

# DIVERSITY OF ABUNDANCE PATTERNS OF NEUTRON-CAPTURE ELEMENTS IN VERY METAL-POOR STARS

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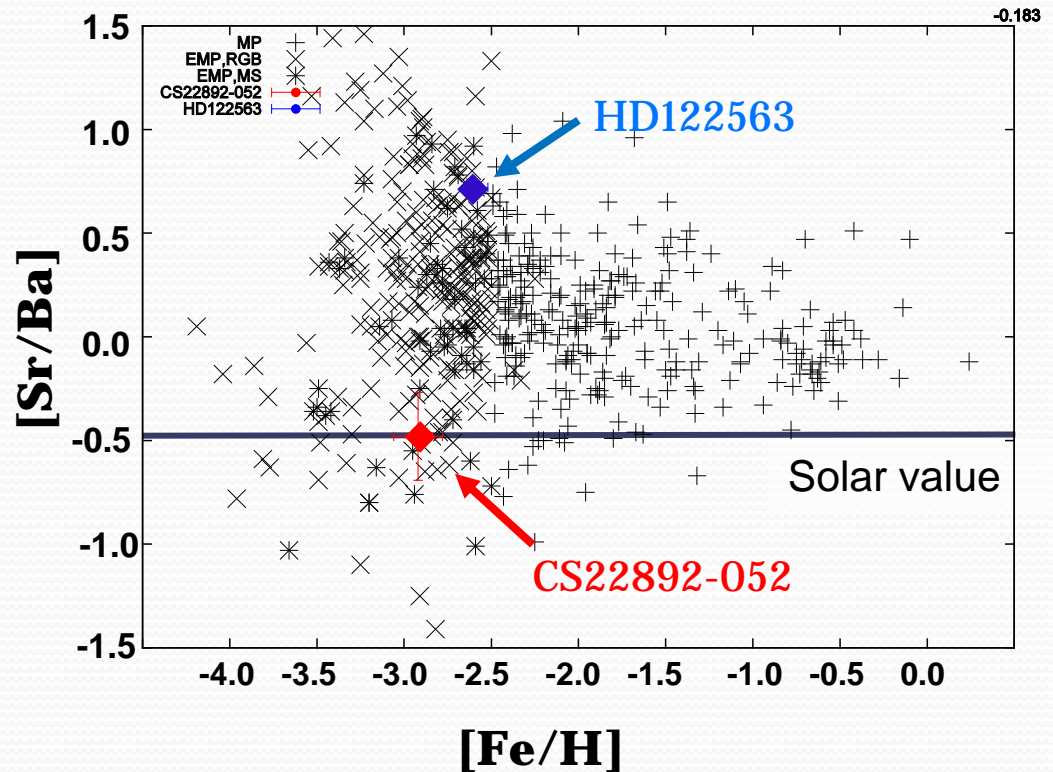
Nuclear in the Cosmos XIII

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# Introduction

Site of r-process  
is unclear

[Sr/Ba] shows  
large scatter at  
low metallicity  
variation in  
processing of  
lighter neutron-  
capture  
elements



