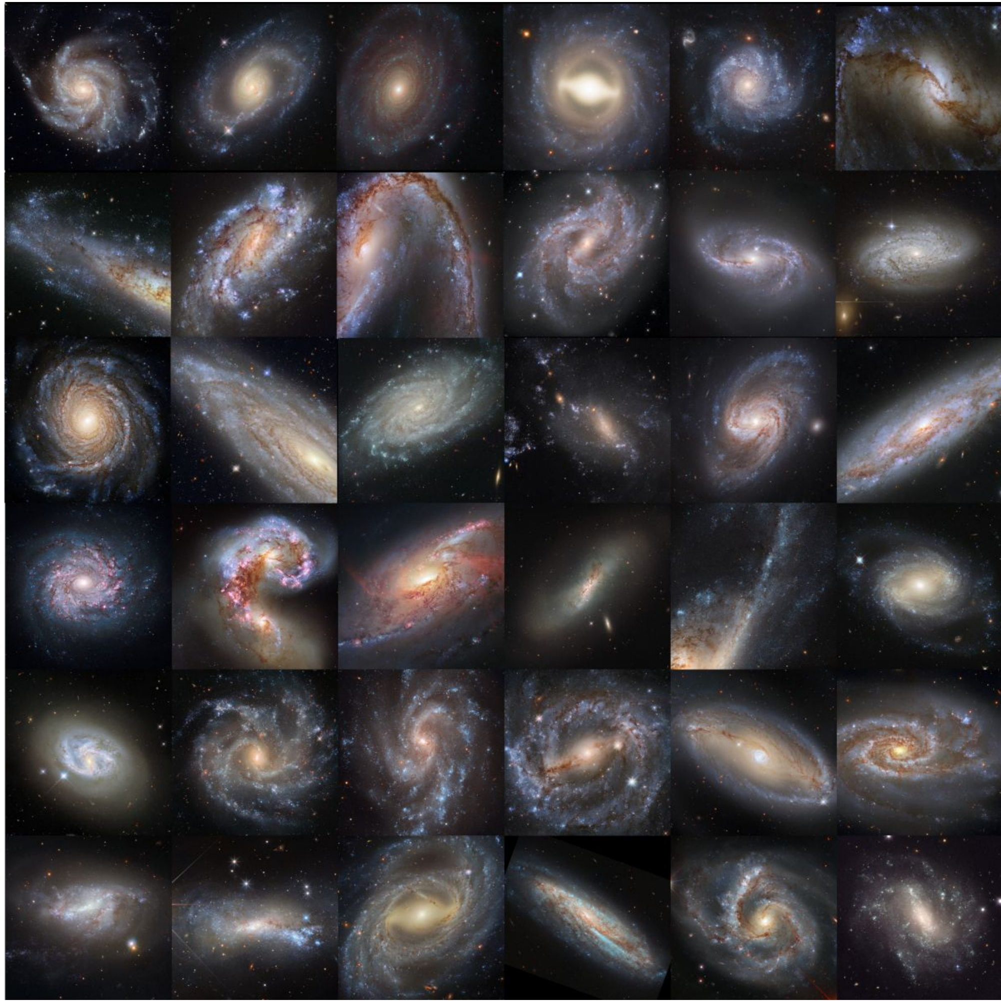
The Hubble Tension and Evolving Dark Energy Measurements, State of the Tensions

Dan Scolnic. @DScol.
Duke University.

Istanbul - Cosmoverse, Tuesday June 24, 2025



Duke Cosmology

Main ideas:

1. We have a great standard model of cosmology.

2. If you poke it at, no good answers, and now tensions.

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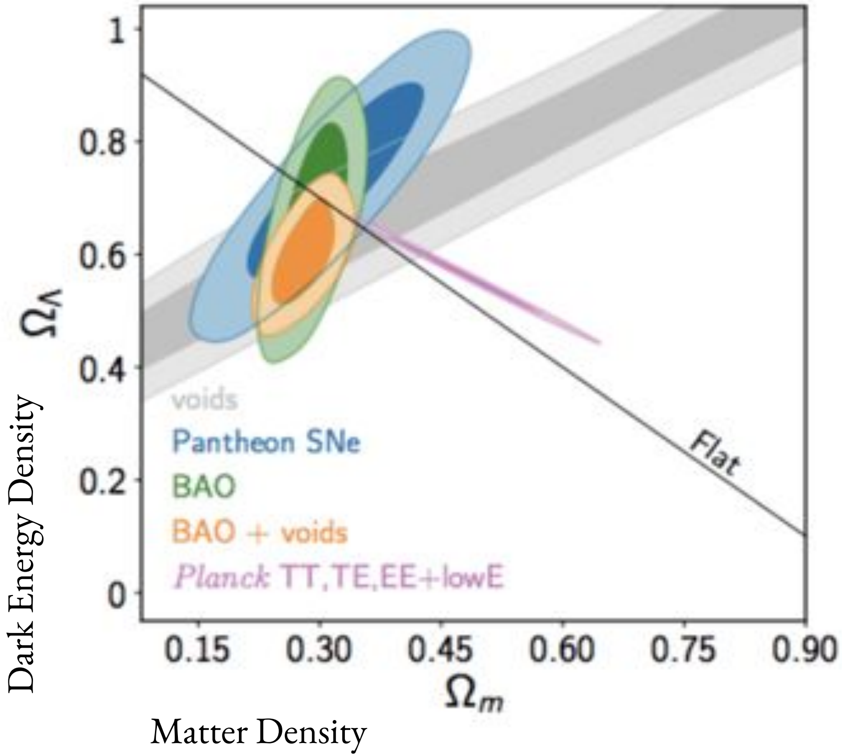
Fig. from Nadathur et al. 2020



Main ideas:

1. We have a great standard model of cosmology.

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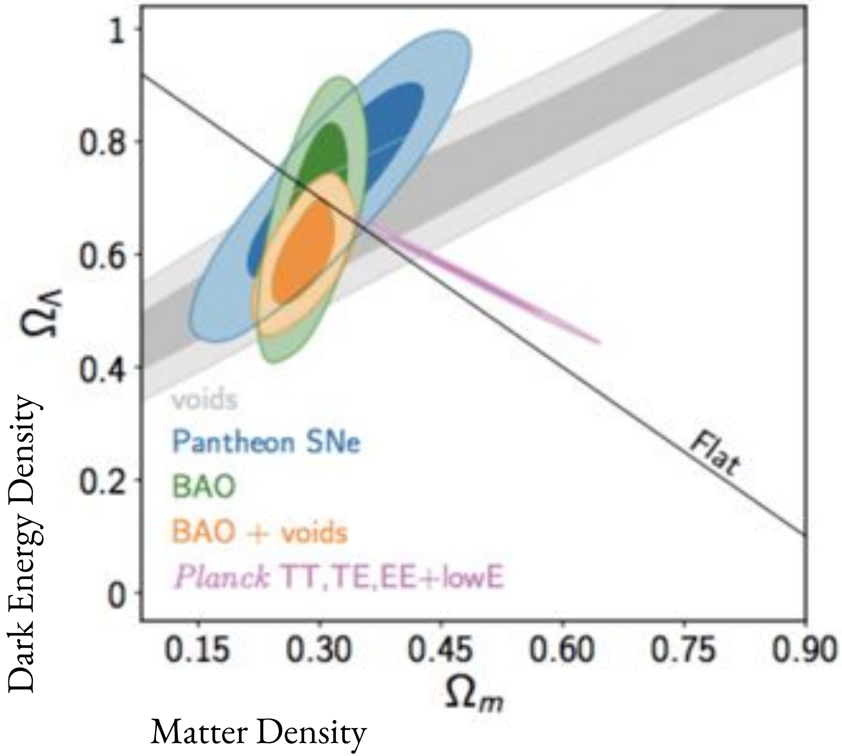
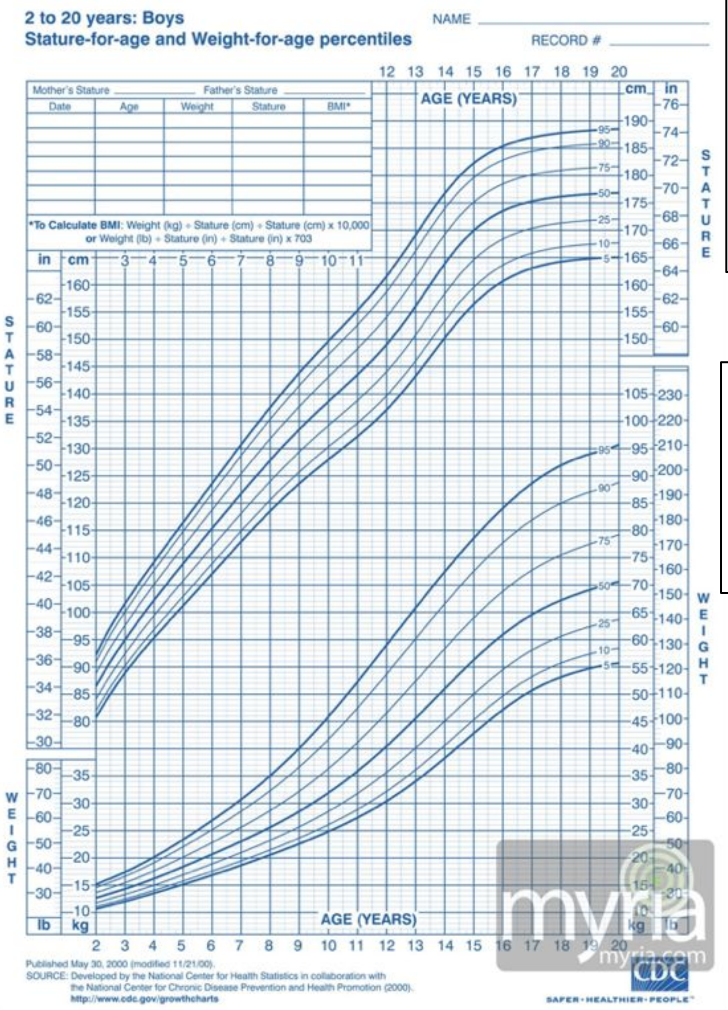
3. The Hubble Tension has been around for >10 years, well poked. Evolving dark energy signal around for ~1.5 years, needs more poking.

Fig. from Nadathur et al. 2020



Universe as an 'adult' - the Hubble constant Measurement



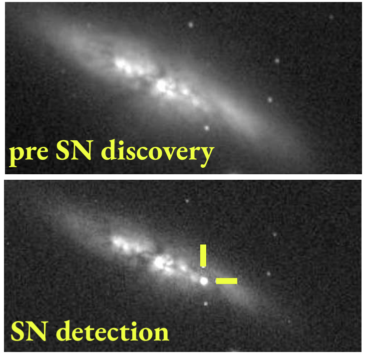
The curve: our standard cosmological Model of ΛCDM (Dark energy, dark matter)

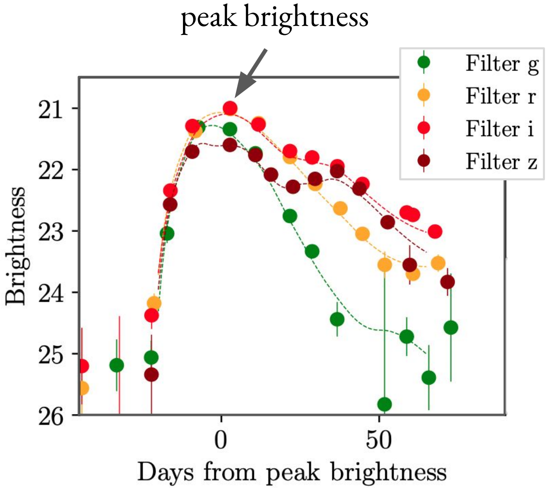
Universe as a 'baby' - the Cosmic Microwave Background

Hubble constant is what we measure today, infer from CMB

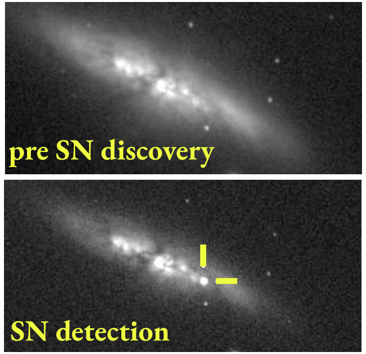
Type Ia Supernovae have been critical for both H0 and EvDE measurements

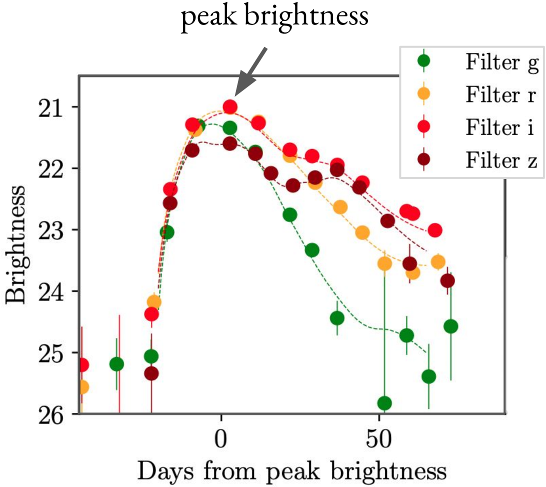
How do we measure stuff?

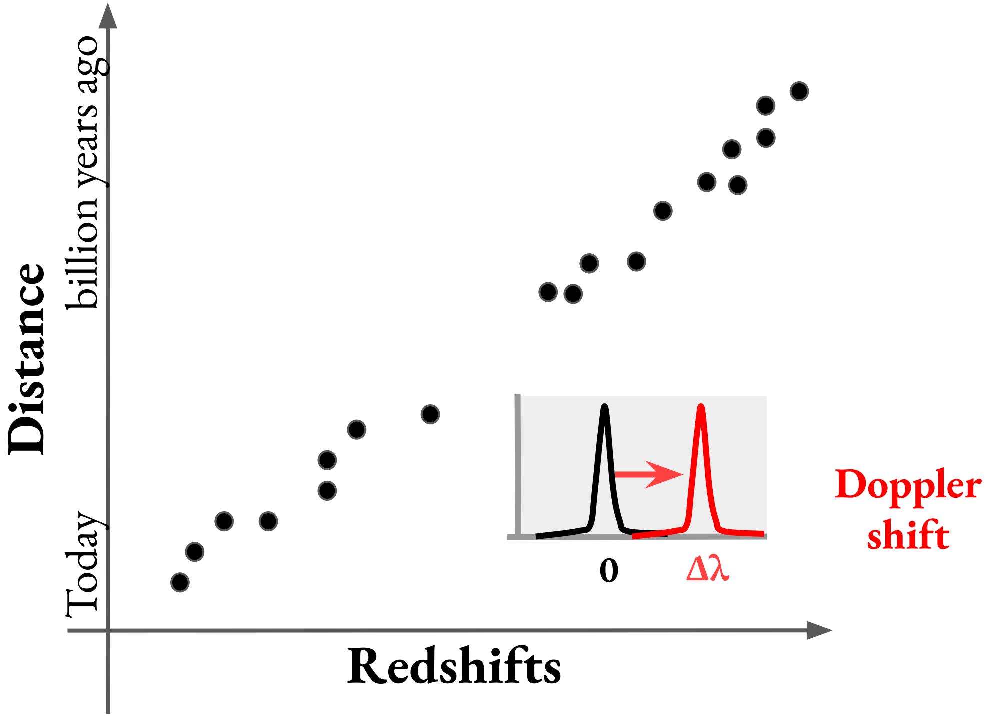




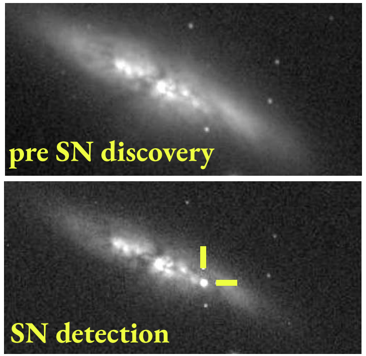
Type Ia Supernovae have been critical for both H0 and EvDE measurements

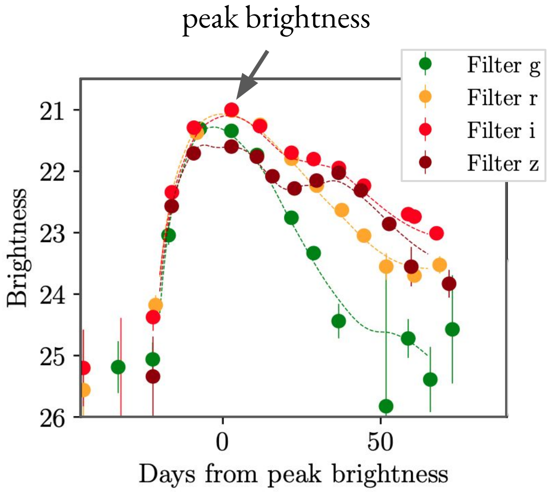


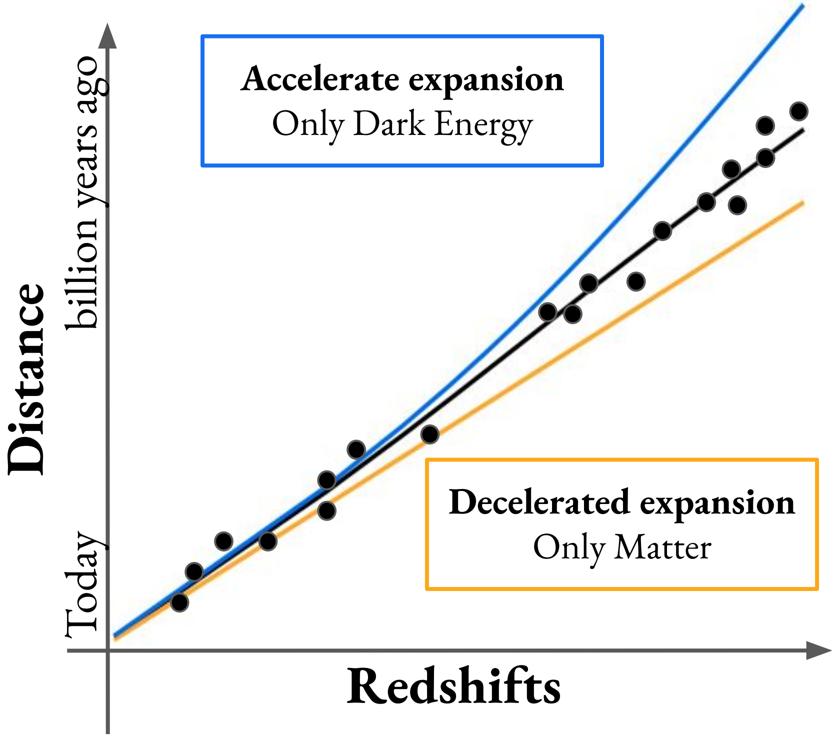




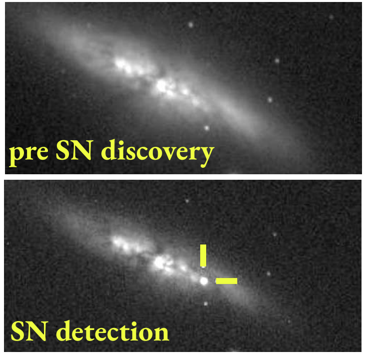
Type Ia Supernovae have been critical for both H0 and EvDE measurements

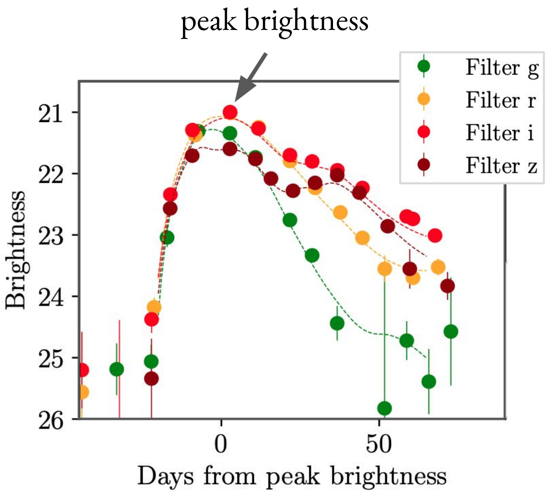


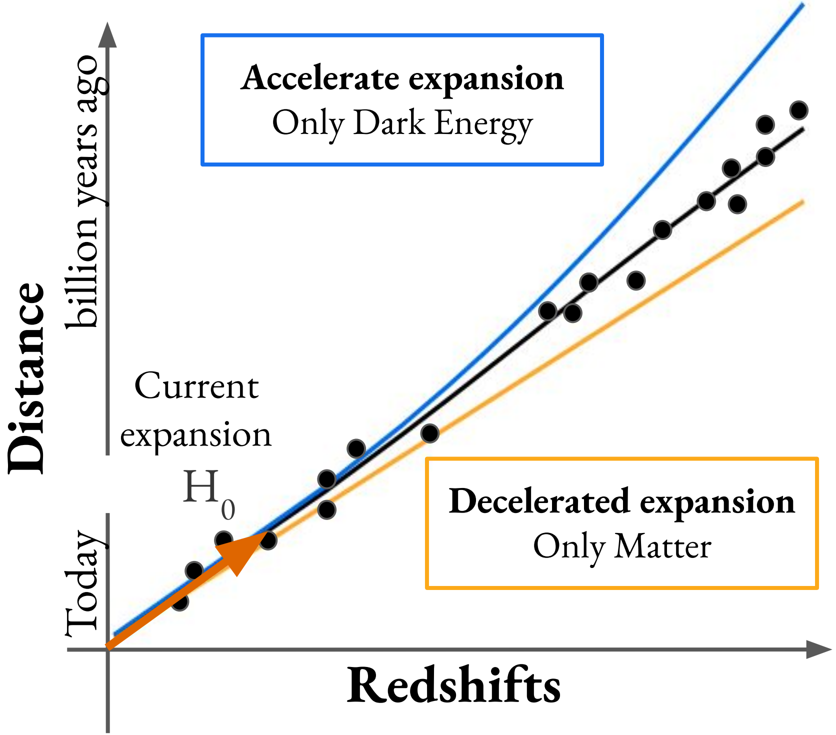




Type Ia Supernovae have been critical for both H0 and EvDE measurements







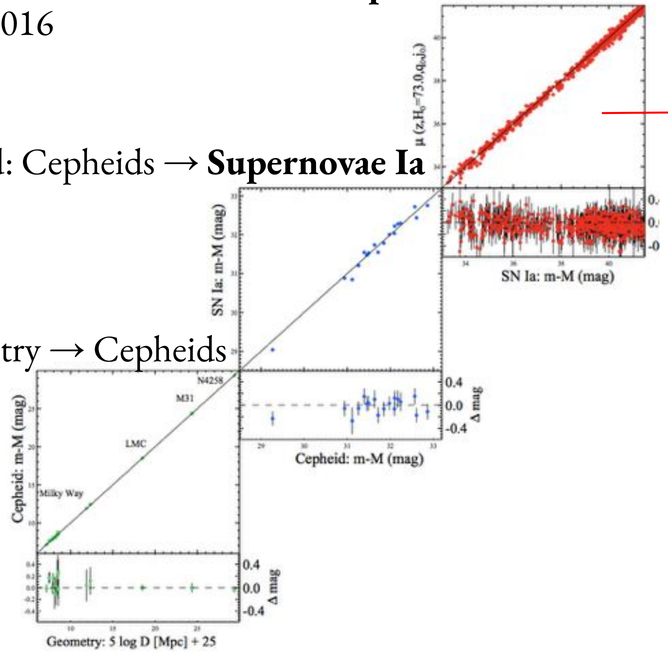
The ways that dark energy (w/wa, or q0) or H0 measurements use Type Ia supernovae are notably different.

