WFIRST Status Report

CSPII Meeting

C. Baltay July 31, 2015

A Brief History so far…

- SNAP (Supernova Acceleration Probe) and JDEM (Joint Dark Energy Mission) were specifically Dark Energy Missions
- WFIRST (Wide Field Infra Red Space Tel) was invented by Decadal Survey (NWNH) and broadened in scope to include:
  - Dark Energy via Supernovae, BAO, and Weak lensing
  - Exoplanet search via gravitational lensing
  - Wide field infrared survey
- WFIRST-AFTA (Astrophysics Focused Telescope Asset) added
  - 2.4 m mirror
  - Coronograph for exoplanet studies

A Brief History so far…

- SNAP 2003-2008
  - Saul Perlmutter PI
  - 2 m mirror
- JDEM Science Definition Team 2005
  - Chaired by Chuck Bennett, Kim Griest
- JDEM Science Coordination Group 2008-2009
  - Chaired by Neil Gehrels
  - 1.5 m mirror
- JDEM Intermediate Science Working Group 2009-2010
  - Chaired by Warren Moos, Charlie Baltay
  - 1.1 m mirror, Probe class mission (~0.8 B$)
- WFIRST Science Definition Team 2010-2012
  - Chaired by Jim Green, Paul Schechter
  - 1.1-1.3 m mirror
- WFIRST-AFTA Science Definition Team 2012-2015
  - Chaired by David Spergel, Neil Gehrels
  - 2.4 m mirror, NASA Flagship Mission~1.6 B$

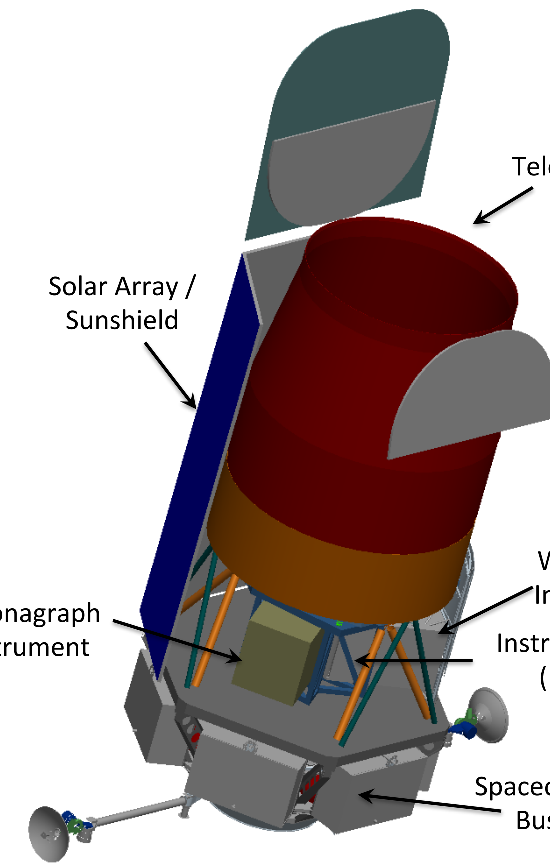
Next Steps

- NASA says they have a "funding wedge" opening in FY 17 (i.e. Oct 1 2016) to start construction
- Declared the work of the Science Definition Team completed and disband it this summer.
- Call for proposals to form "Science Teams"
  - will operate for the next 5 years
  - with some modest funding
  - Expect seven to nine teams (Supernova, BAO, Weak Lensing, Exoplanets, Coronograph, Infrared survey, etc)

WFIRST –AFTA Baseline

Assume 6 months for Supernova Survey

- 2.4 m on axis mirror
- Imager with
  - 18 H4RG detectors (6x3)
  - 0.11 "/pixel 4Kx4K
  - 0.28 sq degrees
- Filter wheel with
  - 4 filters.
- IFU Integral Field Spectrometer
  - R = 75
- 2.0 micron λ cutoff
- Coronograph



