FIRST RESULTS FROM THE UPGRADED PITZ FACILITY *)

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Abstract
Starting in late summer 2007 a general reconstruction of the PITZ facility was performed. A new spectrometer based on a dipole magnet with 180 degree deflection angle was inserted in the facility. The new spectrometer contains two screen stations for the measuring of the longitudinal phase space and the slice emittance. A new "Conditioning Test Stand" (CTS) was added to the facility. Using this CTS a new electron gun having an improved cooling system is under conditioning. A new photocathode laser system (developed by MBI) is under commissioning. The goal is to reach rise and fall times of the laser pulses of 2 ps. The system of laser diagnostics was upgraded. The results reached using this upgraded facility are reported. This concerns the conditioning results of the new gun.

INTRODUCTION

The Photo Injector Test facility at Zeuthen PITZ [1] is a dedicated facility for the development and optimization of rf guns for FELs as FLASH [2] or the European XFEL [3] at DESY Hamburg site. The facility [4] got a major upgrade by a new gun, a new photocathode laser, a magnet spectrometer HEDA1, a Conditioning Test Stand (CTS) and several further diagnostics elements in the last 8 months. The upgrade of the facility will be explained in the next section. The new laser, related infrastructure, laser diagnostics and the new CTS will be described in further sections below. The results of the conditioning of the new gun will be reported. Summary and outlook one can find in the last section.

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FACILITY UPGRADE

The facility was upgraded by a new electron gun (see below), by a new type of Double Diagnostics Cross (DDC) containing screen, mirrors and further diagnostics elements and by a new spectrometer HEDA1 [5] behind the booster cavity. The schematic of the upgraded facility is shown in Figure1.

The new DDC [6] contains a YAG screen for measuring the transverse profile distribution of the electron beam by a TV system. Furthermore, two actuators bearing mirrors are realized for looking downstream and for looking towards the cathode. A further mirror is used for the transport of the photocathode laser beam to the cathode. Also a Faraday cup for charge measurements and a slit to be used in combination with the low energy magnet spectrometer are realized. The reason for a new design of the DDC is the improvement concerning the vacuum conditions by realising a larger cross section for the vacuum pump flange and an improved design which prevents wake field creation.

The low energy magnet spectrometer LEDA was reconstructed. . In the previous spectrometer the beam was cut for certain settings of solenoid, gun phase and gradient. The dipole chamber is now wider and the distance of the pole shoes has been increased.

An essential part of the diagnostics elements was moved downstream to create the space for the new booster cavity under construction, which will be inserted in the facility fall 2008.

The spectrometer HEDA1 is using a dipole with 180 degree bend. It contains two screen stations, the first for measuring the momentum and longitudinal phase space the latter by streak camera, the second for measuring the slice emittance. Furthermore a slit chamber is mounted just behind the dipole for selecting certain momentum ranges and a quadrupole magnet. The radiator for the measurements of the longitudinal phase space is Silica aerogel of refractive index n = 1.05. Both screen stations are equipped with TV systems.

