Neutron-capture in the wild: finding r-process enhanced metal-poor stars in the Milky Way and beyond

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Finding r-process enhanced stars

- Narrow-band photometry → $T_{\rm eff}$, log g, [Fe/H] - [1]
- Medium-resolution spectroscopy ($R \sim 1,500$) → [C/Fe], [α/Fe] - [2]
- High-resolution spectroscopy ($R \sim 50,000$) → lithium to uranium - [3, 4]

SPLUS J1424−2542

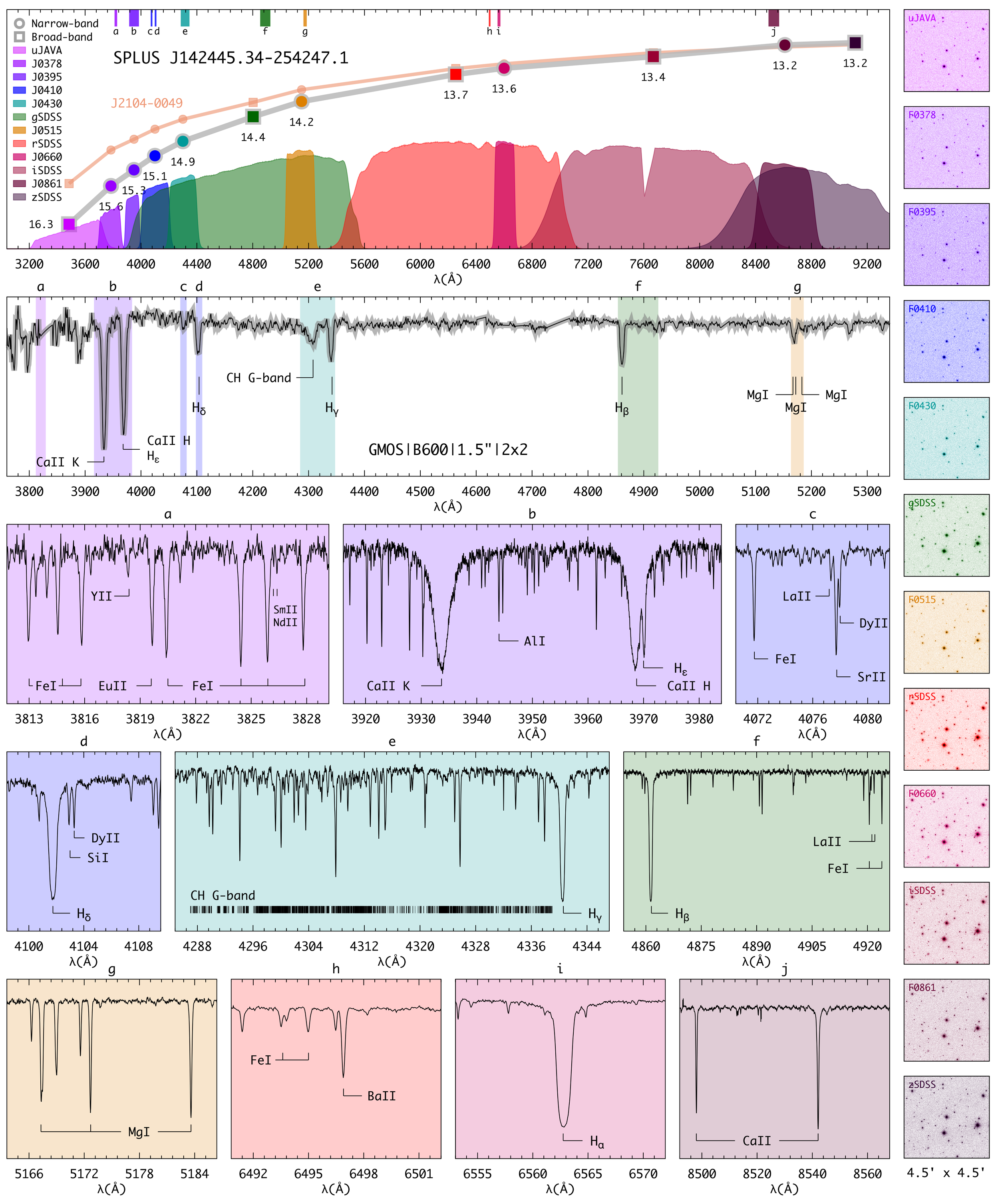

Figure 1: Magnitudes for SPLUS J1424−2542. The second panel shows the Gemini/GMOS spectrum and the remaining color panels show sections of the GHOST spectra and features used for chemical abundance determinations.

