Photo Injector Test Facility under Construction at DESY Zeuthen*

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A **P**hoto **I**njector **T**est Facility is under construction at DESY **Z**euthen (PITZ) within a cooperation of BESSY, DESY, MBI, and TUD. The aim is to develop and operate an optimized photo injector for future free electron lasers and linear accelerators. First operation of the rf-gun is planned for late autumn 2000. In this paper we want to outline the scientific goals, the planned and existing hardware, the status of the project and new developments.

1. Goals

The scientific goal of the project is to operate a test facility for rf-guns and photo injectors in order to optimize injectors for different applications like free electron lasers, production of flat beams for linear colliders and polarized electron sources. We will make comparisons of detailed experimental results with simulations and theoretical predictions. At the beginning we will concentrate on the development of an optimized photo injector for the subsequent operation at the TESLA Test Facility - Free Electron Laser (TTF-FEL) [1]. This also includes the test of new developed components like the laser, cathodes and beam diagnostics under realistic conditions. After the installation of a booster cavity we will be able to test new concepts for the production of flat beams[2]. On a longer term basis we plan to investigate the design of polarized electron sources.

2. Setup

The experimental setup is shown in figure 1. In the future, the teststand will be complemented by more diagnostics, beam optical components and a booster cavity.

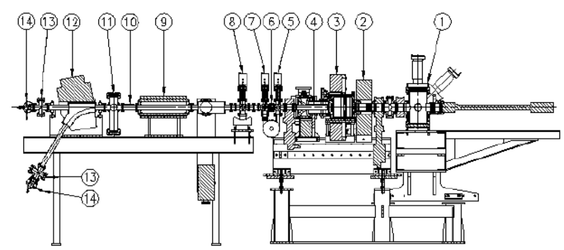

Figure 1. Experimental setup of PITZ in the start-up phase: 1. cathode system, 2. bucking solenoid, 3. main solenoid, 4. coaxial coupler, 5. laser input port, 6. beam position monitor, 7. Faraday cup + view screen, 8. emittance measurement system (slits + pepper pot), 9. quadrupole triplet, 10. wall gap monitor, 11.+13. view screen, 12. dipole, 14. Faraday cup.

3. Schedule and Status

In September 1999 it was decided to built the test facility in DESY Zeuthen. Now the raw construction work is mainly finished and soon we will start the installation of the test stand itself and all the other equipment. We plan to have the first rf inside the gun cavity in November and the first photoelectrons are scheduled for January 2001. A major upgrade of the test stand will take place mid 2002 when a booster cavity will be installed.

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4. Laser Development

The Max-Born-Institute develops the photocathode laser for PITZ. Besides the former requirements for the TTF photocathode laser system [3] a new request on the logitudinal shape of the micropulses will be realized by the MBI: the micropulses should have a flat-top profile, 5-20 ps FWHM, with rising and trailing edges shorter than 1 ps. This requires a new laser concept which is shown in figure 2. The key element is the optical-parametric amplifier (OPA). It provides large amplification bandwidth and therefore allows for the amplification of pulses with sharp edges. A grating combination will be used for programming the shape of the micropulses. Wave front deformations will be corrected by computer-controlled optics. An extended version of the field tested TTF photocathode laser will serve as a pump laser for the OPA. In the beginning it will be used to produce the first photoelectrons. Then a continual upgrade to the full laser system follows.

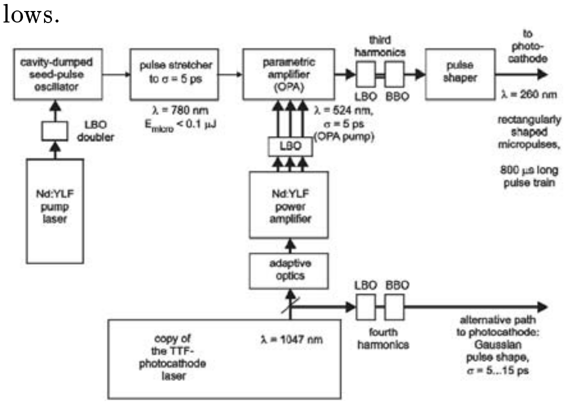

Figure 2. Scheme of the photocathode laser for the generation of micropulses with variable shape.

5. Simulations

One goal of TEMF at TU Darmstadt is the numerical study of the minimum attainable transverse and longitudinal emittance as a function of rf-gun parameters. Figure 3 presents a simulation that takes into account space charge and nonlinear rf forces. It shows that the main part of the transverse emittance is caused by the emission process and that the evolution of the emittance for the first and the second half of the bunch is opposite. The behaviour of the projected emittance seems to be a result of the rf field effects and MAFIA TS2 and ASTRA[4] are shown to be in good agreement. An other topic for TEMF is the development and installation of an on-line simulation program (V-code) [5] that is based on a model of ensembles. It will help to obtain an on-line understanding of the dynamics of the beam. At DESY an ASTRA simulation with a cutted disk structure booster cavity was performed. This cavity provides an average gradient of $\approx$ 12.6 MV/m and boosts the beam up to about 30 MeV. According to that simulation emittances in the sub-mm-mrd regime can be obtained.

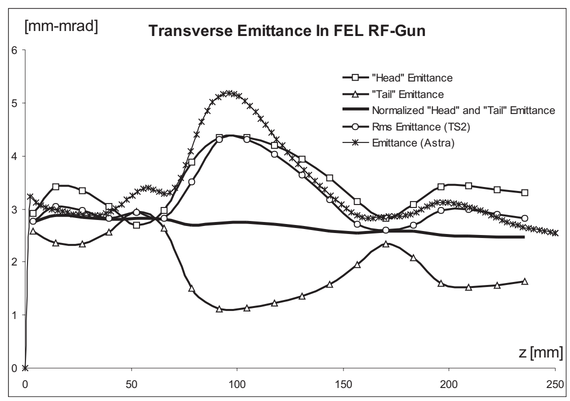

Figure 3. Development of transverse emittance in the rf-gun.

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