THE DARK ENERGY SURVEY

Preliminary Spectroscopic SNeIa 3-Year Cosmology Results

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On behalf of the DES Supernova Working Group

DECam Community Science Workshop - May 21st, 2018

Penn
University of Pennsylvania

Fermilab

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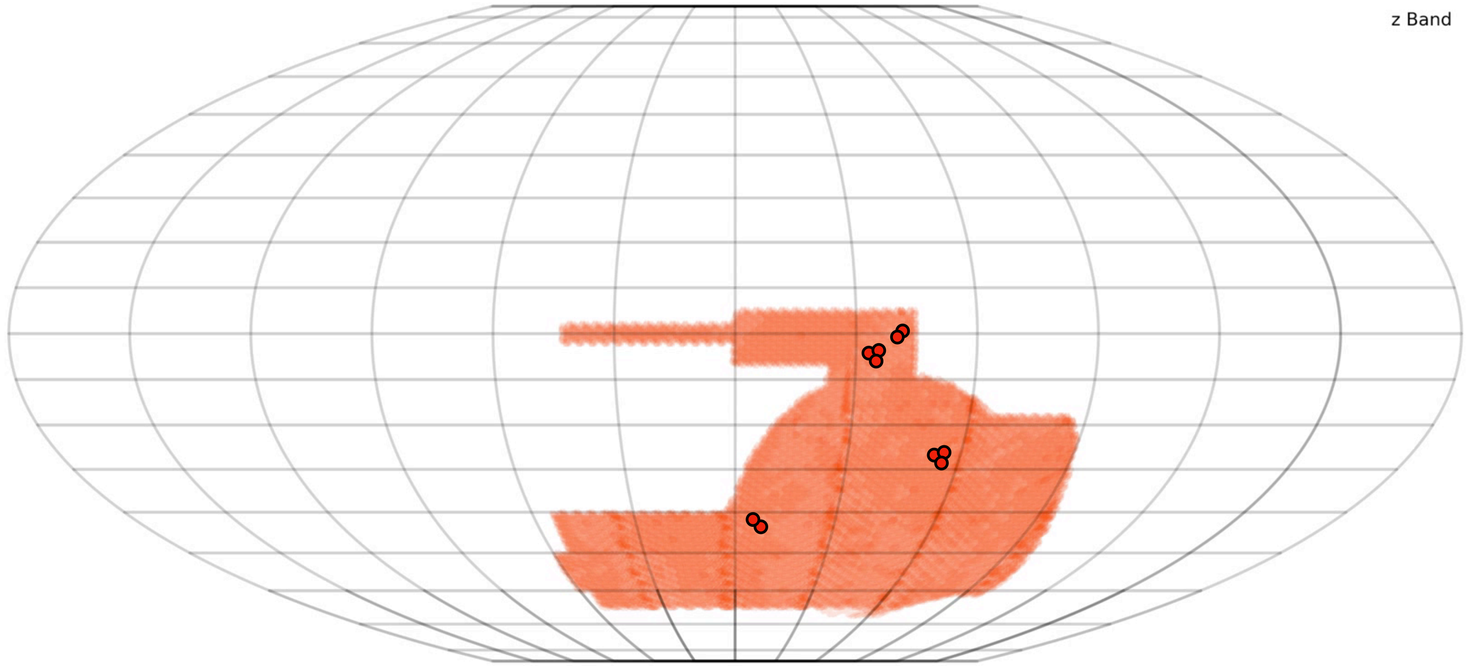
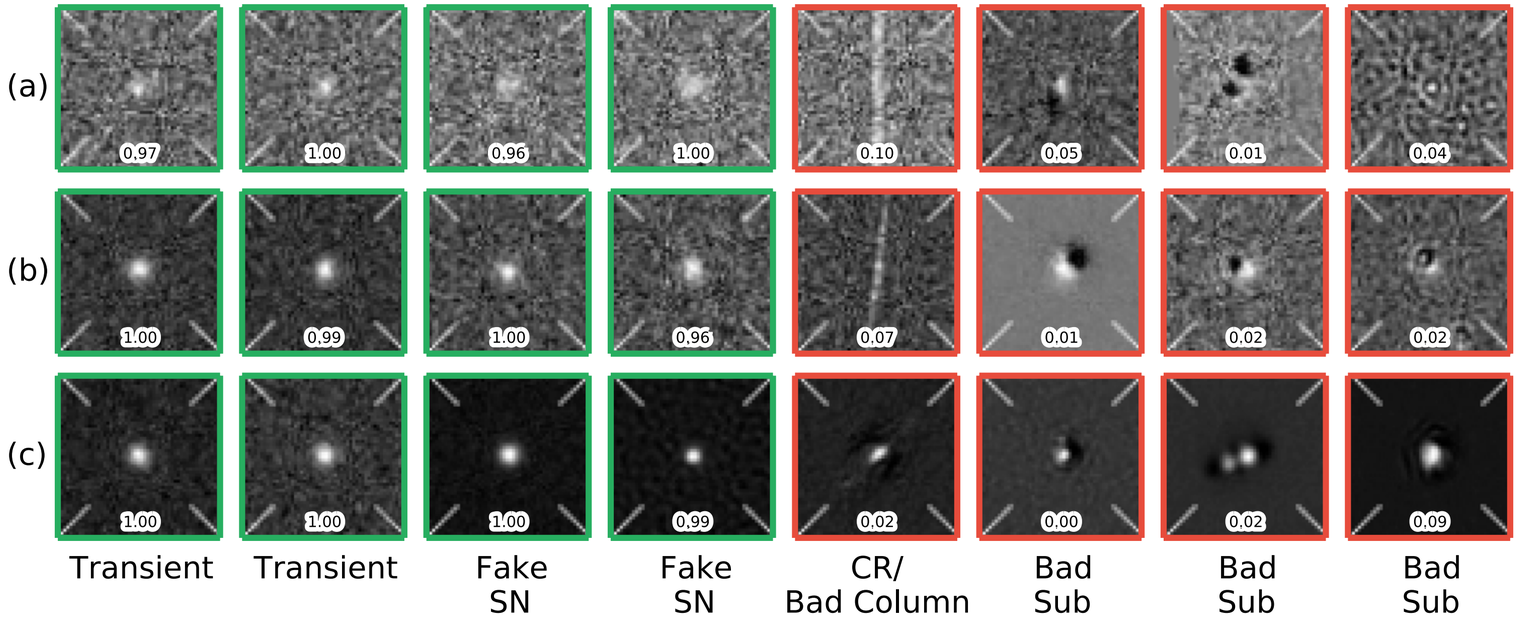


	area (deg^2)	visits (per filter)	filters	exposure time in sec (per visit)	Depth
SN shallow	22	125	*griz*	175/150/200/400	23.5
SN deep	5	125	*griz*	600/1200/1800/3630	24.5

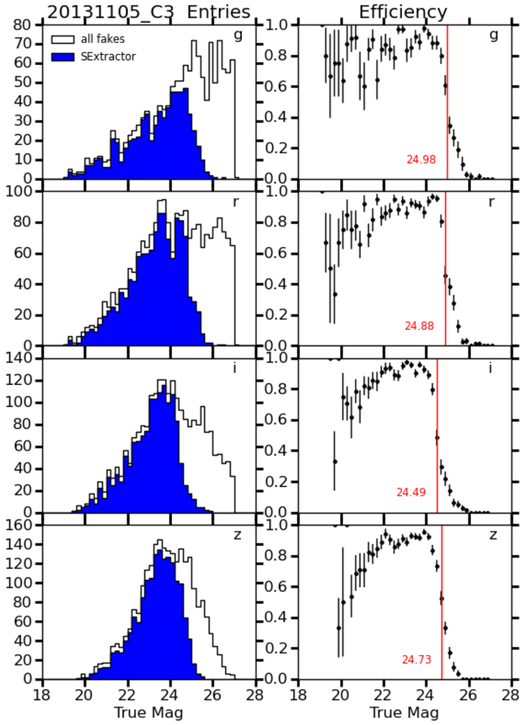
Automated Supernova Survey Monitoring

Machine learning to filter junk detections.
~200-500 detections per visit; only ~4% artifacts!



Goldstein et al. (2015)

Realtime monitoring system with fake SN



Kessler et al. (2015)

+ Realtime difference imaging (a few hours)

The DES-SN Survey

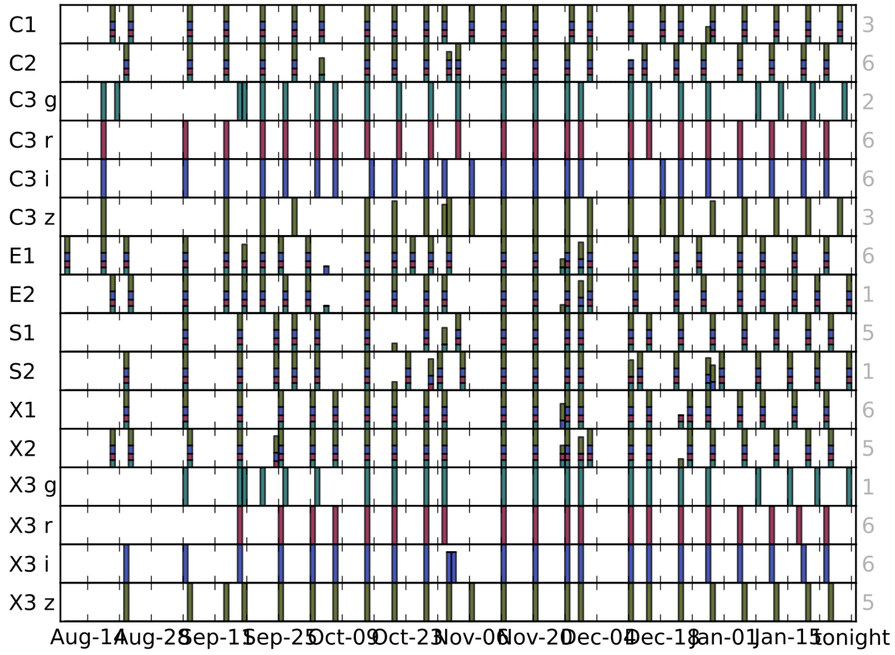
DES-SN “discovered” **~15,000** Likely Supernovae

~2000 High quality photometrically classified Type Ia SNe from $0.1 < z < 1.2$ over all 5 years (all with host spectroscopy)

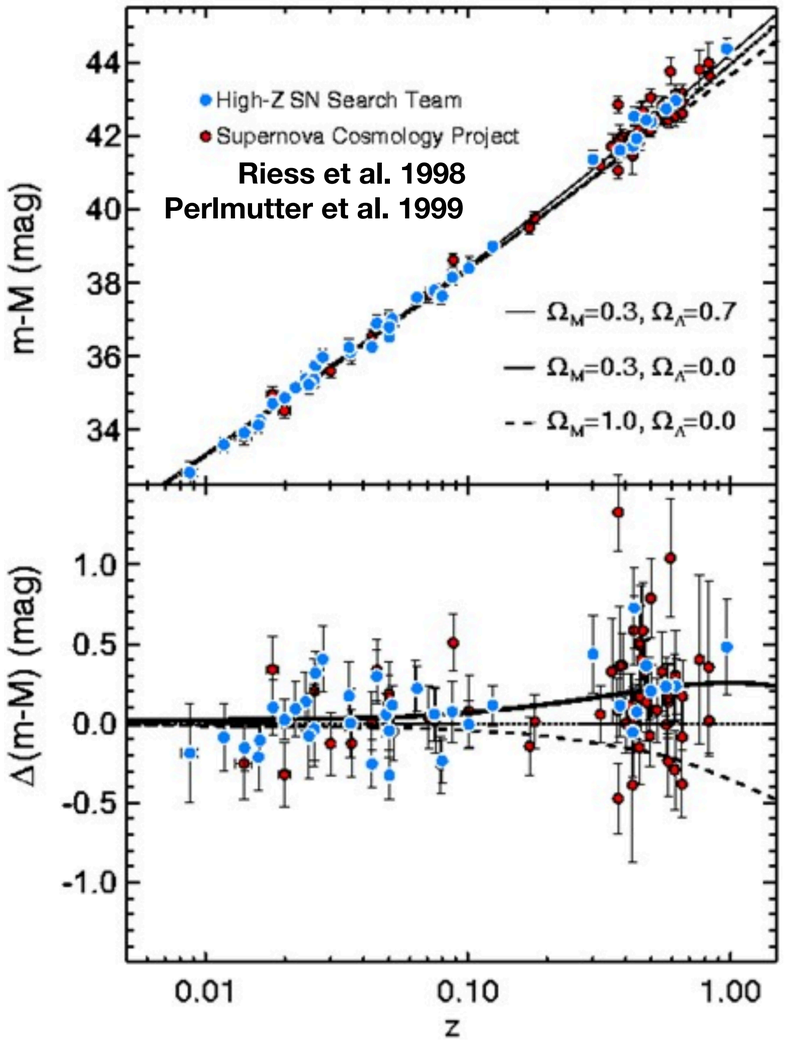
~500 Spectroscopically confirmed Type Ia Supernovae over all 5 years. (**251** in first 3 years)

