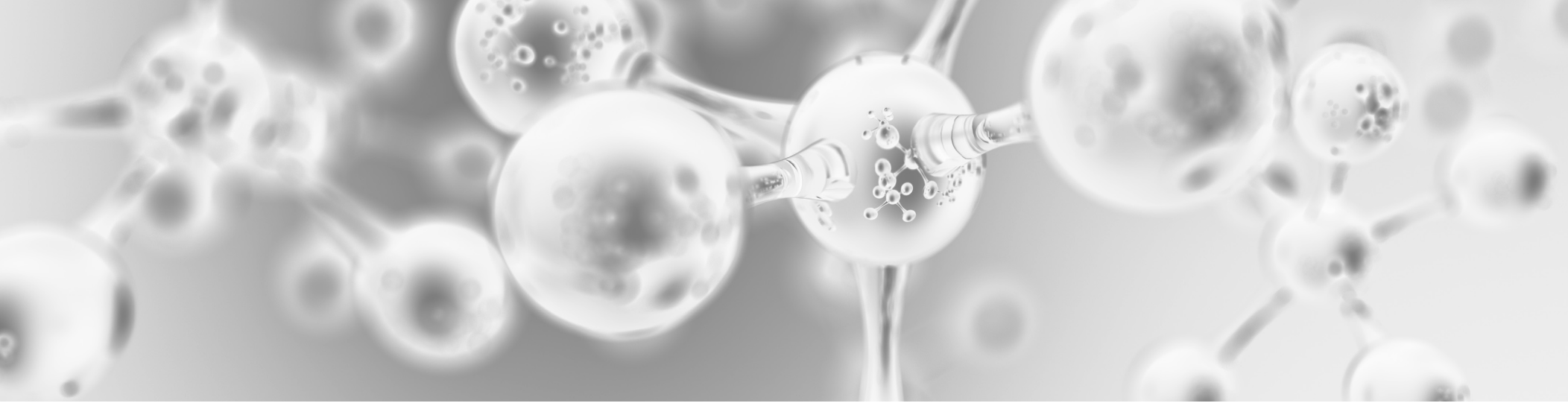


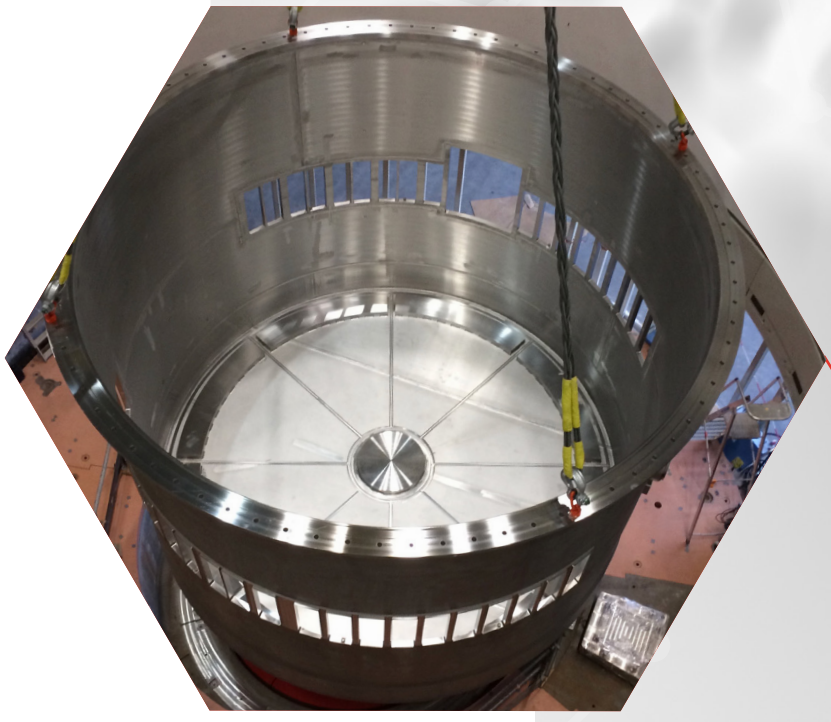
ESS bilbao

newsletter

MARCH 2021

Courtesy of ESS

summary



MARIO PÉREZ
Executive Director

ESS Bilbao, fully committed to delivering

Throughout 2020, the way we lived and worked changed. One year into a global pandemic, we remain committed to delivering our contribution to ESS Lund. We've heard consistently from partners and customers alike that in a remote world, they need different, more meaningful ways to communicate. That's why we're excited to share this second issue of our newsletter with you, to continue strengthening and bringing information to our community together.

On this occasion, we wished to highlight the delivery of the Monolith Vessel, which represented the first major technical component for the ESS Target Station delivered to the construction site in Lund. We´ve made good progress on other fronts as well: nine LLRF systems for the MEBT, RFQ and DTL were delivered to Lund, whilst the FAT for the Target Drive Unit and Shaft were also successfully conducted. The manufacture of the Target Wheel has been concluded, and at present, the tungsten cassettes are being loaded. We expect to have everything ready for the Integrated FAT (Drive Unit, Shaft and Wheel) towards this summer. Last but not least, the tuning tests with the cooling water temperature of the first RFQ segment have been successfully completed, validating the assembly and manufacturing strategy, and allowing a contract to be set in place for the manufacture of the remaining three segments.

In this issue, we are also presenting the ARGITU project, a unique and versatile Low-Energy Accelerator-Driven Neutron Source being proposed by ESS Bilbao. Construction of this type of source is being considered by several EU countries and has recently been highlighted by LENS (the League of European Neutron Sources) to play a critical role in re-creating the European neutron scattering ecosystem that has been so successful over the past decades. We also include an article on our Advanced Welding Facility in Jundiz, where we briefly describe our capabilities and the services we are providing to our customers in E-beam and brazing welding techniques.

Finally, we complete this issue with an interview with Mark Anthony, ESS Project Director, and with Erik Fernandez and Aitor Echeandia from Ineustar.

I hope you will find the content of this issue to your interest and that you will enjoy reading it.

