THE DWARF GALAXIES' GUIDE TO THE FIRST STARS

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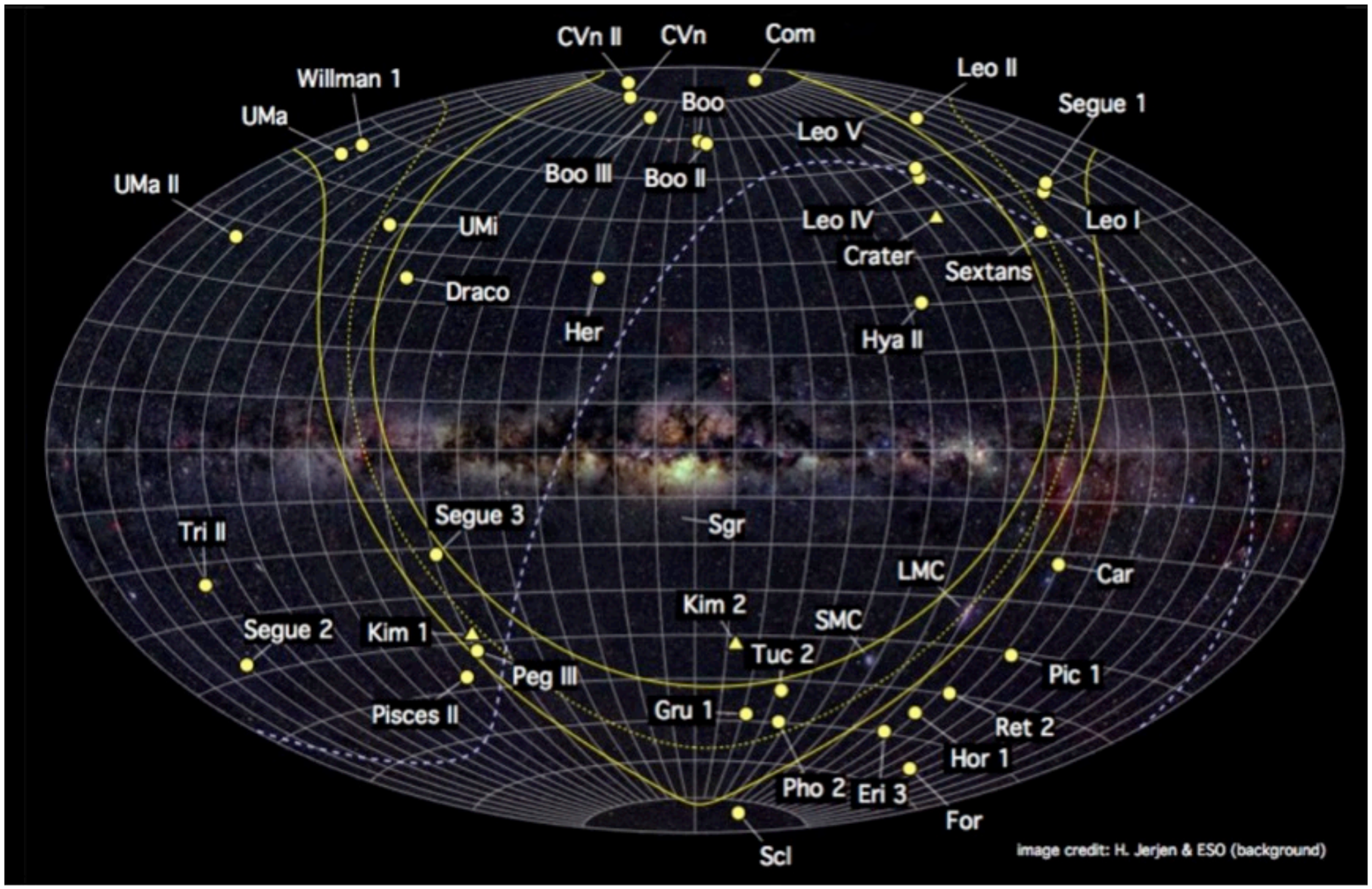
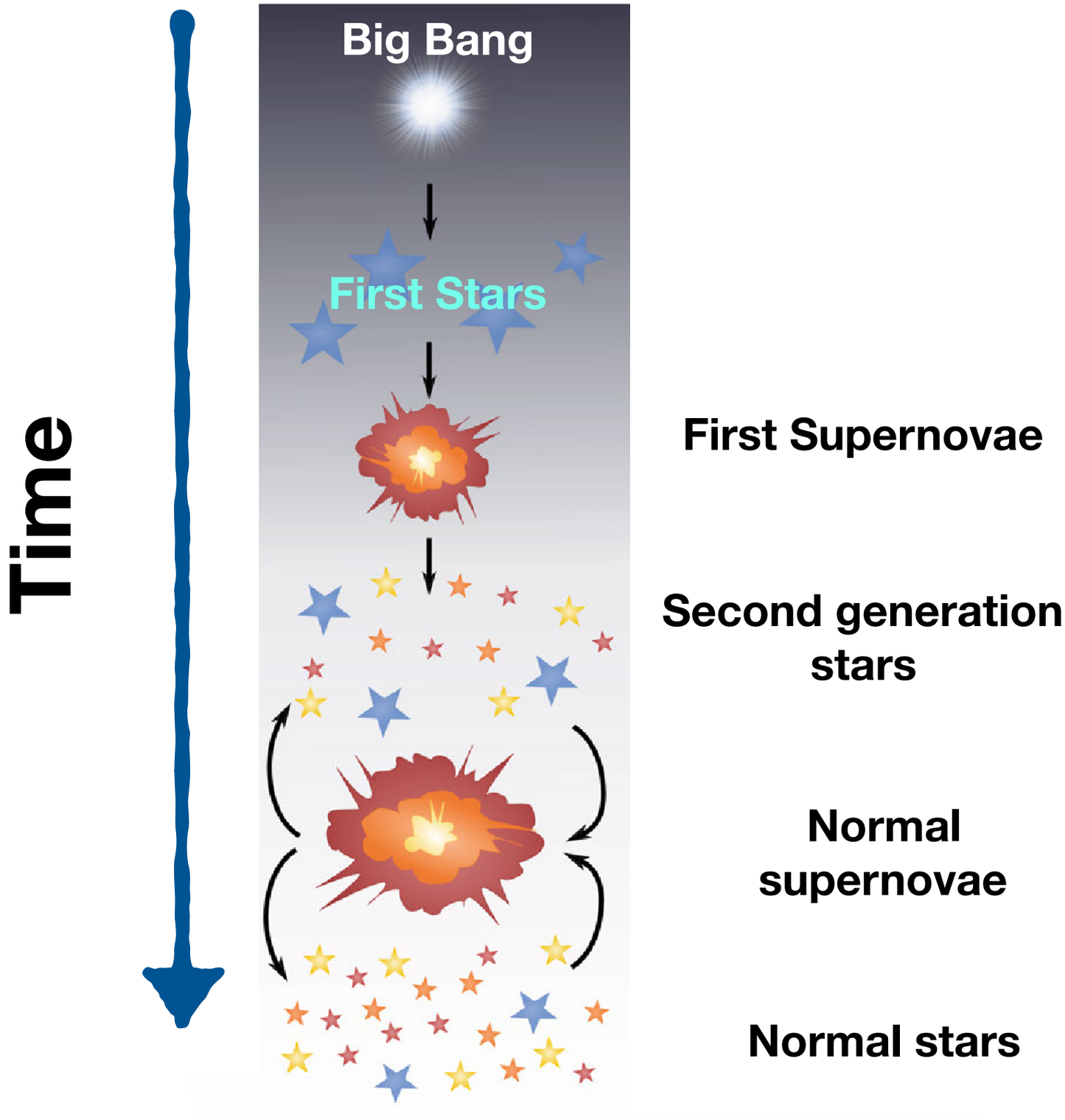
DWARF GALAXIES AROUND THE MILKY WAY

- The Milky Way has >50 known dwarf galaxy satellites
- Old and intrinsically metal-poor → windows into early chemical enrichment and the first stars



FIRST STARS (POPIII)



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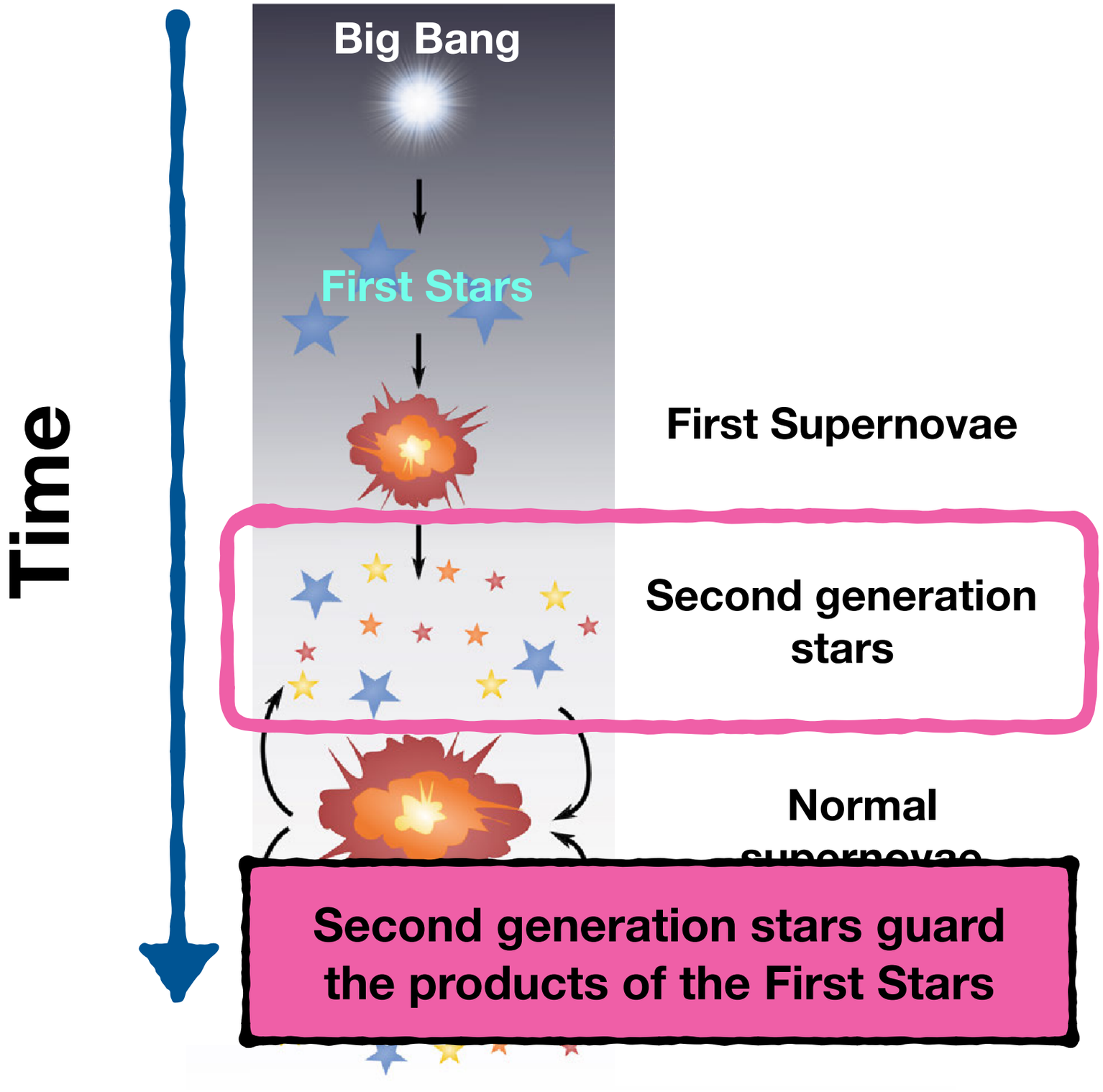
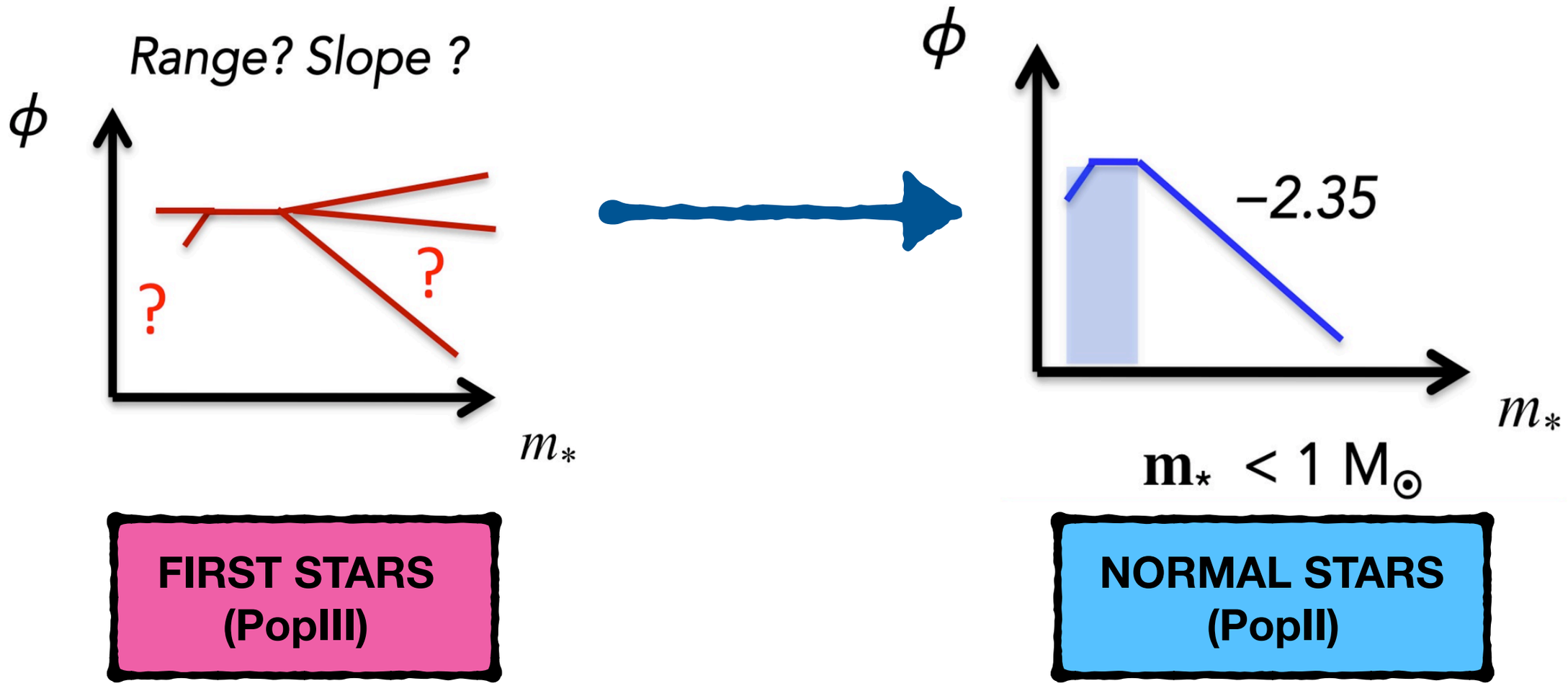

Time
Big Bang
First Stars
First Supernovae
Second generation stars
Normal supernovae
Second generation stars guard the products of the First Stars

