



ent of High Intensity Neutron Source at the European Spallation Source: the HighNESS Project

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ESS

On Behalf of the HighNESS Consortium





<u>construction</u> in Lund, a city in southern Sweden.

 The facility's <u>unique capabilities</u> will both greatly exceed and complement those of today's leading neutron sources, enabling new opportunities for researchers across the spectrum of scientific discovery, including materials and life sciences, energy, environmental technology, cultural heritage and fundamental physics.



| ESS | GROUNDBREAKING | INITIAL OPERATIONS | INSTRUMENT COMMISSIONING BEGINS | USER PROGRAMME BEGINS | PROJECT COMPLETION STATUS |
|----------|----------------|-----------------------|------------------------------------|--------------------------|------------------------------|
| Timeline | 2014 | 2019 | 2022 | 2023 | 76% |





ESS current moderator

ess

rator was based on the novel concept of low-dimensional moderators . It is a **high-brightness** oderator system placed on top of the spallation target.

All of the first 15 instruments built, plus a test beam line, will view that moderator

Butterfly Moderator Hydrogen moderator of 3 cm height above the target



Design of the cold and thermal neutron moderators for the European Spallation Source

L Zanini, et all Nuclear Instruments and Methods in Physics Research Volume 925, 1 May 2019, Pages 33-52 Time average brightness averaged over 42 beamports.



Comparison of time average brightness with official ILL "Yellow Book", and a more recent evaluation (unpublished)









Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment Volume 925, 1 May 2019, Pages 33-52



Design of the cold and thermal neutron moderators for the European Spallation Source

L. Zanini ^a $\stackrel{ imes}{\sim}$ \boxtimes , K.H. Andersen ^a, K. Batkov ^a, E.B. Klinkby ^{a, b}, F. Mezei ^a, T. Schönfeldt ^{a, b}, A. Takibayev ^a

With all initial instruments pointing to the top moderator, and a beamport system that allows the possibility to extract neutrons from above and below the target, the adopted configuration opens the possibility to have different types of moderators below the target, so that other neutron beams of different intensity, or spectral shape, with respect to the ones delivered by the top moderator, could be envisaged, adding additional scientific opportunities to the facility









Liquid deuterium moderator design on-going



- Neutronic study of large D₂ moderator ongoing
 - Intensity variation with dimensitons, number of beamlines, use of Be filter /reflector
- Additional works:
 - Design of nanodiamond reflector for cold and very cold neutrons (advanced reflector)
 - Design of UCN source
 - Prototype experiment will be performed at Budapest reactor



opening optimization





Use of Be filter/reflector











- Recent years have seen intense research towards novel moderator/reflector materials and for beam extraction system.
- In order to use these materials in Monte Carlo simulations you need to create thermal scattering libraries
- WP2 in HighNESS making use of NJOY+Ncrystal have generated 200+ evaluations for 100+ new and updated materials, validated against total cross sections, specific heat capacity (Cp) measurements, and X-ray diffraction.
- This is the largest contribution ever made to thermal scattering libraries (by an order of magnitude!), and it is 100% reproducible, documented and open source

Github repository: <u>https://github.com/highness-eu</u>

K. Ramic, D. Di Julio, J.I. Marquez Damian, T. Kittelmann and many others.





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Wavelength spectra as simulated for (a) ConvSANS and (b) WOF-SANS. The insets in both panels show a zoomedin view of the wavelength spectrum at the sample position. In (b) the blue and green spectra are overlapping almost exactly since there are minor losses through the monolith.

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Condensed Matter (II)



Relative intensities as calculated from the simulations for the ConvSANS and WOF-SANS instruments.



Q ranges as a function of wavelength for ConvSANS and WOF-SANS.



Q-resolution as a function of scattering vector Q for LoKI, SKADI, ConvSANS, and WOF-SANS.

1000

9000

8000

7000

6000

5000

4000

3000 2000

1000

15

- 5x5 cm²

- 10x10 cm²

- 15x15 cm²

- 20x20 cm²



Initial tests of different window sizes for the moderator in McStas. The bottom right panel shows the wavelength spectra for each case as measured 1 mm from the moderator surface.



Fundamental Physics



euterium moderator that we are developing in the project is ideal for the NNBAR experiment (see Zanini's talk)

 In the HighNESS project will also be developed the Conceptual Design Report of the NNBAR experiment





- Development on-going in NNBAR:
- reflector design (Oliver Zimmer, Richard Wagner ILL)
- detector simulations and reconstruction studies (Milstead, Meirose, Sze Chun Yiu, Dunne)



Conclusions



ect started in October 2020: the scope is the development of the ESS upgrade composed by Liquid deuterium moderator that will serve a UCN moderator and a VCN source using advanced reflectors.

- In the project will be also developed the associated instruments both from condensed matter science and fundamental physics
- Several results already obtained:
 - first moderator baseline available
 - to deliver cross section data for the materials in the project we developed a tool (NJOY+NCrystal), which was also used to generate the largest contribution in thermal scattering libraries
 - the conceptual designs of three future neutron scattering instruments already developed
 - first detector design for NNBAR almost complete



www.highness.eu https://cordis.europa.eu/project/id/951782

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