NOMATEN

Centre of Excellence in Multifunctional Materials
for Industrial and Medical Applications

ANNUAL REPORT 2022

European Funds
Republic of Poland
FNP Foundation for Polish Science
European Union

PROJECT PARTNERS

Narodowe Centrum Badań Jądrowych w Świerku
National Centre for Nuclear Research
Poland

Commisariat à l'energie atomique et aux énergies alternatives
Alternative Energies and Atomic Energy Commission
France

Teknologian tutkimuskeskus VTT Oy
Technical Research Centre of Finland
Finland

Partners and funding of the NOMATEN CoE 4

National Centre for Nuclear Research, Poland 5

The Atomic Energy and Alternative Energy Commission, France 6

VTT Technical Research Centre of Finland Ltd 6

NOMATEN's Funding 7

CoE Director's Foreword 8

Future look 10

Highlights 12

Scientific developments 22

Strategic Research and Innovation Agenda (SRIA) 24

Implementation of SRIA 25

Team Development 26

HR Policy 28

Staff Recruitment 29

Research infrastructure 30

Current Infrastructure at NOMATEN CoE 31

Site visit at VTT and CEA infrastructure 34

Providing access to CoE infrastructure to third parties 35

Innovation-based sustainability Industrial collaboration 36

Commercial contracts 38

IPR Management 38

Communication 40

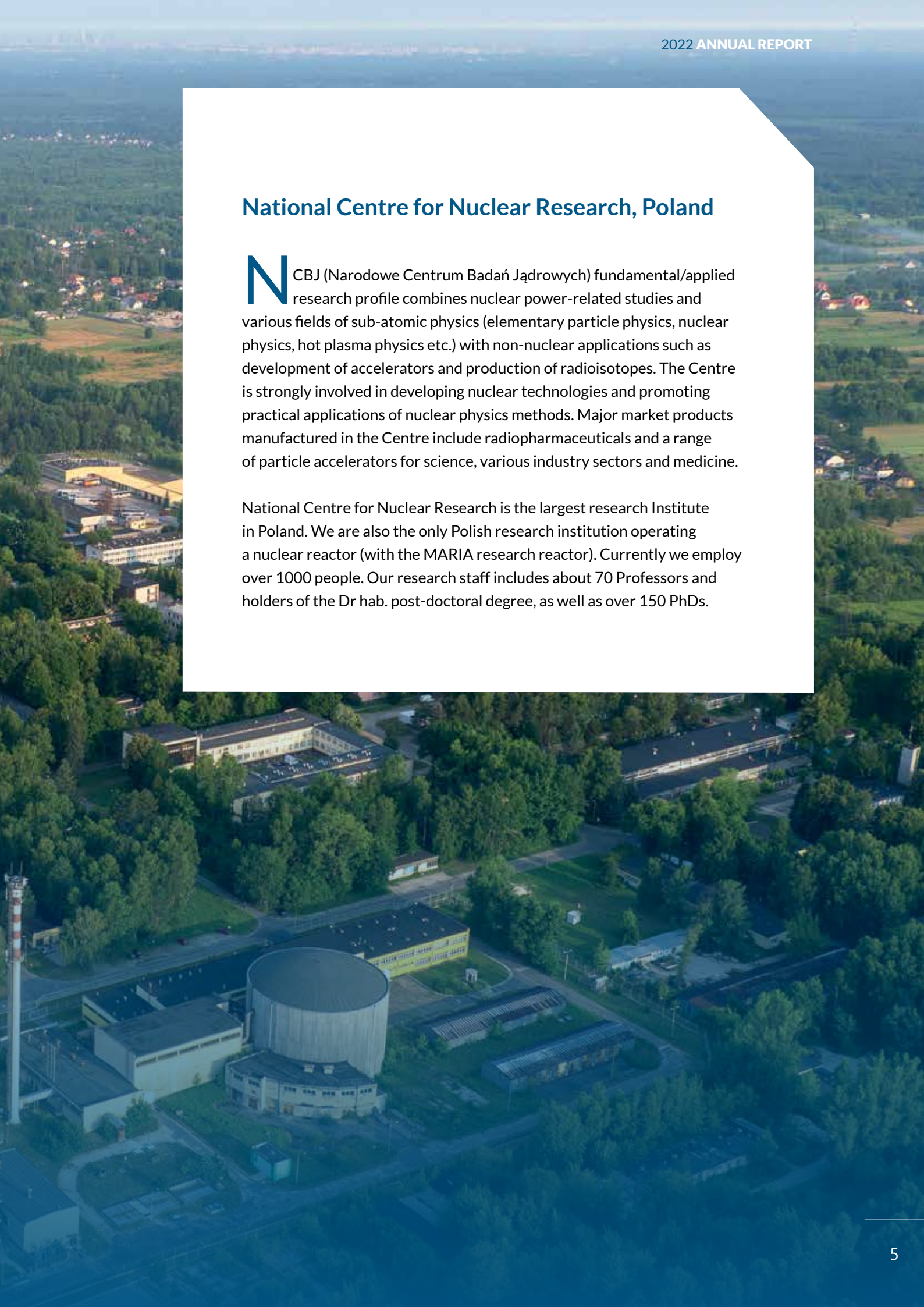
Partner's activities: CEA 42

Partner's activities: VTT 46

List of the NOMATEN open and public seminars in 2022 48

List of the scientific papers by the NOMATEN scientists 50

PARTNERS AND FUNDING OF THE NOMATEN COE



National Centre for Nuclear Research, Poland

NCBJ (Narodowe Centrum Badań Jądrowych) fundamental/applied research profile combines nuclear power-related studies and various fields of sub-atomic physics (elementary particle physics, nuclear physics, hot plasma physics etc.) with non-nuclear applications such as development of accelerators and production of radioisotopes. The Centre is strongly involved in developing nuclear technologies and promoting practical applications of nuclear physics methods. Major market products manufactured in the Centre include radiopharmaceuticals and a range of particle accelerators for science, various industry sectors and medicine.

National Centre for Nuclear Research is the largest research Institute in Poland. We are also the only Polish research institution operating a nuclear reactor (with the MARIA research reactor). Currently we employ over 1000 people. Our research staff includes about 70 Professors and holders of the Dr hab. post-doctoral degree, as well as over 150 PhDs.

THE ATOMIC ENERGY AND ALTERNATIVE ENERGY COMMISSION, FRANCE

The Atomic Energy and Alternative Energy Commission (CEA, Commissariat à l'Énergie Atomique et aux Énergies Alternatives), is a public establishment devoted to scientific, technical and industrial research and development, under the authority of the Ministries of Energy, Research, Industry and Defence. The CEA is today a major player in research, development and innovation in four areas: defense and security, low-carbon energies (nuclear and renewable), technological research for industry and fundamental research (sciences matter and life sciences). It conducts a part of its research in the framework of the French nuclear deterrent programme. It also provides technology to strengthen security in the face of new hazards such as terrorism and cyberattack, and to upgrade response to earthquakes and tsunamis.

CEA is a key actor in the French and European energy transition policy toward the net zero carbon 2050 achievement and for this mobilizes its expertise and multidisciplinary competencies to propose innovative technological solutions to address major societal challenges, such as energy transition, nuclear and renewable energy, and understanding the mechanisms of climate change. The CEA follows a research strategy encompassing the whole energy system, focusing simultaneously on means of electrical power production, both nuclear and renewable (solar), improving energy efficiency and dynamic adjustment of supply and demand through energy storage (batteries), the use of hydrogen as an energy vector, or smart power grids.

Beside challenges associated with energy and climate changes, the CEA also mobilizes its expertise and multidisciplinary competencies to biotechnologies and biomedical innovations. Challenges linked to personalized medicine and technologies for the medicine of the future are priorities, and dedicated research are conducted in the field of in vivo molecular imaging probes, diagnostic tools and molecules for therapeutic or theragnostic uses. Methodologies devoted to isotopic labelling remains a specificity of the CEA, both serving drug development and radiopharmaceutical development.

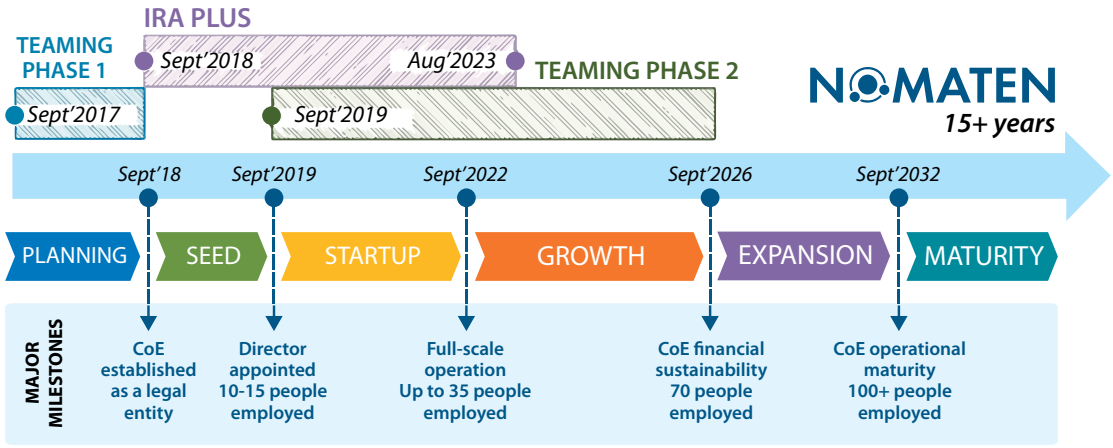
VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

VTT is the leading research and technology company in the Nordic countries. We use our research and knowledge to provide expert services for our domestic and international customers and partners, and for both private and public sectors. We use 4,000,000 hours of brainpower a year to develop new technological solutions. We have over 2,000 experts. VTT Group turnover is approximately EUR 270 million yearly. VTT's mission is to help customers and society to grow and renew through applied research. We have 75 years' experience supporting our clients growth with top-level research and science-based results. We develop new smart technologies, profitable solutions and innovation services. We cooperate with our customers to produce technology for business and build success and well-being for the benefit of society. A brighter future is created through science-based innovations.

