# FRIB, stars, and r-process elements

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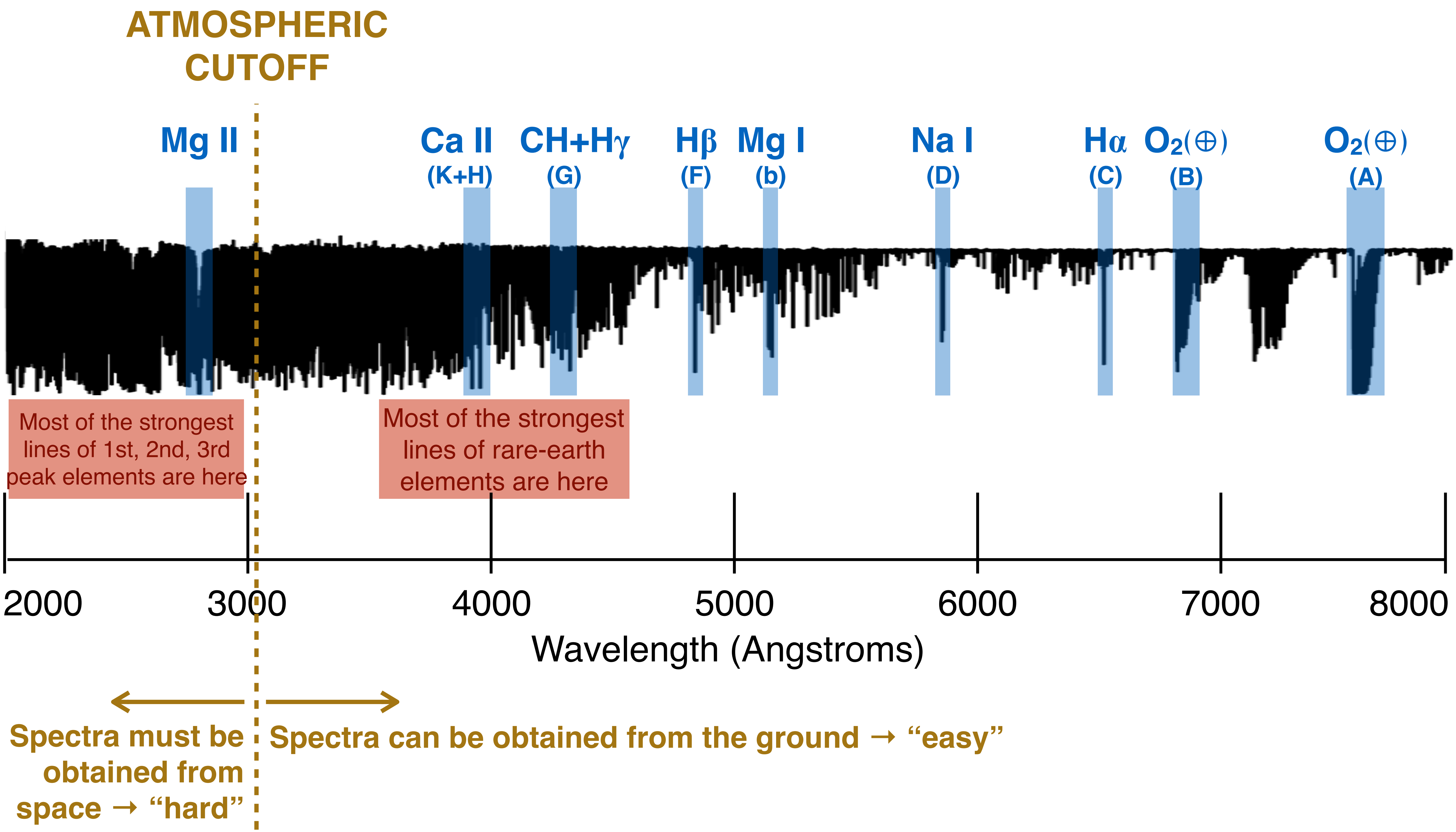
**FRIB [virtual] proposal preparation workshop: May 04, 2020**

My expertise is in deriving stellar abundances of heavy elements produced by the r-process to create a more complete and accurate inventory of the abundance pattern(s) produced by r-process nucleosynthesis events. I also do observations of dwarf galaxies and metal-poor stars throughout the Galaxy.

My interest is in providing astrophysical motivation to measure properties of radioactive progenitor isotopes of r-process elements.

I want to help you get a sense for what is easy/hard or possible/impossible in terms of measuring r-process (or s-process, or i-process) elements in stars. Hopefully this can help motivate and (de)prioritize radioactive progenitor isotopes for study with FRIB.

**This is a spectrum of a metal-poor star*. Notice (1) the red boxes and (2) the yellow text.**




*HD 108317, a metal-poor ([Fe/H] = –2.4) red giant (Teff = 5100 K) with moderate r-process enhancement ([Eu/Fe] = +0.5).
Spectra taken by HST/STIS, Keck/HIRES, and Magellan/MIKE.

