sck cen

Highlights 2021

In 2021, more than ever before, SCK CEN joined forces with partners across the world to stimulate groundbreaking progress in society. It can be compared to two

co-pilots

Two partners who merge their expertise and trust each other implicitly to get projects off the ground.

Anchoring growth through partnership

Dear Reader,

I am proud of our staff. (Coronavirus) year after (coronavirus) year, they continue to give their all so we can meet our obligations to society. They are the driving force behind our research centre – the pilot of our growth.

We know from experience that we can only anchor that growth through partnership. If you want to produce groundbreaking social miracles, you need a co-pilot – a partner who shares a vision, but has mastery of a different professional discipline. In short: two partners, two specialisms, one goal and the explicit will to share.

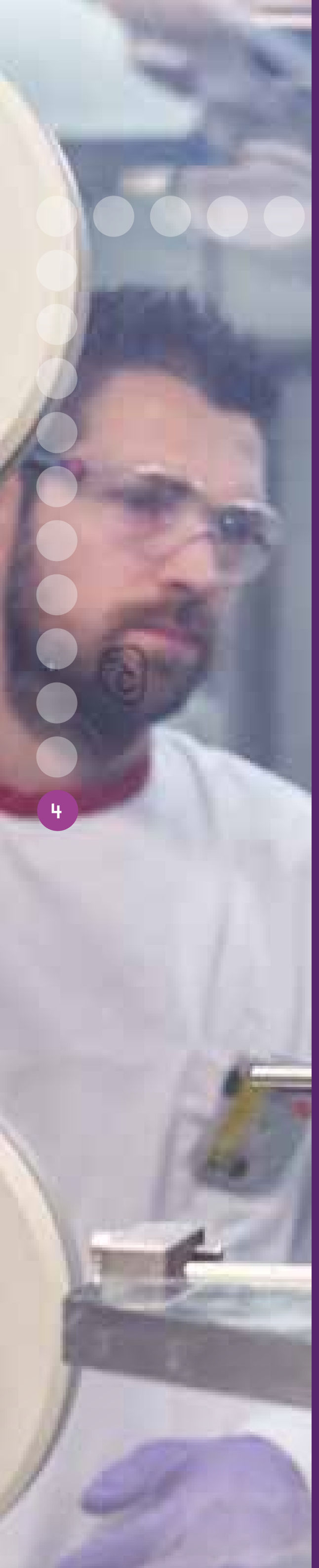
And our will to share is great. We concluded numerous partnerships in 2021. They provide a strong stimulus, or structured framework, for the way in which we drive nuclear medicine forward, approach research into waste and disposal, and aim to achieve our largest projects.

This annual report brings together all these invaluable partnerships and introduces you to our precious co-pilots. You will not only meet partners who have saved us a great many air miles, such as the Belgian company IRE or the Belgian waste manager ONDRAF/NIRAS, but we have welcomed some new co-pilots to our cockpit too. These include the Belgian aviation specialist SABCA and the Canadian start-up POINT Biopharma.

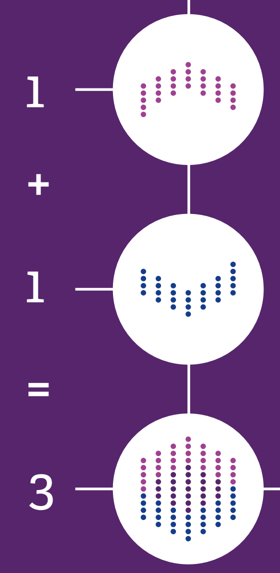
I invite you to browse through the annual report and discover the collaborations we have enthusiastically sealed with a firm handshake. Well, rather with a clumsy fist bump or an awkward elbow.

Happy reading!

Eric van Walle
Director-General at SCK CEN



SCK CEN has a lot of knowledge.
In order to make the most of that knowledge, we are reaching out to both **research institutions** and **industry**.



networking valorization

Heading to the future

SCK CEN was founded in the 1950s to study the applications of nuclear energy, but since then we have expanded our knowledge to a wide range of research fields, each of them with a strong future-orientated and international focus. MYRRHA, NURA and RECUMO are the largest projects of SCK CEN, and it is through these projects that the research centre intends to make a significant difference in the near and further future. High time then, according to annual 'tradition', to check on the status of these projects.

MYRRHA rapidly enters a new era

MYRRHA entered a new era on 17 September 2021. On that exact date, the deed of incorporation of MYRRHA AISBL (international non-profit organisation under Belgian law) was signed. But what does this mean exactly? It means that countries, research organisations, and international institutions can now officially join the project. "Those who join now will be blazing the trail," says Hamid Aït Abderrahim, Deputy Director General of SCK CEN and director of the MYRRHA project [read more on page 48]. And that trailblazing is happening rapidly. In 2021, SCK CEN engineers installed electronics to help ensure the reliability of MYRRHA's particle accelerator, while SCK CEN entered into an agreement with four leading nuclear players in Europe. Together they will help to complete the design of MYRRHA. [Read more on pages 34 and 38].

NURA is expanding

Discover, test and produce new radioisotopes? This is only possible with the right expertise and infrastructure! SCK CEN is proud of its internal specialisation and unique irradiation facilities. Soon, the nuclear research centre may be a touch prouder: it has plans to expand its facility park. Together with the National Institute for Radioelements (IRE), we plan to develop a large-scale production line for lutetium-177, and, in collaboration with the Belgian company IBA, we plan to bring research and development on actinium-225 up to cruising speed [read more on pages 16 and 53]. By increasing supply, we will provide numerous cancer patients with access to effective treatment and thus life-saving care.

License granted for RECUMO plant

SCK CEN has been allowed to expand an existing nuclear installation on its site. In the RECUMO installation, the nuclear research centre will purify the radioactive residues resulting from the production of medical radioisotopes. Two authorities have officially approved the project. The Flemish Region issued the environmental license in 2021, while the Federal Agency for Nuclear Control (FANC) has granted the establishment and operating licence in 2022. "I am pleased that all competent authorities have granted us the necessary licenses," says Eric van Walle, Director General of SCK CEN. These licenses are a necessary condition to be able to carry out the RECUMO project. "Thanks to the RECUMO project, Belgium will be embedding its extensive nuclear expertise and consolidating its leading position in the production of medical radioisotopes." Now that all competent authorities have given their approval, SCK CEN can start the actual construction. The research centre is scheduled to start work on its technical site in autumn 2022. The completion of the plant is scheduled for 2025.

belgian partnerships

Small in area, big in expertise.
Despite its rather small land area of 30,688 square kilometres, Belgium is home to a wealth of expertise – within the nuclear sector and beyond.

SCK CEN

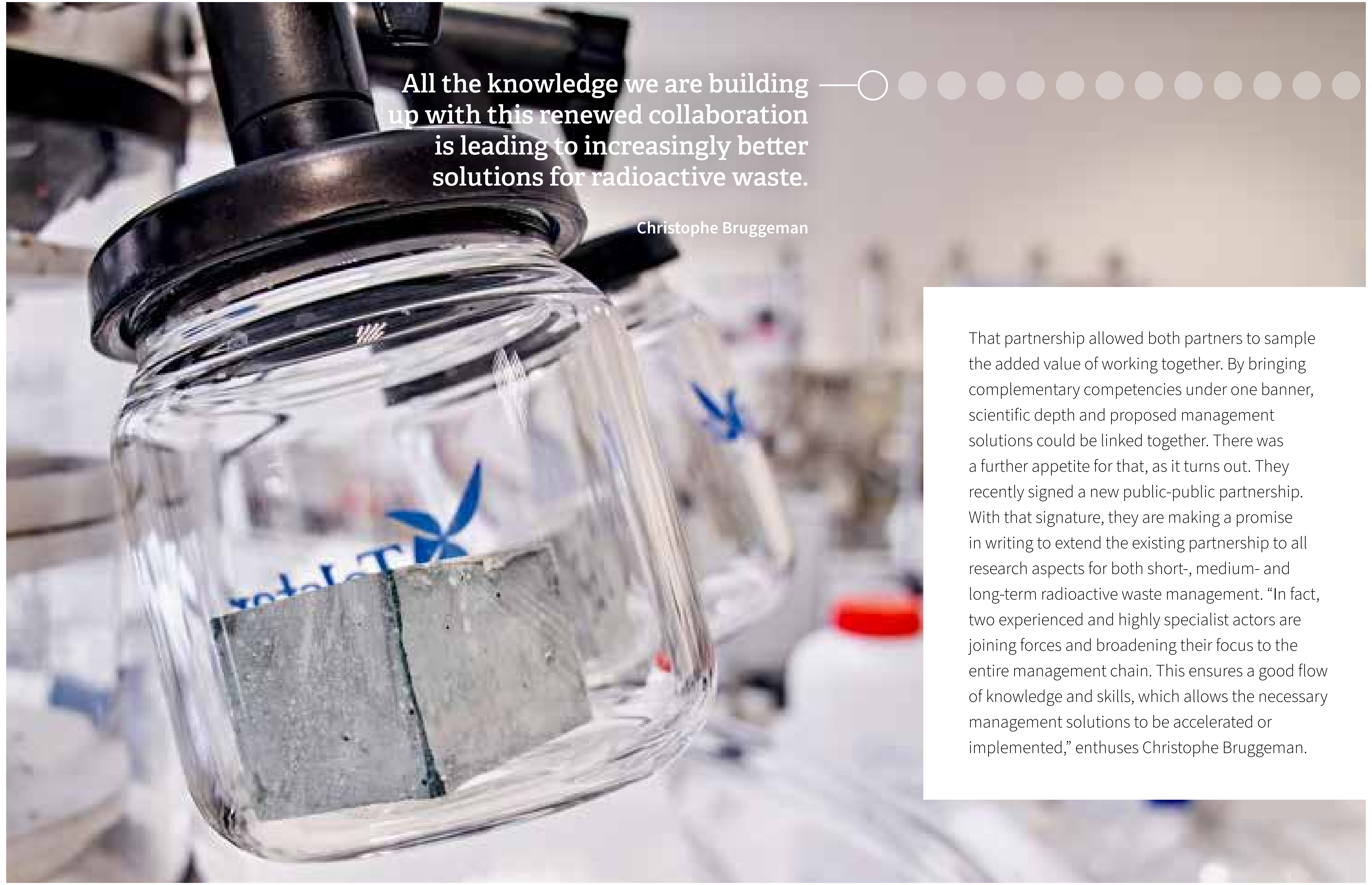
ONDRAF/NIRAS

Radioactive waste: from origin to final destination

Experienced research partners SCK CEN and ONDRAF/NIRAS interweave fundamental and applied research

