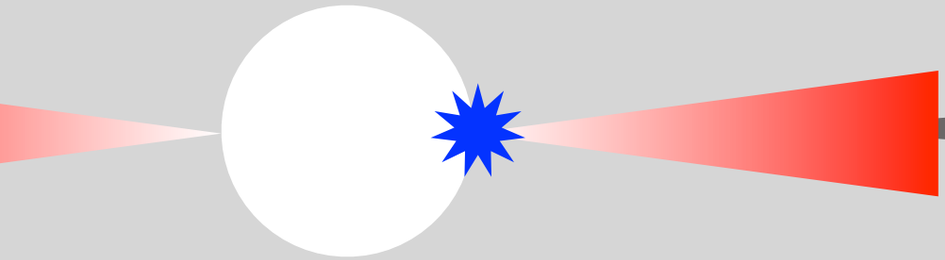
A New Way to Infer CSM Properties

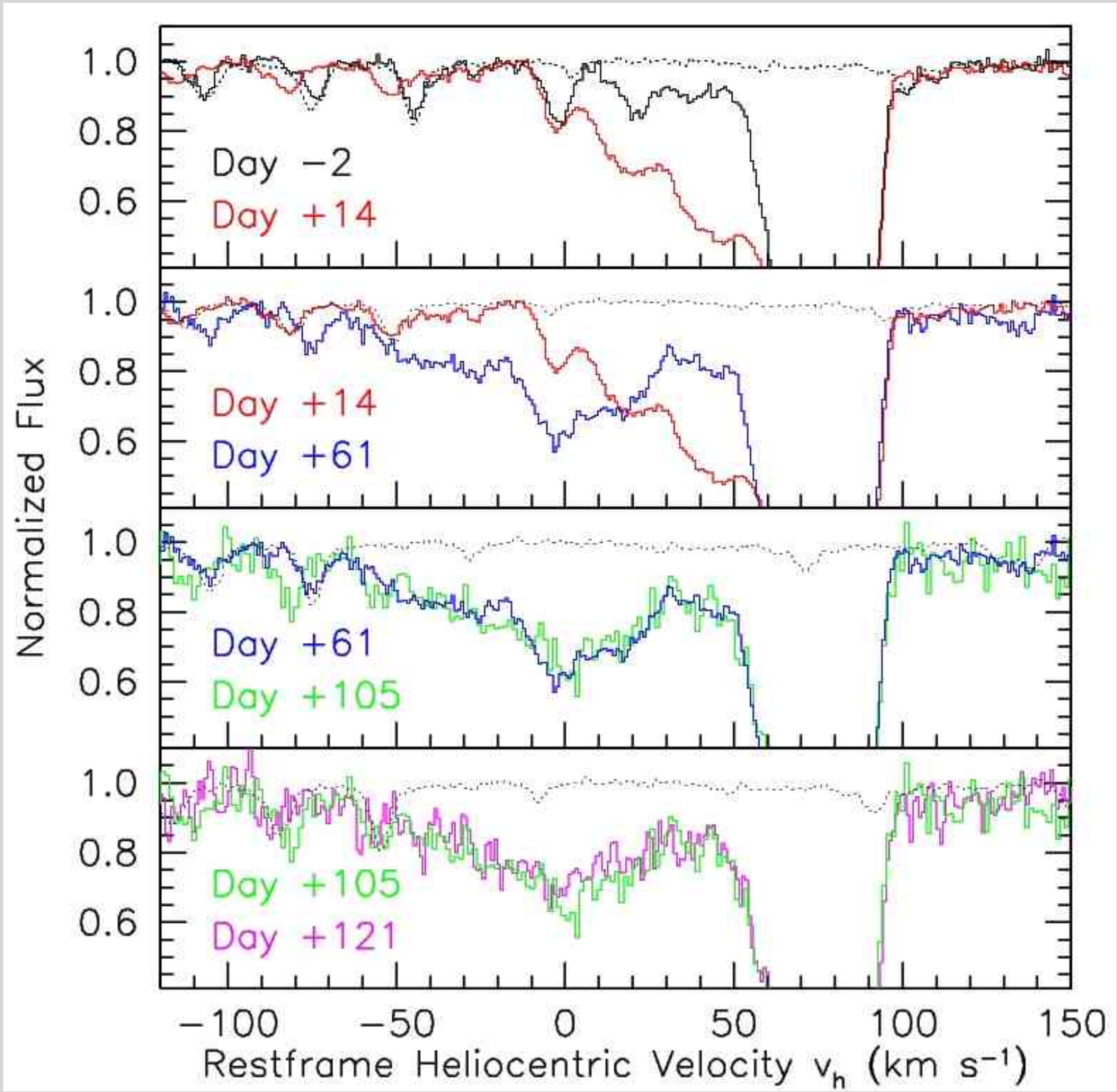
Ryan Foley
University of Illinois

Single Degenerate Wind Accretion



Single Degenerate Wind Accretion

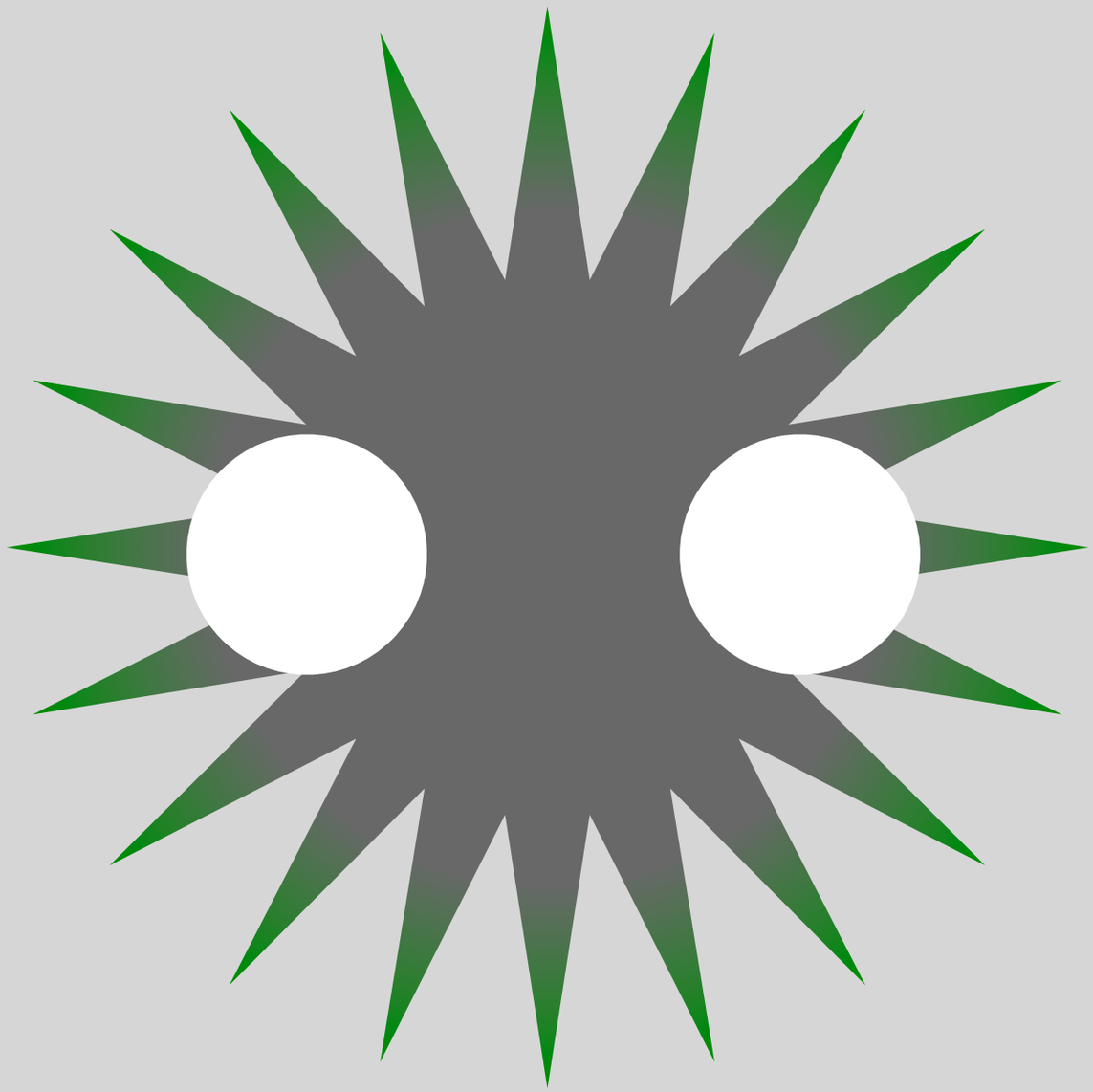
Variable Na ➡ Circumstellar Material



Time

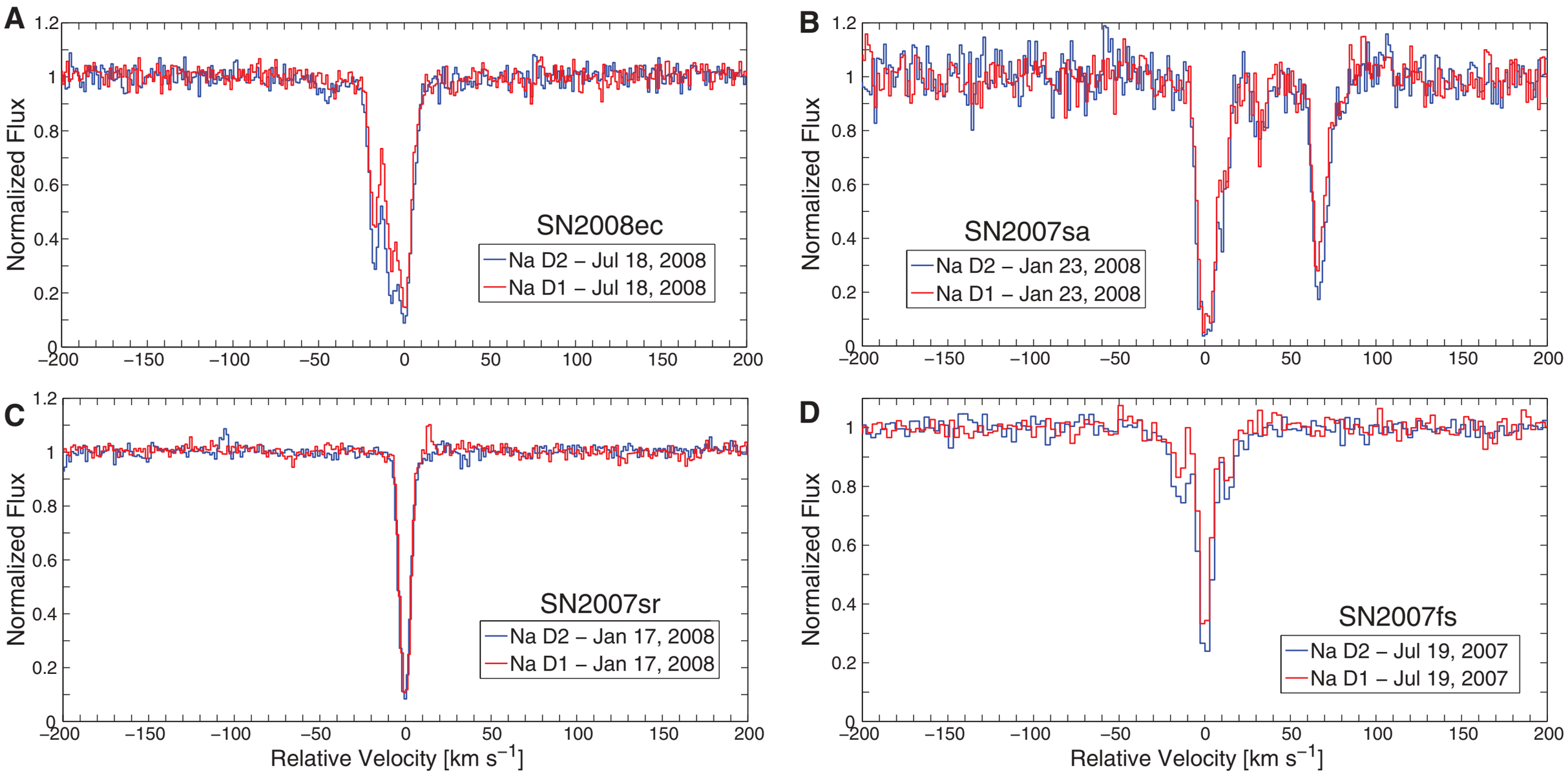
Patat et al. 2007

Double Degenerate



Double Degenerate

High-Resolution Spectra Probe CSM



Sternberg et al. 2011

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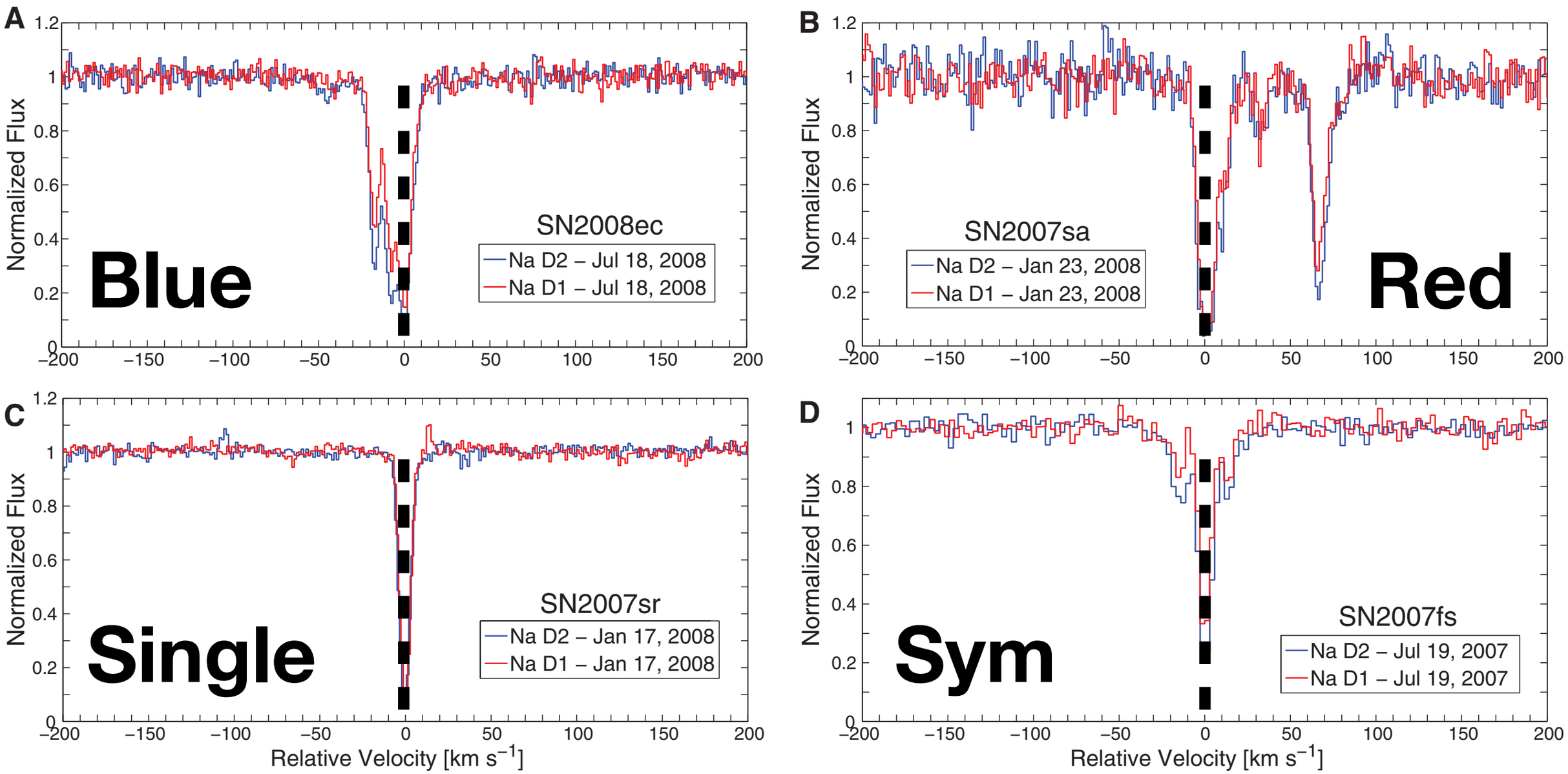

