Hunting the Descendants of the Very Massive First Stars

David Aguado

Stefania Salvadori

Ása Skúladóttir

& the NEFERTITI Group

UNIVERSITÀ DEGLI STUDI FIRENZE

NEFERTITI

The NEFERTITI group

Credit: S. Salvadori

Credit: V. Gelli

The NEFERTITI group

Credit: S. Salvadori

Credit: V. Gelli

The Observers

2.5 m Isaac Newton Telescope

10 m Hobby Eberly Telescope

10 m Keck & 8.2 m Subaru Telescopes

10.4 m Gran Telescopio de Canarias

The Observers

Credit: NOT telescope

Credit: DA

The Observers

Credit: DA

The Observers

MORE DATA!!

The Observers

MORE DATA!!

Demanded facilities

The Observers

MORE DATA!!

Demanded facilities

High error bars

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Accuracy of orders of magnitude

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Accuracy of orders of magnitude

The Observers

MORE DATA!!

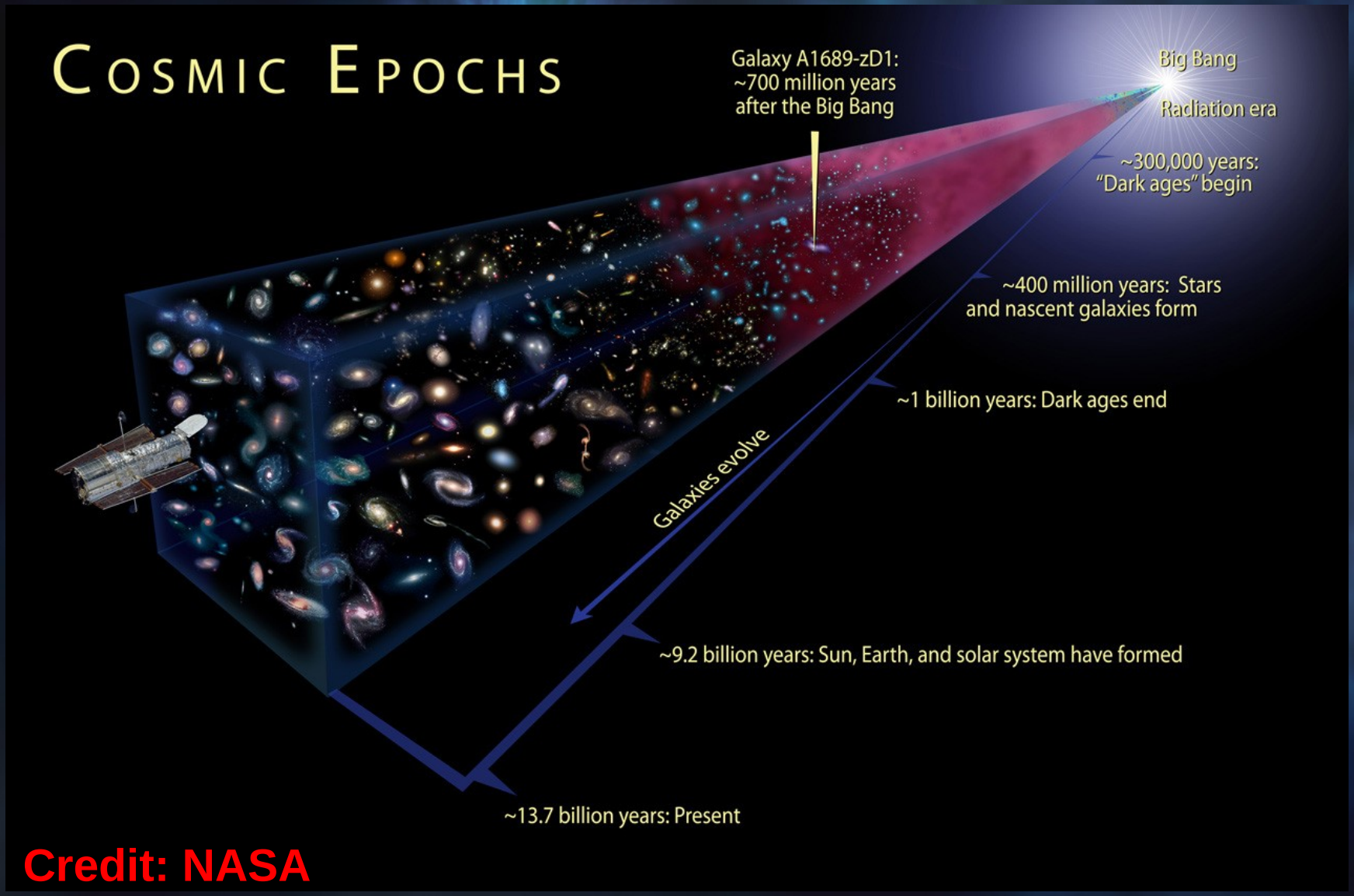
Demanded facilities

High error bars

Accuracy of orders of magnitude

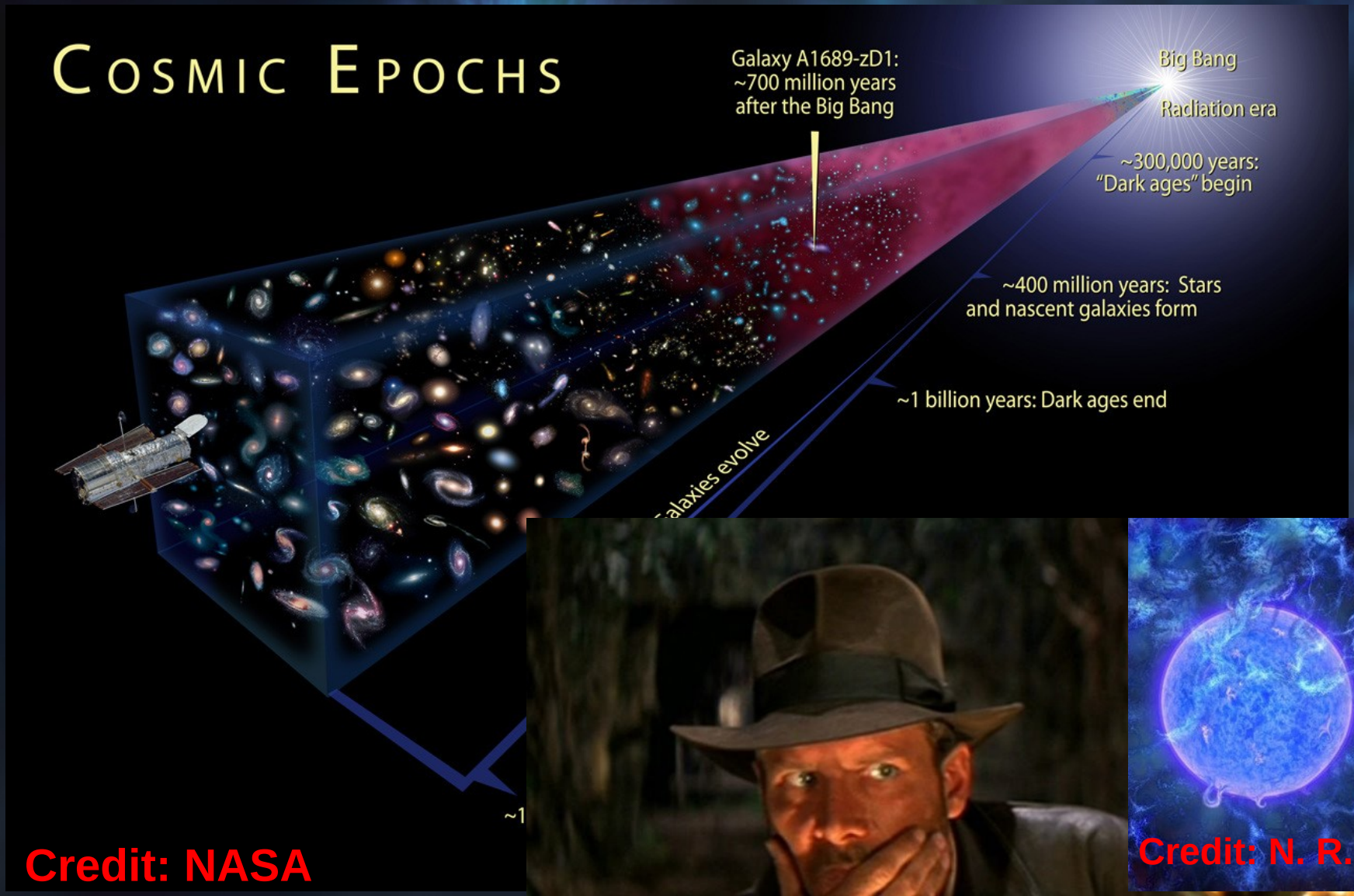
Credit: Sandra Benet

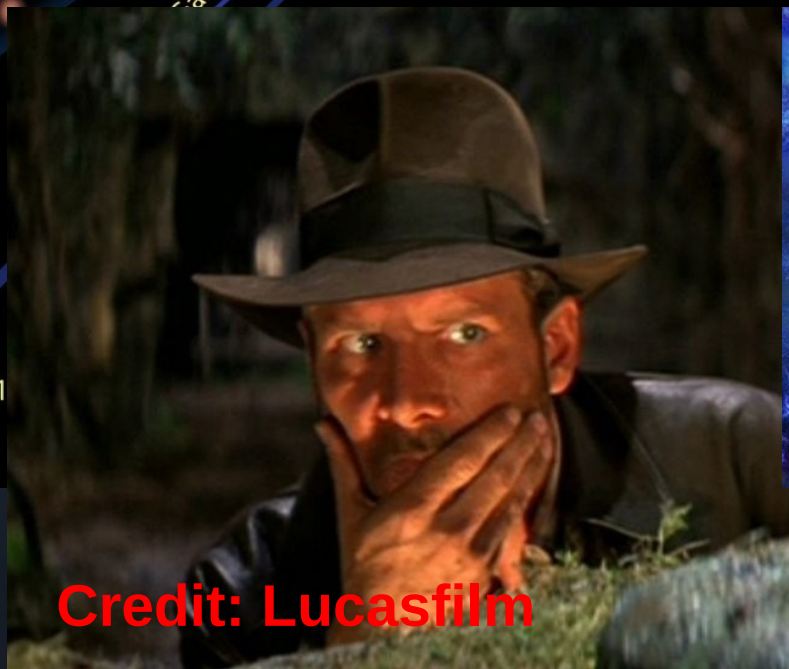
1-The First Stars



Credit: NASA

1-The First Stars





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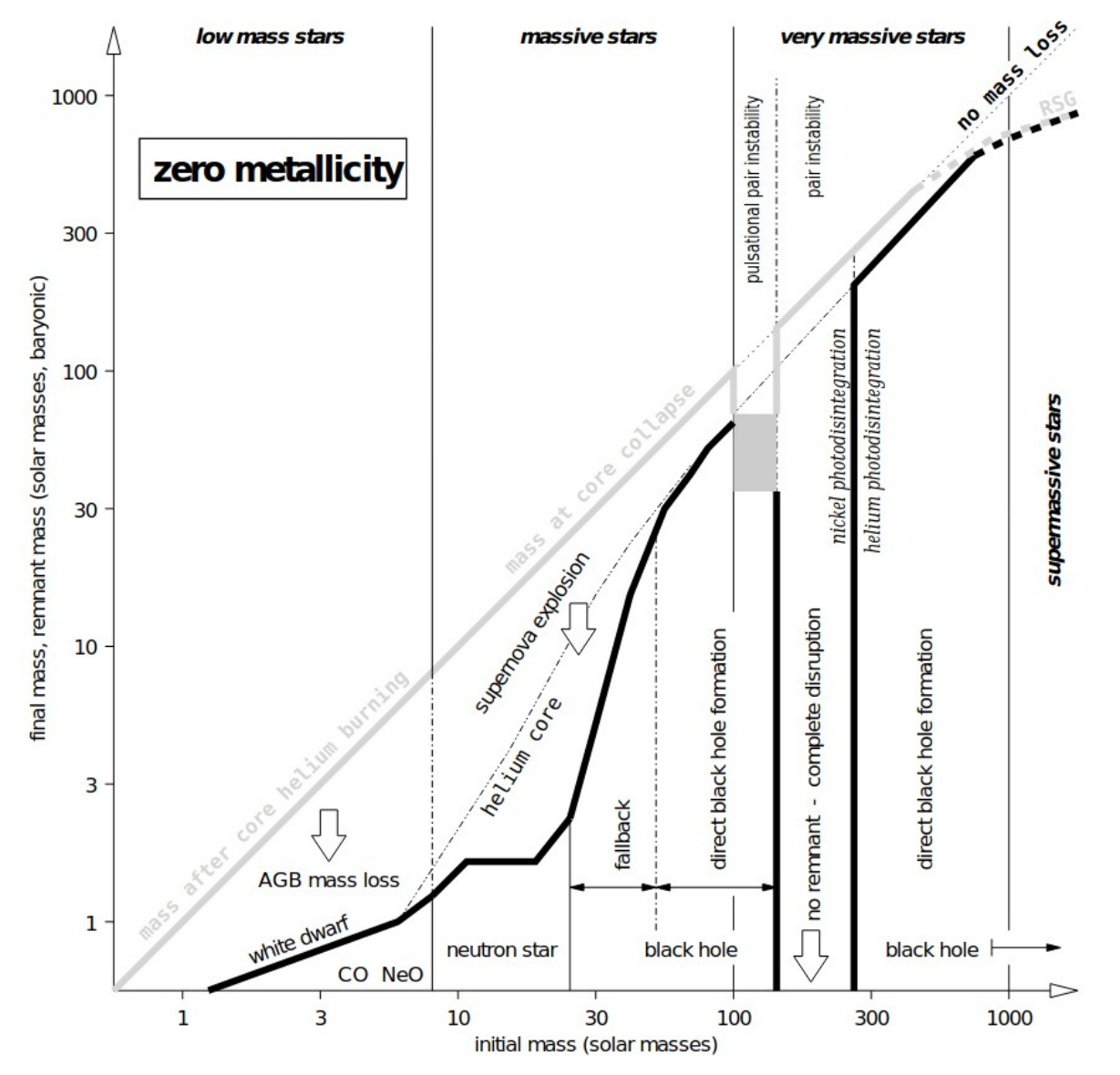
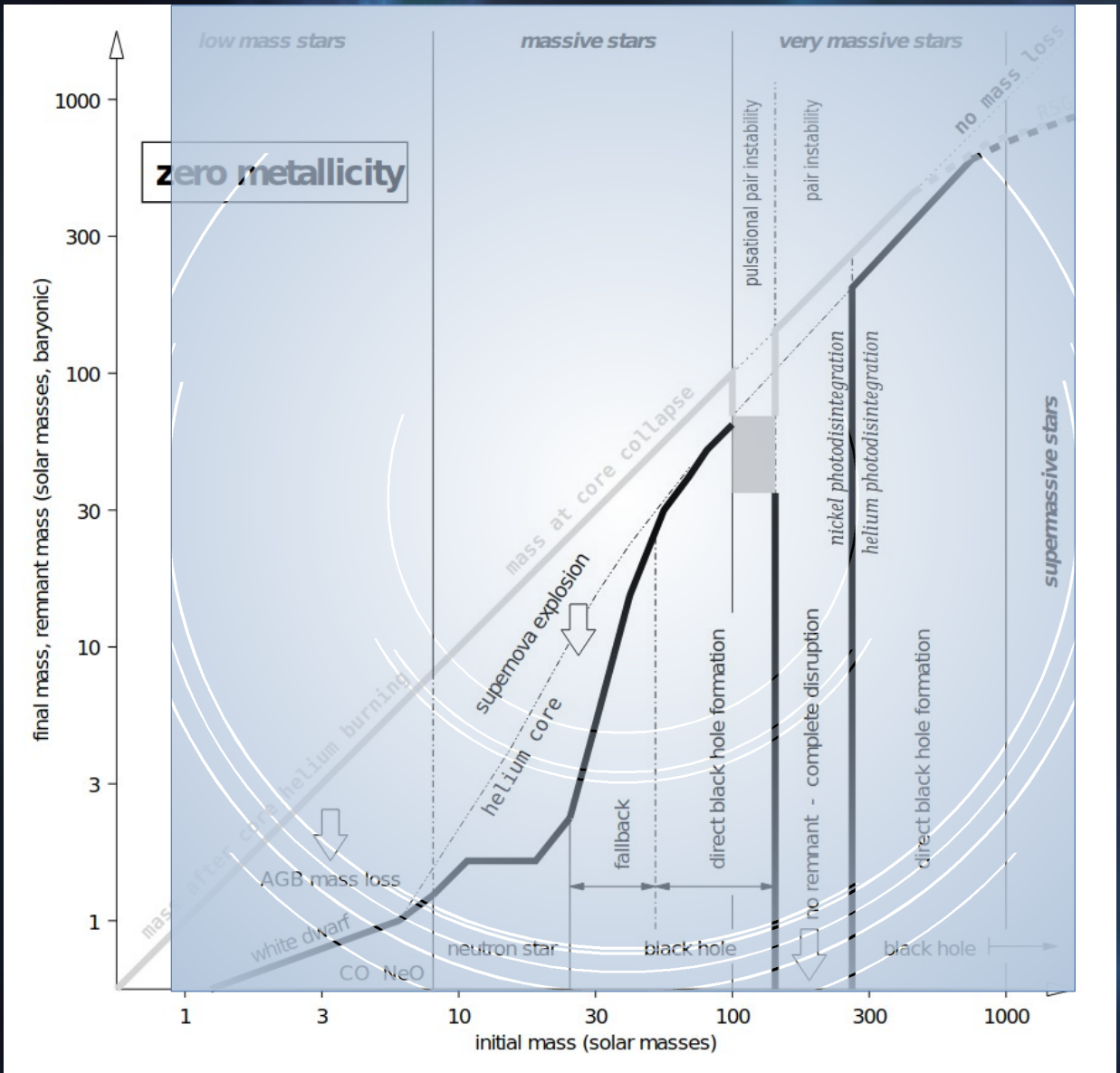


Heger & Woosley 2002

1-The First Stars



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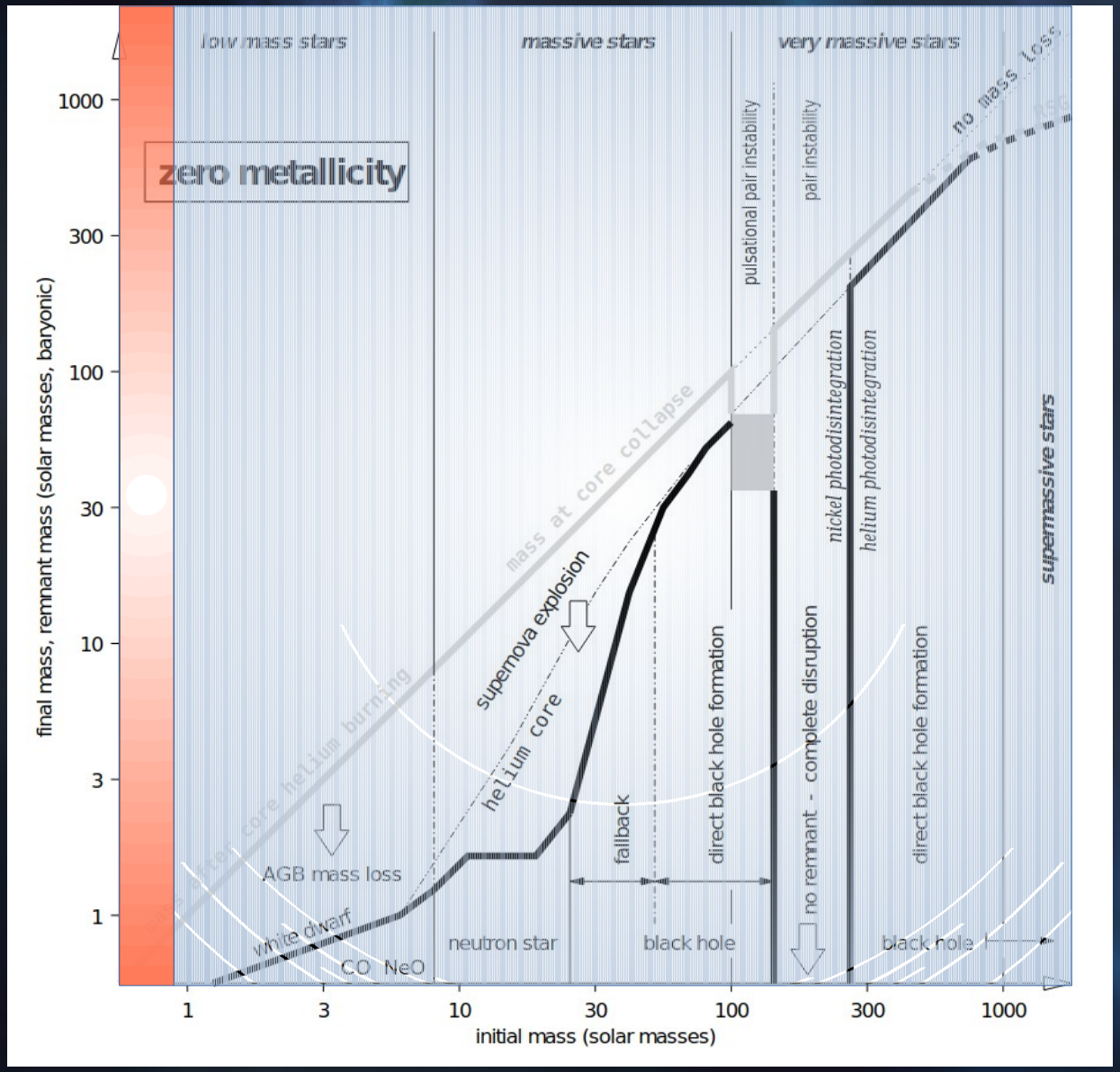

