Improving SI-traceablity of Flux Standards for NGRST

Greg Aldering
Berkeley Lab
Nov 18, 2021

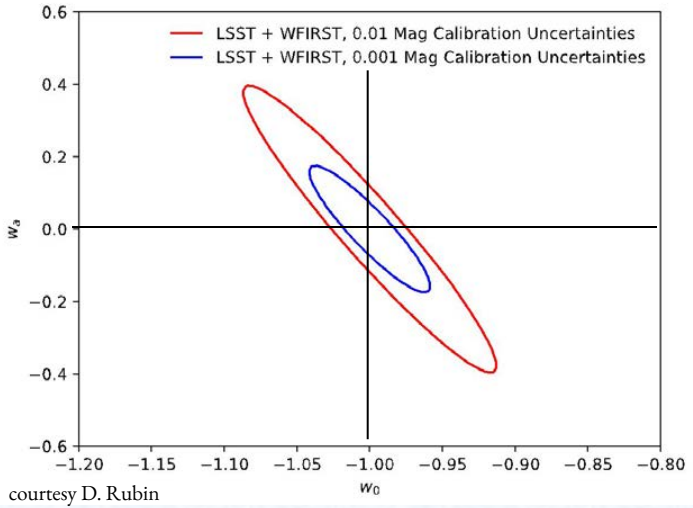
Flux Calibration on International System of Units

Needed to get to physical parameters - $\mathcal{L}$, $\mathcal{T}$

Driver for SN Ia Cosmology FoM

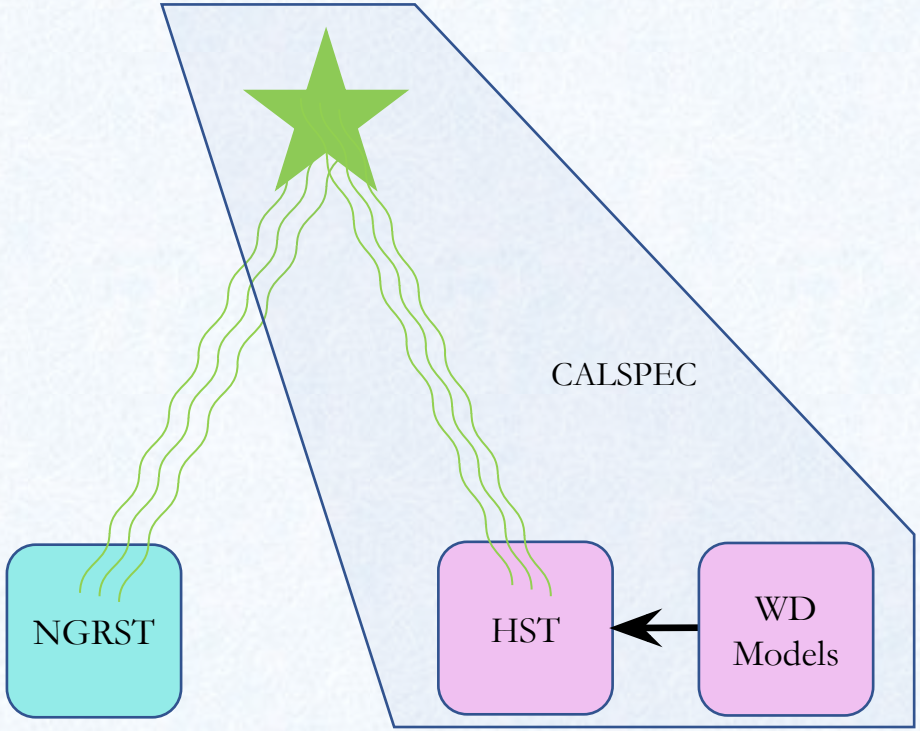
- SNe Ia with WFIRST and LSST could be the most powerful cosmology probe, if flux calibration is good to mmag

