Low-Metallicity Host Galaxies of Type Ia Supernovae from the Nearby Supernova Factory

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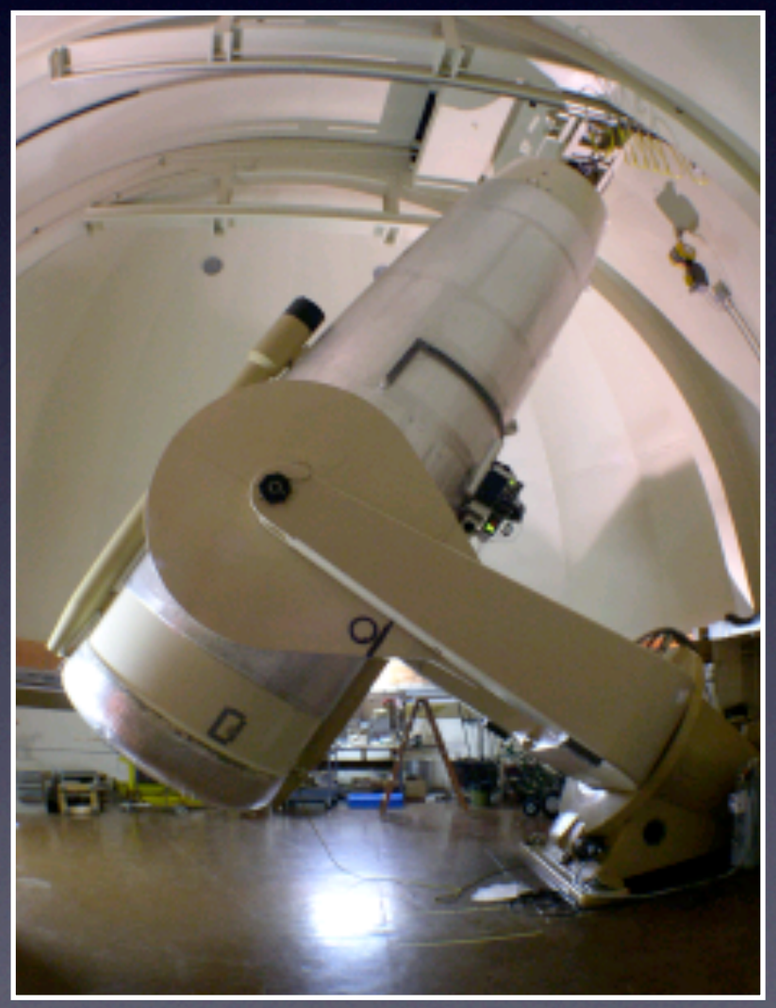
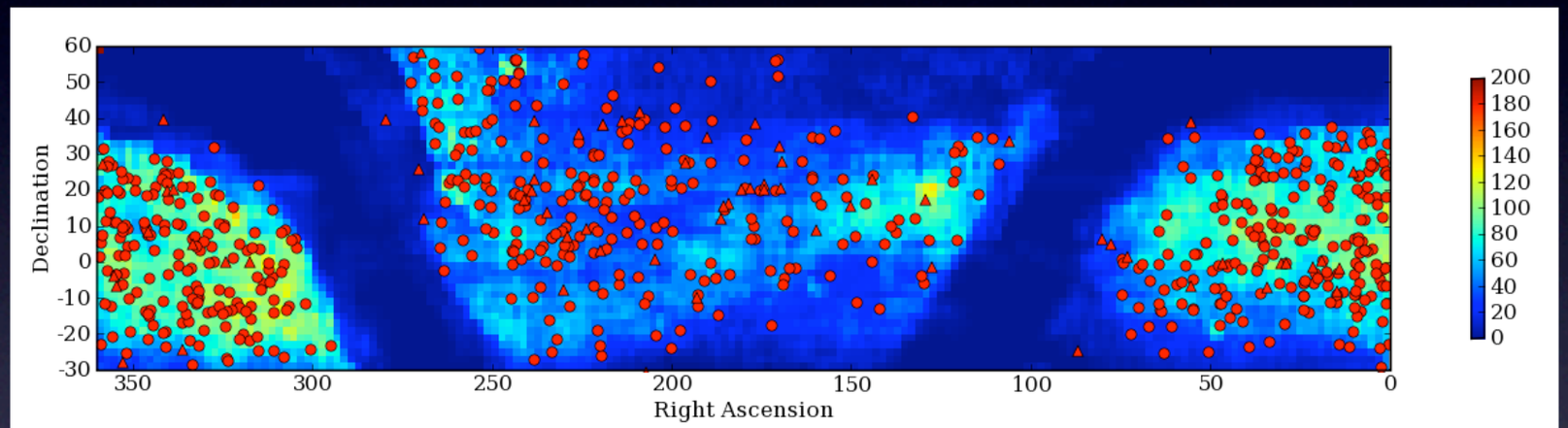
Outline

- SNfactory Overview
- Host Galaxy Studies from SNfactory:
  - Host Mass + Hubble Residuals
  - Low-Metallicity Hosts
  - "Host-challenged" SNe Ia
  - Host Galaxy of super-Ch SN 2007if

SNfactory Search

- Untargeted wide-field search w/ QUEST camera on Palomar 48-in - overlap with NEAT asteroid search
- Discovered over 1000 SNe in 28 months of search 2005-2008

