Program for LUVOIR !

Formation of the lightest neutron-capture elements Ge As Se in the early Galaxy

Different teams working on this subject:
"r-process alliance" (Roederer et al.)
our group GEPI+IAG et al.
"japanese group" (Wanajo et al.)
etc...

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Early phases of the Chemical evolution of the Galaxy

programs

"First stars first nucleosynthesis"
stars selected in the BPS catalogue

"TOPoS"
stars selected in the SDSS (Sloan Digital Sky Survey)

"PRISTINE"
stars selected at the CFHT (photometry, 2 filters) ....

→ low mass stars with very weak metallic lines
(G-M stars mass < $0.9M_{\odot}$ life time > 13 Gyr), born in the first Gyr of the Galaxy.

when these stars were born, the matter had been enriched only by
the ejecta of massive stars with a life time < 1Gyr.

Neutron capture elements in very metal-poor stars

From C to Zn elements are created by different burning processes (H, He, C, Ne, O, Si)

The "heavy" elements (beyond Zn) are created by neutron captures on iron seeds through different processes:

The abundance distribution of these elements depend on the process of formation

r-process high neutron density and flux (see Cowan et al. 2019)

main-r mergers of neutron stars

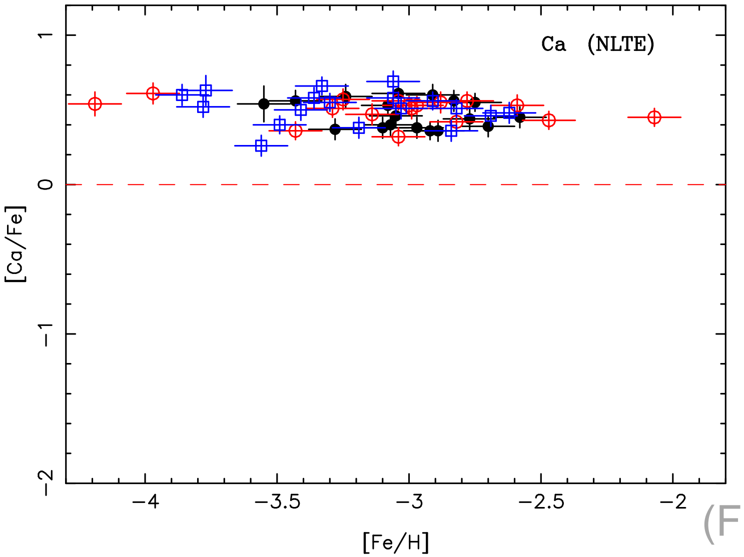
(recent detection of a neutron star merger (GW170817, Metzger, 2017b)

weak-r massive supernovae ...

~~**s-process**~~ low neutron flux and density (low mass AGB stars)

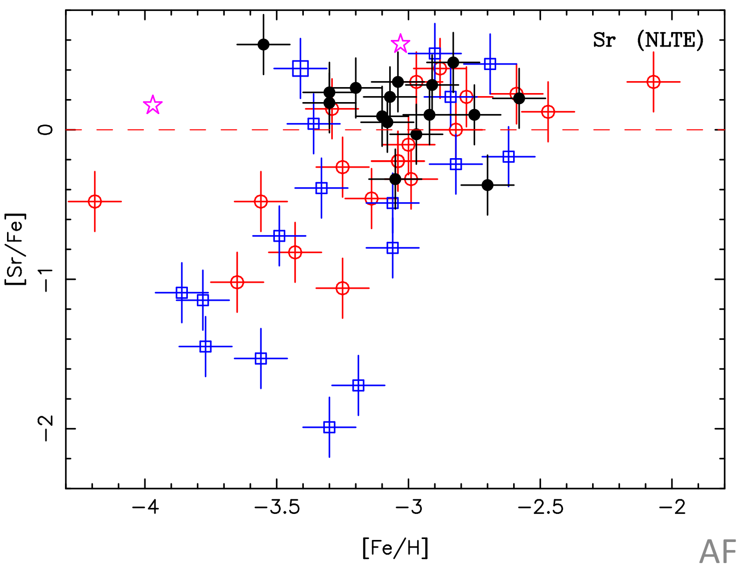
In the very old stars the low mass AGB stars had no time to enrich the matter through the main "s" process.