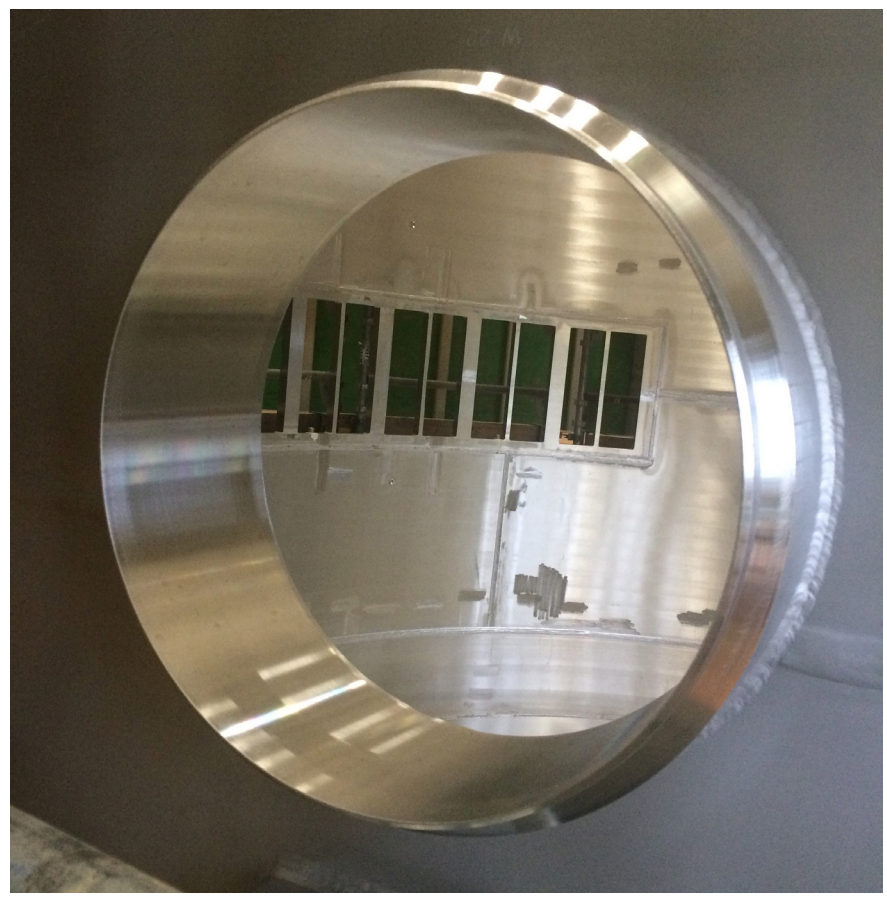
Please stay healthy and safe.

MONOLITH VESSEL, a key milestone

The ESS Bilbao Monolith Vessel is a stainless-steel key component for the ESS Target System, a pressure vessel enclosing the monolith internals, like the target wheel and moderator, reflector plug as well as central shielding block structures. It works to confine the activated material in a vacuum helium atmosphere.

This provides a leak-tight boundary between the outer air atmosphere and the target moderator reflector system atmosphere. Its lifetime is around 40 years and during this time the activated material is confined for normal and accidental conditions. Consider this, the Monolith Vessel has been manufactured under nuclear design rules. It is going to act as a safe barrier due to the reactions produced during the spallation process.

The principal tasks of the monolith vessel are maintaining the helium or vacuum atmosphere inside its volume; supporting its own weight; supporting target components; providing connection positions for electrical supply, cooling circuits and instrumentations



Sucessful work in collaboration with AVS and Cadinox, our industrial partners

and limiting the deformation of the Drive Unit supports to 2mm in vertical direction.

To produce neutrons, it is necessary to accelerate protons (H+ particles) using electromagnetic fields until they get a huge amount of energy and a speed close to light velocity. Then the protons impact on a nucleus of a heavy atom, tungsten, producing what is known as a spallation reaction. Where the spallation takes place is the Target, which is the core of the proper neutron source and for this is considered a complex and challenge engineering device.

A Long journey, ending in success

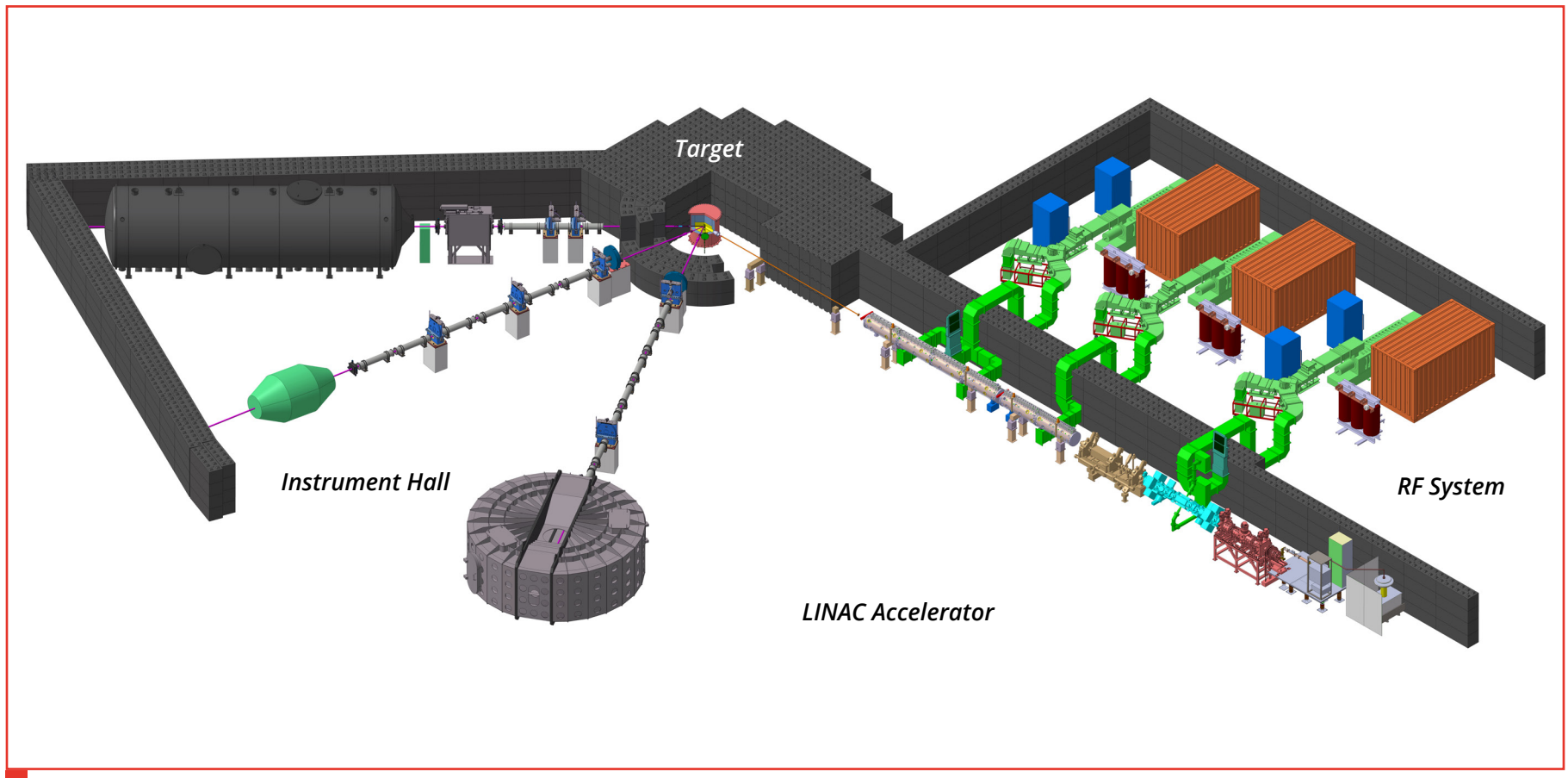
During the last 5 years, ESS Bilbao has been responsible for this important work package always in collaboration with our industrial partners AVS, for the design, and Cadinox, for manufacturing, and all in coordination with the ESS team in Lund. When the latest leak and vacuum test were successfully completed, the Monolith Vessel started its journey to its final destination in the Target building at the European Spallation Source in Lund.

It was delivered in two pieces due to its large weight and size – in total 45 tonnes, six metres high and almost six metres wide. The complex vessel is an important contribution from Spain, provided through the Spanish partner ESS Bilbao and its industrial suppliers AVS and Cadinox.