NOMATEN'S FUNDING

NOMATEN-Teaming project received funding from the European Union Horizon 2020 research and innovation programme under grant agreement No 857470. NOMATEN CoE is supported by the from European Regional Development Fund via Foundation for Polish Science International Research Agenda PLUS programme grant No MAB PLUS/2018/8. Additional NOMATEN activities are funded through the ORIENT-NM (Organization of the European Research Community on Nuclear Materials) grant (Horizon 2020 Framework Programme, grant agreement No. 899997) and the GOSPOSTRATEG-HTR project financed by the National Centre for Research and Development. Several new grants have been received recently, among them MSCA grant obtained by Aleksandra Baron-Wiecheć- or Polonez Bis project received by Wenyi Huo from Poland's NCN, and INNUMAT funding are encouraging examples. It should be emphasized, that the long-term development plans of the NOMATEN Center of Excellence (schematically shown in the figure below) require a gradual transition to self-sourced funding by CoE, mainly in the form of research grants, contracts with industrial companies and statutory subsidies.

15+ YEARS PLANNING HORIZON

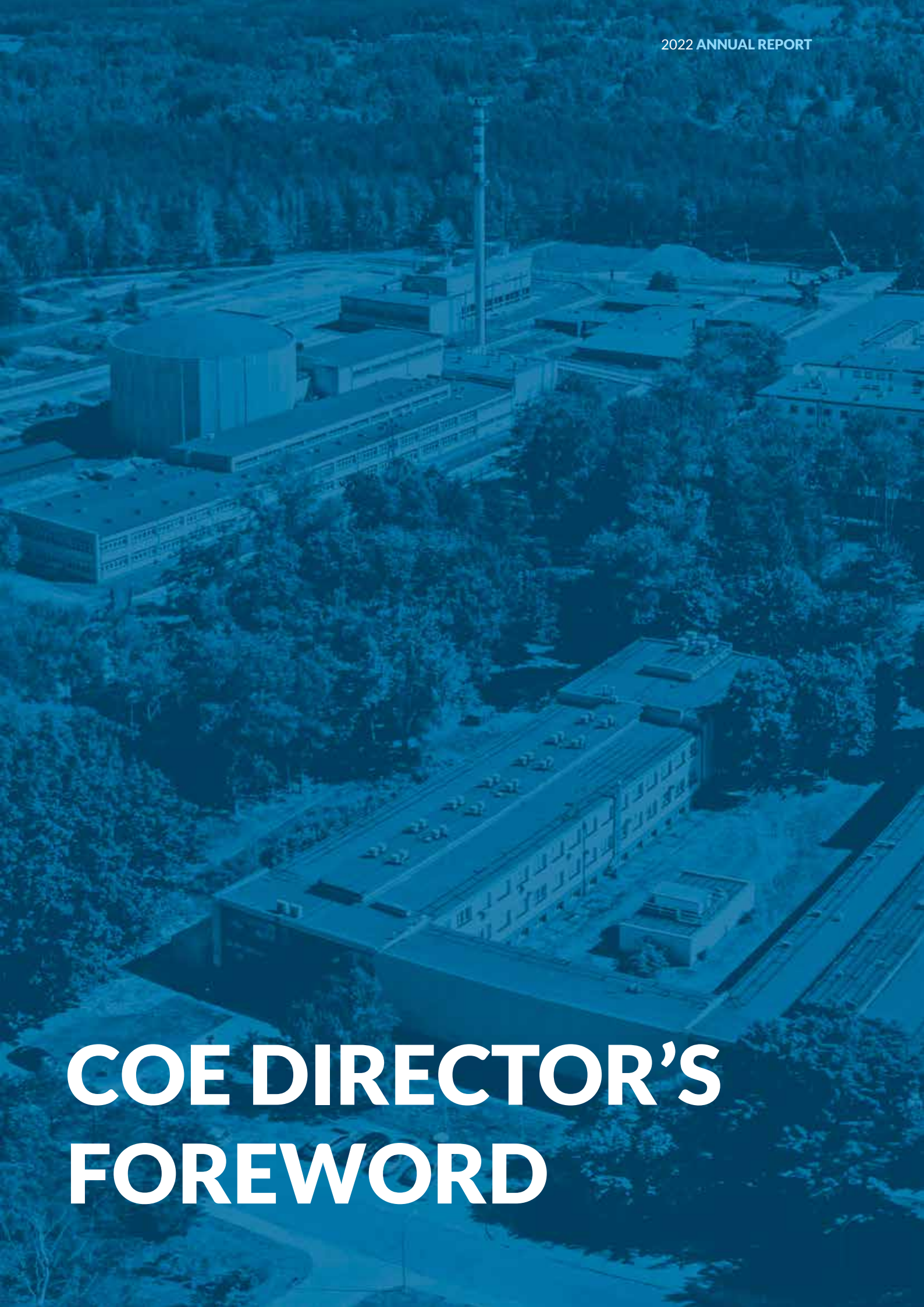


NOMATEN CoE Director
prof. Mikko Alava

2022 was devoted mainly to the further development of operational procedures of the CoE, hiring of personnel, initialization of the scientific activities, the completion of research equipment and organization of cooperation with NCBJ teams and with strategic partners of the project. Despite some problems caused mainly by the pandemic in 2020 and 2021, we believe that the main objectives have been achieved and that the Centre has reached a level of development suitable for its planned activities.

The Centre currently employs 48 members of personnel, has fully equipped headquarters at the premises of the National Centre of Nuclear Research, has acquired a number of own research devices and works in collaboration with other NCBJ laboratories, cooperating with strategic partners and research units in Poland and other countries, as well as project partners, CEA and VTT.

The contacts with potential customers lead to the first two commercial contracts in the NOMATEN history. The contracts were signed with Mercedes-Benz Manufacturing Poland, engine and battery manufacturer, and TOMEX Brakes, breaking systems manufacturer. Another commercial partner, Australian BlueScope Steel, collaborates with NOMATEN in terms of SEM microscopy.



COE DIRECTOR'S FOREWORD

FUTURE LOOK

Director for Scientific Operations
prof. Paweł Sobkowicz

In 2023 NOMATEN CoE will develop its three key areas, materials science for extreme conditions, nuclear materials and radiopharmaceuticals further in particular in excellence aspects. Our on-going research capability measures from large-scale equipment plans (SEM, TEM, metallurgy lab, corrosion, material informatics, radiopharmaceutical research including CERAD preparations) will shift to the exploitation phase, where these are used for novel research and collaboratiotsns within the CoE and externally.

This is easy to illustrate by pointing out the start of several grants and projects from external fundings (INNUMAT, Polonez Bis, MCSA to name the most central ones) that will exploit these resources. We also expect to demonstrate success not only in the quality and quantity of our publications, but in the way this attracts new (successful) proposals and collaborations.

In 2022 we have formulated a road map for the CoE and it presents across the board targets that we hope to match and eventually exceed.

HIGHLIGHTS

NOMATEN and National Centre for Nuclear Research established research cooperation with Mercedes Benz Manufacturing Poland

Mercedes Benz Manufacturing Poland has chosen the National Centre for Nuclear Research as a partner in materials research concerning the lifecycle of the tools for engine's mechanical processing. The technological challenge that Mercedes Benz plant in Jawor faced was the heterogeneity of the ceramic tools used in the cylinder honing process, i.e. too fast wear of the tools and the deposition of undesirable residues inside them. Therefore Mercedes Benz Manufacturing Poland asked NOMATEN Centre of Excellence to perform research and expertise on this topic.

Prof. Łukasz Kurpaska (Functional Properties Research Group Leader) and Dr Iwona Jóźwik (Materials Characterization Research Group Leader) managed the research activities at NOMATEN in order to develop the expertise for Mercedes Benz Manufacturing Poland. Moreover, NOMATEN took advantage on high performance scientific infrastructure like x-ray diffractometer (XRD) and the scanning electron microscope (SEM).

NOMATEN conducted a series of research activities for Mercedes Benz Manufacturing Poland: among others macroscopic tests of the surface of ceramic elements before and after operation, microstructure tests, chemical and phase composition in selected areas of the tool surface, phase analysis by x-ray diffraction, tests of the surface topography of ceramic elements and mechanical tests of these elements.

Picture 2 Mercedes Benz Manufacturing Poland factory in Jawor, Poland

NOMATEN and BlueScope Limited cooperation on FIB-SEM sample preparation and characterization of materials in practice

NOMATEN Centre of Excellence and BlueScope Steel Limited, Australia, have established a cooperation in the field of scientific research of which the aim is the exchange of knowledge and experience in FIB-SEM (Focused Ion Beam – Scanning Electron Microscopy) sample preparation and characterization of materials for industrial needs.

BlueScope Steel Limited (BSL) is at the cutting edge of materials technology for applications in prepainted and metal coated steel products in Australia with operations spread across North America, Australia, New Zealand, Pacific Islands and throughout Asia. A fundamental aim of BSL is to provide the customers with safe, durable and sustainable products, the development of which is heavily reliant on the ability to interrogate process outcomes and product performance to the highest possible level of detail. Therefore, delivery of BSL's innovation roadmap requires usage of cutting-edge equipment such as FIB-SEM to investigate improvements in materials performance and this is why collaborations with institutions such as NCBJ is of great importance.