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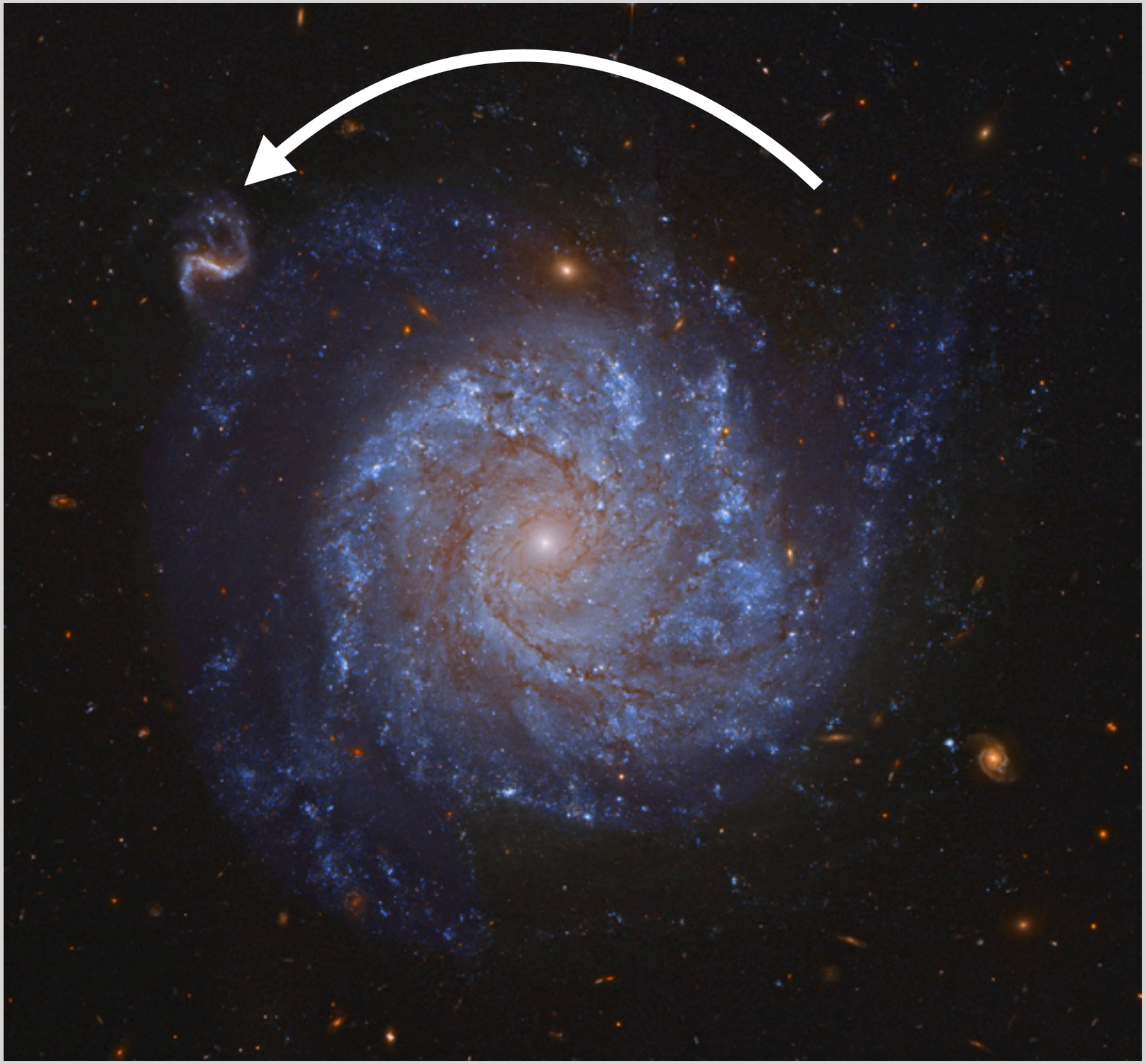
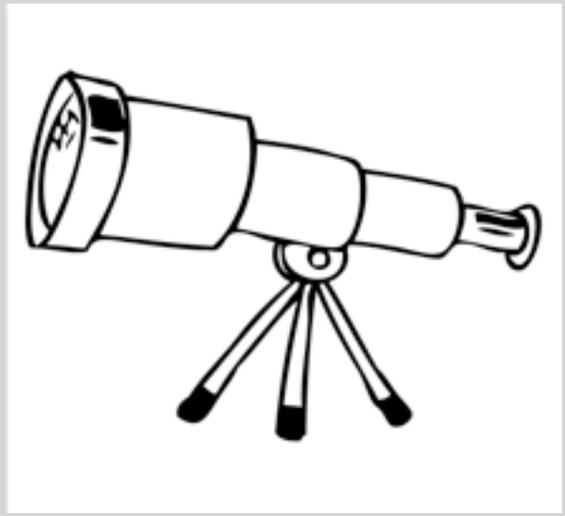
Equal Blue/Redshifted Fraction for ISM





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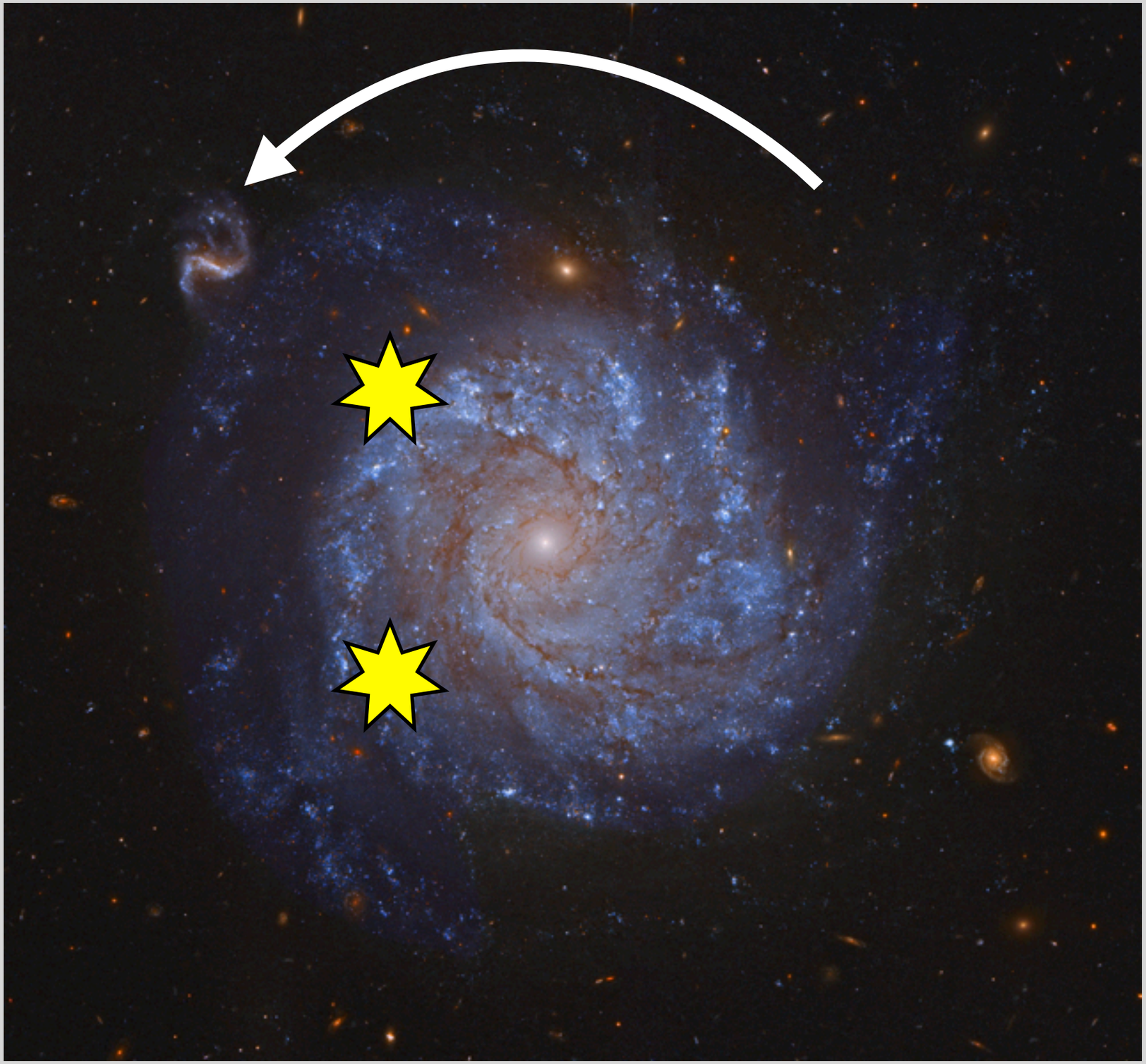