The Monolith Vessel encloses the Target system, in which the neutrons for use in scientific experiments will be generated. In this steel container, the rotating target wheel, the moderator and reflector plug, and proton beam instrumentation will be installed. In addition, the vessel will contain 1,000 tonnes of steel, shielding the outside from activated materials and ionising radiation generated in the process. Once in operation, a vacuum atmosphere will be kept inside the immense vessel to isolate the critical parts of the target system from the external environment, and to ensure that the neutrons for research can be guided to the instruments.

ARGITU Low-Energy Accelerator-Driven Neutron Source

A unique infrastructure fostering R&D ecosystem in Euskadi.



ARGITU layout.

Background

As per the conclusions of a recent report published by LENS (League of European Neutron Sources), much of the development of neutron scattering capabilities has been through the development of instrument technologies, such as neutron optics and detectors, rather than through the enhancement of the neutron sources themselves.

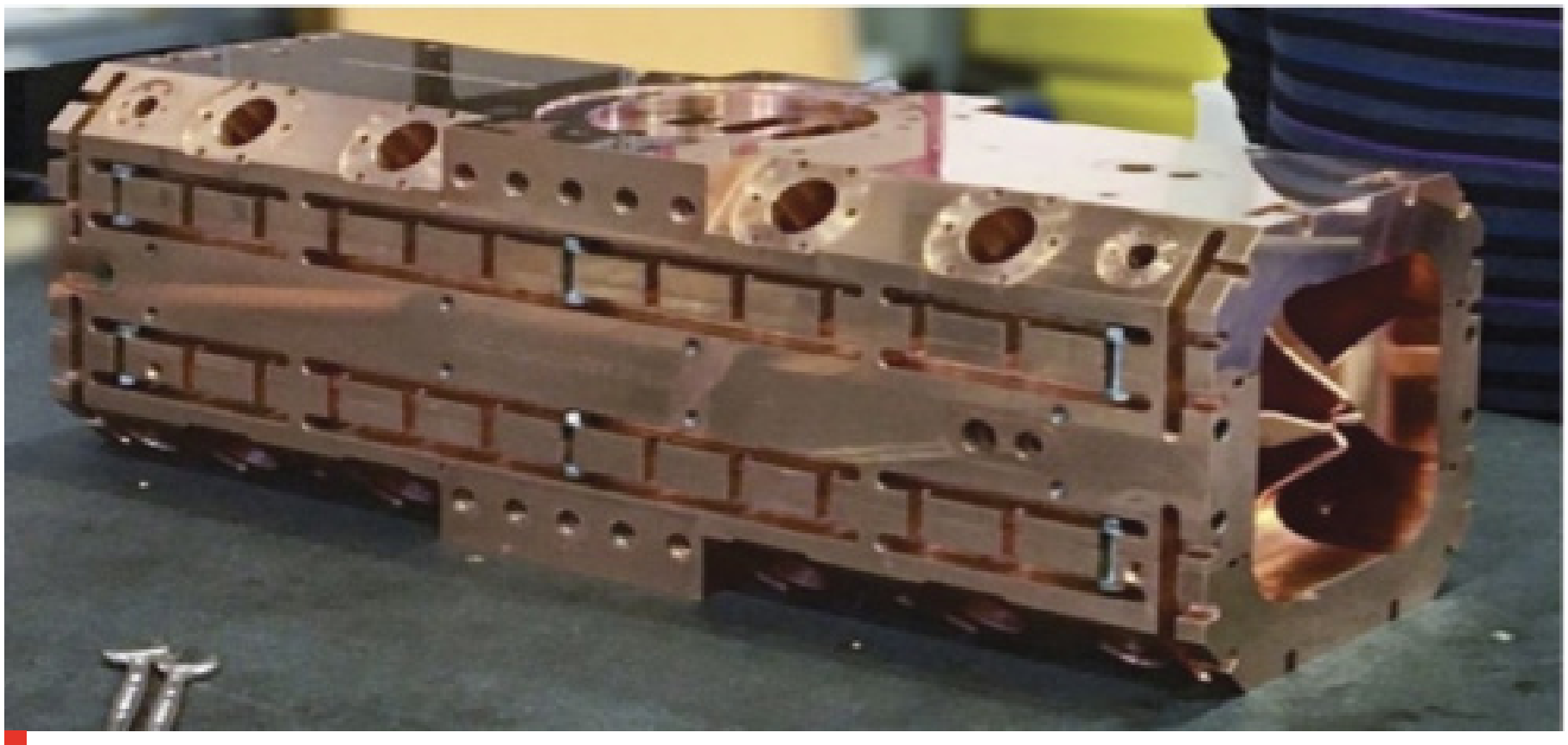
Low-energy accelerator driven neutron sources have existed for decades but have had relatively limited performance and small numbers of users. However, the combination of technological developments, including accelerators, targets and moderators, now offers the possibility to construct and operate such neutron scattering facilities with greatly enhanced performance and considerable flexibility in terms of cost, capacity and capability. These could play a critical role in re-creating the European neutron scattering ecosystem that has been so successful.

ARGITU is a unique and versatile example of such a Low-Energy Accelerator- Driven Neutron Source being proposed by ESS Bilbao. This infrastructure will undoubtedly place the Basque country at the forefront of research in neutrons within Europe and will serve as a magnet for attracting talent, thus fostering a neutron R&D ecosystem.

Accelerator system

The LINAC is conceived of as a multi-purpose machine that could provide a 30 MeV proton beam. The first part of the ARGITU injector is comprised of a proton source of the Electron Cyclotron Resonance (ECR) kind, which has already been built and is in routine operation at the ESS Bilbao R&D lab in Zamudio.

The low energy beam is transported along a two solenoid Low Energy Transport System (LEBT) that will couple the ion source to the 352,2 MHz Radio Frequency Quadrupole (RFQ). This RFQ is based on a modular



First RFQ segment assembled and being thoroughly tested at ESS-Bilbao R&D Lab.

design where the vane sections are held in place by bolts and aims to accelerate a 40mA beam from 45 keV up to 3 MeV while keeping the beam both transversely and longitudinally focused, together with minimum emittance growth. The first segment of the RFQ is being extensively tested at our R&D lab, whilst the other three segments are currently being manufactured.

Once the RF timing structure is set to the beam, it is conveniently matched through the Medium Energy Beam Transport (MEBT) to the Drift Tube Linac (DTL), which will take this 3 MeV beam up to the energy level required by the designed beryllium target (31.5 MeV). The MEBT line will be very similar to the one designed and manufactured for the ESS, which has already been successfully installed at Lund. The current mechanical design of the DTL is based upon results from a collaboration with the Linac4 group from the CERN. Most of the key components of the DTL have already been manufactured. In order to reach the desired 30 MeV beam energy, a 11.5-meter-long structure composed of two tanks is required.

