Dwarf Galaxies, Chemical Evolution, and the Future for the Primordial Helium Abundance

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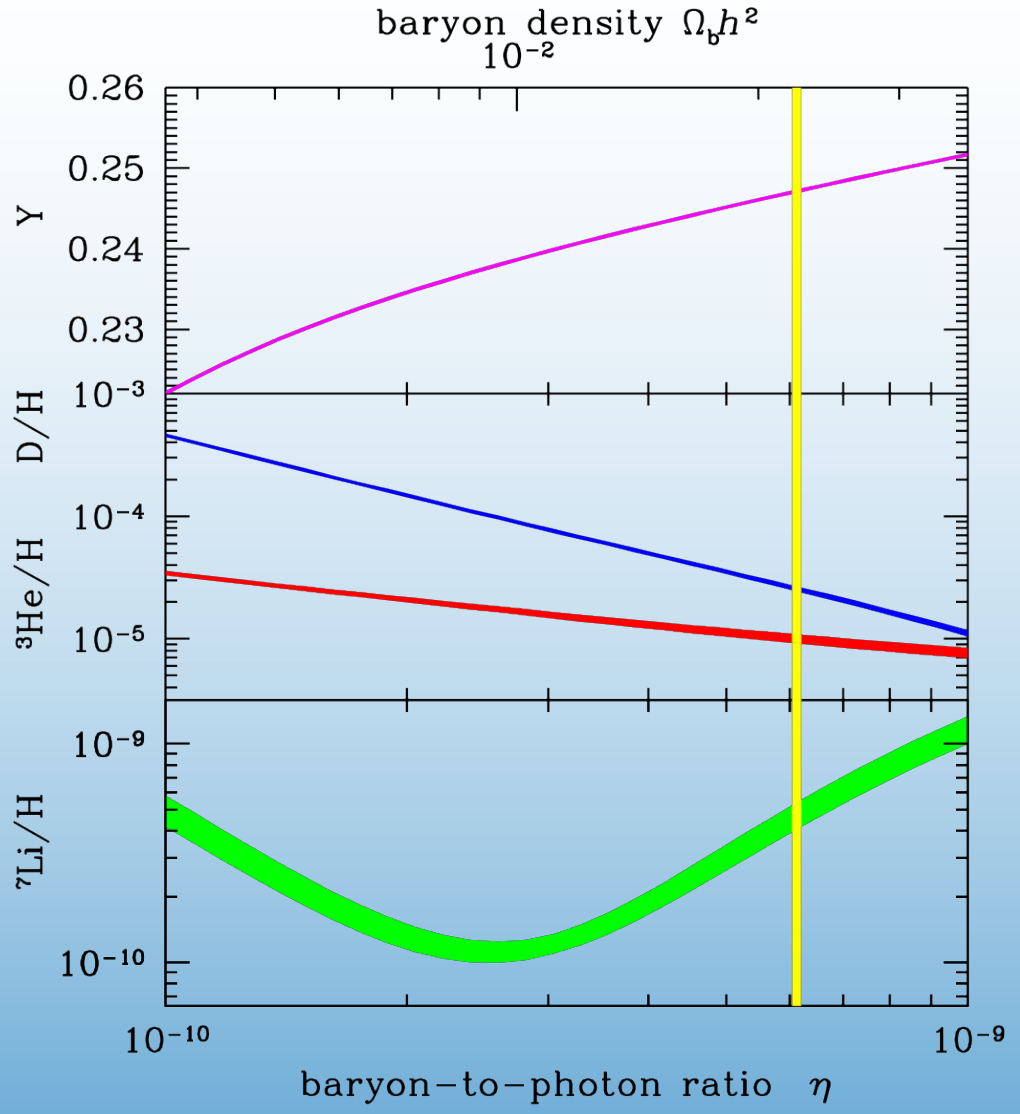
Small Galaxies, Cosmic Questions
Durham, August 2, 2019

CMB + BBN

- CMB Power Spectrum highly sensitive to Ω_B
- CMB+BBN
  => very high precision primordial abundance predictions
- $\Omega_B h^2 = 0.02237 \pm 0.00015$
- $\eta = (6.12 \pm 0.04) \times 10^{-10}$
- $Y_p = 0.2447 \pm 0.0002$



Cyburt, Fields, Olive, Yeh (2015)

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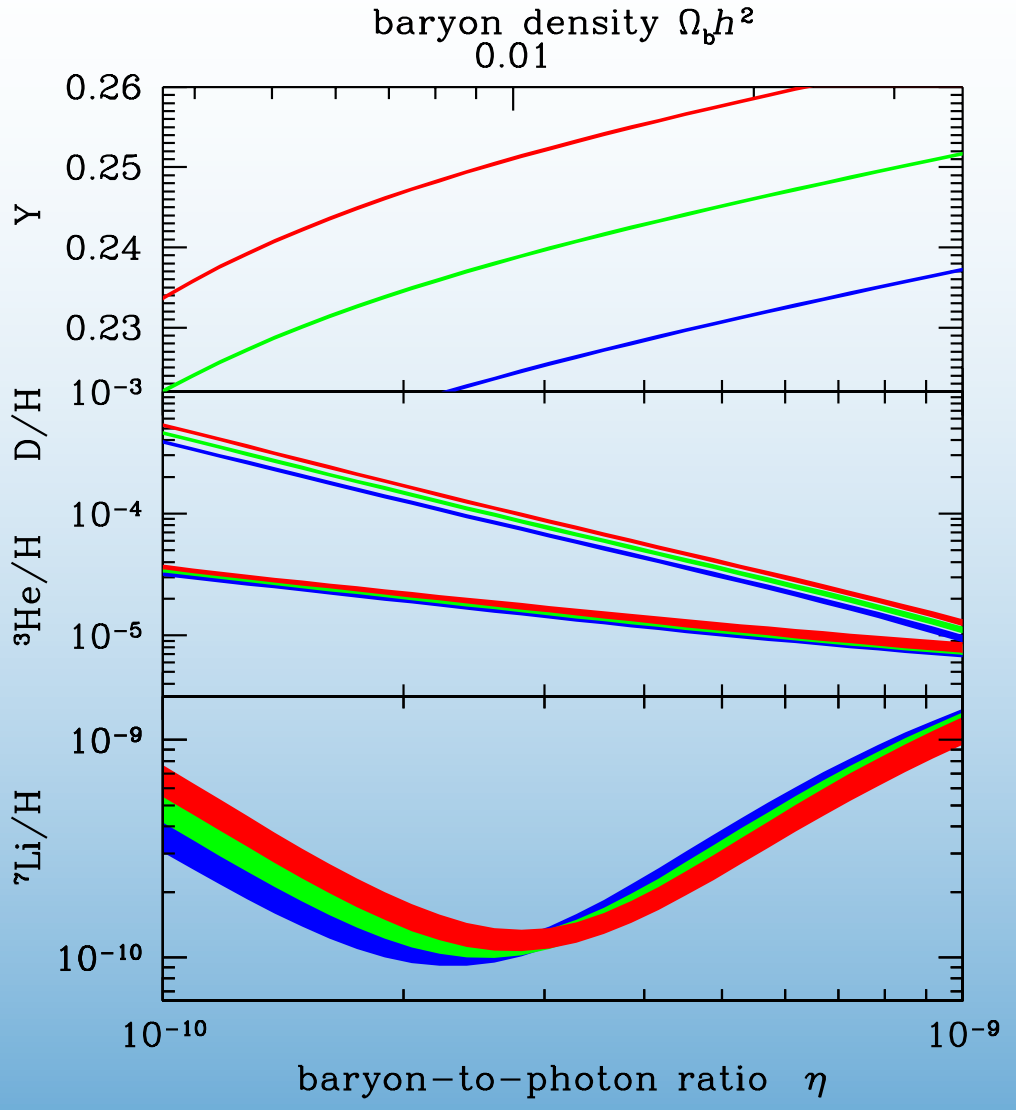

