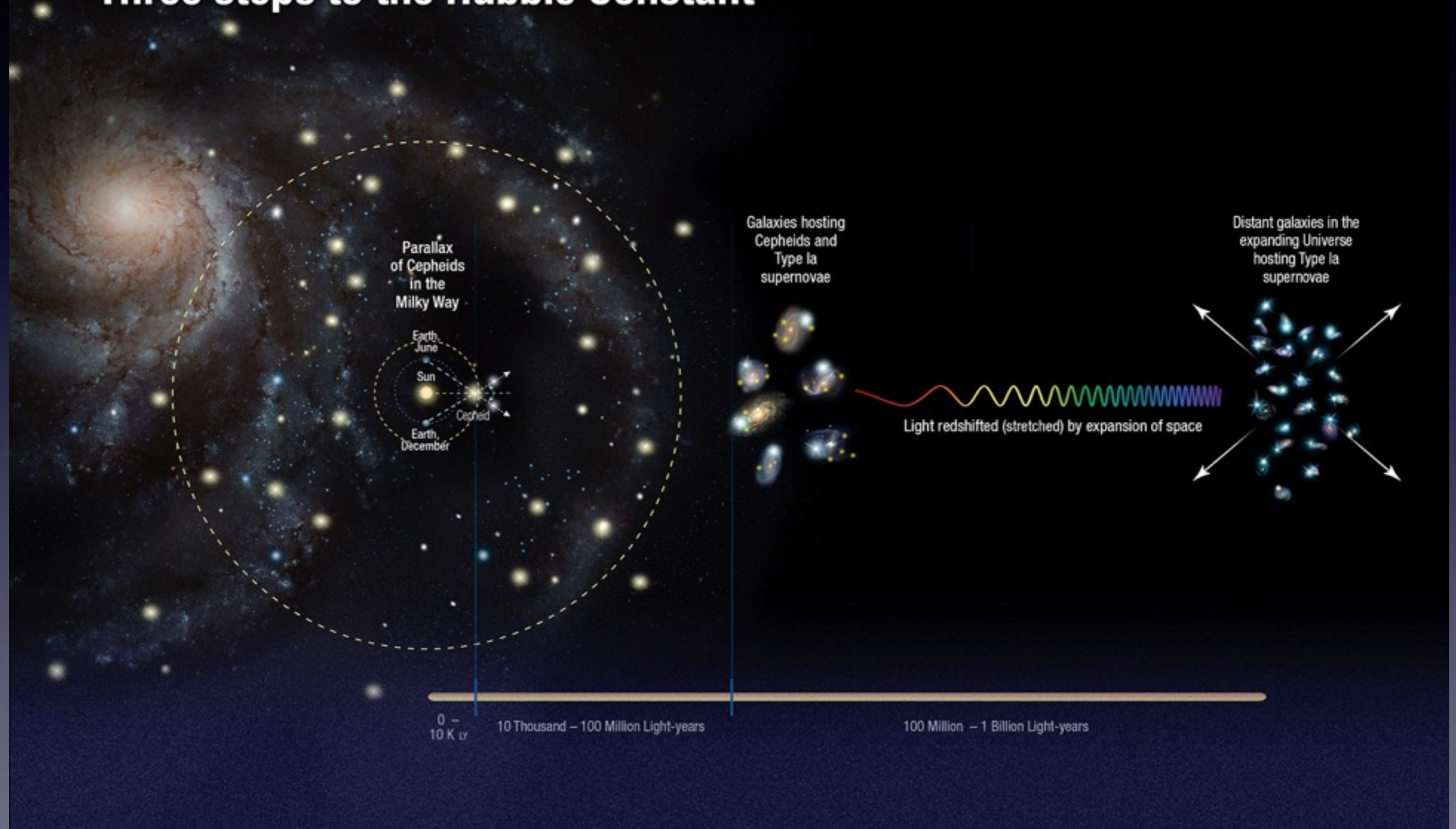


A 2.4% Determination of the Local Value of the Hubble Constant¹

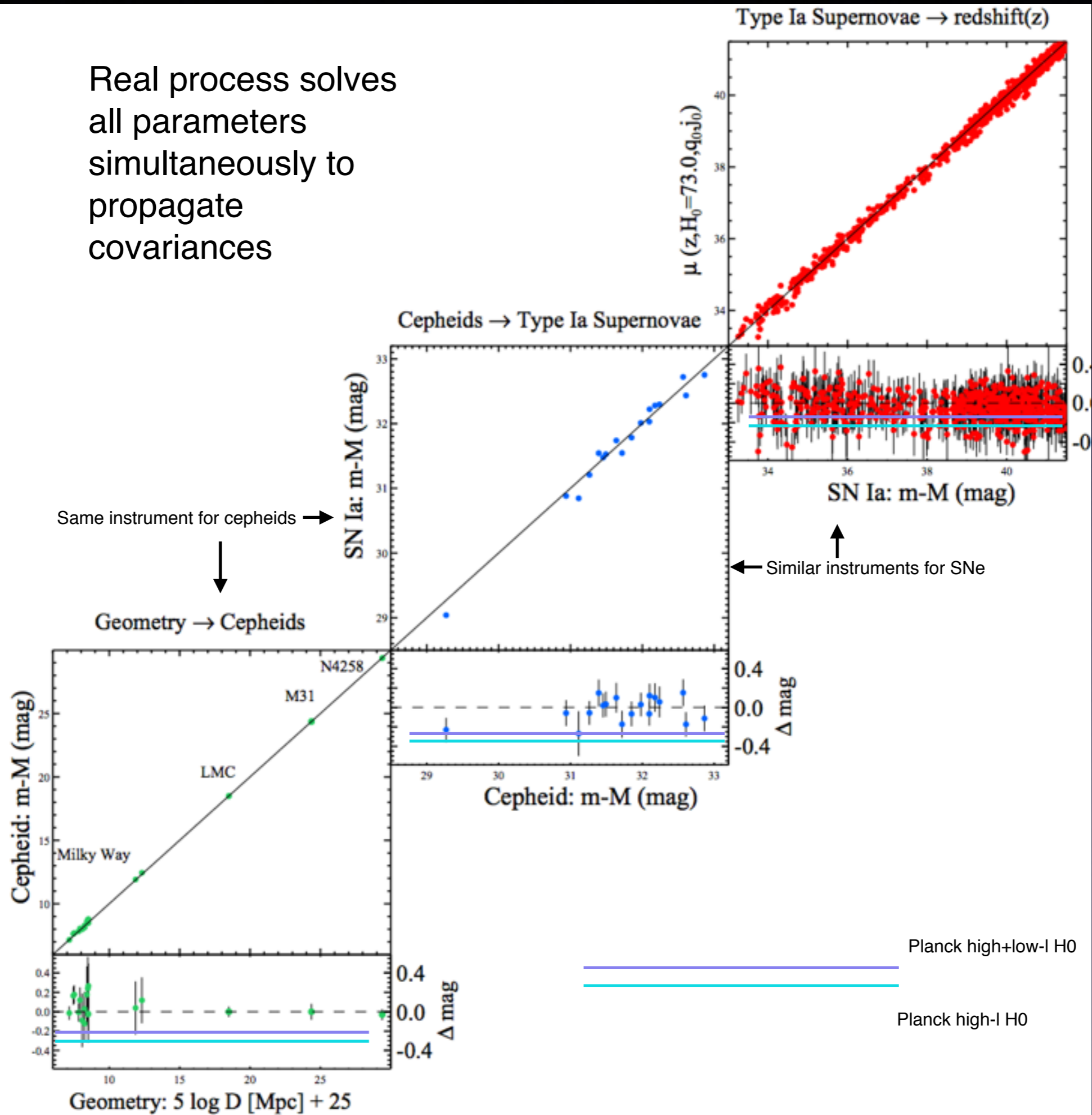
Adam G. Riess^{2,3}, Lucas M. Macri⁴, Samantha L. Hoffmann⁴, Dan Scolnic^{2,5}, Stefano Casertano³,
Alexei V. Filippenko⁶, Brad E. Tucker^{6,7}, Mark J. Reid⁸, David O. Jones², Jeffrey M. Silverman⁹,
Ryan Chornock¹⁰, Peter Challis⁸, Wenlong Yuan⁴, Peter J. Brown⁴, and Ryan J. Foley^{11,12}

Three steps to the Hubble Constant



Dan Scolnic, KICP/Hubble Fellow

Real process solves
all parameters
simultaneously to
propagate
covariances



New
Physics?

$$\Delta w_0 = -0.1$$

$$\Delta w_a = -1$$

$$\Delta N_{\text{eff}} = +1$$

$$\Delta \Omega_K = -0.01$$

3.4σ
tension

Planck15+ Λ CDM

WMAP9yr+SPT+ACT+BAO+ Λ CDM

Here

R11

E14(R11)

Non-SN Ia Ave.

