Characterizing *r*-Process Sites through Actinide Production

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Background: Actinides in Metal-Poor Stars

Metal-poor stars enhanced in *r*-process elements ("*r*-II stars") exhibit **differences in scaled actinide abundances** (Th/Eu). Is there a choice of nuclear or astrophysical input that can account for difference actinide levels?

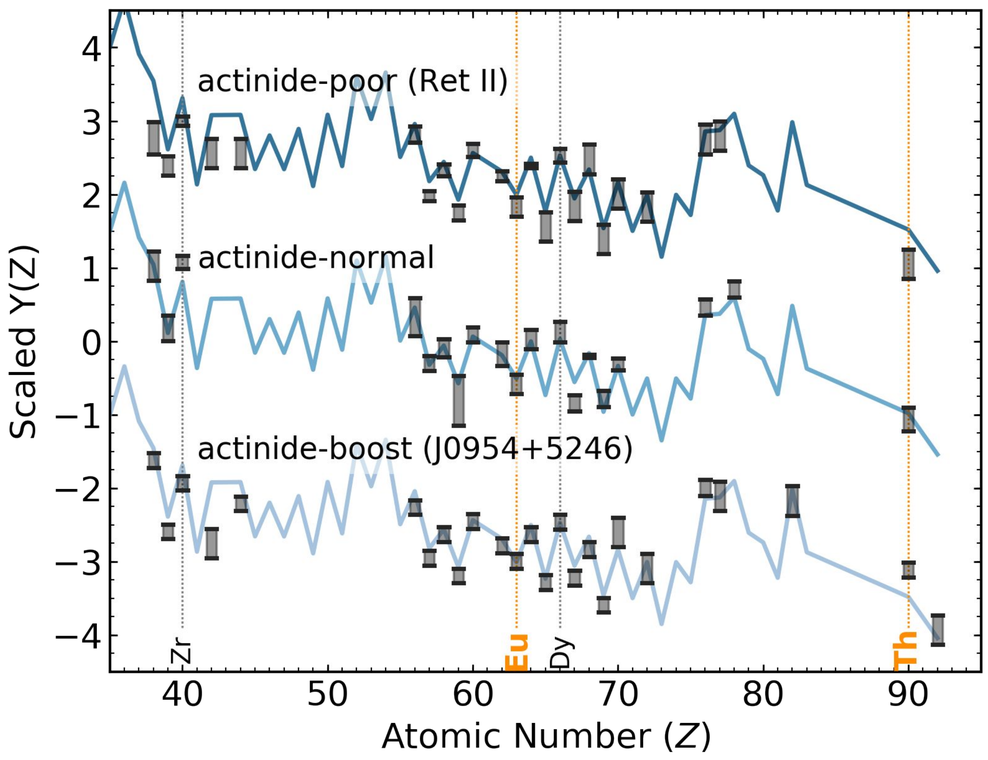

Fig 1. Three examples of *r*-II abundance patterns with a range of Th/Eu levels, including the lowest (Ret II, [1]) and the highest (J0954+5246 [2]) measured.

Research Question #2

Do actinide variations **necessarily call for separate *r*-process sources**, or is **one *r*-process source** capable of producing **all actinide variations**?

Research Question #1

Is the **actinide-boost** a **nuclear effect** (e.g., from fission)? If so, what choice of nuclear input can reproduce the observational actinide-boost signature?

Actinide Production by the *r*-Process

Conclusion #1: No single choice of nuclear input in a fission-cycling *r*-process can reproduce the actinide-boost signature, but a **mixture of astrophysical conditions can** [3].

