3½ CELL SUPERCONDUCTING RF GUN SIMULATIONS

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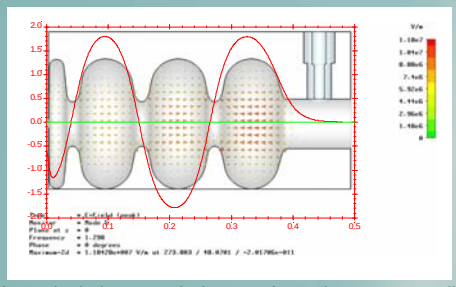
Abstract

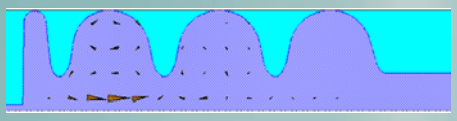
This work forms part of the European Framework (EuroFEL) to carry out a design study for an injector for free electron laser. The objective of this task is to develop a superconducting gun capable of accelerating 100 mA to 10 MeV with sufficiently low emittance. The development work is initially based on the 3½ cell superconducting RF photocathode gun developed at Forschungszentrum Rossendorf (FZR). The FZR gun is designed for CW operation mode producing a 1 mA average current of 1 nC electron bunches accelerated up to energy of 9.5 MeV and is due to be installed at the ELBE superconducting electron linear accelerator [1]. The gun has a 3½ cell niobium cavity operating at 1.3 GHz. The cavity consists of 3 TESLA-type cells and a specially designed half-cell in which the photocathode will be placed. Typical ERL-based projects require ~100 mA average current, and therefore suitable upgrade paths are required. Simulations have been carried out to evaluate the design and to determine suitable ways to upgrade for higher current operation. In order to optimise beam transport and minimise beam emittance growth an alternative shape for part of the cavity around the cathode is proposed. Coupler issues have also been investigated. All the investigations that have identified possible solutions to higher current operation are discussed in this article.

RF Simulations

In order to carry out this investigation a detailed study of the Rossendorf gun has been carried out to verify the simulations techniques adopted, and to expand this work to evaluate the effect of subtle design changes for higher current operation.
The limitations of the current gun design has been addressed and operational techniques have been highlighted in this paper that may allow higher beam currents to be accelerated without significant design changes to the current injector.



The calculations carried out using Microwave Studio and MAFIA agree with the initial calculations using SuperFISH. Observations using MAFIA suggested the TE_{021} mode was resonant in a different cell to the SuperFISH calculations, however this would be compensated for during cavity tuning.

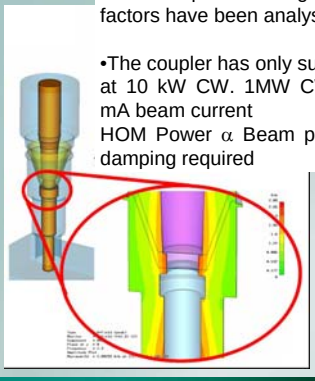


bunch charge :	**1 nC**
laser profile :	**flat top**
rise time :	**1 ps**
bunch length (FWHM) :	**20 ps**
rms transverse bunch size :	**1.5 mm**
thermal emittance :	**not included**
cathode :	**2.6 mm backtracked (+ visor)**
calculated long. emittance :	**» 70 π keV·mm**

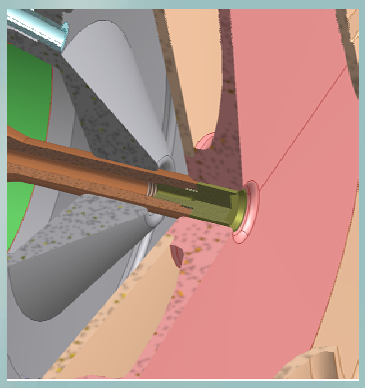
Upgrading for Higher current Operation

The current gun design is limited to 1 mA. In order to operate at higher current the limiting factors have been analysed. These are;

