

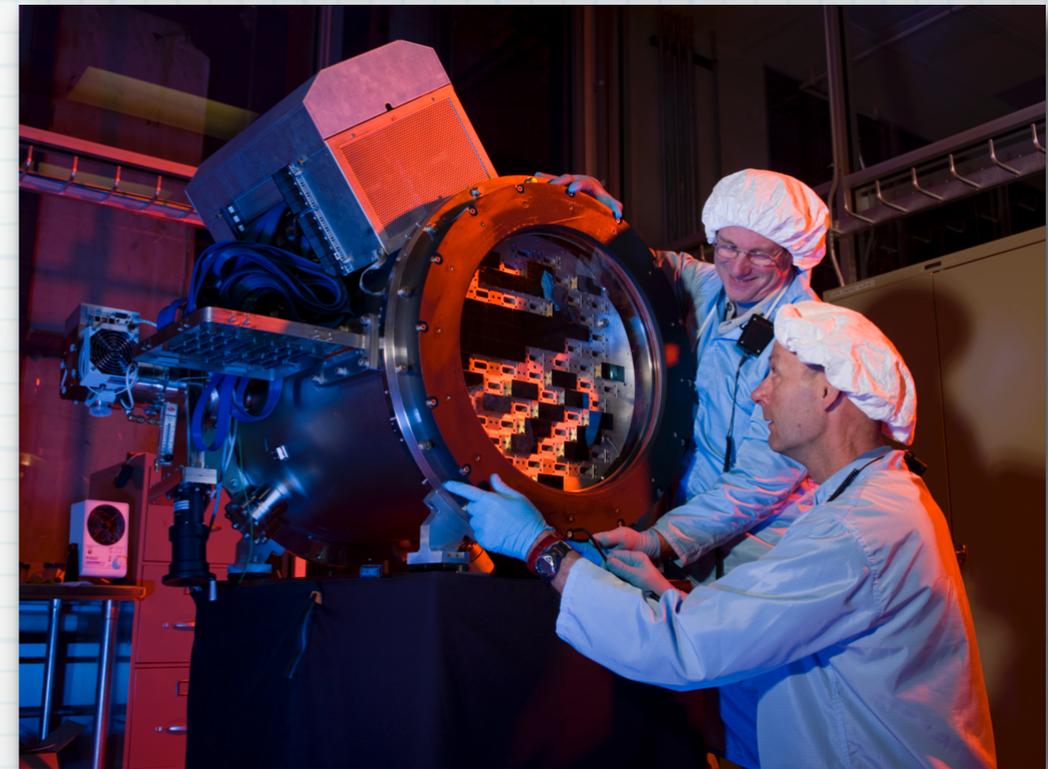
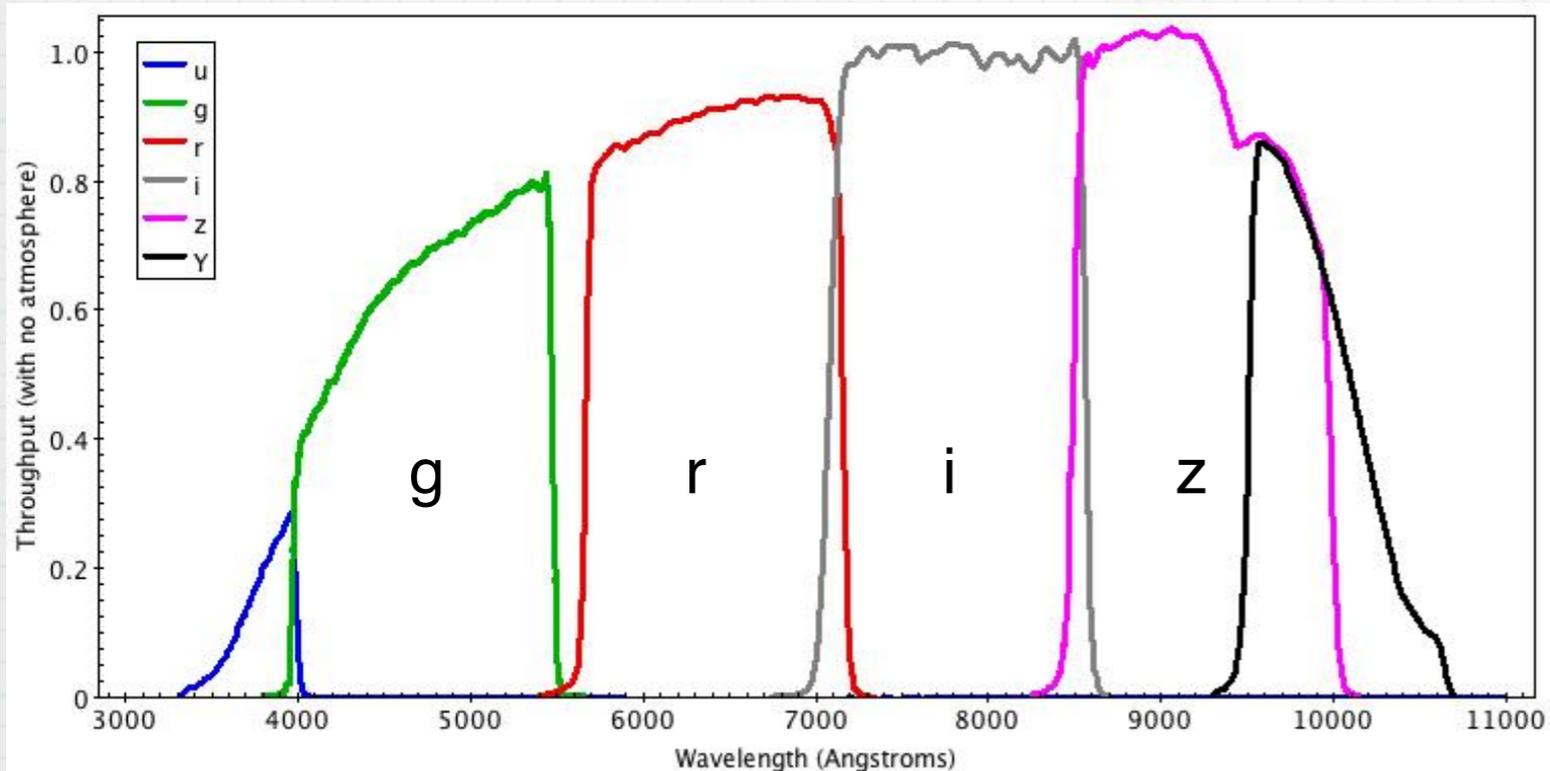
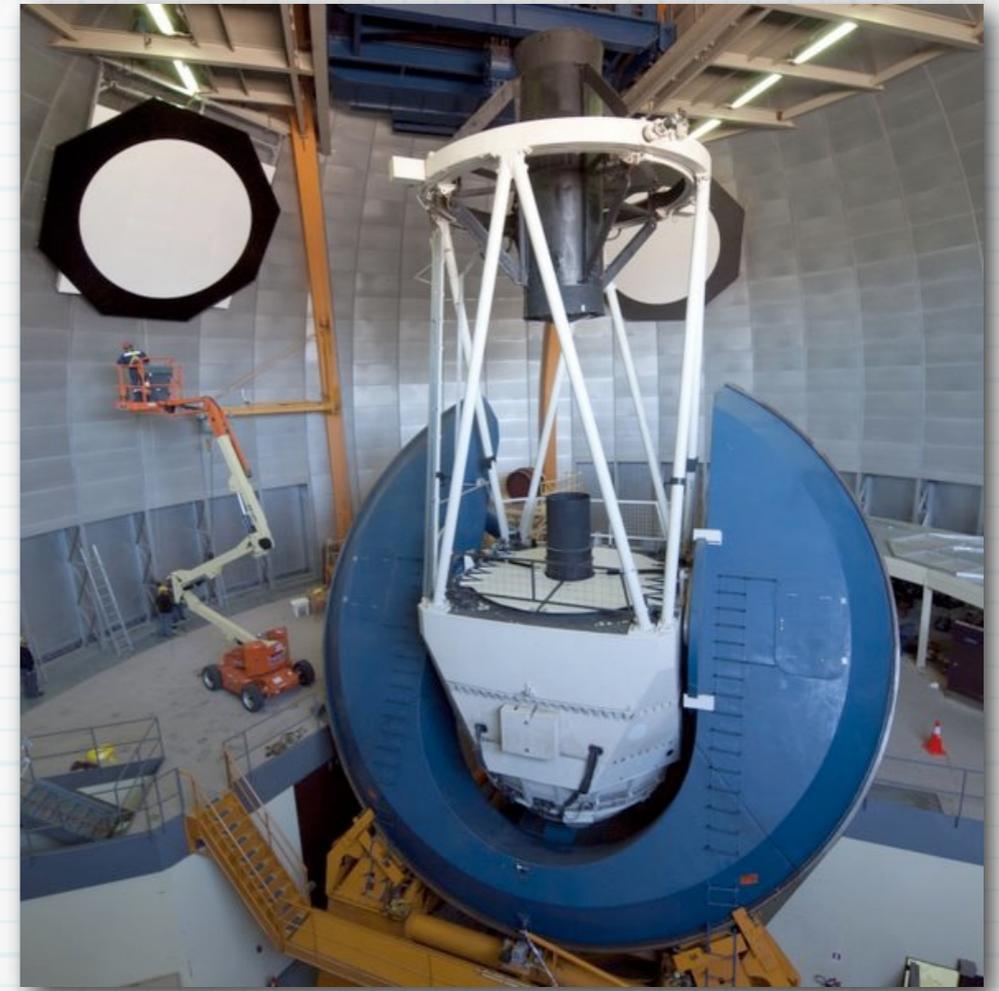
# The Dark Energy Survey Supernova Program

