Designing a photocathode RF electron gun

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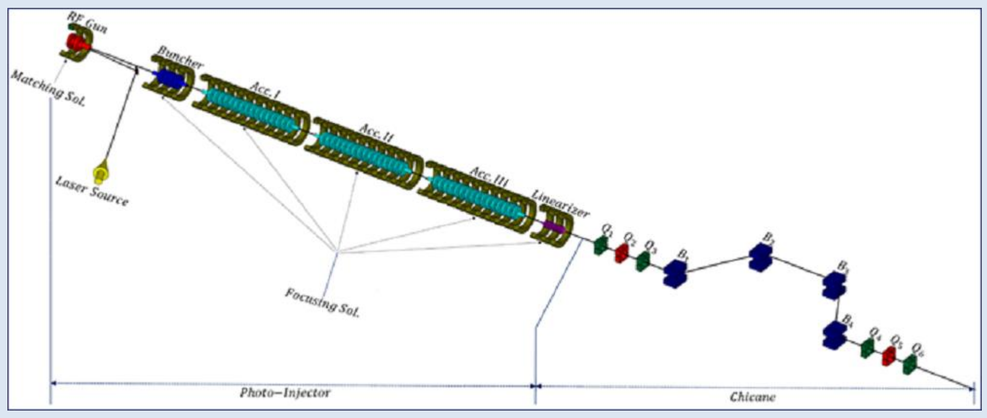
Abstract:

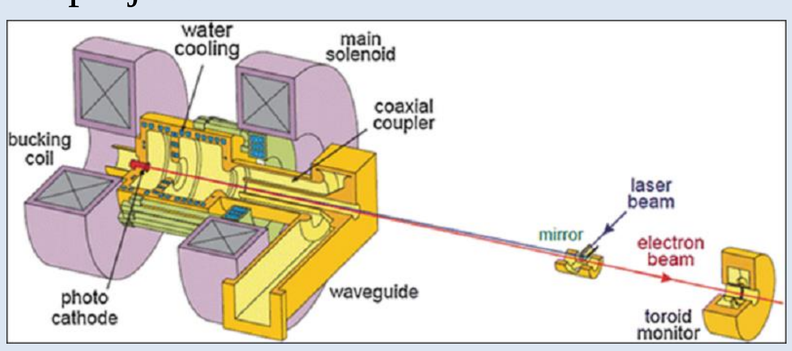
Nowadays, production of ultra short and high-current electron bunches of few fs to hundred fs with several pc charge is a very attractive subject in the context of many recent applications, specially, in light sources, free electron lasers and plasma wake field accelerators. In the light sources and free electron lasers, the radiation gain is directly proportional to the beam pick current and so obtaining very short bunches on the order of fs plays an essential role for high gain machines. Consequently, recent approaches for production of such electron bunches are based on usage of photo injectors in combination with a chain of bunch compressors. In the Iranian light source project attempts are directed toward the designing a novel compact soft X-ray synchrotron beyond the state of the art, using the latest advanced studies worldwide. The project will be started form a novel photo injector which can provide very high quality, and in the meantime, ultra-short electron bunches in a compact structure. Moreover, finding the best structures for the RF components, specifically, the RF gun and its associated buncher cavity has a crucial effect on the function of the whole light source in near future. In this poster I will show my designs for the photo cathode RF gun.

Electron Source Layoout

Fig.1 shows the general layout of our proposed novel electron source for the ILSF project (not to scale). The electron source composed of two main parts: a photo-injector and a chicane. In the photo-injector, using a high-quality pulsed laser beam with few ps pulse lengths illuminating



