Supernovae Host Galaxy Dust Extinction Evolution

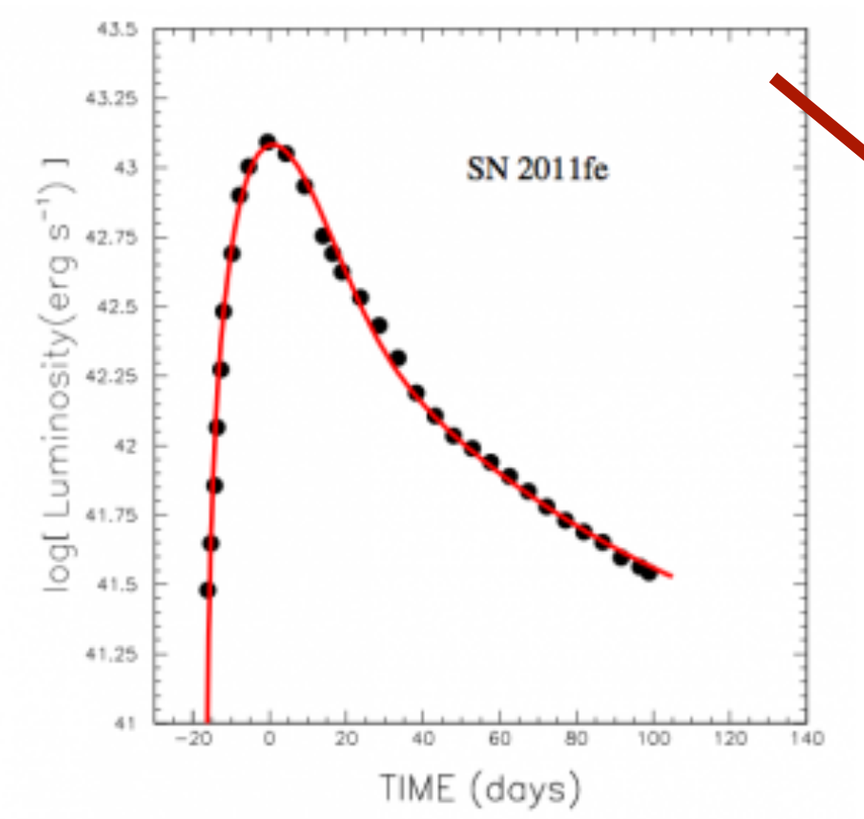
B.W. Holwerda
(University of Louisville)
K. Mack, A. Jacques, J. Hill, W. Roemer
& GAMA team.

Motivation

- Supernova Ia distances are one of two cosmological mainstay methods.
- The main uncertainty remains the host galaxy extinction.
- Evolution in the host galaxy dust extinction could mask or mimic cosmological results.
- There is a tension with the CMB results.