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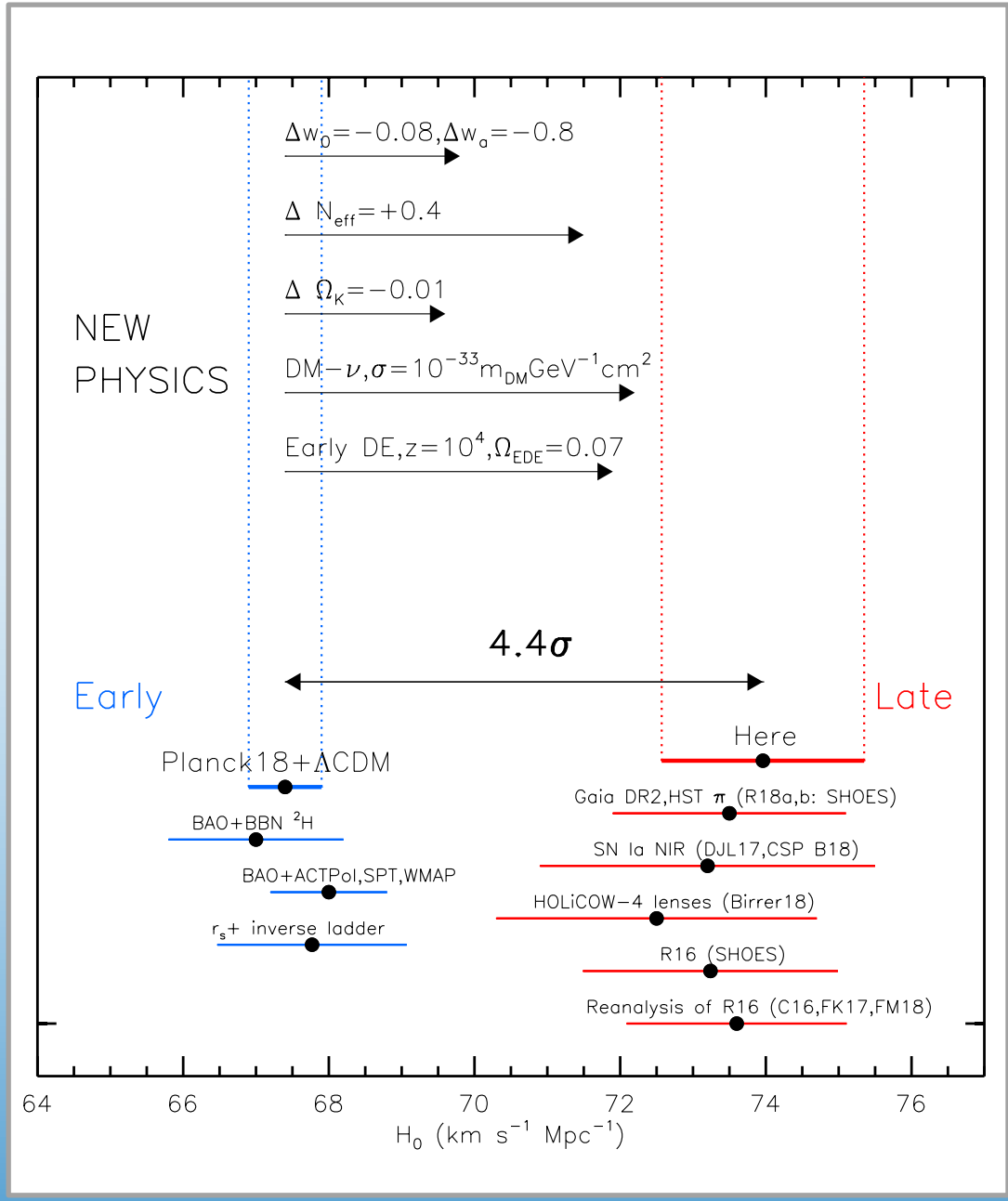
