THE DEVELOPMENT OF A SUPERCONDUCTING RF GUN: STATUS OF THE DROSSEL COLLABORATION

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Abstract

In the beginning of 1996 the Drossel collaboration was established between the FZR and the BINP Novosibirsk for the development of a new electron injector. The injector combines the principle of a photocathode rf gun [1] with the use of superconducting (sc) accelerating cavities. The objective of this development is a sc rf gun, which delivers a bunched electron beam in continuous wave (cw) mode. The beam parameters should fulfill the requirements of the ELBE project [2, 3], a superconducting accelerator currently under construction at Forschungszentrum Rossendorf. The applications of this accelerator are an infrared FEL user facility and nuclear physics, radiation physics experiments, which demand a high flexibility for the beam parameters of the injector.

1 DESIGN OF THE SUPERCONDUCTING RF GUN

First a new design was developed to insert a high quantum efficiency photocathode (Cs_3Sb, Cs_2Te) into the sc cavity. According to the results of an experiment at the University of Wuppertal [4], the heat load of the photolayer, caused by dielectric rf losses, is a severe problem. Therefore the photocathode is hold into a cooling insert with an independent liquid nitrogen circuit (fig.1. The heat load will be transported out of the cryostat without causing additional liquid helium losses. This insert has also the function of a multistaged rf filter to solve the problem of a parasitic rf coupling by the cathode stem to the sc cavity. A dc bias voltage supplied to the cathode stem avoids electron multipacting in the coaxial line between cathode stem and sc cavity.

2 BEAM DYNAMICS SIMULATIONS

In parallel the cavity shape of the rf gun was optimized. The conical back wall of the first half cell focusses the beam at low energy and compensates beam blow up due to space charge effects. Beam dynamics simulations (PARMELA [6]) show a transverse emittance of 6.1 mm mrad for 200 pC bunch charge and a gradient of 20 MV/m at the cathode. The full cell cavities of the rf gun have the TESLA geometry [5] to simplify production by using existing sc cavity technology. The low gradient allows both single bunch and cw mode of operation without exceeding present field limits for sc cavities.

To generate an electron beam with low energy spread for the nuclear physics experiments, the injection angle ϕ is set to 5^o. This effects a bunch compression of the electron pulse by a factor of four. The resulting short bunch length of less than 1.5 ps diminishes the energy spread increasing influence of the rf field in the main accelerator. In the FEL mode ϕ is 34.6^o with slightly higher electrical peak field. The higher momentarilly cathode field $E_{peak} * \sin(\phi)$ allows the extraction of bunch charges up to 500 pC from the cathode, which is necessary to achieve high peak currents for FEL operation. The beam parameters are summarized in table 1.

3 OUTLOOK

First tests with a 1.3 GHz half cell to prove the feasibility of our design concepts are scheduled for the middle of 1997. The test cavity is currently into production at the workshops of BINP. First design considerations and price estimations for the laser system were done by the Max Born Institute, Berlin. For the design of the cryogenic system we are in contact with the TU Dresden and VIK Dubna.

4 REFERENCES

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	Nuclear physics mode	FEL mode
Beam parameters		
E_{cath}	14.5 MV/m	19.6 MV/m
Bunch charge	1 pC	200 pC
Energy	4.2 MeV	5.7 MeV
Energy spread (rms)	$1 * 10^{-4}$	$3 * 10^{-3}$
trans. emitt. (rms)	0.18 mm mrad	5.3 mm mrad
long. emitt. (rms)	0.040 deg keV	6.1 deg keV
Laser parameters		
Injection angle ϕ	5.0 deg	34.6 deg
Pulse length (FWHM)	5 ps	10 ps
Spot size	3 mm	3mm

Table 1: Beam parameters of the prototype gun

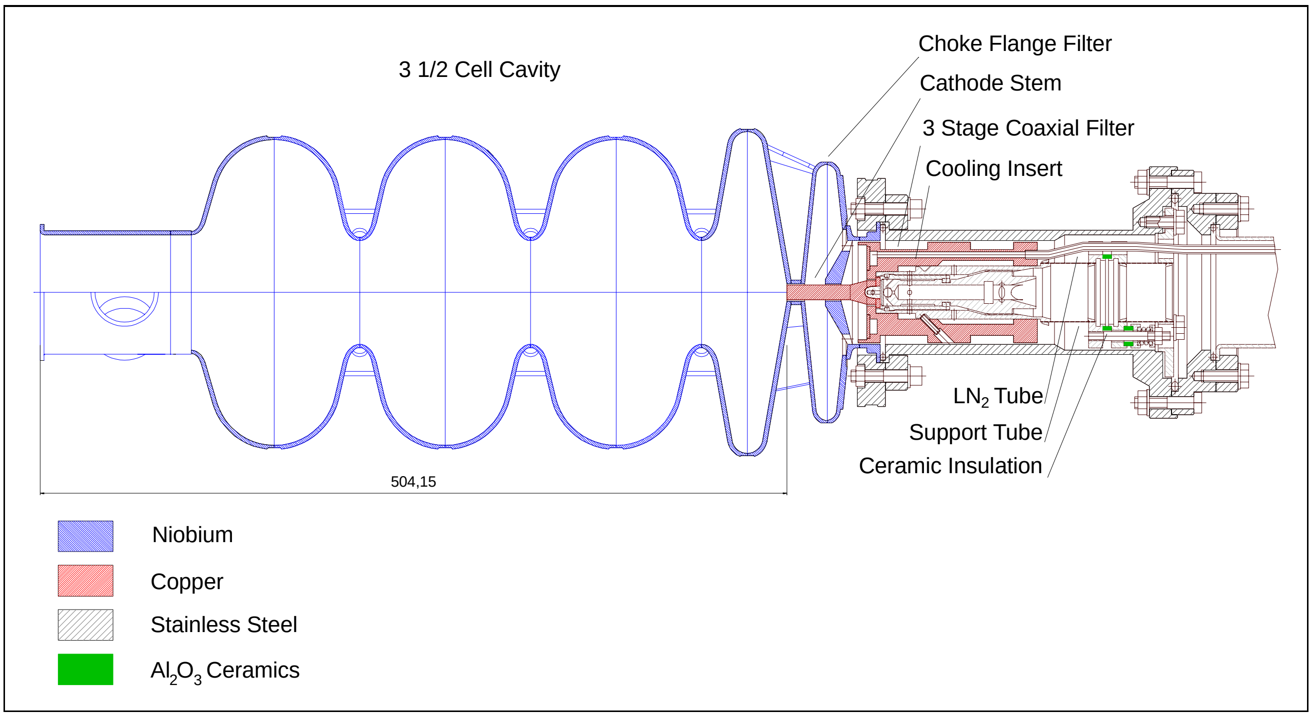

Figure 1: Draft of the prototype rf gun