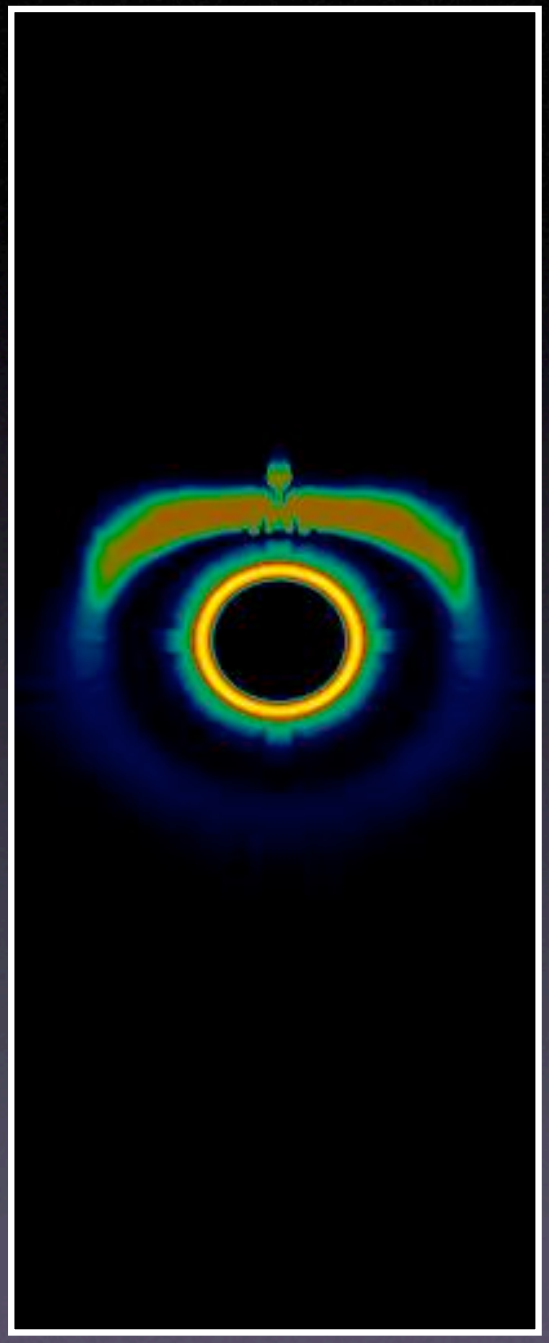
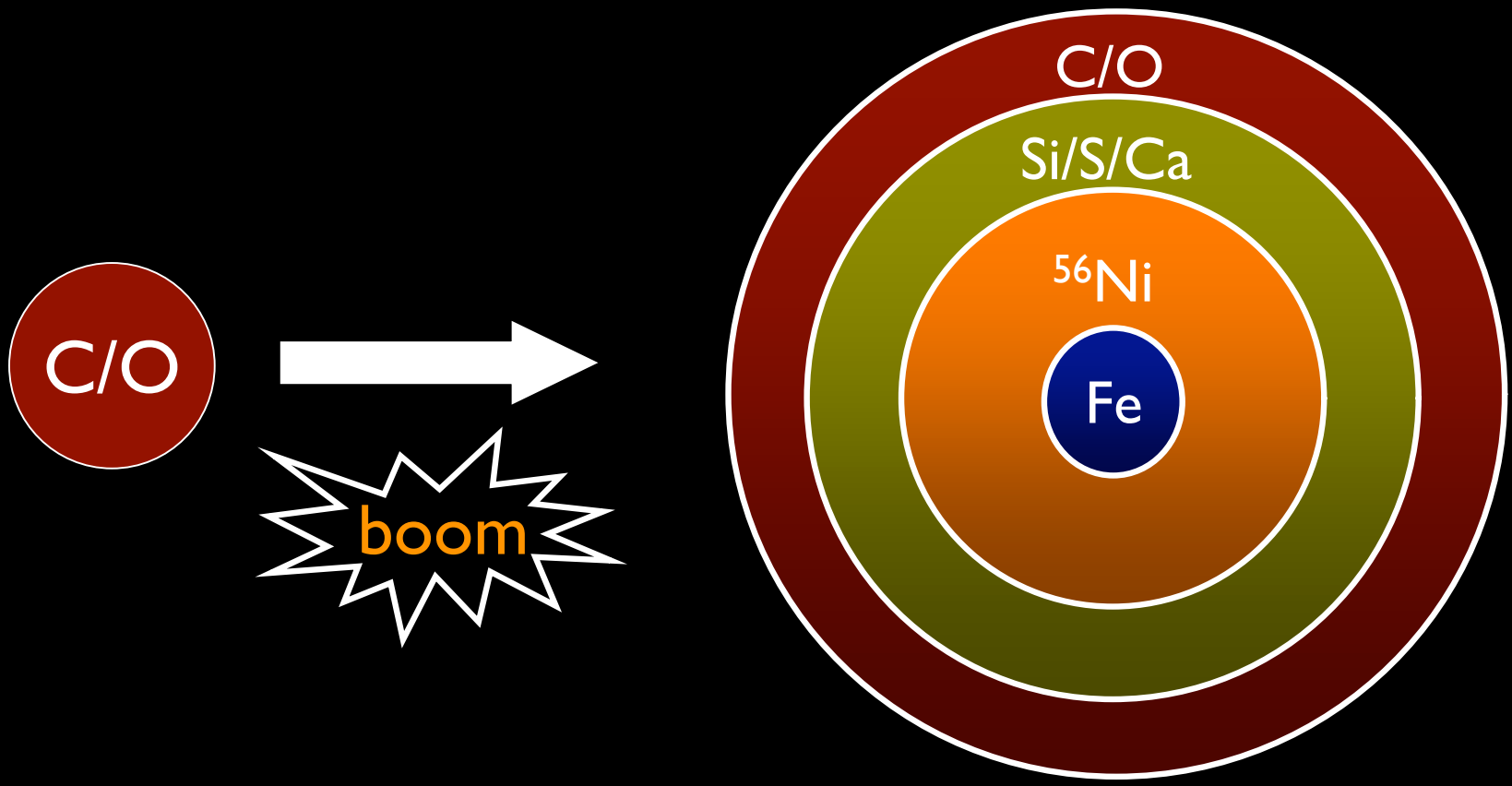
the theoretical understanding of

Type Ia Supernova Light Curves

Daniel Kasen

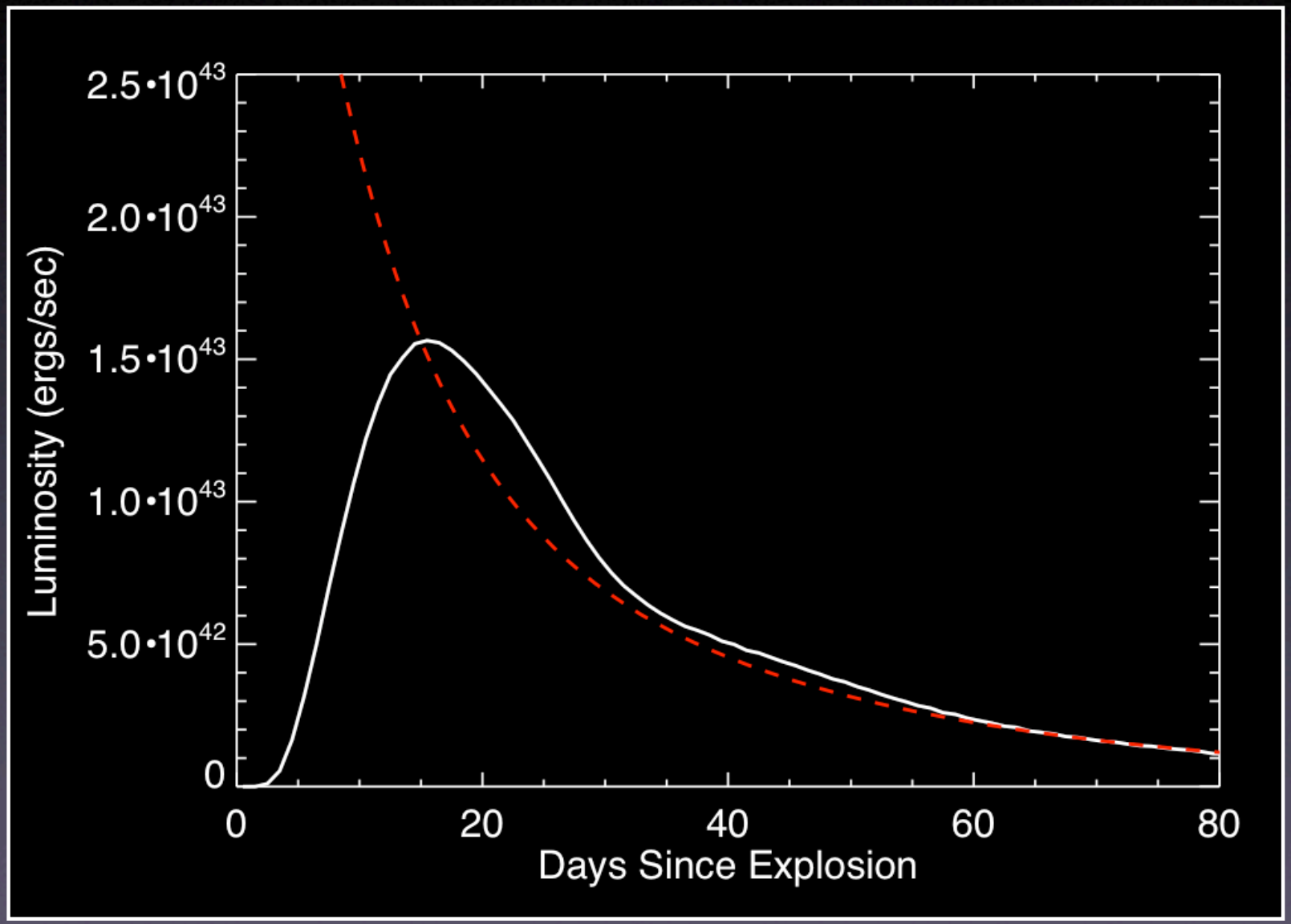


$$\mathrm{E_{nuc}} \approx 2(M_{\mathrm{Burn}}/M_{\mathrm{ch}}) \times 10^{51}\ \mathrm{ergs}$$



