

Simulating Populations of CEMPs

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Onno Pols

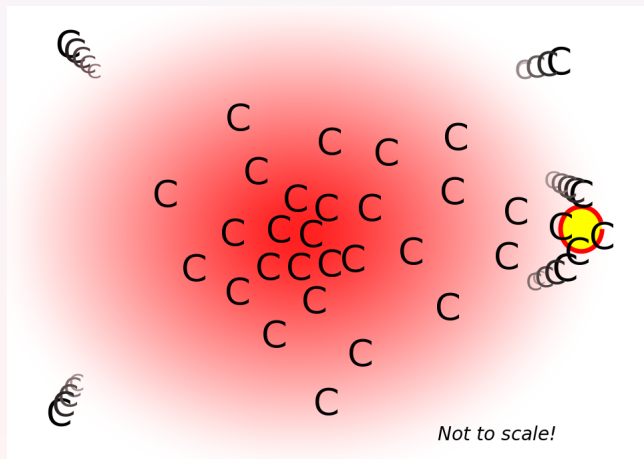
University of Utrecht

Richard Stancliffe

Monash University

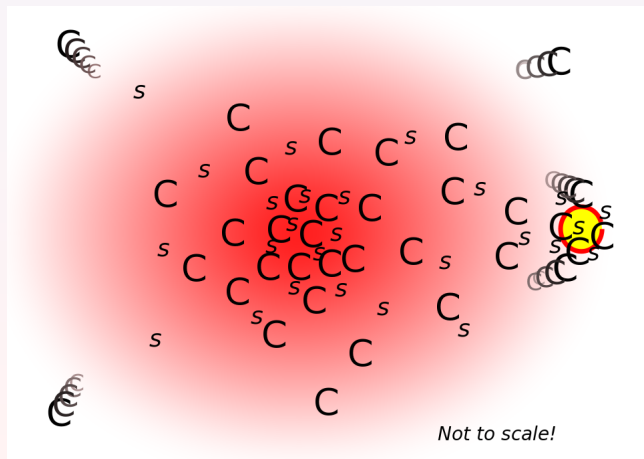
What are CEMP stars?

| | |
|-----------------|----------------------|
| Carbon-Enhanced | $[C/Fe] > 1$ |
| Metal-Poor | $[Fe/H] \lesssim -2$ |
| Mostly giants | $\log g \lesssim 4$ |

