RF Commissioning of the Photo Injector Test Facility at DESY Zeuthen

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The photo injector test facility at DESY Zeuthen (PITZ) was built to develop, operate and optimize photo injectors for future free electron lasers and linear colliders. First photo electrons were produced in January 2002. An extensive conditioning work on the rf gun has been done in order to achieve high gradients for different pulse lengths and repetition rates. To increase the efficiency and safety aspects of the rf commissioning an Automatic Conditioning Program (ACP) was developed. In addition, a Data Aquisition system (DAQ) which enables a deeper analysis of the commissioning work was realized. The conditioning procedures, the specific diagnostic elements and the achieved results are described. Furthermore, dark current measurements under different conditions are presented.

1. Introduction

The laser driven rf gun at DESY Zeuthen consists of a 1.5 cell L-band copper cavity with coaxial rf coupler, and a Cs_2Te cathode, and two solenoids for space charge compensation. The diagnostic section contains several diagnostic elements as Faraday cups, beam position monitors, and YAG screens to measure the beam parameters (see Fig. 1). An extensive rf commissioning based on a 5 MW klystron was done to allow a stable production of short electron bunches with a low transverse emittance and a small energy spread [1].

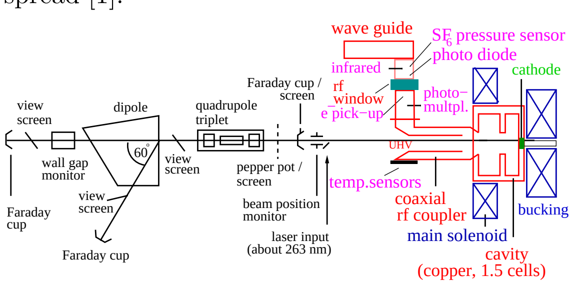

Figure 1. Sketch of the photo injector test facility.

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2. Data aquisition and conditioning

A Data Aquisition system (DAQ) has been established to enable a deeper analysis of the behaviour of the facility and all its parts as well as the correlation between different components. This program was developed in the framework of ROOT [2], which supplies an object-oriented data base as well as multiple analysis tools. DOOCS servers are used to get access to the elements of the facility [3]. Especially rf conditioning is the crucial procedure in which different effects like field emission and sparks can produce destructions. To prevent this, a gun interlock consisting of e.g. vacuum pressure, temperature and photo-optic sensors is installed. An Automatic Conditioning Program (ACP) has been developed to increase the efficiency and the safety of the conditioning work. The ACP controls the rf power and reacts appropriately on interlock signals. ACP is based on a C++ program running a graphical user interface as a collection of Labview virtual instruments. It offers a comfortable control of the conditioning process in connection with an online-analysis. The ADC signals of fast gun interlock detectors as well as the rf signals are dumped with a sampling rate of 1-9 MHz into a ring buffer. This buffer is stopped just after an interlock event happened which allows to read out the data stored during the last rf pulse trains. Acoustic sensors with a sampling rate of 1 MHz and a high position resolution are in development to localize the emission of rf breakdowns.

3. rf commissioning and dark current

The rf commissioning was started with a low average power corresponding to short rf pulse lengths ($50-100\,\mu$s) and a repetition rate of 1 Hz. The resonance frequency of the cavity was tuned with the cooling water system. The current of the solenoids were swept within a small range starting from zero which was extended step by step up to the full range of 0–400 A of the main.

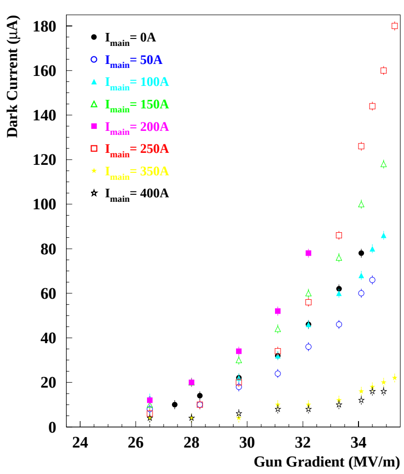

Figure 2. Dark current for $100\,\mu$s long rf pulses.

In the beginning the gradient on the cathode was limited to about 20 MV/m whereas at the end the gradient was swept within 20 to 37 MV/m. The vacuum pressure was reduced within this time by almost three orders of magnitude. The dark current emission from the cavity has been measured as a function of the gradient at the cathode position for different currents of the main solenoid. The current of the bucking was chosen accordingly to zero the magnetic field at the cathode. Fig. 2 shows the measurement results for the Cs_2Te cathode for different solenoid currents. A maximum dark current of about $180\,\mu$A was observed for gradients of 35 MV/m. For bigger solenoid currents above 250 A (corresponding to a standard operation with 1 nC charge), the dark current is over-focussed, as expected. The dark current emission was also studied for the Mo cathode. Here, the dark current is reduced by a factor of 2 compared to the Cs_2Te cathode (see Fig. 3).

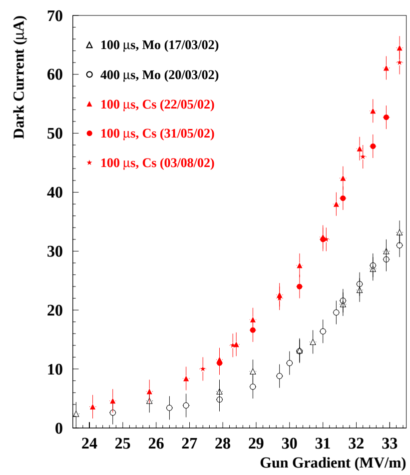

Figure 3. Dark current for the Mo and Cs_2Te cathodes, solenoids are switched off.

4. Conclusions

Using an automatic conditioning program a stable operation for rf pulses up to a length of $400\,\mu$s at a repetition rate of 5 Hz including a solenoidal field between 0 and 0.25 T was obtained. A maximum gradient was measured of about 37 MV/m with a repetition rate of 1 Hz and a rf pulse length of $100\,\mu$s.

REFERENCES

1. J. Bähr et al., “First Beam Measurements at the Photo Injector Test Facility at DESY Zeuthen”, FEL 2002, Argonne.
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3. http://tesla.desy.de/doocs/extprograms/daq/index.html