The Best Path to Constraining Dark Energy

Kaisey Mandel

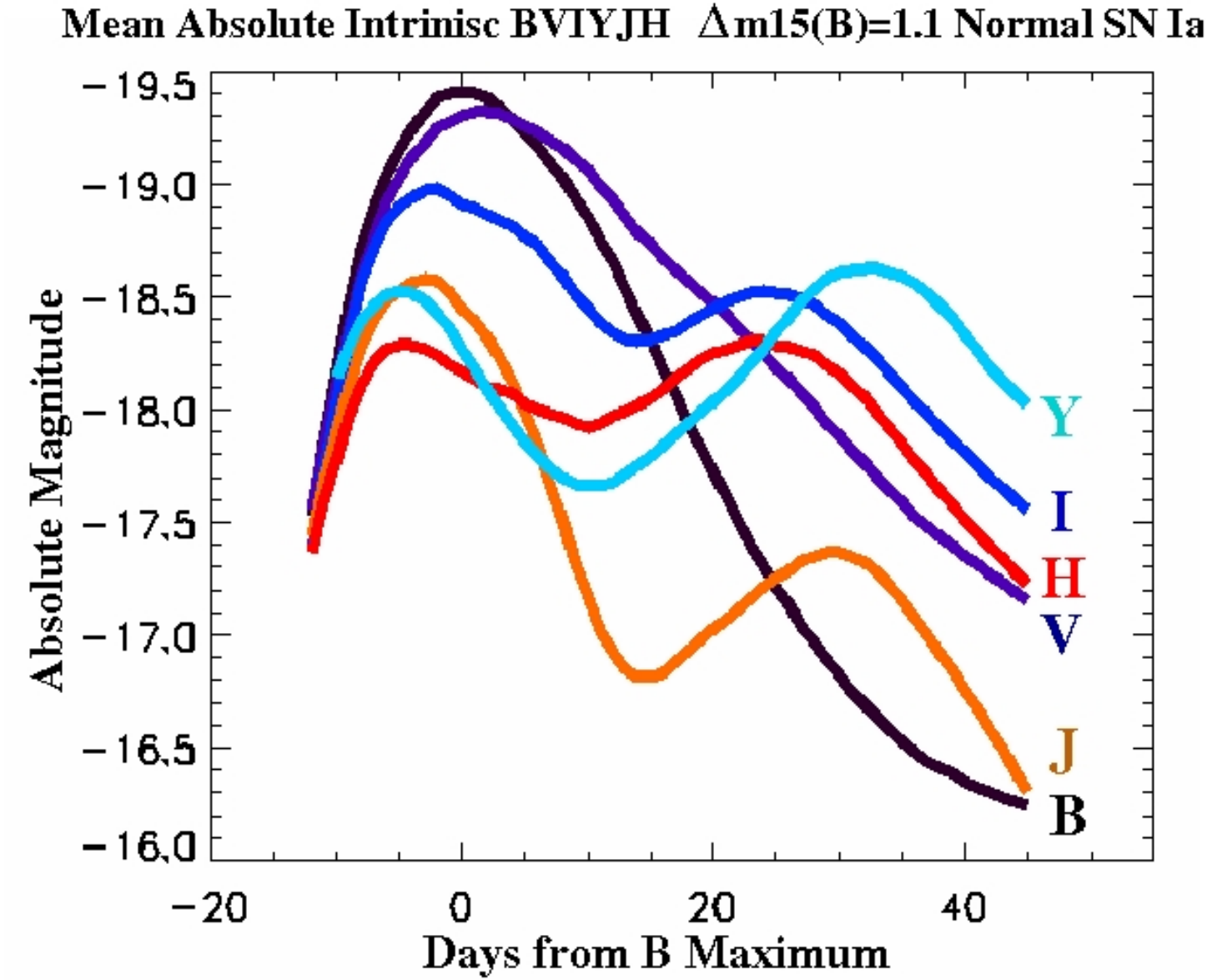
ApJ 731, 120 (2011)
arXiv1402.7079

See also
Andy Friedman et al.
CfaIR2
arXiv1408.0465

And 2012cg
Howie Marion et al.
Interacting SN Ia!
arXiv:1507.07261

Another Good reason:

Infrared Light Curves are Different



Evidence for a SN Ia companion!

SN 2012cg: EVIDENCE FOR INTERACTION BETWEEN A NORMAL TYPE Ia SUPERNOVA AND A NON-DEGENERATE BINARY COMPANION

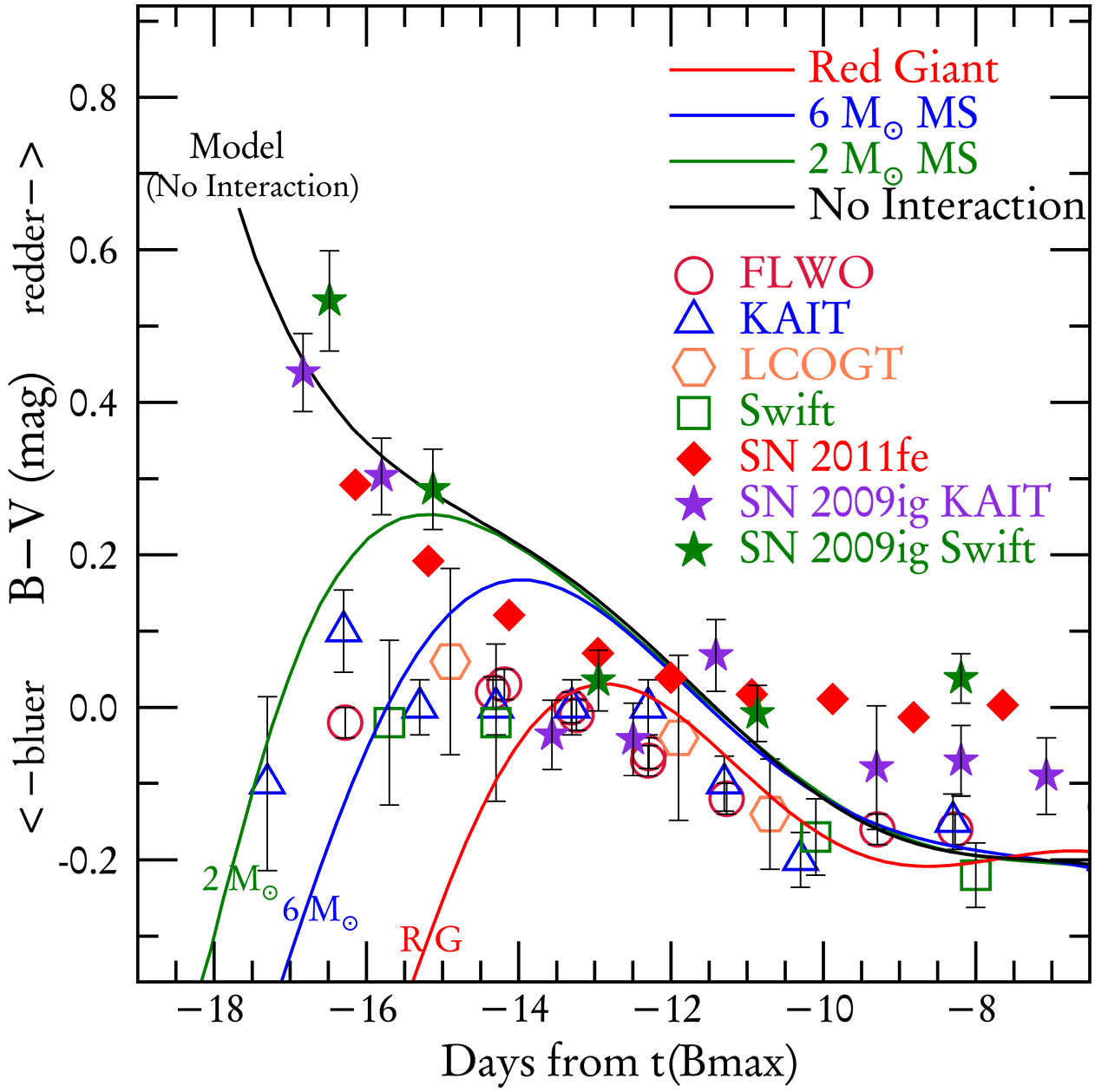
G. H. Marion[1,2], Peter J. Brown[3], Jozsef Vinkó[1,4], Jeffrey M. Silverman[1,5], David J. Sand[6], Peter Challis[2], Robert P. Kirshner[2], J. Craig Wheeler[1], Perry Berlind[2], Warren R. Brown[2], Michael L. Calkins[2], Yssavo Camacho[7,8], Govinda Dhungana[9], Ryan J. Foley[10,11], Andrew S. Friedman[12,2], Melissa L. Graham[13], D. Andrew Howell[14,15], Eric Y. Hsiao[16,17], Jonathan M. Irwin[2], Saurabh W. Jha[7], Robert Kehoe[9], Lucas M. Macri[3], Keiichi Maeda[17,18], Kaisey Mandel[2], Curtis McCully[14], Viraj Pandya[7,20], Kenneth J. Rines[21], Steven Wilhelmy[21] and Weikang Zheng[13]

Draft version August 2, 2015

ABSTRACT

We report evidence for excess blue light from the Type Ia supernova SN 2012cg at fifteen and sixteen days before maximum $B-$band brightness. The emission is consistent with predictions for the impact of the supernova on a non-degenerate binary companion. This is the first evidence for emission from a companion to a *normal* SN Ia. Sixteen days before maximum light, the $B-V$ color of SN 2012cg is 0.2 mag bluer than for other normal SN Ia. At later times, this supernova has a typical SN Ia light curve, with extinction-corrected $M_B = -19.62 \pm 0.02$ mag and $\Delta m_{15}(B) = 0.86 \pm 0.02$. Our data set is extensive, with photometry in 7 filters from 5 independent sources. Early spectra also show the effects of blue light, and high-velocity features are observed at early times. Near maximum, the spectra are normal with a silicon velocity $v_{Si} = -10,500$ km s^{-1}. Comparing the early data with models by Kasen (2010) favors a main-sequence companion of about 6 solar masses. It is possible that many other SN Ia have main-sequence companions that have eluded detection because the emission from the impact is fleeting and faint.