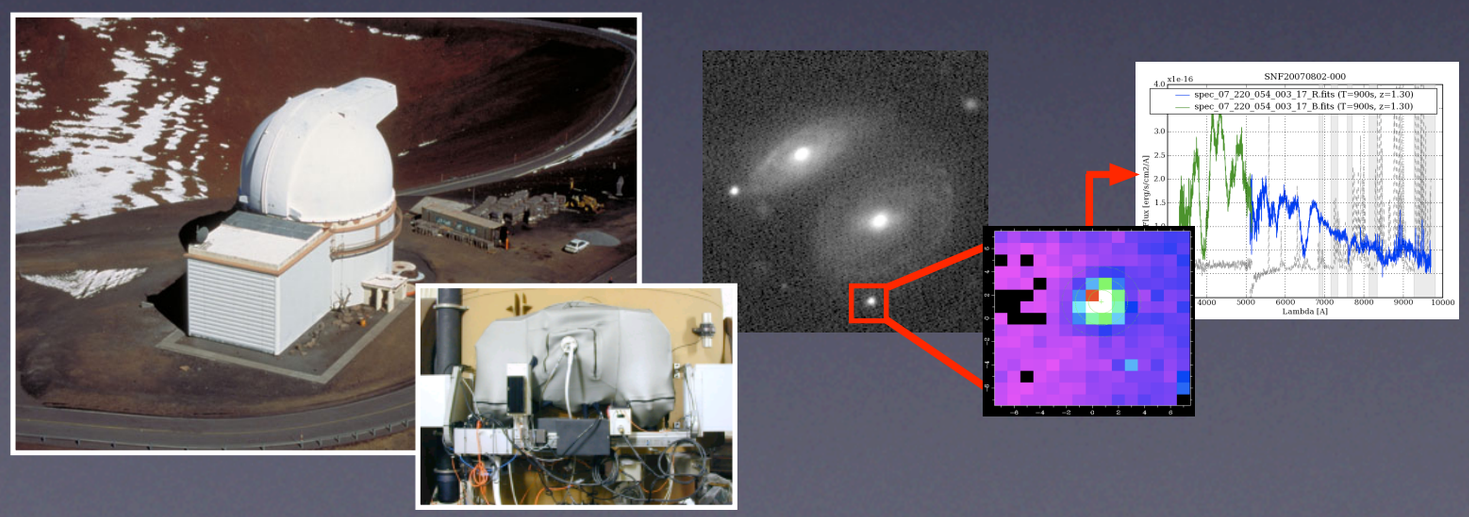


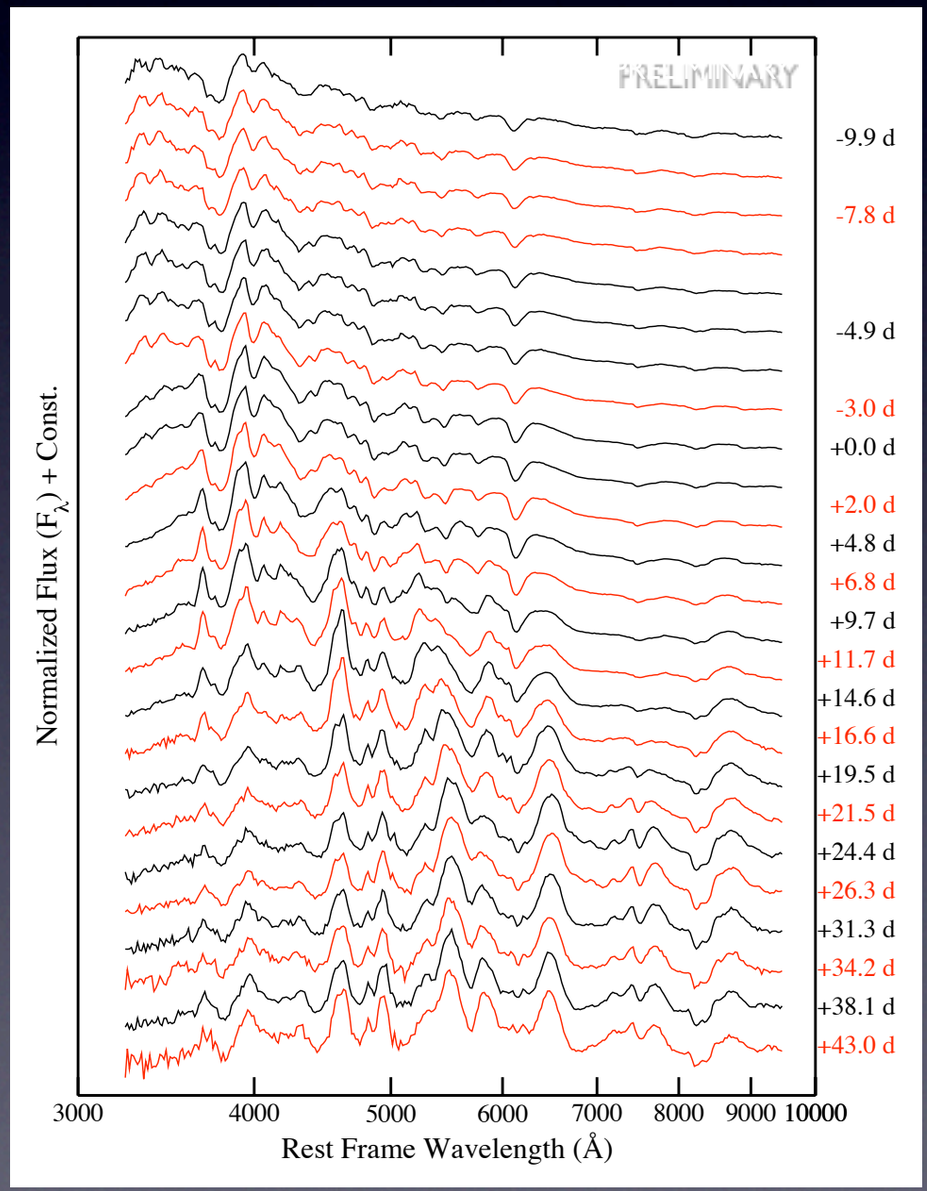


Type	Count	Spectra
SNe Ia	396	>2500
SNe II	191	207
SNe Ib/c	37	49
Untyped	405	-

SN Ia Followup with SNIFS

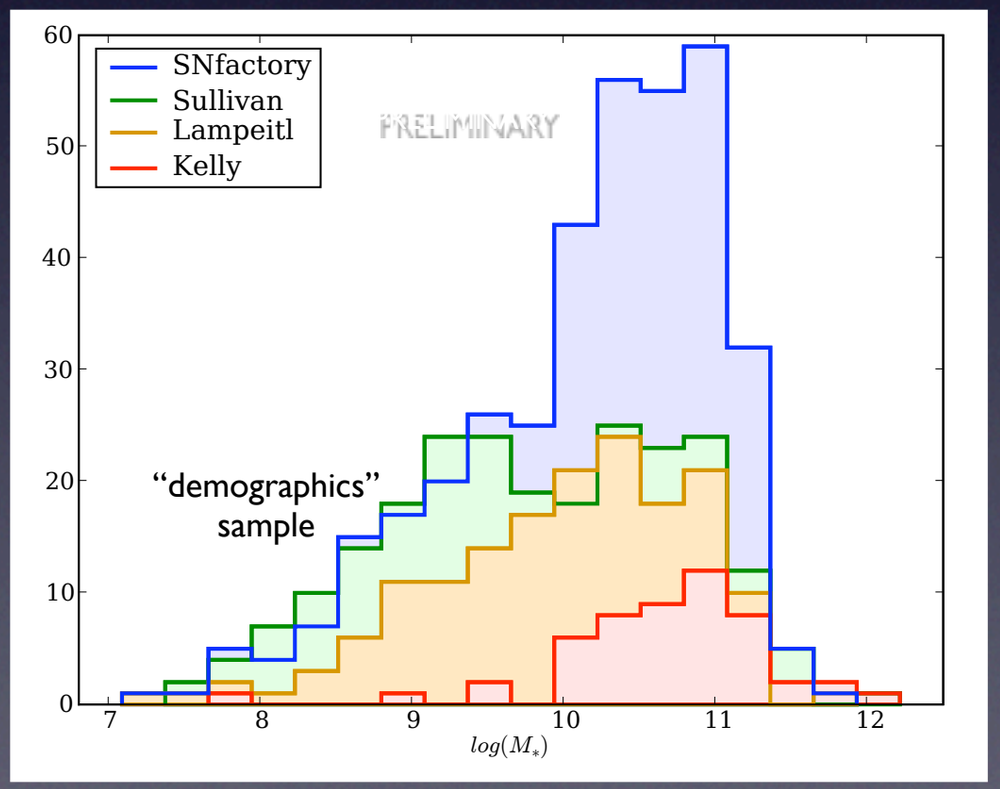
- 396 SNe Ia discovered by SNf ("demographics" sample)
- 185 SNe Ia with well-sampled LCs ("cosmology" sample)
- Followup with SuperNova Integral Field Spectrograph (SNIFS) on University of Hawaii 2.2m (UH88)
- Flux-calibrated spectral times series with 2-3 day cadence
- Can synthesize light curves in any band without K-corrections



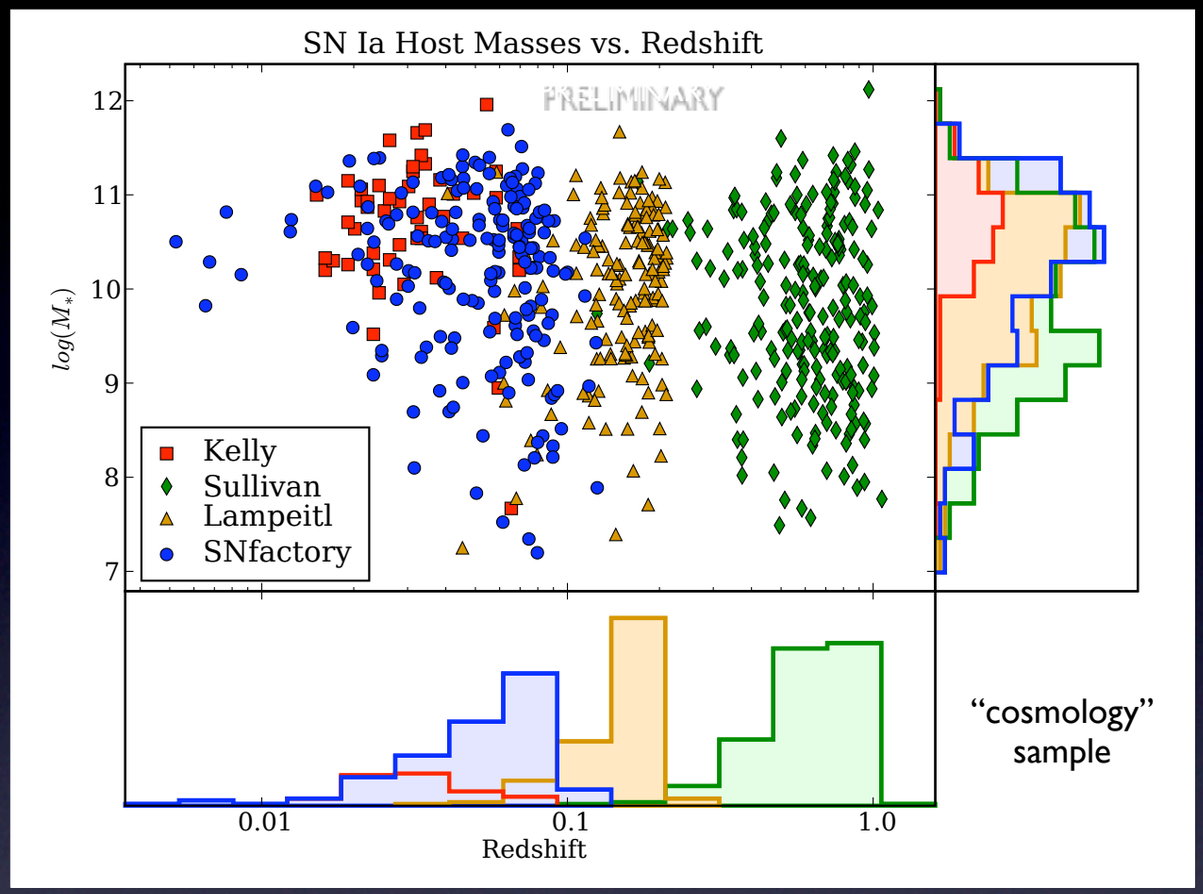


Host Galaxy Studies with SNfactory

- "Cosmology" SN Ia hosts will contribute to Hubble residual-host mass studies
- Spectra for 385 hosts will provide insight into the role of metallicity



Credits: Kelly+ 10 (literature SNe), Sullivan+ 10 (SNLS), Lampeitl+ 10 (SDSS)

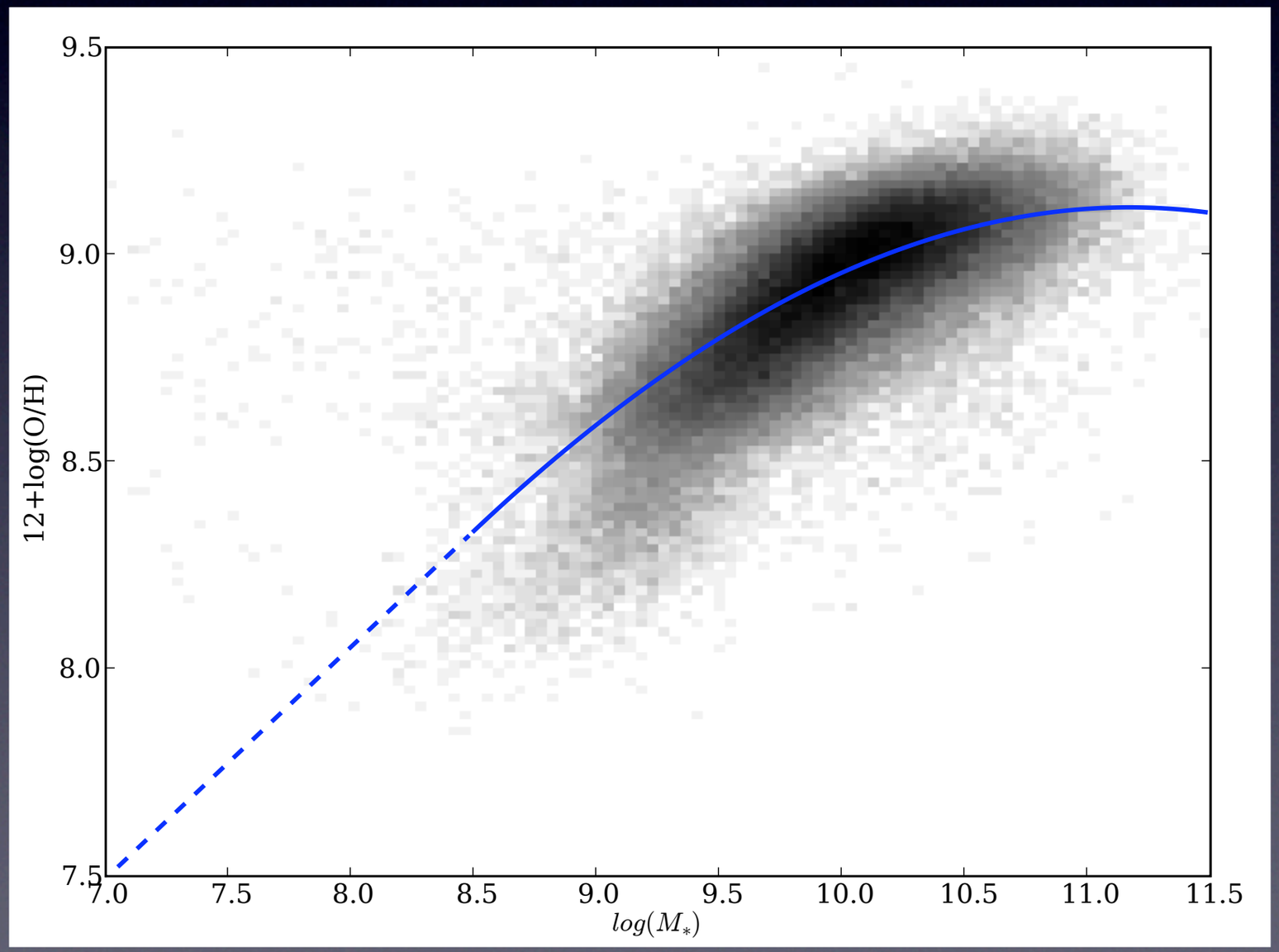


- Low-Z hosts very interesting
  - most analogous to high-redshift environments
  - untargeted searches have best yield of SNe in low-Z hosts

Low-Metallicity SN Ia Hosts

- Mass-metallicity (M-Z) relation tells us low metallicity galaxies should have low masses

