The Distinct Chemical Signature of Single-Enriched Second-Generation Stars

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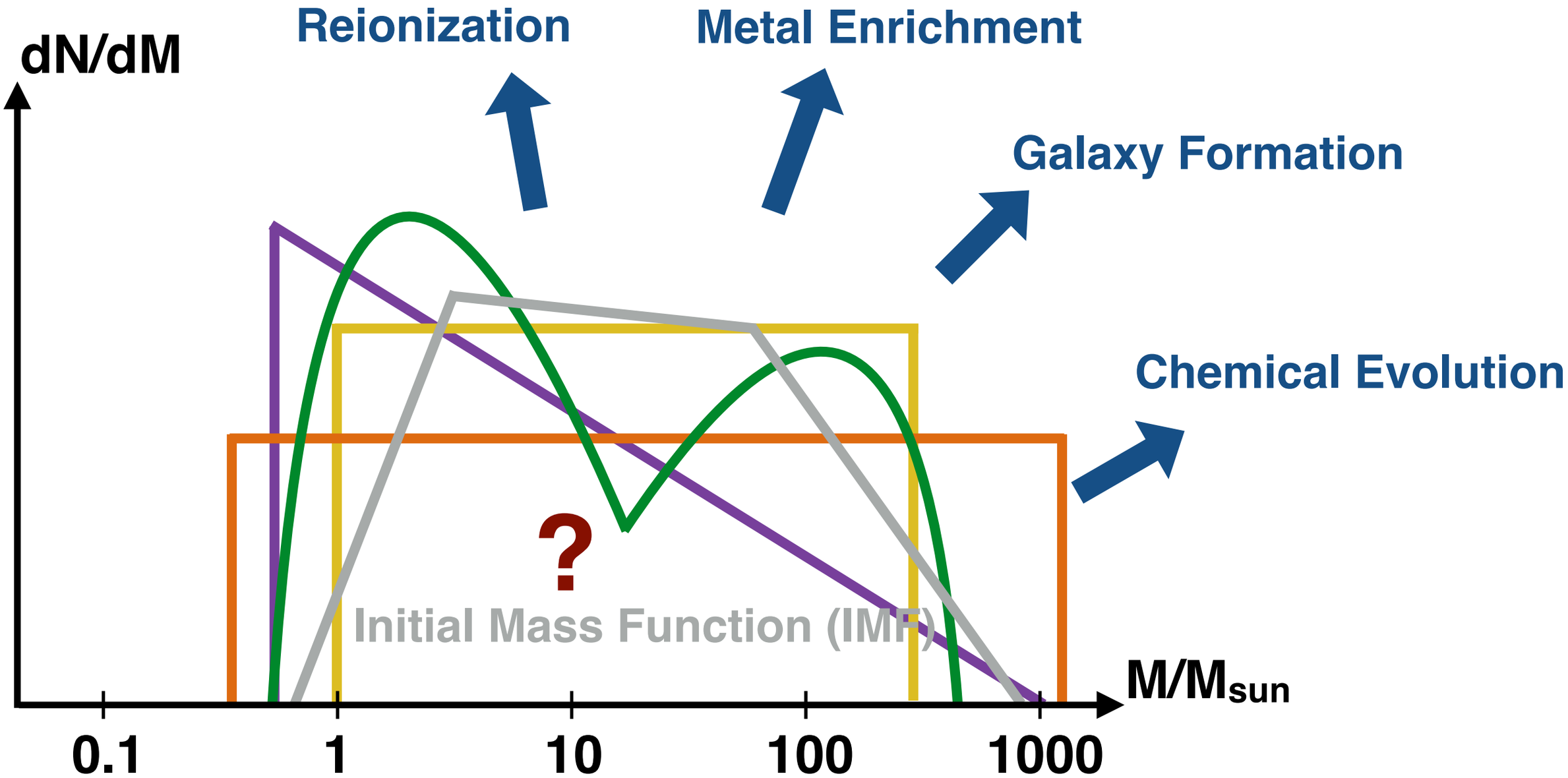
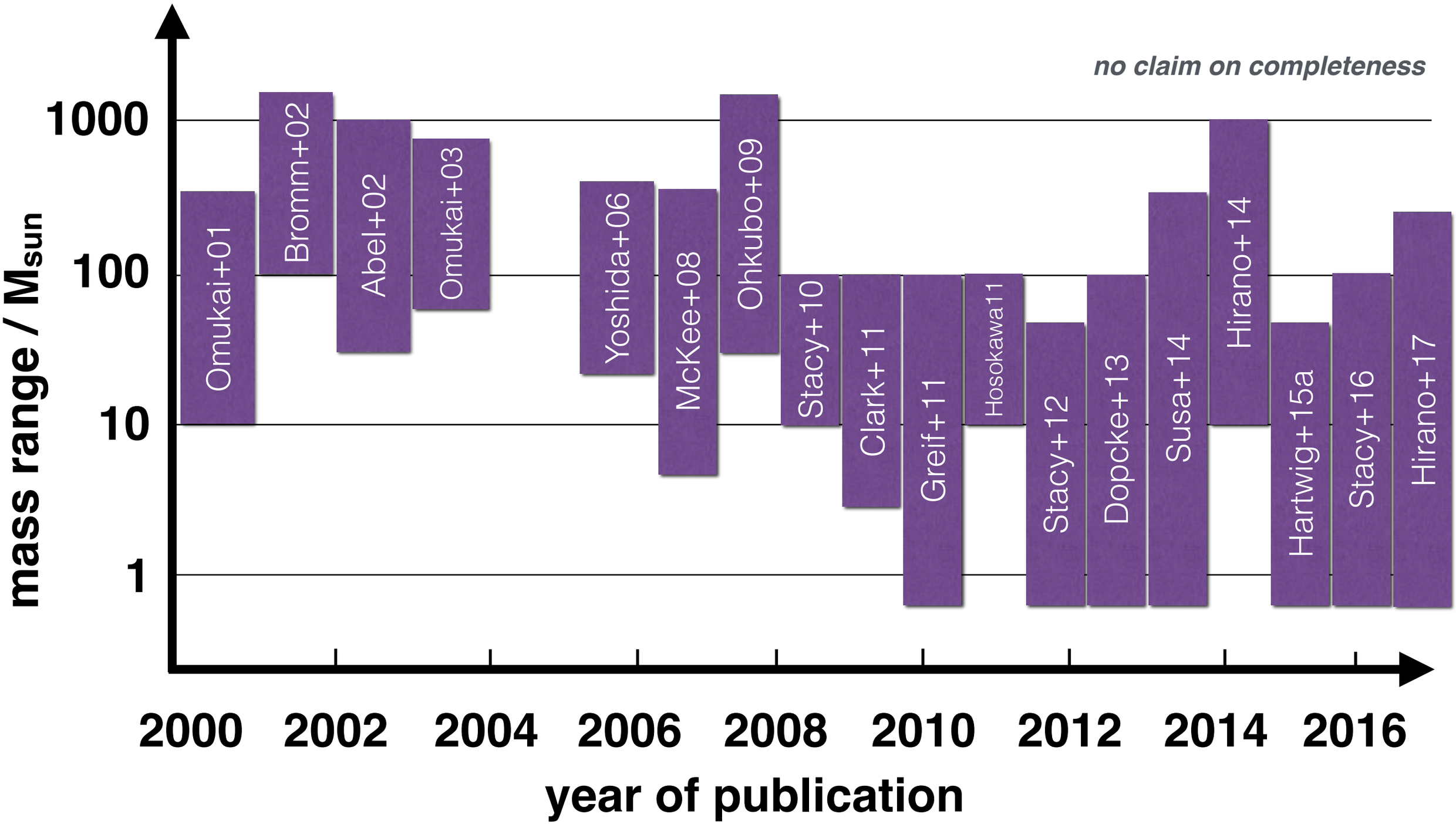
The first stars set the scene

