DESI R-process Enhanced Stars (DESIRES) Survey: an efficient way to identify r-process enhanced stars from low-resolution spectra

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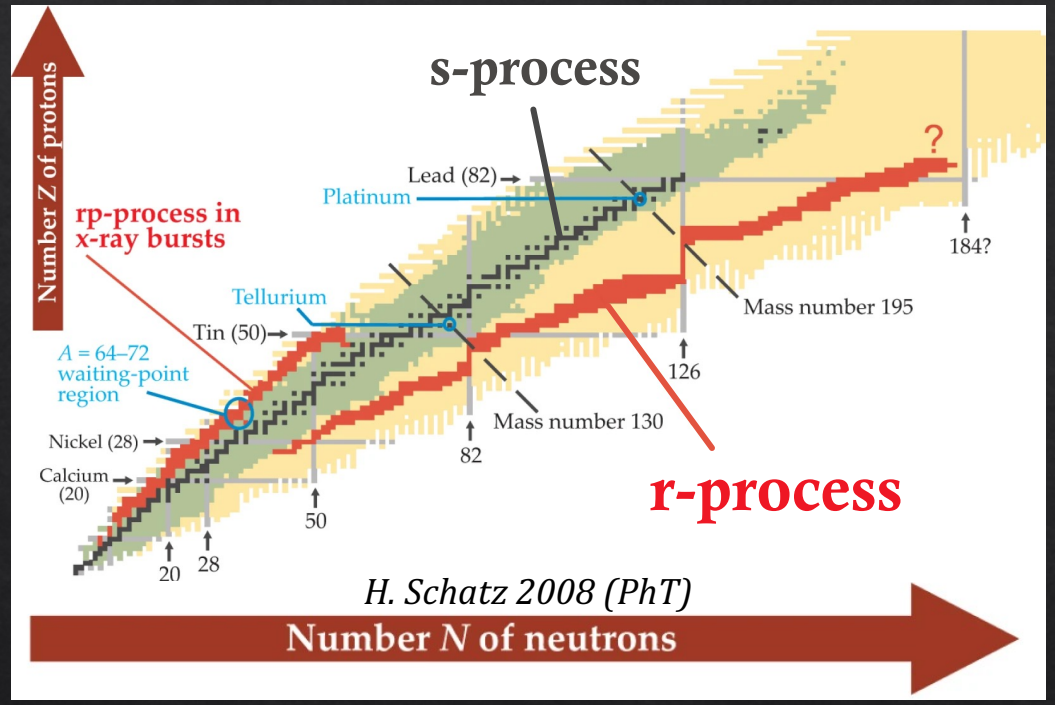
Instituto de Astrofísica de Canarias

