Comparing the elemental yields from low-mass single and binary star populations

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17/06/2025

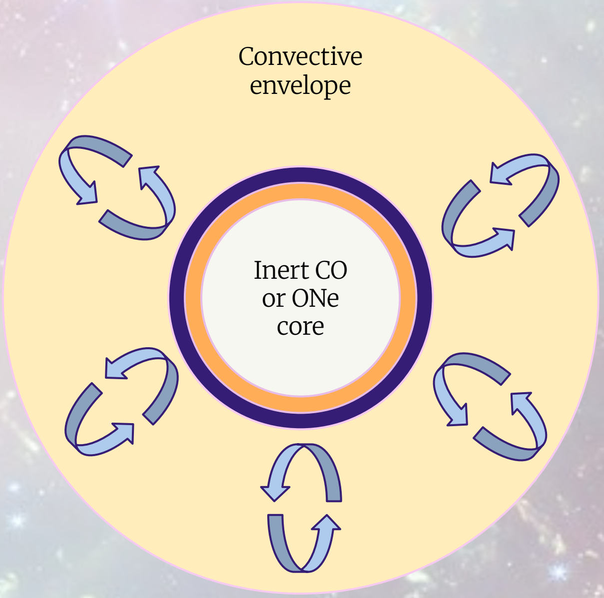
Low-Mass Stars

Born with mass ~1-8$M_{\odot}$, depending on metallicity.

Chemically enrich their environments by ejecting their envelopes through stellar winds.

The ejected amount of a specific element or isotope is known as the **stellar yield**.

Most material is ejected during the **Asymptotic Giant Branch** (AGB).



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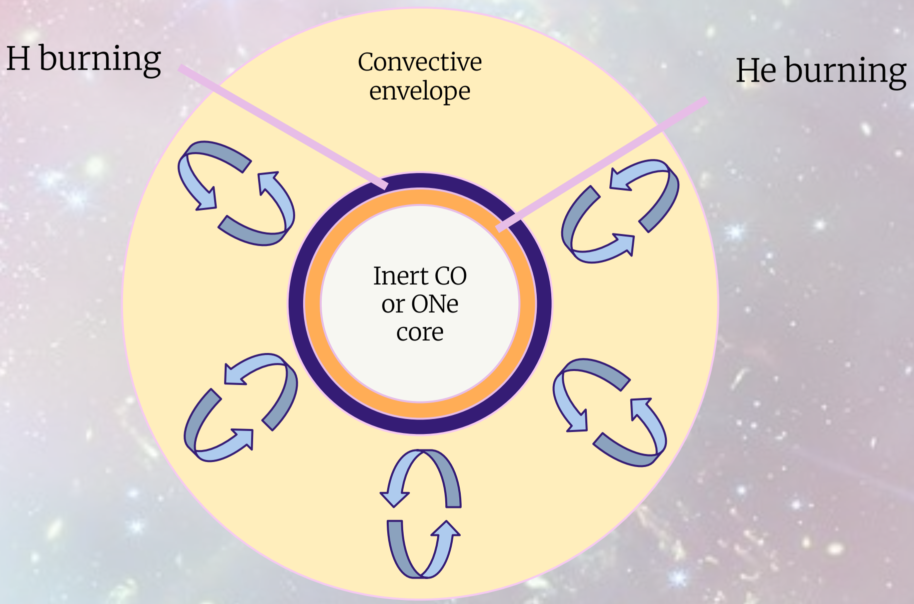

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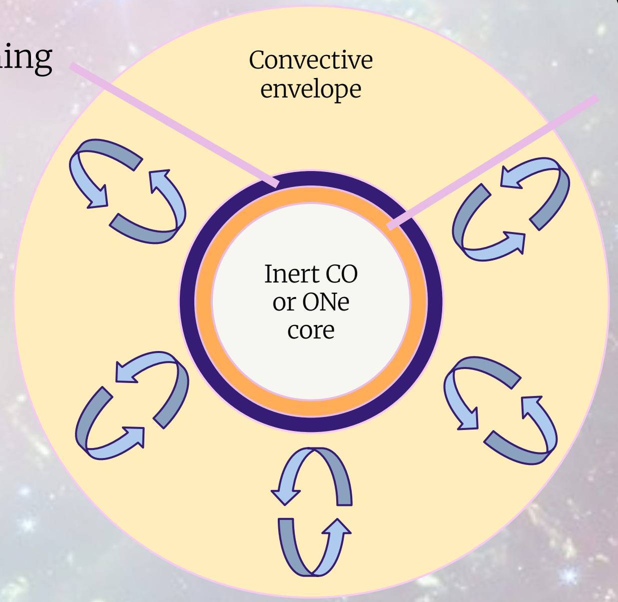

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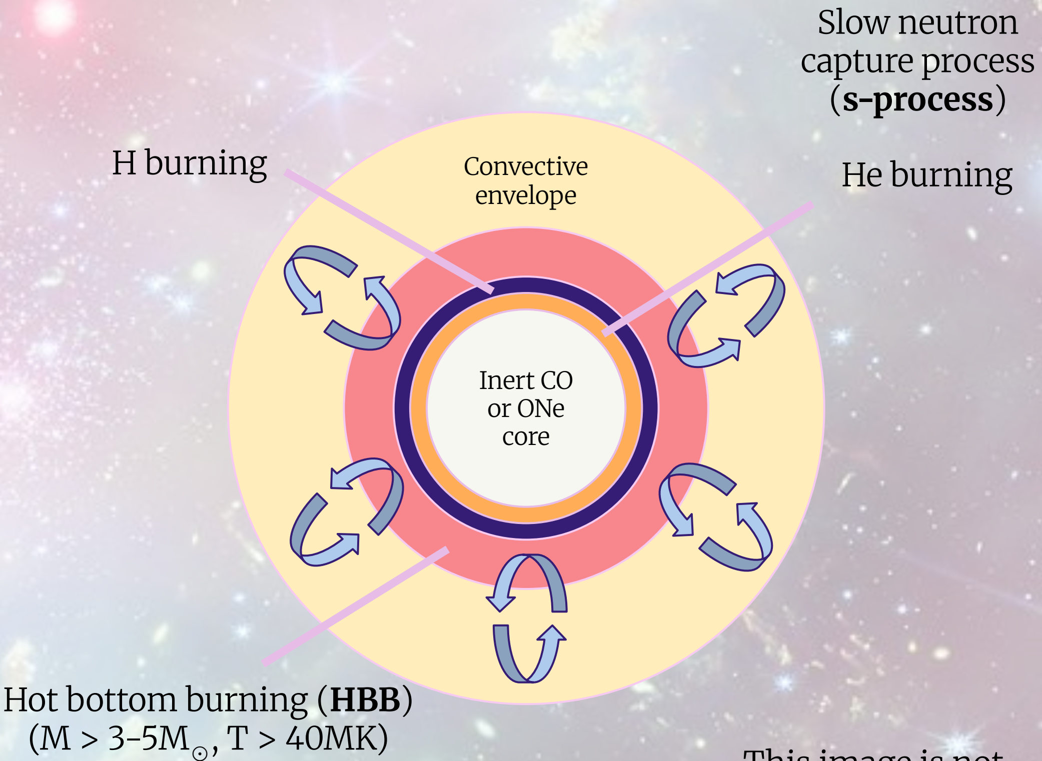

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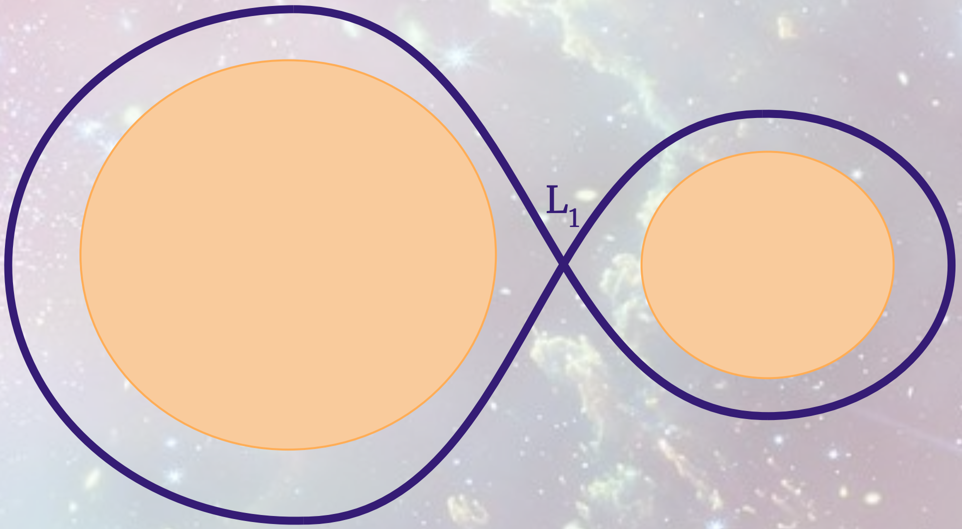
What changes when we have a stellar companion?



