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Observation of Coherent Transition Radiation in Super-radiant Regime and its Application for Longitudinal Diagnostics

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Coherent TR (CTR) is generated when the radiation wavelength is comparable to or longer than the bunch length. In that case, all particles emit radiation more or less in phase, and the radiation intensity is proportional to a square of the number of particles in a bunch. However, if we have a sequence of bunches (a train) separated by a fixed distance from one another, the radiation is generated in a so called super-radiant regime. In that case the coherent radiation generated by individual bunches interfere. The radiation spectrum, in this case, is no longer continuous, but represents a set of very narrow lines separated by the bunch sequence frequency, which is proportional (if not equal to) the accelerating (RF) frequency. The width of those lines depends on the number of bunches in the train. For example, for 7000 bunches the relative monochromaticity can reach 10^{-4} - 10^{-7} depending of which radiation harmonic is observed. With modern interferometer based Fourier Transform spectrometers or gratings it is not possible to achieve sufficient resolution to precisely measure those lines.

In this report we will present CTR measurements in super-radiant regime using a horn antenna and a spectrum analyser at MT-25 microtron in Dubna. The measurement system enabled us to precisely resolve several radiation harmonics. We will demonstrate how RF frequency shifts during the acceleration and evaluate the single electron bunch length from the extracted spectrum.

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