From the Weeds to Cosmology with SNIa

Dan Scolnic, KICP Fellow, DES Chicagoland Meeting

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All plots are preliminary!

The Steps to Get to Science-Ready Lightcurves

- Detection - will improve with better photometry, sim/data agreement to 5%
- Astrometry - Serious improvement, starting to get to 0.06”
- Photometry - 2-3% systematics, attacking in multiple ways
- Calibration - First measurements accurate to 2%

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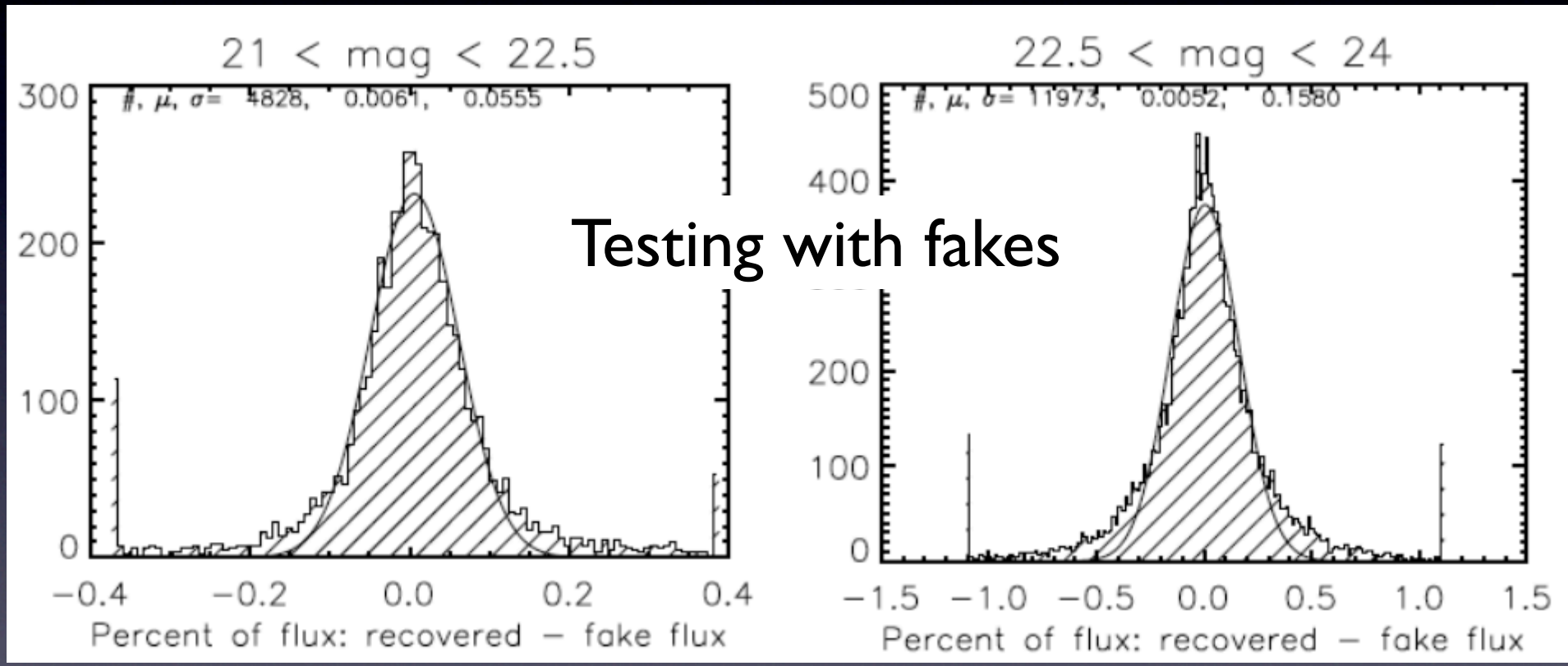
The most difficult step in SN photometry is how to make the galaxy templates and do image subtraction

- Two main approaches:
  - Stacking -- convolution -- subtraction
  - Scene modeling

The first approach is the more traditional approach

-Template is made from stacking pre-explosion epochs.
-Convolve template match image.
-Subtract template.



