



Zwicky Transient Facility

Cosmology science working group

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Zwicky Transient Facility

3 filters (g, r, i)

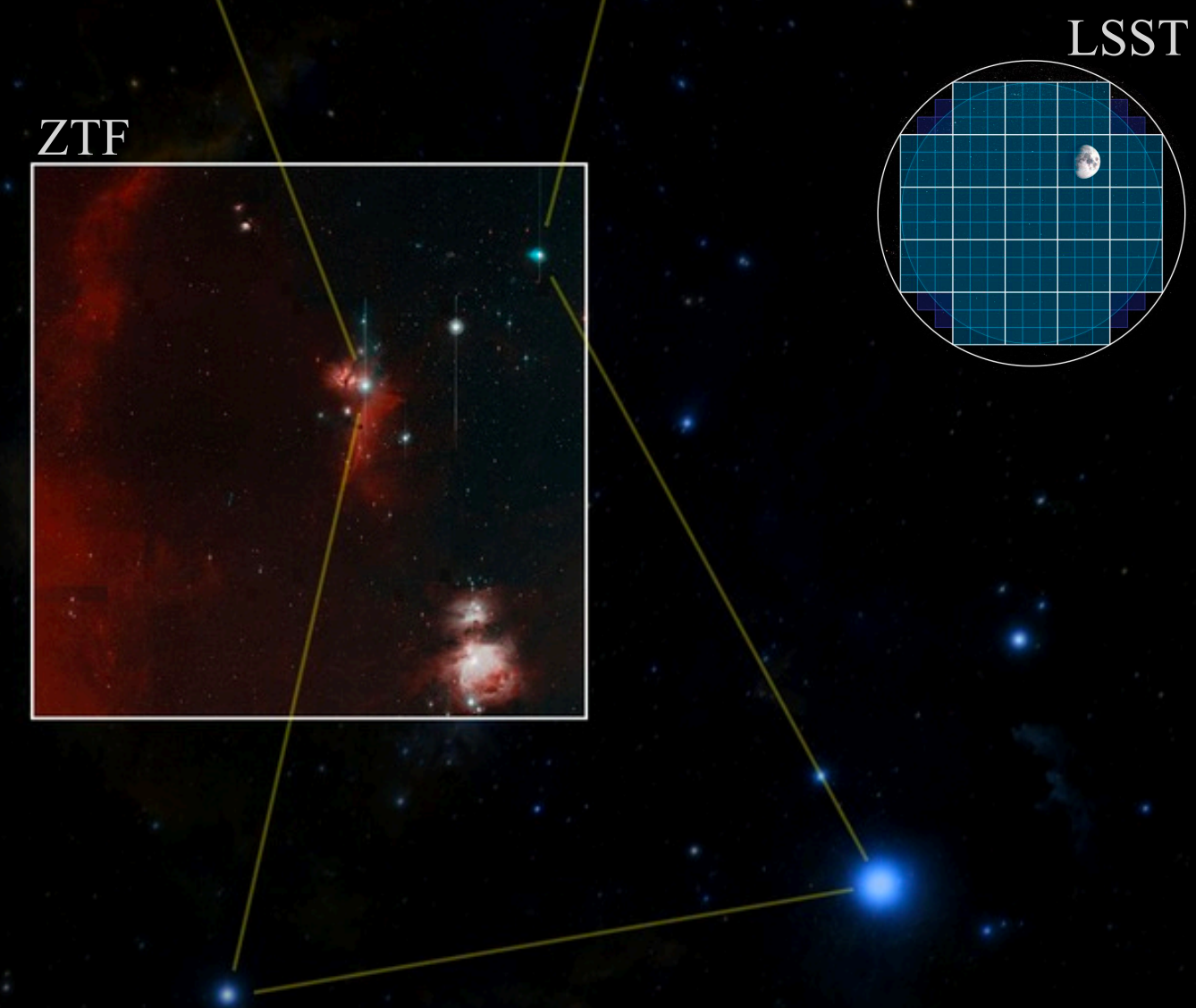
FoV 47 deg²

surveys 3750 deg²/h

20.5 mag 5 σ depth

1 arcsec/pixel

dedicated spectroscopy



Caltech



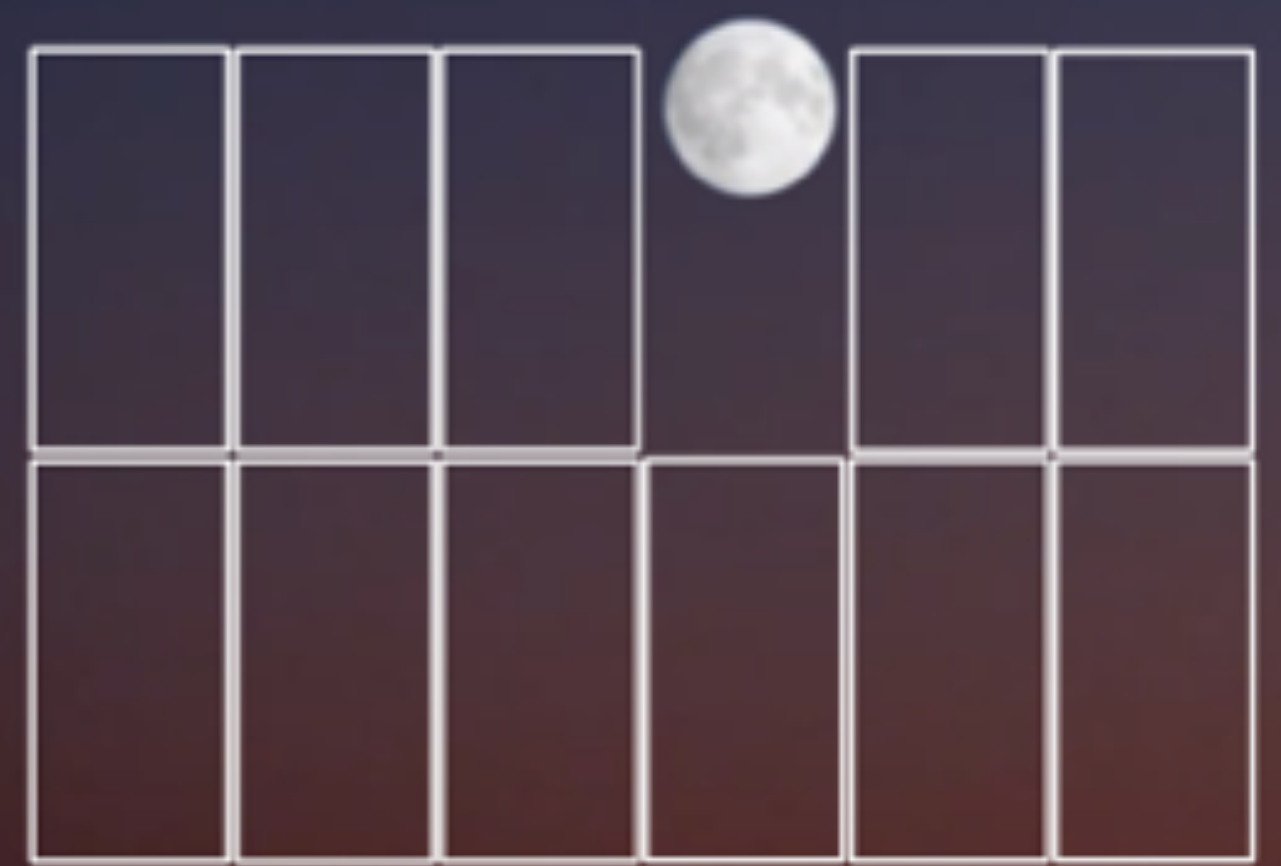
HSC,
1.7 deg²



MegaCam,
1.0 deg²



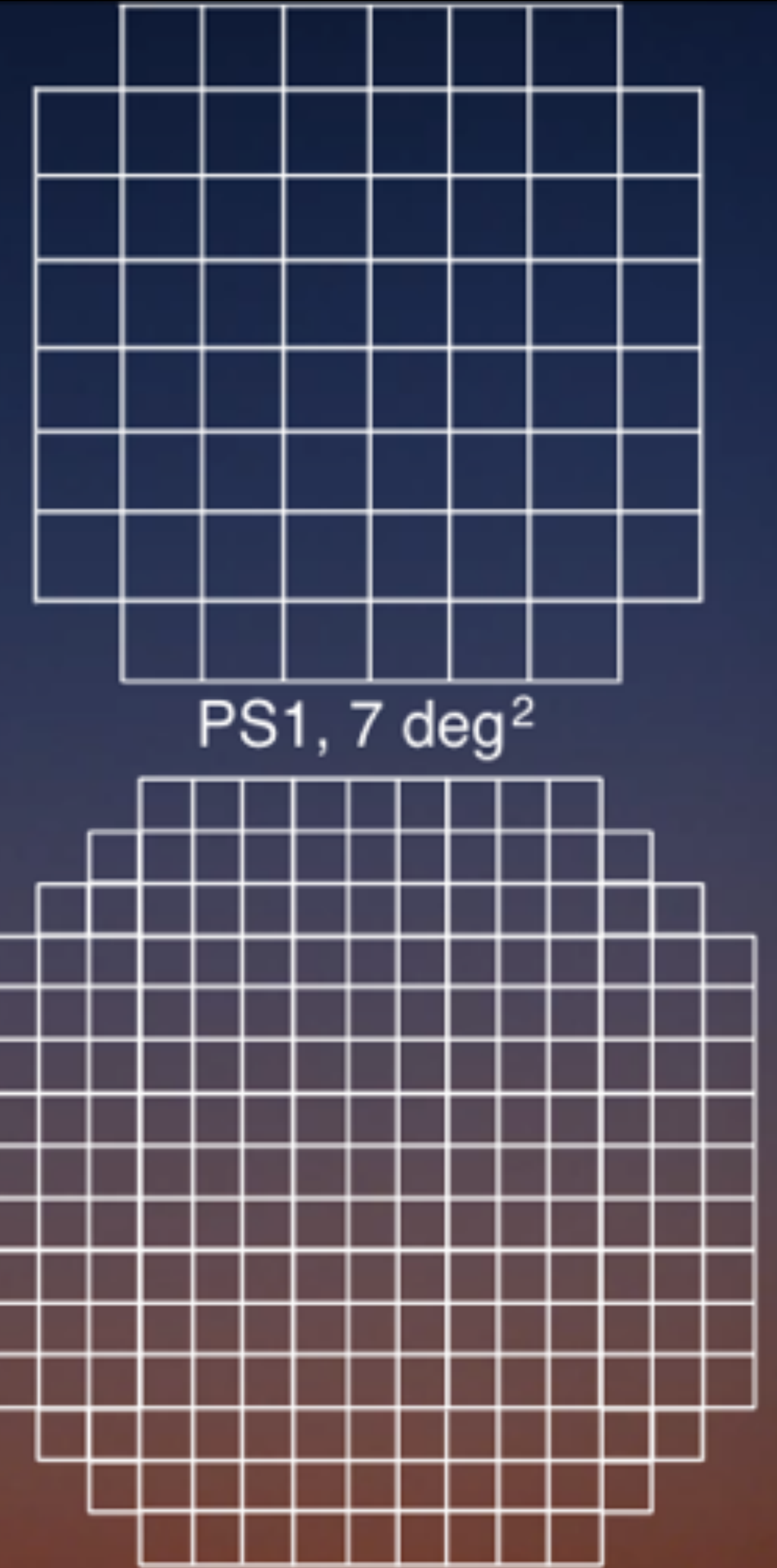
DES,
2.5 deg²



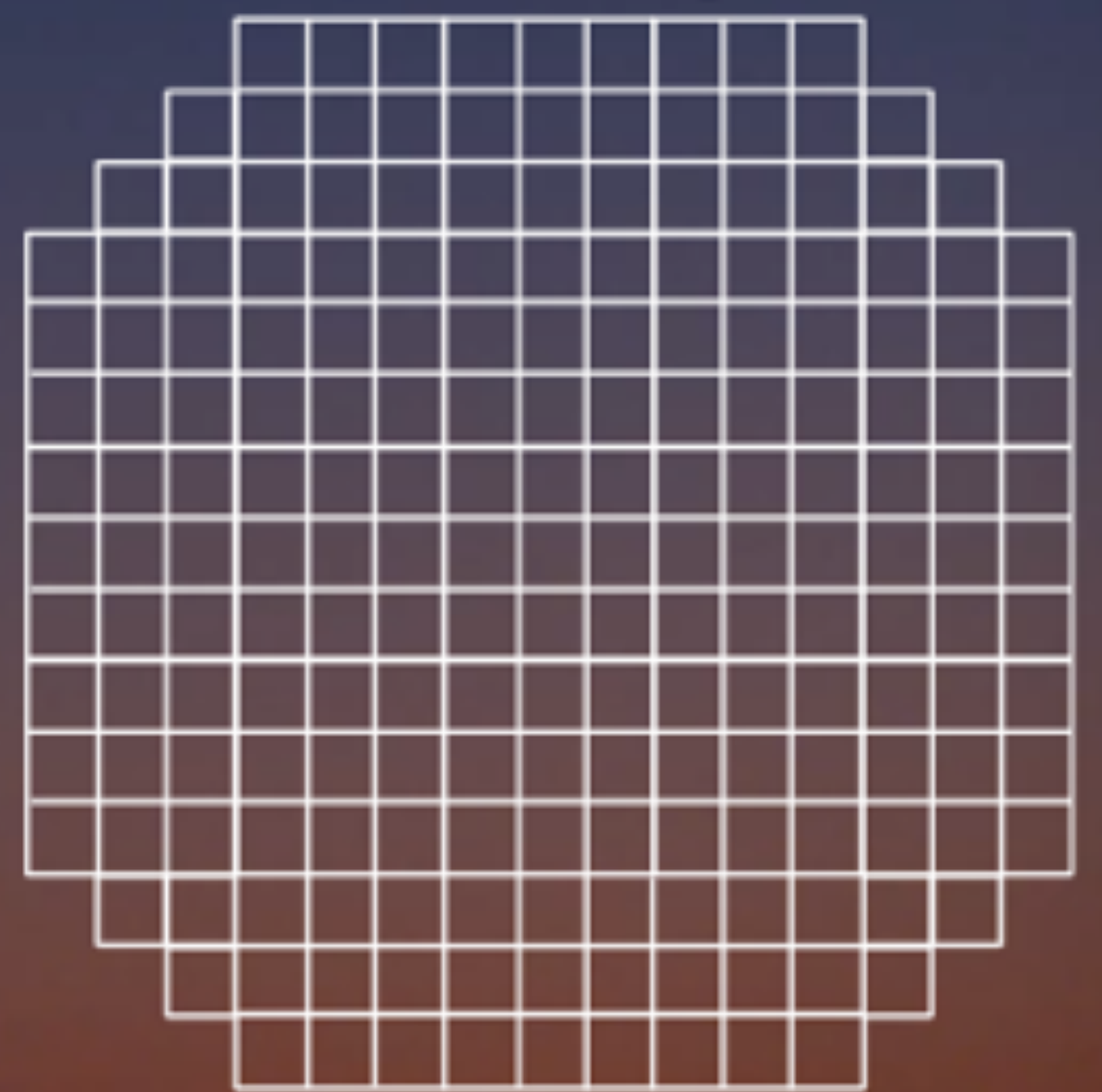
