News from the Past: 2019 Updates on Metal-Poor Stars

Tilman Hartwig

初代星・初代銀河研究会2019 @名古屋

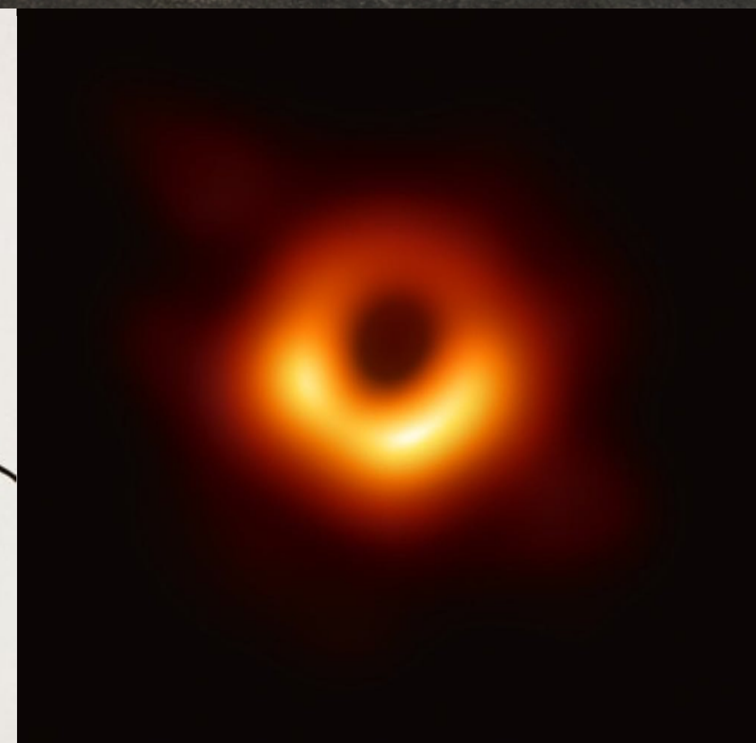
THE UNIVERSITY OF TOKYO

Institute for Physics of Intelligence
知の物理学

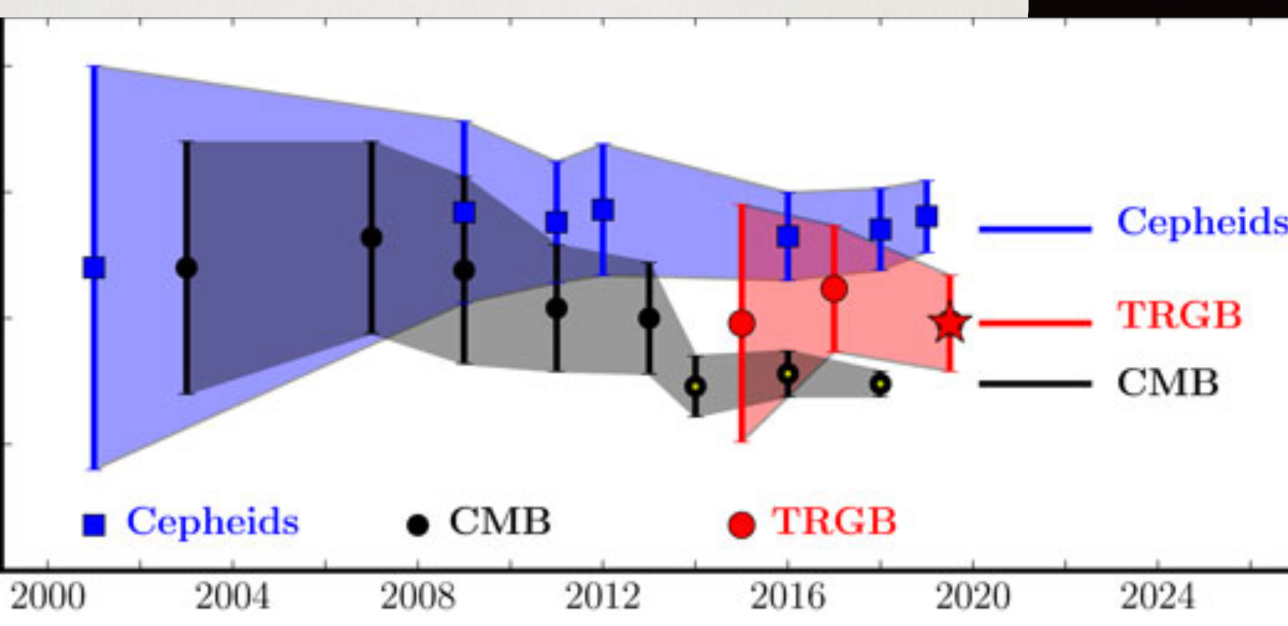
KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE


2019


Donald J. Trump
@realDonaldTrump
AMERICAN HERO!