Testing with fakes

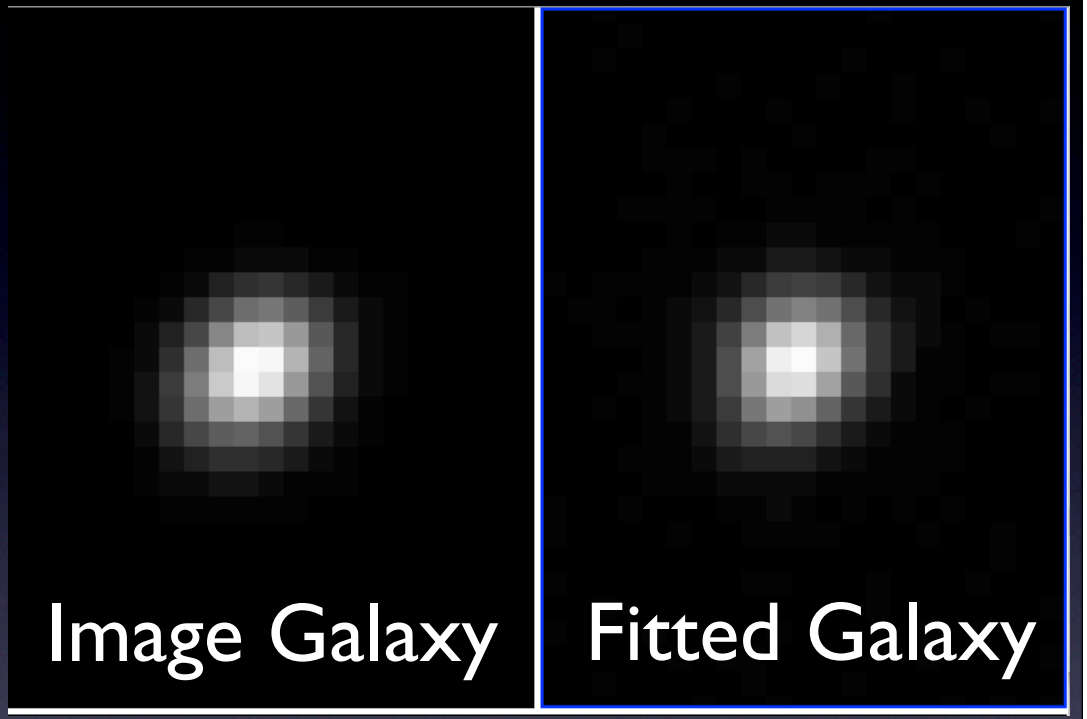
Current systematics on recovered fluxes (g,r,i,z: mmags): ~5,3,6,15

Caveat is we know PSF in these tests

The second approach is to do scene modeling

Forward modeling of a galaxy on a pixel-by-pixel grid

- Does a n_pix x n_pix + n_image fit over SN brightness and galaxy intensity



$$M(x,y) = sky(x,y) + S\left(\sum_{stars} I_{star} PSF(x - x_{star}, y - y_{star}) + I_{SN} PSF(x - x_{SN}, y - y_{SN}) + \sum_{x_g, y_g} \mathcal{G}(x_g, y_g) PSF(x - x_g, y - y_g)\right)$$

Holtzman 2008

$$\chi^2 = \sum_{xy} \frac{(O(x,y) - M(x,y))^2}{(M(x,y)/G + (\frac{\sigma_{sky}^2}{G^2}))}$$

