

Bolometric Light Curves of Type II^p Supernovae from UV-NIR observations



Tyler Pritchard | Pennsylvania State University
SNGRB Workshop | Kyoto University
2013/10/22

Collaborators

Swift/UVOT SNe Group

- Pete Roming (*Advisor*)
- Amanda Bayless
- Peter Brown
- Stephen Holland
- Stefan Immler
- Peter Milne
- Sam Oates

LANL

- Wesley Evan
- Lucy Frey
- Chris Fryer

CSP

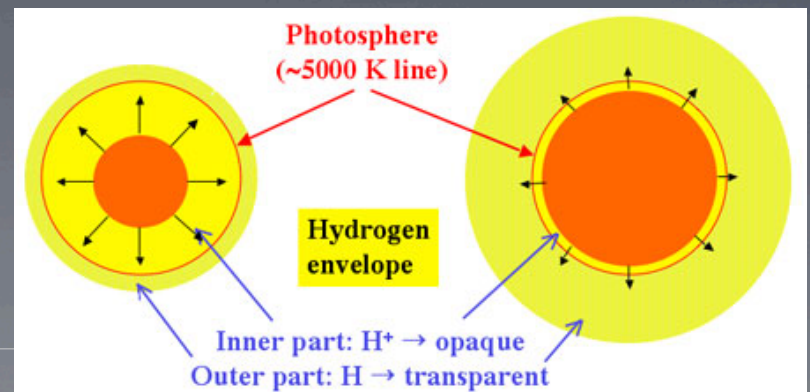
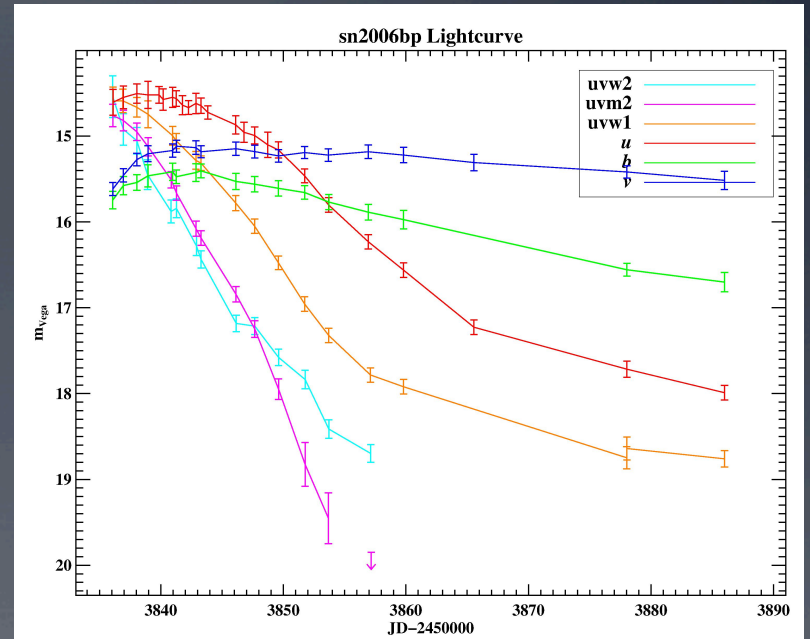
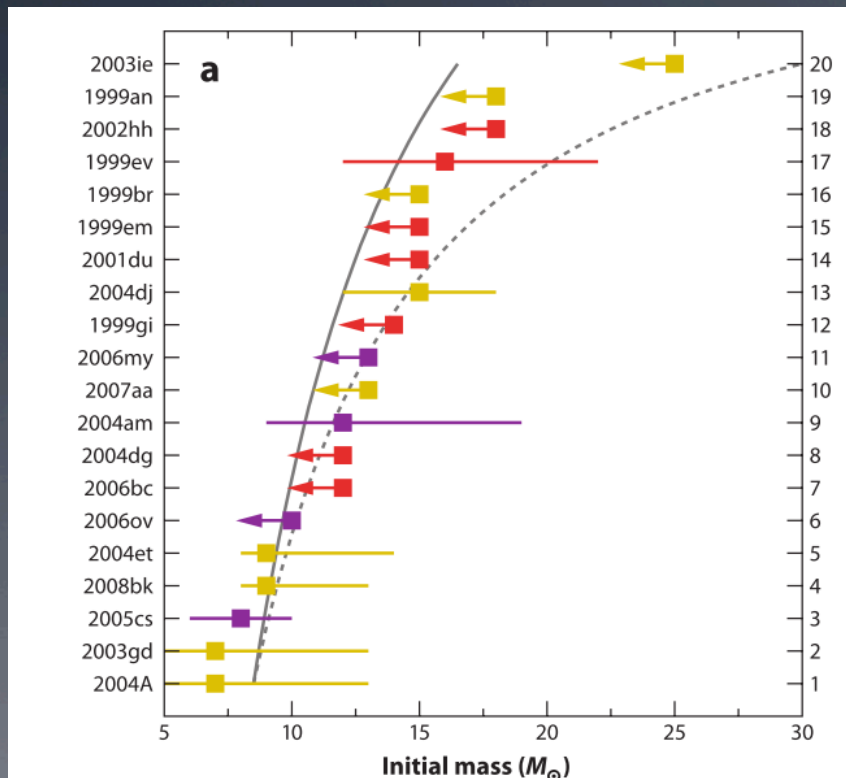
- Joe Anderson
 - Max Stritzinger
-

