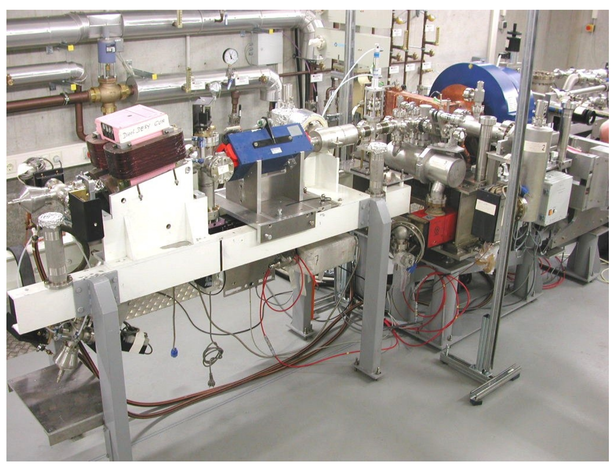
RF Commissioning of the Photo Injector Test Facility at DESY Zeuthen

K. Abrahamyan, J. Bähr, I. Bohnet, S. Choroba, K. Flöttmann, H.-J. Grabosch, M.v. Hartrott*, R. Ischebeck, O. Krebs, Y. Li, D. Lipka, A. Oppelt, V. Peplov, B. Petrosyan, M. Pohl, J. Rossbach, S. Simrock, F. Stephan, T. Thon, R. Wenndorff, M.Winde

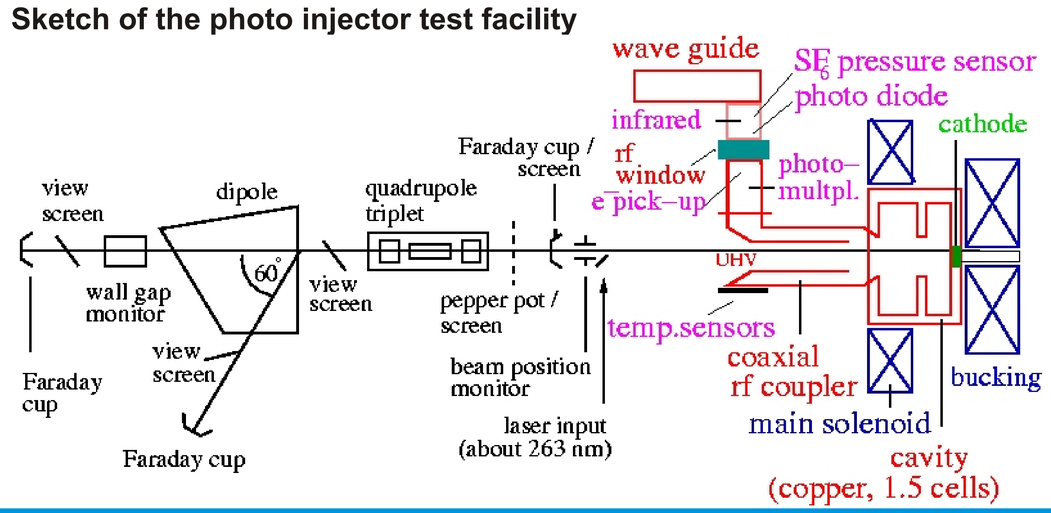
DESY, 22603 Hamburg and 15738 Zeuthen
*BESSY, 12489 Berlin

Description and scientific goals



A photo injector test facility has been commissioned at DESY Zeuthen. The aim is to develop and operate an optimized photo injector for future free electron lasers and linear accelerators which require extraordinary beam properties. First operation of the rf gun was done in December 2001. The project is a common effort of collaboration originated by BESSY (Berlin), DESY (Hamburg and Zeuthen), Max-Born-Institut Berlin and the Technical University Darmstadt.
It is funded partially by the HGF-Vernetzungsfond.