05/11/26 @BUAA, OECE 2026

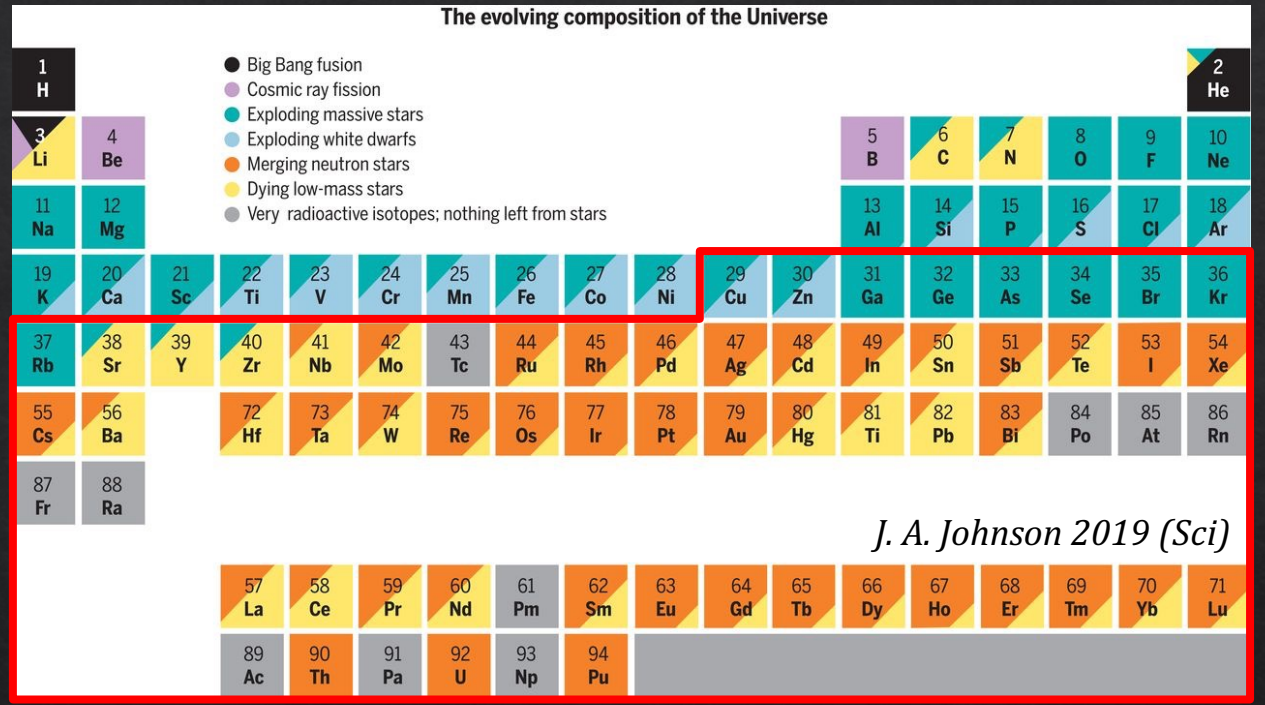
Collaborators: D. S. Aguado, C. Allende-Prieto, S. E. Koposov, L. Lombardo, A. Ruiz del Pozo, T. S. Li, A. J. Burgasser, M. Valluri, M. E. Heiger, and DESI MWS working group

Credit: KPNO/NOIRLab/NSF/AURA/R.T. Sparks

The neutron-capture process



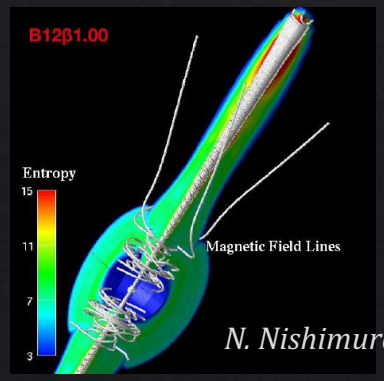
H. Schatz 2008 (PhT)



J. A. Johnson 2019 (Sci)



Credit: Illustration by Robin Dienel



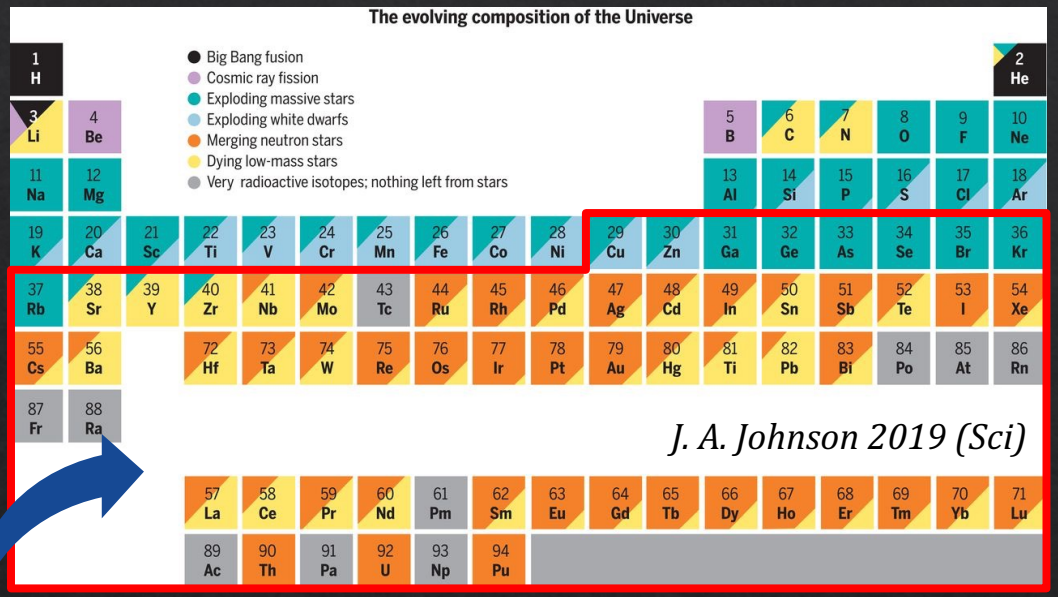
N. Nishimura+2015 (ApJ)