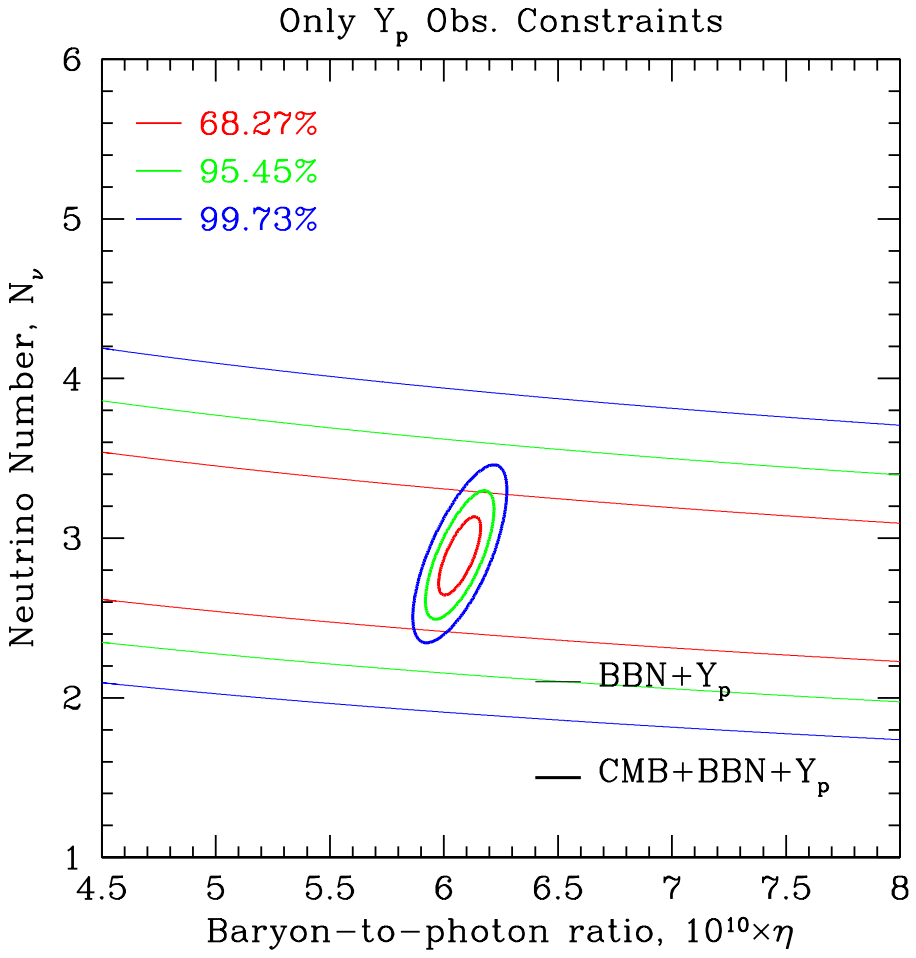
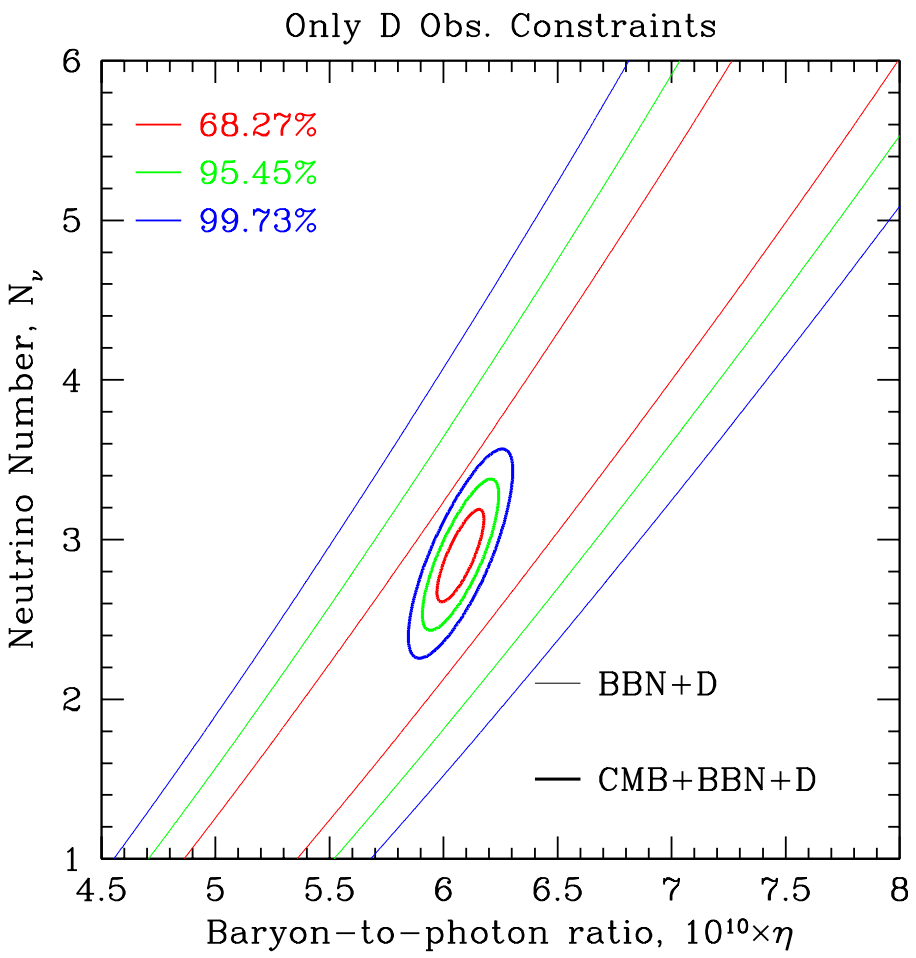
Why do you care about N_{eff}?