Cadence Monitor

mean cadence of ~7 days



The Landscape of Spec Supernova Surveys



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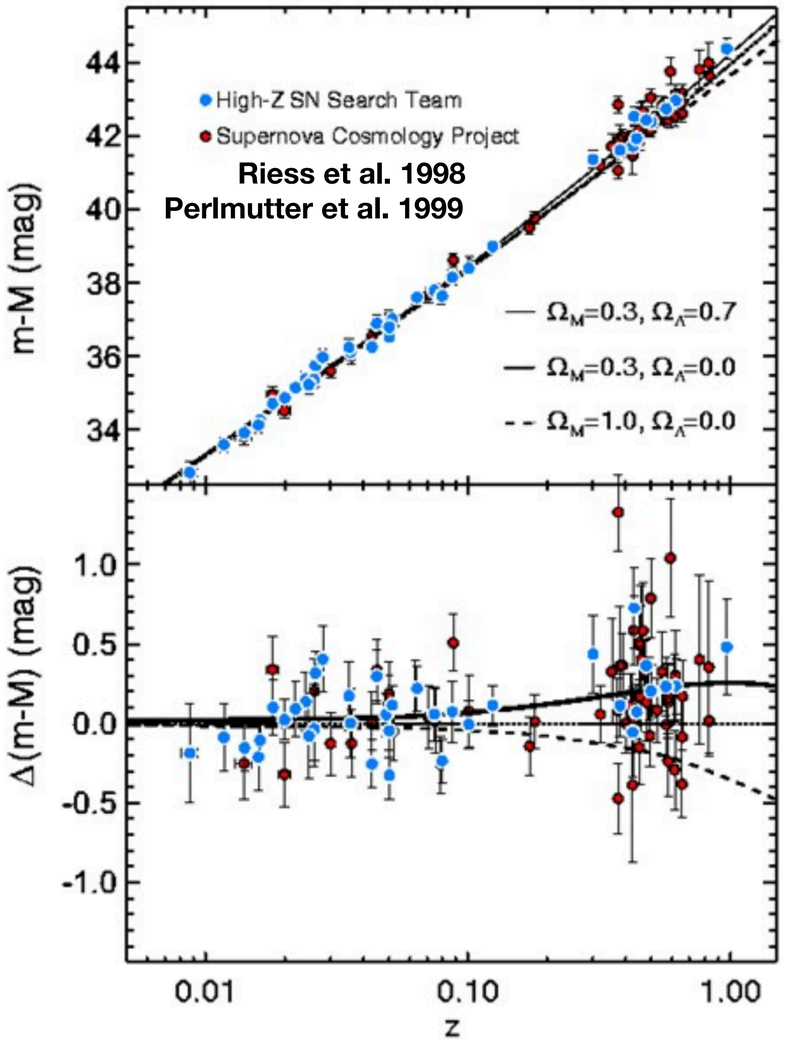
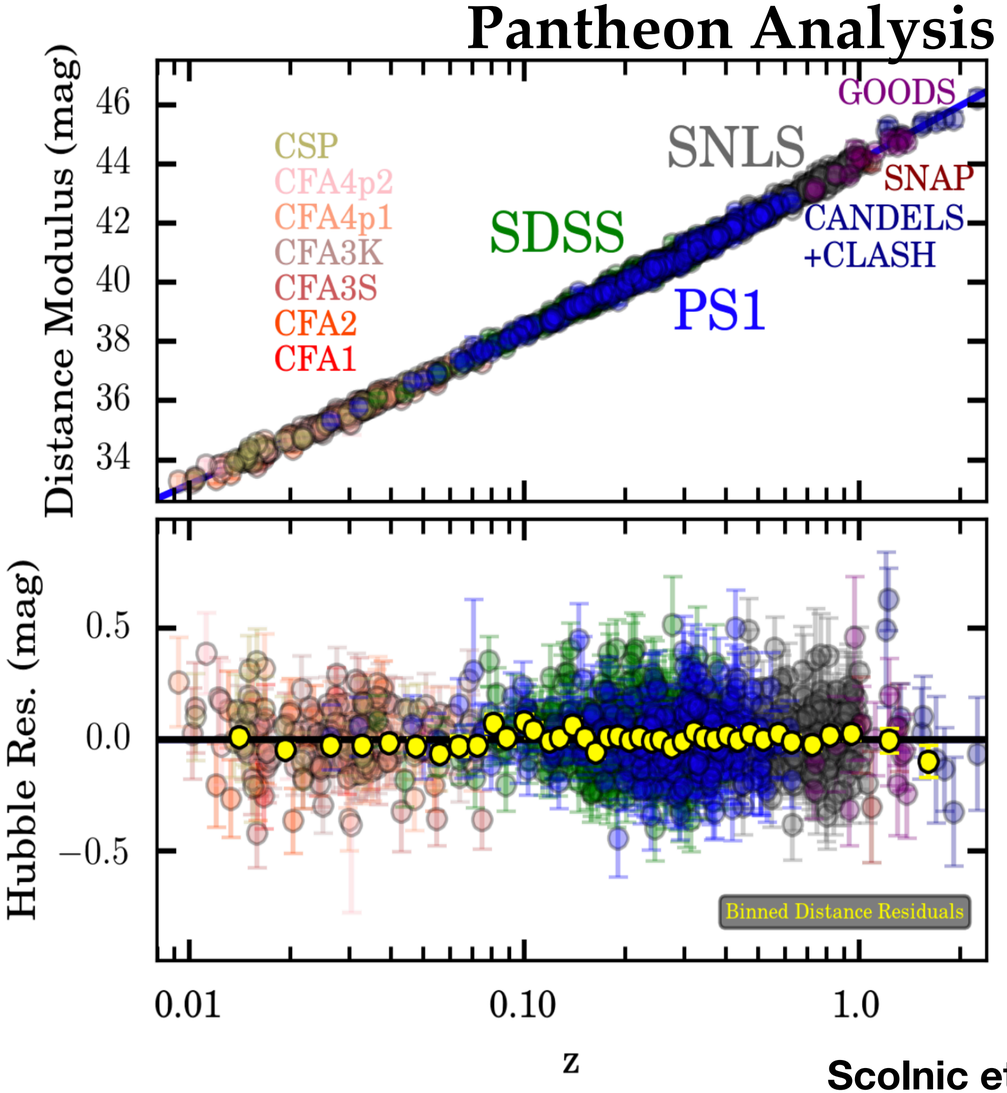
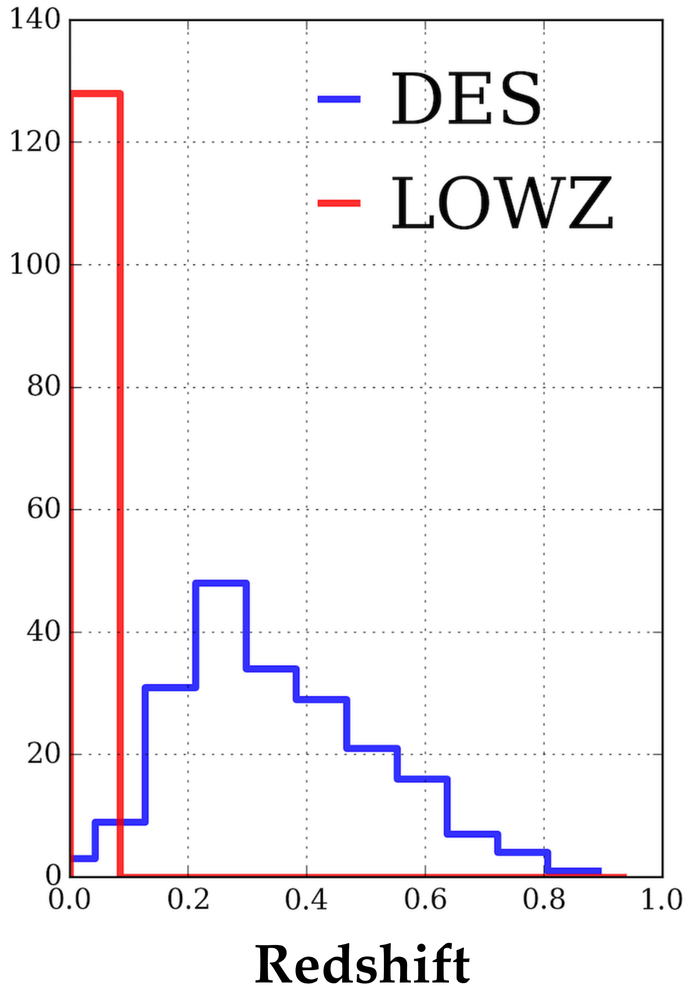




Scolnic et al. 2018

The DES 3YR Spec Ia Dataset

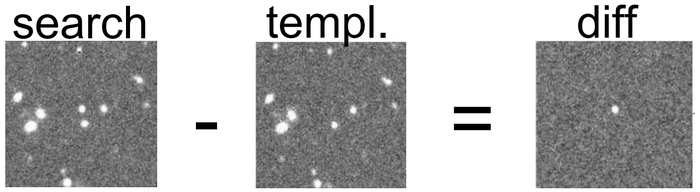
Source	Spec. Redshifts	#Spec Ia
DESSN (3yr Spec)	$0.02 < z < 0.85$	206 SNe after cuts
External LOWz (CFA,CSP)	$z < 0.10$	128 SNe after cuts



Ingredients for Supernova Cosmology

Difference Imaging

→ SNe Candidates



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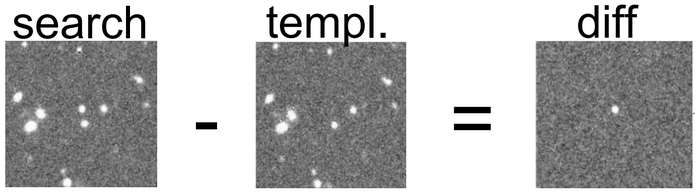

→ SNe Candidates

Spectra → Type & redshift

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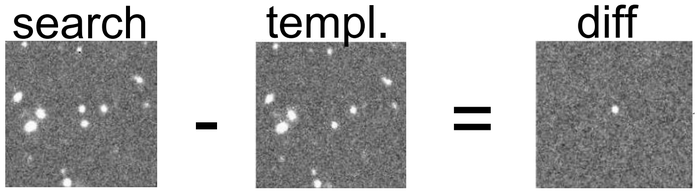

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Spectra → Type & redshift

Photometry → “Standardizable Candles”

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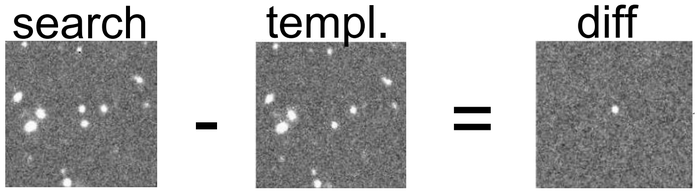

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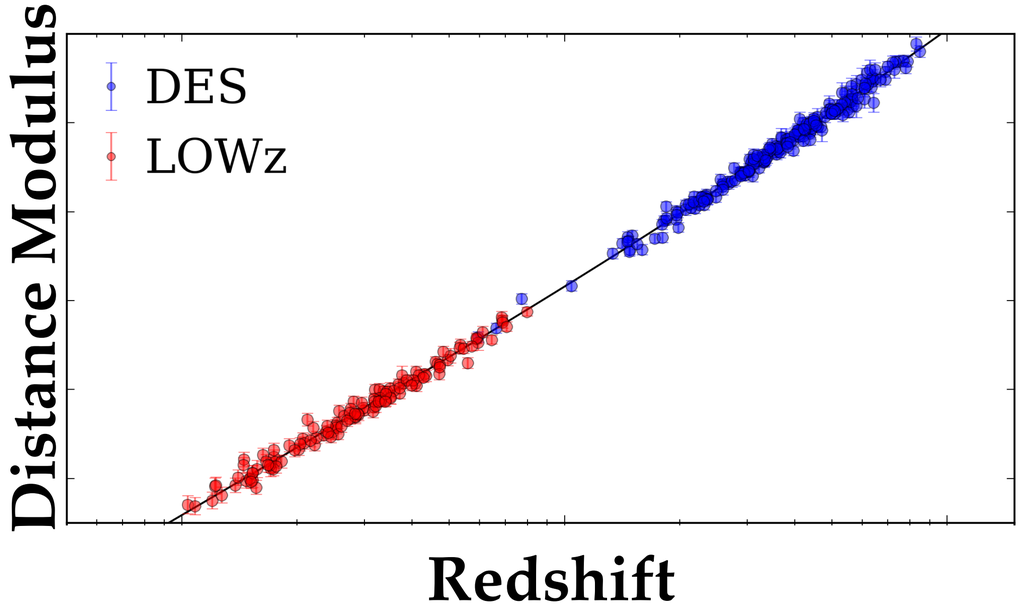

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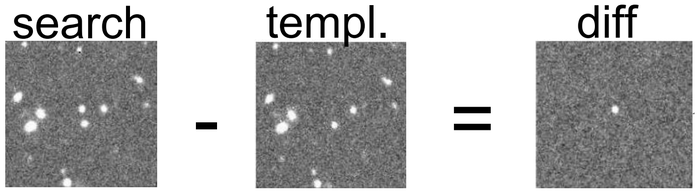