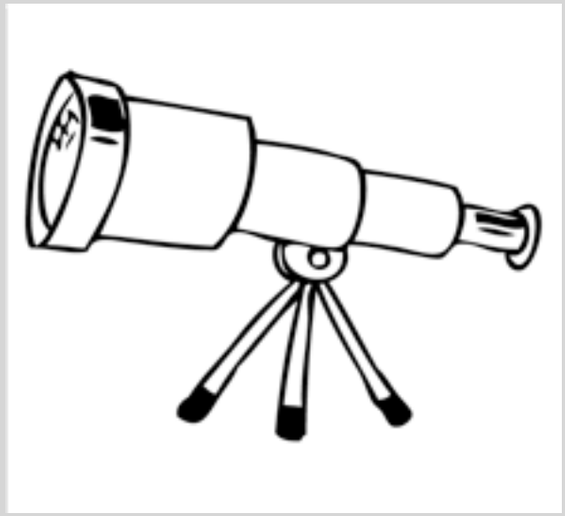

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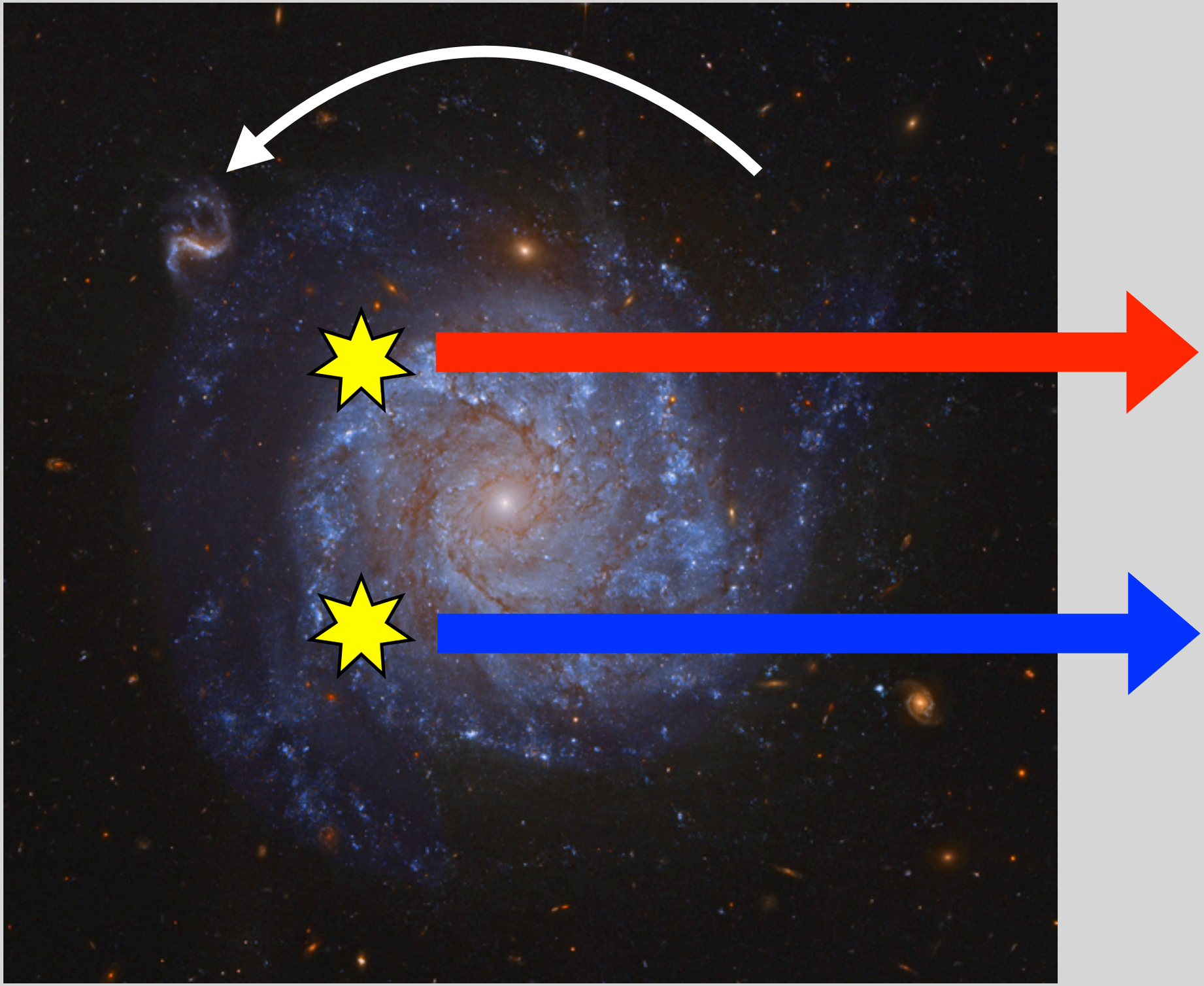
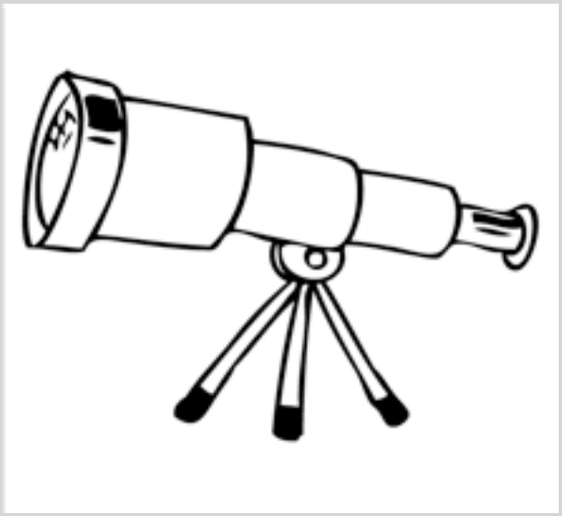
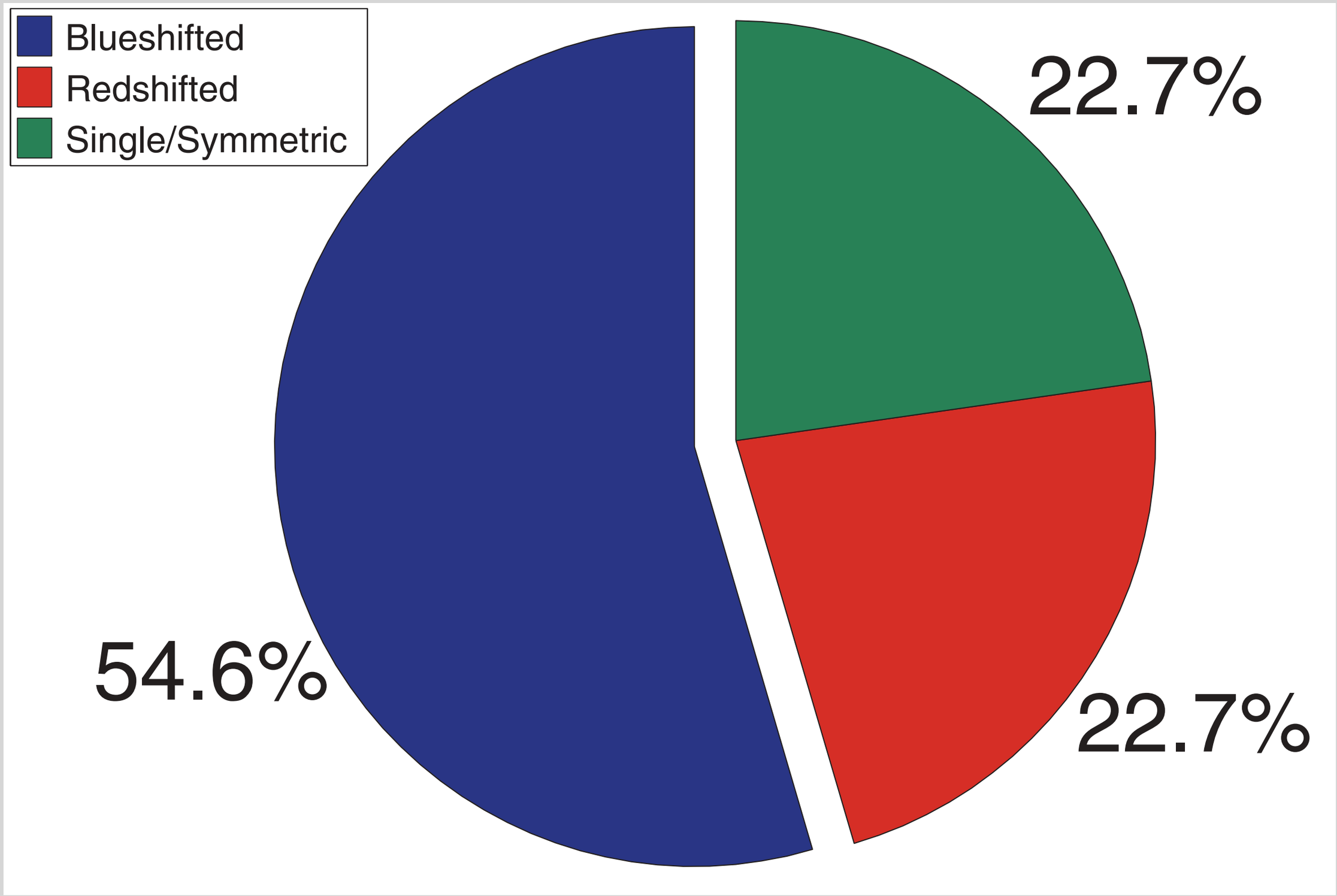


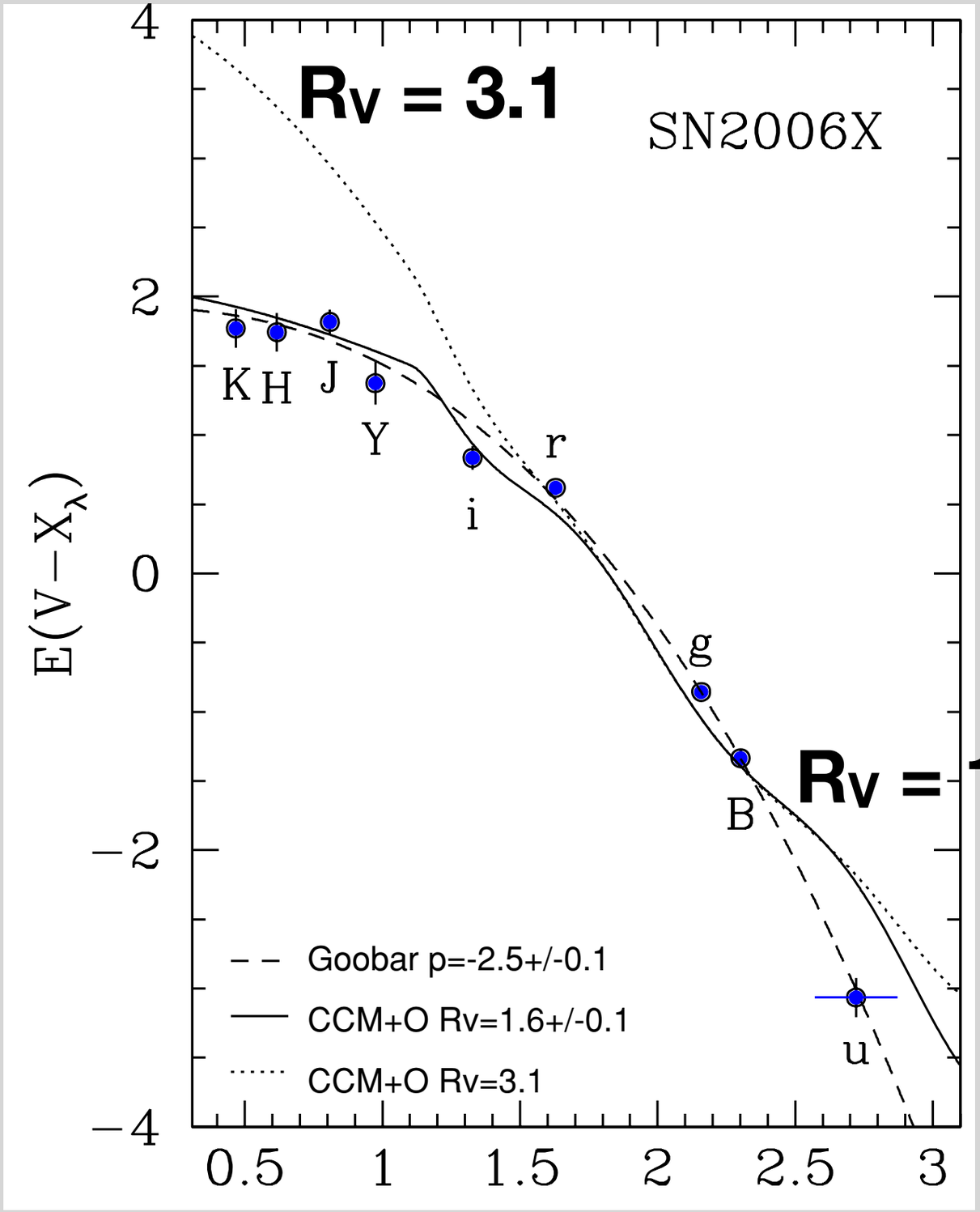


Many SN Ia Progenitors Have Winds



Sternberg et al. 2011

SNe Ia With Variable Na Have Low R_V

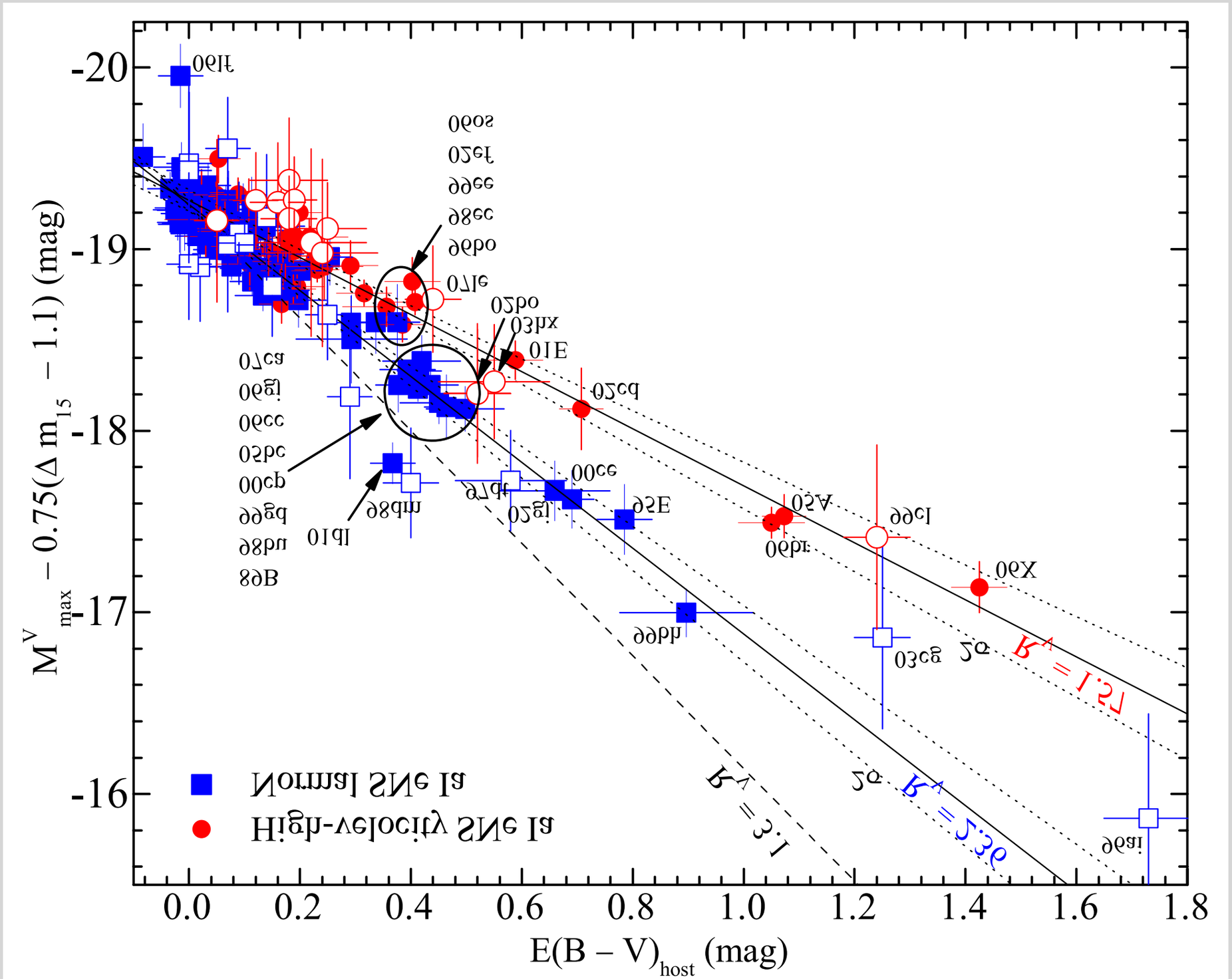


Rv = 1.6

Circumstellar Scattering

Folatelli et al. 2010

2 Values of Rv?

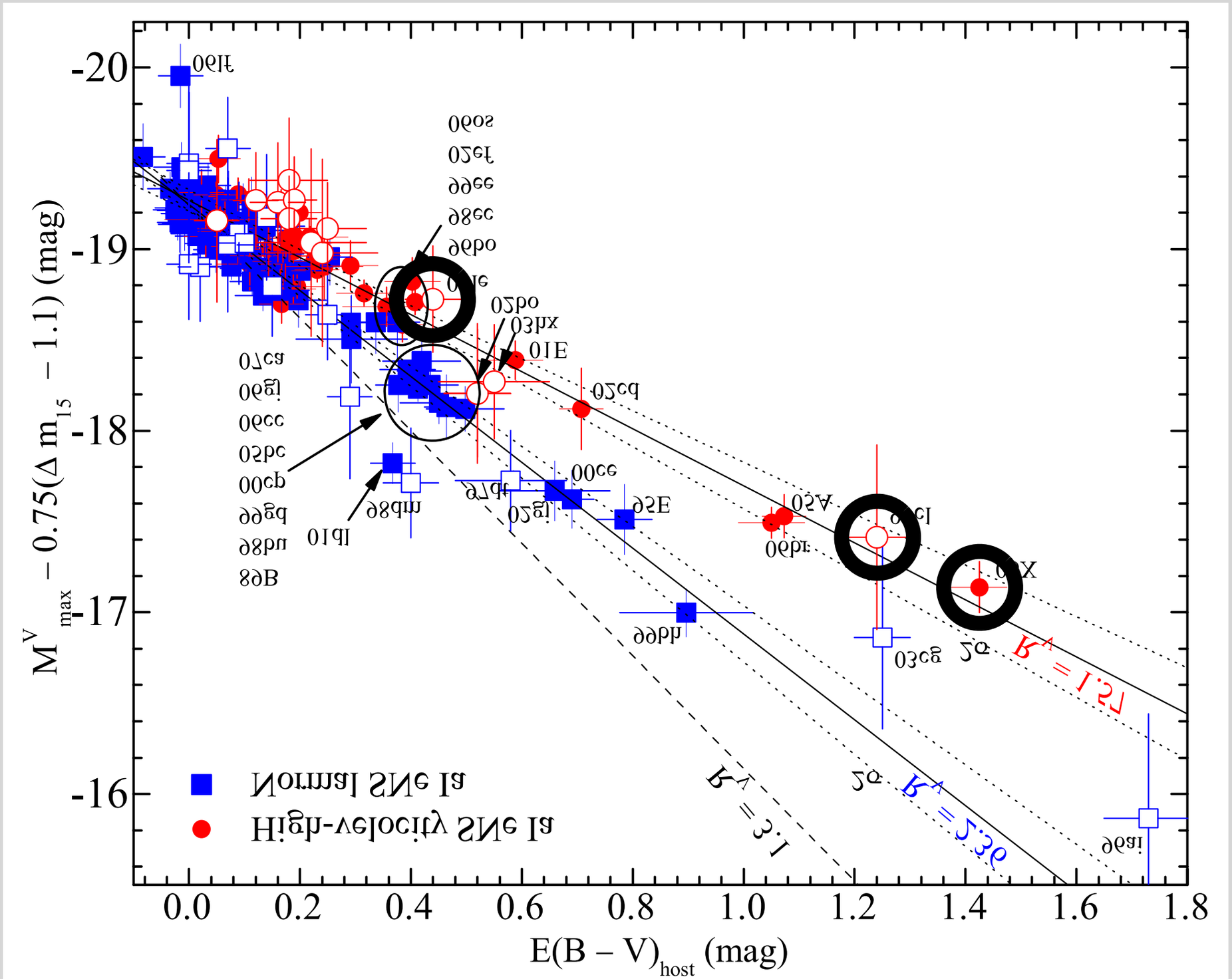


Av

Rv = Av/E(B-V)

