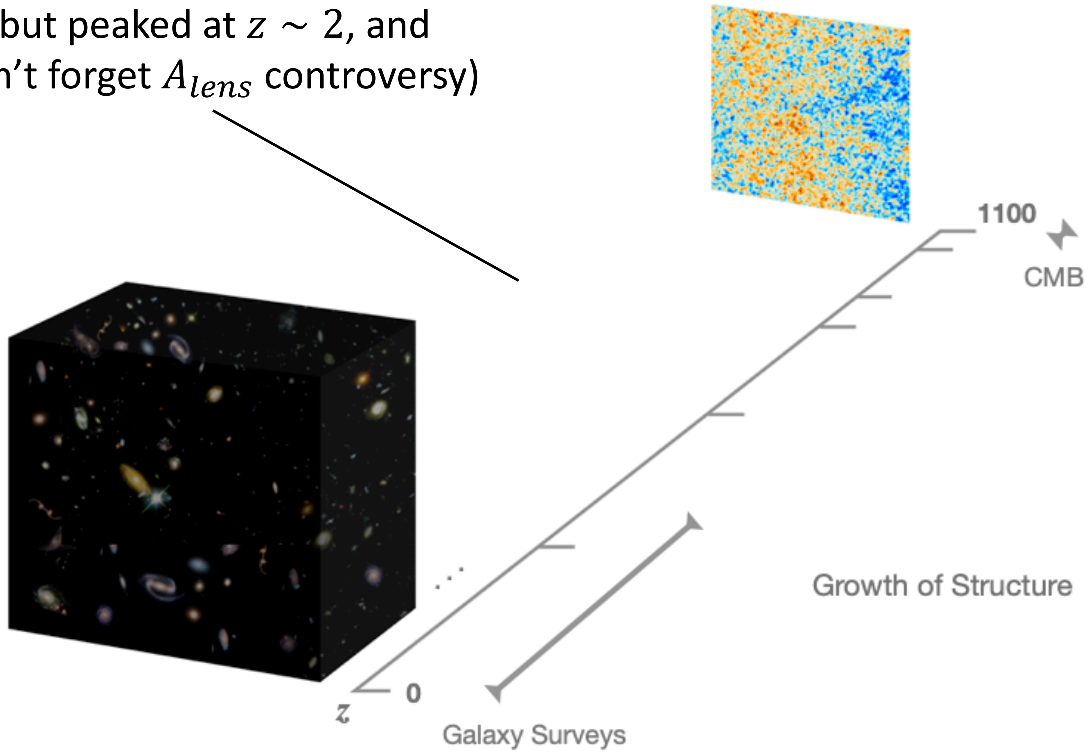
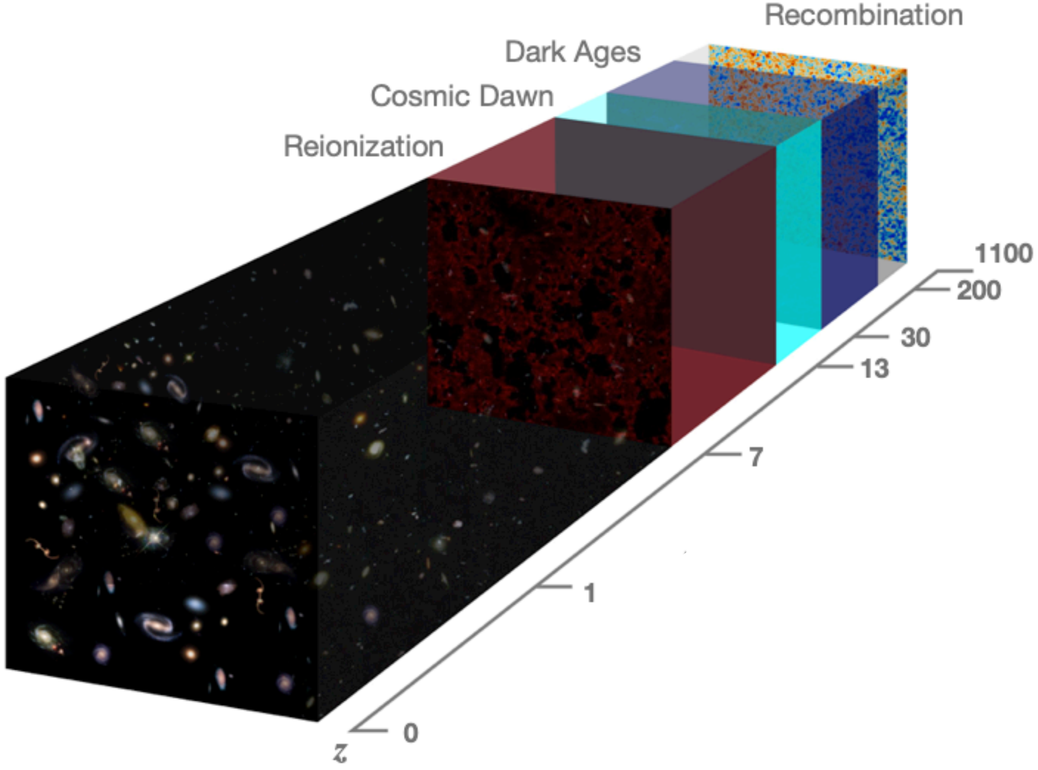
Probed Universe

What happens at $2 \lesssim z \lesssim 1000$?

Indirect measurements with CMB lensing
(but peaked at $z \sim 2$, and
don't forget A_{lens} controversy)