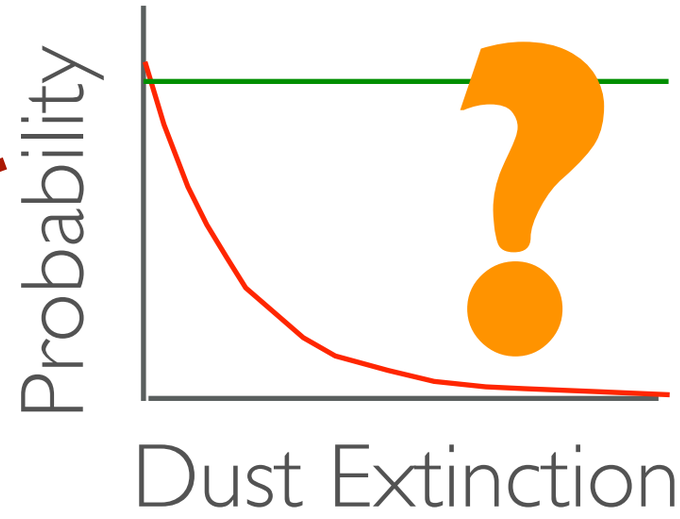
II. SNIa light curve fit

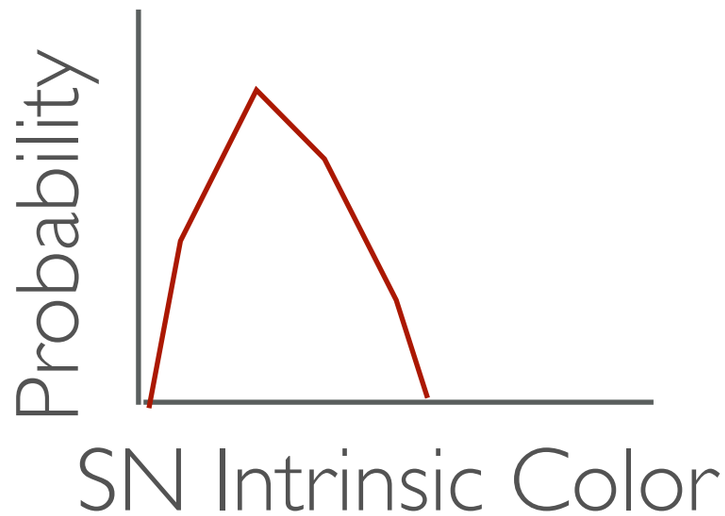
Observed Lightcurve
+ color



Some kind of
probability fit

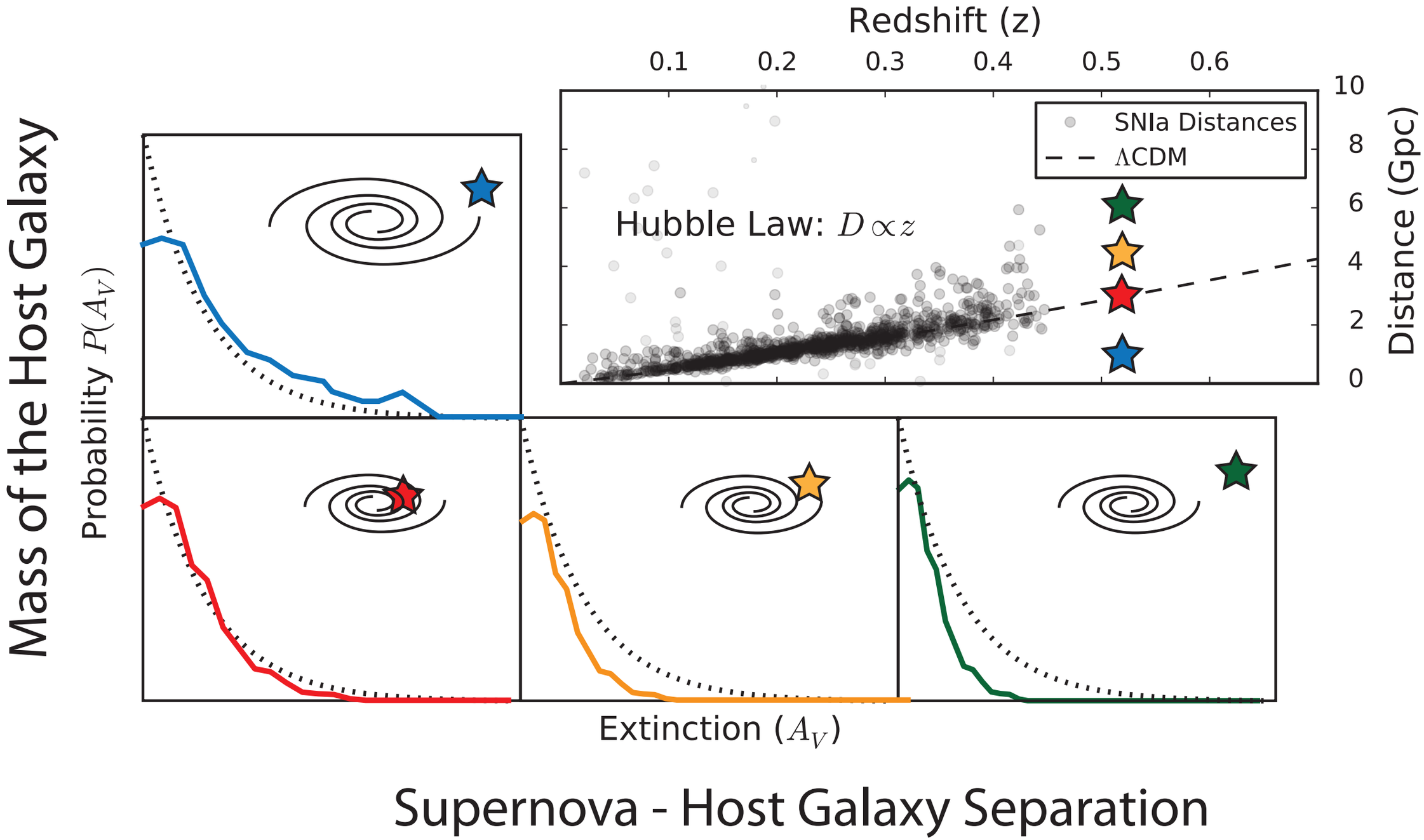
Priors





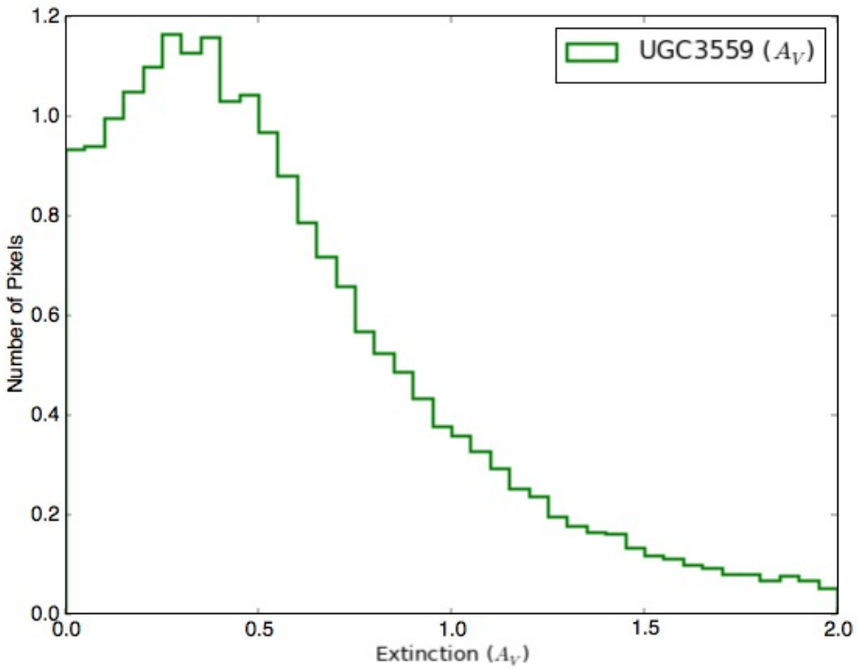
Distance modulus

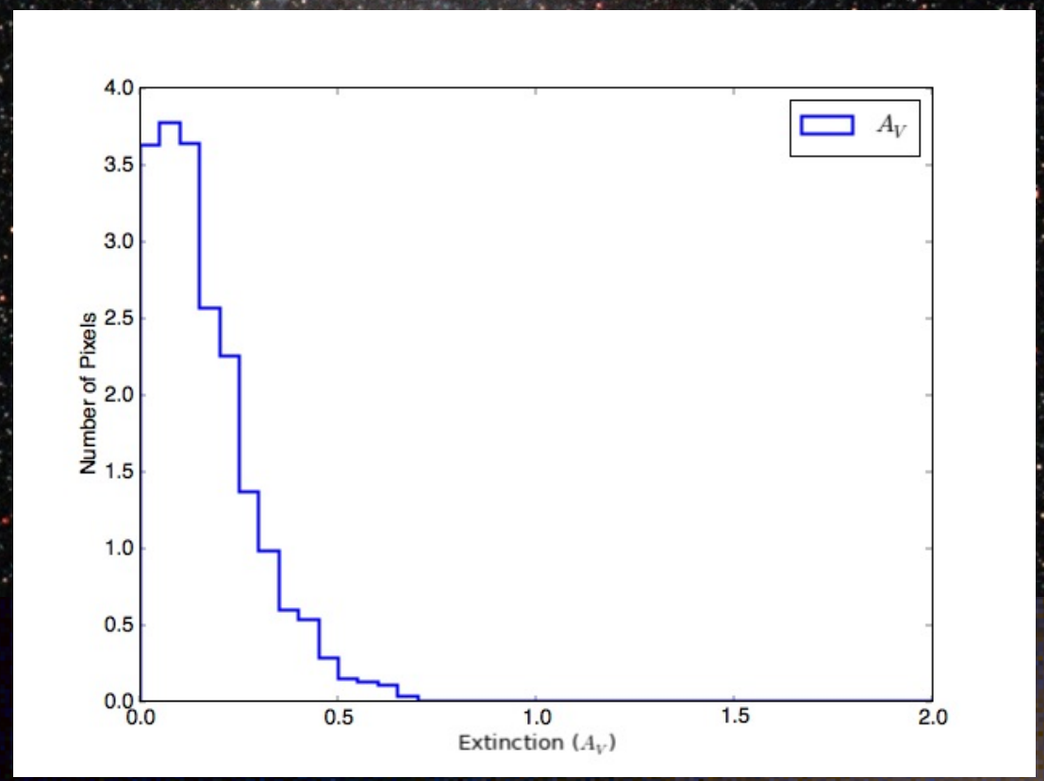
P(A$_V$) scenario

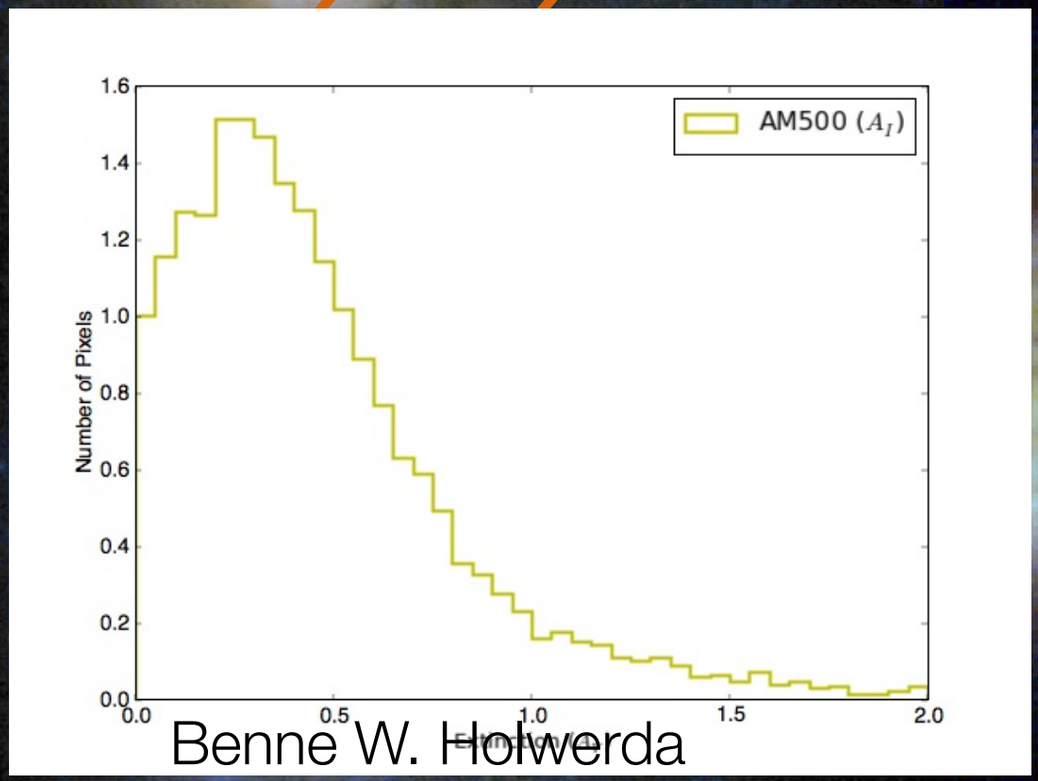


Supernova - Host Galaxy Separation

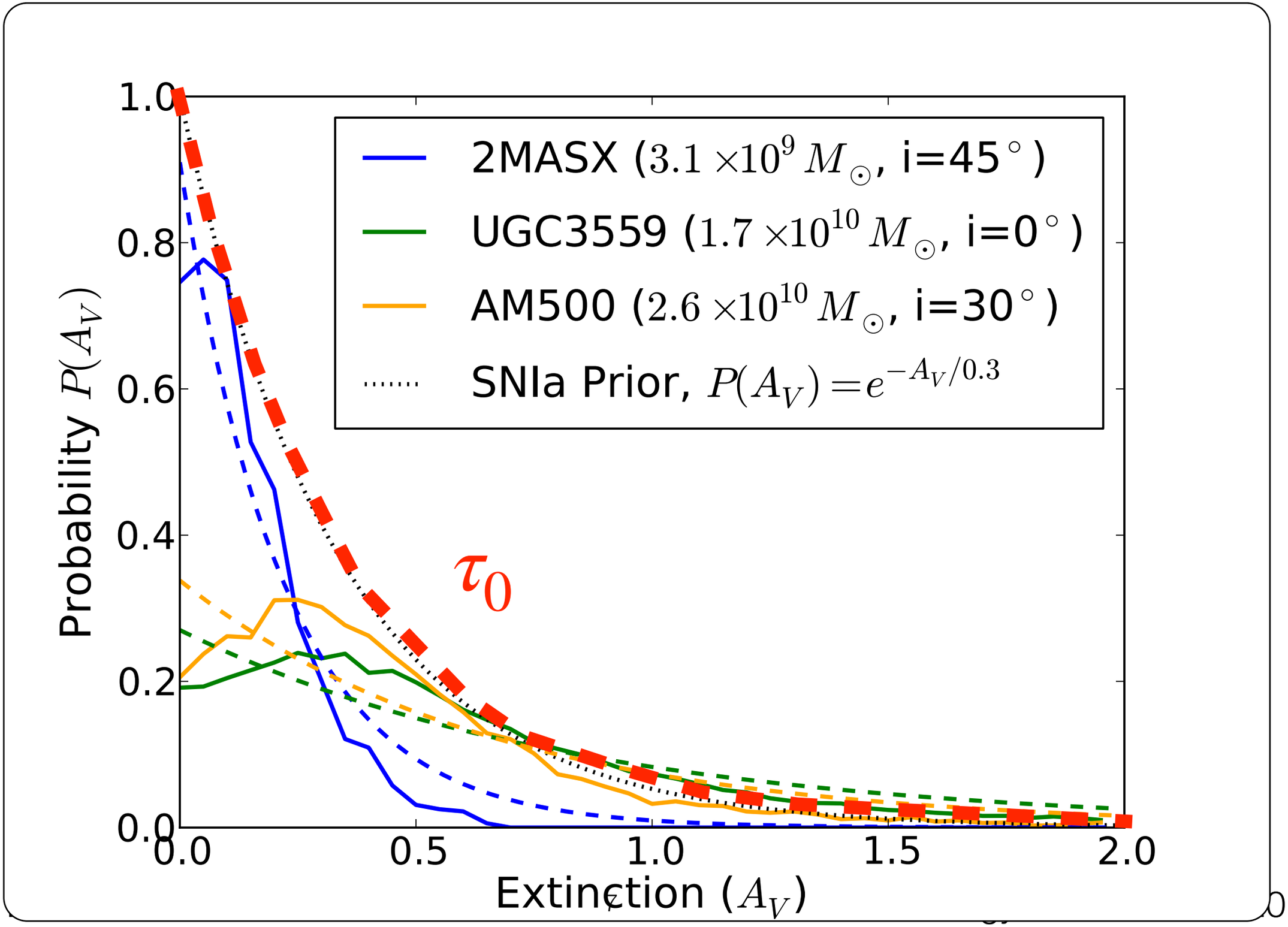
Holwerda et al., 2009, AJ, 137, 3000

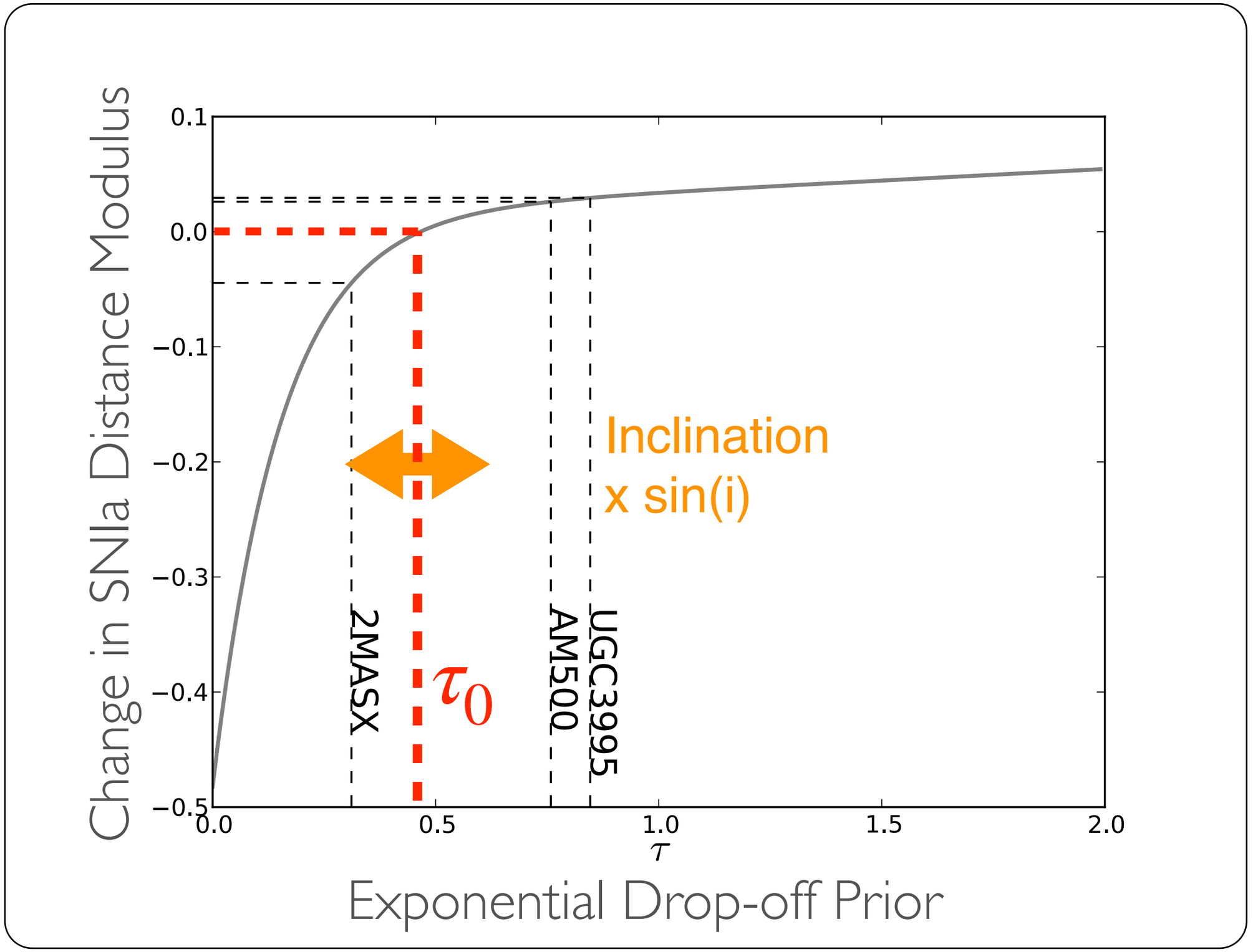

UGC3559 (A_V)
Number of Pixels
Extinction (A_V)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0


A_V
Number of Pixels
Extinction (A_V)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0


AM500 (A_I)
Number of Pixels
Extinction (A_I)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0.5
1.5
2.0

Dust Extinction Prior

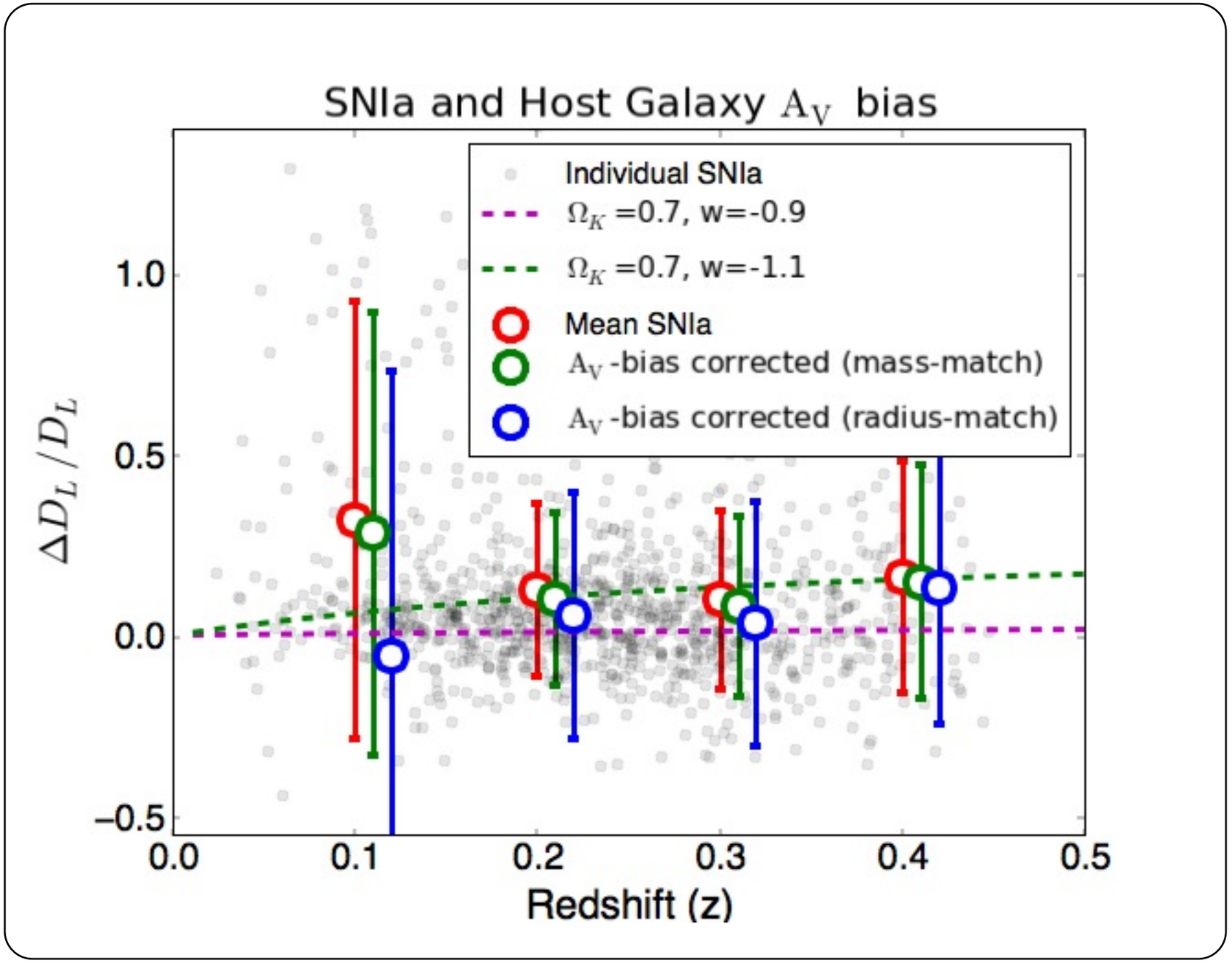




Jha+ (2007), Holwerda+, MNRAS, 2014, 446, 3768, MNRAS, 2015, 451, 2390

SNIa residual

- SDSS-III SNIa.
- Match SNIa host to occulting galaxy.
  - **mass-matched**
  - **radius-matched**
- The prior is stellar mass driven.

