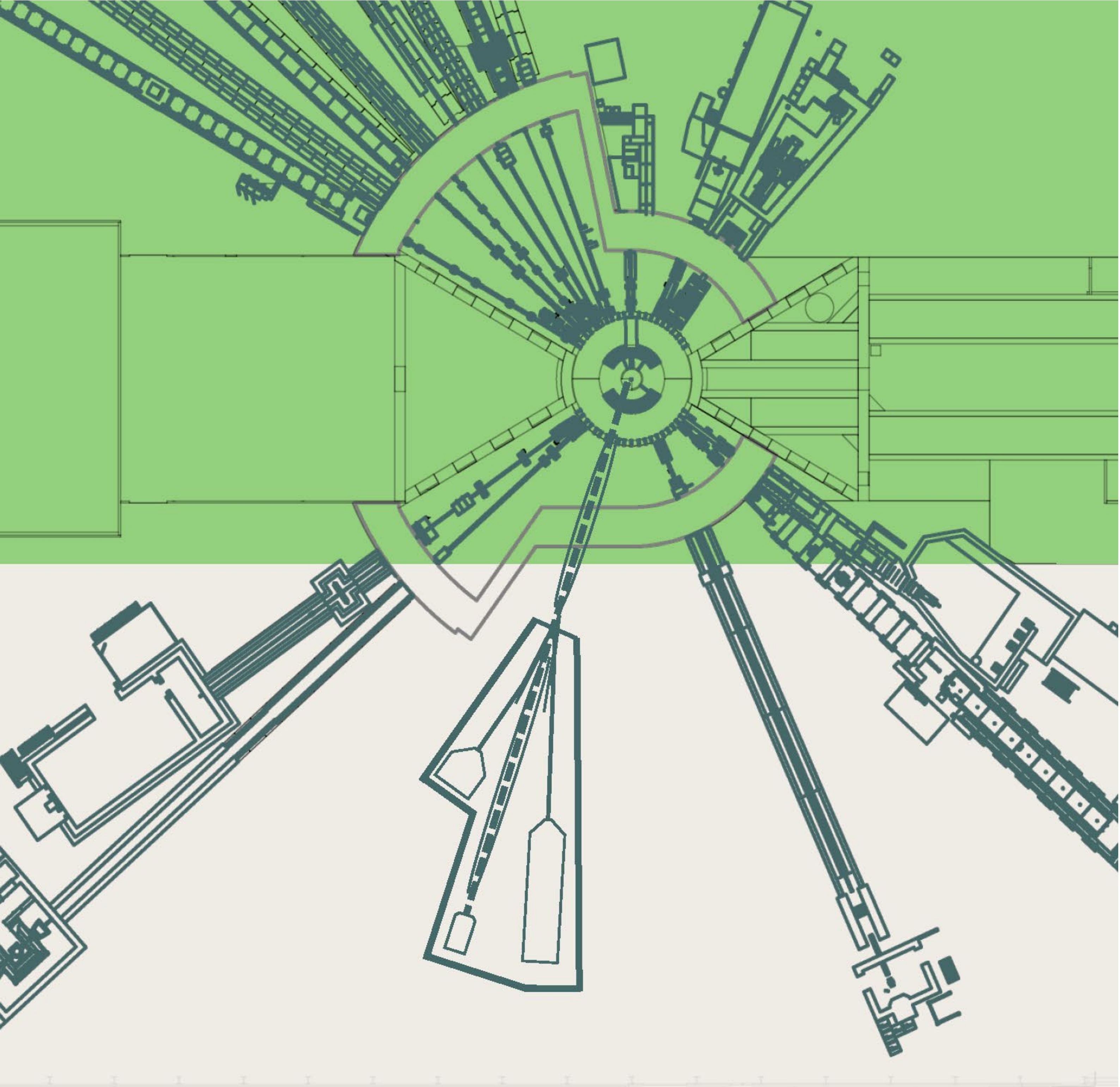

IDUN

Industrial & Utilitarian Neutron Instruments

ESS Instrument Roadmap 2026

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Executive summary

IDUN is a **high-performance guide bundle** concept that combined with work-horse instrument designs and automated systems will enable ESS to provide high throughput state-of-the-art measurements for a multitude of scientific and industrial users. With focus on automation and standardized modes of operation, IDUN will provide advanced materials characterization methods to both established **SANS, imaging**, and **reflectometry** user communities as well as new non-expert scientific users and R&D teams in high-tech industries.

The priority is to provide a **low barrier of entry to neutron experiments**, where researchers can utilize the techniques as one of many scientific tools in their work. The goal is to expand the future user base within many different fields of research, e.g. energy technologies, advanced manufacturing, semiconductor technology, quantum devices, pharmaceutical development, and food science.

The examples of research areas listed above are also highly relevant to high-tech industries across Europe where neutron measurements can accelerate product development and play an important role in quality control. To provide these services, IDUN will be designed to provide reliable and reproducible measurements with high throughput and fast access to results.

Proposed by

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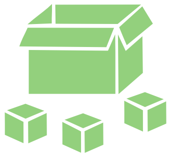
Jonas Okkels Birk

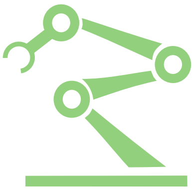
Acknowledgement

We would like to thank Ken Andersen, Mark Johnson, Kim Lefmann, and Paul Hurley for helpful discussions and comments on the manuscript. And the ESS staff for support and help, especially Robin Woracek and Andrew Jackson, for sharing their insights.

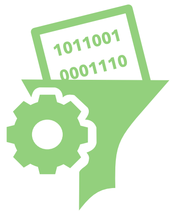
1. “Neutron science for everyone” (scientific driver)

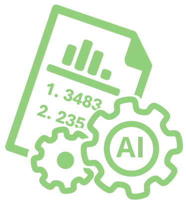


The “key scientific driver” of IDUN is slightly different from typical neutron instruments, as the instrument(s) will be designed with a focus on ease of access to advanced materials characterization methods to non-expert researchers, both from academia and in high tech industries across Europe.