…but we don't know their IMF



Expected mass range from numerical simulations: no convergence / agreement



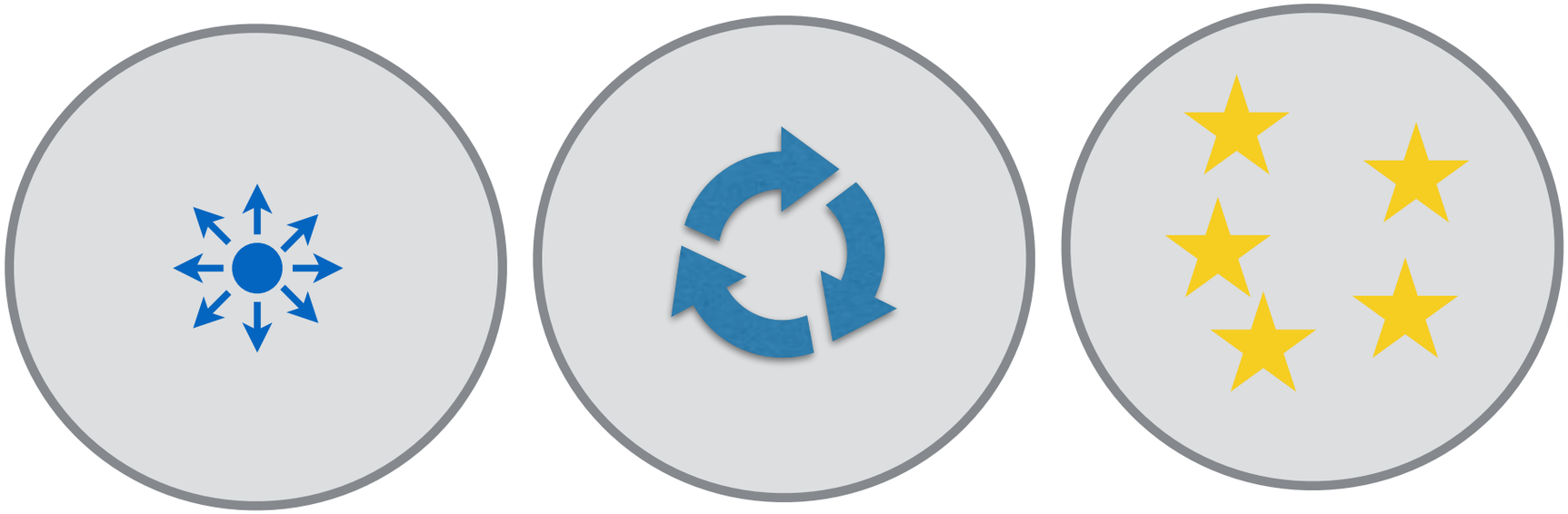
Star formation after the first SNe

first stars

mixing

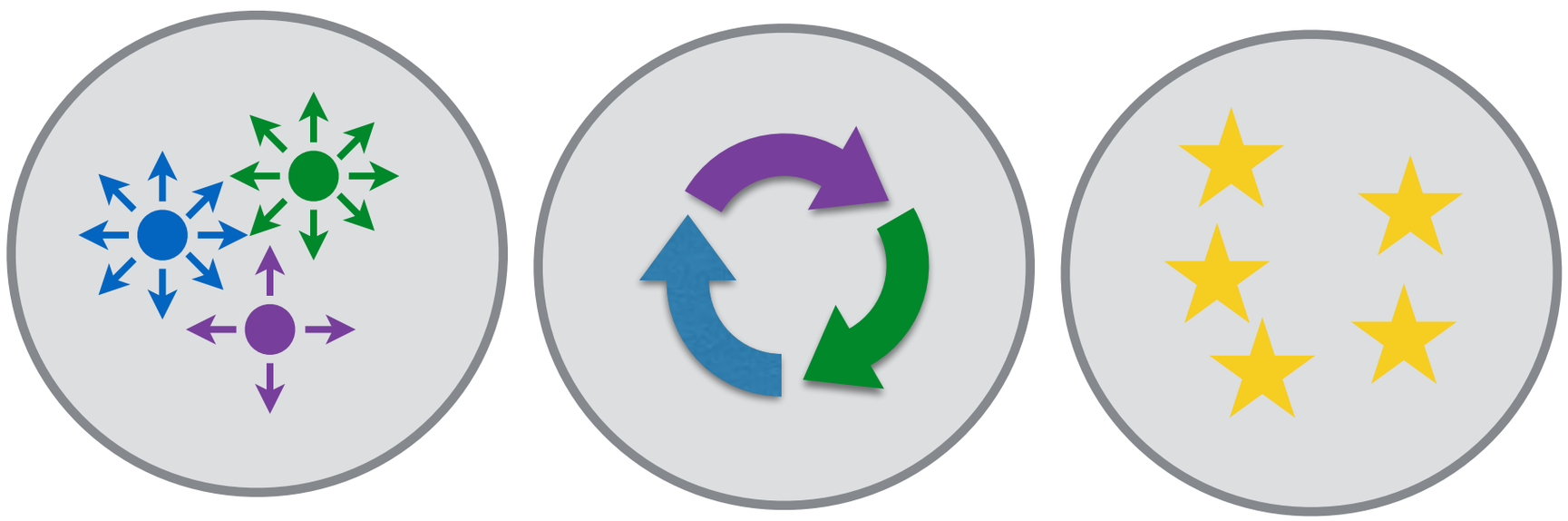