Masao Sako (UPenn)  
DES SN Working Group

# The Dark Energy Survey DES

4 major probes of dark energy  
(WL, BAO, CL, SN)

- Prime focus of 4-m Blanco Telescope (CTIO)
- 520 Megapixel, 3 deg<sup>2</sup> FoV Dark Energy Camera (DECam)
- *ugrizY* filters
- 6-year survey (Sept 2013 - Feb 2019)
- community instrument

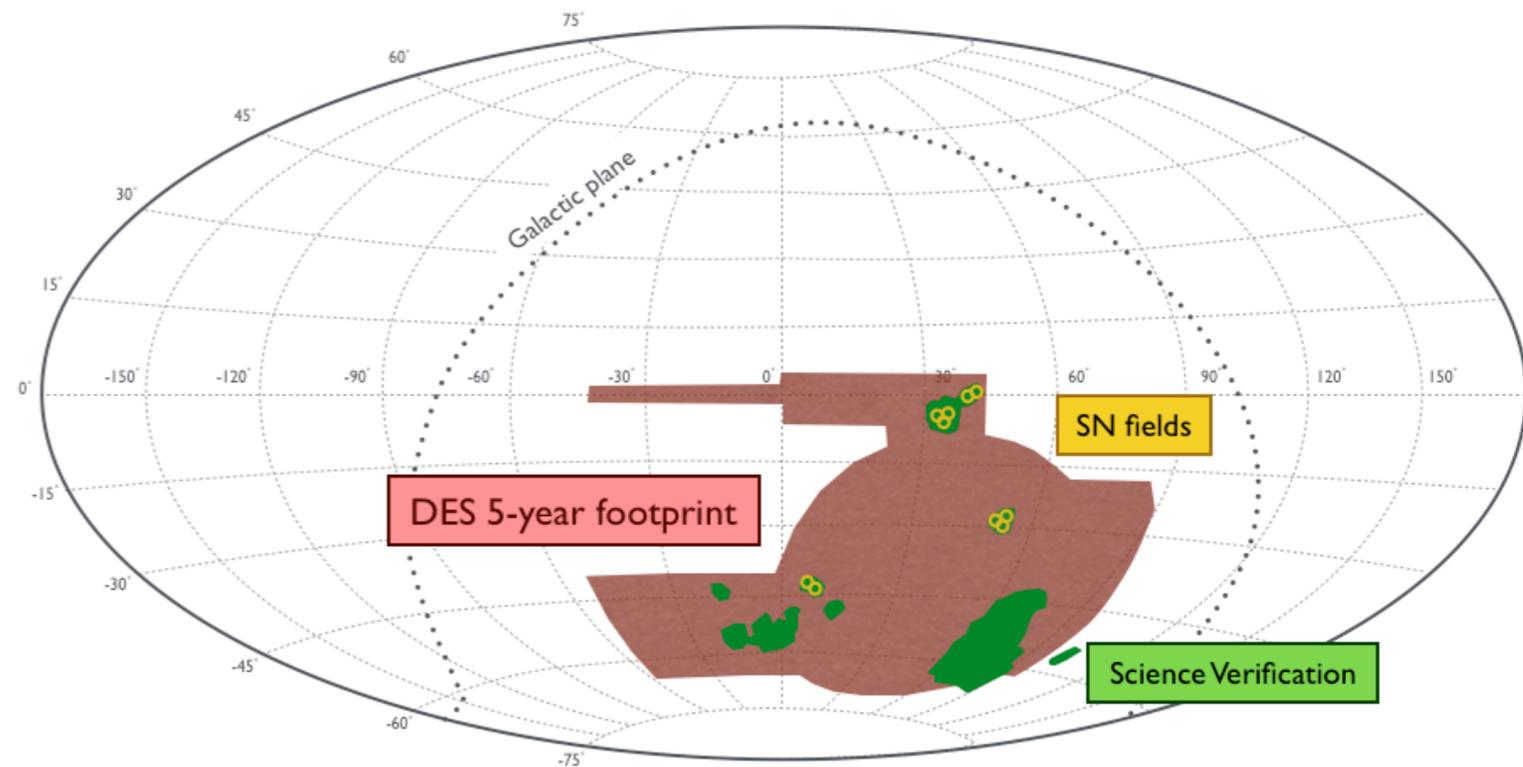


	area (deg <sup>2</sup> )	visits (per filter)	filters	exposure time in sec (per visit)	SN Ia z range
Wide	5000	10	<i>grizY</i>	90/90/90/90/90	0.0 - 0.3
SN shallow	22	125	<i>griz</i>	<i>g/r/i/zz</i> (same night) 175/150/200/400	0.1 - 0.6
SN deep	6	125	<i>griz</i>	3 <i>g</i> /3 <i>r</i> /5 <i>i</i> /11 <i>z</i> 600/1200/1800/3630	0.2 - 1.1