Light-element abundance pattern

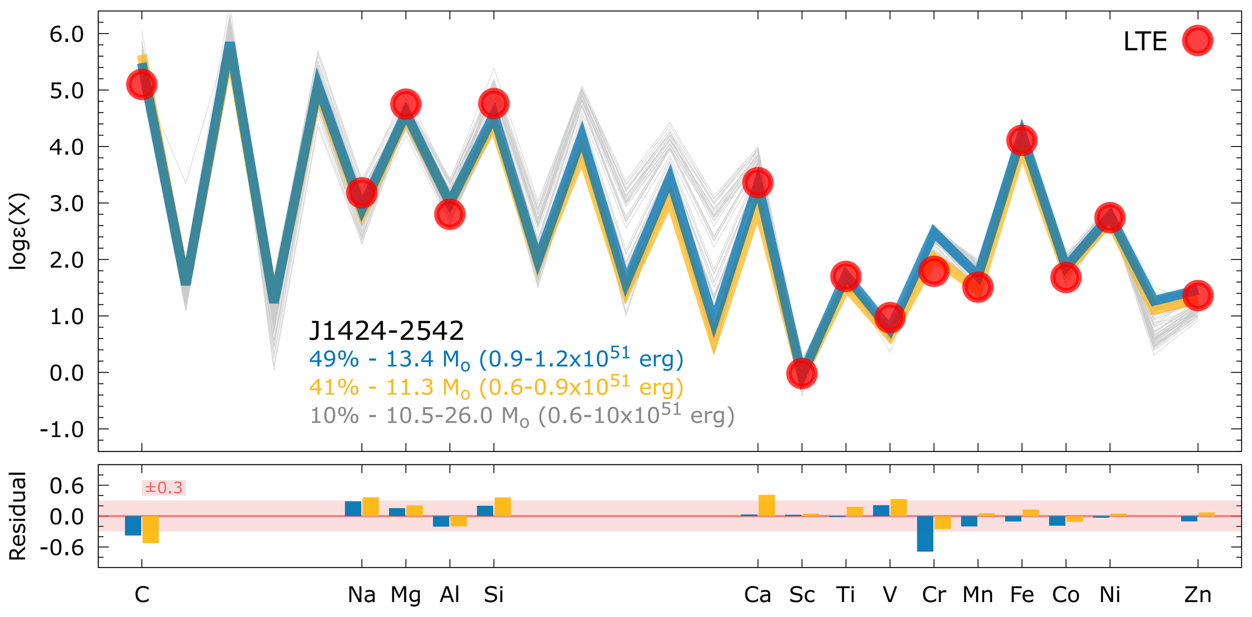

Figure 2: Light-element abundance pattern compared with metal-free supernova models. The labels show the model progenitor masses and explosion energies.

