Diagnostics at JINR LHEP Photogun Bench

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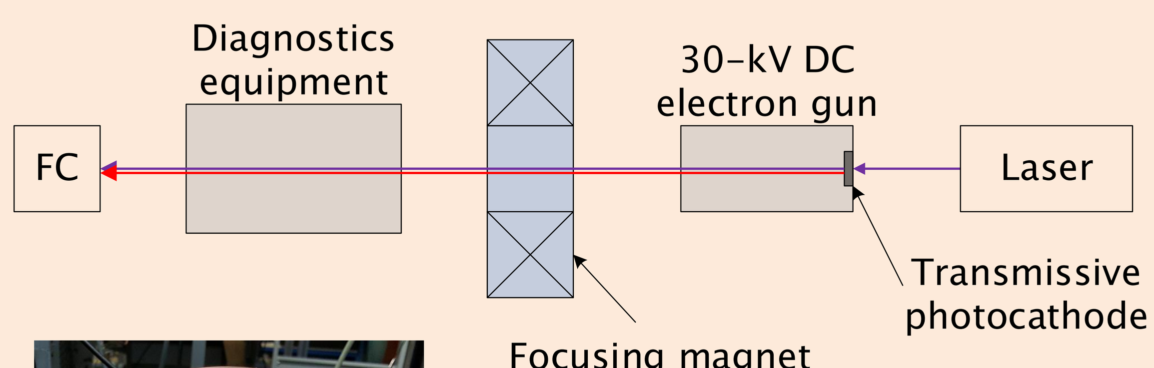
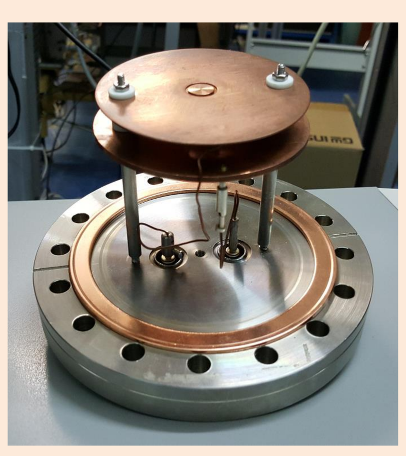
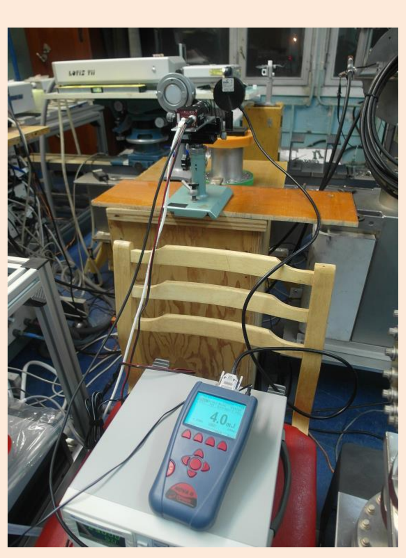
Introduction

Photogun bench of JINR LHEP aims to develop and improve “transmissive” photocathodes to increase quantum efficiency, lifetime and to decrease vacuum requirements. “Transmissive” photocathode is the development of the “Hollow” photocathode conception developed at JINR. It consists of micron-sized metal mesh or quartz/sapphire plate with thin-film coating: either metal or semiconductor. Beam diagnostics, both electron and laser, is important in order to investigate cathode characteristics. To accomplish this, a set of diagnostics subsystems is installed at the bench.

Bench Equipment







Main bench elements are 30-kV DC photogun with the transmissive photo-cathode, focusing magnet with correction windings, diagnostics equipment and a driver laser. Bench beamline vacuum is < 10^{-8} torr. A faraday cup is used for electron bunch charge measurement. Laser pulse energy is measured by an Ophir Nova II power/energy meter equipped with PE25 pyroelectric sensor.

