The Local Perspective on the Hubble Problem

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Hubble Problem Today

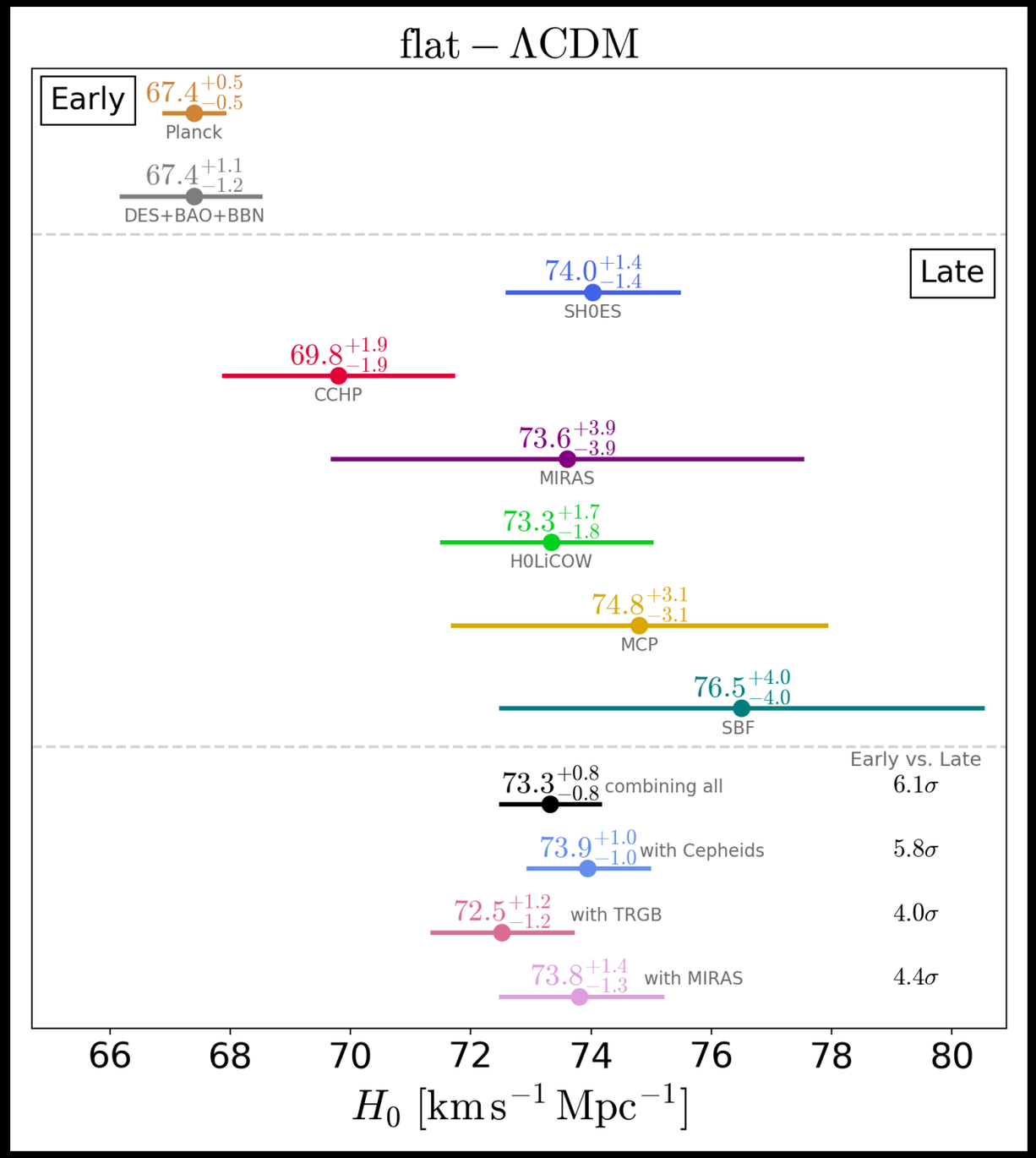


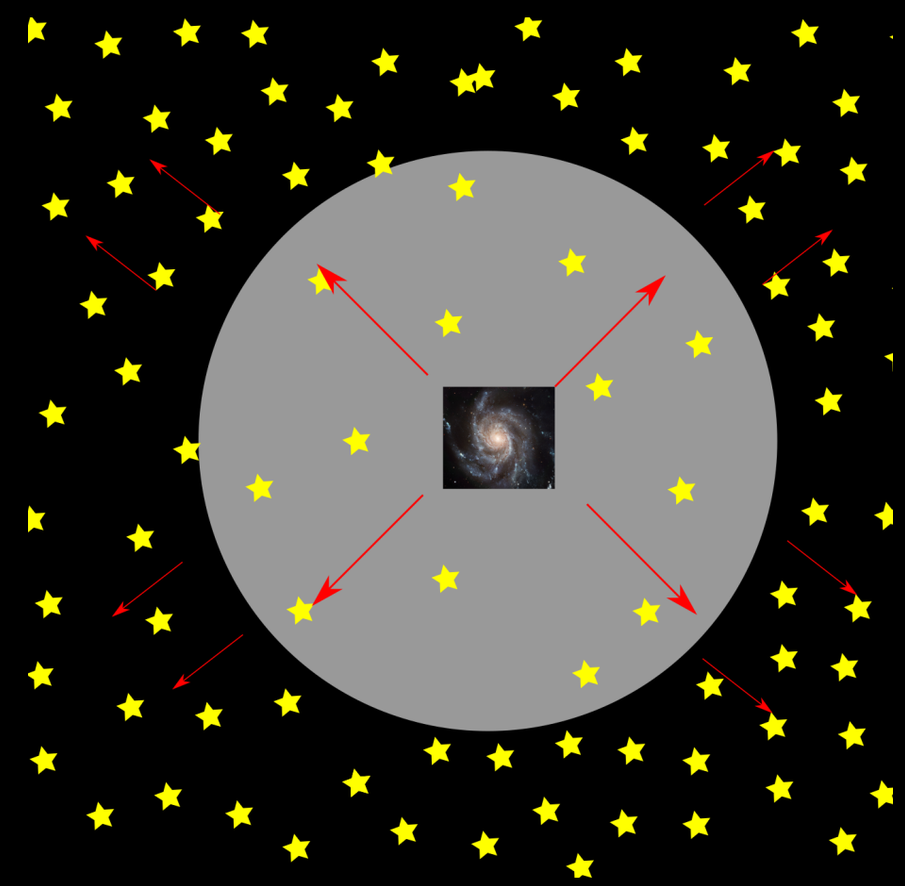
Figure Source: Verde et al 2019

Can a Void solve the Hubble Problem?

