DES Supernova Hubble Diagram Studies

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for James DerKacy (grad school app coming to you soon!),
+ many more …

SALT2 Type Ia SNe Light Curve Model Basics

Individual SN Fitting:

$Flux(p,\lambda) = x0*(M0(p,\lambda) + x1*M1(p,\lambda))*\exp(c*CL(\lambda))$

M0, M1, CL fit to previous training set (p is phase in days)

x0, x1, c, t0 fit to new individual light curves (maybe z)

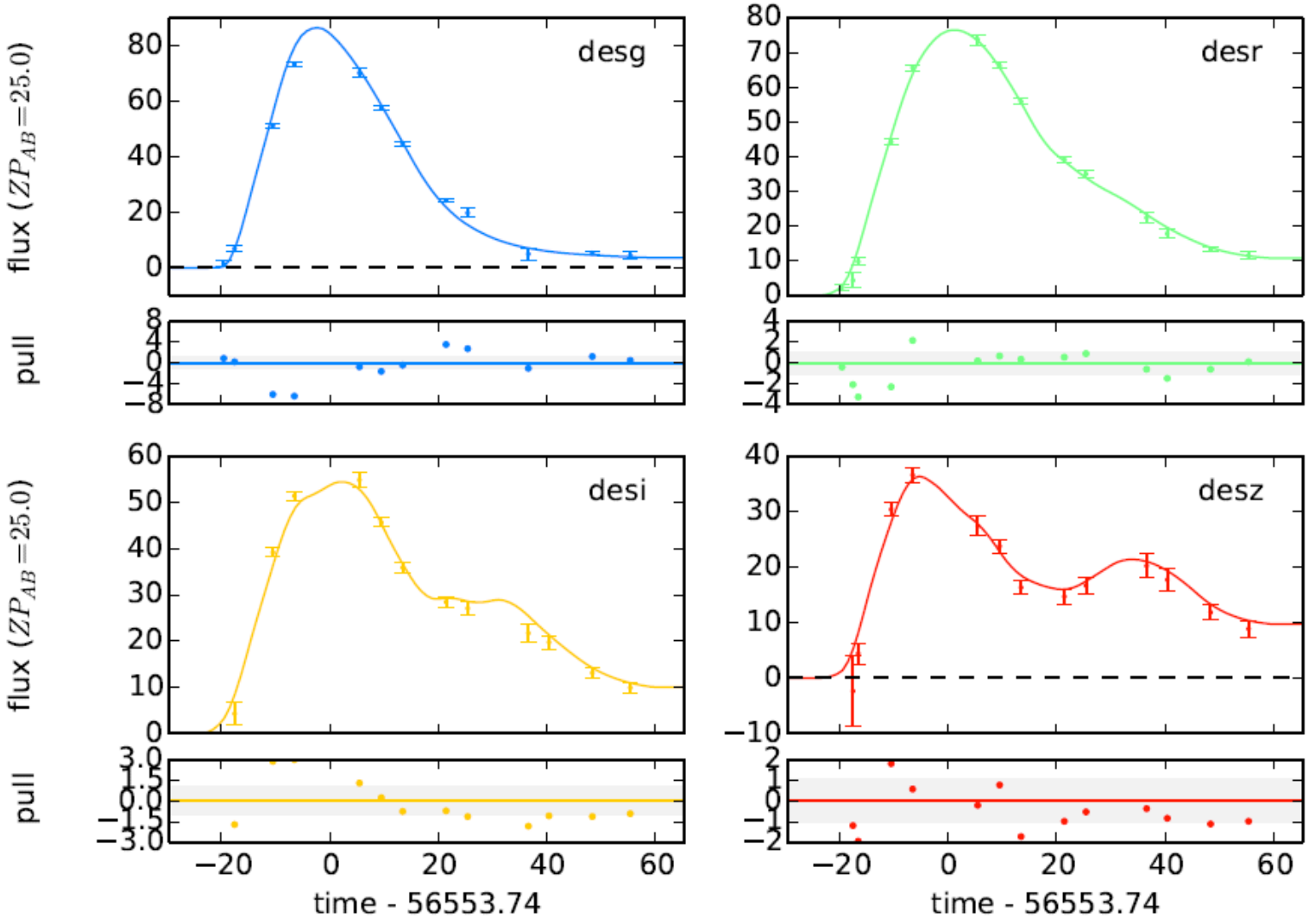
Distance Modulus Corrections from Entire Sample:

$\mu = m - M + \alpha*x1 + \beta*c$

DES13S1qv
$\chi^2\ /dof = 0.680642$

$z = 0.19134 \pm 0.00047$
$t_0 = 56553.742 \pm 0.063$
$x_0 = (1.455 \pm 0.048) \times 10^{-4}$

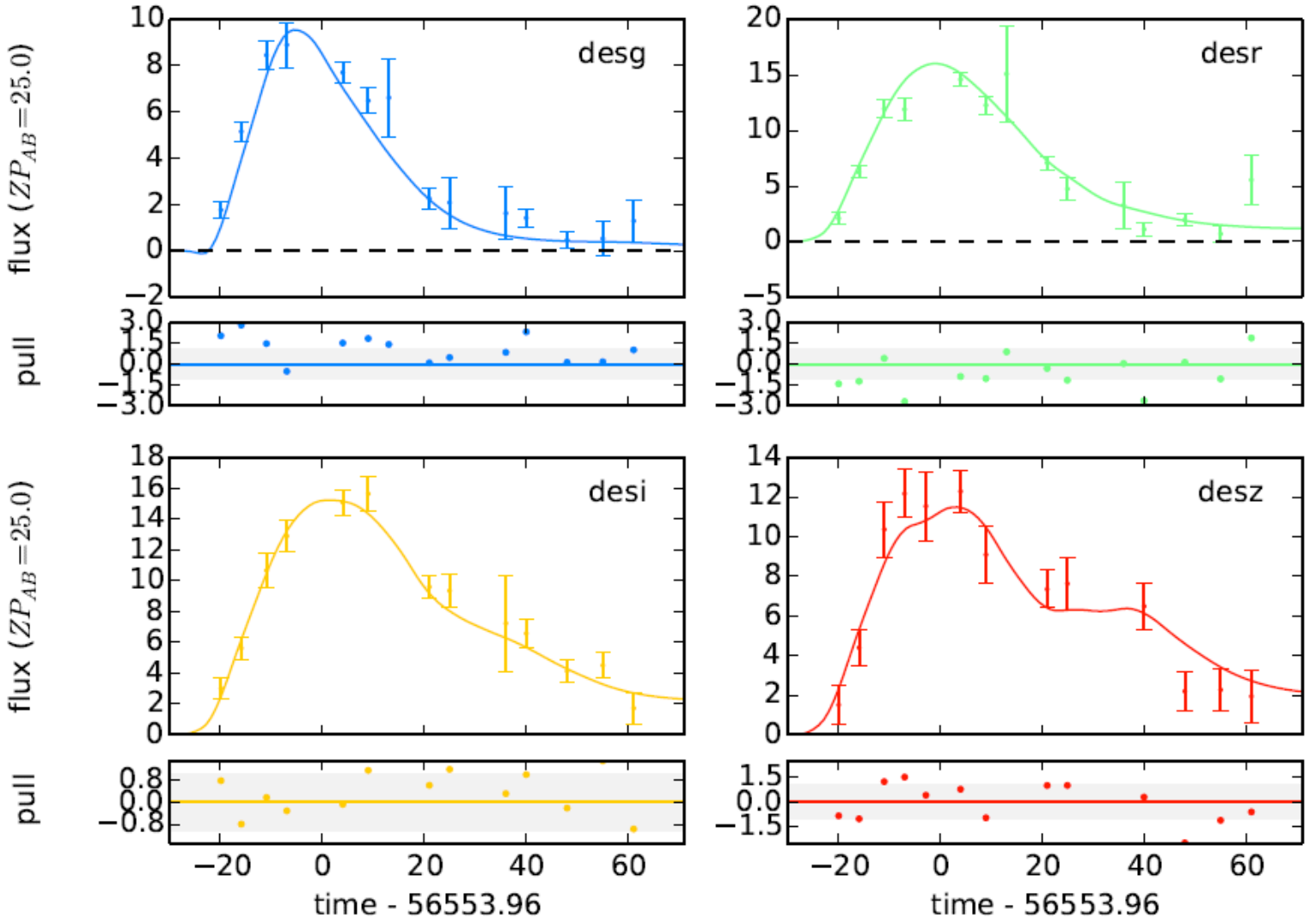
$x_1 = 1.19 \pm 0.20$
$c = -0.165 \pm 0.028$
mw $E(B-V) = 0.0566274$



