Unveiling the nucleosynthetic signature of the first stars

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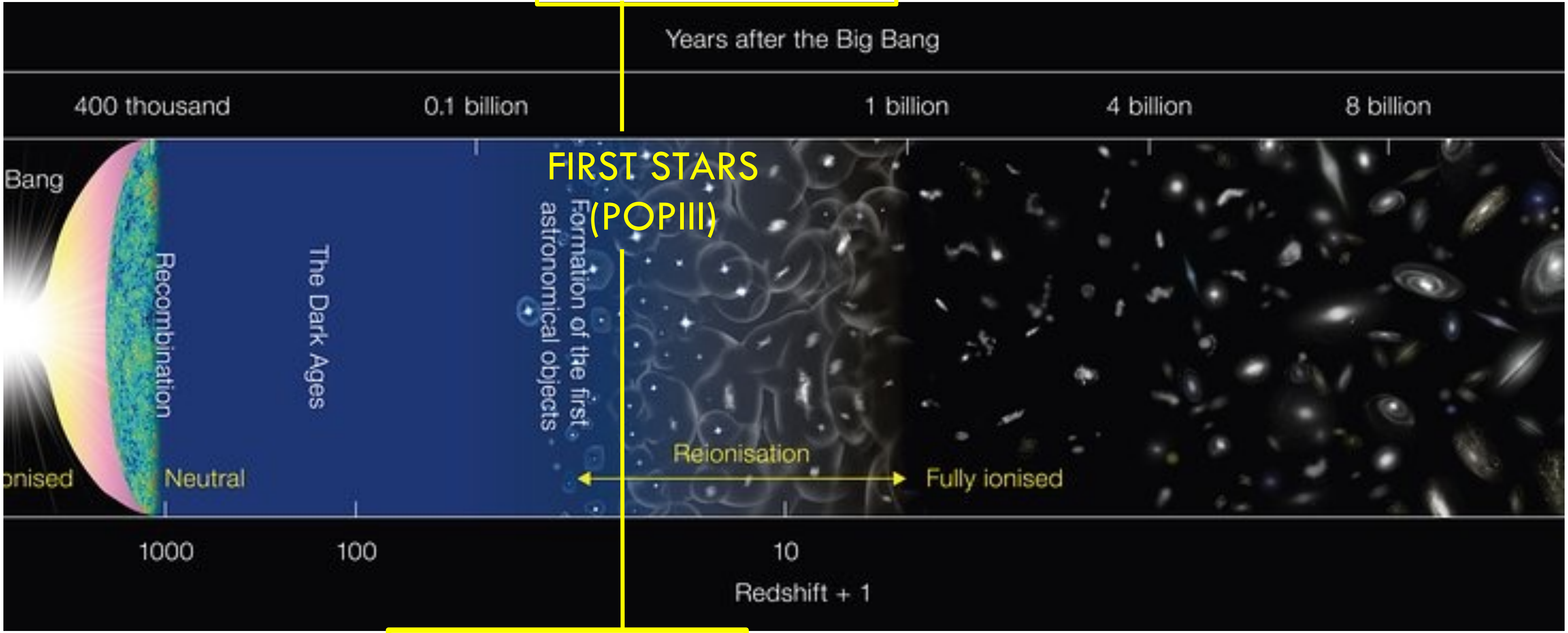
18TH RUSSBACH SCHOOL ON NUCLEAR ASTROPHYSICS

Why first stars?

~200 million years



Redshift z ~ 30-20

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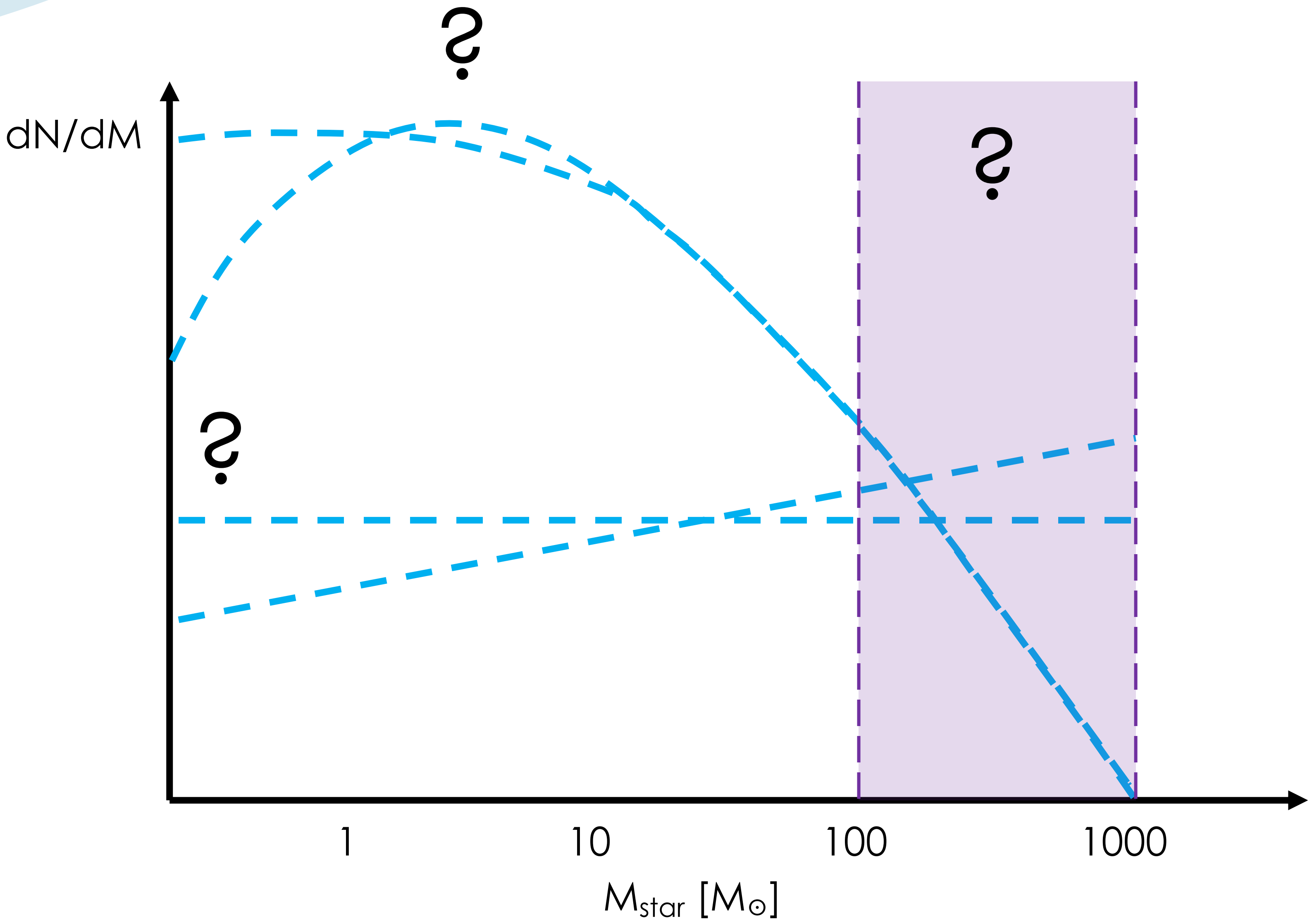
Initial masses of first stars



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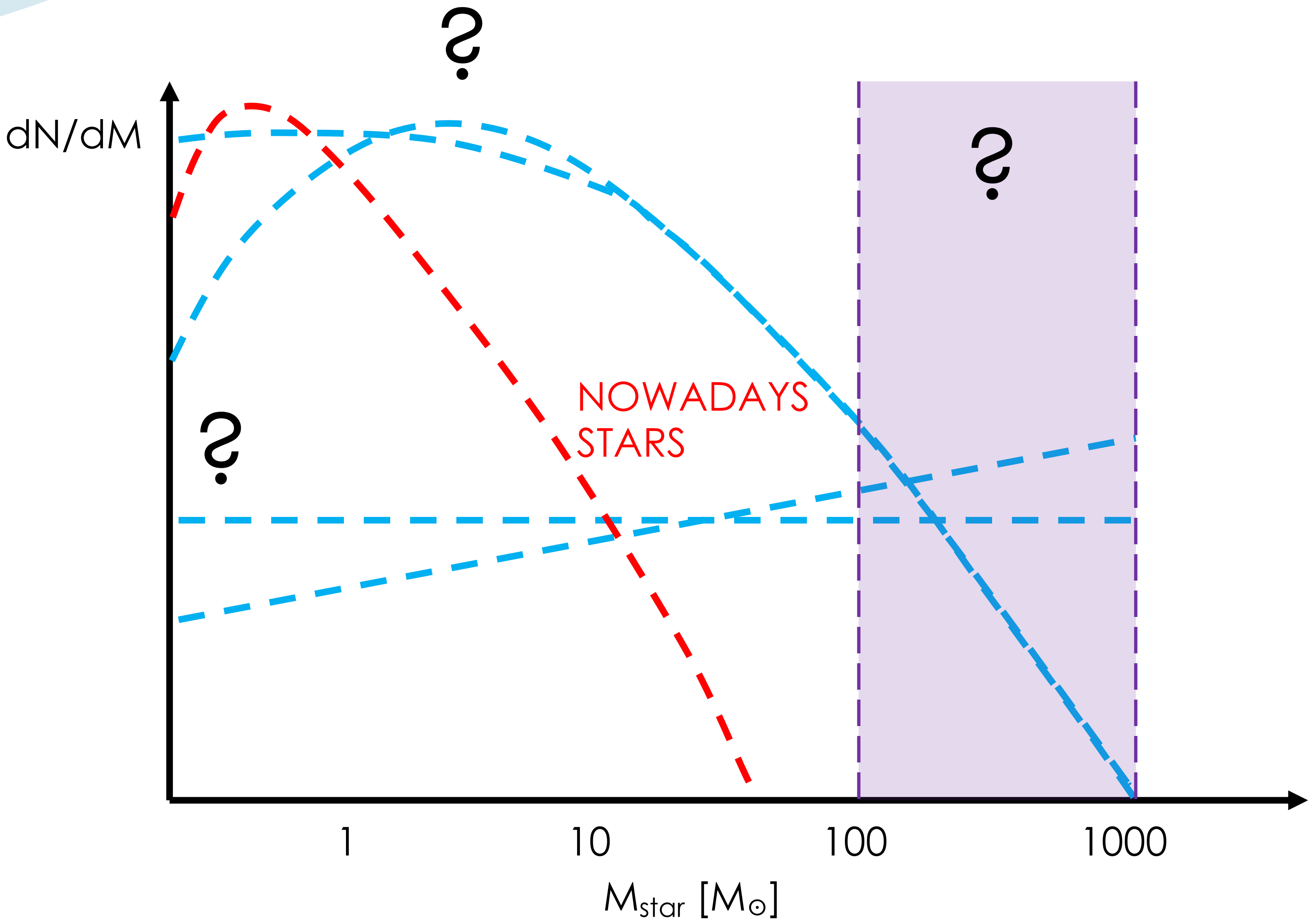
Initial masses of first stars