WFIRST SN Ia DE constraints



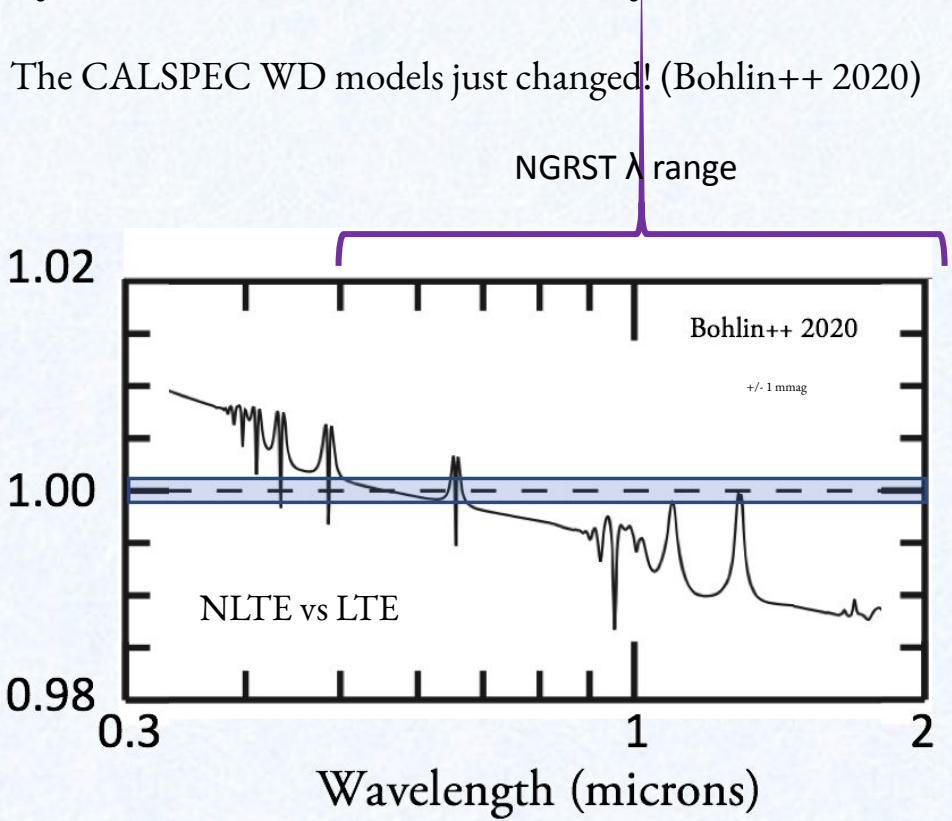
courtesy D. Rubin

Stellar Atmospheres Model Method

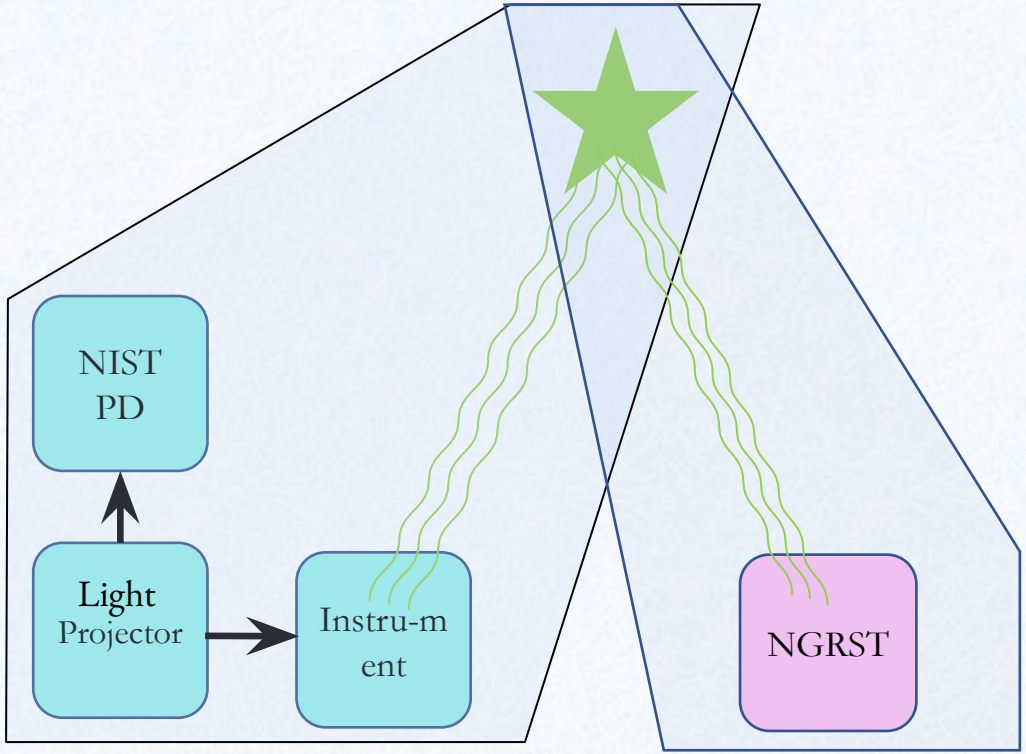


Reliance only on Models is Risky

The CALSPEC WD models just changed! (Bohlin++ 2020)



