Instrument Proposal for the ESS Roadmap

MAGNI - Microscopy, Advanced and Grating Neutron Imaging

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1. Executive Summary

We propose MAGNI, a **second dedicated neutron imaging instrument at ESS**, designed and optimized to **complement the capabilities of ODIN.** In contrast to ODIN the **short imaging instrument MAGNI** will be specialized for high flux, high spatial resolution and various operando techniques utilizing white beam and in particular low wavelength resolution techniques catered by a broad wavelength band. The base instrument will, thus, offer unprecedented performance for cutting edge advanced multi-scale and operando techniques to tackle scientific challenges in particular energy, manufacturing and soft matter research for sustainability. Beyond this, a disruptive progress for highest spatial resolution and neutron flux for imaging is envisaged by MAGNI's pioneering development of neutron microscopy as an inherent aim of the instrument project leveraging a Danish initiative in dedicated optics development.

The short length (up to 30 m) implies high flux conditions in the base instrument, which supports high spatial resolution and fast operando measurements, the limits of which are challenged continuously by the user community. The low natural wavelength resolution at short distances from the long pulse source creates unique opportunities for techniques that profit from low wavelength resolution and broad wavelength bandwidths, which are not efficiently implemented at short pulse or continuous sources (and which take a penalty by the length of ODIN). This concerns, in particular, advanced and quantitative dark-field contrast neutron imaging which is mapping small angle scattering structures in 2D and 3D and inelastic contrast mapping through spectroscopic neutron imaging contrast, which provides unique insights into dynamics governed by hydrogen and hydrogen bonds in spatially inhomogeneous processes.

The high divergence that can be extracted under such conditions is well suited for large fields of view for bulk industrial or cultural heritage samples requiring the high transmission capabilities of neutron imaging. However, a homogeneous high divergence is also an asset for nested mirror optics lenses, which promise game-changing gains in available flux and spatial resolution, when overcoming the current pinhole imaging geometry through the envisaged microscopy optics for MAGNI.

The concept is being jointly developed by leading experts in particular at DTU, PSI, FRM II, DTI and ESS, which are dedicated to coordinate and consider the wide interests of the community and from different institutions including leading neutron imaging groups at neutron source facilities and neutron imaging user groups at universities and research as well as R&D institutes in Europe.

This proposal aims to strategically extend ESS's imaging and, thus, scientific capabilities, in particular at the interface to transformational technologies, innovation and industrial applications and to cater the growing global demand for neutron imaging and advanced neutron imaging methodologies across scientific and industrial sectors.

2. Scientific Case

2.1 Key Scientific Drivers

The primary drivers for the new instrument are:

- **Operando/in-situ observations** supporting **emerging technologies** in
  - **Energy conversion** (batteries, fuel cells, electrolysers, hydrogen storage, carbon capture, ammonia, molten salts, novel fuels, etc.)
  - **Manufacturing technologies** (additive manufacturing, food processing, heat treatments, phase transformations, extrusion, freeze casting, liquid metals, freeze drying etc.)
  - **Liquids rheology and flow** (diffusion, shear, porous media, cooling, two phase flow, porous media, foams, liquid/liquid phase separation, bubble formation etc.)
  - **Magnetic materials** (manufacturing, tuning magnetic properties, efficient electric machinery, novel materials and phenomena etc.)
- **Multiscale characterization** in materials research and **materials technology**
  - **Sustainable materials** (cellulose, green concrete, wood, artificial meat, circular economy materials etc.)
  - **Environment** (soil, permafrost, landslides, avalanches, microplastic, etc.)
  - **Life science** (plants, roots, implants, biodegradables, membranes etc,)
  - **Emerging technologies** (new materials for emerging technologies, multiscale architectures, nature inspired structures/materials, advanced nuclear materials, raw materials, recycling, etc.)
  - **Space** (additive manufacturing, meteorites, space mission samples, radiation damage etc.)
- **Industry and Infrastructure**
  - **Industrial manufacturing** (processes and optimization)

- **Service life and structural failure** (corrosion, degradation, extreme conditions, early stage fracture detection, nuclear materials etc.)
- **Tailored structural material properties** (advanced manufacturing techniques, multi-material printing, microstructure design, additive manufacturing progress from research to market, etc.)
- **Safety** (material characterization, wear characterization, structural evolution, hydrogen embrittlement, nuclear safety etc.)
- **Quality control** (failure detection, forensics, quality assessment, troubleshooting, production process optimization, etc.)

