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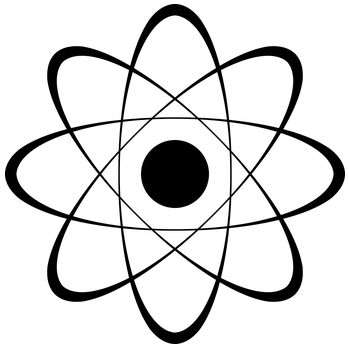

Assessing the metrics of *r*-process sensitivity studies

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Outline

- What is the *r*-process?
- Sensitivity studies and sensitivity metrics
- Standardizing sensitivity metrics

What is the *r*-process?

- The *r*-process (rapid neutron capture) is a chain of nuclear reactions
  - **Neutron capture**
  - Beta decay
  - Photodissociation
  - Beta-delayed neutron emission

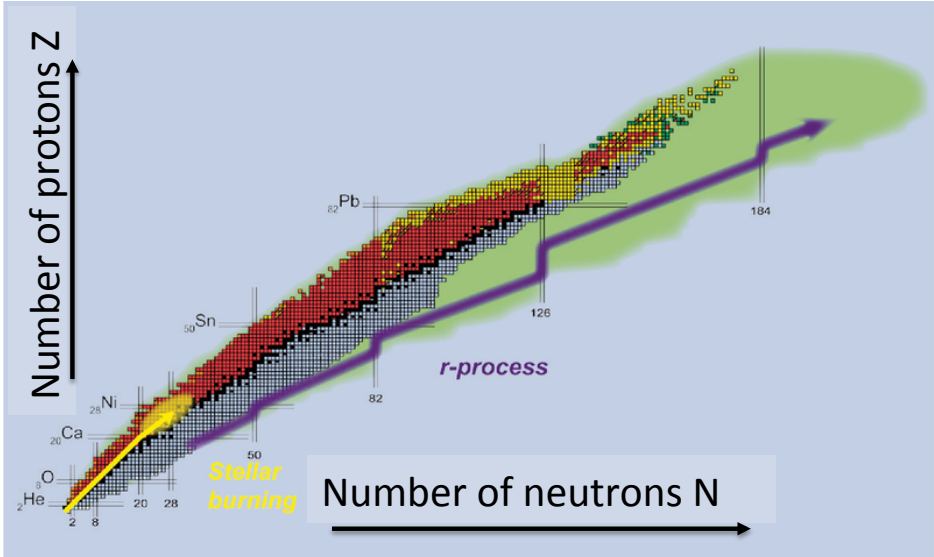

Figure from Institut für Kernphysik, Technische Universität Darmstadt

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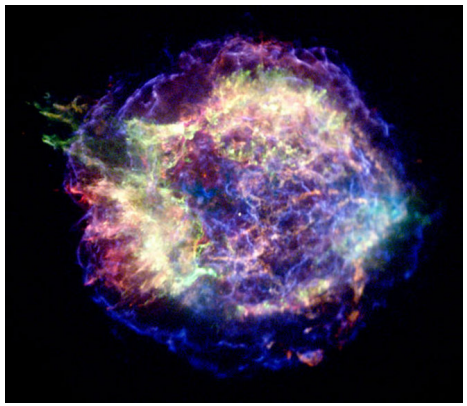
What is the *r*-process?

- The *r*-process is partly responsible for the creation of heavy elements in our universe

- It is believed to occur in extreme astrophysical environments (e.g. supernovae)



Picture: www.space.com

Sensitivity studies: the rationale

- The *r*-process involves neutron-rich nuclei far from stability
- Little is known about the properties of these nuclei
- Sensitivity studies determine which nuclei are most important to the *r*-process

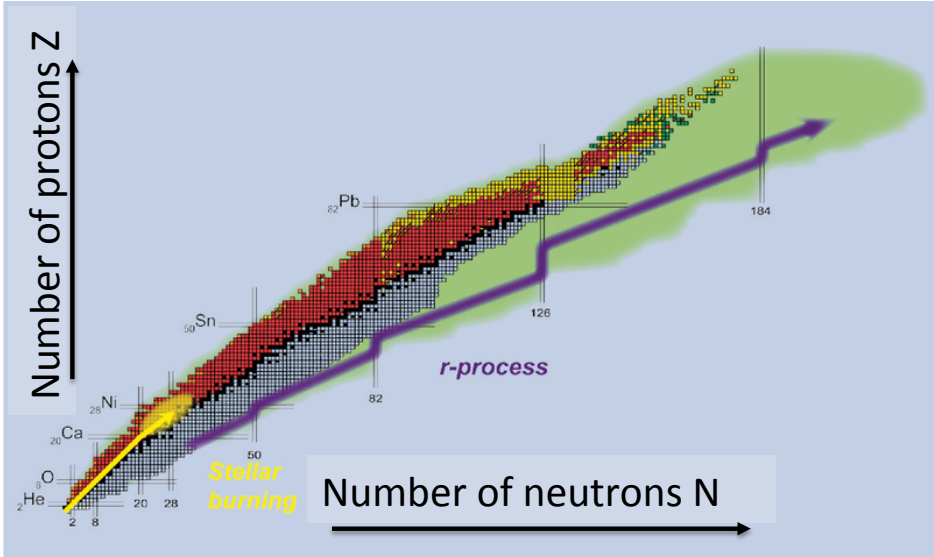


Figure from Institut für Kernphysik, Technische Universität Darmstadt

Sensitivity studies – example (^{138}Sn)