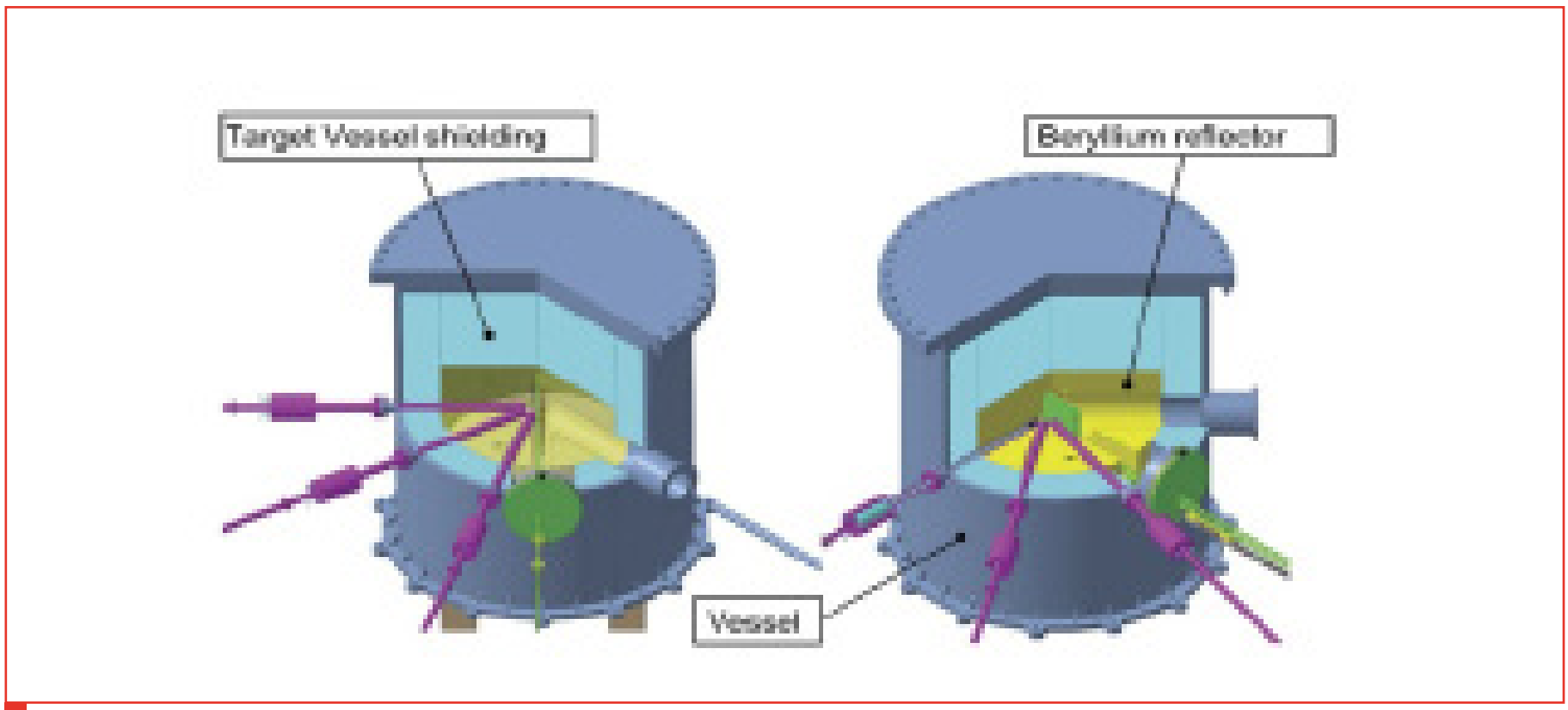
Target system

Based upon the design parameters of the LINAC, a conceptual design of a neutron target station has been developed. The target concept relies upon the neutron-yield properties of the 9Be(p,n) direct reaction. For a proton energy of 31.5 MeV, beryllium maximizes the neutron yield and is thus the selected candidate for the target material. With the expected beam current and duty cycles, the total calculated neutron yield reaches ~$2.7 \cdot 10^{14}$n s^{-1}.

ARGITU is a Low Energy Accelerator-Driven Neutron Source being proposed by ESS Bilbao, for being located in the Basque Country

This expected integrated neutron flux represents an adequate level of particle production for the testing of neutron-instrumentation components, as well as for the operation of several irradiation and scattering instruments.

The target will consist of a beryllium plate joined to a cooling system. In order to avoid blistering, the pro-



Target station (Target – Moderator – Reflector). The target vessel is surrounded by biological shielding (heavy concrete) to avoid doses to the public and workers.

tons will be stopped directly in the coolant. As a back-up solution, an intermediate material with larger hydrogen diffusion coefficient like vanadium will be used as beryllium back plate to stop the protons.

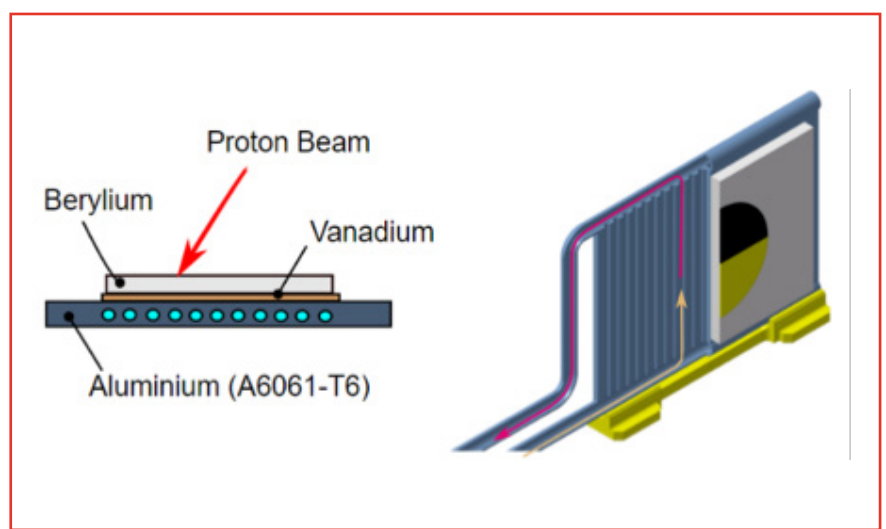
As aforementioned, the neutron source configured with beryllium target will produce ~10^{14} n s^{-1}, being therefore considered as a medium flux neutron source. However, the proton free path in beryllium will be 10–15 mm and thus neutron production will be concentrated in very small volumes, allowing the optimization of the coupling between target and moderator. As the proposed neutron source will have up to four instruments per target station, it could be possible to consider a dedicated moderator per instrument. The proposed moderator will be a methane or mesitylene volume (ϕ40–60 x 40–60 mm) at 22 K. The low thermal load in the moderator (<10 W) will allow the cooling to be done through the aluminum structure, and thus permit the positioning of the cooling circuit outside of the target vessel, therefore minimizing activation.

The target and moderators will be integrated in a beryllium reflector to increase the neutron moderation efficiency. The three systems (target-moderator-reflector) will be surrounded by an aluminum nuclear vacuum vessel ensuring that all the activated material is confined under any operational scenario.

This facility will have enhanced performance in terms of costs, capacity and capability

Instrument suite

The selection of the instrument suite will be made jointly with the potential user community. At this moment, preliminary contacts have been held but a consensus is still to be reached. Notwithstanding, any potential selection should consider both the needs of the scientific community, focusing on the neutron



Beryllium Target Concept, incl. Vanadium back plate.

