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INFLUENCE OF COULOMB FIELDS ON THE FORMATION OF EMITTANCE IN PHOTOGUNS

V.Ya. IVANOV

Budker Institute of Nuclear Physics, Novosibirsk, Russian Federation

The modern colliders require intensive high quality electron beams. The beam parameters for such projects, as SKEKB [1,2], FCC [3] or Super C-Tau factory [4] need the beam charge of a few nC (1-6.5 nC), the energy spread less than 1%, the normalized transverse emittance less than 20 mm-mrad, The DC electron guns with thermionic cathode allow to achieve the beams with such charges, but the low emittance and the energy spread are difficult to obtain with such guns. For example, when one uses S-band accelerating structures, the beam length has to be of a few millimeters, and to have the energy spread less than 1%. There is nothing wrong with that, since for FCC or Super C-Tau Factory the rms energy spread is about 0.1%, therefore the beam length should be less than 1 mm in this case. Thus, the DC guns with thermionic cathode need the bunching system, but the beam compressing with high quality can be a very difficult challenge.

In spite of the promising of the RF photoguns, there are a lot of challenges, which should be resolved. One of these is the high charge of the beam, and especially the effect of them on the beam emittance. Since 1985, when the first photogun was constructed at the Los Alamos laboratory, such sources have become more and more popular. Photoguns are promising sources of electron bunches with a small transverse emittance [5-9].

The performed theoretical analysis and numerical calculations give an idea of the emittance acquired by the bunch due to the influence of Coulomb fields when moving in the accelerating cavity of the photogun. The data obtained provide a relationship between the emittance not only with the geometric dimensions of the beam, but also with an arbitrary distribution of the space charge density in the bunch. It is shown that the output value of the bunch emittance is minimal for a compact (uniform) charge distribution and increases significantly when the charge is smeared for a normal distribution in the longitudinal and transverse directions. For a bunch in the form of a thin disk, the growth of the transverse component of the emittance is much greater than that for the longitudinal direction. In practice, the degree of smearing of the space charge is determined by the shape of the laser pulse that excites photoemission. The results of numerical simulation will further serve as the basis for comparing the degree of influence of the high-frequency field of the resonators and the Coulomb fields of the bunch on the total emittance of the beam at the output of the photogun. The analysis performed allows us to formulate a number of recommendations for the design of the photogun to compensate for the growth of the emittance.

REFERENCES

[1] T. Miura et al., Upgrade Status of Injector LINAC for SuperKEKB, in Proceedings of the IPAC'14, Dresden, Germany (2014), pp. 59-61.

[2] https://www-linac.kek.jp/linac-com/report/b2gm/linac-status-satoh-200622.pdf

[3] https://link.springer.com/content/pdf/10.1140/epjst/e2019-900045-4.pdf

[4] https://ctd.inp.nsk.su/c-tau/

[5] D. Nguyen, J. Lewellen, L. Duffy, RF Linac for High-Gain FEL. Photoinjectors/ US Particle Accelerator School, June 16-20, 2014.

[6] K.-J. Kim, RF and Space-Charge Effects in Laser-Driven RF Electron Gun, NIM A275 (1989) 201-218.

[7] T. Natsui, M. Yoshida, X. Zhou, Y. Ogawa, Quasi-traveling wave gun and beam commissioning for SuperKekb, Proc. Of IPAC2015, Richmond, VA, USA, PP. 1610-1612.

[8] H.Bluem, A. Todd, M. Cole et al. ELECTRON INJECTORS FOR NEXT GENERATION X-RAY SOURCES, SPIE 49 th Annual Mtg., Denver, CO, 206 August, 2004.

[9] D. H. Dowell, Sources of Emittance in RF Photocathode Injectors: Intrinsic emittance, space charge forces due to non-uniformities, RF, and solenoid effects, http://arxiv.org/abs/1610.01242.