PTF/iPTF, 7.3 deg²



ZTF, 47 deg²



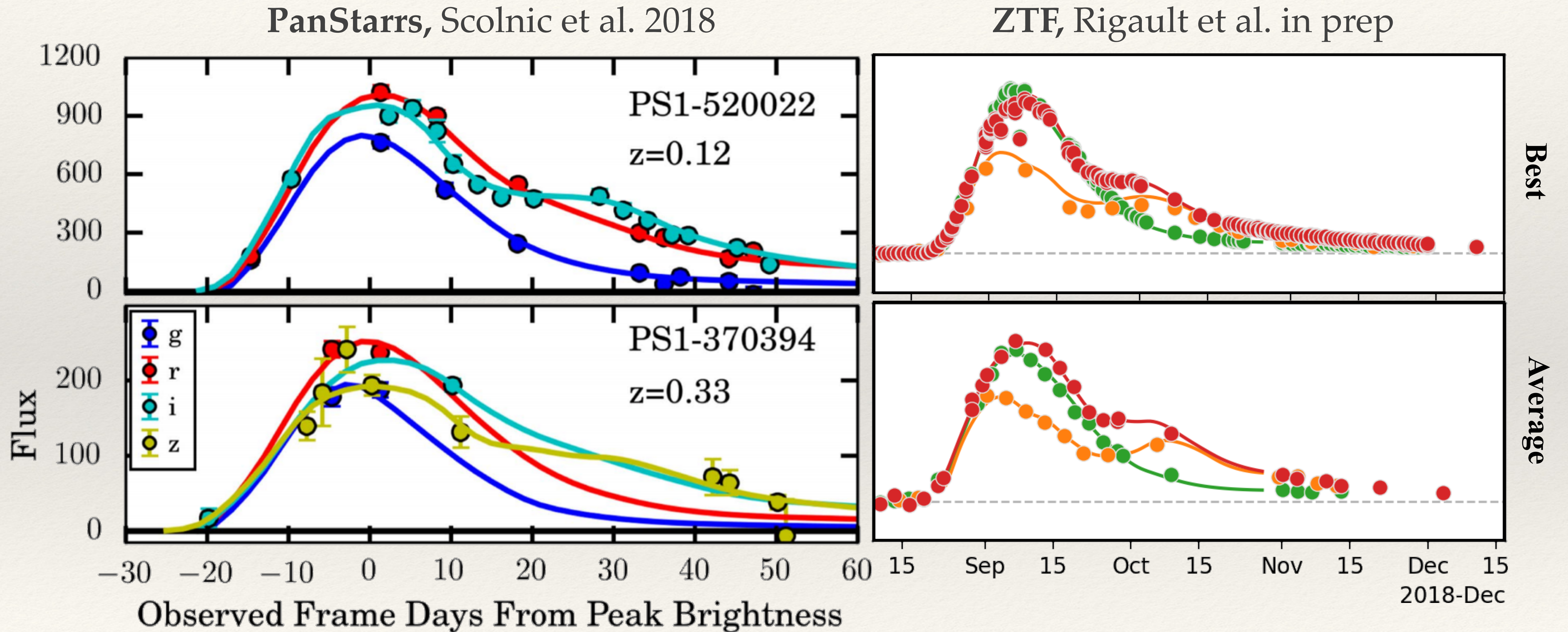
PS1, 7 deg²

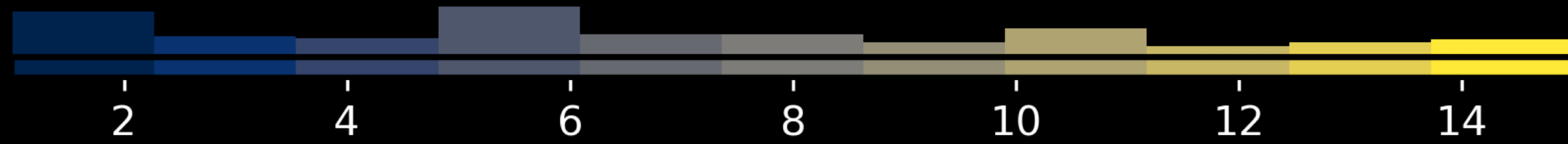
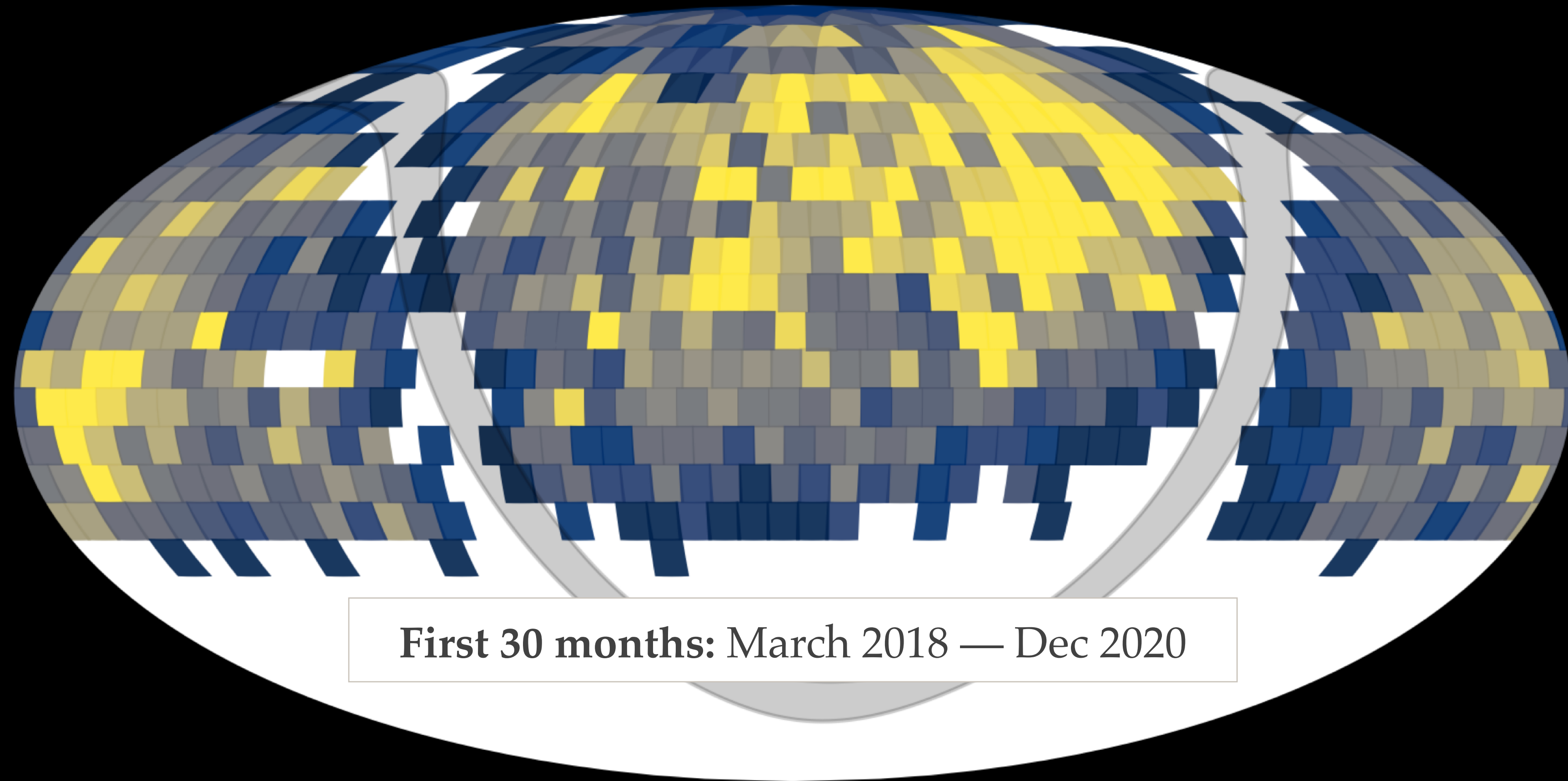


LSST, 9.6 deg²

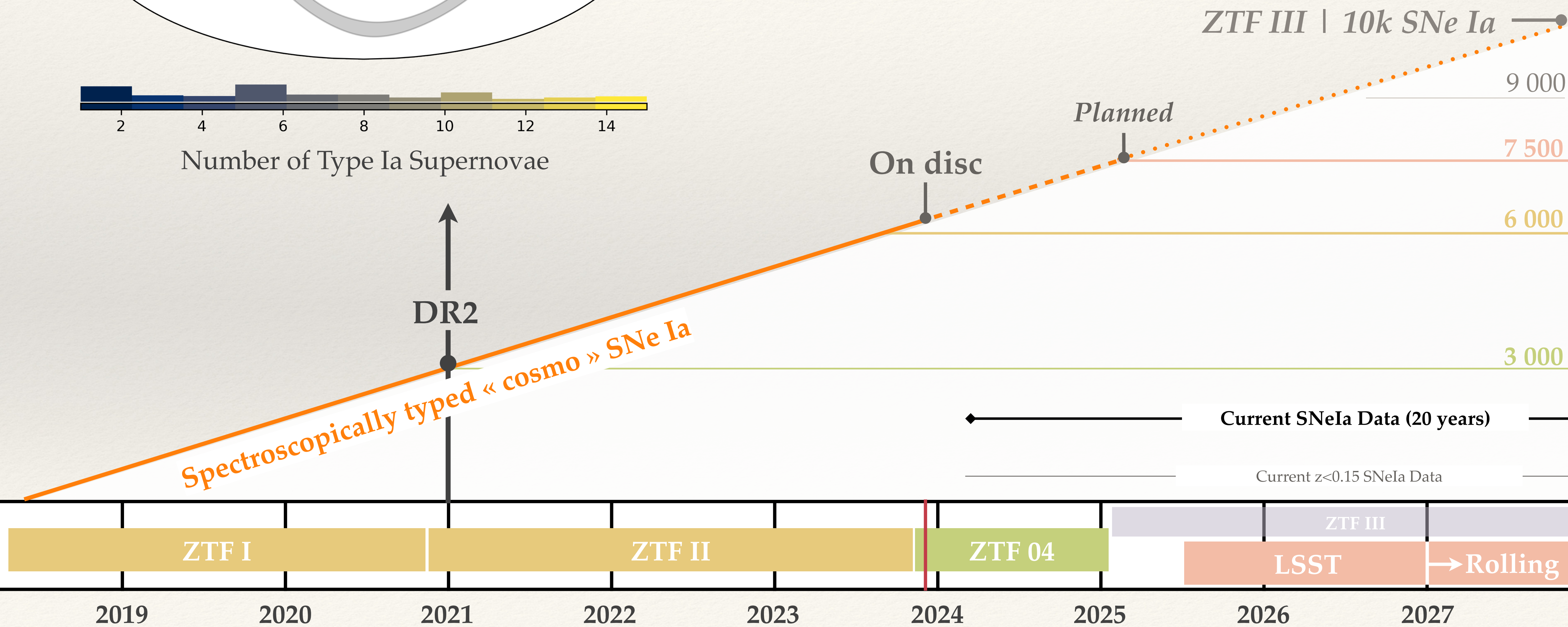
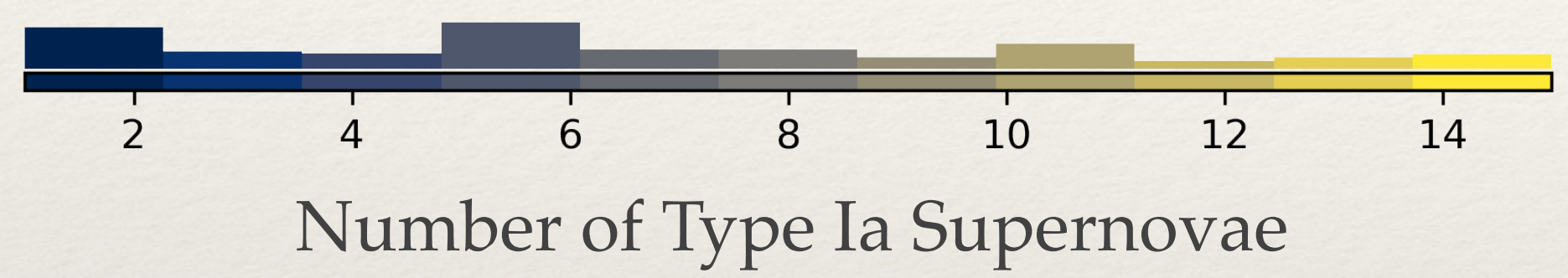
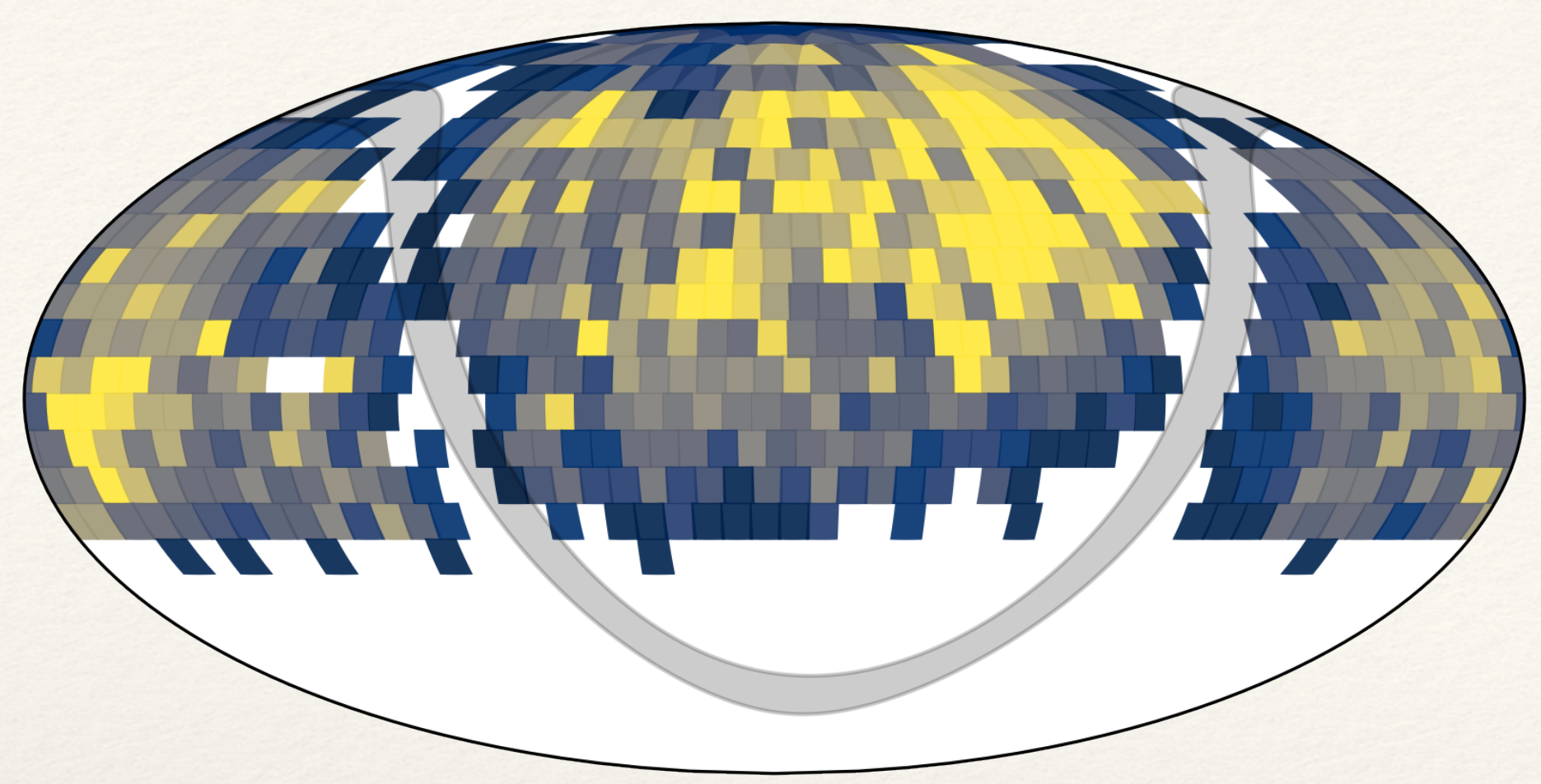
1 deg

Unprecedented sampling statistics





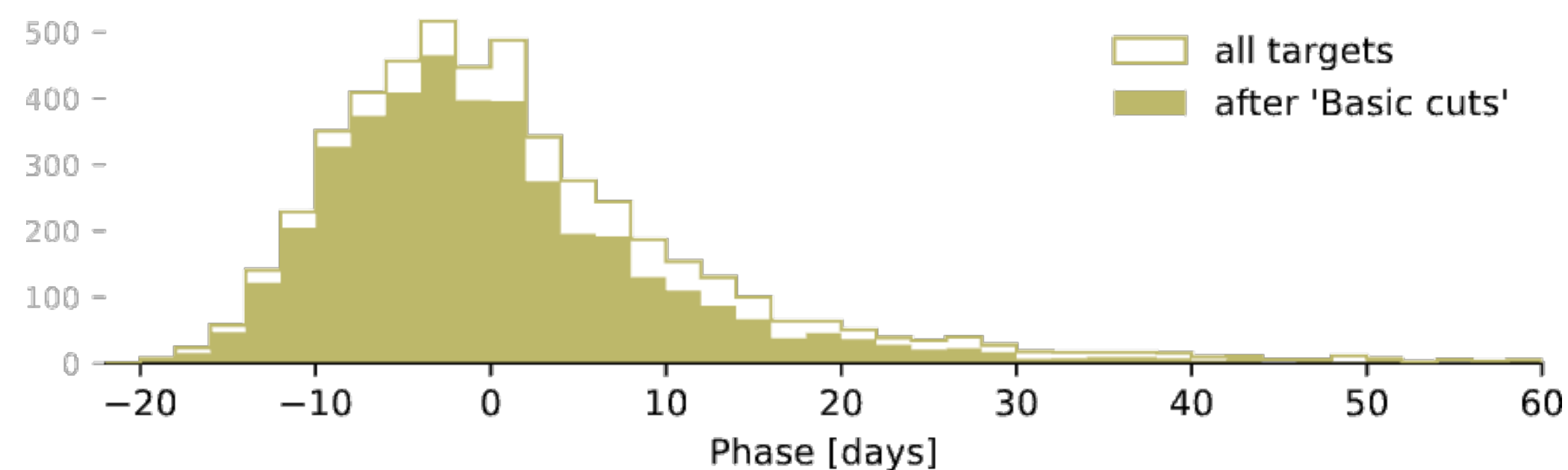
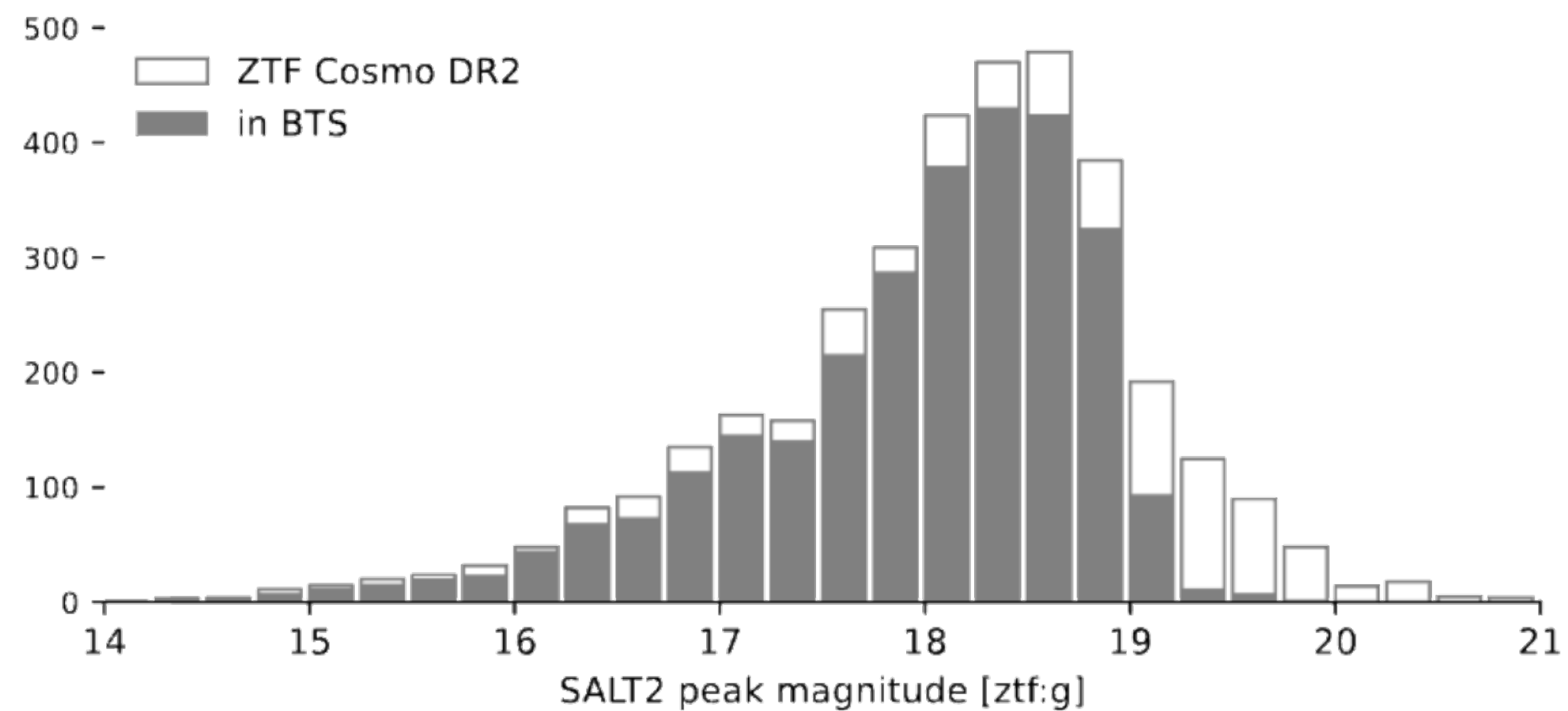
Number of Type Ia Supernovae