2nd generation stars

one supernova



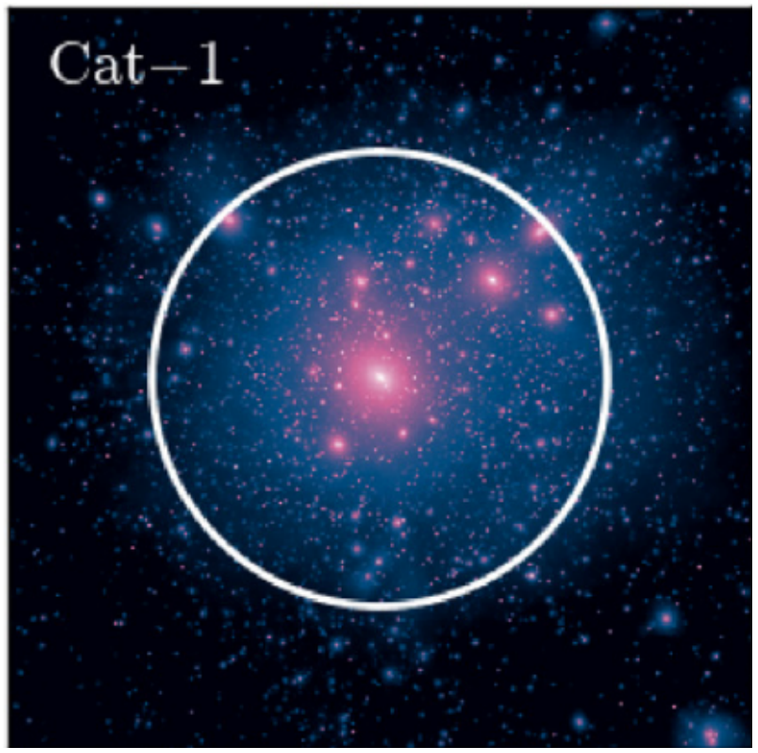
→ constrain progenitor mass
(Miho's talk/Miji's poster)

multiple supernovae



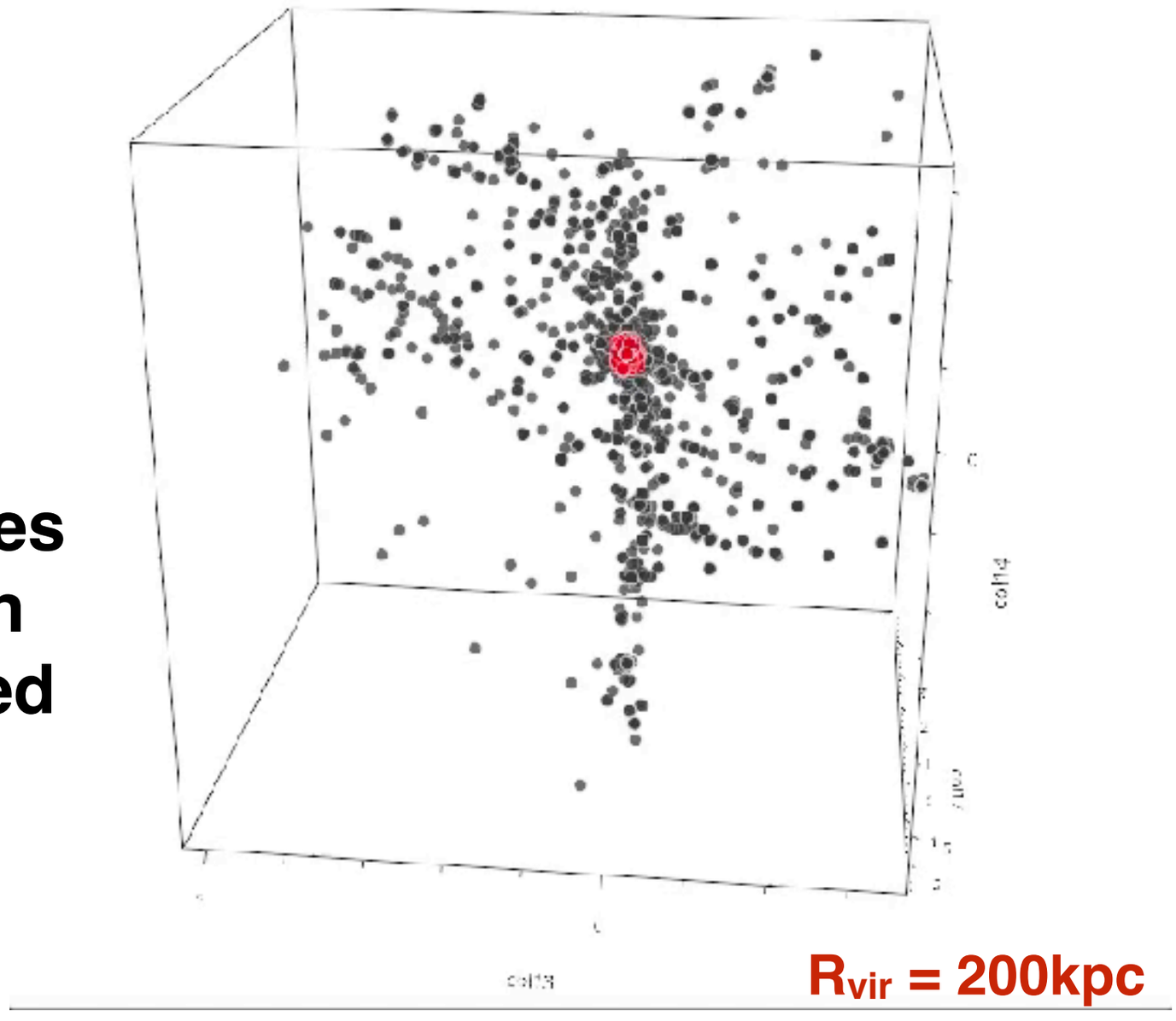
→ constrain progenitor masses?