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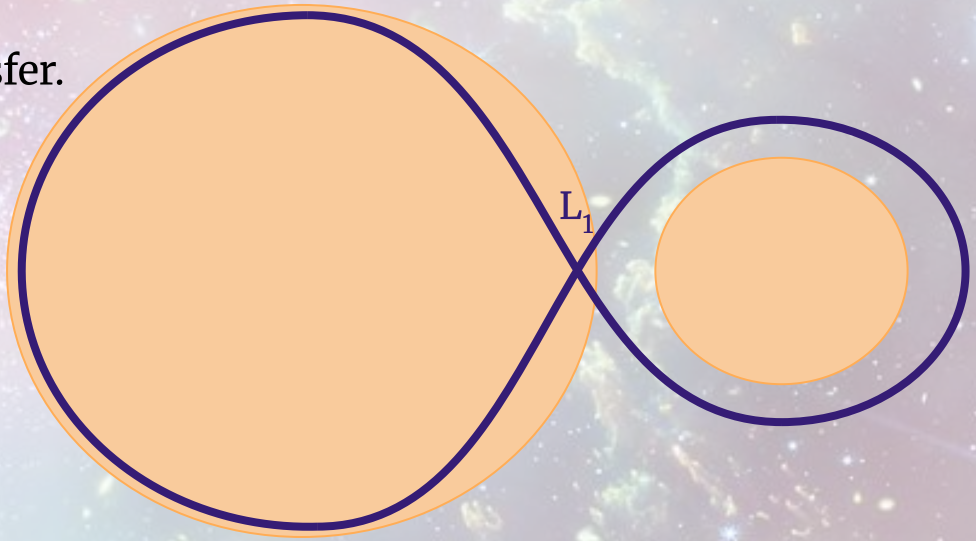
Roche lobe overflow → Mass Transfer.



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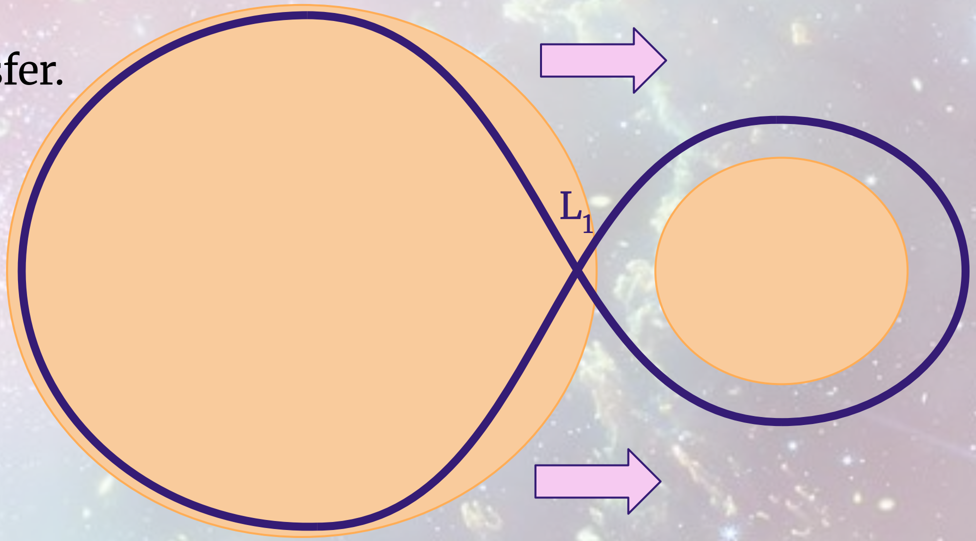

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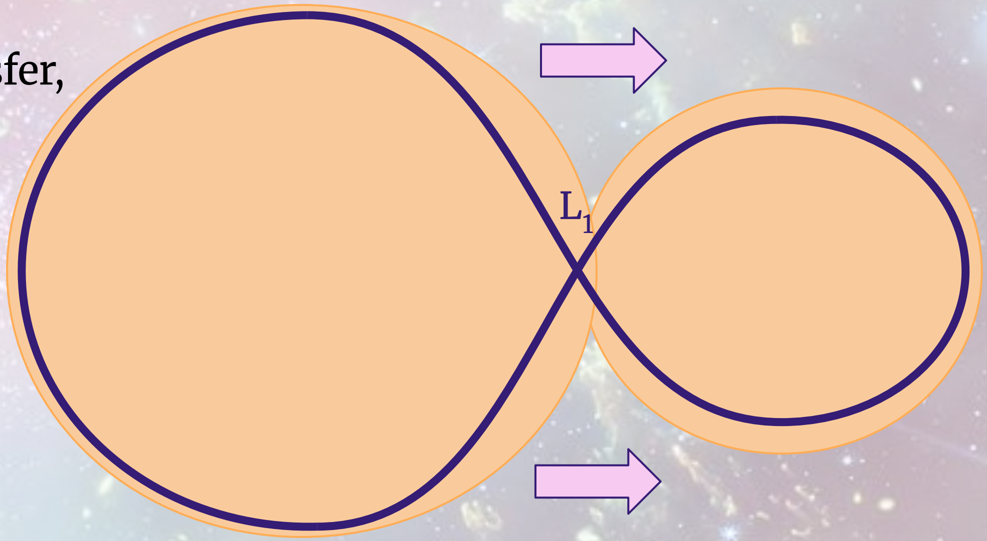
Roche lobe overflow → Mass Transfer,

Common Envelope:
- → Merger,
- → Ejection.



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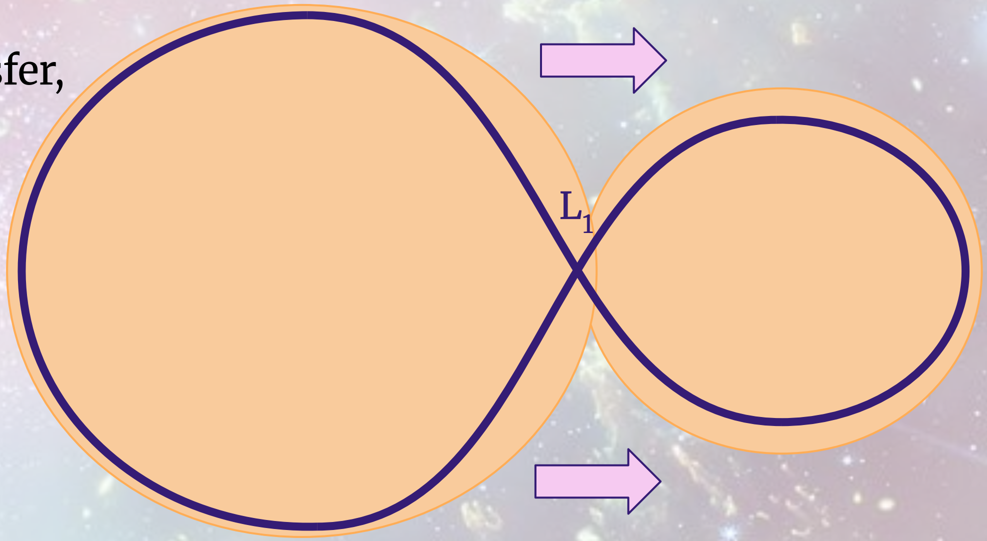
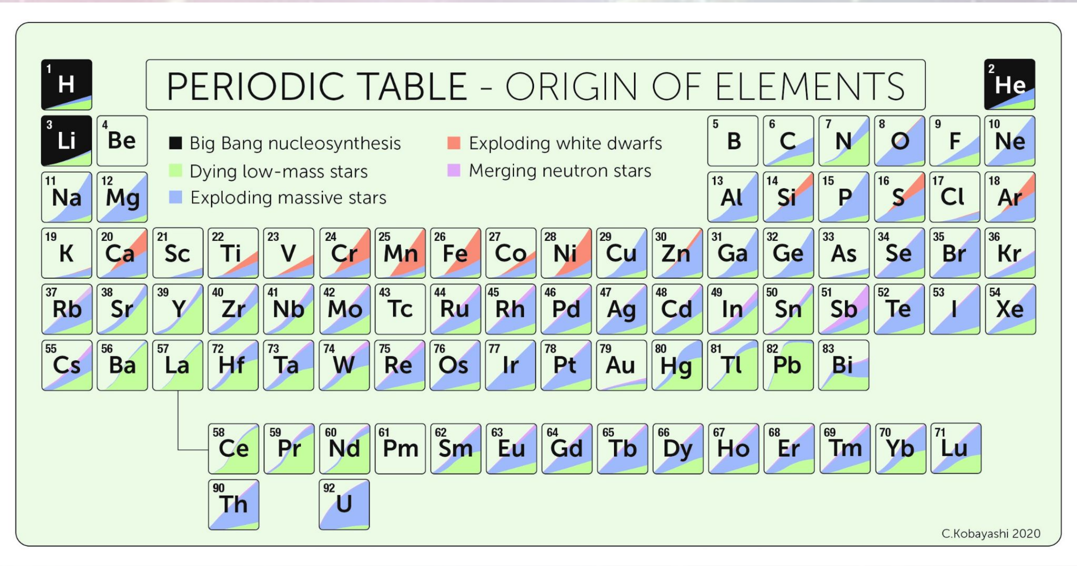
Binary evolution can alter or prevent stars from evolving onto the AGB.



