

STATUS AND FIRST RESULTS FROM THE UPGRADED PITZ FACILITY

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Abstract

Since December 2004, the photo injector test facility at DESY in Zeuthen (PITZ) has been upgraded. A normal conducting booster cavity has been installed and the diagnostics beamline was significantly modified. An extended water cooling system has been installed and was successfully taken into operation. Currently, the new diagnostics elements are being commissioned. Since the installation of the new 10 MW klystron in June/July, the gun is being conditioned towards higher peak and average power, and the whole beamline including the booster is being taken into operation. First results from the commissioning phase including gun and booster conditioning are reported.

INTRODUCTION

The first phase of PITZ has successfully concluded in November 2003 with the full characterization of a gun that has been installed and is currently in operation at the VUV-FEL. In the year 2004, the gun was replaced, the PITZ1 setup has been improved, and the photo injector properties were optimized. The main results have been summarized in [1]. The PITZ1 facility stopped operation in November 2004 for a large upgrade of the water cooling system, the dismantling of the PITZ1 beamline, and the installation of the first diagnostics components that belong to the PITZ2 phase. Meanwhile, an intermediate setup (PITZ1.5, Fig. 1) was taken into operation with two main goals: (a) to run the gun at higher gradients with up to 60 MV/m, and

(b) to study the emittance conservation principle by using a booster cavity. In order to completely characterize the photo injector, the beamline will be continuously extended towards the final setup (PITZ2, Fig. 4).

COOLING UPGRADE

Since December 2004, the electrical power system as well as the water cooling system at PITZ have been upgraded in order to provide the necessary power and cooling for gun, booster, and two 10 MW klystrons. This is a basic precondition for doing high power gun tests and reaching a gradient of 60 MV/m as required for reaching the XFEL baseline parameters for beam quality.

Tests of this system have been done in July 2005 with maximum available power consumption, i.e. at power level of ~ 500 kW. Fine tuning of the parameters will happen when more cooling is needed (e.g. after the delivery of the second 10 MW klystron).

10 MW MULTI BEAM KLYSTRON

The 10 MW multi beam klystron from Thales has been delivered to Zeuthen on 9.6.05. During the first tests after its installation 10 MW at 1.2 ms rf pulse duration were reached when running on a load. In autumn, tests with longer rf pulses up to the design parameter (1.5 ms) are foreseen. For the moment, the currently reached parameters are sufficient for running the PITZ facility and doing high power tests of the gun.

The rf output of the 10 MW klystron is via two 5 MW arms. In order to combine the rf power from the two arms, a power combiner has been developed [2] and tested on a load up to two times 2.5 MW (5 MW combined) at a rf

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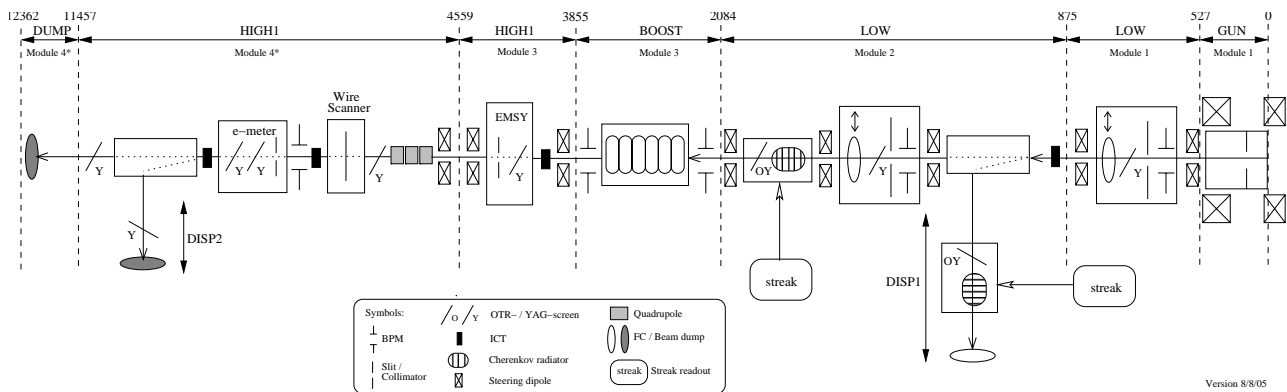


Figure 1: Scheme of the PITZ1.5 setup as it is currently realized.

pulse length of 200 μs before its installation in the vacuum system of the PITZ gun.

The delivery of a second 10 MW klystron is foreseen for January 2006. Until then the booster is operated with the old 5 MW klystron.



Figure 2: Photograph of the power combiner.