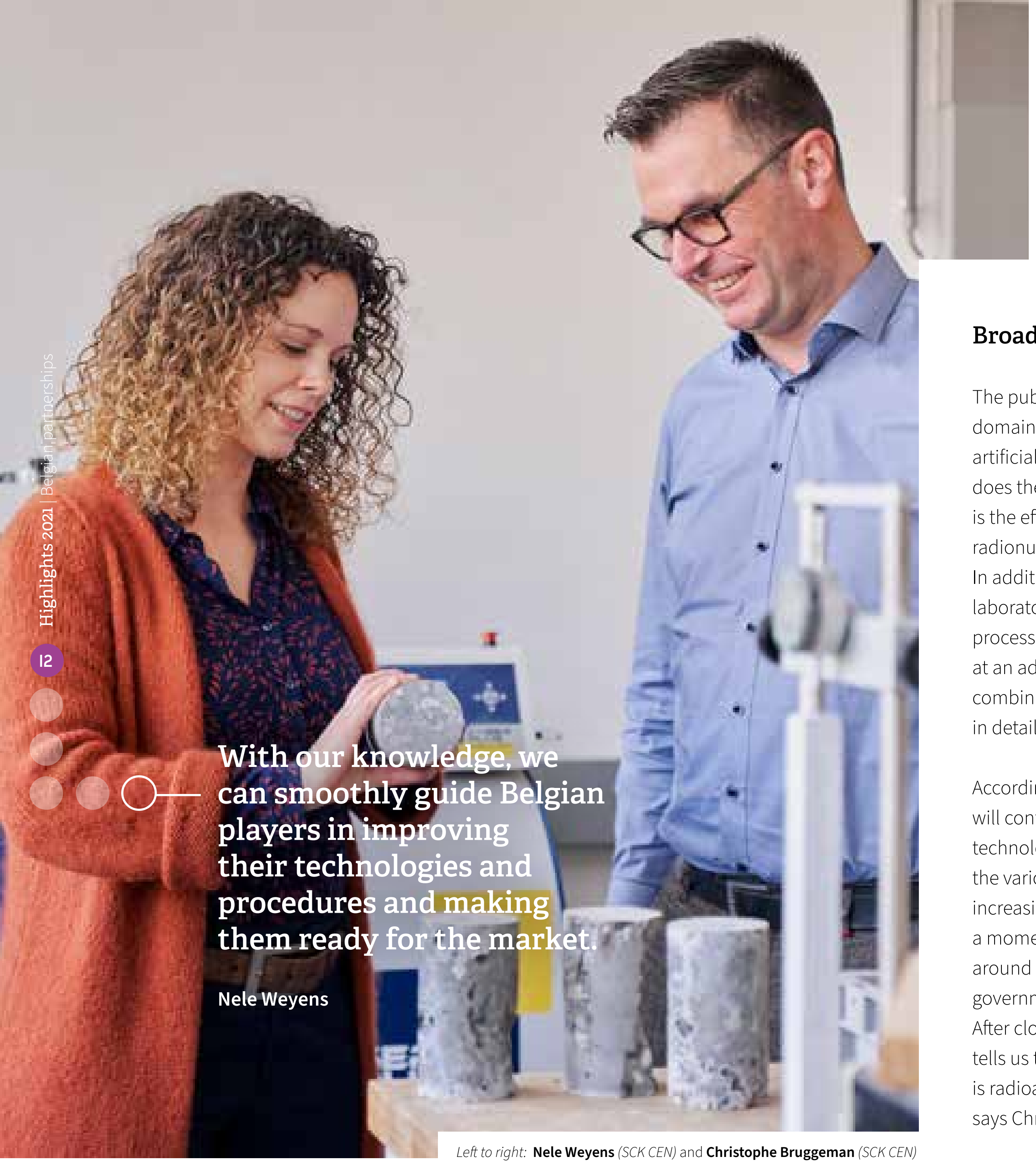
How do we ensure safe disposal of radioactive waste? And in the long run too? This, has been research fodder for the nuclear research centre SCK CEN for decades, commissioned by the Belgian radioactive waste manager ONDRAF/NIRAS. To achieve even better solutions, the two agencies are interweaving their research programmes into a public-public partnership. That legal structure enables us to combine our efforts to further fuel specific knowledge and expertise.

“Radioactive waste is a broad term. The waste comes from power generation, as well as nuclear medicine, agriculture and industry. The term therefore includes multiple waste types, subdivided by activity level or life span. Each type of waste requires a different management route up to, and including, disposal,” explains Christophe Bruggeman, an expert at SCK CEN. Highly radioactive and/or long-lived waste is one type of waste. For that type, geological disposal as a management solution has been on the radar for some time. In the 1970s – the very beginning of Belgium’s nuclear energy era – the nuclear research centre began to explore that avenue. “At first we carried out tests in laboratories, but soon we felt the need for an underground laboratory to test geological disposal against reality. The goal was to demonstrate its safety and feasibility at a representative scale,” he explains. In 1980, SCK CEN began to excavate that underground laboratory, called HADES. HADES later came to be managed by ESV EURIDICE, a joint economic venture between SCK CEN and Belgian waste manager ONDRAF/NIRAS.



> All the knowledge we are building up with this renewed collaboration is leading to increasingly better solutions for radioactive waste.
>
> Christophe Bruggeman

That partnership allowed both partners to sample the added value of working together. By bringing complementary competencies under one banner, scientific depth and proposed management solutions could be linked together. There was a further appetite for that, as it turns out. They recently signed a new public-public partnership. With that signature, they are making a promise in writing to extend the existing partnership to all research aspects for both short-, medium- and long-term radioactive waste management. “In fact, two experienced and highly specialist actors are joining forces and broadening their focus to the entire management chain. This ensures a good flow of knowledge and skills, which allows the necessary management solutions to be accelerated or implemented,” enthuses Christophe Bruggeman.



> With our knowledge, we can smoothly guide Belgian players in improving their technologies and procedures and making them ready for the market.
>
> **Nele Weyens**

Left to right: **Nele Weyens** *(SCK CEN)* and **Christophe Bruggeman** *(SCK CEN)*

Broad knowledge spectrum

The public-public partnership covers a broad spectrum of knowledge domains. "For example, we are studying the behaviour of natural and artificial barriers. How do those barriers help retain radioactivity? How does the waste affect the properties of those barriers? For example, what is the effect of heat-emitting waste? How does the clay layer prevent radionuclides from spreading further as the artificial barriers degrade? In addition, we have particular regard to keeping our underground laboratory HADES up to date, and to the long-term acquisition, processing and validation of measurement data. The research is already at an advanced stage, but it takes on a new dimension thanks to the combination of all these angles," Christophe Bruggeman explains in detail.

According to the expert, this renewed collaboration ensures that we will continue to take into account the latest scientific insights and technological innovations in the development and implementation of the various management solutions in the coming period. This will lead to increasingly better solutions for radioactive waste. And it has not come a moment too soon. After all, one of the largest dismantling sites is right around the corner. With the nuclear phase-out law of 2003, the federal government decided to close down the nuclear power plants step by step. After closure, the nuclear power plants must be dismantled. "Experience tells us that we can repurpose 98% of the material, but that remaining 2% is radioactive waste. That waste deserves specific, adapted management," says Christophe Bruggeman.

SCK CEN as a knowledge compass in the decomissioning process

The collaboration focuses specifically on radioactive waste, but SCK CEN is also playing a key role in the forthcoming decommissioning. This decommissioning offers economic opportunities for Belgian industry. For this reason, the federal government included decommissioning in its ambitious recovery plan. This Recovery and Resilience Plan (RRF) is intended to revitalise the Belgian economy after the blow it was dealt by the corona crisis. In total, it is releasing 5.9 billion euros. 25 million euros will flow to research and development in sustainable decommissioning. In doing so, the amount of radioactive waste will be minimised in a cost-effective manner.

The intention is that SCK CEN will act as a knowledge compass for Belgian industry. "We have built up extensive dismantling and decommissioning experience. We are familiar with the current requirements from the Federal Agency for Nuclear Control for the release of materials, and the challenges surrounding the management of radioactive waste. With that knowledge, we can guide Belgian players smoothly. We will help them to improve their existing technologies and procedures and make them ready for the market," says Nele Weyens, RRF project leader at SCK CEN. These technologies cover several areas: from decontamination techniques for significantly reducing the amount of waste, to characterisation techniques for precisely determining whether materials can be given a second life. It also includes extensive safety testing to ensure the stability and thus recoverability of the waste, as well as modern ways of managing waste streams. "These include artificial intelligence or 3D visualisation, for example. SCK CEN will invest in new facilities for validating techniques and innovations."

HADES: decade-long experiment over halfway complete

Disposal experiments take time. "We need to be able to guarantee the safety of geological disposal for the very long term. We're studying very slow processes: that's why experiments can even take decades," says Christophe Bruggeman. One example of this is the 'PRACLAY Heater' experiment. This large-scale test is intended to study the impact of heat on a deep clay layer. In a real repository, the highly radioactive waste will give off heat for hundreds to several thousands of years. With heating elements, researchers are mimicking that heat release. Specifically, they are keeping the place where the gallery wall and the clay meet at a temperature of 80°C for ten years. "Ten years is enough to be able to make a reliable evaluation of the effect on the clay," Christophe Bruggeman explains. The experiment began in 2014 and is now more than halfway through. "We equipped the gallery and the surrounding clay with measurement devices to closely monitor the experiment. To date, we are recording the same results as our small-scale and short-term experiments. In other words, the project is reaffirming our earlier conclusions."

Knowledge export

It is anticipated that Belgian players will be able to export their decommissioning technologies abroad later on. "In the next ten to fifteen years, many countries will want to start decommissioning their power stations. It's just that there isn't enough capacity at the moment to dismantle all those nuclear power stations at the same time. That means there's room for new players in the market. This creates prospects for Belgian industry wanting to specialise in the nuclear sector," concludes Nele Weyens.

Extensive decommissioning and dismantling experience

SCK CEN has solid expertise thanks to the decommissioning and dismantling of numerous nuclear facilities, including the BR3 pressurised water reactor, the Thetis research reactor, and the former MOX plant Belgonucléaire. The dismantling of hot cells–a shielded, ventilated room in which specialists can handle radioactive material from a distance – also provided a mountain of expertise. In 2021, the research centre added cyclotrons to that list. Commissioned by the Australian company Telix Pharmaceuticals Limited, SCK CEN dismantled two cyclotrons at the radiopharmaceutical production facility in Seneffe, Belgium. Both cyclotrons were removed in one piece and taken to the SCK CEN site in Mol for further dismantling. This approach is unique, even by international standards. It gives the client the opportunity to reuse the space immediately. The construction of a new, state-of-the-art production facility for medical radioisotopes and pharmaceuticals could therefore begin shortly after decommissioning.

Responsible research

As a nuclear expertise centre, SCK CEN has been fulfilling its societal role since the very beginning. When the first nuclear power plants started up, we began looking for a solution for the safe management of long-lived radioactive waste. This led to the opening of our underground laboratory HADES. Today, we use our knowledge and expertise as a compass for safe and efficient radioactive waste management, dismantling, sustainable nuclear energy, innovative research on the effects of radiation and solutions to cancer, with respect for people and the environment. We stand for responsible research for a sustainable world.

Hildegarde Vandenhove

Environment, Health and Safety

SCK CEN

IBA

Joining forces makes treatment of cancer patients more effective

SCK CEN and IBA pave the way to production of actinium-225 for patient use

The nuclear research centre SCK CEN and the Belgian company IBA want to bring research and development on actinium-225 up to cruising speed. Indeed, the radioisotope possesses the resounding potential to treat cancers more effectively. By working towards large-scale production, both partners are helping to make the innovative cancer therapy widely accessible.

Left to right: **Bruno Scutnaire** *(IBA)* and **Pascal De Langhe** *(SCK CEN)*

Today, numerous studies are underway on the potential of actinium-225 to fight cancer. Initial results show that the theranostic radioisotope completely eliminates cancer cells, rather than just inhibiting tumour growth. The risk of recurrence also appears to decrease. The list of cancers for which actinium-225 can make a difference is long. Prostate cancer is at the top of that list. It is closely followed by lung, colon, breast, pancreatic, blood and kidney cancer and glioblastoma, the deadliest form of brain cancer. Millions of patients will therefore benefit from the rapid market entry of cancer therapies containing actinium-225.

