

**Using Adaptive Optics and
Supernovae to Unlock some of
the Secrets of the Universe**

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Supernovae

- **Brighter than a nova**
- **Explosions of stellar systems where the inputs are destroyed and/or transformed**
- **Bright! ($-13 > M_v > -32$)**
- **Point sources!**
- **Track Star formation**

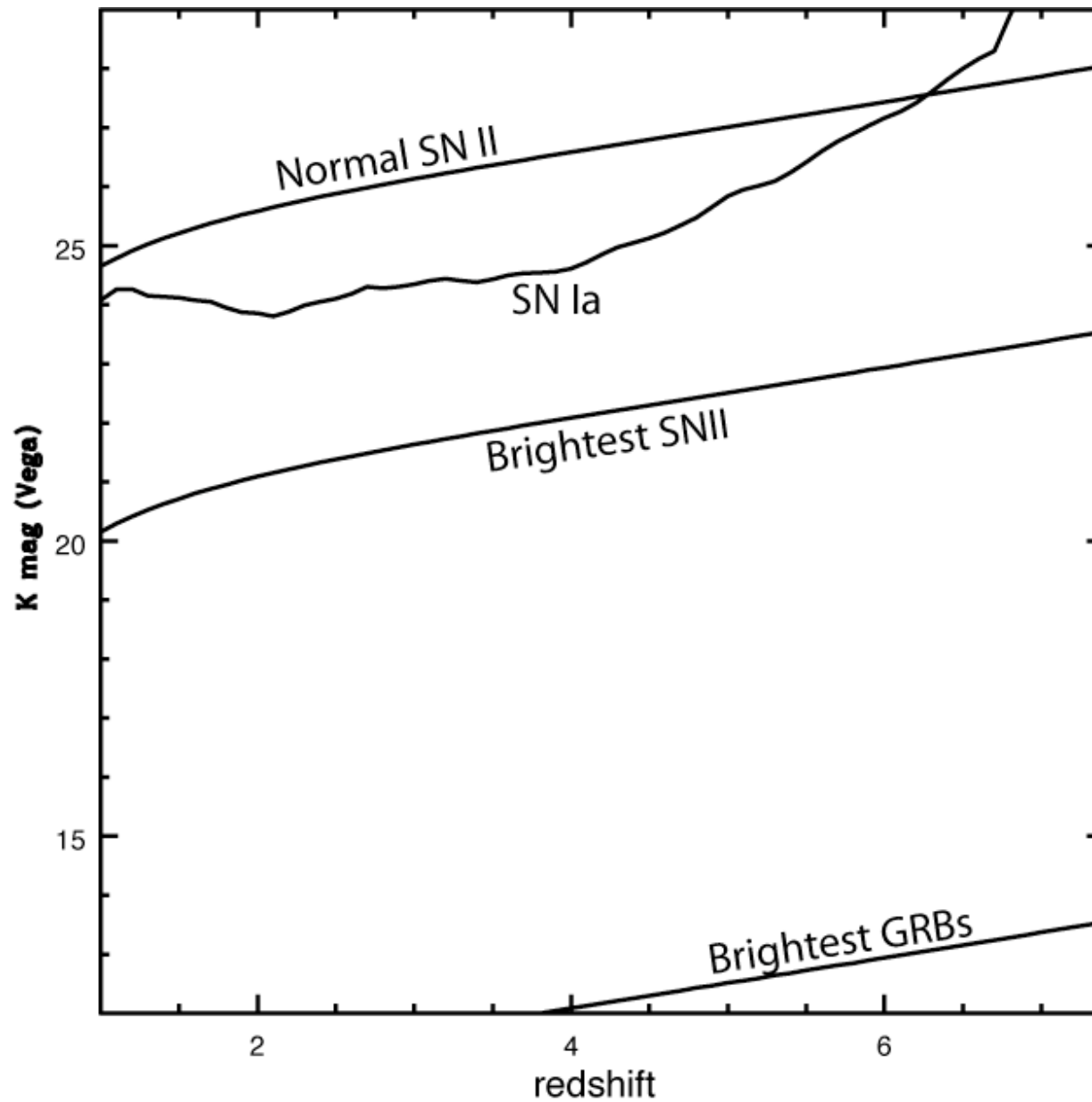
Types of Supernovae

Thermonuclear Detonations (SN Ia)

Core Collapse

- **SN II** (hydrogen envelopes, powered by shock deposited energy)
- **SN Ib/c** (C/O or He envelopes), powered by ^{56}Ni production and some shock energy
- **II-n** (Circumstellar Matter Dominated)
- **GRBs** (jet powered stripped envelopes)
- **???**

