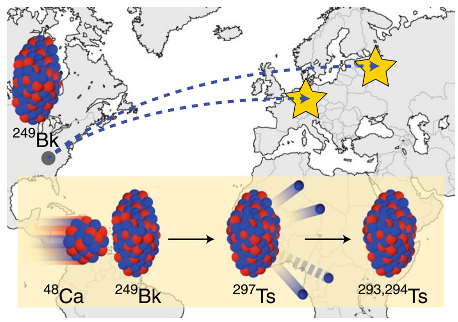
Targeting tennessine

Liz Williams explores the synthesis of tennessine, a story in which elements in supporting roles play a crucial part.

All experiments have their struggles. In the quest to create new superheavy elements, there is a lot of anxious waiting. Weeks, even months can go by without a single piece of evidence that an element exists. The time between the first day of beam time and an initial promising event can feel like eternity. Is the experiment set up properly? Were the calculations correct?

The first few syntheses of element 117 were full of such moments. The penultimate element of the periodic table as we know it was first discovered by a Russian–US collaboration at the Flerov Laboratory of Nuclear Reactions (FLNR) at the Joint Institute for Nuclear Research in Russia[1,2]. Their findings were later confirmed by a GSI-led international collaboration at the GSI Helmholtz Centre for Heavy Ion Research in Germany[3]. The independent verification of an element by a different team may not carry the same prestige as its initial synthesis, but for superheavy elements it is an important part of the discovery process. In the case of element 117, this second synthesis was also valuable in its own right, as it lifted some uncertainties in the GSI team's quest for the even-heavier element 119.

In 2009, the FLNR team was running an experiment using a technique called hot fusion, in which a radioactive actinide nucleus (in this case, berkelium-249, with 97 protons) reacts with, typically, calcium-48 (20 protons). Hot fusion reactions are capable of producing nuclei close to where we think we might find the 'island of stability' — a cluster of relatively stable nuclei (in comparison to their neighbours) predicted to exist either around elements featuring 114, or between 120 and 126 protons, and 184 neutrons. If it does indeed exist, the exact locations and the decay properties of the island's nuclei will be powerful tools for refining our understanding of nuclear structure.



During 70 days of beam time, the FLNR team saw evidence[1,2] that six atoms of element 117 had been created by first forming tennessine-297, which rapidly emitted three or four neutrons to form two isotopes (pictured). This evidence came in the form of α-decay chains that went down to dubnium and roentgenium. Cross-sections — a measure of the probability of creating a particular element for a given reaction — are incredibly small, and the detection of only a handful of such chains makes an experiment a successful one. On a second run in 2012, the FLNR team saw evidence for[4,5] another seven atoms. Both experiments confirmed a rise in stability for elements with more than 110 protons, supporting the existence of the island of stability.

Meanwhile, the GSI team had embarked on a hunt for element 119 by colliding titanium-50 (22 protons) with berkelium-249. They had put a lot of effort into refining their experimental set-up for this purpose by creating a very intense titanium-50 beam, introducing a digital data acquisition system, and working to reduce background radiation. But, four months into the experiment, element 119 remained undiscovered.

The radioactive berkelium target was decaying away and tension was running high in the team, so in 2012 they switched to a calcium-48 beam to check their experimental set-up by trying to detect a rare but known superheavy element. In doing so, they confirmed[3] the existence of element 117 through independent synthesis, and established that their observation of nothing in the element 119 experiment was simply a sign that the fusion cross-section for this reaction was smaller than expected. A year after the GSI team published their results, element 117 — along with 113, 115, and 118 — were officially welcomed onto the periodic table by the International Union of Pure and Applied Chemistry and International Union of Pure and Applied Physics joint working party.

When the FLNR team was asked to propose a name for element 117, they made an unconventional suggestion: tennessine, whose suffix identifies the element as a halogen, is rooted in the state of Tennessee, USA. Rather than the location of discovery, this name — approved by the IUPAC in 2016 — honours the place where some of the FLNR collaborators came from, but also where the berkelium-249 material had been crafted. The state's Oak Ridge National Laboratory had successfully taken on the herculean task of producing the berkelium-249 target so essential to the element's discovery. ❐

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Competing interests
The author collaborated with the GSI group on other superheavy element research (not $Z = 117$ or 119).