THE HOST GALAXIES OF SUB-CHANDRASEKHAR MASS EXPLOSIONS

ANYA NUGENT, NORTHWESTERN UNIVERSITY

THE TRANSIENT AND VARIABLE UNIVERSE

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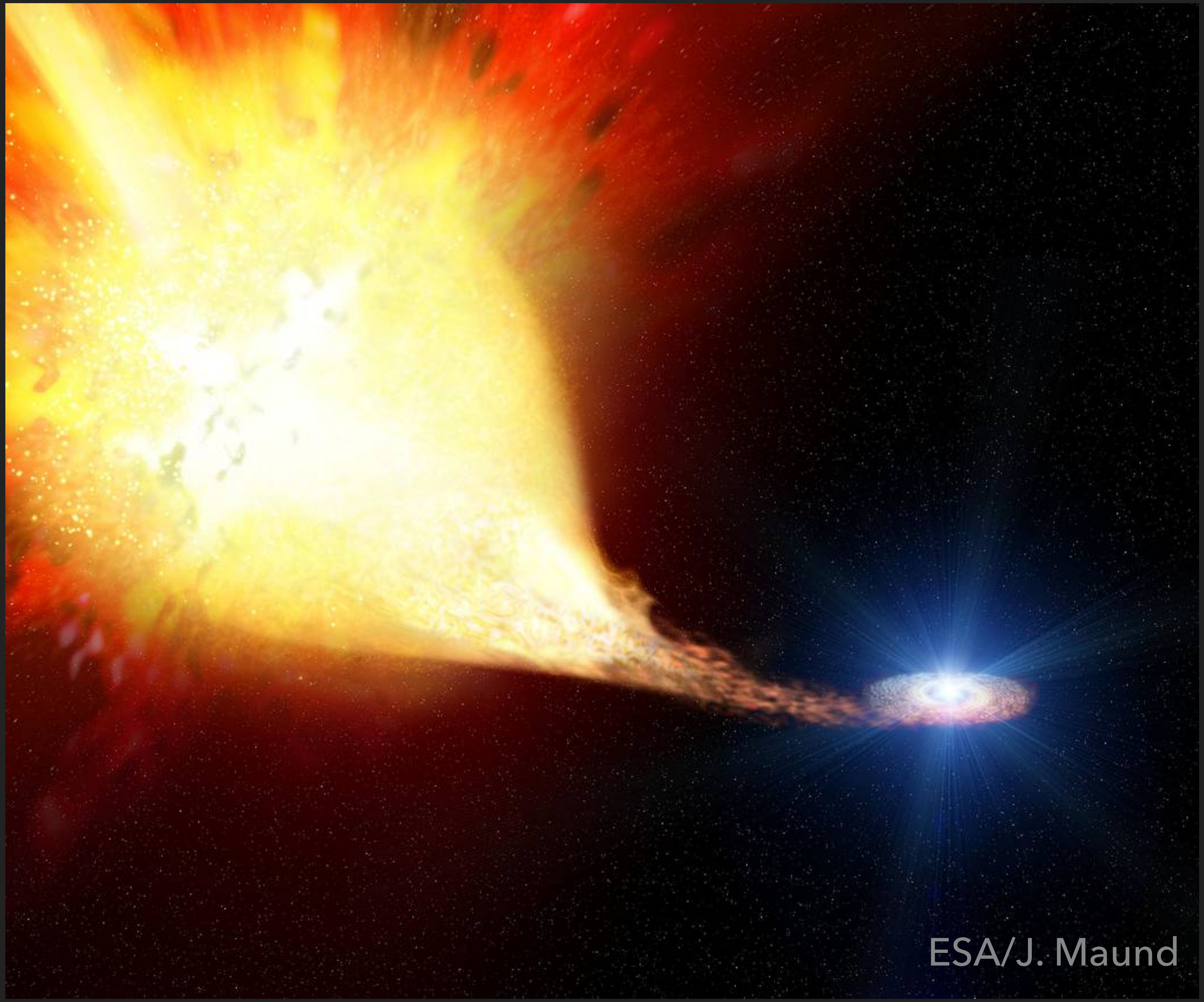
TYPE IA SUPERNOVAE



Type Ia supernovae (SNe) derive from the thermonuclear explosion of a white dwarf that approaches the Chandrasekhar mass limit**

$(\approx 1.4 M_{\odot})$

**likely not in every case

see: Howell+ 2006, Scalzo+ 2014, Goldestein & Kasen 2018, Shen+ 2018, Polin+ 2019, Liu+ 2023, Ni+ 2023

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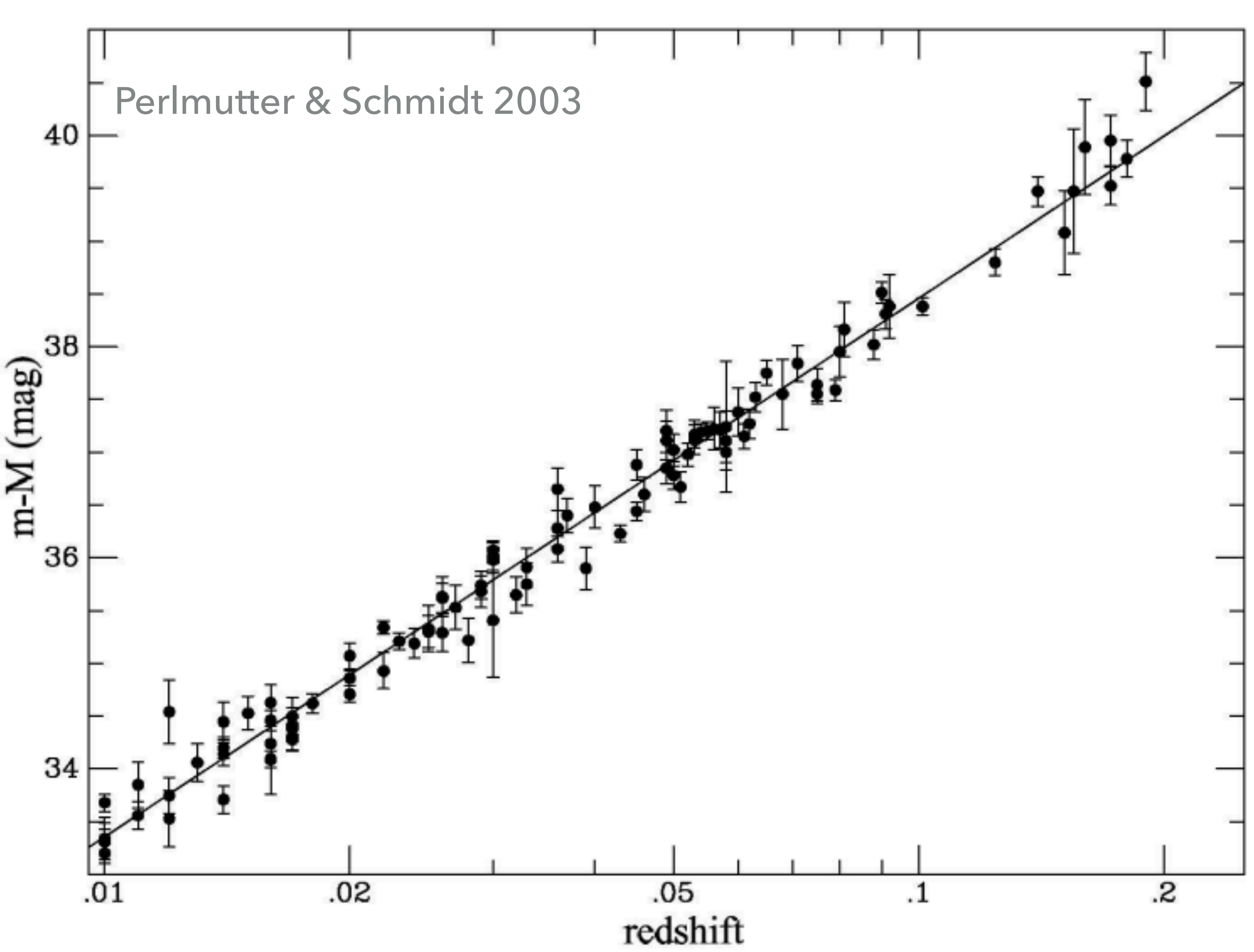

Type Ia SNe are standardized candles given how their peak brightness relates with distance and thus are important tools in measuring the expansion rate of the Universe

see: Perlmutter+ 1999, Riess+ 1998

Variations in peak brightness have been observed and are problematic for cosmology