O=Image

I=Intensity, G=Galaxy,M=Model

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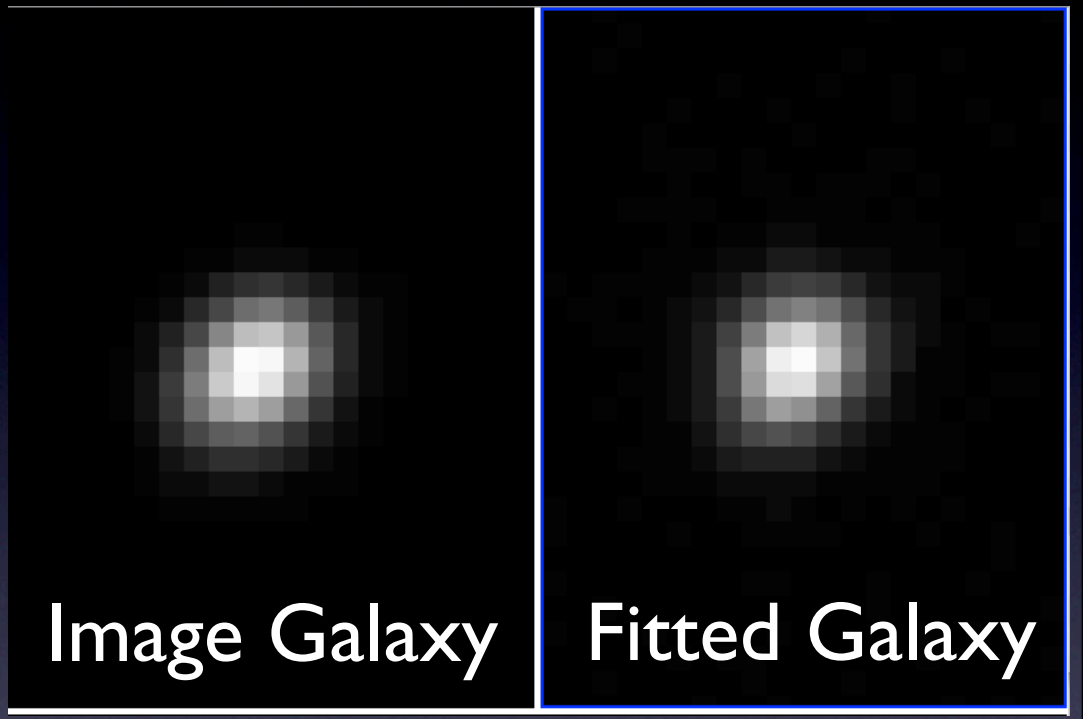
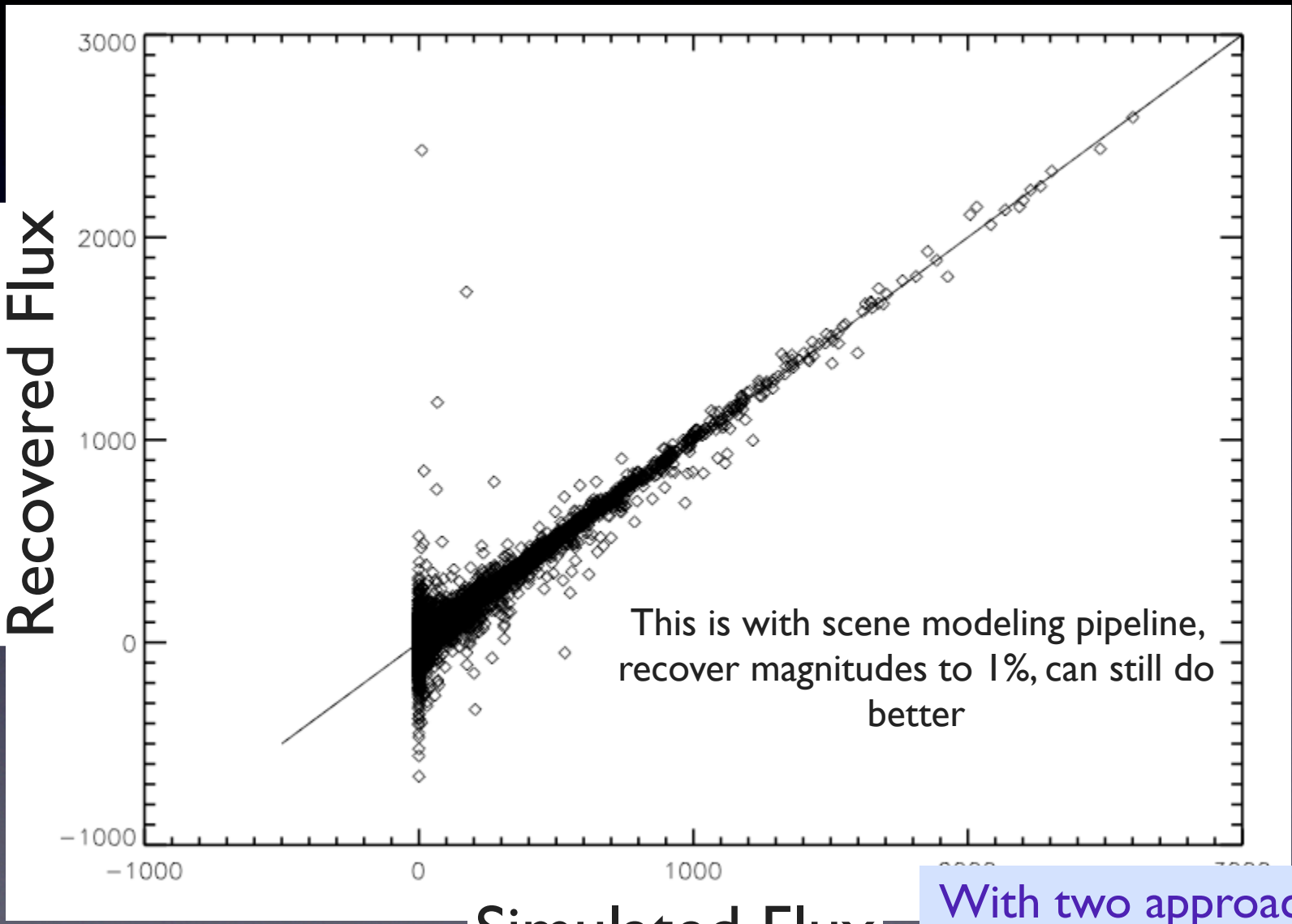