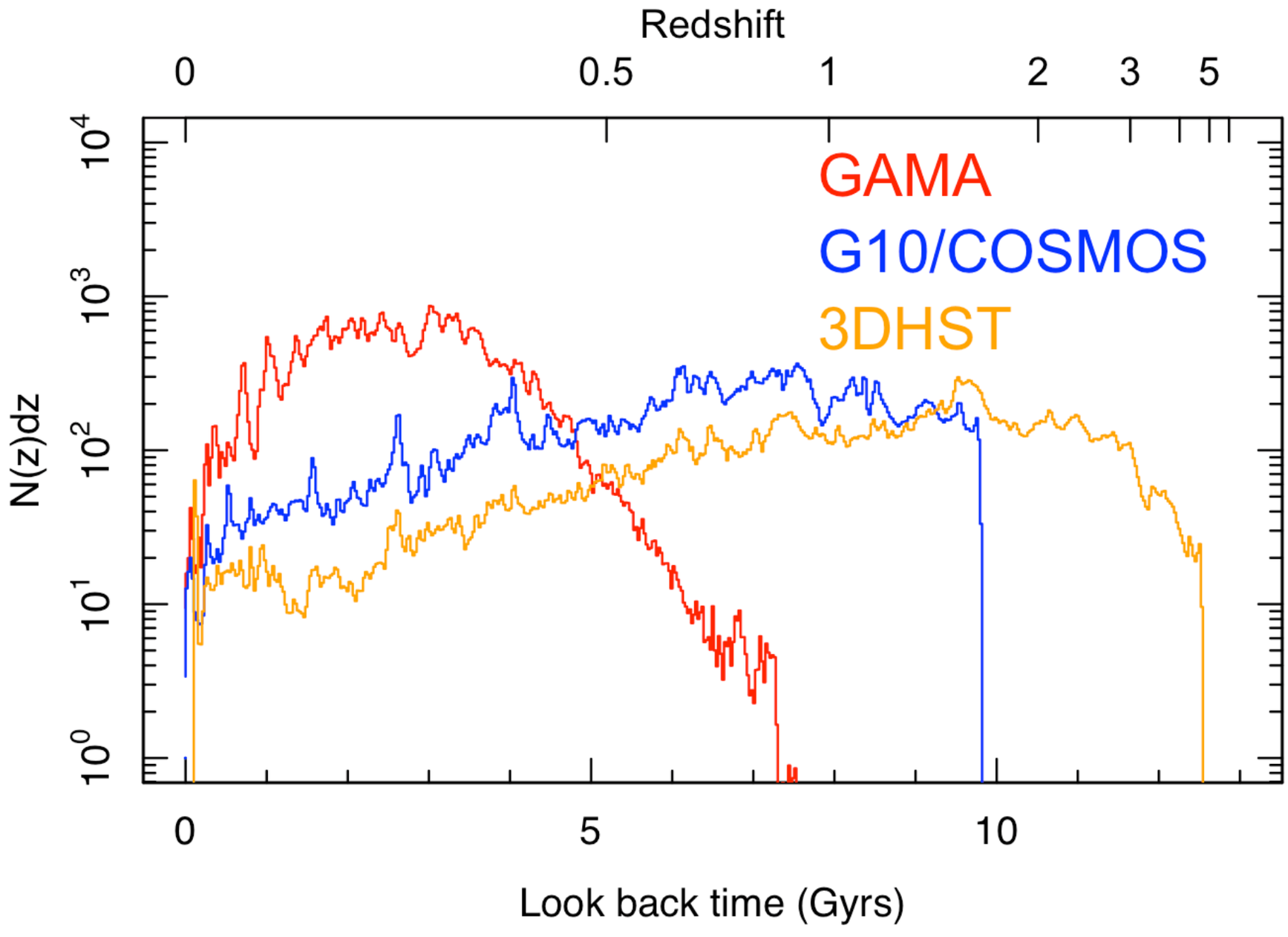


Holwerda+, MNRAS, 2008, 386, 475, MNRAS 2015, 451, 2390

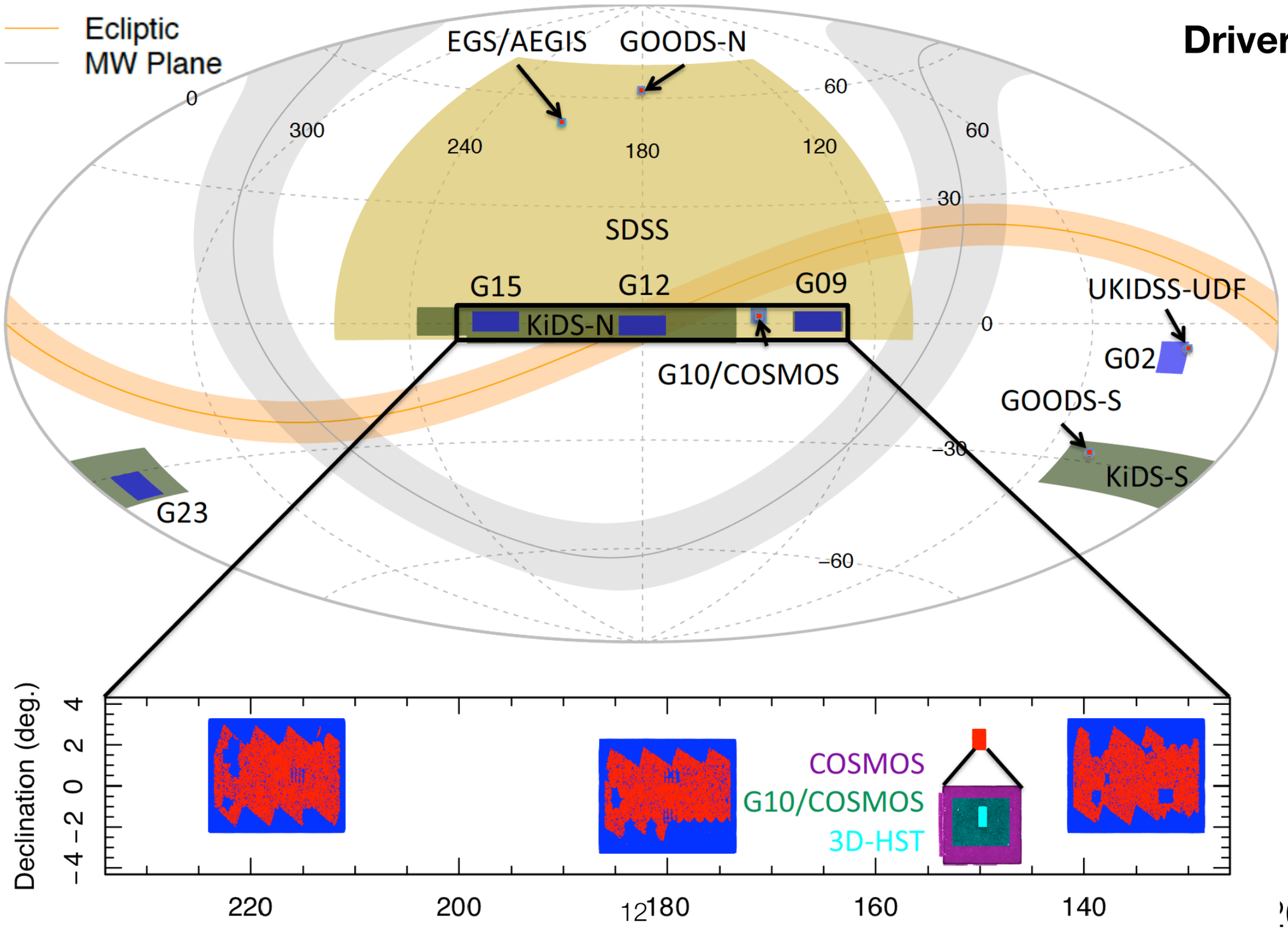
Need to know how the prior evolves with time

- Star formation peaks at z~1-2
- Does dust content of galaxies?
- Does dust geometry?

