Turning Gravitationally Lensed Supernovae into Cosmological Tools

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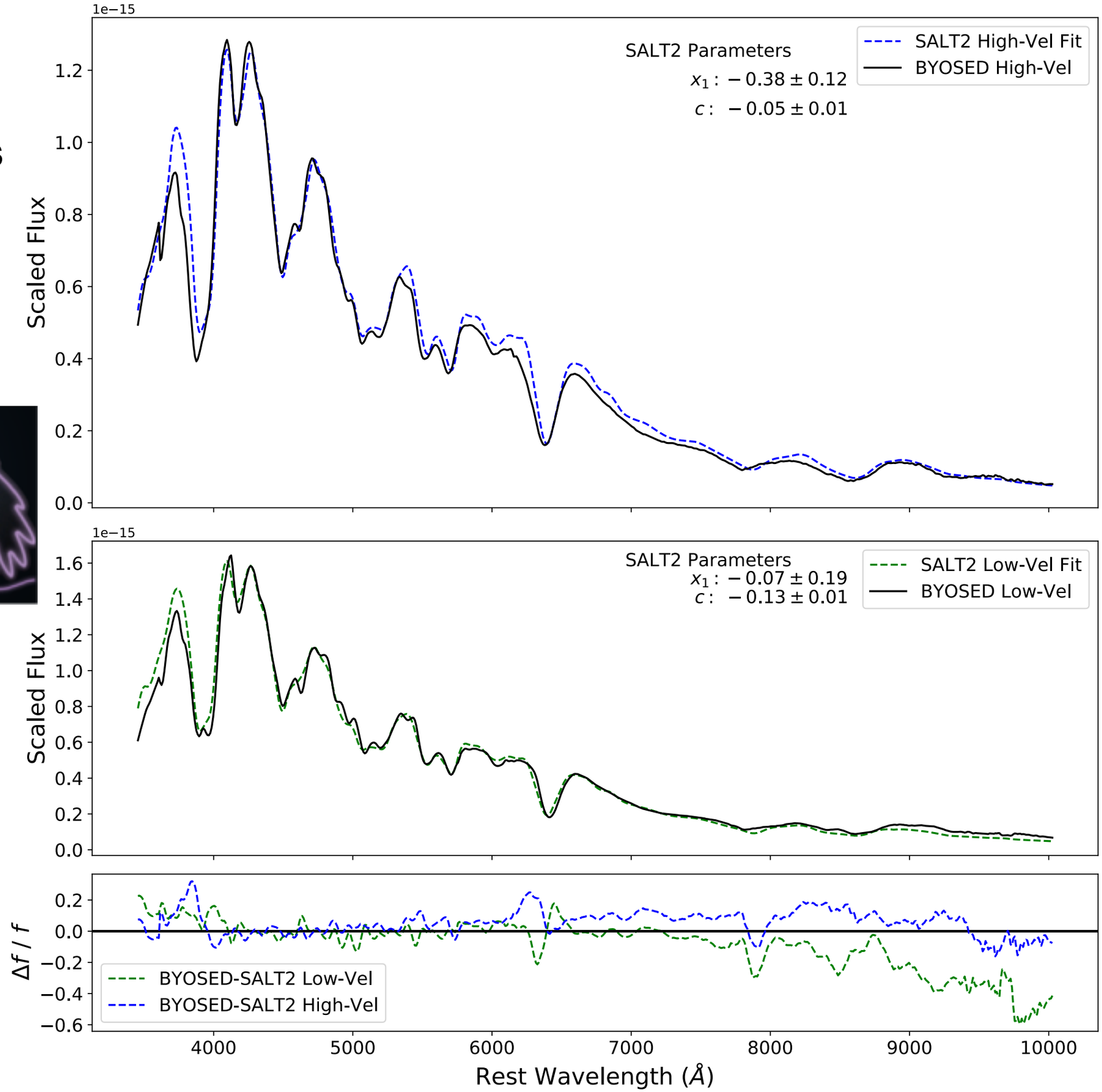
BYOSED
"Understanding Type Ia Supernova Distance Biases by Simulating Spectral Variations"

Pierel et al. in prep.



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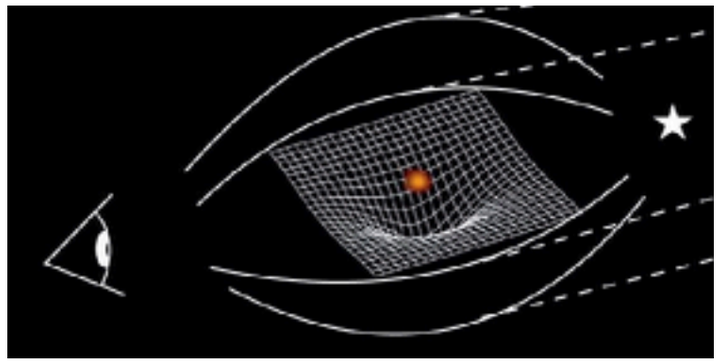
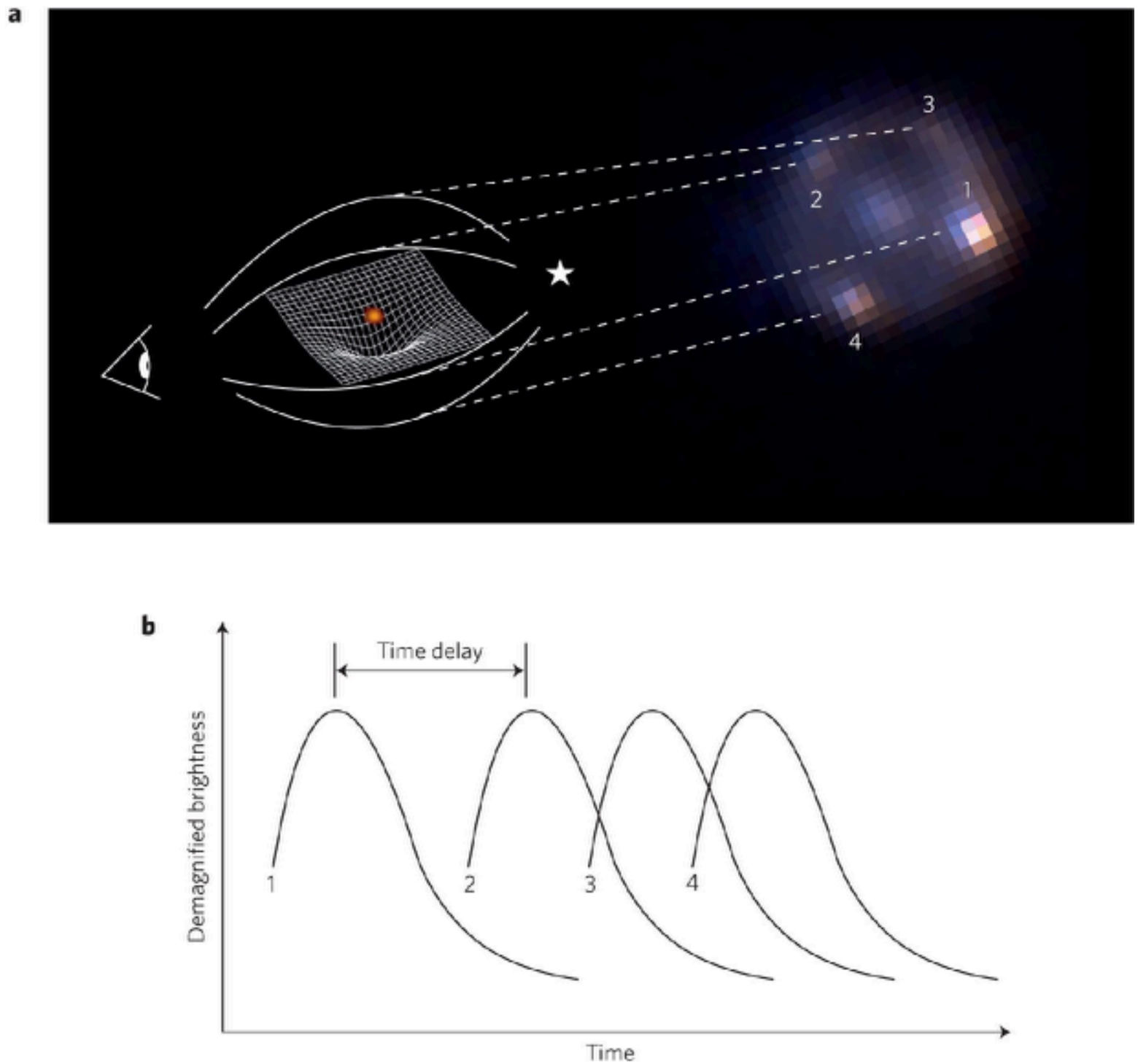



a
3
2
1
4
b
Time delay
Demagnified brightness
1
2
3
4
Time

Why?