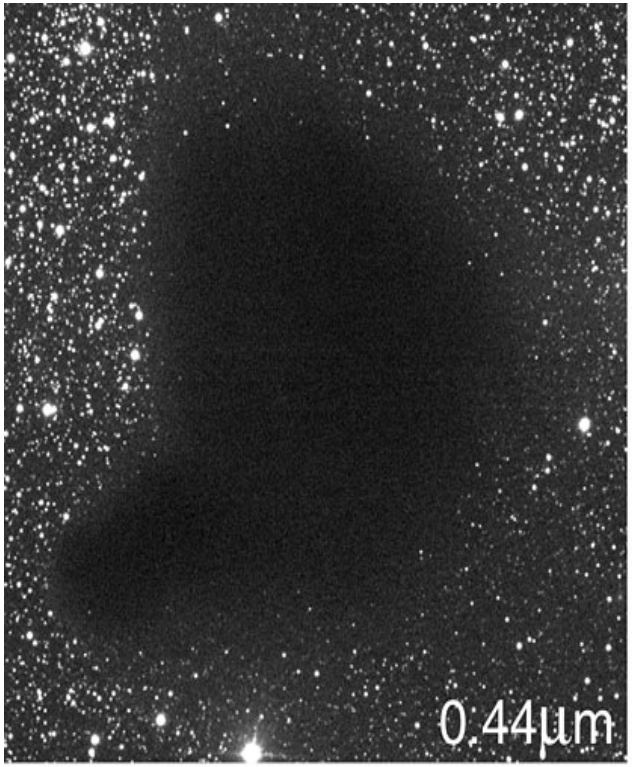
Subject headings:


Red Giant
6 M⊙ MS
2 M⊙ MS
No Interaction
Model
(No Interaction)
FLWO
KAIT
LCOGT
Swift
SN 2011fe
SN 2009ig KAIT
SN 2009ig Swift
2 M⊙
6 M⊙
RG
B−V (mag)
<−bluer redder−>
0.8
0.6
0.4
0.2
0.0
-0.2
−18
−16
−14
−12
−10
−8
Days from t(Bmax)