Tale of Three Surveys

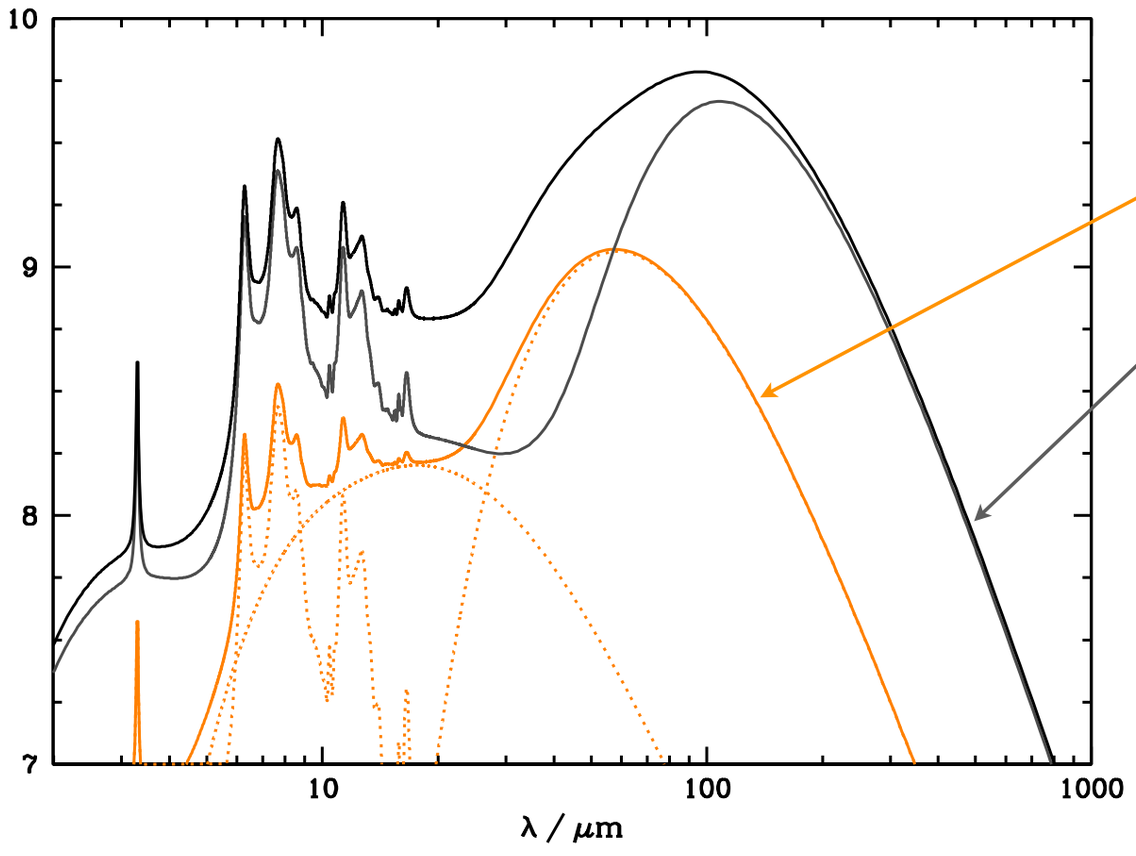


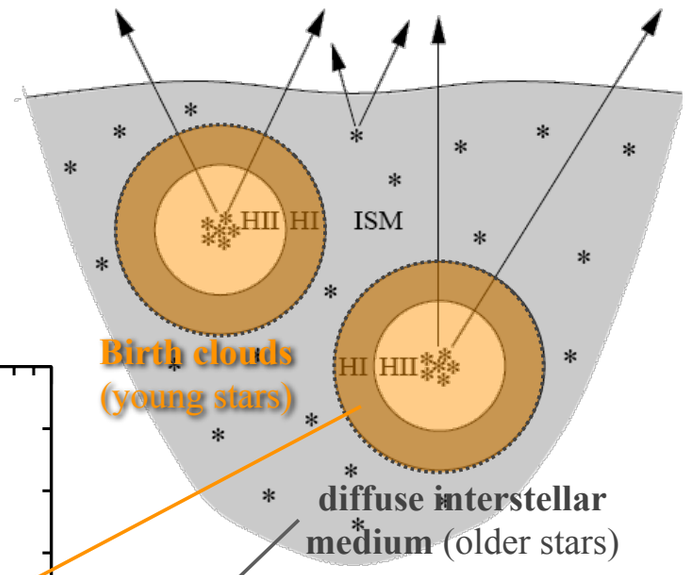
GAMA, G10, 3D-HST



[illegible] 2020

MAGPHYS Spectral Energy Distribution Fit

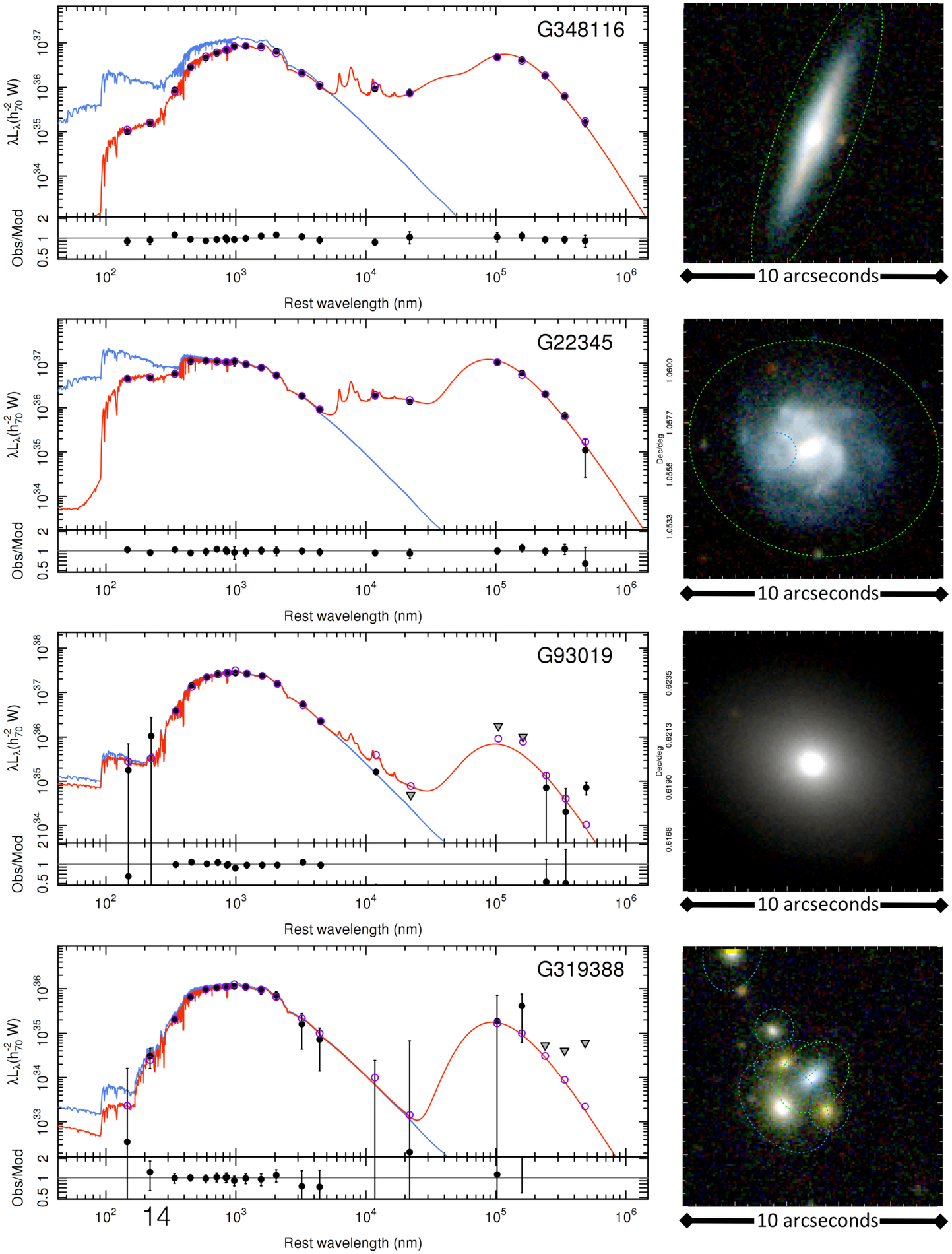




SED fits to all kinds of galaxies

Driver+ 2018

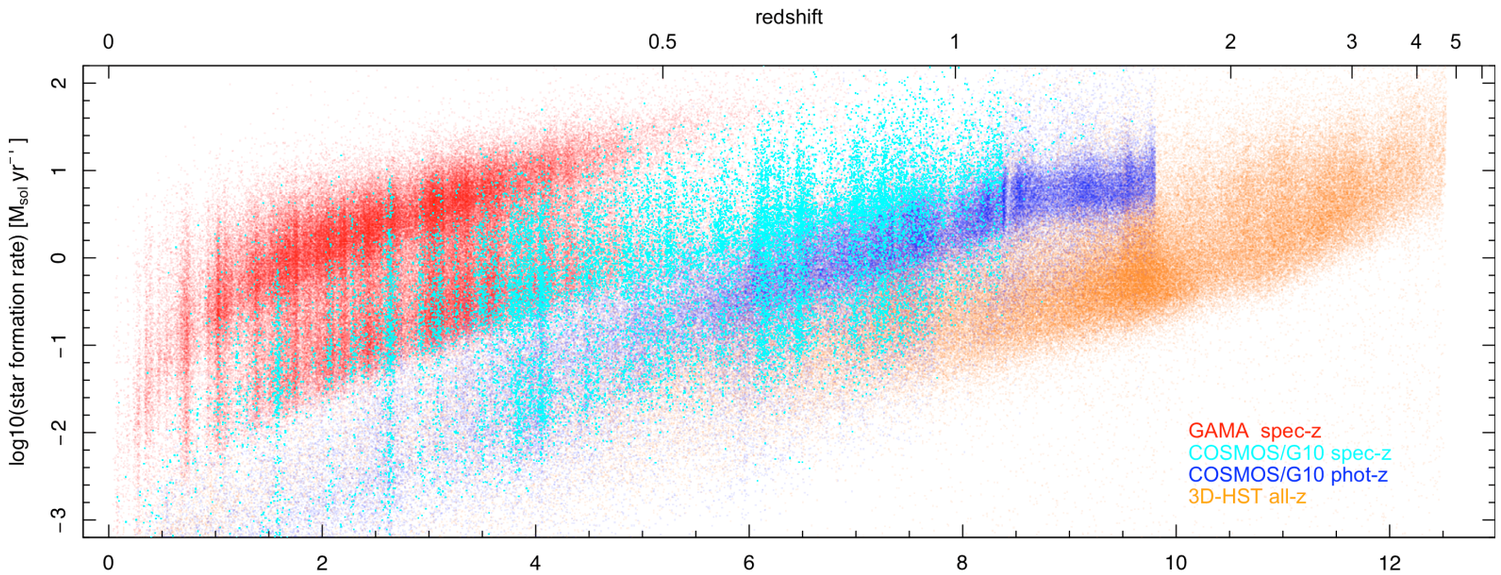
Benne W. Holwerda



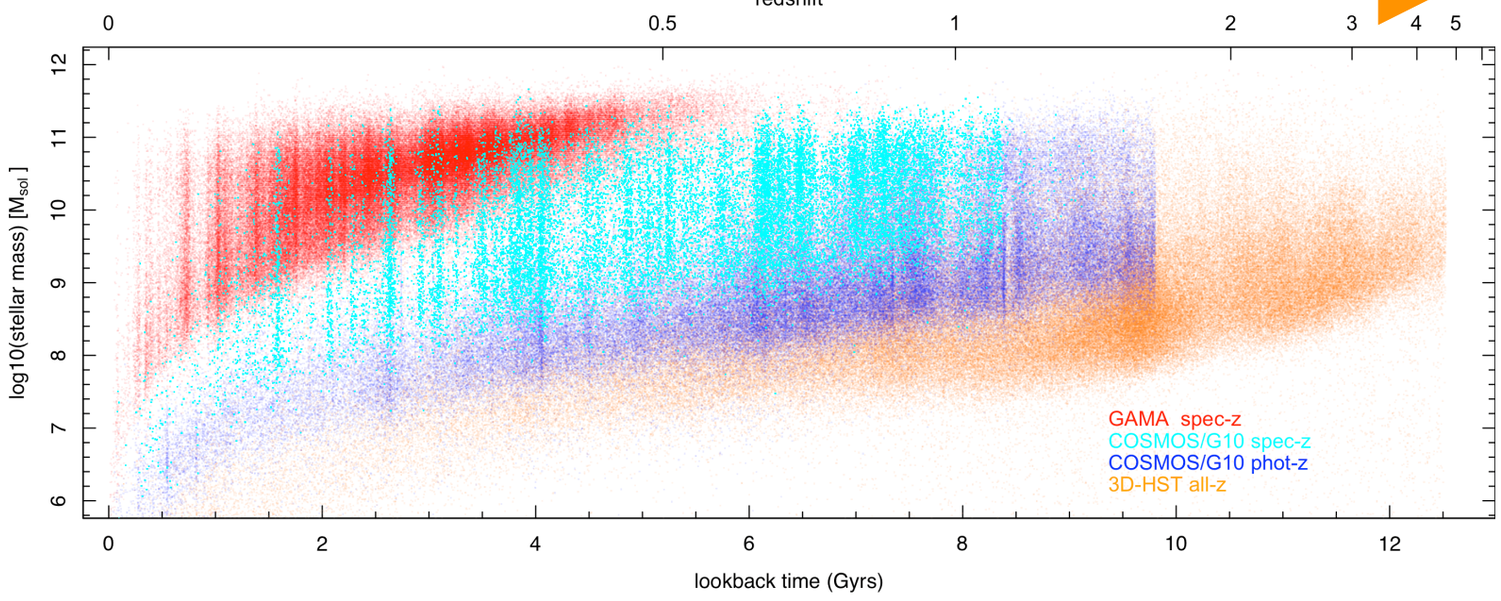
Stellar Mass