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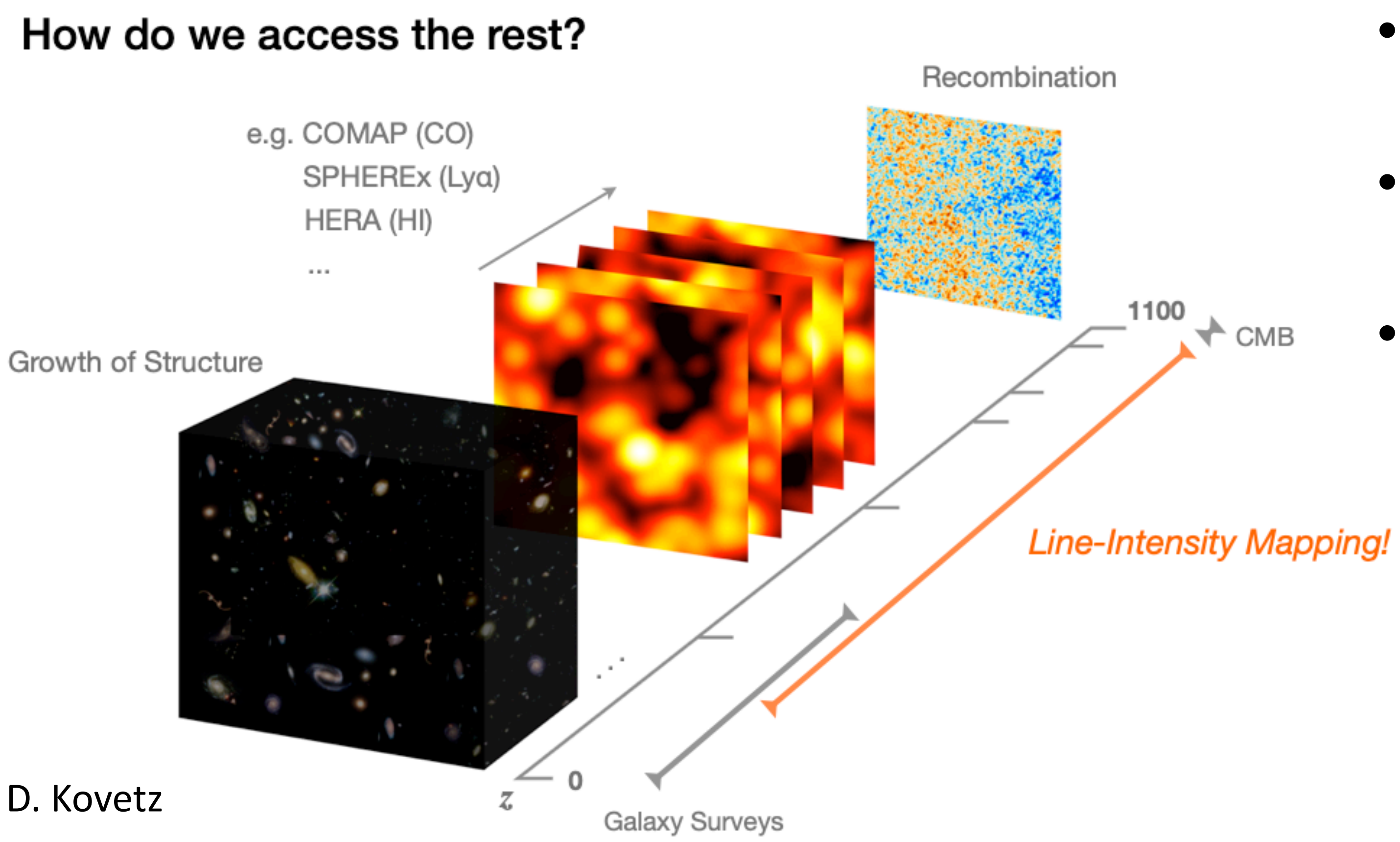

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Optimistic experimental status

- Different stages of evolution across time
- But we have only exploited a small part
- LIM: integrated signal from all sources

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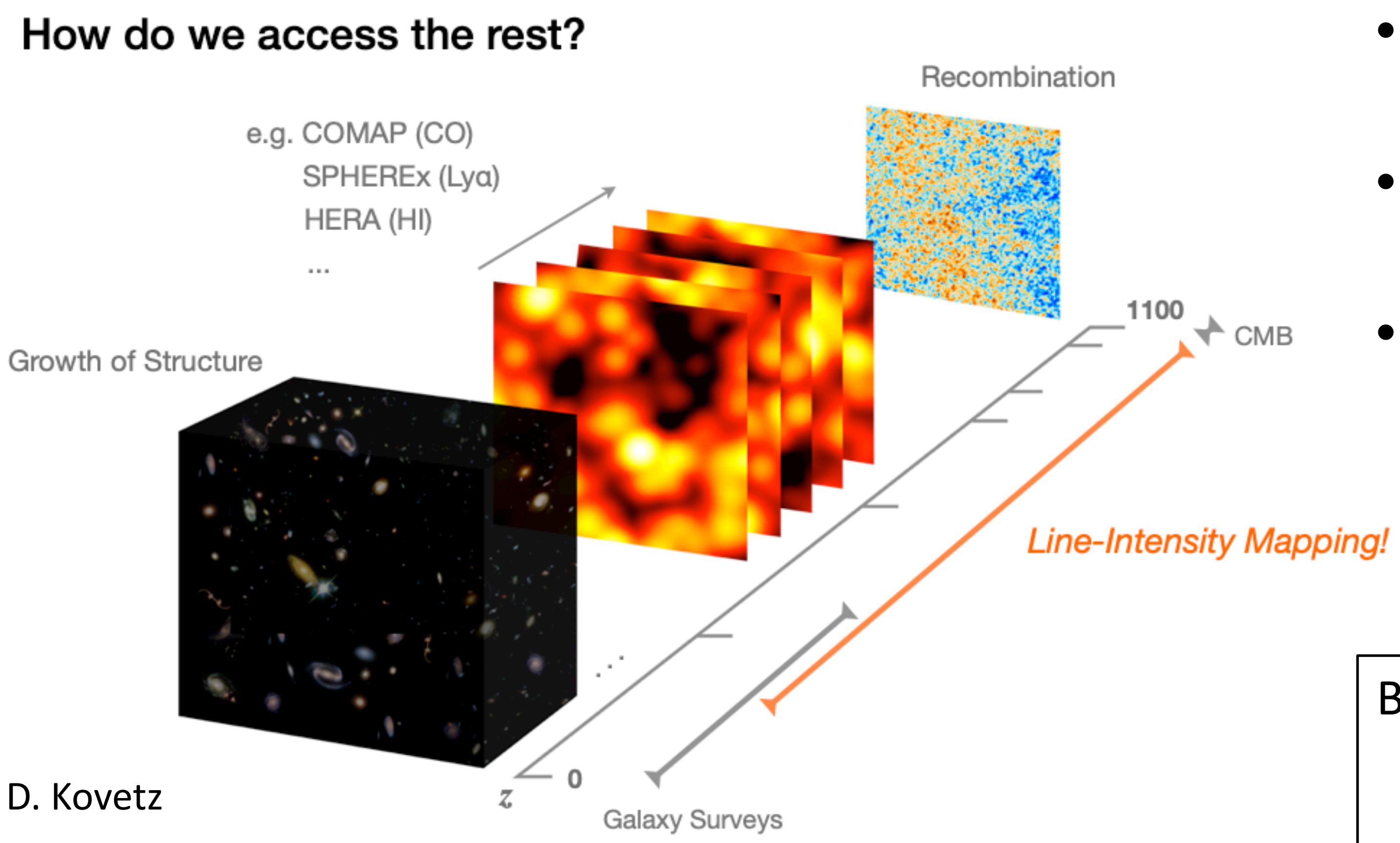

E. D. Kovetz

Optimistic experimental status

- Different stages of evolution across time
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- LIM: integrated signal from all sources

Biased tracer of the density fluctuations

Cosmological information

But degenerate with astrophysics

Using LIM for cosmology

- Focus on the anisotropic power spectrum:

$$P(k,\mu,z) = \langle T(z)\rangle^2 b^2(z) F_{RSD}^2(k,\mu,z) P_m(k,z) + P_{shot}(z)$$

$$\langle T(z)\rangle \propto \int L \frac{dn}{dL} dL$$

$$P_{shot} \propto \int L^2 \frac{dn}{dL} dL$$

Using LIM for cosmology

- Focus on the anisotropic power spectrum:

- Alcock-Paczynski effect: $k_{\parallel}^{meas} = k_{\parallel}^{true}\alpha_{\parallel}$; $k_{\perp}^{meas} = k_{\perp}^{true}\alpha_{\perp}$

$$\alpha_{\parallel} = \frac{(H(z)r_s)^{fid}}{H(z)r_s}$$

$$\alpha_{\perp} = \frac{D_A(z)/r_s}{(D_A(z)/r_s)^{fid}}$$

BAO feature helps to measure the AP effect

Using LIM for cosmology

- Focus on the anisotropic power spectrum:

- Alcock-Paczynski effect: $k_\parallel^{meas} = k_\parallel^{true}\alpha_\parallel; \qquad k_\perp^{meas} = k_\perp^{true}\alpha_\perp$

- Breaking degeneracies: $P(k,\mu,z) = \left(\frac{\langle T\rangle b\sigma_8 + \langle T\rangle f\sigma_8\mu^2}{1+0.5(k\mu\sigma_{FoG})^2}\right)^2 \frac{P_m(k)}{\sigma_8^2} + P_{shot}(z)$

Cosmo params

$$\vec{\theta} = \{\alpha_\parallel, \alpha_\perp, \langle T\rangle f\sigma_8, \langle T\rangle b\sigma_8, \sigma_{FoG}, P_{shot}\}$$

Using a template for $P_m(k,z)$

Using LIM for cosmology

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- Alcock-Paczynski effect: $k_{\parallel}^{meas} = k_{\parallel}^{true}\alpha_{\parallel}$; $k_{\perp}^{meas} = k_{\perp}^{true}\alpha_{\perp}$
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- Include experimental window function: $\tilde{P}(k,\mu,z) = W(k,\mu,z)P(k,\mu,z)$

Using LIM for cosmology

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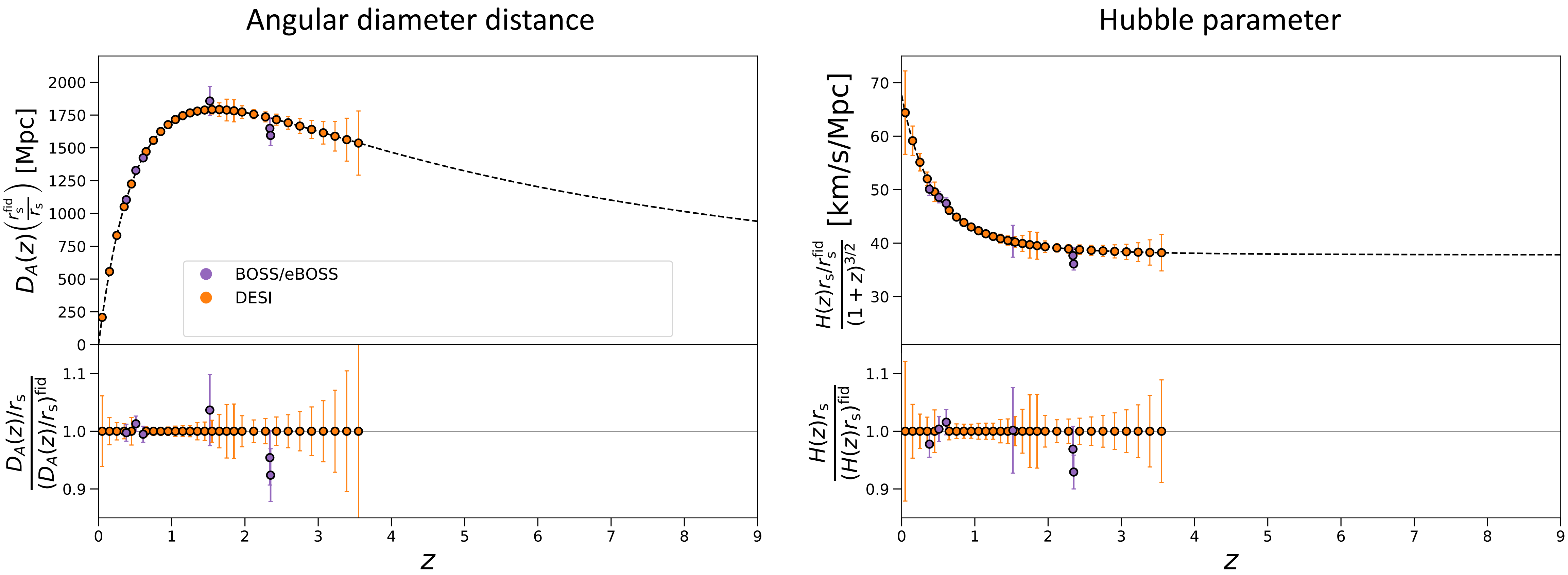
- Include experimental window function: $\tilde{P}(k,\mu,z) = W(k,\mu,z)P(k,\mu,z)$
- Legendre multipoles: up to the hexadecapole! $\alpha_\parallel, \alpha_\perp, \langle T\rangle f\sigma_8$

$$\tilde{P}_\ell(k^{meas},z) = \frac{H(z)}{H^{fid}(z)}\left(\frac{D_A^{fid}(z)}{D_A(z)}\right)^2 \frac{2\ell+1}{2}\int_{-1}^{1} d\mu^{meas}\, \tilde{P}(k^{true},\mu^{true},z)\mathcal{L}_\ell(\mu^{meas})$$

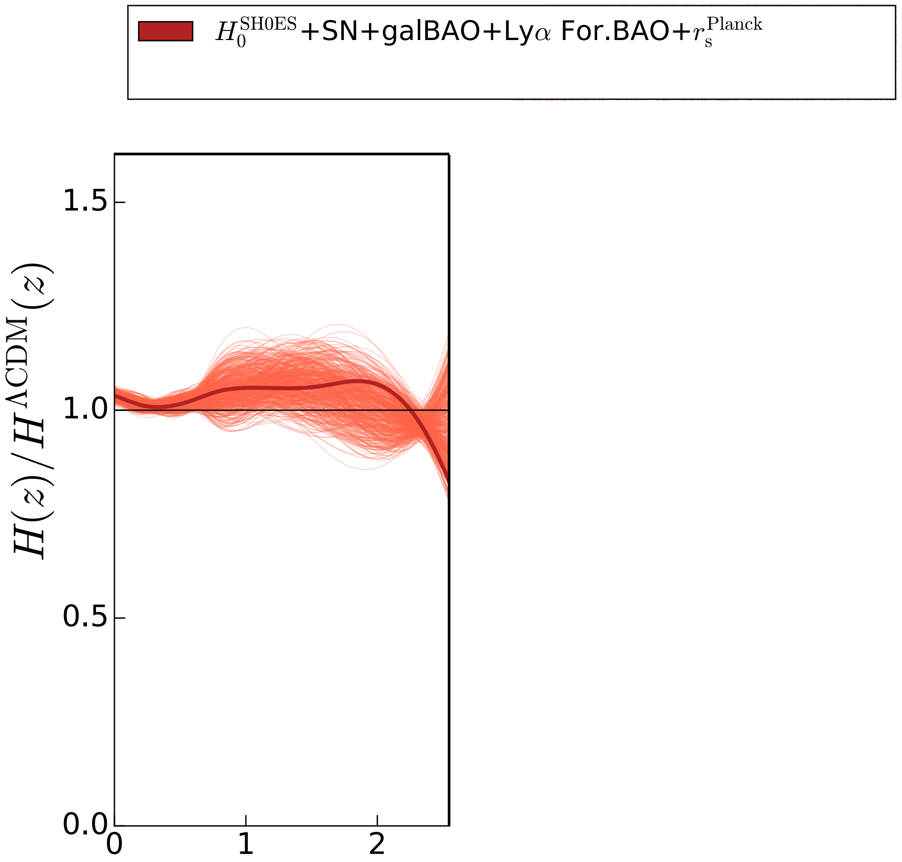
LIM BAO



Current and coming constraints using galaxy surveys

Constraining the expansion history

Model independent $H(z)$ reconstructed with cubic splines



Current constraints using galaxy surveys (and H_0 and r_s)