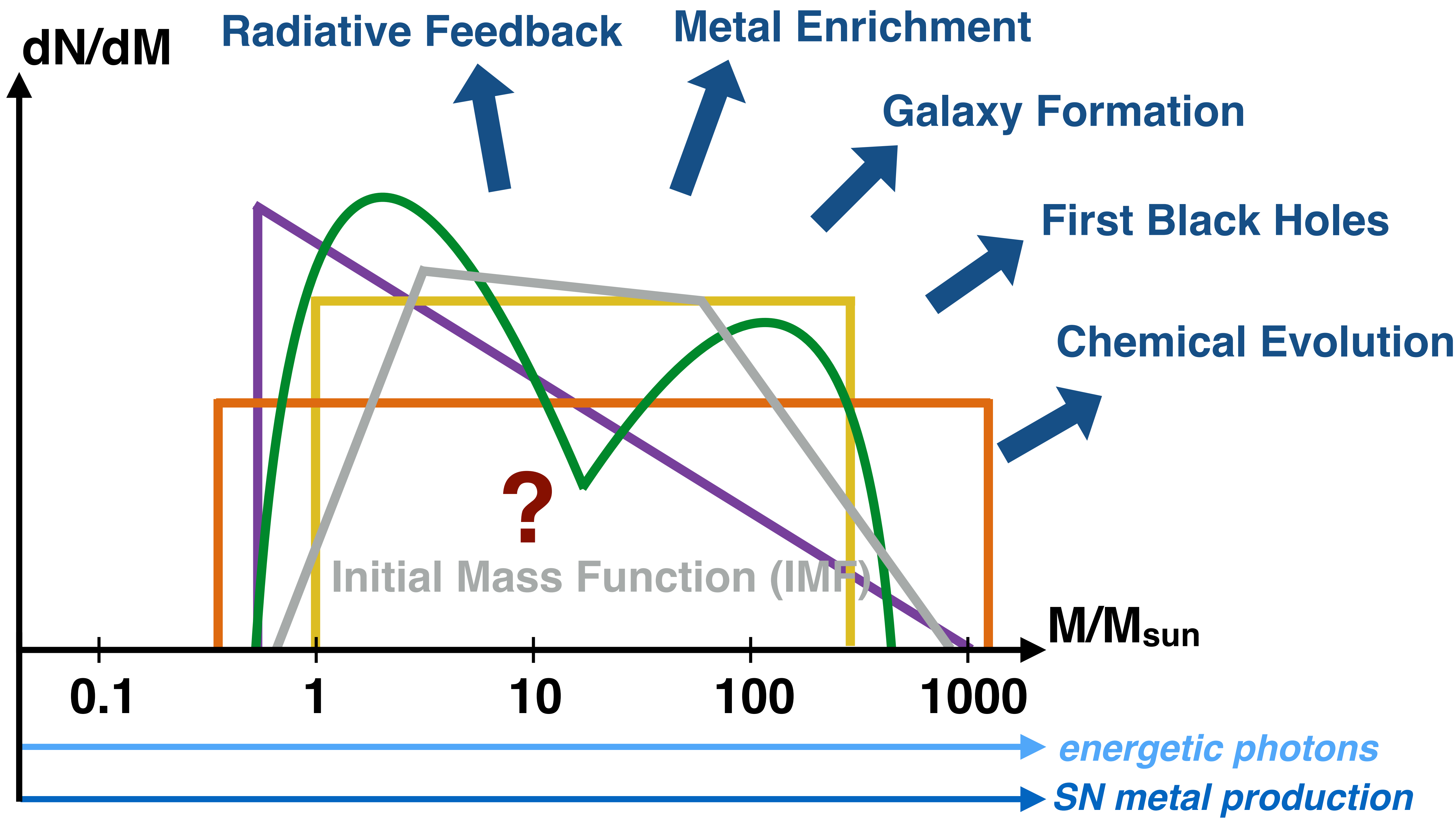

EU
OH DEAR!.. HELP..! HELP!
BREXIT


Cepheids
TRGB
CMB
Cepheids
CMB
TRGB
2000
2004
2008
2012
2016
2020
2024


令和


SKOLSTREJK
FÖR
KLIMATET

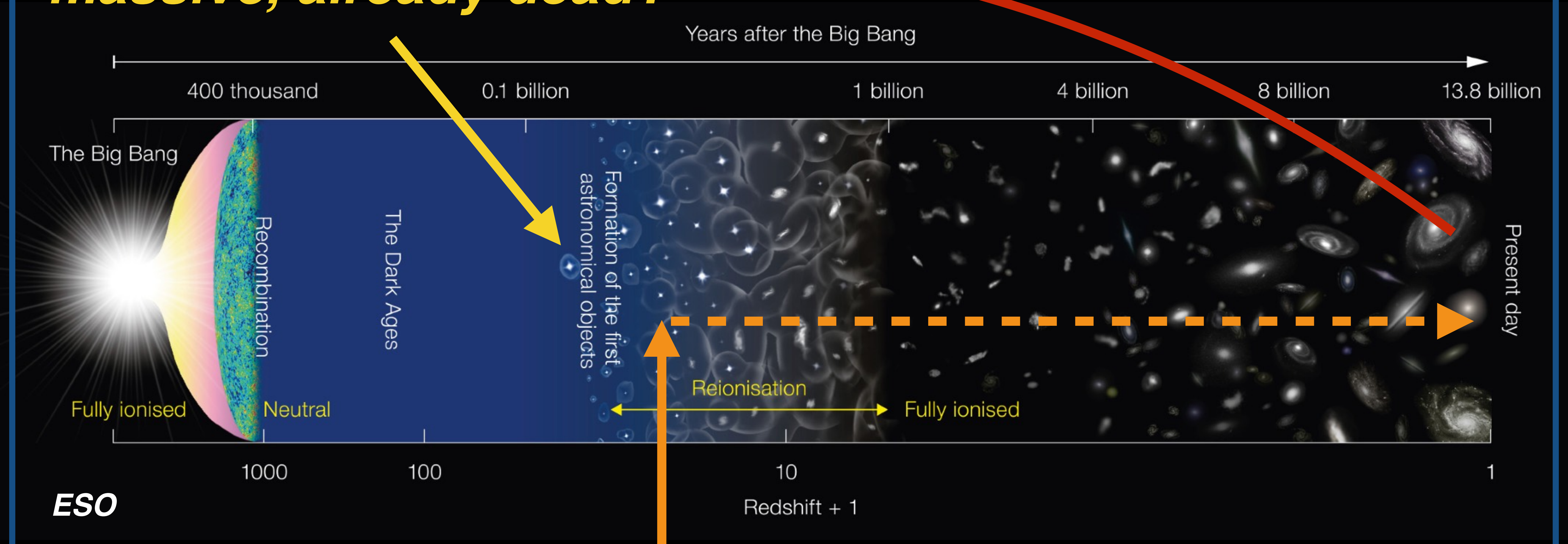
The first stars set the scene



A Brief History of Time

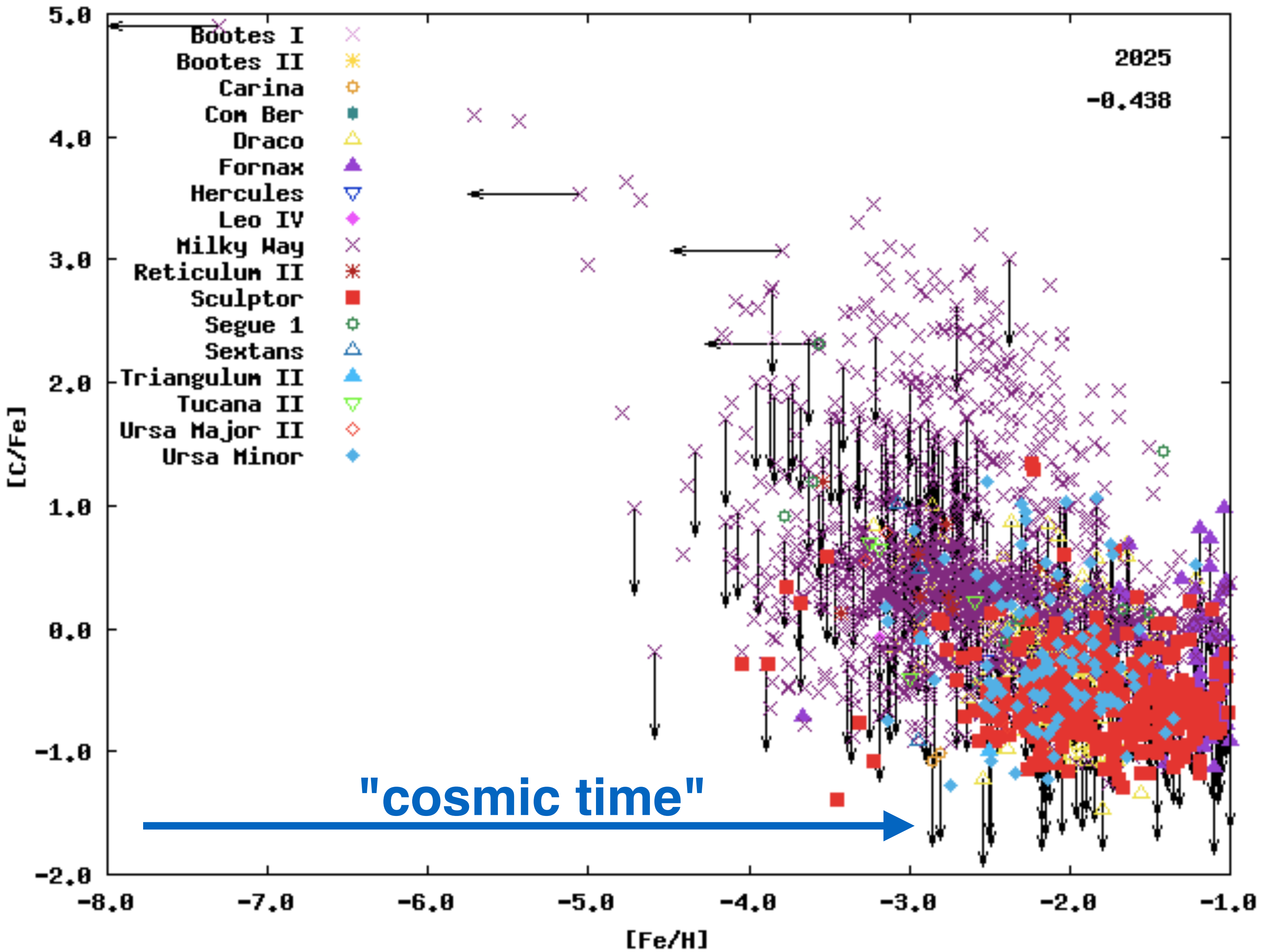
First generation massive, already dead?

"Stellar Archaeology"