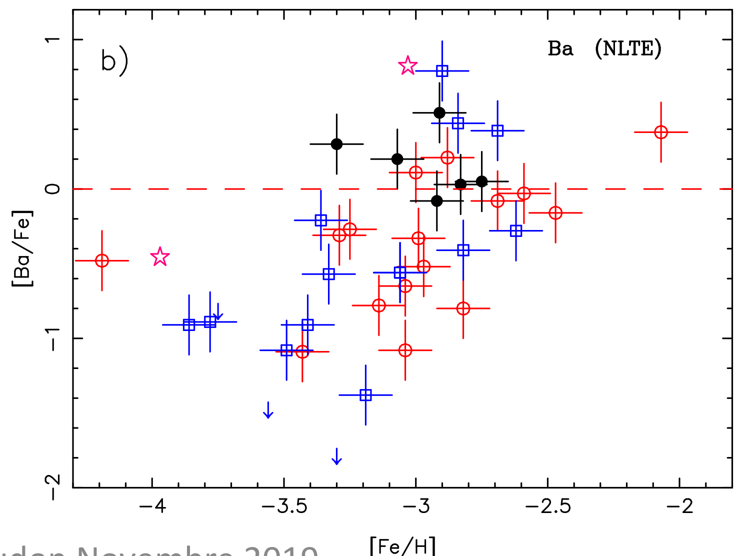
Comparison of the behavior of [Ca/Fe] vs. [Fe/H] with [Heavy/Fe] vs. [Fe/H] in very metal poor stars



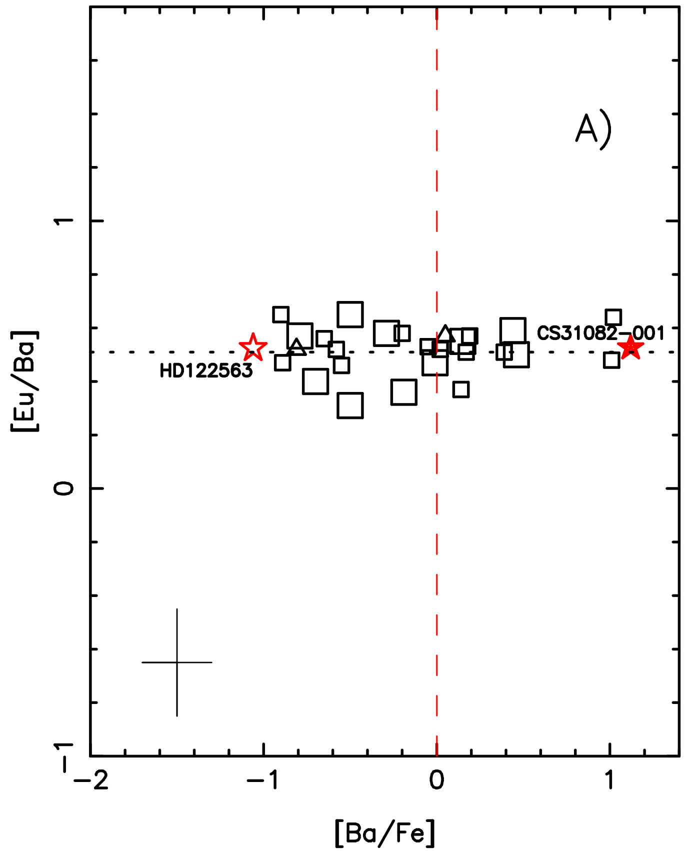
But are the Ba-poor stars also Eu-poor Sr-poor etc... ?