WHAT IS THE MASS DISTRIBUTION OF FIRST STARS

- First stars were likely more massive than the present day.
- Initial mass function still unknown - likely more massive than today



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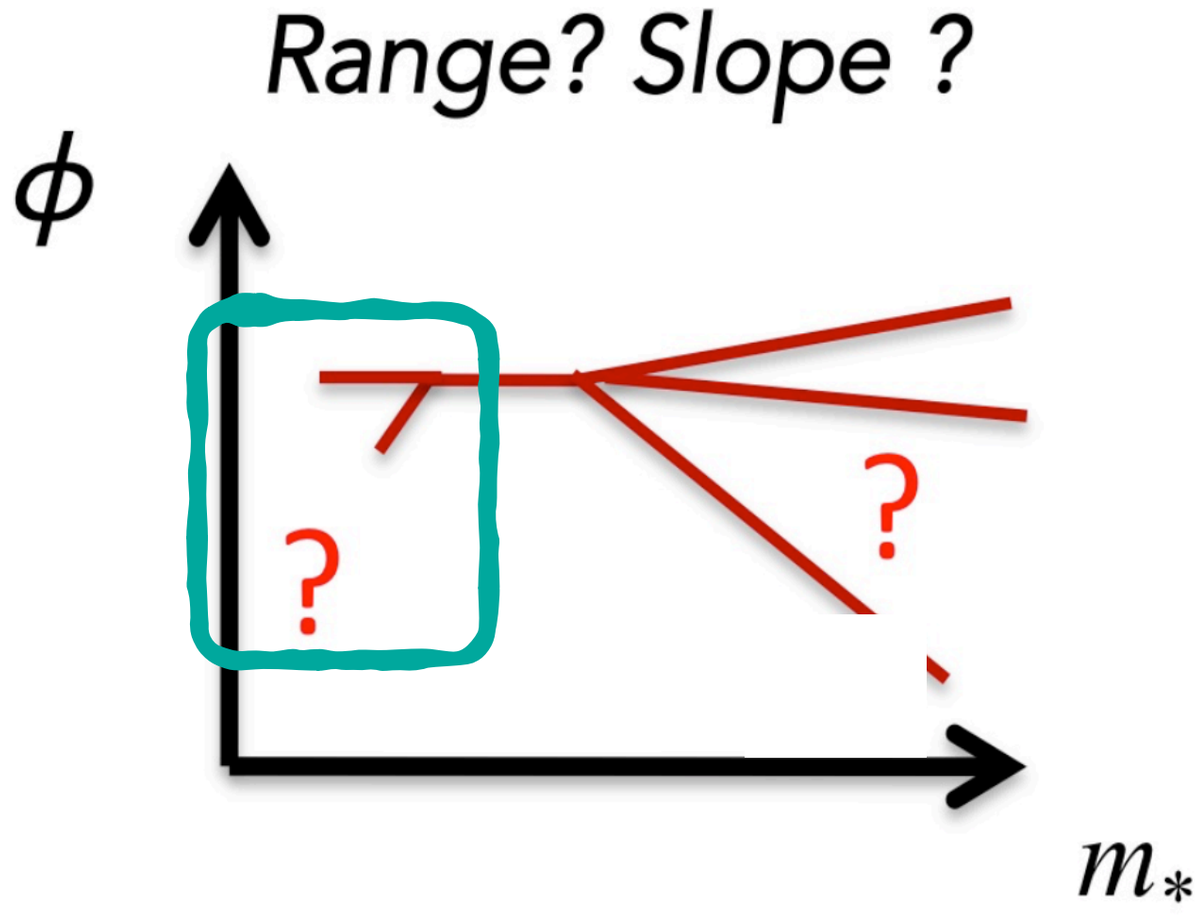

Were low mass stars able to form?

If stars ≲0.8 $M_\odot$ formed they would be alive today!

NON-DETECTION OF ZERO-METALLICITY STARS

- The smallest dwarf galaxies, ultra faint dwarf galaxies have the highest fractions of metal-poor stars → perfect systems to search for metal-free stars.

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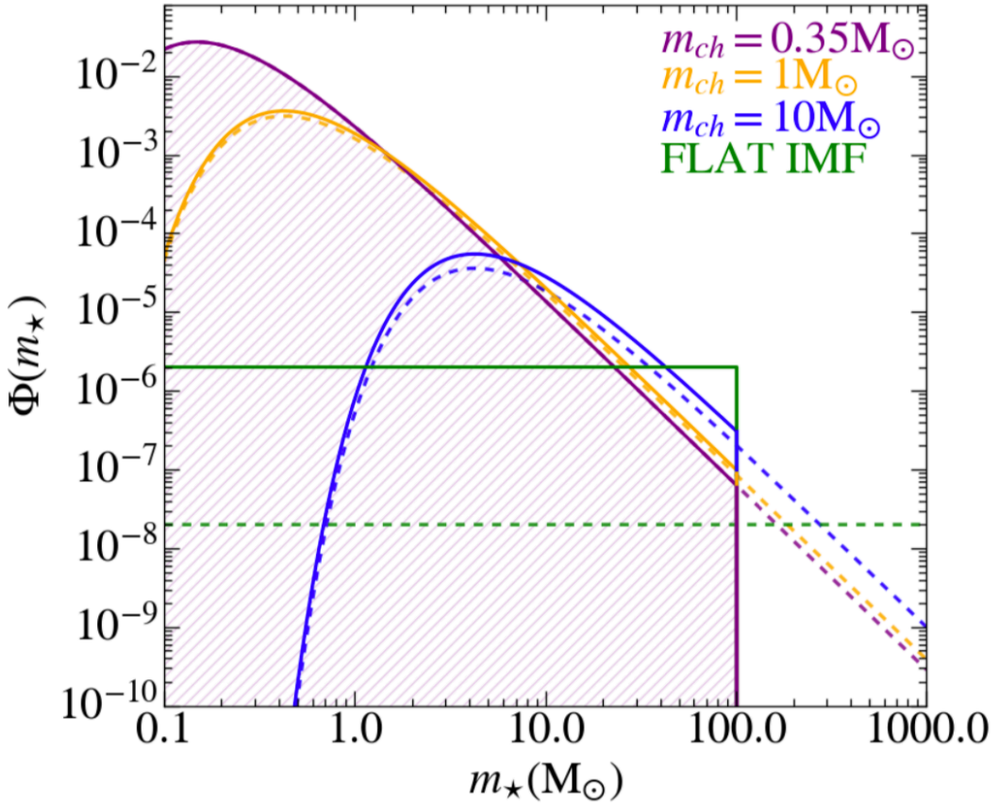

Rossi, Salvadori & Skúladóttir 2021

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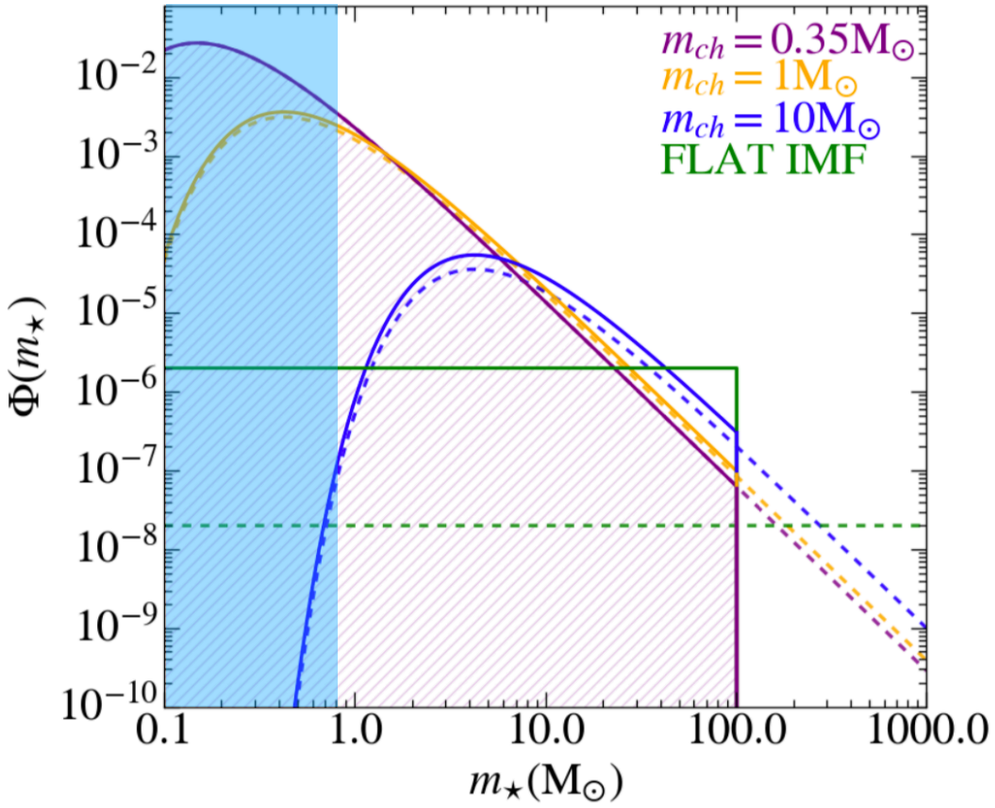

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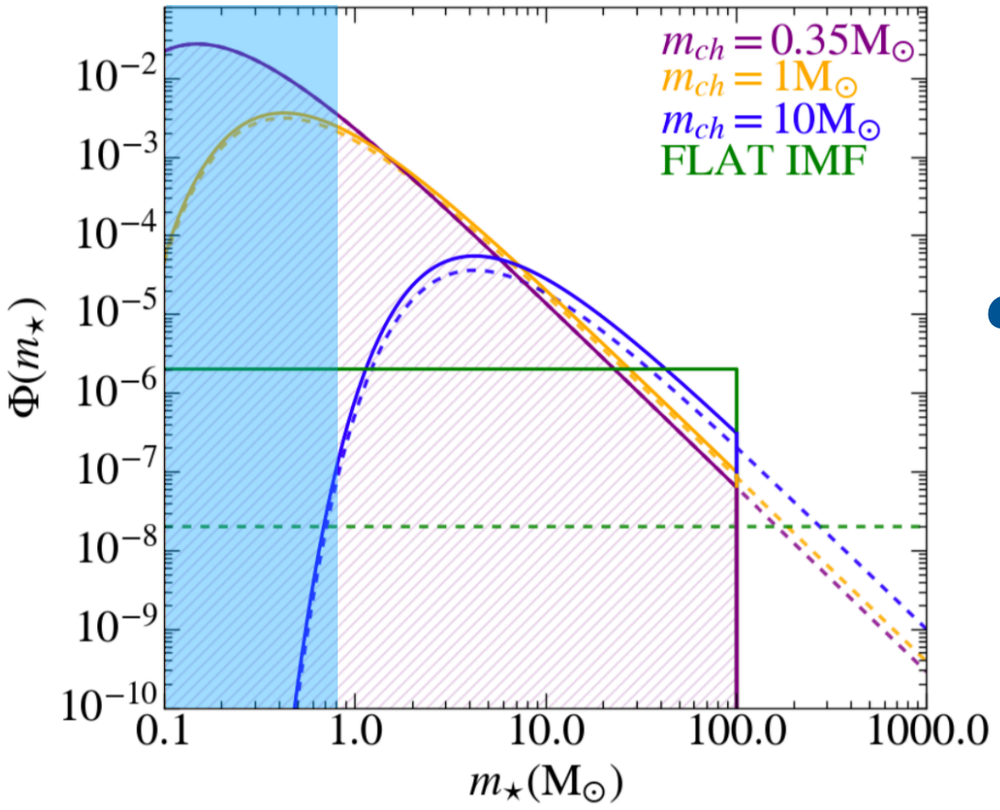
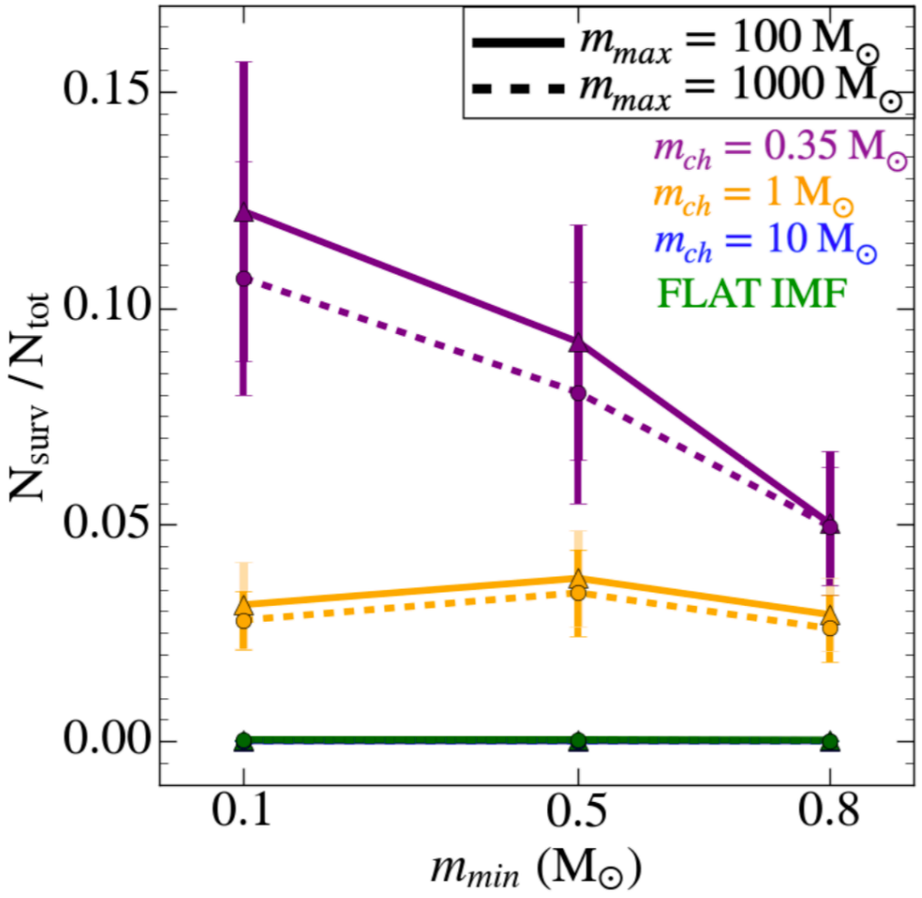


Number of surviving first stars!