IRTF

Lensing

SZ Clusters

Masers

60

65

70

75

80

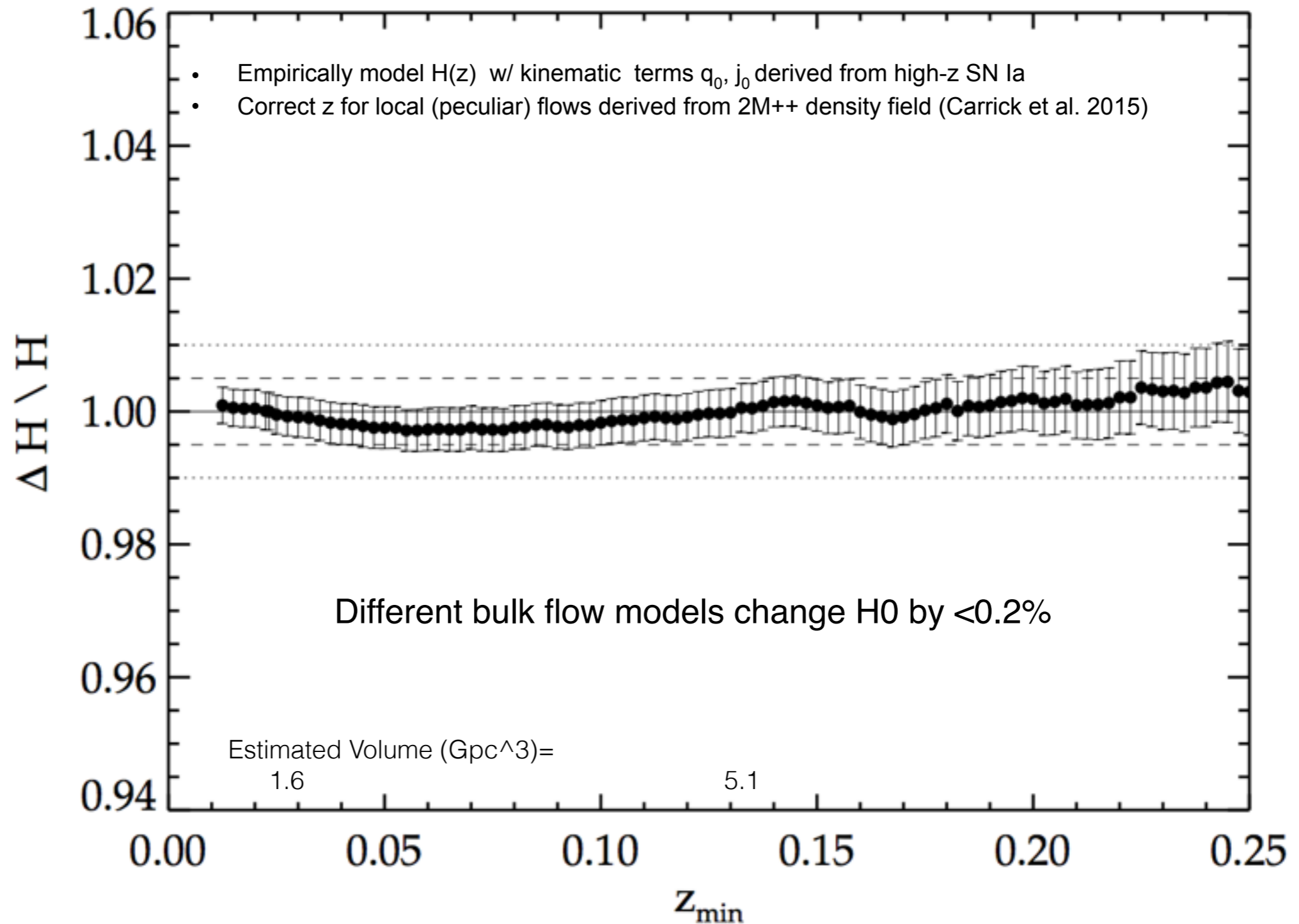
85

H_0 ($\text{km s}^{-1} \text{Mpc}^{-1}$)

This is the total error budget

Term	Description	Prev.	R09	R11	This work	
		LMC	N4258	All 3	N4258	All 3
σ_{anchor}	Anchor distance	5%	3%	1.3%	2.6%	1.3%
$\sigma_{\text{anchorPL}}^a$	Mean of $P-L$ in anchor	2.5%	1.5%	0.8%	1.1%	0.7%
$\sigma_{\text{hostPL}}/\sqrt{n}$	Mean of $P-L$ values in SN Ia hosts	1.5%	1.5%	0.6%	0.4%	0.4%
$\sigma_{\text{SN}}/\sqrt{n}$	Mean of SN Ia calibrators	2.5%	2.5%	1.9%	1.3%	1.3%
σ_{m-z}	SN Ia $m-z$ relation	1%	0.5%	0.5%	0.4%	0.4%
$R\sigma_{\lambda,1,2}$	Cepheid reddening, zeropoints, anchor-to-hosts	4.5%	0.3%	1.4%	0%	0.7%
σ_Z	Cepheid metallicity, anchor-to-hosts	3%	1.1%	1.0%	0.4%	0.8%
σ_{PL}	$P-L$ slope, $\Delta \log P$, anchor-to-hosts	4%	0.5%	0.6%	0.2%	0.5%
σ_{WFPC2}	WFPC2 CTE, long-short	3%	N/A	N/A	N/A	N/A
subtotal, $\sigma_{\text{H}_0}^b$		10%	4.7%	2.9%	3.4% ^c	2.2%
Analysis Systematics		N/A	1.3%	1.0%	1.0%	0.9%
Total, σ_{H_0}		10%	4.8%	3.3%	3.5%	2.4%

