

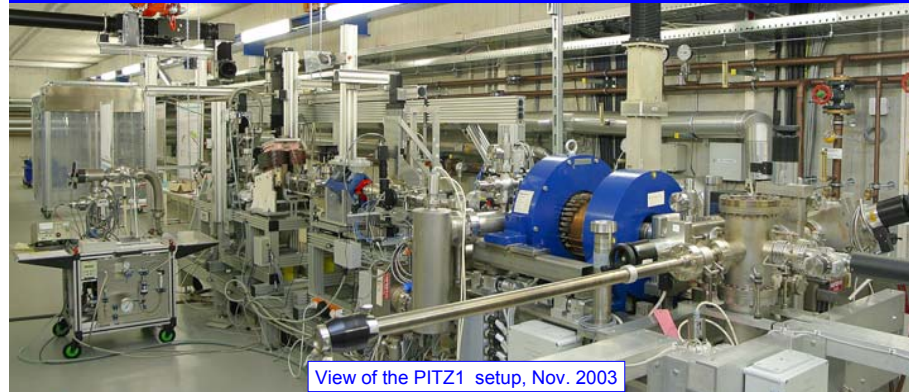
# Results of the first phase of PITZ



The PITZ collaboration:

BESSY Berlin, DESY Hamburg and Zeuthen, INFN-LASA Milano, INR Troitsk, INRNE Sofia, MBI Berlin, TU Darmstadt, YERPHI Yerevan

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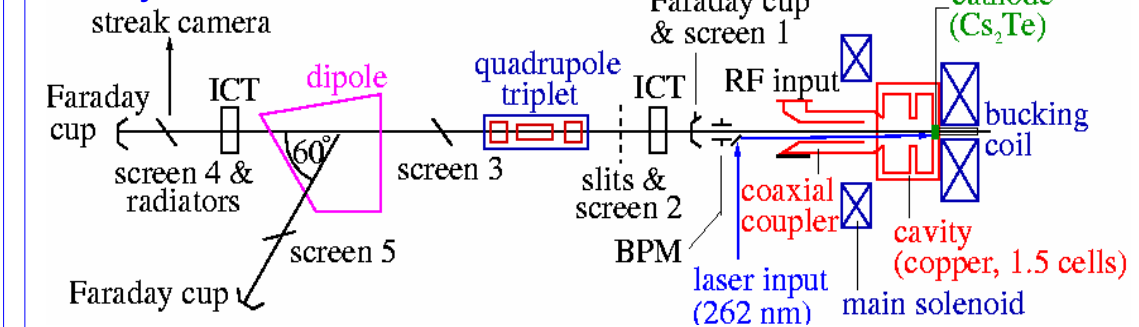
View of the PITZ1 setup, Nov. 2003

## The Photo Injector Test Facility at DESY Zeuthen (PITZ) -- a test facility for FELs like TTF2 VUV-FEL and European XFEL

### Goals:

- produce electron beams with small emittance ( $\sim 1\pi$  mm mrad at a nominal bunch charge of 1 nC) and small energy spread
- compare detailed experimental measurements with simulations in order to improve the theoretical understanding of photo injectors
- test and optimize new developments (photo cathode laser, gun cavities, photo cathodes, beam diagnostics)

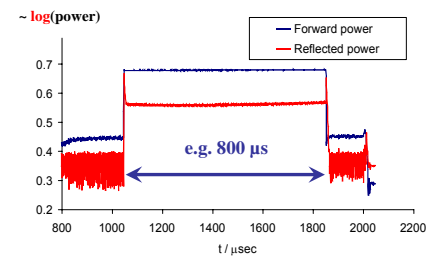
### PITZ1 layout



### Achievements on RF conditioning (2003)

rf frequency: 1.3 GHz  
 rf pulse duration: 900  $\mu$ s  
 repetition rate: 10 Hz  
 rf input peak power: >3 MW  
 max. gradient:  $\sim 42$  MV/m at the cathode