They are expected to effectively enter the market in a few years. The prerequisite is that pharmaceutical players can count on reliable production, including during the clinical trials. That is where the shoe pinches. "At least for now," Pascal De Langhe, Director of Business Development & Support at SCK CEN, corrects. Indeed, last year, the nuclear research centre and the Belgian listed company IBA concluded a partnership that should lead to large-scale, reliable production of actinium-225. "The patients who have access to this promising radioisotope, with the current production capacity, can be counted on one hand, so to speak. This is also how actinium-225 got its nickname: the rarest drug on earth. By working together, we aim to fill acute market needs. The goal is to allow numerous patients to enjoy the benefits of this latest generation of nuclear medicine," he clarifies.

Two heavyweights

SCK CEN and IBA obtain actinium-225 through photonuclear reactions, in which a photon knocks a neutron out of the atomic nucleus of radium-226. This creates radioactive radium-225, which subsequently decays into actinium-225. A technically challenging process, but not for these two heavyweights with unparalleled expertise. SCK CEN is a leading nuclear research centre worldwide, while IBA is the reference in particle accelerator technology. “Our complementary knowledge and expertise fall together like two pieces of a puzzle,” explains De Langhe. “We have excellent core competencies in designing the target – the radium target that will be irradiated – and the necessary radiochemistry to get a pure final product. IBA knows the technology of the particle accelerator, the radiation source, like no other. In addition, the company has the engineering experience to turn the plant design into reality.”

Phased approach

The strategic partnership comprises several phases. First of all, both partners conducted an in-depth evaluation of the technical and economic feasibility of the project. “How many cancer patients are in need of this new cancer therapy? To what extent will the demand for actinium-225 increase? What facilities do we need to produce actinium-225? Do the targets we develop deliver the desired production yield? What technical optimisations do we still need to implement? … In this feasibility study, we take all kinds of factors into account and make estimates that we have validated by external experts,” De Langhe explains. Both partners are optimistic that the feasibility study will have a positive outcome. Following such positive outcome, they plan the construction and commissioning of a production unit on the site of SCK CEN in Mol, Belgium.

> What was first regarded as waste will become a valuable resource again. Circularity at its best!
>
> **Pascal De Langhe**

Circular economy

The raw material is important to the success of this project. SCK CEN is one of only a few organisations that has large quantities of high-quality radium-226. “This stock allows us to produce actinium-225 on an industrial scale,” De Langhe says. In fact, radium-226 is normally radioactive waste. “Now, we can convert that waste into more targeted cancer therapies with higher therapy response rates.” This way, this project also contributes to the circular economy.

Alignment with Belgian coalition agreement and European recovery plan

The collaboration fits within the implementation of the Belgian coalition agreement, which aims for significantly more and better cancer treatments. It is supported by Pierre-Yves Dermagne, Belgian Deputy Prime Minister and Minister of Economy and Employment, Tinne Van der Straeten, Belgian Minister of Energy, and Thomas Dermine, Belgian State Secretary for Economic Recovery and Strategic Investments. Furthermore, the initiative is also in line with the recent European recovery plan for Belgium. In that plan, the European Commission includes investments for the development and production of lutetium-177 and actinium-225, two promising isotopes.

Fighting cancer with precision

The alpha emitter actinium-225 is an emerging talent among theranostic radioisotopes. With the radiation it emits during the decay, it can destroy cancer cells. The cancer cells are destroyed through “precision bombardments”, sparing the healthy tissue.

Drones measure radiation with precision

The expertise of SCK CEN and SABCA come together in the form of an innovative drone project

Flexible to use, accurate in measurements. After years of testing, the nuclear research centre SCK CEN proved that drones can map out radioactivity with extreme precision. "Now is the time to take the leap from research to industrial deployment," says Geert Olyslaegers, drone pilot at SCK CEN. By working with the Belgian aviation specialist SABCA, SCK CEN hopes to land there quickly.

The drones will take radiological measurements without any human intervention. This represents an important step forward in radiation protection.

Johan Camps

Monitoring the growth process for cereal crops, inspecting offshore wind turbines and transporting medicines: Drones are conquering the business world. Very soon, the nuclear sector too will be able to rely upon the assistance of these unmanned aircraft. The drones will take radiological measurements, and do so without any human intervention. "This represents an important step forward in radiological protection," says Johan Camps. The SCK CEN scientist sees potential in three domains. "The drones can fly in the context of emergency planning, decommissioning and radiological monitoring of nuclear and industrial sites and their surroundings. The advantage of drones is that they can map out all the nooks and crannies that we cannot reach on foot or with a helicopter. This information flows back to us in real-time, while the drone is still in the air. In short: information in real-time from a larger number of specific locations."

In 2015, SCK CEN assembled an enthusiastic research team to explore the possibilities of drones in a nuclear setting. The nuclear research centre now has two licensed drone pilots and has organised numerous test flights in collaboration with FPS Home Affairs. Those test flights allowed us to improve our measurement equipment and ensure the quality of measurement results. "Now is the time to take the leap from research to industrial deployment," says Geert Olyslaegers, one of the drone pilots. By partnering with the Belgian aviation specialist SABCA, SCK CEN hopes to land there quickly. Olyslaegers: "SABCA provides services to the civil, space and military aviation industries. The company has experience with drone flights in a challenging context and knows the corresponding laws and regulations. We're combining this expertise with our nuclear and radiological knowledge for peaceful applications. It creates a synergy that promotes quality, reaching deeper."

Demonstration project

Thanks to this synergy, industrial deployment is within reach. Both partners emphasise, however, that this is an industrial demonstration project. "We're convinced that use of drones will enable the nuclear sector to take precise measurements on a large scale. Whether drones will also become the standard, only time will tell. First, it's up to us to perfect that technology down to the last detail," says Camps.

Innovative projects for improving the protection of the population, the environment and the workforce have my full support.

Annelies Verlinden

This demonstration project, which is in full swing, started on May 18, 2021. The launch was announced in the presence of Annelies Verlinden, Minister of the Interior. She sounded delighted at the launch.

Custom made detector

By 'technology', he is referring to the scintillation detector, as it is known, that will be attached to the drone. "The device measures radioactivity by counting flashes of light in the scintillation material which are caused by the passage of the ionising radiation particles, which in turn indicates the amount of the radiation dose. The more flashes of light, the more radiation," Olyslaegers explains. The detectors were designed not to exceed the maximum payload – the drone's maximum carrying capacity – while retaining the highest possible sensitivity of measurement.

Both partners have now completed two test flights, which confirmed the desired high measurement sensitivity. "We catapulted a fixed-wing drone into the air and flew it over the fields. First in circular movements, then in a grid. We had it fly both low and high to test whether we could record a difference in readings. And indeed we could. So the measurement equipment passed with flying colours," said a satisfied Olyslaegers. During the test flight, no radioactive sources were hidden on the training grounds. "The natural radioactivity contained in the soil served as a source. It once again demonstrates the sensitivity of the detector."

Two drone types

The fixed-wing drone is just one of two drone types that the aviation specialist supplies. The project is also studying the use of a multicopter. "A fixed-wing drone can continue to fly autonomously in the air for hours, while a multicopter can carry heavier detectors without sacrificing flexibility," explains Camps. "The first drone can monitor a larger area. The second drone can hover on the spot to get a very local image. The choice of drone depends on the application." The detector for the multicopter is still in development at this time.

Federal support

This innovative project on the use of drones falls within the scope of the FPS Economy's energy transition fund, which encourages and supports research, development and innovation in the field of energy. The projects must relate to one of the three thematic axes: renewable energy sources, nuclear energy applications, and grid balancing and the security of supply. Overall, a budget of 25 million euros is being distributed across the various projects. SCK CEN and SABCA were awarded a subsidy of 1 million euros and will invest additional sums into the project themselves.

All-seeing eye of the nuclear sector

The industrial demonstration project 'Buddawak' was named after 'Buddawak Burri Bootyau', an Australian sooty owl. "Owls have acute vision. With this project, we want to make the invisible visible," concludes Camps. The choice of this owl is not accidental. The animal lives in regions of Australia that contain a lot of natural uranium in the soil.

Historic living with contemporary comforts. That's how the residential quarter can now be described.

Jan Veraghtert

SCK CEN & VITO

CORDEEL

Residential quarter gets a facelift

Belgian company renovates with respect for heritage value

With a thorough renovation, the nuclear research centre SCK CEN and the Flemish Institute for Technological Research (VITO) are breathing new life into the adjacent residential quarter. The neighbourhood was first established to house employees, but after renovation, it will welcome non-employees as well. Both owners placed the renovation steering wheel in the hands of the Belgian construction company Cordeel.

The residential quarter that flanks the site of the nuclear research centre SCK CEN and the Flemish Institute for Technological Research (VITO) is a historical gem. The iconic, modernist neighbourhood was was initially constructed in the late 1950s to house workers. Until now, the infrastructure was maintained in-house. "We've always made an effort to keep the homes in good condition, but after more than 60 years, an extensive renovation was required," says Jan Veraghtert, Project Manager at SCK CEN. A thorough renovation was needed to breathe new life into the once vibrant neighbourhood: a tough assignment that falls outside the core business of both owners. "The neighbourhood has a high heritage value. However, we are not heritage specialists. To protect the heritage value, we put the renovation in the hands of an external partner who had a feel for this."

The choice landed upon the experienced, Belgian construction company Cordeel. Cordeel was awarded the impressive renovation project through a public tender. In its submission, the company gave extensive attention to how it would handle the historic value. The elements dating from that time were carefully weighed against their use value. "In the 1950s it was progressive to centralise all the garages in the middle of the neighbourhood. This kept pedestrians, cyclists and motorised traffic strictly separated. That concept is outdated. Now, everyone wants to be able to park at home," illustrates Jan Veraghtert. So the central garages disappeared from view, making way for brand-new apartments. The villas were also repurposed. "Villas are being transformed into multi-family housing. Little is changing apart from that. The neighbourhood will retain its original design, appearance, and above all, charm."

In total, the construction company is renovating 323 housing units. It involves a mix of student rooms – the so-called dormitories – studio flats, apartments, terraced houses and villas. Cordeel is allocating a budget of 50 million euros for it. The renovation will take place in several phases. The experienced construction company delivered the bulk of the first renovation phase in 2021. With a successful result, according to Project Manager Jan Veraghtert. "Historic living with contemporary comforts. That's how the residential quarter can now be described."

Maintenance

The upgrade should entice not only employees of SCK CEN and VITO, but also non-employees to move to the neighbourhood. Their arrival will create a new dynamic. Anyone who purchases or rents a residential unit there will immediately have the assurance of a well-kept neighbourhood, full of character, included in the price. “We’ve signed a DBFM agreement with Cordeel. DBFM stands for Design, Build, Finance and Maintenance. In concrete terms, the construction company will also take care of the maintenance of the neighbourhood for the next 25 years,” explains Kris Iven, Facility Manager at SCK CEN.

