The relationship between SNe and their host galaxies

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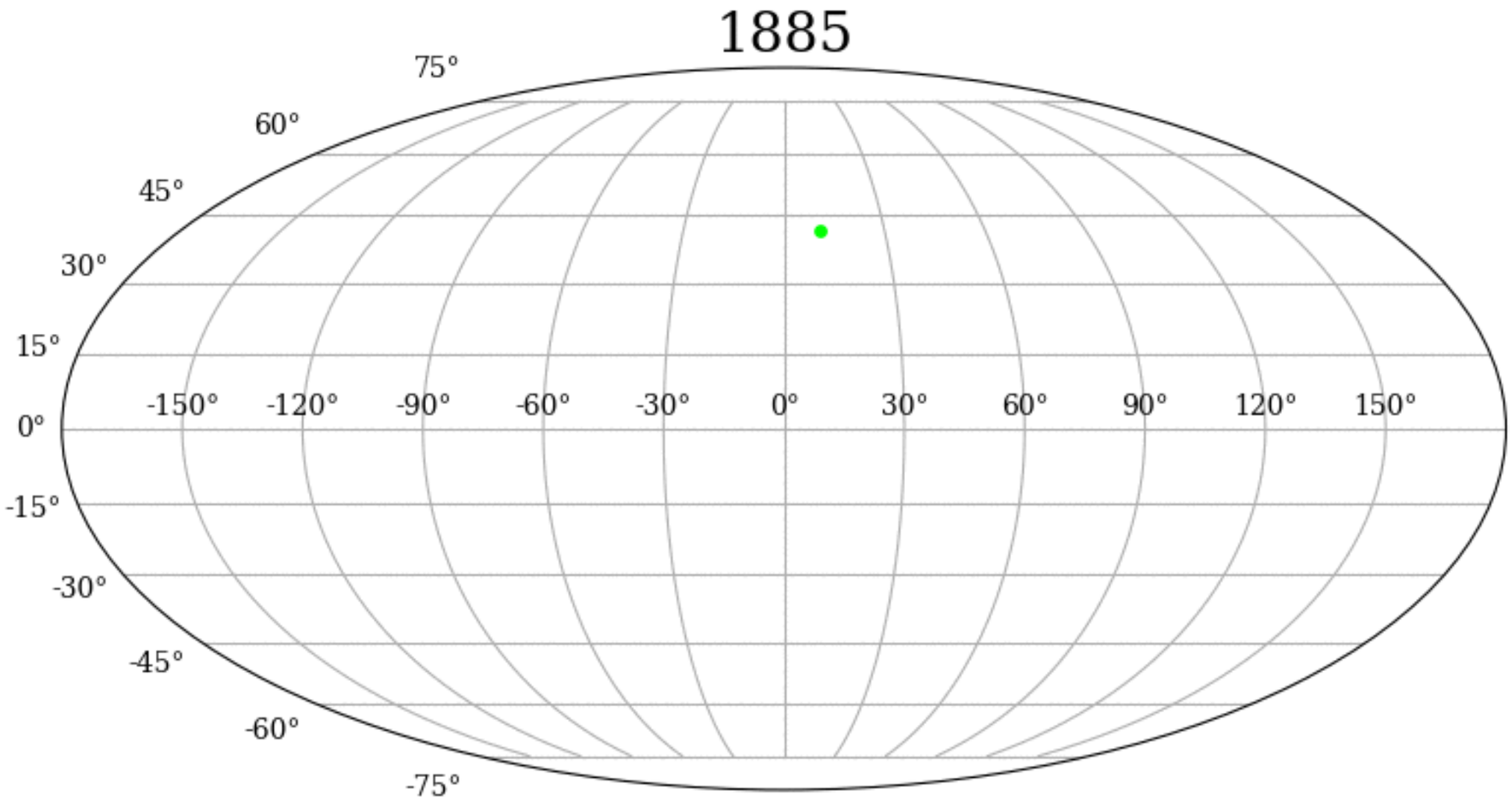
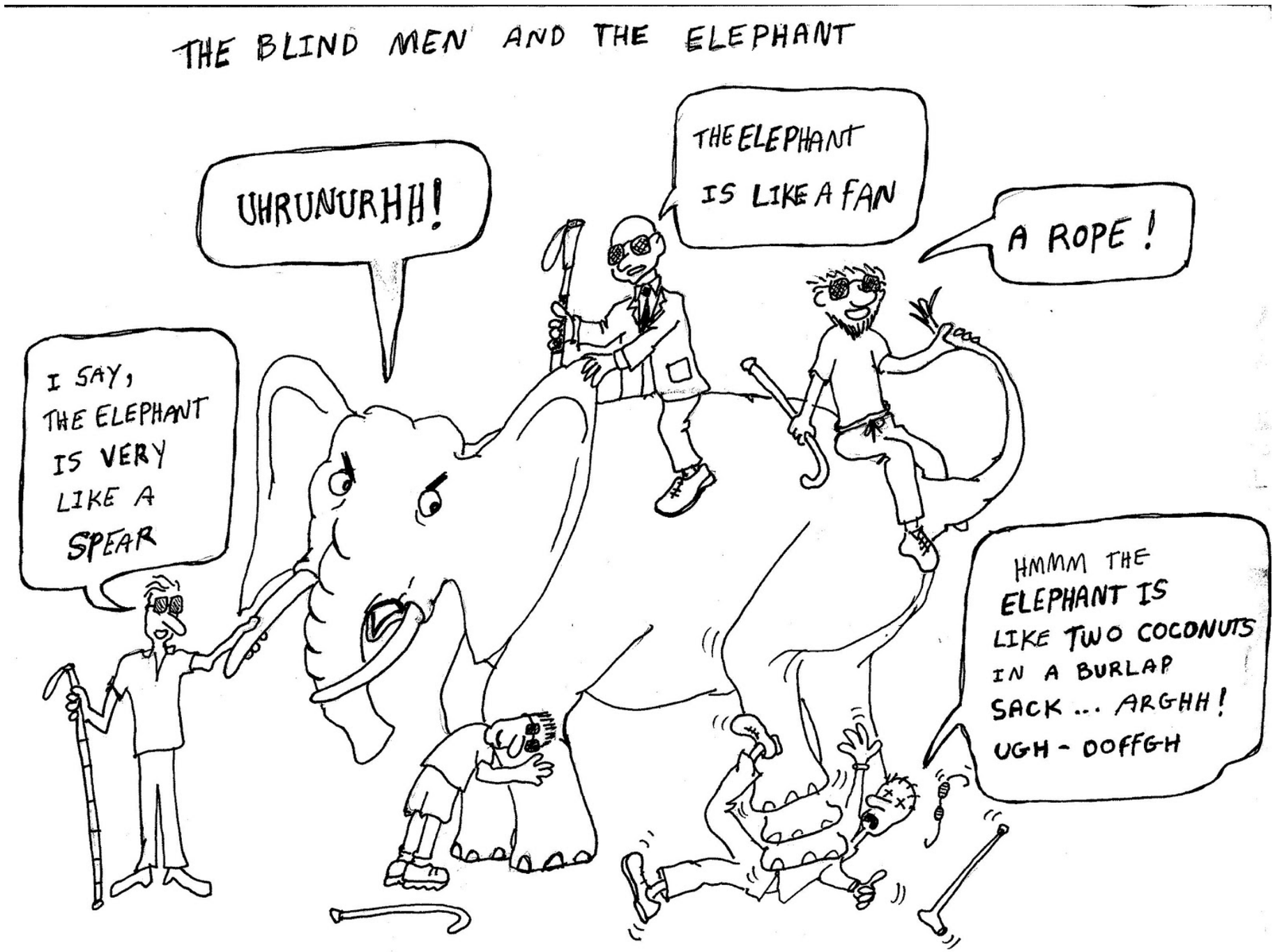
Golden age of transient astronomy