A Spectroscopic sample | *Typing & Redshift*

Rigault et al. in prep

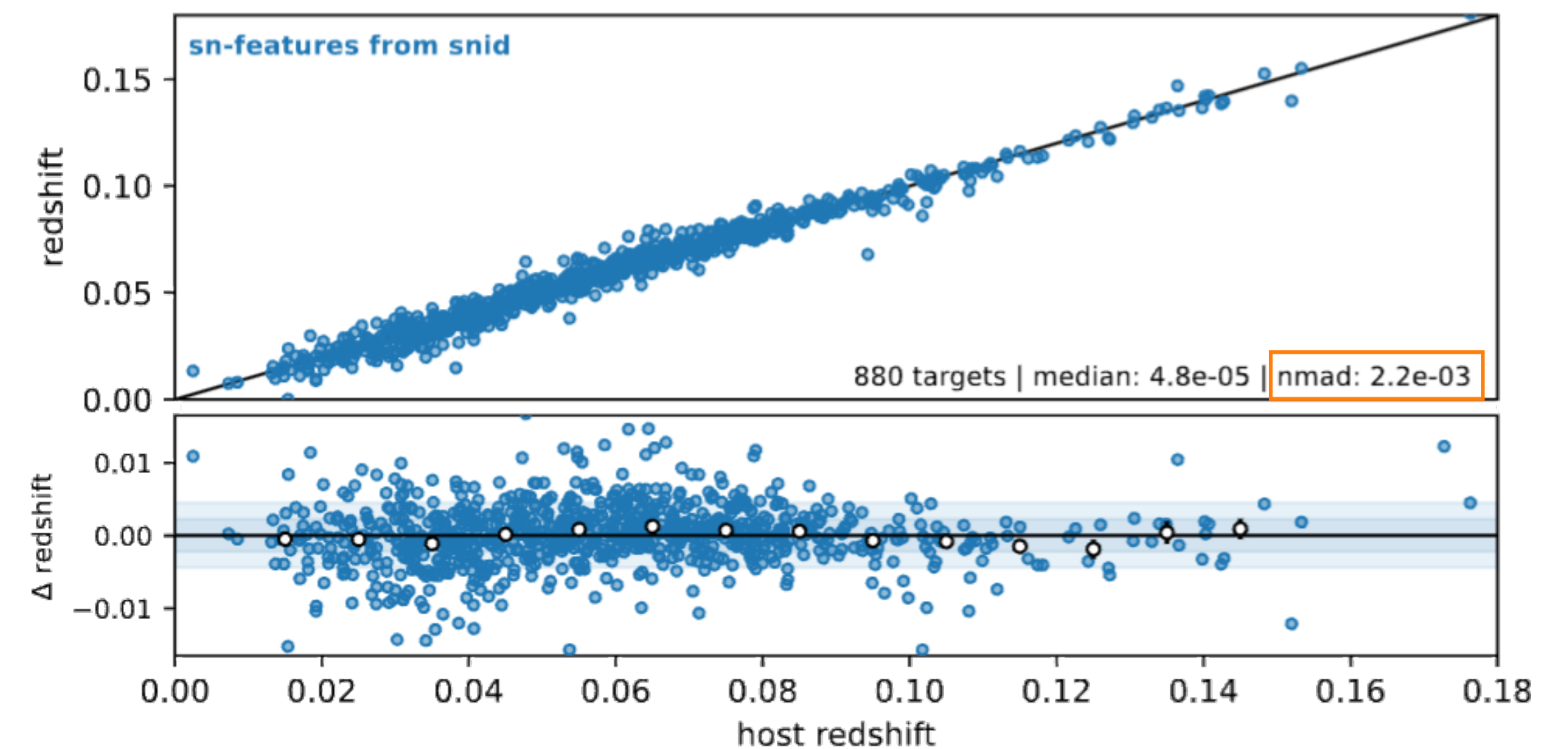
Typing | Magnitude limited up to 18.75



Redshifts | $\Delta z \leq 10^{-3}$

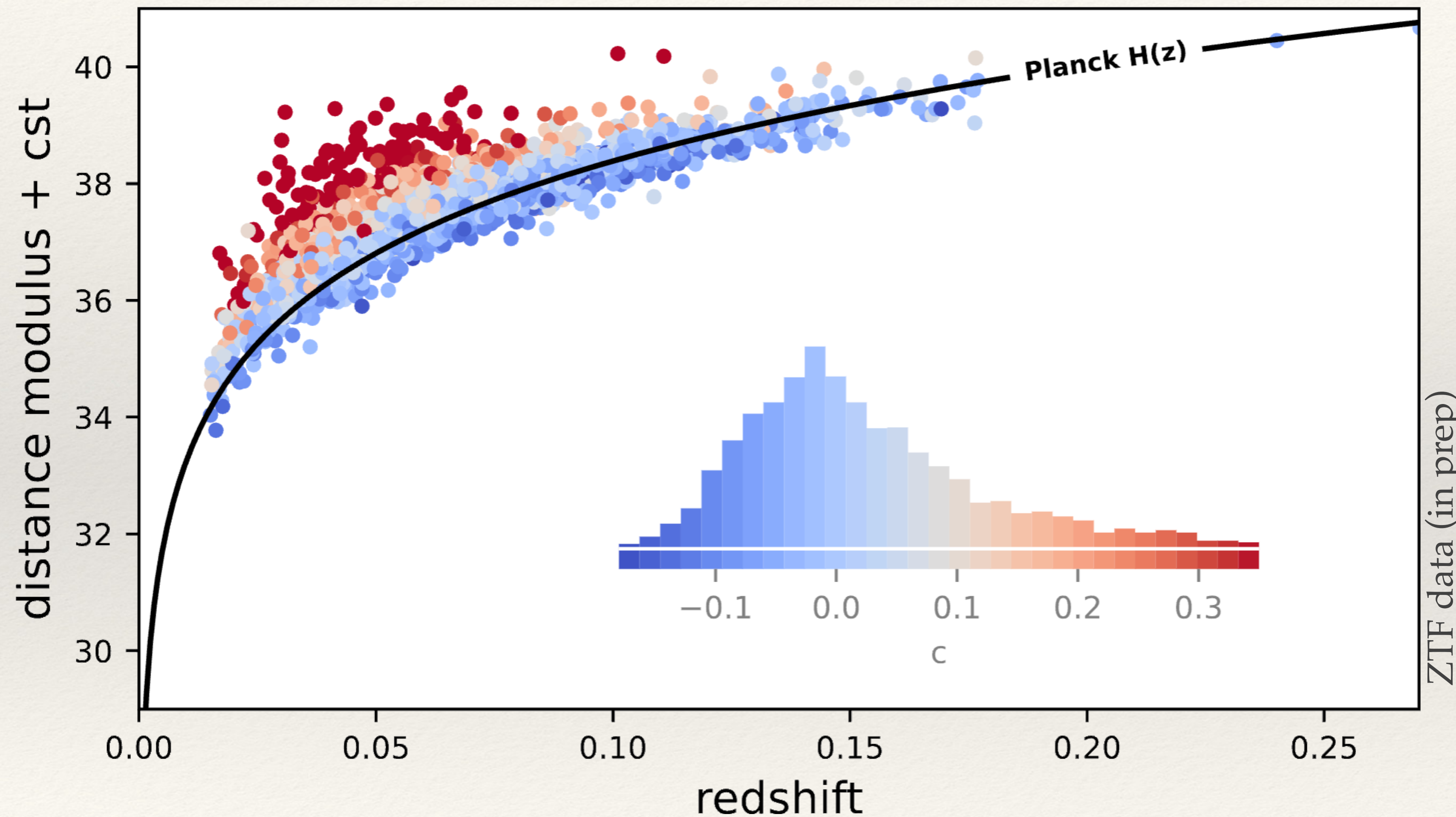
50% have host literature redshifts
 $\Delta z \leq 10^{-4}$

All have sn-spectra redshifts (50% used)
 $\Delta z \leq 10^{-3}$



Type Ia Supernovae | $H(z)$

Rigault et al. in prep

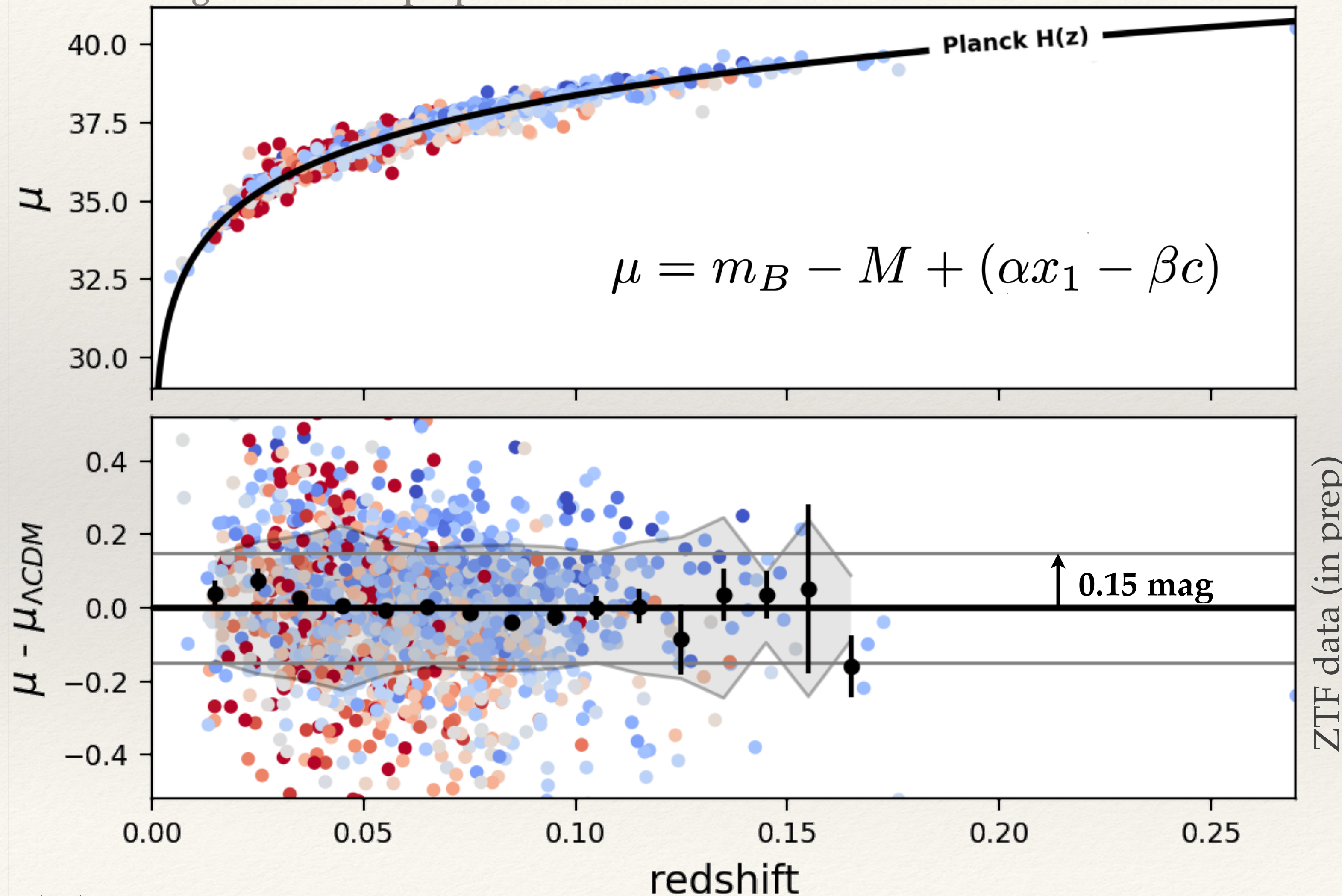


Cuts	Number left
Master list	3793
has a spectrum	3681
secured Ia typing	3644
has a lightcurve	3627
Basic cuts	
good sampling	3184
$x_1 \in [-4, +4]$	3148
$c \in [-0.3, 0.8]$	3106
$\delta t_0 \leq 1$	3062
$\delta x_1 \leq 1$	3035
$\delta c \leq 0.1$	3011
Additional cuts	
volume ltd ($z < 0.06$)	1196
non-peculiar SNe Ia*	2703
non-SN redshift**	1558

Type Ia Supernovae

The first large ZTF release is happening | 20 papers in parallel with this dataset

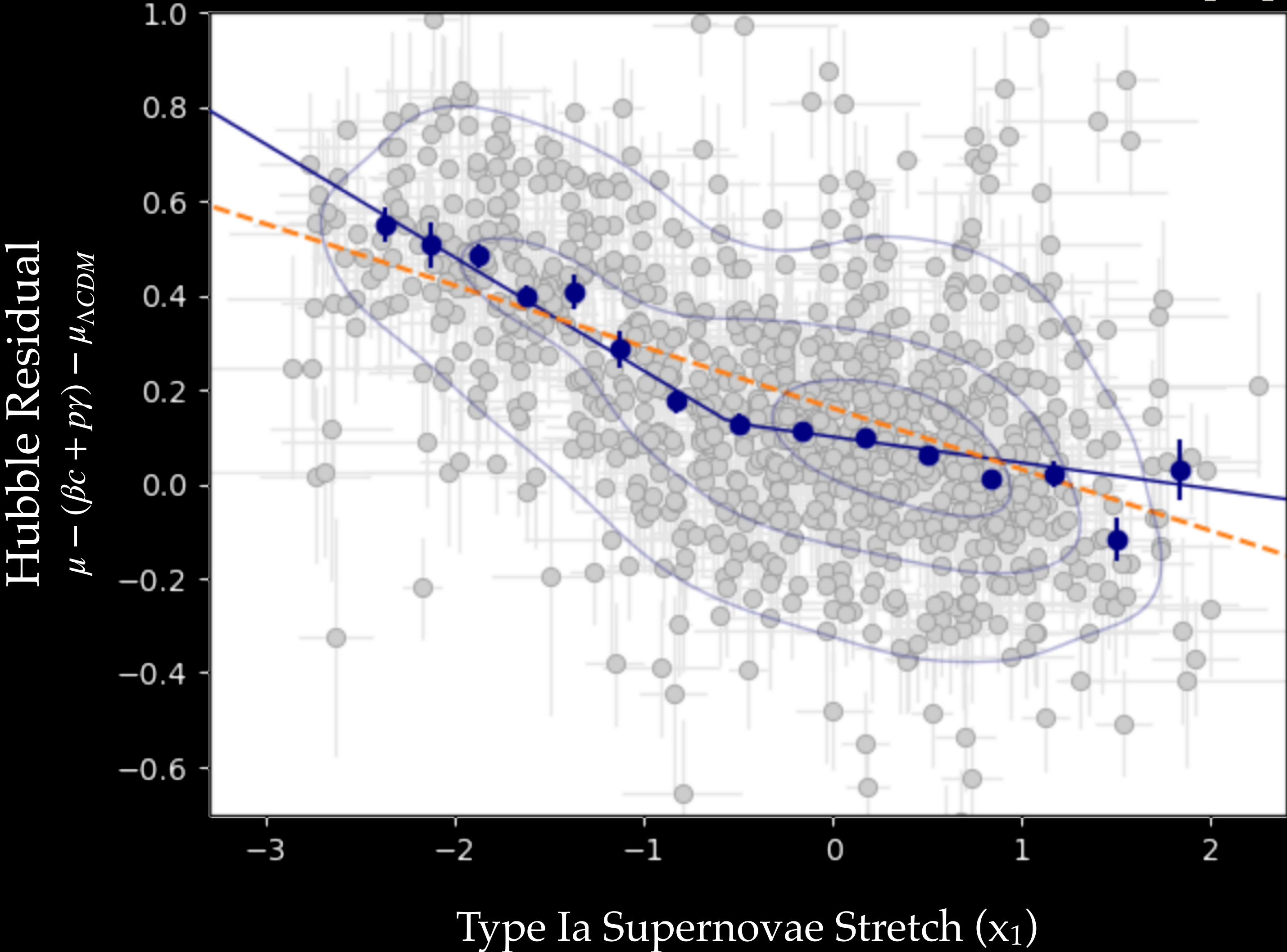
Rigault et al. in prep



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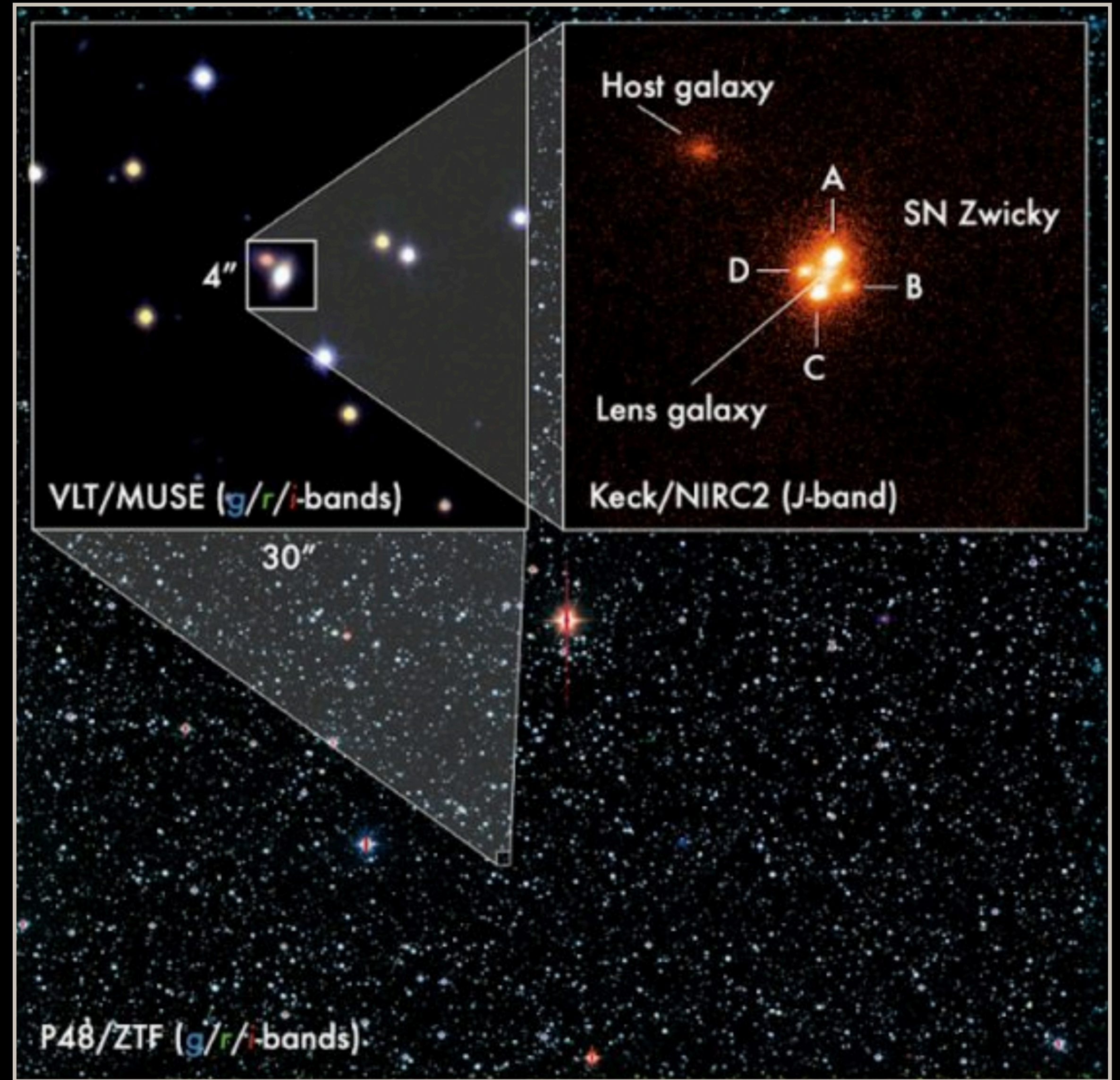
*Sets new standards
on the way to do
correct SN Cosmology*