- Under-density increases local Hubble constant

$$\delta H_0/H_0 = -f(\Omega_M)/3 \times \delta\rho/\rho$$

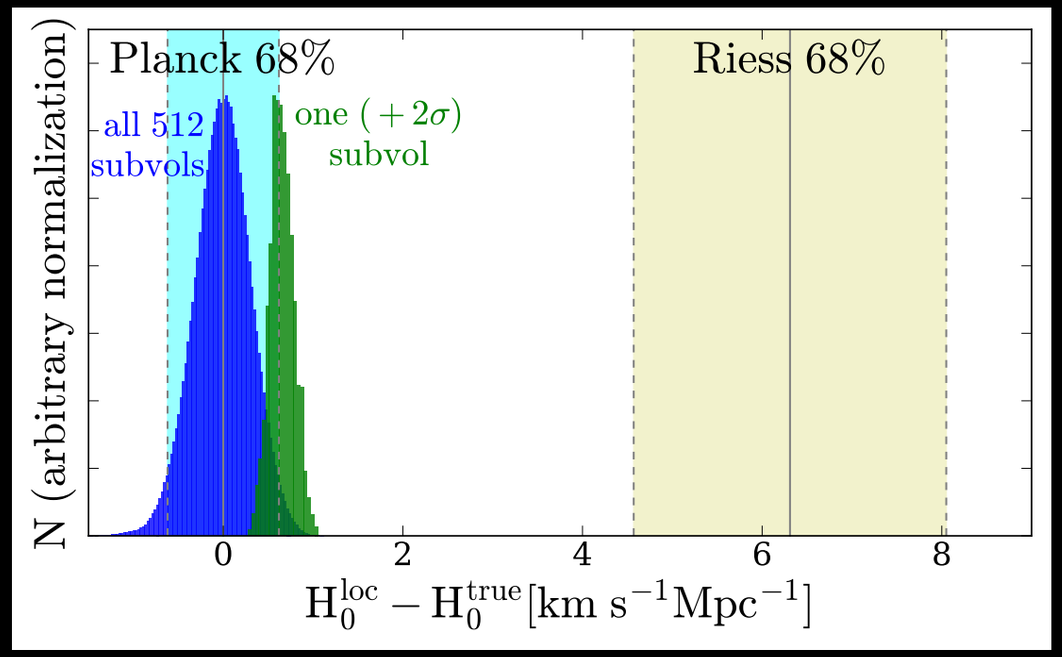
$$\approx -1/6 \times \delta\rho/\rho$$



Grey, underdense region will expand more quickly than black background

Can a Void solve the Hubble Problem?