On May and June 2022, Dr. Monika Wyszomirska, a Materials Evaluation Specialist from BSL, was visiting the NOMATEN CoE. Dr. Wyszomirska together with the members of Materials Characterization Group led by Dr. Iwona Jóźwik, practiced the advanced FIB-TEM preparation of various types of samples, discussion of technical aspect related to specific preparation needs and exchanging ideas and sharing their experience related to experimental approaches in individual cases. The visit was very fruitful for both sides, with a view for future collaboration.

Picture 3 Iwona Jóźwik performing SEM investigations

NOMATEN at the 35th Annual Congress of the European Association of Nuclear Medicine

The 35th Annual Congress of the European Association of Nuclear Medicine (EANM) was held on October 15-19, 2022 in Barcelona, Spain. The EANM Congress with more than 150 Sessions is the most valuable Nuclear Medicine Meeting worldwide. Each year, nearly 7,000 participants and 180 companies use the possibility to discuss the newest trends and findings in the field of Nuclear Medicine.

This year, during the congress were shown remarkable innovations in every area of this specialist field: new whole-body PET tomographs that are now being used clinically, PSMA tracers were incorporated into clinical guidelines, and excellent trials of theranostic radiopharmaceuticals were presented and published. Furthermore, many other new radiopharmaceuticals which facilitate the study and treatment of new targets were introduced, with more and more protocols addressing unmet clinical needs and new applications in operation.

Picture 4 POLATOM Radioisotope Centre and NOMATEN joint stand at European Association of Nuclear Medicine congress

During the congress, Anna Krzyczmonik and Marek Pruszyński from the Radiopharmaceuticals Group at the NOMATEN Centre of Excellence in National Centre of Nuclear Research in Otwock have promoted research and development capabilities of the group on the design, synthesis and preclinical evaluation of novel diagnostic and therapeutic radiopharmaceuticals. Promotion has been done together with a collaborating team from POLATOM.

Picture 5 Marek Pruszyński, research group leader, and Anna Krzyczmonik representing NOMATEN

1st NOMATEN Conference on Materials Informatics

Picture 6 NOMATEN's materials informatics conference advertisement

NCBJ organized the 1st NOMATEN International Conference on Materials Informatics. Materials informatics is a new field of research that uses advanced artificial intelligence (AI) tools to better understand and design materials needed primarily for work in extreme conditions, as well as in medicine.

The 1st NOMATEN International Conference on Materials Informatics was organized by the NOMATEN at the National Centre for Nuclear Research. More than 60 scientists, experts and industry representatives from over 15 countries attended the conference on materials computing, a pioneering field that is based on a new approach to researching existing and new materials through the use of machine learning, artificial intelligence and statistical methods.

The conference project received a partial financial support from the Polish National Agency for Academic Exchange (NAWA) as part of a grant from the Welcome to Poland program.

Material informatics offers new possibilities in materials research – emphasized the Chairman of the Conference,
prof. Stefanos Papanikolaou, head of the NOMATEN materials science research group. Thanks to the techniques we use, it is possible, for example, to identify defects in the material in electron microscopy photos, which otherwise could escape the researcher's attention. Material computing allows for the collection and analysis of large data sets from research and experiments. In this aspect, material informatics tools can be used in cooperation with other research groups, with experimental teams that study functional properties and characterize materials – both within NCBJ and NOMATEN, as well as in cooperation with research units from Poland and other countries.

Picture 7 Famili photo at NOMATEN's materials informatics conference

New corrosion laboratory at NOMATEN

On the 1st of September 2022 the MagniFiCor ("Magnetism for the functionalization of metallic materials surfaces and its effect on corrosion phenomena" MSC Actions – Horizon 2020, 101026899 MSCA-IF-2020 — Individual Fellowships) has been launched. The research project is dedicated to study magnetism for the functionalization of metallic materials and understanding its effect on corrosion phenomena in harsh environments, such as the fission and fusion industry. The grant was awarded in 2020, but due to travel limitation caused by pandemic situation, it had been postponed. Nevertheless, preparation was ongoing since June 2022, which includes conceptual design of the MagniFiCor experimental set up, decision about the instruments needed and some initial tests of the samples have been carried out, the exploratory experiment helped to find out about potential technical problems and issues to be solved beforehand.

Picture 8 MSC Actions funding the individual fellowship for Aleksandra Baron-Wiecheń

Aleksandra Baron-Wiechec is supported in her MCSA fellowship by The Electrochemistry and Corrosion Lab (EC Lab) team at the NOMATEN which consists of 3 people: in addition to Aleksandra Baron-Wiechec, Muralidhar Chourashiya (senior staff member) and Agata Skotniczuk (junior staff member). The EC Lab is, in terms of organization, under the umbrella of the Functional Materials Research Group.

Aleksandra Baron, Muralidhar Chourashiya and Agata Sotniczuk have a complementary backgrounds in materials engineering, electrochemistry and surface analysis, and except leading their own research, they will support and closely co-operate with all NOMATEN groups and beyond.

Dr. Aleksandra Baron-Wiecheć is an experienced and well established scientist working in the field of material science and surface engineering with a robust scientific profile. She obtained her PhD from the Silesian University of Technology in Poland, then she conducted research at the University of Manchester (UK), in France at the Institut des NanoSciences de Paris, and in Portugal at the Instituto Superior Técnico. She has worked many years for the government regulatory body (UK Atomic Energy Authority) and for EUROFusion consortium. Since 2018, she is a professor and a leader of the Baron-Lab (www.baron-lab.com) at Guangdong Technion – Israel Institute of Technology in China.

Aleksandra Baron has made significant contributions into two main fields: the materials – plasma interactions in extreme conditions, and the surface engineering using isotopic tracing methods. Regarding the later topic, she pioneered isotopic tracing of oxygen and hydrogen isotopes for Ion Beam Analysis (IBA) combined with high-resolution electron microscopy to study complex growth process of self-ordering nano-pores in oxide films formed by anodizing. Today her research focuses on functionalization of metals surface, stable isotopes application in materials science, mass spectrometry and corrosion at the nanoscale.

Aleksandra Baron published her research results in over 90 peer reviewed papers. She has been awarded twice the very prestigious European Fellowship Programme: Marie Skłodowska - Curie Actions in 2008 and 2020. She is a member of the EU Alumni initiative of the European Delegation in Beijing.

NOMATEN at NuMat Conference in Belgium

NOMATEN staff participated in the NUMAT conference held in Ghent, Belgium from 24th till 28th October. The Nuclear Materials Conference (NuMat) was created in 2012 in association with the Journal of Nuclear Materials to serve as an umbrella for international meetings on nuclear materials science related to fission and fusion reactors and the overall nuclear fuel cycle.

We presented there our works related to high temperature properties and radiation damage resistance of Ni-based single crystalline alloys, martensitic-ferritic steels and High Entropy Alloys (with fcc and bcc structures).

NOMATEN team presented the following topics due to the submitted papers during the conference sessions: Impact of precipitates on radiation damage resistance of oxide dispersion strengthened (ODS) concentrated solid-solution alloys (CSAs); In-situ high temperature structure evolution studies of refractory high entropy alloy (AlCoCrFeNiTi) layers; Microstructure and properties of CoCrFeMoNi high-entropy alloys additive-manufactured using laser melting.

Moreover, more research outcomes have been presented at the poster sessions: Novel low-activation W-Ta-Cr-V refractory high entropy alloy for nuclear applications; On the effects of alternative oxides particles on microstructure and mechanical behavior of ferritic ODS steels; Raman spectroscopy as a characterisation tool for various types of graphite modified by the ion beam for the nuclear applications; The Fe addition as an effective treatment of improving the radiation resistance properties in fcc NiFex single-crystal alloys.

Arc melting device at NOMATEN

In October 2022, new Arc Melting device has arrived to NOMATEN. On October, two of our employees (W. Huo and M. Brykała) visited the company site in Germany in order to check purchased system (and received first basic training). Installed device will allow melting samples of up to approx. 200 g at temperatures up to 3500°C. It is equipped with:

- Water-cooled copper crucible plate with multi-purpose molds (for button and rod samples)
- Water-cooled, double-walled high vacuum chamber
- Electric drive for easy lifting of the chamber
- Motor-driven, water-cooled tungsten electrode which can be moved freely above the crucibles
- It allows observation of the melting process through viewing port(s)
- Control panel with all major operating functions at the top of the electrode for safe and convenient operation
- Crucible plates with customized molds on request
- Contactless ignition of the arc
- It allows setting up different melting programs to prevent overheating of the system
- High-vacuum pumping and measuring system, built into the rack system ready for operation.

Picture 10 Arc melting infrastructure

POLONEZ BIS National Science Centre's grant for Wenyi Huo's HOT HEA project

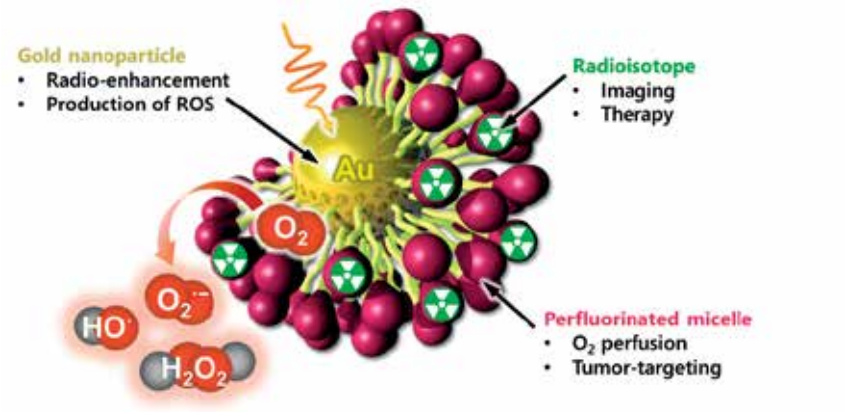
NOMATEN's researcher Wenyi Huo has been selected as one of the POLONEZ BIS MSCA Fellows and will receive a grant from NCN National Science Centre. His project „Hot HEA Development of nano-twinned high-entropy alloys with superior mechanical properties and enhanced irradiation resistance" is focused on high entropy alloys, an important area of research at NOMATEN. Polish NCN National Science Centre awarded 50 of 151 applications. The grant will help Wenyi Huo develop his research in Poland at NOMATEN and National Centre for Nuclear Research. NCN's decision of 25 May 2022 accepted the project under ID: 532820, acronym: HOT HEA, title: "Development of nano-twinned high-entropy alloys with superior mechanical properties and enhanced irradiation resistance". The agreement with the National Science Centre is being signed at the moment.