credit: Ravi Gupta

The blind men and the elephant …

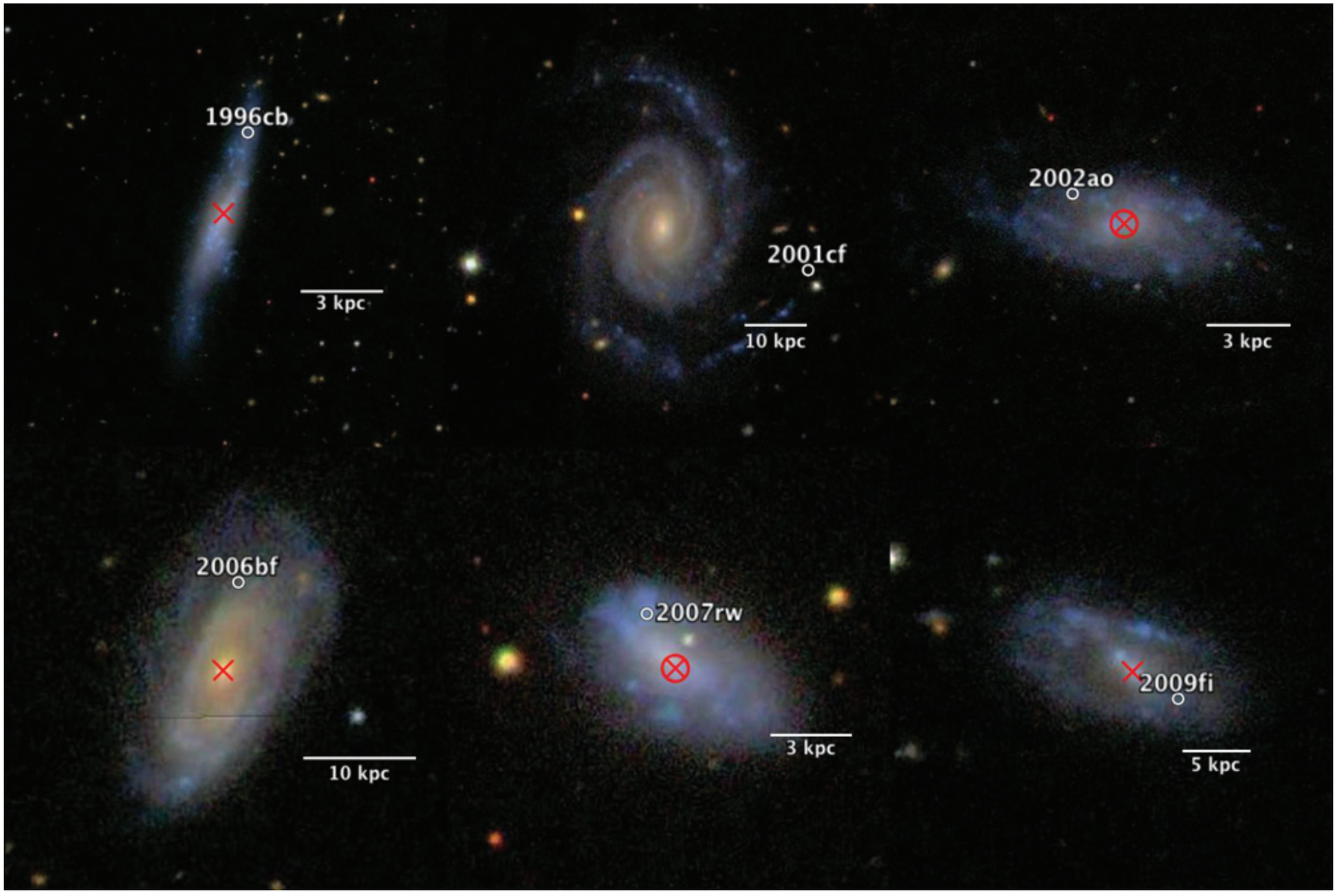


credit: Not Two

Outline

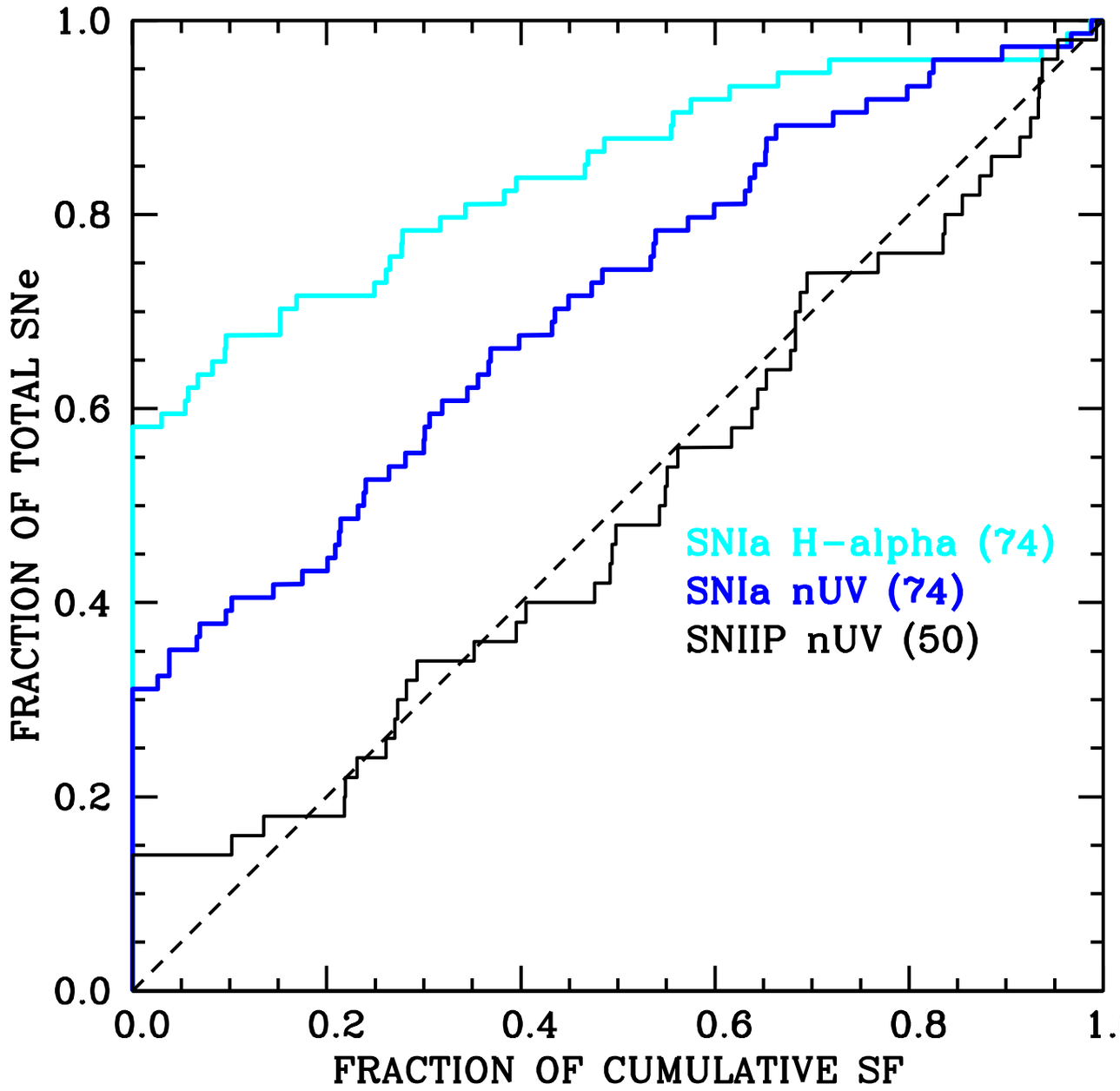
- Core-collapse supernovae
- Superluminous supernovae
- Type Ia supernovae

Host galaxies of core-collapse SNe



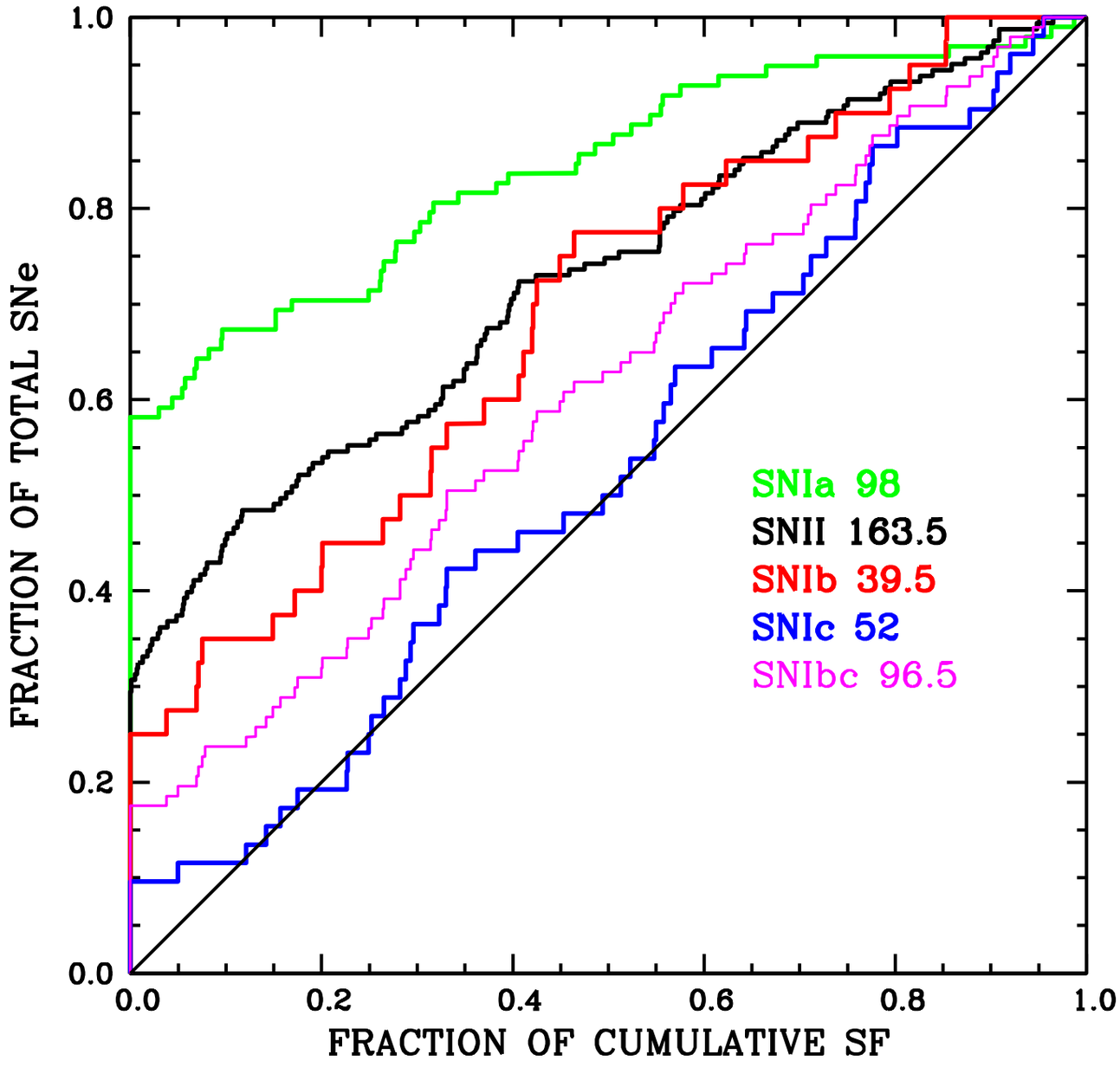
Kelly+ 2012

Core-collapse SNe trace the star formation



Anderson+ 2015

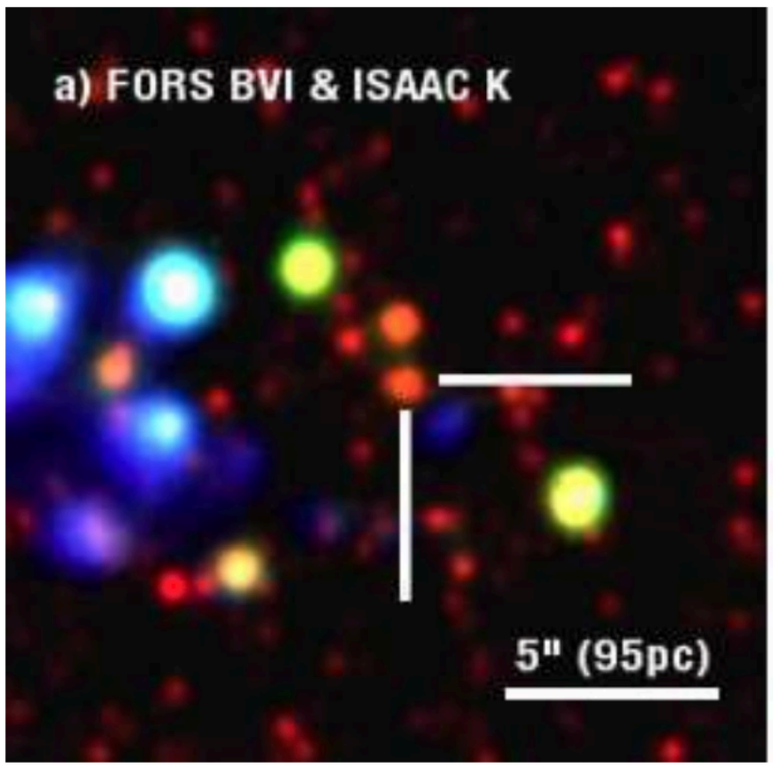
Core-collapse SNe trace the star formation