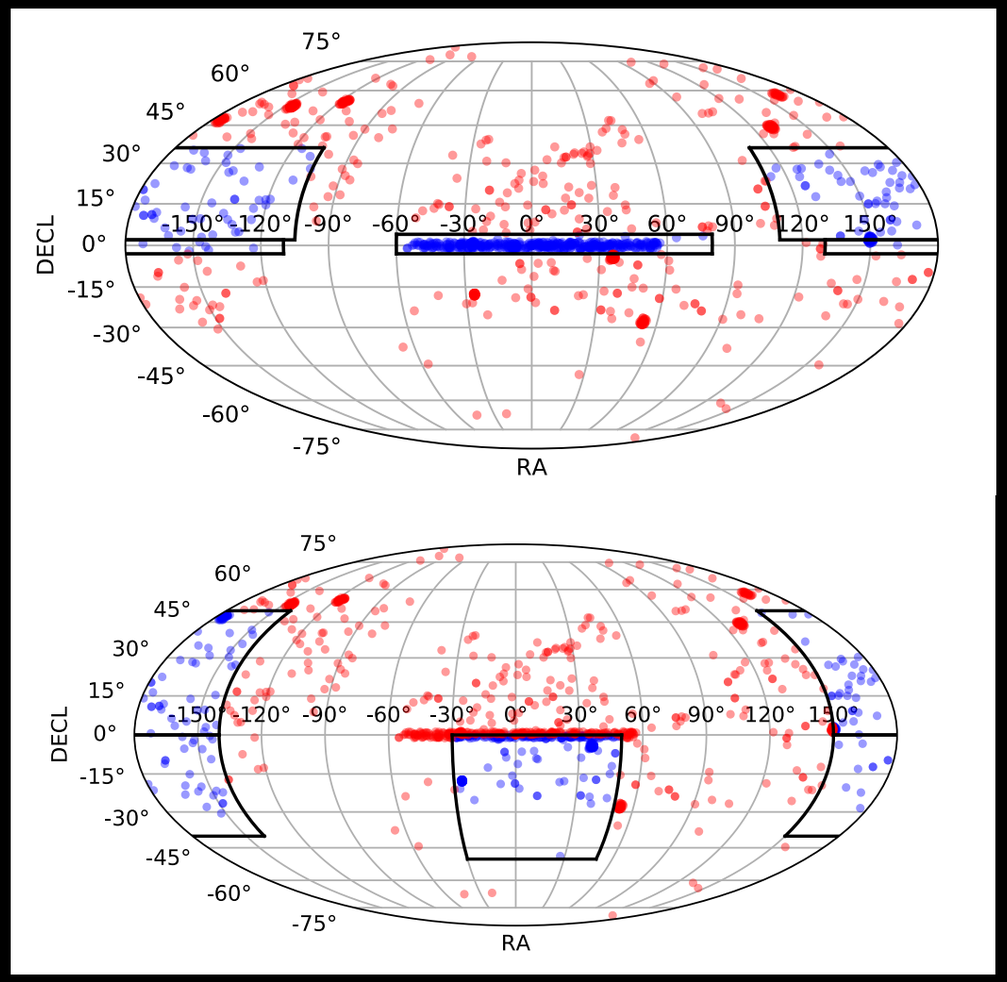
- SH0ES cuts at low redshift
- Theoretical effect on SH0ES is 0.48%
- Peculiar velocity corrections



Simulated realizations of SH0ES - like H0 measurements affected by local structure from Wu and Huterer, 2017

Suggested Voids

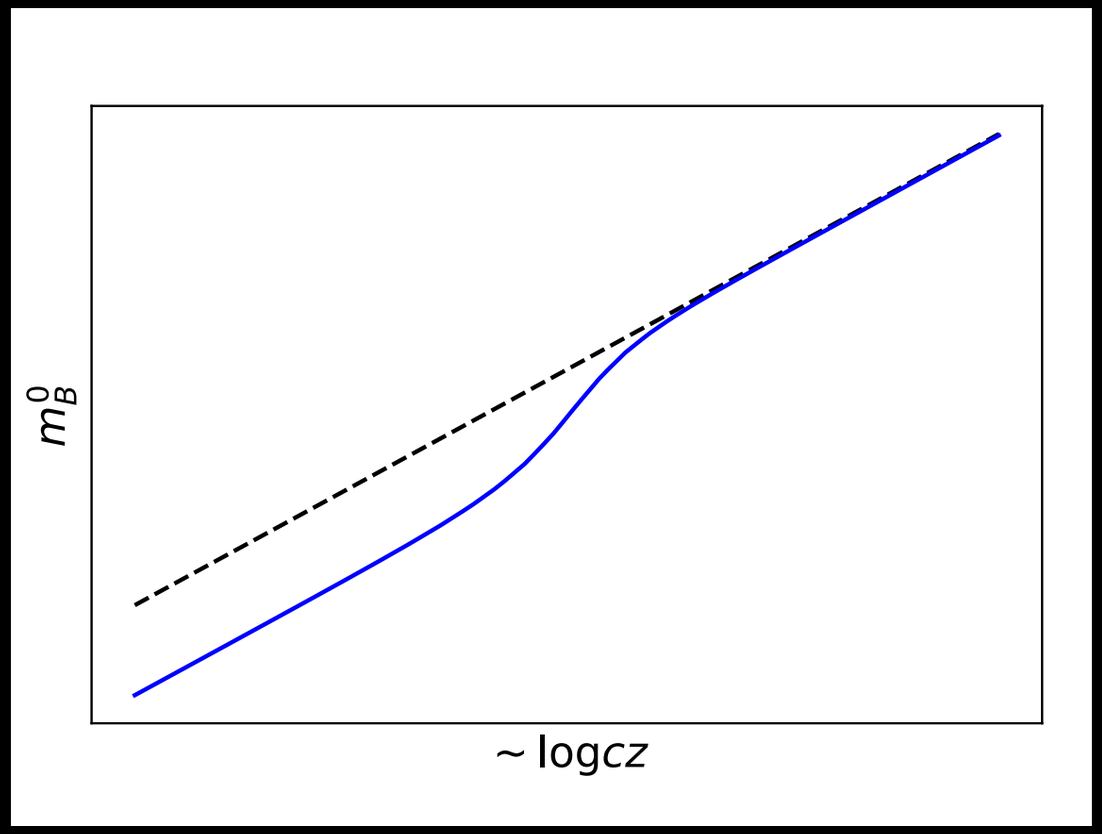
- Keenan, Barger, and Cowie 2013 (KBC) found 30% under-density within z=0.07
- Whitbourn and Shanks 2014 (WS14) found 20% under-density within z=0.05
- These studies cover minorities of the sky
- Some overlap with SN Ia distribution