1st international dual PhD degree doctorate at NOMATEN

In 2022 the IDEX Paris-Saclay announced the ADI program (PhD International Actions – co-tutelle) in order to support the establishment of PhD projects as part of the international dual PhD degree. The program has several main objectives, including: to begin ambitious PhD projects as part of the international dual PhD degree; to encourage the international mobility of the PhD students; to contribute to the internationalization of the PhD schools and the research laboratories; to contribute to the development of partnerships and the international attractiveness of the Paris-Saclay University.

Mrs Mathilde Ponchelle was granted a scholarship / salary for performing her doctorate work related to design and synthesis of theranostic micellar nanocarriers for imaging and targeted radiosensitization. The objective of this co-tutelle PhD thesis is to design nanometric platforms based on gold nanoparticles encapsulated in fluorinated micelles. Micelles will be designed in such a way that they become biocompatible and can passively reach the tumour area thanks to local leaky vasculature (EPR effect, *Enhanced Permeability and Retention*). Contribution of gold is essential as sensitizer for radiotherapy. In fact, gold can potentiate radiotherapeutic treatments by producing altering species upon irradiation. Thus, better efficacy of radiotherapy is anticipated. In addition, tumour tissues are often hypoxic, which poorly respond to radiotherapeutic interventions. The fluorinated core of the micelle will contribute favourably to the latter point as fluorinated phases have the ability to dissolve and carry molecular oxygen. Encapsulation of oxygen close to the reactive metallic core (gold) will allow the production of reactive oxygen species (ROS), upon irradiation. This phenomenon will contribute to the eradication of the cancer tissues. Micellar carriers with various surface chemistries will be produced and radiolabelled with 177Lu as internal source of irradiation and imaging probe (gamma camera) for biodistribution studies.

Work will be done in collaboration between the Nanosciences Group (led by prof. Eric Doris) from the "Department of Bioorganic Chemistry and Isotopic Labelling" of the CEA and the Radiopharmaceuticals Group (led by prof. Marek Pruszyński) from NOMATEN CoE / NCBJ. PhD degree will be awarded by both the University Paris-Saclay (UPS) and the Institute of Nuclear Chemistry and Technology (ICHTJ) in Warsaw.



Picture 11 Mrs Mathilde Ponchelle was granted a scholarship / salary for performing her doctorate work related to design and synthesis of theranostic micellar nanocarriers for imaging and targeted radiosensitization

SCIENTIFIC DEVELOPMENTS

As NOMATEN CoE entered into a "growth" phase, ending the start-up period, nearing 2/3 of the MAB PLUS funding and 1/3 of the Teaming funding, the main focus of the strategic management activities may be divided into three closely interrelated categories:

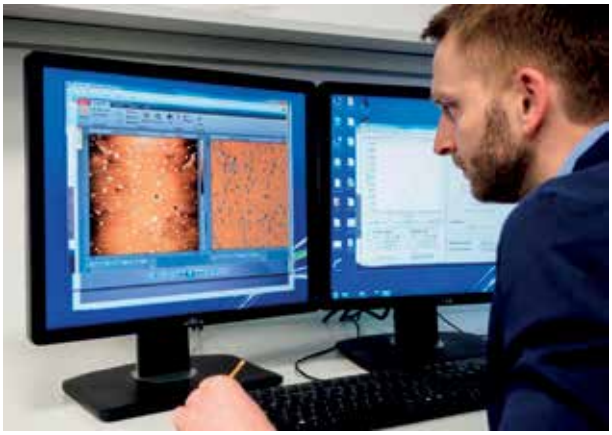
- Development of long-term evolution of the Strategic Research and Innovation Agenda (SRIA), ensuring that the SRIA allows us to achieve and maintain research excellence and that it corresponds to the national and European goals.
- Development of the network of collaborations with research institutions and industrial partners, as well as the establishment of the recognition and presence at the level of national and international stakeholders (government institutions, industrial associations etc.)
- Planning of financial sustainability for the CoE beyond the H2020 grant timeline.

SCIENTIFIC DEVELOPMENTS

The evolution of SRIA – taking into account the current research focal directions (described in the report on WP5) assume expansion of the range of topics (for example through building of personnel/technical competencies related to studies of corrosion, on the basis of Ms Aleksandra Baron-Wiechec MSCA Magnificor grant). Similar expansion is planned for the radiopharmaceutical domain, where after the establishment of prof Marek Pruszynski research group (chemistry, radiochemistry, preclinical in vitro evaluation). We are also strengthening the combined research/information technology activities devoted to the creation of dedicated, Artificial Intelligence/Machine Learning tools for materials science.

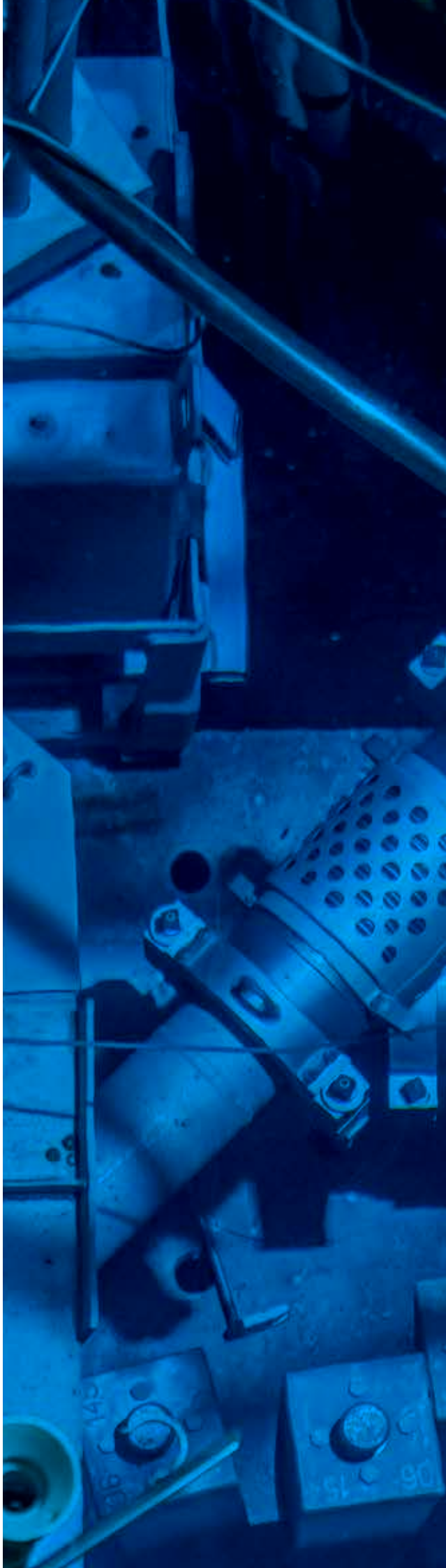
During the reported period, NOMATEN has developed direct contacts with several renowned international research centres (CIEMAT (SP), BAM (DE), JRC, MPP Garching (DE), Fraunhofer (DE) Harvard (US), MIT (US), as well as Polish Universities (e.g. Warsaw University of Technology)) and participates in multinational initiatives, such as ORIENT-NM (aimed at producing a convincing strategic research agenda (SRA) for materials for nuclear fission reactor generations).

In the national scope, NOMATEN is participating in initiatives devoted to the development and modification of national and regional Smart Specialization Strategies, energy-related strategies (including active participation in the governmental nuclear energy initiatives related to the *Polish Nuclear Energy Programme and to the Polish Hydrogen Strategy with perspective till 2030*, cooperating also with local industrial associations/clusters and individual companies in these sectors. We have established contacts with Polish industrial associations (e.g. Polish Chamber of Power Industry and Environmental Protection and two Hydrogen Economy clusters), as well as with multiple Polish-international cooperation chambers (Italian, German, Finnish). These activities aimed at the promotion of the strategic positioning of NOMATEN as a knowledge and R&D provider of choice and encourage joint participation in R&D programmes.



STRATEGIC RESEARCH AND INNOVATION AGENDA (SRIA)

Our mark on the research landscape is now established. Our personnel is moving forward, as an example one may quote the habilitation of RGL Papanikolaou (plus the subsequent promotion as an institute professor at NCBJ) and the decision to make some of the more senior research staff who show promise tenured. The first NOMATEN Conference on Material Informatics in June 2022 was about establishing the CoE as a host of a real international meeting with some of the top scientists in the world. The science palette of the CoE is presented by a number of key publications showing excellence and collaborative capabilities. In the reporting period, we have published works on the mechanical properties such as yield strength of complex metal alloys, material informatics, nanoindentation of metals in extreme conditions combining careful experiment and simulations.



IMPLEMENTATION OF SRIA

Complex alloys: the NOMATEN team has started to take a fresh look at the question of how the mechanical properties of HEAs (High Entropy Alloys and similar complex alloys) depend on the constitution and why. Several manuscripts, combining methods, and competencies of NOMATEN researchers have been submitted. Experimental research in this area has been initiated and is growing. We are part of a consortium (INNUMAT) that was awarded in a recent Euratom call.