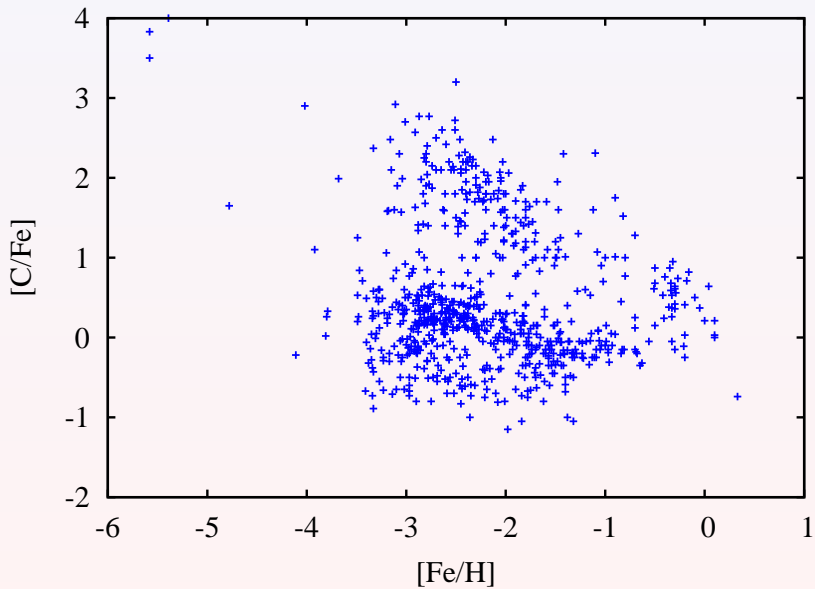


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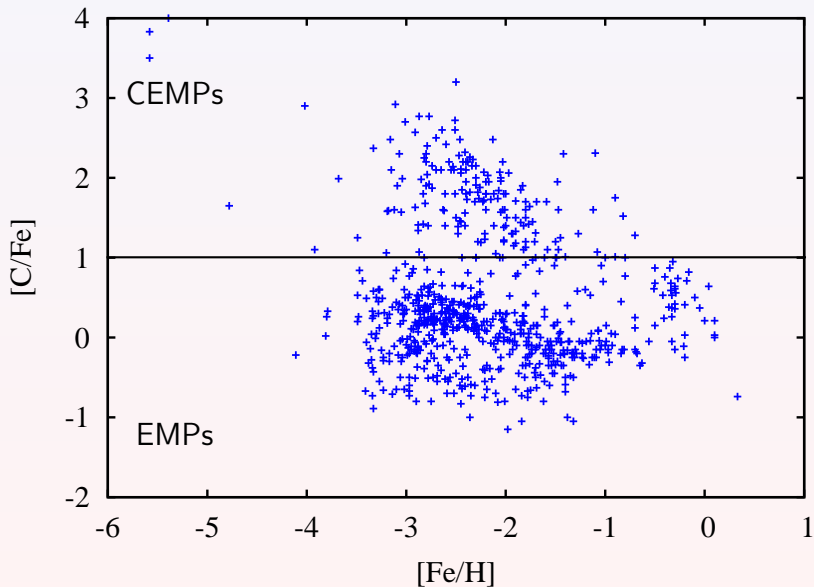
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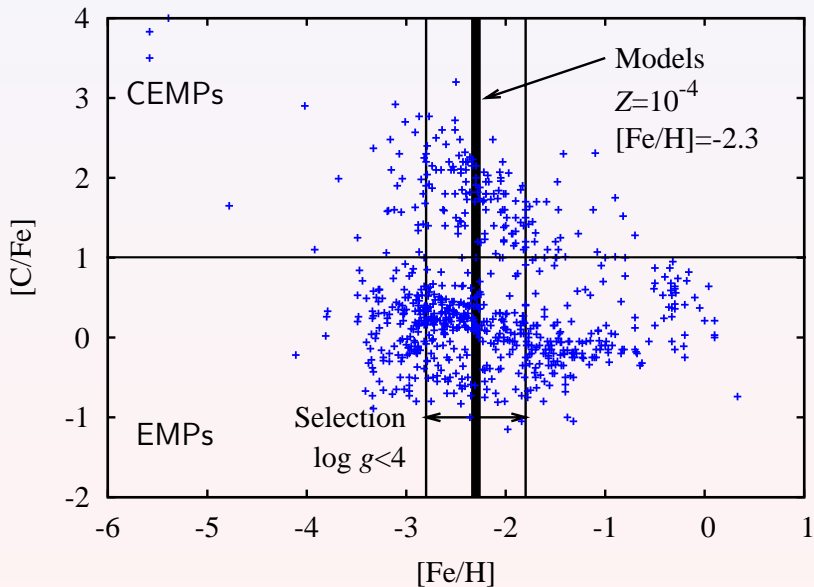
[C/Fe] vs [Fe/H] (SAGA)



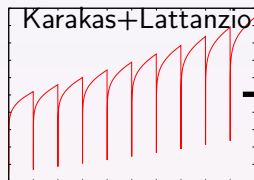
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[C/Fe] vs [Fe/H] (SAGA)



Model 1: Single Stars



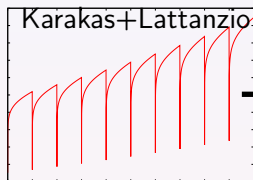
$$L = L(M_c, M_{\text{env}})$$

$$\log R \propto \log L$$