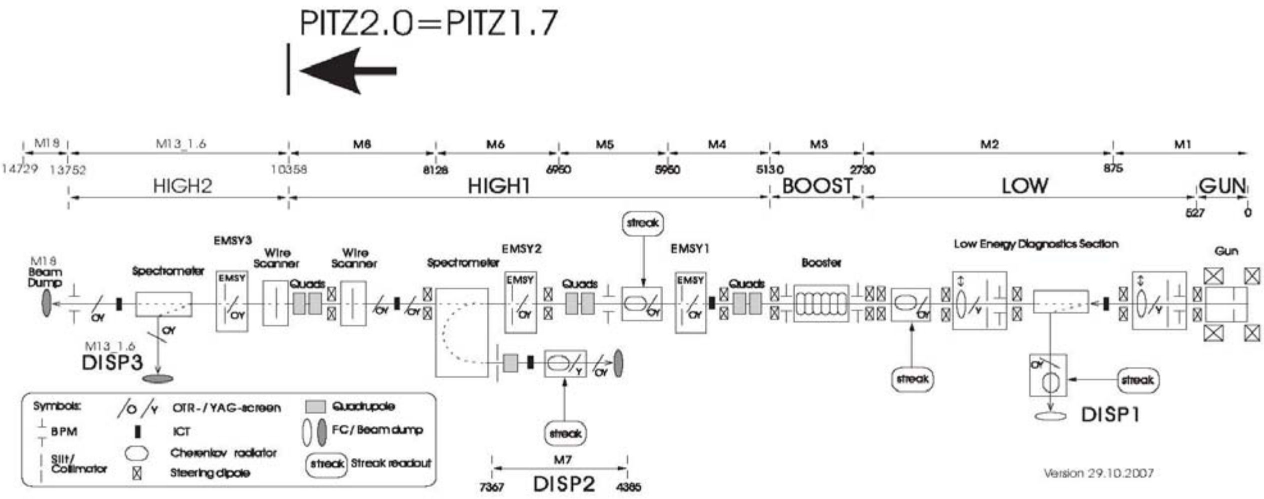

Figure 1: Schematic of PITZ after the described upgrade

A separate setup, the Conditioning Test Stand (CTS) was erected and used for the conditioning of the new gun. This is efficient for the conditioning of new guns parallel to the use of the PITZ linac.

The photocathode laser was exchanged for a new one and the laser diagnostics upgraded essentially.

The klystron of the rf system for the booster cavity was replaced by a 10 MW klystron.

UPGRADE OF LASER AND LASER DIAGNOSTICS

The photocathode laser used up to August 2007 was replaced by a new one developed at Max Born Institute Berlin which will be described in a separate paper [7]. The goal of the new development is to reach a flat top laser pulse of 20 ps length (FWHM) with rise and fall times of 2 ps.

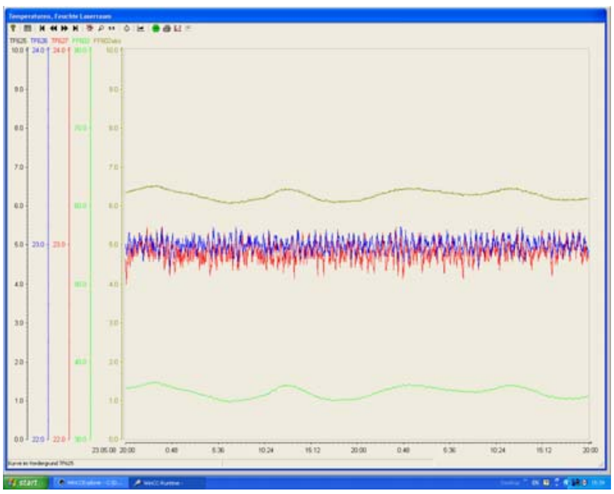

Figure 2: Plot of temperature and humidity in laser room over 2 days. The blue and red curve: temperatures, relative humidity: green curve (should below 40 %).

The laser is under commissioning in June 2008. The laser beam transport system is adapted to the new laser.

The laser hutch had to be increased for the new laser. A new air conditioning system was installed to assure a deviation of maximum 0.1 degree from a demanded value and a relative humidity lower than 40 %. A plot of temperature and humidity is shown in Figure 2.

The system of laser beam diagnostics got a major upgrade. The transverse laser profile can be measured by an improved system of 4 virtual cathodes. The laser pulse energy is monitored on the laser table and at the linac, the measurement is absolute. The longitudinal laser profile can be measured by a streak camera and a new Optical Sampling System (OSS) also developed by MBI [8]. The pointing stability can be measured on the laser table and near to the gun by systems of quadrant diodes.

NEW ELECTRON GUN, CTS AND GUN CONDITIONING

A Conditioning Test Stand (CTS) was installed in the PITZ tunnel. It allows the conditioning of the electron guns independently of the linac running. The CTS contains the gun and both solenoids, a simplified cathode system with only one cathode (usually molybdenum), and a simplified diagnostics section. The diagnostics part consists of a DDC, a magnet spectrometer, a further screen station and Faraday cups both at the end of the straight beam line and in the magnet spectrometer. The three YAG screens in the screen stations are read out by TV systems.

The new gun 4.2 was conditioned in the CTS since December 2007 [9]. This gun was cleaned using a new method of dry ice cleaning [10]. The special characteristics of this gun differing from the previous type gun 3 are the cooling system. There are 14 cooling channels with common inlets and separate outlets in gun 4.2. A water distribution system was developed which allows the control of the 14 channels and the readout per channel of water flow, pressure and temperature. This is the base for further development of optimised guns.

The conditioning is continued since May 2008 in the PITZ linac. The goal was to reach a gradient of at least 60 MV/m. This is one of the conditions to reach a minimal transverse emittance of about 0.9 mm mrad corresponding to the demands for the European XFEL. The conditioning was performed by use of molybdenum cathode plugs.