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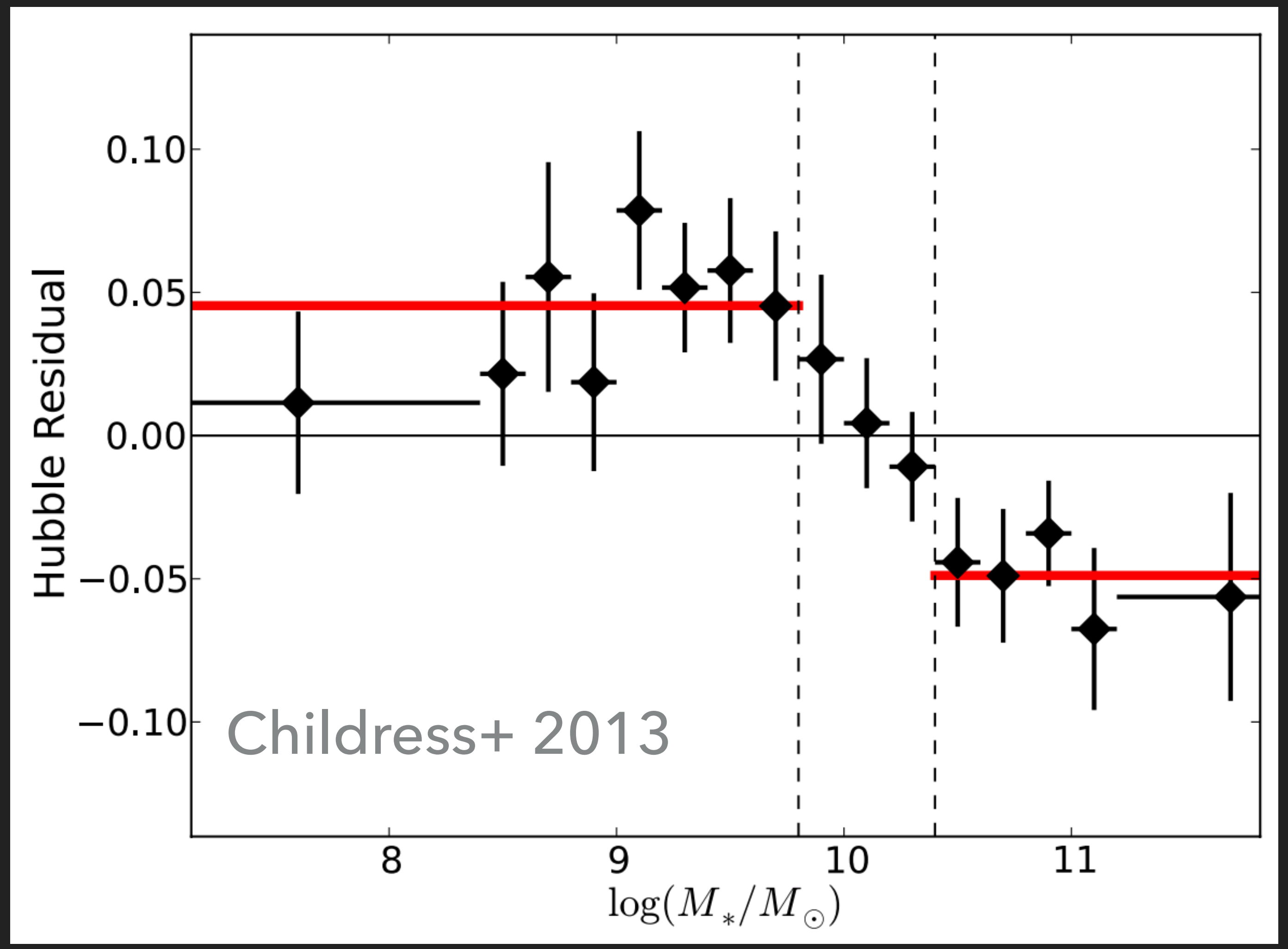
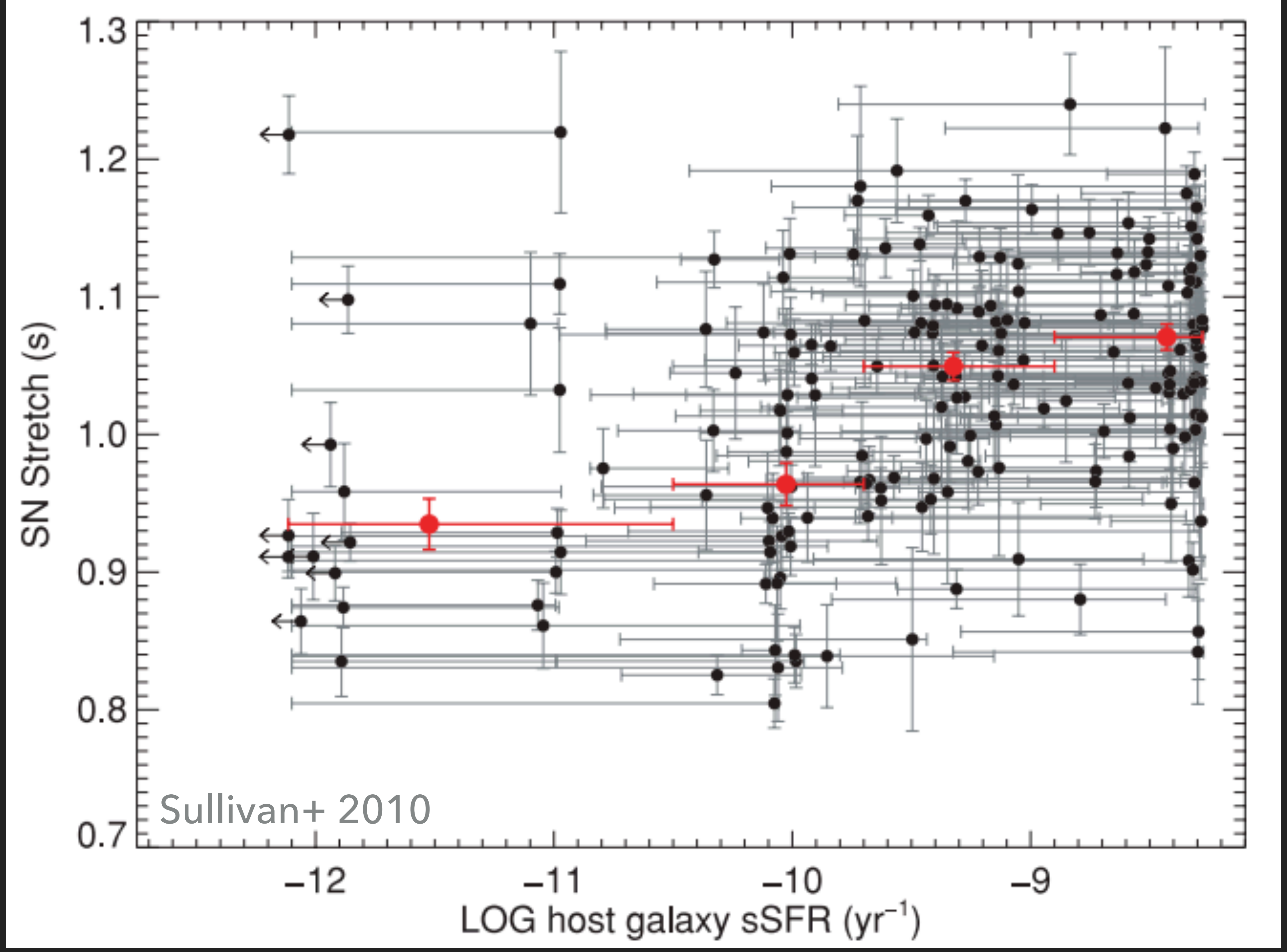
SN luminosity, light curve width, colors, and Hubble residuals relate to host morphology, stellar mass, global and local star formation

see also: Sullivan+ 2006, Gupta+ 2011, Pan+2014, Rigault+ 2020





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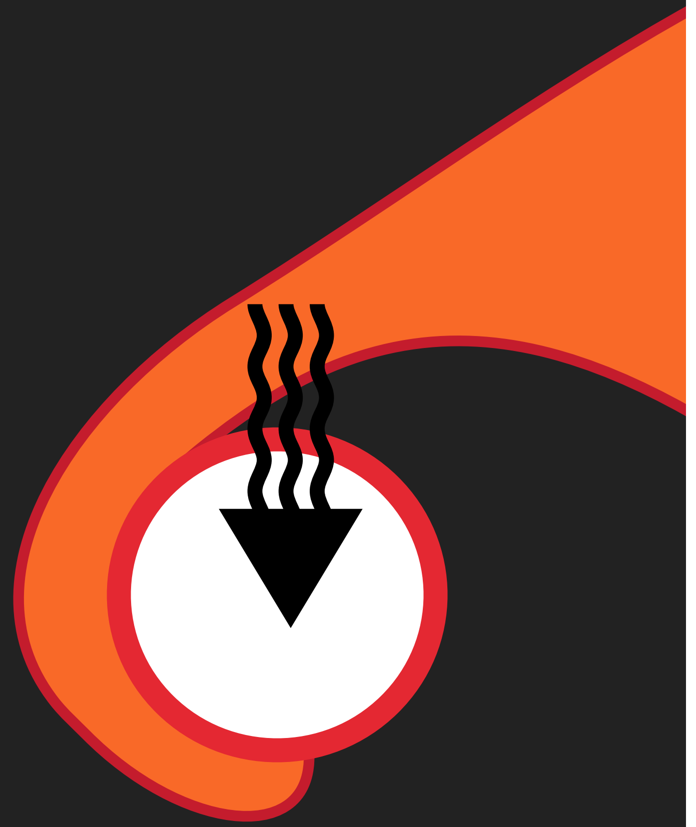
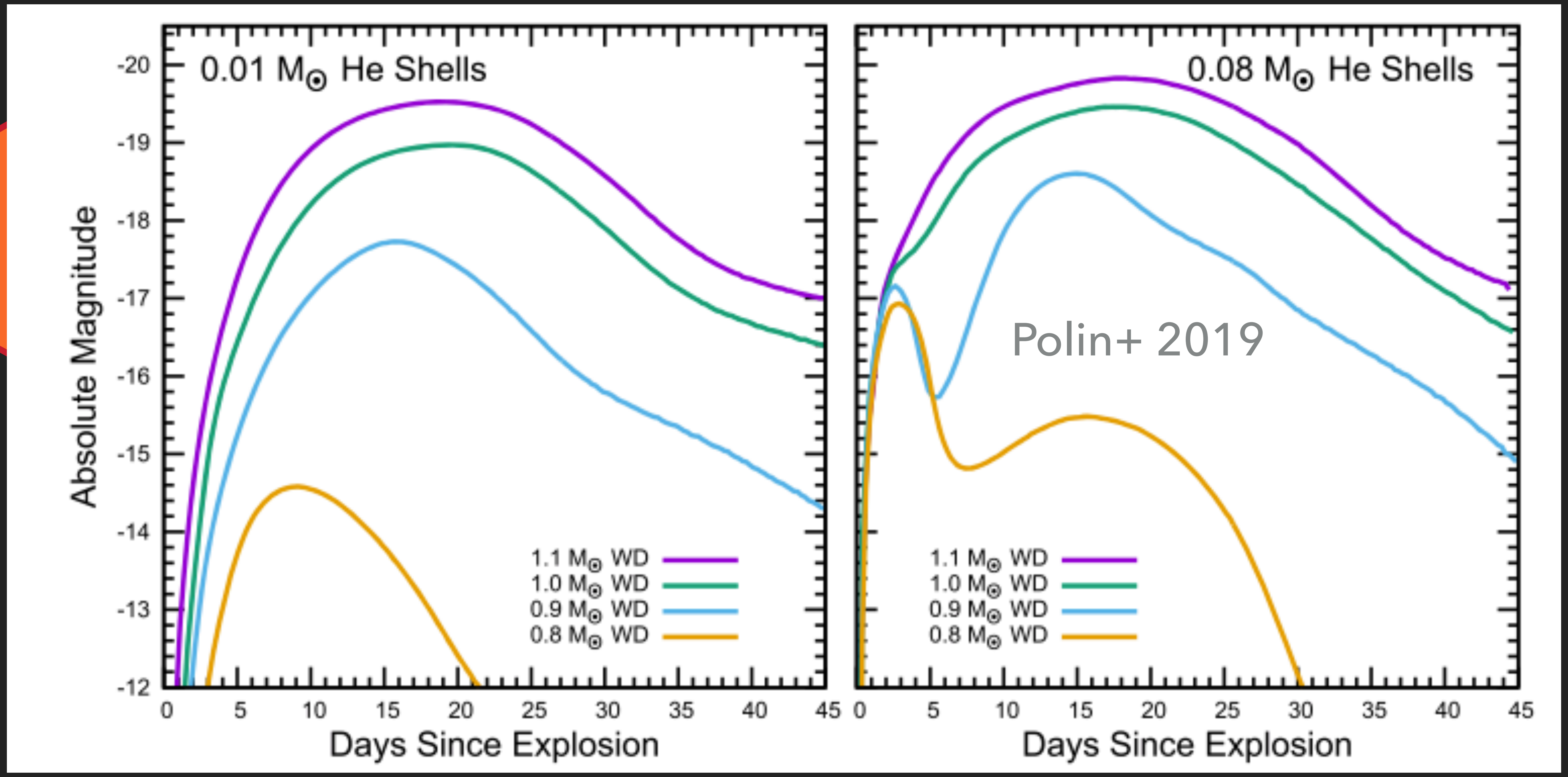
Multiple progenitor systems: sub-Chandrasekhar mass explosions

see: Scalzo+ 2014, Goldestein & Kasen 2018, Shen+ 2018, Polin+ 2019, Liu+ 2023, Ni+ 2023