Riess et al. 2016

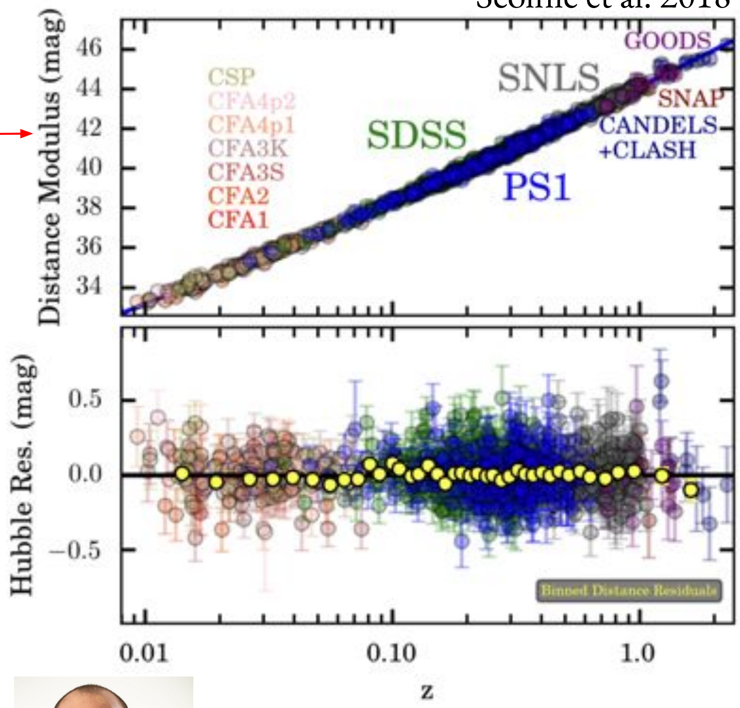
3rd: **Supernovae Ia** → H0

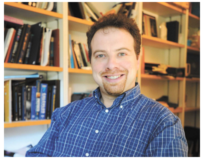
2nd: Cepheids → **Supernovae Ia**

1st: Geometry → Cepheids



Scolnic et al. 2018

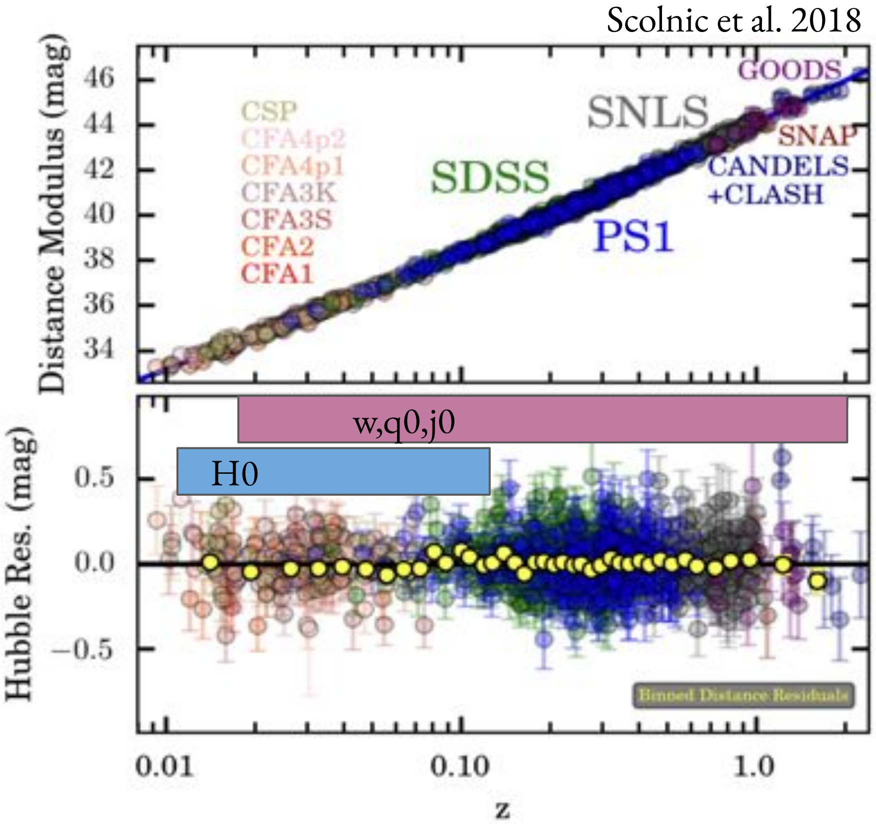




SH0ES Team (A. Riess, L. Macri, S. Casertano et al.)

Pantheon+ Team (D. Brout, D. Scolnic et al.)

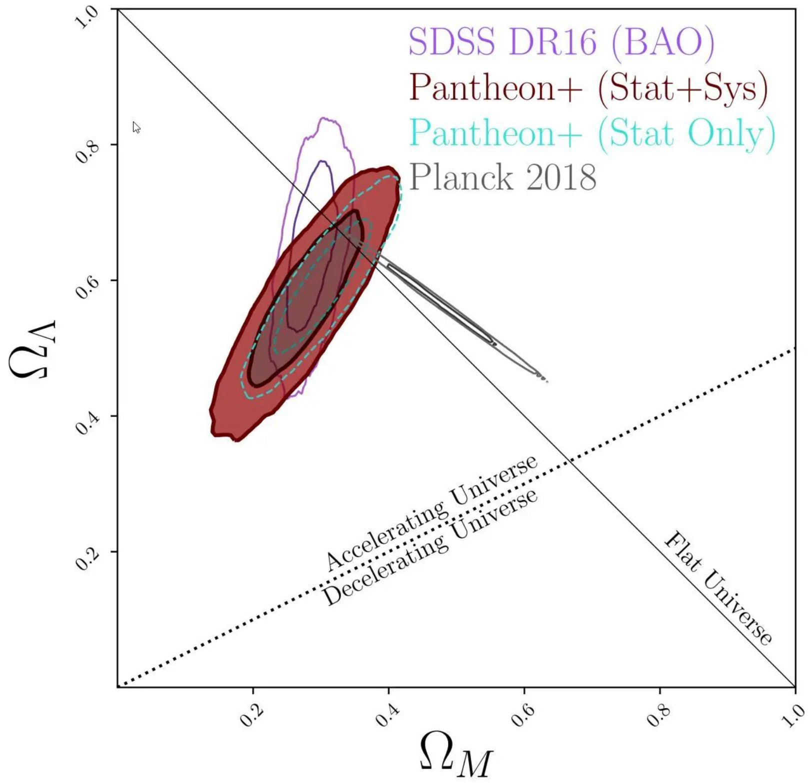
The sensitivity of cosmological measurements for these two use cases is very different.



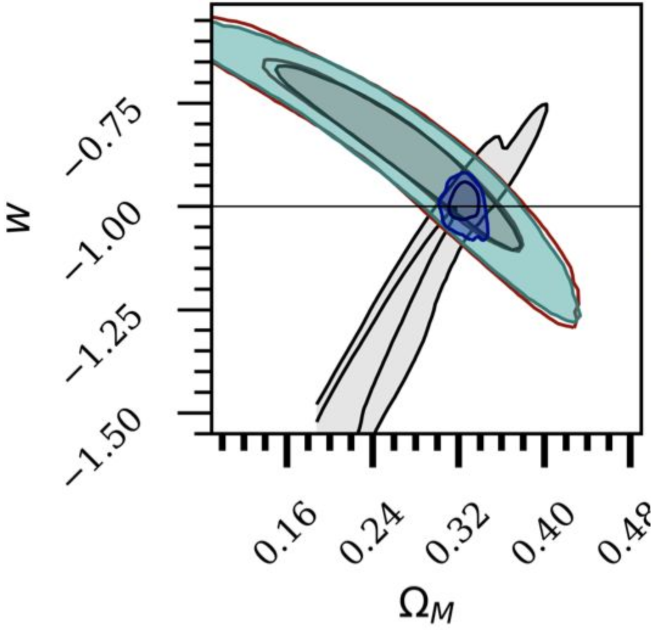
For w, measuring changes on scale of **0.02** mag over Δz of **1.0** (have to worry about combining low/high-z surveys, evolution)

For H_0, the `Hubble tension' is **0.20** mag over Δz of **0.1** (do not have same systematic worries)

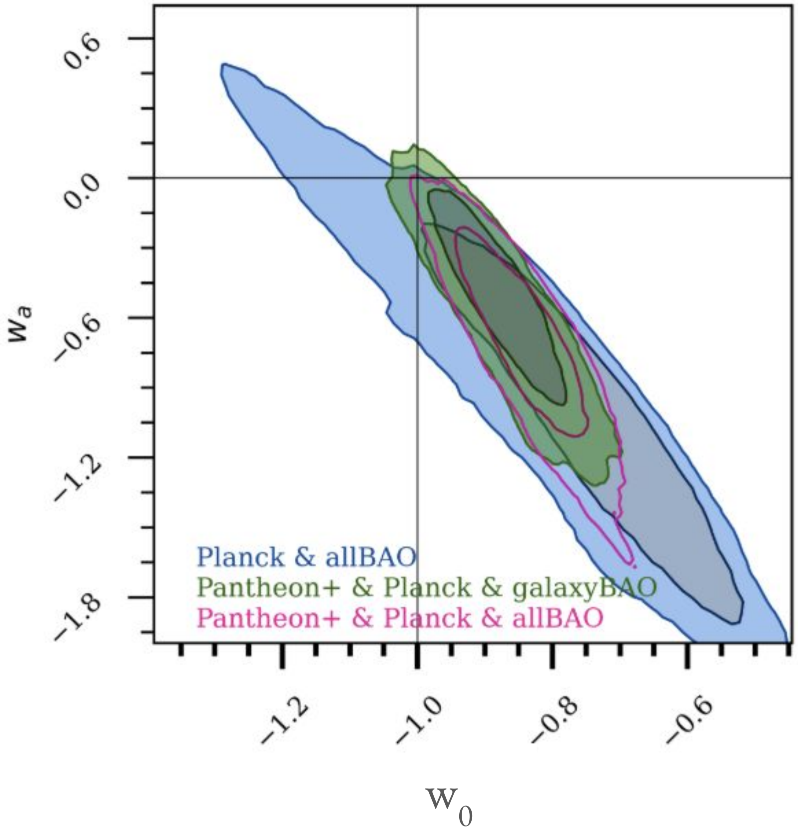
Pantheon+ constraints on Dark Matter and Dark Energy appear consistent with concordance cosmology



Consistent with Einstein's cosmological constant w=-1

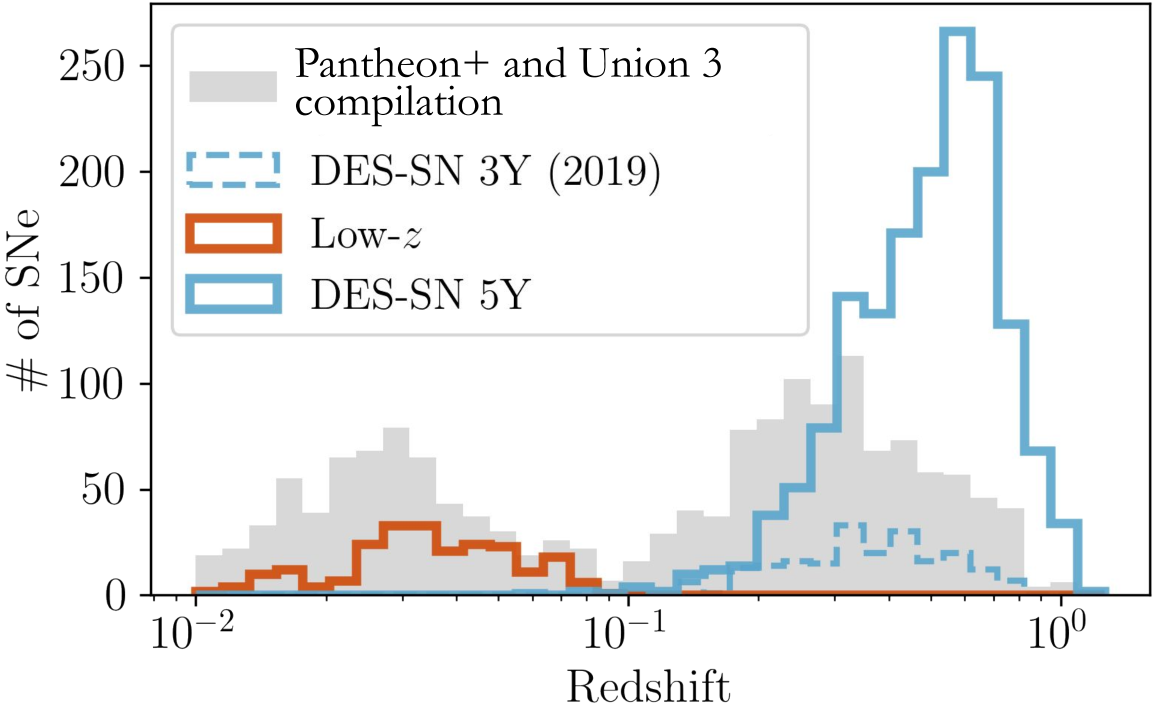


With a hint of evolution of the dark energy parameter….



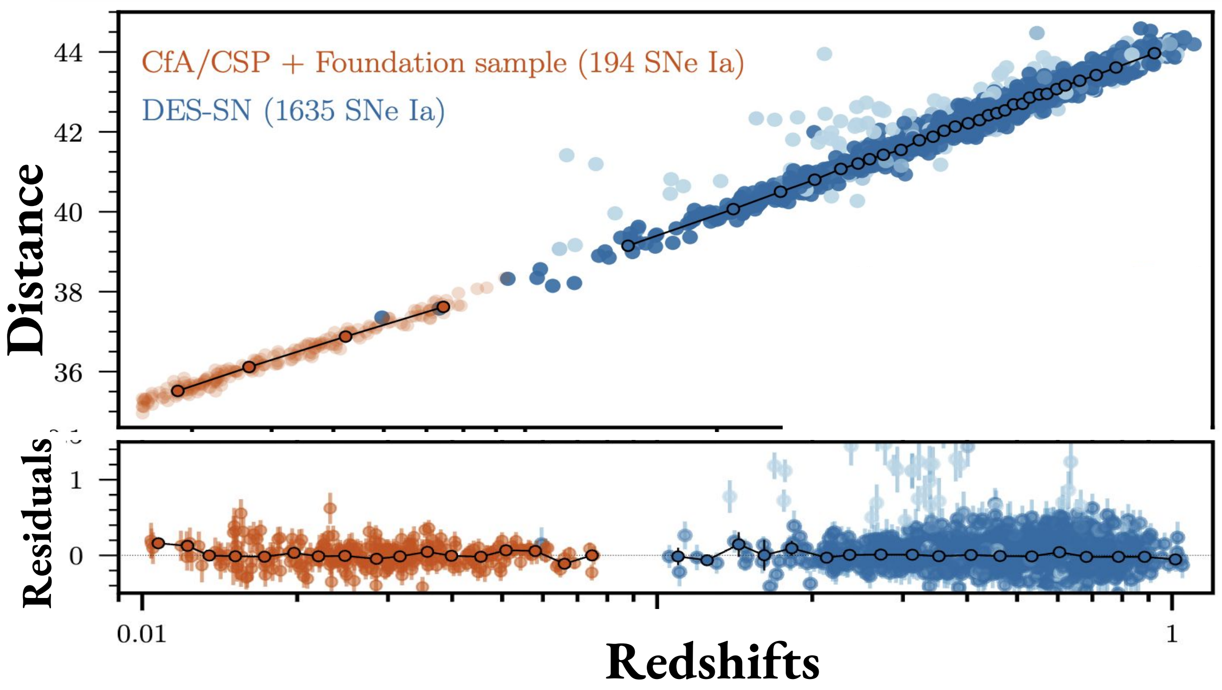
~2 sigma deviation from cosmological constant.

The Dark Energy Survey Supernova Sample is independent high-z sample, can check dark energy signal..



Vincenzi et al. (2024), DES Collaboration et al. 2024

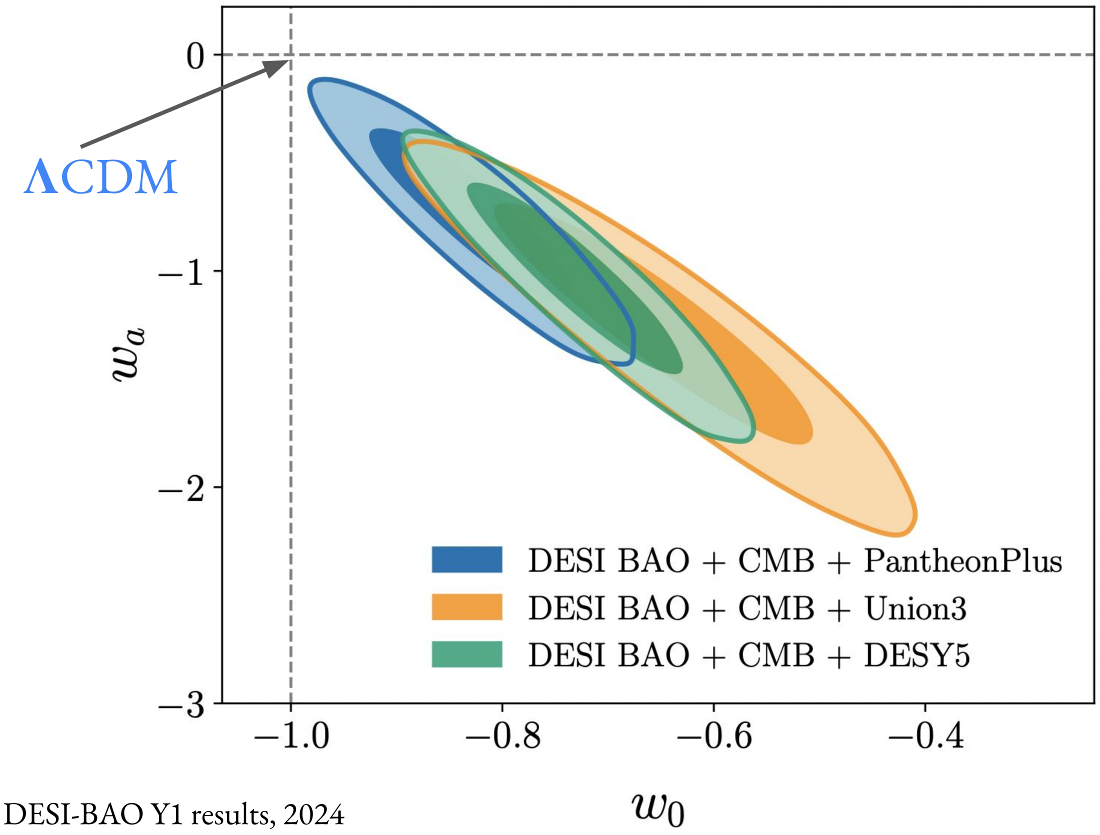
But a new challenge with photometric classification from light curves



The DES-SN 5YR sample:
~1600 SNe Ia
"Photometrically-classified"
Type Ia SNe

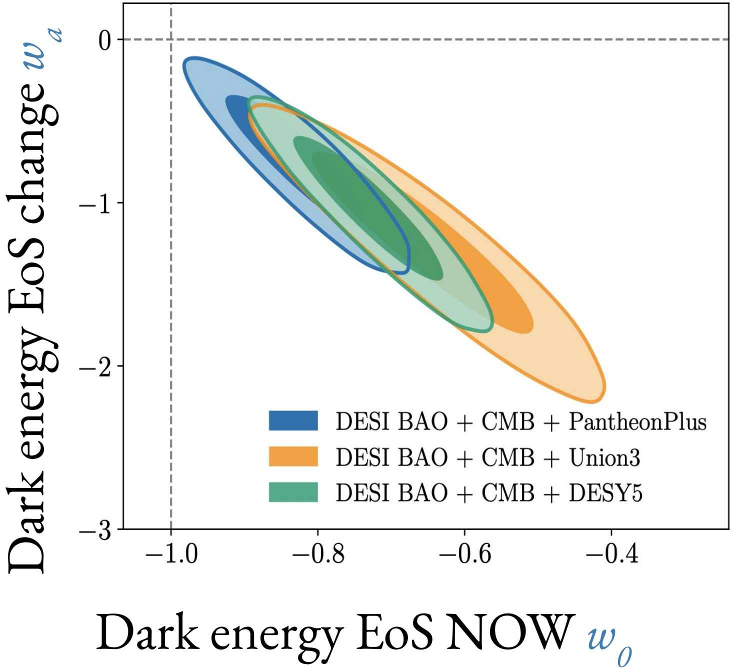
Vincenzi et al. (2021, 2023)

With DES, even stronger signal in same direction, showing here combination with DESI BAO Y1



DESI-BAO Y1 results, 2024

Generally good agreement between SNe, but differences have been subject to recent analyses



	Spectroscopic SN Ia sample	**Photometric SN Ia sample**
Simulation-based method	**Pantheon+**	**DES-5YR**
Bayesian Hierarchical method ("UNITY")	**Union3**	

Are systematics plaguing these measurements?