Halo substructure membership

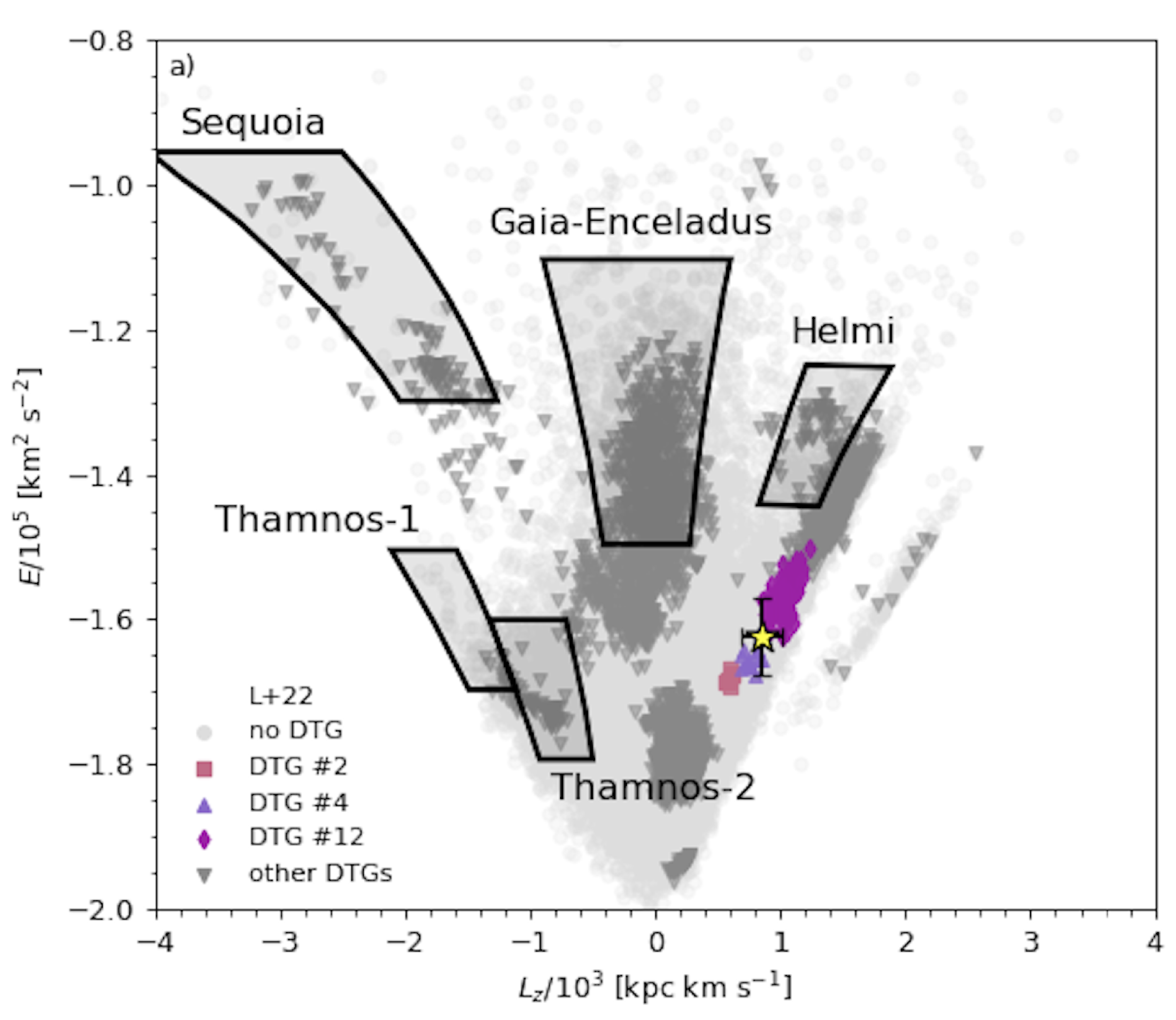

Figure 3: Energy vs. angular momentum comparison for SPLUS J1424−2542 and known halo substructures / dynamically tagged groups in the Galaxy.