Magneto-rotationally driven jet supernova



Credit: NASA Goddard Space Flight Center

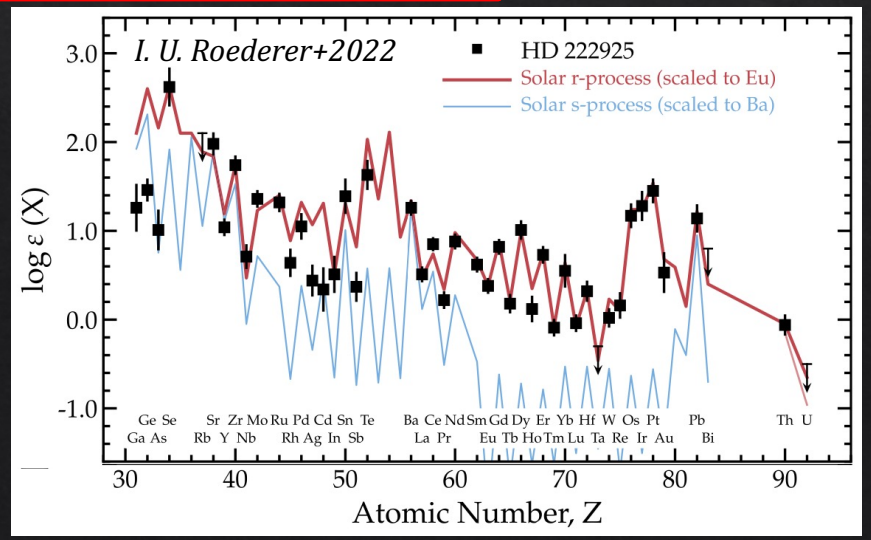
The r-process and r-process-enhanced stars