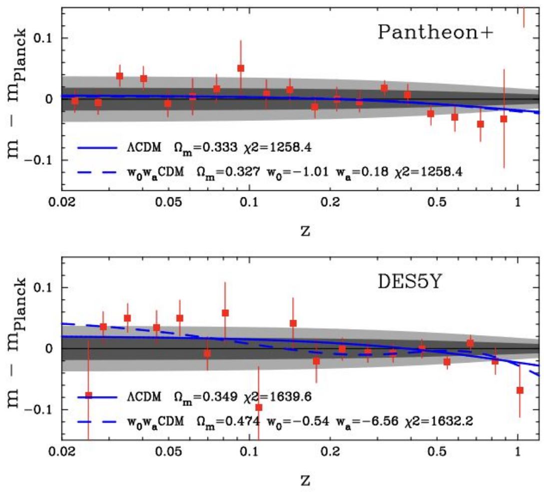
Evolving Dark Energy or Supernovae Systematics?

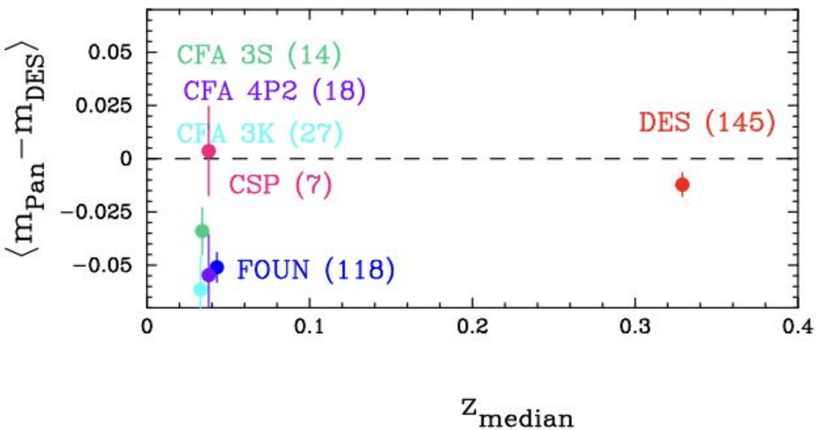
George Efstathiou
Kavli Institute for Cosmology Cambridge and Institute of Astronomy, Madingley Road, Cambridge, CB3 OHA.

18 October 2024

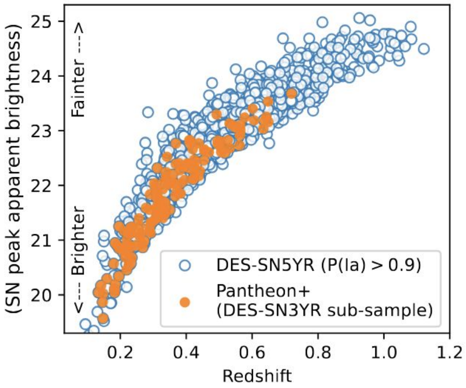
ABSTRACT
Recent results from the Dark Energy Spectroscopic Instrument (DESI) collaboration have been interpreted as evidence for evolving dark energy. However, this interpretation is strongly dependent on which Type Ia supernova (SN) sample is combined with DESI measurements of baryon acoustic oscillations (BAO) and observations of the cosmic microwave background (CMB) radiation. The strength of the evidence for evolving dark energy ranges from $\sim 3.9\sigma$ for the Dark Energy 5 year (DES5Y) SN sample to $\sim 2.5\sigma$ for the Pantheon+ sample. Here I compare SN common to both the DES5Y and Pantheon+ compilations finding evidence for an offset of ~ 0.04 mag. between low and high redshifts. Correcting for this offset brings the DES5Y sample into very good agreement with the *Planck* ΛCDM cosmology. Given that most of the parameter range favoured by the uncorrected DES5Y sample is discrepant with many other cosmological datasets, I conclude that the evidence for evolving dark energy is most likely a result of systematics in the DES5Y sample.

Key words: cosmology: cosmological parameters, dark energy, supernovae





Are systematics plaguing these measurements? Not obviously.



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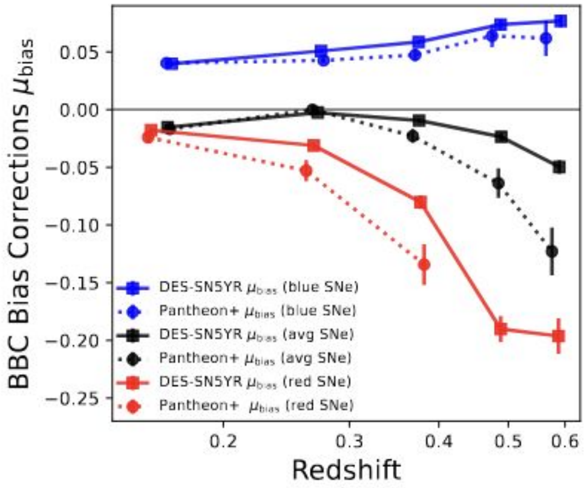
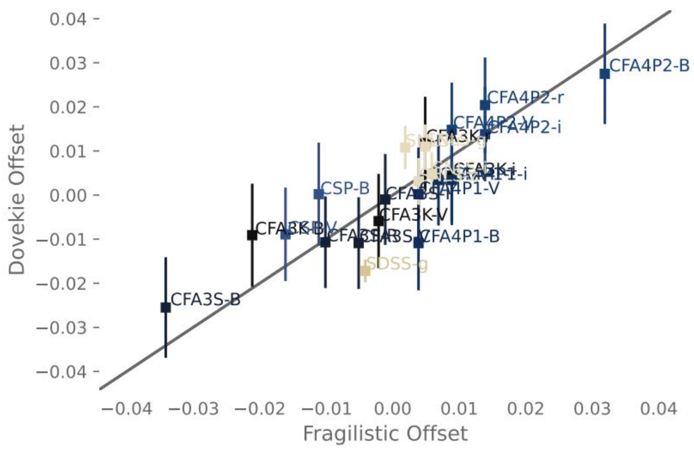
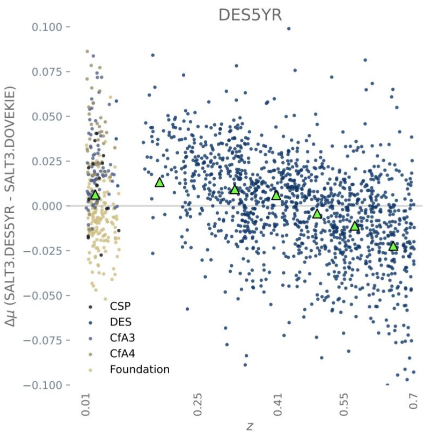
1. Efstathiou claims 0.04 mag systematic
2. Some improvement in modeling for DES- systematic on (0.02 mag)
3. Apples to bananas comparison of distances of same SNe (0.02 mag)

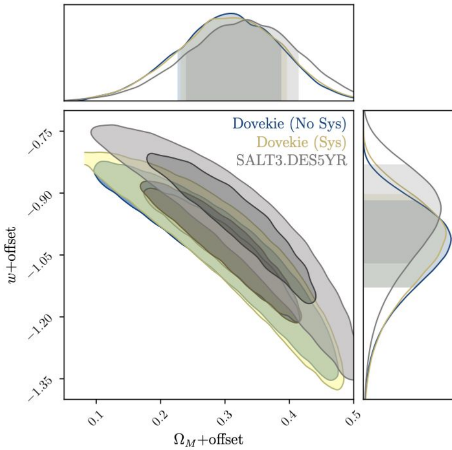


One analysis to keep eye on is Dovekie analysis by Popovic et al.

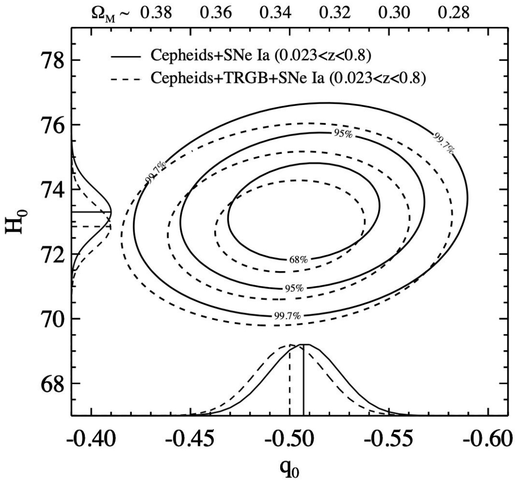


1. Full re-calibration study
2. Finds very good agreement with P+/DES
3. But shows small ~5 mmag shifts can propagate to up to 0.03 mag signal over large redshift range
4. https://arxiv.org/pdf/2506.05471
5. Full DES re-analysis ongoing

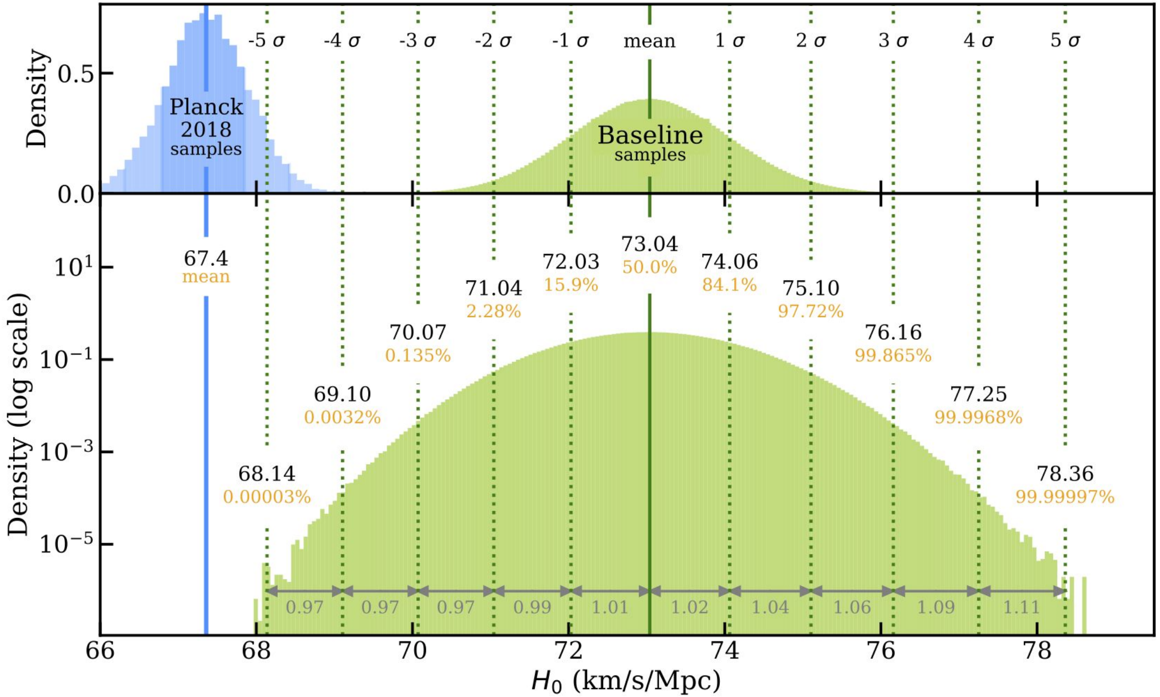




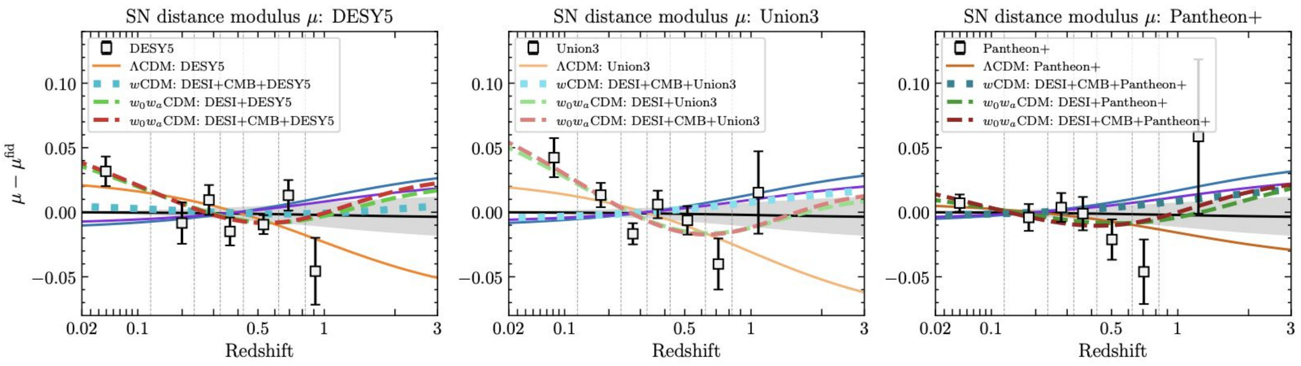
Pantheon+SH0ES simultaneously fit for H0 and q0, didn't change H0 much



H_0=73.30 +/- 1.04

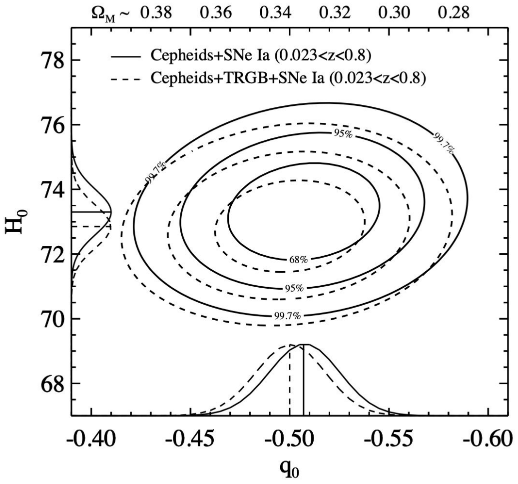


The Evolving Dark Energy signal makes Hubble Tension bigger!



Model/Dataset	$\Omega_{\rm m}$	H_0 [km s^{-1} Mpc^{-1}]
$\boldsymbol{w_0 w_a}$**CDM**$+\boldsymbol{\sum m_\nu}$		
DESI BAO+CMB	0.353 ± 0.022	$63.7^{+1.7}_{-2.2}$
DESI BAO+CMB+Pantheon+	0.3109 ± 0.0057	67.54 ± 0.59
DESI BAO+CMB+Union3	0.3269 ± 0.0088	65.96 ± 0.84
DESI BAO+CMB+DESY5	0.3188 ± 0.0058	66.75 ± 0.56

How sensitive is this measurement to systematics?



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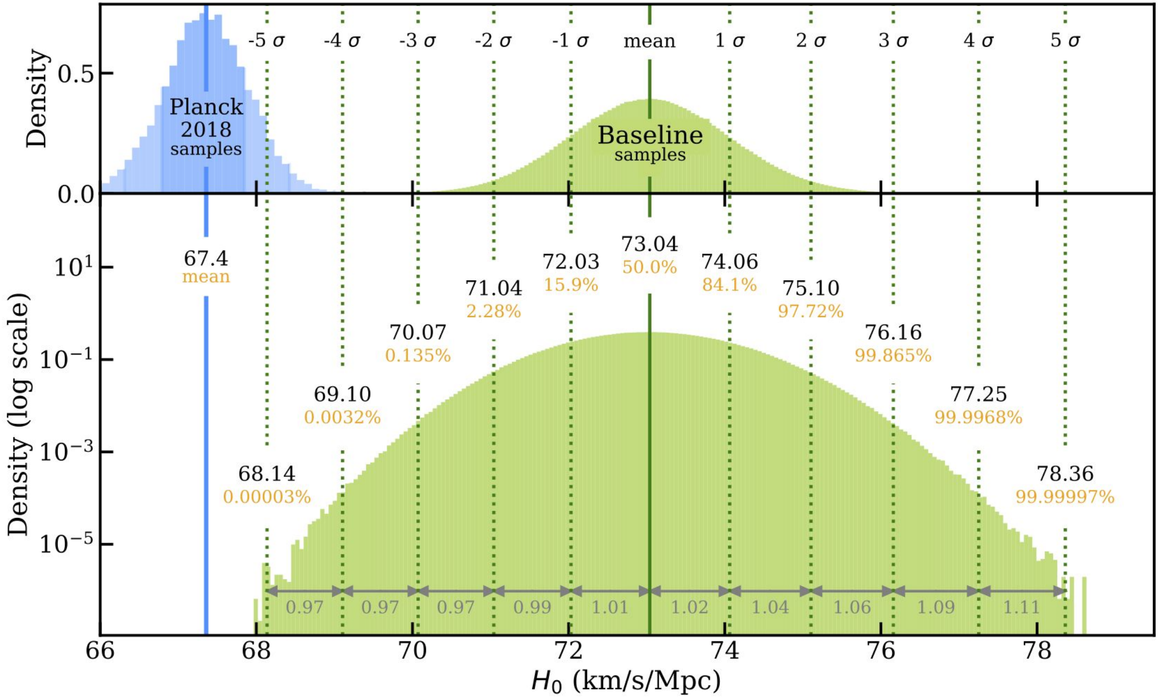
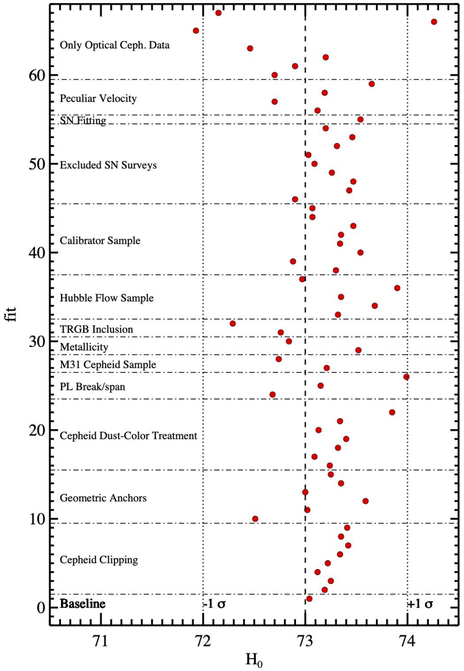
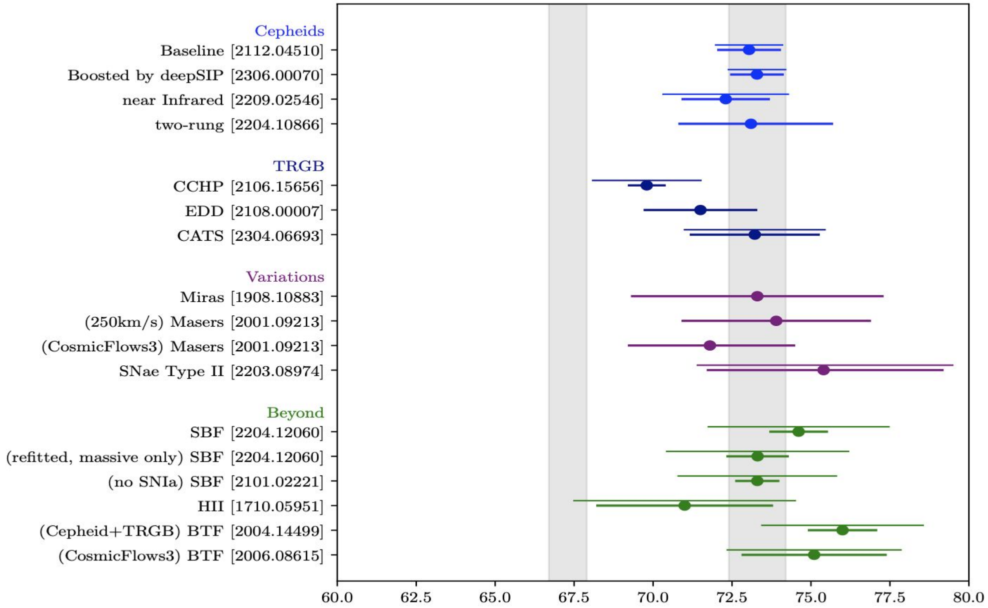