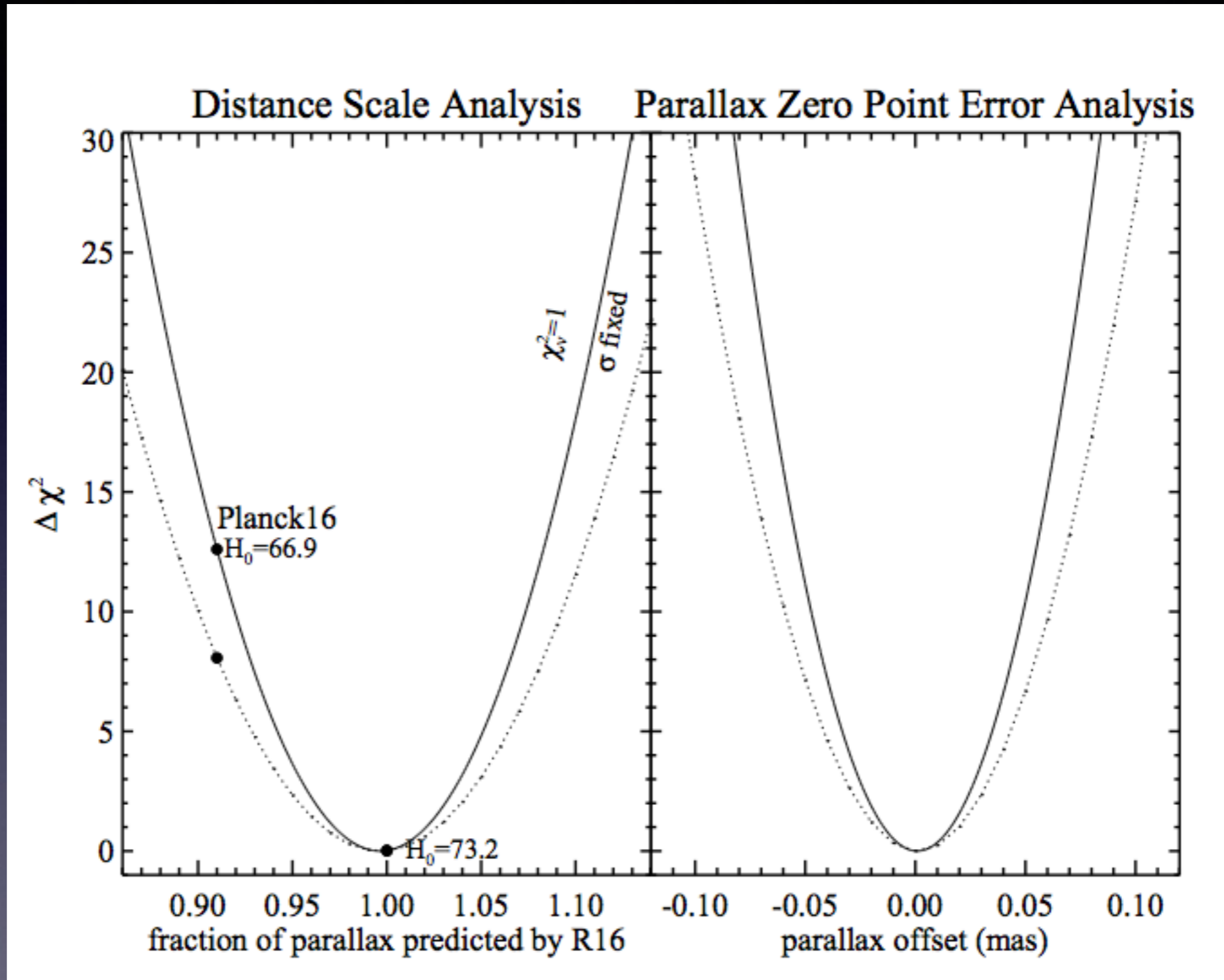
Is local H_0 ($0.02 < z < 0.15$) same as global H_0 ?



Test: explore larger volume, $z_{\min} < z < z_{\min} + 0.15$, $\Delta H_0 < 0.4\%$

- N-body sims in 700 Mpc box $\rightarrow 0.3\%$ (Odderskov et al. (2016))

Gaia released parallaxes of ~ 200 cepheids



Casertano
et al. 2016

Show agreement with R16. Next year 10,000 cepheid measurements to come...