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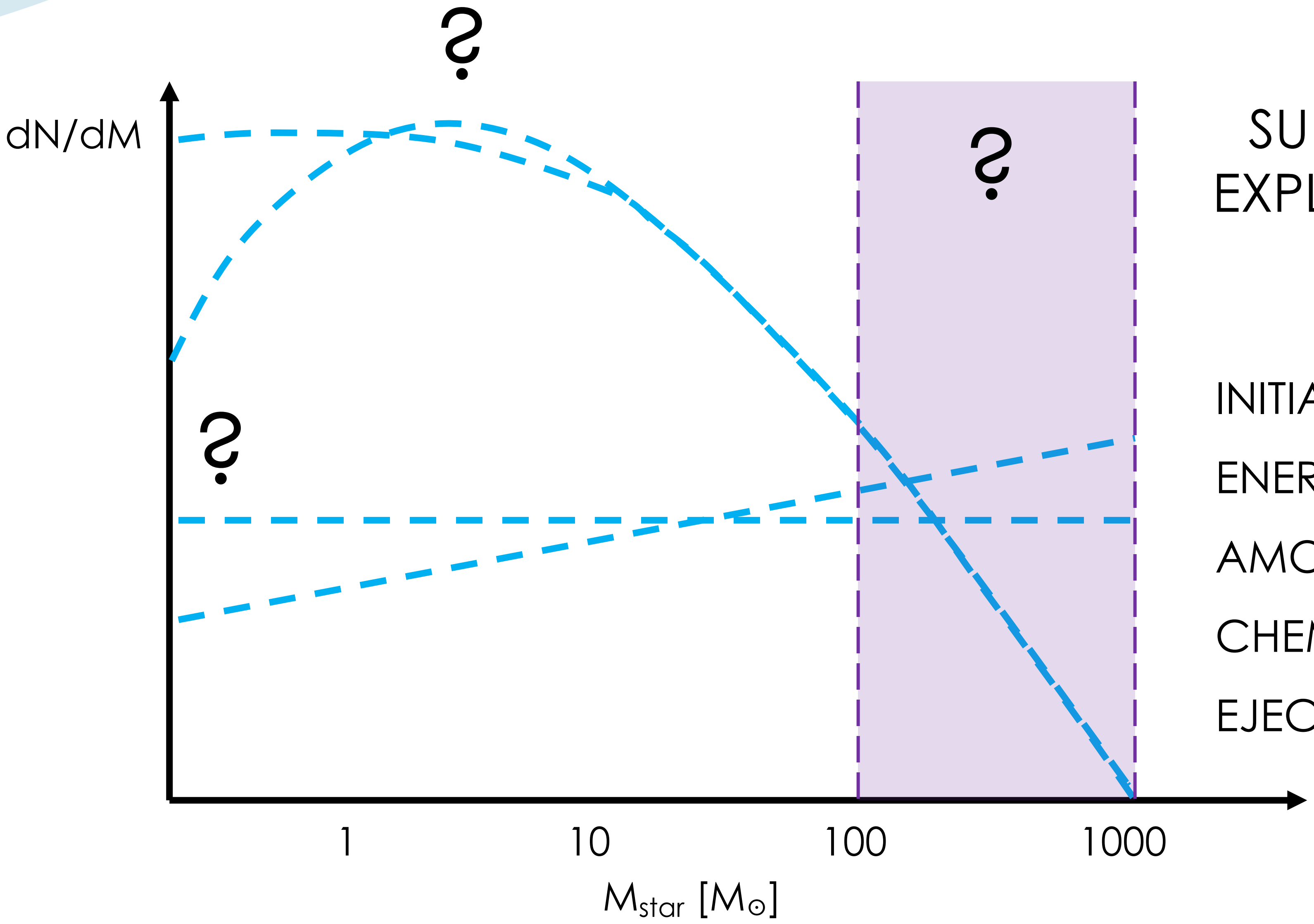
Initial masses of first stars



SUPERNOVA (SN) EXPLOSION ENERGY

?

INITIAL MASS AND SN ENERGY AFFECT THE AMOUNT OF CHEMICAL ELEMENTS EJECTED

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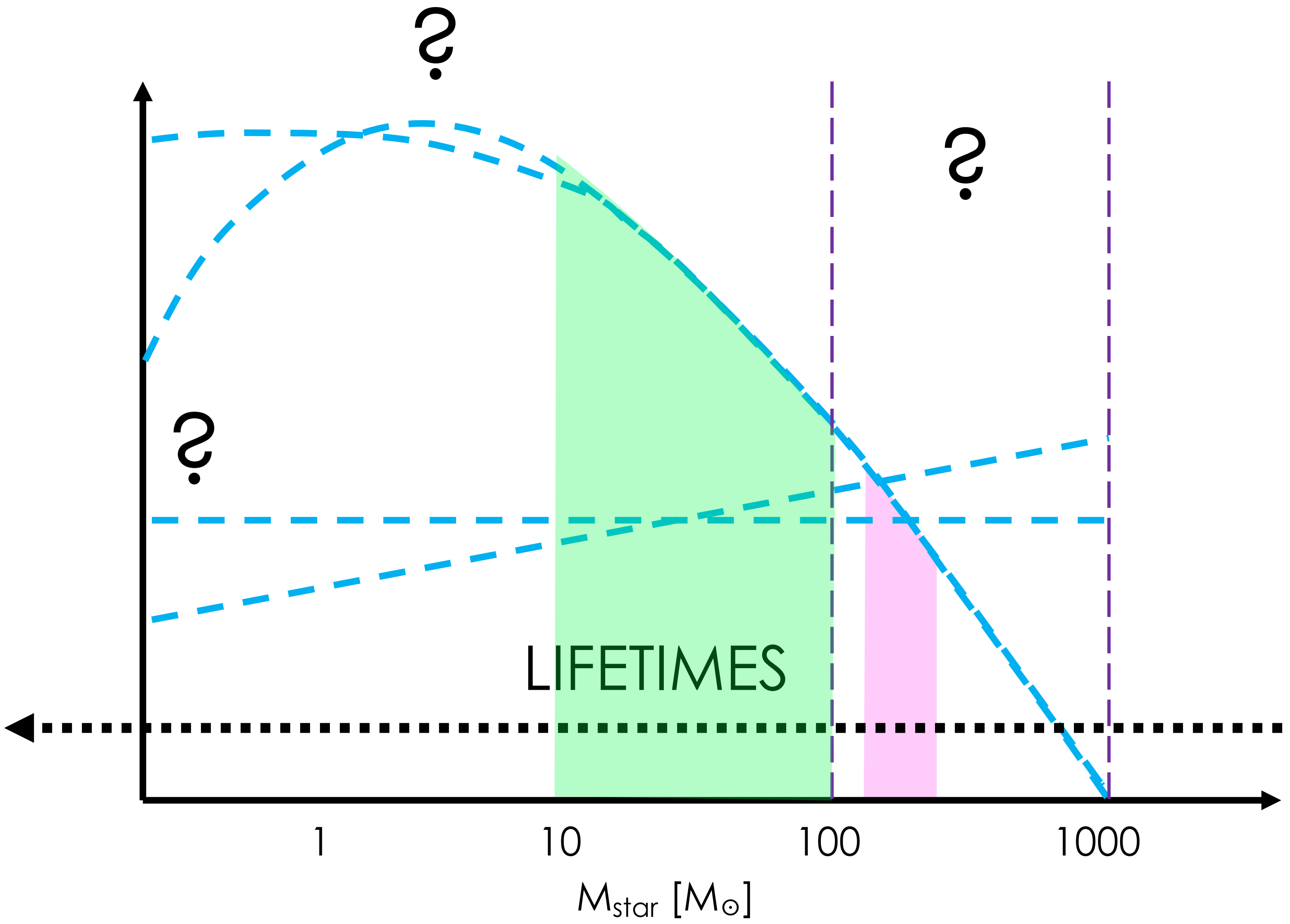
Masses and SN energies of first stars



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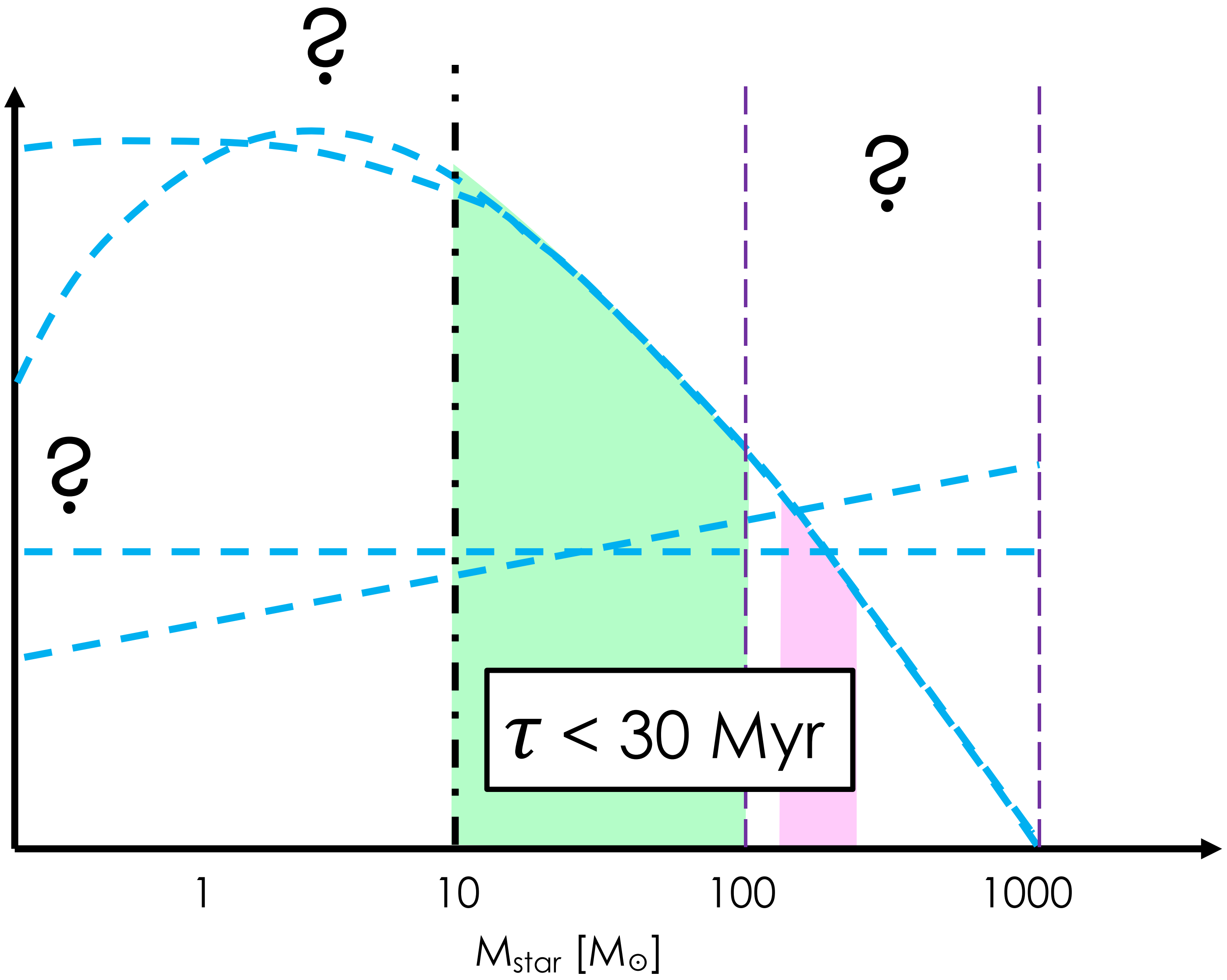
Masses and SN energies of first stars