Why do we care about binary evolution?

AGB stars synthesize and eject significant amounts of C, N, F, and about half of the material heavier than iron (Kobayashi et al. 2020).

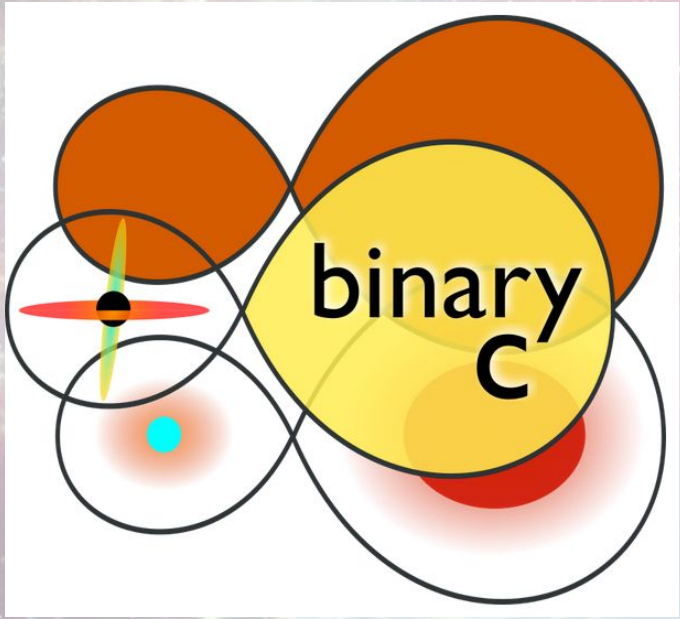
At least 40% of low-mass stars are observed with a companion.



Research Question:

How does binary evolution alter the stellar yields from low-mass stellar populations?

Binary Population Synthesis



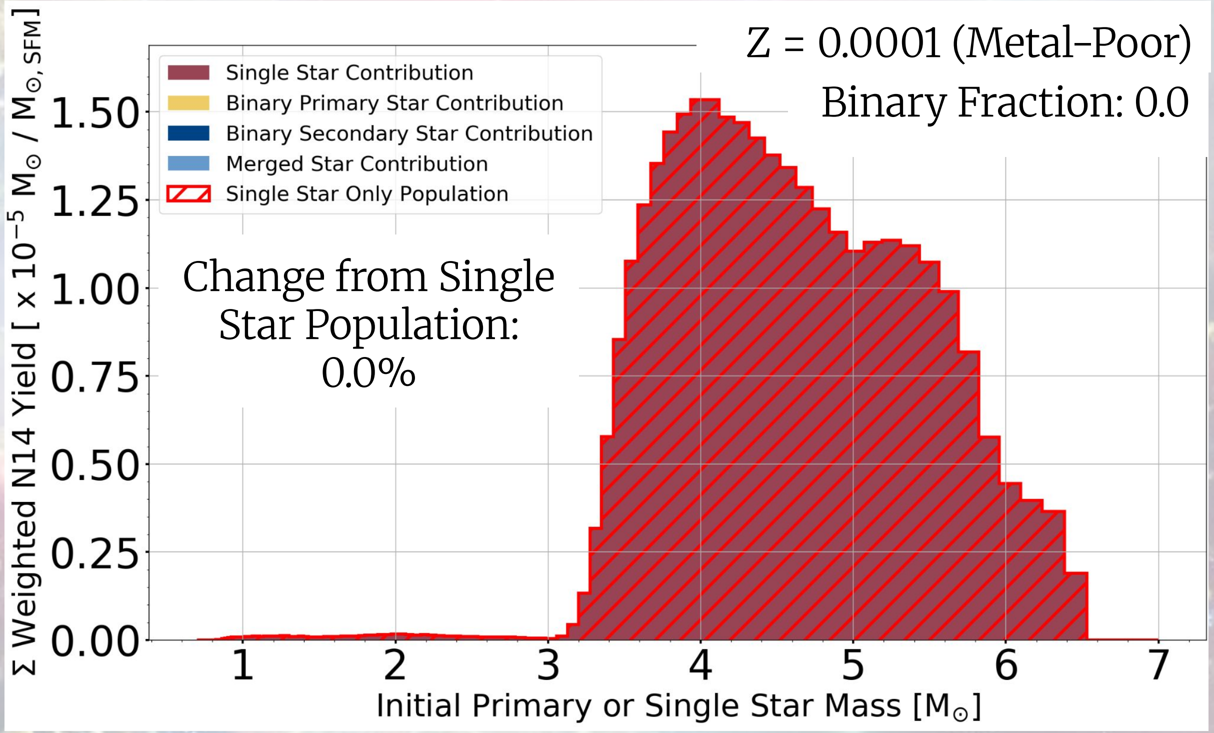
Binary population synthesis allows us to build stellar populations by modelling thousands of stars with a wide variety of initial conditions.

We use the binary population synthesis code, binary_c (Izzard et al. 2006),

- Computes AGB stellar nucleosynthesis,
- Evolved populations at Z = Solar, SMC and Metal Poor populations.

Elemental Yield Example: Nitrogen

*Preliminary Results



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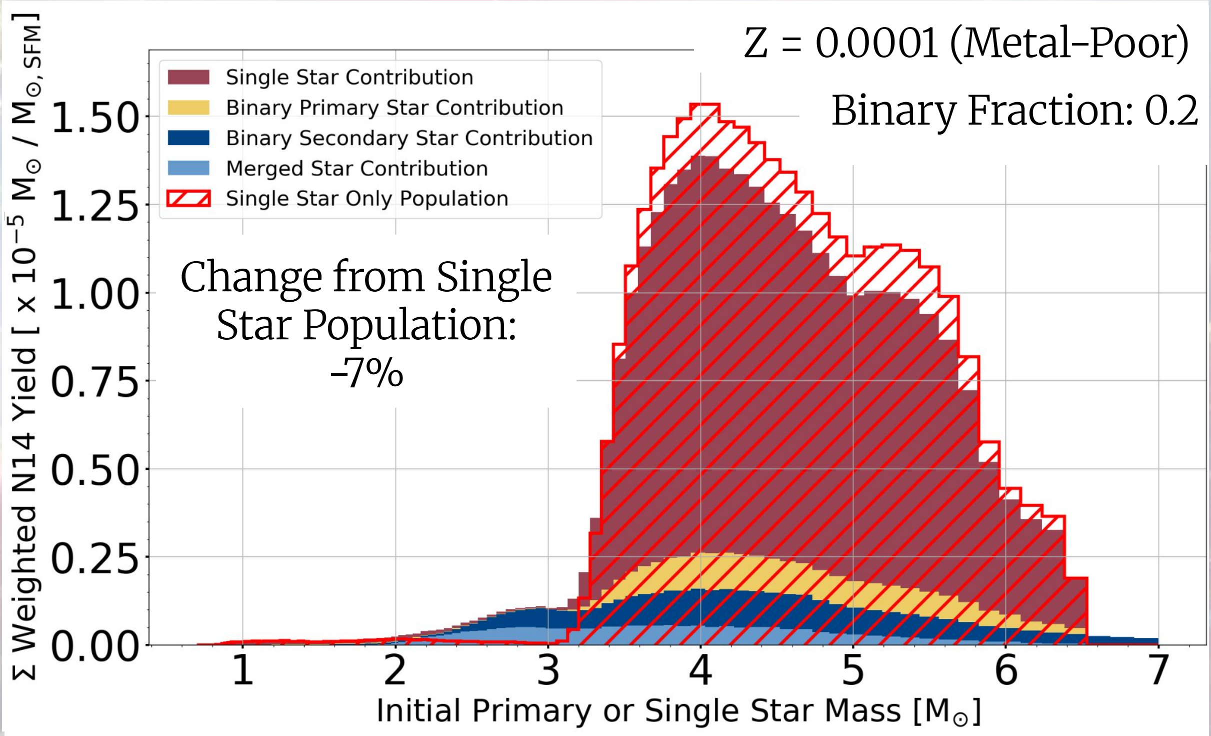