GUN CONDITIONING

After the power combiner has been installed at the gun, conditioning of power combiner and gun started on July 29, 2005 with the goal to reach a gradient of 60 MV/m in the gun: according to simulations, this is the necessary gradient to reach the XFEL emittance of $0.9 \pi \text{ mm mrad}$.

The conditioning is still ongoing. The following parameters have been reached so far: estimated input power of 4.3 MW at 10 Hz repetition rate with 100 μs pulse length. In order to reach a gradient of 60 MV/m at the cathode, an input power of 6.7 MW is needed which requires still some conditioning.

BOOSTER CONDITIONING

The preliminary booster cavity for PITZ is a normal conducting TESLA prototype cavity. It has been formerly used

with very short rf pulses and a maximum average power of 1.4 kW. Thus, only small cooling tubes are attached to the booster, limiting the use at PITZ to the same average power. The cleaning and tuning of the cavity has been done at Zeuthen in 2003/2004. A field flatness of 91 % and a maximum field imbalance of 6 % has been obtained, Fig. 3.

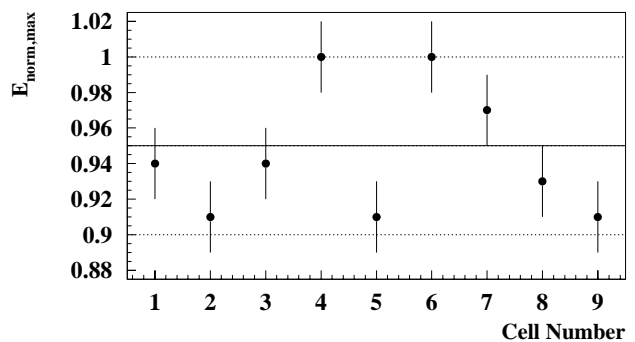


Figure 3: Field flatness obtained as a result of the booster tuning including measurement errors. The maximum field is normalized to 1. The average field is shown as full line.

In 2005, the booster has been fully conditioned at different repetition rates up to the cooling limit (maximum average power $\sim 1.3 \text{ kW}$, maximum peak power: $\sim 3 \text{ MW}$, table 1).

The reached maximum peak power of 3 MW corresponds to an average accelerating gradient of 16.4 MV/m which is far above the needed gradient of 12.5 MV/m (obtained with an input power of 1.7 MW).

On August 11, the electron beam from the gun was ac-

| Repetition rate (Hz) | 10 | 5 | 2 | 1 |
|--------------------------------|------|------|------|------|
| Pulse length (μs) | 50 | 85 | 250 | 500 |
| Peak power (MW) | 2.5 | 3.0 | 2.7 | 2.6 |
| Mean power (kW) | 1.25 | 1.27 | 1.32 | 1.29 |

Table 1: Maximum parameters obtained during the booster conditioning.

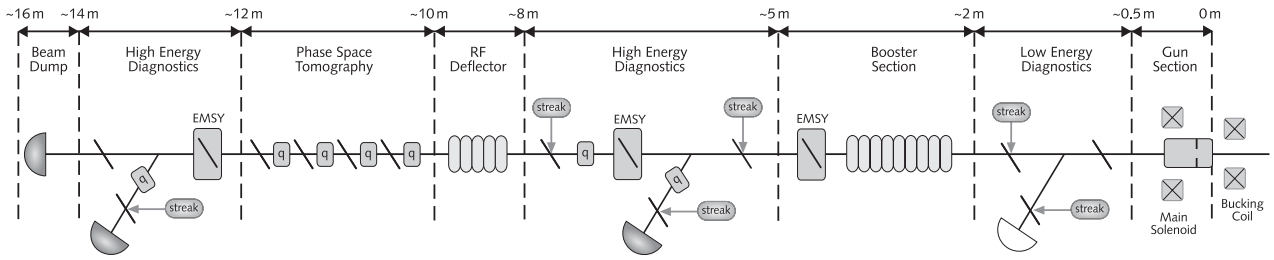


Figure 4: Preliminary layout of PITZ2.

celerated through the booster for the first time and a mean momentum of 12 MeV/c was measured. Fig. 5 shows a more recent momentum measurement. More detailed studies of the field distribution and energy gain in the booster will follow in the run periods until the end of the year.

