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A new method to find optimal neutron moderator size based on instruments' parameters

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Last decade saw an introduction of low-dimensional neutron moderators, made up of almost pure para-hydrogen. Thanks to the large difference between scattering cross-sections for thermal and cold neutrons, such moderators shaped as tubes or disks can provide a significant brilliance gain over traditional voluminous cold sources. Studies at ESS [1] showed potential gains of 2-3 times in useful neutron flux when reducing the moderator height from 12 to 3 cm. Gain factors are especially prominent for the high-resolution instruments exploiting well-collimated beams. Unfortunately, such small moderators in many cases cannot fully illuminate the guide entrance, which in turn leads to non-uniform divergence beam profile at the sample position. Larger neutron moderators with lower brilliance are thus preferrable for some neutron instruments.

We present a general framework that allows to estimate the required moderator size basing on such instrument parameters as sample size, angular resolution and collimation distance. Phase space considerations are the basis of this method, while extensive Monte-Carlo simulations have been used to further prove it.

This framework is especially useful for newly built neutron sources, or ones where the cold neutron source upgrade is happening. It can also be used in reverse, allowing to find optimal instrument parameters for a given moderator size, providing full sample illumination and maximal sample flux with minimal background.

[1] Andersen K. H. et al. J. Appl. Cryst. 51 (2018) 264.

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