Expanding the border of superheavy nuclei—new seaborgium isotope discovered

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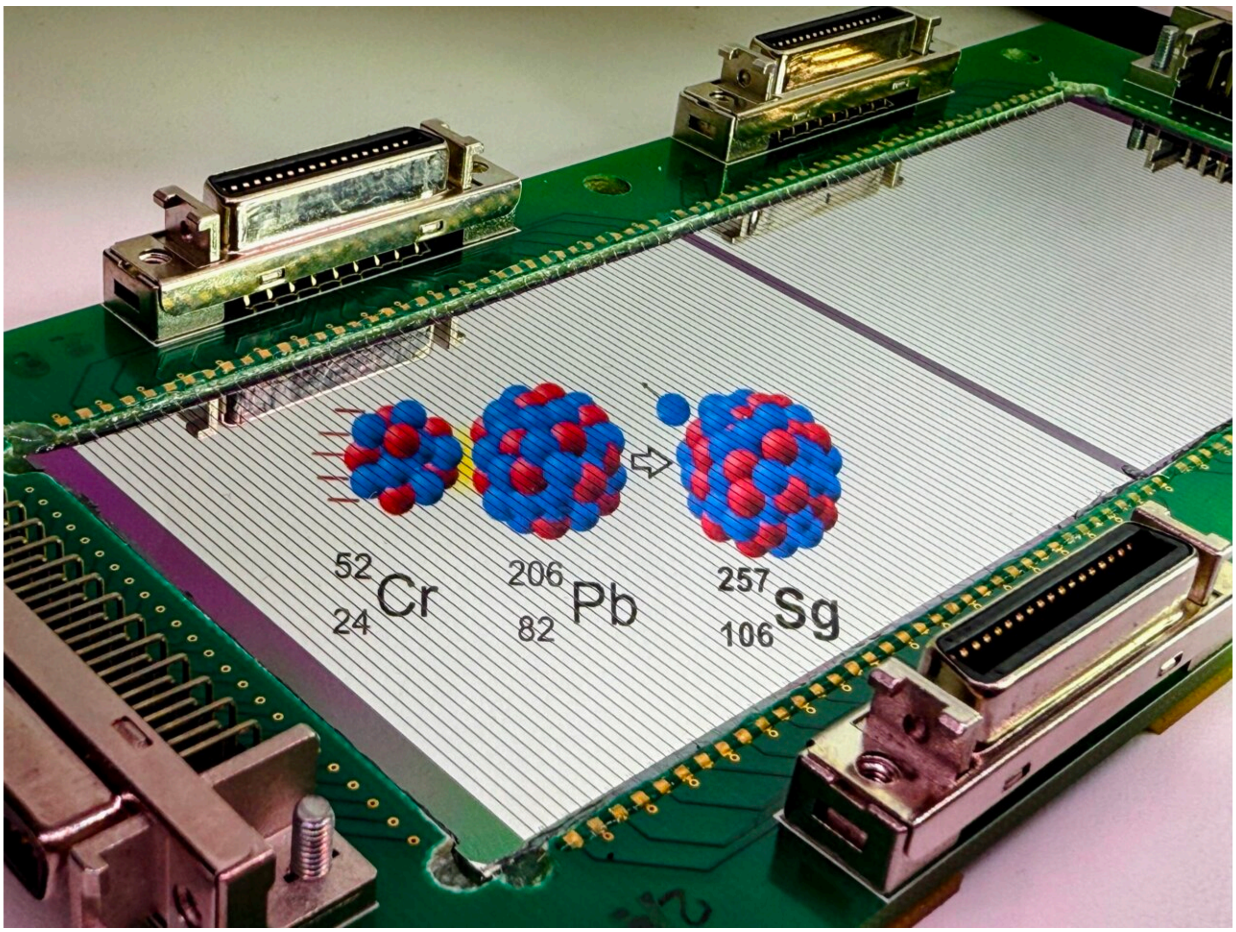