$$[X/Y] = \log(N_X/N_Y) - \log(N_X/N_Y)_\odot$$

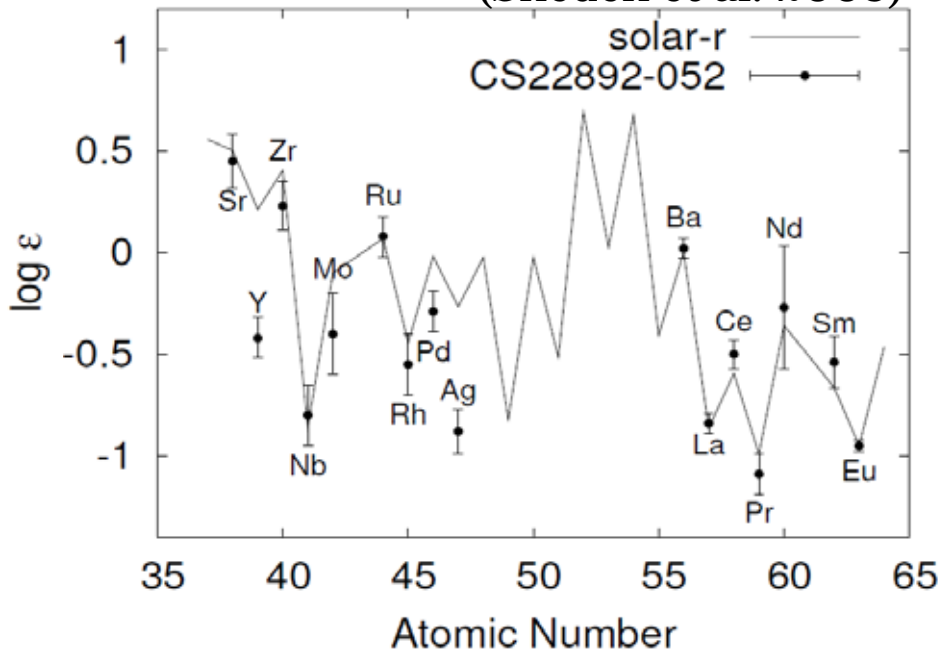
Data from SAGA database

# Representative of Main r and Weak r- stars

$\log \epsilon_x$   $\log(N_x/N_H)+12$

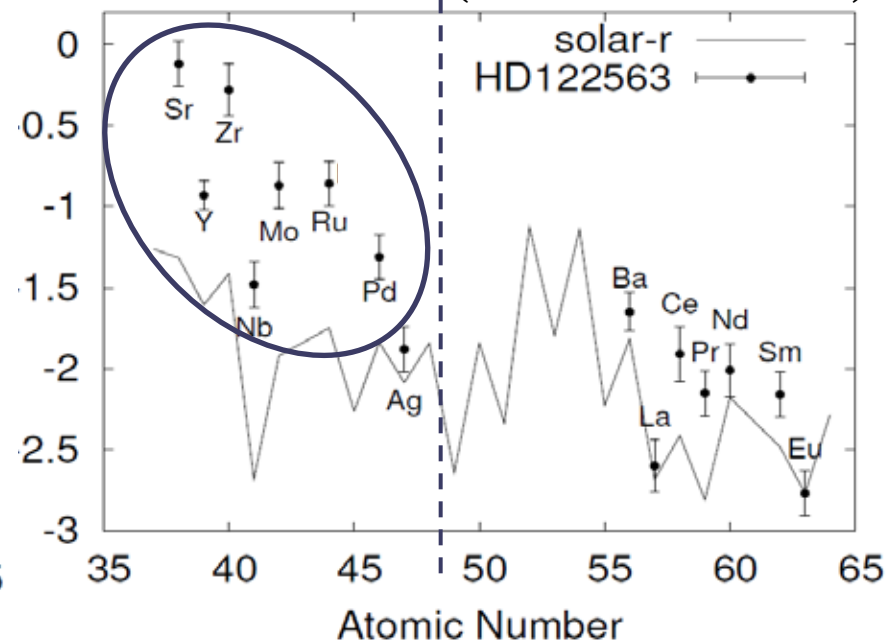
CS22892-052 ([Fe/H]=-3.10)

**Main** r-star (Sneden et al. 2003)



HD122563 ([Fe/H]=-2.65)

**Weak** r-star (Honda et al. 2006)



## **Main r-process:**

Process which creates neutron-capture elements including heavier elements (eg. Ba, Eu etc.)

## **Weak r-process:**

Process responsible for lighter neutron-capture elements (eg. Sr, Y, Zr etc.)

# Objective

To know whether the abundance patterns of weak r-process has

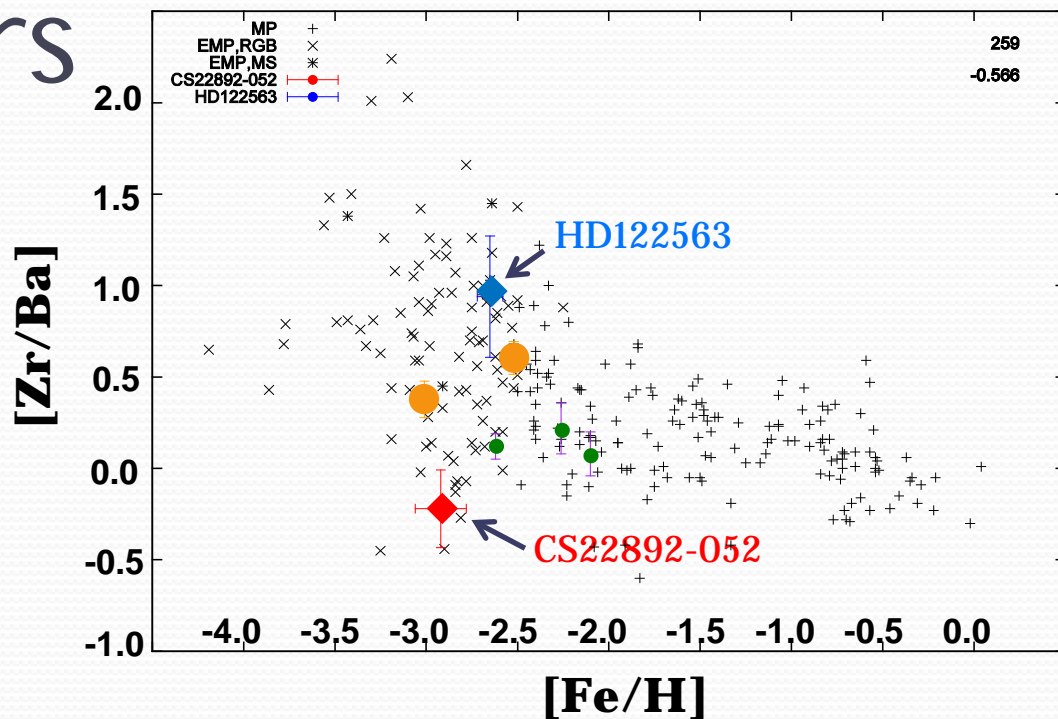
**UNIVERSALITY or DIVERSITY**

Our study...

Analyzed abundance pattern of metal-poor stars.  
Chose intermediate of **Main** r-star and **Weak** r-star, with lighter r elements mildly enhanced