Outline

- Background
 - Swift observations of Core Collapse SNe
 - UV-NIR Studies
-

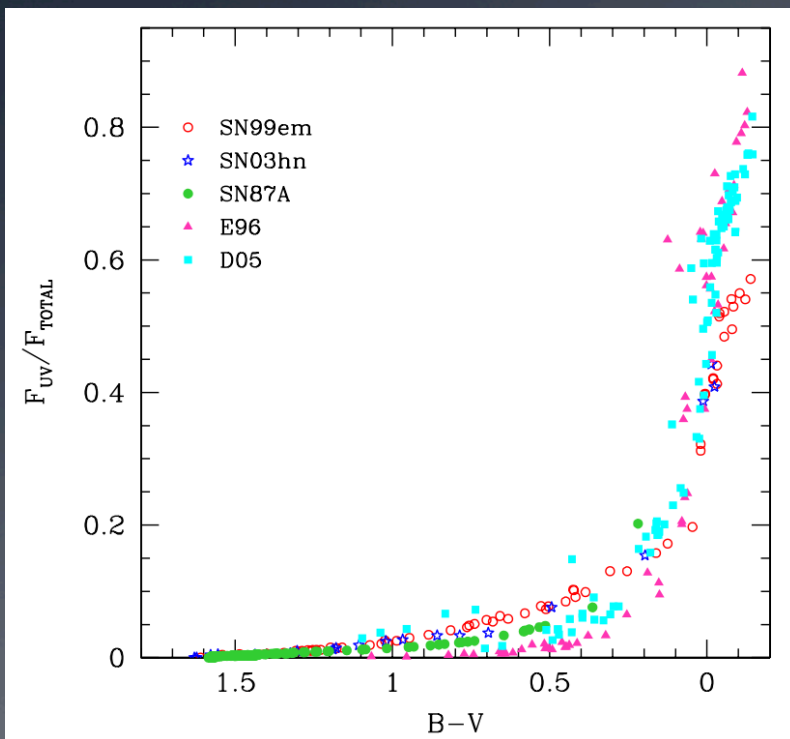
Type IIP SNe

Smartt 2009

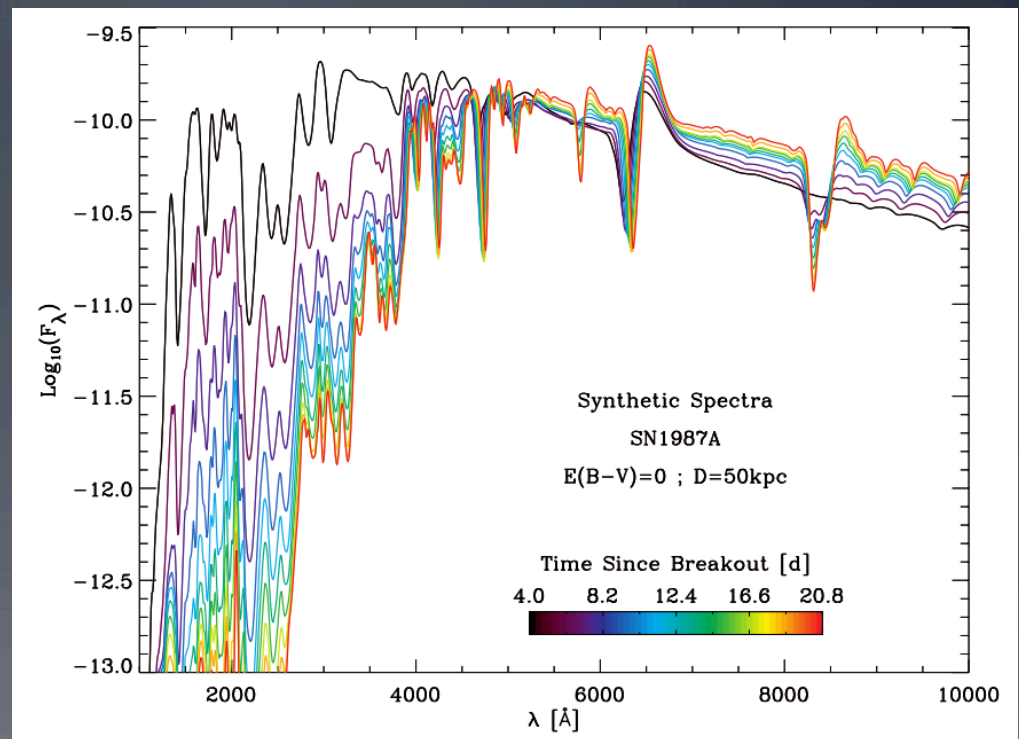


Plateau driven by Hydrogen recombination wave

Why UV?



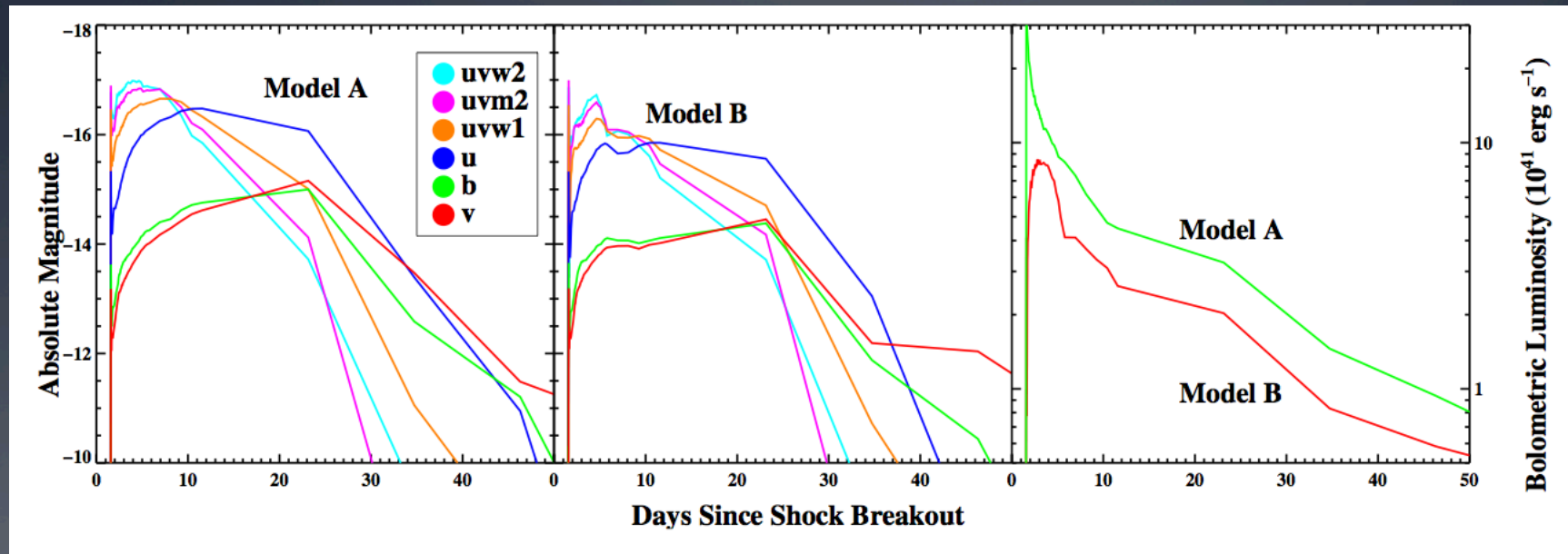
Bersten+ 09



Dessart & Hillier 10

-Lots of Flux -O/Fe/Ni -Extinction -Rapid Evolution

UV Variation Impact on Bolometric LC

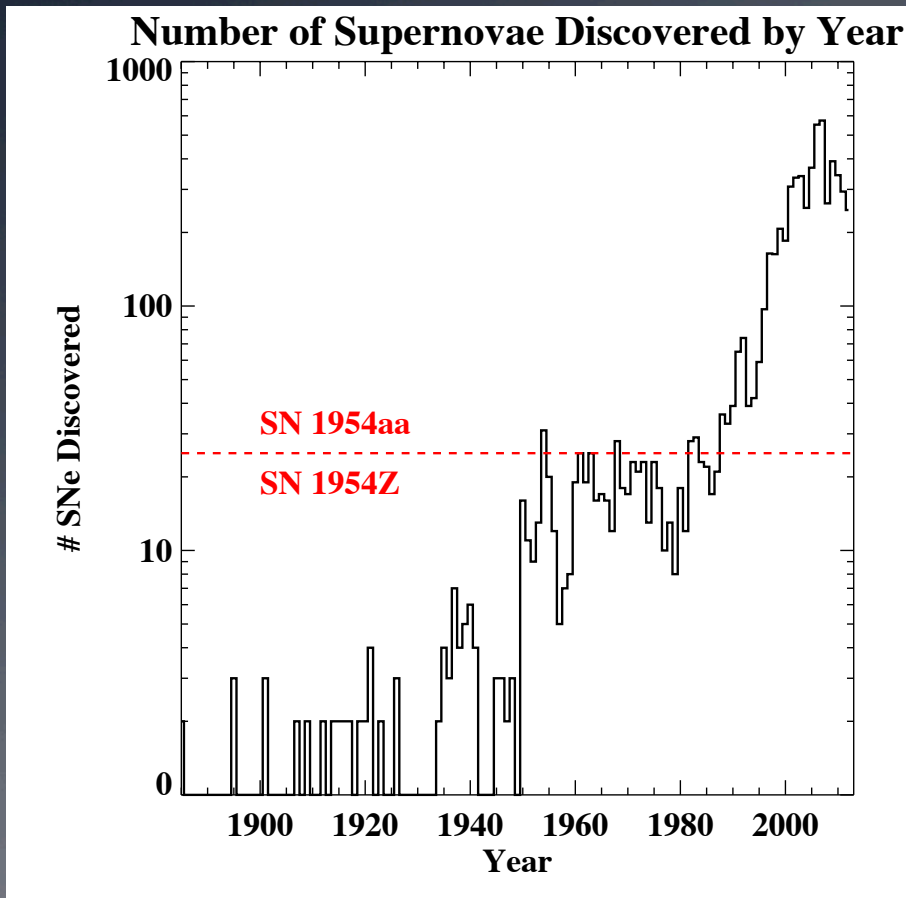


- At these early times, for UV bright SNe, progenitor differences appear more clearly in the UV