See Madeleine's Talk



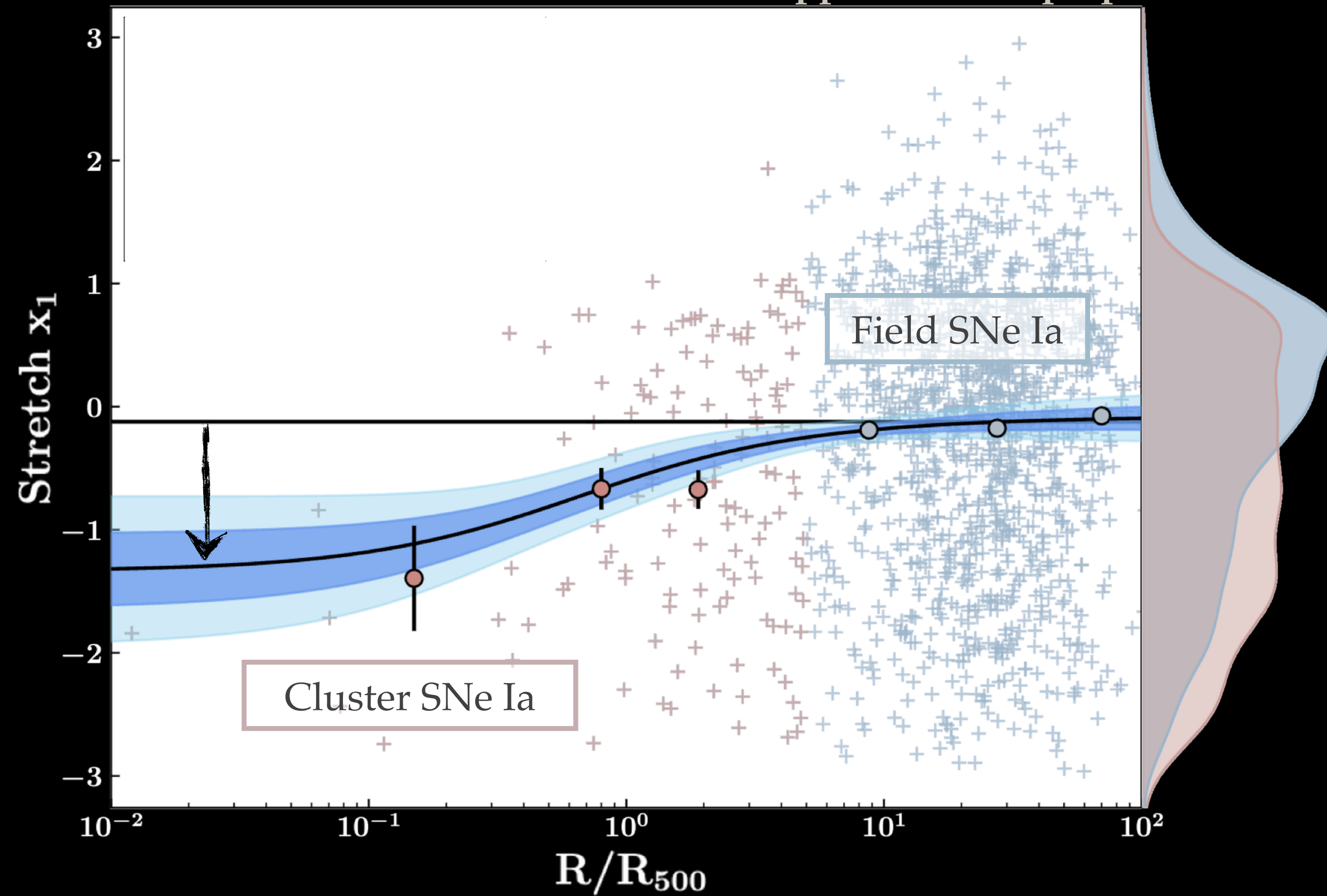
*Discovery of new mind
blowing events !*

*Here SN Zwicky, a
strongly lensed SNe Ia*



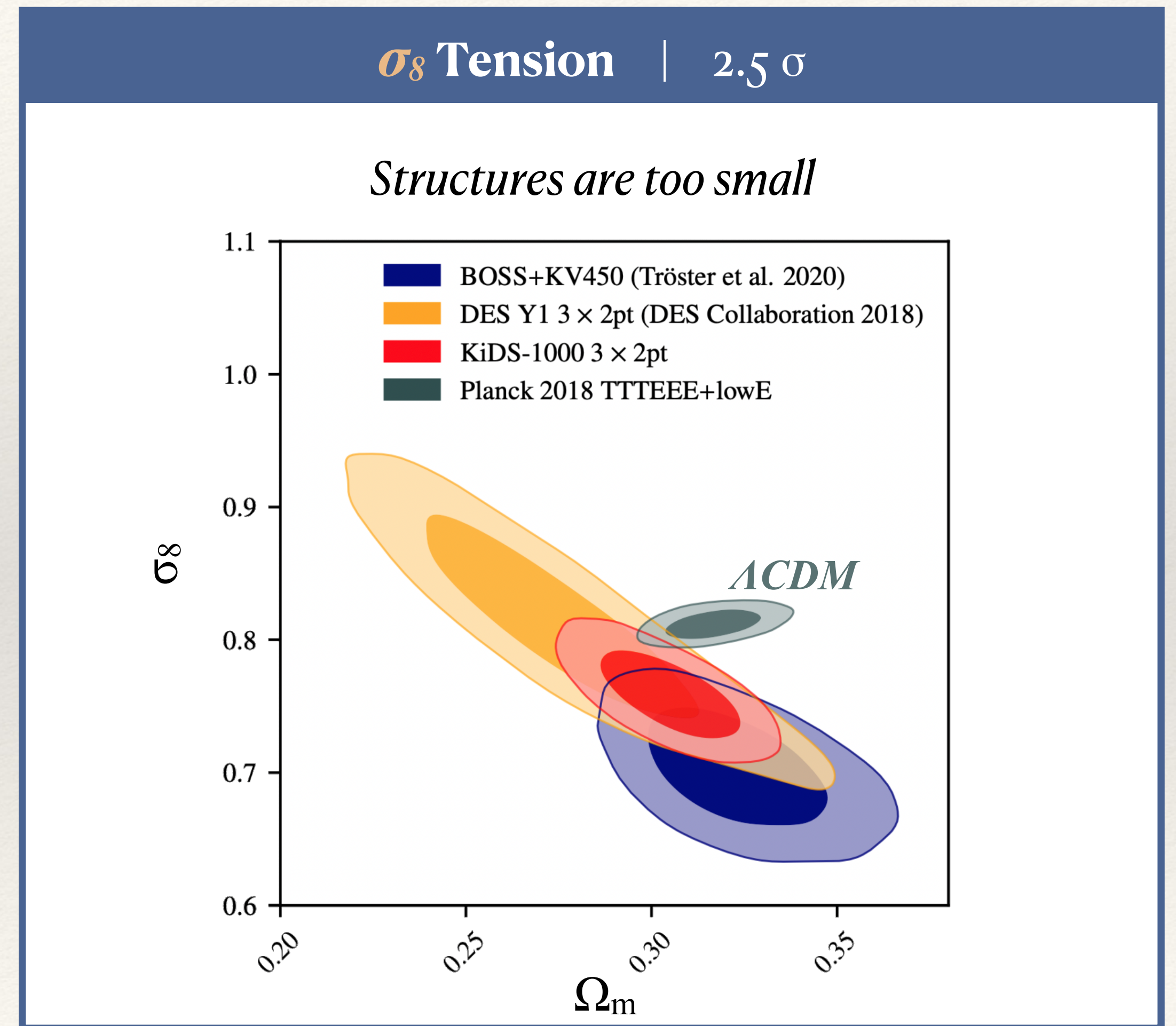
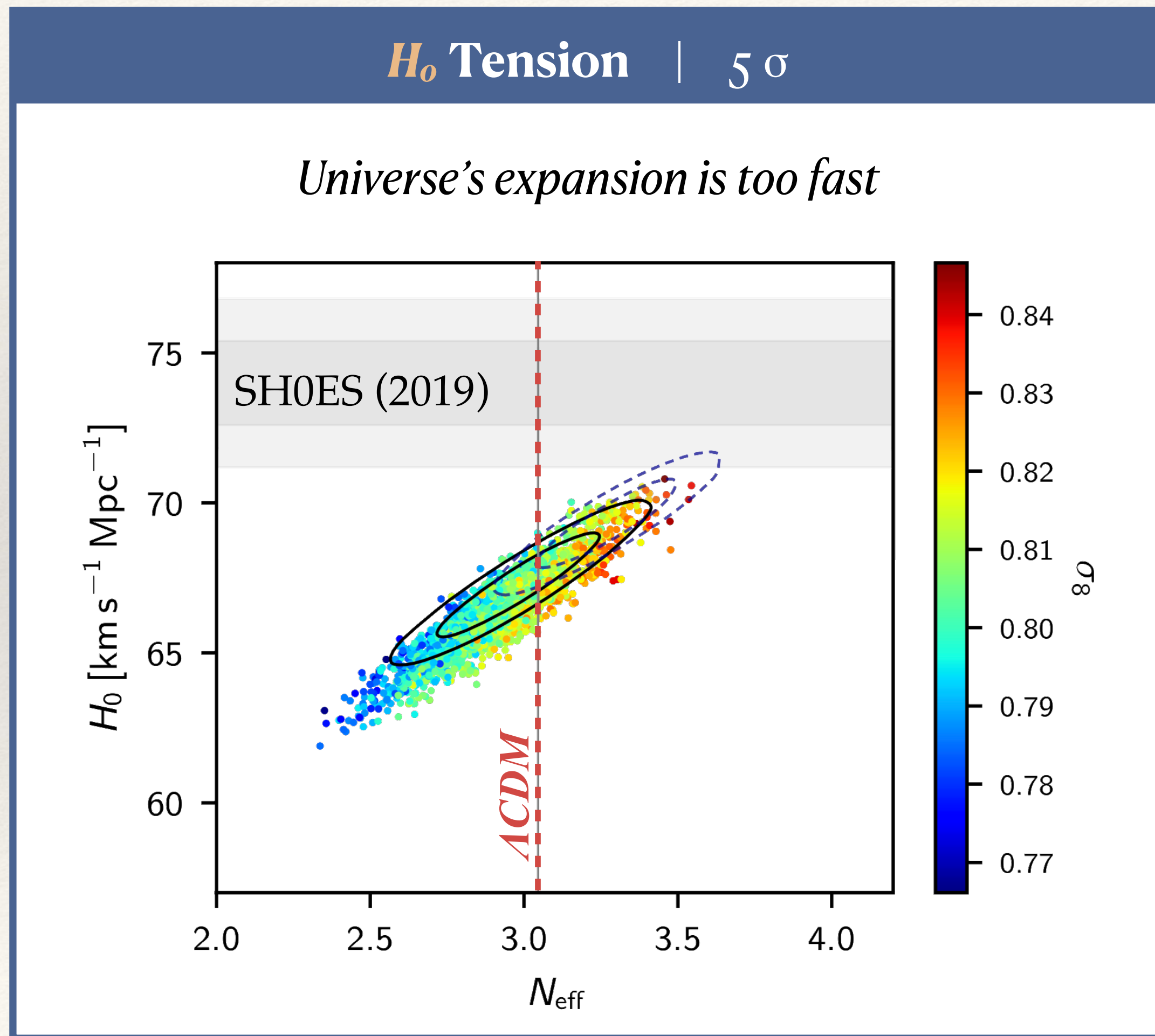
*SNe Ia x
large scale structures.
A new way to probe the
Univers*

See Marie's Talk



Λ CDM works | *except when it doesn't!*

Only 6 free parameters | *but “ Λ ” and “CDM”*



ZTF Cosmology

H_0 Tension | 5σ

Universe's expansion is too fast

ZTF → **Pure ZTF- H_0**

Solving all current SNe Ia Systematics
selection & Photometry

σ_8 Tension | 2.5σ

Structures are too small

ZTF → **SNe Ia Peculiar Velocities**

New Cosmology probe
Enable to get current σ_8

Astrophysical bias

Volume limited sample
O(1000) SNe Ia

Strong Lensing Search

Search for Strongly lensed
SNe Ia

Dark Energy

Next decade era
low-redshift sample

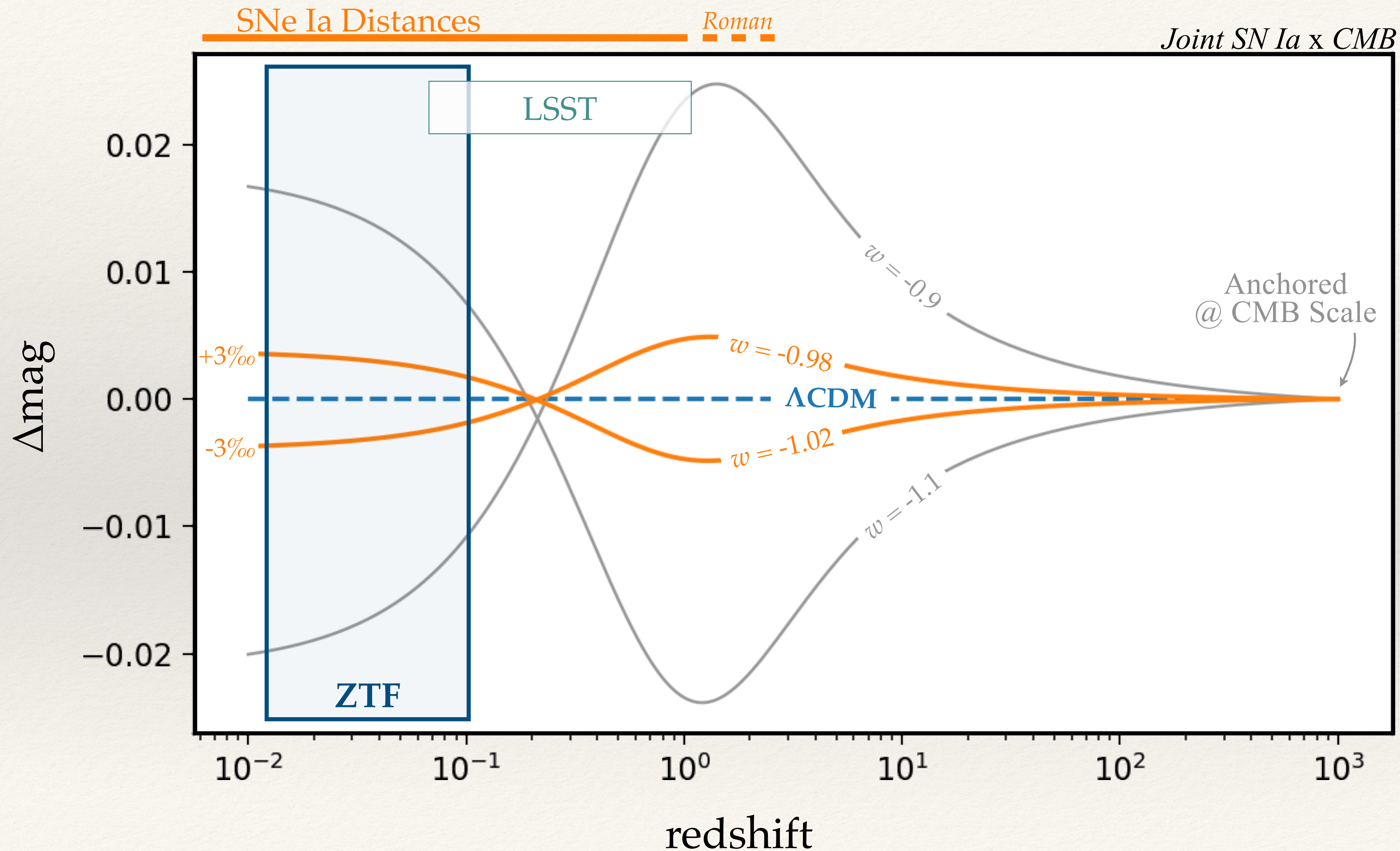
State of the art Calib.