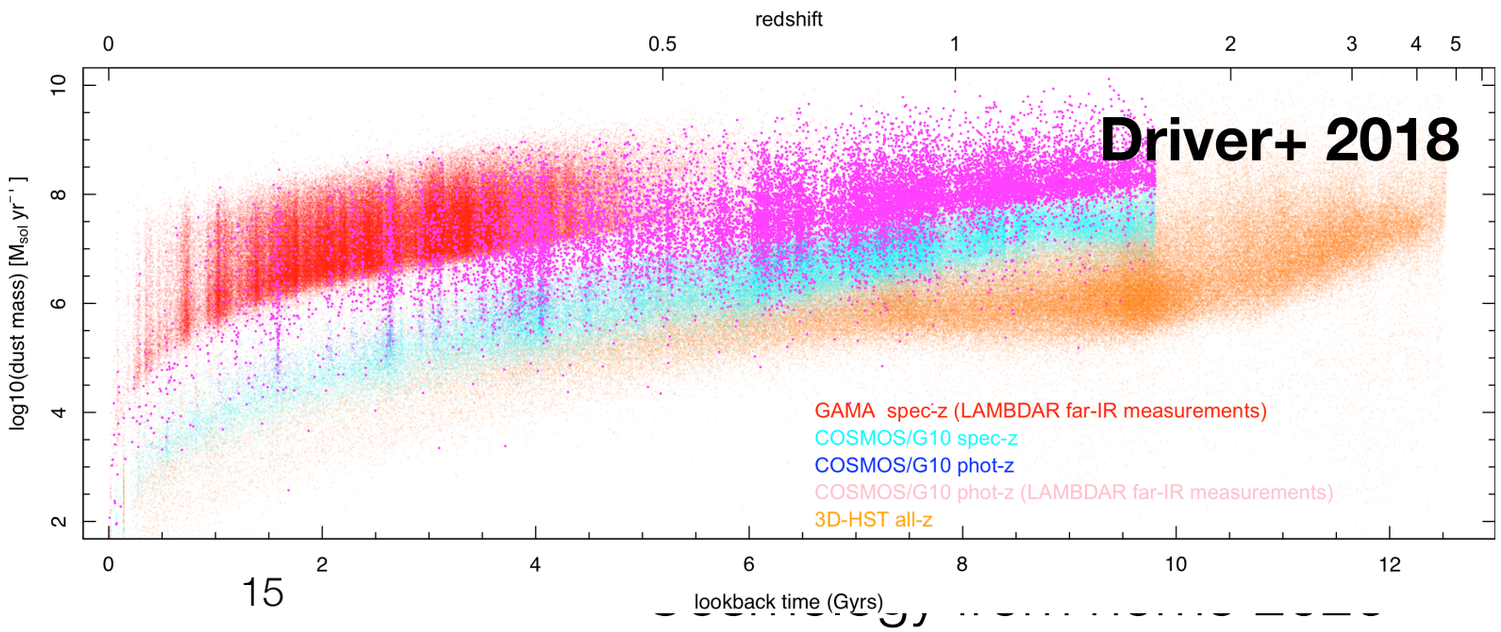
Star-formation

Dust mass



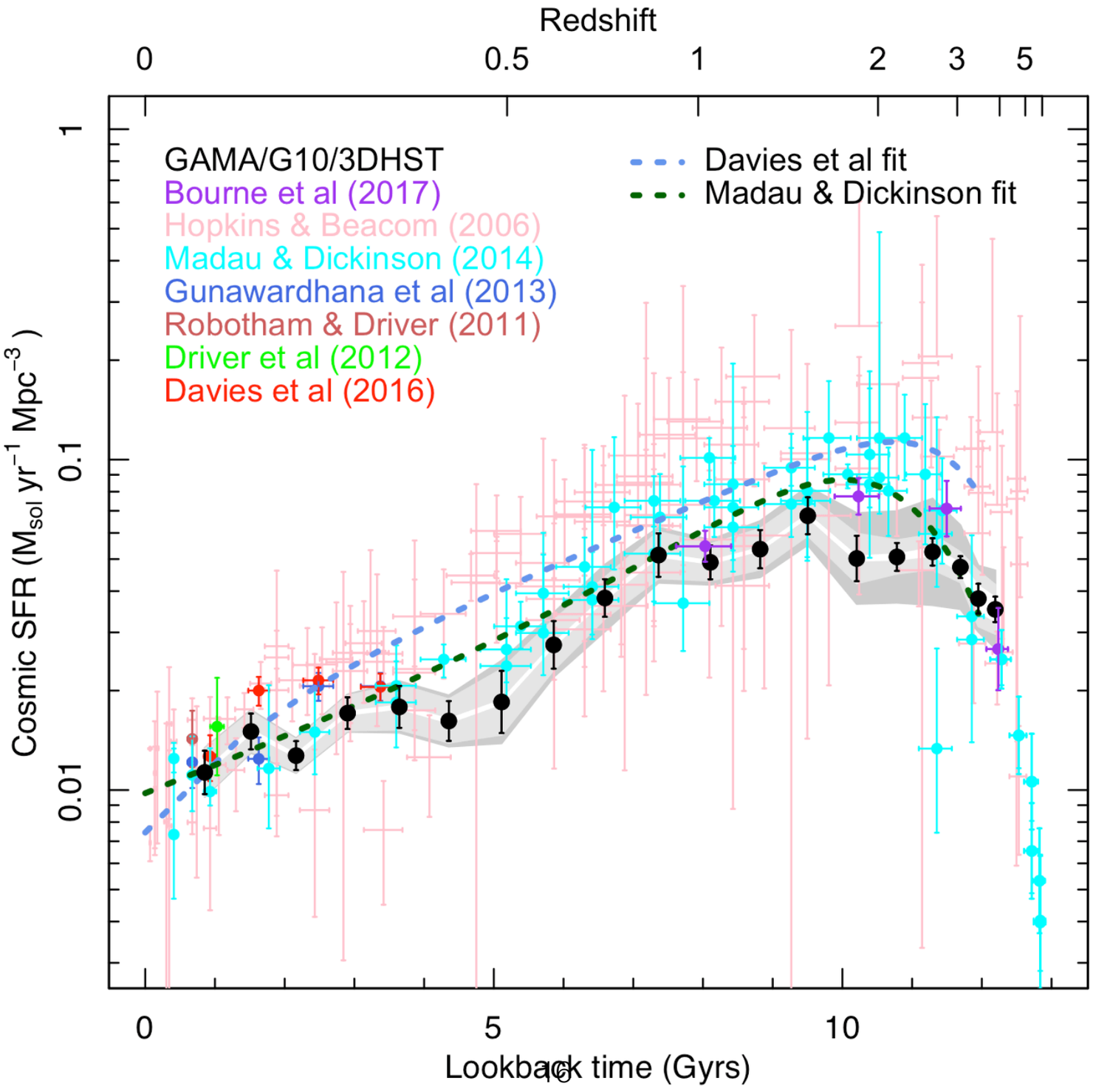
Back in time





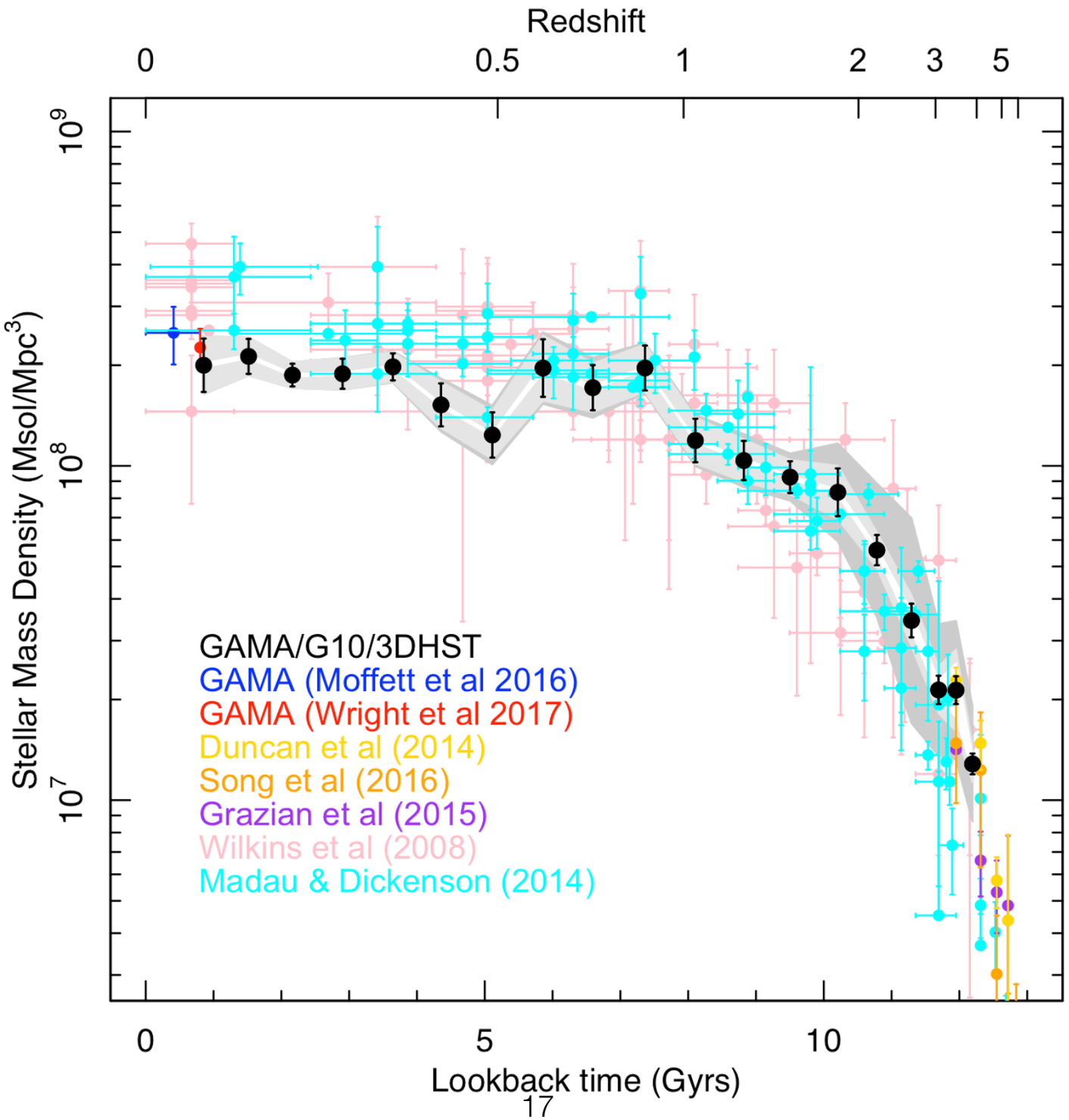
Benne W. Holwerda

Star formation volume density



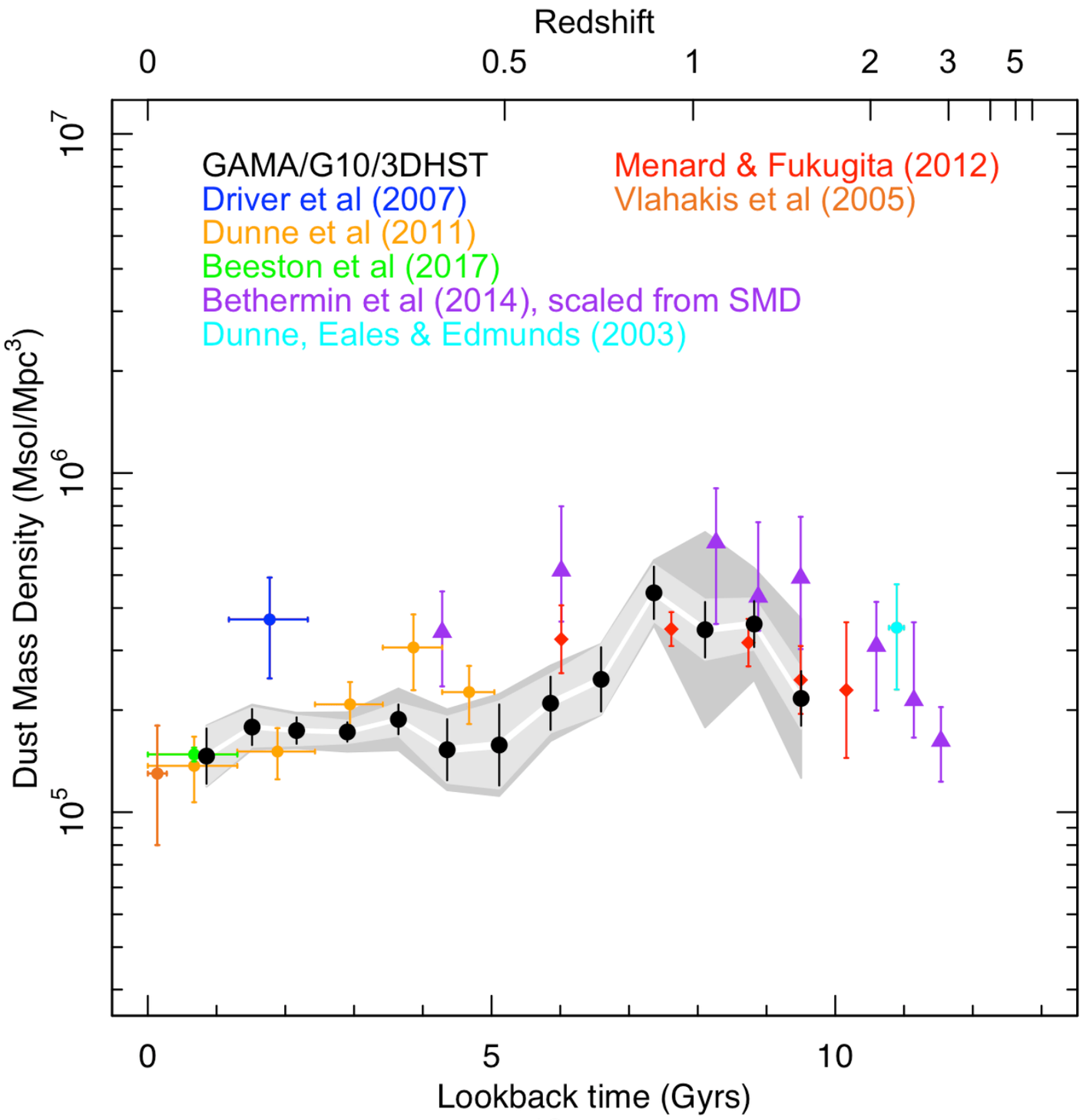
Driver+ 2018

Stellar mass volume density



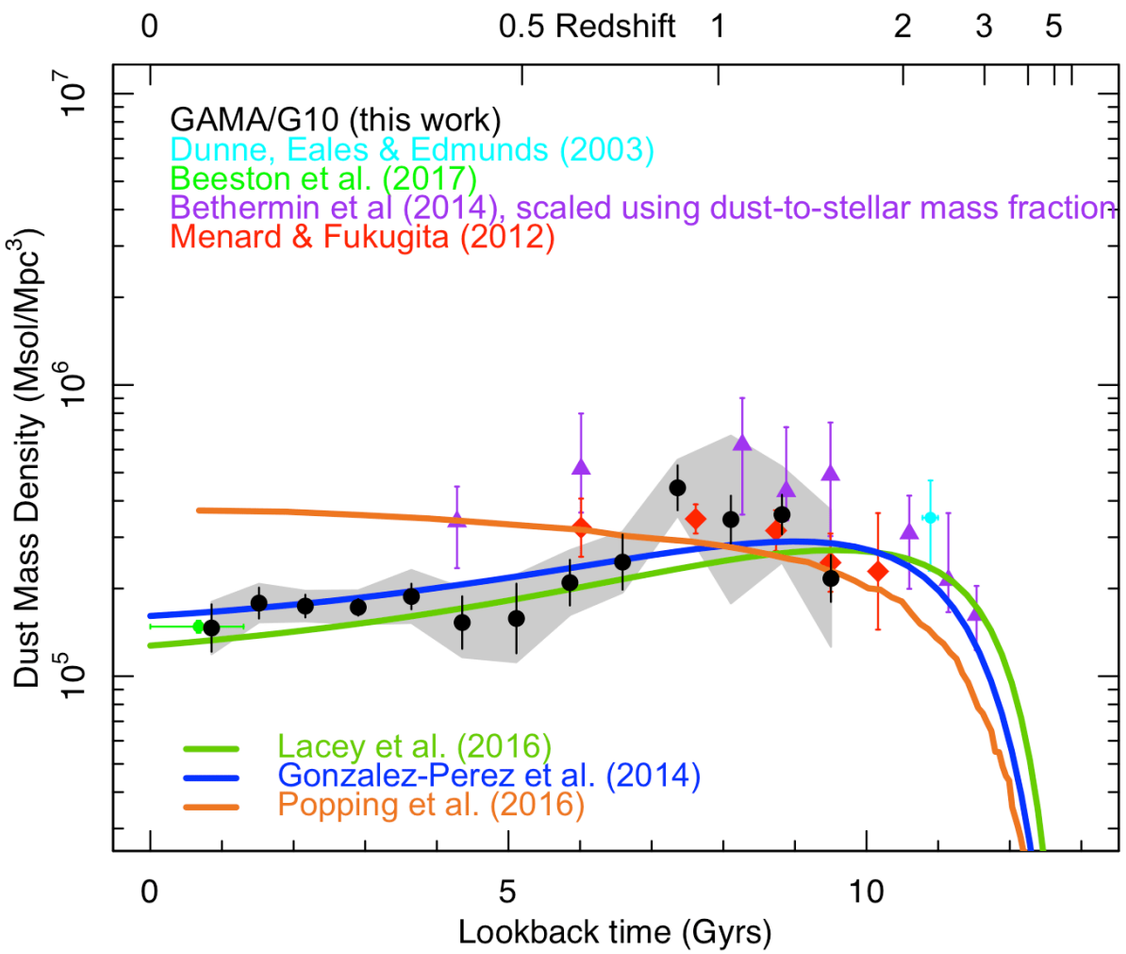
Driver+ 2018

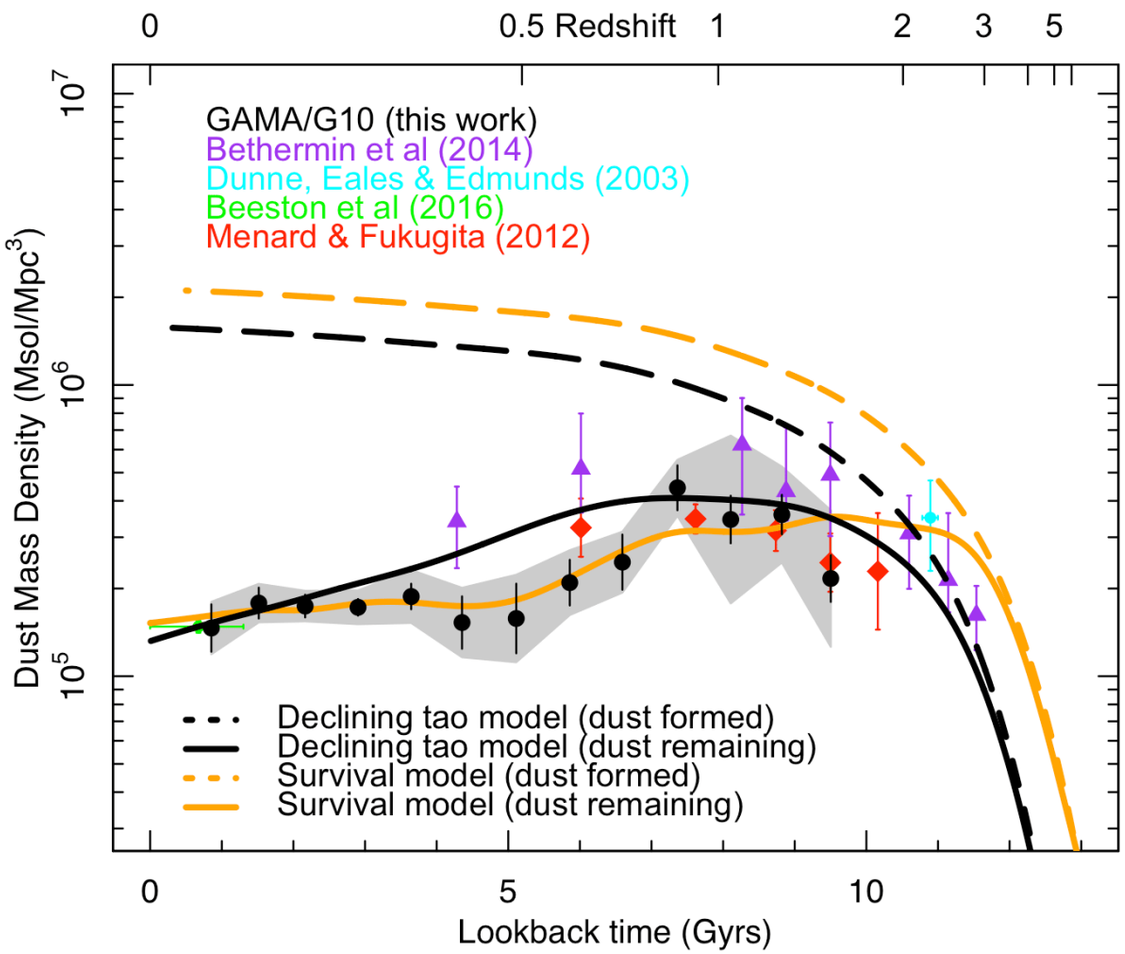