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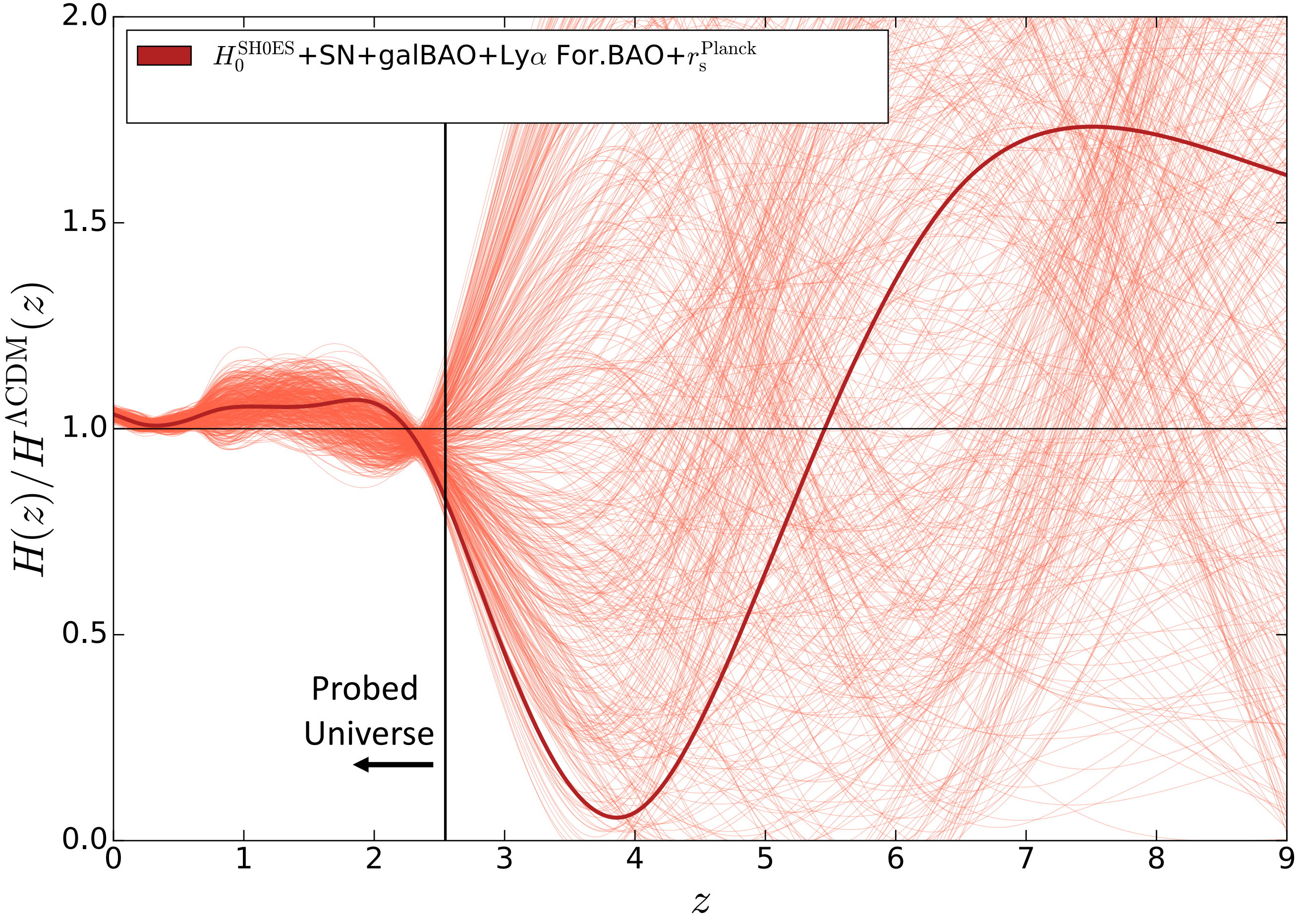
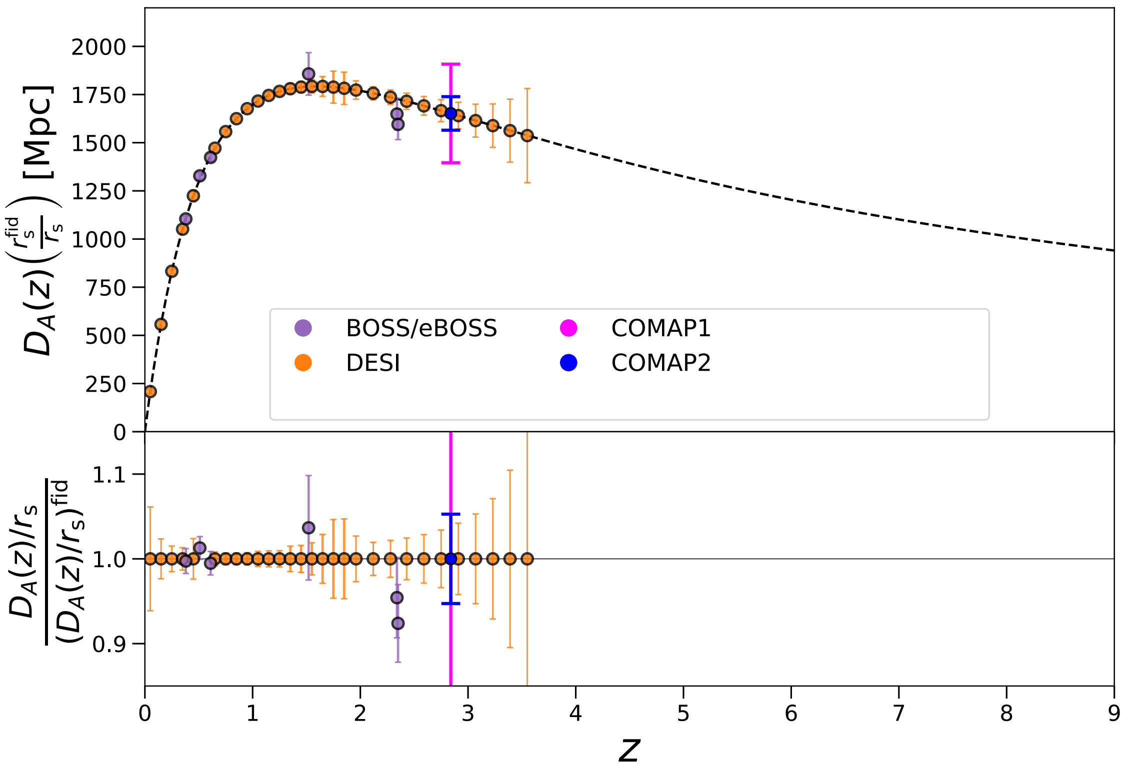


