ESRF	**Experiment title:** **Time dependence of a X-ray resonator**	**Experiment number:** **MI 224**
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Report:

The aim of the experiment was to investigate the time dependence of an X-ray beam stored in a resonator as sketched in figure (1). Photons of the backscattering energy transmitted with a probability T and reflectivity R at each of a pair of crystals should be trapped by multi reflection in-between resulting in a time delay which depends on the path length the photon travels. The resonator is made by two monolithic Si 111 crystal plates in a distance of L = 15 cm. Each plate has a transmission T and reflectivity R depending on the reflection used and the thickness D of the plates. To vary the latter the crystal plates are wedge shaped and a translation allows to choose the appropriate thickness. A short photon pulse can be transmitted by T^2 through the system and then counted in a fast detector behind the setup. Alternatively, it can oscillate N times between the crystal plates and leave the device with a probability $T^2 \cdot R^N$ after a time $t_N = 2\,N\,L\,/\,c$ where c denotes the speed of light. In the present case two pulses should be separated by $t_1 = 1$ ns.

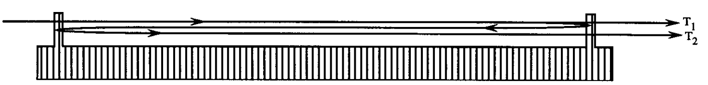

Figure (1): Sketch of the resonator

The beam has been pre-monochromized by the vertical double monochromator of BM5 and a single silicon 53 1 reflection in the horizontal plane impinging on the resonator. The energy was determined by rotating the resonator around its vertical axis to use the -220 reflection in (++) and (+-) geometry. Rotation angles to the right backscattering energy have been calculated by the energy deviation, however it turned out to be difficult to get a pure backscattering signal. The detector measured the transmitted intensity with the idea to get glidges when part of the beam is scattered back. However the 999 reflection in backscattering is a highly symmetrical condition which allows other multiple reflections to be excited taking as well intensity off the beam without going into the back direction. Some typical crystal rotation scans are given in figure (3) which can show tremendous oscillations around the symmetry point. In addition time resolved scans have been undertaken while the energy was varied, the latter being difficult to follow the change in angle and position behind the pre monochromators.

A typical time scan is displayed in figure (3) showing the main bunch followed by two not completely empty bunches. Note that the time axis is negative. The intensity ratio between the main and parasitic bunches is 10^{-6}, thus the signal of stored photons should have been observed. The expected reflectivities were some 10^{-3} for the first and then less than an order of magnitude down for each further back and forth reflection. Additionally it has been found that the detector signal has a shoulder 1 ns, but this should be acceptable to observe the signal of multi reflection.

Resuming, no back and forth reflection has been observed. We attribute this to the inaccuracy in the incident energy and the fact that we used the detector in transmission. A narrower energy band together with a better temperature stability would be very helpful in a future experiment. In addition a fixed exit monochromator should be investigated.

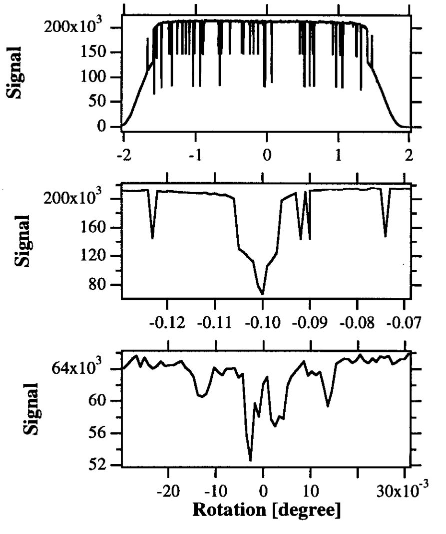

Figure (2): Glidges in the transmission near the 999 back reflection condition.

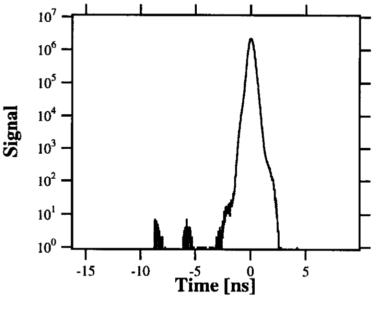

Figure 3: Time spectrum of the synchrotron fill showing the main bunch in 16 bunch mode and 3 unproperly filled bunches later. The time axis is negative and goes from left to right.