

# New CC Spectral Templates

Dan Scolnic, 2012

- SNANA currently uses warped Nugent templates to match CC lightcurves using Saurabh Jha's warping routines (fit a smooth function of time and wavelength that multiplies (and can warp the time axis) the starting time-varying SED to get the required photometry. )

## Peter Nugent's Spectral Templates

**Last Revised: March 1, 2007**

Ok, I am still working on this page.... templates are here, in various states of disarray. Basic format for the templates are: *time* (days), *lambda*(Angstroms), *f\_lambda*(in arbitrary units). You can do this yourself, though it is a major pain. I have gotten good at it over the past few years. Basically it is an art. Careful attention needs to be paid to both the spectroscopic reduction, getting the *UV* right, looking at some spectrum synthesis models when there are no observations at the epoch/wavelength you want, and knowing where you can get away with interpolation/extrapolation. Most all of the data I used to make these templates is available at [SUSPECT](#), a database I only wish I had when David Branch, Adam Fisher and I started looking at correlations between SN Ia spectra in the very early 1990's. I strongly encourage everyone involved in this game to use it, cite it, and dump your spectra there once they become public.

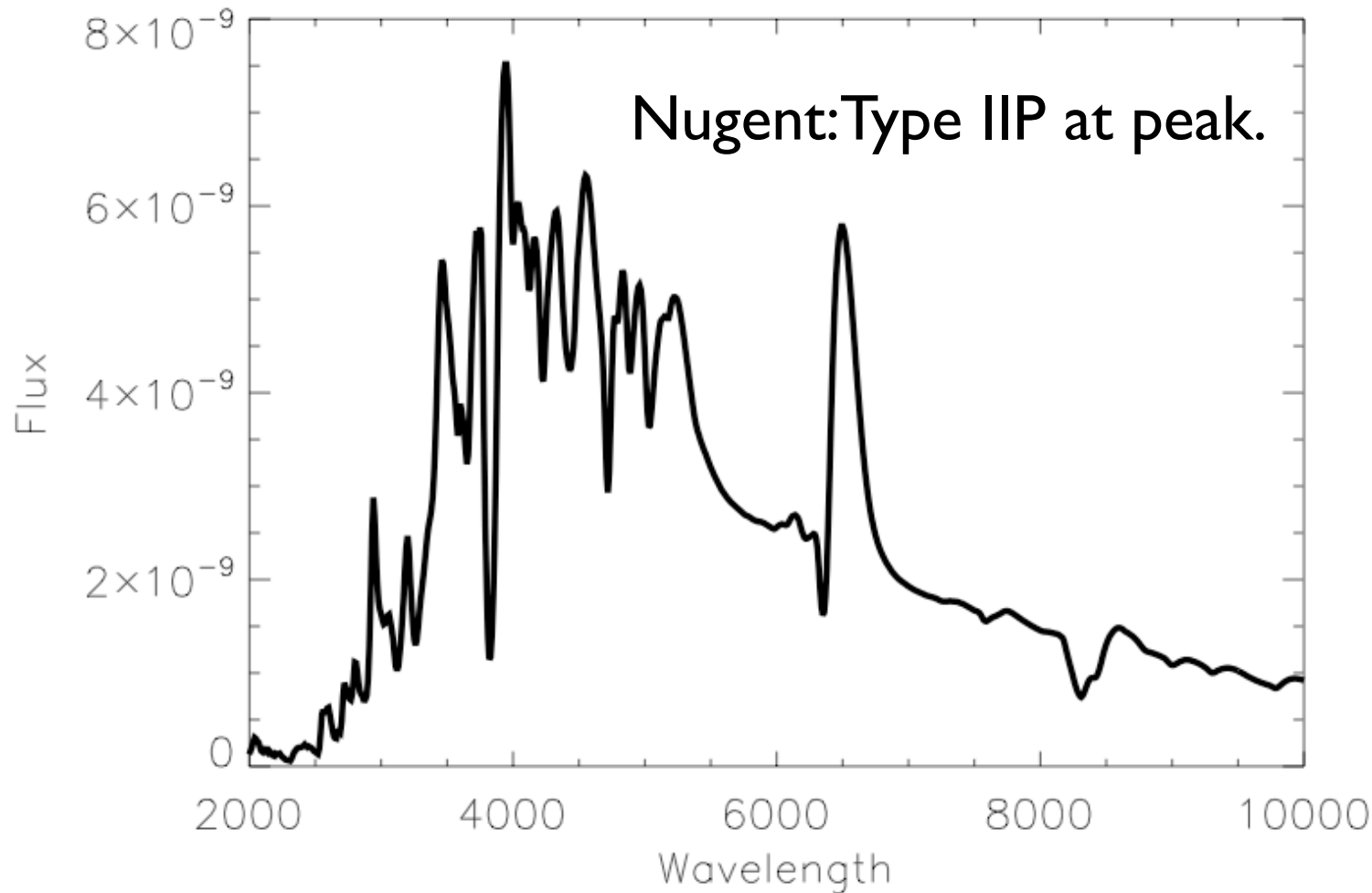
*time* is set to 0.0 at the explosion, and *f\_lambda* is now scaled so that it is 0.0 at peak *V*-band magnitude. I have also included a lightcurve file for each template. Sometimes they are just in *B* or *V*, sometimes *UBVRIJHK*. For the II<sub>n</sub>'s they include the effective temperature. Instead of being set by the explosion date, they are usually set so they peak in *B* or *V* at day 0.0.