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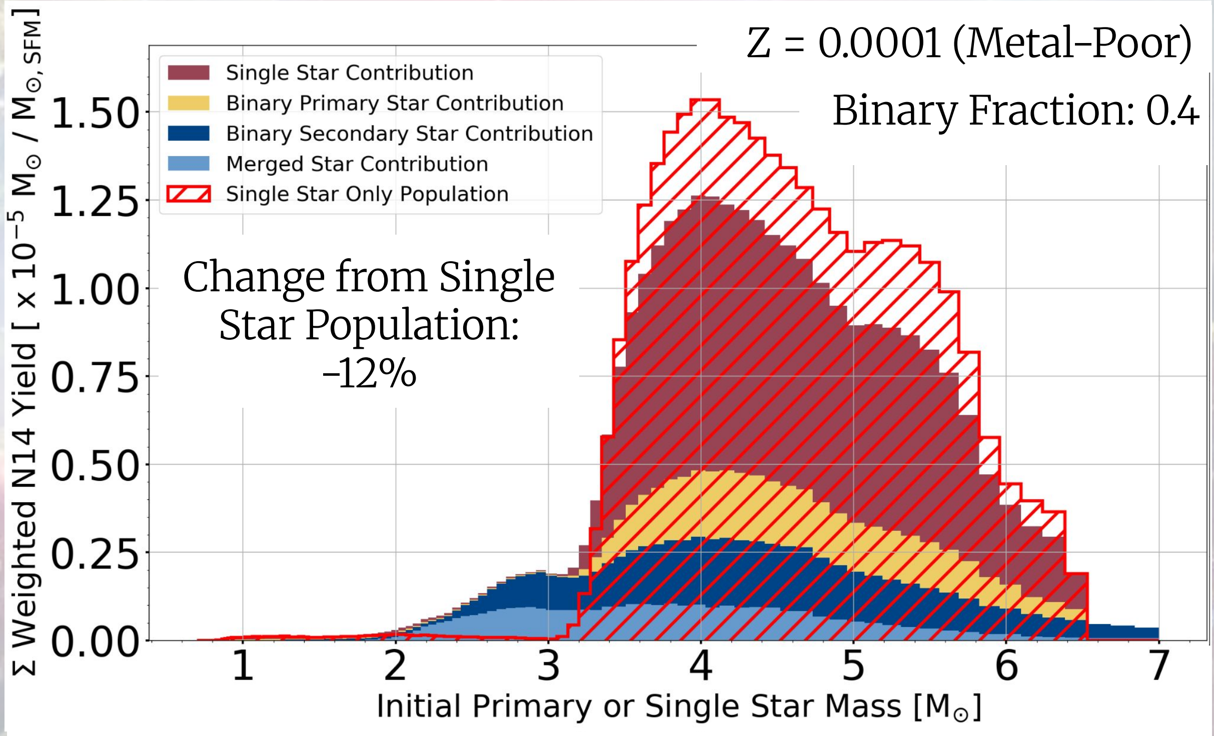

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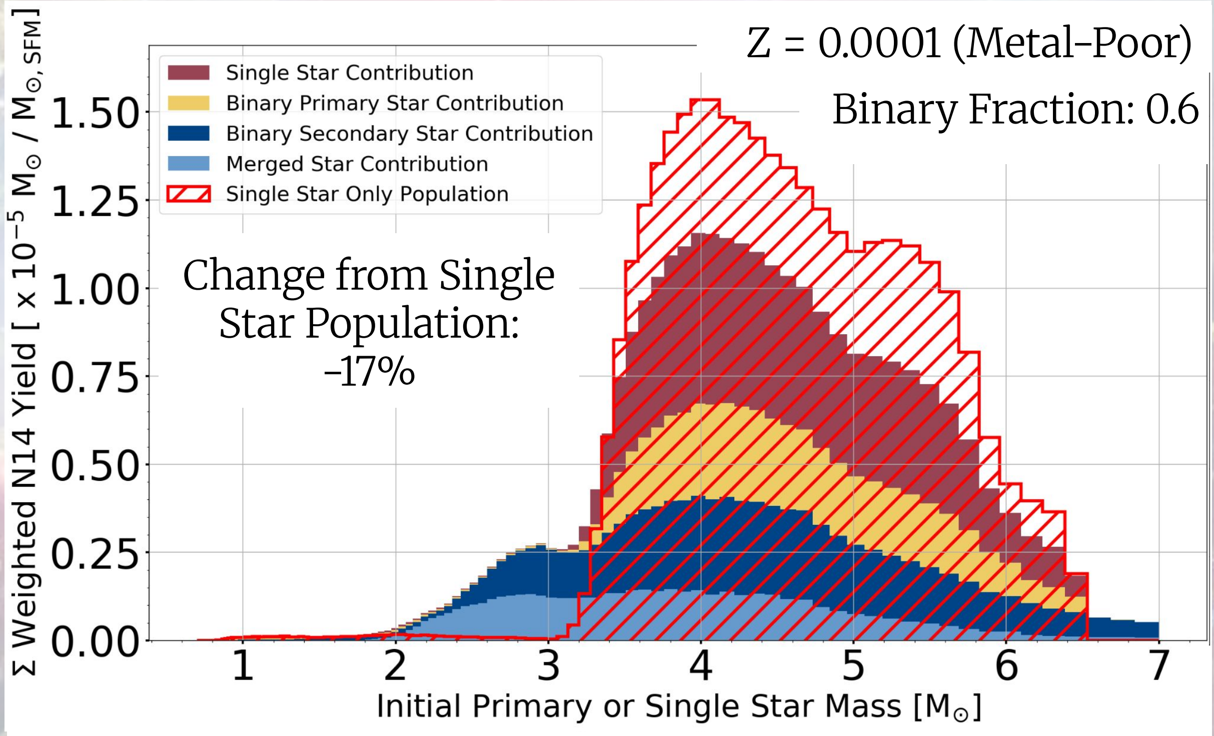

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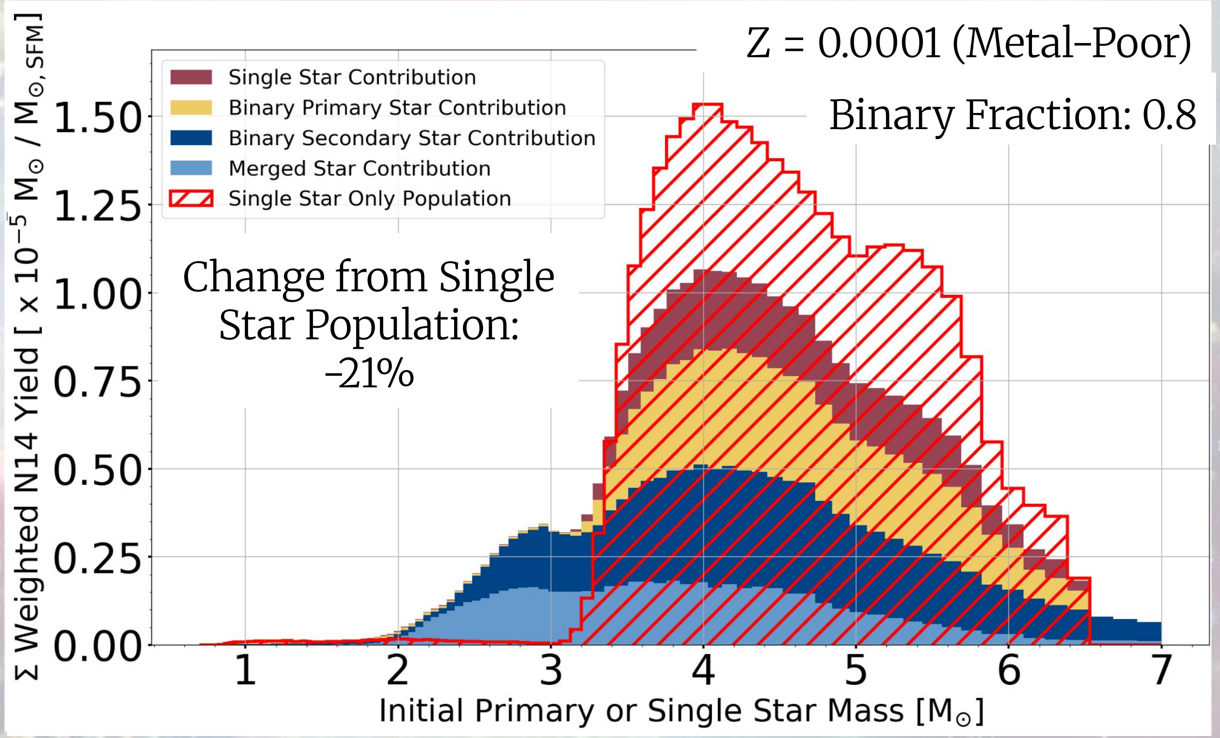