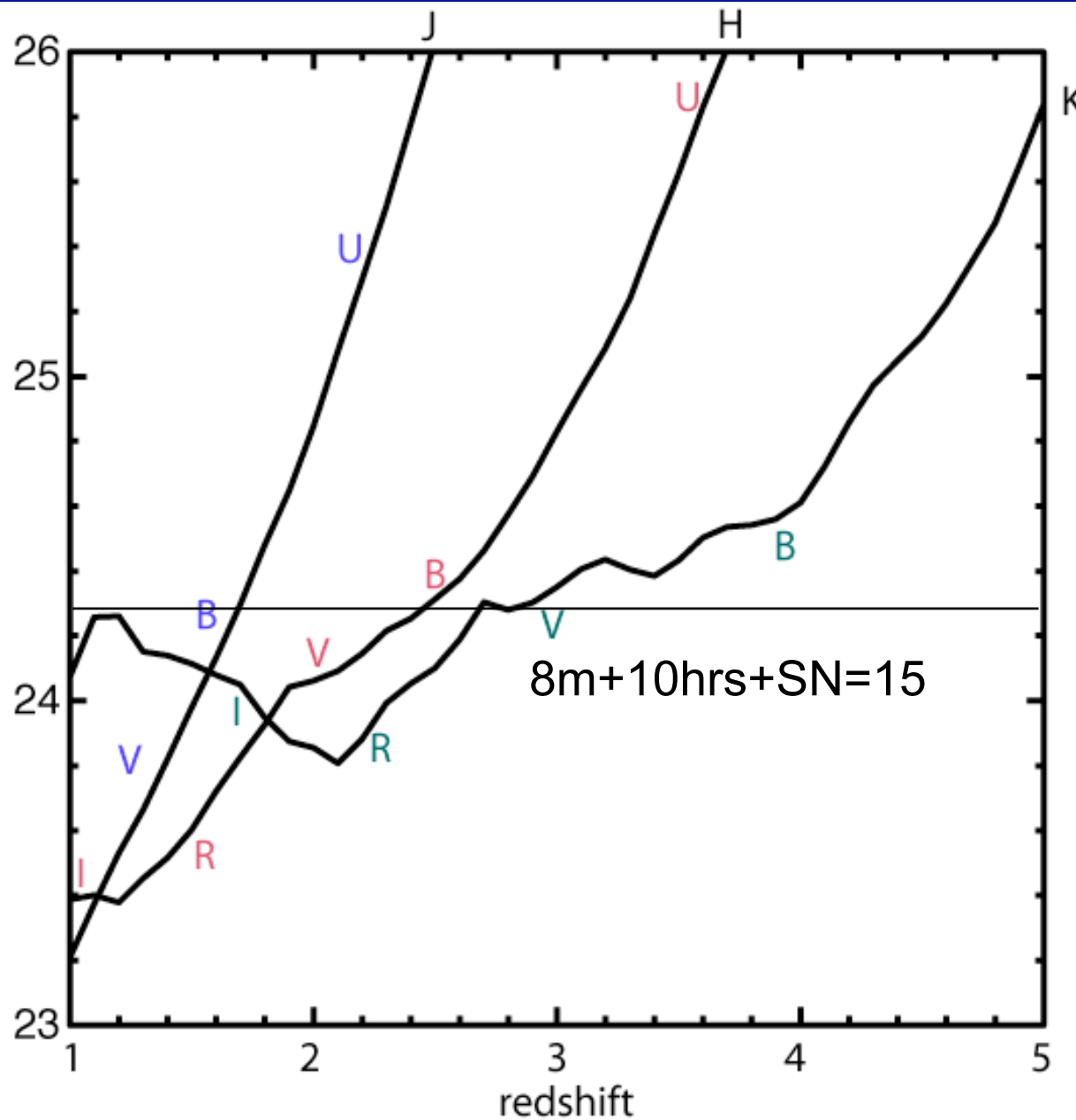
Brightness of SN



Type Ia SN

- **Basic Model: White dwarf accretes from a subgiant or Giant and exceeds $1.38 M_{\odot}$. But could be merger of two white dwarfs**
- **Has long and relatively short time scale as seen from the galaxies it explodes in.**
 - **Seen in old-dead Ellipticals (but rare by Mass)**
 - **Much more frequent (by Mass) in star forming galaxies**
- **Very Popular in Cosmology circles for measuring distances**
- **But very important in Chemical enrichment.**

Type Ia brightnesses

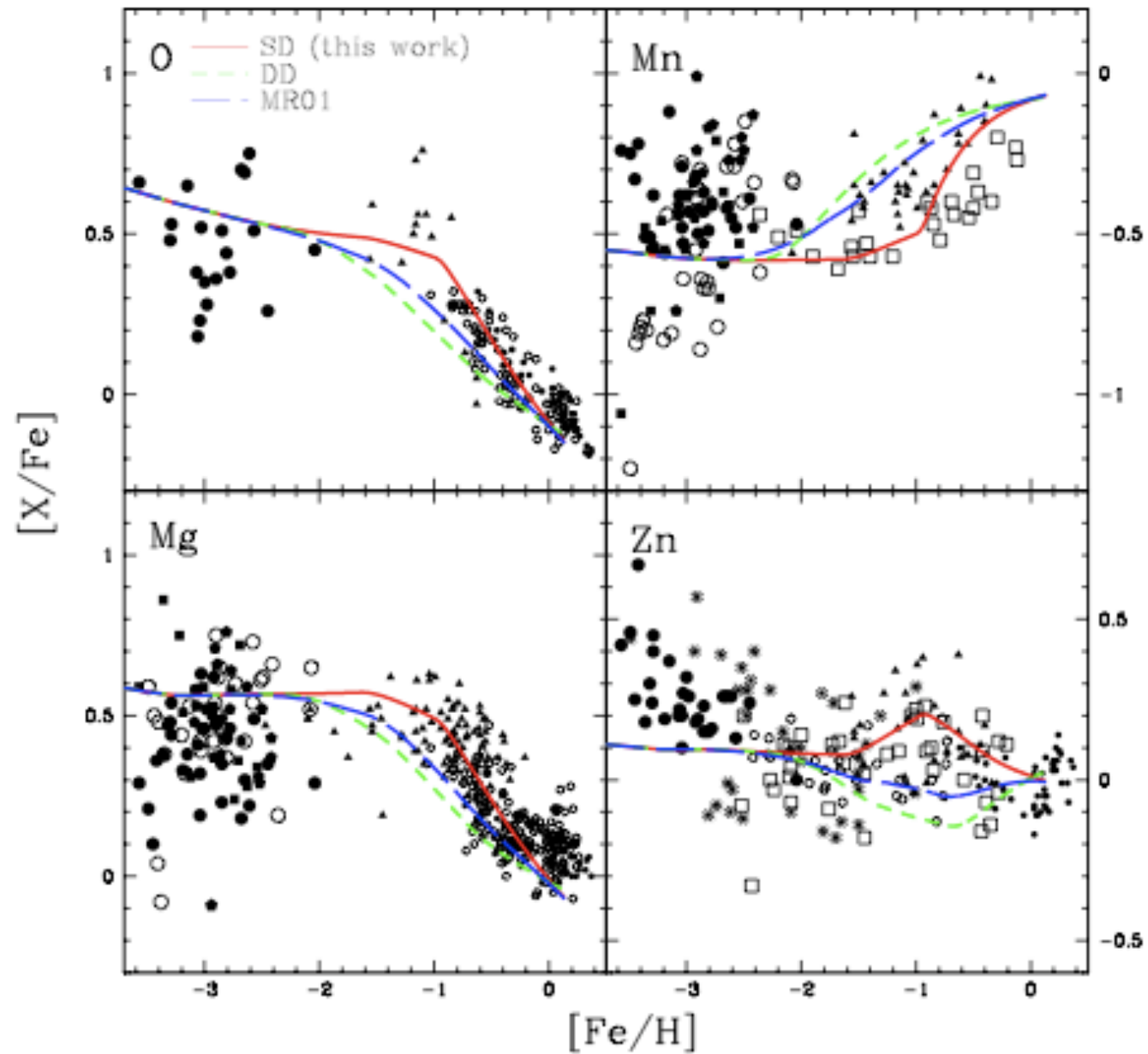


Project: Cosmology with SN Ia

- **Extend SN Ia distances to $z > 1$ to look for depending on your perspective...**
 - **early time evolving Dark Energy (crazy theorists)**
 - **independent measure of Ω_M (Cosmological number crunchers)**
 - **Evolution of SN Ia population (Skeptics..me!)**
- **Current SN Ia data extend to $z=1.2-1.5$ but data are really very poor, despite the HST salesmanship.**

Project

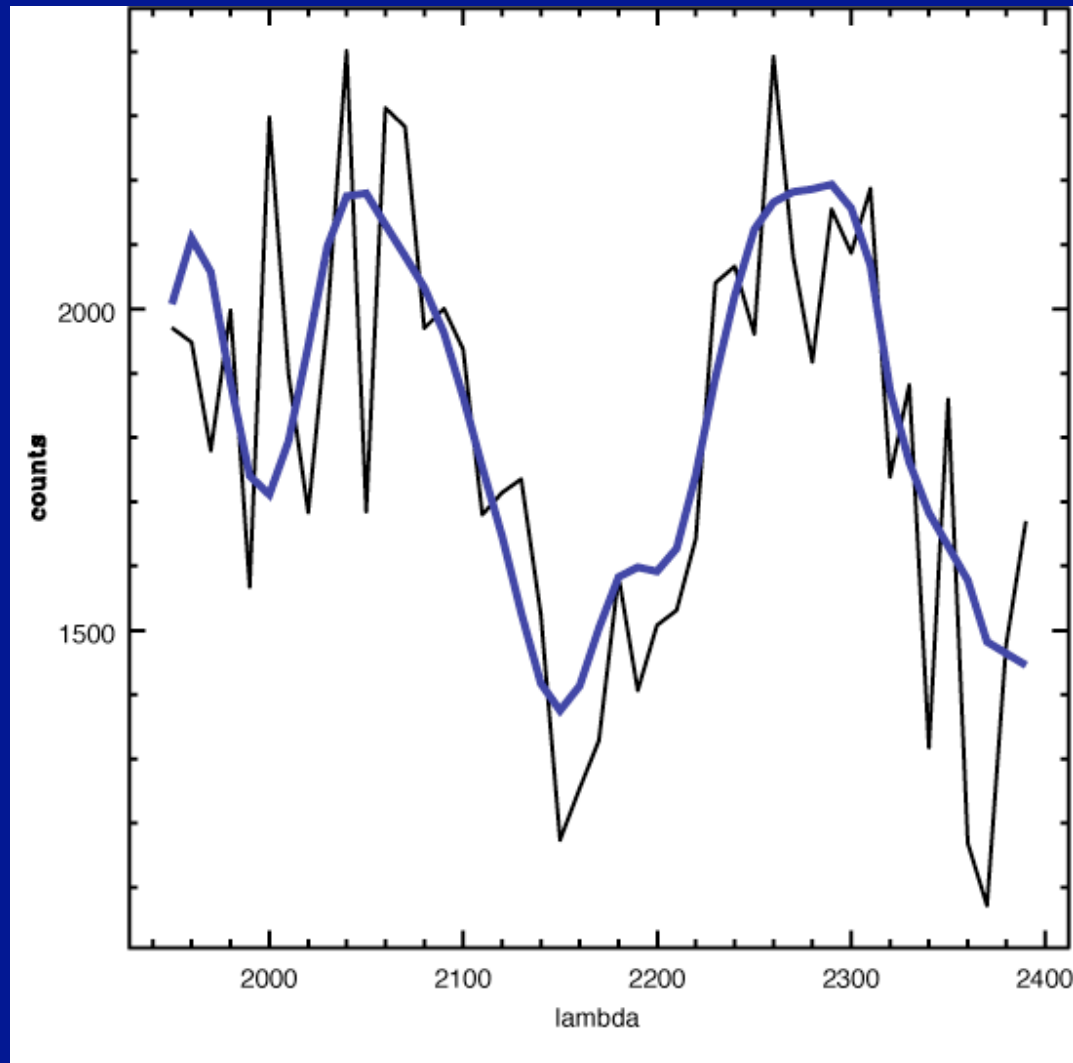
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Project: SN Ia