In Pantheon+SH0ES, we looked at everything that the community has raised … and redundancy for each part of ladder

All Analysis Variants (Riess+21)





H0 Tension/SH0ES Result in Perspective : Table

Table of Cross-checks and Tests of Components of SH0ES Distance Ladder

Author	Year/Journal	Cross-checked/reproduced/substituted (or claim made if conflicting)	Comment/Followup Analyses	Result
Geometry				
Breuval	2020/A&A	Gaia Parallax photometric and color variability	Uses Open Cluster parallax and binary companion parallax instead of Cepheid parallaxes	73.0 ± 1.9
Pesce	2020/ApJL	Gaia, Parallax, Cepheids , SNe, basically everything	1 rung independent distance ladder using Megamasers geometry (no Gaia, no parallax).	73.9 ± 3.0
Riess	2018/ApJ	Cepheid Parallaxes before Gaia	Parallaxes from Spatial Scanning of HST 8 Cepheids	Yields H0=75 of 2016 ladde
Groenewegen	2018/A&A	Gaia	different derivation of Gaia parallax offset	76 ± 1.3
Benedict	2007/AJ	Cepheid Parallaxes before Gaia	Parallaxes from the FGS on HST of 9 Cepheids	Yields H0=76 of 2016 ladde
Cepheids				
Molinaro	2023/MNRAS	Gaia Parallax offset, Cepheid metallicity term	New low metal MW Cepheid sample, finds Gaia offset, -22+/- 4 consistent with SH0ES (-14 +/- 5) and metallicity term -0.29 +/- 0.10 (SH0ES -0.22 +/- 0.05)	consistent Ga metallicity val
Bhardwaj	2023/Submitted	Cepheid Metallicities	new spectra, metalliciity term consistent with SH0ES	gamma=-0.3
Riess	2023/ApJ	JWST: Crowding, dust, very strong tests	JWST, eliminates crowding, Measures at 2.7 microns so dust ~0.	Excellent agr in PL relation
Breuval	2023/ApJ	Distance to M33 by many methods compared to SH0ES Cepheid	RR Lyrae, TRGB, Miras, JAGB, ground-based Cepheids	agreement in < 0.05 mag a many method
Scolnic	2023/ApJL	TRGB Standardization process. Peculiar Velocities. Calibration	Tip contrast ratio improves tip calibration. Shifts in H0 come from tip standardization, SN peculiar velocities, and CSP Calibration	73 ± 2
Anderson	2023/Submitted	TRGB instead of Cepheids	Better tip calibration using intrinsically non-variable red giants	71.8 ± 1.5
Sharon	2023/Submitted	Crowding, re-assessed from amplitudes	reanalysis of Riess 2020, above, test passed	0.013+/-0.05
Uddin	2023/Submitted	Cephids, SN optical	Cepheids+TRGB+SBF+SNe(NIR)	71.43 ±0.62 (±2.43 (sys)
Cruz, Anderson	2022/A&A	Gaia Parallax offset	independent analysis of cluster Cepheids	same result
Riess	2022b/ApJ	Gaia Parallax offset	use of cluster parallaxes where offset is negligible	72.9 ± 1.0
	/ApJ	Crowding, photometry, light curve fitting	Independent check on SH0ES. Raw pixels to distance of NGC 5584 using different methods at each step in analysis	Excellent agr in distance

Supernova					
Bidenko	2023/Submitted	Generic unknown systematic	Include additional systematic covariance to be fit simultaneously with cosmology.	No evidence for missing covariance	https://arxiv.org/abs/2308.05157
Marukami	2023/JCAP	Dust modeling, intrinsic scatter modeling	Uses spectral feature twinning process to explain SNIa variation (for both rungs)	73.01 ± 0.92	https://arxiv.org/abs/2306.00070
Dhawan	2023/MNRAS	Check on dust for SN calibrators and hubble flow	Near-Infrared+Optical SNIa can get dust fits for each SN/Host individually	74.82 ±0.97 (stat) ±0.84 (sys)	https://arxiv.org/abs/2211.07657
Kenworthy	2022/ApJ	Eliminates SNIa rung entirely	2 rung distance ladder	73.1 (+2.6/-2.3)	https://arxiv.org/abs/2204.10866
Garnavich	2022/ApJ	Crosshcheck on SNIa host demographic systematics (and by proxy dust)	4 rung distance ladder	74.6 ±0.9(stat) ±2.7(syst)	https://arxiv.org/abs/2204.12060
Keeley	2022/Submitted	Crosscheck of statistical uncertainties and covariance	Find that the P+ SN distance uncertainties are overestimated by 5%	Correcting errors by 5% results in no deviation	https://arxiv.org/abs/2212.07917
Galbany	2022/A&A	Dust	Near Infrared public data	72.3 ±1.4 (stat) ±1.4 (syst)	https://arxiv.org/abs/2209.02546
de Jaeger	2022/MNRAS	SNIa general Crosscheck	SN II instead of SNIa	77.6 +5.2 −4.8	https://arxiv.org/abs/2203.08974
Peterson	2022/ApJ	Peculiar velocities	CSP/CCHP does not use spactial maps of peculiar velocity corrections	delta H0 of -0.4 for not using peculiar velocities	https://arxiv.org/abs/2110.03487
Brownsberger	2022/ApJ	SNIa Calibration	allow free parameters for grey SN survey offsets	No inflation of H0 uncertainties	https://arxiv.org/abs/2110.03486
Dhawan	2022/ApJ	SNIa Calibration, TRGB	ZTF Only in Calibrators and Hubble Flow	76.94 ± 6.4	https://arxiv.org/abs/2203.04241
Blakeslee	2021/ApJ	Tie together Cepheids, TRGB, and SNe with SBF	also crosschecks vpec modeling systematic.	73.3 ± 0.7 ± 2.4	https://arxiv.org/pdf/2101.02221.pdf
Kourkchi	2020/ApJ	SNIa general Crosscheck	Uses Tully Fisher relation, ties to Cepheids and TRGB	H0 = 76.0 ± 1.1(stat.) ±2.3(sys.)	https://arxiv.org/abs/2004.14499
Jones	2018/ApJ	Mass step, global vs local	Negligible impact on H0.	delta H0 of -0.14 km/s/Mpc	https://ui.adsabs.harvard.edu/abs/2018ApJ...
Burns	2018/ApJ	Different SN fitting, SNoopy, NIR	Carnegie SN Project	73 ± 2	https://ui.adsabs.harvard.edu/abs/2018ApJ...
Dhawan	2018/A&A	NIR SN and different fitting, check on dust too	J-band	72.8 ± 2.8	https://ui.adsabs.harvard.edu/abs/2018A%26
Many Such Studies		Inverse distance ladder using SNe Ia calibrated to sound horizon + BAO	Suggests that SNIa are not the reason that one obtains a high H0 in local universe	Low H0	
Global Fit					
Feeney	2018/MNRAS	frequentist vs Bayesian formalism	Bayesian hierarchical, based on SH0ES 2016	72.7 ± 1.6	https://ui.adsabs.harvard.edu/abs/2018MNR/
Cardona	2017/JCAP	linear equations, errors	fit distance ladder with hyper parameters (based on SH0ES 2016)	73.8 ± 2	https://ui.adsabs.harvard.edu/abs/2017JCAP
Zhang	2017/MNRAS	formalism, bayesian components, blinded	based on SH0ES 2011	72.5 ± 3.1	https://arxiv.org/abs/1706.07573
Efstathiou	2014/MNRAS	various, different assumptions	based on SH0ES from 2011	72.5 ± 2.5	https://ui.adsabs.harvard.edu/abs/2014MNR/
Camarena and Marra	2023/submitted	Cosmographic alternative fitting		73.1 +/- 1 for LCDM, 74.5 for non	https://arxiv.org/pdf/2307.02434.pdf

Conflicting or Claims of Systematics					
Miller	2023/unpublished ?	Claim: SNe Ia not good standard candles, 2 mag errors	appears to be artifact of not subtracting mean cosmology before calculating correlation coefficient	Inflation of SN uncertainties.	https://arxiv.org/abs/2304.01831
Wotjak & Hjorth	2022/MNRAS	Claim: SNe on 2nd and 3rd rung have different color calibration, ~2-2.5 sigma, could impact H0	Based on 2016 sample, analysis of 2022 sample its 1.2 sigma, not significant	Table 2: H0 73-74, however lower H0 if choose a reference SN color bluer than full sample range	https://arxiv.org/abs/2206.08160
Perivolaroupoulos	2022/Universe	Allows there to be different intrinsic luminosities for SNe in second and third rung to solve tension due to a phase change in the phsyics of the Universe at a look back time corresponding to the distance between rungs, ~150 Myr years ago	Non-Copernican, no evidence	73.0 for one luminosity, 68.2 for two	https://arxiv.org/abs/2208.11169
Rameez	2021/ Classical & Quantum Gravity	Claim: redshift changes in supernova datasets over time, tried looking at high redshift SNe, not used for SH0ES H0.	This has been checked with Carr et al., https://arxiv.org/abs/2112.01471, changes to redshifts cause <0.1 in H0	Said Pantheon redshifts favor H0=72, JLA favor H0-68	https://arxiv.org/abs/1911.06456
Khetan	2020/A&A	Claim: low H0 from SBF, SNe: large scatter (0.3 mag) and conflicting SNoopy parameters	Used Ground-based, pre-2000 SBF data and LMC=18.50 cal. See Blakeslee 2021 above, they homogeneously calibrate all SBF with HST. Khetan uses literature estimates, some 20 years old.	70.50 ±2.37(stat) ±3.38(sys)	https://arxiv.org/abs/2008.07754
Steinhardt	2020/ApJ	Claim: Mis-estimation of supernova redshift uncertainties can cause changes in H0	This has been checked with Carr et al., https://arxiv.org/abs/2112.01471, changes to redshifts cause <0.1 in H0	H0 varies depending on subset of supernovae.	https://iopscience.iop.org/article/10.3847/153
Rigault	2018/A&A	Claim: SNe luminosities depend on age. 2013 paper said this can change H0 as second and third rung supernovae have different mean ages. Based on unpublished SN sample not used by SH0ES	This has been checked with Jones (https://arxiv.org/abs/1506.02637), checked in SH0ES paper, effect on H0 <0.2	No H0 value given, but showed dependance	https://arxiv.org/abs/1806.03849
Mortsell	2022/ApJ	Claim: Cutting the Cepheid sample by color reduces H0, also raises error by discarding up to 2/3rds of full sample	The proposed cut biases photometry because it was not also applied to artificial stars; The trend arises because the background of NIR images are dominated by red giants so a red Cepheid color also correlates to a higher-than-average background which produces a bias if the background is not also derived from artificial stars with the same color criteria. to do this cut one must remeasure the photometry applying this cut to artificial stars consistently,see Riess+2023. Also this was based on 2016 data, not current	showed dependence	https://ui.adsabs.harvard.edu/abs/2022ApJ...
Supplemental					

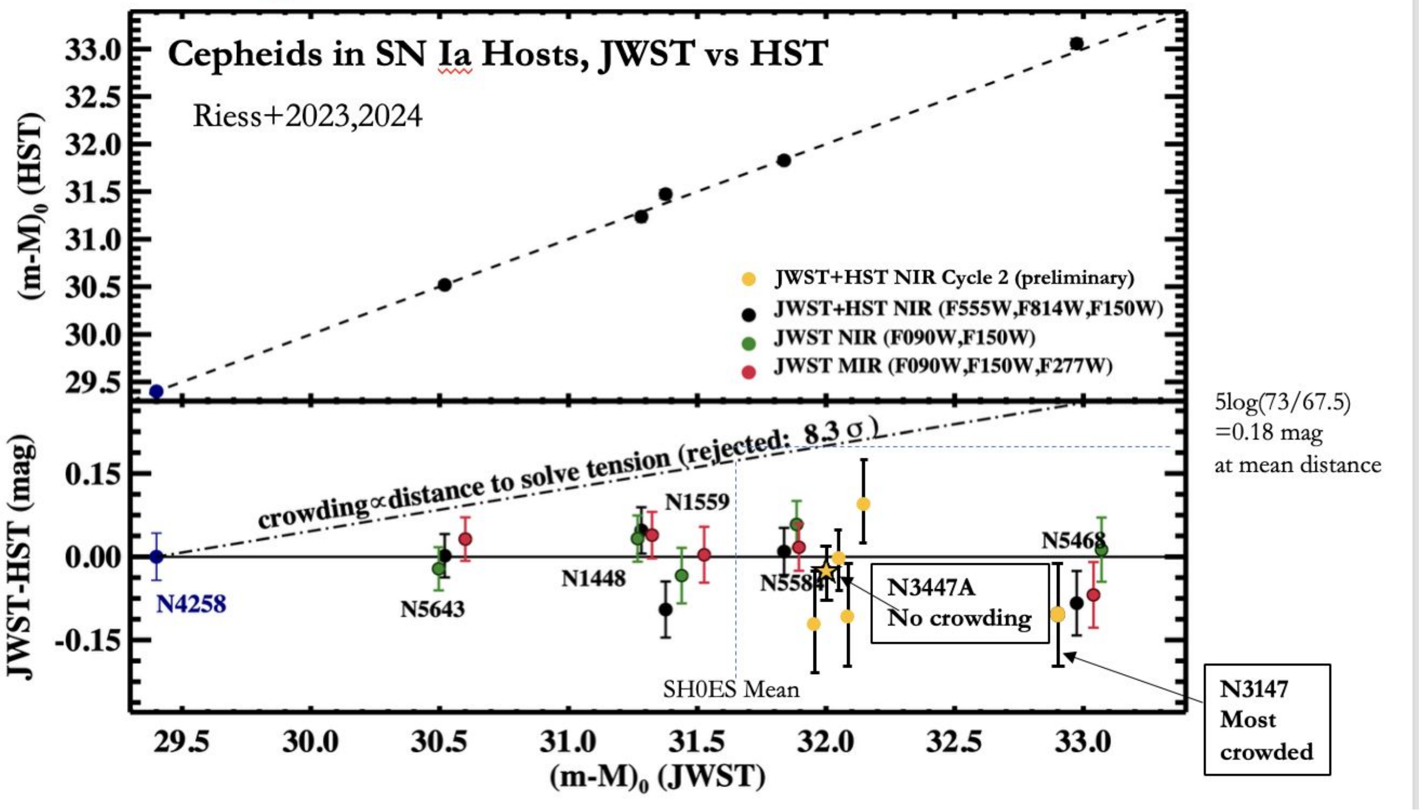
https://dibrout.github.io/SHOESrefs.html

The most discussed systematic idea was Cepheid crowding, but now ruled out.

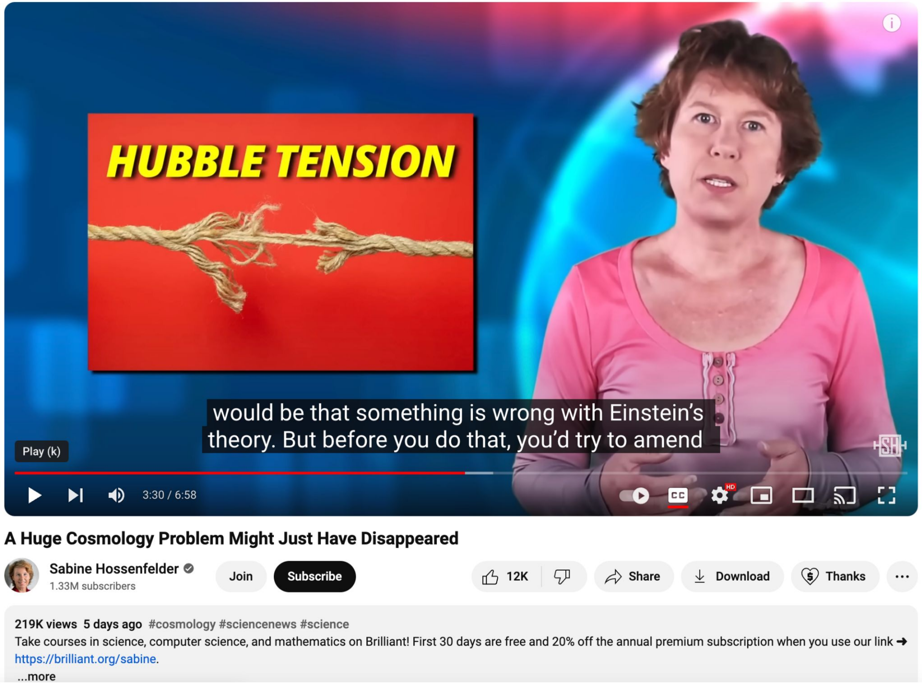
Now 19 hosts of 24 SN Ia (>half) JWST-HST=-0.02+-0.02 mag, 8 at D>23 Mpc 0.00+-0.03 mag

Rules out distance-dependent HST crowding error needed to solve tension at 8.2sigma.

Confirms Hubble Tension--with stronger evidence then evidence of Tension itself!

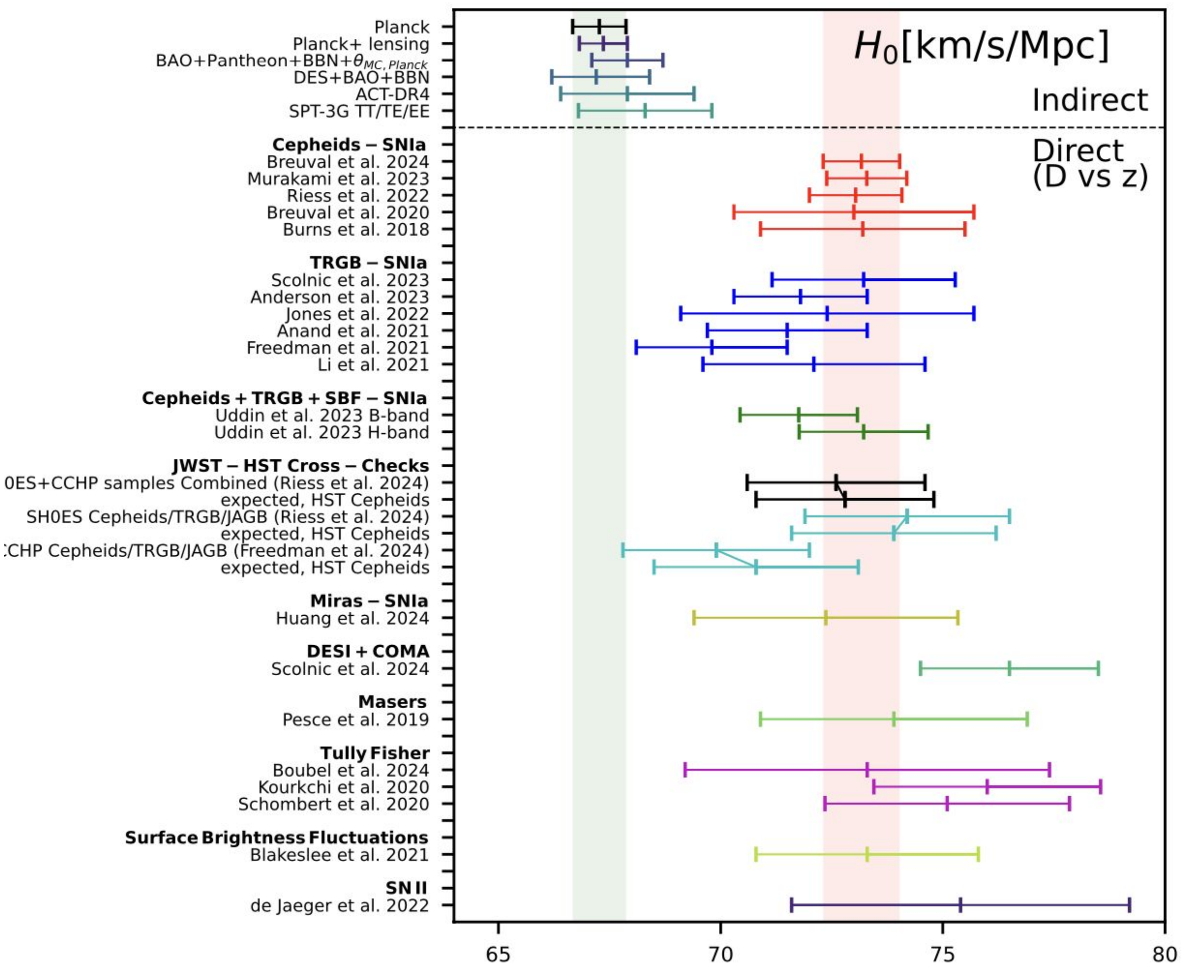


I was feeling we had gone over every part of this measurement, but the Youtube community said it's not done after recent CCHP results.