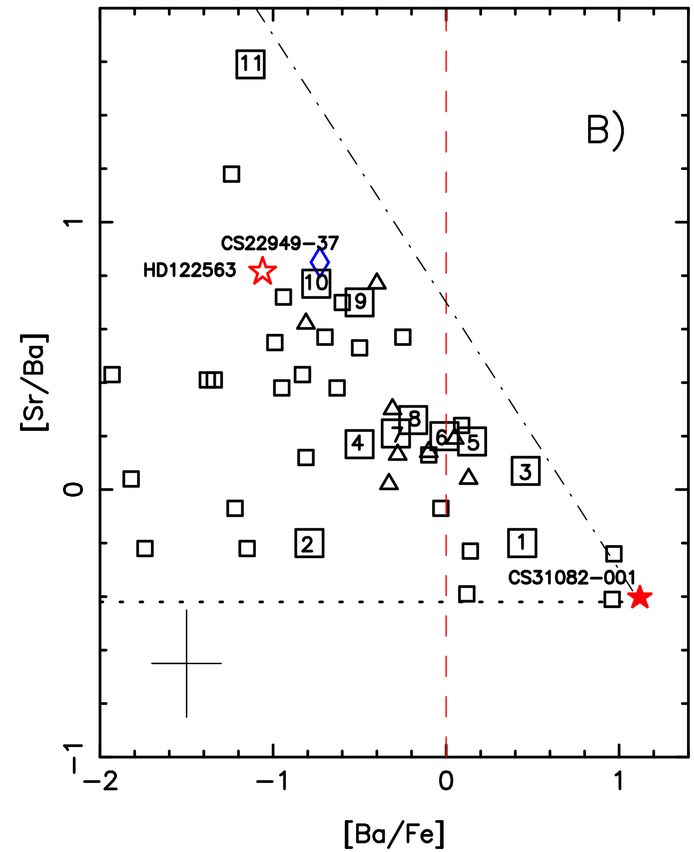
(François et al. 2007)





I Neutron-capture elements from Sr to Ba (38 ≤ Z ≤ 56)