Focus of the IN2P3 WP | the
1‰ calibration

Type Training

O(10 000) SN spectra & LC
All kinds

Dark Energy (end-2024)

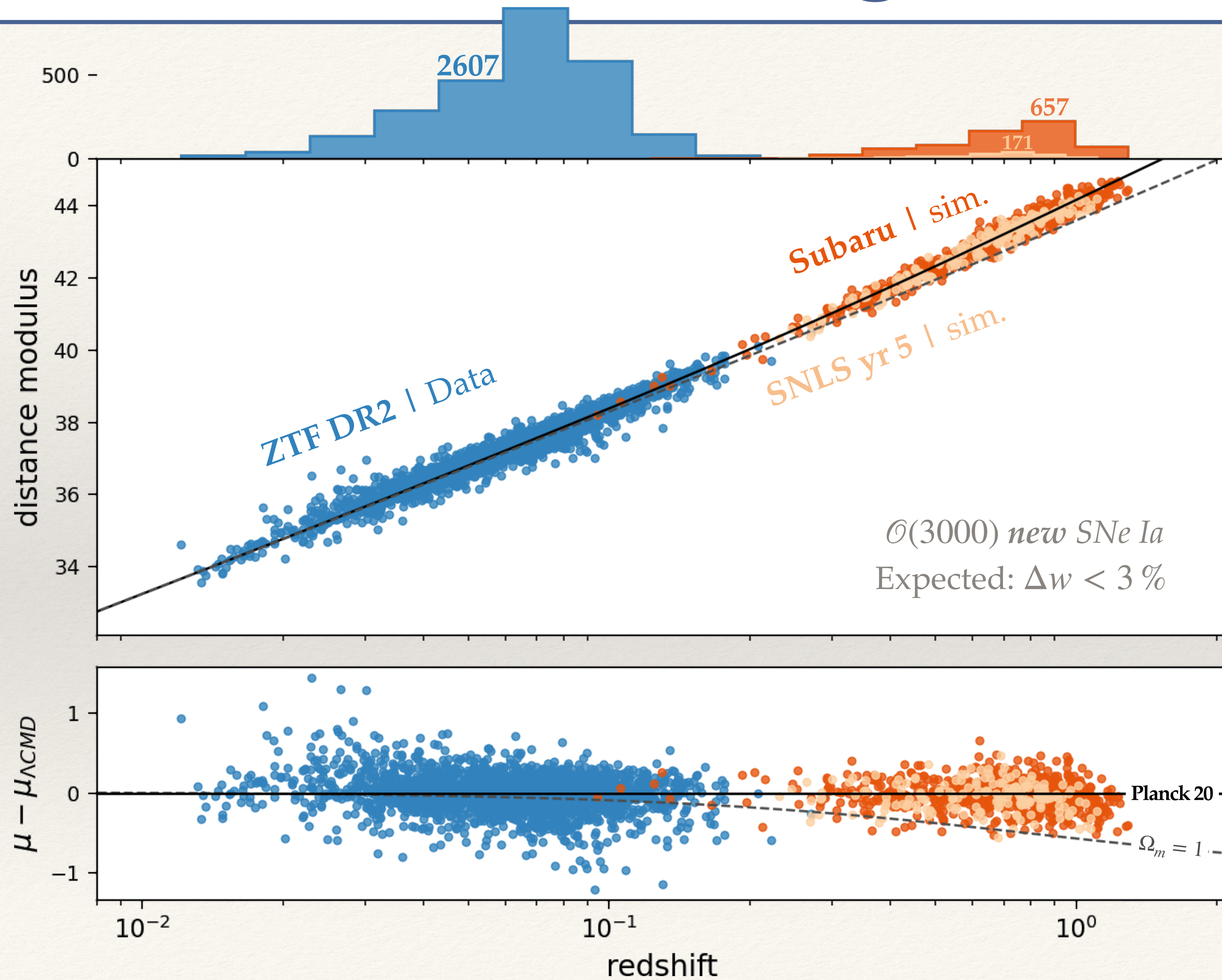


SNe Ia
 → Δmag=15%

O(5000) SNe Ia
 → Δmag=0.2%

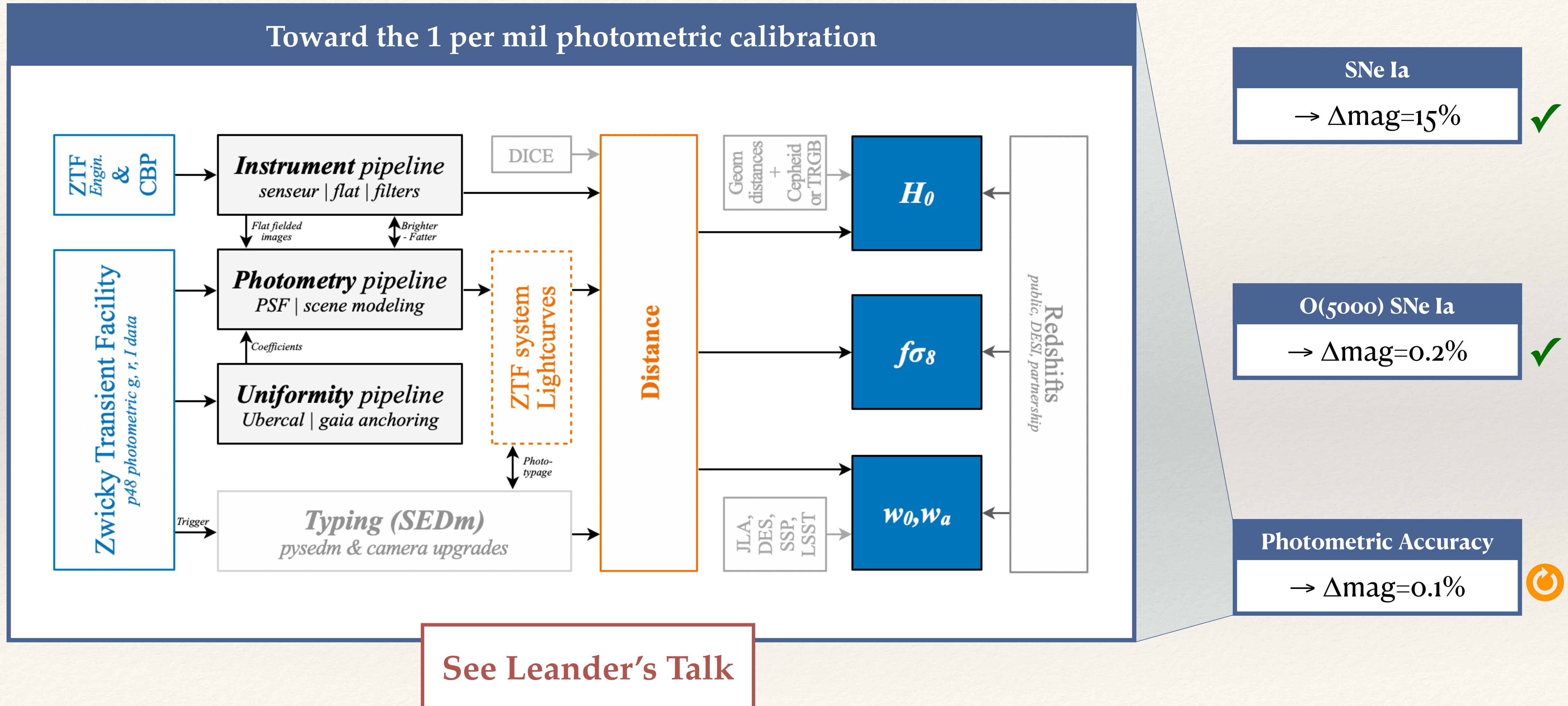
Photometric Accuracy
 → Δmag=0.1%

The *Lemaitre* Diagram



None of these SNe Ia have ever been used for cosmology

Calibration | *we are finishing the pipeline*



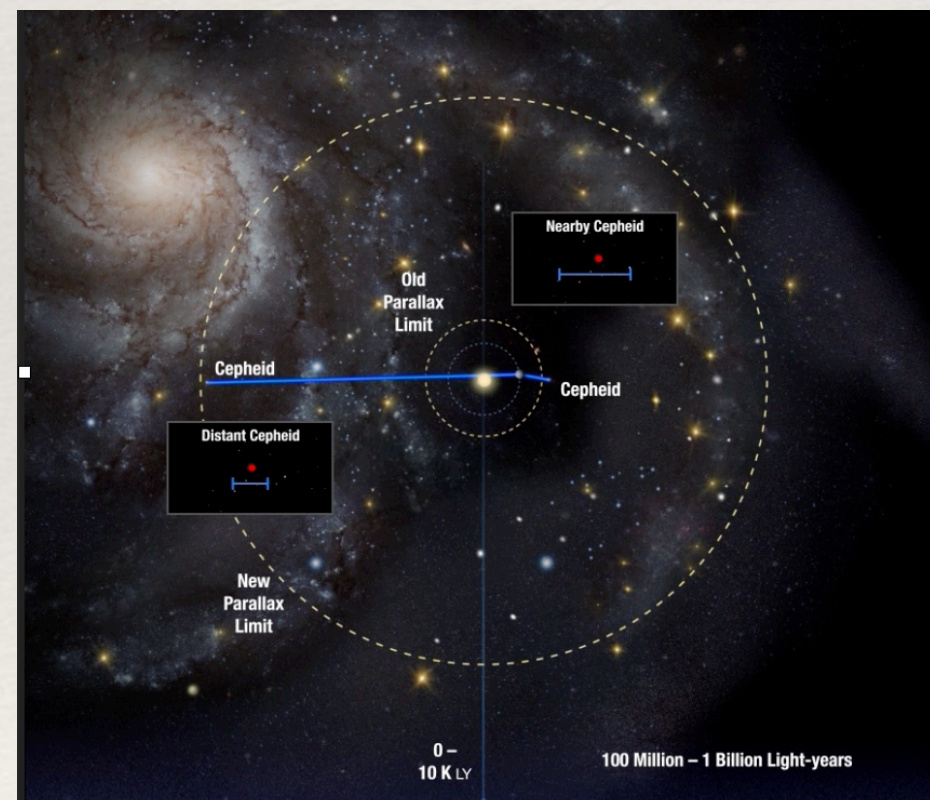
Direct Distance Ladder | *SHOES*

Get independent distances for SNe Ia



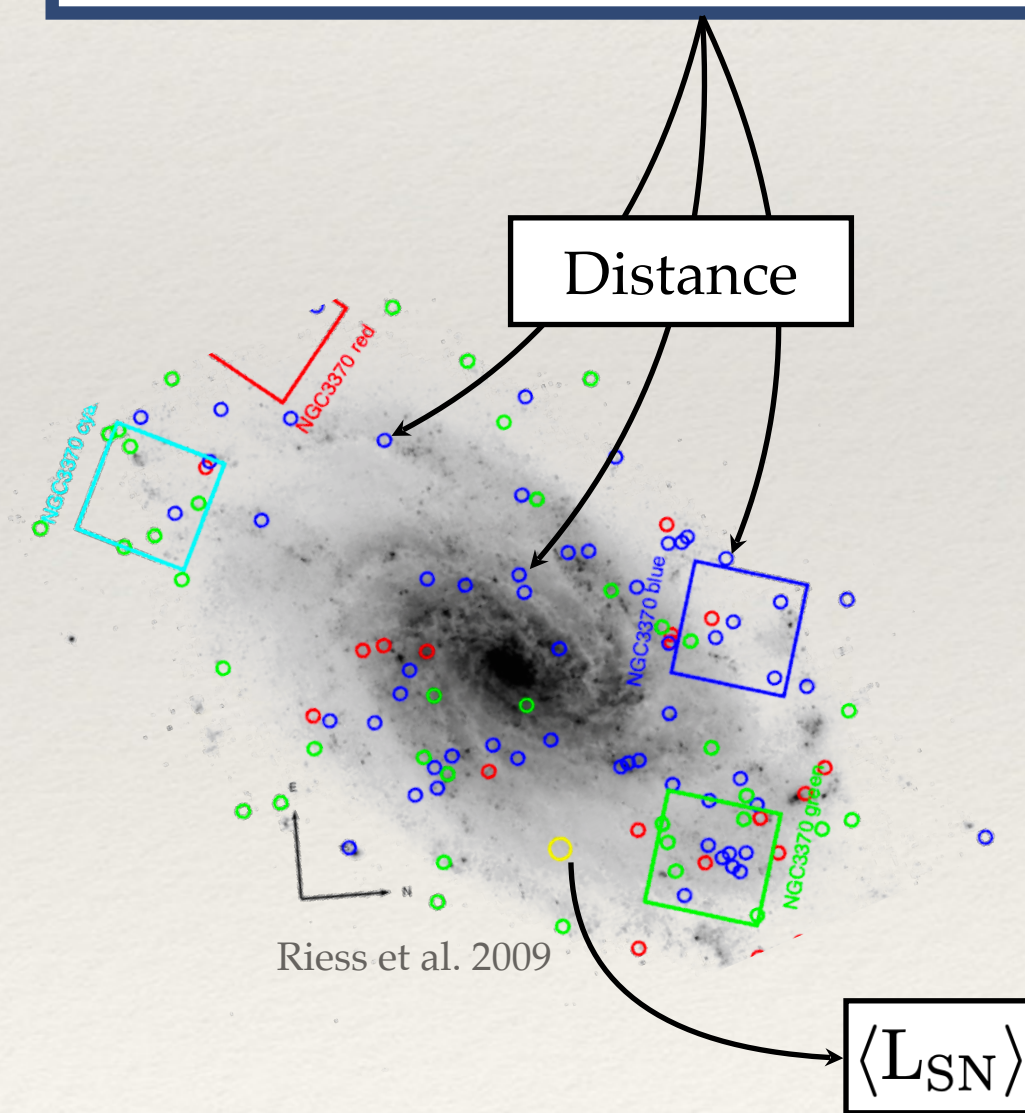
"Geometry"

Parallaxes | D.E.B. | Maser

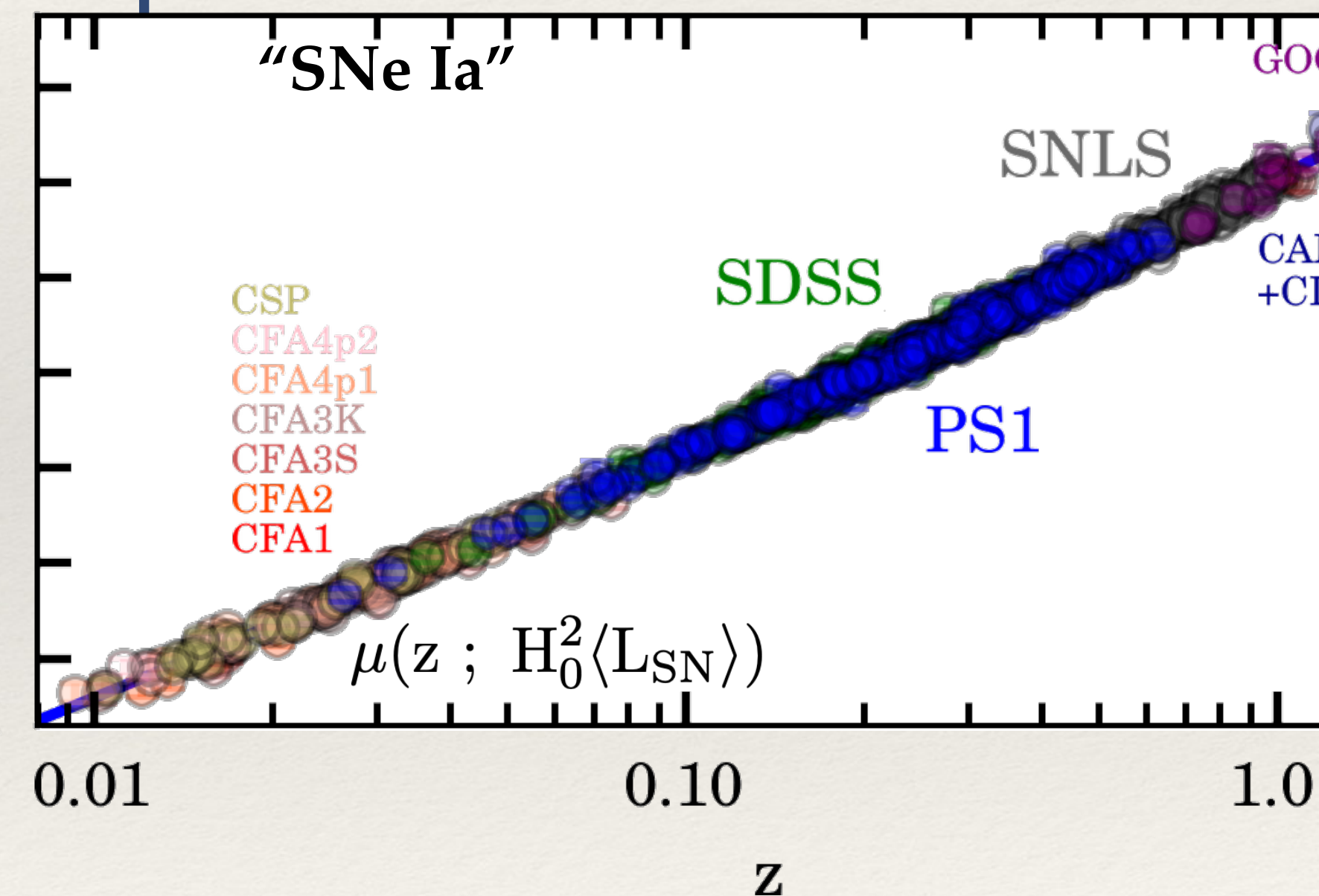


"Calibrators"

Cepheids



Distance Modulus (mag)



Riess et al. 2022

$$H_0 = 73.0 \pm 1.0 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

ZTF Sample | *Toward a self-consistent H_0*

Measure " L_{SN} "

Get " H_0 "

distance

Calibrator Sample

Volume limited ZTF-SNeIa < 50 Mpc

Technique

TRGB (doable in any galaxy)

Statistics: ~40 already acquired

Hubble Flow Sample

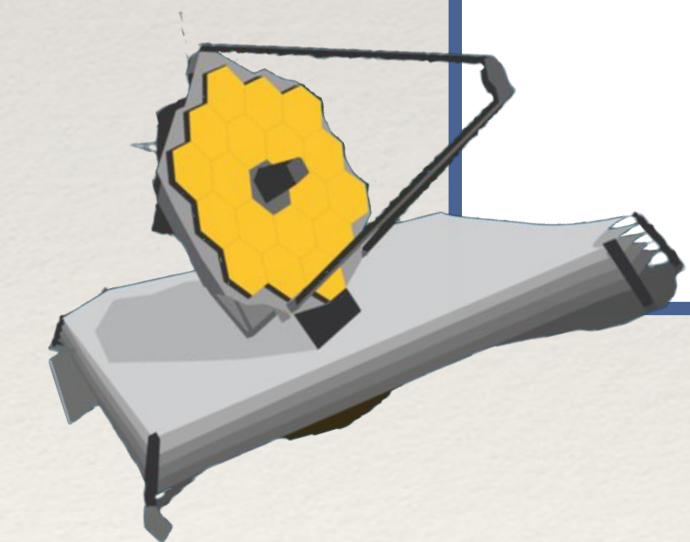
Volume limited ZTF-SNeIa $z < 0.06$ Mpc

ZTF detects, follows and classifies
all SNe Ia in the northern sky up to
 $z \sim 0.06$