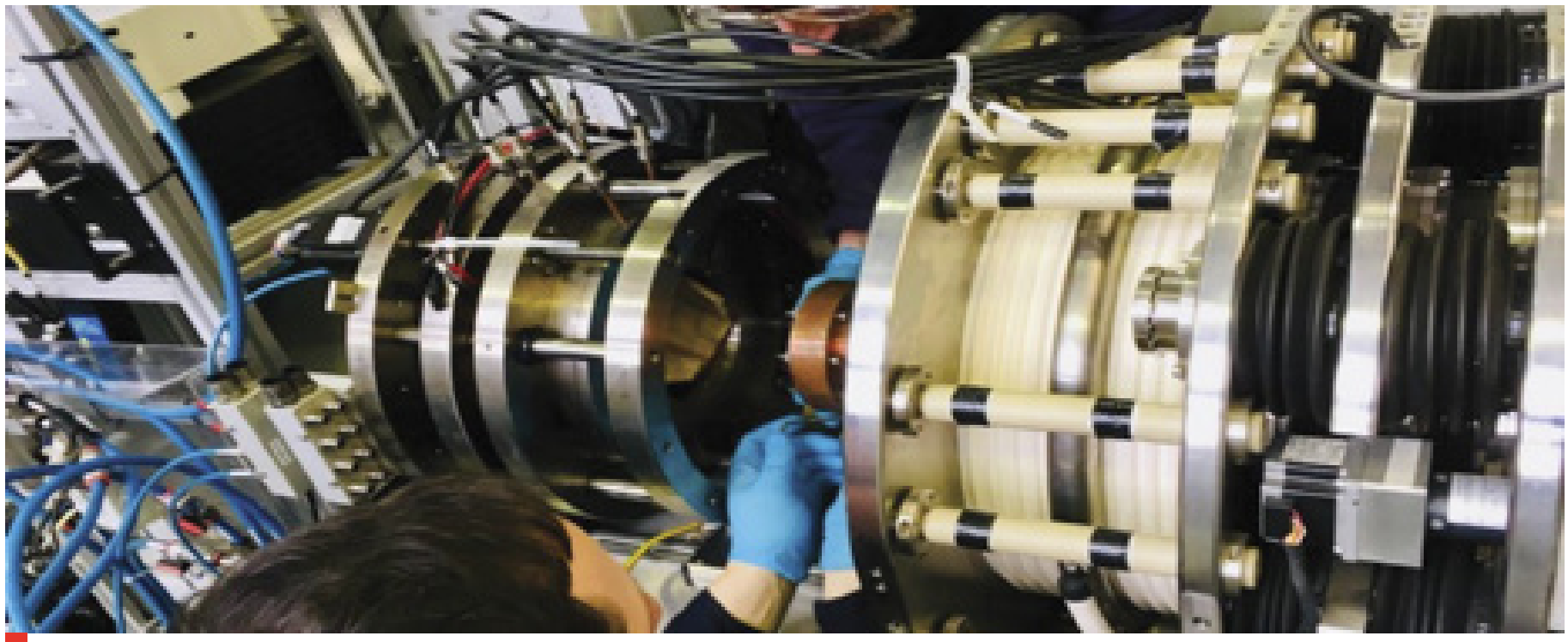


Image of the ion source operating at ESS Bilbao R&D Lab.

Instrument	Pulse length (ms)	Frecuency (Hz)	Beam size (cm^2)	Divergence (º)	Source (λ)		Δ λ/ λ
SANS	~1-2	20-48	1x1	0.4	3-16	Cold	0.1
Single Crystal Diffractometer	0.002-0.2	100-300	0.5 x 0.5	0.5x1	0.6-4	Bispectral	0.01
Powder Diffractometer	0.002-0.2	100-300	1x1	0.5x 1~2	0.6-4	Bispectral	0.01
TOF-BS Spectrometer	0.002-0.2	20-300	3x3	5	3-10	Cold	
NSE	~1-2	20-48	3x3	5	5-10	Cold	0.2
Imaging & PGAA			10x101x30	0.2	0.6-4	Bispectral	1
Reflectometry	~1-2	20-48		0.2x2~4	2-6	Cold	0.1

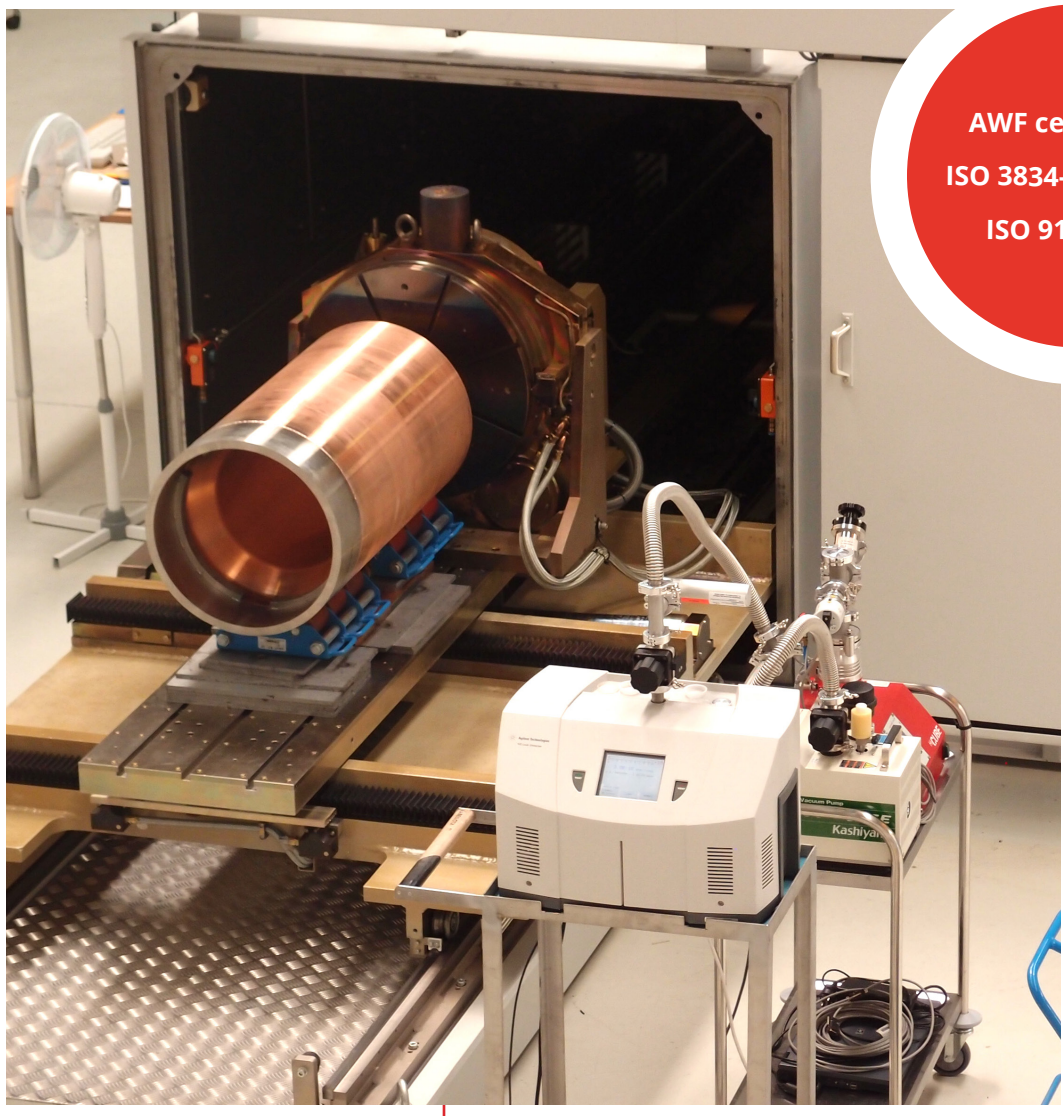
scattering techniques that are more frequently used and yielding the best scientific results, and the technical limitations, due to the moderate flux delivered by the source.

