Astrostatistics

Lecture 07:
Fri, 31 January 2020

- Statistics Foundations

  - Ivezic Ch 4 “Classical Statistical Inference” & Ch 5 “Bayesian Statistical Inference”

  - F&B Ch 3 “Statistical Inference”

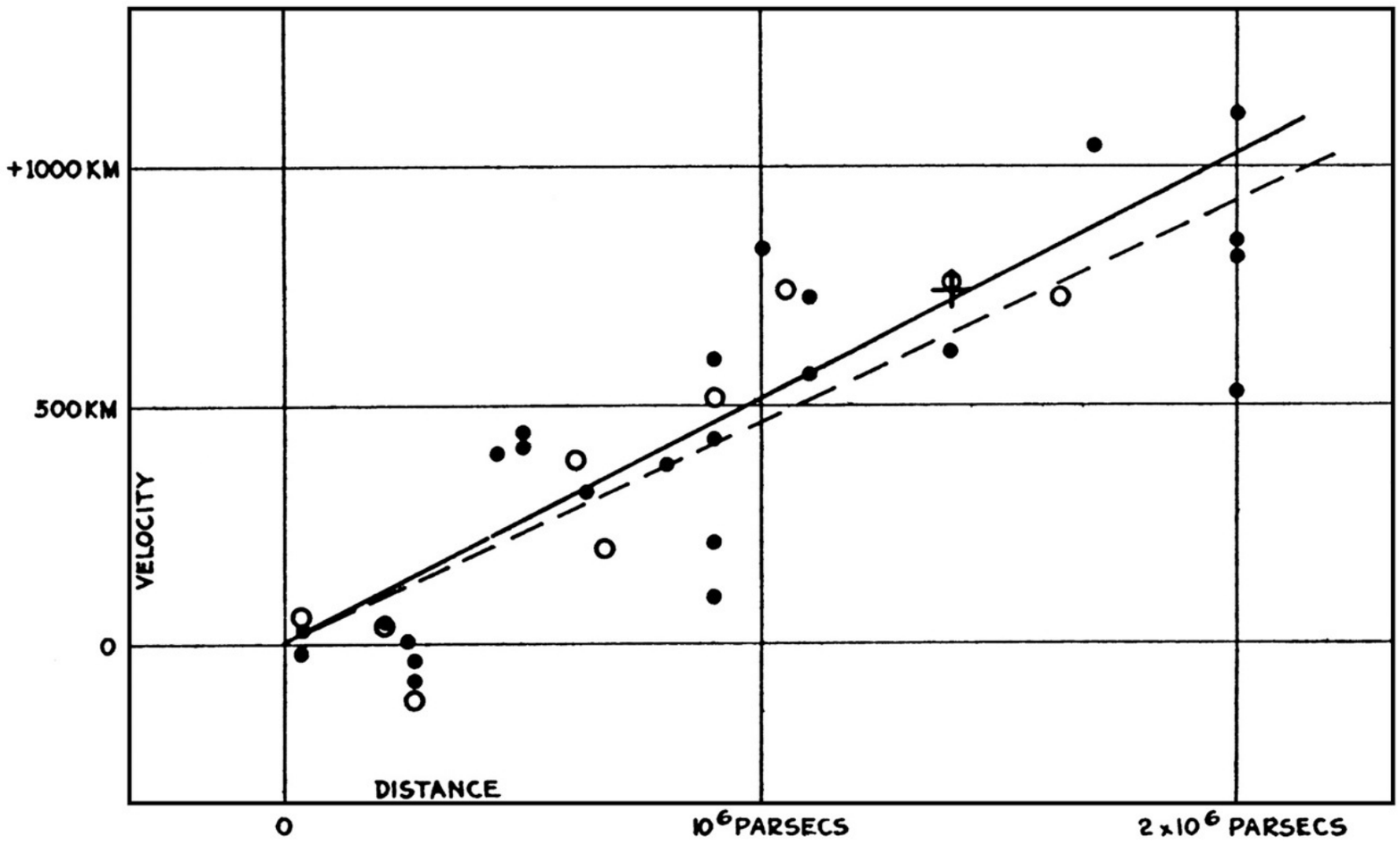
- Review (on your own) properties of multivariate Gaussian random variables and densities (see multivariate_gaussian_notes.pdf on website).

