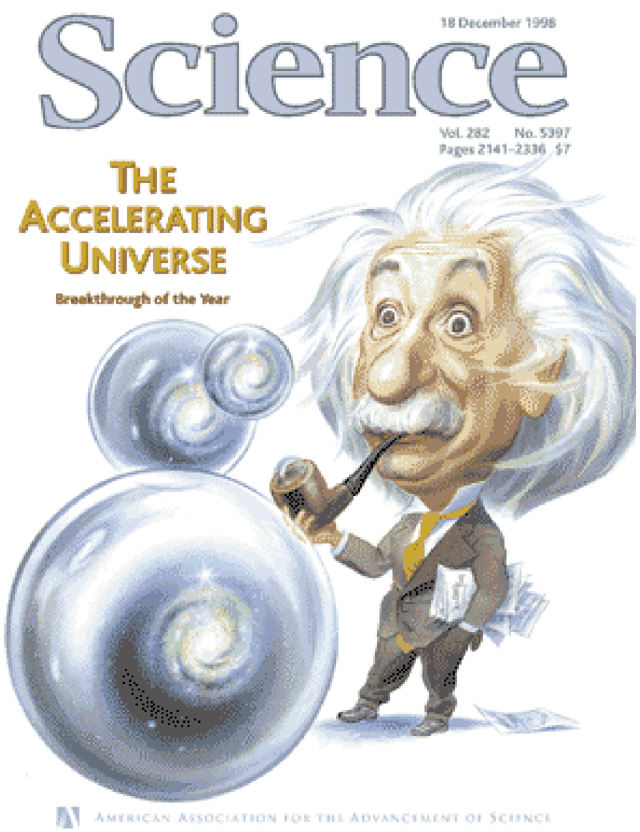
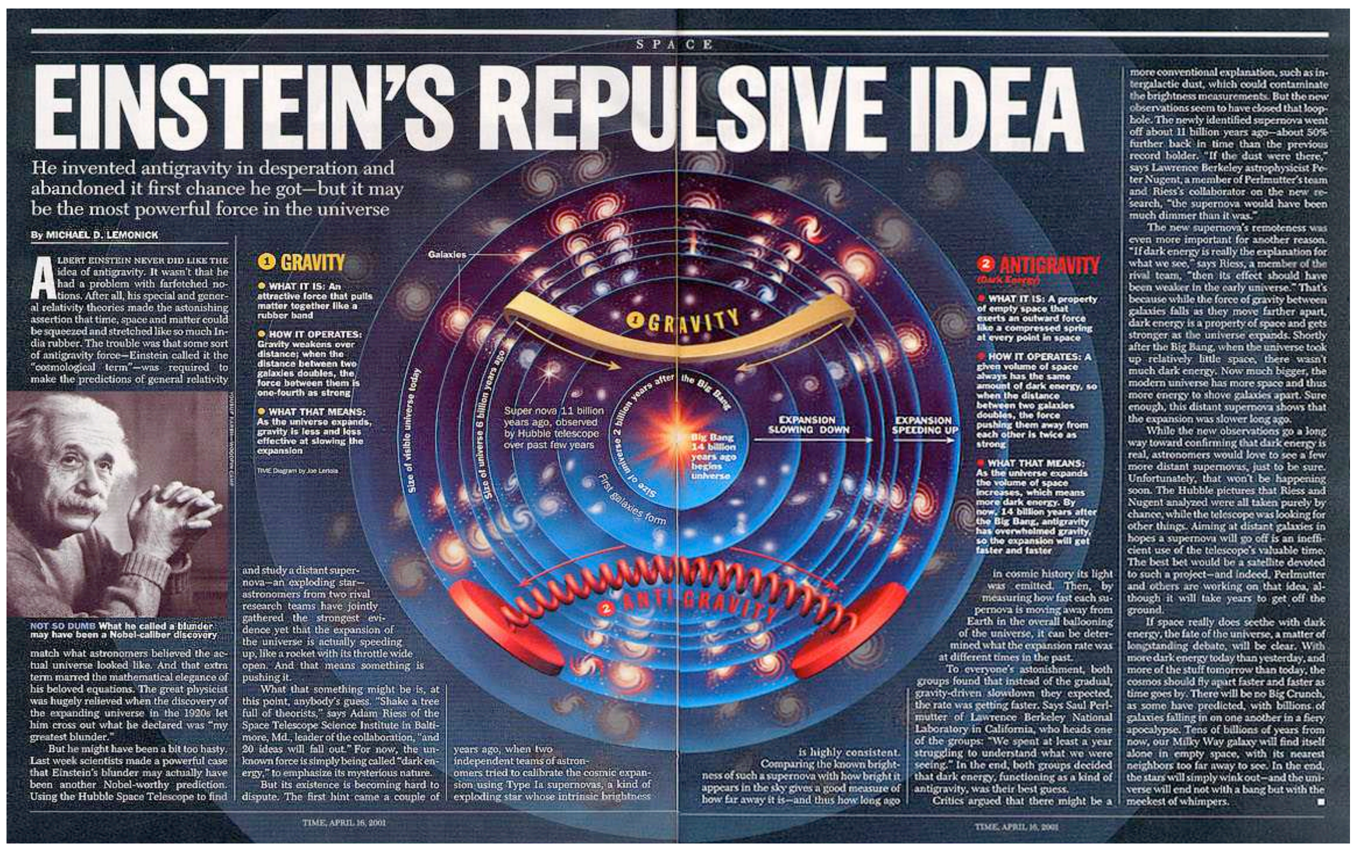
SN Factory & SN Physics
Theory Meets Observation

Why Do We Want to Do the SN Factory in the First Place?
Fame, Glory, all the usual reasons…





Why Do We Want to Do the SN Factory in the First Place?
Fame, Glory, all the usual reasons…

Actually we want do do something much more mundane yet crucial for the whole field of SN cosmology measurements:

We need to develop SNe into the best possible distance indicators they can be, with a full understanding of their statistical and systematic limitations.

Which means we have to increase our understanding of the progenitors and physics of these mechanisms.

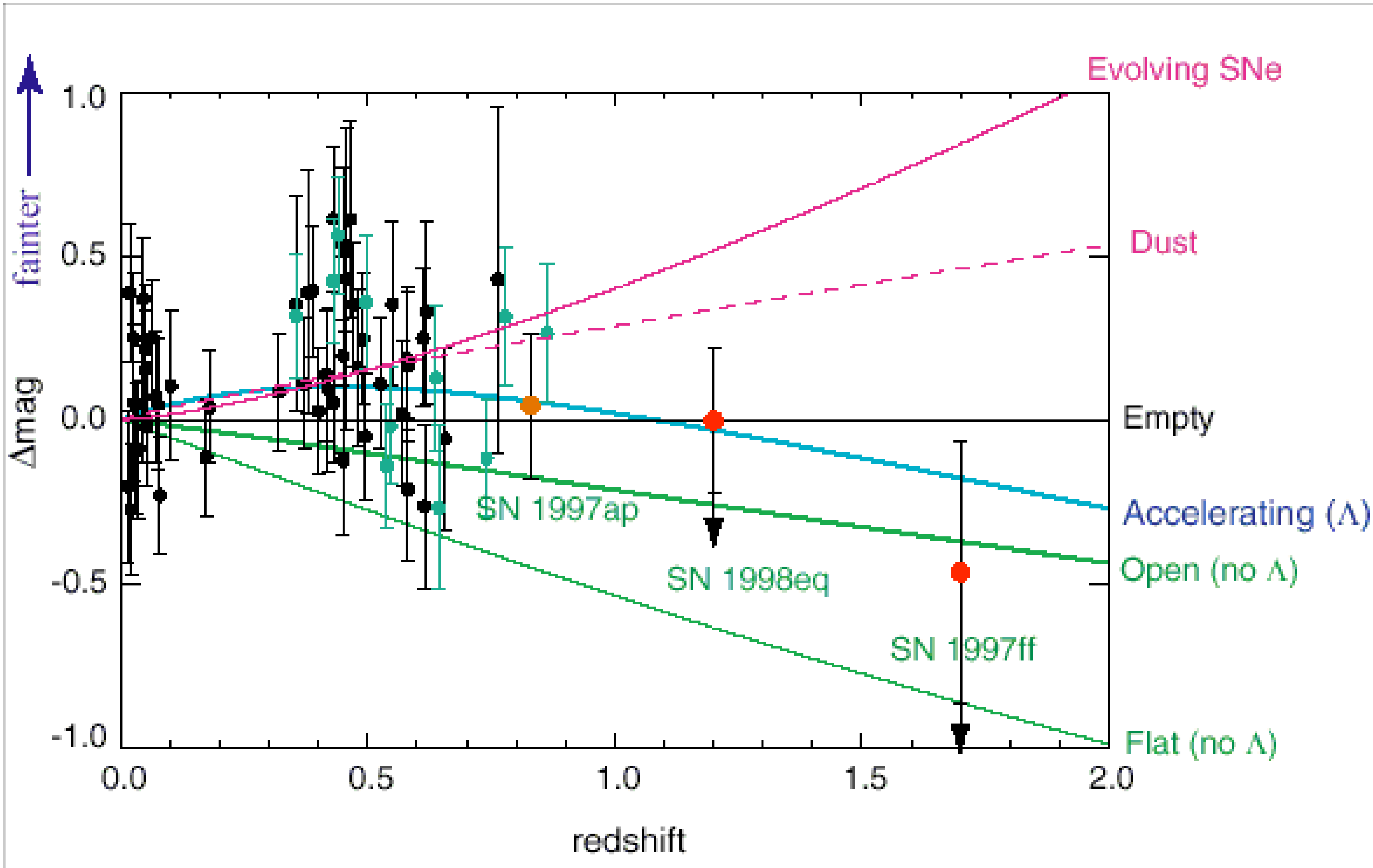
The ultimate success of the following programs hinges on our ability to deliver the goods:

SNAP
CFHTLS
Essence/*w*-Project
Carnegie SN Search

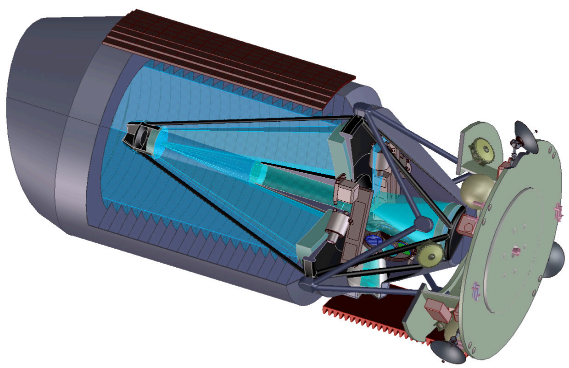
All of these projects have cited us, in one form or another, as grounding our knowledge and understanding of nearby SNe so that the cosmological measurements made at higher-*z* can be improved to measure the equation of state and beyond…

So while we won't get the glory, we will get the most important citations in the papers for each of the above projects.

Current Hubble Diagram

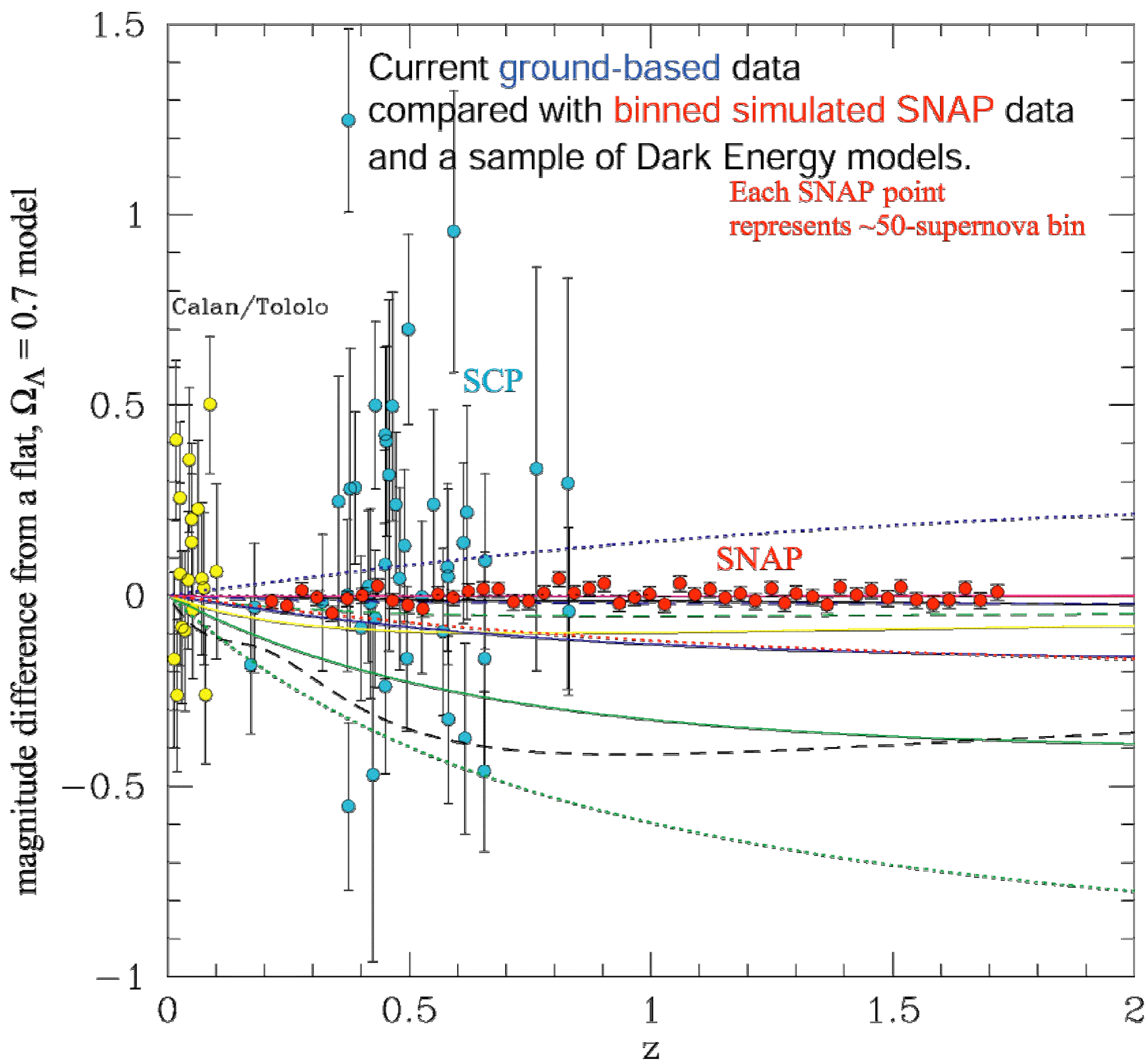


Future Hubble Diagram?



