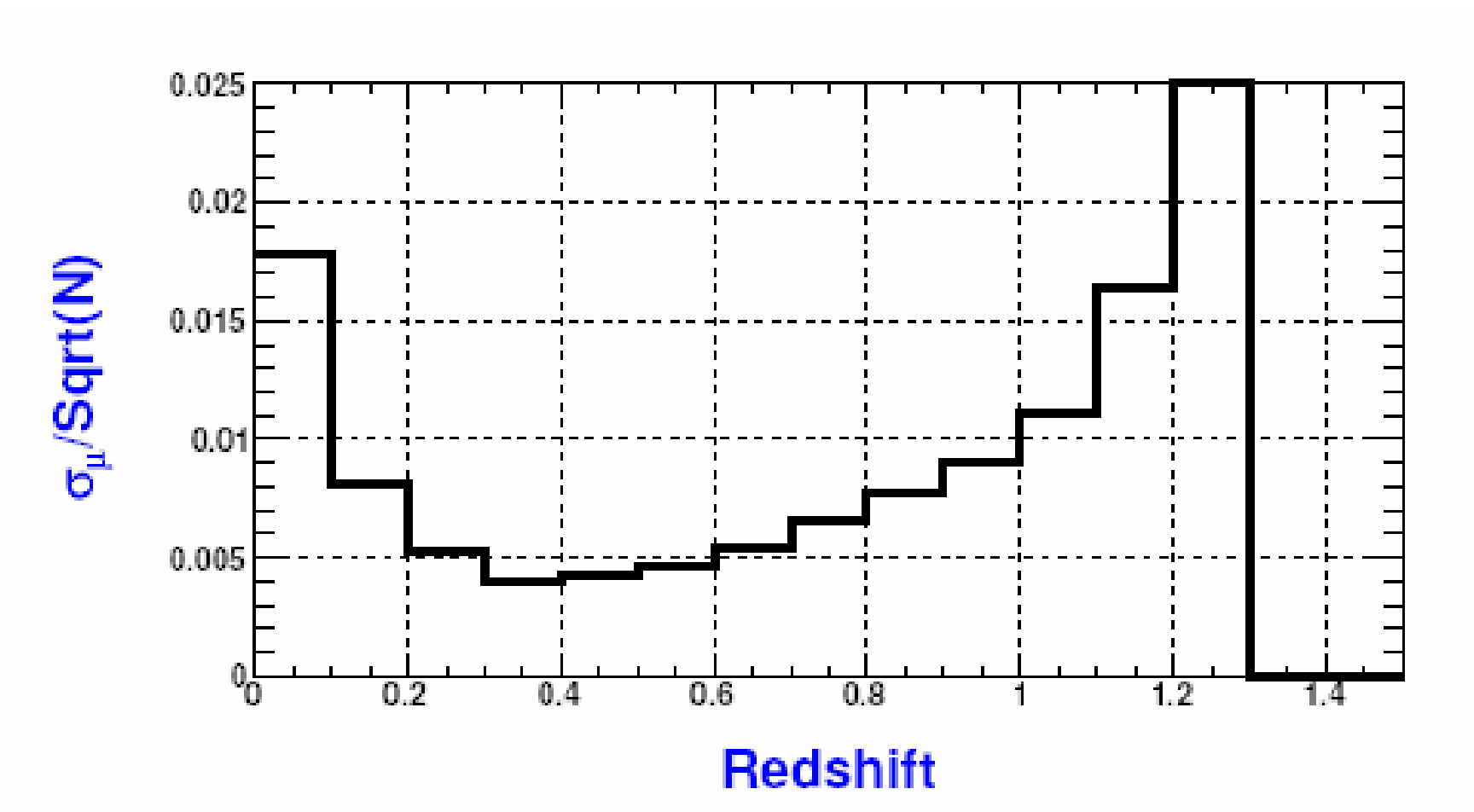
DES Calibration Requirements for Supernovae

John Marriner

Fermilab

April 4, 2008

DES Supernova Survey
Statistical Accuracy



Systematic Errors

- SN Model uncertainty
  - Light curve
  - k Corrections
  - Spectral templates
- Extinction corrections (host galaxy dust)
- Light curve fitting uncertainty
- Backgrounds (non-Ia events)
- Photometric calibration

Calibration
Accuracy versus Bias

- Individual SN fluctuate in magnitude by ~10% around a one parameter model.
  - Measurement of a single SN should not be dominated by calibration error
  - 2% error (DES goal) seems adequate
- When many SN averaged, one obtains a statistical precision of better than 1% in redshift bins of $\Delta z=0.1$. Calibration bias should contribute less than 1%.

SN Calibration Strategy & Requirements

- Spectro-photometric standards whose flux is known (on average) to 1% (absolute) and to 0.5% (color) in the DES filters.
- Transfer of standard magnitudes to field stars used as reference to an accuracy of 0.005 magnitudes.
- Filters that yield synthetic magnitudes accurate to within 0.005 magnitudes for a known supernova spectrum.

Spectro-photometric Standards

- Standard stars are hydrogen atmosphere white dwarves?
  - "Absolute" magnitude scale comes from comparison to Vega or equivalent.
  - Color comes from T_{eff} + log(g) + theoretical model of H atmosphere
- HST has 3 bright, hot DA WD's used as primary standards.
- SDSS has many fainter (~100) WD's in stripe 82
- Systematic bias?
  - Is the knowledge of the empirical parameters adequate? Do we need more (high resolution) spectroscopy?
  - Do we need a theoretical study?
  - Extinction corrections?

Transfer of Photometric Calibration to Supernovae

- We imagine that the standard stars will be measured directly by DECam (with short exposures).
- The calibration will be transferred to SN via nearby field stars.
- Issues
  - Non-linear response
  - Non-uniform response of focal plane
  - Atmospheric extinction (2nd order corrections)
- Bottom line: How many pointings for standard stars? 1000? Mapping non-linearity?

Filter Knowledge

- The synthetic magnitude accuracy of 0.005 is supposed to apply to both the standard stars and supernovae, but the supernova requirement is more demanding.
- The science is sensitive to errors in magnitude and that is why the requirement is specified in terms of a magnitude.
- Given a filter model parameterization and/or limit function, one can translate the magnitude error into a filter parameter limit.
- Nonetheless, the bottom line is thought to be that an *in situ* measurement of the telescope response function will be required to achieve 0.005 magnitude accuracy.

Self Calibration?

- One can make use of the SN themselves to calibrate the filter zero points if some assumptions are made.
- These techniques will certainly be used, but it seems important to do as well as possible before bringing in assumptions about the behavior of SN versus redshift.

SN Fields

- SN fields will be *very* deep exposures with multiple visits – over the 5 year survey
  - 60,000 sec in *g*
  - 600,000 sec in *z*
- SN fields will overlap spectroscopic surveys
  - CDFS (VVDS)
  - SNLS D1 (VVDS)
  - Stripe 82 (could overlap a DEEP2 field)

PRIMUS?

- Calibration fields could be used for time varying studies (*e.g.*, finding and measuring SN)

☛ Comments on how SN strategy can complement other DES science goals are timely *now*!

Summary

- Photometric calibration is an important source of systematic error.
- A precisely known set of standard stars is essential. Some work developing a set of standard stars is probably required.
- Current techniques are probably sufficient to transfer the standard star calibration to field stars near the supernova.
- Accurate knowledge of filter responses, such as an *in situ* response function measurement would provide, is essential.