Determining Astronomical Distances using Standard Candles

1. Estimate or model Luminosity L of a Class of Astronomical Objects
2. Measure the apparent brightness or flux F
3. Derive the distance D to Object using Inverse Square Law: $F = L / (4\pi D^2)$
4. Optical Astronomer's units: $\mu = m - M$

m = apparent magnitude [log apparent brightness flux],
M = absolute magnitude [log Luminosity],
μ = distance modulus [log distance].

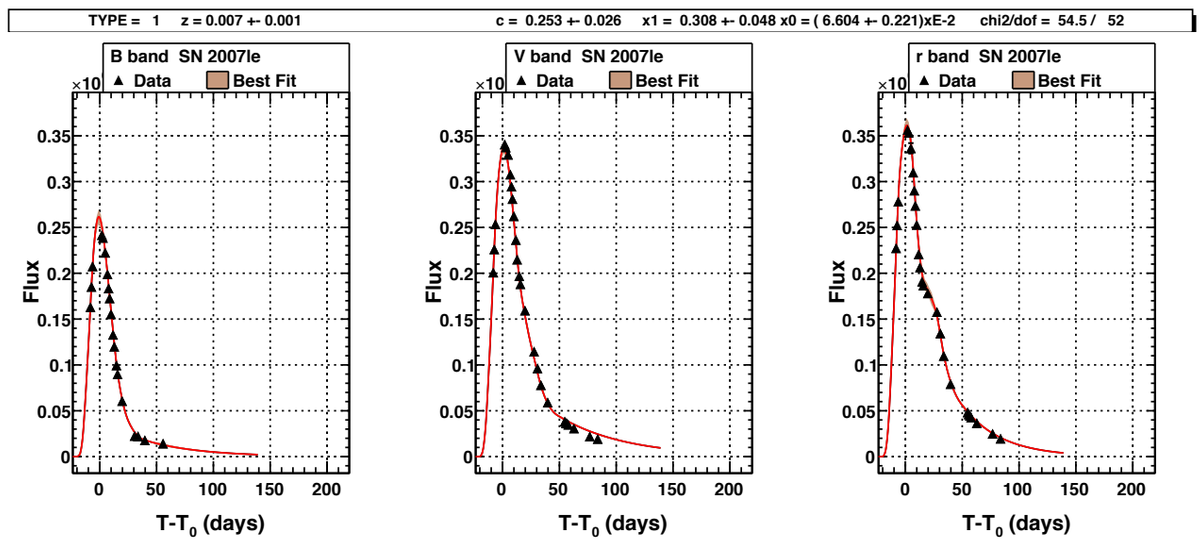
The Expanding Universe:
Galaxies are moving apart! Hubble's Law (1929)