We wish to transform the user experience from neutron *experiment* to neutron *measurements*, where IDUN will provide reliable and reproducible measurements with automated high throughput service, where samples are labeled and stored potentially in an anonymized way, to provide confidentiality for companies and researchers.





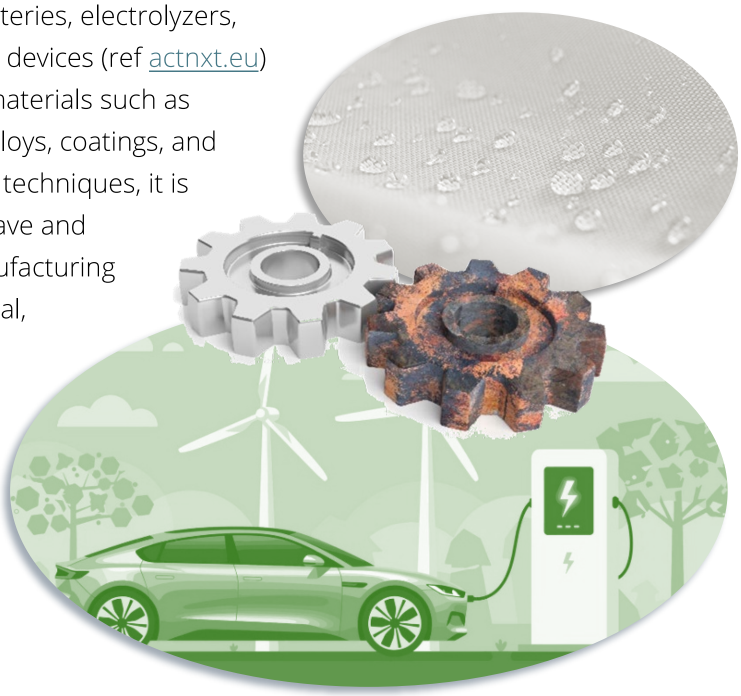
Automated data reduction and AI assisted data analysis will provide fast access to results, and the instrument scientists should focus on providing useful results that can add value for high tech industrial research and enable neutron techniques to become one of many scientific tools at the disposal for researchers both in academia and for industrial product development work.

1.1. Societal relevance

Europe holds, with its large-scale neutron research infrastructures, a world-leading position in specialized materials research. By embedding this expertise into industrial innovation pipelines, Europe can accelerate the deployment of green technologies, develop new types of drugs, strengthen strategic value chains and infrastructure, and support a more resilient and competitive Europe.

Green energy solutions and environmental protection

Companies producing next generation- batteries, electrolyzers, hydrogen technologies, and energy storage devices (ref actnxt.eu) dependent on development of advanced materials such as specialized polymers, high-performance- alloys, coatings, and porous media. With the help from neutron techniques, it is possible to understand how materials behave and find ways for environmentally friendly manufacturing practices where materials recycling is central, and perhaps even the cheapest option when fully developed (ref remade-project.eu). Europe can exploit the leading position in materials research to protect the environment by designing smart advanced filter solutions for PFAS, microplastics, or other persistent pollutants.



Raw materials and low emissions heavy industries

To minimize CO_2 emissions, it is vital to find new ways to produce steel. Neutron techniques can give a unique insight into how iron ore can be reduced using Hydrogen as a fuel (ref zerosteel.eu). Due to the neutron's ability to penetrate large objects while still being sensitive to Hydrogen, it is possible to take images of the reduction process while it takes place inside a furnace and crucible. A second good example where CO_2 emissions can be reduced is in concrete production (ref eCem). Additive manufacturing can provide a more sustainable production with less excess material, and new materials and properties are needed to make 3D printed components more versatile and useful across industrial sectors.

Neutron-based characterization can play an important role in the sustainable management of critical raw materials (CRMs), including rare earth elements, by providing detailed insight into their chemical speciation and phase distribution in complex primary and secondary resources. This is particularly relevant for end-of-life magnets, batteries, electronic waste, industrial process residues, slags, and tailings, where valuable elements are often embedded in heterogeneous, multiphase matrices that are difficult to analyze with conventional methods alone. Neutron methods are well suited for studying materials under in-situ conditions relevant to hydrometallurgical and pyrometallurgical recycling routes, including leaching, precipitation, solvent extraction, thermal treatment, and redox-driven separation processes. Such capabilities are valuable for optimizing selective recovery routes for rare earths and other CRMs, improving process efficiency, reducing chemical consumption, and minimizing waste generation. More broadly, neutron methods can support the design of advanced recycling strategies and secondary refining technologies that strengthen supply security and contribute to a circular materials economy.

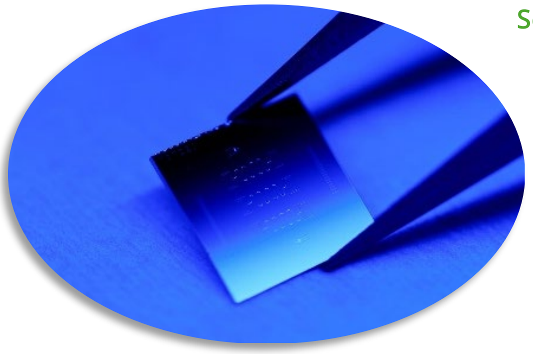
Food science

Neutron scattering provides access to the multiscale structure and dynamics of food systems, particularly in soft, heterogeneous, and water-rich materials where hydrogen contrast is highly informative. It can be used to probe protein aggregation, gelation, fat crystallization, emulsions, phase separation, and water distribution at molecular to mesoscopic length scales. This is especially relevant for the development of plant-based foods, where the structure–function relationships determine texture, stability, and sensory performance. By resolving how processing conditions affect protein networks, lipid organization, and hydration, neutron scattering can support the rational design of food products with improved functionality and consumer acceptance.

