WFIRST/AFTA
NAS Dark Energy Presentation

David Spergel

Instrument Comparisons

Feature	JDEM/Omega	IDRM	WFIRST DRM1	WFIRST 2.4
Mirror Diameter	1.5 m	1.3 m (unobs.)	1.3 m (unobs.)	2.4 m
Imager				
Detectors	24 H2RG	28 H2RG	36 H2RG	18 H4RG
Total Pixels	96 Mpix	112 Mpix	144 Mpix	288 Mpix
Area on Sky	0.25 sq deg	0.29 sq deg	0.36 sq deg	0.28 sq deg
Plate Scale	0.18”/pix	0.18”/pix	0.18”/pix	0.11”/pix
Wavelength	0.4 – 2.0 µ	0.6 – 2.0 µ	0.6 – 2.4 µ	0.6 – 2.0 (2.4) µ
Spectrometer	Slitless Prism (2x6 H2RG 0.37”/pix)	Slitless Prism (2x4 H2RG 0.45 “/pix)	Slitless Prism	GRISM + IFU
Coronagraph	No	No	No	Yes

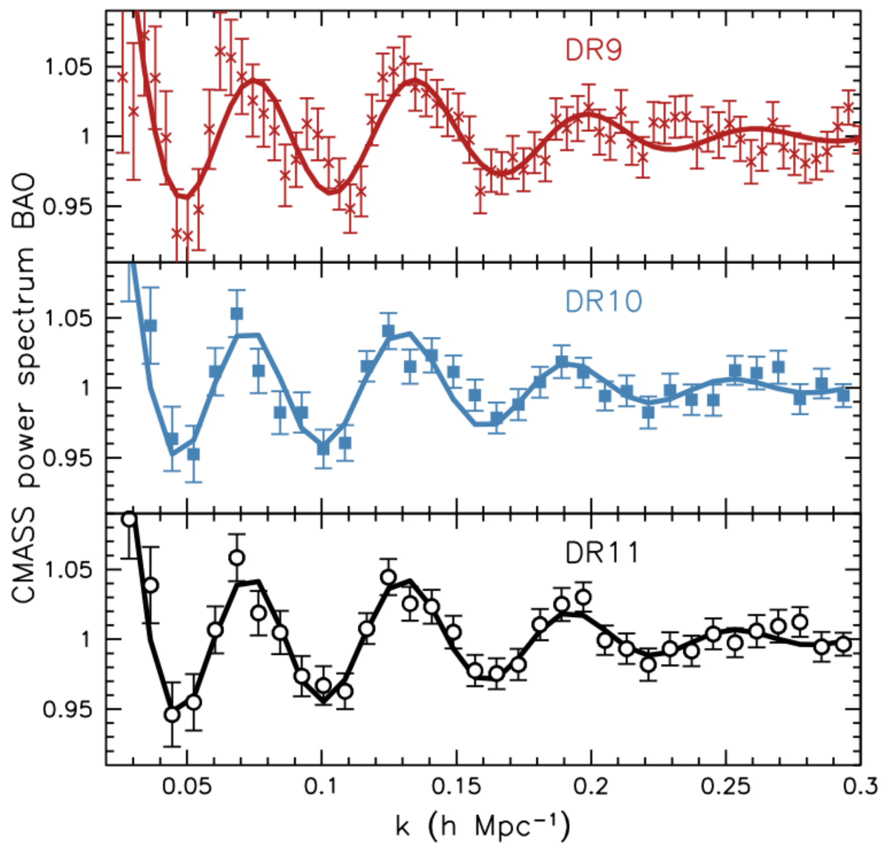
WFIRST/AFTA has 2.9x larger etendue than JDEM/Omega, the version of WFIRST proposed to the decadal survey

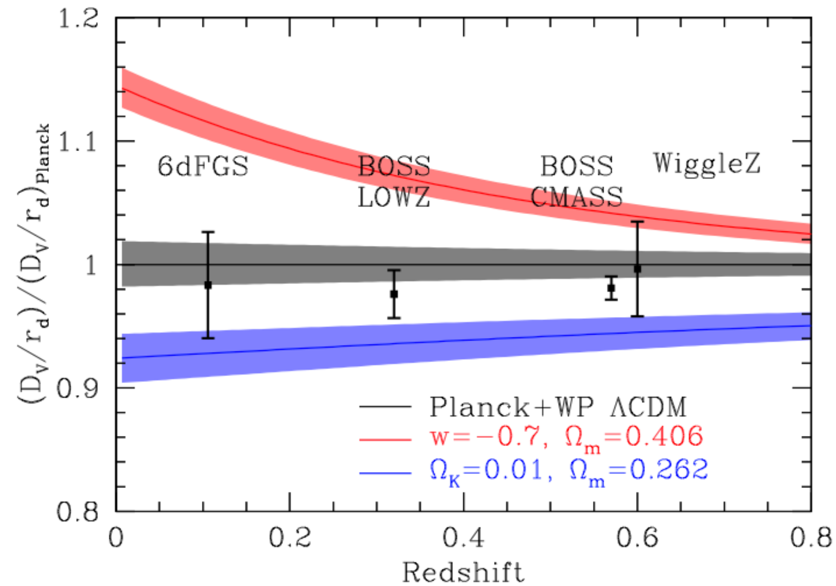
What is new with dark energy?

- Beyond FOM
  - Deviations from GR
  - Desire to measure growth rate and distance as a function of redshift using many techniques
- Experimental improvements
  - Planck, BOSS results
  - Intriguing tensions in Planck
  - Euclid selected, defined
  - LSST moving forward with NSF+DOE support
  - DESI likely with NSF/DOE support
- By 2023, precision measurements at lower redshifts are likely well underway

IMPORTANCE OF MULTIPLE TECHNIQUES AND CONTROL OF SYSTEMATICS!

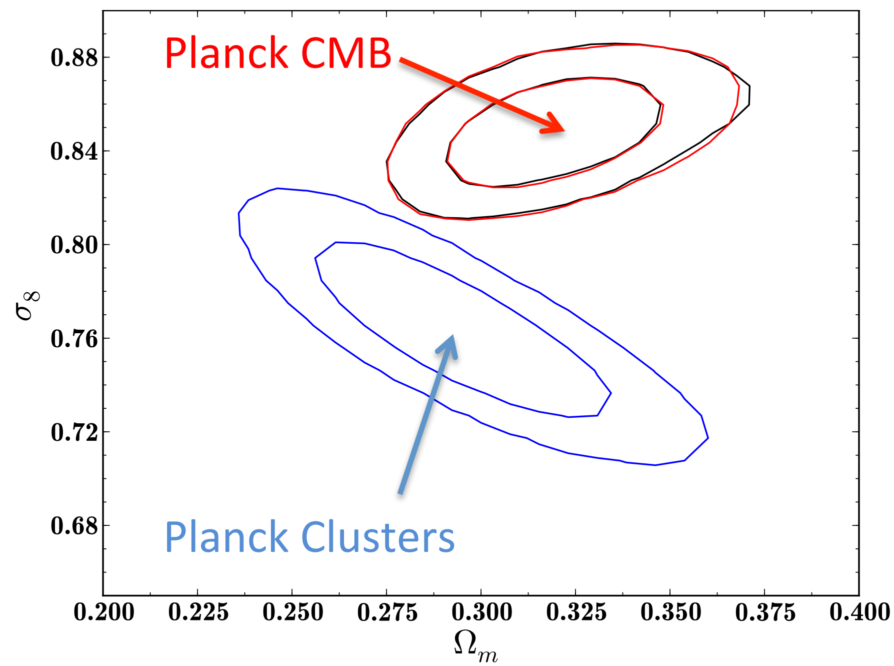
Success of z<1 Ground-Based BAO





Anderson et al. 1312.4877 (SDSS III)

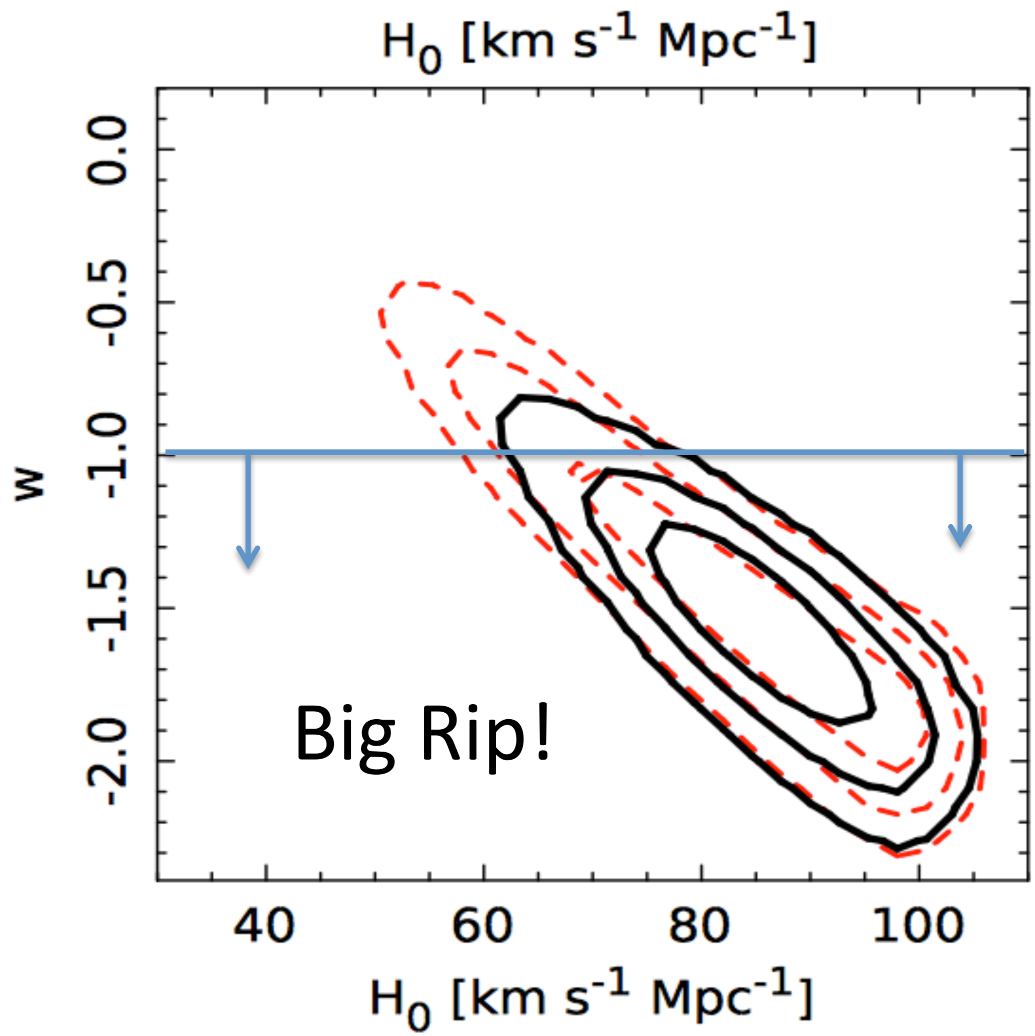
Has Planck Ruled Out ΛCDM?



Planck Paper XX

- Either new physics or a reminder of the importance of control of systematics
  - Need to use only cross-correlations in Planck maps [dangers of auto-correlations in single channel!]
  - Need to better calibrate cluster masses

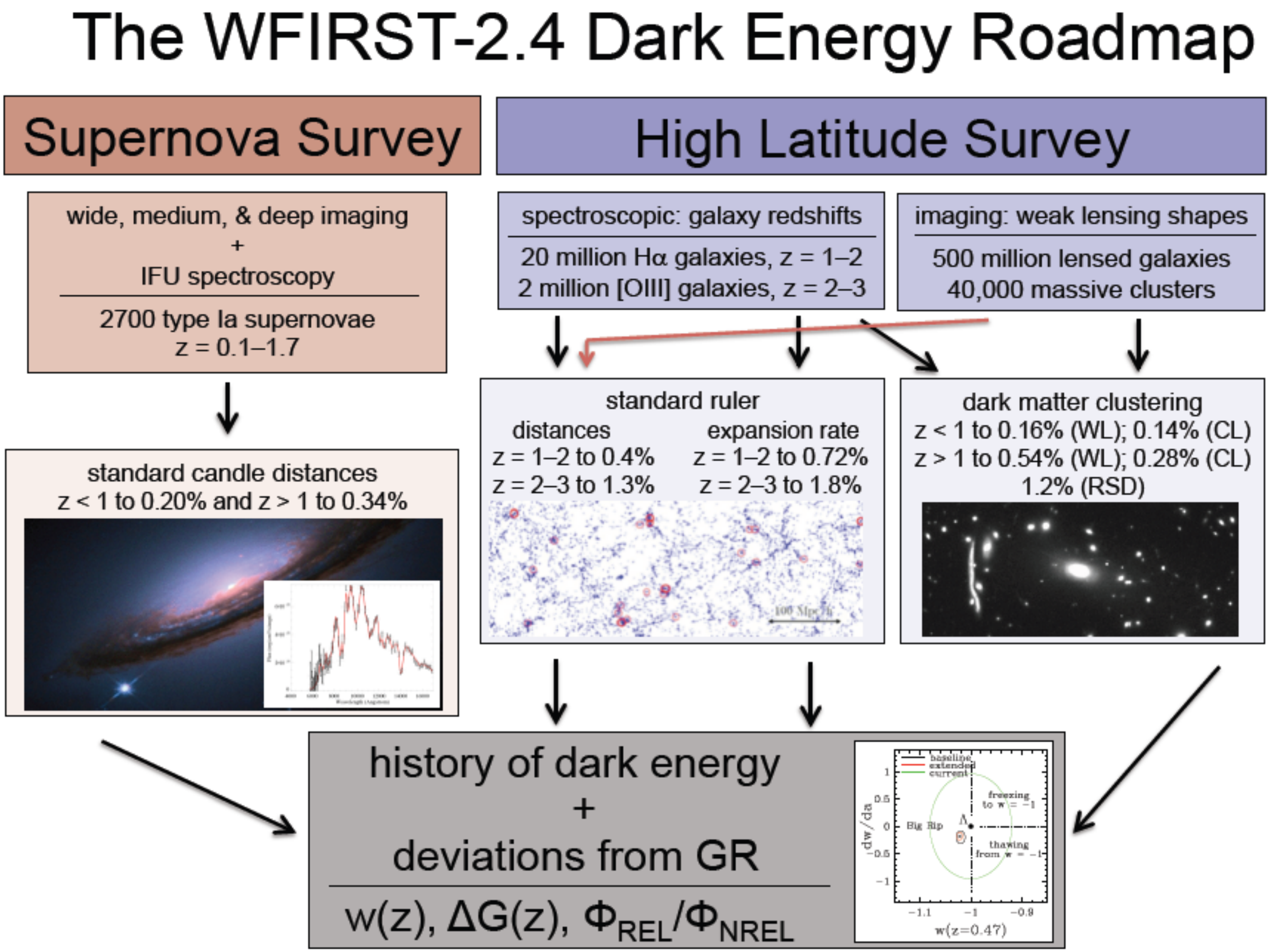
Is the Big Rip Coming?