Bench Equipment: LOTIS TII UV Lasers

LS-2134	LS-2132UTF
	
t = 15 ns, E = 15 uJ	t = 5 ns, E = 30 uJ

Bench Equipment: Prosilica Camera

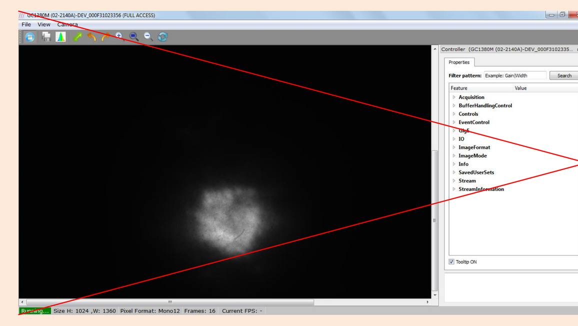
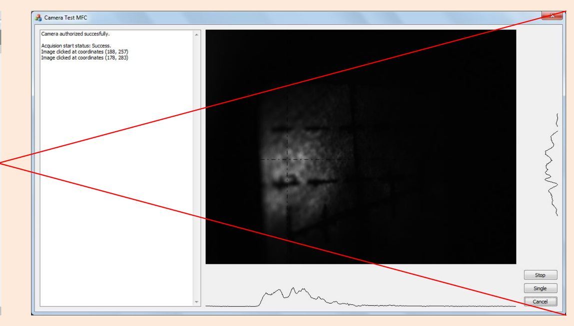
- 2/3" Sony ICX285 CCD Sensor
- 1360 × 1024 Resolution
- 6.45 μm × 6.45 μm Pixel Size
- 20,2 fps Frame Rate
- Less than 3,3 W (5-25 VDC)
- IEEE 802.3 1000BASE-T
- GigE Vision Standard 1.0
- 12 bit Digitization
- Triggering (2 channels)

Bench Equipment: Emittance Measurement

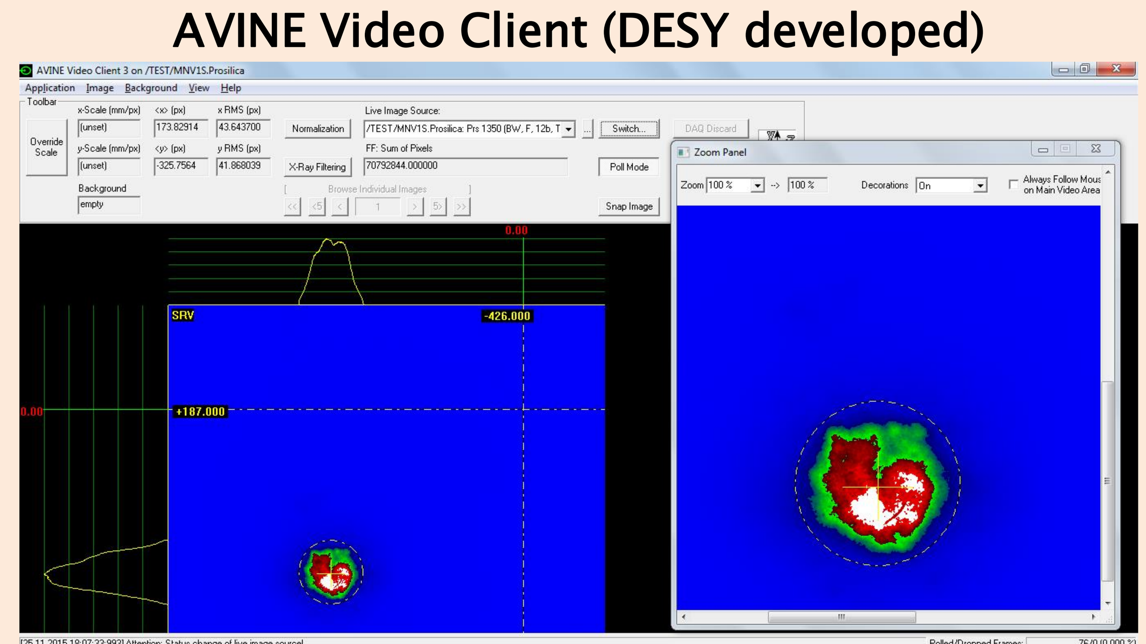
Emittance is one of the main particle beam parameters, its measurement is one of the key photocathode investigation tasks. Therefore, a slit emittance measurement system is being developed at the bench. It consists of the following equipment:

- slit mask, 1mm thick tungsten plate with 9 50 μm slits located at 3mm distance from each other;
- vacuum chamber with 2-position pneumatic actuator where the slit mask is installed;
- scintillator screen;
- high sensitivity CCD camera Prosilica GC1380 for beam imaging;
- compressor with 7 atm maximum pressure for pneumatic actuator operation.

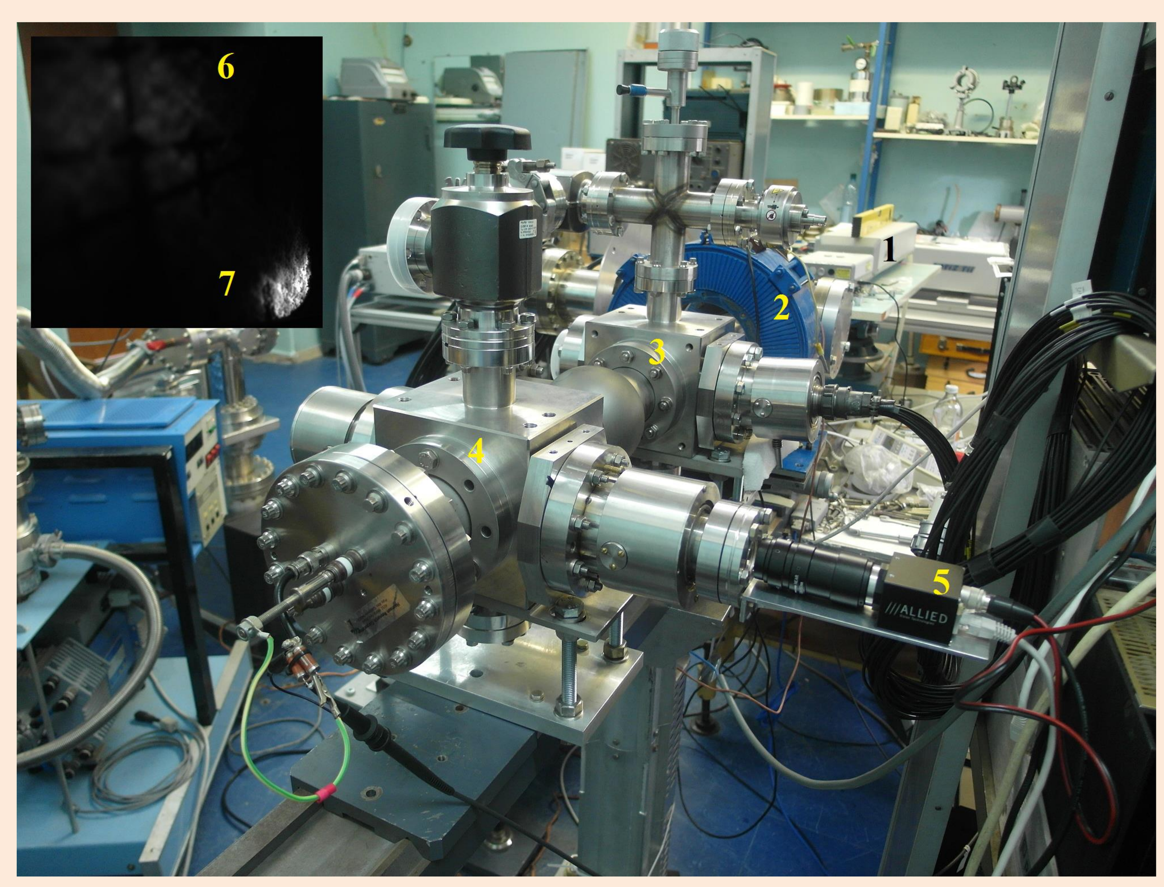
Software

Vimba Viewer	Own Software
	

AVINE Video Client (DESY developed)