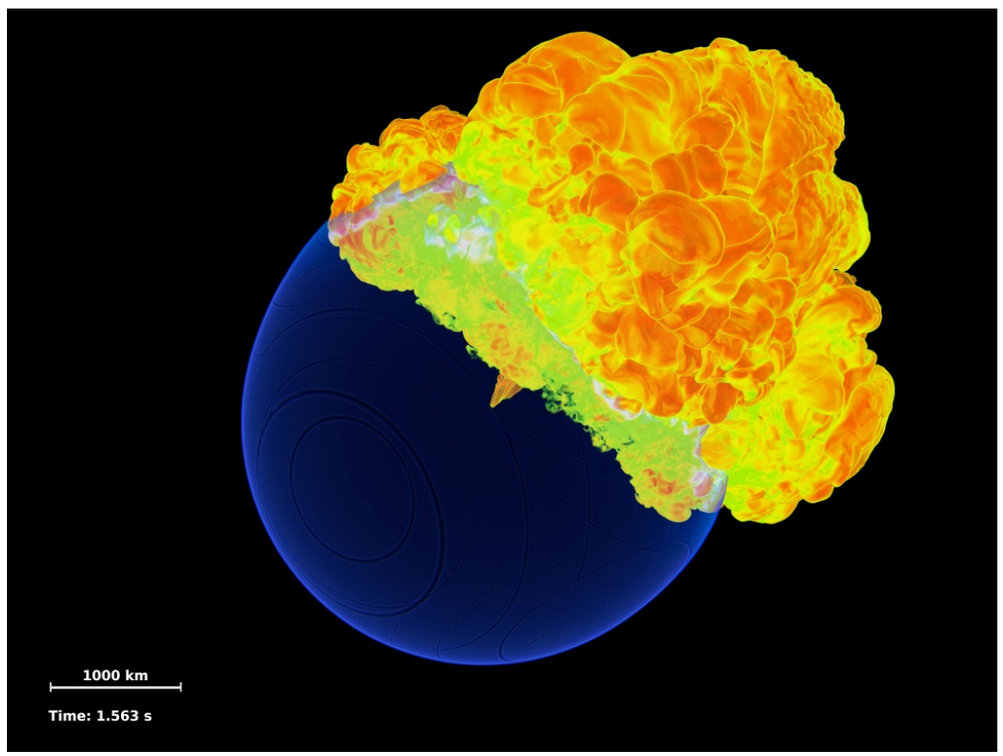
Einstein & Hubble

Distance ∝ Velocity (Redshift)

Type Ia Supernovae (SN Ia) are Almost Standard Candles

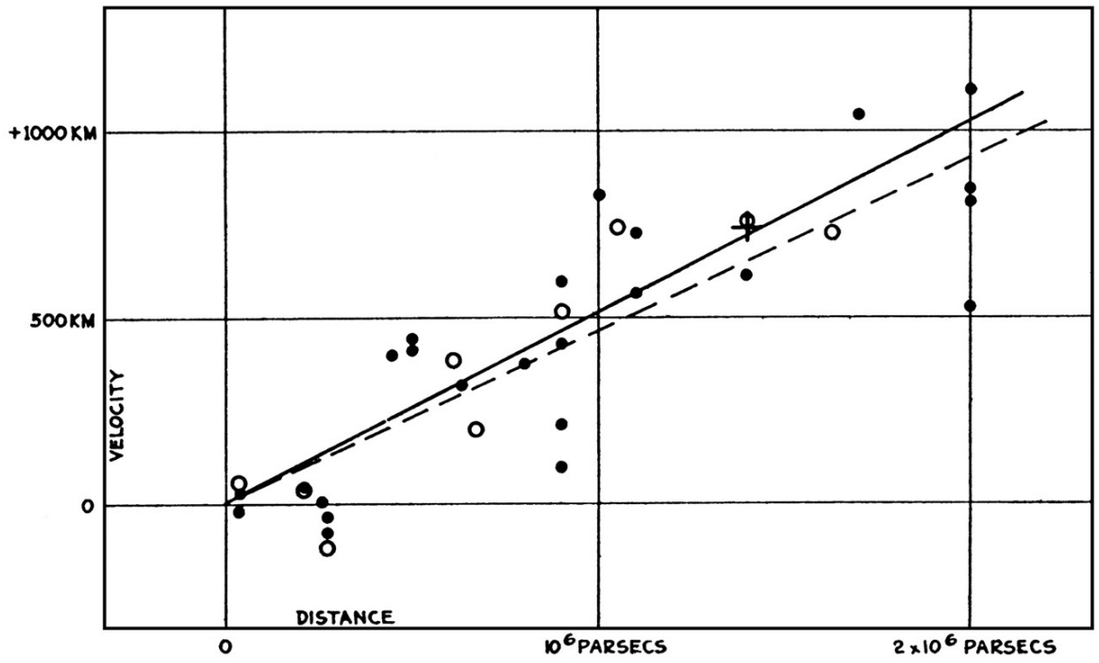


- Progenitor: C/O White Dwarf Star accreting mass leads to instability
- Thermonuclear Explosion: Deflagration/ Detonation
- Nickel to Cobalt to Iron Decay + radiative transfer powers the light curve