Suyu et al. 1306.4732

H_0 tension between Planck , Cepheid and time-delay measurements

Systematics or New Physics?


The WFIRST-2.4 Dark Energy Roadmap
Supernova Survey
High Latitude Survey
wide, medium, & deep imaging
+
IFU spectroscopy
2700 type Ia supernovae
z = 0.1–1.7
spectroscopic: galaxy redshifts
20 million Hα galaxies, z = 1–2
2 million [OIII] galaxies, z = 2–3
imaging: weak lensing shapes
500 million lensed galaxies
40,000 massive clusters
standard candle distances
z < 1 to 0.20% and z > 1 to 0.34%
standard ruler
distances
z = 1–2 to 0.4%
z = 2–3 to 1.3%
expansion rate
z = 1–2 to 0.72%
z = 2–3 to 1.8%
100 Mpc/h
dark matter clustering
z < 1 to 0.16% (WL); 0.14% (CL)
z > 1 to 0.54% (WL); 0.28% (CL)
1.2% (RSD)
history of dark energy
+
deviations from GR
w(z), ΔG(z), Φ_REL/Φ_NREL
baseline
extended
current
freezing to w = −1
Big Rip
thawing from w = −1
dw/da
w(z=0.47)

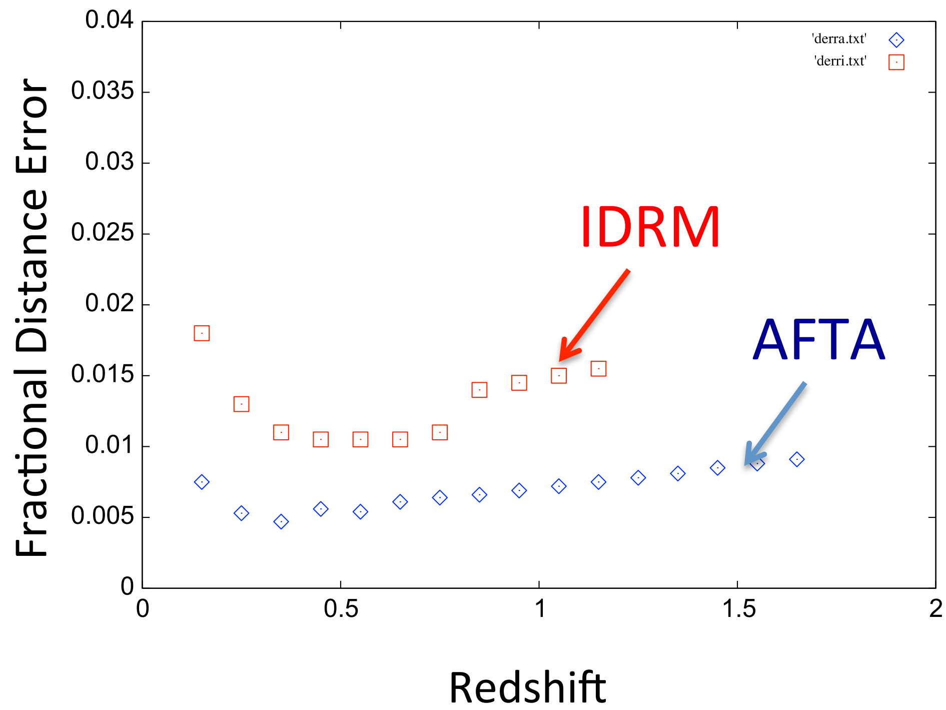
Supernova Comparison

Larger aperture and IFU allow *major* improvements over DRM1 and IDRM:

- More SNe (2750 vs. 1500)
- More even redshift distribution
- *Lower systematics*: Better photometry and calibration, no K-corrections, spectral diagnostics to compare similar high- and low-z SNe

Observing strategy can be tailored to match statistical and systematic uncertainties in each redshift bin.

Euclid has no planned SN program

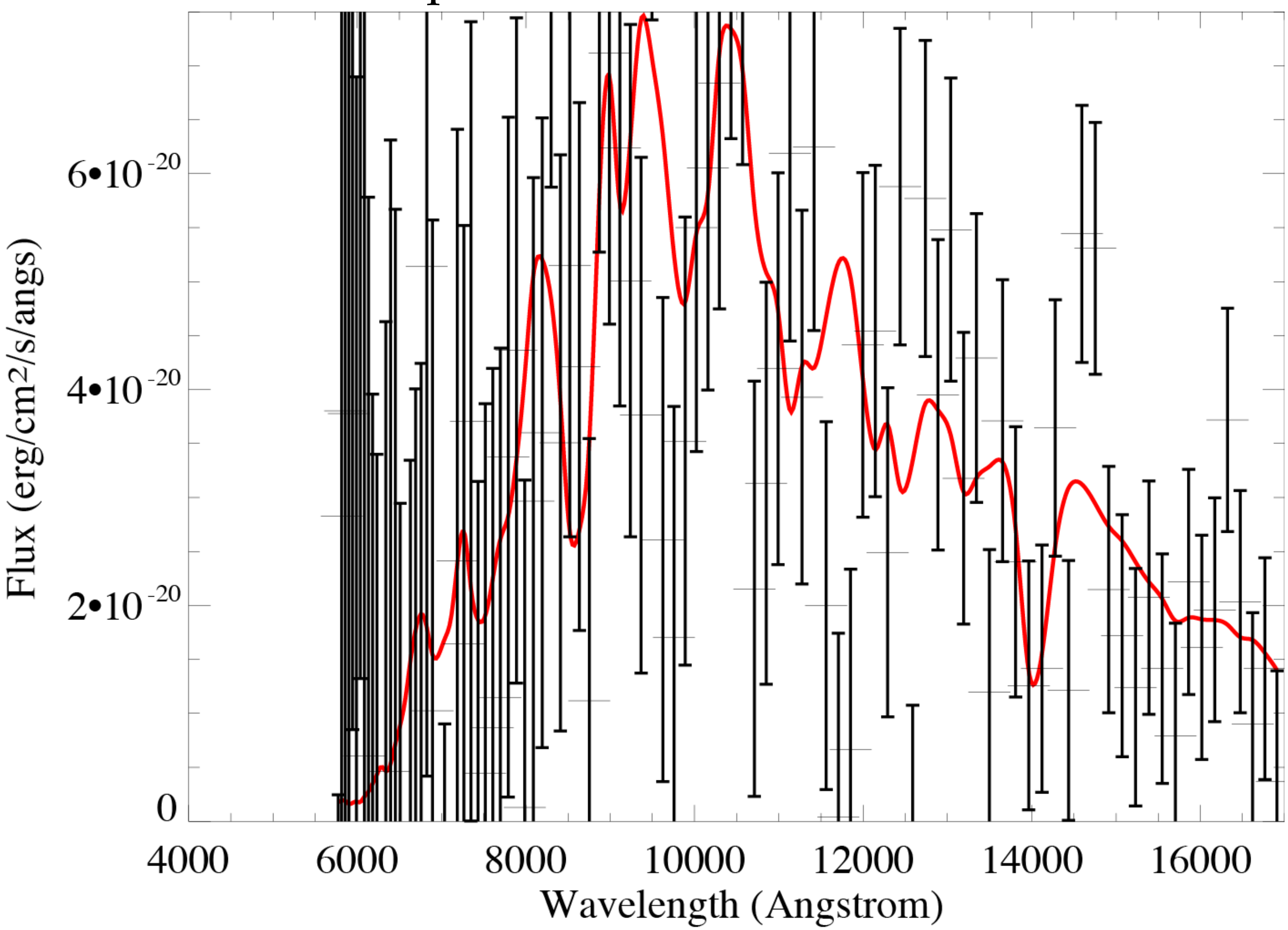


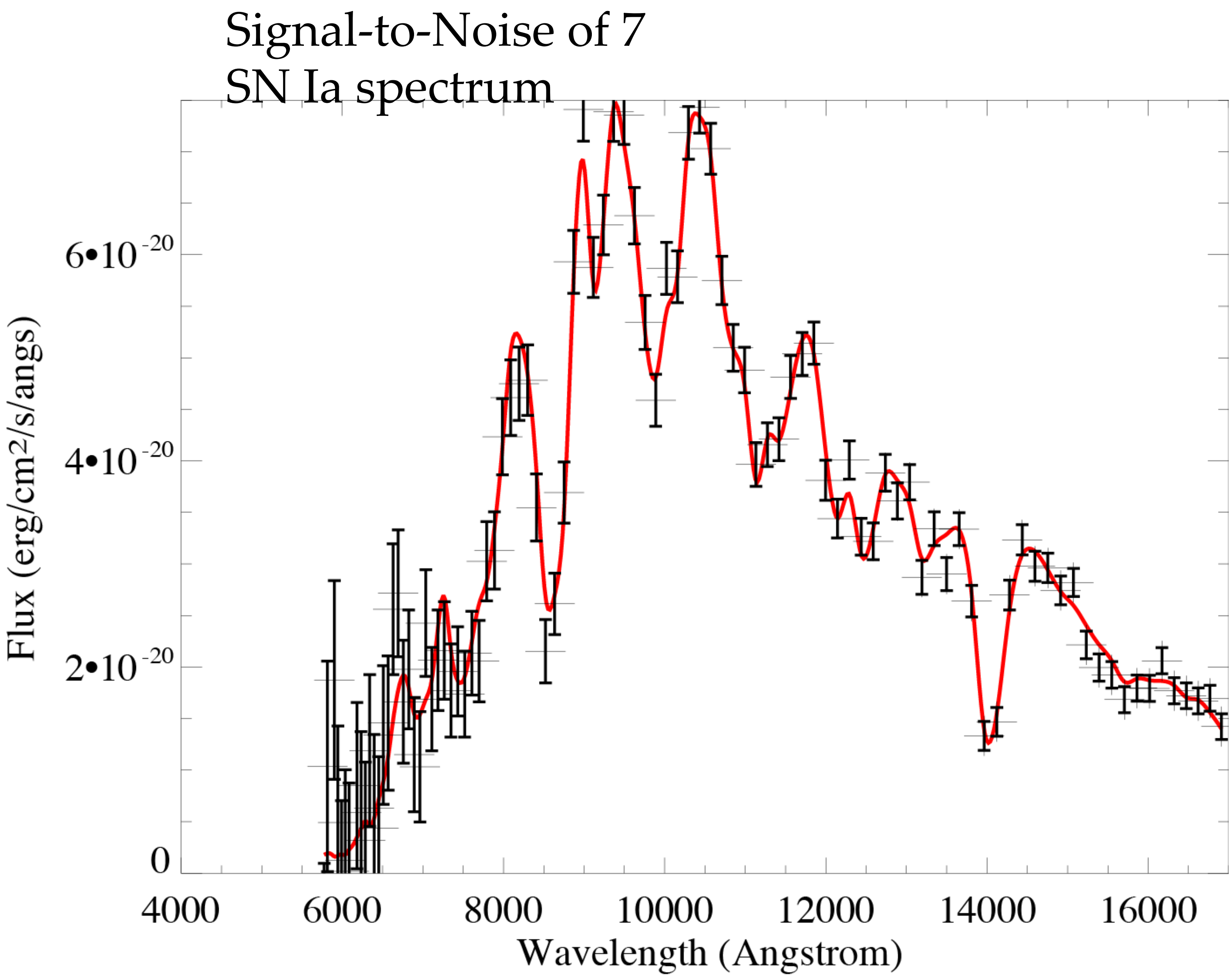
SN has greatest leverage in FoM

Supernova Survey Comparisons

Feature	IDRM	WFIRST2.4
Total no of SNe	1200	2750
Z Range	0.2 – 1.2	0.2 – 1.7
Lightcurves from	Filters	IFU Spectra
Spectroscopy	Prism	Integral Field Unit
R(2 pixel)	75	75
Peak S/N *	15	47
σ(dist) at best z	0.007-0.010	0.0045
FoM(AFTA)/FoM(IDRM) **	1.0	2.3 – 3.4