Type Ia Supernova Light Curves

powered by the beta decay: $^{56}Ni \rightarrow {}^{56}Co \rightarrow {}^{56}Fe$

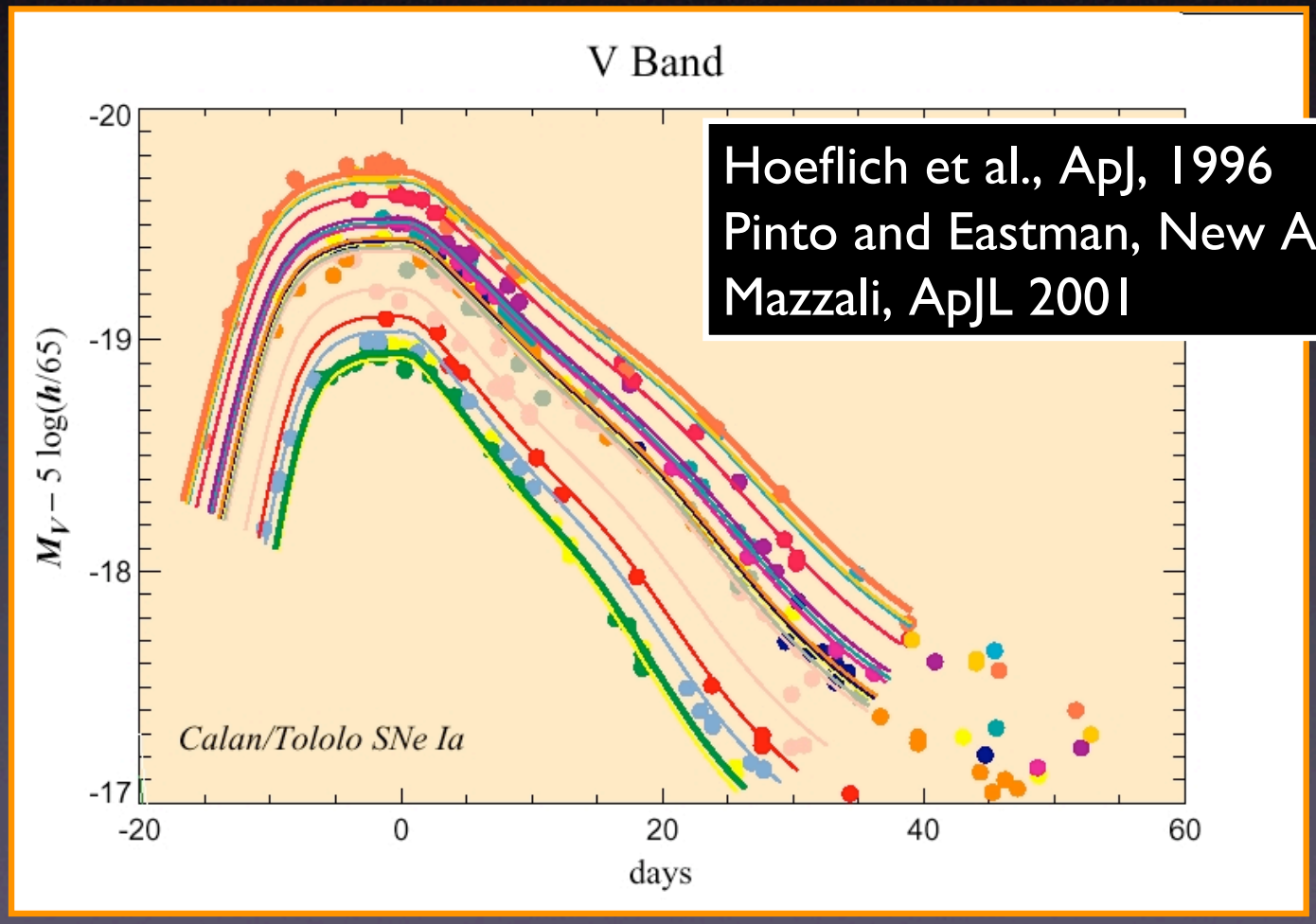


Type Ia Width-Luminosity Relation

brighter supernovae have broader light curves

$$L \sim M_{Ni}$$

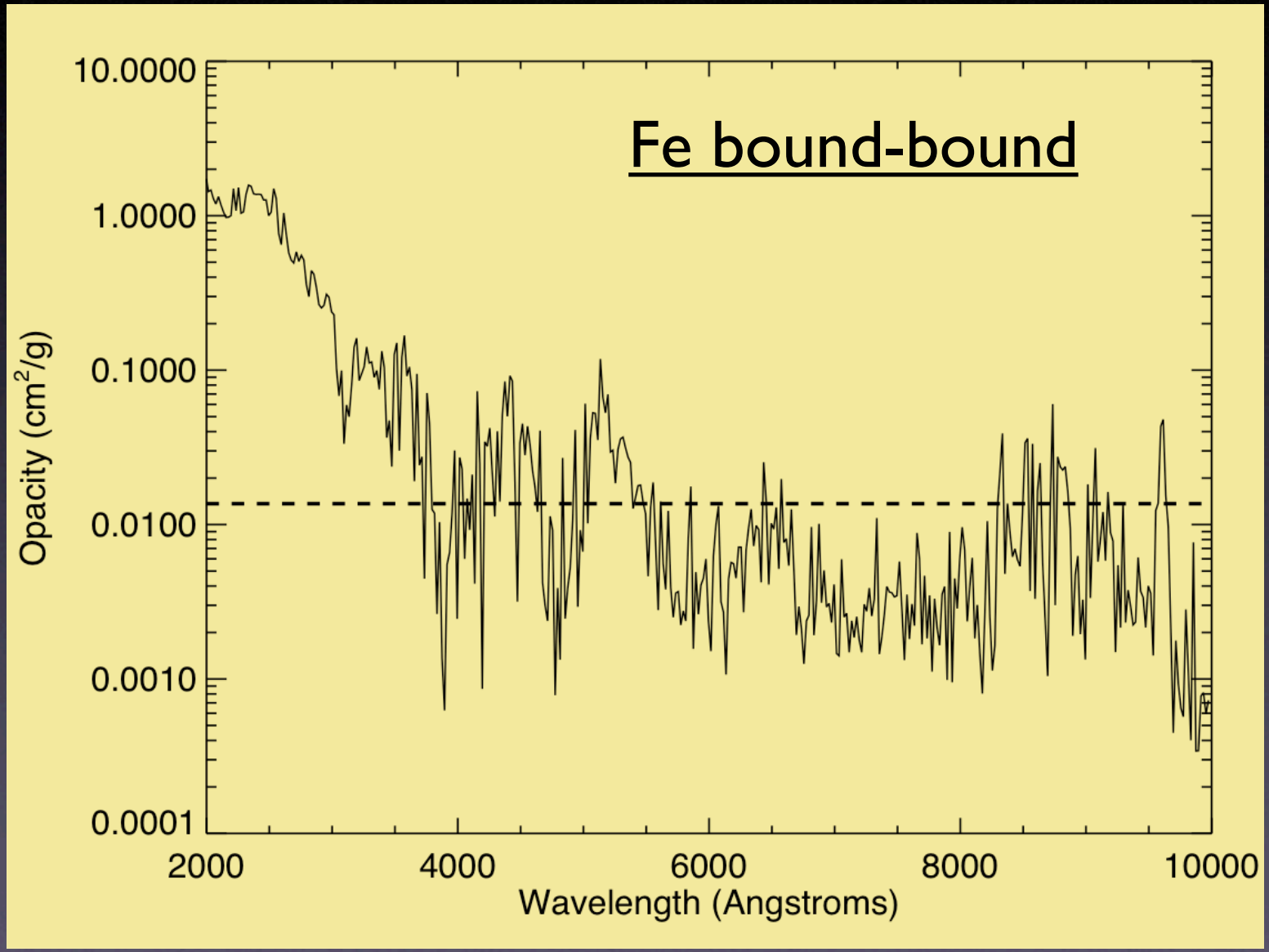
$$t_{diff} \sim M^{3/4} E_K^{-1/4} \kappa^{1/2}$$



