Near-infrared SN Ia Cosmology in the LSST era

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The problem

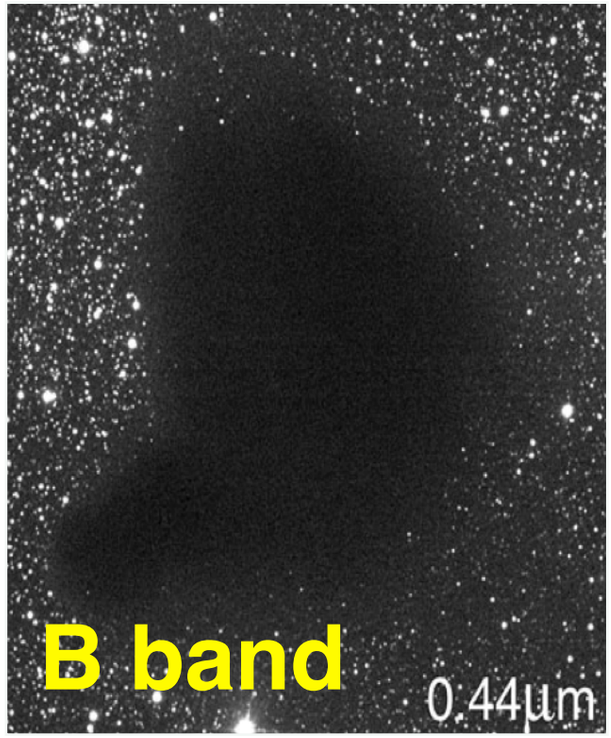
Optical samples of SN Ia for cosmology have reached their limit to constrain the nature of the dark energy (DE) because of the systematic uncertainties.

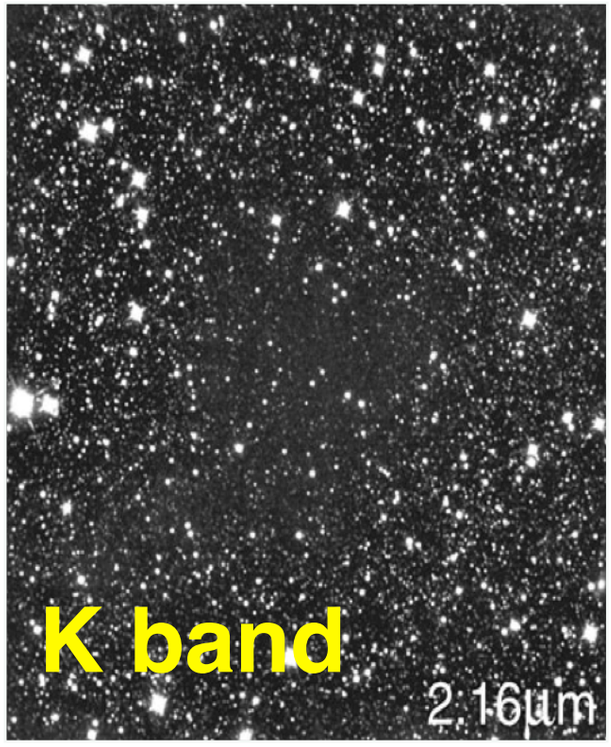
- More optical data *doesn't* mean better DE constraints.

- **Optical** light is **dimmed** and **reddened** by **dust** in the host galaxy, the Milky Way, and the extragalactic medium.

A solution: NIR observations!

- Near infrared (**NIR**) light is much **less sensitive to dust** than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.