As a novel opening, we have invested a lot of effort in *material informatics*. A comprehensive review article was published in 2021 by the NOMATEN team (*Materials Informatics for Mechanical Deformation: A Review of Applications and Challenges*, Materials 2021, 14, 5764). In 2022 the 1st NOMATEN International Conference on Materials Informatics took place on June 1-3 and bought together over 60 world class scientists in this particular research area. The conference proceedings are available within Springer's *Journal of Materials Science*. This shows that we have quickly taken a leading international role here, and we are expecting the results of two Horizon Europe Twinning proposals which both have key elements from this dimension. This kind of work is in full alignment with the EC promoted trends for FAIR and open data.

Nanoindentation is a key testing method for the properties of metals and alloys in particular as concerns the effects of irradiation. We are now developing joint experimental/simulation workflows for scientific synergy and the first papers have already appeared from this effort that should only grow stronger and give us a unique strength.

The *radiopharmaceutical* group has started its activities and is already involved in joint research with CEA and POLATOM and VTT. Key RG members have been recruited and we actively support the start-up phase of this direction.

The innovation dimension of the SRIA is being cultivated both in terms of nuclear and non-nuclear materials science. The ILG has established contacts with a large number of companies in Poland and elsewhere, and we have now the first actual research contracts (e.g. Mercedes-Benz Poland). NOMATEN is positioned in a key role for the Polish nuclear energy programme, with a strong participation at the April Finnish-Polish summit for nuclear energy (initiated by VTT but then "upgraded" as a governmental initiative) and with a drive to establish in the close future joint funding schemes for international collaboration.

For the funding and sustainability dimension of the SRIA several actions have taken place in addition to the above mentioned ILG activities. Discussions with national stakeholders (FNP, ministries, other Teaming and MAB PLUS centers) have taken place and go on continuously on the future steps. Beyond the efforts of the ILG we have launched an active policy of participation in funding calls. This involves identifying such possibilities, finding collaborators (national and international, including SMEs), following through the preparations (where the PI may be a RGL and also a RG member), mentoring, and post-call analysis.

TEAM DEVELOPMENT

TEAM DEVELOPMENT

At the end of the second Reporting Period NOMATEN Centre of Excellence counted 48 employees, among them: 34 in research positions (including 2 directors of NOMATEN and Research Group Leaders who combine scientific and managerial activities), 7 research and technical positions, 3 people of Machine Learning (IT) team and 4 in administrative. In October 2022 the Centre counted 13 Ph.D. students and 13 post-docs and 2 senior researchers. The Centre is supported also by NCBJ personnel employed by NOMATEN on part-time positions working on administrative duties (public procurement, financial, legal issues) and technical personnel (workshops, preparation of materials, sample finishing, technical assistance etc.). The number of supporting personnel varies depending on actual CoE needs - is 27 people, but in total only 7.15 FTE.

HR POLICY

The HR policy was developed in 2019-2020 and in its final version was adopted on June 31, 2020. The basis of an effective team is the high motivation of its members. Employee motivation is cared for by meeting their needs. Sources of information about the needs of employees we used:

- employee satisfaction surveys (two surveys)

- the leaders' observation,

- individual appraisal interviews

The overall picture from surveys is very positive. In order to continue improving the weaker aspects of the work environment at NOMATEN and NCBJ, consistent local and central actions are required. The surveys clearly show that in teams managers should pay more attention to employees' needs and expectations and such discussions are necessary.

Improvement of the gender balance at all levels is our priority. A detailed analysis has been carried out in this issue. Recruitment activities are only one element. There seems to be no need to make major changes. Interview panels always contain at least one member of each gender. In December 2021, it was developed „NCBJ Gender Equality Plan for 2022-2025". This action plan can help to strive to ensure that the workspace is free from all forms of discrimination. Non-discrimination - treating diversity as a fundamental value - builds a sense of security for female and male employees, fostering their development and commitment. The planned activities will increase the awareness and sensitivity of employees and female employees at various levels of the organisation and career stages. We hope, that thanks to the planned activities, NOMATEN (and NCBJ) will become a more attractive place for women.

The most important conclusions from our analyses:

- NOMATEN's employees are satisfied (high average ratings on all 12 Gallup Questions).
- Significant improvement in average answers to statements about encouraging development and opportunities for it (12 Gallup Questions).
- People know what is expected of them at work and they have the opportunity to do what they like.
- Employees feel that they are needed and heard and prised positive atmosphere in teams, a high sense of inclusion and belonging
- Working conditions are generally evaluated to be very good or good.
- Positive evaluation and feedback about the recruitment and on-boarding process.

STAFF RECRUITMENT

NOMATEN MAB has been growing during the fourth year of its activities. Now we have a team of: 43 active researchers (RGLs, senior scientists, postdocs and PhD candidates, technical and research specialists and ML team), with of three selected and committed candidates awaiting the finalization of formal procedures There are recruitment process in underway on for 11 research positions and 2 administrative positions.

CEA and VTT supported all recruitment activities. Recruitment information was disseminated very actively by them. In addition, in the case of recruitment for the RGL of the radiopharmaceutical group, the representative of the partners actively participated in preparing advertisements and conducting the pre-selection process. Together – NCBJ and Advanced Partners prepared the HR policy, the on-boarding procedure and recruitment procedures.

The management of NOMATEN was very actively involved in all processes. They participated actively in the work at every stage of the selection process.

It is obvious that working in a multicultural team is a real challenge. Sometimes it may be difficult to understand that someone else's behaviour is a product of culture and not of personality. That is why we want to support the team in the effort to create a truly diverse environment where people like and respect each other. On January and February, 2022, the workshop "Communication in intercultural team" was organized. Participants discussed their experience of leaving in different culture first time. The focus was placed on improving their ability to communicate in a constructive way, resolve conflicts and benefit from the team diversity.

RESEARCH INFRASTRUCTURE

RESEARCH INFRASTRUCTURE

CURRENT INFRASTRUCTURE AT NOMATEN COE

Current research equipment owned by CoE includes Scanning Electron Microscope ThermoFisher HELIOS 5 UX with FIB, EDS, EBSD, GIS systems and Bruker D8 X-Ray Diffractometer with GID and high-temperature vacuum chamber. In the current Reporting Period, the new software for SEM allowing for creating 3D structures from SEM analysis has been purchased. The XRD Diffractometer has been equipped with new elements needed to manipulate the vacuum chamber for HT analyses and the works on the construction of a gas filling station were started.

Among new devices purchased using external funds (not listed in Grant Agreement as complementary funding), one may note thermal properties laboratory (dilatometry, digital scanning calorimetry, thermal conductivity and diffusivity, mass analysis), two inductively coupled plasma mass spectrometers, three ovens allowing for processes in a vacuum and controlled atmospheres, vacuum arc melting device, two Charpy hammers, new devices for non-destructive testing (video-boroscope and Eddy current system), sample preparation laboratory. All these devices are selected basing on the main idea of the NOMATEN concept, i.e. to build capabilities allowing for synthesis and studies of materials expected to be used in various environments and high temperatures.

Apart from that, CoE bought and installed several other small research infrastructures. These purchases were made mainly in Structural Property Group, led by Dr. Iwona Jozwik, and at Functional Property Group, led by Dr. Lukasz Kurpaska. A list of equipment purchased (from the CoE budget) and installed is given below:

- Metallography laboratory (including six devices for cutting, polishing, and embedding in the conductive resin)
- Broad Ion Beam polishing system
- High-temperature water vapour stove
- Hydraulic press (25t)
- Slice and view software for SEM
- High-temperature muffle stove
- Eddy current system for non-destructive testing

All purchased equipment has been installed in the NOMATEN CoE facility or at NCBJ partner laboratories (Material Research Laboratory). This was done to initiate the preparation of new joint projects and assure the continuation of already defined works. Among these actions, we would like to highlight the collaborative concept of using the tensometric stage for irradiation of materials at controlled strain levels. The stage will be used in various devices, including Raman, X-ray diffraction, and an ion implanter in NCBJ. It is also planned to be used in a new irradiation chamber at the Jannus facility in CEA. Other examples are small tensile machines and small Charpy impact devices that will be used for testing miniaturized samples (planned joint study within Eurofusion project consortium) and irradiation of prestrained samples (collaborative project with the IPPT PAN, Warsaw). Technical discussions with industrial partners like BIMO company (on qualifications of materials for ITER construction involving surface rugosity, magnetic permeability, and composition analysis) or Mercedes Benz (functional properties of tools used for manufacturing engine blocks) are ongoing.

NOMATEN CoE started physical exchanges with collaborating partners: CEA and VTT. In the first step, two Ph.D. candidates (from the experimental group) were sent to CEA for training at the JANNUS facility. The training lasted for about a week. During the first NOMATEN Winter School in Paris, Dr Kurpaska and Ms Frelek-Kozak visited the mechanical laboratory at CEA. Technical specifications of the machines installed at this facility were discussed directly with the operators. This knowledge is being used to prepare the technical specification of the devices to be

purchased and installed at NCBJ (funded by HTR sources). As a result of this visit, another training in the mechanical laboratory is being planned. It is expected that during the third reporting period, two Ph.D. students will visit the mechanical lab of CEA and be trained in small-scale sample testing (with an emphasis on fracture toughness and tensile tests). In addition, several students from the numerical groups of Dr Papanikoloau and prof. Alava, visited CEA and participated in training using CEA original codes and tools.

Besides purchases made by the NOMATEN CoE itself, we actively used other resources and projects won in the past two years to increase the technical capabilities of the infrastructure at NCBJ. Mainly two projects were used: SPUB (dedicated to supporting operational activities of the Hot Cells at Materials Research Laboratory) and the HTR project (won by NCBJ in June 2021). These two projects finance the purchase of:

- Universal hardness tester (purchased from SPUB project)
- Two Charpy impact machines: 450J and 25J (purchased from the SPUB project)
- Three independent fume hoods - are installed in the metallography laboratory (purchased from the SPUB project)
- Planetary ball mill (purchased from Preludium project)
- Thermal properties laboratory that includes (a high-temperature dilatometer, a device for measuring thermal diffusivity of volumetric materials, a device for measuring thermal diffusivity of thin films, a set for simultaneous thermal analysis dedicated to DSC and TG, a mass spectrometer) (purchased from HTR project).