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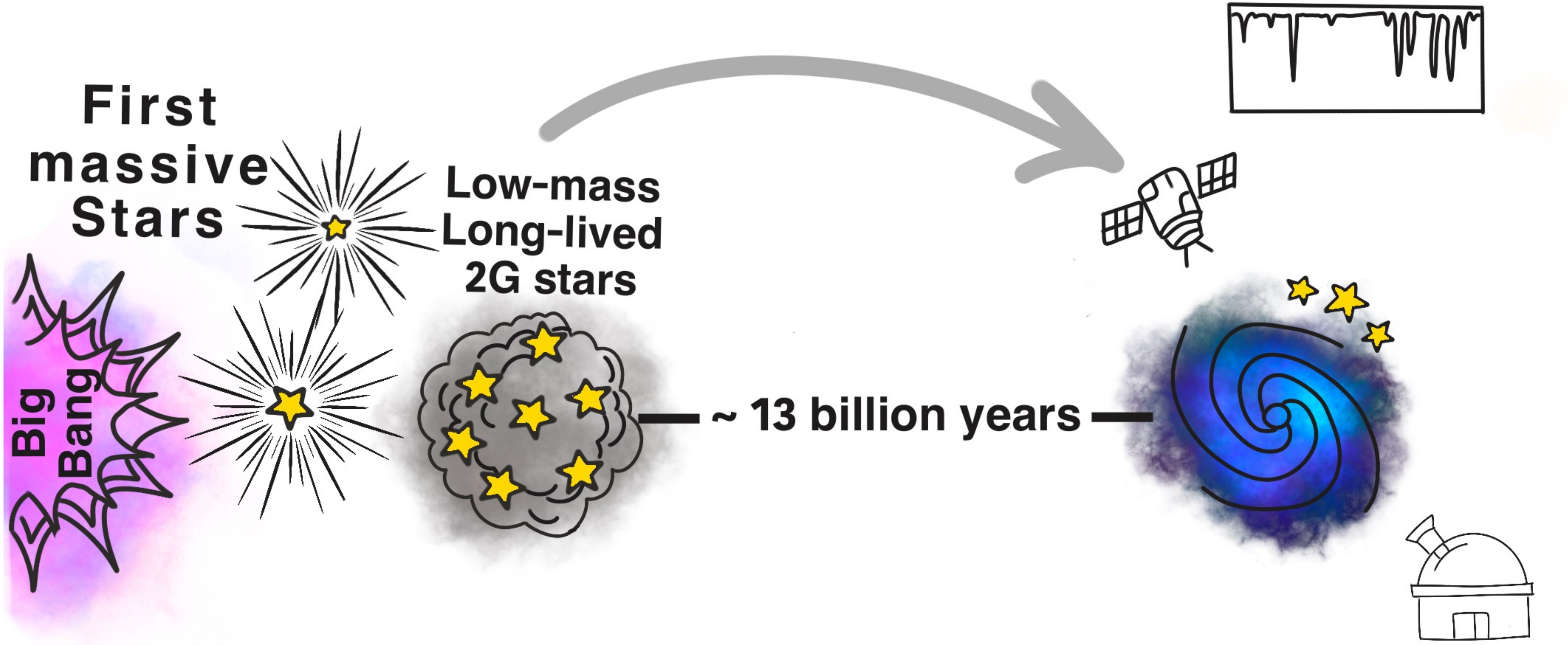
Stellar archaeology



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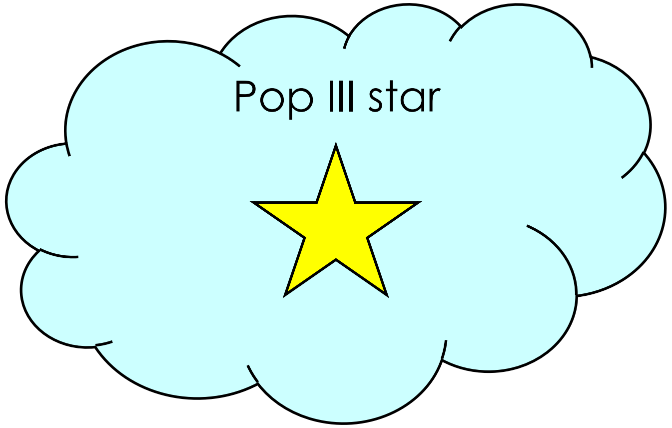
Credits: Martina Rossi

A general model

Salvadori+19, Vanni+23 (in press)

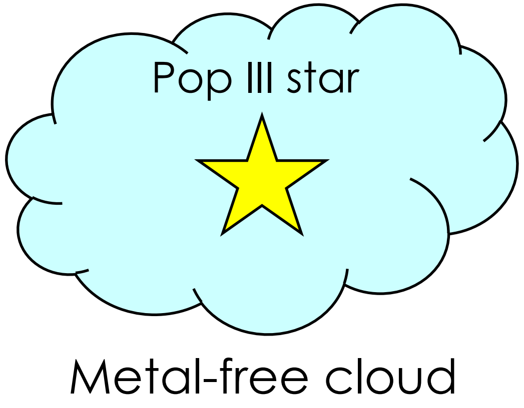


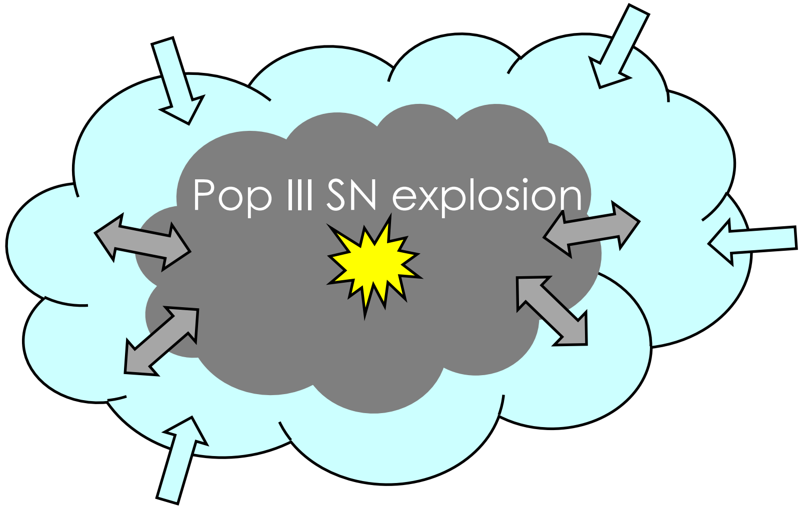
Metal-free cloud

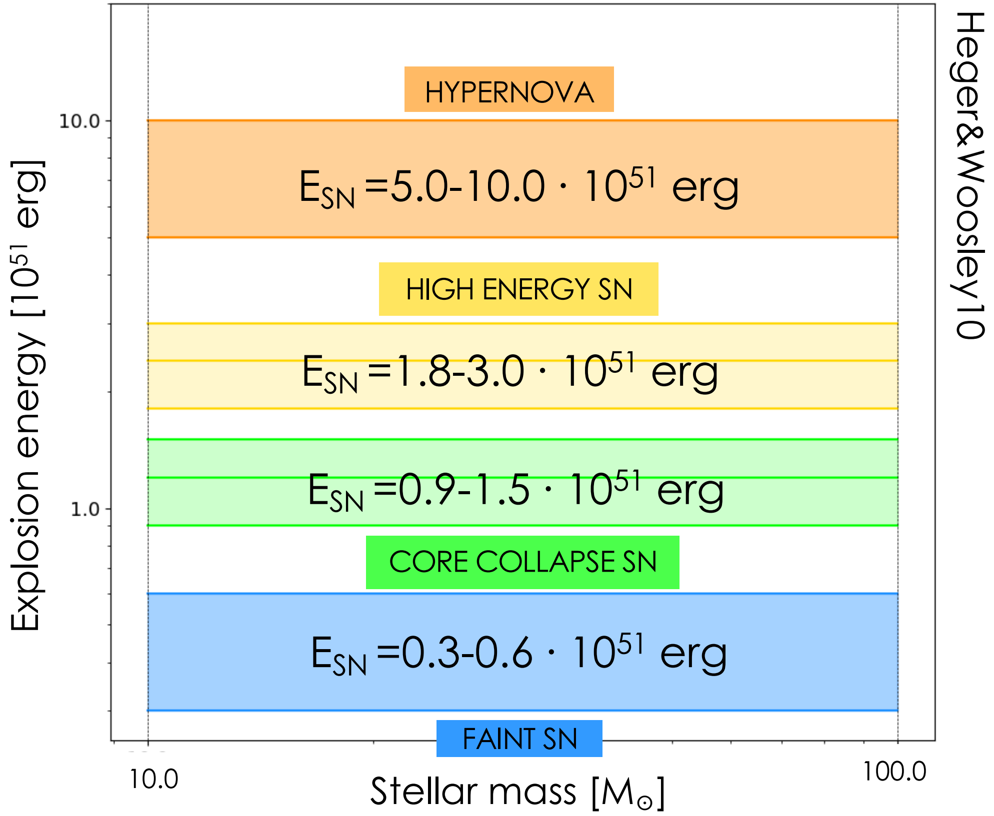
$M \in [0.1; 1000]\ M_{\odot}$

A simple and general model

Salvadori+19, Vanni+23 (in press.)