Wang et al. 2009

2 Values of Rv?



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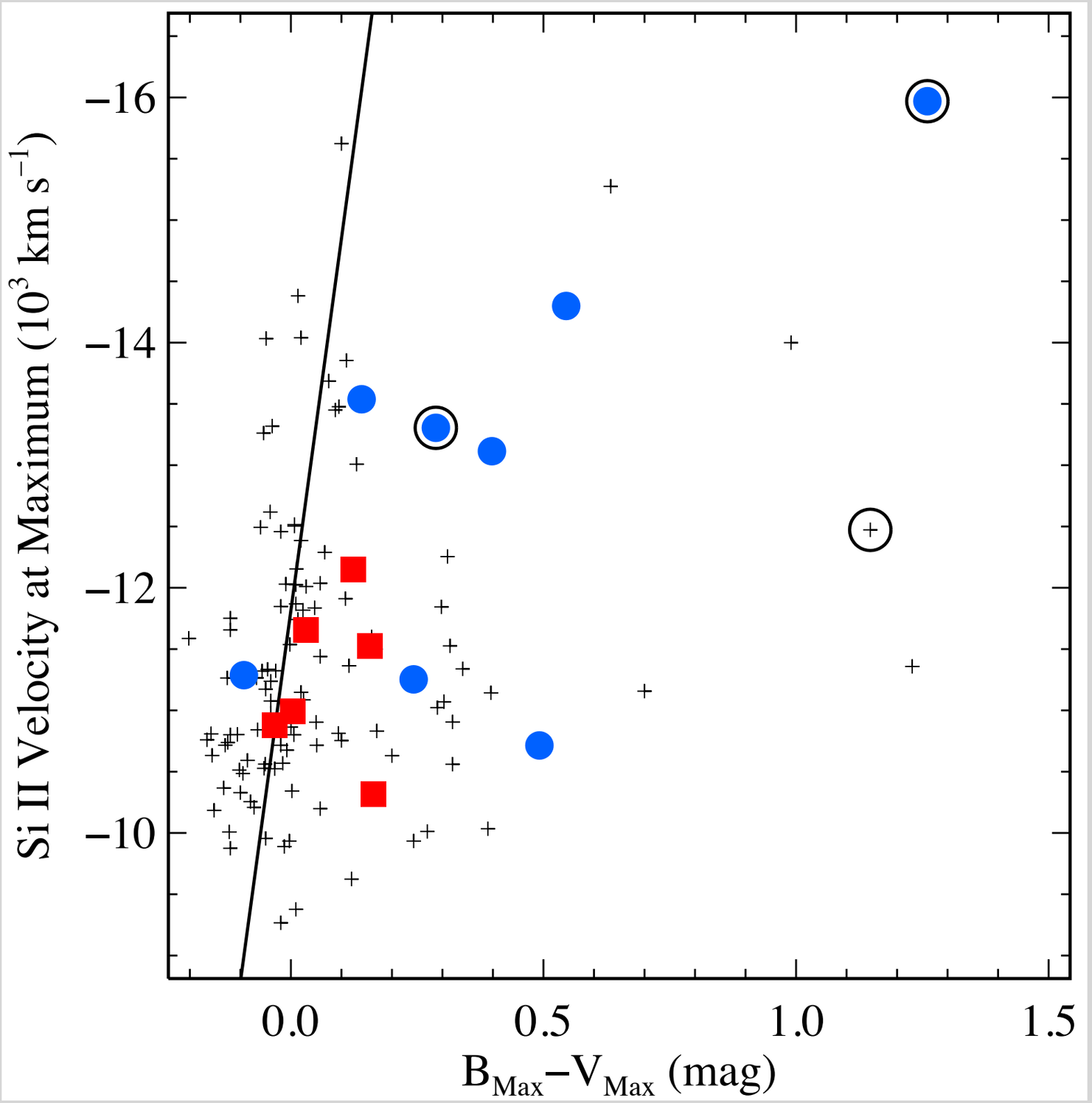
Explosion Linked to Environment



Full SN Ia Sample

CSM

No CSM

Foley et al., 2012

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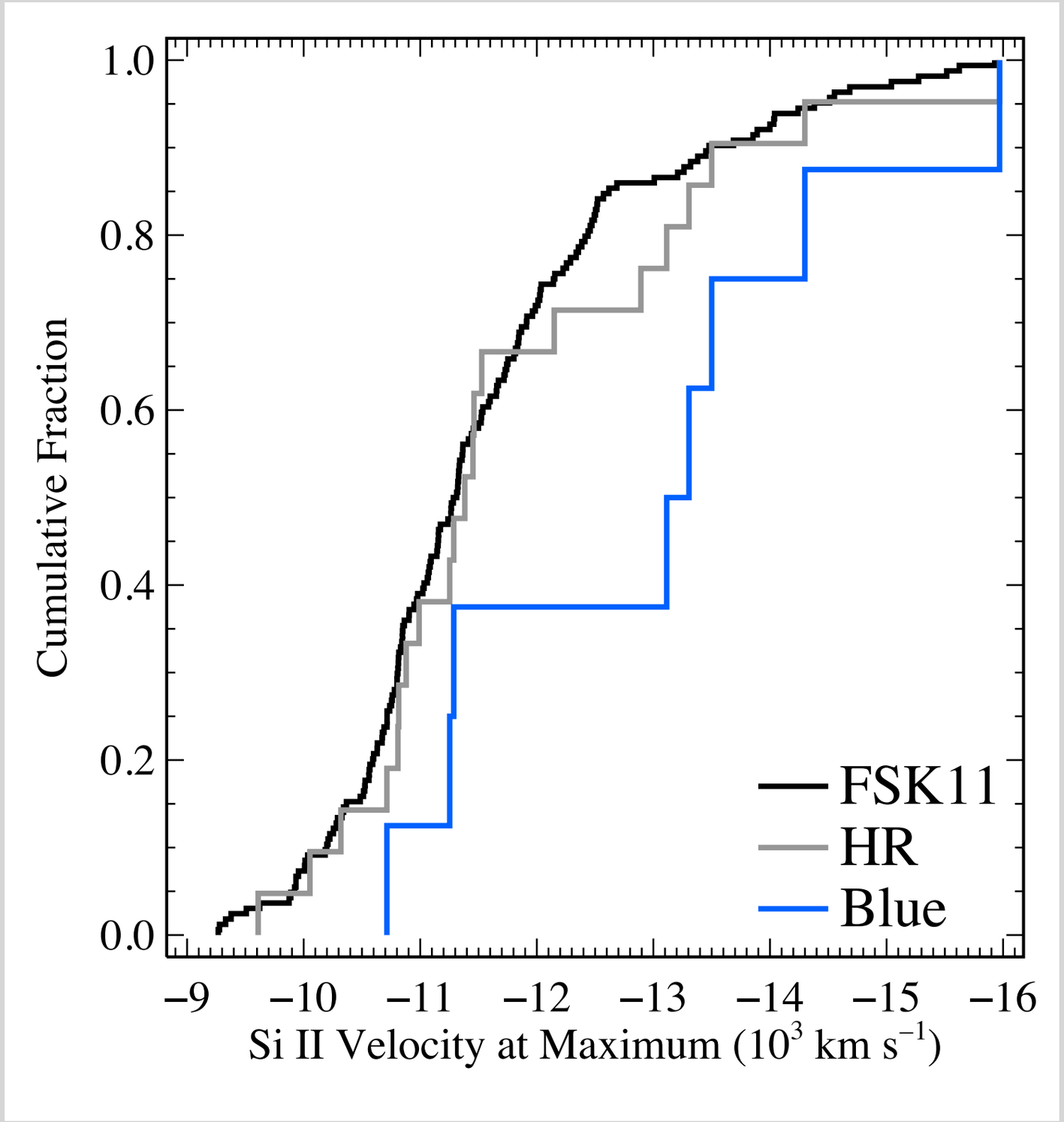


Full SN Ia Sample

High-Res Sample

Blueshifted Na

Foley et al., 2012

Implications

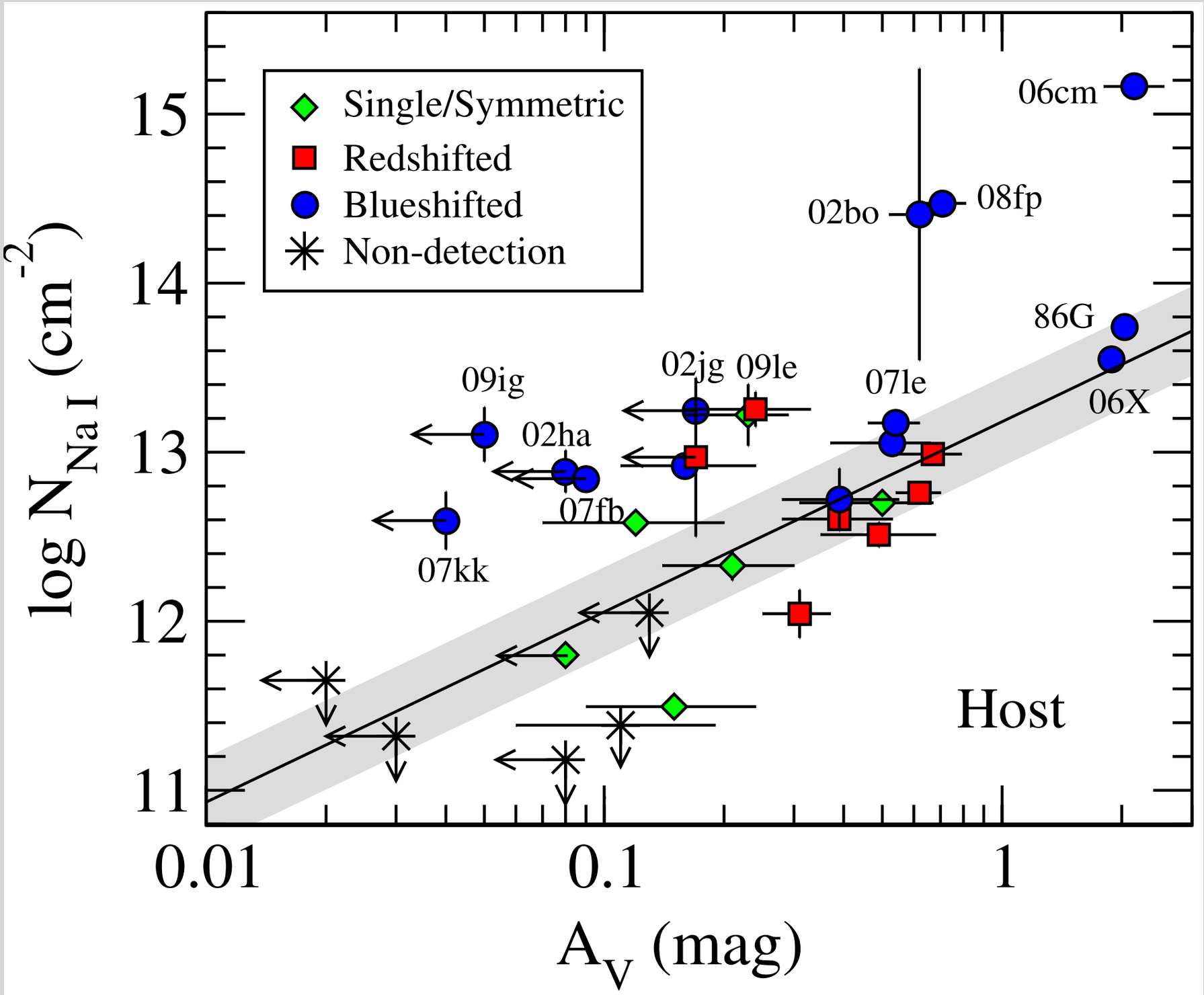
Either:

Multiple progenitor channels where progenitors with winds produce more energetic explosions