**Warning to the user:** Please use these carefully for doing anything like *K*-corrections for rates, cosmology, whatever. Understand what you are doing. Read my [K-corrections and Extinction Corrections for Type Ia Supernovae](#) paper to get an understanding of what is involved. It is easy to get messed up and I have to go back to the paper frequently to remind myself how to do things right. At the very minimum you will need some piece of code to warp the templates to get the color to be what you want at any given epoch and another piece of code to interpolate between epochs. I have left things usually in some unextinguished form (though SNe like Ib/c rarely have no extinction) so be forewarned. Also remember to check the [revision history](#).

Please let me know if you find any problems.

- **Type Ia Branch-normal:** This is based on my original work in Nugent, Kim and Perlmutter, *PASP* (2002), vol. 114, pg. 803. I have modified what appeared there in a few ways. The *UV* wasn't completely smooth as a function of time. Therefore at the suggestion (forcible) from my friends with the [SuperNova Legacy Survey](#) I smoothed them out. In addition, there was a glitch near the *R*-band in my original template due to one odd-ball supernova being in there. This has been taken care of in the current version. Note, this is a stretch = 1.0 SN Ia template. It is good for that. I think these are good for restframe *UBV* if you want to stretch the template (between  $0.8 < s < 1.1$ ), beyond that I think they can be subject to some systematics.
  - [Fluxed, time-evolving spectral series.](#)
  - [Photometry UBVRIJHK](#)
- **Type Ia 1991T-like:** This is a brand-new one I've made, based almost exclusively on SN 1991T. It first appeared in Stern *et al.* (2004) *ApJ*, vol 612, pg. 690, [Discovery of a Transient U-Band Dropout in a Lyman Break Survey: A Tidally Disrupted Star at z=3.3?](#). I assumed an  $E(B-V)$  of 0.2 and corrected accordingly.
  - [Fluxed, time-evolving spectral series.](#)
  - [Photometry UBVRI](#)

- Nugent: Misunderstood date of explosion for CC - 7 day shift?



- We can use SNID template library: SNIb (11), SNIb\_pec (1), SNIc (13), SNIc\_broad (4).