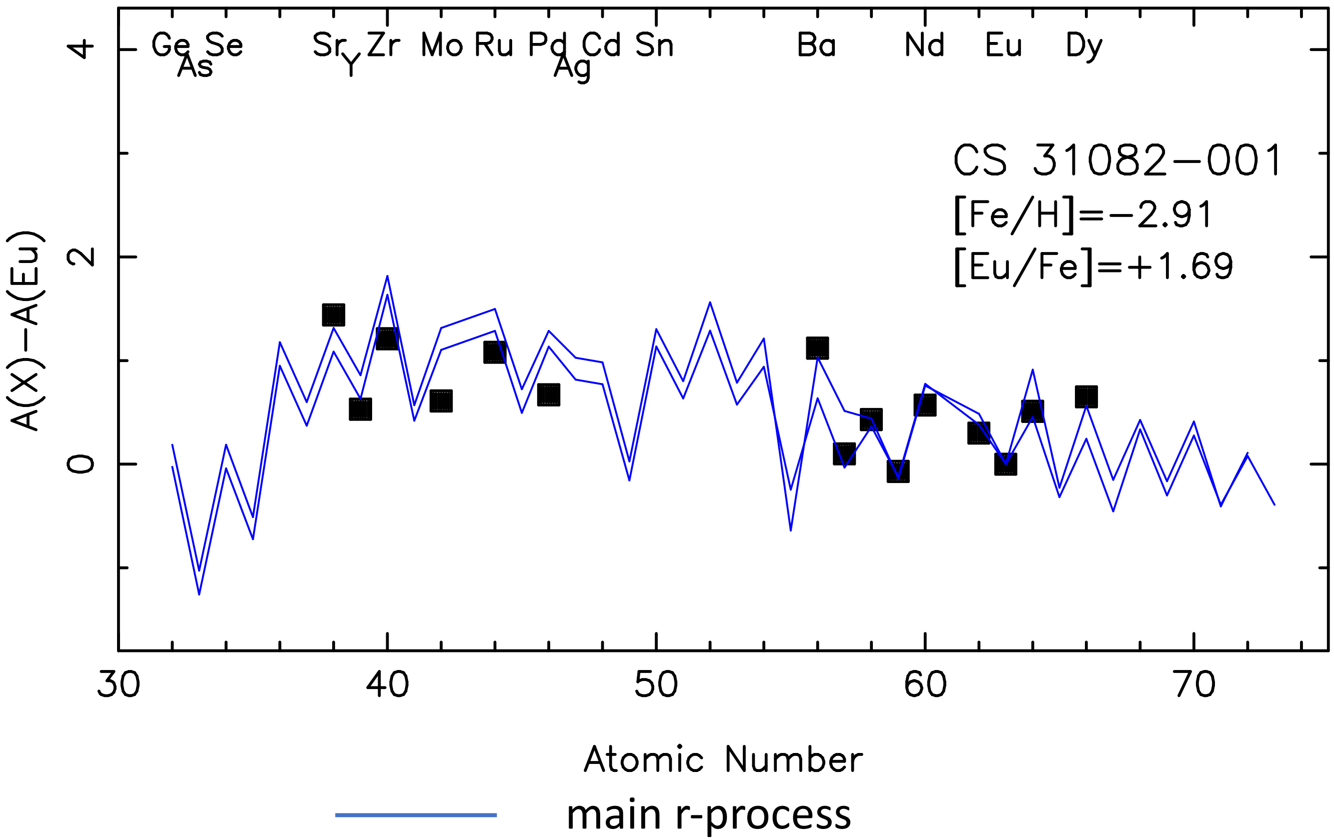




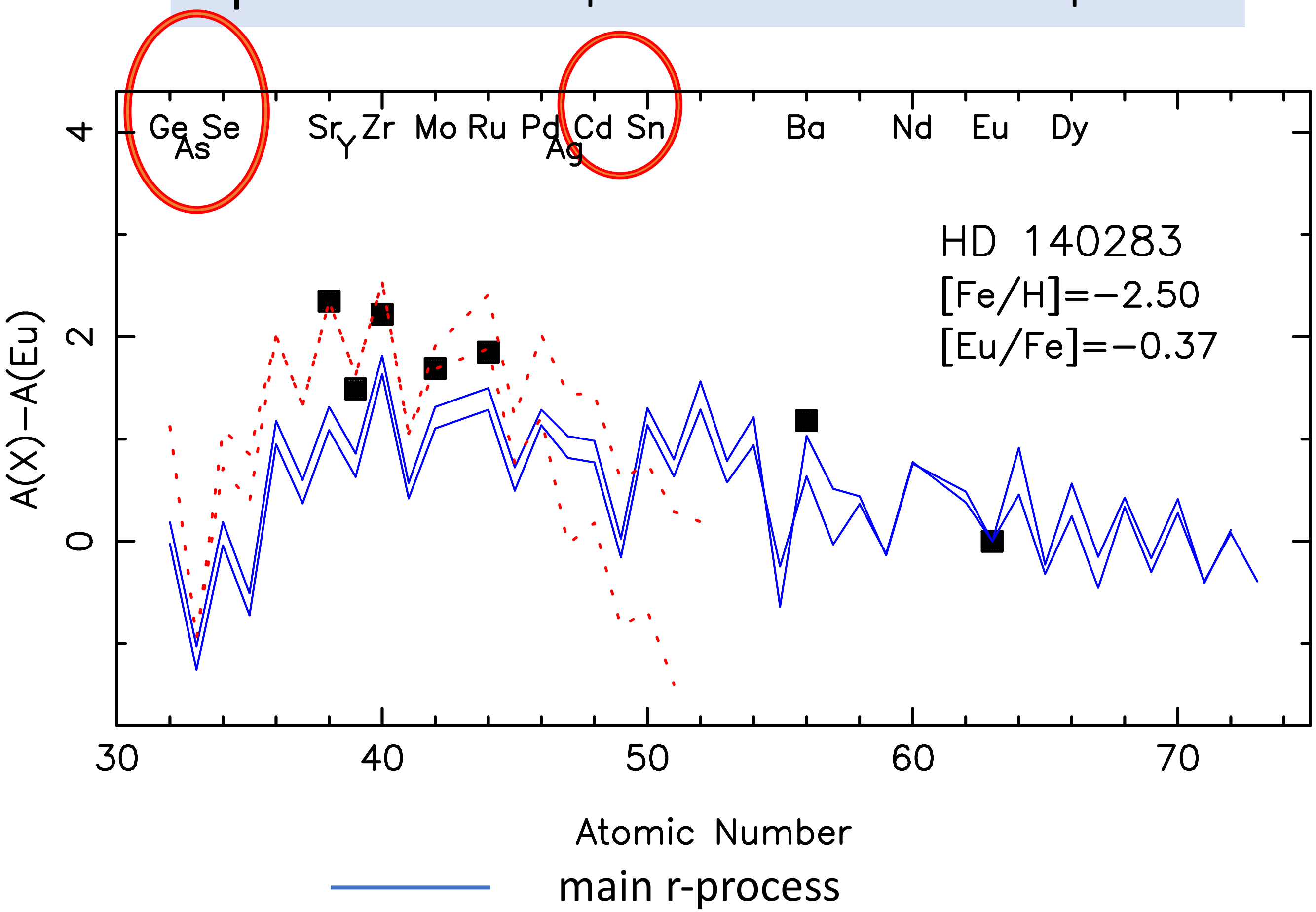
Below [Fe/H]=-2.5: scatter of [Sr/Ba] ↗ when [Ba/Fe] ↘ it reaches 2dex !

