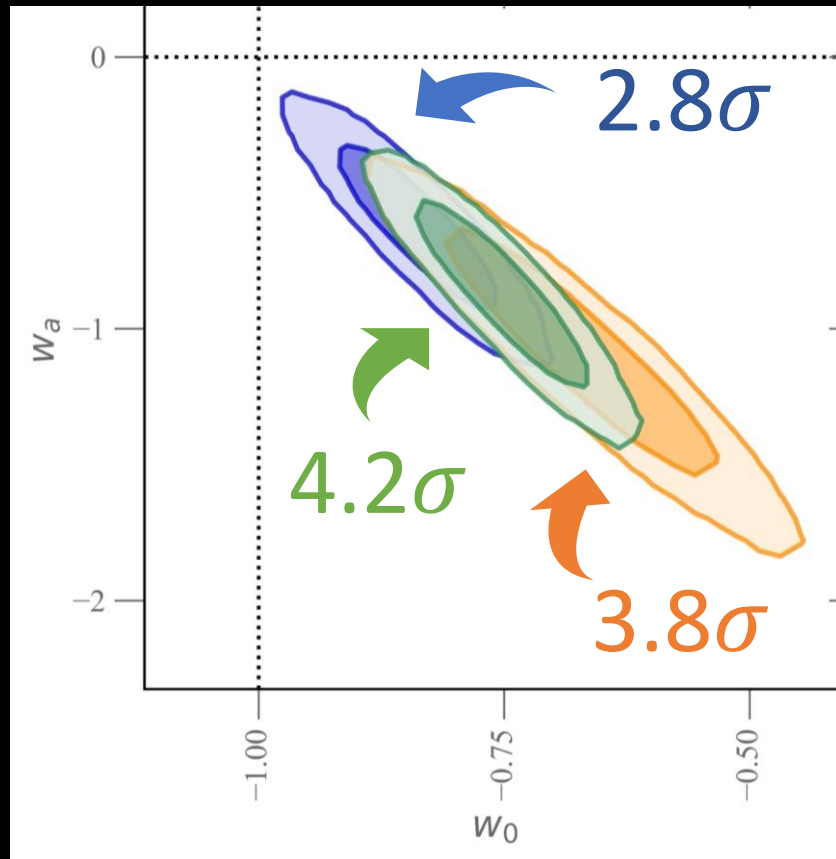

Are SN Ia safe?