In addition, the technical stall of NOMATEN CoE was very much occupied with preparing the technical specifications for other equipment to be installed in the third reporting period. Among many, one can name: HT vacuum stove, Arc Melting device, video-boroscope, ICP-MS with LIBS system, WEDM machine, 5 kN small tensile-compression table to be installed in Raman spectrometer, SEM or XRD, and finally dynamic and static machines for tensile-compression tests equipped with DIC option (15 and 25 kN respectively).

SITE VISIT AT VTT AND CEA INFRASTRUCTURE

During the project meeting at VTT (October 2021) technical trip to the Hot Cell Facility, mechanical and structural properties laboratories were conducted. During these visits, it has been tentatively decided that NCBJ will send Ph.D. students and post-docs to receive training in conducting mini-Charpy tests at high temperatures (specimens of KLST type). Another possibility was to use an HR TEM microscope installed at VTT to train CoE staff in radiation defect detections and such training was performed just after the second NOMATEN Autumn School organized by VTT on September 2022.

In conclusion, one can see that both experimental and numerical groups of NOMATEN reached their critical mass. With the installation of essential equipment like SEM, XRD, metallography lab, and HT stove, we can manufacture, heat treat, and handle a variety of specimens. Technical discussions at various levels, including directors of the CoE, RGL, and post-doc, are being performed between CoE and the team from CEA and VTT. One can note that the working atmosphere at the CoE is stimulating, the technical discussion between numerical and experimental groups is being made daily, and the first publications are being drafted. Several project proposals were also submitted for review. The received INNUMAT project (funded by European Commission) is the best example of collaboration between NOMATEN partners. One must admit that plenty of mandatory equipment (e.g., Arc Melting, mechanical devices, or ICP-MS system) must still be delivered and installed (by the end of the first quarter of 2023). However, given the results achieved so far, one can predict that the build of the CoE technical capabilities will end at the turn of I and II quarters of 2023. This will allow strategic planning for the future to become real.

PROVIDING ACCESS TO COE INFRASTRUCTURE TO THIRD PARTIES

Such activities were limited, mainly due to the deep modernization of the MRL, which at present significantly hinders research, especially in cooperation with other units. This does not concern two new laboratories: SEM and XRD. Several samples originating from the Functional properties group, IPPT, AGH, and industrial companies (e.g., Mercedes Benz, Tomex Brakes, or BIMO) were tested in the last year. As part of making the equipment available to other research groups and commercial companies, we participated in joint research as part of European projects: GEMMA, SafeG, and M4F.
A new project from EC has been granted that NOMATEN CoE is part of – INNUMAT. In the frame of the project, NOMATEN CoE will perform MD simulations of radiation damage in martensitic ferritic steels, conduct nanoindentation (both at room and high temperature), and will perform structural analysis (SEM, XRD, ICPMS) of the samples manufactured by the project partners: mainly CEA, KIT, and IIT. We are also involved in the bilateral INLAS project with UNM Port Elizabeth, South Africa, and one of the Ph.D. students – Małgorzata Frelek-Kozak – is conducting her research in the frame of the Preludium project (financed by the NCN - National Science Centre).

Further talks on cooperation with TEPRO SA are conducted on the use of CoE and MRL infrastructure in a joint project devoted to developing welding technology for materials used in the construction of a high-temperature reactor HTR. Given the deep modernization of the technical capabilities of CoE, MRL, and NCBJ, we expect to submit several research projects and significantly increase the publication record (especially in experimental groups of the CoE).

INNOVATION -BASED SUSTAINABILITY INDUSTRIAL COLLABORATION

Networking activities:

- NCBJ (including NOMATEN ILG personnel) has participated in the 2021 WNE (World Nuclear Exhibition), as one of the exhibitors in the Polish Pavilion (December 2021, not mentioned within the 2021 report)

- In order to find and create public funding opportunities in the area of materials for nuclear energy, both Finland's and Poland's funding agencies have been contacted. VTT started discussions with Business Finland (BF) and had a meeting with their representative, presenting the needs and opportunities for a program to support Poland's starting nuclear energy market. The CEA has been in contact with relevant French funding agency and they will be joined as trilateral part to the programme/cooperative actions, if possible.

- CEA has started initial discussion with GIFEN on potential co-operation with NOMATEN. GIFEN is a trade association created in 2018 with the ambition of uniting the entire French nuclear industry into a single professional association

- NCBJ became a full member of CEN 64 Workshop, European organization working on the establishment of new European standards in nuclear engineering

- NOMATEN participated in cooperation with VTT to 14th International Conference on Boiler Technology (ICBT), Szczyrk, Poland, in October 2022. VTT and NOMATEN had a joint presentation in the scientific and technical information session at company presentations. In the conference, NOMATEN also brought visibility by own booth and started several initial discussions on potential future cooperation with the attending companies.

Picture 13 NOMATEN and VTT team in the ICBT conference in Poland, October 2022.

COMMERCIAL CONTRACTS

The contcts with potential customers lead to the first two commercial contract in the NOMATEN history. The contracts were signed with Mercedes-Benz Manufacturing Poland, engine and battery manufacturer, and TOMEX Brakes, breaking systems manufacturer. Another commercial partner, Australian BlueScope Steel, collaborates with NOMATEN in terms of SEM microscopy.

Mercedes Benz Manufacturing Poland has chosen the National Centre for Nuclear Research as a partner in materials research concerning the lifecycle of the tools for engine's mechanical processing. The expertise will be run by the NOMATEN Centre of Excellence team based at the National Centre for Nuclear Research Warsaw capital city. The technological challenge that Mercedes Benz plant in Jawor faces is the heterogeneity of the ceramic tools used in the cylinder honing process, i.e. too fast wear of the tools and the deposition of undesirable residues inside them. Therefore Mercedes Benz Manufacturing Poland asked NOMATEN Centre of Excellence to perform research and expertise on this topic.

NOMATEN Centre of Excellence and BlueScope Steel Limited, Australia, have established the cooperation in the field of scientific research of which the aim is the exchange of knowledge and experience in FIB-SEM (Focused Ion Beam – Scanning Electron Microscopy) sample preparation and characterization of materials in practice.

Moreover, NOMATEN did the research expertise for another automotive company. Identifcation of the sub-surface structures on brakes discs after the break tests The company Tomex Brakes is the leading Polish and Central European manufacturer of the breaking systems.

IPR MANAGEMENT

NOMATEN also continued the work on the IPR management. The work on management of IPR was started in 2021. A joint work group defined the IPR strategy for the CoE. This strategy was documented in within the document NOMATEN CoE IPR protection, commercialization and technology transfer strategies submitted in April 2021. In 2022, a joint work group performed an evaluation of the IPR situation and described in the document "Analysis and evaluation of CoE IP portfolio in April 2022.


DELL

COMMUNICATION

According to scientific developments, NOMATEN continues to communicate and disseminate the project outcomes. In 2022 we released over 30 news releases and reached over 4000 unique users via webpage. Moreover, our LinkedIn profile (830 followers) reached over 40 000 people with NOMATEN's content.

Both for Polish government entities as well as international companies are nowadays able to notice NOMATEN's innovation and scientific potentials is drown from its three partners: highly equipped, A+ category National Centre for Nuclear Research of Poland (NCBJ) and two internationally-leading institutions with established reputations and outstanding scientific and innovation expertise: the French Alternative Energies and Atomic Energy Commission (CEA) and VTT Technical Research Centre of Finland Ltd. (VTT). At the event by Poland's National Centre for Research and Development during HORIZON2020 and WIDENING Days, NOMATEN has been a special guest and an example of EU funded success story.

Thus, NOMATEN can be trusted with solving industrial problems in research deployment of nuclear energy or development new materials for industry and radio-pharmaceutics for medicine. We use targeted actions like vocation of Industry Liaison Group, specially trained linkers between industry and science because we understand the problems with the dialog between the two. NOMATEN appeared at number of government, industrial and research related events: Intelligent Development Forum in Toruń, HORIZON 2020 and WIDENING Days and many others.

COMMUNICATION

COMMUNICATION AND DISSEMINATION IN NUMBERS:

- Over 4000 unique webpage users
- Over 50 news releases and communicates
- 830 LinkedIn followers
- Almost 40000 users reach at LinkedIn
- 25 online public events and seminars
- presence at 8 on-site industrial events

Recently, NOMATEN has launched "VISITING NOMATEN" initiative. We welcome scientists to work with us and offer thesis, projects and, eventually internships for students. NOMATEN also welcomes senior scientific visitors.

Moreover, NOMATEN has promoted its own format: NOMATEN SCHOOL. To support the training of a new generation of young Polish researchers (education programme) and to boost the growth of NOMATEN CoE capacity to implement and manage research programmes. This second edition of the school took place in Finland on September 2022.

Through a generous contribution from Poland's NAWA (Narodowa Agencja Wymiany Akademickiej – National Agency for Academic Exchange), NOMATEN organized a conference on June 1-3, 2022, with the title „Materials Informatics". The scientific importance of this workshop was the widely defined interplay of materials science with machine learning, and it will feature presentations from renowned experts in applied mathematics, drug design, material science, and renewable energy. Materials Informatics has become a rather fast-emerging novel paradigm in materials science, that requires non-trivial data processing methods in Large Data for the identification of novel scientific pathways.

Moreover, due to an innovative work carried out by the groups of Mikko Alava and Stefanos Papanikolaou (Complexity in Materials; Materials Informatics – Structure and Function) the team decided to add an additional webpage dedicated to all AI/ML experts employed at NCBJ (astrophysics, fundamental research, nuclear energy) to boost the cooperation among its members and take an advantage of the wide scope of the simulation work and investigations they do. The subpage is called Machine Learning Network at NCBJ.

