UCN possibilities at the ESS

Klinkby, Esben Bryndt; Batkov, K.; Mezei, F.; Schönfeldt, Troels; Takibayev, A.; Zanini, L.

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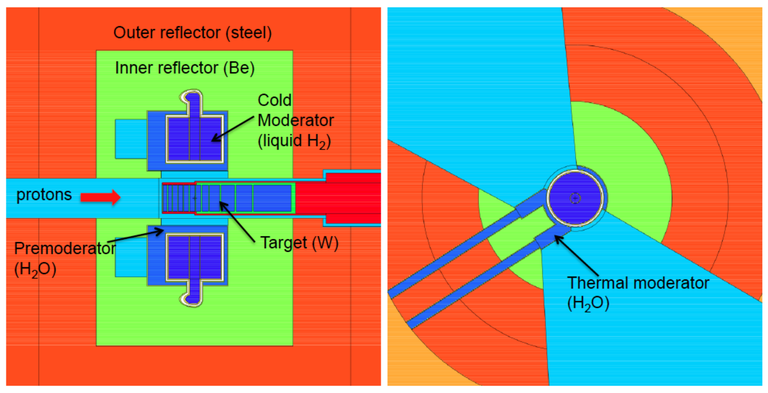
E. Klinkby[1,2] K. Batkov[1], F. Mezei[1], T. Schoenfeldt[1,2], A. Takibayev[1] , L. Zanini[1]
[1]European Spallation Source ESS AB,[4]DTU Nutech

The ESS target, moderator and reflector system

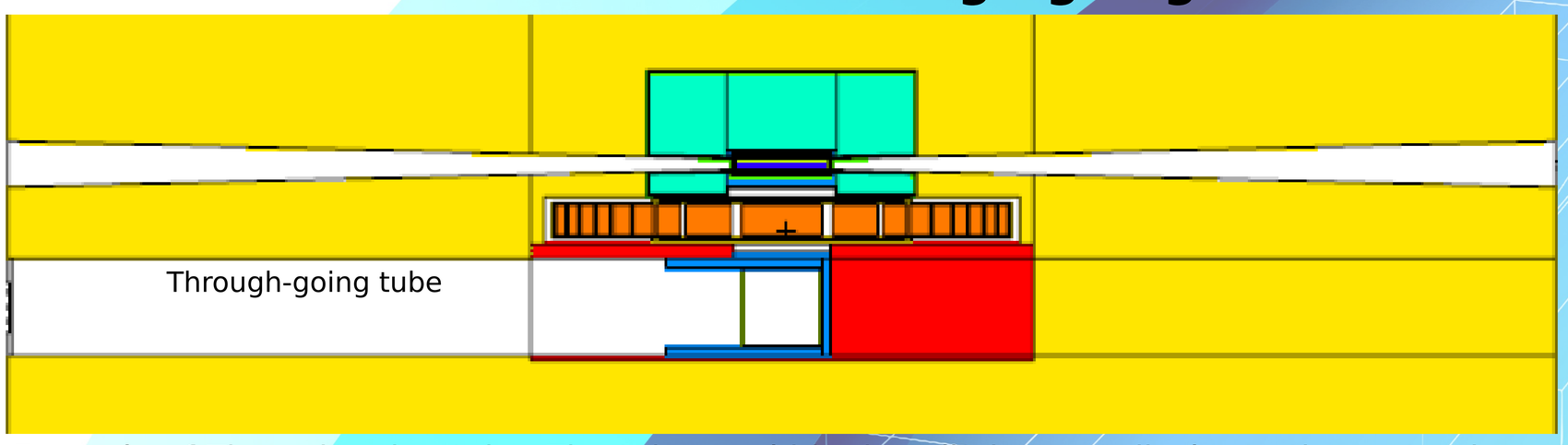


ESS target, moderator and reflector – TDR design

ESS will be a premier neutron source facility. Unprecedented neutron beam intensities are ensured by spallation reactions of a 5 MW, 2.0 GeV proton beam impinging on a tungsten target equipped with advanced moderators.