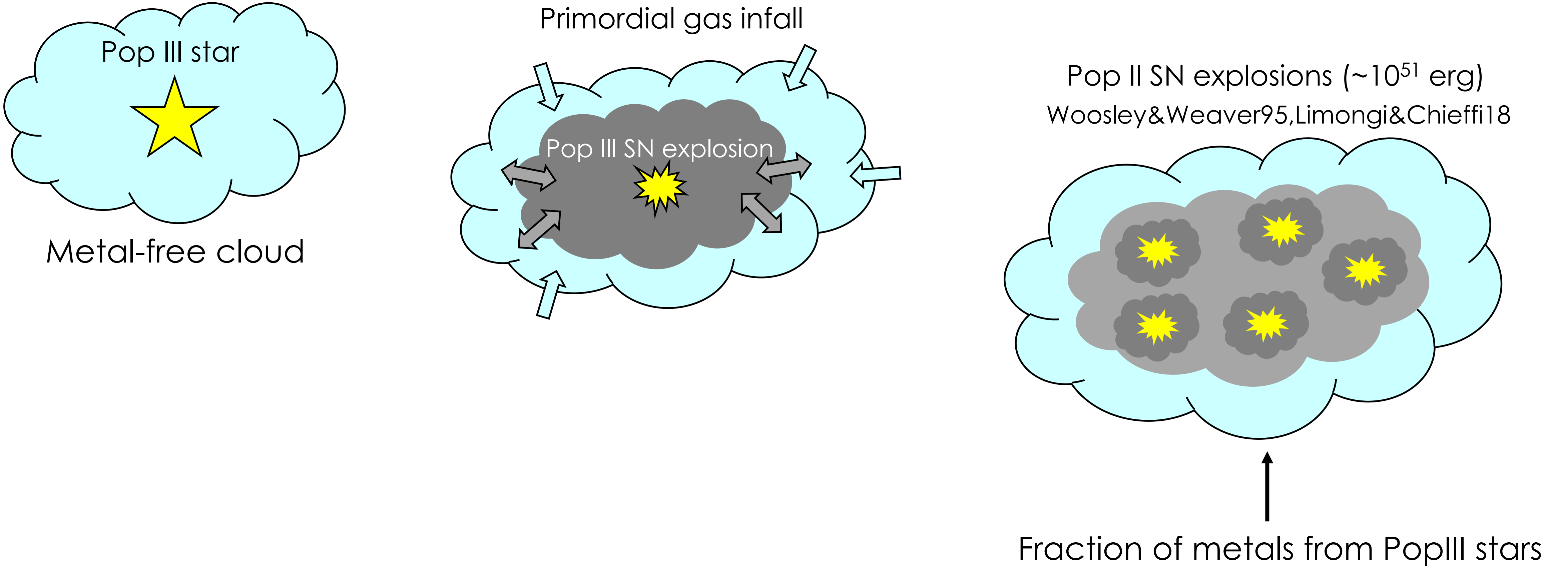






A simple and general model

Salvadori+19, Vanni+23 (in press)



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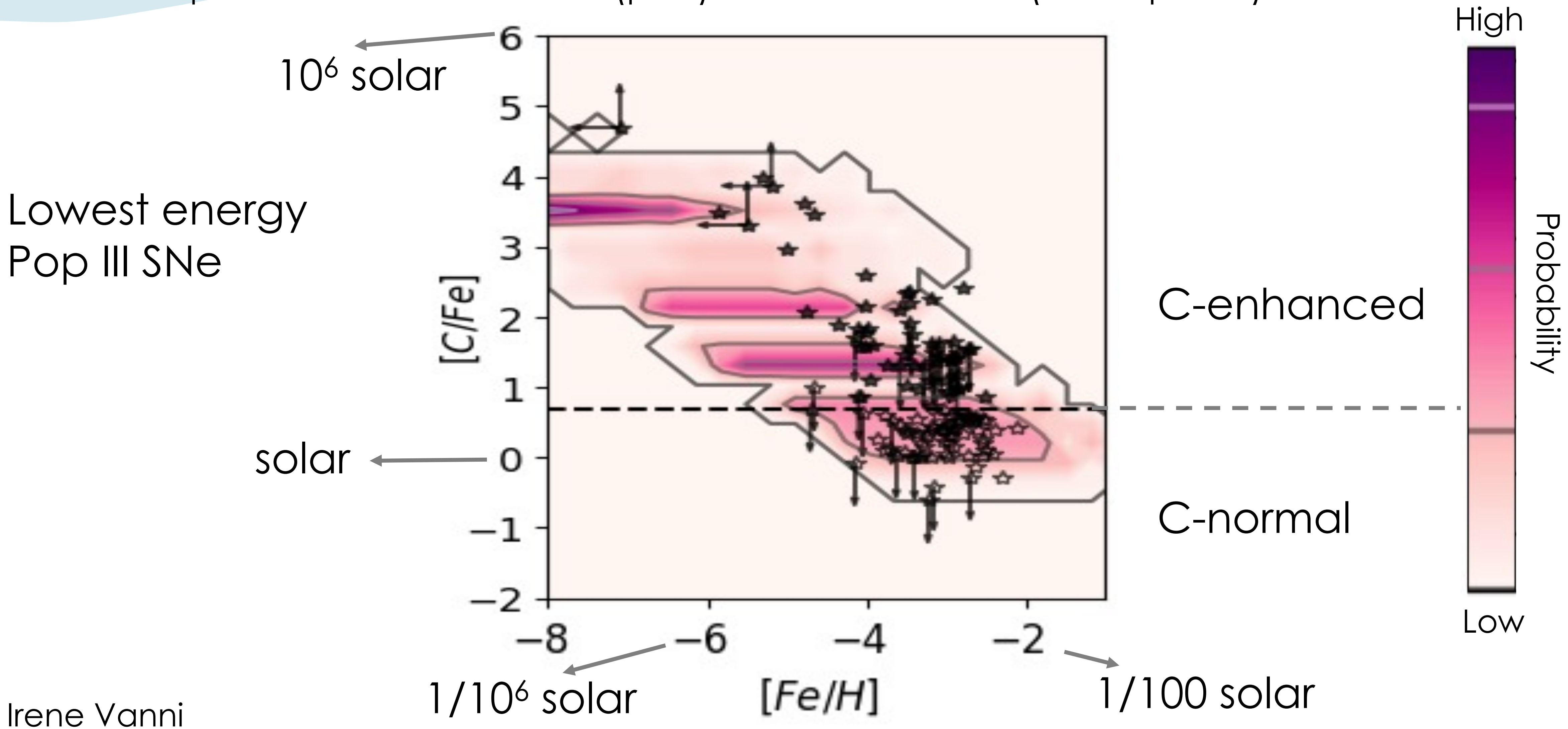
Pure Pop III descendants

Comparison between model (pink) and observations (black points)



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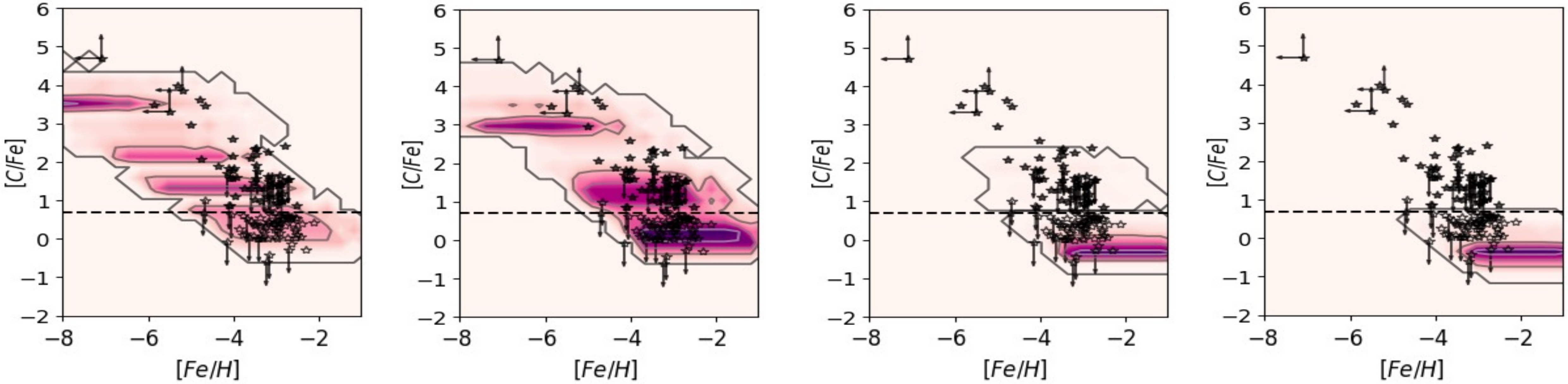
Pure Pop III descendants

Vanni+23 (to be sumb. in march)

Faint SNe | Core-collapse SNe | High-energy SNe | Hypernovae

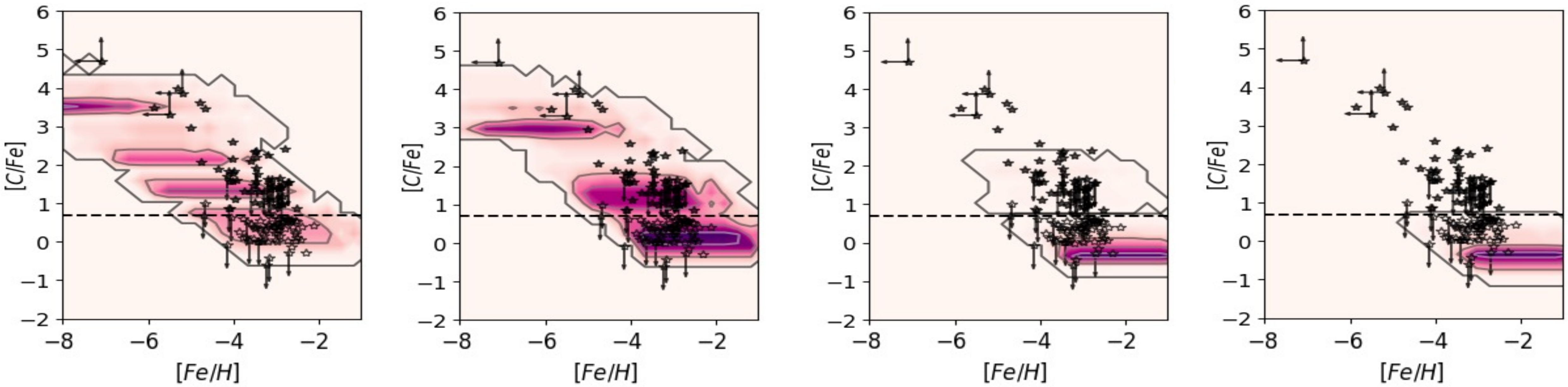


SUPERNOVA EXPLOSION ENERGY

Pure Pop III descendants

Vanni+23 (to be sumb. in march)

Faint SNe | Core-collapse SNe | High-energy SNe | Hypernovae



The most C-enhanced halo stars are likely the descendants of faint and/or core-collapse Pop III SNe

