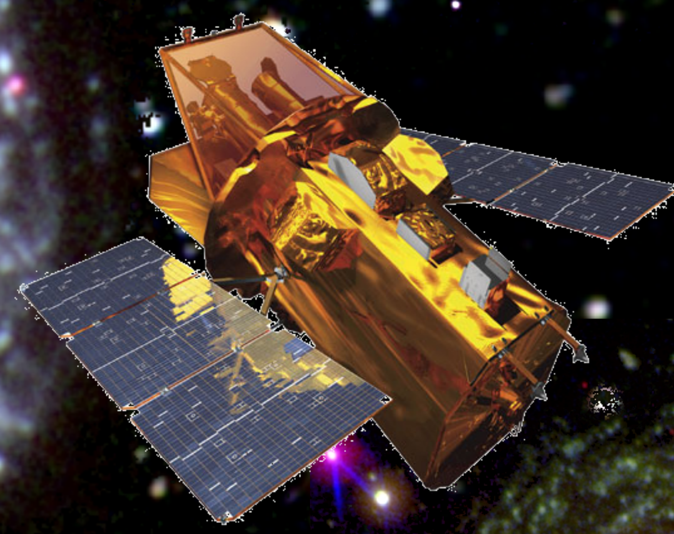
Ultraviolet Observations of Supernovae : The Peril and The Promise

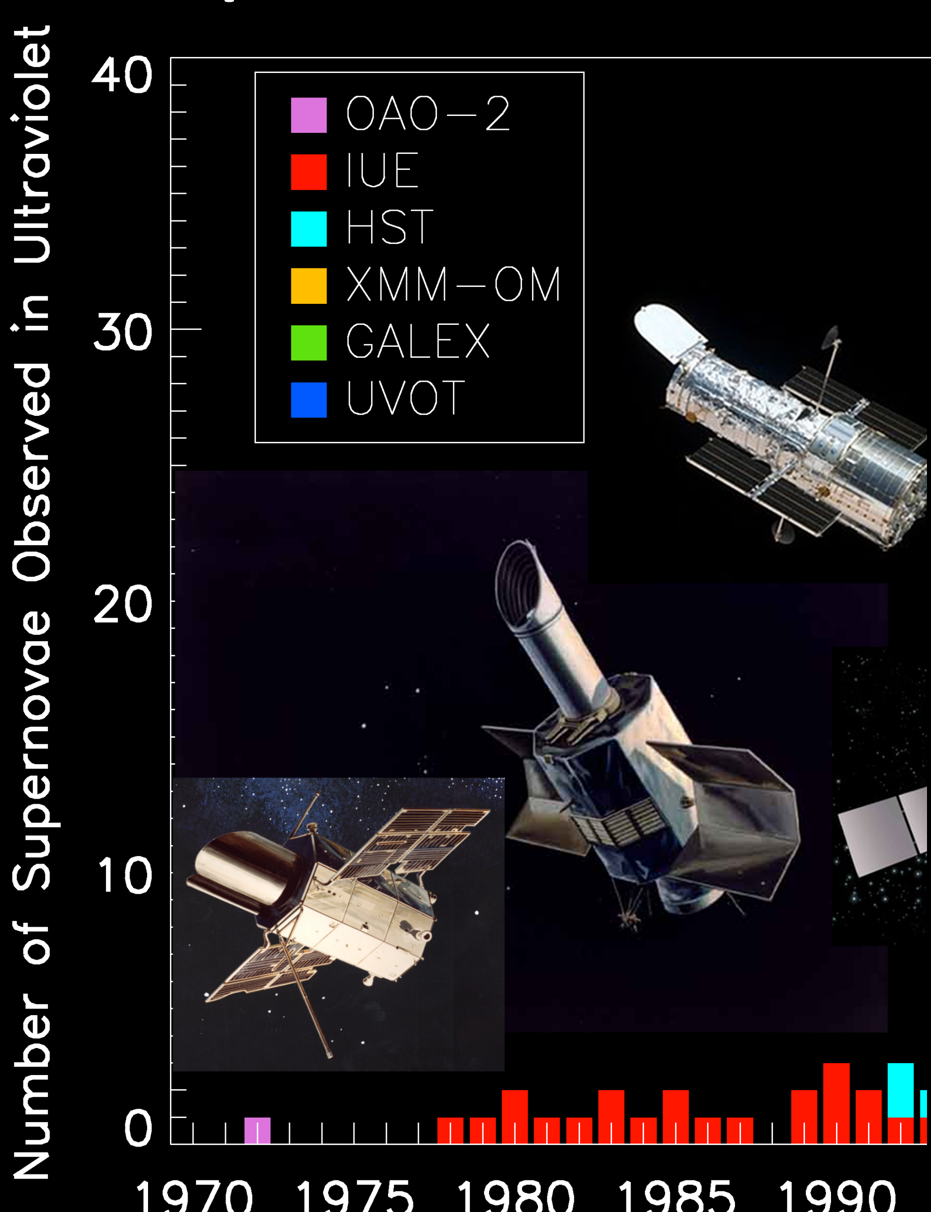


Peter J. Brown

Mitchell Institute -- Texas A&M

Challenges in UV Astronomy, ESO Garching 7 Oktober 2013

Supernova Observed in the UV

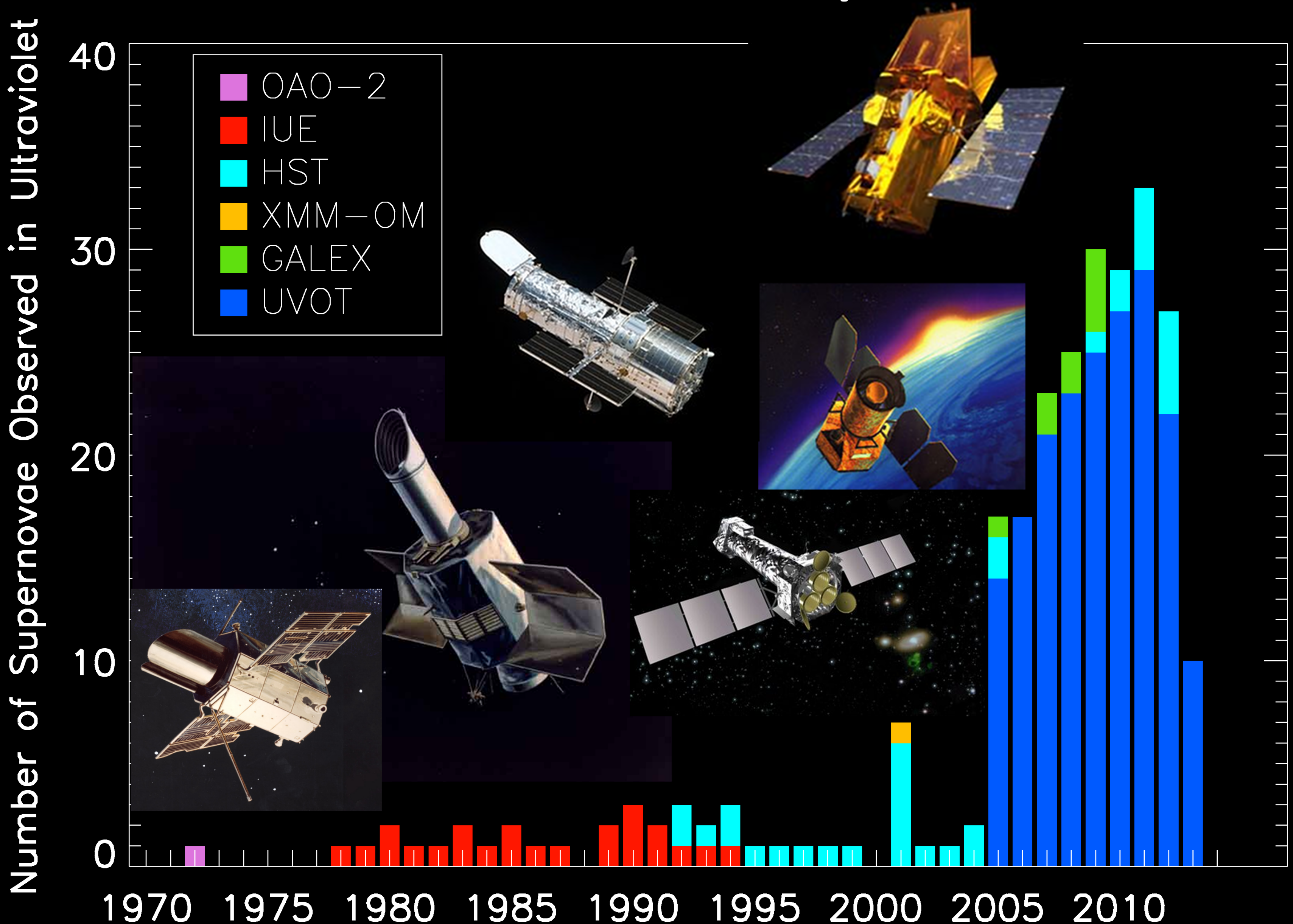


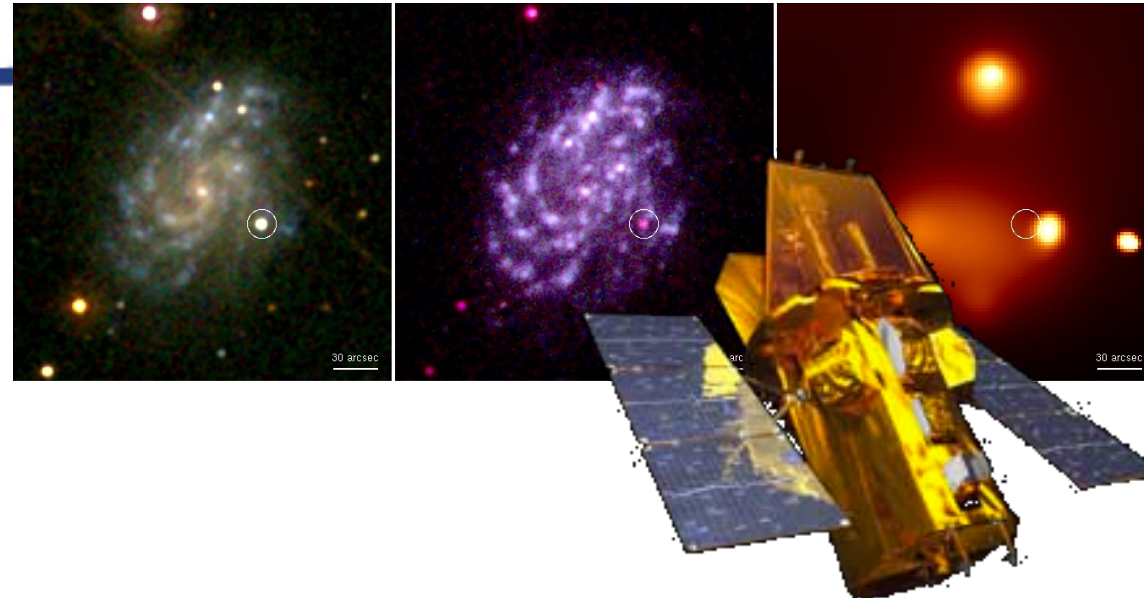
Sample size is historically small but with key contributions