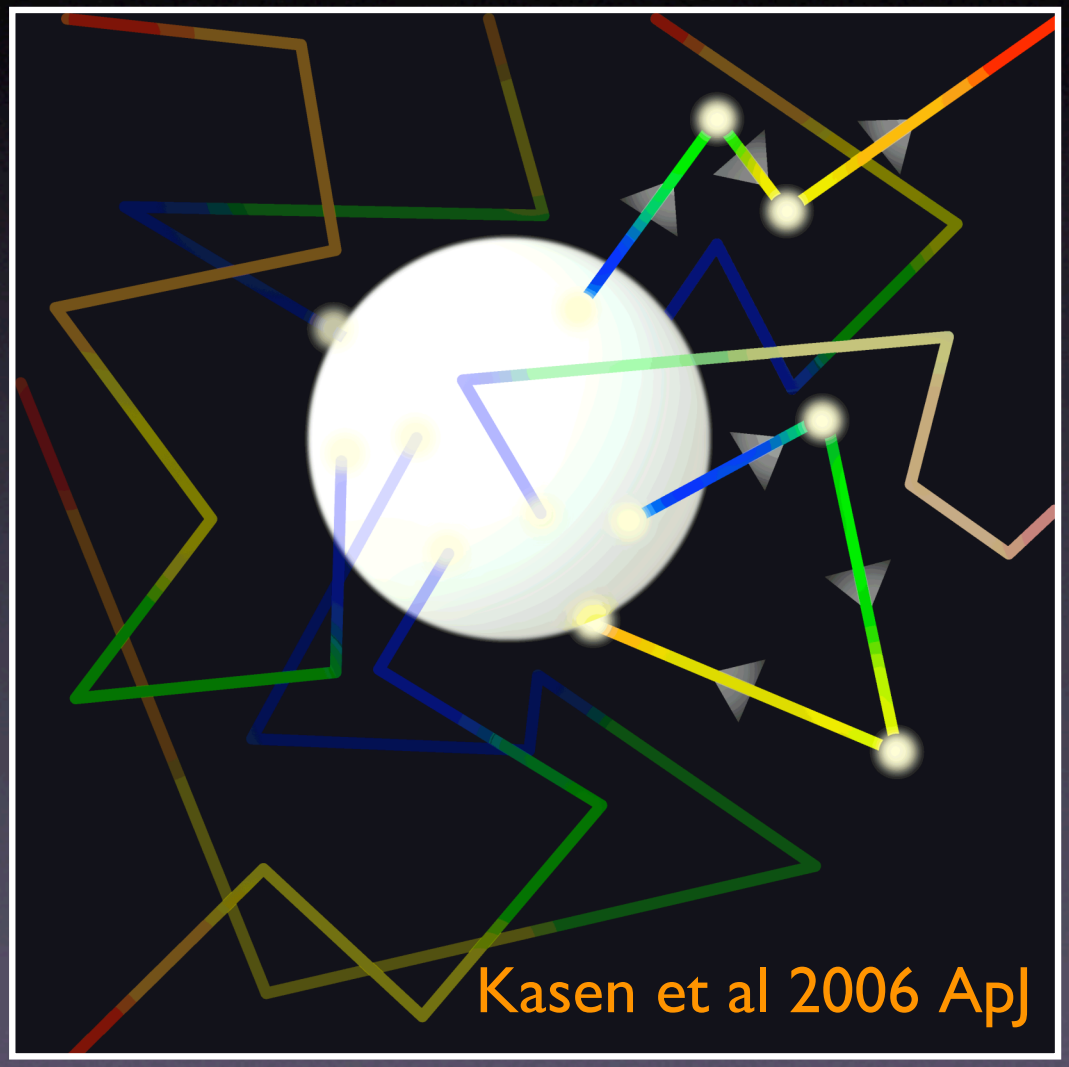
Hoeflich et al., ApJ, 1996
Pinto and Eastman, New A, 2001
Mazzali, ApJL 2001

Supernova Ejecta Opacity

blending of millions of line transitions



3-dimensional Time-Dependent Monte Carlo Radiative Transfer



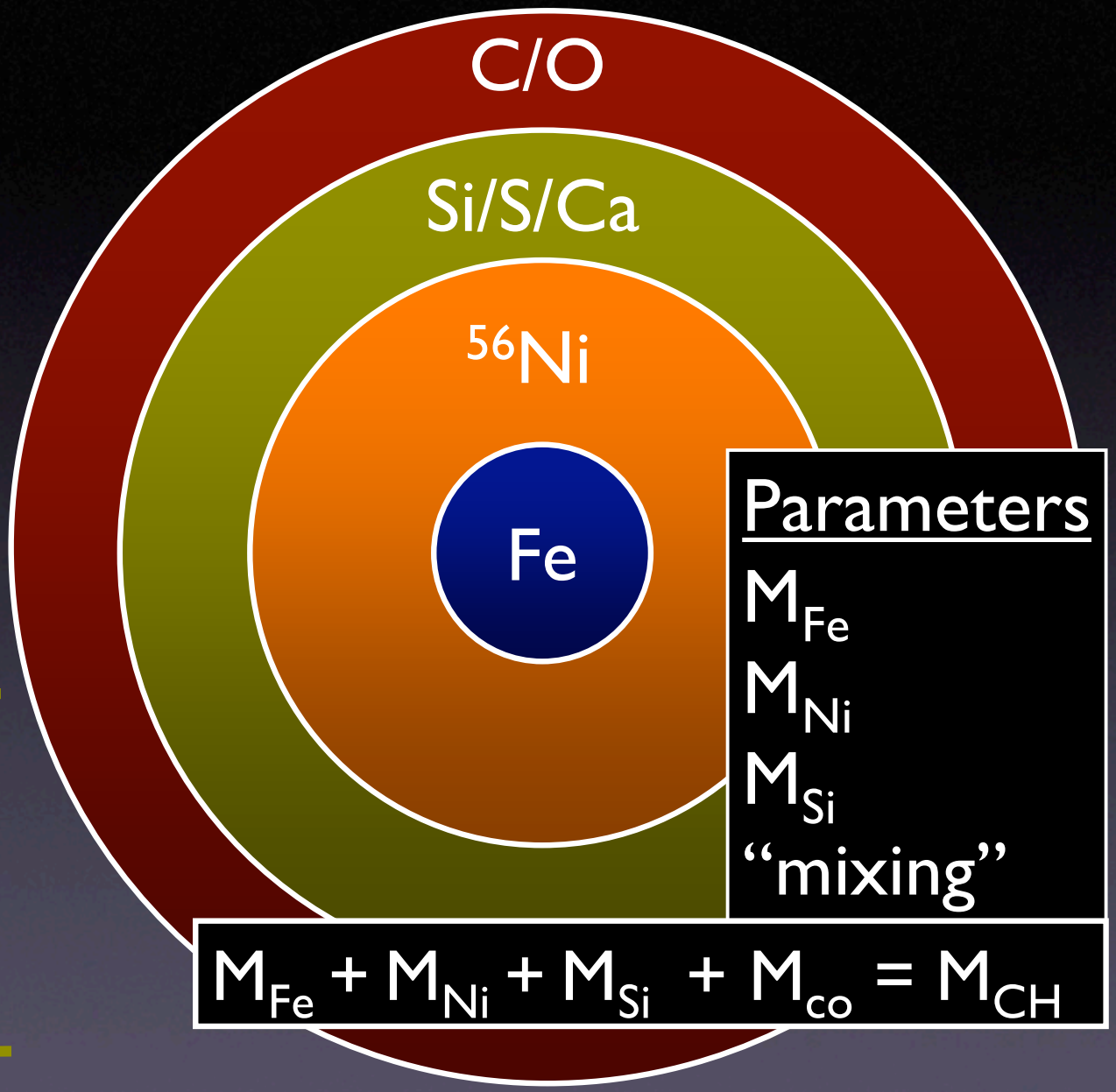
SEDONA Code

Expanding atmosphere
Realistic opacities
Three-dimensional
Time-dependent
Multi-wavelength
Includes spectropolarization
Includes radioactive decay
and gamma-ray transfer
Iterative solution for
thermal equilibrium