Different strategy than weak lensing:
WL: take galaxy models, convolve with PSF, compare to galaxy image
SN: For all pixels, convolve with PSF, compare to galaxy image

Fake testing is looking really encouraging



With two approaches, can beat this down

Calibration is currently the top systematic in SNIa Cosmology analyses

- 1% calibration is 3% distance systematic

- William Wester, Douglas Tucker and I started a special program to observe multiple HST Calspec standards to improve calibration systematic by 2x

Many thanks to Tom Diehl, Alistair Walker, Eric Nielsen, Robert Gruendl, Brian Yanny!!

Credit to William Wester

BD+17 4708
Absolute flux calibrator

DARK ENERGY SURVEY

BD+17 4708 was used by SDSS as THE fundamental spectrophotometric standard

In (perhaps without full thought), this star was tied to DES science requirements:

DocDB 20

> **R-12** The i-band magnitude zeropoint relative to BD+17, and therefore the AB system, must be known to 0.5% rms.

The bandpass zeropoint requirement **R-12** derives from the same considerations as **R-11**. Tying our photometry to BD+17 places us as close to an absolute scale as we can achieve inside the context of the DES. The verification of this requirement relies on ~100 hot dwarfs in the survey area and the fact that the SDSS Strip82 is tied to BD+17 as well as direct observations of BD+17.

Driven by SN science

Two issues for observations of BD+17 for DES
- it's North … observable but at airmass larger than 1.5
- it's bright … brighter than 10th magnitude

It had been observed twice. Once during commissioning and once during Y1 where the star fell right on the A/B amplifier boundary of chip 35

Credit to William Wester

DARK ENERGY SURVEY

BD+17 4708
Absolute flux calibrator

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We now know BD+17 is a binary star; so we will need other standards to get to accuracy level!