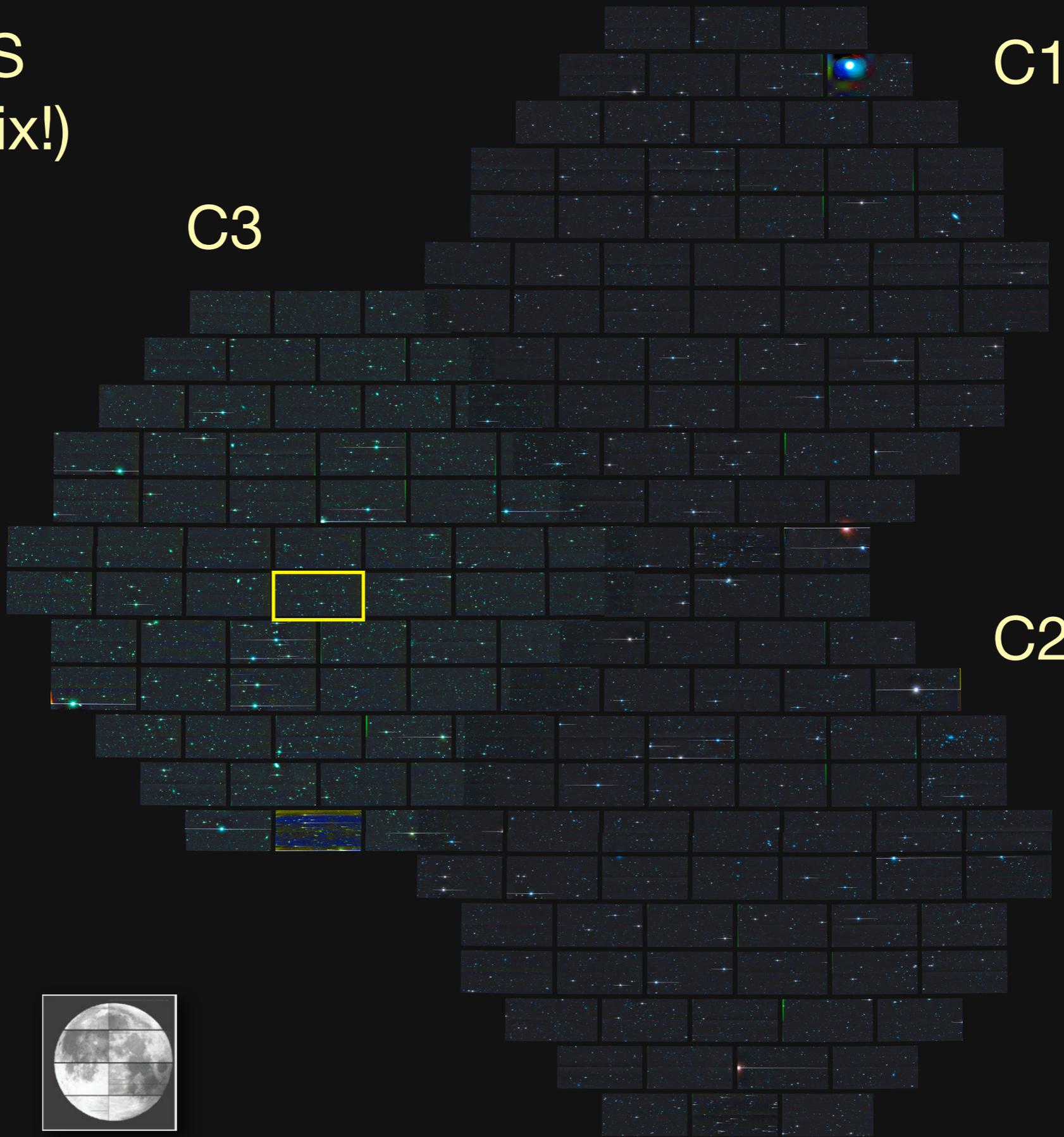
## Two-tiered SN Survey

### Goals

- \* **2500 SN Ia** with good light curve color and shape measurements.
  - \* e.g., *r-i* & *i-z* at  $z \sim 1.0$
- \* Live spectroscopy of  $\sim 20\%$  of SN Ia candidates + all  $r < 24$  SN hosts.
  - \* AAT, Gemini, GTC, Keck, Magellan, MMT, SALT, VLT
- \*  $\sim 1\%$  photometric calibration



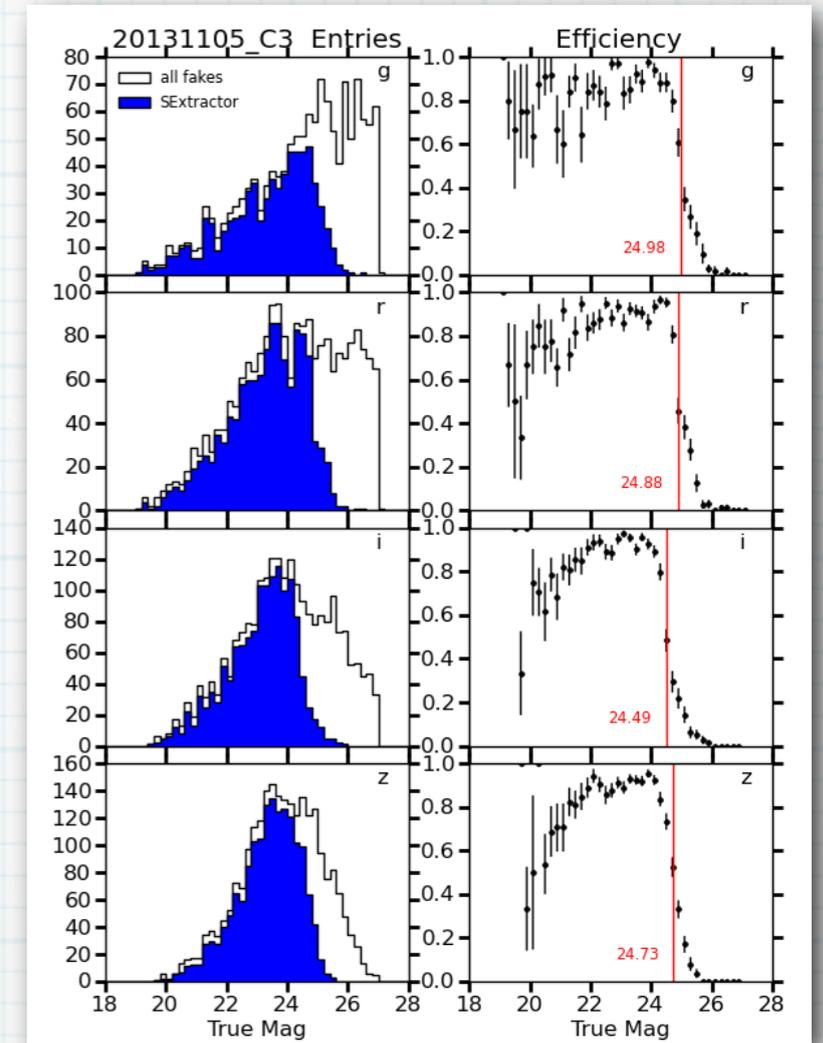
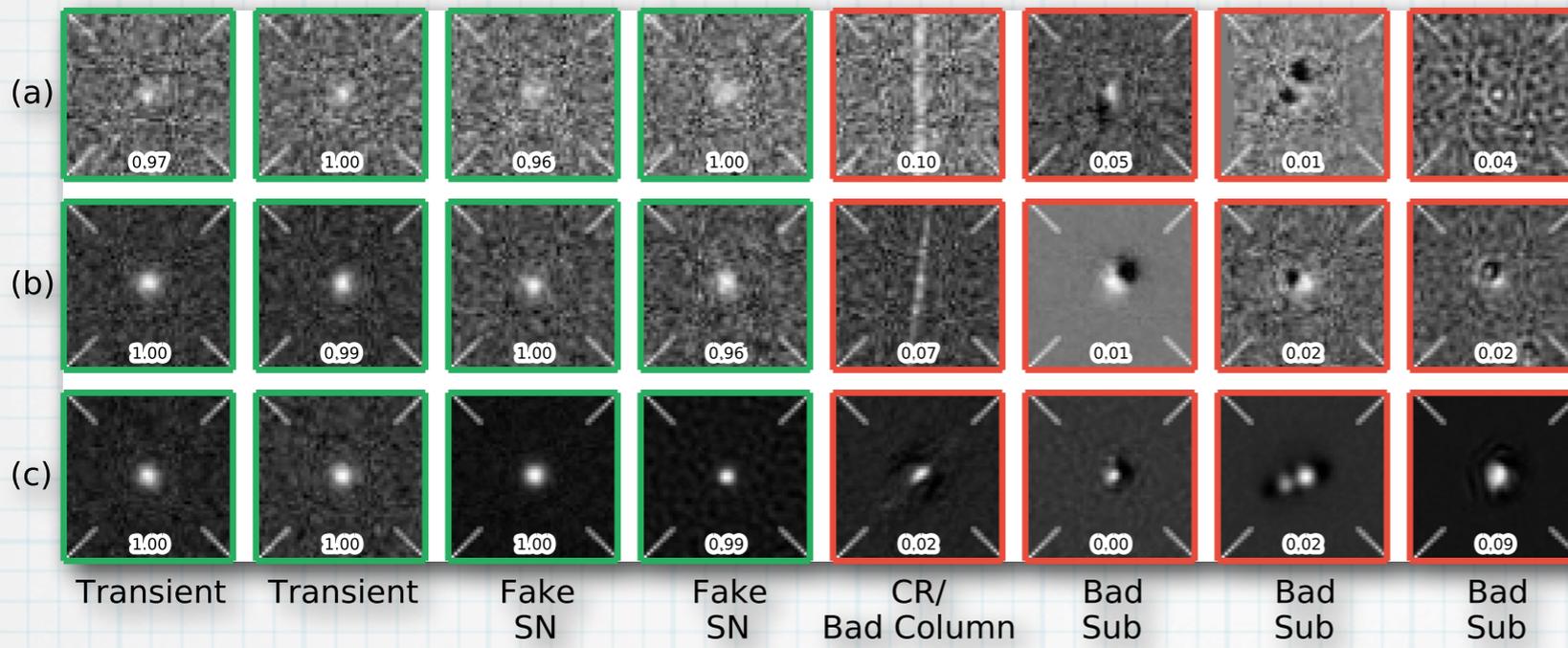
CDF-S  
(1.5 Gpix!)