# Observed Stars

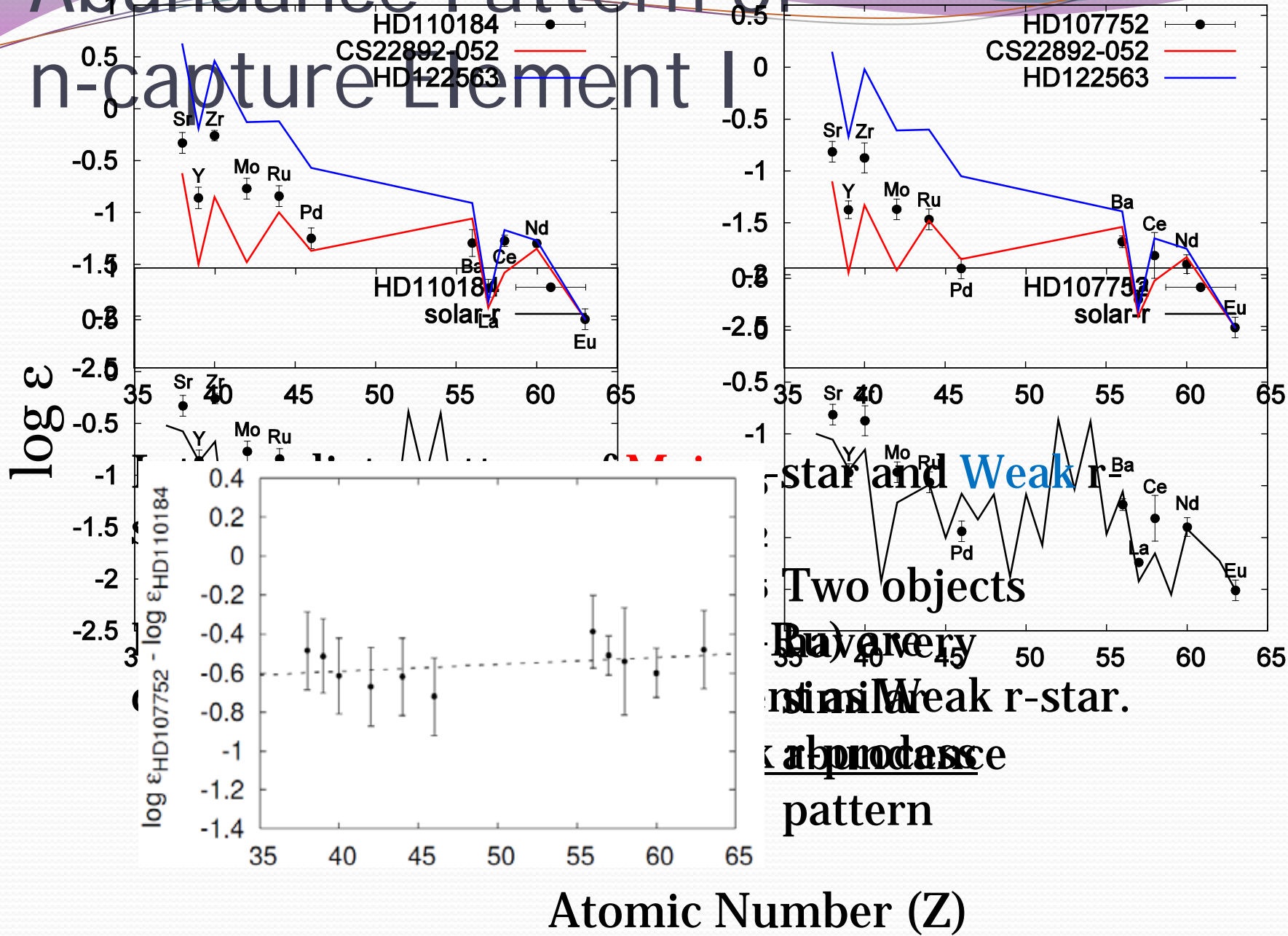
Five metal-poor stars  
observed using 8.2m  
Subaru Telescope, High  
Dispersion Spectrograph  
(HDS)



Object	HD107752	HD110184	HD85773	HD23798	BD+6 648
[Fe/H] (dex)	-3.01	-2.52	-2.62	-2.26	-2.10
$T_{\text{eff}}$ (K)	4400	4240	4268	4450	4400
Log g	0.7	0.5	0.9	1.3	1.3

Used same analyzation process as Honda et al. 2006

# Abundance Pattern of n-capture Element I



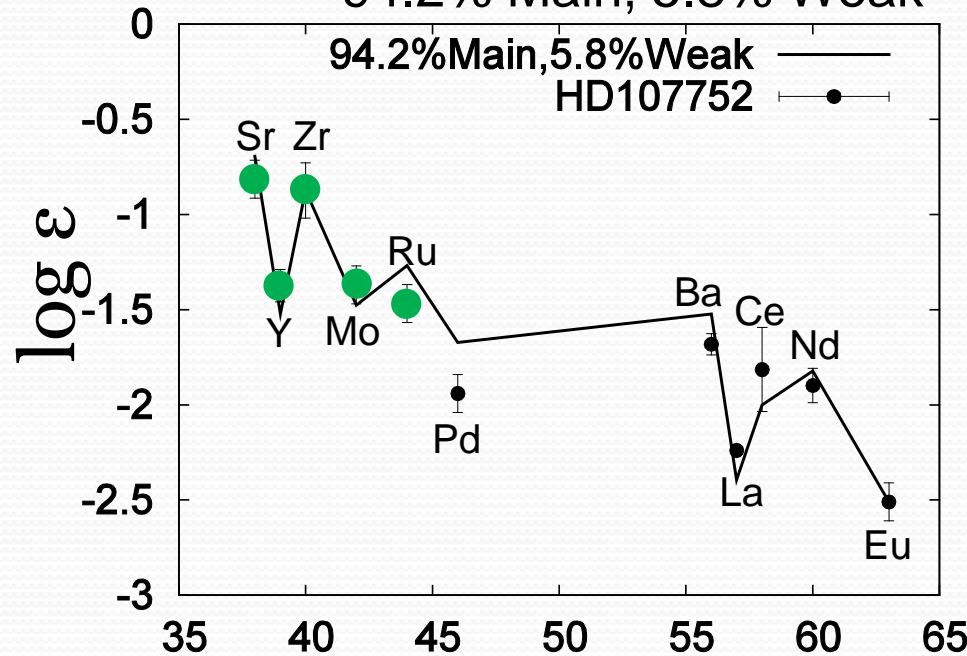
Two objects  
 Ba very  
 similar  
 abundance  
 pattern

Weak r-  
 star and  
 Weak r-  
 star.