Semi-analytical model of Pop III star formation



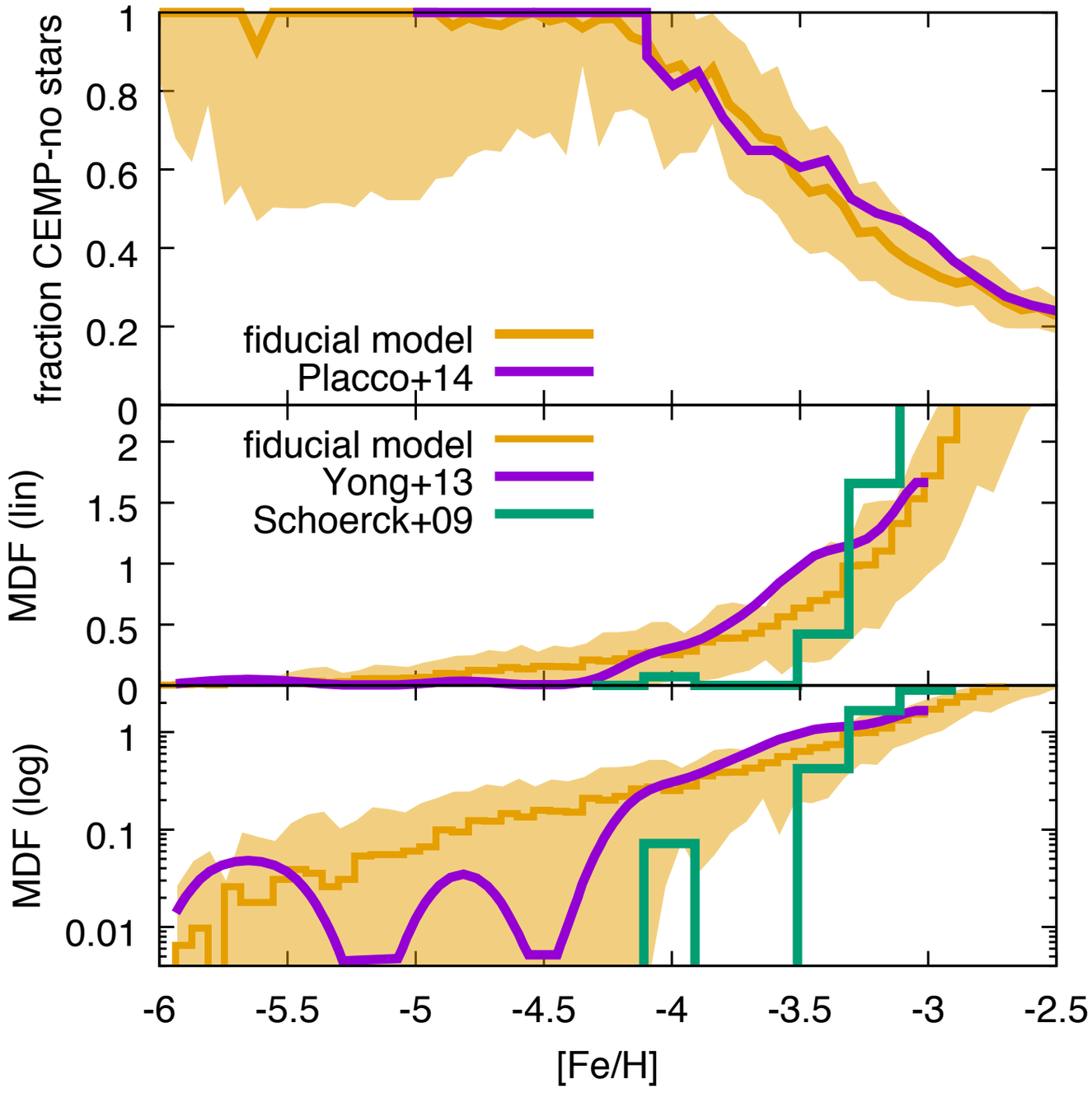
Griffen+16

- **30 MW-like DM merger trees from Caterpillar simulation**
- **Pop III star formation based on Hartwig+15b, Magg+17**
- **Chemical yields from Nomoto+13**