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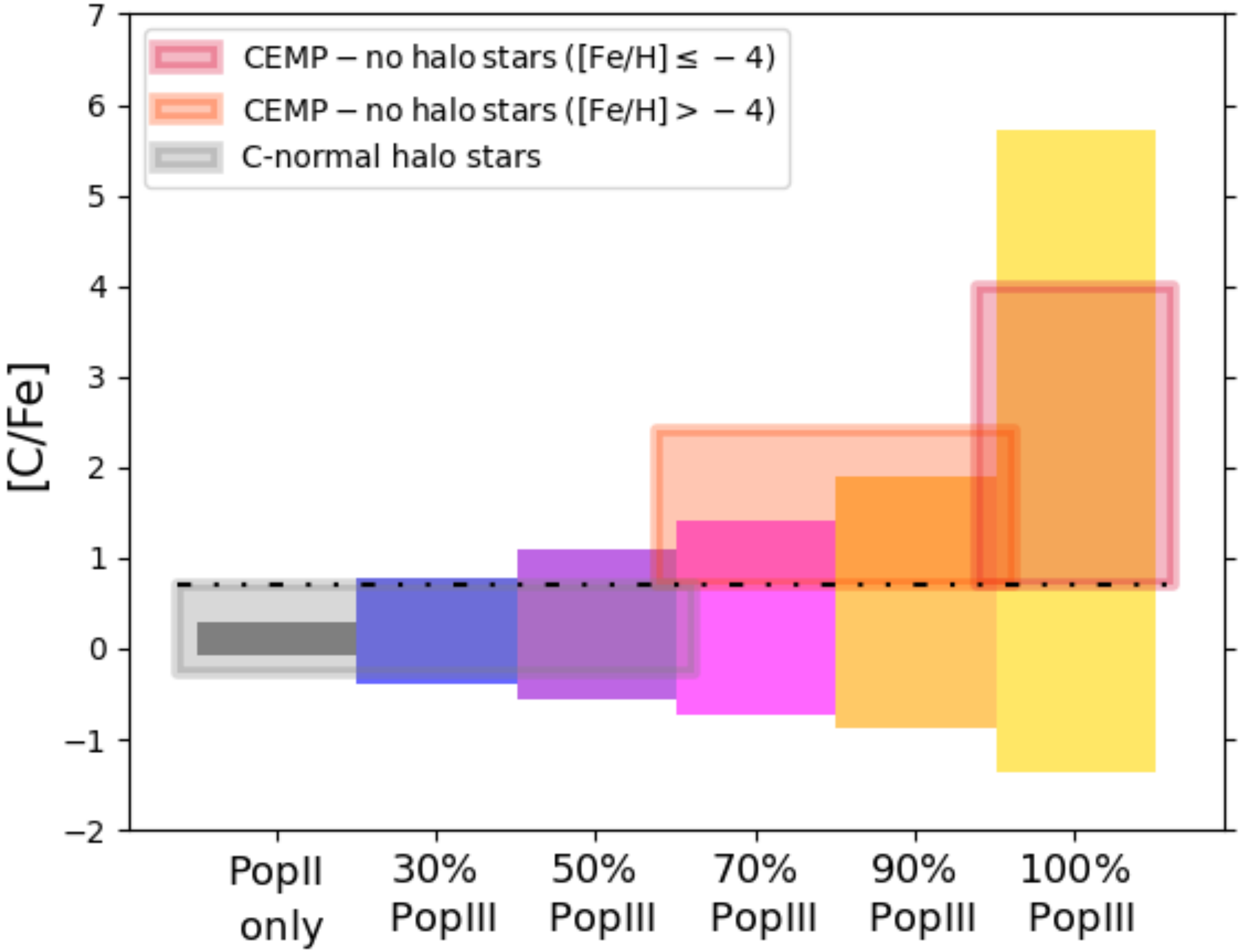
The star-to-star scatter

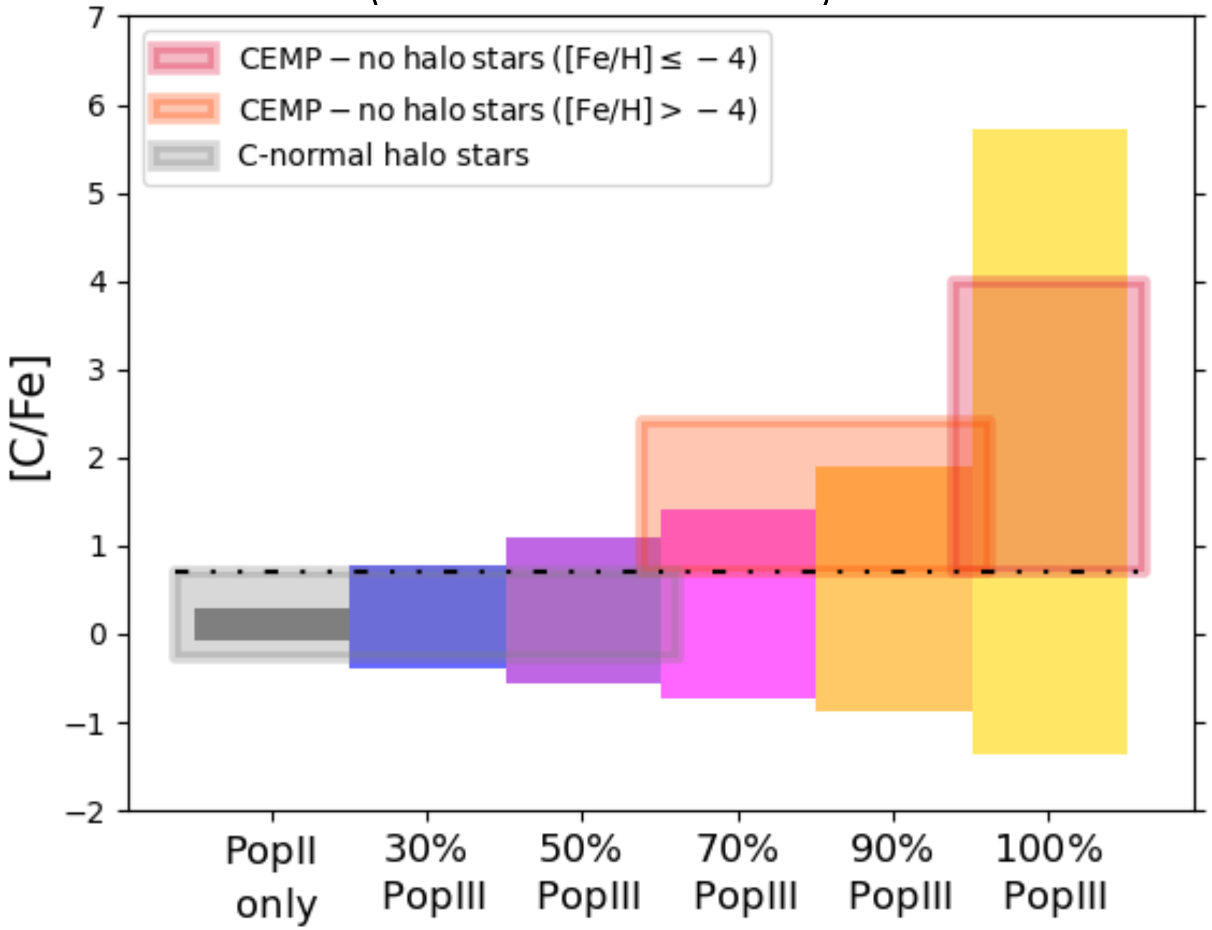
Vanni+23 (to be sumb. in march)

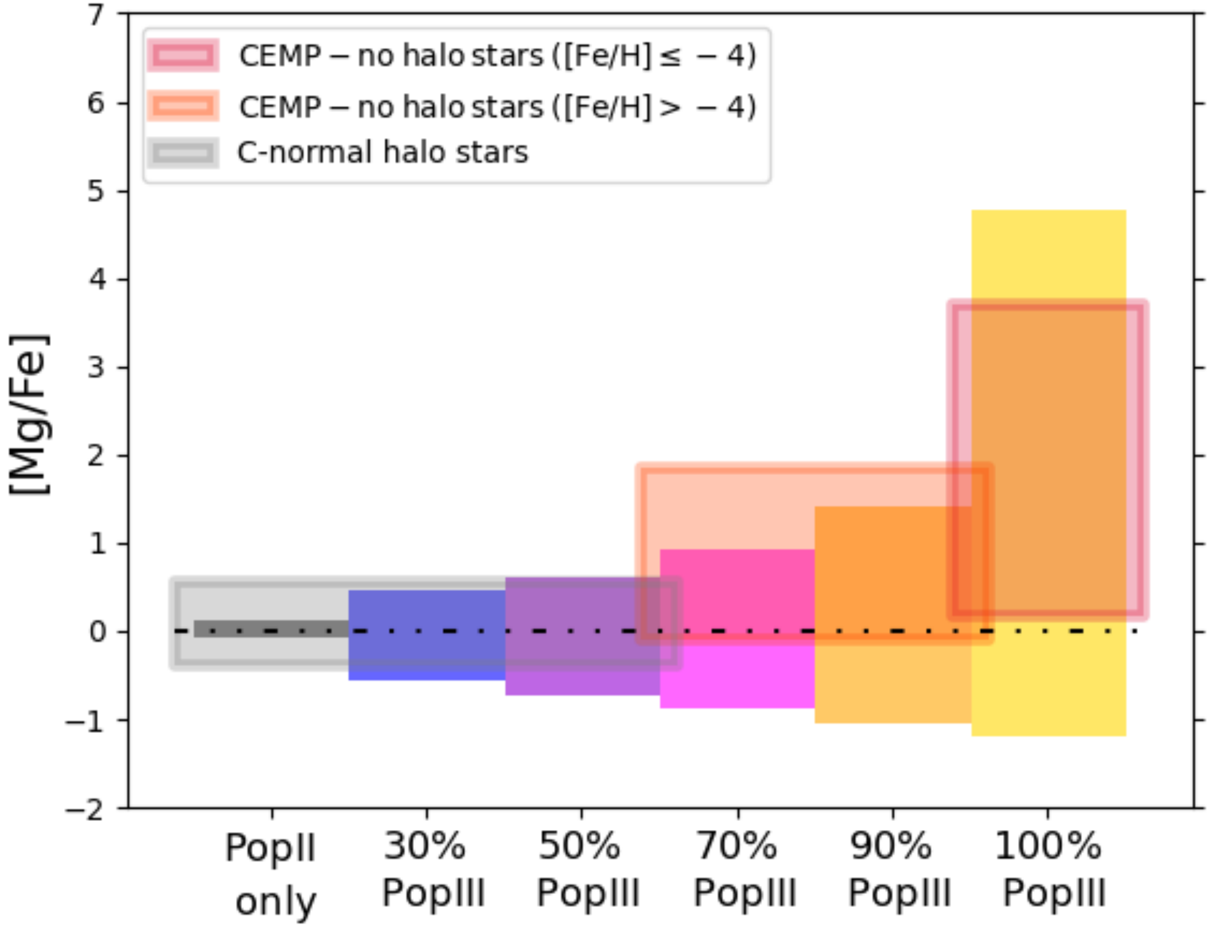


THE SCATTER PREDICTED FOR THE DESCENDANTS OF POP III STARS DECREASES WITH INCREASING CONTAMINATION FROM NORMAL POP II STARS

The star-to-star scatter

Vanni+23 (to be sumb. in march)





The star-to-star scatter of C-normal stars is consistent with an enrichment driven by Pop II stars

