Photo Injector Test Facility in the Commissioning Phase at DESY Zeuthen*

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A photo injector test facility is in the commissioning phase at DESY Zeuthen within a cooperation of BESSY, DESY, MBI and TU-Darmstadt. The aim is to develop and operate an optimized photo injector for future free electron lasers and linear accelerators which require extraordinary beam properties. The scientific goals, the planned and existing hardware and the developments for the photo injector facility are briefly described. First operation of the rf gun is expected for autumn 2001. Even higher gradients are aimed for in Zeuthen than achieved today in similar rf guns, so that in the near future more conditioning work of the rf gun needs to be done. The effects which might happen during conditioning based on the experiences gained so far in Hamburg (at the FEL and the FNAL guns) are briefly described. Information about diagnostic elements at the rf gun and the requirements for a simplification of the upcoming conditioning work are given.

1. Introduction

A photo injector test facility is in the commissioning phase at DESY Zeuthen in order to optimize injectors for different applications like free electron lasers, production of flat beams for linear colliders and polarized electron sources [1]. The experimental setup in the start up phase is shown in Fig. 1. A primary goal is the stable production of short electron bunches ($\approx$ 20 ps) with a transverse emittance of $\approx 1\pi$ mm mrad at 1 nC and a small energy spread. We expect to produce first photoelectrons with energies up to 5 MeV in autumn 2001.

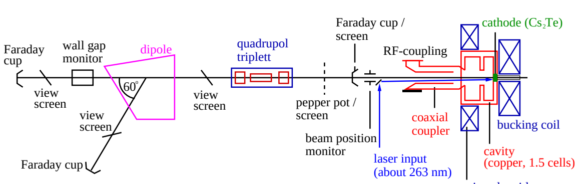

Figure 1. The present electron beamline corresponding to a total length of $\approx$ 5 m. The electron beam is accelerated from right to left.

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2. Plans

Measurements of the transverse and longitudinal phase space will allow a detailed comparison between experimental results and simulations after the commissioning of the facility. The integrated optimization of all components of the photo injector is also foreseen, especially for the subsequent operation at the TESLA Test Facility - Free Electron Laser (TTF-FEL). Presently we work on the development and improvement of beam diagnostics [2,3], and on the development of an automatic conditioning program for rf guns [4].

3. Conditioning of the cavity

Conditioning of a normal conducting cavity is the successive increase of rf power in the cavity in order to achieve high gradients. It is a time consuming and boring work. To increase the efficiency and to protect the rf gun it is planned to develop an Automatic Conditioning Program (ACP). The aim is to get even higher gradients ($>$ 35 MV/m) in the rf gun than achieved today in similar normal conducting cavities.

3.1. Which effects could happen?

A fundamental process in a high gradient cavity is field emission of electrons from protrusions on the surface. Electrons which hit the cavity with some keV can produce secondary electrons. If the trajectory of those secondaries terminates close to the emission side of the primary electron a resonant phenomenom can appear called multipacting. A different effect is a spark which is accompanied by a strong light emission, a strong reflected power signal and an increase of the vacuum pressure. Probably it can be explained by an exponantially increasing emission of electrons from a protrusion due to field emission and the heating of the protrusion. All these effects guide to an increase of vacuum pressure and can destroy cathode, cavity, rf window or rf coupler. The details of these processes are not well understood. For example during conditiong of the rf gun at TTF it has been observed that the probability for an event which happens in the beginning of an rf pulse is influenced by the length of the previous rf pulse. It seems to be a memory effect of the cavity with respect to the rf pulse structure.

3.2. Automatic Conditioning Program

The ACP has to control the rf power and to react appropriately on interlock signals. Several detectors are installed close to the rf coupler, rf window and cavity. Fast signals from photomultipliers interrupt the rf power within an rf pulse so that the conditionioning can be continued with the next rf pulse. Slow signals from temperature or vacuum pressure sensors interrupt the conditioning to offer a recovering time for the rf gun. The ACP works on the rf power P. The gradient $\vec{E}$ can be obtained by the relation $\vec{E}^2 \propto P$. After resetting an interlock the program increases the power rapidly. To condition multipacting effects the program can sweep the solenoidal field additionally. Within the dangerous power region the power is increased slowly until the alarm threshold is reached just below the level at which the interlock occured. The power could be turned down by a significant step and than slowly increased again for a while to improve the vacuum (see Fig. 2). Then the alarm threshold is increased.

3.3. Data acquisition and analysis

During the conditioning process of the cavity slow and fast signals will be read out, so that a huge amount of data will grow up. Reasonable selections of recorded data and analysis programs are required. A solution is offered with ROOT which is an object oriented data base for large scale data analysis developed at CERN. Root is based on C++ and offers also capabilites for data compression and analysis during standard operation, especially for a use at TTF-FEL at a later date. However, presently a deeper analysis of the ACP data will be realized by an event recorder reading out the fast signals just in case of significant data content.

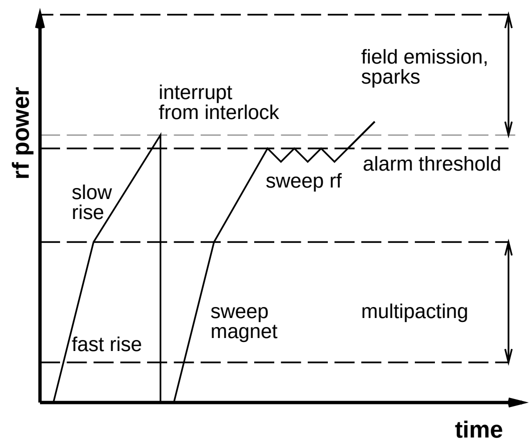

Figure 2. Sketch of rf power control of the ACP.

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