Second generation survive as "extremely metal-poor" (EMP) stars in the Milky Way

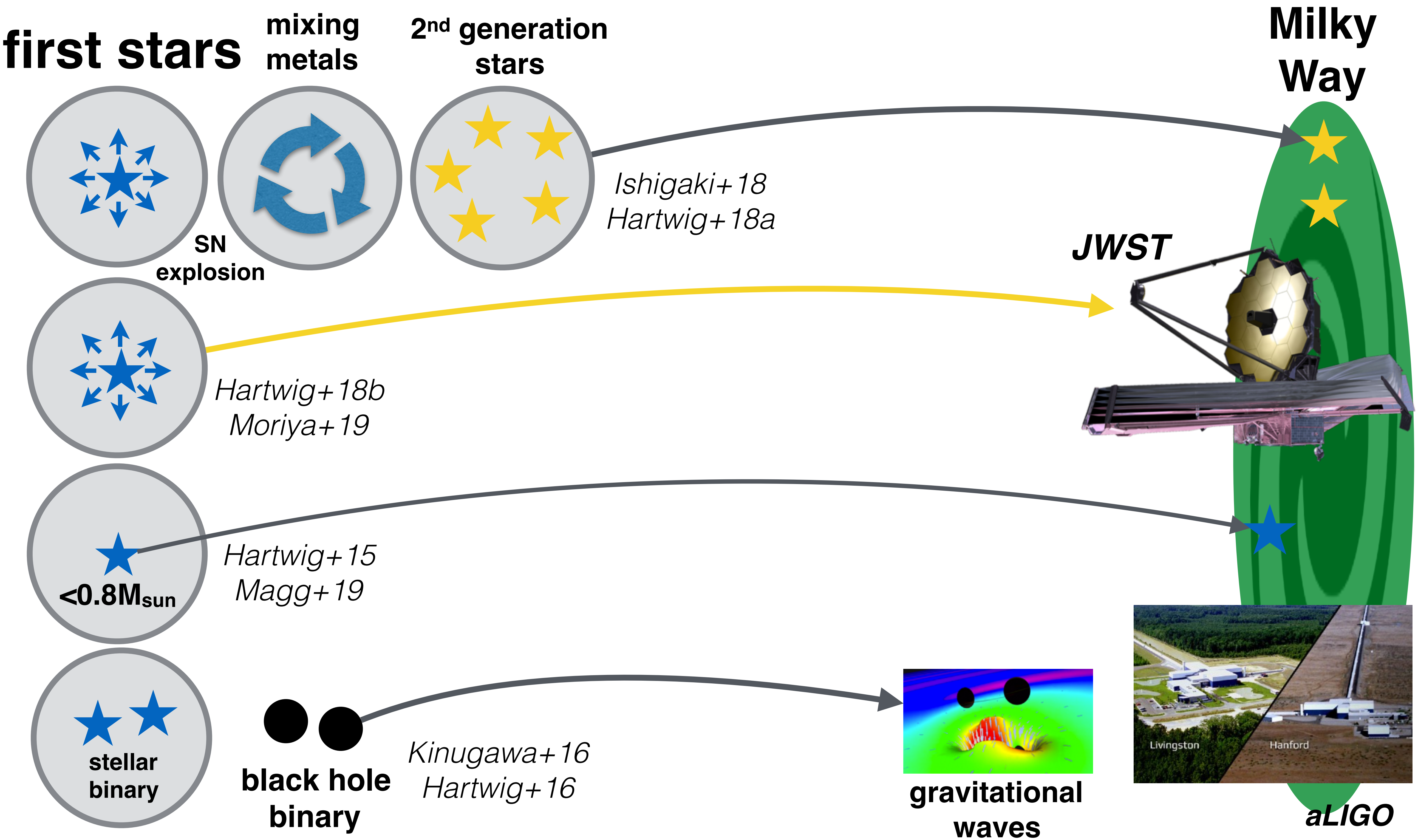
Metal-Poor Stars are a Time Machine



Saga database, Suda-san

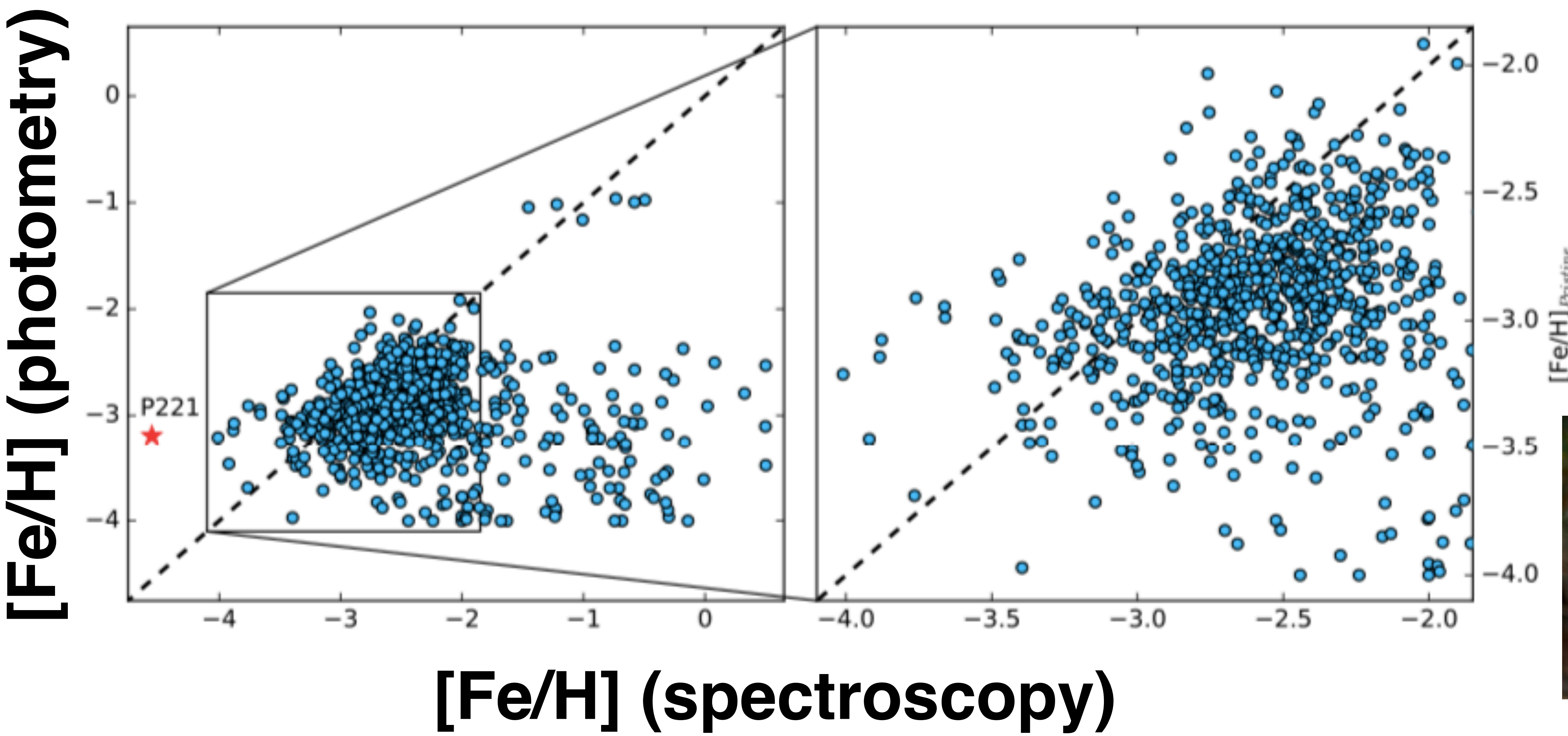
$$[X/Y] = \log_{10}(N_X/N_Y) - \log_{10}(N_{X,sun}/N_{Y,sun})$$

Observing the First Stars



The *Pristine* Survey – VI. The first three years of medium-resolution follow-up spectroscopy of *Pristine* EMP star candidates*

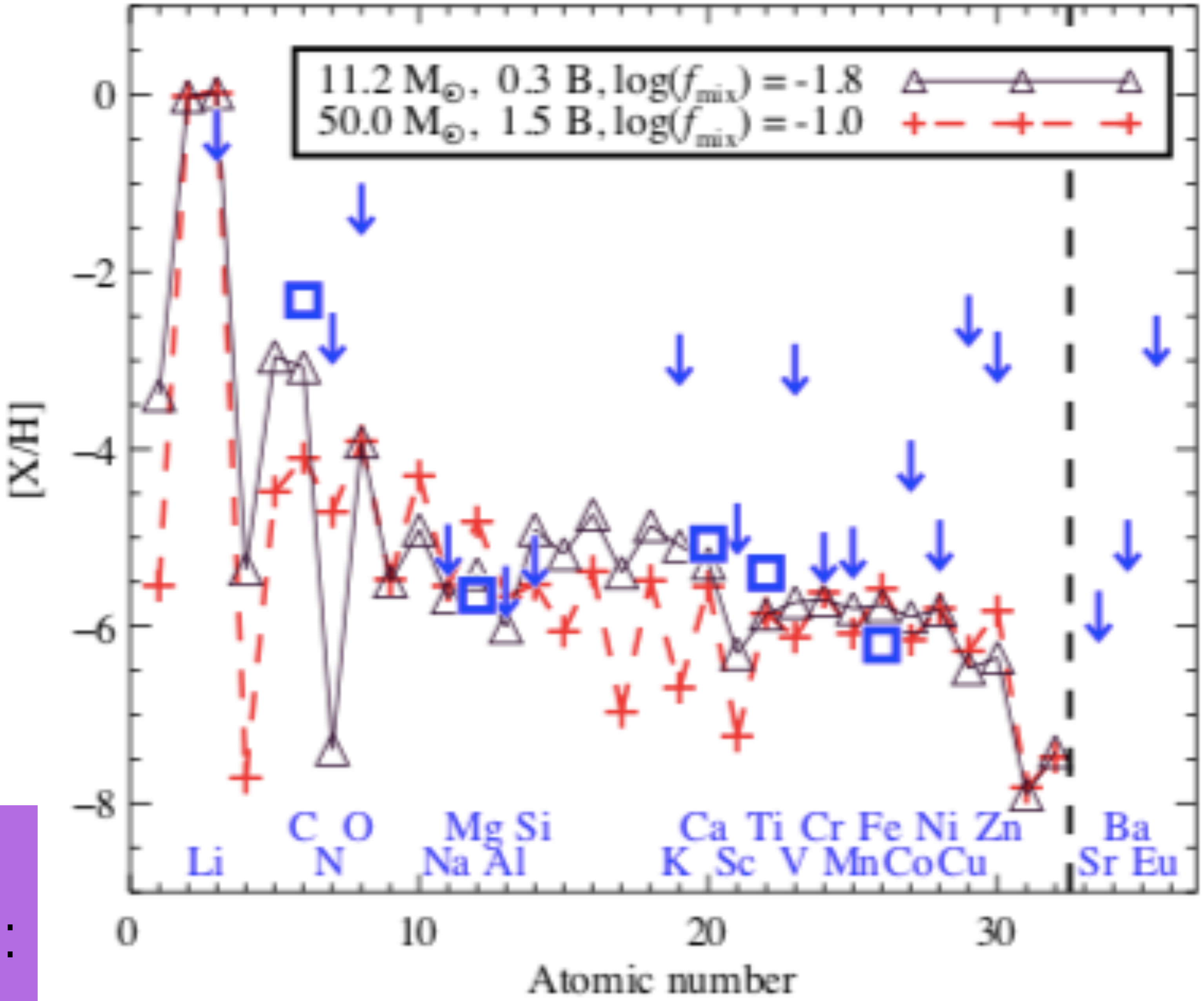
Aguado et al., arXiv:1909.08138



707 new very metal-poor stars with [Fe/H] < −2.0
95 new extremely metal-poor stars with [Fe/H] < −3.0