Paul Shah

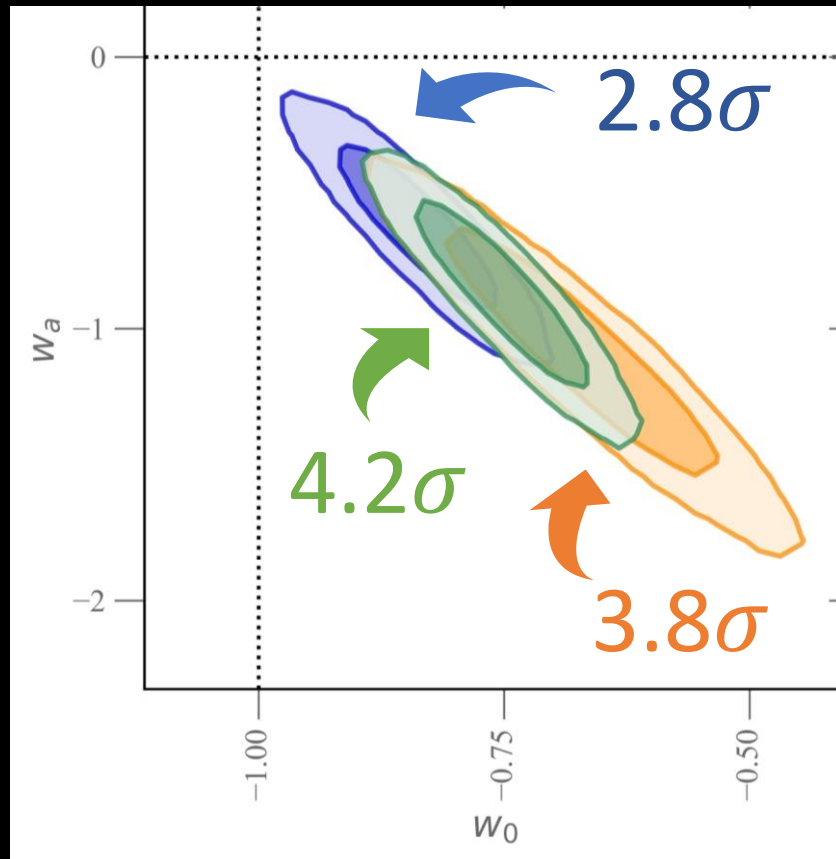


SN in early 2025

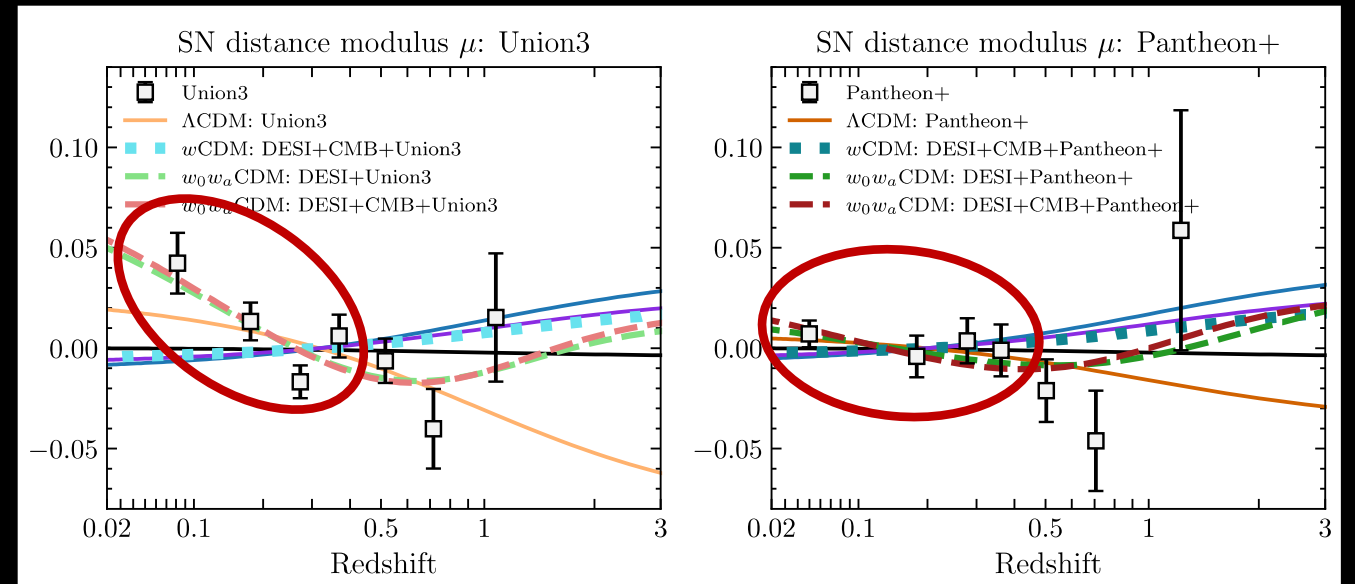


CMB+DESI DR2+Pantheon+
CMB+DESI DR2+Union3
CMB+DESI DR2+DES-5Y

SN in early 2025

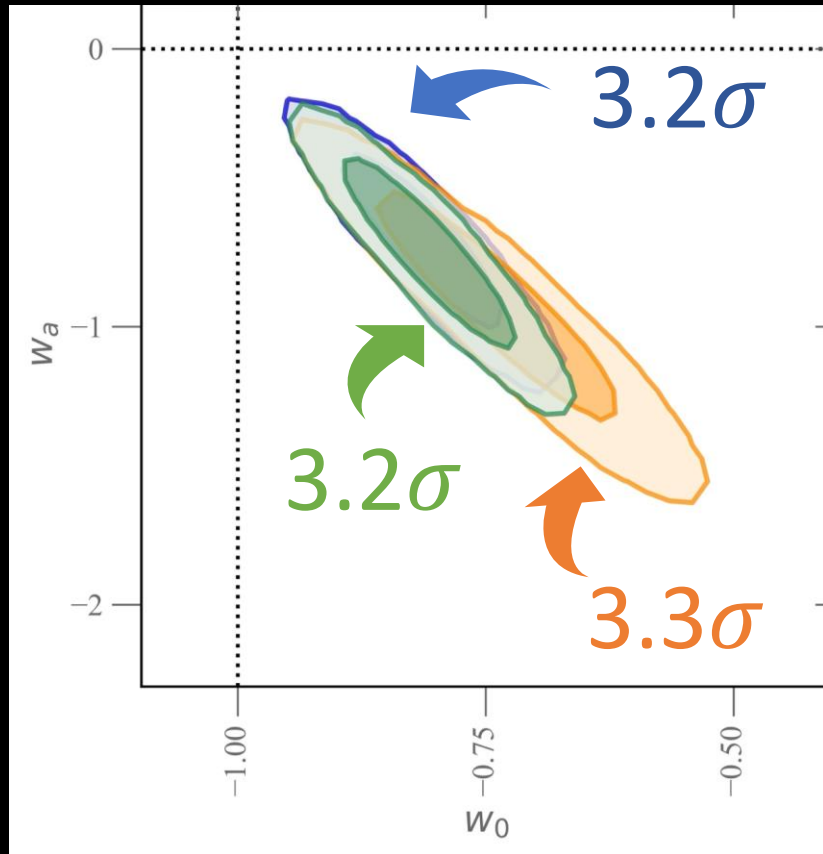


CMB+DESI DR2+Pantheon+
CMB+DESI DR2+Union3
CMB+DESI DR2+DES-5Y



- Strong evidence for w_0w_a requires sub 1% accuracy

SN today



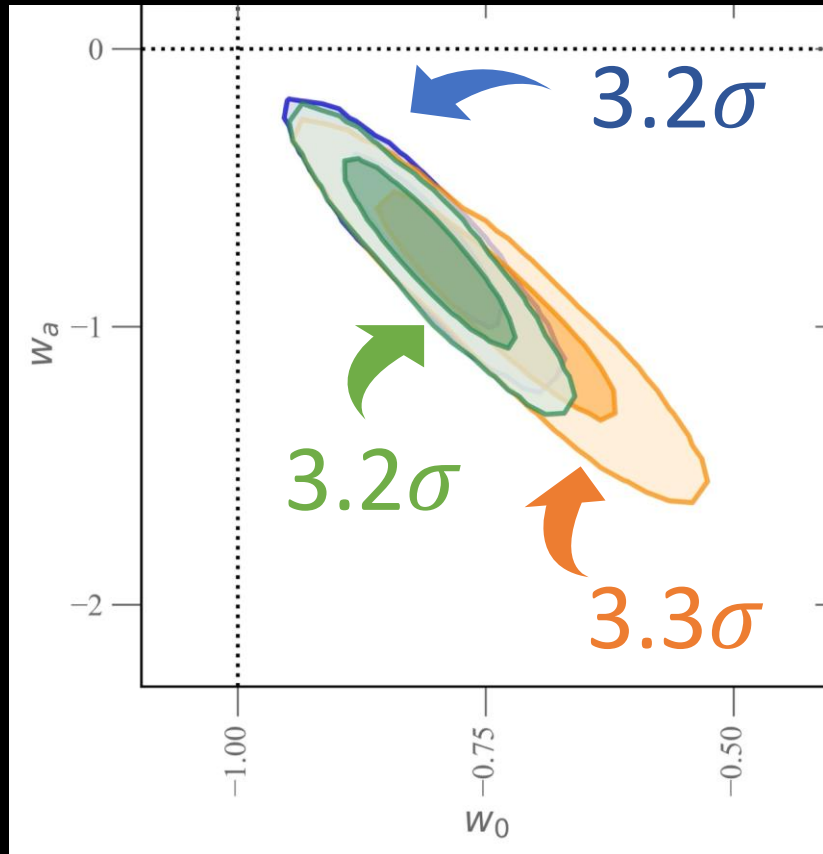
- Same data !

CMB+DESI DR2+Pantheon+ (new hostmass)

CMB+DESI DR2+Union3.1 (two population)

CMB+DESI DR2+DES-Dovekie (photometry)

SN today



- Same data !

Strong Progenitor Age-bias in Supernova Cosmology. II. Alignment with DESI BAO and Signs of a Non-Accelerating Universe

Junhyuk Son,^{*} Young-Wook Lee,[†] Chul Chung,[‡] Seunghyun Park and Hyejeon Cho
Department of Astronomy & Center for Galaxy Evolution Research, Yonsei University, Seoul 03722, Republic of Korea

Evolving Dark Energy or Supernovae Systematics?

George Efstathiou

Kavli Institute for Cosmology Cambridge and Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA.