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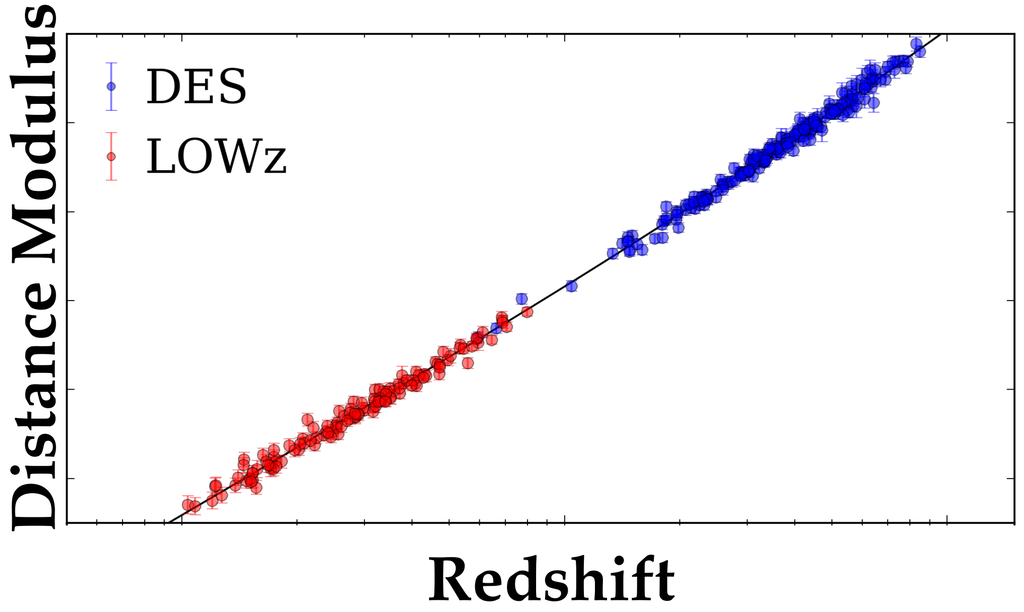
Calibration → Rel. Dist. btwn. All SNe



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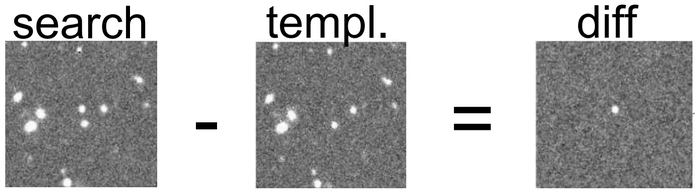

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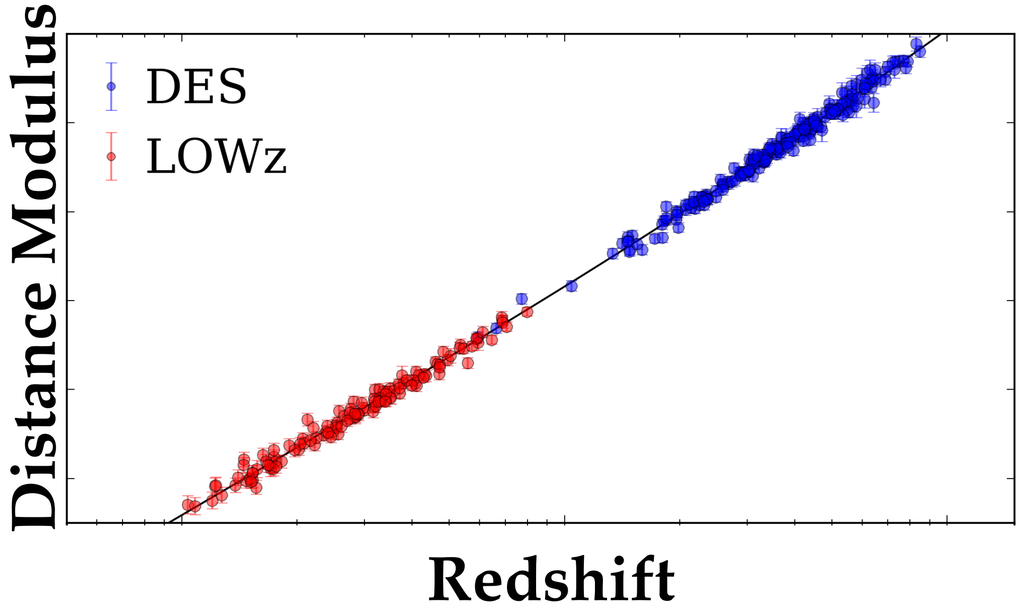

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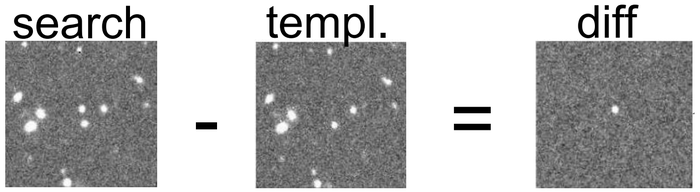

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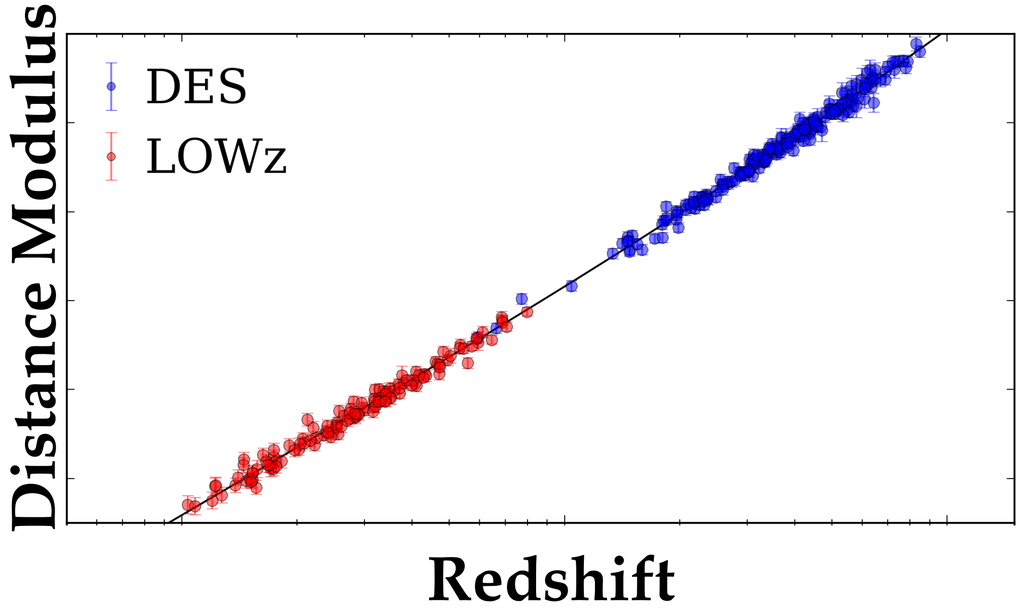

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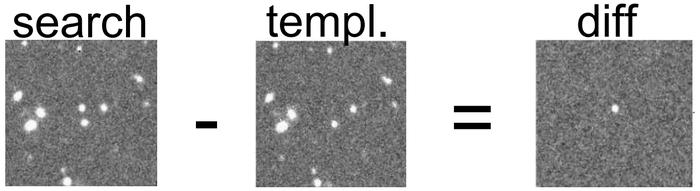

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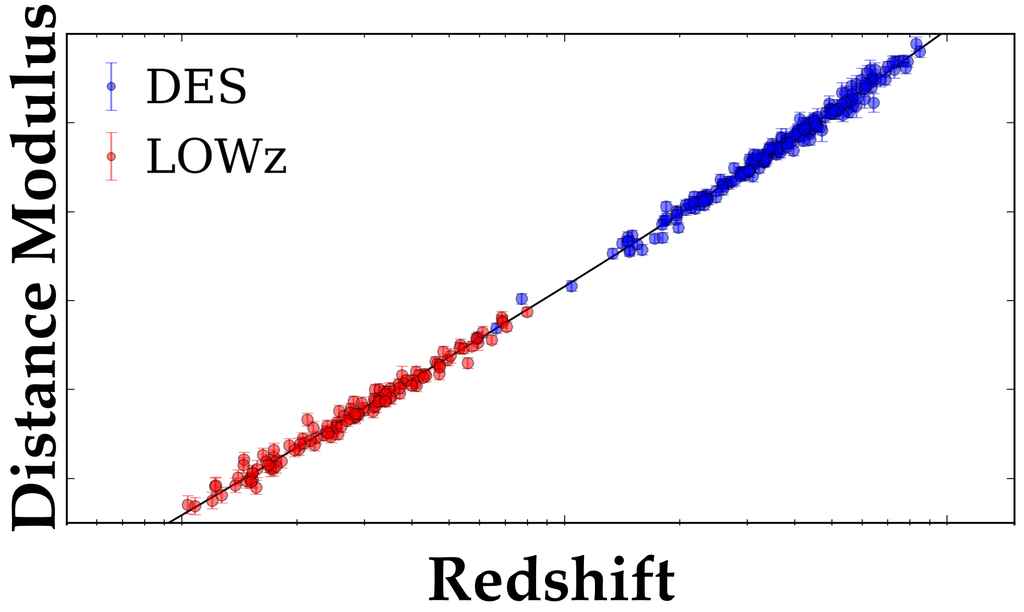
CosmoMC → wCDM fit with SNeIa + Planck 2015



Ingredients for Supernova Cosmology

Difference Imaging

search - templ. = diff

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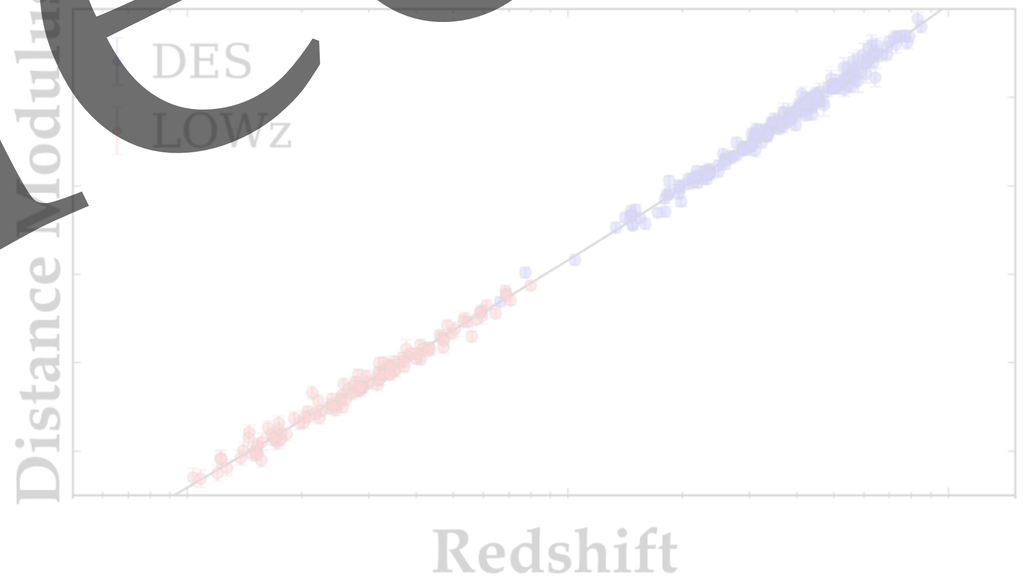

Blinded

How Does DES Stack Up?