DES13E1cza
$\chi^2\ /dof = 1.04383$

$z = 0.4091 \pm 0.0026$
$t_0 = 56553.96 \pm 0.22$
$x_0 = (1.920 \pm 0.074) \times 10^{-5}$

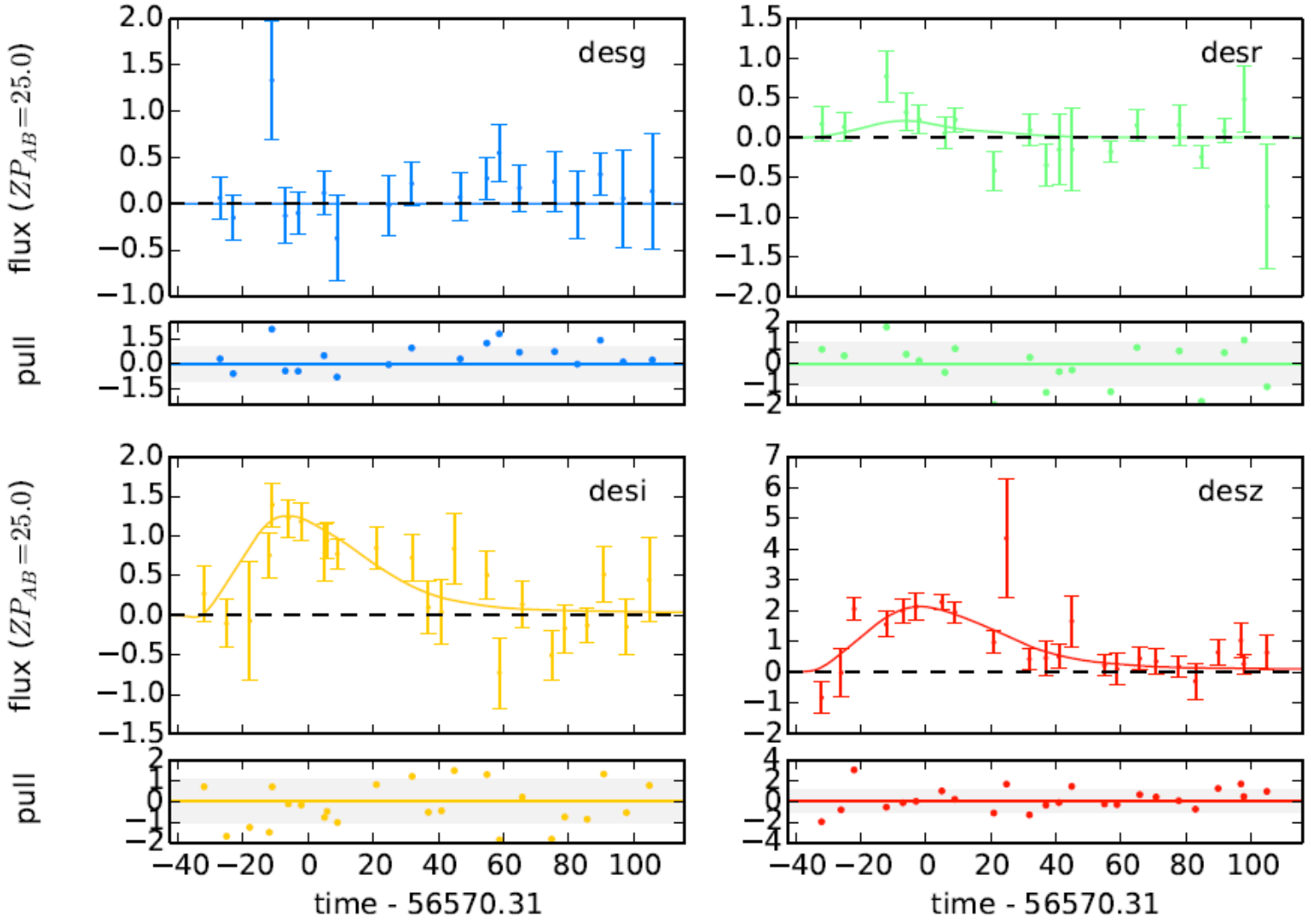
$x_1 = 1.34 \pm 0.35$
$c = -0.045 \pm 0.030$
mw $E(B-V) = 5.74805 \times 10^{-3}$



DES13C3jmt
$\chi^2\ /dof = 1.1532$

$z = 1.1212 \pm 0.0033$
$t_0 = 56570.3 \pm 2.0$
$x_0 = (1.55 \pm 0.15) \times 10^{-6}$