Electron Beam: option 1 (obsolete)



1 — LS-2134 laser, 2 — focusing magnet, 3 — wire profilometer, 4 — box with scintillating screen, 5 — camera, 6 — laser beam, 7 — electron beam

Electron Beam: option 2 (current)

1 — LS-2134 laser, 2 — electron gun, 3 — focusing magnet, 4 — emittance measurement station, 5 — camera. The yellow arrow indicates the scintillating screen position.

Electron Beam: Laser Light Issue

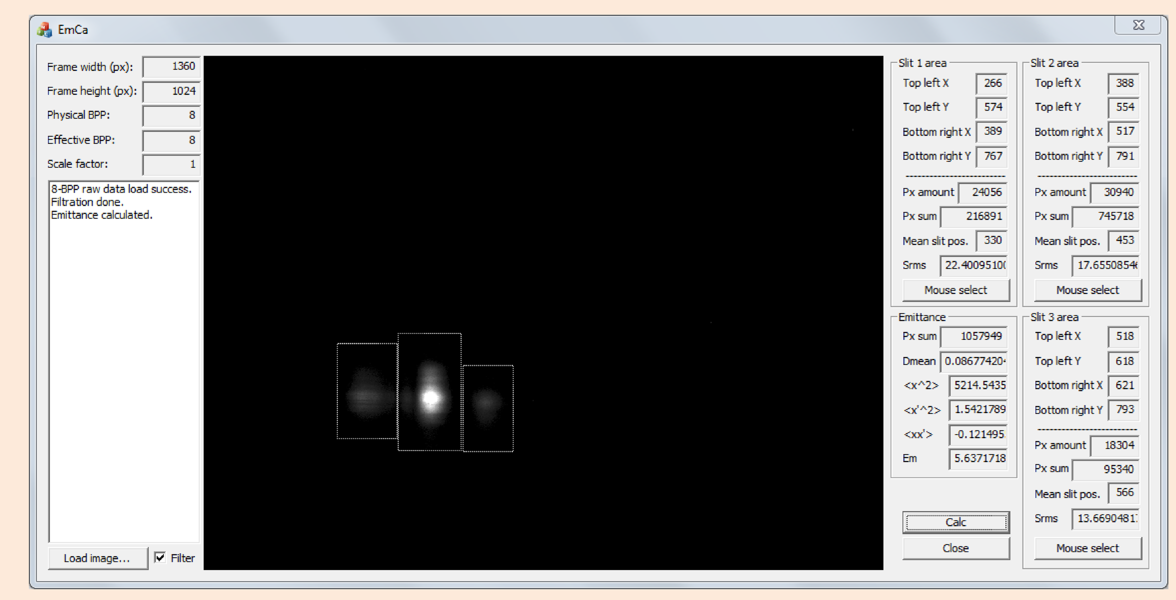
The main problem for electron beam imaging is the simultaneous laser beam at the scintillating screen, which also becomes a part of the video image. This issue is redoubled due to low electron energy. The separation of electron and laser beam is not possible in the current setup. The following mitigation scenarios are being considered:

- usage of different screen materials (i.e. YAG and P-22 phosphor);
- electron beam deflection with a dipole magnet;
- foil, transparent for electron beam and opaque for laser.