Grid of Type Ia Supernova Models

w/ Stan Woosley
Sergei Blinikov
Elena Sorokina

130 one-dimensional Chandrasekhar mass models with varied composition



Broadband Synthetic Light Curves

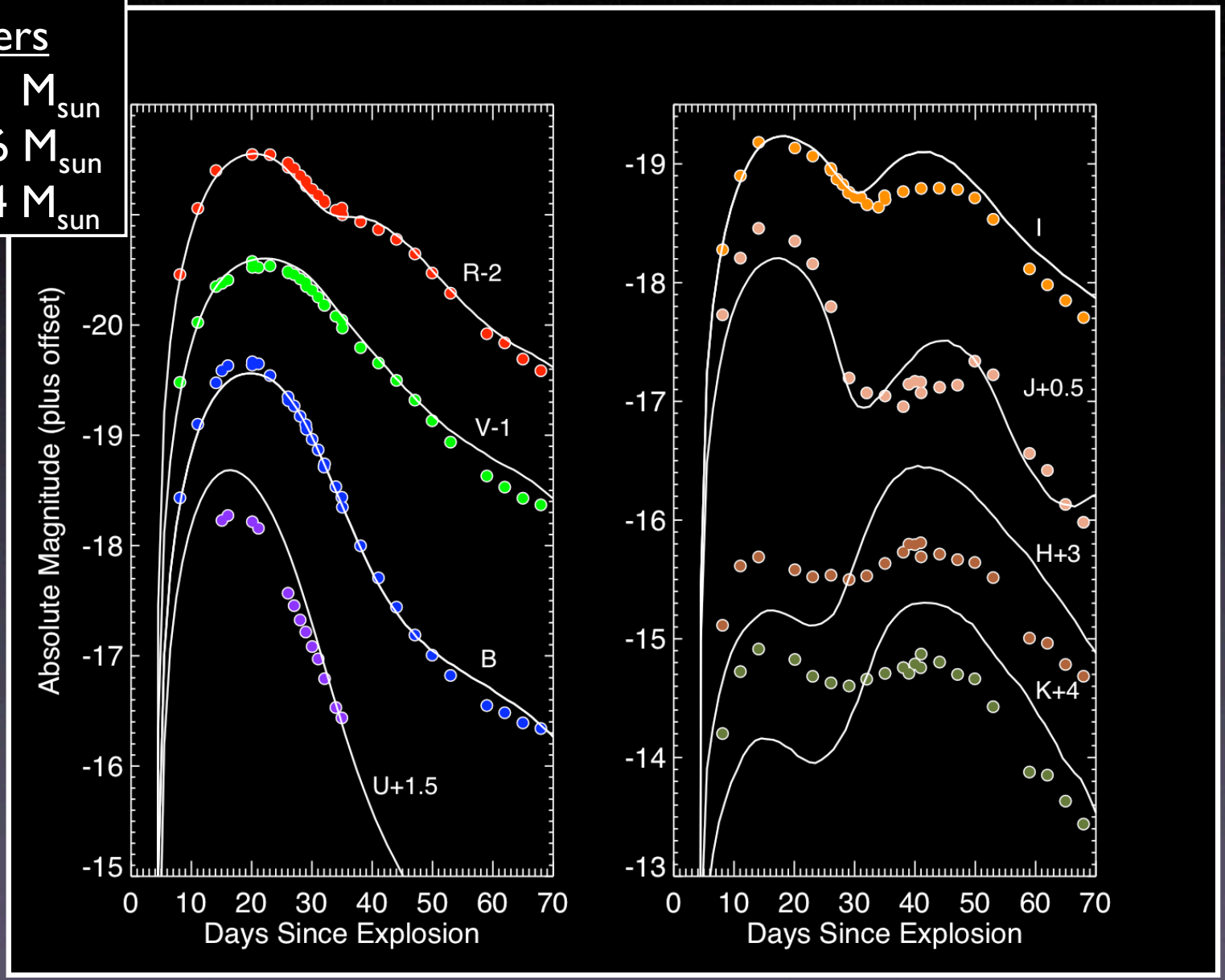
Model Compared to observations of SN 2001el