SUB-CHANDRASEKHAR SNE

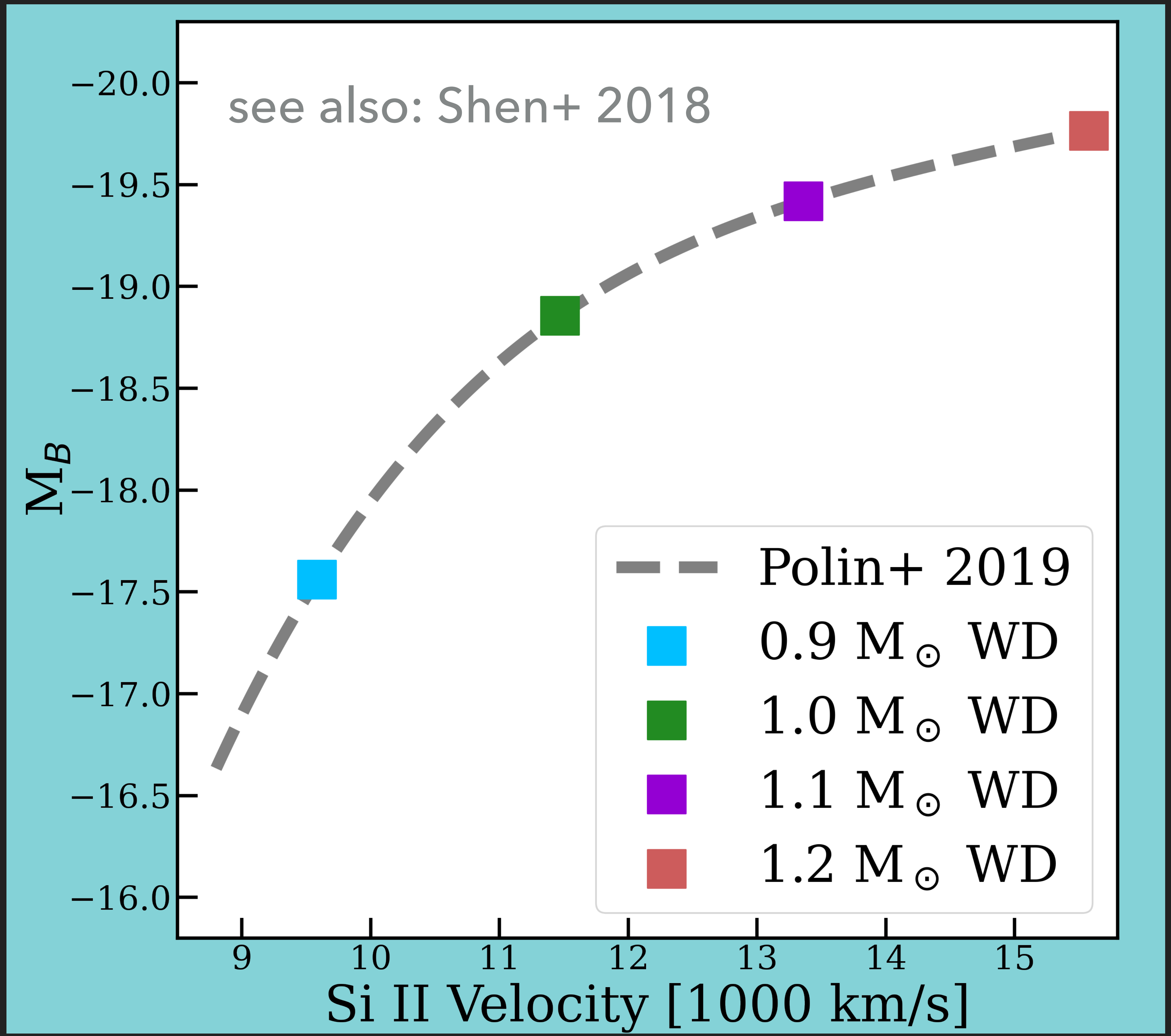
A white dwarf may be able to explode *before* it approaches the Chandrasekhar mass limit if the ignition of its helium shell sends a shock wave that ignites the CO white dwarf or its core





Early red evolution and bimodality in light curve: different from Chandrasekhar mass explosions

SUB-CHANDRASEKHAR SNE

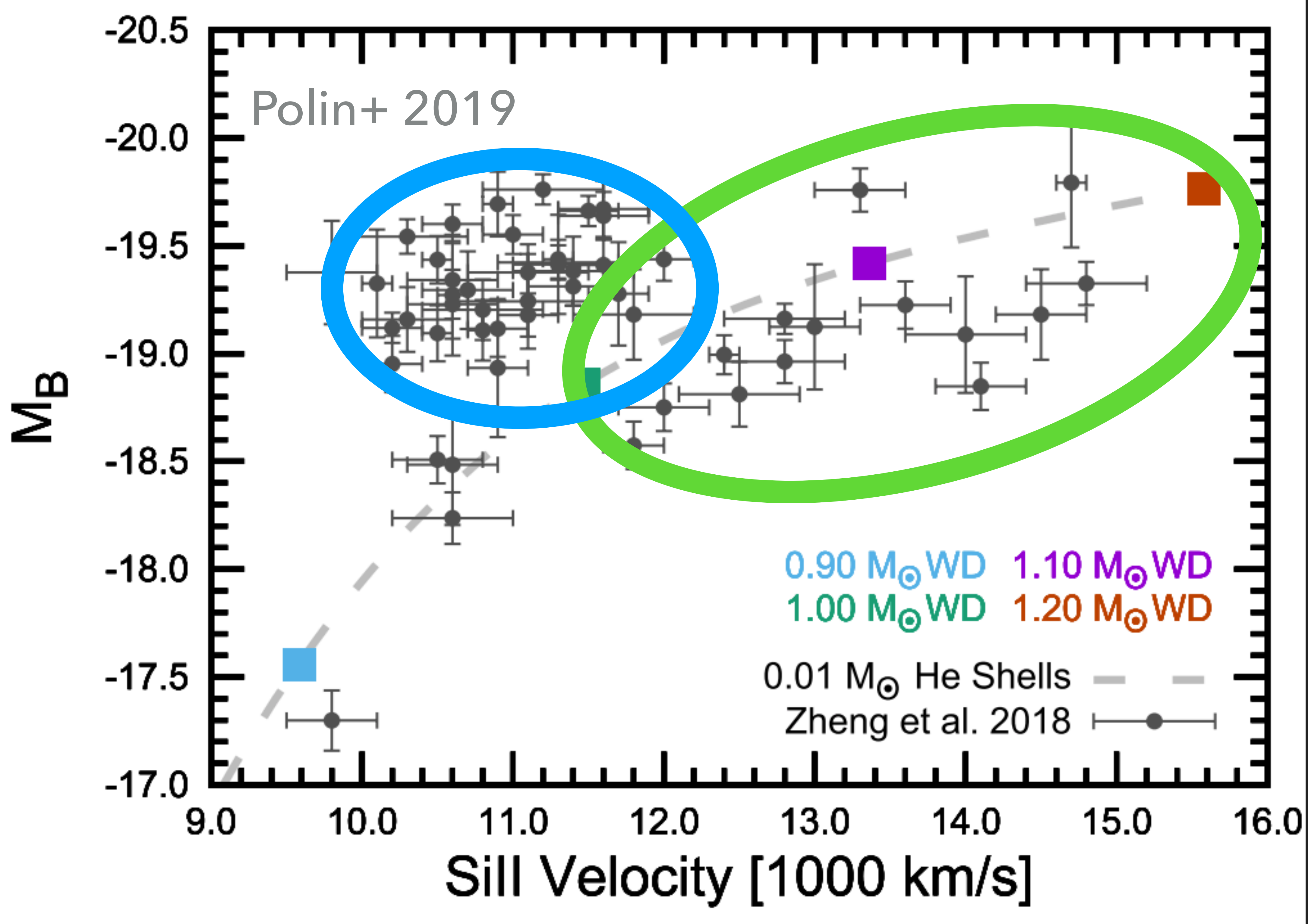


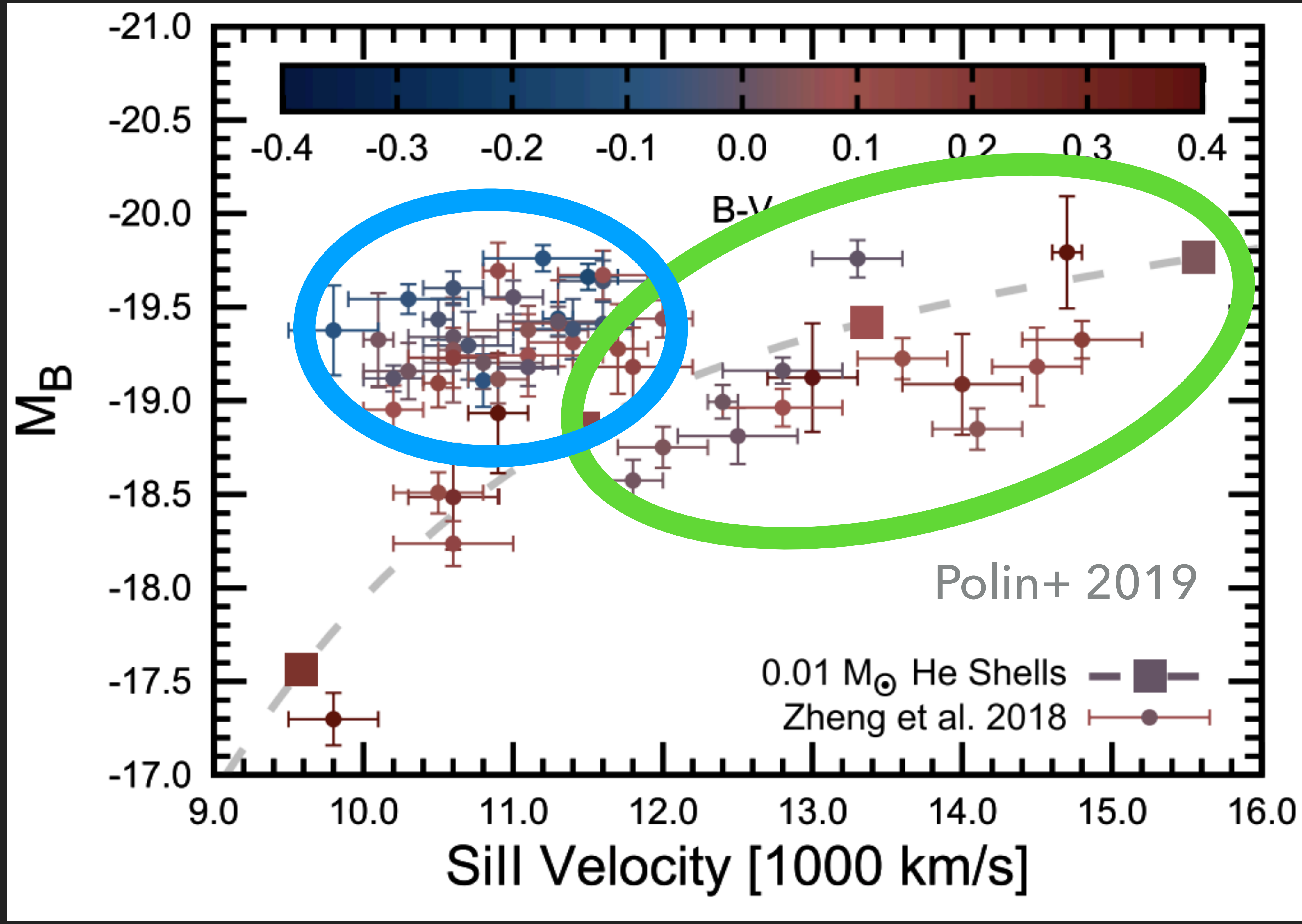
Models suggest there is a tight relationship between the mass of the white dwarf and the amount of ^{56}Ni produced

Over $0.85 < M_{WD} < 1.2M_{\odot}$:

- gravitational binding energy only increases 3.5 times while ^{56}Ni increases by two orders of magnitude
- this mean kinetic energy must increase, which can be observed with the Si II velocities!