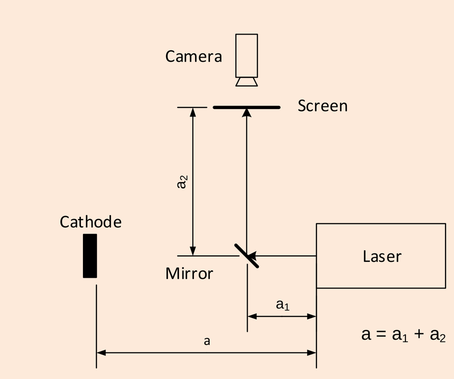
Electron Beam: Transverse Emittance

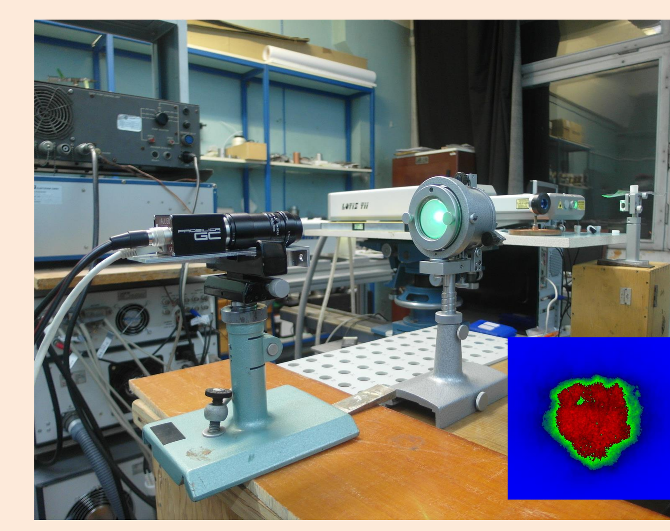
EmCa software was developed for emittance calculation out of images (sequences) previously saved with AVINE Video Client 3. Microsoft Visual Studio 2010 and C++ programming language were used. A formula derived from [Min Zhang, FERMILAB-TM-1988] is used for calculation.

$$\epsilon_x^2 \approx \frac{1}{N^2}\left\{\left[\sum_{j=1}^{p} n_j\left(x_{sj}-\bar{x}\right)^2\right]\left[\sum_{j=1}^{p}\left[n_j\sigma_{x'_j}^2+n_j\left(\overline{x'_j}-\overline{x'}\right)^2\right]\right]-\left[\sum_{j=1}^{p} n_j x_{sj}\overline{x'_j}-N\bar{x}\overline{x'}\right]^2\right\}$$