Dust mass volume density



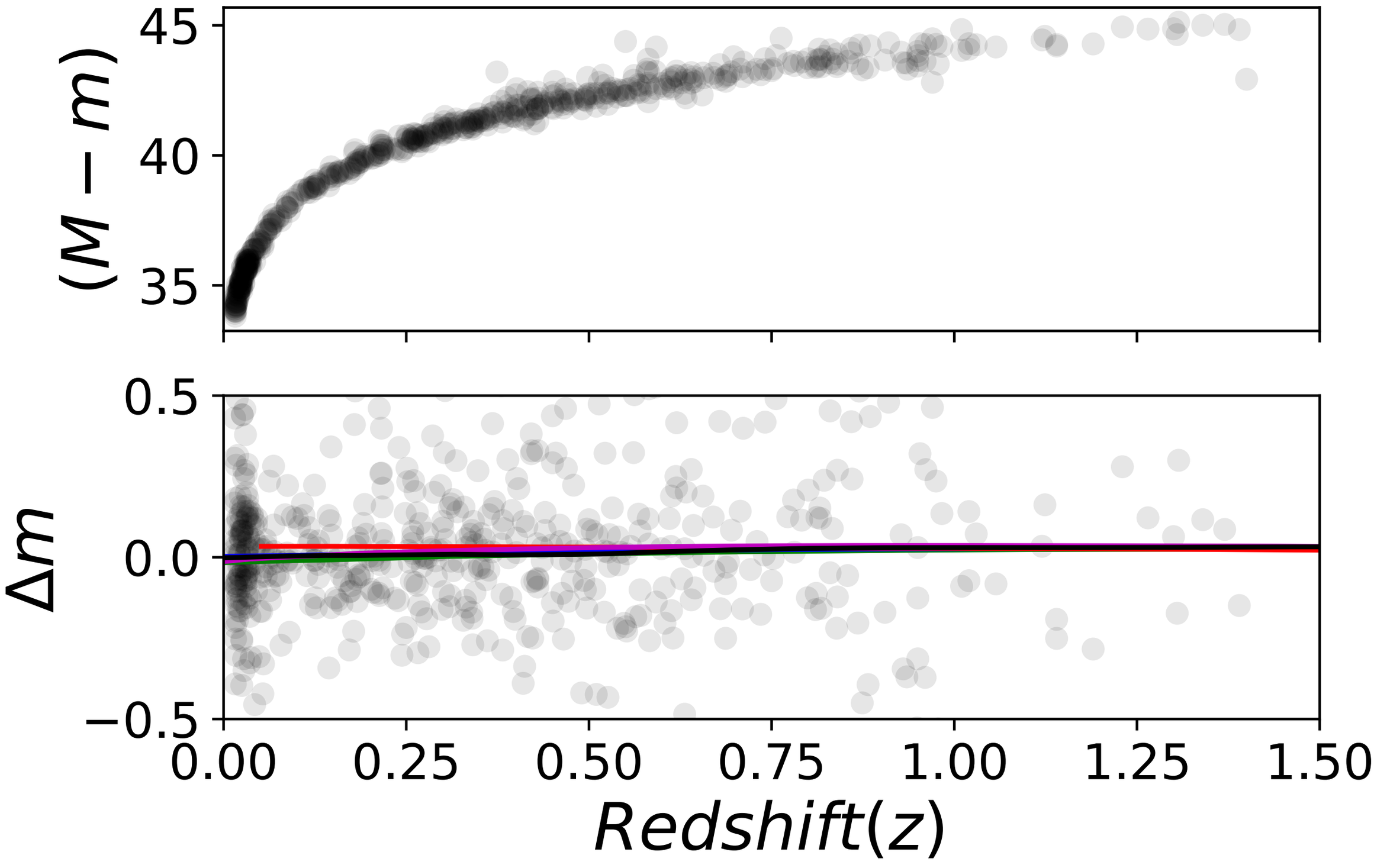
Driver+ 2018

Dust volume density evolution





Driver+ 2018

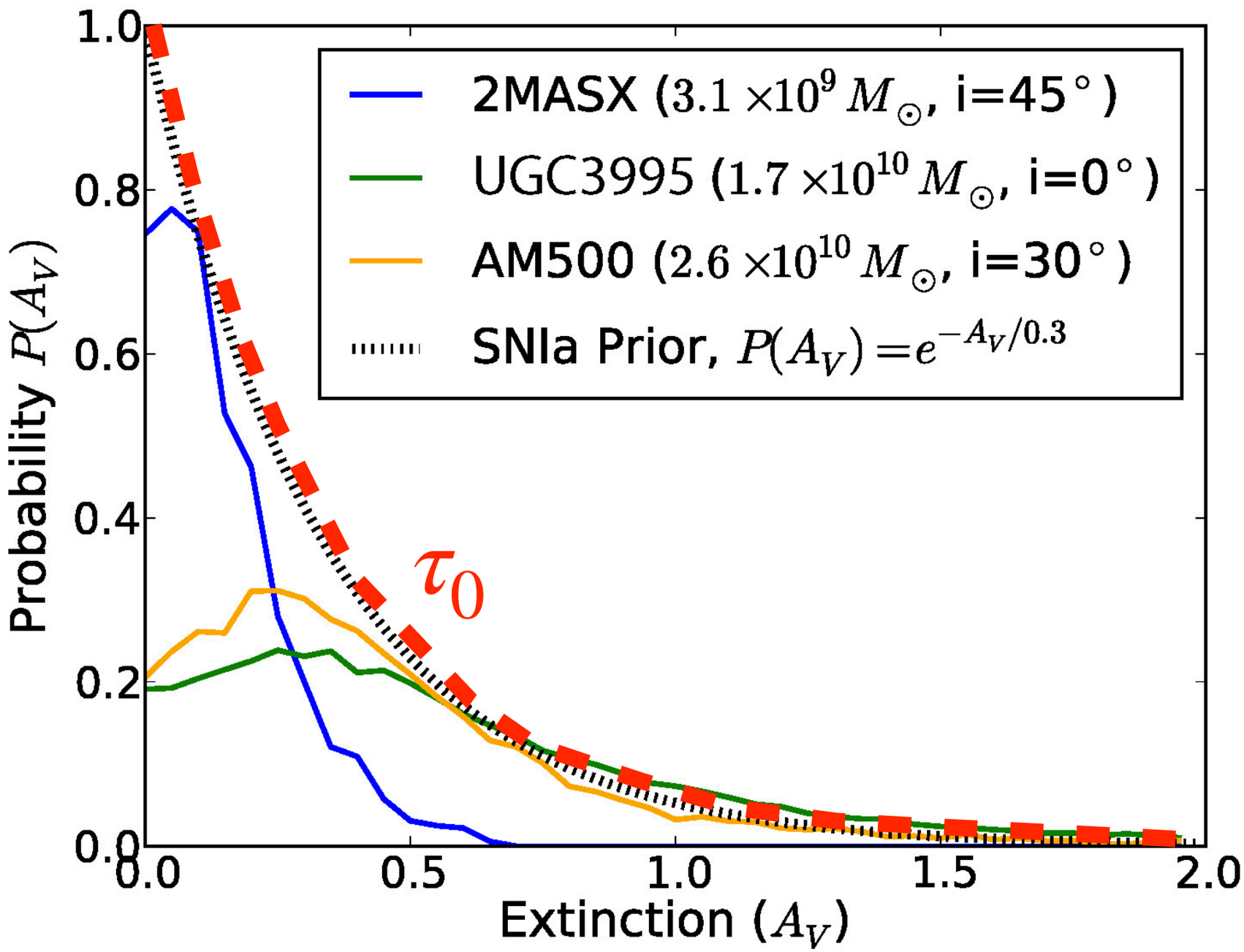

45
40
35
$(M - m)$
0.5
0.0
−0.5
Δm
0.00
0.25
0.50
0.75
1.00
1.25
1.50
$Redshift(z)$

Dust Geometry

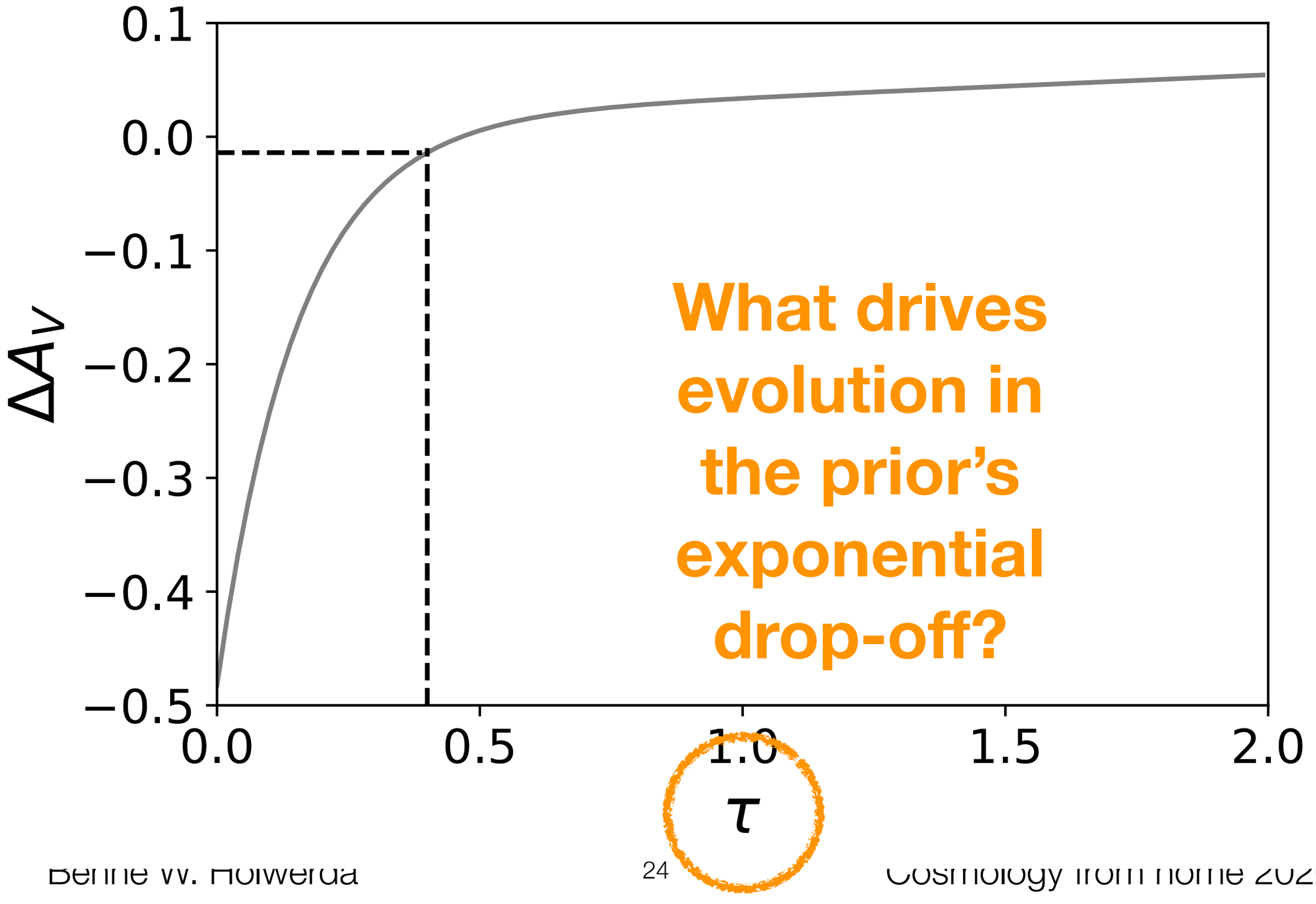
- MAGPHYS assumes a dust geometry wrt the stellar populations.