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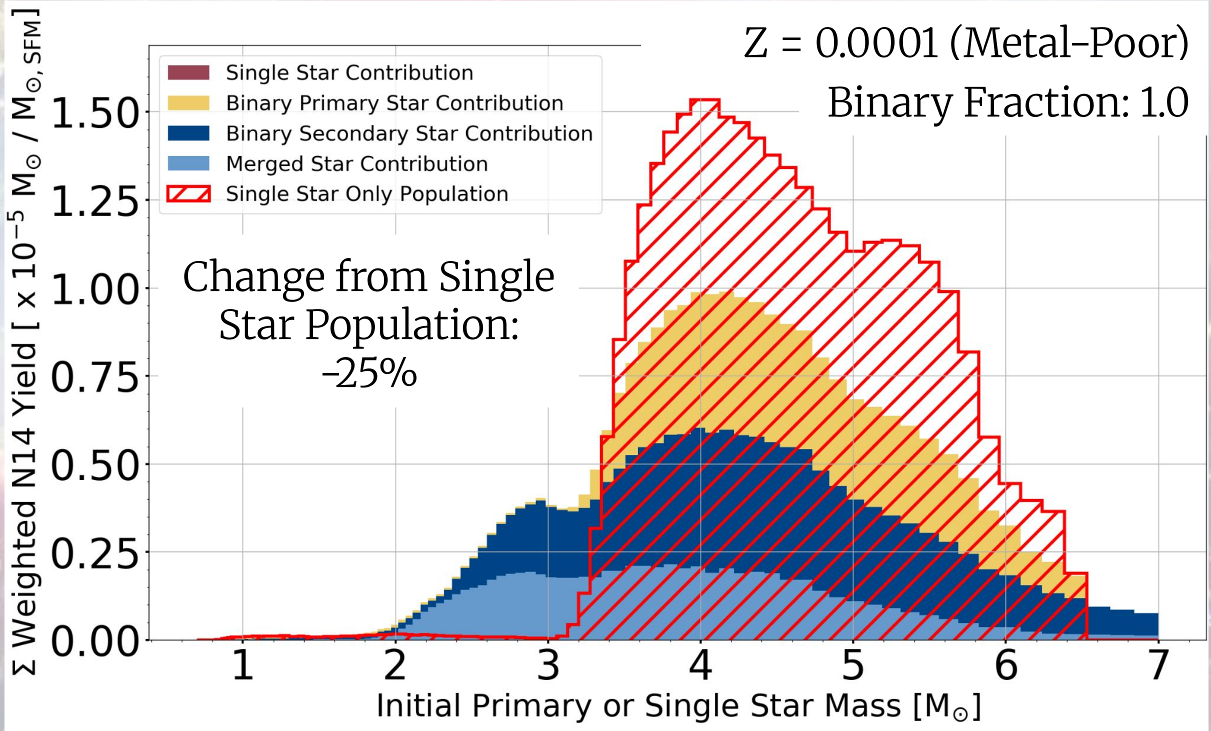

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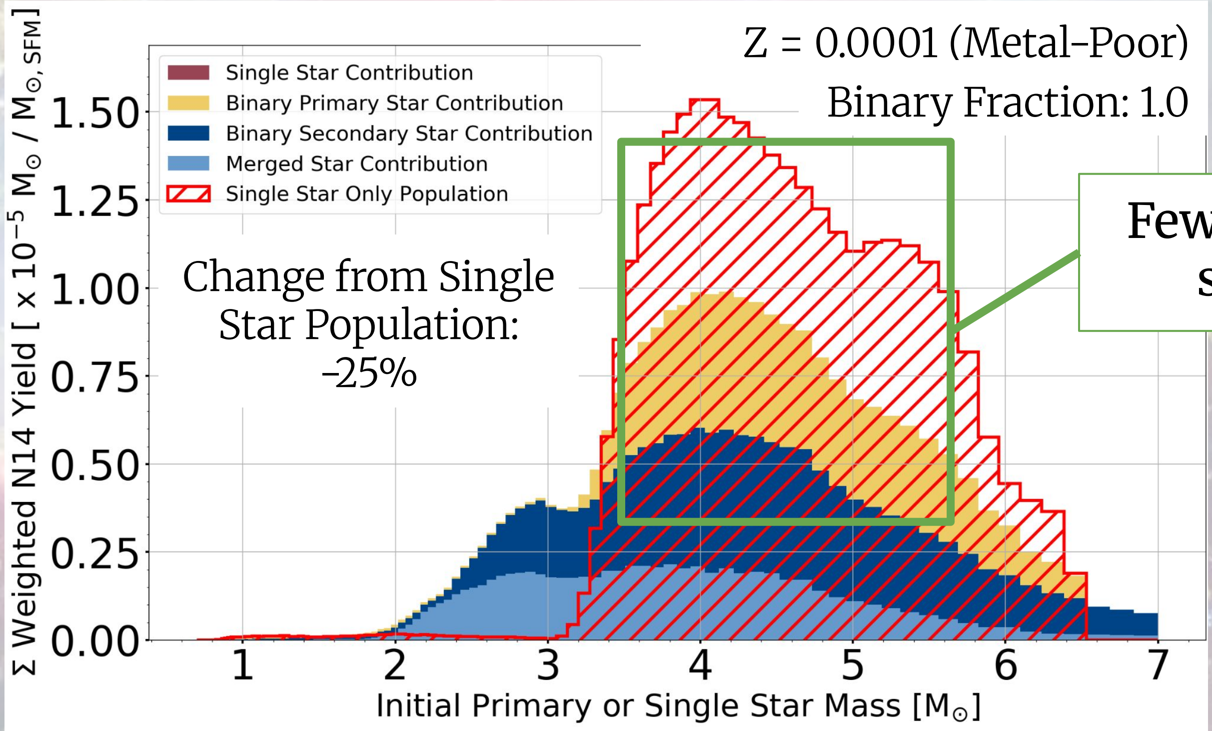

Fewer HBB stars

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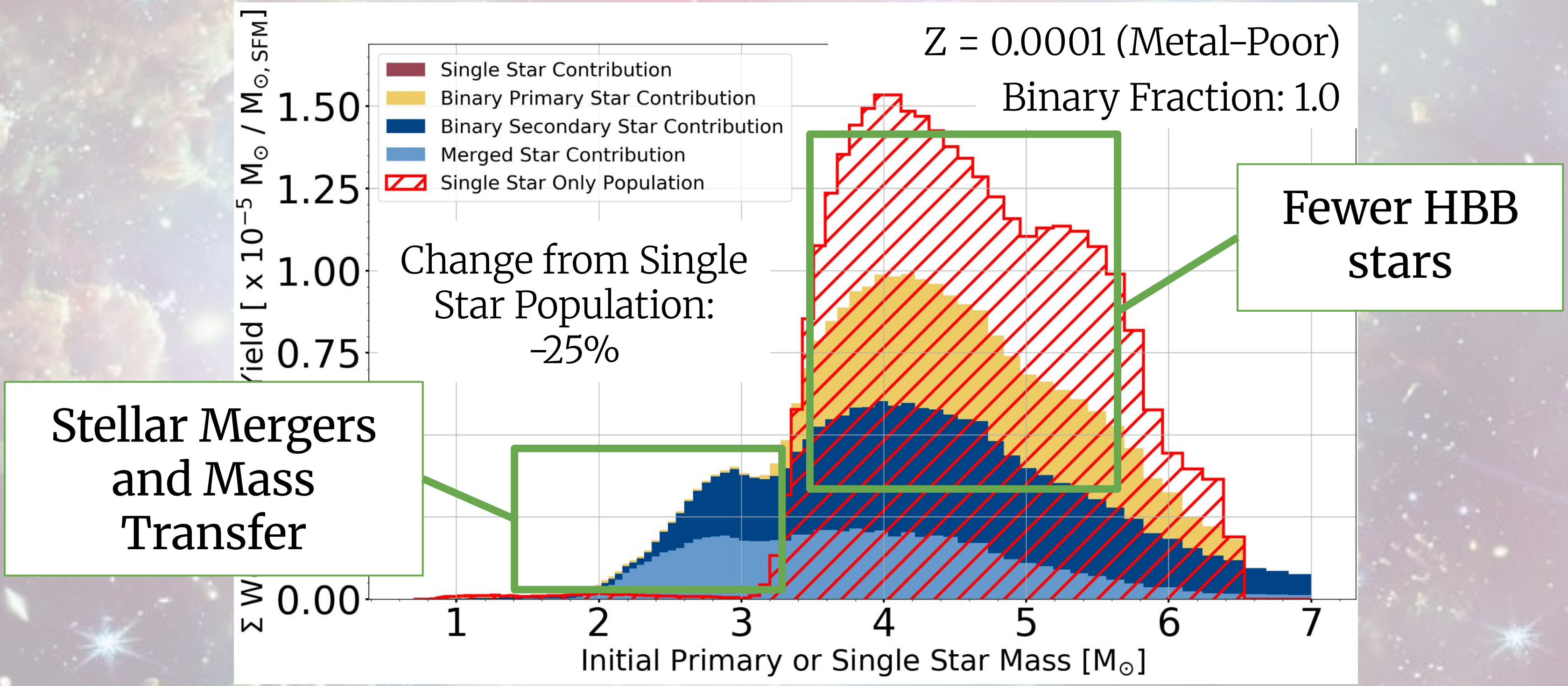

