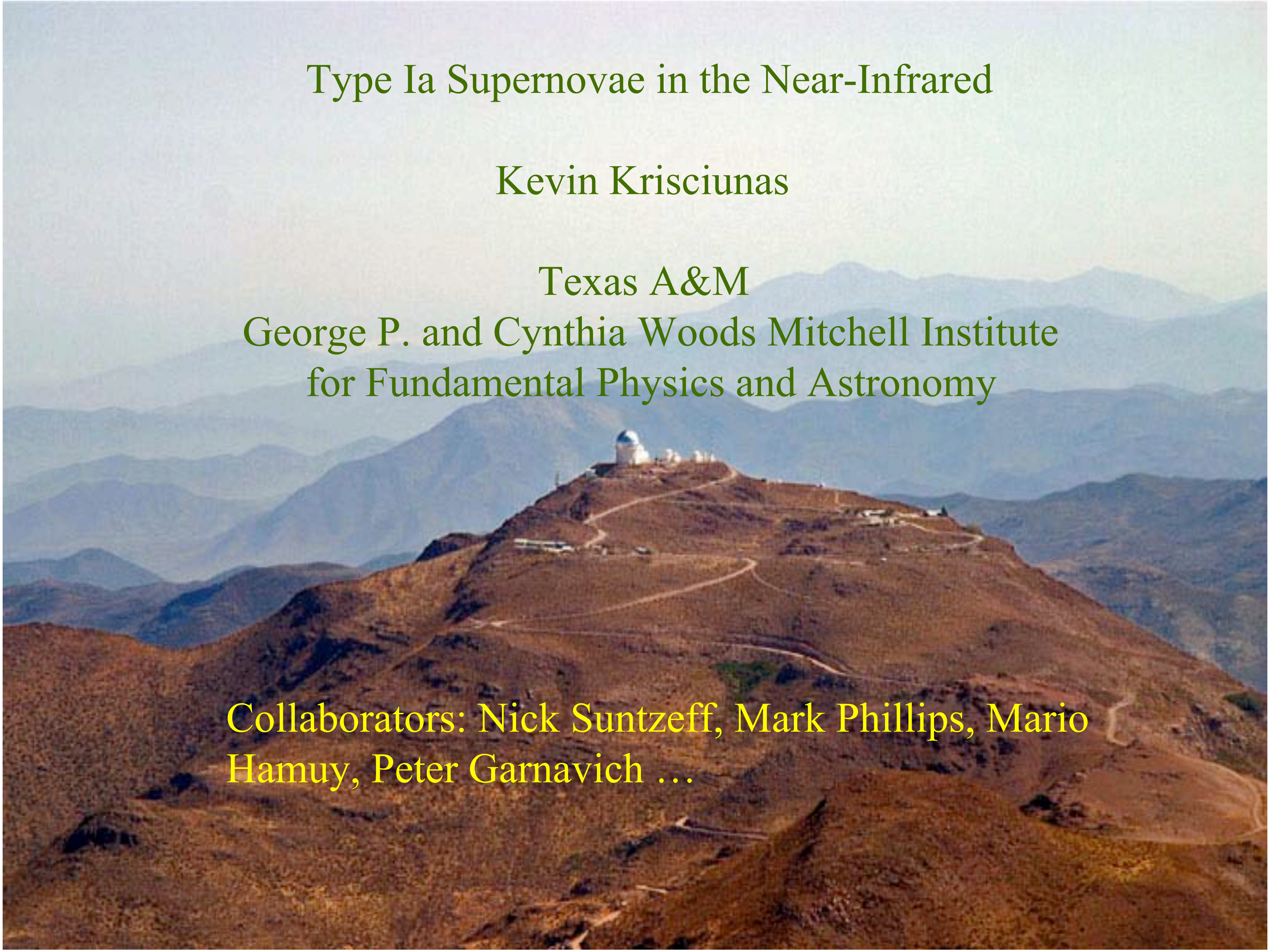

Type Ia Supernovae in the Near-Infrared

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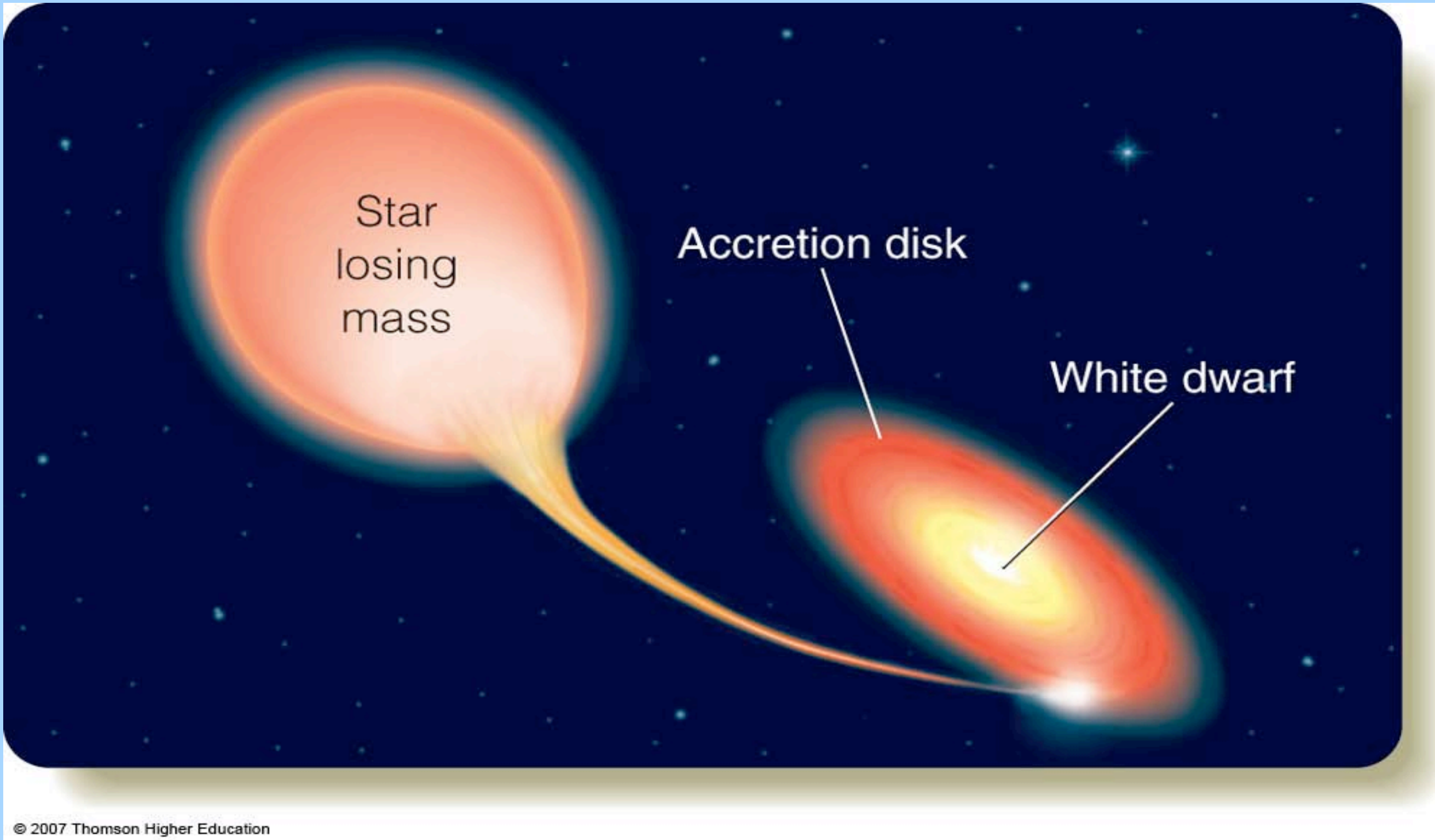
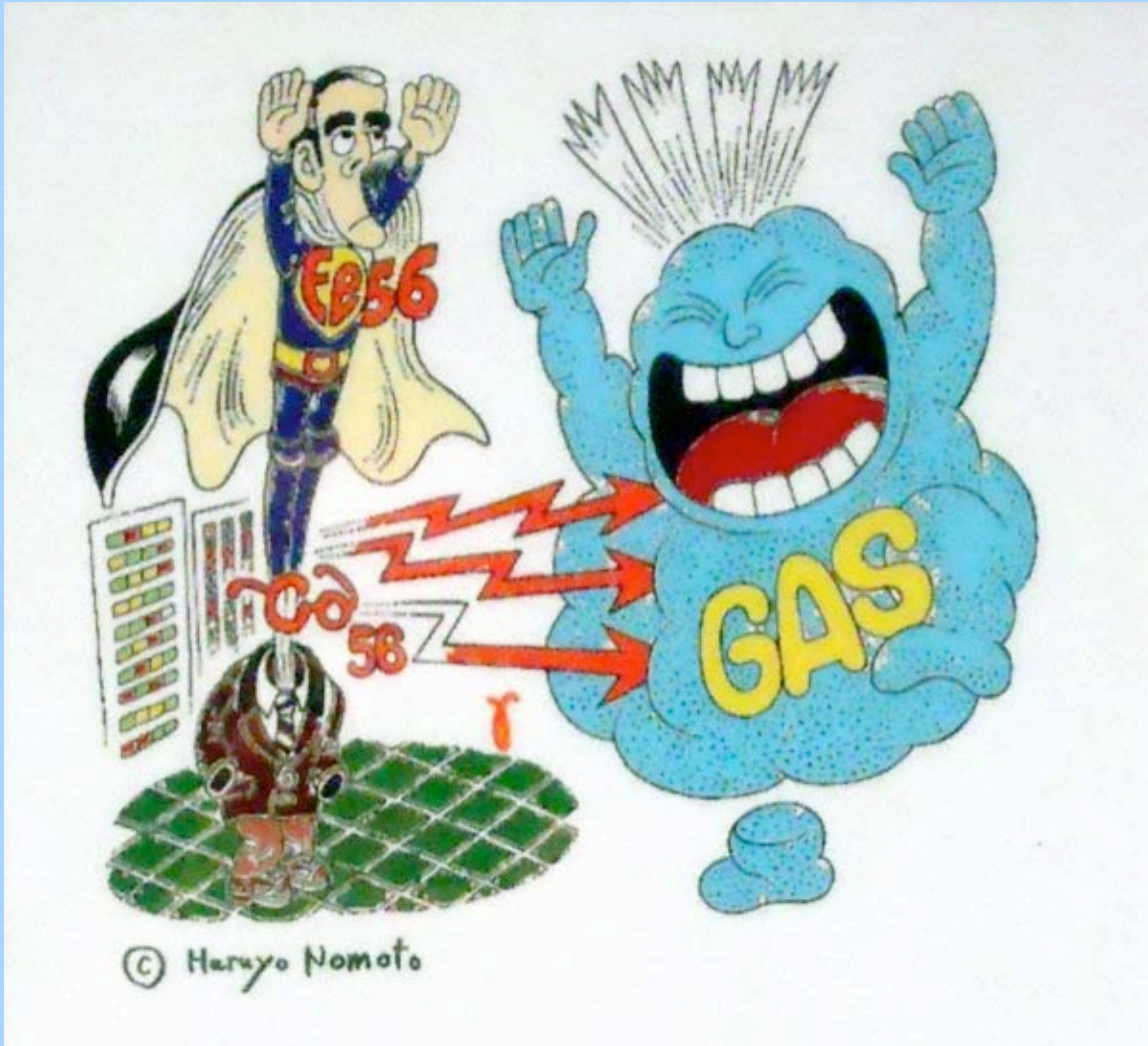


The most popular model of a Type Ia supernova.

It is generally believed that a Type Ia SN is a carbon-oxygen white dwarf that acquires mass from a nearby donor star. When the mass of the WD exceeds 1.4 M_{sun} the WD *completely* obliterates itself.

The spectra of Type Ia supernovae are characterized by having *no* hydrogen emission. The prime signature is a blue-shifted absorption line of singly ionized silicon observed at ~6150 Angstroms.

A Type Ia SN produces between 0.1 and 1.0 solar masses of radioactive Nickel-56, which decays to Cobalt-56, which decays to Iron-56, which is stable.