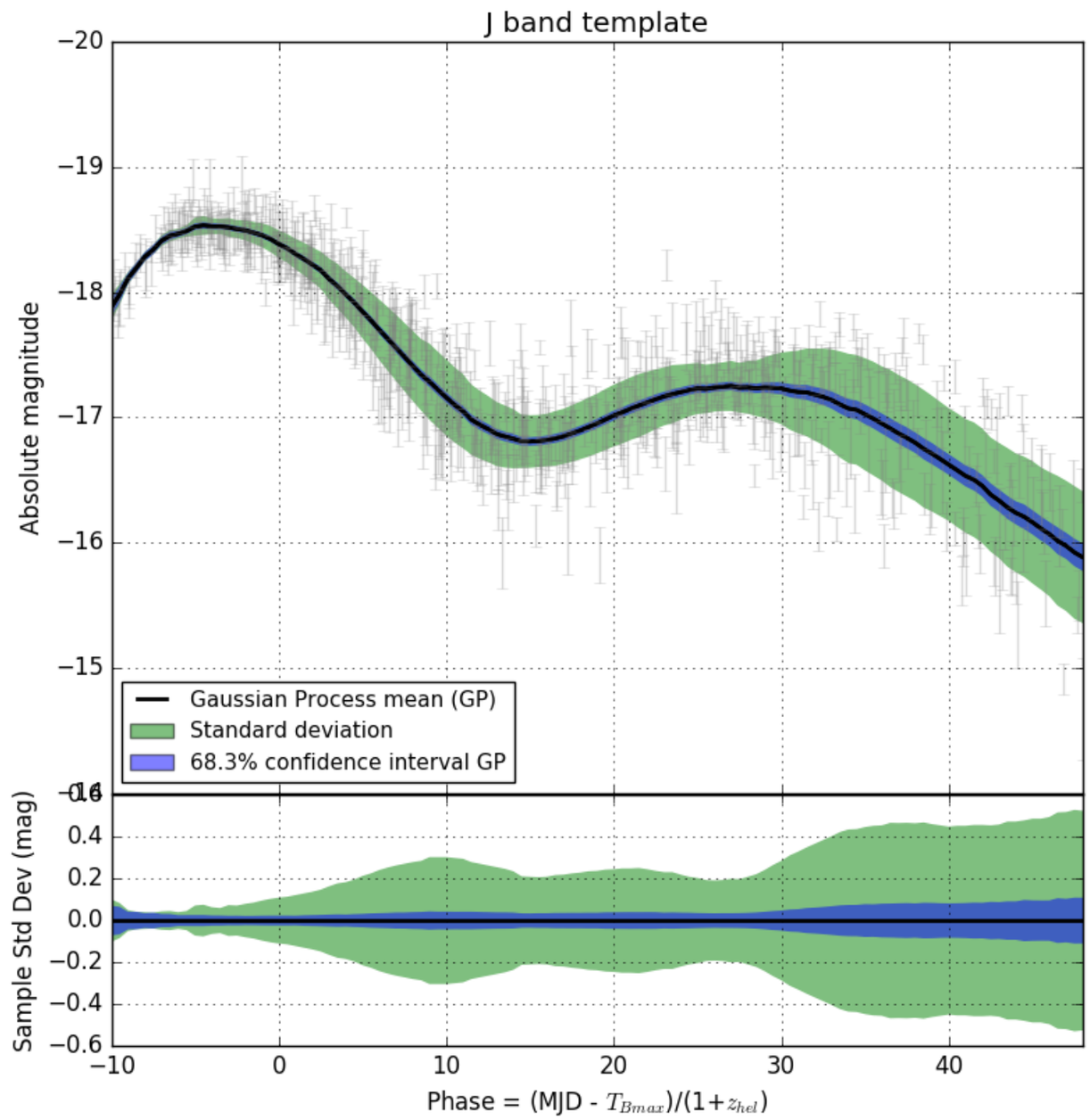


A solution: NIR observations!

- Near infrared (NIR) light is much less sensitive to dust than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.

- SN Ia observed in **NIR** are much **more standard candles** than in optical wavelengths, even when you correct the optical light curves for light curve shape. Previous works:

  - Wood-Vasey et al. 2008
  - Mandel et al. 2009 (BayeSN code)
  - Burns et al. 2011 (SNooPy code)
  - Friedman et al. 2015
  - Avelino et al. 2017, in prep