Signal-to-Noise of 1
SN Ia spectrum

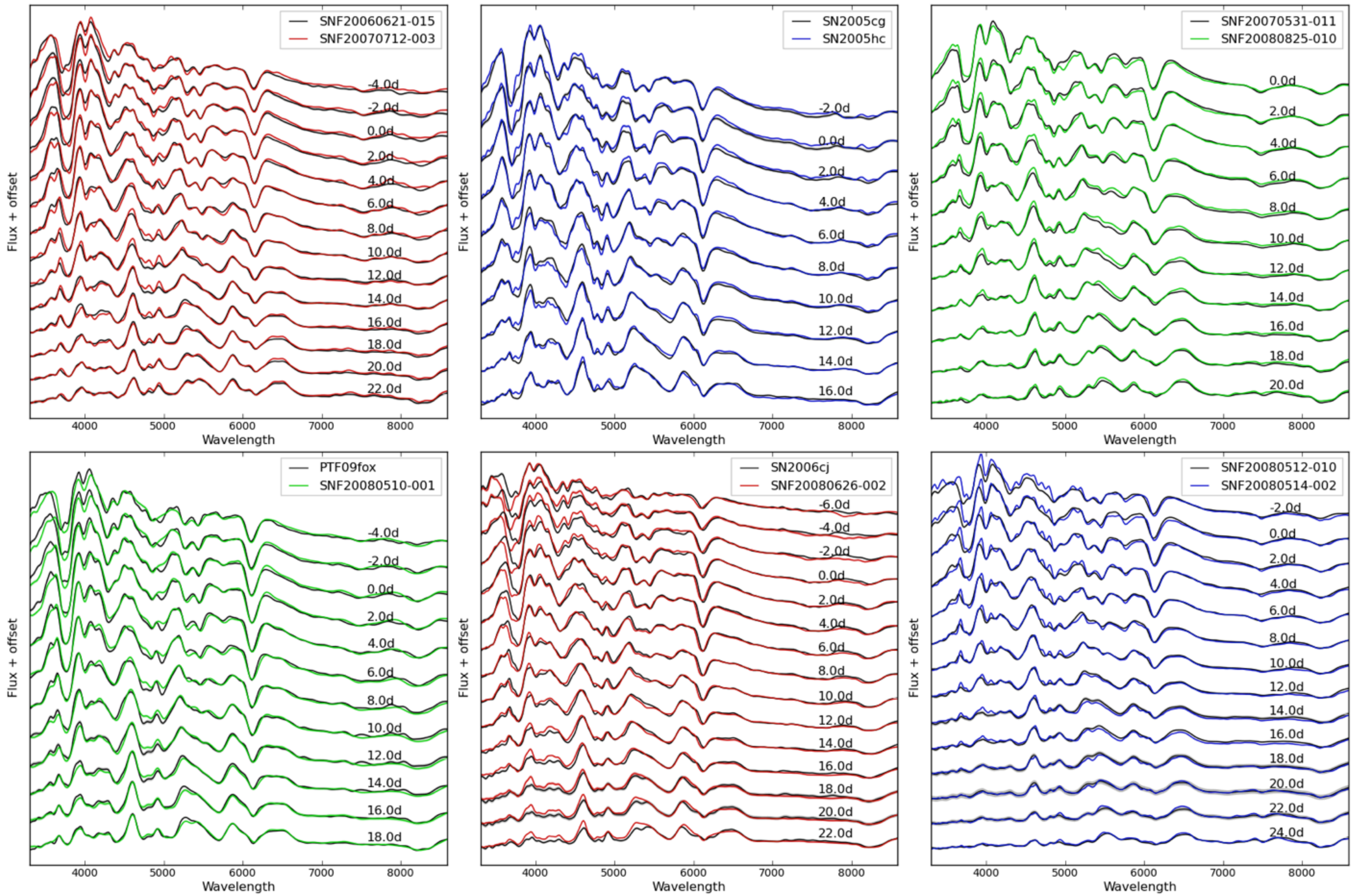


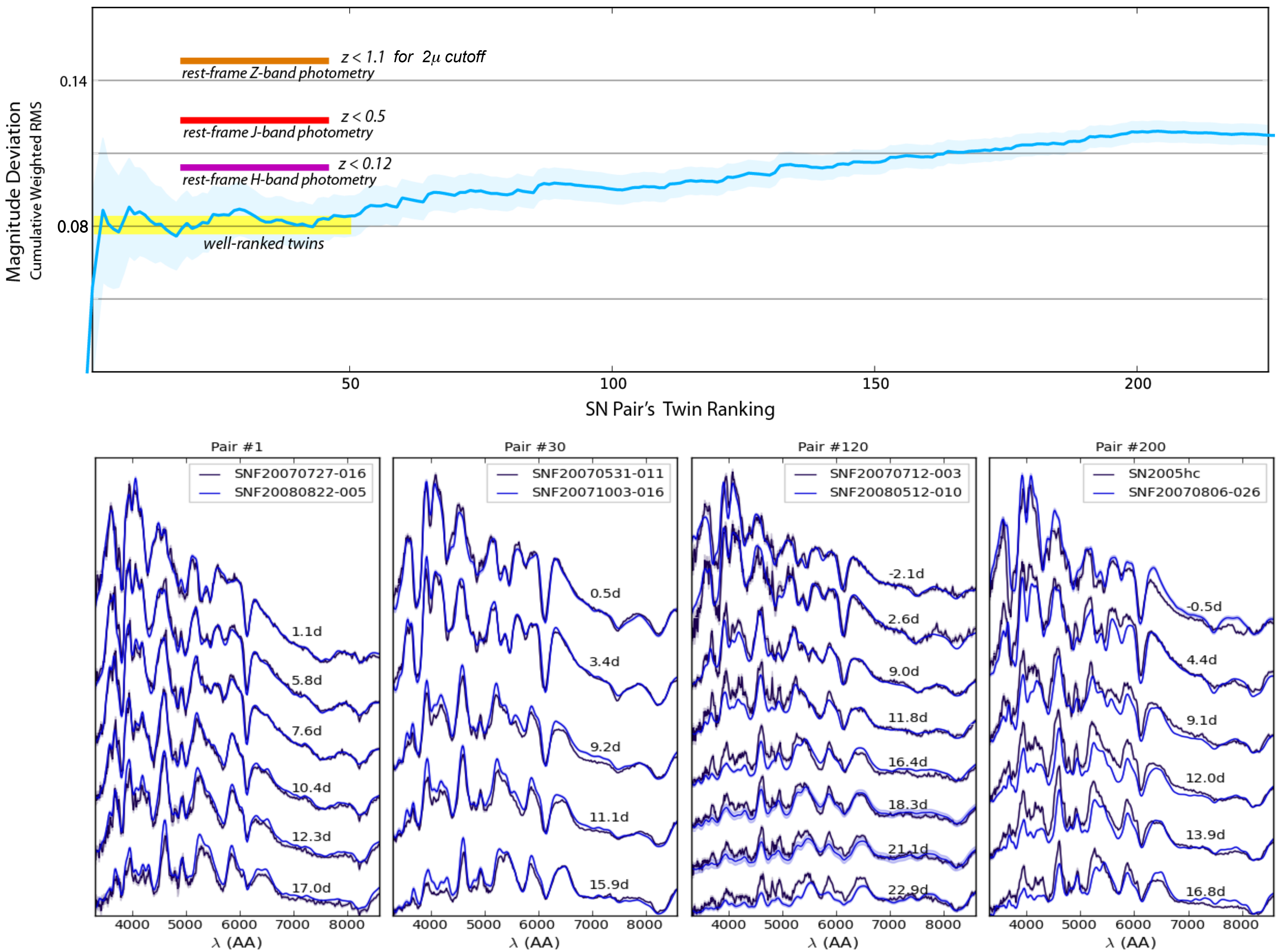


High quality SN spectra will also produce insights into SN progenitors

SN Twins

Nearby Supernova Factory





z < 1.1 for 2μ cutoff
rest-frame Z-band photometry
z < 0.5
rest-frame J-band photometry
z < 0.12
rest-frame H-band photometry
well-ranked twins
Magnitude Deviation
Cumulative Weighted RMS
0.14
0.08
50
100
150
200
SN Pair's Twin Ranking
Pair #1
SNF20070727-016
SNF20080822-005
1.1d
5.8d
7.6d
10.4d
12.3d
17.0d
Pair #30
SNF20070531-011
SNF20071003-016
0.5d
3.4d
9.2d
11.1d
15.9d
Pair #120
SNF20070712-003
SNF20080512-010
-2.1d
2.6d
9.0d
11.8d
16.4d
18.3d
21.1d
22.9d
Pair #200
SN2005hc
SNF20070806-026
-0.5d
4.4d
9.1d
12.0d
13.9d
16.8d
4000
5000
6000
7000
8000
λ (AA)

Weak Lensing Comparison

Comparison to DRM1

+Smaller survey area (2000 deg^2 vs. 2700 deg^2) but higher n_{eff} (74 $arcmin^{-2}$ vs. 36 $arcmin^{-2}$ when stacked) leads to 1.5× increase in galaxy number, corresponding to about 1.5× improvement in FoM contribution.

+ Higher n_{eff} makes higher order statistics much more powerful, allows detailed dark matter maps, greater gains in extended survey

+ STOP analysis shows best performance of all designs studied (PSF stability)

Comparison to Euclid

- Euclid has lower n_{eff} (20-35 $arcmin^{-2}$) but larger area (15,000 deg^2) with 6 years devoted to dark energy, with more shape measurements and thus higher statistical precision

+ AFTA-WFIRST has *much tighter control and cross-checks of systematics*: 8-9 exposures in 3 shape measurement filters (allowing 6 auto/cross correlations) vs. 3-4 exposures in a single wide optical filter

AFTA-WFIRST much more likely to achieve statistics-limited accuracy

WFIRST-2.4 IFU in Parallel Mode will provide 10-25 K spectroscopic measurements.
Without large spectroscopic sample, weak lensing FoM is reduced significantly.

Weak Lensing comparison

	Euclid	IDRM	AFTA
Shape bands	1 [Vis]	2 [J/H]	3 [J/H/F184]
PSF EE50	0.13" [Vis]	0.16" [J]	0.12" [J]
Galaxy density n_{eff} (gal/am^2) [Cuts: Res>0.4, S/N>18, σ_e<0.2]	35 [21 with $N_{exp}\geq3$*]	26/28 [36 stacked]	54/61/44 [74 stacked]
# Exposures per galaxy	3—4	10	16
# Observing passes per field§	1	4	6
Sky coverage (deg^2)	15,000 [primary mission]	2,700 [in 1 year]	2,050 [in 1.17 years]
Statistical error on amplitude of matter fluctuations	0.08%	0.13%	0.10%
Median source redshift	0.8	1.0	1.2

* Defined as 3 exposures with no cosmic ray within 3 pixels of the galaxy center (the same cut as used in the WFIRST forecasts).

§ The number of passes differs from the number of exposures in that small-step dithers are not counted as separate. This determines the number of repeat observations available for null tests.

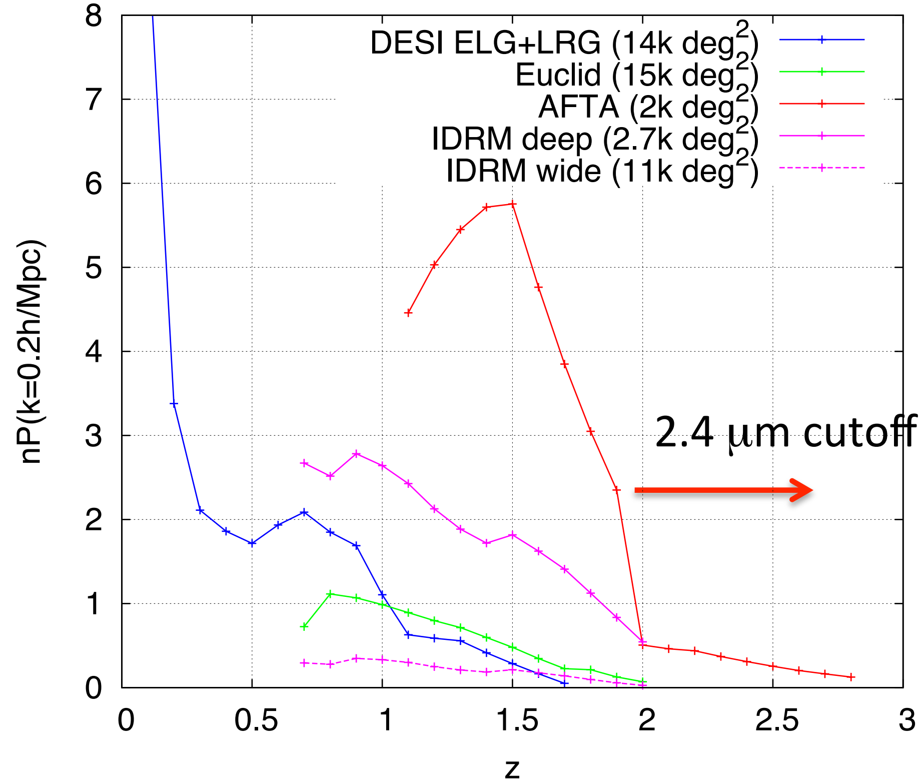
Redshift Survey/BAO Comparison

Comparison to IDRM

- Hα redshift range z = 1-2 (2.7) instead of z=0.7-2
- Smaller survey area (2000 deg² vs. 2700 deg²) but much higher galaxy space density
- FOM ratio = 0.99 for full sample. AFTA is a 1.6x improvements for z> 1
- [OIII] emitters provide sparsely sampled tracers for BAO and RSD at z=2-3

Comparison to Euclid

- Euclid has larger area but 10x lower space density.
- DESI numbers



Forecast aggregate precision: 0.40% in D_A, 0.72% in H, at z=1-2

1.3% in D_A, 1.8% in H, at z=2-3 ([OIII] emitters)

1.2% in $\sigma_m(z)f(z)$ at z=1-2 (from RSD)

Redshift Survey Comparison

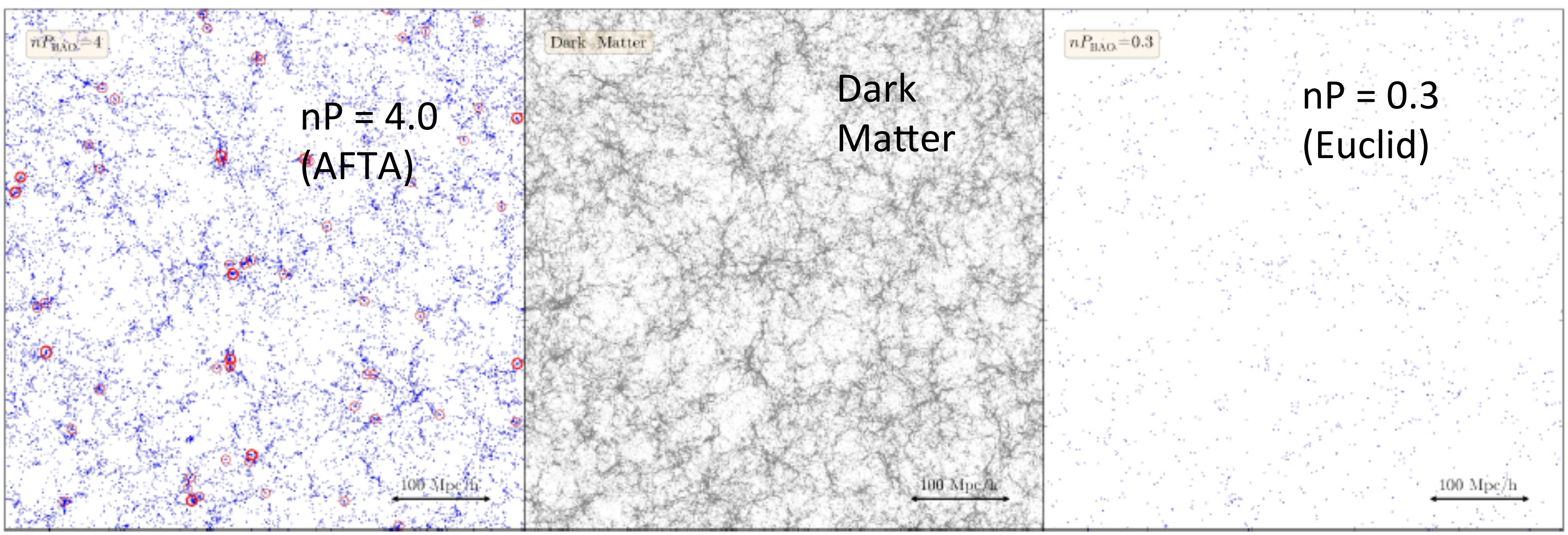
	DESI	Euclid	IDRM	AFTA 2 μm cutoff	AFTA 2.4μm cutoff
Redshift range	[OII], [OIII]: 0.1<z<1.7 LRG: 0.1<z<1	Hα: 1<z<2	Hα: 0.7<z<2	Hα: 1<z<2 [OIII]: 1.7<z<2.9	Hα: 1<z<2.7 [OIII]: 1.7<z<3.8
Main gal. # /(deg)^2	1,300	1,700	9,300	11,600	TBD
2nd gal. # /(deg)^2	300	0	0	> 1,000	TBD
Survey time / 1000 (deg)^2	~118 days	~122 days	135 days	118 days	TBD

Complementarity in Redshift Range and Depth enables Richer Science

Compared to Euclid and DESI: smaller survey area but much denser sampling. Focused on redshift range z>1 that is most difficult from ground.