Heger & Woosley 2002

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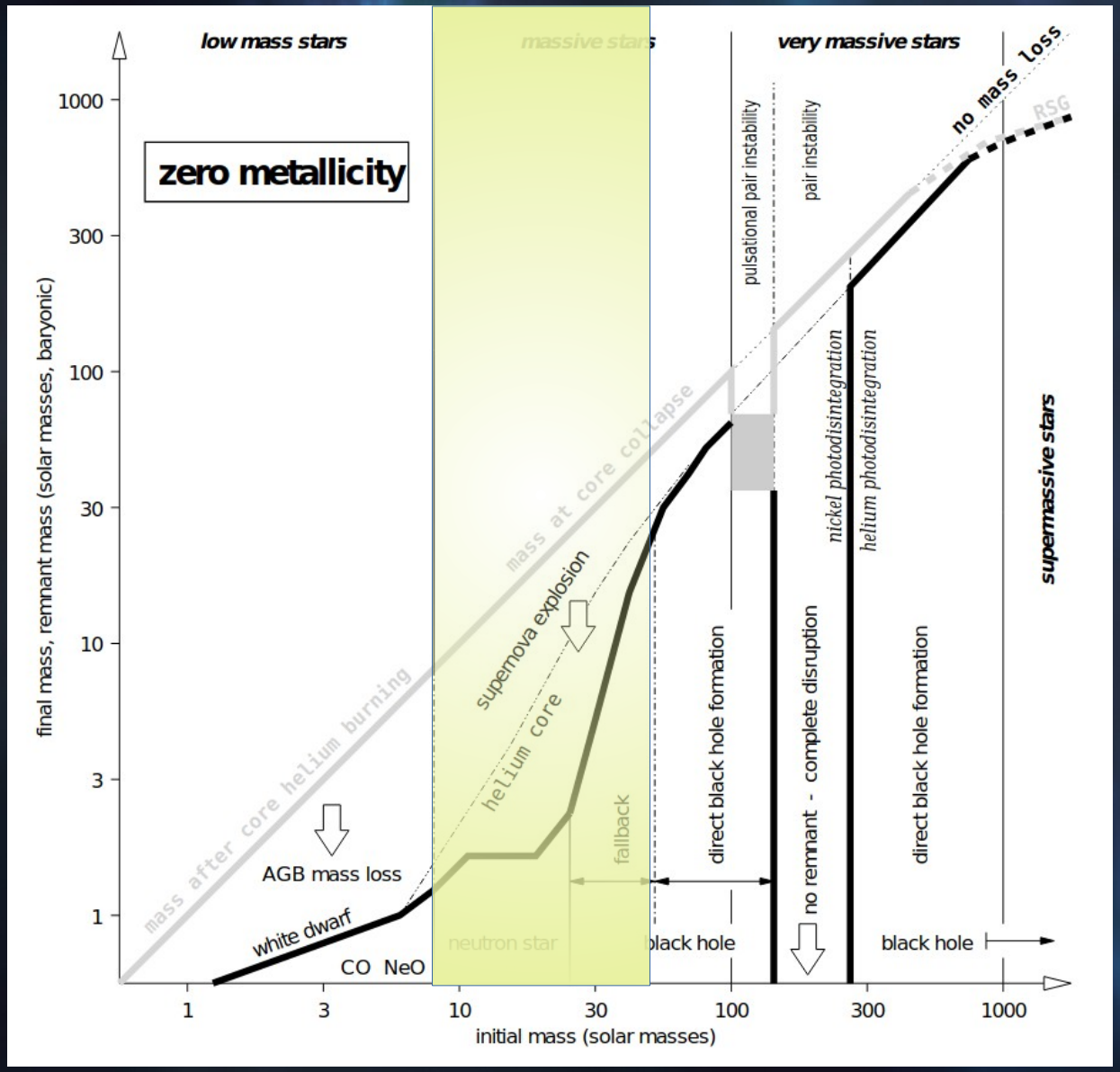


Heger & Woosley 2002

1-The First Stars

Christlieb+2012

Frebel+2005

Norris+2007

Caffau+2011

Keller+2014

Hansen+2014

Allende+2015

Bonifacio+2015

Bonifacio+2015

Bonifacio+2015

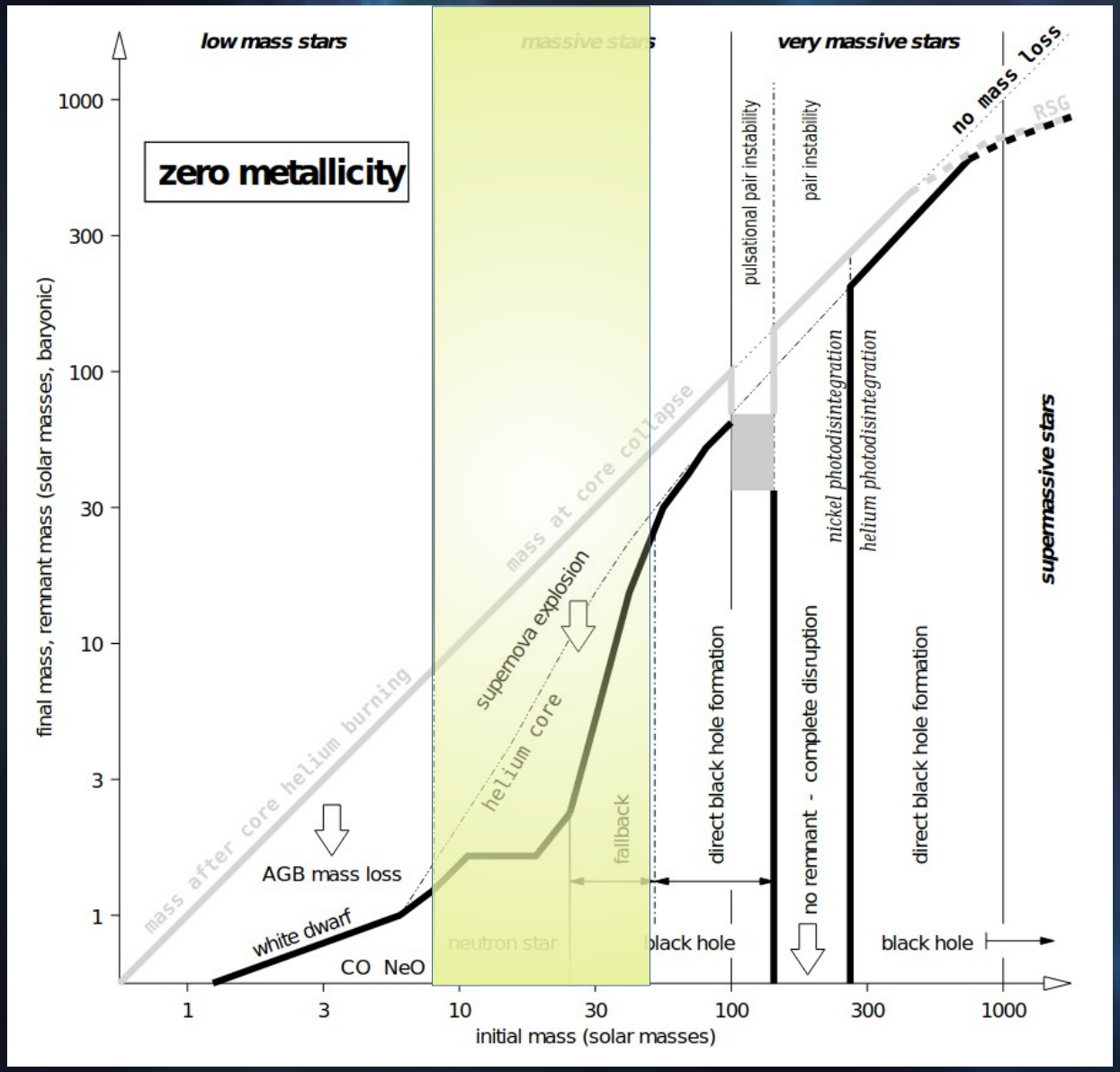
DA+2018a

DA+2018b

Starkenburg+2018

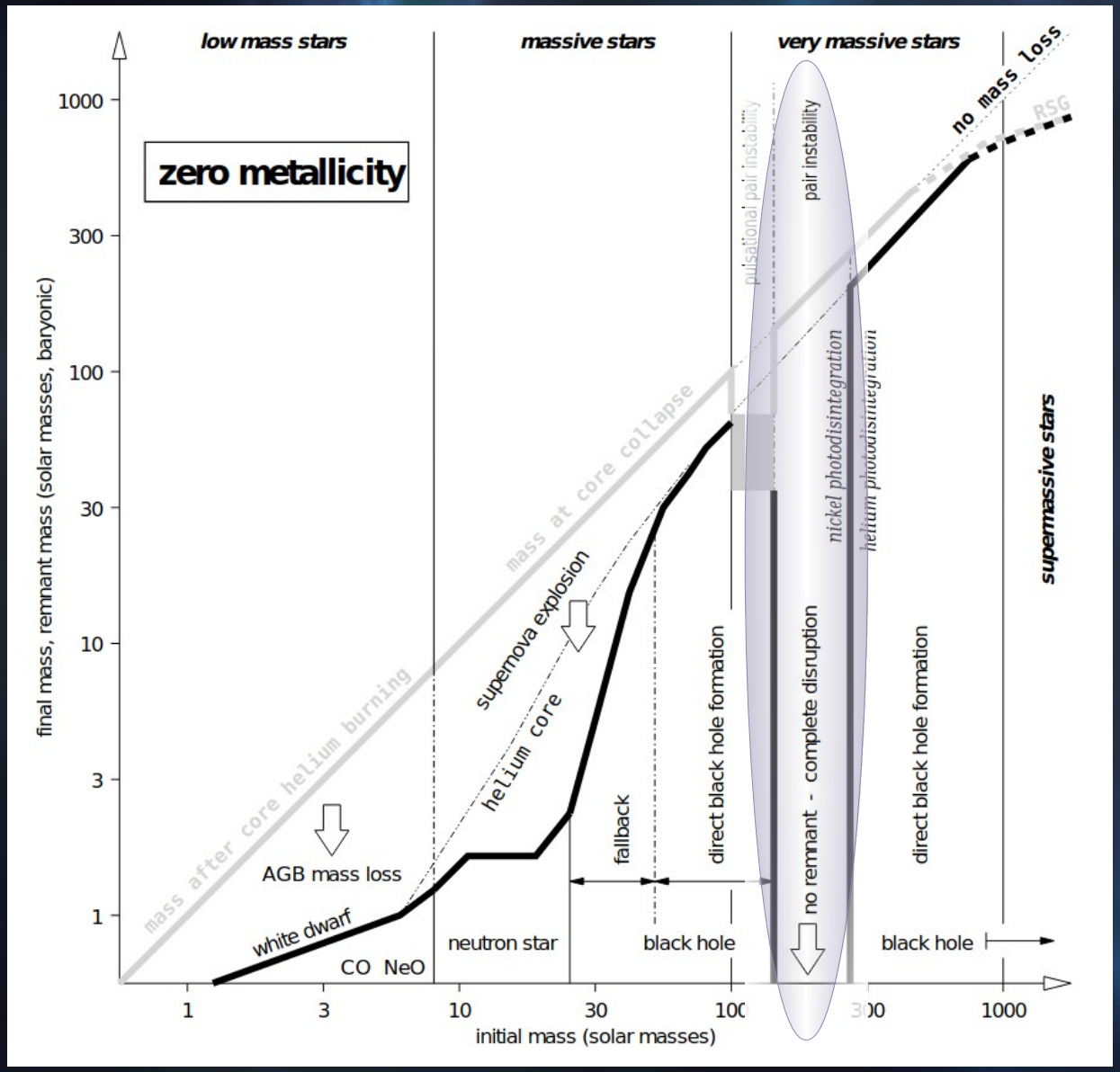
Nordlander+2019

Skúladóttir+2021



Heger & Woosley 2002

2-Pair Instability SuperNova (PISN)



