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Abstract

Funneling electron beams from Gallium Arsenide photocathodes

By

Omer Habib Rahman

Gallium Arsenide (GaAs) is the most widely used source of polarized electrons around the world. After a circularly polarized light of specific wavelength extracts the electrons from the surface which is coated by a Cesium-Oxygen layer, a DC electric field is used to accelerate the electron beam. This beam can ionize residual gas in the chamber, and the DC field accelerates the resulting ions into the cathode surface, damaging the Cesium-Oxygen layer. This process, called 'Ion Back Bombardment', is the dominant mechanism for limiting photocathode lifetime. As a result, high average current operation yields charge lifetimes too low to be used in a collider design. One idea to extend the charge lifetime is to combine the beams from multiple cathodes using a rotating magnetic field - if operation of one cathode does not affect the operation of another cathode in the same chamber, then the source's lifetime can be extended by simply adding more cathodes. This dissertation presents the design, construction and commissioning of a unique electron gun capable of operating twenty cathodes. Results of combining two electron beams with a rotating magnetic field are also presented. For average currents at 175 nA and 350 nA, the charge lifetimes for individual cathodes and two-cathode operation were measured, showing that the charge lifetime for two beam combination is the sum of the individual Ion Back Bombardment charge lifetimes. The addition of charge lifetime implies that beam combining can be used to increase charge lifetime by an order of magnitude to match eRHIC requirements.

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