

# JLAB FEL DC Photoemission guns

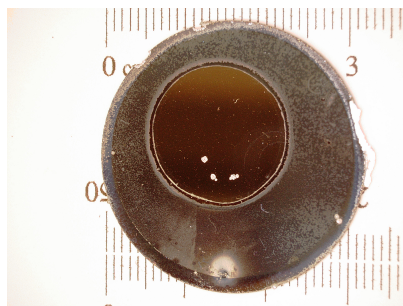
Carlos Hernandez-Garcia  
for the FEL team  
ERL 2009

(DISTRIBUTION STATE A)

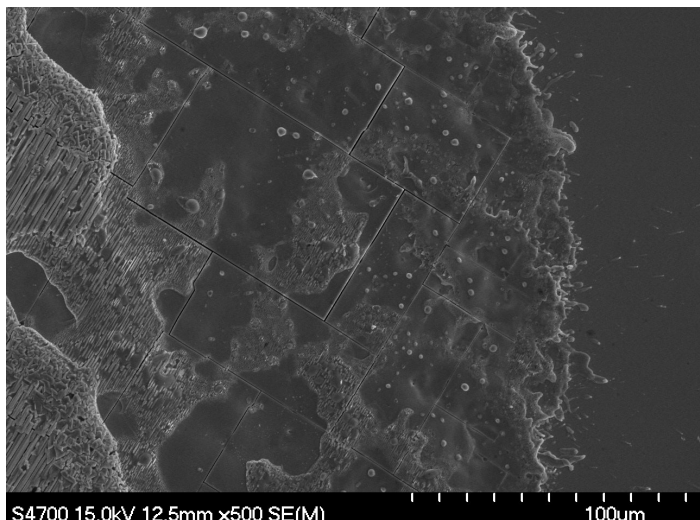
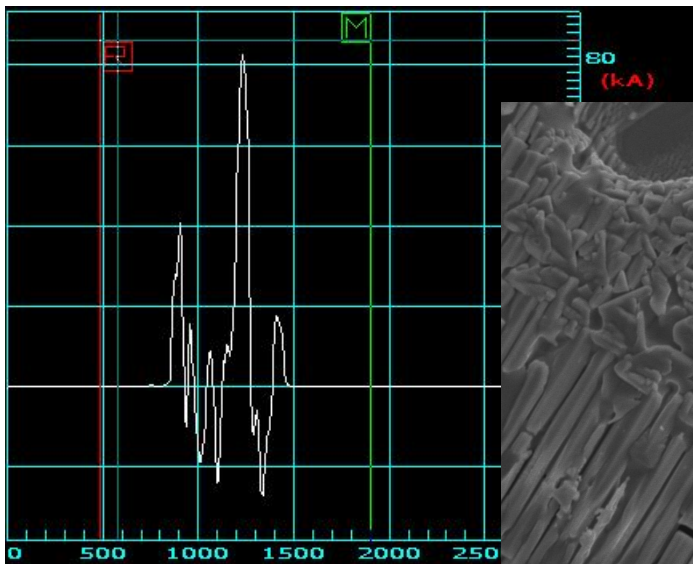
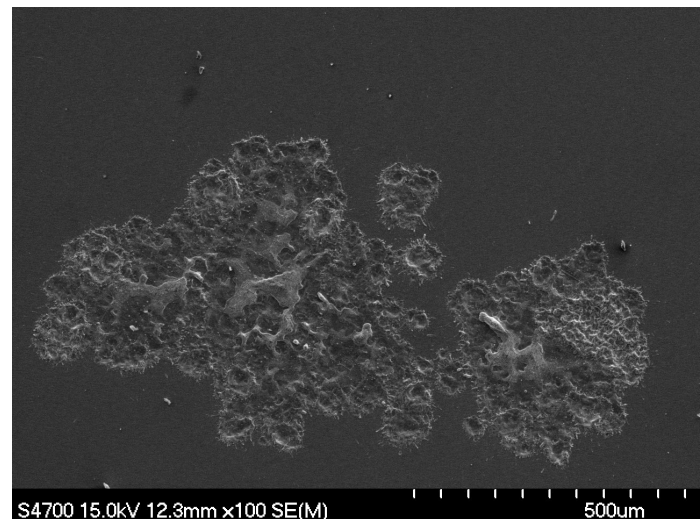
# The used and abused 7000 Coulomb cathode