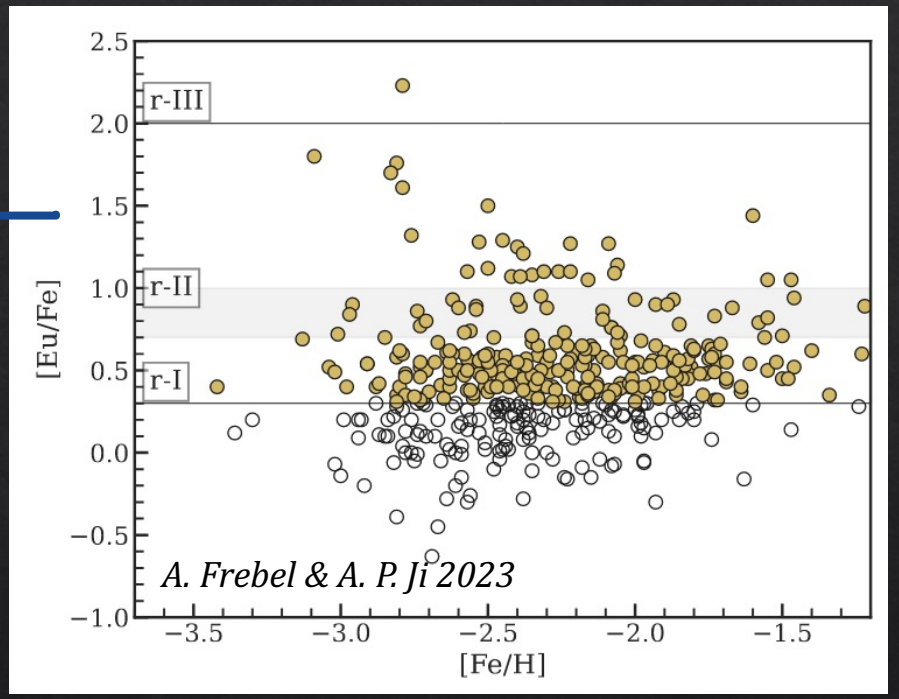
produce

s-process
r-process

Astrophysical cite

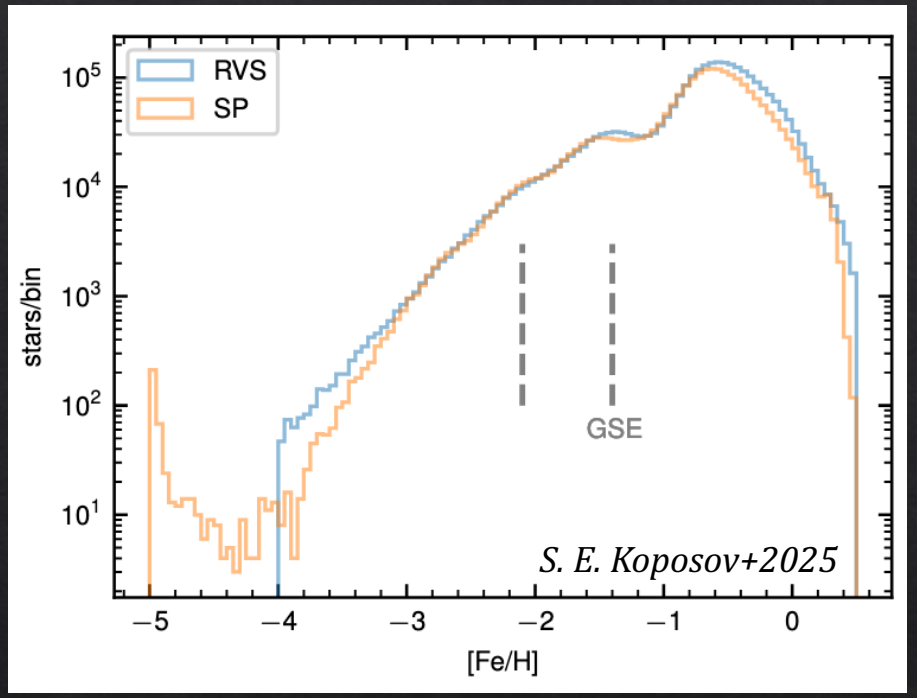


Full pattern



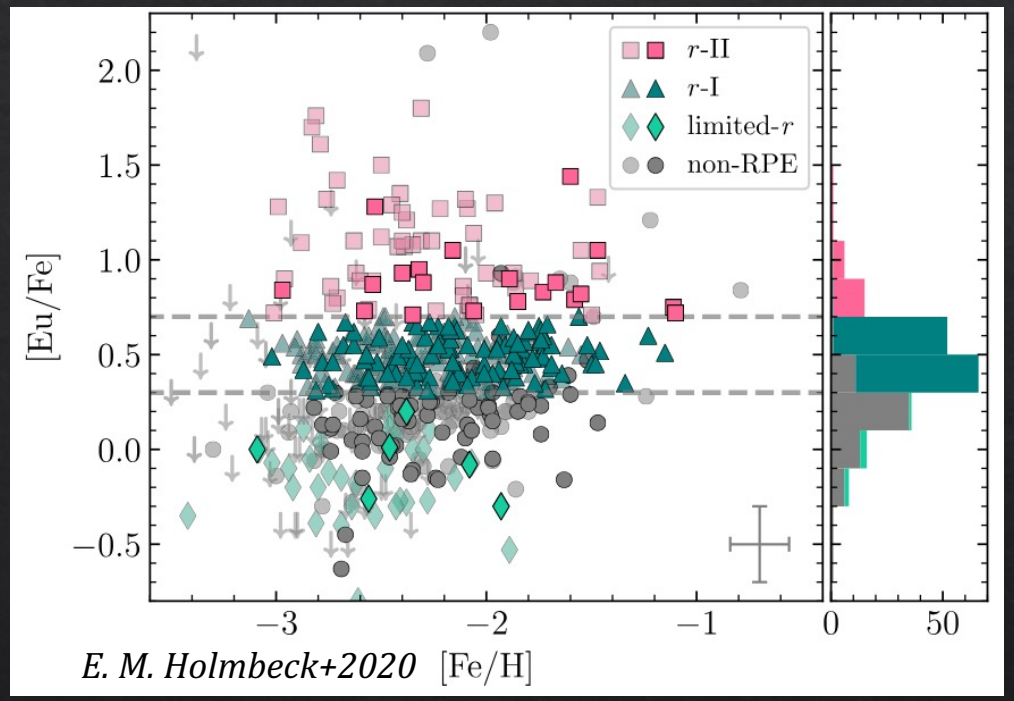
R-process enhanced metal-poor stars are rare!