- **Requirements:**
 - **SN Discovery**
 - **SN Photometry (5% requirement)**
 - **SN Spectroscopy (R=300) for redshift and type confirmation.**
- **Plan: Discovery is straightforward (JWST) or MCAO on ELTs ... ~ 1 per 10sq arcmin per month**
- **spectroscopy is harder, work between the lines, then bin up to required resolution**

20000s, 22m R=200

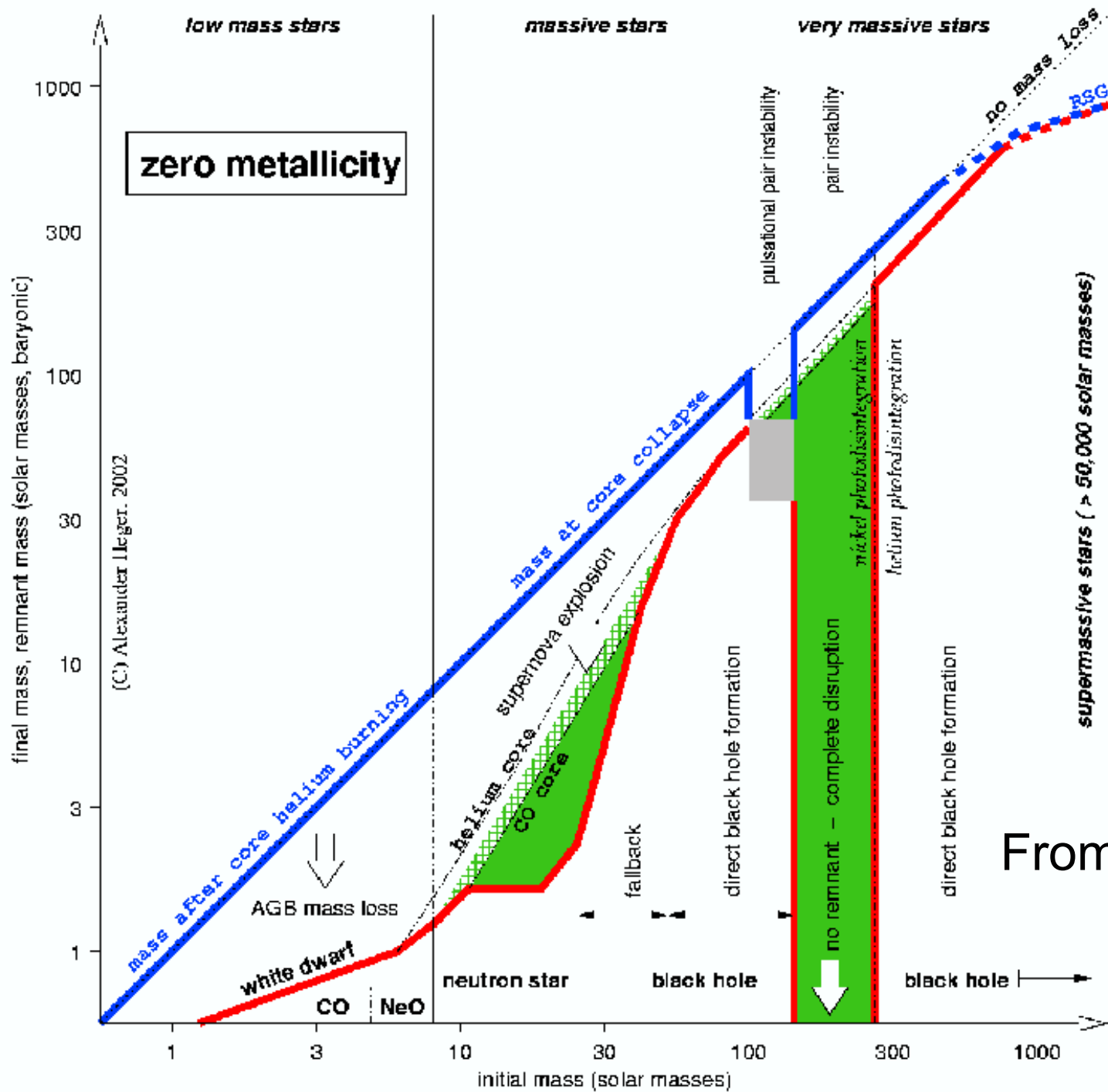


Using Bright SN to probe the First Stars

- **SN track star formation, and they are by far the easiest things to track the first stars**
- **Hydrogen dominated SN are bright in the UV, have broad features, and are suitable continuum sources to undertake absorption spectroscopy to measure chemical abundances and kinematics and see how galaxies are built up.**

First Stars

- **Detection...**
 - **Measure redshift from Gunn-Peterson effect. (K-band)**
- **But what are we going to detect?**