Ready for installation

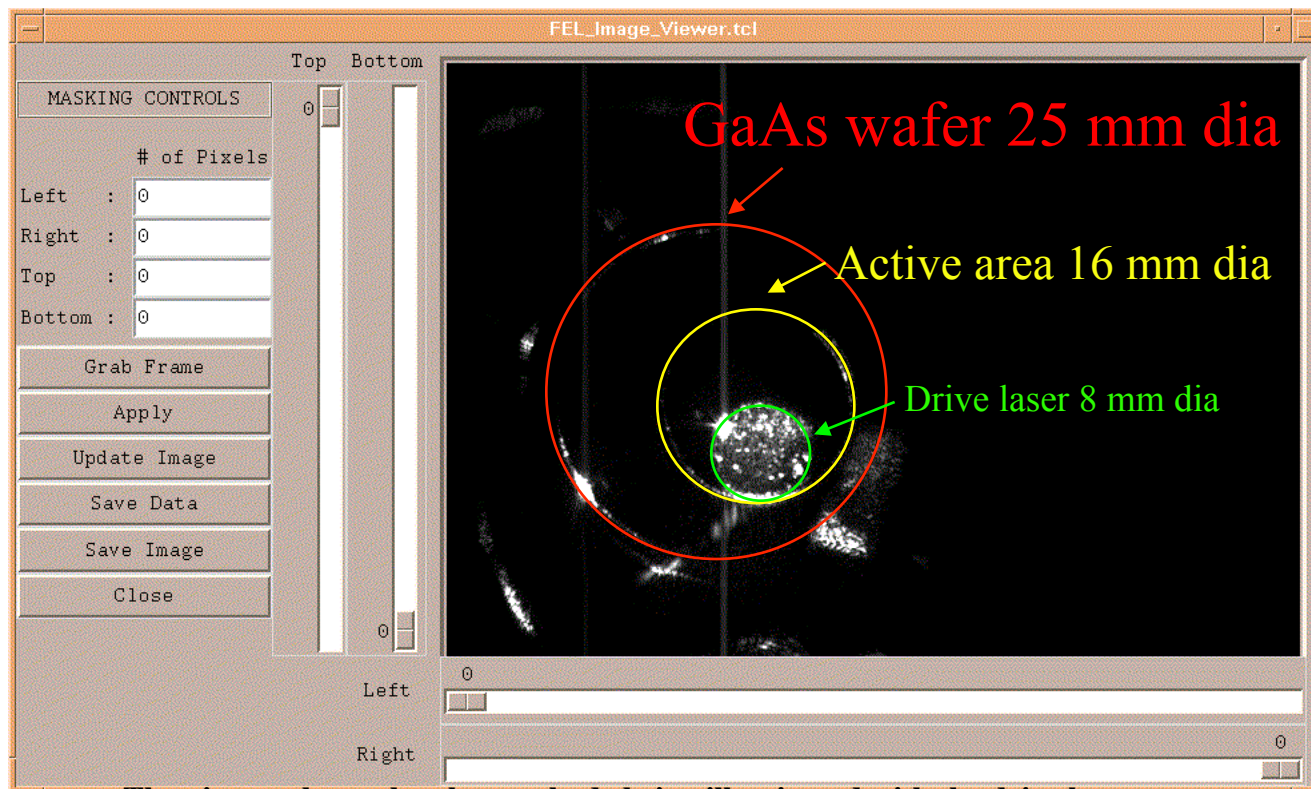


After 3 years in the gun  
delivering 900 hours of  
cw beam time



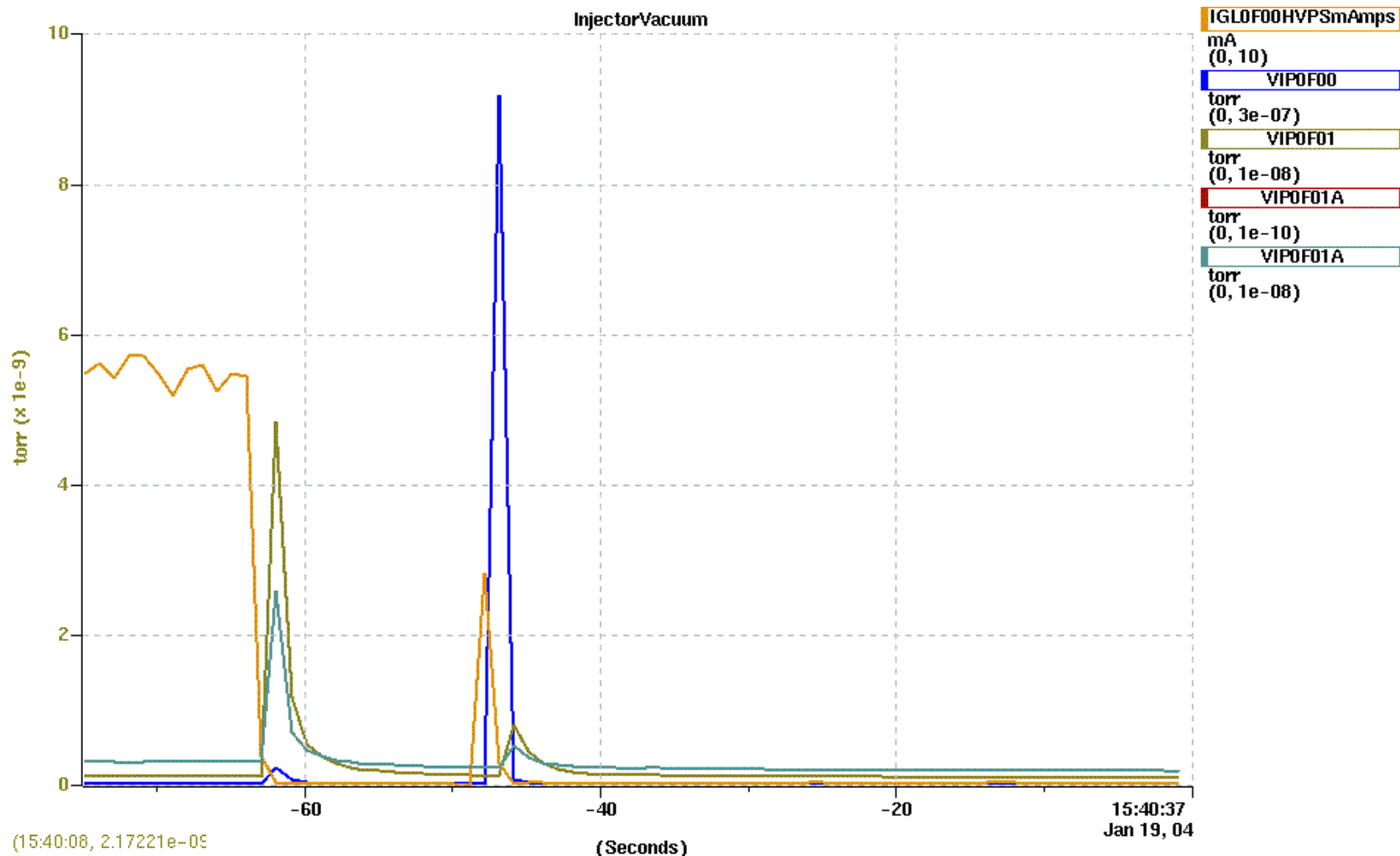
8- $\mu$ m peak on damage spot

**The FEL gun delivered over 7000 Coulombs and over 900 hours of beam time at 1-8.5 mA CW with a single wafer, which was activated into a photocathode a total of 9 times in 36 months of operation with an average of 6 re-cesiations per activation**