Does that mean the neighbourhood loses its original mission? “Not at all,” clarifies Kris Iven. In total, both companies employ more than 1,500 highly qualified specialists, many with international backgrounds. “We want to offer our international experts a warm welcome. This includes nearby housing in beautiful surroundings, along with modern comforts. For this reason, SCK CEN will continue to use the dormitories and studio flats and has offered Cordeel a rental guarantee for eight terraced houses. This gives us sufficient capacity to facilitate a move to Belgium for our foreign employees and doctoral students. The residential quarter will serve as a springboard to the private real estate market.” In time, SCK CEN wants its foreign employees to move into the private real estate market, in order to promote integration into Belgian society.

50
different nationalities
at SCK CEN in 2021

Figuratively green

The residential quarter is known as a distinct, green environment, although how to make it figuratively “green” was also considered. “With a new heat grid and intelligent LED lighting, we are preparing the residential quarter for a 100% green future,” concludes Jan Veraghtert.

Prize-winning architecture

In the late 1950s, modernism was the main architectural movement in Belgium. That movement visualised the new, post-war sense of life and the flourishing of science and technology. Frugality and simplicity characterized the choice of materials used and proportions chosen for rooms and buildings. The whole thing blends seamlessly into the wooded surroundings. The design comes from the young architects Jacques Wybauw and Jacques Thiran. They received numerous awards for their design, which was innovative and refreshing at the time. In its time, the residential quarter was featured several times in renowned architectural journals. Because of its heritage value, the quarter is included in the Inventory of Architectural Heritage.

Enriched by our differences

Our research centre employs 966 people, who therefore have 966 different backgrounds, personalities, and skills. We embrace that diversity, because these differences enrich our thinking. We learn to look at matters through a different lens, to put them into a broader perspective and therefore arrive at more innovative solutions. With our wealth of diversity, we are building a bright future for SCK CEN and society.

Kathleen Overmeer
General Services

> We will retain sufficient capacity to facilitate a move to Belgium for our foreign employees and doctoral students.
>
> **Kris Iven**

Left to right: **Banai Shikeb** *(Cordeel)*, **Kris Iven** *(SCK CEN)* and **Jan Veraghtert** *(SCK CEN)*

SCK CEN brings ultra-modern calibration building into use

First-class facilities for first-class irradiation services

The nuclear research centre SCK CEN is progressive: in its knowledge and in its research. Sustaining that requires investment. SCK CEN recently invested in a brand-new and ultra-modern calibration building. More flexibility and more possibilities. This is how the new building can be described. "We designed the building according to the needs of our clients," says Anne Laure Lebacq, dosimetry expert at SCK CEN.

Now, we have six separate irradiation rooms – four more than before! We have the flexibility to carry out several irradiations in parallel.

Anne Laure Lebacq

The nuclear research centre SCK CEN is strong in knowledge and infrastructure. Thanks to that unique blend, it managed to conduct pioneering research, pushed boundaries and grew into a global standard. For this reason, SCK CEN continuously invests in its technologies and laboratories. It also recently renovated its calibration building. With that brand-new, state-of-the-art calibration building, the nuclear research centre ranks itself among the best in Europe. Indeed, Europe has only four facilities of this nature, size and modernity.

It was a conscious decision not to renovate the existing calibration building. By choosing to build new, SCK CEN had the freedom to lay out the new building differently. SCK CEN had the freedom to lay out the building differently. "As such, we created the ability to be responsive to our clients' needs. We were often asked to run long-term irradiation experiments, but the limited number of irradiation rooms did not allow for this. Now, we have six separate irradiation rooms – four more than before! Now, we have the flexibility to carry out several irradiations in parallel," says Anne Laure Lebacq, dosimetry expert at SCK CEN.

Two types of irradiation

Very specifically, the nuclear research centre performs two types of irradiation. “On the one hand, we will irradiate experiments. Consider, for example, plants, skin cells or prototypes for dosimeters. We expose samples to a precise radiation dose in a controlled setting. This provides scientists with certainty when they want to investigate the impact of that dose. on the other hand, we also calibrate measuring devices,” Anne Laure Lebacq continues. And this is extremely important. Radioactivity cannot be perceived by human senses. In order to detect radiation, specific measuring devices are used. These devices allow for accurate monitoring of the radiation dose incurred. “The measurements are only as accurate as the device that performs them,” says the expert. “With our calibration services, we check that those measuring devices are adjusted correctly. And by ‘correctly’, I mean according to international standards.”

Thus, the emphasis is on ‘international standards’. Those standards create uniformity and clarity worldwide. “No difference should occur between a dose of 1 gray in Belgium and elsewhere in the world. This is how we maintain consistency in scientific research,” explains Cristian Mihailescu, radiation expert at SCK CEN.

Indispensable in radiotherapy

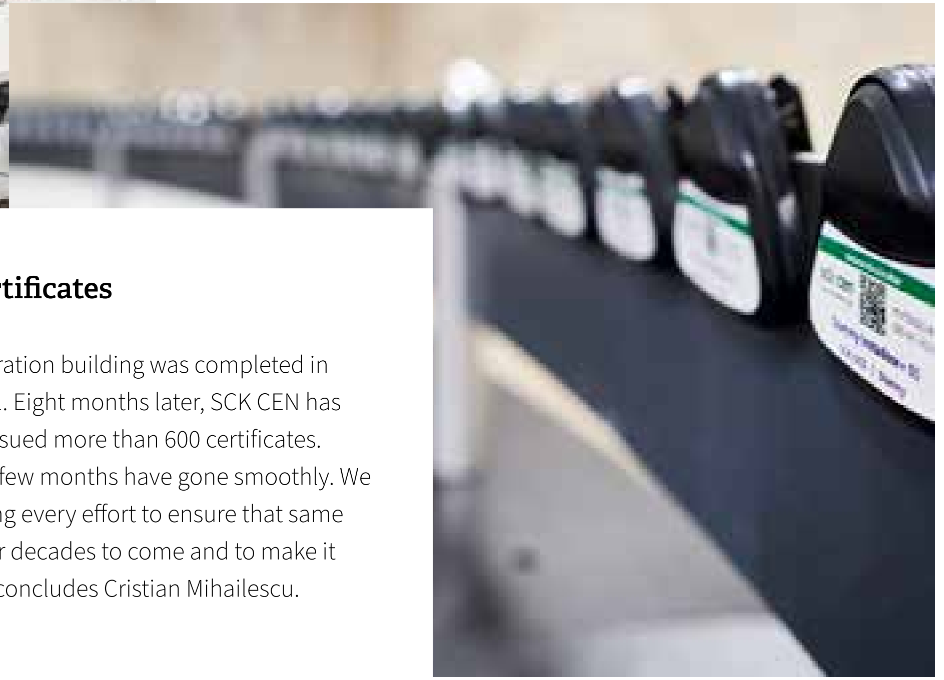
Brand-new to the range of capabilities is the facility for irradiating ionisation chambers used for radiotherapy. “Half of all cancer patients receive radiotherapy at some point in their treatment. In radiotherapy, doctors focus the beam of a radiation device on the tumour. They can thereby reduce the size of the tumour before surgery, clear up the remaining cancer cells after surgery or – whether or not in combination with chemo – destroy cancer. Crucially, the dose that the tumor receives must be both accurate and precise. The actual dose should not differ from the prescribed dose by more than five percent,” clarifies Cristian Mihailescu.

Before irradiating the tumour, medical radiation physicists calibrate the irradiation device – usually a linear accelerator – with an ionisation chamber. That chamber measures the radiation emitted from the device. In order ensure the required accuracy, it too is calibrated in turn. “With our new facility, we can calibrate ionisation chambers, according to international standards, within an accuracy of 1%!”

> **With our new facility, we can calibrate ionisation chambers, according to international standards, within an accuracy of 1%!**
>
> **Cristian Mihailescu**

600 certificates

The calibration building was completed in April 2021. Eight months later, SCK CEN has already issued more than 600 certificates. “The first few months have gone smoothly. We are making every effort to ensure that same quality for decades to come and to make it routine,” concludes Cristian Mihailescu.



european

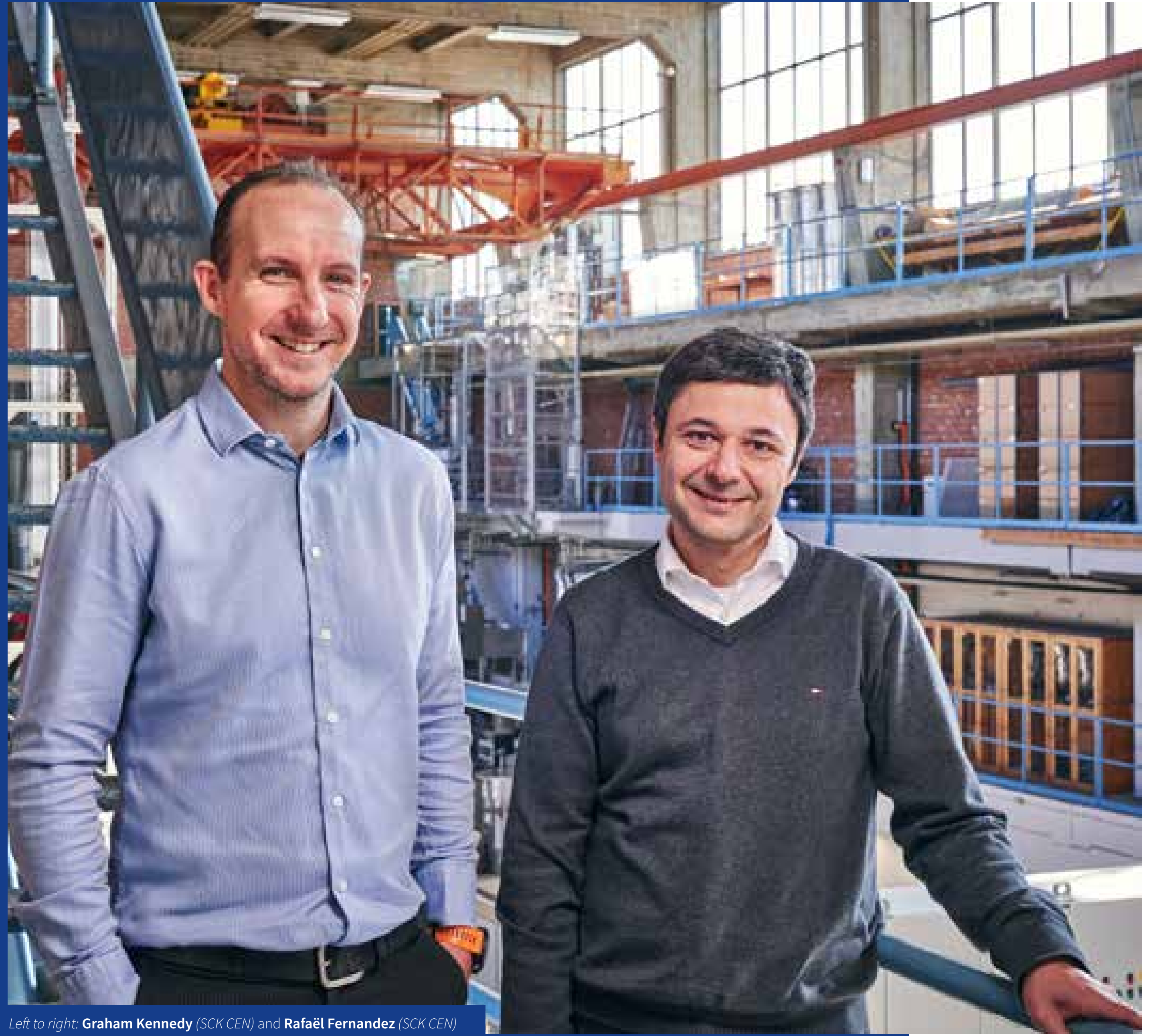
partnerships

Small in size, big in impact. Our European partners provide the nuclear research centre SCK CEN with the corresponding half of the piece that completes the puzzle.