Dots show positions of SNe Ia from our sample across the sky. Fields studied by KBC are shown in the upper panel, and those studied by WS14 in the lower panel

Testing Local Voids with SNe Ia

- Are nearby supernovae too bright?
- Measure H_0 for two bins, look for a step
- SH0ES redshift range is $0.023 < z < 0.15$



Mockup Hubble diagram. Blue line shows effect of a local void on the distance-redshift relation

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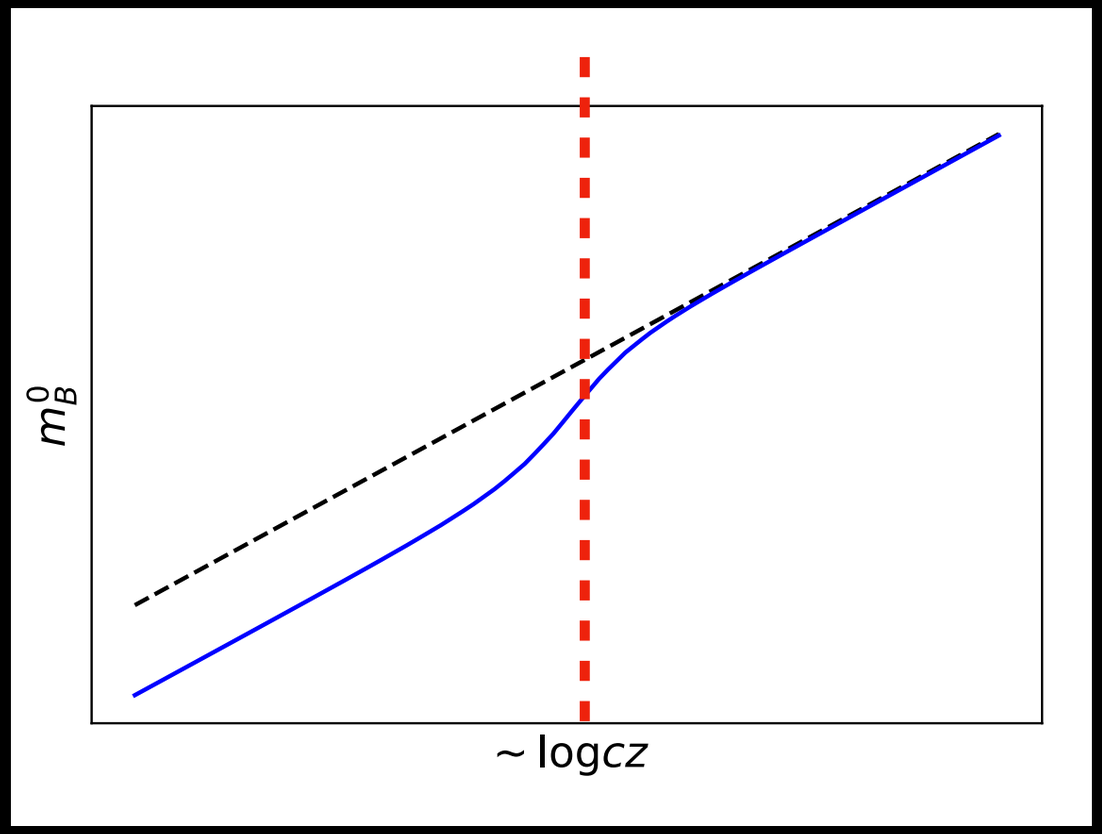

