We investigate a transverse RF kick induced by the transition between rectangular waveguide and coaxial line of the RF coupler in the 1.6-cell L-band normal conducting (NC) RF gun at the Photo Injector Test Facility at DESY, Zeuthen sit (PITZ). A three-dimensional electromagnetic simulation shows the disturbed RF field distributions in the fundamental accelerating mode. Based on the 3D RF field map, an electron beam based characterization and quantification of the coaxial coupler RF kick in the PITZ gun is preliminary. Theoretical predictions of the results are investigated.

**Beam-based Characterization of the RF Kick**

The kick characterization is conducted by scanning the RF start-phase of the gun in particle tracking simulations. The beam centroid on track is initially placed at the center of the cathode plane. It is tracked through the gun cavity till close vicinity of the door-knob transition. The whole calculation domain is covered by the RF field map. In Fig. 4, the particle off-center distance (i.e., in (a) and (b)) on the transverse plane and the corresponding transverse momentum (i.e., in (c) and (d)) are calculated at different longitudinal positions along the cavity axis of symmetry. In Fig. 5, the kick strength and the off-center displacement at z = 0.3 m are plotted as a function of the gun phase.

Note that, a nominal electron bunch of 20 ps in FWHM (full width half maximum) at PITZ corresponds to about 10 degrees gun phase at the resonant frequency of 1.1 GHz. Consequently, the slope and tail of the off-center vs bunch may see a kick slope (see (b)) in Fig. 7. Due to the time dependence of the RF kick, the RF field distribution is dependent on the time of the RF cycle and phase in the MMKG phase. However, the presence of the solenoid field may further complicate the dynamics (35-17).

**Multipole Expansion Based Kick Quantification**

To clarify the multiple composition and quantify their strengths in the integral kick, the transverse momentum of the beam particle is decomposed into a dipole component, a normal and a skew quadrupole component (1) and (2).

\[
P_z = P_{z0} + (K_{zp} X + K_{zp} Y) (1)
\]

\[
P_z = P_{z0} + (K_{zp} X - K_{zp} Y X) (2)
\]

The particle tracking simulation results used to fit the formulas (1-2) are shown in Fig. 7. The initial positions on the cathode plane of all in-track particles in the simulations are illustrated in Fig. 6.

**Summary and Outlook**

In this paper the RF fields with rotational symmetry disturbed by the transition from the input rectangular waveguide to the coaxial coupler of the PITZ gun are shown. The resulting RF kick in the electron bunch is vertical and time-dependent. The latter characteristic can introduce a kick slope along the bunch. The integral kick is, furthermore, quantified in the form of its multipole components using the results of particle tracking simulations. This gives a main dipole kick of about 0.65 mrad at the MMKG phase of the gun for a RF power of 6.5 MW. A small normal and skew quadrupole component is found to be about 1.65 keV-cm/m and 5.6 keV-cm/μm, respectively.

Further studies are foreseen to investigate the impacts of the kick on the beam dynamics when the space charge effect is included. Note that also, to explain the asymmetrically simulated transverse phase spaces and transverse profiles of the electron bunch at PITZ, other effects, such as the imperfect solenoid symmetry are also under investigation (cf. [15-17]).

**References**