IUE – Time-series spectra revealing UV faint SNe Ia/b/c v. UV bright IIL

HST – high quality single epoch UV spectra of each type

The Swift-UVOT Explosion





- Launched November 20, 2004
- Low earth orbit with ~90 min orbit
- Three co-aligned instruments
  - BAT – Burst Alert Tel. (15-150 keV)
  - XRT – X-Ray Telescope (0.2-10 keV)
  - UVOT - UltraViolet/Optical Telescope

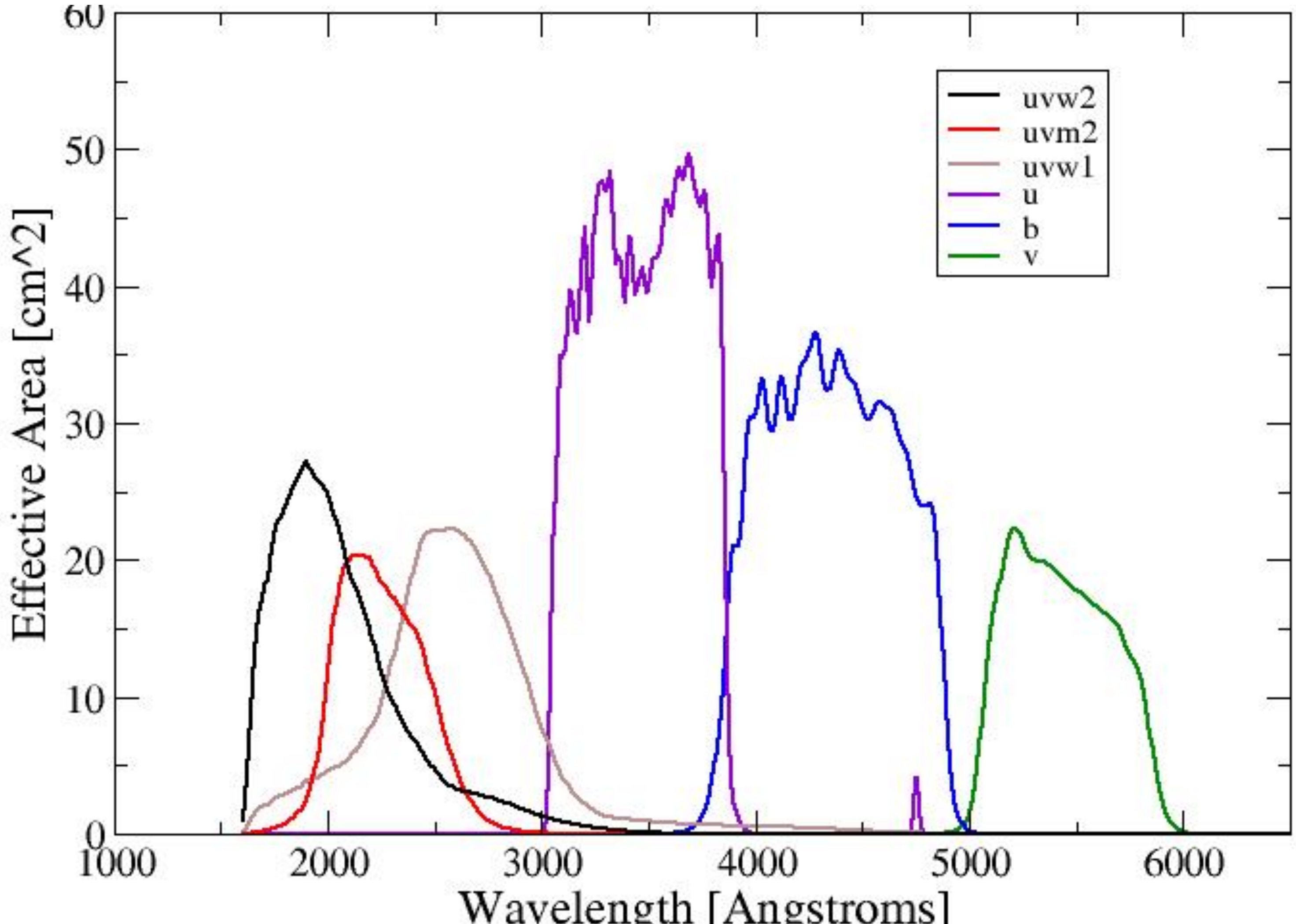
Gamma Ray Burst and Supernova Hunter

- Rapid response capability – Targets of Opportunity can be uploaded to the spacecraft for immediate observation
- Short term scheduling, required by the different behavior of burst afterglows, requires observations to be planned the day before rather than weeks in advance
- SN observations can be analyzed in near real time (hours delay from observation to analysis) to assist in planning the future observations
- Unique UV and X-ray observations unobtainable from the ground

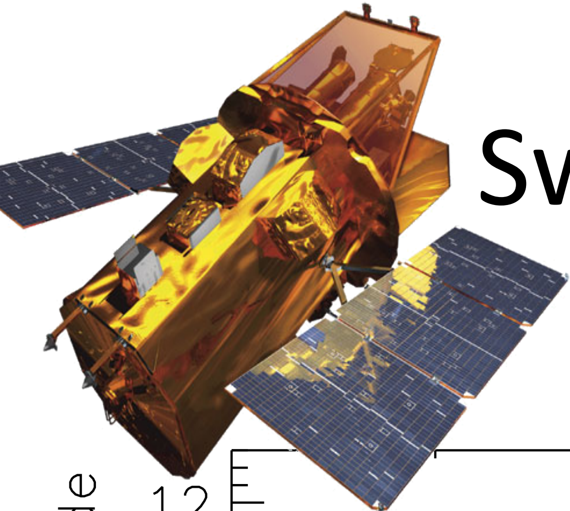
Swift UVOT

- 30 cm modified Ritchey-Chretien Telescope
- Wavelength Range 1600-6000 Angstroms
- Photon Counting detector centroiding into 0.5 arcsec virtual pixels
- 2 arcsec point spread function
- 17x17 arcminute field of view