The axis of systematic bias in SN Ia cosmology and implications for DESI 2024 results

Suhail Dhawan,^{1*} Brodie Popovic,² Ariel Goobar³

¹*Institute of Astronomy and Kavli Institute for Cosmology, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK*

²*Universite Claude Bernard Lyon 1, CNRS, IP2I Lyon / IN2P3, IMR 5822, F-69622 Villeurbanne, France*

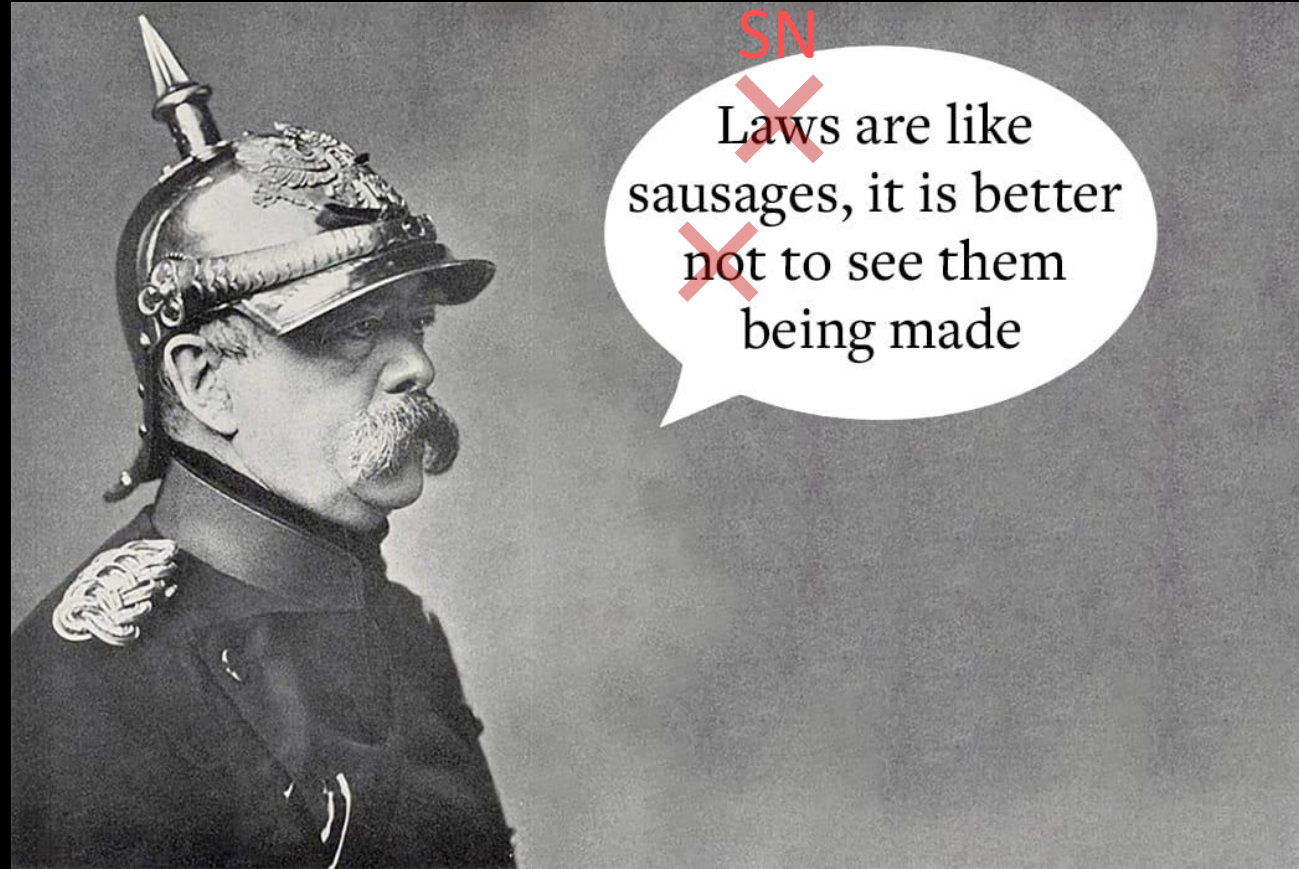
³*The Oskar Klein Centre for Cosmoparticle Physics, Department of Physics, Stockholm University, SE-10691 Stockholm, Sweden*

CMB+DESI DR2+Pantheon+ (new hostmass)

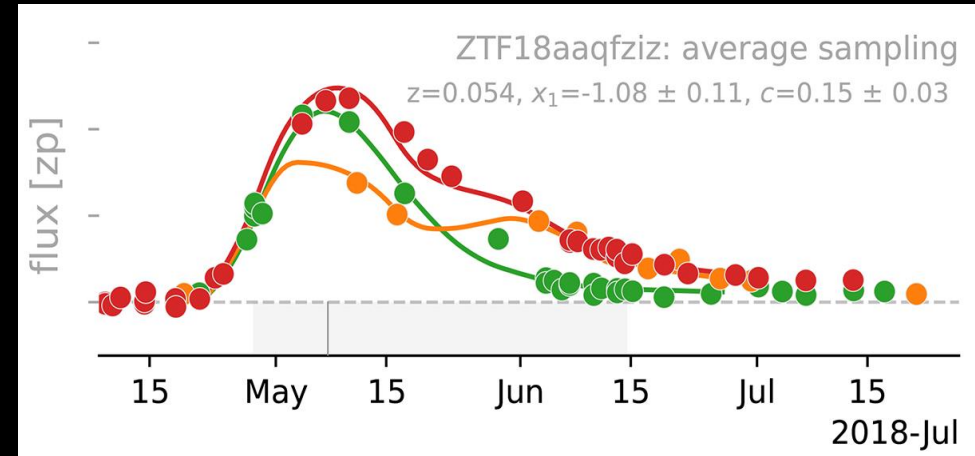
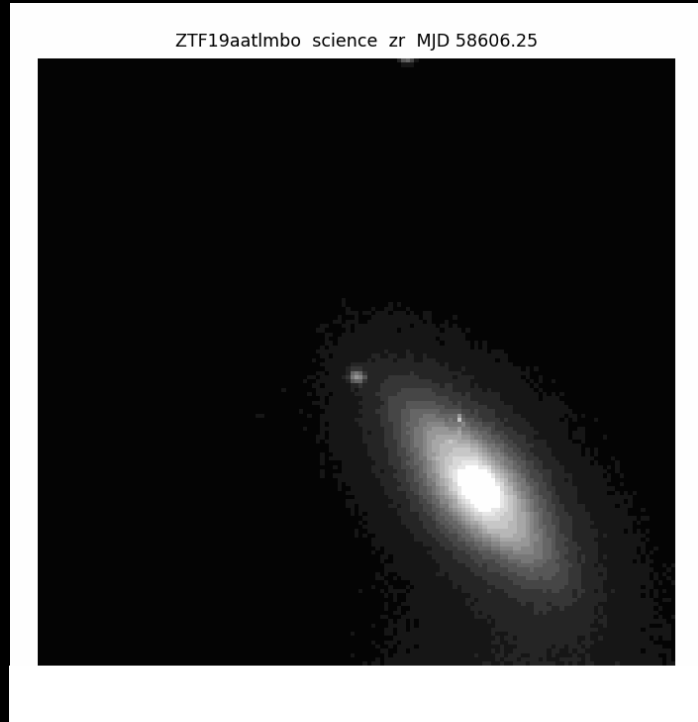
CMB+DESI DR2+Union3.1 (two population)