# Comparison with Mixed Pattern

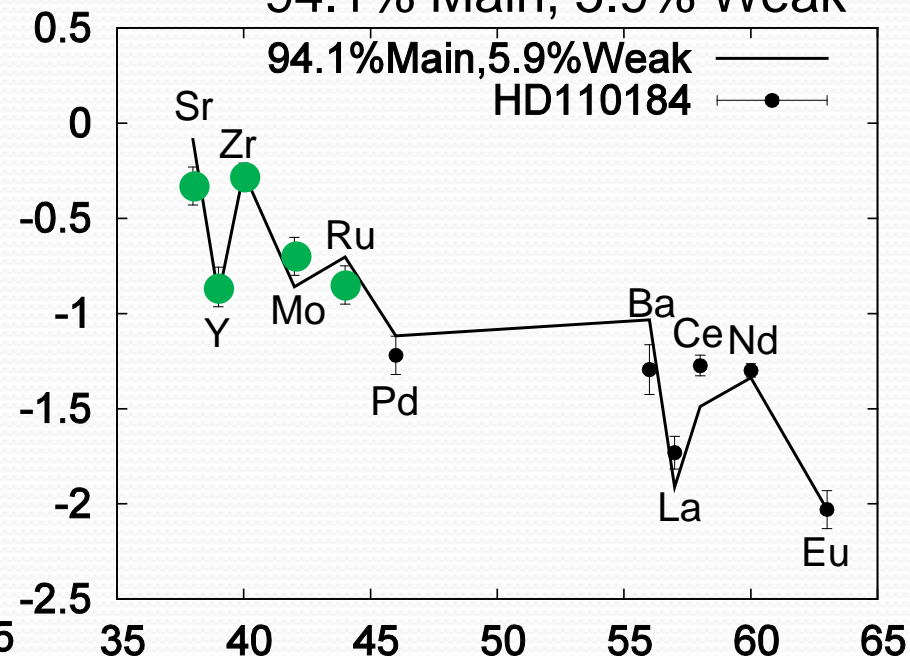
HD107752

94.2% Main, 5.8% Weak



HD110184

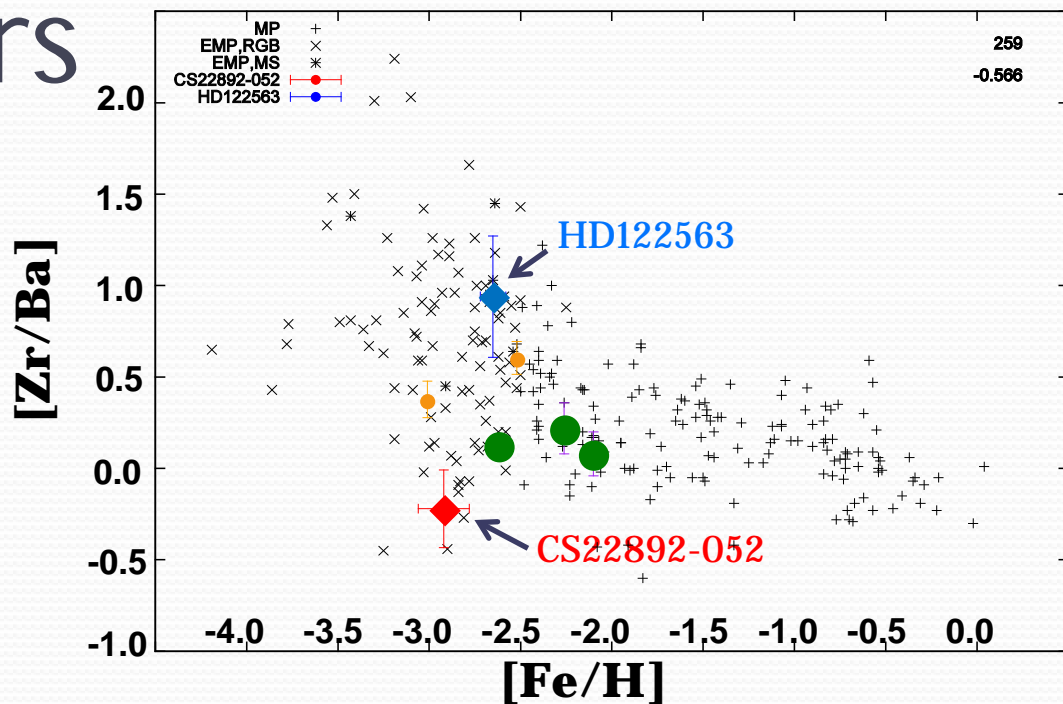
94.1% Main, 5.9% Weak



Atomic Number (Z)