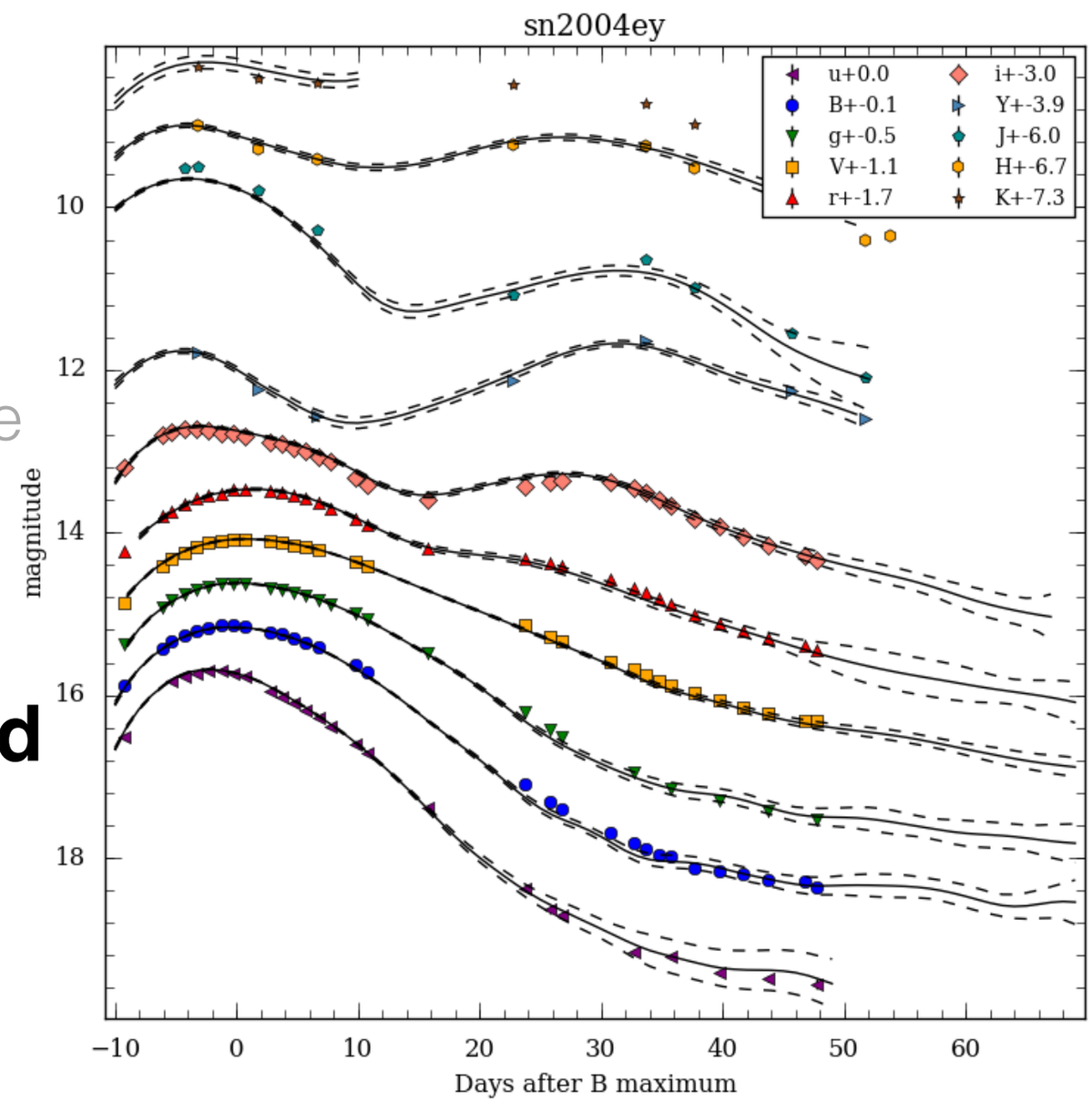


A solution: NIR observations!

- Near infrared (NIR) light is much less sensitive to dust than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.

- SN Ia observed in NIR are much more standard candles than in optical wavelengths.

- **NIR** light curves have a **second maximum** that allow to have a **brighter SN for longer** compared with the optical bands and can help in **photometric classification.**