The lowest detected stellar Fe abundance: The halo star SMSS J160540.18−144323.1

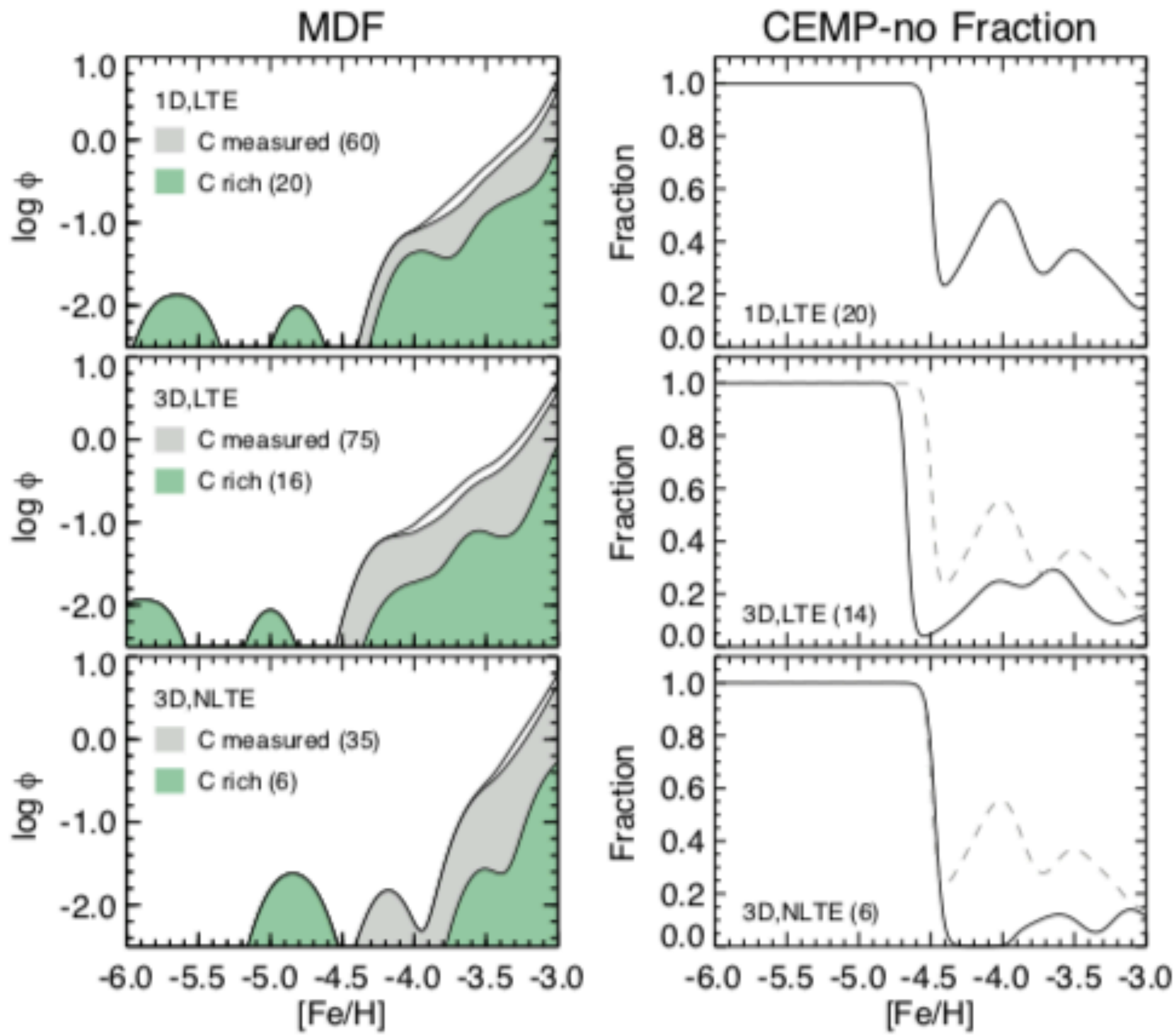
Nordlander et al.
arXiv:1904.07471



Lowest ever detected abundance of iron in a star: [Fe/H] = −6.2 ± 0.2 with no significant s-/r-process enhancement

The Most Metal-Poor Stars. V. The CEMP-no Stars in 3D *and* Non-LTE

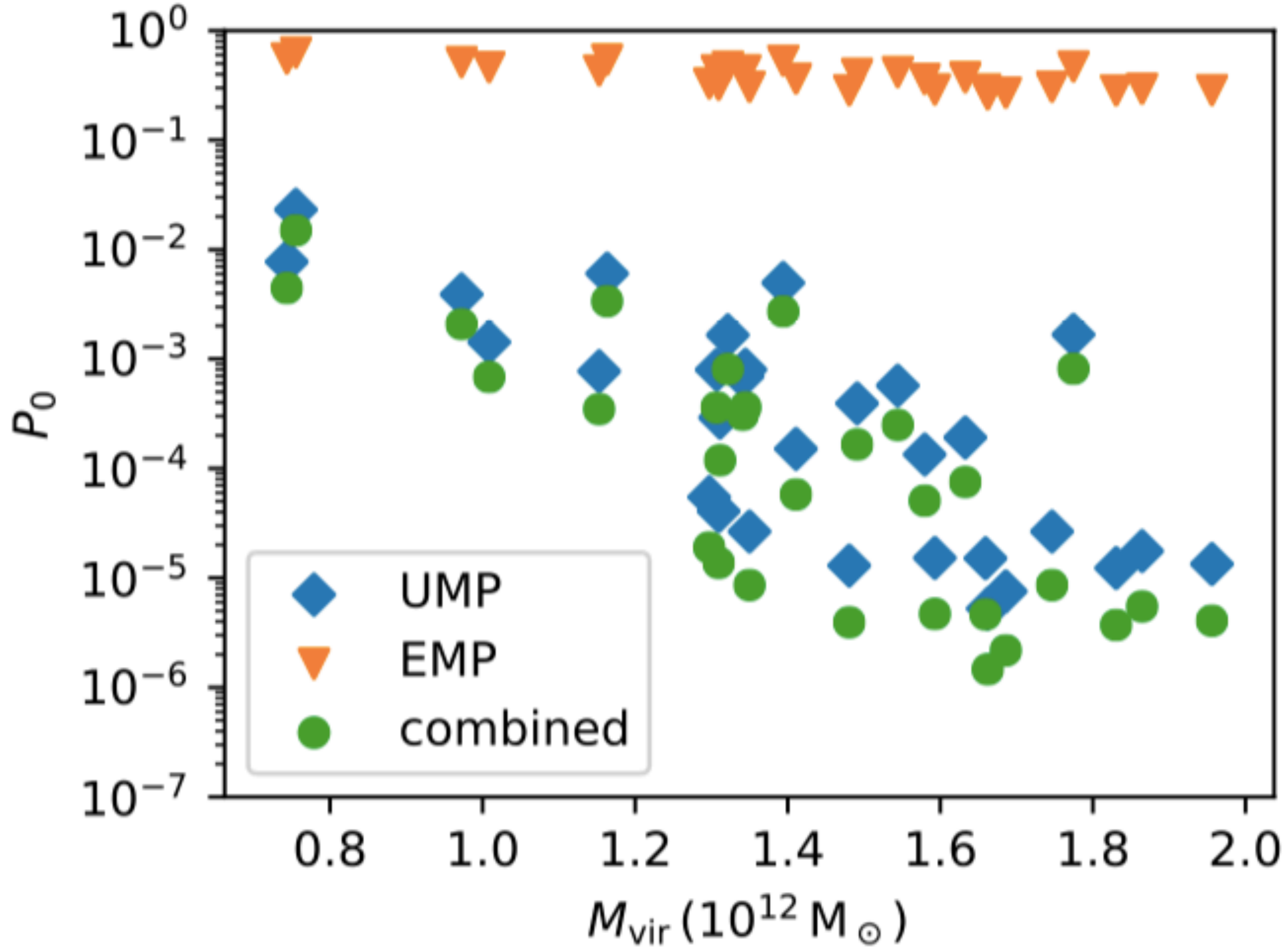
Norris & Yong,
arXiv:1905.04810



3D non-LTE corrections decrease [C/Fe] and therefore the CEMP fraction of EMP stars.

Observational constraints on the survival of pristine stars

Magg et al., arXiv:1903.08661



Probability of metal-free stars with <0.8M_{sun}: <1%

Probability of not detecting metal-free stars until today, as function of halo mass.

Binarity among CEMP-no stars: an indication of multiple formation pathways?

Arentsen et al., 2019, A&A, 621,108

There are:
- CEMP-s stars that are *not* in a binary
- CEMP-no stars that are in a binary

Binary fraction increases with [C/Fe]