# How SNID does it:

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Blondin & Tonry

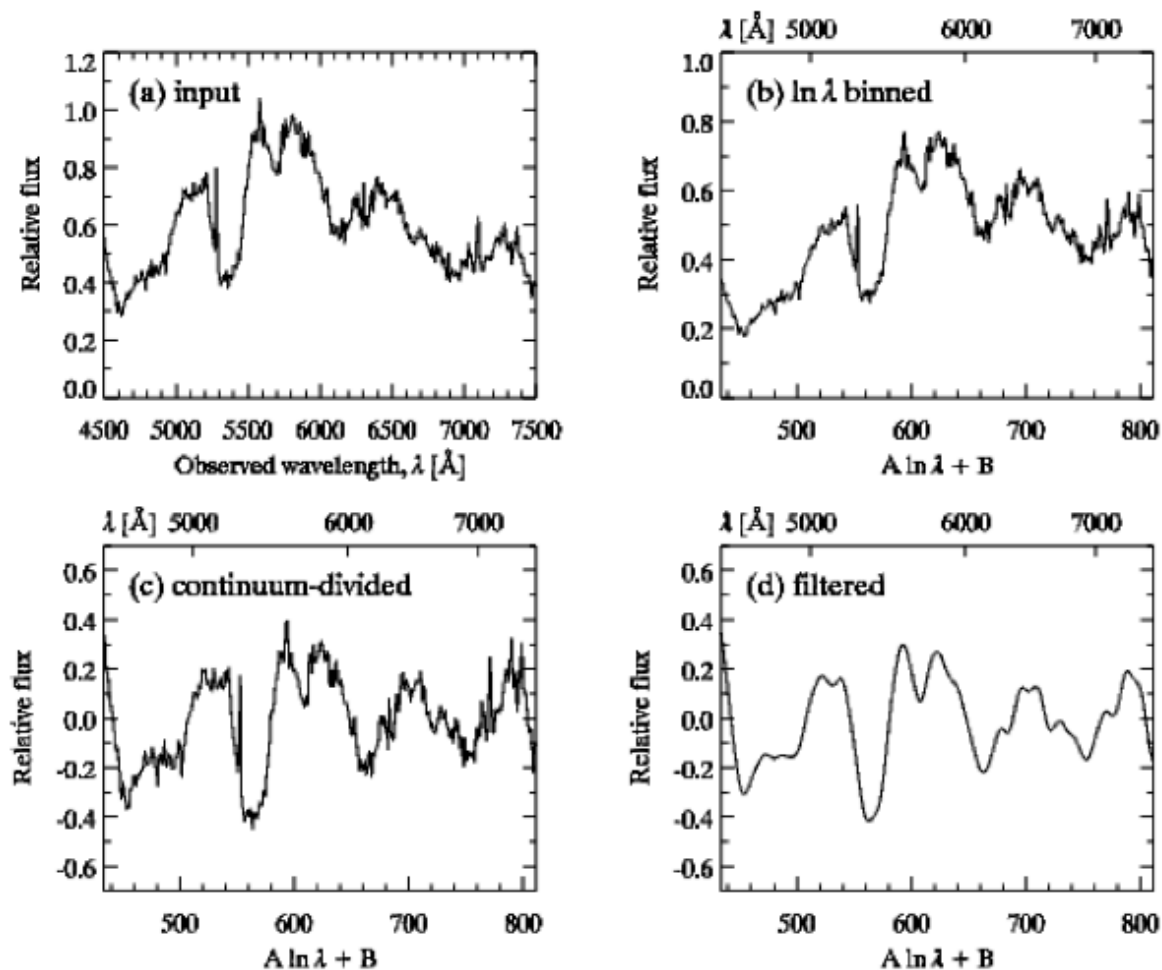