Credit to William Wester

DARK ENERGY SURVEY

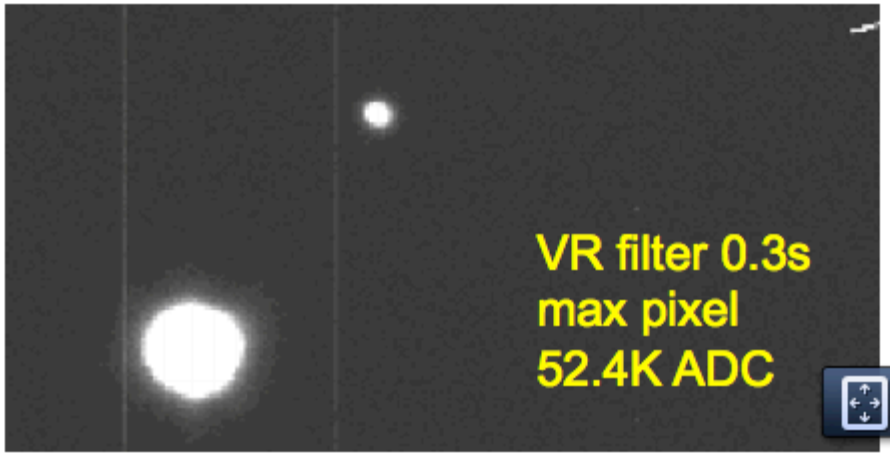
BD+17 4708 Observations during Y2

mid – October Engineering time requested to re-observe BD+17

Nite: 20141011 photometric, late twilight pointing north, before moon rise
IQ 1.3-1.6 arcsec and BD+17 at airmass 1.7

script: bd17+4708_2014.json
Some effort (thanks to Alex Drlica-Wagner) to know where to point telescope to land an object at a specific point in the focal plane. In our case, we land BD+17 in the middle of the A amplifier on chips 35 (near center) and 52 (nearer to the edge)

2 pointings (chip 35 and chip 52)
3 exposure times
7 filters (grizVR 0.1, 0.2, 0.3s
u: 2,4,6s Y: 0.3, 0.6, 0.9s)
42 total exposures: 366045 – 366086
Skilled observer: A. Walker



Credit to William Wester

BD+17 4708 Initial Analysis

Inputs:

standard stars (PSM), site averaged airmass extinction, "k"

zeropoints (per CCD), set by nearby nightly standards

(some indication that standard stars that night might have had high cirrus or other clouds)

exposures processed in Y2 framework

BD+17 synthetic photometry HST based (then adding DES system throughput, atmosphere at 1.3).

Outputs:

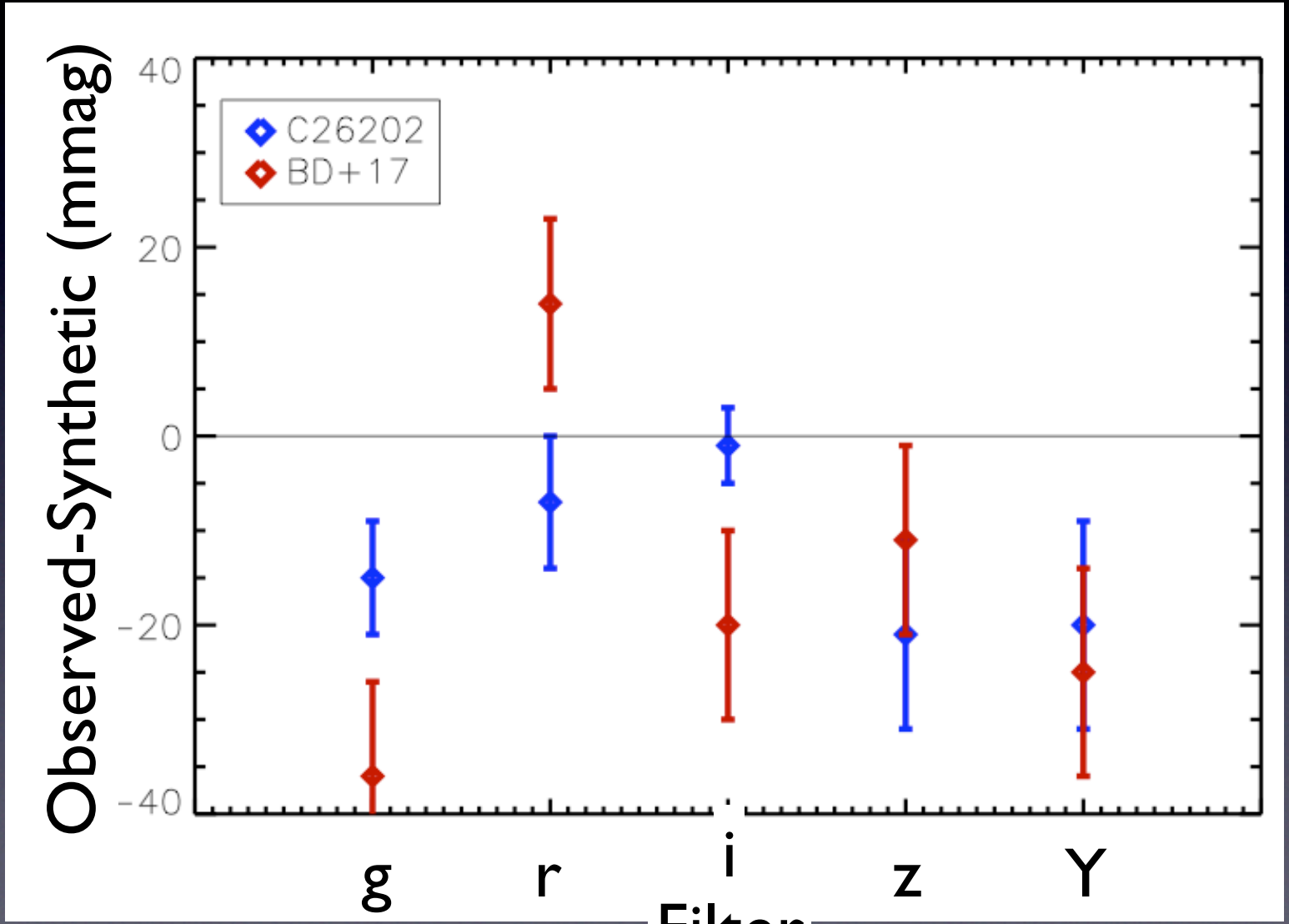
"a", "b" zeropoints/color terms, "k" as above

SExtractor instrumental fluxes after "Y2 detrending"

Calibration:

apply extinction, a, b corrections and iterate on color terms

First calibration results are looking really encouraging



Goal: To conservatively and accurately measure a number of Calspec standards in each filter across the focal plane