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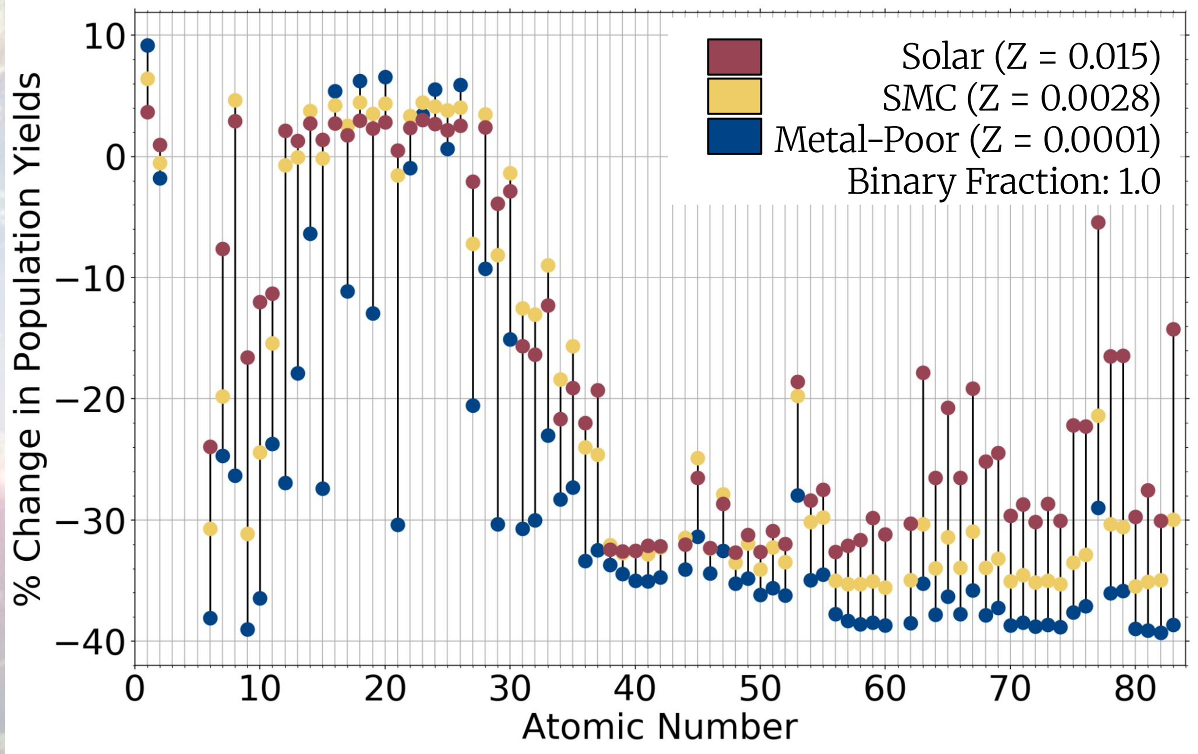
All the elements and metallicities



Note we exclude Li, B, Be, Tc, and Pm

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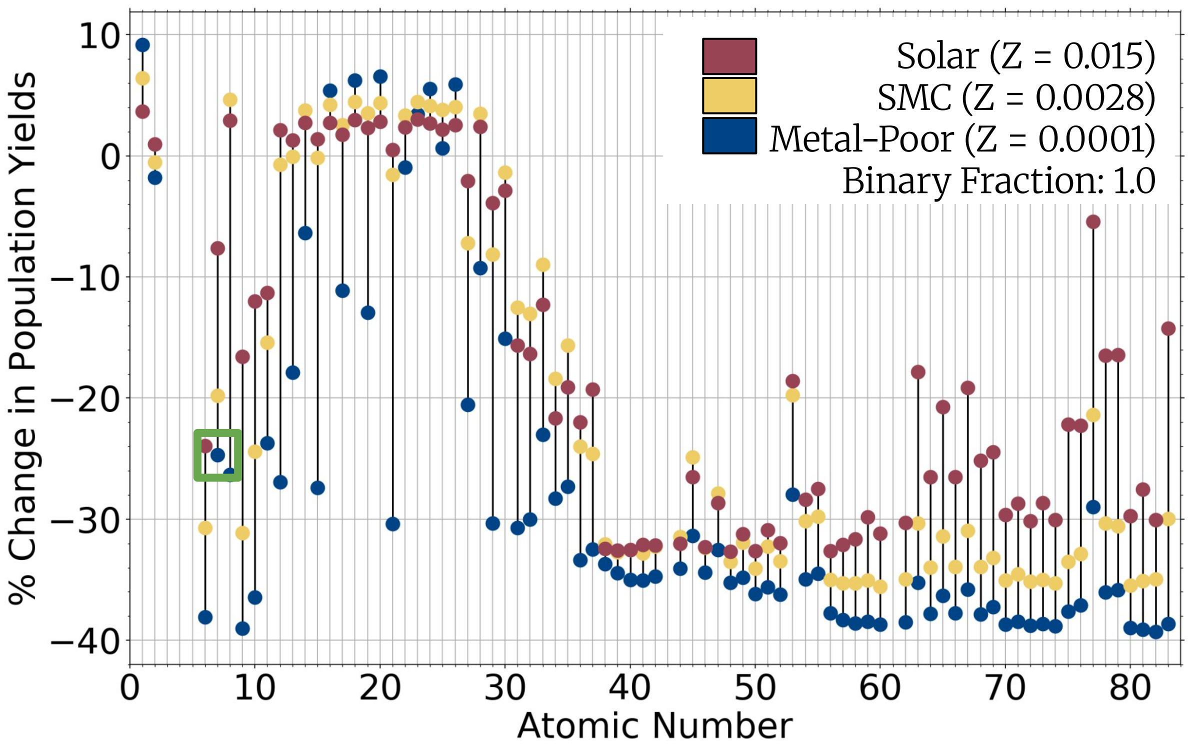

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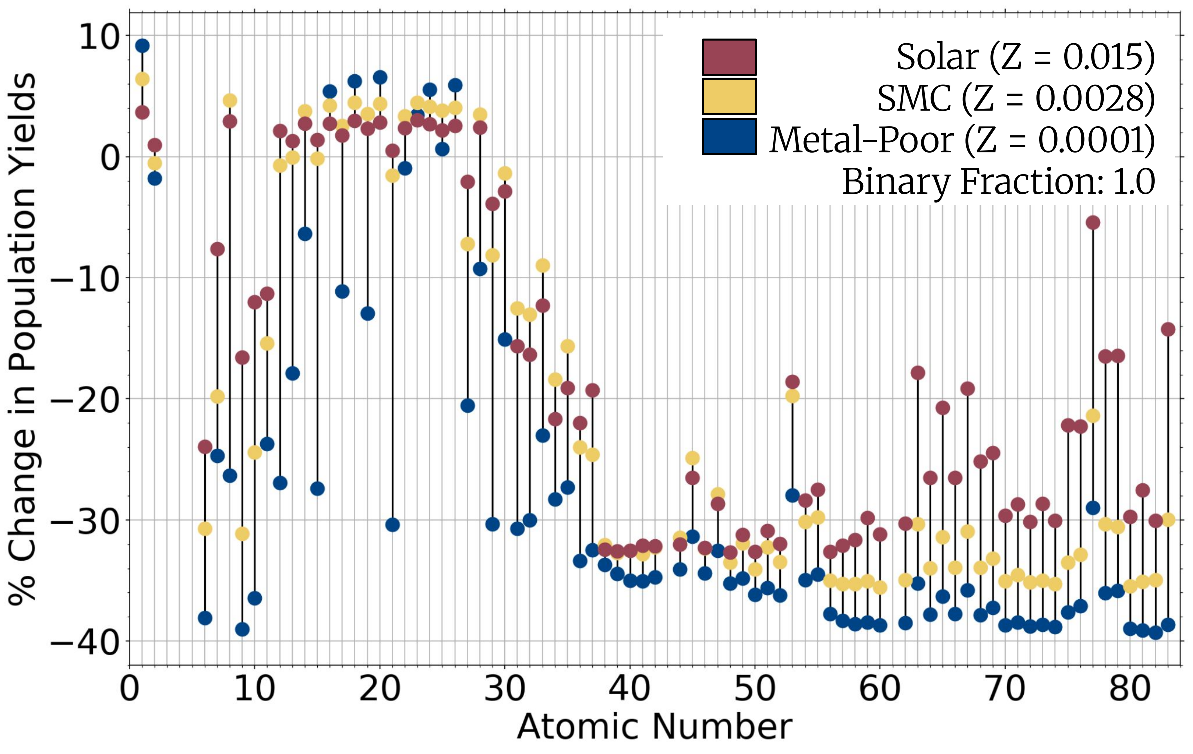

