Photo Injector Test facility at Zeuthen (PITZ 2.0)

Abstract

The Photo Injector Test facility at Zeuthen site (PITZ), has been established for developing and optimizing electron sources for short-wavelength free-electron laser (FEL) applications like the free-electron laser in Hamburg (FLASH) and the European x-ray free-electron laser (XFEL).

- 1999, the DESY directorate decided to build PITZ in Zeuthen.
- 2000 and 2001, civil construction & infrastructure, a 1st version of the RF system & a basic electron beam diagnostics system were installed.
- 2002 and 2003, 1st photoelectrons were produced and full experimental characterization.
- 2004 PITZ (**)
- 2005 PITZ (**)
- 2006 PITZ (**)
- 2007 PITZ (**)
- 2008 PITZ (**)~2012 (**)

Goals & research activities

- **Study and development of electron sources for European XFEL**
- **Produce electron beams with short bunch length, small energy spread (≤10%) and small emittance ≤ 0.9 mm-mrad for electron bunch charge of 1 nC**
- **Operation with high duty cycle for superconducting cavity linac**
- **Operation with long RF pulse length and high average power ≥50 kW, 650 µs @ 10 Hz repetition rate**
- **Operation with long electron pulse trains with several electron bunches (800 bunches)**
- **Preparation (conditioning) & characterization of RF guns for subsequent operation at FLASH & European XFEL**
- **Study on new technologies and benchmark for theoretical & experimental understanding of photoinjectors in parallel to FLASH operation**
- **Test new developments e.g. laser system, cathodes, and beam diagnostics**

Configuration

The PITZ beam transport line in the last version 2012 has the following components:

- **1.6 cell photocathode RF gun, powered by 10 MW klystron to generate electron beam up to 7 MeV/c in the RF peak power,**
- **Two solenoids (main and bucking solenoids) for beam focusing and emittance compensation.**
- **Accelerator structure (CDS booster), to deliver electron beam up to 40 MeV/c.**
- **Two dipole magnets (one in the low energy section after the gun (LEDA) dipole, and second one in the high energy section after the booster, so called High Energy Dispersive Arm (HEDA1) dipole),**
- **Three dipole magnets in the high energy section (HEDA2) just before the beam dump for slice emittance.**
- **Three Emittance Measurement Stations (EMSY),**
- **One phase space tomography module (PST).**
- **Electron beam controlling and diagnostics through the beam line for beam size, shape and position (quadrupole, steers, BPM, YAG or OTR screens and streak cameras).**

Beam Dump

- At the end of the straight section of the PITZ beam line, and at the end of the dispersive arm, the electron beam is dumped into cylindrical aluminum absorbers.
- The dump in the straight section is open to the vacuum chamber whereas the beam pipe in the dispersive arm is separated from it by a 1.3 cm thick blind flange of stainless steel.

HEDA 2

- The second High Energy Dispersive Arm (HEDA2) is located before the beam dump.
- It consists of three dipole magnets (60, -120 and 60) and beam diagnostic equipment.
- For what:
  - Slice momentum spread down to 1 keV/c using the first dipole magnet with its corresponding screen and the TDS.
  - Emittance of the vertical plane using the second dipole magnet, a quadrupole magnet, and a downstream screen station.
  - Help in the electron beam dumping.????

PST Module

- The Phase Space Tomography (PST) module is system used for transverse emittance measurement.
- The basic structure includes four screen stations and quadrupole magnets in between placed periodically (FODO).
- The quadrupole magnets are set to get a phase advance of 45 degrees between the screen stations.
- For what:
  - Simultaneous measurement of the emittance in both planes, and reconstruction of the phase space distribution.

TDS

- The PITZ transverse Deflection structure (TDS) is a S-band disc-loaded waveguide with two mode-locking holes for deflecting plane stabilization.
- It has 16 cells and operates in a deflecting TM11-like travelling mode.
- For what:
  - With the PST module or EMSY3 station for slice emittance phase space reconstruction,
  - With DISP3 arm for longitudinal emittance measurements.