SuperNova
Acceleration
Probe

2000 SNe Ia
(CFHTLS,
Essence, etc.)



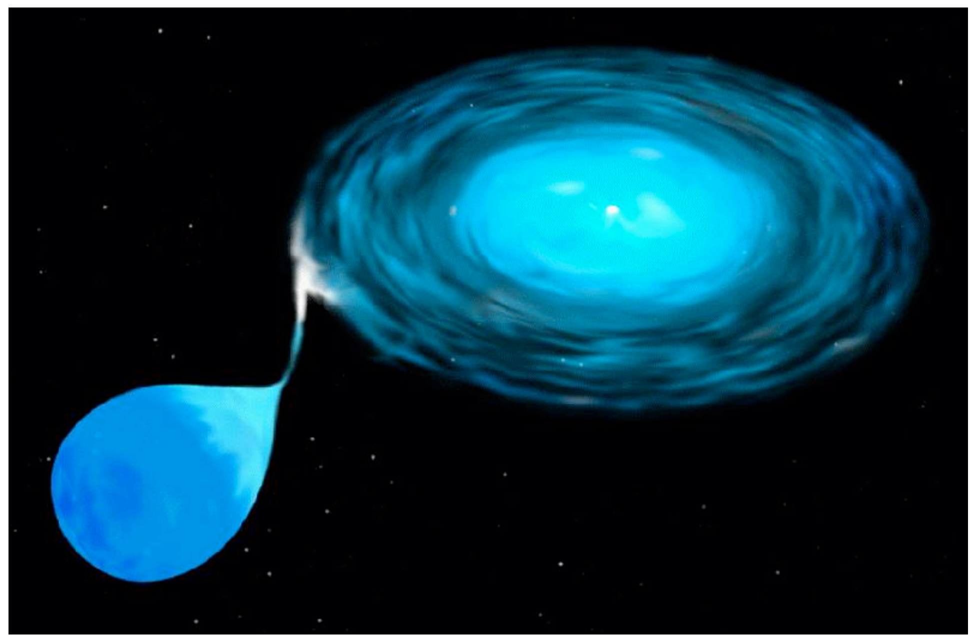
based on
Weller & Albrecht (2001)

Type Ia Supernovae

Type Ia Supernovae are bright: For a few weeks they are as bright as the entire galaxy they originated in.

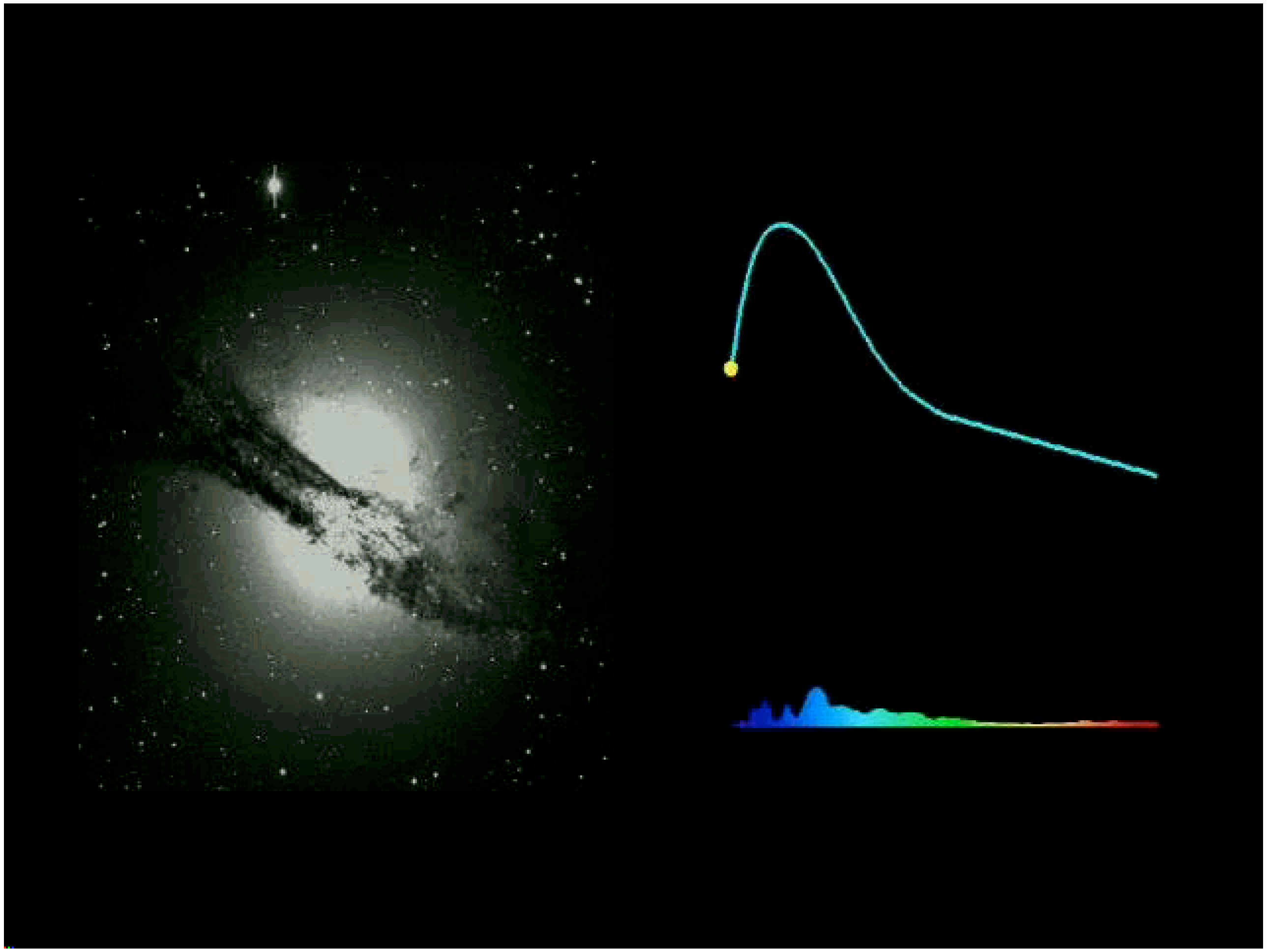
"Before" and "After" for SN 1999be.

Type Ia Supernovae are very similar: They give reliable distances to better than 10%



Artist's rendition of an accreting White Dwarf.

Type Ia Supernovae



Type Ia Supernovae are rare: 1 every 400 years in a galaxy like our MW.

Type Ia Supernovae: Fundamentals

What we absolutely know about SNe Ia:

• Occur in all types of galaxies
• Show the presence of strong SiII and SII in their spectra
• With some small calibration (based on light-curve shape and colors) they can be turned into an excellent standardized candle < 10% in distance.

What we surmise from these observations:

• Thermonuclear explosion of a C/O white dwarf
• Powered by the decay of ^{56}Ni
• Probably close the the Chandrasekhar mass

After 30 years we only have a weak understanding of the progenitor-mechanism

Parameters which control the SN Ia SED

- Total mass of Ni^{56} synthesized
- Total mass of star.
- Kinetic energy of explosion.
- Composition and density of the star.

All of the above are a function of position in 3D and of time.

SNIFS: Fundamentals

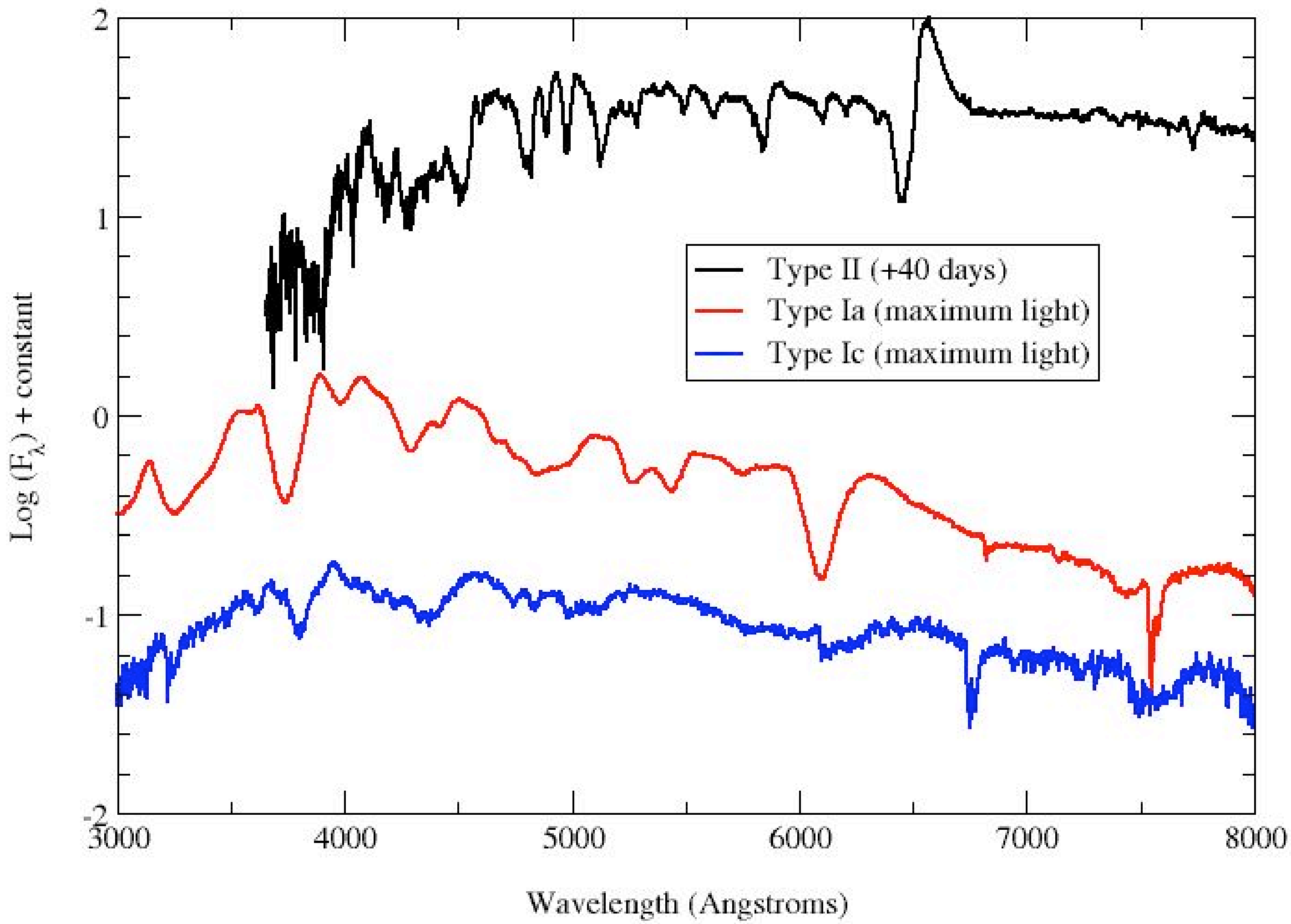
For the purposes of this talk I propose we consider SNIFS in 3 modes:

- Science-grade spectrum: Measure velocity and strength of all spectral features to desired accuracy

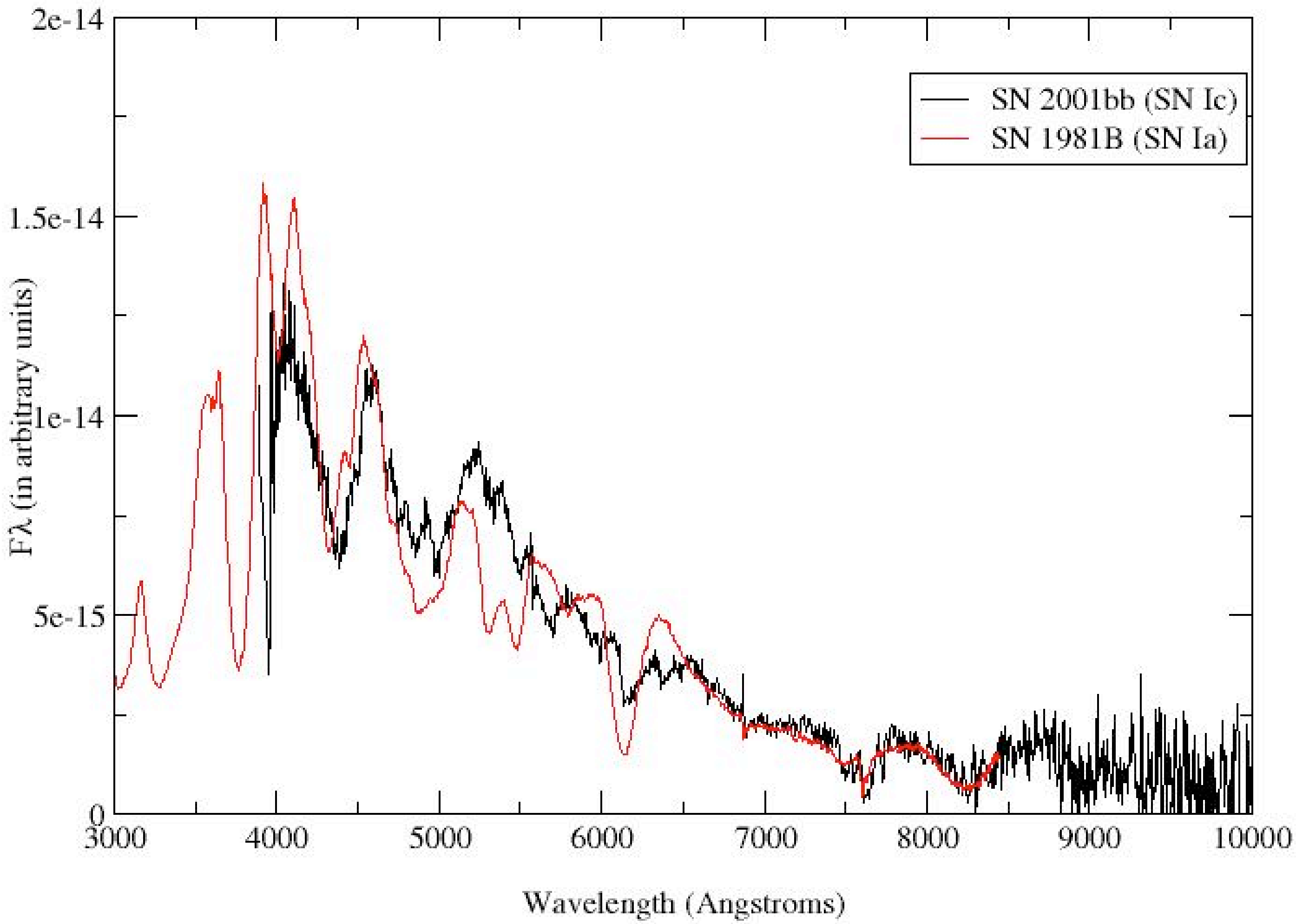
- Id-level spectrum: Enough to separate subtypes, junk…

- Photometry: S/N high enough to measure extinction properties, color evolution, etc.