Drug delivery and pharmaceutical formulation

Neutron imaging can support the development and optimization of medical devices by enabling real-time visualization of drug dispersion, for example from injector pens into muscle tissue or other processes where operando studies will provide new vital information.

Neutron reflectometry and SANS can be used to elucidate delivery mechanisms at biological interfaces, including lipid nanoparticle (LNP)-membrane interactions, endosomal escape pathways, and the influence of the protein corona on the delivery of RNA-, DNA-, and other advanced therapeutics. In addition, these techniques can reveal the molecular basis of antibiotic-membrane interactions and membrane-active antimicrobial peptide function, contributing to research on antimicrobial resistance. They are further relevant for investigating membrane-associated pathophysiological processes such as liquid-liquid phase separation and protein aggregation linked to neurodegenerative disorders. In pharmaceutical formulation science, neutron methods can also support the characterization of nanostructured carriers and polymer-based systems, including materials produced by Polymerization-Induced Self-Assembly (PISA), a scalable one-pot route to block copolymer nanoparticles with tunable morphologies.



Semiconductor technology and quantum devises

Neutron-based analysis can provide essential complementary information for the development of the next generation of electronics and optical devices. With the current development of dedicated technologies for energy efficient AI processors, 3D monolithic integration and next generation micro-LED technologies, the understanding and quantification of hydrogen in semiconductors is growing in importance.

Neutron techniques can play a vital role in the development of monolithic integration for semiconductors used in optoelectronic devices, where hydrogen can de-passivate dopants in III-V semiconductors. It could also be possible to engineer the presence of hydrogen to achieve multi-level memories required for dedicated AI processors. The study of hydrogen in semiconductors has remained an essential aspect from the perspective of scientific understanding and technological development, as hydrogen can be both beneficial and detrimental in semiconductors.

Solid-state based quantum systems are highly attractive for quantum computing due to their compatibility and scalability with well-established Si-based electronics; however, several suggested material systems are challenged by the requirement for ultrahigh isotopic purity of the material. While this is difficult to follow up by conventional electrical or structure characterization methods, neutron scattering and imaging-based approaches are promising both for scientific evaluation of the impact of isotope concentrations and for quality control of new technologies.

1.2. The potential for new technology and science

The neutron-based methods planed for IDUN are imaging, SANS, and reflectometry, which together provide an exceptional toolbox for addressing societally and industrially relevant challenges. The integration of these complementary tools into the same instrument-set-up is unique among neutron sources in the world. The measurement portfolio will support research and innovation for the discovery of new advanced materials in alignment with the ambitions of the Innovative Advanced Materials Initiative The Innovative Advanced Materials Initiative (ref iam-i.eu), and the upcoming Advanced Materials Act (ref ec.europa.eu/research-area).

A key strength of neutron techniques is their ability to deliver non-destructive measurements under realistic operating conditions, making it possible to study how materials and components behave during actual use or processing. This capability is highly valuable for understanding performance, structural evolution, and degradation in complex systems, and can play a crucial role in materials optimization and in shortening industrial development cycles.

Neutron methods also provide powerful tools for quality assurance, defect detection, and failure analysis, helping to reduce the risk of manufacturing defects, unplanned downtime, and environmental incidents across a wide range of industries. By enabling deeper insight into internal structures, interfaces, and dynamic processes that are often inaccessible with other techniques, they support more robust product development and process control.

Access to cutting-edge neutron-based R&D is therefore of strategic importance for European industry, strengthening innovation capacity, supporting advanced manufacturing, and enhancing technological competitiveness. The European Research Infrastructures (RIs) are leading in the world and a key element in the new European strategy for Research and Technology Infrastructures is to strengthen the coupling between RIs and industry (ref europa.eu/strategy). IDUN will deliver on this strategy. In a rapidly evolving global landscape, these capabilities contribute not only to industrial leadership, but also to European resilience, supply security, and the ability to stay at the forefront of technological development.

1.3. Potential user community

The goal of this instrument concept is to expand the future user base within many different fields of research and high-tech industries and to transform neutron techniques from only being used by a small community of expert users and into a tool or service that bridges the gap between academia and industry. The absolute majority of industrial problem holders do not perform neutron experiments and are currently deterred from such measurements by the complexity and cost of running such experiments.

To service industry effectively, experiments must become measurements, and these measurements must be reproducible. Industry – especially pharmaceutical and biomedical activities – requires reliable, reproducible results, such that two measurements carried out months or years apart are directly comparable, without caveats e.g., for inclusion in drug approval applications. Academia often seeks bleeding-edge equipment, which often comes at the cost of having an instrument that is constantly in a prototype-like state. IDUN should be a reliable, consistent instrument, whose operation is transparent to end users, where reproducibility is assured. Such constant performance characteristics also enable stronger integration with industrial standards, which again increases the applications and value of such measurements considerably.

2. Technical overview of IDUN

The novelty of the IDUN instrument design lies with the implementation of a high performing guide bundle idea first developed during the early instrumentation work performed for ESS. The concept and initial **McStas** simulation results were presented at IKON1 in 2011, and later optimized with **Guide_Bot**. An in-depth description of the full work can be found in ref Neutron guide-split: A high-performance guide bundle concept for elliptical guides by Sonja L. Holm, Mads Bertelsen, Jörg Voigt, Ken H. Andersen, Kim Lefmann, *Nucl. Instr. Meth. Phys. Res. A, 782* (2015).

2.1. Neutron guide-split in short

The beauty of the guide-split concept is that ALL sample stations simultaneously receive a fully illuminated phase space, making each sample station on par with other ESS instruments when using a cold neutron wavelength band and a divergence below 0.5°. An illustration and brief explanation of how this can be achieved can be found in Figure 1.