Fe56
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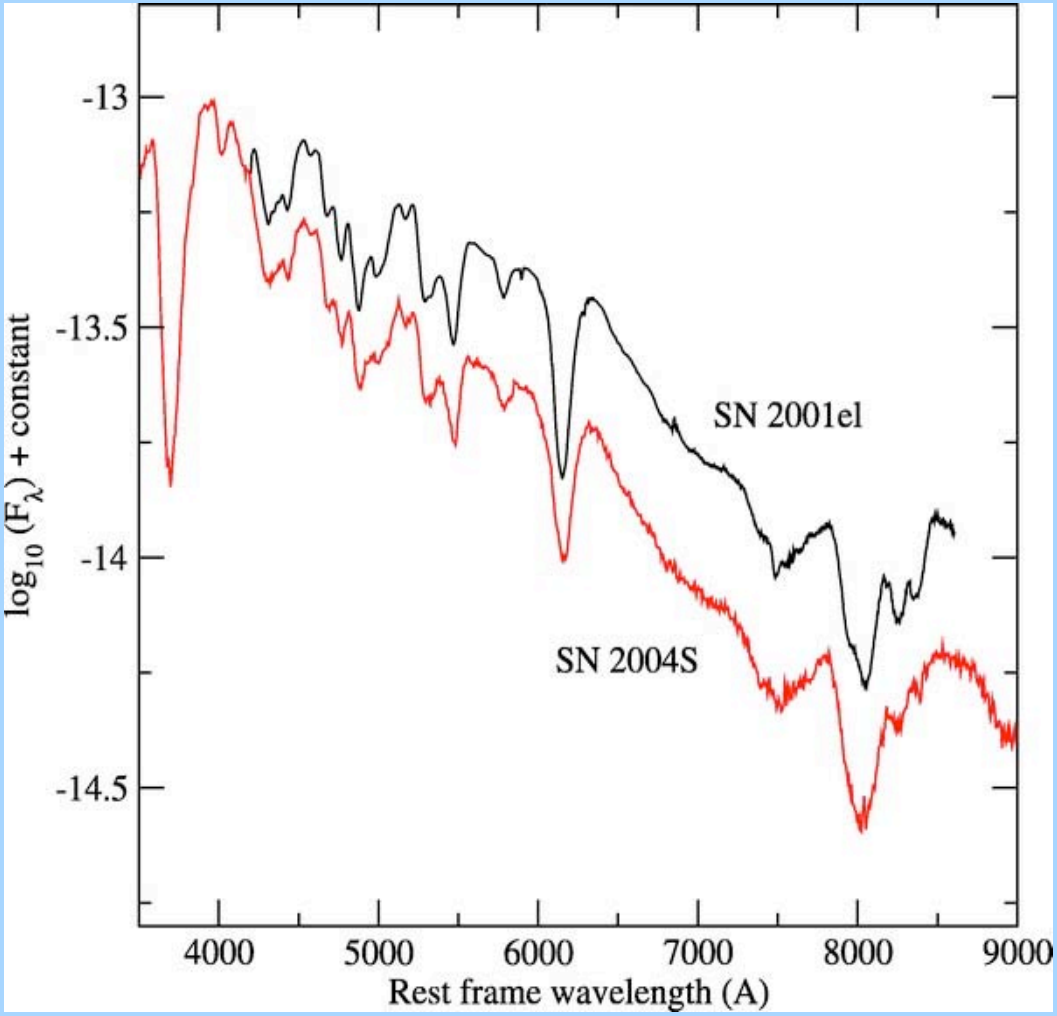
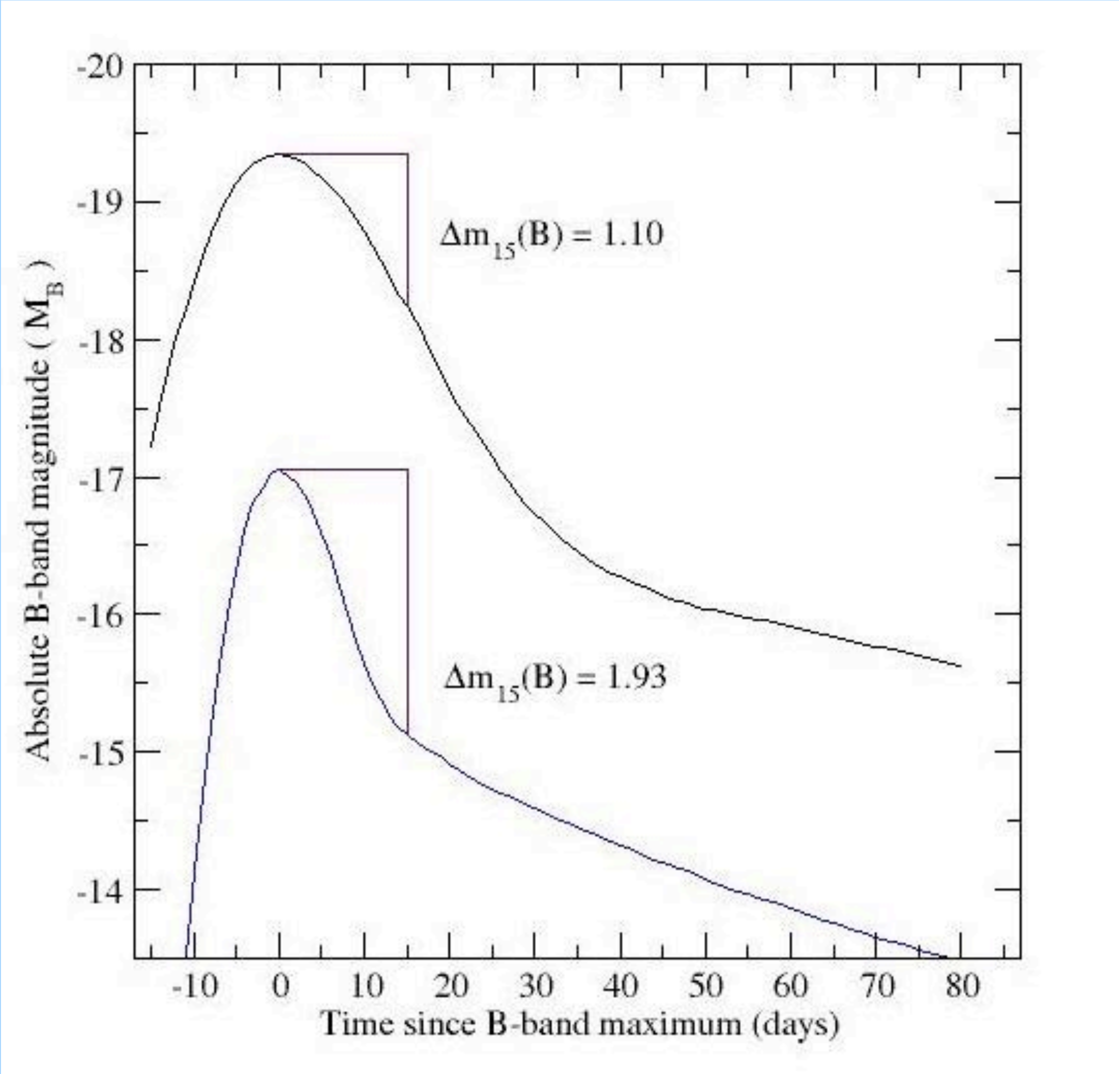
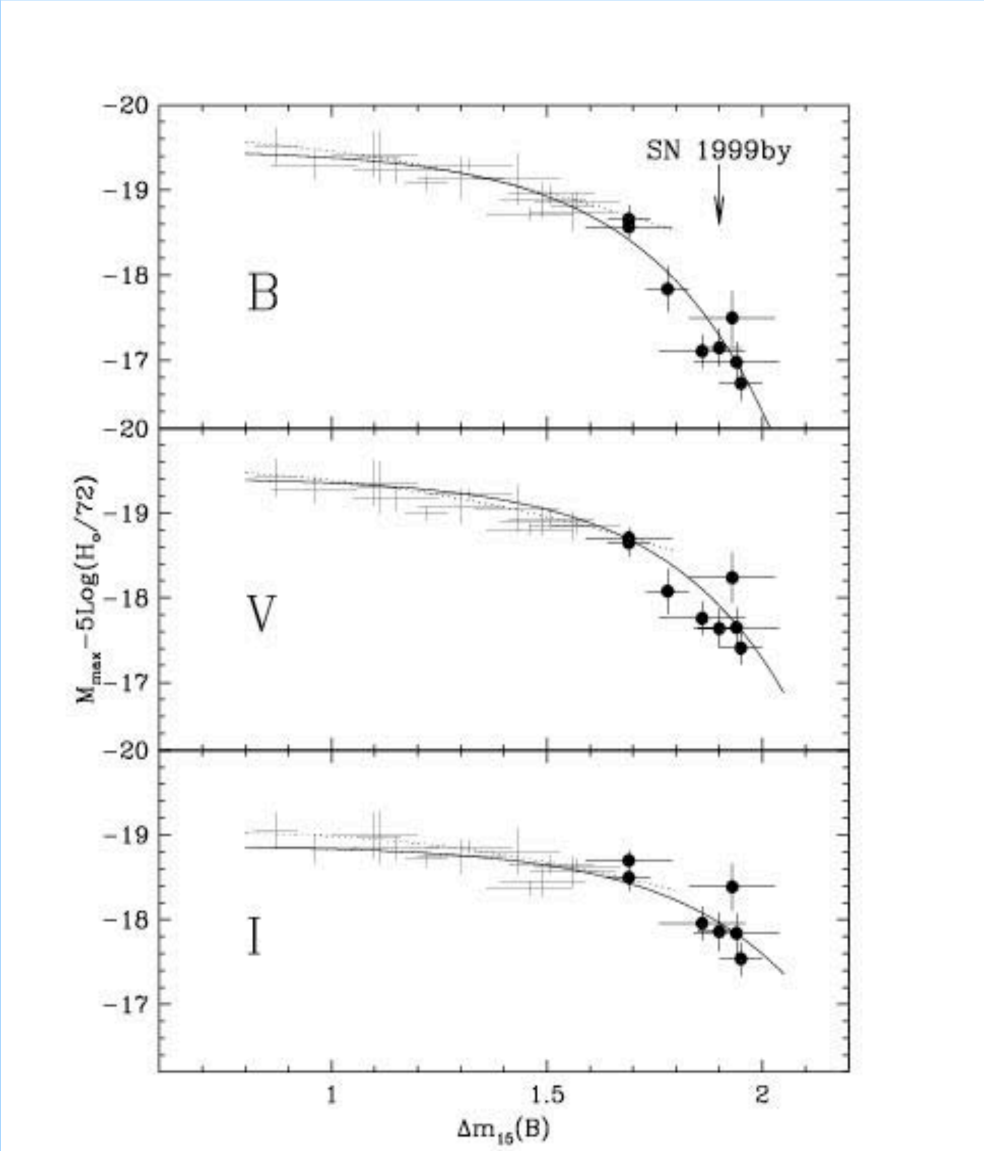


Krisciunas et al. (2007)

Two Type Ia supernovae at about the same number of days after explosion. The spectra are *almost* identical.