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Iron-Peak Elements

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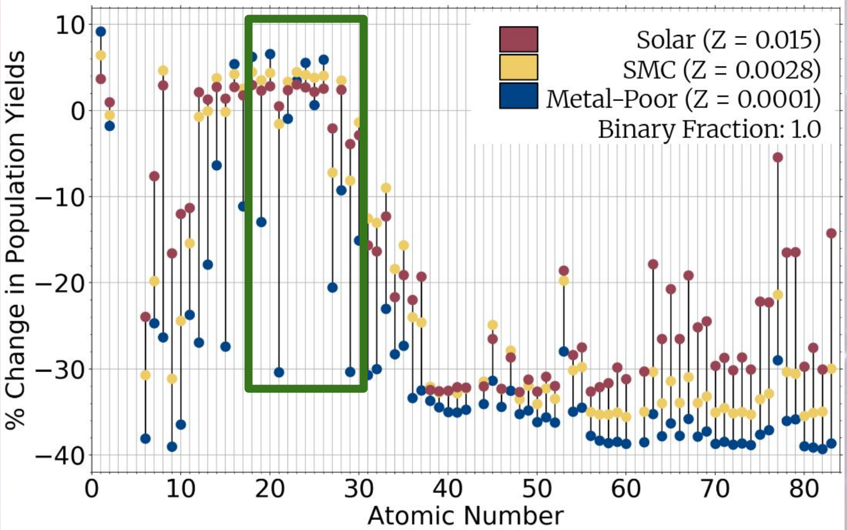
~ 5% increase from the single-star population.



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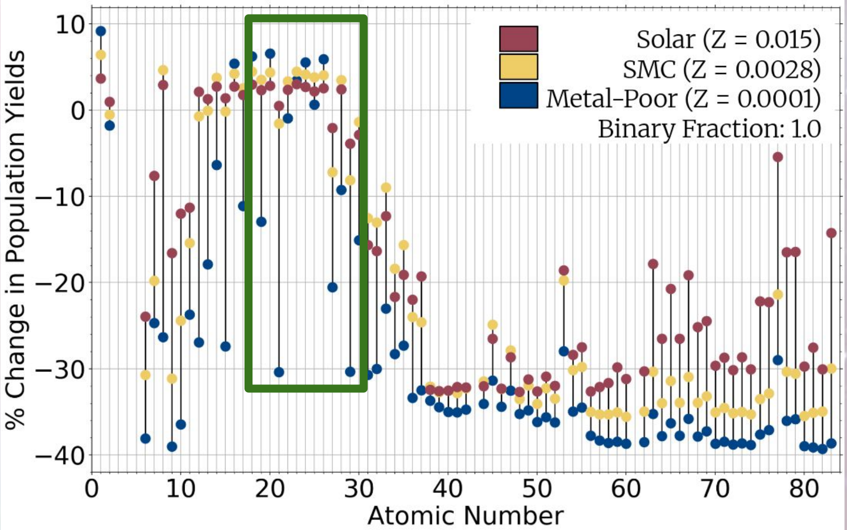

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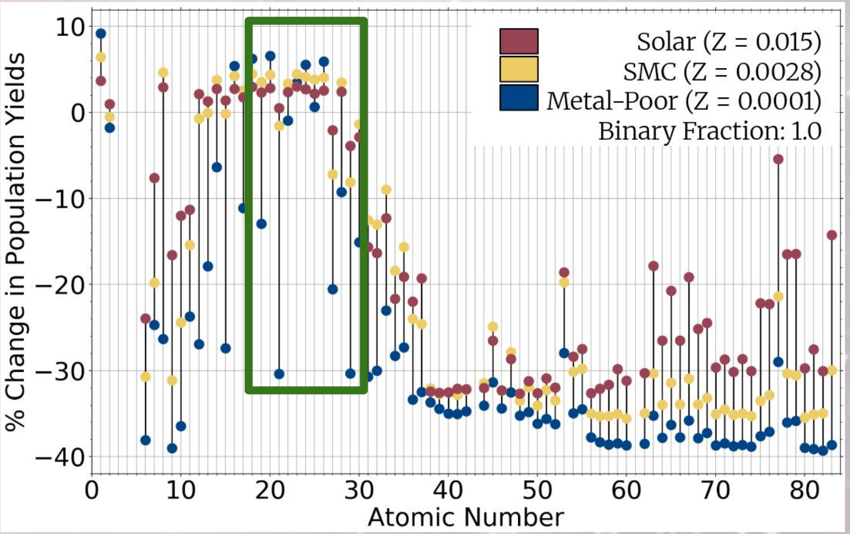

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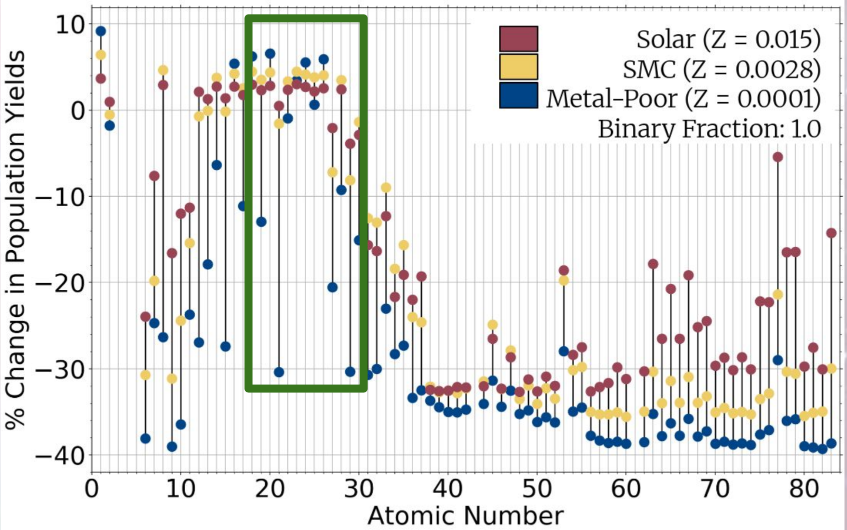
- There is no net production.
- Bin. Pop ejects ~5% more material than our single star population.



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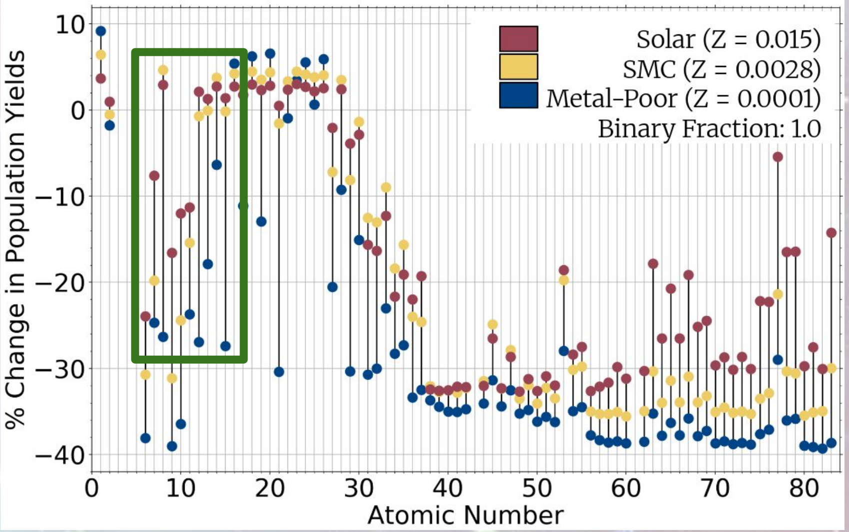
Hot-bottom burning elements: N, Na, etc.

~30% fewer HBB stars in our binary population.