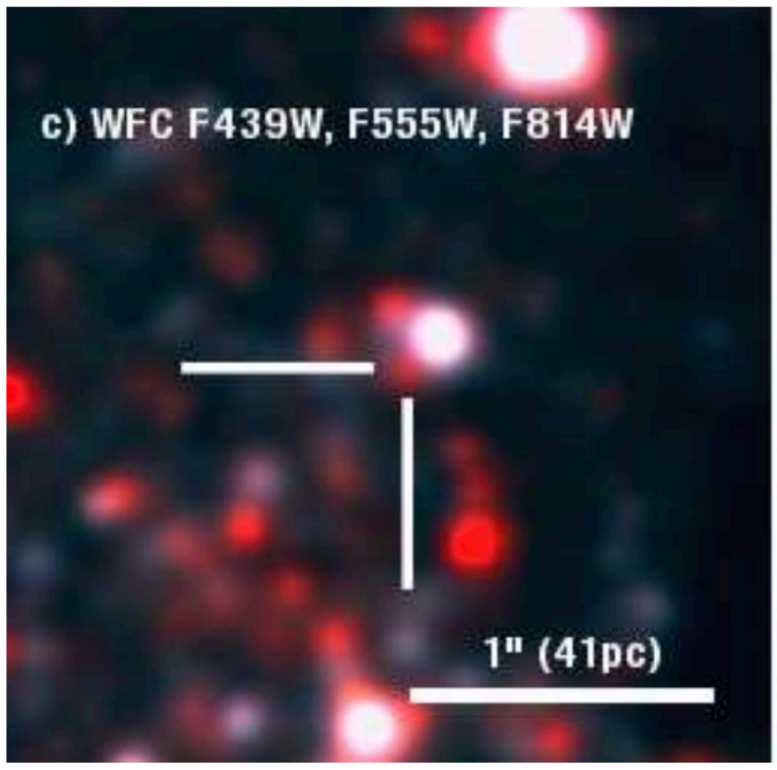
Anderson+ 2015

Pre-explosion imaging of core-collapse SNe

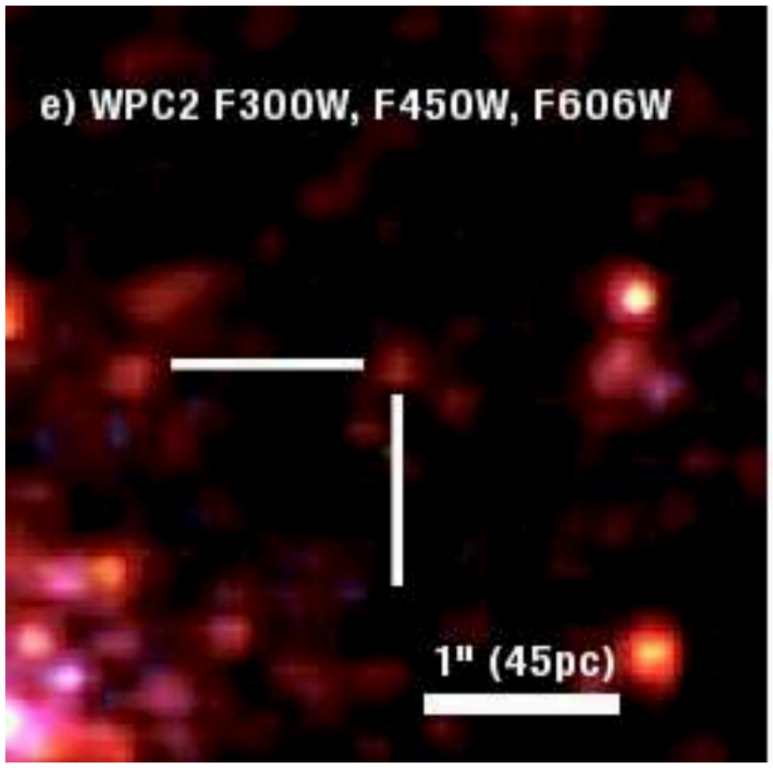
SN 2008bk



SN 2005cs

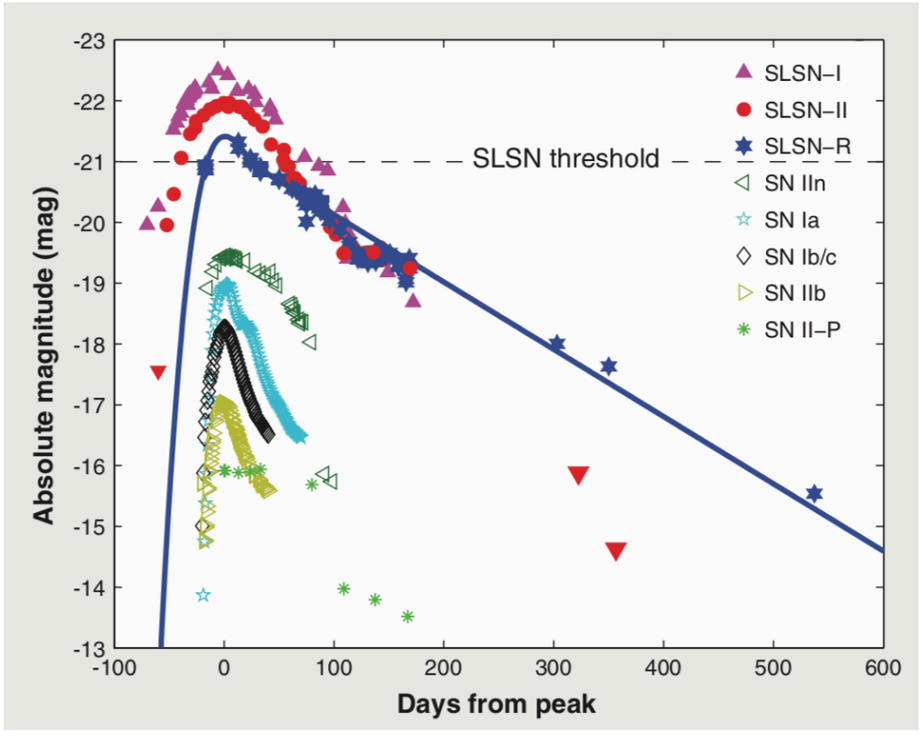


SN 2003gd

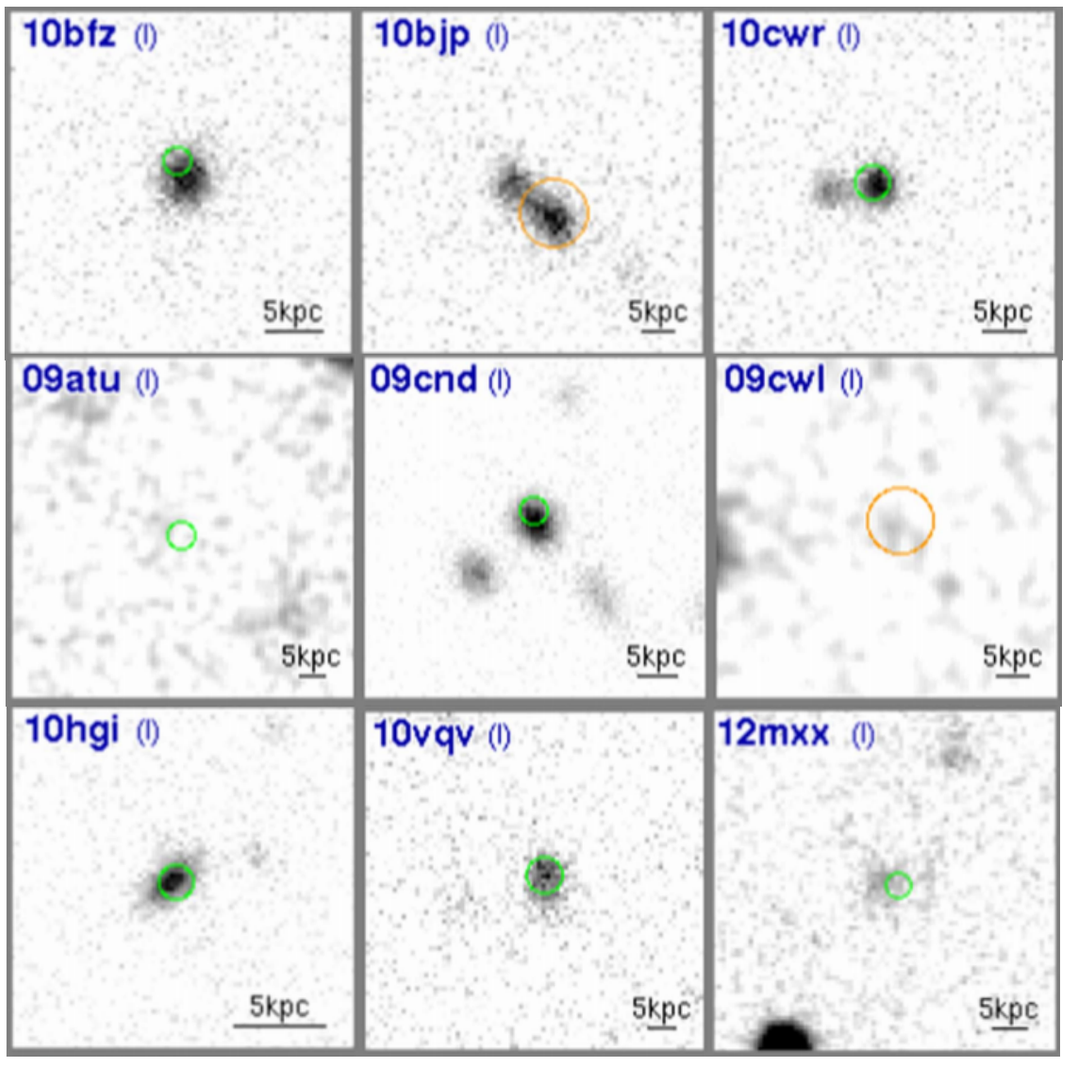


Smartt+ 2009

Host galaxies of Type I Superluminous SNe

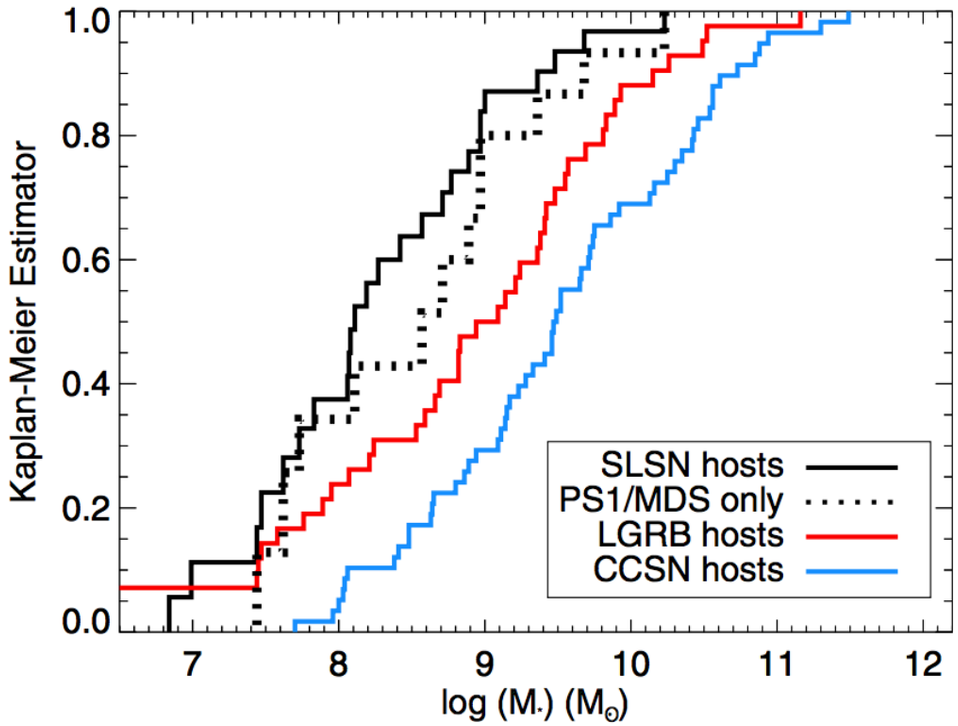


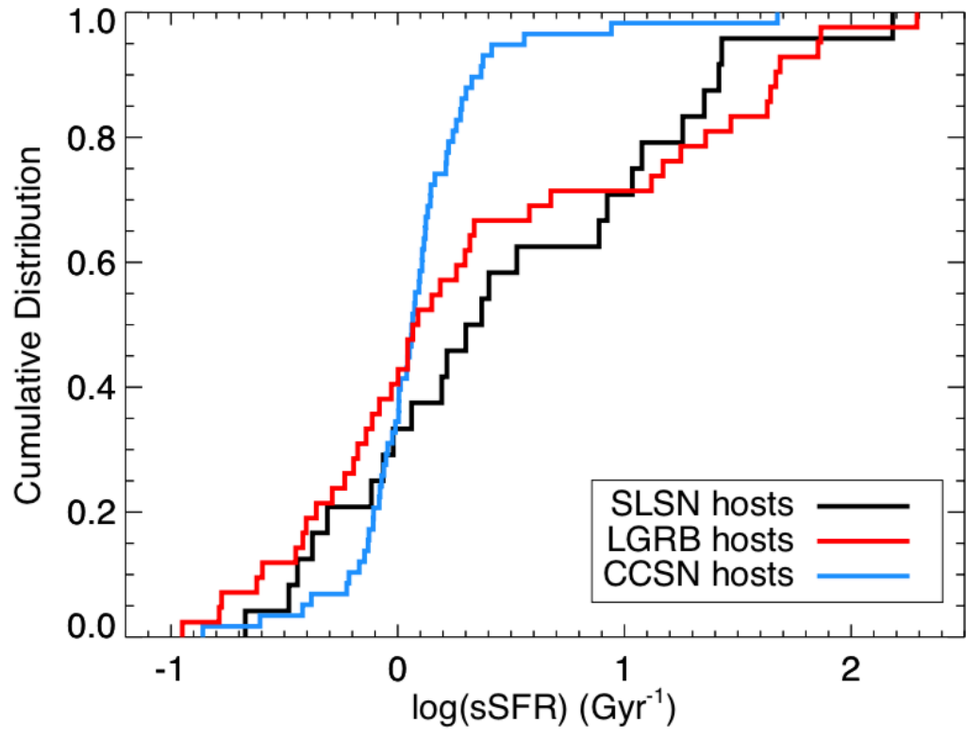
Gal-Yam+ 2012



Perley+ 2016

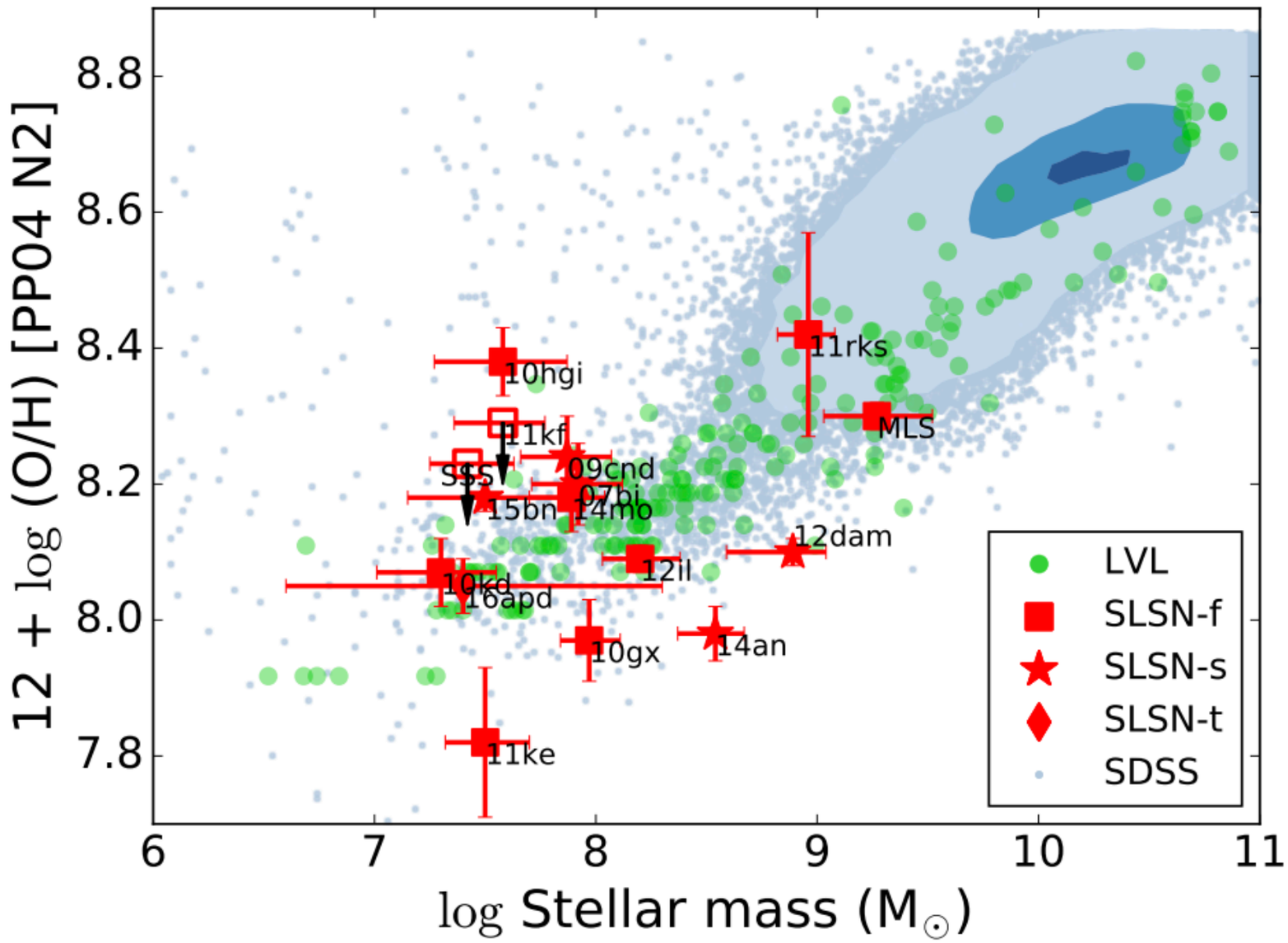
SLSNe-I tend to be found in galaxies of lower mass and stronger star formation





