# STATUS OF THE PITZ FACILITY UPGRADE*

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*Abstract*

The upgrade of the Photo Injector Test Facility at DESY in Zeuthen towards the PITZ2 stage is continuously ongoing. In Spring 2006, a new intermediate stage was taken into operation (PITZ1.6), including a new gun cavity that has been tuned and commissioned. Three new emittance measurement systems were installed along the beamline. Together with the available booster cavity, they allow to study the emittance conservation principle. In the paper, the results of the high power run in autumn 2006, and the results of the commissioning of the new gun will be presented. The ongoing developments of further new diagnostics components for the PITZ2 phase will be discussed as well.

## INTRODUCTION

The Photo Injector Test Facility at DESY in Zeuthen (PITZ) has been built in order to test and optimize electron sources for Free Electron Lasers (FELs). The goal of PITZ is to produce intense electron beams with small transverse emittance and short bunch length as required for FEL operation.

After the successful conclusion of the first phase of PITZ (PITZ1) [1], a large extension of the facility started in November 2004. In 2005, a booster cavity and new diagnostics components adapted for the increased beam energy have been installed. The setup (called PITZ1.5) was used for first measurements at a beam energy of about 13 MeV [2]. In addition, high power tests of the existing gun cavity have been done. In 2006, the PITZ facility was further extended. The current stage (PITZ1.6) is characterized by the installation of a new gun cavity and three new emittance measurement systems [3] which allow to study the emittance development along the beamline. Figure 1 shows a photo of the diagnostics beamline with these new systems.

## HIGH POWER GUN CONDITIONING

In Autum 2005, high power tests of the existing gun (prototype No.1) were done using a 10 MW multi beam klystron.

Figure 1: Photograph of the PITZ1.6 beamline after the booster with the new emittance measurement systems.

A peak power level of 6.8 MW has been reached at 10 Hz repetition rate and 100 $\mu$s rf pulse length. At this power level, the high momentum edge of the measured dark current momentum spectrum (Figure 2) is located at a value of 6.5 MeV/c, corresponding to an accelerating gradient of 57 MV/m at the cathode plane. This value is close to the goal gradient of 60 MV/m needed in order to reach the XFEL injector emittance of 0.9 mm mrad. In terms of average power, a value of 14.5 kW was reached during the high power conditioning that suddenly ended due to a vacuum problem of the gun cavity.

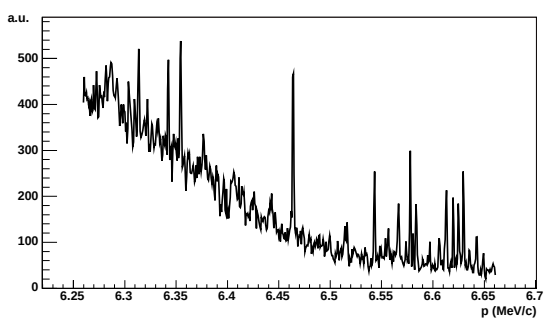


Figure 2: High momentum part of the dark current spectrum at a power level of 6.8 MW, as measured on 8.9.2005. The high momentum edge is found at about 6.5 MeV/c.

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## A NEW GUN FOR PITZ AND FLASH

A new gun cavity (prototype No.3.1) was built and tuned. For the tuning, a special tuning device was constructed and used [4]. Figure 3 shows a sketch of this device that allows pushing the cavity walls of both, half and full cell, in order to increase the resonance frequency to the goal value of 1.3 GHz at an appropriate operation temperature.

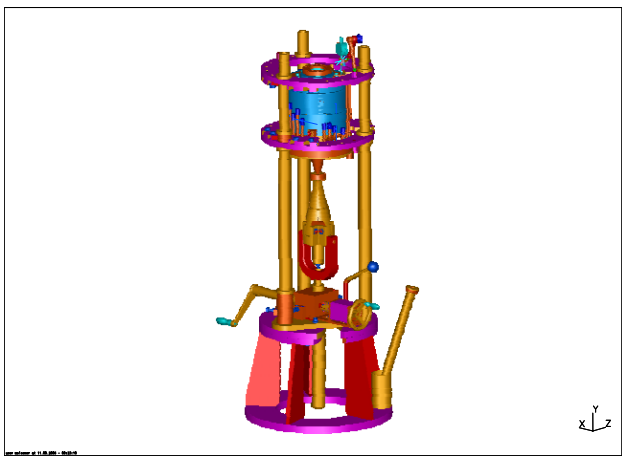

Figure 3: The tuning installation with the gun cavity.