Density important for higher order clustering measurements, allows splits of sample to test for systematics (should get same cosmology from different galaxies).

Simulated slices at z=1.5. Circles mark clusters of 5e13 and 1e14.



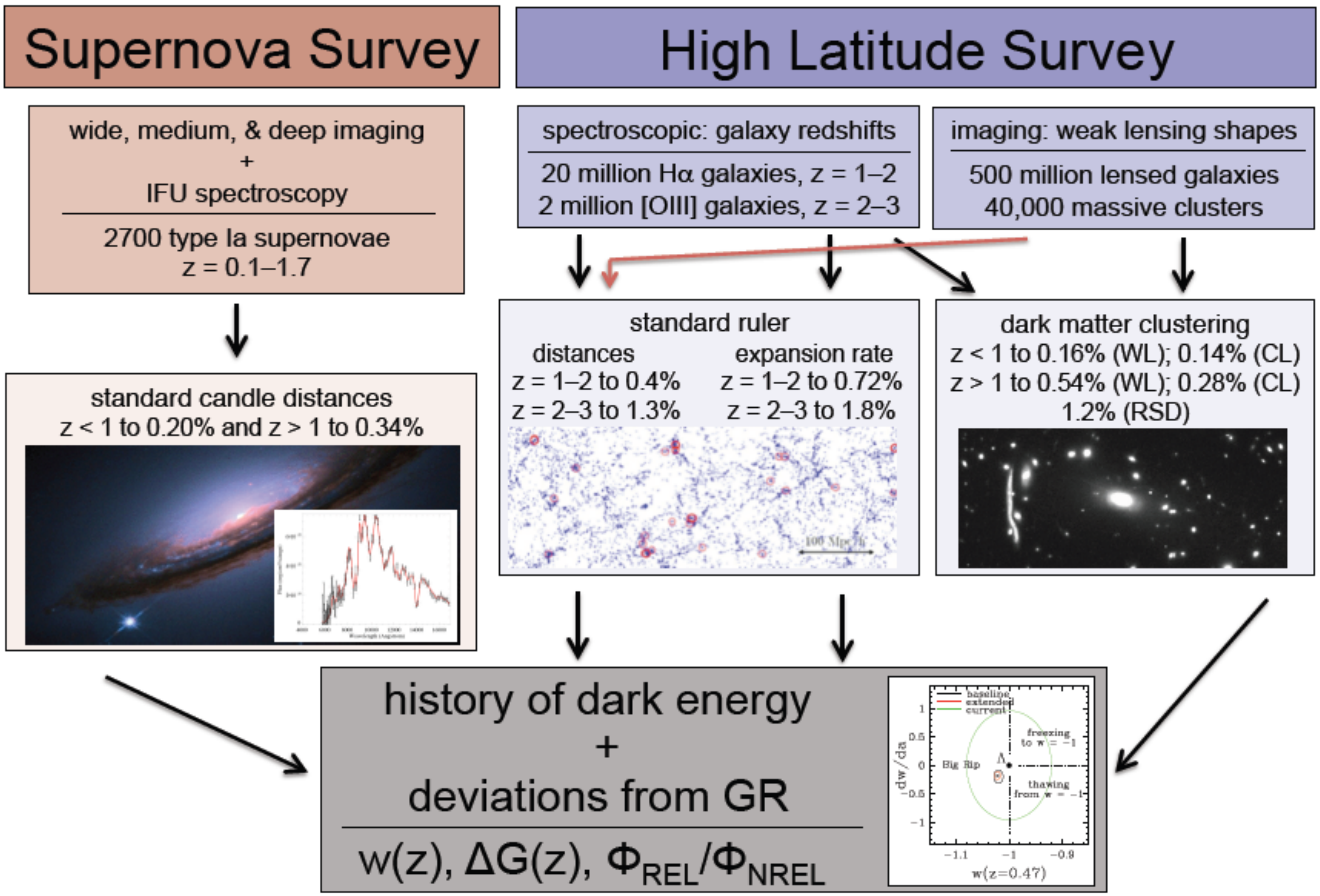
DETF-FOM Improvement

	Norm. to IDRM
Supernova	**2.3-3.4**
BAO (for z > 1)	**1.6**
Weak lensing	**1.5 (x 1-1.7 for IFU redshifts)**

The FoM comparison underestimates improvement :

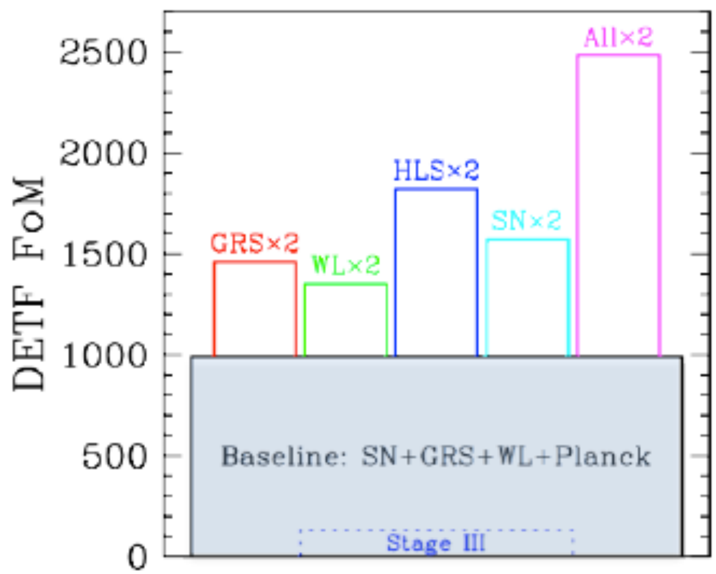
- Significantly improved control of systematics (particularly for SN)
- Significantly improved higher order statistics (WL)
- Improved complementarity to other surveys (higher median redshift)
- Increased flexibility

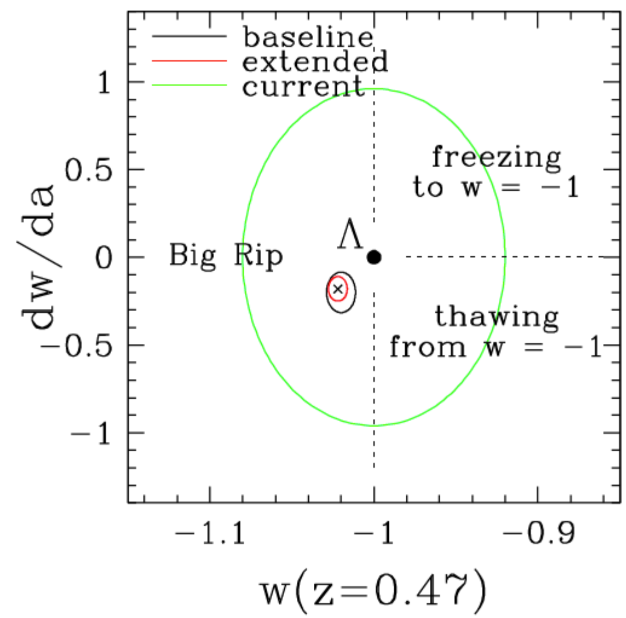
The WFIRST-2.4 Dark Energy Roadmap



BACKUP SLIDES

- Supernova
- Increased Flexibility
- Weak Lensing
- IFU
- BAO
- Dark Energy
- Planck
- Euclid





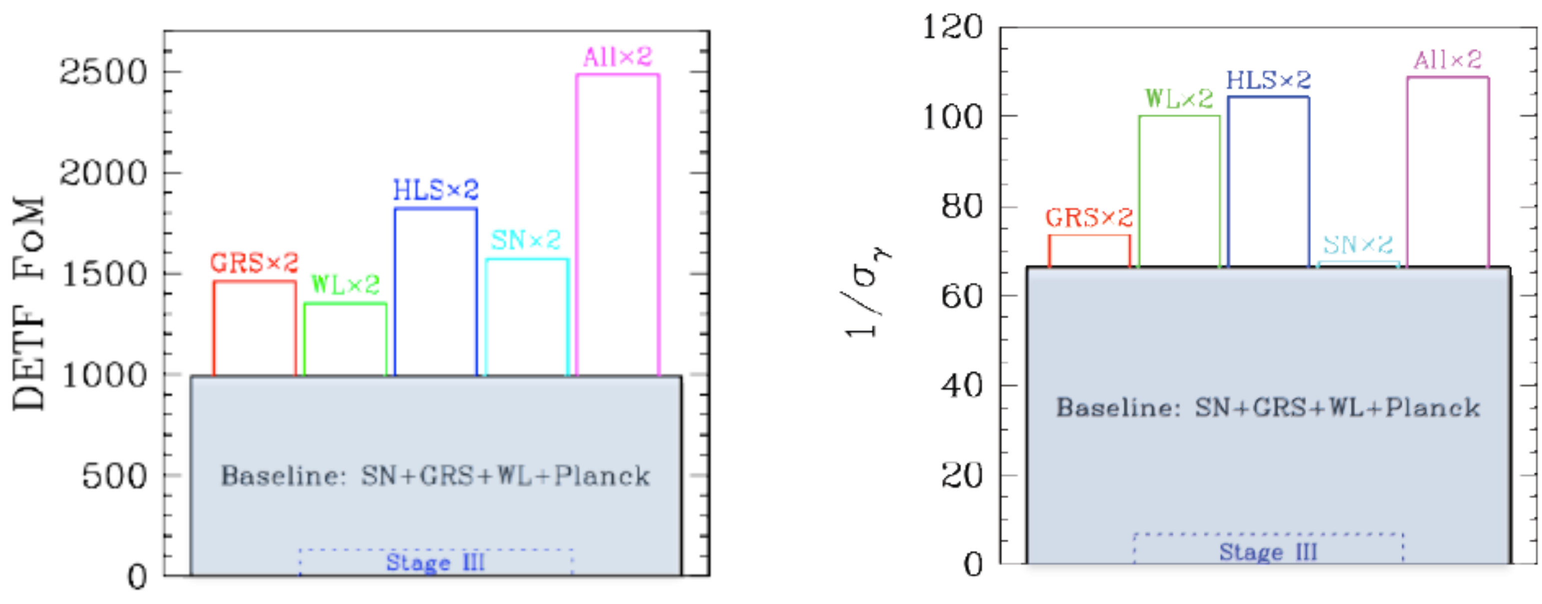
FoM = $[\sigma(w_p) \times \sigma(w_a)]^{-1}$ for baseline case is 7.5× increase over "Stage III" forecast.

This represents big advance in ability to distinguish physically interesting models.

All elements of program contribute, as one sees by doubling precision of any one of them; such doubling might be achieved by further tightening systematics, increasing survey area in extended mission, better theoretical modeling.

Calculation includes AFTA-WFIRST, Planck, local SN calibrators, BOSS.

Doesn't include cluster-galaxy and galaxy-galaxy lensing; forecasts for these are more uncertain, but likely to improve constraints significantly.



Major advance in testing modified gravity explanations of cosmic acceleration, here parameterized by deviation of growth index γ.

With baseline assumptions, WL dominates these constraints; cluster-galaxy and galaxy-lensing likely to improve them by significant factor.

Comparison of WL and RSD is itself an important test of modified gravity models; affected by different gravitational potentials that are equal in GR.

AFTA-WFIRST RSD also probes higher redshift.

Why did the IFU become baseline in AFTA-WFIRST?

Lower systematics

Better calibration:

- Each pixel on detector illuminated by light of fixed wavelength for both source and backgrounds
- Total # of pixels to calibrate is small; feasible to scan standard star along length of each slice in IFU

No K-corrections; compare SNe at fixed rest-frame wavelength (slitless spectra have much higher background noise)

Spectral diagnostics for sub-typing SNe; reduce evolutionary systematics and add cross-checks by comparing like-to-like across redshift.

Better statistics

More efficient than wide-field slitless spectroscopy because exposure time tailored to each individual SN. More SNe measured.

Redshift distribution can be tailored to be optimal.

This gain is much larger for the 2.4m than 1.3m aperture.

See Perlmutter slides for much further detail and additional benefits of IFU.

Why did the IFU become baseline in WFIRST-AFTA?

SN data quality	"Clean" SN spectrum now available: Host galaxy light contamination can be removed from SN spectrum by image-subtraction algorithm.
	Each SN observation now has full wavelength range of WFIRST.
Systematic error control	K correction systematic error now removed: each observation performed with spectrophotometry.
	SN evolution (population drift) can now be controlled by matching high-S/N spectrum to low-redshift SN standards. Feasible with 2.4m telescope.
	Photometry calibration systematic errors now controlled wavelength-by-wavelength at R ~ 100.
Observing efficiency	More time-efficient SN follow-up strategy now available: after discovery, faster to follow individual SN with tuned exposure times.
Science results	Can now follow >~150 SNe in each redshift bin (delta z = 0.1) from z = 0.2 to 1.7, with same S/N, yielding sub-percent distances.
	Dark Energy Figure of Merit (FoM=312 from SN alone) now 3.4x higher than IDRM, and SN is now the single most important contributor. Combined FoM with BAO (WFIRST or Euclid) also significantly higher, i.e., SN is complementary to BAO even when measuring distances at the same redshifts .

Weak Lensing data	Parallel IFU spectroscopy during imaging surveys yields 10K--25K galaxy spectra out to z ~4, required to calibrate photo-z's for WL.
Science results	DE FoM from WL could be 1.6x higher, with these IFU photo-z calibrations.

WFIRST WFC calibration	The IFU would be the anchor for photometric calibration of the entire WFIRST Wide Field Camera.

Comments on dark energy Figures of Merit

Widely used measure is FoM = $[\sigma(w_p) \times \sigma(w_a)]^{-1}$ for forecast errors on a model in which $w(a) = w_p + w_a(a_p-a)$, assuming standard matter and radiation content and GR, allowing non-zero curvature. Typically $a_p \approx 0.7$.

Useful standard of comparison and optimization, but doesn't account for sensitivity to GR deviations or early dark energy.

Assumptions about systematic uncertainties have big impact on FoM.

We focus on FoM of combined program and variants around it; much less sensitive to external assumptions than "single-probe" FoM.