The ongoing program of neutronic design of the target-moderator-reflector system concentrates on providing moderators for scattering instruments which use thermal and cold neutrons. Simultaneous work, reported here, aims at investigating possibilities for installing a Ultra Cold Neutron (UCN) source at the ESS.
In the target-moderator-reflector baseline design of the Technical Design Report [1] (left), there is little room for a UCN moderator, except at a beam-line. Recently, however, the use of flat moderators for the scattering instruments was proposed [2] in order to increase the brightness observed by the instruments. One of the consequences of using a flat moderator, is that a single moderator on top of the target could serve most instruments, leaving more freedom in the design of a second moderator below. One of the options studied is to place the lower moderator in a through-going tube.

Through-going tube

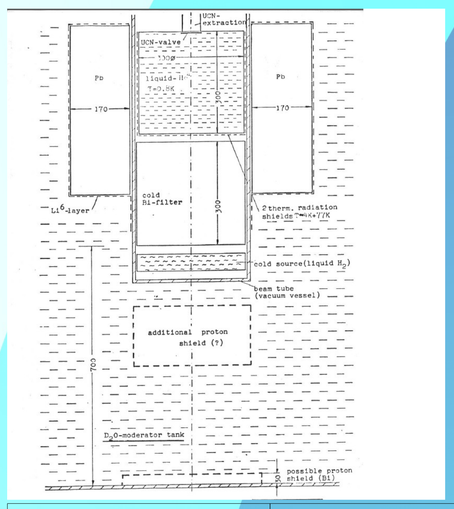


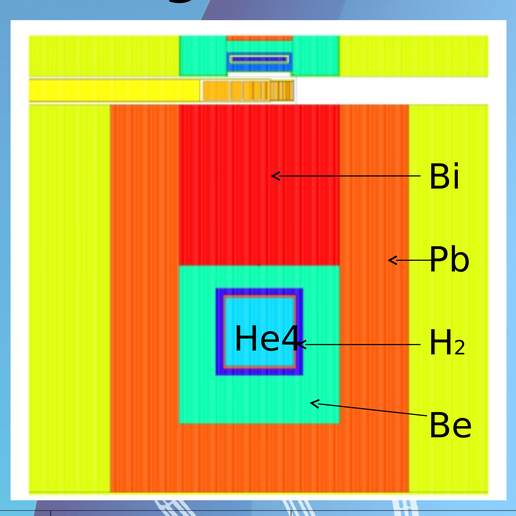
Example of Through-going tube. The tube would be installed perpendicular to the proton beam, to minimize fast neutron background. In addition to providing a view to the UCN moderator, the tube would also function as access service tunnel, and include the moderator piping and will allow the moderator to be interchanged. Outside service periods, the unused view (for example the entire rightward direction as in the above example) would be plugged by reflector material (Be/Pb/Fe)