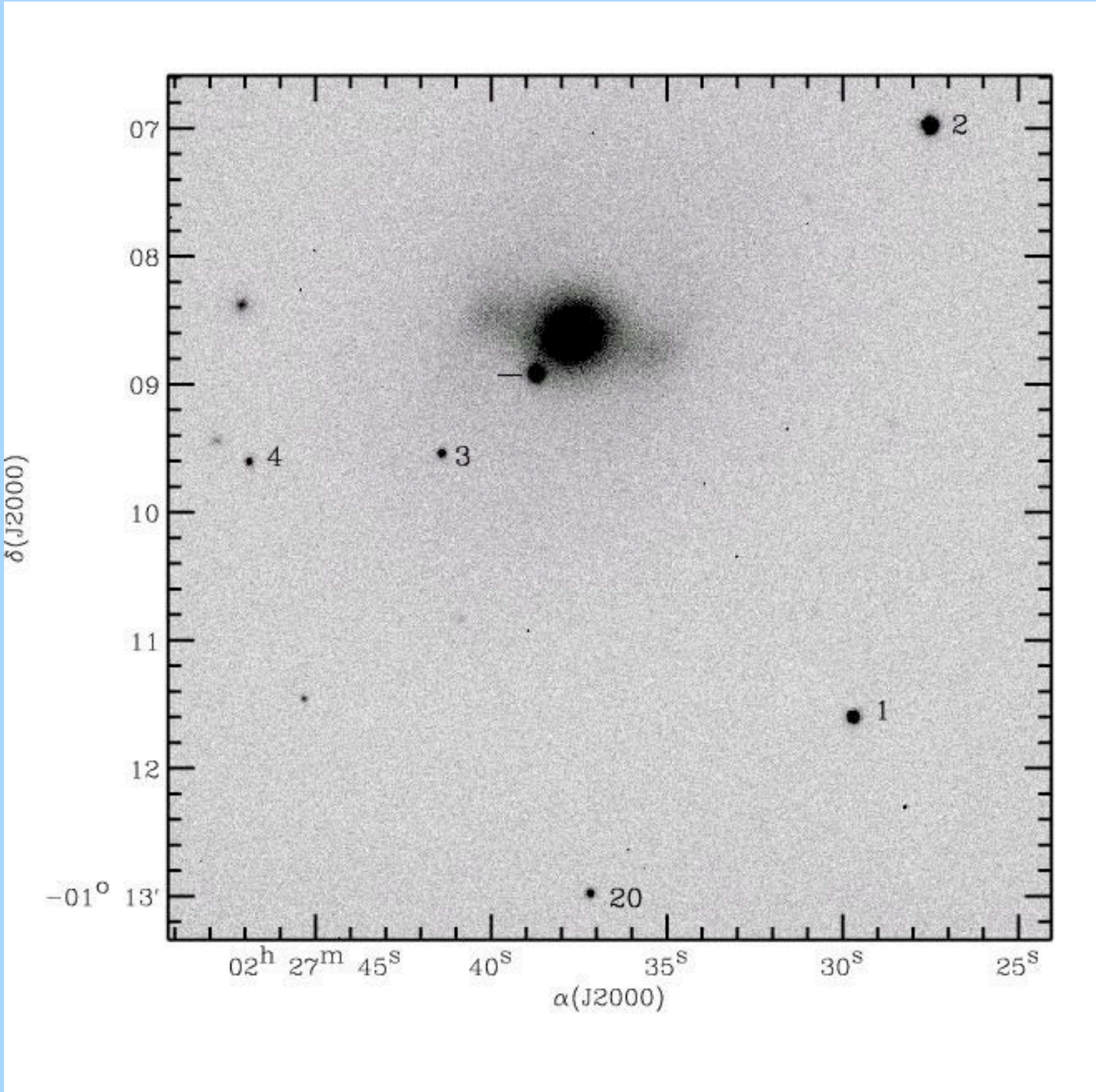


B-band light curves of two Type Ia supernovae. The "decline rate" is the number of magnitudes it gets fainter in the first 15 days after maximum light.