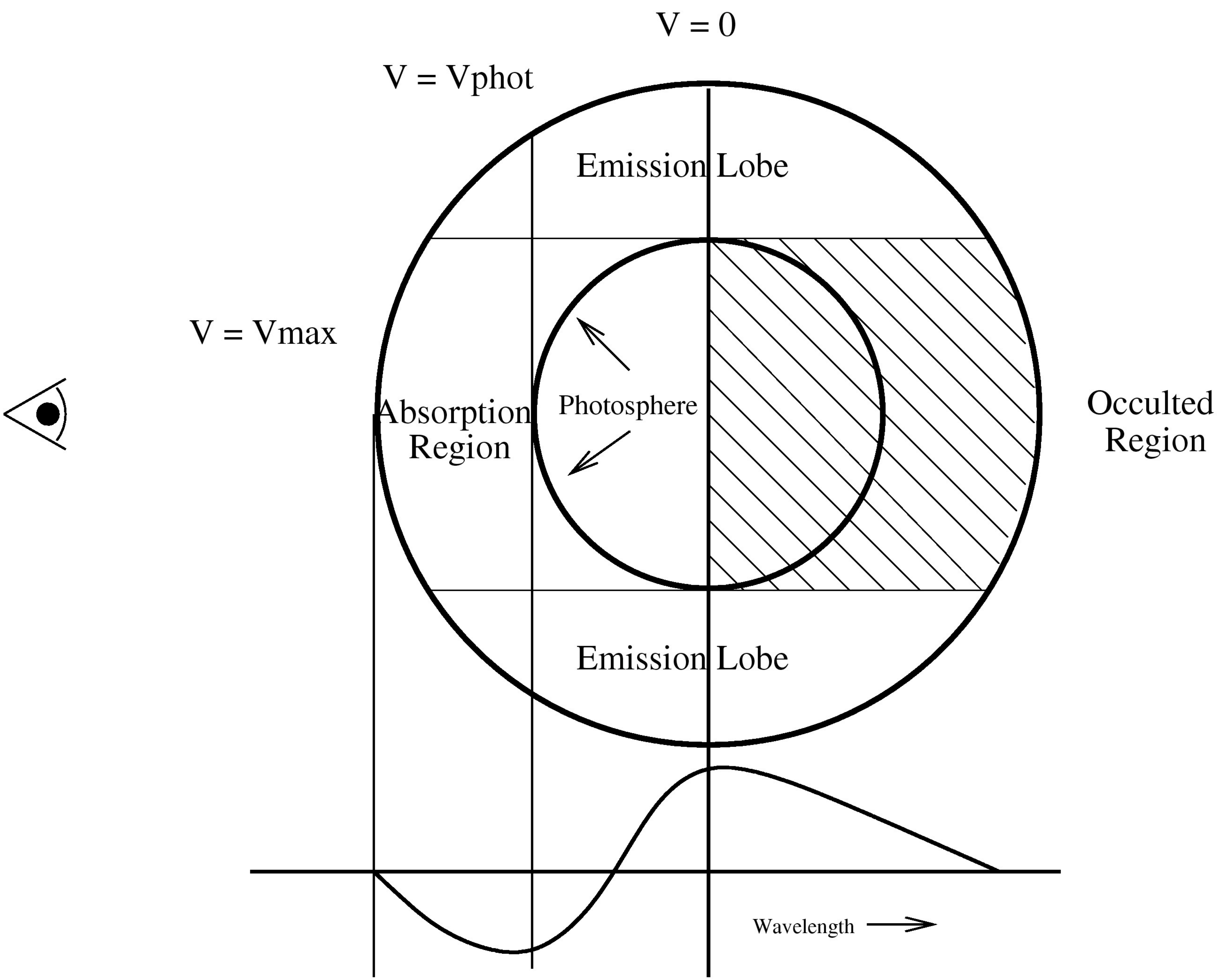
Spectral Comparison



Nasty Spectral Comparison



P-Cygni Spectral Line in a SN



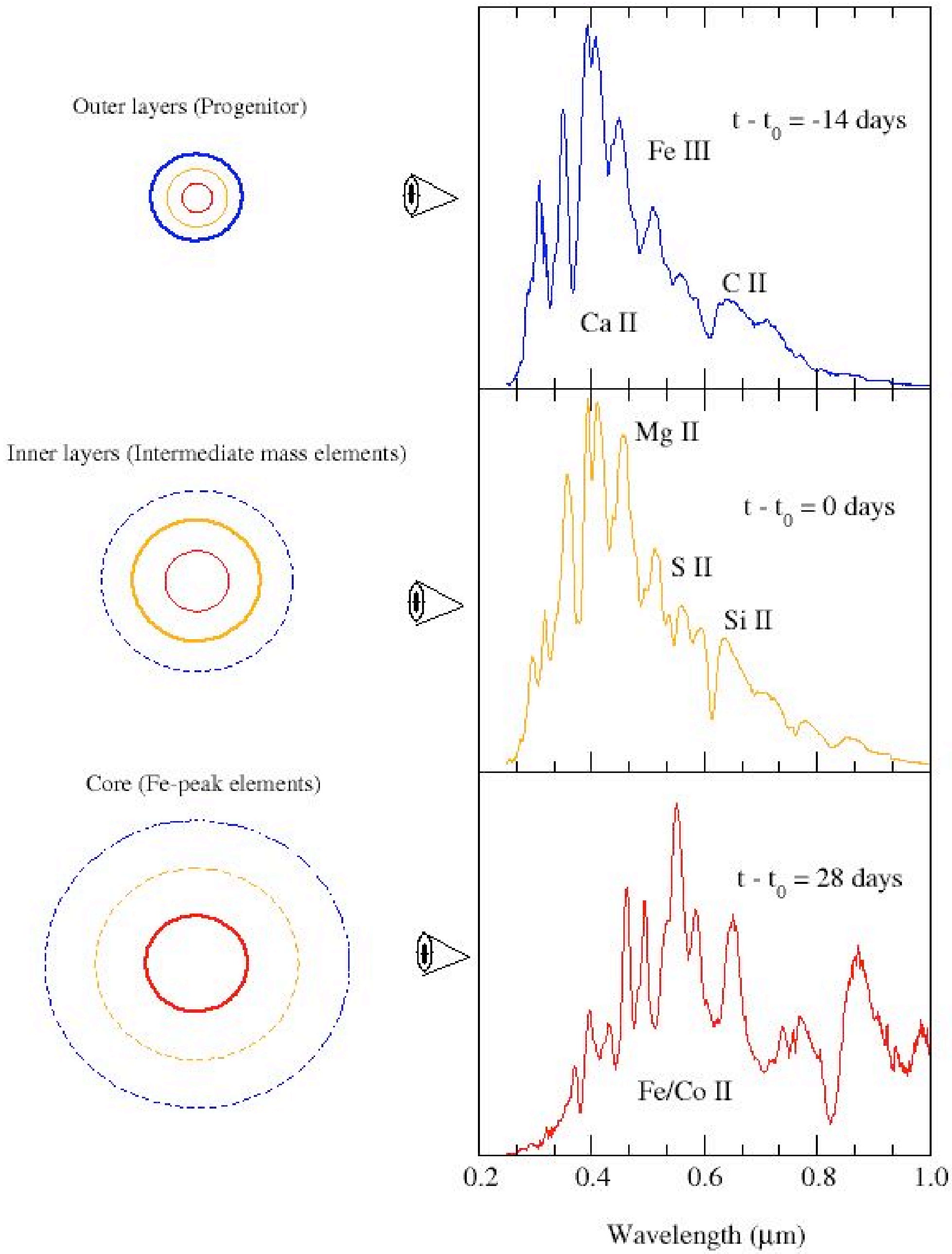
SN Identification & Early Spectra

1. The first spectrum has to be of a quality (S/N) to separate subtypes

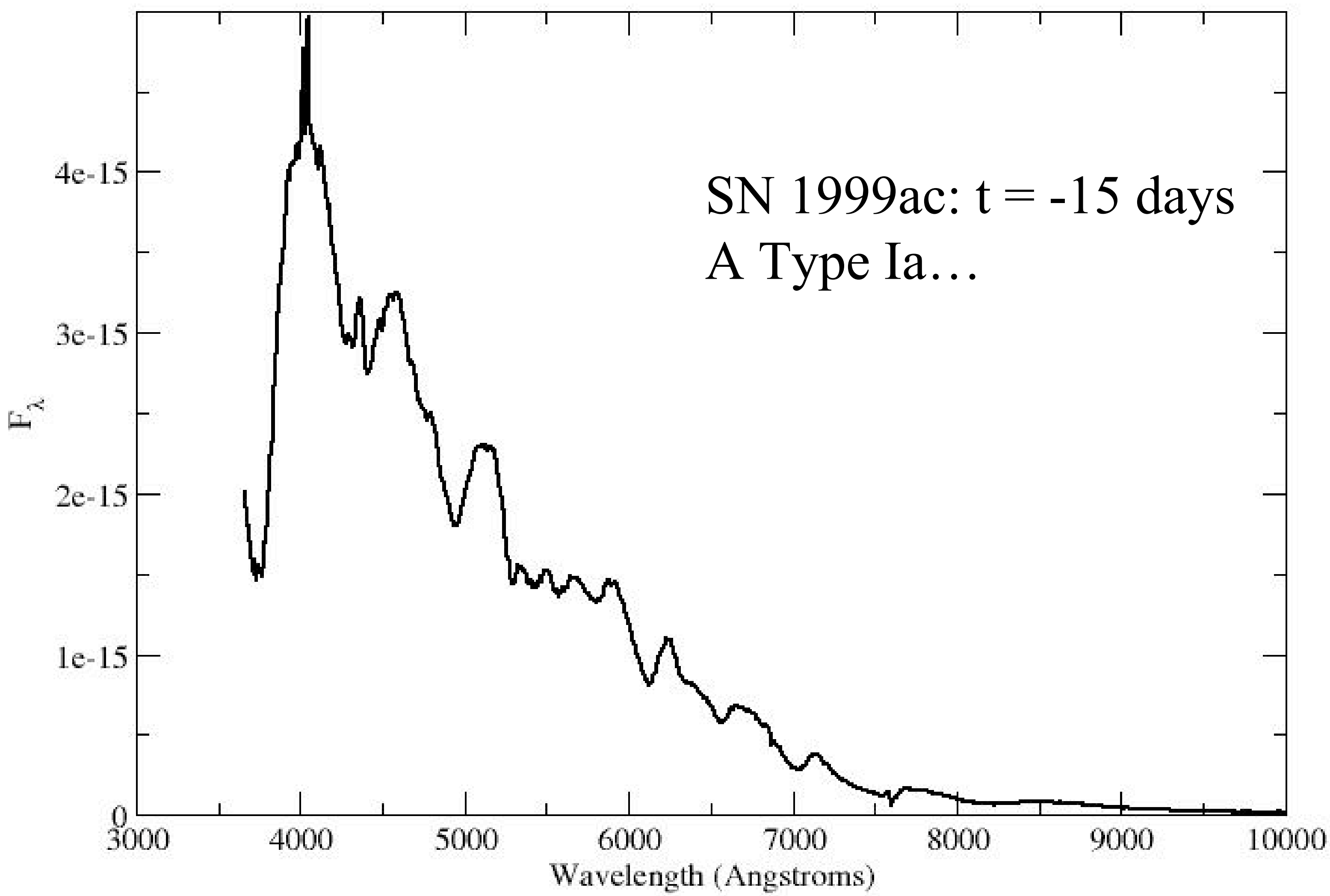
   - In most cases (~80% based on the rates of individual subtypes) the classification can be accomplished with something slightly better than photometry, since most CC SNe are blue and featureless early on.
   - For ~20% (Ib/c) the differences are subtle and higher S/N must be obtained

2. An early spectrum of a Ia will allow us to learn the most about the progenitor.

SN Identification & Early Spectra



Nasty Spectral Comparison



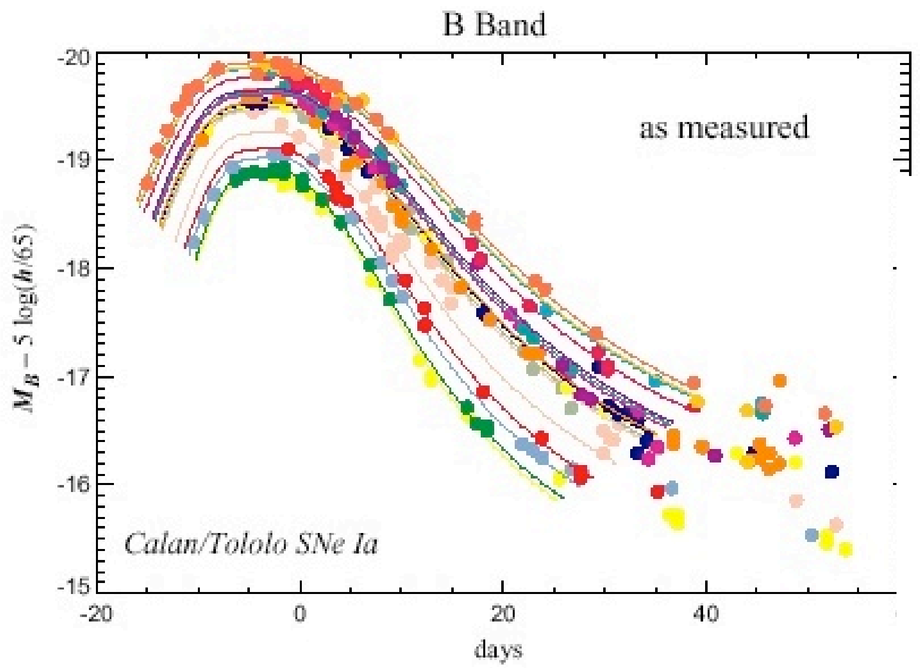
Conclusion (for now):

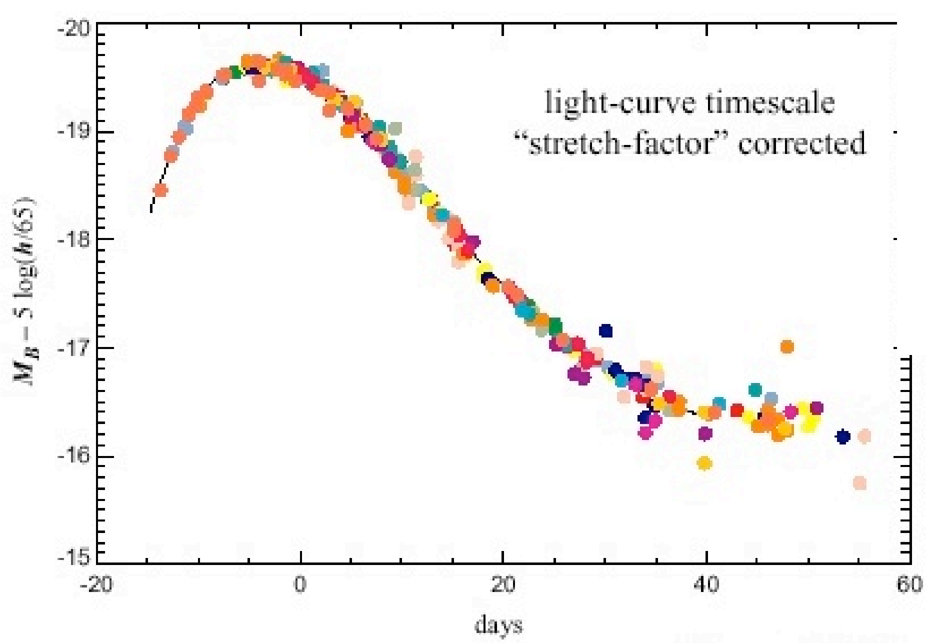
Until we can prove to ourselves that we can conclusively separate subtypes of all SN, I would be in favor of only operating in two modes: Science-grade and photometry.

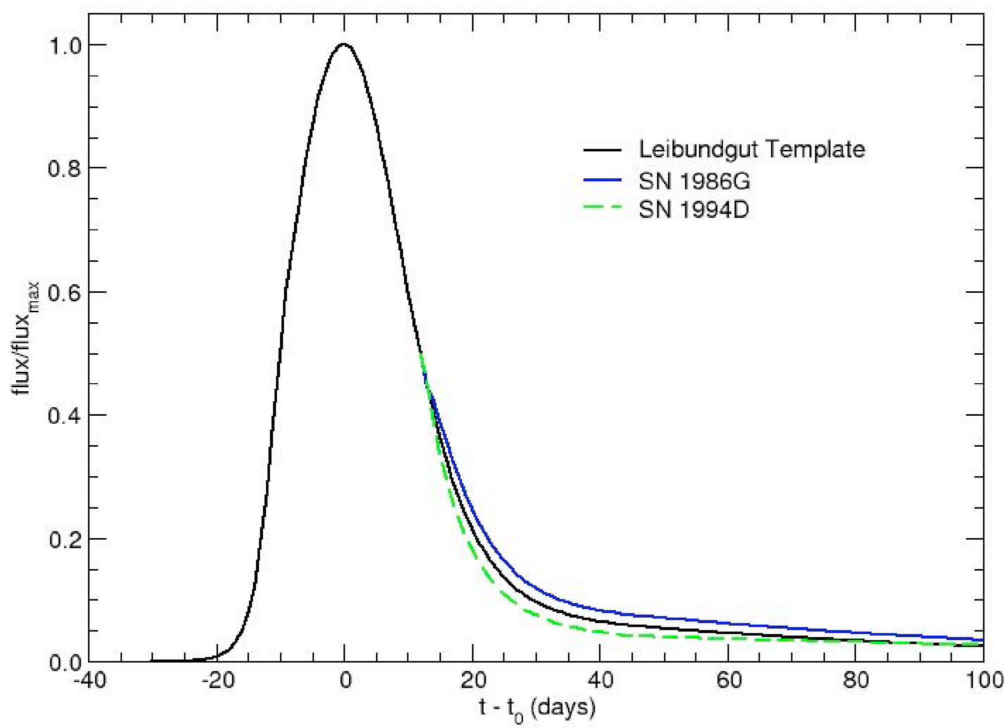
- The science gain is huge for a high S/N early spectrum
- The separations of subtypes, based on what we know/have now, will be difficult without high S/N
- The contamination factor will be acceptable. NEAT & LOTOSS have about a 50/50 split between Ia's and CC SNe while ESSENCE is about 70/30.

Next question: How much of each?