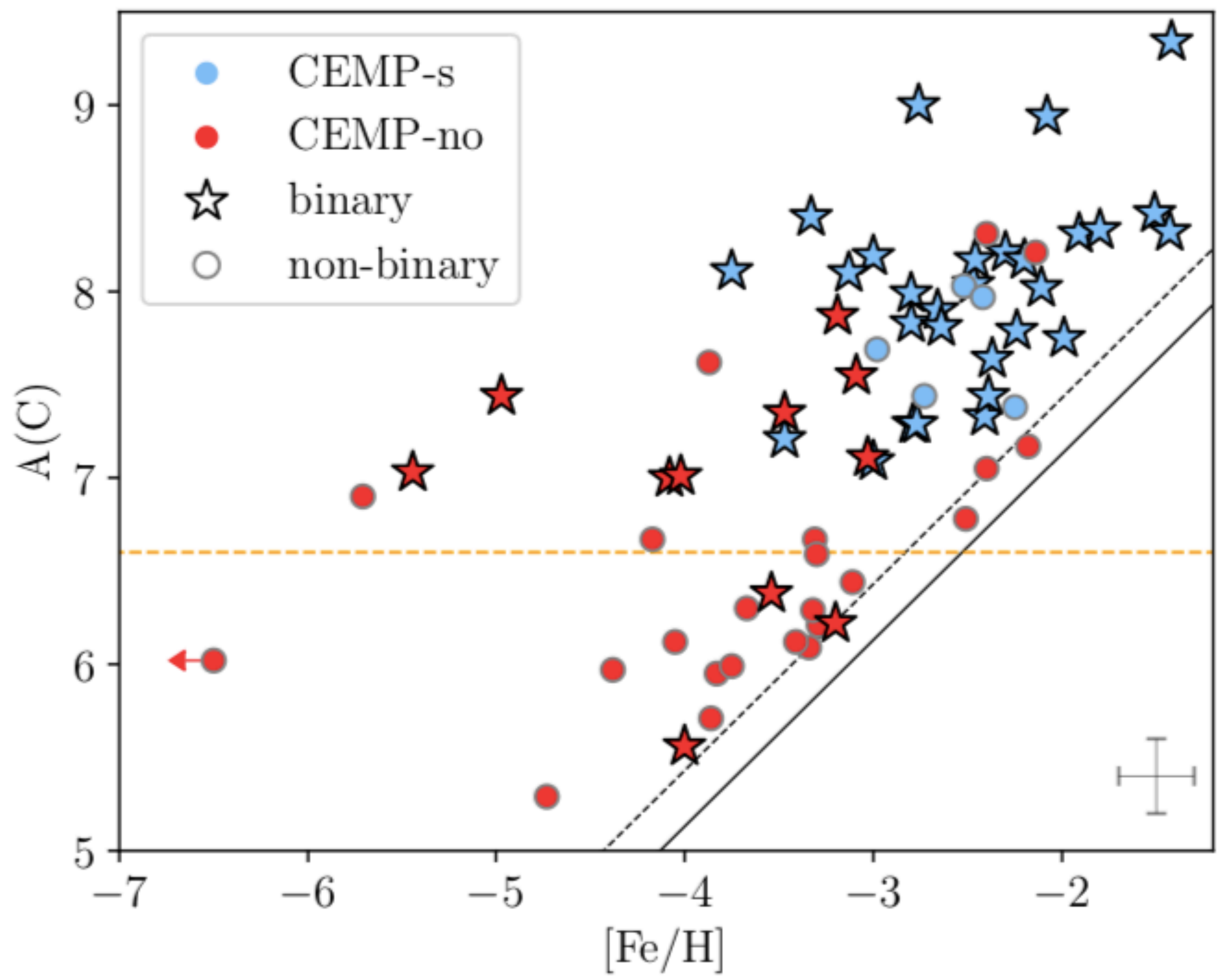


Fig. 8. A(C) as a function of [Fe/H] for CEMP stars, where again CEMP-no stars are shown in red and CEMP-*s* stars in blue. Binary stars are indicated by a star symbol. The orange dashed line is the same as in

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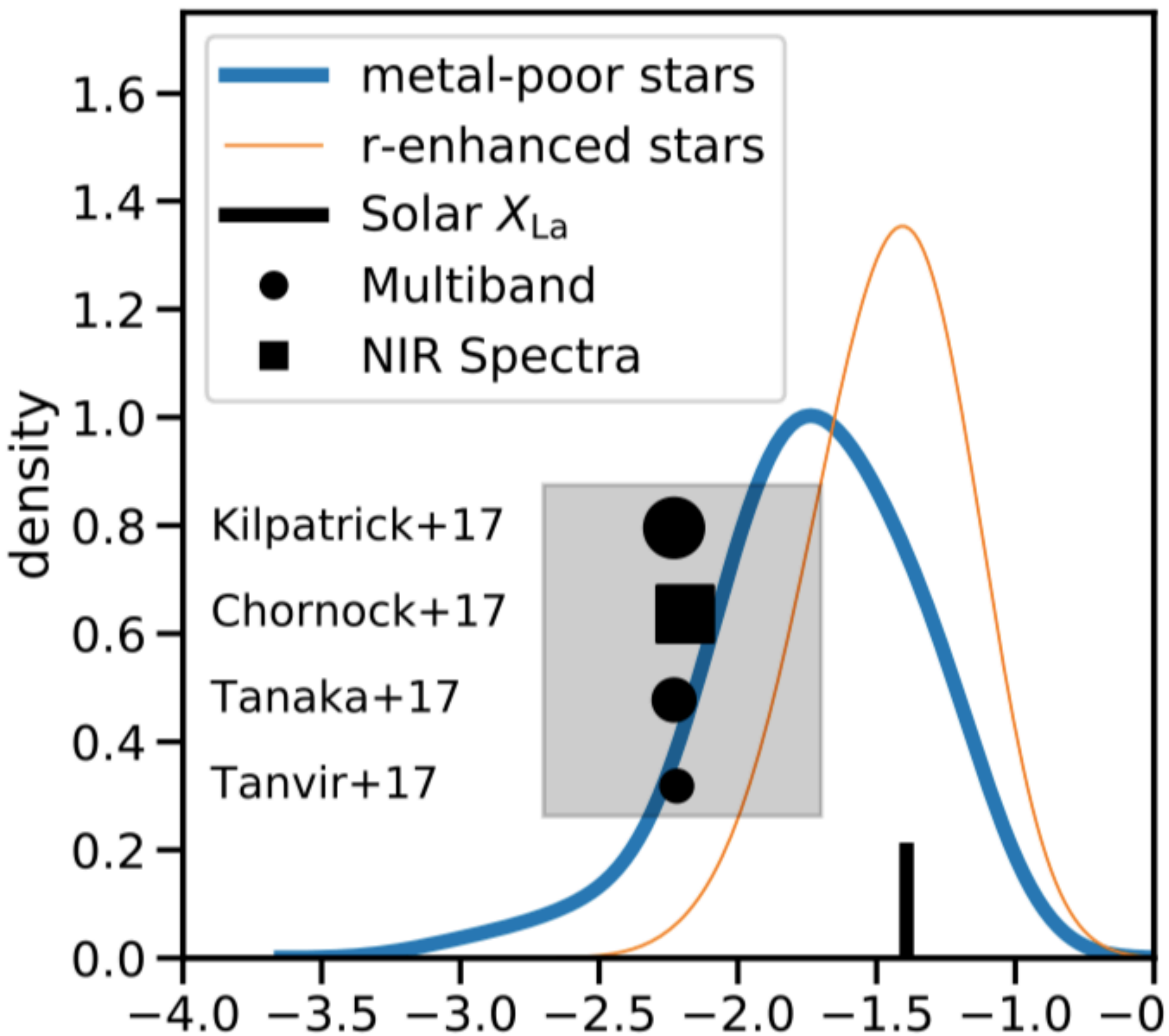
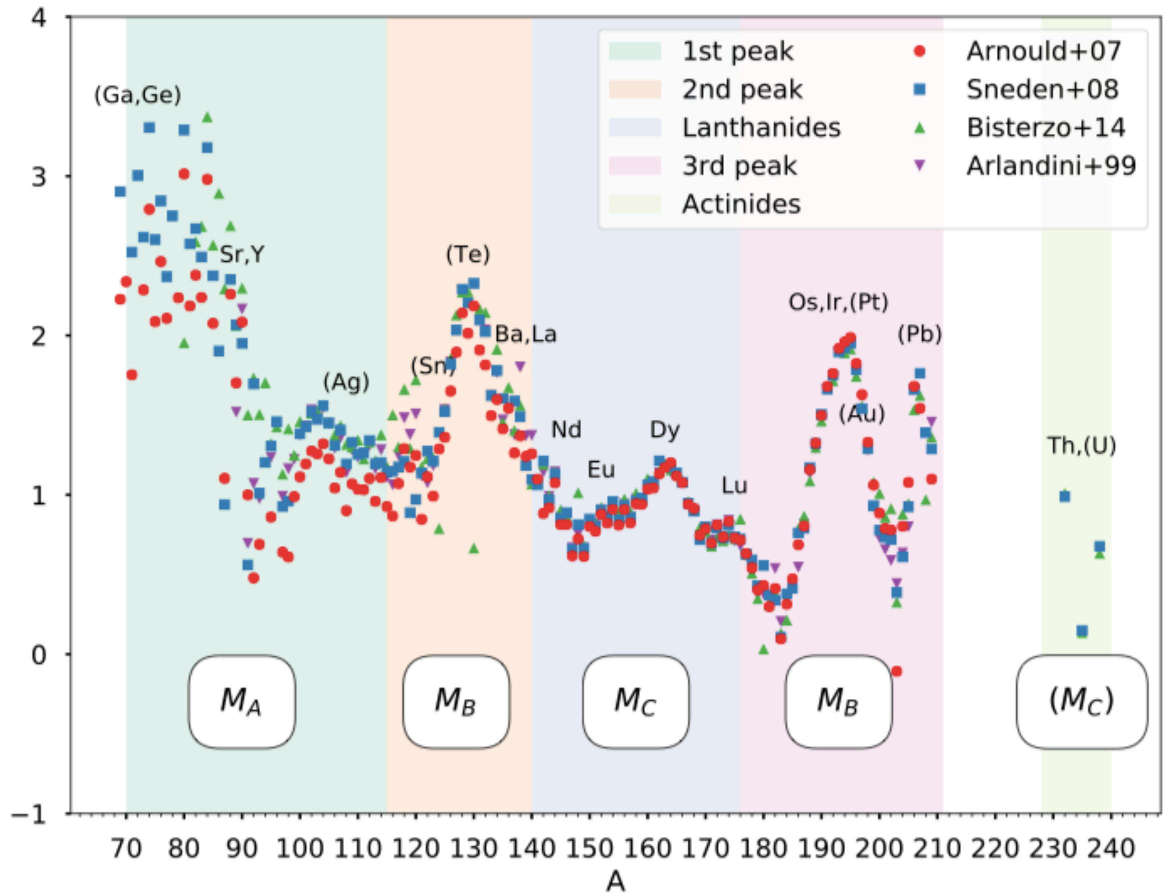
THE LANTHANIDE FRACTION DISTRIBUTION IN METAL-POOR STARS: A TEST OF NEUTRON STAR MERGERS AS THE DOMINANT *R*-PROCESS SITE