- How to convert the changes in average dust density to a SNIa bias?

Host Galaxy *Prior*

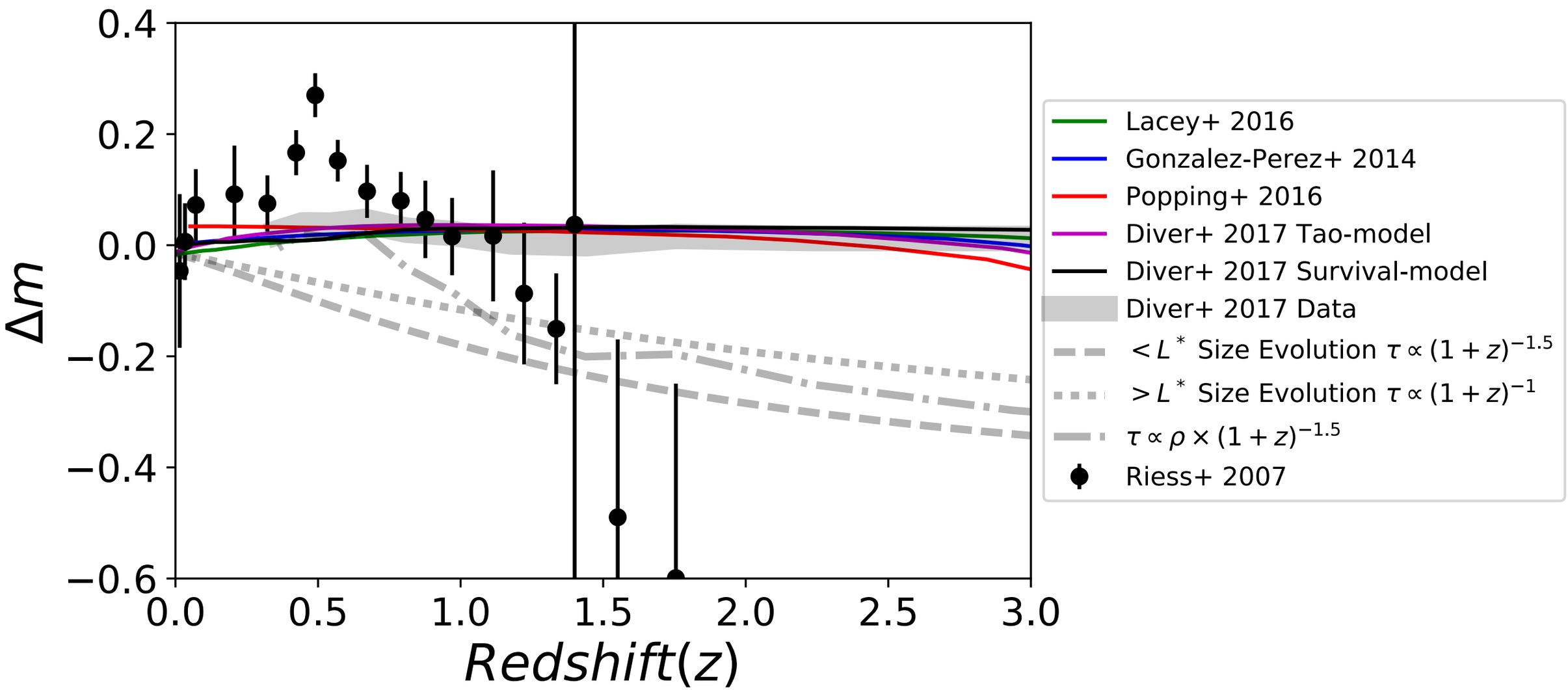


Jha+ 2007

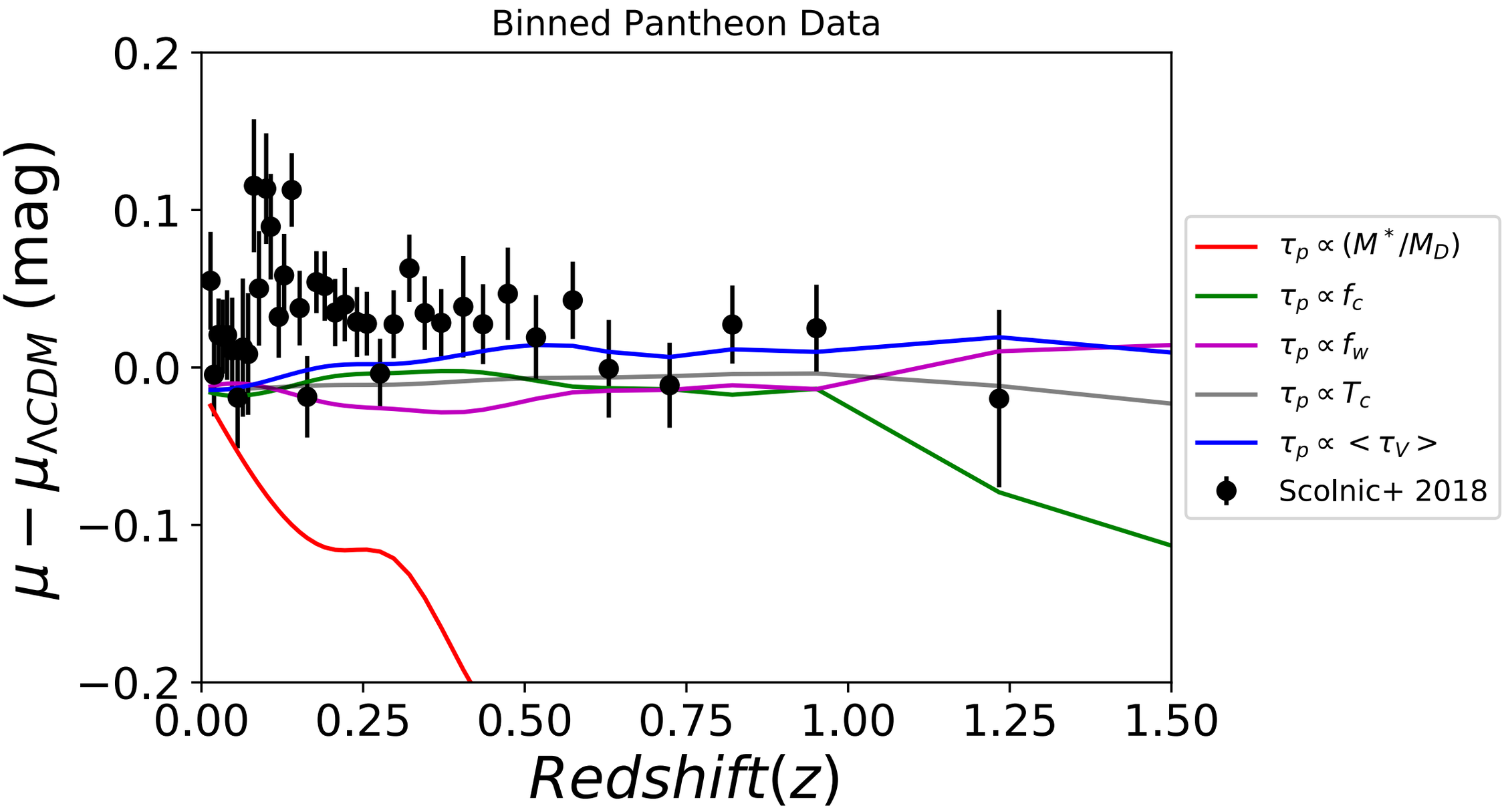


What drives evolution in the prior's exponential drop-off?