We also characterize probes by the aggregate fractional precision with which they measure their primary observable, including estimate of systematic error contribution.

More model-independent than FoM.

Contribution to FoM generally scales as $(\sigma_{agg})^{-2}$.

Supernova Survey Comparison

- The better instrument enables a much better supernova survey
- More supernovae over a broader redshift range with better signal to noise at supernova peak light, which translates into a better distance measurement precision and a better Figure of Merit.
- The high signal to noise spectra enabled by the Integral Field Spectrometer (IFU) promises reduced and better control of systematic errors that allow AFTA-WFIRST2.4 to fully capitalize on the improved statistical errors of the larger sample of supernovae produced by the larger mirror.

Why did the IFU become baseline in WFIRST-AFTA?

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	SN evolution (population drift) can now be controlled by matching high-S/N spectrum to low-redshift SN standards. The 2.4-m & IFU make this possible.
	Photometry calibration systematic errors now controlled wavelength-by-wavelength at R ~ 100. Each pixel on detector illuminated by light of fixed wavelength for both source and backgrounds, and total # of pixels to calibrate is small enough that standard stars can be scanned along each slice of IFU.
Observing efficiency	More time-efficient IFU-follow-up strategy now available: after discovery, faster to follow individual SN with tuned exposure times – and redshift distribution can be tailored to be optimal. This gain is even larger for AFTA than IDRM.
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Weak Lensing data	Parallel IFU spectroscopy during imaging surveys yields 10K--25K galaxy spectra out to z ~4, required to calibrate photo-z's for WL. This will feed into improved DE FoM from WL.

Mission Cost/Complexity	IFU simplifies pointing, calibration, and stability requirements.

WFIRST-AFTA Supernova Program: Improvements over IDRM

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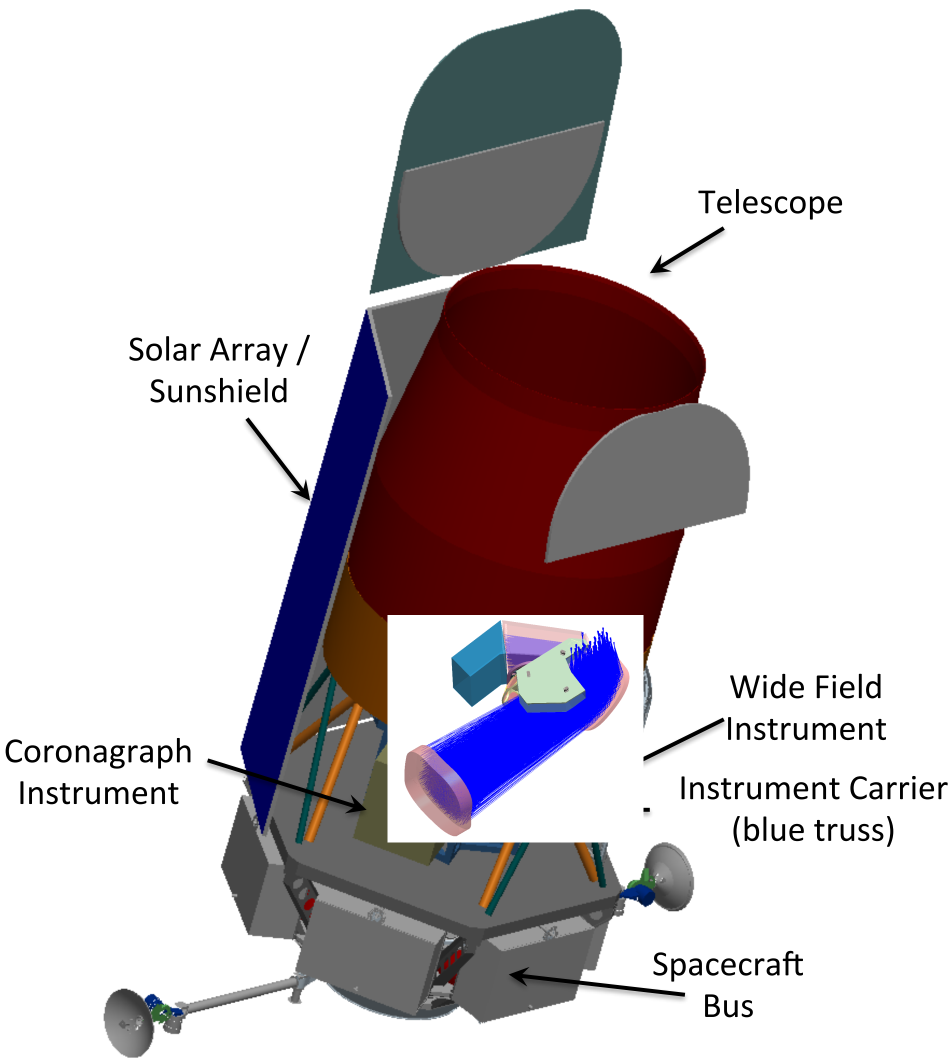
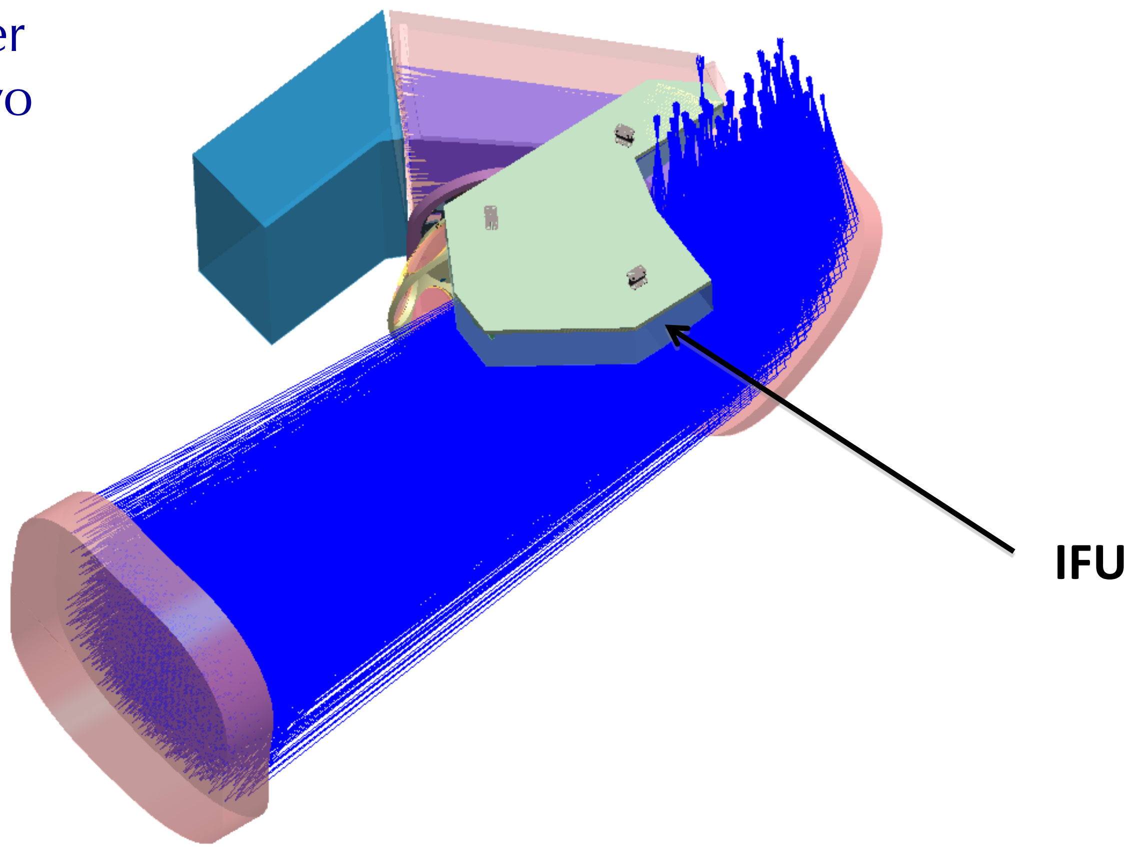
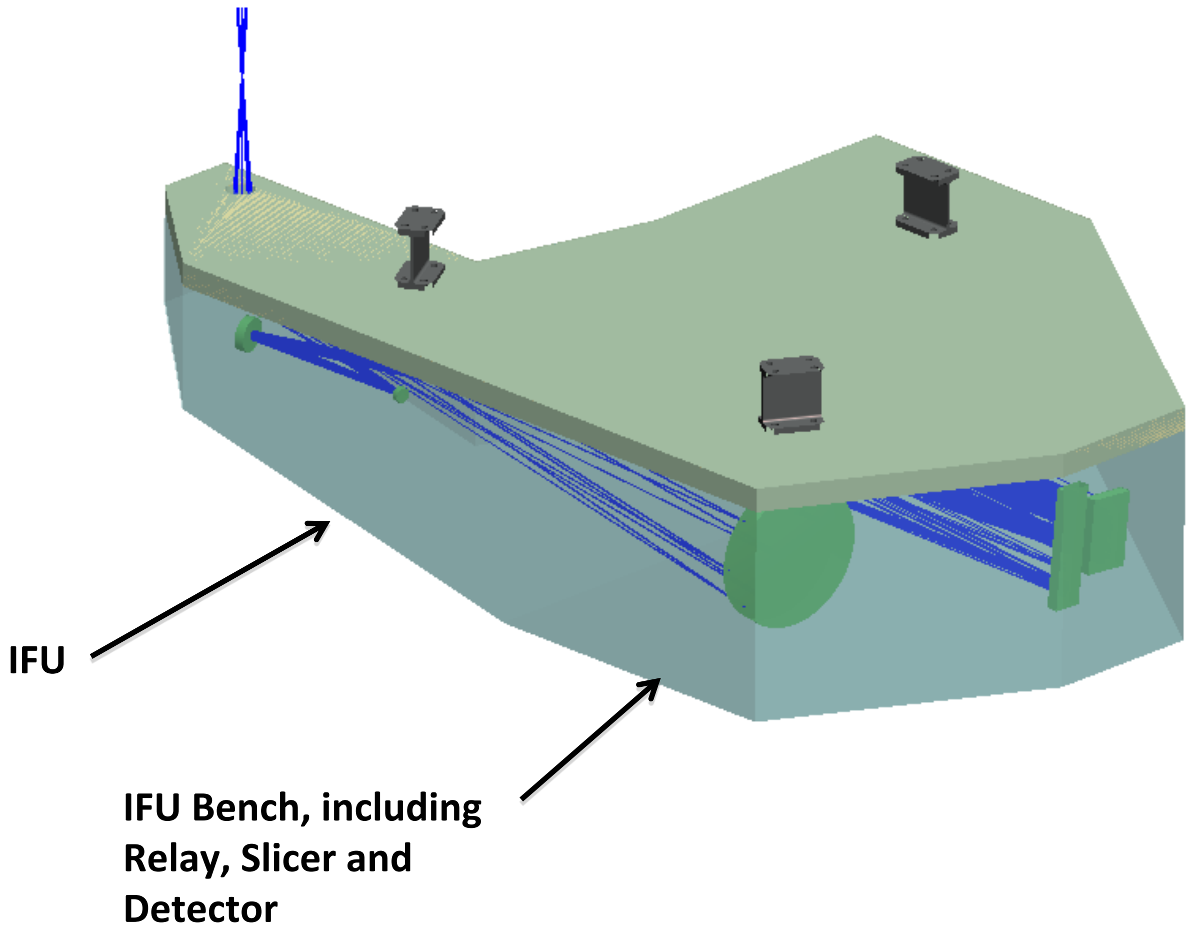

Telescope
Solar Array /
Sunshield
Wide Field
Instrument
Coronagraph
Instrument
Instrument Carrier
(blue truss)
Spacecraft
Bus

Use the 0.28 sq degree Wide Field Imager (with 0.11″ pixels) to discover supernovae in two filter bands.

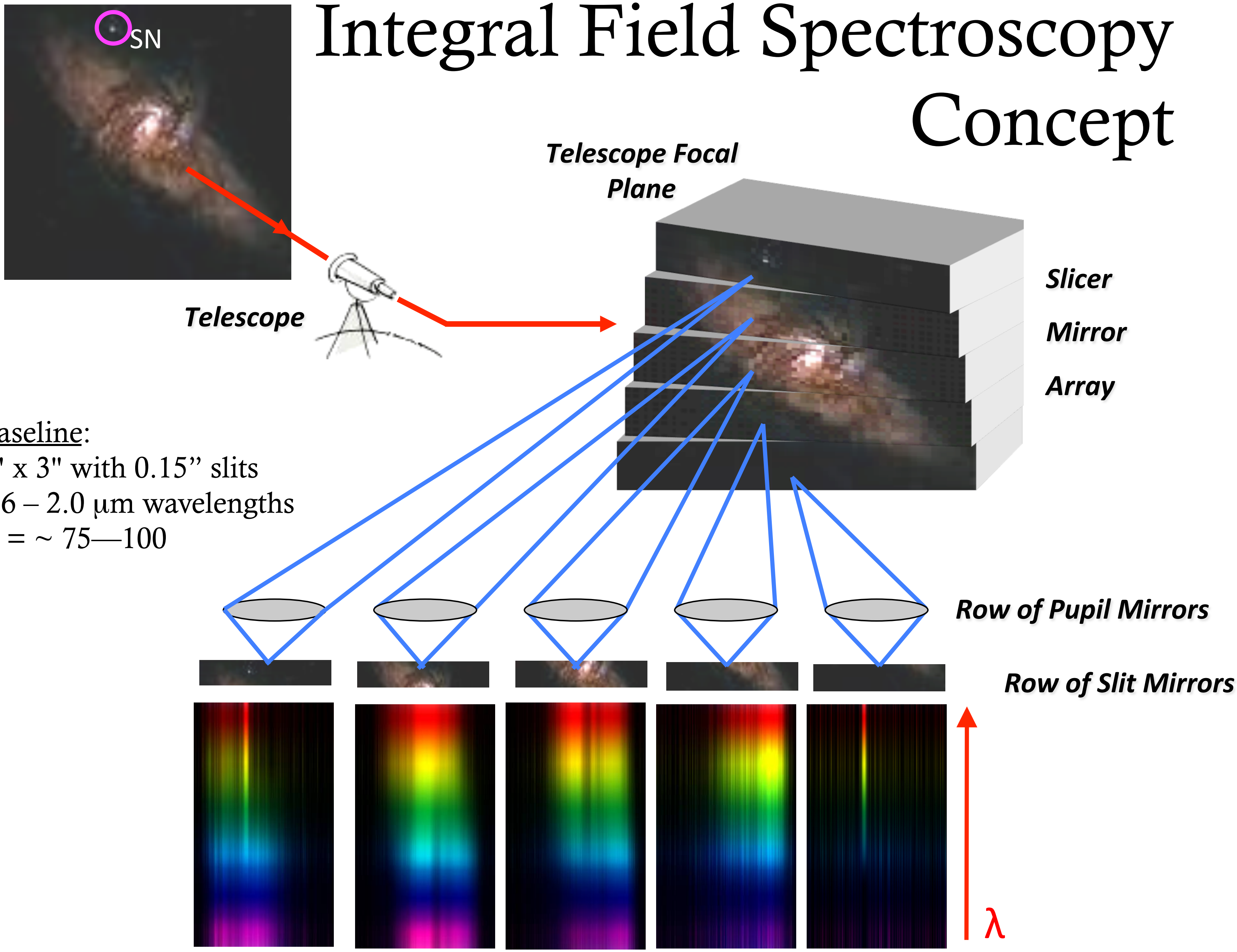


Small, compact assembly:

- ~ 6 to 7 kg
- 30 x 50 x 12.5 cm



Integral Field Spectroscopy Concept

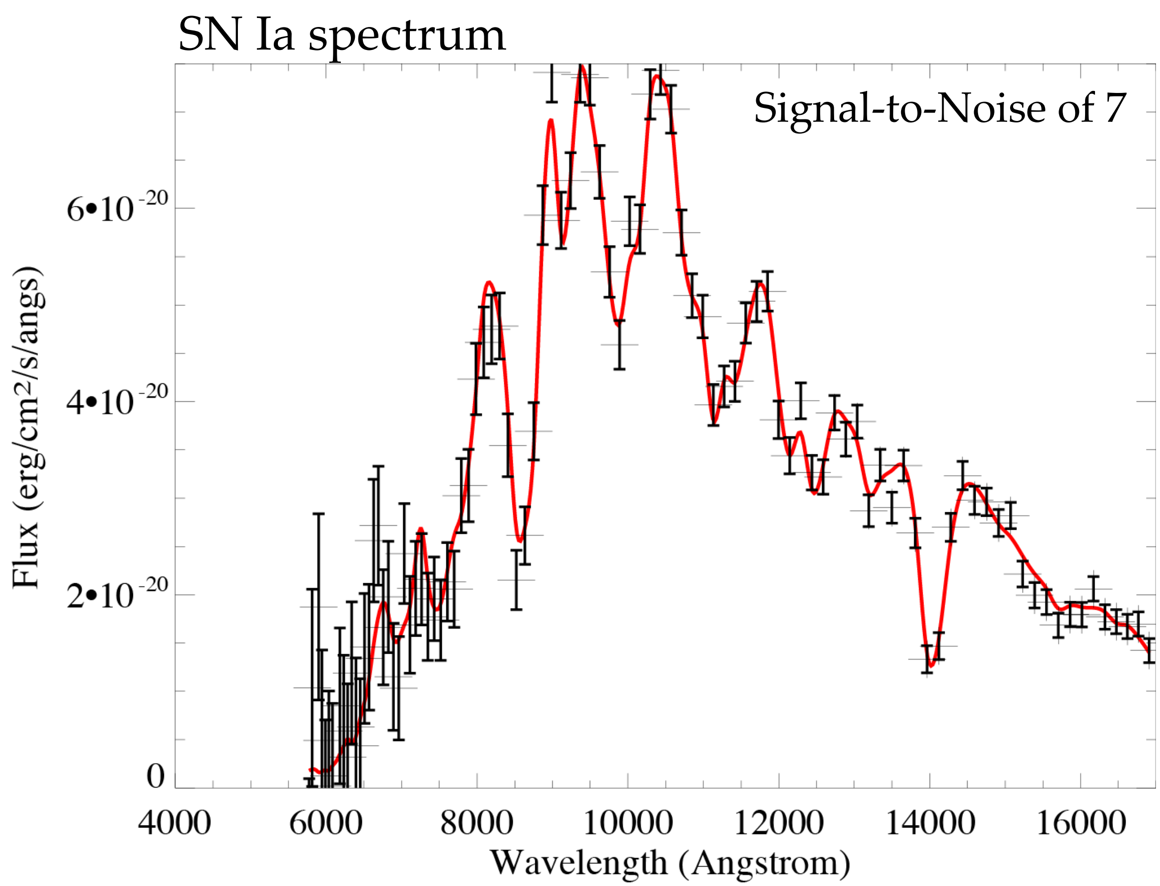


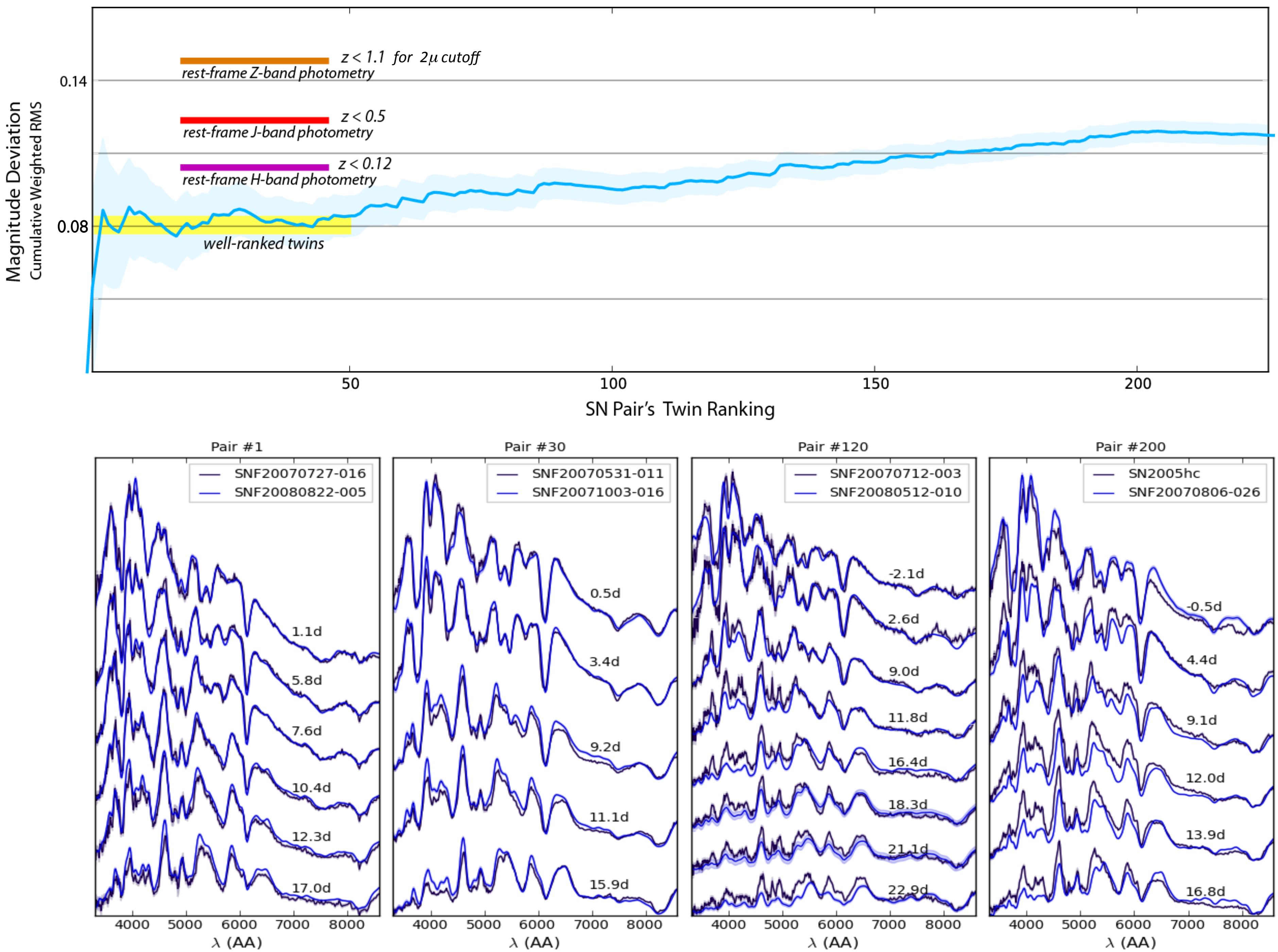
Baseline:
3" x 3" with 0.15” slits
0.6 – 2.0 μm wavelengths
R = ~ 75—100

Use IFU spectra to get SN light curves with roughly a 5 day rest frame cadence.

Example:

- 7 spectra on lightcurve from -10 rest frame days before peak to +25 rest frame days past peak, S/N = 3 per pixel (S/N = 15 per synthetic filter band)
- 1 reference spectrum after supernova has faded, for **galaxy subtraction** with S/N = 6 per pixel
- 1 deep spectrum near peak for subtyping, spectral feature ratios etc. with S/N = 10 per pixel





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21.1d
22.9d
Pair #200
SN2005hc
SNF20070806-026
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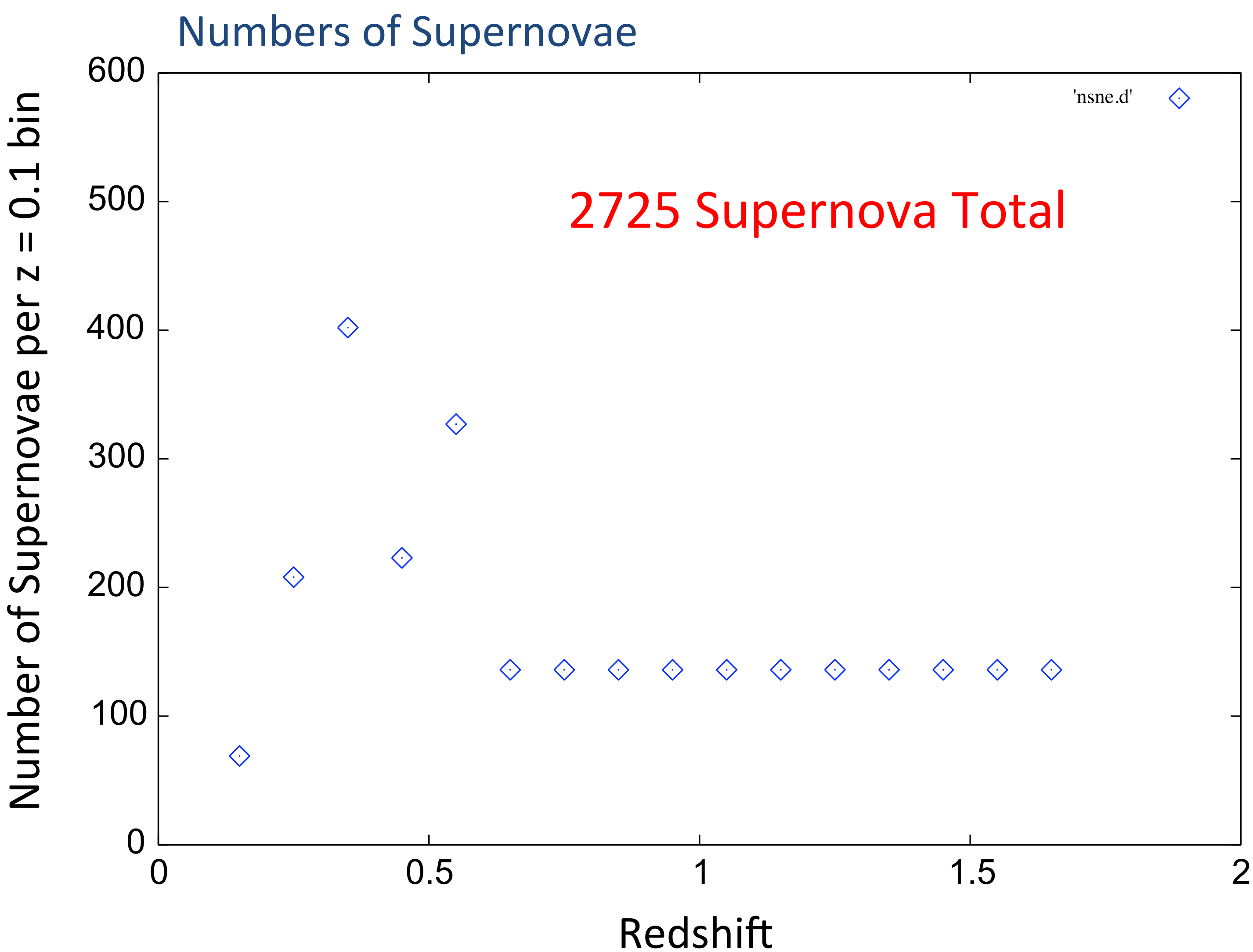
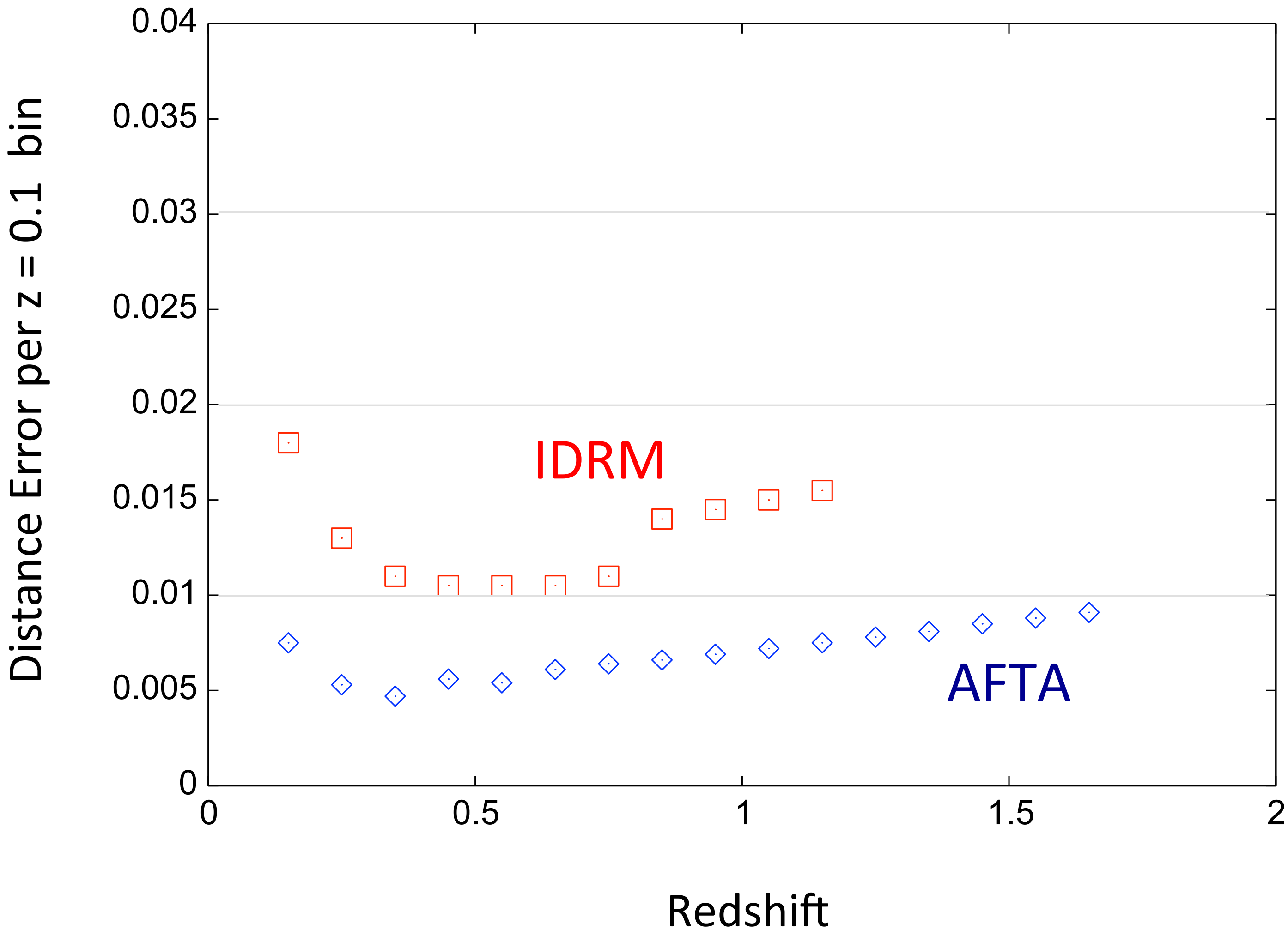
4.4d
9.1d
12.0d
13.9d
16.8d
4000
5000
6000
7000
8000
λ (AA)