Or

Asymmetric explosions with higher velocity ejecta aligned with winds

Blueshifted Systems Are Gas-Rich



Phillips et al., 2013

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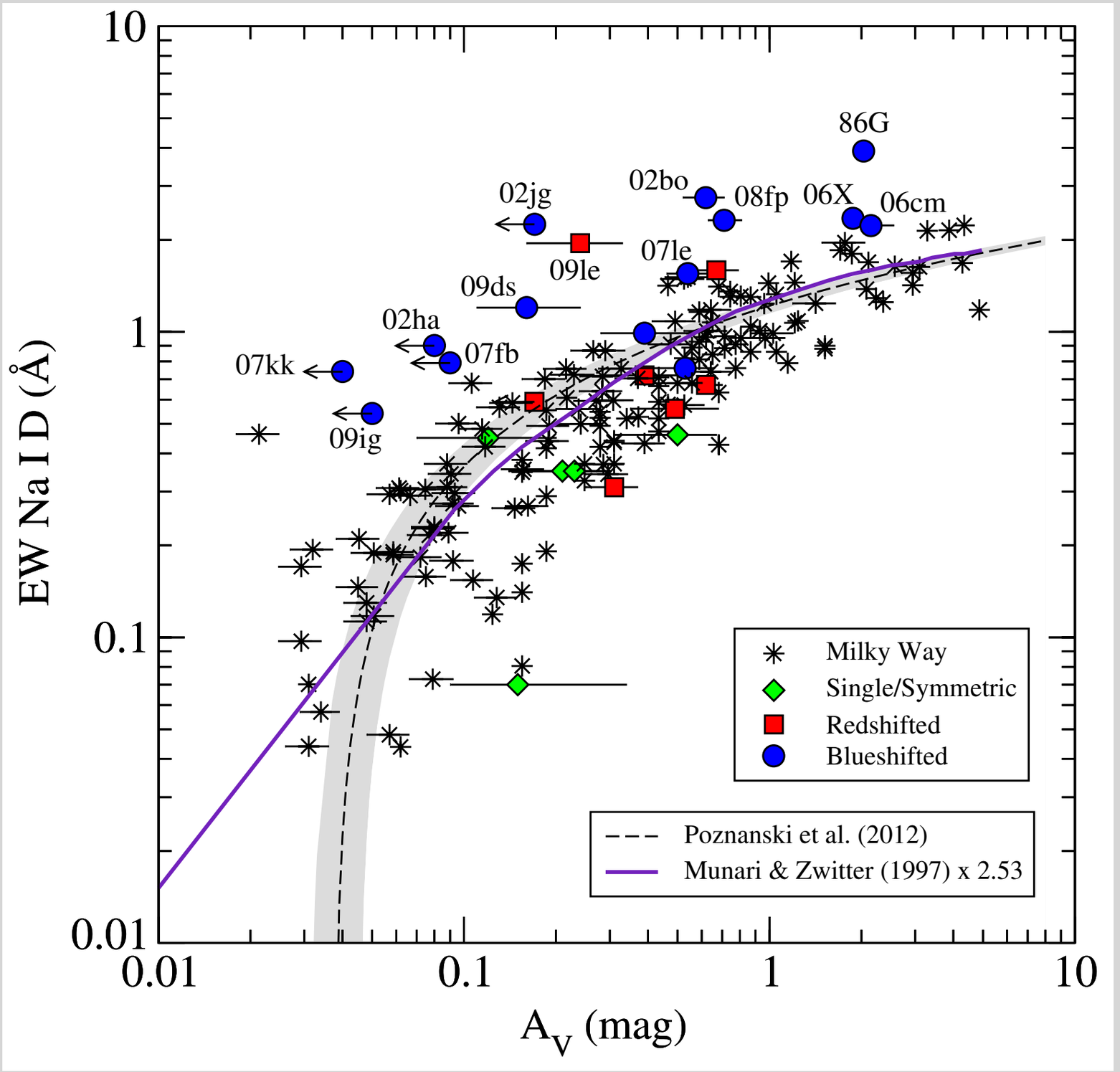
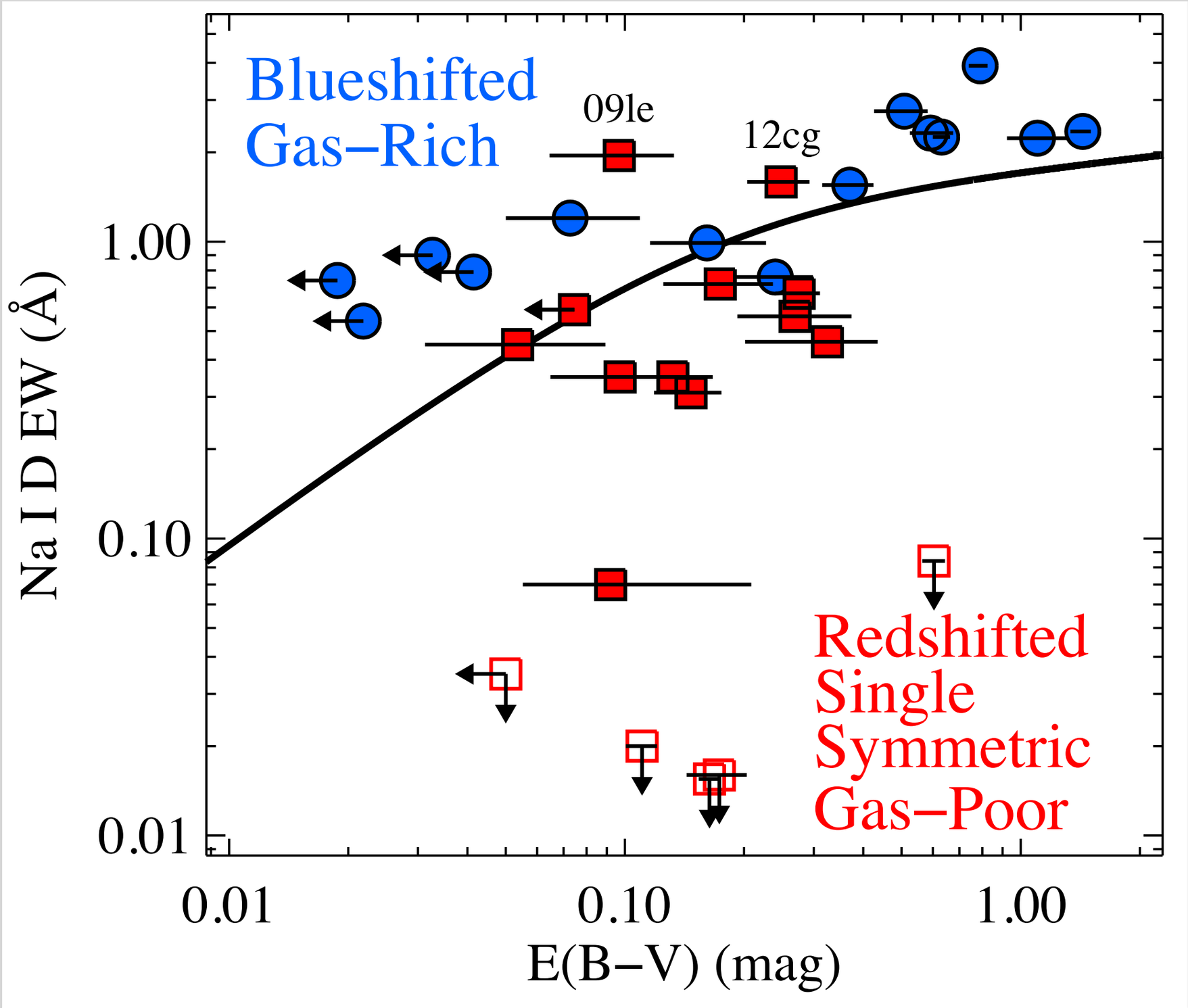


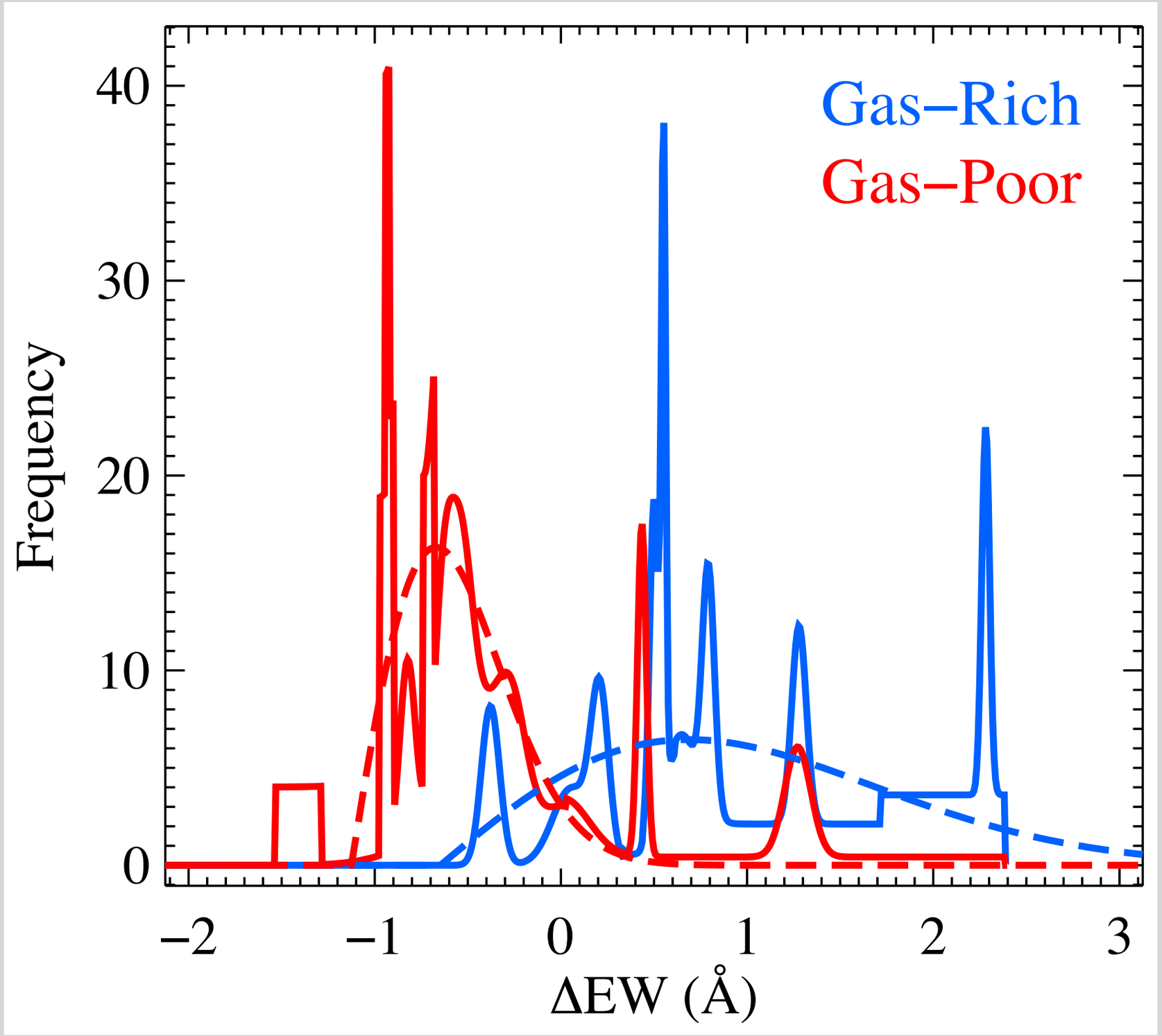
Phillips et al., 2013

Blueshifted/Redshifted Separate Cleanly



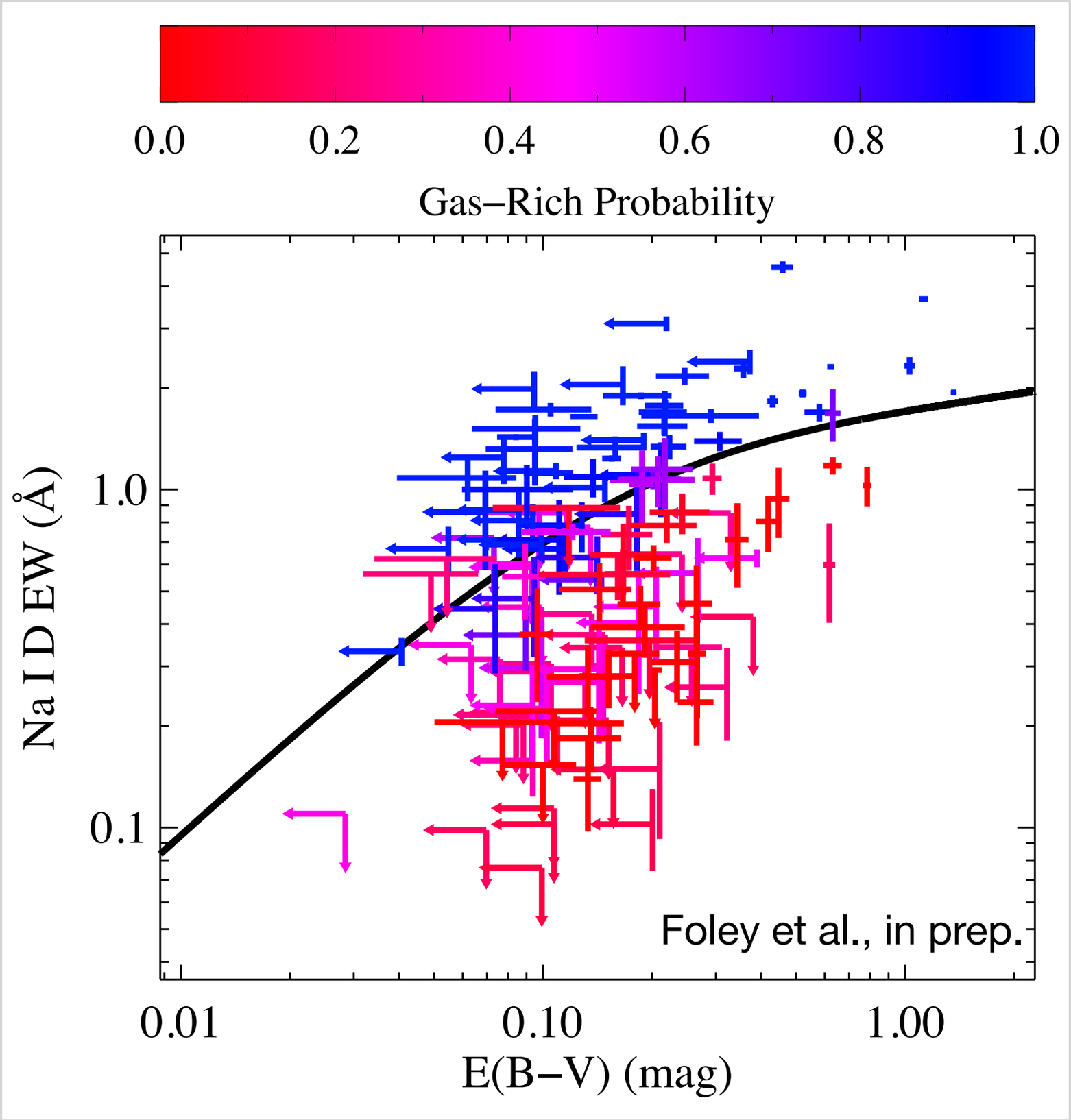
Foley et al., in prep.

ΔEW Separates Gas-Rich/Gas-Poor



Foley et al., in prep.

ΔEW Works for Low-Resolution Spectra!



