Photometric Redshifts for WFIRST and LSST: Challenges and Synergies

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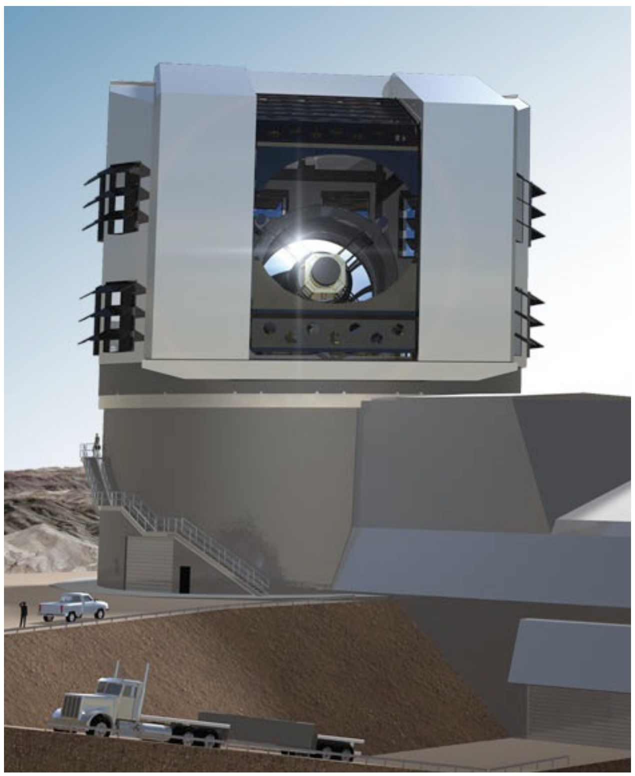
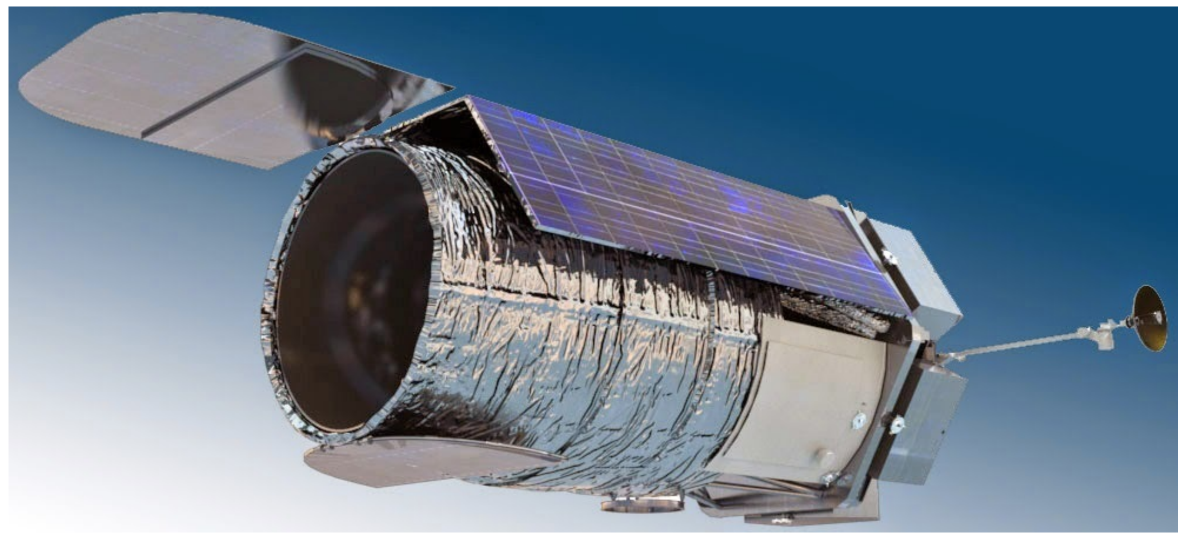
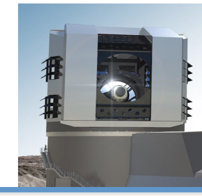




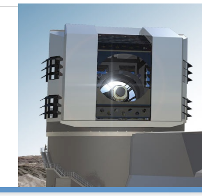
See Snowmass white paper on *Spectroscopic Needs for Imaging Dark Energy Experiments, http://arxiv.org/abs/1309.5388 for more details!*