Supernova Survey with the 2.4 m Mirror

A more detailed presentation of the Feb 15, 2013 Survey

C.Baltay and S. Perlmutter

December 15, 2014

Supernova Survey Strategy

- Use the 0.28 sq degree imager to discover supernovae in two filter bands
- Use IFU spectra to type supernova and get redshift, S/N=6 per resolution element ,expect to need spectra of two candidates for one good Type 1a
- Use IFU spectra to get light curves with roughly a 5 day rest frame cadence, 8 spectra on light curve (including the typing and the deep spectra) from -10 rest frame days before peak to +25 rest frame days past peak, S/N = 3.75 per resolution element (S/N = 15 per synthetic filter band)
- 1 reference spectrum after supernova has faded, for galaxy subtraction with S/N = 6 per resolution element
- 1 deep spectrum near peak to confirm Sne Ia classification,for subtyping, spectral feature ratios etc. with S/N = 10 per resolution element

Survey Cadence

- Plan to run supernova survey for 6 months spread over 2 years calendar time.
- Plan on supernova survey with a 5 day cadence, 30 hours per visit
- (2*365/5)*30 hrs/24 = 182 days = 6 months

Supernova Survey Strategy

- Do a 3 tier survey, scanning different areas of sky for different redshift ranges

Tier	Z max	Sky Area Sq Degrees
1	0.4	27.44
2	0.8	8.96
3	1.7	5.04

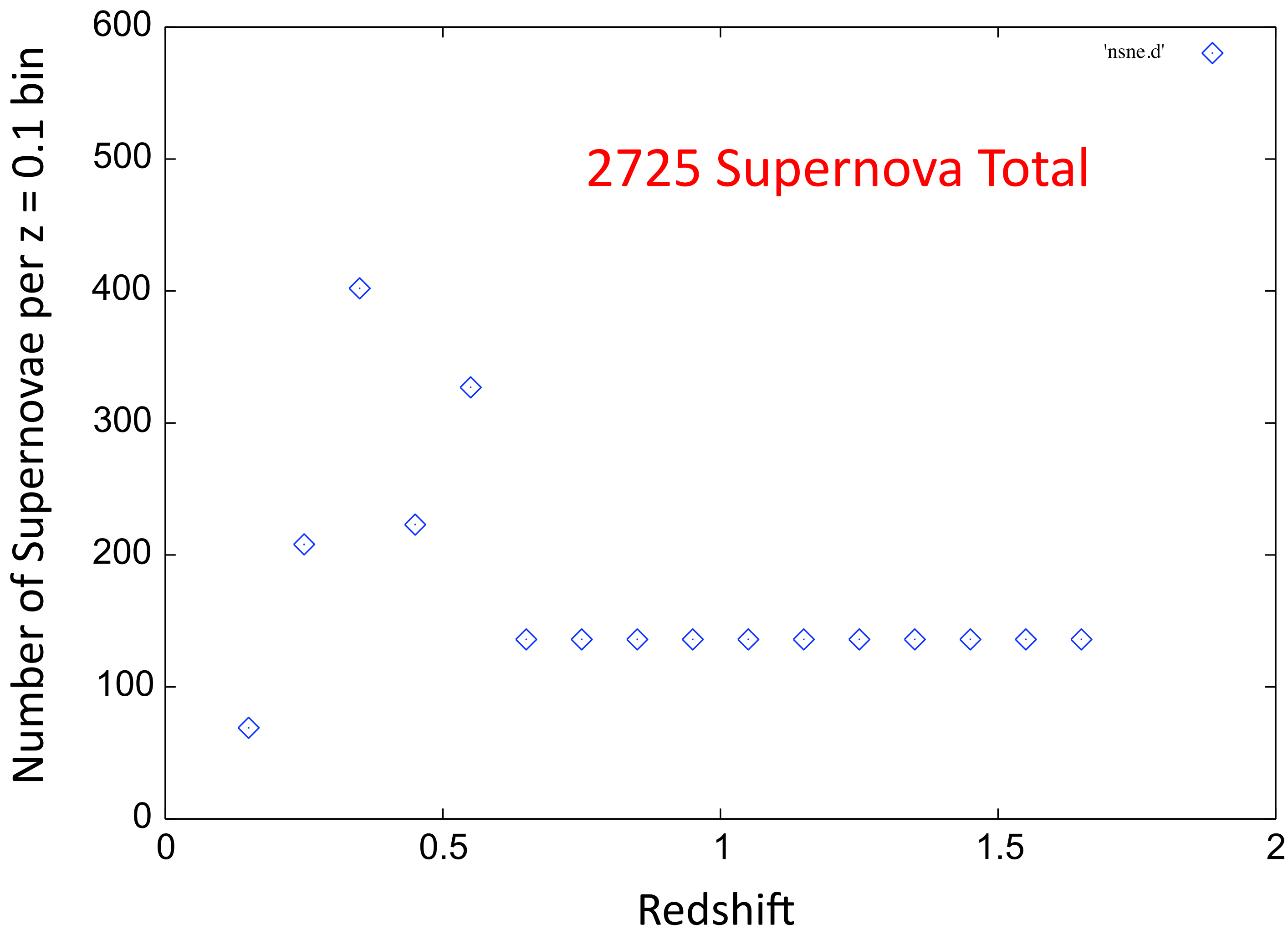
Error Model Used

- Statistical errors
  - Measurement error σ_{meas} = 8 % with S/N = 15 spectra per filter band 2 and one deep spectrum near peak with S/N=47 per filter band
  - Intrinsic spread σ_{int} = 8 % with IFU deep spectra
  - Gravitational lensing error $\sigma_{lens} = 0.07*z$
  - Statistical $\sigma_{stat} = [\sigma_{meas}^2 + \sigma_{int}^2 + \sigma_{lens}^2]^{½}/\sqrt{n}$
- Systematic errors
  - Systematic error $\sigma_{sys} = 0.01(1+z)/1.8$
- Total error per z bin
  - Total error $\sigma_{tot} = [\sigma_{stat}^2 + \sigma_{sys}^2]^{½}$

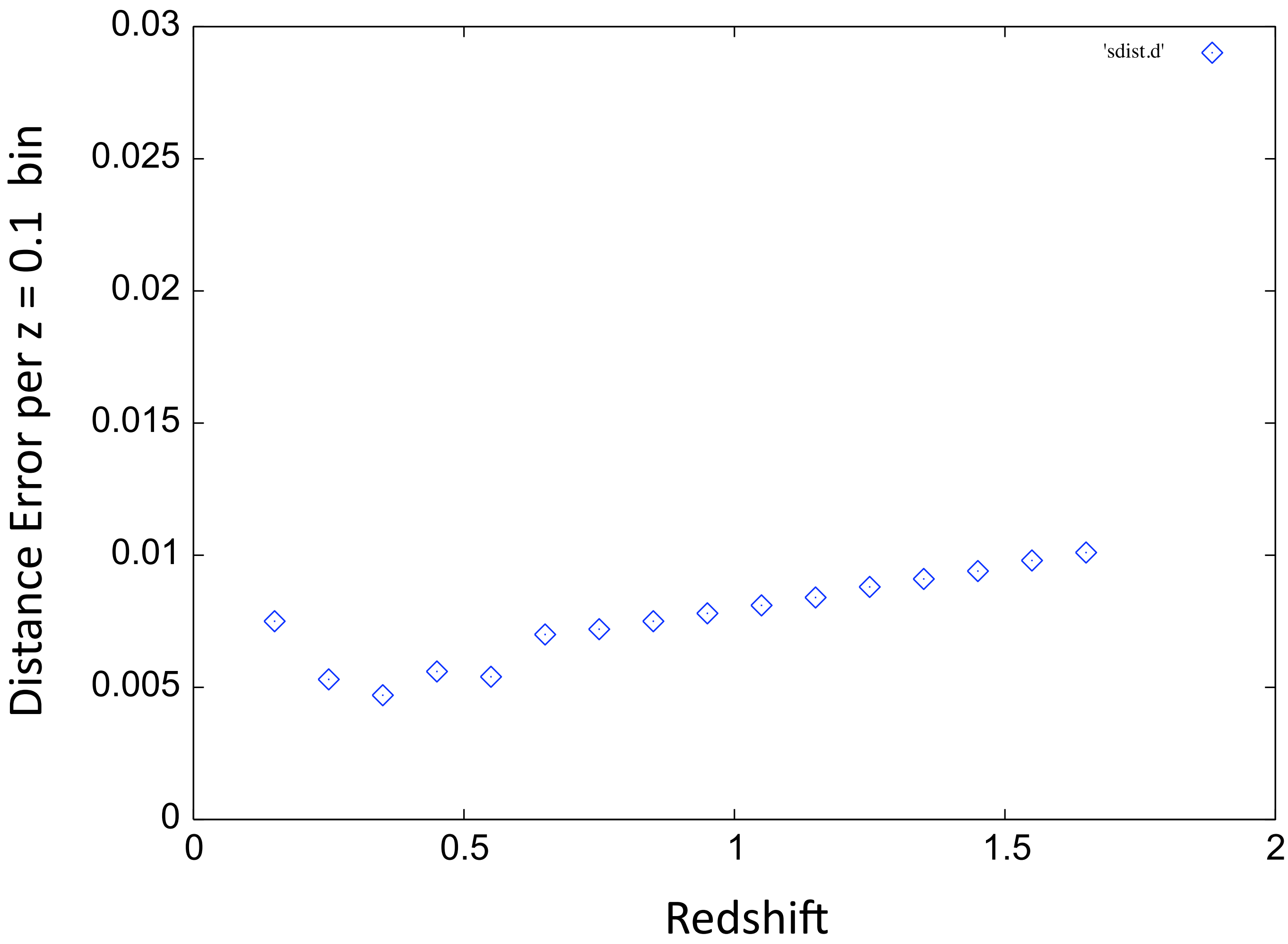
2.4m IFU Deep, Spectro Lightcurves, FoM=312