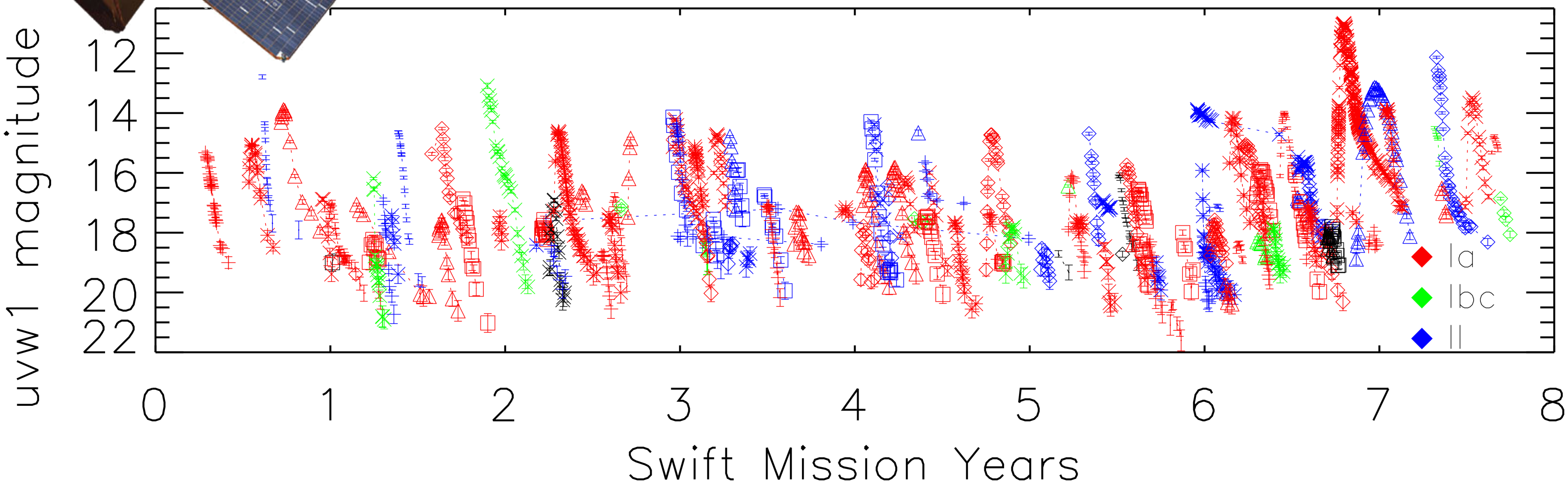
Swift UVOT Filter Curves



Filter Curves from Poole et al. 2008

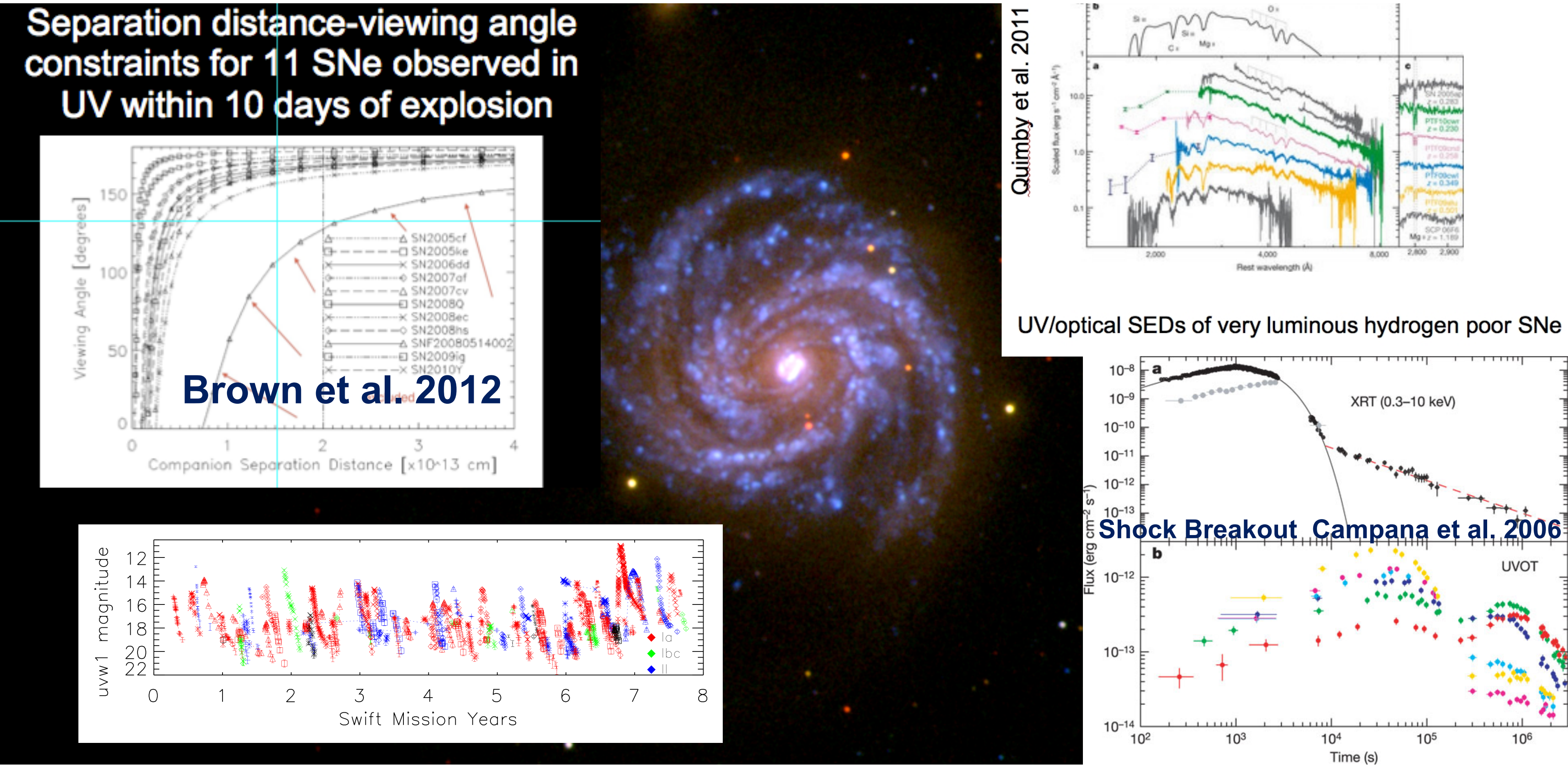


Swift UVOT Light Curves



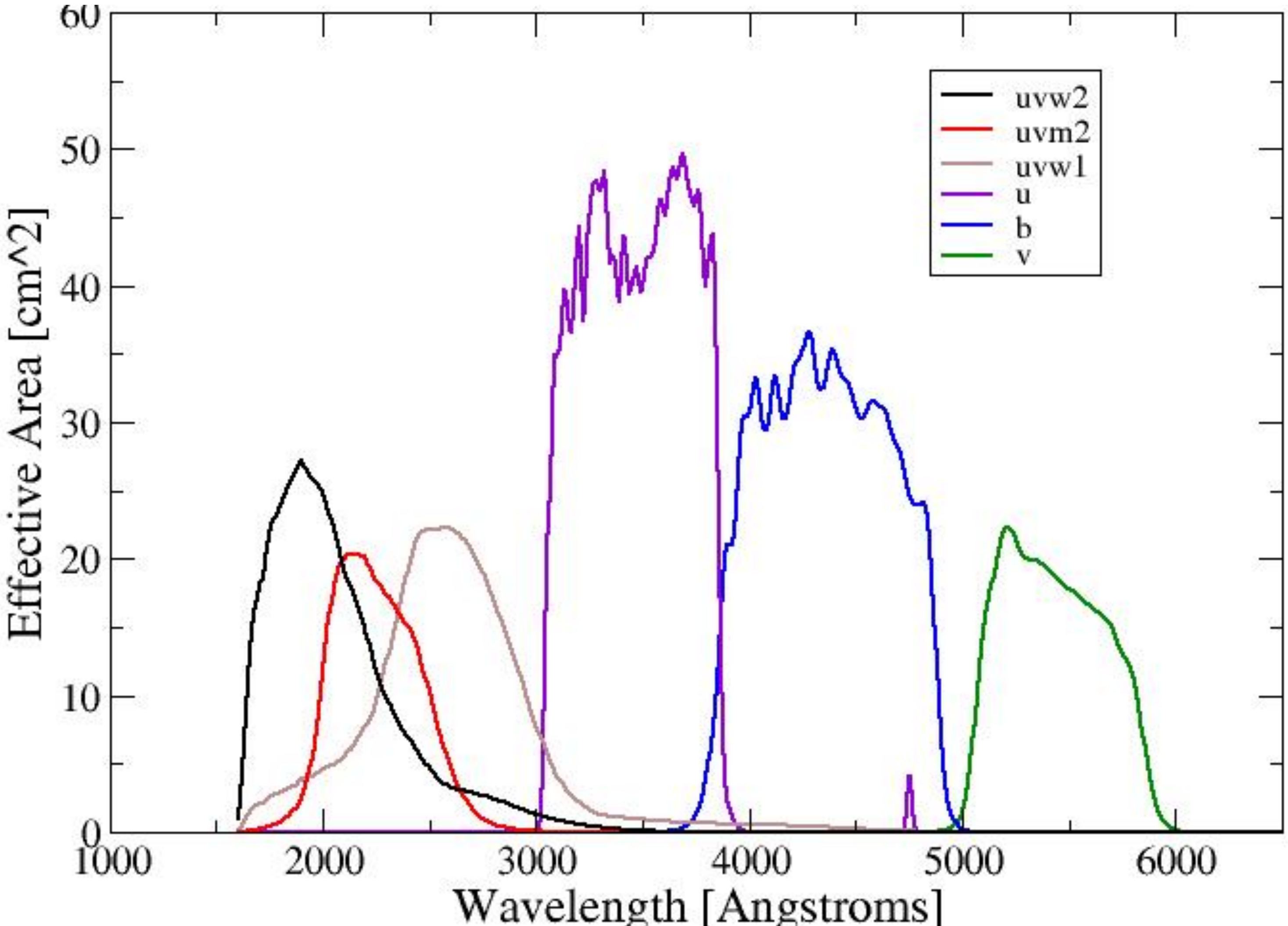
Swift UV observations include many well sampled light curves of SNe of all major types and most subtypes

So what do we see in the UV light?



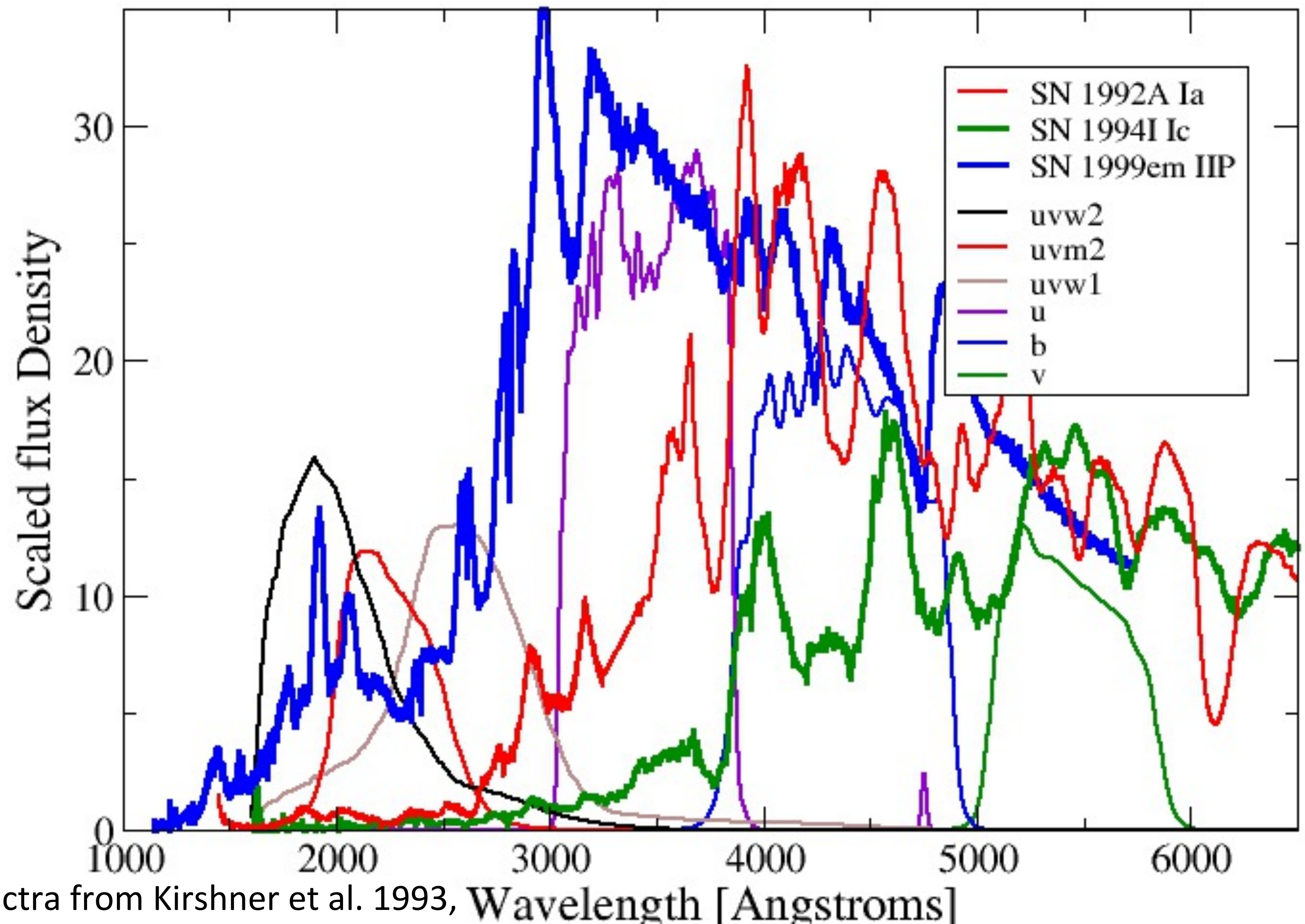
See http://people.physics.tamu.edu/pbrown/SwiftSN/swift_sn.html for a list of the ~250 Supernovae observed by Swift and 90+ publications

