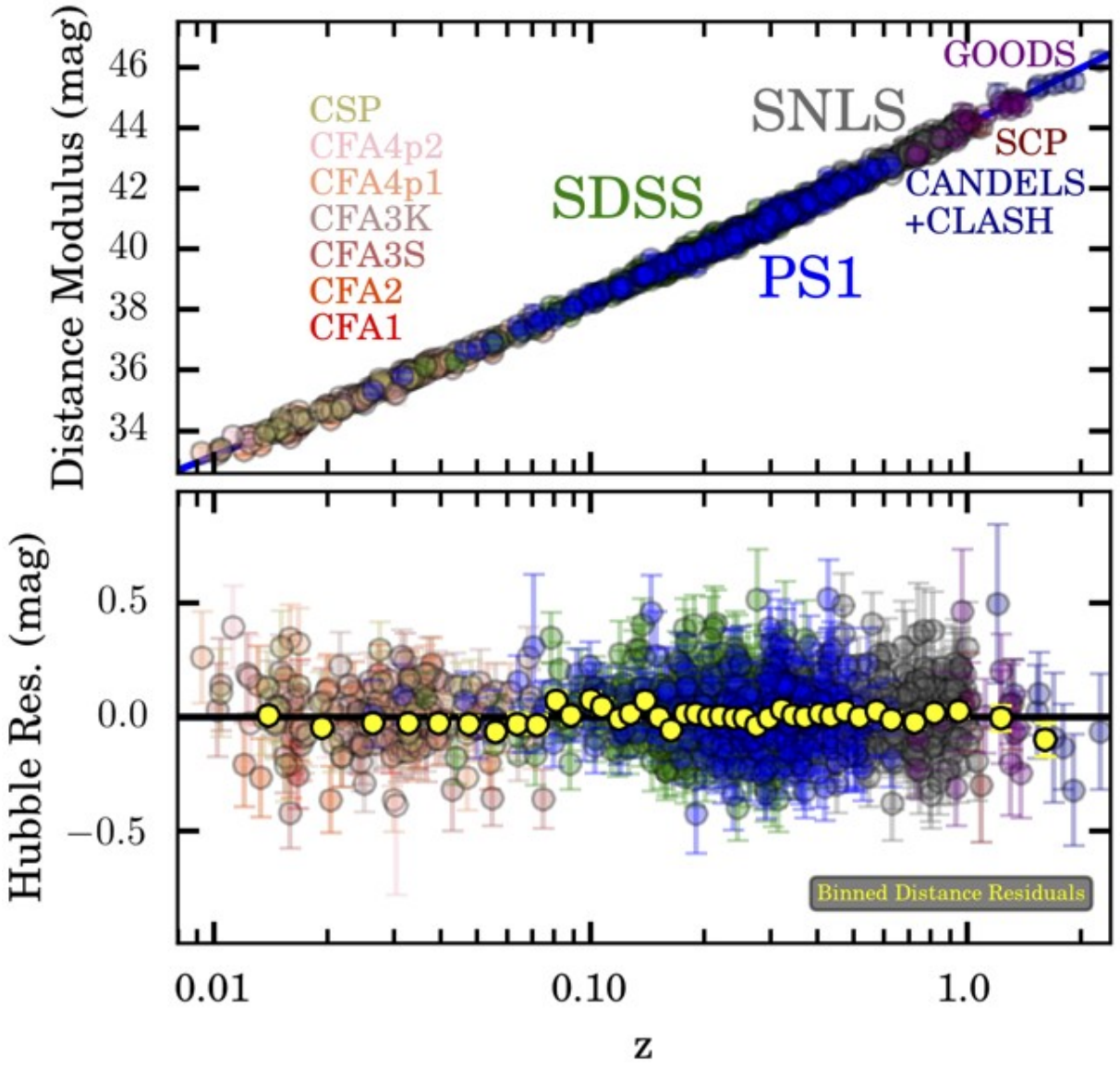
Cosmology with the Zwicky Transient Facility

