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Measurement of the QE Map

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113 MHz SRF gun utilized CsK_2Sb and Na_2KSb cathodes, which were irradiated with a pulsed green laser with a wavelength of 0.53 microns. The drive laser generated 78 kHz pulses with an acousto-optic modulator selecting the desired number of pulses reaching the cathode. The operator can select the aperture size, defining the laser spot diameter on the cathode, and the power level, which is controlled by a rotating polarizer. The laser power reaching the cathode can be measured with a meter based on a photodiode.

The quantum efficiency (QE) of a photocathode serves as a primary indicator of its state. Small QE renders the cathode unusable when the desired bunch charge cannot be achieved. Strong variations in the quantum efficiency on the cathode surface might lead to the growth of the beam emittance due to the space charge effects.

We have created a routine to measure the distribution of the QE on the cathode. The operator selects the aperture size, the central spot location, and the scan ranges for both planes. The scan starts from the central spots and proceeds along a spiral-like trajectory, making N rounds. The number of rounds can be chosen, and the total number of measured points is $(2N+1)^2$. The laser spot movement is shown in Fig. 1.

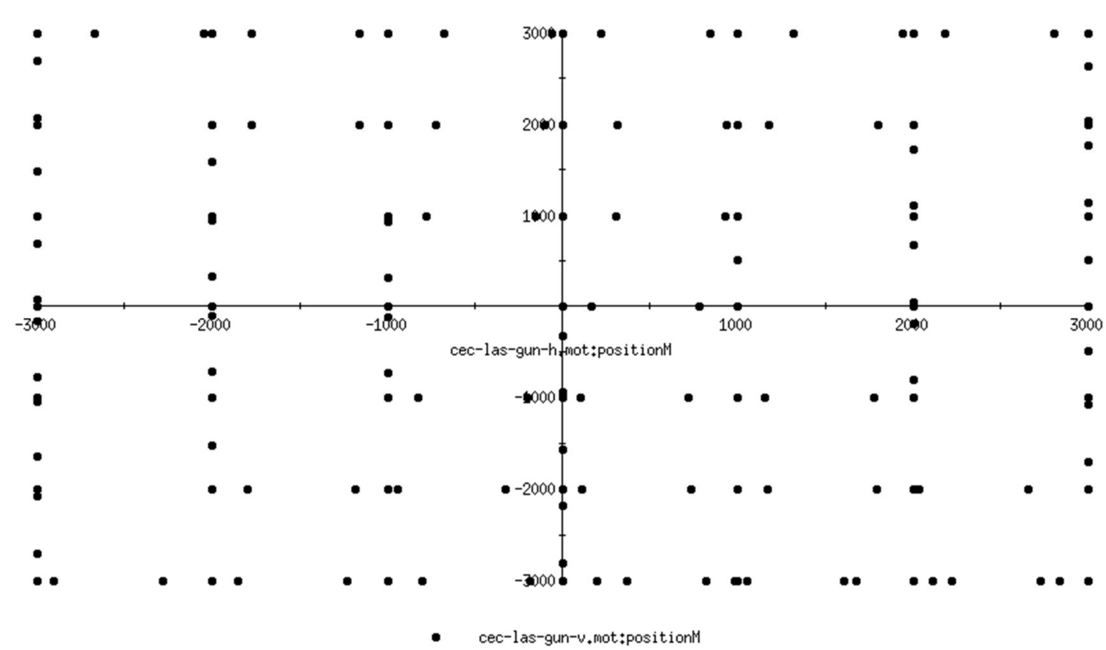

Figure 1: Readings of the laser spot position during QE scan.

Before the scan, the mirror reflecting the laser beam towards the power meter is inserted, and the laser is turned to CW mode (78 kHz pulses). The power is measured, and based on the repetition rate, the laser pulse energy is calculated. We assume constant laser pulse energy during the scan. The number of photons per pulse is found from the photon energy (2.39 eV in our case). The CW mode is switched off, and the mirror is retracted. If laser power meter is not functional (discharged battery) QE map cannot be measured. To reduce errors data can be averaged over the specified number of readings. Upon completion of the scan the data can be saved to file. The application window is shown in Fig. 2.