MYRRHA design enters final phase

European nuclear players co-draft final design

Four leading nuclear players will help complete the design of the innovative research reactor MYRRHA. By concluding a framework agreement with them, the nuclear research centre SCK CEN is bringing extra knowledge and manpower on board. In doing so, SCK CEN is once again making a significant leap towards the implementation of MYRRHA.



Left to right: **Graham Kennedy** *(SCK CEN)* and **Rafaël Fernandez** *(SCK CEN)*

> At the end of the road, we have to be sure that the design can meet all the strict safety requirements.
>
> **Rafaël Fernandez**

SCK CEN is currently working hard on the construction of MYRRHA, the world's first particle accelerator-powered research reactor. The construction of MYRRHA is taking place in several phases. In phase 1, the nuclear research centre is building MINERVA, the particle accelerator with energy of up to 100 megaelectron volts (MeV). In phase 2, the energy level will be raised to 600 MeV, and in phase 3 the construction work on the reactor itself begins. With the MYRRHA reactor, the nuclear research centre will demonstrate the economic and technical feasibility of transmutation [see text box on page 37]. "A prerequisite for starting construction is a final design. This design is entering its final phase," explains Rafaël Fernandez, an engineering manager at SCK CEN.
In 2020, the engineering team gave themselves a well-deserved pat on the back. After extensive analysis and adjustment, they had completed the design of the primary system for the MYRRHA research reactor.

"It was not an easy task. After all, MYRRHA is a global one-of-a-kind. This means we can't rely on third-party knowledge for that part. To test each design aspect in practice, we have established an extensive R&D programme ourselves," Fernandez said. This programme covers a wide range of topics: from safety to economic feasibility and even logistics.

Now that this puzzle has been solved, tin 2021 the engineers began the next design phase: linking the MYRRHA reactor's primary system to secondary systems and auxiliary systems. "The further you move away from the reactor core, the more generic the components become. We are therefore entering areas where there is already a great deal of knowledge and experience available on the market. So the cards are different: at this stage, other nuclear players can make a substantial difference to us," says fellow engineer Graham Kennedy.
In order to attract those players, the nuclear research centre launched a public tender. In the end, they brought four leading nuclear players on board. "The framework agreement is synonymous with additional knowledge, experience and manpower – all of which brings the implementation of MYRRHA closer once more."

Tight schedule

The implementation of MYRRHA is following a tight schedule. Thanks to the relevant experience that the specialists bring to the project, the nuclear research centre can stick to the current schedule. “The aim is to complete an initial integrated design by the end of 2022,” clarifies Graham Kennedy. This design will already be quite mature by that point. “This isn’t their first time for the nuclear players we’ve selected. They have designed nuclear facilities and successfully transformed them into reality before. Thanks to those projects, they can already anticipate potential points of improvement.” This includes the areas for improvement that comprehensive safety studies may point out. Such studies expose the design to specific scenarios.

“What if a plane hits the reactor building, an earthquake hits the region, or there is a fire inside the facility? Even in unexpected situations, can the built-in mechanisms continue to ensure safety? The safety studies will identify areas of improvement that we’ll take to the drawing board. At the end of the road, we have to be sure that the design can meet all the strict safety requirements,” says Rafaël Fernandez. And the end of the journey is 2024. By then, the nuclear research centre must demonstrate that the preliminary design can enter the final design phase: where an external consortium will make the final adjustments to the design in order to submit a licence application.

Experience is an asset

The development of the MYRRHA research reactor involves many domains. “These include conventional nuclear techniques such as civil engineering, ventilation and remote manipulation on the one hand, and specific nuclear techniques for fast reactors on the other. For this reason, we divided the call for public tender into two lots: one lot covering all the conventional systems and components and one lot focusing specifically on components for fast reactors. By dividing the contract into two lots, we were able to choose parties with distinct added value for each lot,” concludes Raphael Fernandez. So experience is an asset. During the course of the project, the chosen parties will be presented with specific assignments , for which they can submit a bid.

We are now entering areas where there is already a great deal of knowledge and experience available on the market. In this phase, other nuclear players can make a substantial difference to us.

Graham Kennedy

Transmutation in a nutshell

Nuclear waste is generated in the production of nuclear energy. That nuclear waste contains long-lived, highly radiotoxic residues, known as minor actinides (mainly neptunium, americium and curium). Those residues remain highly radioactive for hundreds of thousands of years. Bombarding them with fast neutrons causes those heavy nuclei to split. The minor actinides will be converted from highly radiotoxic waste into a waste that is no longer toxic, gives off less heat, and a much lower radioactivity lifespan. The process is called transmutation and thus reduces the requirements for geological disposal. With MYRRHA, the nuclear research centre is aiming to demonstrate the process on a semi-industrial scale. That makes MYRRHA the stepping stone to industrial nuclear waste incinerators.

MYRRHA's engine is roaring along

Belgo-French electronics ensure reliability of MYRRHA's particle accelerator

With the MYRRHA project, the nuclear research centre SCK CEN is aiming to tackle a series of social challenges. The reliability of MYRRHA's particle accelerator is of the utmost importance in achieving the intended applications. Belgo-French electronics are helping to ensure that reliability. "The electronics indicate when adjustment is needed; they determine – so to speak – how the engine roars," the engineers say.

Left to right: **Sofiane Boussa** *(SCK CEN)* and **Wouter De Cock** *(SCK CEN)*

"MYRRHA's reactor core will not have sufficient fissile material to spontaneously sustain a chain reaction. Instead, it must be continuously fed by an external source of neutrons. That's where the particle accelerator comes into play," Wouter De Cock, project engineer at SCK CEN, first recalls. The facility produces and accelerates protons. Those accelerated protons eventually shoot into the reactor core, where they collide with a liquid mixture of lead and bismuth. That impact releases rapid neutrons, which maintain the fission reactions. The particle accelerator that will fire the protons is currently under construction in Louvain-la-Neuve.

Those who visit it regularly will see the facility growing steadily. SCK CEN engineers are systematically adding new components – and in 2021 crucial electronics were installed.

"The electronics we developed and installed last year will ensure that the proton beam remains stable when accelerated," says Wouter De Cock. The system does this by carrying out checks. "The protons roll out of an ion source, then they feel an initial acceleration in the Radio Frequency Quadrupole (RFQ), and then gain more and more energy in a chain of magnets and cavities. In total, there will be nineteen cavities in the low-energy section and sixty superconducting cavities in the linear accelerator. Accelerating the protons also requires a certain degree of power. That power is provided by powerful amplifiers. Our electronics control the interplay between those factors. Among other things, they measure the power received by the cavities, the power delivered by the amplifiers, and the voltage dip that occurs in the first few milliseconds after the particle accelerator is turned on. Thanks to all those measurements, we can adjust the input of the amplifiers so that the protons get an accelerating push at exactly the right moment."

Furthermore, the newly installed system also controls the frequency at which the cavities operate. The proper frequency is important for reducing energy losses. To set the frequency precisely, the scientists introduce a 'rod' into the cavity. The expert compares it to a trombone. "By extending the trombone's tuning slide, the musician shortens or lengthens the tube length. This changes the pitch or frequency. The rod alters the environment in the cavity and thus the tone, or frequency. With this monitoring system, we know if a frequency adjustment is necessary."

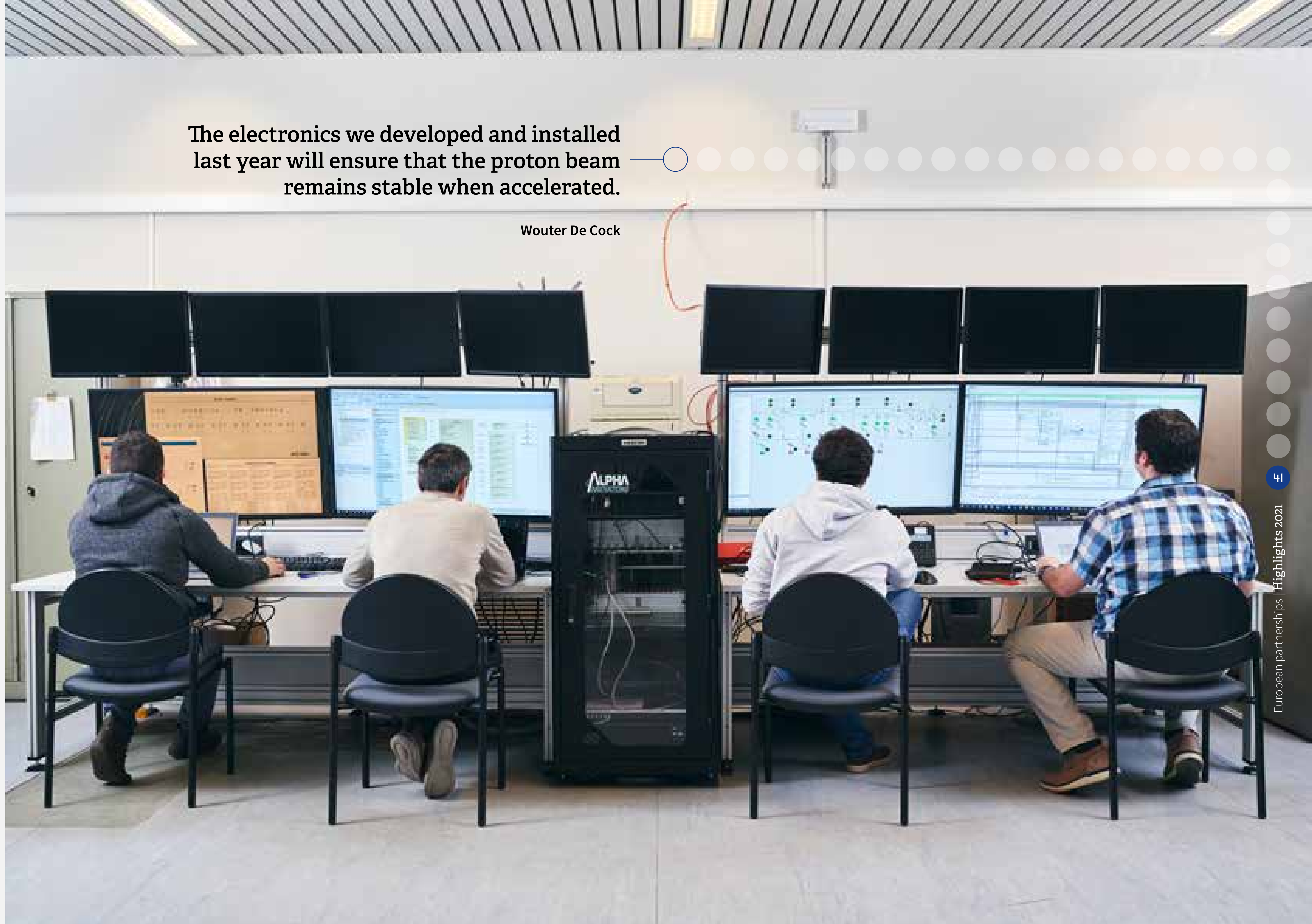
French wealth of experience

The particle accelerator is equipped with multiple control systems. "In fact, each component has its own electronics," Wouter De Cock explains in more detail. SCK CEN engineers built the control system for the cavities operating at room temperature. For the cavities operating under superconductivity, the nuclear research centre relies on the French ICJ Lab. "The research institute in Orsay has experience in building such systems, including for GANIL – one of the most powerful heavy ion accelerators in the world. So it's putting its wealth of experience and proven track record to work in the development of our MYRRHA particle accelerator. Together, we'll ensure it's reliable."