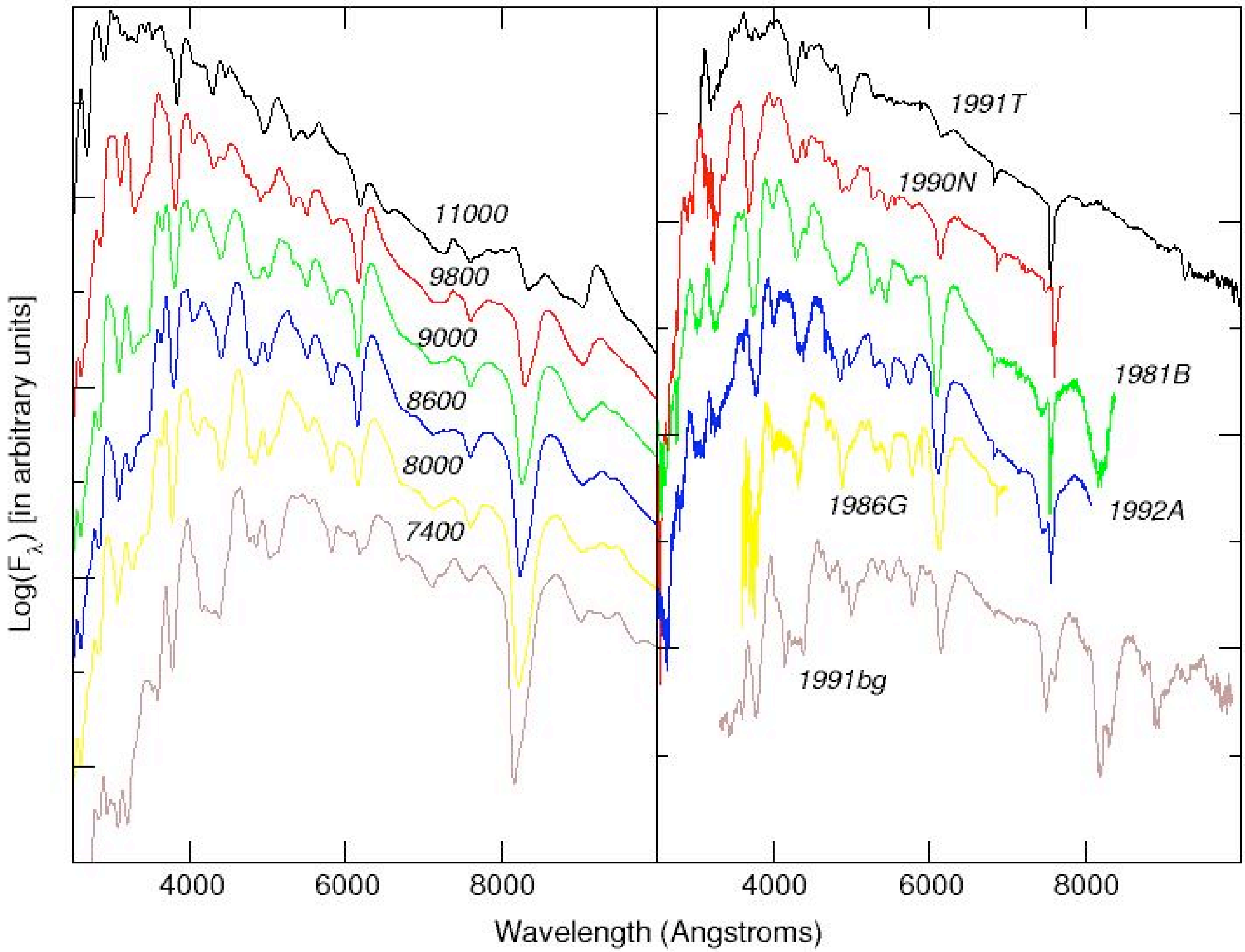
Light Curve Science



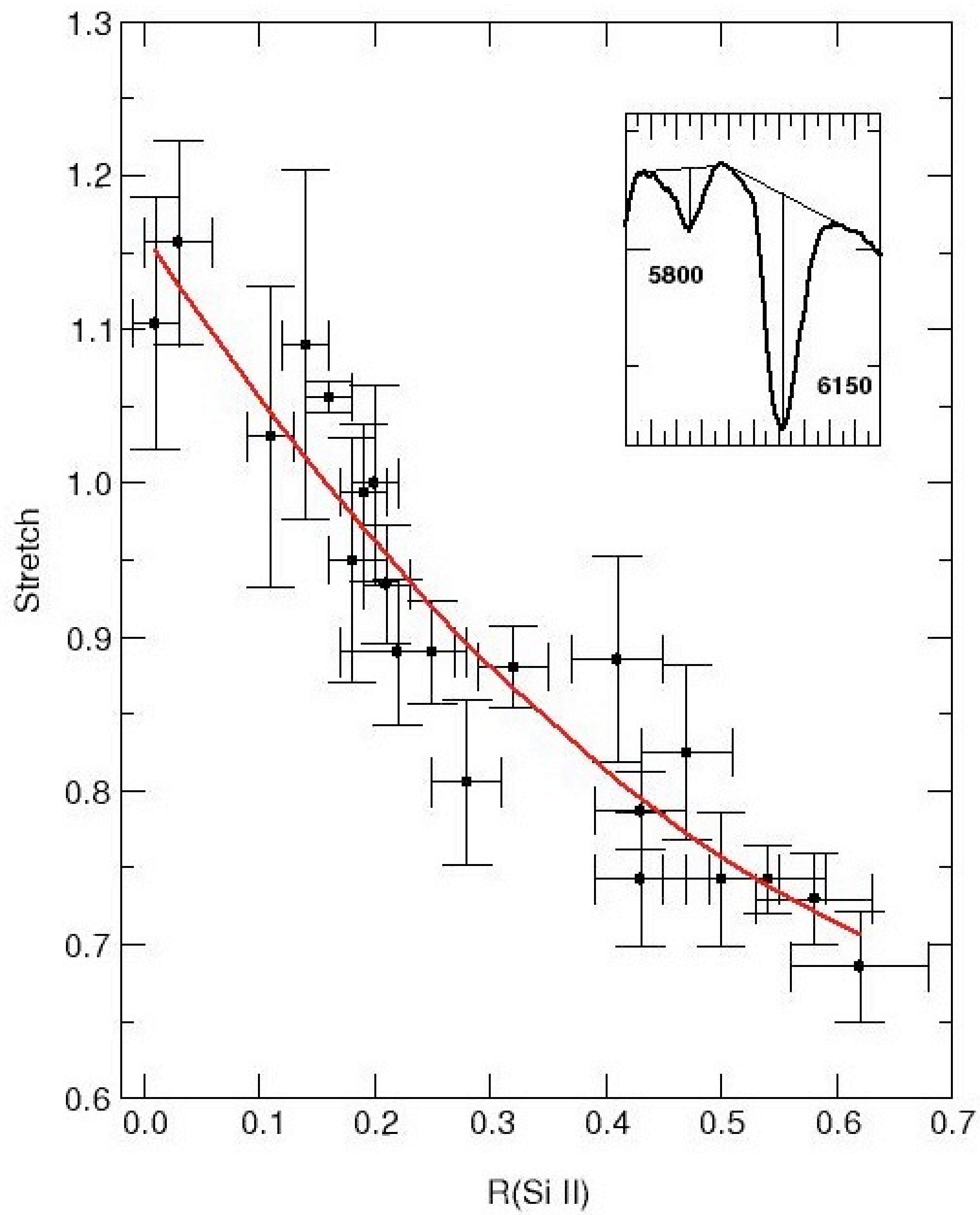




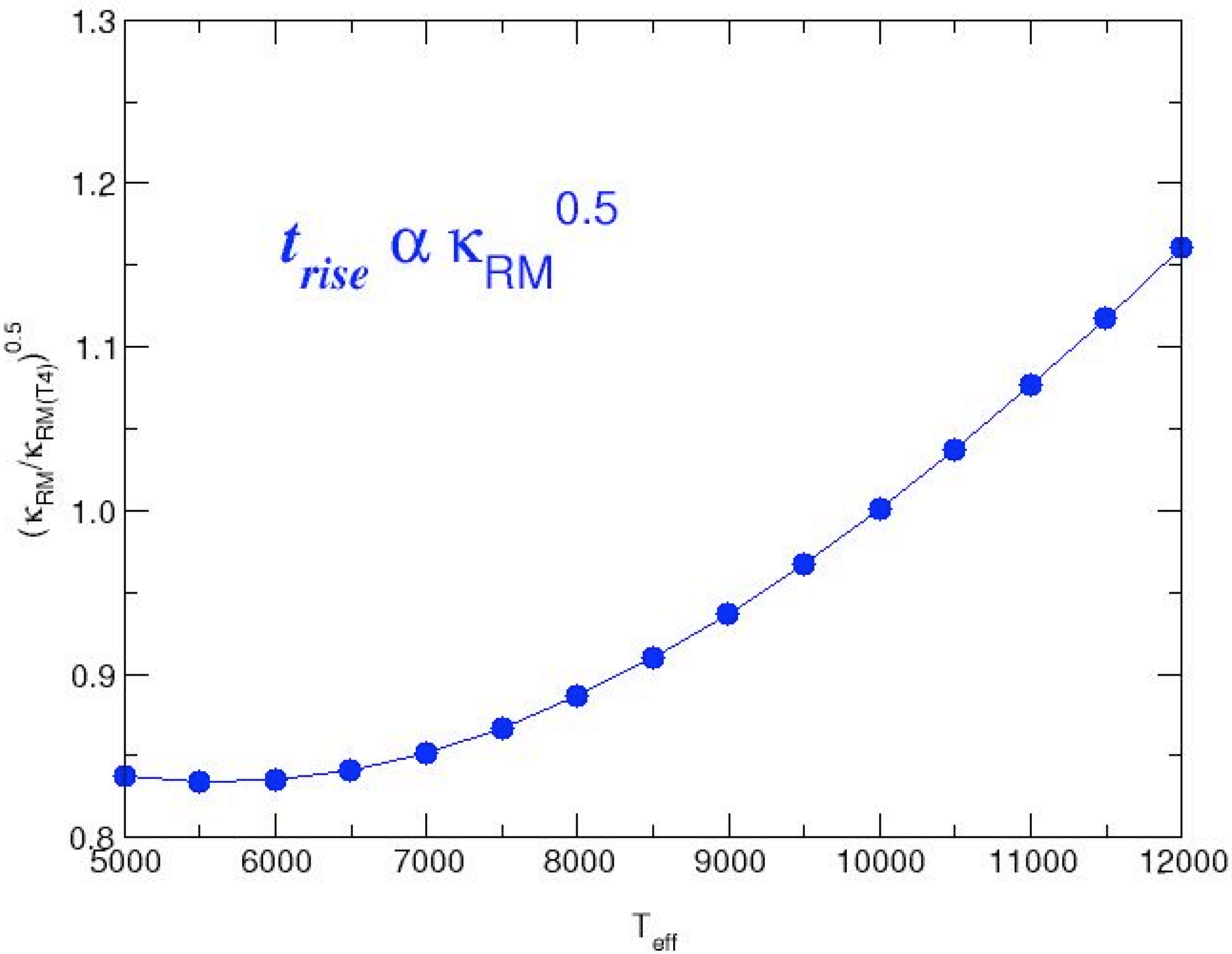
Spectral Science



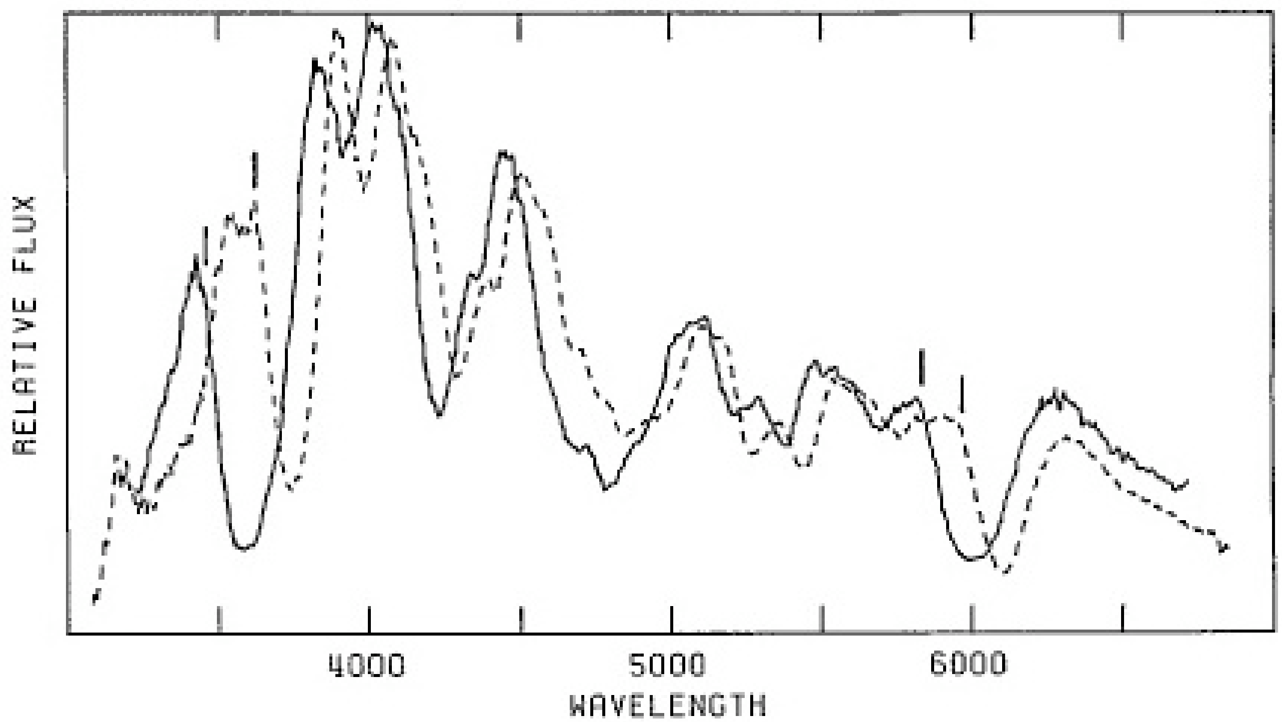
Spectral Science



Putting it together

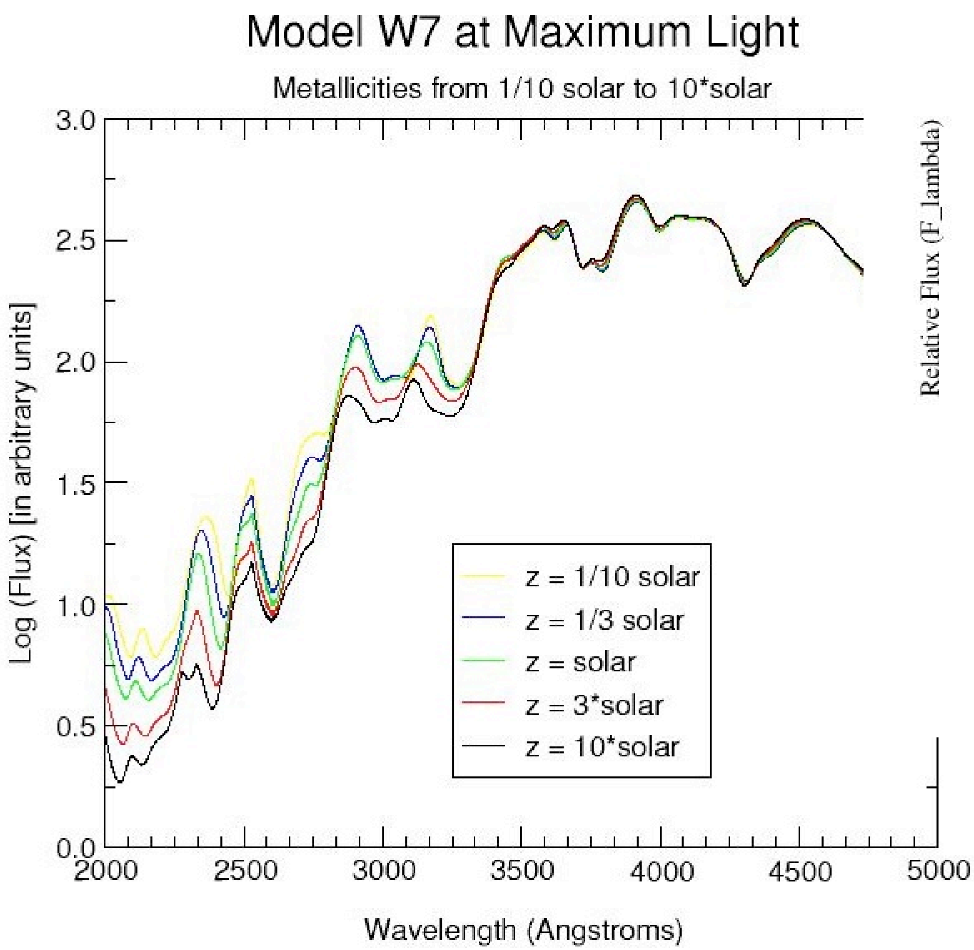


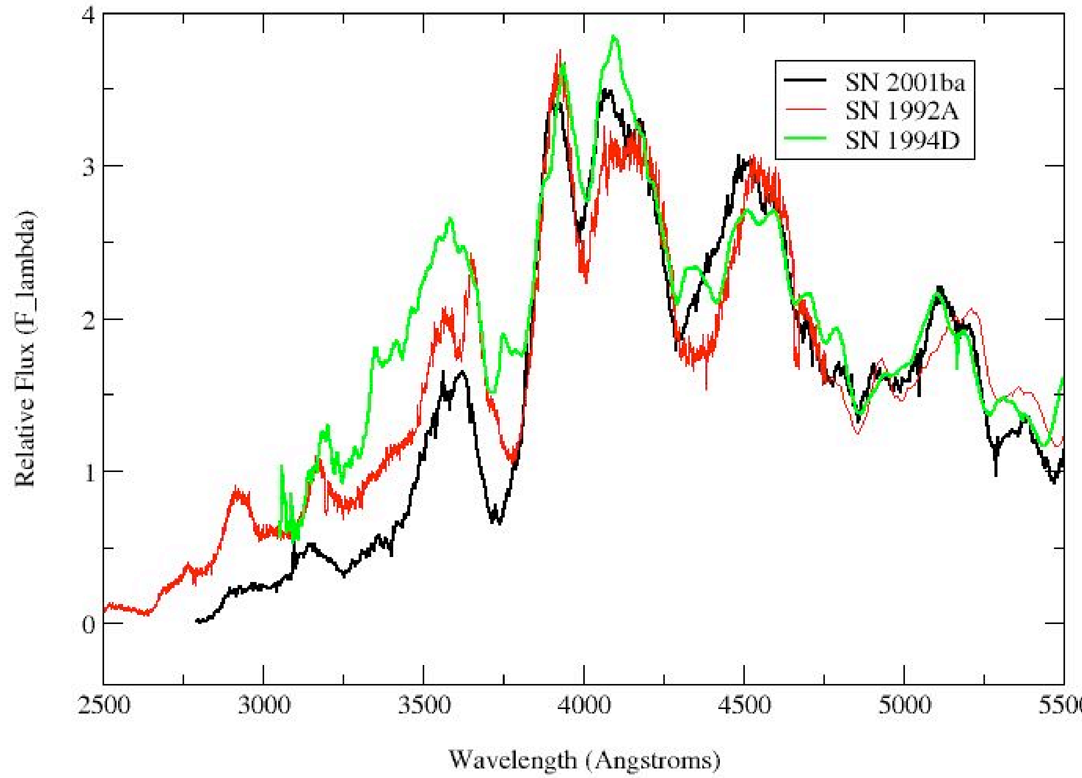
Kinetics



Differences in the Kinetic Energy? A comparison of SN 1984A (dashed) with SN 1981B (solid).

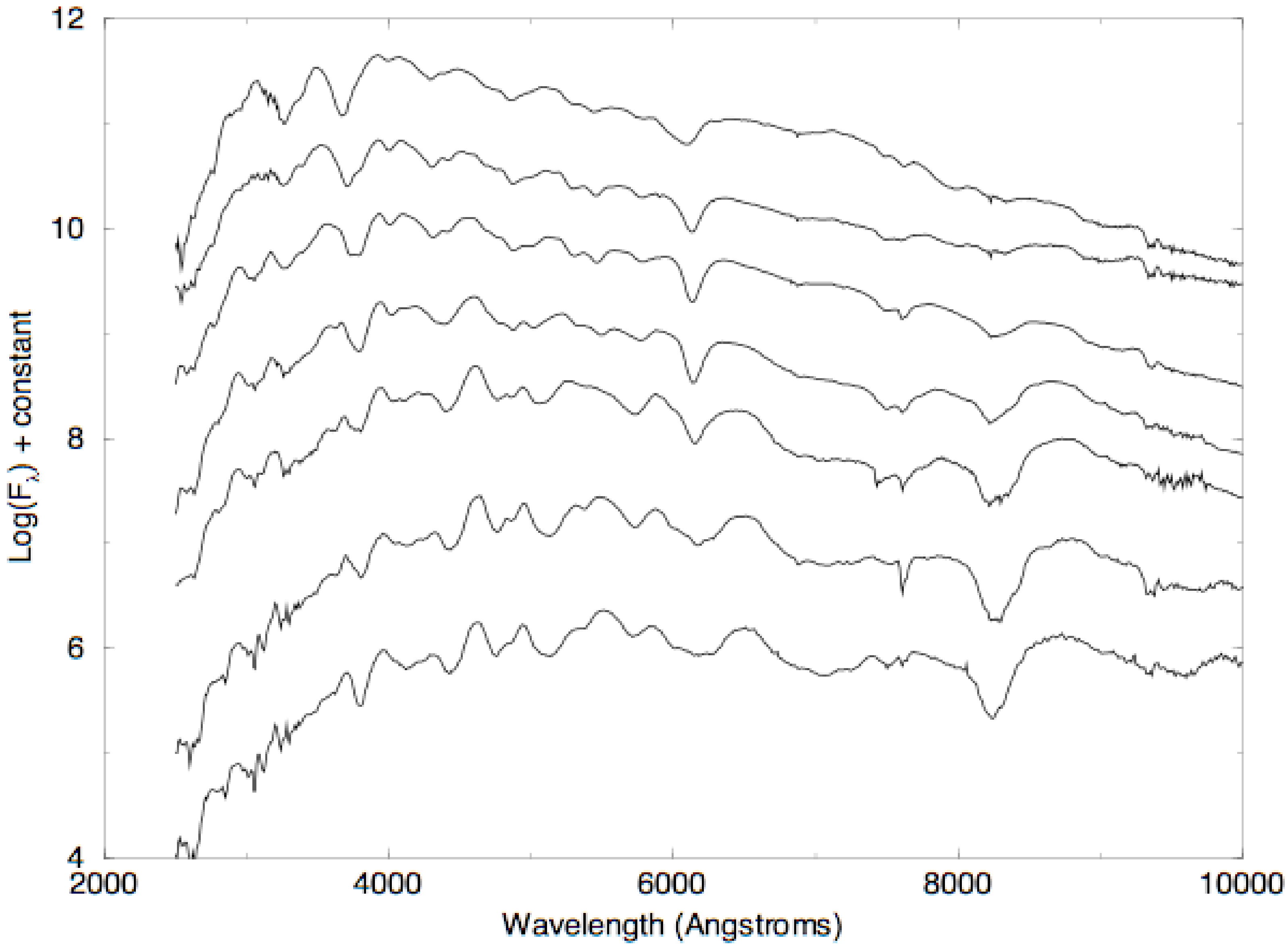