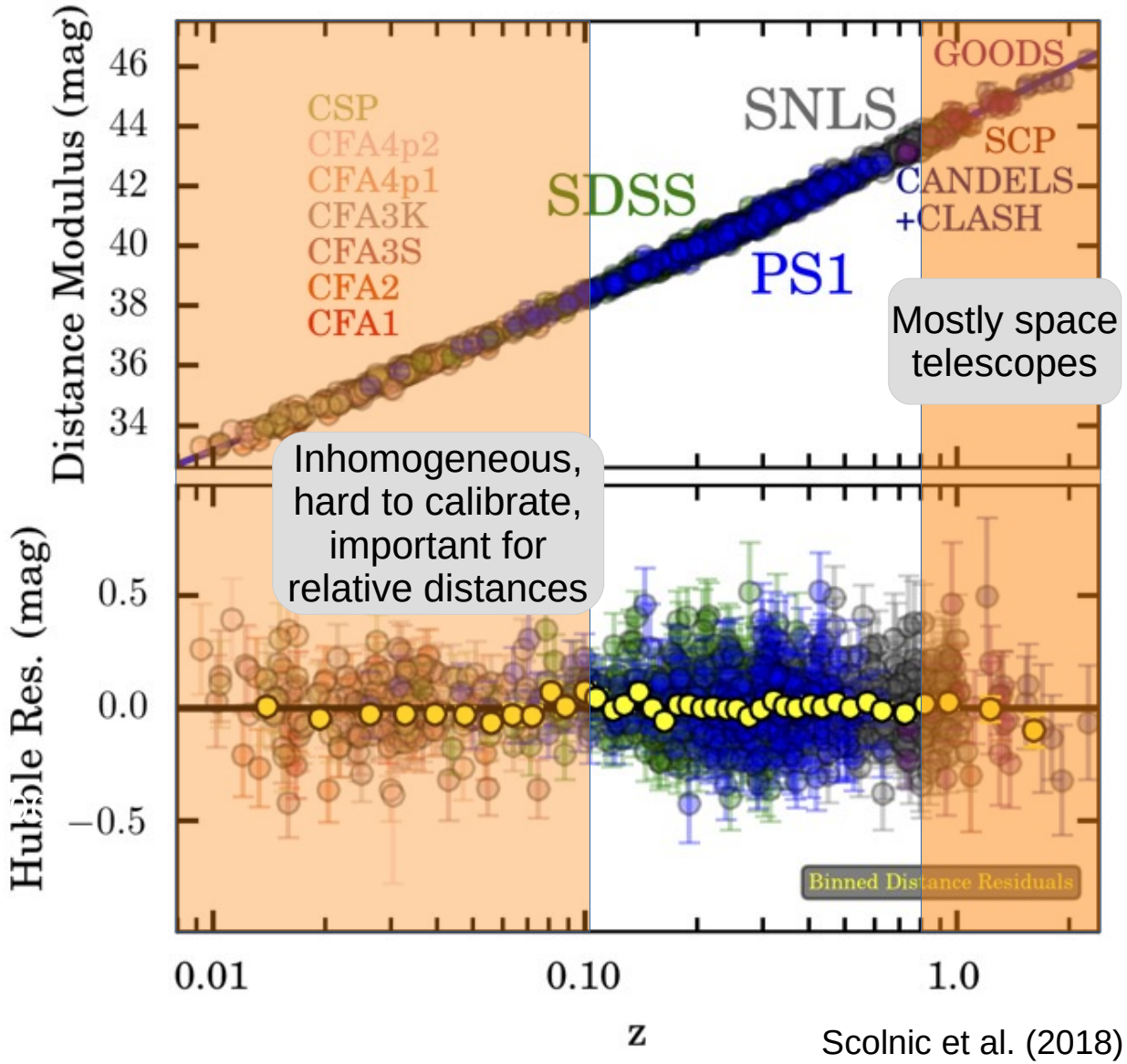
Ulrich Feindt

Oskar Klein Centre, Stockholm

Current state of SN Ia cosmology

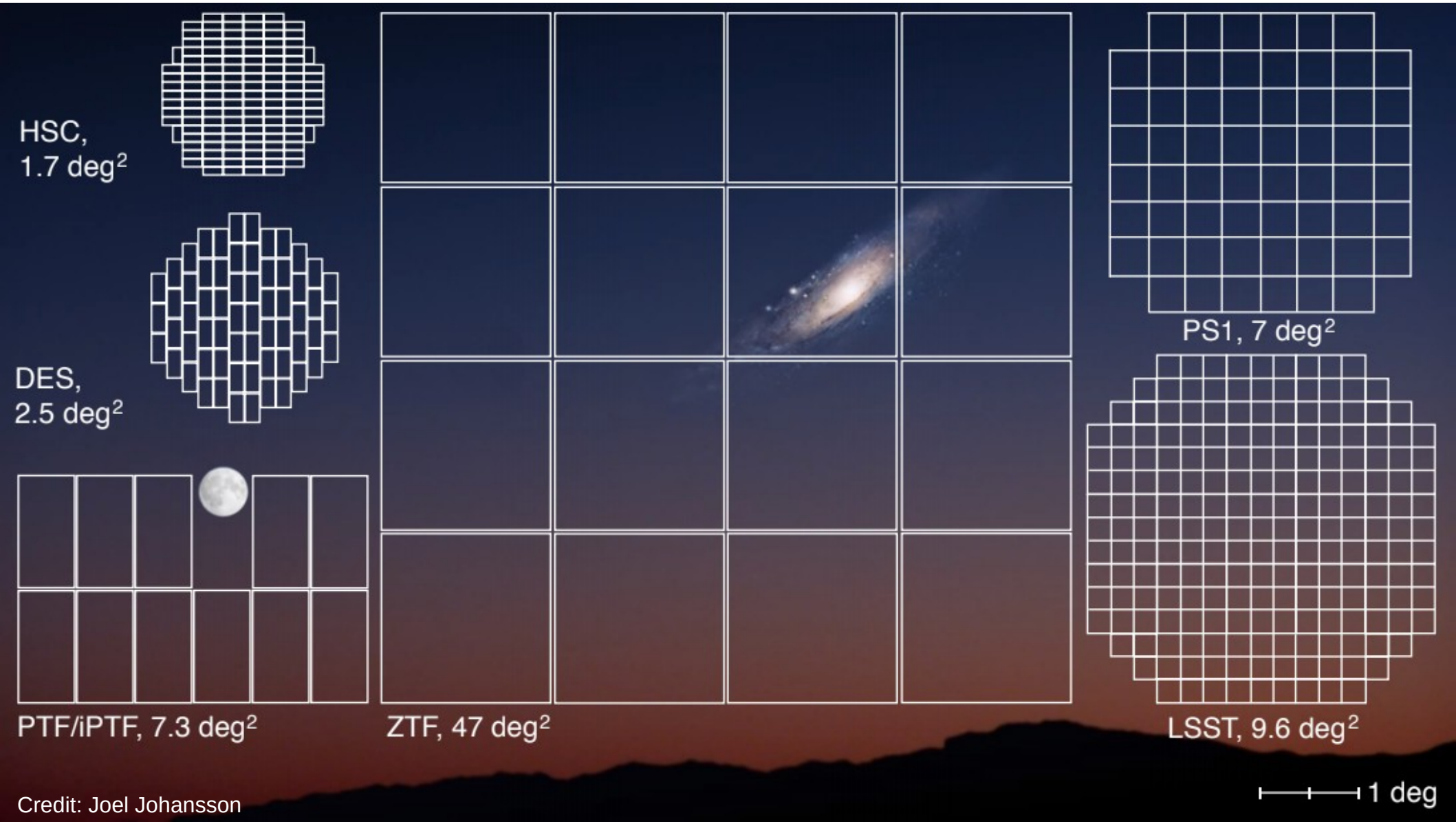


Current state of SN Ia cosmology



Scolnic et al. (2018)