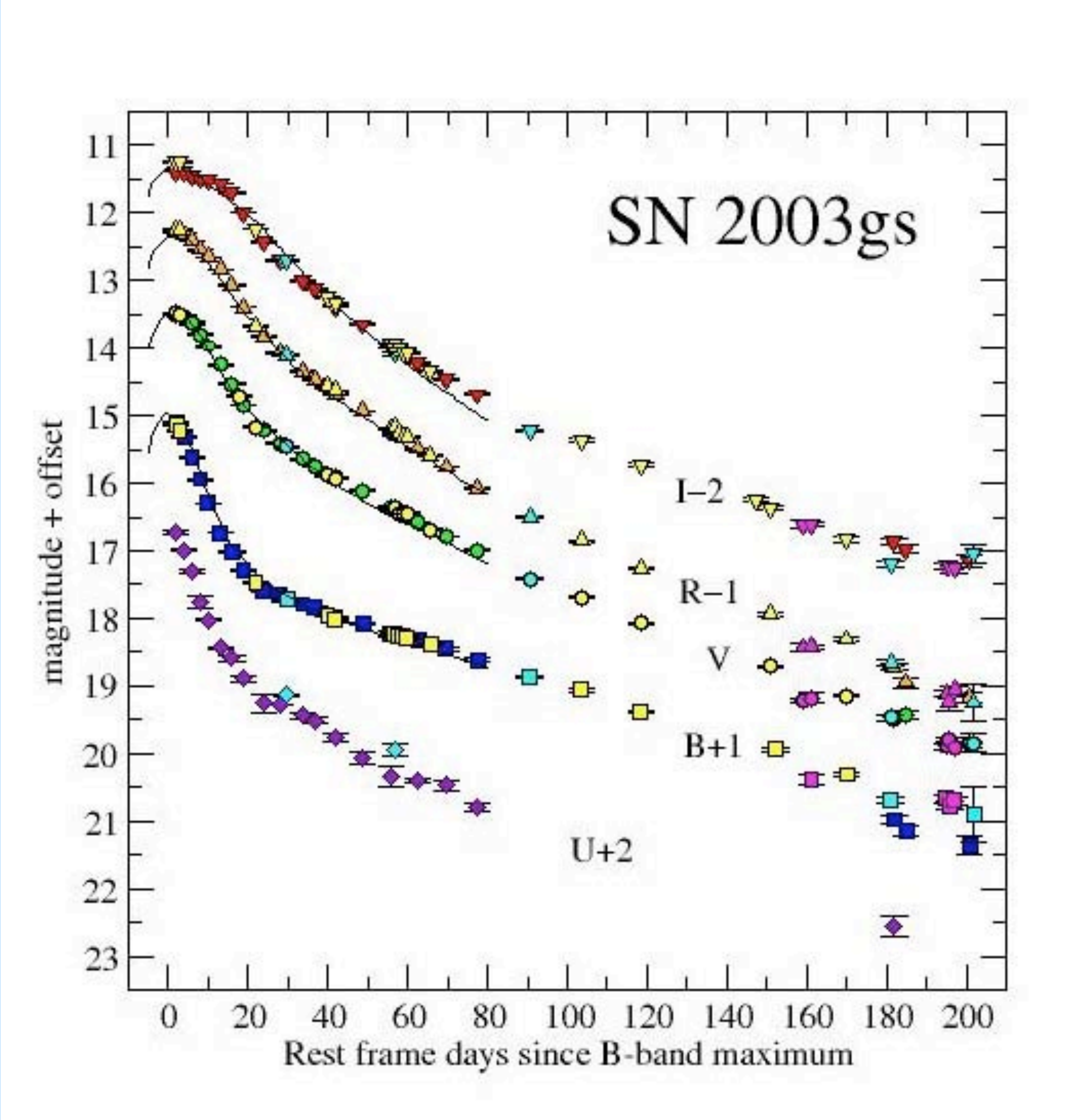


Garnavich et al. (2004)

At optical wave-lengths, the absolute magnitudes of Type Ia supernovae at maximum brightness are related to the decline rate parameter. These supernovae are *standardizable* candles. The brightest ones are 4 billion times brighter than the Sun.

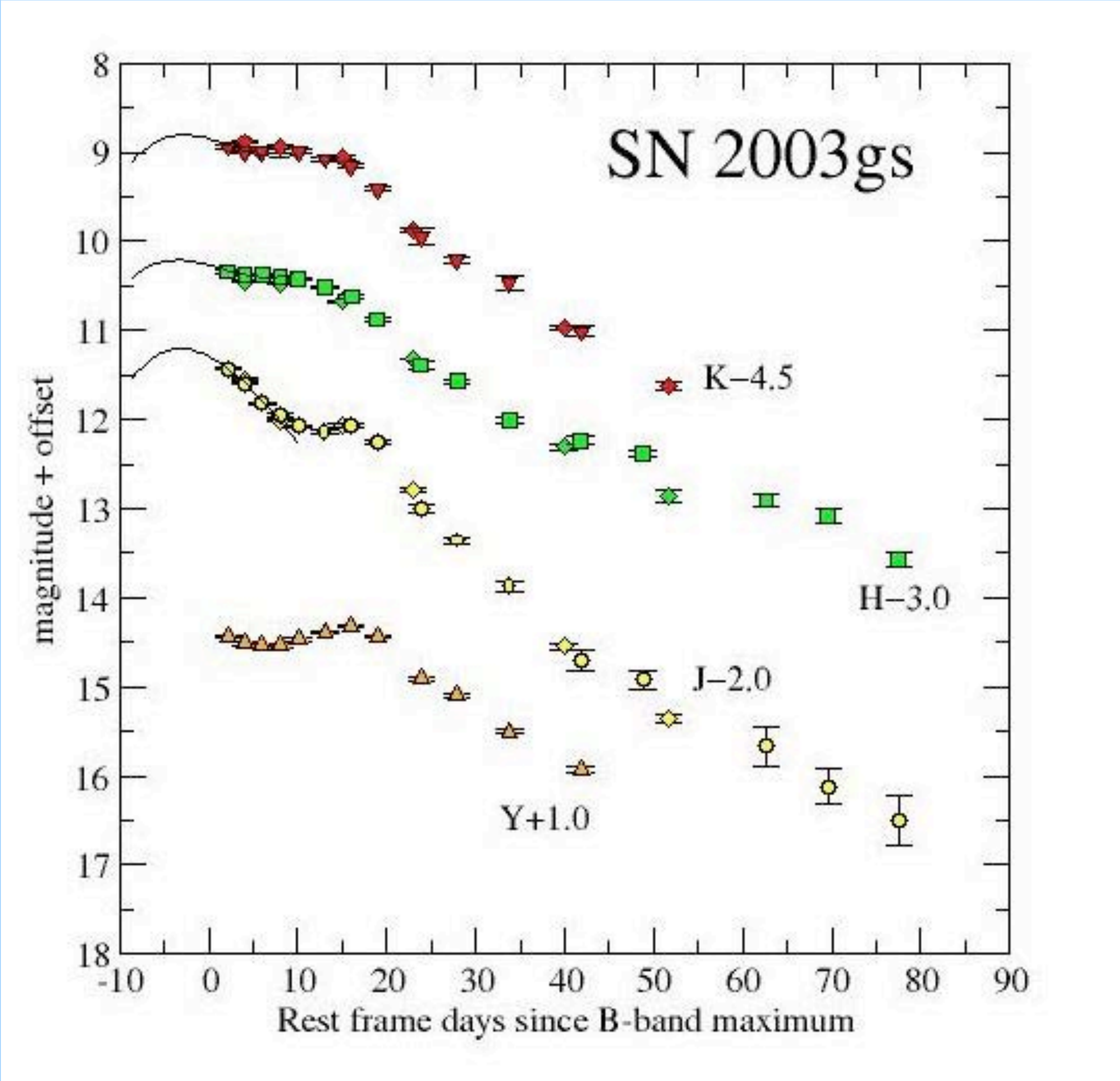


We are publishing a paper in the December, 2009, issue of the *AJ* on SN 2003gs, pictured here next to its host galaxy NGC 936. We know the distance to the host from the method of Surface Brightness Fluctuations.