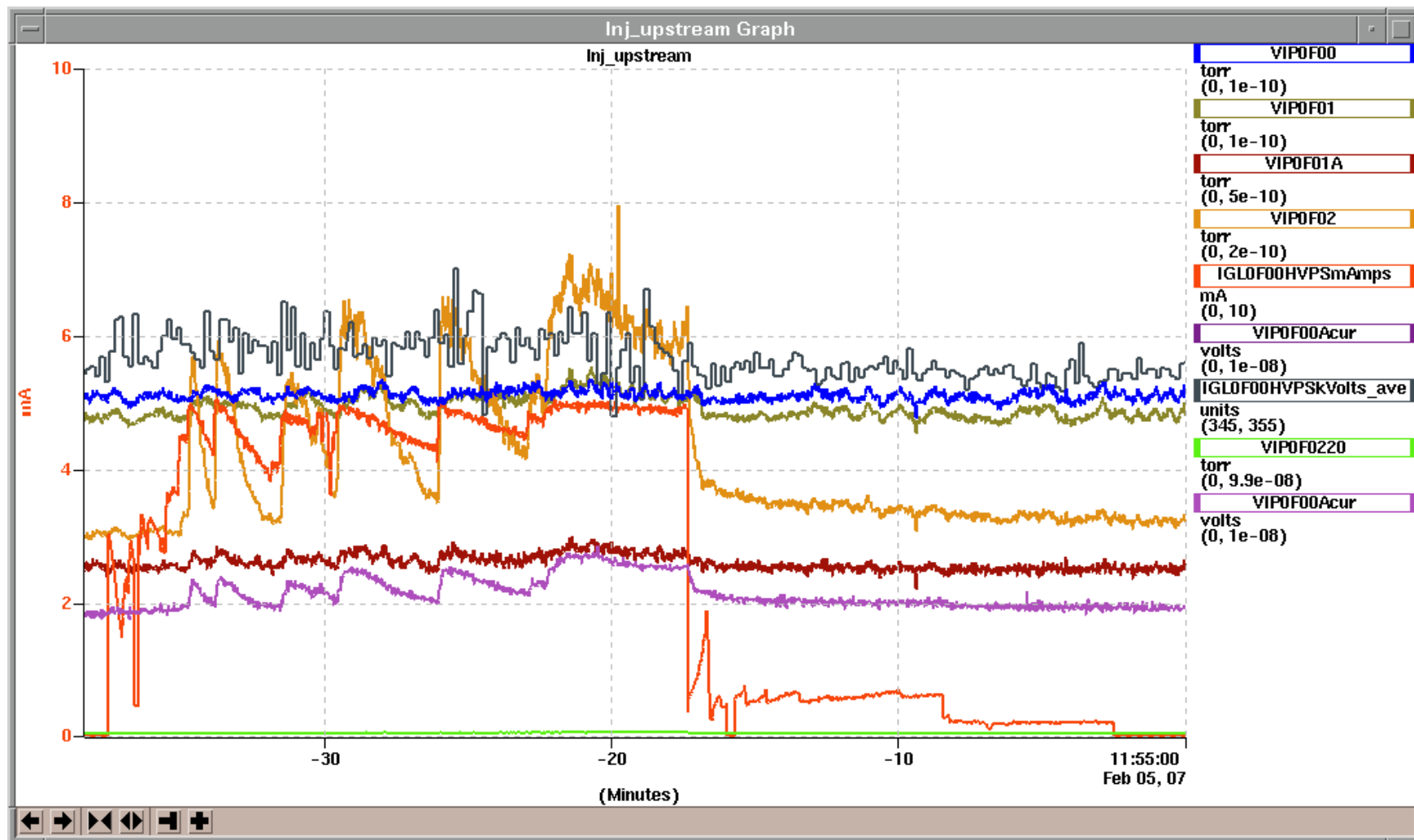
The picture shows the photocathode being illuminated with the drive laser