Swift UVOT Filter Curves



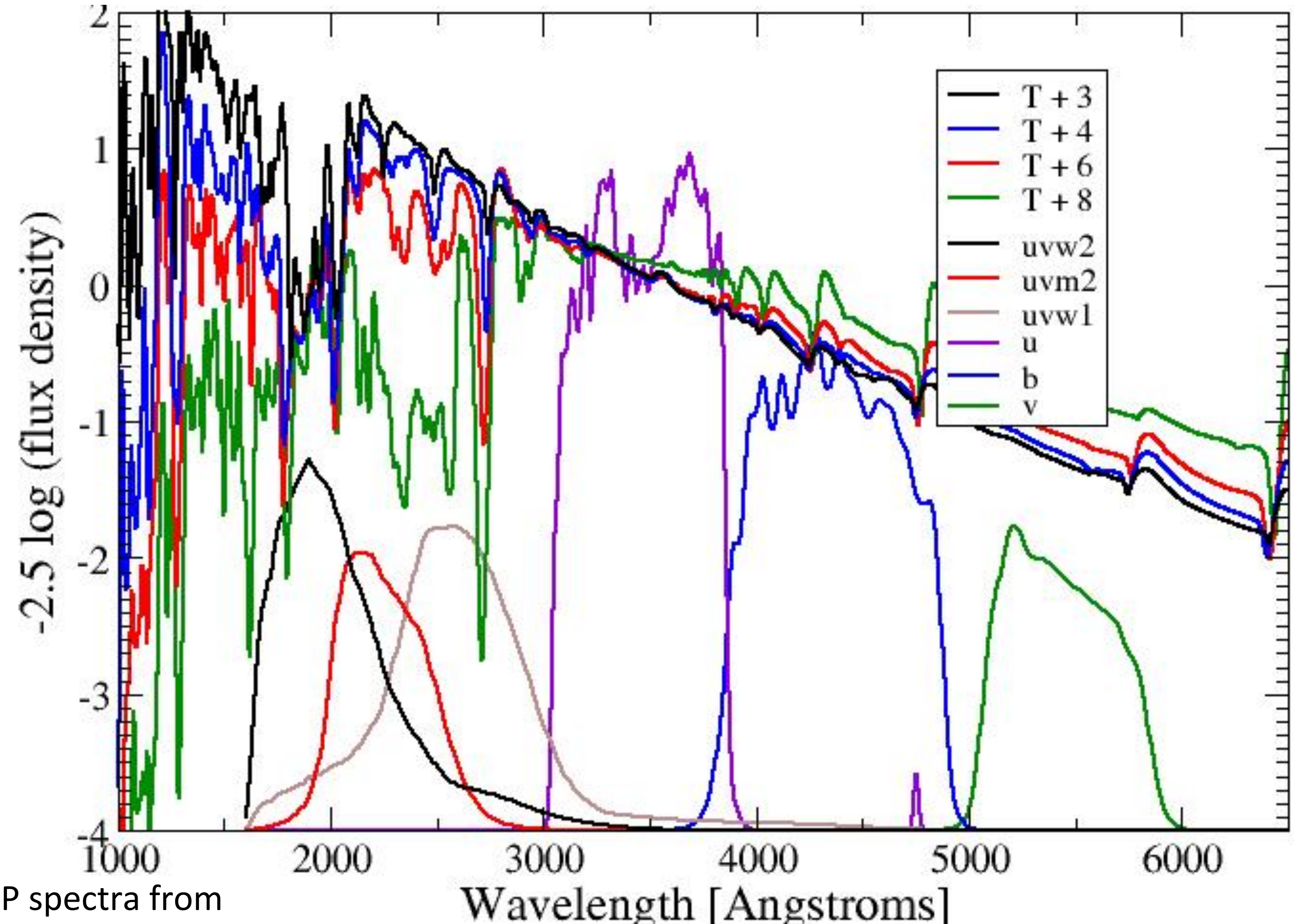
Filter Curves from Poole et al. 2008

SN types are different in the UV



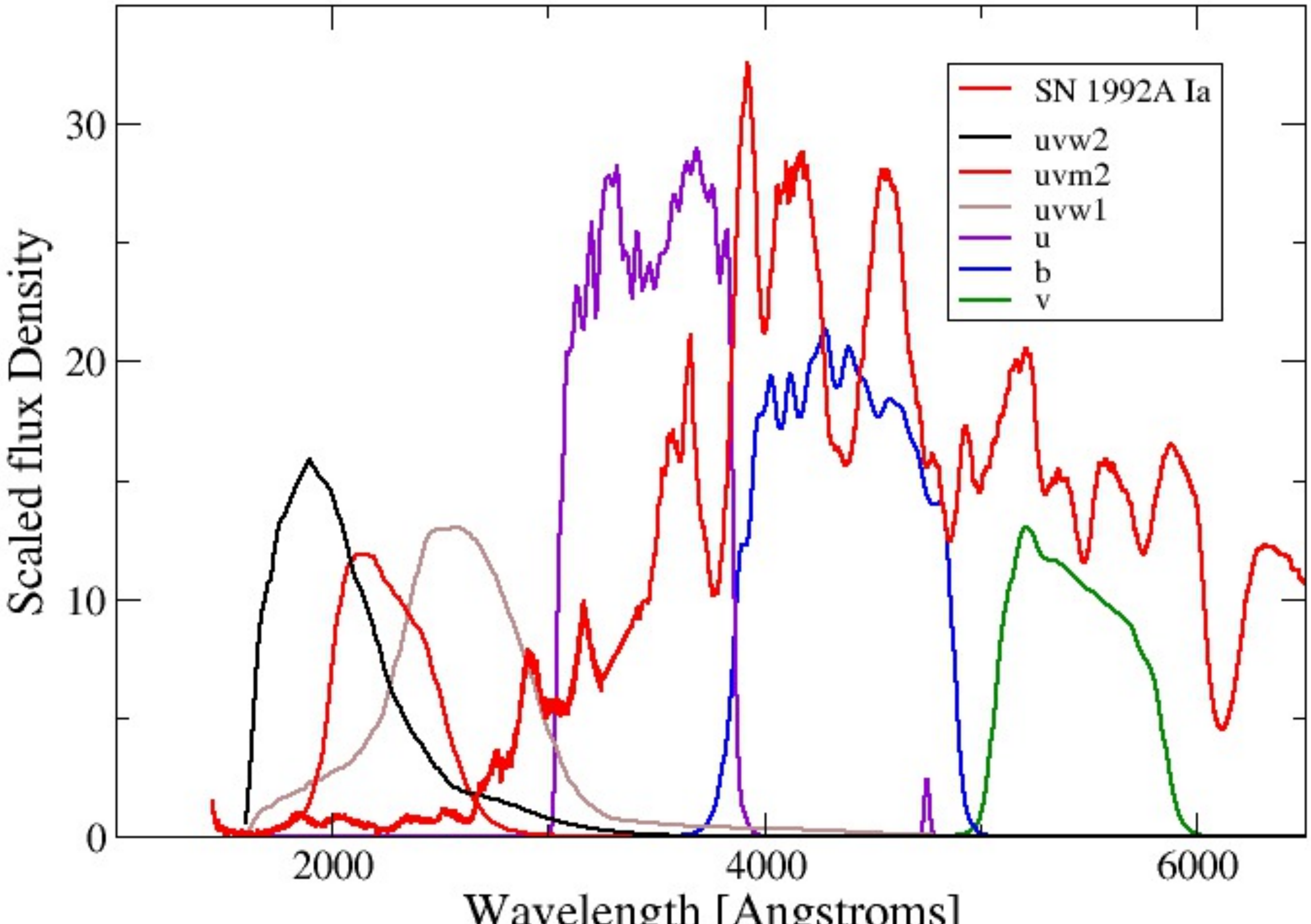
HST Spectra from Kirshner et al. 1993, Millard et al. 1999, Baron et al. 2000

SNe IIP evolve rapidly in the UV



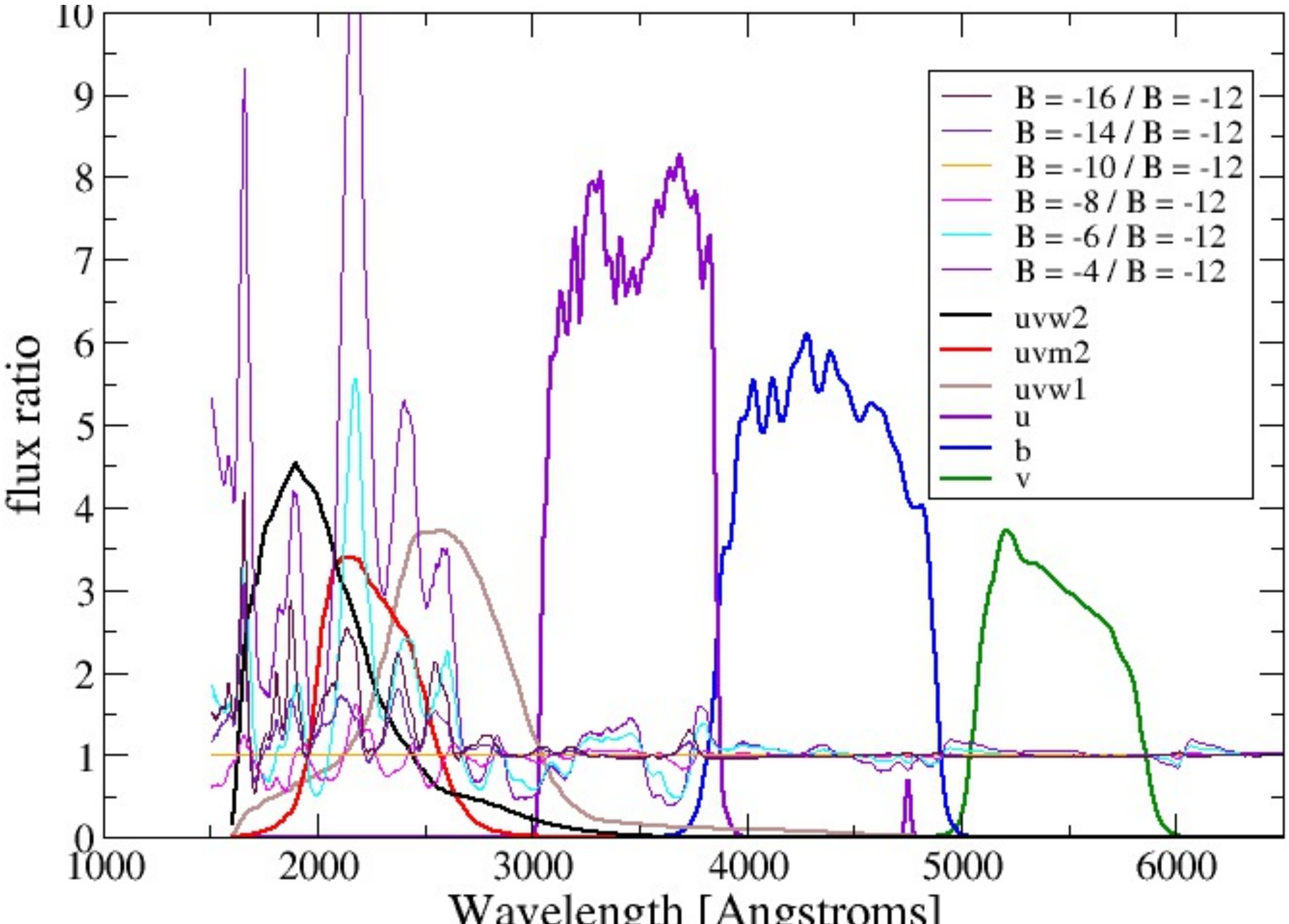
Model IIP spectra from Dessart et al. 2008