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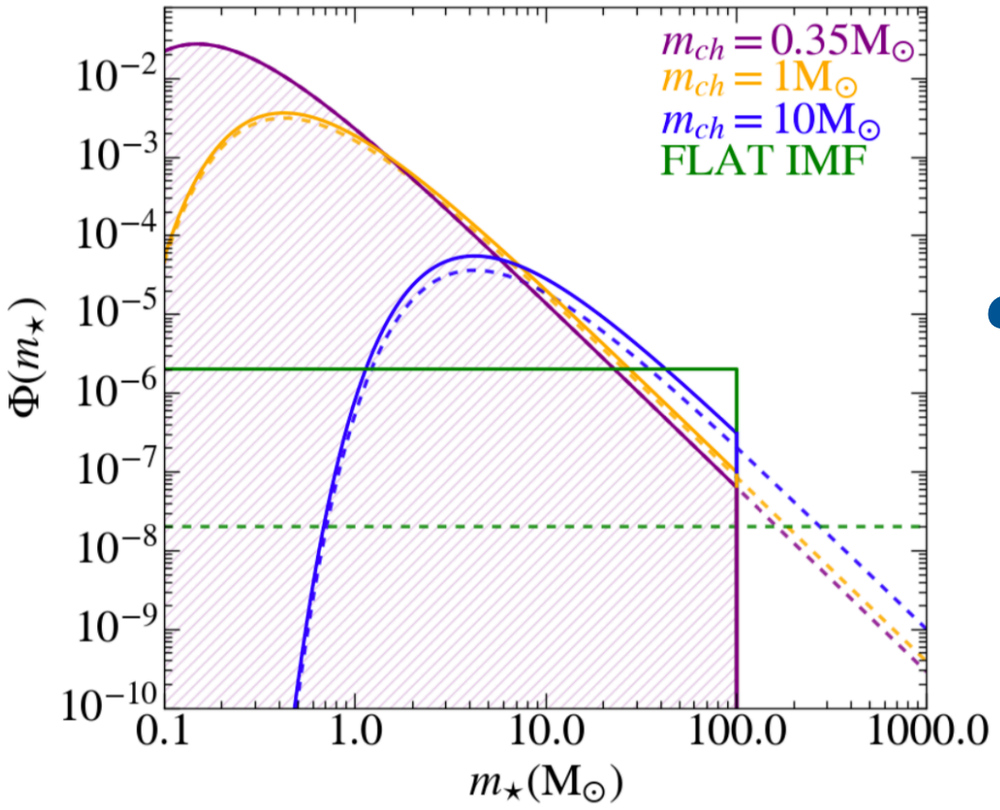
NON-DETECTION OF ZERO-METALLICITY STARS

Present-day IMF excluded by our model!

Different proposed IMFs



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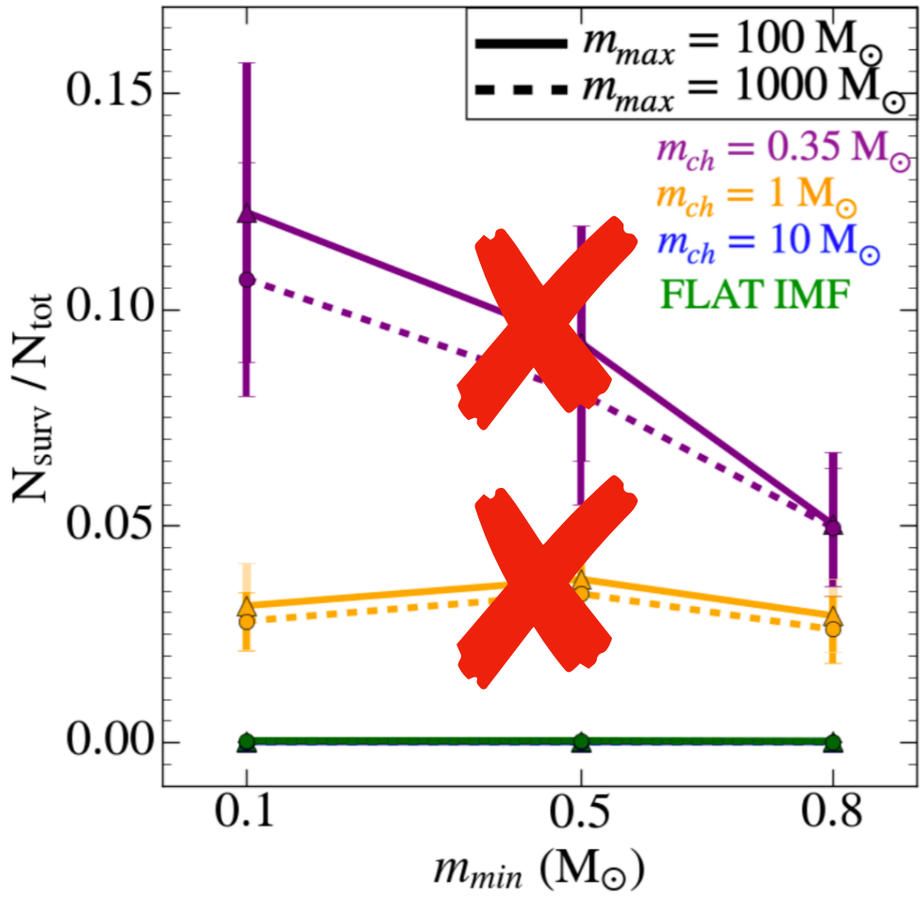

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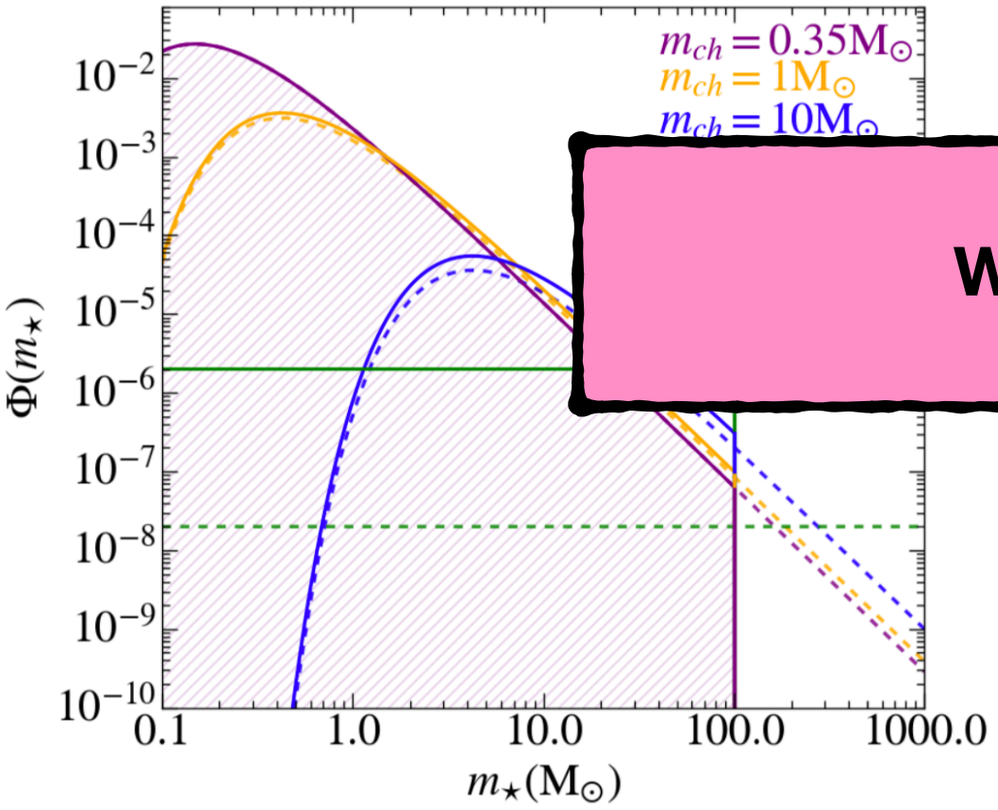

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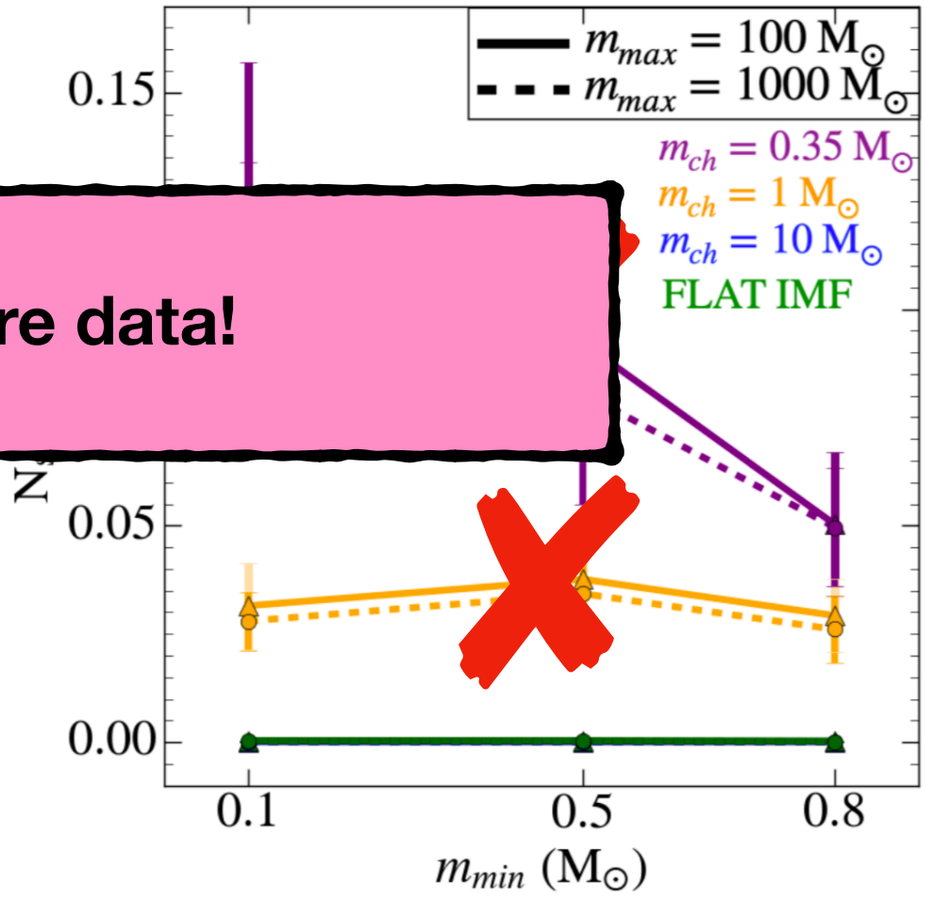
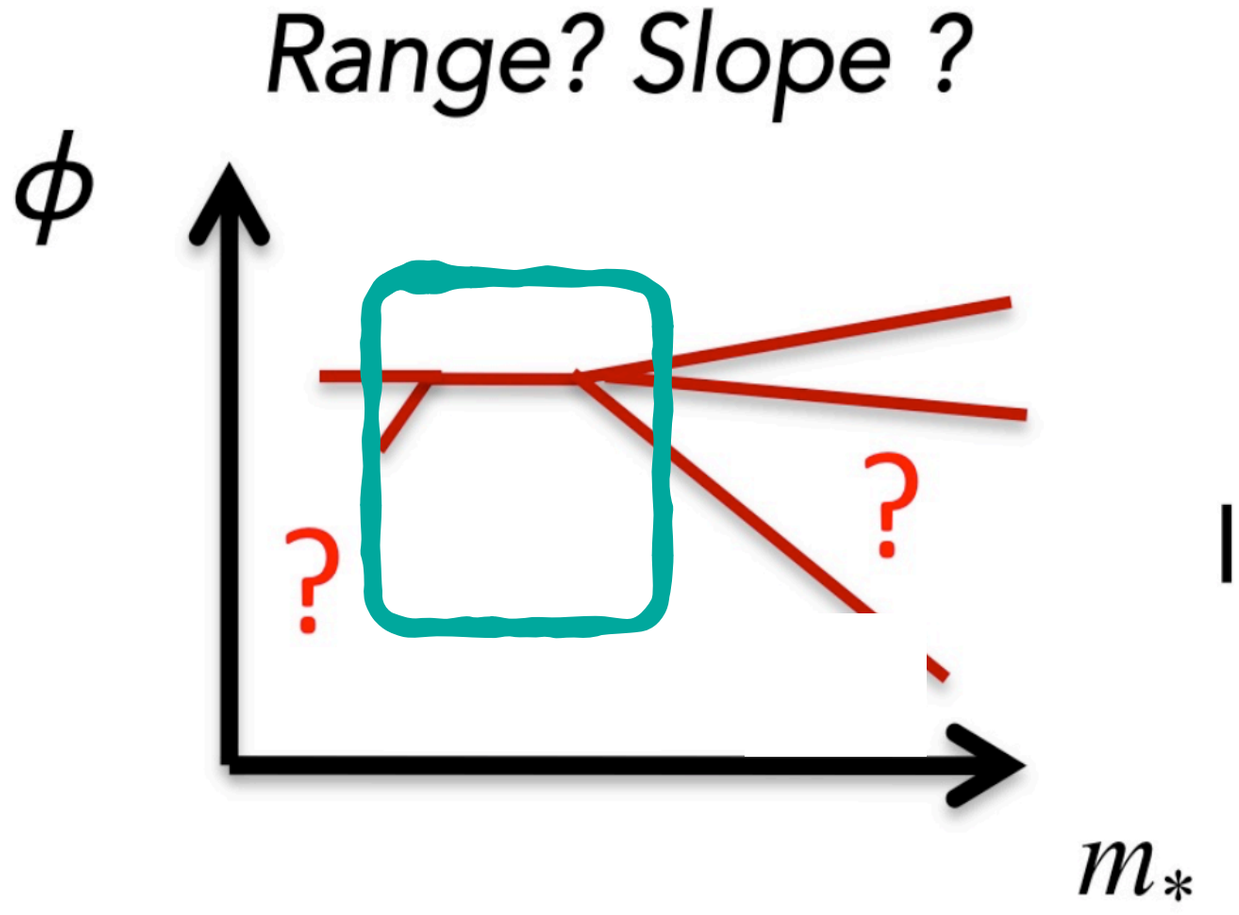


We need more data!

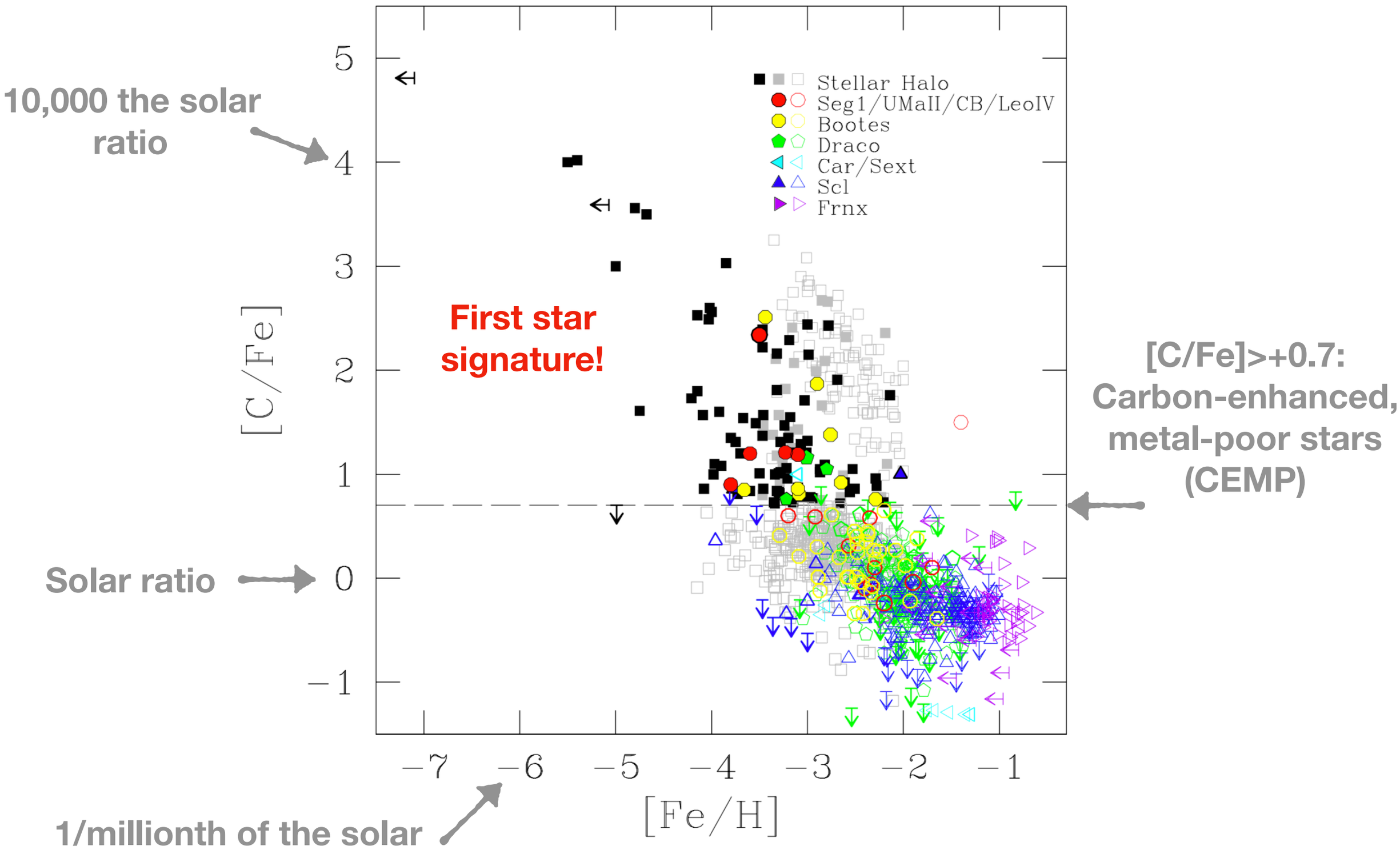
Rossi, Salvadori & Skúladóttir 2021

WHAT IS THE MASS DISTRIBUTION OF FIRST STARS



What can we learn about typical first star supernovae?