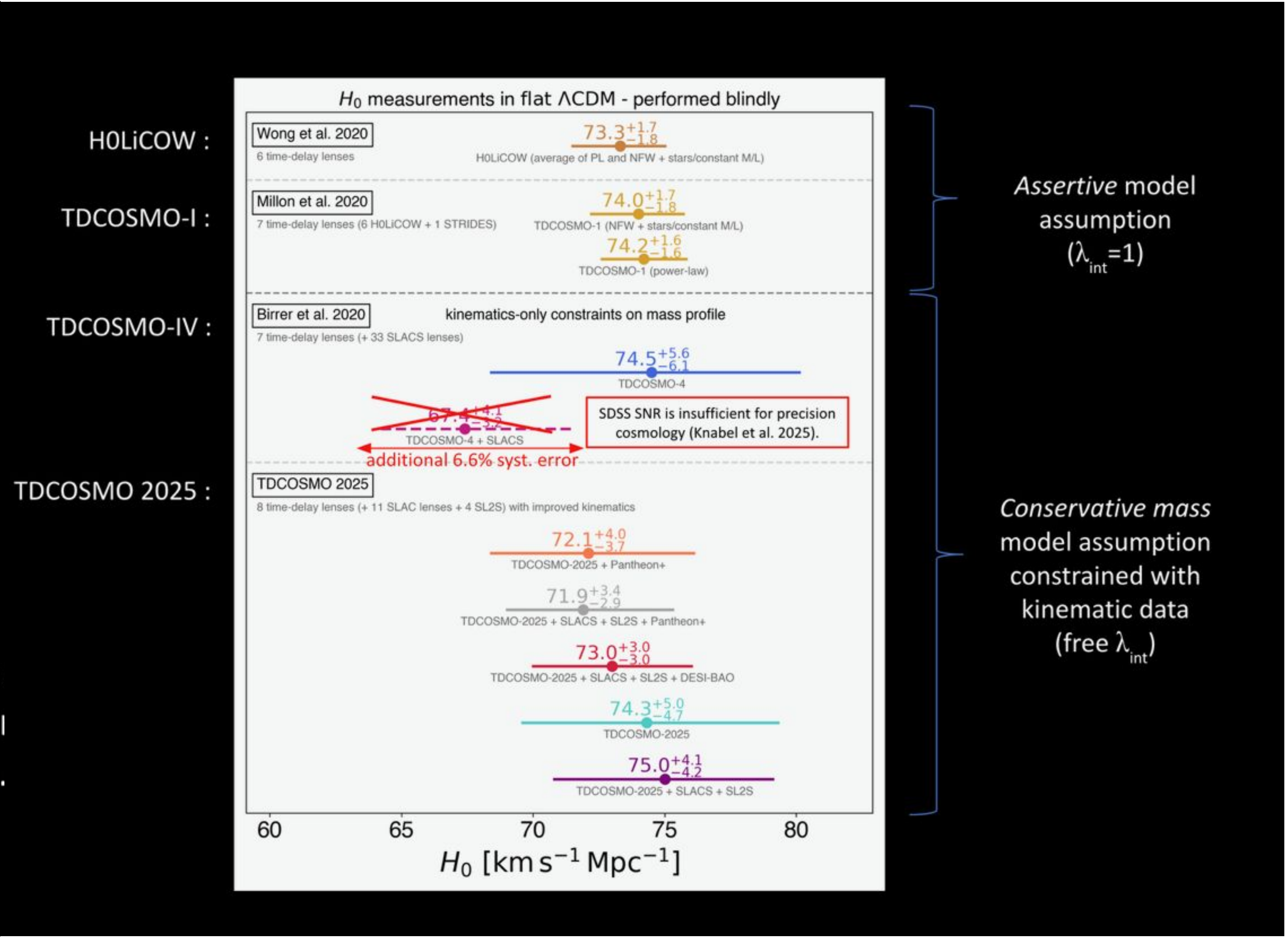
Before I begin...

I think Hubble Tension measurements need to be discussed as a community effort rather than about one or two teams



Di Valentino (2021)

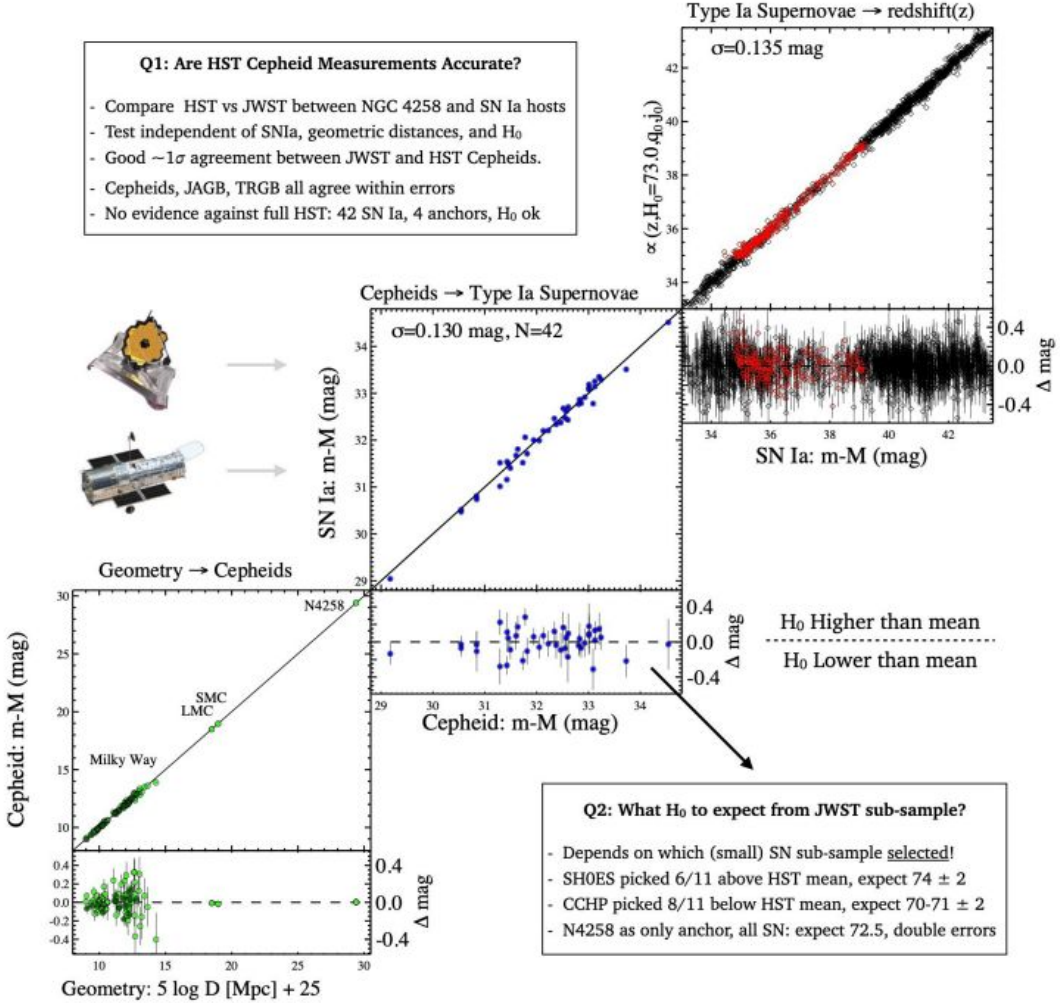
See Cosmoverse talk two weeks ago by Anowar Shajib about new TDCOSMO results



What can JWST help answer?

Q1: Are HST Cepheid Measurements Accurate?

- Compare HST vs JWST between NGC 4258 and SN Ia hosts
- Test independent of SNIa, geometric distances, and H_0
- Good $\sim 1\sigma$ agreement between JWST and HST Cepheids.
- Cepheids, JAGB, TRGB all agree within errors
- No evidence against full HST: 42 SN Ia, 4 anchors, H_0 ok

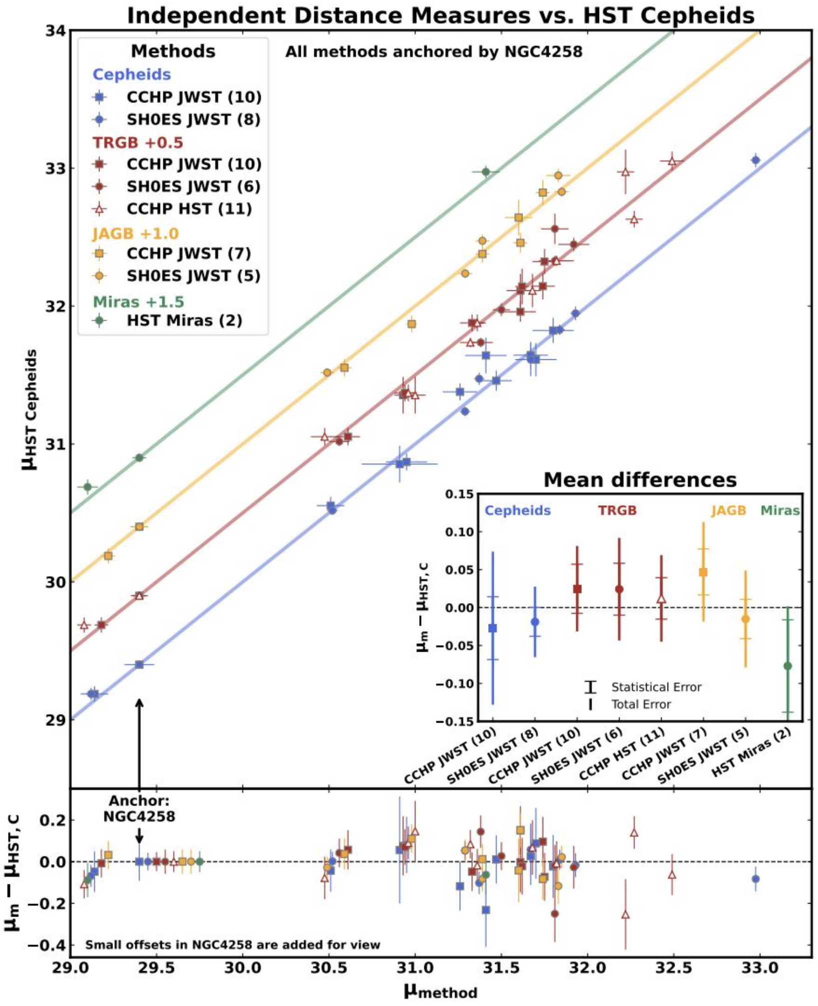


Q2: What H_0 to expect from JWST sub-sample?

- Depends on which (small) SN sub-sample selected!
- SH0ES picked 6/11 above HST mean, expect 74 ± 2
- CCHP picked 8/11 below HST mean, expect 70-71 ± 2
- N4258 as only anchor, all SN: expect 72.5, double errors

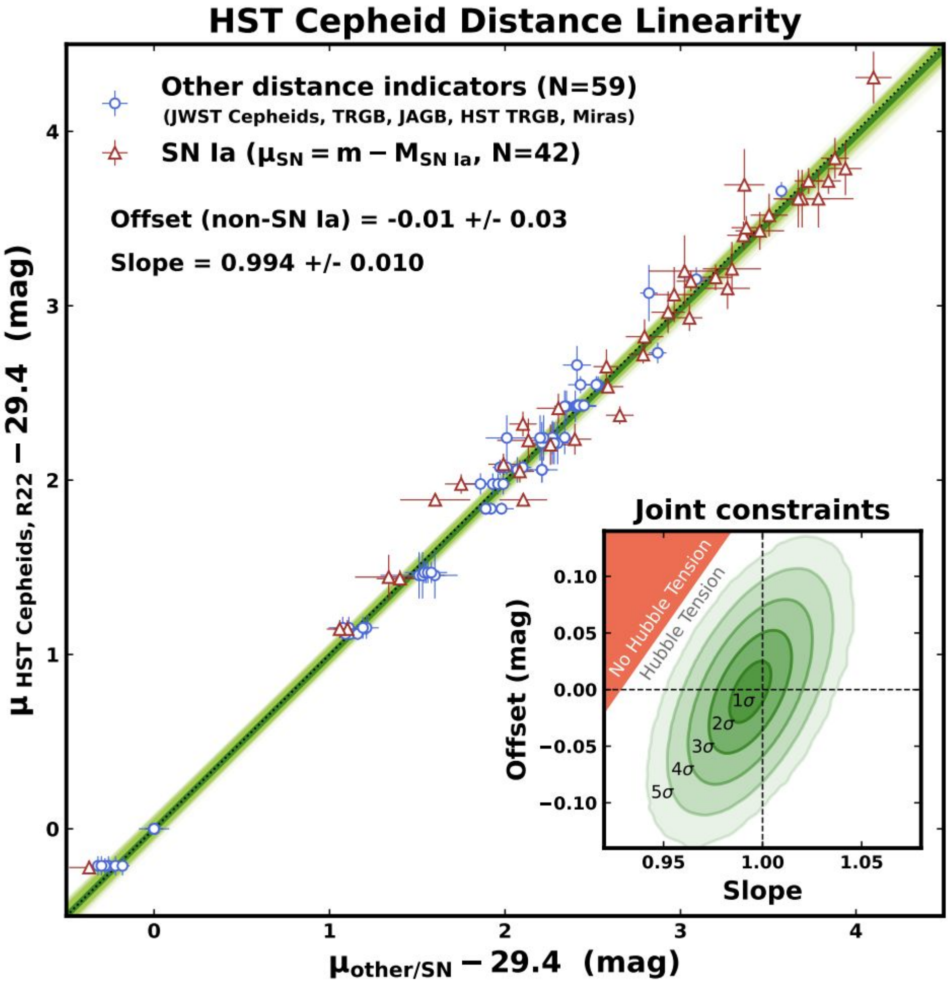
Do new JWST measurements (and other measurements) agree with HST Cepheids?

Yes. At ~0.03 mag level, much smaller than tension (0.18 mag).



Is there evidence of non-linearity in HST Cepheids?

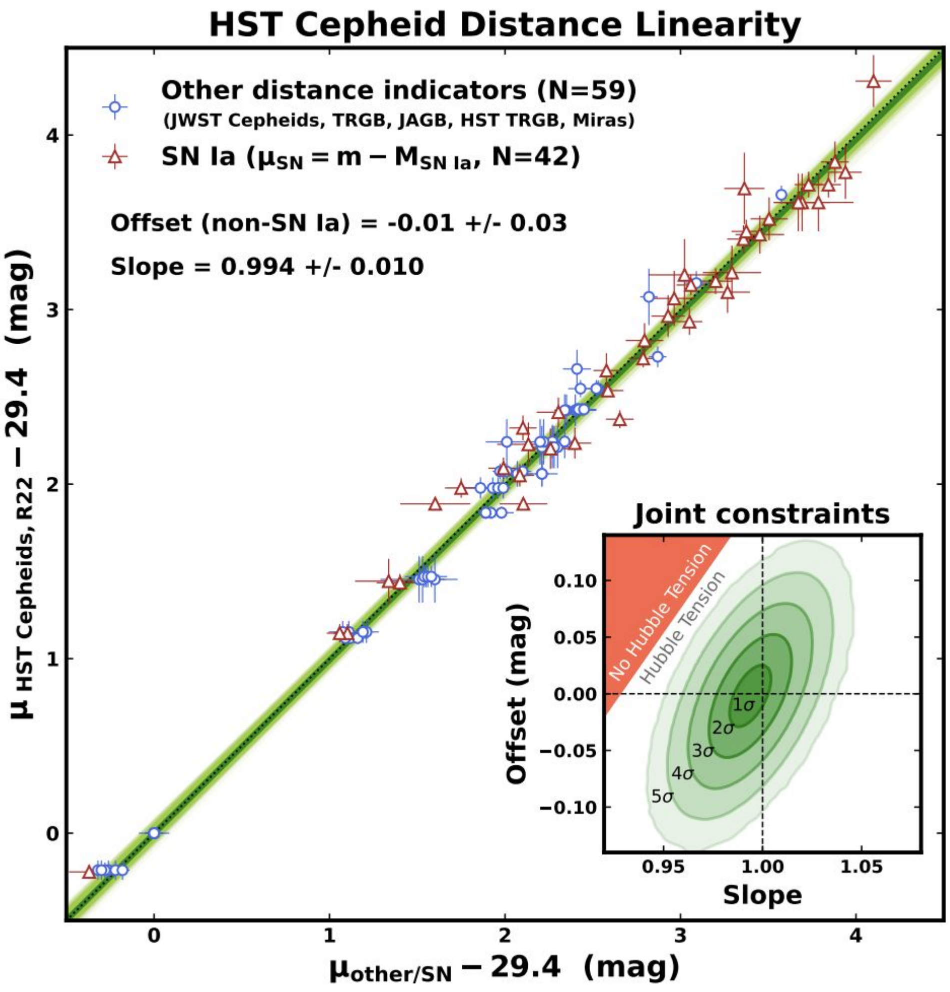
Not at all.

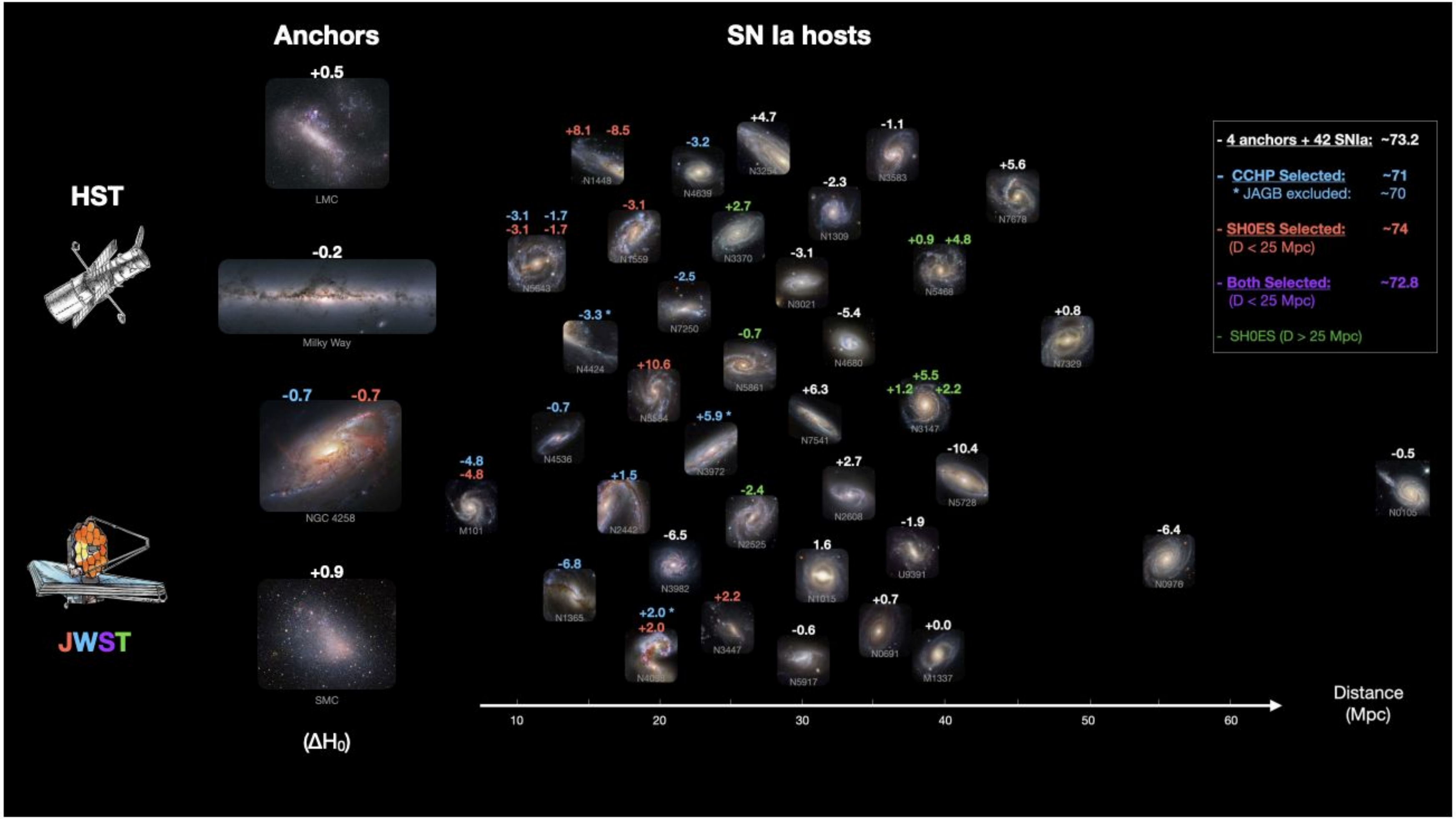


Is there evidence of non-linearity in HST Cepheids?

Not at all.

So where could different final H0 values come from?