R_{vir} = 200kpc

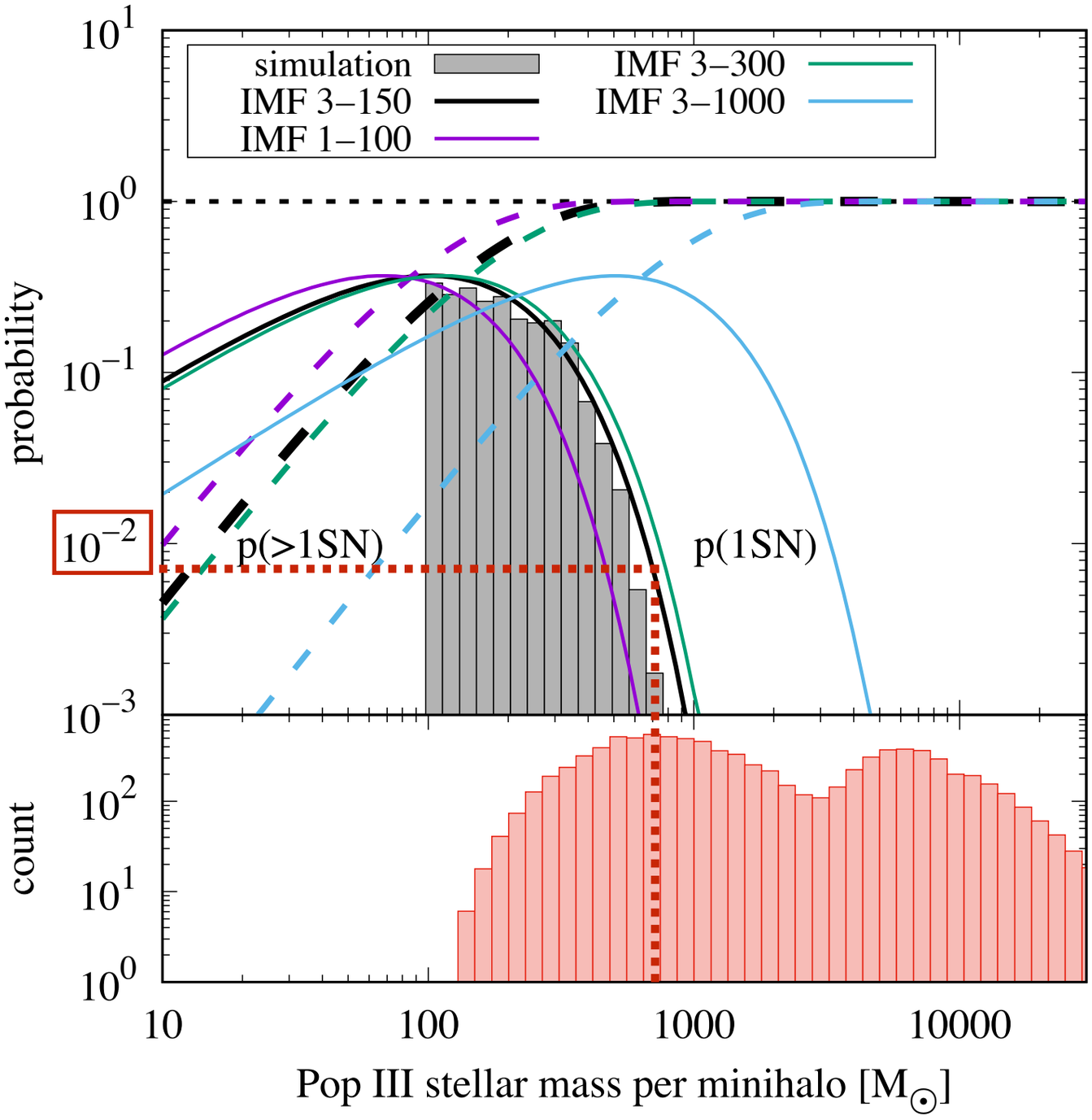
Fiducial Model



- **We can reproduce MDF and fraction of CEMP stars**
- **Main results independent of cosmological model**

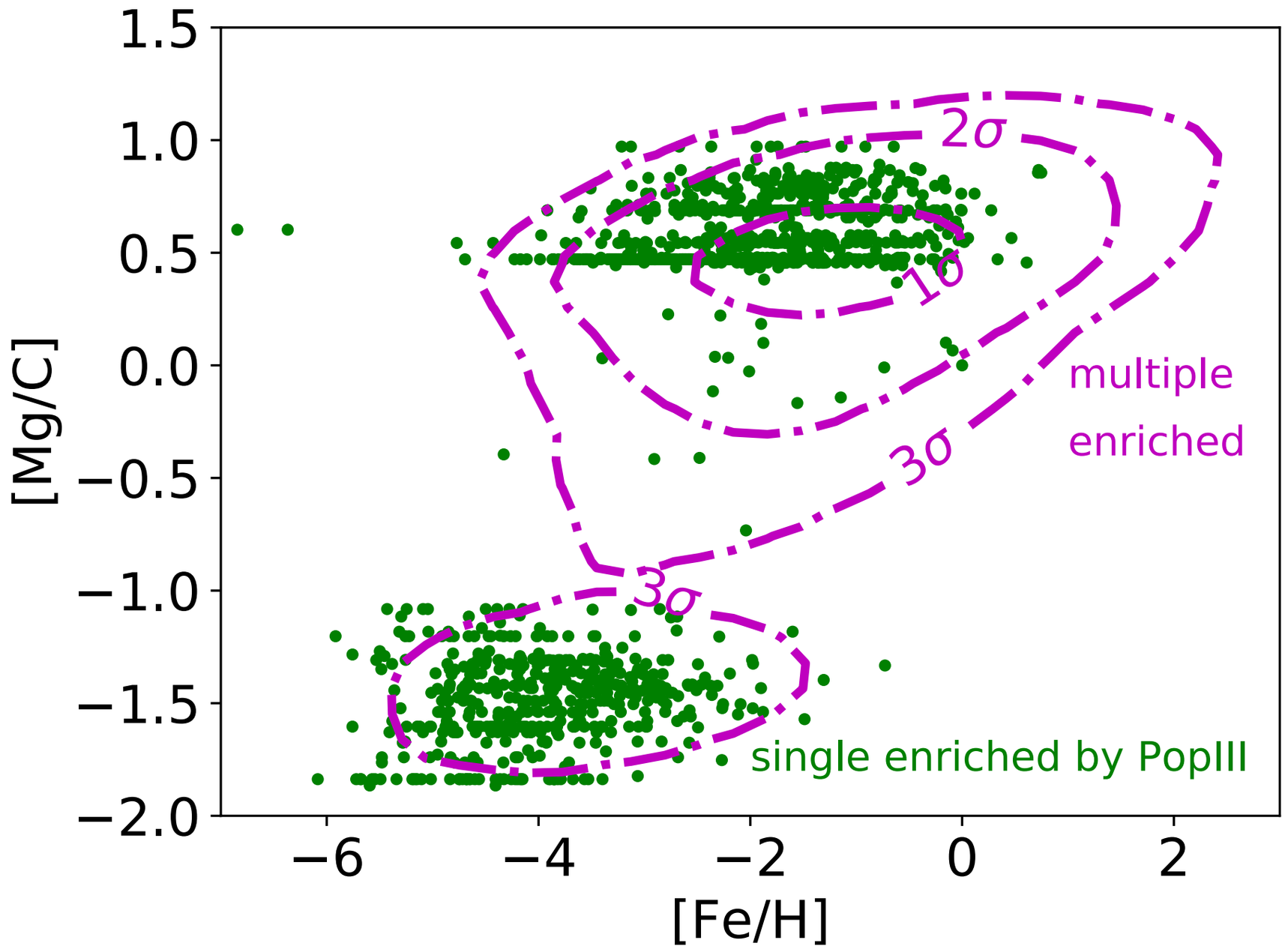
Parameter	Value
mass threshold for Pop III	Eq. 2
mass threshold with LW feedback	Eq. 4
Pop III SFE	$\eta_{III} = 0.001$
PopII SFE	$\eta_{II} = 0.01$
fraction faint SNe	$f_{\rm faint} = 40\%$
metal fallback fraction	$f_{\rm fallback} = 20\%$
metal ejection fraction	$f_{\rm eject} = 80\%$
Pop III SN-driven winds	$v = 10\,{\rm km/s}$
lower IMF limit	$M_{\rm min} = 3\,{\rm M}_\odot$
upper IMF limit	$M_{\rm max} = 150\,{\rm M}_\odot$
recover time	$t_{\rm recov} = 100\,{\rm Myr}$
mean of dilution distribution	$\mu = 10^{-1.5}$
width of dilution distribution	$\sigma = 0.75\,{\rm dex}$