0.9% duty cycle } 27 kW average power

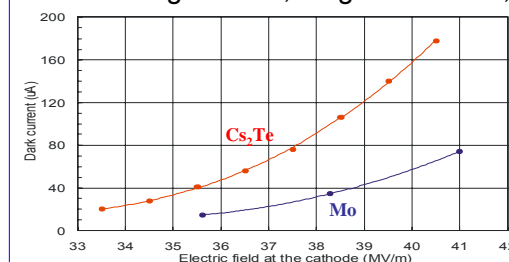


### Recent results (July 2004)

max. rf pulse duration: 1300  $\mu$ s  
 rf input peak power: 4 MW  
 duty cycle: 1.3%  
 average power: 33 kW

### Dark current measurements (2003)

for different gradients, magnet currents, cathodes



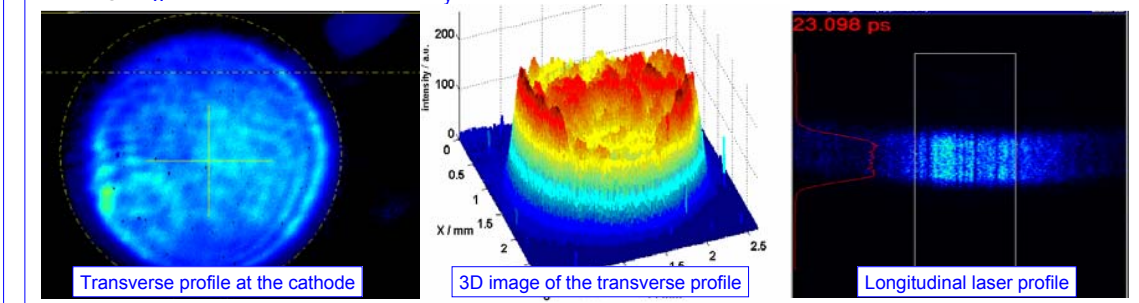
Damaged photo cathode

### Studies of photo cathodes (2004)

observation of surface damages due to high gradient and high amount of dark current with the new gun

### Parameters of the photo cathode laser

- flat-top like longitudinal profile of length  $\sim 23$  ps (FWHM) with  $\sim 6$  ps fall/rise time
- homogeneous circular transverse profile of adjustable rms size, e.g.  $\sigma_x = (0.52 \pm 0.02)$  mm,  $\sigma_y = (0.63 \pm 0.02)$  mm



### Status and future plans at PITZ

The photo injector test facility at DESY Zeuthen has been taken into operation in January 2002. The first stage of the project (PITZ1) aimed in the complete characterization of the photo injector. PITZ1 has been successfully concluded in November 2003 with the transfer of a completely characterized RF gun to DESY Hamburg, where the gun has already been taken into operation at the TTF2 VUV-FEL.

Meanwhile, a new gun has been installed at PITZ. It has extensively been conditioned and measurements of the electron beam properties are ongoing. Preparations for the second stage of PITZ, called PITZ2, are ongoing.

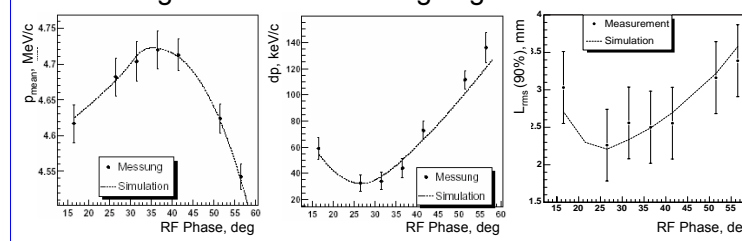
PITZ2 will be a large extension of the experimental setup and its measurement program. The main intention is a further improvement of the electron beam quality with the goal to approach the requirements of the European XFEL. This needs an optimization of the photoinjector and all subsystems, including laser, photo cathodes, and guns, as well as simulation tools. The heart of PITZ2 will be a booster cavity, that increases the beam energy and allows to study the emittance conservation principle. A new diagnostics beamline, adapted to the higher beam energy, will be installed starting in early 2005.