R-process spectral synthesis

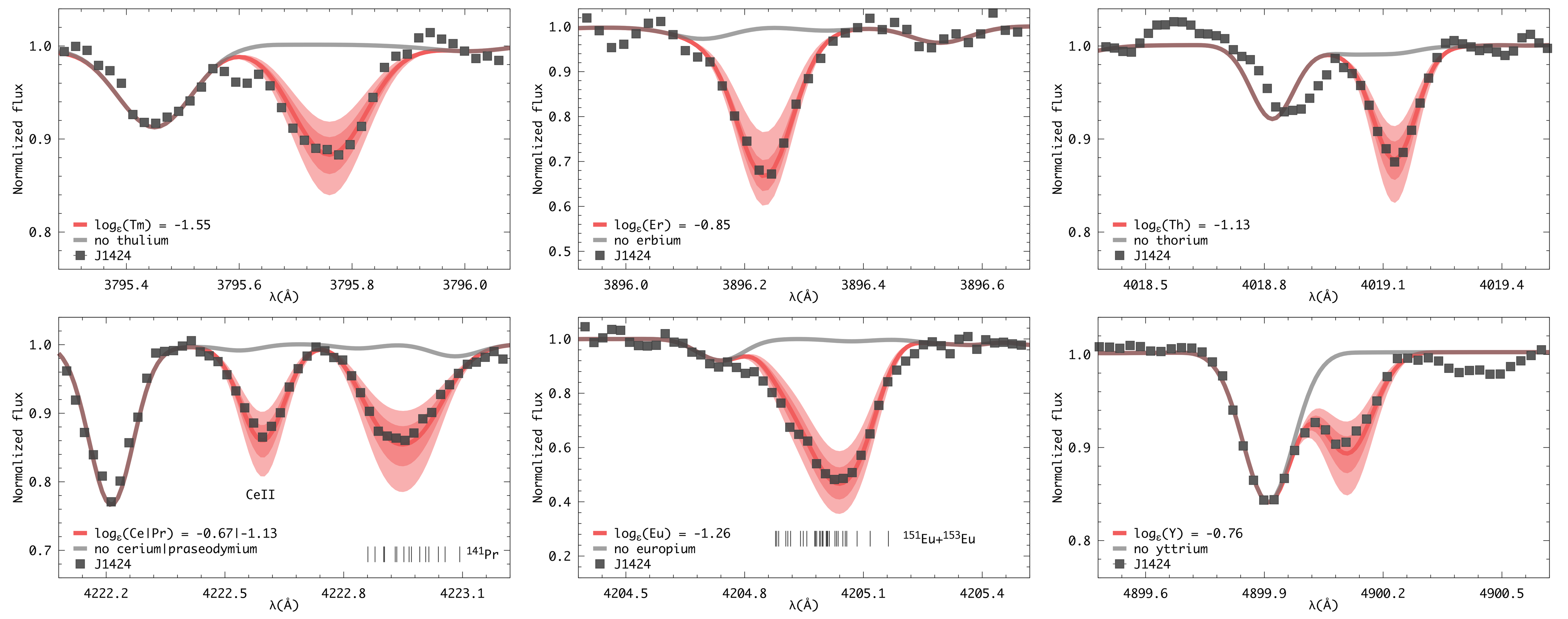

Figure 4: Spectral synthesis for heavy-element chemical abundance determinations.

Heavy-element abundance ratios

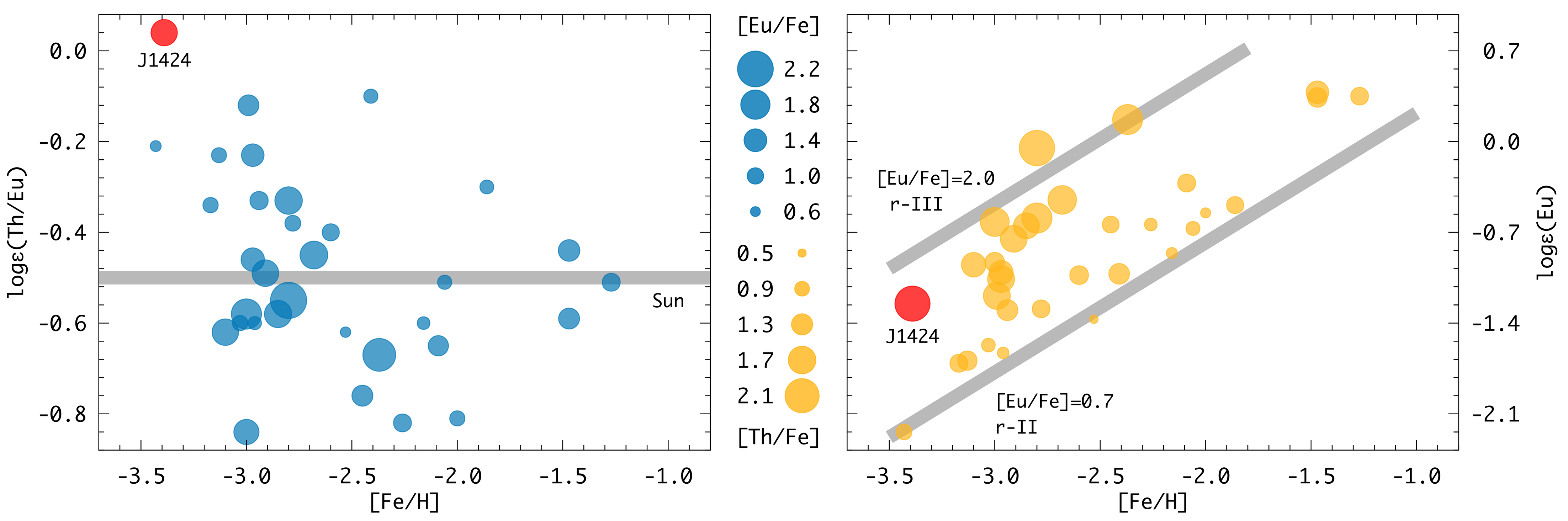

Figure 5: Th and Eu abundance ratios for SPLUS J1424−2542 compared with data from the literature.