flat – ΛCDM

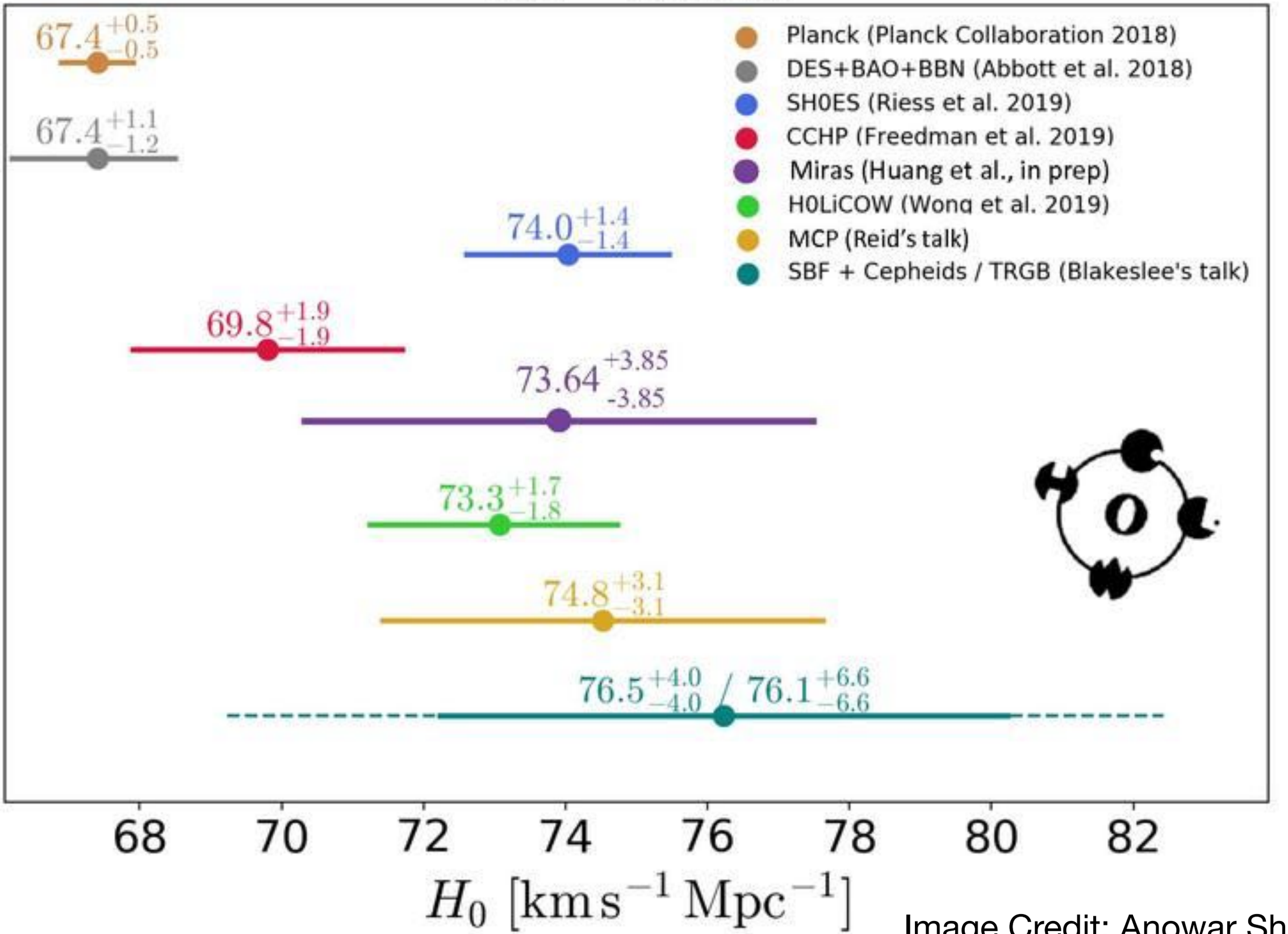
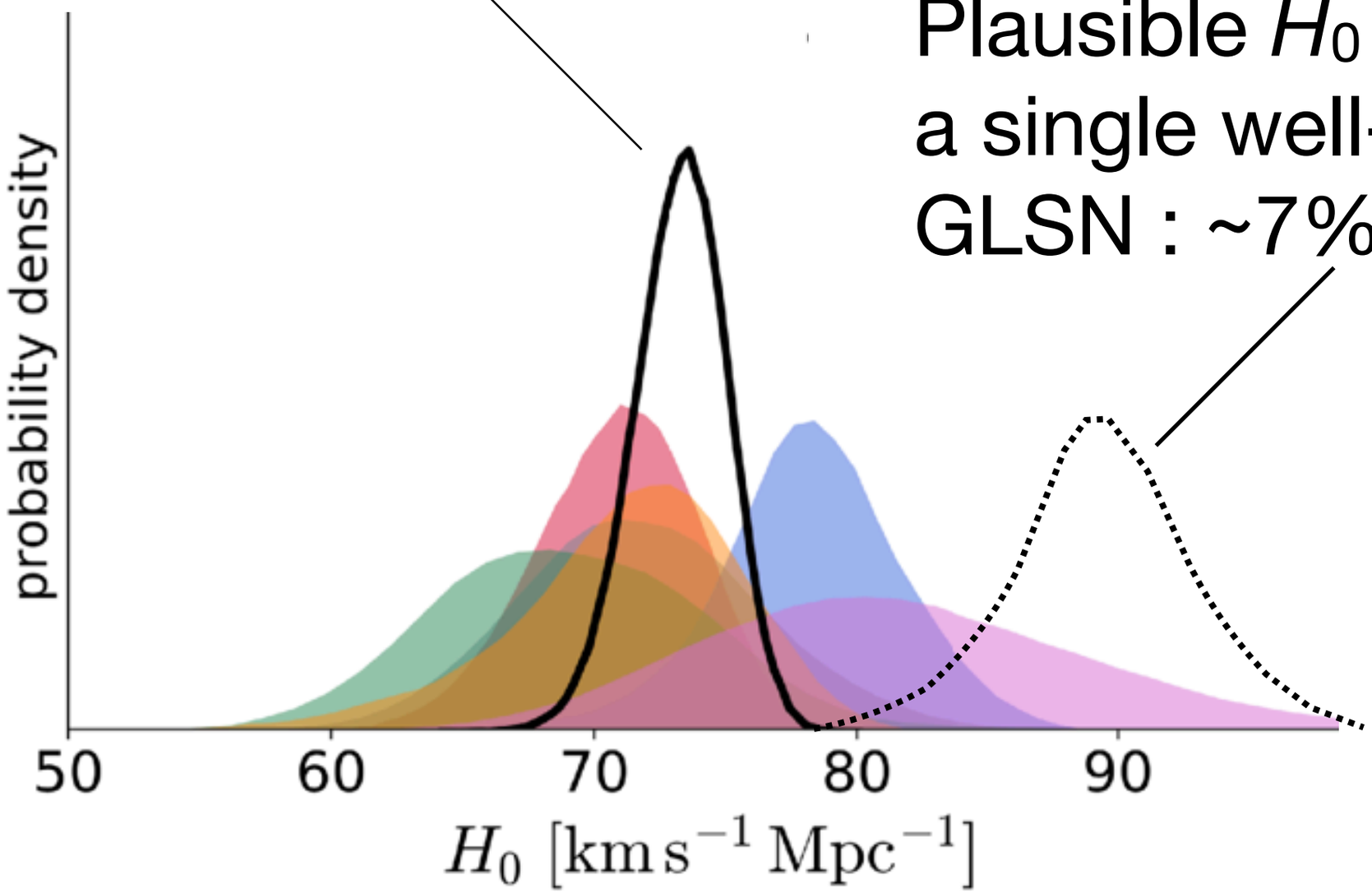


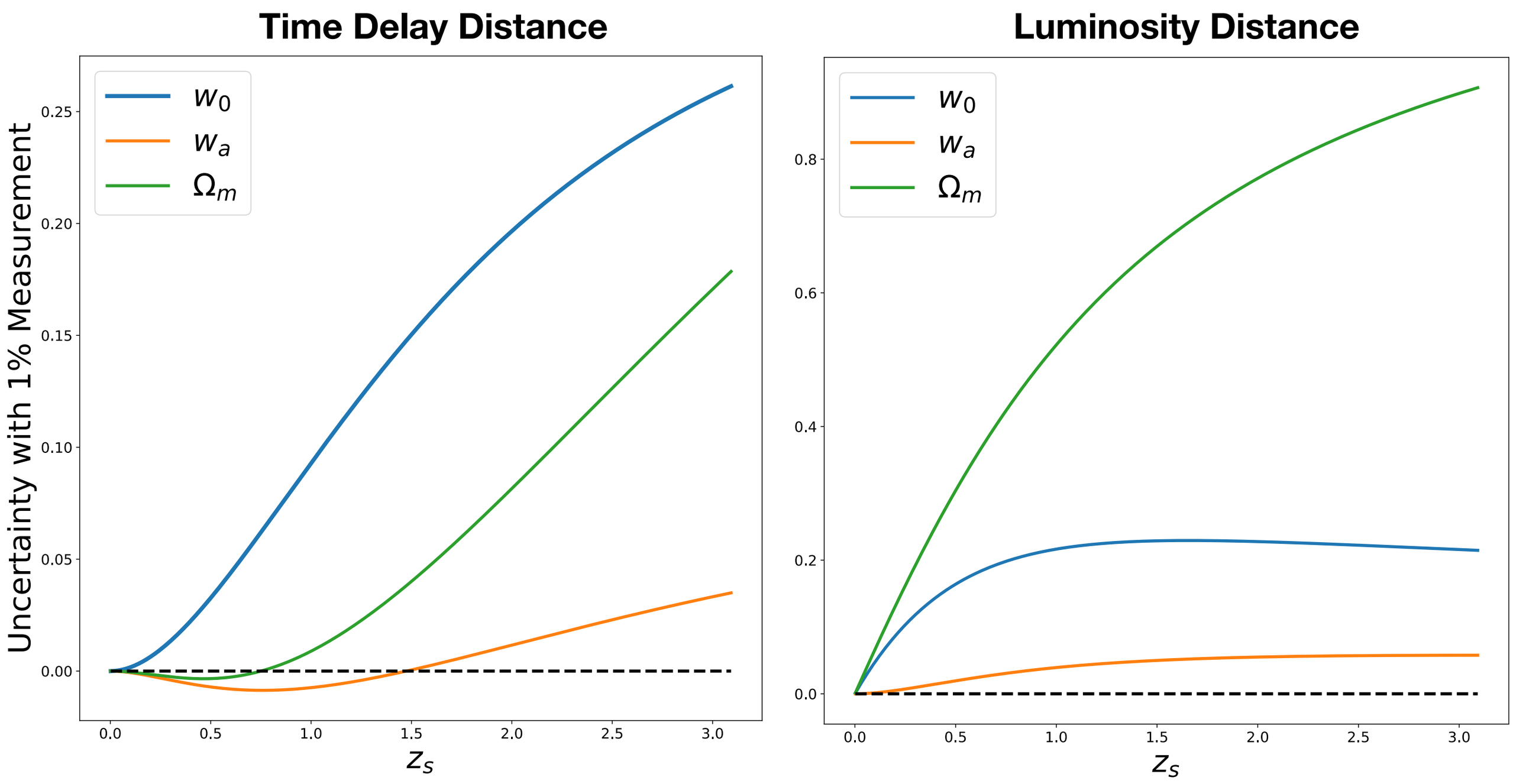
Image Credit: Anowar Shajib

H_0 measured to 2.4%, combining 6 lensed QSOs from H0LiCOW, each with ~6-10% precision

