Grabbing magic tin by the tail

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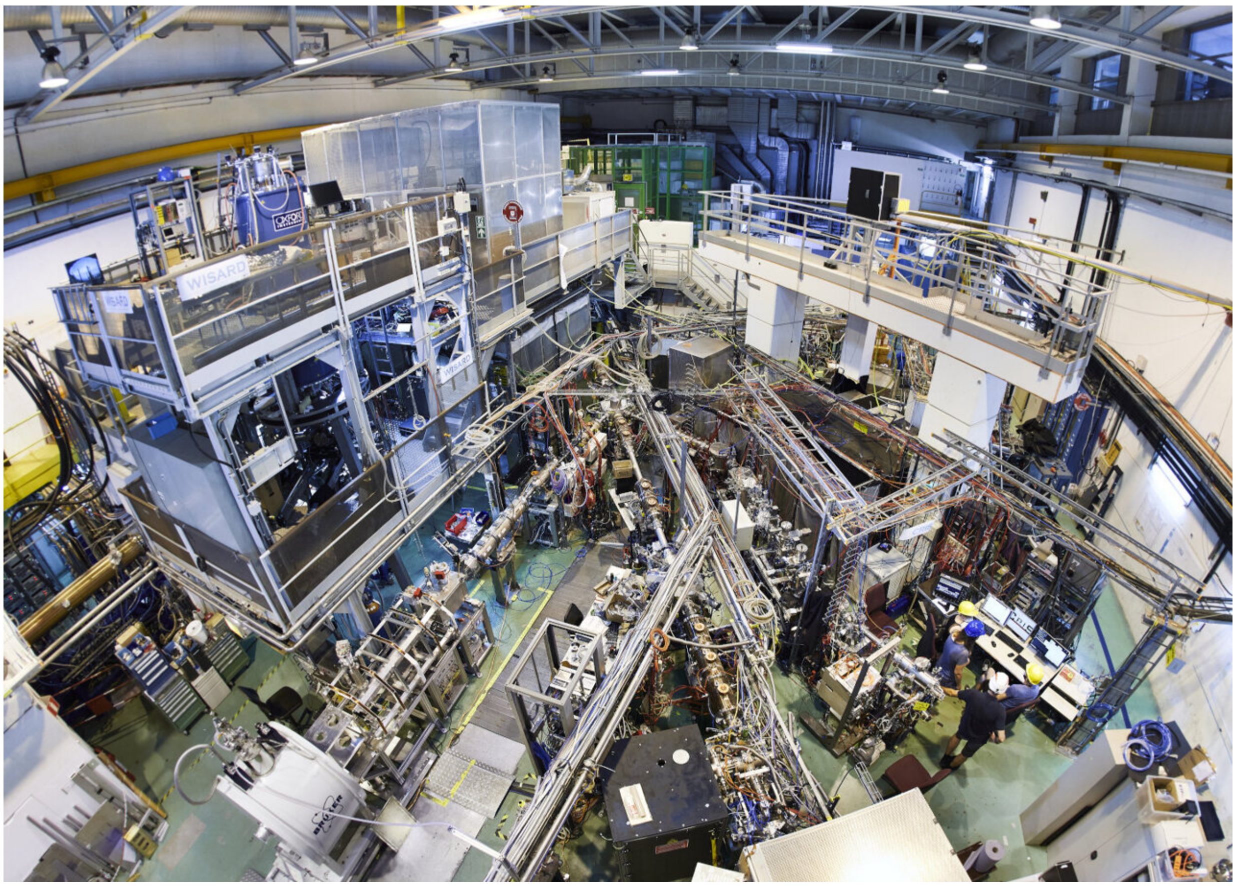

The ISOLDE facility seen from above. Credit: CERN

Atomic nuclei have only two ingredients, protons and neutrons, but the relative number of these ingredients makes a radical difference in their properties. Certain configurations of protons and neutrons, with "magic numbers" of protons or neutrons arranged into filled shells within the nucleus, are more strongly bound than others. The rare nuclei with complete proton and neutron shells, which are termed doubly magic, exhibit particularly enhanced binding energy and are excellent test cases for studies of nuclear properties.

In a paper just published in *Nature Physics*, Maxime Mougeot of CERN and colleagues describe theoretical calculations and experimental results from CERN's ISOLDE facility that shed new light on one of the most iconic doubly magic nuclei: tin-100.

With 50 protons and 50 neutrons, tin-100 is of particular interest for studies of nuclear properties because, in addition to being doubly magic, it is the heaviest nucleus comprising protons and neutrons in equal number—a feature that gives it one of the strongest beta decays, in which a positron (the antiparticle of an electron) is emitted to produce a daughter nucleus.

Studies of the beta decay of tin-100 suffer from difficulties in producing it. Moreover, the two most recent such studies, at RIKEN in Japan by Lubos and colleagues and at GSI in Germany by Hinke and colleagues, yield different values for the energy released in the decay, resulting in discrepant values for the mass of tin-100.

Recent developments at the ISOLDE facility have enabled production of the neighboring nuclei indium-101, indium-100 and indium-99, a mere proton below tin-100. In their new study, Mougeot and colleagues used all of the experimental armament of the facility's ISOLTRAP set-up to measure the masses of these new members of the ISOLDE family, notably the mass of indium-100.

"The mass of tin-100 can be derived from that of indium-100 and the energy released in the beta decay of tin-100 into indium-100," says Mougeot, "So our indium-100 mass measurement grabbed this iconic doubly magic nucleus by the tail."

The ISOLTRAP mass measurement of indium-100 is ninety times more precise than the previous one, magnifying the discrepancy in the values of the tin-100 mass deduced from the most recent beta-decay studies.

The researchers then made comparisons between the measured masses of the indium nuclei and new sophisticated "ab initio" theoretical calculations that attempt to describe nuclei from first principles. These comparisons favor the beta-decay energy result of Hinke and colleagues over that of Lubos and colleagues. Moreover, they show excellent agreement between the measurements and the calculations, giving the researchers great confidence that the calculations capture the intricate nuclear physics of tin-100 and its indium neighbors.

More information: Mougeot, M., Atanasov, D., Karthein, J. et al. Mass measurements of $^{99–101}$In challenge ab initio nuclear theory of the nuclide ^{100}Sn. *Nat. Phys.* (2021). doi.org/10.1038/s41567-021-01326-9 , www.nature.com/articles/s41567-021-01326-9

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