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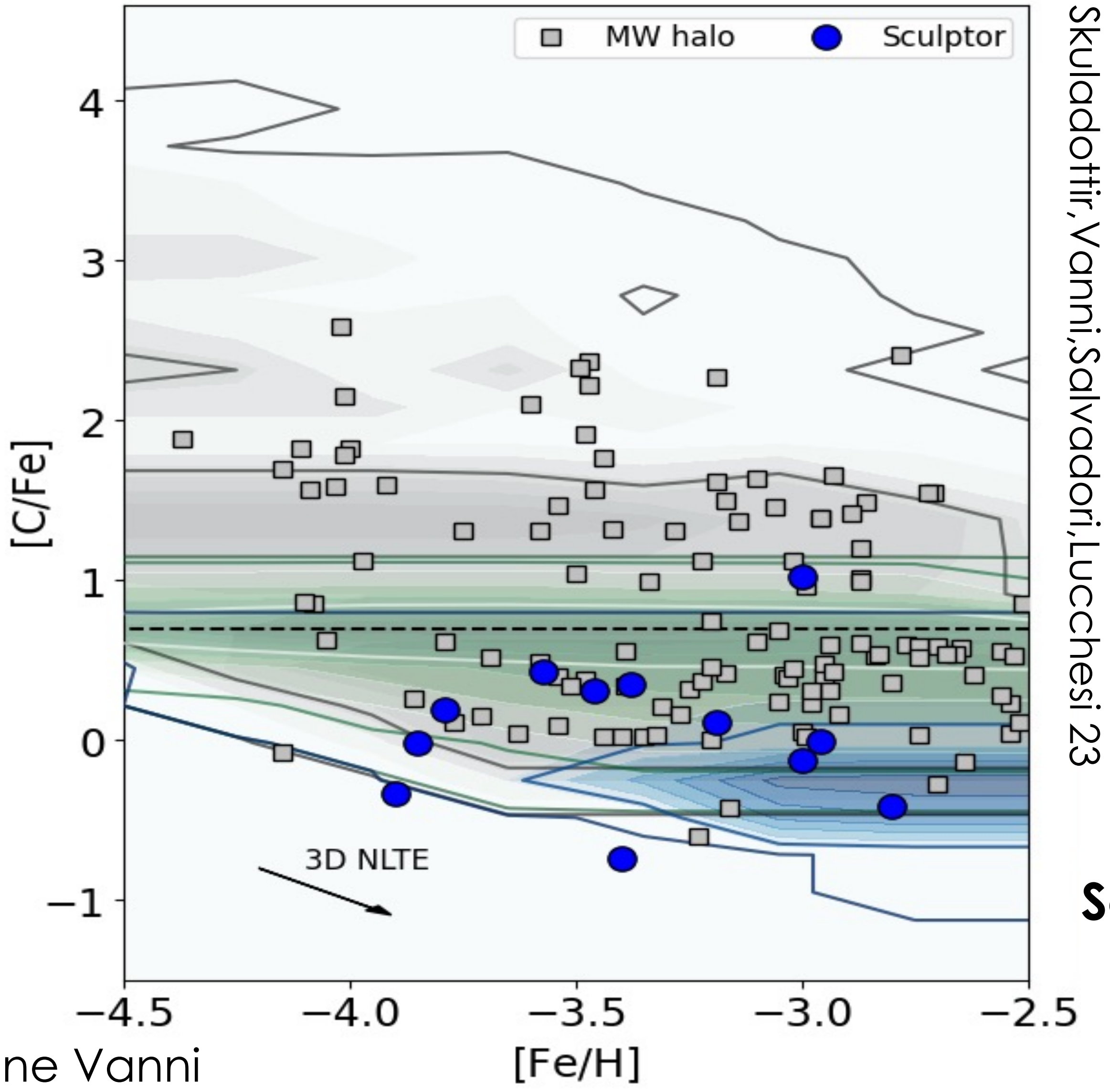
The Sculptor dwarf galaxy



Skuladottir,Vanni,Salvadori,Lucchesi 23

Pop III Faint SN descendants

50% Pop III Faint SN+50% Pop II SN descendants

Pop III hypernovae descendants

Sculptor has been enriched by Pop III hypernovae

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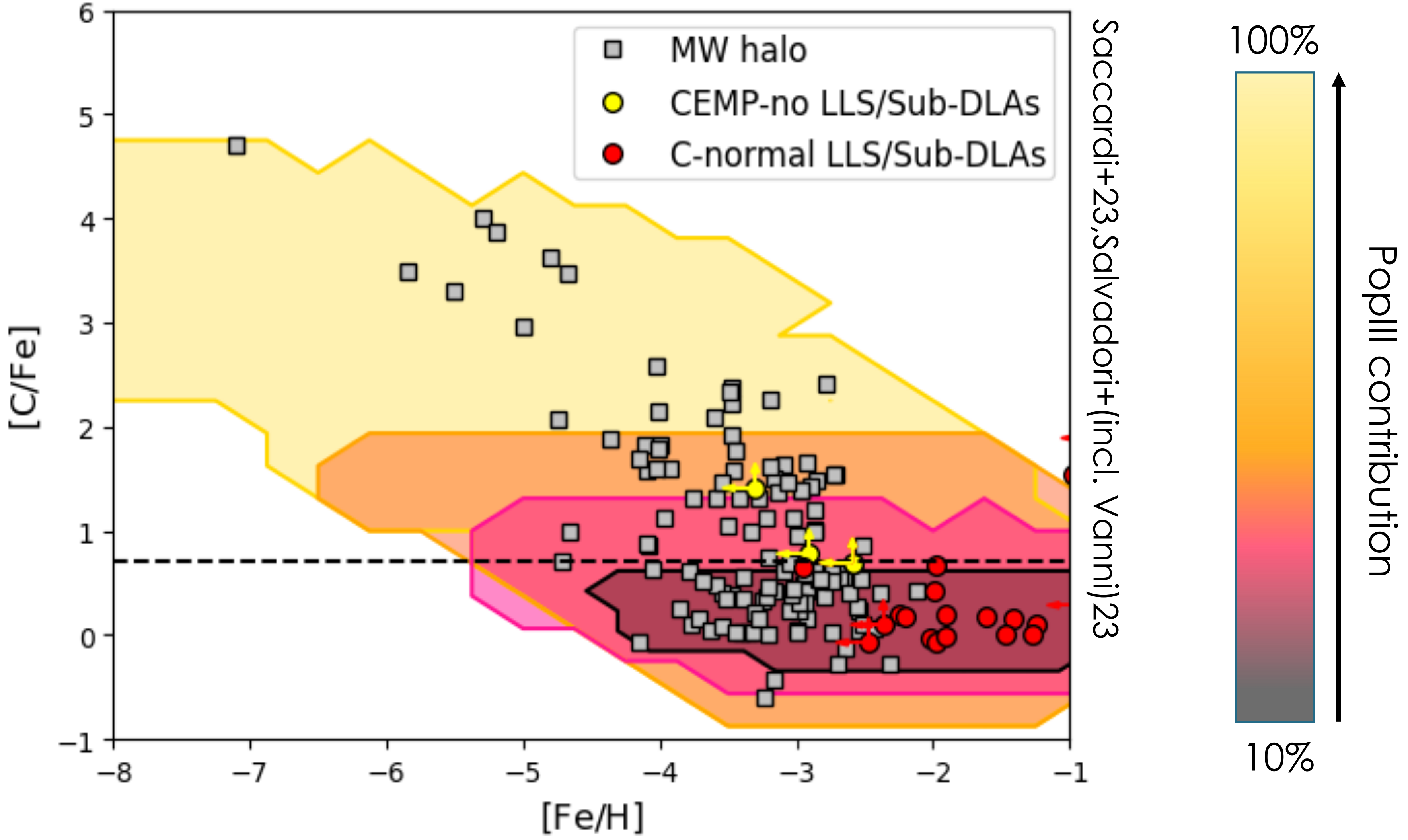
A new science case: Distant absorption systems



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Conclusions

- The MW halo stars with [C/Fe] ≥ +2.5 are 2G stars and carry the chemical imprint of Pop III stars.
- The amount of metals coming from normal Pop II stars increases as the [C/Fe] values of the descendants decrease.
- The model is very simple and general: it can be applied on a broad range of topics regarding early chemical enrichment.

Backup slides

Metal-Poor stars in the Local Group

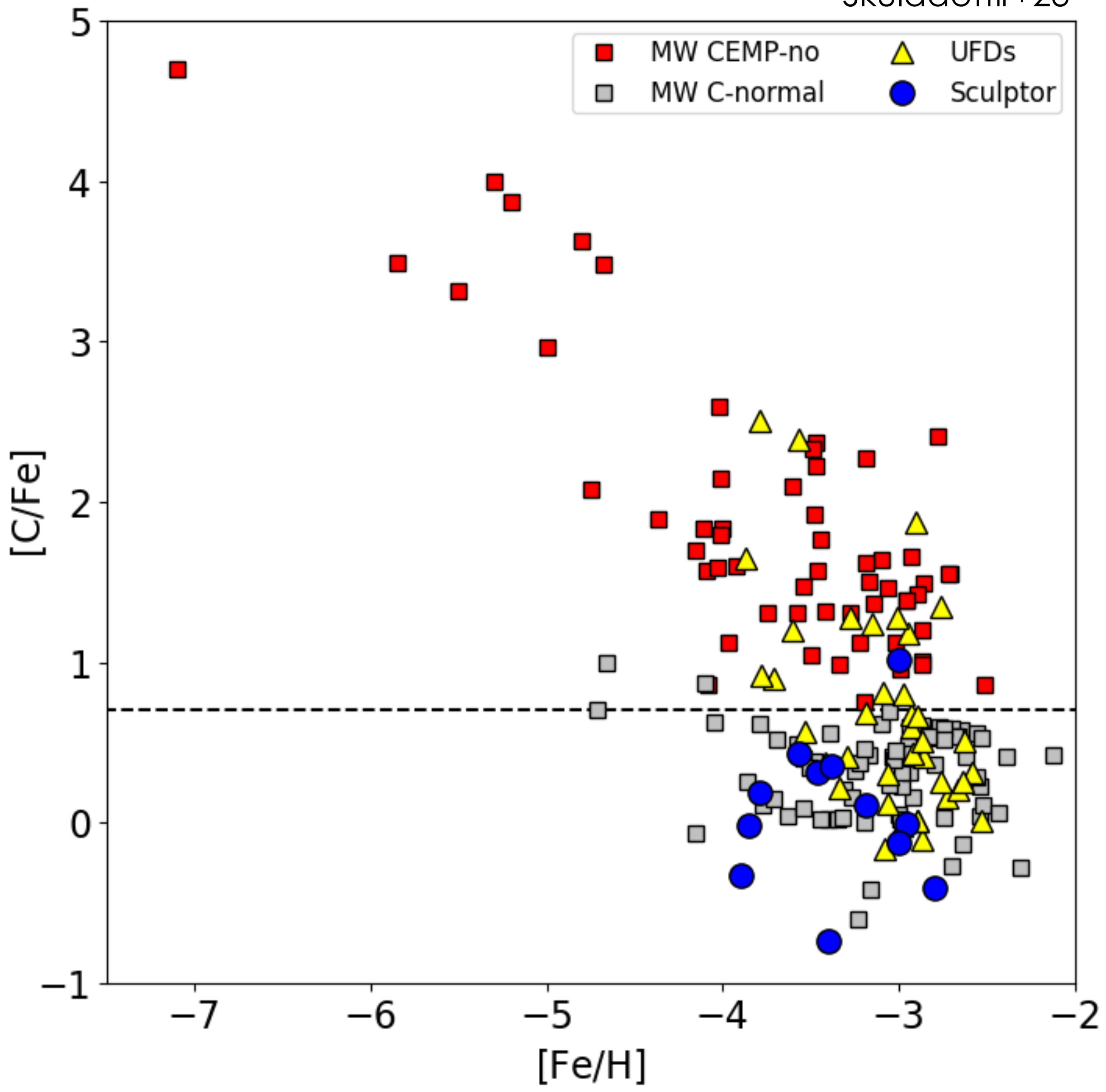
MW: Yong+13,Cayrel+04 and Christlieb+04, Norris+07, Caffau+11, Hansen+14, Keller+14, Frebel+15, Bonifacio+15, Li+15, Bonifacio+18, François+18, Starkenburg+18, Aguado+19, Ezzeddine+19
Sculptor: Skuladottir+23 (submitted)
UFDs: JINA database (Abohalima&Frebel18)