One good reason to observe SN Ia
in the infrared
NASA

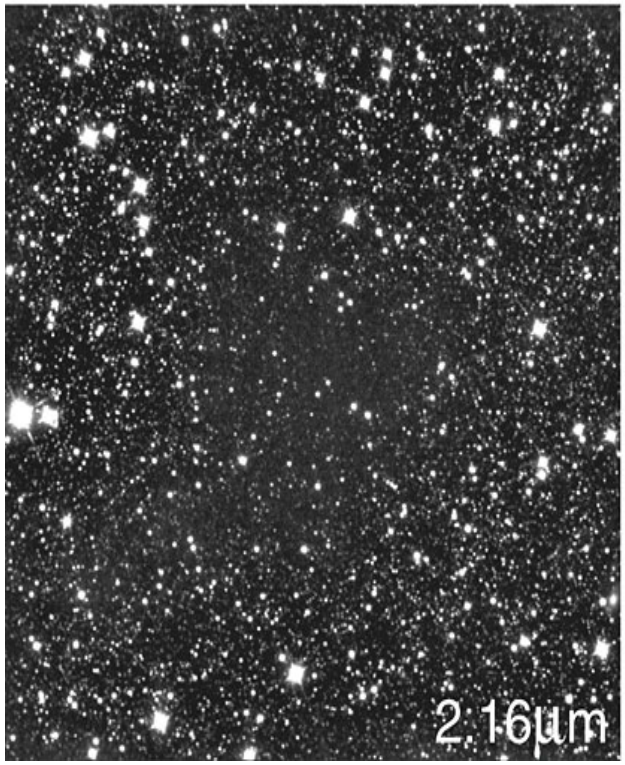
Seeing through the dirt

B



Seeing through the dirt

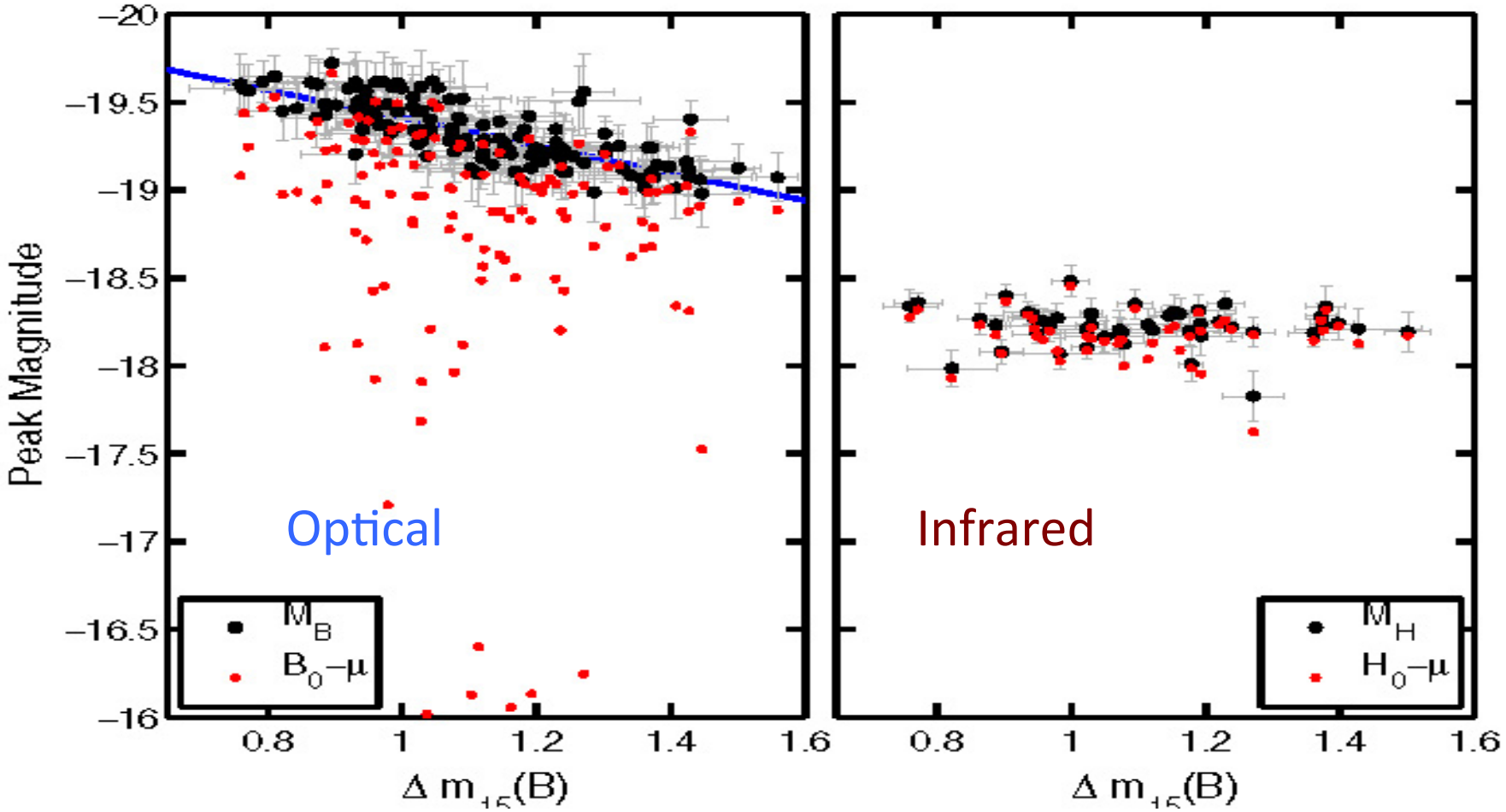
K



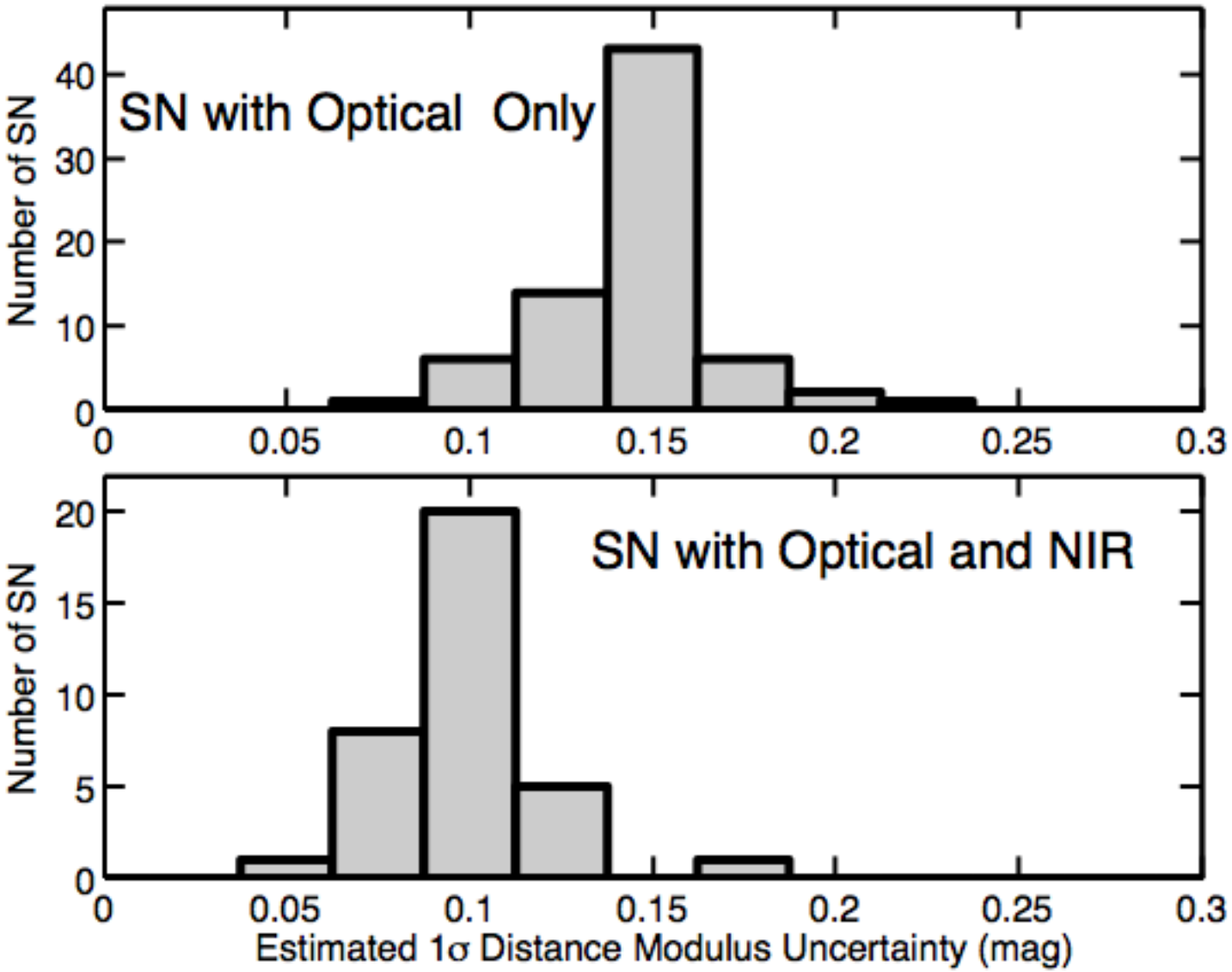
In the IR SN IA really are standard candles!

And there's less trouble with dust.

THE ASTROPHYSICAL JOURNAL, 731:120 (26pp), 2011 April 20