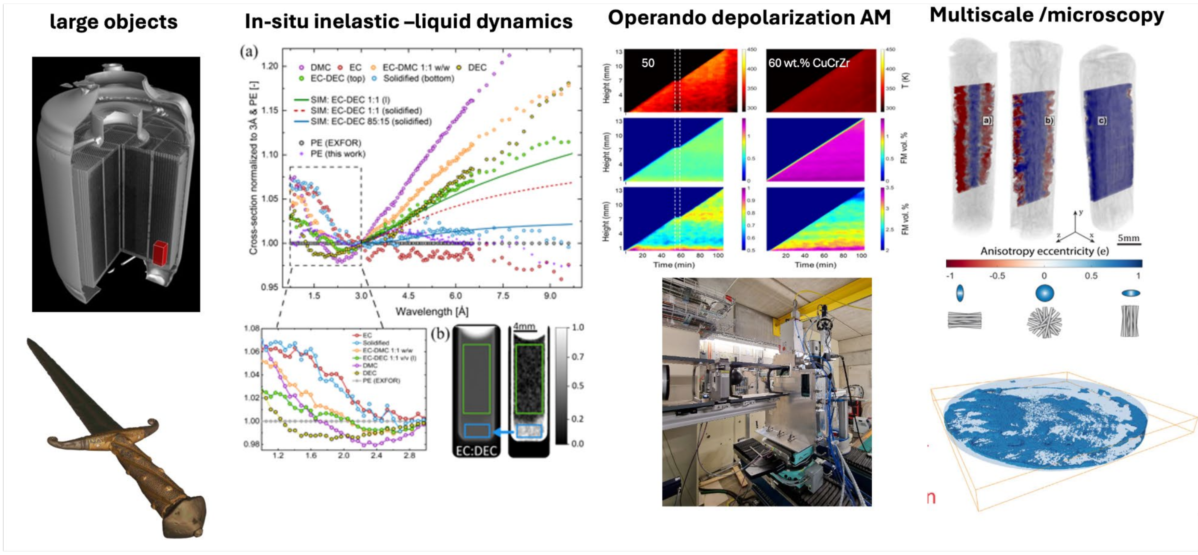


Fig. 1 Science case; Large samples of e.g. industry and cultural heritage (left); in-situ imaging of liquid phases and dynamics through inelastic scattering contrast [1] (mid left); operando metal additive manufacturing through e.g. concurrent depolarisation and inelastic contrast [2] (mid right); multiscale dark-field contrast tomography of e.g. advanced materials [3] (right top) and microscopy of e.g. operando battery cycling [4] (right bottom).

2.1.1 Societal Relevance

MAGNI is of considerable societal relevance as it will be an **invaluable tool to advance**

- **Emerging and transformational technologies** through providing unique capabilities for direct insights into **multiscale materials** and **processes** which **new technology**, but also **nature** are built upon.

MAGNI is designed to make a **considerable impact** with regards to

- **Environment and climate** through advancing **energy** research towards novel solutions for efficient alternative energy storage, **efficiency** and conversion, **novel materials and processe**s in favor of a **circular economy** and **sustainability goals**, as well as creating insights into **environmental effects** of pollution and **climate effects** (plants, roots, soil, geology).

MAGNI will **substantially contribute** to

- **Materials safety** (materials research, manufacturing, quality control, nuclear materials etc.)
- **Ecomomy and growth** (industrial and high TRL research)

- **Life science** (agriculture, water transport in organisms)
- **Medicine** (implants, drug carriers)
- **Cultural heritage** (understanding and preservation)

2.2 Potential for New Science

The **high flux** will enable a wide range of **operando studies** not achievable today in the scientific fields listed above.

The **high divergence** coupled with the high flux will enable **large fields of view** for large **industrial and cultural heritage** objects.

The **low intrinsic wavelength resolution** guarantees **highest efficiency for dark-field** contrast imaging fostering **multiscale and multiscale operando studies** probing structures from the nanometer to the centimeter scale, including **magnetic structures, soft and hard condensed matter**.

The **low intrinsic wavelength resolution** also provides **highest efficiency for operando inelastic scattering contrast imaging**, which bears potential to open a **wide range of investigations which are not possible today** and applications are **not limited to the current** pioneering applications in **energy and metal manufacturing** research.

The **high flux and low intrinsic wavelength resolution** appear also **ideal for fast depolarization** imaging of **magnetic structures and transformations** under **external loads** and **Laue diffraction tomography** resolving **grain-based material arrangements and response** in **structural and functional materials** as are currently pioneered.