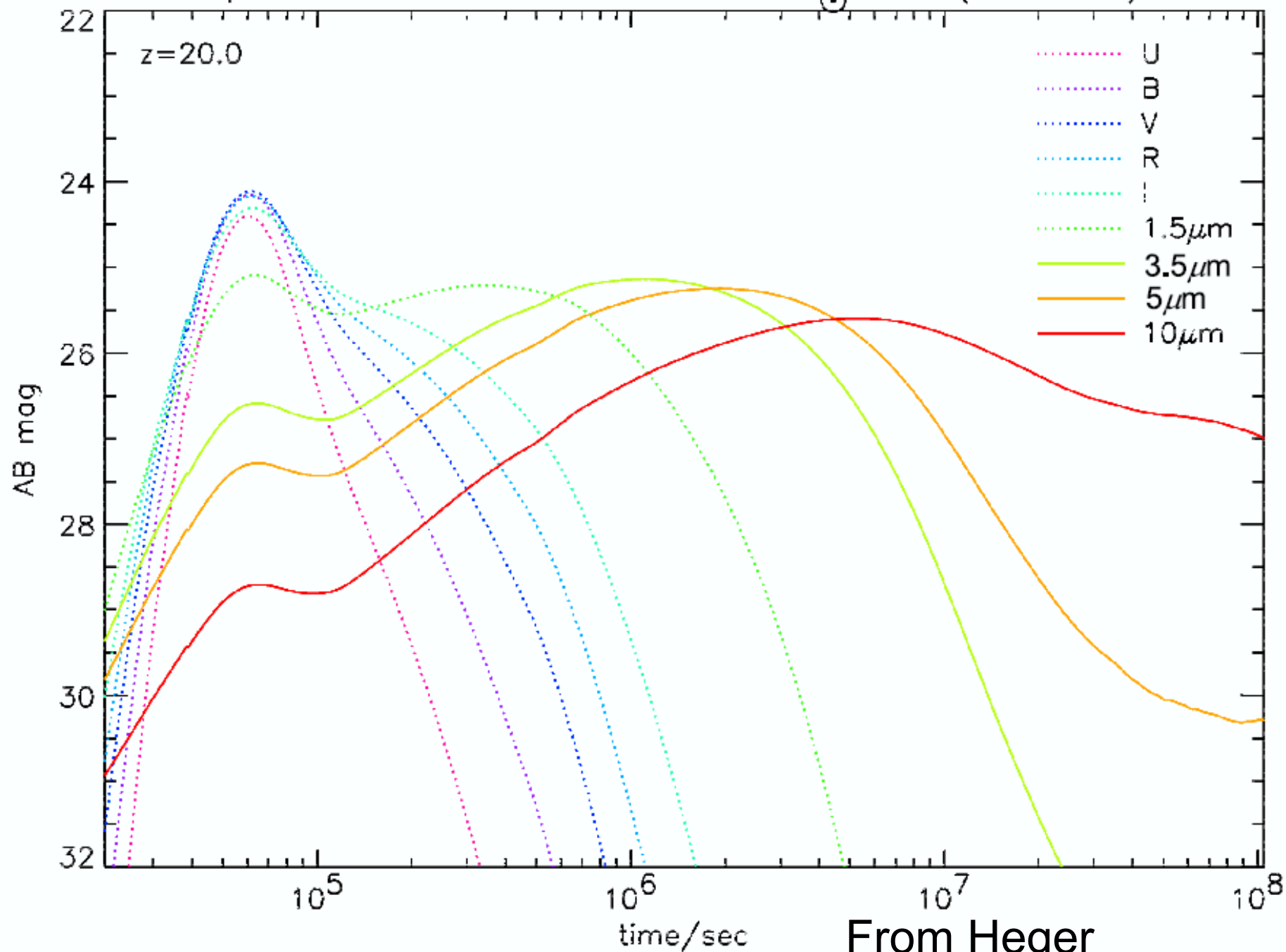
From Heger

A Possibly Overly Optimistic Theorists Version

- **250 M_{\odot} Metal free star that explodes via pair-production mechanism**
- **50 M_{\odot} ^{56}Ni and 10^{53} ergs of energy**
- **Assuming 10^{-6} of all baryons explode as these objects, at $z=20$, event rate could 100 objects/sq degree/yr.**

From Heger

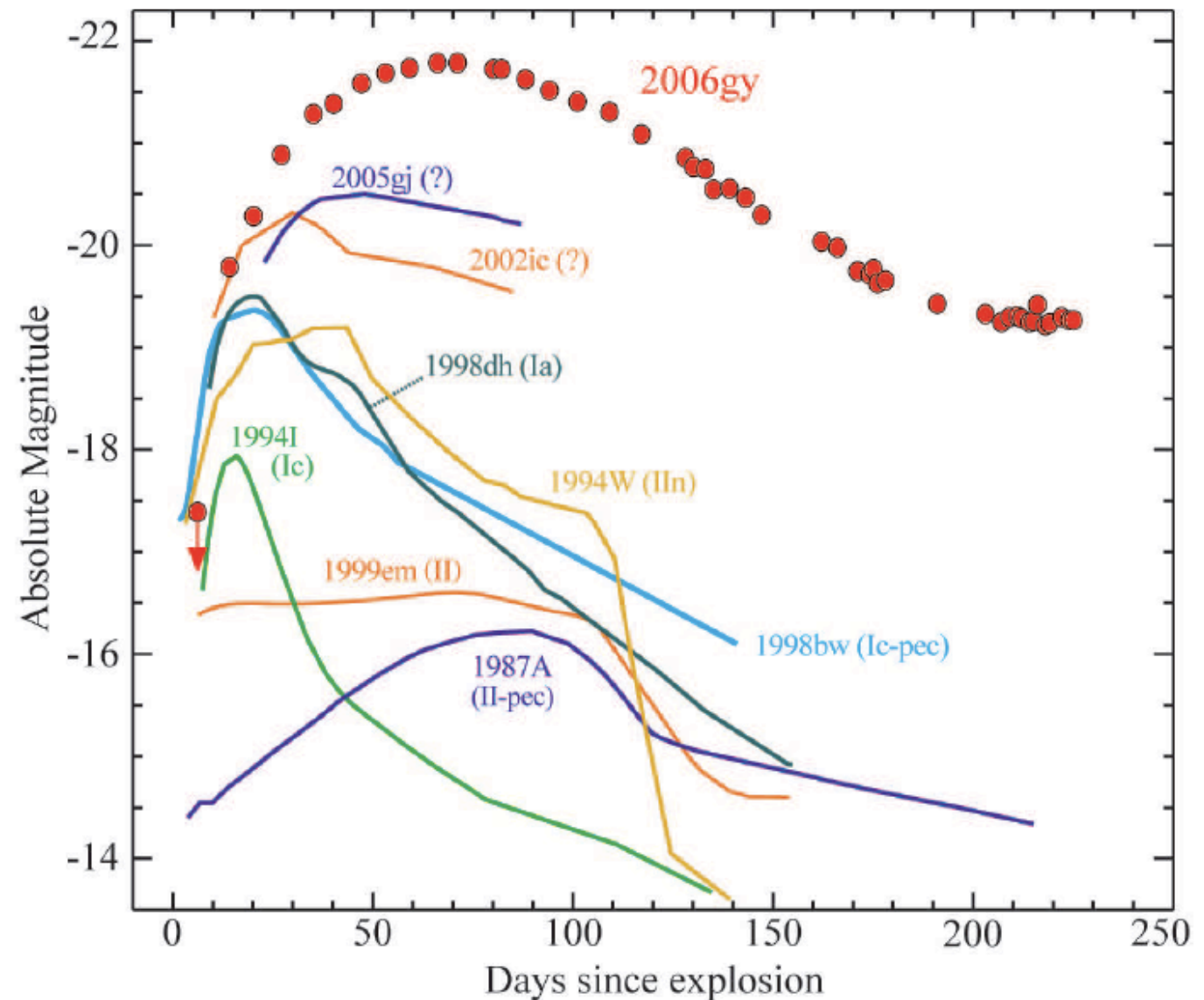
pair-SN of a metal-free $250 M_{\odot}$ star (64.5 foe)