CEMP-NO STAR: BONAFIDE SECOND GENERATION STARS?



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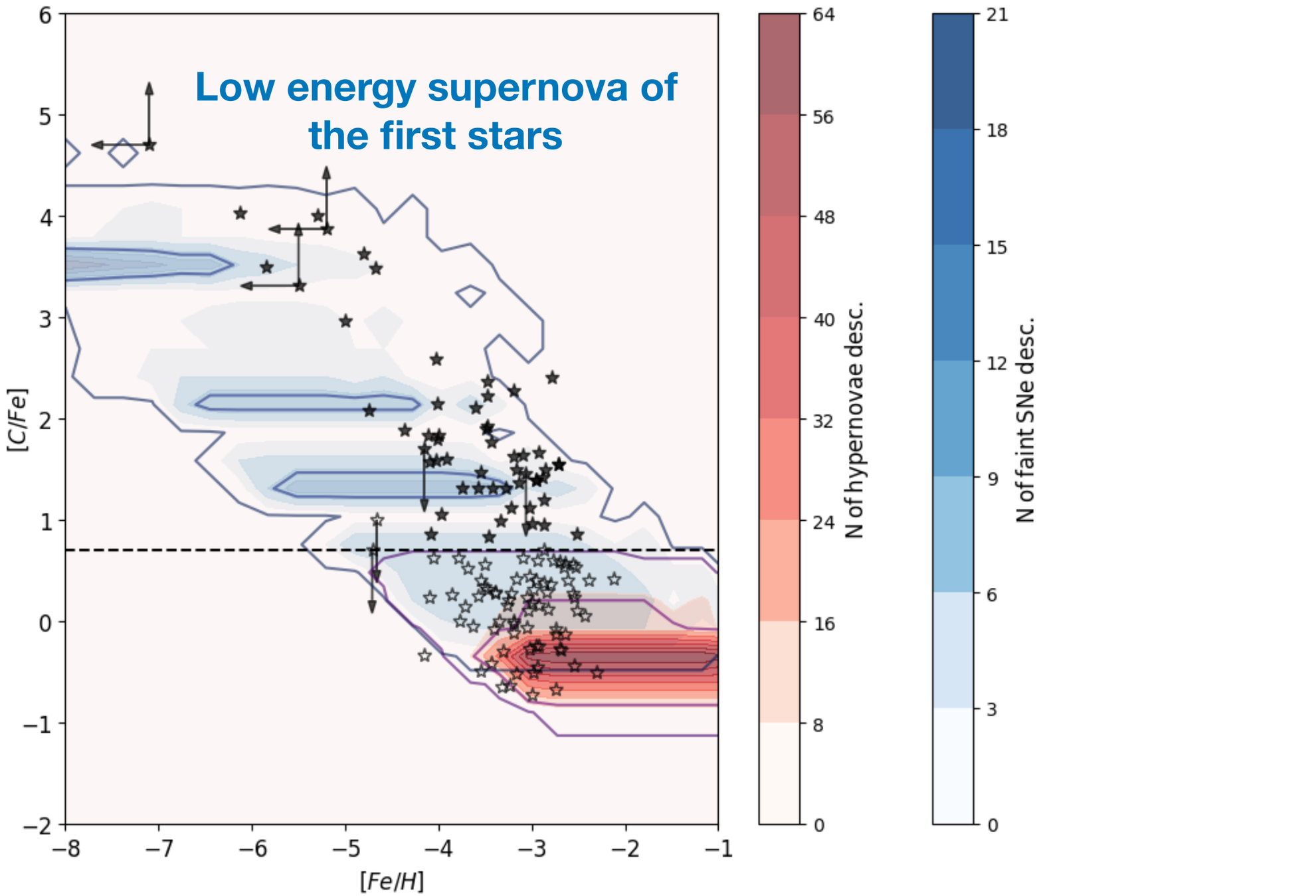

Adopted from, Vanni, Salvadori & Skúladóttir 2023, in press

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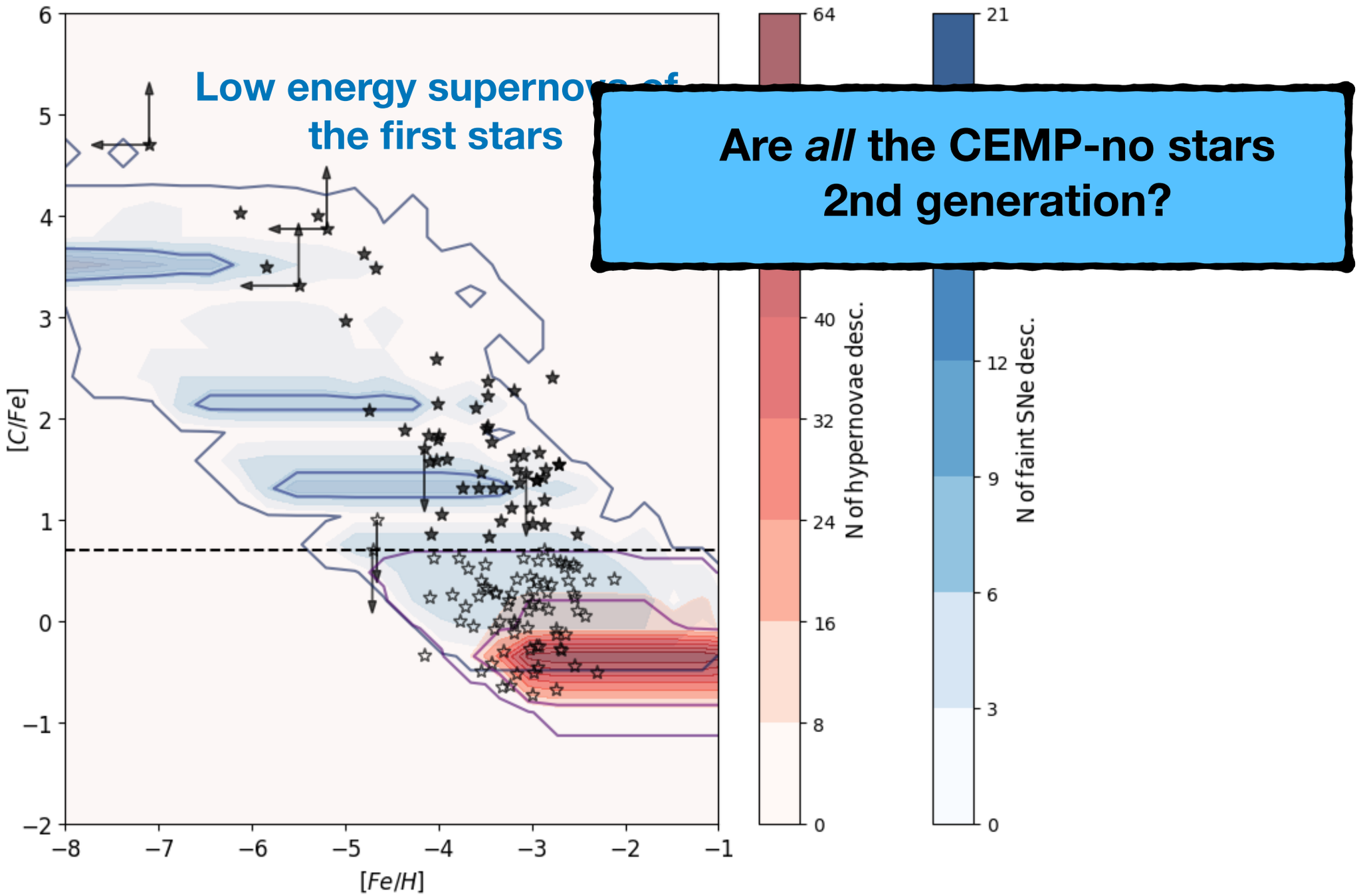

Are *all* the CEMP-no stars 2nd generation?

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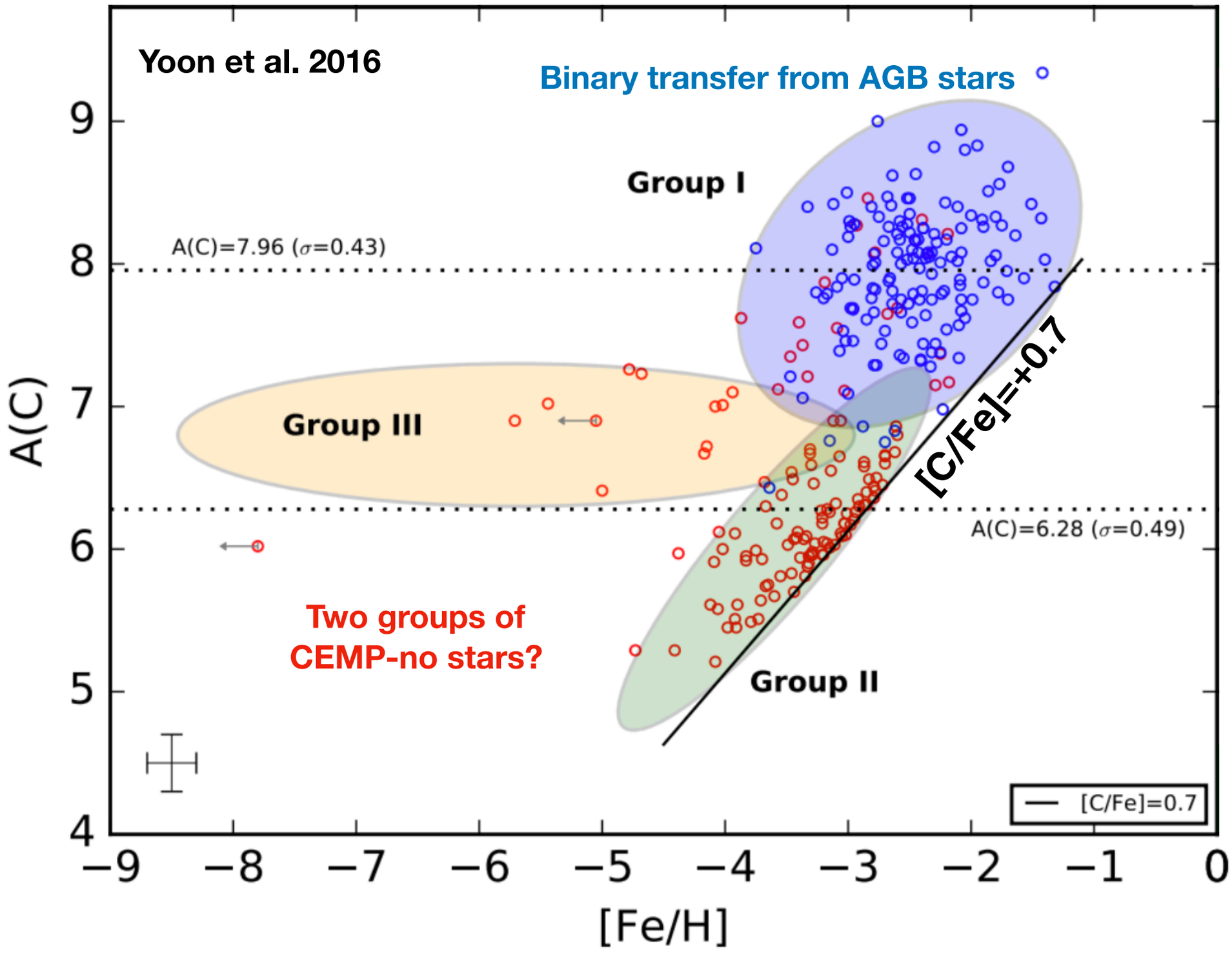
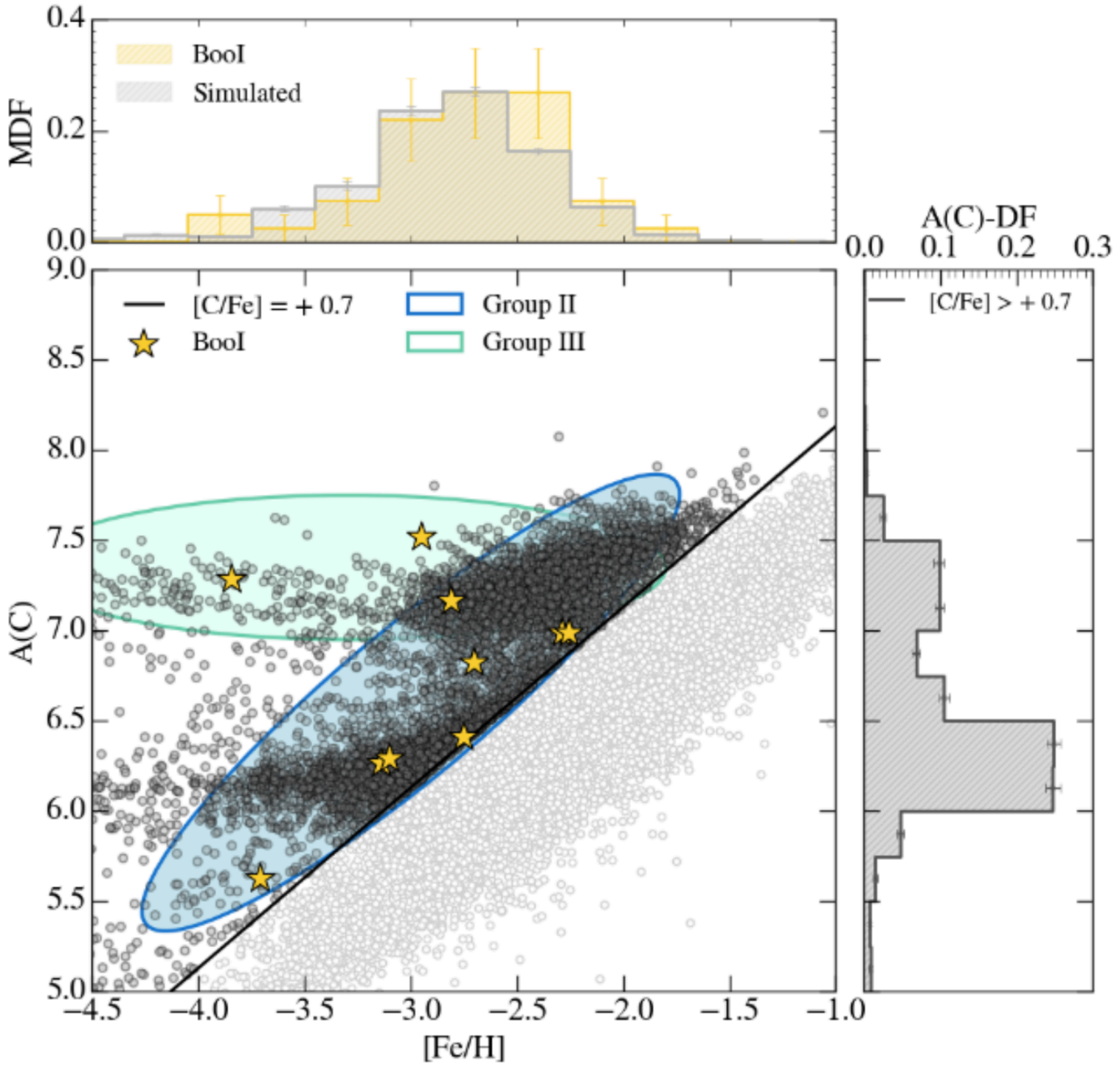
MULTIPLE POPULATIONS OF CEMP STARS?