The **highest resolution**, in particular through the envisioned **microscope optics**, based on high divergence and high flux will enable direct imaging of **micrometer-scale structures** in materials and processes only amenable by neutrons.

Microscope optics will unlock unprecedented **high flux for operando and multiscale measurements**. The high flux allows for studies of e.g. **bulk metals and ceramics**, which x-rays cannot penetrate, but also **soft and biological structures** that high intensity x-ray beams would destroy in the course of a measurement.

2.3 Potential User Community

The user community in **neutron imaging** is extremely diverse and conveys chemistry, physical chemistry, environmental studies, geology and porous materials, life sciences, engineering and construction materials, metal manufacturing, soft matter, magnetism, nuclear materials and safety, electrochemistry and energy research, natural and cultural heritage, space, magnetism, applied materials and processes, as well as industry. **MAGNI** will draw on this **diversity** but is expected to particularly appeal to **academic but also industrial** users engaged with **industrial and natural processes**, **environment and emerging technologies** as well as the **development of sustainable technologies, a circular economy and power-to-X**, but also **space and manufacturing, industry 4.0 and 5.0**.

3. Initial Technical Overview

MAGNI resembles a neutron imaging instrument at a continuous source, however still having the benefits of a time-of-flight neutron beam. It is short and enables measurement positions from about 12 – 30 m from the moderator. It utilizes optionally a white beam or the natural wavelength resolution and bandwidth given at a certain measurement position by its distance from the moderator at a source operation frequency of 14 Hz and 2.86 ms pulse burst times. For time-of-flight measurements, this results in a bandwidth of at least 10 Å and up to about 20 Å, which can efficiently be exploited for dark-field, inelastic and depolarisation contrast modalities and requires merely the use of a bandwidth and T0-chopper system. The length of the instrument provides space for a neutron microscope set-up, which we expect to still advance throughout the early operation of MAGNI.

	Settings	ODIN	MAGNI
Flux (full white) [$n.cm^{-2}.s^{-1}$]	L/D=300	$1 \cdot 10^8$	$5 \cdot 10^8$
	Nested mirror optics		$1 \cdot 10^{10}$
Divergence [deg.]	Incident	1	2
	Nested mirror optics		6
Wavelength bandwidth [Å]	14 Hz	4	10-20
	7 Hz	8	
Wavelength resolution $d\lambda/\lambda$ [%]	Conv. (λ-dependent)	3-15	3-40
		0.7-3	
Maximum Field-of-View [mm^2]		150 x 150	400 x 400

Table 1 Expected performance of MAGNI as compared to ODIN estimated by merely simulating an instrument placed right after the T0 chopper, i.e. with no specific guide design included.

Presently, MAGNI has only been designed at the concept level. McStas simulations using the ESS beam profile after the T0 chopper indicate the rough performance that MAGNI will have when applied as a pinhole camera and compared to ODIN's expected performance (see Table 1). This is without having optimized any optics, and with a 10x10 mm^2 pinhole. This shows a maximized flux of x5 compared to ODIN for the base instrument, yet without the use of nested mirror optics or complete microscopy optics.

The instrument requires ample space for complex and bulky sample environments and their supply systems, as well as for efficient set-up changes. These also need significant infrastructure and supplies such as gases, safety equipment, sensors, and exhaust lines (see section 5) as well as precautions in the access interlock system. Other installations enabling experimental set-ups and measurement position flexibility, such as an optical bench system are rather standard in neutron imaging. The high flux, large divergence and vicinity to the source imply significant shielding needs. A sketch of the MAGNI principle is shown in Fig. 2.

It will be straightforward to supplement MAGNI with an X-ray μ-CT placed perpendicular to the neutron beam path to simultaneously acquire the complementary X-ray imaging signal for multimodal approaches.