Could we get this 2x advantage for the high-z supernovae? RAISIN



SN IA in the IR = RAISIN

PanSTARRS: A Supernova Discovery Machine

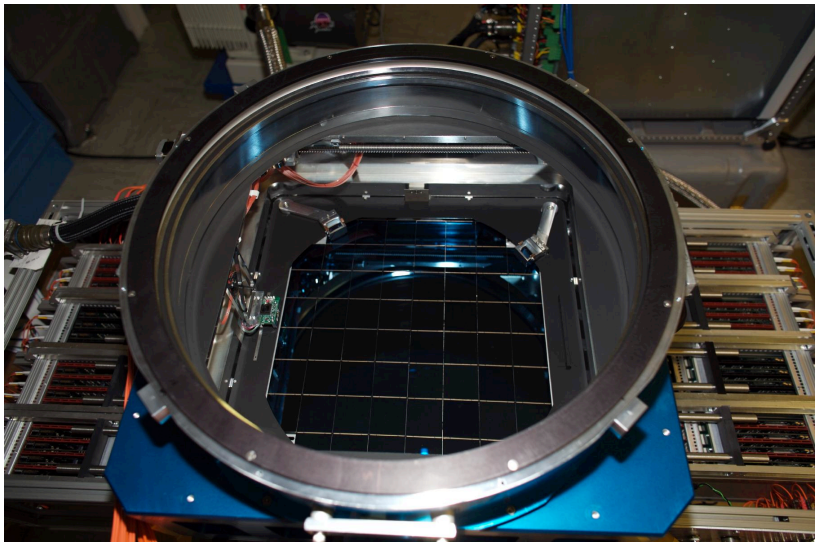
Medium-Deep Fields

Good light curves at z~0.4

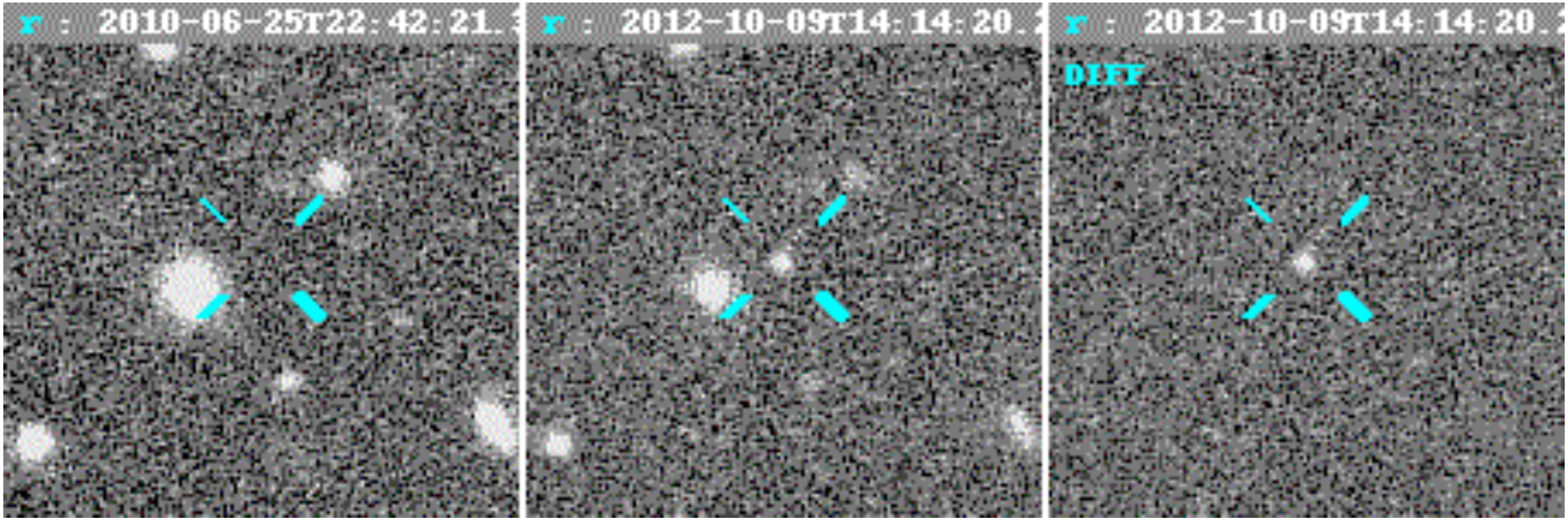
Every 4 days griz

7 square degrees 0.26”/pixel

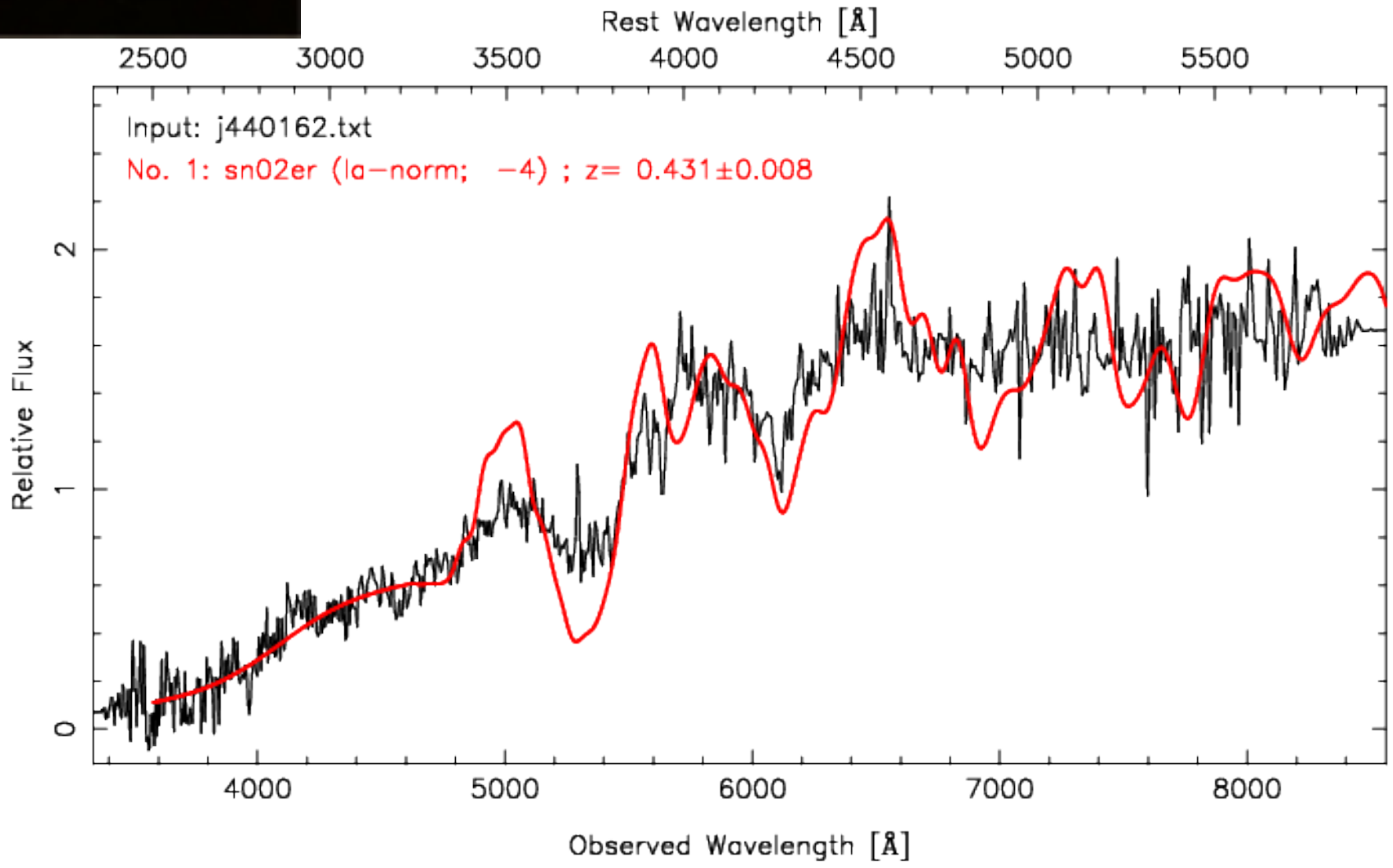
Dozens of supernova candidates every month!