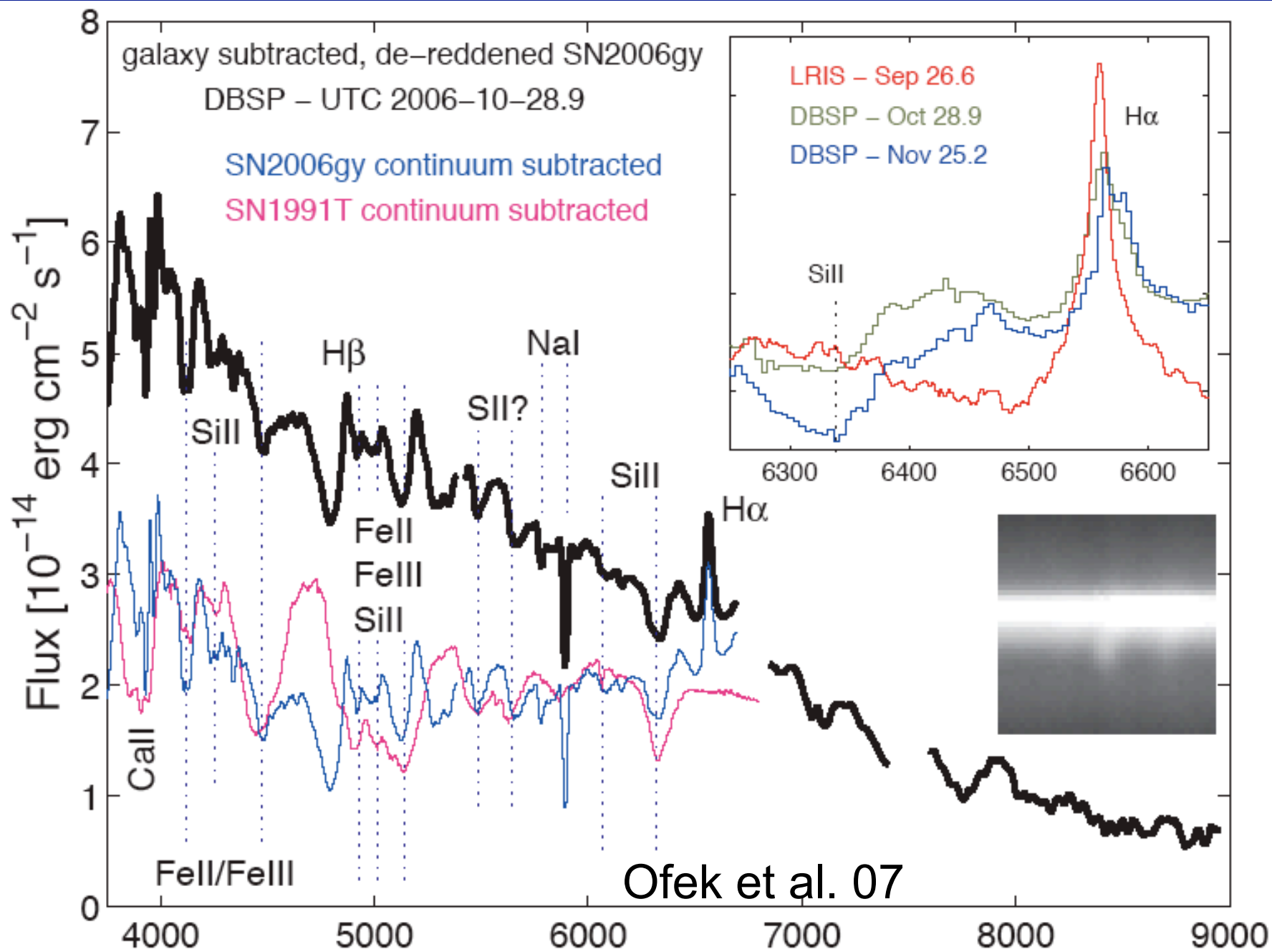


SN 2006gy - sort of looks right.

- unclear yet if this is a pair-production SN. But shows what might exist.

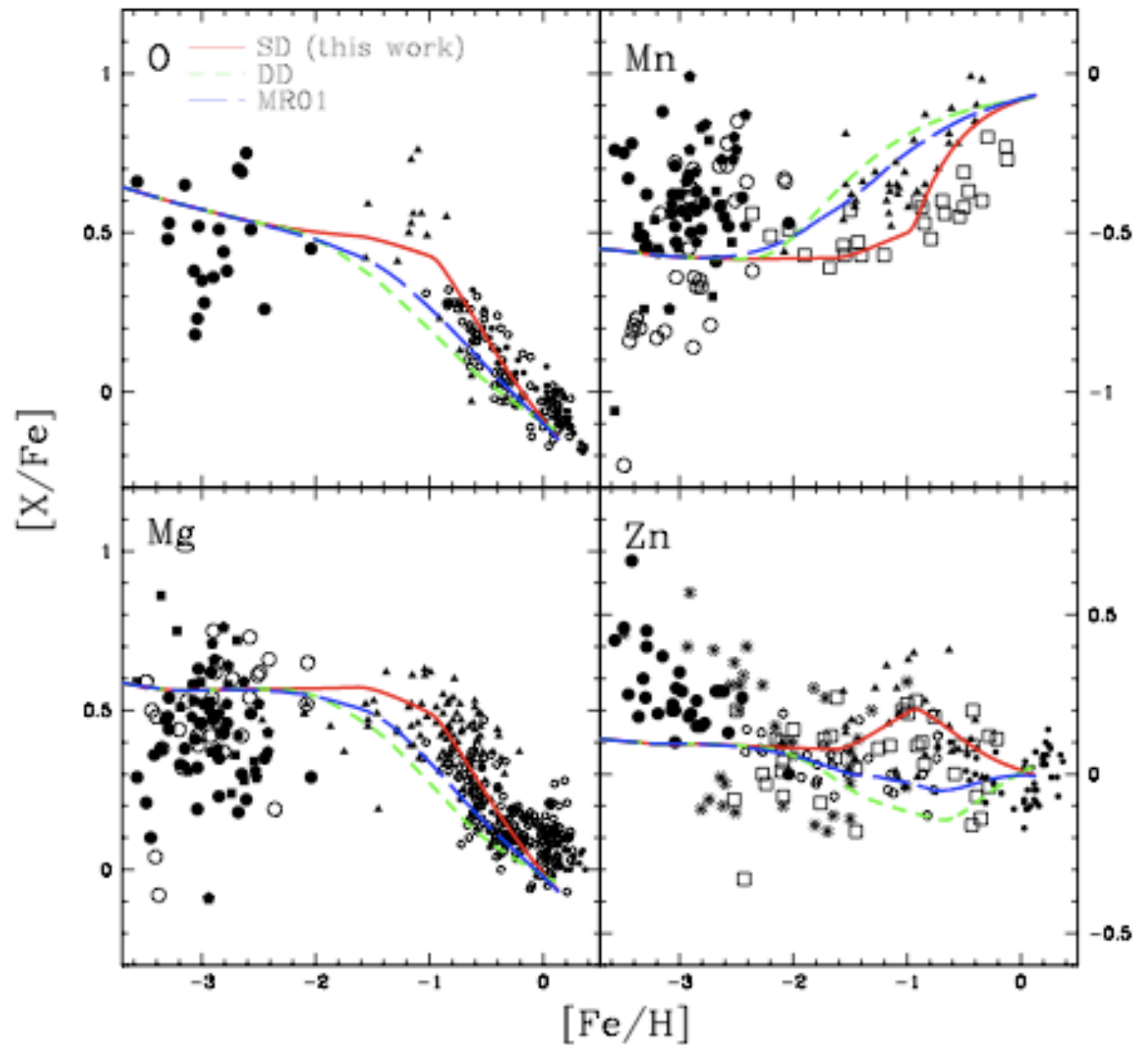
Smith et al 07





Chemistry of Stars at $Fe/H < -2.5$ is consistent with relatively normal (e.g. not Pair-Production) SN.