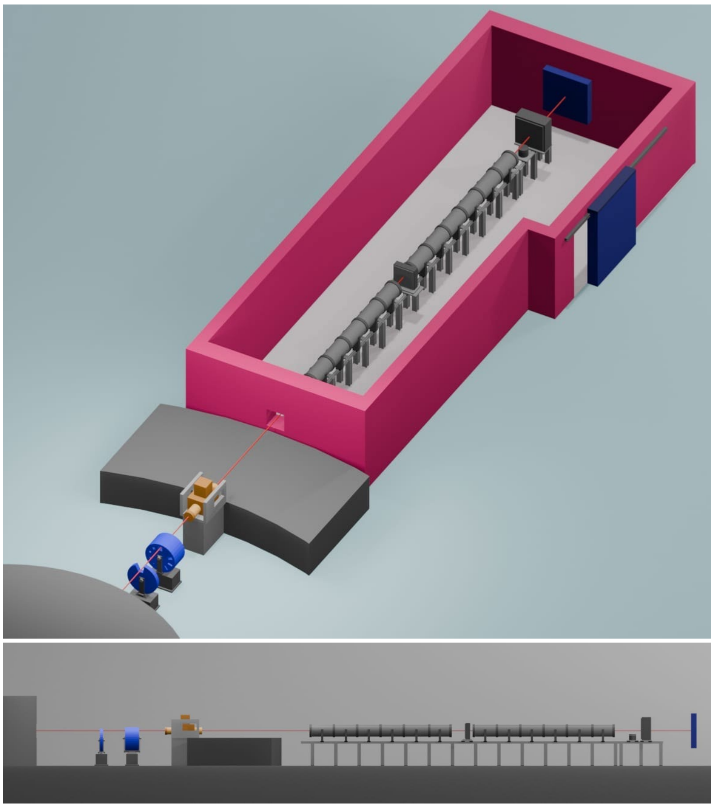


Fig. 2 Preliminary sketch of the MAGNI beamline; optics and positions of components still have to be considered and evaluated.

The different core advanced measurement techniques and modes of MAGNI require the following basic measurement systems:

- **Inelastic contrast**

Unlike other advanced neutron imaging methods, inelastic contrast neutron imaging for mapping dynamics of molecular species [1] does not require any specific additional instrumentation or add-on but a time-of-flight imaging detector capable of accepting a high neutron flux at relaxed ToF resolution. Most likely, a high-end CMOS detector or an advanced TPXCam detector is sufficient. We refer to the detector paragraph below.

- **Dark-field contrast set-up**

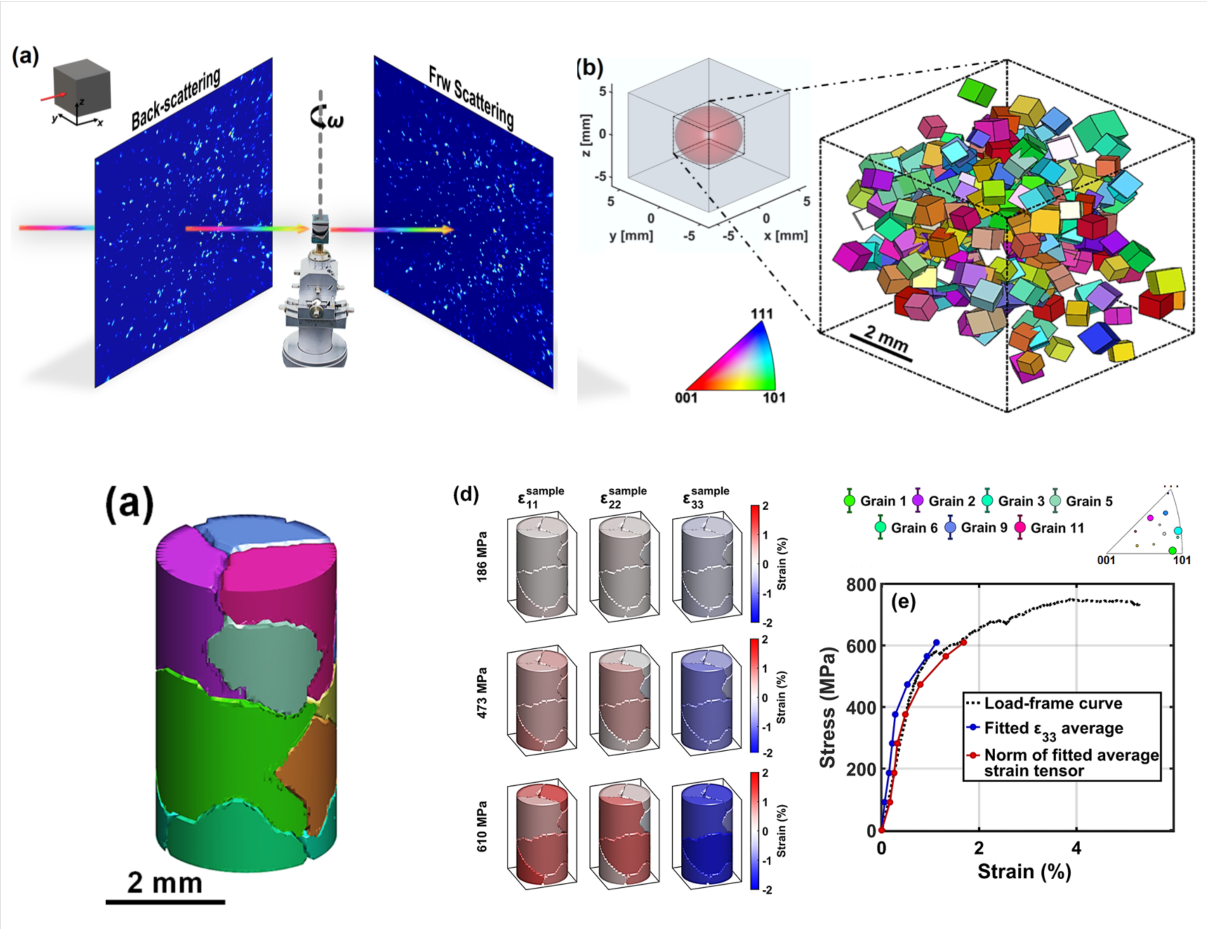
Various dark-field contrast set-ups are considered and a modular set-up enabling ultimate flexibility for various implementations including symmetric, single grating multidirectional and polarized neutron dark-field applications are planned in analogy to the successful prototype at PSI [3]. Set-up of these state-of-the-art add-on is straightforward and of low complexity.