Wong+ 2019

Plausible H_0 precision from a single well-observed GLSN : ~7%





Based on Linder 2011

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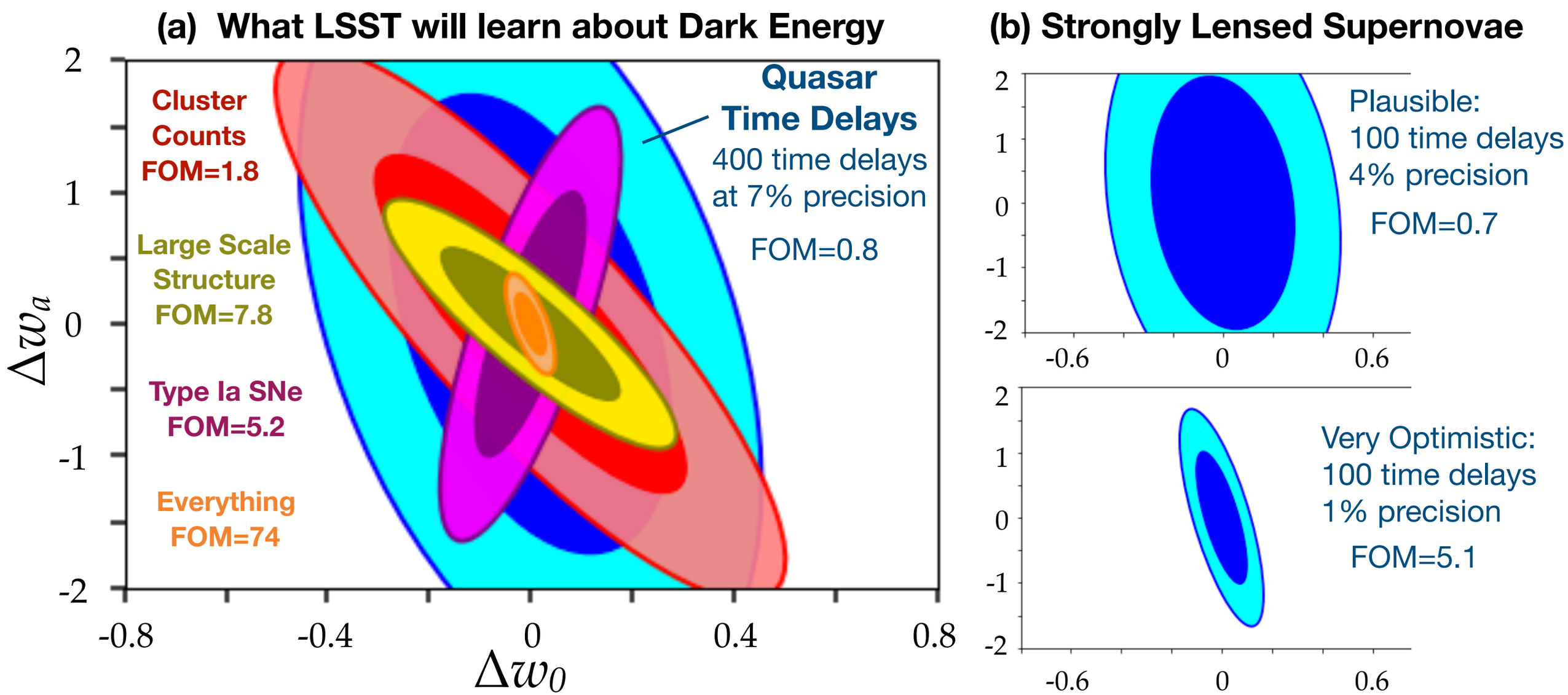
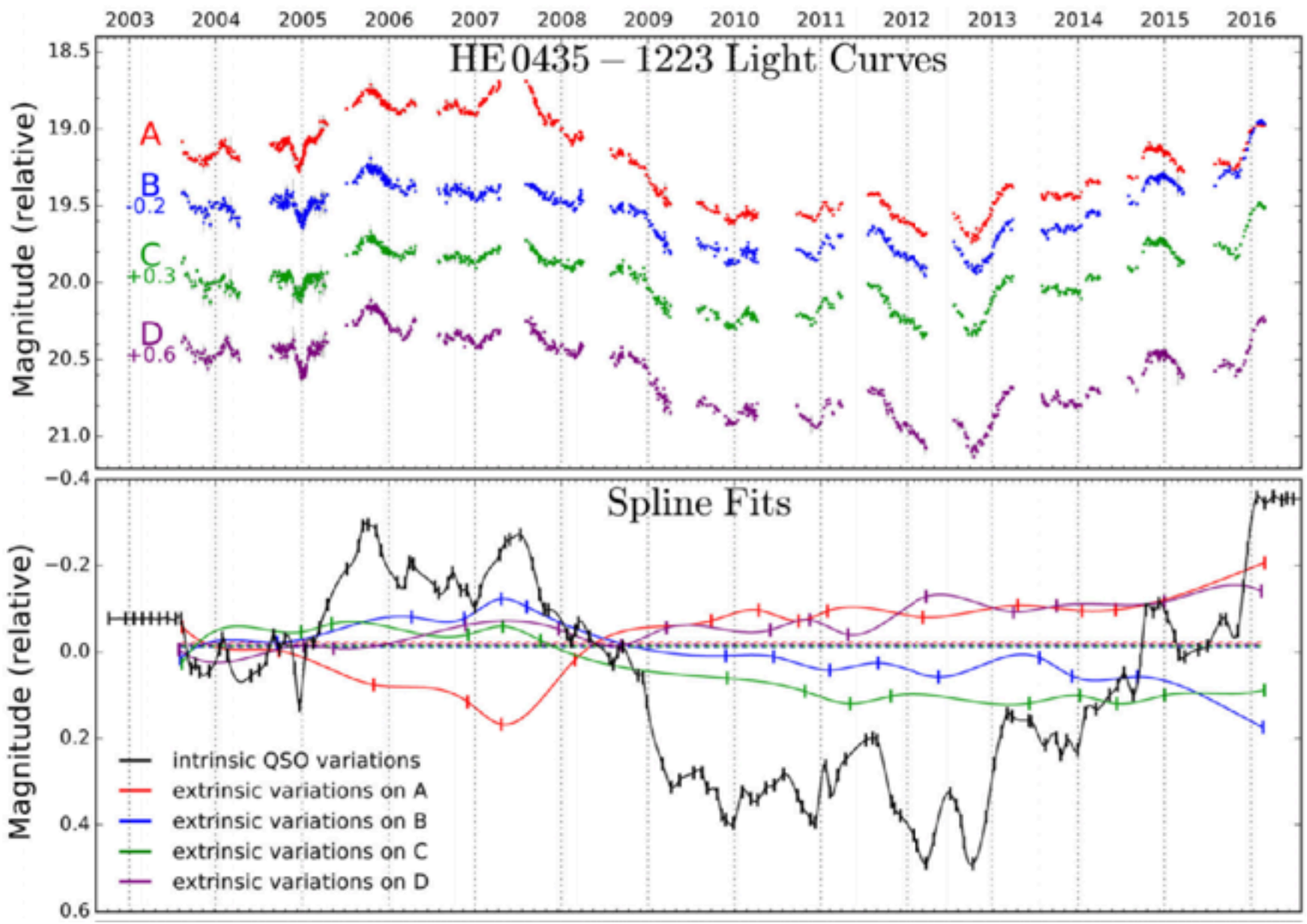
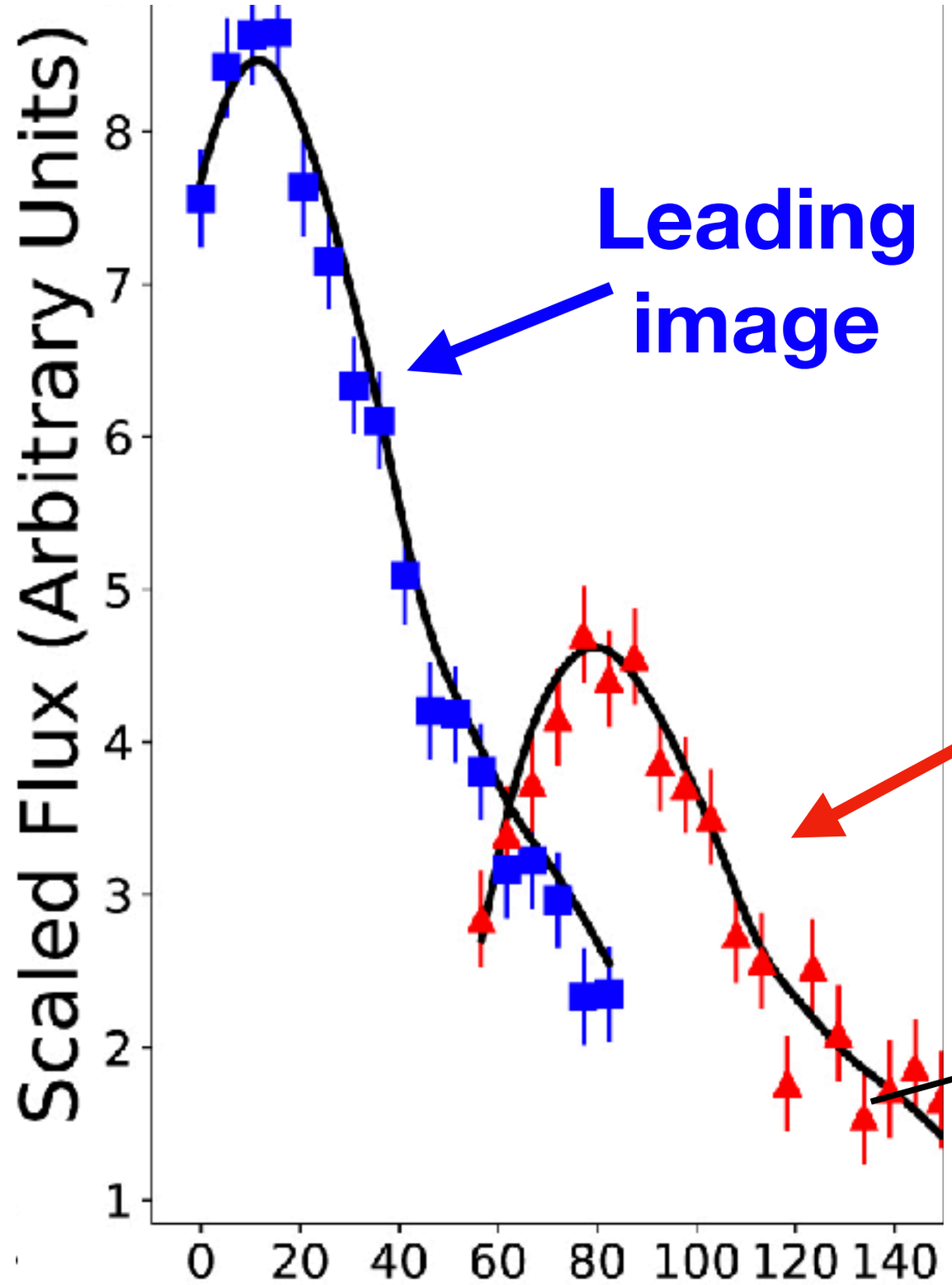