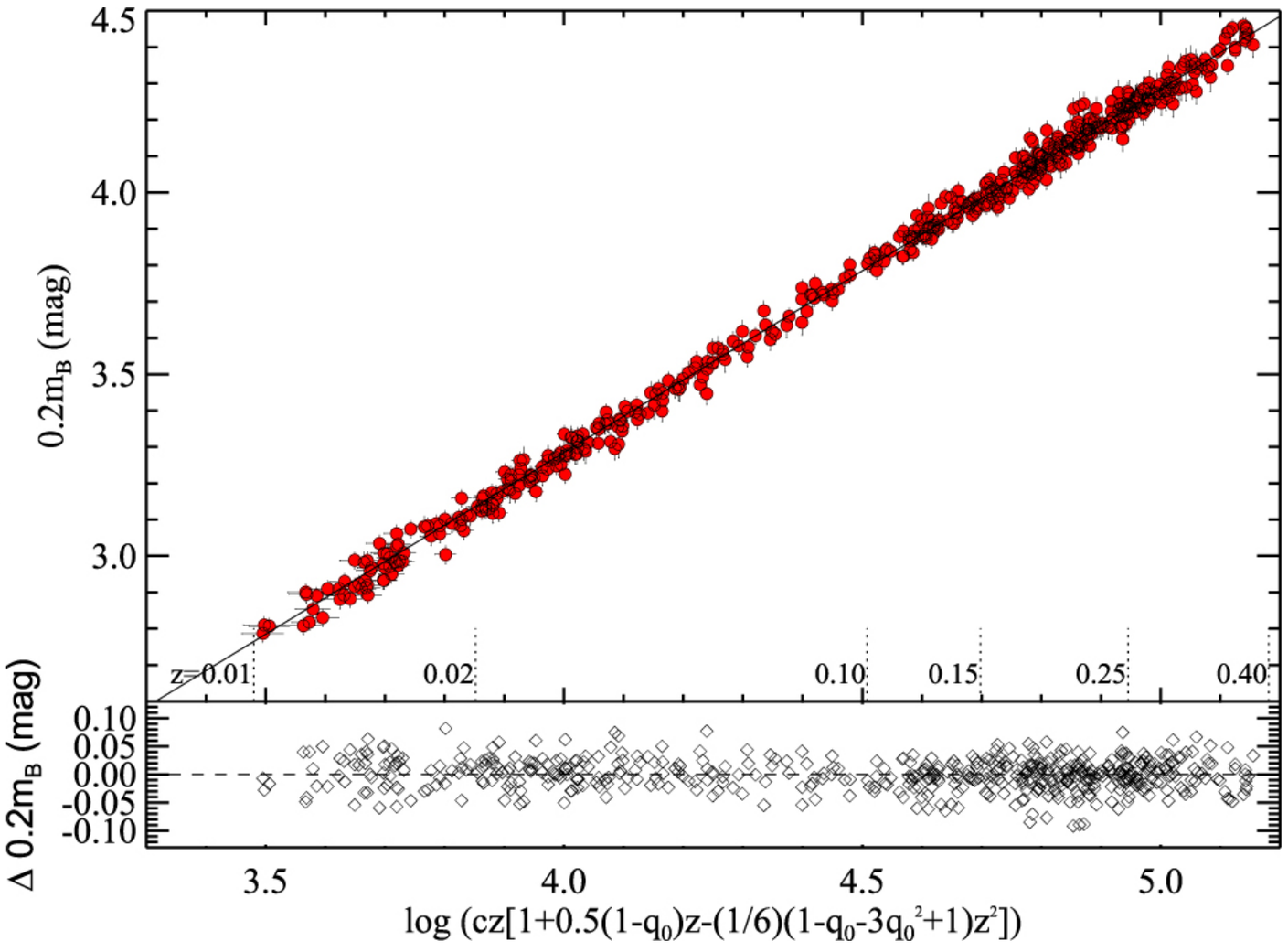


Hubble Constant

Velocity = H_0 × Distance



Hubble (1929)



