# Interactive diagnostics for a pulsed electron beam transport in plasma

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We investigate the transport of a pulsed beam propagating through uniform plasma with powerful tools of non-linear theory. To describe self-consistently and to analyze the beam transport we use a Vlasov-Maxwell model associated to interactive test particle diagnostics based on chaos mechanics. We show that non-linear plasma effects and strong mismatched beam can lead to a chaotic particle behavior.

The propagation of an intense charged particles beam driver in plasma develops a wakefield strong enough to accelerate particles. The method is proven to yield accelerating gradient of the order of GeV/cm and energy gains beyond 1GeV [1]. Recently, proton beam was used as driver [2] instead of electrons or positrons to avoid the transformation ratio limit .But experimentally, electron beam driven acceleration still have the most total energy gain in plasma. A key issue in electron beam driven plasma wakefield accelerators devices is to prevent instabilities and erosion in beam transport. Beam envelope mismatch can lead, in some conditions, to a halo formation which finally increases the particle beam losses. In order to control halo emergence, a better understanding of physics is necessary.

To describe and study the beam transport and the halo emergence we use a self-consistent Vlasov-Maxwell model associated to powerful interactive test particle diagnostics based on chaos mechanics.

A non-linear envelope equation of the rms beam radius coupled to a full Maxwell system in cylindrical geometry is solved self-consistently. The pulsed beam core is assumed to have a bi-gaussian shape characterized by rms radii in longitudinal and transversal direction. The beam core parameters and the electromagnetic fields are advanced as a function of time in accelerator structures or in plasma. Inside the core are injected particles which move in the electromagnetic field [3] and can undergo elastic and inelastic collisions in plasma. In order to study complex particle dynamics, tools adapted from the non-linear theory of chaos mechanics like Poincaré plot of sections were used.

For a perfect matched beam with linear fields, particles are trapped inside KAM surfaces and the beam transport is stable. In contrast,we can show by interactive Poincaré plot of sections that a strong mismatched beam generates an extended chaotic halo far from the core, due to nonlinear forces or stochastic collisions. This method can be used to study beam transport in accelerator devices or plasma medium.

[1] I.Blumenfeld and al., Nature (London) 445, 741 (2007)

[2] A.Caldwell, K Lotov, A. Pukhov, and F. Simon, Nature Phys 5, 363 (2009)

[3]T.P Wangler, K.R Crandall, R. Ryne, T.S Wang, Physical Review Special Topics-Accelerators and Beams Volume 1, 084201 (1998)