Riess + 2019

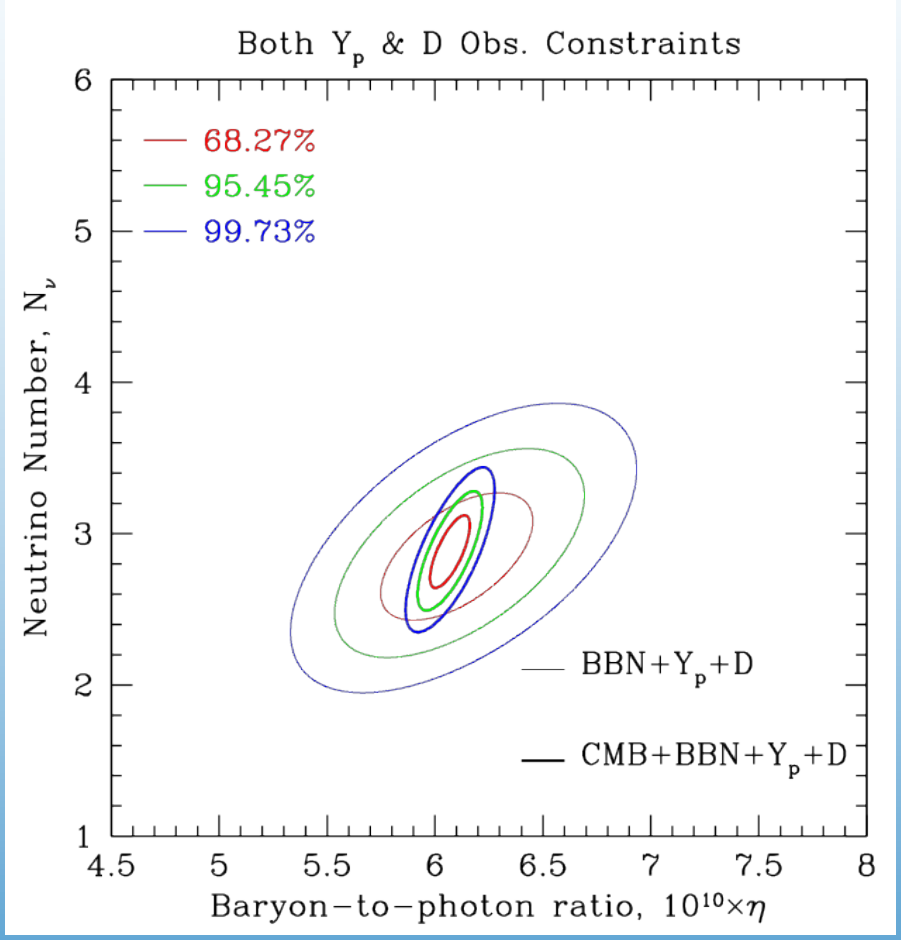
Y_p, D, BBN, the CMB, & N_{eff}





Cyburt, Fields, Olive, Yeh (2015)

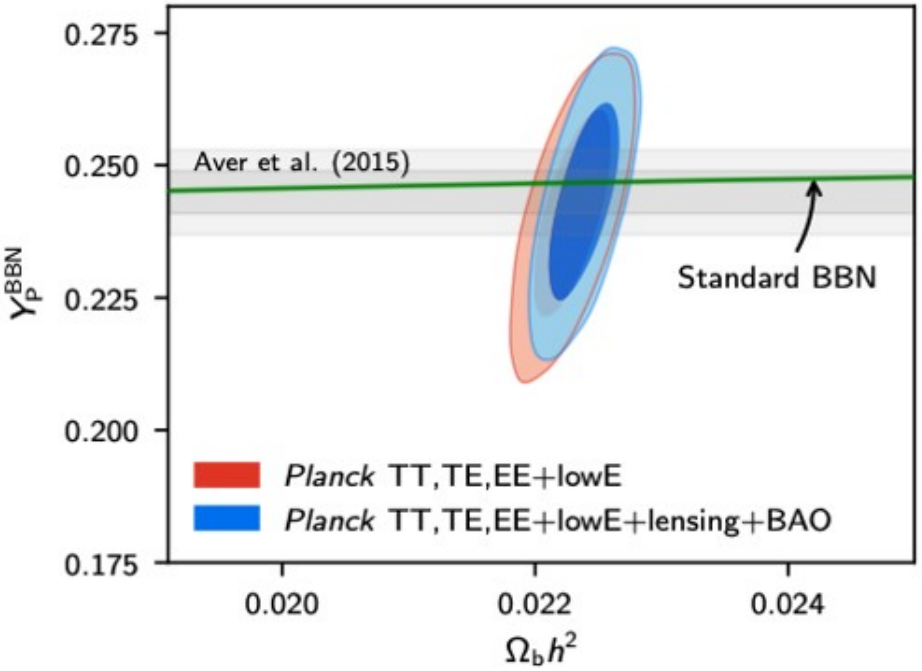
Y_p & BBN

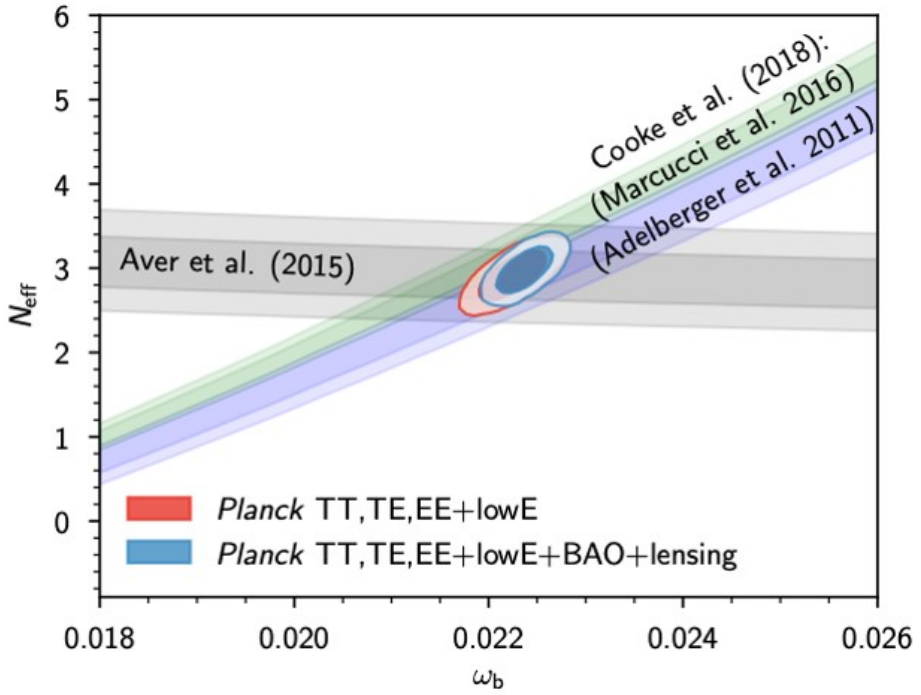


Cyburt, Fields, Olive, Yeh (2015)