Heger & Woosley 2002

2-Pair Instability SuperNova (PISN)

Mass range: 140-260 M_o

Pair production

Released E: ~10^53 erg

No remnant

Peculiar pattern

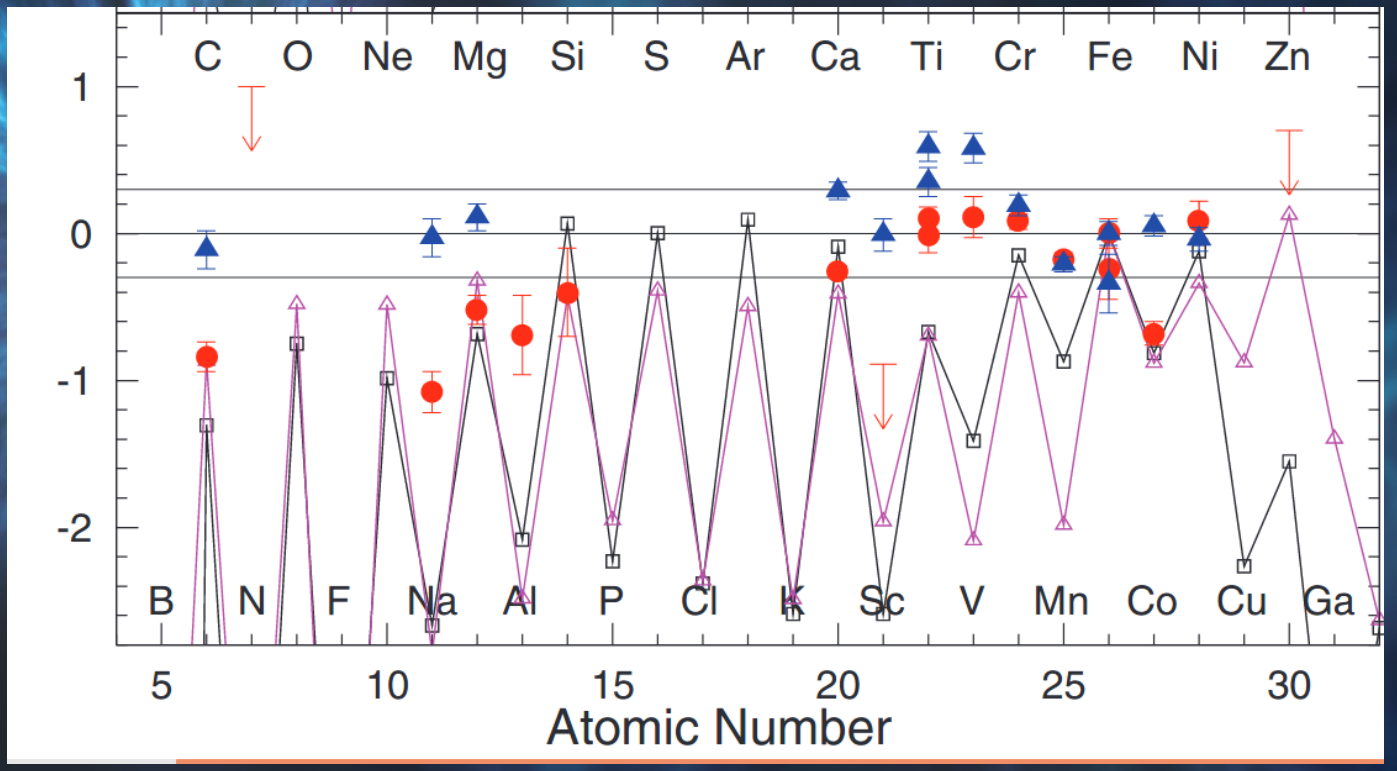
Heger & Woosley 2002

2-Pair Instability SuperNova (PISN)

J0018-0939 a MS with
Teff=4600
[Fe/H]=-2.5

Low α-elements!

Hegel & Hoosley 2002
Ohkubo et al. 2008



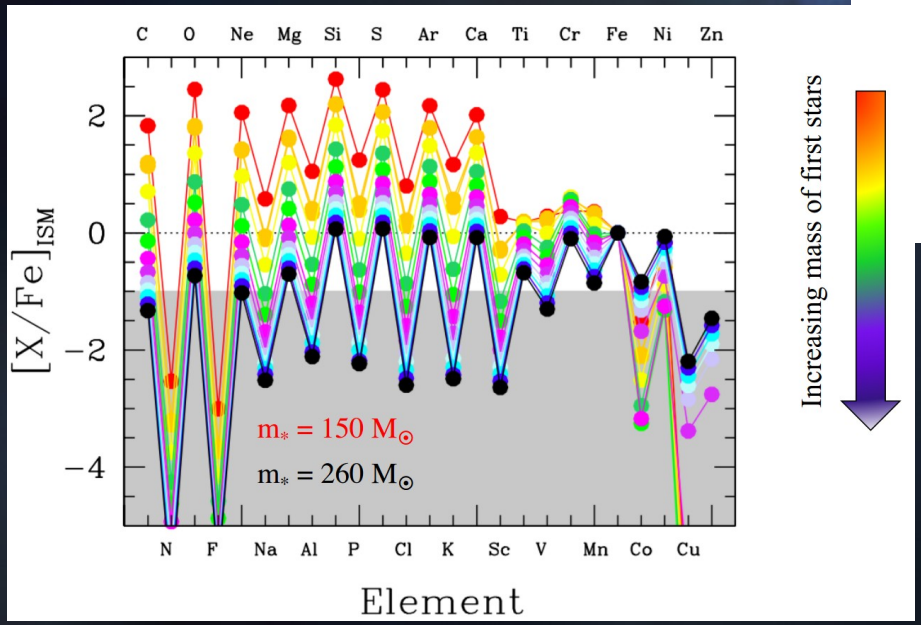
Aoki et al. 2014

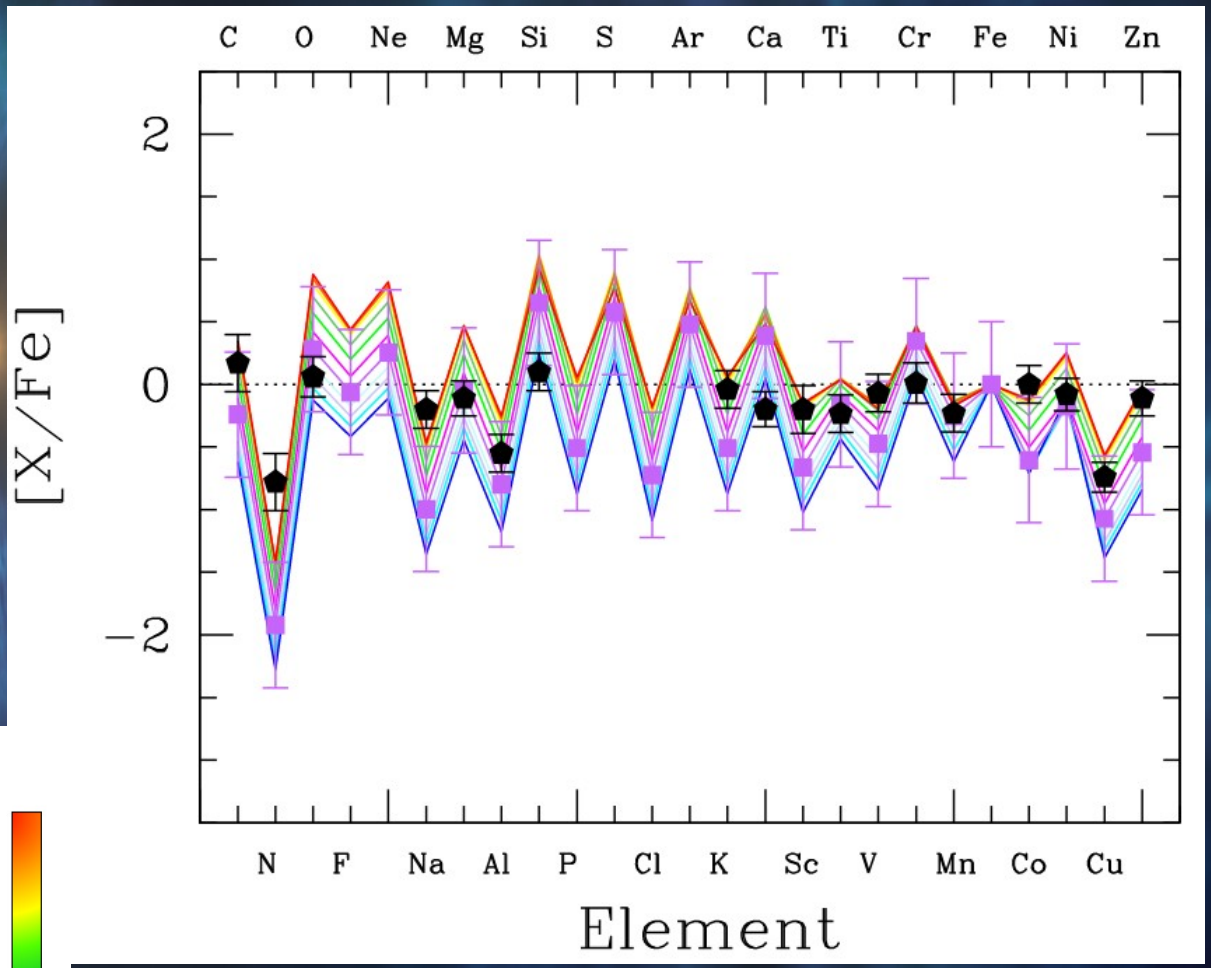
2-Pair Instability SuperNova (PISN)

BD80º245 a Sub-G with
Teff=5225
[Fe/H]=-2.1

Low α-elements
Killing elements Cu and Zn!