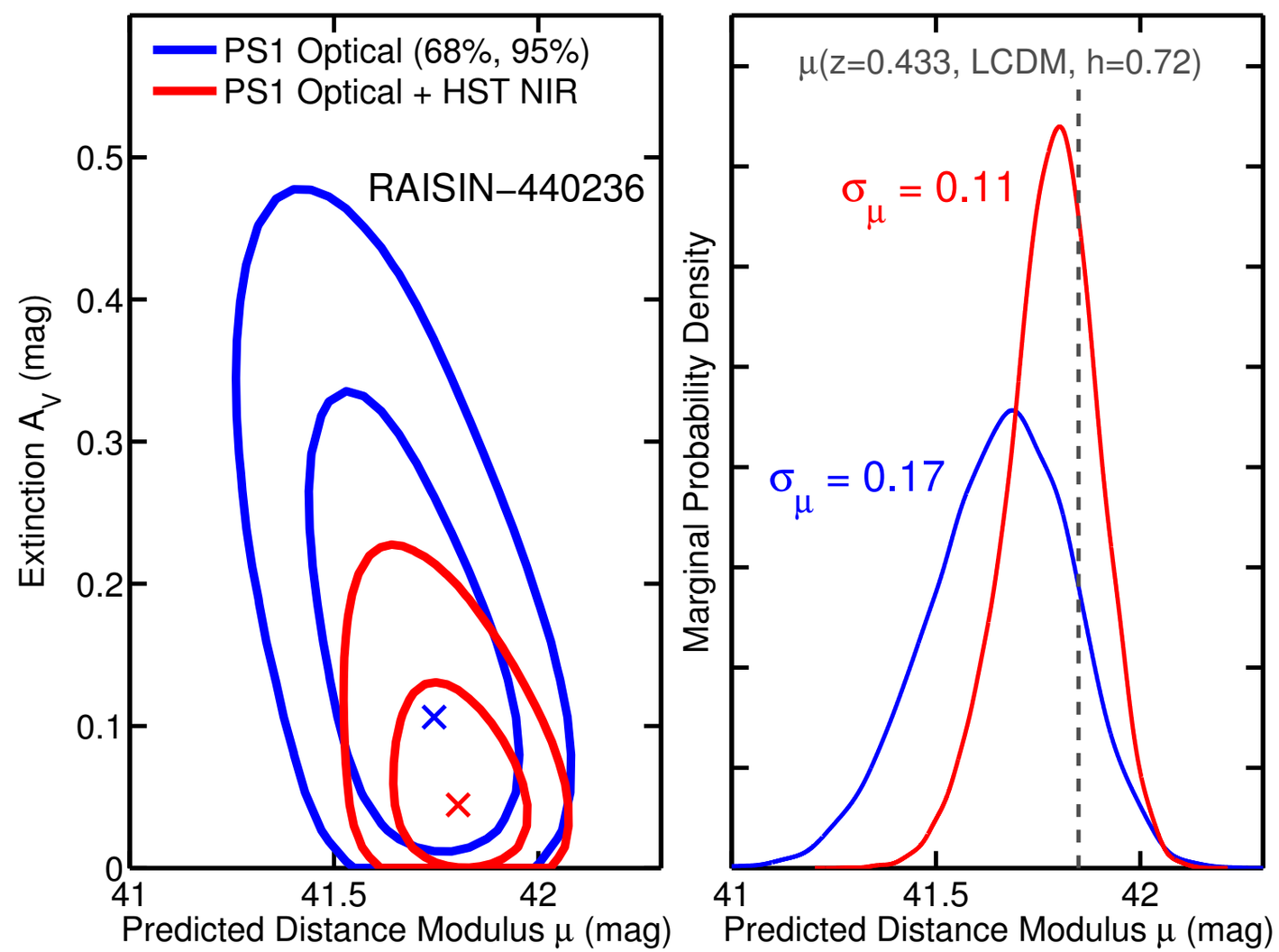


A solution: NIR observations!

Improvement in the precision and accuracy of the photometric distance modulus of individual SN by combining optical + NIR data.

- Previous work has shown that it is possible! (Mandel, Narayan & Kirshner 2011 [BayeSN code])