23 solar Mass, 5×10^{50} erg KE, $10^{-5}/10^{-6}$ (A/B) progenitor mass loss

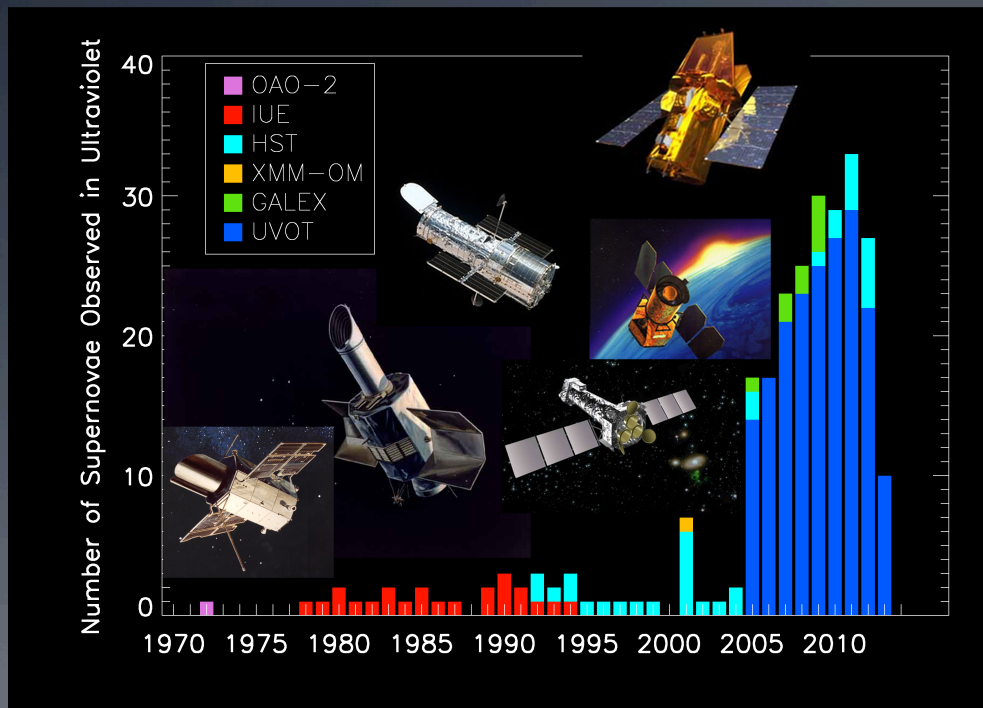
Also, see Frey+2013, Bayless+2013

Drastic Increase in SNe Obs



- SNe observations per year Increased by an order of magnitude in the late 50's
- Again in the 1990's
 - Mostly due to robotic searches
- Mostly Optical, Some more recently have IR

UV Studies of SNe



- But, UV studies historically lag behind optical observations
- Constrained by available instrumentation

Swift – Gamma Ray Burst Finder



- US, UK, and Italian Collaboration
- Swift – adj. quick
 - Also a type of bird (Swallow)
- Primary Science Goal:
 - Gamma Ray Burst Detection & Follow up
- Secondary science goals:
 - Transient Science (Supernovae, novae, SSXRB/FXRT)
 - UV, X-ray observations
 - UV, X-Ray Great Observatory Support