good correlation between Sr (Z=38) , Y (Z=39) , Zr (Z=40)

r-rich star comparison to the main-r process



r-poor star comparison to the main-r process



adding some production by a ------------ weak-r process 🙂

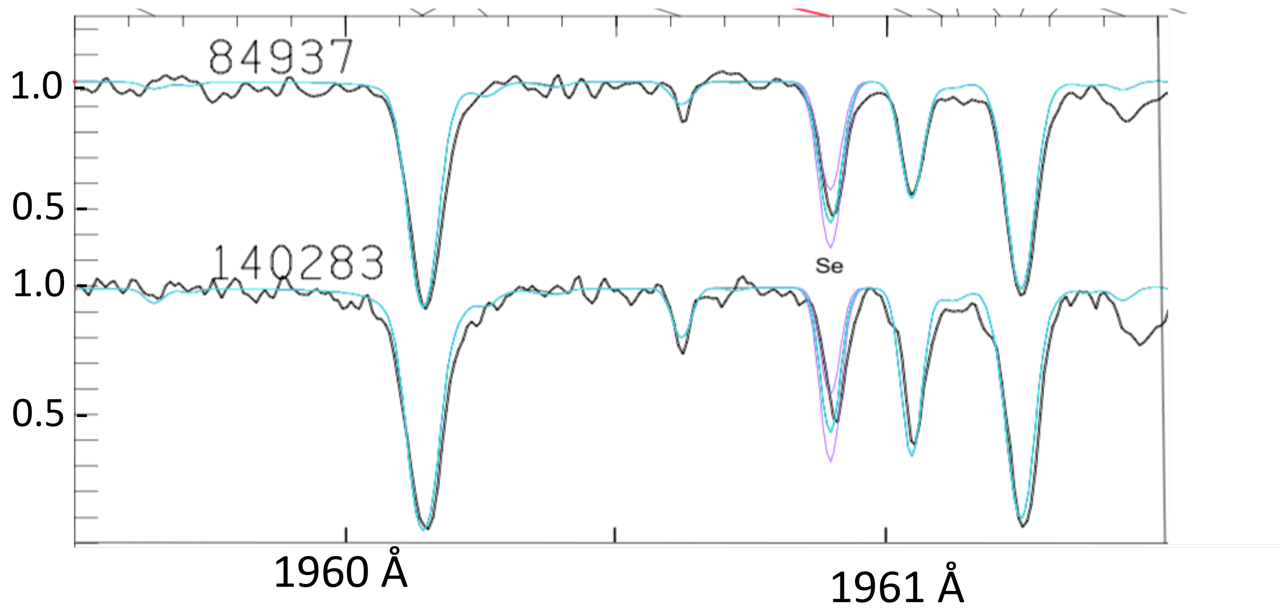
The neutron-capture elements from Ge to Sr (32 ≤ Z ≤ 56)

In the far UV it is possible to measure the abundance of the lightest heavy elements

only possible in metal-poor **turnoff stars** the UV flux of the cool giants is too low !