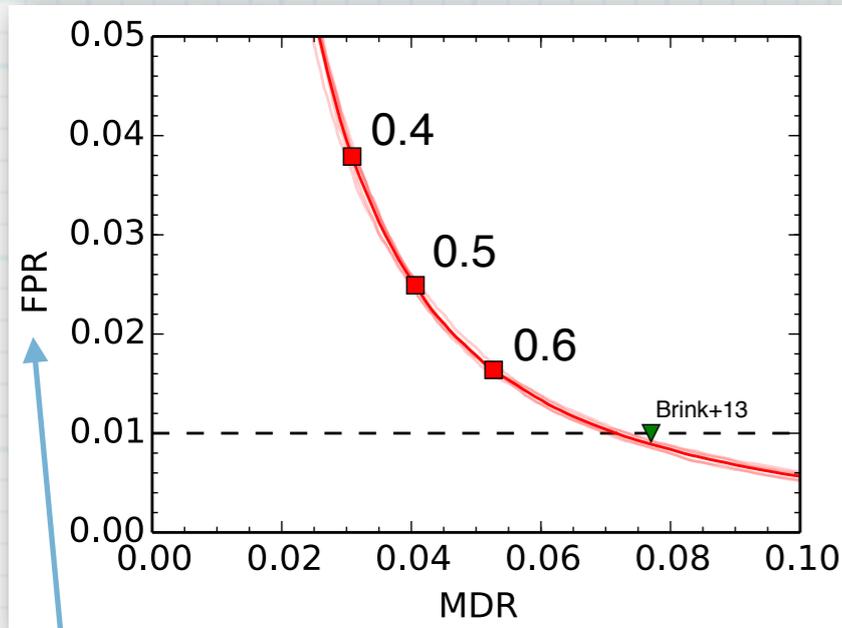
# Deep stack of single CCD



$r_{\text{lim}} \sim 27$



### Machine Learning Classifier



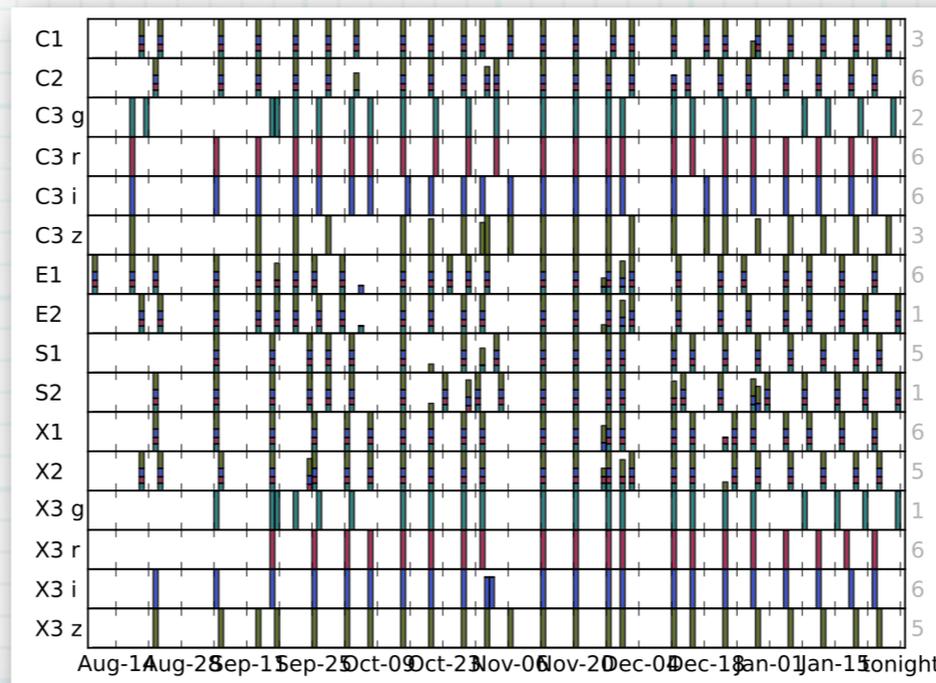
false positive rate

missed detection rate

Goldstein et al. (2015)

### Monitoring fake SN (deep)

### cadence monitor



Kessler et al. (2015)