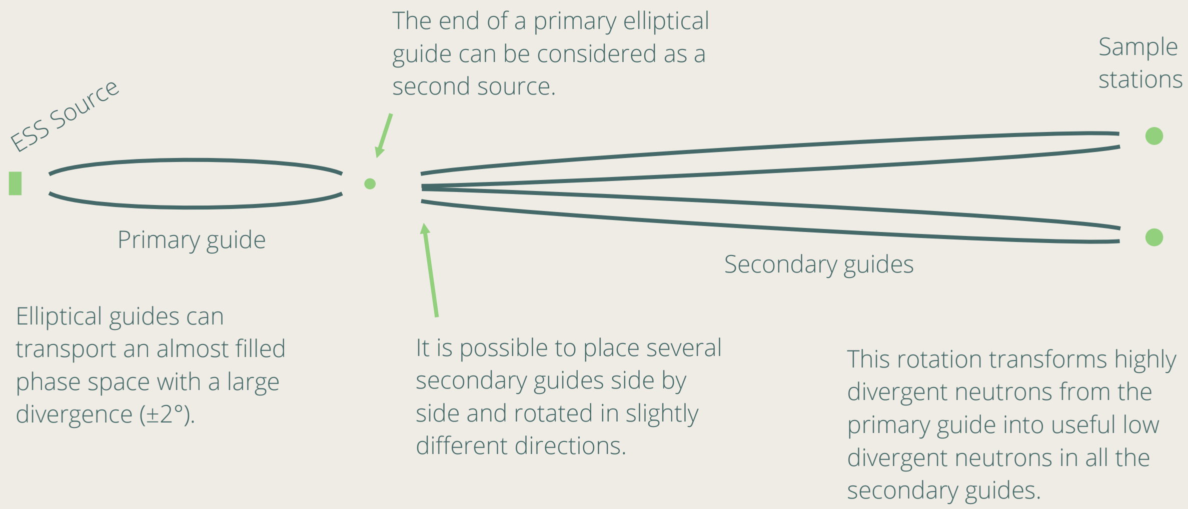


Figure 1: Schematic illustration of the guide-split system where the guide system is split into two.

The performance of a guide system is typically measured in *brilliance transfer*, a number between zero and one, that relates the number of useful neutrons emitted by the source to the number of neutrons arriving at the sample (neutrons with the desired wavelength and angular divergence hitting an area). The primary guide, shared by all end-stations, transports neutrons with a high angular divergence, which in most typical instruments gets filtered away before the sample. The secondary guides each catch these extra neutrons flying in their directions, hence converting otherwise useless neutrons with a high angular divergence into useful neutrons with a low divergence. It is thus possible to fully illuminate more than one sample position from a single beam port. In the study described in the Neutron guide-split paper, several different types of splits were simulated in **McStas** and the graph in Figure 2 shows the main results.

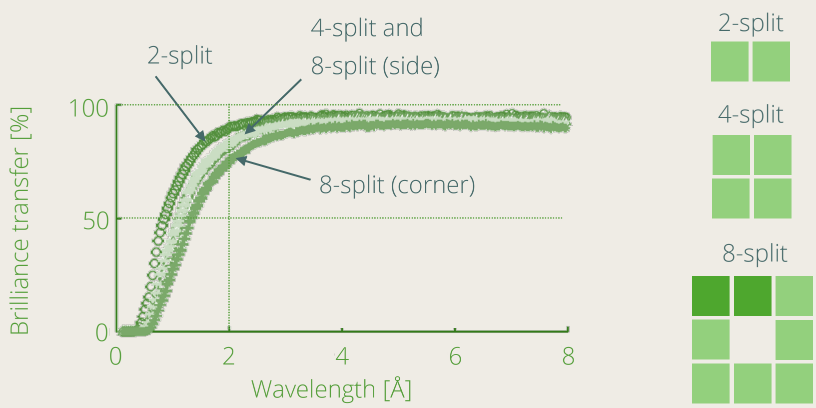


Figure 2: Performance of three different types of guide-splits as a function of wavelength. The right panels show cross sections of the three different simulated guide systems seen from the split point (ref Neutron guide-split).

It is clear from the graph in Figure 2 that guide-splits perform well for neutrons with wavelengths above 2 Å.

As all the end-stations on the guide bundle must share the first chopper that defines the shape of the pulse, all instruments will have to run with the same time resolution. However, each instrument branch can have wavelength band defining choppers placed after the split enabling the instruments to independently operate with different wavelength bands. An illustration of how this works is shown in Figure 3 where two time-of-flight diagrams show how a change in the phase of the wavelength band defining choppers gives a warmer or colder wavelength spectrum.

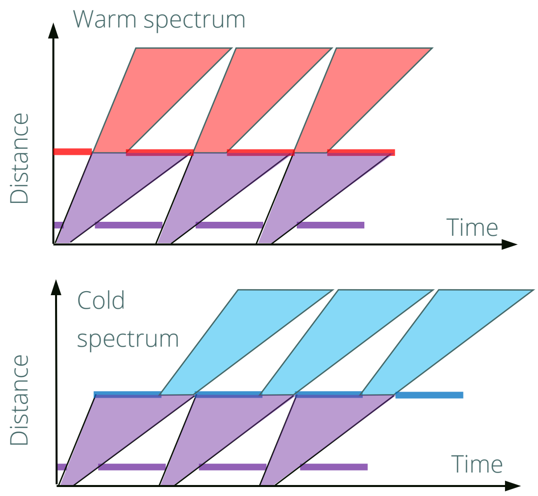


Figure 3: Time-of-flight diagrams.

The guide-split instrument is well suited to be built in several stages, as the end-stations can be added one by one. We propose to design the guide system to be able to accommodate up to six end-stations when finished: three short instruments and three long instruments. For this proposal round, we will focus on the three short instruments, leaving three slots open for later development.