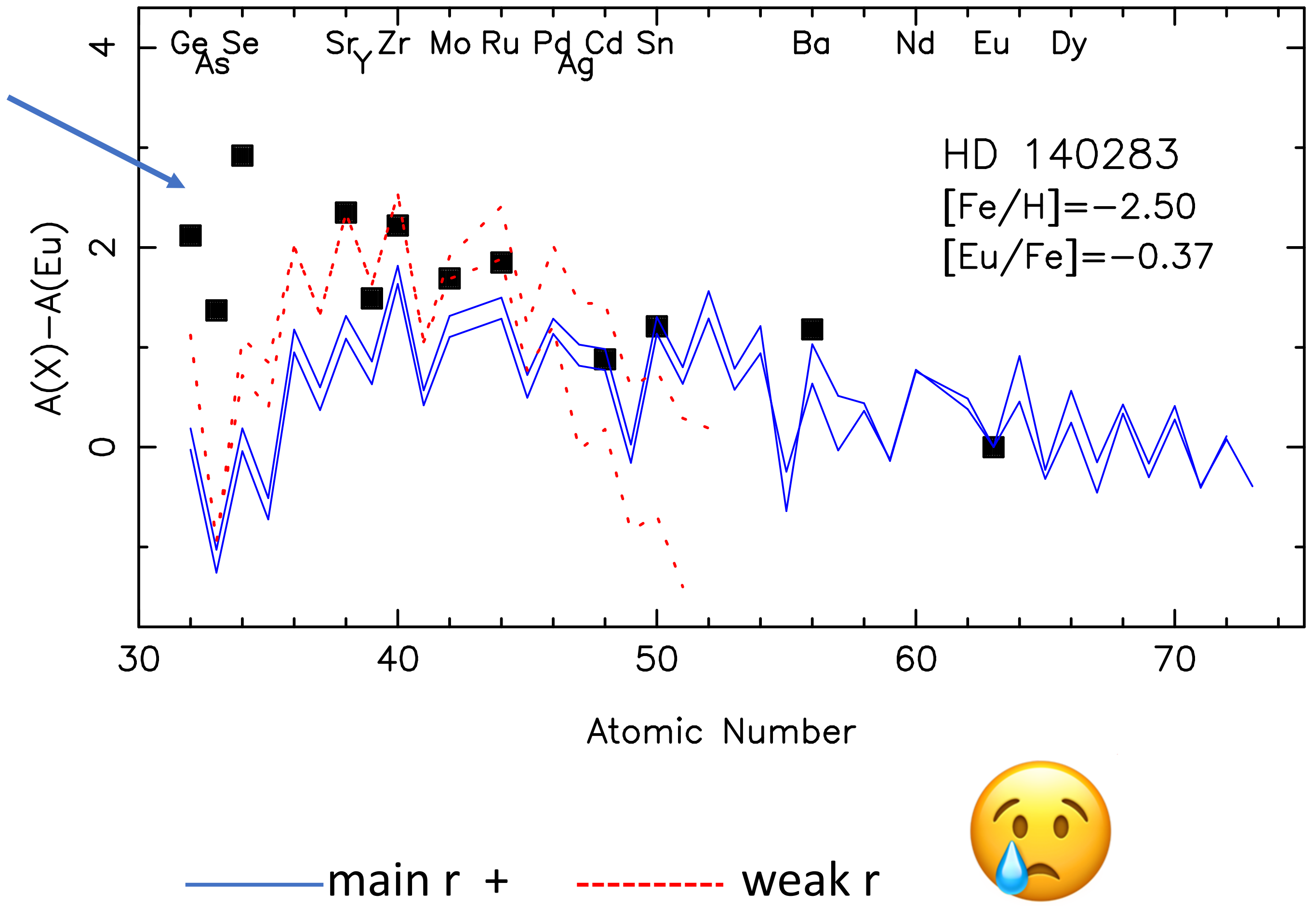
40 HST orbits → high resolution spectra in the far UV (*R*=114 000 with STIS)
(189 nm 304nm) **5 metal-poor turnoff stars**

Abundance of
Ge (Z=32)
As (Z=33)
Se (Z=34)
+ Mo Ru
Cd (Z=48)
Sn (Z=50)