Heavy-element abundance pattern

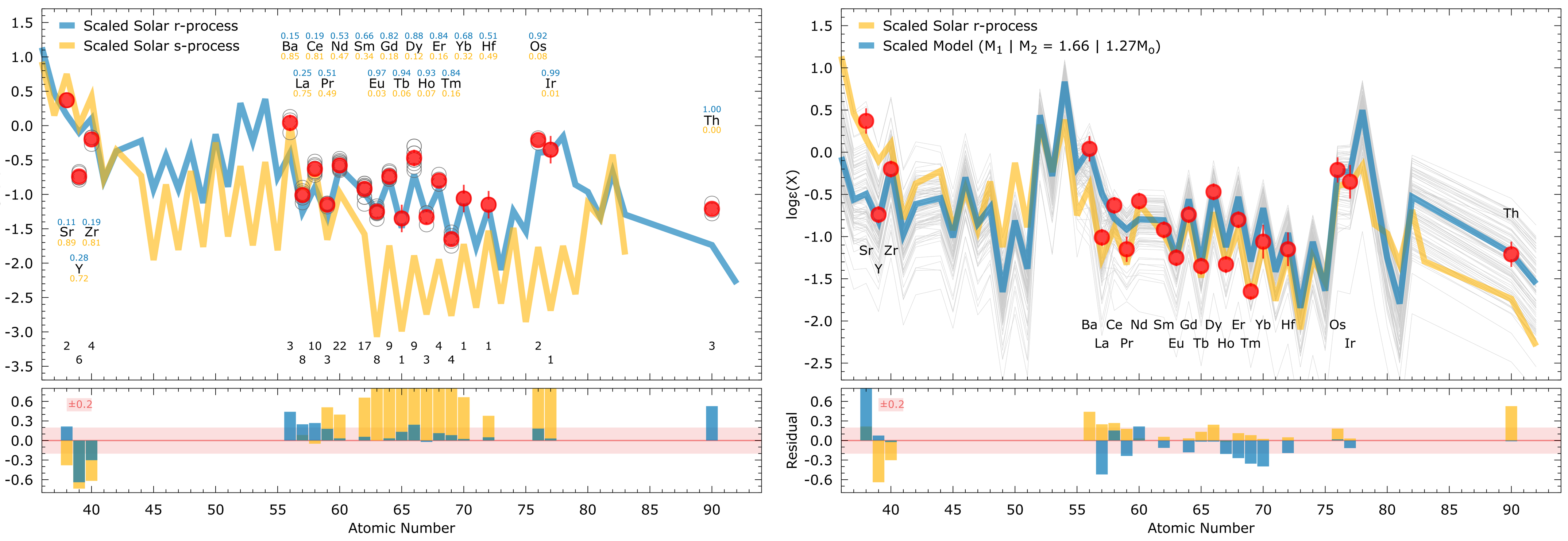

Figure 6: SPLUS J1424−2542 abundances compared to the scaled Solar System (left) and Neutron Star Merger (right) values.

Conclusions and future work

- SPLUS J1424−2542:
  - $T_{\rm eff}$ = 4762 K
  - log g = 1.58
  - [Fe/H] = −3.39
  - [Eu/Fe] = +1.62
  - [Th/Fe] = +2.16 (actinide boost)
  - log ϵ(Th/Eu) = +0.04 (highest observed to date)
  - Age = 10.1 Gyr
  - Mass = 0.84 M$_\odot$
- Formation scenario – at least two progenitors:
  - Light elements: Metal-free Pop. III star (11.3-13.4 M$_\odot$)
  - Heavy elements: Neutron star merger (1.66 M$_\odot$ | 1.27 M$_\odot$)
- Orbit and substructure membership
  - Likely in situ origin
  - Not associated with any known early MW merger events
- What's next?
  - Mining S-PLUS, J-PLUS, and J-PAS to find candidates
  - High-resolution spectroscopic follow-up

Resources

vmplacco.github.io | read the paper | this poster

Acknowledgements

This work is supported by NOIRLab, which is managed by the Association of Universities for Research in Astronomy under a cooperative agreement with the U.S. National Science Foundation.

References

[1] Almeida-Fernandes, F., et al. 2022, MNRAS 511, 4590

[2] Placco, V., et al. 2022, ApJS, 262, 8

[3] Placco, V., et al. 2021, ApJL, 912, 32

[4] Placco, V., et al. 2023, ApJ, 959, 60