Metal poor stars are rare



- < 10% stars are MP, and ~1% are VMP
- MP/VMP candidates are increasing thanks to large photometric and spectroscopic surveys

r-process enhanced stars are rare



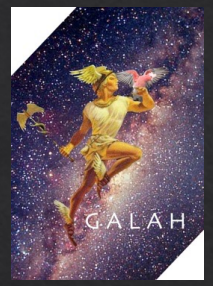
- Eu abundances can only be accurately measured through high-resolution spectra
- ~ 12% stars with Eu abundances are r-II stars

Discover r-process enhanced stars under lower resolution?

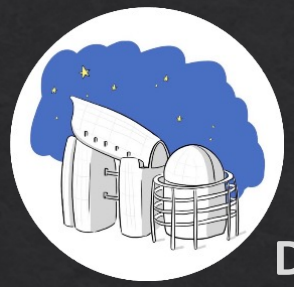






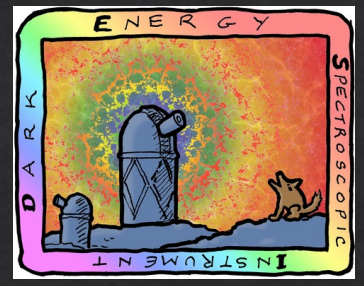


114,324 22,921 7789 917,588



DR11

12 million low-resolution
13 million medium-resolution



DR2: 15 million
DR3: 28 million

- Medium resolution (R ~ 5000):
  - Previous studies (e.g., T. Chen+ 2021/ X. Xie+ 2024; 2025) have successfully selected r-process-enhanced stars from LAMOST medium-resolution spectra.
- Low resolution (R ~ 2000)
  - Positive results from benchmark r–process-enhanced stars (S. Liu+ in prep.)
  - DESI R-process-Enhanced Stars (DESIRES) Survey: Can we find new r-process-enhanced stars?

