Recently, we observed a new anisotropic superconductivity induced transfer of spectral weight between the buckling phonon mode and another phonon peak by inelastic neutron scattering in the system $YBa_2Cu_3O_{6+x}$. Therefore we posed a proposal for ID28 in order to investigate this effect on $YBa_2Cu_4O_8$ with inelastic x-rays, as for this material no samples for neutron scattering are available.
There have been justifiable concerns whether it is possible to measure the phonon buckling mode and this special effect with inelastic x-rays at ID28. Despite these concerns we got 6 days of beam times for first experiments. We split these days in two and four days. The first two days served as test measurements, about which this report will be. During this short beam time, we could indeed find an appropriate Brillouin zone and make first measurements of the buckling phonon mode by inelastic x-rays. We will use the remaining four days for increasing the statistics for the most promising points in reciprocal space. This then will be a good basis in order to make complete measurements of the effect, for which we will submit a continuation proposal.
ID28 is a multi-analyzer very high-resolution backscattering spectrometer which scans the energy of the excitation by variation of the monochromator temperature. The energy resolution is that high, that one obtains for incident x-rays with the energy in the keV range an energy resolution in the meV range. For the (9 9 9) reflection with 17.8 keV we obtain an energy resolution between 3.3 and 4.75meV depending on the analyzer. We used this monochromator reflection because of the higher flux compared to reflections with higher energy resolution. We made our test measurements at room temperature (295K).
Depending on the Brillouin zone we made measurements of the longitudinal and the transversial phonon branches in $YBa_2Cu_4O_8$. Thus we got a good data bases in order to compare our lattice dynamic calculations with experiment and refine the model parameters. Moreover, we made measurements in transmission and reflection geometries. In order to find the optimal Brillouin zones for the measurements of the transversial buckling mode, we calculated the dynamic structure factor of inelastic x-rays for various points in reciprocal space. For these calculations we used the results of our lattice dynamic calculations. The goal of these calculations was to maximize the intensity of the buckling mode and minimizing the intensities of neighboring phonon modes. We found that the Brillouin zones around (1 0 11) and (0 0 24) are good zones for measuring the buckling mode in transmission and reflection, respectively. These Q-values are the nominal values which are valid for the second analyzer. For the other analyzers these Q-values deviated. Due to the nine analyzers of ID28, we could investigate several configurations in reciprocal space around the theoretically optimal Q-values. Thus and by changing Qc, we could find the good values for our measurement, where we indeed could observe the buckling phonon mode.
Figure 1 shows the buckling phonon mode at an energy around 43meV. This is within the range of expected energies, which can be estimated using Raman data and the knowledge that this mode is only weakly dispersing. The effective Q-value is Q = (1.53, 0, 12.271). This Q value has been obtained considering the fact, that we made these measurements with analyzer number four. With four points above the background the mode can be observed clearly. However, further measurements are necessary in order to increase the statistics and improving the quality of the data, before a reliable fit can be performed in order to determine the energy and the line width of the phonon mode. The background is determined by a strong phonon mode at around 34meV. This reflects the principle difficulties in measuring the buckling mode

as it involves the motion of oxygen ions, a element that scatters x-rays less then all the other elements in the unit cell of $YBa_2Cu_4O_8$.

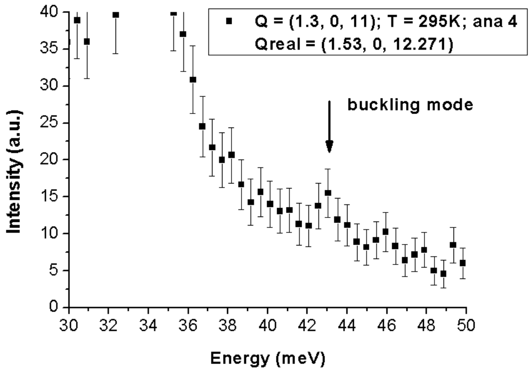

Figure 1: Shows the buckling phonon mode at around 43meV at room temperature. The nominal Q-value is Q = (1.3, 0, 11). As we measured with analyzer number 4 the effective Q-value is Q = (1.53, 0, 12.271). For this analyzer the energy resolution is 3.3 meV. The buckling mode can be well observed, as four points are above the background. One point has been measured with 4 minutes.

However the close neighbors of the buckling mode have less intensity than the buckling mode and hence this is a rather good configuration in order to perform further measurements. Especially the apical oxygen mode at around 40meV seems to be rather weak. This might be important if one considers, that we would like to observe a superconductivity-induced softening of that phonon mode.

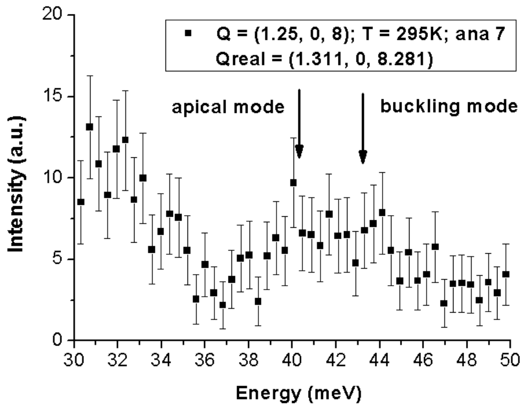

Figure 2: Shows the buckling phonon mode at around 43meV at room temperature. The nominal Q-value is Q = (1.25, 0, 8). As we measured with analyzer number 7 the effective Q-value is Q = (1.311, 0, 8.281). For this analyzer the energy resolution is 3.36 meV. The buckling mode can be well observed as a double peak together with apical oxygen mode at around 40meV. The background is relatively low for this configuration. One point has been measured with 2.7 minutes.

Figure 2 shows a second promising configuration in order to measure the buckling mode, as the background is relatively low. However, this figure shows a double peak structure meaning that the apical oxygen mode at around 40meV is observed with considerable intensity in addition to the buckling mode. This might also be a good point in reciprocal space to make further measurements.

In summary we have shown, that one can indeed measure the buckling mode with inelastic x-rays by measuring in an appropriate Brillouin zone. This is an important first step in measuring the superconductivity-induced transfer of spectral weight in $YBa_2Cu_4O_8$.