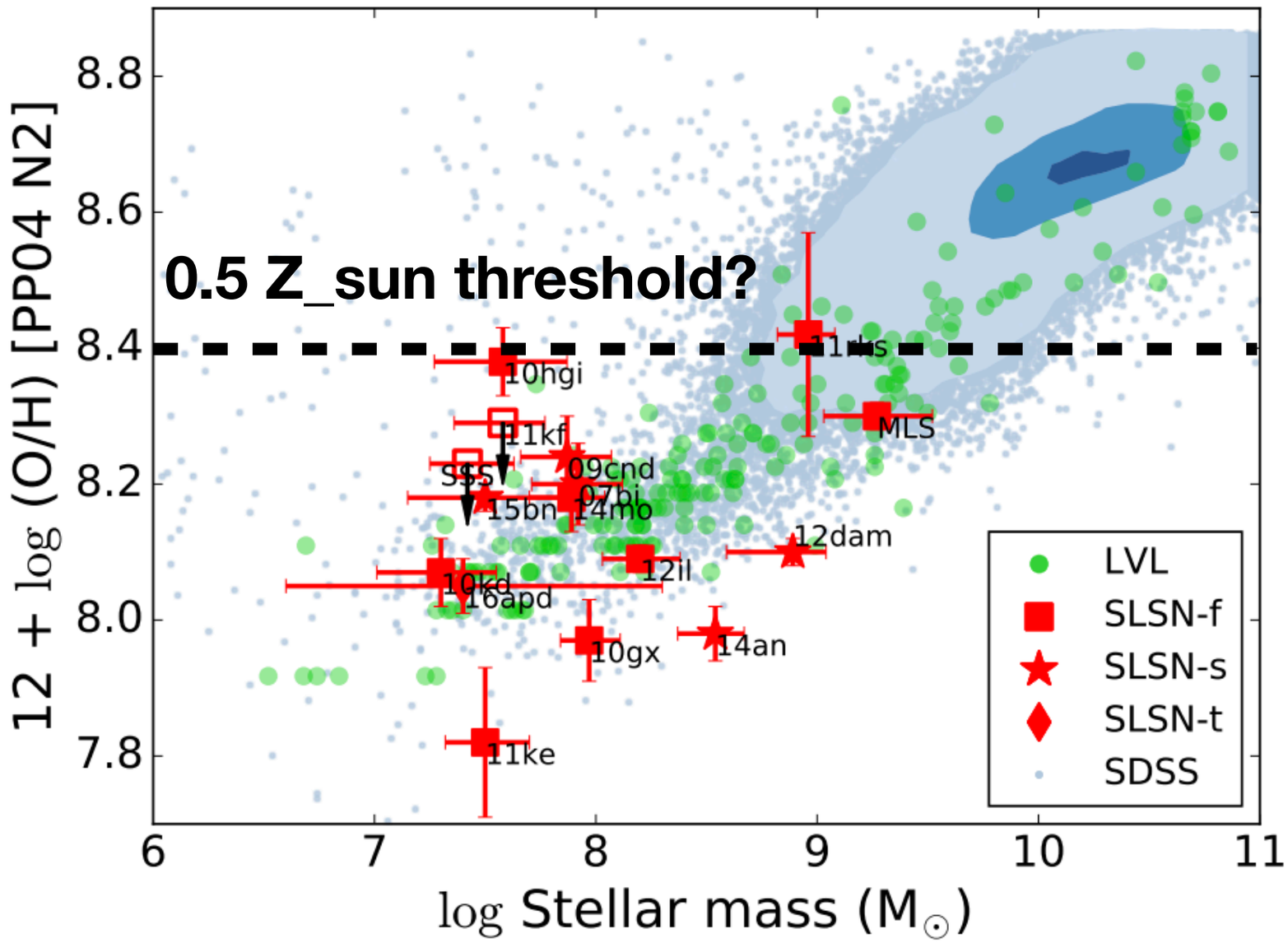
Lunnan+ 2014

SLSNe-I tend to be found in very low metallicity environments



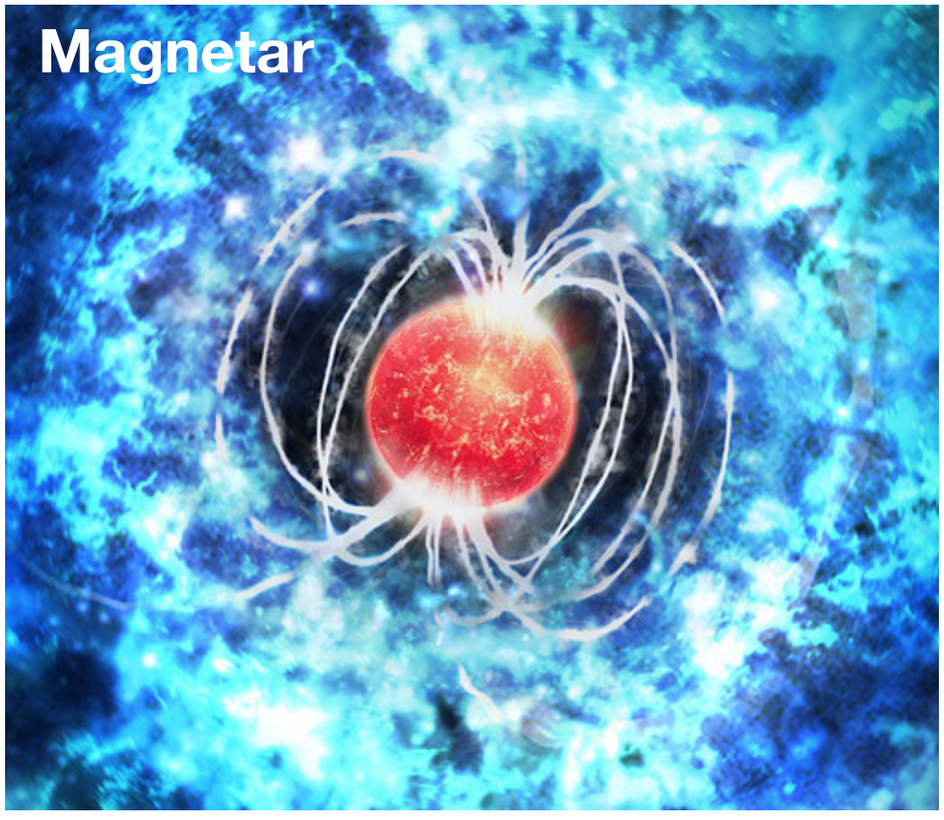
Chen+ 2017

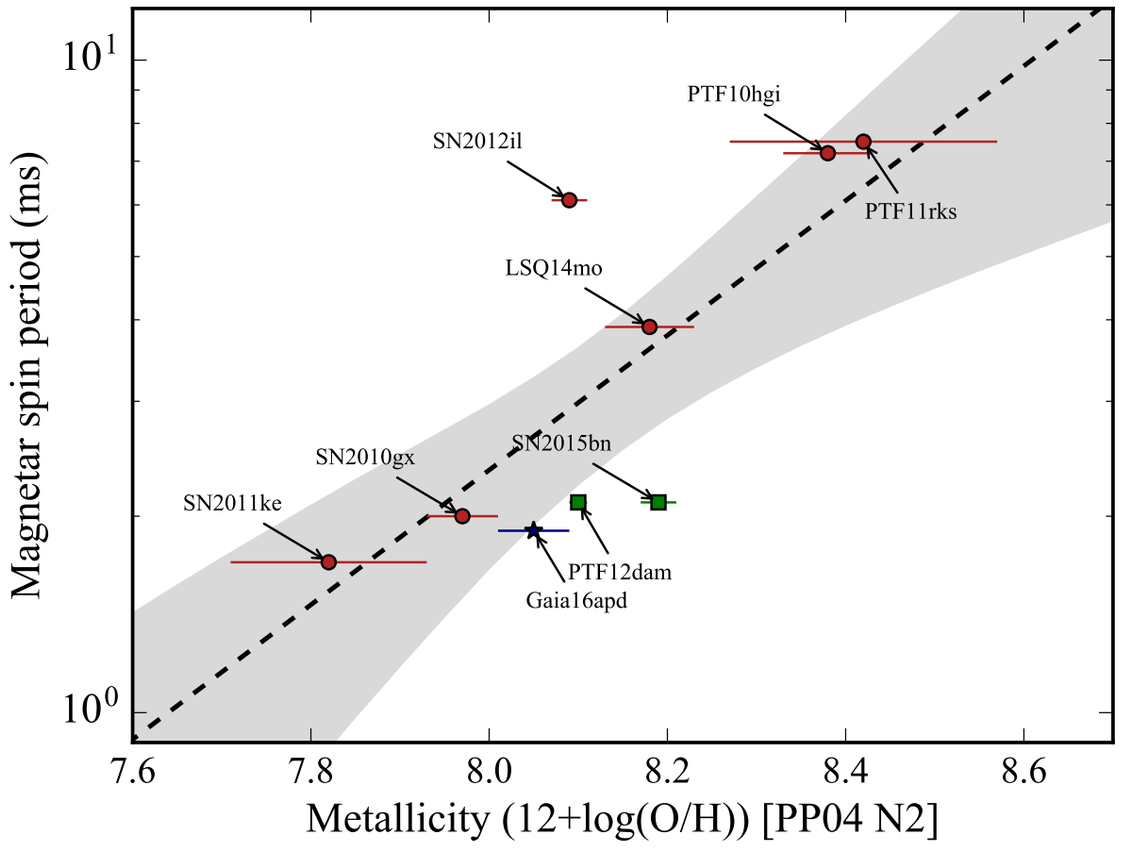
SLSNe-I tend to be found in very low metallicity environments



Chen+ 2017

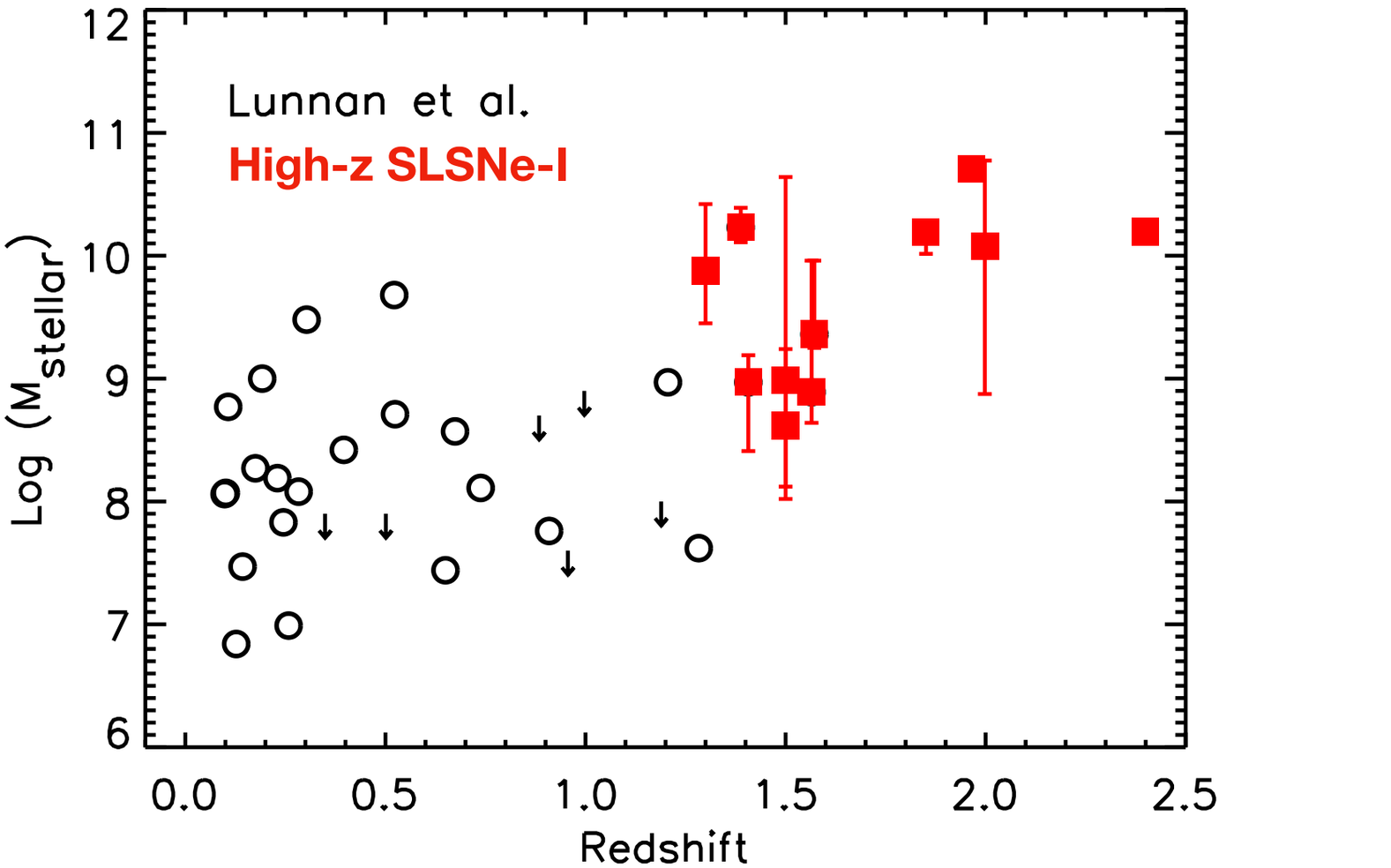
Why low-metallicity is important in forming SLSNe-I?