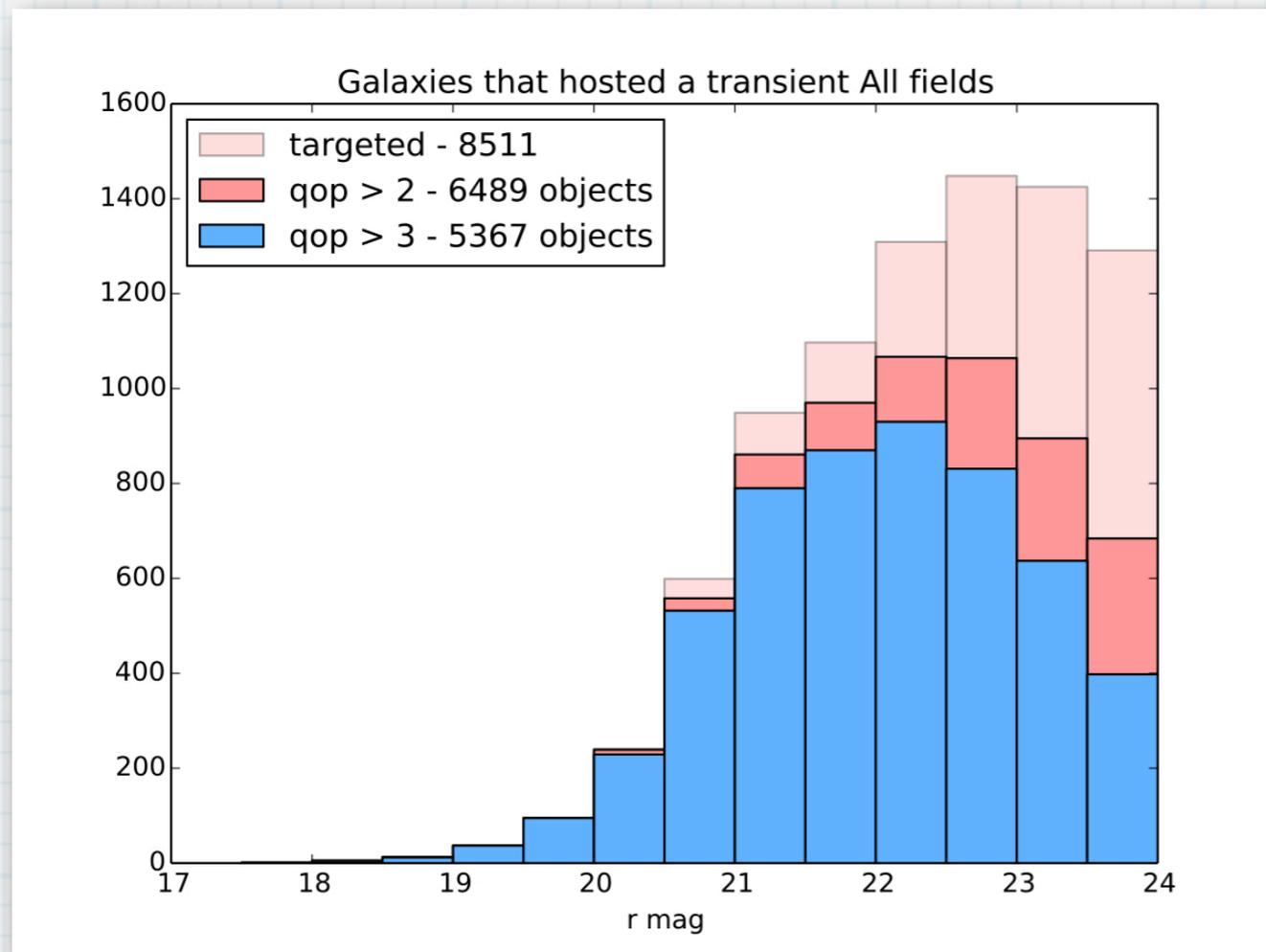
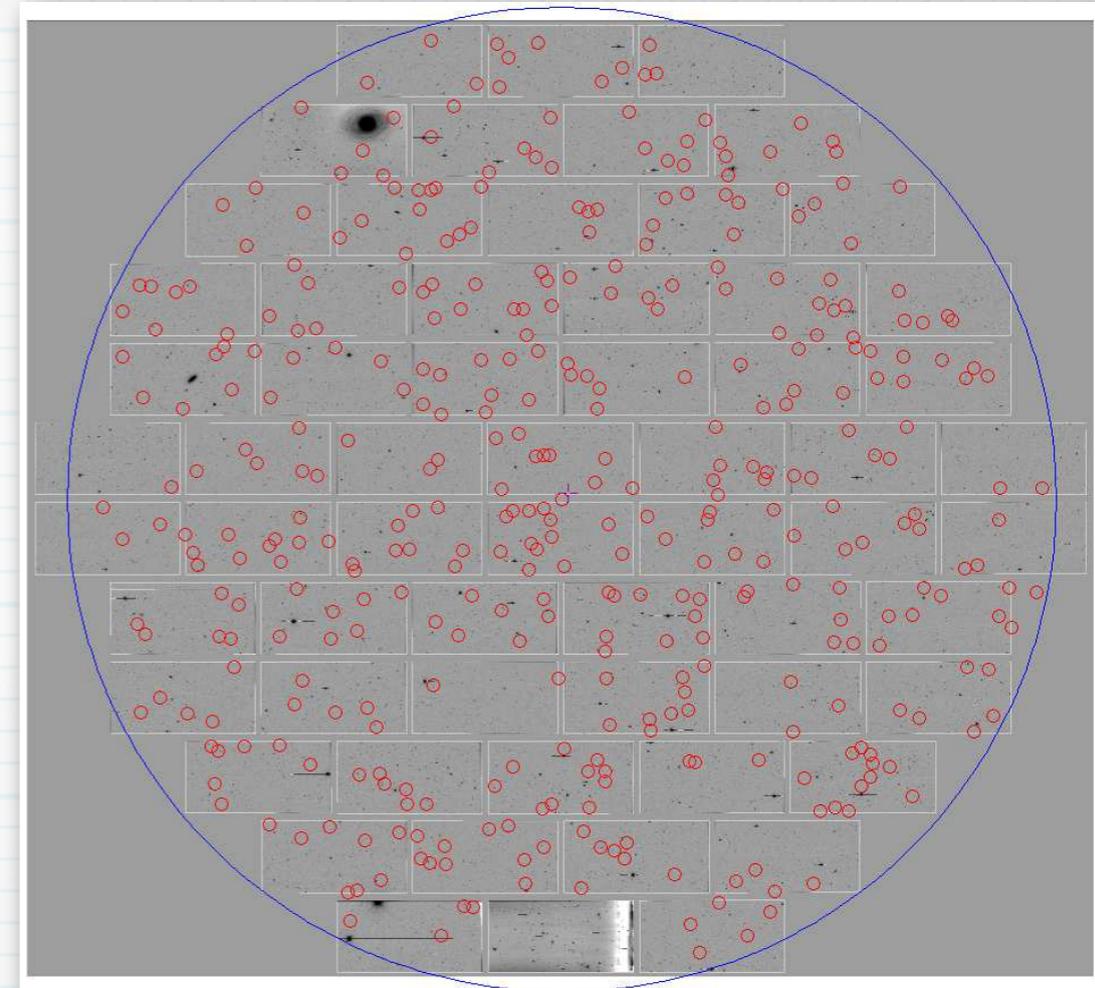
### Results

- 30,000 new variables/persistent transients
- 5,000 SN candidates

# OzDES Collaboration



- 100 nights on AAT over 5 years
- 392 fibers and 3 deg<sup>2</sup> FoV
- Targeting live SN, hosts of SN candidates, quasars, WD, and other galaxies.
- All transients  $r < 21$
- Hosts - stacking of multiple 2-hour exposures