### Longitudinal phase space measurements (2003)

- max. mean momentum: 4.72 MeV/c
- min. momentum spread: 33 keV/c
- min. bunch length:  $(21.04 \pm 0.45 \text{ stat.} \pm 4.14 \text{ syst.})$  ps

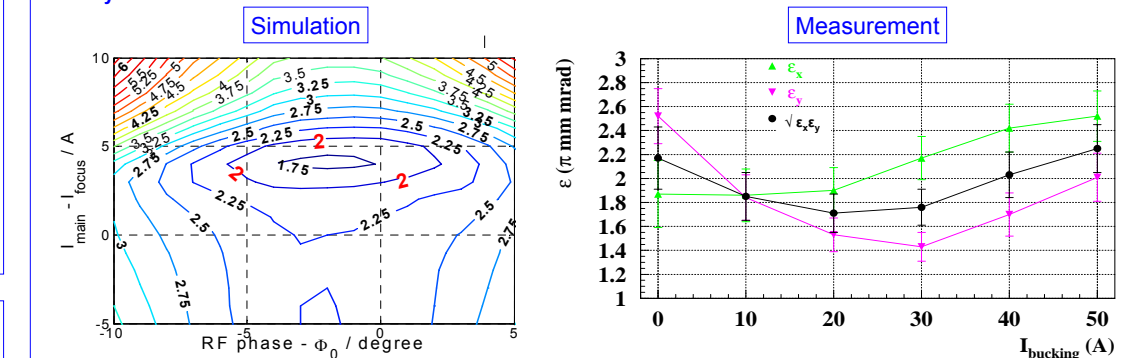
### Recent results (July 2004):

- max. mean momentum: 5.22 MeV/c
- min. momentum spread reduced
- bunch length measurement ongoing



### Transverse beam emittance measurements (2003)

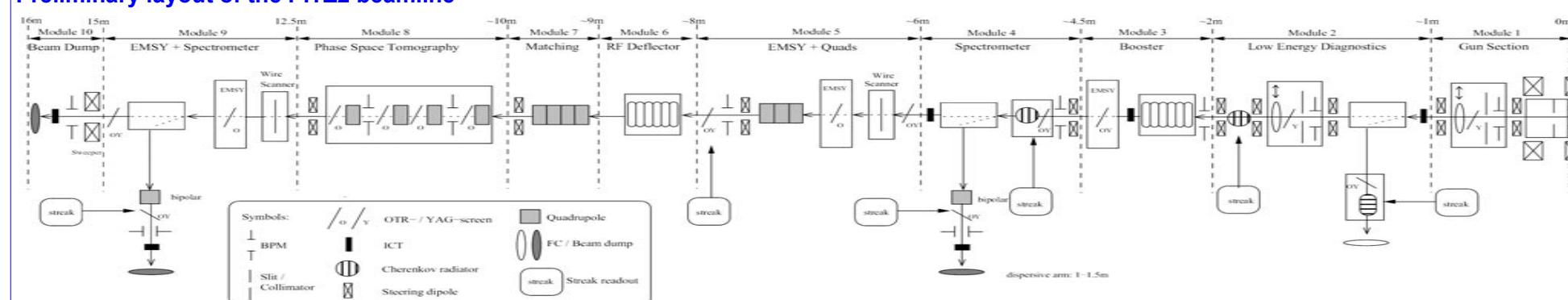
- measured using the slit mask scan technique, at a nominal bunch charge of 1 nC
- optimization of photo cathode laser parameters, rf phase and main solenoid current are necessary preconditions
- fine tuning of bucking solenoid current compensates the magnetic field at the cathode and leads to the measured minimum emittance values
- measured min. normalized projected transverse beam emittance (geometric average):  $\sqrt{\epsilon_x \epsilon_y} = 1.7 \pi$  mm mrad



### Recent measurement results (July 2004)

2.5  $\pi$  mm mrad reached, parameter space optimization ongoing

### Preliminary layout of the PITZ2 beamline



### References

- PITZ1 measurements: M.Krasilnikov et al., "Characterization of the Electron Source at the Photo Injector test facility at DESY Zeuthen", FEL 2003, Tsukuba, Sept. 2003.  
 Recent PITZ results: F.Stephan et al., "Recent Results and Perspectives of the Low Emittance Photo Injector at PITZ", FEL 2004, Trieste, Sept. 2004.  
 Plans for PITZ2: A.Oppelt et al., "Future plans at the Photo Injector Test Facility at DESY Zeuthen", FEL 2003, Tsukuba, Sept. 2003.