(a) What LSST will learn about Dark Energy
Cluster Counts FOM=1.8
Large Scale Structure FOM=7.8
Type Ia SNe FOM=5.2
Everything FOM=74
Quasar Time Delays
400 time delays at 7% precision
FOM=0.8
Δw_a
Δw_0
2
1
0
-1
-2
-0.8
-0.4
0
0.4
0.8
(b) Strongly Lensed Supernovae
Plausible:
100 time delays
4% precision
FOM=0.7
Very Optimistic:
100 time delays
1% precision
FOM=5.1
-0.6
0
0.6

Why Supernovae?

Quasar light curves are stochastic and unpredictable...



(most) SN Light curves are fast, simple, and predictable

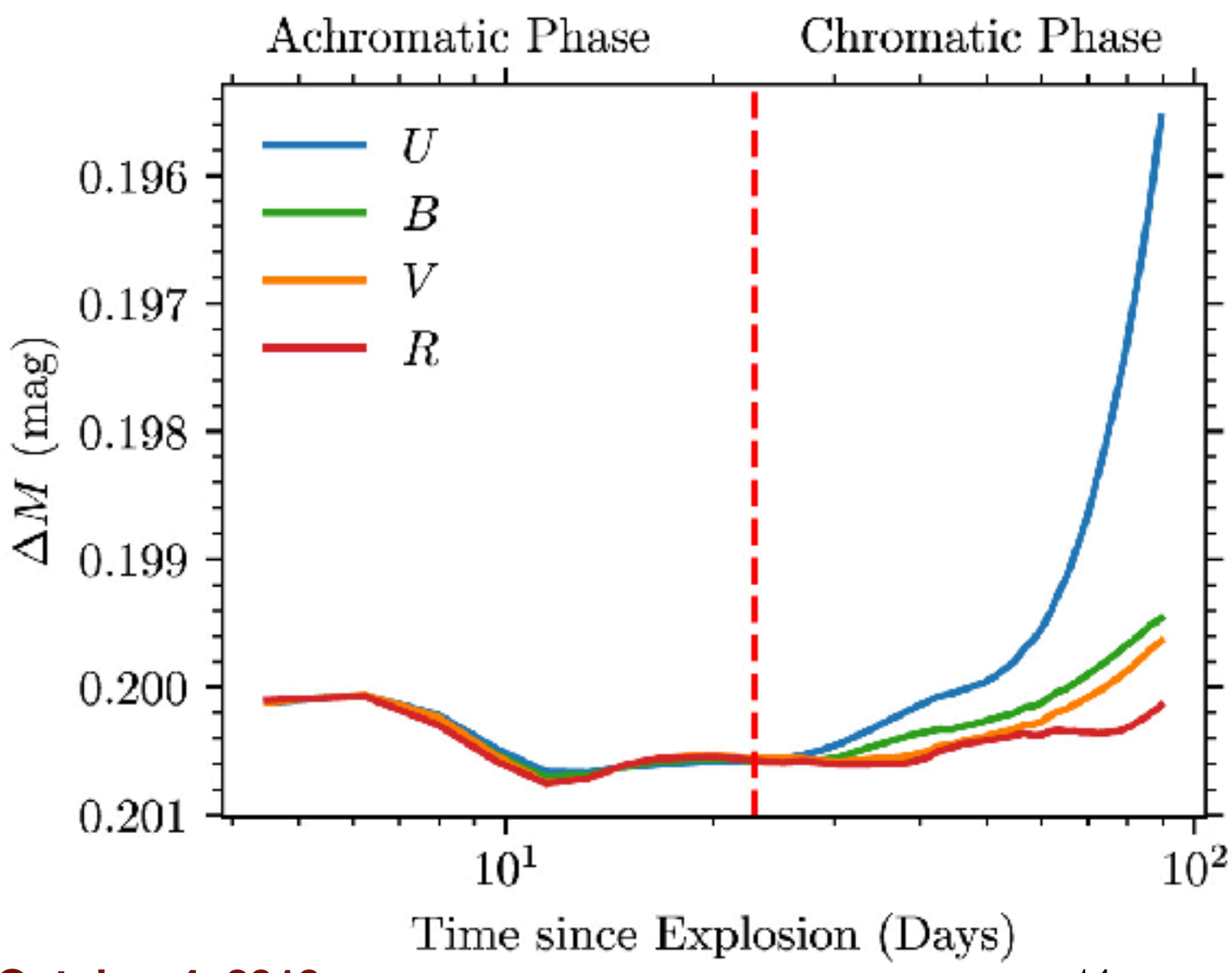


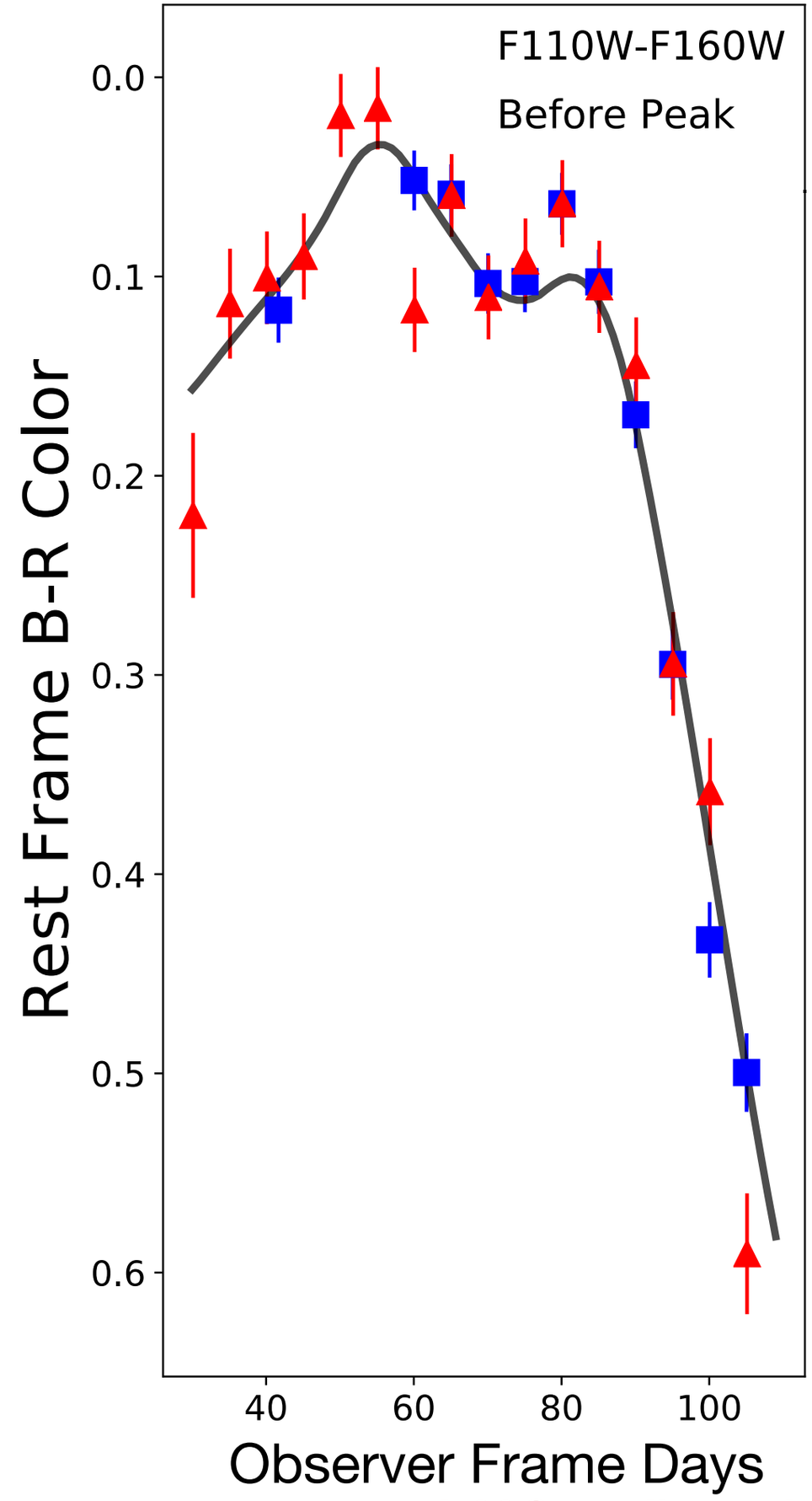
Type Ia model

Observer-frame days

Pierel & Rodney 201

Achromatic Microlensing?





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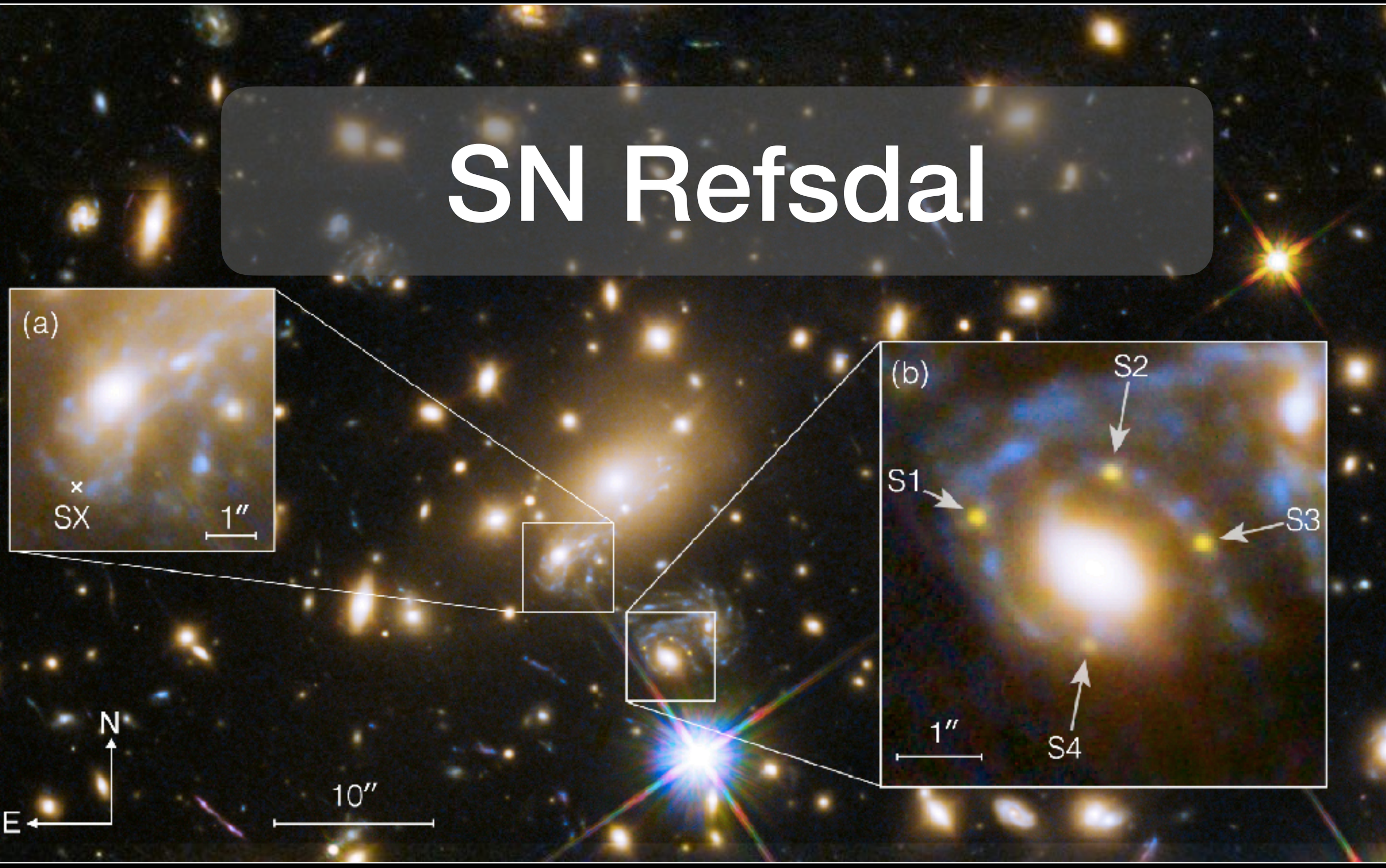
Goldstein et al. 2017

SN Refsdal



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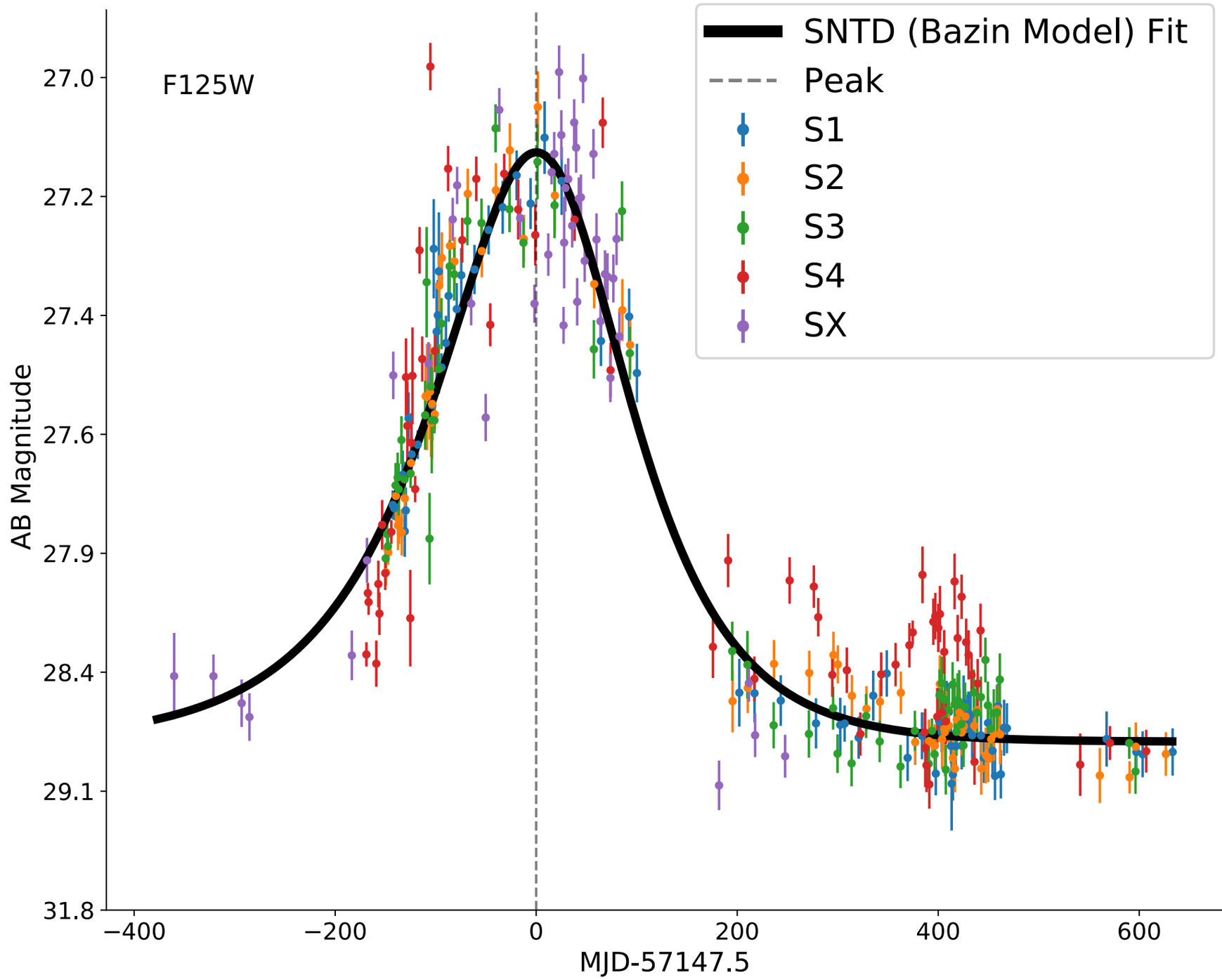
SN Refsdal: SNTD (parameterized)