$x_1 = 0.9 \pm 2.0$
$c = 0.28 \pm 0.17$
mw $E(B-V) = 6.88976 \times 10^{-3}$

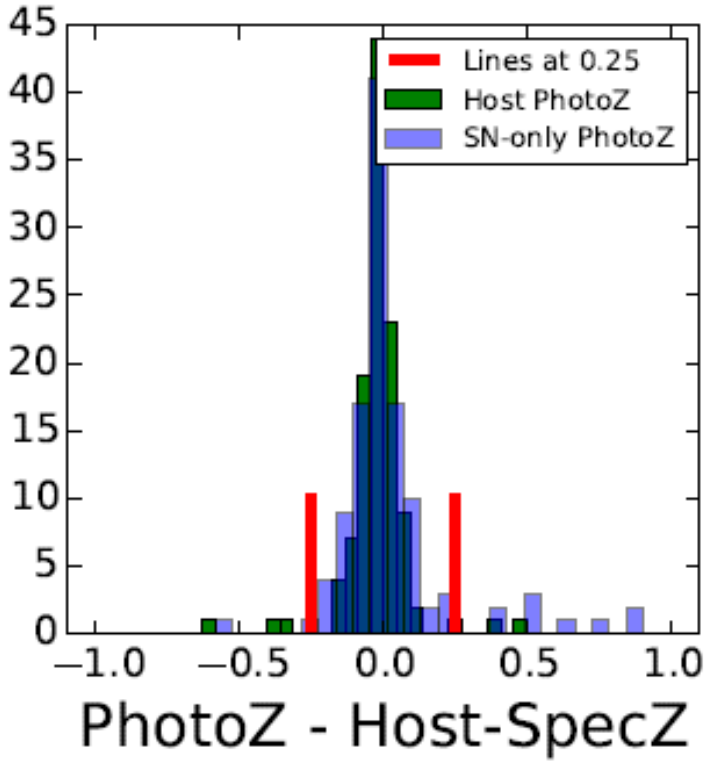


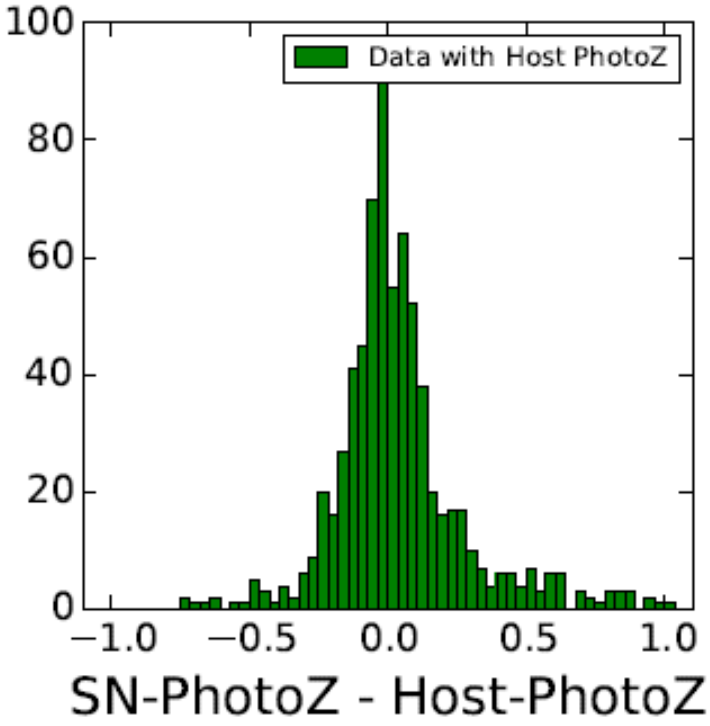
Redshift Options

1. SpecZ means Host-SpecZ (not including SNspecZ yet)
2. Host PhotoZ Only
3. Supernova PhotoZ Only
4. ComboZ = Combined Fit with Host-PhotoZ Prior and SN-PhotoZ

Photo-z qualities:

1) **Pretty good in subsample that includes host SpecZ, which is mostly lower redshift (helps SNphotoz) and brighter galaxies (helps host photoz)**
2) **Noticeably worse for the full sample**