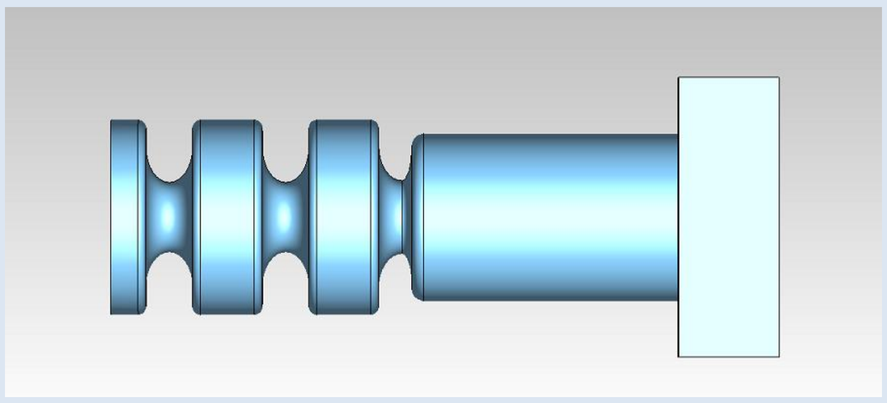
a cathode located on the wall of a high gradient RF cavity (RF gun) and a train of electron bunches are generated with the laser time structure. Fig.2 shows the detail structure of our proposed new photo-cathode RF gun for the project.



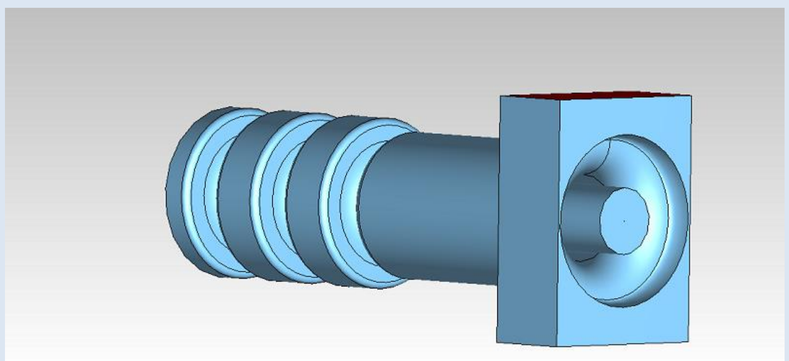
Due to the laser operation, the produced electron bunches have extremely high-quality, but in negative side very low energies ($\approx eV$) where the effects of nonlinear space-charge forces are dominated and able to largely degrade the bunch quality. Nevertheless, fast acceleration of the electrons using high gradient RF fields right after their liberation from the cathode, significantly decreases the action of these nonlinear forces and to a great extent keep the bunch quality. Therefore, what we can gain after the RF gun would be a beam of high-quality relativistic electron bunches with few MeV energies, but relatively large in length about few ps.

The Model:

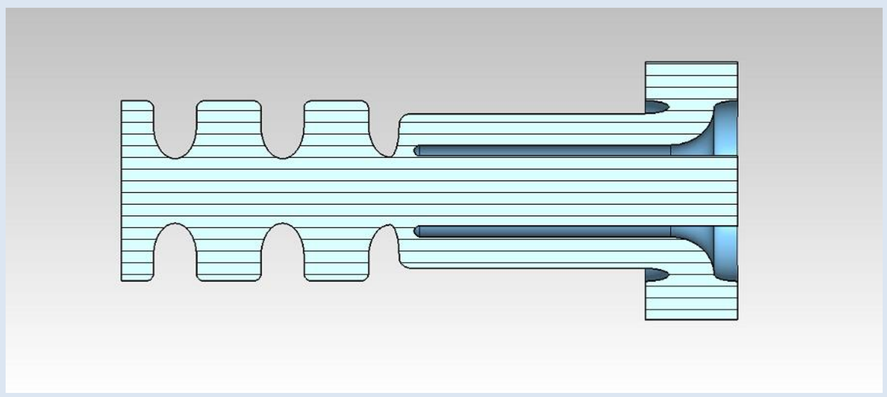
For developing the RF electron gun, which operates in π mode, With a frequency of 3Ghz, we designed the following coaxial structure in order to have more symmetry in magnetic and electric fields. The RF cavity consists of three cells where electrons undergo acceleration by interaction with high-frequency electromagnetic fields. The model is designed as:



and from the front part with the s-band waveguide and two ports is:



Moreover, the cross section of our design is:



We fit the geometrical parameters of the cavity and the waveguide to arrive in to our desired frequency, minimum S_{11} parameter and with the coupling factor β to be one.