Ji et al., arXiv:1905.01814



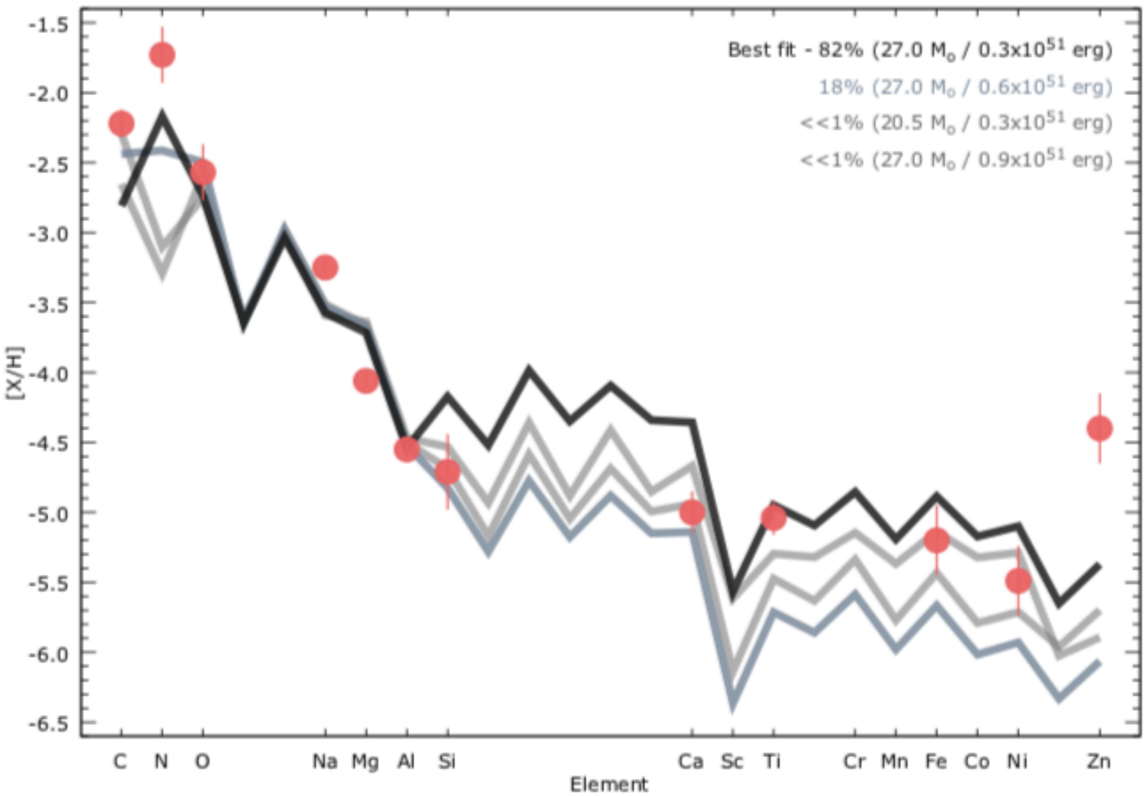
$$X_{La} = M_c / (M_A + M_B + M_c)$$

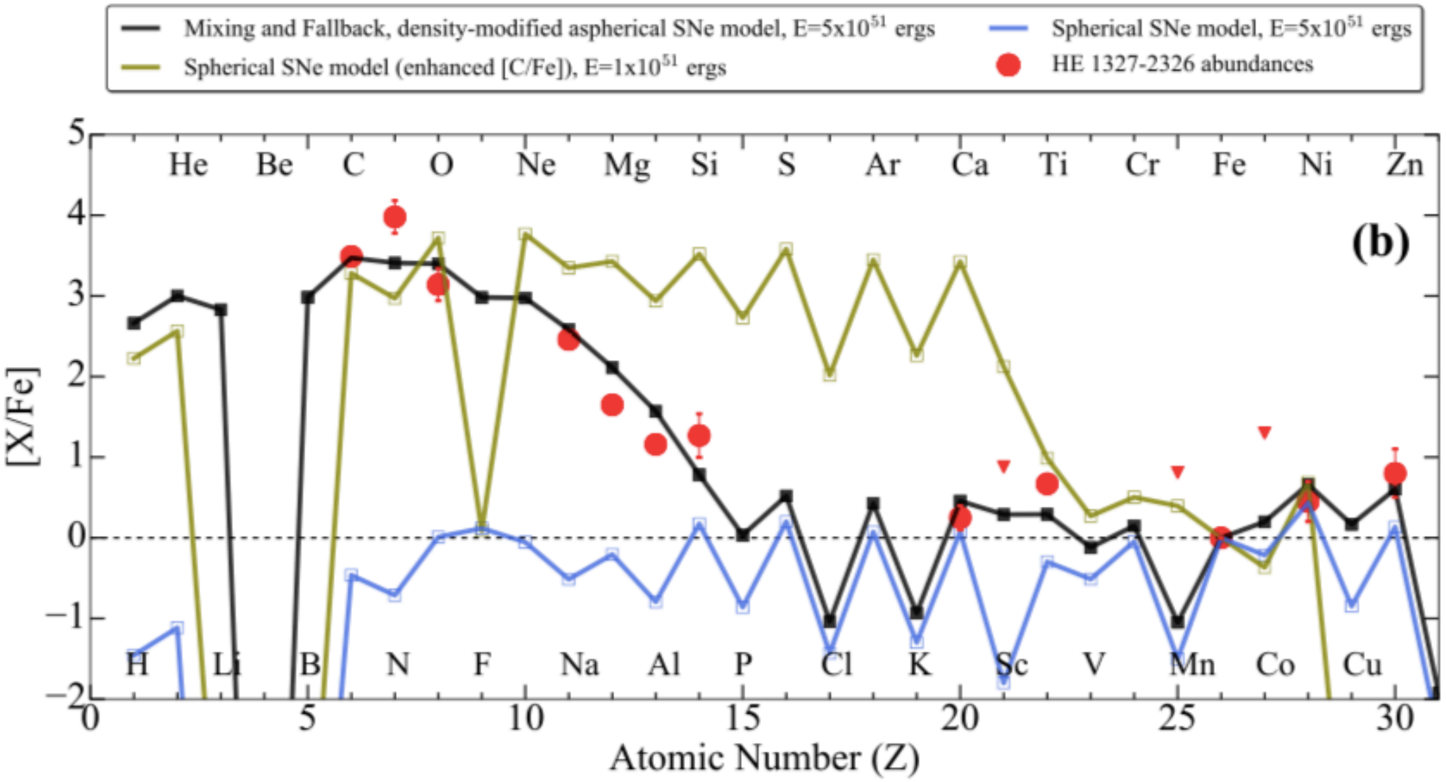


If NSMs are the dominant r-process source, future NSM should have higher lanthanide fractions than GW170817

Evidence for an aspherical Population III supernova explosion inferred from the hyper metal-poor star HE 1327−2326*