Summary



- The WFIRST/AFTA IFU can complement ground-based spectroscopic surveys for training photometric redshifts
  - Leads to improved photo-z algorithms & smaller DE errors
  - This is enabled by current WFIRST plans
- WFIRST/AFTA grism redshifts can contribute to calibrating photo-z's via cross-correlations
  - Without good calibration, DE inference will be incorrect
  - WFIRST helps in a difficult domain from the ground
  - The key question is what the rate of highly-secure redshifts will be

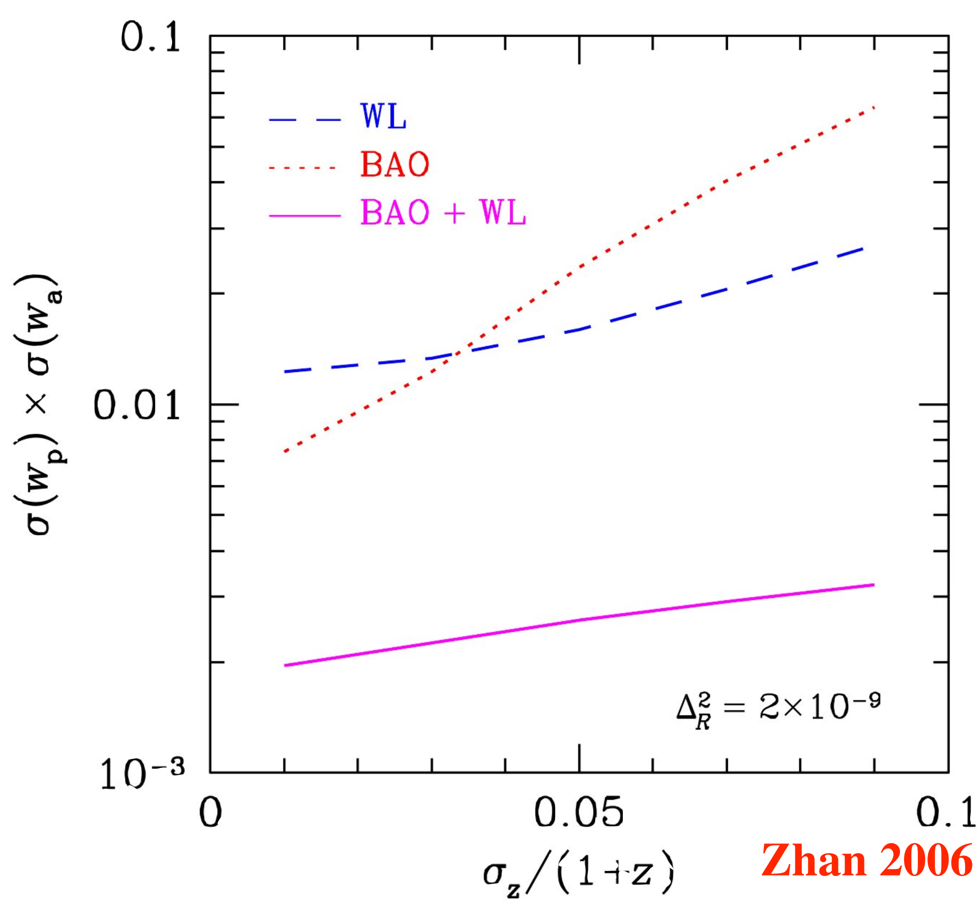
Two spectroscopic needs for photo-z's: training and calibration. WFIRST is relevant to both.



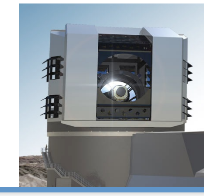
- Better training with spec-z's improves algorithms and shrinks photo-z errors, giving better dark energy constraints

- For weak lensing and supernovae, precision matters less, but the calibration must be accurate - i.e. bias and errors need to be extremely well-understood

  - *uncertainty in* bias, $\sigma(\delta_z) = \sigma(\langle z_p - z_s \rangle)$, and in scatter, $\sigma(\sigma_z) = \sigma(\mathrm{RMS}(z_p - z_s))$, must both be <~0.002(1+*z*) for Stage IV expts.