The neutron techniques proposed to fill the three first end-stations of IDUN are **SANS, imaging, and reflectometry**. They have similar requirements: A cold wavelength band and a low divergence; ideal for the guide-split concept. All three techniques are suited to operate with a relaxed energy resolution and a rather broad wavelength band, meaning that they should work well as "short" instruments which in turn means that they can fit inside the existing guide hall at ESS.

2.2. Instrument layout and proposed location at ESS

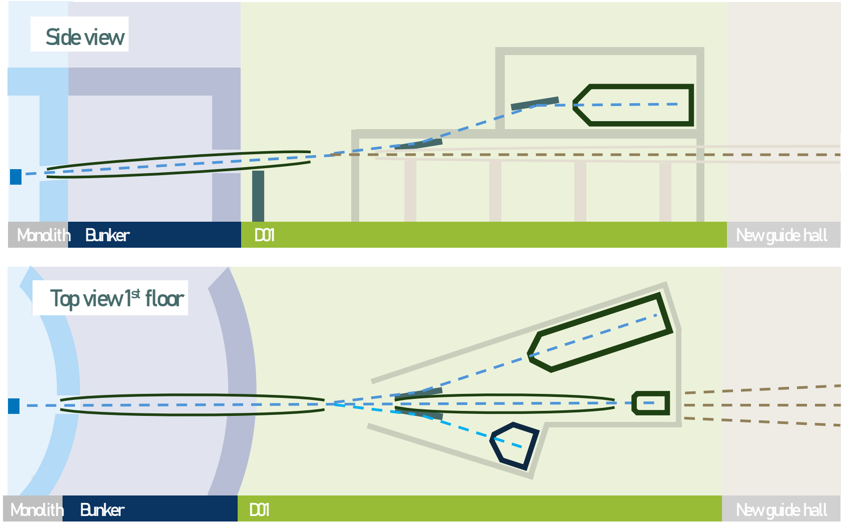


Figure 4: Concept drawings of the instrument layout. The top panel shows the vertical split of the instrument where the short end-stations will be placed on the 1st floor leaving room for the long guides to pass under in the future. The primary guide is slightly inclined so that the future long guides can run horizontally. A set of super mirrors will take the beams for the three short instruments up at the split position and then horizontal to the sample station. The super mirror design will be an integrated part of the beam manipulation system i.e. collimation and other optics components. The bottom panel shows a possible configuration for the three short end-stations seen from above. They all share a common outer cave and smaller crosstalk shielding will be placed between the end-stations.

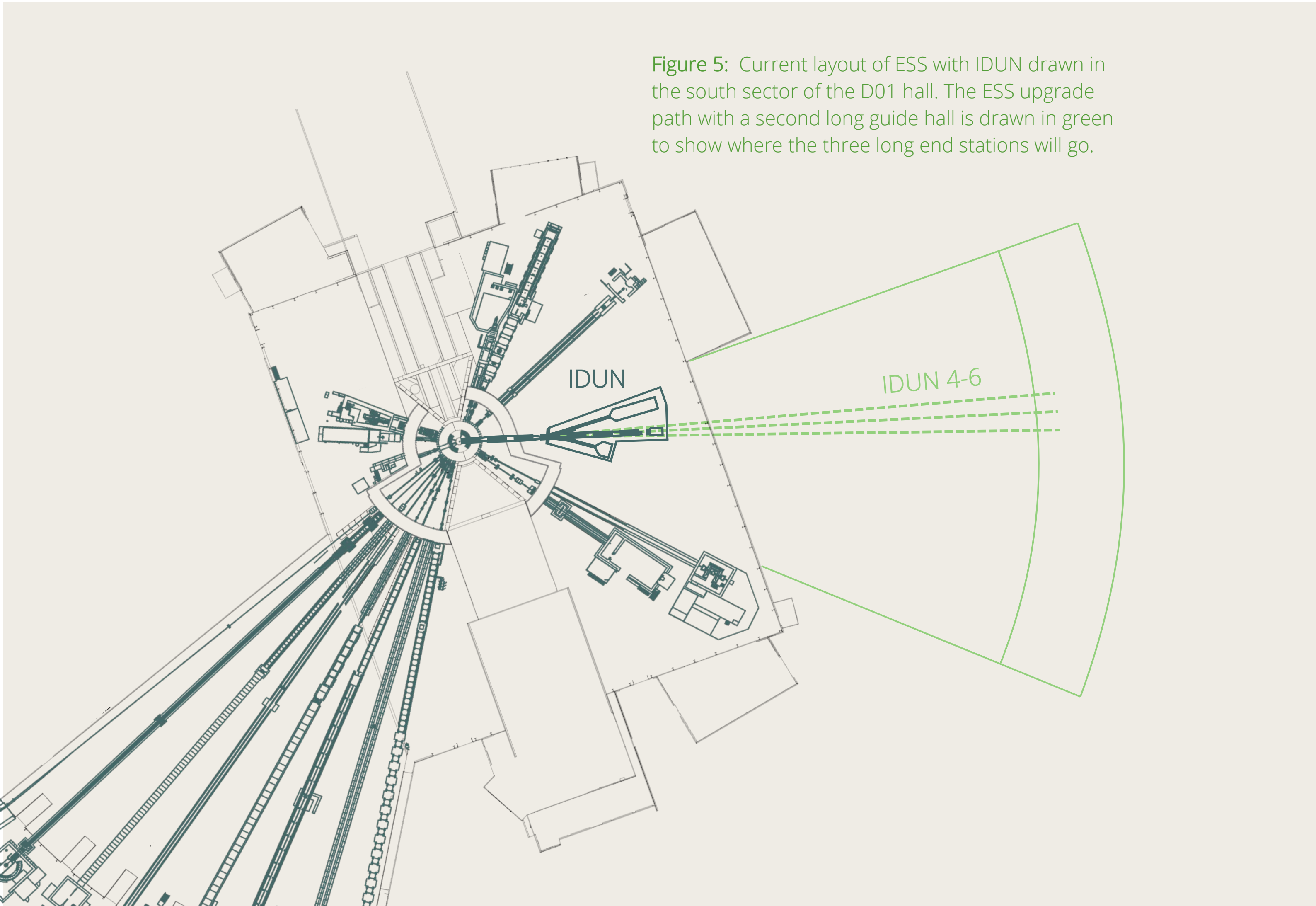


Figure 5: Current layout of ESS with IDUN drawn in the south sector of the D01 hall. The ESS upgrade path with a second long guide hall is drawn in green to show where the three long end stations will go.