After the tuning, the resonance frequency was reached at an operation temperature of $54^\circ$ C which is realized by the water cooling system. The electric field distribution after the tuning is shown in Figure 4. According to simulations, a ratio of 1.05 to 1.10 between the field at the cathode plane and the field in the full cell is preferable: this value corresponds to an optimum ratio between average gradient and space charge compensation due to a high gradient at the cathode plane. The realized field ratio after tuning was measured to be 1.06.

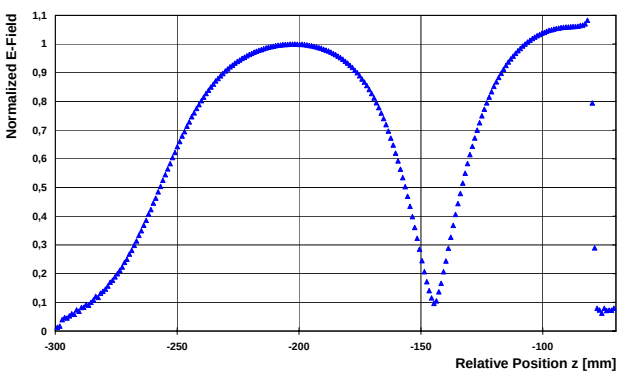


Figure 4: Field distribution in the gun after tuning. The cathode field is 6% higher than the field in the full cell.

The gun was installed in the PITZ facility in early 2006. Being mainly a copy of the formerly used cavities, it is planned to be used as spare gun for the running FLASH facility. In order not to risk any damage of the cavity, conditioning was only performed up to the maximum FLASH requirements: 3.5 MW peak power, 900 $\mu$s rf pulse length and 10 Hz repetition rate. This corresponds to an average power level of 31.5 kW, the maximum ever reached at PITZ. Figure 5 shows a screen shot of the obtained parameters taken during the conditioning at the maximum settings on 23.4.2006.

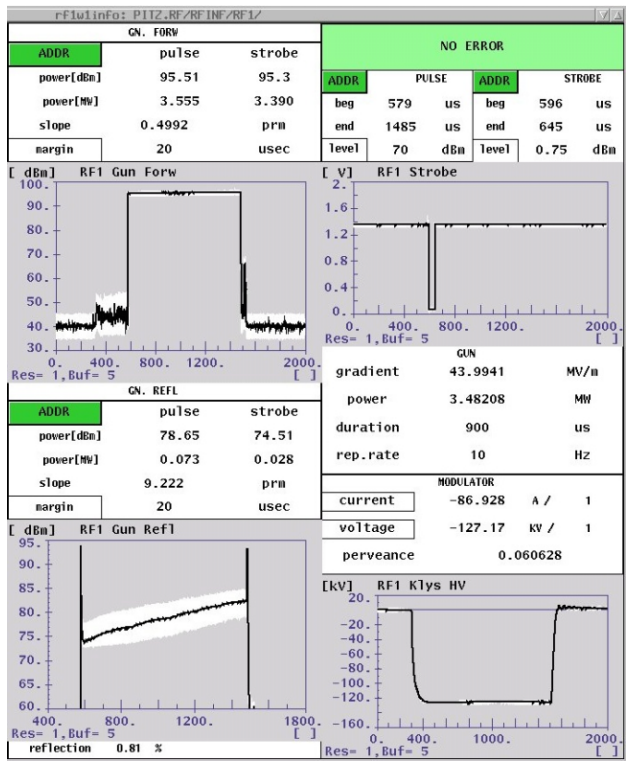


Figure 5: Screen shot of rf parameters taken during the full power conditioning of cavity prototype No.3.1.

After the gun conditioning, extensive dark current measurements have been undertaken for several cathodes at different gradients. Figure 6 shows the measured dark current as a function of the focussing current in the main solenoid and a current in the bucking coil of $I_{bucking} = 0.075 \cdot I_{main}$ for compensating the magnetic field at the photo cathode.

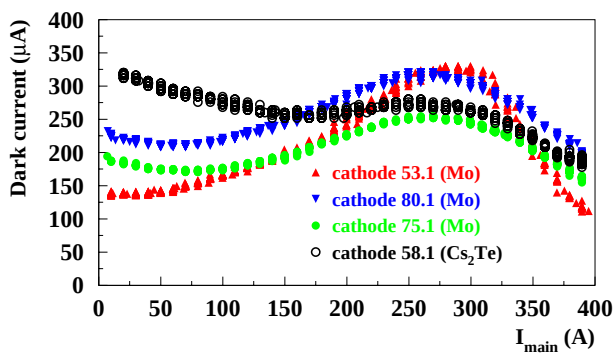


Figure 6: Dark current measurements for different cathodes at a gradient of about 43 MV/m at the cathode plane.