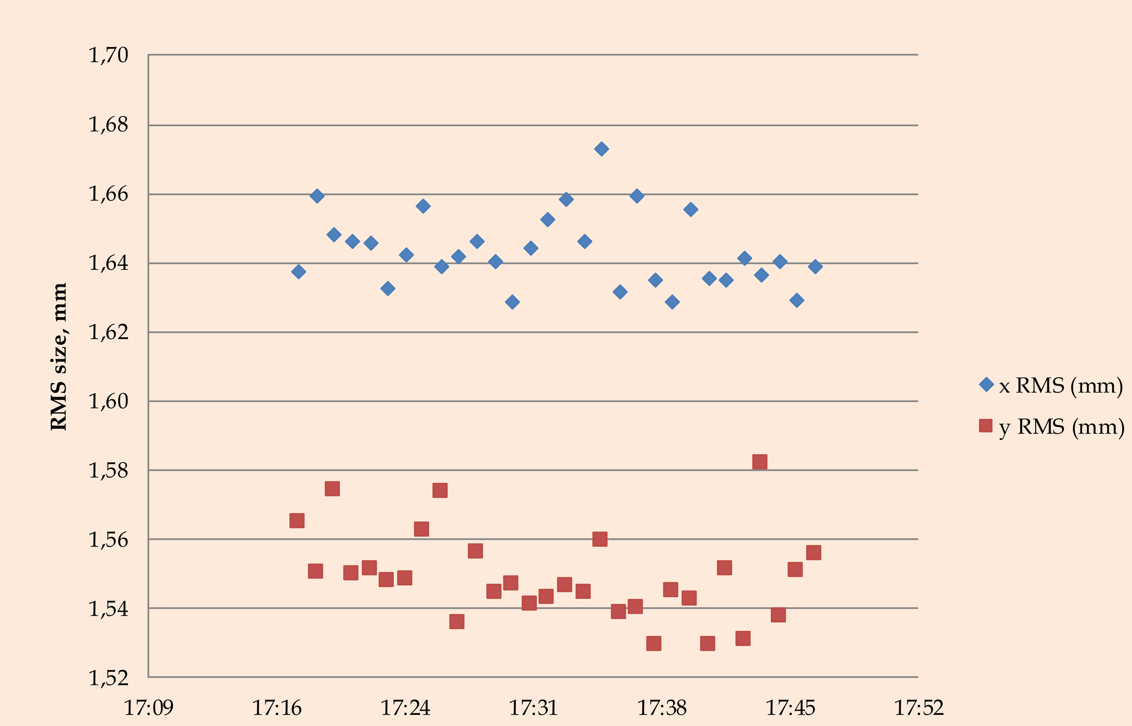


Laser Beam Diagnostics: Virtual Cathode

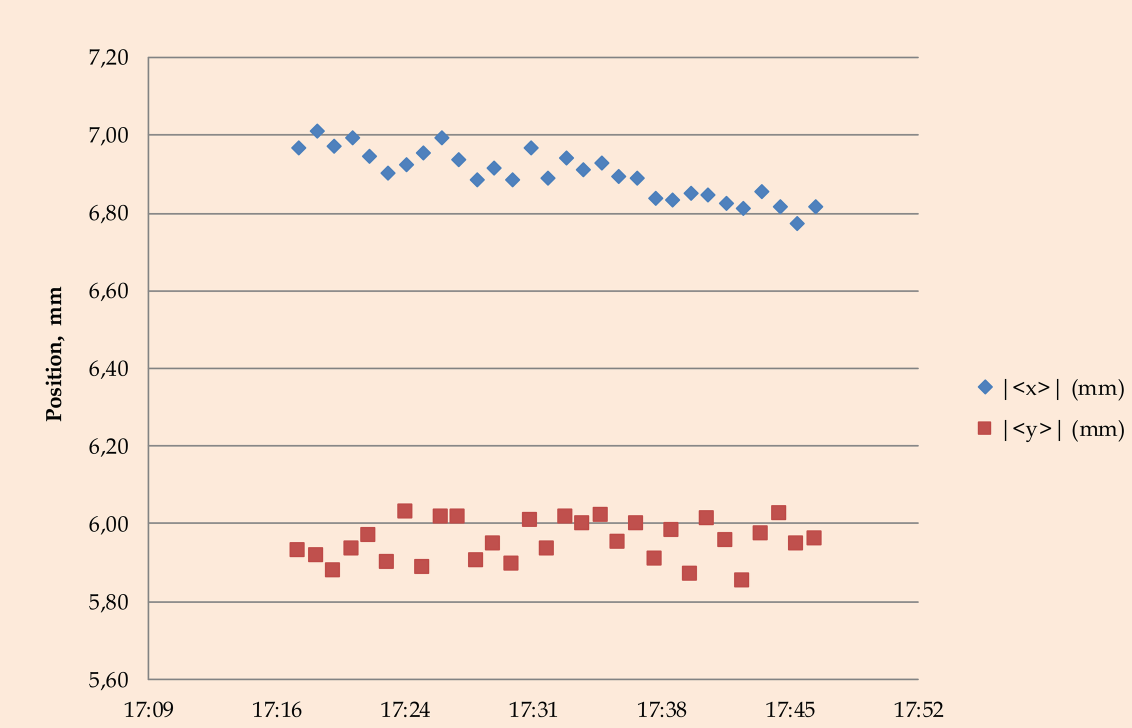




Laser Beam RMS Size Stability Measurement



Laser Beam Position Stability Measurement



Conclusion

Virtual cathode setup was realized at JINR LHEP photogun bench. Imaging is realized using the AVINE construction toolkit developed at DESY Zeuthen. Equipment for slit emittance measurement was installed; software for emittance calculation was developed and tested with laser. First priority issue is the separation of electron and laser beam at the screen using either a window being transparent for electron beam while being opaque for laser beam or a magnet-based electron beam deflection. Afterwards, realization of the 2-plane emittance measurement with the slit/pepper-pot method is foreseen.