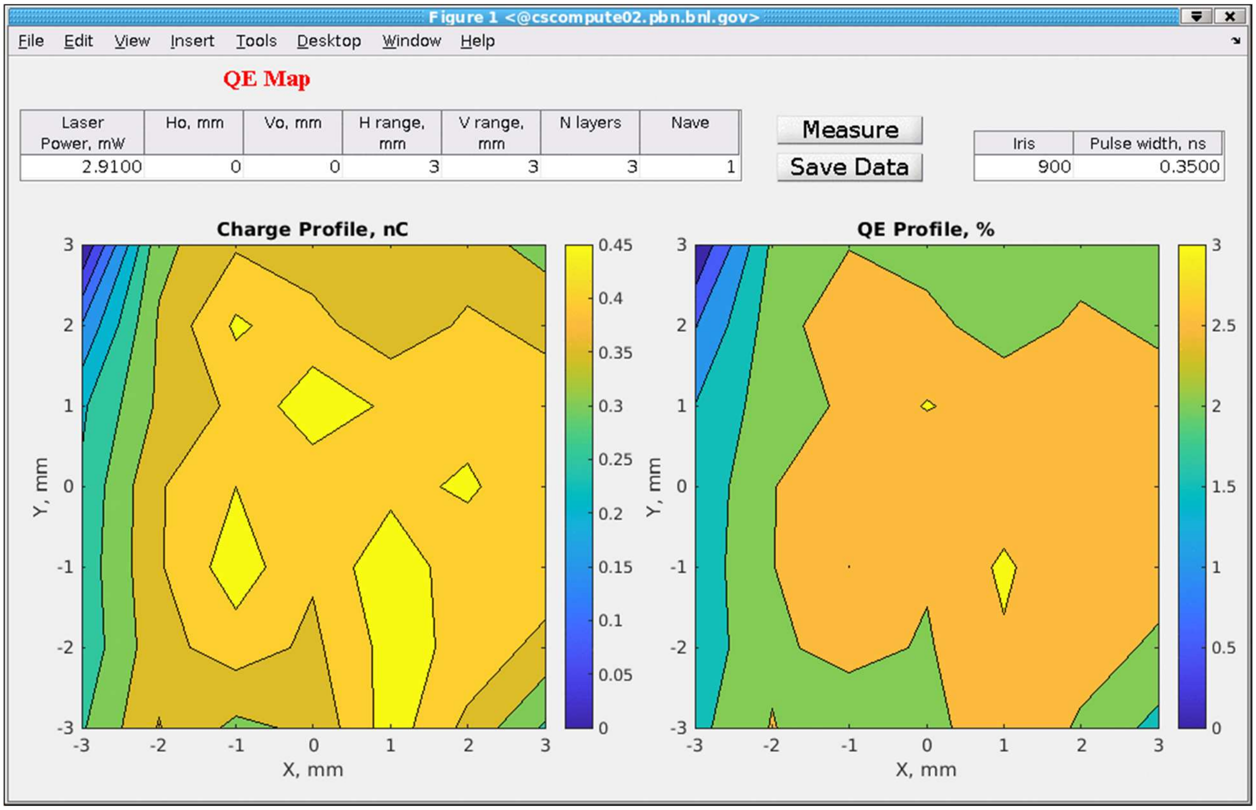

Figure 2: The screenshot of the MATLAB application for the QE map measurement. On the left graph the map of the measured charges is shown to verify that there was no charge saturation. The QE map is shown on the right graph.