Training of photo-z's is limited by incompleteness in redshift surveys

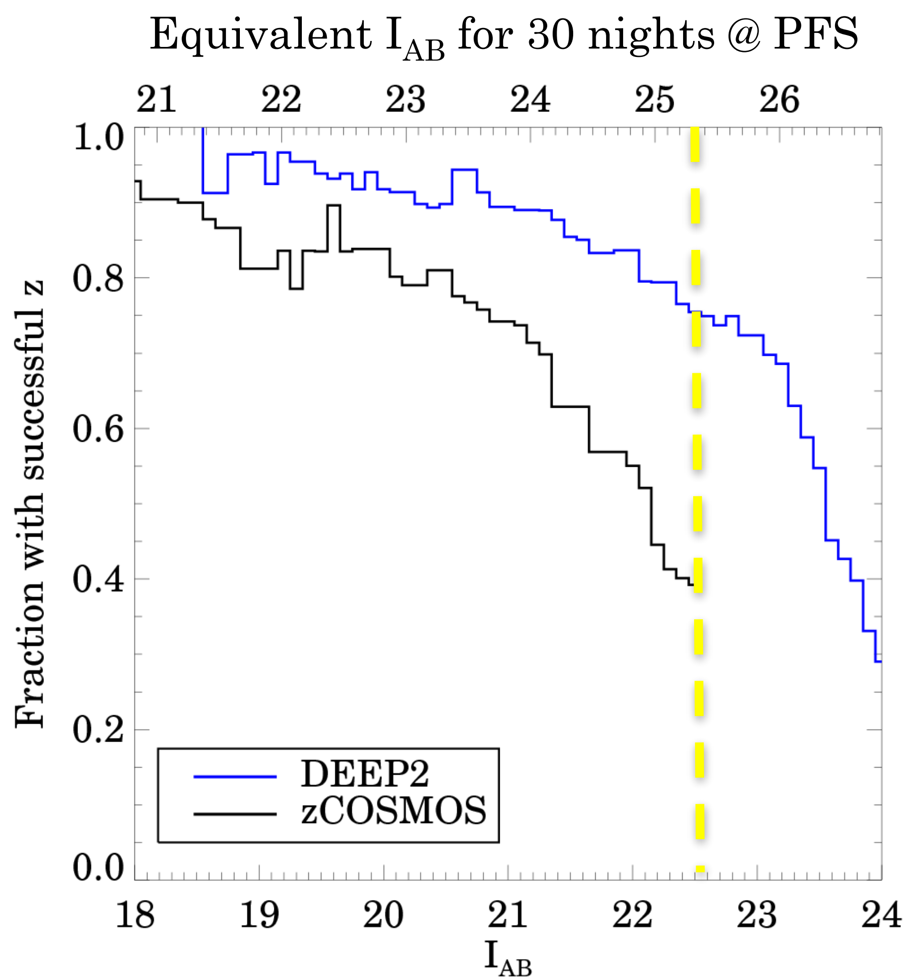


- Desire training set of ≳20k objects with very secure z measurements, spanning full parameter space

- High completeness is very difficult to achieve from the ground, especially at z>2; leaves parts of parameter space untrained, with poor photo-z's

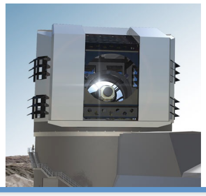
- This degrades the DE FoM

- The WFIRST IFU can improve the situation



Redshift success rates from DEEP2 (Newman et al. 2012), zCOSMOS (Lilly et al. 2009)