Parameters

$M_{Fe} = 0.1\ M_{sun}$

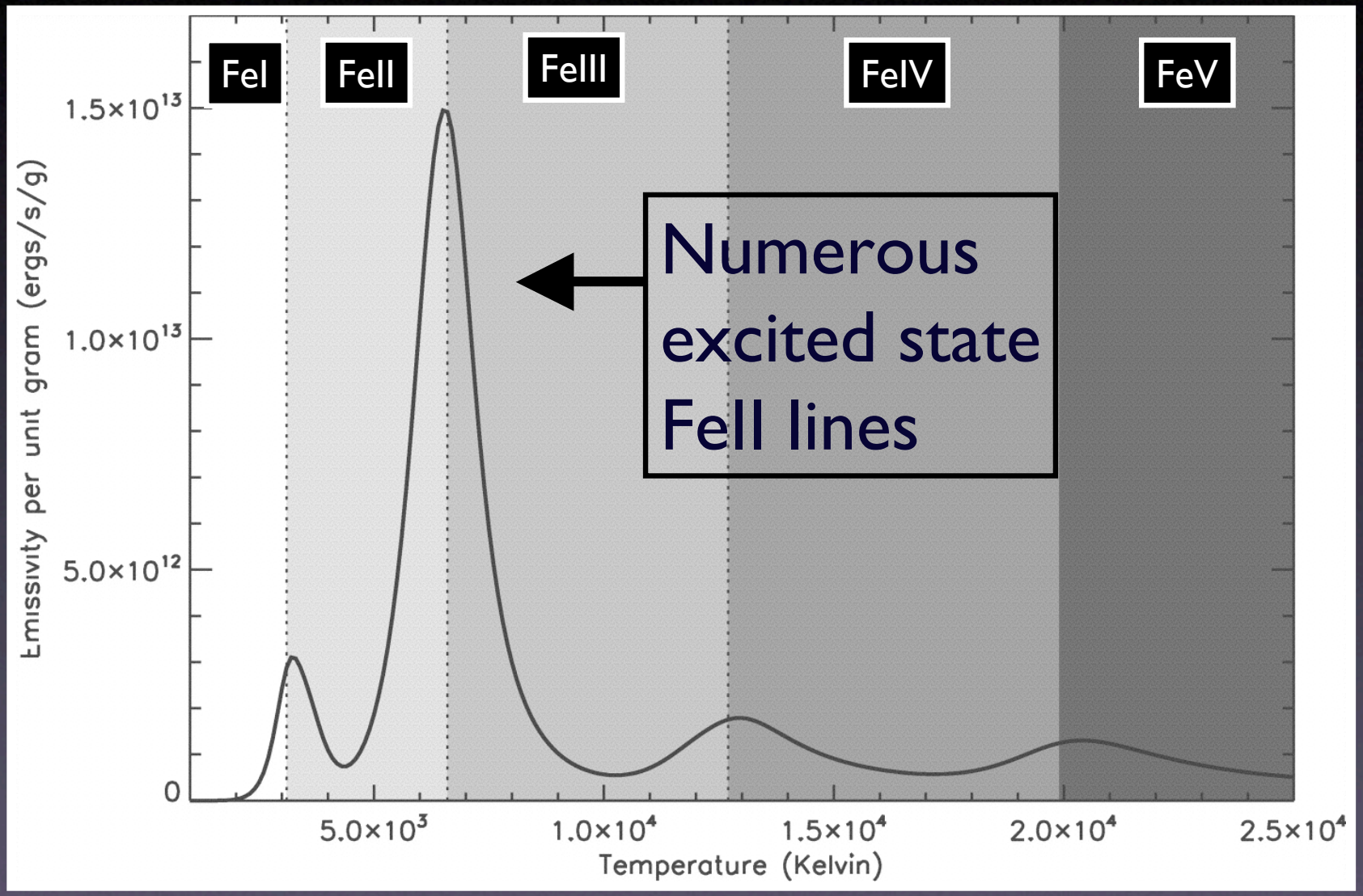
$M_{Ni} = 0.6\ M_{sun}$

$M_{Si} = 0.4\ M_{sun}$



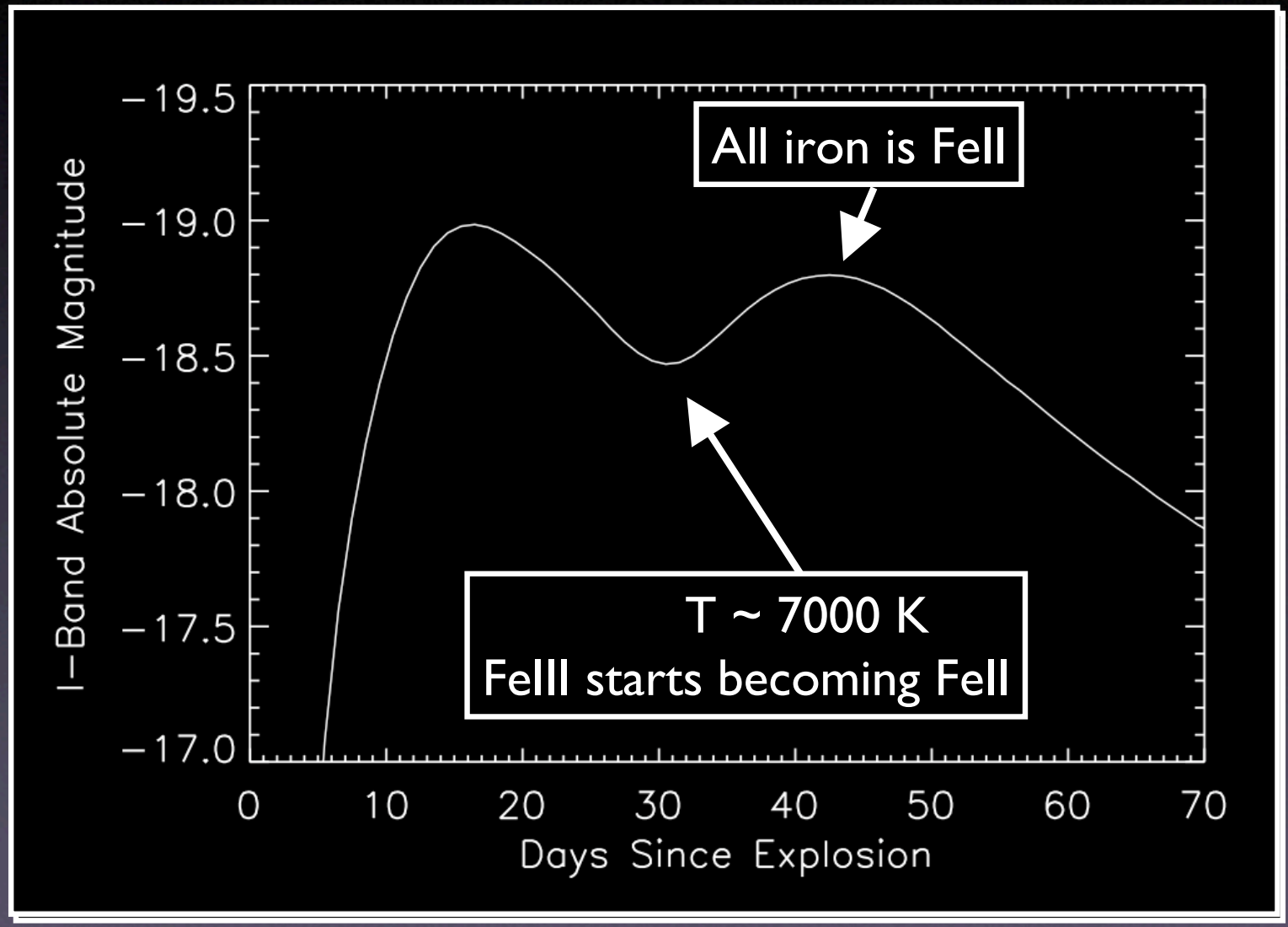
I-Band Emissivity from Lines

as a function of temperature/ionization



Infrared Secondary Maximum

brighter supernovae have later secondary maxima



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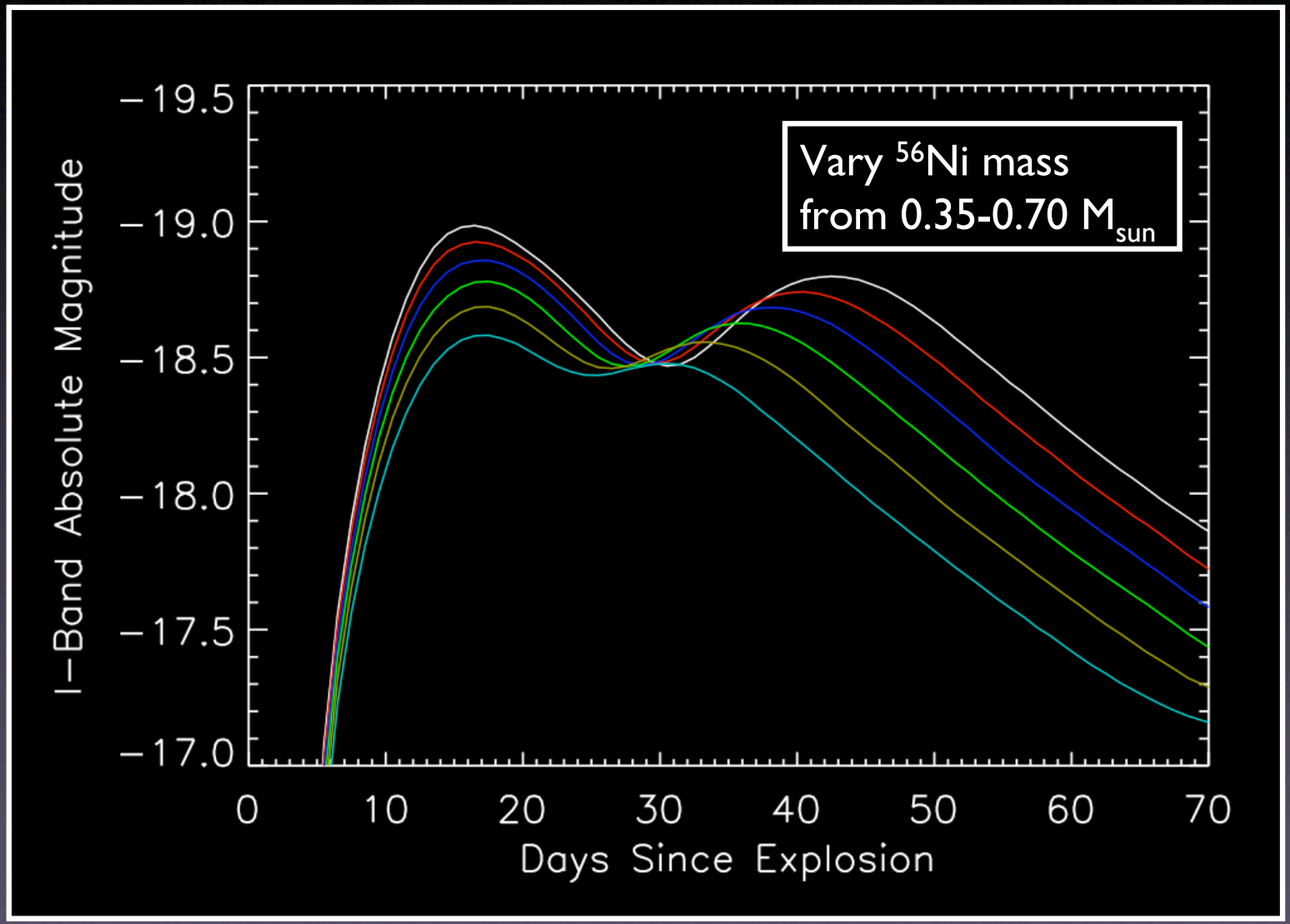
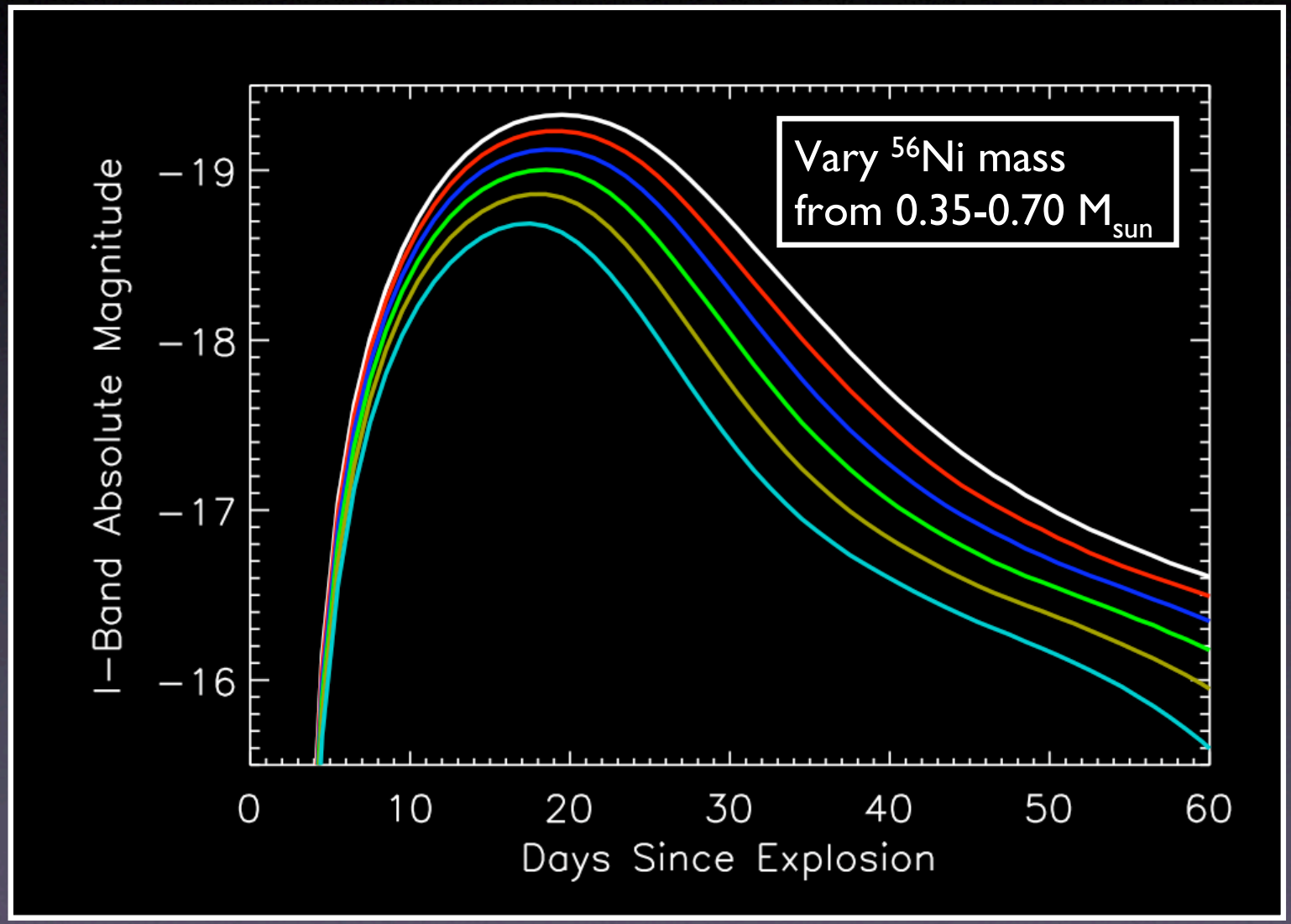