(MPA-JHU SDSS DR7 Data - Tremonti+ 04)



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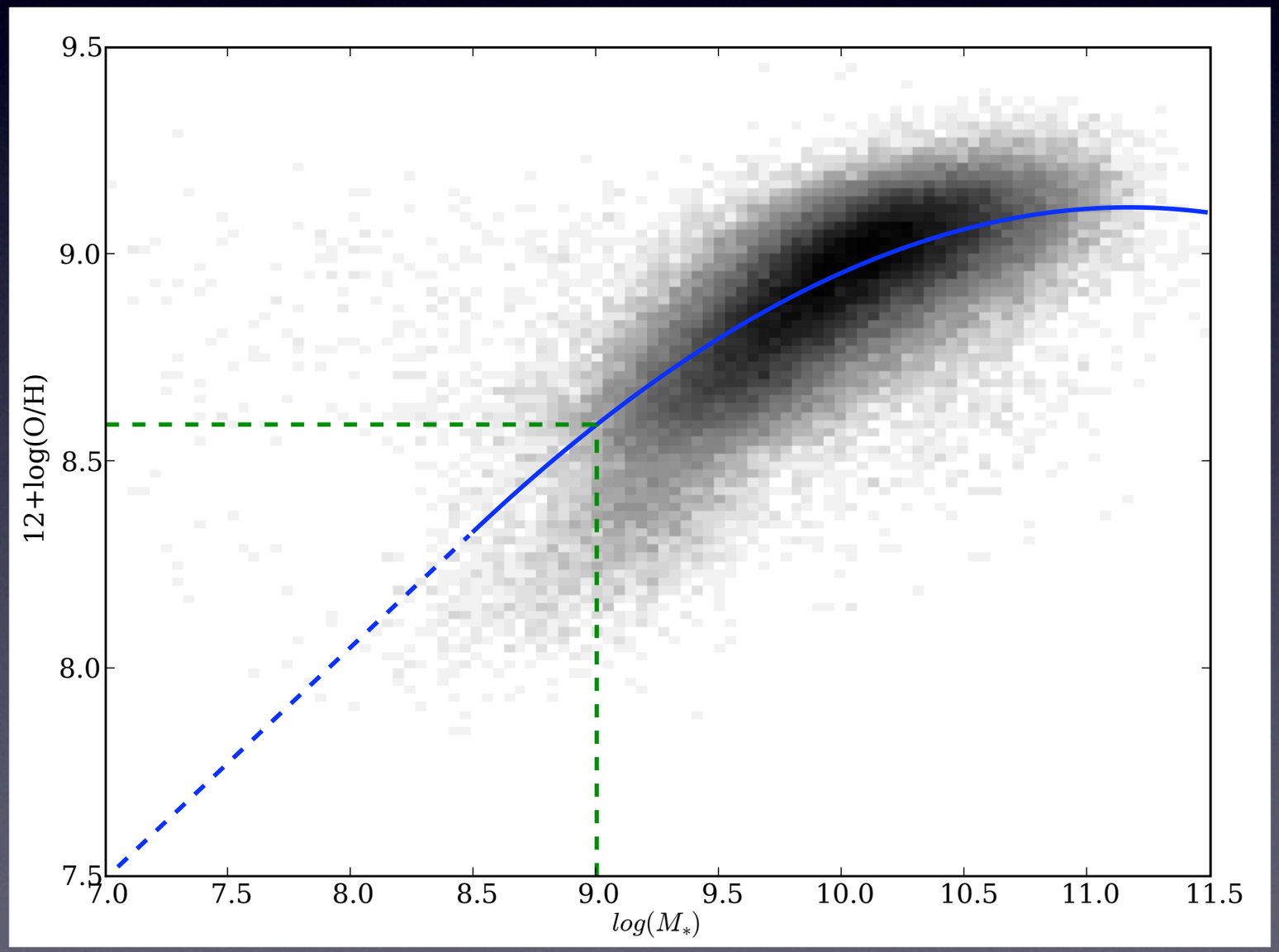
- We target SN Ia hosts with mass smaller than $10^9 M_\odot$



Low-Metallicity SN Ia Hosts

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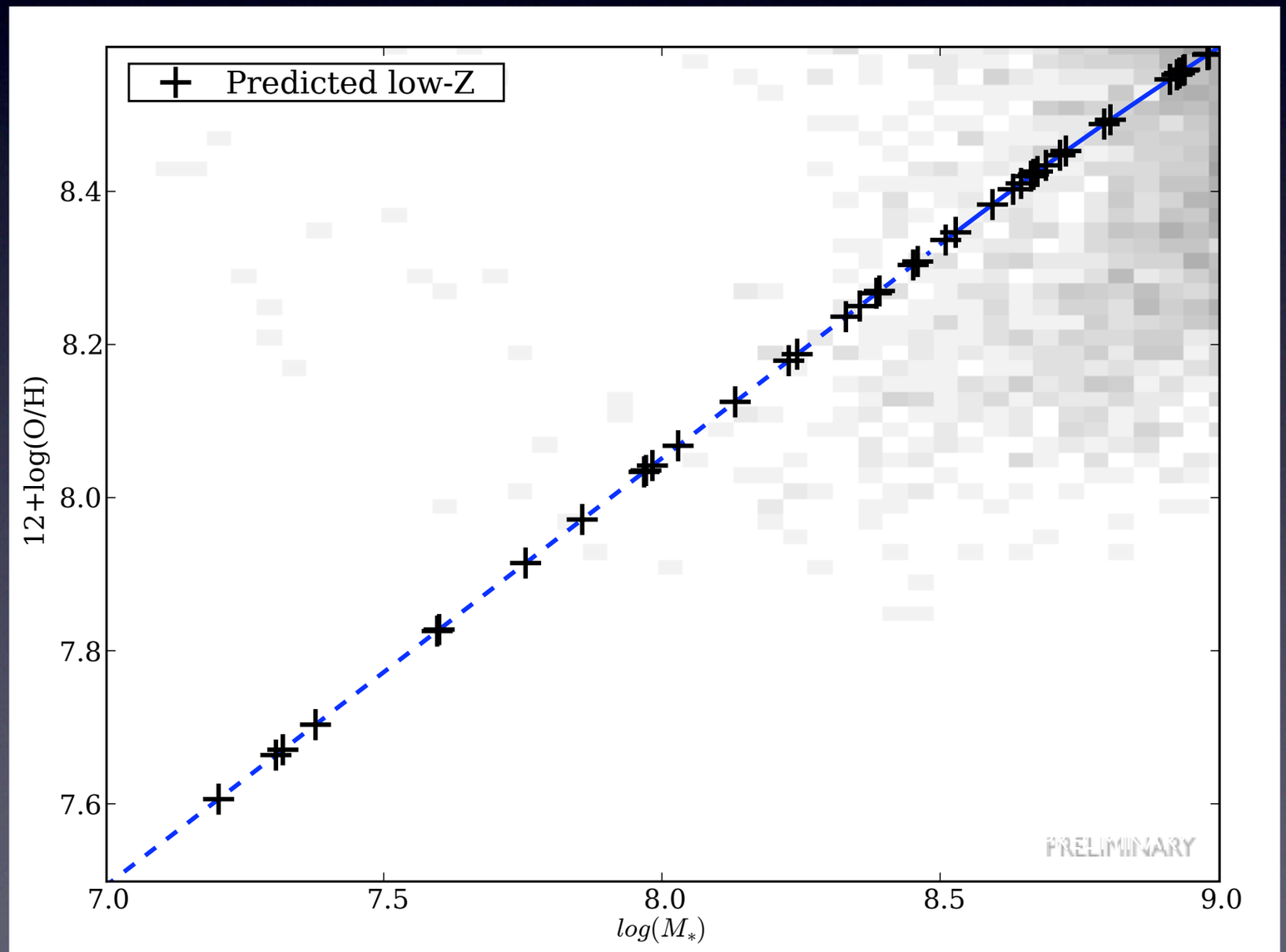
- We target SN Ia hosts with mass smaller than 10^9 $M_\odot$

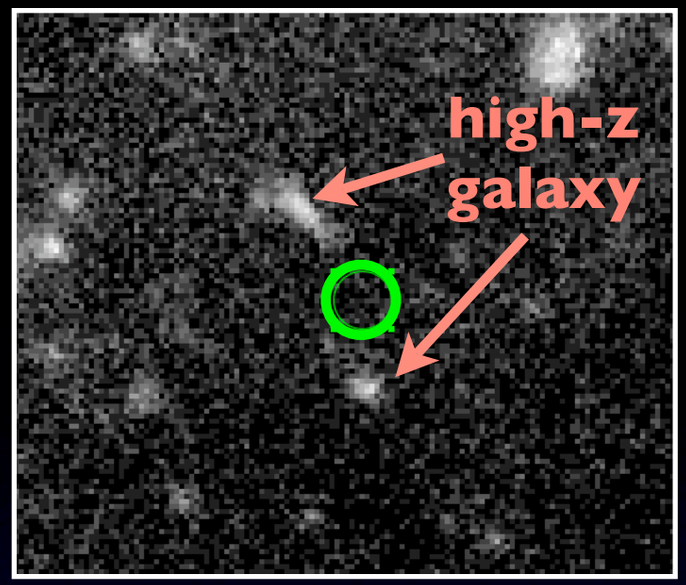
- SNfactory found over 40 SN Ia hosts less massive than this

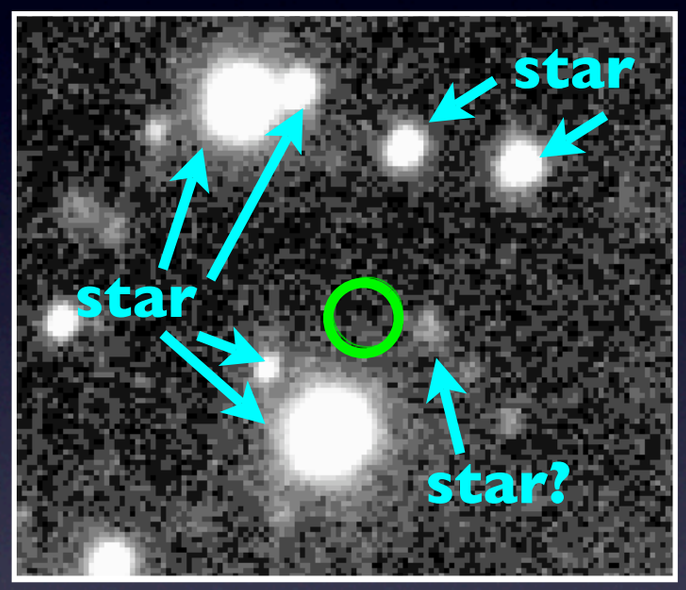


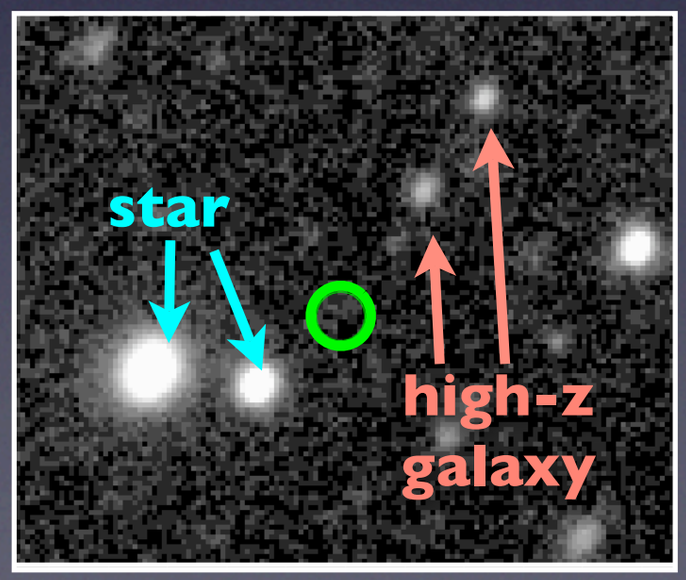
“Hostless” SNe Ia

- Some SNe Ia had multiple faint host candidates which were background high-z galaxies or foreground stars
- No host candidates more massive then 10^7 within 15kpc
- Rule of thumb: faint host candidates not EXACTLY coincident with SN are not going to be the host!