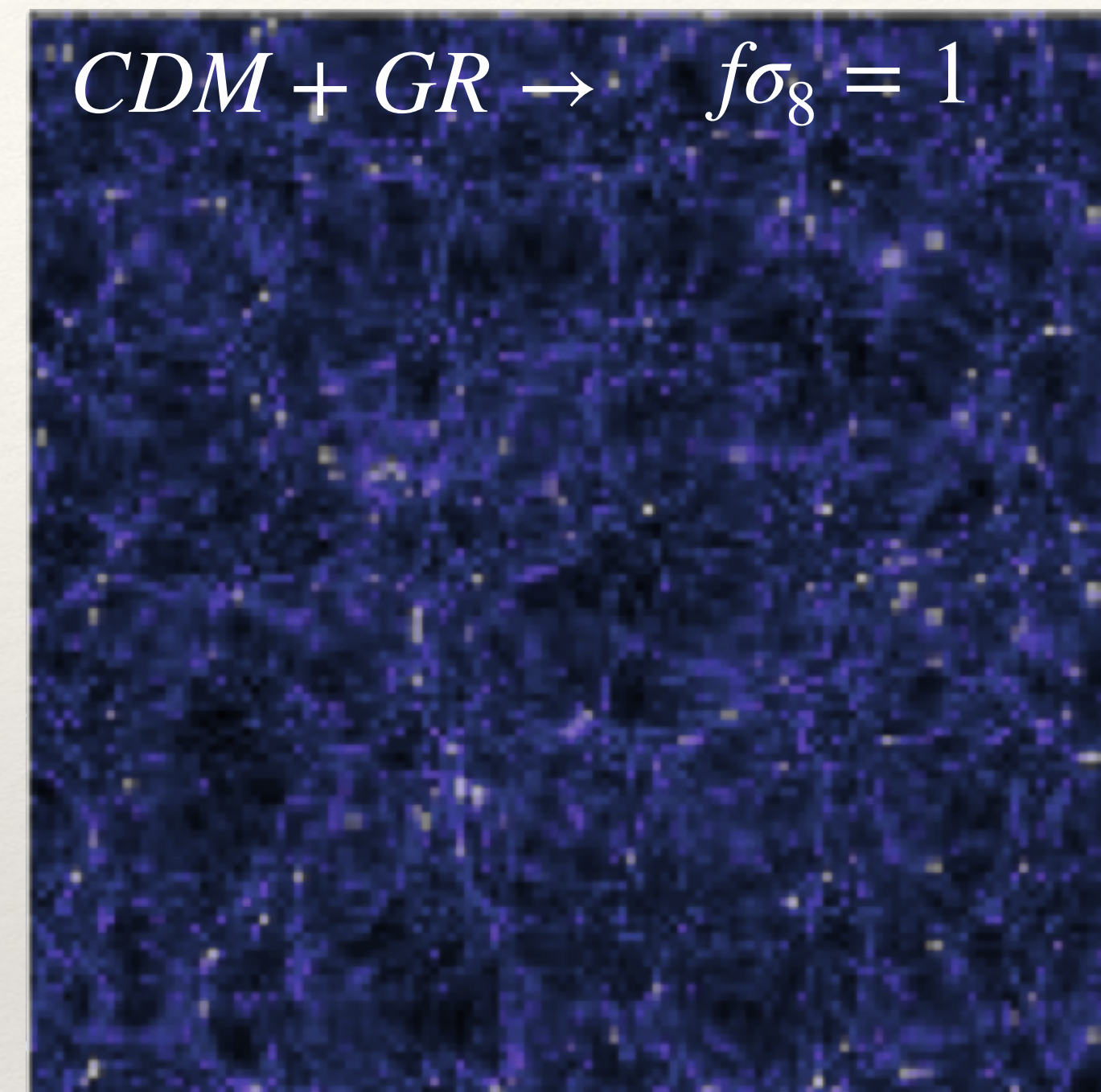
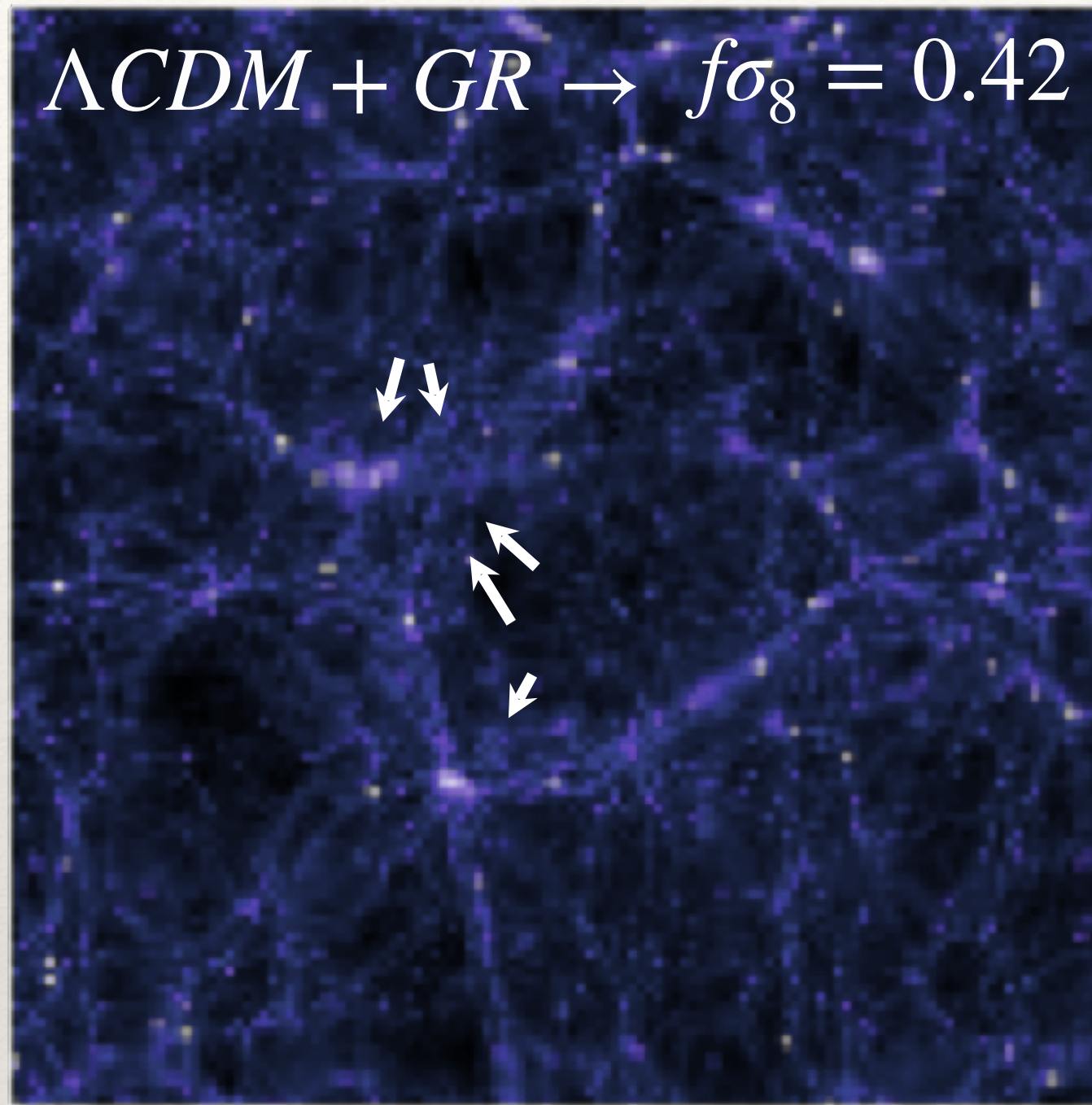
Statistics: ~2000 already acquired

No selection function since both volume limited samples

Unique photometric system, no absolute photometric calibration issue
only relative, which is way easier



A New Probe



Observed redshift
(What we have)

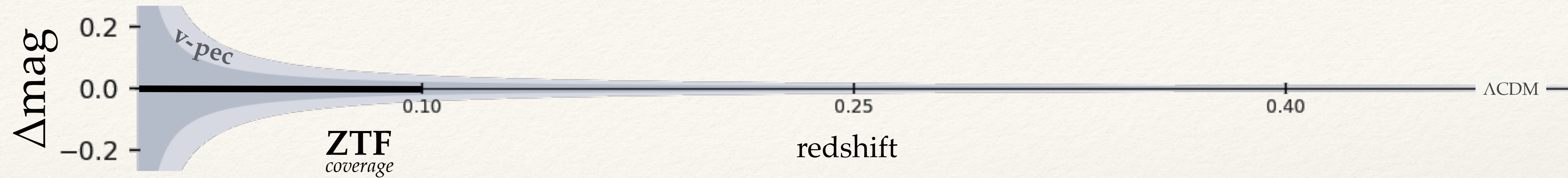
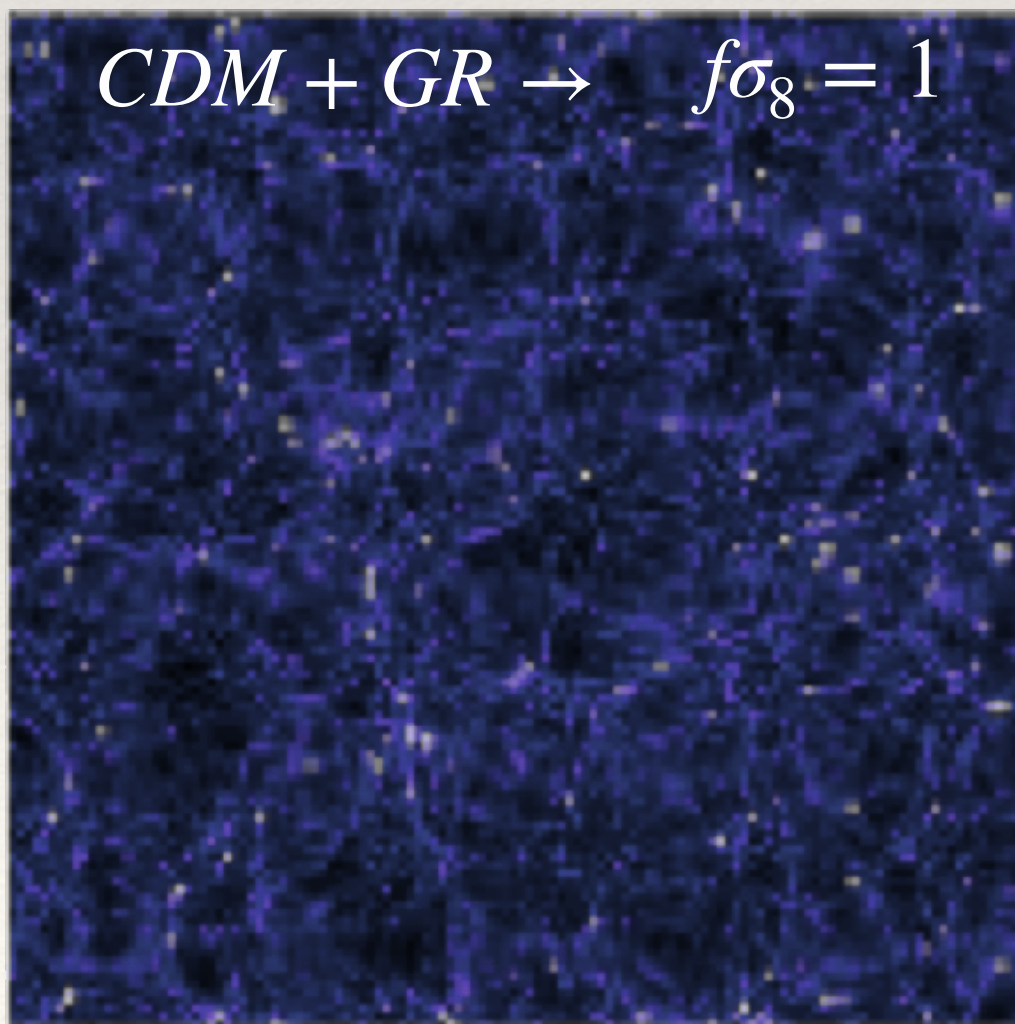
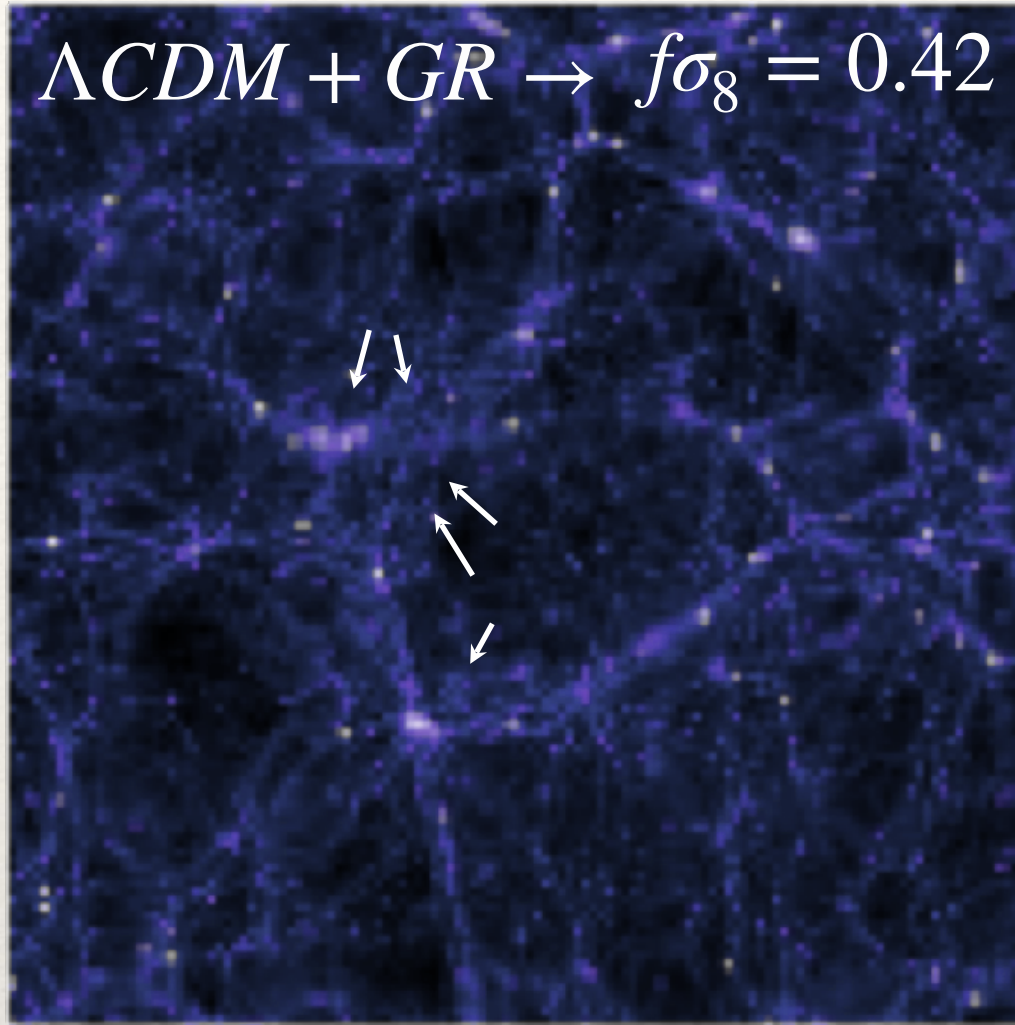
$$(1+z) = (1+\bar{z})\left(1 + \frac{v}{c}\right)$$

Peculiar velocity
(What we want)

Cosmology redshift
(To be estimated)

$SNe\text{ Ia} + \text{Cosmo} \rightarrow \bar{z}$

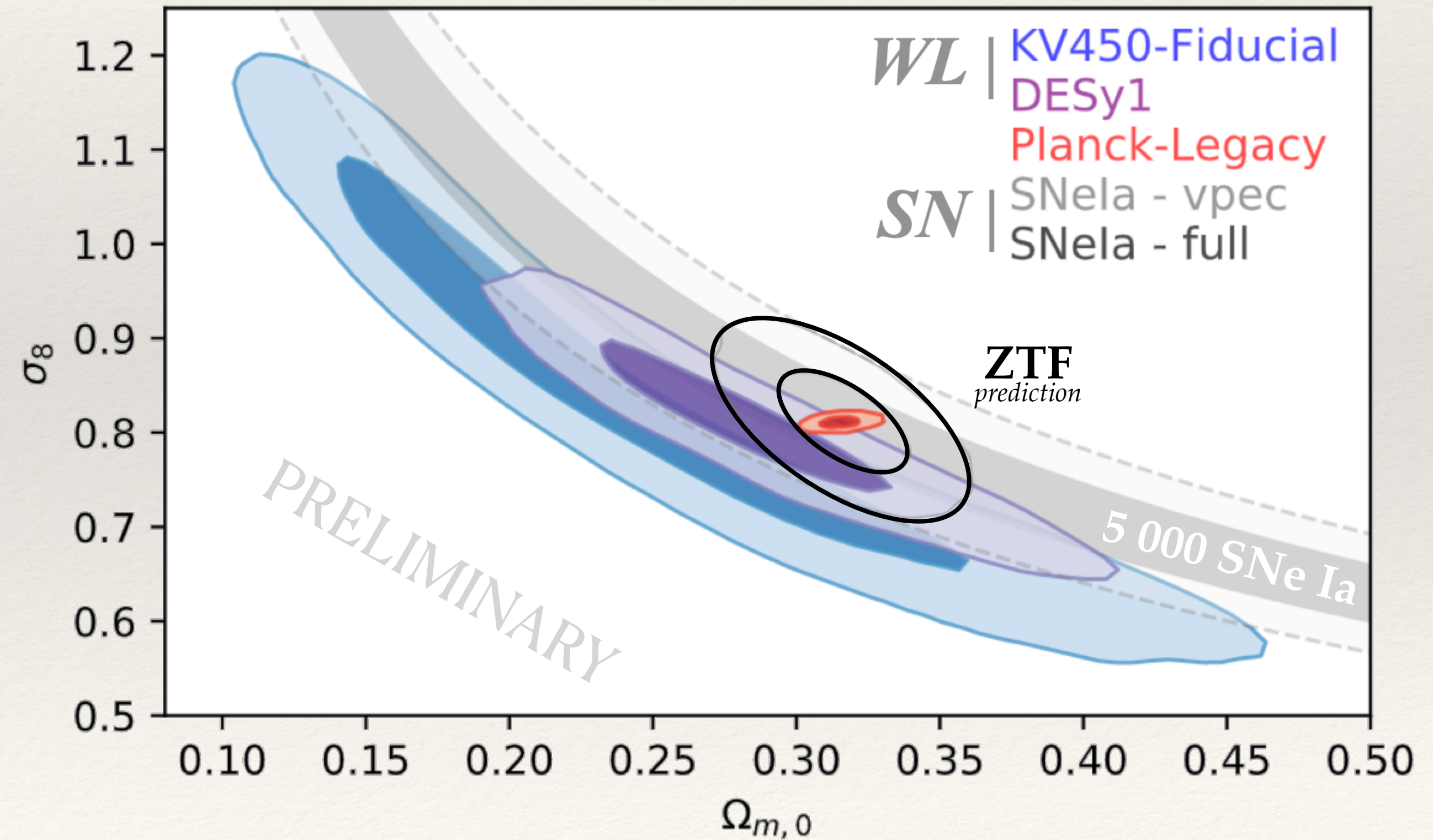
ZTF Cosmology | *A new probe $\sigma_8(z=0)$*