# At least 3 mA of current at 350kV during the cathode 'arcing'

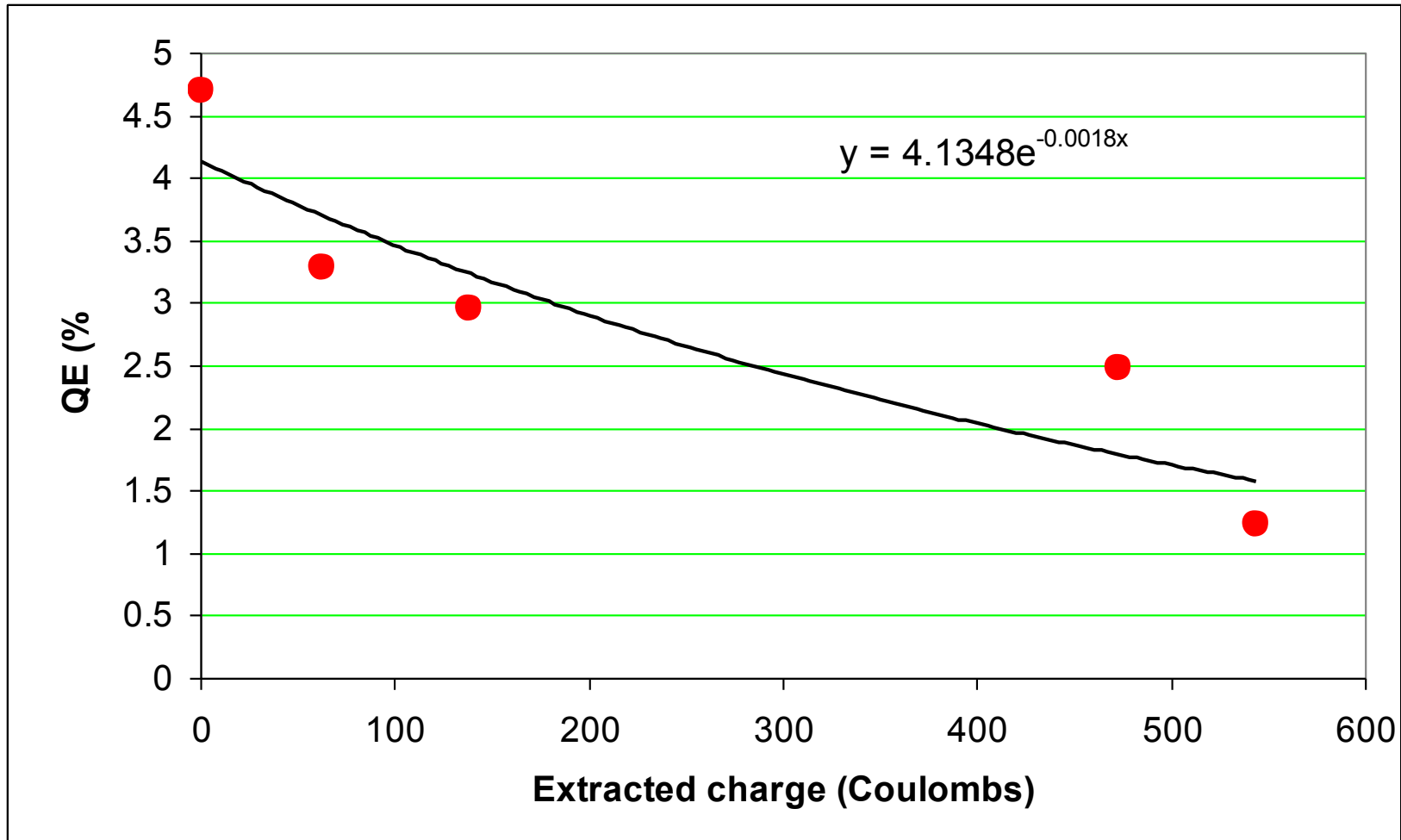




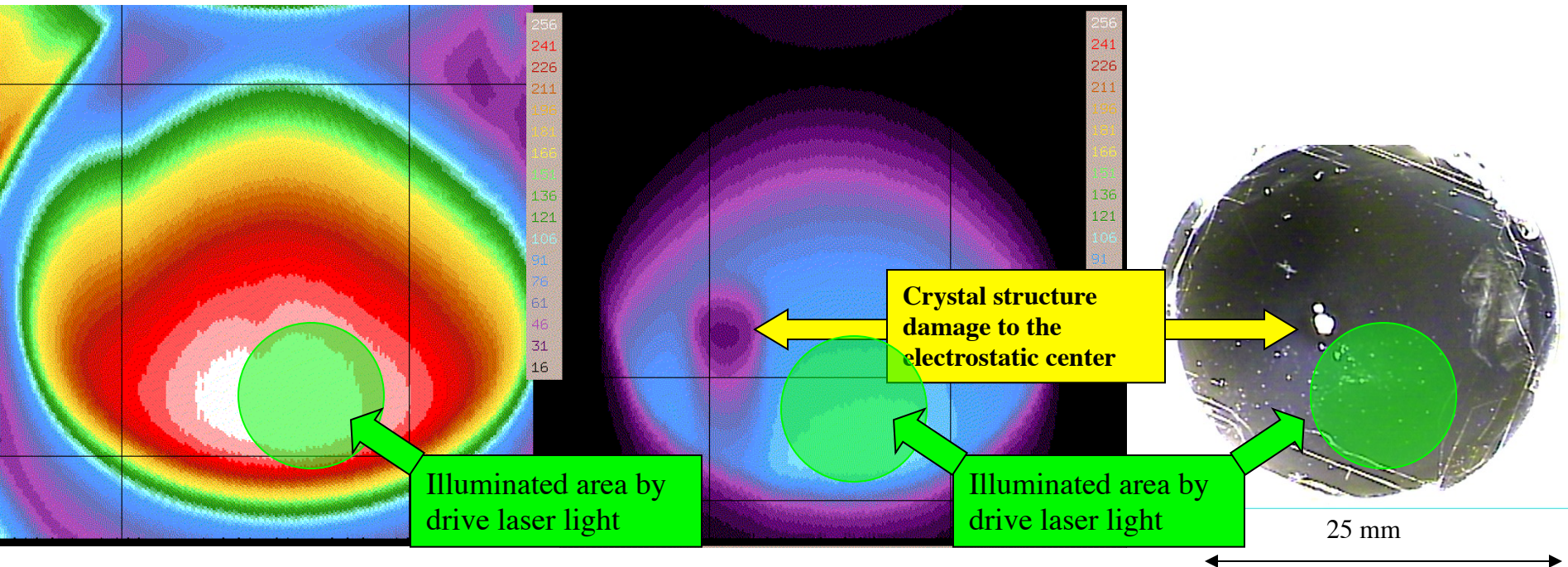
# Gun vacuum during 5 mA CW run



# The best FEL 1/e photocathode lifetime was 550 Coulombs or ~ 30 hr. at 5 mA CW



# The positive ions are accelerated by the electrostatic field impacting on the wafer surface degrading the quantum efficiency and causing crystal structure damage