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



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

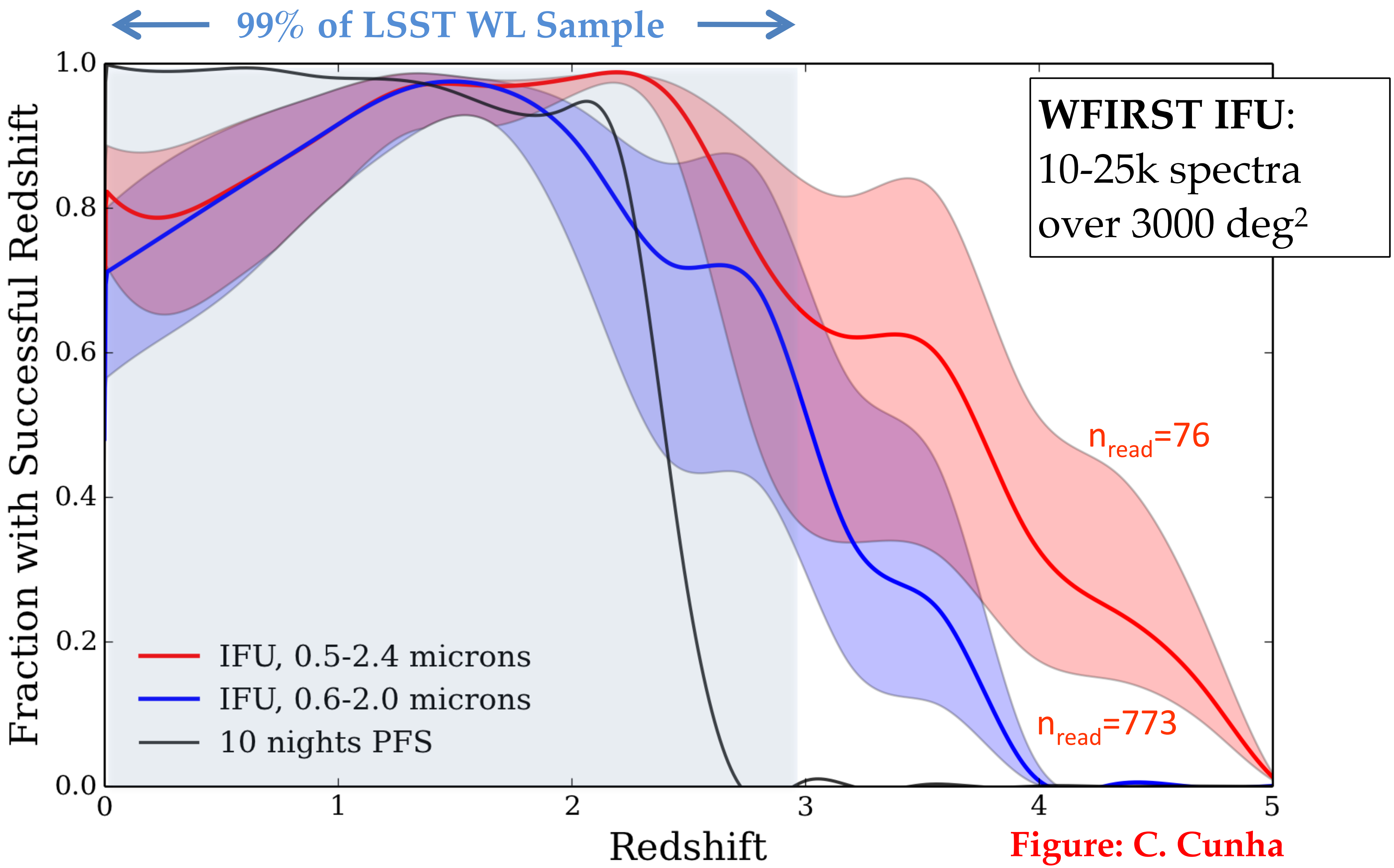
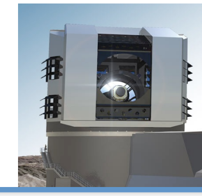
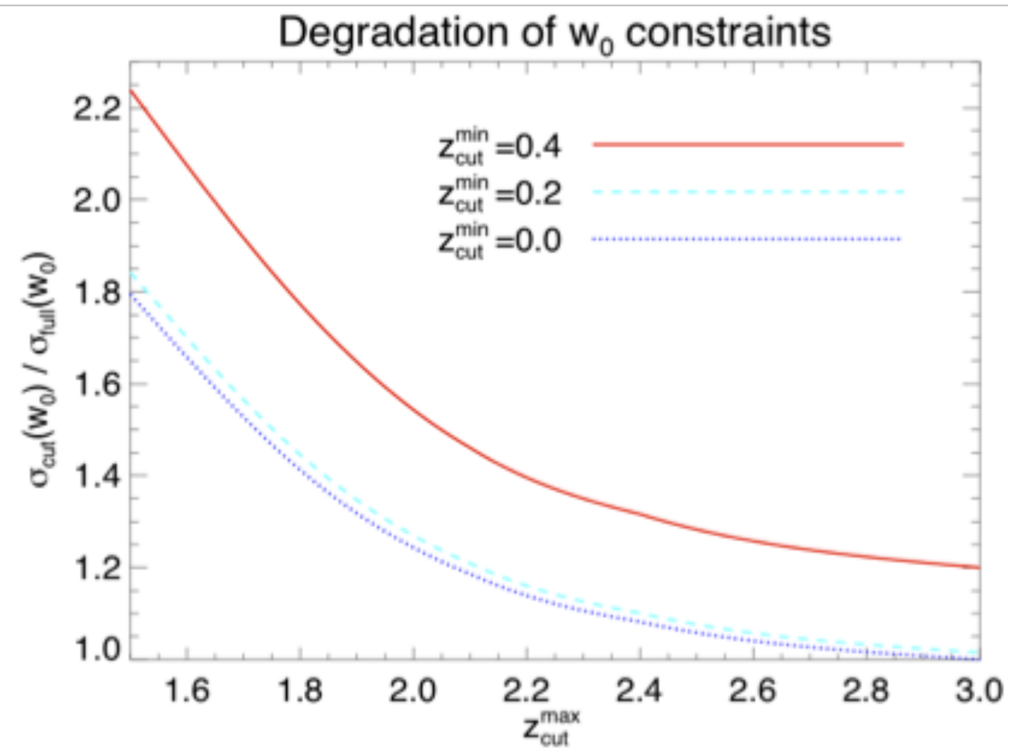