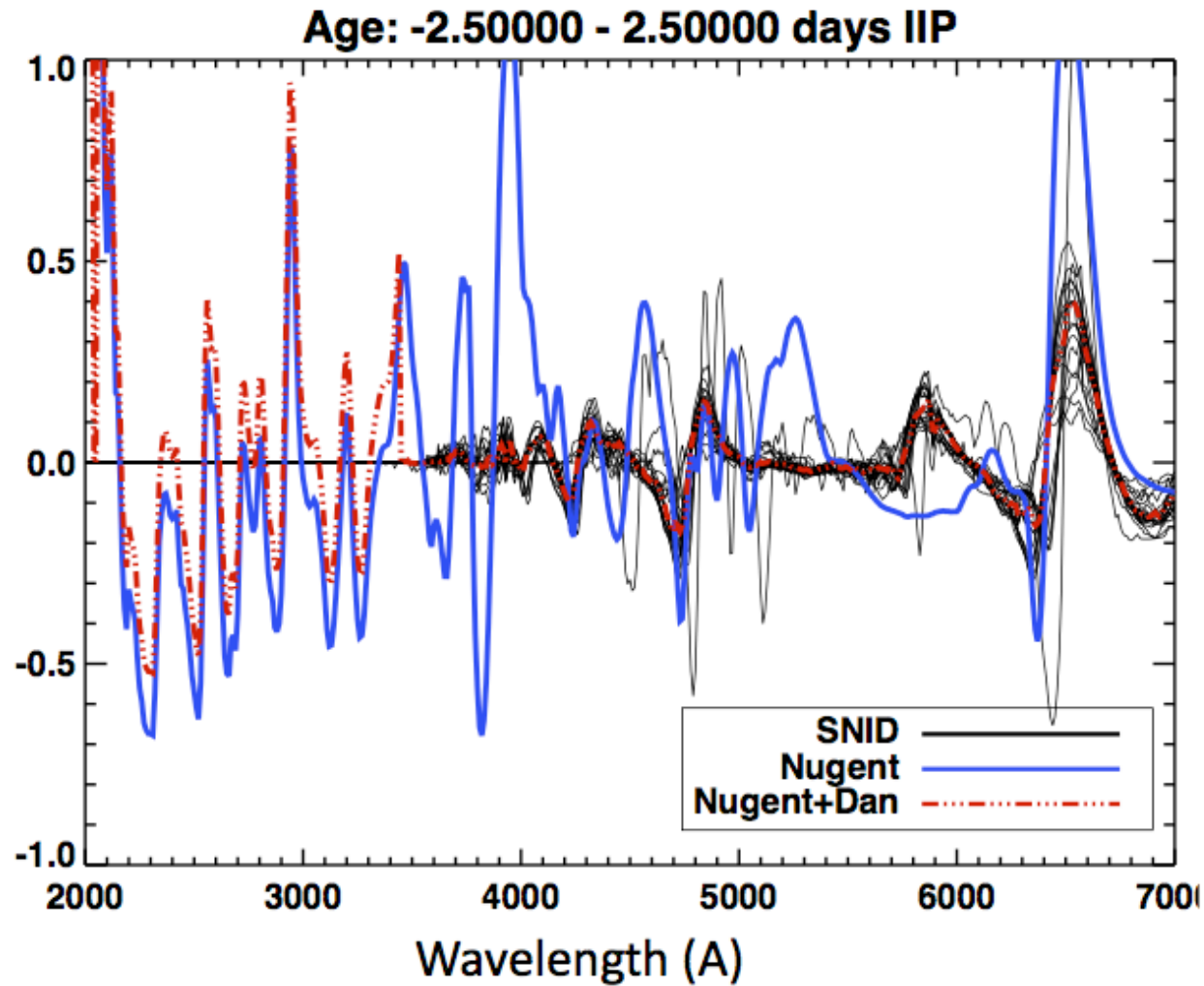
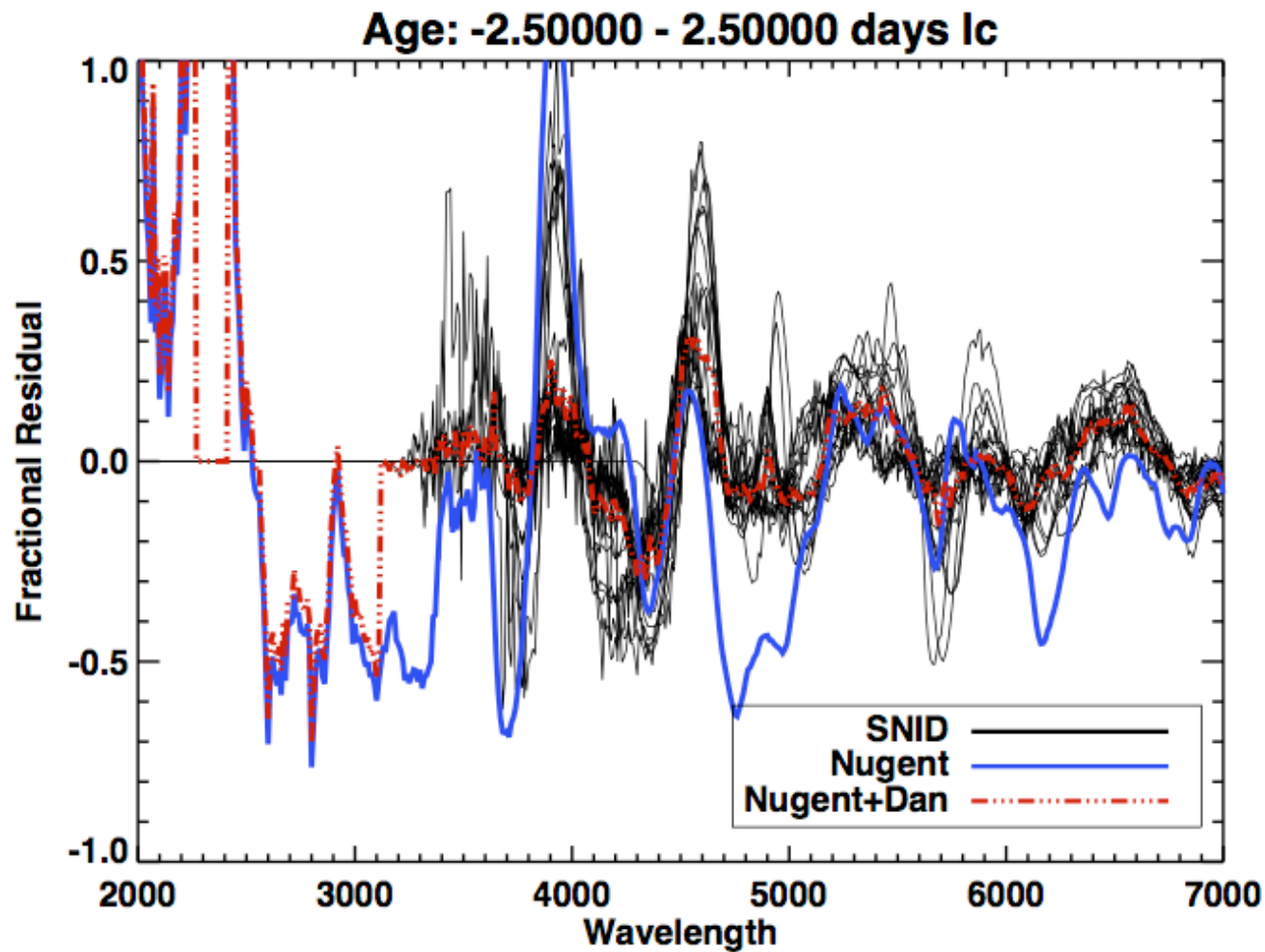


