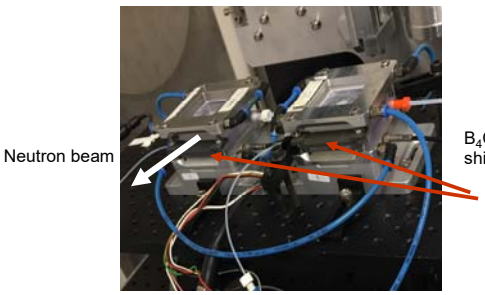
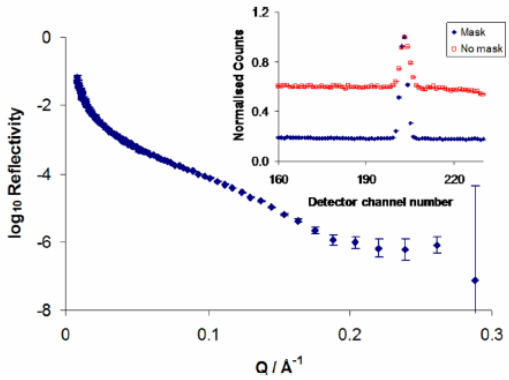
Additive Manufacturing of Neutron Shielding and Collimation materials

Anders Olsson, Maja S. Hellsing, Adrian R. Rennie, Materials Physics & Centre for Neutron Scattering, Uppsala University.

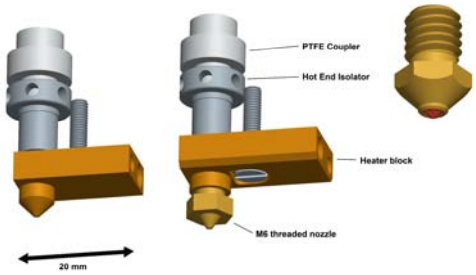
Additive manufacturing allows creation of new designs for scientific equipment that can be manufactured rapidly and economically.



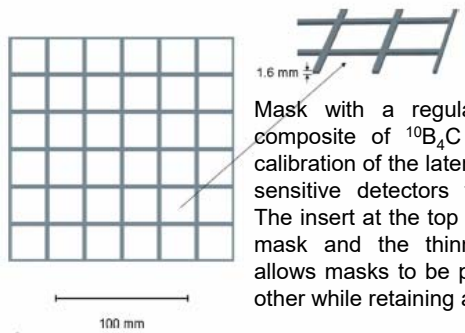
Reflection cells on Inter Reflectometer sample stage at ISIS. $^{10}B_4C$ composite neutron absorber blades reduce background, data shown below.



Reflectivity curve for a sapphire/D_2O surfactant solution interface. The inset shows the comparison of total counts for similar measurements with an absorbing blade to reduce background (blue) and without blade (red).

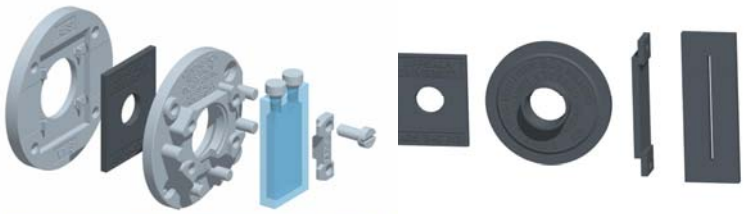


New printer nozzles with ruby inserts have been developed, designed to cope with hard materials such as boron carbide composites [2]. The nozzles are now available commercially.



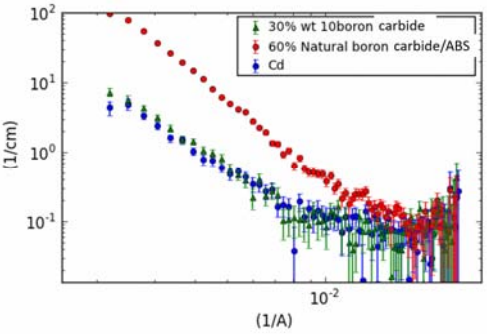
Mask with a regular array of absorbing composite of $^{10}B_4C$ in ABS designed for calibration of the lateral response of position-sensitive detectors for neutron scattering. The insert at the top shows the profile of the mask and the thinner edge section that allows masks to be placed adjacent to each other while retaining a uniform array.

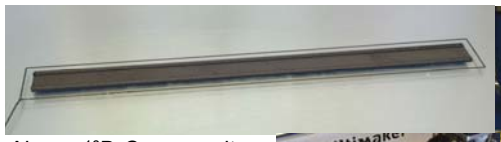
Fused filament fabrication of polymers and polymer composites has been used to make sample holders, neutron shielding, apertures and other items. Apart from benefits in ease of fabrication, this development avoids the use of the environmental hazard and toxic element, cadmium, in many applications.



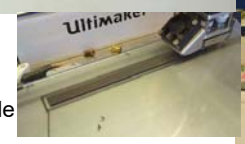
Four rotating mounts with $^{10}B_4C$ apertures on the sample translation stage of the BT5 USANS instrument at the NIST Center for Neutron Research.

Apertures for small-angle scattering that give low background by using $^{10}B_4C$ composite. The observed scattering for the $^{10}B_4C$ composite is approximately the same as that for a cadmium aperture [1], shown below.

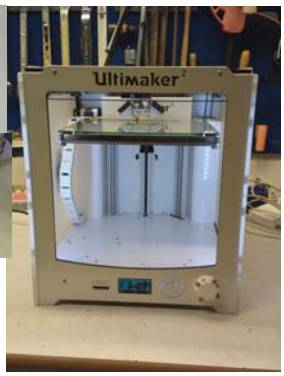




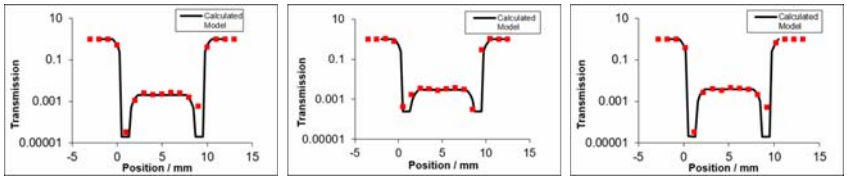
Above: $^{10}B_4C$ composite neutron absorber blade.



Right: Printing of the blade above.



Below: Data showing neutron absorption / transmission for the blade.



Other additives such as tungsten can be used to make shielding and collimation for X-ray beams.

References

[1] A. Olsson, A. R. Rennie, 'Boron carbide composite apertures for small-angle neutron scattering made by three-dimensional printing' *J. Appl. Cryst.* 49, (2016), 696-699.

[2] A. Olsson, M. S. Hellsing, A. R. Rennie, 'New possibilities using additive manufacturing with materials that are difficult to process and with complex structures', *Phys. Scr.* 92, (2017), 053002.