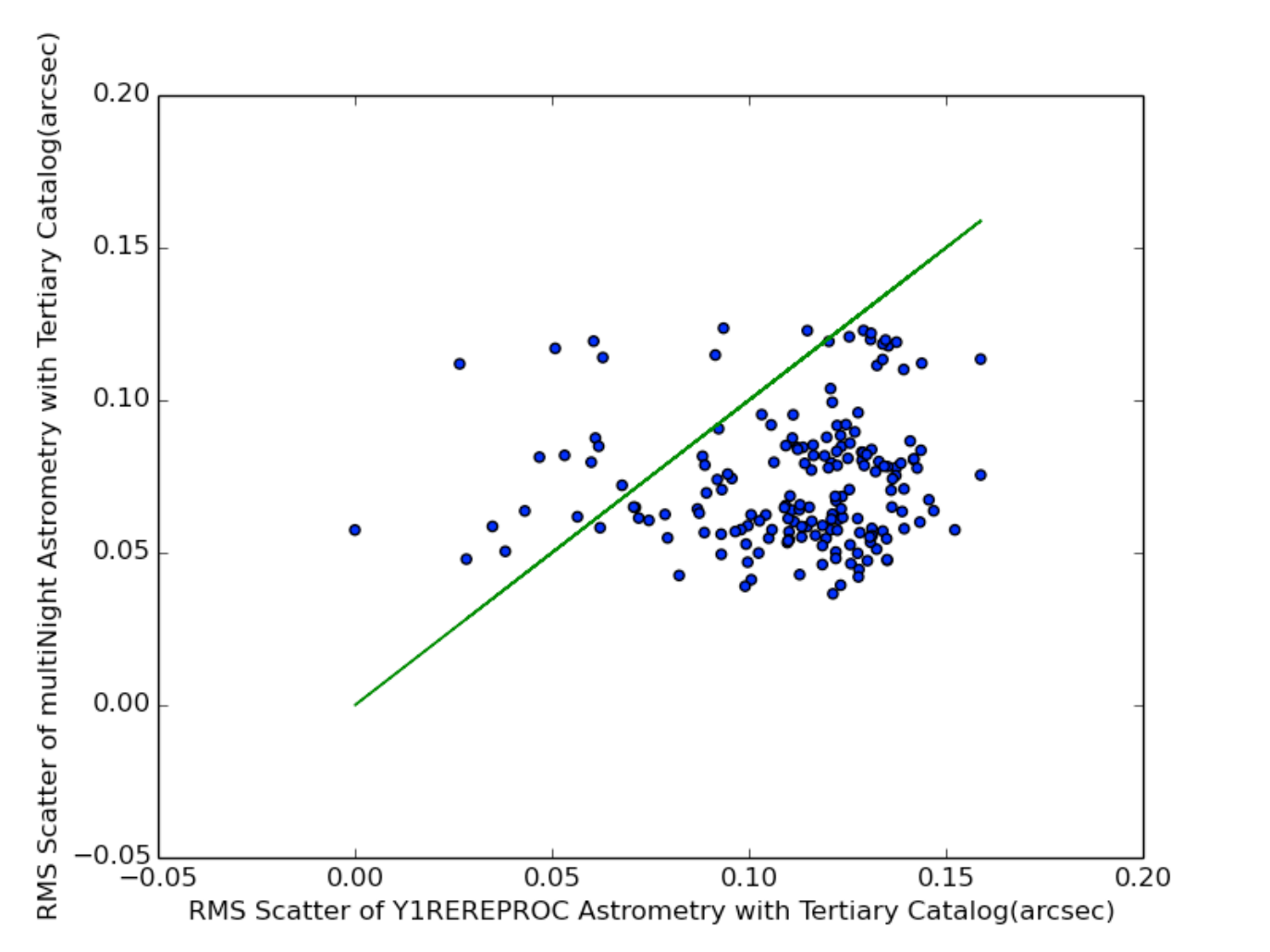
#Positions on Focal Plane	#Filters	# Calspec standards	# exposures	# epochs
3	6	8	3	2
Inner,Mid, Outer	ugrizy	Southern Calspec Standards	For averaging	Time-dependance

This plan would be improvement on SDSS calibration precision by 2x (SDSS had 10 observations per standard per filter)

Each Obs takes 30s. Full plan takes 7 hours.