$$\lambda = \lambda(M, Z)$$

etc.

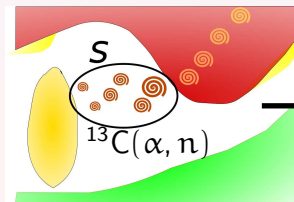
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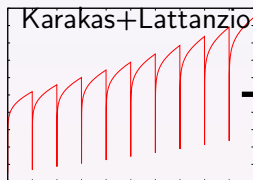
etc.

+



$$s(M_c, N_{\text{TP}})$$
$$Z, {}^{13}\text{C}$$

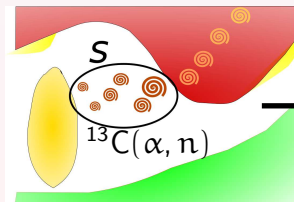
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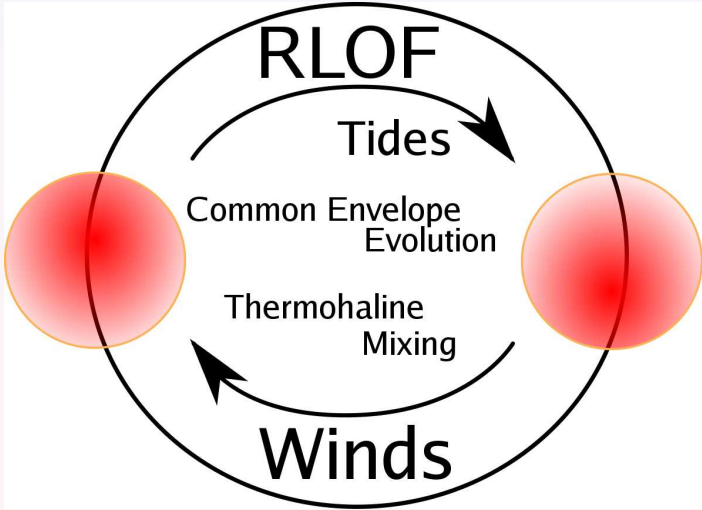
+



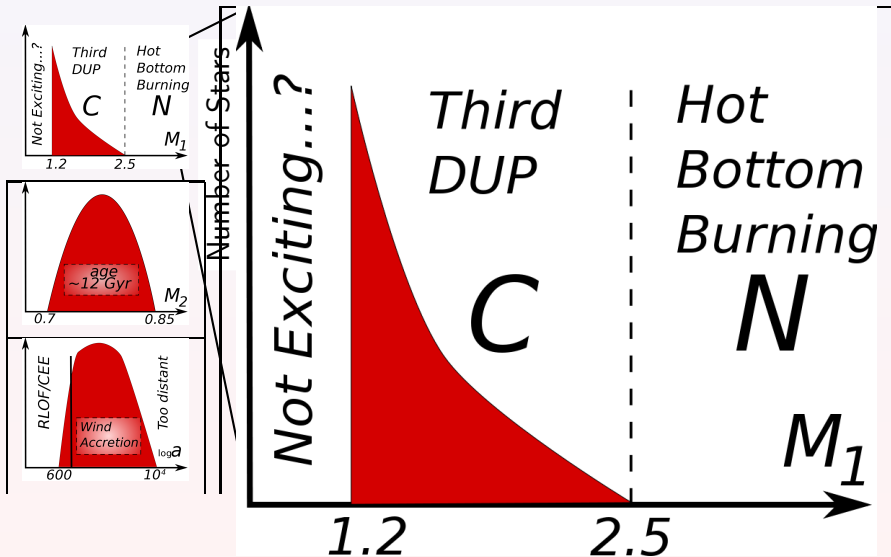
$$s(M_c, N_{\text{TP}})$$
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$$\frac{1}{1,000,000}$$