HEDA 1

- The first High- Energy Dispersive-Arm is located ~ 4 m downstream the center of the booster cavity
- It consists of 180 dipole magnet, a slit at the magnet exit and two screen stations and streak camera.
- For what:
  - The beam momentum and momentum spread up to 40 MeV/c with resolution 3keV/c.
  - The transverse slice emittance
  - The longitudinal phase space.

BOOSTR

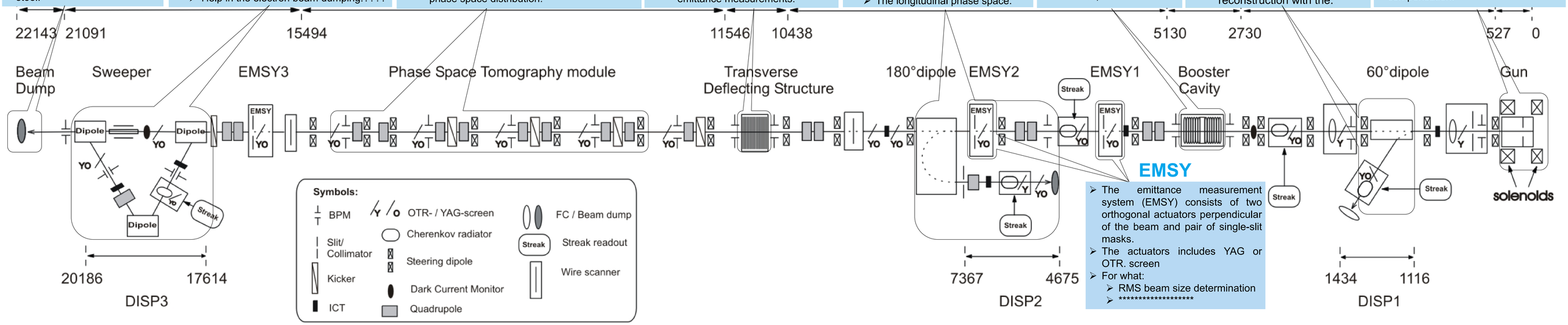
- The PITZ booster is a normal-conducting copper Cut Disc Structure (CDS),
- it has 14-cell and operates in the L-band frequency (1.3 GHz)
- Max gradient in the cavity 14MV/m
- maximum momentum 40 MeV/c at peak power (******MW) and (nominal > 25 MeV/c)

LEDA

- The Low Energy Dispersive Arm (LEDA), is located 1.1 m downstream the gun.
- It has a 60° vertically-bending dipole magnet with observation station of YAG & streak camera.
- For what:
  - Momentum and momentum spread up to 7 MeV/c with resolution up to 3keV/c
  - Longitudinal phase space reconstruction with the.

RF Gun

- The PITZ photocathode RF gun is a normal conducting 1.6 cell L-band RF cavity (1.3 GHz).
- The body of the cavity is made of copper.
- The gun cavity is fed using a 10 MW multi-beam klystron.
- The maximum peak power fed the gun can delivers electron bunches with maximum mean momentum of ~7 MeV/c.
- Cs_2Te have been selected to be the cathode material.
- The cathode is situated on the back side of the cavity and can be replaced with a special exchange system.
- Two (Main and bucking) solenoids are used for beam focusing and emittance compensation.



EMSY

- The emittance measurement system (EMSY) consists of two orthogonal actuators perpendicular of the beam and pair of single-slit masks.
- The actuators includes YAG or OTR. screen
- For what:
  - RMS beam size determination
  - ********************

RF Klystrons

PITZ Laser System

- **********
- The laser system has a master oscillator power amplifier architecture.
- Both the oscillator and the amplifier rely on neodymium-doped yttrium lithium fluoride (Nd:YLF) as the lasing material, and all Nd:YLF rods are pumped from both ends by fiber-coupled laser diodes.
- The main advantage of Nd:YLF in comparison to other laser materials is very weak thermal lensing, which allows the generation of long pulse trains with a stable beam diameter.

Think with me what we have to put in this area ????

- **Recent results**
- **Details**
- **Other parts (RF, etc)**
- **Mesurment Systems (devices)**