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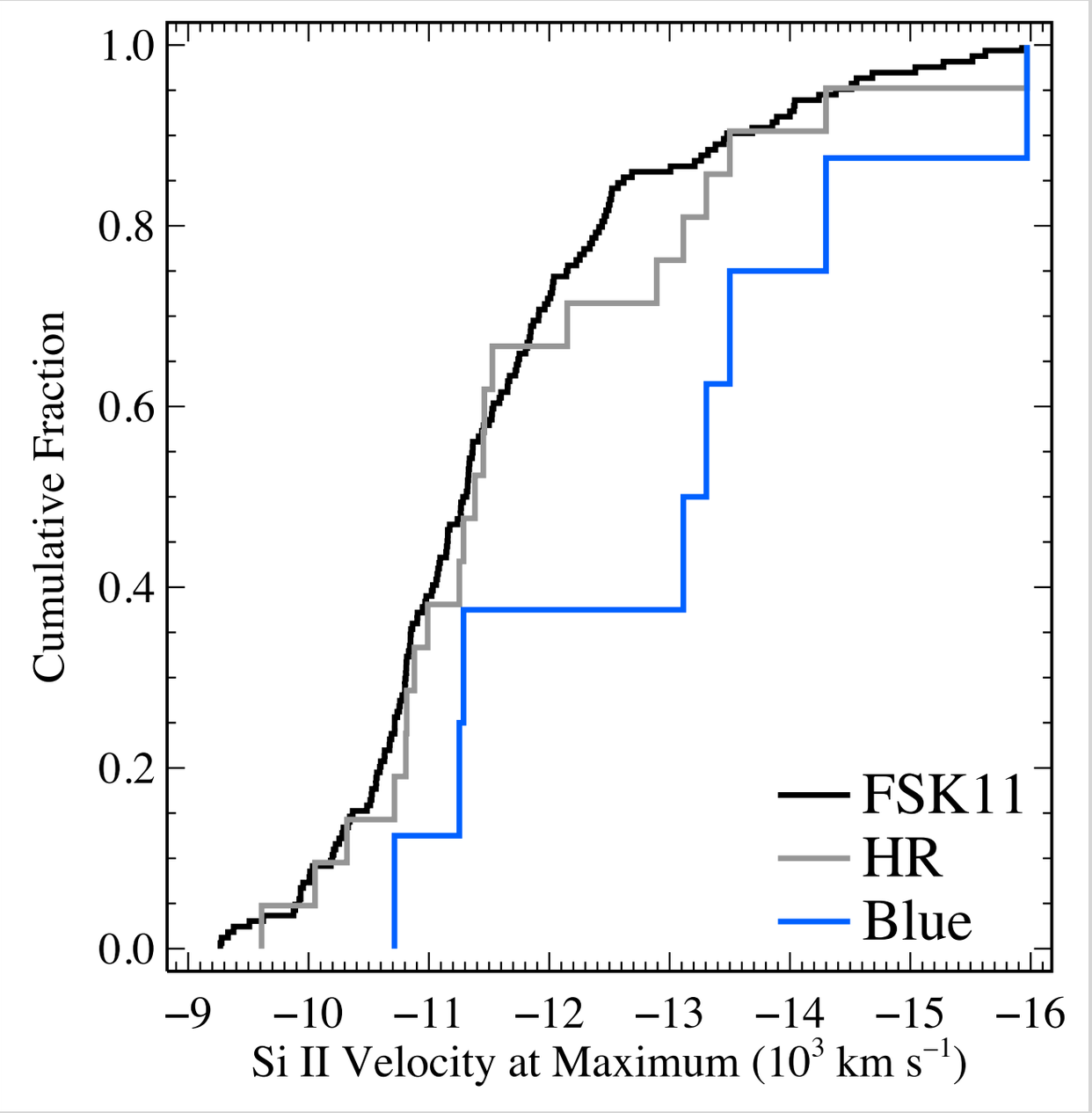
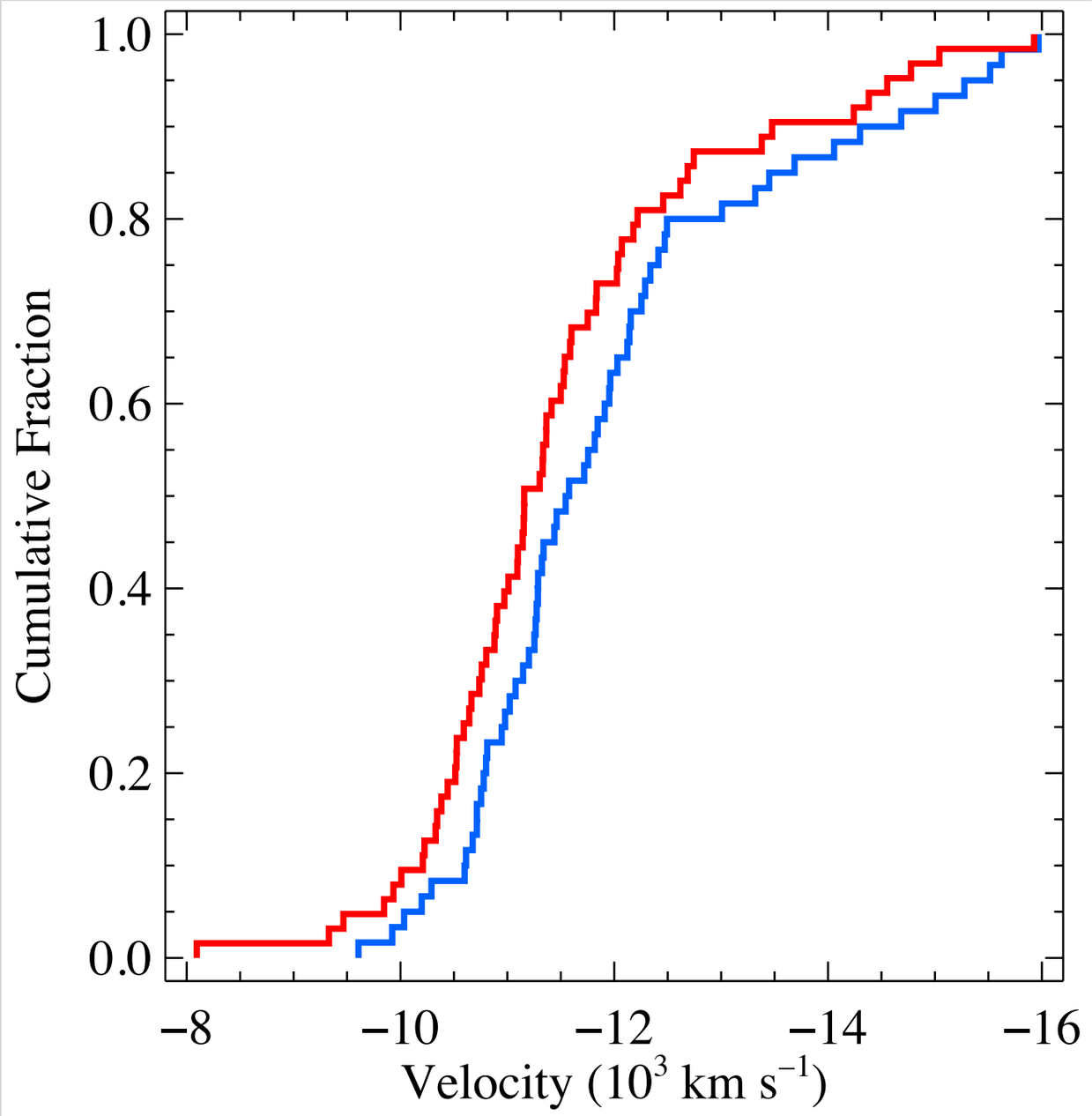


Foley et al., 2012



Foley et al., in prep.

Briefly...

SN Cosmology is Currently Limited by the Low-z Anchor Sample

Table 2: Noise Sources

Noise source	dw
Total Uncertainty	0.072
Statistical Uncertainty	0.050
Systematic Uncertainty	0.052
Photometric calibration	0.045
SN color model	0.023
Host galaxy dependance	0.015
MW extinction	0.013
Selection Bias	0.012
Coherent Flows	0.007

Table 1: Low-z Sets

Set	Total	Final
JRK07	133	49
CFA3	185	85
CFA4	94	43
CSP	85	45

8 (!!) Different Low-z Samples Combined

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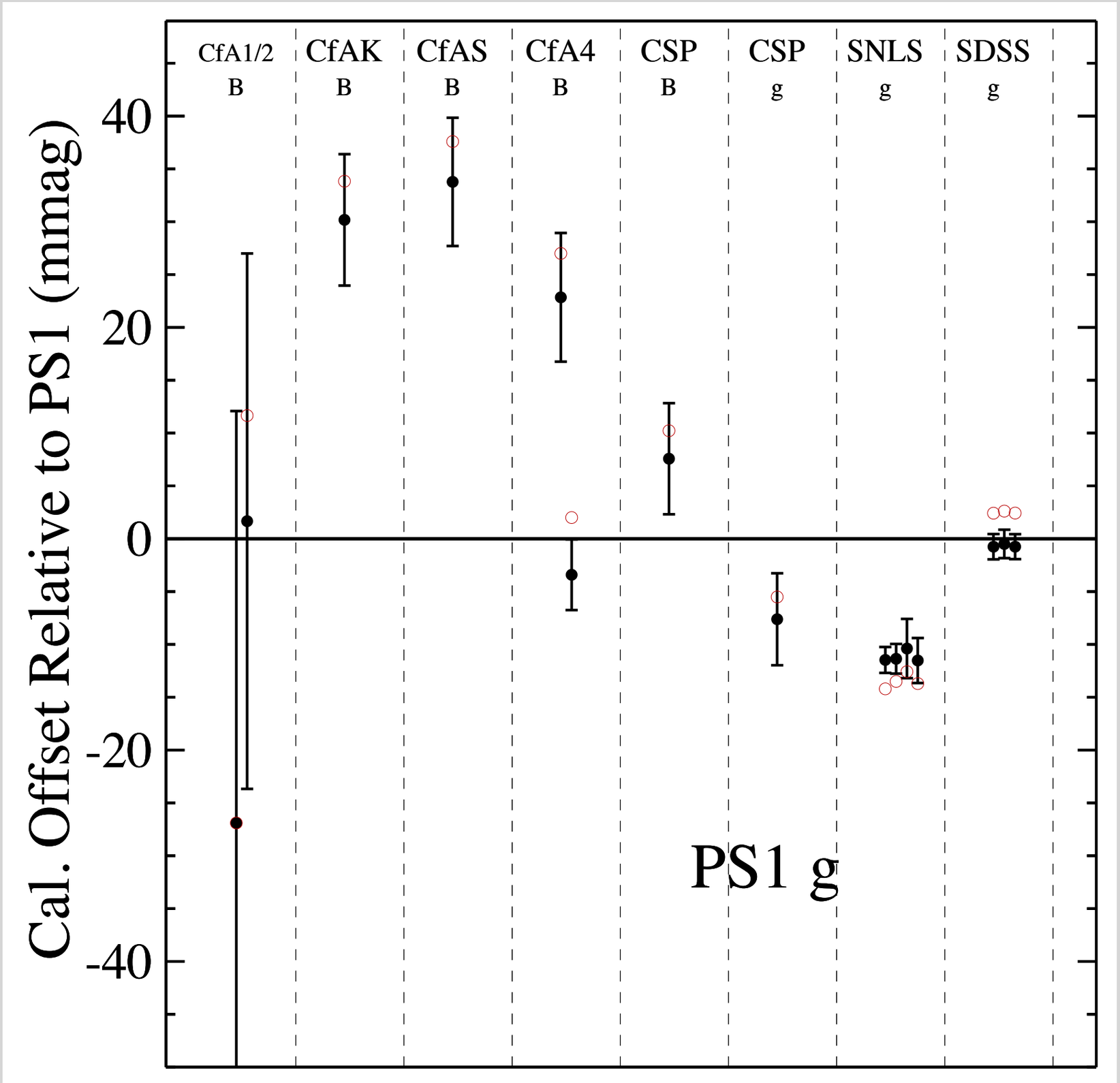
Low-z Calibration a Real Problem



Scolnic et al., in prep.

The Ideal Low-z Sample

Single System

Well Calibrated/Self-Consistent

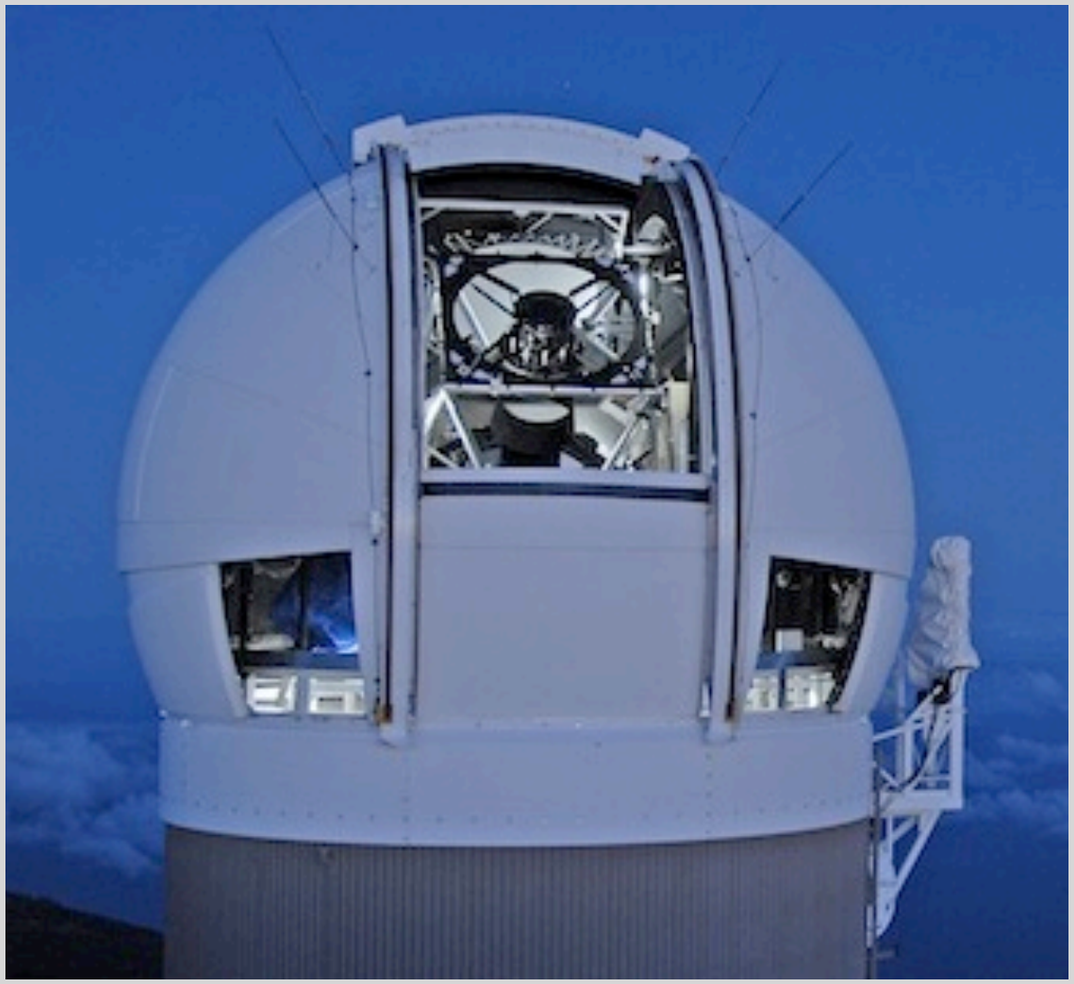
Full Sky Coverage w/Multiple Observations