Lighter neutron-capture elements (Sr-Ru) are fairly fit to mixed pattern

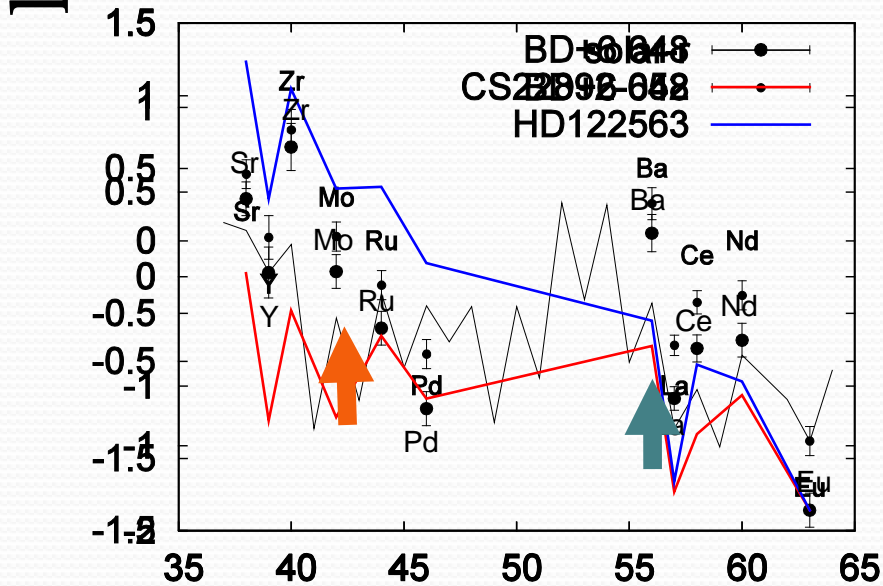
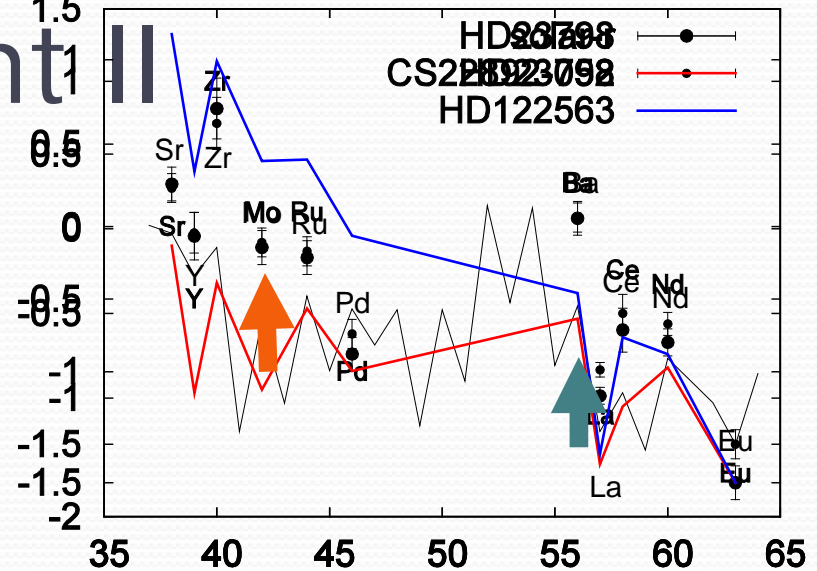
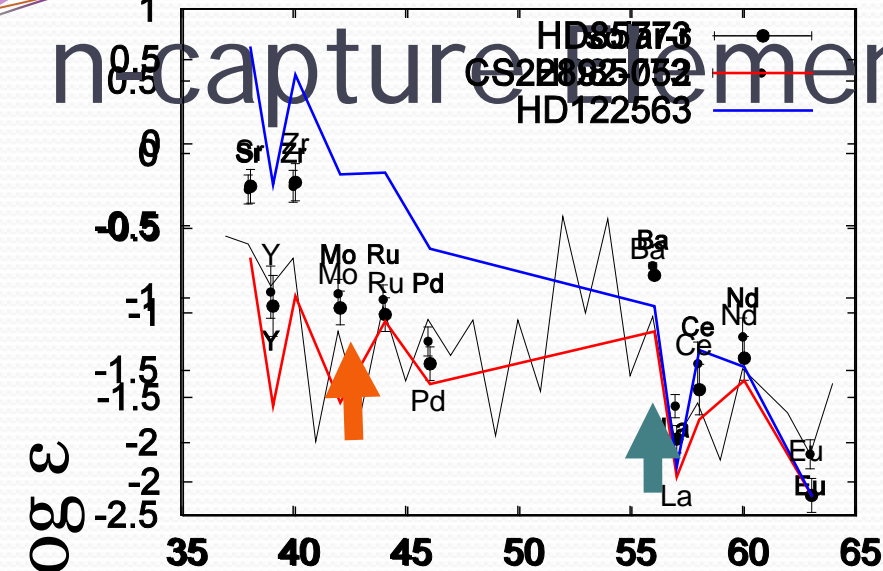
# Observed Stars



Object	HD107752	HD110184	HD85773	HD23798	BD+6 648
[Fe/H] (dex)	-3.01	-2.52	-2.62	-2.26	-2.10
$T_{\text{eff}}$ (K)	4400	4240	4268	4450	4400
Log g	0.7	0.5	0.87	1.26	1.30