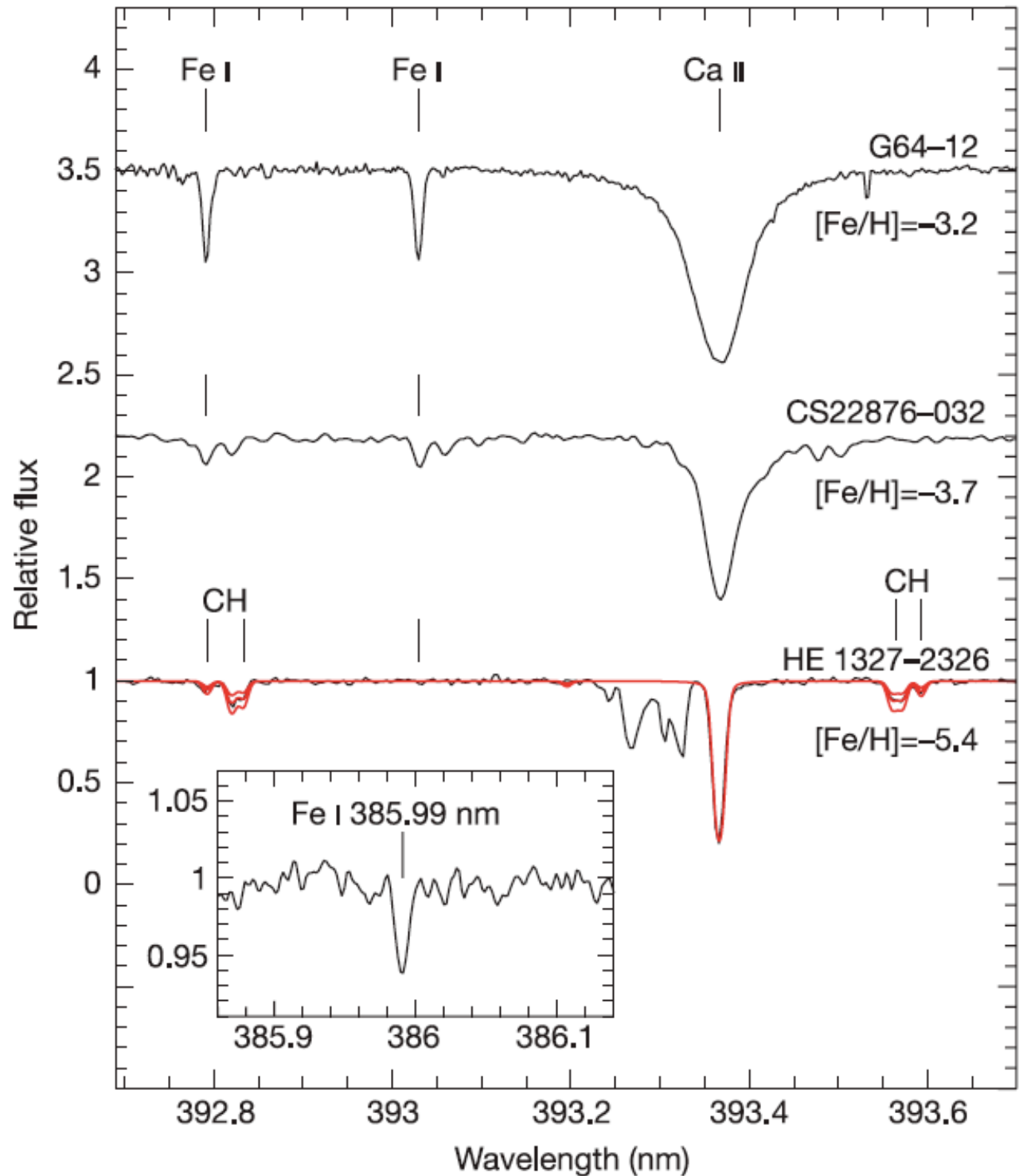
My best guess is that most SN at high- Z will be your run-of-the-mill objects and consequently very hard to see!



The most metal-poor stars show huge excess of Carbon and Oxygen, relative to Fe.

Might be these stars are unusual SN, but low Fe amounts probably means not bright objects.

In summary, we really are not sure what we are going to find until we look.

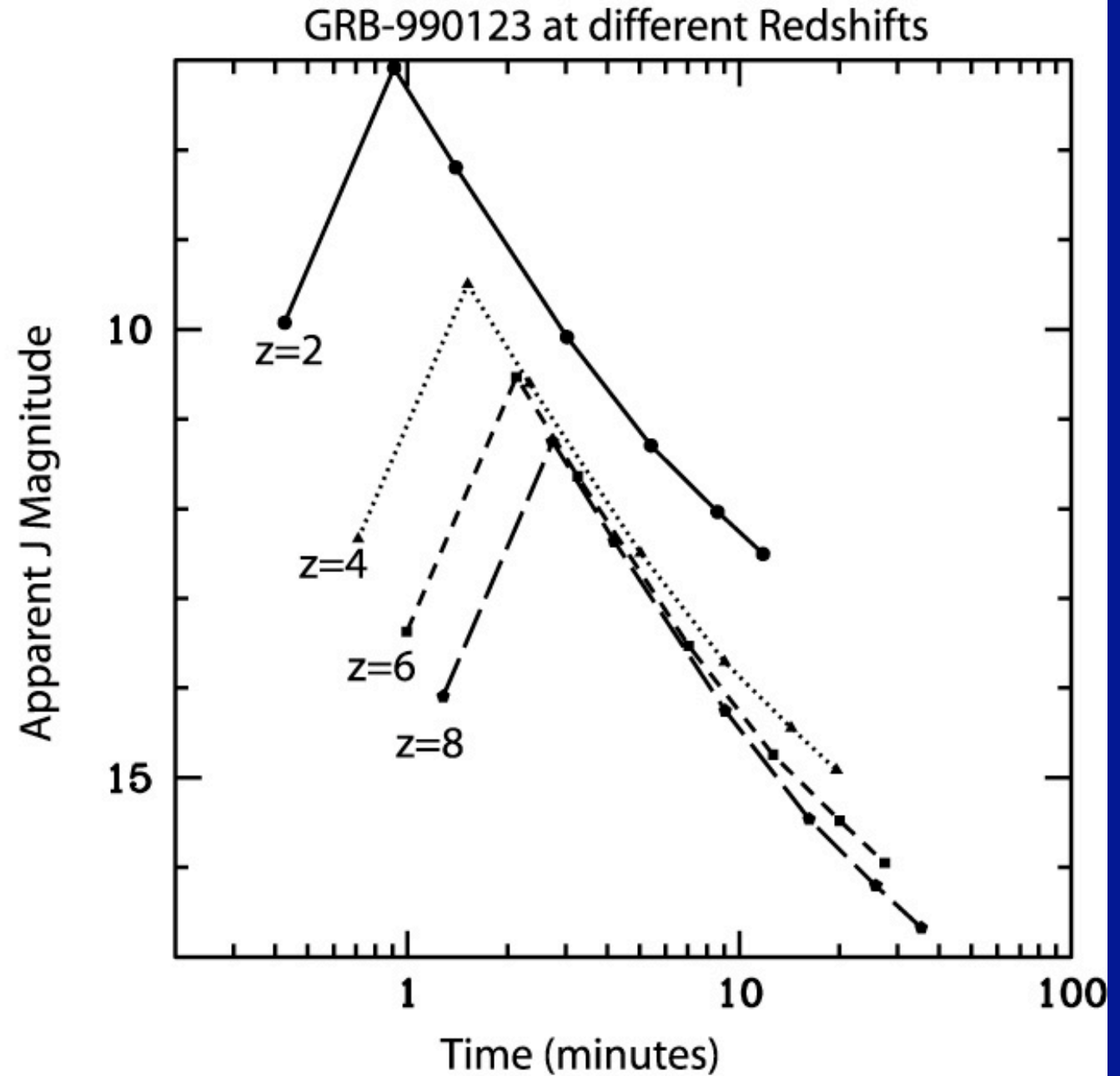


SN as Cosmic Beacons

- **Want $R > 2000$ (preferably $R = 30000$)**
- **Will take anything as a backdrop...**
 - **GRBs..Bright SN..**

**Already
we are
making
progress.**

..