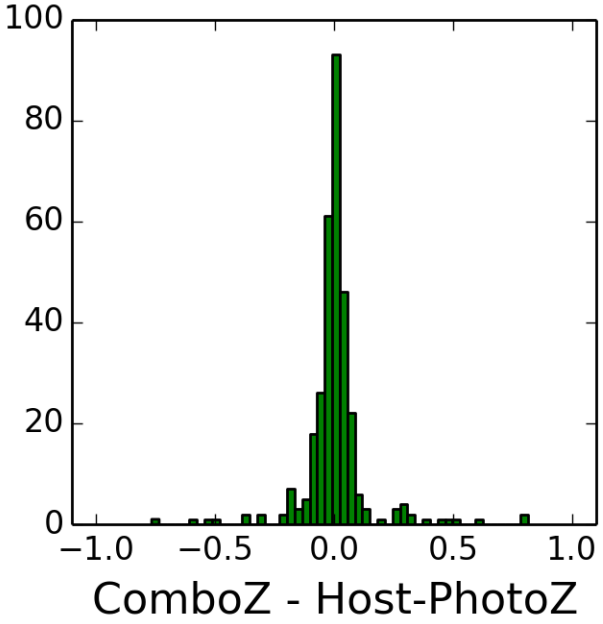


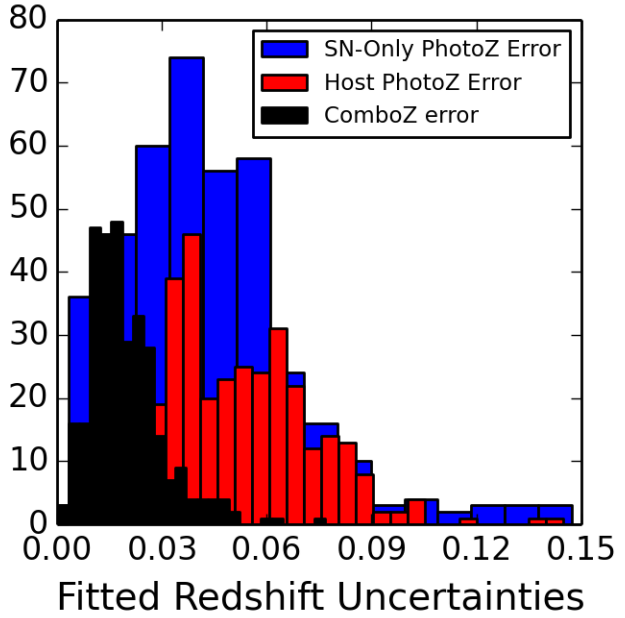


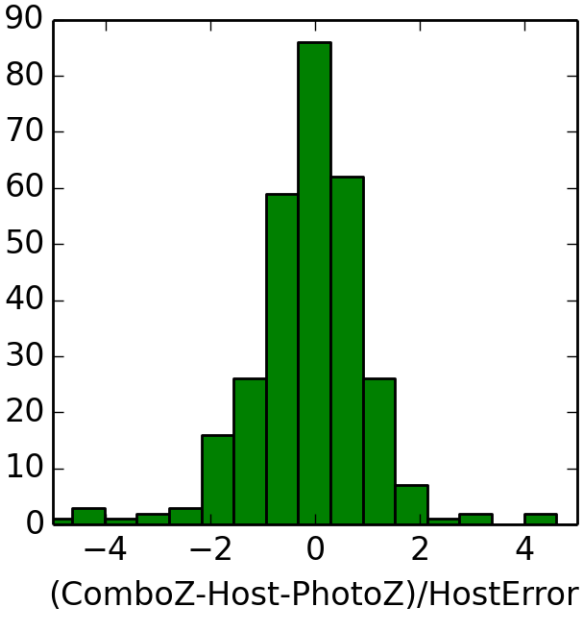
Continuing to study these samples and use them to refine HD…

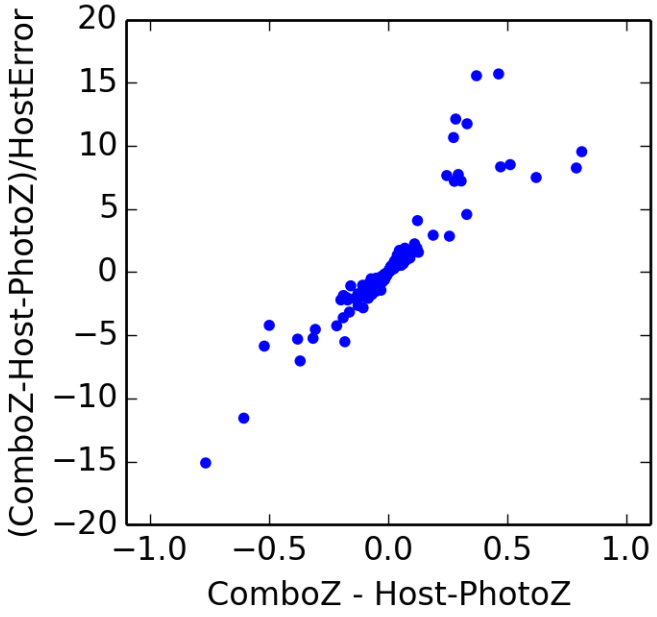
Photo-Z errors and pulls

For ComboZ throw out abs(Pull)>4







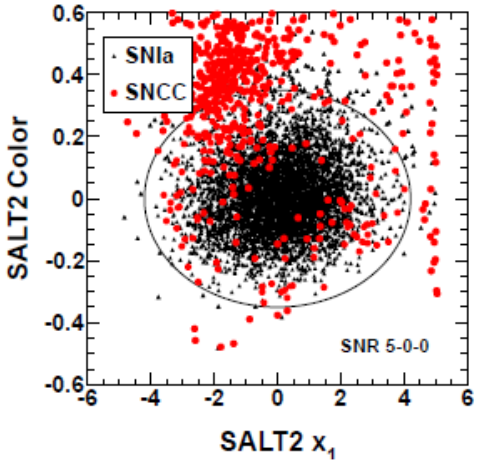


What was done with data:

1. Collect all ~14.5K candidates in REREPROC
2. Keep epochs with photometry flag<8 and psf_nea<2.5
3. Require 1 filter SNR>5
4. Initial Fit with SNcosmo nested sampling to get t0 estimate and trim epochs
5. Require ≥ 5 epochs, 1 epoch before t0, 1 epoch after t0+10days
6. Final Fit with SNcosmo nested sampling (SALT2-only model for now)
7. Keep chisq/dof<2 (loose to allow for photometry issues)
8. Fit degrees of freedom > 20 and t0_error<10
9. Apply x1-c and color-mag cuts tuned on DES 5-year simulations (see below)
10. Calculate distance modulus with fixed JLA values for alpha and beta

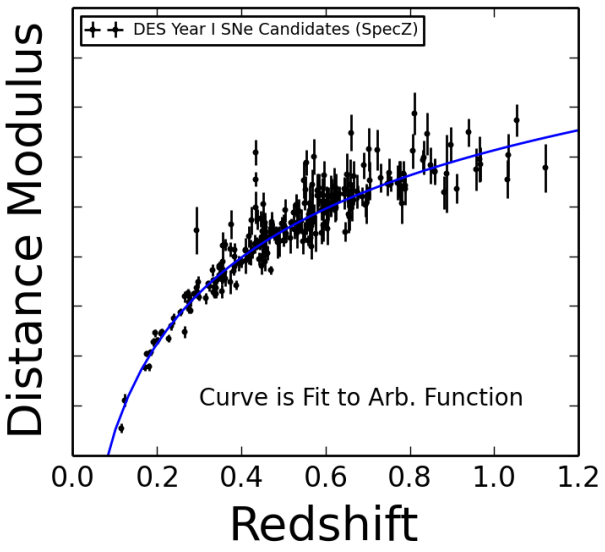
Example Simulation Results for 5-year Survey

SNRMAX Cuts	Number Ia	Number CC	Purity	Ellipse Color	Ellipse x_1
SNR 5-0-0	4629	180	96.30%	4.2	0.35
SNR 5-5-0	4095	161	96.22%	4.3	0.38
SNR 5-5-5	3348	113	96.73%	4.4	0.40
SNR 10-5-5	2317	46	98.10%	4.5	0.45

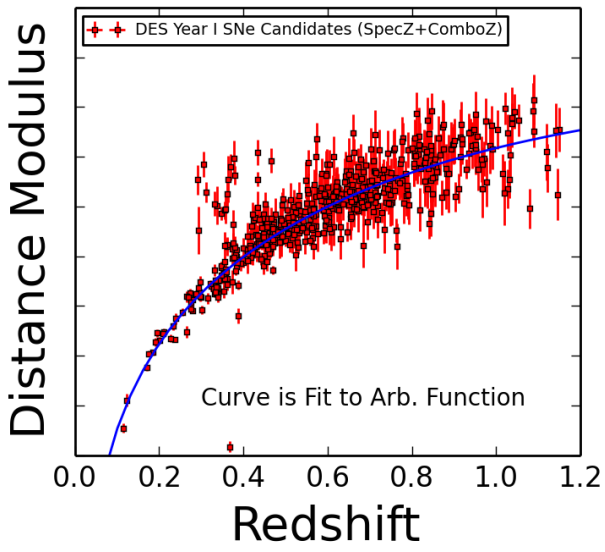


Stanwyck selection tuning on 5-year simulation, maintain >96% purity and optimize SNIa