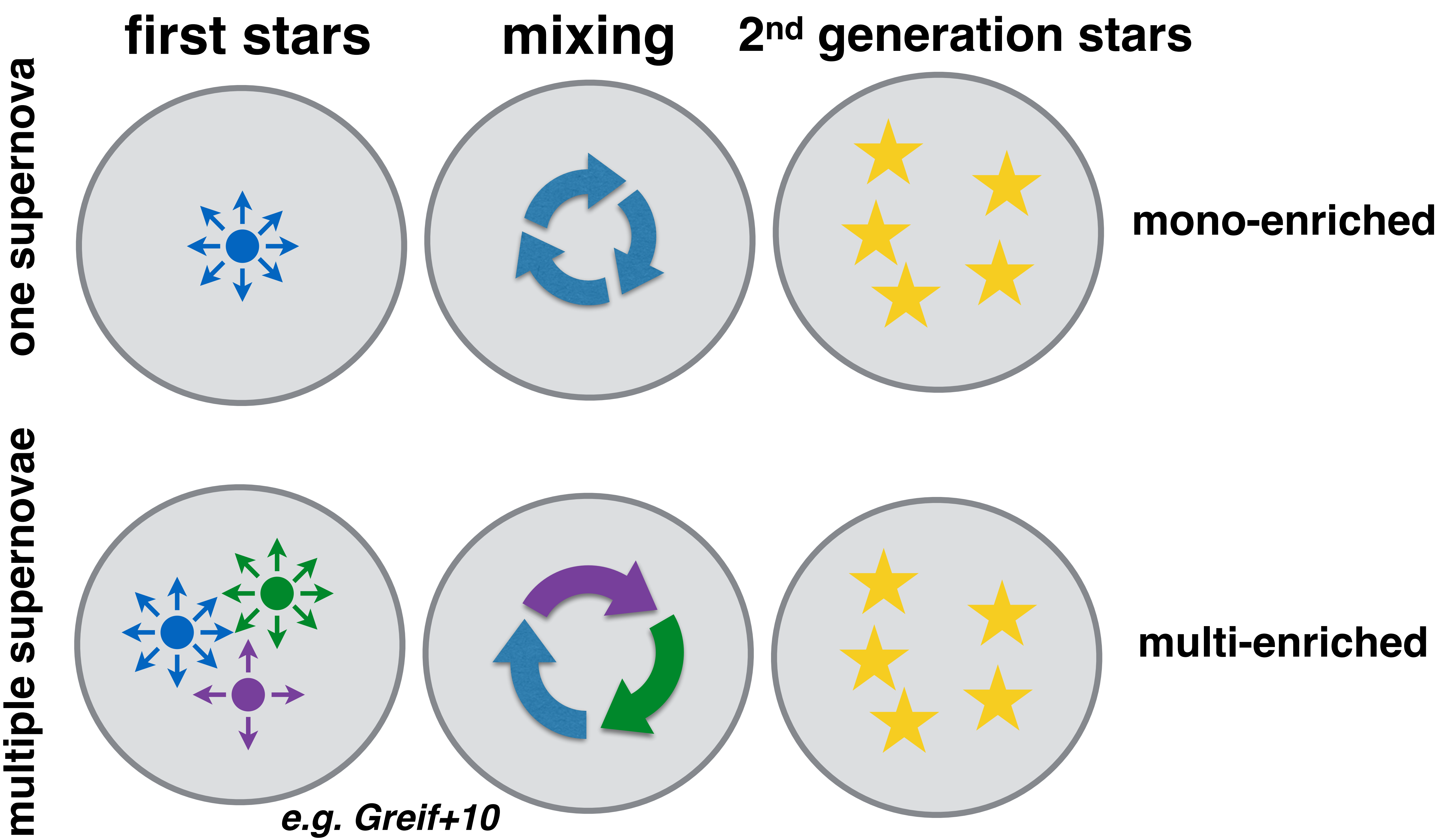
Ezzeddine et al., arXiv:1904.03211



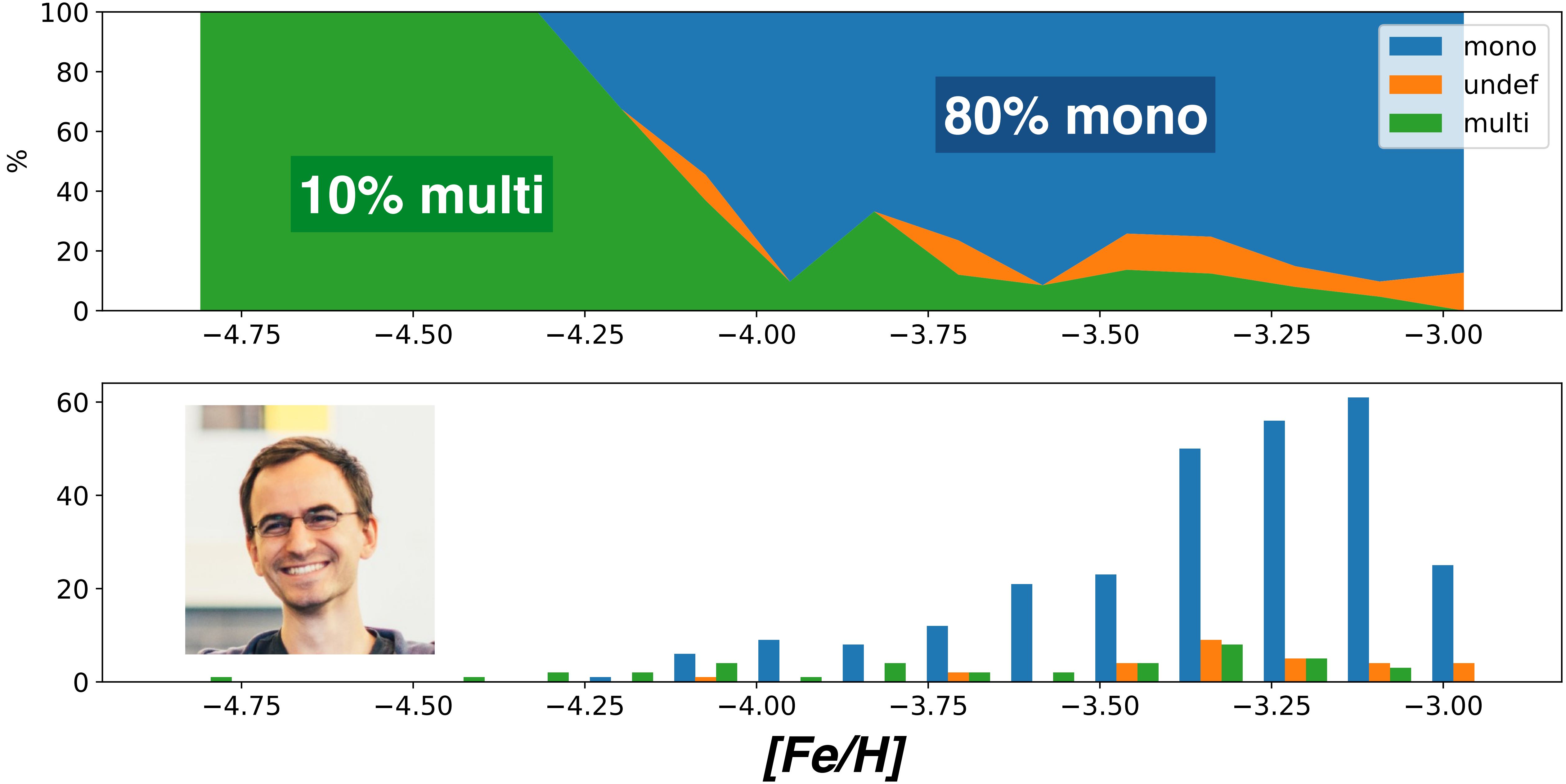


Bipolar PopIII SN explosion can explain high [Zn/H]: external enrichment?

My Research: Multiplicity of the First Stars



Multiplicity of the First Stars

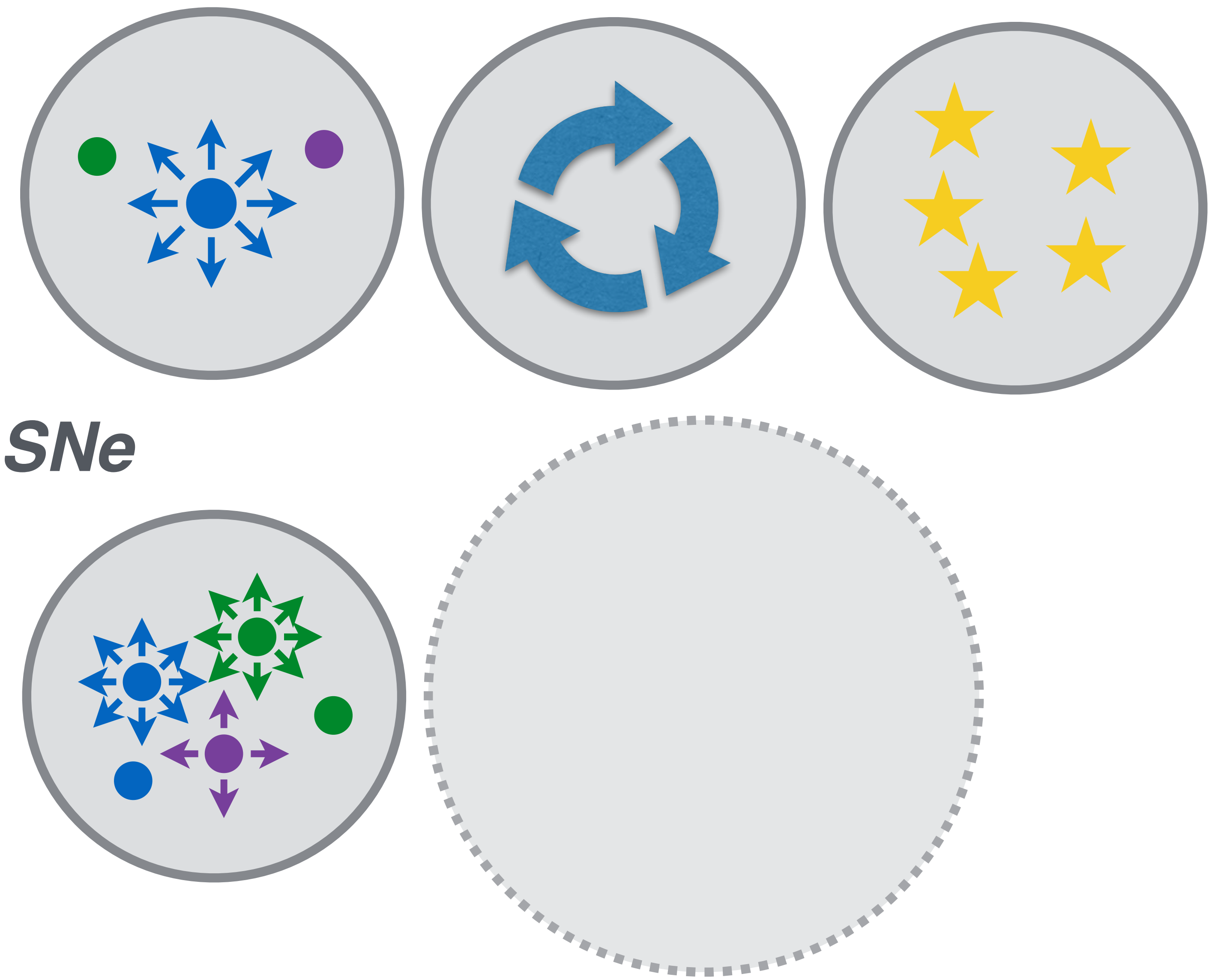


- **Poisson Statistics: p(1)=0.8, p(2)=0.1**
- **0.3 supernovae per minihalo. In contradiction to Susa 2019?**

Only 0.3 supernovae?