For an example: 3 tier survey, scanning different areas of sky for different redshift ranges -- for 6 months spread over 2 years calendar time – yields

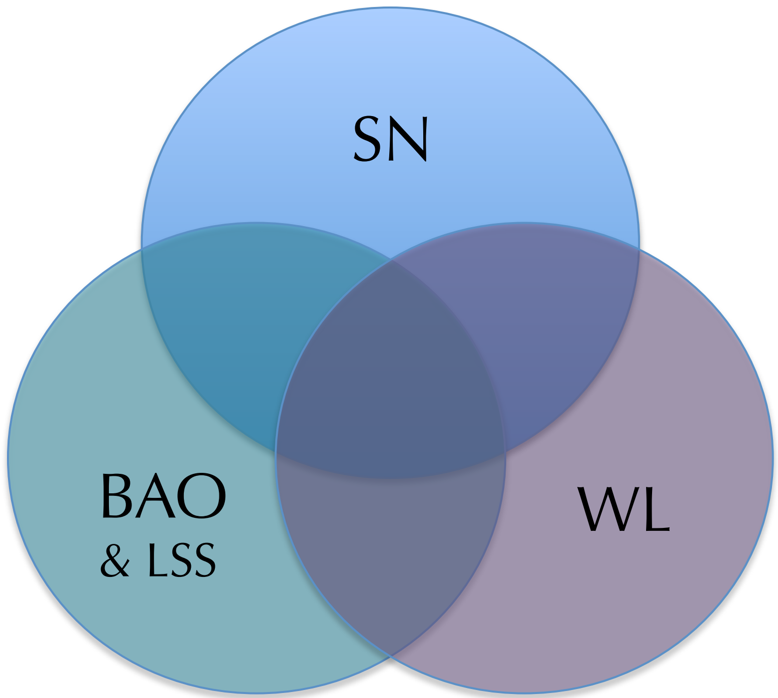


Error on SN Distance Measurement



Figures of Merit

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



LSST & WFIRST Weak Lensing DETF FoM is >1.6x larger if can train at z>2 with IFU

A bigger issue for WFIRST WL: *H*-limited sample skews to higher z!

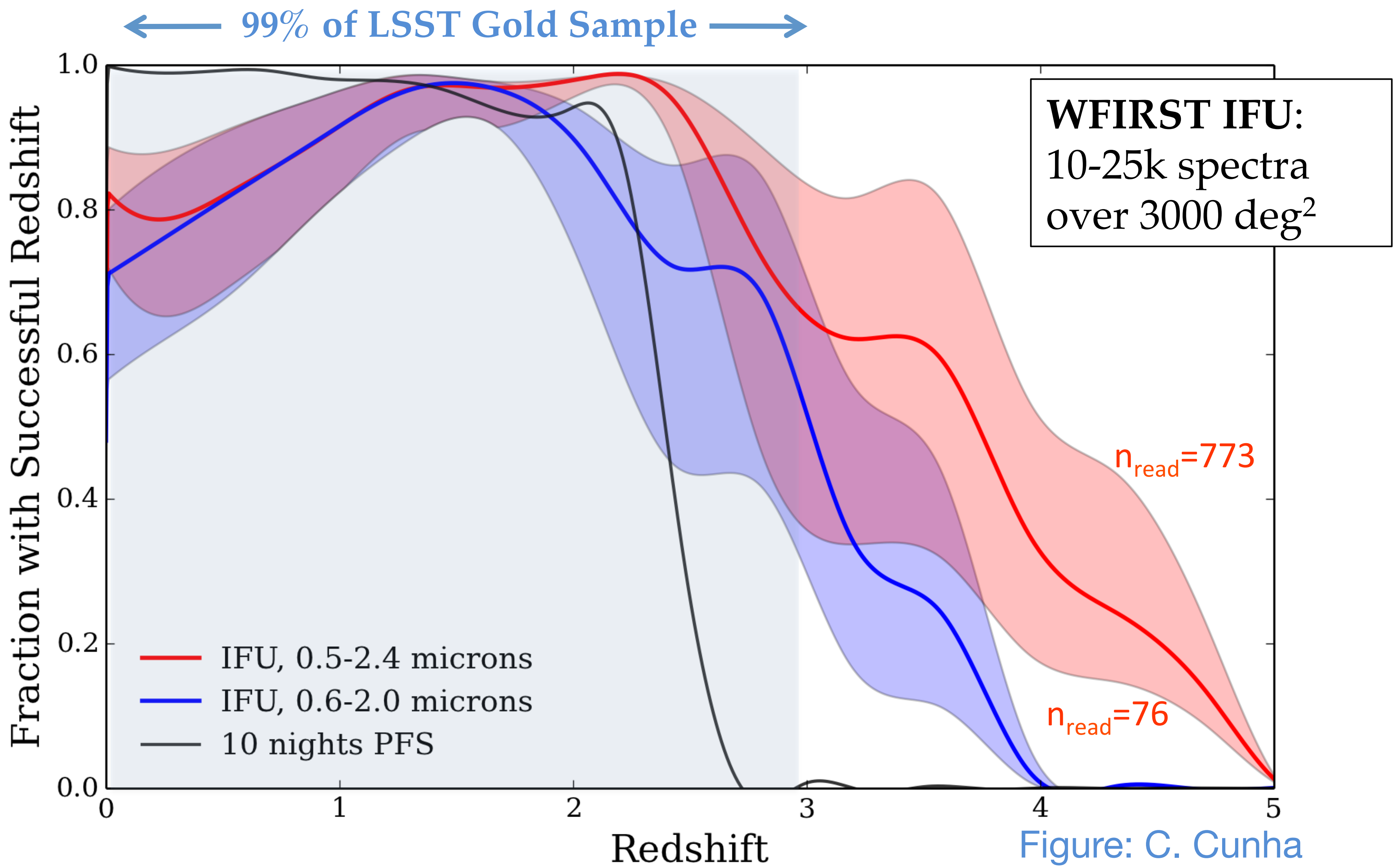
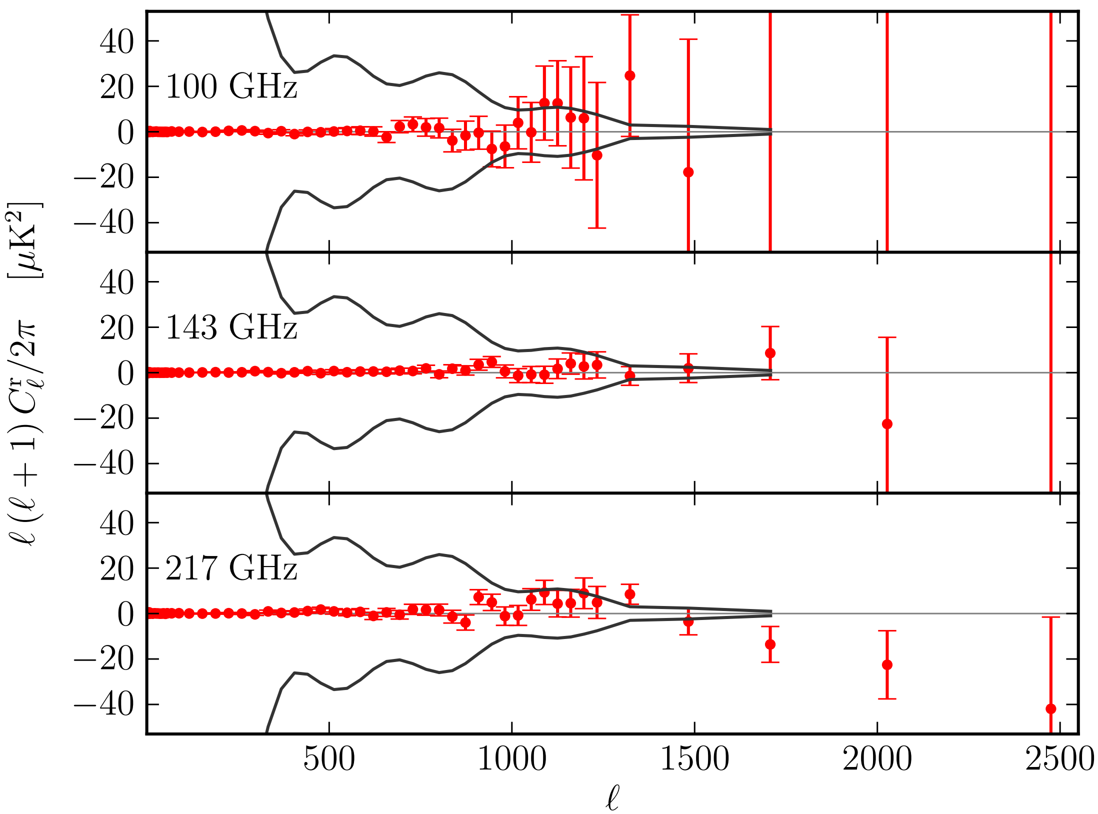


Figure: C. Cunha

Internal Inconsistencies in Planck



Planck Paper VI

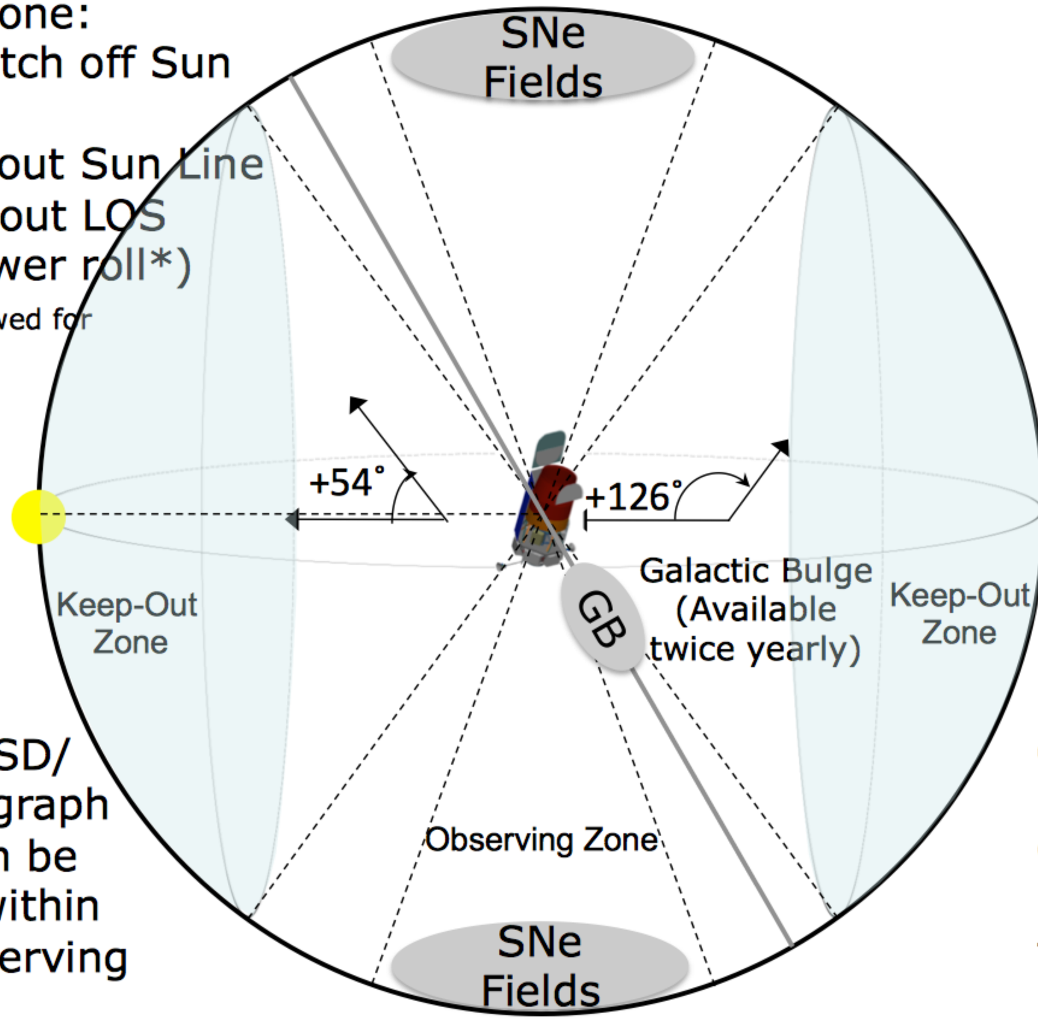
Shows the importance of multiple measurements and cross-checks

WFIRST-AFTA's Central Line of Sight (LOS) Field of Regard (FOR)

Observing Zone:
54°-126° Pitch off Sun Line
360° Yaw about Sun Line
±10° Roll about LOS
(off max power roll*)

* Larger roll allowed for SNe

SNe Fixed Fields be ±20° off one of the Ecliptic Poles, ±15° Roll about LOS from 90° - 110°



WL/ BAO-RSD/ GO/Coronagraph Surveys can be optimized within the full Observing Zone

Microlensing can observe Inertially Fixed Fields in the Galactic Bulge (GB) for 72 days twice a year

PSF Issues for WL – Part I

- Key parameters for WL are PSF size and stability.
  - Size – PSF contribution to final ellipticity scales as ~$(\theta_{psf}/\theta_{gal})^2$; exponent is 4 in the PSF ellipticity power spectrum!
    - Other aspects, such as statistical error on the ellipticity, are similarly affected, albeit with slightly different scalings.
    - For trades between PSFs of different morphologies, have used ½-light radius for "size" (see next chart) – this better matches more detailed calculations than e.g. FWHM.
  - Stability – PSF must be measurable from stars before it changes.
    - Requires detailed analysis. Note that obstructed vs. unobstructed designs have different aberration patterns (e.g. dominant aberration from SM decenter is coma vs. astigmatism).
    - AFTA STOP and RWA-induced vibration analysis meets preliminary stability requirements with large margins, even in GEO. These analyses are more advanced than for previous versions of WFIRST.

