ESRF	**Experiment title:** Ferroelectric excitation dynamics	**Experiment number**: HS 2648
Beamline: ID09B	**Date of experiment**: from: 03-02-05 to: 07-02-05	**Date of report**: 05-03-04
Shifts: 12	**Local contact(s)**: Prof. M. Wulff	*Received at ESRF:*

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Report:

The interest of the present experiment is to derive structural dynamics of ferroelectric crystals subjected to femtosecond laser pulses. In experiment HS1564 we have already studied the lattice reaction of a $BaTiO_3$ powder on femtosecond pulses in the IR (800nm). Within the present experiment a single crystal of $BaTiO_3$ (cut on a <100> plane) has been investigated. The crystal is contacted on the two flat sides by a thermoeelectric heater, which can control the temperature to a fraction of a degree, in order to define the phase of the crystal relative to the ferroelectric- paraelectric transition at 122 °C (tetragonal to cubic symmetry change).
As no timing mode was available for this experiment, the homogeneous filling of the ring was used. Here integrating detectors, such as CCD cameras cannot be used for data acquisition with picosecond time resolution, as the bunch spacing is to narrow for discriminating single pulses. Consequently we tested a fast detector to isolate single x-ray pulses from the pulse train. The scattering was set up by choosing angle of scattering, such that the rising edge of the split reflection (200) was recorded (see arrow in fig. 1). This allows to record transient lattice parameter changes, when the signal amplitude from the detector is stored by an oscilloscope

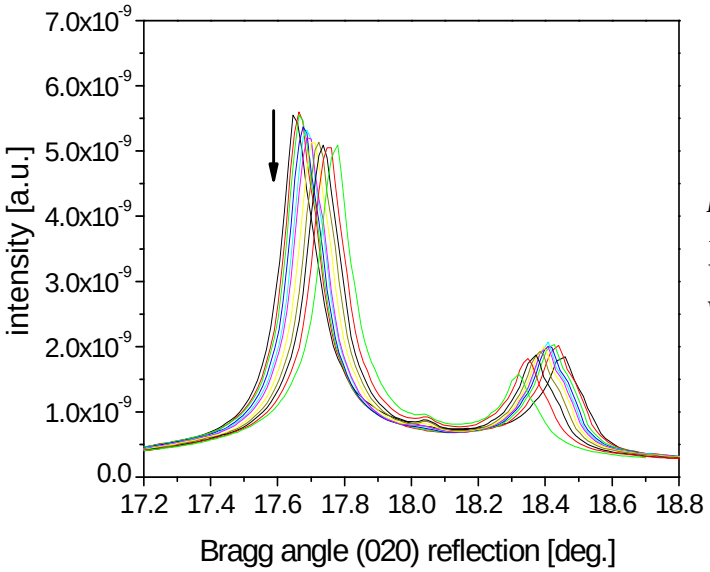

Fig. 1*:Bragg profile of the BaTiO3 crystal (020) reflection as function of temperature (30 °C for the outer peaks up to 110 °C for the inner peak). The <010> face was polarized predominantly perpendicular to the surface, so that the expected 1:2 ratio of long tetragonal to short tetragonal axis was inverted. The rising edge of the low angle peak was used to record scattering changes.*

By setting a region of interest on the oscilloscope trace it was possible to select single pulses, when using an avalanche diode (Becker&Hickl) with a pulse width of 450 ps. In fig. 2 the complete trace of the pulses that are transmitted through the chopper is displayed, as well as the shape of single pulses. The signal to noise ratio of the Tektronix oscilloscope was only 20 (for a low amplification at the diode, which certifies short pulses). It was therefore difficult to detect small changes in the reflectivity induced by the laser. When using a Cyberstar plastic scintillator with an enhanced quantum efficiency was used, changes of the reflectivity of the order of 0.5 % could be tracked. This small change is a consequence of the nonresonant interaction of the laser with the (transparent) crystals, leading to a small energy absorption at the surface.
In consequence it is possible to detect single pulses from strong scatterers to allow picosecond time resolved measurements even for non-timing modes. In the present case the scattering cross section is large, while in contrast the photoinduced changes are very small. The use of a plastic scintillator still allows to detect changes, however this detector has a rise time of 3 nanoseconds, which is too long for single pulse discrimination.

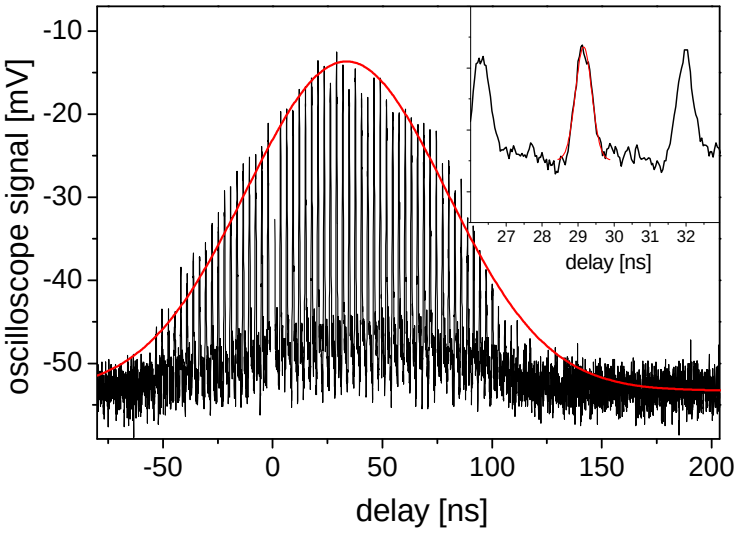

***Fig. 2**:: Trace of the detector signal on the Tektronix oscilloscope in averaging mode for the pulses transmitted through the oscilloscope. The envelope of about 100ns represents the time resolution for integrating detectors. The inset is the enlargement of one peak, as recorded with an avalanche diode with pulse width of 450 ps FWHM.*

In conclusion the nanosecond dynamics of the laser-lattice interaction can be tracked in non-timing mode. This is particularly useful for the determination of the thermal kinetics, such as thermal lattice heanig and subsequent cooling into the bulk. When phase change dynamics are involved, they should even slower, when nucleation and growth plays a role in a first order transition. This mode is adequate to investigate macroscopic phase changes.
However even for single crystals it may become difficult to observe nonthermal behaviour, which is relatively weak, with fast detectors. This experiment depends on the signal to noise ratio of the detector-sampling combination, at present is too low for the envisaged studies.