Beyond the current state of the art

With MYRRHA we are working on a world first. Realizing this requires us to develop technologies and materials that transcend the current state of the art. Groundbreaking innovation and technological progress occurs when we combine different backgrounds and competencies into multidisciplinary teams. Our team members learn from each other and apply newly acquired insights to achieve the successful implementation of the project.

Marc Schyns
Advanced Nuclear Systems



The electronics we developed and installed last year will ensure that the proton beam remains stable when accelerated.

Wouter De Cock

EURATOM — SCK CEN

ITER moving in a straight line towards startup

SCK CEN qualifies materials for nuclear fusion test reactor

Soon, nuclear fusion will shake off its image as an eternal promise once and for all. Indeed, the ITER nuclear fusion reactor under construction in France is navigating in a straight line towards its target, which is expected to start up in 2026. More than 4,800 European scientists, including SCK CEN, dedicate themselves daily to achieving this goal. The pace of research is increasing thanks to a €583 million research budget allocated by the European Commission in 2021.

'The latest cancer therapy is radioactive', 'Belgium starts research into small-scale nuclear power plants', etc. Anyone reading the newspapers these days knows that the nuclear sector is coming up more and more often. Nuclear applications are proving useful in a growing number of fields. In order to encourage nuclear innovation, the European Commission is launching funding through the 'EURATOM Research and Training Programme'. It is releasing 1.38 billion euros for a period of five to seven years. 583 million euros will flow directly into research and development in nuclear fusion. This technology is expected to reshape the energy landscape.

In nuclear fusion, atoms are not split, but in fact joined. Specifically, two hydrogen isotopes fuse into one helium nucleus. This releases a mass of energy, but – unlike its classical sibling – it produces less nuclear waste. This process takes place at high temperatures, which brings challenges. The nuclear fusion reactor ITER, in Cadarache, France, is made to demonstrate the technical and scientific feasibility of controlled fusion reaction at large scale. With the European research budget, scientists will clear up the outstanding question marks. How do we confine the plasma? How do we remove the heat and ash at a fusion reactor so as not to contaminate the plasma? How do we cultivate tritium, the fusion fuel, in a sustainable way?

EUROfusion, a pan-European partnership, is leading that fusion investigation. "In total, there are 4,800 of us scientists working toward that goal," says Dmitry Terentyev, a nuclear fusion expert at SCK CEN. Those scientists come from Europe or associated countries such as Ukraine, the United Kingdom and Switzerland. The nuclear research centre SCK CEN is using its globally unique BR2 research reactor to qualify structural materials for nuclear fusion reactors. After all, the materials must be able to withstand the extreme conditions in a nuclear fusion reactor.

Material tests

In the past, SCK CEN was involved in testing materials for the ‘first wall’, which are directly exposed to the plasma, among other things. Now, SCK CEN will be focusing on the materials for the ‘tritium blanket modules’, the components used to breed tritium supplying the fuel for fusion reaction.

The planning for the experiments has already been completed. BR2 will irradiate experiments on a full-time basis from 2022 to 2025 – and, by extension, 2026 and 2027. Each experiment will typically last for one year. Dmitry Terentyev clarifies: “With this irradiation campaign, we are mimicking the operation of the components until the end of life of the ITER. After the irradiation, we will identify the thermal, mechanical and micro-mechanical properties of the materials to evaluate ageing effects.”

For this assignment, SCK CEN will engage a series of facilities: irradiation installations, an electron microscope for identifying material aging processes with high precision, and mechanical testing in hot cells.

Belgian steel

The results that will emerge from these experiments should lead to the perfect steel recipe. “What type of material do we need? What is that material composed of? With what ingredients? What chemical proportions are needed? We are working with OCAS NV to find that recipe,” says Dmitry Terentyev. The Belgian research centre OCAS NV is a joint venture between ArcelorMittal and the Flemish Region. OCAS NV is one of a few handful providers in Europe who can supply research quantities of steel. “We irradiate that steel in our BR2 research reactor, test it and have the composition adjusted if necessary. We will repeat this until we find the recipe.”

“The goal is to qualify the baseline material,” explains Dmitry Terentyev. In doing so, the researchers are already overcoming a barrier. ITER, of course, will not consist only of base materials. The base materials are welded together or assembled. “In the second phase, in the period from 2024 to 2027, we will analyse how those compounds respond to the extreme fusion conditions. Then we will be ready to put ITER into operation,” concludes the fusion expert.

Closer to fusion conditions

At the same time, the nuclear research centre SCK CEN is building its innovative research infrastructure MYRRHA. MYRRHA will test materials for fission and even fusion reactors. Thanks to its fast neutrons, MYRRHA achieves irradiation conditions closer to those of a fusion reactor, compared to current research reactors. However, with MINERVA, nuclear fusion research could begin as early as 2027. “The construction of MYRRHA is taking place in several phases. In phase 1, we are building MINERVA, the particle accelerator with energy of up to 100 megaelectron volts (MeV). Linked to this is the construction of the “Full Power Facility” installation. This installation uses the proton beam of 100 MeV and 4 milliamps to irradiate and study fusion materials,” explains Dmitry Terentyev.

MYRRHA attracts scientists from all over the world

SCK CEN’s next large research infrastructure, the multi-purpose MYRRHA facility, has already attracted many international scientists in partitioning and transmutation. MYRRHA is also known for its extensive application catalogue covering accelerator technology, fundamental research for (medical) radioisotopes, and fusion related research. The international community participates through an increasing number of scientific collaborations and workshops contributing to design considerations and components for MYRRHA phase 1.

Adrian Fabich
MINERVA Design and Build

> Along with 4,800 scientists, we are working intensively towards a major milestone in 2026: the start-up of the nuclear fusion reactor ITER.
>
> **Dmitry Terentyev**

Left to right: **Daniele Del Serra** *(SCK CEN)*, **Emre Sikik** *(SCK CEN)* en **Dmitry Terentyev** *(SCK CEN)*

international
partnerships

Small in size, big in action. On a global scale, the BR2 and MYRRHA research reactors are no bigger than a pixel, but they are making a decisive mark on cancer research, waste management and nuclear safety around the world.

MYRRHA AISBL has been established

International partners can check in

“MYRRHA AISBL is a reality!” beams Hamid Aït Abderrahim, Deputy Director General of SCK CEN and Director of MYRRHA. The deed of incorporation was signed on 17 September 2021. “That day marked the start of a new MYRRHA era. One in which we can officially join forces with international partners to achieve our ambitions and goals!”

How can we improve the management of radioactive waste? How can we fight cancer even more effectively? How do we ensure the safety of nuclear fission reactors and that of nuclear fusion reactors? Every country, wherever it is in the world, is facing the same challenges. If a sustainable solution is to emerge, international cooperation is crucial, and that opportunity is coming thanks to the creation of the MYRRHA AISBL (international non-profit association under Belgian law). This legal structure allows the Belgian State and SCK CEN to welcome international partners on board with MYRRHA – the project that will enable the nuclear research centre to answer these pressing questions one by one.

MYRRHA AISBL is a reality, you must be a happy man?
Hamid Aït Abderrahim: Of course! Every step we have taken in the MYRRHA project has been made possible by a confluence of knowledge and expertise. In fact, we have been strongly committed to the exchange of these things from Day 1. For example, France has shared its knowledge on linear accelerators, Germany and Italy on liquid metal technology, and Lithuania on ultrasonic visualisation – an optical technique for seeing into an opaque liquid. Japan has also made a significant contribution to the design of MYRRHA by sharing its knowledge on industrial Accelerator Driven Systems (ADS). All of this has allowed us to evolve even faster. Now, MYRRHA AISBL will bring together international partners so all the knowledge, expertise and financial resources come under one roof. It therefore goes without saying that by establishing this organisation, we're not taking a step, but a leap, towards the realisation of MYRRHA.

Who is involved in MYRRHA AISBL?
Hamid Aït Abderrahim: The Belgian State and the nuclear research centre SCK CEN established MYRRHA AISBL. They therefore have the status of founding members. The partners who co-invest in the project will become contributing members. All consortium members will collectively oversee the project, closely monitor its implementation, and have decision-making authority over the research programmes that will be undertaken during its operation.

What kind of programmes are these?
Hamid Aït Abderrahim: We divided the research programmes into four categories. The first category includes all programmes that the consortium members consider to be priorities. The results will remain the property of the consortium members for the time being and will only be published after some time has passed. The second category is fundamental research, for which we receive public funding. The results of that category will be published immediately. The third category includes contract research. This includes, for example, irradiation testing for industries wishing to qualify new fissile materials. The fourth category is for purely commercial programmes. For example, we can produce radioisotopes on behalf of a pharmaceutical company to allow it to explore the potential of that radioisotope.

What privilege do consortium members have?
Hamid Aït Abderrahim: MYRRHA is the only organisation of its kind in the world. The infrastructure will therefore become a source of international interest for research centres and universities, a technology hub for partners and an economic stimulus for (new) industries. There is a good chance that we will receive more requests than we have capacity for. Consortium members have the assurance that a quarter of that capacity will remain reserved for them. They can therefore be safe in the knowledge that their research programmes can continue. What's more, they have the right to approve or reject proposed research programmes in the other categories.

Do consortium members get 'carte blanche'?
Hamid Aït Abderrahim: SCK CEN will remain the nuclear operator of the versatile research infrastructure. That means our research centre has the right to refuse certain experiments or programmes if they may pose a safety risk. Safety is the priority!

Who can become a contributing member?
Hamid Aït Abderrahim: Countries, (international) research organisations and industries can become members of MYRRHA AISBL.

What milestones can brand-new consortium members expect to see in the near future?
Hamid Aït Abderrahim: The very first milestone is expected to be reached as early as the end of 2022: the 'groundbreaking ceremony' for MINERVA [see box text]. The design of the entire MYRRHA facility is also moving into its final phase [see article on page 34]. Those who join now will be blazing the trail!

Can you tell us about a future project beyond that point?
Hamid Aït Abderrahim: It's estimated that in Europe, with fifteen industrial plants like MYRRHA, we will have sufficient capacity to process all highly radioactive waste. I'm talking about the waste from the 144 nuclear reactors in the European Union. It means we can significantly reduce the footprint of geological disposal.

How will international partners reach you?
Hamid Aït Abderrahim: We'll come to them! In the coming months, we'll tour the world and visit potential partners. Countries that can expect a visit include Germany, France, the Netherlands, Spain, the United Kingdom, the United States, and Japan.

Interested in becoming a member?