Precisely Measured Filters

Existing Data Reduction Pipeline

Large High-z Sample on Same System

Pan-STARRS Supernova Survey



1.8 m mirror

7 deg^2 Field of View

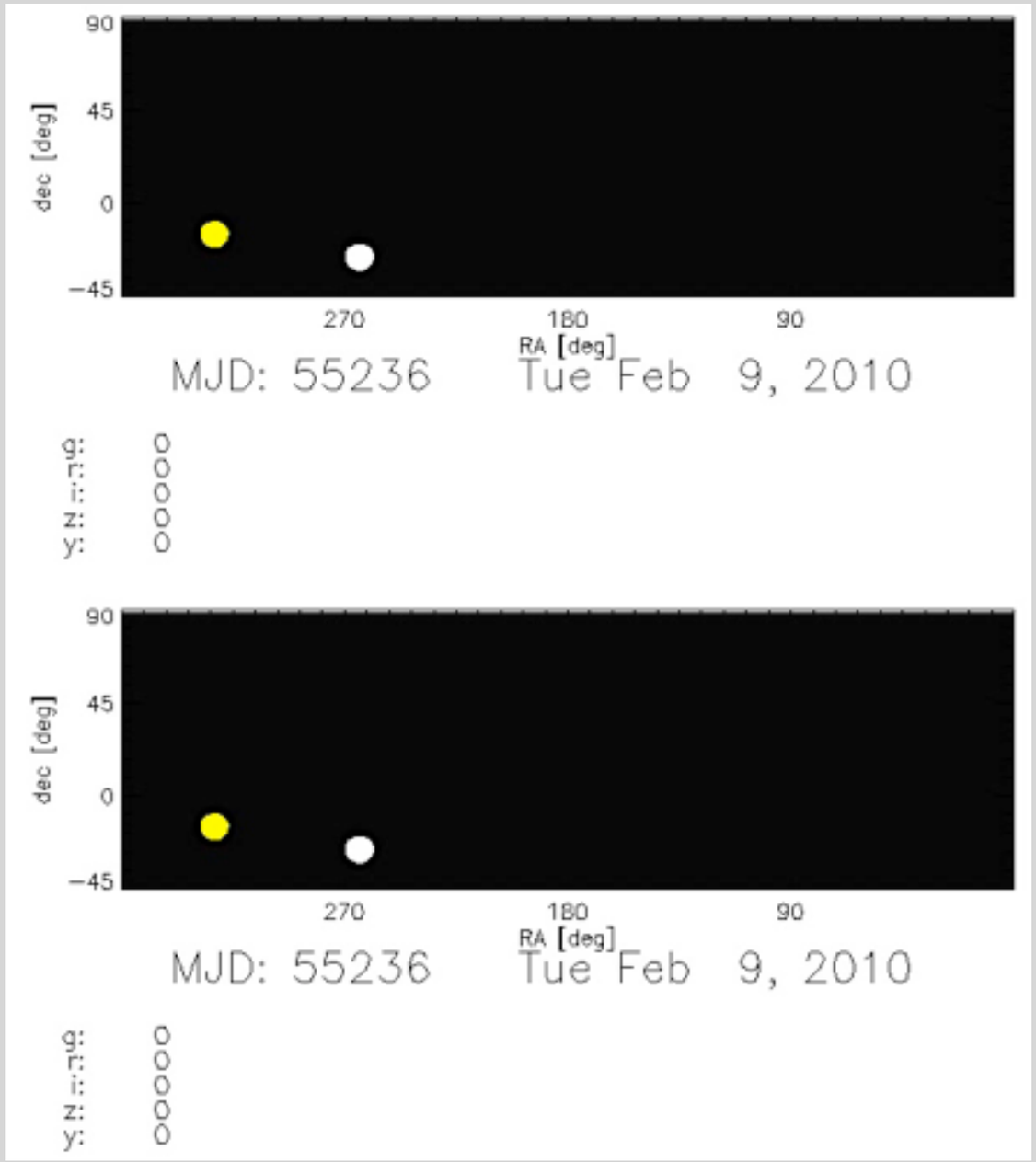
1.4 Gigapixel Camera

25% of time for SN Survey

Nightly Observations of ~6 Fields

~400 high-z SNe Ia

Pan-STARRS Supernova Survey



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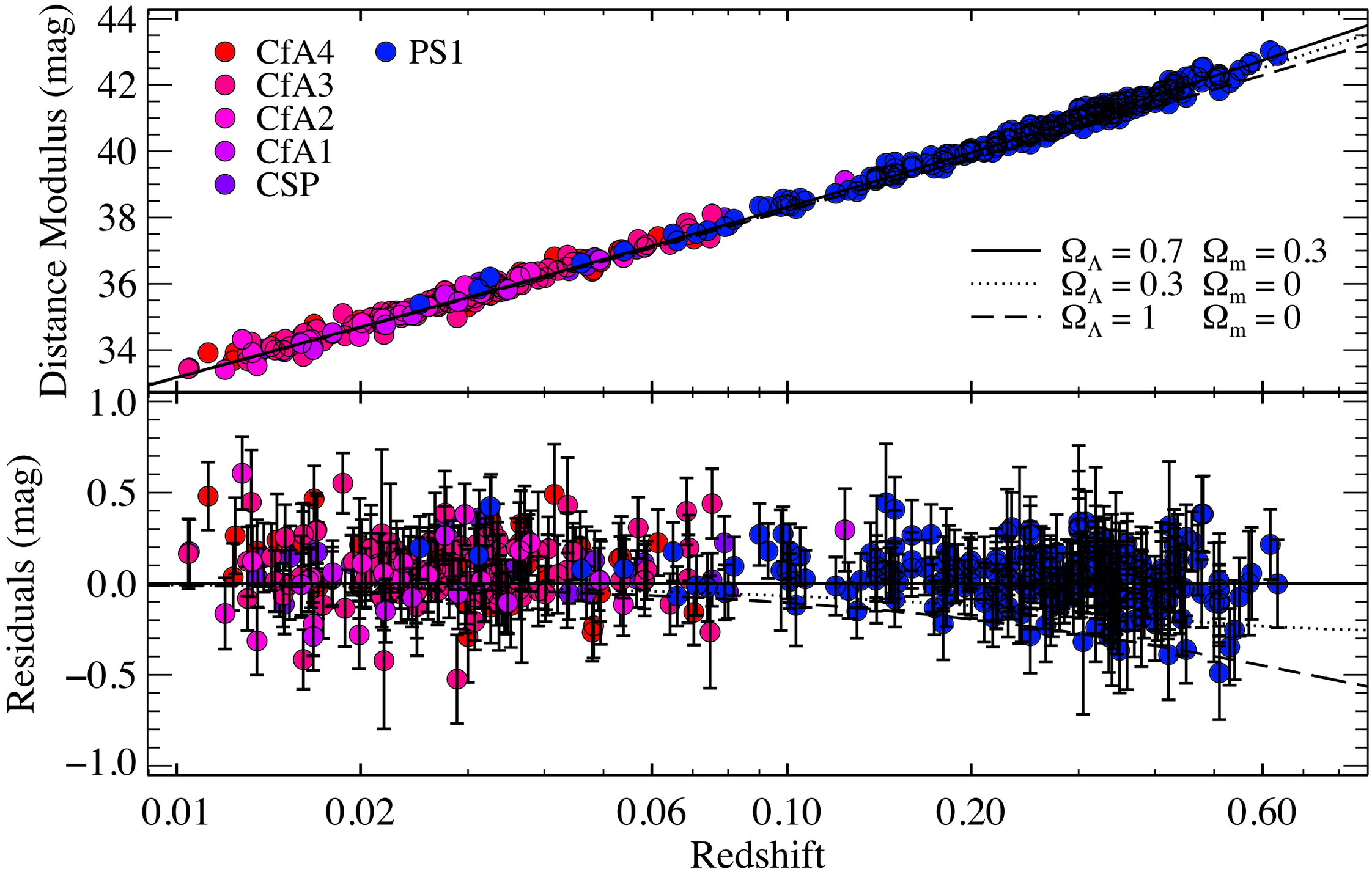
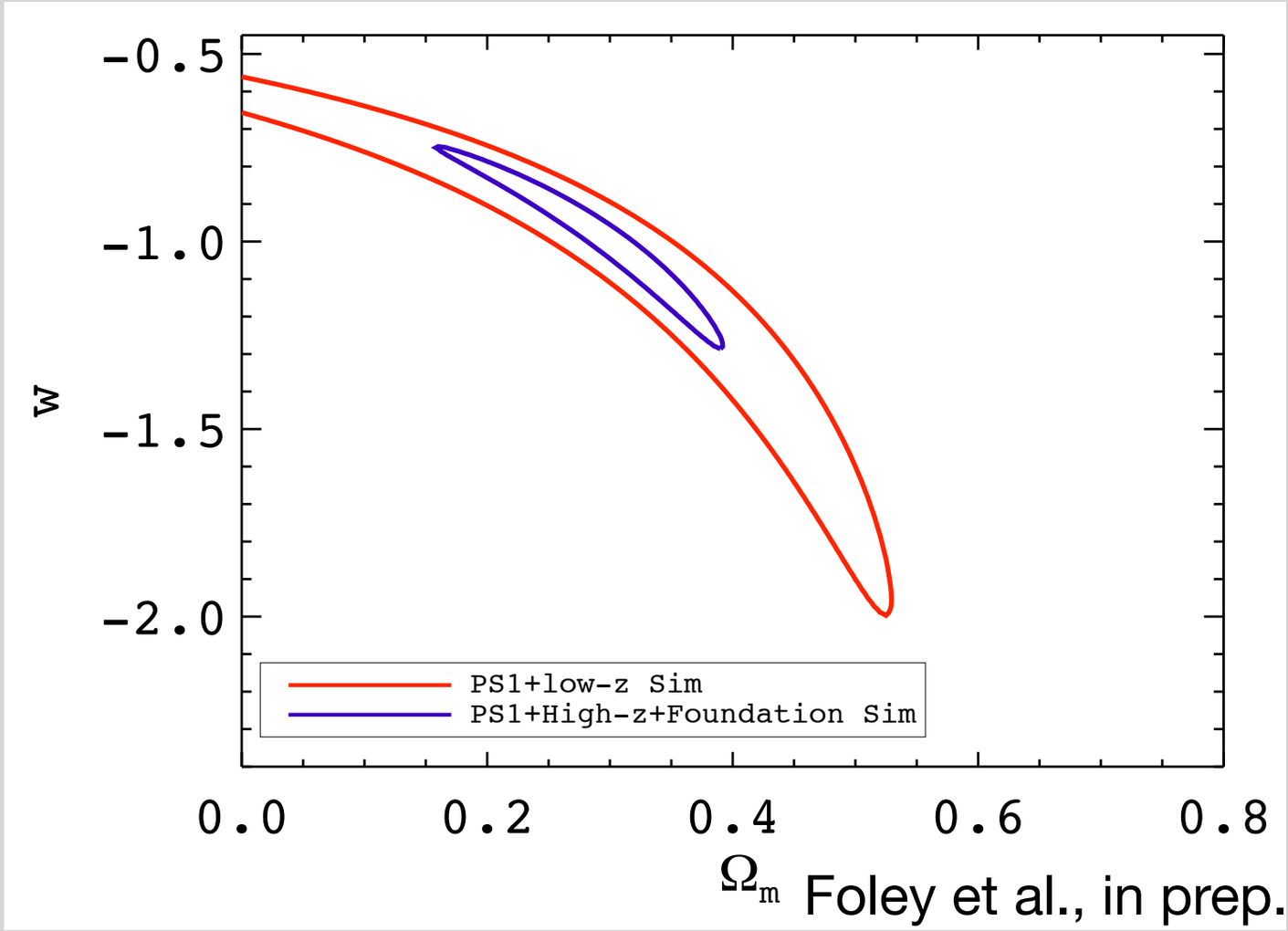
Pan-STARRS High-z Sample



Scolnic et al., in prep.

Redefine Low-z Sample



Foley et al., in prep.

Founding Fathers:

Ryan Foley
Armin Rest
Dan Scolnic
Saurabh Jha

Foundation Sample:

PS1 Telescope
400–800 z < 0.1 SNe Ia
~1000 SNe Ia with 0 < z < 0.8

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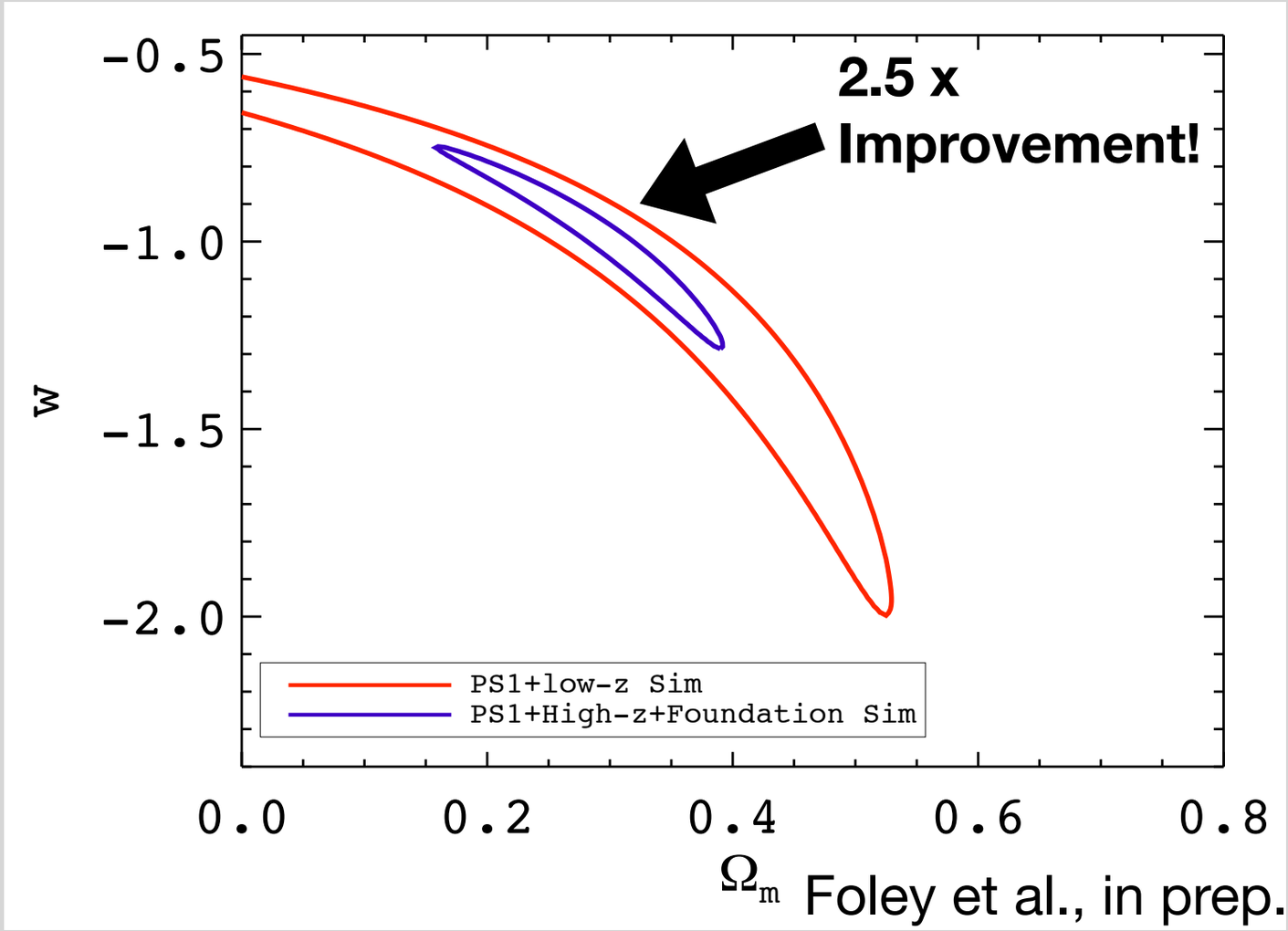