σ_w (stat+sys)	#SNe	Analysis
0.054	740	JLA Spec (2014)
0.063	453	PS1+Lowz Spec (2018)
0.058	~1000	PS1+Lowz Phot (2017)
?	**334**	**DES3YR+Lowz Spec (2018)**

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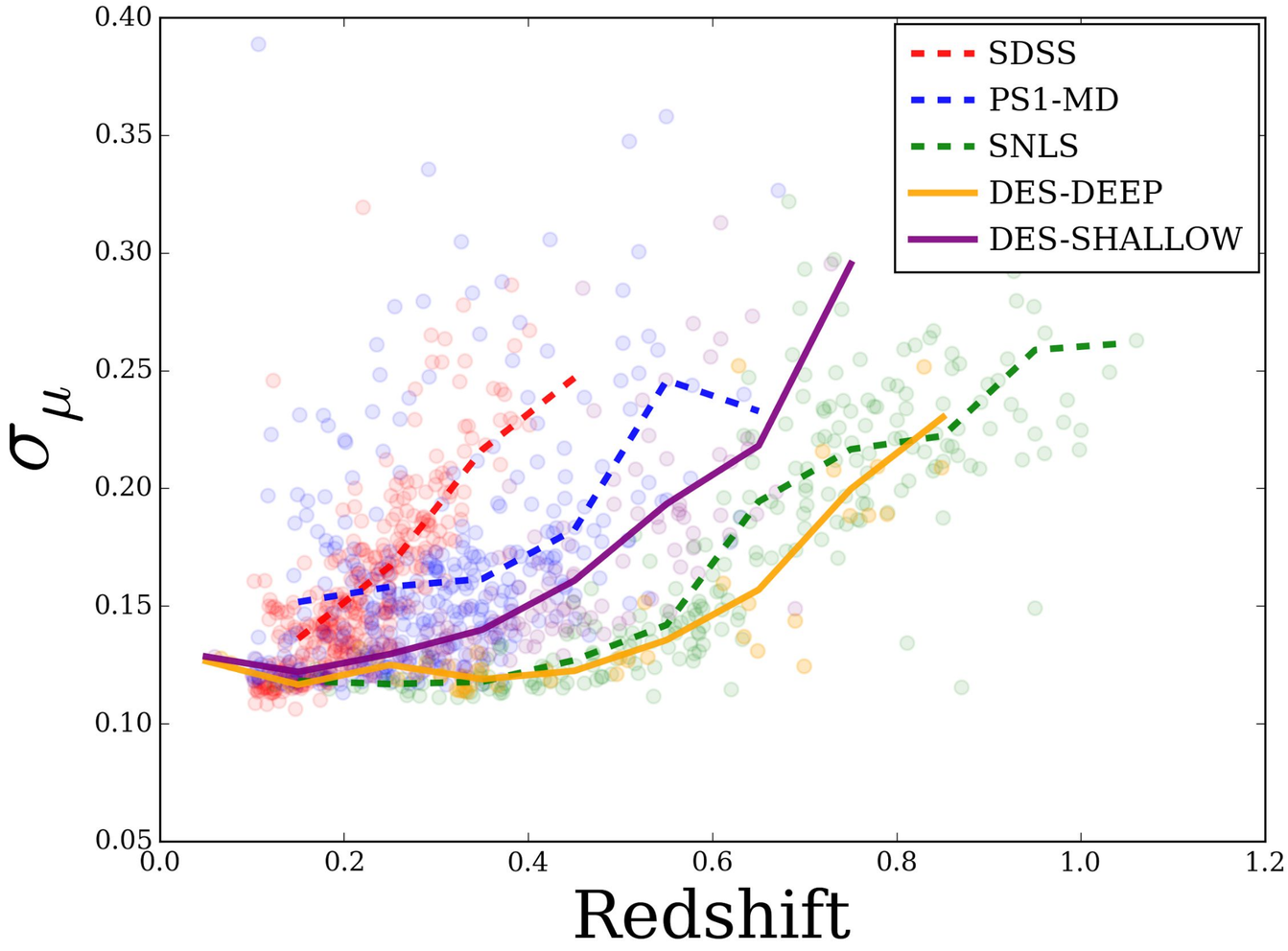


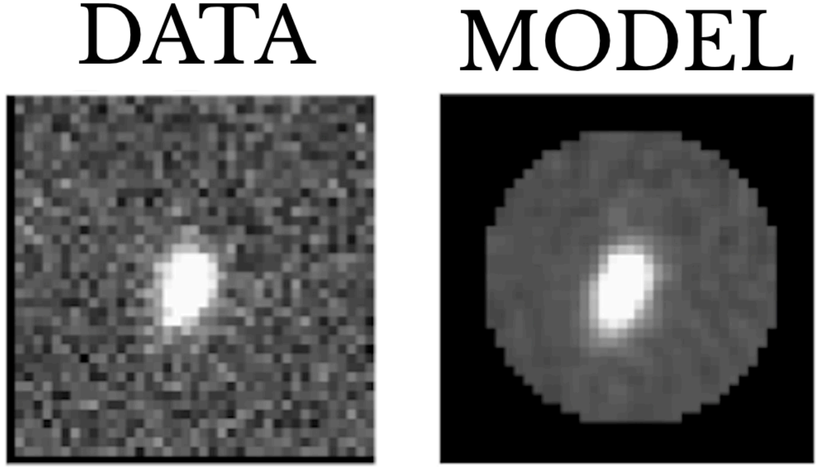
Precision Flux Measurements For Precision Distances

We forward model THE SCENE:

Environment

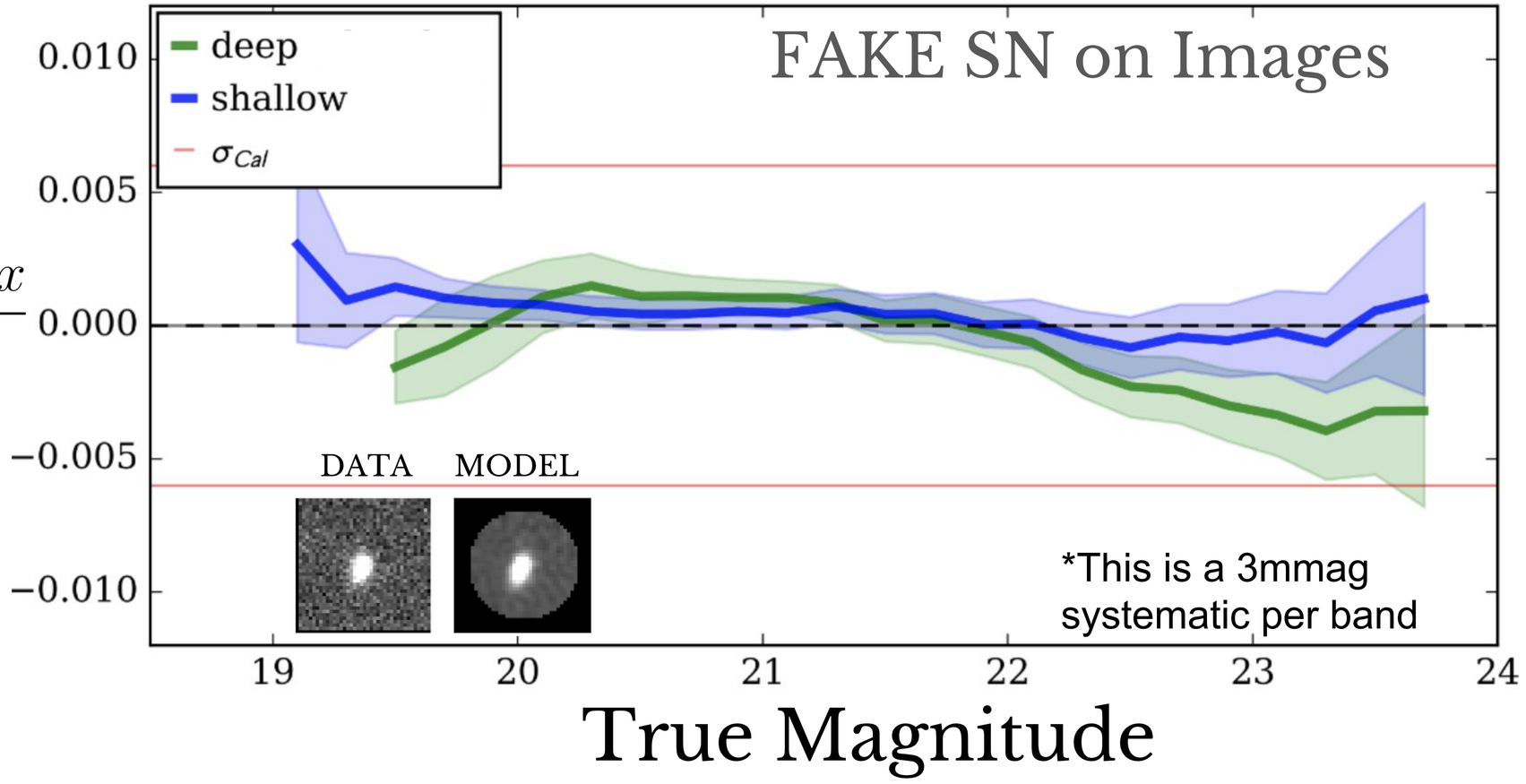
Supernova

Telescope + Atmosphere

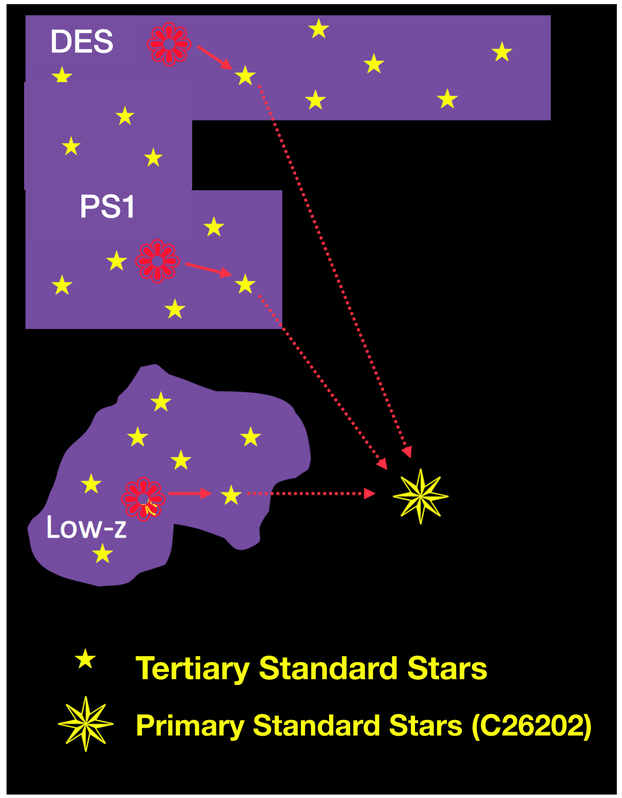


Our photometry is accurate and unbiased

$$\frac{FitFlux - TrueFlux}{TrueFlux}$$



Calibration is our largest systematic uncertainty



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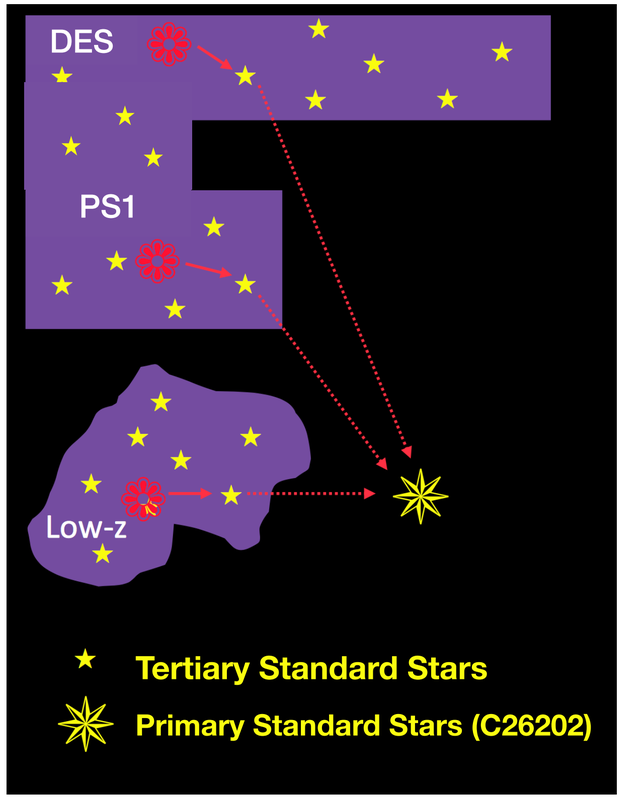


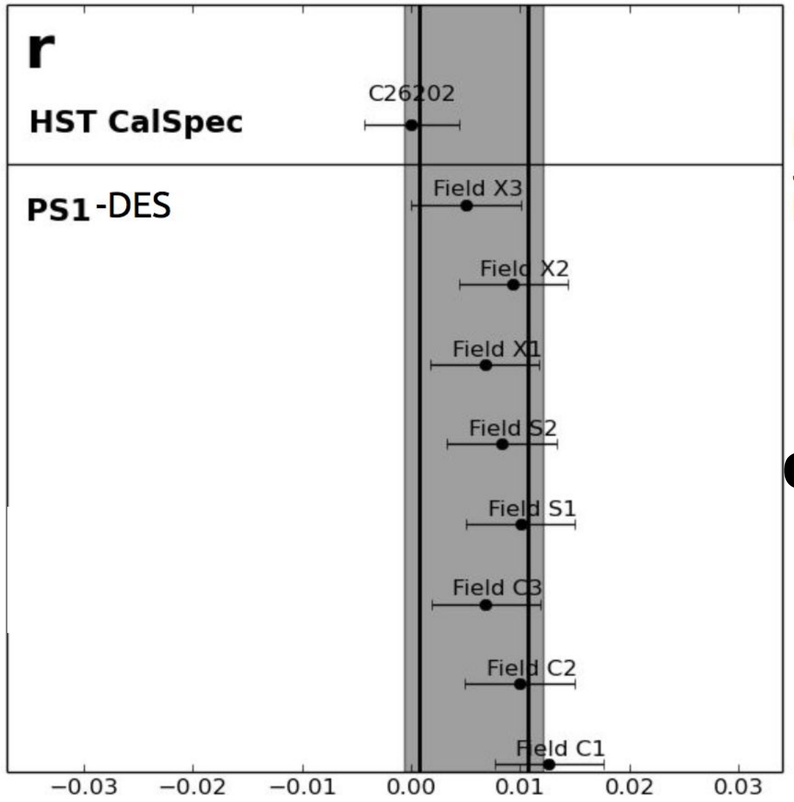
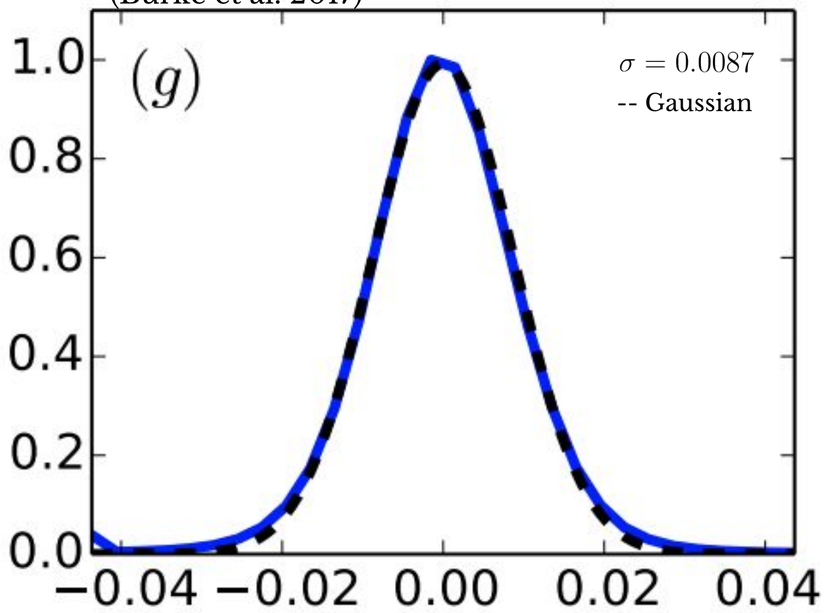