Given the characteristics of the neutron source, the suite of instruments given in the Table below are initially proposed. In principle, it is considered that a SANS, Single Crystal and Powder Diffractometer, and a Spectrometer are the best choices, but this will have to be confirmed with the local neutron user community.

CONCLUSIONS

The development status for ARGITU has been presented. The first part of the accelerator (ion source and LEBT) is in operation at our R&D lab, the RFQ is being manufactured, several components of the DTL are already manufactured, and one RF chain (klystron + modulator) is available, whilst the design of the rest of the components is well advanced. The beryllium target concept is matured, and it profits from the experience gained by ESS Bilbao in delivering key components for the target station of the ESS, Lund. With regard to the instrument suite, even though the number and characteristics of the instruments are still to be decided based upon the needs of the scientific community, an initial set of potential candidates has already been identified.

ESS Bilbao Advanced Welding Facility



AWF certified by ISO 3834-2:2005 and ISO 9100:2018

A facility with advanced welding techniques such as Brazing and Electron Beam Welding (EBW). Strategically located close to 9 important industrial cities in the North of Spain, with a large group of nearby suppliers, it can provide coverage to the industry that needs our services to carry out turnkey projects, with experience in international scientific technology projects such as CERN, ITER or ESS

MAIN SERVICES

- Welding dissimilar materials (CuCrZR-SS316L, V-SS410, Cu-CuCrZr)
- Possibility of brazing with no access via any other method
- Ceramic material brazing
- 1.5m3 furnace capacity and 1200ºC maximum temperature
- e-05 vacuum working zone

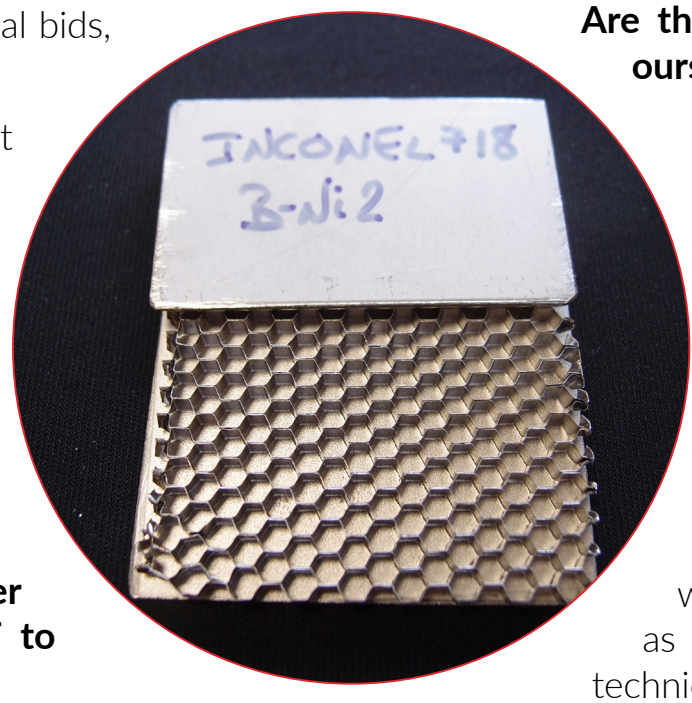
Our added value is to bring together companies with great experience in their fields and provide them with the technological solution that they lack to access international projects

IGOR RUEDA, Head of Manufacturing Division

What is the key to qualify for good national and international tenders?

The strategy followed for years at ESS Bilbao has been to work closely and make good contacts and strong relationships with industrial experts with a high level of know-how in each sector. This has allowed us to achieve the appropriate position to participate in different national and international bids, or even direct offers.

The key is to group the different technologies that the offers require in a serious and solvent technical approach. We always implement our knowledge and experience to offer the best of services, regardless of our role, leaders, partners, or subcontractors.



What added value do we offer with the services of our AWF to companies?

Our added value is that national companies can be technologically trained and therefore choose to present themselves in those turnkey projects that require EBW or brazing technologies. The services offered by ESS Bilbao are always focused on an analysis, study and expert advice to finally provide a solution in projects that require these technologies. That is what our clients demand.

Are we helping companies to train technologically to qualify for international projects?

Yes, clearly. Some examples of participation in international scientific projects are the support and collaboration with companies such as Inmepre, Tecnalia, Sgenia, Gutmar, with AVS in the ITER project; Ramem at CERN; Inmepre and Tecnalia at LIPAC in Japan and Rymsa at the ALBA Synchrotron, to name a few.

Are there advanced welding centres like ours in Spain?

In Spain there is no other facility that combines brazing and EBW technologies in the same location. This fact makes us unique, allowing us to minimize costs and maximize time savings in projects that require both of these advanced welding technologies.

In addition, for those welds that require leak detection as a final test, we can provide intermediate tests, as we have our own vacuum lab and technicians that can carry out a quick leak check on the weld. This is possible since the parts to be welded have to come out of the welding machine a few times for different verification steps, and it helps us in case any repair intervention needs to be carried out. This reduces the risks of final welding and greatly speeds up the processes of those assemblies that have several welding steps, since a leak check as the welded component comes out of the machine can take 45 minutes, whereas if it were done externally, the lead times would be longer with the consequent cost increase.

