Status of the Photo Injector Test Facility at DESY Zeuthen

I. Bohnet for the PITZ-Collaboration

Contents

1 Goals

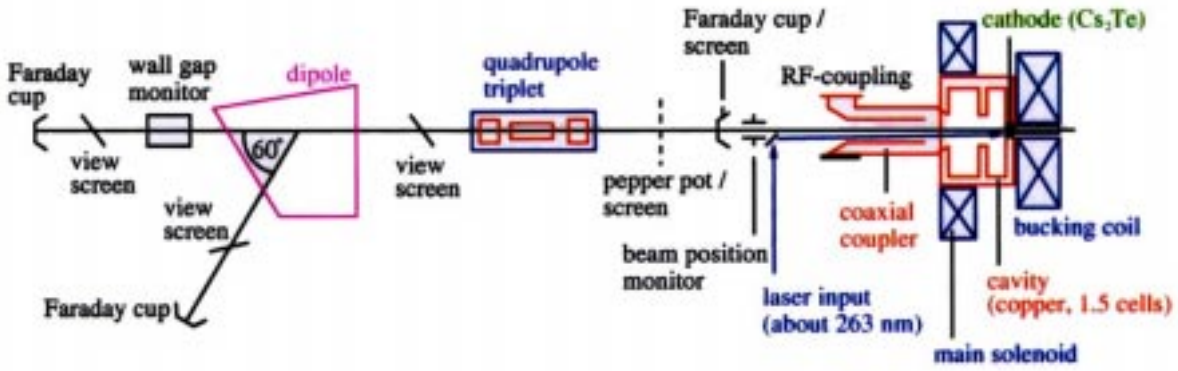
Photo Injector Test facility at DESY Zeuthen:
(BESSY, DESY, MBI, TU-Darmstadt)
in strong collaboration with the INFN Milano, PI Yerevan, INRNE Sofia, INR Troisk, TESLA collaboration, etc.

- operate a test facility for laser driven rf guns and photo injectors for free electron lasers and future linear colliders:
  1. extremely small transverse emittance ($\approx 1\pi$ mm mrad @ 1 nC)
  2. stable production of short electron bunches
  3. small energy spread ($\approx 1\%$ at 5 MeV)
- extensive R&D on photo injectors (pi) independent from TTF operation
- detailed comparison between experimental results and simulations
  1. benchmark theoretical understanding of pi's
  2. optimization of pi for different applications
- conditioning of rf guns for the operation at TTF-FEL
- test of new components, i.e. laser, cathodes, ...
- developments for TESLA: flat beam and polarized electron sources

2 Layout and parameters

How to obtain small emittances?

- longitudinal flat-top laser pulse
- cavity has symmetric rf coupler
- free longitudinal position of the solenoid



Parameters of the photo injector test facility:

charge per bunch	≈1 nC	pulse train length	≤ 800 μs
resonance frequency	1.3 GHz	pulse train rep. rate	1 – 10 Hz
peak rf power (in preparation)	5 MW (10 MW)	micro pulse rep. rate (in preparation)	1 MHz (9 MHz)
Gradient at the cathode	≈50 MV/m		
electron beam energy (with booster)	≈5 MeV (≈30 MeV)		

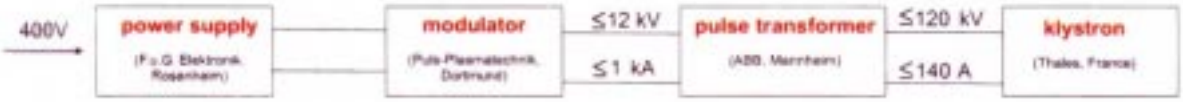
3 Technical and scientific plans

- commissioning of the klystron
  $\Rightarrow$ interlock, hv and rf conditioning
- laser system (1st stage is operational $\rightarrow$ MBI)
  $\Rightarrow$ adjustment of laser beam line, etc.
- cathode system $\rightarrow$ INFN Milano
- development and improvement of diagnostics:
  1. EMSY $\Rightarrow$ emittance measurement system
  2. Cherenkov radiator $\Rightarrow$ bunch length, investigations on Aerogel in vacuum $\rightarrow$ BESSY
  3. optical readout $\Rightarrow$ screen diagnostics
  4. Laser diagnostics $\Rightarrow$ virtual cathode
- Software
  1. Automatic Conditioning Program (ACP)
  2. Data Acquisition (DAQ)
  3. simulations to optimize gun settings
  4. comparison of simulation programs $\rightarrow$ TU-Darmstadt