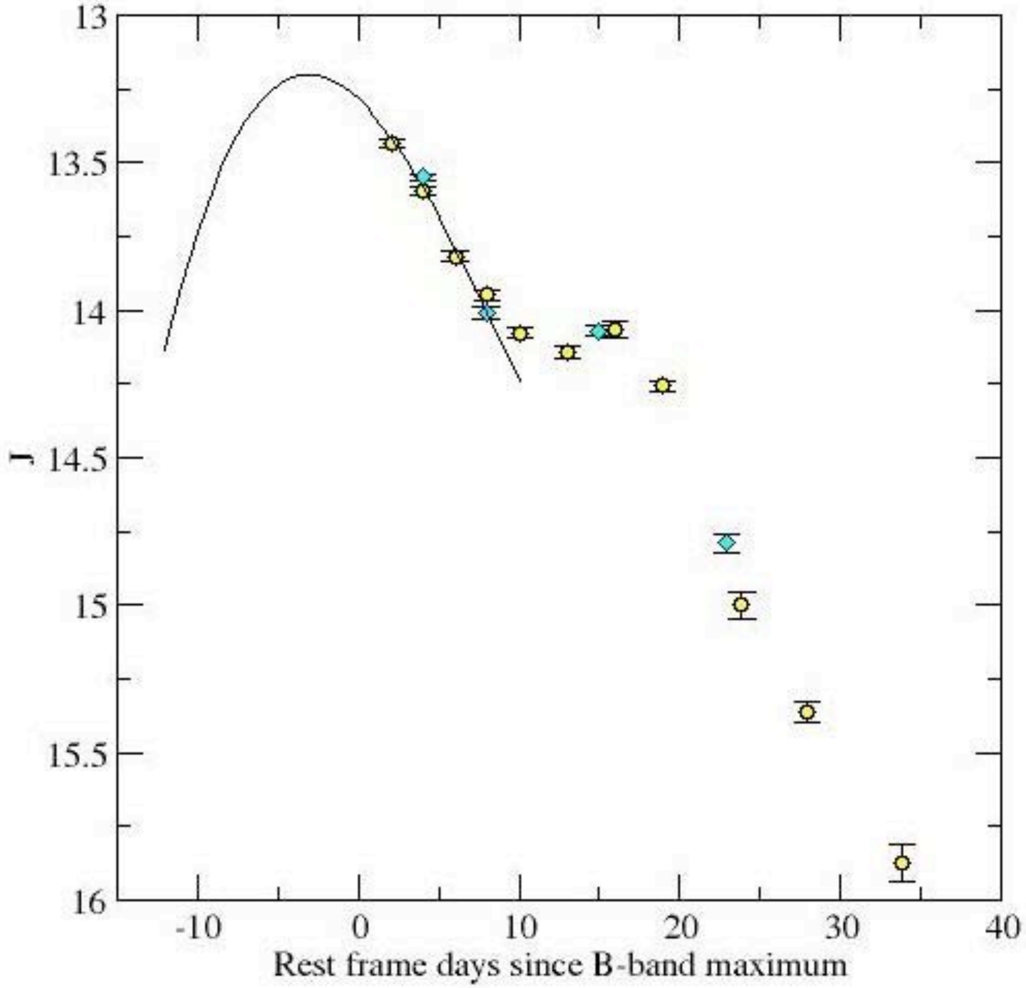
Optical photometry of SN 2003gs obtained with the CTIO 1.3-m, 0.9-m, Las Campanas 1.0-m, and Steward 1.54-m telescopes.

With $\Delta m_{15}(B) = 1.83$ it is a fast decliner and is “faint” in the optical bands.



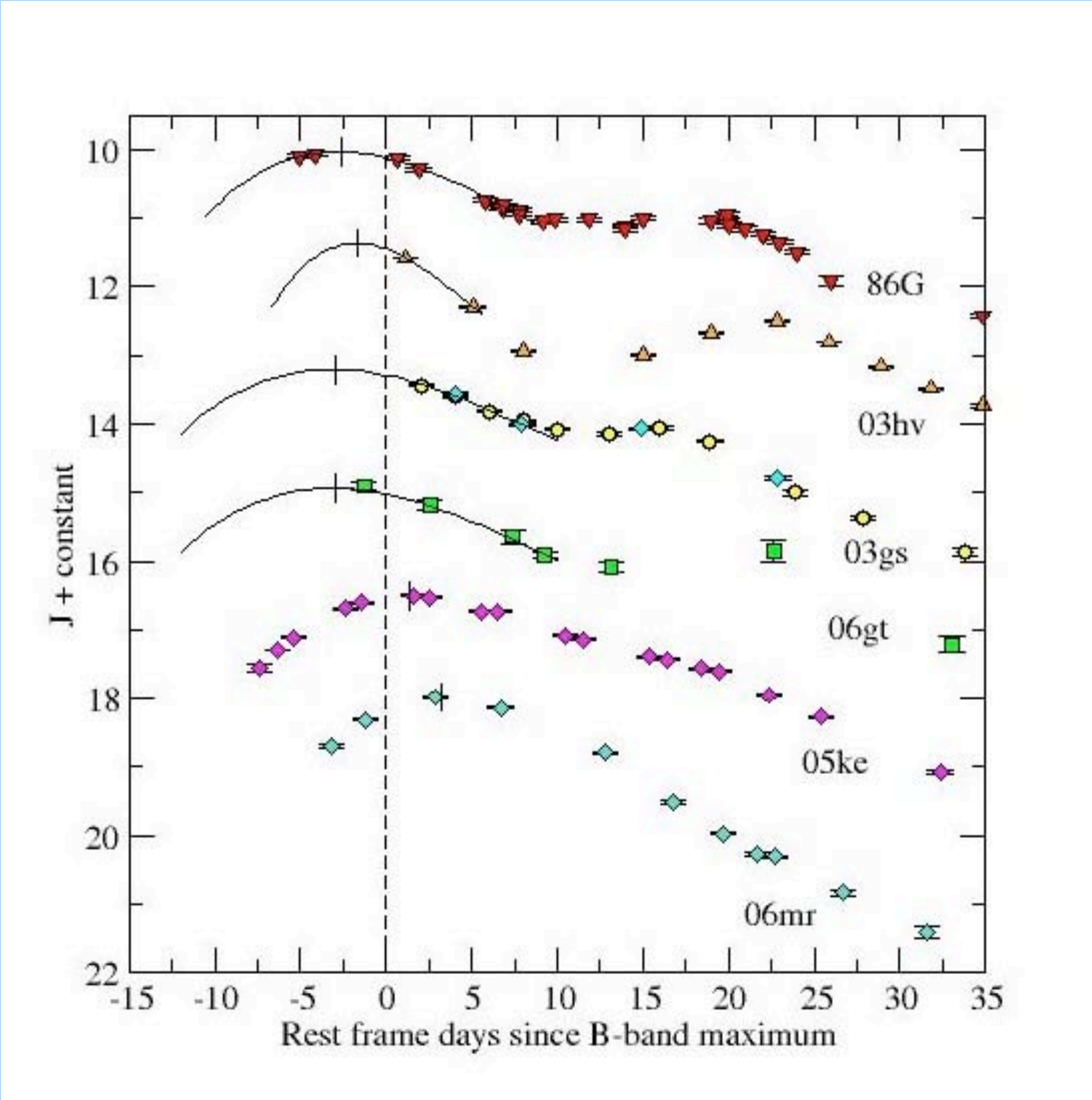
Near-IR light curves of SN 2003gs.

Data from CTIO 1.3-m telescope.