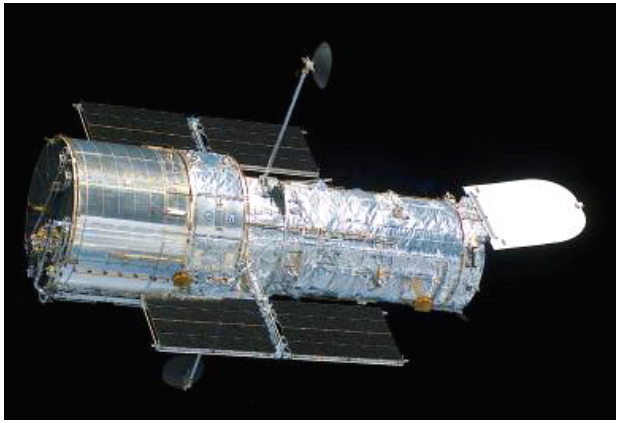


Find SN Ia with Pan-STARRS:
difference imaging with Harvard's Odyssey Cluster

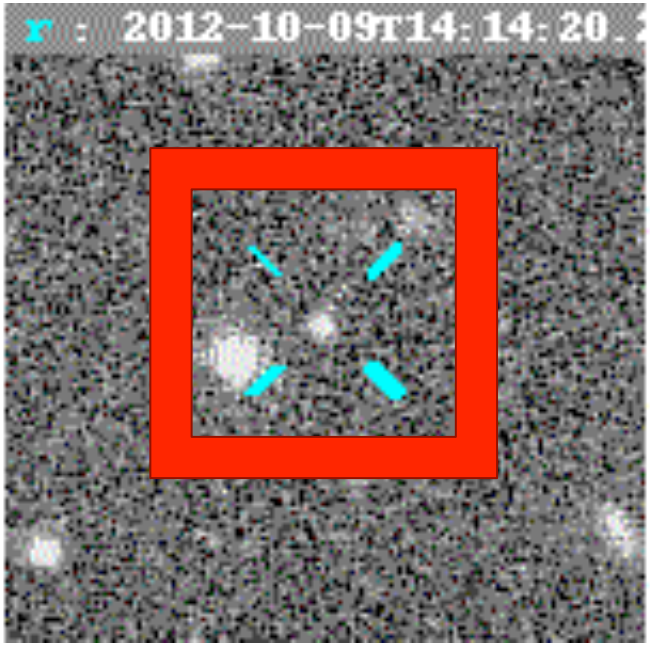


Get spectrum with MMT (or Magellan, Gemini or Keck) 358 Spectroscopic SN Ia

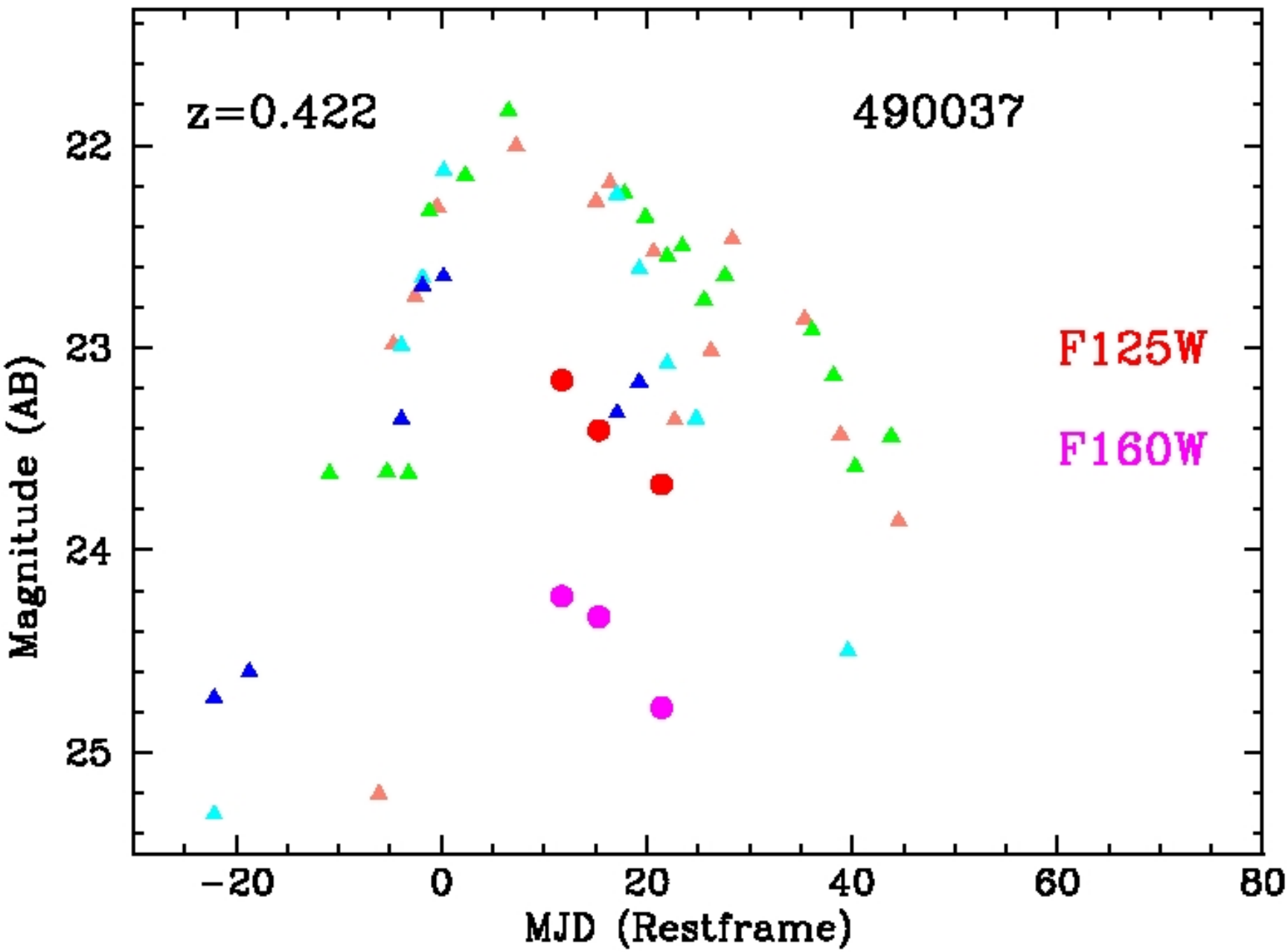


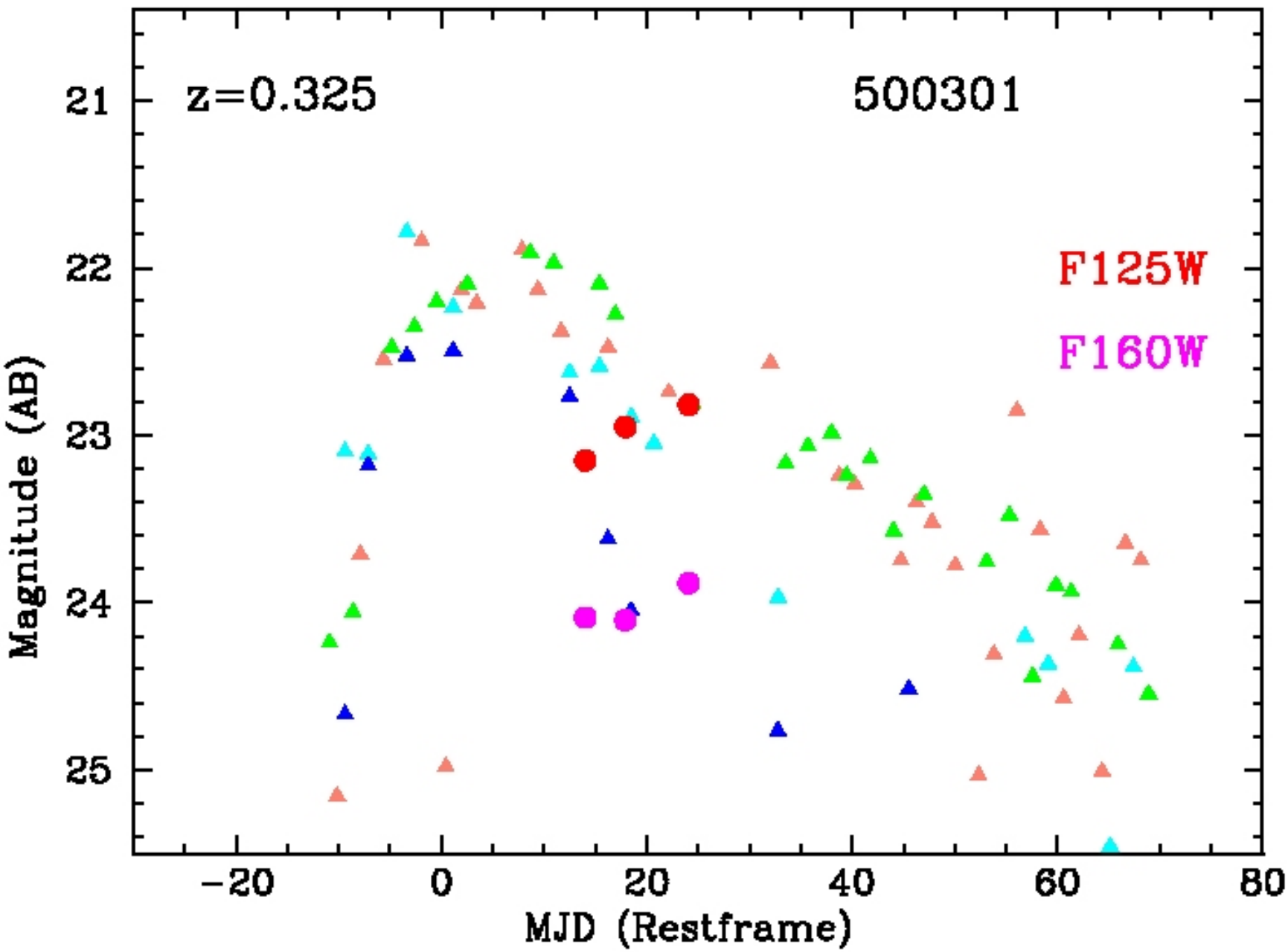


Get IR with WFC3

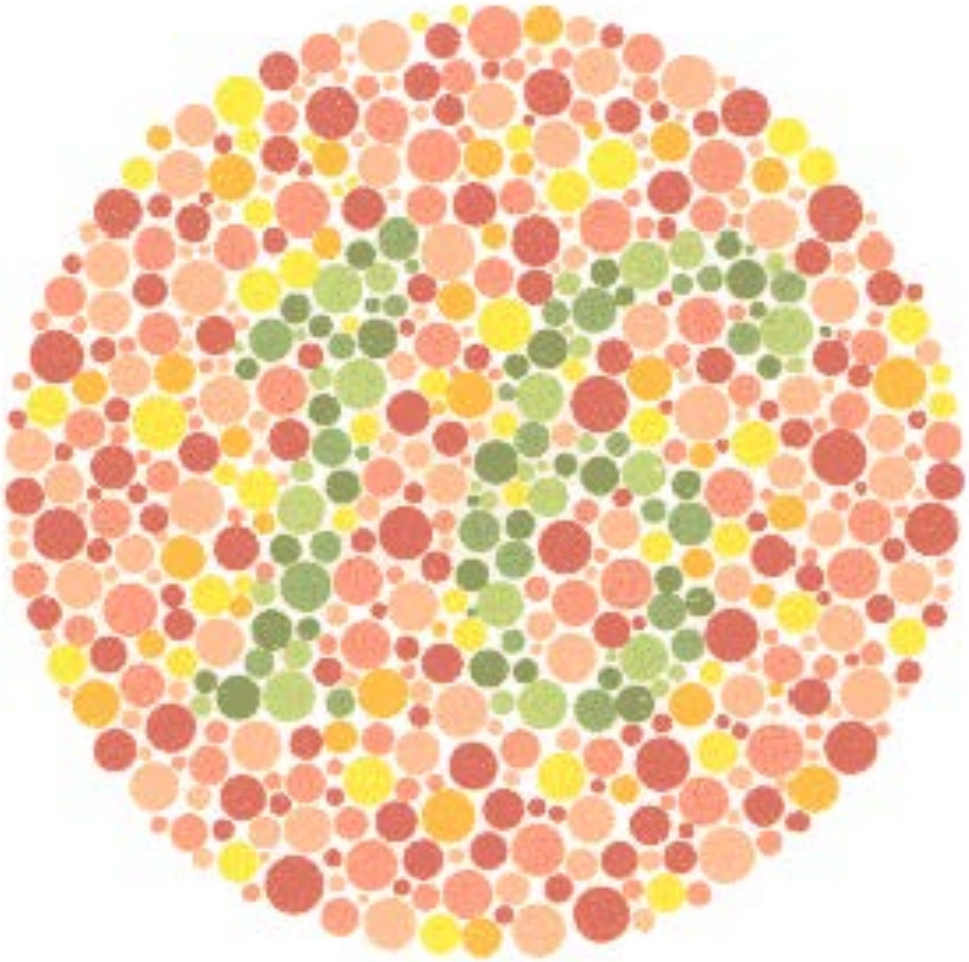


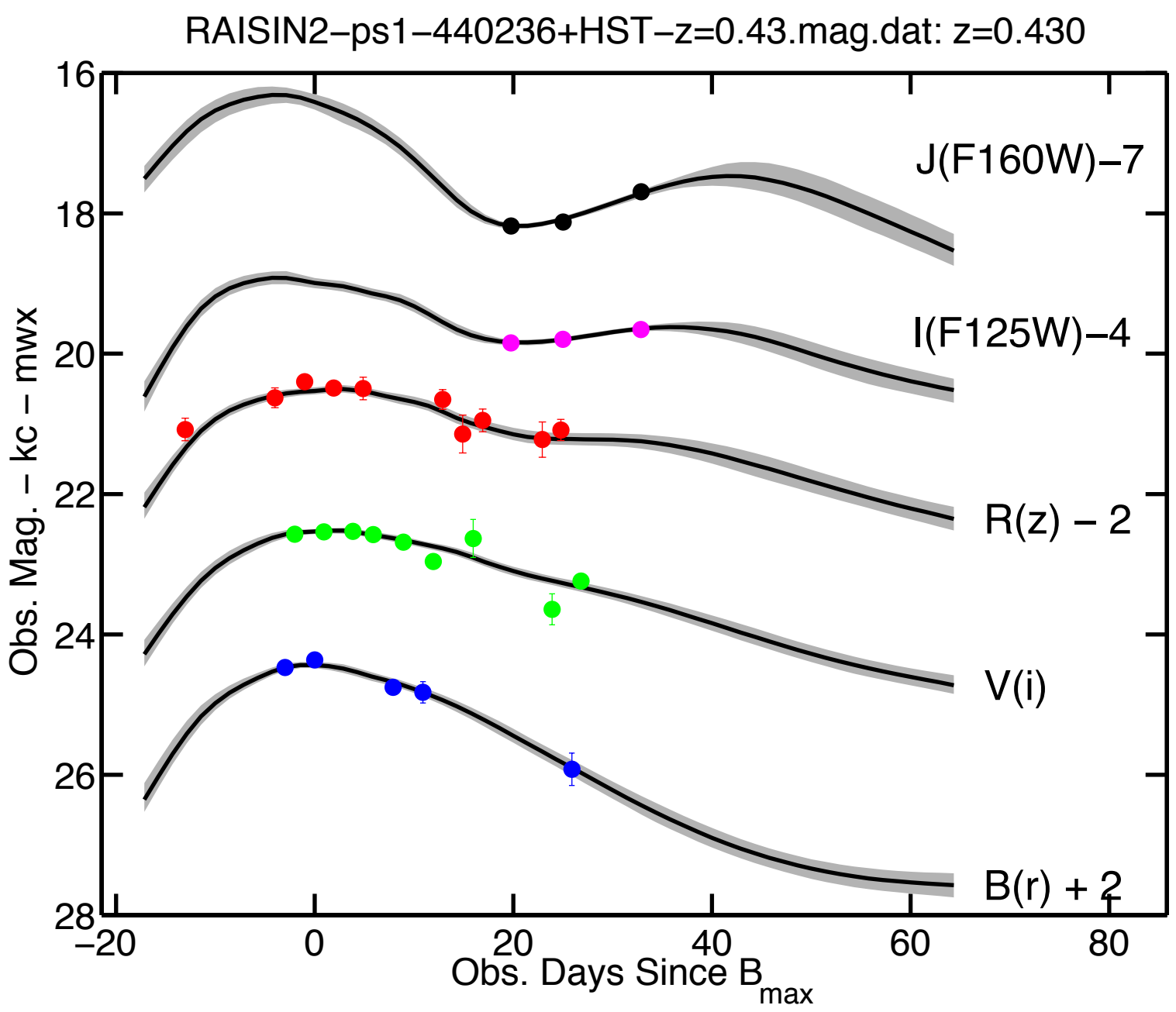
Goal: better knowledge of dark energy by avoiding systematic errors