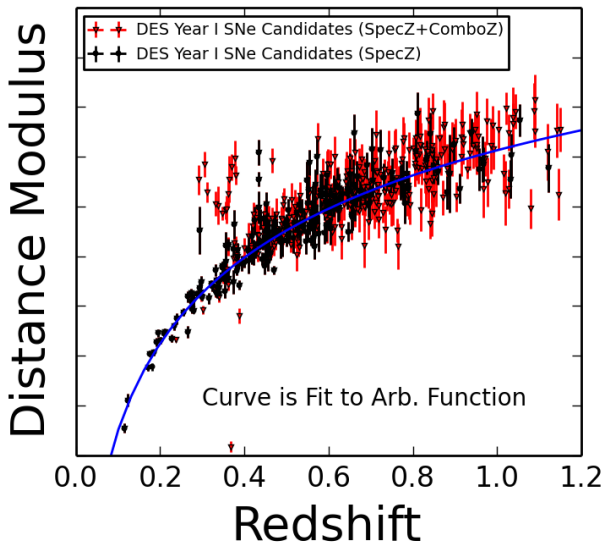
SpecZ (240)



SpecZ+ComboZ (531)

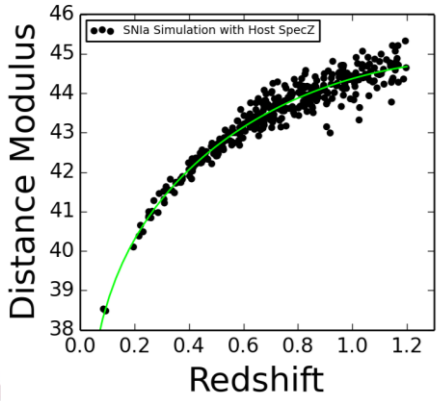


Overlaid



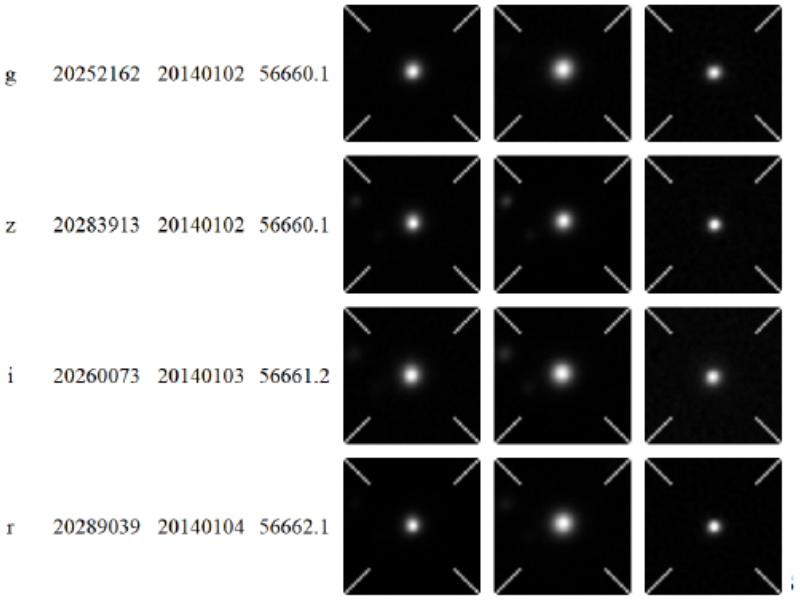
Arb. Function is Rahul's favorite for fitting wide z range:

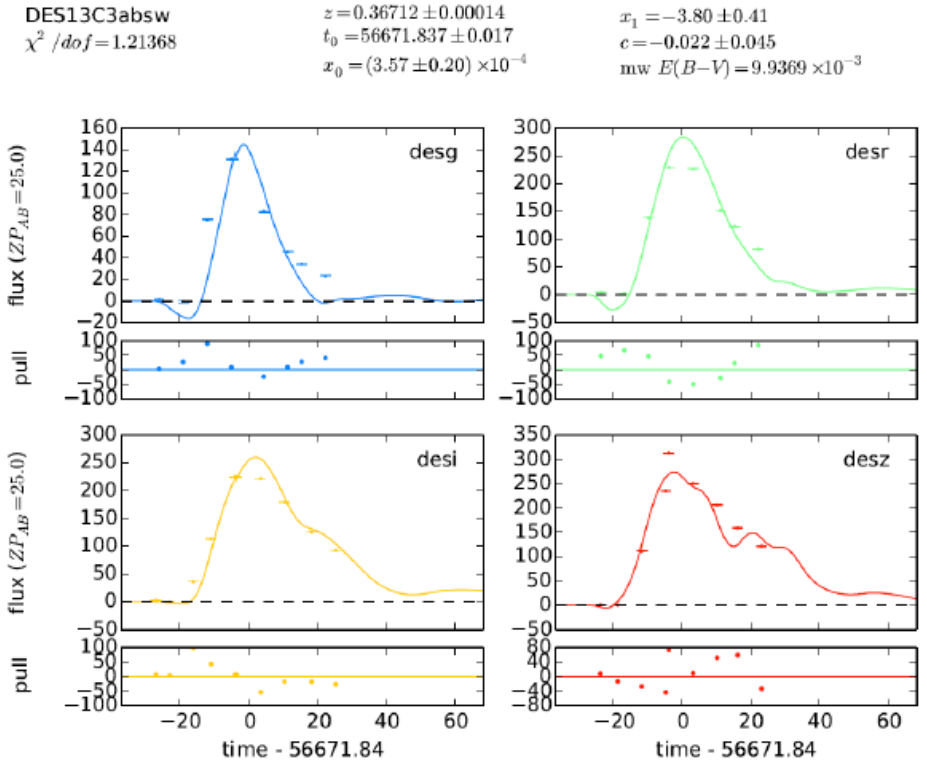
A + B*LOG(z+z*z) + C*z*z + D*z



No sign of 2nd bump, likely Core Collapse?