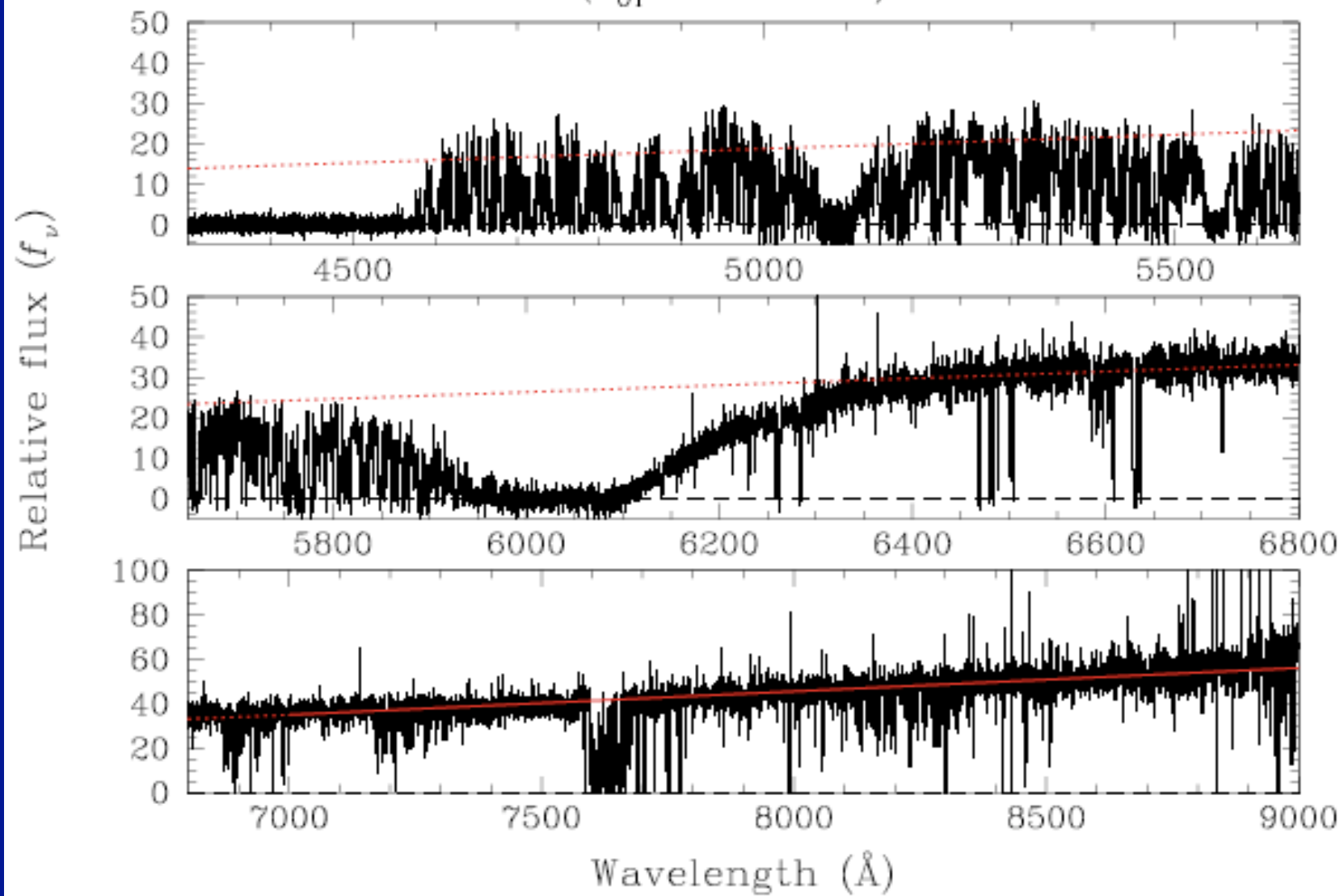


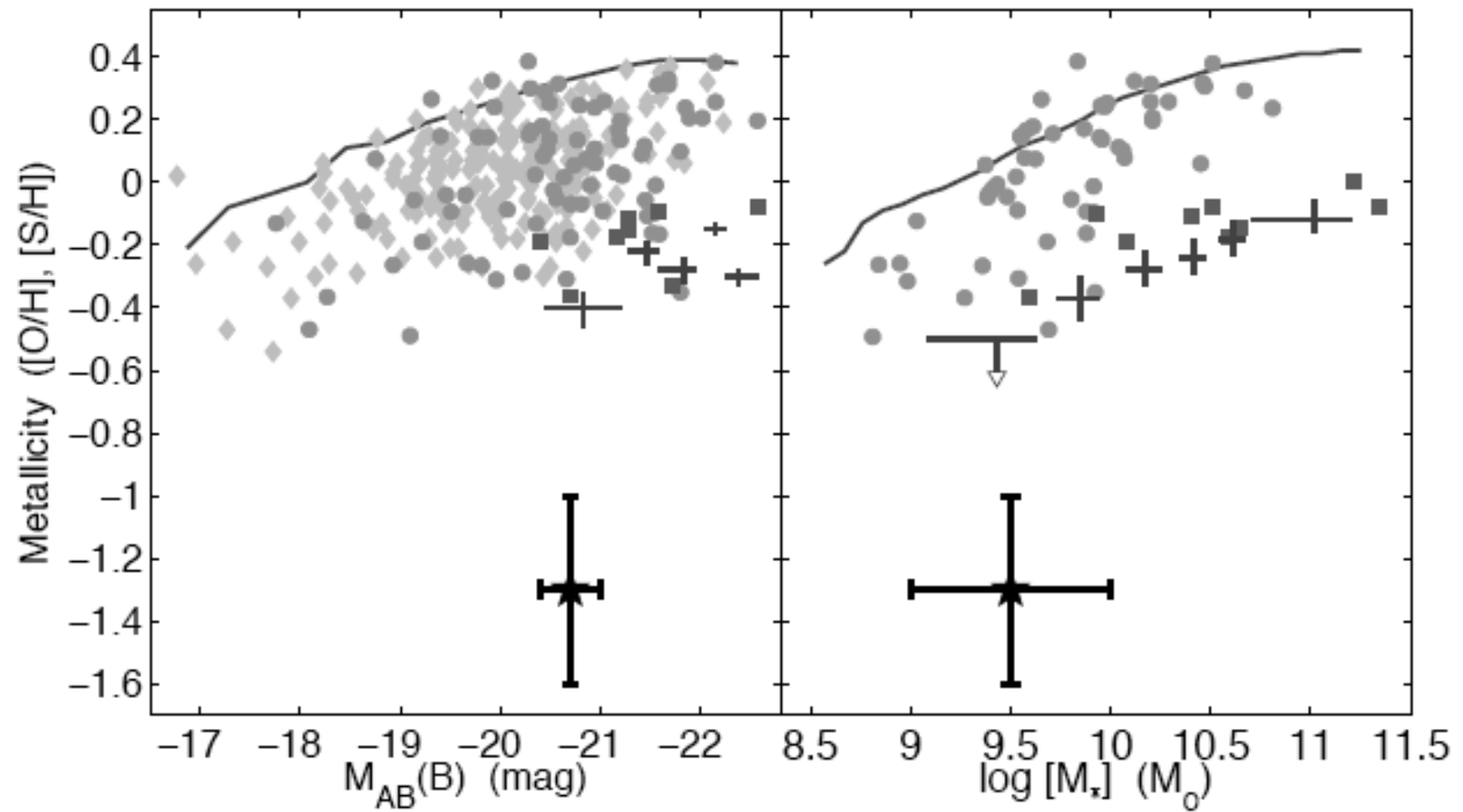
GRBs as backdrops

- **Rare...we have had 1 object in 3 years at $z > 6$**
- **Bright $J=15-20$ for several hours, and $J < 22$ for several days**
- **A0 + IR echelle on 8m could catch the next one, but ELTs could do many...if we can find enough of them in the future.**

Chen et al.