SNe Ia are faint in the UV due to metal line blanketing



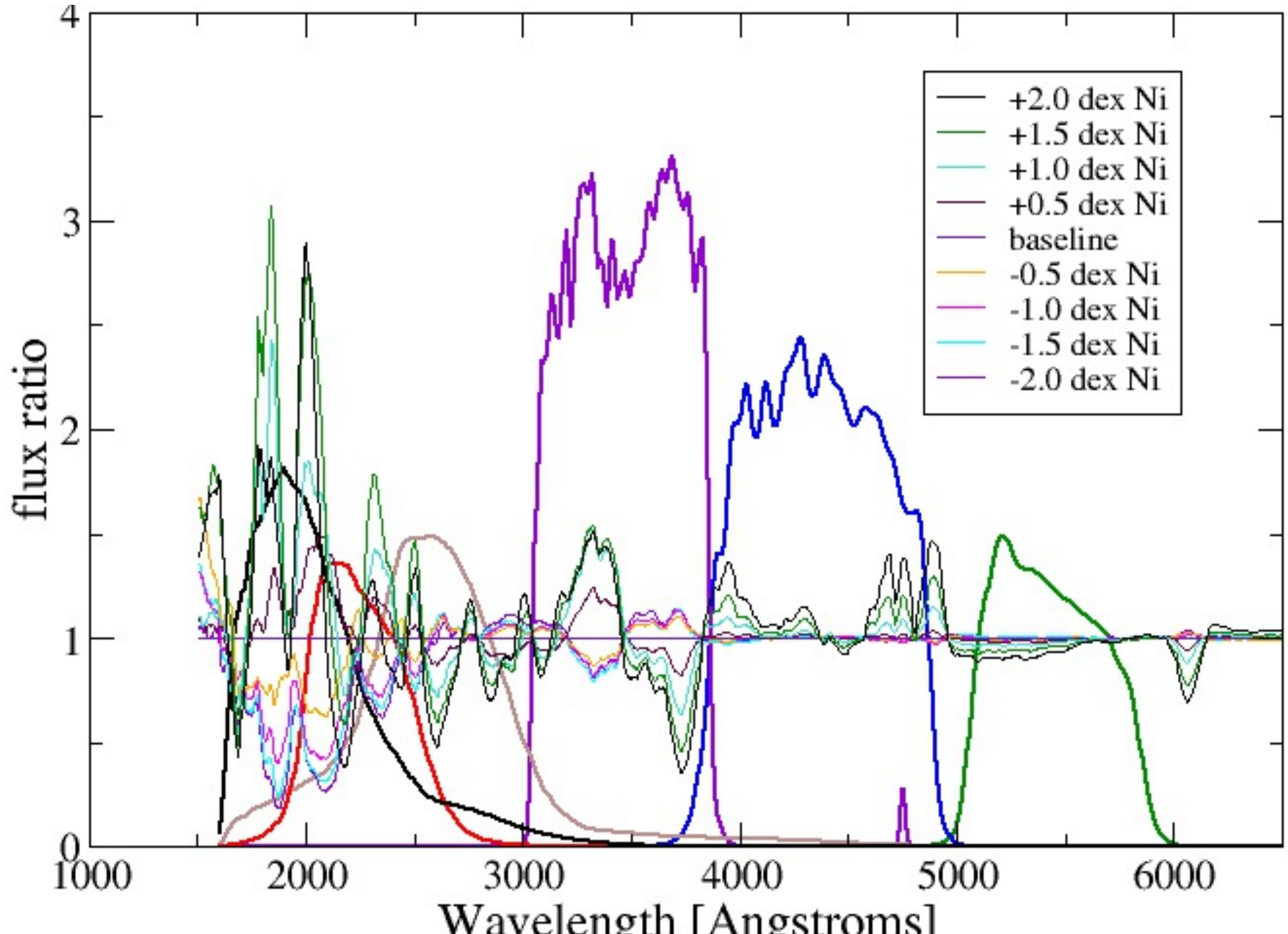
HST spectrum from Kirshner et al. 1993

UV is sensitive to the outer density gradient



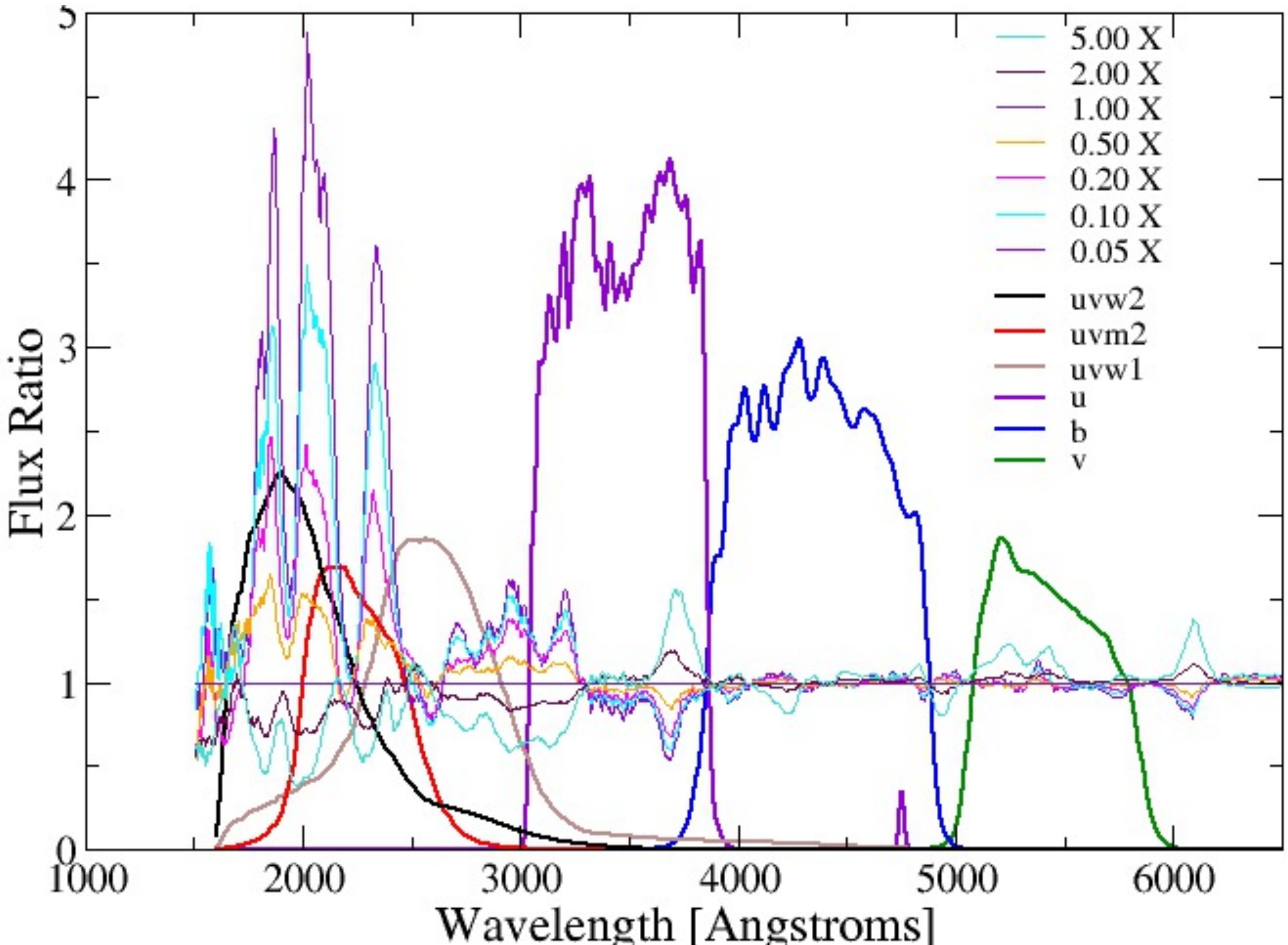
Density models from Sauer et al. 2008

UV is sensitive to Nickel abundance



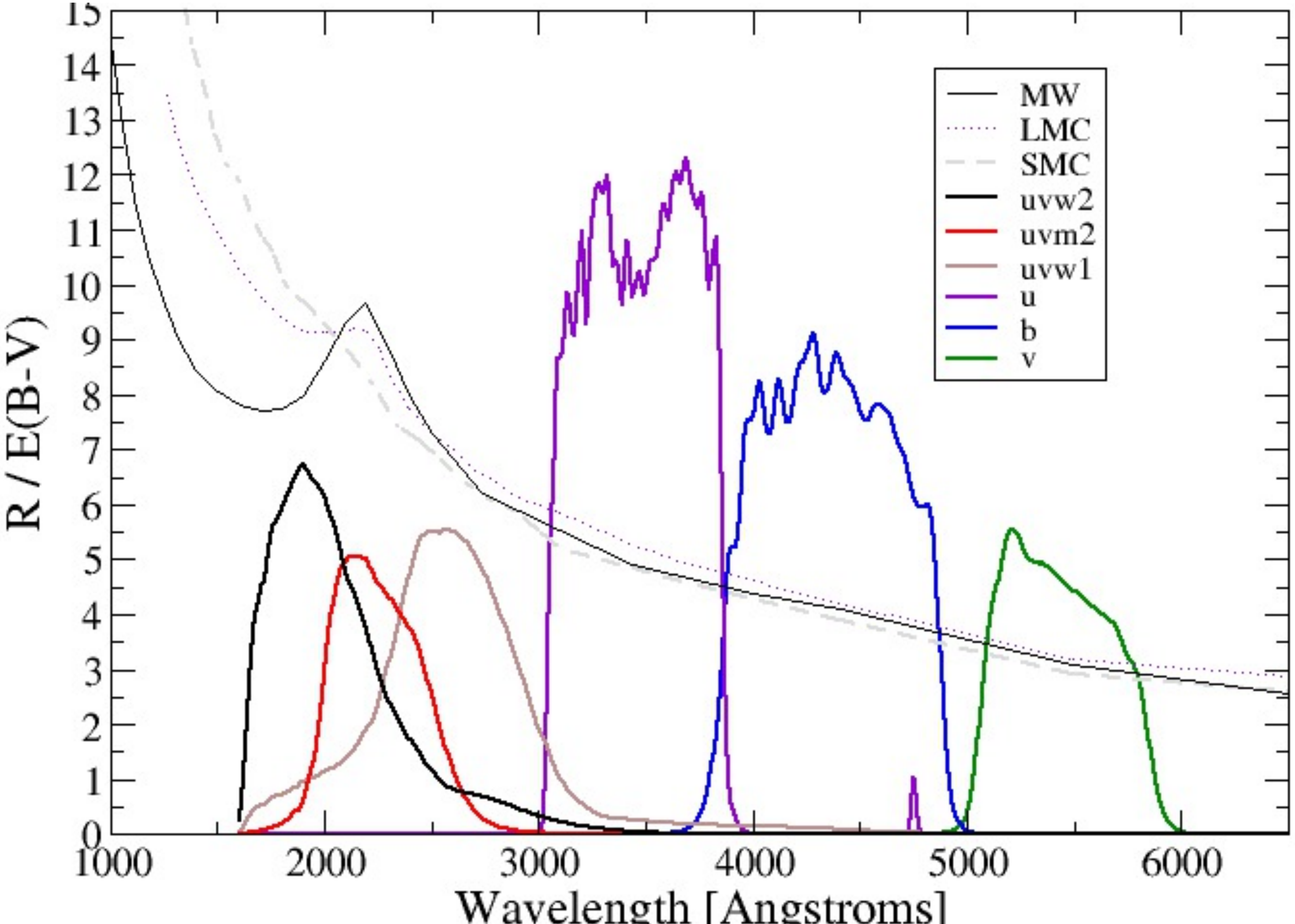
Models from Sauer et al. 2008

UV is sensitive to Metal abundance



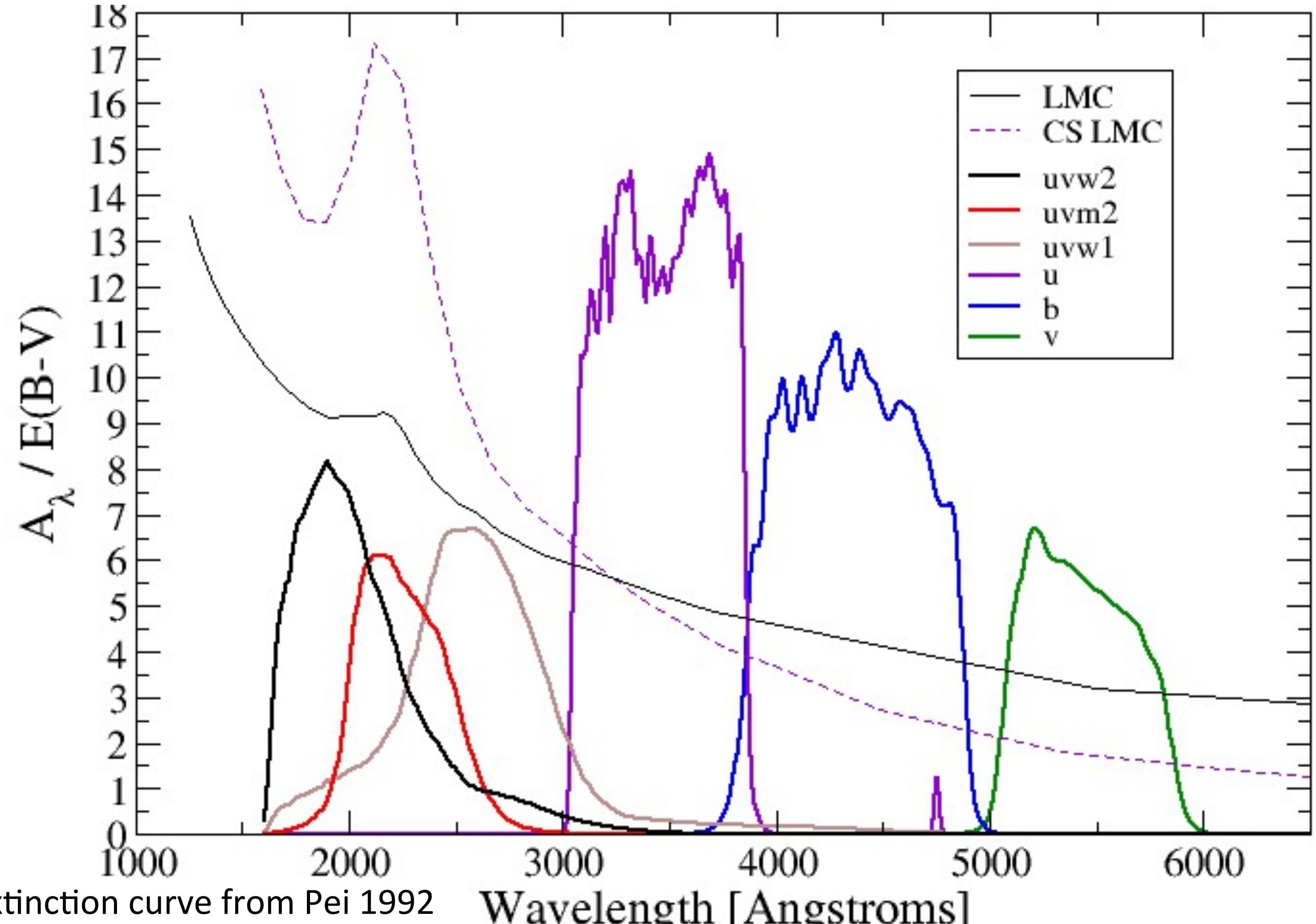
Models from Walker et al. 2012

UV is sensitive to differing extinction



Extinction curves from Pei 1992

UV is extra sensitive to circumstellar (CS) dust scattering



LMC extinction curve from Pei 1992
And CS LMC from Brown et al. 2010 based on Goobar 2008

UV Observations of SNe Ia: The Peril and the Promise

- SNe NOT promising standard candles in the UV