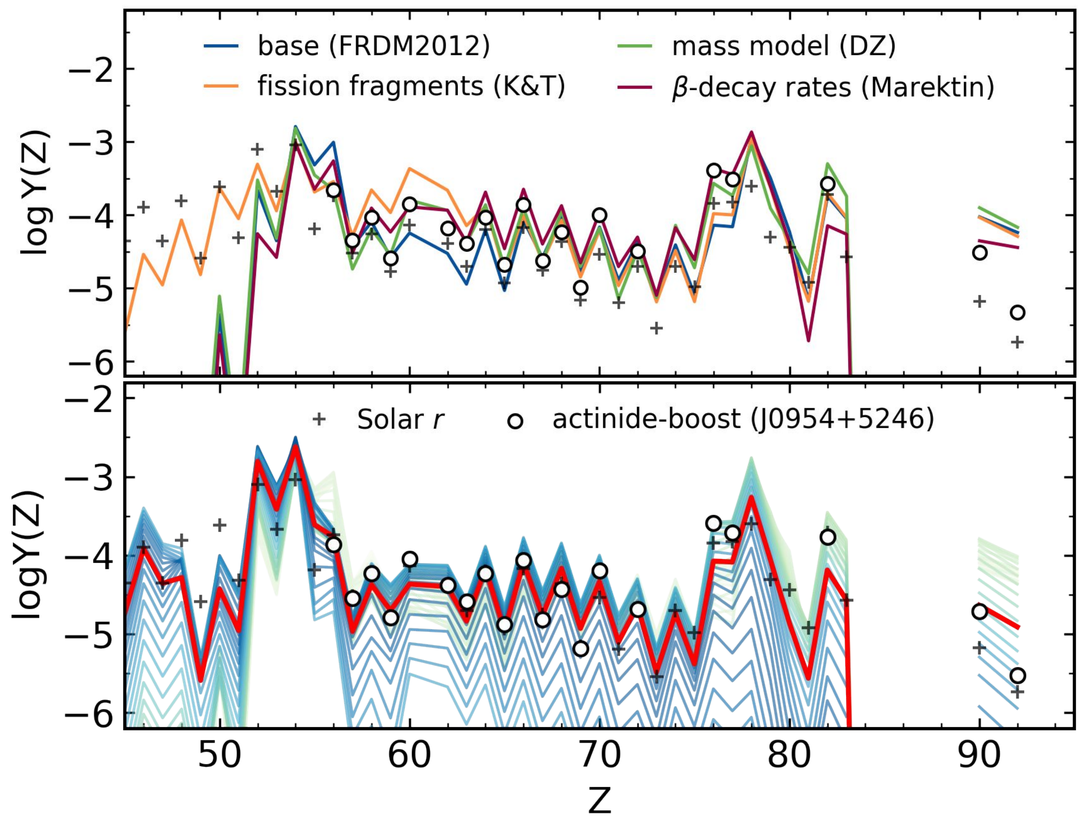

Fig 2. Final abundance patterns using four variations on nuclear input (top) and a mixture of astrophysical conditions (Y_e, bottom) compared to an actinide-boost star.

Method: ADM Model

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The **"Actinide-Dilution with Matching"** model is a Monte Carlo method that uses *r*-II abundances to build **empirical mass distributions** characterizing ejecta from *r*-process events.

Constraints on *r*-Process Ejecta

Conclusion #2: There is no point at which the actinide-boost "turns on." Allowing variations in a **distribution of *r*-process ejecta can reproduce all levels of actinide variation in metal-poor stars** [4]. More detailed nuclear physics input can help constrain and characterize the *r*-process ejecta.

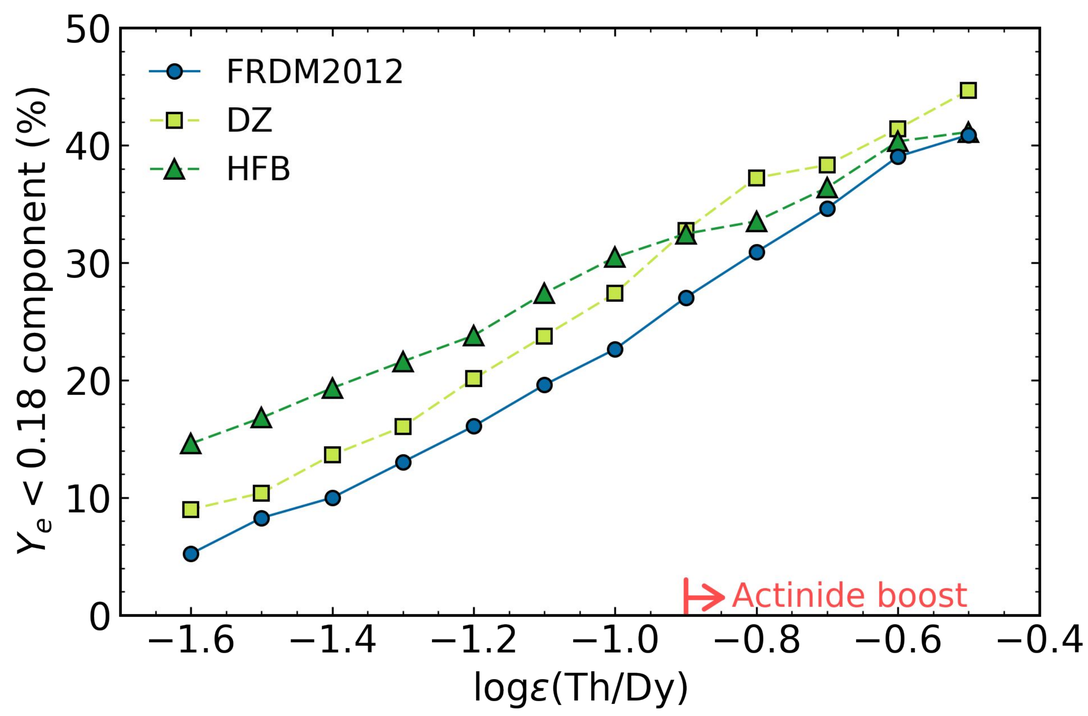

Fig 3. The fraction of ejected low-Y_e material from an *r*-process event vs. increasing actinide abundance. One site can reproduce all actinide abundances yet observed.

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[2] **Holmbeck, E. M.**, Beers, T. C., Roederer, I. U., et al. 2018, The Astrophysical Journal, 859, L24
[3] **Holmbeck, E. M.**, Sprouse, T. M., Mumpower, M. R., et al. 2019, The Astrophysical Journal, 870, 23
[4] **Holmbeck, E. M.**, Frebel, A., McLaughlin, G. C., et al. 2019, The Astrophysical Journal, 881, 5

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