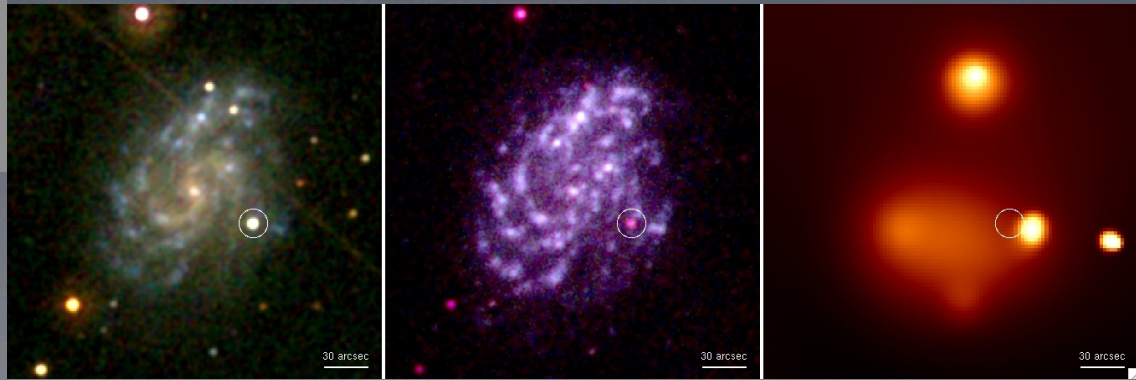
GRB (Transient) Hunter

- 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
-

The NASA *Swift* Satellite Mission



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



Swift/UVOT

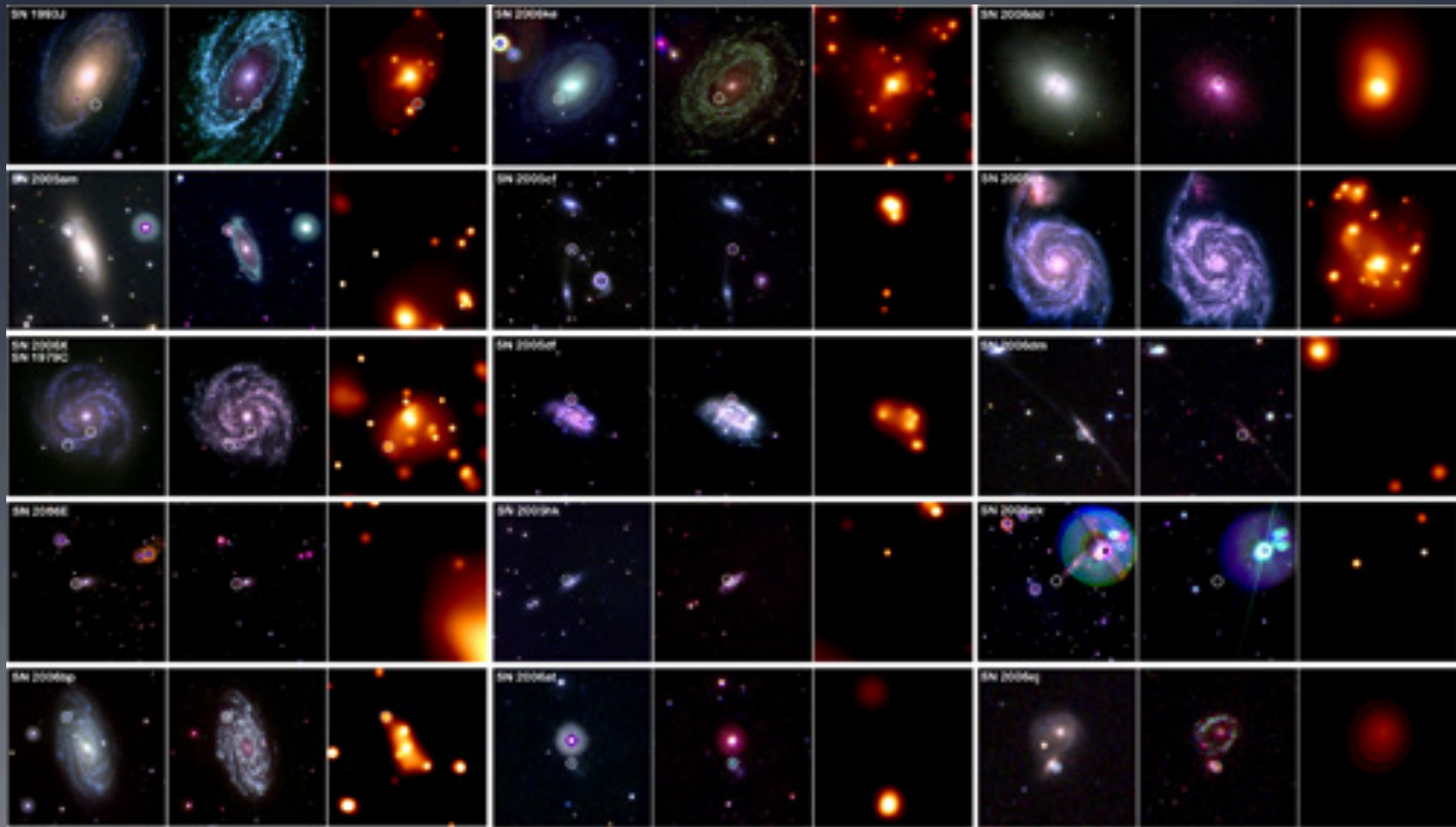
- 30 cm modified Ritchey-Chretien Telescope
- Wavelength Range 1600-6000 Angstroms
- Photon Counting detector centroiding into 0.5 arcsec virtual pixels
- 2 arcsec point spread function
- 17x17 arcminute field of view



Swift Supernovae Program

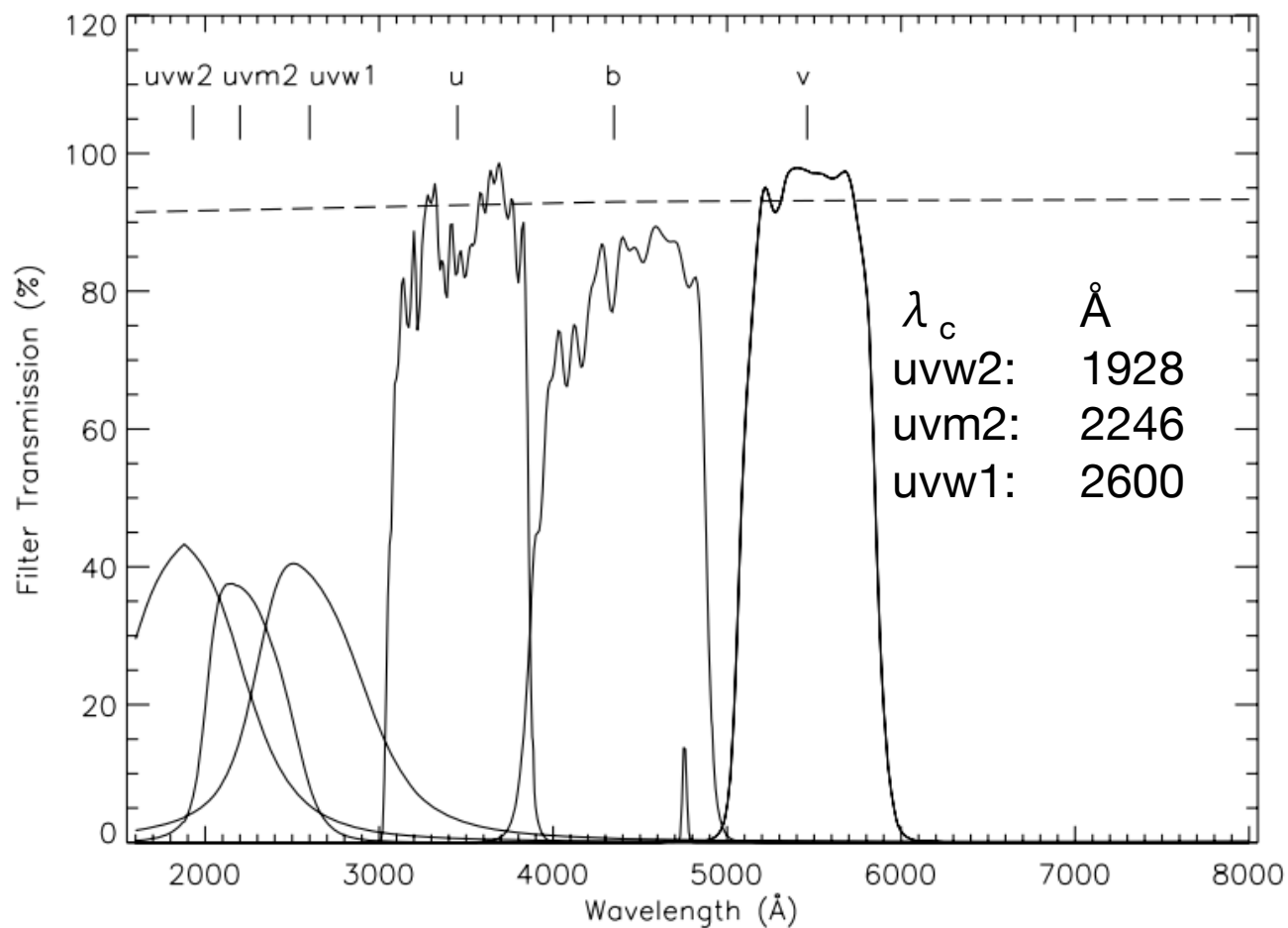
- Open Observatory:
 - TOO: <http://www.swift.psu.edu/too.html>
 - Also, Annual Fall proposal cycle for non time-critical observations
 - Collaborative effort with ground-based SNe Discovery & Observation Groups
 - Targets chosen from those found by robotic search groups and announced over IAUC/CBET/ATEL
 - Informal email list to coordinate observations
 - Targets chosen to maximize science and UV/X-Ray observations
 - Young (the earlier, the better)
 - Nearby ($z < 0.02$)
 - Low Line of Sight Extinction
 - 5-10" Separation from Galactic nucleus
-

