

A PHOTOCATHODE DC GUN BASED HIGH BRIGHTNESS INJECTOR

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Abstract

A compact injector suitable for an ERL based high brightness light source project has been designed. The performance matches with that of the best rf gun based injector. It is basically built on a 500 kV photo-cathode dc gun similar to the one being developed at Jlab and a typical CEBAF cryounit consisting of two 5-cell super-conducting cavities operating at 1497 MHz.

Energy recovering linac(ERL) technology pioneered at the Jefferson Lab is recently finding an application in several accelerator projects including a high brightness light source project. The technology offers a clear advantage in building a high power cw machine and a dc gun is seemingly better suited for that too. A typical beam quality required for such a project can be taken from the Cornell ERL project [1]. The Cornell ERL's injector requirements are:

- To deliver a 77 pC electron bunch at 1.3 GHz repetition rate producing an average beam current of 100 mA.
- To deliver a very low transverse emittance beam on the order of 2 mm-mrad and furthermore the rms bunch length is required to be as short as 2.3 ps at the end of injector.

We have found an injector solution which meets the above injector requirement of the Cornell ERL project. It is designed according to the design steps described in our earlier paper [2]. The injector - roughly consisted of a 500 kV dc gun, a single CEBAF cryounit, and an injection chicane - is capable of producing a very bright 10 MeV electron beam with the maximum deliverable average current of 120 mA. Its small size is mainly due to the exclusive use of 1497 MHz cavities unlike our previous design for the same subject [3] that also required several 500 MHz cavities.

We assume a Gaussian distribution for an 80 pC electron bunch produced at the cathode of the gun with the rms bunch length equal to 20 ps with ± 2 sigma cutoff. The amount of energy gain is 500 keV at the gun and 9.0 MeV at the CEBAF cryounit. The gradient required for 5-cell cavities in the cryounit is 10 MV/m.

The achieved transverse and longitudinal emittances are:

$$\begin{aligned}\varepsilon_x^{\text{rms-normalized}} &= 0.8 \text{ mm-mrad} \\ \varepsilon_z^{\text{rms-normalized}} &= 5.0 \text{ deg-keV}\end{aligned}$$

The rms bunch length is 2.0 ps before entering an injection chicane and is less than 0.5 ps after the chicane. The chicane consisting of three 20 degree bend dipoles is necessary for the beam transfer to the main machine whether it is used for the magnetic bunching or not. See Figure 1 for a sample phase space plots.

We conclude that the performance of this injector will exceed all the beam quality demands requested by any high brightness light source project presently being contemplated making use of the ERL technology by a wide margin. The performance of this injector matches with that of the best photocathode rf gun based injector designed so far. The proven operational stability and high average power capability of dc gun are an added advantage. We chose the 1497 MHz frequency simply because the CEBAF accelerator is built on a 1497 MHz cavity. A similarly well performing injector design with super-conducting cavities operating at a different frequency should equally be possible.

REFERENCES

- [1] M. Tigner, Cornell University (2000).
- [2] B. Yunn, "A New Low Emittance Injector for Future FEL Upgrades", Jlab Technote, Jlab-TN-01-009 (2001).
- [3] B. Yunn, "An Injector for ERL Project", Jlab Technote, Jlab-TN-01-010 (2001).

Figure 1. Snapshots