FIG. 1.— Pre-processing the spectrum for SNID. (a) Spectrum of the SN Ia SN 2003lj at  $z = 0.417$  (Matheson et al. 2003). (b) The result of mapping the spectrum to  $\ln \lambda$  coordinates, with  $(l_0, l_1, N) = (2500 \text{ \AA}, 10000 \text{ \AA}, 1024)$ . (c) A 13-point spline has been divided out and the result normalized to zero mean flux. (d) A bandpass filter with  $(k_1, k_2, k_3, k_4) = (1, 4, 25, 102)$  has been applied to the spectrum.

# SNe II Template



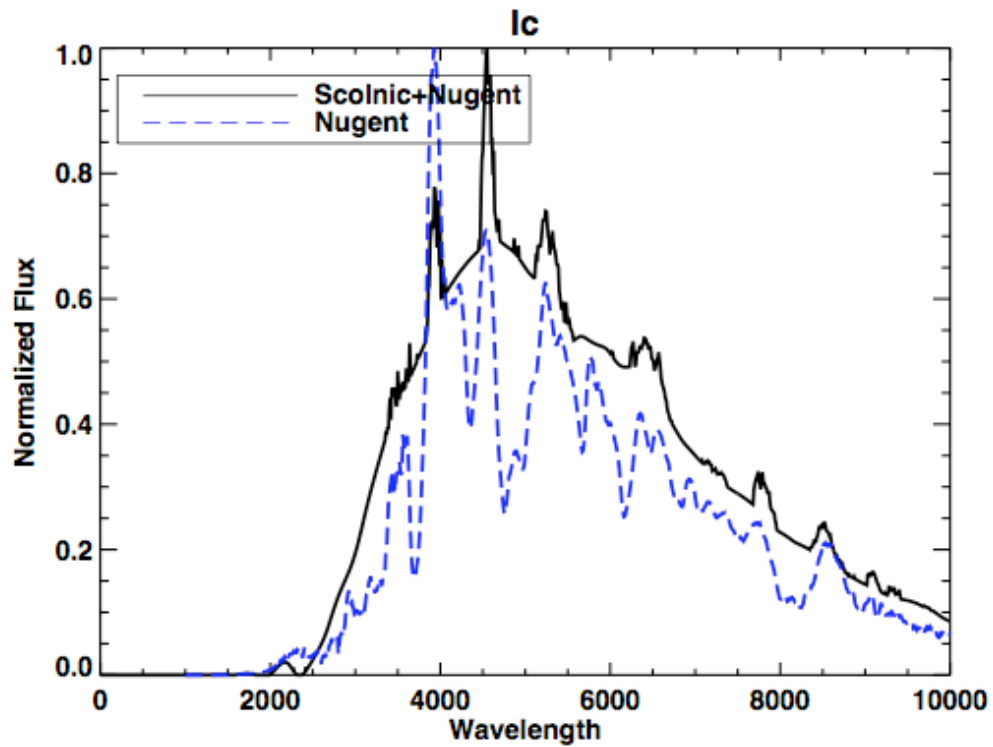
# SNe Ic



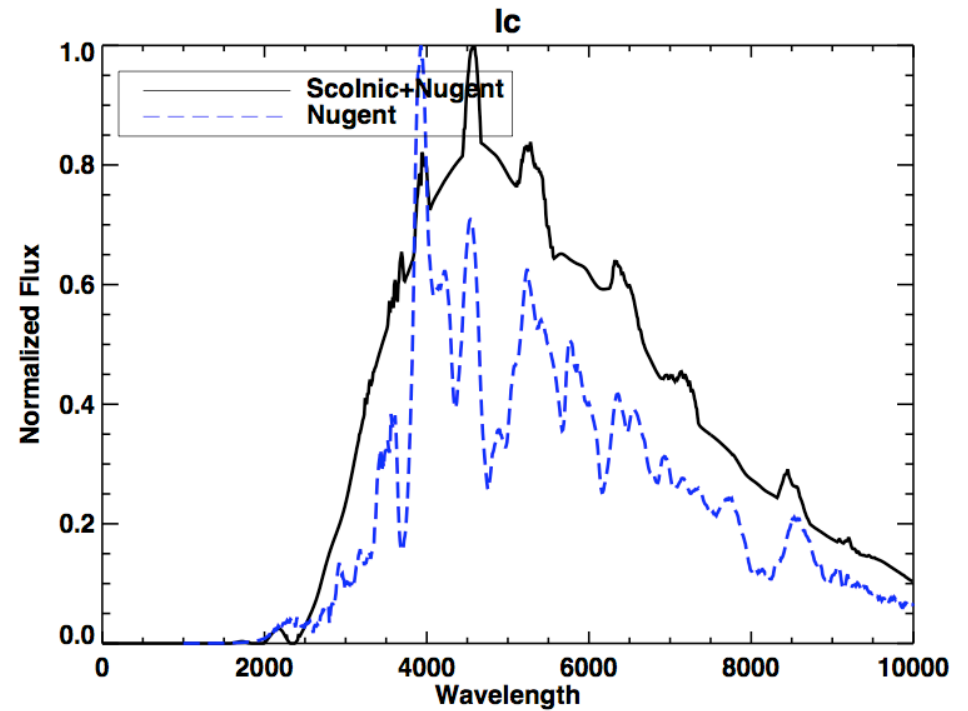
We then add spectral features back onto Nugent continuum for templates..