8 Years of *Swift* SNe Observations ...

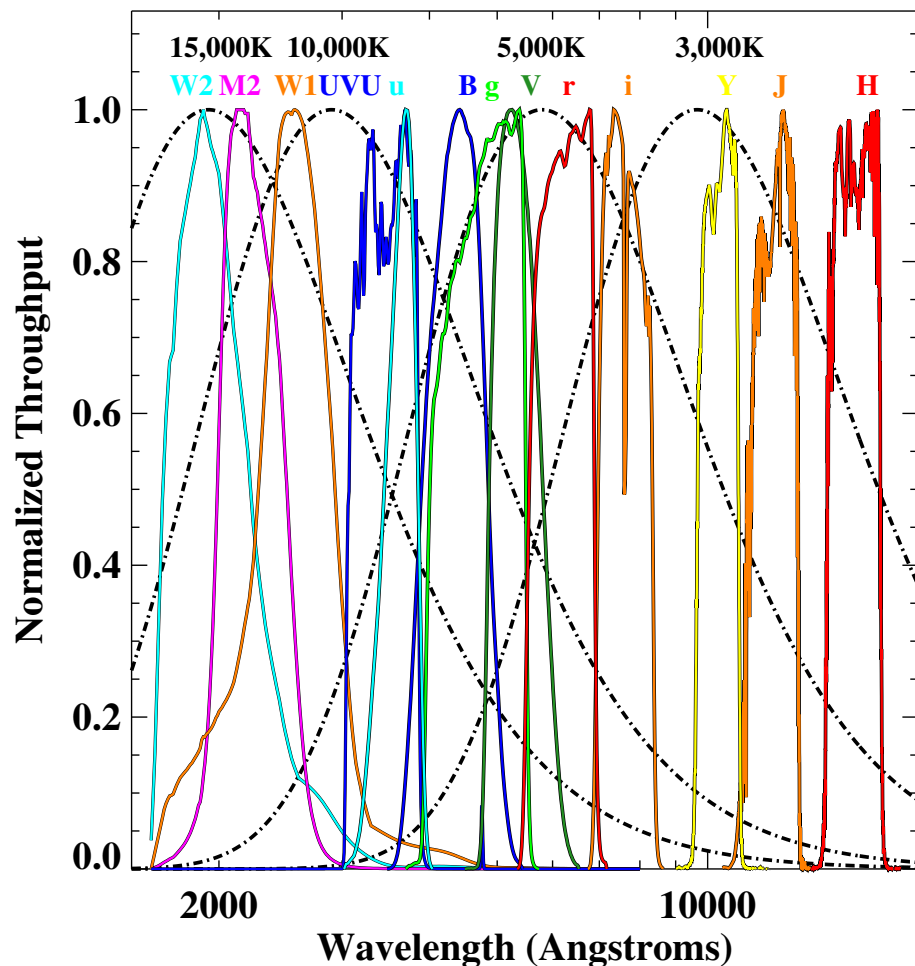


NASA/Swift/S. Immler

Swift/UVOT Filters

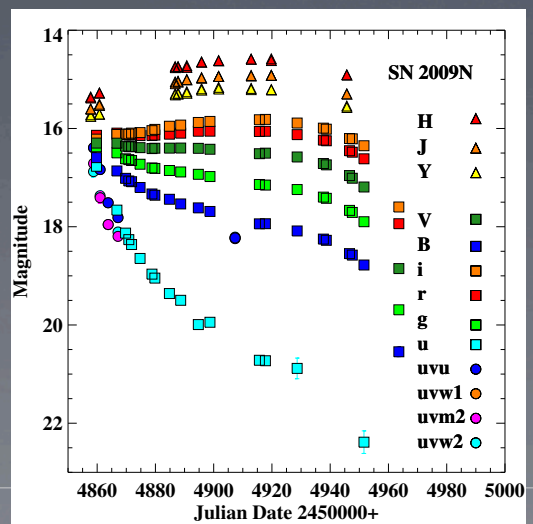
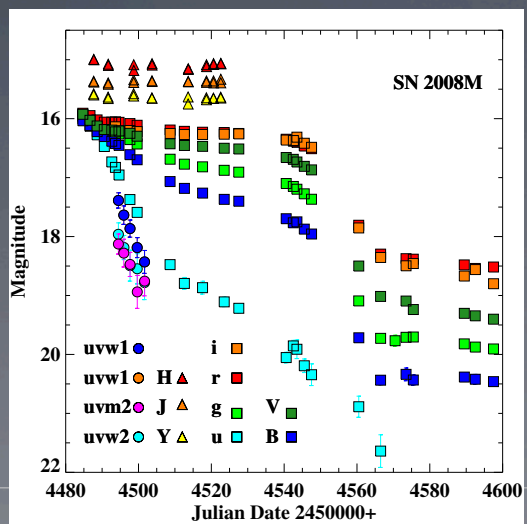
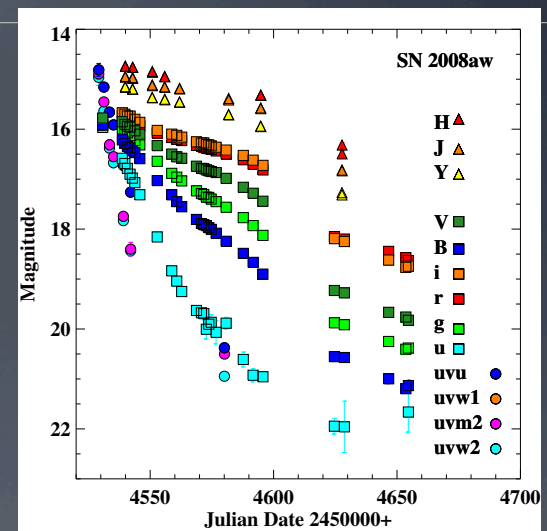
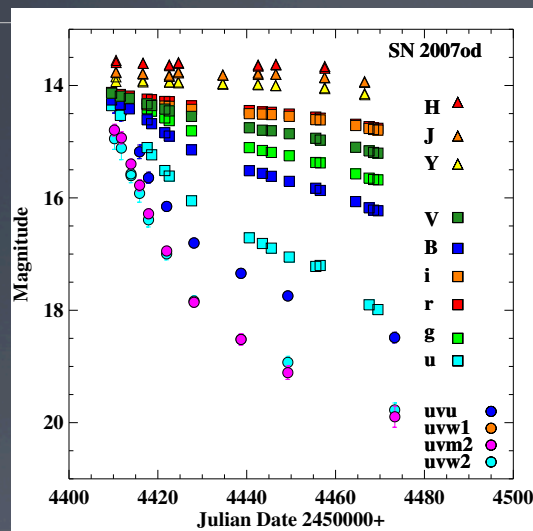
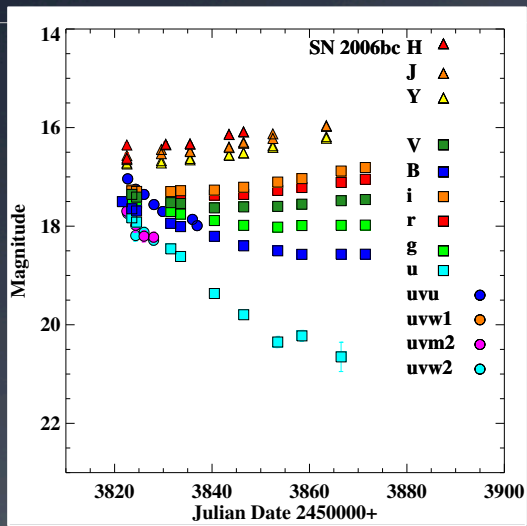