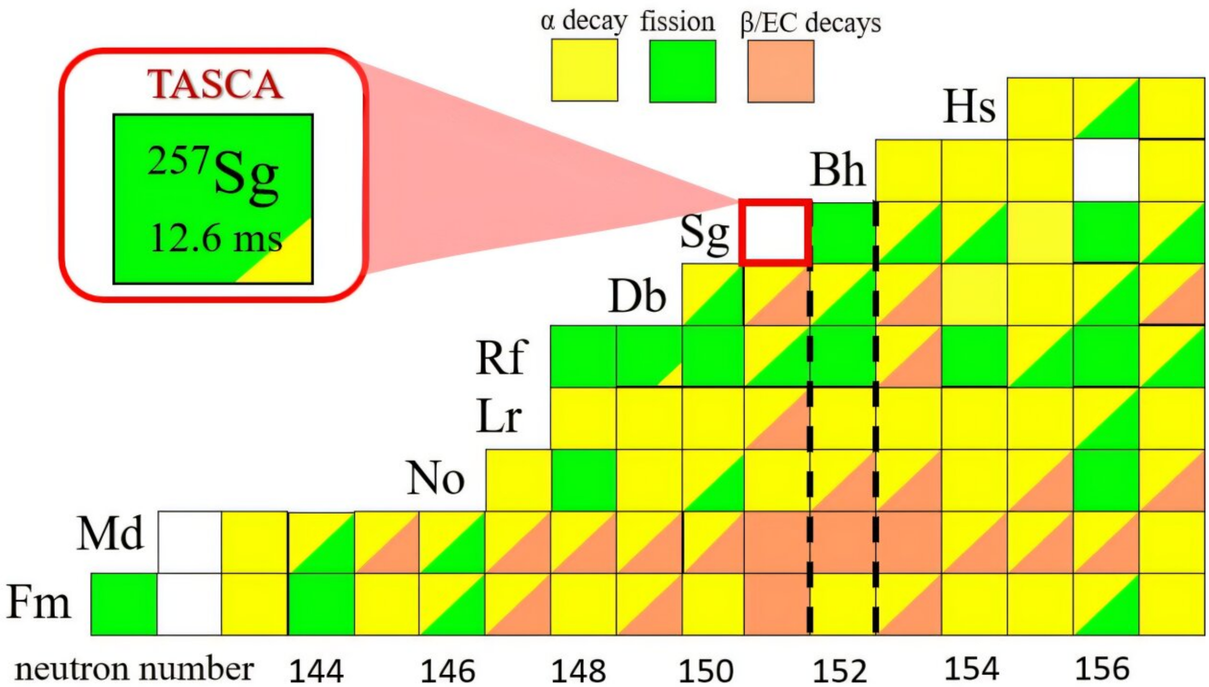
Reflection of the nuclear reaction on the surface of the silicone detector, which was employed to discover the seaborgium-257. Credit: P. Mosat, GSI/FAIR

An international research team led by GSI/FAIR, Johannes Gutenberg University Mainz (JGU) and Helmholtz Institute Mainz (HIM) has succeeded in the production of a new seaborgium isotope. In the experiment conducted at the GSI/FAIR accelerator facilities, 22 nuclei of seaborgium-257 could be detected. The results were published in the journal *Physical Review Letters* and highlighted as an "Editor's Suggestion."

With the newest addition, 14 isotopes of the artificial superheavy element seaborgium (atomic number 106) are now known. For the production of seaborgium-257, an intense chromium-52 beam from the GSI/FAIR linear accelerator UNILAC impinged onto high-quality lead-206 targets.

Using the highly efficient detection system of the gas-filled recoil separator TASCA (TransActinide Separator and Chemistry Apparatus), 22 decays of seaborgium-257 nuclei were detected in total: 21 fission events and one alpha decay. The half-life of the new isotope, situated just next to the enhanced neutron shell gap at 152, is 12.6 milliseconds.

"Our findings on seaborgium-257 provide exciting hints on the impact of shell effects on the fission properties of superheavy nuclei. As one consequence, it is possible that the next lighter, still unknown isotope—seaborgium-256—may undergo fission in a very short time range of one nanosecond to six microseconds," says Dr. Pavol Mosat, the first author of the publication from GSI/FAIR's research department for the chemistry of superheavy elements (SHE Chemistry).



Excerpt of the nuclear chart showing the measured decay properties of seaborgium-257. Credit: J. Khuyagbaatar, GSI/FAIR

The upper limit of this expected half-life range is near or even just below current experimental capabilities—unless a so-called K-isomeric state exists. Such excited states, stabilized by quantum effects, exhibit longer fission lifetimes and open an indirect doorway to the short-lived nuclei.

Recently, significant progress toward the border of stability was made by discovering the 60-ns rutherfordium-252 via its longer-lived K-isomeric state. The exploration of the isotopic border for the element seaborgium is a natural continuation of these experiments, mapping the coastline of the island of stability of the superheavy nuclei.

So far, no K-isomeric state has been observed in seaborgium isotopes. In the present experiment, however, the research team also irradiated a lead-208 target and observed strong evidence for the presence of a K-isomeric state in seaborgium-259.

"Our results on a K-isomeric state in seaborgium–259 open a doorway to explore the K-isomer phenomenon in other seaborgium isotopes and to enable the synthesis of the short-lived isotope seaborgium-256 isotope, if a long-lived K-isomeric state exists also in this nucleus," says Dr. Khuyagbaatar Jadambaa, leader of the corresponding experimental program of GSI/FAIR.

"The present work is a great example of the collaborative efforts of different GSI/FAIR departments—besides SHE Chemistry, the Experiment Electronics and Target Laboratory departments were involved—with our international partner institutes," says Professor Christoph E. Düllmann, head of the SHE Chemistry department at GSI/FAIR, professor at JGU and director of HIM.

"The further exploration of the stability and the properties of superheavy nuclei jointly with our national and international partners will continue to be an important area of research for our research team."

Besides GSI/FAIR, JGU and HIM, the University of Jyväskylä, Finland, the Advanced Science Research Center of the Japan Atomic Energy Agency, Japan, and the Indian Institute of Technology Roorkee, India, are collaborators of the experiment.

More information: P. Mosat et al, Probing the Shell Effects on Fission: The New Superheavy Nucleus ^{257}Sg, *Physical Review Letters* (2025). DOI: 10.1103/s7hr-y7zq

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