- **Depolarisation contrast set-up**

A relatively simple polarized neutron set-up limited to depolarization imaging measurements featuring a broad band polarizer and spin flipper, a guide field and a compact polarization analyser are foreseen. The system at BOA at PSI [5] serves as blueprint and a combination with the dark-field imaging set-ups is considered.

- **Laue 3D neutron diffraction tomography set-up**

A corresponding set-up following the example of the FALCON add-up currently in operation at PSI [6,7] featuring a large forward and back-diffraction detector, the latter enabling the incoming beam passage can be flexibly installed. This is illustrated in Fig.3. In this context the newest detector technology, such as a TPXCam solution should be considered to maximise performance.

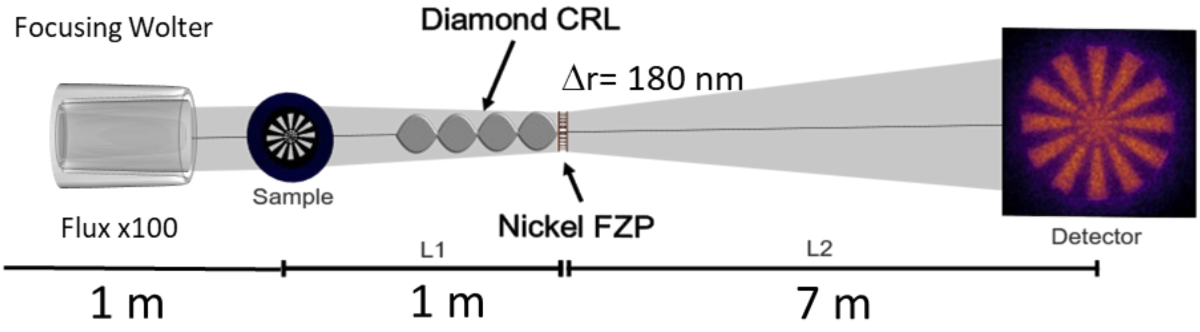


Fig, 3 White beam tomographic Laue grain mapping [6] and grain resolved strain mapping [7].

- **Neutron Microscope Optics**

We propose a conceptually new and innovative modular microscope optic system as an optional add-on. The system is considered to provide unprecedented high flux (x 100) at medium resolution (~50 μm) on the one hand, and ultimately unparalleled spatial resolution down to < 1 μm, on the other hand. In comparison, X-ray μ-CT instruments provide a 100 times increased flux on the sample with a spatial resolution of 2-10 μm, and this has already proven extremely beneficial for a wide range of applications.