Very Metal-Poor stars ([Fe/H] ≤ -2):

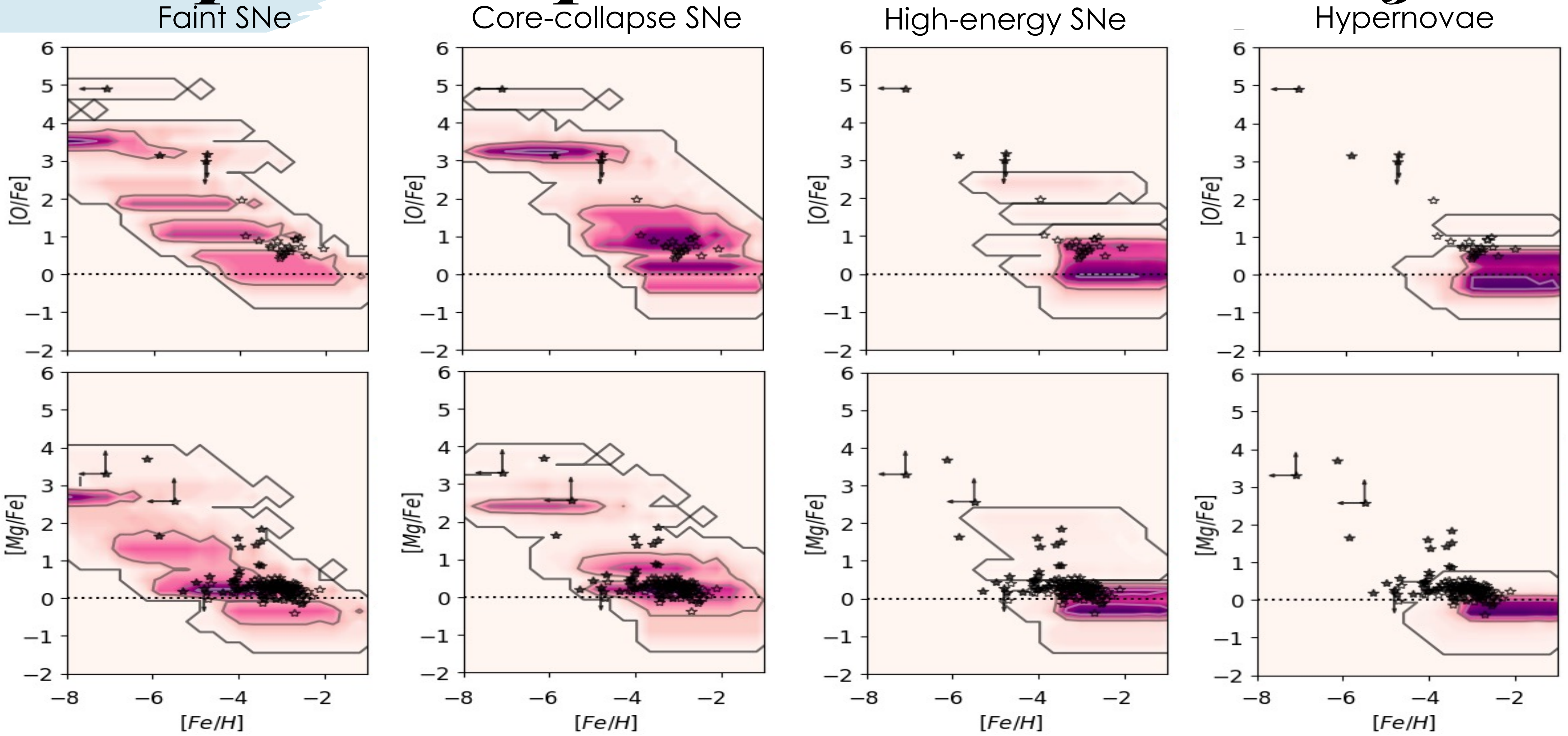
- C-normal: [C/Fe] ≤ +0.7
- CEMP-no: [C/Fe] > +0.7, [Ba/Fe] < 0
- CEMP-s/r: [C/Fe] > +0.7, [Ba/Fe] > +1