The main motivation for placing IDUN at beam port S8 or S9 in the south sector is that it allows room for three additional short instruments at ESS, in a position foreseen only to accommodate space for guide to the next long sector. In addition, it allows room for an upgraded path with very little compromise to the performance of each of the end-stations.

2.3. Modular instrument with flexible upgrade path

As the instrument is modular, there will be the possibility to build, upgrade, and adapt the end-stations as the demands from industrial users change. It is hard to predict which characterization methods will be in high demand ten years from now, especially in the young deep-tech sectors (quantum and AI chip fabrication), where the emerging demands are developed as tech matures.

There will of course be techniques outside the scope of IDUN's capabilities, however, there is a wide range of instrument types well suited to operate with a cold wavelength band with a limited phase space. Short instrument with high-flux and relaxed energy resolution includes SANS, imaging, reflectometry, prompt gamma neutron activation analysis (PGNAA), monochromator base alignment diffraction, and fundamental physics. The future long guide hall planned in the ESS south sector can accommodate instruments requiring a medium energy resolution, including wavelength frame multiplication diffraction (e.g., stress analysis), high speed medium resolution powder diffraction, and Bragg edge imaging.

2.4. Cost efficient design

In addition to the advantages of the six end-stations only taking up one beam port, there are significant cost savings to be made, as the cost of the first half of the instrument is covered only once. In Table 1 is an overview of estimated construction costs. The calculation for the common part of IDUN includes; Monolith insert, heavy shutter, pulse shaping choppers, bunker wall throughput, beam monitor, beam extraction system and primary guide, common vacuum systems, guide shielding, common cave for the short end-stations, and manpower (scientist and engineer).

Table 1: Rough estimates of the full cost of each part of the instrument, including manpower for software development, instrument scientist, and engineer for each end-station (in 2025 €).

Common to all end-stations	k€
First half of IDUN	7,225
Short end-stations	**k€**
SANS	6,320
Imaging	5,060
PGNAA	5,070
Reflectometer	5,200
Alignment diffractometer	2,830

ESTIMATES

2.5. Making use of the long pulse at ESS

As the end-stations are close to the moderator, all three techniques will receive the full pulse of ESS and thus benefit from the high time-average flux while the pulsed nature of the source will give access to a large **q**-range for the two diffraction techniques using time-of-flight. The imaging station will likewise take advantage of the high time-average flux while utilizing the time structure of ESS to perform low resolution Bragg-edge analysis and chemical mapping on top of the "white" beam image without reducing the neutron flux.

2.6. Automated Storage Capacity

Automated sample management and storage capacity must be included from the beginning of the instrument design to support efficient and reliable handling of samples before, during, and after measurement. This should include systems for organized sample intake, temporary storage, queueing, and post-measurement retention, allowing automated workflows to operate with minimal manual intervention. Sample tracking based on QR codes or similar machine-readable identifiers would enable robust traceability throughout the full experimental process, from sample registration to measurement and storage. Such a system would improve operational efficiency, reduce the risk of handling errors, and support integration with instrument control and metadata systems. At the same time, the storage and tracking framework must be designed to ensure confidentiality for industrial and proprietary users, including appropriate access control and secure handling of sample identities and associated data. The automated sample loading system will enable users to load the samples outside the cave and samples being transported automatically through a dedicated chicane to maximize measurement times and limit the impact of three instruments sharing one cave.

2.7. System-Level Integration

The longer-term objective for the operation of IDUN is to have system-level integration of automation, enabling a transition from isolated robotic sample exchange to fully automated, end-to-end experiment execution. This includes the coordinated integration of sample preparation stations, robotic handling, sample environments, instrument control, data acquisition, metadata capture, and analysis workflows into a unified operational framework. Such integration is essential to realize the full potential of automation: not only increasing throughput and reproducibility, but also reducing operational complexity for users, supporting remote and routine measurements. And fully automated design-of-experiments routines more and more frequently applied in industry.

2.8. Space considerations in the D01 hall

The automated storage capacity will require a lot of space and infrastructure. Placing IDUN above the future beam delivery systems for the second long guide hall in the South sector is therefore ideal, as the full instrument and support infrastructure will not take up any room planned to be used in the future.

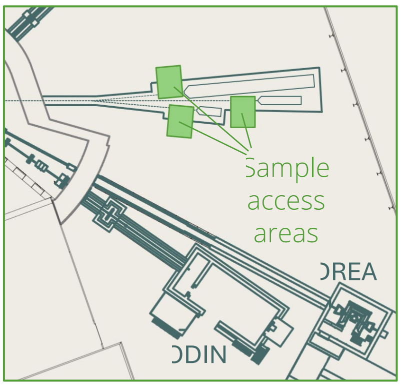


Figure 6: Sketch of the 1st floor layout of IDUN.

The instrument cave of IDUN has a similar footprint to ODIN or DREAM, so floor load needs some careful consideration. The proposed solution is to have one common outer biological shielding and lighter shielding between the short end-stations to avoid cross talk.

The three sample areas should have the same type of access with identical dimensions and mounting system for the sample environments to ease the exchange of equipment, see Figure 6.