Currently, intense preparations, design work and simulations are performed by DTU and PSI [8]. Start-up funding has been secured by DTU to define and provide the neutron condenser optics, and a magnifying unit is being pursued by PSI, respectively. The microscope system as illustrated in Fig. 4 is based on a nested Wolter optics module as well as potential achromat lenses based on Fresnel zone plates and compound refractive lenses, which are currently being developed at PSI. The first 60-degree segments of NiTi supermirrors for the Wolter optics have recently been measured and demonstrate reflectivity of 60-80% for m=2.5, demonstrating that the high flux system appears to be technologically achievable within the state-of-the-art capabilities. As presented in Table 1, McStas simulations show that the neutron flux on the sample at ODIN with L/D~300 is $1 \cdot 10^8$n/(s cm^2) (for ESS@2 MW), while the condensing Wolter optics will result in a neutron flux on the sample of $1 \cdot 10^{10}$n/(s cm^2), so a factor of 100 increase, effectively delivering a larger neutron flux than the imaging beamline NeXT@ILL. The first tests of the magnifying Fresnel zone plates show a promising starting point for further development [9]. The high-resolution microscope is a high-risk high-gain development project currently. The neutron microscope will be designed so it is a complete unit that with great flexibility can be installed or removed as needed on MAGNI.



Fig, 4 Sketch of the principle underlying the neutron microscope with condensing nested Wolter optics and Fresnel zone plates in combination with compound refractive lenses as the magnifying unit.

- **Detectors**

The various foreseen methodologies and applications require an extensive and flexible detector suite from large area to highest resolution detectors for white beam and time-of-flight neutron imaging. CCD, CMOS and TPX technology have to be considered and need to be tailored to the individual methodologies and applications.

Provisions for fast and reliable set-up changes need to be designed and implemented.

Potential extensions of the capabilities are currently considered but still subject to feasibility and impact considerations. These capabilities could be part of a future upgrade path e.g. resonance absorption contrast with a dedicated chopper system could be considered.

All components considered for the base instrument are state-of-the-art and do not require technological development. This is different for the advanced neutron microscopy optics, which is being considered through an ongoing dedicated development project dedicated to MAGNI.

4. Use of ESS Long-Pulse Source

This instrument truly draws on the strengths of ESS in capitalizing on the high flux and brightness, full long pulse utilization for low wavelength resolution and low frequency large bandwidth techniques. The instrument and its capabilities are tailored concurrently to emerging experimental needs but in particular their match with the strengths of the ESS source.

The instrument is highly complementary to ODIN which capitalizes on the potential of tailoring the pulse structure of ESS, while MAGNI fully leverages the strengths of the given unique pulse structure.

5. Sample Environment and Laboratory Access

The science case of MAGNI is resource intense on the sample environment side. This is related to the science case and the corresponding instrument capabilities. Operando studies in the field of emerging technologies and industrial and natural processes implies the need to various complex non-standard sample environments dedicated to specific fields or even individual studies. From today's point of view this includes but is not limited to the following on beam and lab equipment:

- Environmental chambers (temperature, climate, humidity, flow, pressure)
- Electrochemical environments and supplies including gas handling, fuel/electrolysis cell test bench, potentiostats for battery cycling, etc. (currently developed at PSI in frame of HORIZON project ACTNXT and others)
- Glove boxes, including on instrument (currently developed at PSI in frame of HORIZON project ACTNXT)
- Rheometers including Couette shear cell, flow channels
- In beam 3D-printing devices (LBPF, DED, WAAM as available at PSI)
- Industrial processing (e.g. extrusion etc.)
- Non-standard magnetic environments

Particular attention has to be on precautions that enable complex user provided sample environments and smooth implementation and integration, safety checks and feedback loops etc.

The end-station will be **easily accessible** to enable frequent sample and sample environment changes and parallel experiment preparations, promoting **efficient beamtime use**.

Software and AI methodologies to serve the complex methodologies envisioned and support a high data rate combining Fourier and real space components in large pixel arrays at high frame rates are to be considered early on. Such methods are seeing rapid development in the neutron imaging community, and the AI driven tools provided at the imaging beamline VENUS@SNS can serve as a good example of successful implementation. Theory support for data analyses will be a significant asset.

6. Proposed Location at the ESS Facility

We recommend locating the new imaging instrument on a **short beamline at the periphery of the instrument hall**, ideally in a position such as **beamports N9, E6 or E10**. This choice is motivated by:

- Closeness to the monolith
- Space for a short beamline without blocking for longer beamlines
- Placed in already existing experimental hall
- Peripheral (corner) positioning would help decouple this beamline from more complex, tightly packed setups and maximize operational uptime by reducing maintenance complexity.