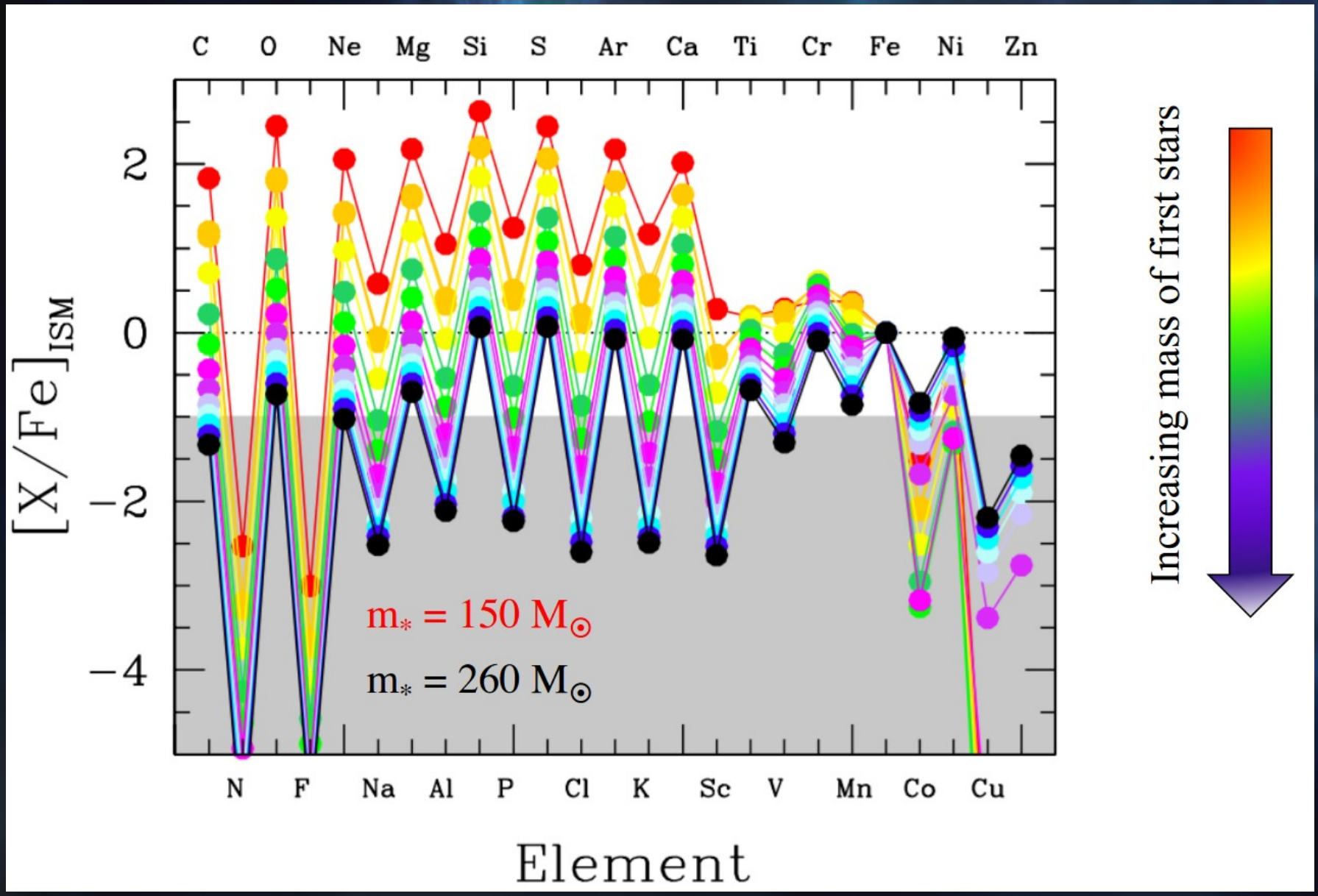
Hegel & Woosley 2002
Salvadori et al. 2019





Salvadori et al. 2019

3- How to find them?



Salvadori et al. 2019

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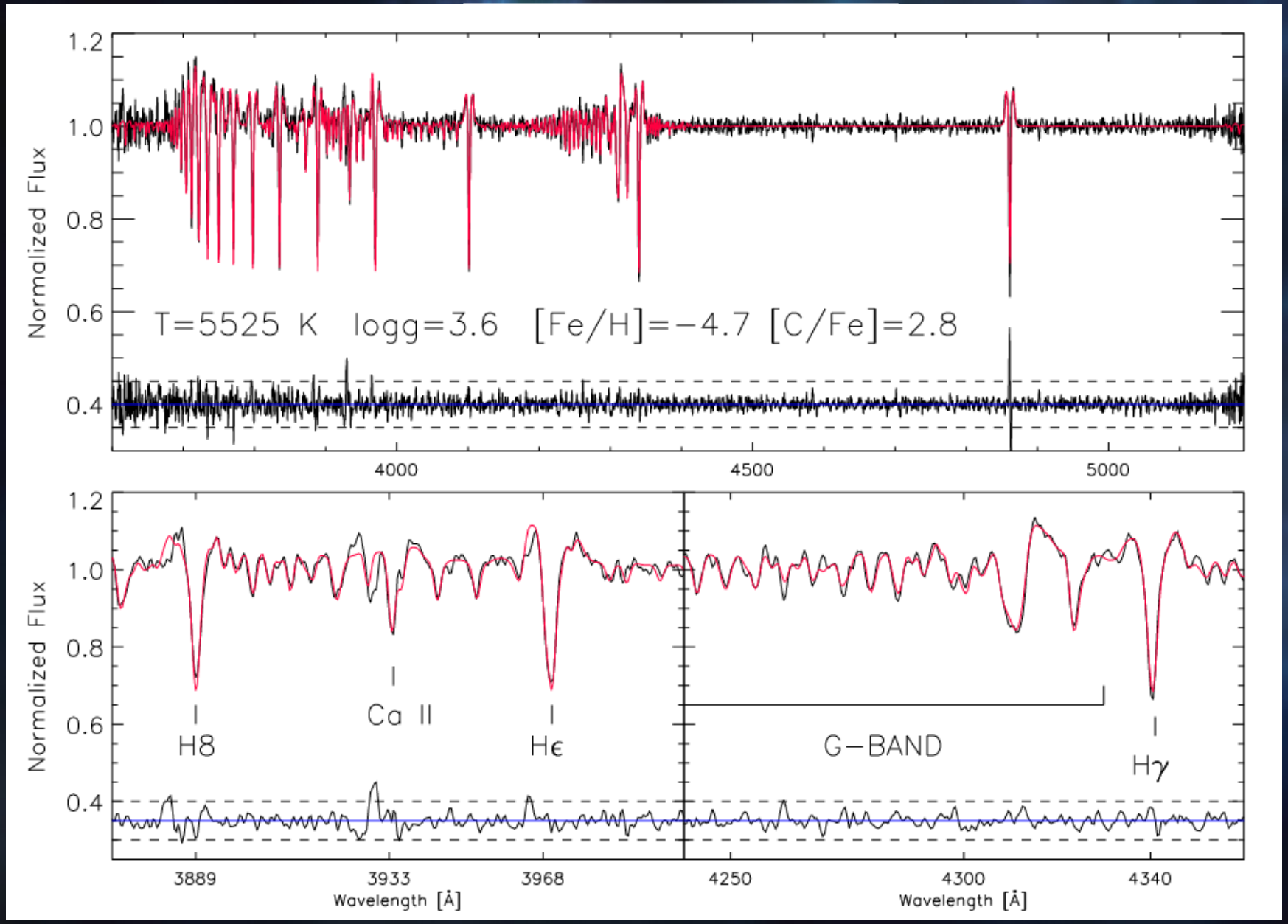
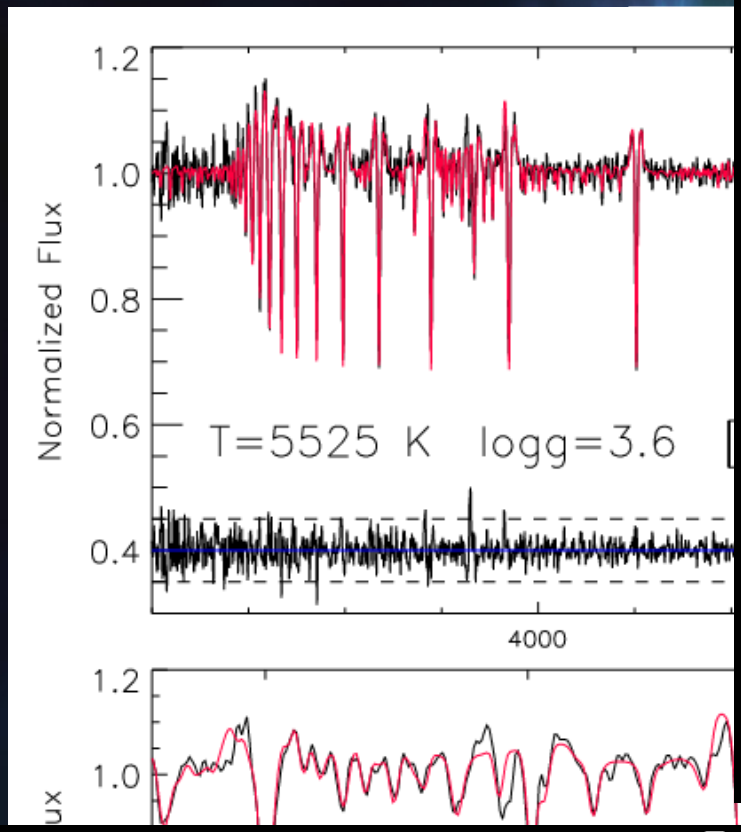
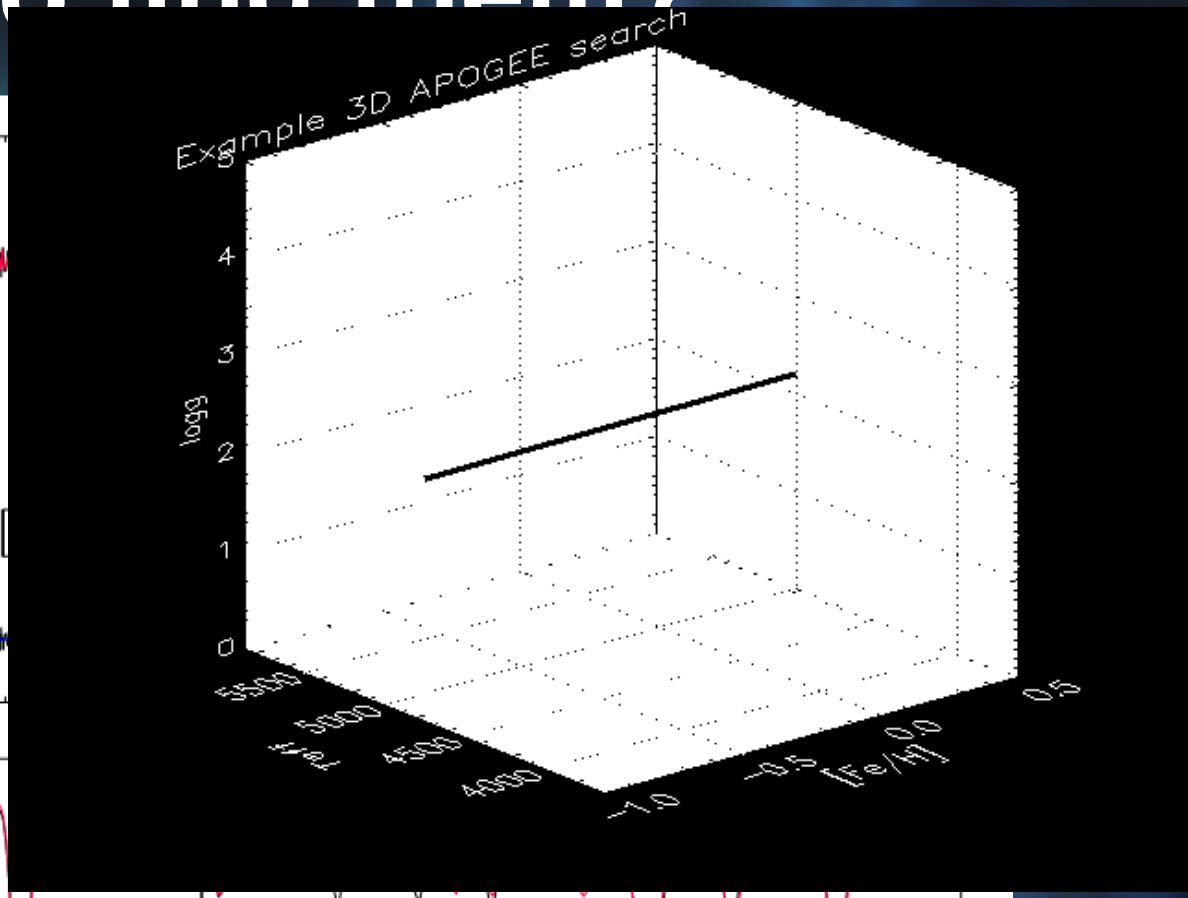
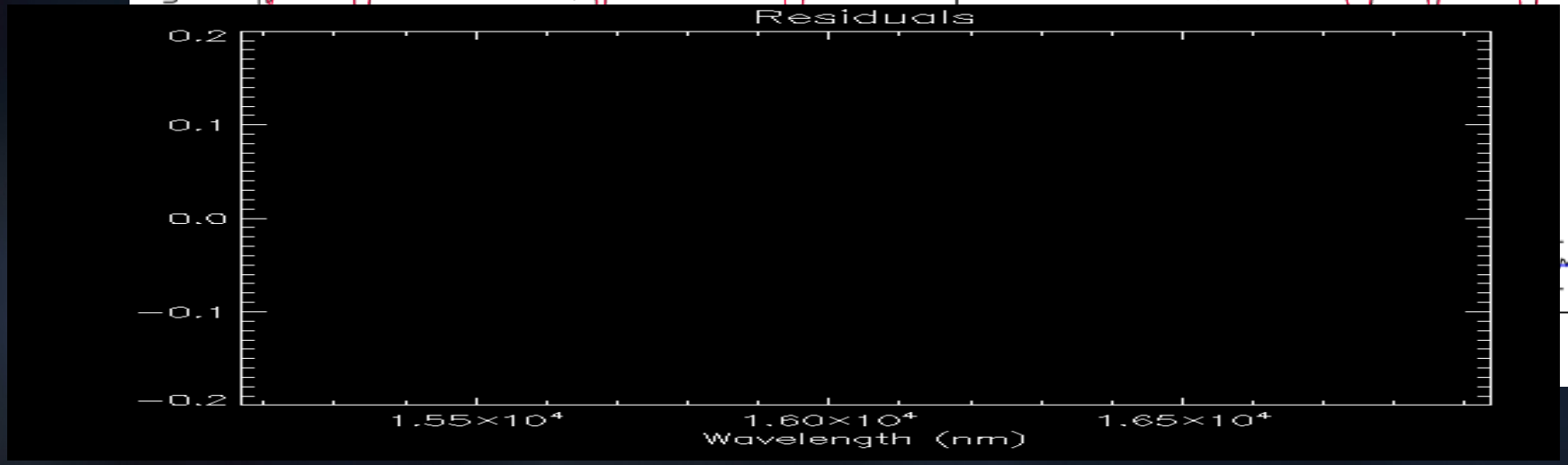