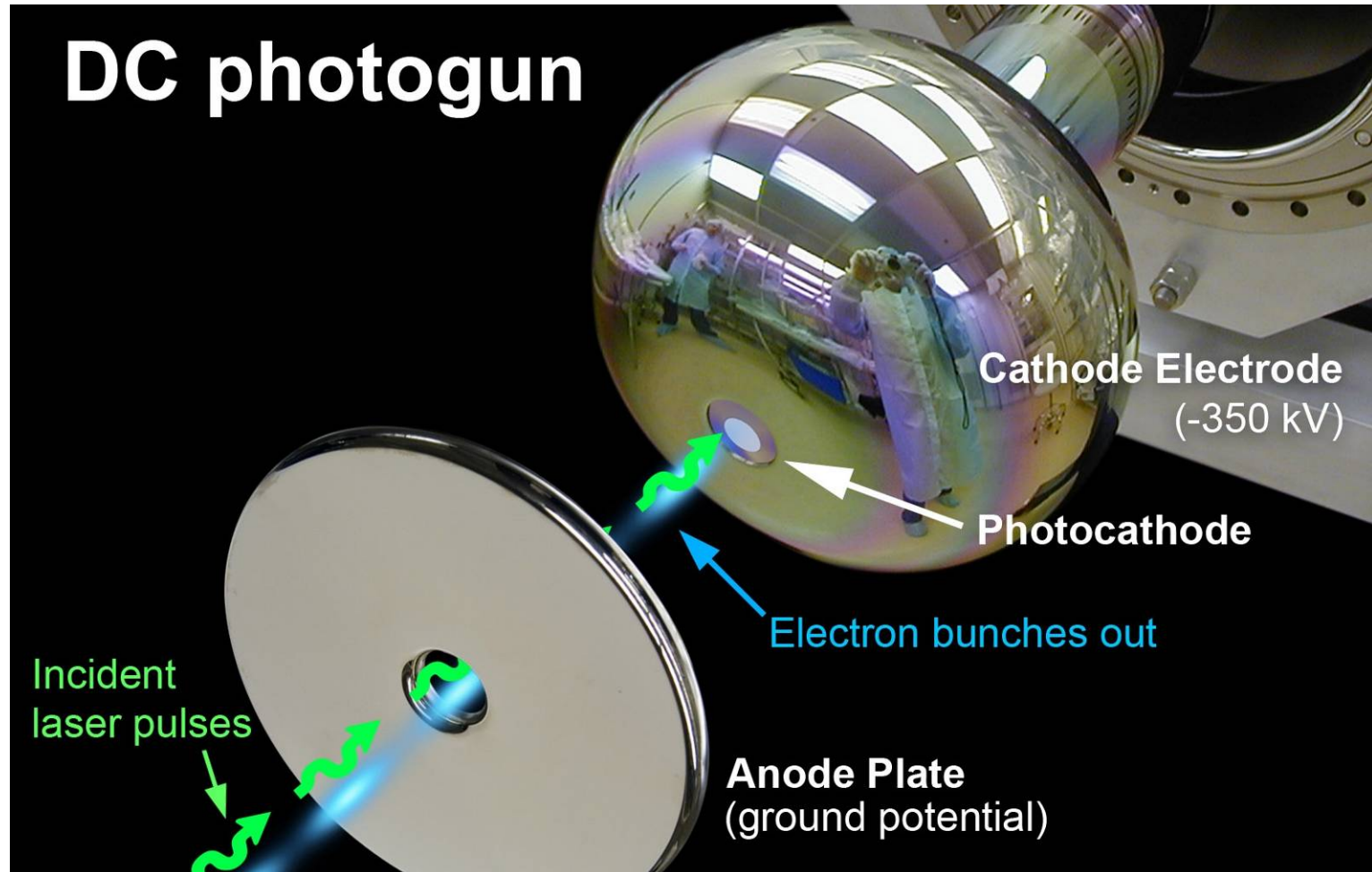


The Quantum Efficiency of a recently activate photocathode is around 5-7%

The Quantum Efficiency of an used photocathode drops to about 1%