GRB050730
($z_{\text{OT}} = 3.96855$)



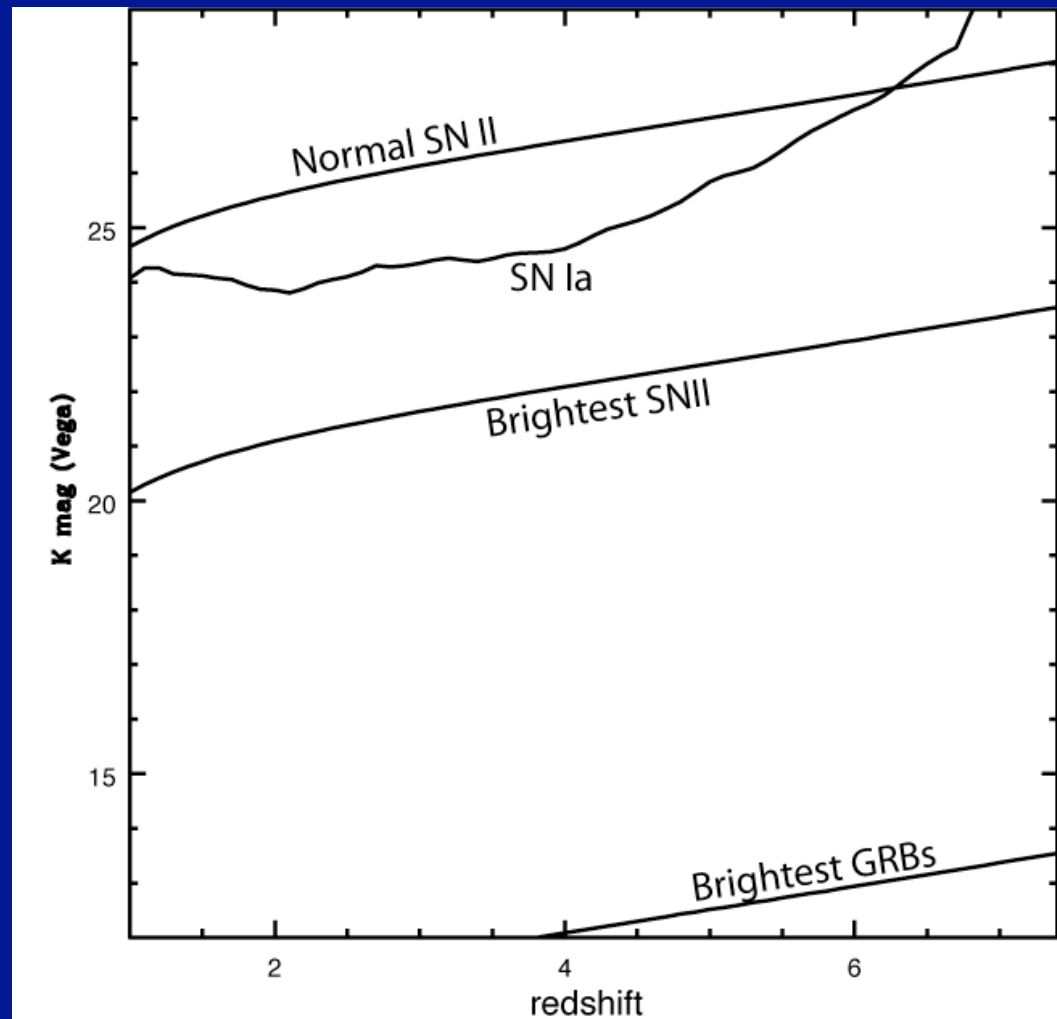


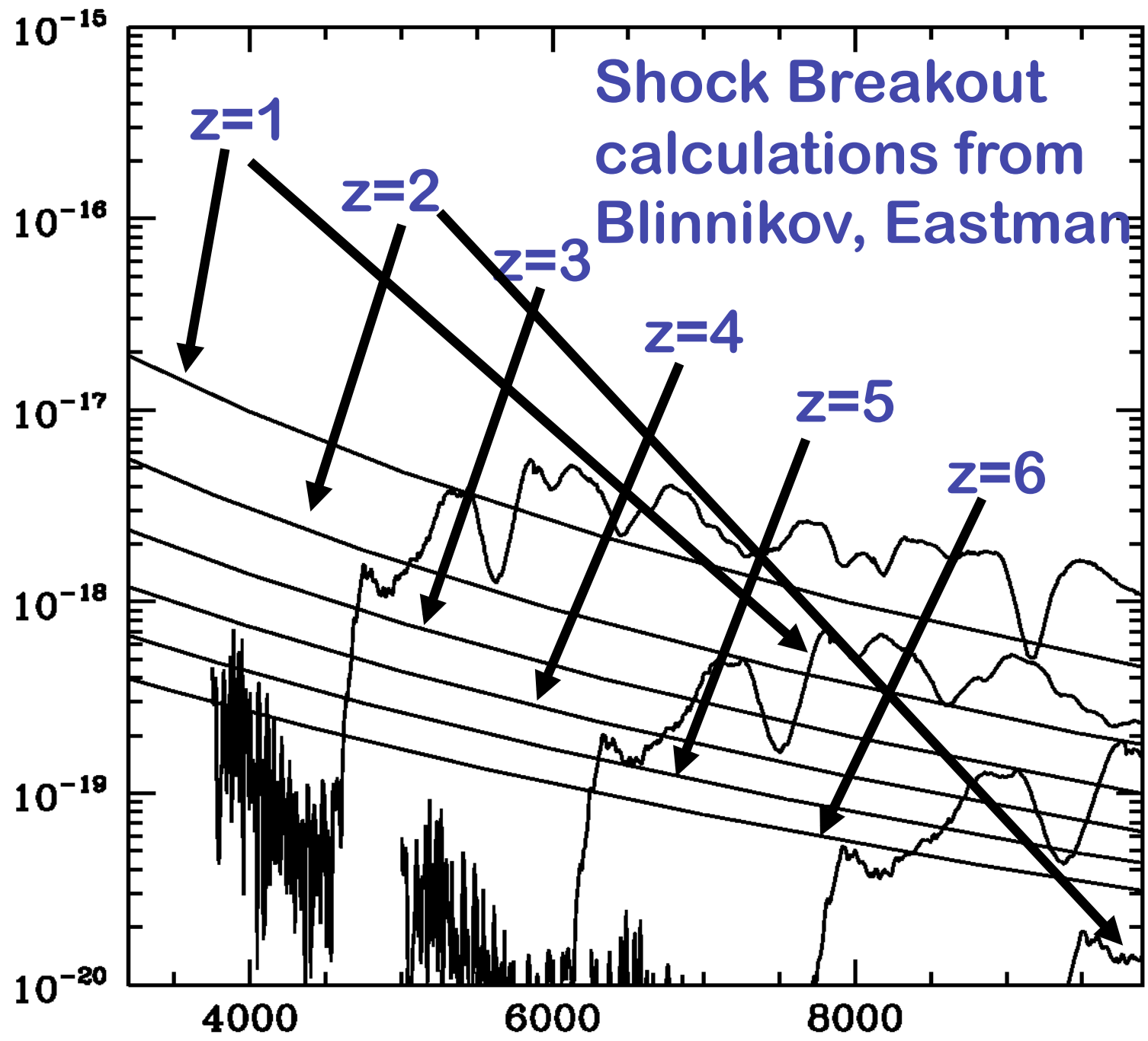
GRB050904 at 6.29, Kawai 06, Berger 06

What about supernovae at $z > 5$

If there are
bright SN II,
they can also
be used...

Echelle
spectroscopy
of $K=23$
objects





How much time

- in K-band, as near as I can tell, still sky-dominated between the lines at $R=40000$ (but close)...
- 80hrs on 22m gives $SNR=15$
- So possible - but just - and requires a hot A0-fed echelle spectrograph, and lots of time.

But will show us the birth of galaxies 13 Gyr ago