Probability of 1SN per halo

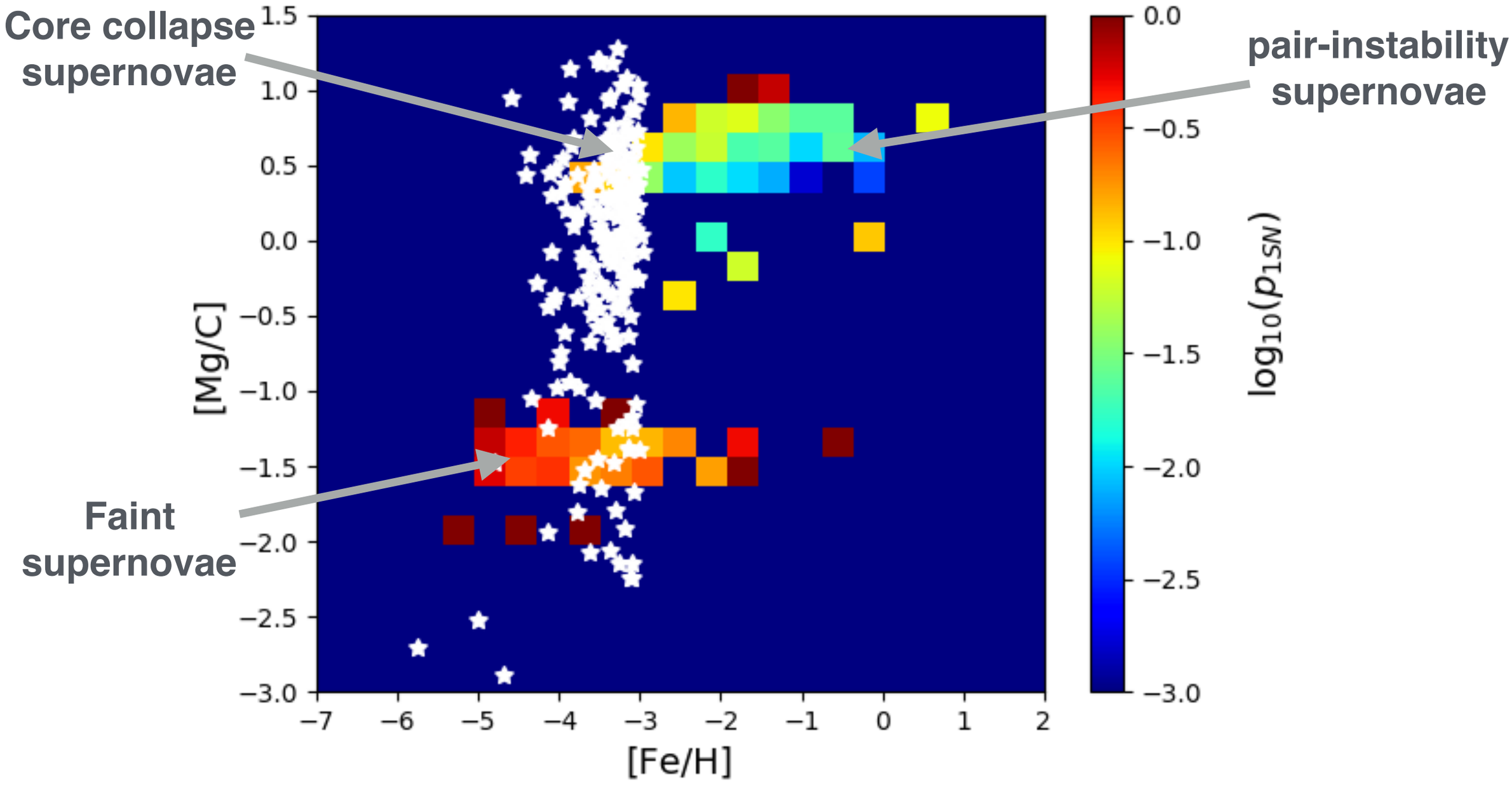


- **Poisson statistics with on average one SN per 100M_{sun} of stellar mass**
- **Single-enriched 2$_{nd}$ generation stars only in one out of 100 halos.**
- **IMF-dependent**

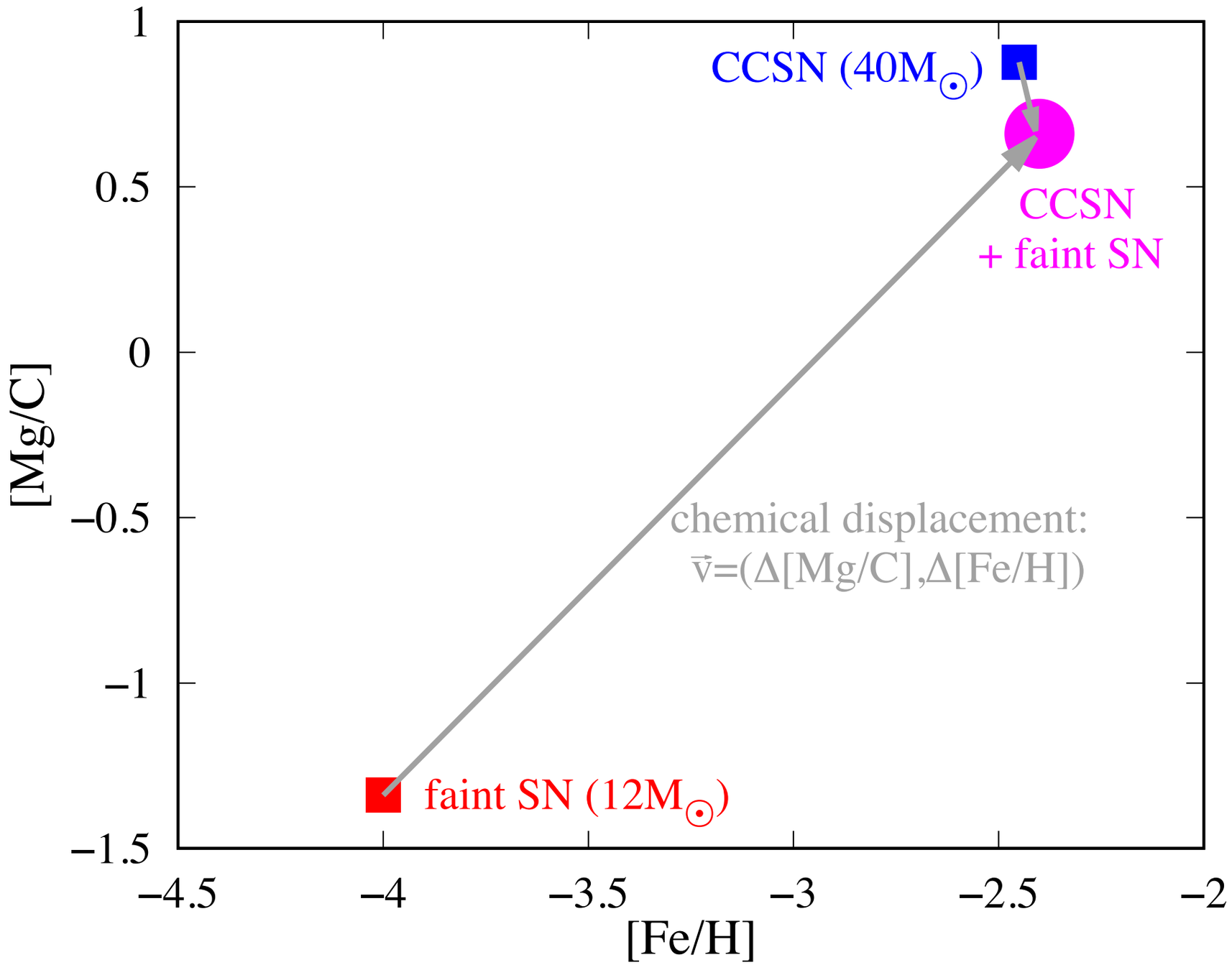
Single-enriched 2nd generation stars occupy specific regions in the chemical plane