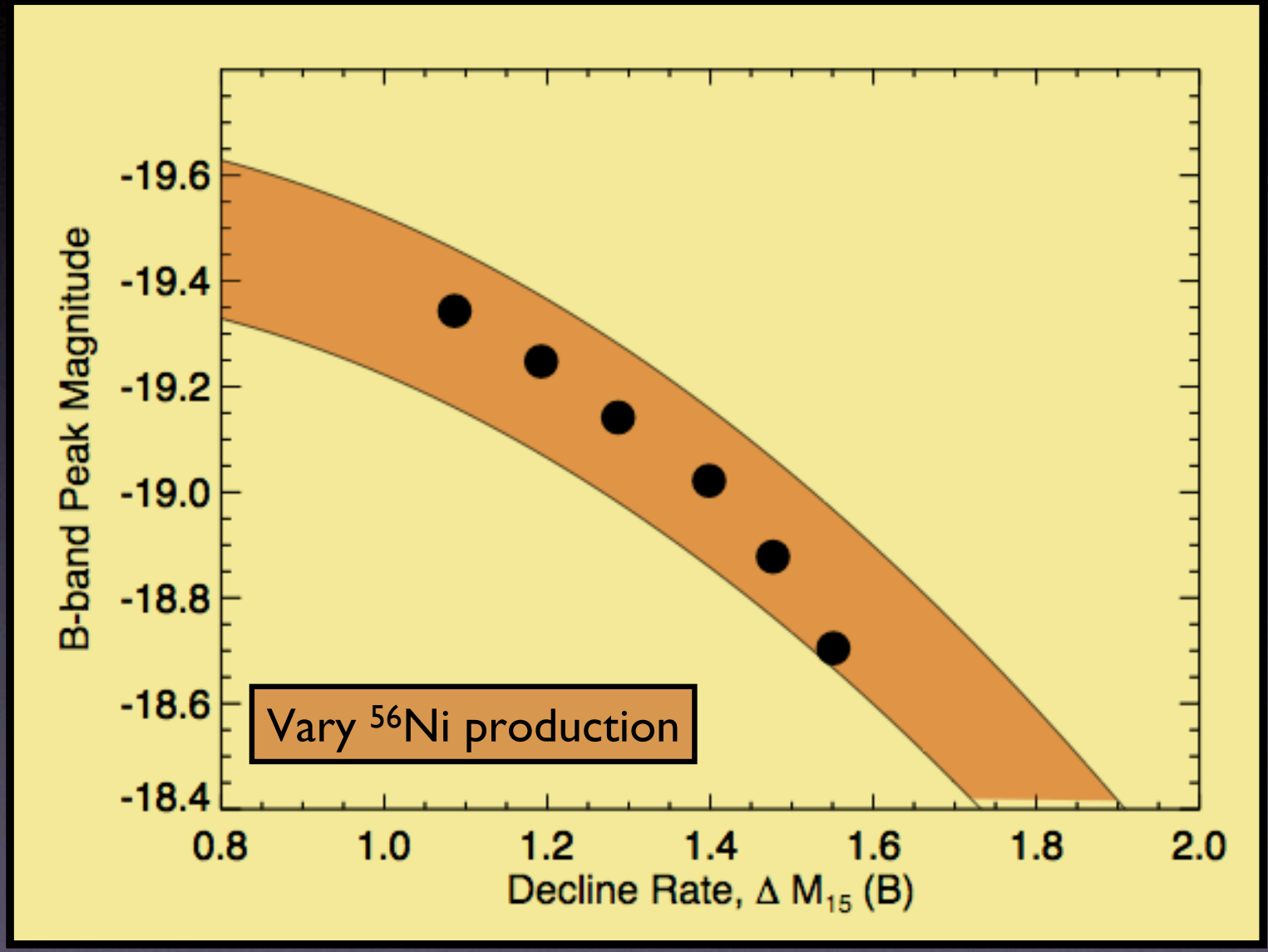
Width-Luminosity Relationship

B-Band Light Curves



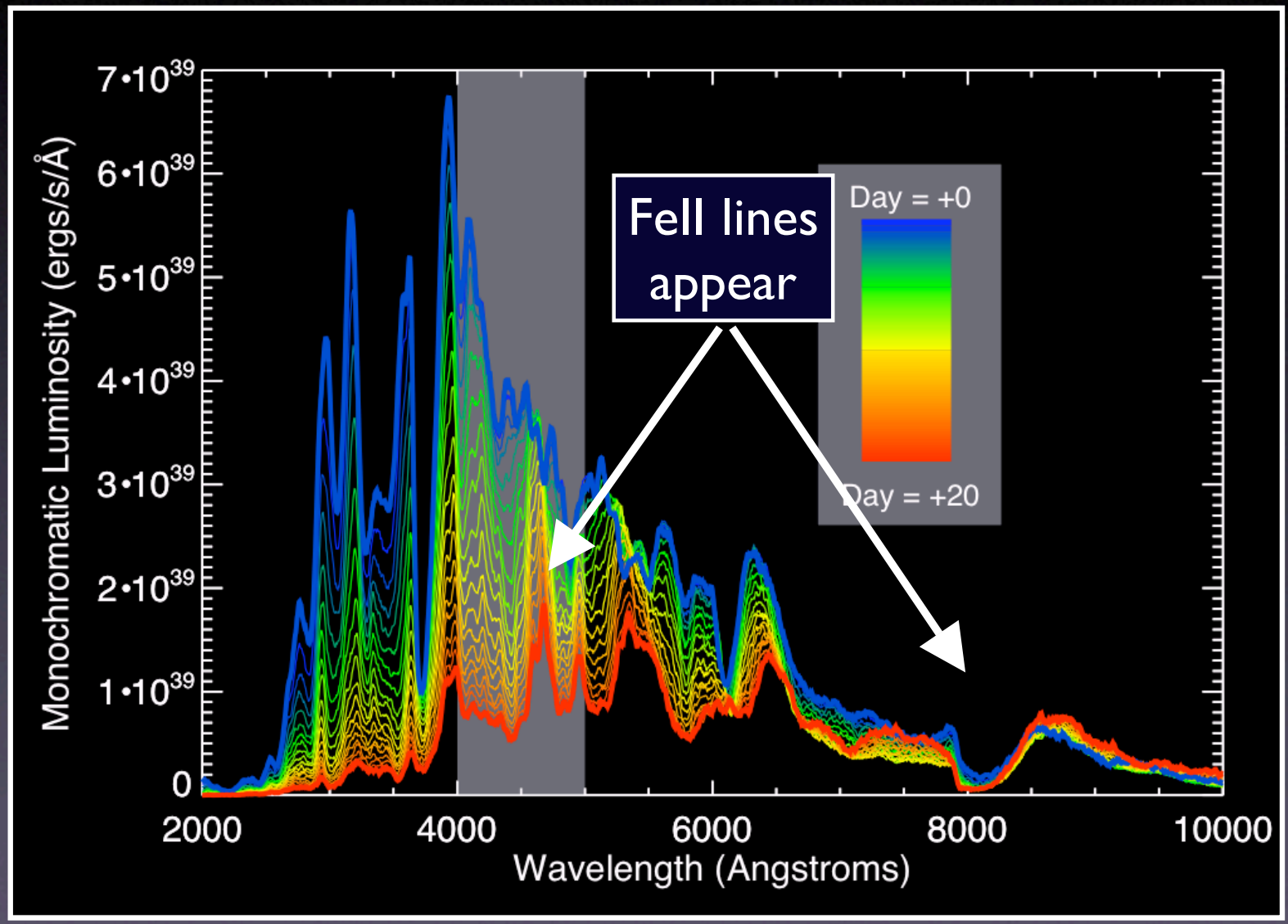
The Width-Luminosity Relationship

Kasen and Woosley, ApJ, 2007



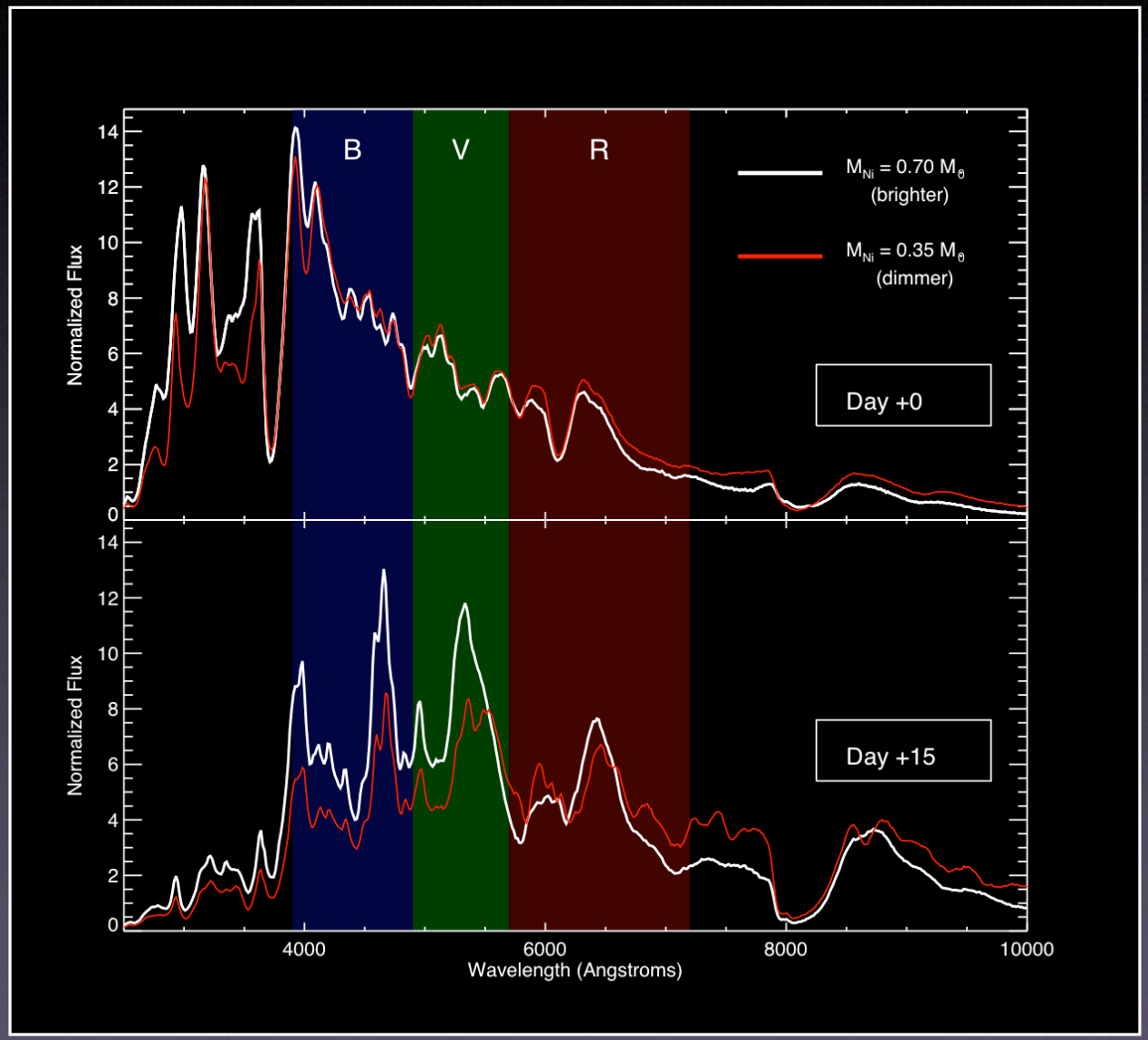
Physics of the Width Luminosity Relation