WHERE IS THE PARENT STELLAR POPULATION?







Not-so-hostless (?) SNe Ia

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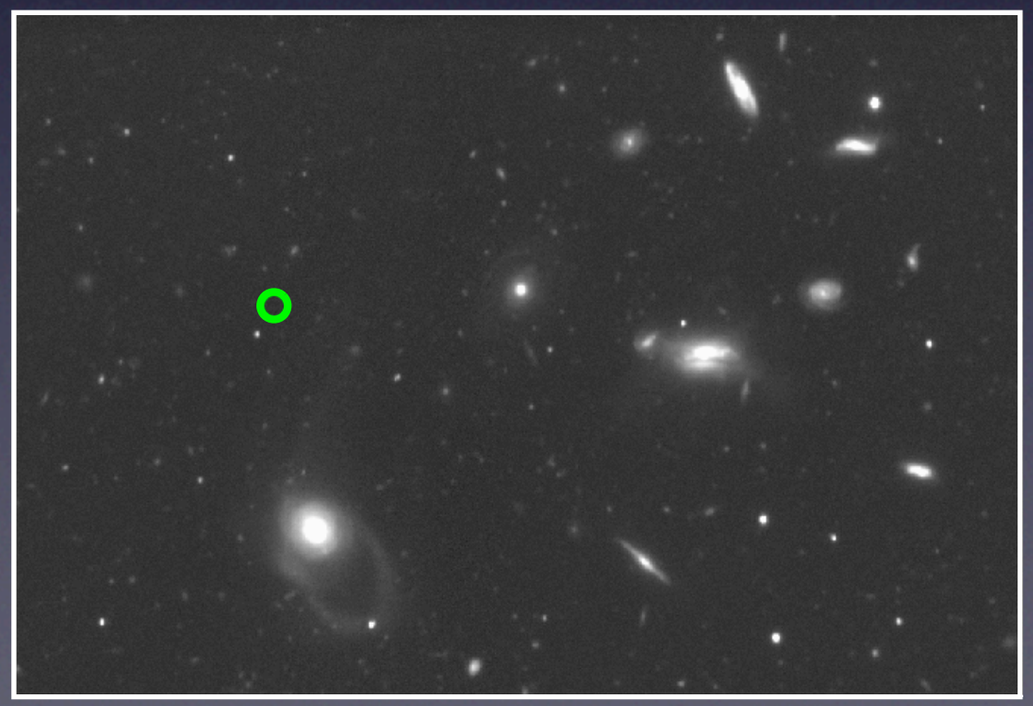
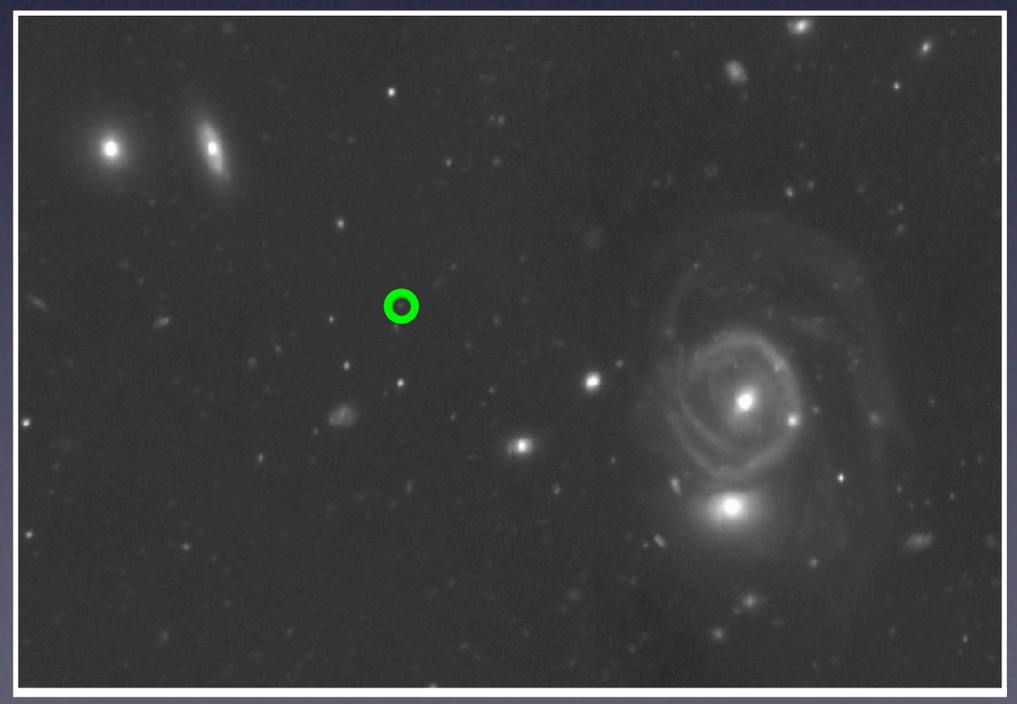
- ... but interacting galaxy groups/clusters at large distances (at the right redshift!)
- Are these ICM SNe Ia? How far out should we look for host associations?





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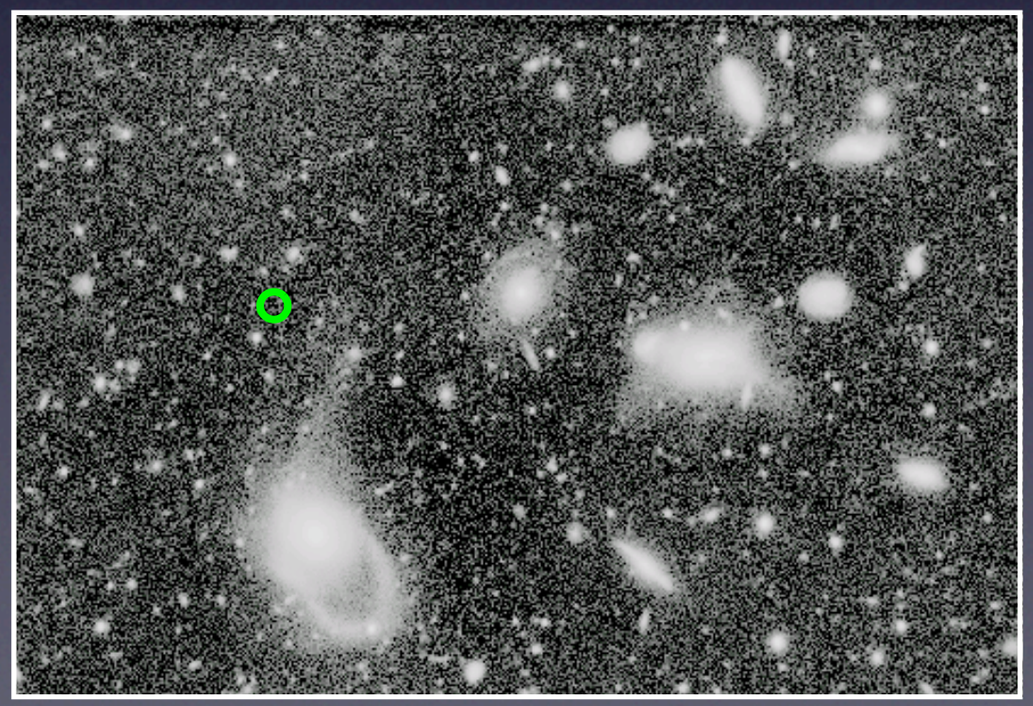
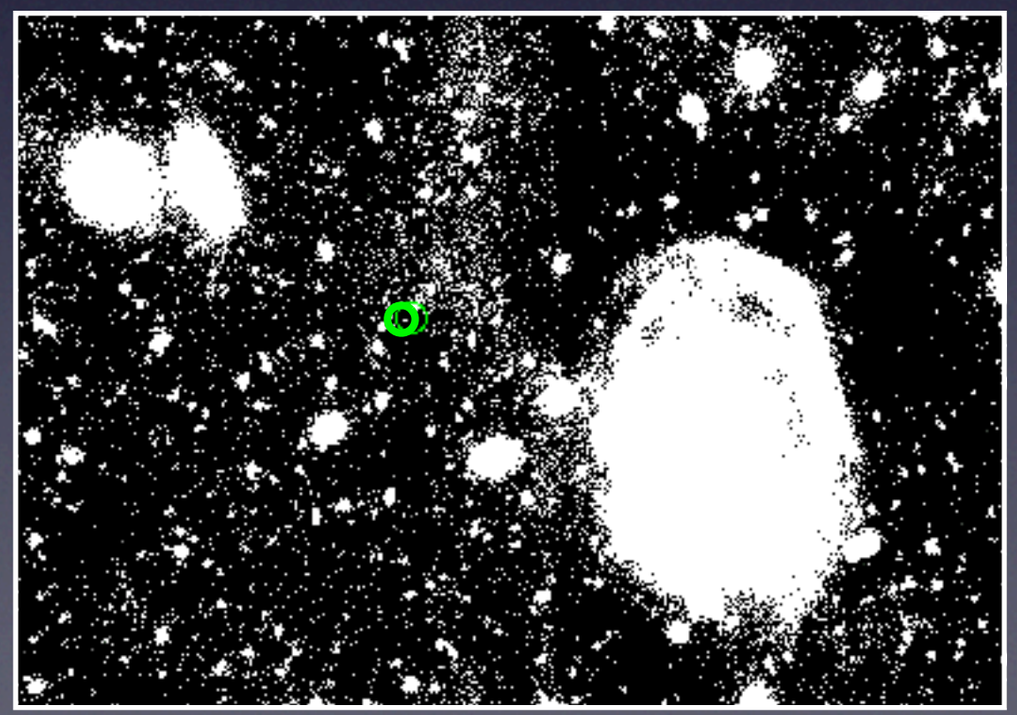