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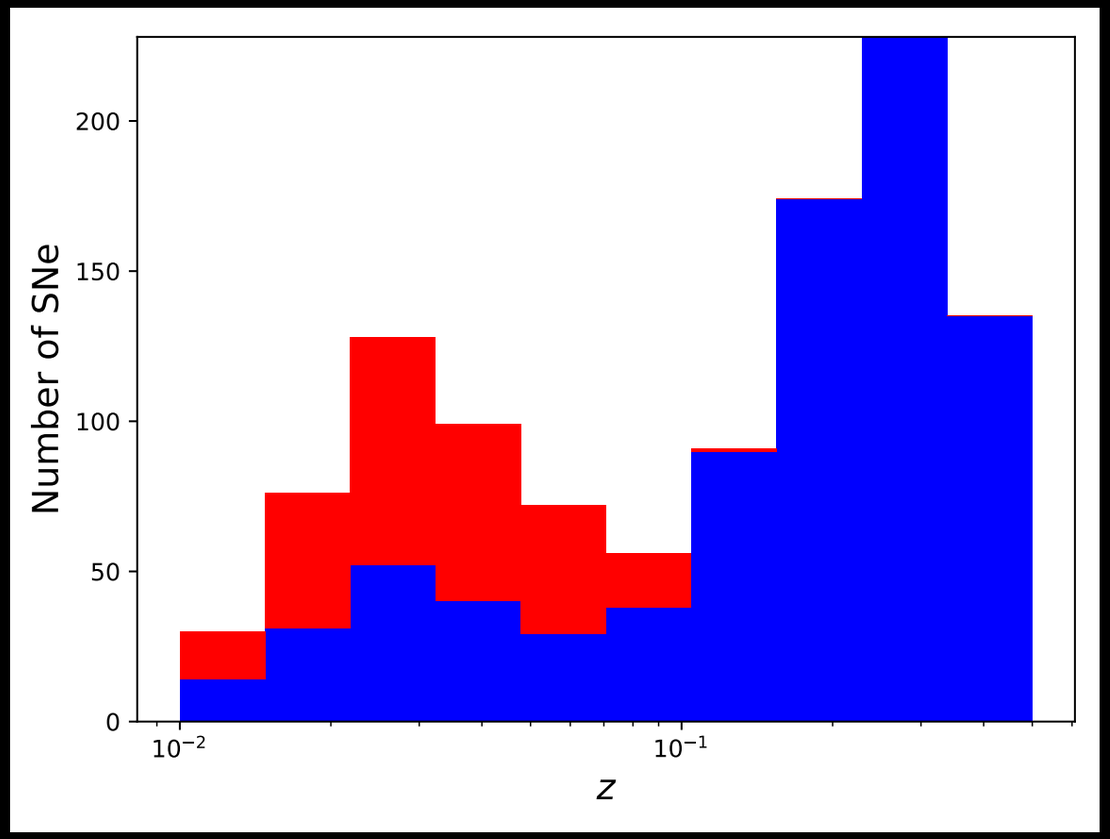
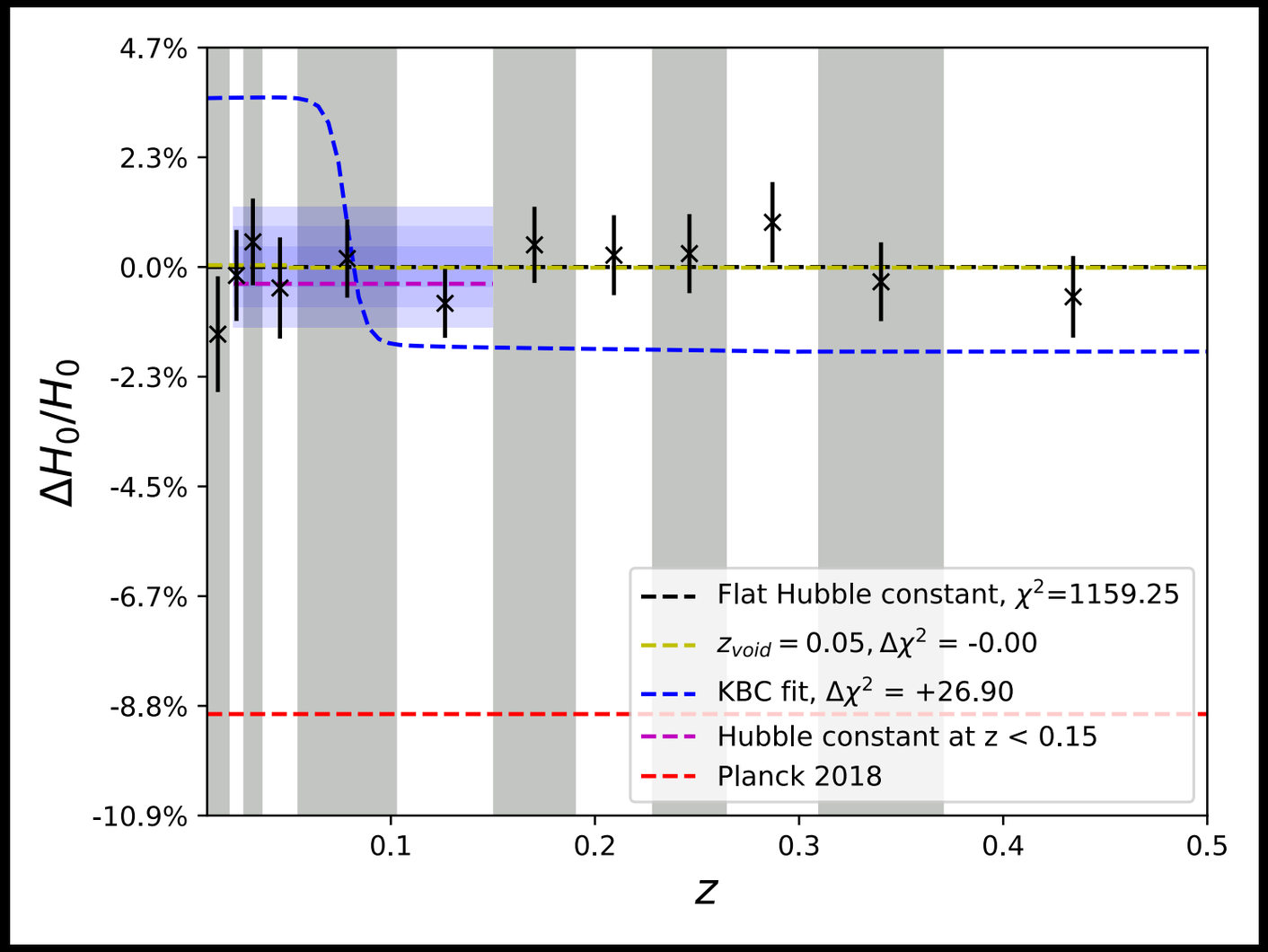
SNe Ia Sample