Figure: C. Cunha

WFIRST IFU can enable dark energy constraints from the high-redshift tail of the *z* distribution

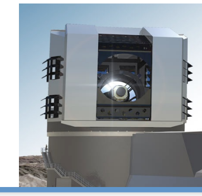


- For LSST, DE FoM is ~40% worse if have to throw out z>2, ~20% worse if only cover z<2.5
- WFIRST skewed to higher z: 40%/20% FoM degradation for training to z=2.6/2.9
- >70% lower FoM if WFIRST cannot work at z>2
- >10k IFU spectra can be obtained for free during WFIRST imaging with a 3"x3" IFU + 3" shift, or >20k with 6" shifts



Hearin et al. 2012
(LSST-like scenario)

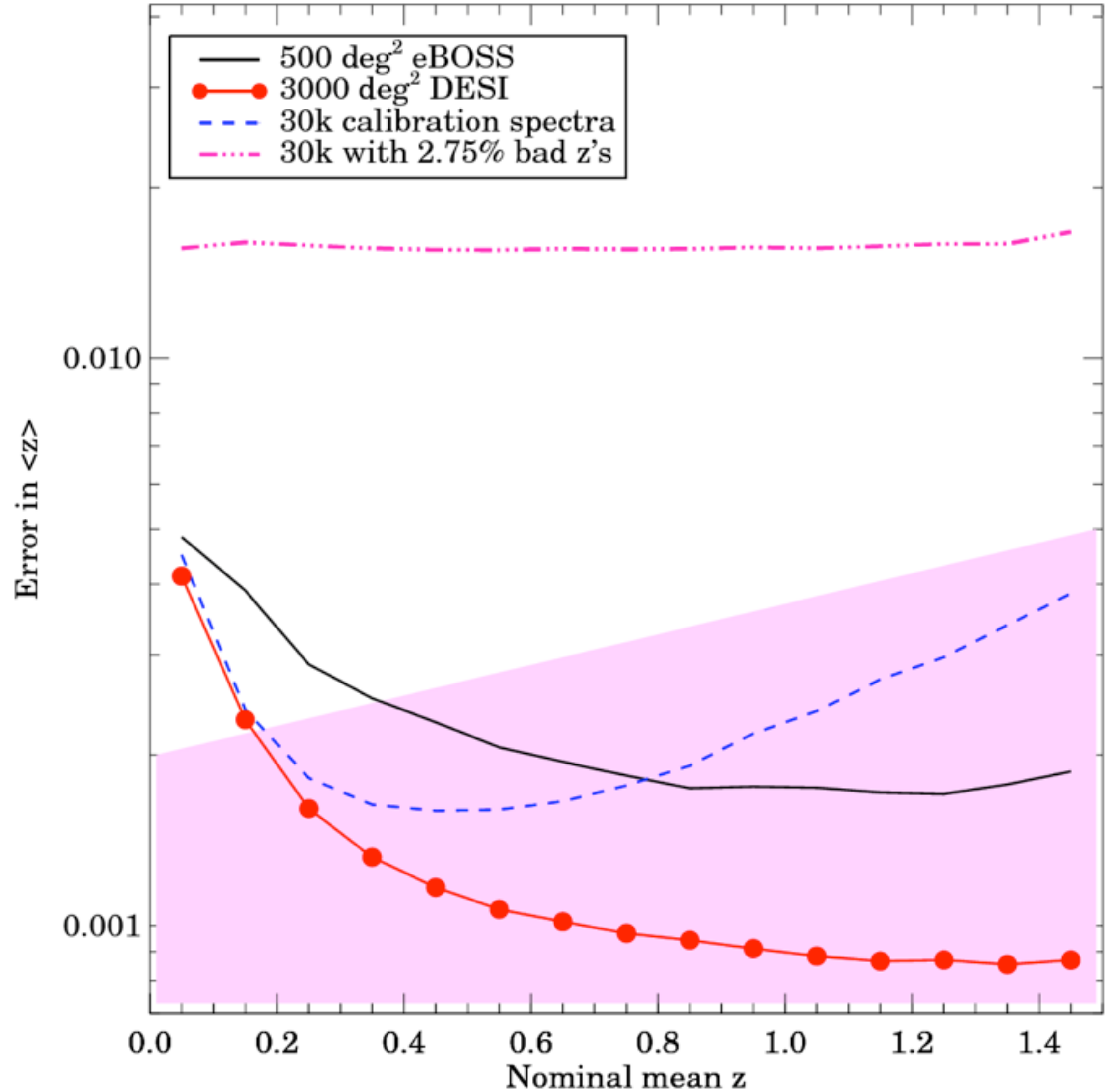
Grism spectroscopy should contribute to cross-correlation analyses



- To reach LSST calibration requirements, require >100k objects over >100 sq. degrees, spanning z range of sample (cf. Matthews & Newman 2010)

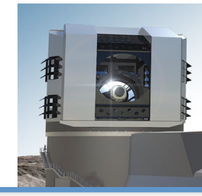
- >500 square degrees of overlap with DESI-like survey enables cross-correlation calibrations to meet Stage IV requirements