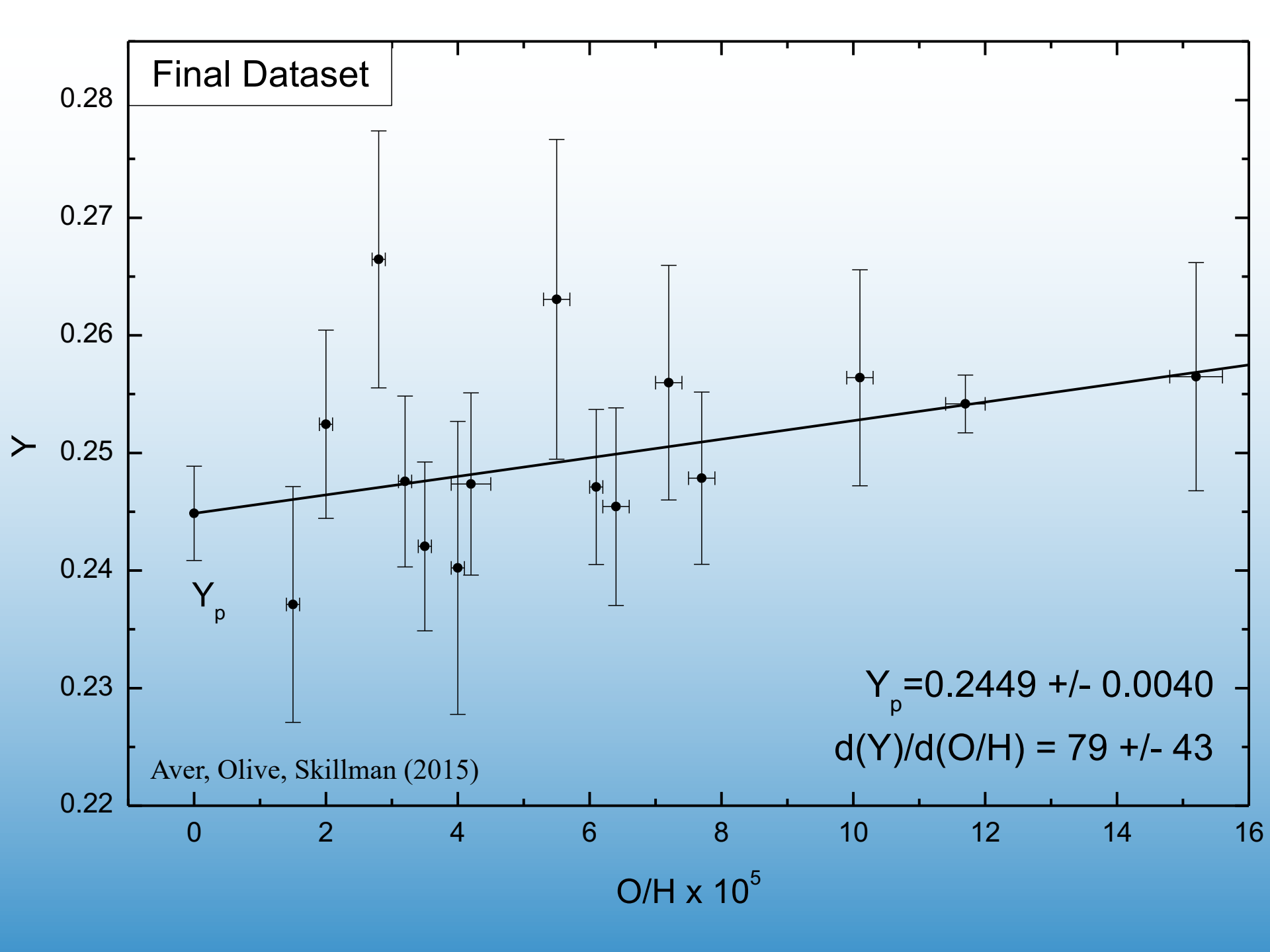
- $Y_p = 0.2449 \pm 0.0040$
  $\frac{D}{H} = (2.53 \pm 0.04) \times 10^{-5}$
  $\Rightarrow \Omega_B h^2 = 0.02228 \pm 0.00084$
  $N_\upsilon = 2.85 \pm 0.28$
- w/ CMB
  $\Rightarrow \Omega_B h^2 = 0.02217 \pm 0.00022$
  $N_\upsilon = 2.88 \pm 0.16$
- Izotov, Thuan, Guseva (2014)
  $Y_p = 0.2551 \pm 0.0022 \ \left(w/ \ \frac{D}{H}\right)$
  $\Rightarrow \Omega_B h^2 = 0.0240 \pm 0.0017$
  $N_\upsilon = 3.53 \pm 0.25$