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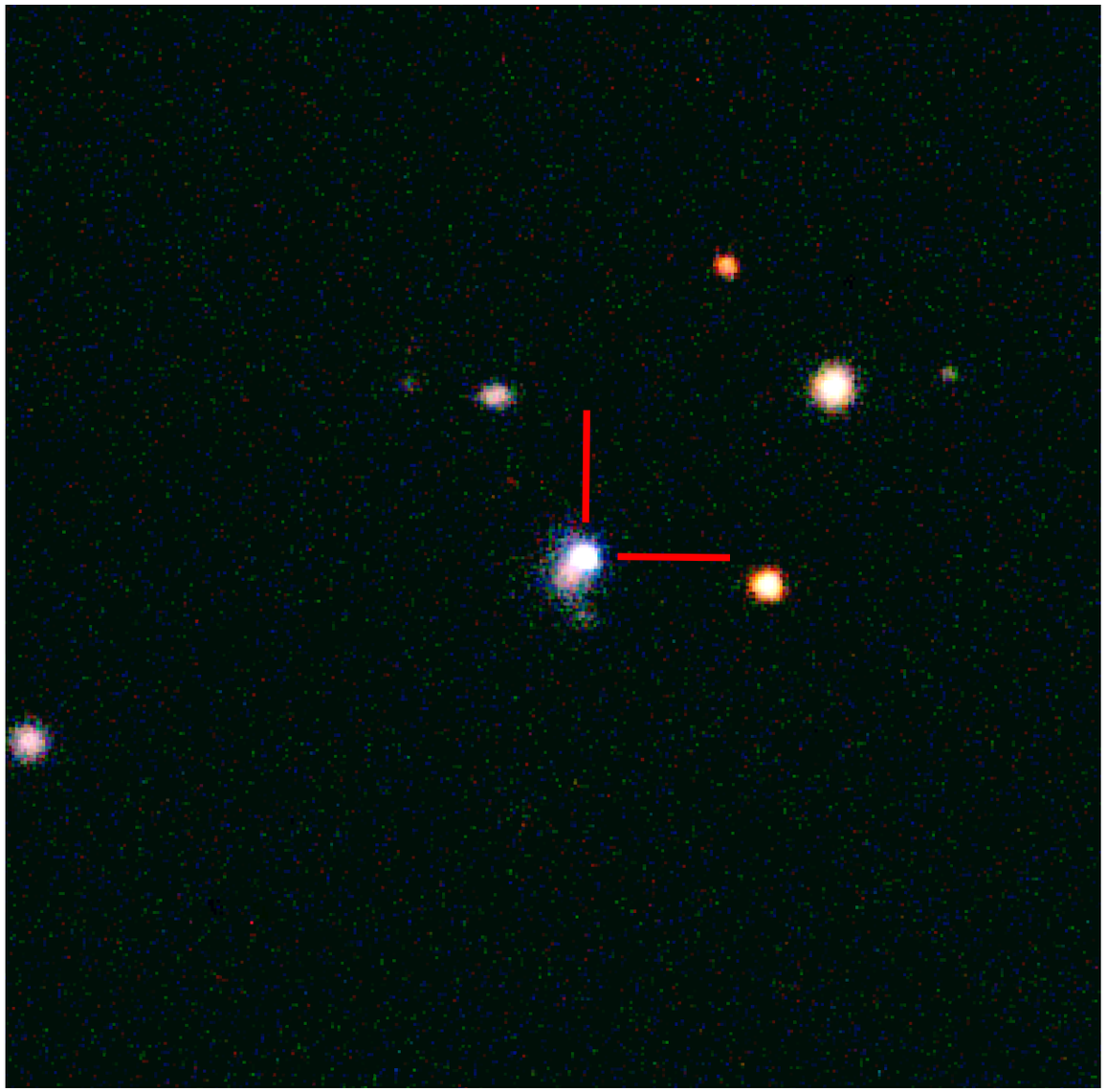
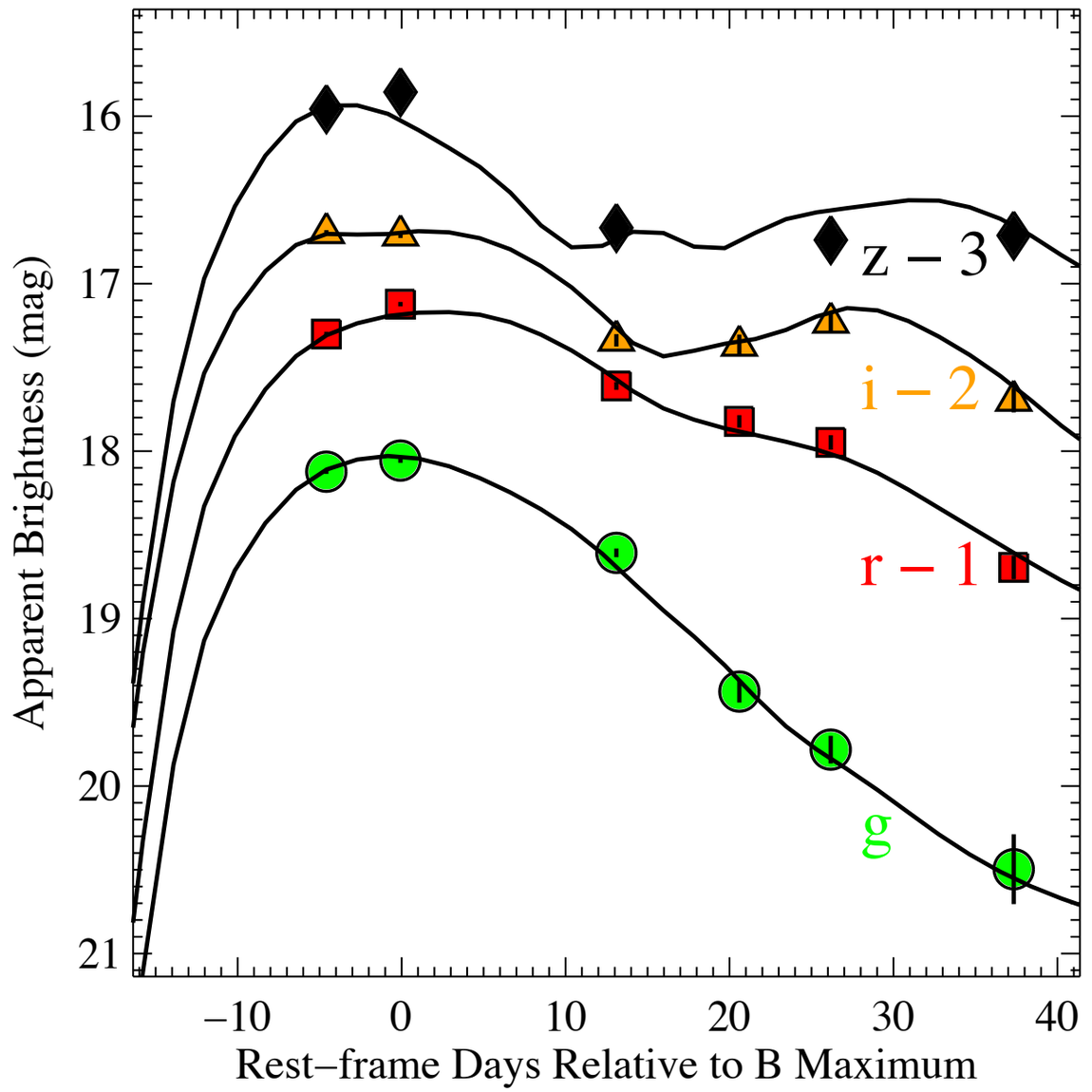
Foundation Data





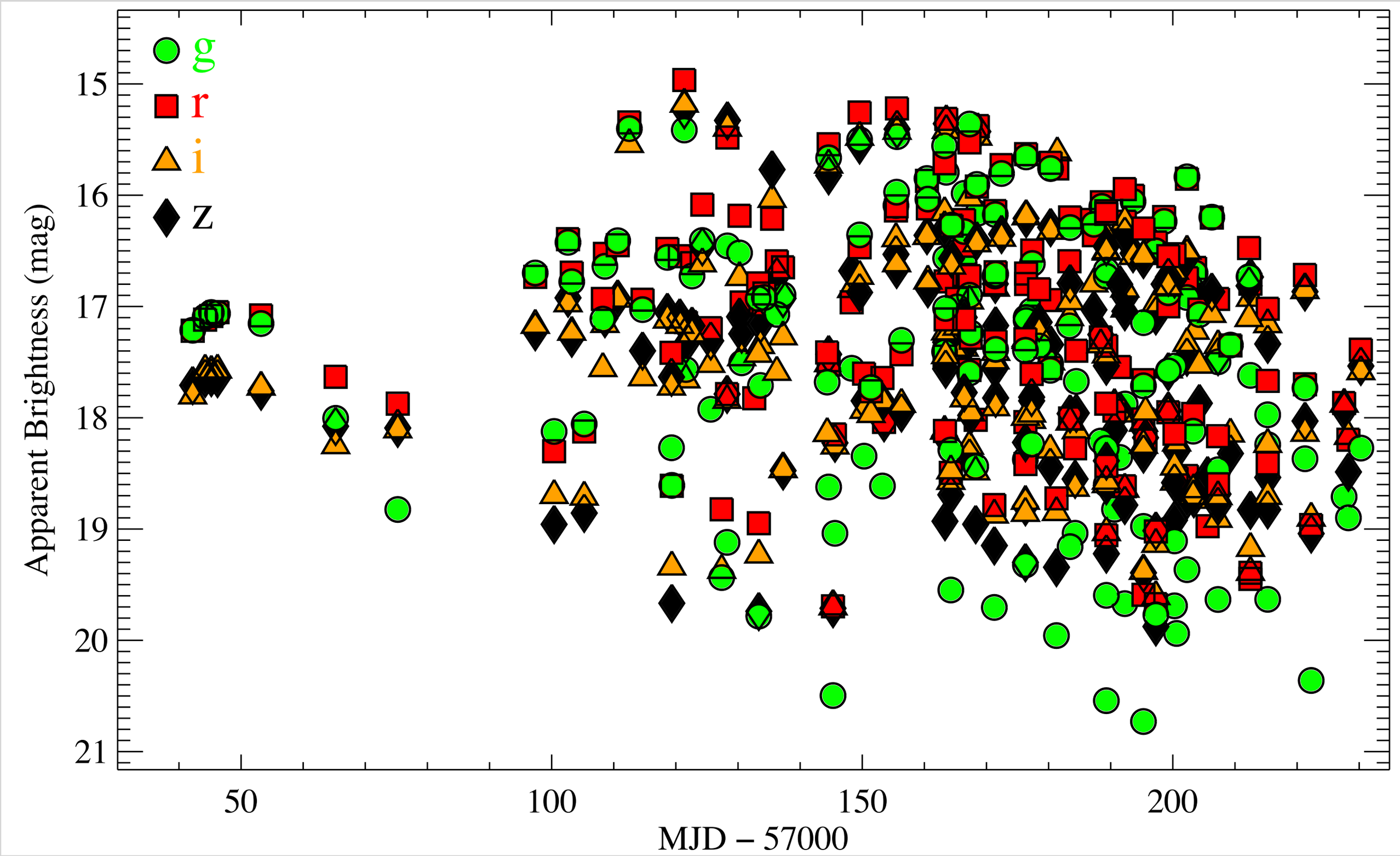
Foley et al., in prep.

Already 37 SNe Ia

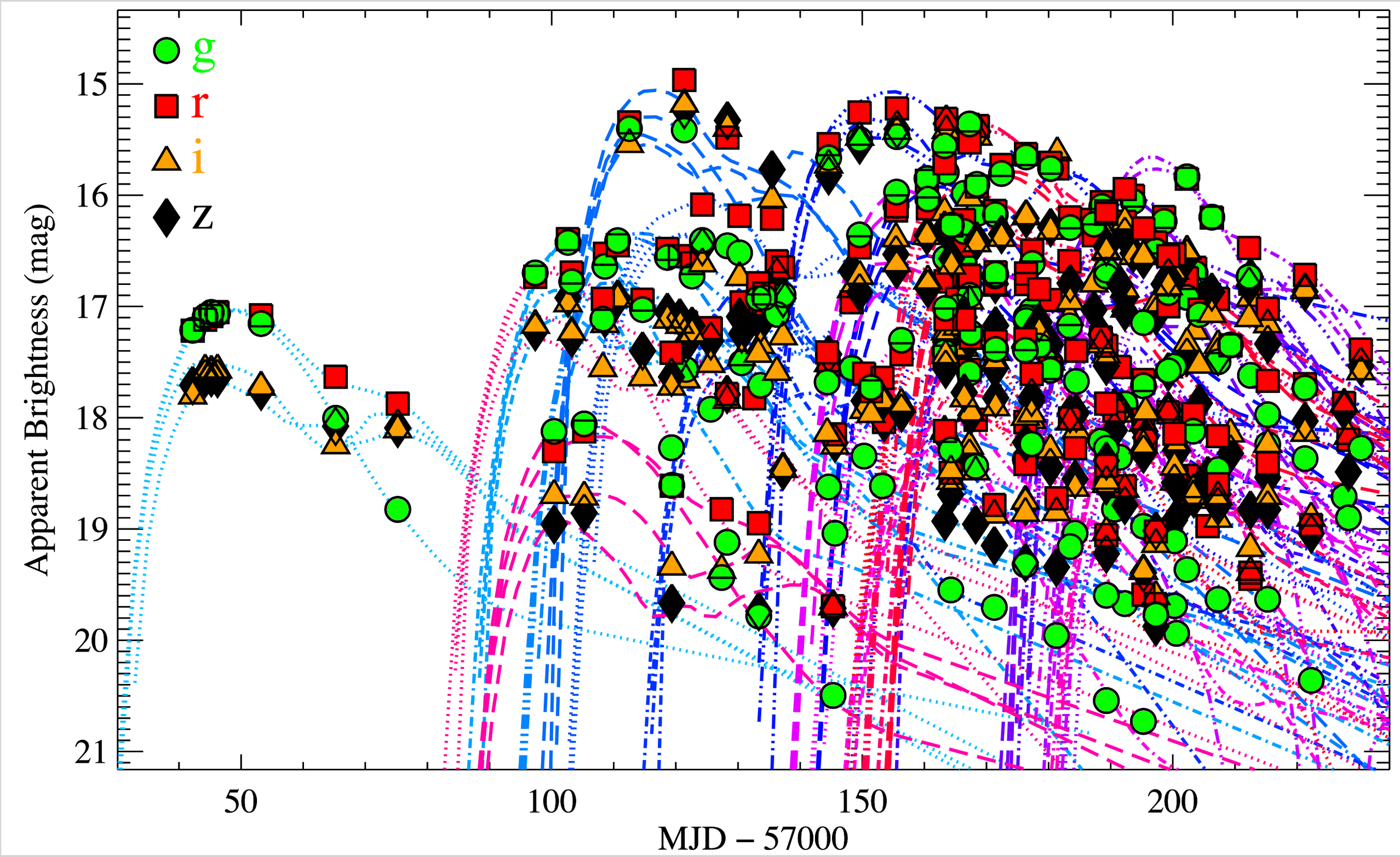
39 SOAR/KPNO nights over 2 years

+Salt for spectroscopy

Foundation Sample As of Today: 37 SNe



Foundation Sample As of Today: 37 SNe



Two Questions:

Why are the observables (and explosions?) so similar for gas-rich and gas-poor SNe?

How can we further improve the Foundation Survey?