Riess et al. 2016

Hubble Constant

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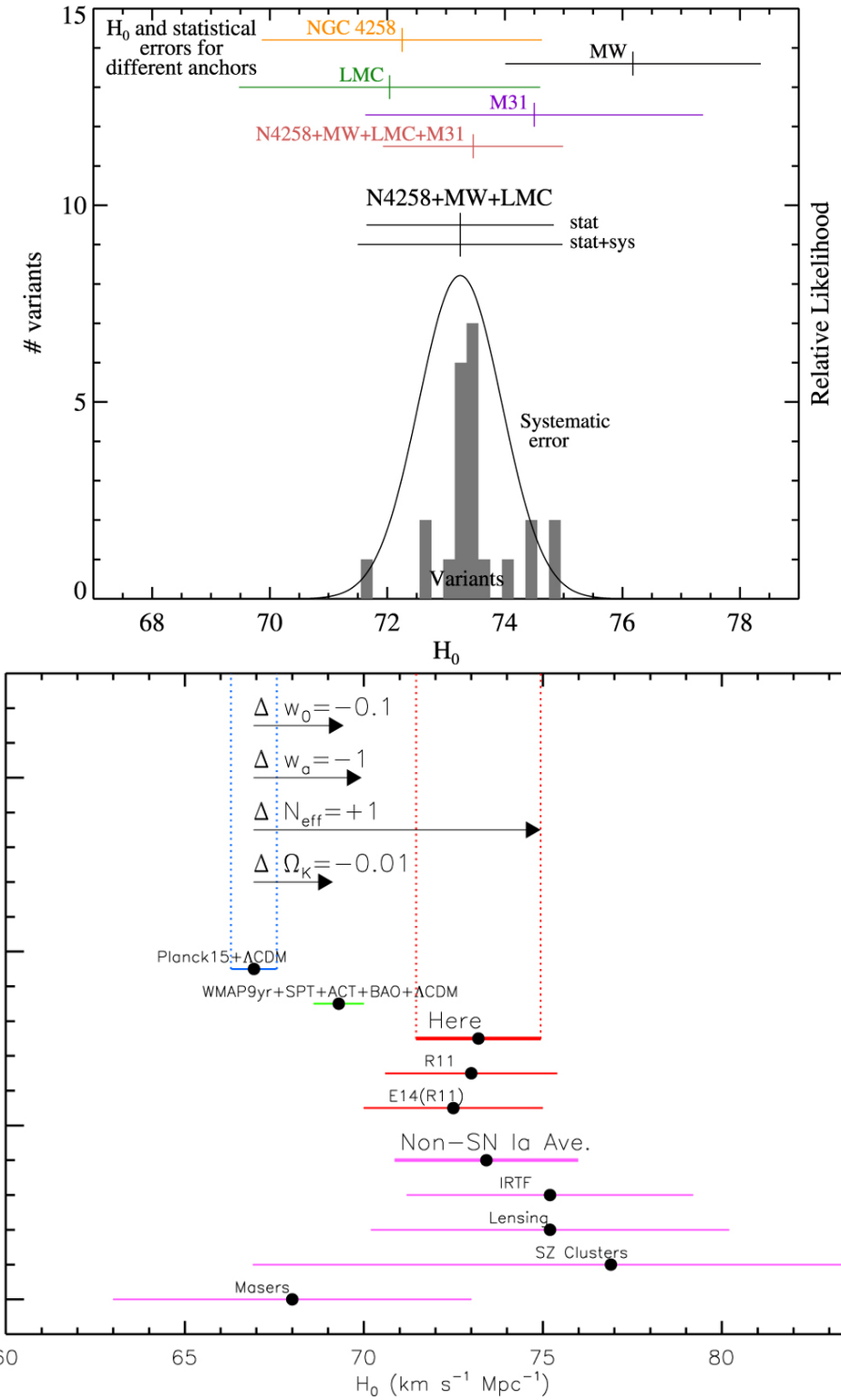