<Z>	SNe Low z	SNe Mid z	SNe Hi z	SNe Total	σ_{stat}	$\sigma/\sqrt{N}$	σ_{sys}	σ_{tot}
0.15	46	14	8	69	0.114	0.014	0.006	0.015
0.25	139	44	24	208	0.114	0.008	0.007	0.011
0.35	269	86	47	402	0.116	0.006	0.008	0.009
0.45	0	144	78	223	0.117	0.008	0.008	0.011
0.55	0	211	115	327	0.120	0.007	0.009	0.011
0.65	0	280	152	136	0.122	0.010	0.009	0.014
0.75	0	349	189	136	0.125	0.011	0.010	0.014
0.85	0	0	233	136	0.128	0.011	0.010	0.015
0.95	0	0	270	136	0.131	0.011	0.011	0.016
1.05	0	0	297	136	0.135	0.012	0.011	0.016
1.15	0	0	311	136	0.139	0.012	0.012	0.017
1.25	0	0	313	136	0.143	0.012	0.012	0.018
1.35	0	0	304	136	0.147	0.013	0.013	0.018
1.45	0	0	282	136	0.152	0.013	0.014	0.019
1.55	0	0	253	136	0.157	0.013	0.014	0.020
1.65	0	0	222	136	0.162	0.014	0.015	0.020