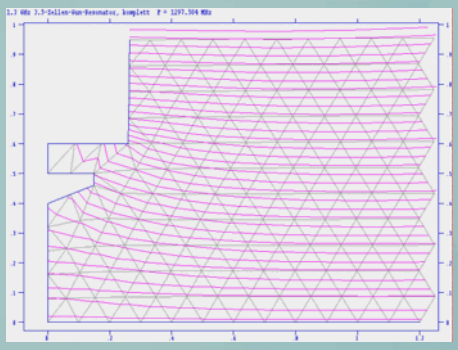
•The coupler has only successfully been tested at 10 kW CW. 1MW CW is required for 100 mA beam current
HOM Power α Beam power, increased HOM damping required



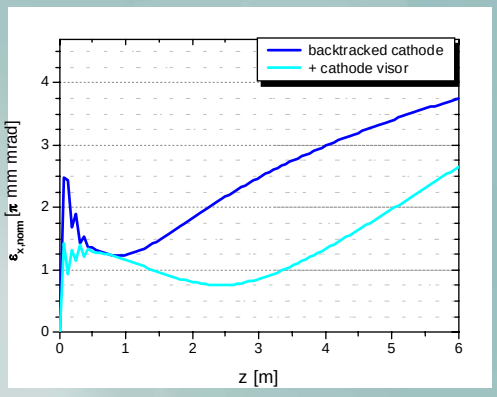
Cathode Shape Investigations



The position of the photocathode inside the half-cell is a crucial parameter for utilising electrical field lines for beam focusing. Investigations into back-tracking the cathode gun and inclusions of a focus electrode shaped visor is presented.

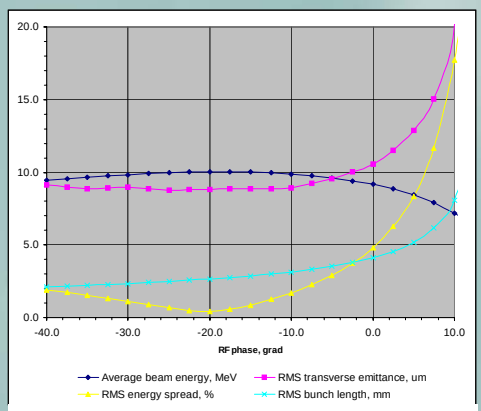


Investigations have demonstrated an emittance reduction by over a half by withdrawing the cathode and including the visors for identical initial conditions.

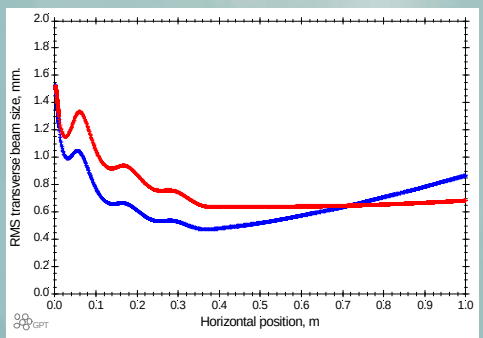


1D / 2D Simulations

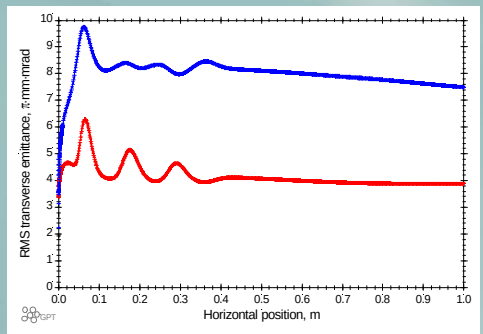
1D and 2D calculations have been carried out using the particle tracking code GPT. Such calculations are required to benchmark the initial calculations with ASTRA, and are to be used for the SRF Gun development



Major beam parameters at the exit of the SCRF gun as a function of the RF phase of accelerating field as calculated with the GPT code.



R.M.S. transverse beam size as calculated with the GPT code for 1-D (red trace) and 2-D (blow trace) presentation of accelerating electric field.



R.M.S. transverse emittance calculated with the GPT code for 1-D (red trace) and 2-D (blow trace) presentation of accelerating electric field