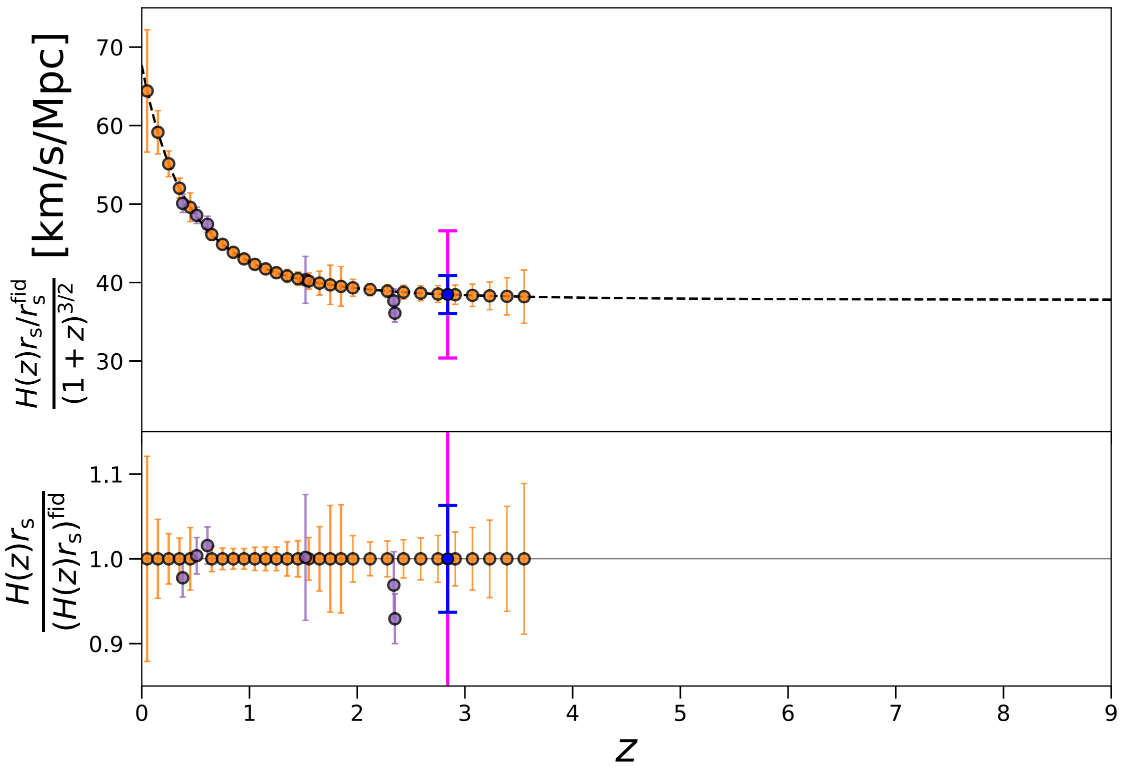
Current constraints using galaxy surveys (and H_0 and r_s)