CMB+DESI DR2+DES-Dovekie (photometry)

What's in the sausage?



SN light curves and environment



Rigault++2025



Light curves

Environment (host galaxy, foreground)

SN are rare : merge multiple surveys

Each filter system

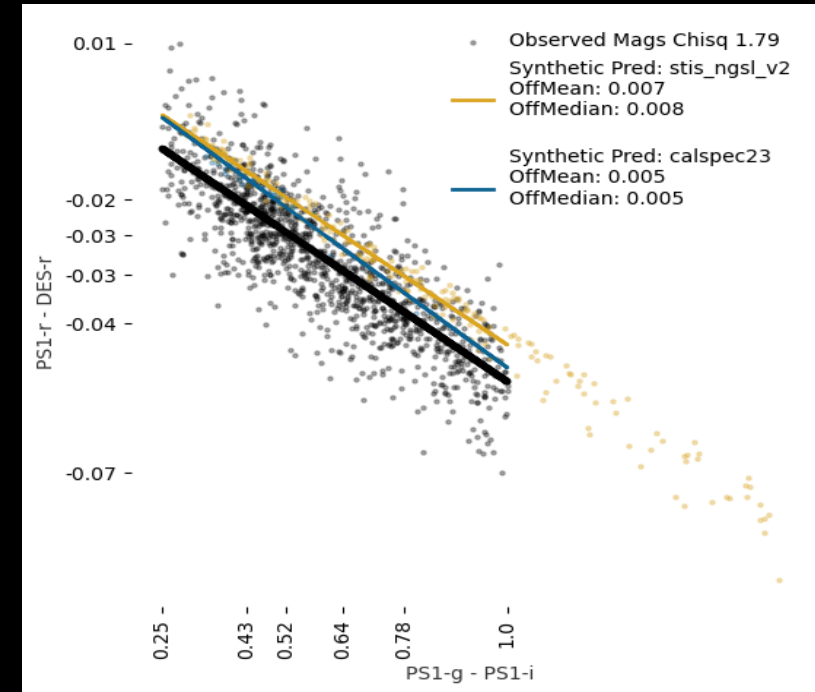


+ standard stars

Adjust passbands to match observations



Common photometric system



Popovic++2024

DES-5Y used the same model as Pantheon+

DES-Dovekie improves the calibration

Each filter system

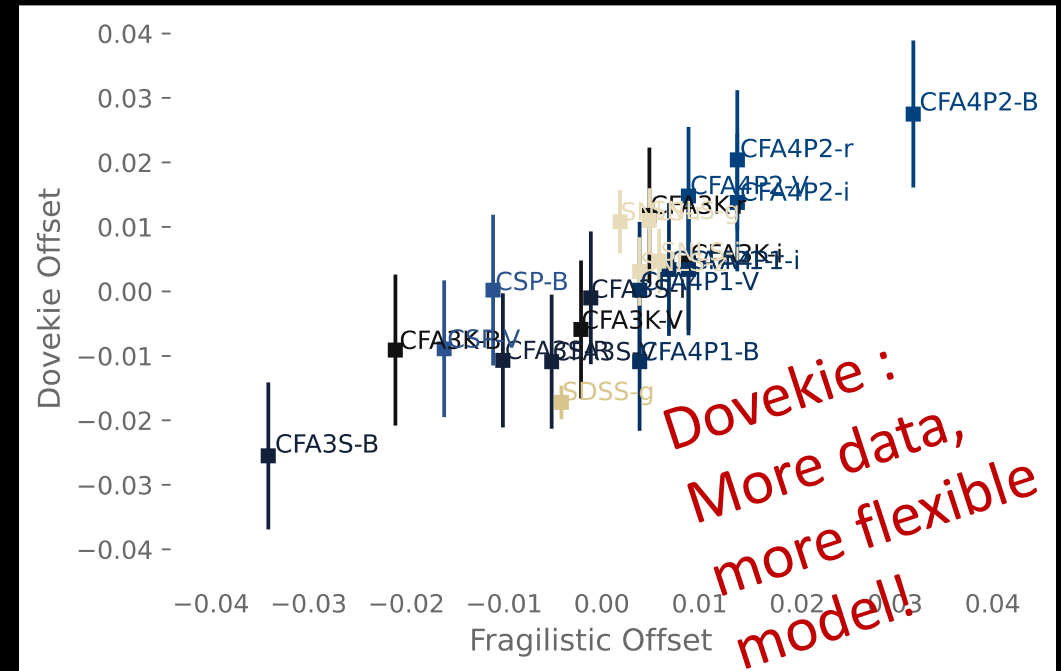


+ standard stars

Adjust passbands to match observations