Metallicity





Differences in the Metallicity?

Cadence (natural 2, 3, 7 & 8 days)

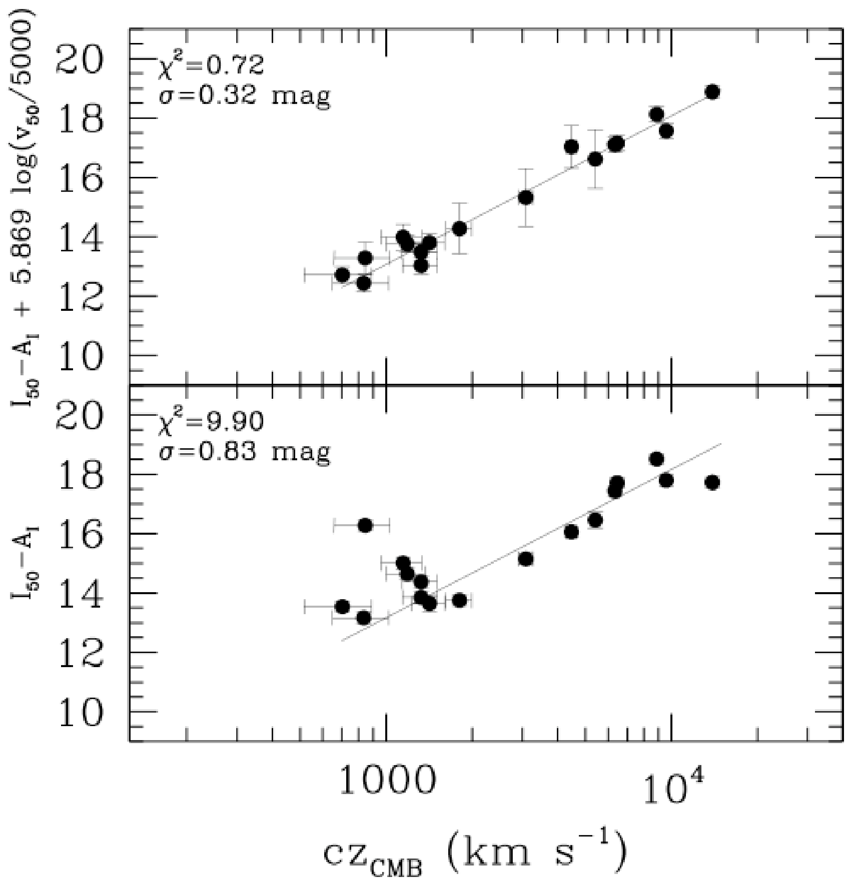


More Science…

Other Possible Science Programs in affiliation with SN Factory:

More Ia research (HST, Polarization, IR, …)
SNe II research (another way to get distances at very little cost)

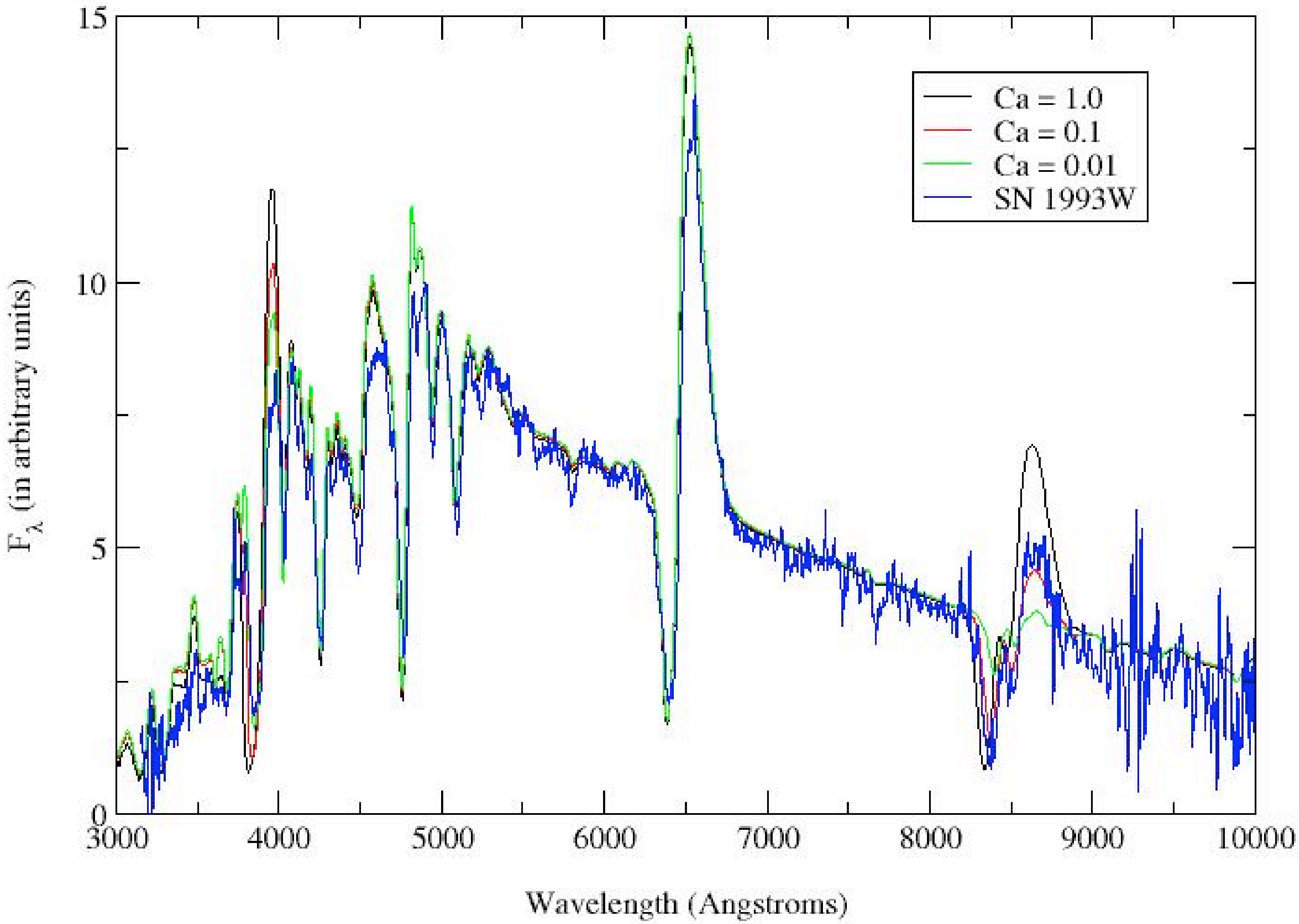
SNe II as Distance Indicators



Hamuy’s Method

~15% distance

SN 1993W
(Hot off the press, 3 days old...)