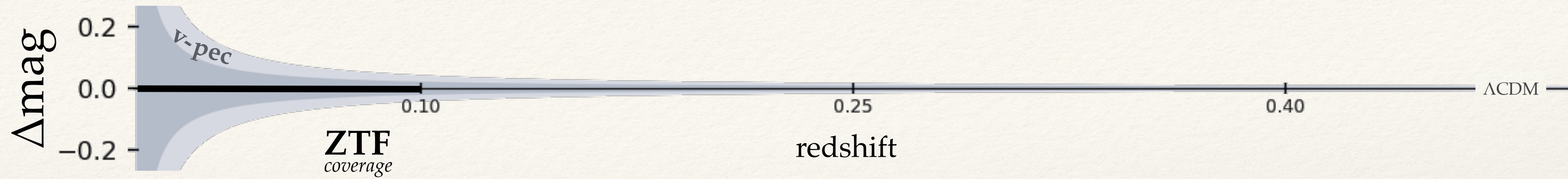
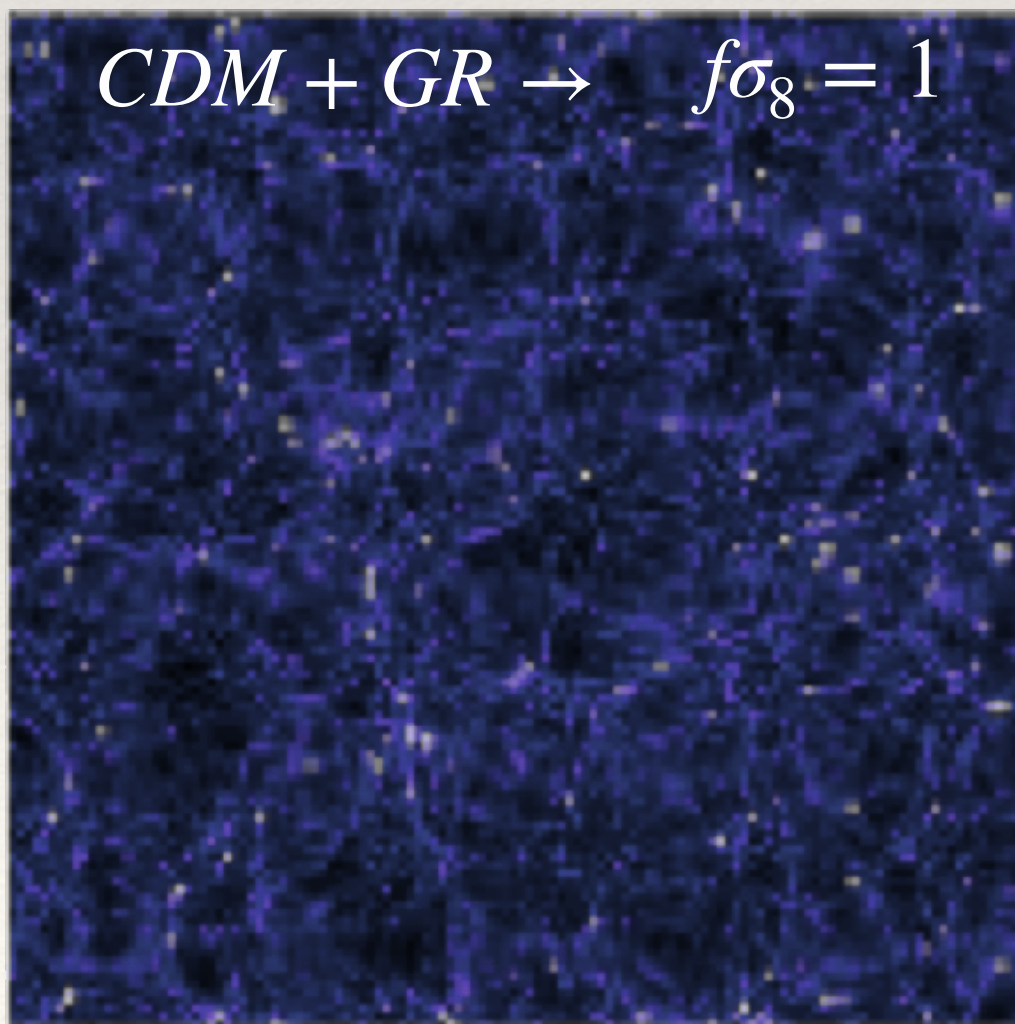
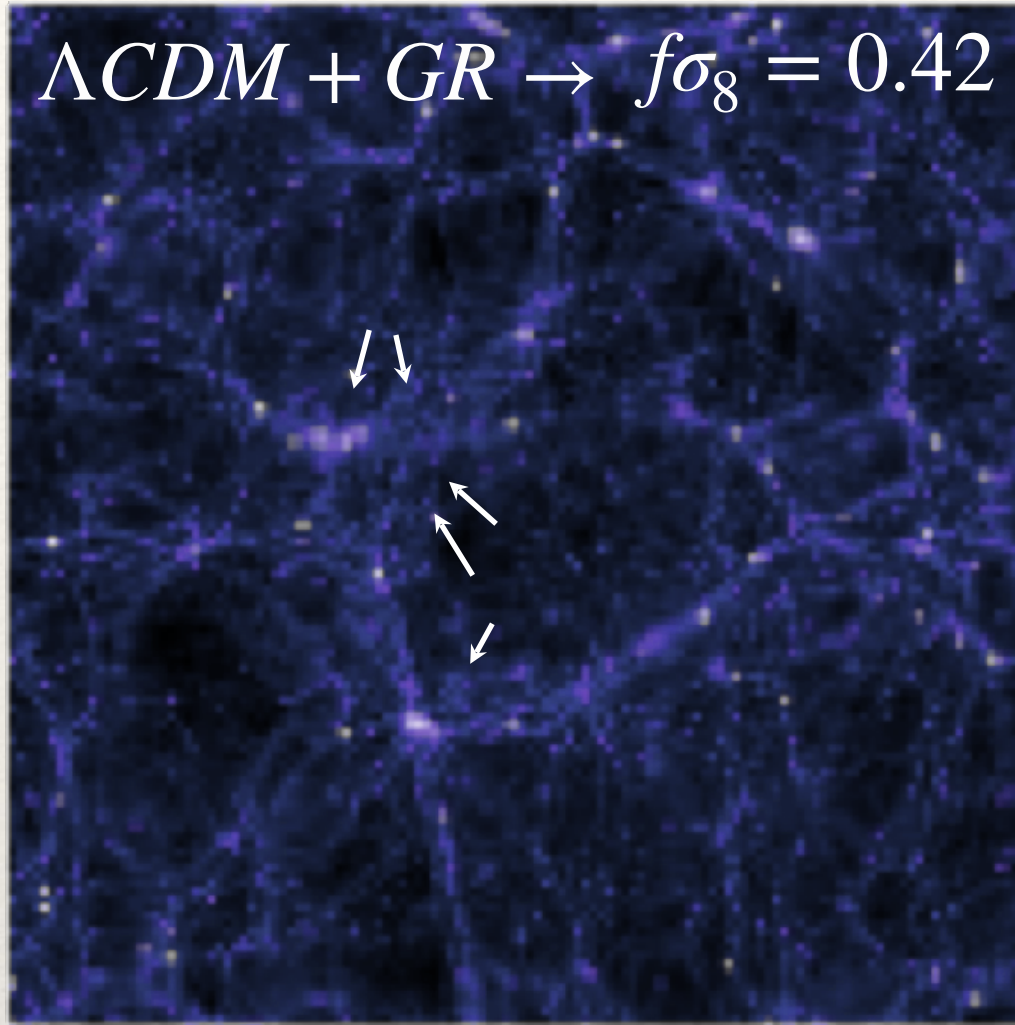
Why is that new ?

Requires $\mathcal{O}(5000)$
 $z < 0.1$ SNe Ia

only ZTF can do that
unclear if LSST could



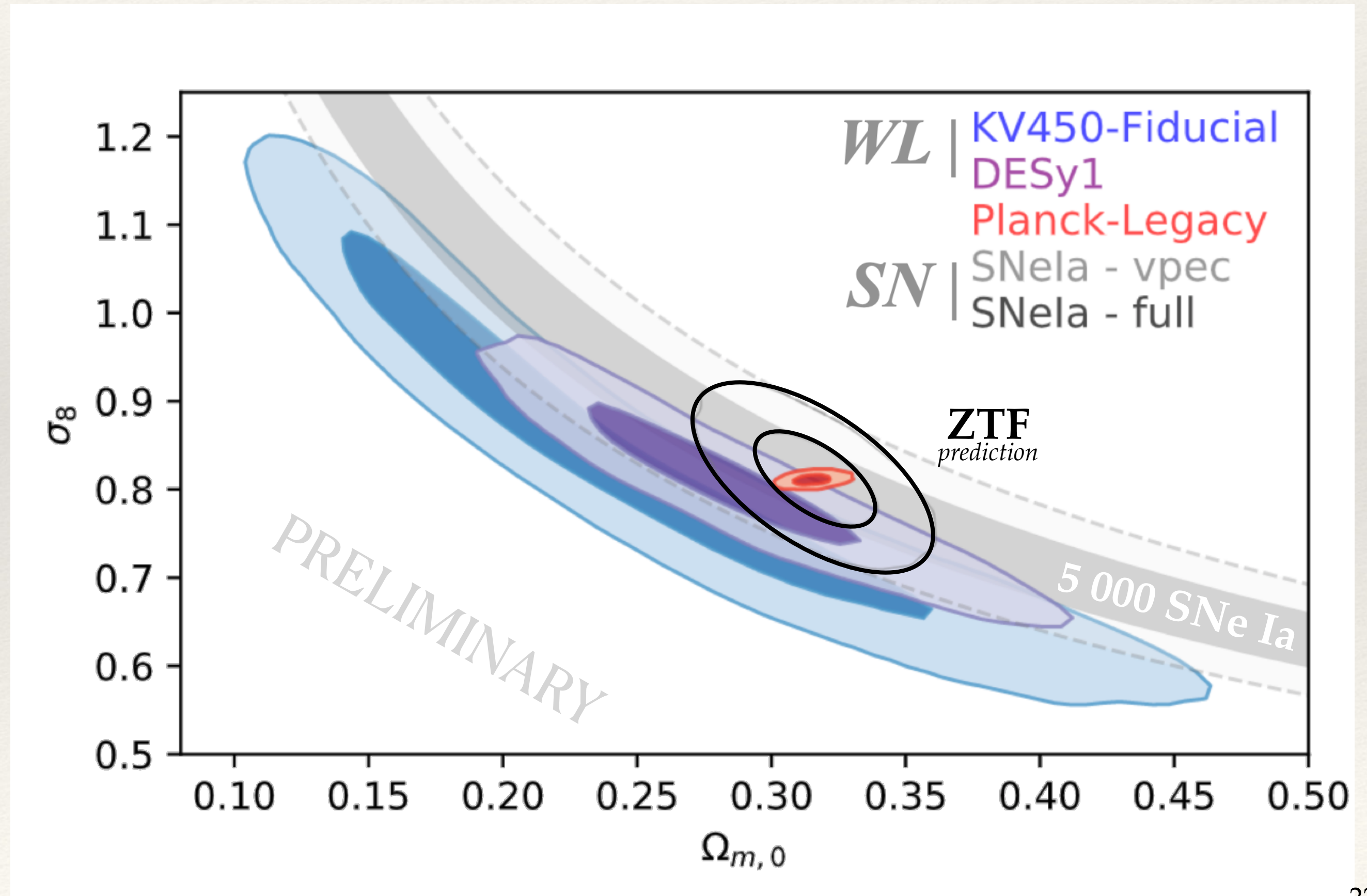
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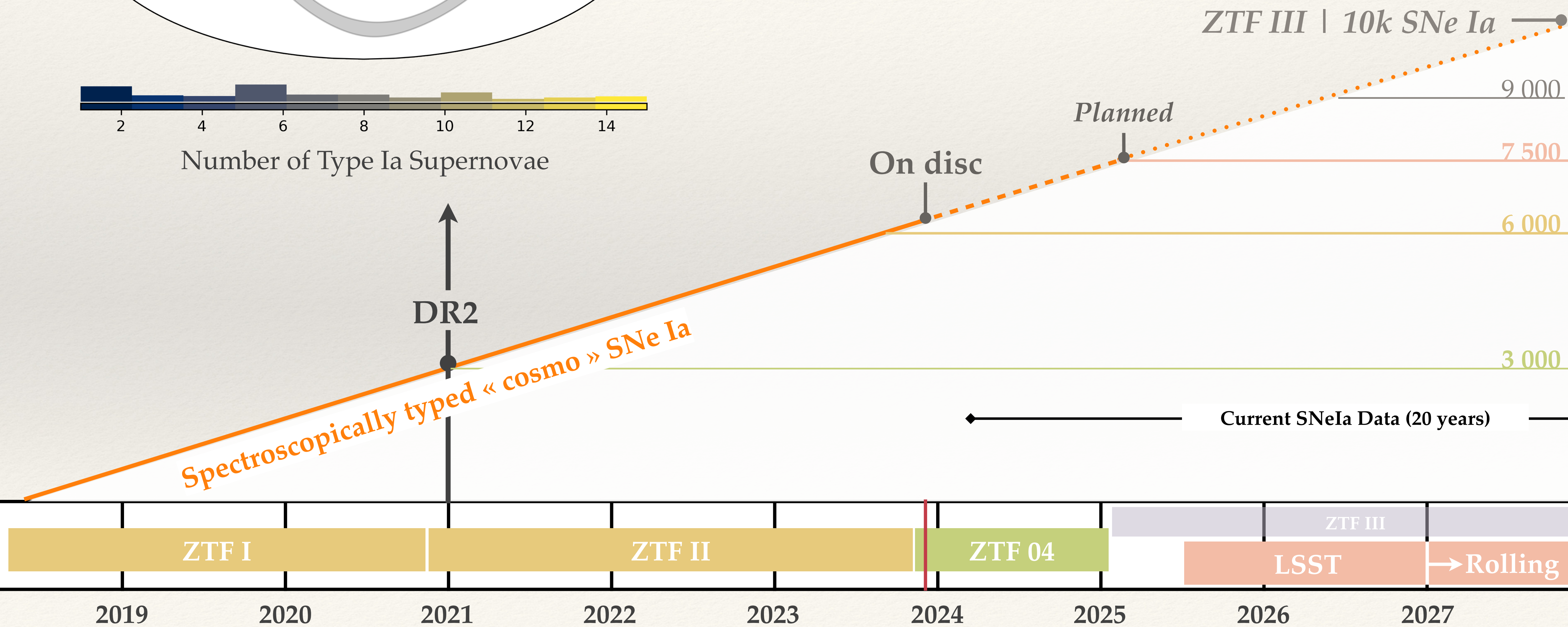
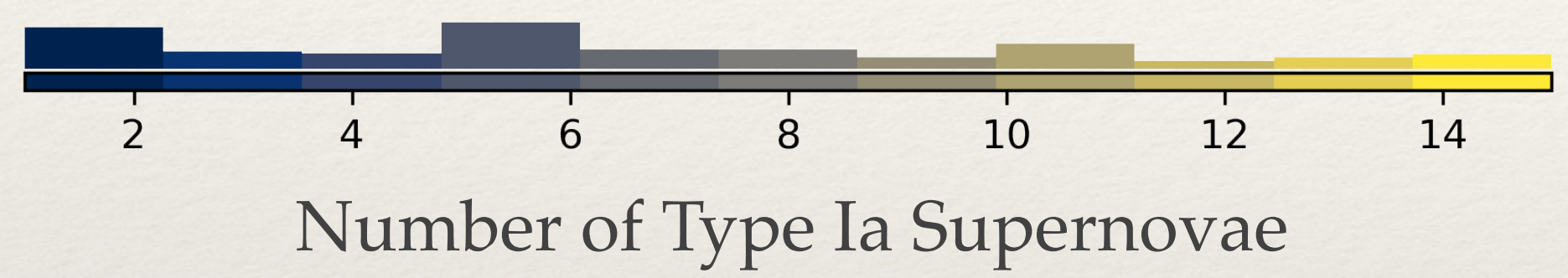
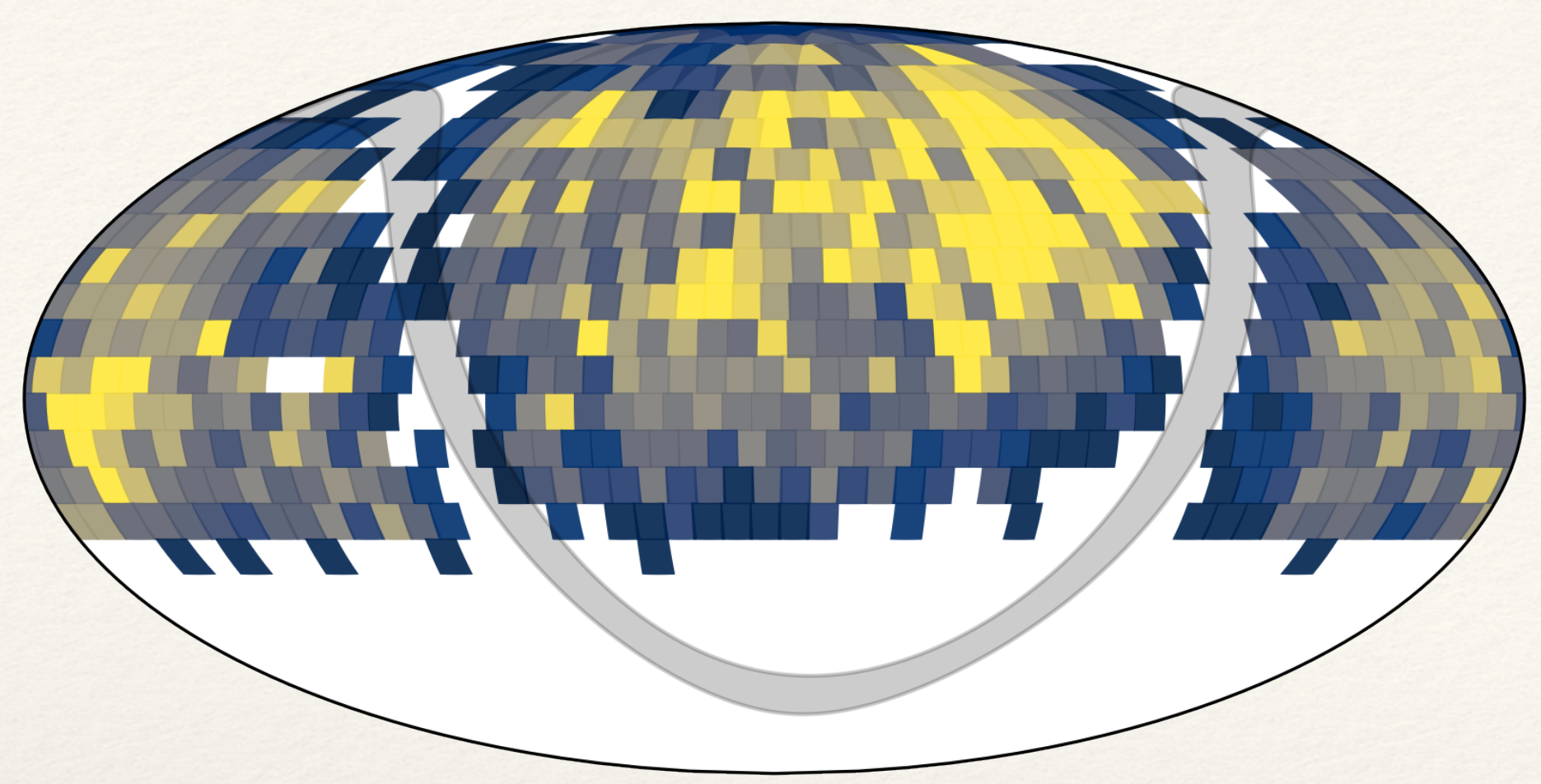