WHAT'S GOING ON AT ESS BILBAO

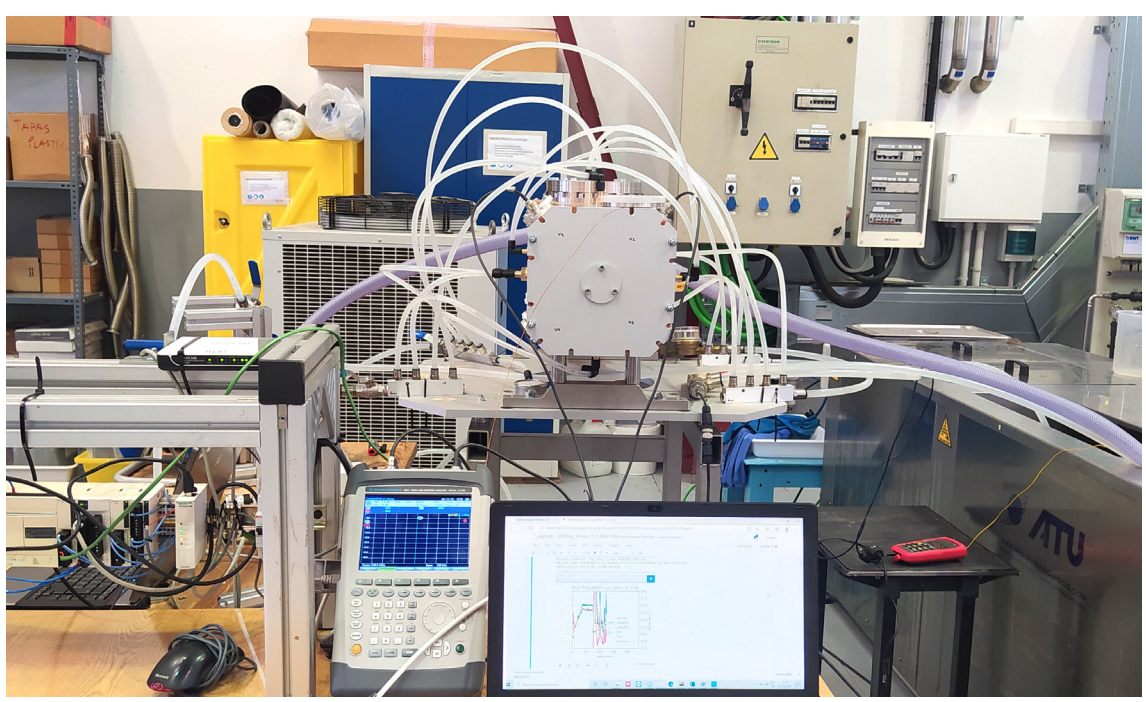
STATUS TECHNICAL PROJECTS

LOW LEVEL RADIO FRECUENCY

ESS Bilbao is responsible for the Low-Level RF systems (LLRF) of the atmosphere temperature accelerator section (RFQ, 3 MEBT buncher cavities and 5 DTL tanks) and the superconducting spoke section (26 cavities), a total of 35 RF systems.

The function of the LLRF control system is to guarantee the stability of amplitude and phase required for adequate acceleration of the pulsed particle beam, without degradation of its quality parameters. Likewise, it is in charge of controlling the cavity's resonance frequency, either by controlling the temperature of the cooling system (in the case of the RFQ), the mechanical tuners (in the MEBT buncher cavities and in the DTL tanks) or the piezoelectric parts (superconducting spoke cavities).

To date, ESS Bilbao has delivered 9 LLRF systems for RFQ, MEBT and DTL. LLRF is a project backed by FEDER funds within the Pluriregional Operational Program of Spain 2014-2020.



RFQ PROJECT

The tuning tests with the cooling water temperature of the first segment have been successfully completed. The next step is to do the tests with the bead pull system, all of this with the aim of concluding the tuning work of the first vane of the RFQ, with both the tuners and with water. At the same time, the mechanization and manufacture of the rest of the segments (2, 3 and 4) in Egile facility continues. Finally, we are working on the power couplers and test boxes where the tests will be done.

TARGET

Final tests are being carried out to insert the cassettes into the target wheel and thus complete the manufacturing process. Once finished, the Target Vessel will be closed. For its part, the wheel shaft will be balanced in the coming weeks to be able to carry out the pressure tests once the machining is completed at the Thuneureka facility in Galicia.

The FAT Factory Acceptance Tests of the drive unit have been successfully concluded at the AVS Added Value Solutions facilities in Elgoibar.

ISOLDE SUPERCONDUCTING RECOIL SEPARATOR

ESS Bilbao, together with a group of national and international institutions, have signed a Letter of Intent to make an installation that uses the beams of HIE-ISOLDE, a laboratory within CERN, in which to carry out nuclear physics experiments (with heavy ions). This facility will have different instruments with which to do the experiments. The proposal comes from a group of experts in nuclear physics and superconducting magnets.

ISRS (ISOLDE Superconducting Recoil Separator) consists of a small ring into which the beams resulting from the interaction between the HIE-ISOLDE ion beam and a gas are introduced. The product of the reaction is what nuclear scientists are interested in studying. For this, an instrument is necessary that manages to separate the primary beam from the different reaction products (gases), this is what is called a mass spectrometer. The differential characteristic is a design based on curved superconducting magnets and it is very compact.

ESS Bilbao's proposal is to design some of the main elements of the instrument, such as the multiharmonic buncher, an RF cavity that manipulates the primary beam to accommodate the spacer ring and the ring insertion and extraction elements.

CERN has validated the Letter of Intent presented by the partners who will now prepare the technical project proposal.

LATEST NEWS BEYOND BORDERS

"ESS Bilbao is an essential partner to ESS"

MARK ANTHONY, ESS Project Director

Perry Nordeng/ESS

How did construction of the ESS progress in 2020? What will be the main milestones at ESS during 2021?

Despite the challenges caused by the pandemic, the ESS construction continues to progress, and the project is now 76% complete. We achieved some very significant milestones during 2020, including the delivery and installation of the target monolith vessel from ESS Bilbao, and the delivery of the first series production cryomodules for the linear accelerator. That said, Covid has struck our partners with different strength, where some have been forced to close down for several months during the year. This has of course had an impact on progress.

One of the main milestones at ESS during 2021 will be the commissioning of the normal conducting part of the linear accelerator, where the proton beam will be accelerated through some 50 metres of room-temperature accelerator components. Another important milestone will be the inauguration of our permanent offices, ESS Campus, which will house the ESS staff and be the meeting point for all visitors and future users of the fa-

cility. We also look forward to important progress in the target station this year, with the delivery of the target wheel, drive and shaft from ESS Bilbao as a major milestone.

How is the Covid19 pandemic affecting ESS and the construction?

Construction work on site in Sweden has continued during the year, but deliveries from our partners in our member countries have been significantly impacted, with the pandemic still ongoing delays of up to 10 months reported so far.

Our priority is to ensure that all of our staff, contractors and visitors remain safe, while keeping the project moving forward as fast as possible. All those who can work from home are doing so, while others carry out installation tasks on site with extra safety measures in place.

Looking ahead, which are the main challenges ESS will face going forward?

We are in an ongoing pandemic which affects deliveries from our partners and installation works on site, and we work hard to reduce the impacts when it comes to schedule and extra costs caused by Covid-19 for the project. This is a unique, global situation, and it is too soon to say with certainty how this will affect our schedule.

How much does the construction of a large international project like ESS depend on the successful delivery of the in-kind model? What is the added value of this model?

Some 30% of the total ESS construction budget comes in the form of in-kind deliveries, comprising equipment, personnel or support services from institutions in the member states. The in-kind model ensures that key technologies are cultivated and enhanced in the member states, supporting national institutes and industry. In addition, the in-kind contributions help foster the political goodwill and collaboration required for large international projects.

How would you describe the coordination of technical works with the in-kind partners, and in particular with ESS Bilbao?

ESS is a collaboration project, with more than 40 in-kind partners in the 13 member countries. The coordination and cooperation with our in-kind partners is crucial for the success of the project, and ESS Bilbao is no exception.

"We are looking forward to important progress in the target station this year, with the delivery of the target wheel, drive and shaft from ESS Bilbao"

Do you think ESS Bilbao is playing a key role during the construction project? How do you see its contribution to the success of ESS?

ESS Bilbao has been an essential partner to ESS for more than ten years, working hard together with us to build the world's leading neutron source. The competent ESS Bilbao teams are designing, manufacturing and delivering several key components to ESS, such as the MEBT in the accelerator, the target wheel and the MIRACLES instrument. We could not deliver this project without the key contributions by ESS Bilbao.

INEUSTAR, The Spanish Science Industry Association

INEUSTAR, The Spanish Science Industry Association, is a Spanish, non-profit association of industrial companies dedicated to the conception, design, construction, exploitation and maintenance of scientific instruments and facilities, located in the Basque Country. Its mission is to work for the benefit of the Spanish Science Industry to contribute to the progress of science and technology.