7. Gap Analysis: Capability and Capacity

A user survey by AMG, the imaging group at PSI, in 2025 supports the impression many leading neutron imaging instrument scientists hold from discussions around beamtime proposals, namely that an increase in time resolution and spatial resolution are the leading demands of the user community in neutron imaging, apart from more capacity to cater their desired experiments. MAGNI will cater all these demands, it will create the desired capacity and it aims to best exploit the ESS source for the highest flux and highest spatial resolution.

7.1 Capability Gap

ODIN is relatively long, which limits beam transport in terms of flux and divergence and it implies at the same time a limit to the capability to trade resolution for flux. While ODIN is versatile in trading flux for resolution there are limits when it comes to optimizing for low wavelength resolution long wavelength band high flux applications. While ODIN is, thus, very well suited for diffraction contrast and some polarized neutron methods with various resolution needs it compromises high flux techniques with no or very low wavelength resolution requirements. Therefore, it leaves a gap between continuous source and common pulsed source applications which are particularly concerning:

- High flux operando studies of natural and technological processes
- Multi-scale dark-field contrast for hard and soft matter structures
- High duty cycle inelastic spectroscopy imaging for liquids and electrochemistry
- Operando depolarisation contrast for magnetic structures and structural phase transitions
- Advanced white beam methods such as 3D Laue diffraction tomography for grain resolved studies in engineering and functional materials under load
- Large fields of view for industrial and cultural heritage

MAGNI will enable very complex measurements of realistic components requiring operando studies and/or investigating large samples, sometimes requiring high-resolution deep inside these samples. These will be better addressed by the MAGNI operando, wide field of view, and microscope capabilities, respectively, than any other existing or upcoming instrument.

7.2 Capacity Gap

MAGNI will focus on complementing ODIN, in particular in the above named fields, but with sufficient overlap with ODIN in capabilities to also build capacity for the high request in neutron imaging studies in all fields of applied materials research, processes and technologies and industrial needs.

ODIN is expected to be **heavily oversubscribed**, based on the reported overload factors (OLF) for top imaging beamlines (e.g., OLF>3 at ILL, PSI, ISIS, HZB, FRM II, NIST). Even with high data acquisition speeds, demand will exceed supply for:

- Cutting edge research in established and new fields of application
- Industrial cases, including time-sensitive- and highly complex measurements
- In-situ/operando experiments with complex protocols
- Novel sample environments with complex beamline configurations
- Science driven cutting edge methodology development

The proposed instrument addresses this by providing dedicated high-flux capacity optimized for conventional high flux/high resolution and specific advanced methods complementary to the strengths of ODIN. ODIN operation profits by being able to focus on the most efficiently covered methodologies of the instrument.

An online workshop was held on 16. January 2026 to collect feedback from the neutron imaging community. Instruments scientists from neutron source facilities in Europe, USA and Japan, and a broad selection of neutron imaging users from various universities provided valuable feedback, which has been incorporated into this proposal. Attached are also letters of support from the Swiss Neutron Scattering Society, DanScatt (the Danish instrument centre for the Danish users of synchrotron- and neutron-sources as well as free electron X-ray lasers), and the recently started Centre of Excellence ESS Lighthouse NeuData4Life, which aims at expanding the capabilities within neutron imaging in life science.

8. Comparison to Global Instruments

Generally, it is difficult to directly compare the various neutron imaging instruments at the different neutron sources as the instruments are tailored to the individual neutron beams fabricated by either fission or spallation and as either continuous or pulsed neutron sources. Globally, only a few neutron sources support both high flux and moderate resolution white-beam imaging, and below we highlight in rough terms the strengths and limitations for cold and thermal neutrons for comparison with ODIN@ESS and MAGNI@ESS (ToF: Time-of-Flight):

Facility	**Instrument**	**Strengths**	**Limitations**
PSI (CH)	NEUTRA / ICON	White beam/ monochromatic	Flux, ToF methods
NIST (USA)	BT-2 Imaging	White beam/ monochromatic	ToF methods
ILL (FR)	NEXT	White beam/ monochromatic	ToF methods
J-PARC (JP)	RADEN	High ToF resolution	White beam, medium/low wavelength resolution
SNS (US)	VENUS	High ToF resolution	White beam, medium/low wavelength resolution
CSNS (CN)	ERNI	High ToF resolution	Flux, White beam, medium/low wavelength resolution
ISIS (UK)	IMAT	High ToF resolution	Flux, White beam, medium/low wavelength resolution
ESS (SE)	**ODIN**	**High**/medium **ToF resolution**	**Highest flux ToF imaging, White beam**
ESS (SE)	**MAGNI**	**Flux, White beam, low wavelength resolution**	**High/medium ToF resolution**

This proposal would establish a **first-of-its-kind** beamline optimized specifically for **ESS's long-pulse architecture**. No existing instrument globally offers this particular **balance of flux, resolution, and agility, uniquely supporting a number of established and pioneering advanced imaging techniques.** While this is true already for the MAGNI base instrument, the successful establishment of the envisioned **focusing and magnifying optics will be truly transformational**.