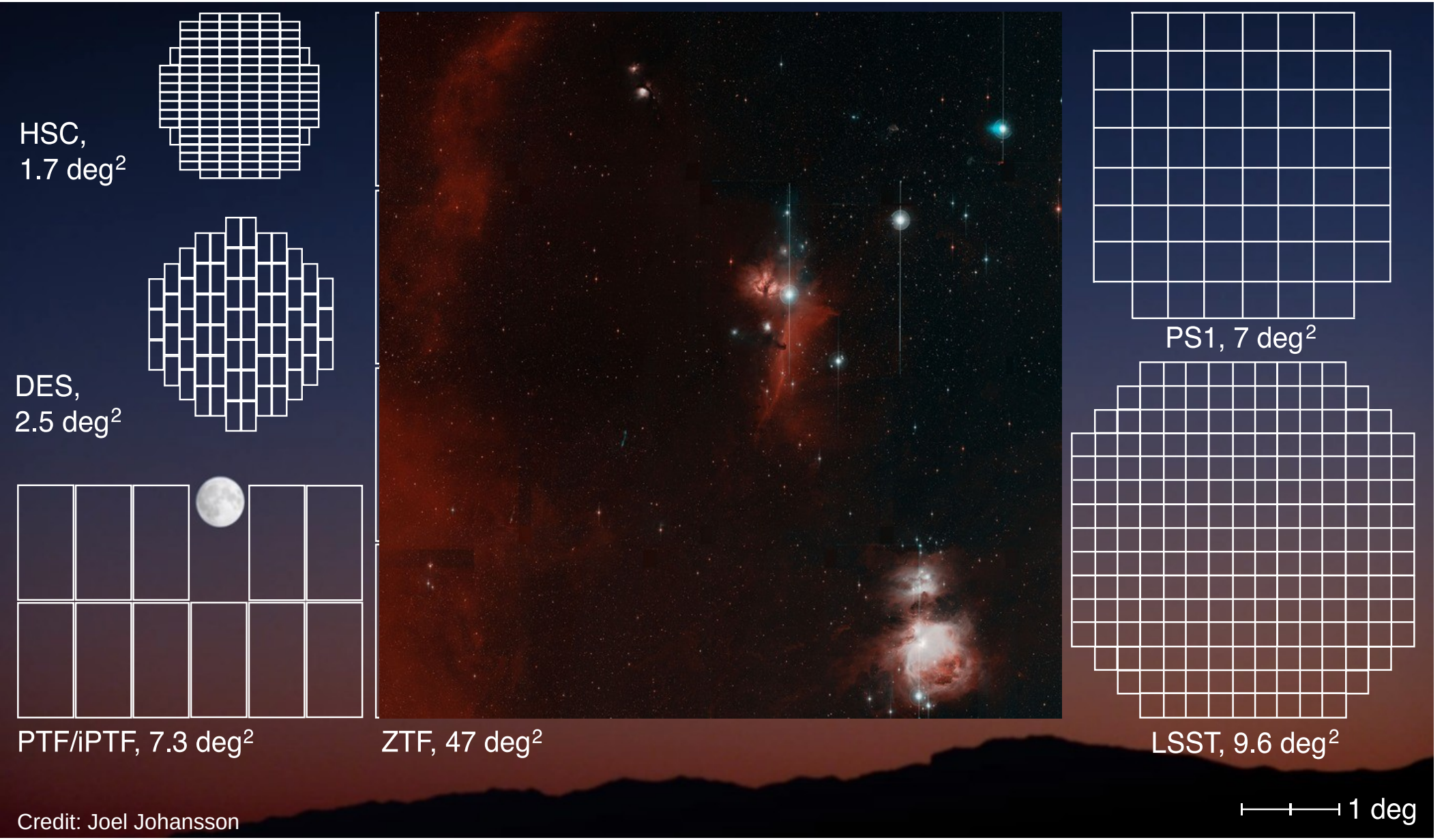
Zwicky Transient Facility

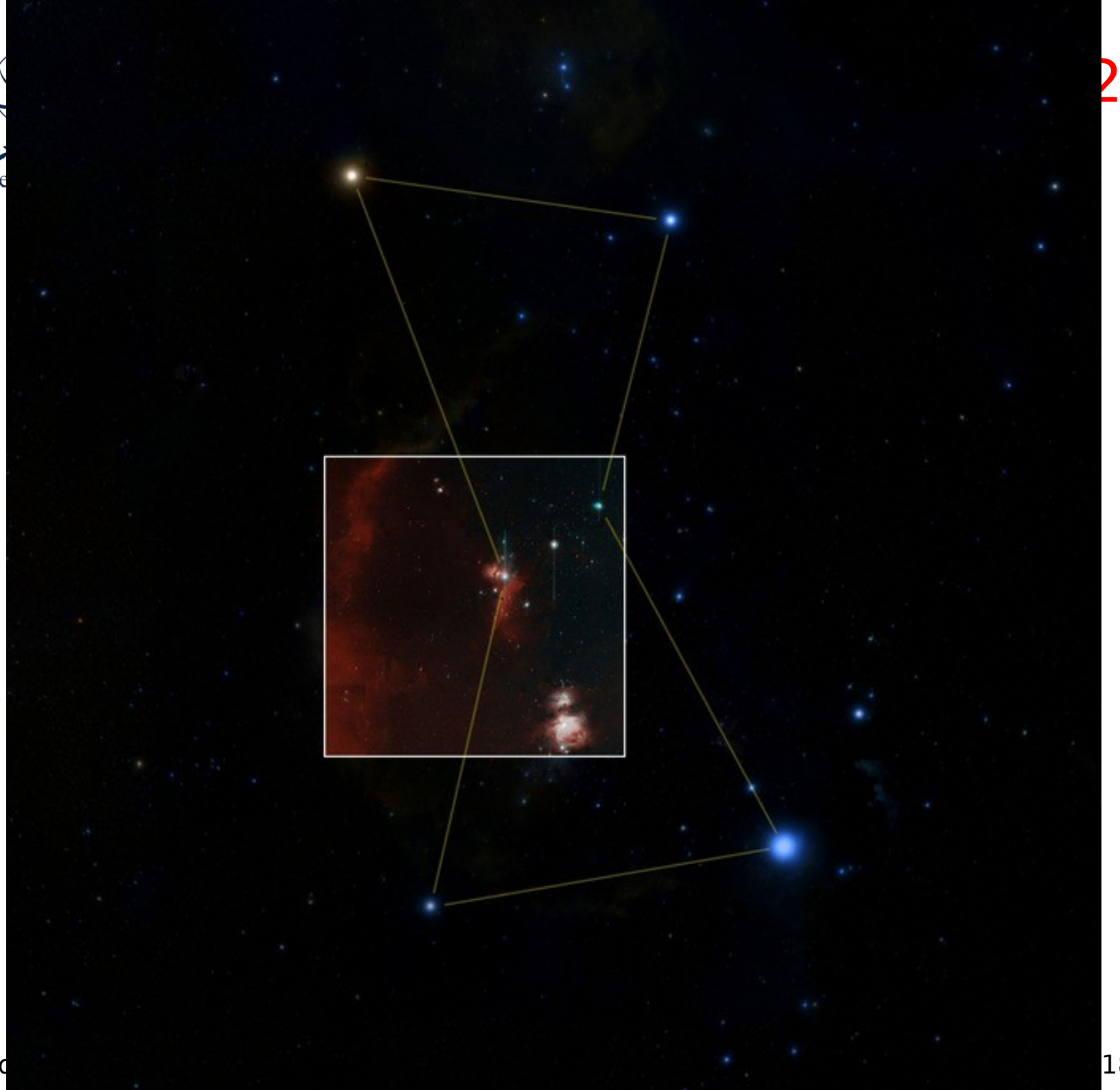


ZTF Survey Plan

- ZTF time on Palomar 48-inch telescope (P48) shared between "partnership" (10 institutions), NSF *public* survey ("MSIP") and Caltech private time (40%, 40%, 20%). Funded for 3 years
- Spectroscopic time on Palomar 60-inch (P60) with SEDmachine (IFU): 65/35% split partnership/Caltech
- MSIP year 1: a "mini LSST" g,r survey of all Northern sky every 3 nights, including sweep of Galactic plane
- Partnership year 1: High-cadence observations of 1/10 of the Northern extragalactic sky, 5-6 visits/night + i-band survey with 4-day cadence of ½ sky, 9 months
- Dedicated inner Galactic plane continuous monitoring for 2 summer weeks
- Solar System Science program for ~1 month