Figure: James Lasker

$\sigma = 0.6\%$

Calibration Consistency Check

(Burke et al. 2017)



Repeated Measurements of Thousands of HST Tertiary Standard Stars

$$\sigma_{cal} = \sqrt{\sigma^2 - \sigma^2_{phot}} = \mathbf{0.6\%}$$

Overview of Cosmology Fitting

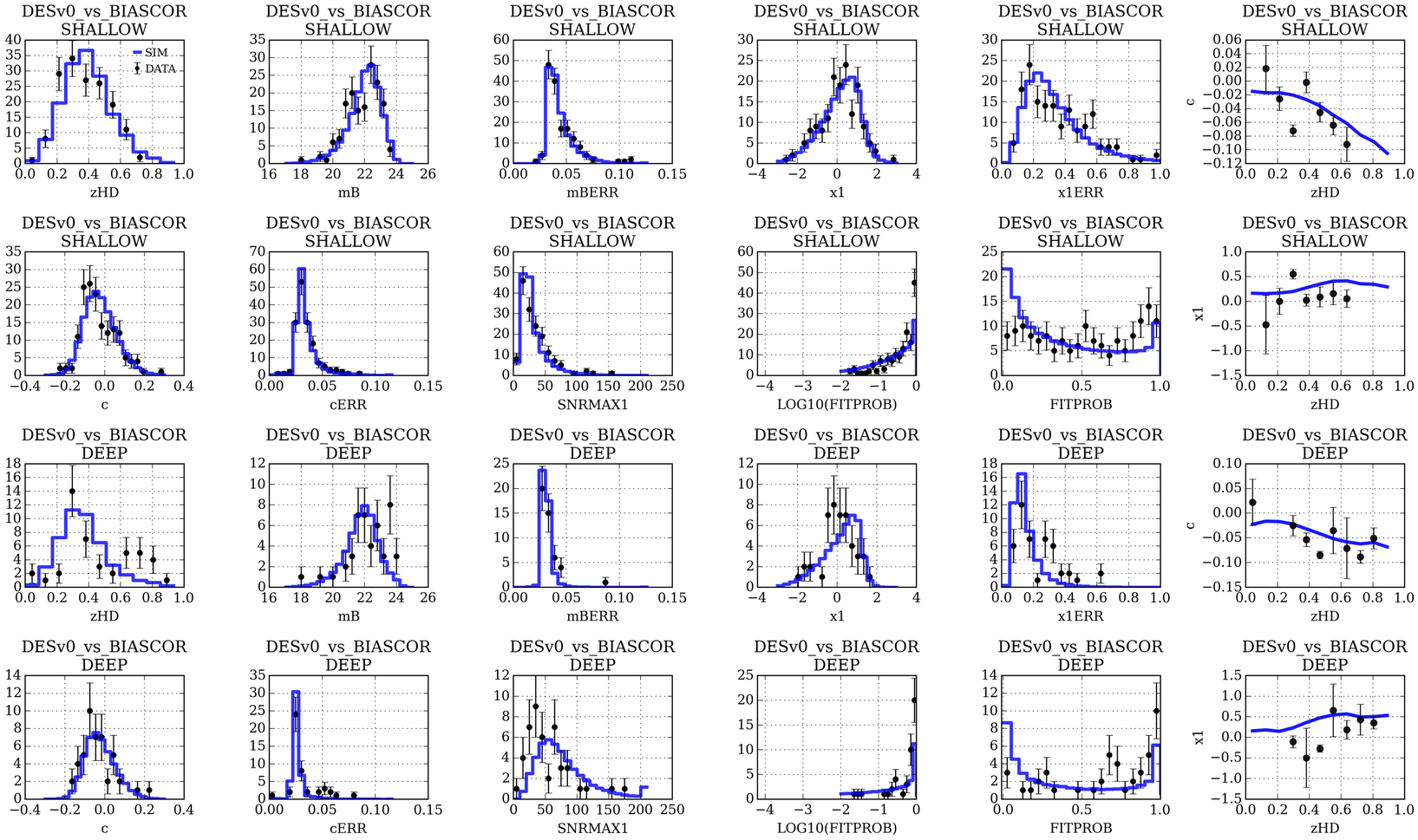
We use the BBC method to produce a bias-corrected Hubble diagram in log spaced z-bins along with nuisance parameters.

For each of 60 source of systematic uncertainty we re-derive a binned Hubble diagram.

Using all systematics we compute a binned covariance matrix.

—> CosmoMC cosmology fit

To predict biases, we need accurate simulations



Atmospheric Transmission

Peculiar Velocities

Lensing of Galaxies

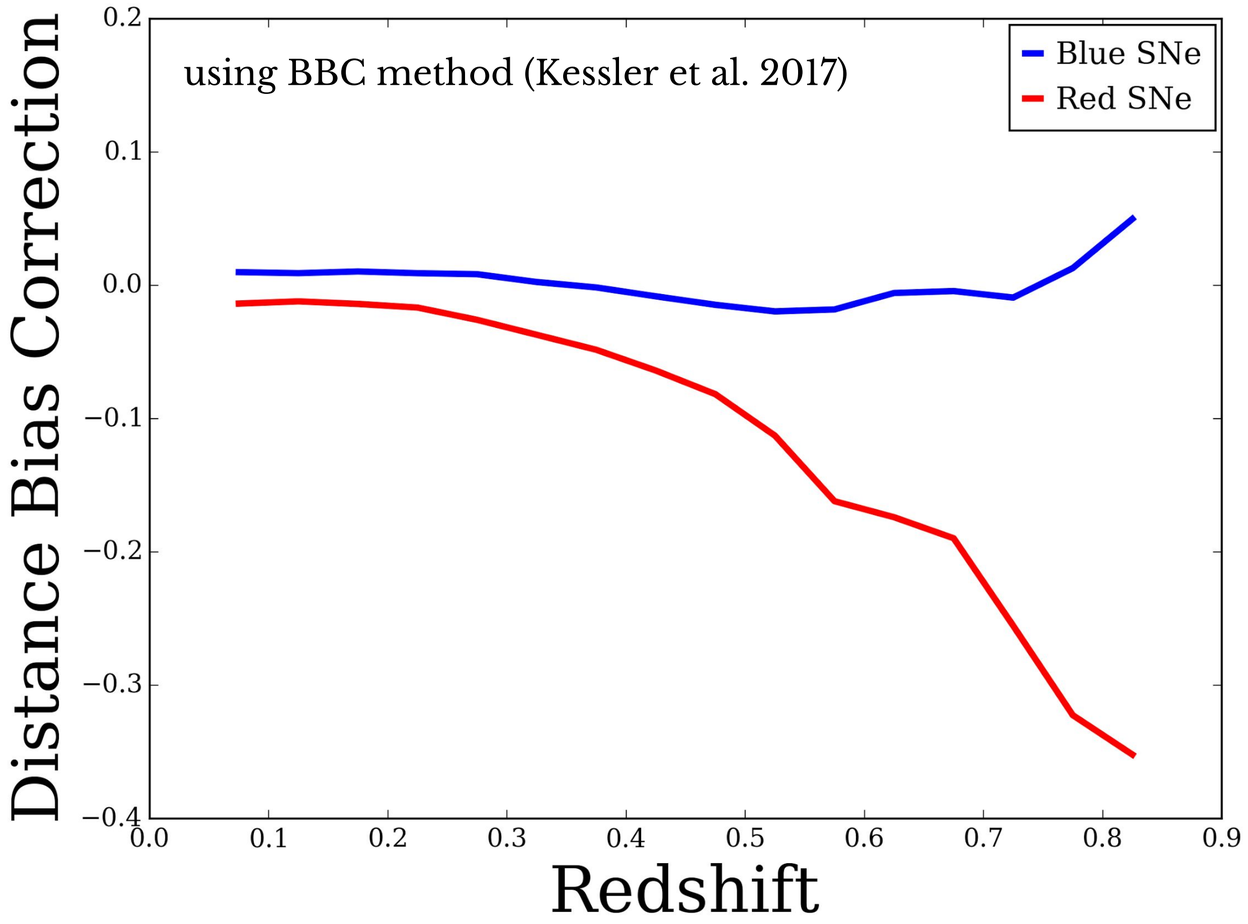
Cadence

PSF

Sky Noise

and more…

Compute Distance Bias Corrections

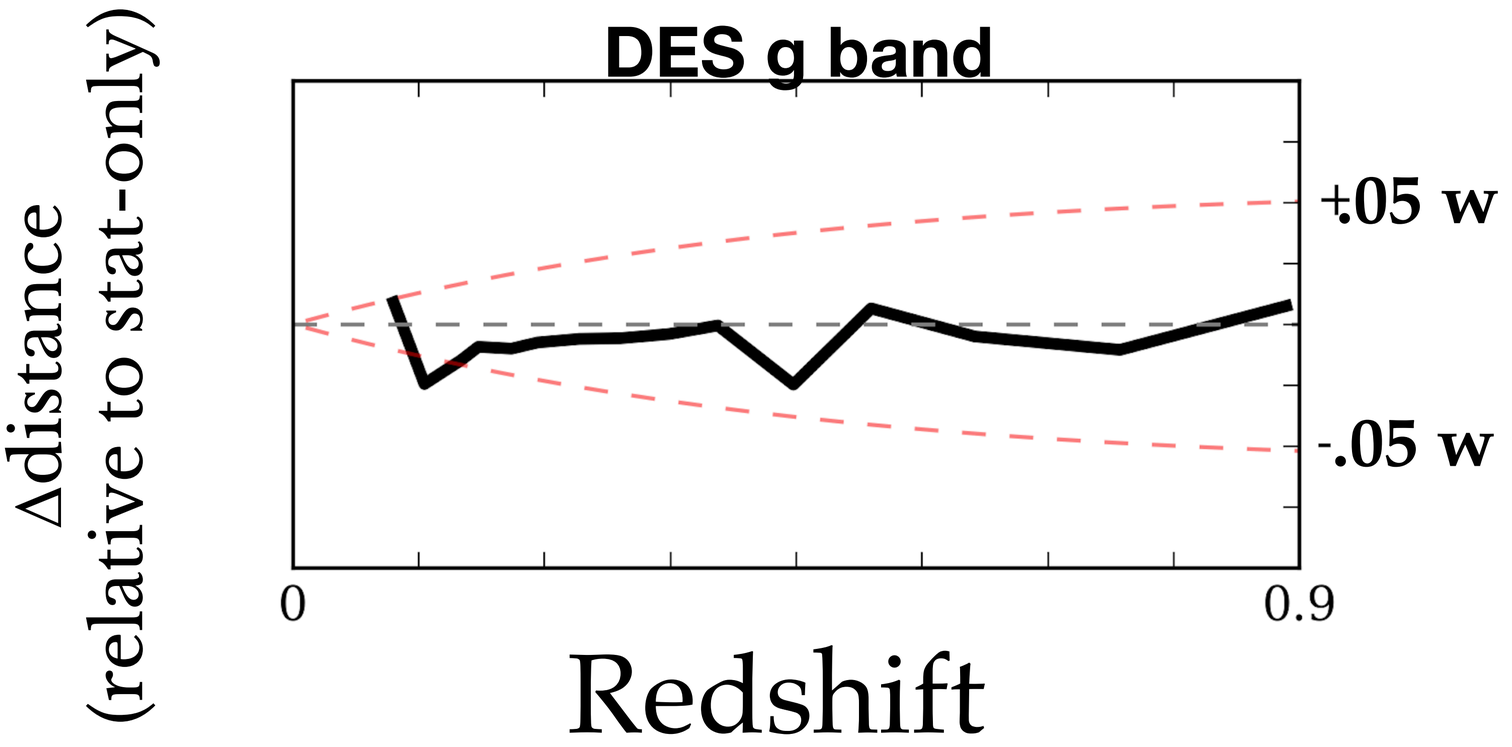


Our systematics fall in the following categories

1. Calibration (20 low-z bands + 4 DES bands)
2. SNeIa Lightcurve Model
3. Distance Bias Corrections
4. Milky Way Extinction