More to come

Our astrometry is getting much better

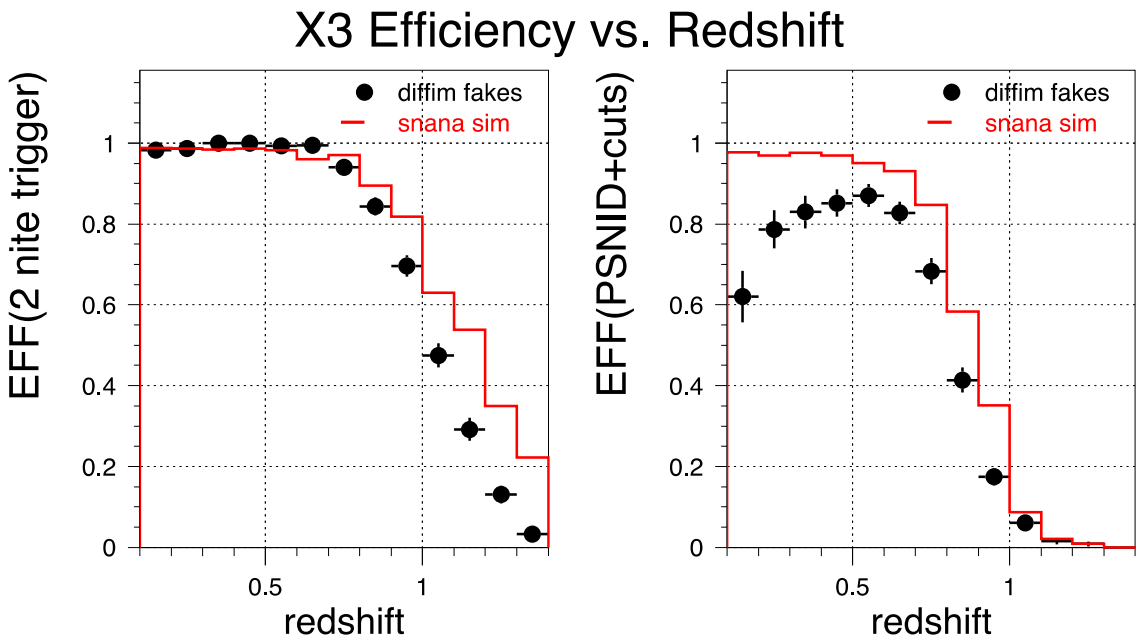


Now running multiple images through Scamp at same time, getting as low as 0.04”

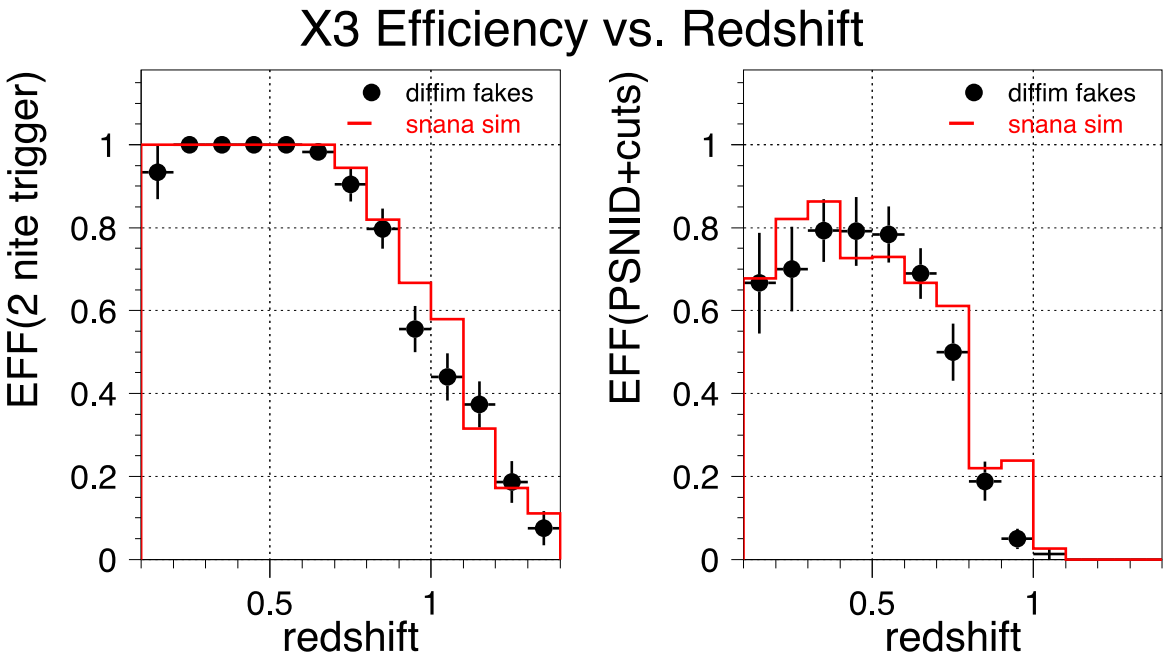
Credit to James Lasker

We are really starting to understand our efficiency!

Credit to Rick Kessler



Year 1: Bad agreement between SIM and data because of bad templates



Year 2: Good agreement between SIM and data

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