DES13C3absw
Large outlier on host_photoz_prior Hubble diagram
zfit = 0.367, zfit_err = 0.00013,
host_photoz = 0.178 host_photoz_err = 0.0646



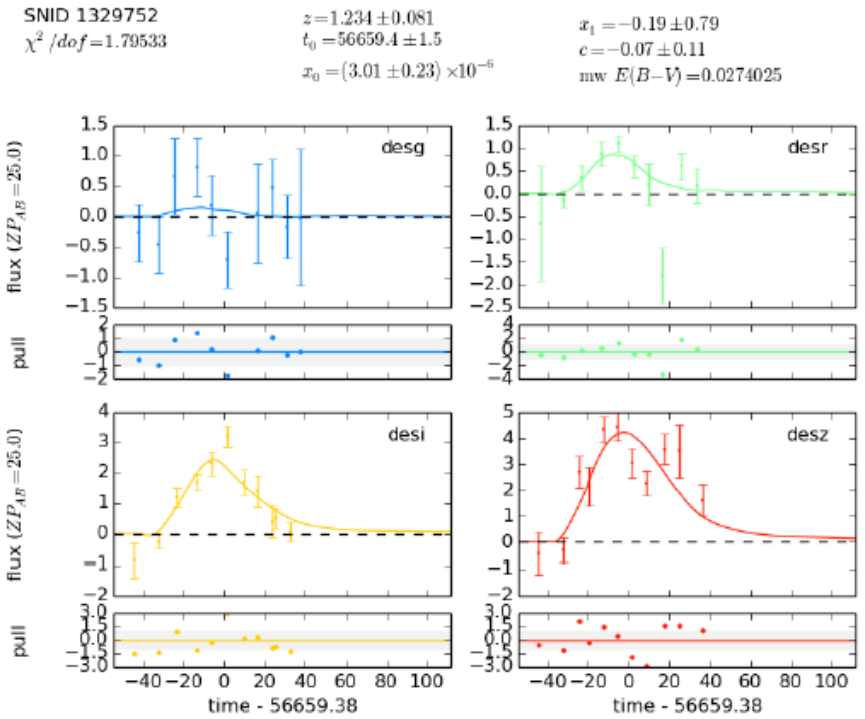


GalID	Type	RA	Dec	Sep (arcsec)	DLR	Photo z	Photo z err	Spec z	g mag	r mag	i mag	z mag
8080	GALAXY	52.81997	-27.33580	0.599	0.70	0.178	0.065	0.0000	19.603	19.063	18.892	18.775
8081	GALAXY	52.81954	-27.33492	3.521	6.80	0.631	0.040	0.0000	24.763	23.271	22.498	22.165
8082	GALAXY	52.82056	-27.33425	6.319	8.22	0.622	0.035	0.0000	23.479	21.977	21.177	20.843

SN-only photoz fit

Host Photoz:0.18
Host Specz: 0.31
SN-only Photoz: 1.2

Chisq/dof using Forced z=Specz:
SNIa chisq/dof: 527.36
Ib - s11-2005hm chisq/dof: 1.67

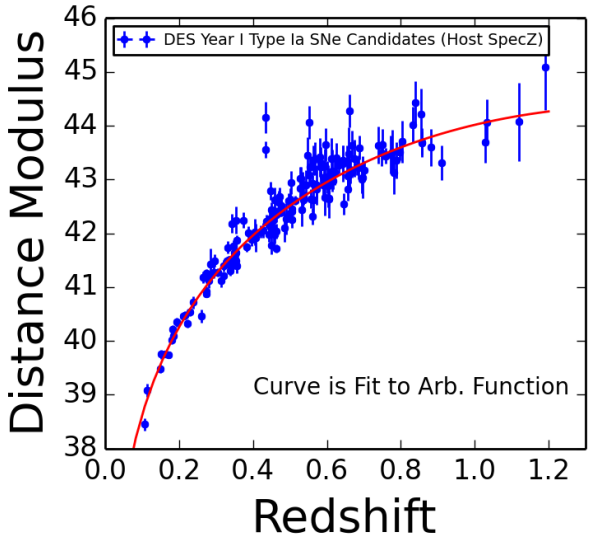


z 11051457 20140103  Kovacs SN

SN Galaxies

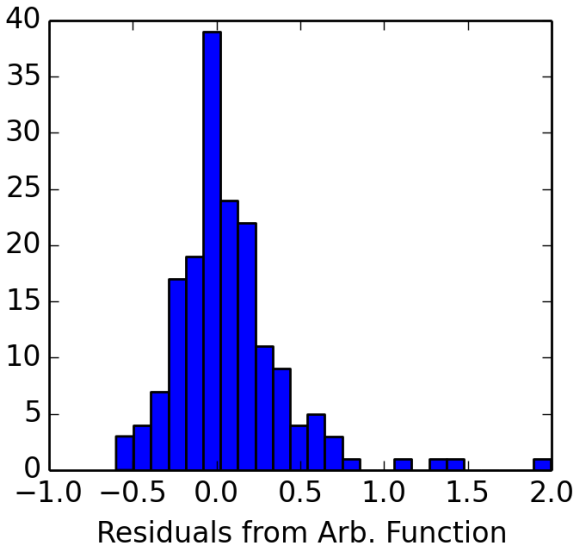
GalID	Type	RA	Dec	Sep (aresec)	DLR	Photo z	Photo z err	Spec z	g mag	r mag	i mag	z mag
76880	GALAXY	36.68183	-4.55496	1.884	1.04	0.182	0.041	0.3085	19.262	18.337	17.990	17.703
76881	GALAXY	36.68137	-4.55296	5.945	9.02	0.517	0.059	0.0000	24.266	22.980	22.613	22.442
76882	GALAXY	36.68322	-4.55709	10.338	10.95	0.464	0.110	0.0000	23.014	22.327	22.158	22.046