SUB-CHANDRASEKHAR SNE





High-velocity SNe might represent sub-Chandrasekhar mass explosions: as their peak luminosities, Si II velocities, and redder colors match Polin+ 2019 models

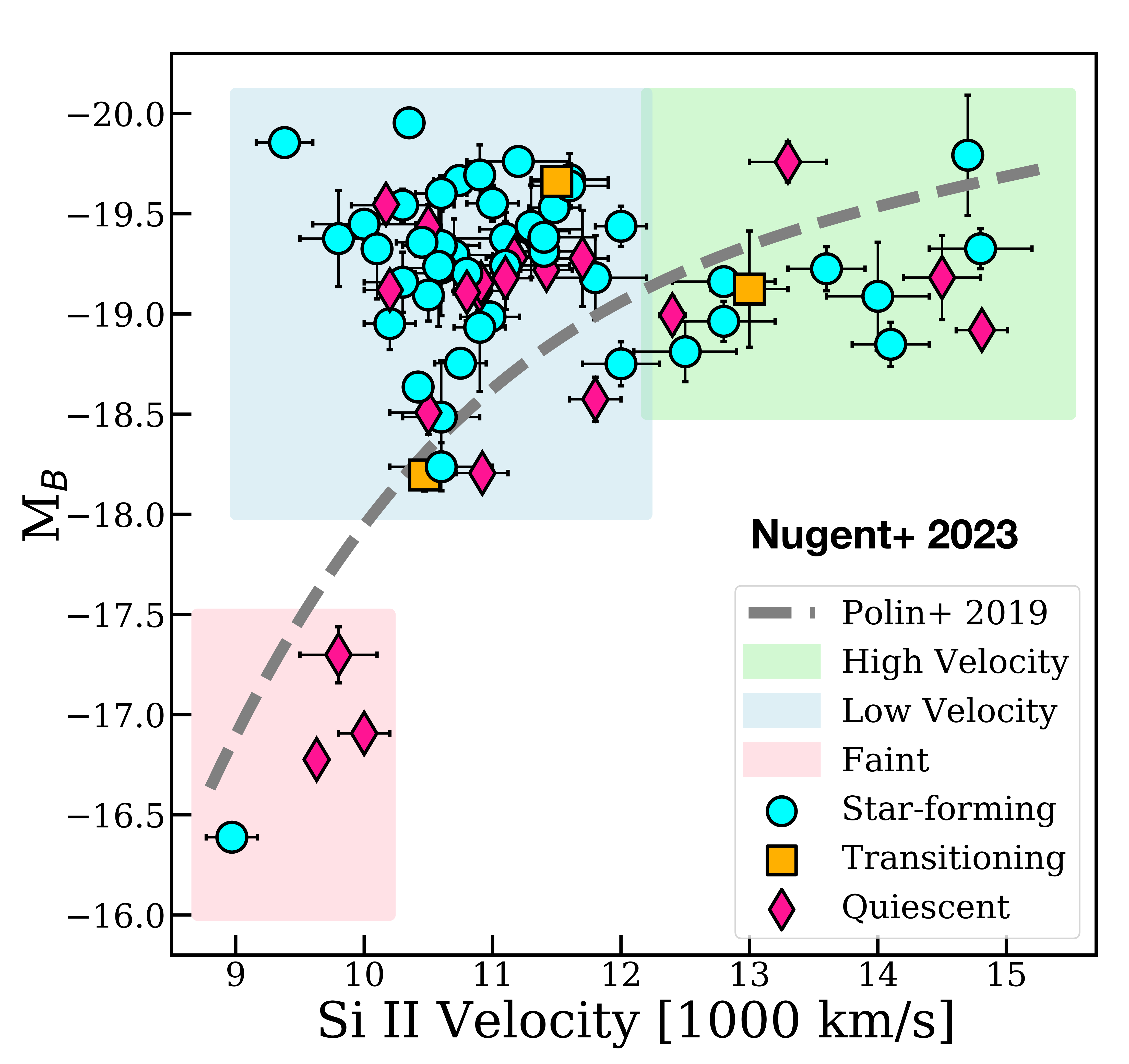
see also: Wang+ 2009, Foley & Kasen 2011

WHY ARE HOST GALAXIES IMPORTANT?

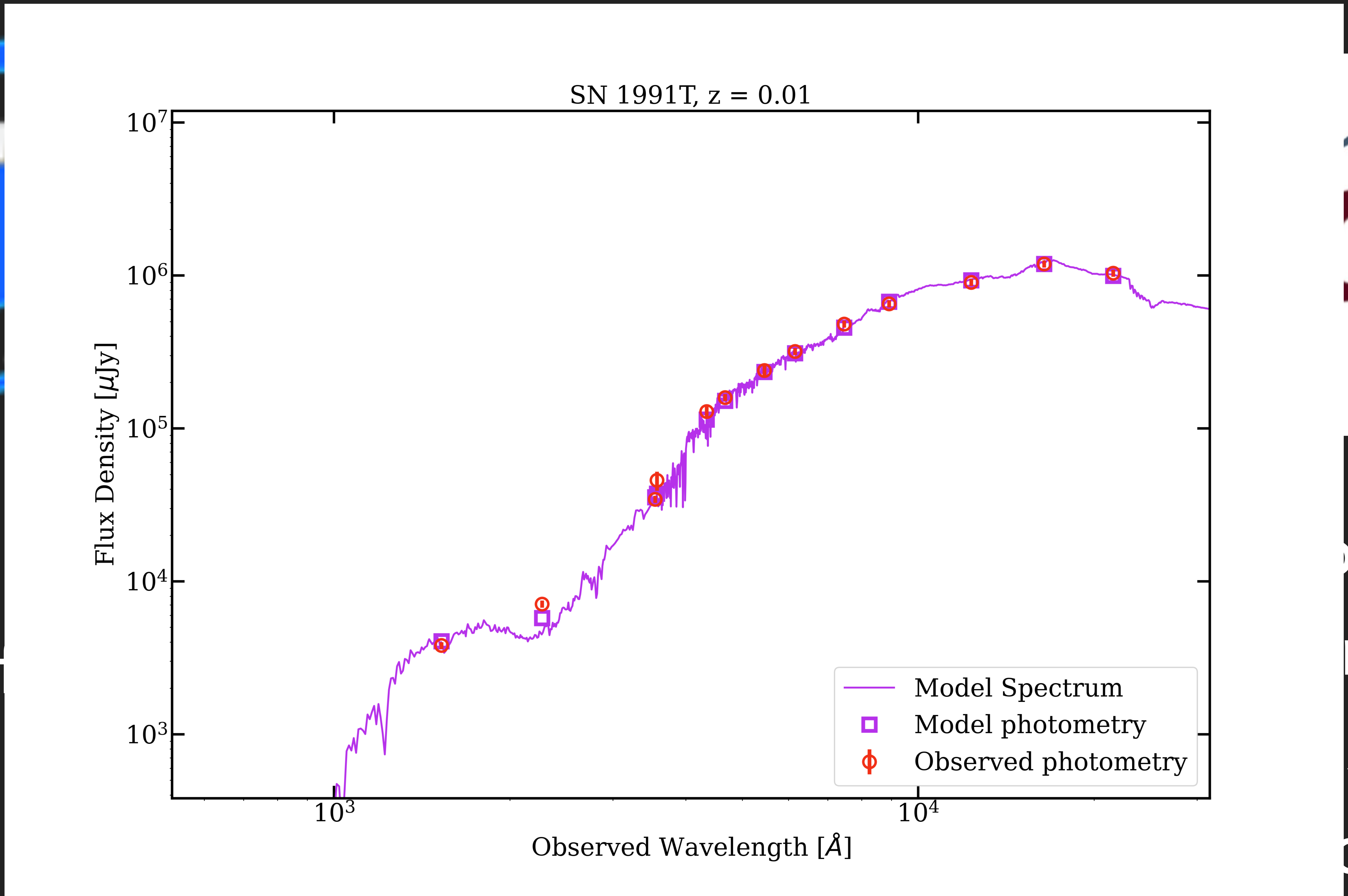
- Using star formation rates, stellar masses, ages, metallicities, dust with sub-Chandrasekhar SNe candidate hosts:
    - we may be able to infer if sub-Chandrasekhar SNe trace different environmental properties than classical SNe Ia;
    - determine if faintness and redness are caused from dust extinction in the global properties of the host or are intrinsic to the progenitor;
    - use any environmental differences to separate sub-Chandrasekhar candidates in the future of large photometric surveys

OUR SAMPLE

- 74 local universe SNe from LOSS sample:
  - 14 Sub-Chandrasekhar SNe candidates = high velocity
  - 56 Chandrasekhar SNe candidates = low velocity
  - 4 very faint, low velocity, SN 1991bg -like SNe = faint



OBSERVATIONS AND STELLAR POPULATION MODELING



All data collected f

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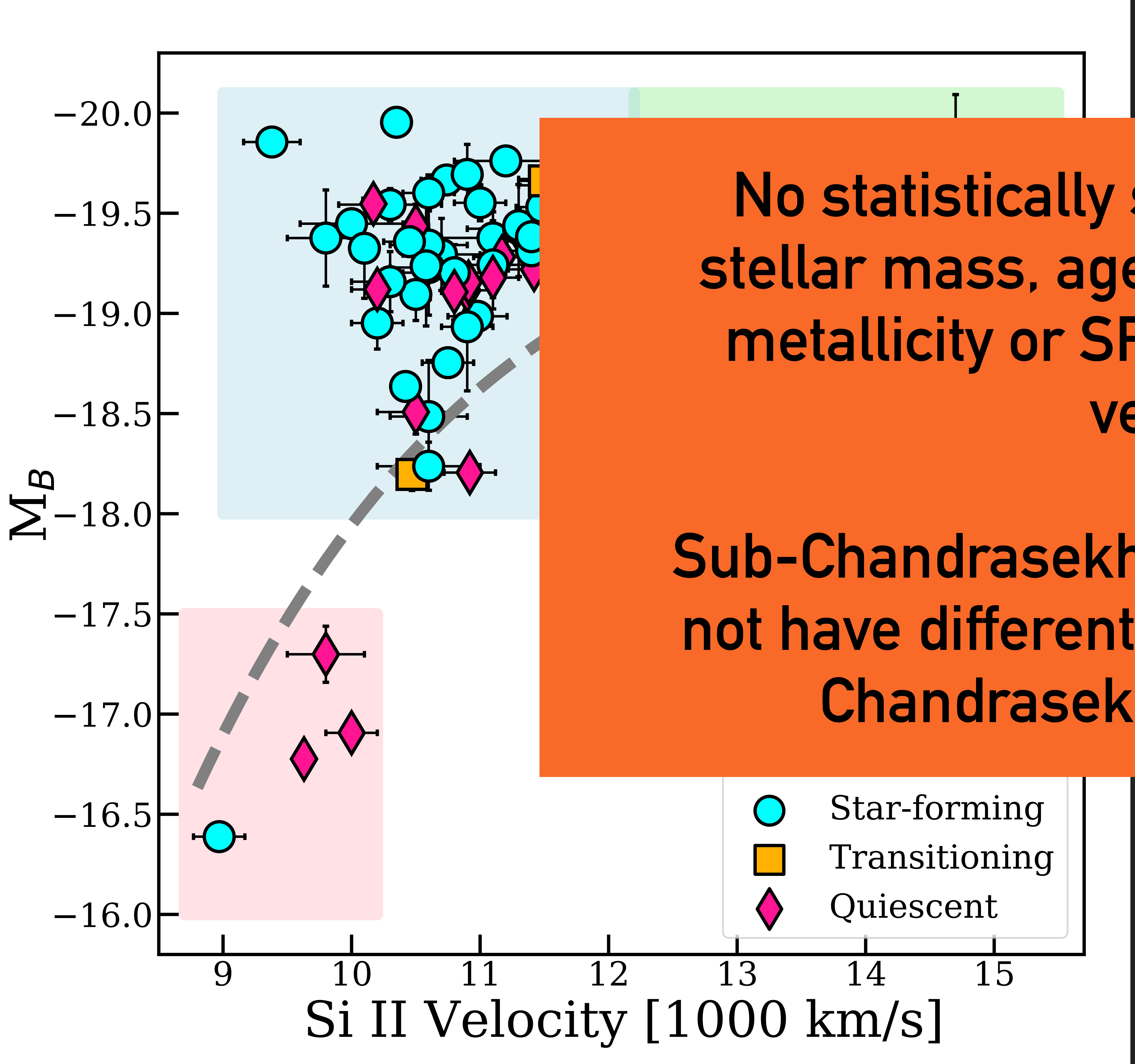
GLOBAL HOST GALAXY PROPERTIES