Y_p, BBN, & the CMB

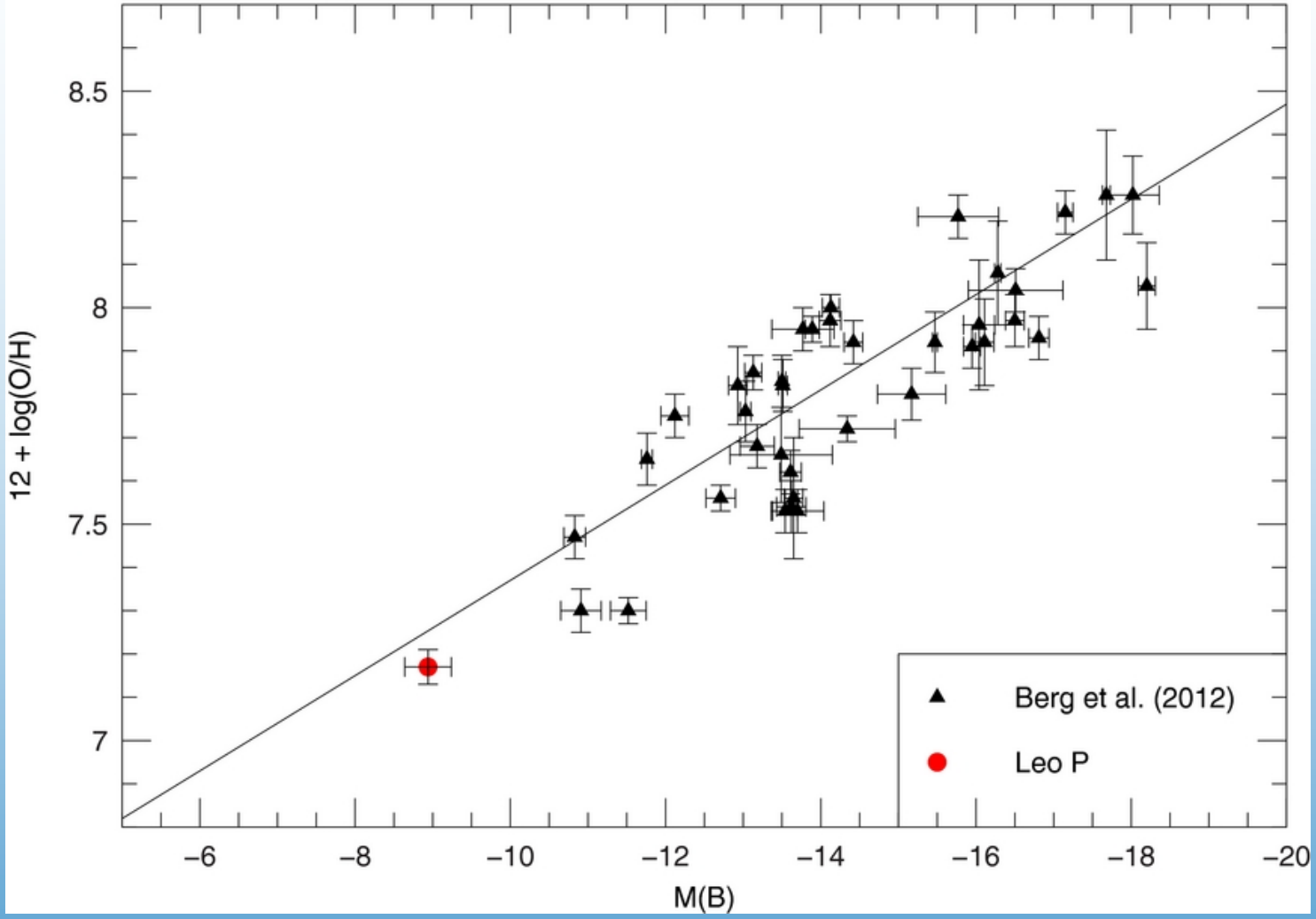




Planck (2018)


Final Dataset
0.28
0.27
0.26
0.25
0.24
0.23
0.22
Y
0
2
4
6
8
10
12
14
16
O/H x 10^5
Y_p
Y_p=0.2449 +/- 0.0040
d(Y)/d(O/H) = 79 +/- 43
Aver, Olive, Skillman (2015)

(1) Add New Low z Targets



Skillman+ (2013)

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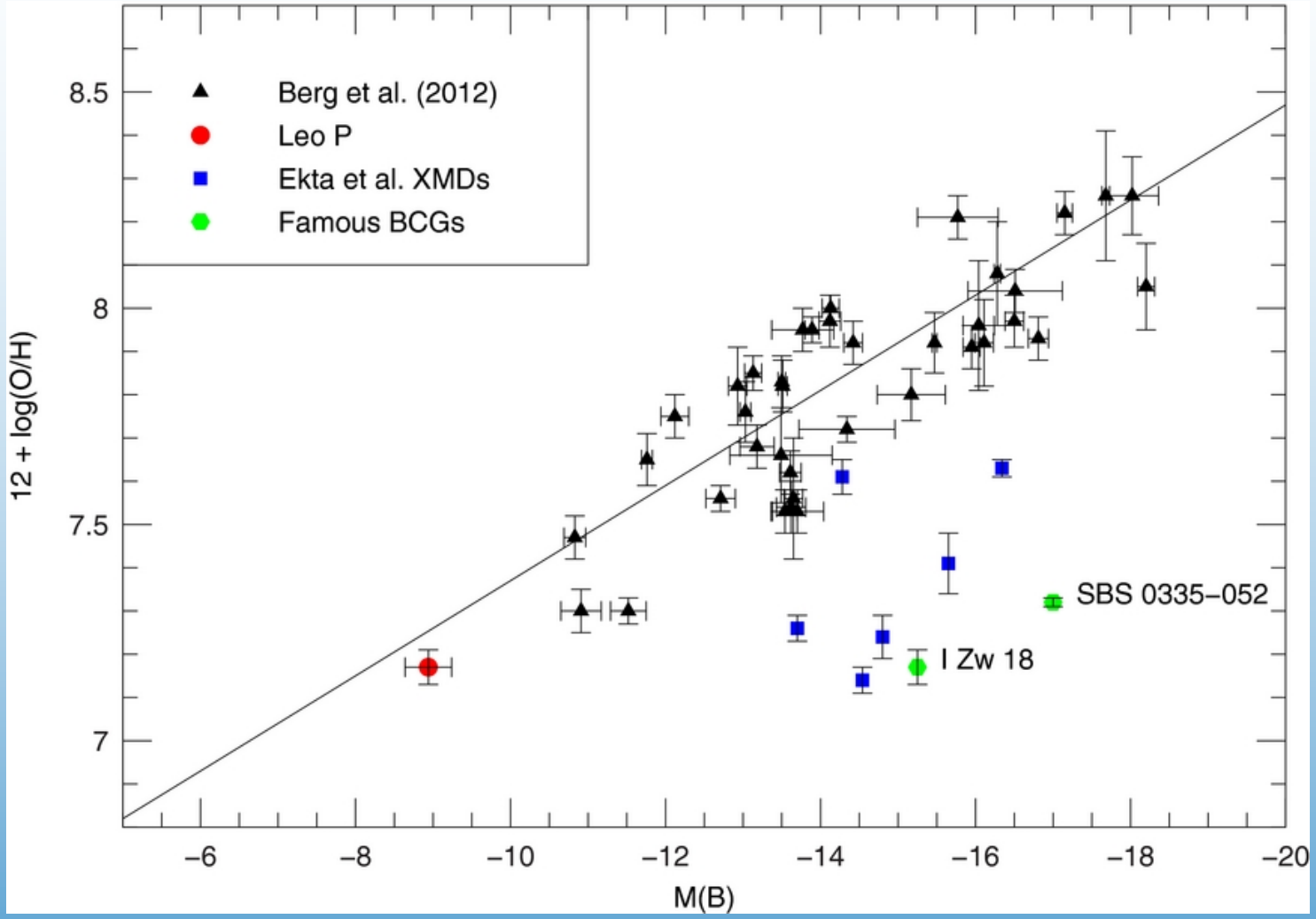