Common photometric system

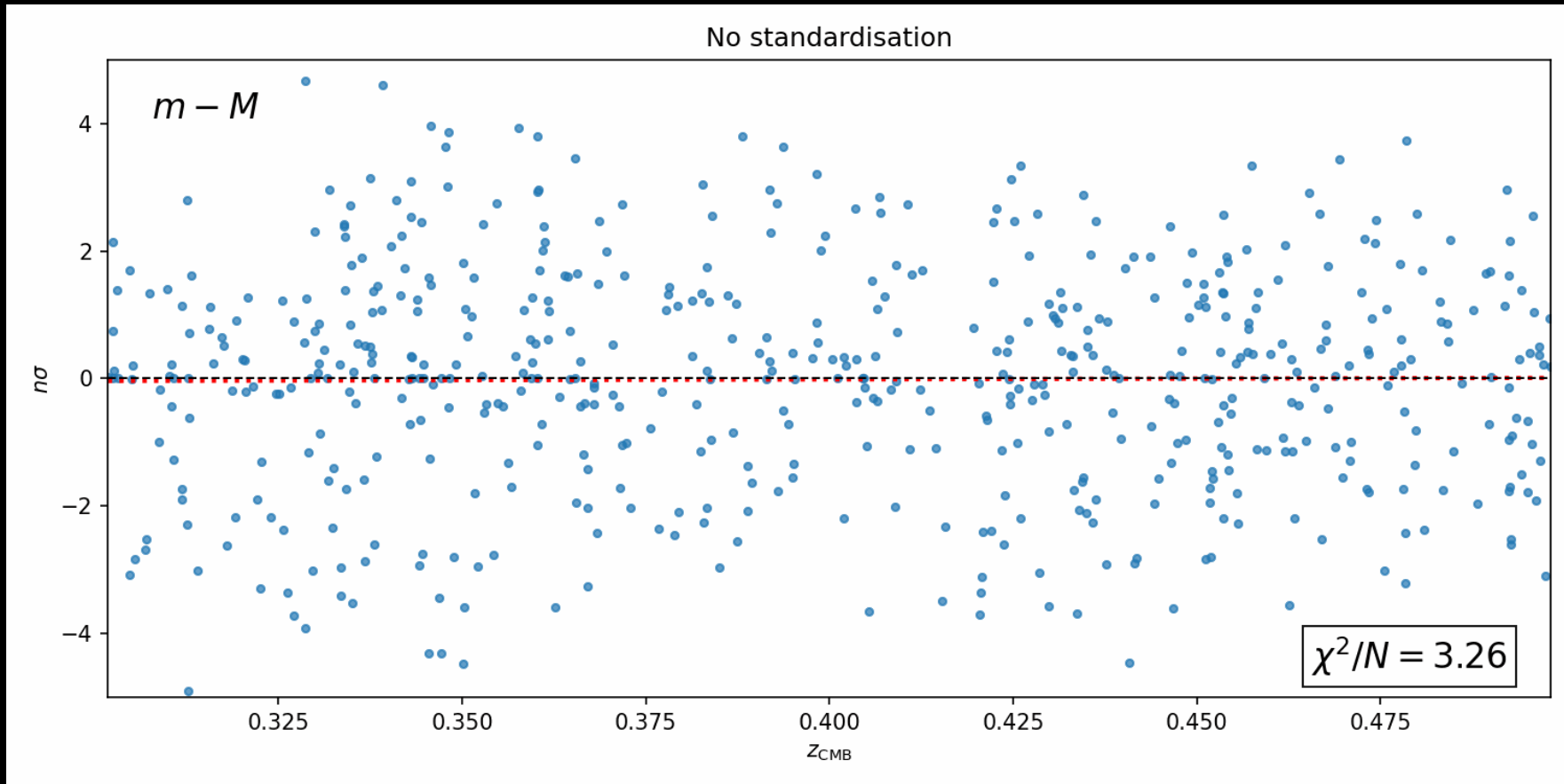


Popovic++2024

Or : use the same telescope (DEBASS)!

SN are standardisable candles

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$



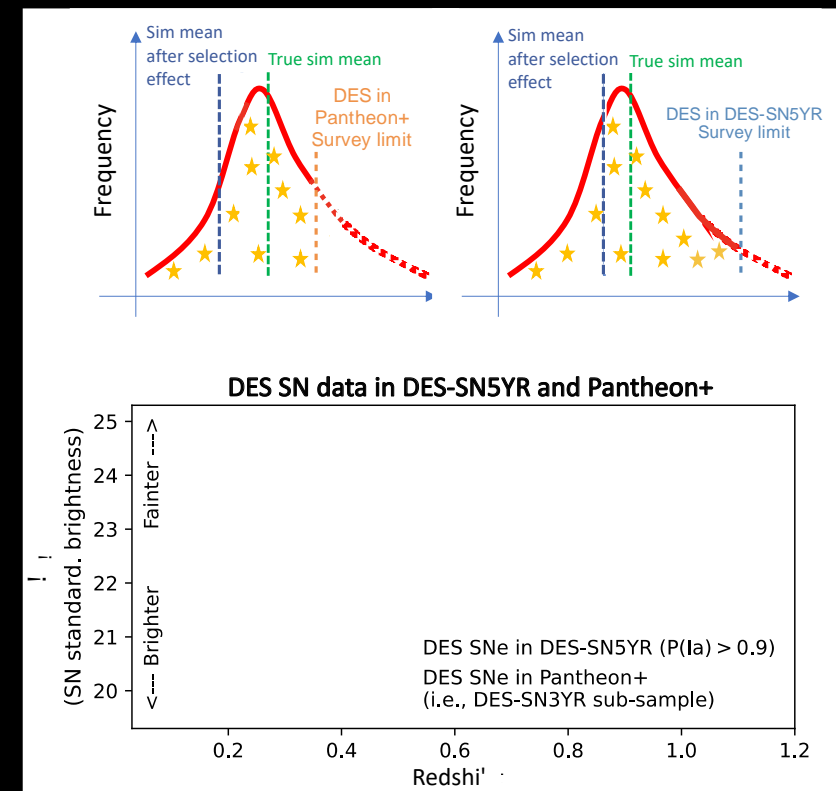
Same SN, different distance...?

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$

- Distances are corrected for selection effects
- Pantheon+ used a brighter subset of DES
- This accounts for the difference

Comparing the DES-SN5YR and Pantheon+ SN cosmology analyses: Investigation based on “Evolving Dark Energy or Supernovae systematics?”