Chen+ 2017

However, the observations of high-z SLSNe challenged the low-metallicity threshold…

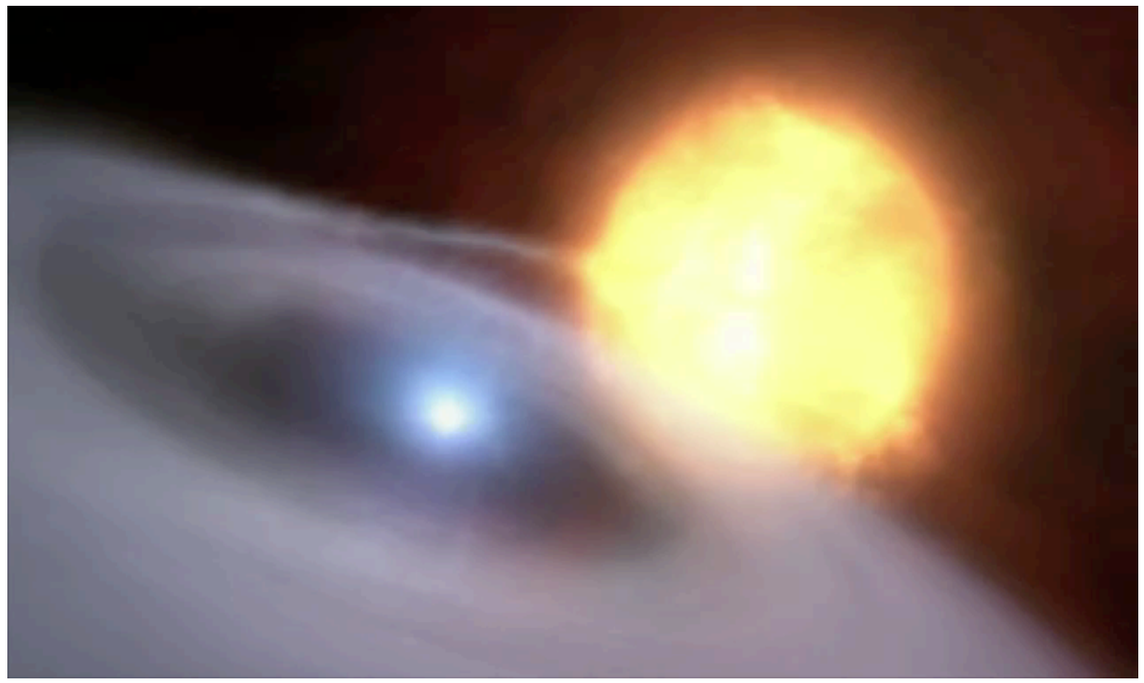


Pan+ in prep.

SN Ia host galaxies

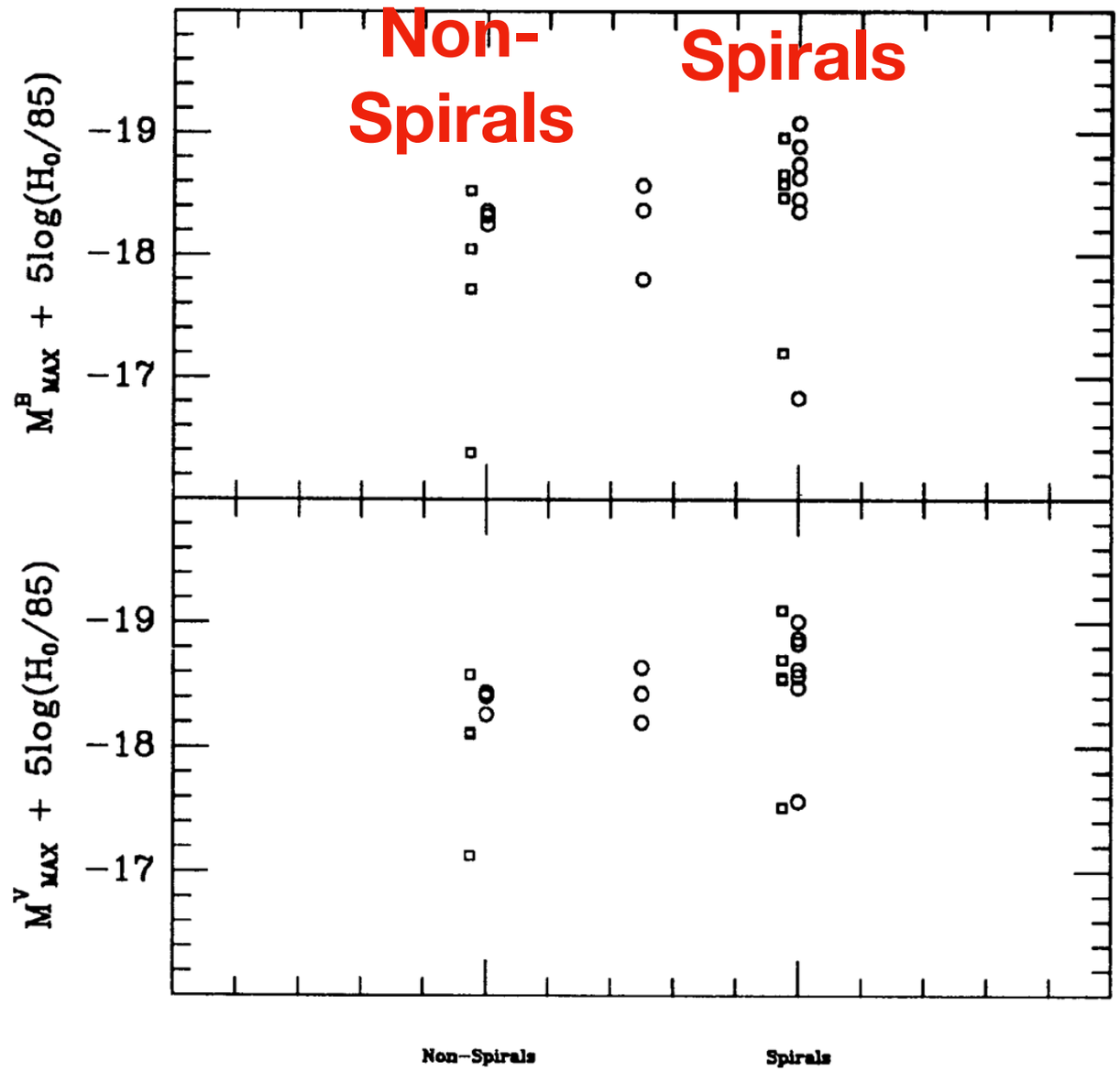
credit: SDSS-II Supernova Survey

SNe Ia are exploding white dwarfs



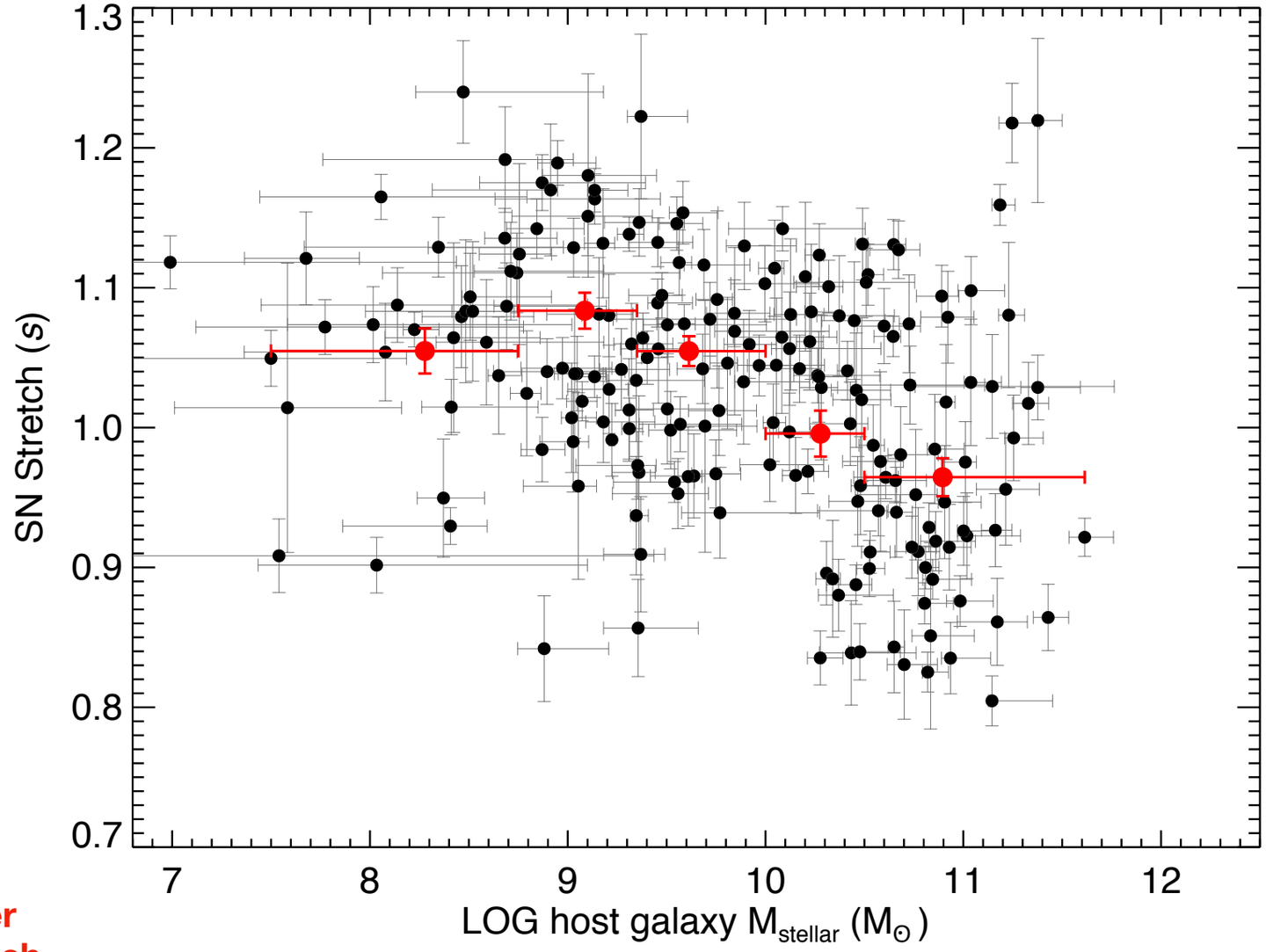
- White dwarfs in close binary
- Accretes matter until ~M_{ch} , but the sub-M_{ch} channels are also widely discussed recently
- Progenitors still unclear
  1. single v.s. double degenerate
  2. M_{ch} v.s. sub-M_{ch} channels

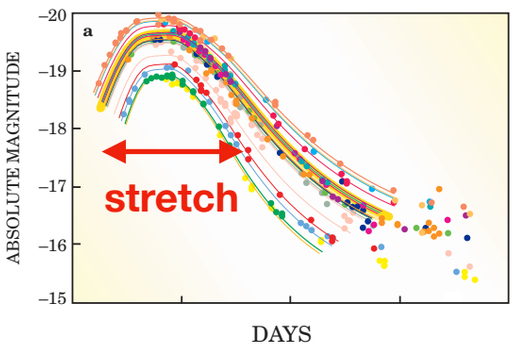
SNe Ia in spirals tend to be brighter than others



Hamuy+ 1995

Fainter SNe Ia tend to be found in more massive galaxies

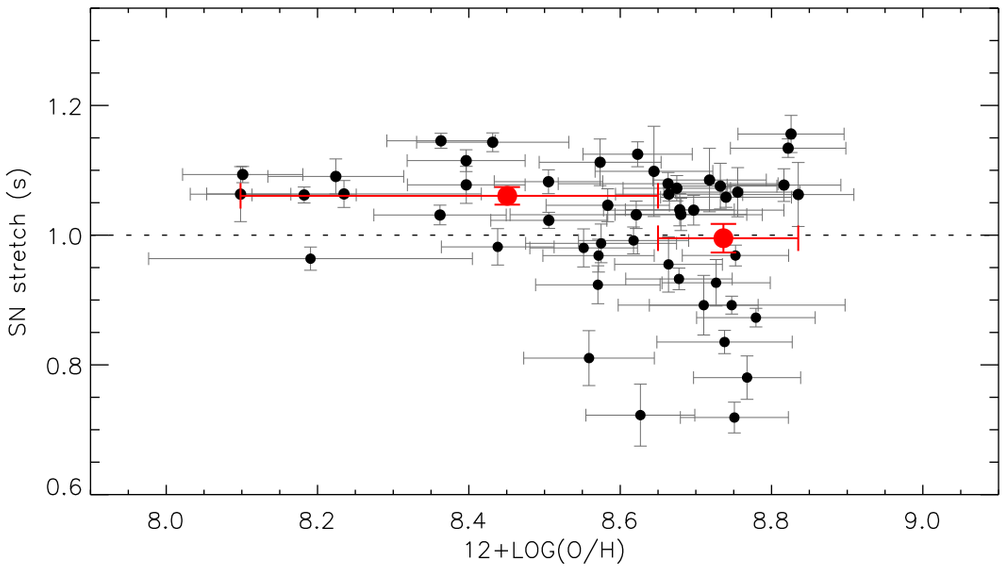




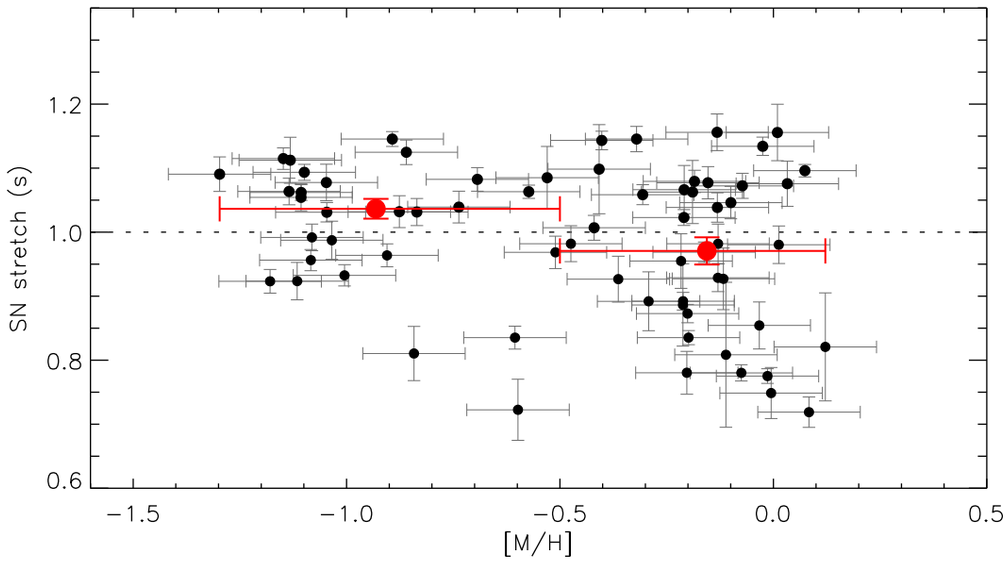
Brighter SNe Ia have broader light curves and higher stretch