→ Total 60 Sources of Systematic Uncertainty

To assess the impact of each systematic uncertainty, we re-derive distances after varying each systematic



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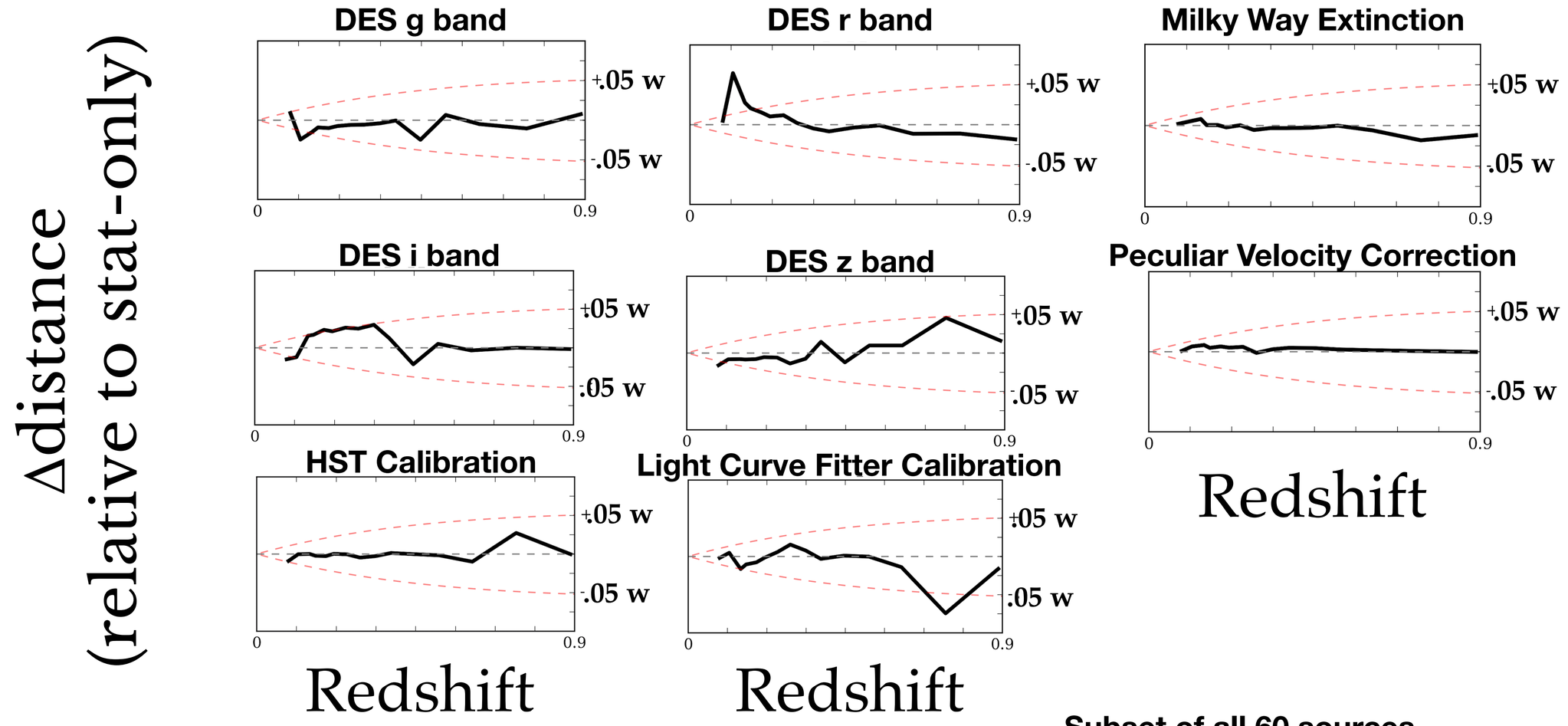
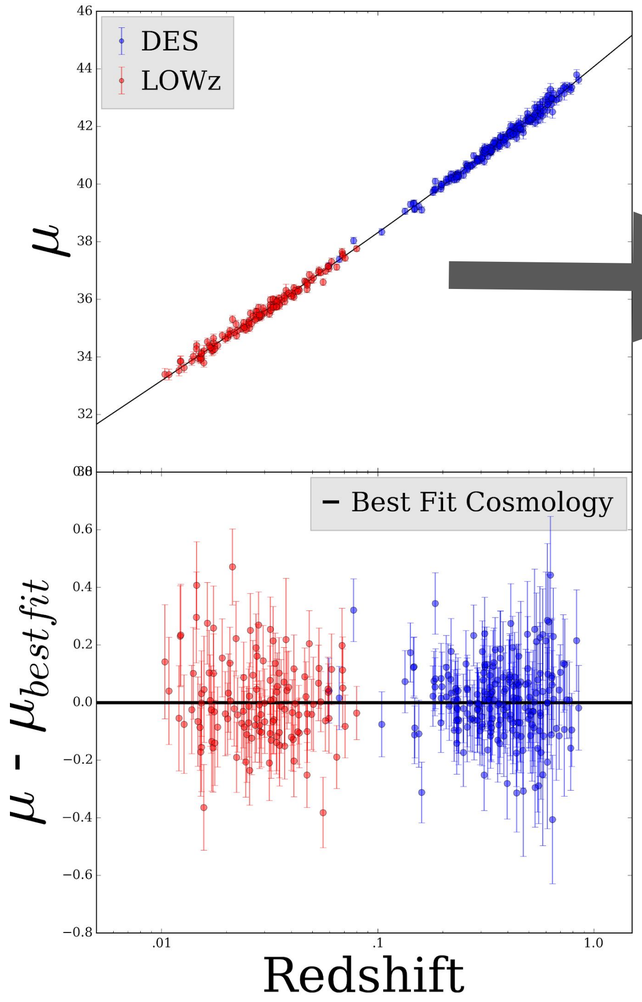
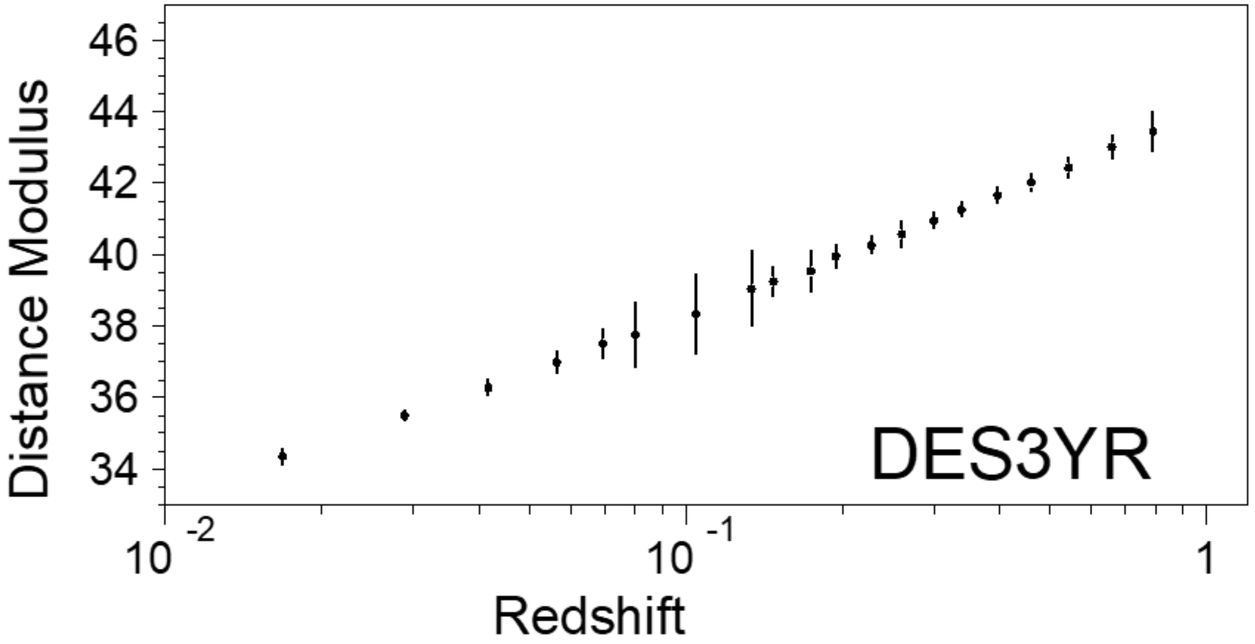


Subset of all 60 sources of systematic uncertainty

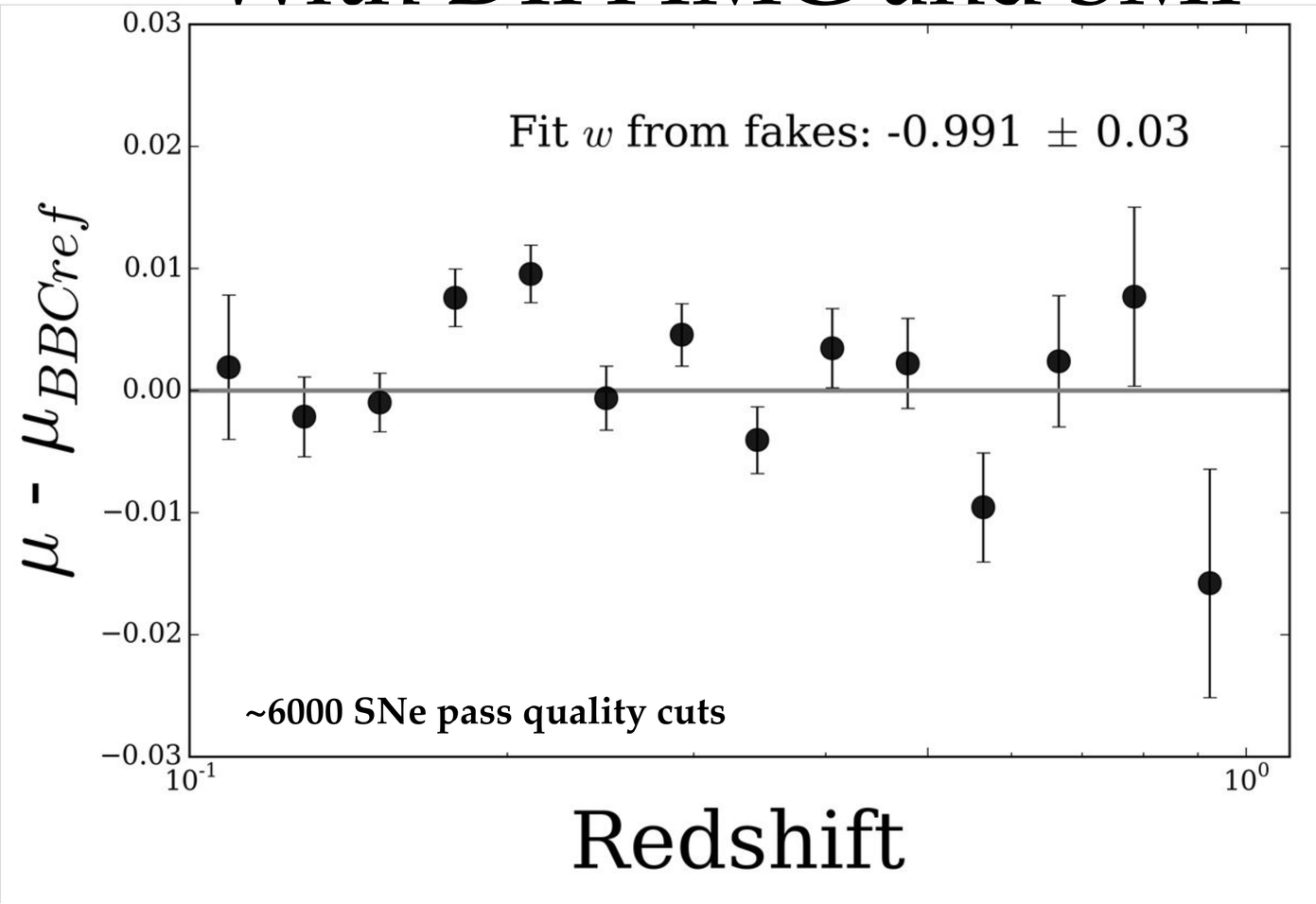
Constraining Cosmology in the Era of Large Datasets