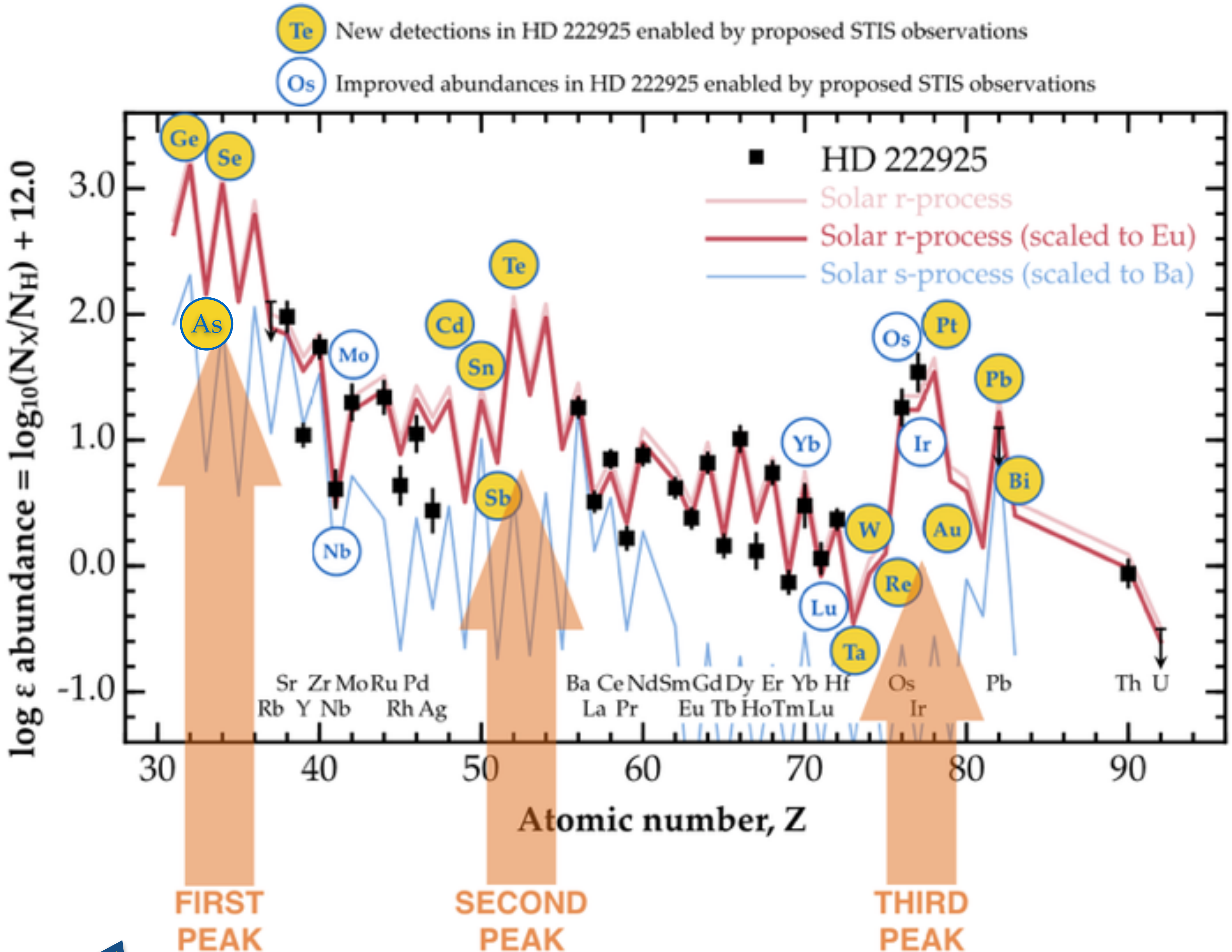
Here is a best-case scenario.

HD 222925

V = 9.0
Teff = 5600 K
[Fe/H] = −1.5
[Eu/Fe] = +1.3 (r-II)

We will finally be able to detect elements at all three r-process peaks in an r-II star. We should have 42 r-process elements in the pattern (plus U upper limit).

Please (please!) let this pattern supplant (or at least supplement) the solar r-process residuals… **this pattern is independent of the solar s-process residuals!**




black points: already published in Roederer et al., Astrophys. J., 865, 129 (2018)

**Coming in late 2020!**

Here is a list of r-process elements that can be detected from the ground. These spectra are always going to be much more available.

- Easy: **Sr, Y, Zr, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Hf**
- Moderate: **Nb, Mo, Ru, Rh, Pd, Ag, Lu, Os, Ir, Pb, Th**
- Difficult: **Rb, U**

Here is a list of r-process elements that can be detected in the UV from space. These spectra are always going to have much more limited availability.

- Easy: **Ge, Lu, Os, Ir, Pt**
- Moderate: **Cd, Te, W, Au**
- Difficult: **As, Se, Ta, Re, Pb, Bi**
- Not yet proven (and would definitely be difficult): **Sn, Sb, Hg**

Here is a list of r-process elements that are unlikely ever to be observable in an r-process enhanced star:

- **Ga, Br, Kr, In, I, Xe, Cs, Tl**

Isotopic abundances are not generally possible—just elemental sums.

Astronomy observing proposals framed as, "**Observations of element ratios A/B and X/Y will provide a clear discrimination between models M and N of r-process nucleosynthesis**" stand a good chance. If you can identify these ratios (and a killer plot is even better!), I will do all that I can to identify the right stars to make the observations.

Is there an analogous framing that I, as an observational astronomer, could provide you to strengthen your proposal for FRIB beam time?