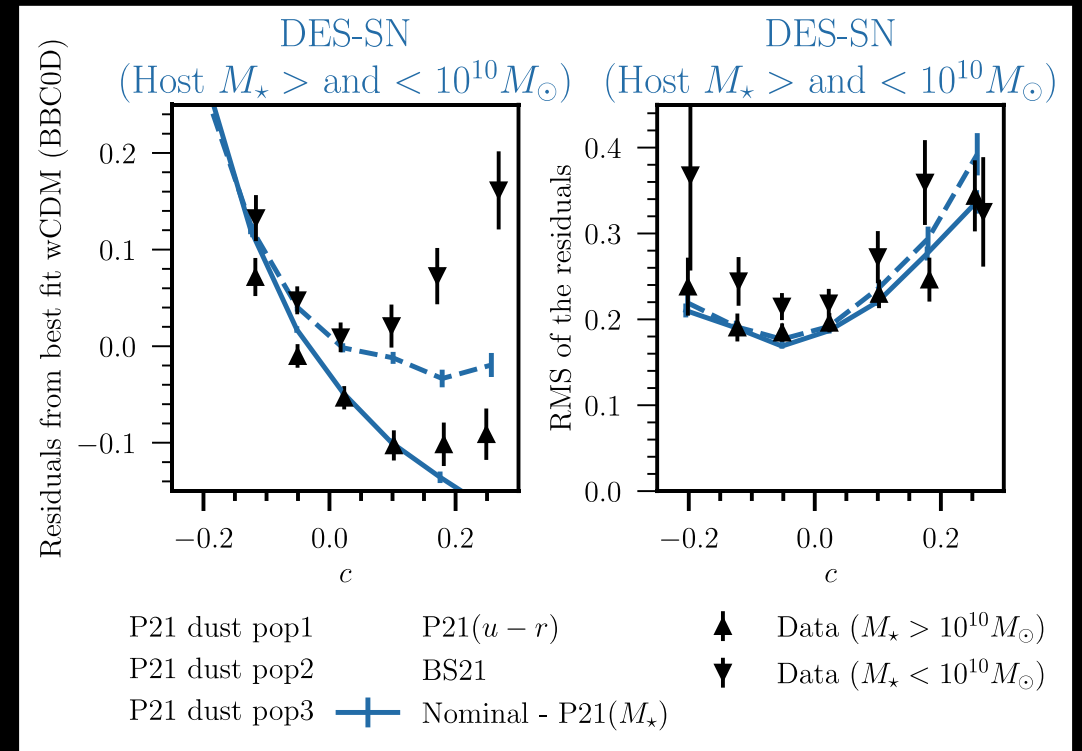
M. Vincenzi,^{1*} R. Kessler,^{2,3} P. Shah,⁴ J. Lee,⁵ T. M. Davis,⁶ D. Scolnic,⁷ P. Armstrong,¹² D. Brout,⁸



Do SN evolve with distance?

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$

- Fit population model to data
 - Intrinsic variation
 - Host dust extinction
 - Evolution

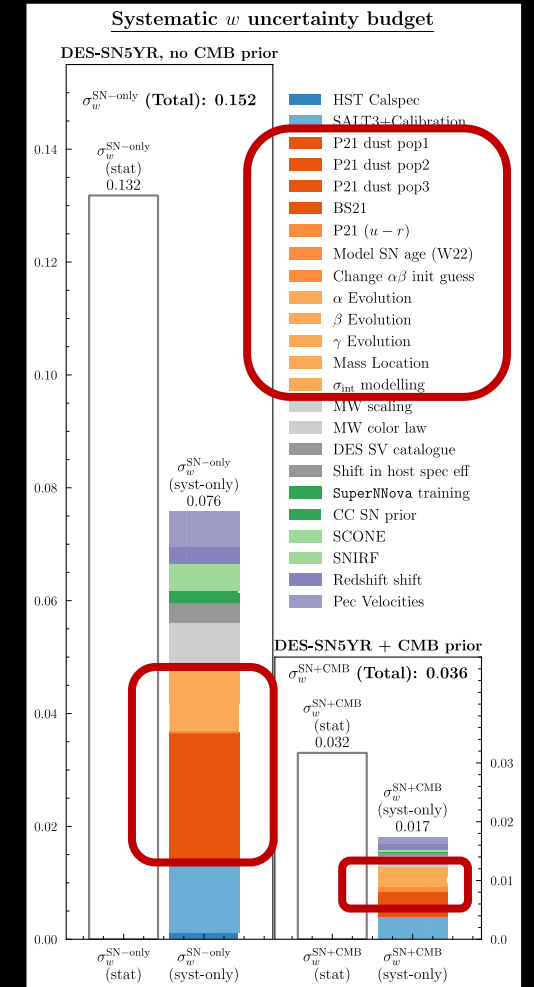


Do SN evolve with distance?

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$

- Fit population model to data
 - Intrinsic variation
 - Host dust extinction
 - Evolution

} systematics



Do SN evolve with distance?

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$

- SN in high mass galaxies are brighter
 - But age and host mass are correlated !

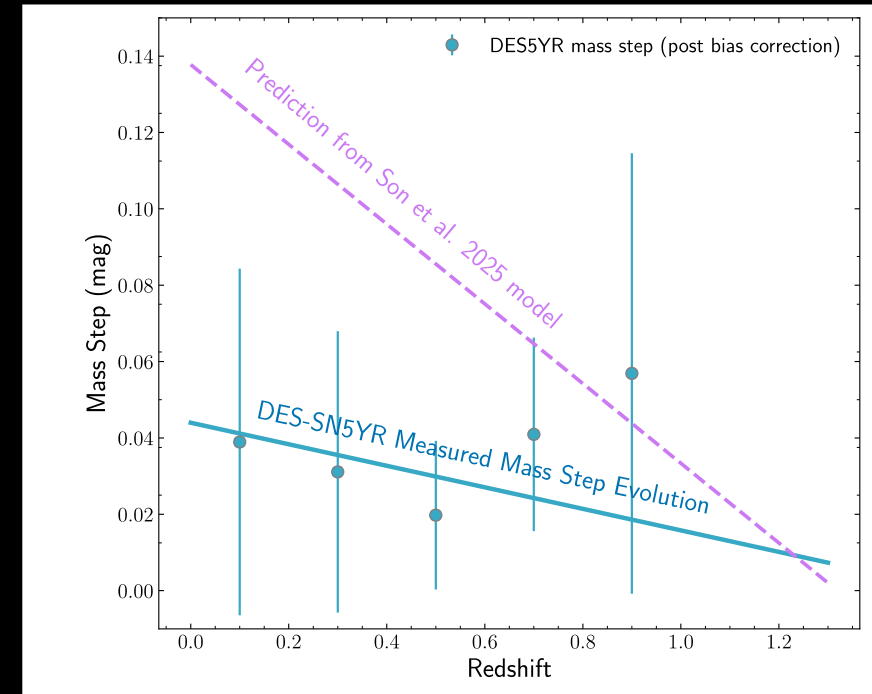
After host mass correction, minimal age correlation

Still Accelerating: Type Ia supernova cosmology is robust to host galaxy age evolution

Phil Wiseman^{1*}, Brodie Popovic¹, Mark Sullivan¹, Adam G. Riess^{2,3}, Dan Scolnic⁴, Rebecca C. Chen^{5,6,7},

Old Universe, Young SNe Ia: A Statistical Analysis of Type Ia Supernova Progenitor Age from 6,983 TITAN Host Galaxies, and Implications for Cosmology