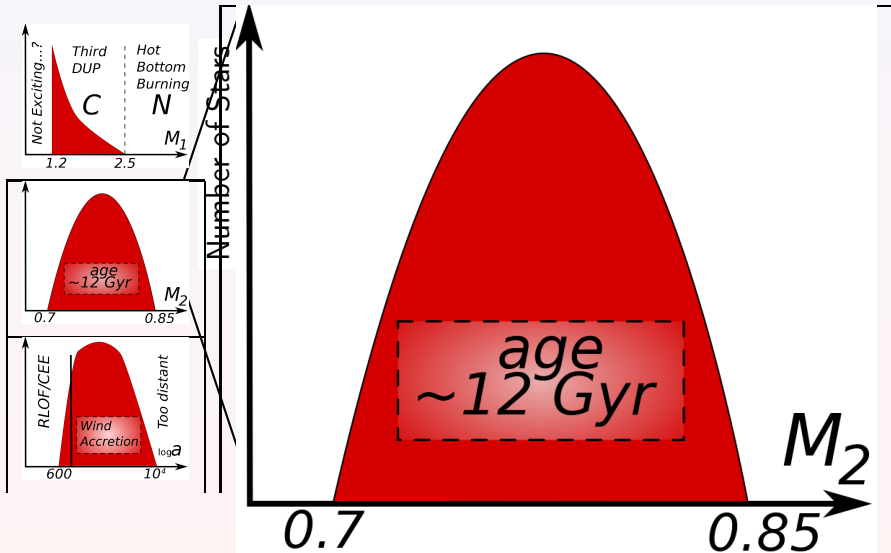
Binary Star Model



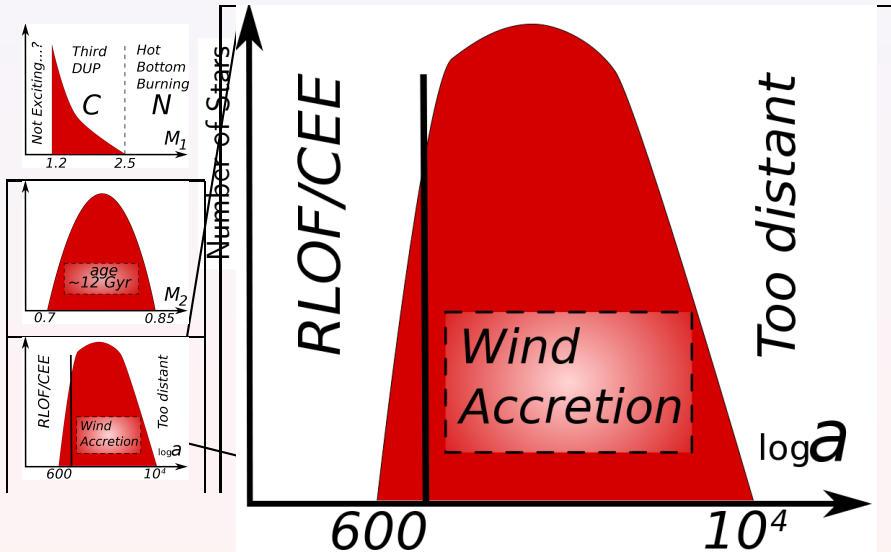
Results



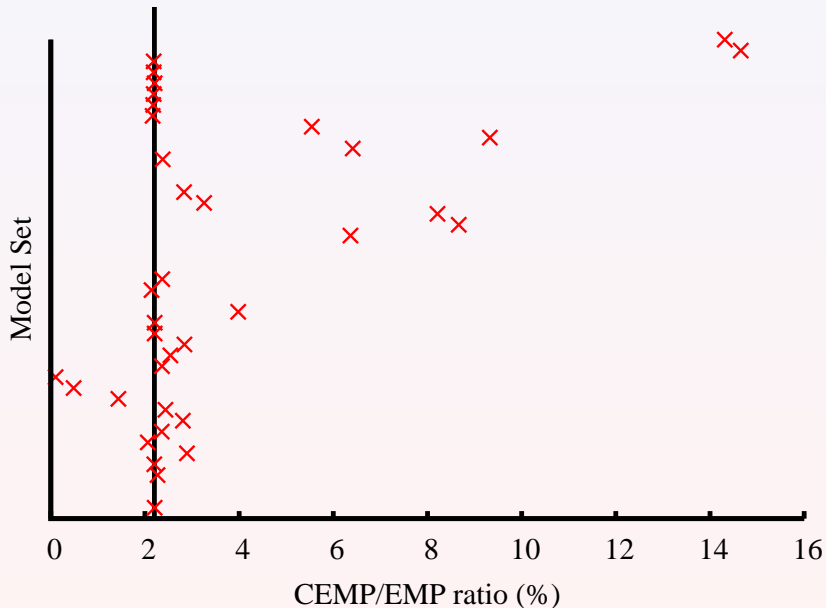
Results



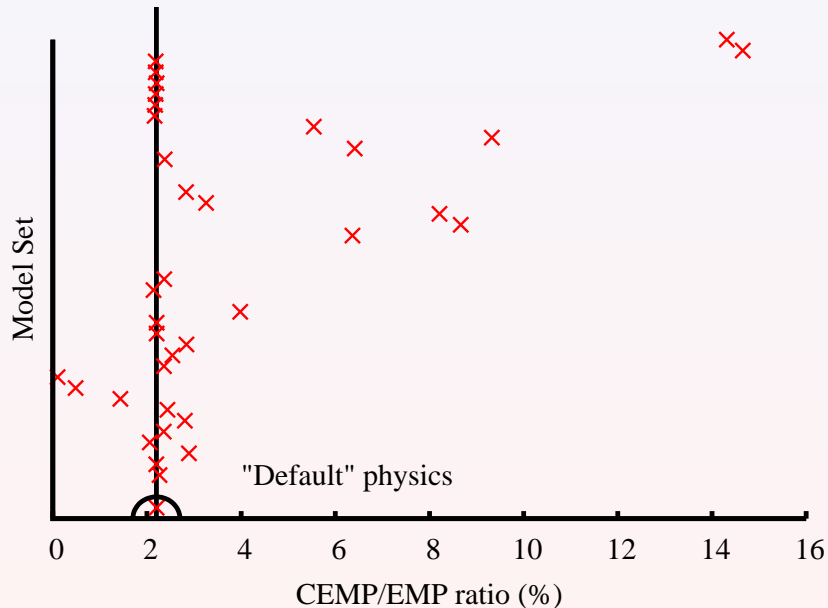
Results



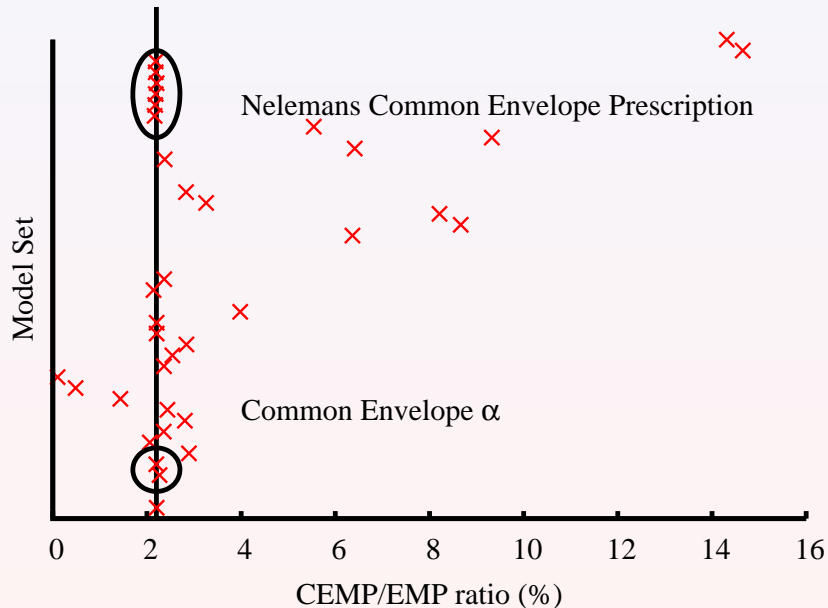
CEMP/EMP ratio (observed $\sim 20\%$)