For the detailed QE map the aperture defining laser spot size should be reduced to minimum. This can create situation when the bunch charge will be below detection level by the integrating current transformer and/or noise will be too high. As it was mentioned before the laser power was assumed no changing during the measurements which generally is not true and might lead to the errors in the QE value. To overcome such drawbacks another method was developed. Both bunch charge and laser energy were characterized by the brightness of the image. For the electron beam image was observed on the first profile monitor after the gun. The laser energy was measured using camera monitoring laser spot near the gun, which utilizes the partial transmission of the mirror. In principle both measurements can be calibrated but we did not do it, and the QE map is displayed in arbitrary units and can be used only as indicator of the QE evenness. If the images are too dim the exposure time and number of pulses can be increased. The screenshot of the application is shown in Fig. 3.

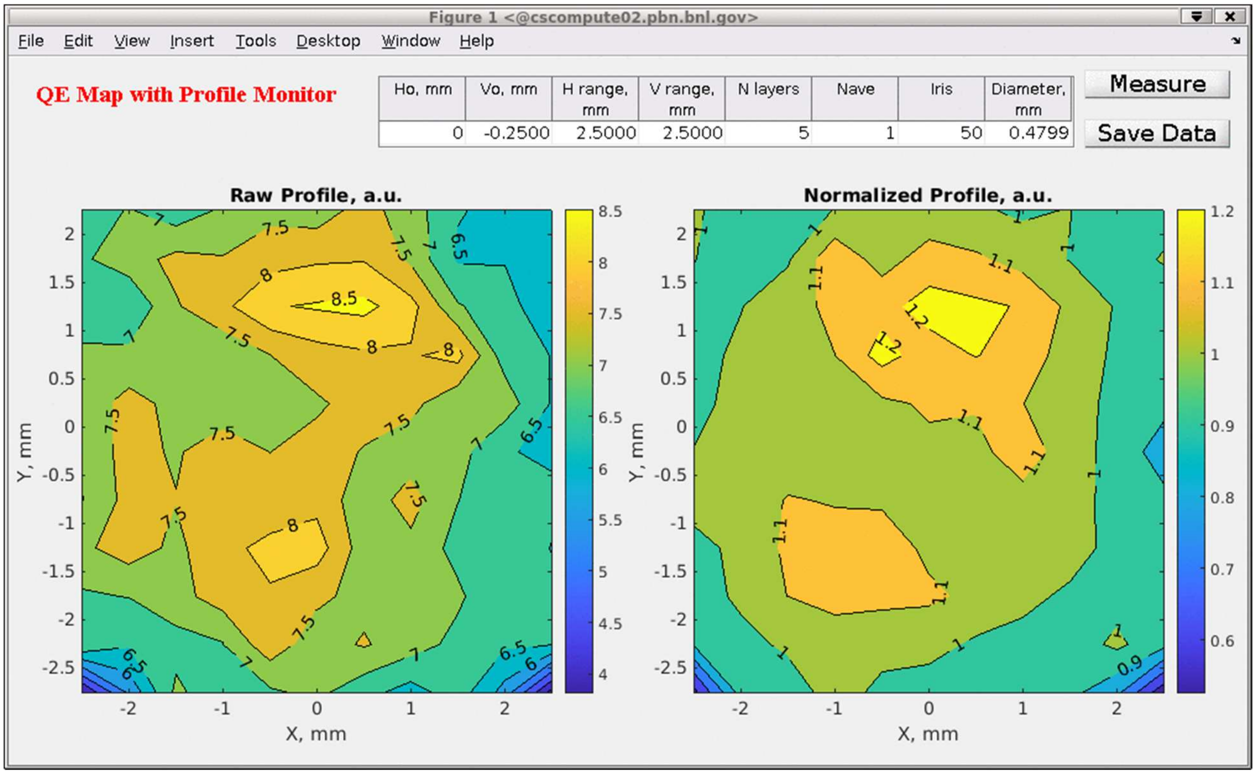

Figure 3: Screenshot of the application for the QE map measurement based on the images of the electron and laser beams. The raw profile on the left side shows brightness of the spot on the electron profile monitor. On the right side it is normalized on the laser spot brightness and shows more uniformity.