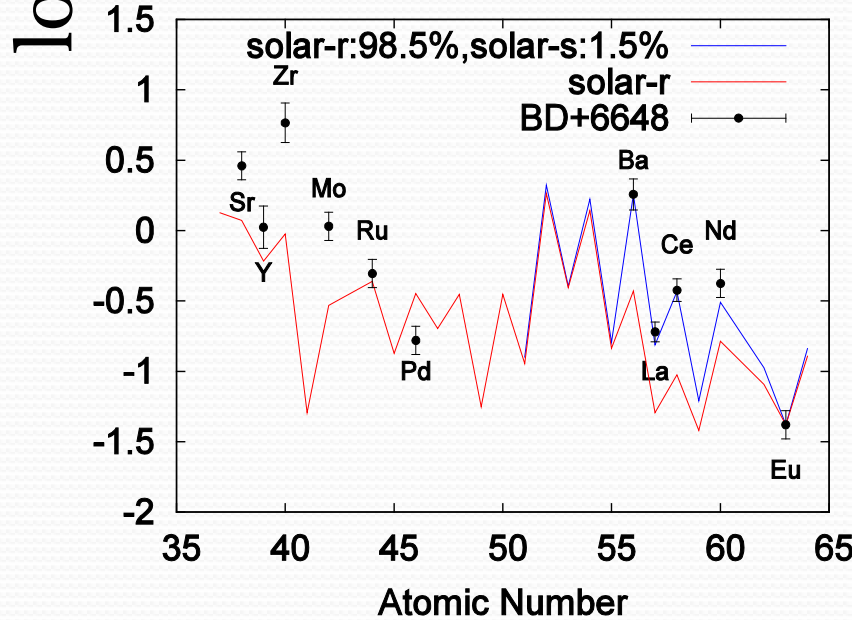
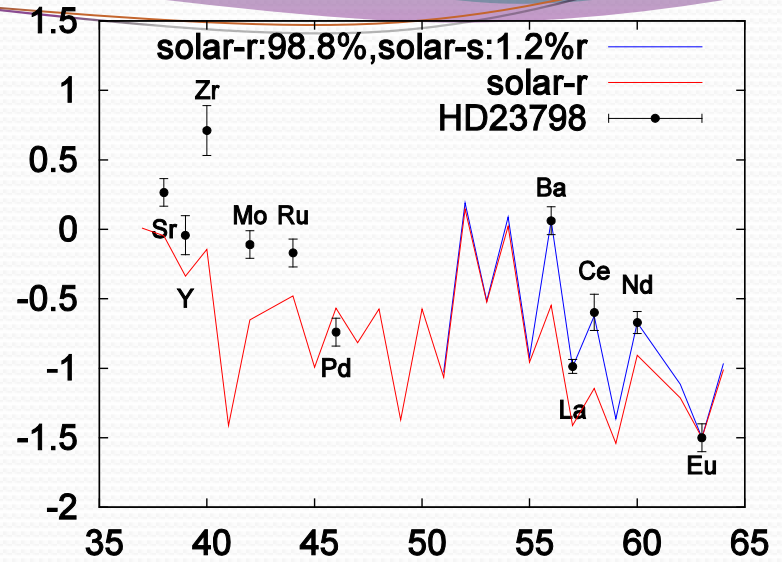
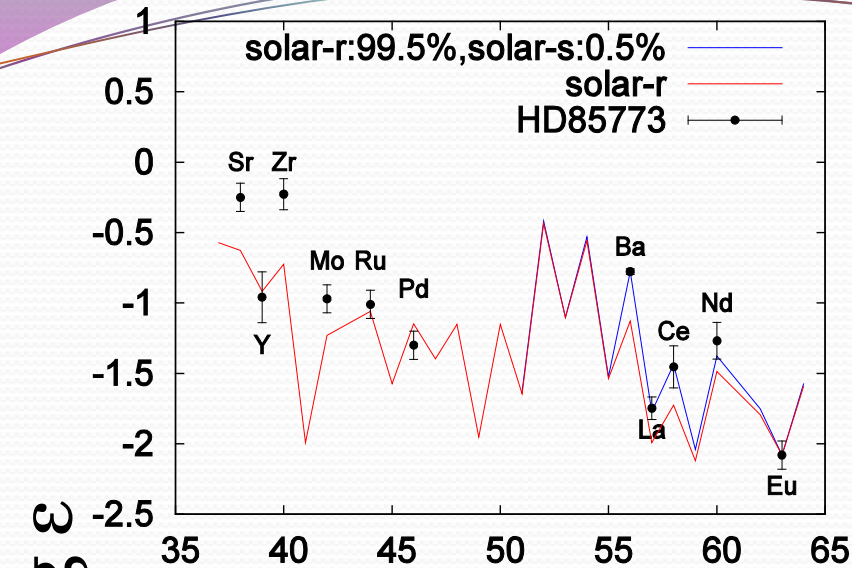
# Abundance Pattern of $r$ -capture Element II



 Intermediate pattern of **Main** r-star and **Weak** r-star.  
 slight contribution of weak r-process

 Overabundance at Barium  
 s-process contamination?

Atomic Number (Z)