PARTNER'S ACTIVITIES: CEA

During the third year (M27 – M38) of the NOMATEN project, CEA continued to bring its support to the development and the strengthening of the NOMATEN CoE. As leader of the "Capacity building programme" (WP6), the CEA supported and contributed actively to the deliverables of this WP, notably by encouraging exchanges and stimulating common works and collaborations between the NOMATEN CoE and all partners (NCBJ, VTT, CEA). CEA actively participated to all monthly Project Management Board meetings (PMBs), a well as to all NOMATEN Steering Committee (SC) and General Assembly (GA) meetings. At the beginning of 2022, CEA leaded and contributed to the writing and the publication of the second implementation report (D6.2) and was a key contributor of the report on the infrastructure use and build-up activities (D4.3). It also participated to the writing of the second technical report (June 2022) and to the second project review by the EC organized in September 8, 2022.

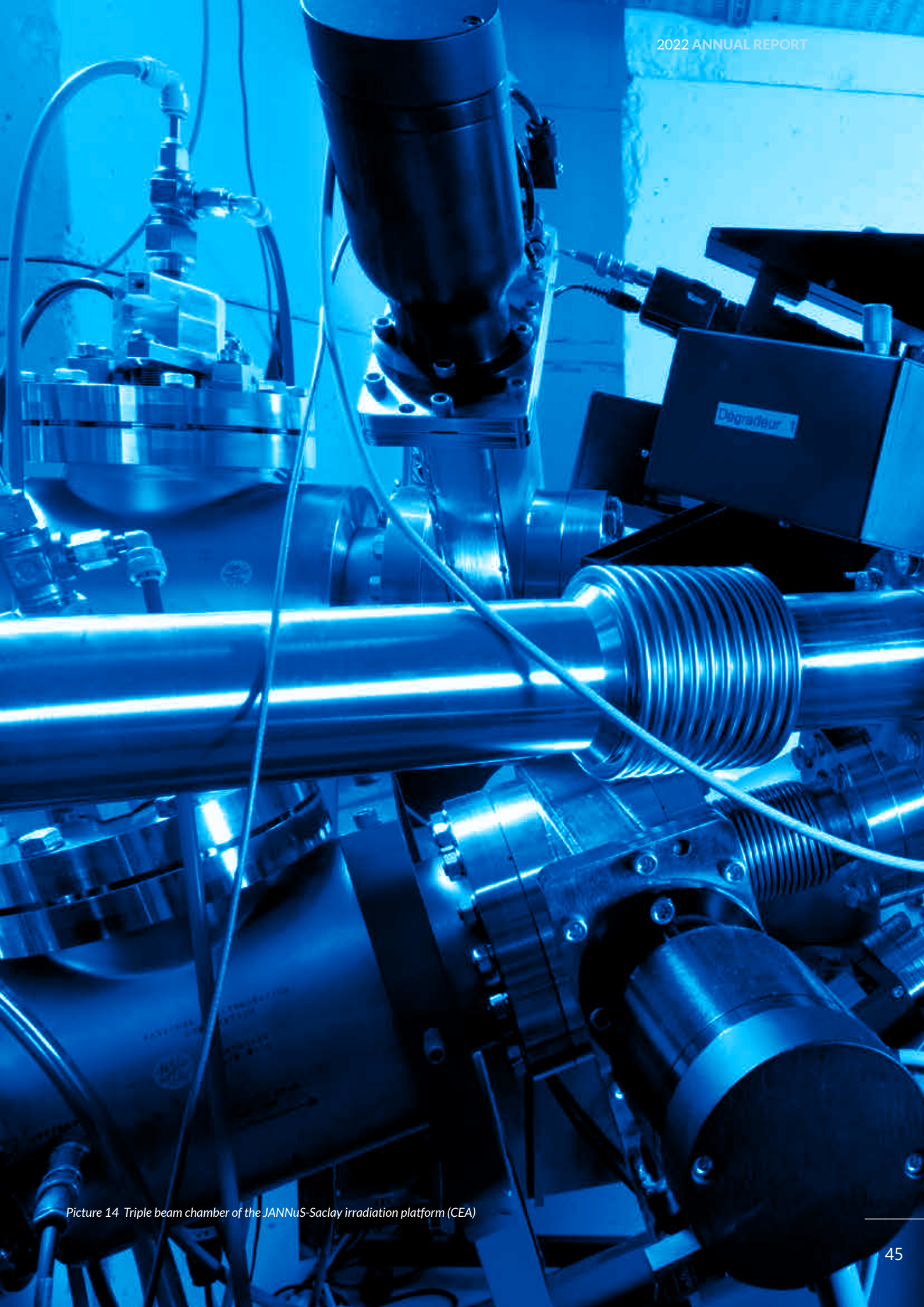
As in 2021, mainly due to the remaining restrictions and consequences induced by the COVID-19 pandemic, series of scientific seminars within the CoE NOMATEN was still organized on a regular basis, but all through digital mode (webinars). In this context, CEA had two contributions related to Radiopharmaceutical sciences: "Translational development of radiotracers for PET imaging at SHFJ" (April 2022) and "Nanometric micelles for the in vivo imaging and drug delivery" (May 2022). In this domain and in the framework of the ADI University Paris-Saclay co-tutelle programme call (March 2022), the first co-directed PhD student was hired, bridging CEA /Joliot Institute and NOMATEN CoE / NCBJ, and started on October 17th, 2022, her research on the following topic: "design and synthesis of theranostic micellar nanocarriers for imaging and targeted radiosensitization". Still in the field or Radiopharmaceutical sciences, it must be remembered that in March 2022, discussions aiming at the constitution of a scientific consortium between NCBJ (NOMATEN CoE, POLATOM), VTT, CEA and ICHTJ started.

In 2022 the IDEX Paris-Saclay announced the ADI program (PhD International Actions – cotutelle) in order to support the establishment of PhD projects as part of the international dual PhD degree. The program has several main objectives, including: to begin ambitious PhD projects as part of the international dual PhD degree; to encourage the international mobility of the PhD students; to contribute to the internationalization of the PhD schools and the research laboratories; to contribute to the development of partnerships and the international attractiveness of the Paris-Saclay University. Mrs Mathilde Ponchelle was granted a scholarship / salary for performing her doctorate work related to design and synthesis of theranostic micellar nanocarriers for imaging and targeted radiosensitization. The objective of this cotutelle PhD thesis is to design nanometric platforms based on gold nanoparticles encapsulated in fluorinated micelles.

In the field of Materials sciences, a training dedicated to the ion accelerator JANNUS-Saclay facility, related to the materials ion irradiation issue, was organized by CEA (Physical Metallurgy Research section of DMN Department), on March 25 & 26, 2022, for two members of the "Functional properties" NOMATEN research group. The training was focused on courses dealing with the ion beam production, the preparation of an experiment and the radioprotection issue. After the visit of the JANNuS irradiation experiment room, the participants followed the preparation of an irradiation with the JANNuS team. In relationship with the training issue, it should be mentioned that another training, dealing with micro-mechanical testing (samples preparation, best experimental practices, and practical strategies for mitigating undesirable size effects) is under discussion for the end of 2022. Concerning the scientific collaborative issue, discussions between the "Functional properties" research group and CEA have been held about the possible submission a new proposal for EMIR&A network concerning the understanding of the radiation damage mechanism in High Entropy alloys (HEA). At the European level, CEA and NCBJ will contribute to the new Euratom INNUMAT project– Innovative Structural Materials for Fission and Fusion – started in October 2022. Moreover, in the framework of the organization of the first NOMATEN international conference on "Materials informatics" (June 1-2, 2022, Otwock, Poland), CEA participated with two majors contributions, one dedicated to the "Machine learning for atomistic materials science "and a second one to the "Atomic-scale modelling of chemical disordered compounds by means of generative models".

Additionally, following the holding of the first NOMATEN Winter School in Paris (France) in November 2021, organized by the CEA, a second school was successfully organized by VTT in Finland in Espoo (September 27-29, 2022). As part of this event, the CEA was in charge of the organization and of the chairing of two scientific sessions (session 2 dedicated to Materials sciences applied to the nuclear field and session 4 dedicated to Radiopharmaceuticals sciences). Session 2 was a unique opportunity to present the French National Synchrotron Facility SOLEIL and the new developments offered by the MARS beam line, aiming at characterizing radioactive samples for environmental, health and energy applications. Session 4 was the first face-to-face opportunity to gather researchers from the Radiopharmaceutical sciences community, and especially the just recruited PhD and PD positions at the CoE NOMATEN. Last, mid-2022, on the initiative of the CEA, preliminary discussions have been engaged about the construction and the setting-up of a Doctoral Network (DN, EU / Marie Skłodowska-Curie Actions, i.e., MSCA); Such DN, that would ideally be leaded by the CoE NOMATEN and NCBJ, with the support of his partners (CEA, including INSTN, and VTT associated to LUT University) aims to promote the students mobility, and strength and develop trainings of excellence.

On the other hand, the CEA has shared with the NOMATEN CoE its experience on how to propose service offers and develop industrial partnerships. Moreover, the CEA has reminded of its training offer in the broadest sense of the term (scientific, management, industrial partnerships, purchasing/ finance, etc.)



Picture 14 Triple beam chamber of the JANNuS-Saclay irradiation platform (CEA)

PARTNER'S ACTIVITIES: VTT

Picture 15 NOMATEN Autumn School 2022 participants in Espoo, Finland.

VTT organized three events for the NOMATEN during 2022. The first event was obliged to change from physical meeting to online event due to worsened corona pandemic situation, but the following two were managed to organize at VTT, Finland.