- **WFIRST grism redshifts should only be better for this than DESI QSOs at z~1.5-3.** Redshift range will be limited by need for multiple emission lines for secure z's, however.



Snowmass White Paper: Spectroscopic Needs for Imaging DE Experiments

Summary



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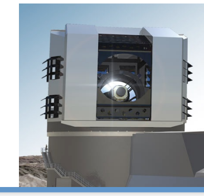
A few details on the Cunha et al. calculations



- **With a 3"x3" IFU & 3" dither, expect ~10k/15k spectra down to LSST/WFIRST depth, with 1.4-2ksec exposure time. 6"x6" IFU or 6" dithers nearly doubles the sample size.**
- **Typically read-noise dominated:**

$$n_{read} = 76 \left(\frac{N_{exposures}}{3}\right)\left(\frac{\text{Read noise}}{3e^-}\right)^2\left(\frac{\#\text{ spatial pixels}}{2}\right)\left(\frac{\#\text{ spec. pixels per FWHM}}{1.4}\right)$$

- **Tested a range of scenarios:**

Parameter	Optimistic	Baseline	Pessimistic
Readout noise (r_{out})	$3e^-$	$4e^-$	$4e^-$
Readout rate (f_{rout})	1/480s	1/300s	1/240s
Num. of spatial pixels (n_{pix})	2	3	4
Pixels per res. element (p_{ratio})	1.4	1.4	2.0
Total n_{read} (1440s exposure)	76 phot.	323 phot.	773 phot.