- Pantheon, Foundation, CSPDR3
- 1054 SNe in redshift range $0.01 < z < 0.50$
- Analysis similar to Riess *et al* 2016
- Pantheon systematics
- Cosmology included as systematic



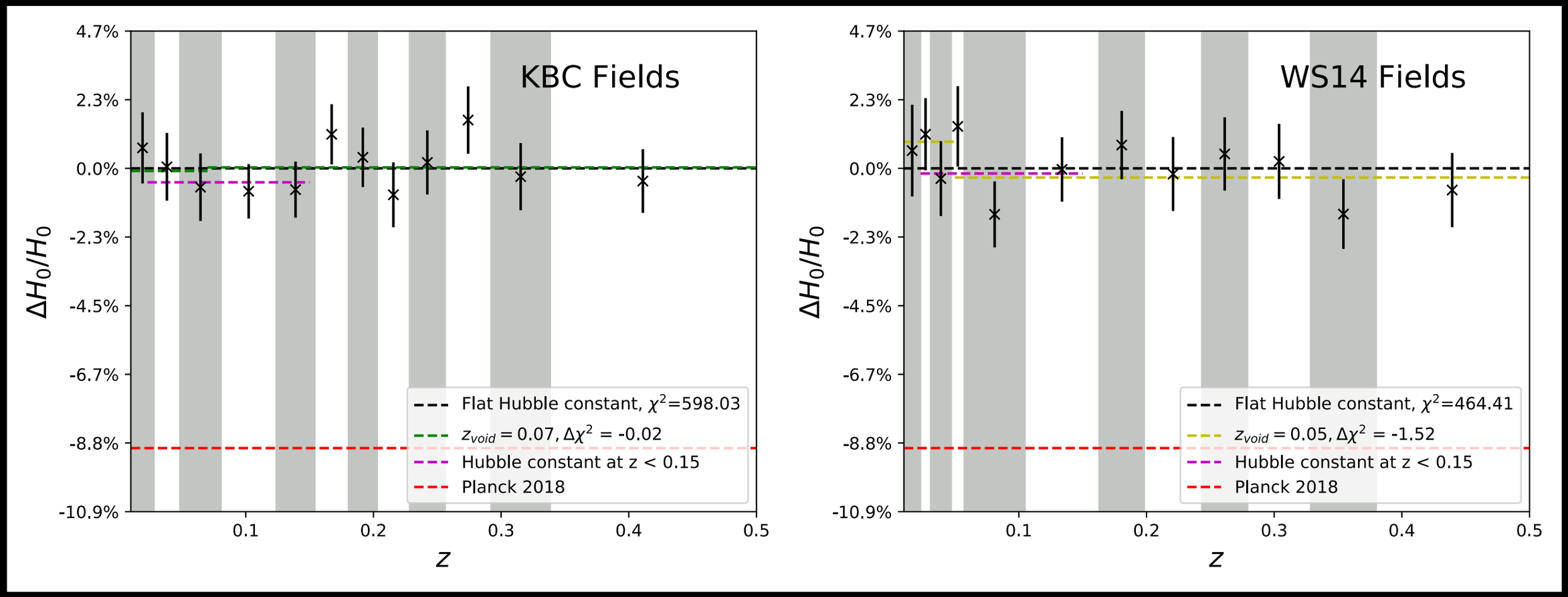
Histogram of redshifts in our sample of SNe. Blue is Pantheon, red is Foundation/CSP