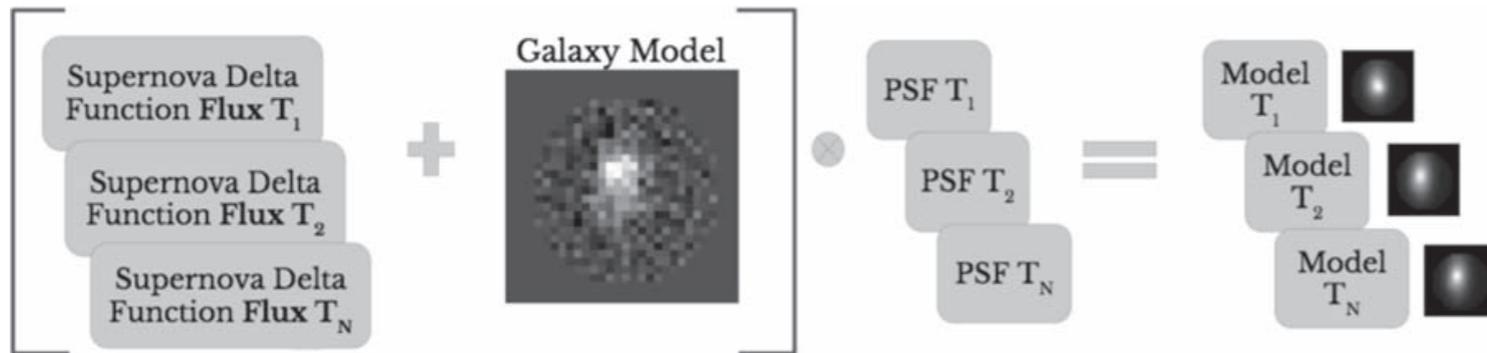
## AAT/AAOmega



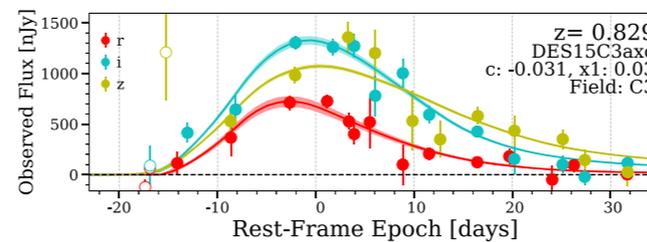
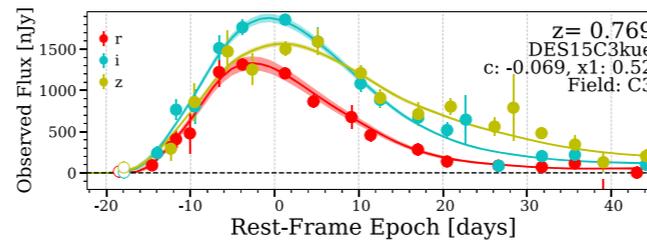
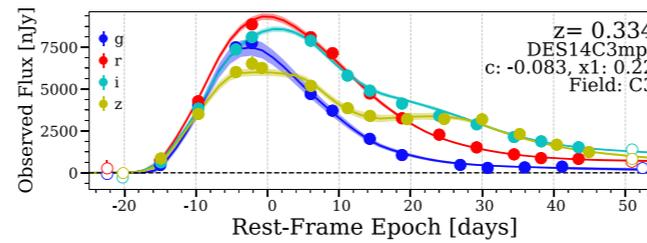
From C. Lidman

© Australian Astronomical Observatory

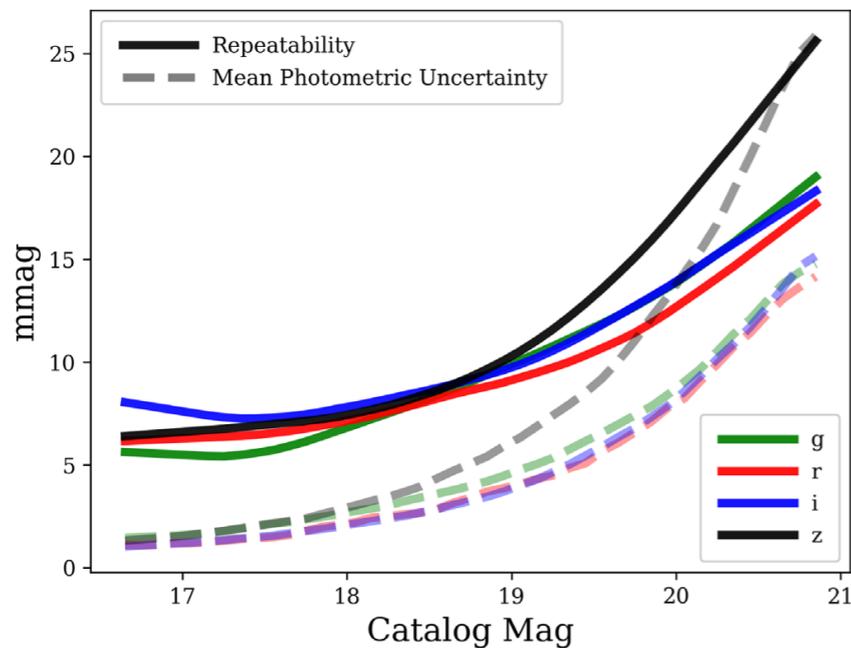
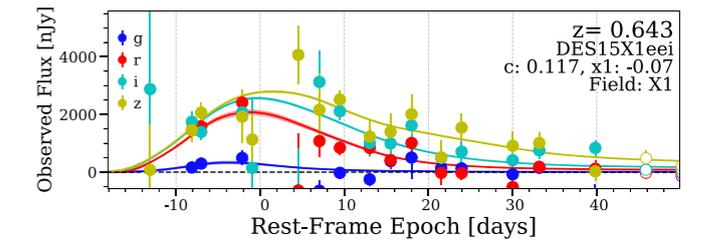
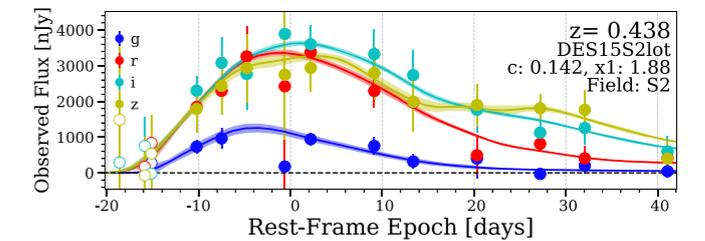
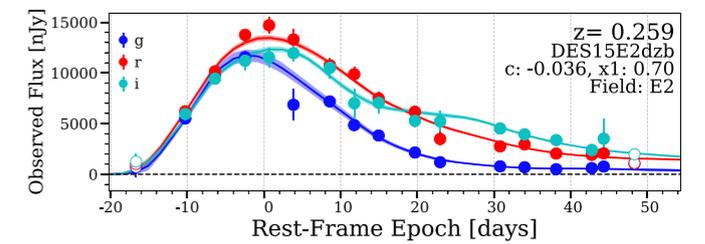
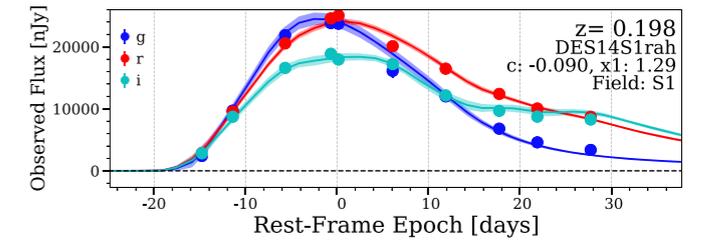
# Scene Modeling Photometry