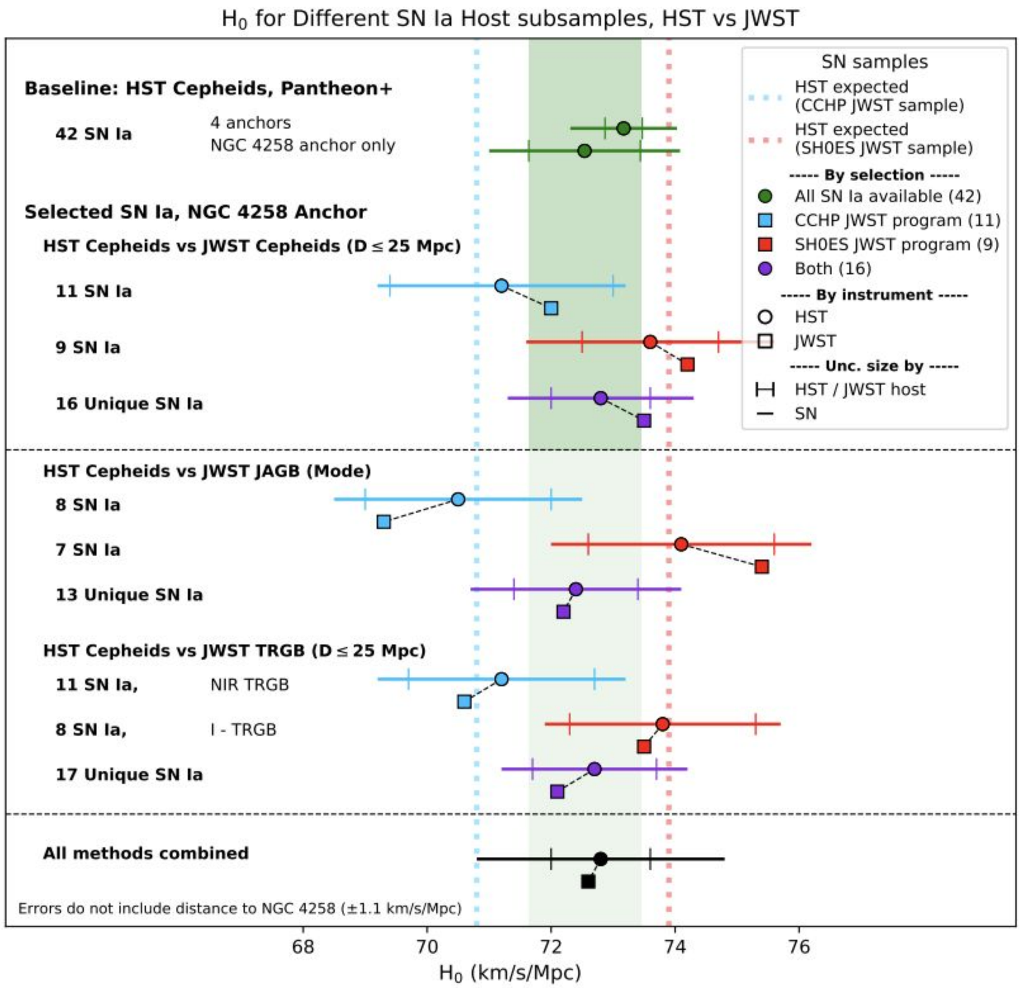


Anchors
SN Ia hosts
HST
JWST
+0.5
LMC
-0.2
Milky Way
-0.7 -0.7
NGC 4258
+0.9
SMC
(ΔH0)
- 4 anchors + 42 SNIa: ~73.2
- CCHP Selected: ~71
* JAGB excluded: ~70
- SH0ES Selected: ~74
(D < 25 Mpc)
- Both Selected: ~72.8
(D < 25 Mpc)
- SH0ES (D > 25 Mpc)
+8.1 -8.5
N1448
-3.2
N4639
+4.7
N3254
-1.1
N3583
+5.6
N7678
-3.1 -1.7
-3.1 -1.7
N5643
-3.1
N1559
+2.7
N3370
-2.3
N1309
-3.1
N3021
+0.9 +4.8
N5468
-2.5
N7250
-3.3 *
N4424
-0.7
N5861
-5.4
N4680
+0.8
N7329
+10.6
+6.3
N7541
+5.5
+1.2 +2.2
N3147
-0.7
N4536
+5.9 *
N3972
-4.8
-4.8
M101
+1.5
N2442
-2.4
N2525
+2.7
N2608
-10.4
N5728
-0.5
N0105
-6.5
N3982
1.6
N1015
-1.9
U9391
-6.4
N0976
-6.8
N1365
+2.0 *
+2.0
+2.2
N3447
-0.6
N5917
+0.7
N0691
+0.0
M1337
10
20
30
40
50
60
Distance
(Mpc)

So where could different final H0 values come from?

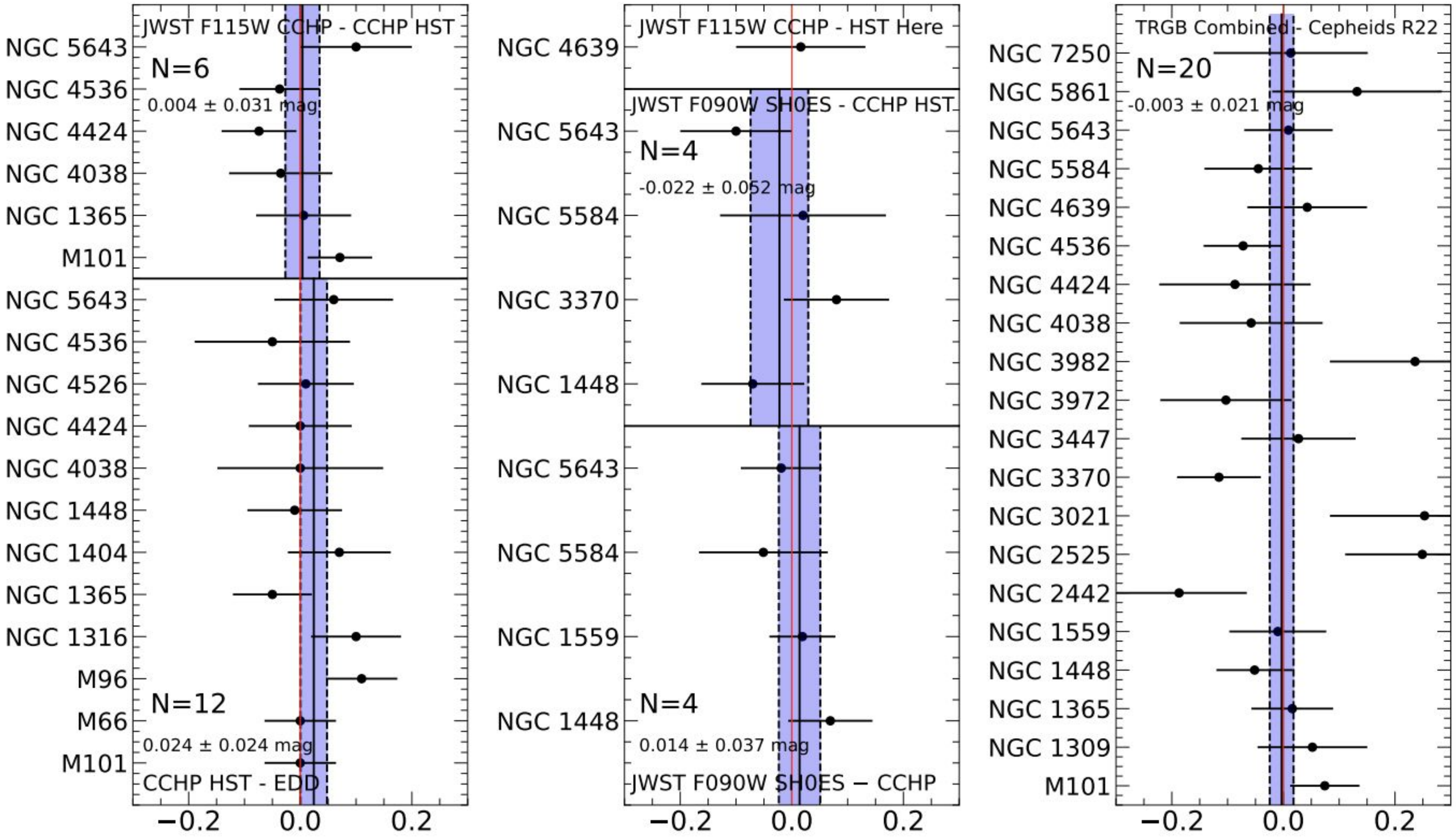
Breaking large sample into small subsamples will produce fluctuations, differences in H0 can be predicted and recovered!

Main story: JWST great crosscheck of HST, and with combined sample H0 agreement.



The agreement between Cepheids and TRGB in 2nd rung now excellent: https://arxiv.org/abs/2504.08921 (Siyang Li et al)

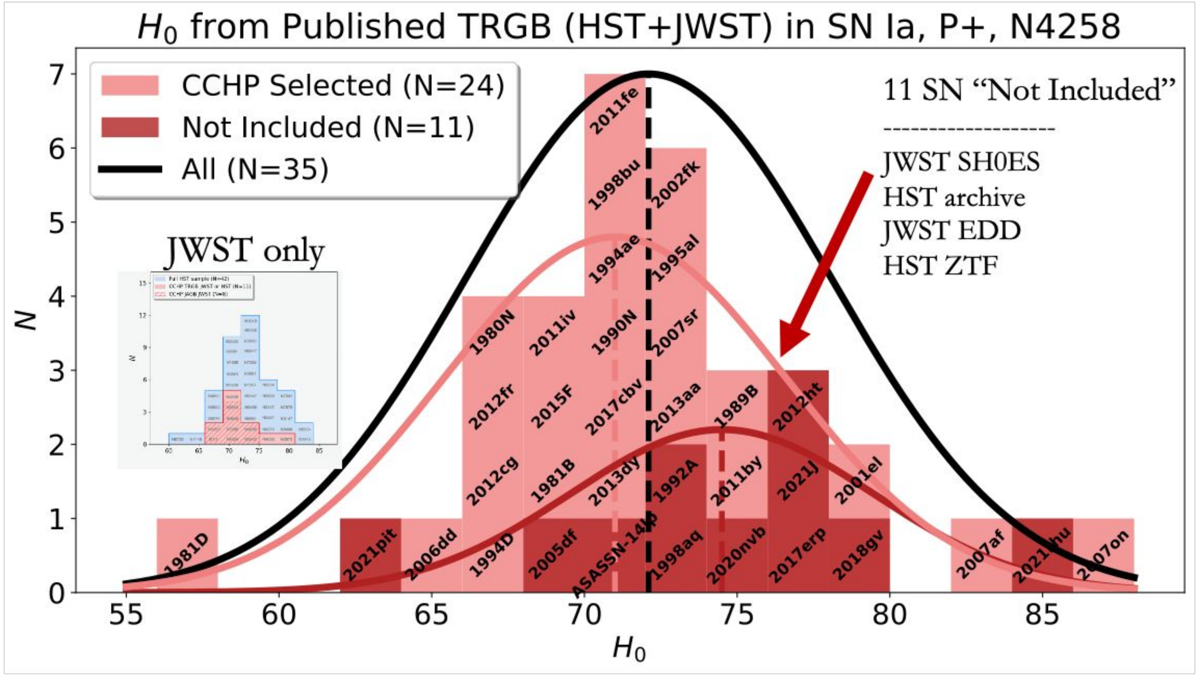
•



Selection of SN Subsamples Explains Remaining Differences in H_0 *

ALL TRGB Sample HST+JWST **N=35** $H_0 \rightarrow 72+$, CCHP subsample less by~1.5 (Li+2025)

No reason not to use full sample



*Smaller: Differences in H_0 between CSP I+II vs Pantheon+ & pec vel corr. at ~0.5 level

See also for an outsiders take:

If Hubble Tension is right, should show up in many different ways/techniques.

[Submitted on 25 Aug 2024]

DESI Peculiar Velocity Survey -- Fundamental Plane

Khaled Said, Cullan Howlett, Tamara Davis, John Lucey, Christoph Saulder, Kelly Douglass, Alex G. Kim, Anthony Kremin, Caitlin Ross, Greg Aldering, Jessica Nicole Aguilar, Steven Ahlen, Segev BenZvi, Davide Bianchi, David Brooks, Todd Claybaugh, Kyle Dawson, Axel de la Macorra, Biprateep Dey, Peter Doel, Kevin Fanning, Simone Ferraro, Andreu Font-Ribera, Jaime E. Forero-Romero, Enrique Gaztañaga, Satya Gontcho A Gontcho, Julien Guy, Klaus Honscheid, Robert Kehoe, Theodore Kisner, Andrew Lambert, Martin Landriau, Laurent Le Guillou, Marc Manera, Aaron Meisner, Ramon Miquel, John Moustakas, Andrea Muñoz-Gutiérrez, Adam Myers, Jundan Nie, Nathalie Palanque-Delabrouille, Will Percival, Francisco Prada, Graziano Rossi, Eusebio Sanchez, David Schlegel, Michael Schubnell, Joseph Harry Silber, David Sprayberry, Gregory Tarlé, Mariana Vargas Magana, Benjamin Alan Weaver, Risa Wechsler, Zhimin Zhou, Hu Zou

The Dark Energy Spectroscopic Instrument (DESI) Peculiar Velocity Survey aims to measure the peculiar velocities of early and late type galaxies within the DESI footprint using both the Fundamental Plane and Tully-Fisher relations. Direct measurements of peculiar velocities can significantly improve constraints on the growth rate of structure, reducing uncertainty by a factor of approximately 2.5 at redshift 0.1 compared to the DESI Bright Galaxy Survey's redshift space distortion measurements alone. We assess the quality of stellar velocity dispersion measurements from DESI spectroscopic data. These measurements, along with photometric data from the Legacy Survey, establish the Fundamental Plane relation and determine distances and peculiar velocities of early-type galaxies. During Survey Validation, we obtain spectra for 6698 unique early-type galaxies, up to a photometric redshift of 0.15. 64\% of observed galaxies (4267) have relative velocity dispersion errors below 10\%. This percentage increases to 75\% if we restrict our sample to galaxies with spectroscopic redshifts below 0.1. We use the measured central velocity dispersion, along with photometry from the DESI Legacy Imaging Surveys, to fit the Fundamental Plane parameters using a 3D Gaussian maximum likelihood algorithm that accounts for measurement uncertainties and selection cuts. In addition, we conduct zero-point calibration using the absolute distance measurements to the Coma cluster, leading to a value of the Hubble constant, $H_0 = 76.05 \pm 0.35$ (statistical) ± 0.49(systematic FP) ± 4.86(statistical due to calibration) $\mathrm{km\ s^{-1}\ Mpc^{-1}}$. This H_0 value is within 2σ of Planck Cosmic Microwave Background results and within 1σ, of other low redshift distance indicator-based measurements.

Draft version September 22, 2024
Typeset using LaTeX twocolumn style in AASTeX631

The Hubble Tension in our own Backyard: DESI and the Nearness of the Coma Cluster

Daniel Scolnic,[1] Adam G. Riess,[2,3] Yukei S. Murakami,[3] Erik R. Peterson,[1] Dillon Brout,[4] Maria Acevedo,[1]
Bastien Carreres,[1] David O. Jones,[5] Khaled Said,[6,7] and Cullan Howlett[6,7]

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[2] Space Telescope Science Institute, Baltimore, MD 21218, USA
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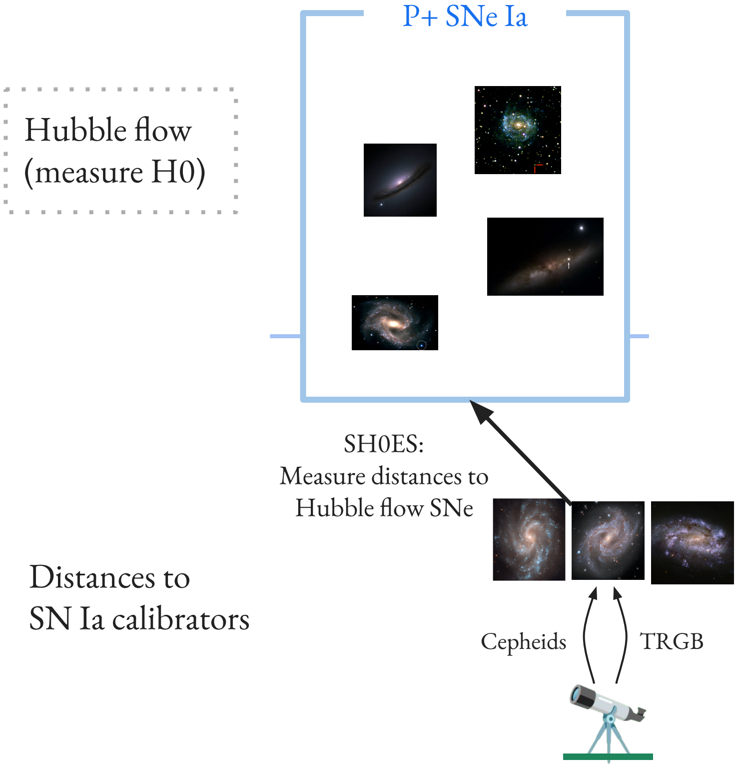
[6] School of Mathematics and Physics, University of Queensland, Brisbane, QLD 4072, Australia
[7] OzGrav: The ARC Centre of Excellence for Gravitational Wave Discovery, Hawthorn, VIC 3122, Australia

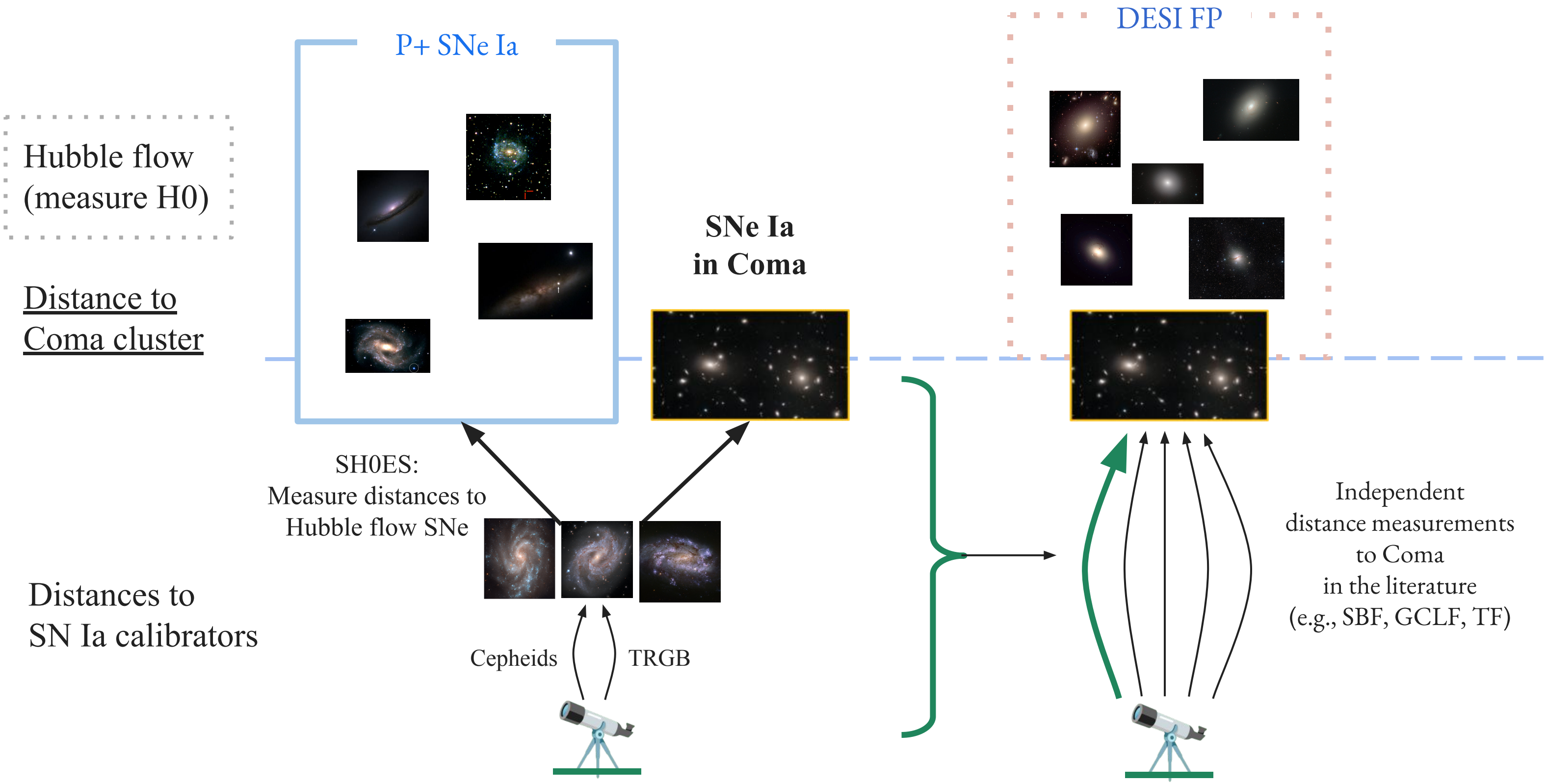
ABSTRACT

The Dark Energy Spectroscopic Instrument (DESI) collaboration measured a tight relation between the Hubble constant (H_0) and the distance to the Coma cluster using the fundamental plane (FP) relation of the deepest, most homogeneous sample of early-type galaxies. To determine H_0, we measure the distance to Coma by several independent routes each with its own geometric reference. We measure the most precise distance to Coma from 12 Type Ia Supernovae (SNe Ia) in the cluster with mean standardized brightness of $m_B^0 = 15.712 \pm 0.041$ mag. Calibrating the absolute magnitude of SNe Ia with the *HST* distance ladder yields $D_{Coma} = 98.5 \pm 2.2$ Mpc, consistent with its canonical value of 95–100 Mpc. This distance results in $H_0 = 76.5 \pm 2.2$ km/s/Mpc from the DESI FP relation. Inverting the DESI relation by calibrating it instead to the Planck+ΛCDM value of $H_0 = 67.4$ km/s/Mpc implies a much greater distance to Coma, $D_{Coma} = 111.8 \pm 1.8$ Mpc, 4.6σ beyond a joint, direct measure. Independent of SNe Ia, the *HST* Key Project FP relation as calibrated by Cepheids, Tip of the Red Giant Branch from *JWST*, or *HST* NIR surface brightness fluctuations all yield $D_{Coma} <$ 100 Mpc, in joint tension themselves with the Planck-calibrated route at $> 3\sigma$. From a broad array of distance estimates compiled back to 1990, it is hard to see how Coma could be located as far as the Planck+ΛCDM expectation of >110 Mpc. By extending the Hubble diagram to Coma, a well-studied location in our own backyard whose distance was in good accord well before the Hubble Tension, DESI indicates a more pervasive conflict between our knowledge of local distances and cosmological expectations. We expect future programs to refine the distance to Coma and nearer clusters to help illuminate this new, local window on the Hubble Tension.