J. Pierel
S. Rodney



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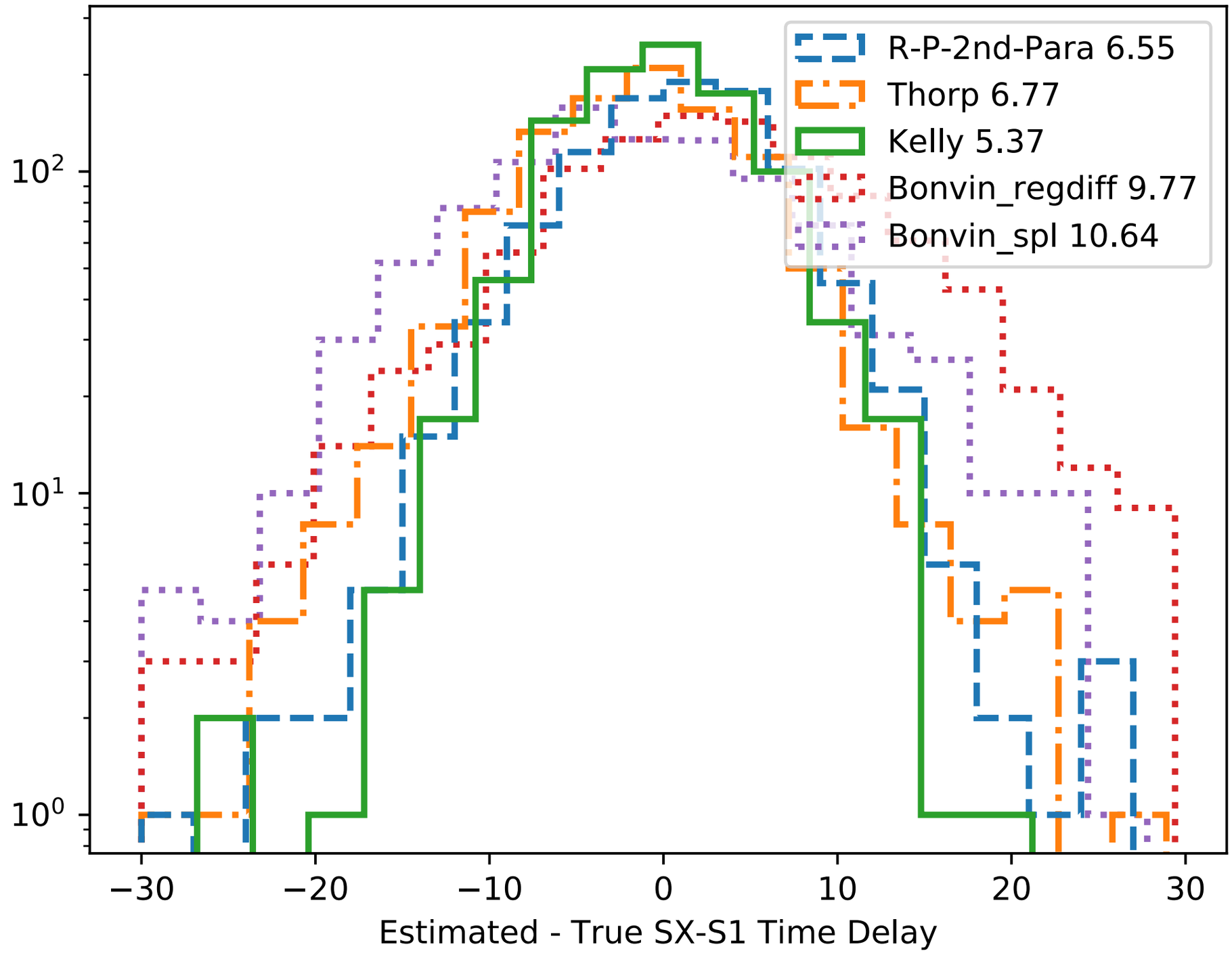
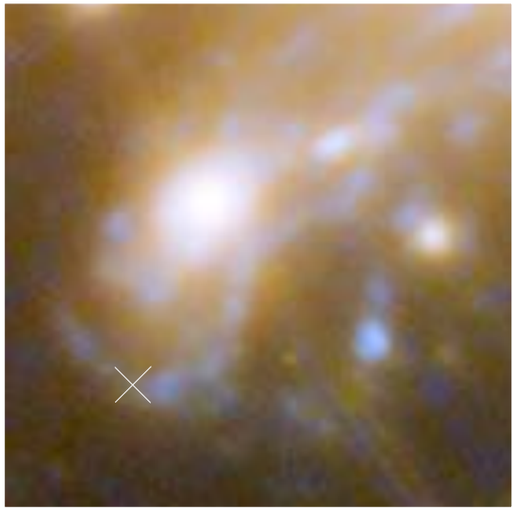
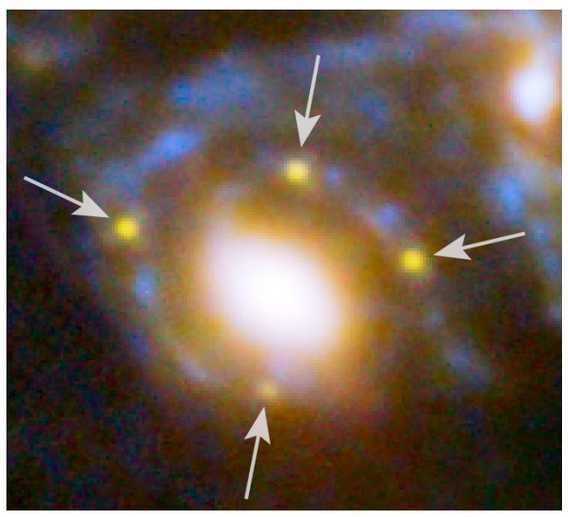
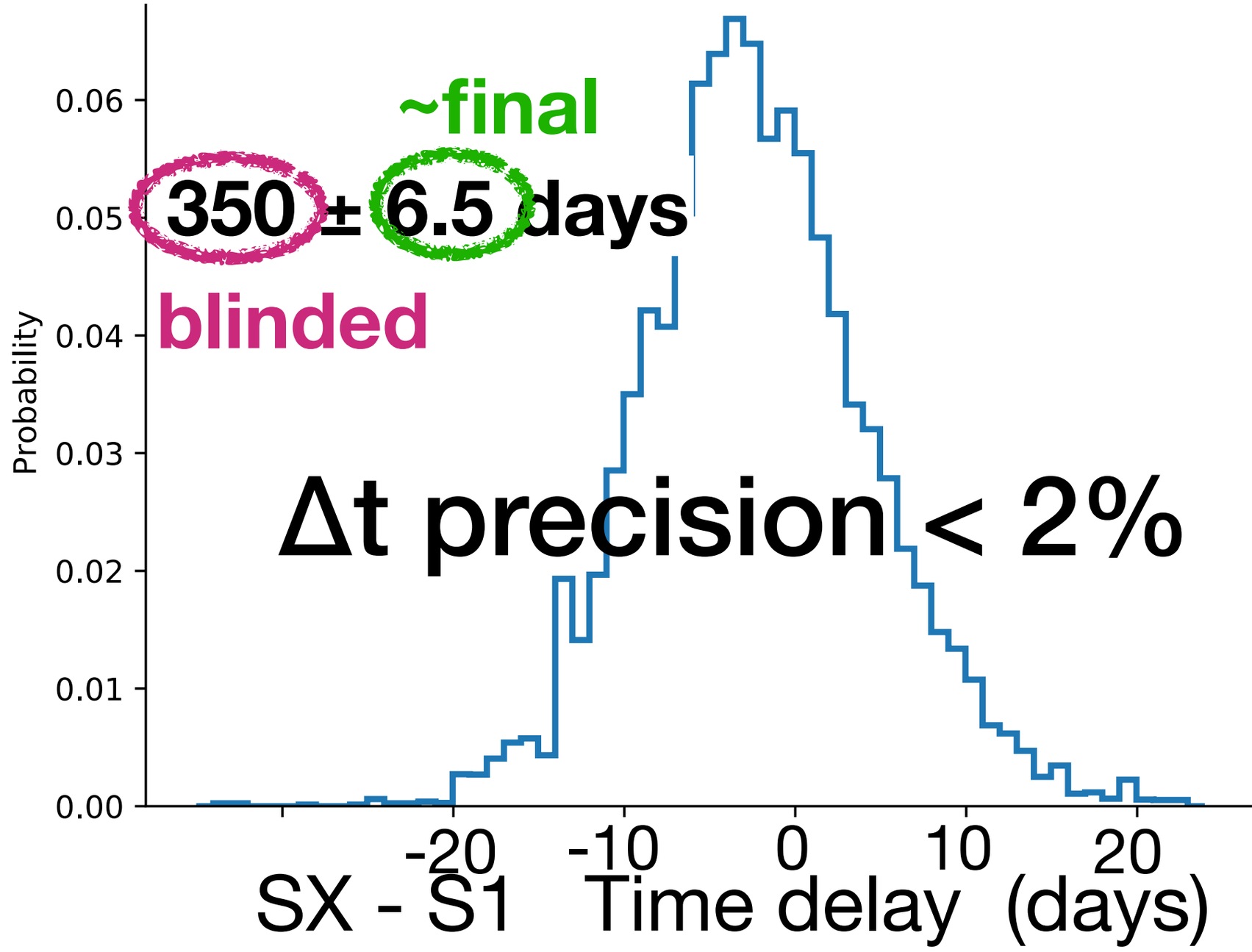
Accuracy in fitting simulated light curves: SX-S1