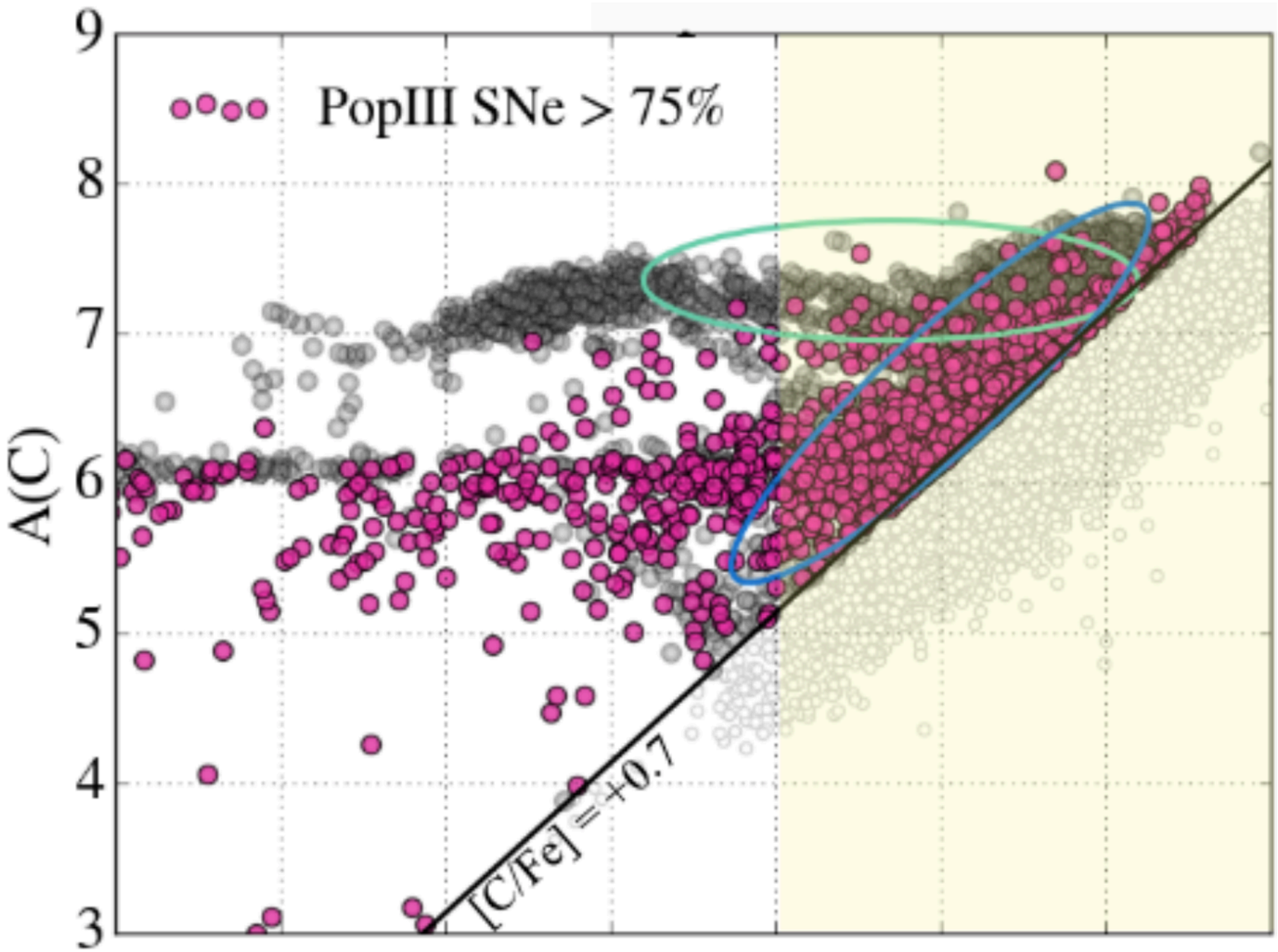


MODEL OF BOOTES I



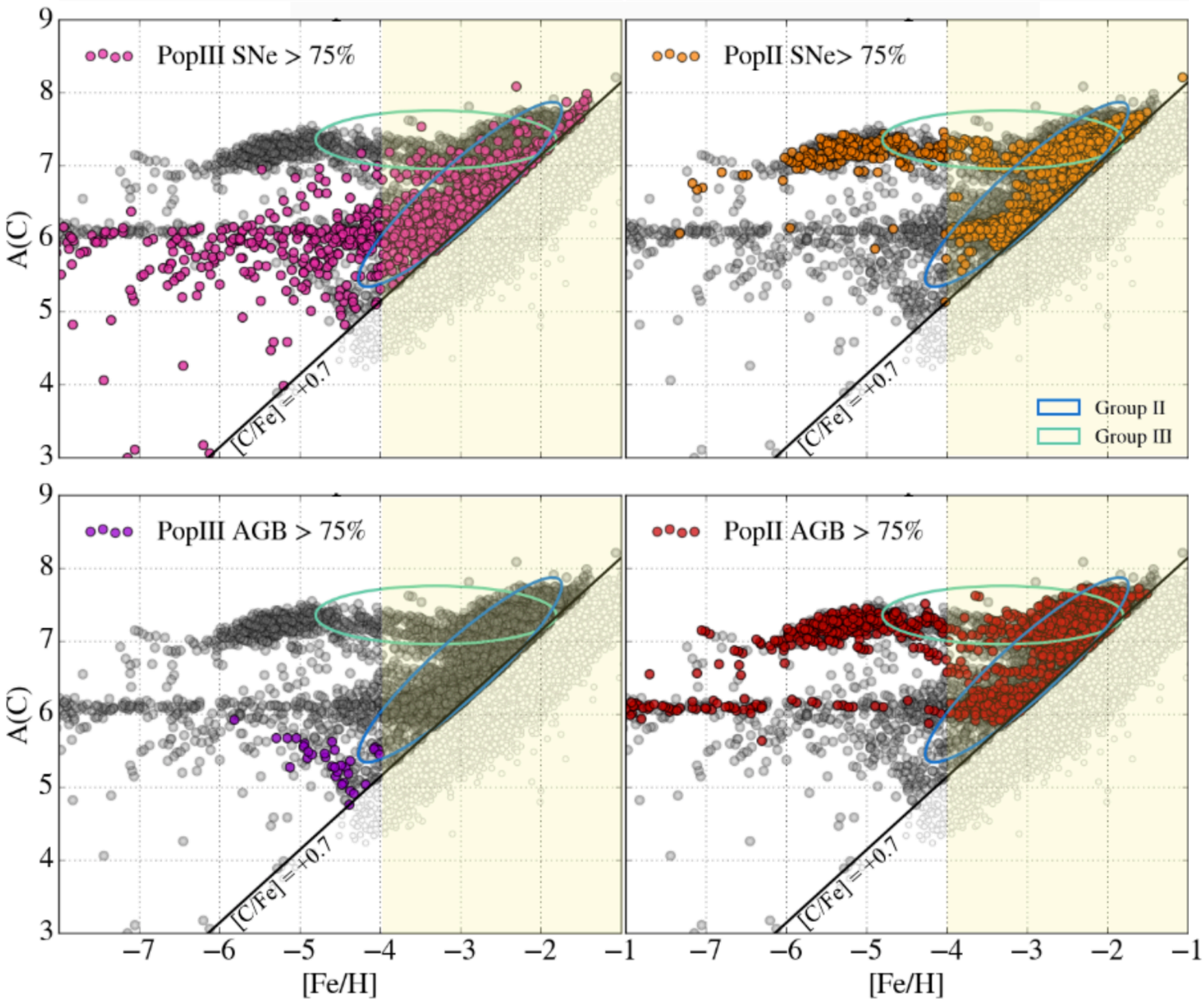
Rossi, Salvadori, Skúladóttir and Vanni, submitted (last week!)

DESCENDANTS OF FIRST SUPERNOVAE (POPIII)



Rossi, Salvadori, Skúladóttir and Vanni, submitted (last week!)

DIFFERENT CEMP POPULATIONS



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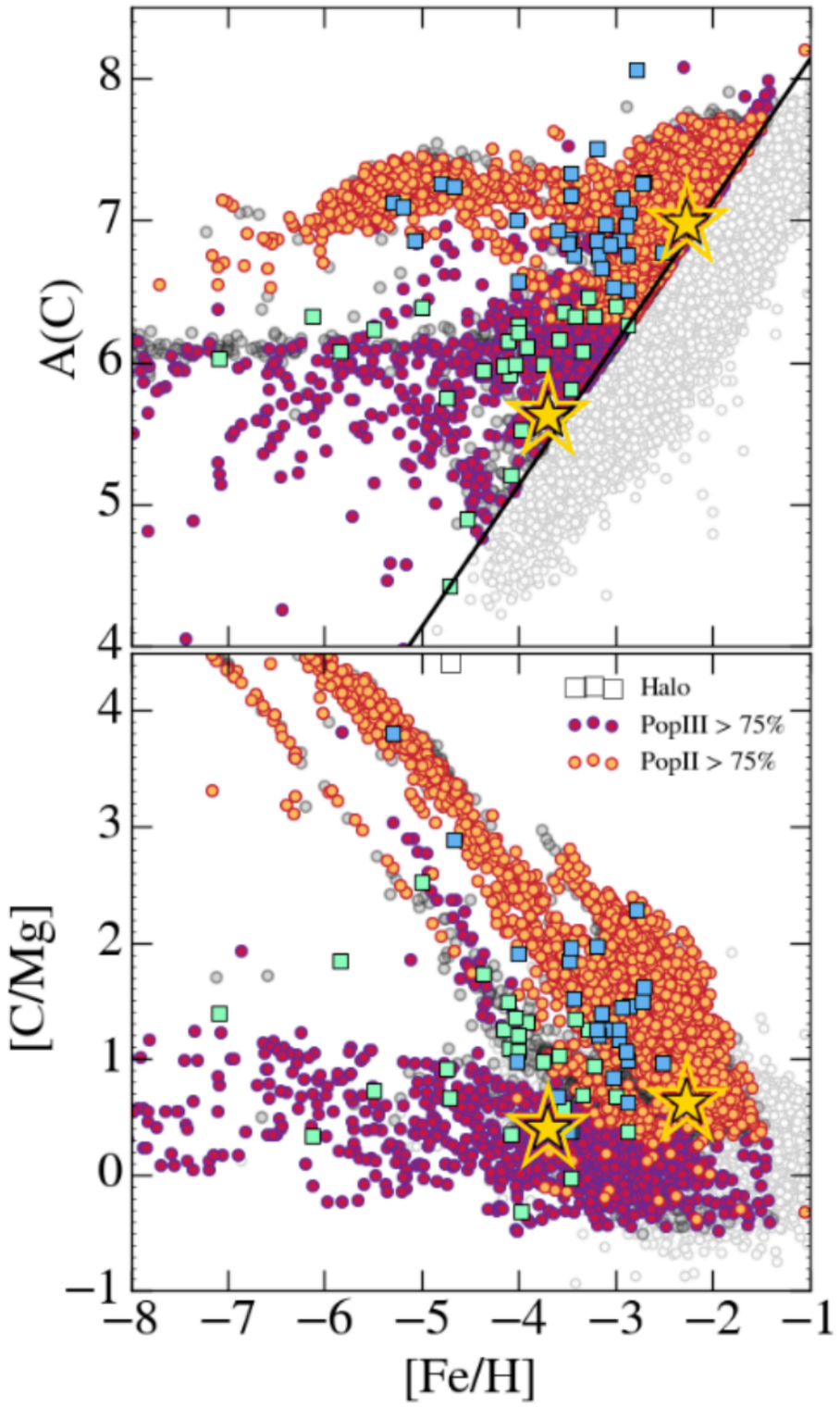
COMPARISON WITH THE HALO