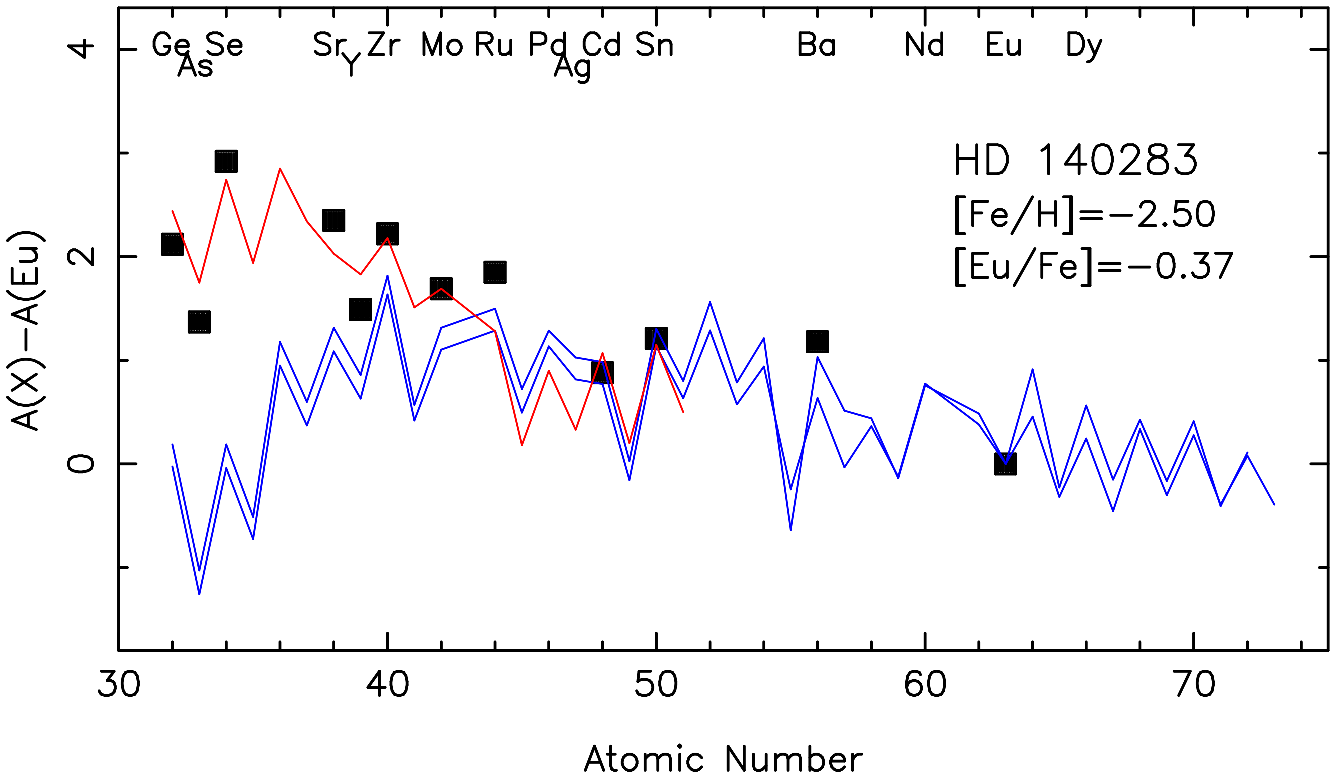
ongoing work: Peterson-Barbuy-Spite

The neutron-capture elements from Ge to Sr (32 ≤ Z ≤ 56)



The neutron-capture elements from Ge to Sr (32 ≤ Z ≤ 56)

i-process ???



i-process : neutron flux intermediate between "s" and "r" in evolving stars when protons enter the He burning convective region → $^{13}C(\alpha n)^{16}O$ (super AGB stars, core He flash). (see Cowan &Rose 1977, Bertolli 2013, Dardelet 2015, Roederer 2016)

How to increase the sample of turnoff stars ?

Observations HST : 5 metal-poor stars, only 3 with [Fe/H]<-2.0

➤ We must observe more stars ! and more metal-poor stars !

LUVOIR + Pollux ! (launch in ≈2040)

Large UV Optical Infrared Surveyor

HST=2.4m LUVOIR 9m? 15m?

I leave you this as a legacy

Thank you very much !

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