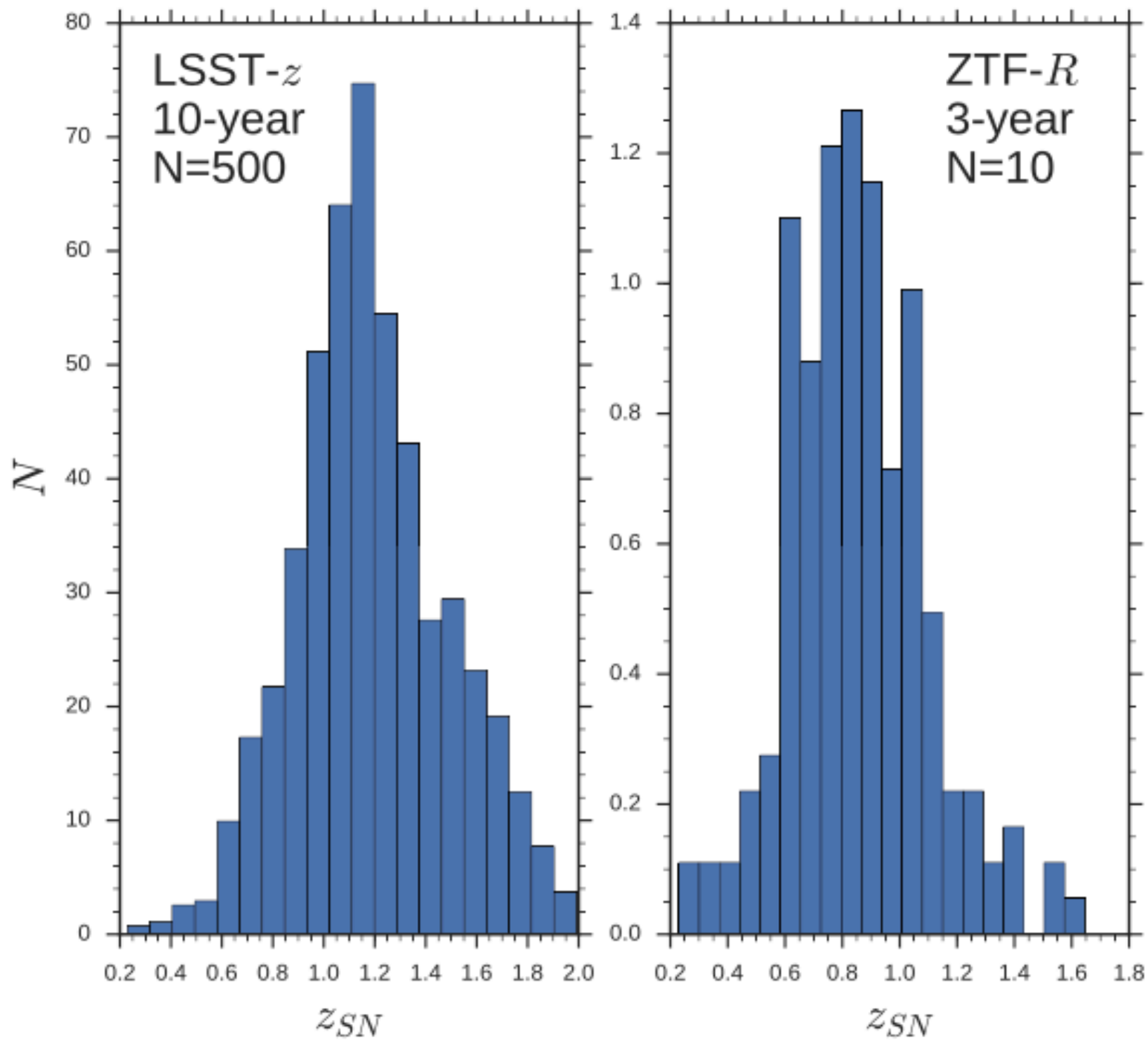
Composite Time Delays : SX-S1





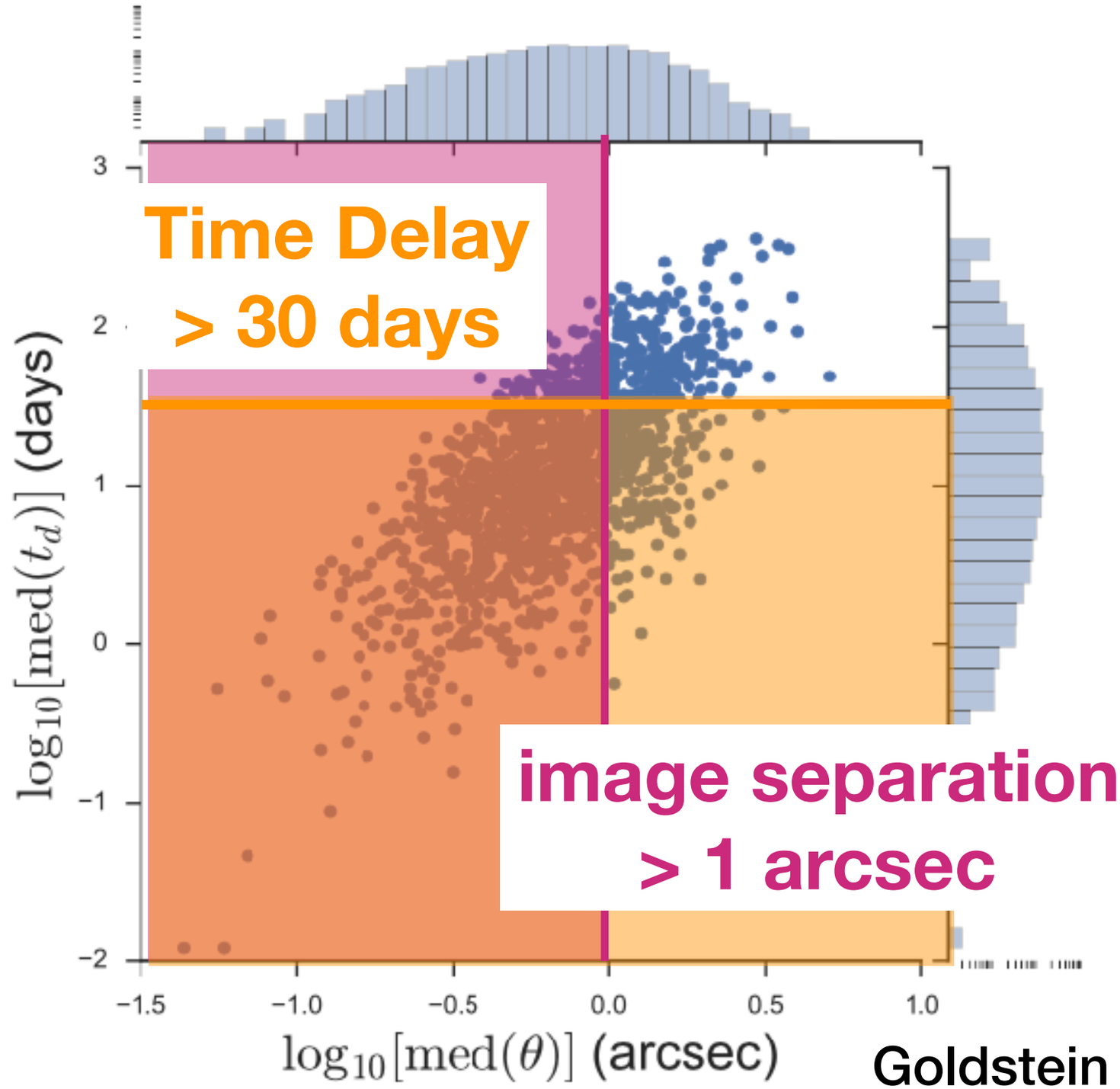


ZTF should find a handful, LSST will find hundreds



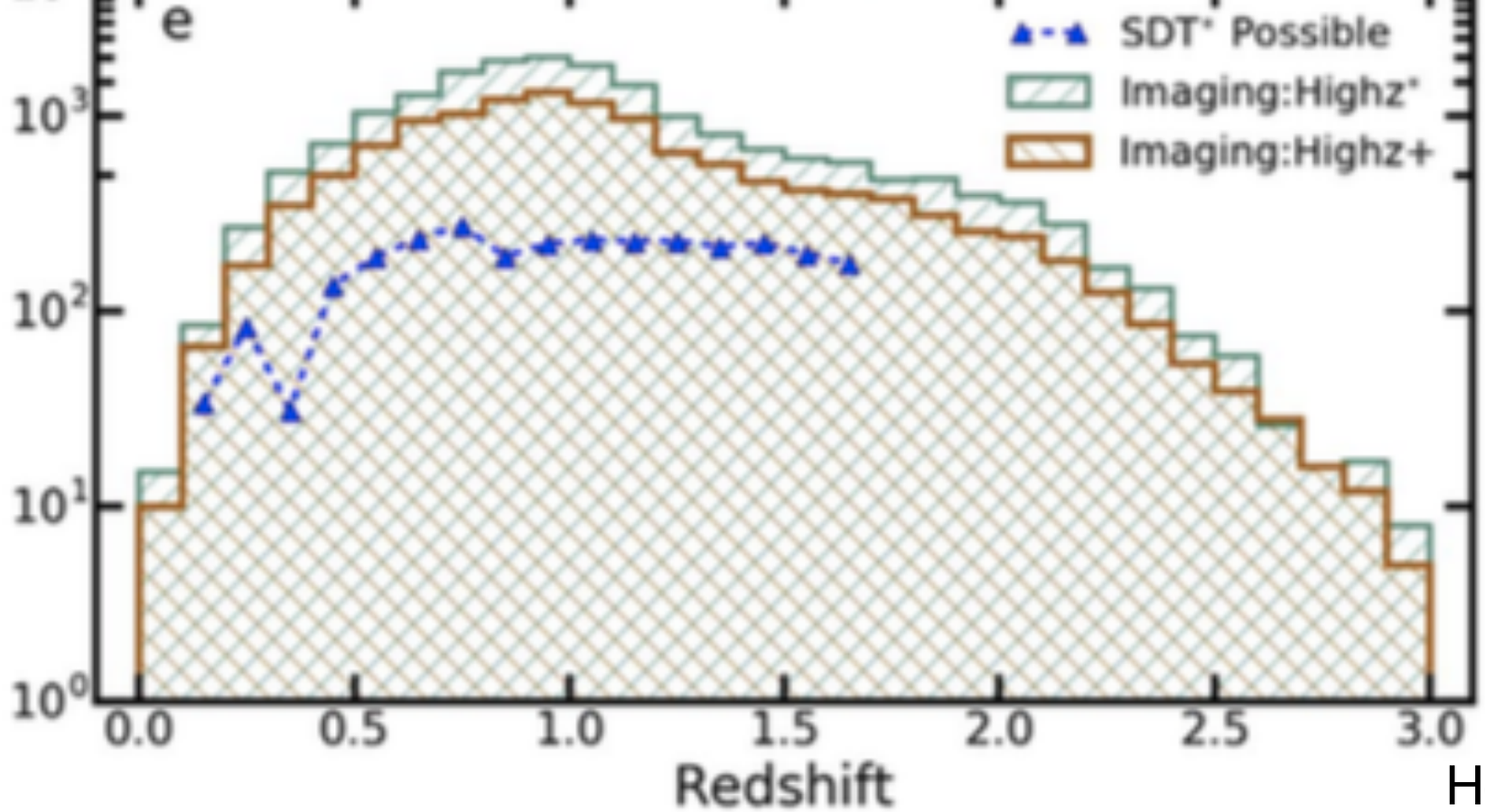
Goldstein & Nugent 2017

Only a small fraction will be suitable for time delay cosmography



Goldstein & Nugent 2017

Next…



Hounsell et al. 2018

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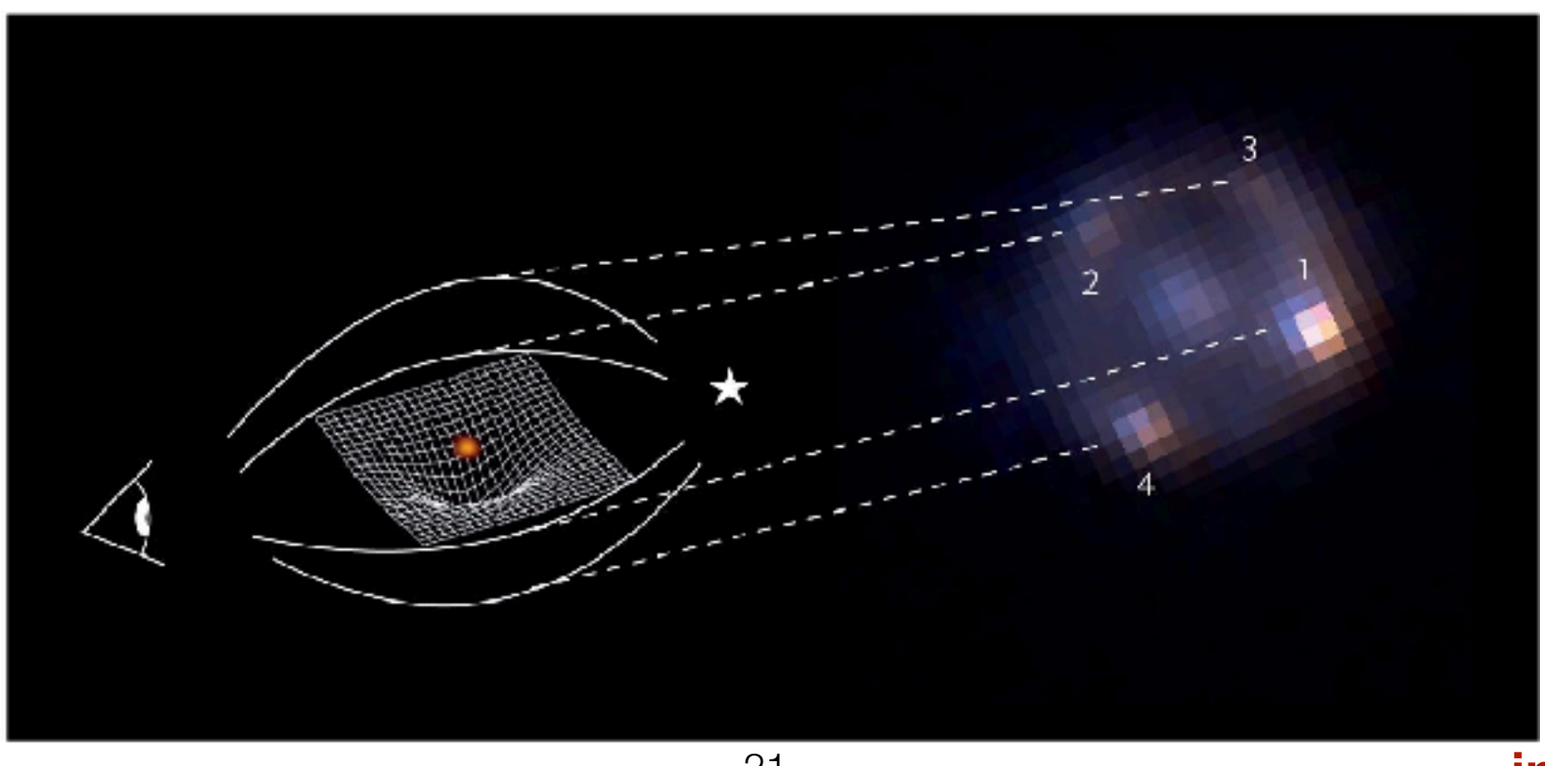
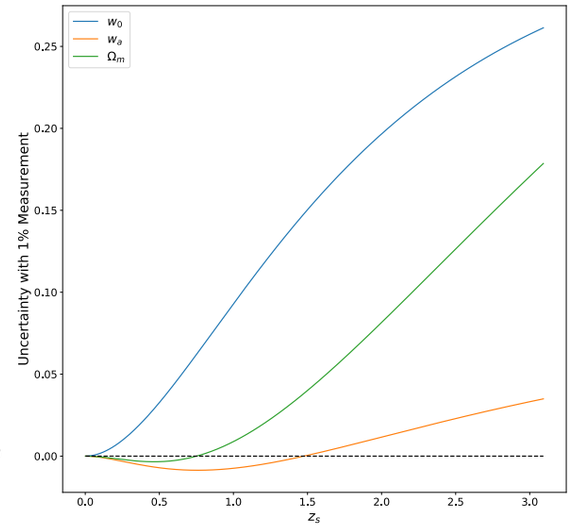