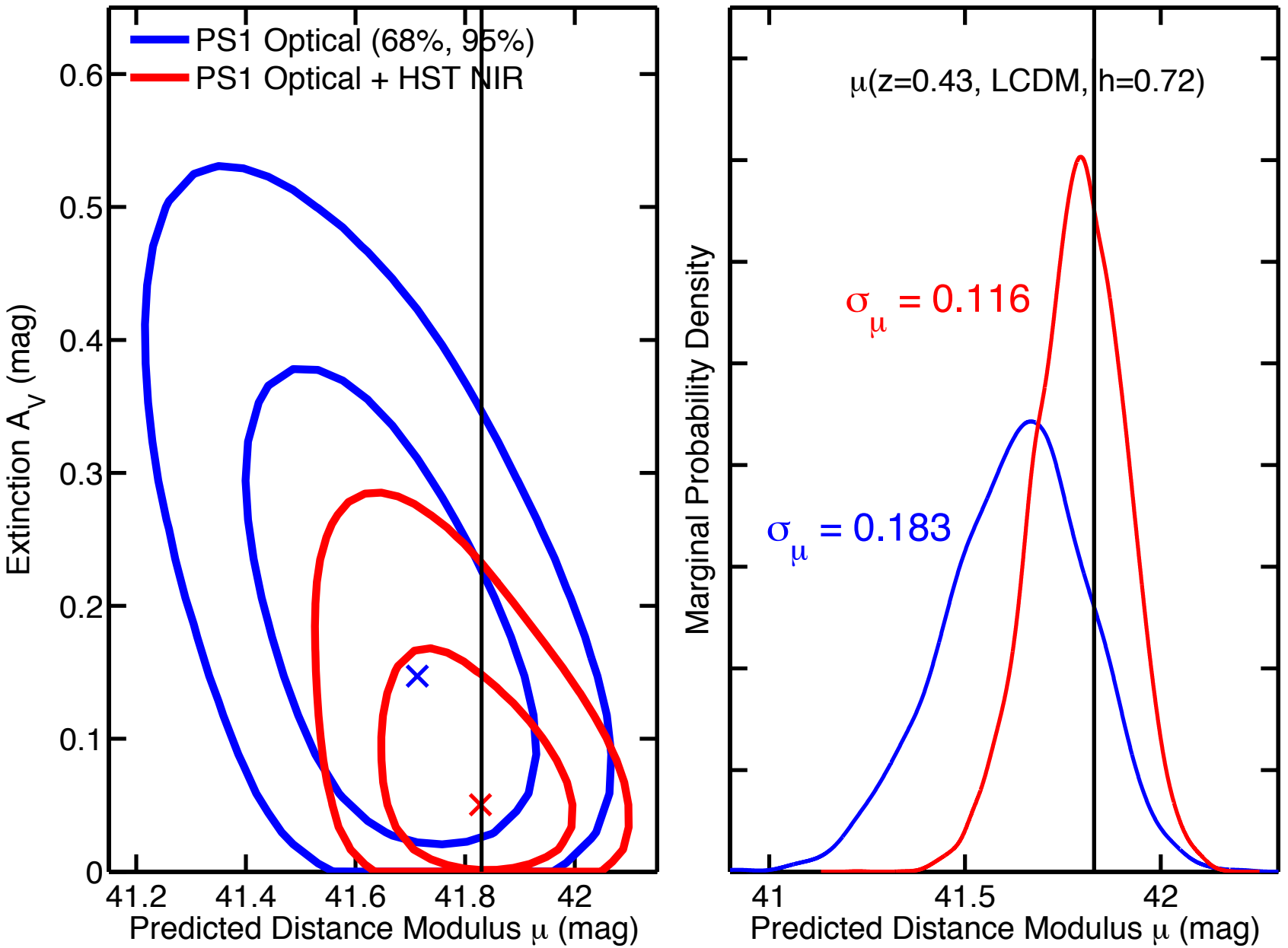

z=0.422
490037
F125W
F160W
Magnitude (AB)
MJD (Restframe)
22
23
24
25
−20
0
20
40
60
80


z=0.325
500301
F125W
F160W
Magnitude (AB)
MJD (Restframe)
21
22
23
24
25
−20
0
20
40
60
80