Deep



Shallow

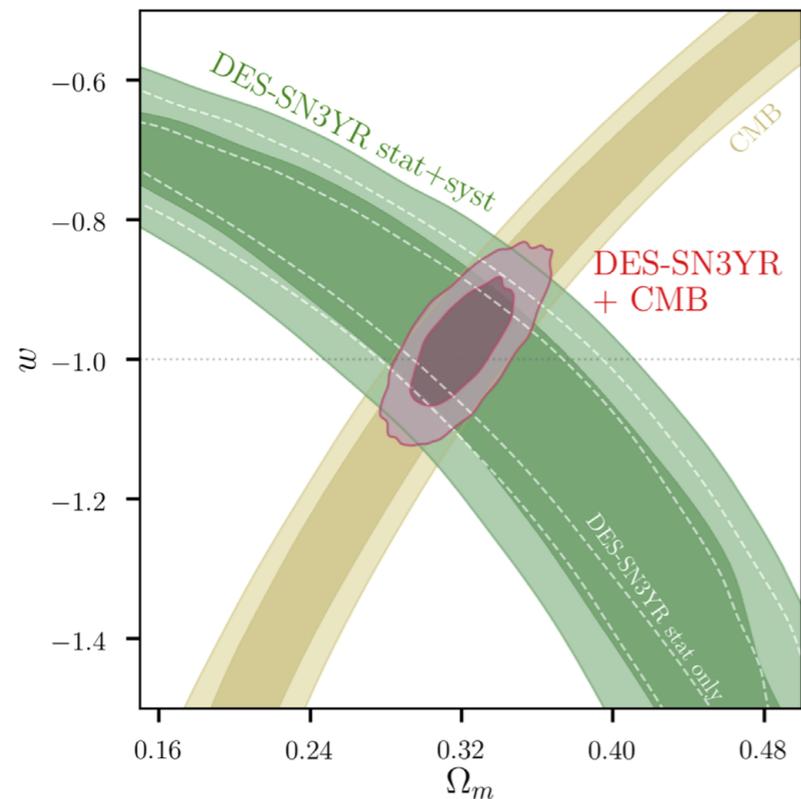
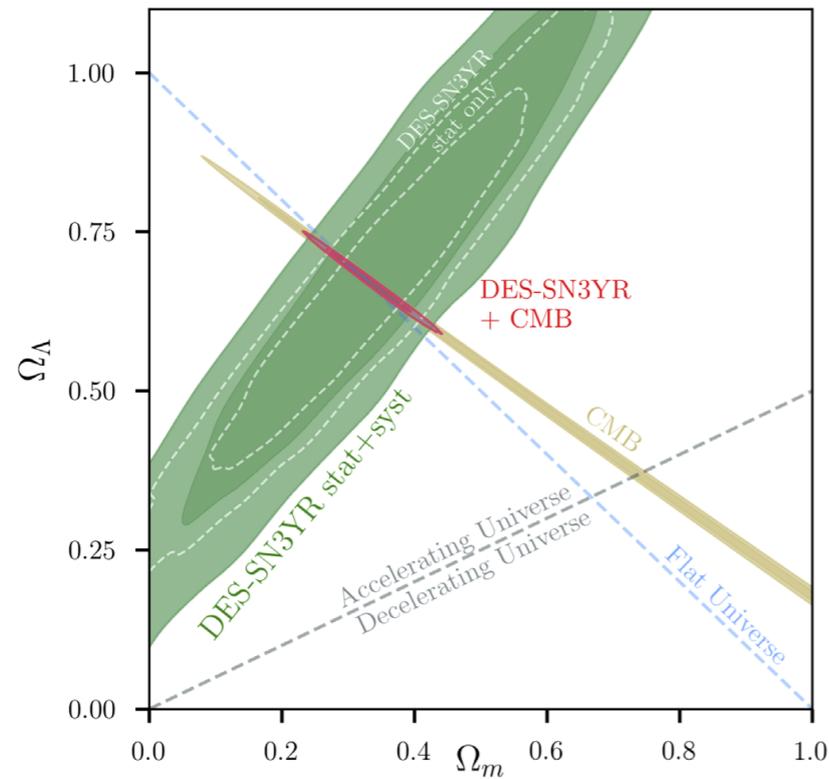


Z

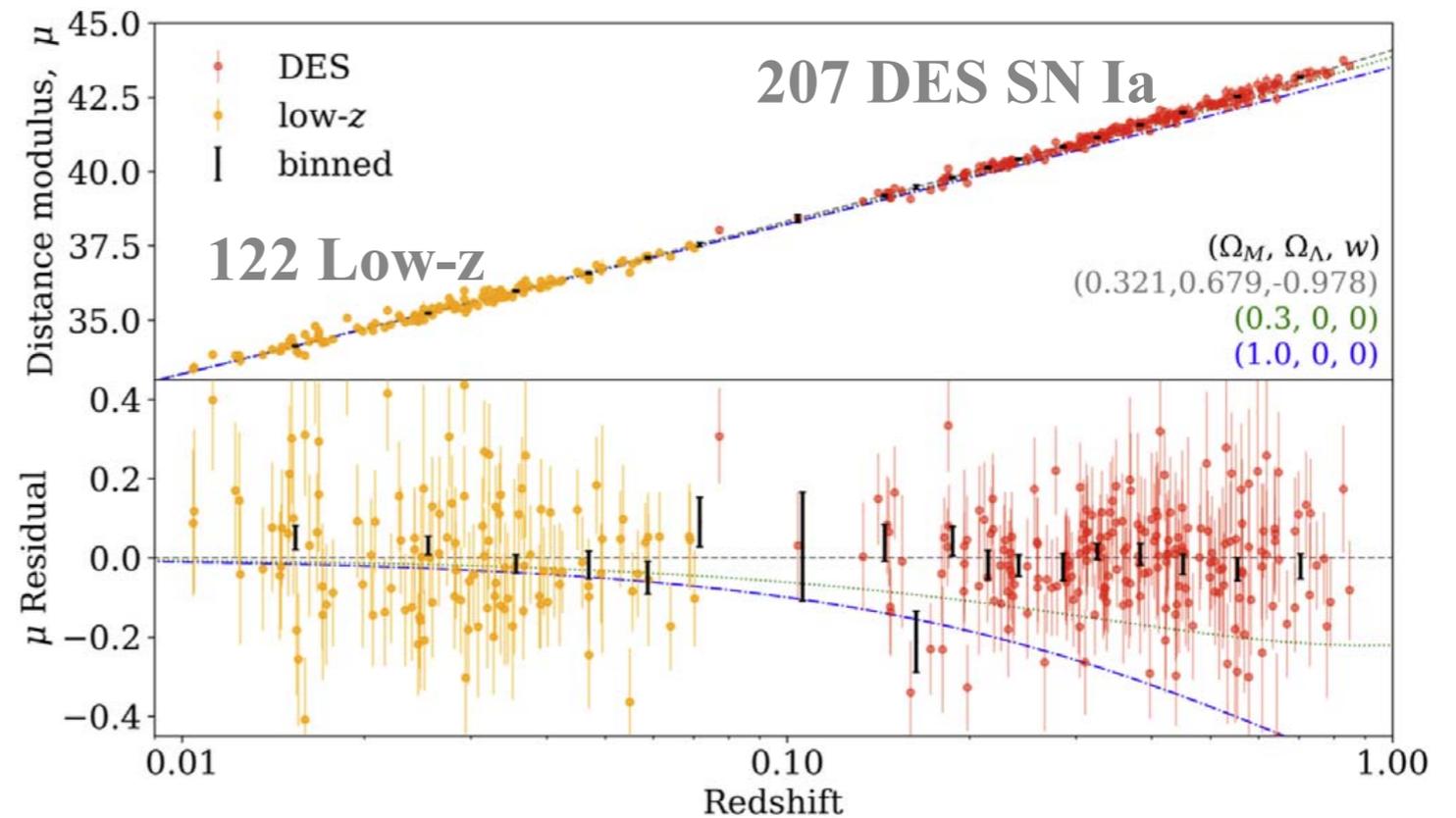
Brout et al. (2018)