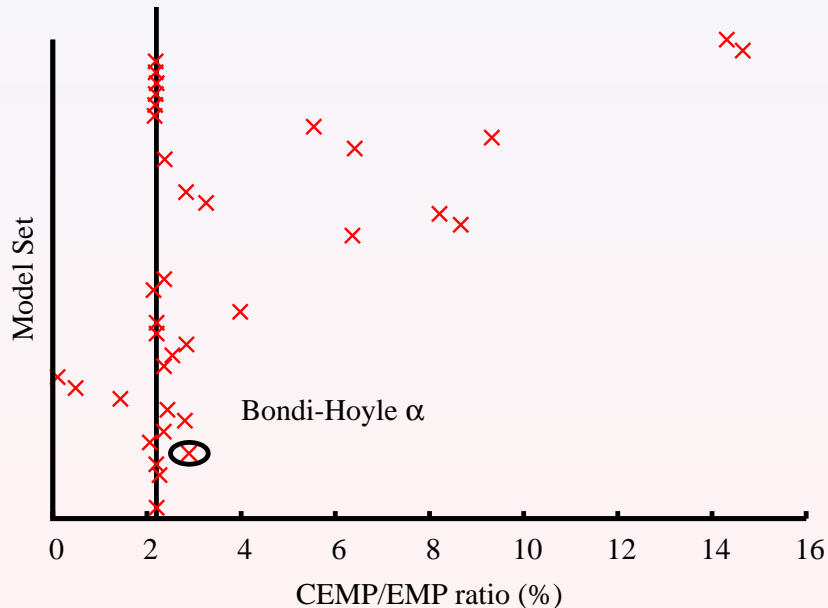
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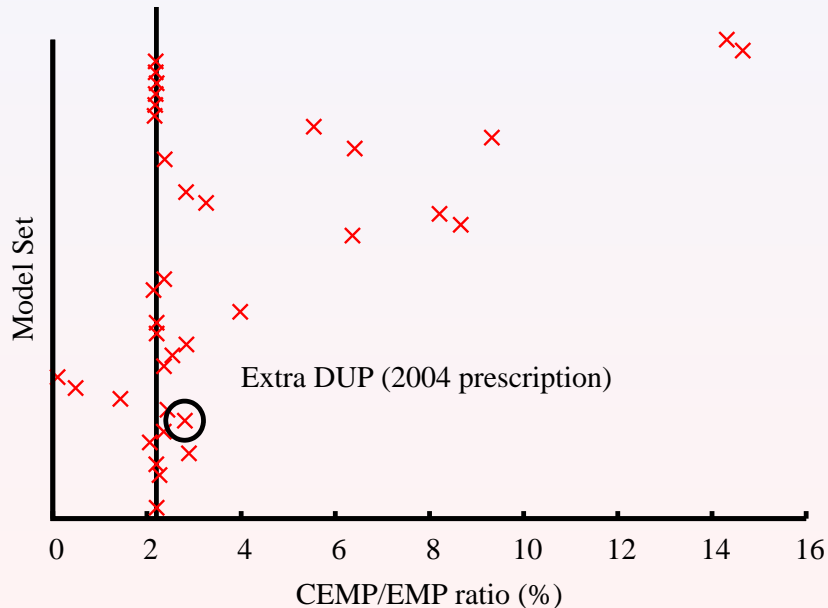
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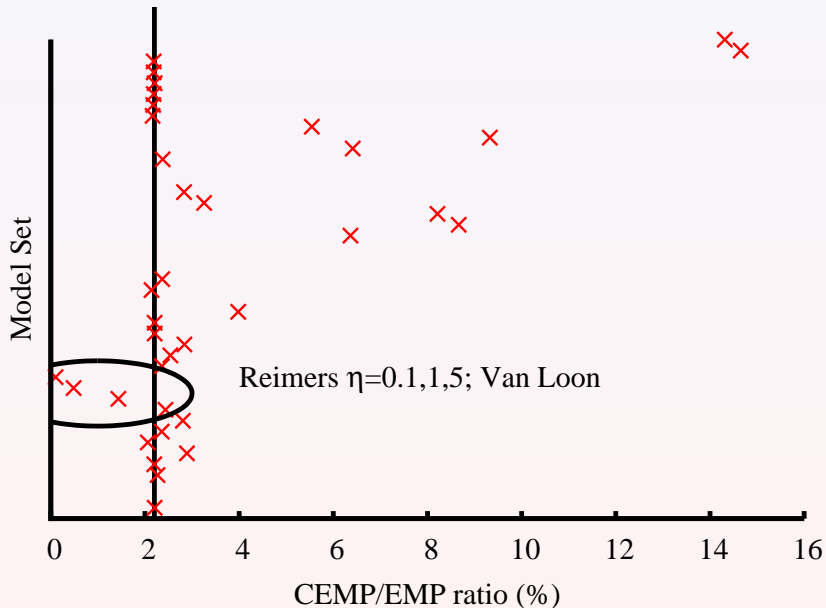
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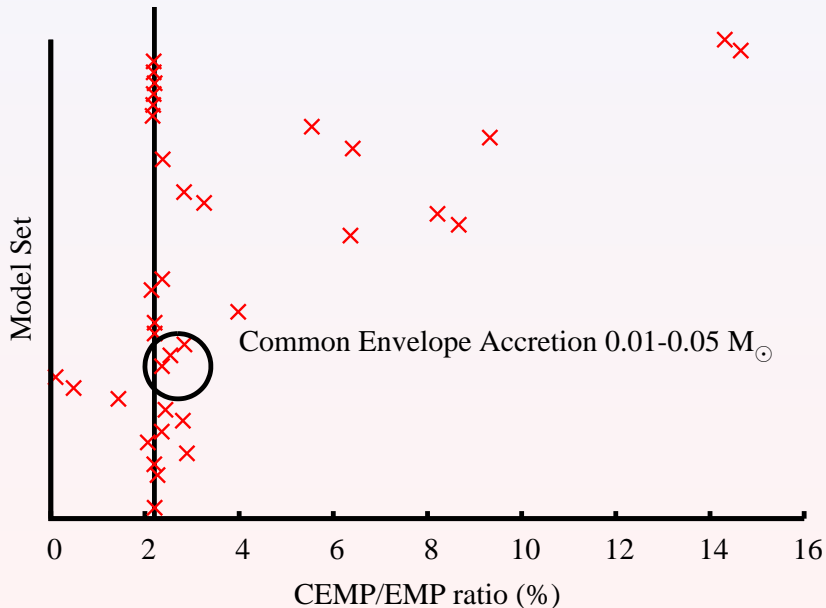
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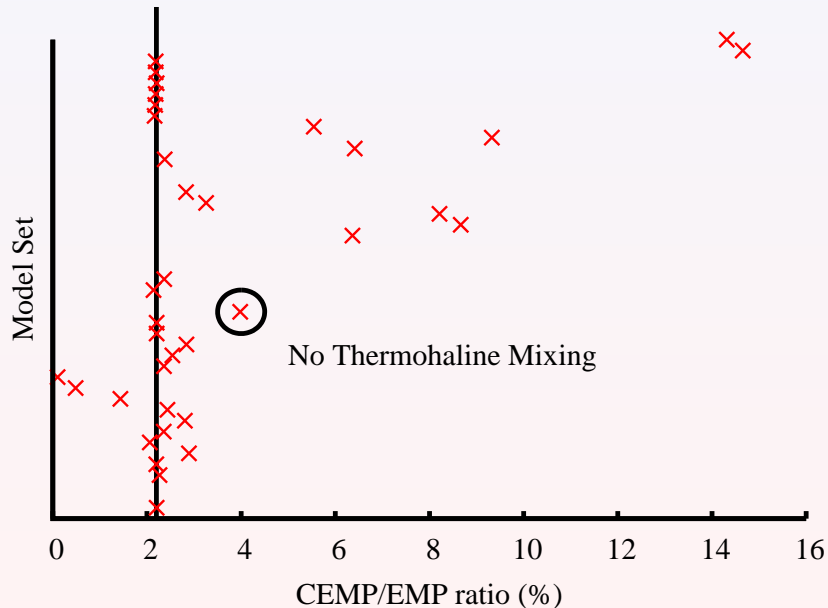