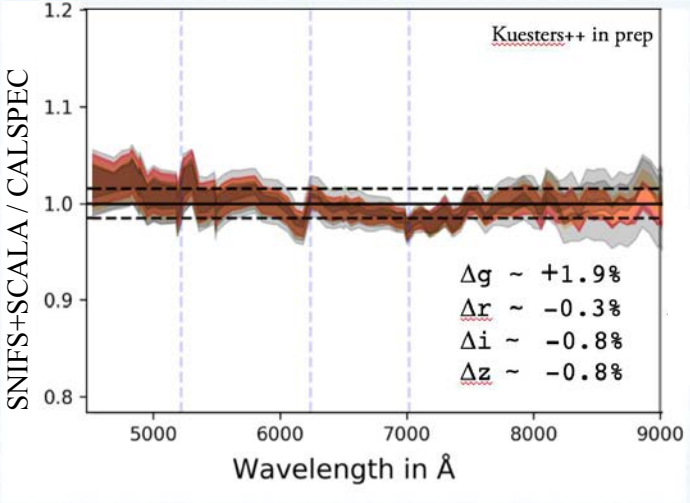
Physical Calibration Method

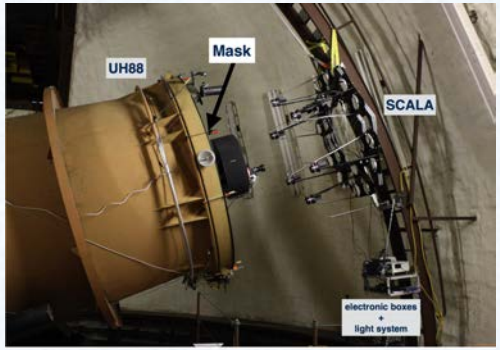


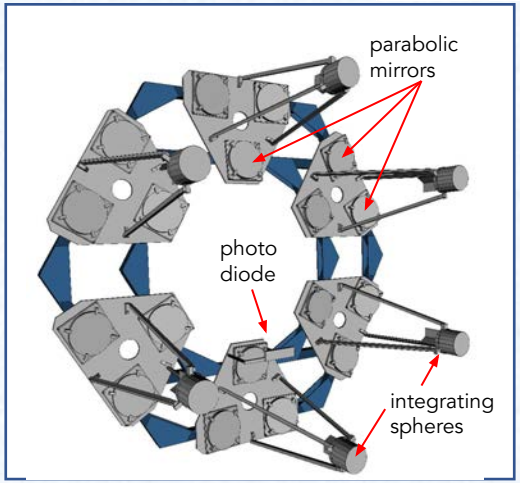
Model vs Physical Calibration

- Model Atmospheres of Stars:
  - Compute model spectra of specific stars, i.e., CALSPEC DA white dwarfs
  - Pros:
    - The reference sources look like regular science targets to instrument
  - Cons:
    - Worry about model limitations - metallicity, convection, turbulence, etc.
    - Galactic extinction – need to be in Local ISM Bubble or else be limited by dust knowledge
    - External uncertainty model essential, but hard to assess
- Physical Calibration:
  - Calibrate a telescope+instrument on SI system, then transfer to any star
  - Pros:
    - No modeling or dust extinction; applicable to any source
    - Multiple experiments provide external uncertainty
  - Cons:
    - Project light and star/SN light have differences in path through the telescope

Physical Calibration from SNIFS+SCALA





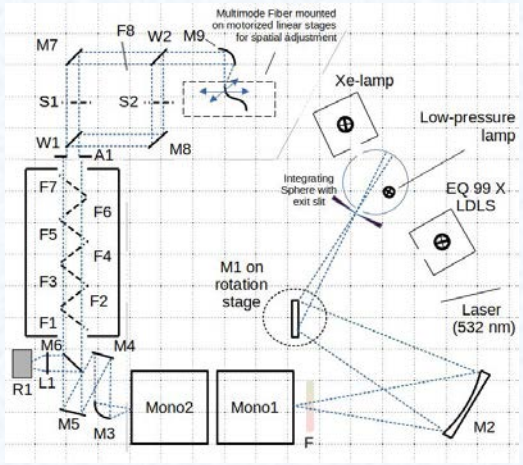


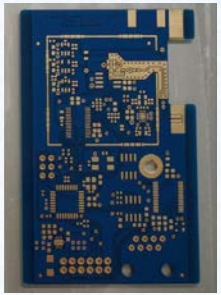
Differences may come from SCALA+SNIFS, CALSPEC, or, more likely, both.