BayeSN fits



Dust

Distance modulus

A potential Optical+NIR program

1. Discover supernovae using LSST.

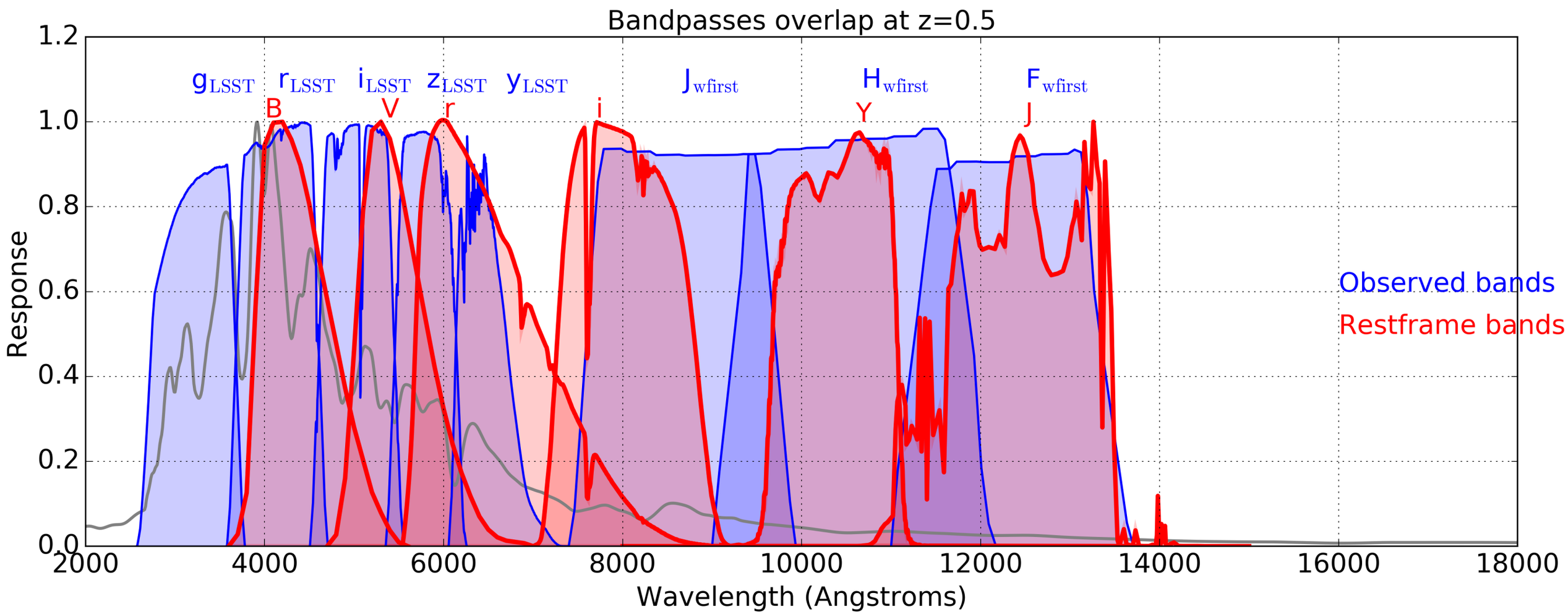
2. Determine the type of supernova and its redshift *z* (either photometric or spectral classification).