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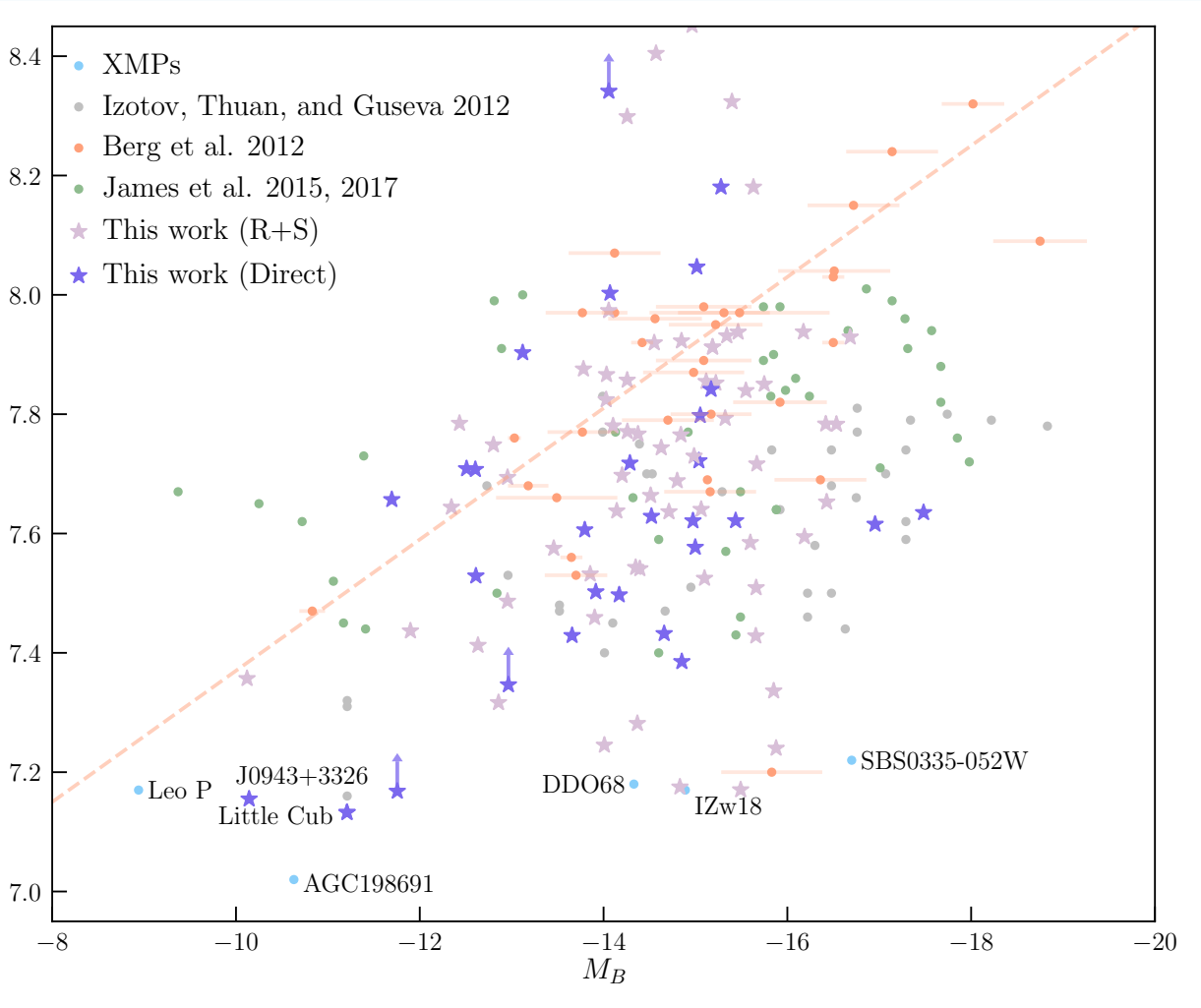

Hsyu+ (2013)

