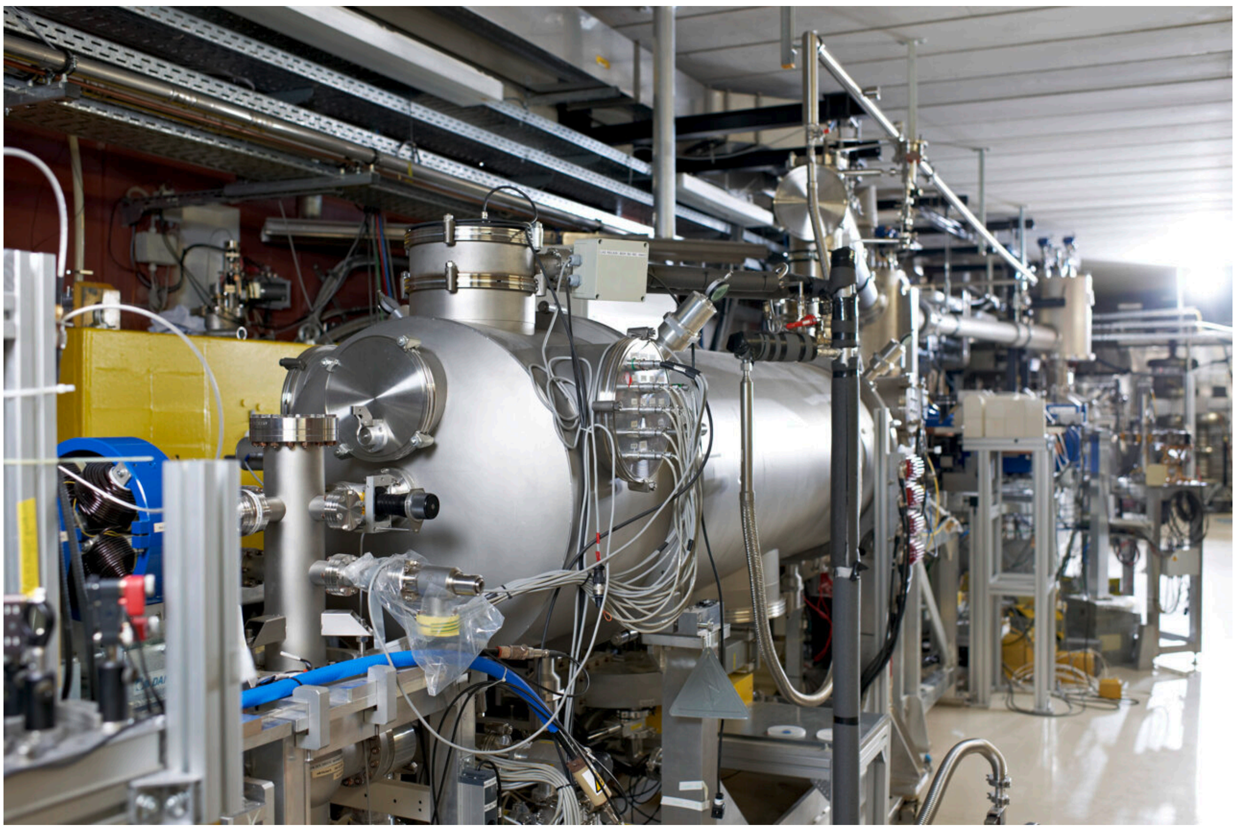
Producing medical isotopes at extreme energy density

February 22 2022



With this main module of ELBE, electrons can be accelerated to nearly the speed of light. In the SMART experiment, the particles generate "bremsstrahlung", which knocks out one neutron each from molybdenum atomic nuclei, leaving the radioisotope Mo-99. Credit: HZDR/Jürgen Jeibmann

Molybdenum (Mo-99) plays a seminal role in the diagnosis of cancer and other diseases. After a few hours, the radioisotope decays to produce Technetium-99m, which is used in the imaging procedures needed to examine millions of people around the world every year. The current fission-based process has many challenges like the aging reactors and the environmental impact of the process. That is why researchers are searching for alternative methods of production. At the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), the European SMART collaboration has now successfully tested the production of Mo-99 with the help of the superconducting linear accelerator ELBE.

"We drove ELBE to its very limits and, for almost a week, non-stop, we shot a 30-kilowatt beam of high-energy electrons at a millimeter-sized target of Molybdenum," explains Prof. Peter Michel, head of ELBE in HZDR's Institute of Radiation Physics.

"This meant we could deposit energy totalling 13 gigajoules in a tiny volume. It's roughly comparable to the kinetic energy of a fully-loaded Boeing 747-400 flying at a top speed of around 900 kilometers an hour."

Such extreme energy density is required to trigger the desired reaction: "The bremsstrahlung generated at the target knocks out one neutron each from the atomic nuclei so that eventually what is left over is the desired product Molybdenum-99."

While HZDR provided the necessary accelerator technology, the Dutch technology company Demcon was responsible for the experimental set-up. One of the world's largest producer of Mo-99, the Belgian Institute for Radio Elements (IRE), initiated SMART (Source of MedicAl RadioisoTopes) and develops the technology together with the Dutch corporation ASML and in collaboration with partners from science and industry.

"The ELBE accelerator is the only research facility in Europe that was suitable for our experiment because it's only here that the beam quality is such that it remains stable when we deploy it over a number of days," says Johannes Jobst, senior mechatronic system engineer at Demcon.

"But what was decisive for our success was the very good, trusting collaboration between the partners. In the case of ELBE, we not only benefited enormously from the unique technology but also from the scientific expertise and great dedication of the ELBE team."

Complex experimental set-up: Cooling with liquid sodium

Due to the extreme conditions, the experiment posed numerous challenges to researchers and required a complex experimental set-up. For example, they had to contain the enormous pressures and potential radiation damage in the materials they were using and thus put special safeguards in place.

Another challenge: Under normal circumstances, Molybdenum would evaporate after only a short time under radiation. Demcon therefore used special cooling technology based on the high thermal conductivity of liquid sodium. The metal, which is also used as a heat transfer fluid in nuclear reactors, is capable of absorbing a particularly large amount of heat due to its high boiling point and the wide range of process temperatures this allows.

This test run, that was successfully conducted at the beginning of February, is a major step in the confirmation of the feasibility of the whole concept and gives confidence that this technology can be employed on a larger industrial scale. The advantages of the novel method are obvious: Because Molybdenum-100 is used as the starting material, it is no longer necessary to split uranium in a nuclear reactor

—which means less radioactive waste, especially of the type with a long half-life. IRE and its partners are continuing the development of the full installation. The scientific foundations for this ambitious scheme have now been confirmed by the experiment at ELBE accelerator.

Provided by Helmholtz Association of German Research Centres

Citation: Producing medical isotopes at extreme energy density (2022, February 22) retrieved 24 May 2024 from https://phys.org/news/2022-02-medical-isotopes-extreme-energy-density.html