3. Gap analysis and synergies with other instruments

3.1. The capabilities and capacity of the IDUN end-stations

There are currently no high throughput state-of-the-art neutron instruments serving primarily industry and non-expert users in Europe or the rest of the world. There are examples of companies having custom set-ups at a few large sources worldwide (e.g. at NIST and J-PARC), however these instruments cater to only a few companies with neutron experts in their R&D divisions. So, IDUN and ESS will be pioneering this new capability and service, thereby providing ESS and the neutron science community at large with several new capabilities:

- Standardized workhorse instruments, increasing throughput and industrial relevance.
- Automated measurements and data analysis, improving accessibility for non-expert users.
- Design of experiment ready set-ups, enabling integration between neutron measurements and optimization of complex industrial processes.

With the increased flux capability of ESS instruments measurements will become faster, meaning that relatively more time will be spent on sample change and instrument set-up. While the flux at the IDUN end-stations will be comparable to similar ESS instruments, the automatic sample changers and few standardized settings for each IDUN end-station will minimize sample change and set-up times, increasing the capacity of the ESS instrument pool significantly. The high capacity of such dedicated workhorse instruments will free capacity for more demanding experiments at the other ESS flagship instruments, better utilizing their full potential.

3.2. Planned requirements for sample environment and laboratory access

The push toward automation is a clear trend across leading X-ray and neutron facilities, and there is significant overlap with other ESS instruments and proposals that are also developing automation for sample handling, experimental workflows, and data analysis.

Bio sample automation

For instruments with a bio science focus IDUN can draw on the relevant experience and development paths in automated sample environments and instrument control for LoKI and FREIA and potential synergies with proposals such as ASGARD, where automation is essential for systematic studies of solid-liquid interfaces, and SMÅ. Across these activities, there is clear potential to share software, operational experience, and laboratories for sample preparation. Furthermore, inspiration should be drawn from existing solutions and practices, both from industry and research facilities such as synchrotron protein crystallography, where systems, good practices, and standards have already been developed for reliable high-throughput operation.

Chemistry lab for materials science sample handling

While a dedicated chemistry laboratory for materials science sample handling will be an important part of the supporting infrastructure, IDUN does not require any unique laboratory capabilities and will be able to share laboratories with other instruments such as DREAM and SKADI.

3.3. Comparison of the IDUN end-stations with current ESS instruments

The SANS end-station will be similar in length to SKADI giving access a similar range of **q**. However, no polarization analysis capability is planned for IDUN putting its capability somewhere in between the two SANS instruments of ESS.

Due to geometric restrictions IDUN will not be ideal for probing liquid surfaces. However, IDUN will be optimized for characterization of surface chemistry and coatings also giving capabilities between FREIA, optimized for liquid surfaces and ESTIA, that focuses on hard condensed matter.

The imaging end-station will be significantly less flexible compared to the multi-Purpose Imaging instrument ODIN. However, the IDUN end-station will have the capability to perform many standard measurements, giving room for ODIN to focus on the advanced experiments with expert users.

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eCem: Electrification of cement production for significant CO2 reduction https://www.dti.dk/services/ecem-electrification-of-cement-production-for-significant-co2-reduction/47159

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Danish Quantum Community

Copenhagen, March 25th 2026

Dear Members of the ESS Instrument Selection Committee,

On behalf of the Danish Quantum Community (DQC), I am writing to express our strong support for the proposed IDUN instrument at the European Spallation Source.

Denmark is currently making significant investments in quantum science and technology, and the Danish quantum ecosystem is expanding rapidly across both research and industry. To remain at the forefront of innovation and maintain the high-quality standards required for quantum technologies, access to advanced analytical and characterization techniques is essential. In this context, neutron-based methods offer highly promising new opportunities for industrial research and development.

Quantum industry technologies are still at an early stage, and it is therefore difficult to predict exactly which characterization methods will be most critical five to ten years from now. This makes it especially important to establish flexible and accessible infrastructure that can support emerging needs as the field matures. In this regard, the modular nature of IDUN and proposed upgrade path are precisely what is needed to push Danish quantum industries to the forefront of innovation.

For industrial R&D teams operating under demanding development timelines, the possibility of accessing neutron techniques as a more routine characterization tool could be transformative. IDUN's strong emphasis on automation, standardized operation, and high throughput appears especially well aligned with the needs of industrial users, including members of DQC who are developing next-generation quantum materials, devices, and manufacturing processes, particularly solid-state quantum systems. In our view, IDUN could become an important enabling platform for Danish industry by broadening access to neutron-based characterization and by making these techniques more compatible with the pace and practical requirements of industrial innovation. IDUN's ambition to lower the barrier to neutron experiments and to provide fast, reliable, and reproducible measurements is particularly compelling.

DQC therefor strongly support the establishment of IDUN at ESS as we believe it will represent a valuable addition to the European research and innovation infrastructures available to the Danish quantum sector.

Sincerely,

Kristine H. Falgren

Kristine Helen Falgren
Managing Director
Danish Quantum Community

BASF
We create chemistry

BASF SE, 67056 Ludwigshafen, Deutschland

ESS Instrument Selection Committee

March 25th 2026
RGS/BM – B007
Dr. Stefan Becker
Tel.: +49 621 60-46266
stefan.becker@basf.com

Dear Members of the ESS Instrument Selection Committee,

On behalf of BASF, one of the world's largest chemical companies and a leader in the development of innovative materials, chemicals, and solutions for a wide range of industries, I am writing to express our staunch support for the proposed IDUN instrument at the European Spallation Source (ESS).

We are particularly impressed by IDUN's ambition to lower the barrier of entry for neutron experiments and to provide fast, dependable, and reproducible measurements. For Europe's chemical industry, operating in an extremely competitive global environment under margin pressure, time to market is crucial for success: Therefore, the ability to easily access neutron techniques as a characterization tool on demand would represent a major step forward for industrial R&D teams operating under tight development timelines.