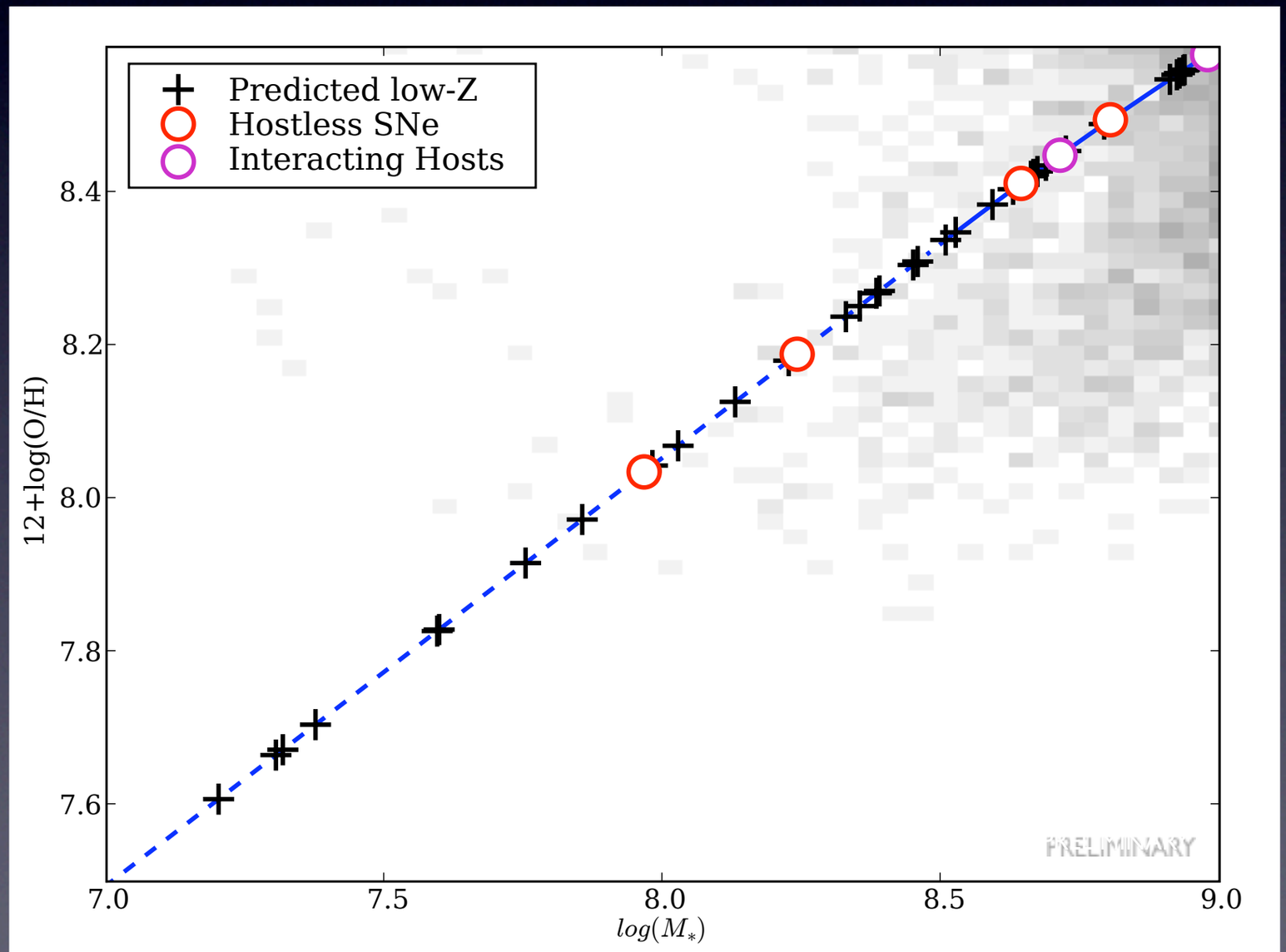


Low-Metallicity SN Ia Hosts

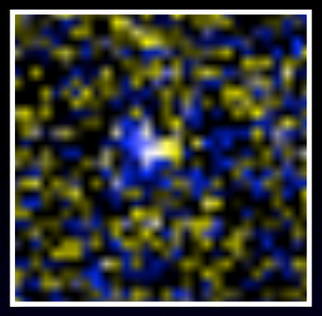
- Difficult host associations urge caution if considering a host-based 3rd SN Ia parameter

- Our hunt for low-Z hosts yielded some interesting surprises!

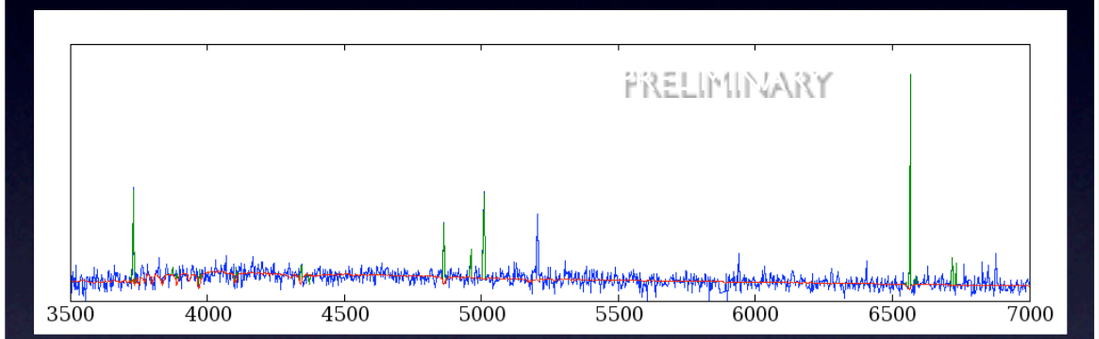
- ...on to the main attraction

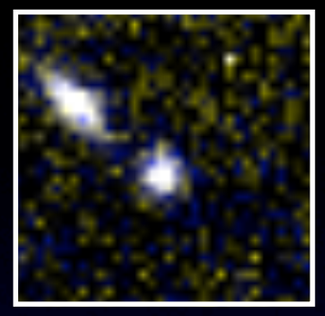


Confirmed Low Metallicity SN Ia Hosts

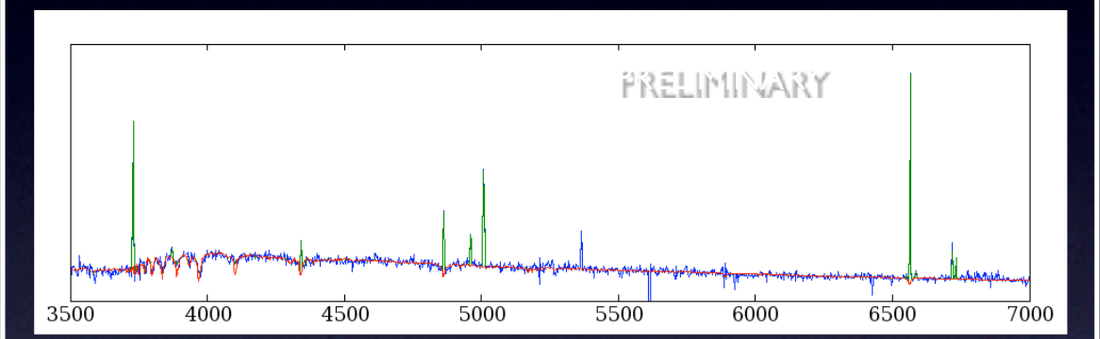


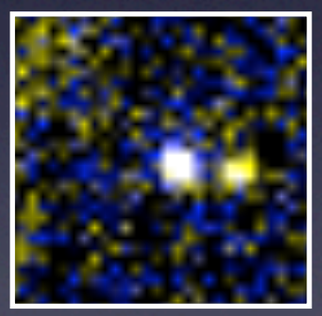
SNF20080510-001
log(M*) = 7.30
12 + log(O/H) = 7.80