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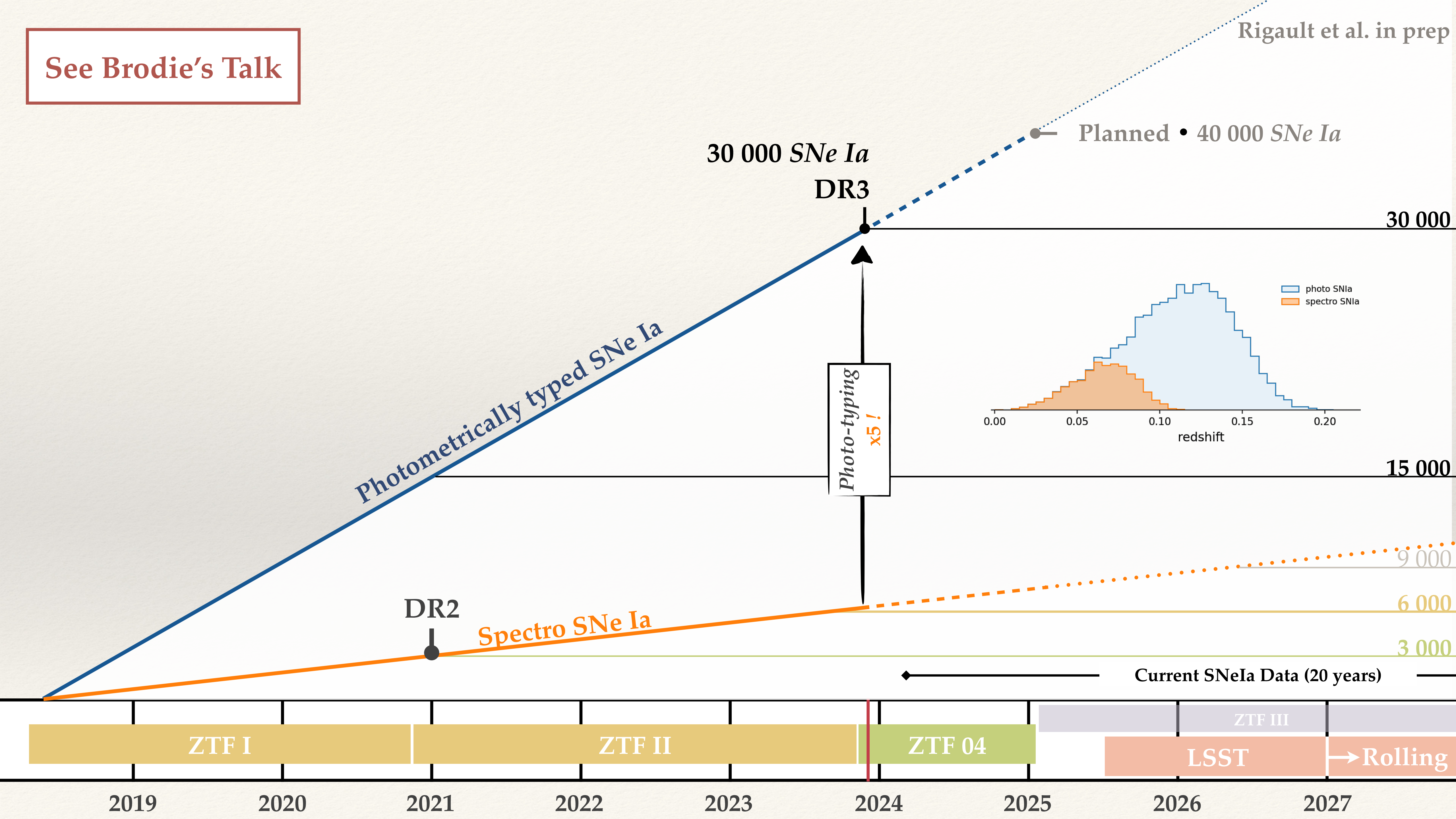
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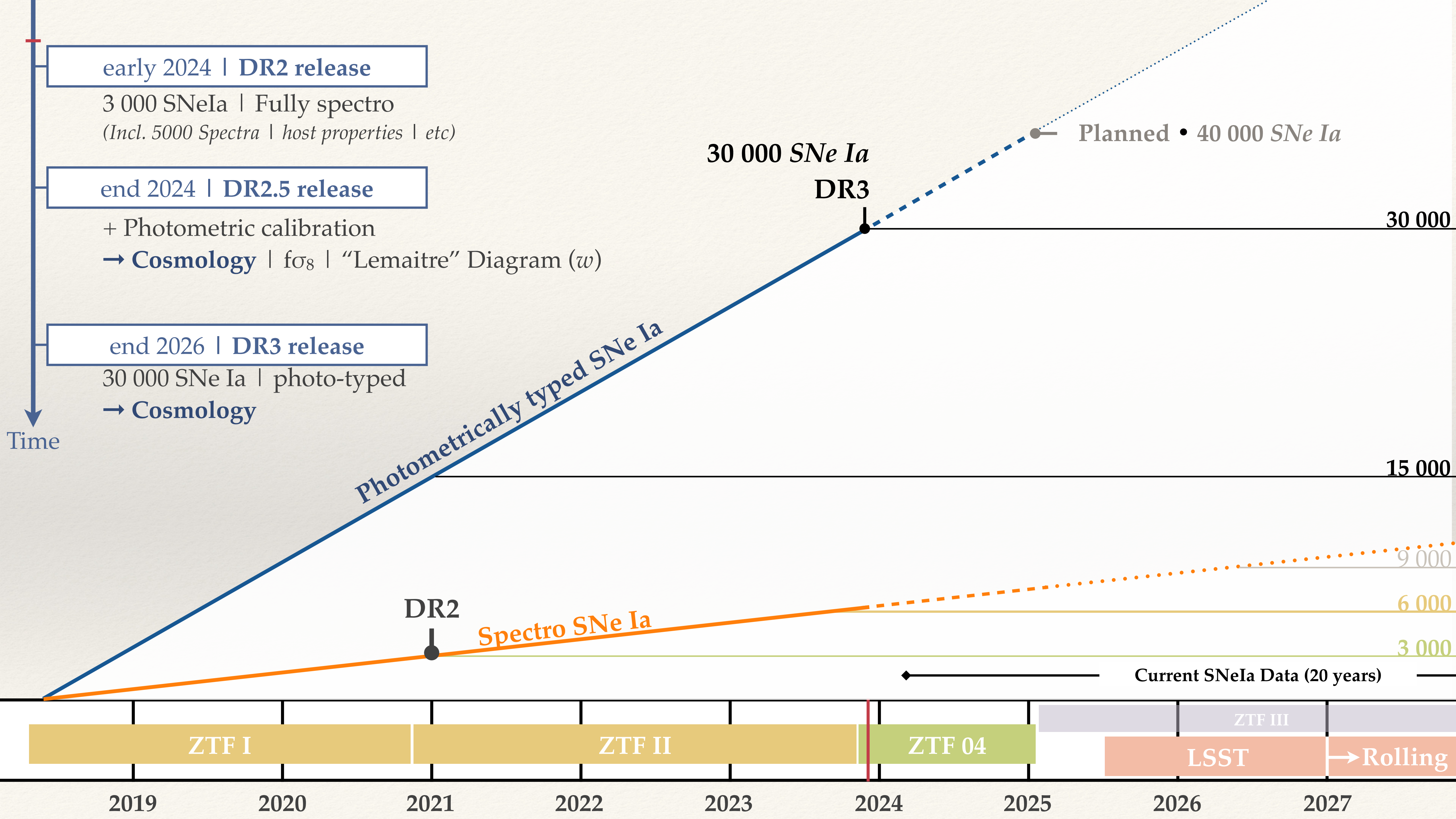




See Brodie's Talk

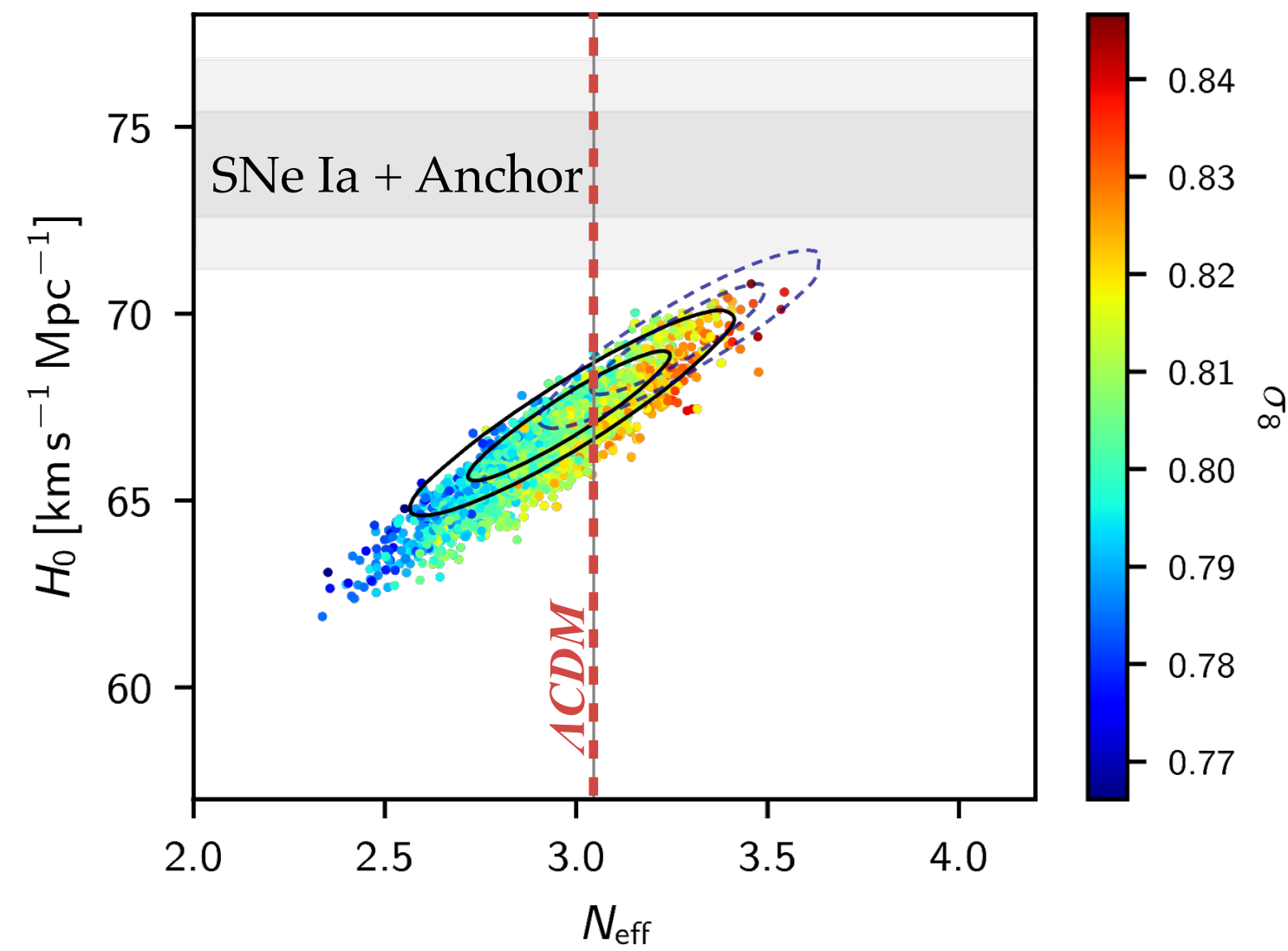
Rigault et al. in prep





ZTF Cosmology | 3 000 SNe Ia now, 30 000 soon

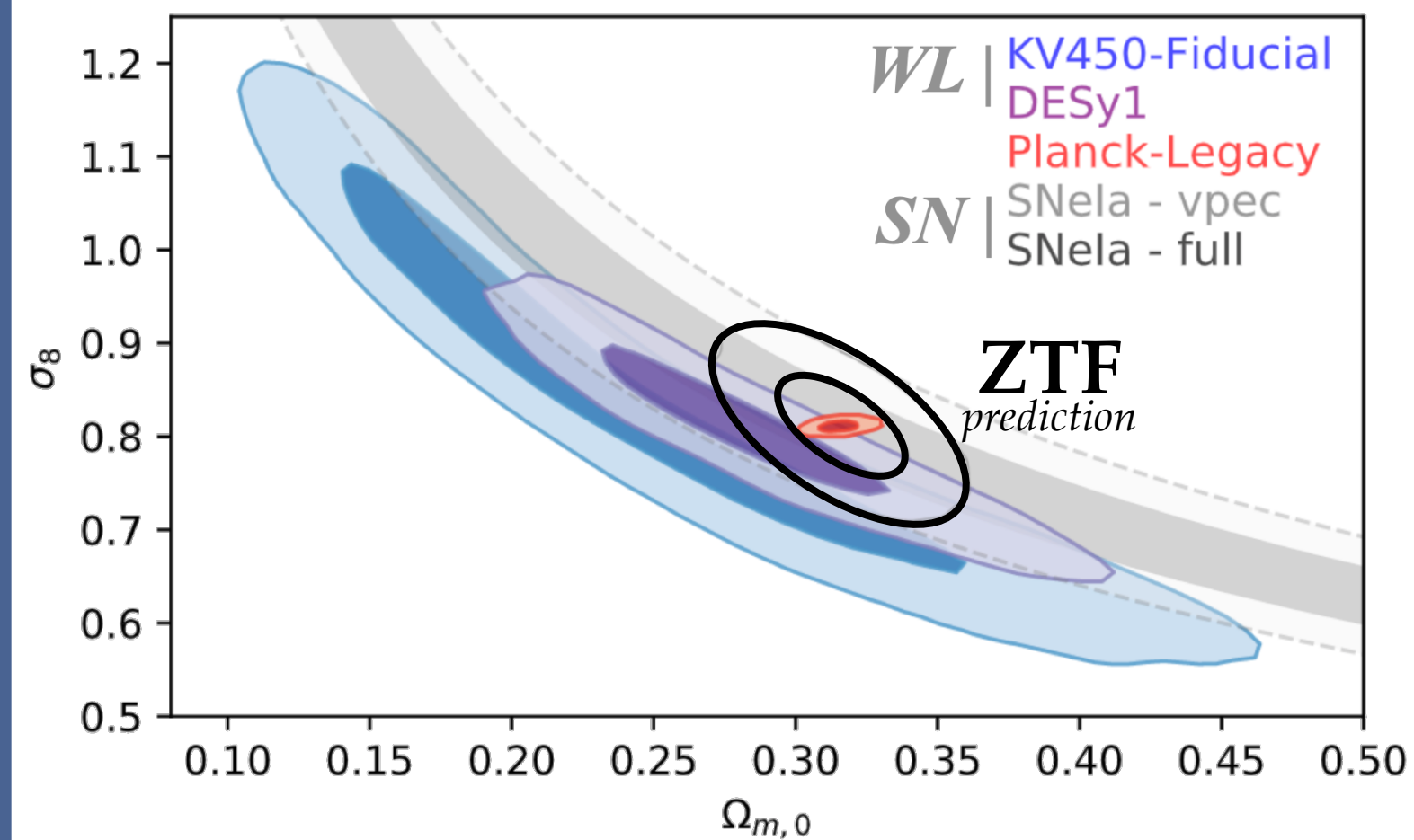
H_0 | Hubble Constant



Statistics ■ ■ ■ ■ Pipeline ■
 Calibration ■ ■ External ■ ■ ■ ■

LSST cannot do that

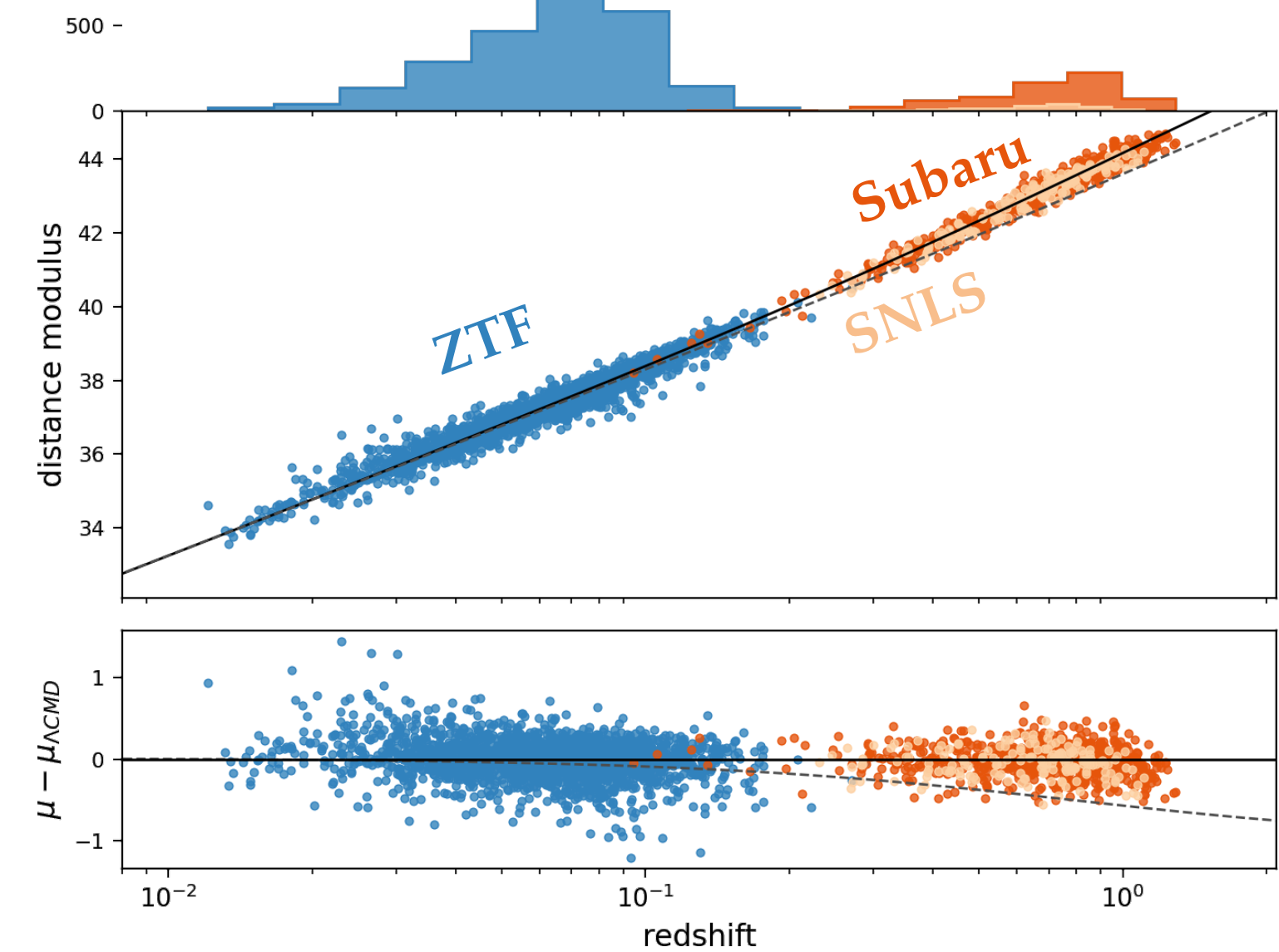
$f\sigma_8$ | Growth rate of Structure



Statistics ■ ■ ■ ■ Pipeline ■ ■ ■
 Calibration ■ ■ External ■

LSST might not be able to do that

w | Dark Energy



Statistics ■ ■ ■ Pipeline ■ ■
 Calibration ■ ■ ■ ■ External ■ ■ ■

LSST will need an anchor