Design of a TV Diagnostics System for the Photo Injector Test Facility at DESY Zeuthen

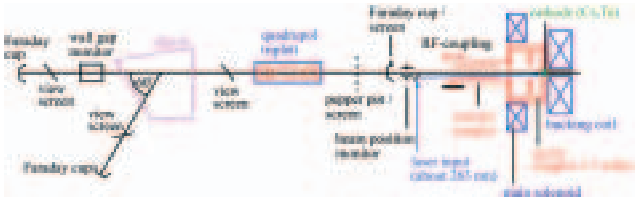
J. Bähr, K. Flöttmann, F. Stephan
DESY, 22603 Hamburg and 15738 Zeuthen, Germany

A photo injector test facility for free electron lasers (FEL) and the TESLA linear collider is under construction at DESY Zeuthen and will be commissioned in autumn 2001. The project is a common effort of a collaboration originated by the following institutions: BESSY Berlin, DESY (Hamburg and Zeuthen), Max-Born-Institut Berlin, Technical University Darmstadt.
It is funded partially by the HGF-Vernetzungsfonds.

Goal

Operate a test facility for laser driven RF guns and photo injectors to optimize injectors for different applications: free electron lasers and future linear colliders.

Description of PITZ



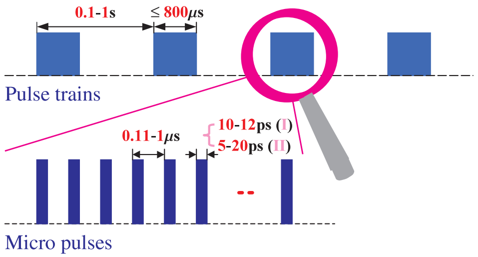
Main components of PITZ

- photocathode: Cs_2Te
- cavity: 1.5 cell geometry
- laser: 263 nm
- RF-system: Klystron 5 MW...10 MW, 1.3 GHz
- control system based on DOOCS (Distributed Object-Oriented Control System)
- diagnostics section

Parameters of PITZ

- charge per bunch: 1 nC
- laser beam diameter on cathode: 1...10 mm diameter
- electron beam energy: ~5 MeV (without booster) ~30 MeV (with booster)

Schematic time structures of the laser beam



I) Phase 1: gaussian shape ~6 ps

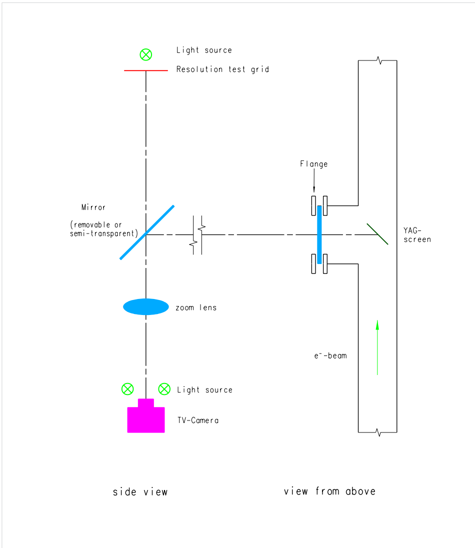
II) Phase 2: rectangular shape with rise and fall time < 1ps

TV diagnostics System

Goal

- measurement of beam position at different positions along the beam line
- measurement of beam profile and intensity distribution at different positions
- measurement of intensity distribution of the pattern behind the emittance measurement system EMSY
- measurement of energy spectrum behind the dipole
- use as virtual cathode

Therefore, the TV diagnostics system is one of the most important,univeral and flexible diagnostics systems of the PITZ facility.



TV-Camera: JAI M10RS

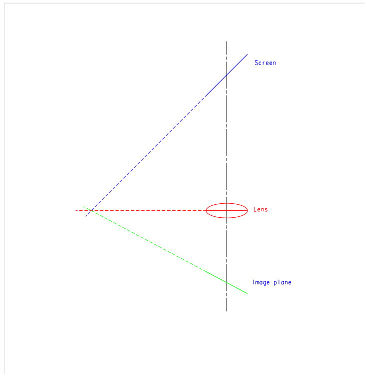
-1/2" CCD Camera black/white
-progressive scan mode
-782 x 582 pixels
-pixel dimensions 8.3 μm x 8.3 μm
-non-interlaced readout mode
-external gain control
-external trigger
-interface RS 232
-readout by framegrabber over 40m Distance
-linear characteristic curve

Specifications and features

- imaging the light distribution of a YAG-screen to the camera
- different magnifications:
  - large field and demagnification
  - magnification and smaller field
- high resolution (< 10 μm) for high magnification
- possibility to measure resolution for the given magnification
- possibility to measure magnification in-situ using a pattern on the YAG screen
- avoid radiation damage
- avoid direct illumination of the camera sensor by Xrays
- remote control of focal length, focus and diaphragm
- illumination of the screens by a light source
- virtual cathode: measure laser beam position and profile at a position corresponding to the photocathode of the PITZ facility
- overcome depth-of-field problem of the screen in the 45 degree position

The depth-of field problem

- can be solved by using the option of a view screen camera



Readout

- The video signal is read out and analysed by a computer based frame-grabber.

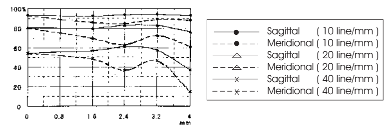
Image analysis

- The graphic measurements are realized using standard tools of image processing.

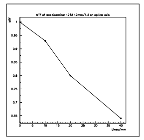
Optimization of optical resolution

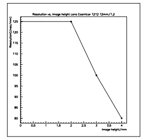
Influences:

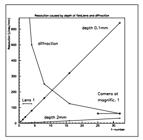
- depth of field
- diffraction
- pixle size and pixle number of the camera
- lens resolution



Optical transfer function of the H1212B lens







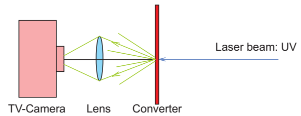
Discussion of limitations

- depth of field of 2mm is hardest limitation overcome by view screen camera principle (drawback: non-equal magnification in the image field)
- small defocusing (0.1mm): Optimum of defocusing and diffraction at about fno= 10. In this case limitation by resolution of lens and camera
- The limitation of the camera can be eliminated by higher magnification (drawback: smaller object field)
- Conclusion: one can match f-number and magnification such, that the resolution of the lens remains the limiting factor (solution of the depth-of-field problem assumed) .

Virtual Cathode

Goal:

- simulates the cathode
- measures characteristics of the laser beam spot:
  - position
  - shape
  - intensity distribution



The converter consists of plastic scintillator or a evaporated YAG screen both used in transmission.