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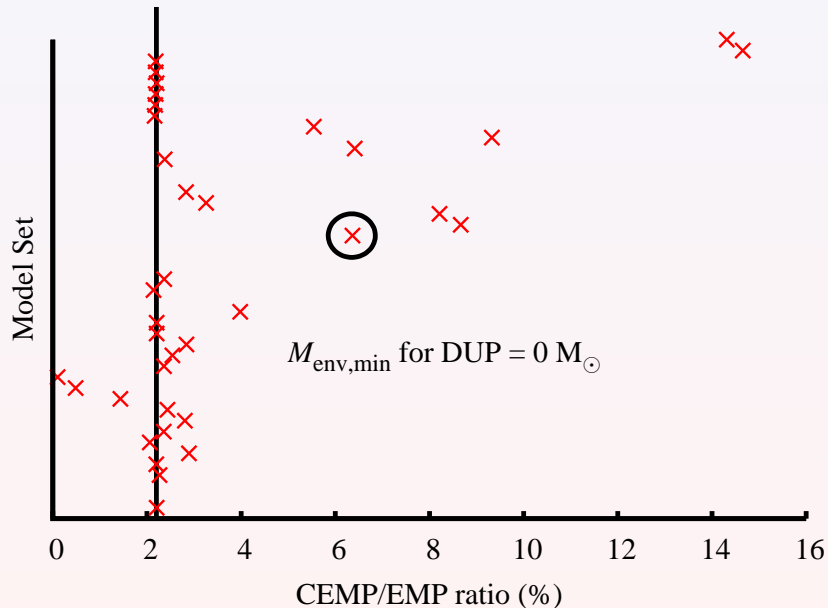
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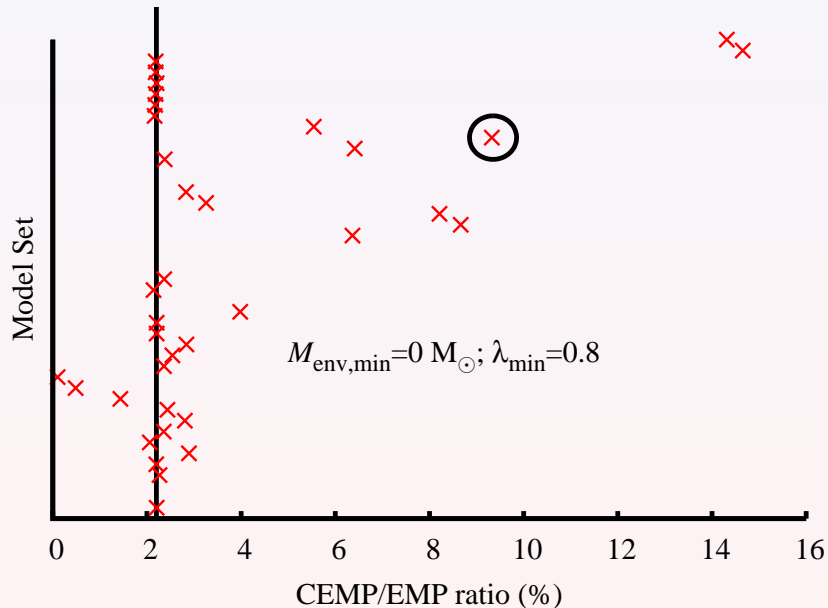
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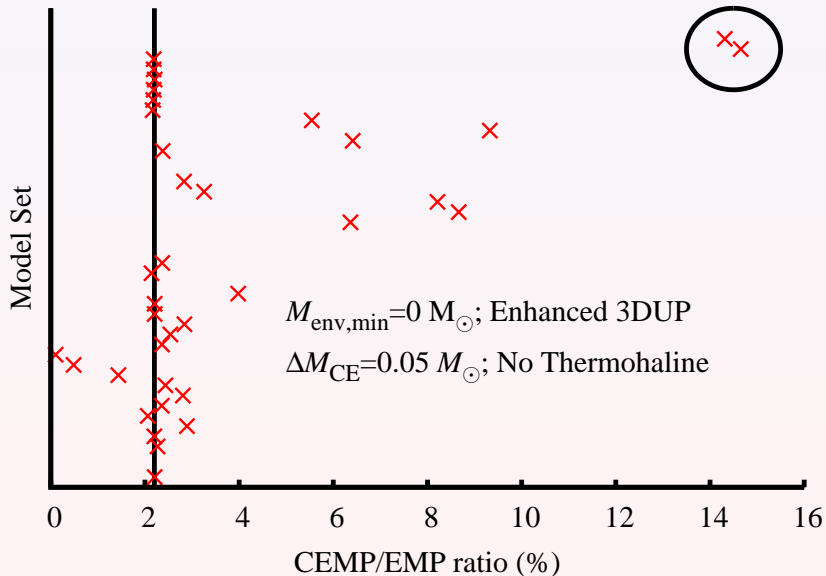
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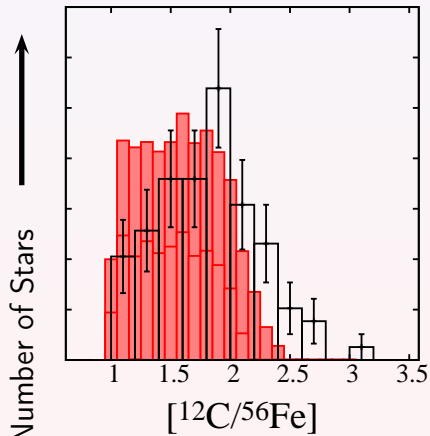