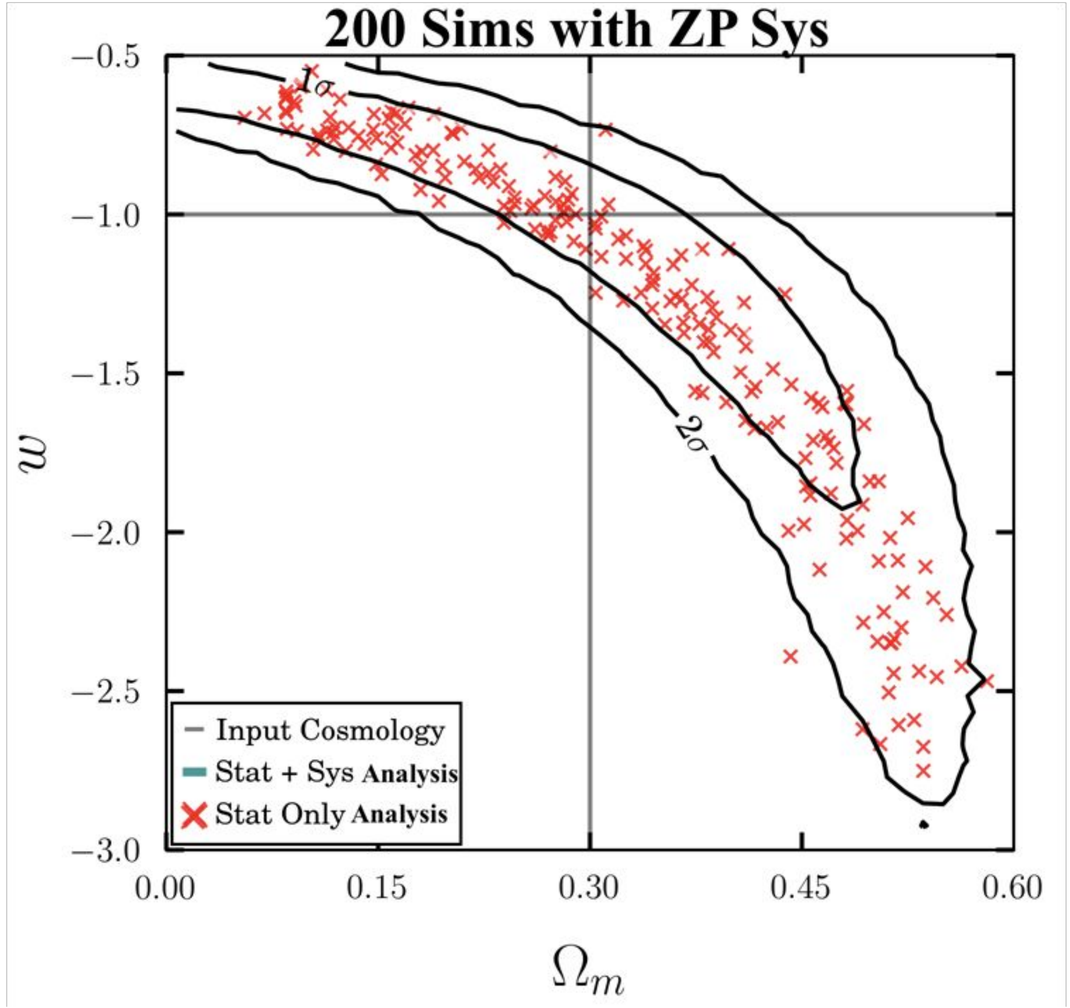


Fake Mus

Cosmology Analysis using 10,000 Fake SNe Processed With DIFFIMG and SMP



Generate 200 Simulated Samples with input systematics and check w bias and uncertainty



$$\sigma(w_{sys})/RMS(w_{stat}) = 1.03$$

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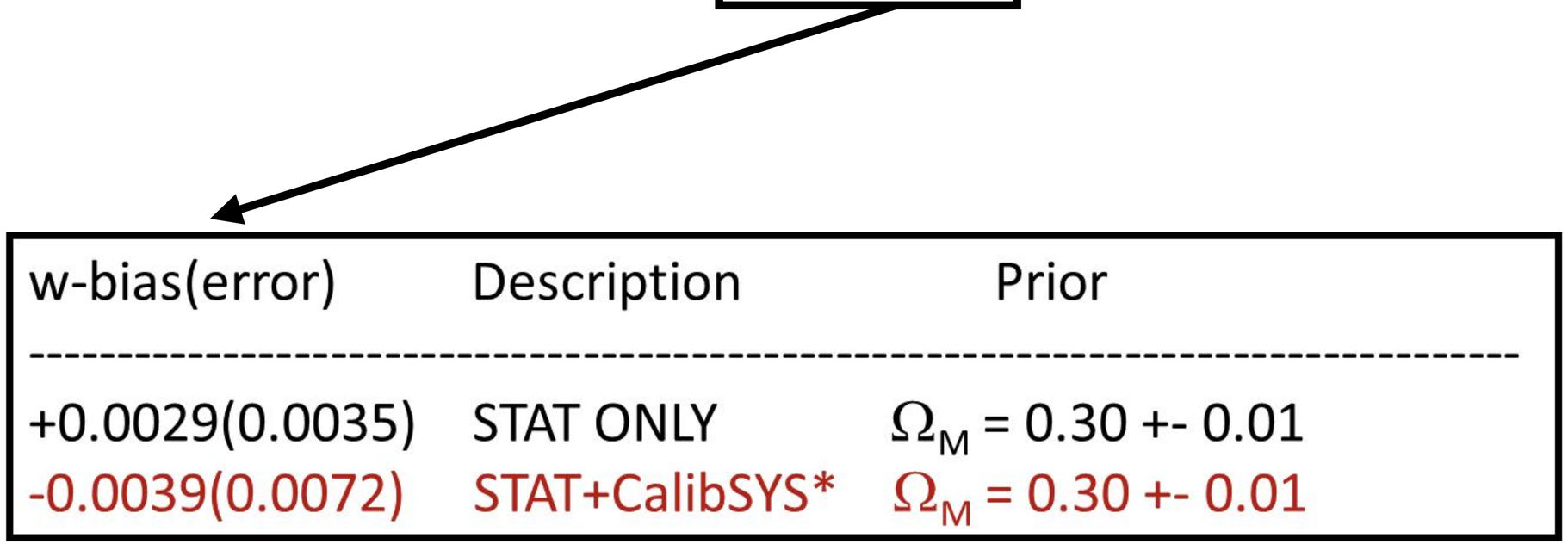

w-bias(error)	Description	Prior
+0.0029(0.0035)	STAT ONLY	Ω_M = 0.30 +- 0.01
-0.0039(0.0072)	STAT+CalibSYS*	Ω_M = 0.30 +- 0.01

Preliminary Results!

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Fitted Hubble residual step across M_{host}

vs.

Intrinsic Scatter

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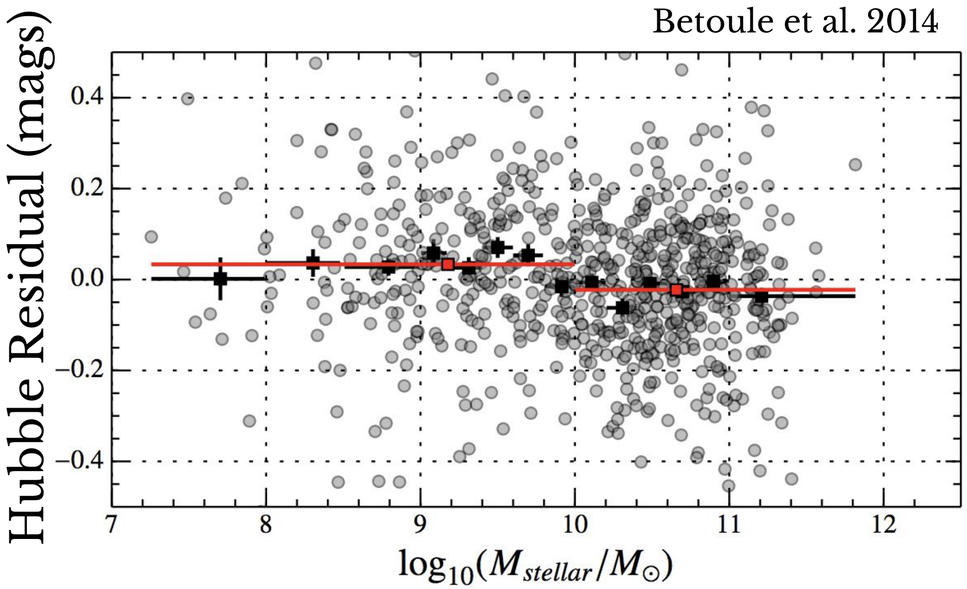

First found by (Hicken et al. 2009, Sullivan et al. 2010, Lampeitl et al. 2010)

Preliminary Results!

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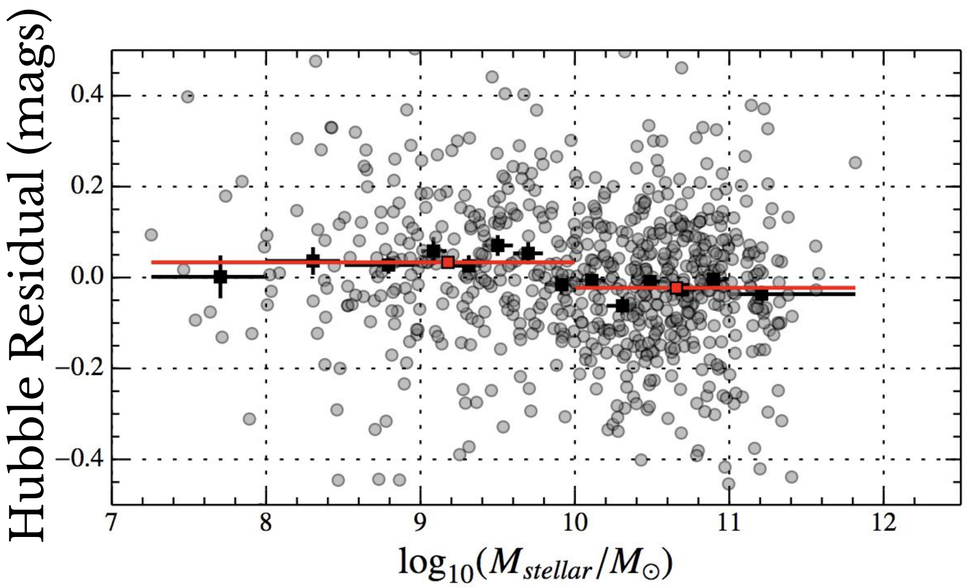