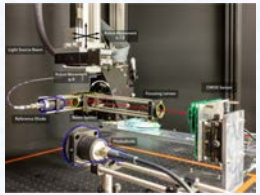
Already competitive with previous physical calibration

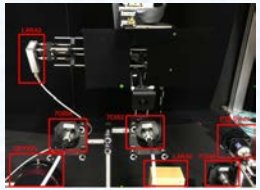
Supported in part by NGRST SIT and NIST PMG

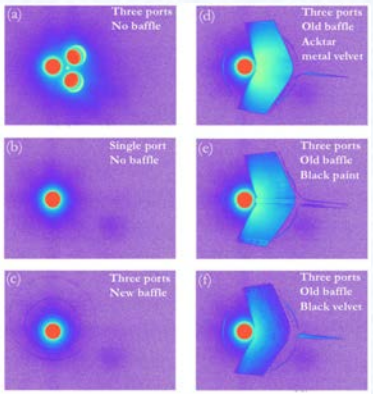
Upgraded SCALA



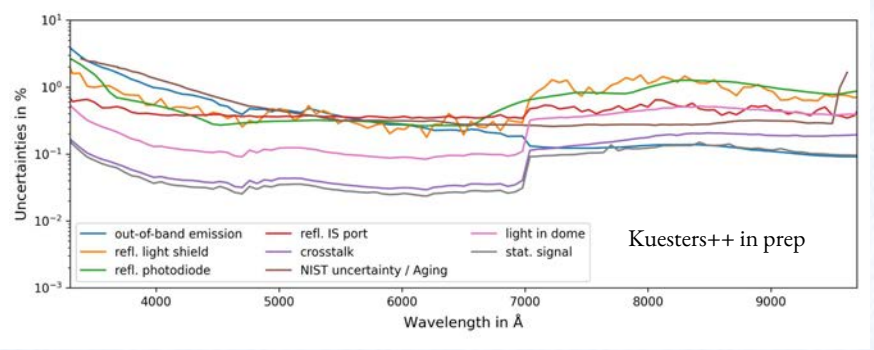






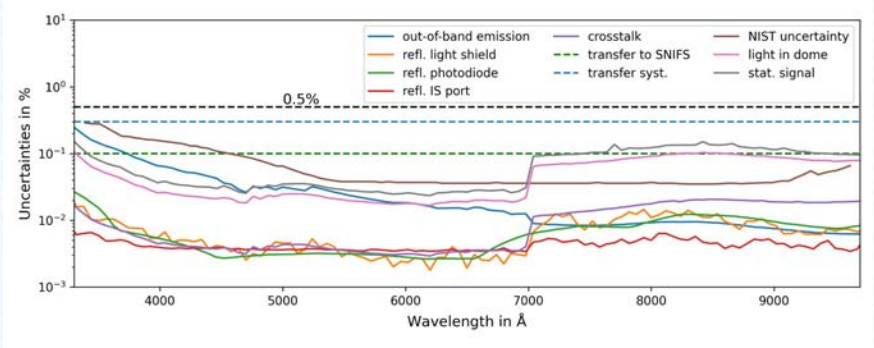


SCALA as measured before upgrades



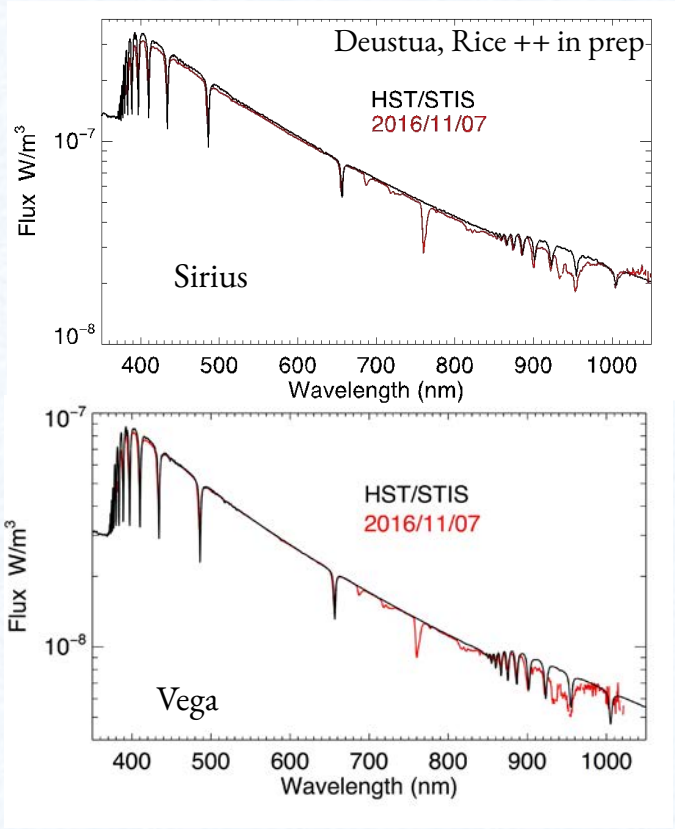
Kuesters++ in prep

SCALA anticipated w/ upgrades



Expected to reach 3-5 mmag over 0.32 - 1.0 micron

NIST STARS



Source of Uncertainty (~630 nm)	%Error
FEL Calibration	0.35
Transfer FEL calibration to Transfer Spectrometer	0.01
FEL to Transfer Spectrometer Distance	0.10
Transfer Spectrometer Linearity	0.20
Transfer Spectrometer Reproducibility	0.20
Transfer Calibration from Transfer Spectrometer to light source	0.01
Transfer Spectrometer to light source Distance	0.10