YUKEI S. MURAKAMI,¹ JACK W. TWEDDLE,² PHIL WISEMAN,³ SAURABH W. JHA,⁴ ADAM G. RIESS,^{1,5}



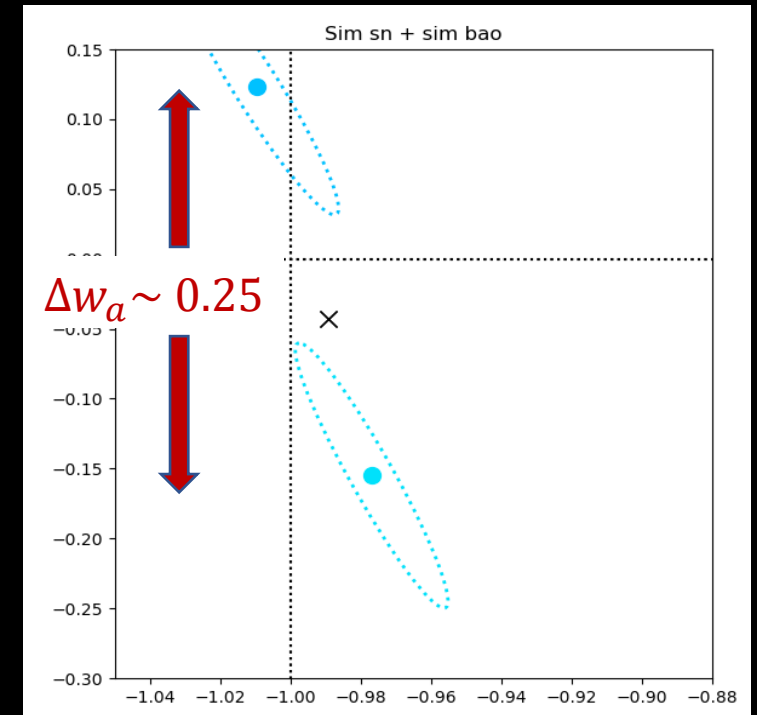
Wiseman++ 2026

What I worry about #1

$$\mu_{obs} = m - M + \alpha x_1 - \beta c + \Delta_B + \Delta_M$$

- Distances depend on population models
 - The fit is better with latest models but...
- Ongoing debate
 - Host dust?
 - Intergalactic dust?
 - Progenitor?

More data \longrightarrow better systematic control



Changing SN host mean R_V by +1.5, -1.0

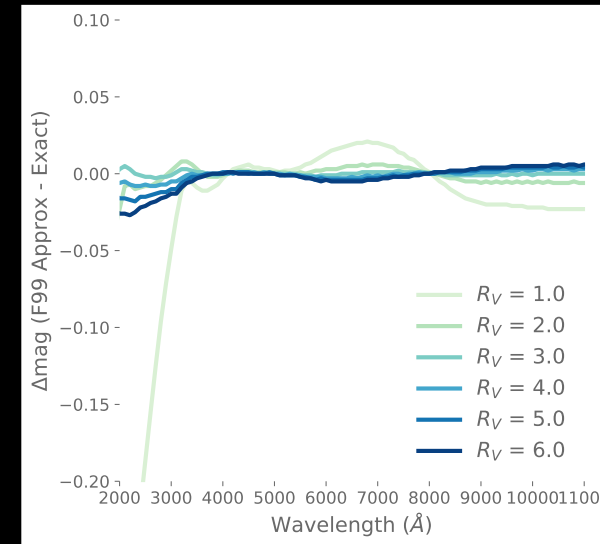
(but doesn't seem preferred by data)

What I worry about #2

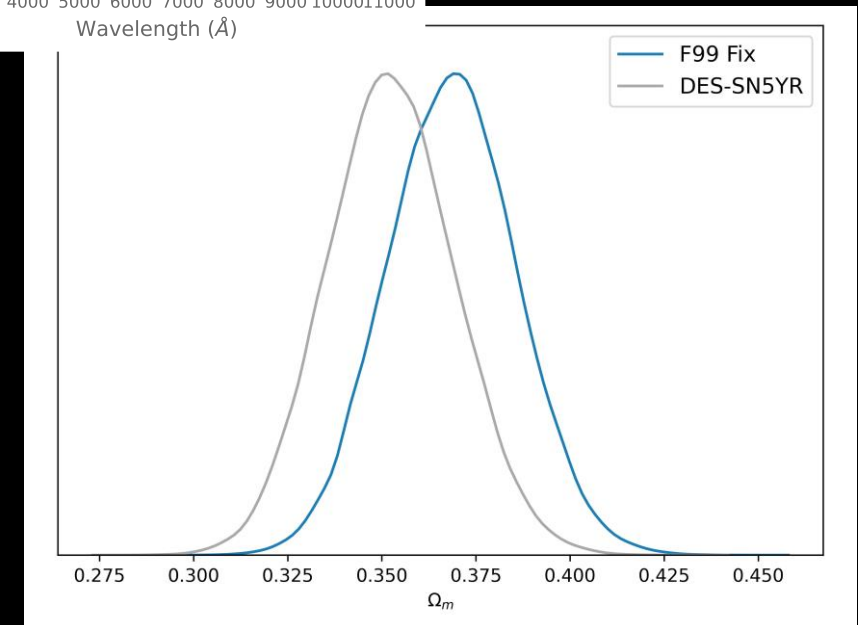
- Inaccurate colour law was used in DES-5Y
- Was used to simulate data
- ...and analyse the simulated data
- DES-5Y would have been $>5\sigma$ evidence for $w_0 w_a$!

Data challenge? Regression testing?