No statistically significant differences in stellar mass, age, dust attenuation, stellar metallicity or SFR between high and low velocity SNe

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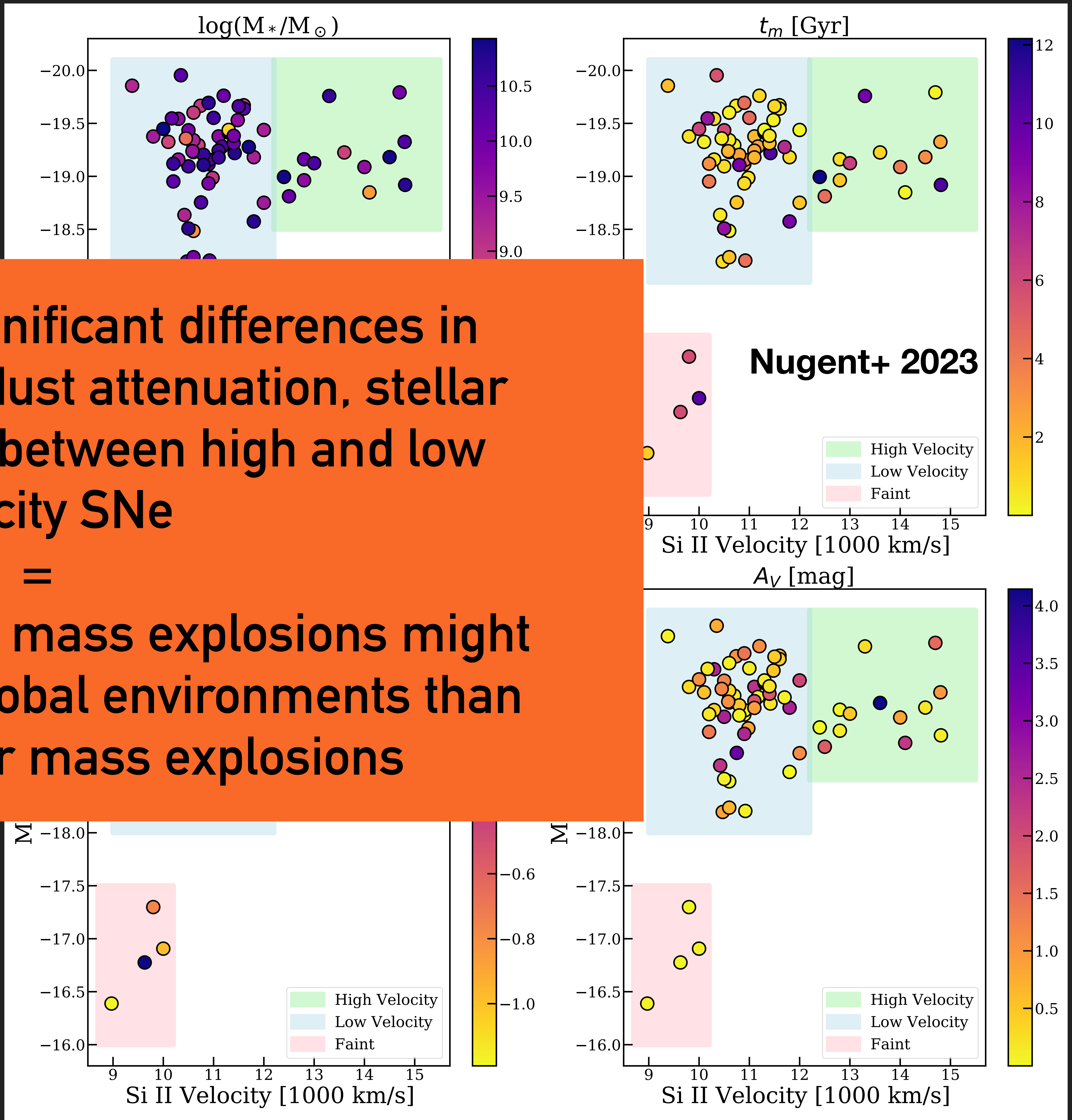
Sub-Chandrasekhar mass explosions might not have different global environments than Chandrasekhar mass explosions