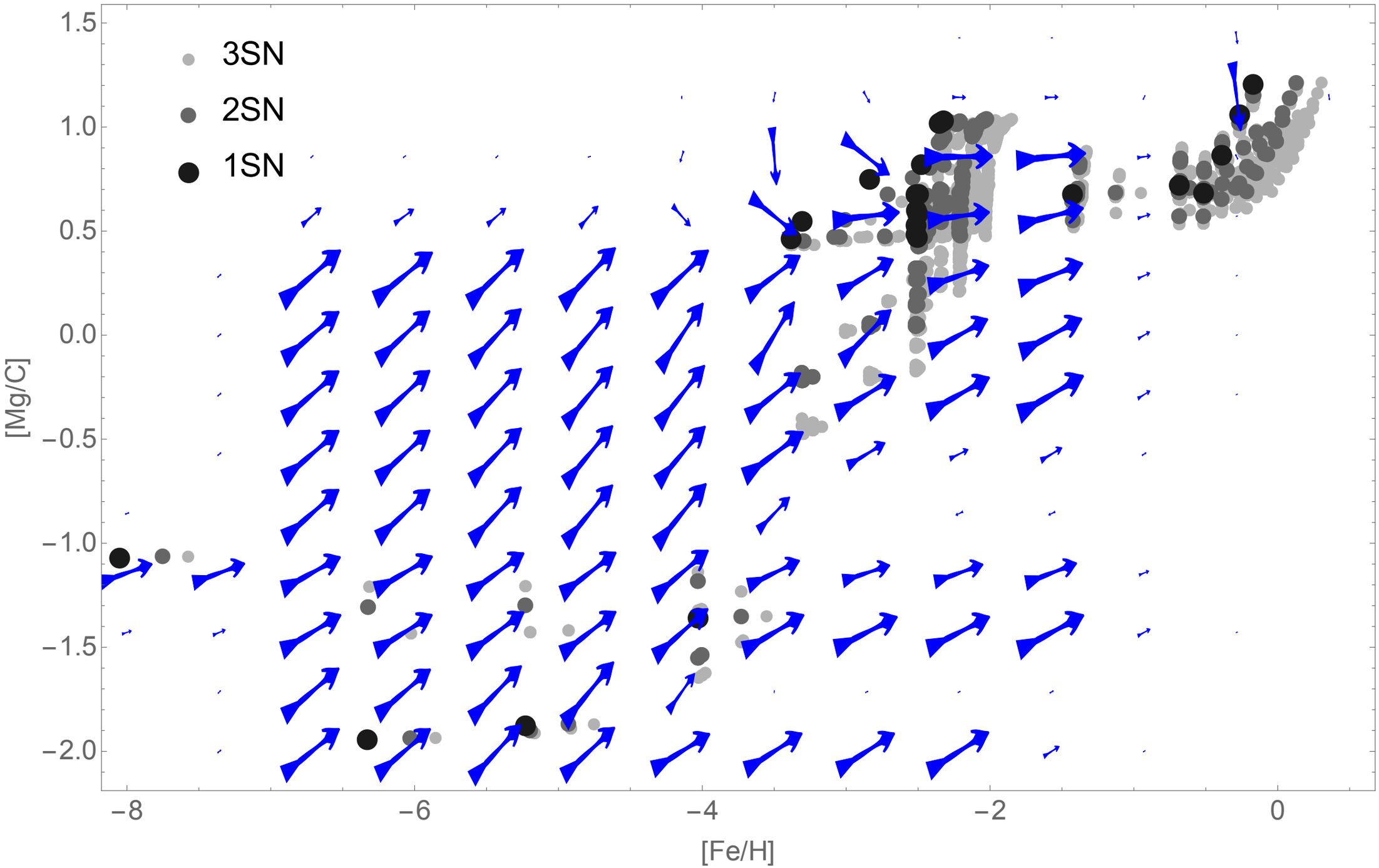
Probability to find single-enriched 2nd generation stars depends on [Mg/C]