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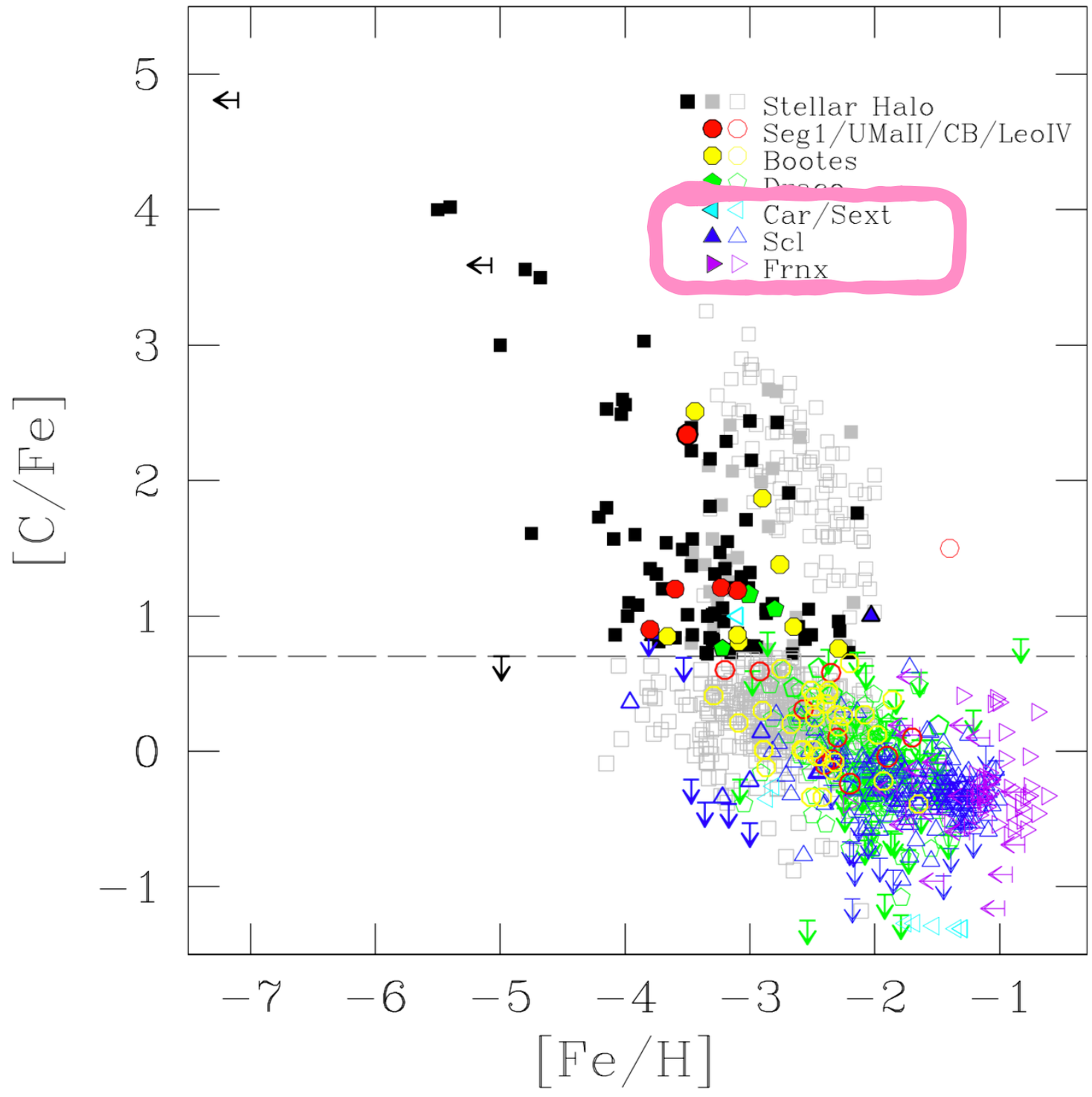
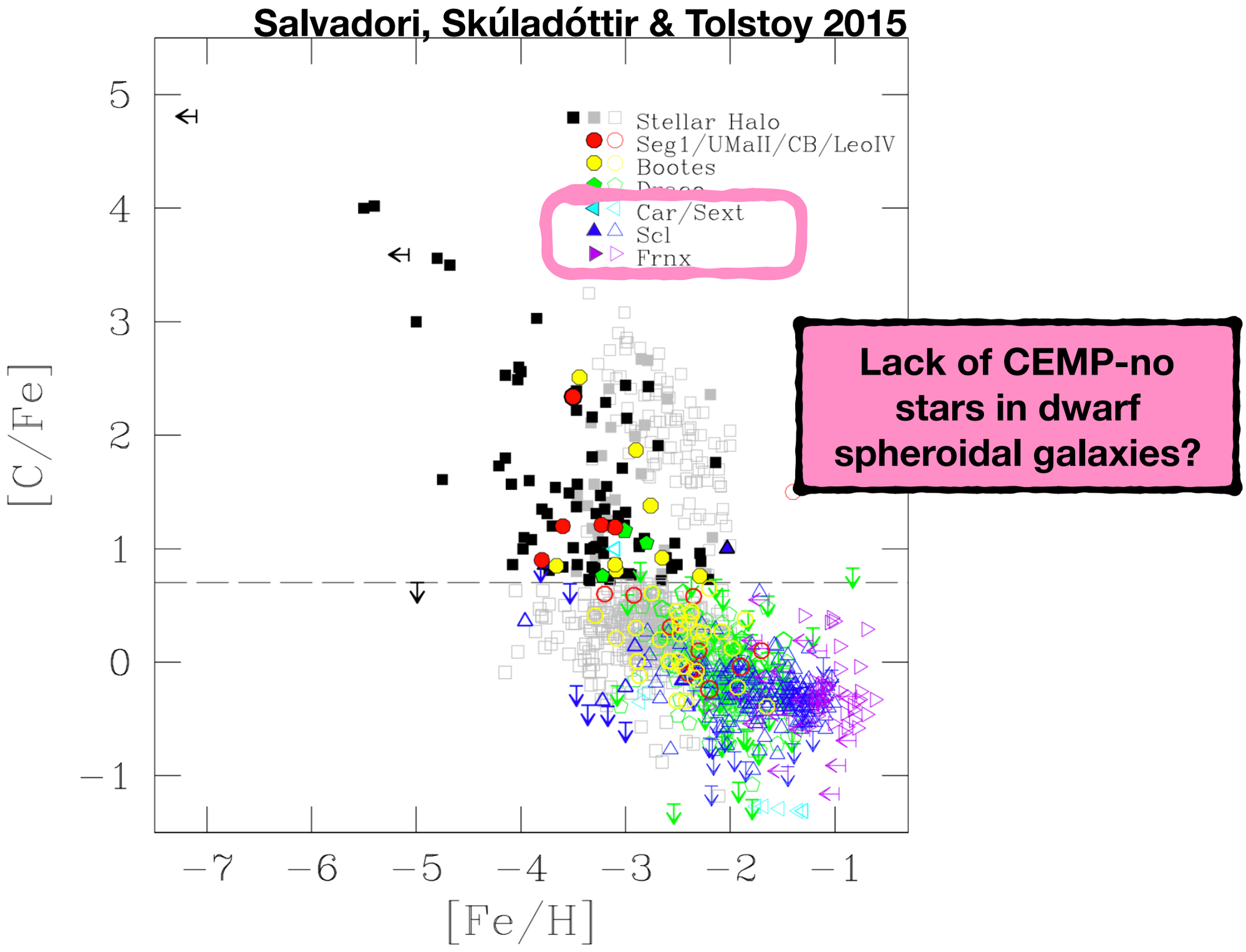
CEMP STARS


Stellar Halo
Seg1/UMaII/CB/LeoIV
Bootes
Car/Sext
Scl
Frnx
5
4
3
2
1
0
−1
−7
−6
−5
−4
−3
−2
−1
[C/Fe]
[Fe/H]

CEMP STARS


Salvadori, Skúladóttir & Tolstoy 2015
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5
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2
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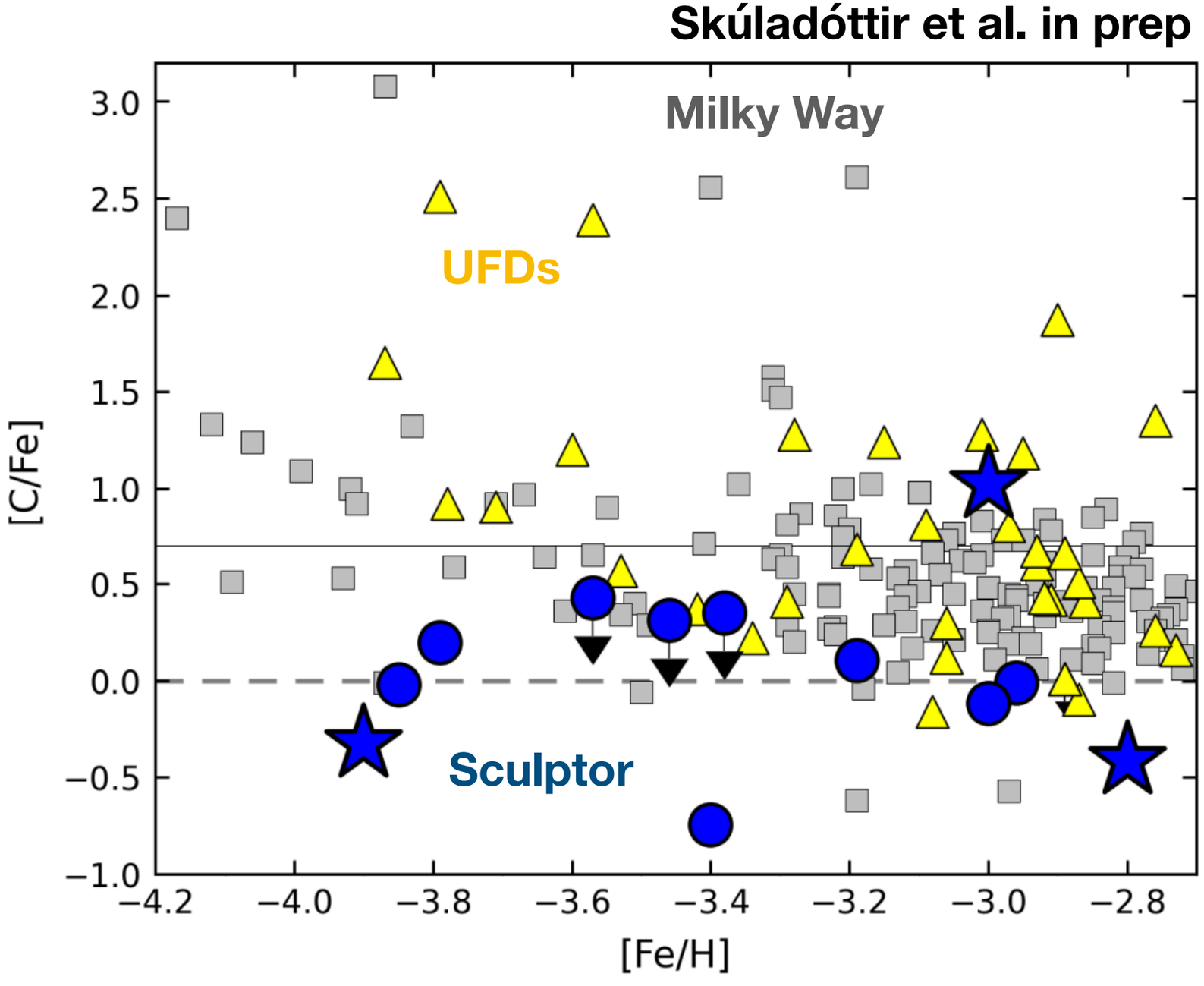
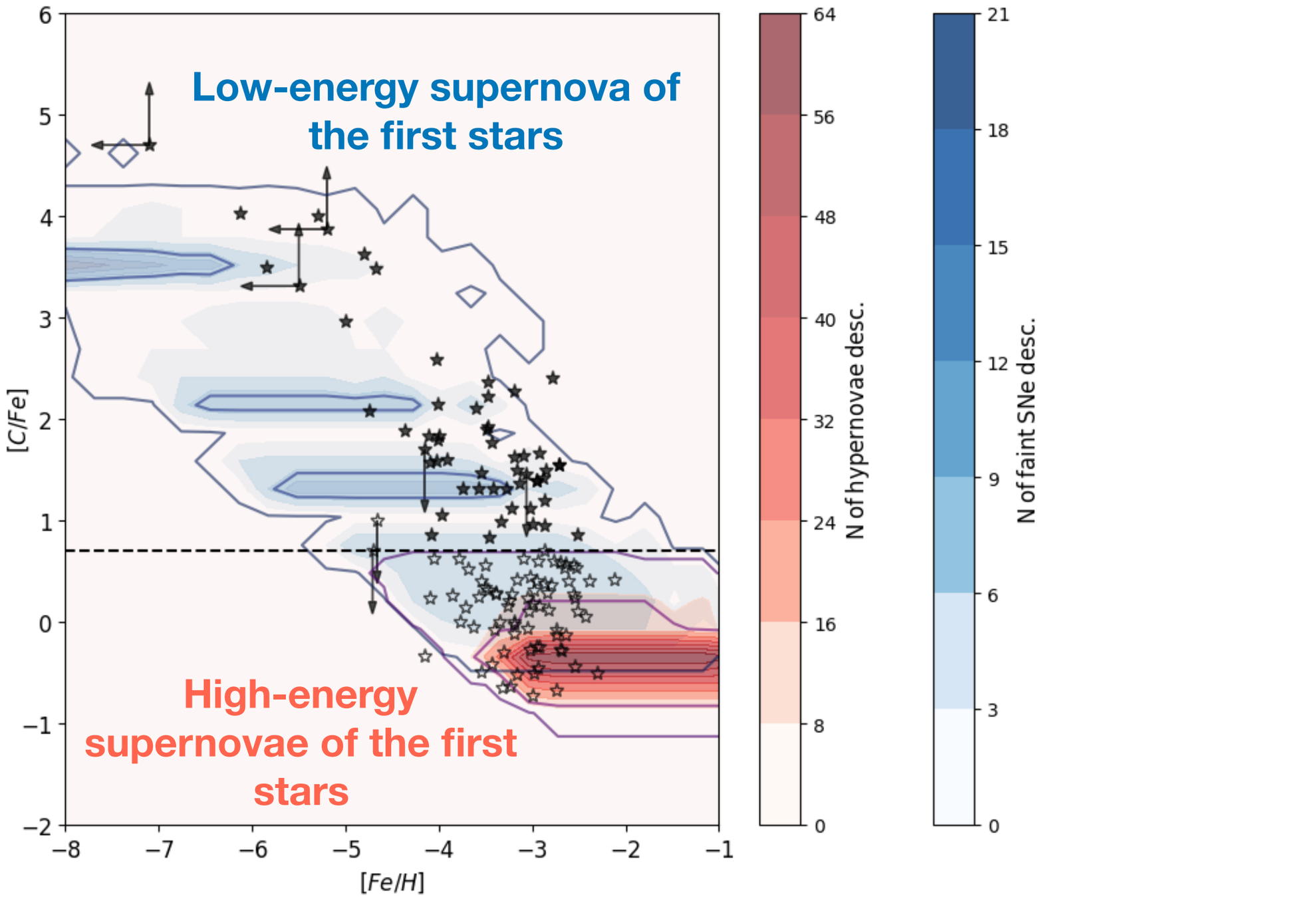
0
−1
−7
−6
−5
−4
−3
−2
−1
Lack of CEMP-no stars in dwarf spheroidal galaxies?

THE SCULPTOR DWARF SPHEROIDAL



Low fraction of CEMP-no stars in Sculptor!

SIGN OF HIGH ENERGY POPIII SUPERNOVAE?