DA+ 2017

3- How to find them?







3- How to find them?

According to Salvadori et al. 2019

252 models with PISN yield predictions
Spaning:

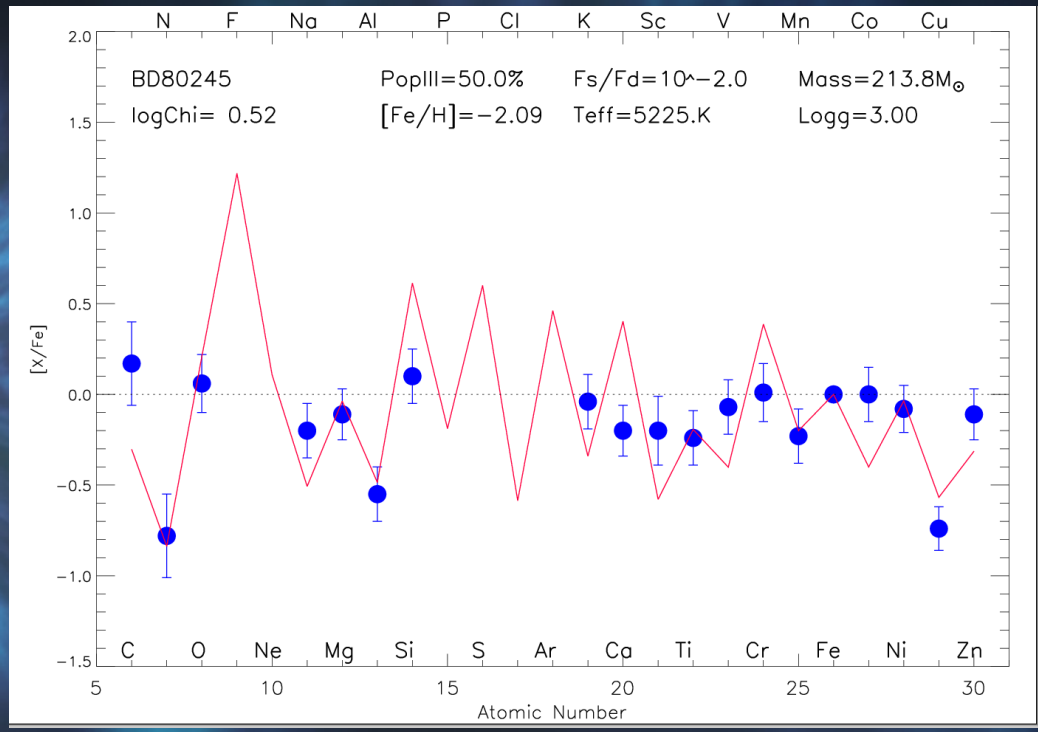
Percentage of PopIII: 50%-100%
Fraction of SF and gas dilution: 10^-2-10^-4
Mass of the progenitor: 140-260$M_\odot$

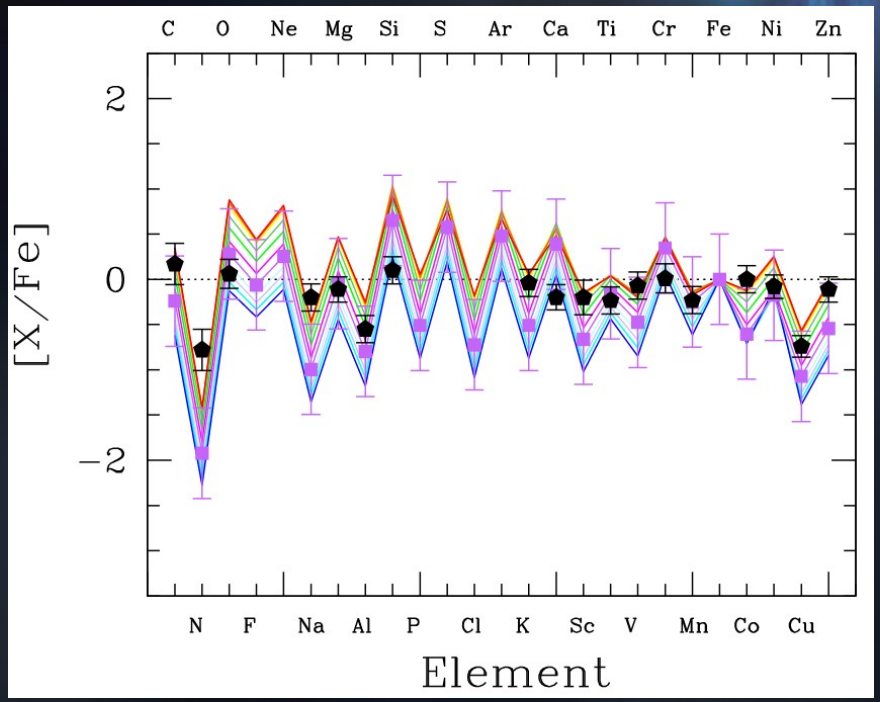
+ FERRE fitting with:
Powell's truncated Newton Algorithm
quadratic interpolation.

3- How to find them?

FERRE fit

PopIII: 50%
Fs/Fd: 10^-2
Mass: 214M$_\odot$

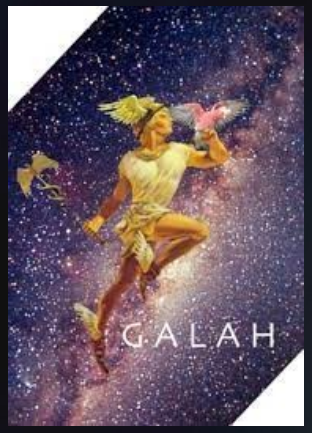




FERRE fit

PopIII: 50%
Fs/Fd: 10^-4
Mass: 223M$_\odot$

3- How to find them?



GALAH: 500k

C, O, Na, Mg, Al, Si K, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn

APOGEE: 600k

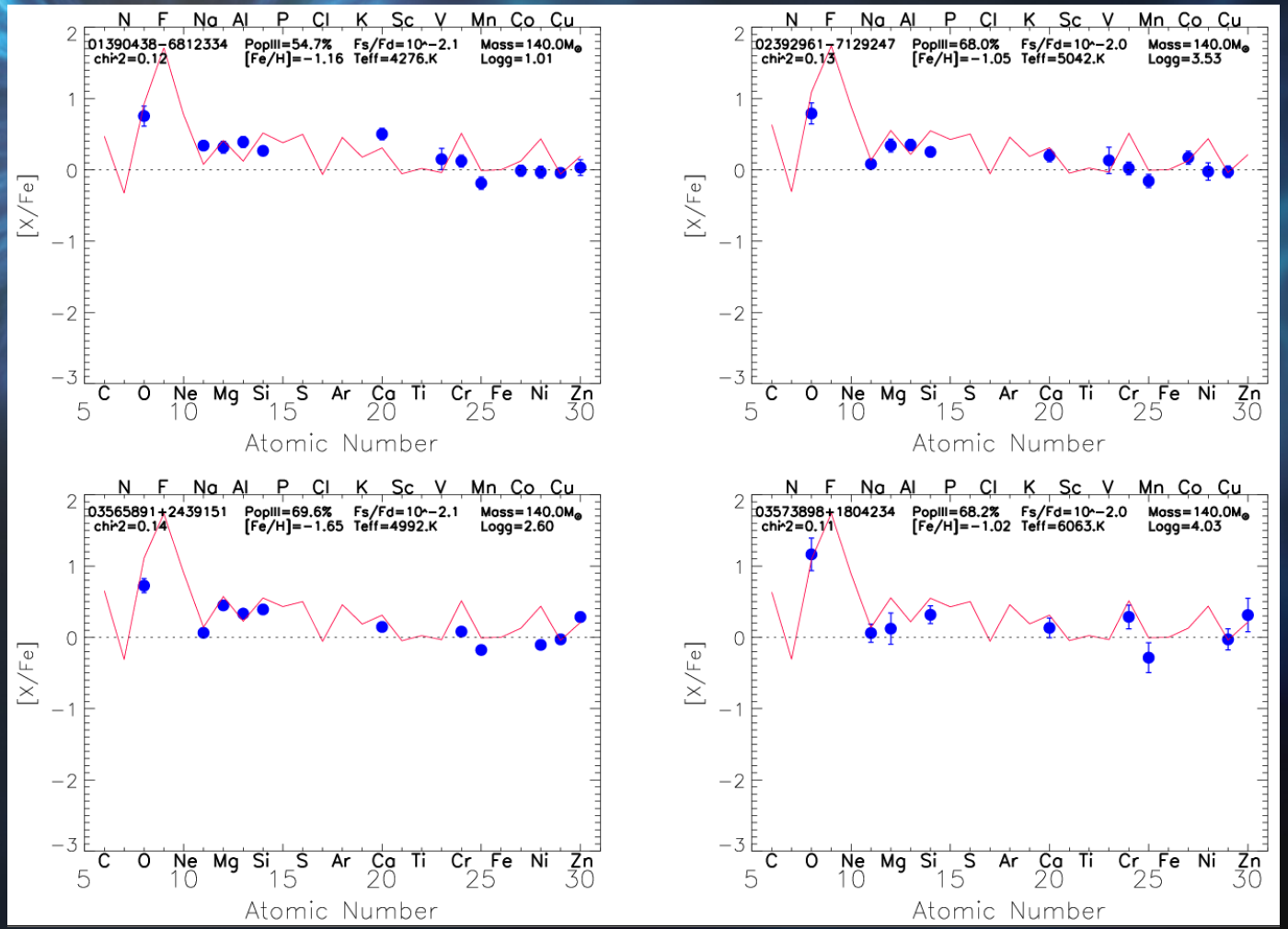
C, N, O, Na, Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu