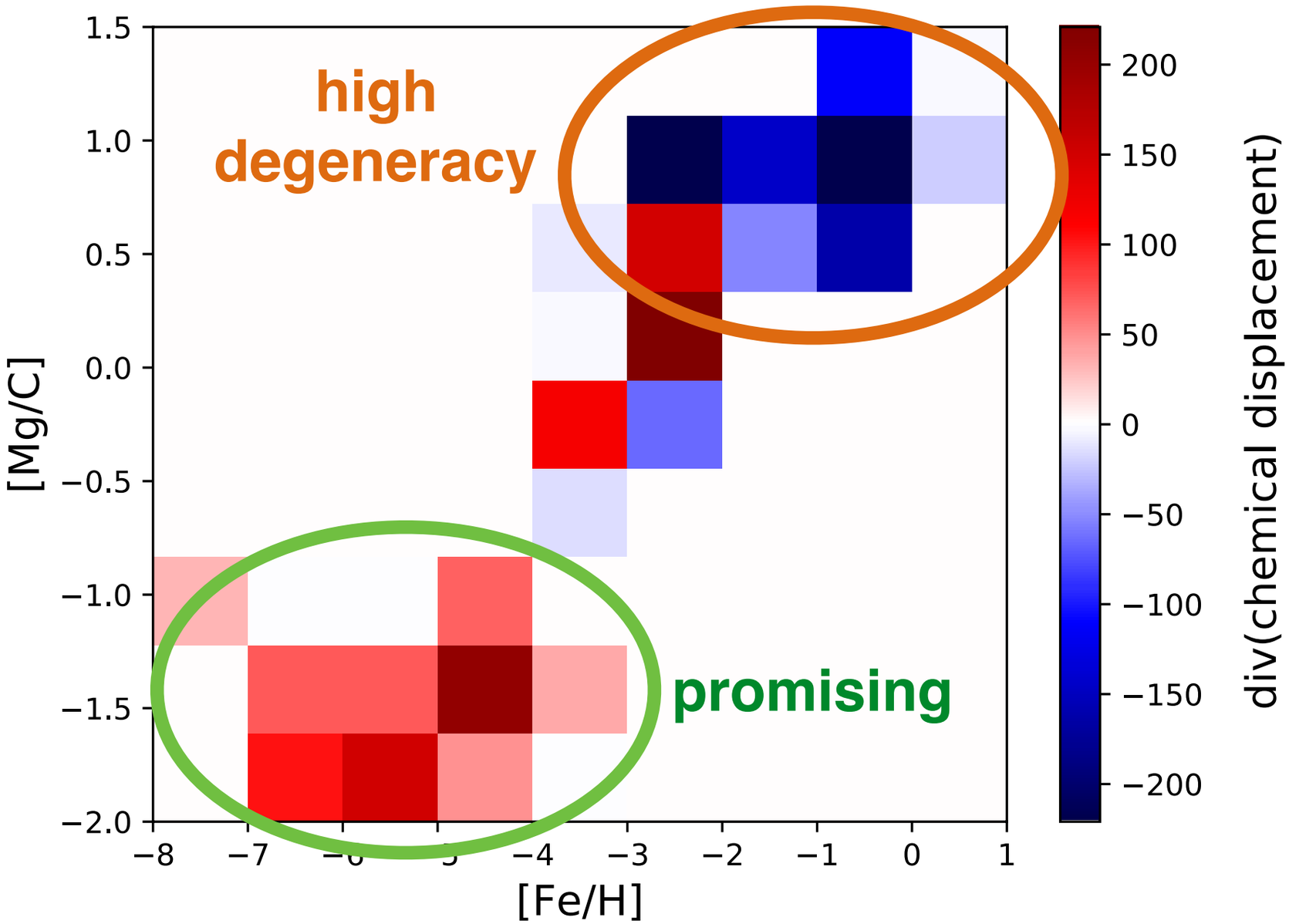
Illustrate PopIII SN yields in chemical plane



Vector field of combining yields from different SNe

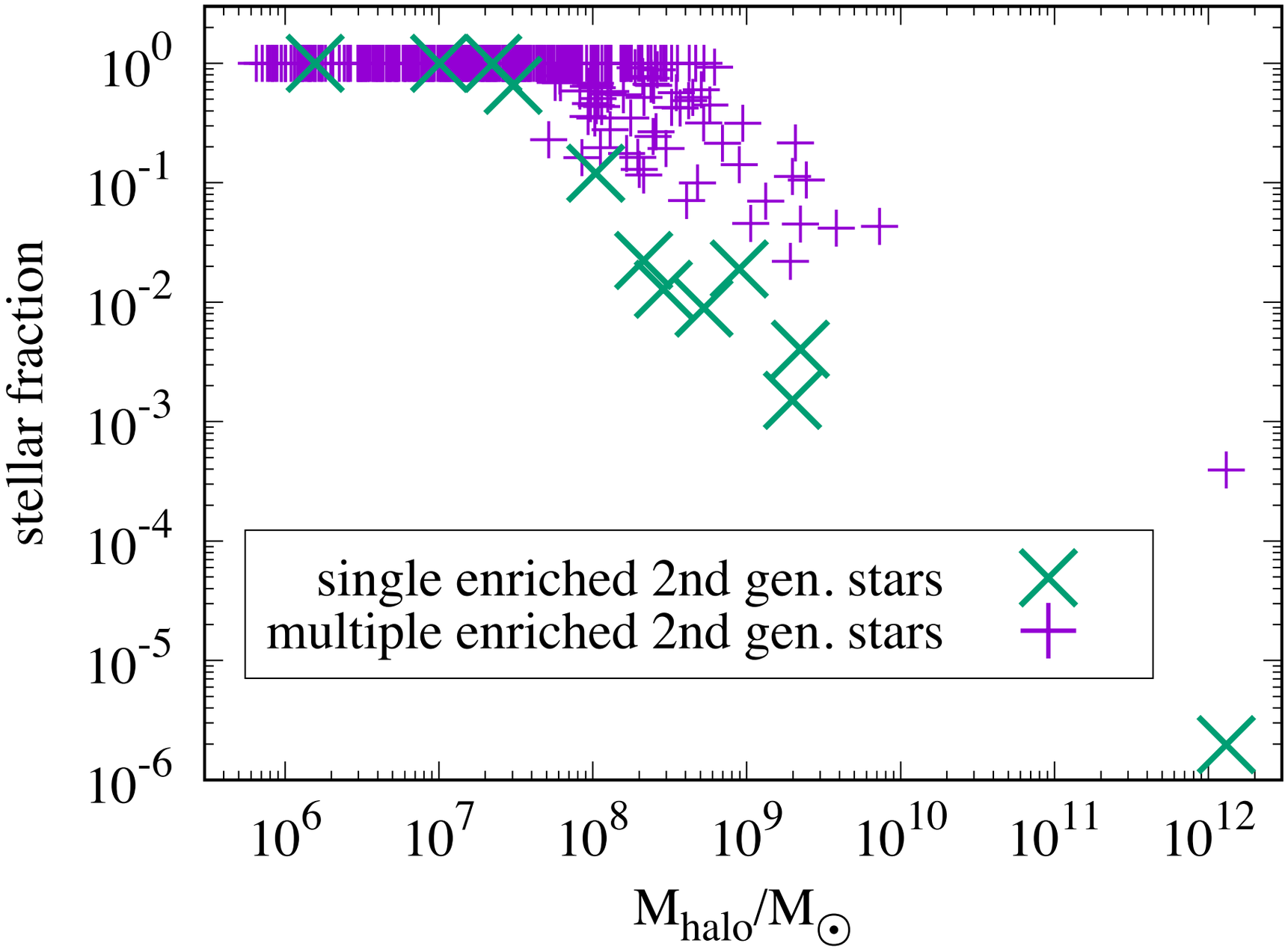


Novel diagnostic to identify single-enriched 2nd generation stars: Divergence of the chemical displacement



- Computationally cheap
- Depends only on SN yields
- Other element ratios provide additional information

Dwarf galaxies are most promising targets to find single-enriched 2nd generation stars



Summary & Conclusion

- Goal: find single-enriched 2_{nd} generation stars to constrain Pop III progenitor mass
- Single supernova occurs only in one out of 100 halos
- *Divergence of the chemical displacement* as diagnostic to identify single-enriched 2_{nd} generation stars
- Dwarf galaxies are most promising targets
- Very rich data available