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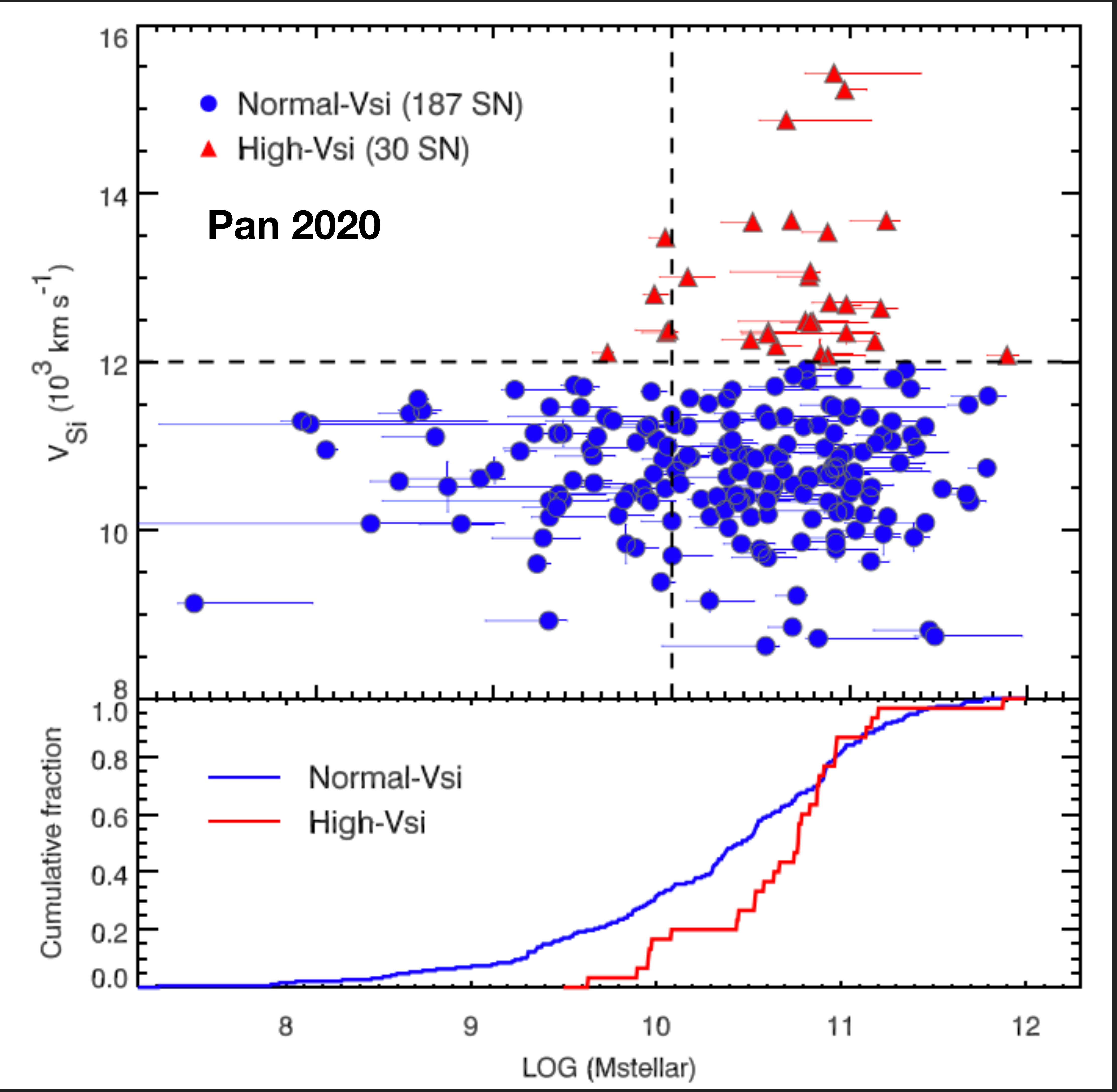
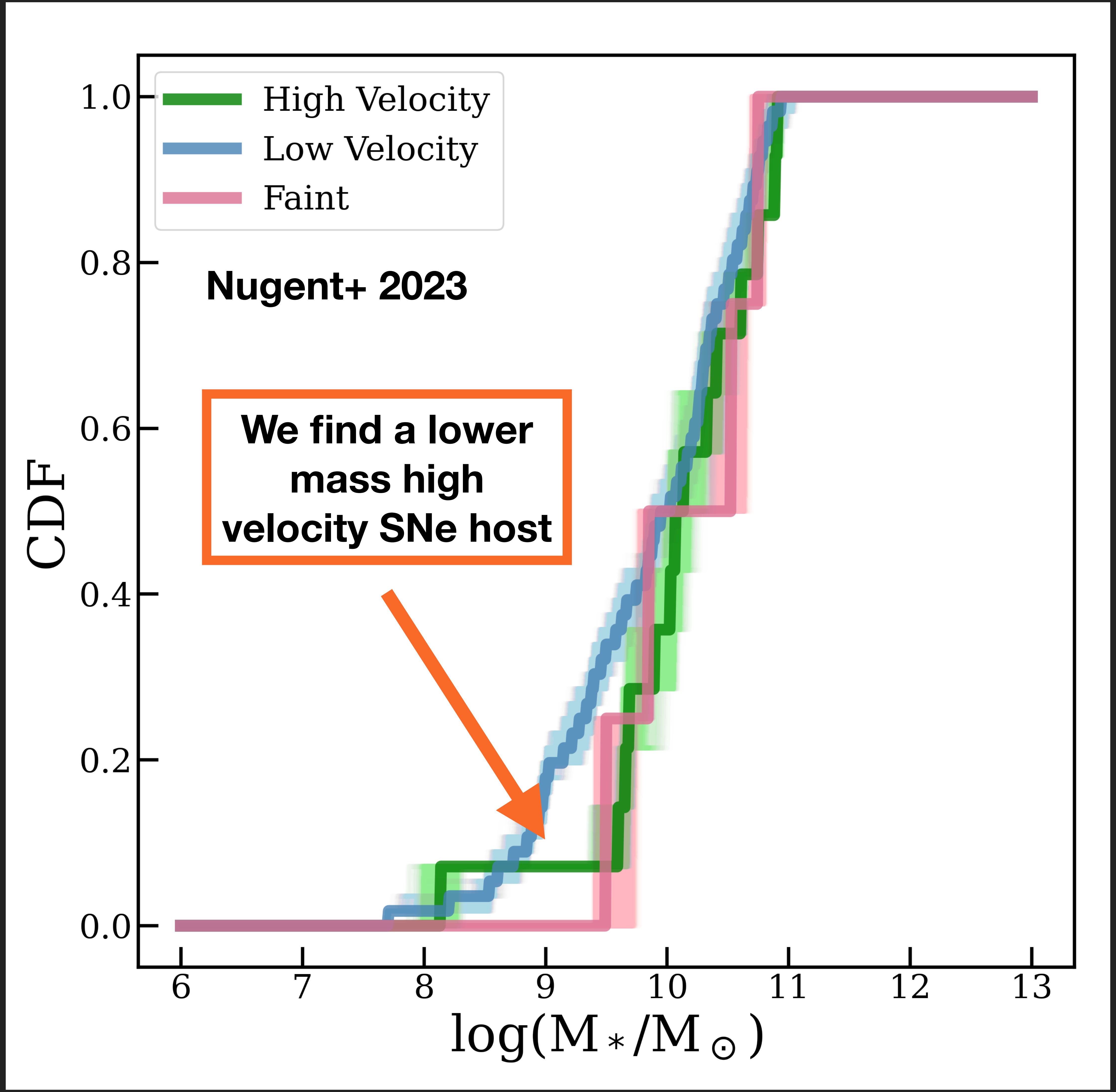
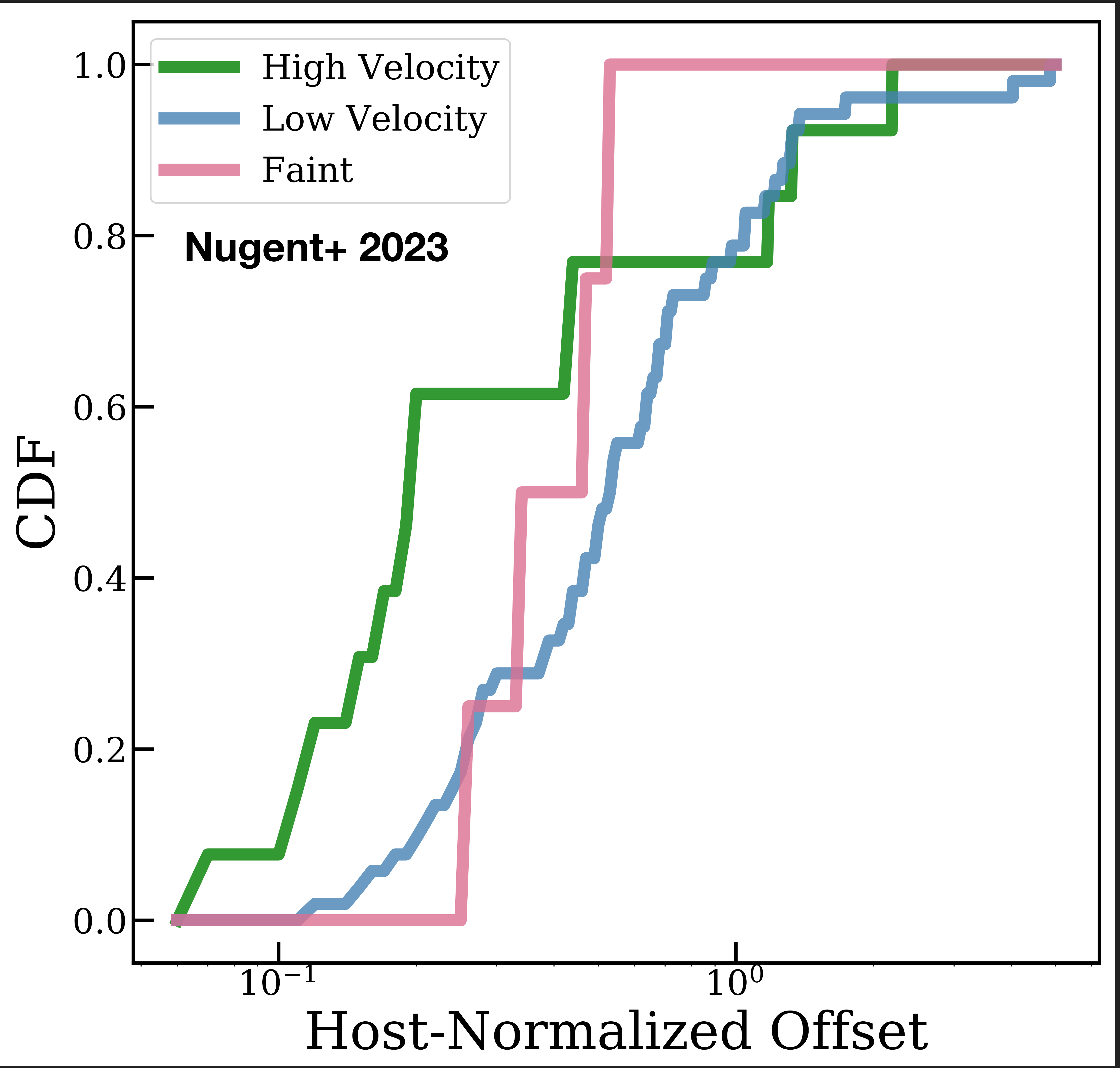




LOCAL ENVIRONMENTS: OFFSETS

- Using offset of SN to host center and the 2MASS K-band total host radius (all provided on NED), we can calculate host-normalized offsets
- We find statistically significant results that high-velocity SNe are at lower offsets from their hosts than low-velocity SNe



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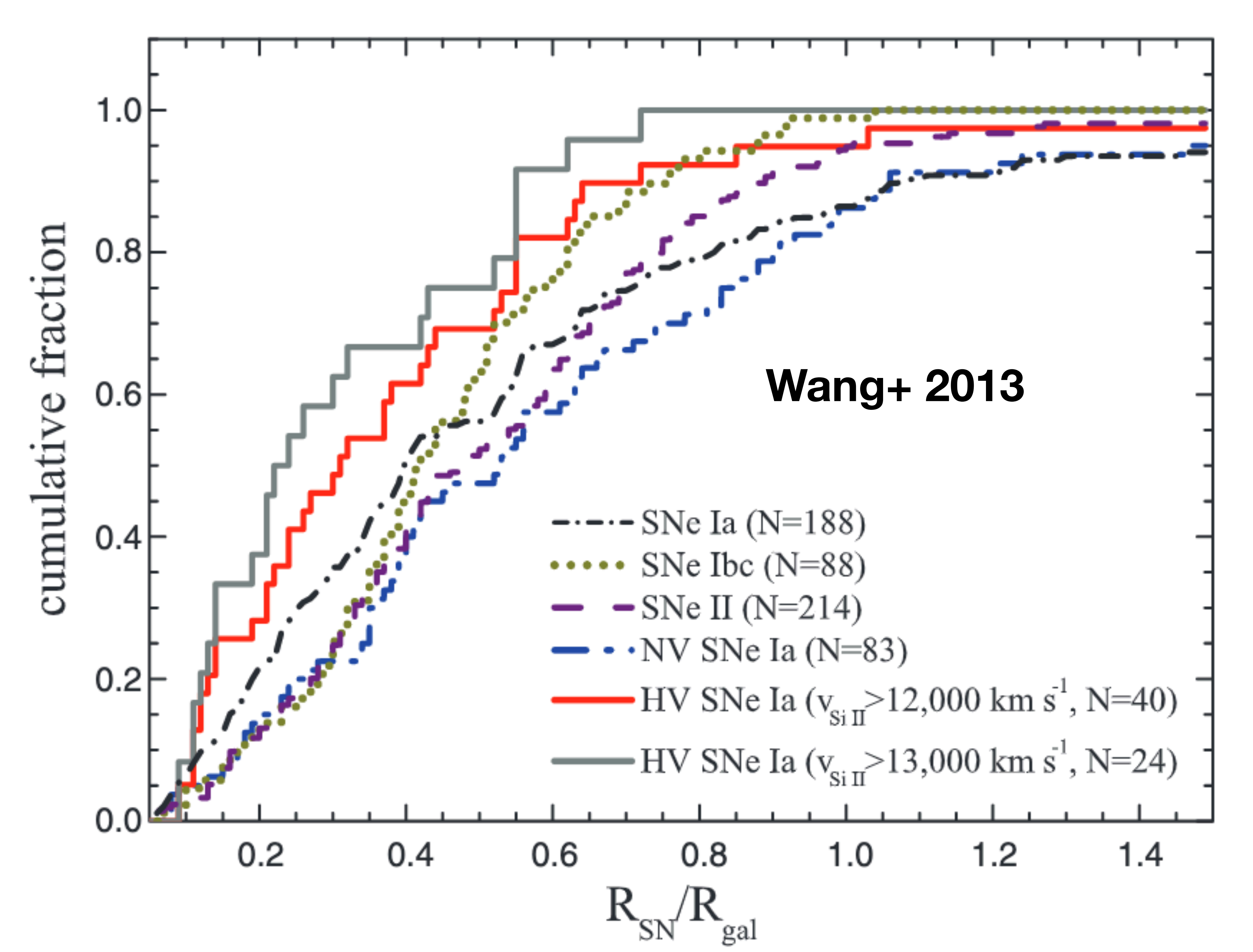
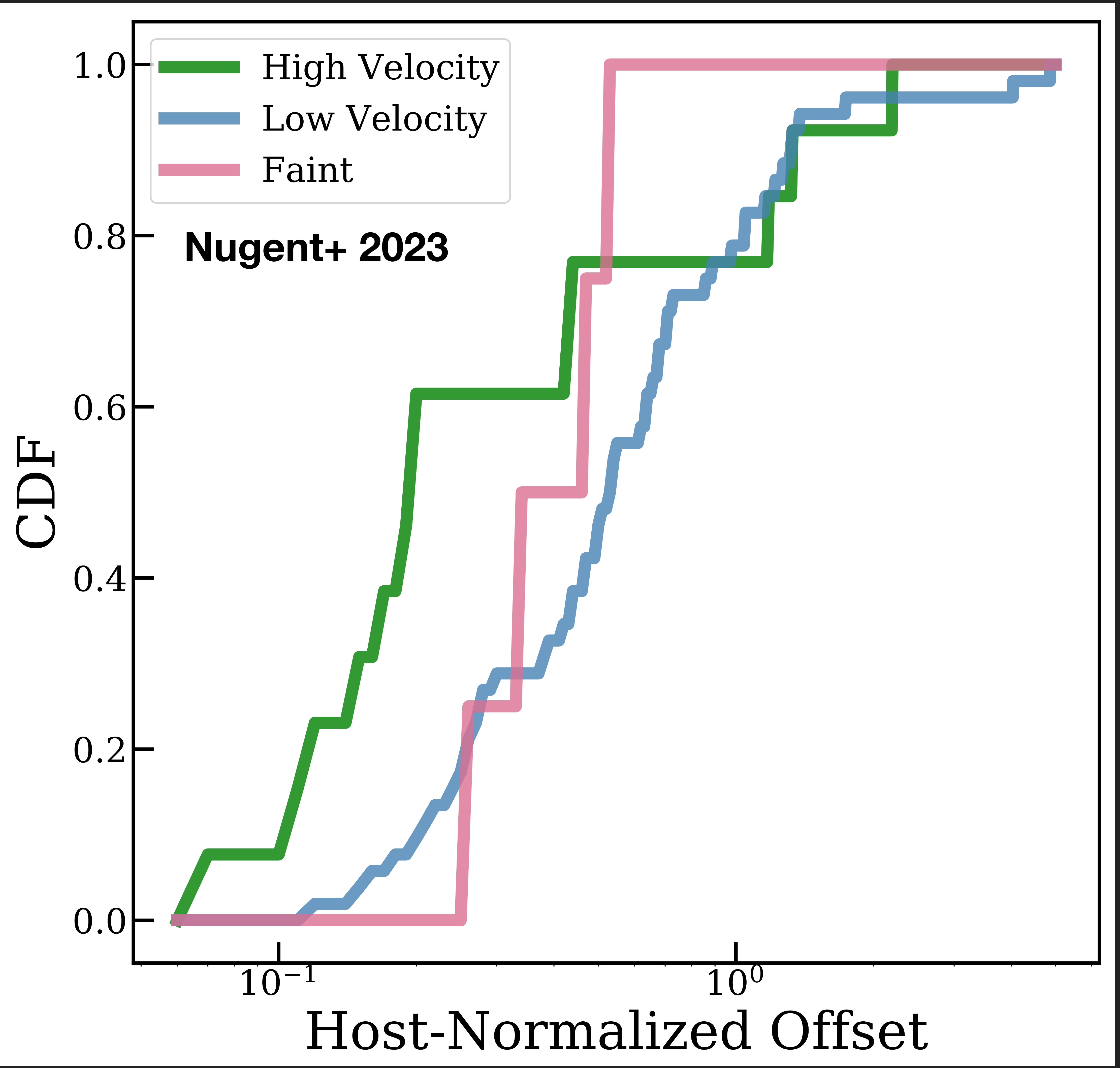