  - Low flux due to line blanketing from metal lines
  - Possible evolution of metallicity with redshift
  - Large, possibly uncertain, extinction
  - Uncertain extinction law
  - Velocities, asymmetry, density differences, etc, may all affect the UV much more than the optical

UV Observations of SNe Ia: The Peril and the Promise

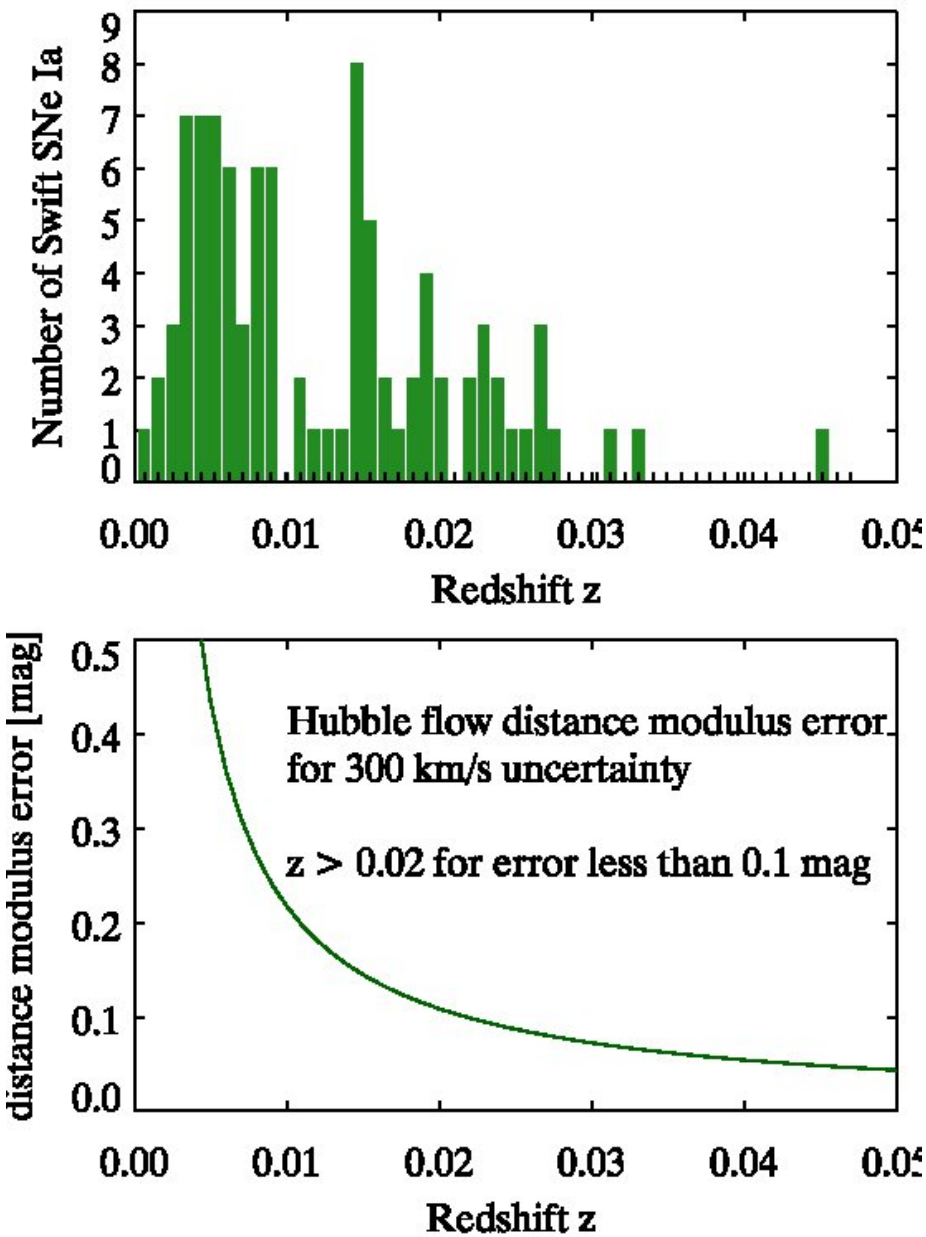
- But UV observations might have a lot to teach us about SNe Ia and how to improve their usefulness
  - Sensitive to metallicity differences which may effect the optical by a small but significant amount
  - Test for evolution of metallicity with redshift
  - Measure extinction more accurately
  - Determine shape of extinction law
  - Differences from velocities, asymmetry, density differences, etc, may be determinable from UV photometry rather than requiring spectra