A plot of dark current in dependence on the main solenoid current with the rf power in the gun as parameter is shown in Figure 3 for 0.4 ms rf pulse length. The maximum dark current as function of the rf power in the gun is shown in Figure 4 for rf pulse lengths 0.4 ms.

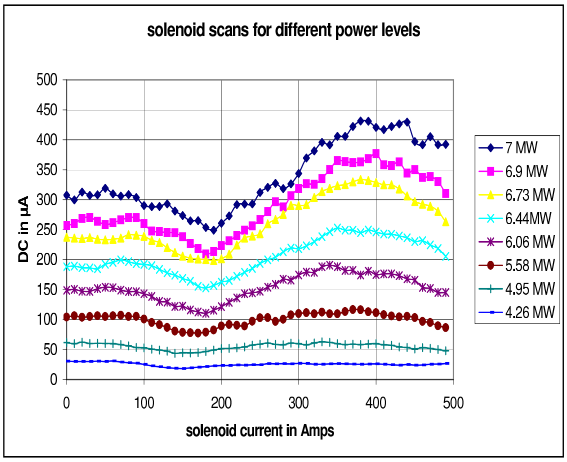

Figure 3: Dark current vs. main solenoid current for rf pulses of 0.4 ms with different rf power levels

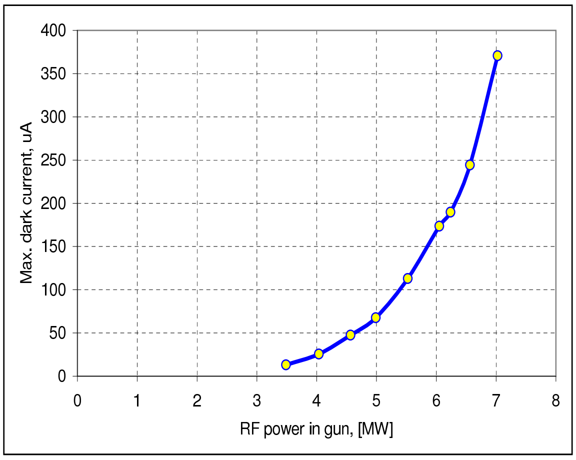

Figure 4: Maximum dark current vs. rf power in the gun for rf pulses of 0.4 ms length (corresponding to the data in Figure 3)

The maximum average power reached with is about 50 kW at an rf peak power of about 7.2 MW in the gun. The rf peak power was reached at a repetition rate of 10 Hz with rf pulses of 0.7ms length. During conditioning a gradient in the gun of about 63 MV/m was reached. In the CTS a maximum mean momentum of the dark current of about 7.2 MeV/c was reached for a rf peak power of 7.6 MW and pulse length of 60 µs.

SUMMARY AND OUTLOOK

In a long shutdown of about 8 months the PITZ facility was remarkably upgraded. An additional CTS was established, so independently of the running of the linac electron guns can be conditioned. A new gun named gun 4.2 was conditioned. It has an extended cooling system and was dry ice cleaned. The diagnostics of PITZ had a major upgrade. A new magnet spectrometer which allows measurements of the longitudinal phase space and slice emittance as well was installed. A new DDC was inserted and the LEDA (Low Energy Dispersive Arm) was reconstructed. A new photocathode laser is installed and the laser diagnostics essentially upgraded.

In summer 2008 the gun 4.2 will be characterized in the upgraded facility. In fall 2008 a new booster cavity of cut disk type (CDS) will be installed, conditioned and used for measurements. A phase space tomography module including a matching section is under technical design and will be installed in fall 2008 in PITZ. It consists of five screen stations and four pairs of quadrupole magnets completed by a matching section. Kicker magnets will allow the measurement of selected bunches. An rf deflector cavity is under technical design for the XFEL project and will presumably be installed first at PITZ. It will be used for the investigation of the longitudinal phase space and slice emittance. A further magnet spectrometer is under development which allows the analysis of long bunch trains including complete measurements of the longitudinal phase space. The development of an optical system for the bunch length and longitudinal phase space measurements is ongoing. This will lead to an improvement of the temporal resolution essentially and will allow to restrict the use of band pass filters, which are used at present to suppress the effect of time dispersion. It will be based on aspheric mirrors instead of lenses. Most of the analog TV cameras will be replaced by 12 bit digital cameras.

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