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Optimized thermal moderators for Compact Accelerator-driven Neutron Sources

U. Rücker, P. Zakalek, J. Li, J. Voigt, D. Shabani, S. Böhm[1], E. Mauerhofer, T. Gutberlet, Th. Brückel

JCNS-HBS, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany
[1]NET, RWTH Aachen, Wüllnerstr. 2, 52062 Aachen, Germany

Compact Accelerator-driven Neutron Sources (CANS) have the advantage (compared to research reactors or spallation sources) that the primary neutrons are emitted from a volume well below 1 dm^3. The thermal moderator is used to change the energy of the primary neutrons (typically in the MeV range) down to the 100 meV range, where they are useful for the structural investigation of matter. This moderation process takes place by multiple scattering events with the nuclei of the moderator material(s). To be able to extract neutron beams efficiently from the thermal moderator, it is important not to dilute the primary neutron cloud too much, but to keep it confined and dense for the time of the neutron pulse length desired.

The different materials useful for building a moderator-reflector assembly around a target of a CANS differ in their absorption probability, scattering power, and energy transfer during a single neutron scattering event. The scattering leads to energy loss and confinement (by a randomized flight direction of the neutron after the scattering), while absorption and diffusion out of the moderator-reflector region are the main mechanisms of intensity decay. Some typical materials are e.g. light water or polyethylene as hydrogen rich materials that lead to fast energy transfer (complete thermalization within 7 µs) and a good confinement of the thermal neutron cloud (about 8 cm FWHM), but the thermal neutrons decay with a time constant below 200 µs due to the nuclear absorption by the hydrogen nuclei. Beryllium or lead show a much weaker scattering probability and a lower energy transfer, which lead to slower moderation, a larger size of the thermal neutron cloud, but a longer lifetime due to an absorption probability that is several orders of magnitude lower.

We try to optimize the geometry and the combination of materials in a way to be able to provide the extraction of several neutron beams from a single moderator-reflector assembly with a suitable pulse time structure either for thermal neutron instruments or for feeding cold neutron sources inserted into the thermal moderator assembly.