Sullivan+ 2010

Fainter SNe Ia tend to be found in more metal-rich galaxies



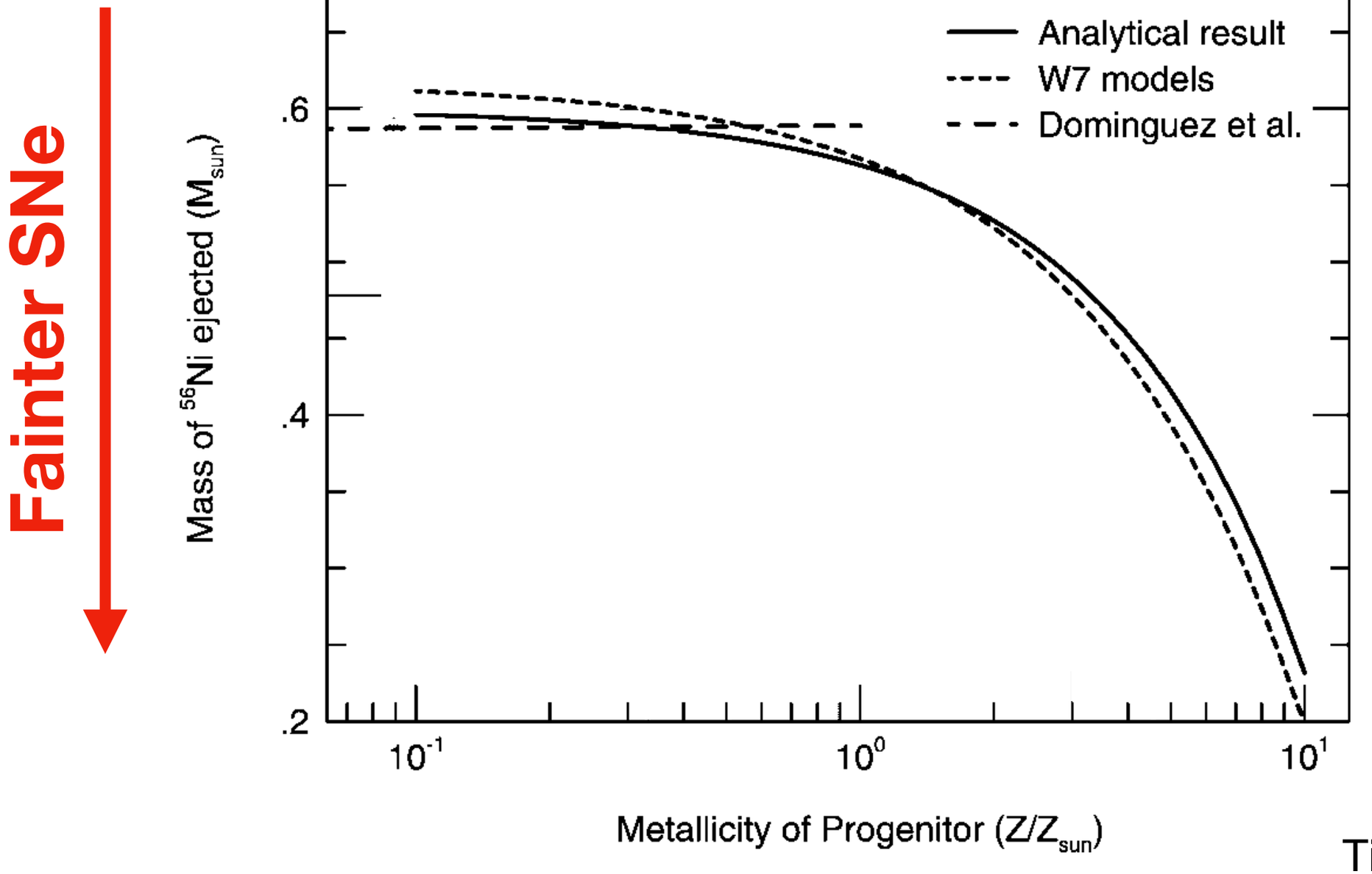
gas-phase metallicity



stellar metallicity

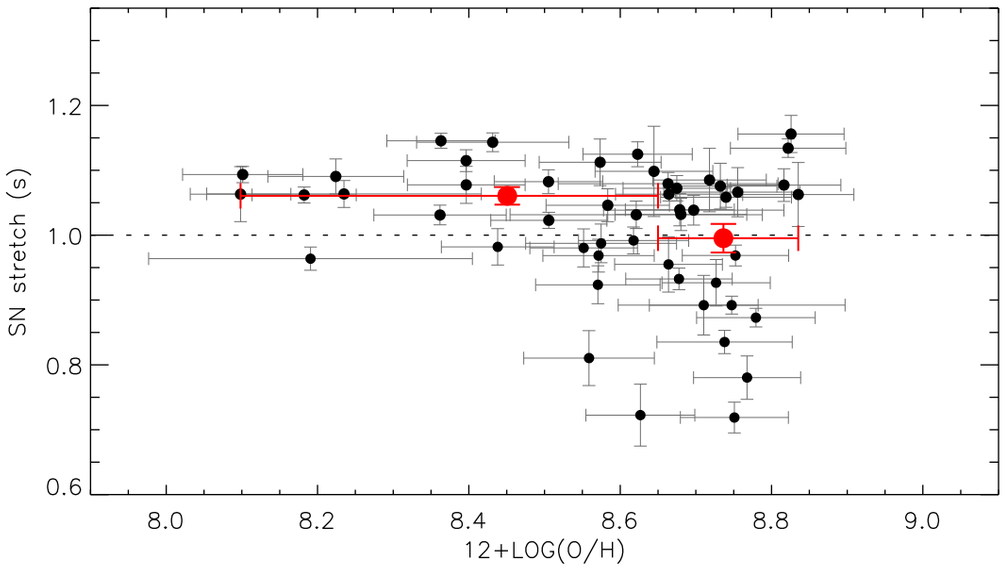
Pan+ 2014

Theories predict SN Ia luminosity should correlate with progenitor metallicity

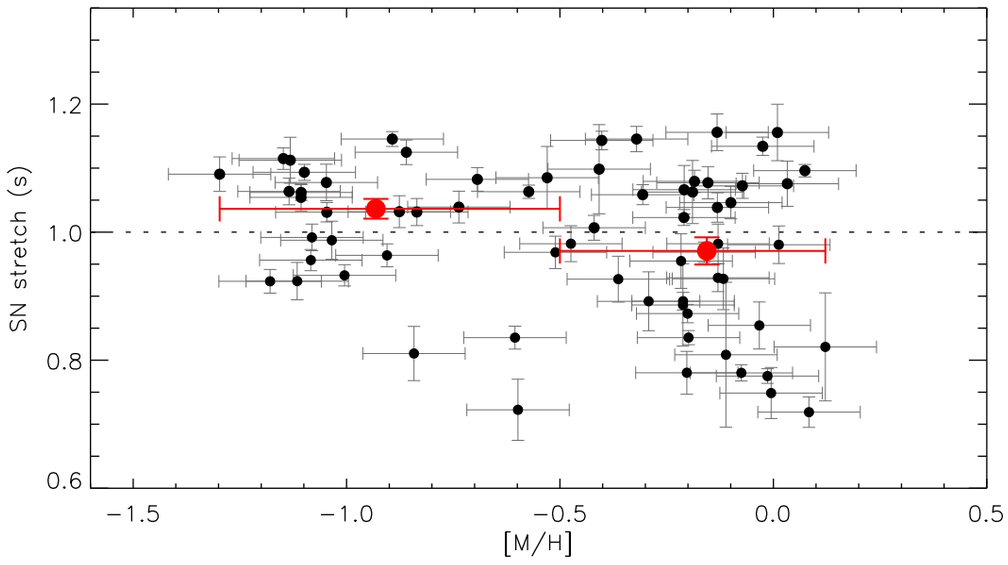


Timmes+ 2003

Other possibilities?



gas-phase metallicity

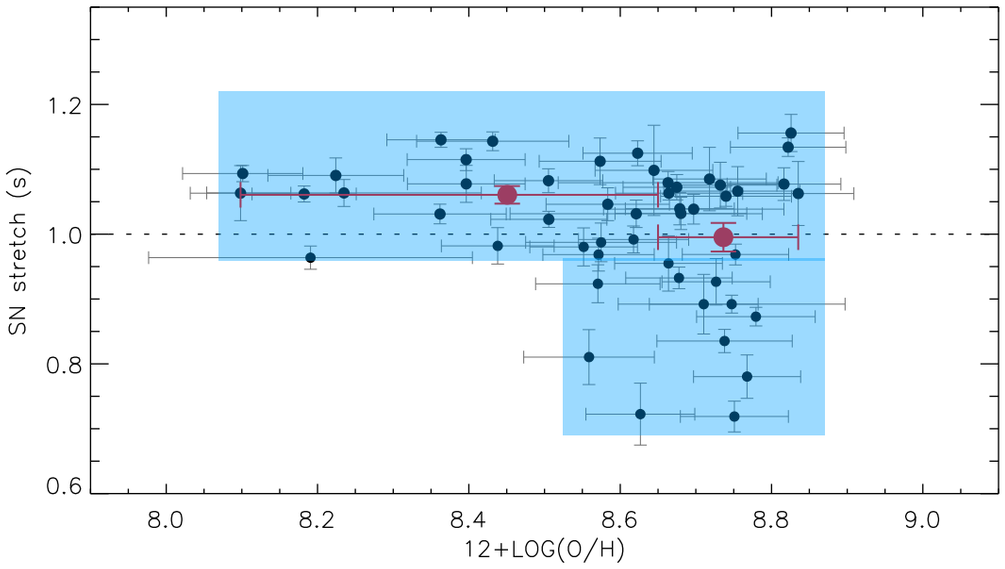


stellar metallicity

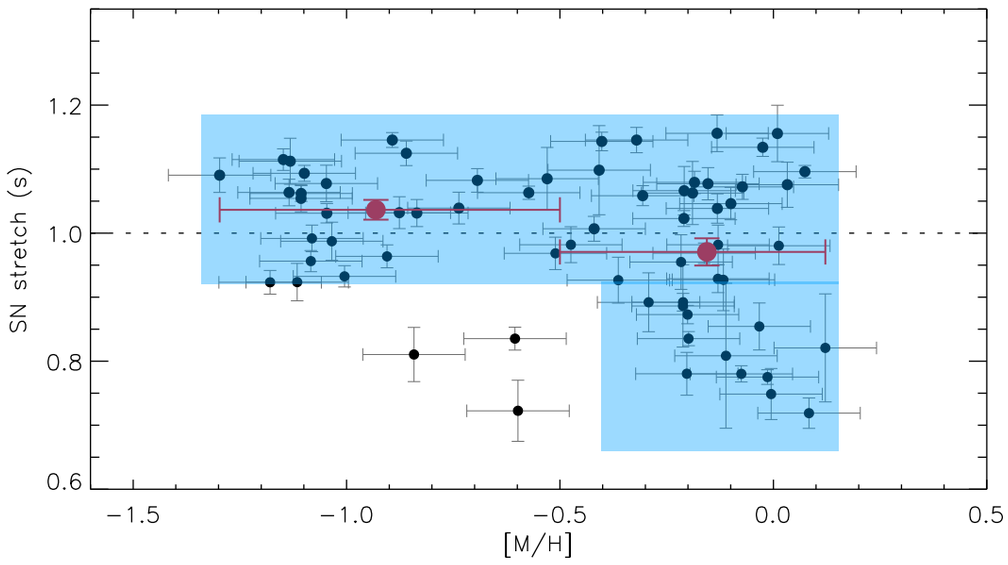
Pan+ 2014

Other possibilities?

More than one population??