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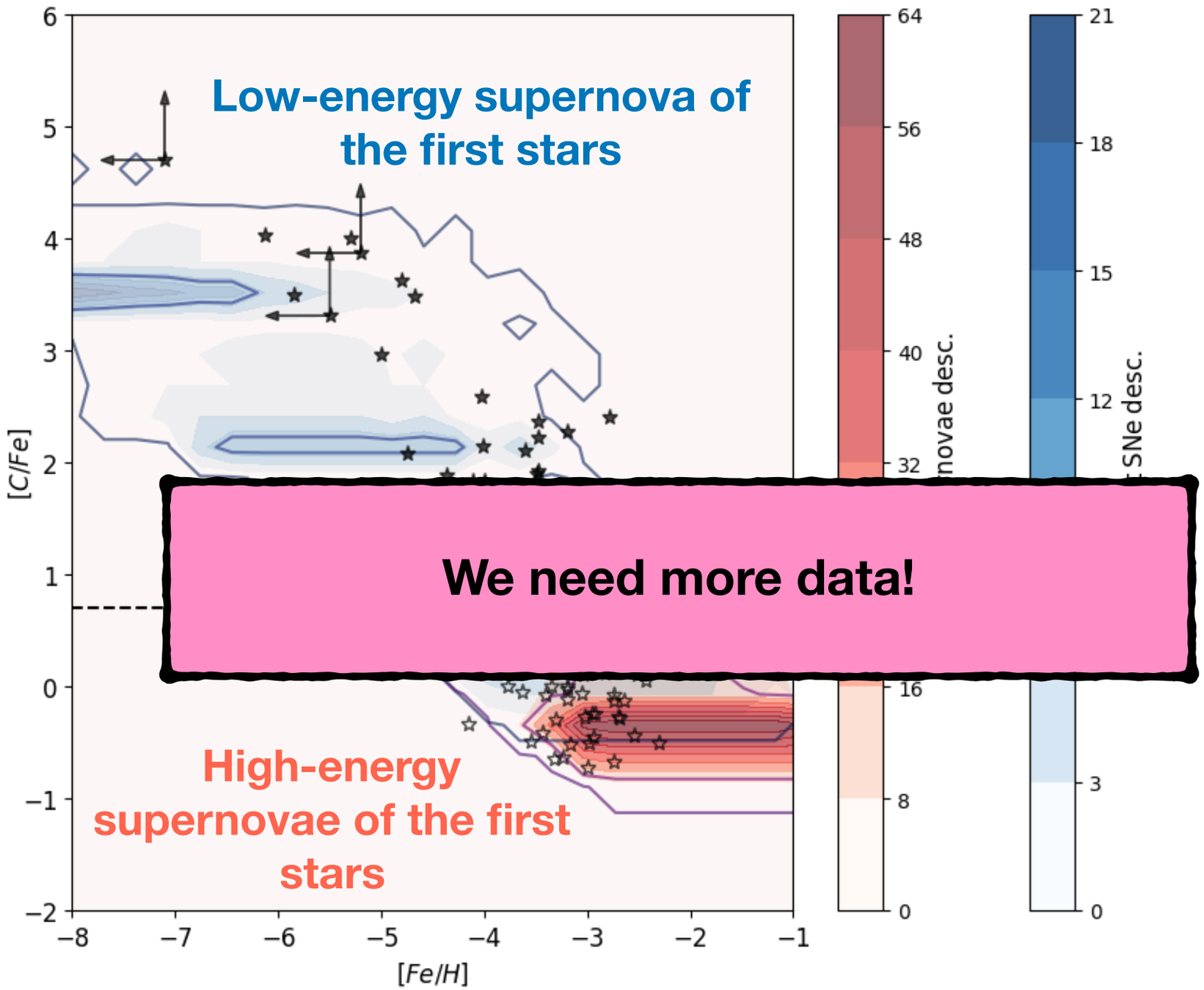

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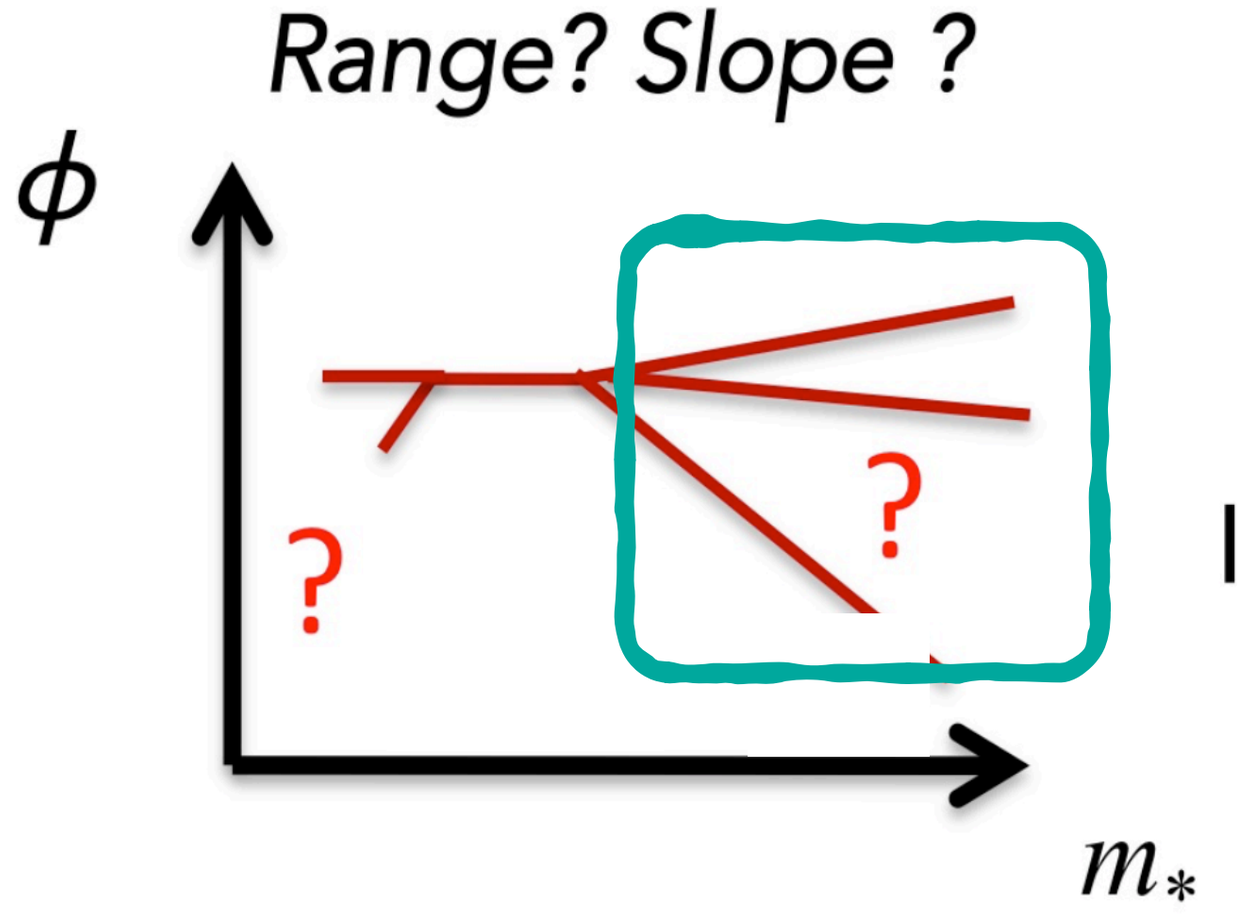
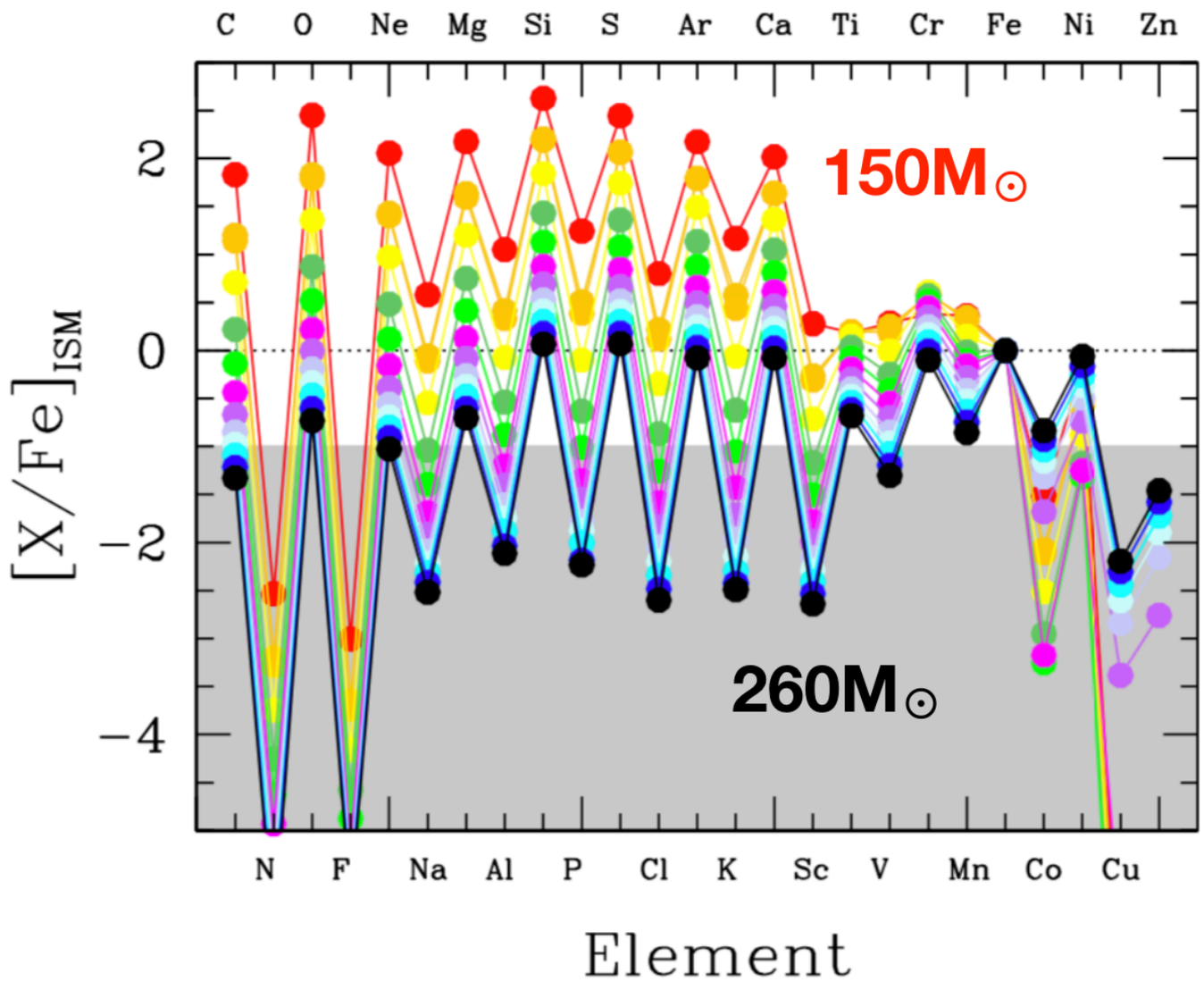


What about massive first stars?

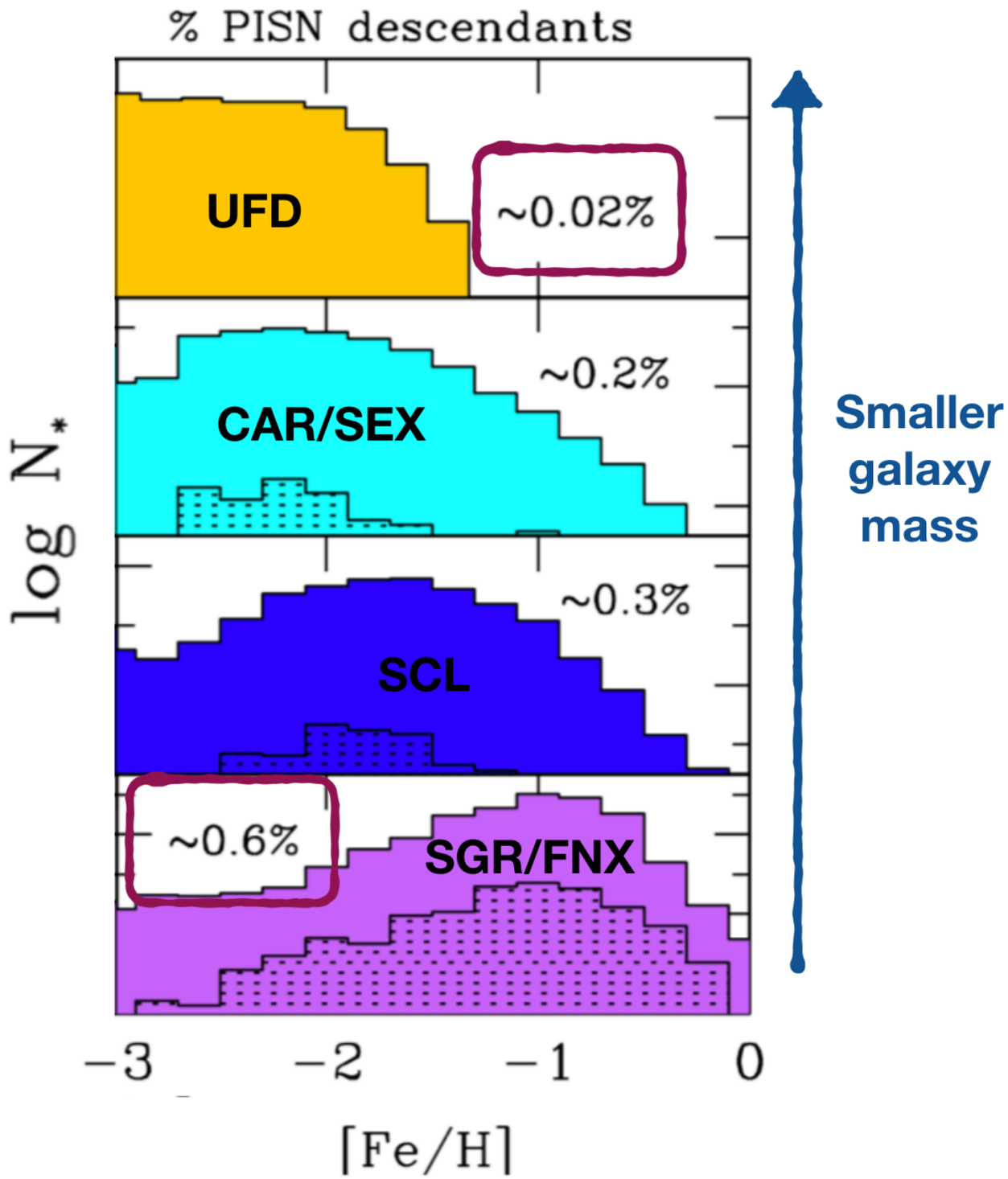
(PISN

- Stars in mass range ~150-260 M ⊙ are expected to end their lives as pair-instability supernovae, with very distinctive yields - strong odd-even effect.