ISHIHARA COLOR BLINDNESS TEST PLATE 12

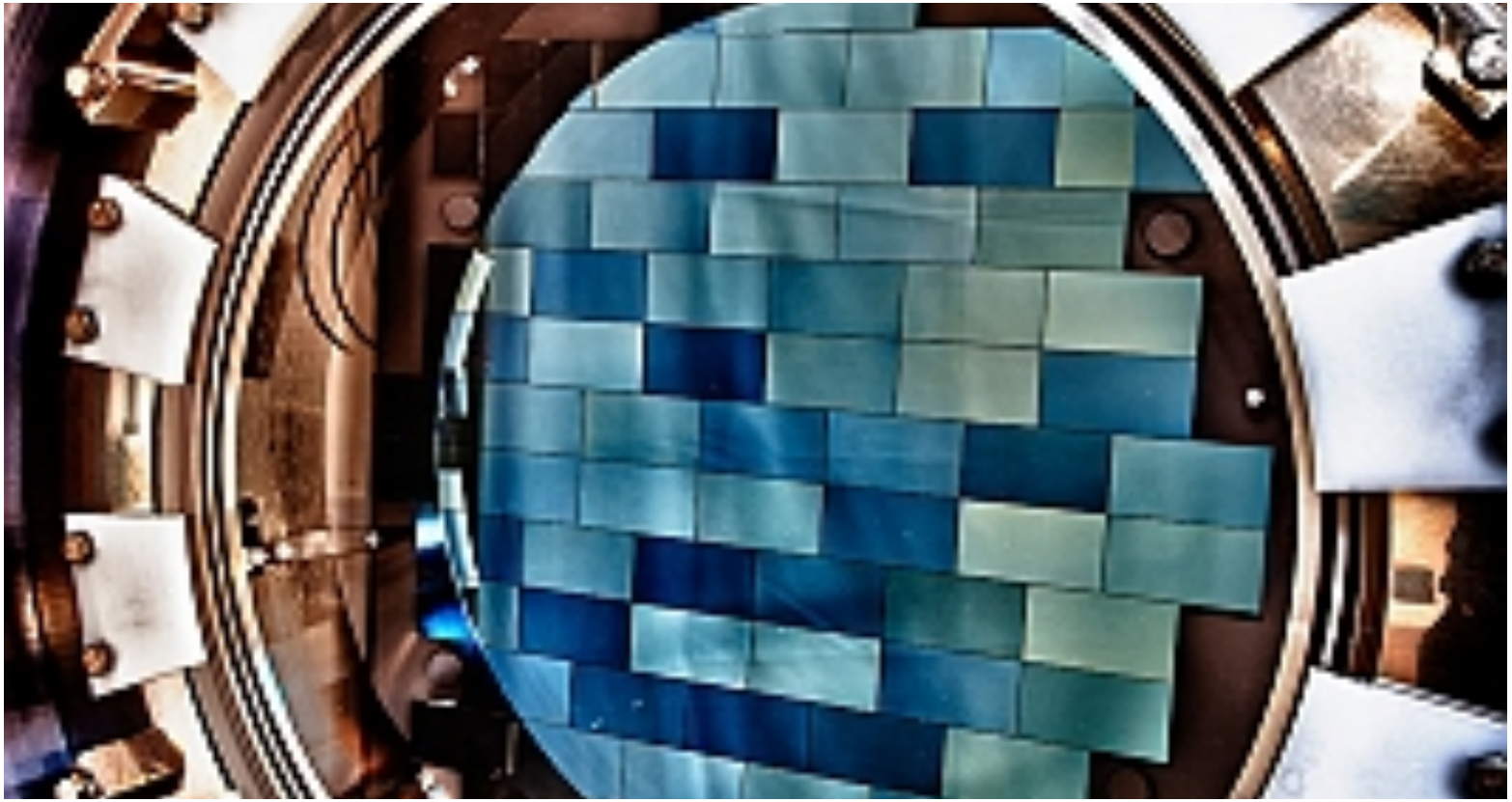


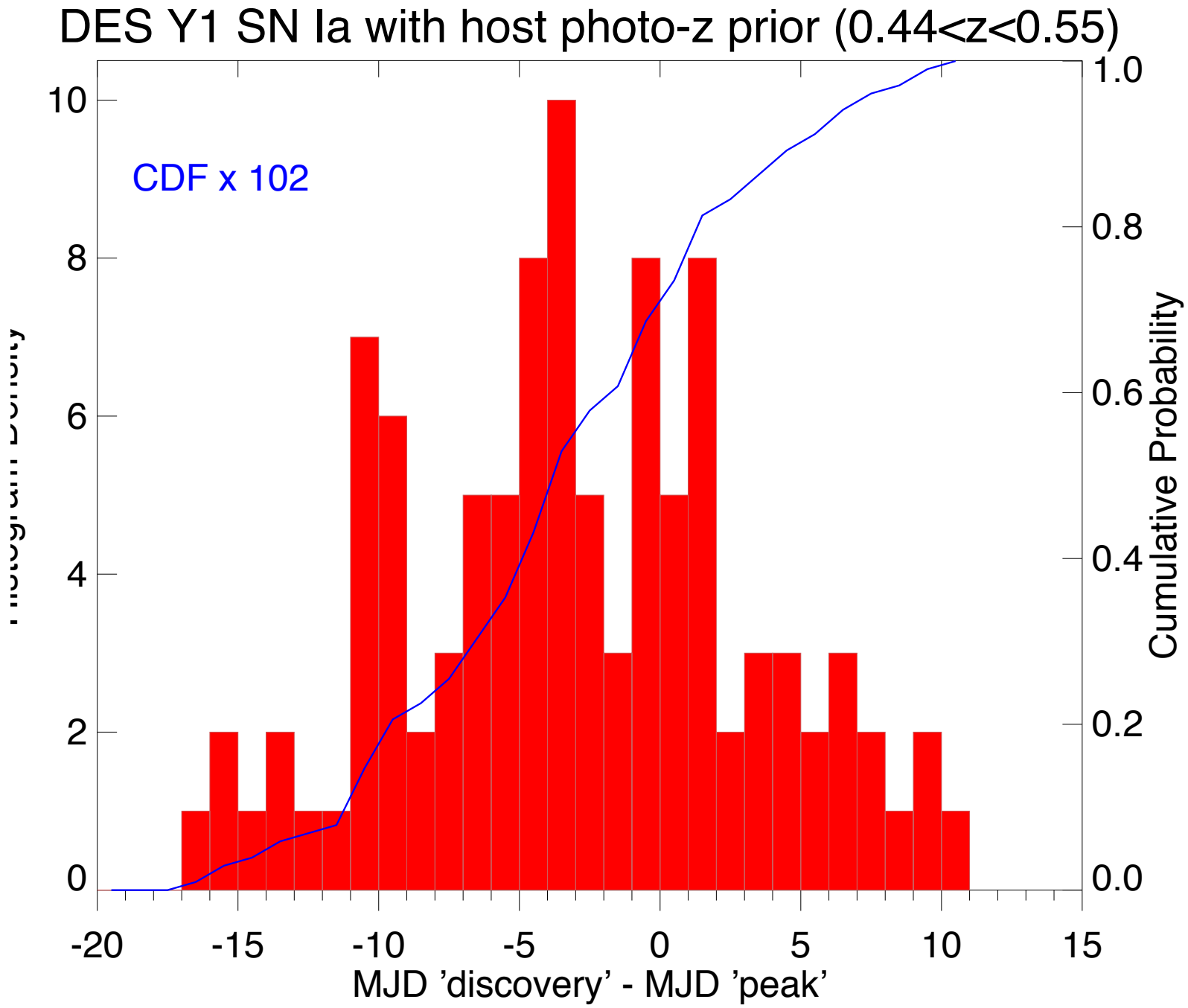

RAISIN2–ps1–440236+HST–z=0.43.mag.dat: z=0.430
J(F160W)–7
I(F125W)–4
R(z) – 2
V(i)
B(r) + 2
Obs. Mag. – kc – mwx
Obs. Days Since B max
16
18
20
22
24
26
28
–20
0
20
40
60
80

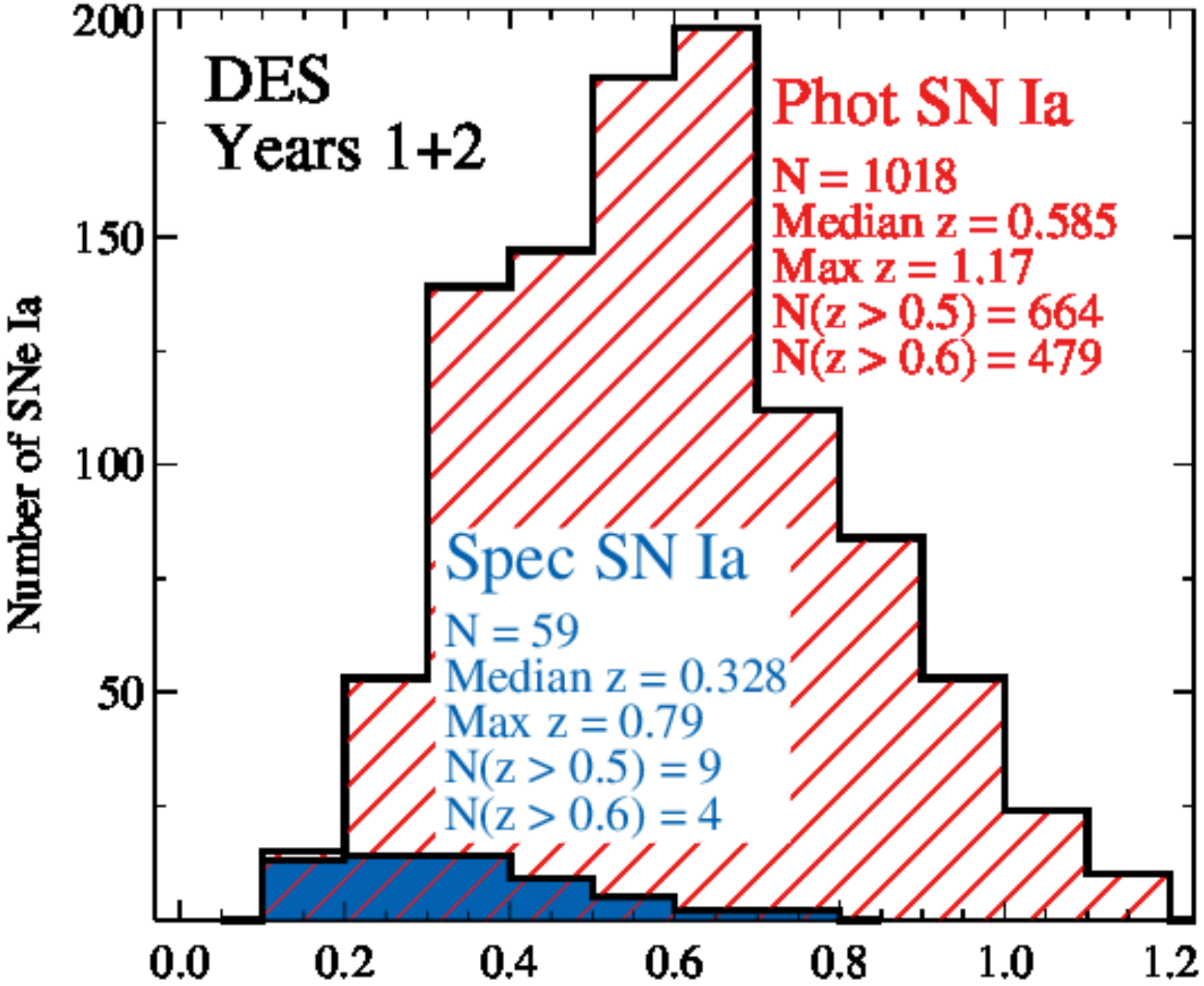

PS1 Optical (68%, 95%)
PS1 Optical + HST NIR
Extinction A_V (mag)
0.6
0.5
0.4
0.3
0.2
0.1
0
41.2
41.4
41.6
41.8
42
Predicted Distance Modulus μ (mag)
μ(z=0.43, LCDM, h=0.72)
Marginal Probability Density
σ_μ = 0.116
σ_μ = 0.183
41
41.5
42
Predicted Distance Modulus μ (mag)

Dark Energy Survey

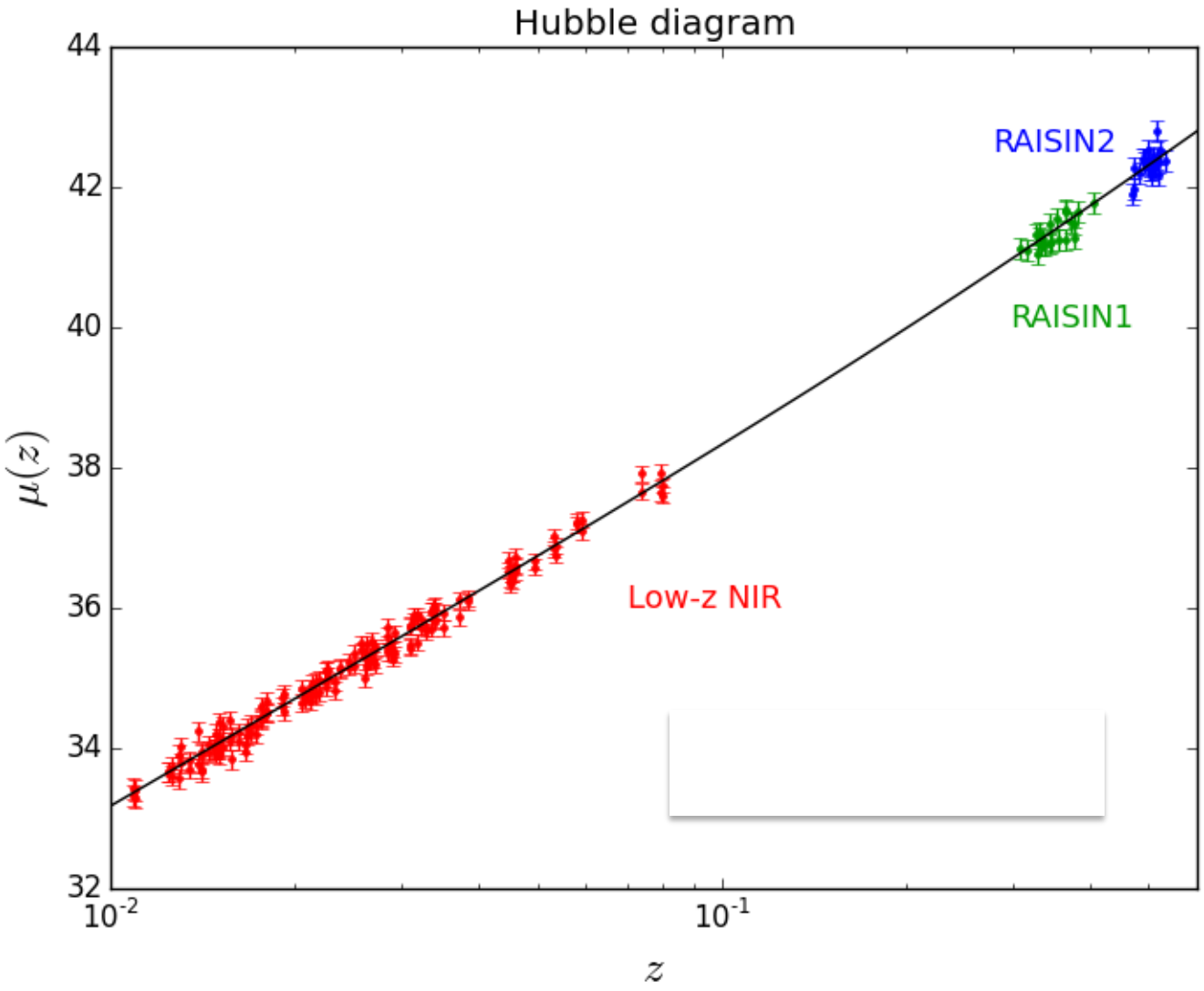
External Collaborators: Spectra of SN Ia with MMT & Magellan to demonstrate targets for RAISIN2
w/ Masao Sako and Bob Nichol and others…