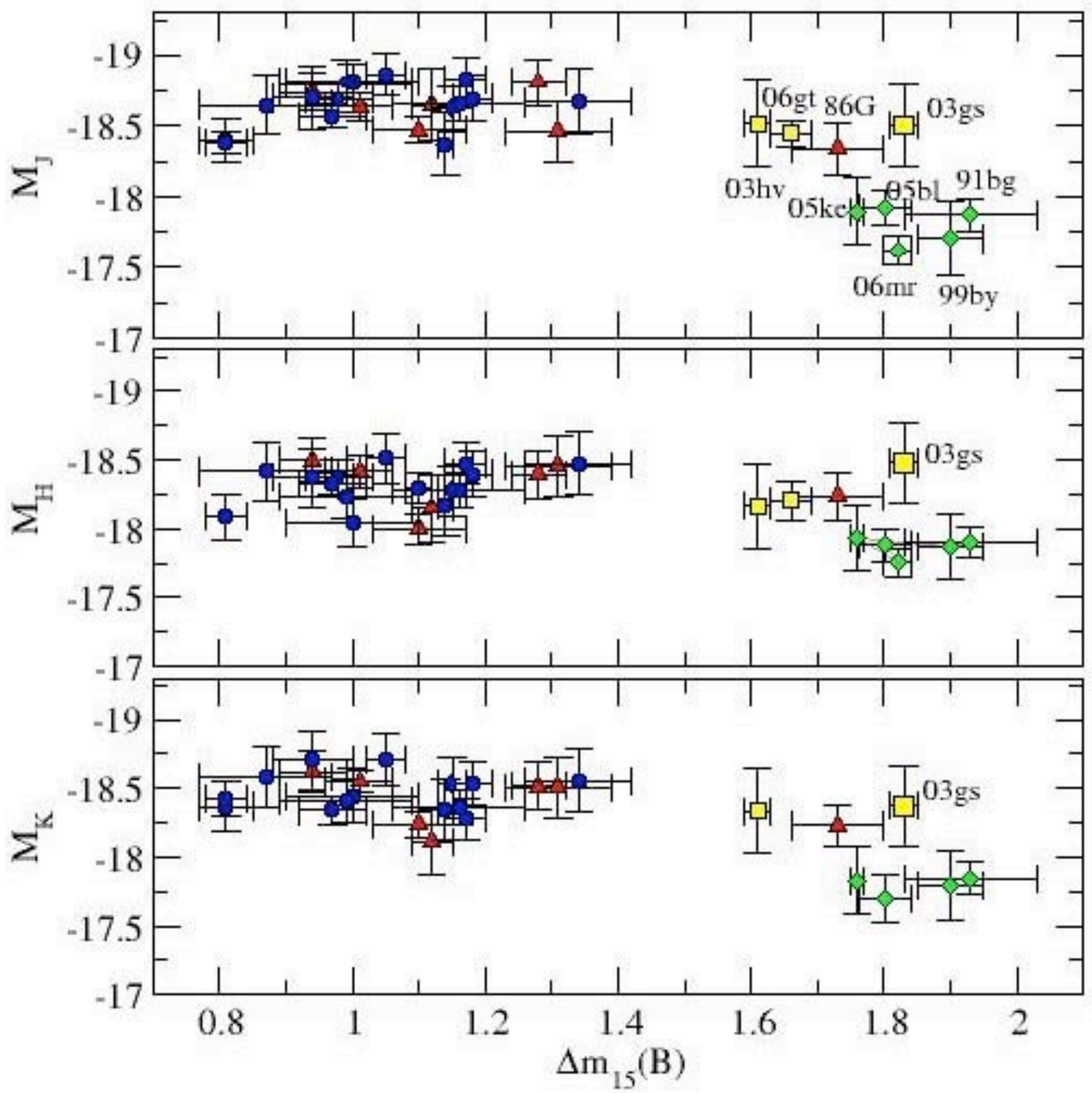
It seems that SN 2003gs peaked in the near-IR about 3 days before the time of *B*-band maximum.

Curved locus is stretchable template of Krisciunas et al. (2004b).

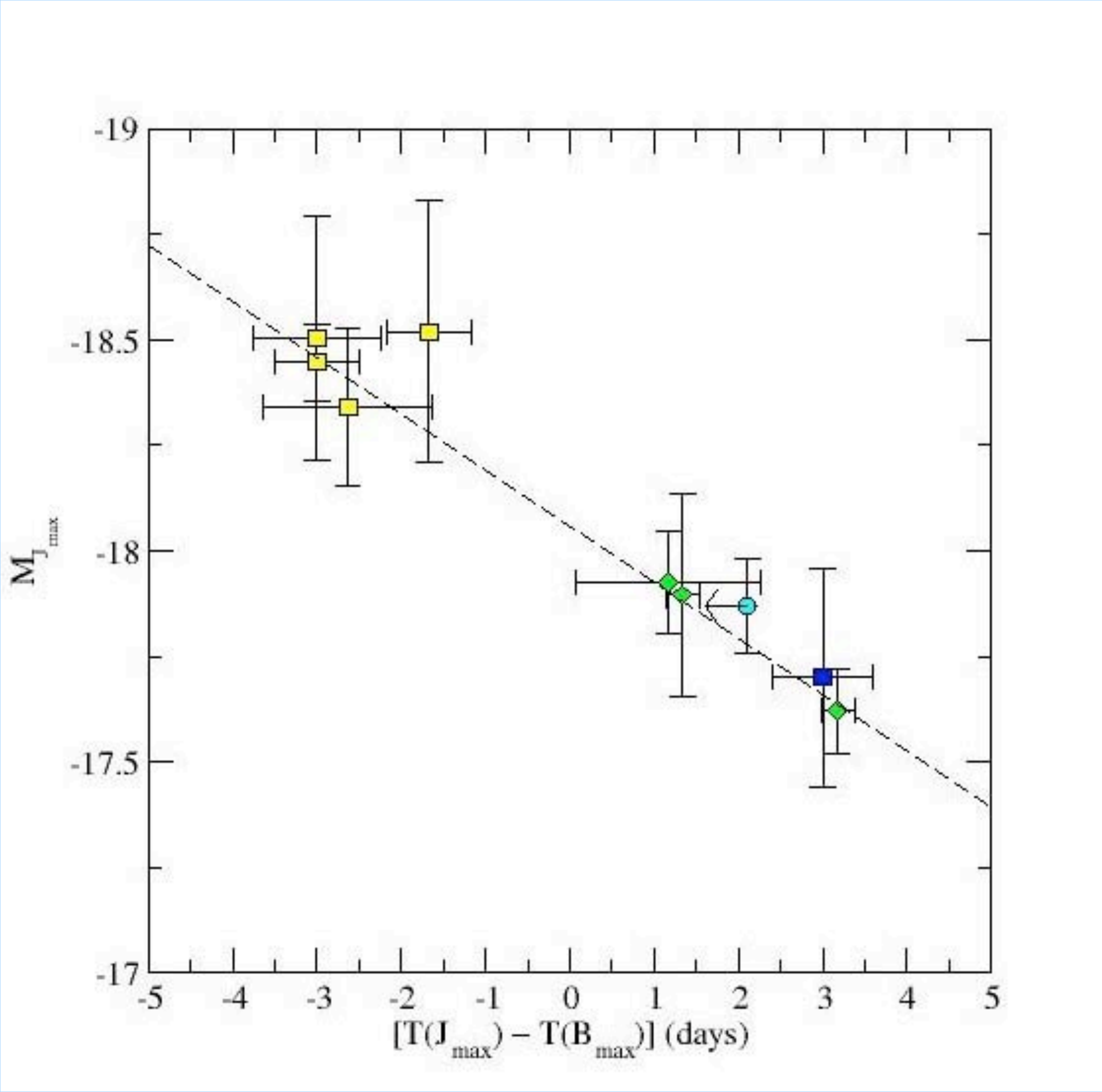


SN 2003gs is not the only fast decliner that peaked prior to $T(B_{max})$. There was 86G, 03hv, and 06gt.