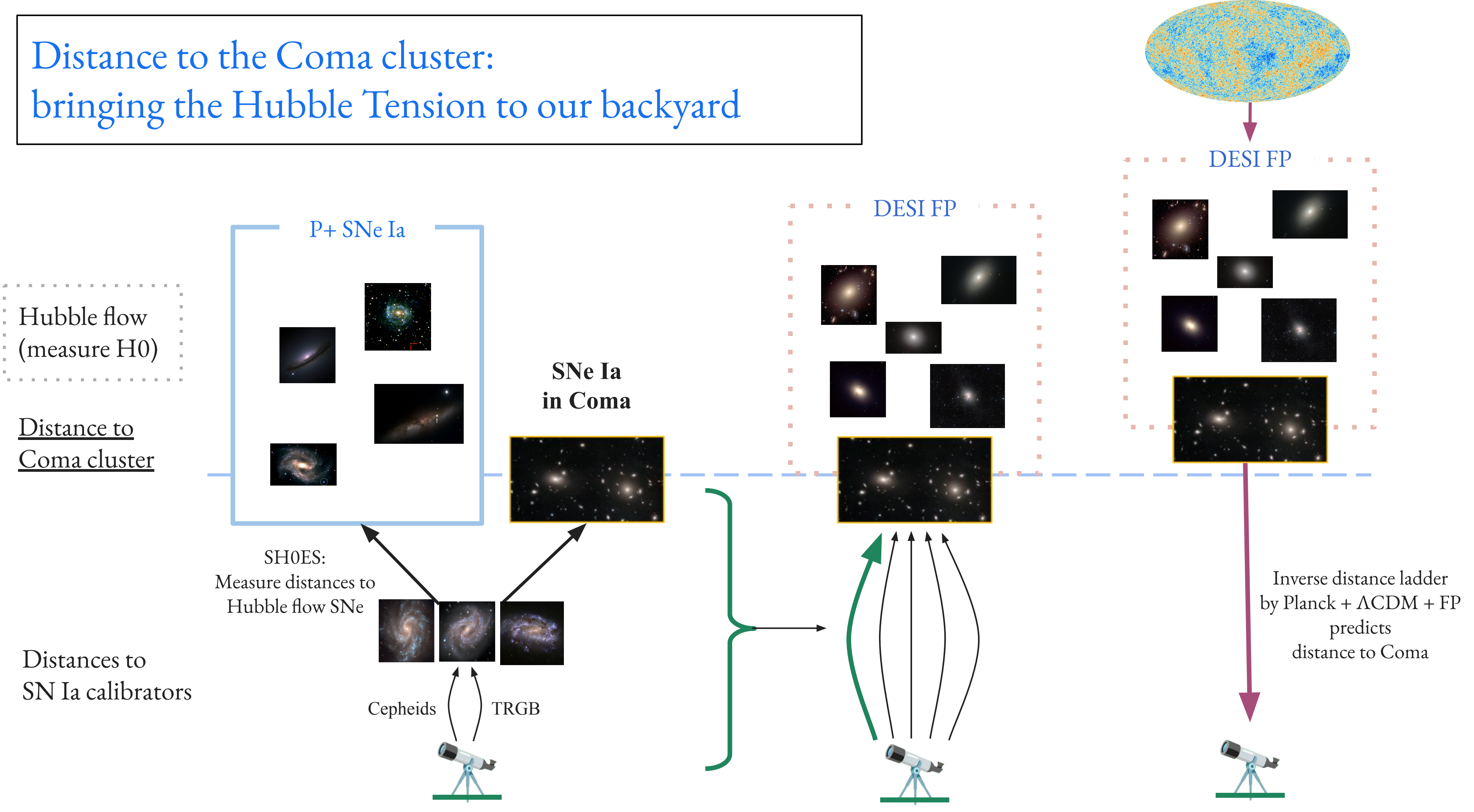
Distance to the Coma cluster: bringing the Hubble Tension to our backyard



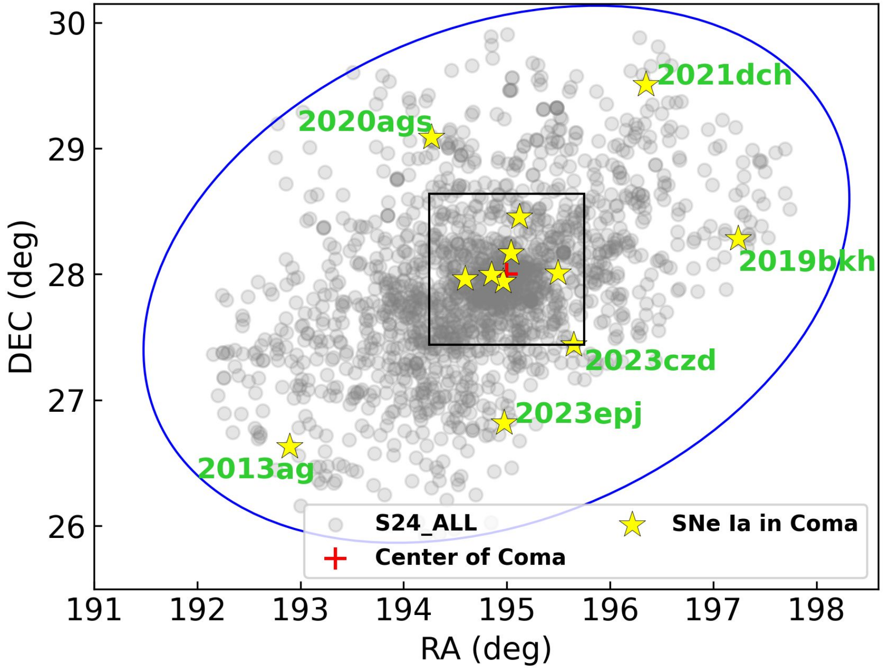
Distance to the Coma cluster: bringing the Hubble Tension to our backyard



Distance to the Coma cluster: bringing the Hubble Tension to our backyard



Step 1: Find SNe Ia in Coma



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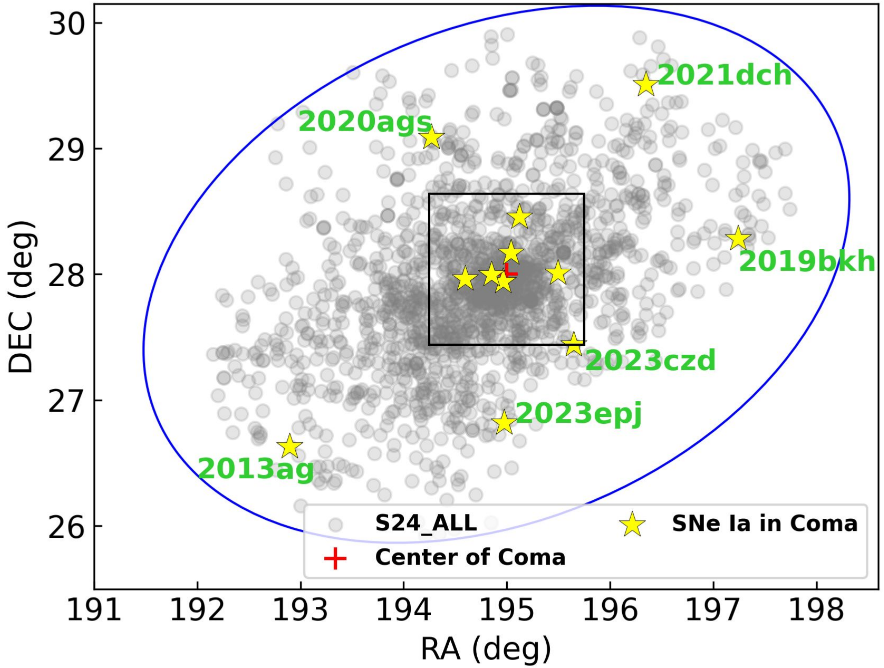
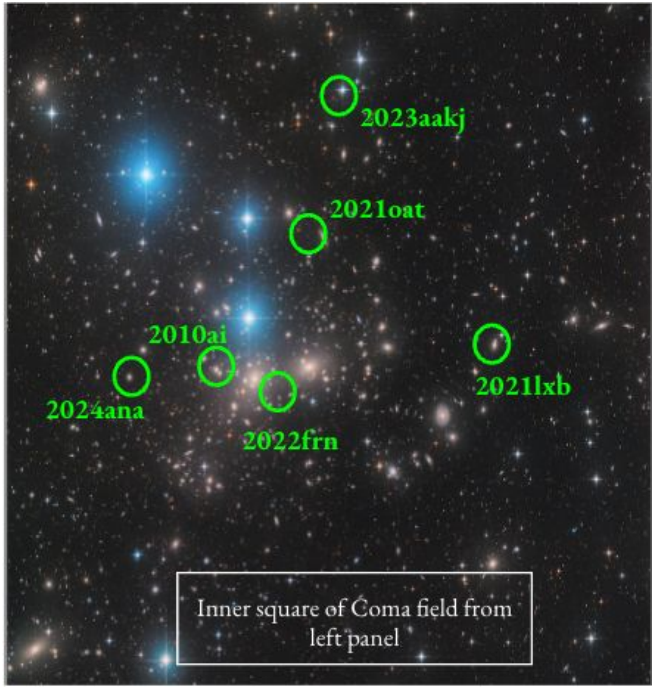
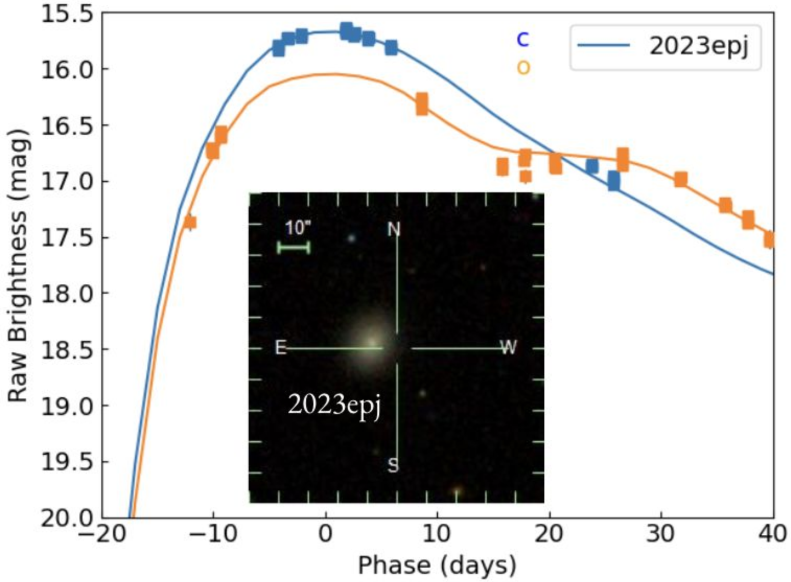
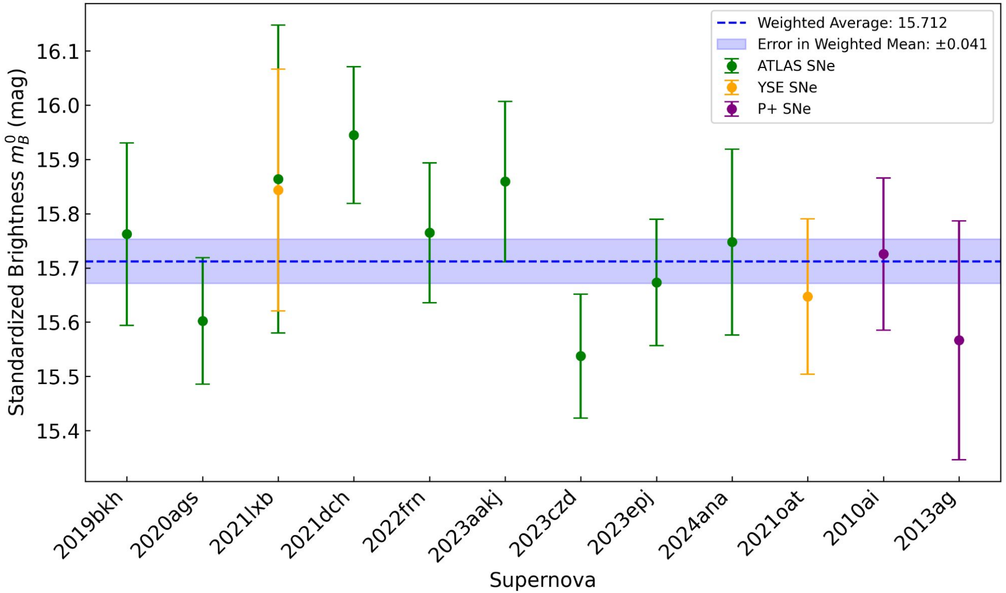


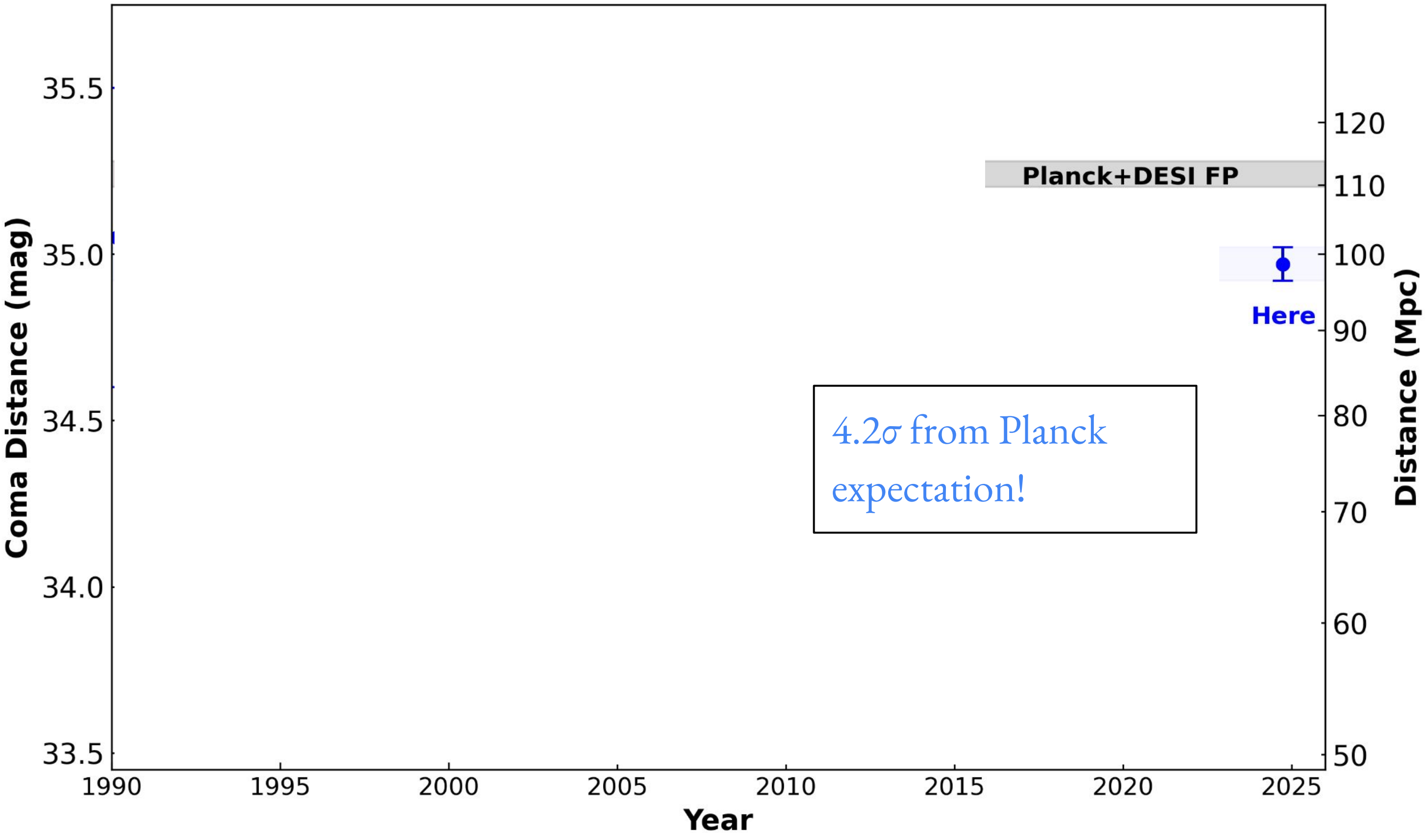


Step 2: Fit SNe Ia light curves, measure mean brightness.

