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Probing the neutron skin with ultrarelativistic isobaric collisions

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Neutron structure and skin thickness in nuclei have been traditionally measured by low-energy scatterings where the nuclei are only gently disturbed. Their precisions have been limited by theoretical uncertainties in modeling the nuclear force. Here, we propose an unconventional approach to probe the neutron skin by smashing isobar nuclei completely apart at relativistic energies to compare their produced hadron multiplicities. Because particle production in relativistic heavy-ion collisions depends on the details of the nucleon density distributions in the colliding nuclei, we demonstrate that the small difference in hadron multiplicities between isobar collisions, together with state-of-the-art calculations of nuclear structure, can provide an exquisite sensitivity to the poorly constrained neutron density distributions and skin thickness, which can in turn put stringent constraints on the nuclear symmetry energy. Such a premise may already be in stock in the isobar collision data taken at BNL's Relativistic Heavy-Ion Collider in 2018. If realized, it can significantly advance our knowledge of nuclear matter in normal nuclei as well as in astronomical objects like neutron stars.

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