LIM BAO

Angular diameter distance



Hubble parameter

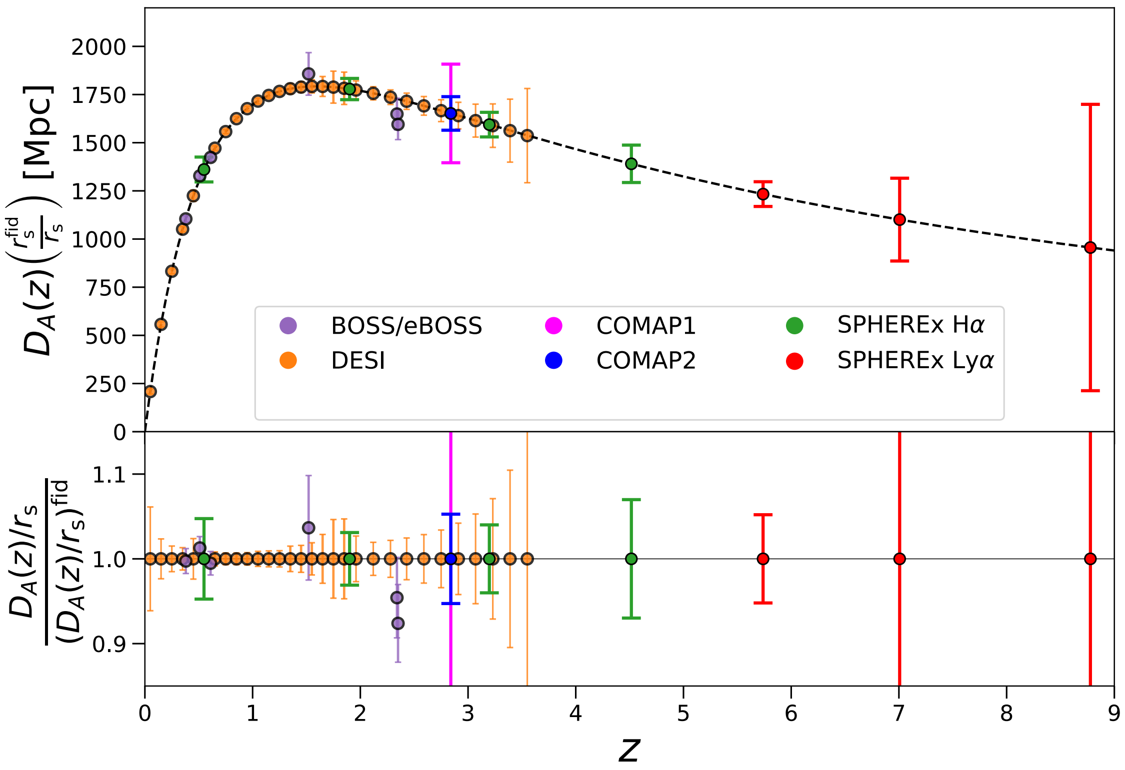


Current and coming constraints using galaxy surveys

+ Star-Formation-related LIM BAO

LIM BAO

Angular diameter distance



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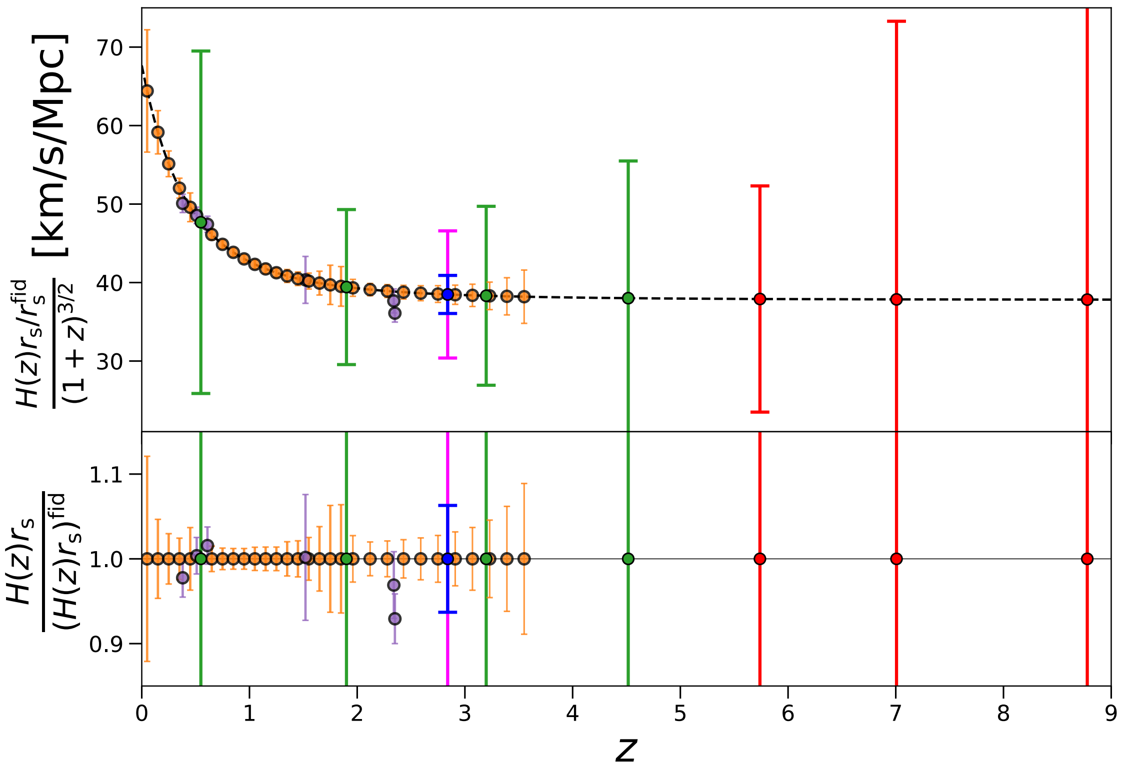

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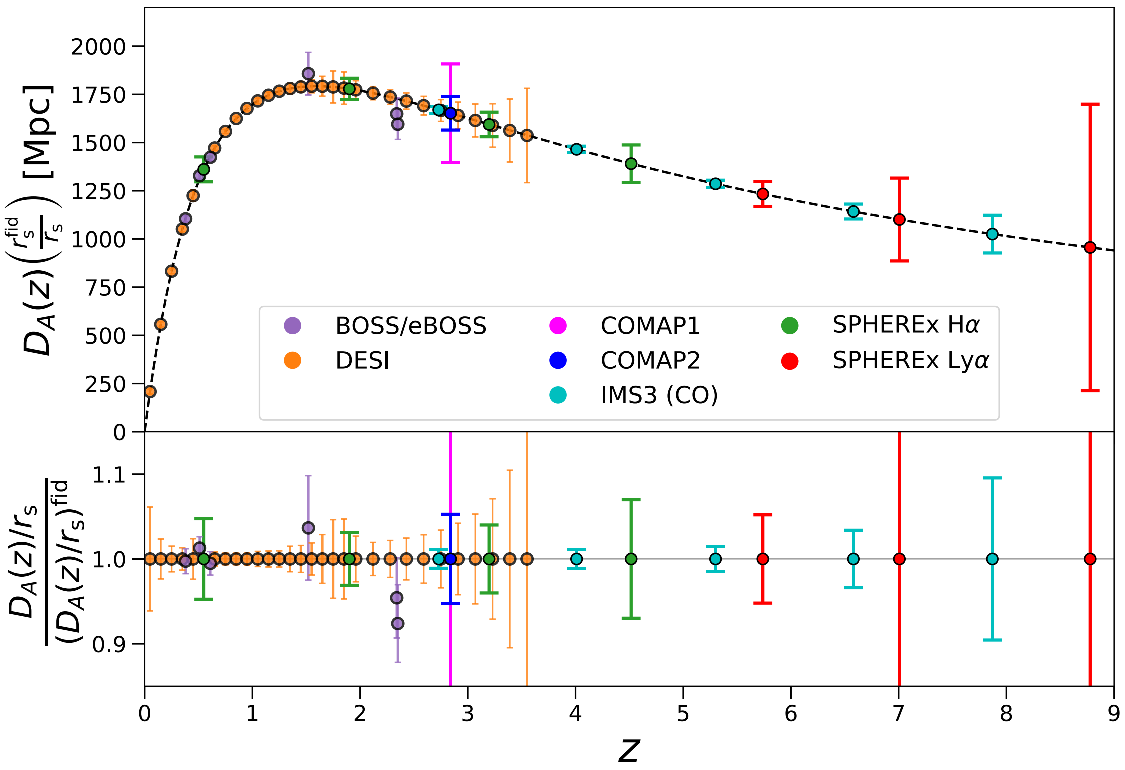

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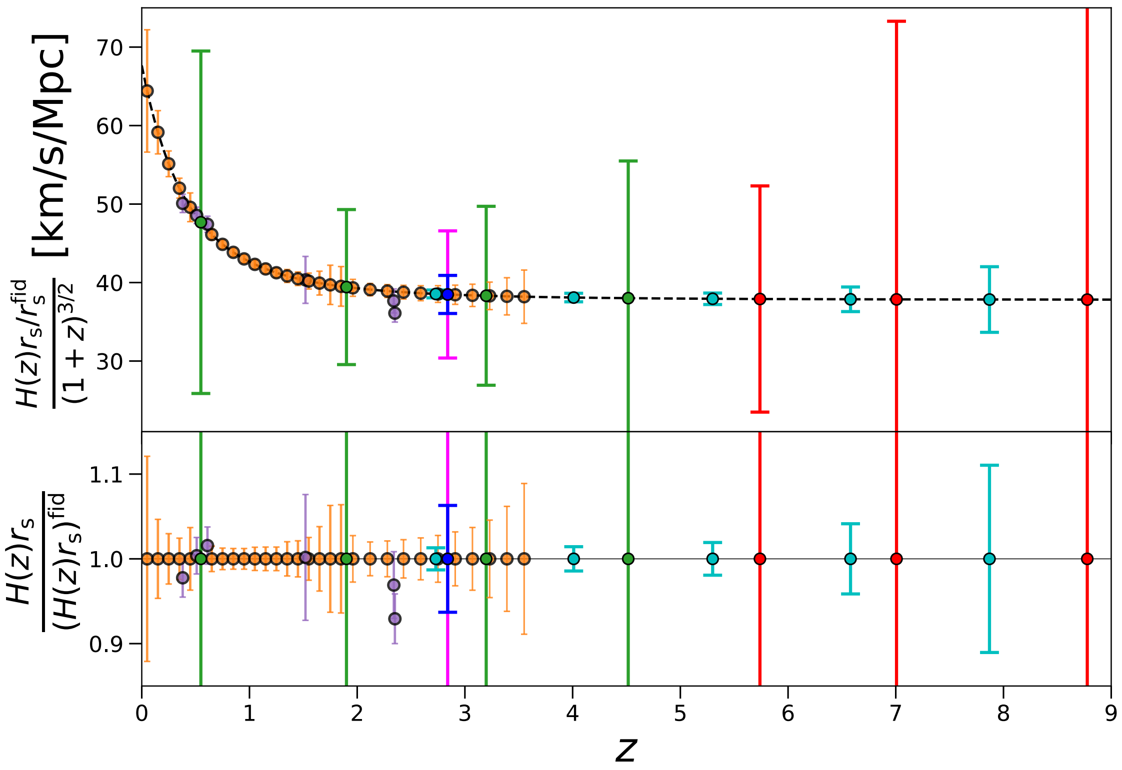