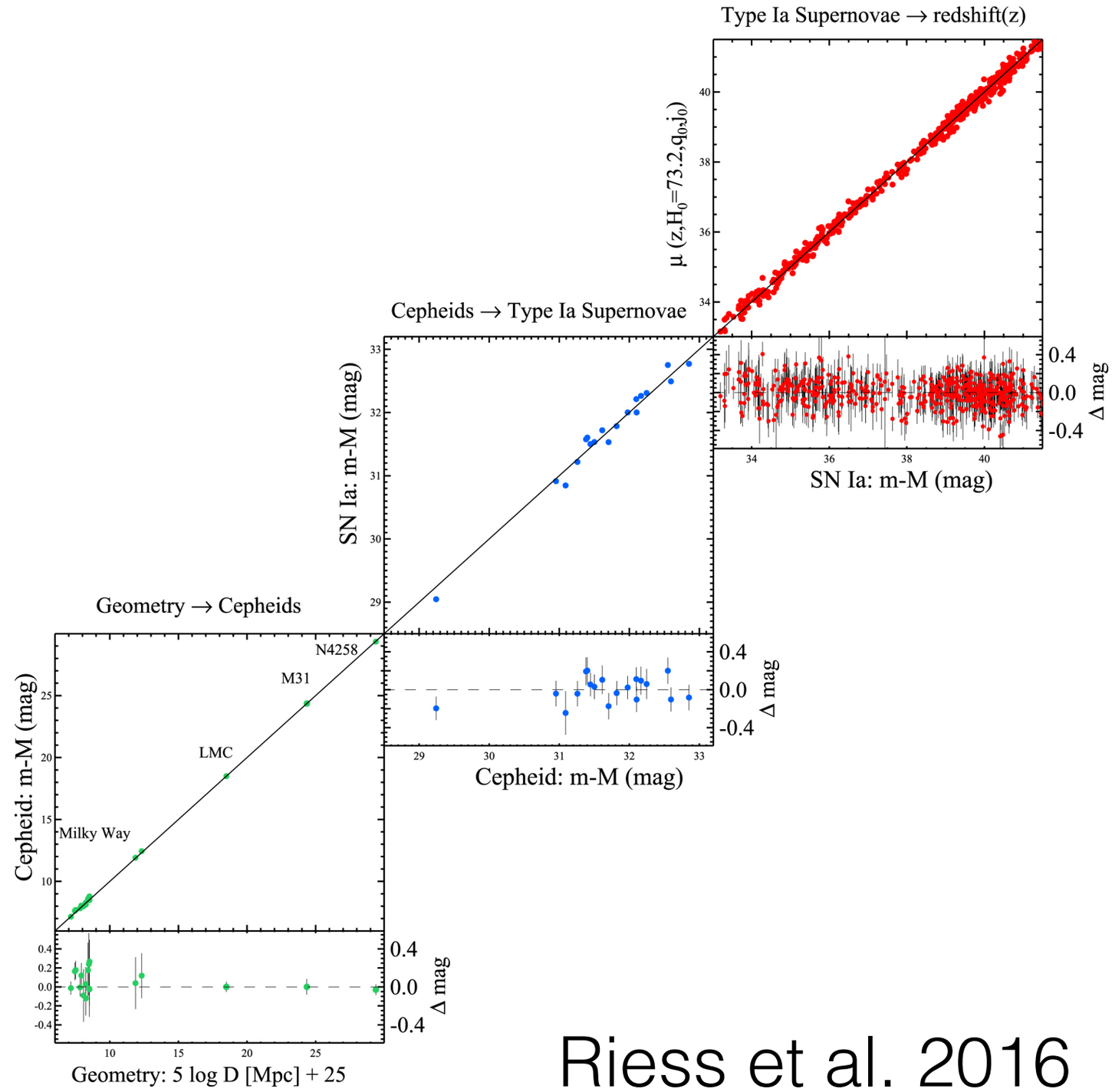

Riess et al. 2016

Calibrating SN Ia Standard Candles
(Avelino, Friedman, Mandel et al. 2019)