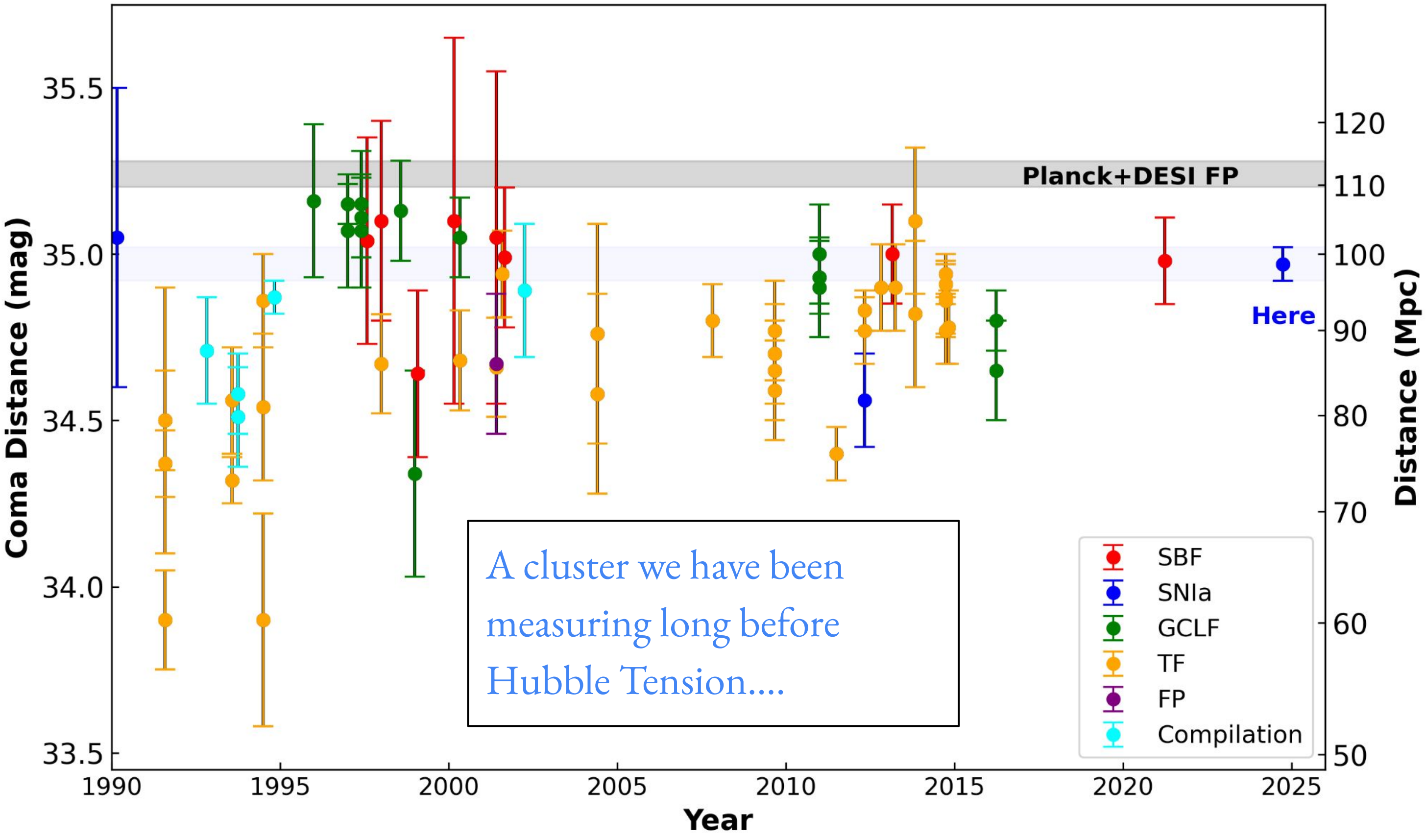




Step 3: Convert brightness to distance

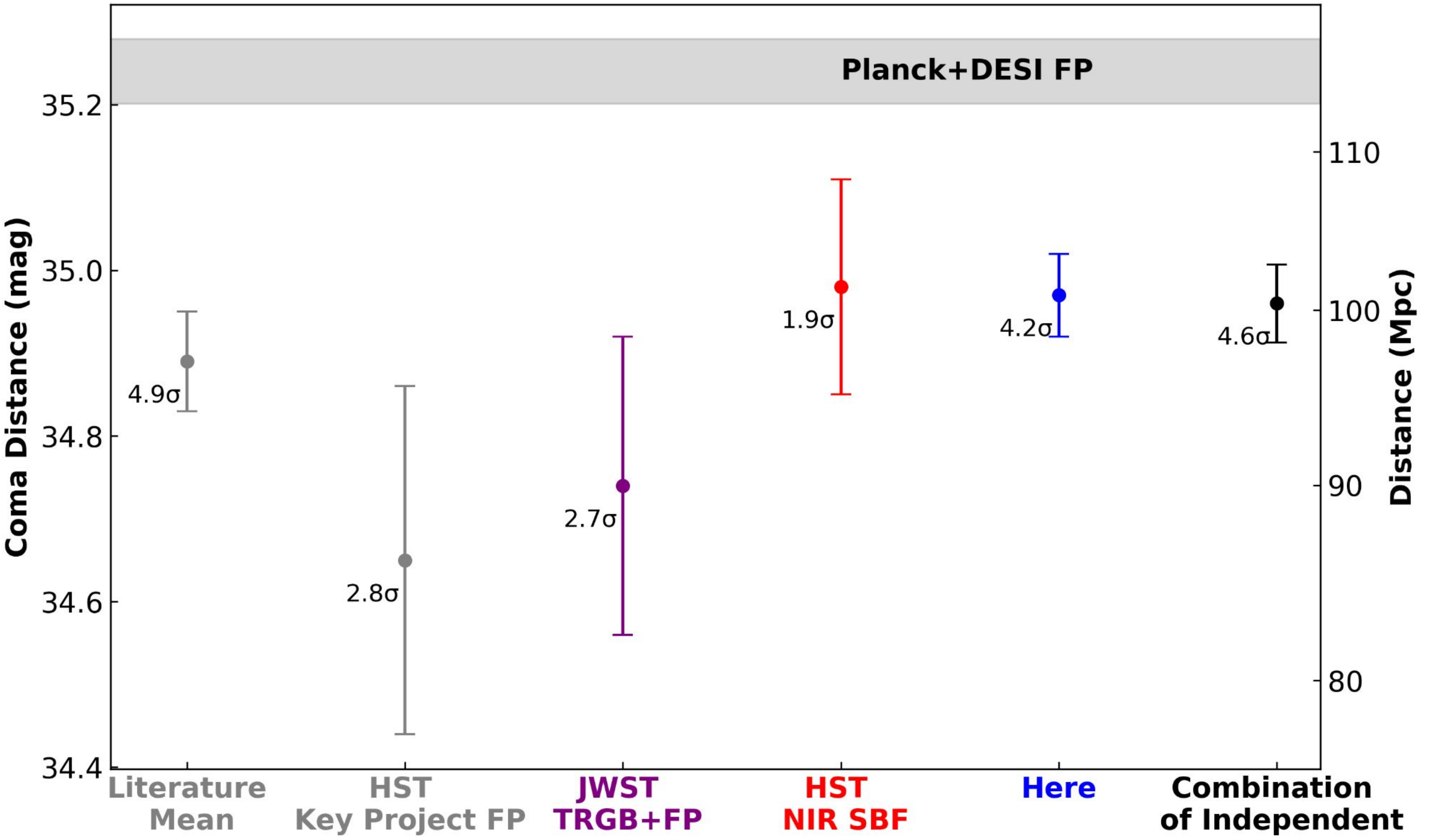


Step 3: Convert brightness to distance, compile other methods.



A cluster we have been measuring long before Hubble Tension….

We can reframe Hubble Tension: Measurements of nearby objects are closer than Planck+LCDM would predict.



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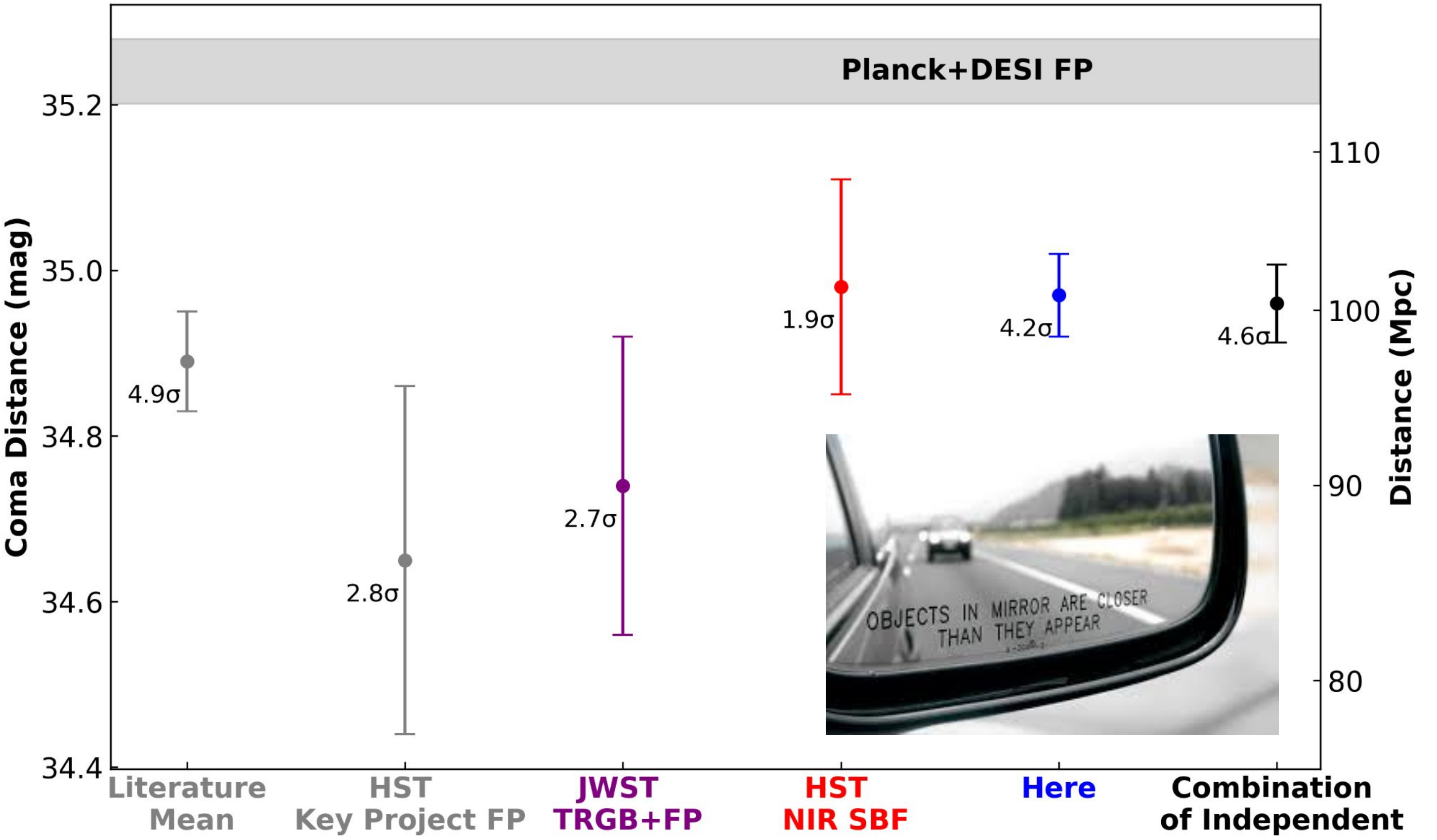

New Tully-Fisher Measurements

An improved Tully-Fisher estimate of H_0

Paula Boubel[1⋆], Matthew Colless[1], Khaled Said[2] and Lister Staveley-Smith[3]
[1]Research School of Astronomy and Astrophysics, The Australian National University, Mount Stromlo Observatory, Canberra, ACT 2611, Australia
[2]School of Mathematics and Physics, University of Queensland, Brisbane, QLD 4072, Australia
[3]International Centre for Radio Astronomy Research (ICRAR), University of Western Australia, 35 Stirling Hwy, Crawley, WA 6009, Australia

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ABSTRACT
We propose an improved comprehensive method for determining the Hubble constant (H_0) using the Tully-Fisher relation. By fitting a peculiar velocity model in conjunction with the Tully-Fisher relation, all available data can be used to derive self-consistent Tully-Fisher parameters. In comparison to previous approaches, our method offers several improvements: it can be readily generalised to different forms of the Tully-Fisher relation and its intrinsic scatter; it uses a peculiar velocity model to predict distances more accurately; it can account for all selection effects; it uses the entire dataset to fit the Tully-Fisher relation; and it is fully self-consistent. The Tully-Fisher relation zero-point is calibrated using the subset of galaxies with distances from absolute distance indicators. We demonstrate this method on the Cosmicflows-4 catalogue i-band and $W1$-band Tully-Fisher samples and show that the uncertainties from fitting the Tully-Fisher relation amount to only $0.2\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$. Using all available absolute distance calibrators, we obtain $H_0 = 73.3 \pm 2.1\,(\mathrm{stat}) \pm 3.5\,(\mathrm{sys})\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, where the statistical uncertainty is dominated by the small number of galaxies with absolute distance estimates. The substantial systematic uncertainty reflects inconsistencies between various zero-point calibrations of the Cepheid period–luminosity relation, the tip of the red giant branch standard candle, and the Type Ia supernova standard candle. However, given a reliable set of absolute distance calibrators, our method promises enhanced precision in H_0 measurements from large new Tully-Fisher samples such as the WALLABY survey.

New Tully-Fisher Measurements

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Paula Boubel[1★], Matthew Colless[1], Khaled Said[2] and Lister Staveley-Smith[3]
[1]*Research School of Astronomy and Astrophysics, The Australian National University, Mount Stromlo Observatory, Canberra, ACT 2611, Australia*
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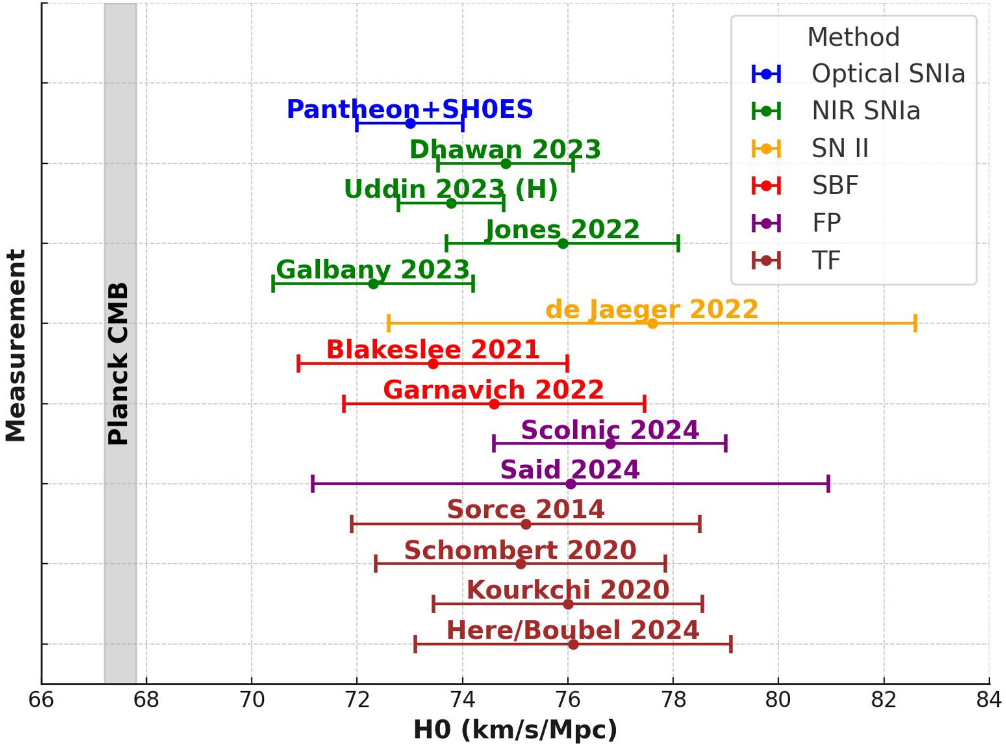
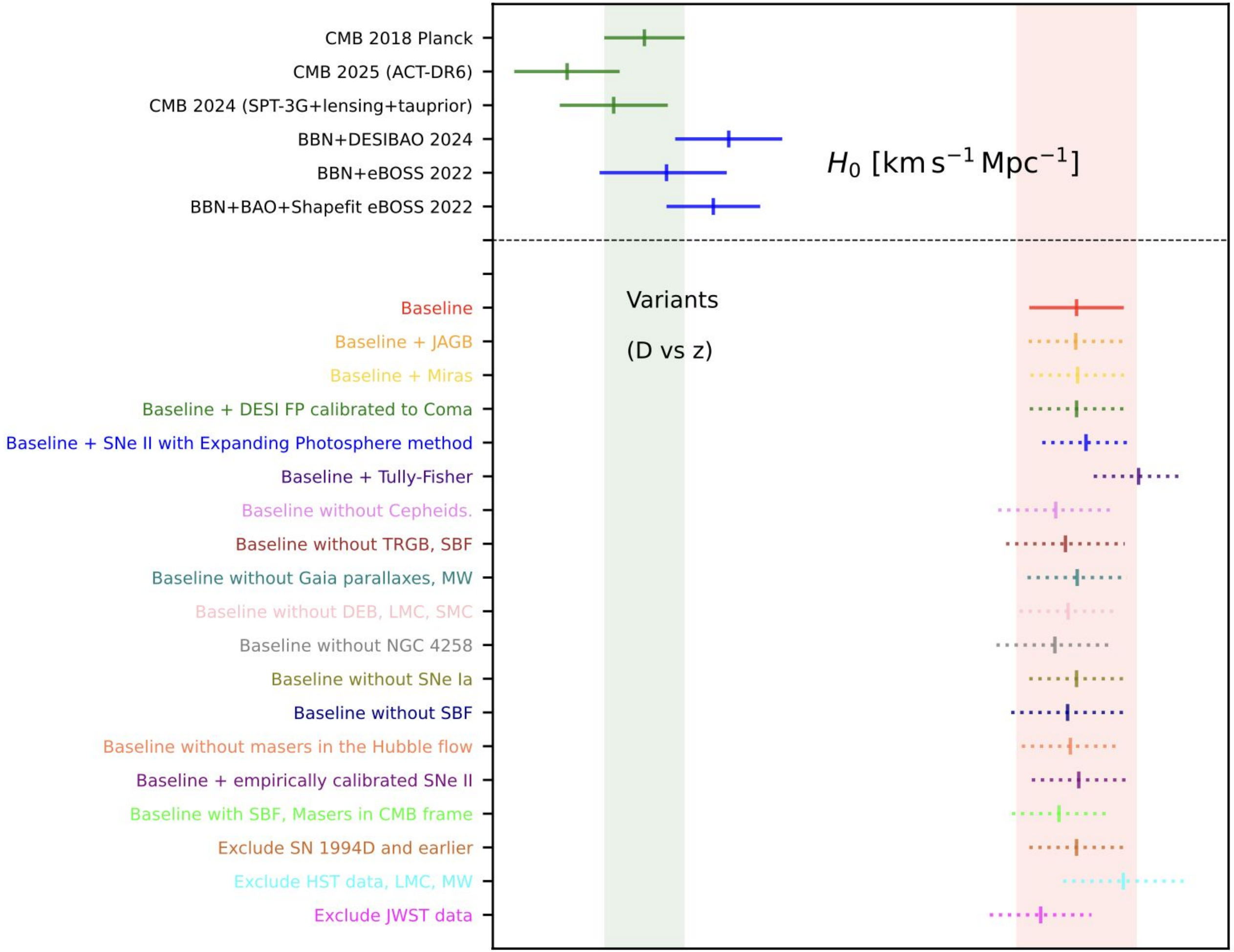


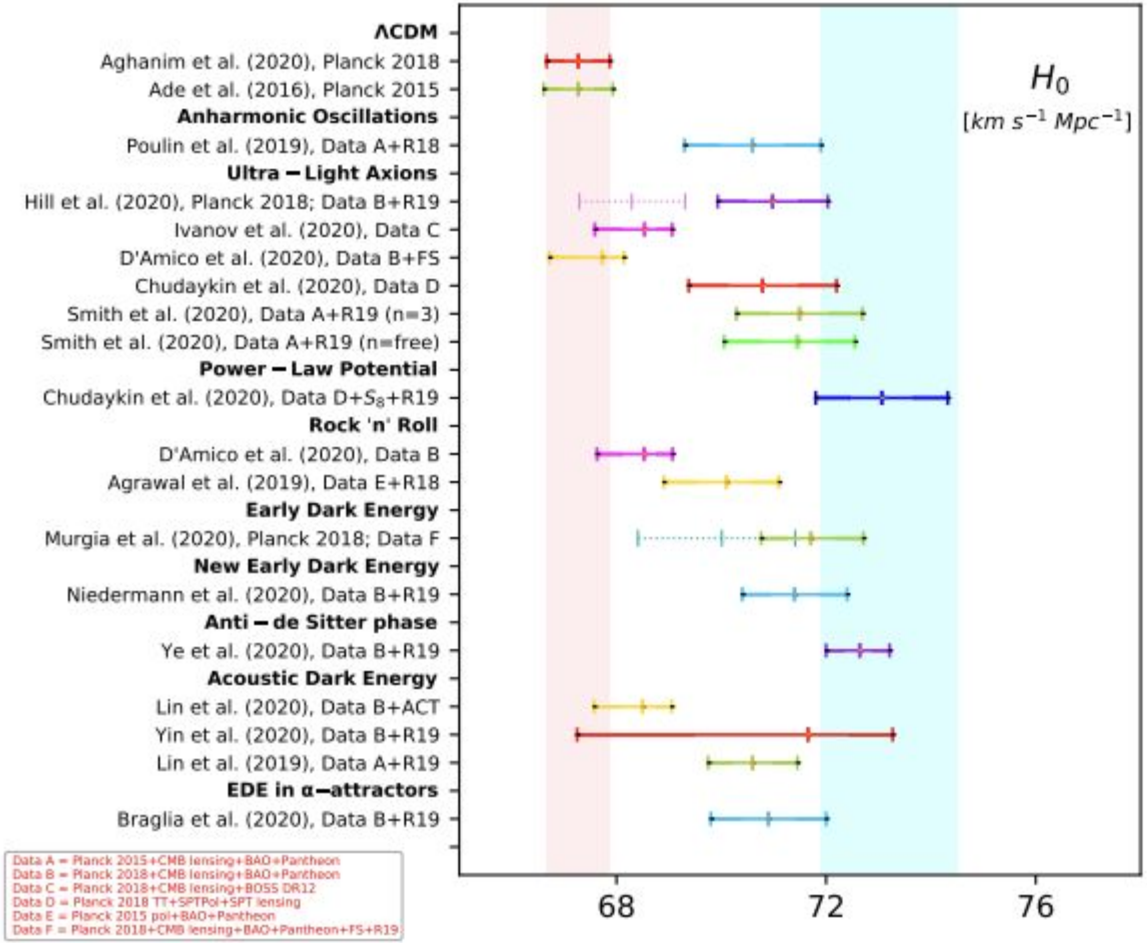
Pantheon+SH0ES H0
looks a little ... low

Before I end, one advertisement for the " Team (Casertano et al.) - Full covariance matrix of many techniques.



Assuming real, what could be causing H_0 tension?

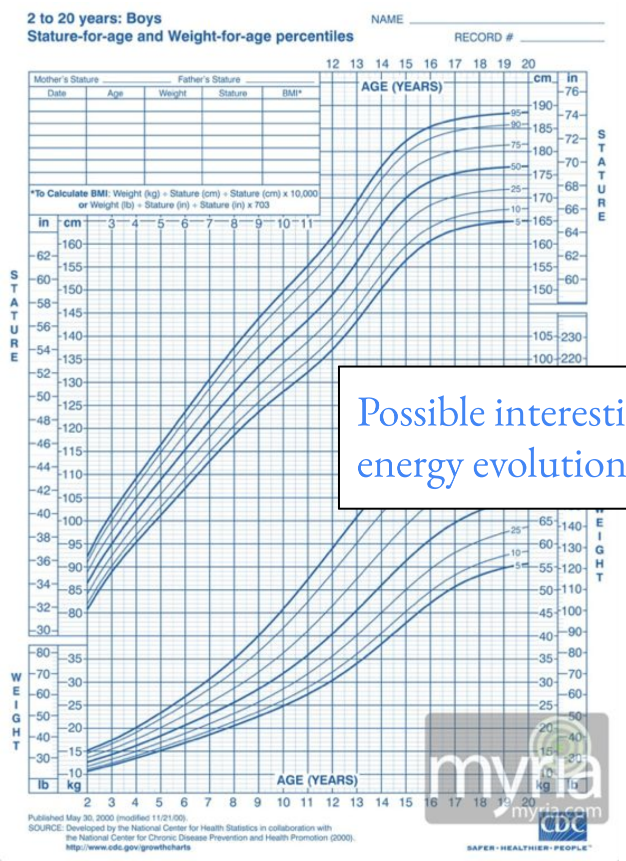
Still not a great theory out there..



Di Valentino ea. 2021.

Assuming real, what could be causing H_0 tension?

With new DESI measurements, local universe looks.. normal.



Possible interesting dark energy evolution?

Interesting possibilities of early dark energy, strange neutrino properties..

I hope to hear more this week!