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Ressort: Special interest

Advanced technology against cancer

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With millimetre precision, certain tumours can be irradiated at the Paul Scherrer Institute (PSI) using protons – that is, positively charged elementary particles. PSI is the one place in Switzerland where this especially protective and precise option for radiation therapy is possible.

Now PSI, where more than 8,000 patients have already been irradiated successfully, has expanded its capacity through a joint project with the University Hospital Zurich and the University of Zurich, with a state-of-the-art treatment facility: the new, 270-ton machine called Gantry 3.

After four years of planning and construction as well as a one-year test phase, the time has come: The most modern irradiation facility at the Centre for Proton Therapy CPT of the Paul Scherrer Institute PSI – Gantry 3 – is now open. With a total weight of 270 tons and a diameter of 10.5 metres, Gantry 3 is the largest machine installed to date at CPT.

The main benefit the collaborators cite with the arrival of Gantry 3 is shorter waiting times for patients with cancer. Damien Weber, head and chairman of the proton therapy centre at PSI: "With Gantry 3, we can offer highly effective proton therapy to more patients than ever before, because we have more capacity. That will be especially beneficial for children, for whom a conventional cancer irradiation would be too risky. With the proton therapy, we irradiate the tumour more accurately and better protect the healthy tissue around it."

Radiation oncologist Matthias Guckenberger from the University Hospital Zurich, which collaborates closely with CPT, also has high expectations for the new radiation treatment facility: "Half of the patients we refer to the Paul Scherrer Institute are children. Gantry 3 makes it possible to send all eligible patients promptly for proton therapy. In parallel with that, this joint project further strengthens the cooperation between PSI and the University Hospital Zurich. Proton therapy is a highly specialised treatment that belongs at specialised centres and university medical institutions."

Cancer treatment is advanced by many years of experience

The Paul Scherrer Institute has decades-long expertise in the area of proton therapy and has already been able to help more than 8,000 cancer patients. More than 500 of these were children. Years ago, with

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pioneering contributions such as the development of a new irradiation technique – so-called spot scanning –PSI researchers revolutionised proton therapy. With the introduction of this technique, it has become so precise and low-risk that doctors in ever more countries are using proton therapy to treat cancer patients.

Spot scanning accurate precision

With spot scanning, even tumours in parts of the body that are close to radiation-sensitive, critical structures can be treated. Among these are, for example, certain brain tumours such as meningiomas, tumours in the ear-nose-and-throat area, tumours near the spinal cord, and several types of connective tissue and bone tumours. "With proton therapy and spot scanning, cancer patients who would have been classified as incurable 20 years ago finally have a chance of survival", Weber says. "We are very happy about this, and the many patients who have been healed at PSI alone show that our years of intensive research went in the right direction."

Proton therapy with the spot scanning technique means that a beam of positively charged atomic particles is fired at a tumour, and that the beam scans this tumour from back to front, layer by layer and row by row – until the proton beam has hit every spot on the tumour. Some types of cancer grow around sensitive structures in the body, such as the optic nerve for example, or have a very irregular form. "If these tumours are treated with conventional radiation therapy, a much too large area has to be irradiated in order to really hit the whole tumour," Weber explains.

It is precisely with these complicated tumours that the special advantage of proton therapy comes into play: Only with a proton beam can the doctors control how deep in the body the particles should exert their maximum effect. Up to that point they do in fact penetrate other tissues, yet they do very limited damage there. The tissues behind the tumour remain unscathed. Consequently, there are fewer side-effects from proton irradiation than with conventional radiation therapy.

Steel colossus for precision work

To hit the tumour with the proton beam with one-millimetre precision, large and heavy technological equipment is required. The patient doesn't notice much of this at the treatment facility, seeing only the patient couch in front of a white-clad wall. Its design resembles an oversized wheel and hides the actual gantry. The beam head, from which the proton beam emerges, is in a cabinet above the patient couch. Shielded by thick concrete walls, the beam covers a distance of 50 metres from its source in the particle accelerator to the beam head. Only in the last few metres does it run through the gantry.

"A gantry is a rotatable beam guide mounted on a mechanical rotor", explains physicist Alexander Koschik,

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project leader for Gantry 3. "It consists mainly of a vacuum pipe in which the proton beam is guided on the last couple of metres before the beam head. Gantry 3 can be rotated 180 degrees to the right or to the left. This allows the beam head, and the beam that comes out of it, to be aimed at the tumour from all sides." Nine primary magnets, which surround the vacuum pipe, steer the protons to the patient as a beam with up to one-millimetre accuracy.

Next to the rotor, these magnets are responsible for the weight of Gantry 3. A weight of 220 tons – more than that of a blue whale – must be rotated during irradiation with a concentric precision of 50 micrometres. This is accomplished by two drive motors, just 10 horsepower each.
The new machine immediately breaks several records at CPT. Not only is it the largest of the three gantries, but it was also installed in the shortest time to date. “To build an irradiation facility like this gantry was a big challenge“, says Damien Weber. “It was only possible thanks to the outstanding collaboration with our Swiss industry partners as well as the support of various departments of PSI“.

The first patient at Gantry 3 is expected to be treated in June. For PSI, Gantry 3 is the first irradiation facility to be constructed jointly with a commercial provider – the company Varian Medical Systems from Cham. Damien Weber comments: In Gantry 3 we brought two different worlds together. The industrial partners with their know-how and PSI with its many years of experience in fundamental research and the development of innovative solutions for proton therapy. That was a learning experience for both. The greatest challenge: Gantry 3 had to be adapted to CPT's own particle accelerator as well as the control and safety systems of PSI.

"The two systems work very differently, especially in terms of the software", explains Alexander Koschik. "It's as if they speak two different languages and can't reach an agreement". To overcome this "language barrier" and connect the two systems, PSI researchers and Varian staff developed special interfaces through several years of work. These now function with absolute reliability, and they control, for example, the multi-stage safety systems along the beam line. Knowledge of this technology also benefits the industrial partners. The irradiation facility Gantry 3 was financed with money from the lottery of the canton of Zurich as well as PSI's own funds. The total budget amounted to 25 million Swiss francs. (Text: Sabine Goldhahn)

About PSI

The Paul Scherrer Institute PSI develops, builds and operates large, complex research facilities and makes them available to the national and international research community. The institute's own key research priorities are in the fields of matter and materials, energy and environment and human health. PSI is committed to the training of future generations. Therefore about one quarter of our staff are post-docs, post-graduates or apprentices. Altogether PSI employs 2100 people, thus being the largest research institute

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in Switzerland. The annual budget amounts to approximately CHF 380 million.

PSI is part of the ETH Domain, with the other members being the two Swiss Federal Institutes of Technology, ETH Zurich and EPFL Lausanne, as well as Eawag (Swiss Federal Institute of Aquatic Science and Technology), Empa (Swiss Federal Laboratories for Materials Science and Technology) and WSL (Swiss Federal Institute for Forest, Snow and Landscape Research).

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