If so, please contact:

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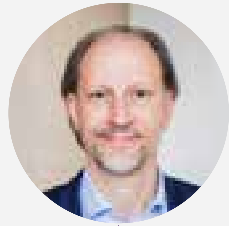
'Groundbreaking ceremony' for MINERVA

MINERVA is the first construction phase of MYRRHA – the particle accelerator capable of powering up to 100 MeV. The first components of the accelerator are currently being built at the Centre de Ressources du Cyclotron (CRC) at UCLouvain in Louvain-la-Neuve, but that set-up is limited to 5.9 MeV. To reach an energy level of 100 MeV, the current setup must first move to Mol. The buildings that will house MINERVA have yet to be built. The 'groundbreaking ceremony' is currently scheduled for late 2022. The building is expected to take 18 months to construct, then it will be ready for installation of the systems.



Investing pays off

With our unique installations, our employees have written history. Our activities have ushered in the Belgian nuclear energy era, and led to the emergence of targeted cancer therapies and effective dismantling technologies. We'll continue to invest in new facilities into the future. Investing means innovating. We strive to innovate in areas such as nuclear medicine, sustainable nuclear energy, decommissioning and waste & disposal. And we're doing that for society, for the people.

Peter Baeten
Deputy Director General

BR2 gets low-enriched uranium as fuel

Research reactors around the world follow in BR2's footsteps

In the future, the BR2 research reactor will run on low-enriched uranium. By changing its nuclear fuel, SCK CEN is helping to prevent the potential spread of highly enriched uranium – a possible component of nuclear weapons. With each new test, the nuclear research centre SCK CEN is approaching its destination: a changeover in 2026. Institutes around the world are following in SCK CEN's footsteps as it goes down this new path.

Left to right: **Jared Wight** *(SCK CEN)* and **Bert Rossaert** *(SCK CEN)*

> **The fact that the U.S. Department of Energy is having low-enriched uranium fuel tested in Belgium confirms the global role that the BR2 research reactor and our researchers play in this field.**
>
> **Jared Wight**

BR2 is one of the most powerful research reactors in the world. It plays a vital role in the global supply of medical radioisotopes and testing nuclear innovations. The versatile facility currently runs on highly enriched uranium. The nuclear research centre plans to replace this nuclear fuel – the fuel of a nuclear reactor – with its low-enriched variant. In 2021, nuclear researchers at SCK CEN, closely followed by international partners, made considerable progress in their preparations. If everything continues to go as planned, the research centre will be able to add another first to its impressive list of achievements. "We are aiming for 2026 to make the switch. BR2 would then be the world's first, high-performance research reactor converted from highly enriched uranium to low-enriched uranium as fuel," beams project leader Jared Wight. With this switch, the nuclear research centre is helping to limit the risk of proliferation of highly enriched uranium – a possible component of nuclear weapons.

Nevertheless, the nuclear fuel cannot simply be changed overnight. A comprehensive safety plan needs to be put in place before the conversion. SCK CEN must prove to the Federal Agency for Nuclear Control (FANC) - the nuclear watchdog in Belgium - that the new fuel type is as safe as the current one. "Typically, the qualification of a new fuel goes through several phases," explains Jared Wight. In the first phase, small samples are tested in moderate conditions. This means that the power is limited and the burnup fraction - the degree to which the fuel has been burned up - goes up to 40%. "In the second phase, we expose full-size, individual fuel plates to higher power and a higher burnup fraction. In the third phase, these fuel plates are incorporated into future fuel elements and tested in real conditions. For BR2, 18 plates are incorporated into a tube-shaped fuel element."

A challenging process

Last year, the fuel developed for BR2 went through phase two. The fuel plates stayed in the reactor core of BR2 for one to three cycles - i.e., 30 to 93 days. “By irradiating these plates, we wanted to see how the fuel behaves. It is inevitable that the fuel will swell, but this swelling process must be stable, limited and predictable. Is the fuel plate swelling too quickly and too much? Are processes occurring due to the nuclear fission, causing risks of cracks in the fuel coating? The results that emerge from our material testing should provide insight into this,” confirms Jared Wight. “During the previous tests, there were no blisters which could have caused issues.”

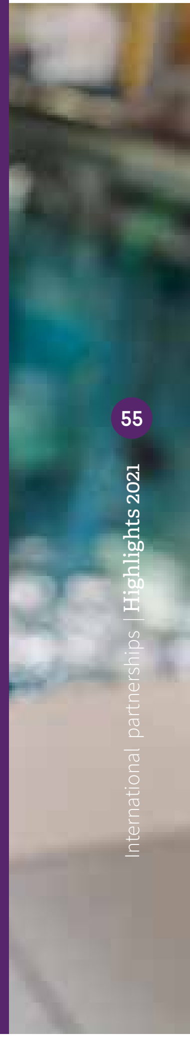
Moreover, the research reactor must not lose technical performance. “In highly enriched uranium, we can split almost all of the uranium atoms. In the case of low-enriched uranium, only one in five atoms can be split. But the nuclear fuel must be able to perform to the same level. It’s like a driver filling their car’s tank with 20% petrol and with 80% water, and still wanting to travel the same distance at the same speed,” explains Jared Wight. In order to achieve this, the SCK CEN experts multiplied the uranium content of low-enriched uranium by 5 to bring it up to the same level as the current fuel. They did this by increasing the number of uranium grains in the fuel plates and by choosing a uranium compound with a higher density. The uranium atoms are therefore closer together. “With our tests, we are checking whether the new nuclear fuel can effectively create the same conditions we need for our technical mission. This is crucial for our customers and patients. They are counting on us.”

South Korean fuel manufacturer turns to BR2

The fuel suppliers offering low-enriched uranium fuel assemblies for research reactors are few and far between. The U.S.-based BWX Technologies and France-based Framatome are the two main providers worldwide. The South Korean research institute KAERI has ambitions to join this select group. SCK CEN is helping the institute achieve this ambition. Jared Wight explains, “KAERI has developed a new type of nuclear fuel for commercial use, but has yet to qualify it. We are making our irradiation services available, to put the developed fuel elements to the test. That test is the final piece in the fuel qualification and is KAERI’s ticket to enter the market.”

United States orders material tests at BR2

The Oak Ridge National Laboratory in Tennessee also plans to run its research reactor, High Flux Isotope Reactor (HFIR), on low-enriched uranium. The reactor produces one of the highest neutron fluxes in the world. “The neutron flux describes how many atoms are split per second. A high neutron flux enables material testing and the production of unique radioisotopes. The research reactor has to be capable of high performance at the technical level, making the transition to low-enriched uranium a challenging process. The demands to be met by the new fuel are therefore high”, explains Jared Wight, project manager at SCK CEN. To qualify the fuel, the U.S. Department of Energy, through the Idaho National Laboratory, is having material tests conducted by the Belgian research centre SCK CEN. Jared Wight is proud: “It confirms the global role played by the BR2 research reactor and our researchers in this field.”



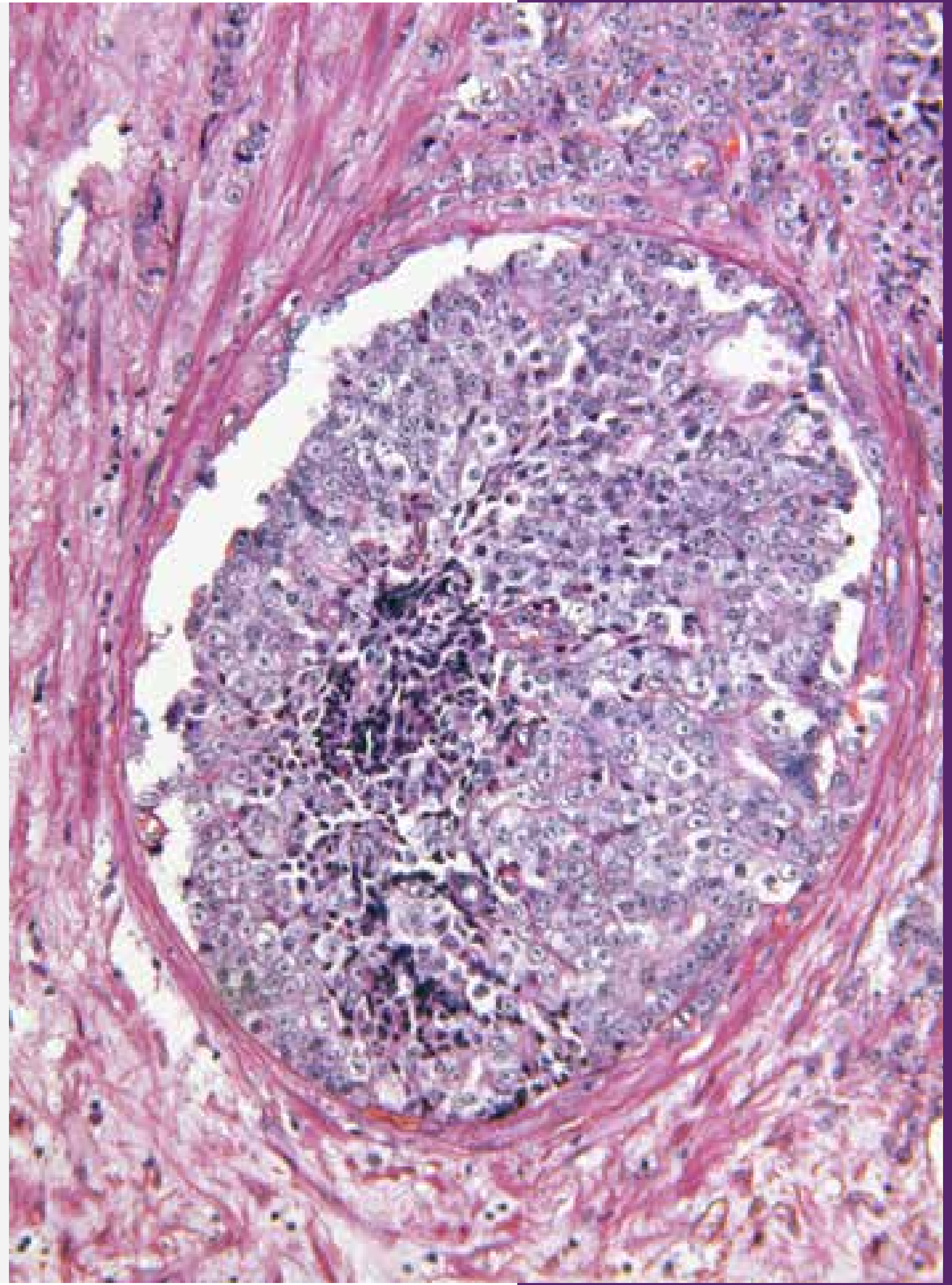
Gradual transition

The successful irradiation tests brings the researchers one step closer to their goal of switching from highly enriched to low-enriched uranium. According to the current planning, the first, low-enriched uranium fuel elements will make their appearance in the reactor core in 2026. “We refer to the ‘first’ fuel elements because the changeover will be gradual,” Jared Wight points out. For each reactor cycle, the core - consisting of around 80 irradiation channels - is rearranged. Generally, half of these channels are reserved for fuel, of which five to ten channels are for fresh fuel elements. The remaining irradiation channels are filled - according to the needs – with partly used fuel elements, experiments, or the necessary raw materials for the production of (medical) radioisotopes. “The transition to a reactor core without highly enriched uranium is important for SCK CEN. It illustrates our leadership position in the qualification of nuclear fuel with low-enriched uranium and our commitment to non-proliferation,” stresses Jared Wight. The researchers are working hard to achieve this conversion. Institutes around the world are following in SCK CEN’s footsteps as it goes down this new path [see box text].