Transfer light source Calibration to telescope	0.30
Light Source to Telescope distance	0.20
Measurement of star	0.10
Horizontal Extinction Between Light Source and Telescope	0.20
Uncertainty Without Line of Sight Extinction	**0.63**
Line of Sight Extinction to Star	1.00?
Total Uncertainty	**1.18?**

Current: to 1 micron
To be sited on Paranal, wavelength range to 2.5 microns

Supported in part by NGRST SIT and NIST

Summary

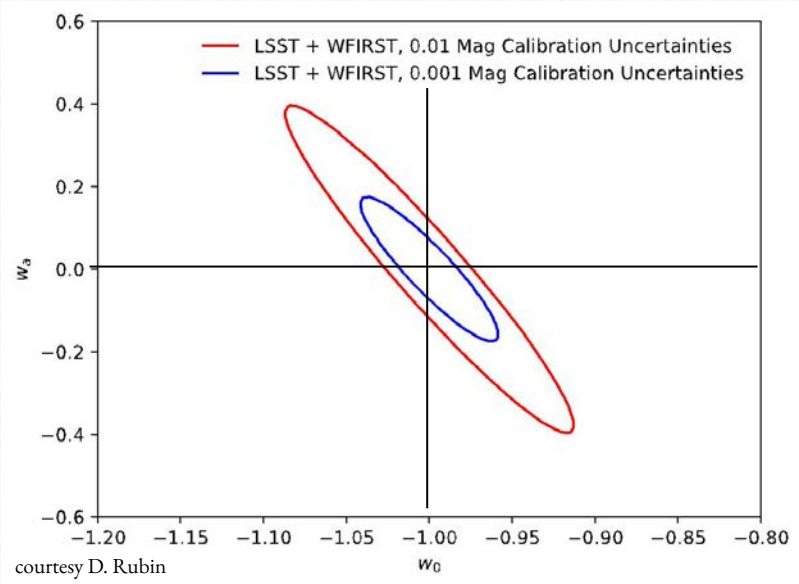
Calibration on SI system w/ accurate uncertainties is essential for NGRST

Alternative to stellar atmospheres models needed

Better physical calibration is now within reach!

Cosmology w/ SNe Ia FoM strongly depends on Flux Calibration on a Physical System

WFIRST SN Ia DE constraints



courtesy D. Rubin

SNe Ia with WFIRST and LSST could be the most powerful cosmology probe, if calibration is good to mmag