## Abundance pattern of n-capture elements

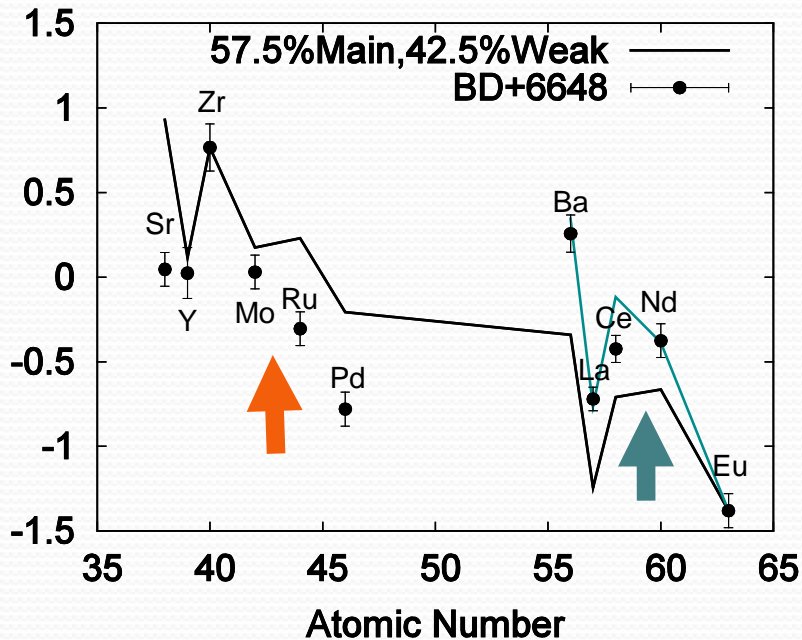
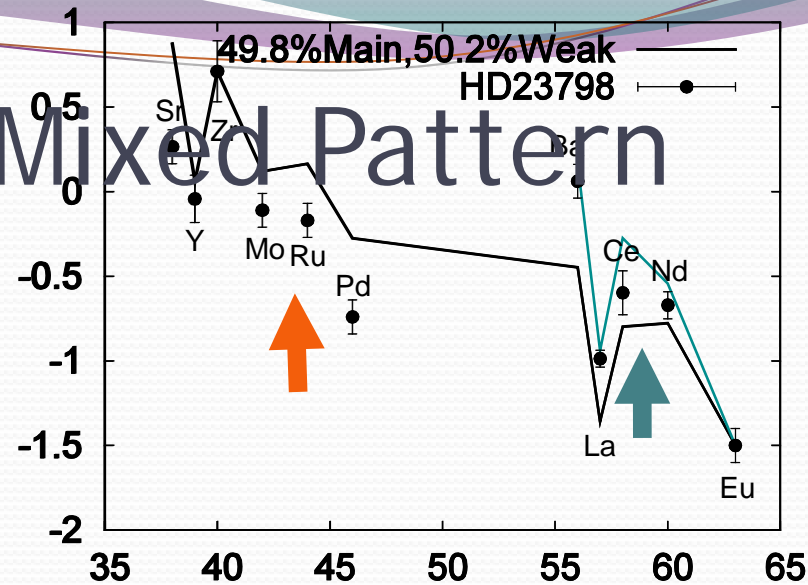
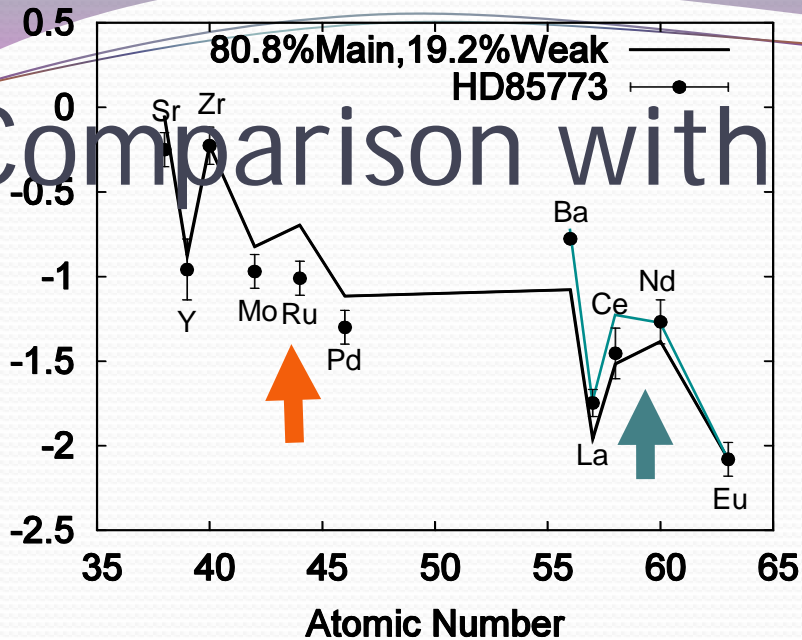
- **RED** : solar r-process pattern
- **BLUE** : solar r-process and s-process mixed. Percentage depends on Ba/Eu ratio.

(s-process: Sneden et al. 2008)