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Support of instrument proposal MAGNI for the call for Input to the ESS Instrument Roadmap

The Swiss Neutron Science Society (SNSS) is pleased to express its support for the MAGNI instrument proposal submitted to the ESS Instrument Roadmap.

The MAGNI (Microscopy, Advanced and Grating Neutron Imaging) proposal outlines a second dedicated neutron imaging instrument at the European Spallation Source (ESS), designed to complement the existing ODIN instrument by specializing in high flux, high spatial resolution, and advanced operando techniques. Optimized for a short beamline length (up to 30 meters), MAGNI leverages ESS's long-pulse source to deliver exceptional flux, low wavelength resolution and broad wavelength bandwidth, making it uniquely suited for techniques such as dark-field contrast, inelastic scattering, and neutron microscopy—capabilities that are less efficient at short-pulse or continuous sources. The instrument targets transformational research in energy, manufacturing, soft matter, and cultural heritage, enabling real-time, multiscale studies of materials and processes, including operando observations of batteries, additive manufacturing, and liquid dynamics. MAGNI's innovative modular microscope optics, high divergence, and optional epithermal neutron imaging aim to unlock unprecedented spatial resolution and elemental mapping, while its flexible sample environments and detector suite cater to diverse academic and industrial needs. By addressing both capability and capacity gaps, MAGNI will expand ESS's scientific impact, particularly in emerging technologies, sustainability, and industrial applications, positioning it as a first-of-its-kind facility globally. The project is a collaborative effort led by DTU, PSI, and ESS, with strong community input and a focus on advanced methods including the addition of a high-risk, high-reward development in focusing optics for neutron imaging.

In response to the SNSS call to members, Switzerland has expressed strong support for MAGNI, recognizing its potential to complement and expand the capabilities of existing neutron imaging facilities at PSI and ESS. MAGNI's focus on high flux and low intrinsic wavelength resolution, advanced operando techniques, and neutron microscopy will open new avenues for research in energy materials, manufacturing processes, and industry—areas of strategic importance for Swiss and European science. The instrument's unique design, optimized for ESS's long-pulse source, will enable groundbreaking studies in multiscale material characterization and dynamic processes, further strengthening Switzerland's and Europe's research in neutron scattering and applied materials research.

Sincerely,

On behalf of the Swiss Neutron Science Society board

Villigen, Switzerland, 26th March 2026

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

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Support for the MAGNI proposal

I am director of the Danish center of excellence *ESS lighthouse NeuData4Life* that was funded end 2025 and will be active for the next decade. NeuData4Life combines efforts of 32 co-PIs in life and data science with large scale facility experimentation, in particular aiming at ESS, to make deep scientific impacts. It encompasses a large transect of the Danish structural biology community across most Danish universities and additionally has active participation by DMSC.

The MAGNI proposal is particularly interesting for the NeuData4Life community. Neutrons are, in principle, an ideal probe for imaging biological samples, as they provide significantly stronger contrast for hydrogen-, carbon-, and oxygen-containing materials than X-rays. In addition, selective deuteration offers a powerful means to highlight specific components within a structure. Another important advantage is that radiation damage is considerably less severe than in X-ray-based techniques.
In practice, however, neutron imaging has been used only rarely for biological specimens. This is primarily because the signal of interest—attenuation contrast—is often overwhelmed by background contributions arising from incoherent scattering by hydrogen. Neutron microscopy provides an elegant solution to this challenge. Within the NeuData4life Lighthouse, we have dedicated personnel to the development and demonstration of this approach. In anticipation of establishing such a modality, we are also pursuing strategies to enable functionalized imaging, analogous to methods employed in advanced light microscopy in the life sciences. Secondly, we see a strong synergy with current developments in X-ray imaging.

I am excited by this initiative and hereby wish to lend it my strong support.

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Sincerely,

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