Spectral Evolution after maximum light

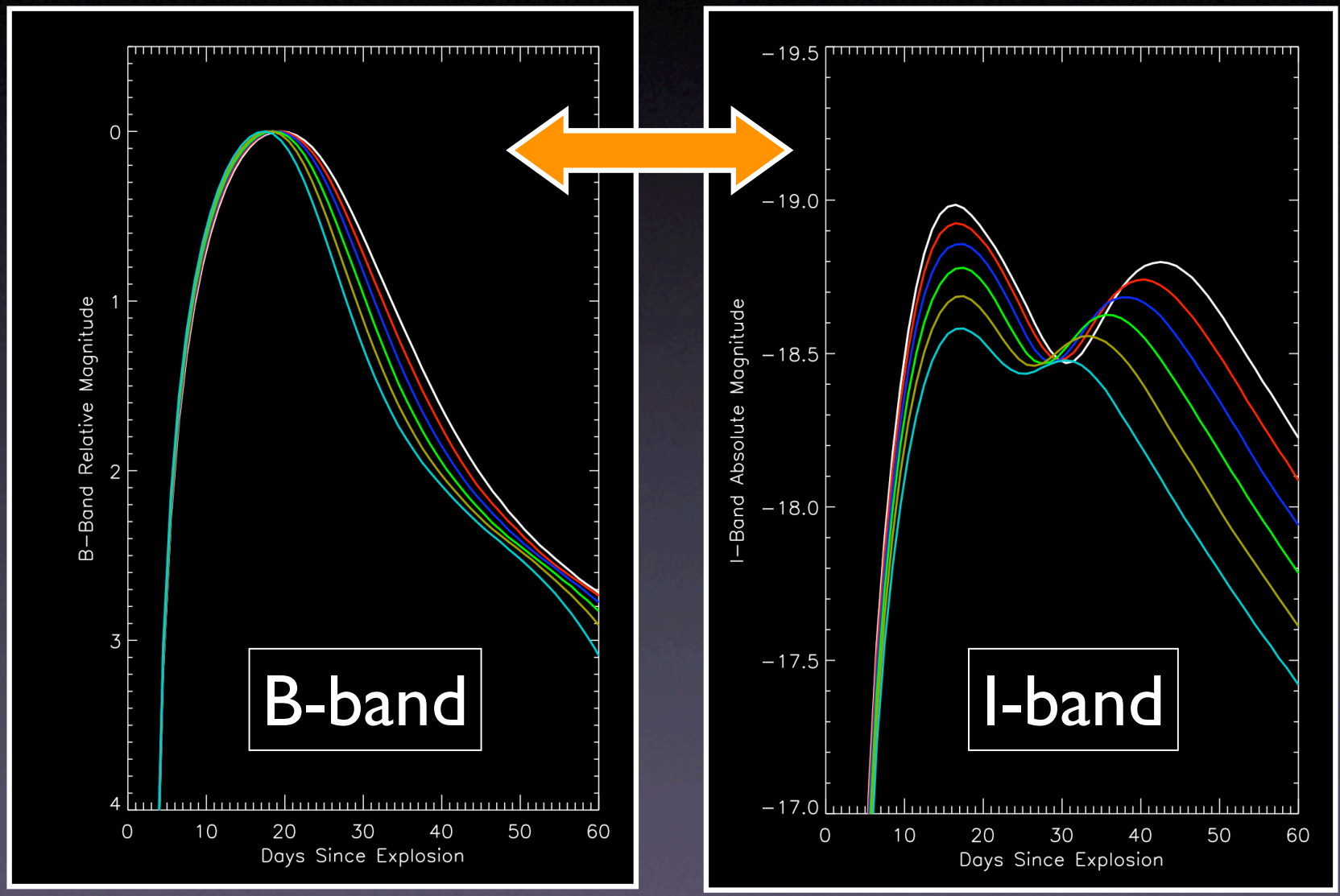


Model Spectral Evolution

Dimmer model evolves redward more quickly

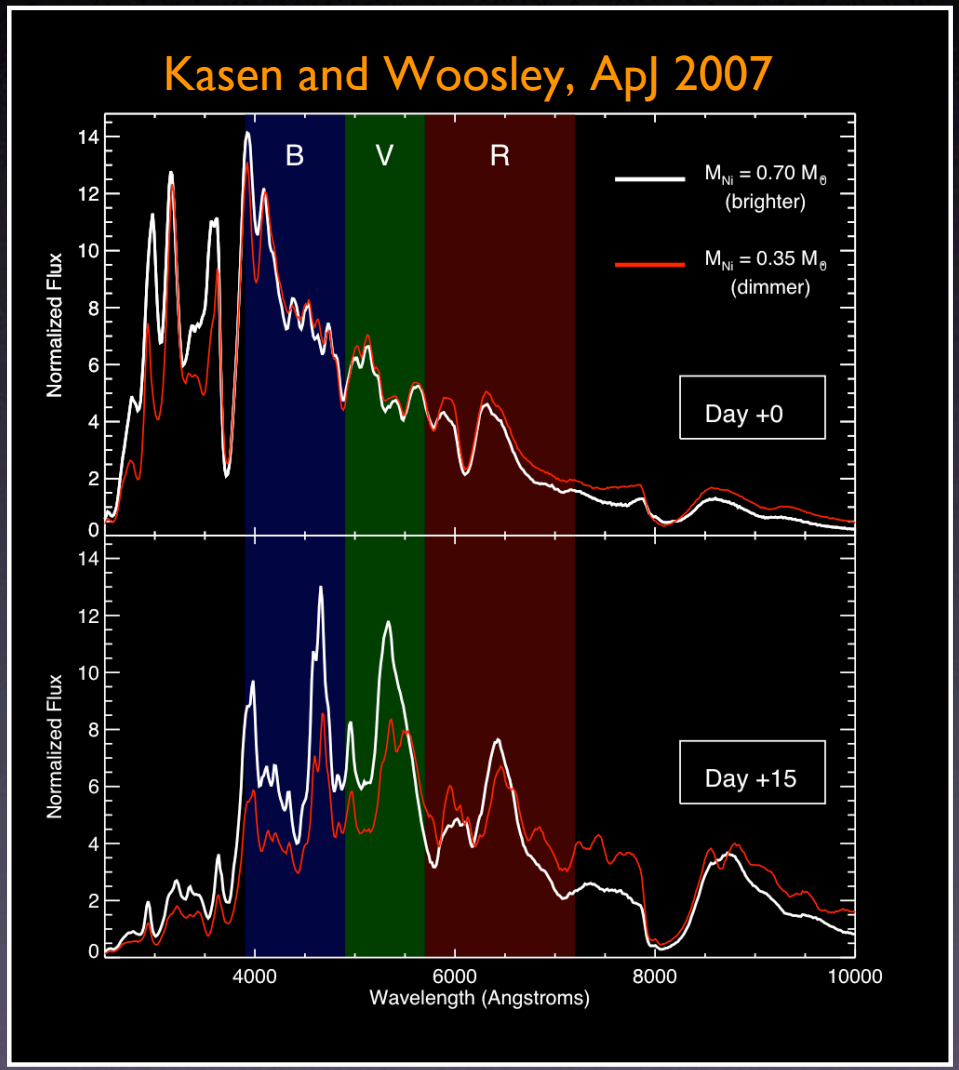


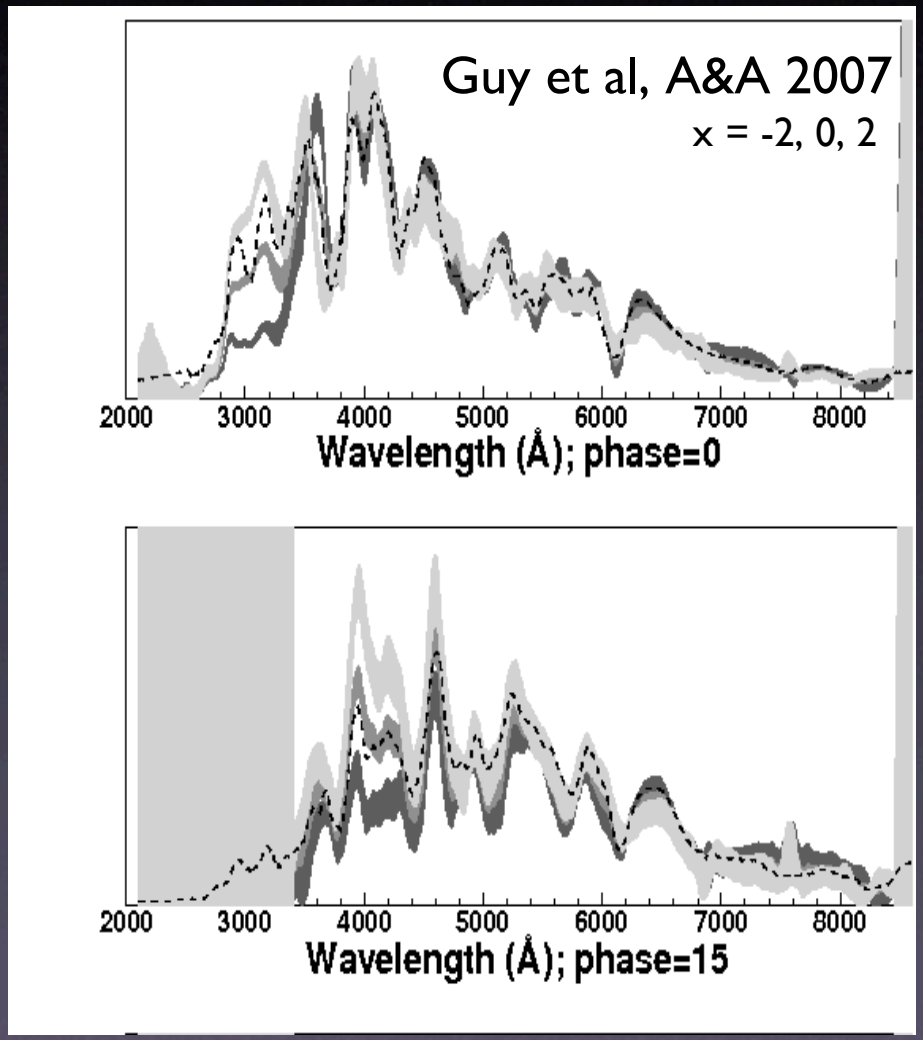
Two Sides of the Same Coin



Spectroscopic/Color Evolution

Comparison to SALT2 observational templates