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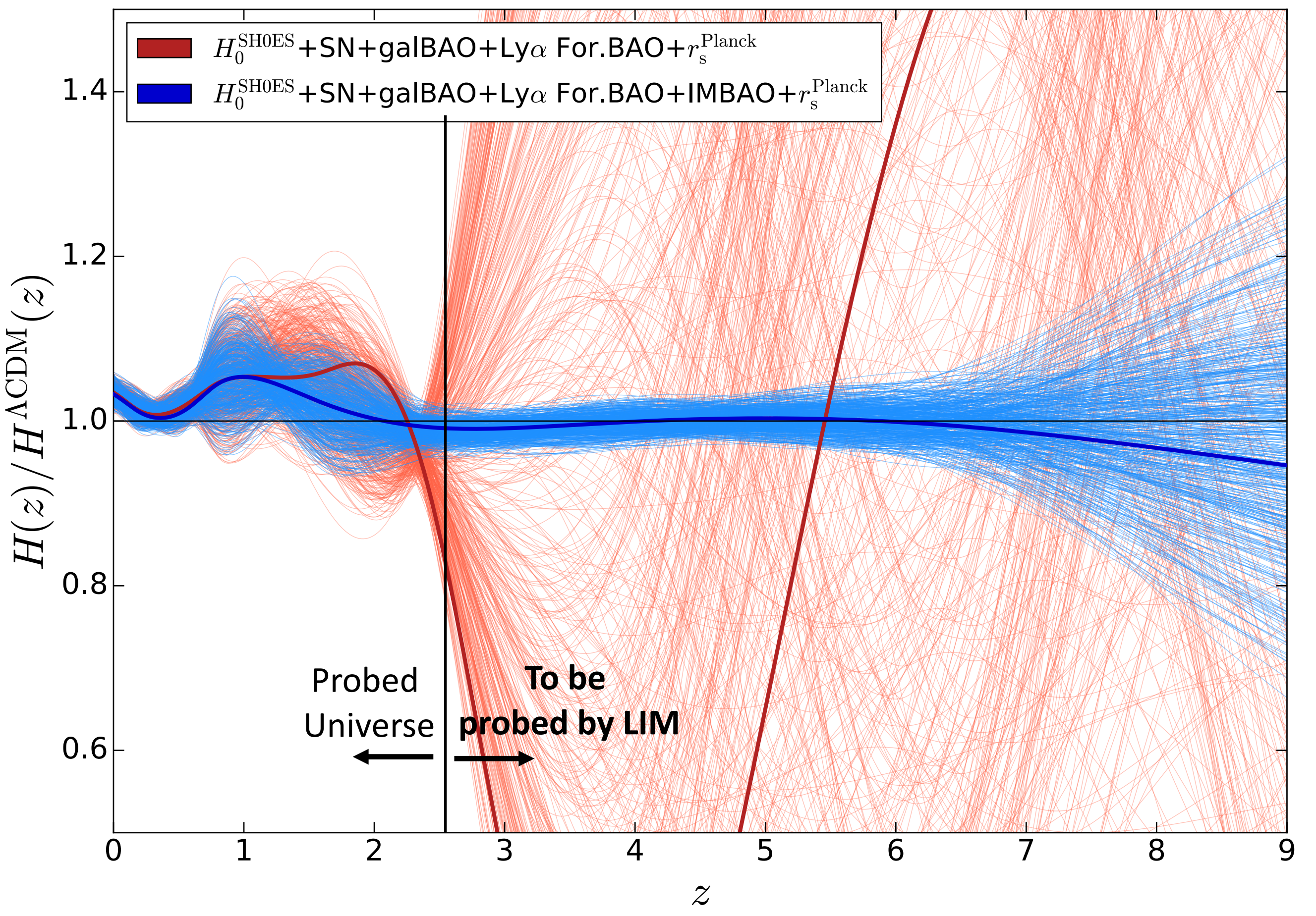


Bridge early and late Universe to probe post-recombination solutions

Current constraints using galaxy surveys (and H_0 and r_s) and **ADDING LIM BAO**

Conclusions

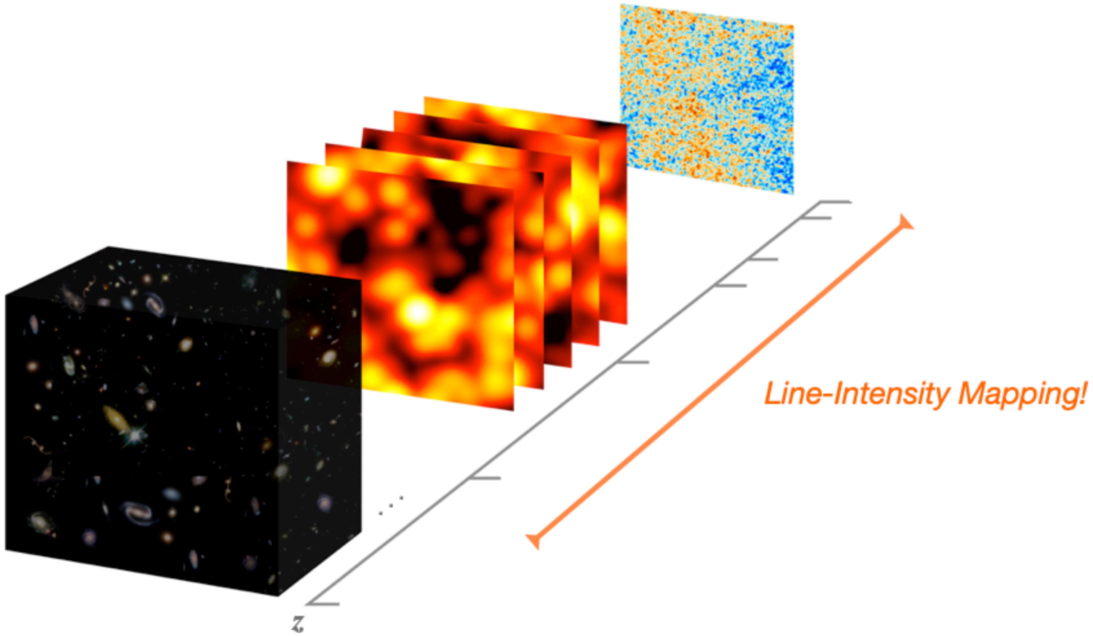
- Optimal exploitation of the anisotropic LIM power spectrum for cosmology:
  - Identify degeneracies and isolate the cosmological information
  - Multipole expansion up to the hexadecapole
  - Experimental window
  - Flexible for models beyond ΛCDM