The electron beam moves in the similar manner as laser spot and can be used for studying multipole fields between the gun and profile monitor. The position readings of the electron beam on the profile monitor are shown on the Fig. 4. The round corners at the bottom and in the upper right corner are caused by the limits of the YAG screen. Some nonlinearities are visible in the upper left corner and might be caused by the spherical aberrations of the solenoid. The image is slanted due to the rotation of the plane of motion by solenoid.

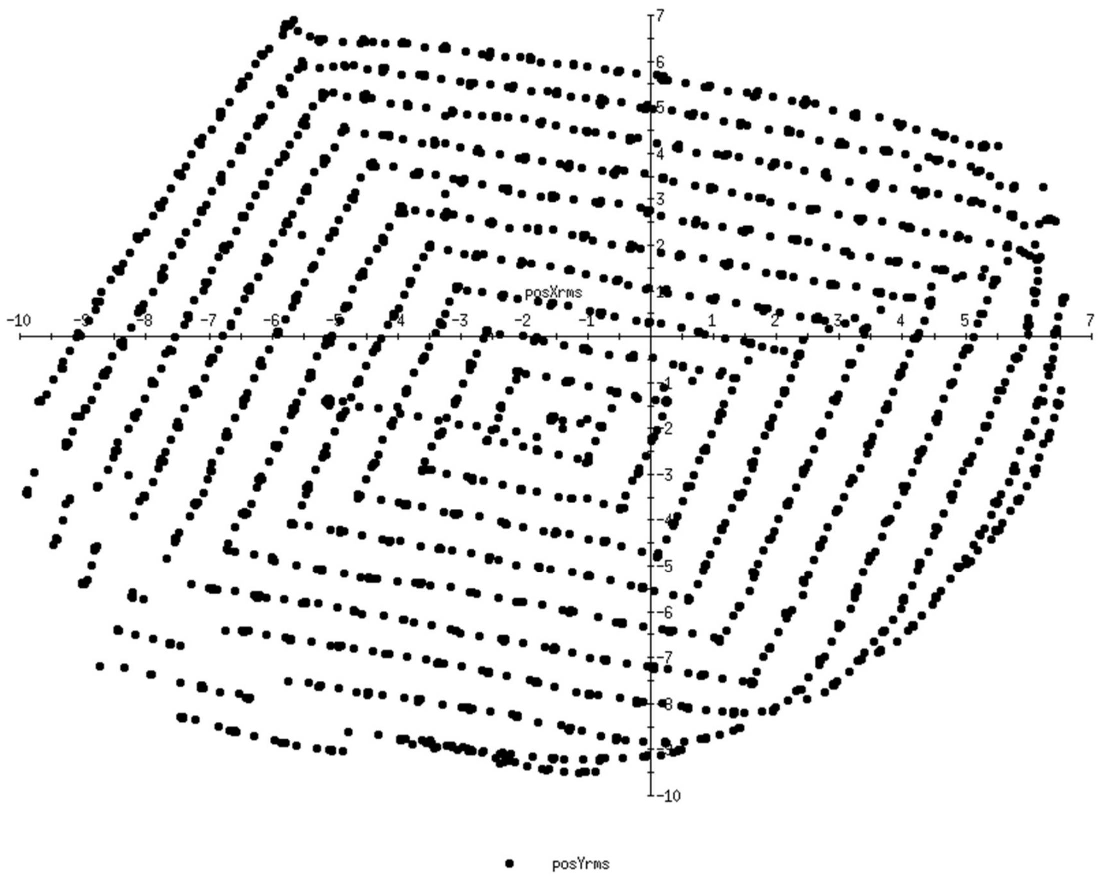

Figure 4: The readings of the electron beam position on the profile monitor during the QE map measurement.