Variation in H_0



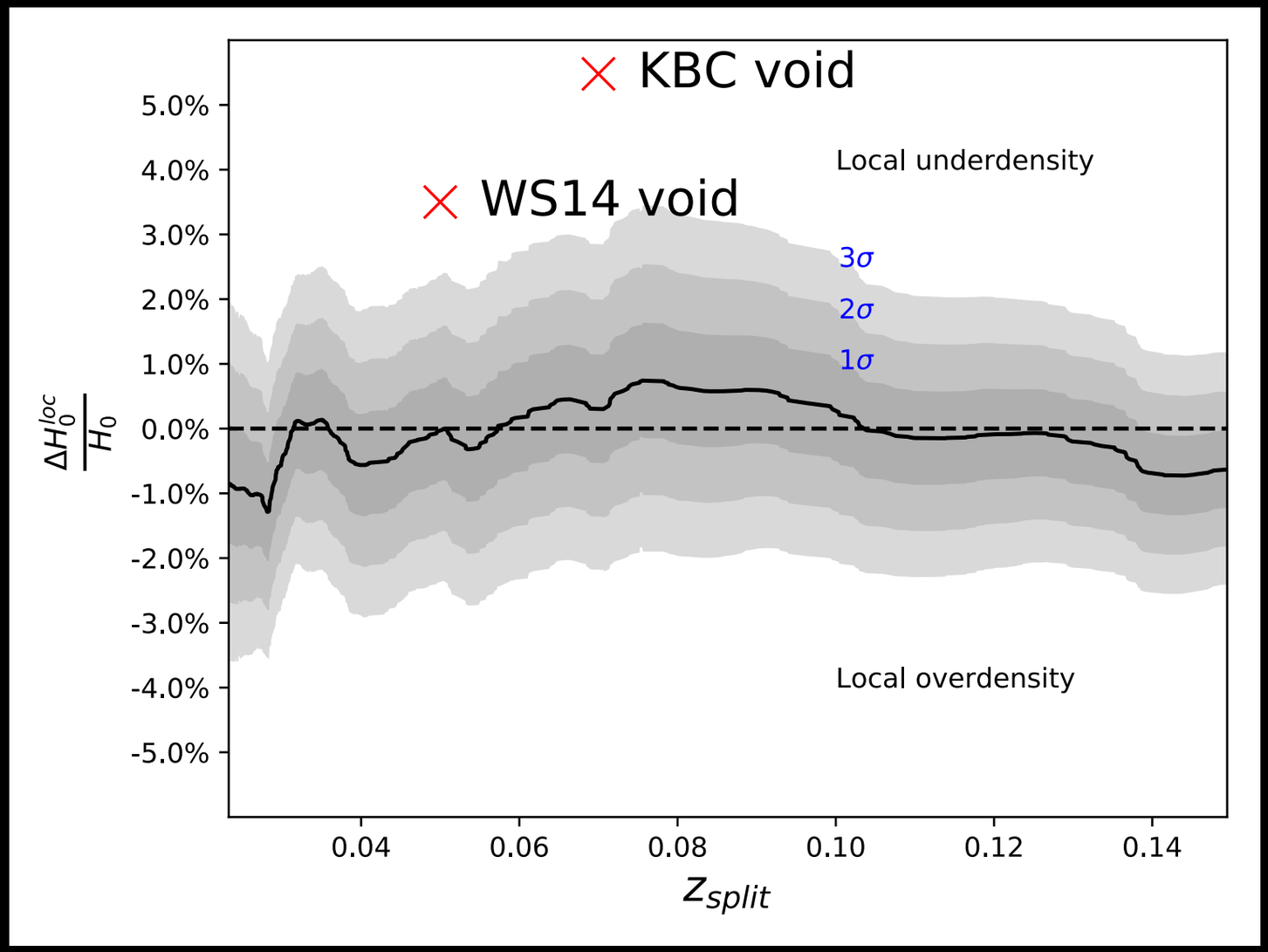
Hubble constant relative to background value against redshift. Each point represents ~80 SNe. Blue shading shows expected cosmic variance from Wu and Huterer 2017

Isotropy



Hubble constant relative to background value against redshift, for supernovae contained within the KBC fields (left) and WS14 fields (right).