Erik Fernández, General Manager of the Association affirms that Ineustar, in addition to being the first with these characteristics in Europe, is also a clear example of public-private collaboration between companies, public administrations, research organizations, technology centres and unique technical scientific infrastructures -ICTS-.

Know how to identify joint interests through In-Kind contributions.

During the more than 10 years since it was created in the Basque Country, Ineustar has achieved structures in a sector giving it visibility through actions that have managed to technologically train the companies that make up the association. The key, according to Fernández, has been to identify joint interests for all of them, be they scientific, technological and industrial through In-Kind contributions.

ERIK FERNÁNDEZ, INEUSTAR General Manager

"The pillars on which Ineustar bases its relationship are collaboration, optimization of synergies and knowledge transfer"

What are the science and technology sectors in which Spain and Spanish companies play a prominent role?

The science industry in Spain encompasses different types of technologies ranging from optics and optical instruments, electronics, magnetism and superconductivity, RF, vacuum, precision mechanics. Many of these are transversal to all business sectors: medicine, space, aeronautics, energy, transport. The Spanish science industry is present in projects of the size of ITER, in addition to other international projects in the field of particle accelerators, or in the sector of Astrophysics and Space Sciences.

The joint work that Ineustar does with the collaborating companies and institutions on what pillars is it based? What is the relationship between Ineustar and ESS Bilbao?

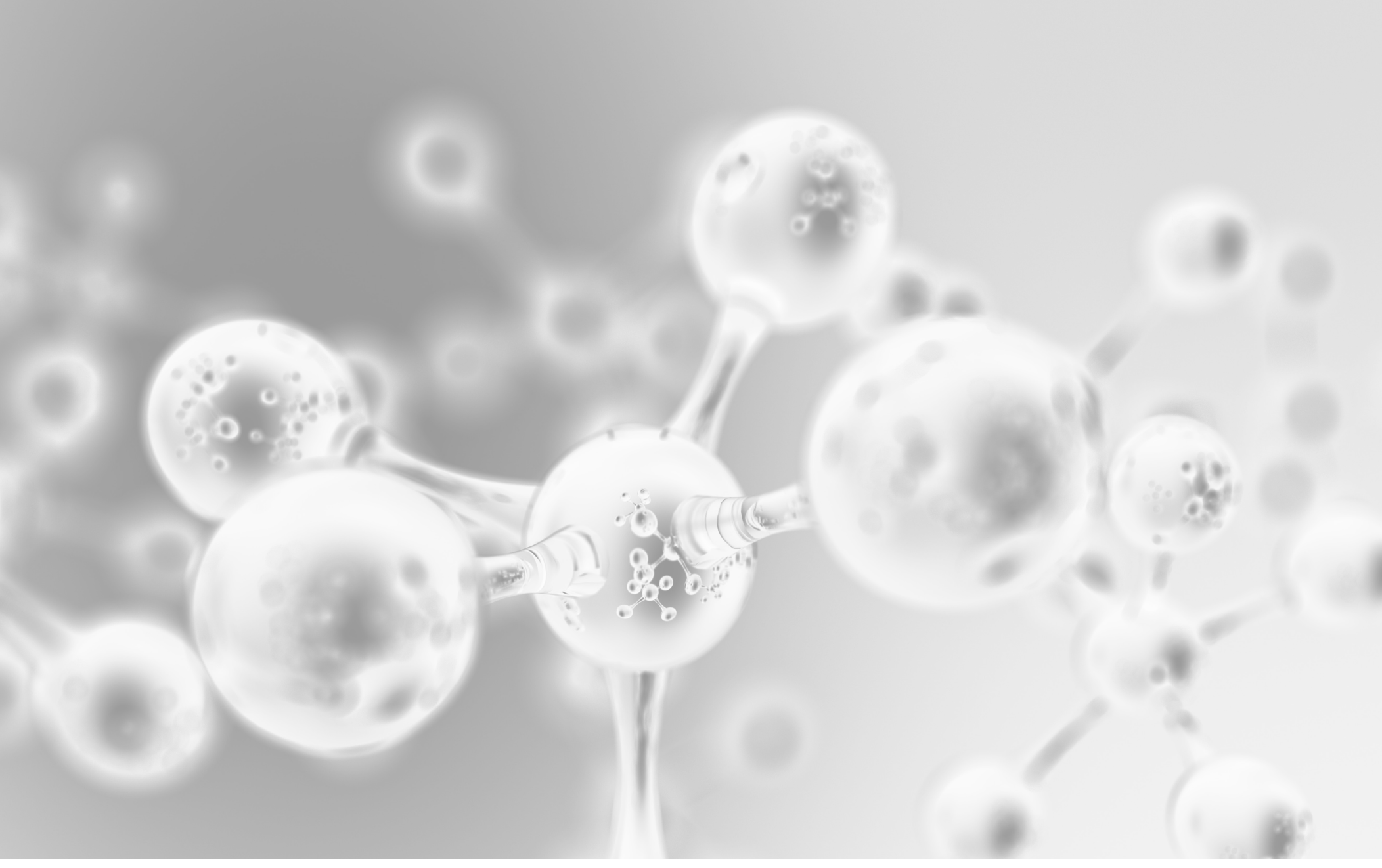
The pillars on which Ineustar bases its relationships are collaboration, optimization of synergies and knowledge transfer. Thanks to this, the participation and responsibility of Spanish companies has grown to become responsible for systems of great technological challenge and critical elements within large research infrastructures. Since its creation, ESS Bilbao and Ineustar have maintained a close collaboration, promoting this from the early stages of the design of the different contributions and fostering the participation and training of Spanish companies. ESS Bilbao has had a driving effect within the industrial and scientific sector, offering the possibility of participating in large international projects and always with a collaborative disposition.

Aitor Echeandia, Chairman of INEUSTAR and CEO of Elytt Energy, thinks the in-kind contribution model as a leverage factor for the industry is a very useful methodology that favours the role of companies in the sector in large international scientific facilities, training them in cross-cutting technologies with great potential and application in multiple scientific infrastructures throughout the world. This In-Kind contribution method offers the possibility to companies to participate in large projects, it is the gateway to the main facilities. Luckily, we have many examples of contributions that helped catapult many companies in this sector thanks to different factors, such as the case of Elytt Energy, where the start of small engineering activities led to a large contract of 35 M€ with ITER. Moreover, the experience and reference gained in RCC-M rules thanks to the contracts for the design and manufacture of the ESS drive-unit and monolith vessel by AVS and Cadinox in the manufacturing of the monolith vessel is very useful for obtaining new contracts in facilities under nuclear regulations. Also, the case of JEMA, directly related to ESS Bilbao, is very representative. They manufactured a Klystron modulator together with ESS Bilbao as part of the Spanish contribution to ESS. Later, they achieved a direct contract with ESS for the manufacture of at least another 9 modulators with a budget higher than 9 M€.

In your opinion, what are the main challenges ahead for the Science Industry in Spain?

We can affirm that we are currently in one of the best moments in recent years, which is a great opportunity to improve the international positioning of our industry. Even with this, we must continue to promote joint actions that reinforce our image as a science industry to be competitive and be attractive to highly qualified people, we must learn to attract talent.

We have years ahead where science will play a key role in the development of social welfare, as a science industry we will have to adapt to new technological developments, generating synergies that provide added value and allowing us to tackle new challenges.



newsletter

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