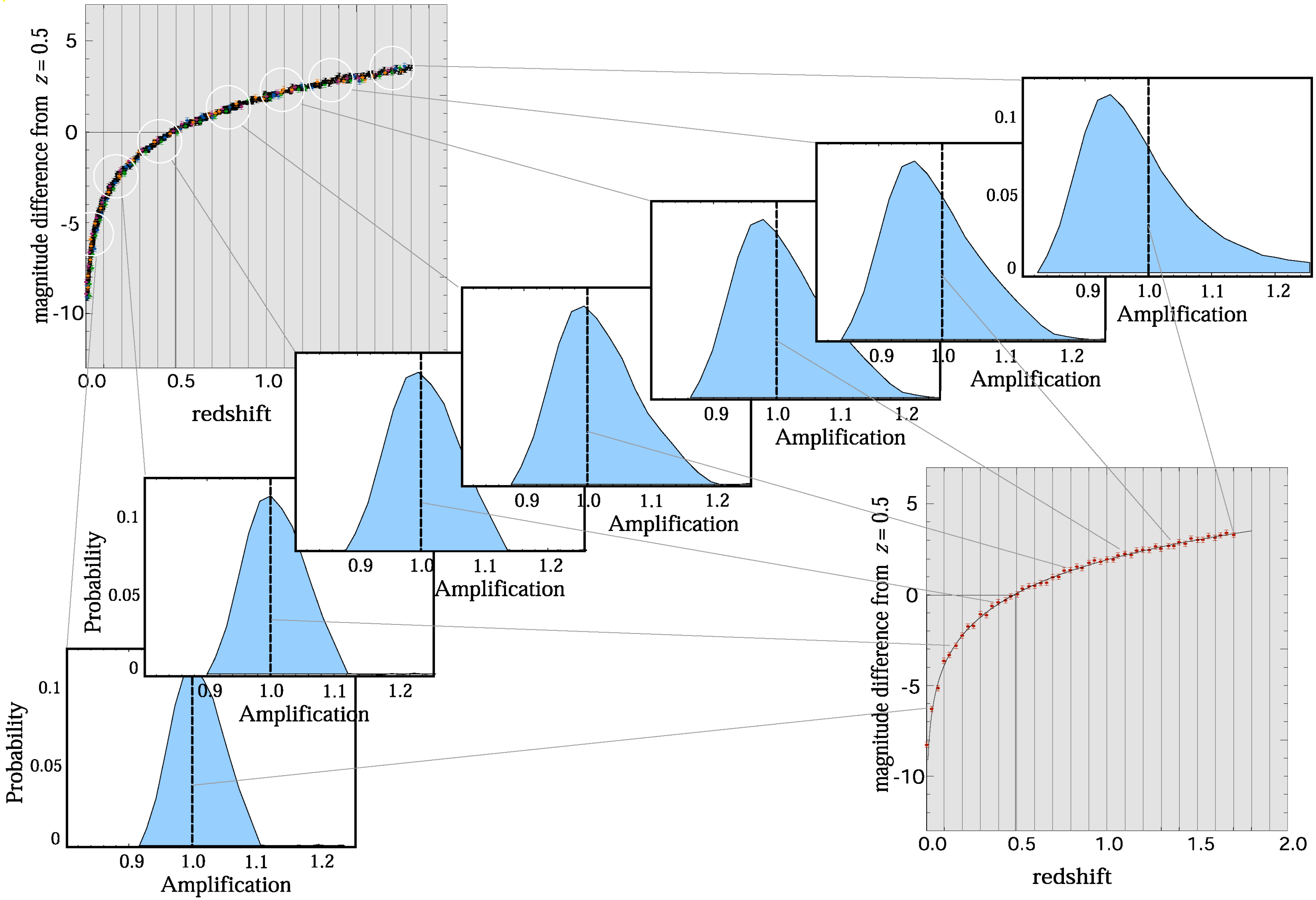


SEAM

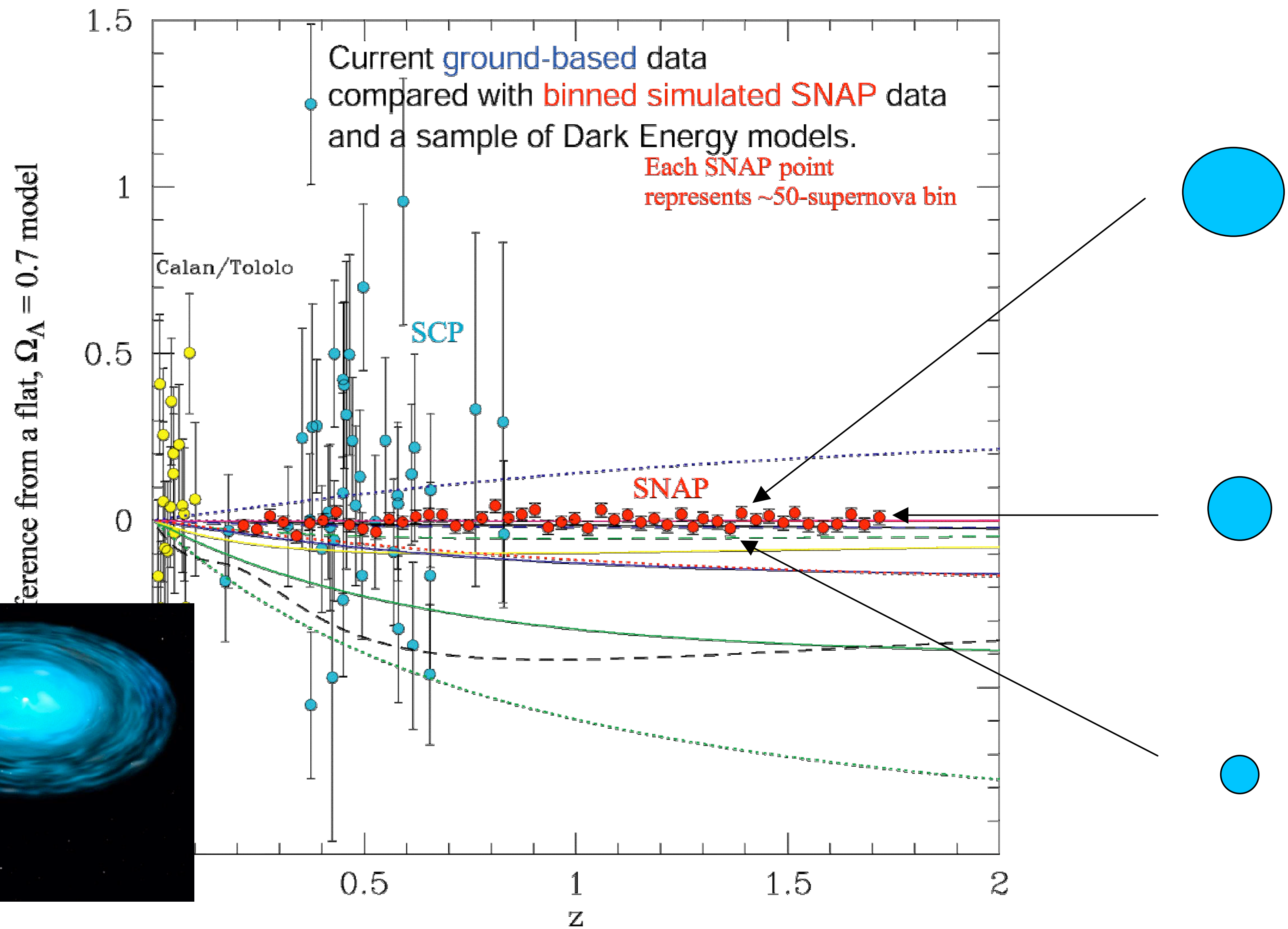
~ 10% distance

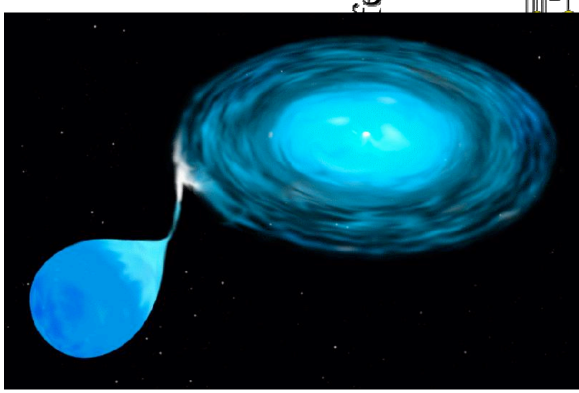
Lensing & the Hubble Diagram

3 Fit/average lensing distributions to construct redshift-binned Hubble diagram:



Future Hubble Diagram?