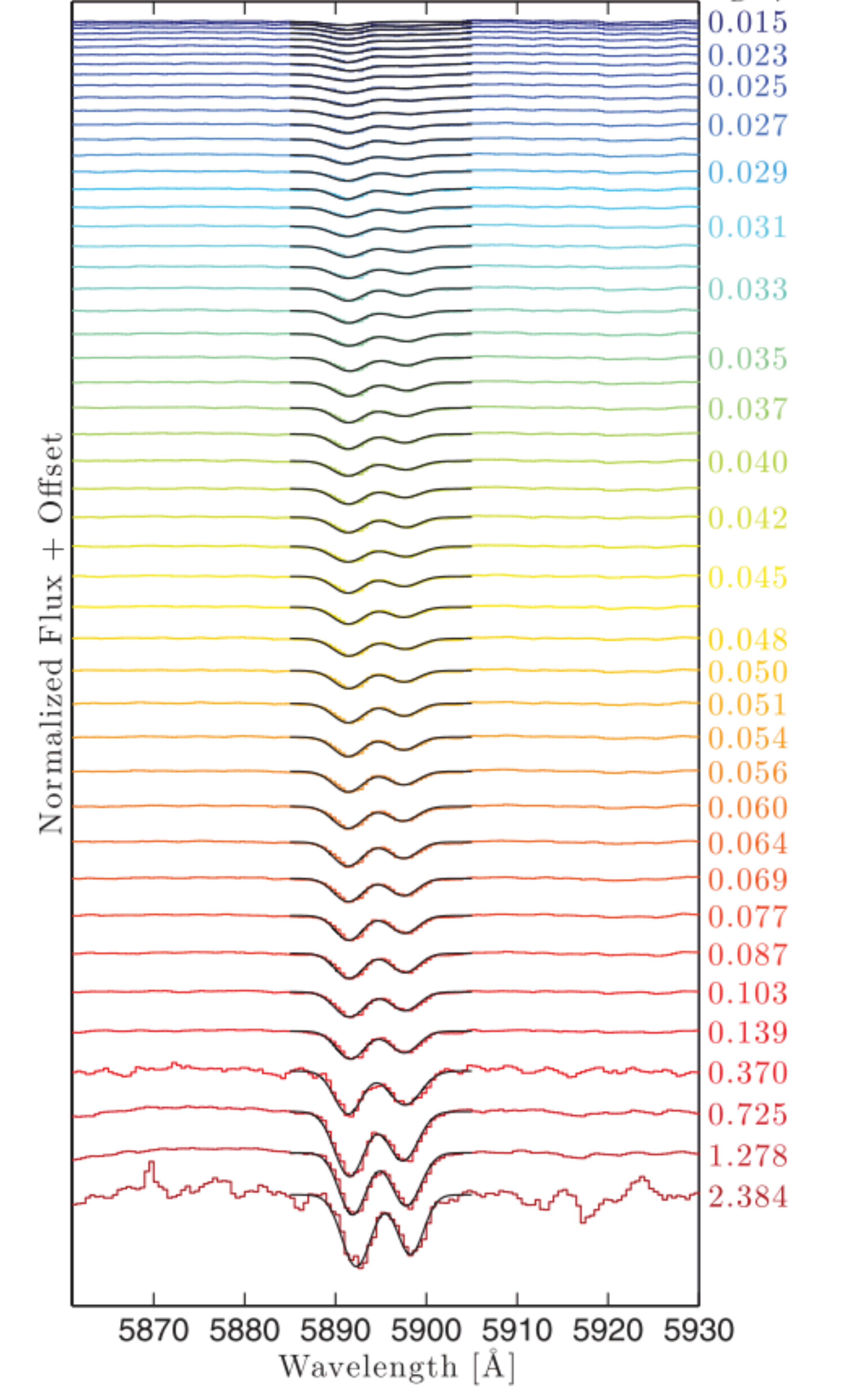


LOCAL ENVIRONMENTS: NA I D EQUIVALENT WIDTHS

- Na I D lines in SNe Ia spectra directly probe the amount of circumstellar gas, dust, and metals
- Nearly all SNe in our sample had a published Na I D equivalent width value (we did analysis for 13)

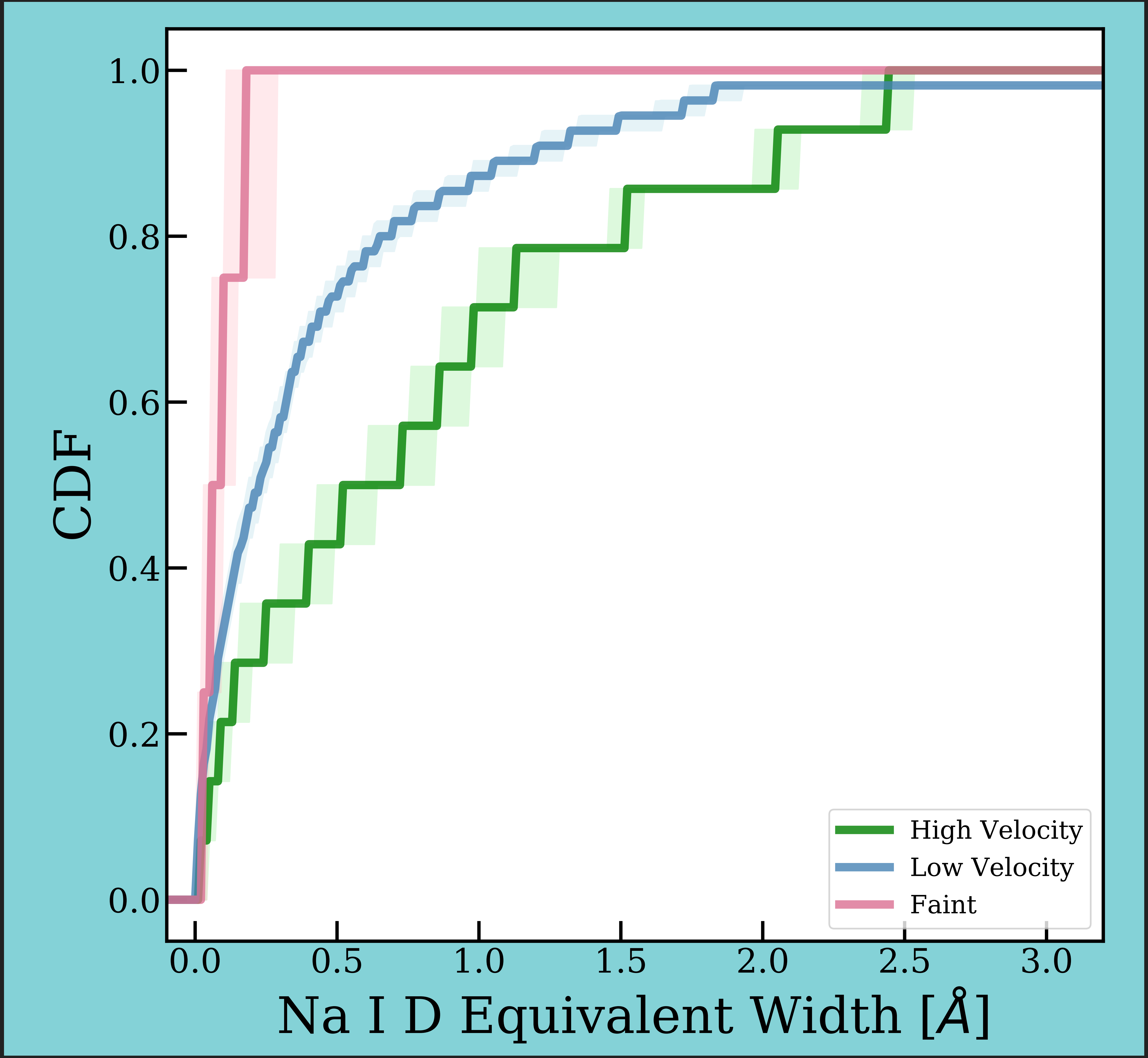
see: Blondin+ 2009, Folatelli+ 2010, Phillips+ 2013