The online event on Materials Science in February 2022 gathered participants from all three partners with presentations and discussions on status and plans for year 2022, research groups and activities, as well as an overview of VTT's facilities. The event included also commercial and IPR training on VTT ProperScan, APROS software and VTT ProperTune. Discussion on international collaboration and joint project activities took also place.

The first in-person event at VTT, Espoo, Finland, on topic Materials Science and Radiopharmaceuticals took place in March 2022, with presentations of VTT activities in the fields of NOMATEN, visits to the laboratories including the VTT Centre for Nuclear Safety with extensive modern hot cell facilities, VTT Research Hall with mechanical testing facilities, high temperature corrosion, creep and fatigue testing and VTT protein production lab. Discussion on cooperation in relevant fields took place. VTT presented the current status in the small modular reactor (SMR) plans and development.

VTT organized the second NOMATEN school. The Autumn school 2022 "Materials and compounds for industrial and health applications" at Espoo, Finland, was 27-29 September 2022. The event consisted of one session on presentations from the NOMATEN TEAMING project and NOMATEN CoE, presentations from project partner organisations and NOMATEN CoE Research Groups. Three topical sessions on both materials science and Radiopharmaceuticals included in total of 22 scientific presentations of on-going research at CEA, NOMATEN, POLATOM (NCBJ) and VTT, and 17 PhD presentations. The sessions also included panel discussions e.g. on the impact of NOMATEN TEAMING/ CoE for RTO collaboration and the role of NOMATEN project's international research cooperation in supporting the industry. The participants visited research facilities in Otaniemi campus area, including VTT facilities and Aalto University Nanomicroscopy Centre. There was also a presentation from NCBJ of the MARIA Reactor, to discuss on collaboration potential with the facility.

VTT initiated discussions with Finnish funding agency Business Finland in collaboration with NOMATEN and Polish funding agency NCBR to start a R&D programme on nuclear materials to support the potentially approaching Polish Nuclear Energy Programme. VTT and NOMATEN were also invited to participate to the Polish-Finnish Nuclear Summit in Warsaw, Poland, in April 2022, where NOMATEN with VTT held a specific workshops and discussion on NOMATEN cooperation possibilities. The event gave several fruitful contacts with both Polish and Finnish companies, with whom the dialogue is continuing.

LIST OF THE NOMATEN OPEN AND PUBLIC SEMINARS IN 2022

Date	Speaker	Topic	Affiliation
January 11	Nori Sri Tapaswi	High temperature-ultrafine precipitate strengthened steel	NOMATEN
January 25	Peter Haehner	Nanoindentantion of virgin and irradiated materials	Joint Research Centre (JRC)
February 8	Victor Panaretos	Mathematical statistics	EPFL
March 1	Fabio Di Fonzo	Highly ductile amorphous oxide at room temperature and high strain rate	Istituto Italiano di Tecnologia
March 15	Konstantina Mergia	Fusion energy materials	NCSR - Dimokritos
April 5	Aurelie Gentils	Radiation effects and ion beam synthesis of nano-oxides in metallic alloys	Université Paris-Saclay, CNRS/IN2P3, IJCLab
April 19	Bertrand Kuhnast	Translational development of radiopharmaceuticals at Service Hospitalier Frédéric Joliot	CEA-SHFJ-Orsay
May 10	Eric Doris	Nanometric micelles for in vivo imaging and drug delivery	CEA-SCBM-Saclay
May 24	Christian Linsmeier	the development of new materials and their use in a fusion reactor	Forschungszentrum Jülich GmbH
May 31	Stefano Zapperi	Predicting the failure of two-dimensional silica glasses	University of Milan
June 7	Mikko Vepsäläinen	VTT ProperScan	VTT
June 21	Fei Gao	the development of high performance ODS alloys	University of Michigan
July 4	Mike Lee	Applications and limitations of EDS in SEM	Centre HRTEM, Nelson Mandela University
Sep 13	Jorge Alcala	Understanding spherical indentation experiments across the material scales	Universitat Politecnica de Catalunya

Oct 11	Roberto Guerra	Nanofriction under the lens of MD simulations	University of Milan
Oct 18	Monika Wyszomirska	BlueScope Steel – inspiring smart solutions in steel	BlueScope Limited
Oct 25	Jacques O'Connell	Practical examples of the benefits and limitations of TEM	Nelson Mandela University
Nov 8	Katarzyna Nowakowska	Metastable Structure of Layers Shaped During Pulse Magnetron Sputtering	NCBJ
Nov 22	Misaki Ozawa	Machine learning methods in numerical modelling	CNRS
Nov 29	Marie Loyer-Prost	Transmission Electron Microscopy	CEA
Dec 6	HECK Marie-Pierre	Pharmaceuticals	CEA
Dec 13	Daniele Passerone	VDW Interactions	Swiss Federal Laboratories for Materials Science and Technology

LIST OF THE SCIENTIFIC PAPERS BY THE NOMATEN SCIENTISTS

Authors	Title	Periodic	Link
F. J. Dominguez - Gutierrez	Temperature effects on the point defects formation in [111] W by neutron induced collision cascade	Nuclear Inst. and Methods in Physics Research, B	https://doi.org/10.1016/j.nimb.2021.11.025
A. Zaborowska, L. Kurpaska, M. Clozel, E.J. Olivier, J.H. O'Connell, M. Vanazzi, F. Di Fonzo, A. Azarov, I. Jóźwik, M. Frelek-Kozak, R.Diduszko, J.H. Neethling, J. Jagielski	Absolute radiation tolerance of amorphous alumina coatings at room temperature	Ceramics International 47 (2021) 34740	https://doi.org/10.1016/j.ceramint.2021.09.013
Kamran Karimi, Amin Esfandiarpour, René Alvarez-Donado, Mikko J. Alava, and Stefanos Papanikolaou	Shear banding instability in multicomponent metallic glasses: Interplay of composition and short-range order	Phys. Rev. B 105, 094117	https://doi.org/10.1103/PhysRevB.105.094117 arxiv
A. Esfandiarpour, J. Byggmastar, J.P. Balbuena, M.J. Caturla, K. Nordlund, F. Granberg	Effect of cascade overlap and C15 clusters on the damage evolution in Fe: An OKMC study	Materialia, Volume 21, 101344	https://doi.org/10.1016/j.mtla.2022.101344
Daniele Lanzoni, Fabrizio Rovaris, Francesco Montalenti	Machine learning potential for interacting dislocations in the presence of free surfaces	Scientific Reports volume 12, Article number: 3760 (2022)	https://doi.org/10.1038/s41598-022-07585-7
Tero Makinen, Markus Ovaska, Lasse Laurson, Mikko J. Alava	Portevin-Le Chatelier effect: modeling the deformation bands and stress-strain curves	Materials Theory volume 6, 15	https://doi.org/10.1186/s41313-022-00044-w
T. Hochrainer, L. Laurson, S. Papanikolaou, G. Po, R. Sills	Characterization of Dislocation Ensembles: Measures and Complexity	Materials Theory 6, 16	https://doi.org/10.1186/s41313-022-00045-9
A. Esfandiarpour, S. Papanikolaou, M. Alava	Edge dislocations in multicomponent solid solution alloys: Beyond traditional elastic depinning	Physical Review Research 4, L022043 (2022)	https://doi.org/10.1103/PhysRevResearch.4.L022043

Juha Savolainen, Lasse Laurson, and Mikko Alava	Effect of thresholding on avalanches and their clustering for interfaces with long-range elasticity	Phys. Rev. E 105, 054152	https://doi.org/10.1103/PhysRevE.105.054152
Karol Frydrych, Stefanos Papanikolaou	Unambiguous Identification of Crystal Plasticity Parameters from Spherical Indentation	Crystals 2022, 12(10), 1341	https://doi.org/10.3390/cryst12101341
Ł. Kurpaska, F.J. Dominguez-Gutierrez, Y. Zhang, K. Mulewska, H. Bei, W.J. Weber, A. Kosińska, W. Chromiński, I. Jóźwik, R. Alvarez-Donado, S. Papanikolaou, J. Jagielski, M. Alava	Effects of Fe atoms on hardening of a nickel matrix: Nanoindentation experiments and atom-scale numerical modeling	Materials & Design, vol. 217, 110639	https://doi.org/10.1016/j.matdes.2022.110639
Fabrizio Rovaris, Stefanos Papanikolaou, Mikko Alava	Effects of surface curvature and dislocation dynamics: Dynamical deformation mechanisms for uniaxial compression tests at the nanoscale	Materials Science and Engineering: A, Volume 846, 143270	https://doi.org/10.1016/j.msea.2022.143270
P.S. Krstic, E.T. Ostrowski, F.J. Dominguez-Gutierrez, S. Abe, B.E. Koel	Sputtering and reflection processes from amorphous lithium surfaces by low-energy impacts of H and D atoms and D2 molecules	Journal of Nuclear Materials, Volume 568, 153848	https://doi.org/10.1016/j.jnucmat.2022.153848
Tero Mäkinen, Agata Zaborowska, Małgorzata Frelek-Kozak, Iwona Jóźwik, Łukasz Kurpaska, Stefanos Papanikolaou, and Mikko J. Alava	Detection of the onset of yielding and creep failure from digital image correlation	Phys. Rev. Materials 6, 103601	https://doi.org/10.1103/PhysRevMaterials.6.103601

NOMATEN

NOMATEN Centre of Excellence
National Centre for Nuclear Research, Poland

ul. Andrzeja Sołtana 7
05-400 Otwock - Świerk
Poland

nomaten.ncbj.gov.pl

linkedin.com/company/nomaten

twitter.com/nomaten_ncbj

Prof. Mikko Alava
NOMATEN CoE Director

mikko.alava@ncbj.gov.pl

Prof. Paweł Sobkowicz
Director for Scientific Operations

pawel.sobkowicz@ncbj.gov.pl