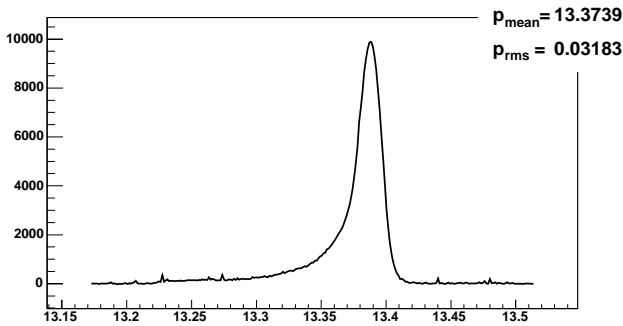


Figure 5: Measured momentum distribution after the booster. The momentum after the gun was 4.1 MeV/c.

FACILITY OPERATION

In March 2005, the PITZ1 beamline was dismantled and the installation of the new diagnostics components according to Fig. 1 started. Commissioning of the diagnostics has been done in parallel to the booster conditioning and still continues. Since July 29, the facility is operated continuously: partly for gun conditioning, partly for beam measurements.

Apart from many other components, the new diagnostics beamline includes a movable emittance meter (e-meter) from LNF, which was temporarily installed at PITZ for beam tests and will be finally mounted at the SPARC facility in autumn 2005. The e-meter has been commissioned and first emittance measurements have been done with and without booster (i.e. at low and high energy). The measurements based on the slit mask technique have been compared with the data taken with the PITZ emittance measurement system (EMS) [1] and a good agreement has been found. The cross-checks will continue until end of September. For more information on the e-meter see [3].

In addition to the beamline installation, an upgrade of the laser happened: the laser system is now fully diode pumped

and uses a different attenuation scheme which gives much more flexibility in choosing the charge while keeping the transverse and longitudinal laser profiles unchanged. The improvements related to laser and laser beamline are described in [4].

PREPARATIONS FOR PITZ2

In autumn, the present beamline setup (PITZ1.5) will be extended and more diagnostics will be installed. Preparations towards the realization of the final setup (PITZ2) are continuing. A simplified scheme of the PITZ2 setup is shown in Fig. 4.

Emittance measurement systems. In a first step, the installation of three new emittance measurement systems at different distances from the cathode is planned for October. These systems, built by INRNE Sofia, are based on the slit mask technique. They allow characterizing the emittance evolution along the beamline, a necessary precondition for proving the emittance conservation principle and its experimental realization, one of the major goals of PITZ2. For cross-checking the emittance measurement results it is foreseen to use the quadrupole scan technique and the four screens method.

High energy spectrometers. The work on the design of two high energy spectrometers is in progress. For the first of them many different solutions were discussed. Fig. 6 shows two possible setups [5]. The big advantage of the system based on a 180° dipole magnet is the resolution control due to spot size changes on screen S1 using a quadrupole triplet placed in front of the dipole entrance [6].

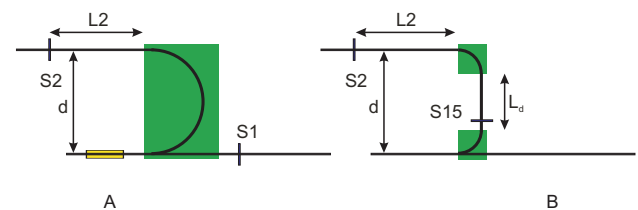


Figure 6: Two spectrometer setups under discussion. (A) A 180° dipole magnet followed by a drift space L_2 . (B) Two 90° dipole magnets separated by a drift space L_d and followed by a drift space L_2 .

Due to space limitations in the PITZ tunnel and fabrication problems of this type of dipole, setup (B) is preferred: the 180° dipole magnet is split into two successive 90° magnets. By a proper choice of the bending radius and the distances d and L_2 one can realize a system with a momentum resolution of about $4 \cdot 10^{-4}$, according to simulations. In this system, the resolution does not depend on the initial beam size but only on the initial beam divergence which can be additionally extracted from the measurements by comparing the beam spot sizes on screens S15 and S2.

CDS Booster. A booster cavity specially developed for PITZ has been designed [7] and is currently under construction at DESY in Hamburg. First rf measurements have been done with a couple of manufactured test cells. According to the time schedule, the CDS booster shall be installed in the PITZ facility by the end of 2006.

Gun development. The design of a new gun that can withstand higher power level is progressing. A first design of such a high gradient / high average power gun has been presented. Even if the cooling water distribution has been improved, recent simulations from BESSY show that still more cooling is needed, especially in the iris region.

SUMMARY

The PITZ1 facility stopped operation in November 2004 for a large upgrade of the water cooling system, the dismounting of the PITZ1 beamline, and the installation of the first elements of the PITZ2 phase. A first 10 MW klystron was taken into operation and the commissioning of the PITZ1.5 setup has started. This includes full conditioning of a normal conducting booster cavity and first beam operation through the complete beamline. Preparations for the final PITZ2 setup are ongoing.

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