Numbers of Supernovae



Error on Distance Measurement

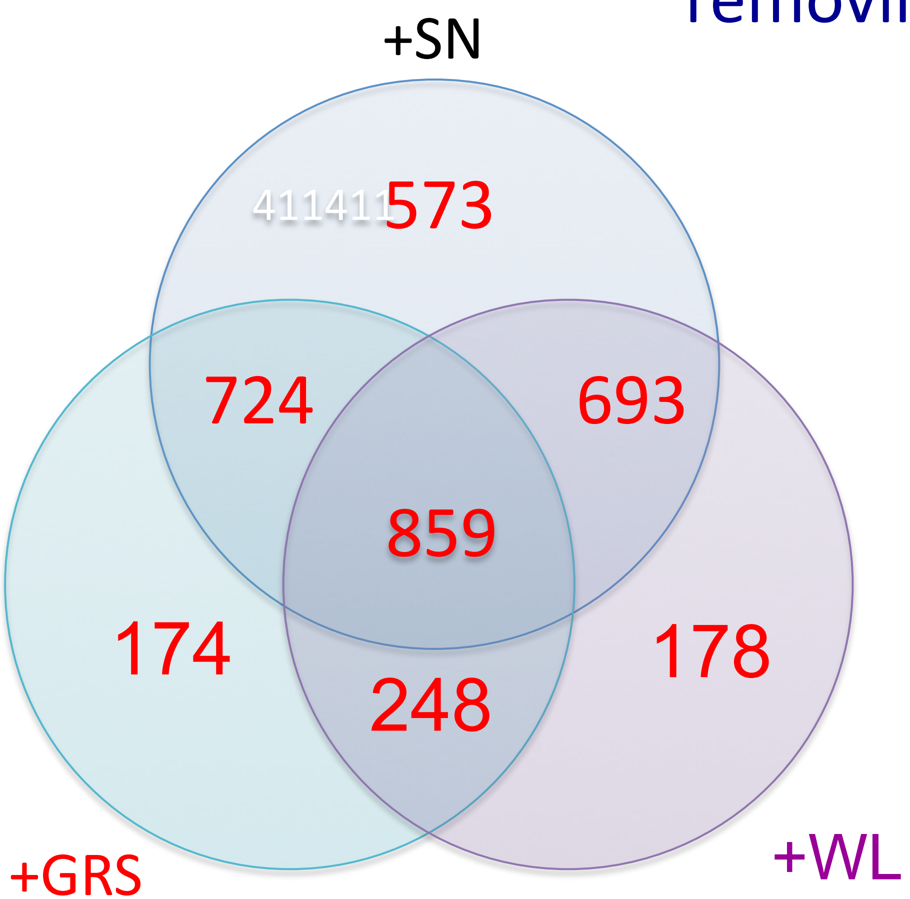


Figures of Merit

- For the Supernova Survey only FoM = 312
- Supernova with Stage III prior FoM = 582