Gaia-ESO Survey 10k

C, N, O, Na, Mg, Al, S Ca, Sc, Ti, V, Co, Ni, Zn

3- How to find them?

BEST FITS & Cu, Zn: 40

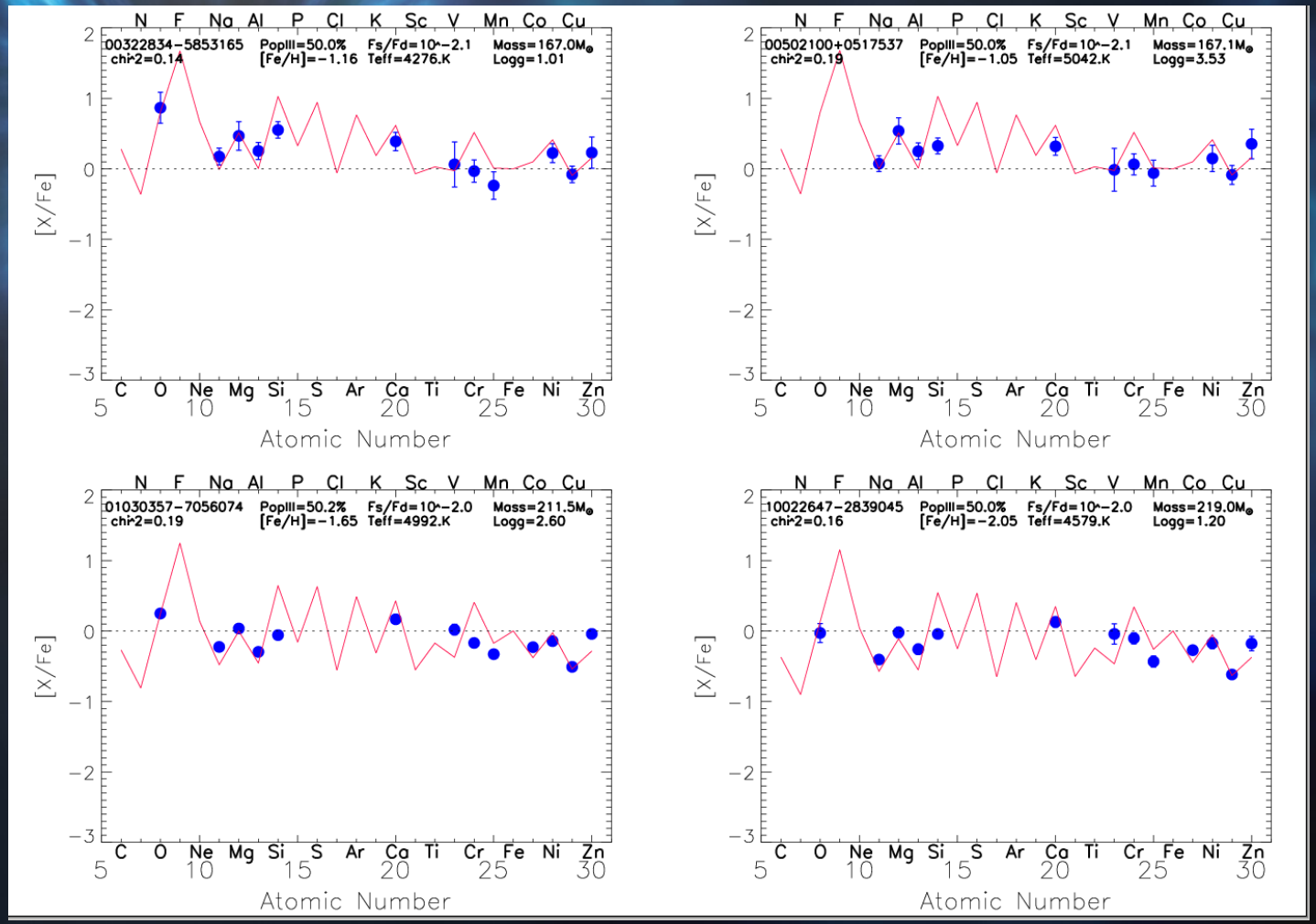


GALAH: 500k----->58k

C, O, Na, Mg, Al, Si K, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn

3- How to find them?