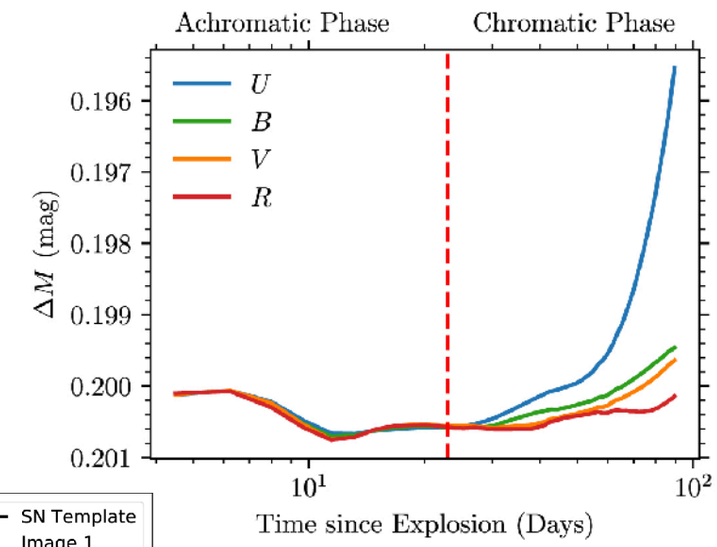


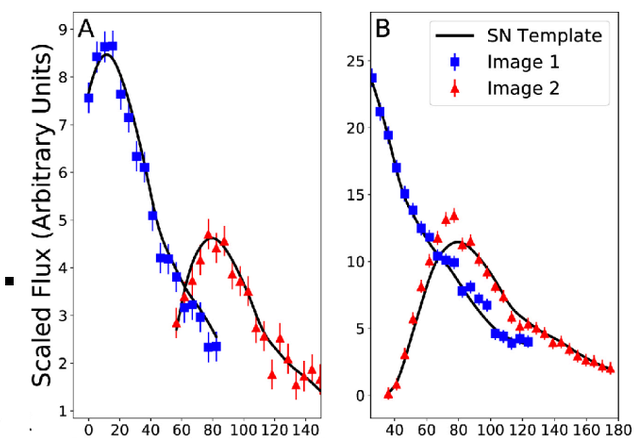
1. Why Time Delay Cosmography? *Independent of other methods, unique constraints on parameters.*



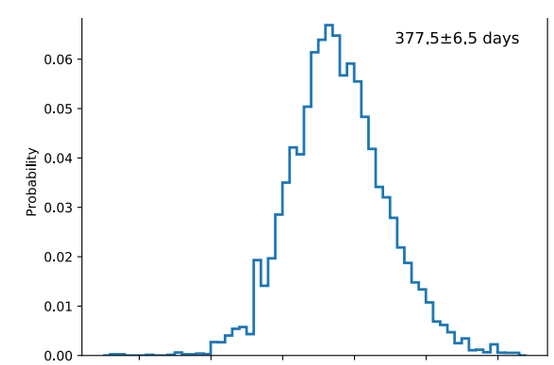


2. Why use GLSN? *They have natural strengths for time delay cosmography.*

3. Measuring time delays: SNTD is designed to leverage those strengths.



4. SN Refsdal is delivering a time delay measurement <2%, will deliver H0~7%



5. Expect a handful more by 2025, hundreds by 2030