PSF Issues for WL – Part II

- See expressions for WL biases (additive and multiplicative).
  - Massey et al. paper is an update of the formalism that underlies error budgeting for weak lensing programs.
  - PSF size (R_{PSF}) and determination errors (terms with δ) are key.

$$\mathcal{A}(\ell, z_A, z_B) = \frac{1}{{P_\gamma}^2} \left\langle \frac{R^4_{\rm PSF}}{R^4_{\rm gal}} \right\rangle \left\langle \left|\boldsymbol{\delta\varepsilon}_{\rm PSF}\right|^2 \right\rangle (\ell, z_A, z_B) + \frac{\left\langle \left|\boldsymbol{\varepsilon}_{\rm PSF}\right|^2 \right\rangle}{{P_\gamma}^2} \left\langle \frac{R^4_{\rm PSF}}{R^4_{\rm gal}} \right\rangle \frac{\left\langle \left|\delta(R^2_{\rm PSF})\right|^2 \right\rangle}{\left\langle R^4_{\rm PSF} \right\rangle} (\ell, z_A, z_B)$$

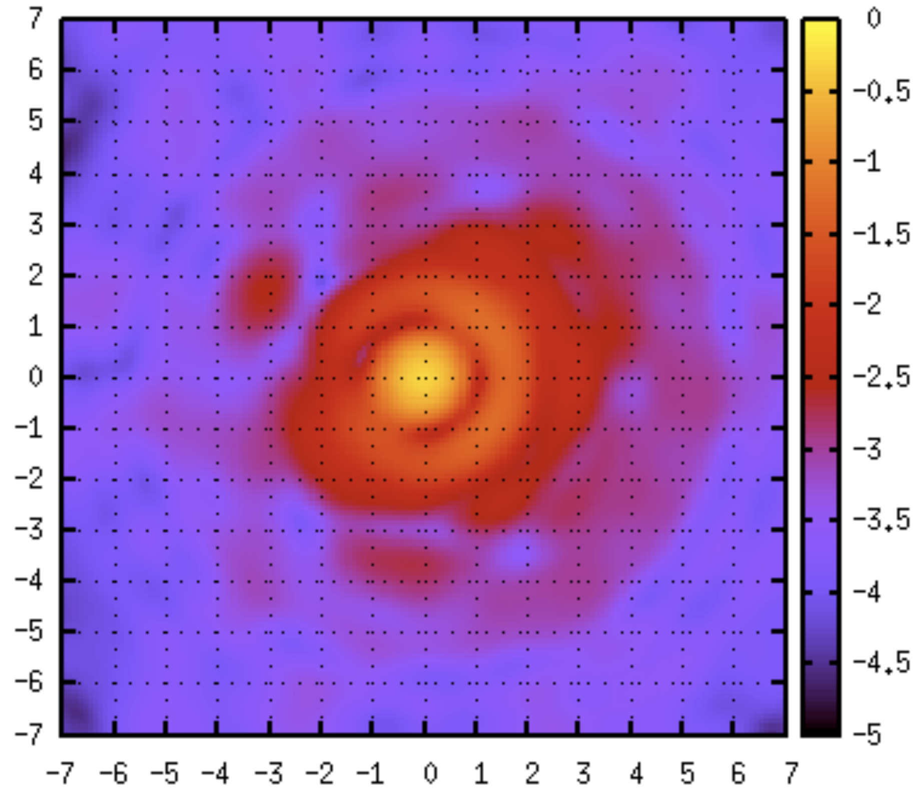
$$\mathcal{M}(\ell, z_A, z_B) = \left\langle \frac{R^4_{\rm PSF}}{R^4_{\rm gal}} \right\rangle \frac{\left\langle \left|\delta(R^2_{\rm PSF})\right|^2 \right\rangle}{\left\langle R^4_{\rm PSF} \right\rangle} (\ell, z_A, z_B) + 2 \left\langle \frac{R^2_{\rm PSF}}{R^2_{\rm gal}} \right\rangle \frac{\left\langle \delta(R^2_{\rm PSF}) \right\rangle}{\left\langle R^2_{\rm PSF} \right\rangle} (z_A, z_B) \, .$$

Massey et al. 2013 (MNRAS 429, 661)

- A simpler PSF (off-axis) is helpful and may simplify the book-keeping for the error budget, but would not be chosen at the expense of size or stability.

Obstruction Effect on PSF

- On-axis telescope leads to greater complexity:
  - More power in diffraction rings.
  - 12 spikes; complex features in inner few λ/D as spikes interfere with rings (see figure at right).
- Power sprayed into rings leads to worse performance than an unobstructed mirror of the same outer diameter.
- AFTA ½-light radius is equivalent to a 1.74 m unobstructed entrance pupil (both in J band, same WFE).



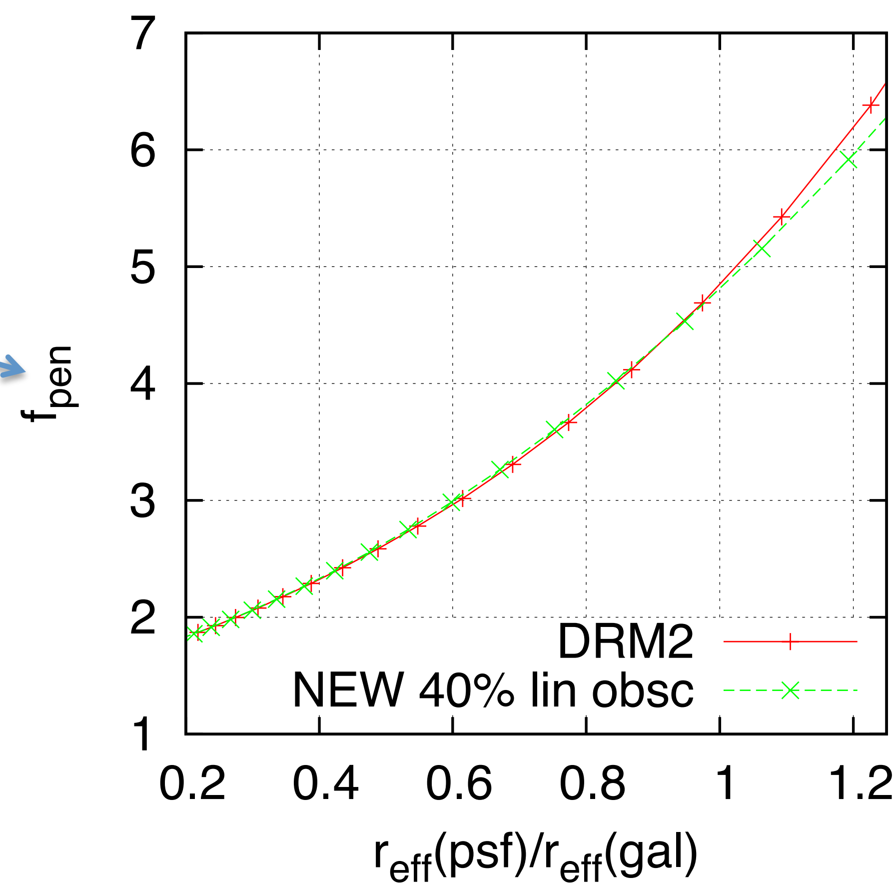
Obstructed PSF on **$\log_{10}$** intensity scale, with 90 nm aberrations; grid is in units of pixels.

Why the PSF half light radius, r_{eff}?

- ✓ WL shape measurement depends on the SNR of a galaxy and a "penalty factor" for PSF smearing and non-Gaussian profile.

$$\sigma_e = \frac{2\sqrt{f_{\mathrm{pen}}}}{\mathrm{SNR}}$$

- ✓ The plot on the right shows a comparison of WL shape measurement penalty factor for DRM2 and 2.4 m on-axis (computed by the Fisher matrix integral over spatial frequencies), for an exponential profile galaxy in H band. [NOTE: This comparison is for an old pupil with bigger obstruction – 0% and 40% are bounding cases.]
- ✓ In comparing off- and on-axis telescopes, **scaling by the half-light radius is an excellent indicator of the amount of degradation**.



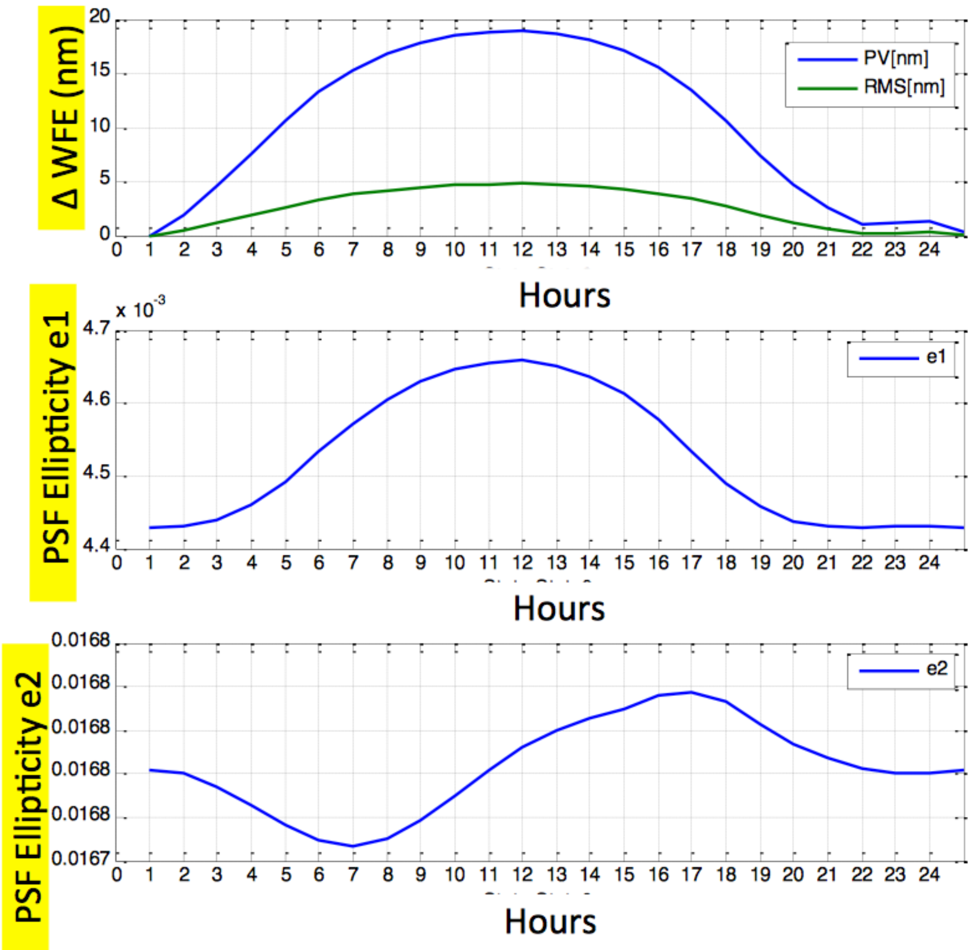
[Ratio of half-light radii]

WL Summary for Obstructed Telescope

- Obstructed pupil reduces AFTA performance *relative to an off-axis telescope of the same aperture*.
  - Larger PSF (by any metric).
  - Longer exposure times (even the effect of the spider is significant, up to 18% in background limited mode – this is taken into account in the ETC).
- Wavefront stability is essential in any case, and the top Zernike modes are different for the two cases.
  - There is no strong driver to "prefer" one aberration pattern over another – only to make wavefront drift small and confined to a finite set of degrees of freedom.

- <u>Bottom Line</u>: obstructed telescopes are at a disadvantage, but going up to a 2.4 m mirror much more than offsets these losses.
  - The off-axis IDRM was a solution to a problem: improve the PSF without increasing the mirror size. This is no longer the problem at hand.

WFE and PSF Ellipticity Stability Margins for STOP Fixed-Attitude Case



- ΔWFE worst rate 0.041 nm/184s
- ΔWFE drift allocation (0.707 nm/184s) easily met at worst rate
- **Margin factor (worst rate) x17**

- PSF Ellipticity = sqrt(rss(e1,e2))/sqrt2
- Worst rate = 1.6 e-6/184s
- Portion of total PSF Ellipticity Stability Budget (≤4.7e-4/184 s) consumed at worst rate is very small!
- **Margin factor (worst rate) = x290**

Key Cyc-3 STOP Assessments

- Inclined GEO Orbit introduces variable Earth thermal loads
  - Sensitive to the Observatory's Earth orbit position and attitude.
- Assess impact on the WFI PSF Ellipticity stability margins
  - Evaluate at WFI Imager focal plane
  - Evaluate at a **fixed attitude** with margin on Earth loads on WFI radiator
  - Evaluate for a **worst-slew** with worst case Earth loads on WFI radiator
- For the Coronagraph Team
  - Provide motions and shapes (Zernike's) of the T1 and T2 mirrors as a function of time
  - Provide above for a **fixed attitude** case (at worst angle for Earth thermal disturbances to the Telescope)
  - Slew cases are of much less interest, given the long (2 week?) fixed attitudes expected during CG Operations

STOP Assessment Summary

- The STOP results are summarized in detail on p.2
- They show excellent WFI PSF Ellipticity stability and solid WFI WFE stability margins, the best DRM results that we have seen (even for the worst-slew case)
  - x9 margins on WFI WFE drift stability rqt
    - x25 better than HST WFE variations, which can be ±30 nm over an orbit
  - x108 margins on WFI PSF Ellipticity total stability rqt
- The T1/T2 Shape/Position Stabilities, from fixed-attitude case, are viewed positively by the Coronagraph Team
  - Zernike instability dominated by focus at a fraction of a nanometer to a few picometers range over 24 hours
  - Sub-micron rigid body motion ranges over 24 hours