WFIRST24 FoM Combined by CB March 14

WFIRST-24 with Planck + Stage III Priors
removing z<0.1 duplication

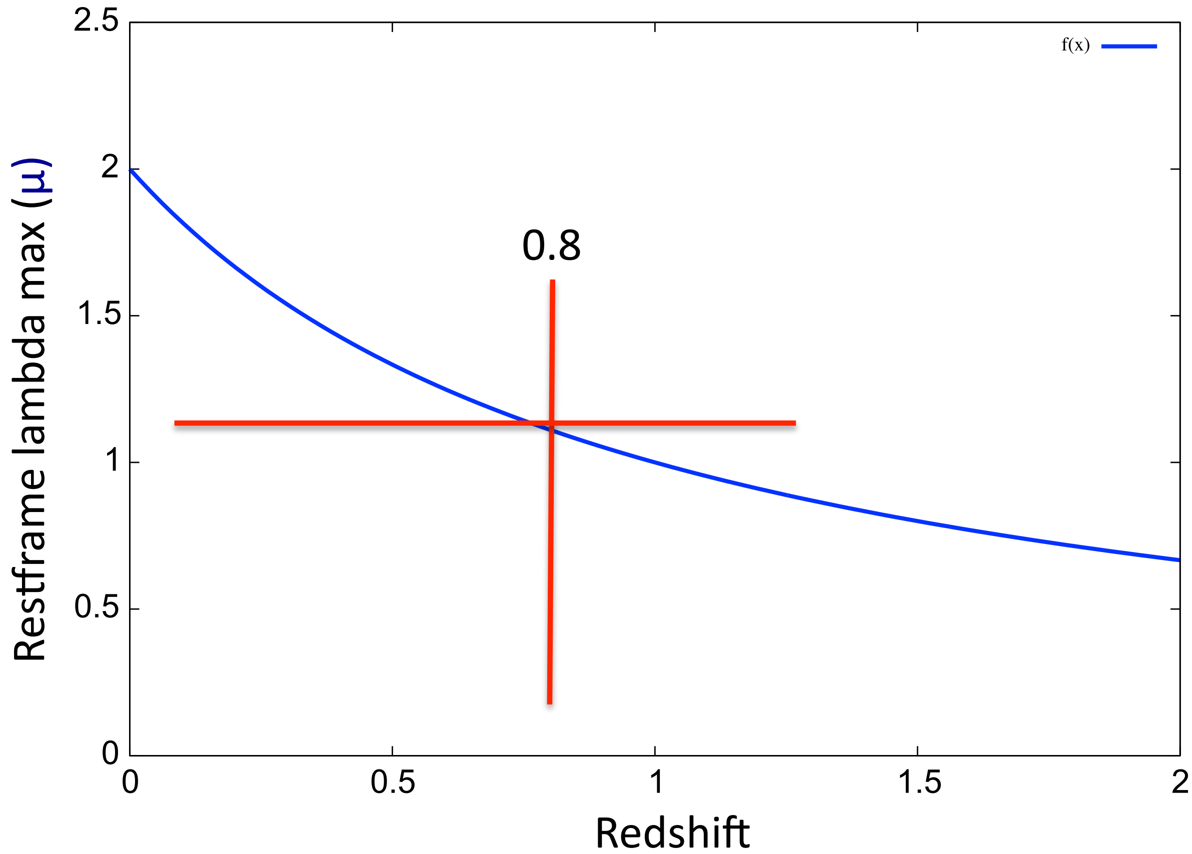


Two possible approaches to optimize survey

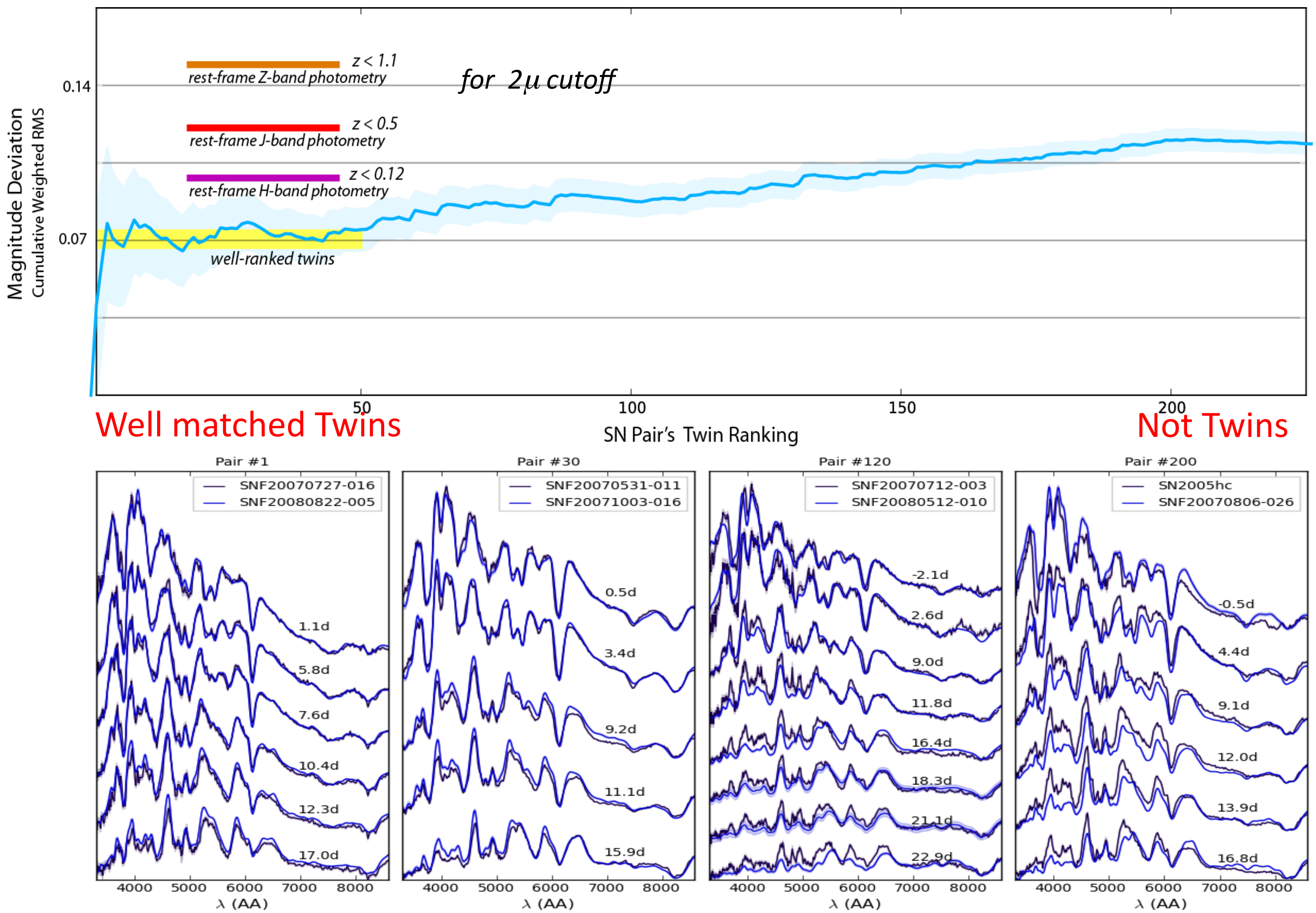
- Go to near infrared in supernova restframe to minimize intrinsic peak magnitude spread.
  - Observer frame λ max limited to 2.0 μ by telescope temperature
  - Emphasize redshift < 0.8 or so to go up to λ > 1.1 or so in supernova rest frame
- Rely on deep spectrum with Integral Field Spectrometer to minimize peak magnitude intrinsic spread
  - Go to as high a redshift as time allows