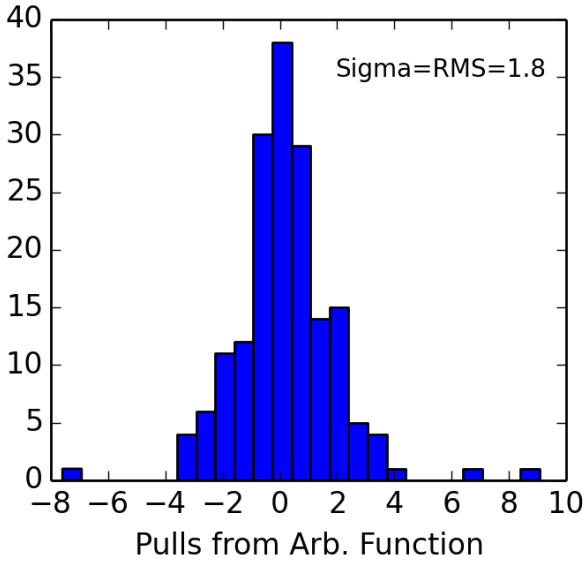
Backup Slides …



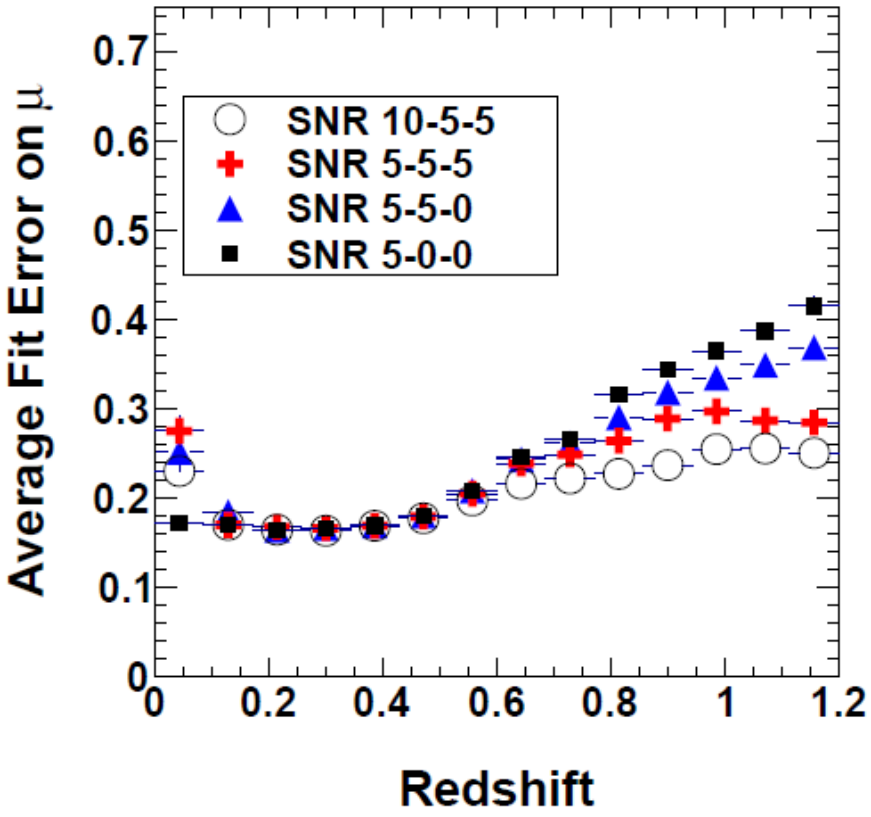
Residuals and Pulls from Arb. Function.

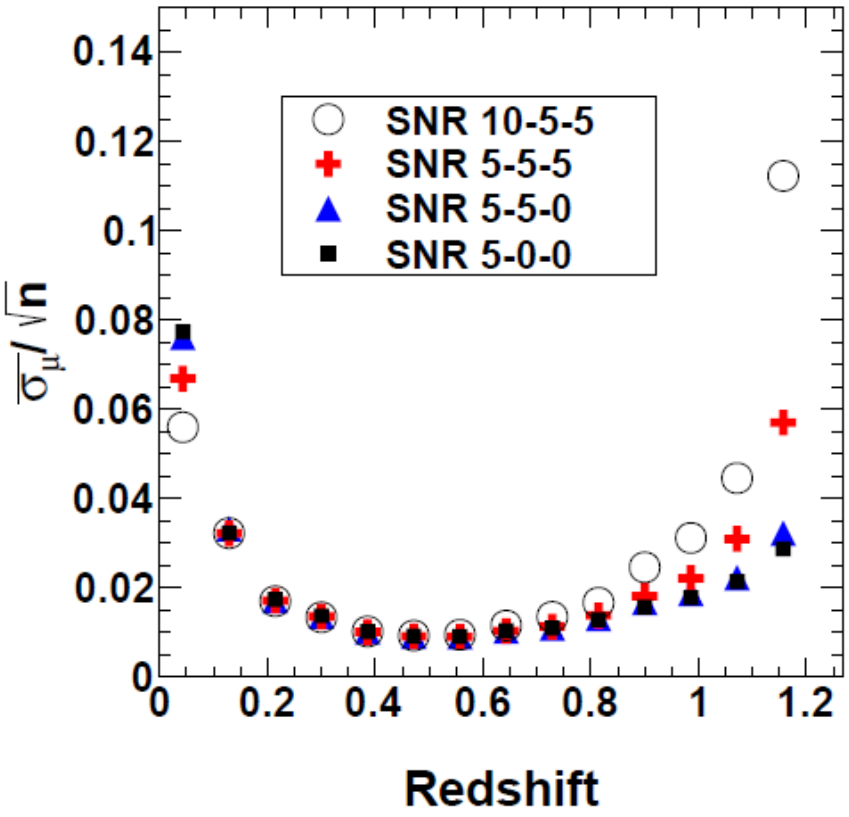
Tails partly due to expected ~5% core-collapse contamination, non-Gaussian core more likely due to photometry/calibration

