# A new experimental probe for investigating the spatiotemporal dynamics of relativistic electrons in storage rings

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In an electron storage ring, relativistic electrons are "trapped" during a long time (typically several hours). This type machine is of particular interest for producing producing synchrotron radiation, as various wavelengths for users. However the operation of such machines involves complicated nonlinear dynamics issues.

From the theoretical point of view, the electron bunch experiences spatiotemporal dynamics, in a phase space (in the thermodynamical sense) with 6 dimensions. As an ubiquitous feature, a perturbation with wavenumber $k$ will experience both rotation in space space at a slow frequency, typically in the 10 KHz range for our accelerator (UVSOR-II, Japan) called the synchrotron frequency, and a diffusion process. An important point is that these processes provide only a slow damping of perturbations. Therefore instabilities of the system are likely to occur easily. A important destabilizing ingredient is the interaction between electrons of the bunch, via the so-called *wakefield* effect. This leads to the so-called microwave and CSR (coherent synchrotron radiation) instabilities.

Although theoretical desriptions exists since a long time, few direct comparisons between theory and experiments have been performed up to now, essentially because of the high difficulty to observe in real time the space space evolution of the electrons. Moreover, though of major importance for the dynamics, theoretical and experimental investigations of the electron wakefield is a difficult task.

In this work, we adopt an alternate strategy. We have constructed an experimental setup allowing to perturb selectively the electron bunch using various wavenumbers, and to study the transient following the perturbations. This uses an external laser, as presented in the last ECC conference [1], and an additional setup for analyzing the damping/growth of perturbations from the terahertz emission analysis. This allows to compare new features of theoretical models against experiments. In particular we will make comparison with the Fokker-Planck-Vlasov equations, and show that characteristic features of the dynamics are due to the presence of wakefields, and thus interactions between electrons.

[1] *Tunable narrowband terahertz emission from mastered laser-electron beam interaction* S. Bielawski, C. Evain, T. Hara, M. Hosaka, M. Katoh, S. Kimura, A. Mochihashi, M. Shimada, C. Szwaj, T. Takahashi, and Y. Takashima Nature Physics 4, 390 (2008)