$[X/Y]=\log_{10}(M_X/M_Y)-\log_{10}(M_X/M_Y)_\odot$

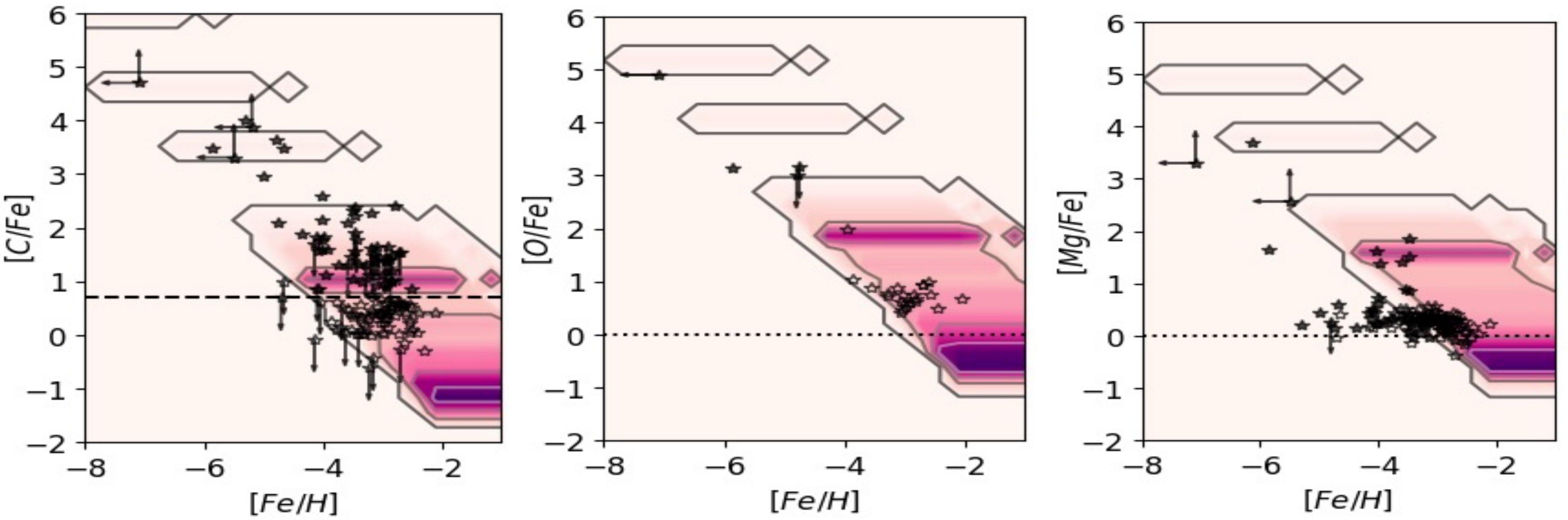
Skuladottir+23



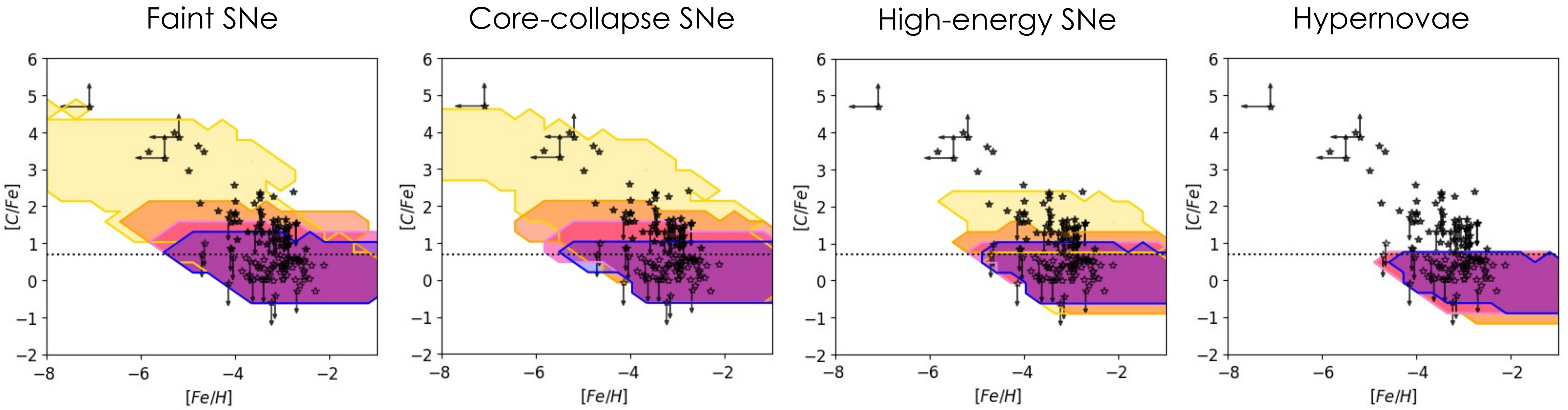
Pop III stars pure descendants – O, Mg



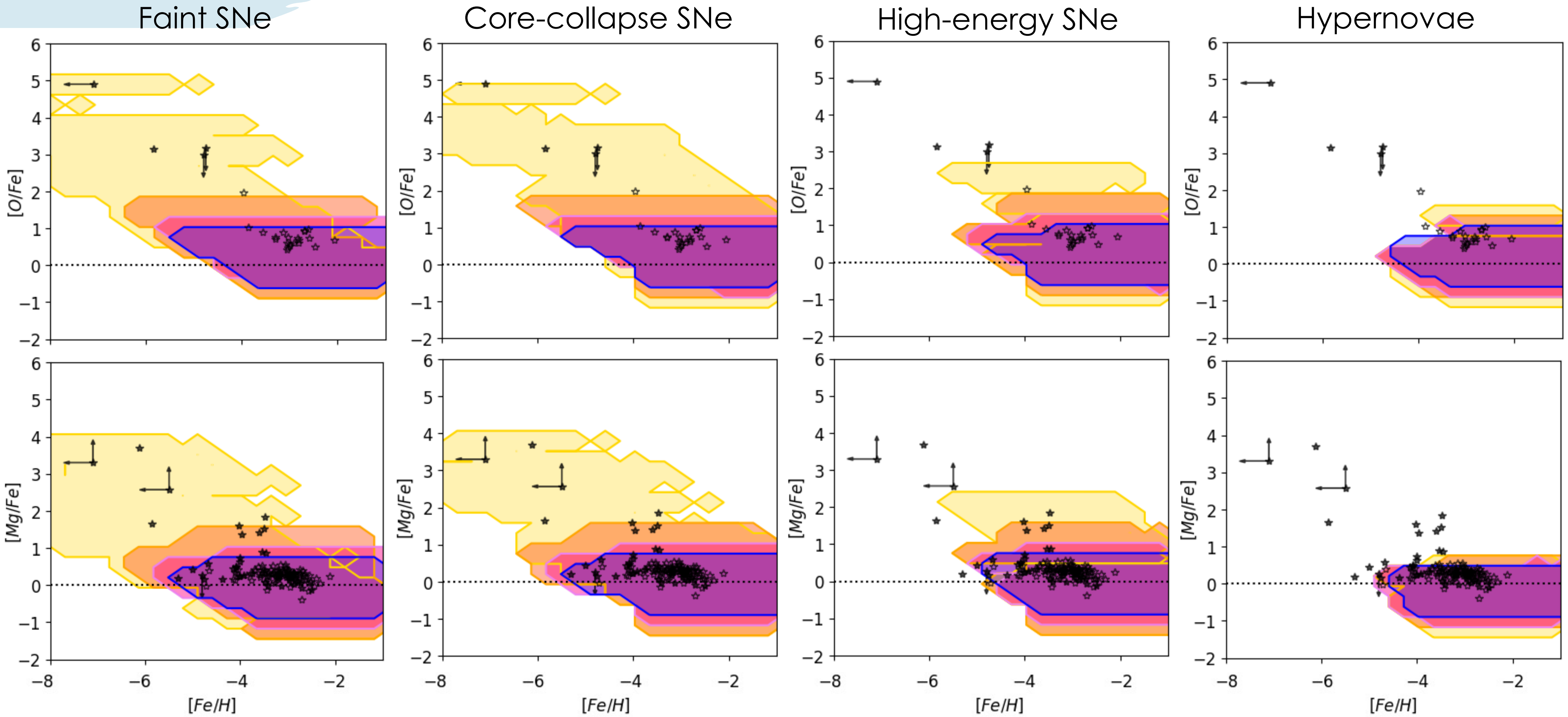
PISN pure descendants



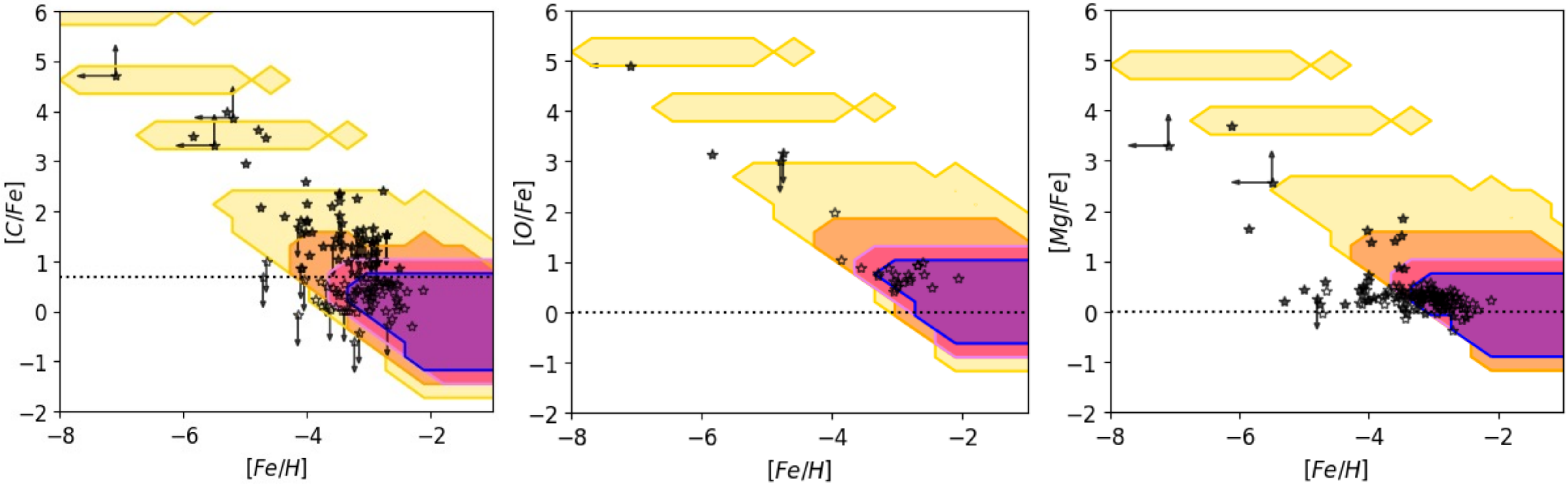
Pop III descendants - C



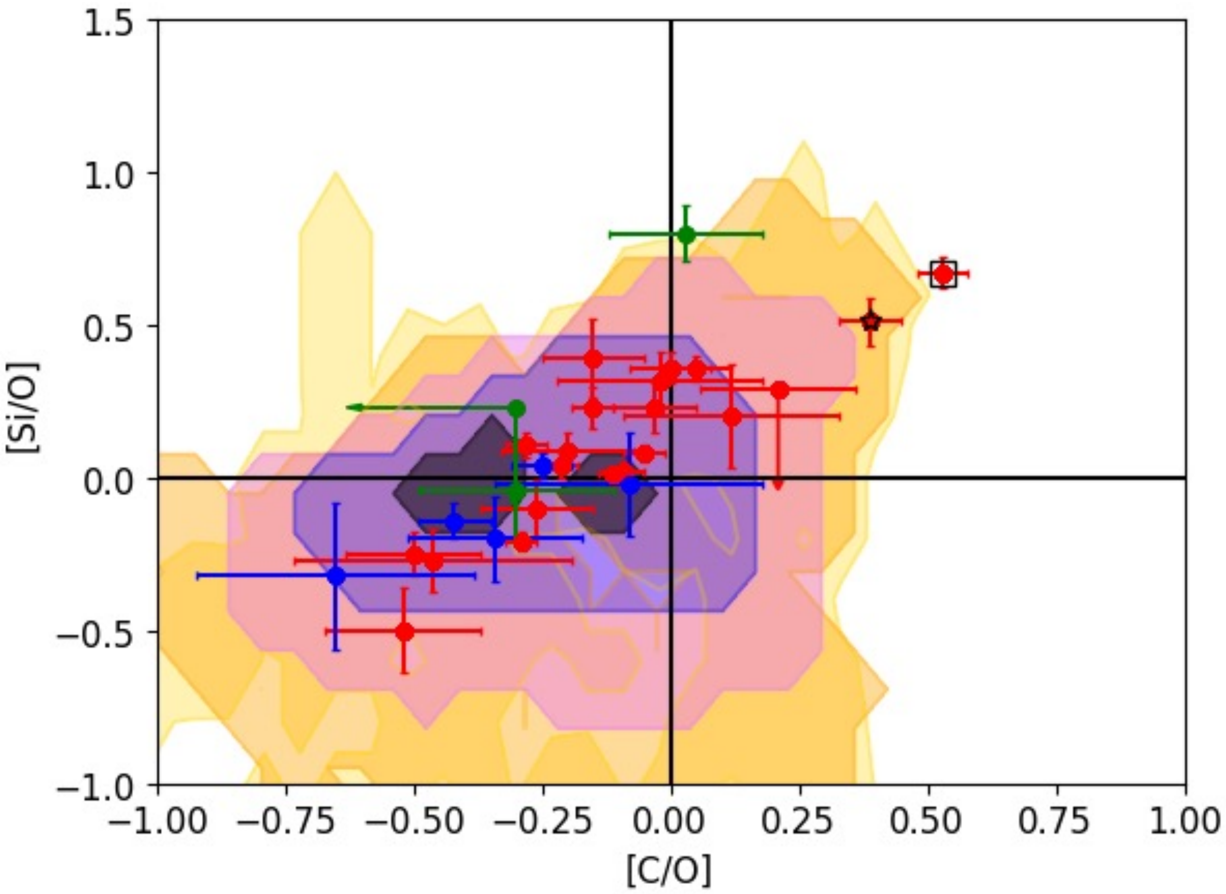
Pop III descendants – O, Mg

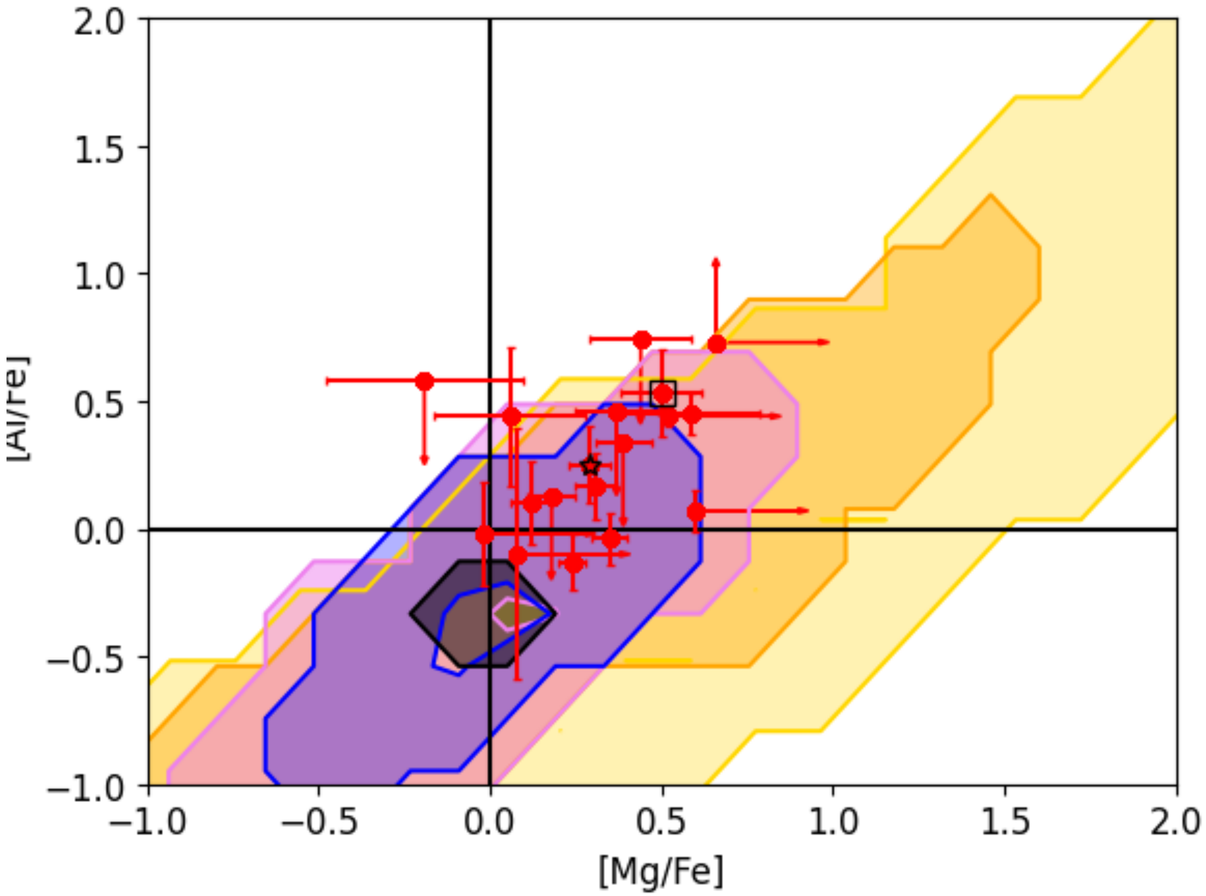


PISN descendants



A new science case: High-redshift absorption systems





Sodini+(incl. Vanni)23 (in prep.)