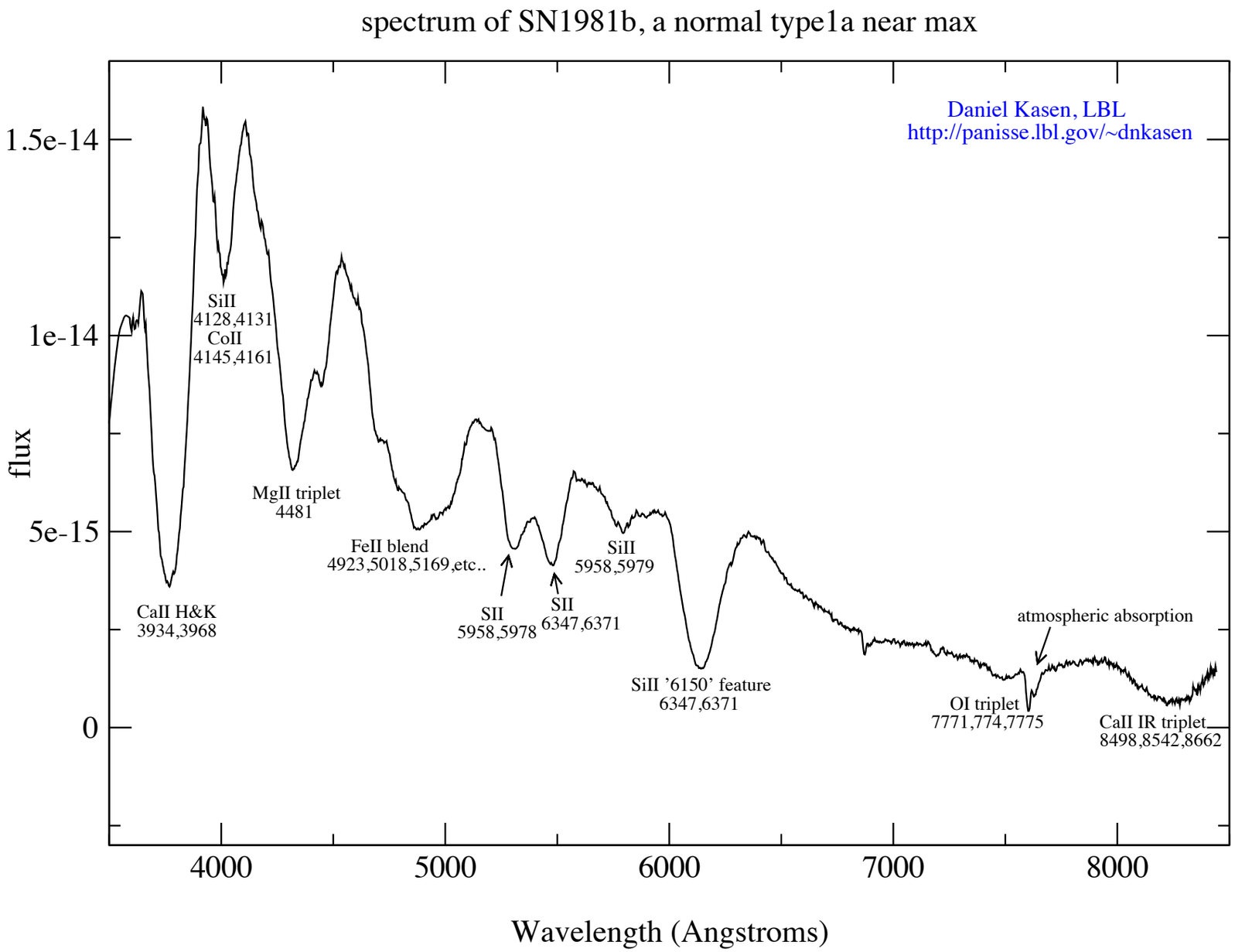
gas-phase metallicity



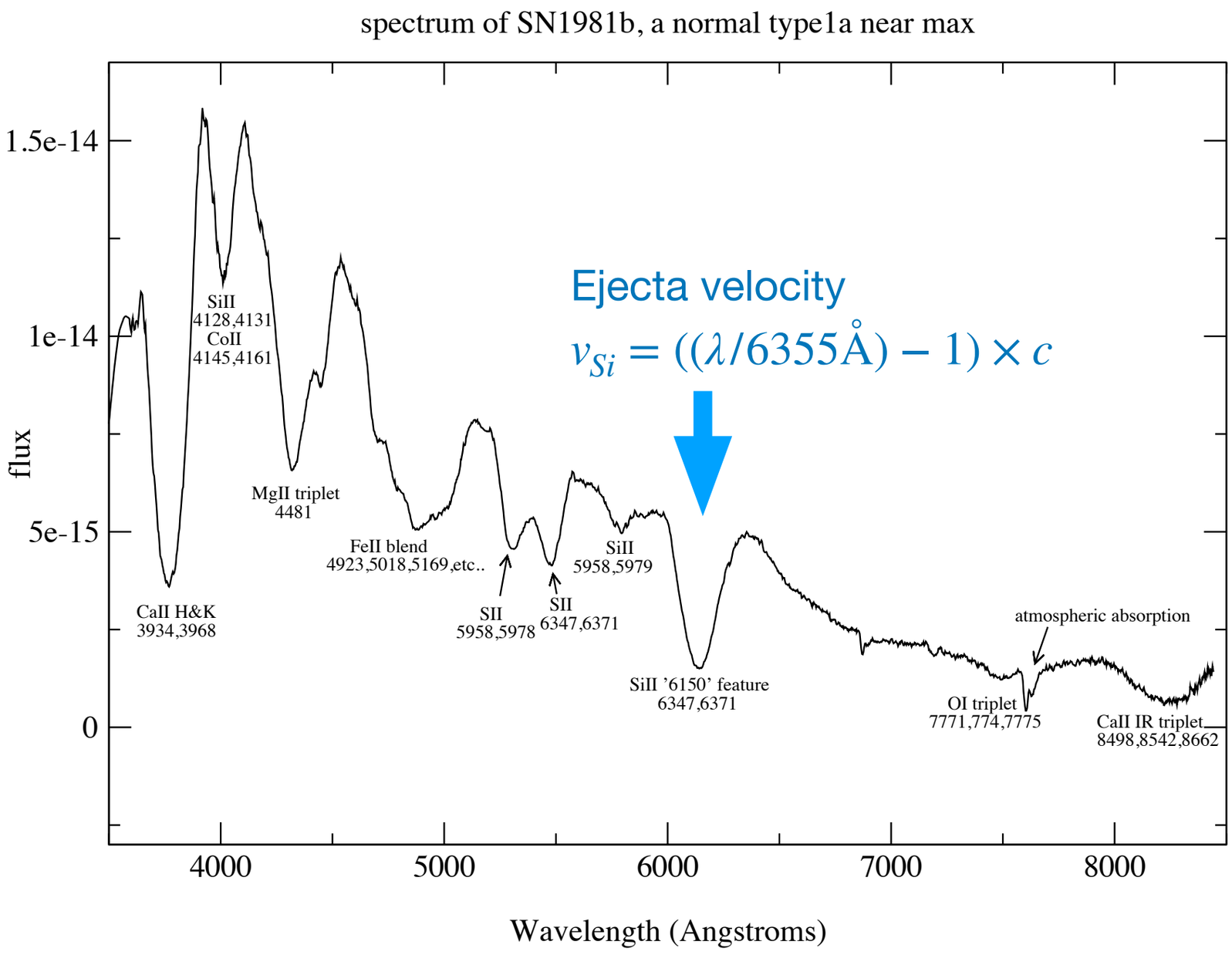
stellar metallicity

Pan+ 2014

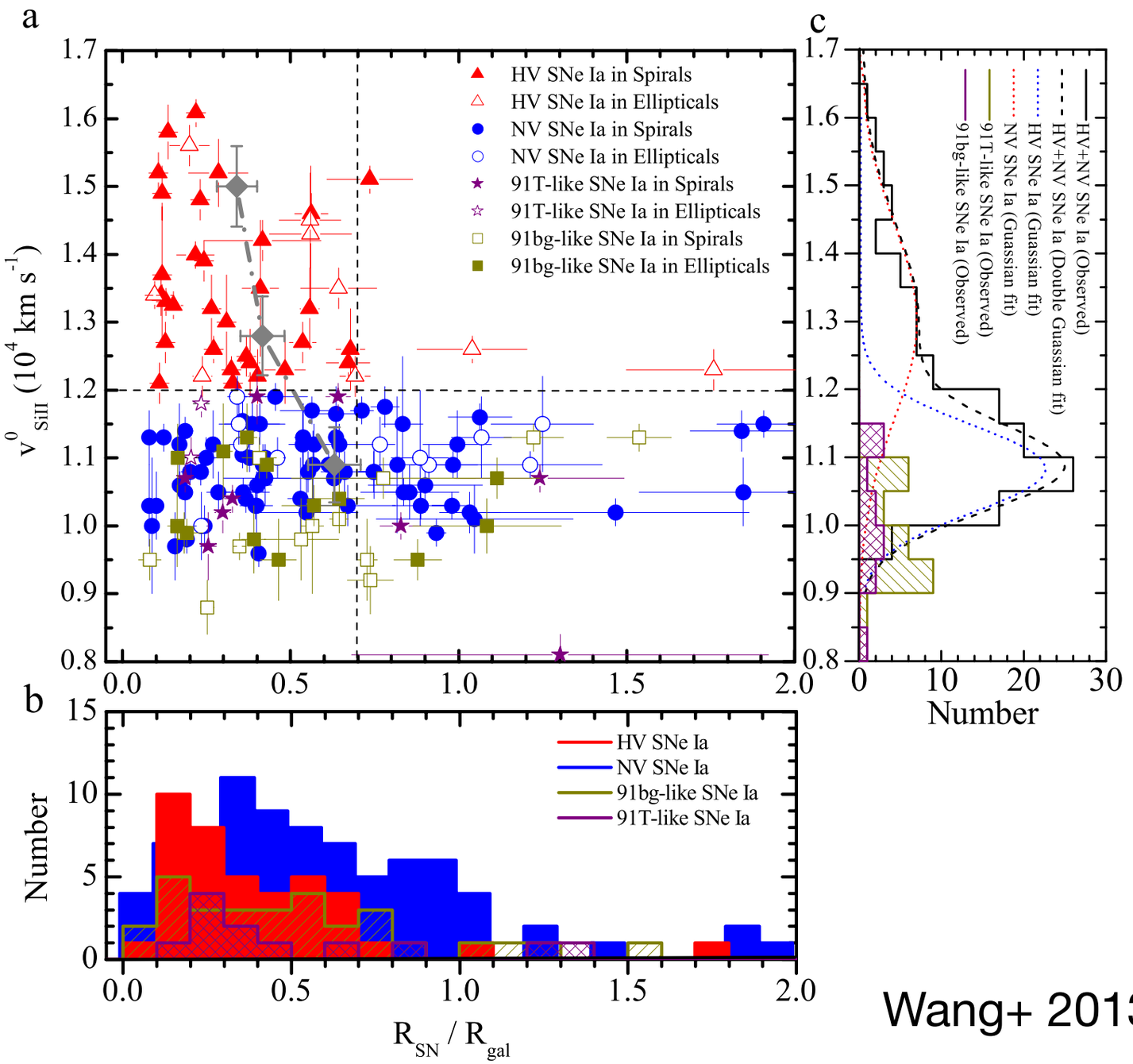
Recent evidence from SN Ia spectrum



Recent evidence from SN Ia spectrum

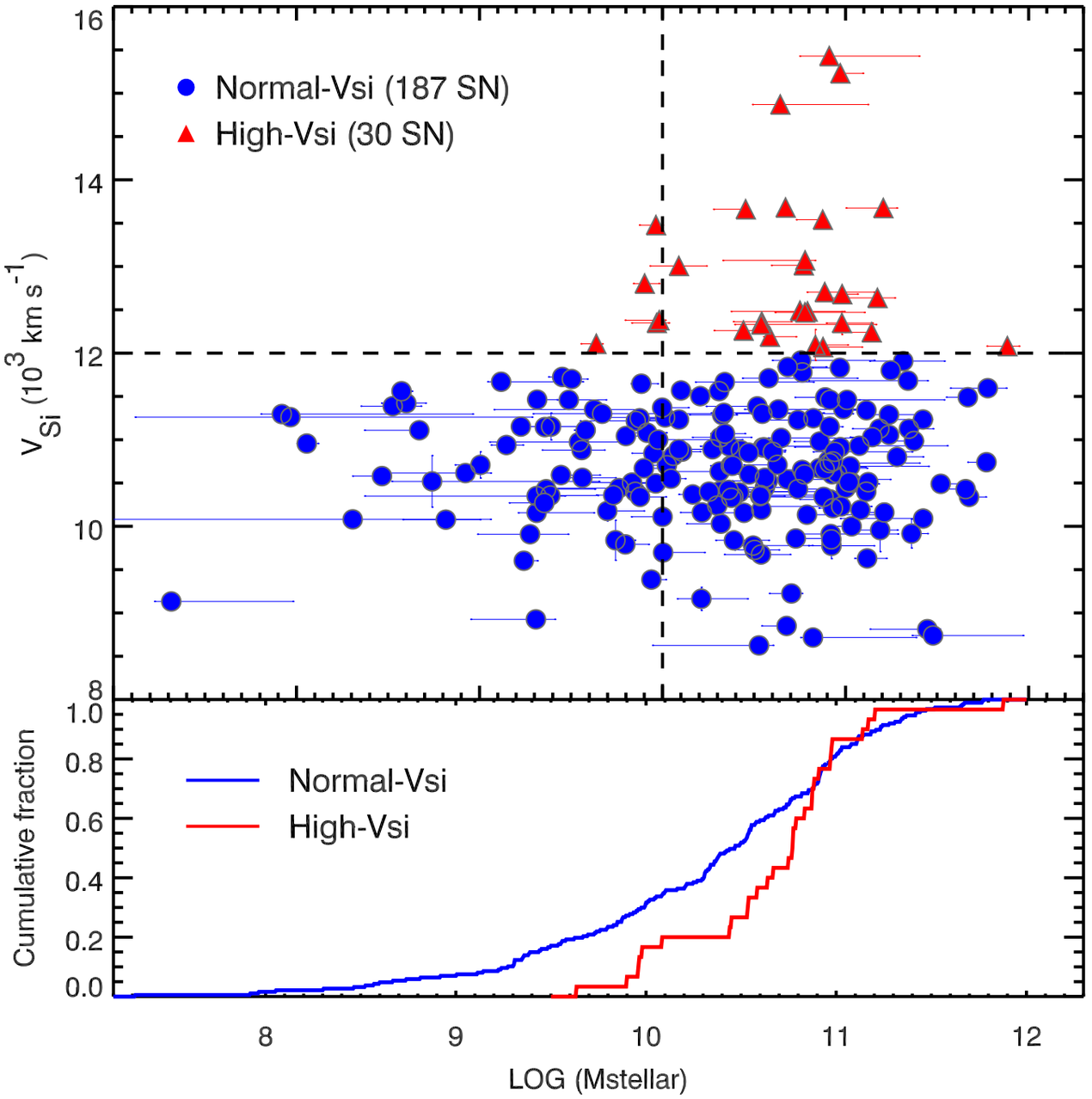


High-velocity SNe Ia tend to be found in the inner region of their host galaxies



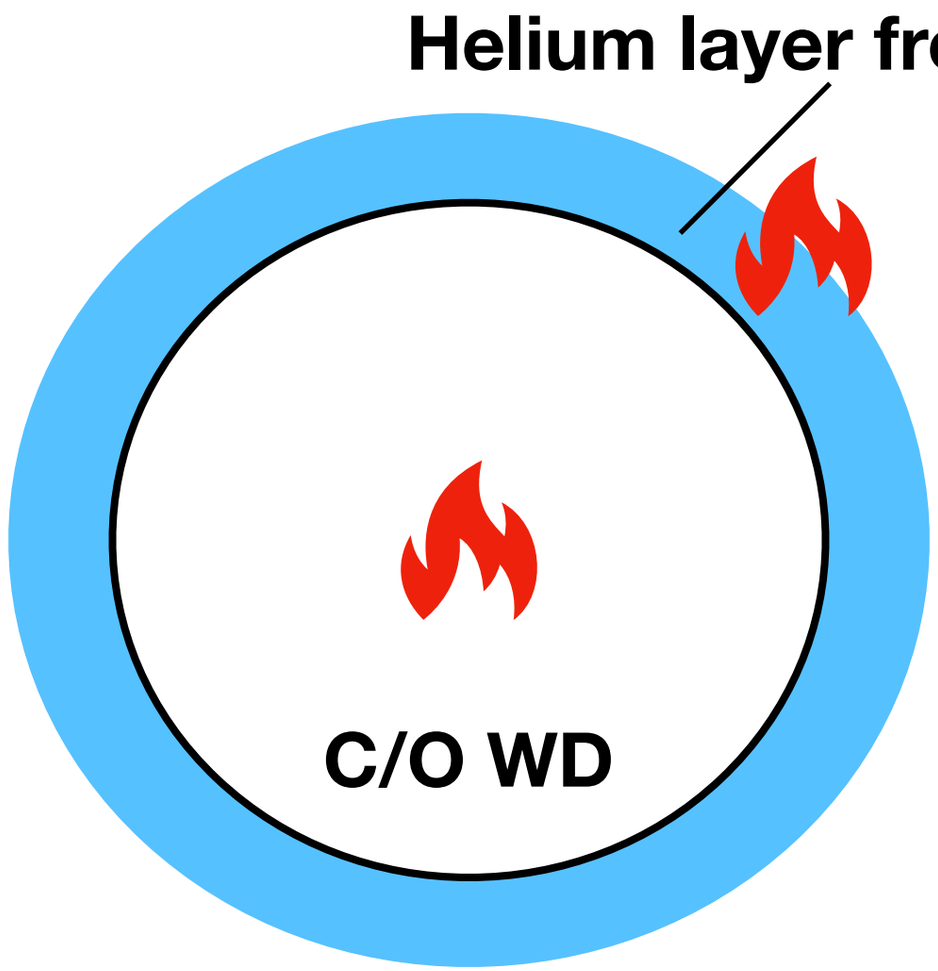
Wang+ 2013

High-velocity SNe Ia tend to be found in massive galaxies



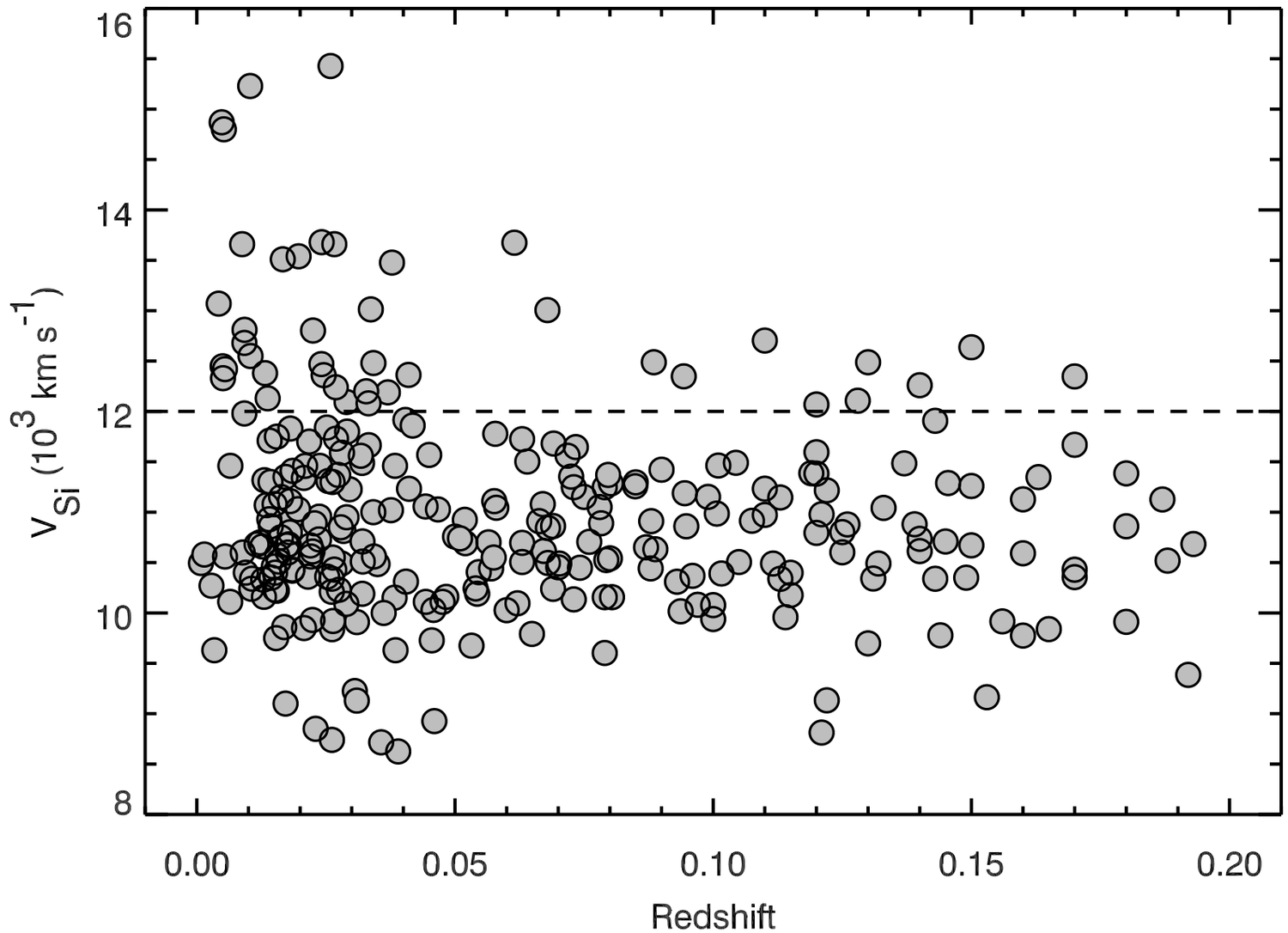
Pan 2020

Is metal-rich environment important to produce HV SNe Ia? Why?



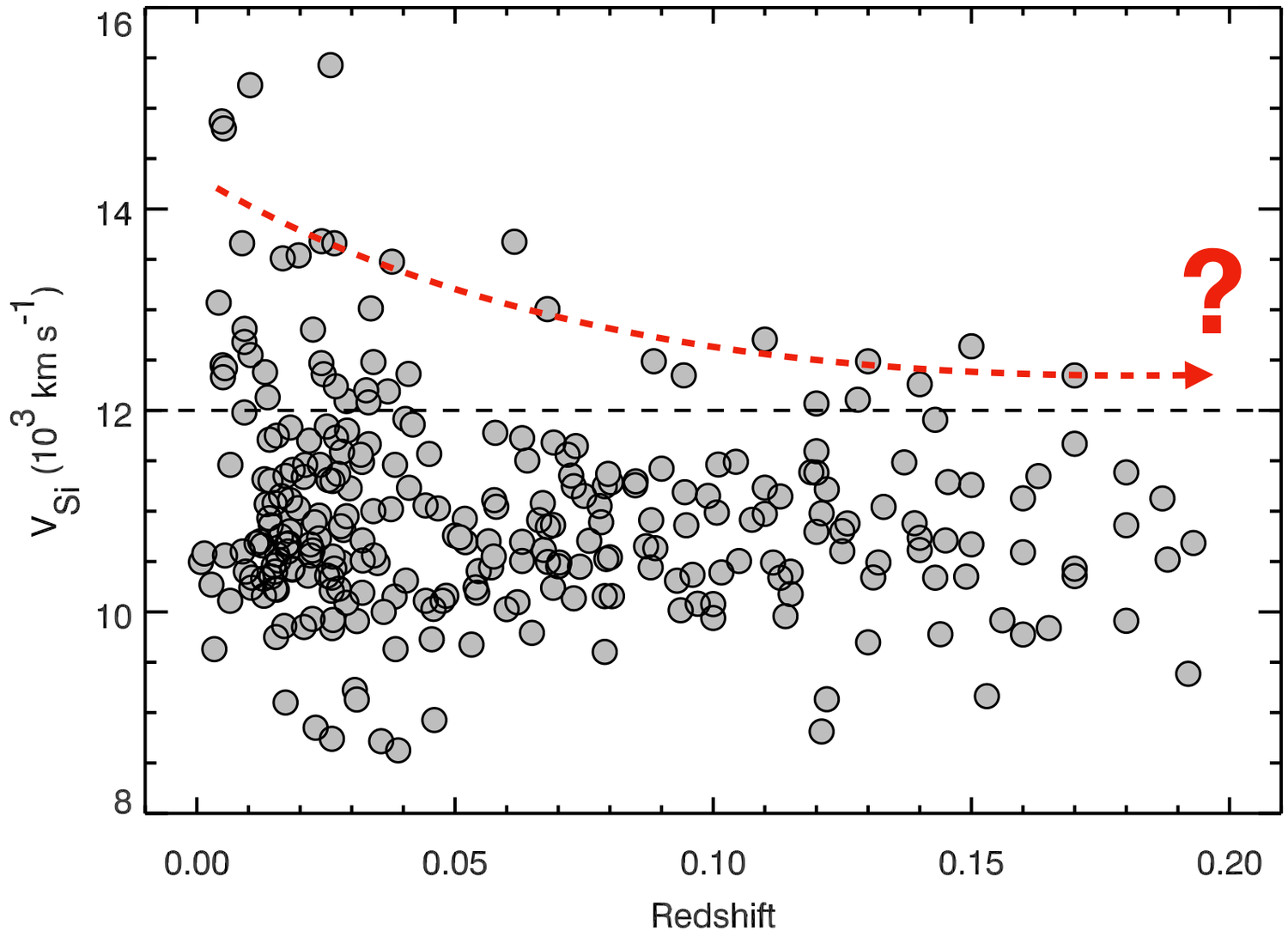
High-velocity SNe Ia may originate from sub-M_{ch} explosions, *via double detonation:* ***Helium shell detonation triggers carbon core detonation!***

Potential evolution of SN Ia populations with redshift. Implication on metallicity effect?



Pan 2020

Potential evolution of SN Ia populations with redshift. Implication on metallicity effect?



Pan 2020

Unanswered questions from SN host-galaxy studies…

- Why is metal-poor environment necessary to produce SLSNe-I? Is there a metallicity threshold for forming SLSNe-I?

- Is metallicity the underlying driver for many relations we found between SNe Ia and their host galaxies? Or something else?

- Do SN Ia populations evolve with redshift? If they are sensitive to the environmental metallicity, we should be able to see the evolution, but higher-z data is needed!