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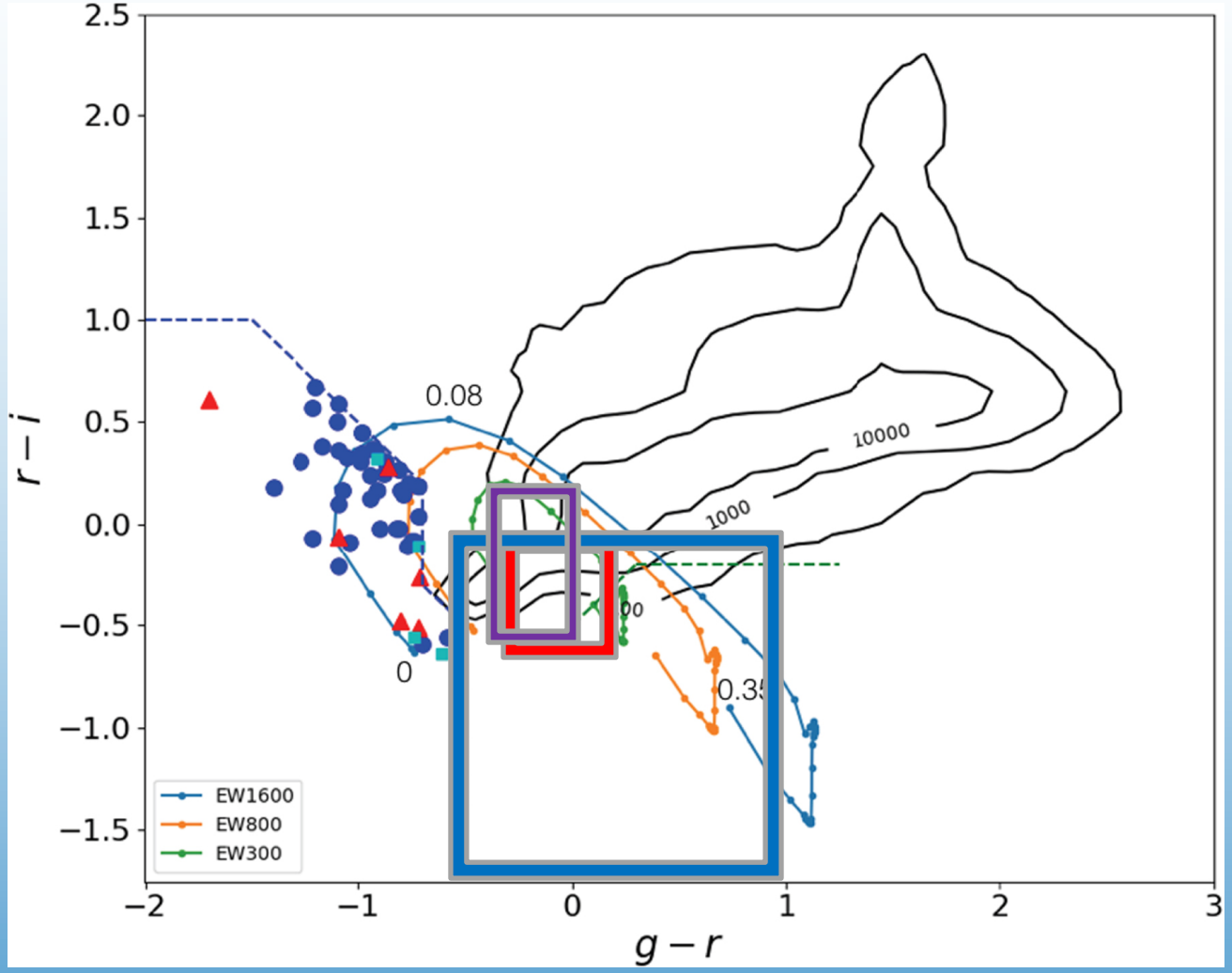
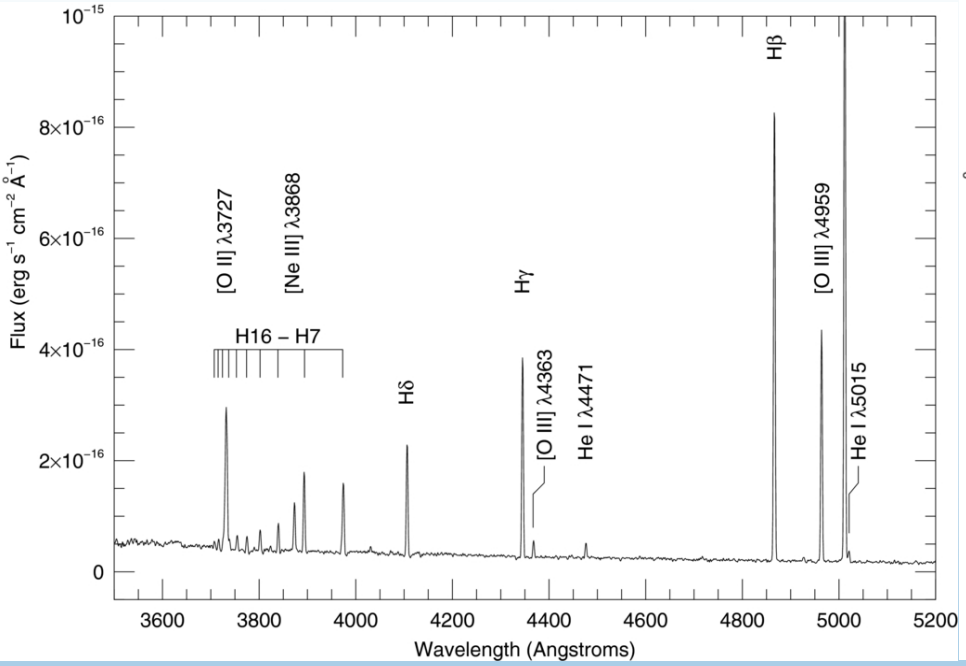
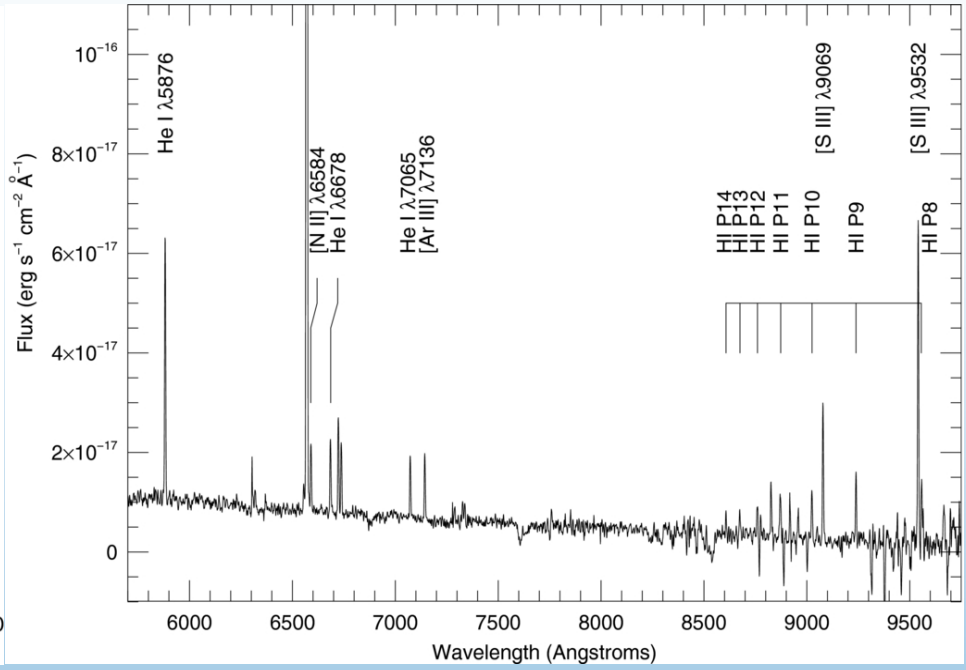


Yang+ (2017)

(2) Reduce the Uncertainties





Skillman+ (2013)

Recent Improvements

- Higher Quality & Higher Resolution Spectra
  - LBT MODS Spectra
  - LBT near-IR Spectra
  - Include additional H I lines in solution
  - Include additional He I lines in solution
  - Improved atomic data for H collisional excitation
  - Improved modeling of underlying H and He absorption

=>As a result, roughly factor of two reduction in He/H uncertainty on individual objects.

Summary

- BBN's ability to predict the light element abundances with high precision is a great accomplishment of the Big Bang model.
- Our current determination of the Primordial Helium Abundance agrees well with the CMB result.
- Self-consistent analysis of ^{4}He using MCMC has proved insightful and effective.
- More targets and higher quality spectra are needed (and coming!).
- Constraints on N_{eff} will be tightened.