# What Our New Template Spectra Look Like:

## Normal Ic

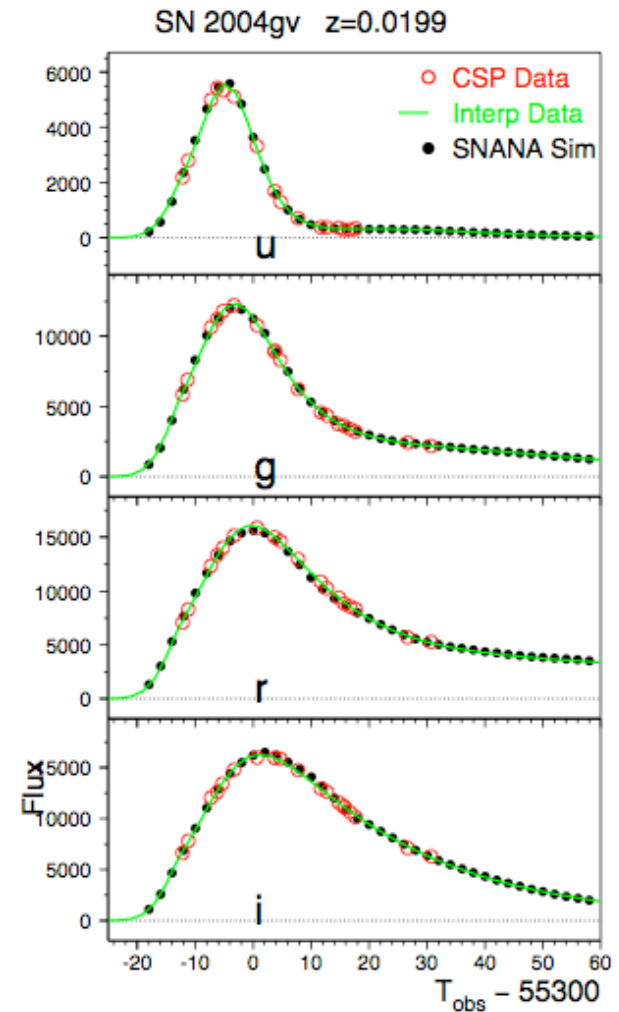


## Ic\_Broad



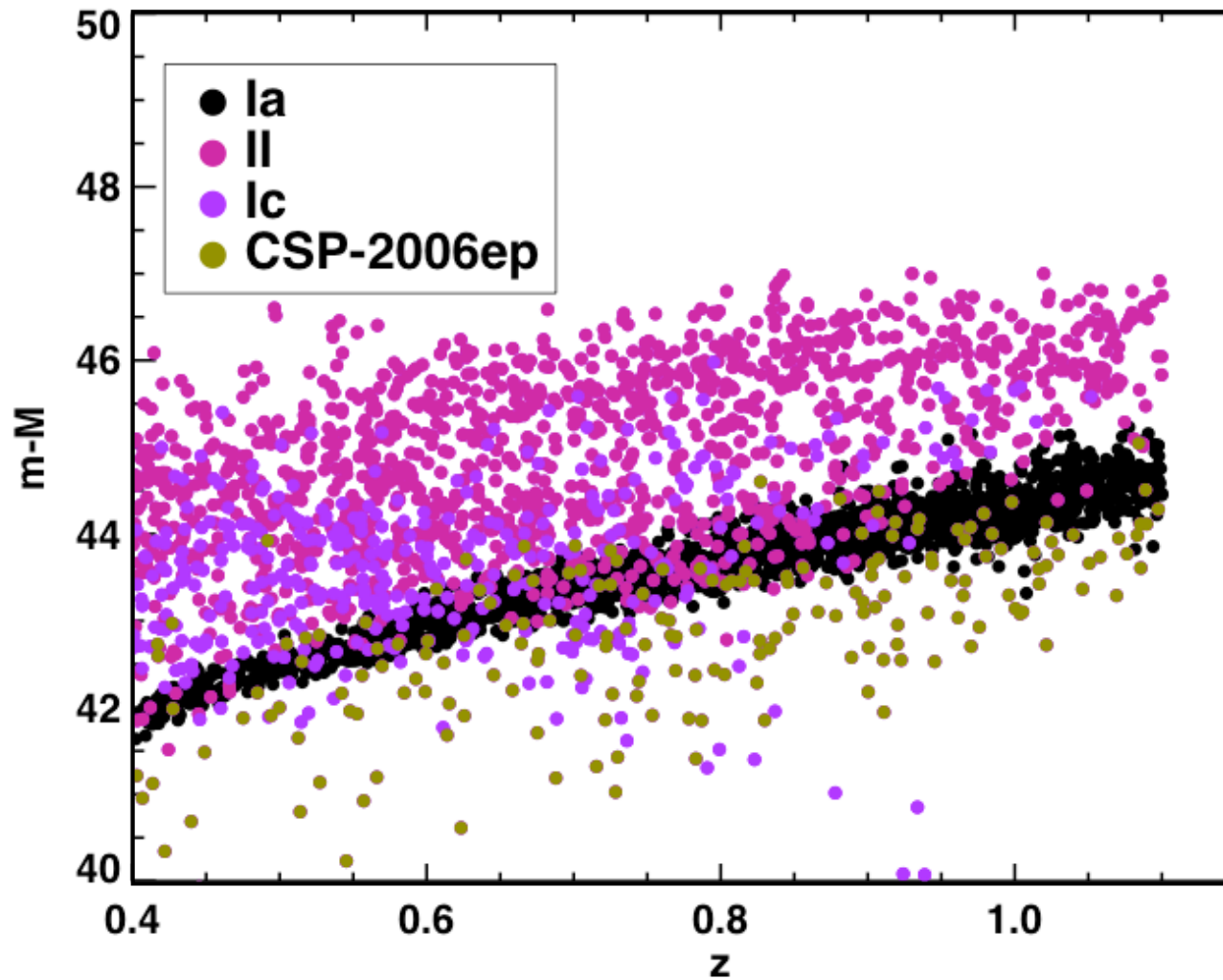
# With New templates..