Heavier n-capture elements have contamination of s-process

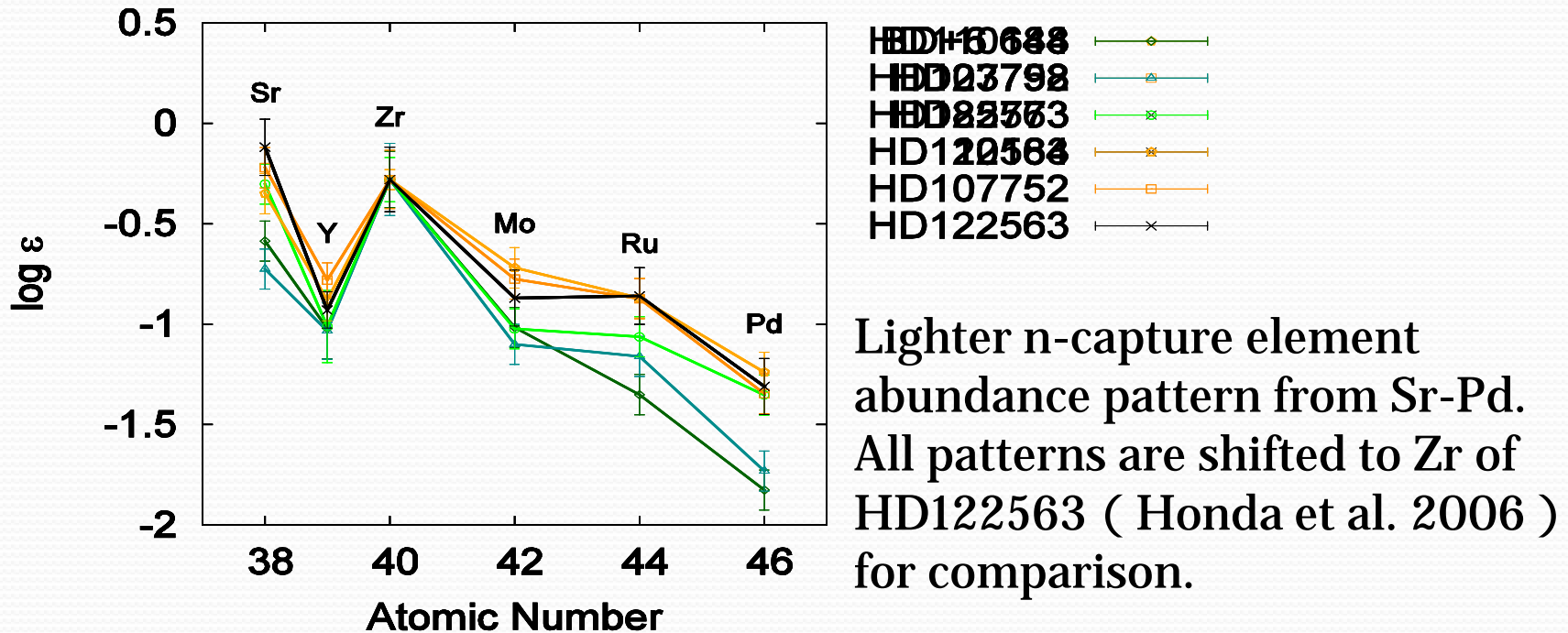
# Comparison with Mixed Pattern

$\log \epsilon$



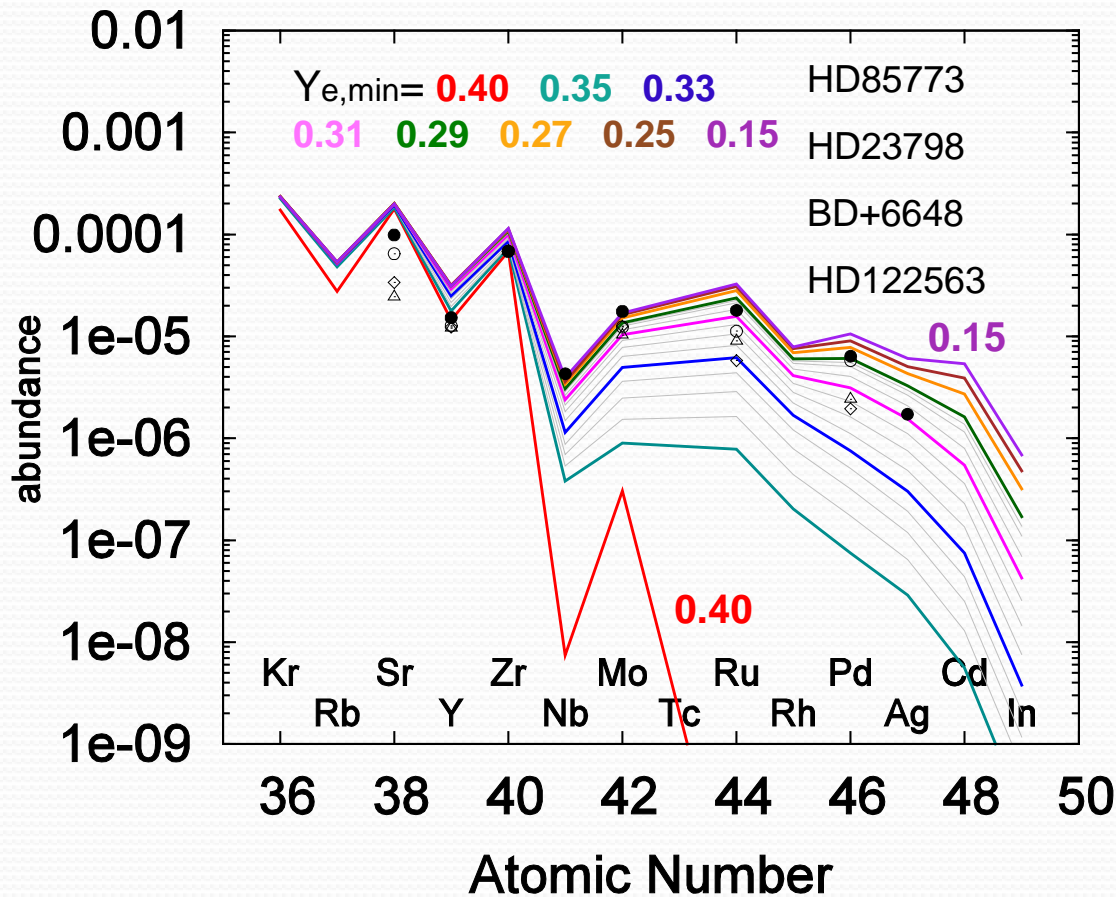
↑ Green line: Mixed line + abundance increased by contamination of s-process  
↑ Lighter n-capture elements (Mo-Pd) patterns are unreproducible by mixed pattern.

# Comparison of Lighter n-capture Element Abundance Pattern



- **HD110184, HD107752** are similar to that of Weak r-star  
Representative pattern of weak r-process
- **HD23798, BD+6 648** shows drastic drop towards Pd.  
Implicating the diversity in abundance pattern of lighter n-capture elements

# Comparison with ECSN Model



HD122563 ( **Weak** r-star),  
 HD85773, HD23798,  
 BD+6648 compared with  
 model of ECSN (Wanajo,  
 Janka and Müller. 2011) as  
 a possible model of weak r-  
 process

The diversity in abundance pattern of weak r-process may be caused by the variation of electron fraction in SN ejecta.

# Summary

We analyzed five VMP stars and compared their abundance patterns of neutron-capture elements.

Lighter r element patterns of 3 out of 5 stars cannot be reproduced by mix of **Main** r-star and **Weak** r-star pattern.

**DIVERSITY** in weak r-process pattern

The diversity possibly come from variation of electron fraction in SN ejecta