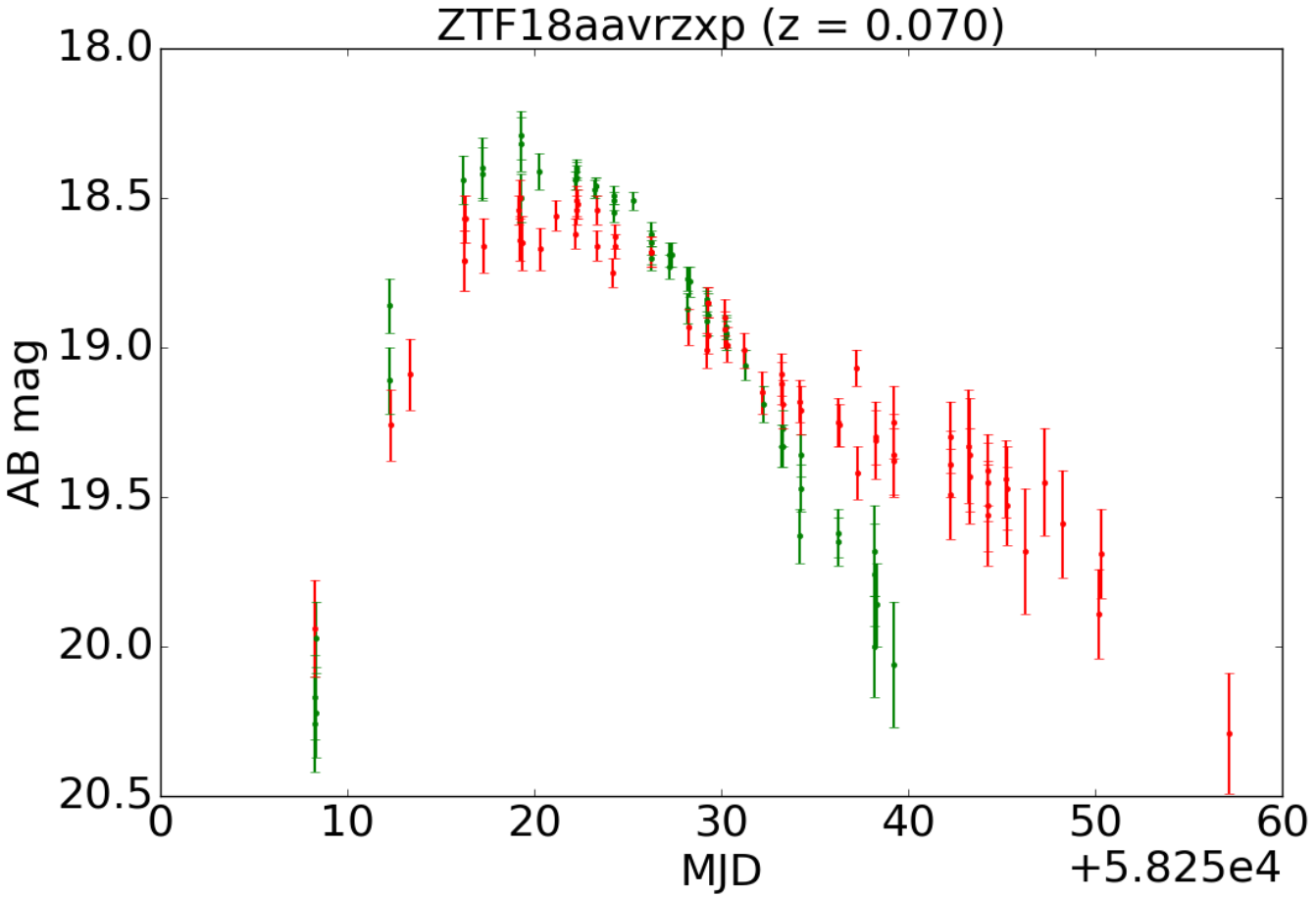
ZTF First Light: November 15, 2017





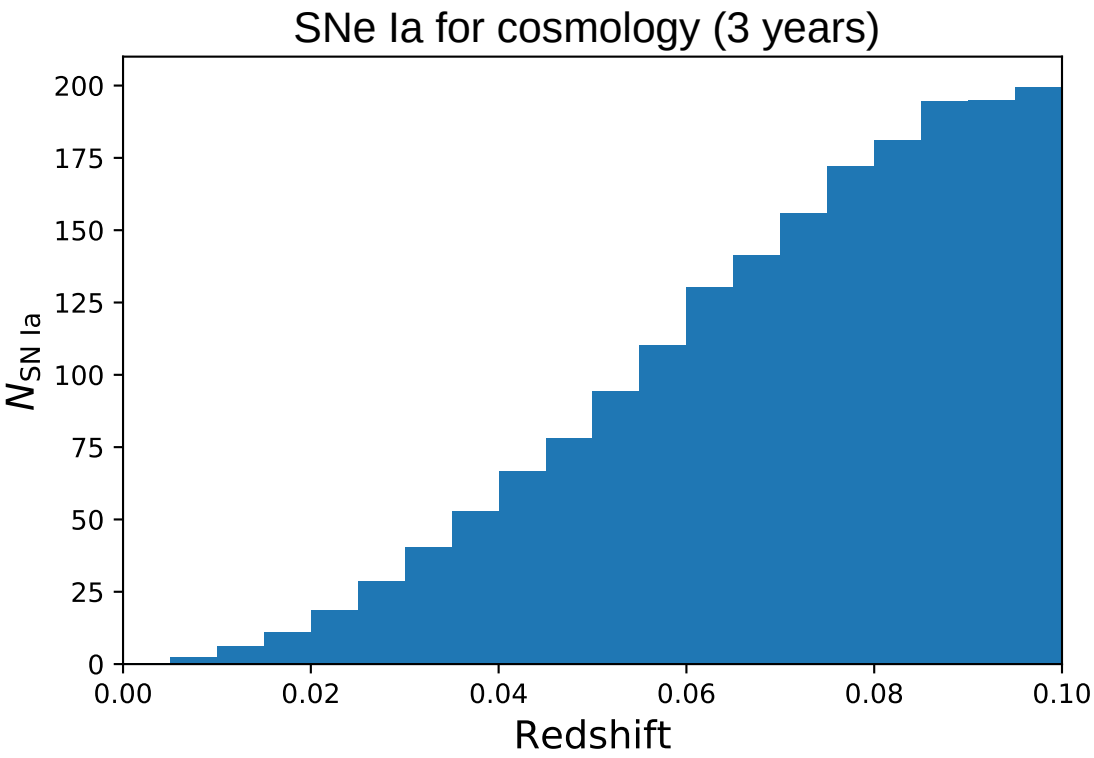
First SNe Ia from ZTF

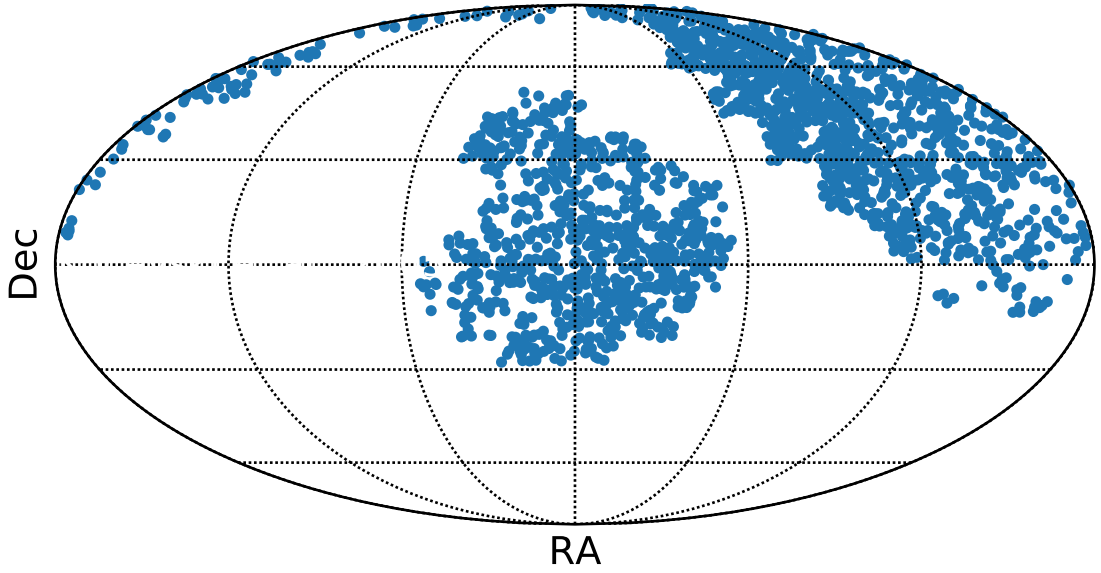
- > 300 SNe Ia have been found in the first few months of the survey
- > 100 SNe have sufficient lightcurve coverage to determine distances
- Many SNe found within days of explosion