Independent code/teams

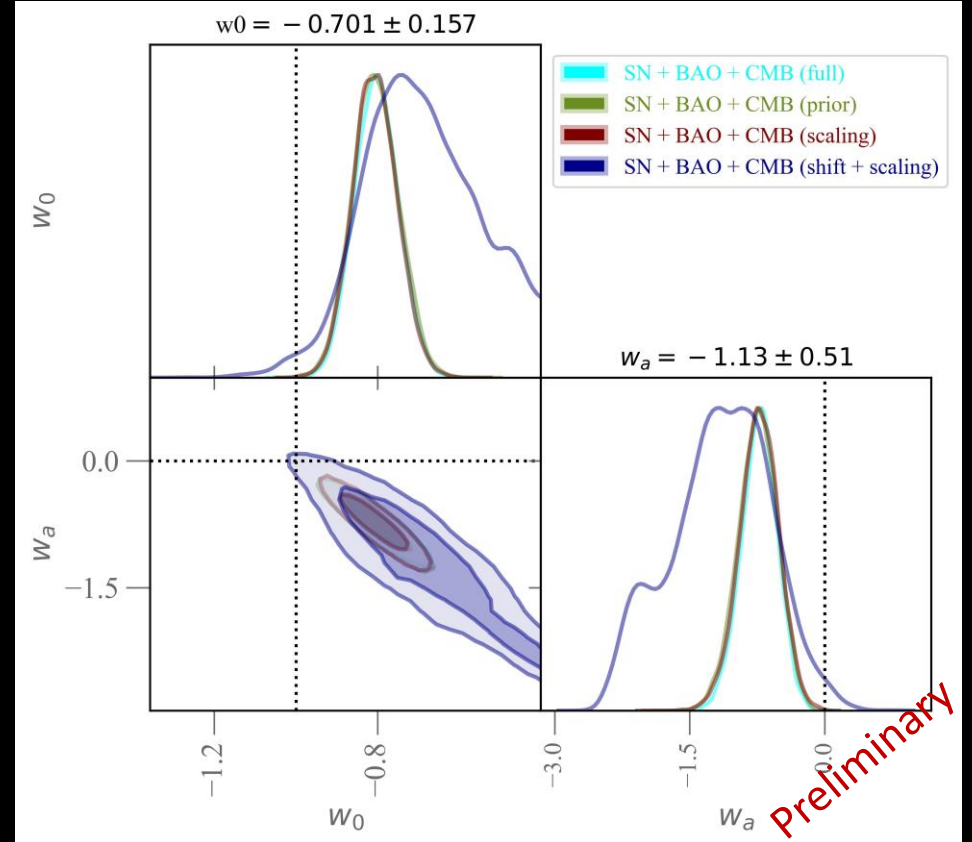


Popovic++ 2025



A Bayesian test for systematics

- Hyper-parameters
 - $\Omega_{m,SN} = \Omega_{m,true} + \Delta_{SN}$, etc.
 - $Cov_{SN} = S * Cov_{SN}$
 - ...also for BAO, CMB
- *No evidence* that SN have larger systematics
- Λ +Systematics is an even bet to $w_0 w_a$



Forecasting is difficult, especially about the future...

- Figure of merit for $w_0 w_a$
 - Best = 227 (Popovic++ 25)
- TIDES-SN (LSST + 4MOST)
 - 150k SN + DESI DR3 + CMB + SPT-10k
 - Figure of merit ~ 800
 - but 'Pessimistic' systematics ...

Also : ATLAS, ZTF, ...

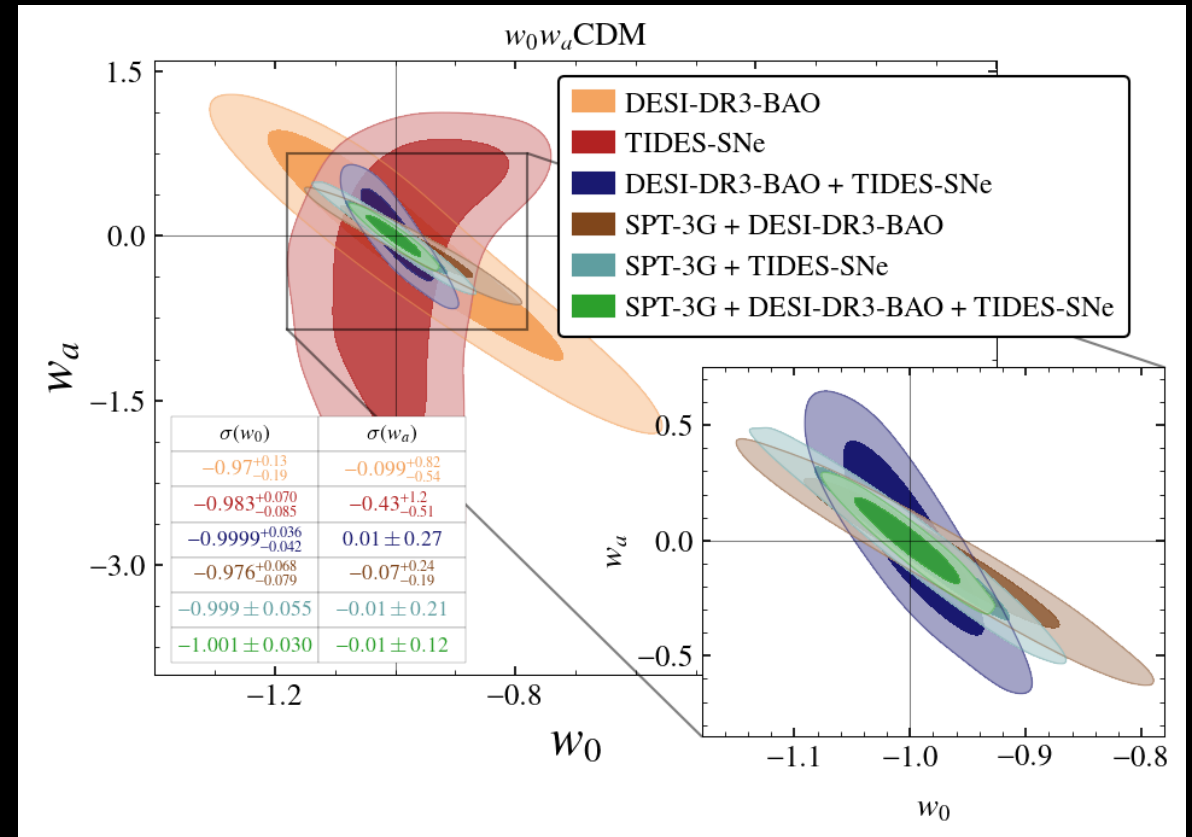


Figure courtesy of Srinu Raghunathan

Which SN dataset should I use?

| | <u>Pantheon+</u> | <u>DES-Dovekie</u> | <u>Union3.1</u> |
|--------------------|------------------|--------------------|-----------------|
| Number of SN | 1701 | 1820 | ~2000 |
| Classification | Spec | Photo | Spec |
| Number of surveys | 20 | 7 | 24 |
| Oldest photometry | 1980 | 2001 | 1992 |
| Light curve fitter | Salt2 | Salt3 | Salt3 |
| Bias correction | Frequentist | Frequentist | Bayesian |

- DES-Dovekie and Union3.1 are current state-of-the-art
 - (Mostly) different data
 - (Mostly) different pipeline
 - Different teams

Conclusions

- SN distances consistent
 - (mostly) independent data from independent teams
- Systematics under control *at the current precision of data*
 - We can be optimistic for the (SBI) future!