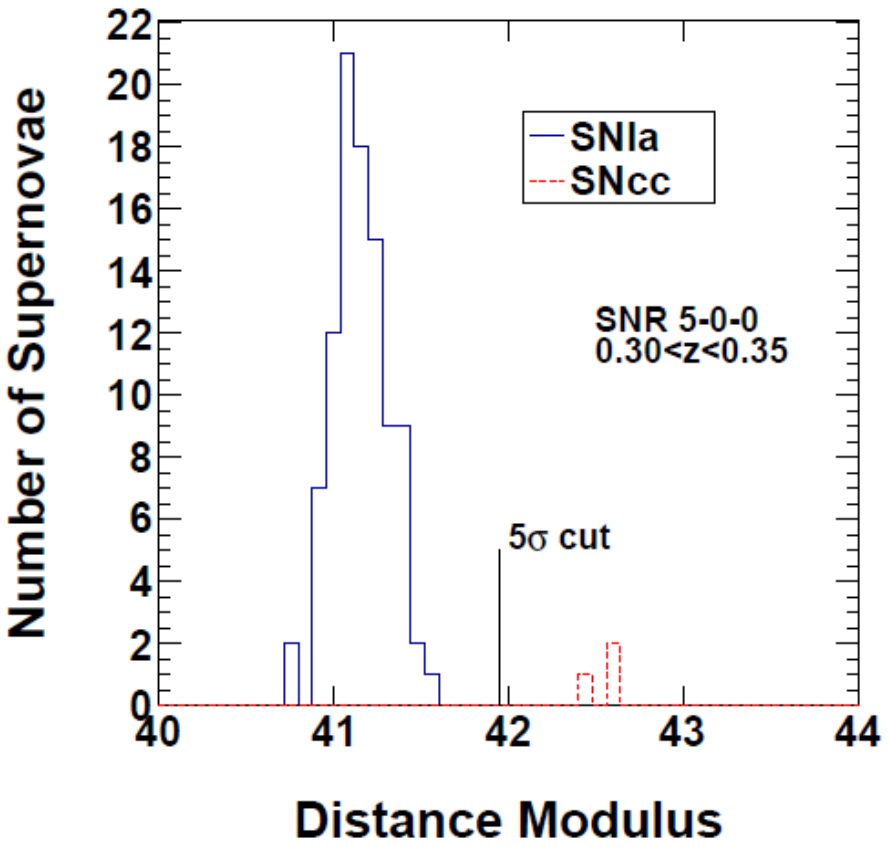


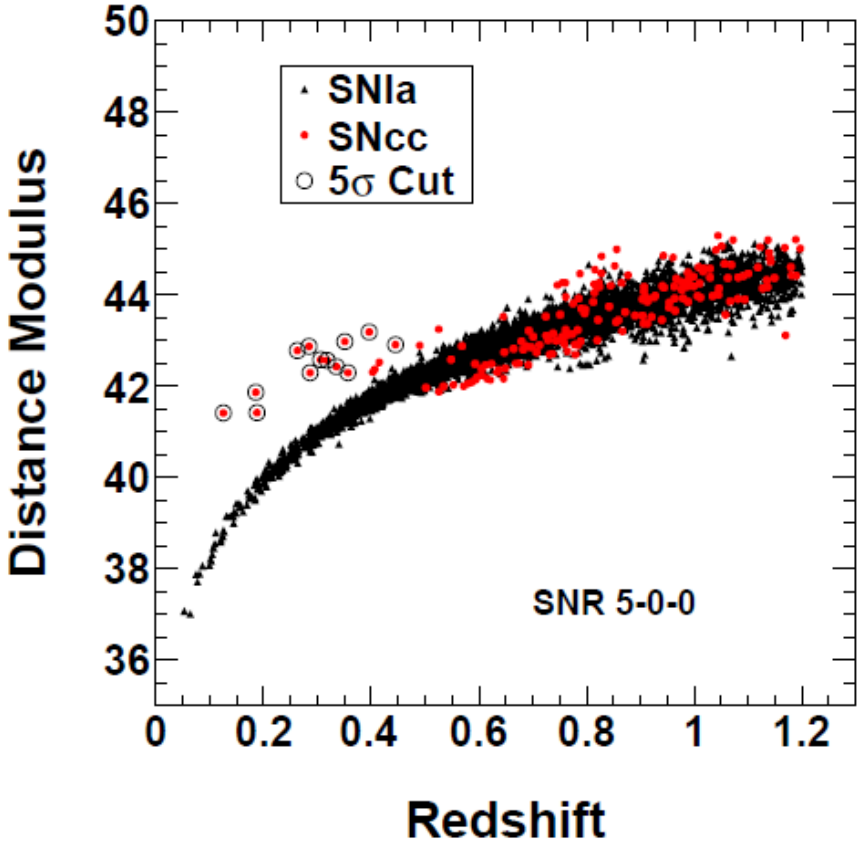


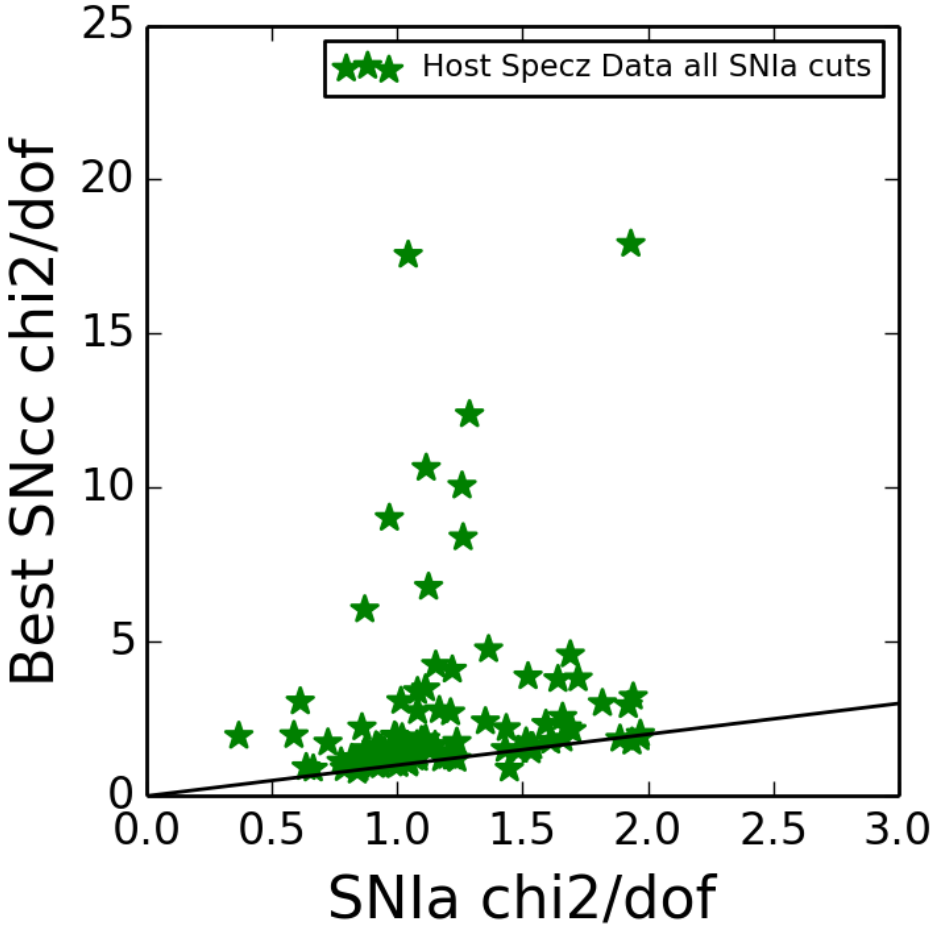
Stanwyck study of optimal cut in SNIa+SNcc simulation (each time tuning x1-c cut to maintain >96% purity)






Number of Supernovae
Distance Modulus
SNIa
SNcc
SNR 5-0-0
0.30<z<0.35
5σ cut
0
2
4
6
8
10
12
14
16
18
20
22
40
41
42
43
44


Distance Modulus
Redshift
SNIa
SNcc
5σ Cut
SNR 5-0-0
36
38
40
42
44
46
48
50
0
0.2
0.4
0.6
0.8
1
1.2


Host Specz Data all SNIa cuts
Best SNcc chi2/dof
SNIa chi2/dof
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0

How nested sampling works

1) draw random N (=50 now) points inside initial bounds for all parameters (50 total not 50 per fit parameter)

2) calculate likelihoods for all 50 and find the smallest likelihood, remove that point and draw an ellipsoid that covers the remaining 49 points.

3) throw random 50 points in that ellipse and find smallest likelihood and remove and draw new ellipsoid

4) repeat until converged

5) what is the convergence criteria? 2 parts: a) if the total weight, which is average likelihood x ellipsoid volume, has dropped consecutively for 1/6 of the total iterations, b) and if the total weight has dropped for at least 10 straight iterations to avoid small fluctuations.

Example: total iterations 1000, but for last 166 iterations the weight has dropped, then it has converged.