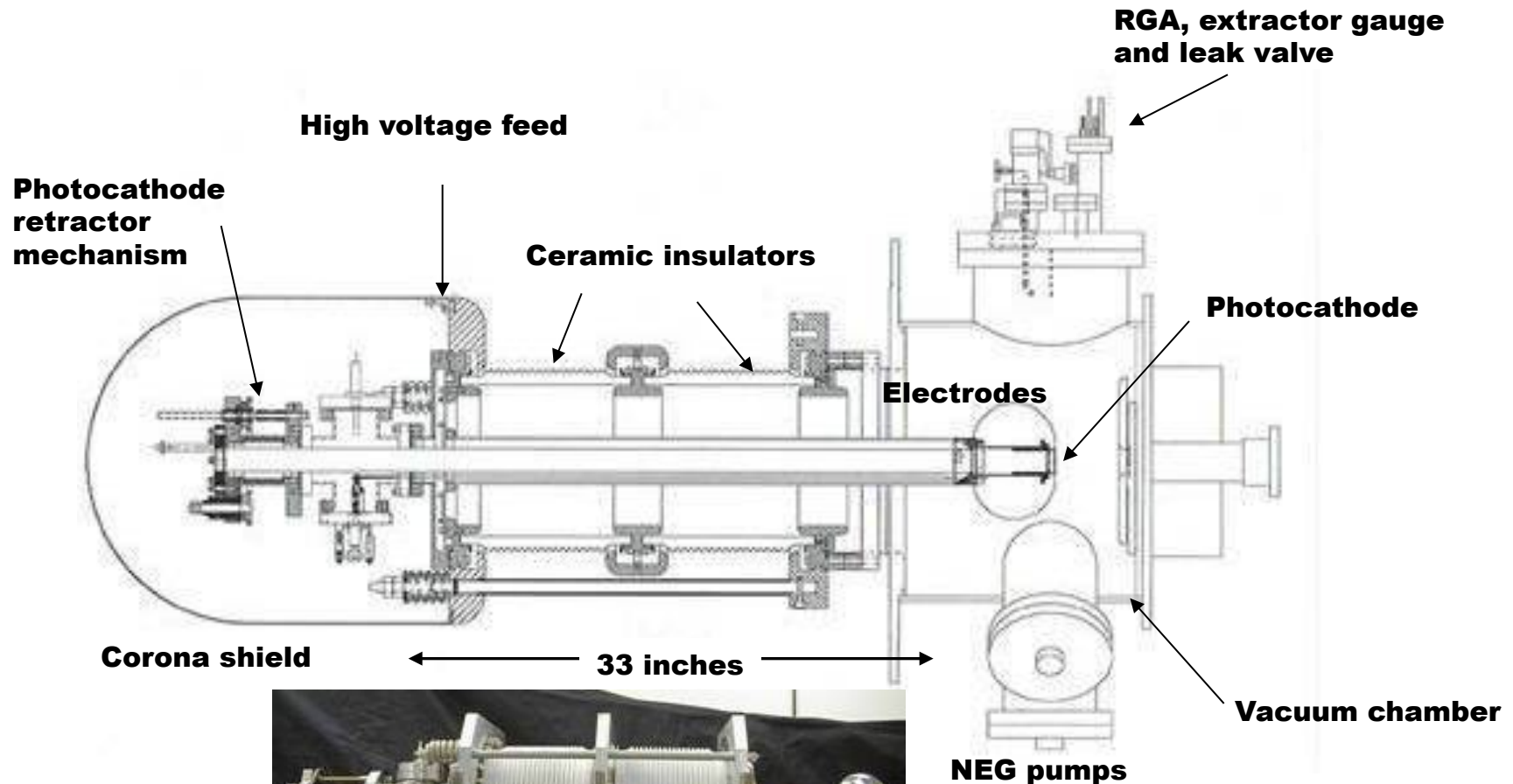
Picture of a damaged GaAs wafer after delivering over 8 mA of average current during one year of operation