BEST FITS & Cu, Zn & Mass > 140M$_\odot$: 60



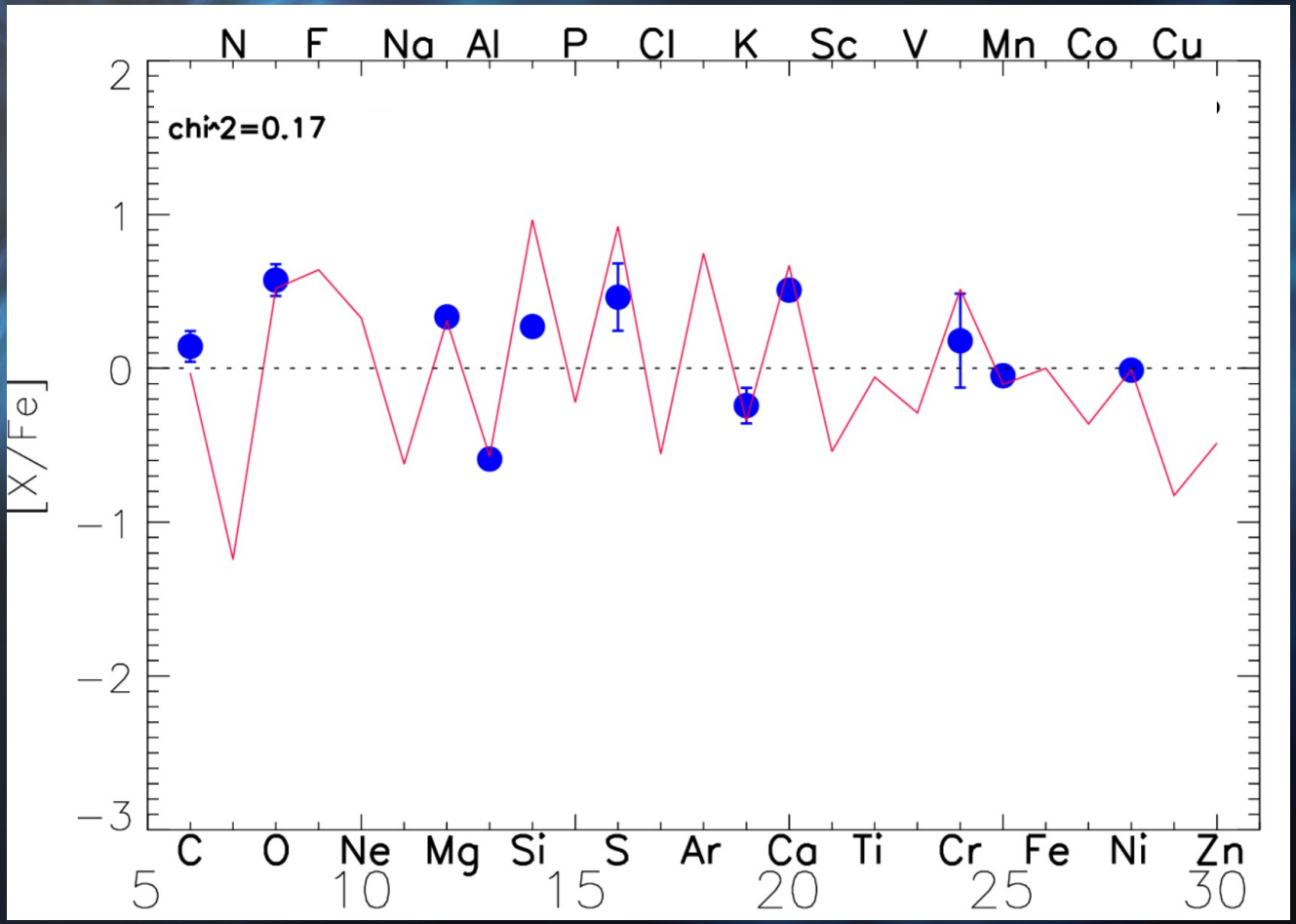
GALAH: 500k----->58k

C, O, Na, Mg, Al, Si K, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn

4- A very promising candidate

APOGEE: 600k

C, N, O, Na, Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu



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APOGEE: 600k

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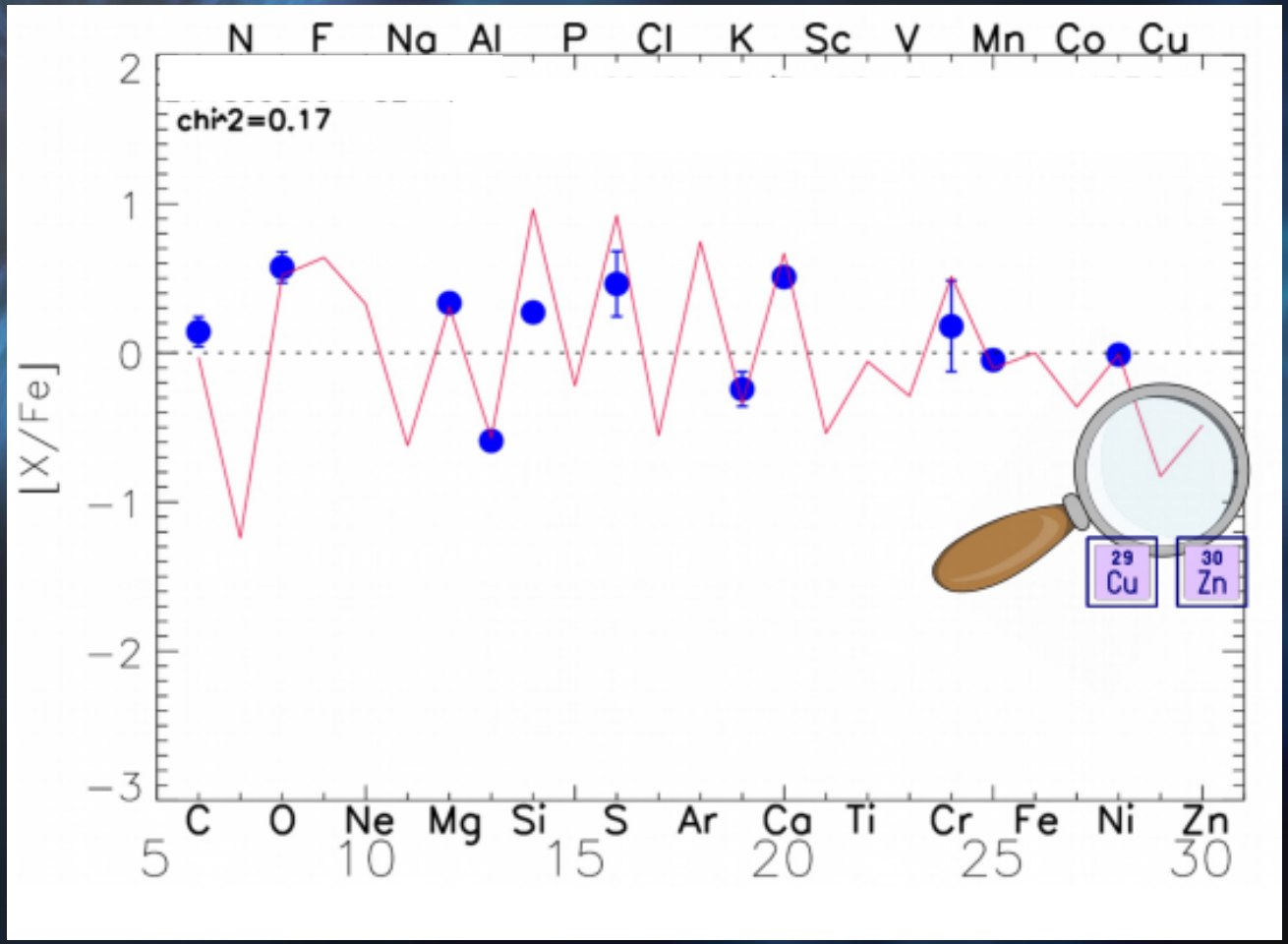


4- A very promising candidate

Credit: ESO

C, N, O, Na , Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Y, Zr, Ba, La, Ce, Nd and Eu

4- A very promising candidate

Credit: ESO

C, N, O, Na , Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Y, Zr, Ba, La, Ce, Nd and Eu

DDT proposal ID: 108.23N5 [internalId 2108.B-5031]

Recibidos

Silvia Cristiani 9:48

para mí

Dear Dr Aguado,

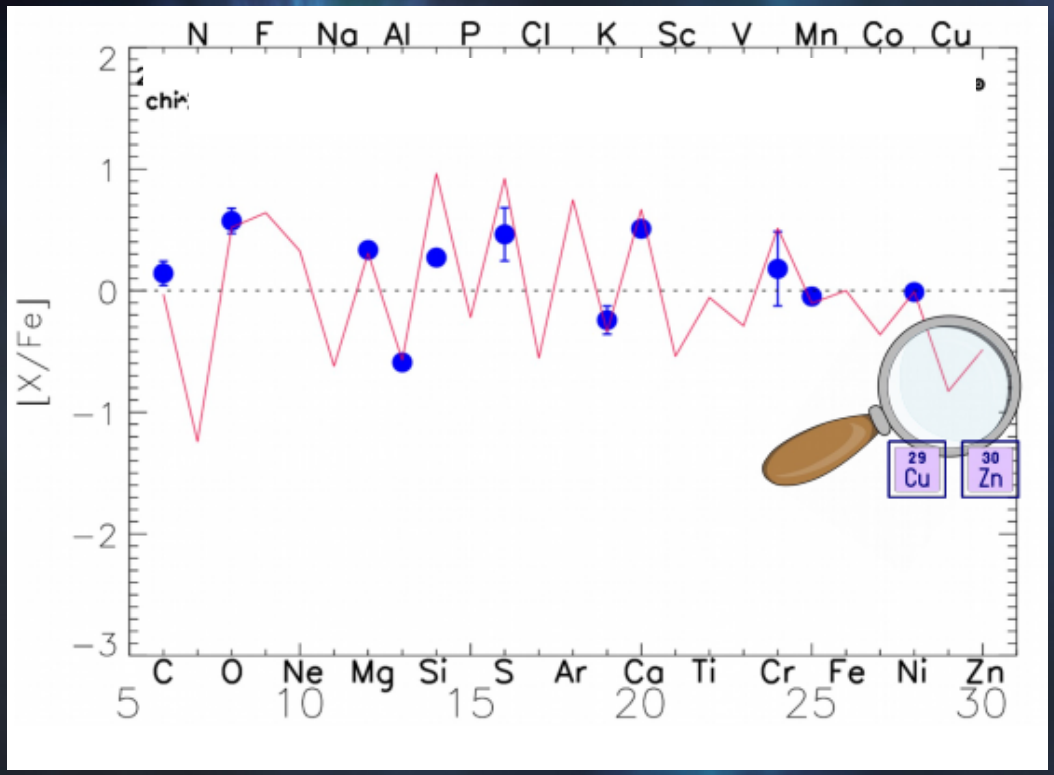
We are pleased to inform you that your DDT proposal 2108.B-5031 with the title "A Unique Descendant of the First Very Massive Stars" was approved by the ESO Director for Science on behalf of the Director General in rank class A, and time was allocated to it as requested:

1 hr with UVES

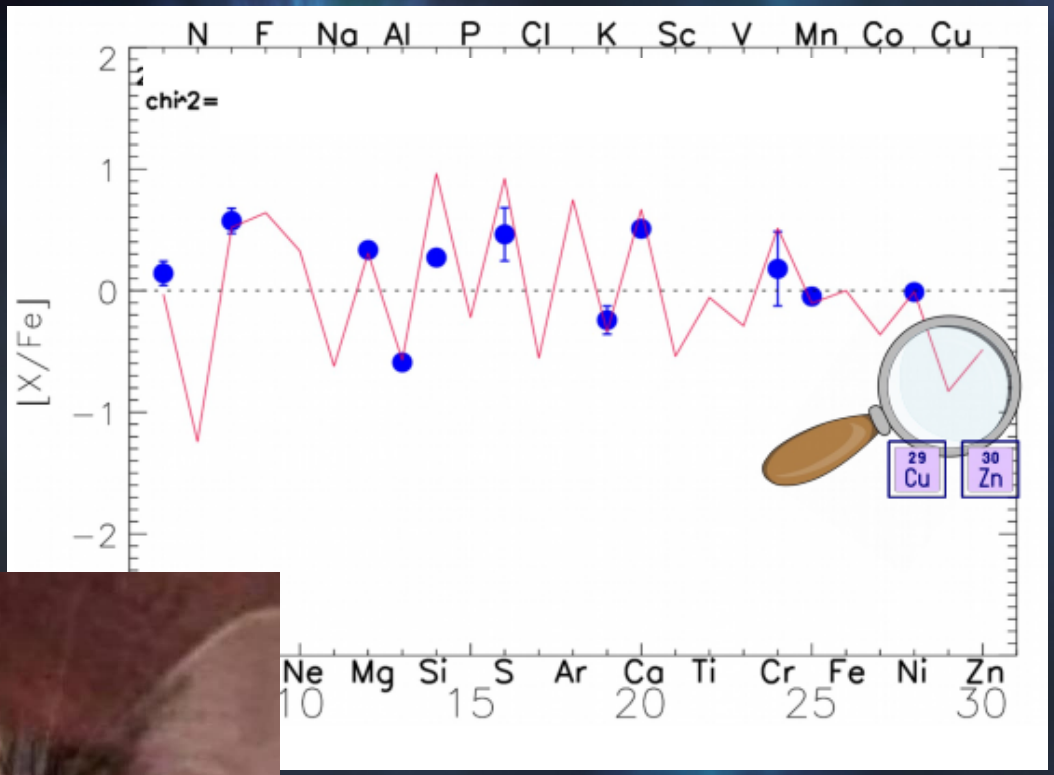
You will soon receive a message from the User Support Department containing details about the preparation of your observations for this DDT programme.

In case of questions, the User Support Department can be contacted by submitting a ticket under the URL: https://support.eso.org.

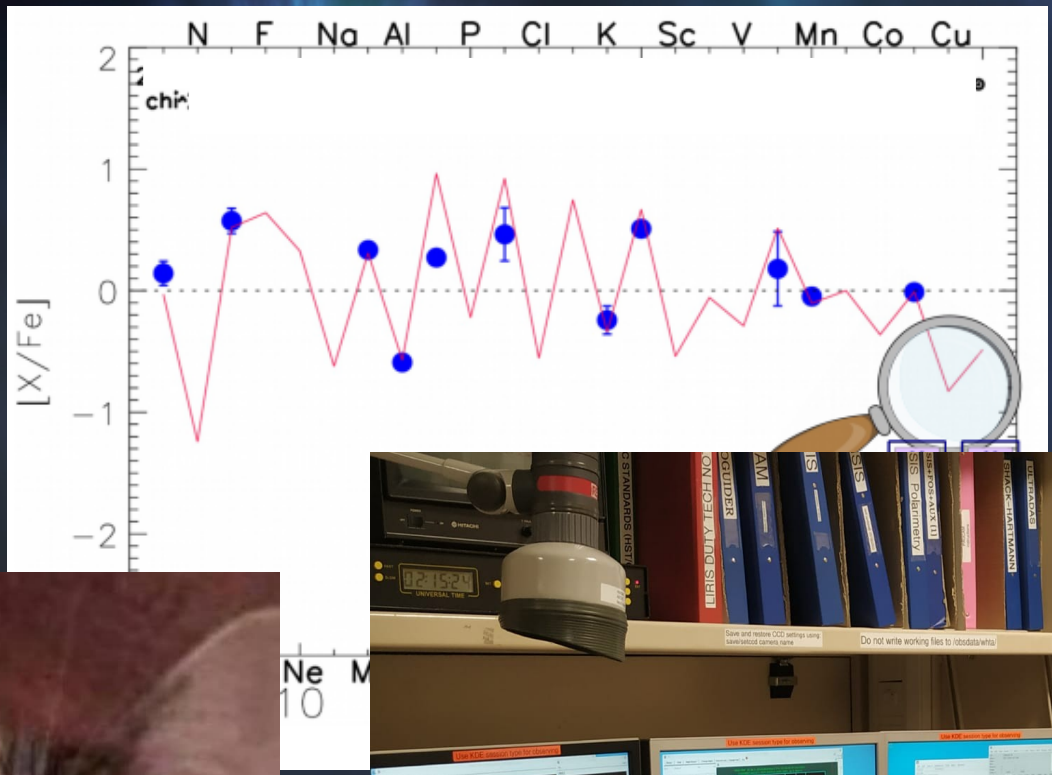
4- A very promising candidate



4- A very promising candidate



4- A very promising candidate



Thanks for your attention!

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NEFERTITI
Near Field cosmology: Re-Tracing Invisible Times