UV-NIR Coverage

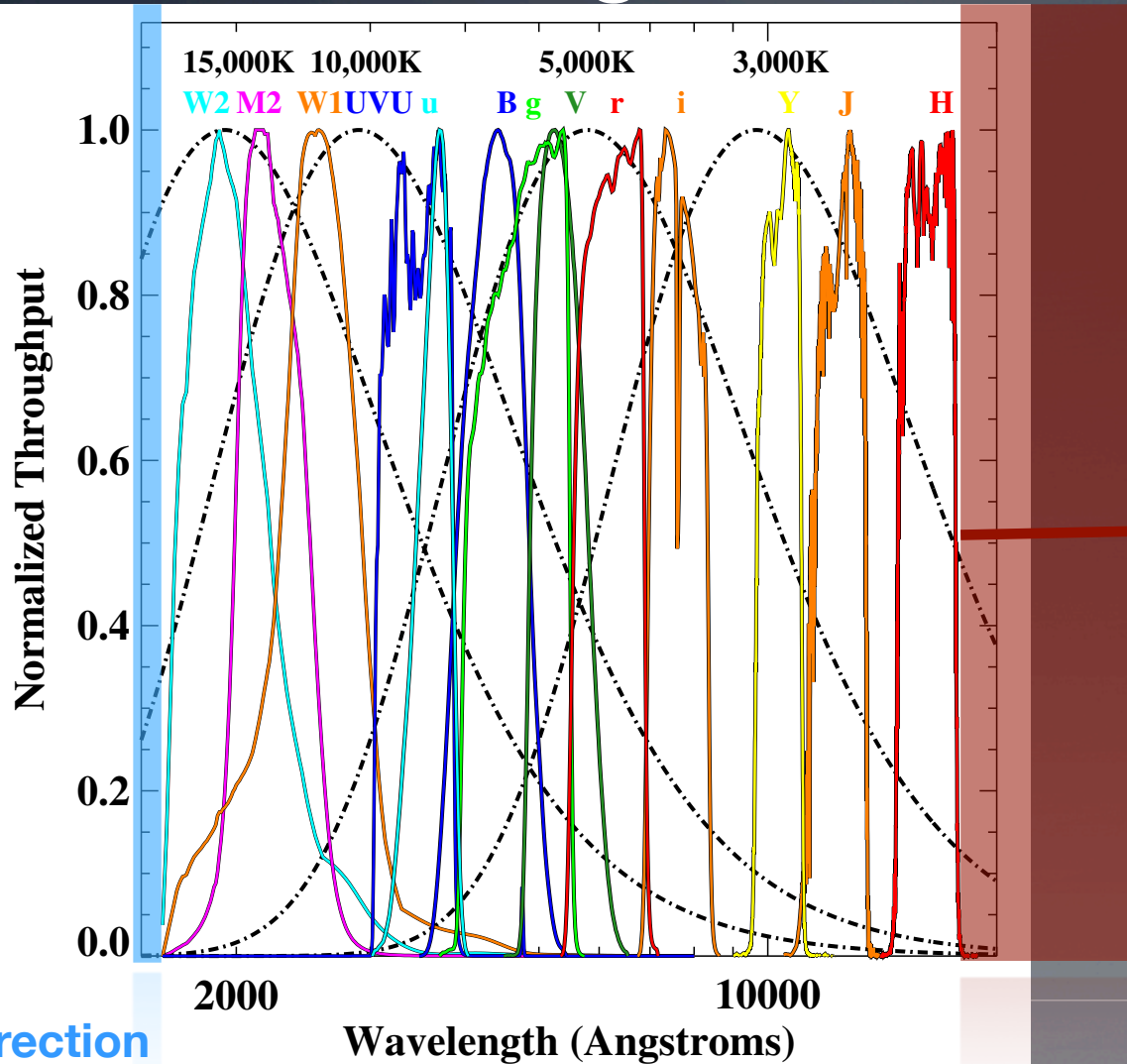


- Combine UVOT and CSP I Optical/NIR Data
- $\lambda \approx 1800-18000 \text{ \AA}$
- *Swift/UVOT*
 - uvw1, uvm2, uvw1, u
- CSP I
 - ugriBVYJH

Swift+CSP | SNe



Bolometric Light Curves



UV Correction =
integral of all
wavelengths blue-
ward of bluest
observed
wavelength

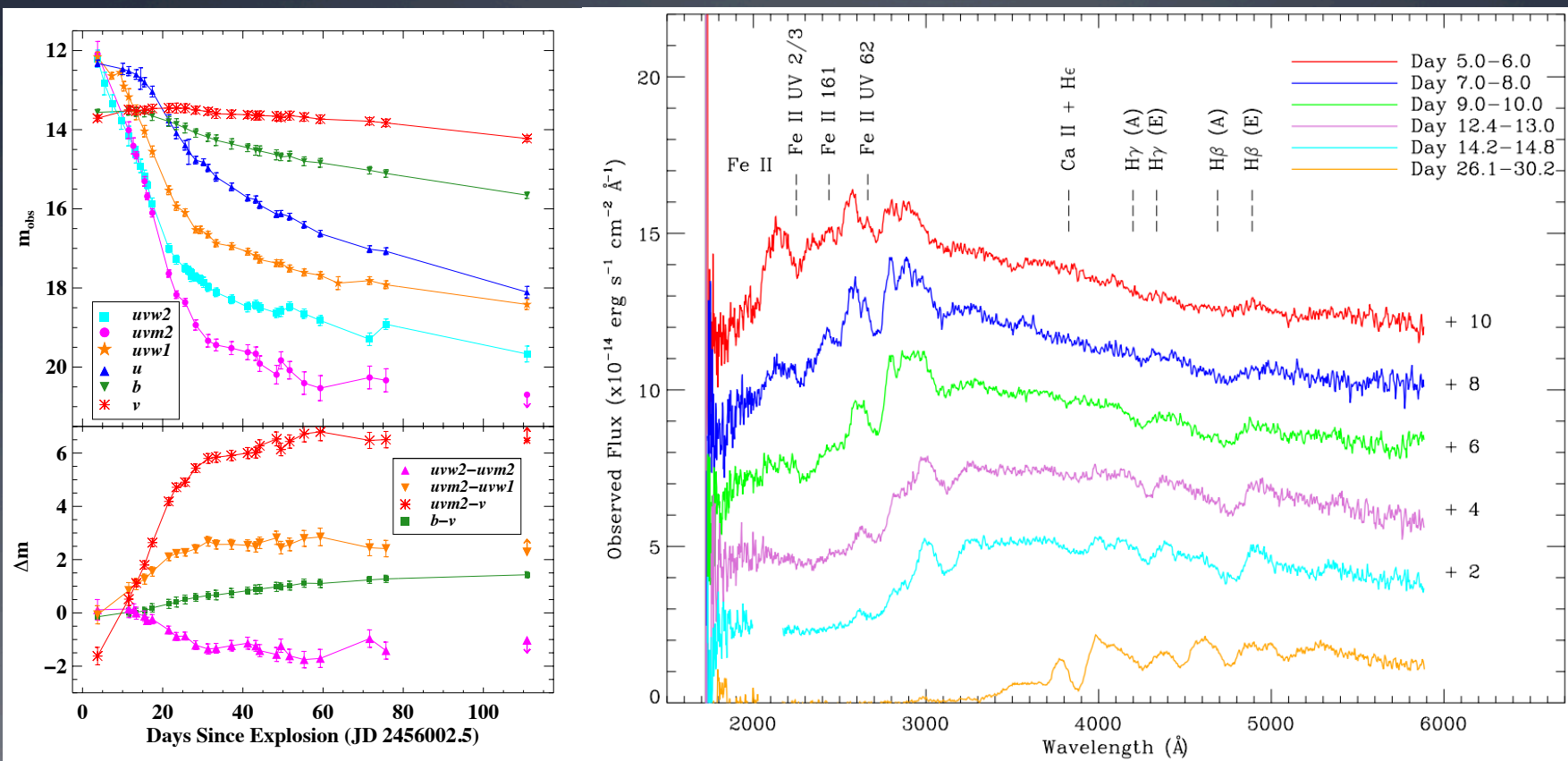
IR Correction =
integral of all
wavelengths red-
ward of reddest
observed
wavelength