BASF has a long history of utilizing large-scale research infrastructure across Europe, and we recognize the ESS as a flagship facility with transformative potential. We believe that IDUN will serve as an excellent link between the neutron science community and the industrial sector, enabling new forms of collaboration and accelerating the translation of fundamental research into commercial innovation. IDUN presents a novel instrument concept bundling a range of relevant techniques and coupling it with a strong emphasis on automation, standardized operation, and high throughput well suited to the needs of industrial research organizations such as BASF.

BASF operates at the forefront of chemical research and advanced materials development, serving sectors that include automotive, construction, agriculture, pharmaceuticals, energy, and consumer goods. Innovation is a key lever to maintain and strengthen a competitive edge. This said, our commitment to innovation demands access to the most advanced analytical and characterization techniques available, and neutron-based methods present interesting new characterization opportunities for our R&D.

We see significant value in the following areas:

- **Energy technologies:** BASF is heavily invested in the development of battery materials, catalysts for efficient, environmentally friendly production processes, and other technologies central to the energy transition. Neutron imaging and scattering can provide operando insights into the function and degradation mechanisms of these materials under realistic conditions.

- **Advanced materials and manufacturing:** Understanding the nanoscale and mesoscale structure of polymers, coatings, catalysts, and composite materials is essential to our product development pipeline. SANS and reflectometry measurements provide structural information that is difficult or impossible to obtain through other analytical methods.
- **Food science and agriculture:** As a major supplier of ingredients and solutions for the food and agriculture industries, BASF can benefit from neutron-based characterization of emulsions, surfactant systems, and agrochemical formulations.
- **Solutions for the Pharmaceutical Industry:** Neutron scattering techniques, particularly SANS and reflectometry, offer unique insight into the structure of drug delivery systems, lipid membranes, polymer matrices, and nanoparticle formulations. These capabilities are directly relevant to BASF's pharmaceutical ingredients and formulation science divisions.

We fully endorse the IDUN proposal and strongly encourage the ESS to support its realization.

Sincerely,

Dr. Stefan Becker
Head of Material Science – Structure Elucidation & Surface Characerization
RGS/BM – B007
BASF SE, Ludwigshafen, Germany

Date: 2026-03-25
Your ref: Nikolaj Zangenberg
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Support letter for ESS instrument IDUN

Dear Members of the ESS Instrument Selection Committee,

On behalf of Alfa Laval, a global leader in heat transfer, separation, and fluid handling technologies, I am writing to express our strong support for the proposed IDUN instrument at the European Spallation Source (ESS).

As a high-tech company with headquarters in Lund and operations in over 100 countries, Alfa Laval is continuously engaged in the development of advanced materials and products for energy efficiency and sustainable industrial process development. Access to world-class materials and process characterization capabilities is of strategic importance to our ongoing research, development, and quality assurance activities.

The IDUN concept - a high-performance instrument bundle enabling measurements within SANS, imaging, and reflectometry with a strong emphasis on automation, standardized modes of operation, and high throughput - is well aligned with the needs of industrial users such as Alfa Laval. In particular, we see significant potential in the following areas:

- **Advanced manufacturing:** Neutron imaging and scattering techniques can provide unique insights into the internal structure and performance of our heat exchangers, separators, and other key products, supporting both product development and quality control.
- **Energy technologies:** As we develop next-generation solutions for energy efficiency and decarbonization, access to reliable and reproducible neutron measurements will accelerate innovation cycles.
- **Food science and pharmaceutical applications:** Alfa Laval supplies process equipment to the food and pharmaceutical industries, where a deeper understanding of materials at the nanoscale and microscale is increasingly important.

We are particularly encouraged by IDUN's emphasis on providing a low entry barrier to neutron experiments. For industrial R&D teams, the ability to utilize neutron techniques as a readily accessible characterization tool, with fast access to results and minimal need for specialized expertise, would be transformative. This approach has the potential to significantly broaden the user base and ensure that European industry can fully benefit from the ESS investment.

We believe that IDUN will serve as an important bridge between the neutron science community and the industrial sector, and we look forward to the opportunities it will create.

We wholeheartedly endorse the IDUN proposal and encourage the ESS to prioritize its construction.

Lund 2026-03-25

Magnus Fredriksson, Program Manager
Alfa Laval Corporate AB

European Spallation Source management

27 March 2026

Letter of support for instrument proposals SLEIPNER, IDUN, and MAGNI for the call for Input to the ESS Instrument Roadmap

It is with great pleasure that DanScatt, which is the instrument centre for the Danish users of synchrotron and neutron sources as well as free-electron X-ray lasers and funded by the Danish Agency for Higher Education and Science, hereby expresses its strong support for the ESS instrument roadmap proposals SLEIPNER, IDUN, and MAGNI. In the view of that many of the reactor-based neutron sources in Europe have been closed or face an uncertain future during the coming 20 years, it is of utmost importance to DanScatt that capacity-building within neutron scattering and imaging is highly prioritized to be able to support growth of the neutron user community to be able to capitalize fully on the investment in ESS. Despite the considerably higher neutron flux available at ESS when in full operation, DanScatt expects that this will benefit the more complex and time-consuming measurements and therefore not necessarily lead to equivalently more beamtime for different measurements.

The three proposals SLEIPNER, IDUN and MAGNI have been prepared by very experienced consortia of European neutron scientists involving the Technical University of Denmark (DTU) and the Danish Technological Institute (DTI). Besides the excellent science that these proposed instruments will undoubtedly support, DanScatt would like to highlight that they are expected to expand ESS's societal impact considerably within emerging technologies, sustainability, and also the industrial use of neutron scattering and imaging. Further, they will expand the options for educating the next generation of neutron users, thereby supporting the growth of use of neutron methods for analysis at universities as well as in industry.

Best regards

M. Meedom Nielsen

Martin Meedom Nielsen
Chair of DanScatt's Board
Professor, Deputy Head of Department
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