# DES 3-Year Spectroscopic SN Ia (DESY3)

Abbott et al. (2018)



(Brout et al. 2018a, 2018b; D'Andrea et al. 2018; Kessler et al. 2018, Lasker et al. 2018; Macaulay et al. 2018; Smith et al. 2019)



$$w_0 = -0.885 \pm 0.114$$

$$w_a = -0.387 \pm 0.430$$

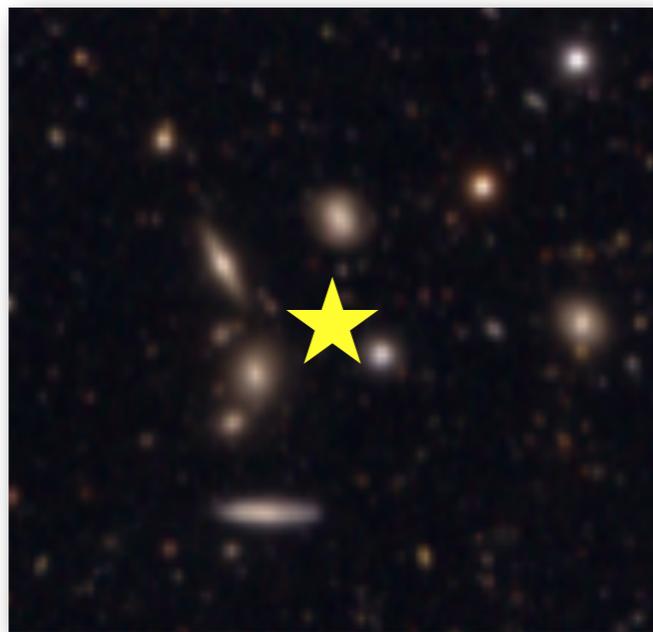
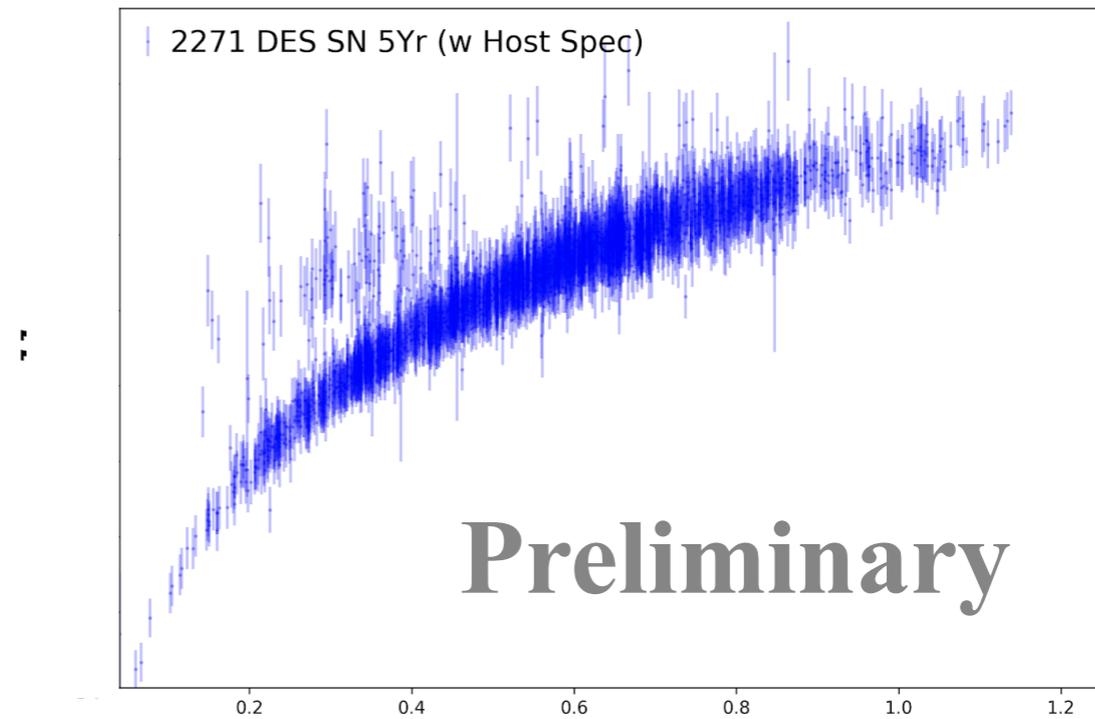
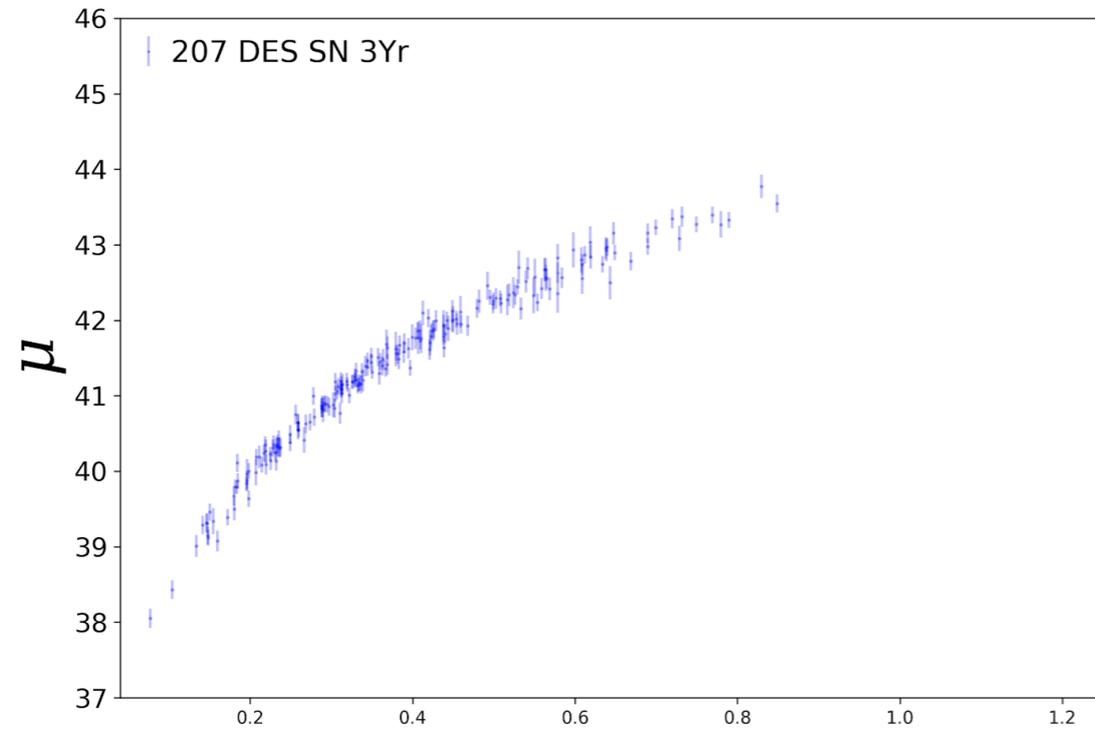
329 DESY3

$$w_0 = -1.007 \pm 0.089$$

$$w_a = -0.222 \pm 0.407$$

1048 Pantheon

# DES 5-Year photometric SN Ia



## 2 types of contamination

- non SN Ia ( $\sim 3\%$ )
- misidentified host galaxies ( $\sim 3\%$ )