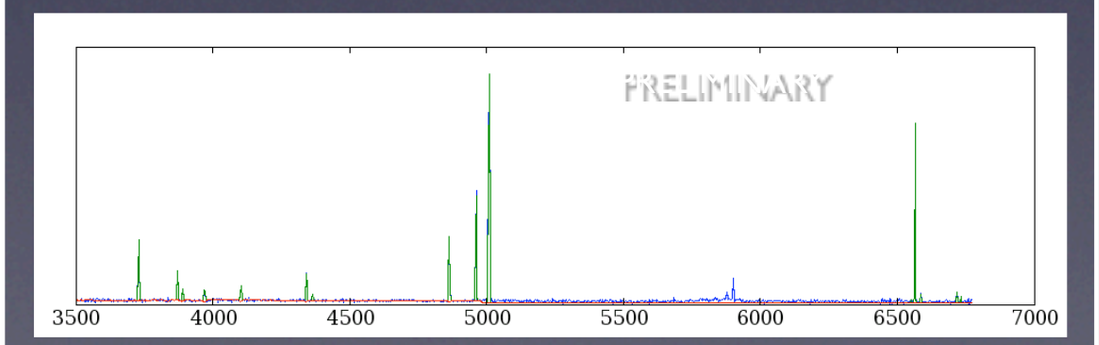


SNF20070424-006
log(M*) = 7.85
12 + log(O/H) = 7.87

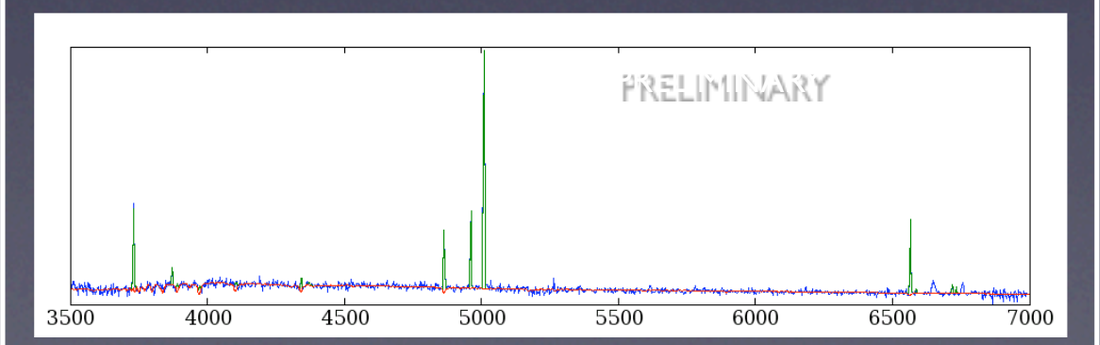




SNF20050824-002
log(M*) = 7.97
12 + log(O/H) = 8.29

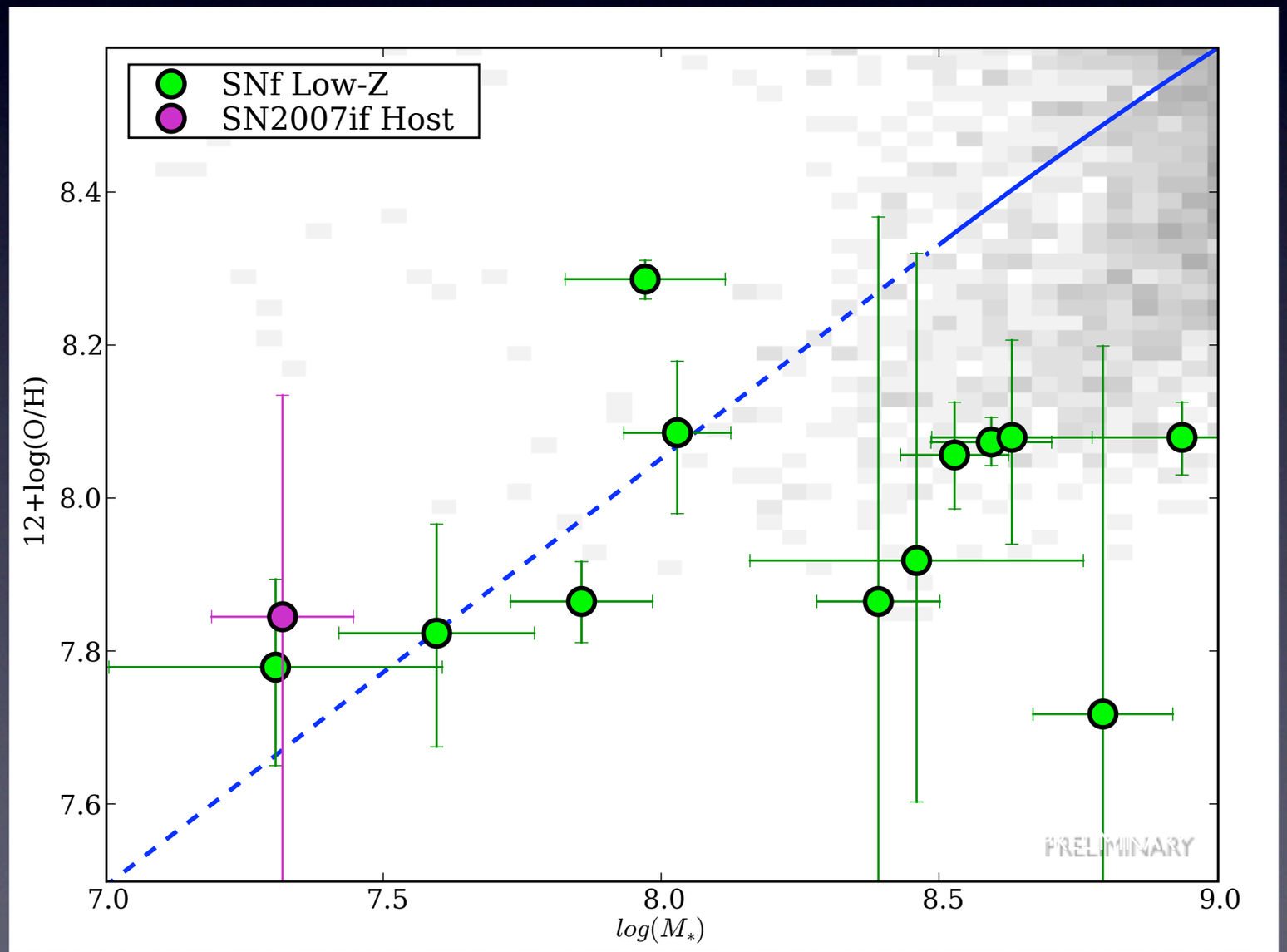


SNF20070331-013
log(M*) = 8.53
12 + log(O/H) = 8.06



Low-Metallicity SN Ia Hosts

- Most low mass SN Ia host candidates were true low metallicity galaxies



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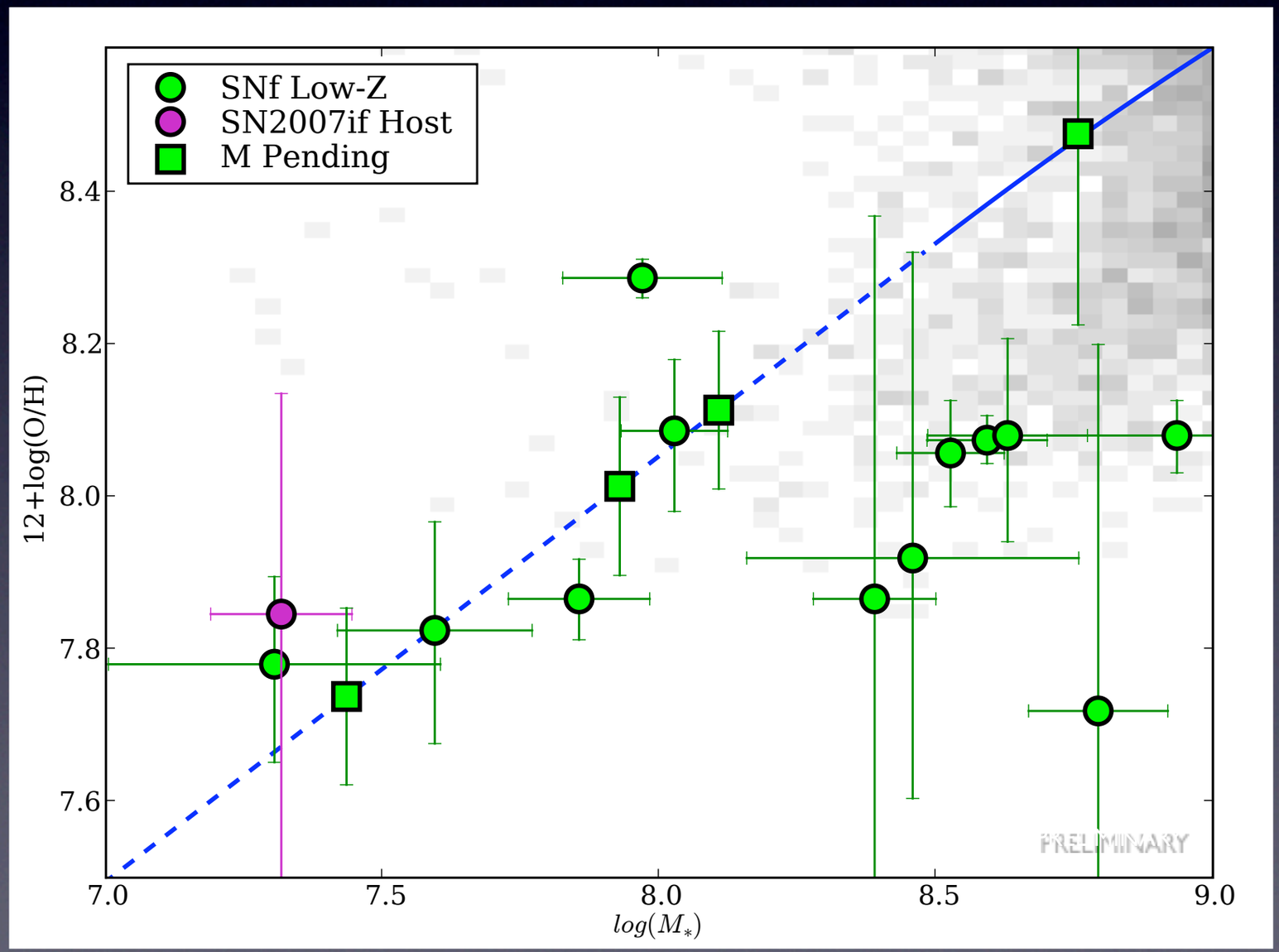
- Some hosts with measured 12+log(O/H) don't yet have measured M



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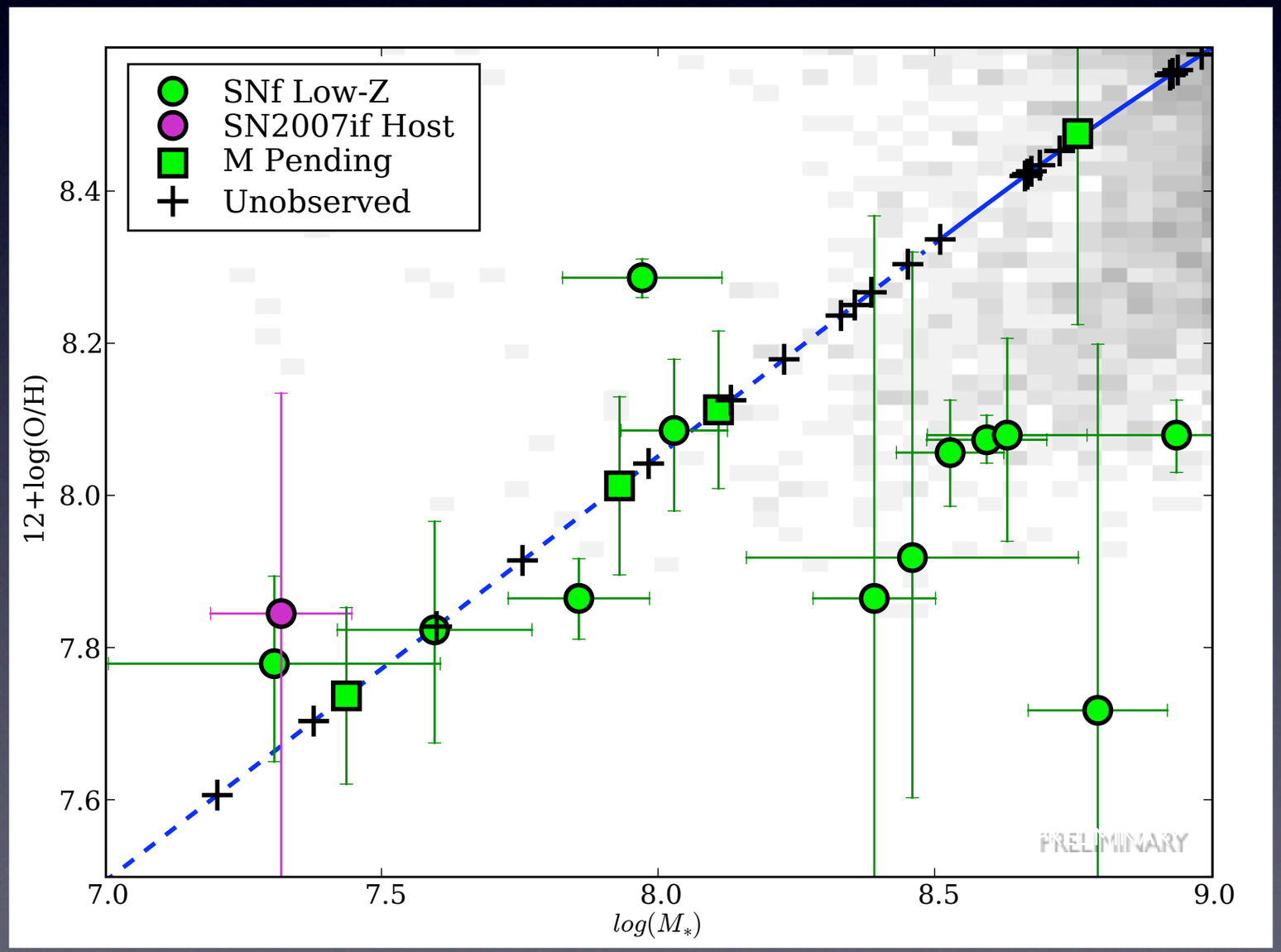
- Most low mass SN Ia host candidates were true low metallicity galaxies