3. If it is a SNIa and *z*~0.5 then get NIR data with WFIRST to obtain rest frame YJ bands

4. Fit the optical (LSST) + NIR (WFIRST) photometric data to determine the distance modulus of each SN Ia.

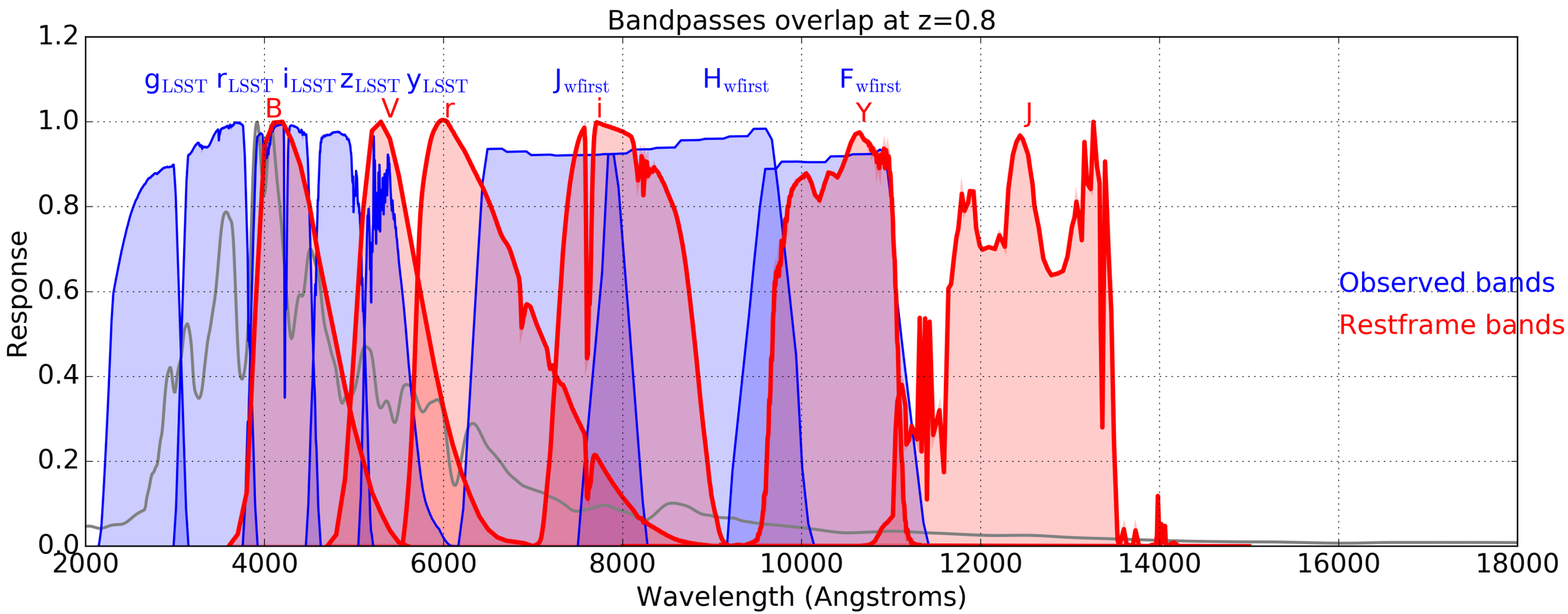
5. Constrain the dark energy using the Hubble diagram.

Filters overlaps



z=0.5

Filters overlaps



z=0.8

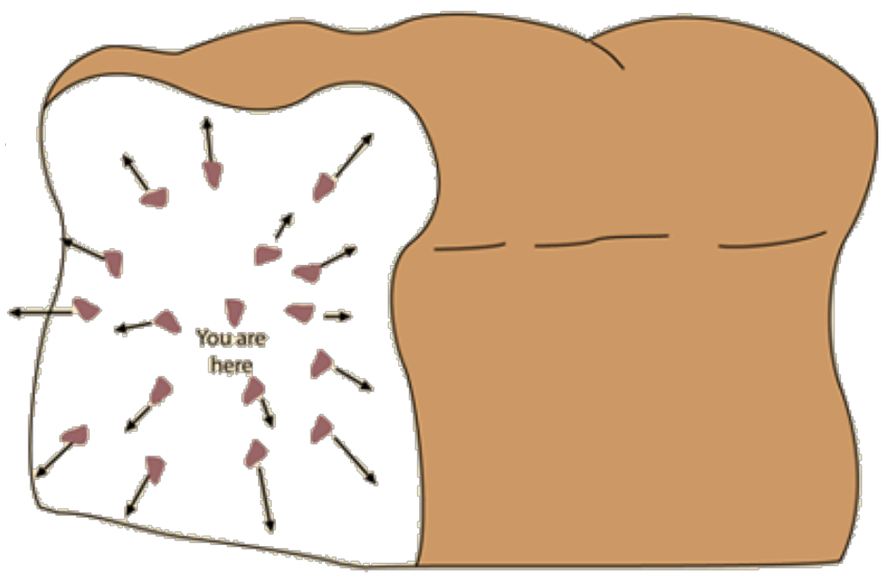
Optical+NIR program

We are already learning how to do it ***now*** and with ***real data***!

RAISIN = **SN IA** in the **IR**

"Tracing cosmic expansion with SN Ia in the Near Infrared"

Robert Kirshner (PI), Arturo Avelino, Kaisey Mandel,
Peter Challis, Andrew Friedman and the RAISIN team



- Expanding Universe like raisins in a bread

Takeaway for LSST

- SN Ia observed in NIR are much more standard candles than in optical wavelengths and less affected by dust.

- Combine optical + NIR data to obtain more accurate distance modulus than from optical data only!

- NIR LC can help in SNIa classification.