CEMP/EMP ratio (observed $\sim 20\%$)

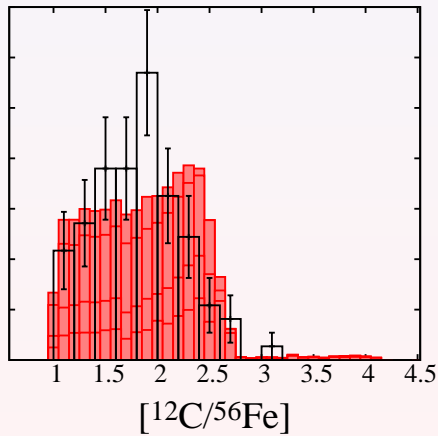


CEMP C-distribution

thermohaline



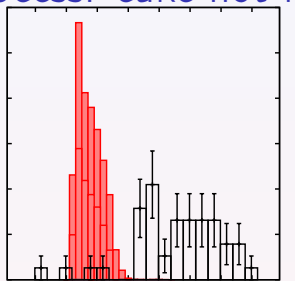
no thermohaline



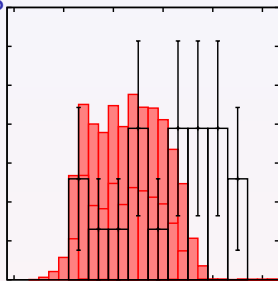
s-process: cake not for eating

↑

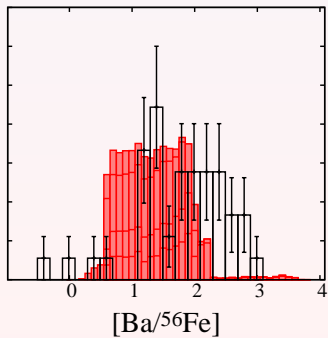
Number of Stars



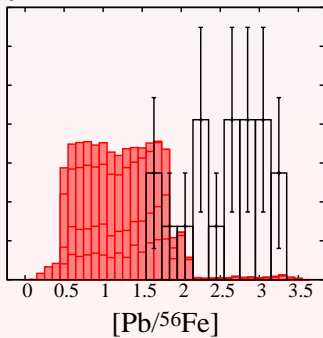
$s = 1$



^{13}C efficiency s



$s = \frac{1}{100}$

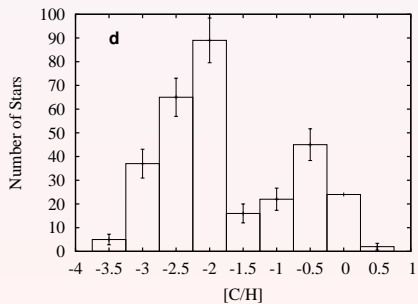
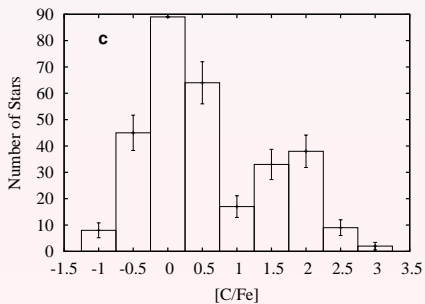
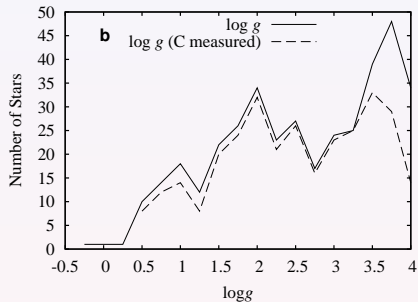
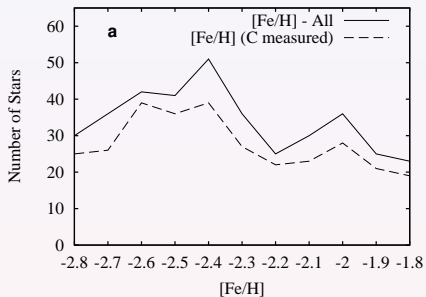