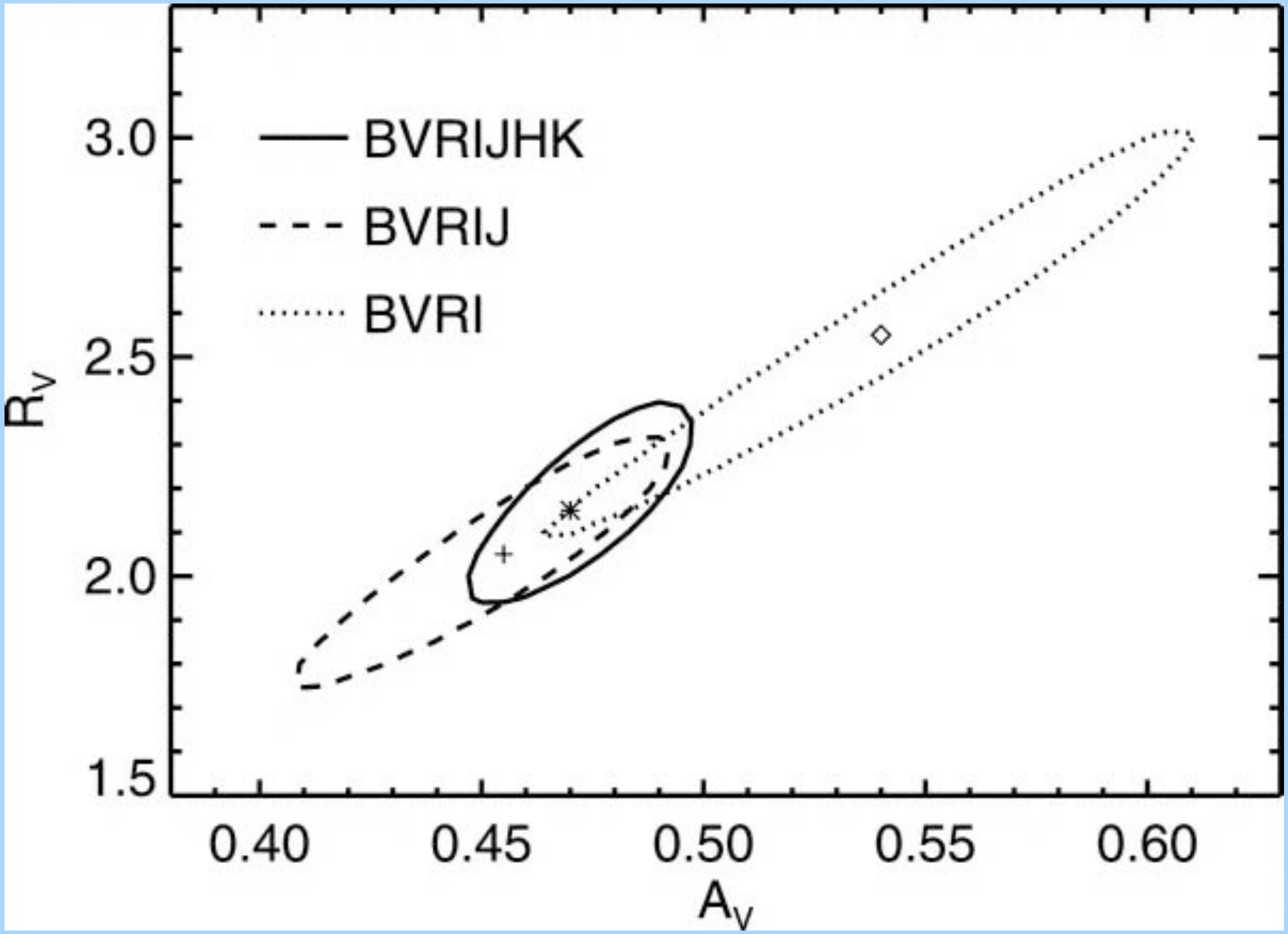
Other fast decliners observed in the near-IR have weak secondary maxima and peak after $T(B_{max})$.



The fast decliners that peak early are just as bright as the much slower decliners. Except for the late-peaking fast decliners, Type Ia SNe are standard candles in the near-IR.



If we never find any objects in the middle, then we'll have to consider the near-IR absolute magnitudes of the fast decliners a bimodal distribution.



In the case of SN 2001el vs. 2004S, a combination of optical and near-IR photometry allowed us to get an accurate value of the parameter $R_V = A_V / E(B\text{-}V) = 2.15 \pm 0.24$, and the extinction A_V.

Standard Milky Way dust has R_V ~ 3.1. Many Type Ia SNe have host galaxy dust with R_V ~ 2.4.

Some Type Ia SNe have R_V in the range 1.55 to 1.8 (1999cl, 2002cv, 2003cg, 2006X).

To do the very best cosmology with Type Ia SNe, you should determine R_V for every object.

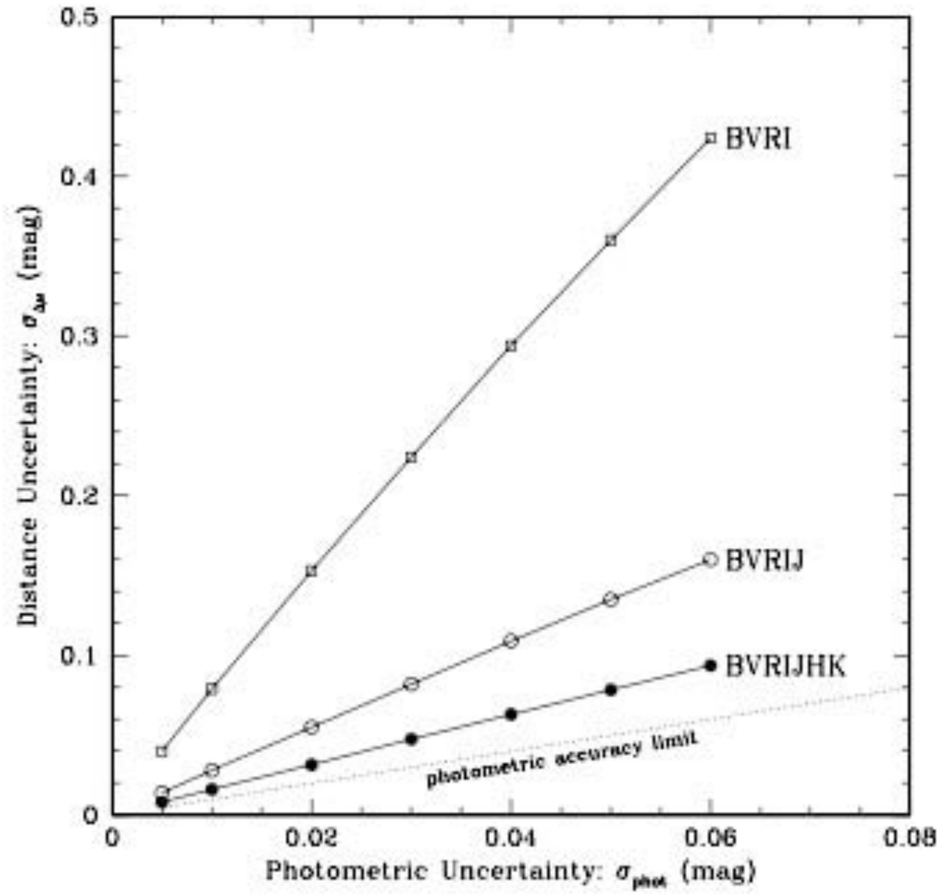


FIG. 17.—Uncertainty in the distance modulus for Type Ia SNe as a function of the photometric accuracy and the number of filters used to determine the photometric solution. The dotted line corresponds to the photometric accuracy. It is not possible to recover a distance modulus more accurately than the level of accuracy of the photometry.

The accuracy of a distance determination can be greatly improved by having both optical and IR data.

Krisciunas et al. (2007)

For near-IR spectra of Type Ia SNe see :

Marion et al. (2009), *AJ* **138**, 727

Kotak et al., in preparation (SN 2003gs)

Conclusions

Type Ia SNe are *standardizable* candles in optical bands.

Type Ia SNe are *standard* candles in the near-IR, except the fast decliners that peak after the time of B-band maximum.

A combination of rest-frame optical and near-IR photometry can give you distances/absolute magnitudes which have systematic errors due to extinction corrections as low as 0.02 mag. This is true even if the dust in the host galaxies is very different than dust in our Milky Way.