UV Observations of SNe Ia: The Peril and the Promise

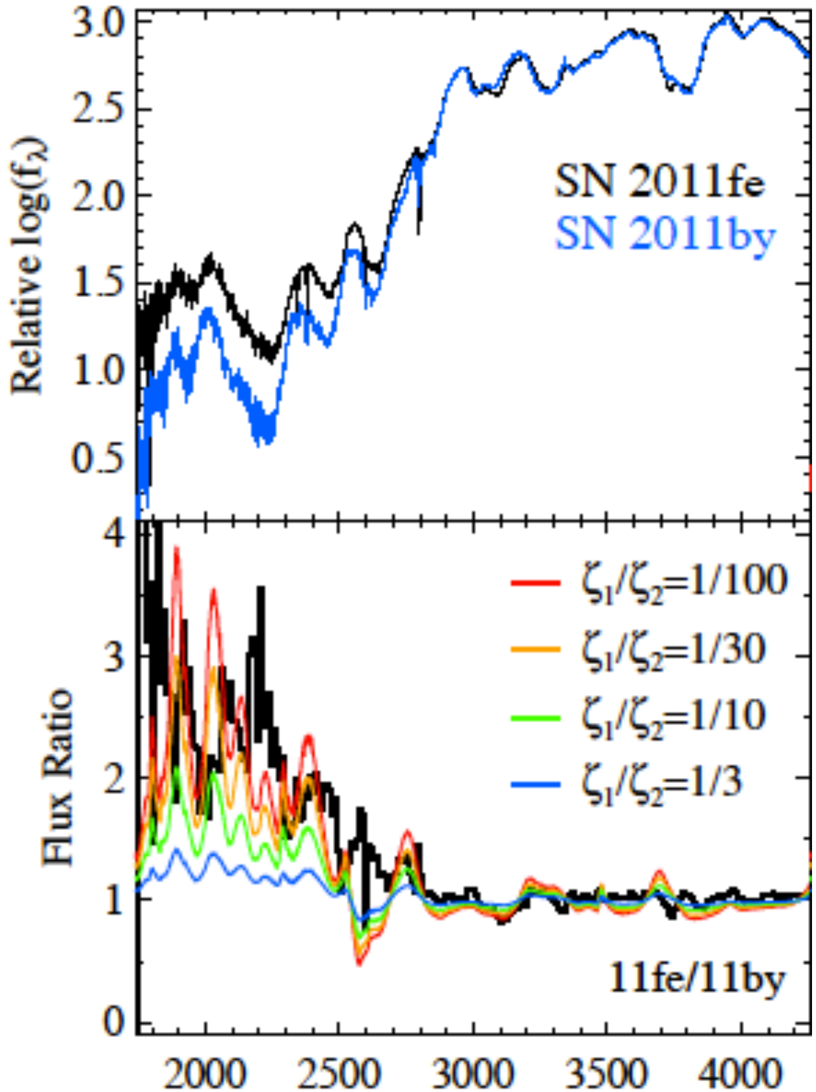
- This Challenge and Opportunity is a very challenging opportunity
  - How do we look for differences by comparing the intrinsic colors if first we have to correct for an unknown amount of extinction with an unknown wavelength dependence which may require us to know the intrinsic colors due to metallicity, velocity, asymmetry, density, etc

Requires larger samples from Swift, HST,

and future UV missions

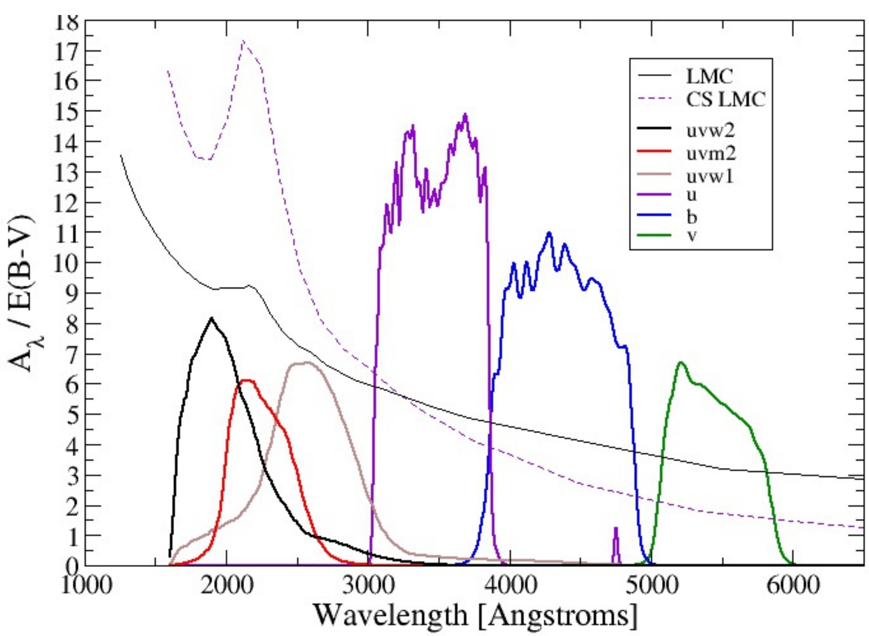


A larger aperture UV instrument could probe the Hubble Flow where the UV properties could be better correlate with the absolute magnitudes to improve the standard candles



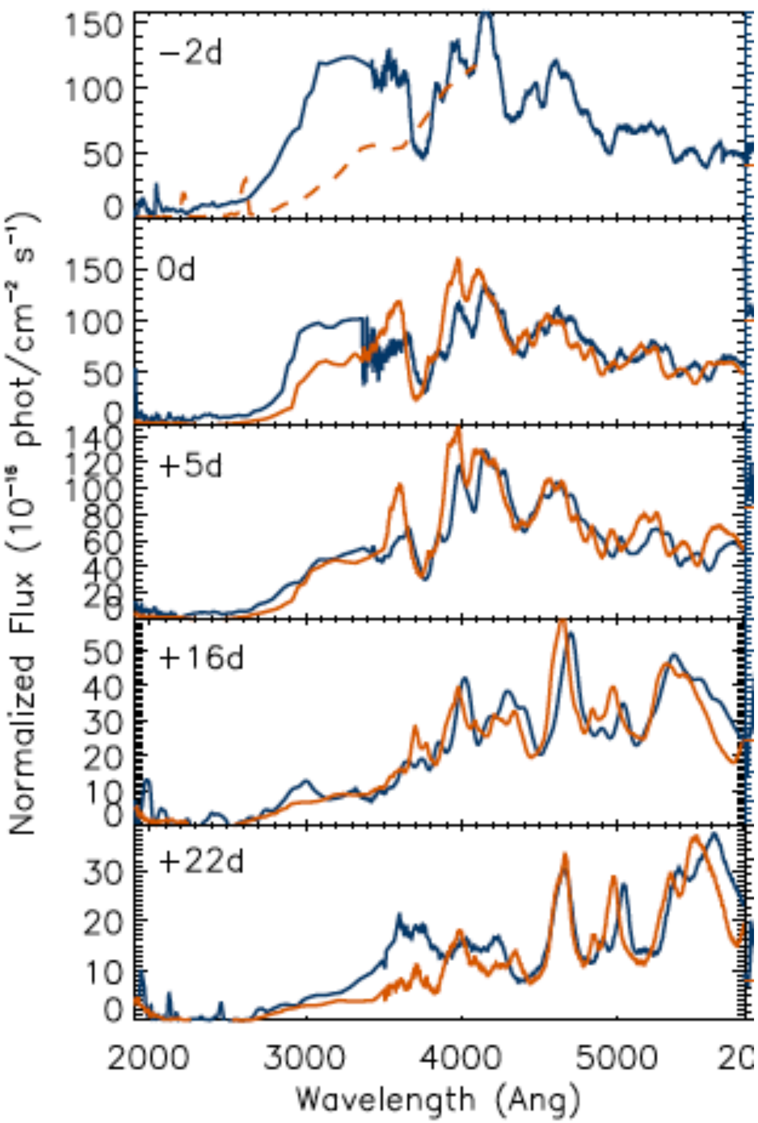
UV Spectral differences between nearby SNe Ia 2011by and 2011fe from Foley & Kirshner 2013

A larger aperture UV instrument could probe the Hubble Flow where the UV properties could be better correlate with the absolute magnitudes to improve the standard candles



A larger aperture UV instrument could detect more highly reddened SNe Ia or moderately reddened SNe in the Hubble Flow to better understand the UV extinction

Near-UV differences between `normal' Type Ia Supernovae



Type Ia supernovae are used as cosmological indicators based on the assumption that they are standardizable based on light curve width and colors

Swift/UVOT has identified two different groups of `normal' SNe Ia which have different features in the near-UV. This is not seen in ground-based u band.