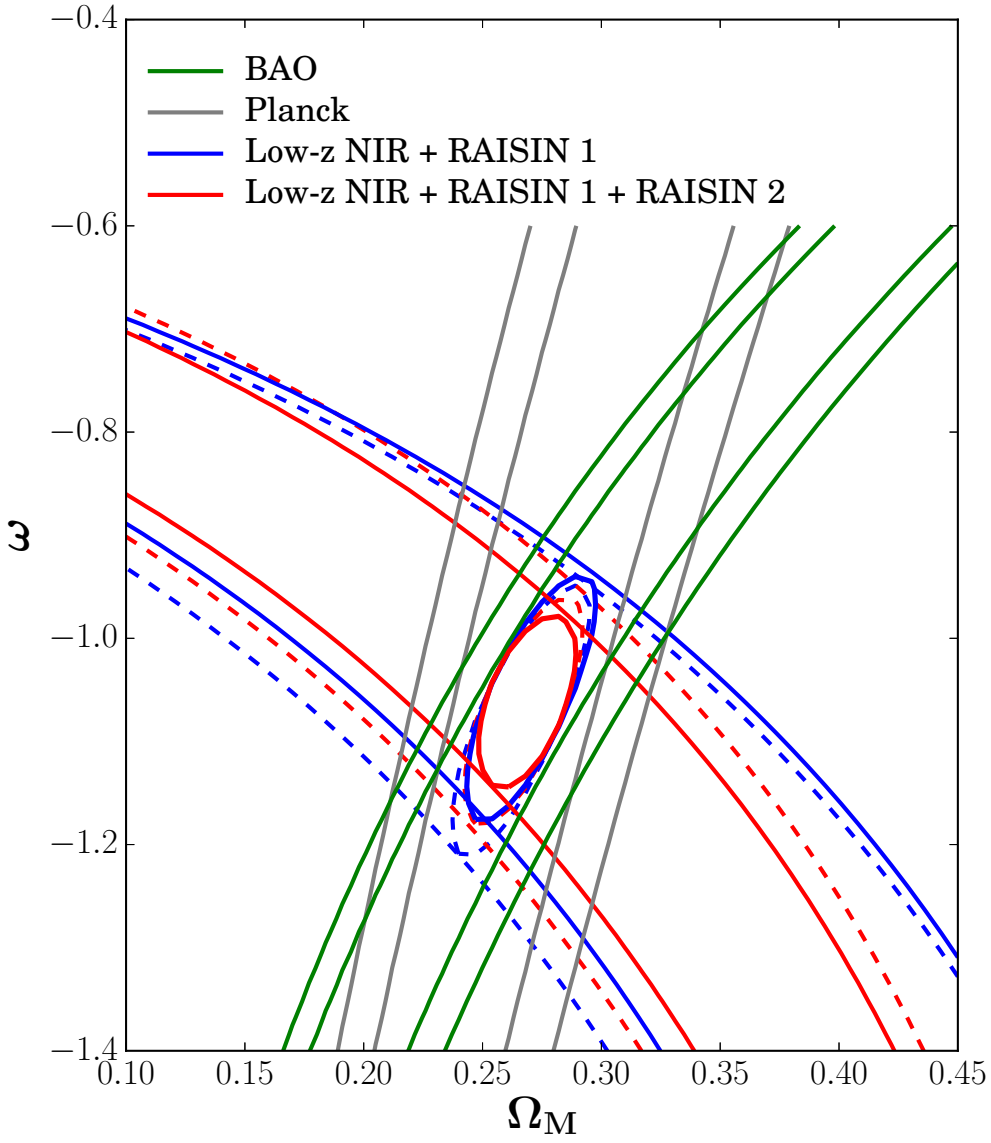

DES Y1 SN Ia with host photo-z prior (0.44<z<0.55)
CDF x 102
Cumulative Probability
MJD 'discovery' - MJD 'peak'
0
2
4
6
8
10
0.0
0.2
0.4
0.6
0.8
1.0
-20
-15
-10
-5
0
5
10
15


DES
Years 1+2
Phot SN Ia
N = 1018
Median z = 0.585
Max z = 1.17
N(z > 0.5) = 664
N(z > 0.6) = 479
Spec SN Ia
N = 59
Median z = 0.328
Max z = 0.79
N(z > 0.5) = 9
N(z > 0.6) = 4
Number of SNe Ia
200
150
100
50
0.0
0.2
0.4
0.6
0.8
1.0
1.2

Simulated Hubble Diagram



More RAISINS, thank you HST TAC!



Based on IR + Optical for 25 additional SN Ia at z~0.5 from DES

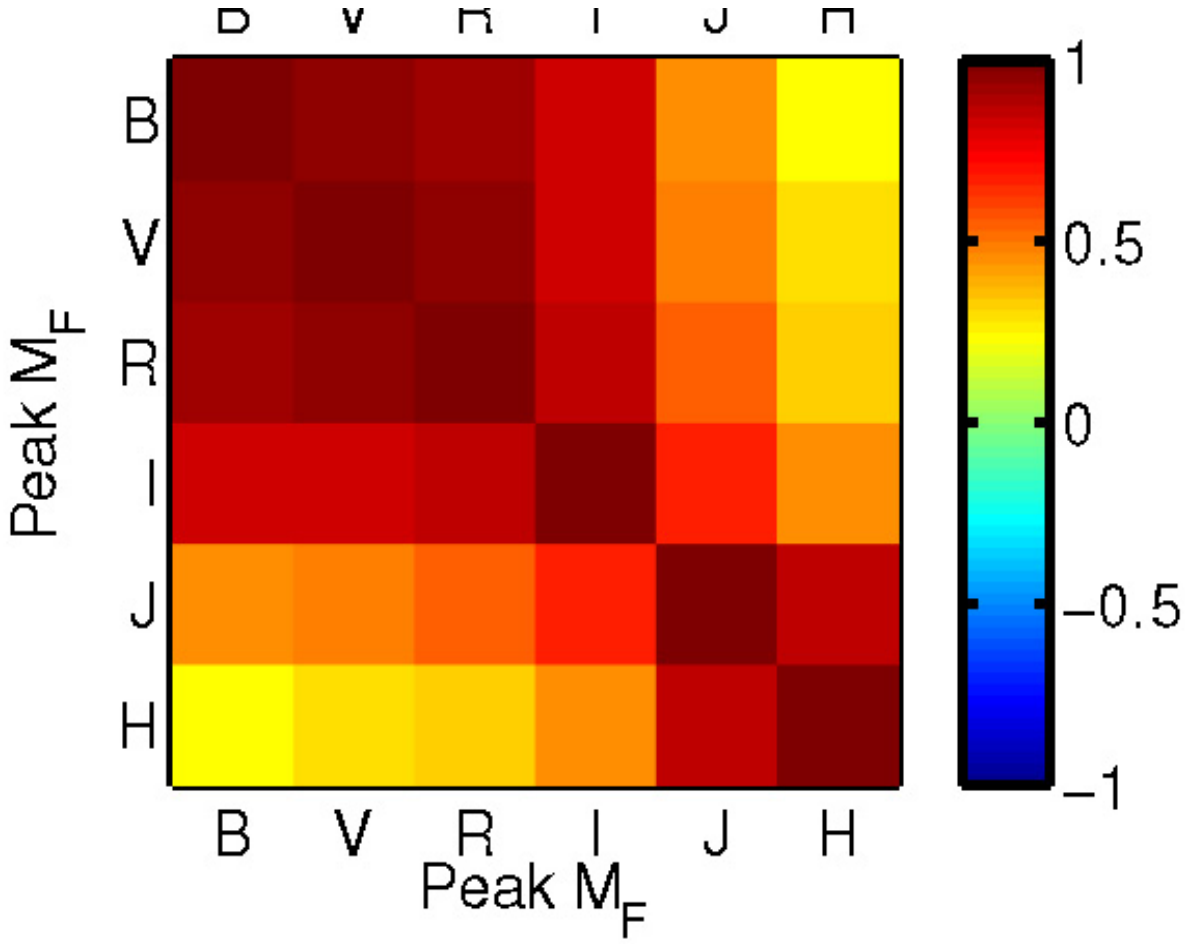
Low-z from CFAIR2 + Carnegie

Smaller systematic errors in distances based on good behavior of SN Ia in the IR at low-z & at cosmological distances

$\sigma \sim +/- 0.07$

(Betoule $\sigma = +/- 0.06$)

The IR is not strongly correlated with the Optical (and that is good!)



Two Questions

1> Why is it that supernovae that differ in their optical emission are less different in the IR? (Could mask differences in their origin… even for 2012cg…)

2> If you think you know the answer to #1, can you test it with spectrum synthesis in the NIR and comparison to the spectra compiled by the CSP & CfA?

Postdoc Available!

- Please see me
- Support from NSF and from the Gordon and Betty Moore foundation
- Located in Cambridge, MA or vicinity of Palo Alto, CA