BR2 as an international testing station

Our BR2 research reactor dates back to the iconic ‘golden sixties’ era. The work it has done since then is equally iconic. It is one of the world’s leading ‘isotope brewers’ for medical and industrial applications, and it has also served as an international testing station for decades. Hundreds of materials and fuels have been extensively tested in its reactor core before being deployed in fission and fusion reactors. In the last twenty years, BR2 has reaffirmed that position thanks to its use for the qualification of low-enriched uranium for research reactors.

Sven Van den Berghe
Nuclear material sciences



The fight against cancer is gaining momentum

SCK CEN shares knowledge with Canadian start-up for rapid launch of production line

The nuclear research centre SCK CEN and the Canadian start-up POINT Biopharma have concluded a technology transfer licence agreement. This agreement is POINT Biopharma’s *one-way ticket* to a rapid start-up of lutetium-177 production. This radioisotope is very promising for the treatment of prostate cancer, which is responsible for 90,000 deaths in Europe every year.

SCK CEN — POINT Biopharma

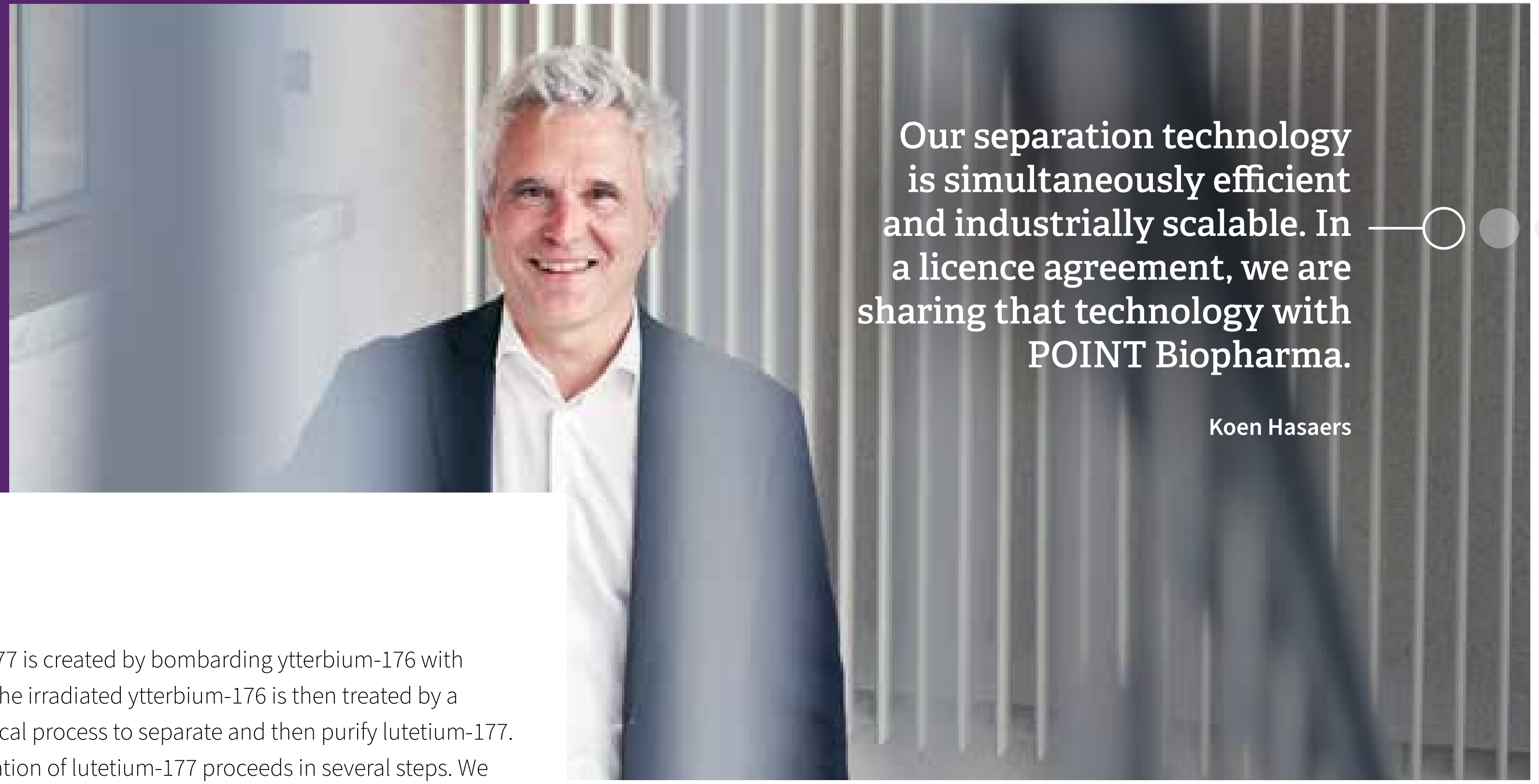
Belgian production line

The innovative production method from SCK CEN also forms the basis of a Belgian production line. This large-scale production line will be set up at the initiative of SCK CEN and the National Institute for Radioelements, who have been great partners in the battle against cancer for many years. “By helping to increase supply, they are providing numerous cancer patients with access to effective treatment and thus life-saving care,” says Eric van Walle, Director-General of SCK CEN. The production facility will be on the nuclear research centre SCK CEN’s site in Mol (Belgium), while IRE will actually bring the radioisotopes to the customers. The the research center will receive funding from the Recovery and Resilience Plan (RRF) to perform the research and development necessary to enable the production line.

Radioisotopes can make the difference not only in medical imaging but also in targeted cancer therapies. That dynamic did not go unnoticed by Allen Silber and Joe McCann. Together, these men founded POINT Biopharma at the height of the pandemic. This Canadian start-up aims to be a driving force in the development of therapeutic radioisotopes. The company’s primary focus will be lutetium-177, a promising radioisotope for the treatment of prostate cancer, among other things. The need for this is expected to increase exponentially: from 16,000 patients in 2020 to 138,000 patients in 2026.

Successful roll-out of cancer treatment depends largely on operational reliability. “Patients need the assurance that their treatment can continue. In order to do this, the market must have the assurance that no link in the supply chain is broken: from raw materials to finished radiopharmaceuticals. In the case of medical radioisotopes, the time aspect also comes into play. It’s a race against time to get them to the patient,” says Koen Hasaers, Director of SCK CEN’s cancer control programme NURA. Supplies need to be secured.

The Canadian start-up therefore decided to focus on every facet of the chain. Among other things, the company arranged for access to the essential basic raw material, they will purify the radioisotope itself, and then link it to a carrier molecule. However, that vision must not slow down the pace at which it plans to start production. For this reason, POINT Biopharma is engaging partners with knowledge and experience. SCK CEN is one of these. SCK CEN will share the production method it has developed for pure lutetium-177 with the Canadian start-up.



Trust

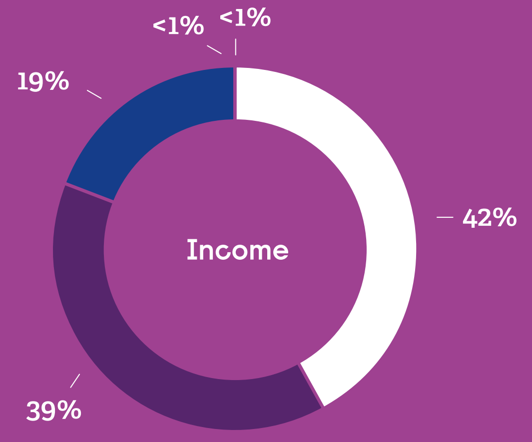
Lutetium-177 is created by bombarding ytterbium-176 with neutrons. The irradiated ytterbium-176 is then treated by a radiochemical process to separate and then purify lutetium-177. “The separation of lutetium-177 proceeds in several steps. We developed a technique that achieves high purity with minimal steps. This makes our separation technology simultaneously efficient and industrially scalable. In a licence agreement, we are now sharing that technology with POINT Biopharma,” Hasaers says. The willingness to subscribe to this licence agreement is a substantial recognition for SCK CEN. “POINT Biopharma is taking the risk that the technology provided may affect its business model. This agreement demonstrates the trust and appreciation that these external partners have for SCK CEN, which is a result of our extensive professional knowledge and experience in the nuclear domain.”

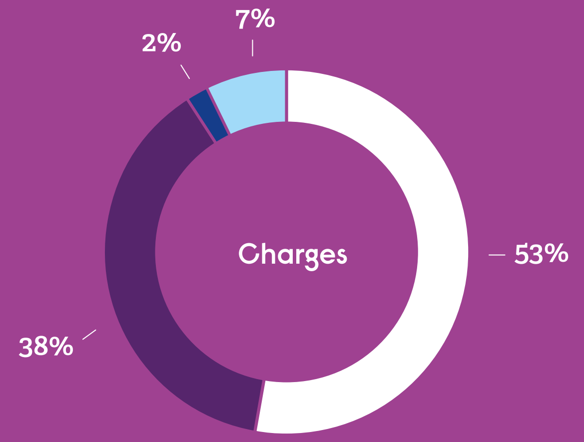
Far-reaching collaboration

The collaboration goes beyond a mere technology transfer. “If demand exceeds their supply, we will step in. Indeed, along with the National Institute for Radioelements, we will also establish a Belgian production line,” concludes Hasaers. Also, the two partners do not rule out future collaborations for other emerging radioisotopes.

Key figures

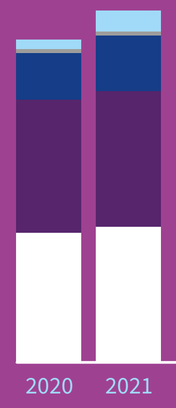
Budget execution





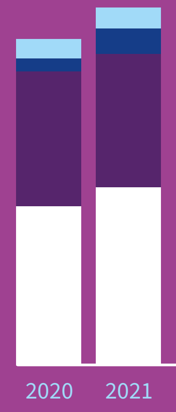
Budget evolution

Income (in kEUR)



	2020	2021
Turnover	76.652	84.364
Subsidies from government, grants	77.372	78.615
Other	32.446	37.411
Financial income	1.101	232
Extraordinary income	12.277	57
TOTAL	**199.847**	**200.679**

Charges (in kEUR)



	2020	2021
Personnel costs	100.371	106.680
Purchases, services	76.549	76.597
Provisions	15.026	3.069
Depreciation	11.984	13.257
TOTAL	**203.930**	**199.603**

68
Completed theses
2 secundary education
11 Bachelor
44 Master (+ BNEN)
11 PhD

523
Scientific publications & presentations

92
PhD students
29% from Belgium
71% from abroad

26
Internships
in Belgium and abroad

27
PhD students selected in 2020

108
Training courses
with 1603 participants
68% online

Staff

722
men

966
employees

244
women

13
average years of service

39%
with an academic degree

54
nationalities

Active in 65 countries

(indicated in white)

Belgian Nuclear Research Center
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sck cen

70 years of experience in nuclear science and technology

SCK CEN is one of Belgium's largest research centres. It has more than 850 employees who devote themselves every day to developing peaceful applications of nuclear energy. The research activities of SCK CEN relate to **three main themes.**

SCK CEN is recognised worldwide and shares its knowledge through numerous publications and training courses in order to keep up this exceptional pool of talent.

More info: www.sckcen.be

The safety of nuclear facilities

The development of nuclear medicine

The protection of the population and the environment against ionising radiation