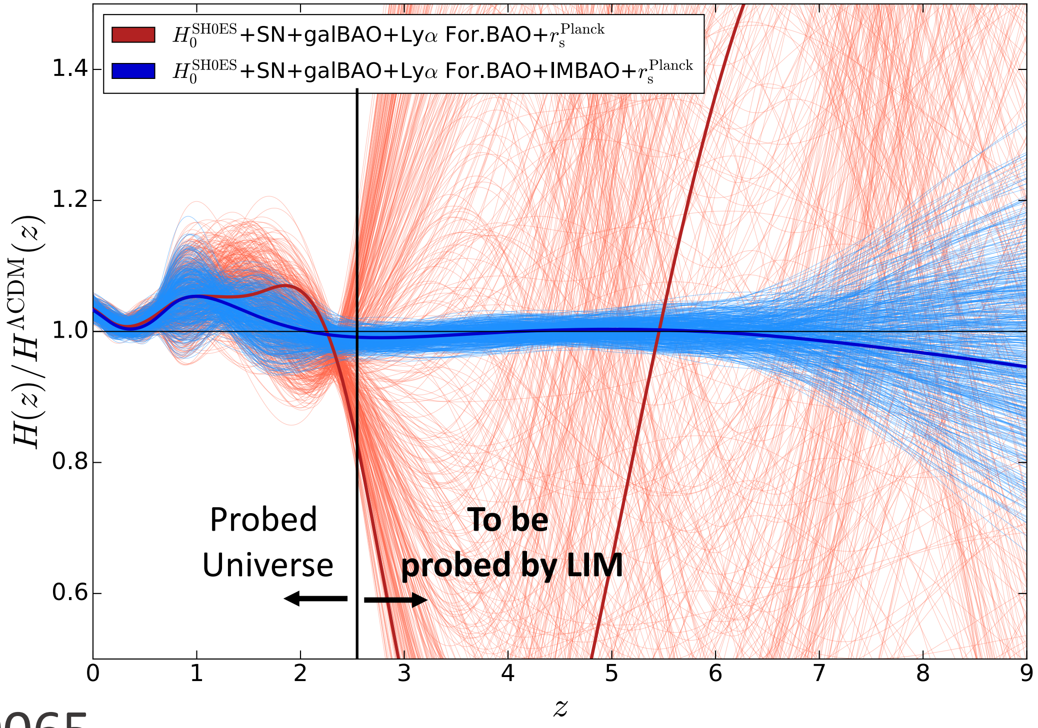
- LIM will grant access to unprobed stages of the Universe

- LIM will bridge between late and early Universe and probe $H(z < 7)$ to $\sim 10\%$ in the coming years ($\sim 2\%$ with IMS3) in a model independent way

- Best way to probe post-recombination solutions to the H_0 tension

For more information





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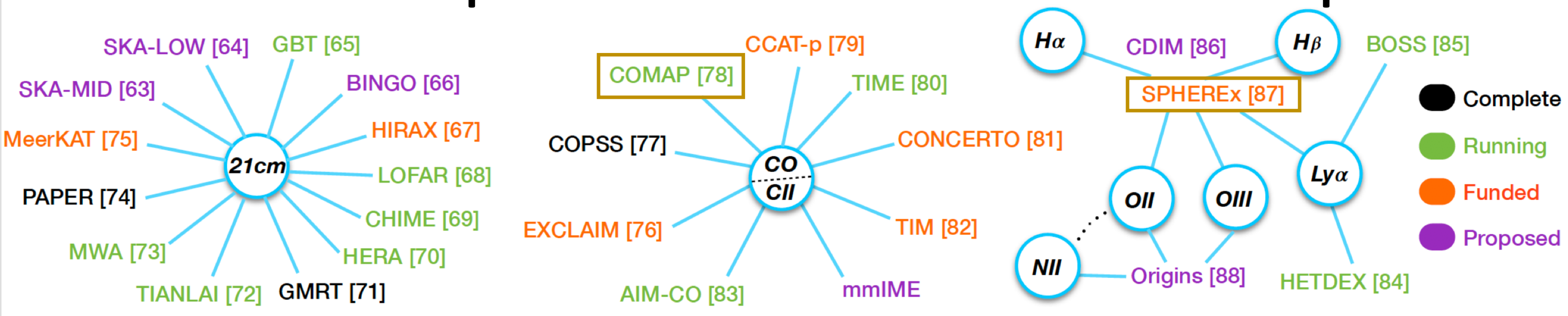
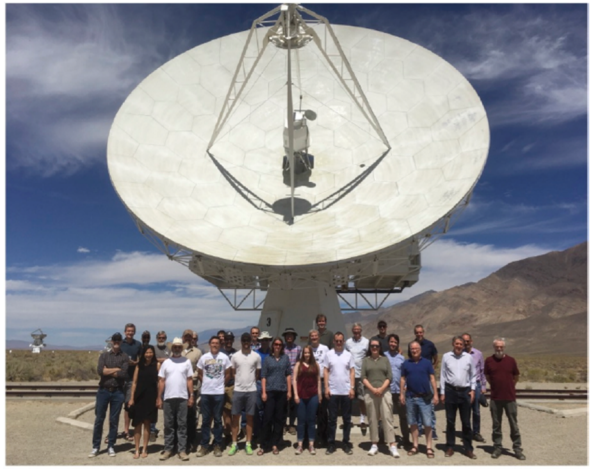
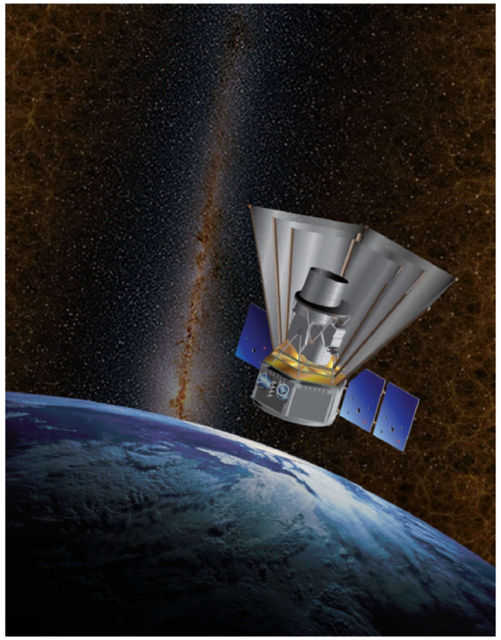
Back up slides

LIM experimental landscape





Instrumental Paramater	COMAP 1	COMAP 2	IMS3 (CO)
$T_{\rm sys}$ [K]	40	40	max(20,$\nu_{\rm obs}$)
Total # of independent detectors	19	95	1000
Ang. resolution (FWHM) [arcmin]	4	4	4
Frequency band [GHz]	26-34	26-34	12-36
$\delta\nu$ [MHz]	15.6	8.0	2.0
$t_{\rm obs}$ [h]	6000	10000	10000
$\Omega_{\rm field}$ [deg^2]	2.25	60	1000



Hα	*Lyα*
80-300 THz	250-360 THz
200 deg^2	200 deg^2

6.2 arcsec
R=41.4