Predicted SN Ia data set

Expect to find ~2000 SNe Ia with good lightcurve coverage in gri during three-year survey



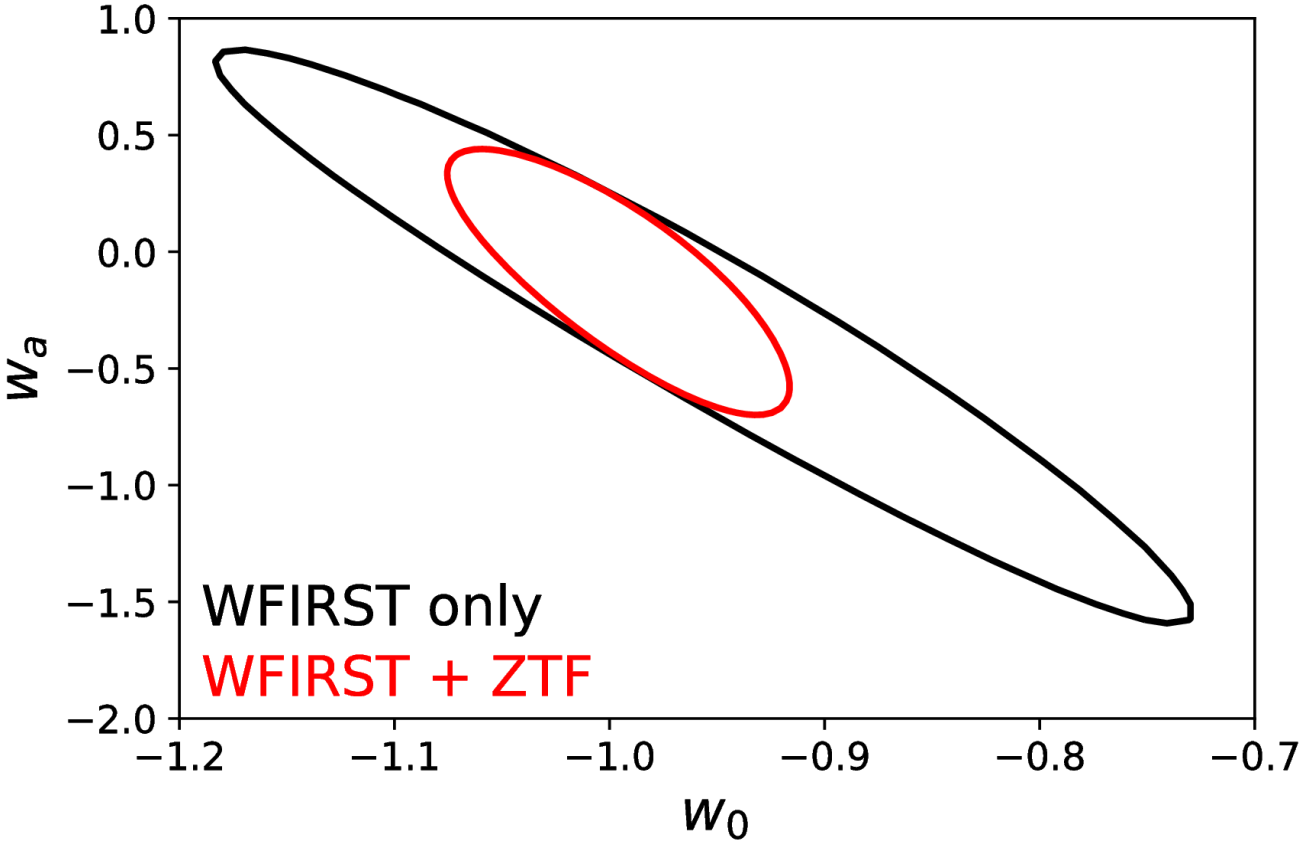


Covering most of the northern sky

➔ Can study structure in the nearby universe through peculiar velcoities

Anchoring the Hubble Diagram

- Future surveys (e.g. LSST) will mostly provide a high-redshift sample of SNe Ia.
- A large low-redshift sample will be essential for precise measurement of dark energy.
- Additionally having a single well-calibrated data set will reduce systematics for measurements of H0.