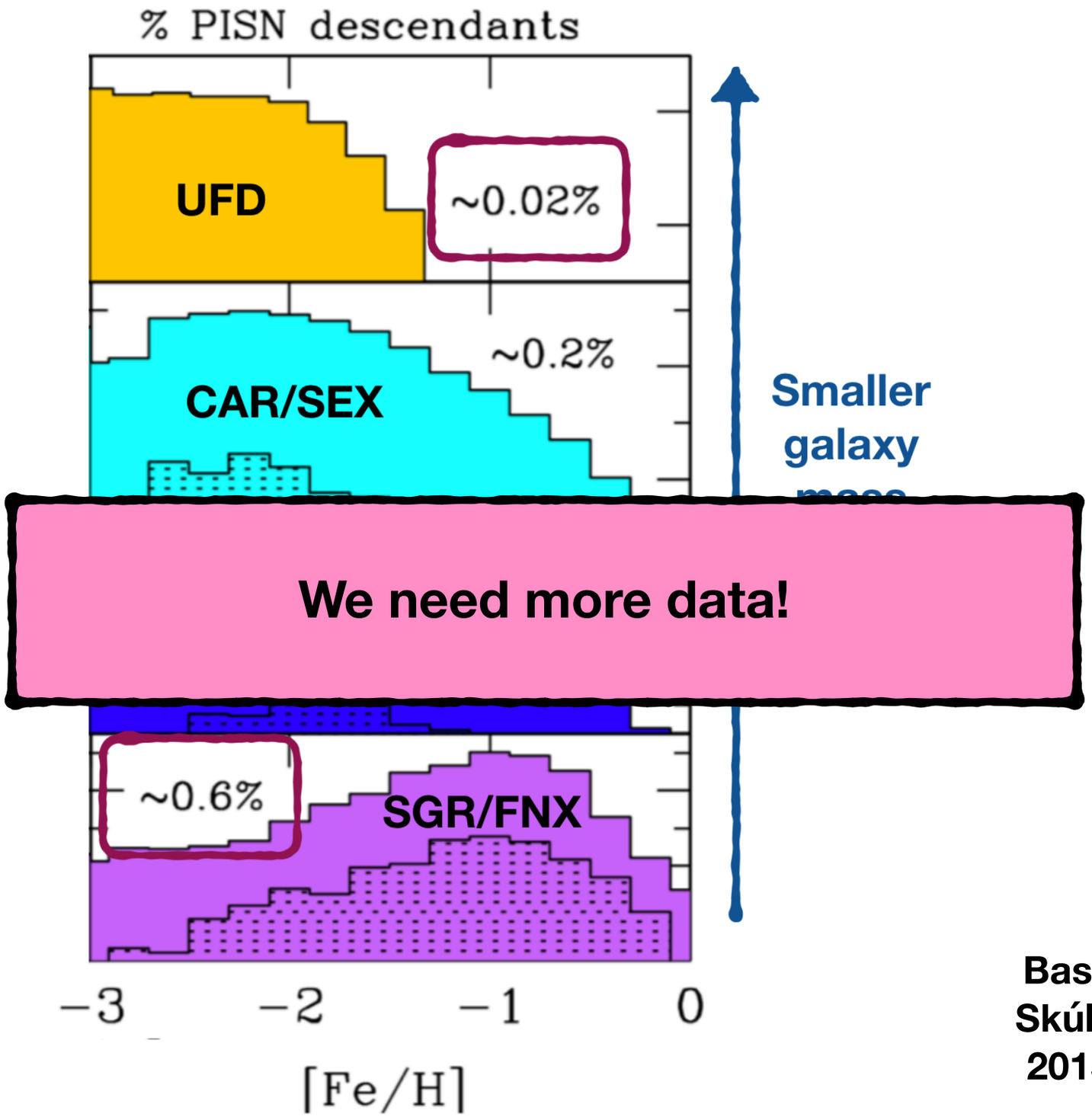
Salvadori et al. 2019

DWARF GALAXIES



Based on Salvadori, Skúladóttir & Tolstoy 2015, and Salvadori et al. 2019

DWARF GALAXIES



Based on Salvadori, Skúladóttir & Tolstoy 2015, and Salvadori et al. 2019

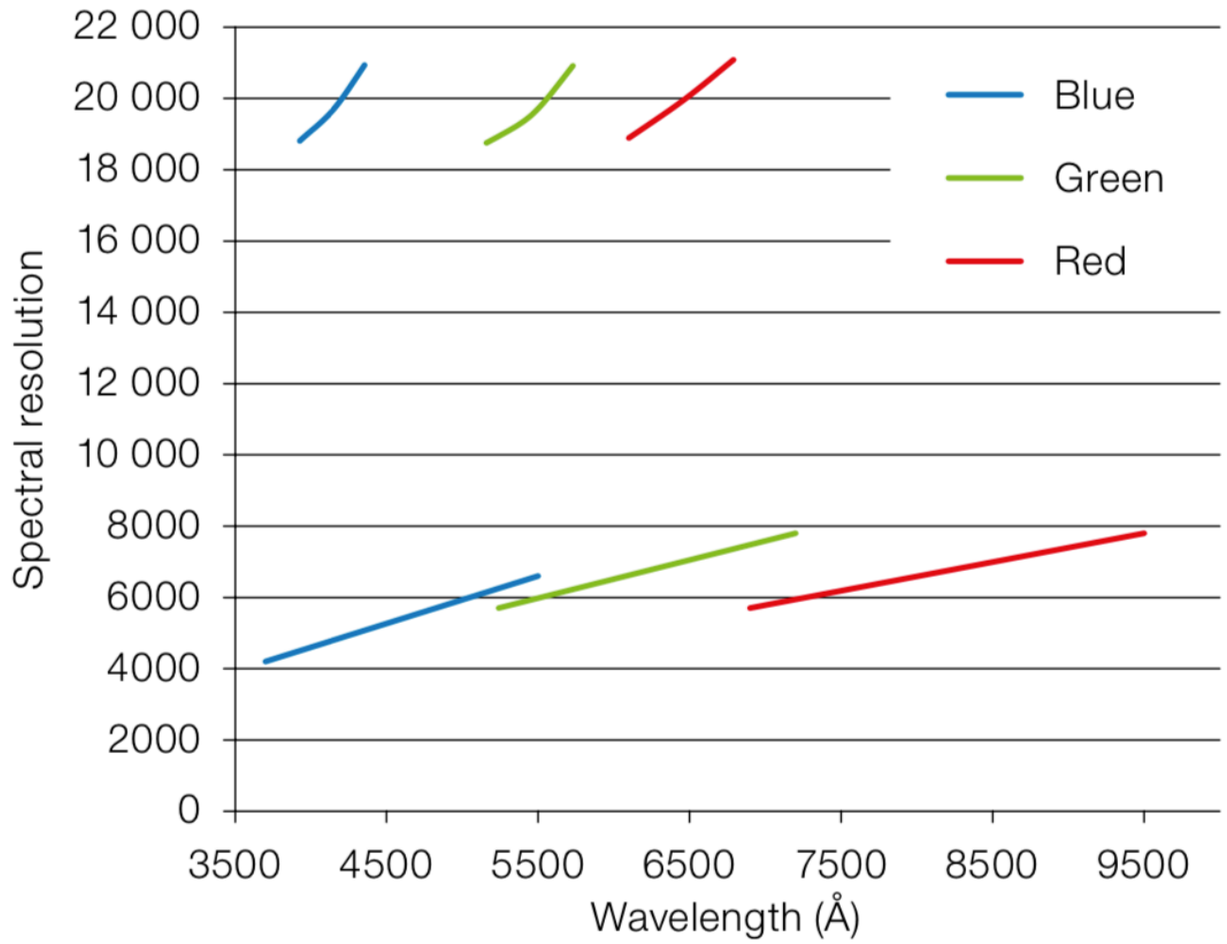
4DWARFS: 4MOST SURVEY OF DWARF GALAXIES

Logo by Martina Rossi

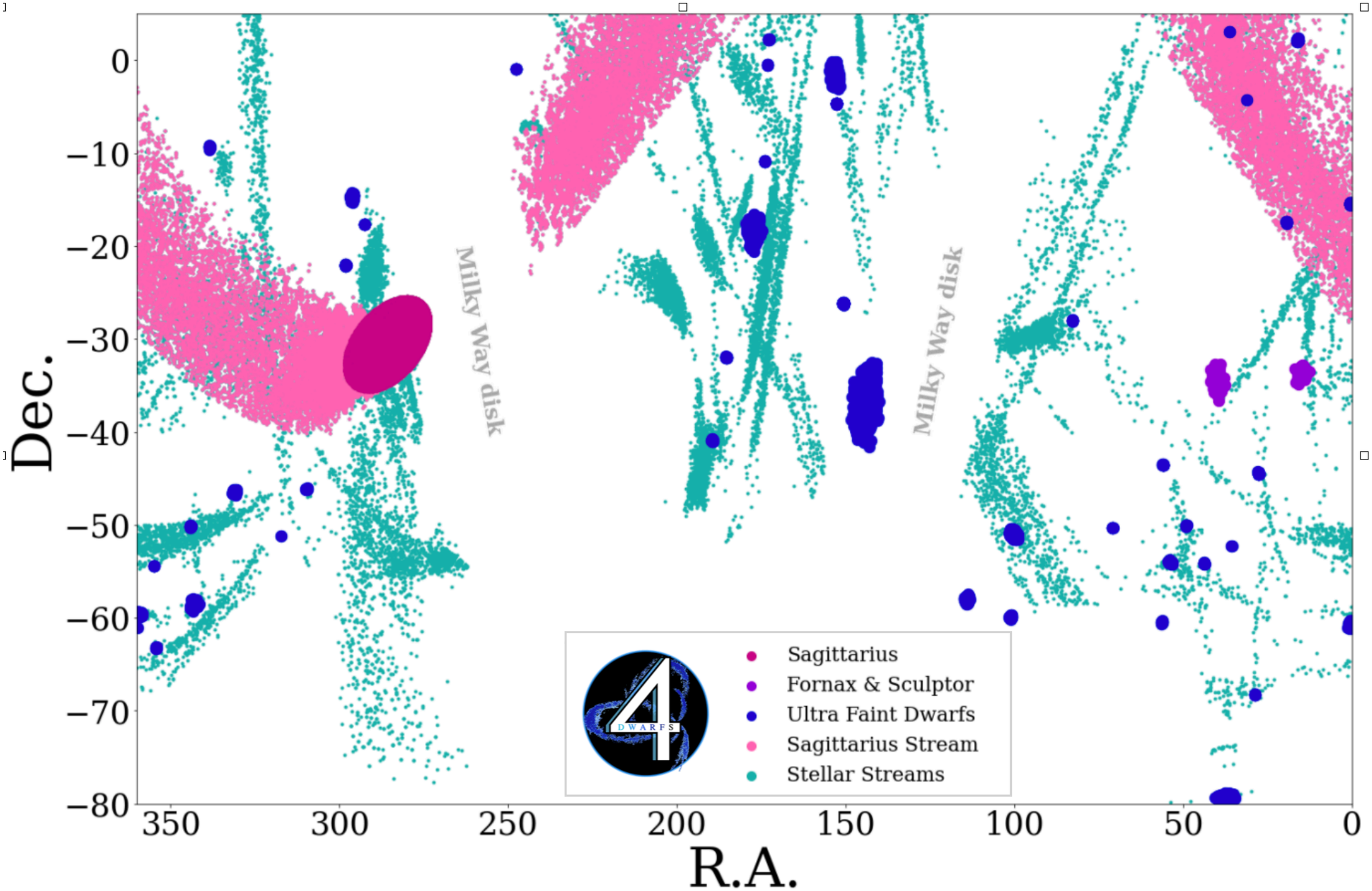
4DWARFS PI: *Á. Skúladóttir*
4DWARFS members: *A. Alencastro Puis, A.M. Amarsi, A. Arcones, G. Battaglia, S. Buder, S. Caliskan, S. Campbell, S. Cardona-Berrero, N. Christlieb, J.G. Fernández-Trincado, D. Feuillet, A. Gallagher, V. Gelli, C. J. Hansen, V. Hill, R. Ibata, P. Jablonka, N. Kacharov, A. Karakas, A. Koch-Hansen, I. Kushniruk, K. Lind, L. Lombardo, R. Lucchesi, M. Lugaro, N. Martin, D. Massari, T. Nordlander, M. Reichert, M. Rossi, A. Ruiter, S. Salvadori, I.k Seitenzahl, E. Tolstoy, T. Xylakis-Dornbusch, K. Youakim.*

4MOST

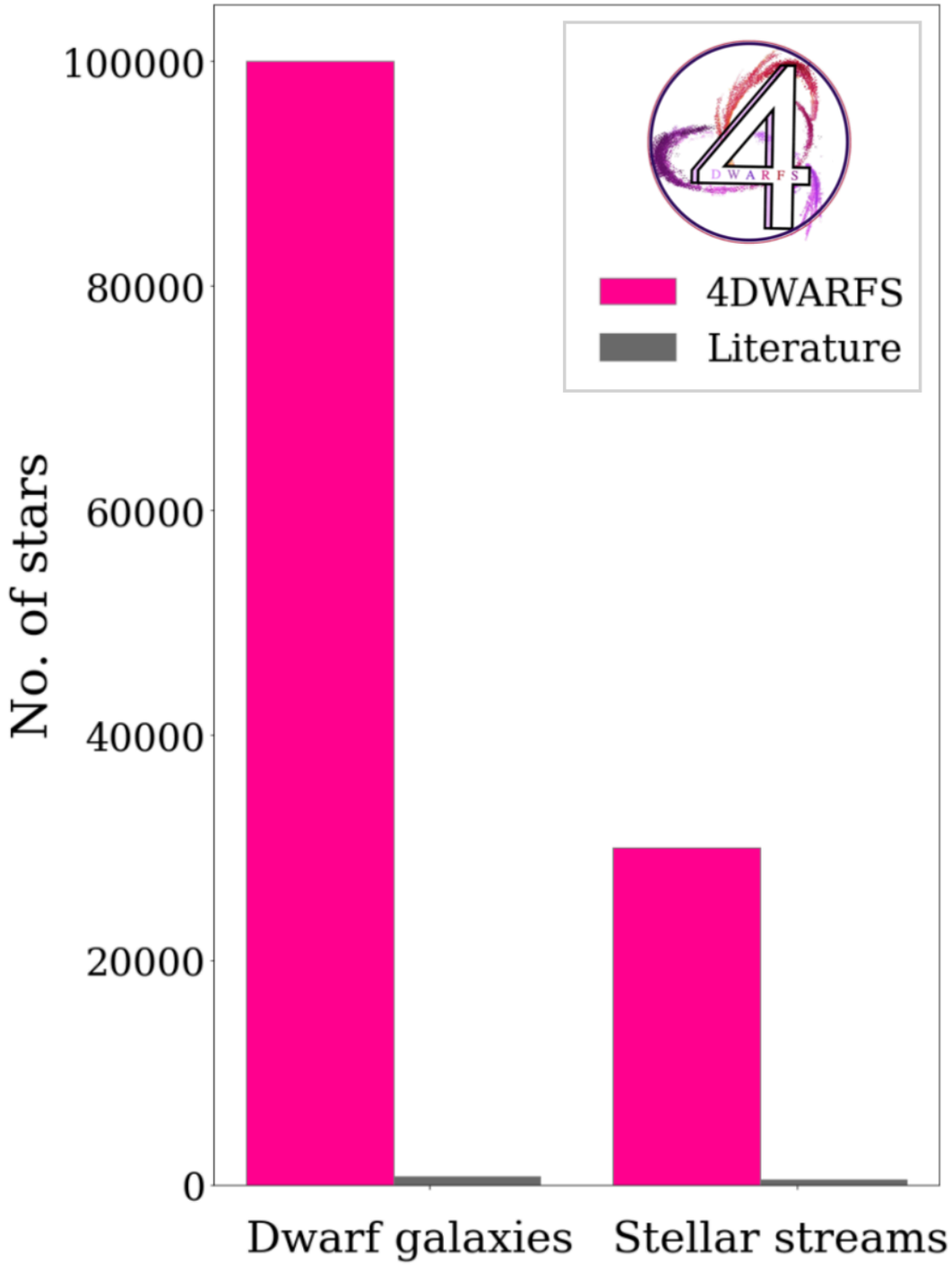
- Large field of view (4.2 deg^2)
- Large number of fibres (>2400)
- 4m telescope
- 5 year surveys (starting 2024)
- Combination of HR + LR
- Uppsala University is a consortium member!



4DWARFS


Milky Way disk
Milky Way disk
Sagittarius
Fornax & Sculptor
Ultra Faint Dwarfs
Sagittarius Stream
Stellar Streams
Dec.
R.A.
0
−10
−20
−30
−40
−50
−60
−70
−80
350
300
250
200
150
100
50
0

4DWARFS SCOPE



Number of stars with >10 elements

4DWARFS SCIENCE CASES

First stars

Origin of elements:
(AGB stars, SNIa, Neutron star mergers)

Hierarchical galaxy formation and dark matter

CONCLUSIONS

Dwarf galaxies are great!

Data are coming

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