- Run an *r*-process simulation
- Vary a specific nuclear property (e.g., mass) for a specific isotope in the initial state of the simulation
- Measure the difference in the results

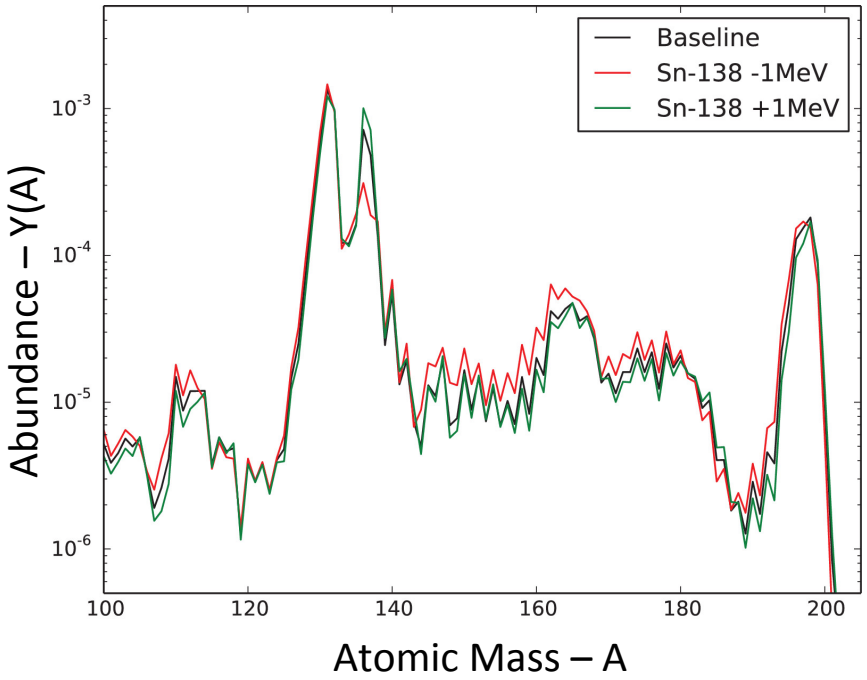


Figure: Change in the abundance pattern from increasing and decreasing the mass of ^{138}Sn, from A. Aprahamian, I. Bentley, M. Mumpower, and R. Surman, AIP Advances **4**, 041101 (2014).

Sensitivity metrics

- The "sensitivity" of a particular isotope is quantified by a sensitivity metric
- However, the sensitivity metrics vary between studies
- Standardizing these metrics makes it easier to compare studies[1]

- A1: $\sum|X-X\downarrow base|$
- A2: $\sum|Y-Y\downarrow base|$
- R1: $\sum|Y-Y\downarrow base|/Y\downarrow base$
- R2: $\sum|\log\downarrow 10\ Y-\log\downarrow 10\ Y\downarrow base\ |$

[1]Z. Shand, R. Ouyed, N. Koning, C. Osakwe, I. Dillmann, R. Krücken, and P. Jaikumar, Phys. Rev. C (submitted) (2018).

Sensitivity metric performance comparison

- Figure: baseline (control) simulation vs. eight most sensitive isotopes for three different sensitivity metrics

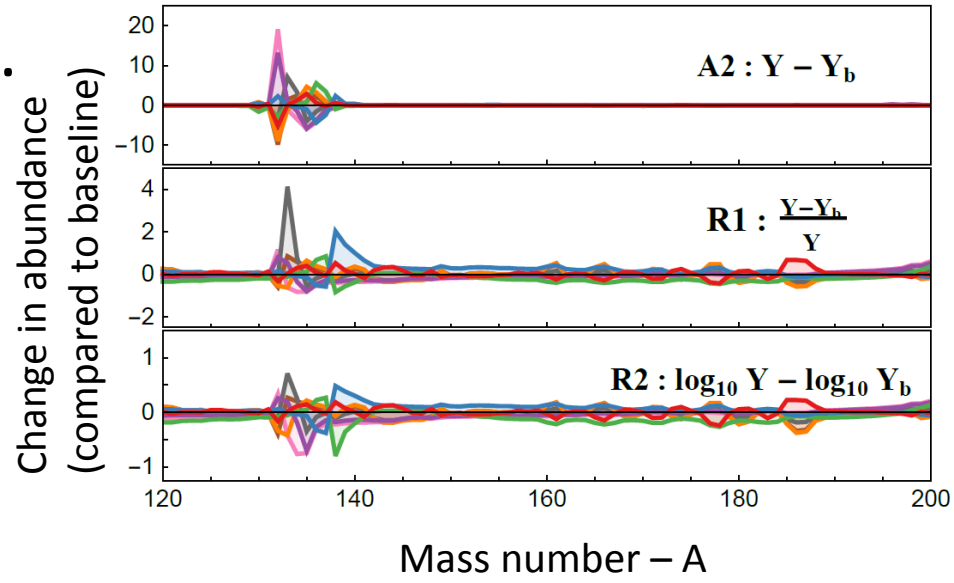


Figure: Z. Shand et al., Phys. Rev. C (submitted) (2018).

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Summary

- The *r*-process helps create heavy elements, but many of the nuclides involved have not been observed
- Sensitivity studies help determine which nuclides are most important to the *r*-process
- My research has helped standardize the way this sensitivity is described

Thank you
Merci