<u>UCN Moderator options studied so far include:</u>

1. Goloub like He4 source
2. Satellite He4 source
3. D2 UCN pump

1. Goloub's design at ESS [3]

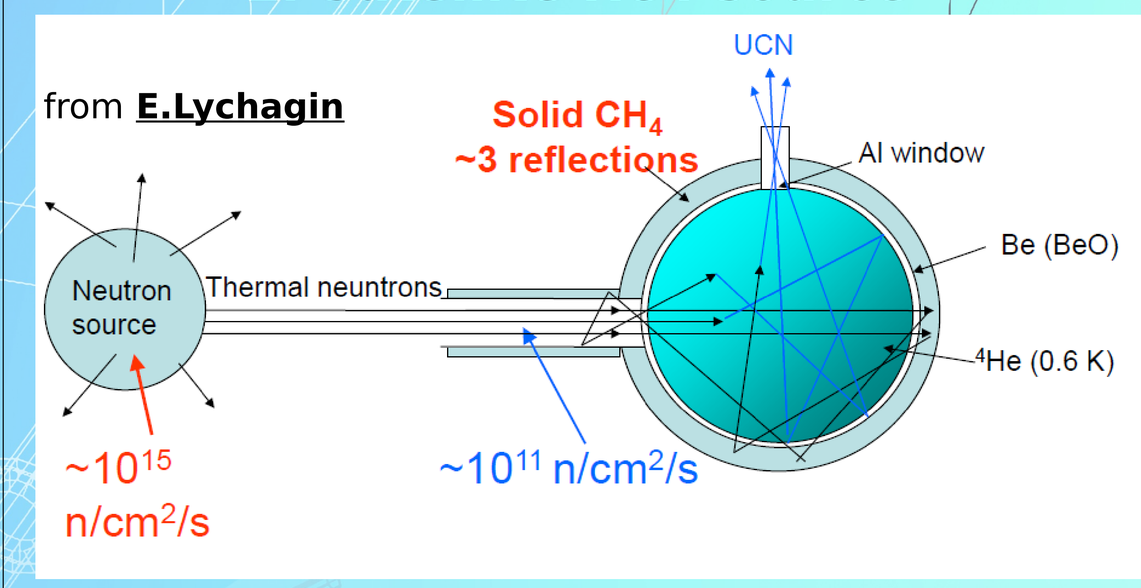




Heatload in moderator [W]	Flux: [0-5] meV [n/cm2/s]	Flux: [5-20]meV [n/cm2/s]	Flux: [20-100]meV[n/cm2/s]
68 (=2.5mW/cm3)	3.8E12	9.0E12	1.77E12

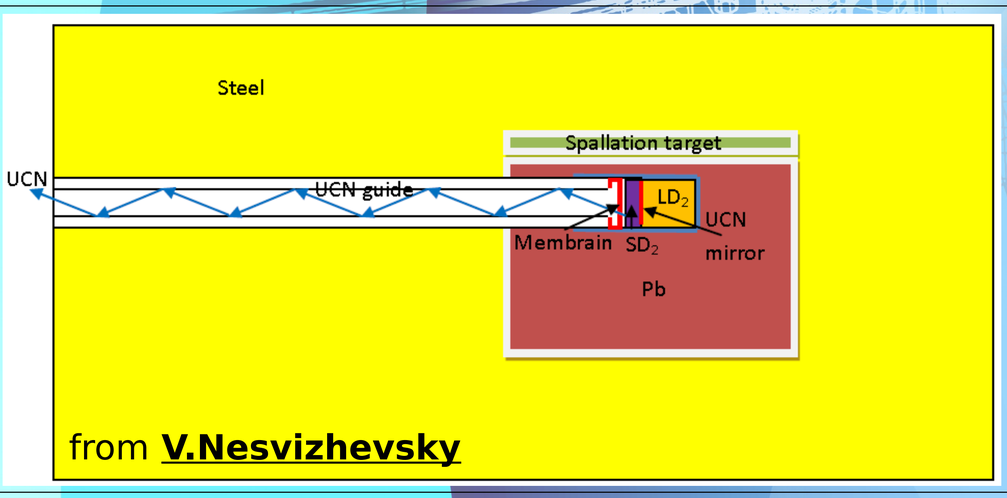
Maximum UCN production:
$P_{UCN} = \Phi_{th} * E' / T^2 \, e^{-E'/T} * 10^{-7}$ UCN/cm3/s
Inserting the ESS parameters gives : 10^8 in 30cm x 30cm x 30cm pr second in the He^4

2. Satellite He4 source



The basic idea [4] is to move the UCN moderator to a distance where the heating is manageable. When this is combined with the use of low neutron capture materials, a very high UCN density (~10^5cm^{-3}) can be achieved even at a significant distance (~5m) to the spallation target. The viewed surface of the cold (or even thermal) moderator is a limiting parameter. The above assumes 20cm tube (i.e. 20cm by 20cm moderator)

D2 UCN pump



In this design, proposed by V. Nesvizhevsky, some of the characteristics of the 2GeV long pulse proton driver at the ESS are exploited.

- An ultra-cold (few K) solid deuterium moderator (~1cm thick) is installed close to the spallation target, and is fed by a large liquid deuterium moderator.
- During the duration of the pulse: 2.5ms, the UCN will move ~0.5cm (at 4m/s), thus filling the "halo" in front of the D2. During the time between pulses, a membrane slowly push the UCN back – away from the D2, after which it rapidly moves back to the D2, ready for the next pulse.

The UCN density achievable in this design should be able to approach 10^6cm^{-3}

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[1] S. Peggs, editor. ESS Technical Design Report. April 2013.
[2] F. Mezei et al, Low dimensional moderators for enhanced source brightness. arXiv: 1311.2474
[3] R. Golub et al, Ultra-Cold Neutrons at the SNQ Spallation Source. TUM-E21/SNQ-UCN/81-4, 1981
[4] A.E Verkhogliadov, E. Lychagin et all, "Helium UCN source at the extracted beam of thermal neutrons". GRANIT 2014, Les Houche