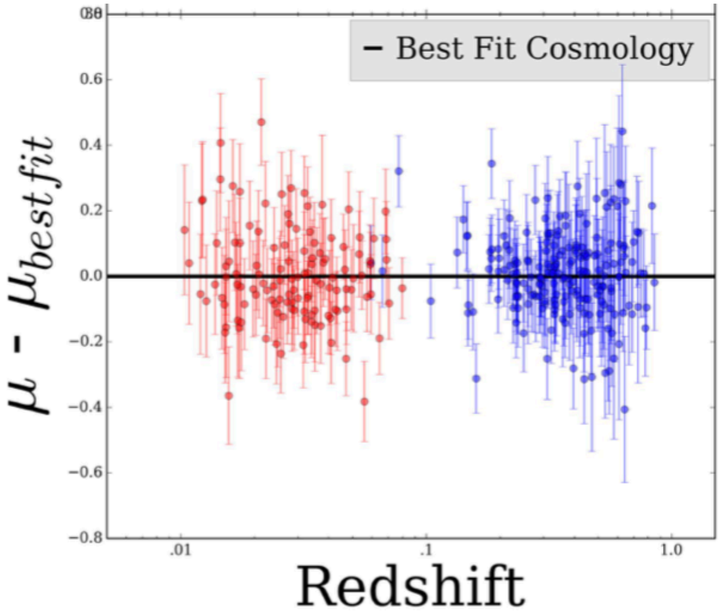

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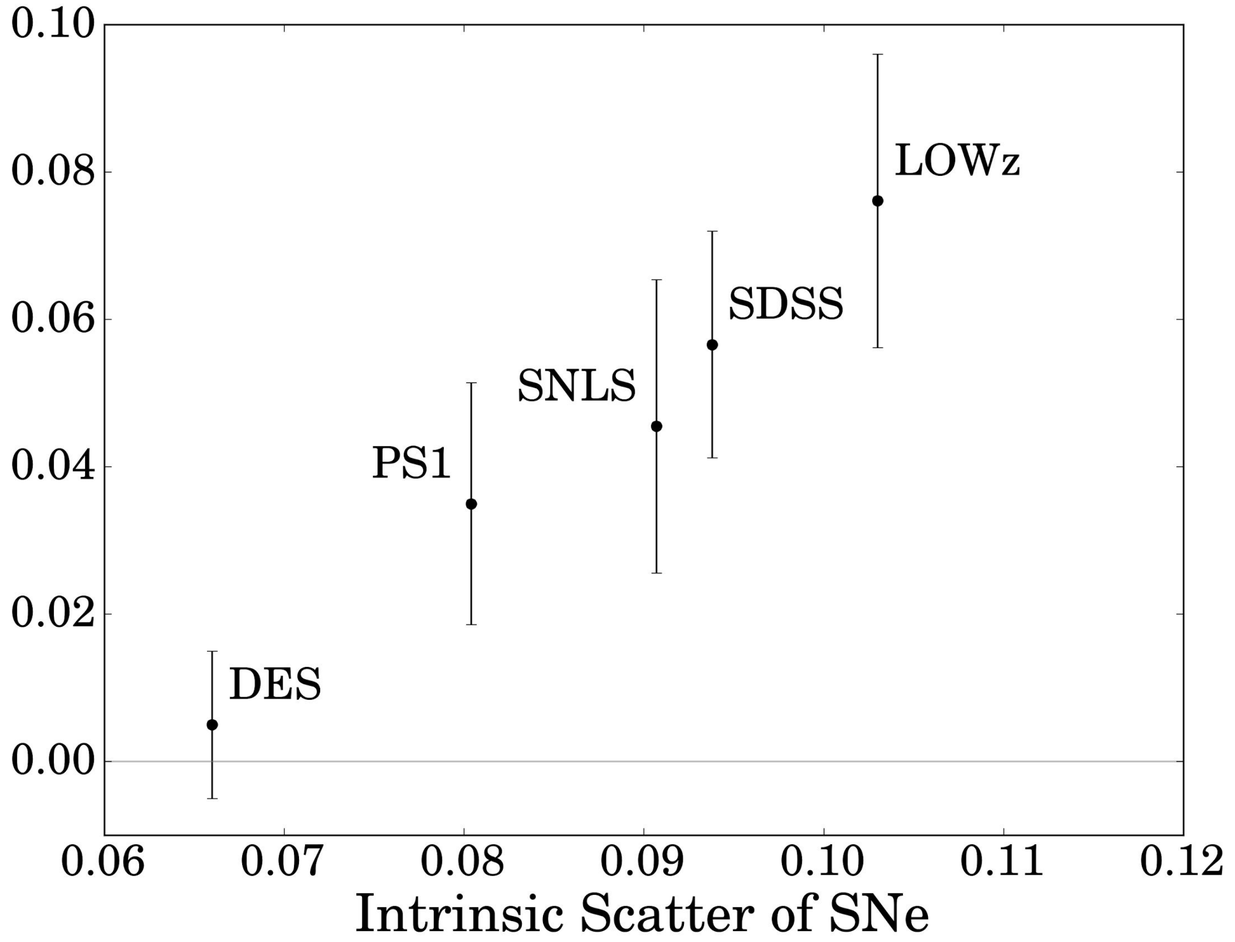

DES has lowest intrinsic scatter and doesn't see HR effect. Not understood, but interesting clue...

Preliminary DES Results!

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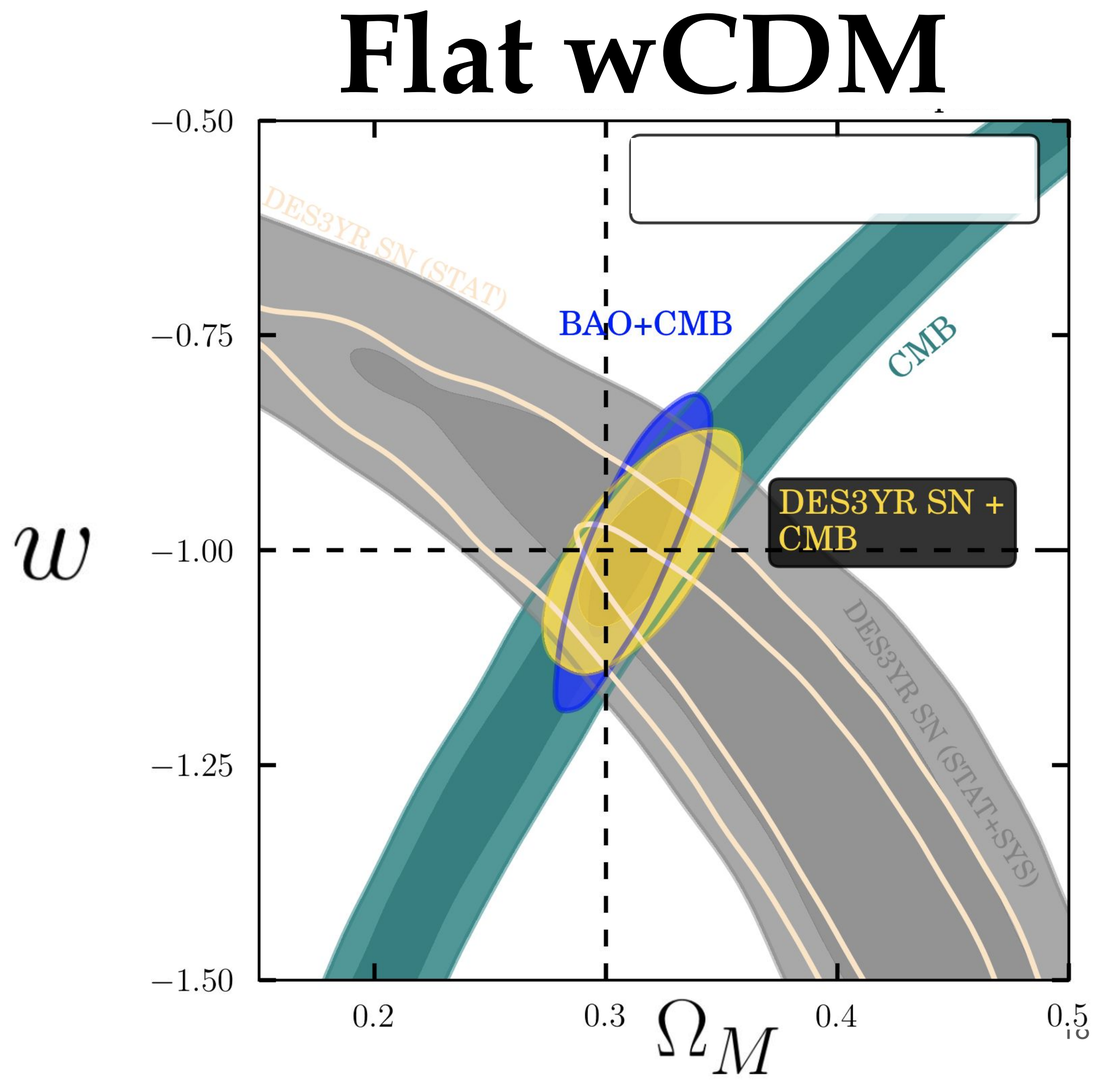
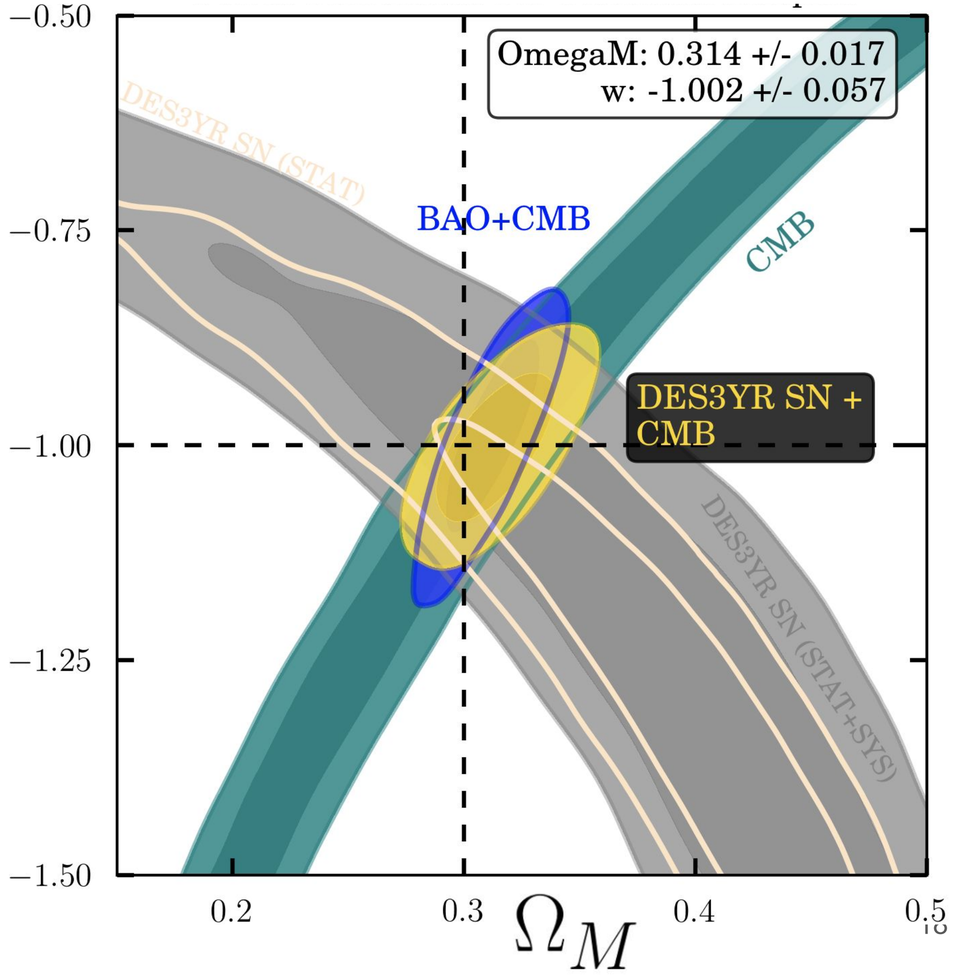


Preliminary DES Results!

$$w = -1.002 \pm 0.057$$

$$\Omega_M = 0.314 \pm 0.017$$

Flat wCDM



Preliminary DES Results!

$$w = -1.002 \pm 0.057$$

$$\sigma_w = 0.041(STAT), 0.040(SYS)$$

The beginning of an era dominated by systematic uncertainties

$$\Omega_M = 0.314 \pm 0.017$$

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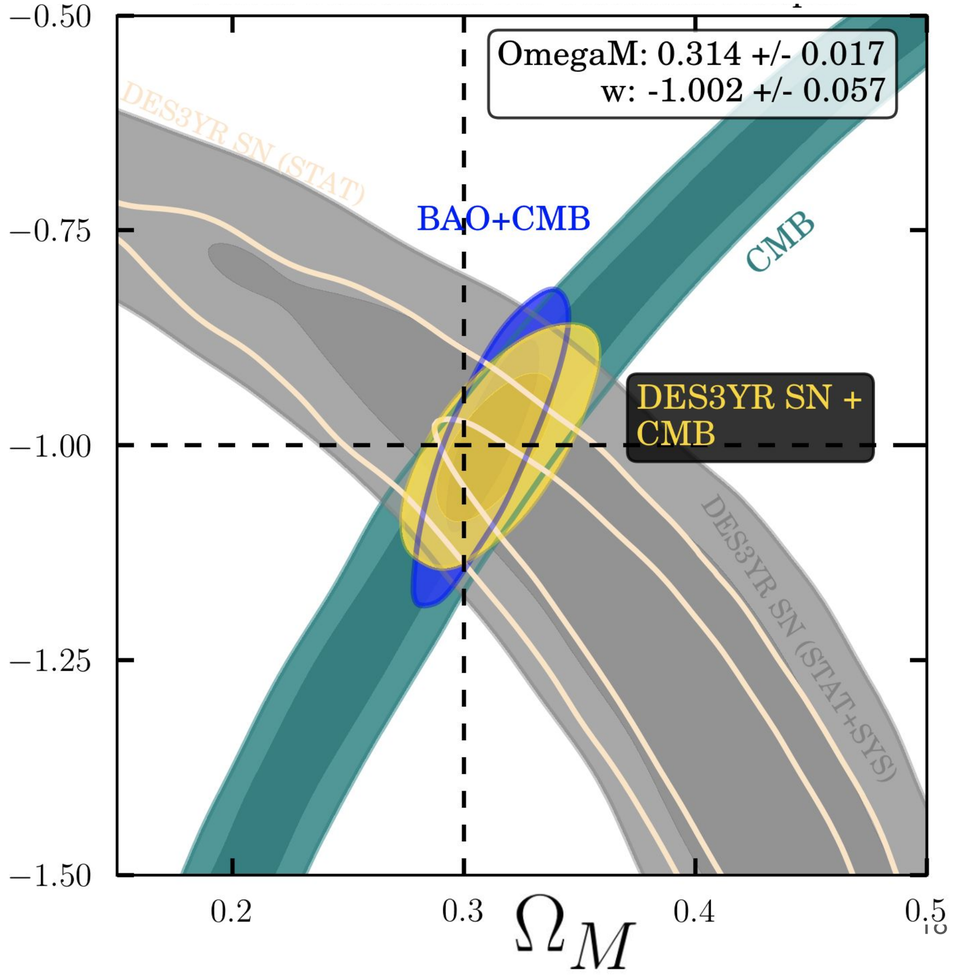

Proposed Data Products

(not confirmed)

Survey

DECam Filter Curves

Photometric Light Curves

Host Galaxy Properties (SB, Mass, etc…)

Redshifts

Light Curve Fit Parameters

Cosmology

Bias corrections

Binned z Covariance matrix

Hubble Diagram (each event & binned)

CosmoMC Chains

Code Releases

THE DARK ENERGY SURVEY

Thank You

DECam builders

DES shift-takers

Data Processing

OzDES

Calibration