- We warped new templates to match SNANA template light curves
- Ran `sednon1a_prep.pl` (Hosting before/after on local server)
- Can now see what kind of difference this makes.

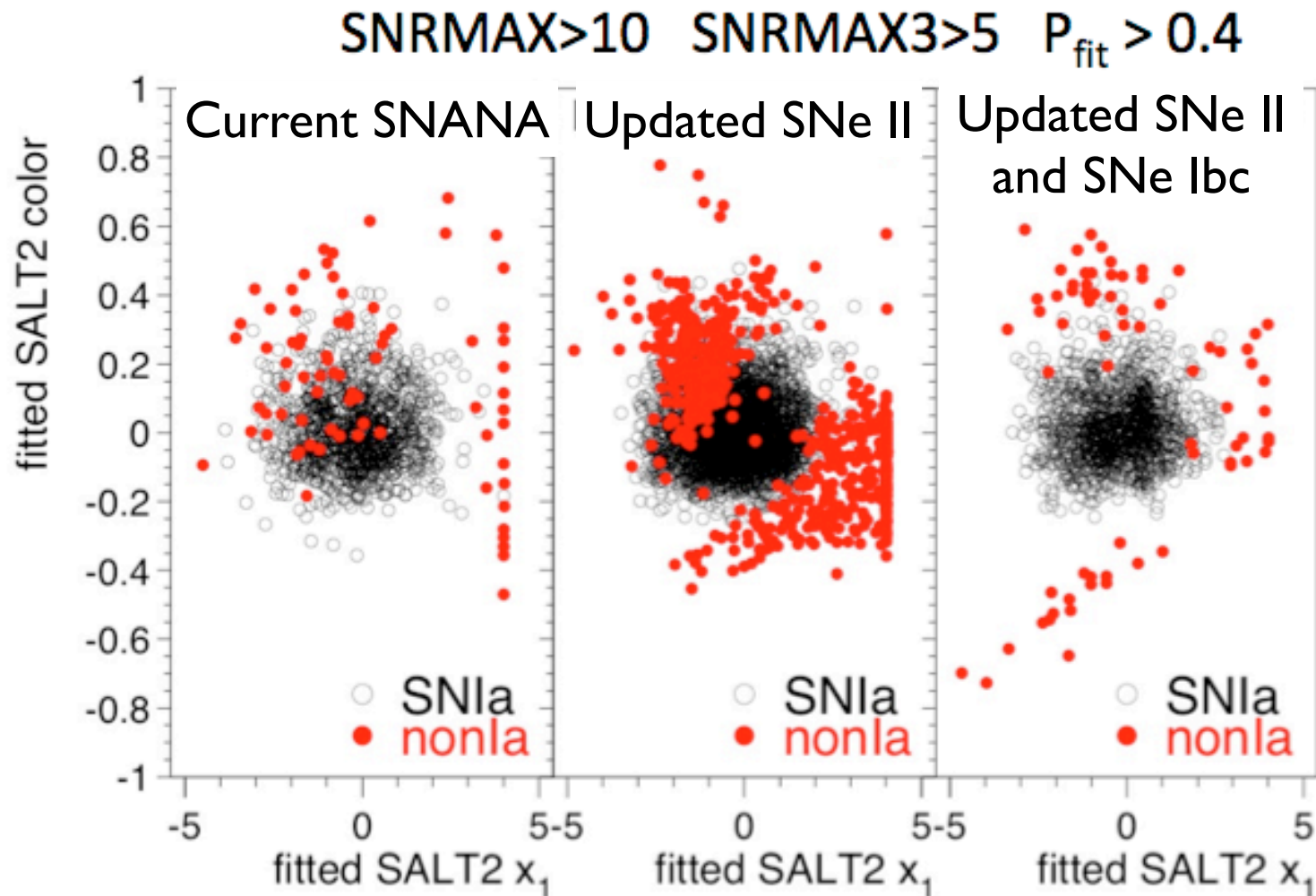




# Our Most Current DES Hubble Diagram



# Effects on Light Curve Fitting of CC SNe



# To Do..

- How to best model spectral diversity of CC SNe?
- Increase size of CC spectroscopic sample
- Host on : [wachowski.pha.jhu.edu/~dscolnic/Scolnic SNANA sed.tar](http://wachowski.pha.jhu.edu/~dscolnic/Scolnic_SNANA_sed.tar)