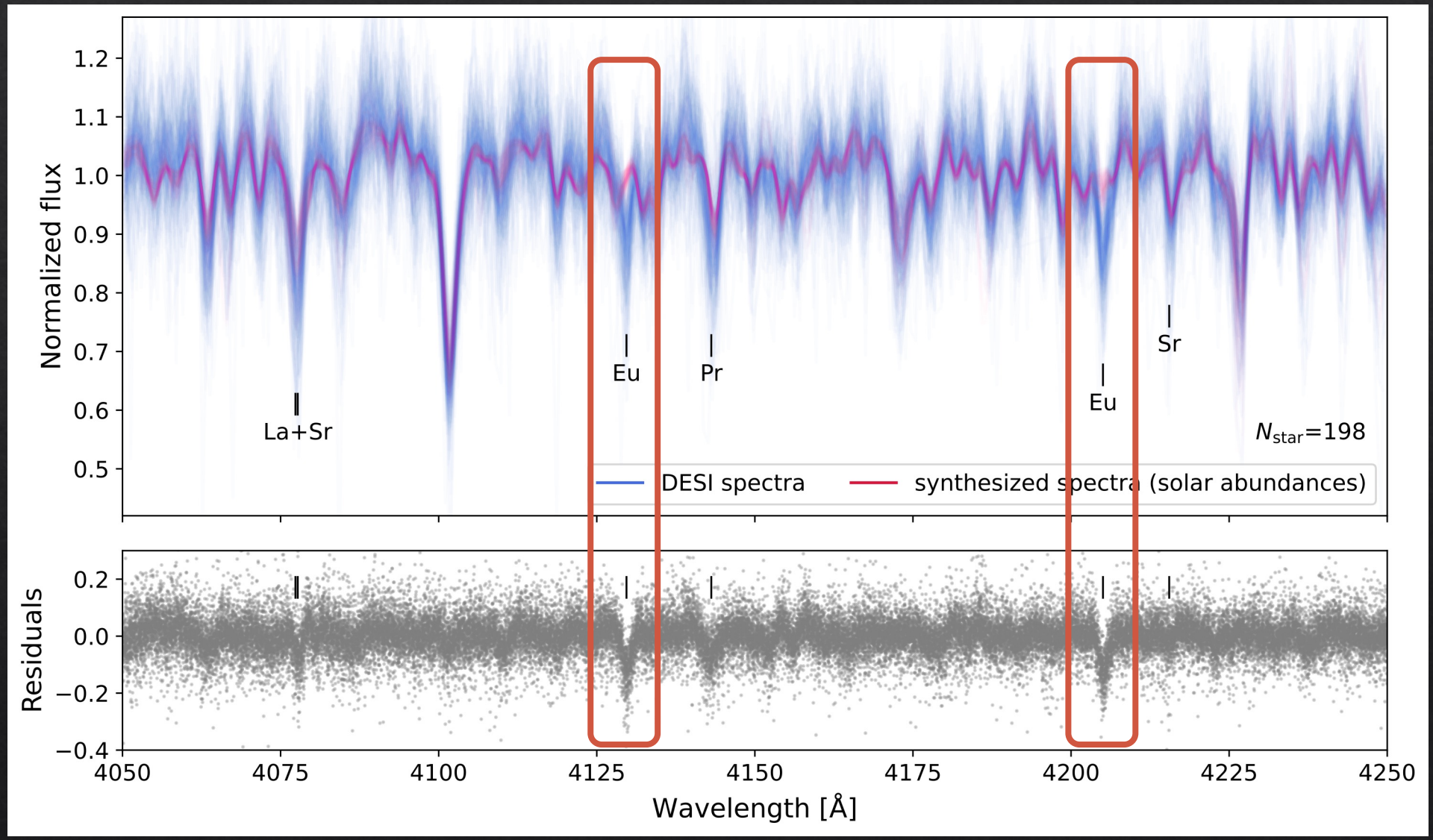
Quantify the Eu features

- Quantify the Eu absorption characteristics:
  - S_{Eu}: The significance of the absorption feature: $S_{\mathrm{Eu}} \sim \frac{\mu_{\mathrm{cont}} - \overline{Flux_{\mathrm{line}}}}{\sigma_{\mathrm{cont}}}$

    μ_{cont}: average flux of the continuum; σ_{cont}: standard deviation of the continuum;

    $\overline{Flux_{\mathrm{line}}}$: average flux at the line center (1.5 Å)
- SELECT giants from the DESI Year-5 data: Teff < 5500, log g <3, S/N@Blue > 15: ~600,000 stars
- Scan the giants with $S_{\mathrm{Eu}} > 1$ at 4129 Å and 4205 Å: 10,653 candidates
- Visually check the spectra and refit the most promising ones with FERRE to check overall r-features
- Over 500 candidates, 198 with the highest priority (Can't wait to observe them tomorrow!)

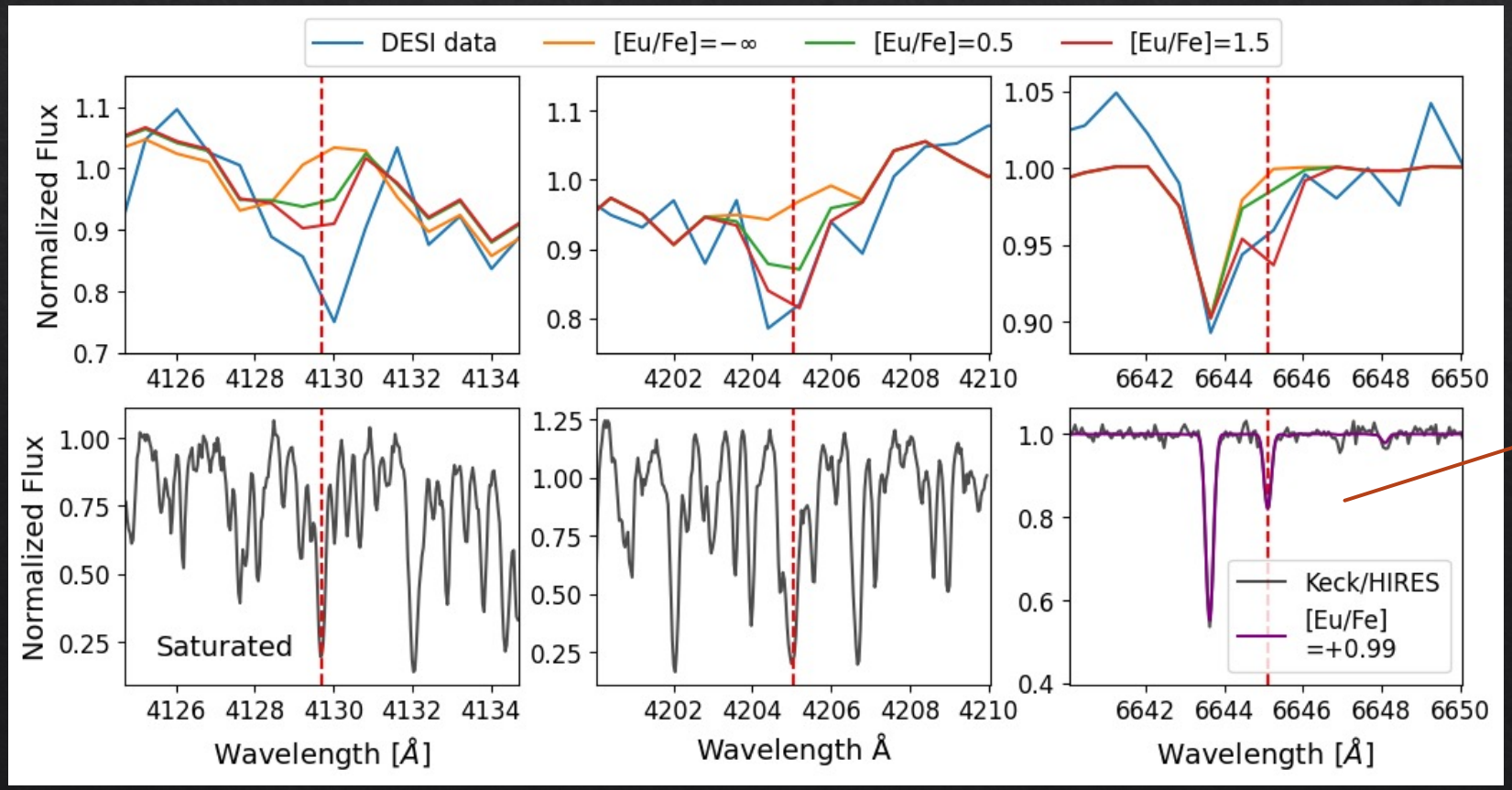
Overview of the highest priority candidates