∞

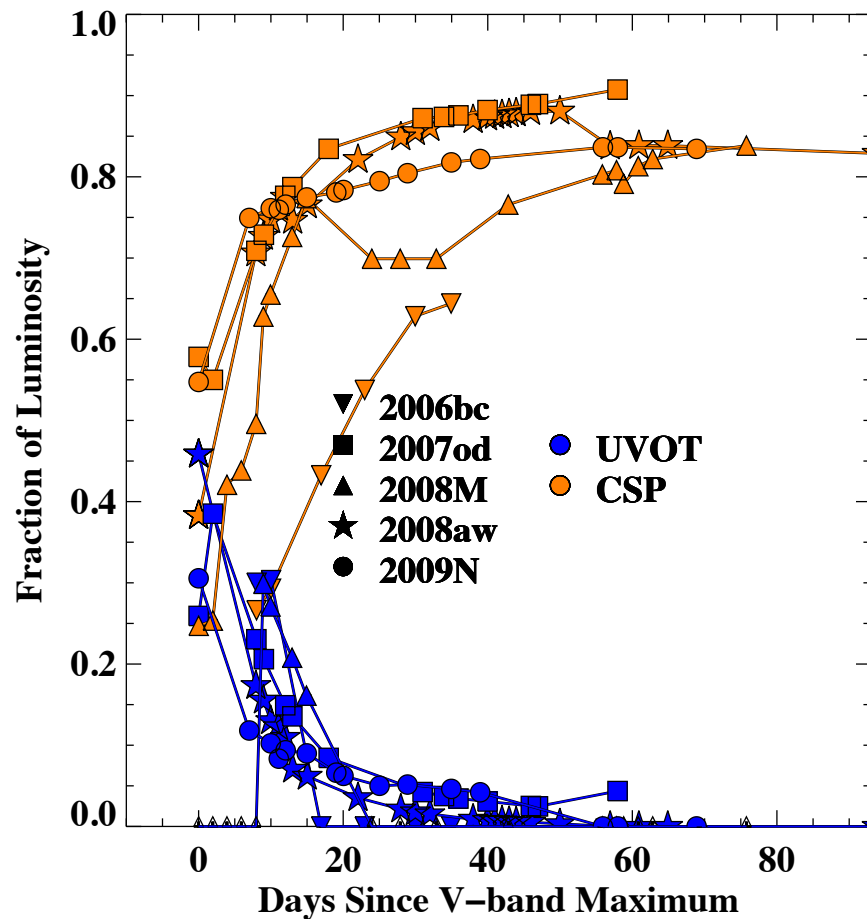
IR Correction

UV
Correction

SN 2012aw

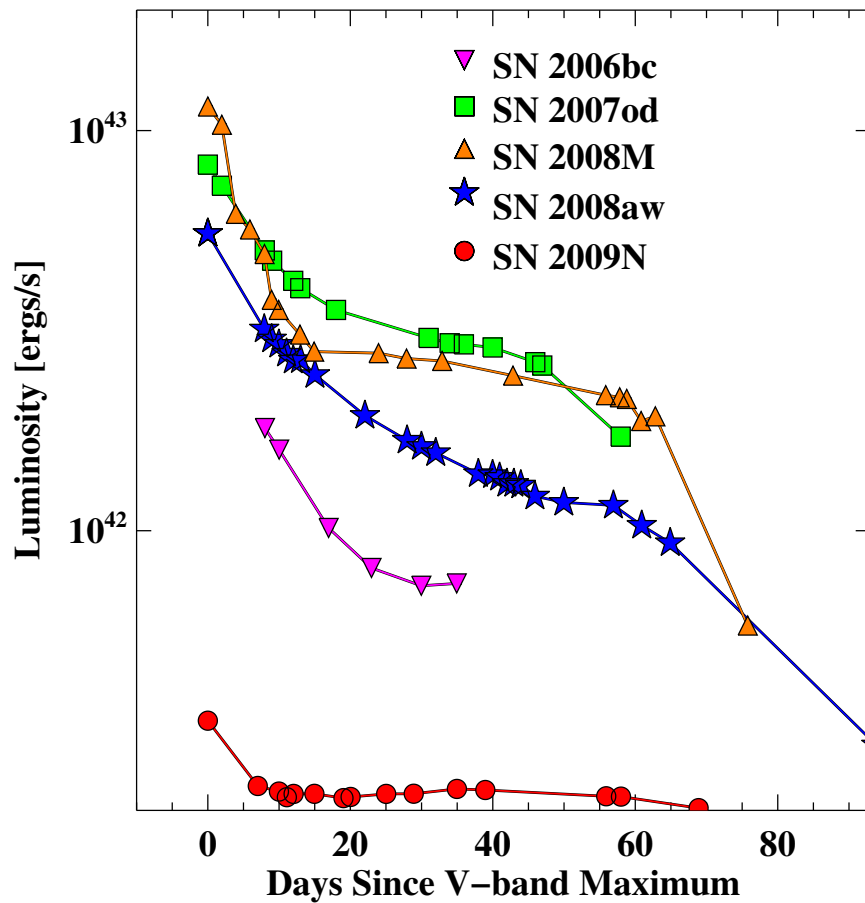


Flux Completeness



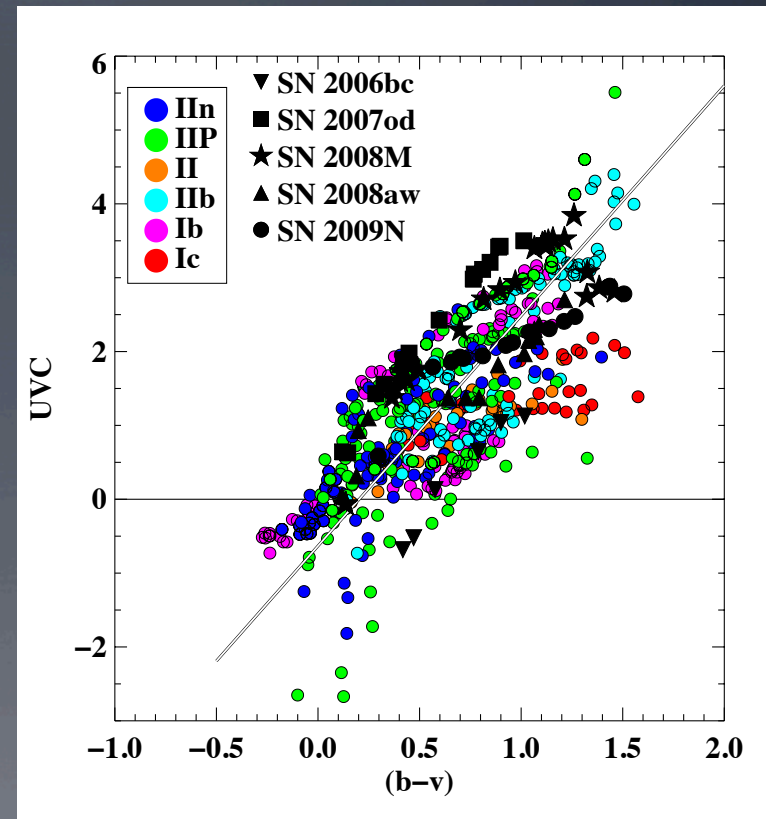
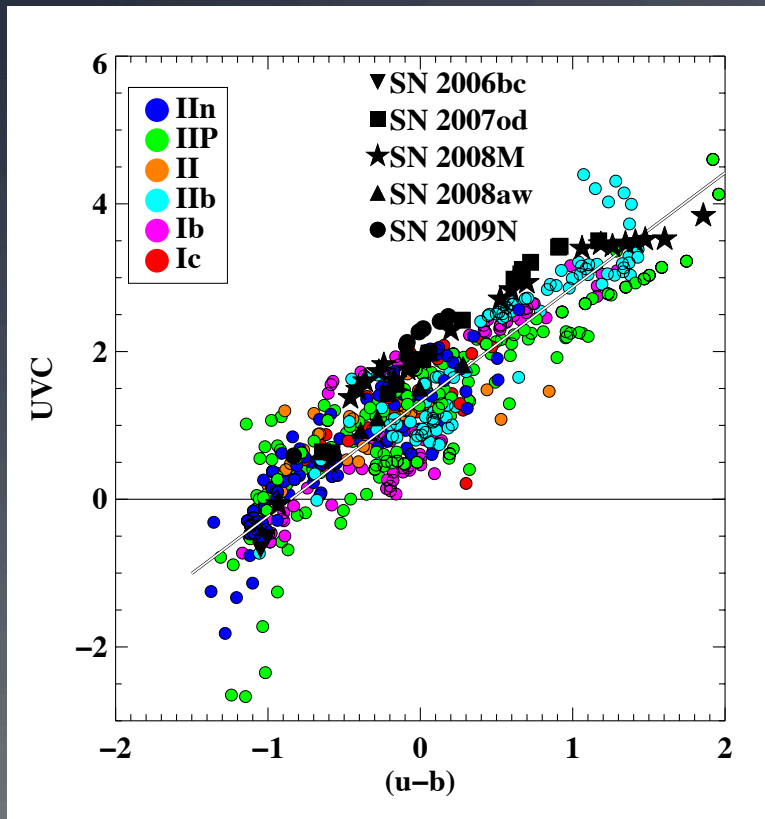
~85-90%+ flux completion
(when observations overlap)

UVOT+CSP Bolometric Light Curves

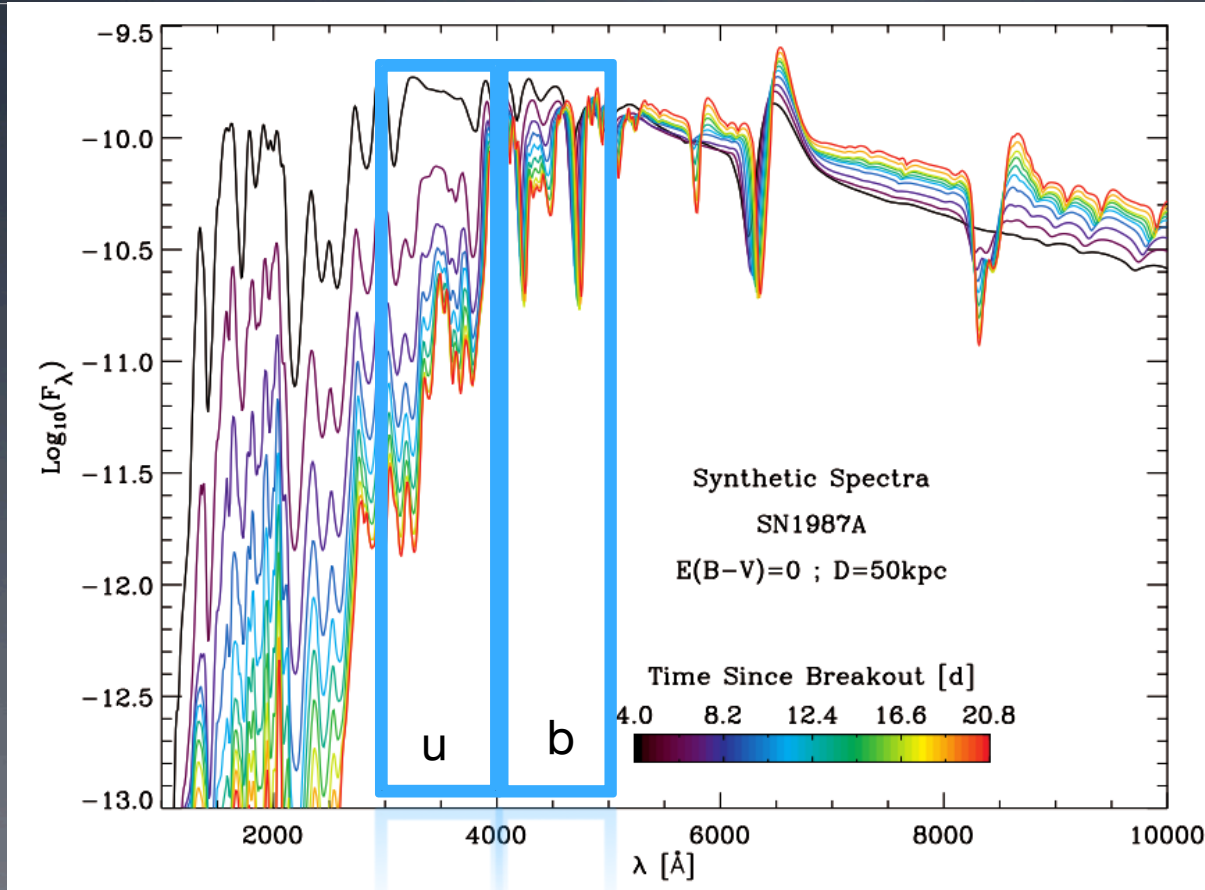


- Early Linear decay
- Variability in bolometric plateau Length/Shape?
- 2009N: sub-luminous object

UV Corrections (From UV-NIR Data)



Why is u so much better?



- -O/Fe/Ni vs H/He
(non SCCSNe)

Dessart & Hillier 10

Summary

- UV Observations important at early times
 - Information on total energetics, metallicity
 - UV behavior heavily dependant on subtype
 - Neglecting UV Flux in bolometric calculations can be dangerous
 - (Ground based u-band can be a good diagnostic of this)
 - We can supply an empirical correction for UV Flux
 - Understanding the locally observed UV flux will be important for interpreting results from future high-z synoptic survey programs (LSST, etc)
 - Variable Extinction, metallicity, stellar structure ...
-