- Some hosts with measured 12+log(O/H) don't yet have measured M

- Others do not have spectra yet (north Galactic cap)

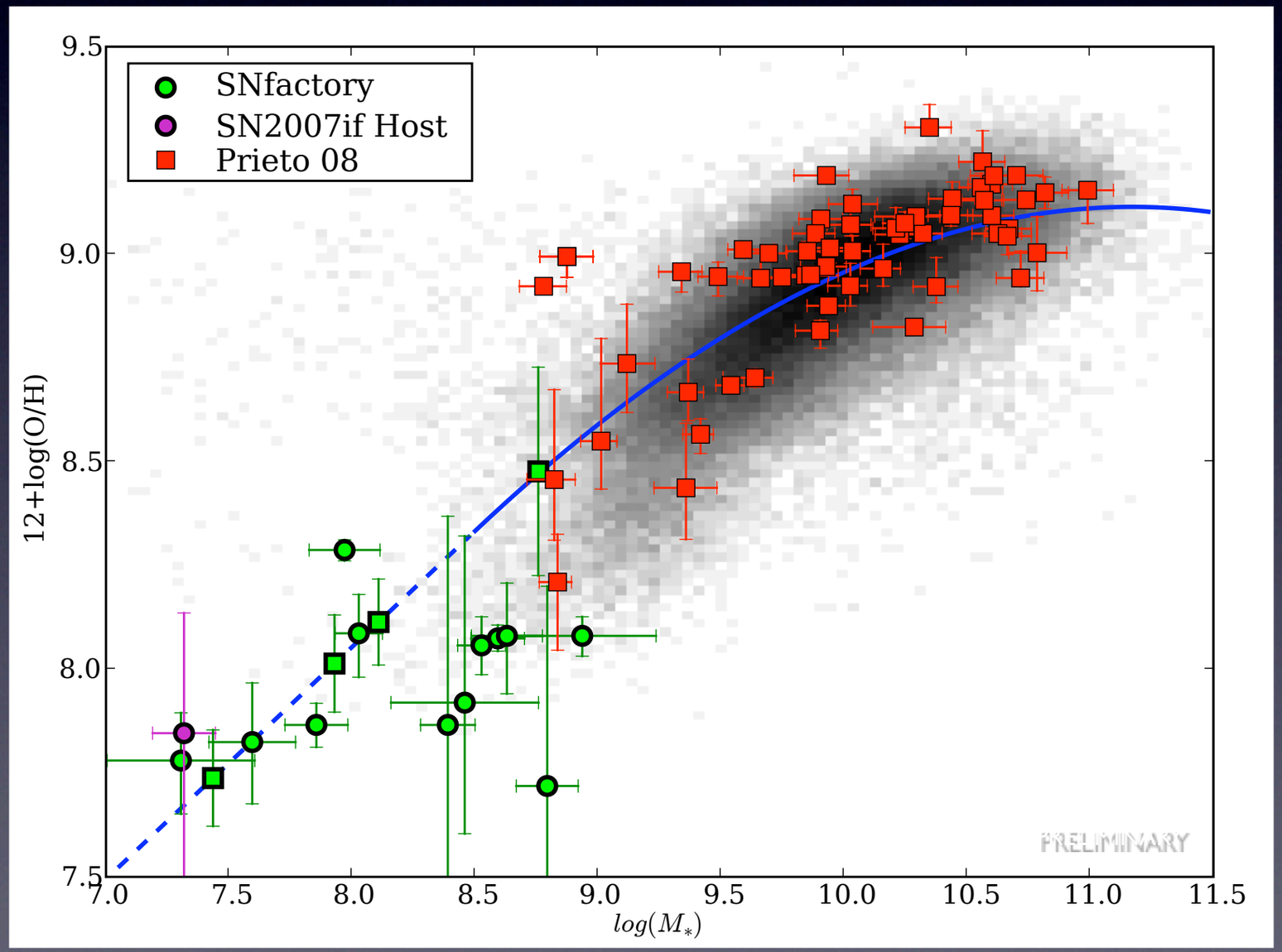


Low-Metallicity SN Ia Hosts

- Lowest spectroscopic SN Ia host Z from earlier samples: 12+log(O/H) ~ 8.2 (Hamuy+ 00, Prieto+ 08)

- Lowest SNf host Z has 12+log(O/H) ~ 7.7

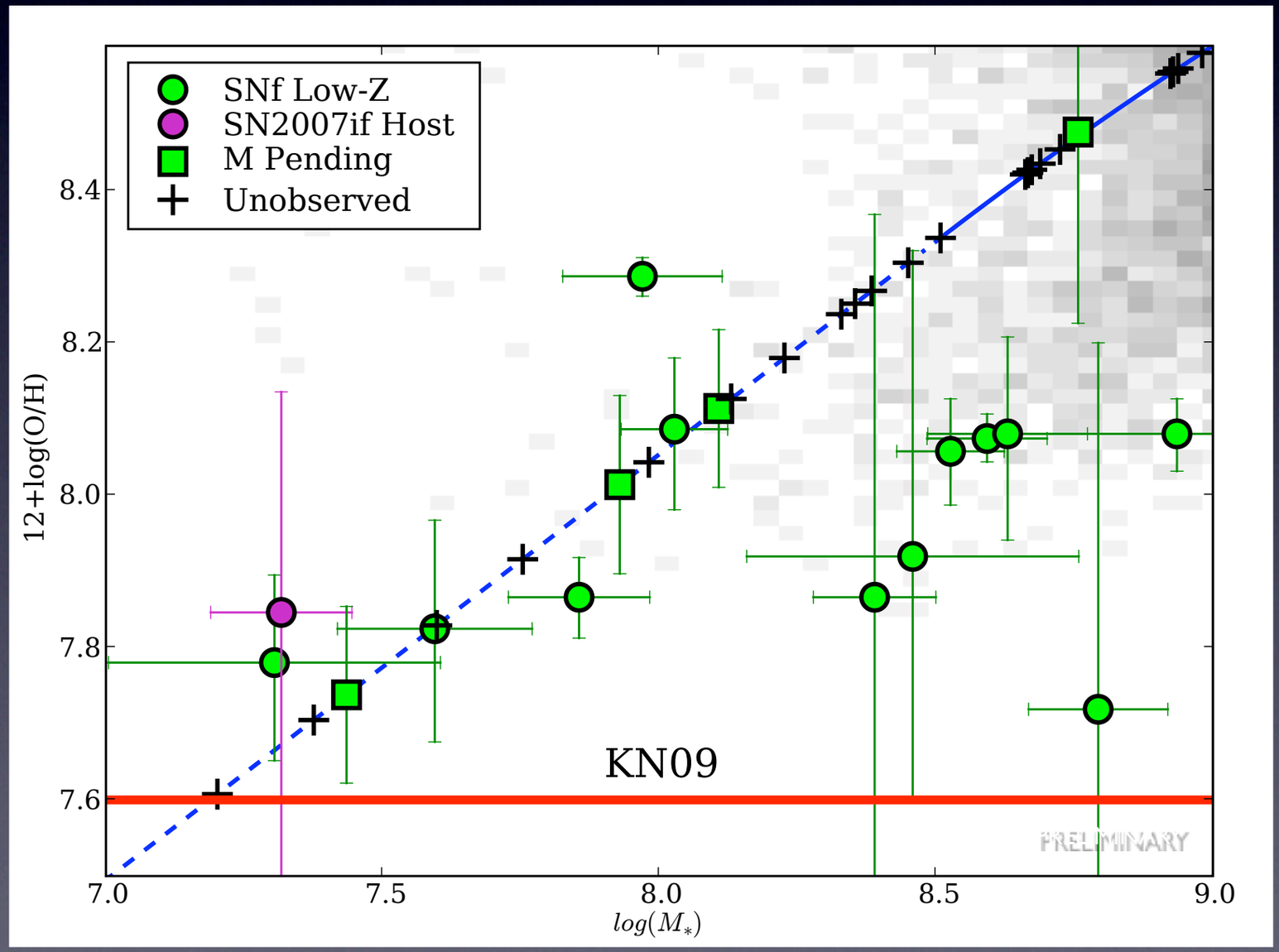
- Lowest spec. measured SN Ia host Z by a factor of 3!



What about low-Z SN Ia inhibition?

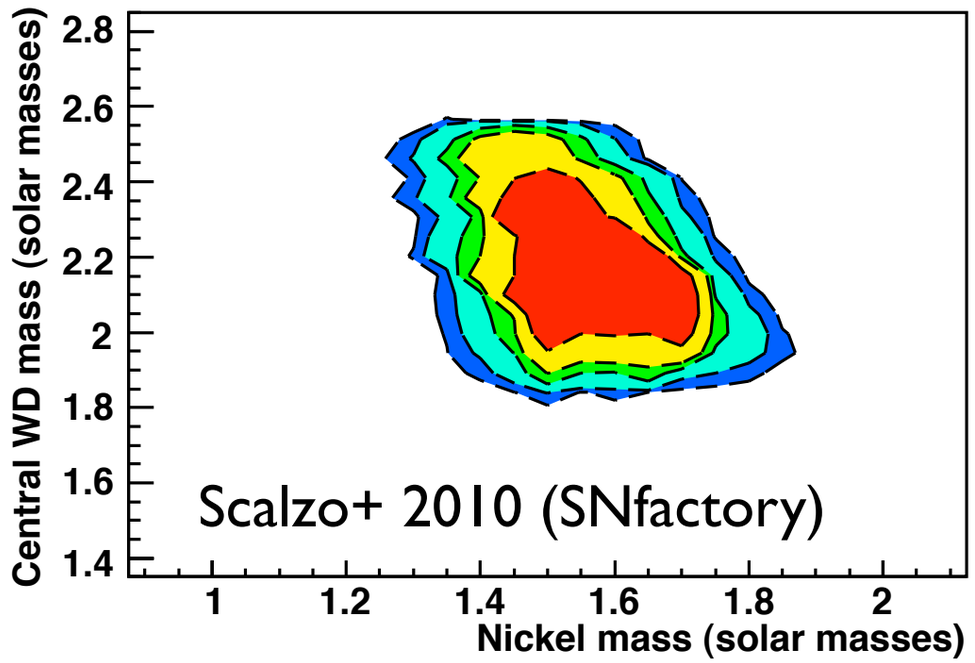
- Kobayashi & Nomoto (1998,2009) predict inhibition of SNe Ia below 12+log(O/H)=7.6