Conclusion: Problems

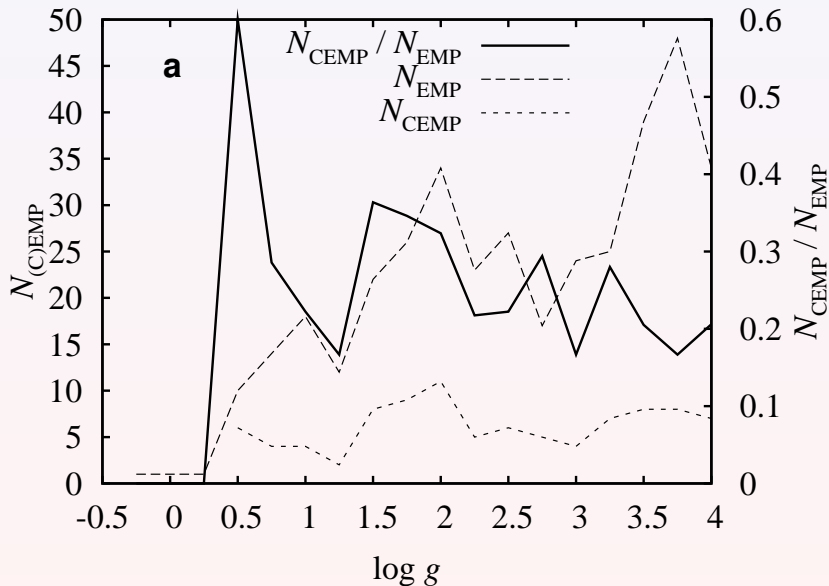
- ▶ Conspiracy of parameters?
- ▶ Need extra C even up to $[\text{Fe}/\text{H}] \sim -2$: how ?
(Flash mixing?)
- ▶ Richard Stancliffe finds 3DUP at $0.85 M_{\odot}$,
 $Z = 10^{-4}$ with Cambridge code ... anyone else?
 $M_{\text{env},\text{min}} < 0.5 M_{\odot}$?
- ▶ Observational selection effects?
- ▶ Trust the abundances? (3D, non-LTE?)
- ▶ Other solutions ...
but beware the NEMPS!

Extra slides (just in case!)

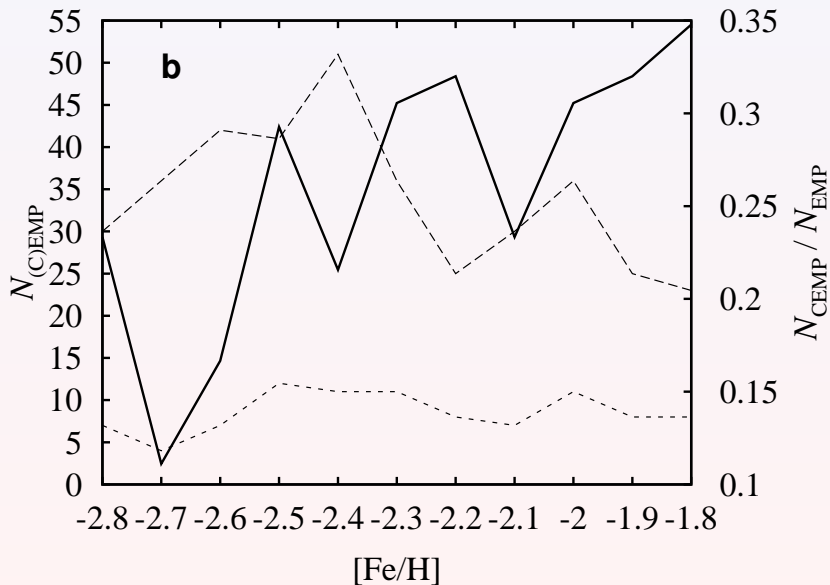
SAGA distributions



Number of (C)EMPs: $\log g$



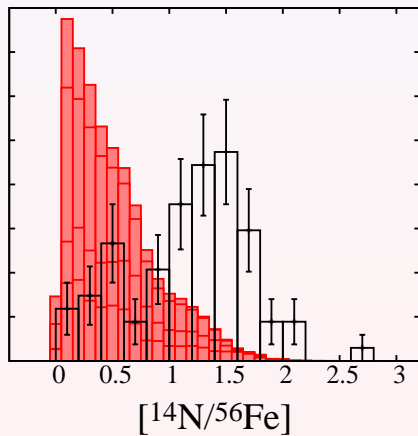
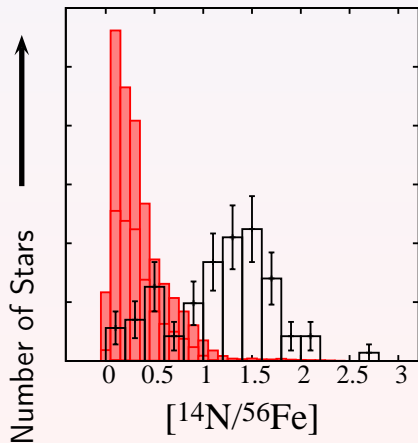
Number of (C)EMPs: [Fe/H]



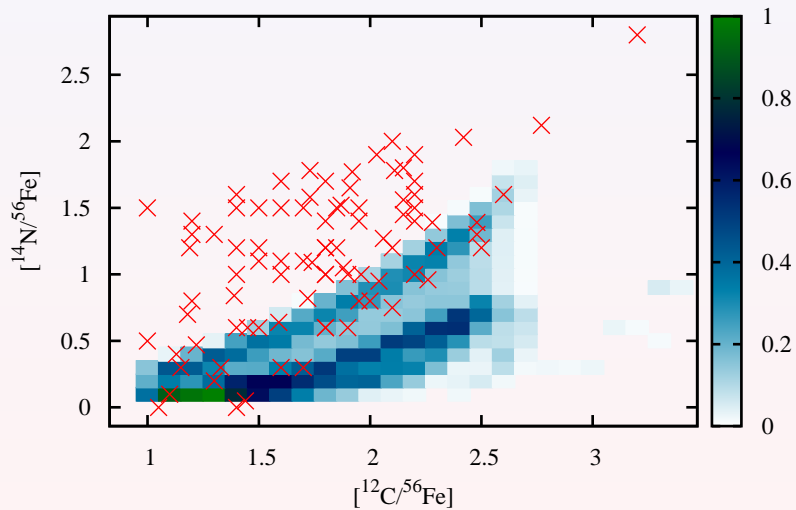
CEMP N-distribution: *extra mixing or flash?*

thermohaline

no thermohaline



C vs N



Ba vs Pb