Visibly, the produced dark current spectrum differs significantly from cathode to cathode, and the maximum emitted dark current shows also large differences. As an example, Figure 7 shows a complete 2D scan for all combinations of $I_{main}$ and $I_{bucking}$ for one of the Mo cathodes (cathode 75.1). More detailed results of dark current studies are reported in [4].

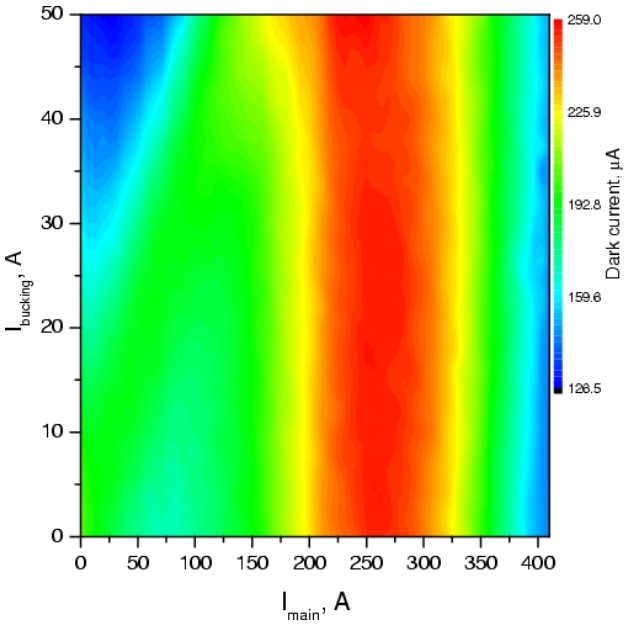


Figure 7: 2D dark current measurement for cathode 75.1 at an accelerating gradient of about 43 MV/m.

Currently, beam measurements have started at PITZ, including beam size and emittance studies, momentum and bunch length measurements [5]. After these measurements, the gun will be dismounted from the PITZ beamline in October 2006. Another gun cavity (prototype No.3.2), a copy of the existing one, will be installed. The gun can be used for the next high power tests, i.e. with the goal to condition and run this gun up to a gradient of 60 MV/m at PITZ.

## TOWARDS THE PITZ2 SETUP

In parallel to the facility operation and measurements with the current setup, the design of the remaining beamline extensions for the PITZ2 stage is in preparation. The final PITZ2 setup is shown schematically in Figure 8. The main differences to the current setup are the two high energy dispersive sections and a phase space characterization section consisting of a rf deflecting cavity and a tomography module. The combination of these diagnostics tools will allow to completely characterize the phase space, including longitudinal, transverse, and slice emittance measurements. The status of the development, the simulation results and expected performances are discussed in detail in [5, 6]. The realization of these sophisticated measurement tools is expected for the next year.

## SUMMARY

The extension of the PITZ facility and its measurement program is continuing. First results of the realized intermediate state of the experimental setup have been presented in the paper, mainly conditioning and dark current measurements. Preparations for the PITZ2 phase are progressing well and will be presented at the forthcoming conferences.

## REFERENCES

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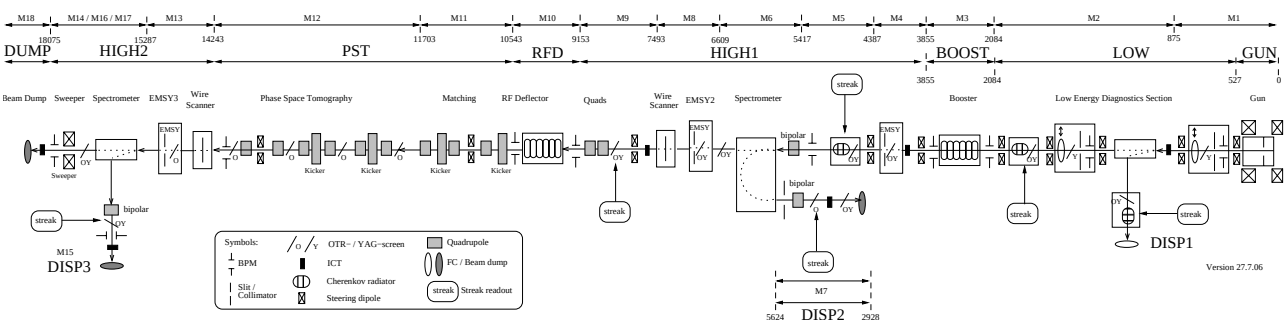


Figure 8: Current layout of the PITZ2 setup.