Sketch of the photo injector test facility

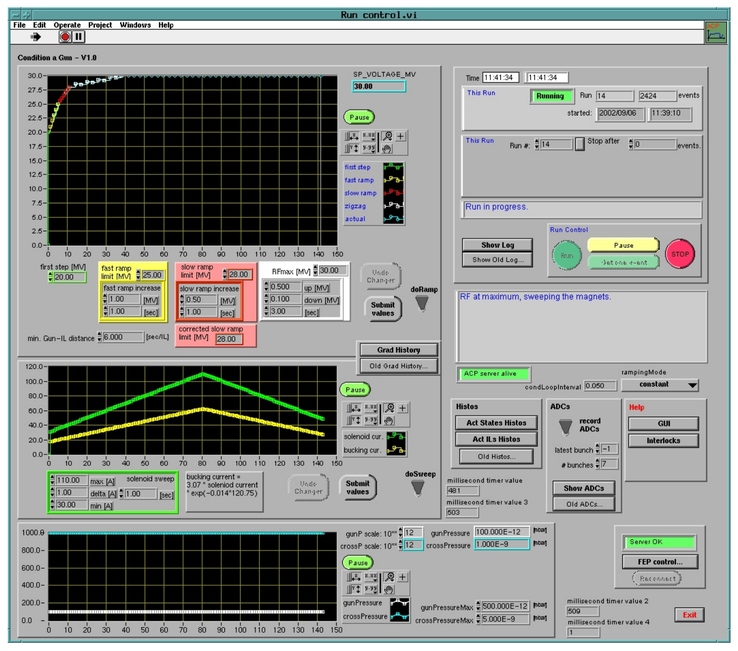


Automatic Conditioning Program (ACP) and Data Acquisition (DAQ)

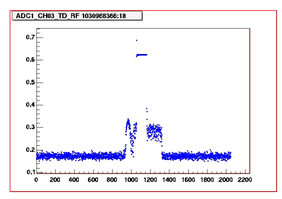
An extensive rf commissioning based on a 5 MW klystron was done to allow a stable production of short electron bunches with low transverse emittance and a small energy spread.
Therefore an Automatic Conditioning Program (ACP) has been developed to increase the efficiency and the safety of the conditioning work and to get even higher gradients (>35MV/m) in the rf gun than achieved today in similar normal conducting cavities.

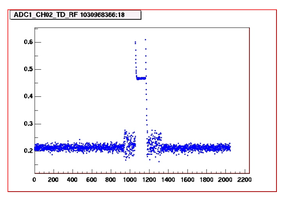
* The ACP controls the rf power and the solenoid currents.
* It reacts appropriately on interlock signals.
* An online analysis allows a quicker and more clever control of the conditioning process.
* A deeper analysis of what's going on during conditioning is realized by an event recorder of ACP.

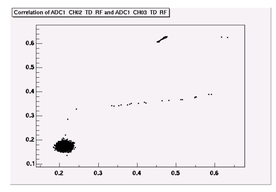
ACP is based on C++ running a graphical user interface of Labview virtual instruments (as shown on the right).



A Data Aquisition system (DAQ) has been established in the framework of ROOT, which supplies an object-oriented data base as well as multiple analysis tools. It uses DOOCS servers to get access to the elements of the facility. The program runs simultaneously on three Sun SPARC workstations and uses a common timing system, which allows to relate different detectors recorded by different computers in different database files. Recorded data are analysed by means of tools developed in the frame of ROOT and MATLAB utilities.







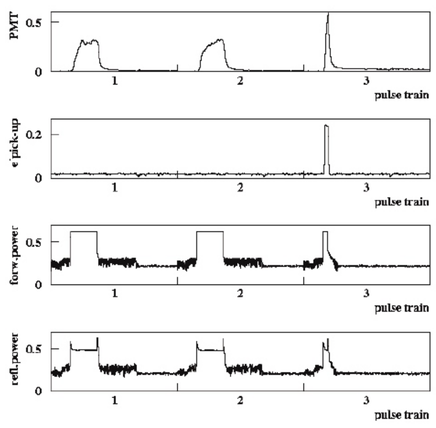
Forward power (left diagram) and reflected power (middle diagram) of the gun for 100us long rf pulses extracted from DAQ. The correlation between the mean reflected power and the mean forward power of two hours running time is shown in the right diagram.

Interlock events

Which effects could happen during conditioning?

* Field emission of electrons from protrusions on the surface.
* Multipacting which is a resonant phenomenon of low energy electrons from field emission depending on a solenoidal field.
* Sparks accompanied by strong light emission and rf power reflections.

All these effects can guide to an increase of vacuum pressure and can destroy cathode, cavity, rf window or rf coupler.

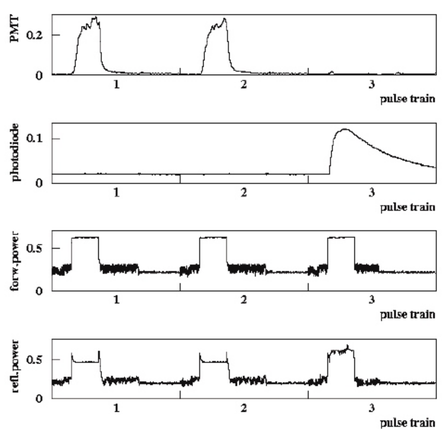


Left diagram:

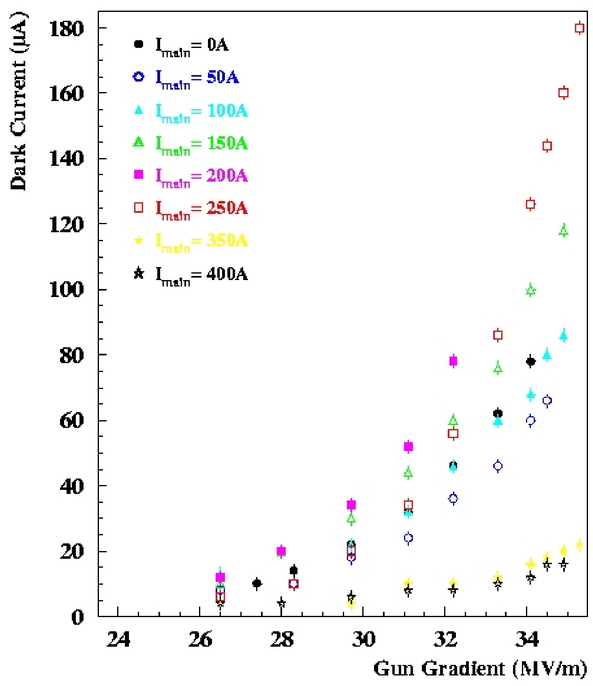
Fast ADC signals in arb. units during the last three pulse trains of a photomultiplier and electron pick-up event.

Right diagram:

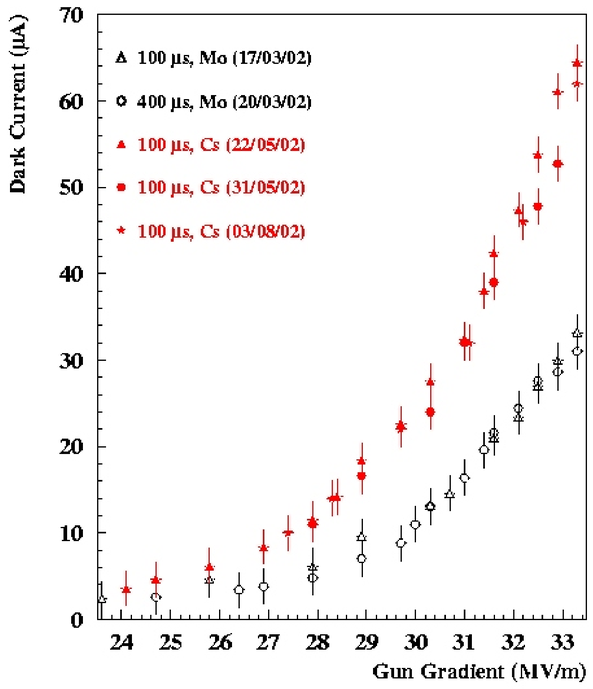
Fast ADC signals in arb. units during the last three pulse trains of a photodiode event.



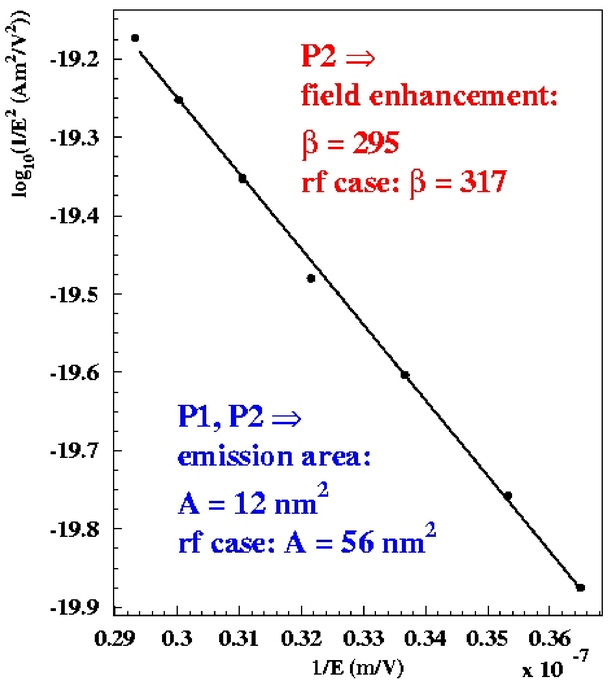
Dark current measurements



The dark current emission from the cathode (here Cs_2Te) has been measured as a function of the gradient for different solenoid currents. The current of the bucking solenoid was chosen to compensate the magnetic field at the cathode.



Dark current measurements for different cathodes (Cs Te and Mo, respectively), the solenoids are switched off.



A Fowler-Nordheim analysis including a linear fit to the rescaled data results in a field enhancement factor of about 300.

The conditioning procedure with ACP obtained a stable operation for rf pulses up to a length of 400us at a repetition rate of 5Hz including a solenoidal field between 0 and 0.25T with a compensated field at the position of the cathode. The maximum gradient was 37MV/m at a repetition rate of 1 Hz and a rf pulse length of 100us.

http://desyntwww.desy.de/pitz/