Determining the Distribution of Absolute Magnitudes

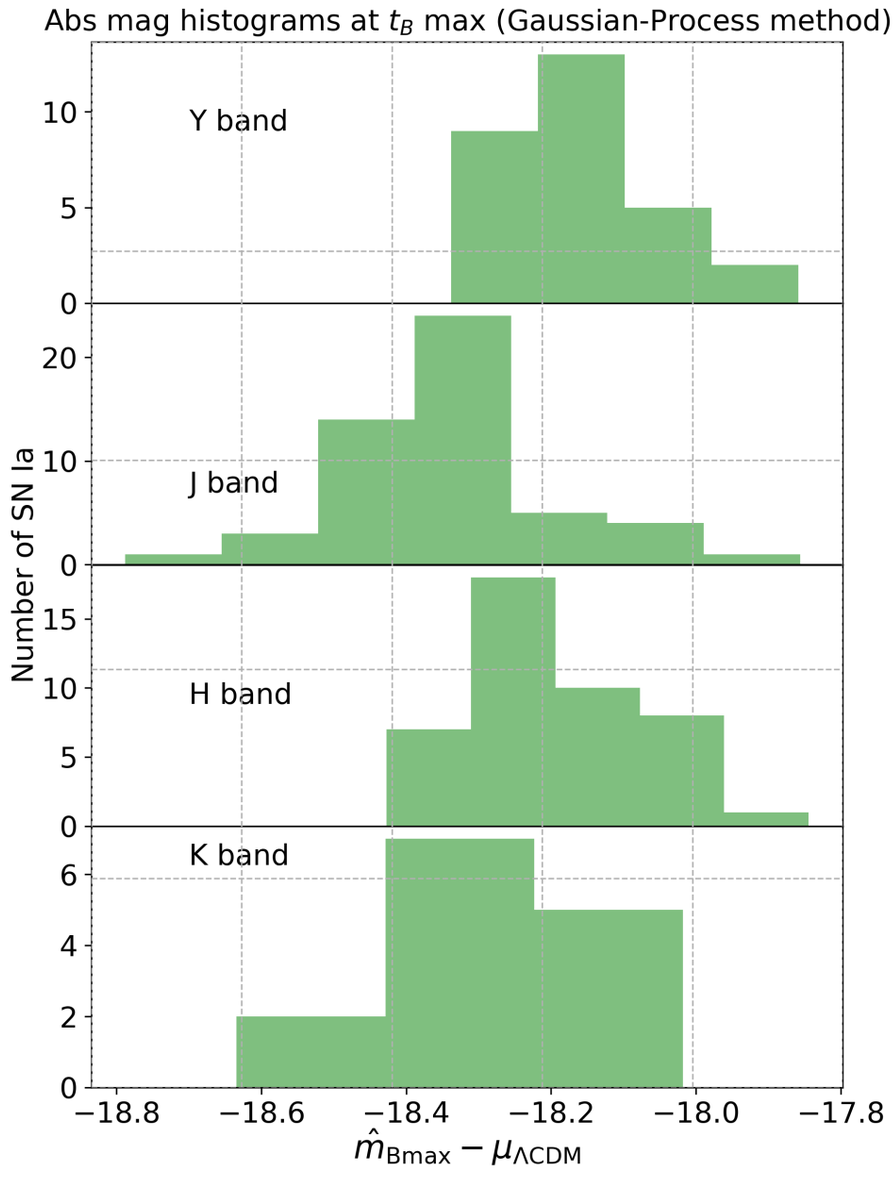

Figure 4: Normalized histograms of the absolute magnitudes at phase = $B_{\max}$, defined as $M_{B_{\max},s} \equiv \hat{m}_{B\max,s} - \mu_{\Lambda\mathrm{CDM}}(z_s)$ for the SN Ia sample in the GP method at B max. The mean, the standard deviation, and the number of supernovae in each histogram are