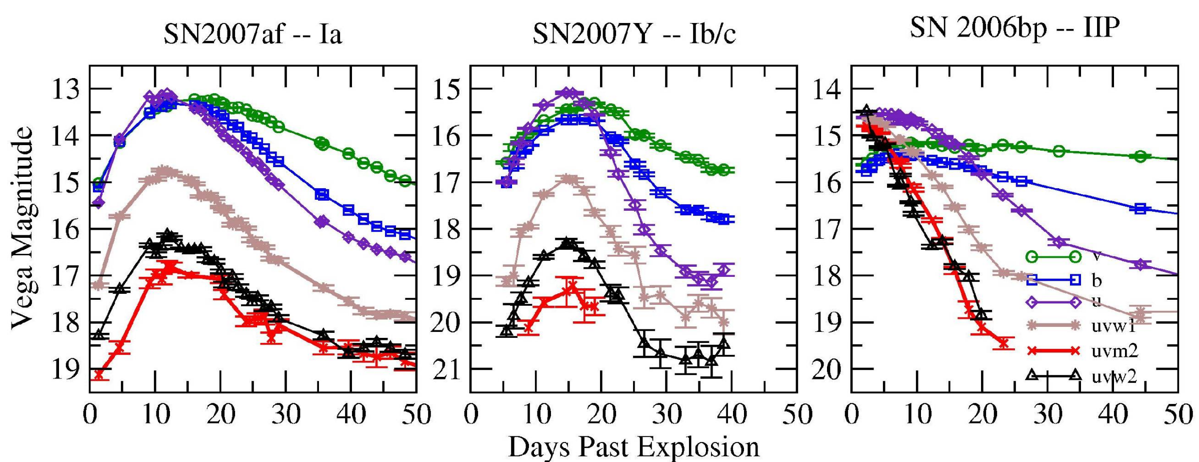
HST near-UV spectroscopy and optical observations show there to be an excess of flux between 3000-3500 Angstroms. Also seen in z~0.4 SNe observed in the optical and may evolve with redshift.

A blue sensitive spectrograph such as CUBES would be able to probe this feature for nearby SNe from the ground as well as at intermediate redshifts.

Milne et al. 2013 arXiv1308.2703M

SOUSA

Swift
Optical
Ultraviolet
Supernova
Archive



SOUSA

Swift Optical Ultraviolet Supernova Archive

- [Raw Images]
- Organized Images (incl. templates)
- Photometry Products (count rates, backgrounds, corrections)
- Final Photometry
- SED-dependent products

(flux values, extinction factors, etc.)

Project funded by NASA's
Astrophysics Data Analysis Program

Ultraviolet Supernova: Swift Su... | Swift SN Publications – Google ... | SwiftSNweblist (uv.supernova@... | Swift Supernovae

http://people.physics.tamu.edu/pbrown/SwiftSN/swift_sn.html

Swift Supernovae | TOO | Current | Swift visibility | QUICKLOOK DATA | Swift Archive | ADS | TCOP | TAMU PHYSICS

Swift Supernovae

http://people.physics.tamu.edu/pbrown/SwiftSN/swift_sn.html

Below is a list of young supernovae (SNe) observed by Swift, along with Swift Ultraviolet/Optical Telescope (UVOT) optical (v, b, u), UV (uvw1, uvm2, uvw2) and X-Ray Telescope (XRT) X-ray images, as well as UVOT light curves and data (where available).

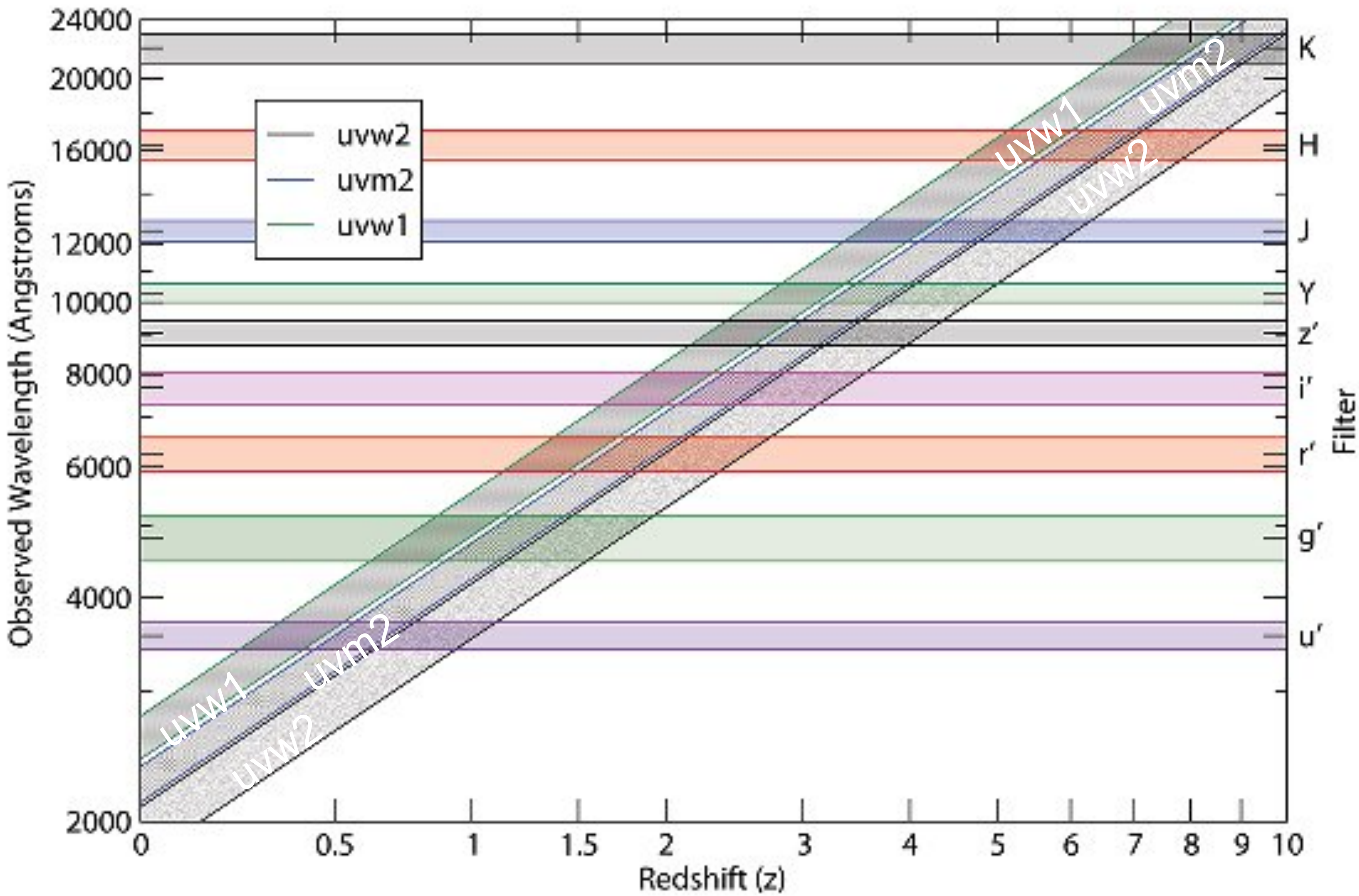
A working list of publications is posted at:
Swift Supernova Publications.

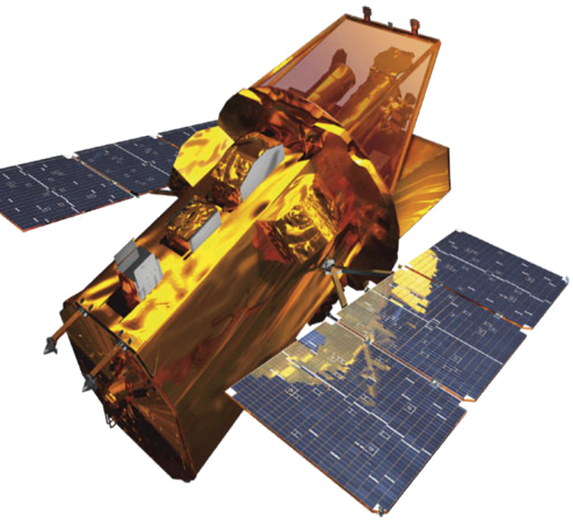
To contact the Swift SN Team, please email:
swift_sn_too@athena.gsfc.nasa.gov.

To contact the website curator Peter Brown about SNe missing from this list or with questions about Swift SNe, data, etc, please email uv dot supernova at gmail dot com

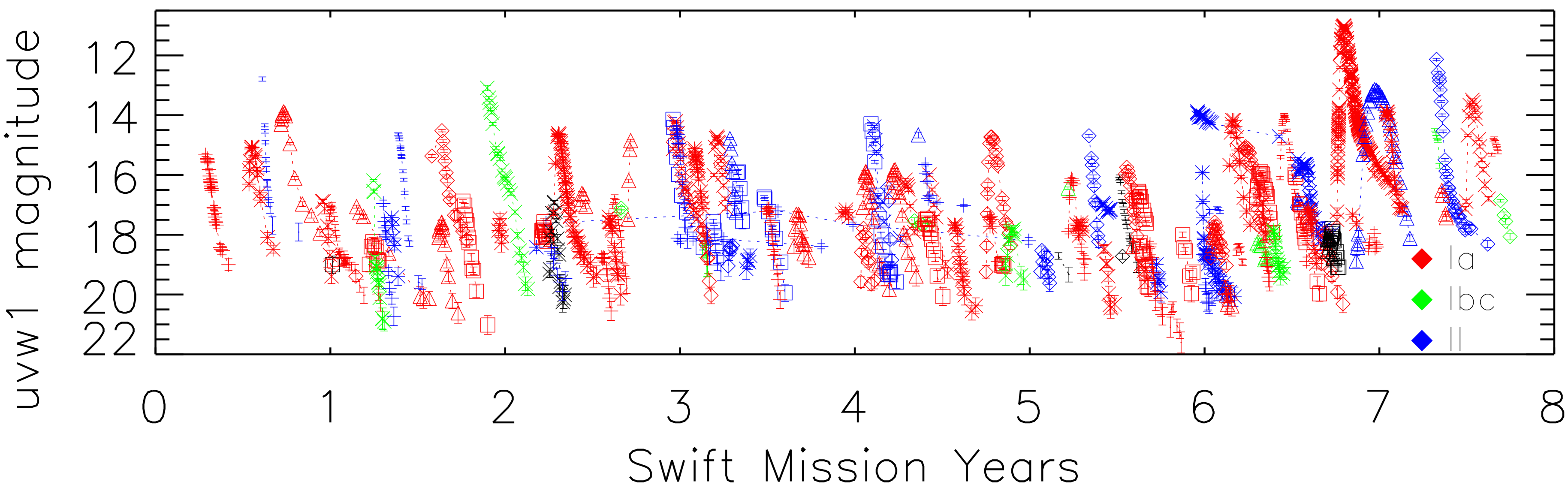
No.	Supernova	Host Galaxy	Redshift	Type	Image | Plot | Data
244	**ASSASN-13dd**	NGC2765	0.01255	?	
243	**iPTF13dge**	NGC1762	0.015854	Ia	

Rest Frame UV at high z





Swift Supernovae



See http://people.physics.tamu.edu/pbrown/SwiftSN/swift_sn.html for more information