ZTF Lensed SN Search

(D. Goldstein, A. Goobar, P. Nugent)

Lensed supernovae “discovered” in ZTF simulation

- New suite of detailed strongly lensed supernova population simulations recently completed (paper forthcoming)
- Simulations include effects of observing strategy, conditions, dust, host galaxies, SN subtypes, and discovery strategy
- Simulations forecast that ZTF should discover up to 20 strongly lensed SNe, ~80% of which will be IIP’s or IIn’s.

Handling O(10^5) alerts

(V. Brinnel, M. Giomi, J. Nordin, J. van Santen)

- ZTF sends out >O(10^5) transient alerts every night (mostly variable stars), of which O(10) are **new** supernovae
- Detection are mainly distributed as AVRO alert packets, including a public alert stream based on the MSIP survey
- AMPEL framework developed at HU Berlin to:
  - Reject previously existing transients
  - Match galaxies of new transients with catalogs and determine photo-z for others
  - Automatic trigger of notices and follow-up observations
  - Could be used to combine data from different sources – connected to TNS and not tied to ZTF

Summary

- ZTF is a new exciting discovery engine and found > 300 SNe Ia in a few months already
- Will produce a unique data set of ~2000 SNe Ia discovered early and sample densely in three bands over a span of three year
- Robotic spectroscopic follow-up of g < 18.5 mag transients with P60, follow-up of fainter SNe Ia with bigger telescopes
- New approaches needed for handling high-rates of transients (AMPEL). ZTF is a stepping stone for LSST.
- Additionally expect ~20 strongly lensed SNe for H_0 measurement.

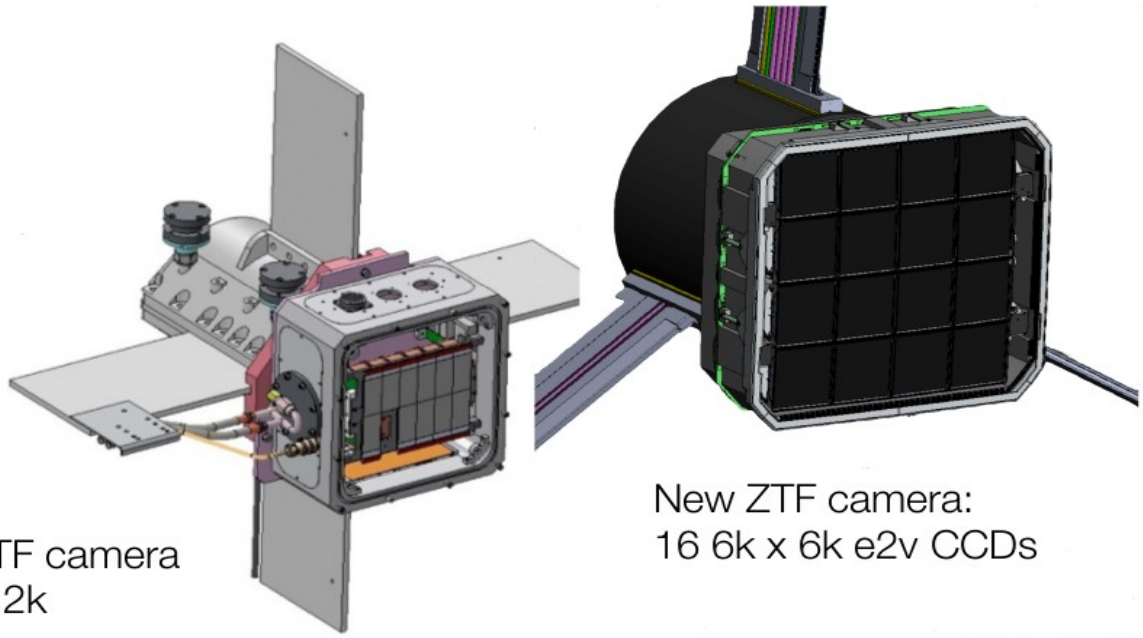
Backup

Faster and Wider Survey

	PTF	ZTF
Active Area	7.26 deg^2	47 deg^2
Overhead Time	46 sec	<15 sec
Optimal Exposure Time	60 sec	30 sec
Relative Areal Survey Rate	1x	**14.7x**
Relative Volumetric Survey Rate	1x	**12.3x**

3750 deg^2/hour
➔3π survey in 8 hours
>250 observation/field/year
for uniform survey

Will observe thousands of SNe



Existing PTF camera
MOSAIC 12k

New ZTF camera:
16 6k x 6k e2v CCDs

Expected *Yearly* yield of *spectroscopically* identified SN

Transients with g < 18.5 mag will be classified using the SEDmachine

SN Type	SNe in 12 months	Median redshift
Ia	1000	0.053
Ibc	220	0.048
IIP/L	375	0.028
IIn	120	0.049
Total CC	715	

Numbers from lightcurve simulations (Feindt et al. in prep.)

Expect ~600-700 SNe Ia with good lightcurve coverage per year
(will require additional spectroscopy)