Poznanski+ 2012

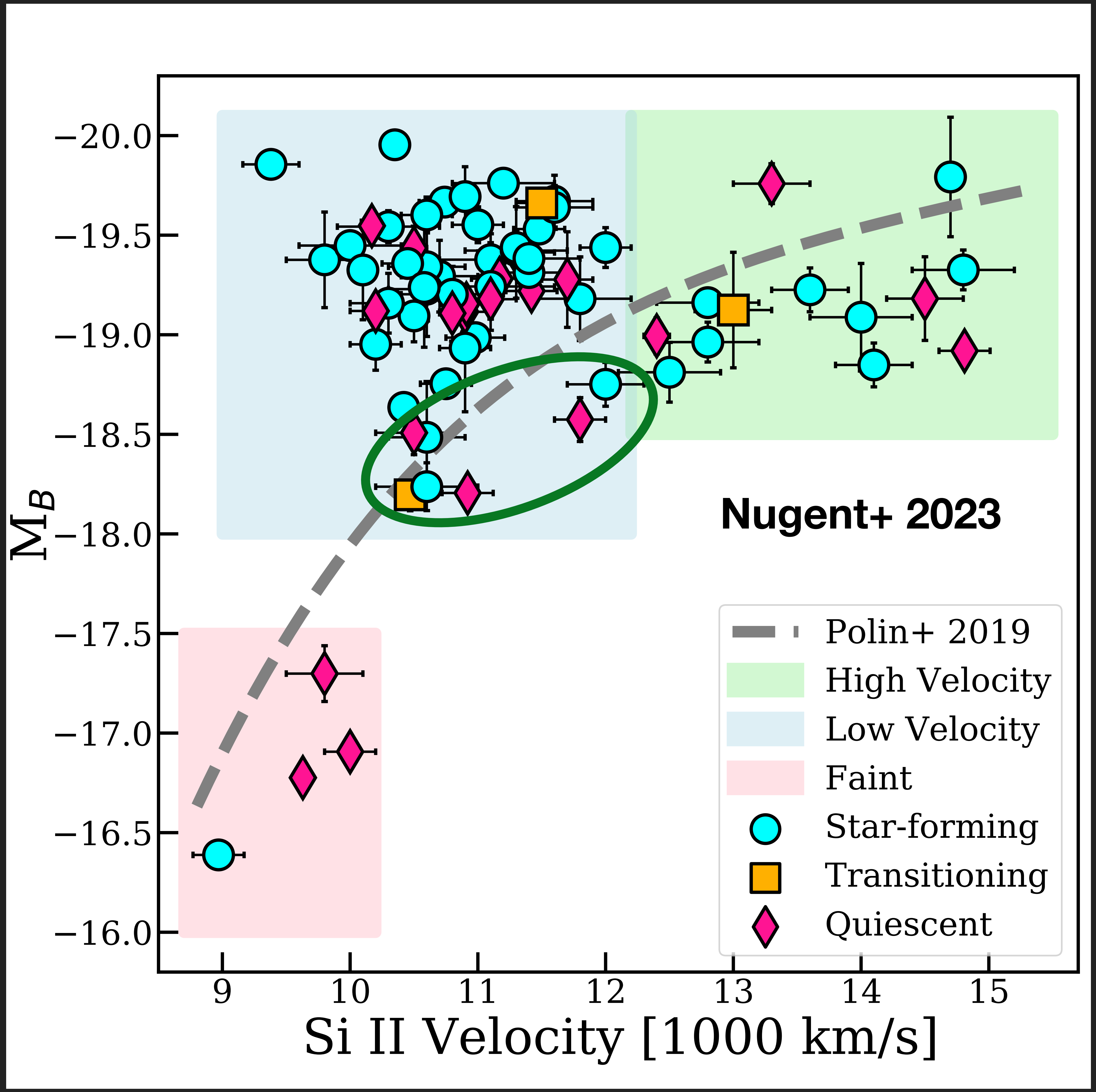


LOCAL ENVIRONMENTS: NA I D EQUIVALENT WIDTHS

High velocity SNe have significantly stronger Na I D lines - potentially more dust or a higher gas to dust ratio surrounding the SNe



LOCAL ENVIRONMENTS: LOW VELOCITY CANDIDATES



A handful of lower velocity SNe with low luminosities that may be derived from sub-Chandrasekhar mass explosions

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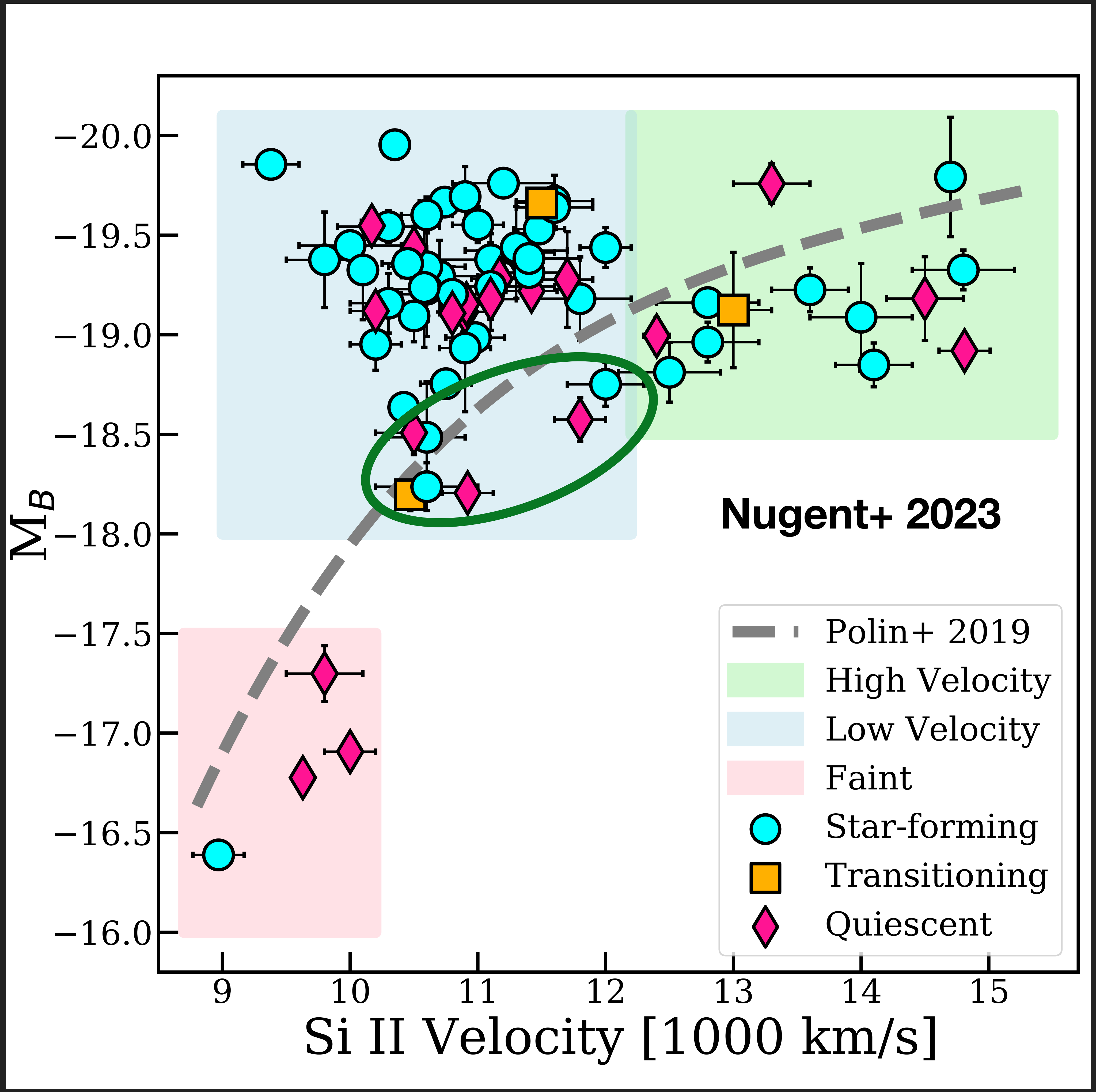

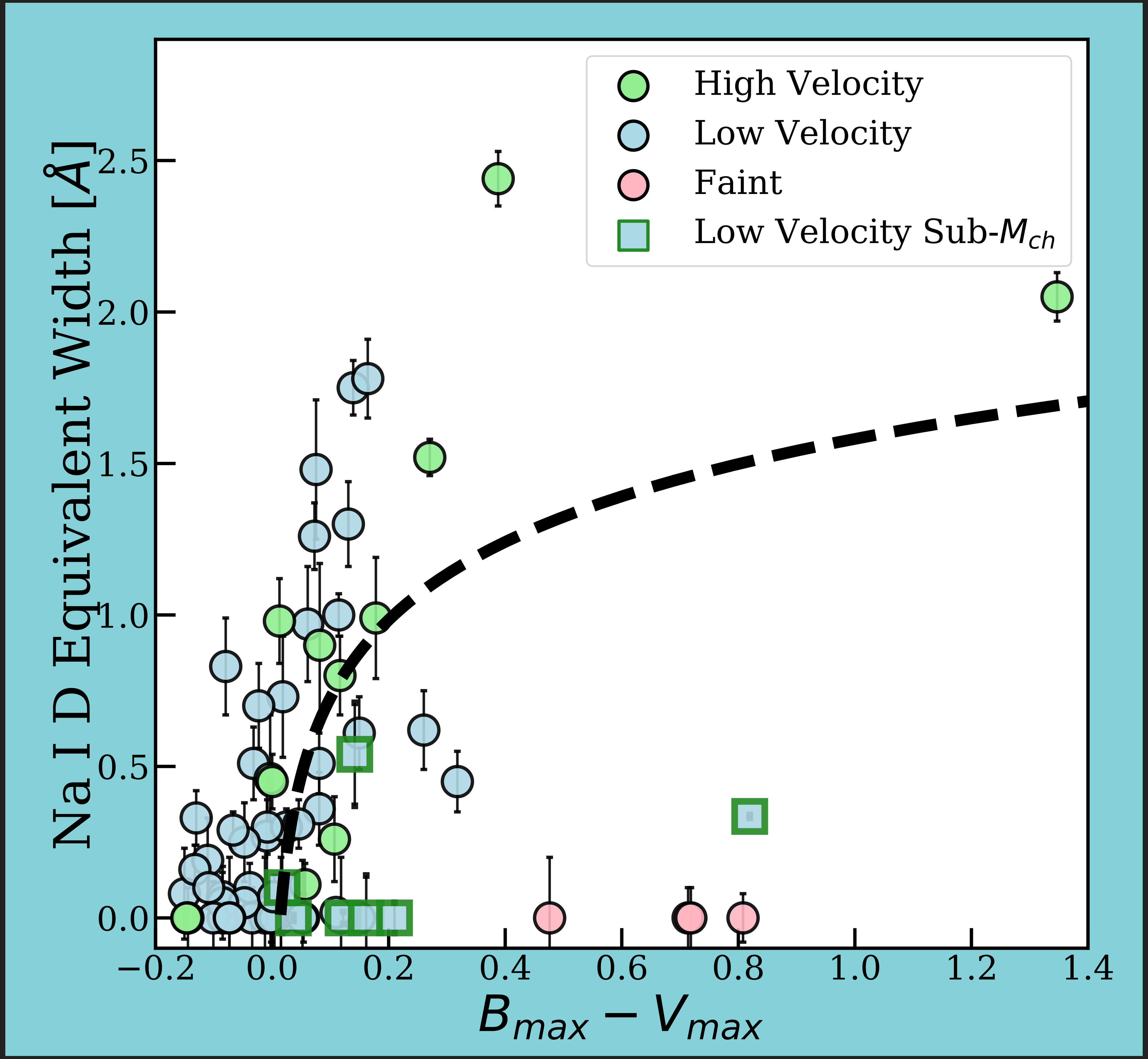

SUMMARY AND FUTURE WORK

- Global host properties cannot be used to distinguish high and low velocity SNe: sub-Chandrasekhar mass explosions do not occur in different global environments
- Local environments may better distinguish these SNe:
    - Na I D line strength clearly a distinguishing trait between high and low velocity SNe
    - Problems: need SN spectrum, local environments can really only be probed in near universe
- Future work: study the resolved stellar populations of these sub-Chandrasekhar environments and find better photometric probes of these SNe that do not require a spectrum (i.e. - redder colors!)