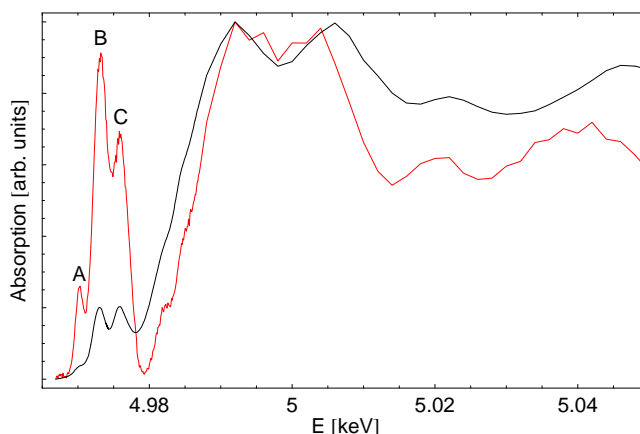




<b>Beamline:</b> BM28	<b>Experiment title:</b> Resonant Borrmann Effect in Rutile	<b>Experiment number:</b> HE-2778
	<b>Shifts:</b> 18	<b>Date of experiment:</b> from: July 23, 2008                      to: July 29, 2008
<b>Local contact(s):</b> Peter Normile	<b>Received at ESRF:</b>	
<b>Names and affiliations of applicants</b> (* indicates experimentalists): M. Tolkiehn <sup>1,2,*</sup> , S.P. Collins <sup>1,*</sup> , M. Priebe <sup>3,*</sup> , R. Pettifer <sup>4</sup> <sup>1</sup> Diamond Light Source Ltd., Diamond House, Harwell Science and Innovation Campus, Didcot, Oxfordshire, OX11 0DE, United Kingdom <sup>2</sup> present address: HASYLAB at DESY, Notkestraße 85, D-22603 Hamburg, Germany <sup>3</sup> Universität Göttingen, Germany <sup>4</sup> Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom		

## Report:

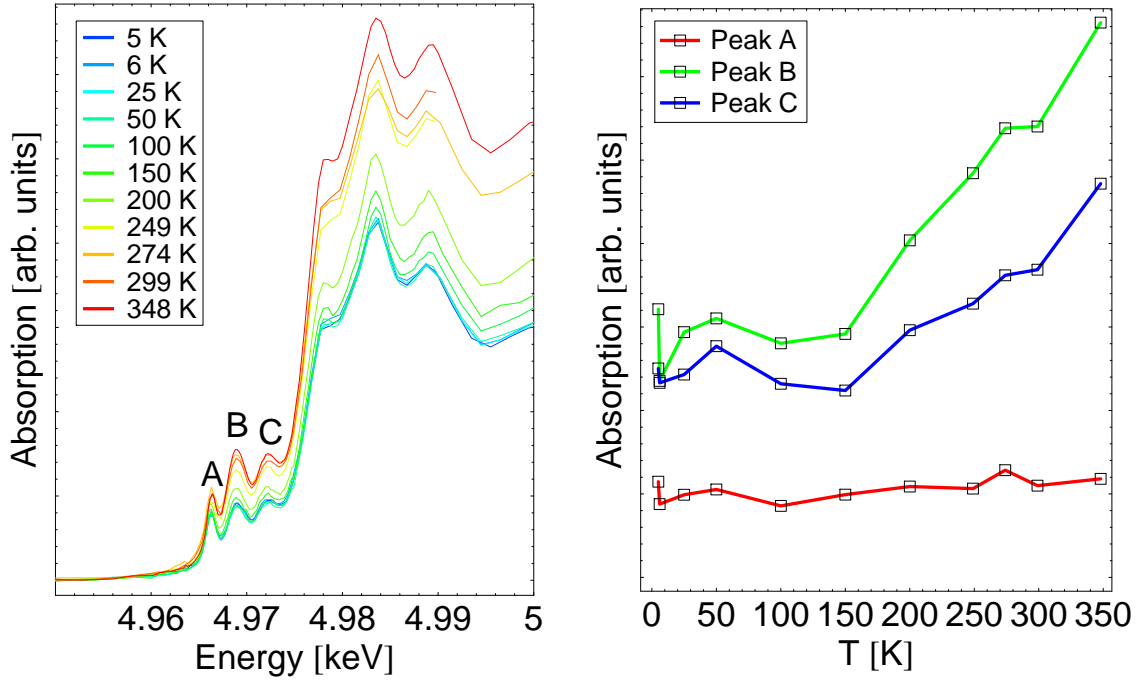
The goal of our experiment was to determine the nature of the features in the X-ray absorption near edge structure (XANES) of rutile (TiO<sub>2</sub>) at the Ti-K edge using the resonant Borrmann Effect. Therefore the intensity of Laue reflections was measured at different energies around the Ti-K edge (4.966 keV). Previous experiments on gadolinium gallium garnet (GGG) have already shown that quadrupole absorption is strongly enhanced at certain Laue reflections. We used this effect to identify the quadrupole contribution to the observed pre-edge peaks of rutile. Figure 1 shows a comparison of the quadrupole enhanced absorption spectrum and a conventional spectrum.



**Figure 1:** Absorption of TiO<sub>2</sub> at the Ti-K edge determined from Ti-K fluorescence yield (black line) and from the integrated intensity of the (020) Laue reflection (red line).

Peak A, which can be hardly seen in the conventional spectrum, is a pure quadrupole transition. Peaks B and C have the same height in the conventional spectrum. In the Borrmann spectrum B is stronger than C. This suggests, that there is a quadrupole contribution to B.

The experiment was repeated at different temperatures in order to investigate the temperature dependence of the quadrupole enhancement. Theoretical calculations predict that dipole absorption will increase with temperature in the Borrmann case while quadrupole absorption does not depend temperature (at least in a first order approximation). This is in good agreement with the results shown in figure 2: While the absorption at peak A does not depend on temperature, a linear increase above 150K is observed for peaks B and C.



**Figure 2:** Left: Absorption obtained from the intensity of the  $\text{TiO}_2$  (011) reflection at different energies and temperatures. Right: Temperature dependence of the three pre-edge features.

From these results it can be concluded that peak A is a pure quadrupole transition, peak B is a mixed dipole quadrupole transition and peak C is a pure dipole transition. The difference between the Borrmann spectra measured at the (020) reflection (fig. 1) and the (011) reflection (fig. 2 left) is partly caused by the different values of  $F_H F_{\overline{H}}$  for these reflections. The quadrupole absorption also depends on the azimuthal angle, which was different for the (020) and (011) measurements. We assume that this azimuthal dependency caused the stronger enhancement of peak B at the (020) reflection, however this could not be studied in full detail in beamtime HE-2778. A more thorough investigation is planned for future beamtimes.

We acknowledge the extensive support by the BM28 staff during our beamtime.