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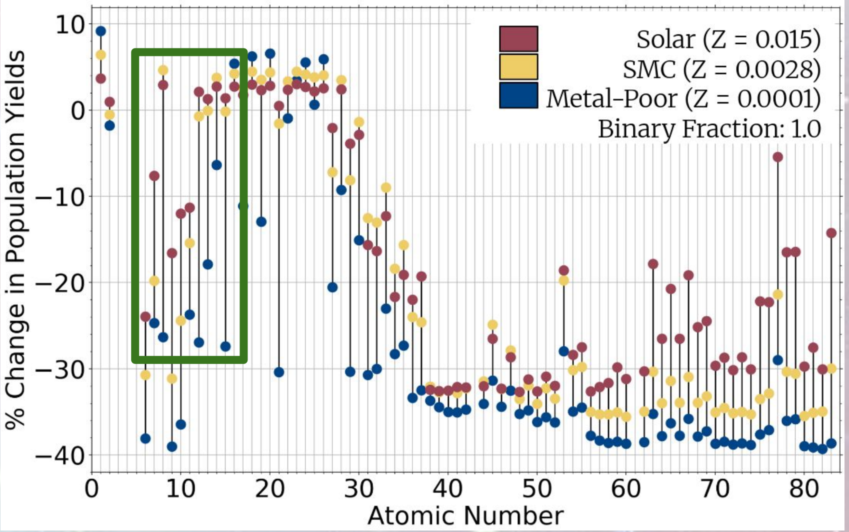

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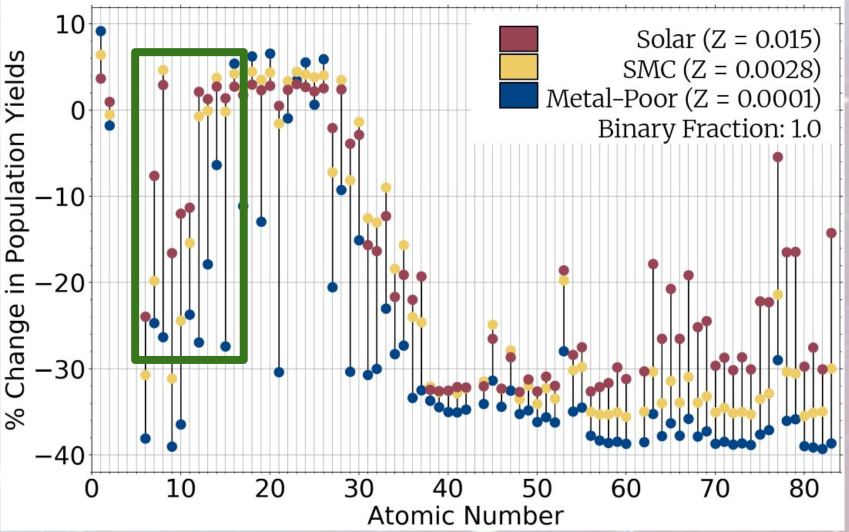
Fewer stars at high metallicity are capable of HBB.



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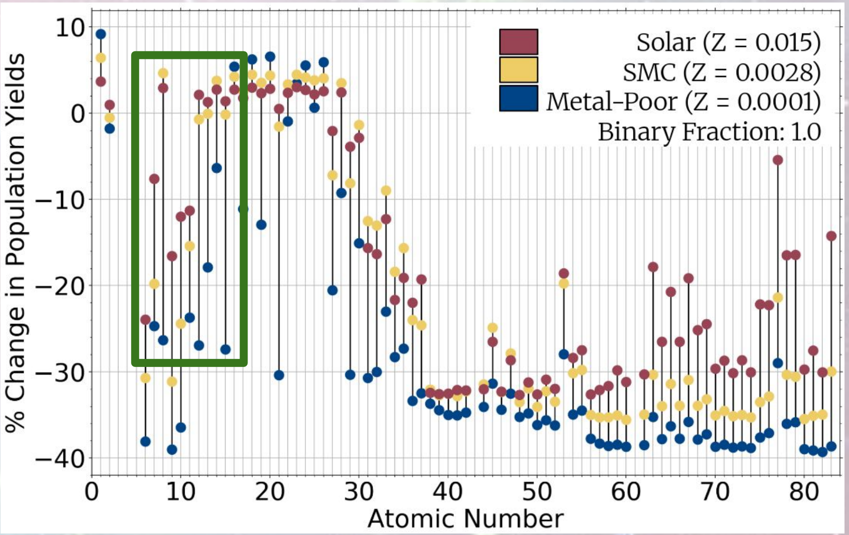
Highly sensitive to our treatment of mass-loss on the AGB.



C, F, and S-Process Elements

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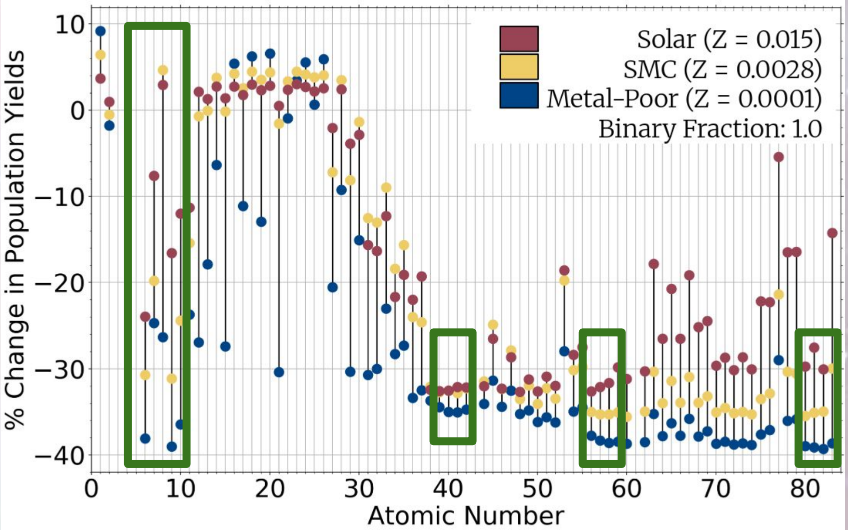
There are ~30% fewer stars evolving to the end of the AGB in our binary population.



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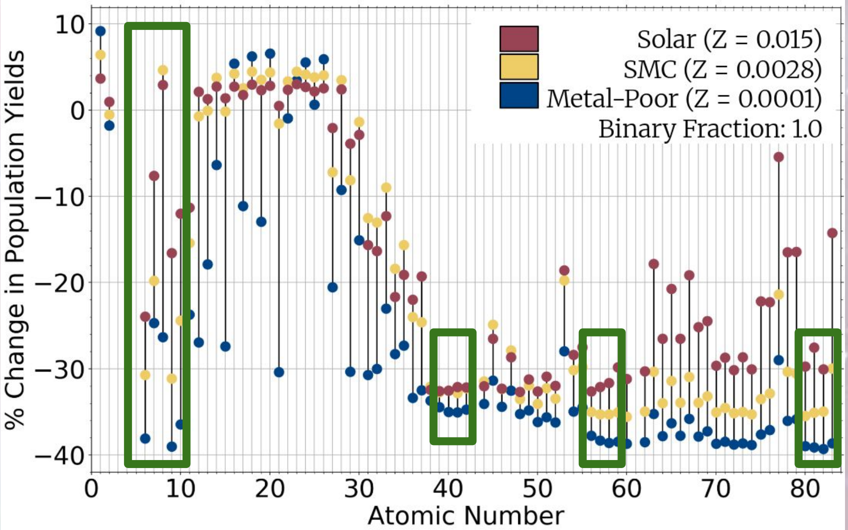

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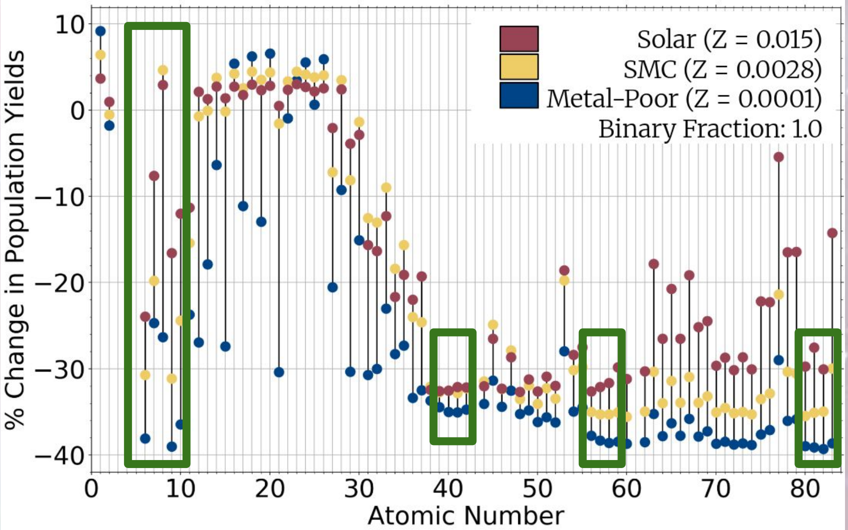
HBB can limit both C production and s-process,

- More HBB stars with decreasing metallicity.



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Summary

We simulate stellar populations of low-mass single and binary stars up to $8M_{\odot}$.

We find 30% fewer AGB stars form in our binary population,

- 25-40% decrease in C production,
- 30-40% decrease in s-process elements,
- Mergers and mass transfer events enhance hot-bottom burning.

Future work will focus on better quantifying uncertainty introduced by binary evolution.

Thank you!

My Website

Published Feb, 2025

Using binary population synthesis to examine the impact of binary evolution on the C, N, O, and *S*-process yields of solar-metallicity low- and intermediate-mass stars

Zara Osborn[1,2], Amanda Karakas[1,2], Alex Kemp[3], Robert Izzard[4], Devika Kamath[2,5], and Maria Lugaro[1,6,7,8]

To be submitted soon

Using Binary Population Synthesis to Calculate Stellar Yields of Low- and Intermediate-Mass Binary Populations at Low Metallicity

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