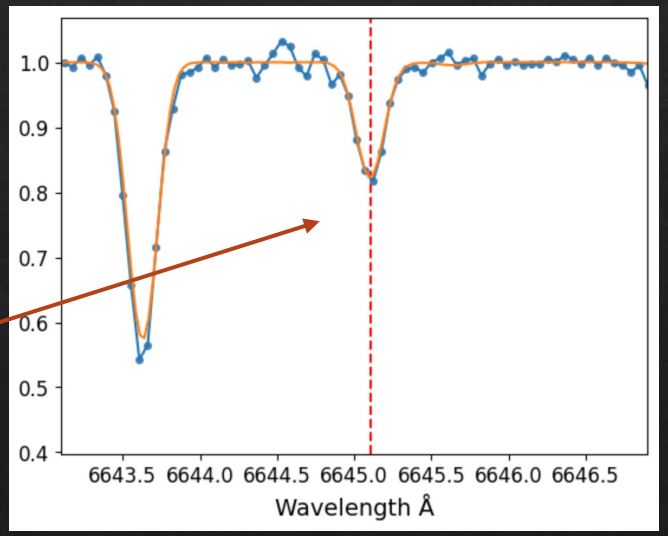


We did it!: DESIRES63181

- DESIRES63181: Teff = 4566.3±38.2K, log g = 1.13±0.08, [Fe/H] = -1.71±0.11, Vmicro = 2.01±0.10

  [Eu/Fe] = +0.99 (Eu6437: +1.00, Eu6645: +0.98)





Follow-up results and method validation

- DESIRES catalog x SAGA database:

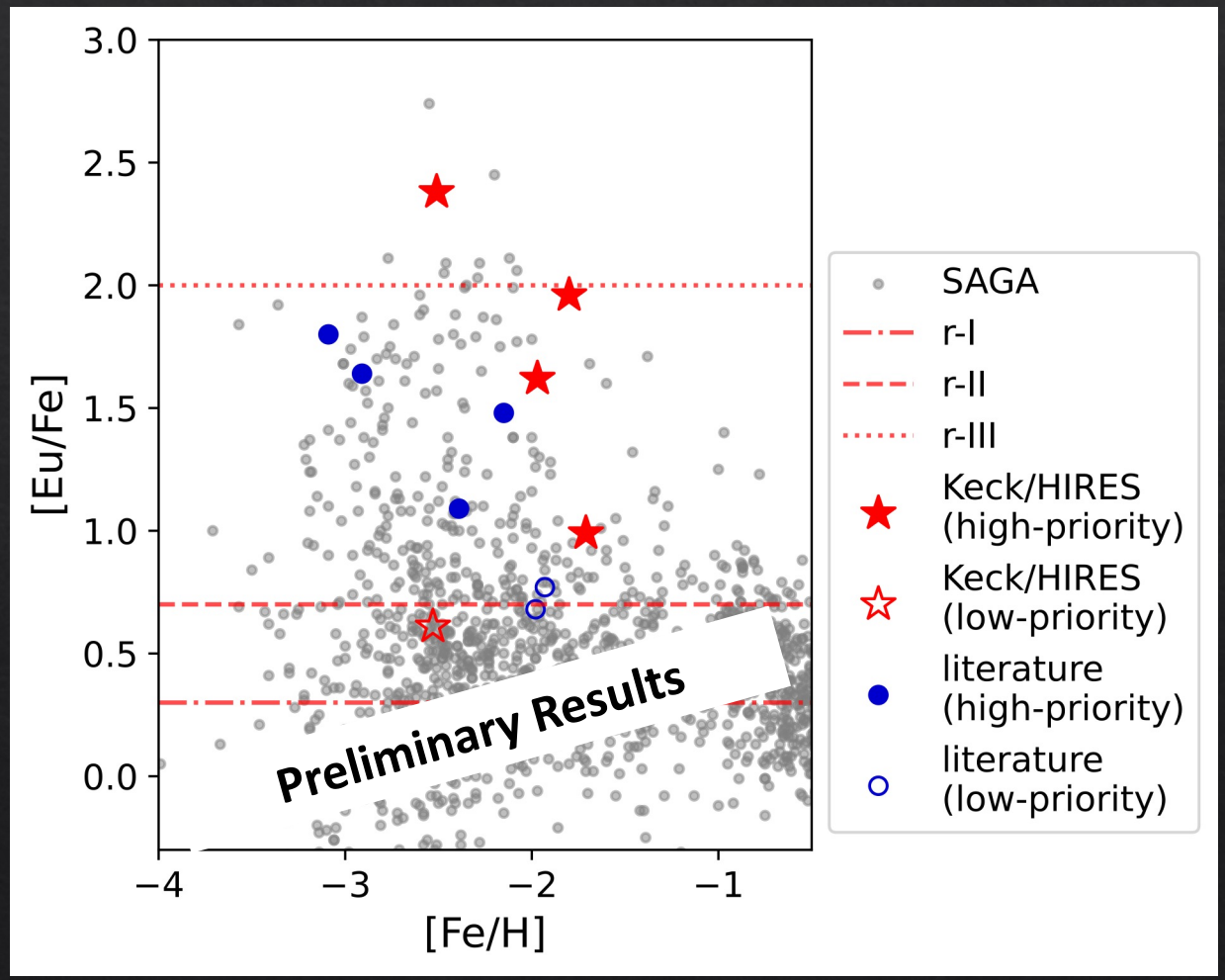
  6 common stars

  - 5 r-II stars and 1 r-I star

- Follow-up program on Keck/HIRES:

  20 candidates

  - 20 stars observed: 19 are r-process-enhanced, 17 have Th detection
  - One potentially r-III star



Future plan

- Follow-up programs: high- /medium- resolution spectra of over 200 candidates in 2 years
  - Semester 2027A: proposals for six instruments to observe ~80 stars
- Analyzing the HIRES spectra: full pattern of 19 new r-process-enhanced stars
- Developing an index including all information from the heavy-element windows we identified
  - Search for more r-process-enhanced candidates under low S/N and weaker features
- Systematic studies of the DESIRES sample
  - The most r-process-enhanced stars (are r-III a separate population? how were they formed?)
  - Chemodynamical studies of the r-process-enhanced stars (collaborate with UoM)

Summary

- We successfully discovered new r-II stars from low-resolution spectra
- 500 r-process-enhanced candidates, ~200 of them with the highest priority
- The success rate of the DESIRES program (Keck/HIRES + literature):
  - ✓ 96% for r-process-enhanced stars
  - ✓ >80% for r-II stars
  - ✓ >70% can detect Th

- An efficient and cheap way to discover more r-process-enhanced stars