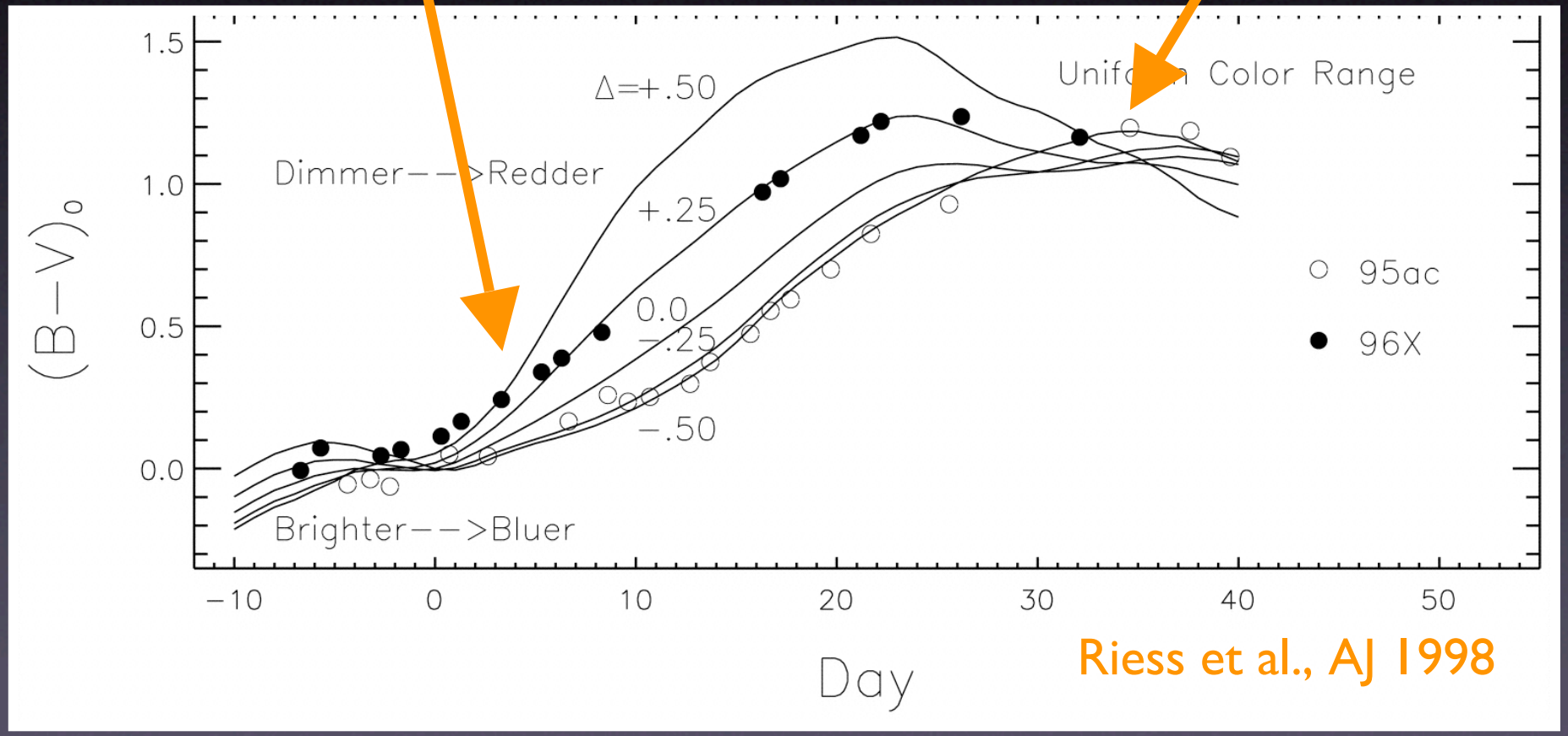


Observed Color Evolution

Riess et al. AJ 1998 observational templates

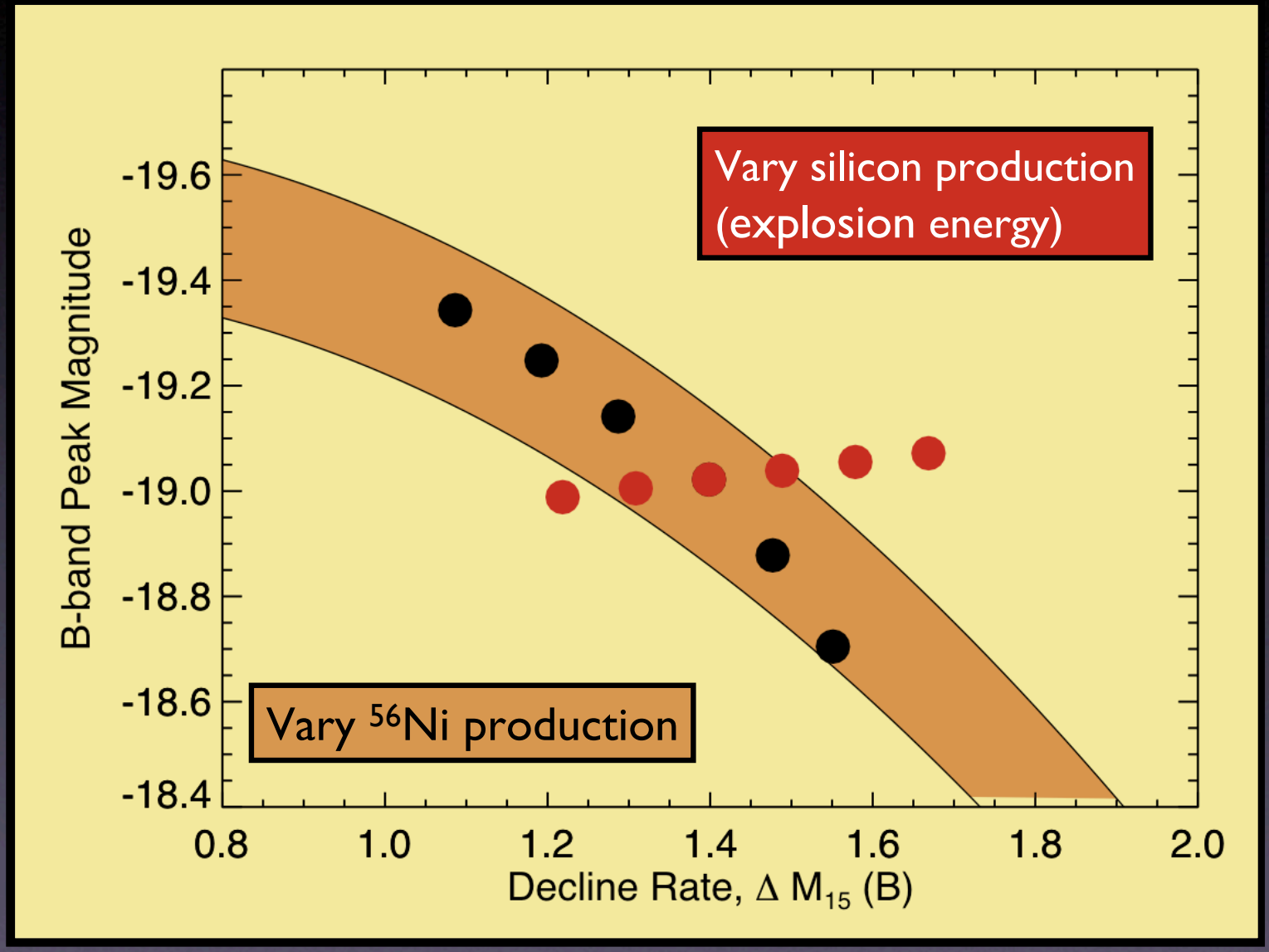
FeIII starts recombining to FeII

FeIII done recombining to FeII



The Width-Luminosity Relationship

Kasen and Woosley, ApJ, 2007



Model Width-Luminosity Relation

Woosley, Kasen, Blinnikov, Sorokina, ApJ in Press (2007)