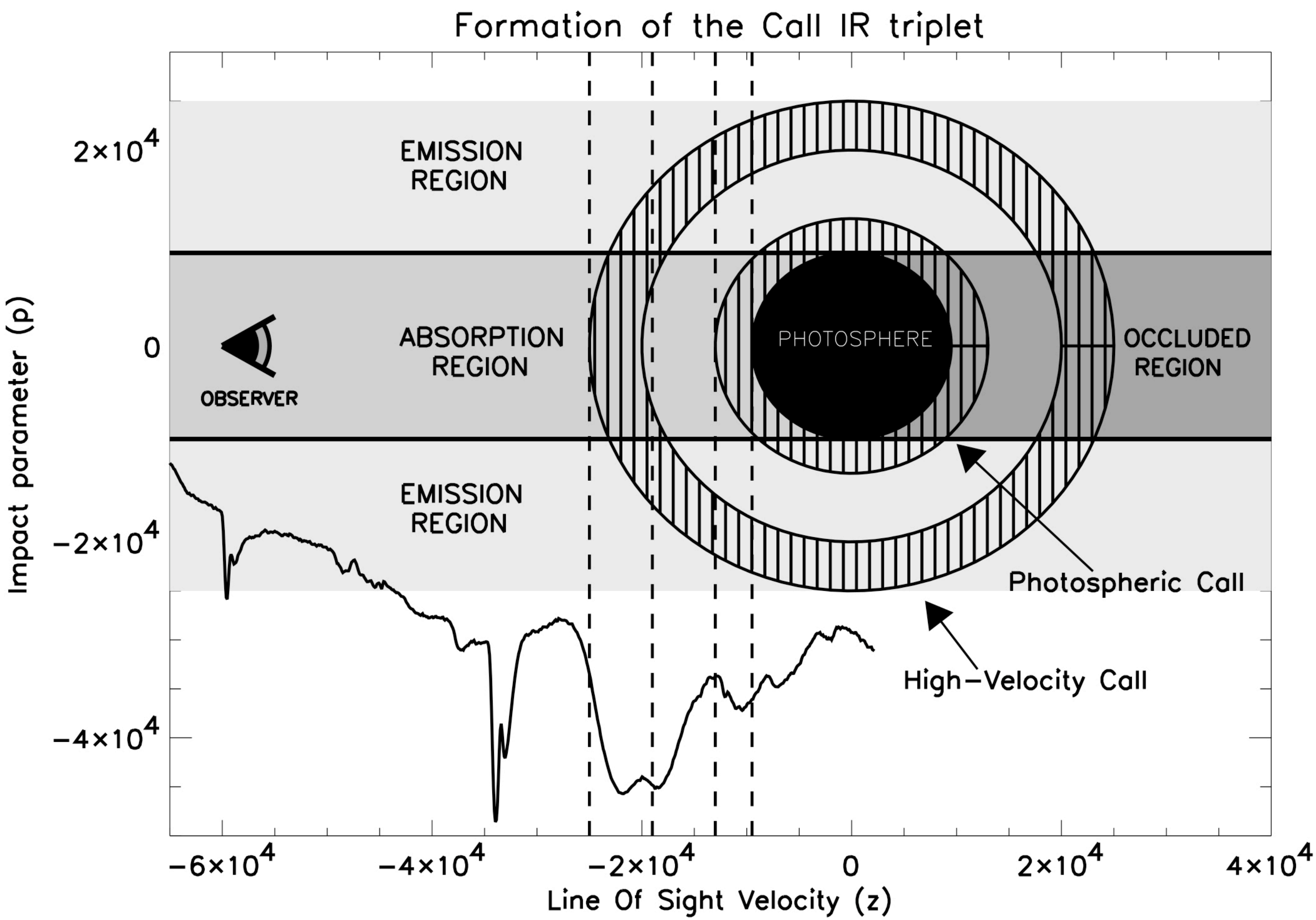




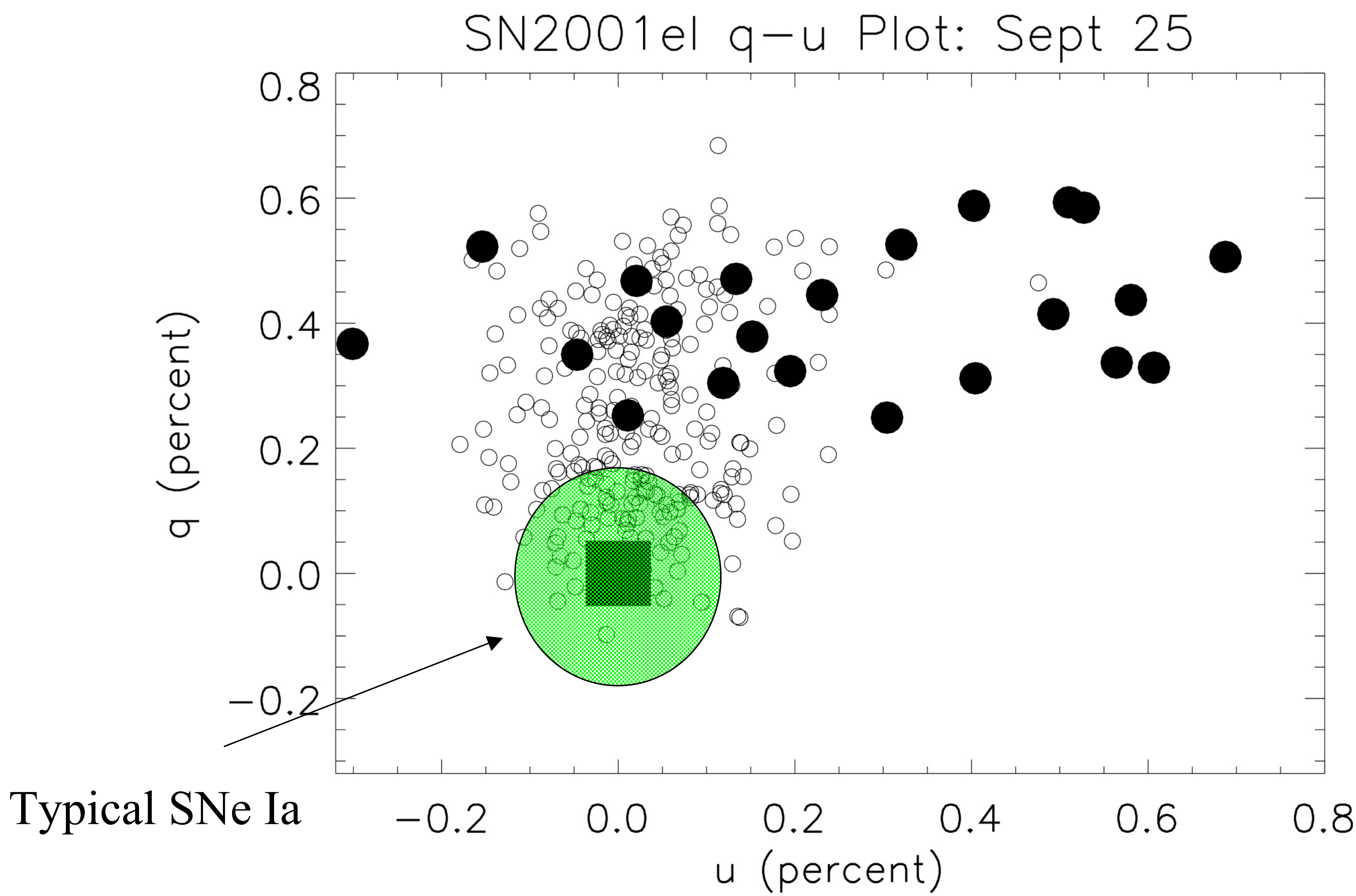
Evolves with Age of Universe?

based on
Weller & Albrecht (2001)

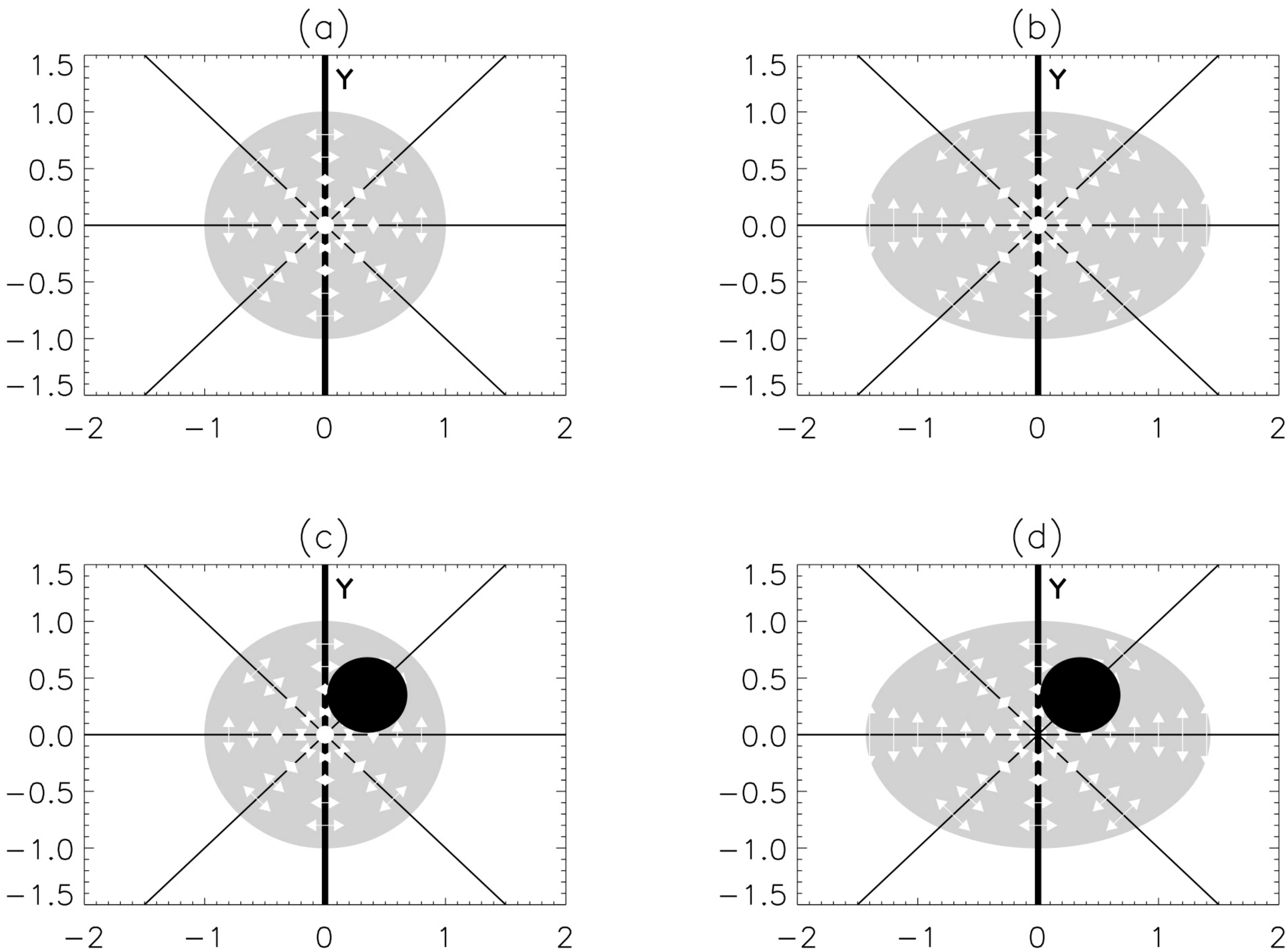
SN 2001el Flux Spectrum



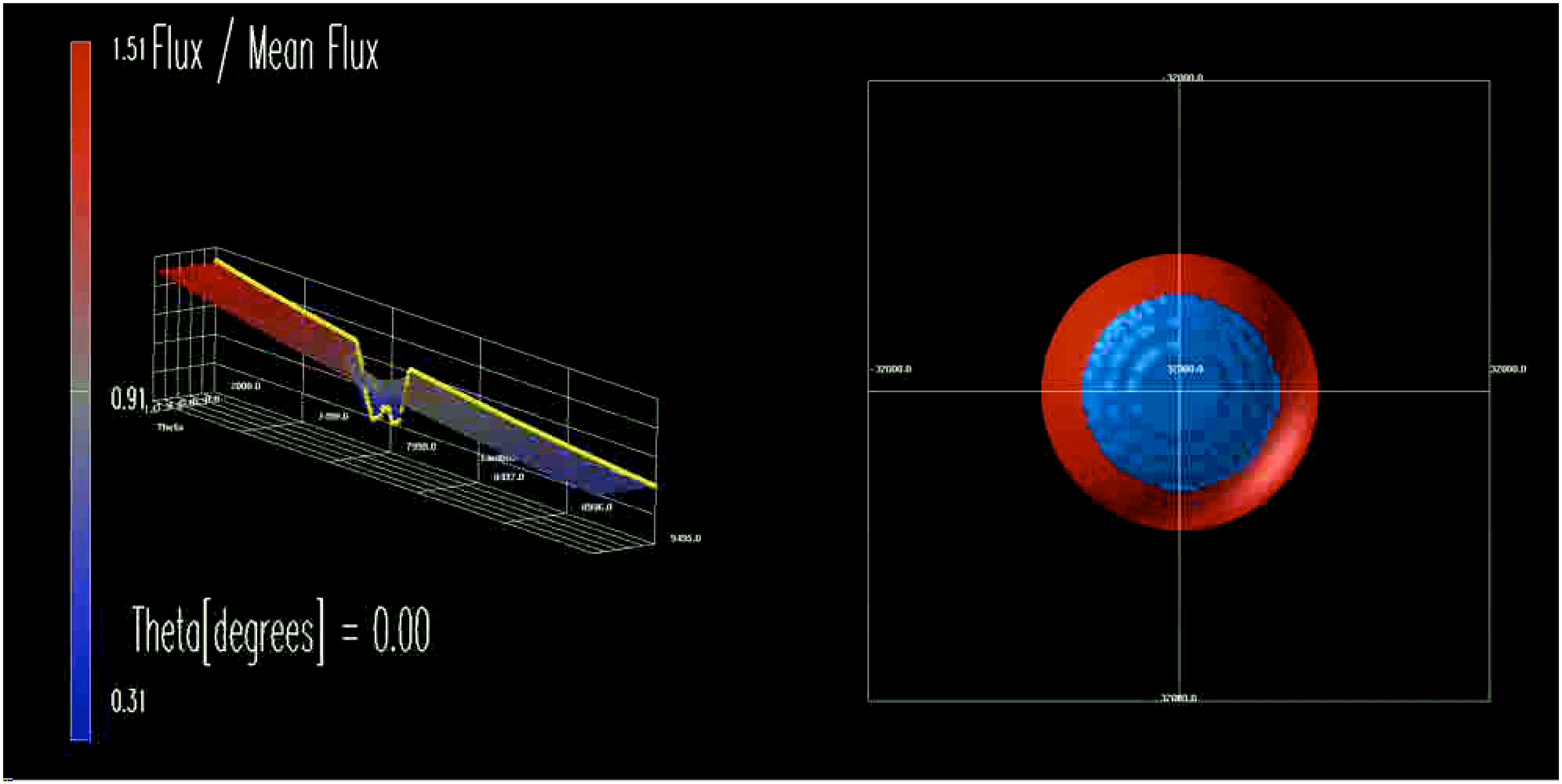
SN 2001el Polarization



Q, U and P



Clump



Clump