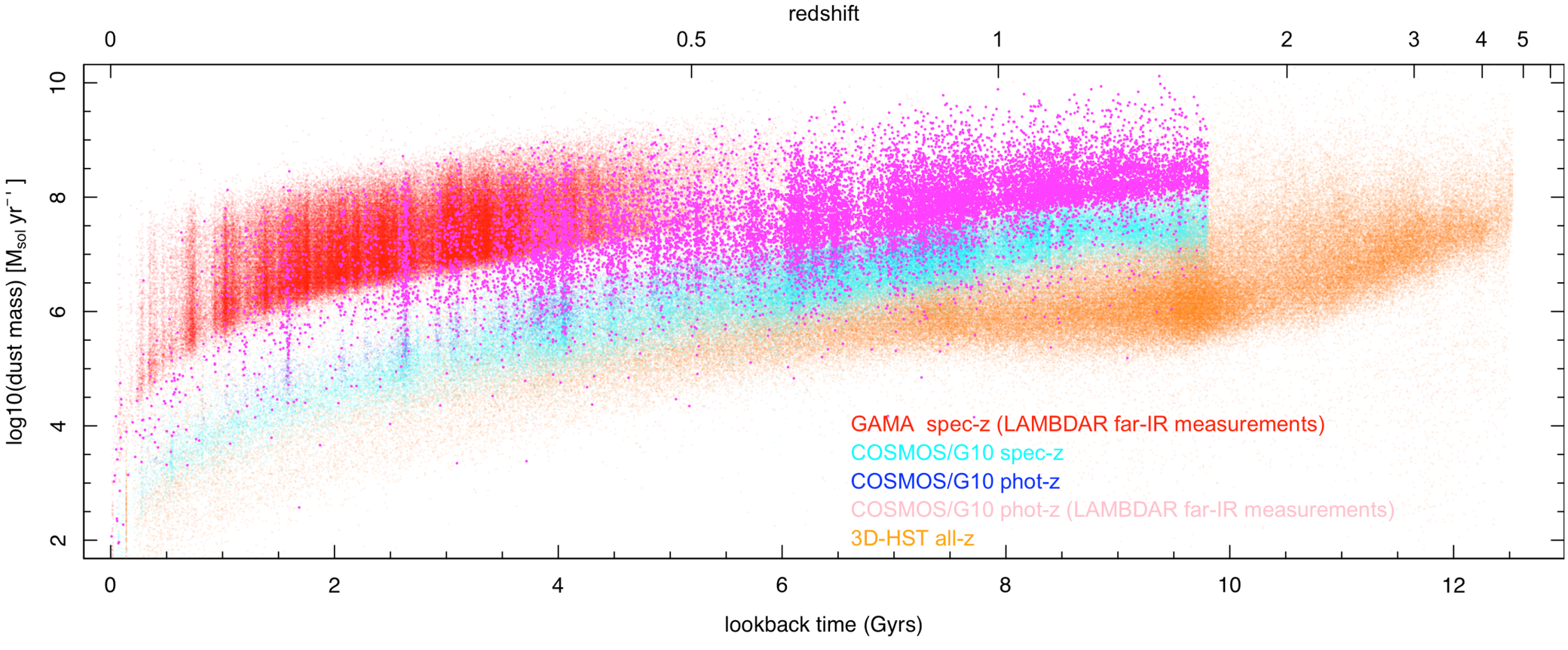
Models, Data and SNIa



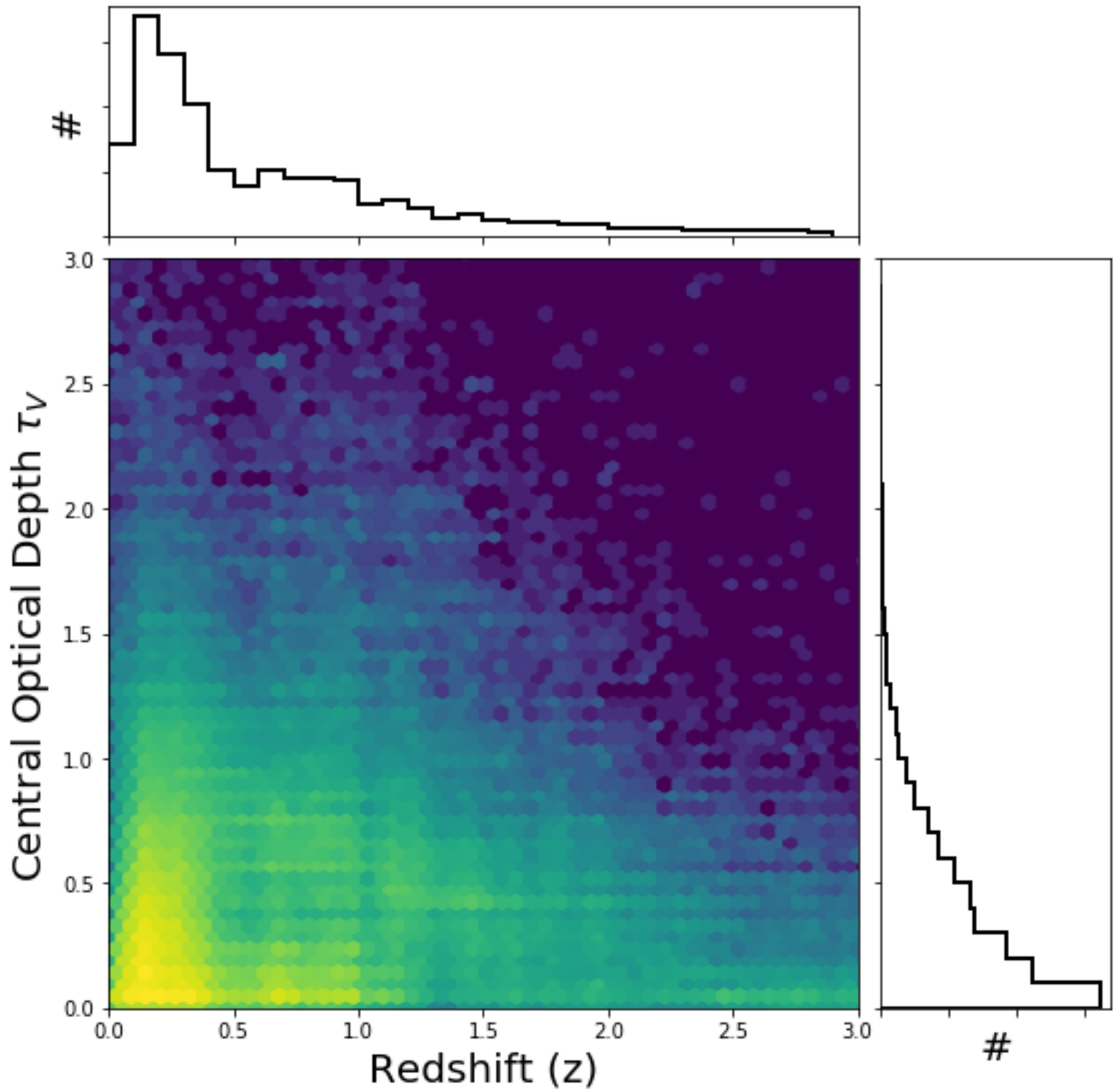
Dust properties?



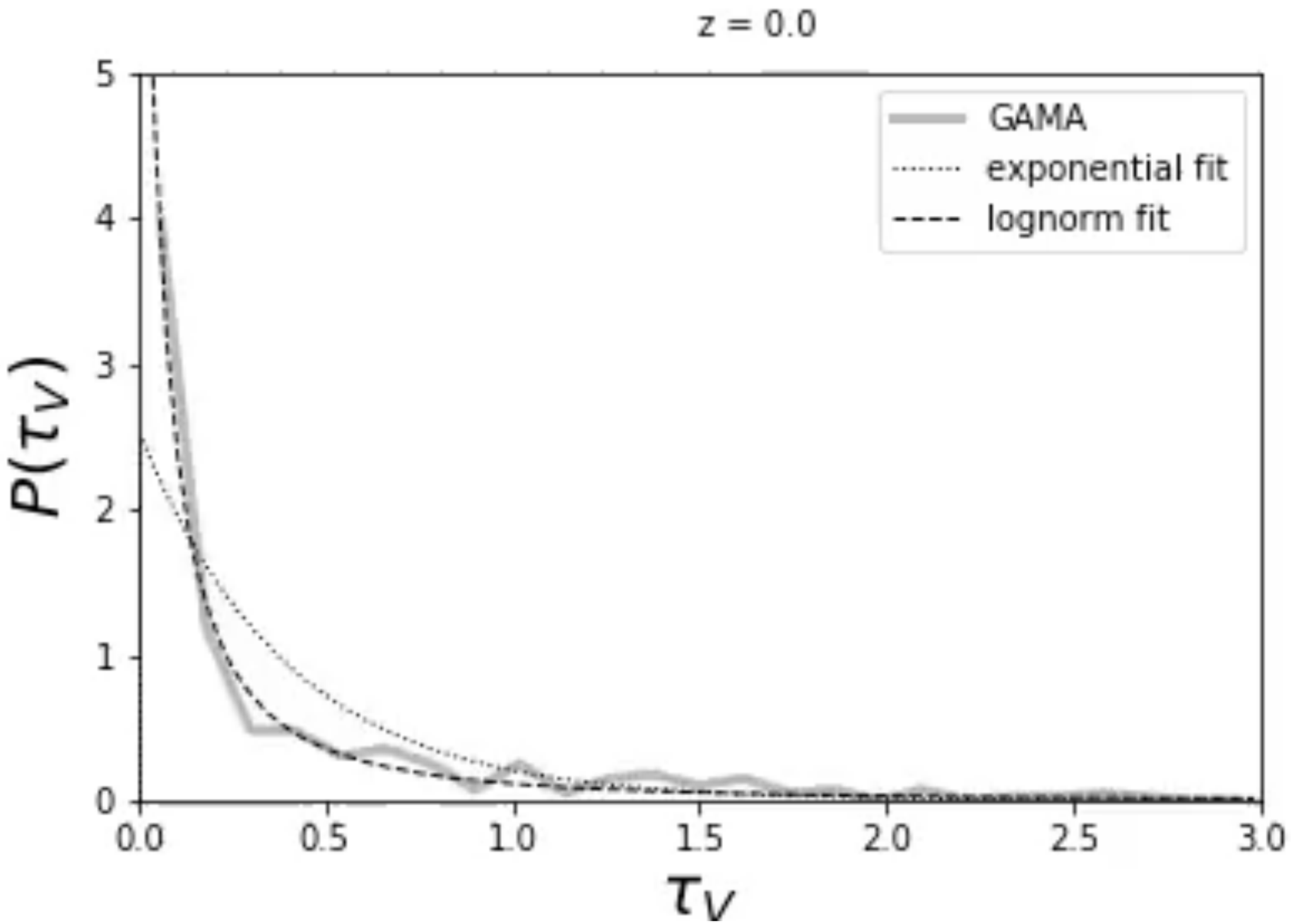
Each galaxy has an central optical depth measure!



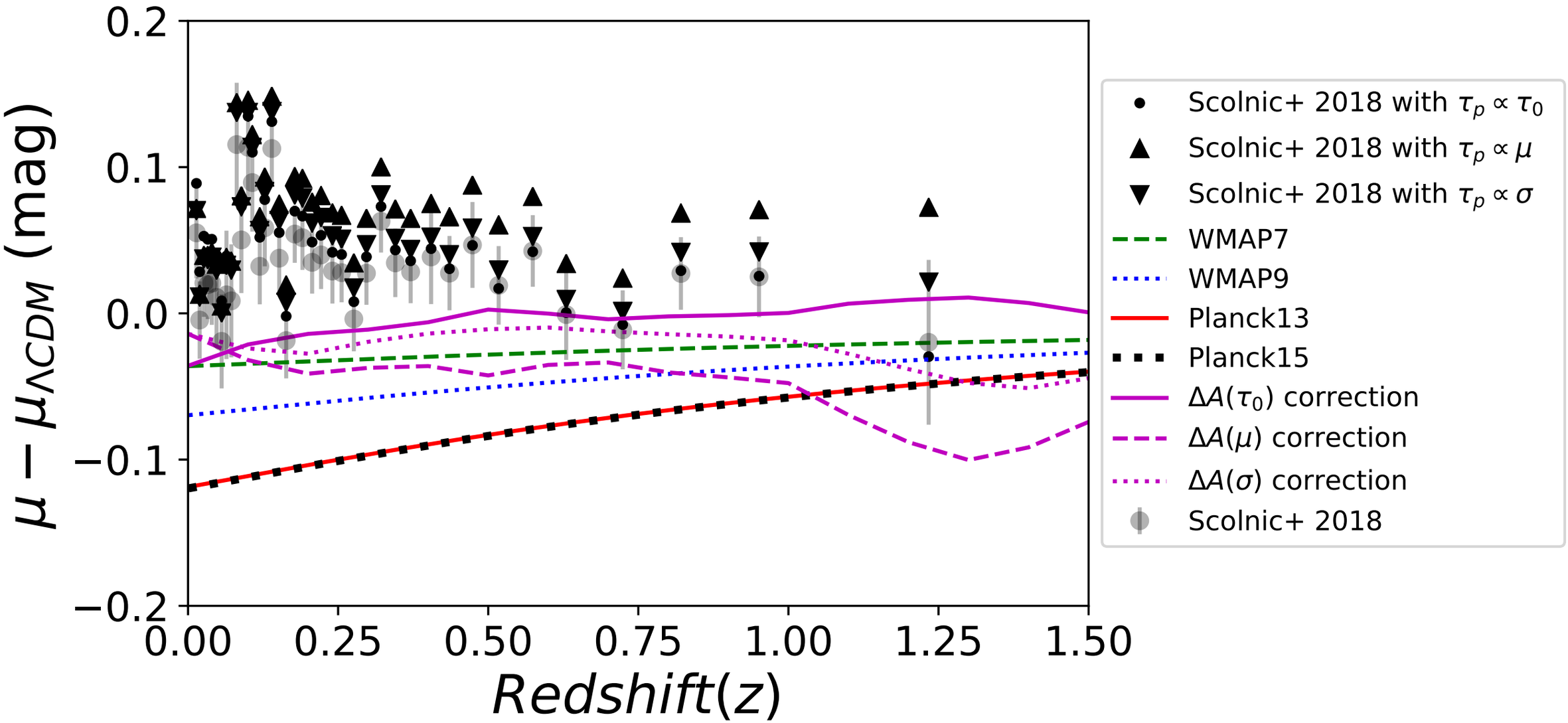
Magphys central optical depth τ_V for every galaxy in the survey!



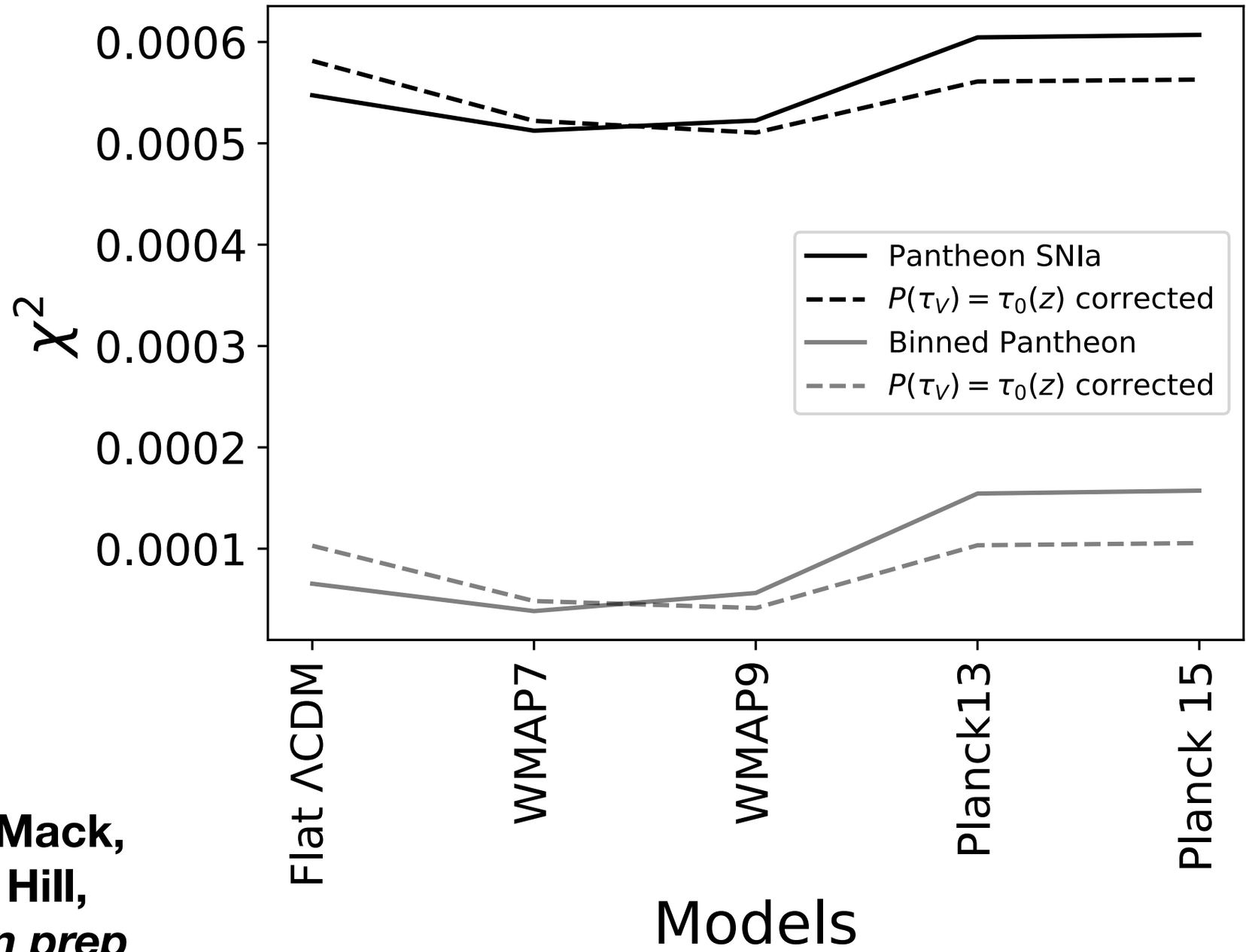
Their distribution evolves with redshift i.e. $P(\tau_V, z)$



Correcting using $P(\tau_V, z)$



Eases CMB tension?



Holwerda, Mack, Jacques, Hill, Roemer,+ *in prep*

Conclusions

- Supernovae are dimmed by their host galaxies.
- This likely skews distances.
- SED models of galaxies produce central optical depth measures.
- Their evolution accounts for some but not all discrepancy with CMB cosmology.