Voids at Arbitrary Distances?



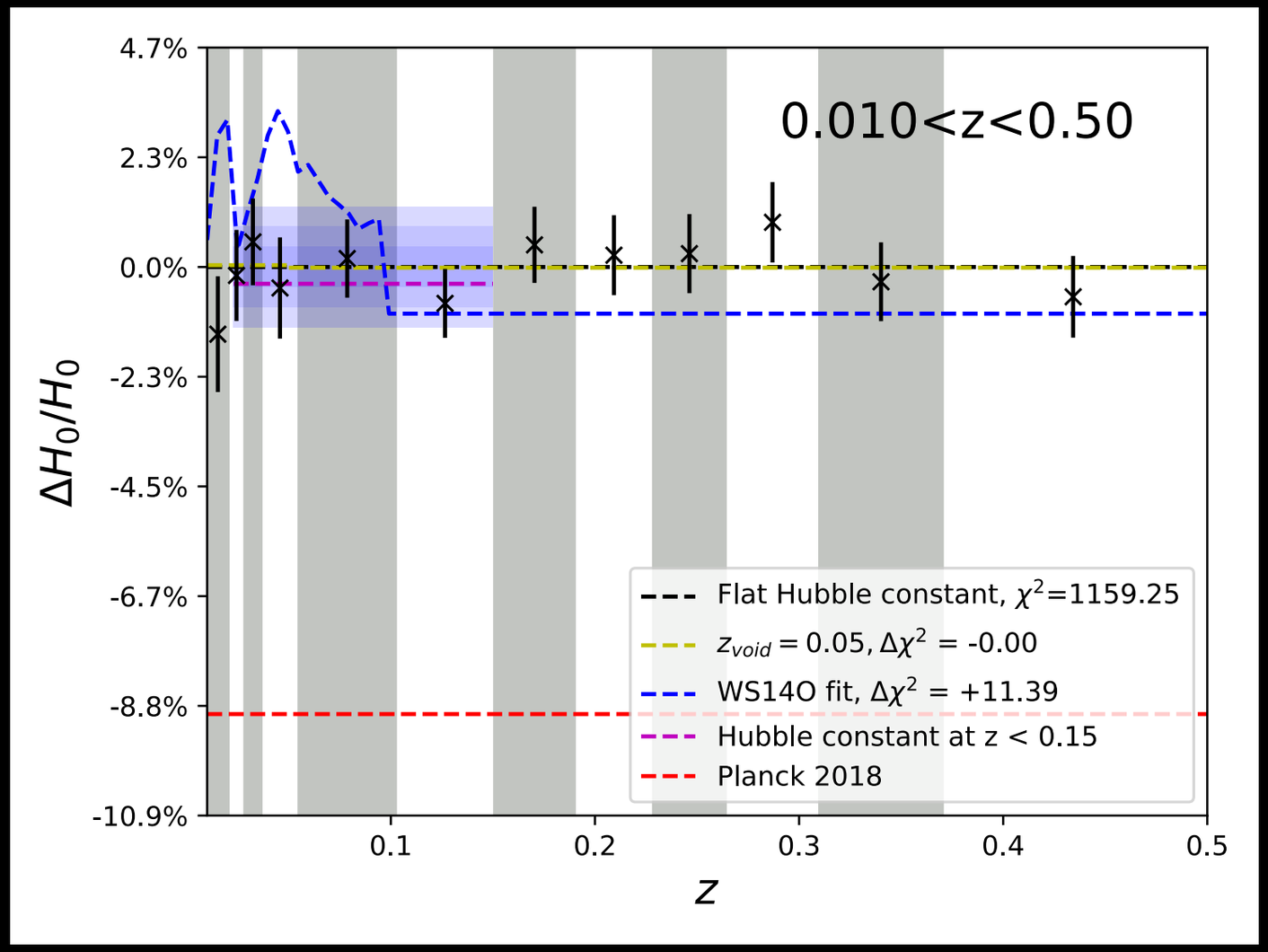
Difference in H_0 when measured above and below z_{split} There is no evidence for a void biasing the local measurement of the Hubble constant at any redshift. Smoothed for visualization

Implications for Hubble Problem

- SH0ES measurement unaffected by local structure with precision of 0.61%, compared to overall 1.91% uncertainty
- Theoretically disfavored at 20σ
- Local structure cannot resolve Hubble problem
- 5σ constraint on scales ≳ 100 Mpc $|\delta\rho/\rho| < 27\,\%$

Questions?

Variation in H_0



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