Supernova Restframe Wavelength Reach

Observer Frame lambda max = 2.0 μ



Supernovae with similar spectra (Twins) have much lower intrinsic spread



tory

Alternative Surveys

Survey	Sne z<0.8	Sne z>0.8	FoM
Design	1501	1224	312
Alt A	2341	1224	322
Alt B	2994	630	299

Enhanced Low z survey FoM = 299

	No of Supernova/bin							
z	Low	Med	Hi	Total	σstat	σ/√N	σsys	σtotal
0.15	69	22	8	100	0.114	0.011	0.006	0.013
0.25	208	67	24	300	0.114	0.007	0.007	0.010
0.35	403	129	47	580	0.116	0.005	0.008	0.009
0.45	0	217	78	295	0.117	0.007	0.008	0.011
0.55	0	317	115	433	0.120	0.006	0.009	0.010
0.65	0	420	152	573	0.122	0.005	0.009	0.010
0.75	0	523	189	713	0.125	0.005	0.010	0.011
0.85	0	0	233	70	0.128	0.015	0.010	0.018
0.95	0	0	270	70	0.131	0.016	0.011	0.019
1.05	0	0	297	70	0.135	0.016	0.011	0.020
1.15	0	0	311	70	0.139	0.017	0.012	0.020
1.25	0	0	313	70	0.143	0.017	0.012	0.021
1.35	0	0	304	70	0.147	0.018	0.013	0.022
1.45	0	0	282	70	0.152	0.018	0.014	0.023
1.55	0	0	253	70	0.157	0.019	0.014	0.023
1.65	0	0	222	70	0.162	0.019	0.015	0.024

Errors assumed are critical

- Before we can meaningfully optimize the supernova survey we have to do some more work on understanding the errors
- We have been using
  - Intrinsic spread $\sigma_{int} = 0.08$
  - Systematic error $\sigma_{sys} = 0.01(1+z)/1.8$
- Larger intrinsic spread would need more supernovae to reduce $\sigma/\sqrt{N}$ to below systematic error
- Larger systematic error would need smaller number of supernovae
- We are working on more careful correlated errors
- One of the jobs for the Science Teams