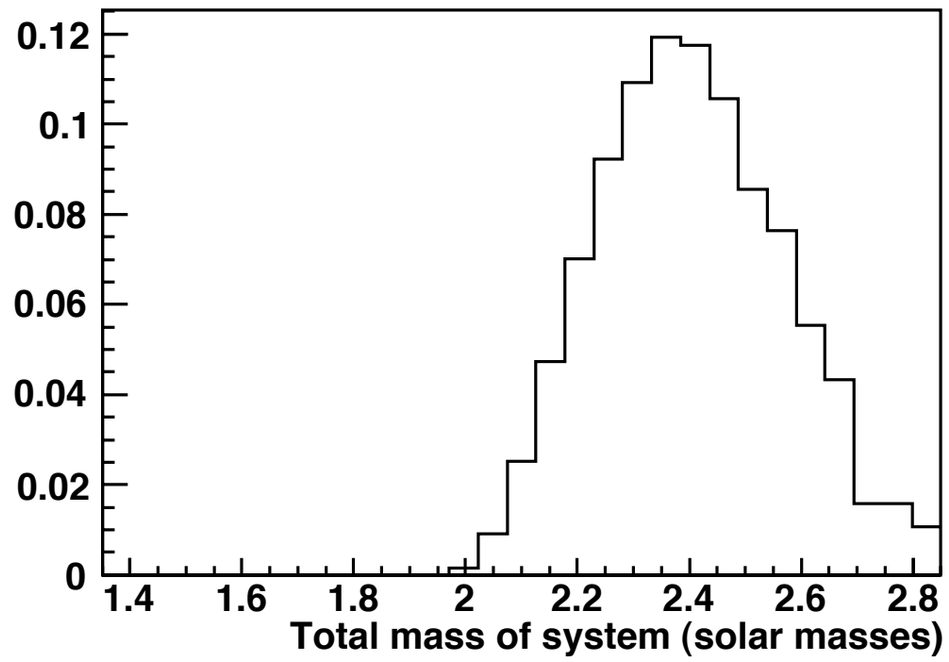
- ~2 expected below KN09 (for observed sample)
- Already suggestive - full sample could yield detection at 3σ



SN 2007if (a.k.a. SNF20070825-001)

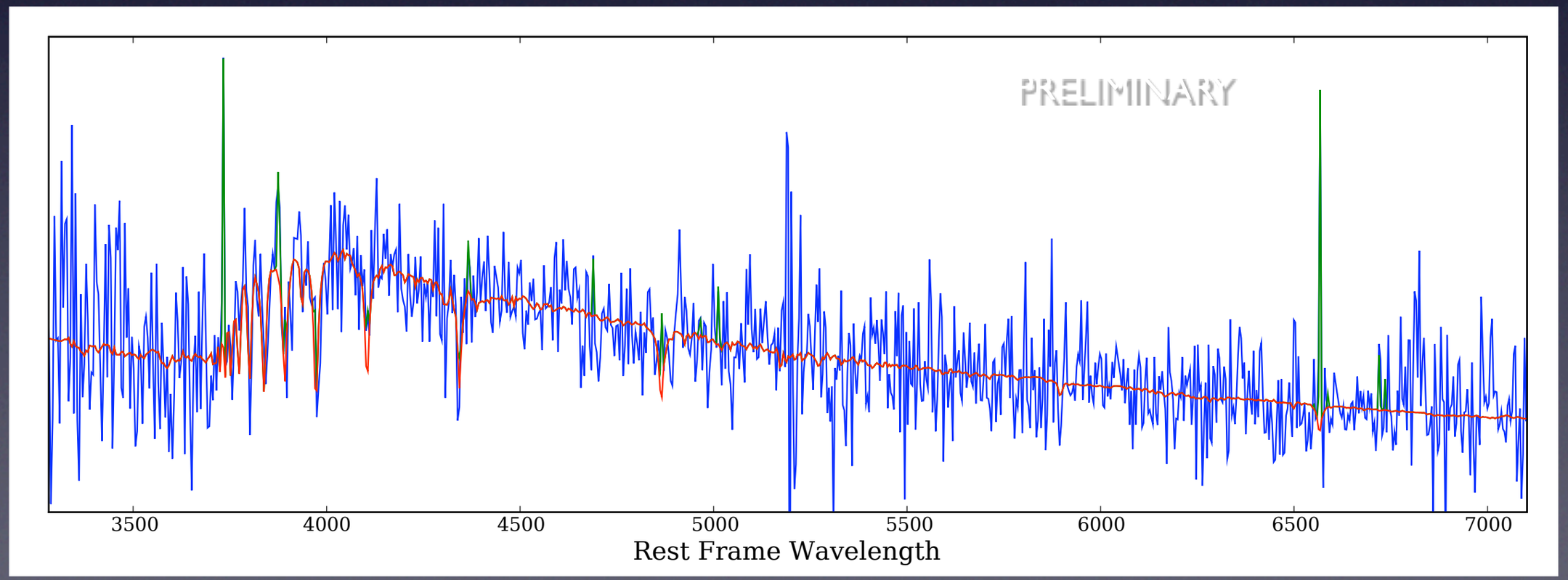
- Brightest known SN Ia: $M_B \sim -20.4$
- Progenitor mass exceeds M_{Ch} to high significance





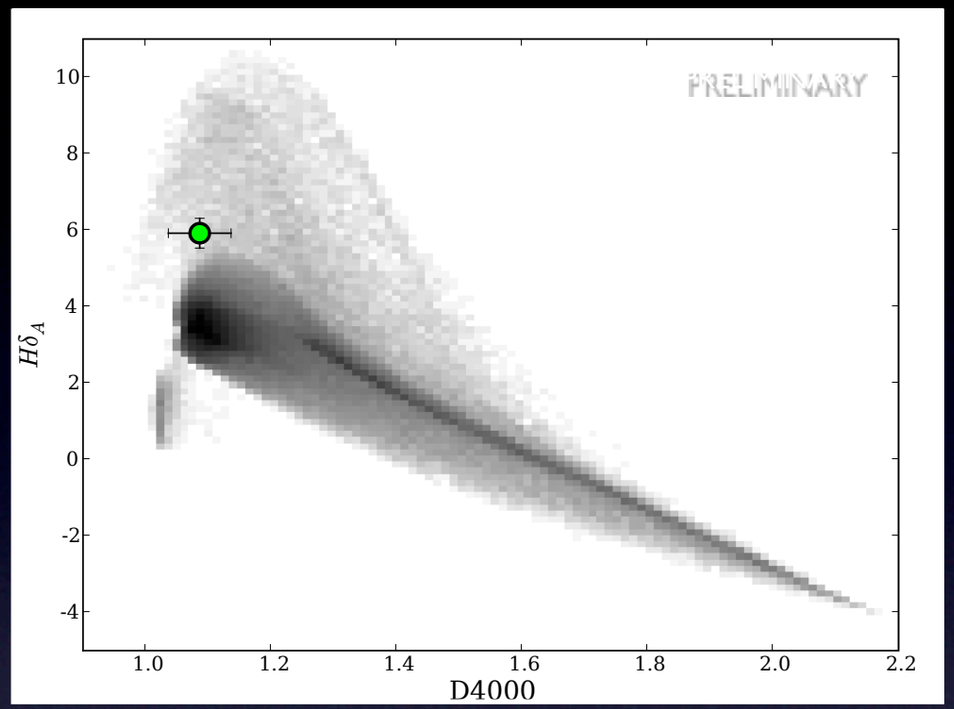
SN 2007if Host Galaxy

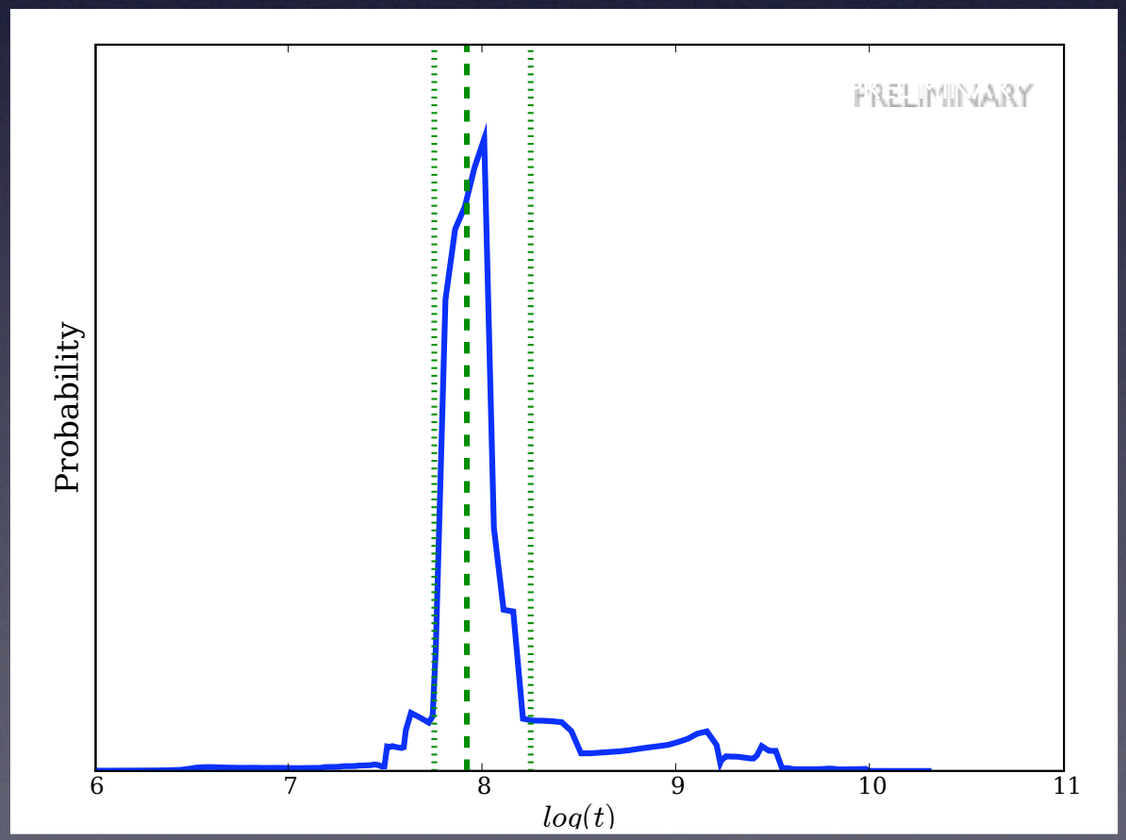
- Faint: m_g = 23.5, M_g = -14.5 (z = 0.0742)
- Blue: *g* - *i* = 0.26
- Low Mass: log(M*) = 7.3
- Low Metallicity: 12+log(O/H) = 7.82



SN 2007if Host Galaxy

- Age of dominant starburst contrained by stellar continuum indices and optical color:
  - D4000 - 4000 Å break
  - $H\delta_A$, $H\gamma_A$, Hβ - Balmer absorption EW's
  - *g-i* optical color





- Reconstructed age of HOST07if starburst:
  - log(t) = $7.92\ ^{+0.33}_{-0.17}$ (stat) +- 0.10 (sys)
  - Equivalently:
    - t = 83^{+100}_{-31} Myr
  - MS turnoff:
    - M = $5.66\ ^{+1.22}_{-1.70}\ M_\odot$

Conclusions

- SNfactory hosts span full mass range
- (Potentially) hostless SNe Ia or those in interacting galaxy groups pose a challenge for host association (and any host-based 3rd LC correction term)
- New observations of low-Z SN Ia hosts set low-Z record and approach KN09 cutoff
- Host galaxy of SN 2007if is faint, young, and low metallicity

SNfactory Collaboration

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