TeV Energy Superconducting Linear Accelerator

The RF system for PITZ

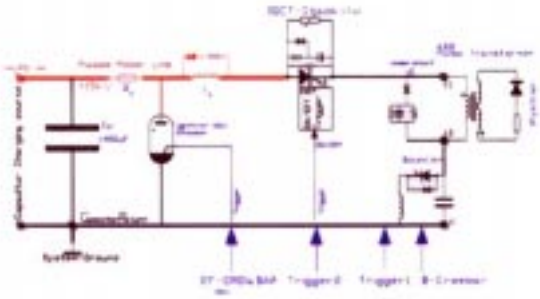
schematic:



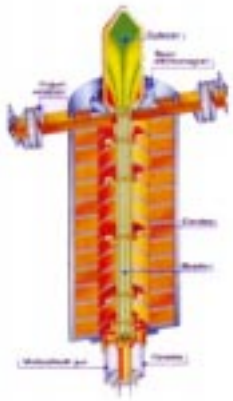
frequency:	1.3 GHz
peak rf power:	5 MW (10 MW in preparation)
length of rf pulse:	~900 µs
repetition rate:	1 - 10 Hz

HVPS capacitor bank bouncer

pulse transformer



modulator circuit



principle sketch of a multi beam klystron

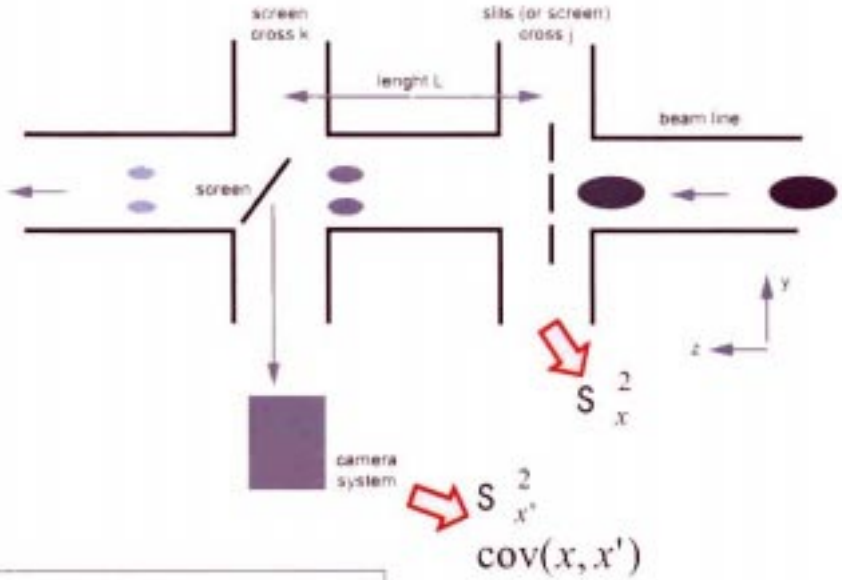
cathode of the MBK TH1801

The new emittance measurement system at PITZ

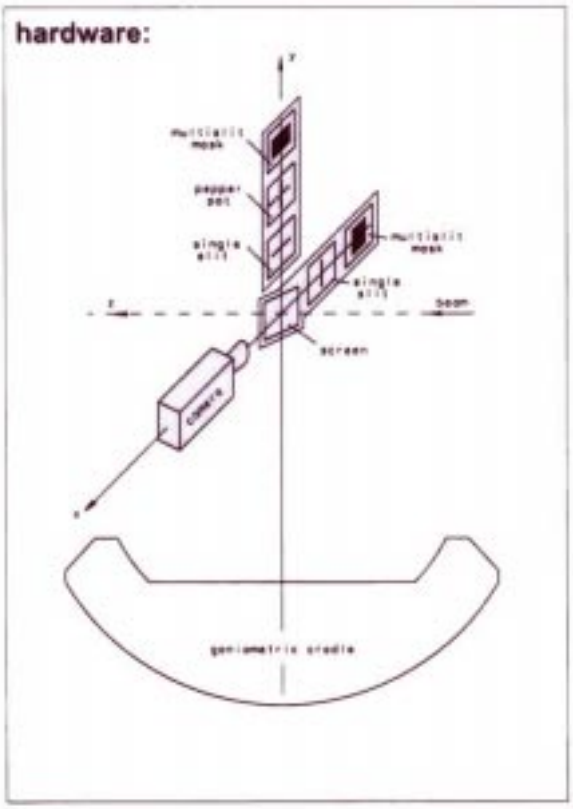
- normalized transverse emittance: $\varepsilon_x^n = \beta\gamma\sqrt{s_x^2 s_{x'}^2 - \mathrm{cov}^2(x,x')}$
- emittance range: ~1-10 π mm mrad

$$\varepsilon_x^n = \beta\gamma\sqrt{\langle x^2\rangle\langle x'^2\rangle - \langle xx'\rangle^2}$$

principle:



hardware:

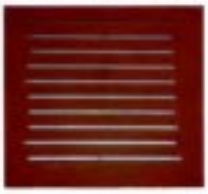


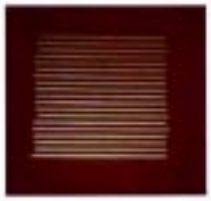
actuators:

vertical

horizontal

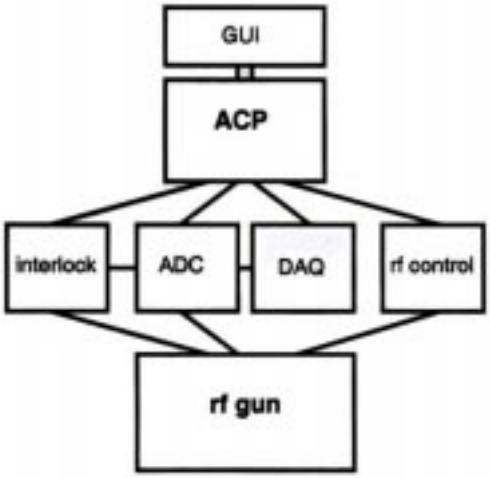
multislit masks:

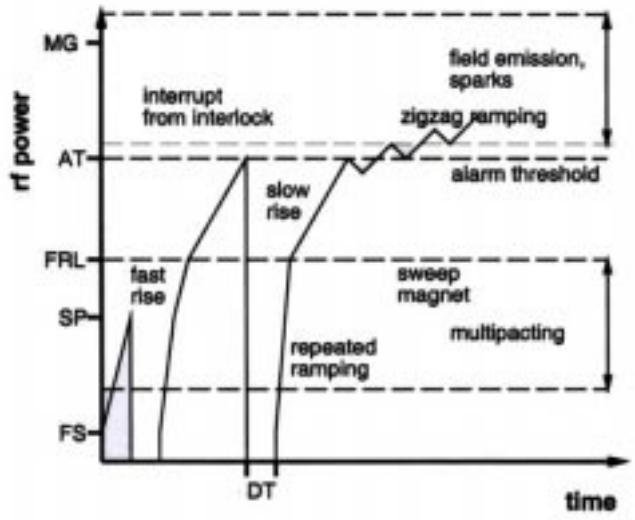




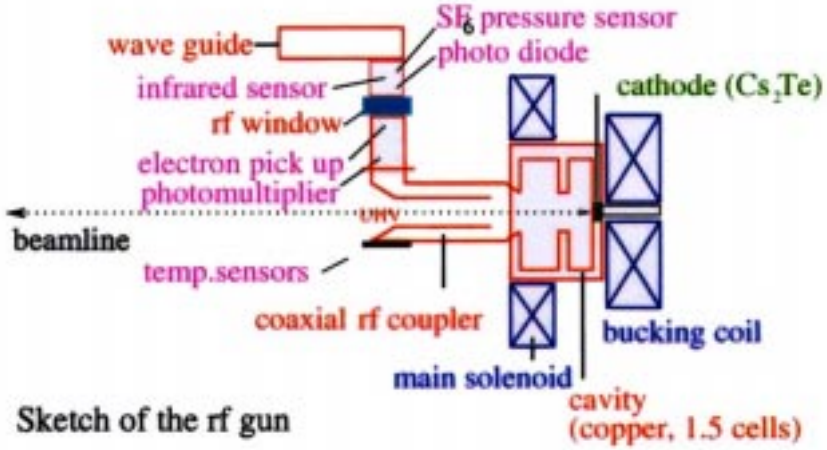
ACP

successive increase of rf power in the cavity
$\Rightarrow$ High gradients on the cathode (> 35 MV/m)





- ACP controls rf power $\rightarrow$ low level rf
- react appropriatly on interlock signals
  $\rightarrow$ slow/fast signals
- store data for deeper analysis



Sketch of the rf gun

4 Status and schedule

Status (October 2001):

- infrastructure ready
- installation of all hardware components mainly finished
- first stage of laser system operational

Schedule:

- commissioning of rf system in November 2001
- start operation of the facility as soon as possible
  $\Rightarrow$ conditioning of the gun
  $\Rightarrow$ production of first photoelectrons
- measurement program in 2002
- installation of the booster cavity in 2003