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From Stars to the Laboratory: Exploring the (weak) r-Process with Nuclear Reactions

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Stellar explosions and colliding neutron stars are significant sources of the chemical elements found in nature. While some astrophysical processes responsible for element creation are well-understood, others, like the rapid neutron capture process (r-process), remain challenging to study. These nucleosynthesis processes often involve reactions on short-lived radioactive isotopes, which can now be produced and studied at accelerator facilities. By measuring charged-particle reactions relevant to the r-process, we can better constrain nuclear reaction rates and properties, allowing laboratory insights into how elements are forged in the cosmos. Breakthroughs in astronomical observations highlight the need for complementary advancements in nuclear experiments on rare isotopes. I will discuss the essential role that charged-particle reactions play in understanding stellar explosions, showcase recent experimental achievements, and offer an outlook on future nuclear astrophysics research, particularly as it relates to the weak r-process.

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