Observation

1 SN



EMP stars:
Interpretation: 1 SN

average: 2 SNe

average: 0.5 SNe

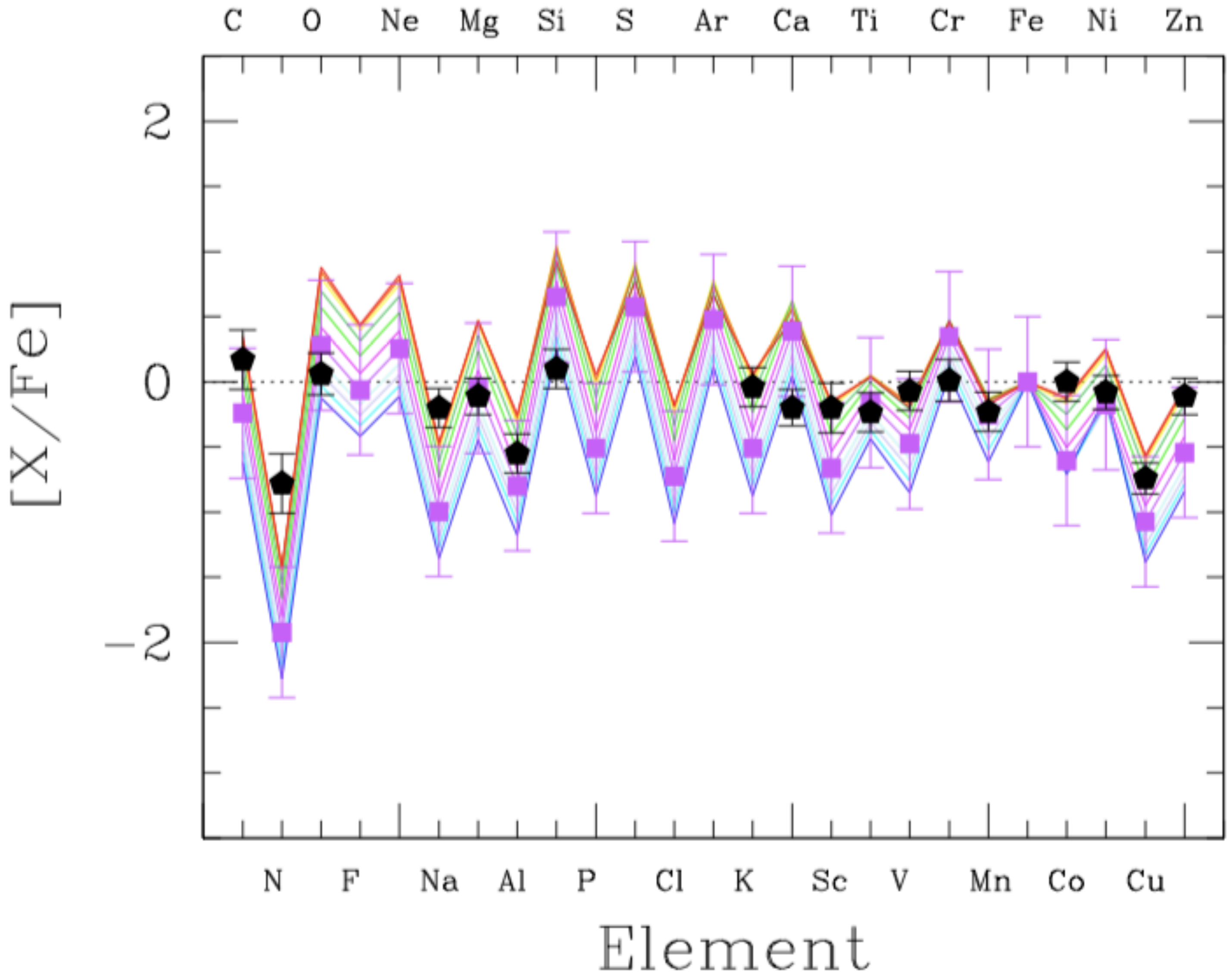
3 SNe

NO EMP stars:
Interpretation: No SN?

- We obtain Information about supernova explosion energies instead of number of supernovae? *(Chiaki+18)*

Probing the existence of very massive first stars

Salvadori et al., arXiv:1906.00994



Chemical signature of PISN hidden behind normal CCSN signature? Under-abundance of [(N, Cu, Zn)/Fe]< 0 are key elements. One candidate: BD+80 245

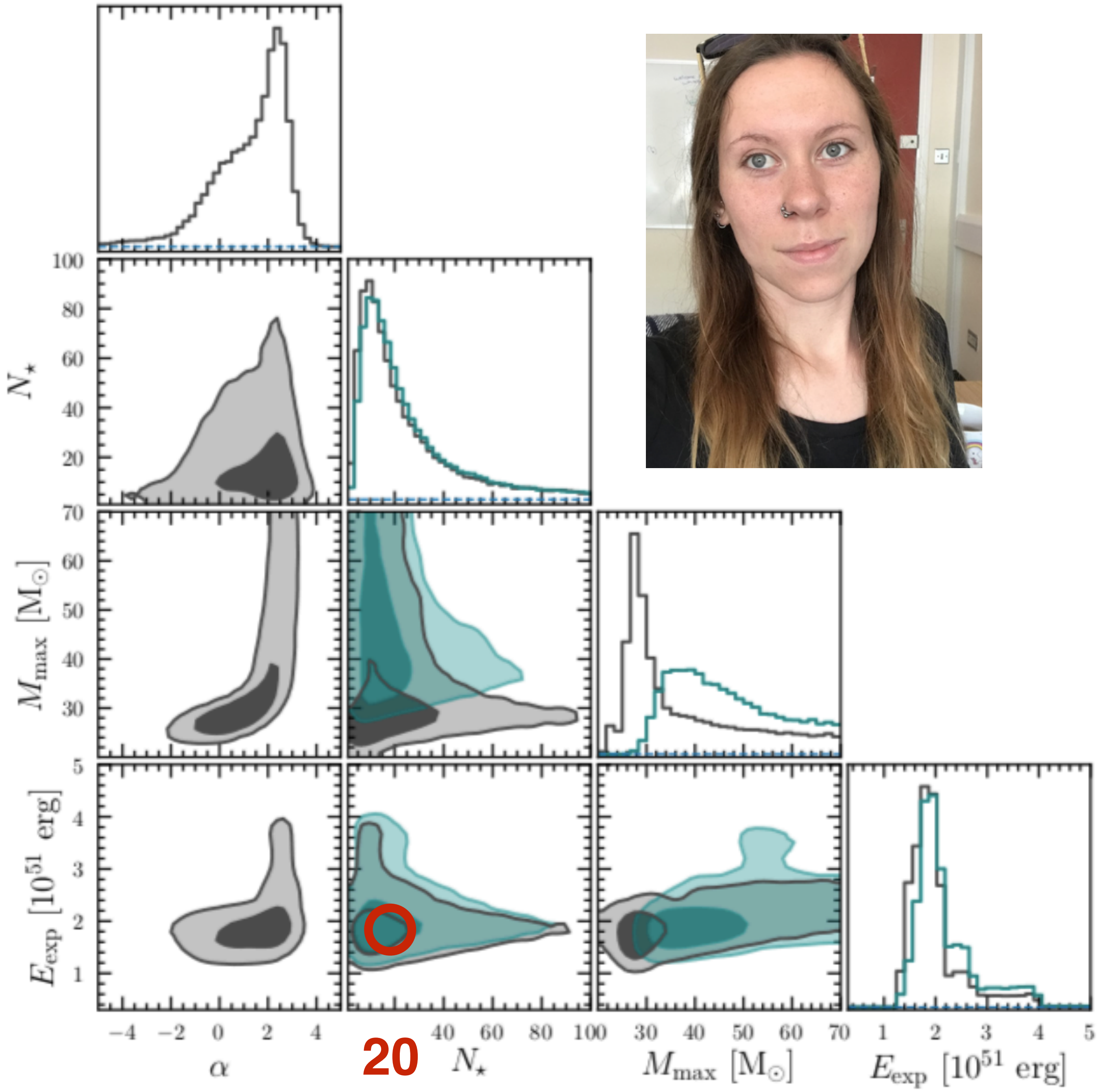
$223M_{sun}$ Pair-Instability SN

+

Metals from 30Myr old stellar population

Modelling the chemical enrichment of Population III supernovae: The origin of the metals in near-pristine gas clouds.

Welsh et al., arXiv:1906.00009



11 most metal-poor DLAs: their chemical diversity indicates that they were enriched by ~20 PopIII SNe

2019 Updates on Metal-Poor Stars

- 100 new extremely metal-poor stars with [Fe/H] < –3.0
- Record detection of [Fe/H] = –6.2
- 3D non-LTE corrections decrease [C/Fe]
- Probability to find metal-free stars with $<0.8M_{sun}$ is <1%
- Some CEMP-no stars may have experienced binary mass transfer
- Lanthanide fraction of future NS merger will help to identify r-process sources.
- Bipolar PopIII explosions can explain high [Zn/Fe]
- Observational hints that the first stars form in multiples:
- Abundance pattern of PISN+X identified.
- DLAs are enriched by ~20 PopIII supernovae.





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