The NEA GaAs wafer is illuminated with 532 nm, 50 ps FWHM laser pulses to generate 135 pC bunches



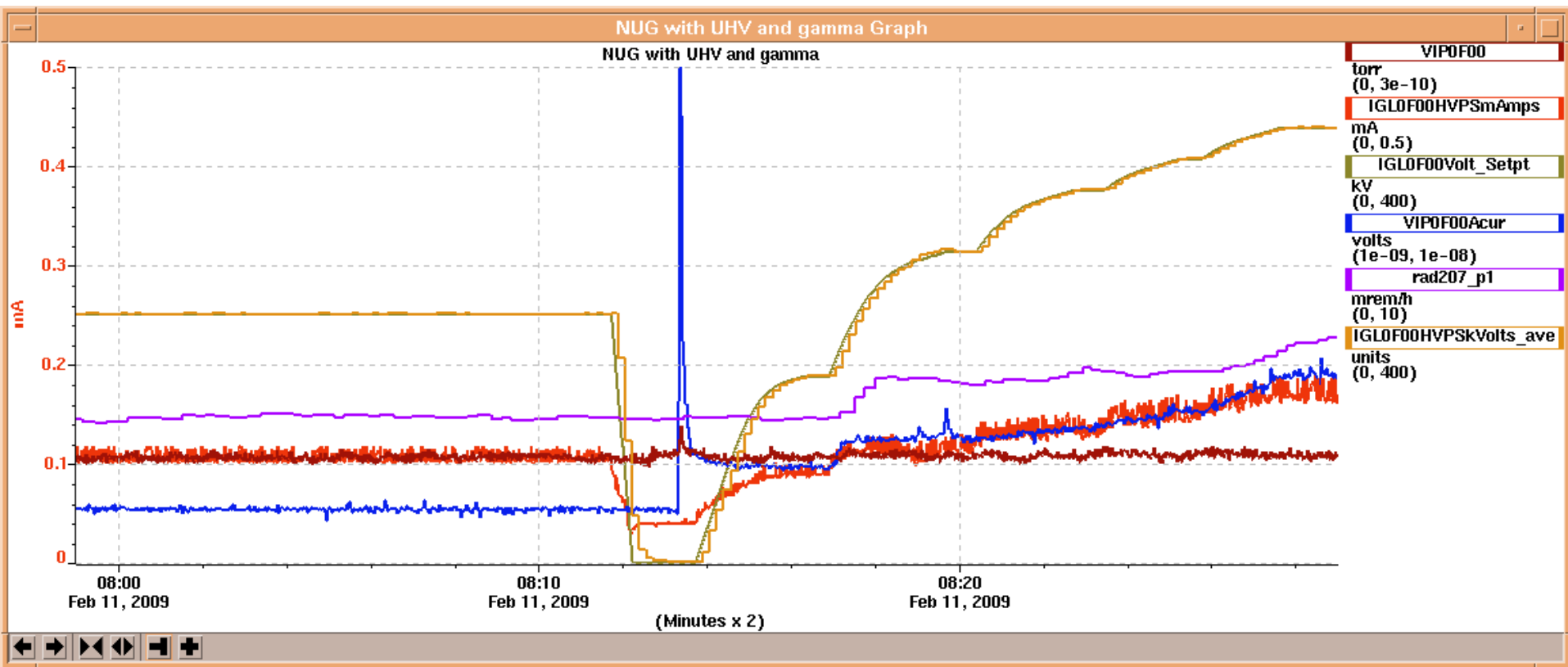


The DC gun consists of electrodes that hold the photocathode inside a vacuum chamber. The electrodes are electrically isolated by ceramic insulators

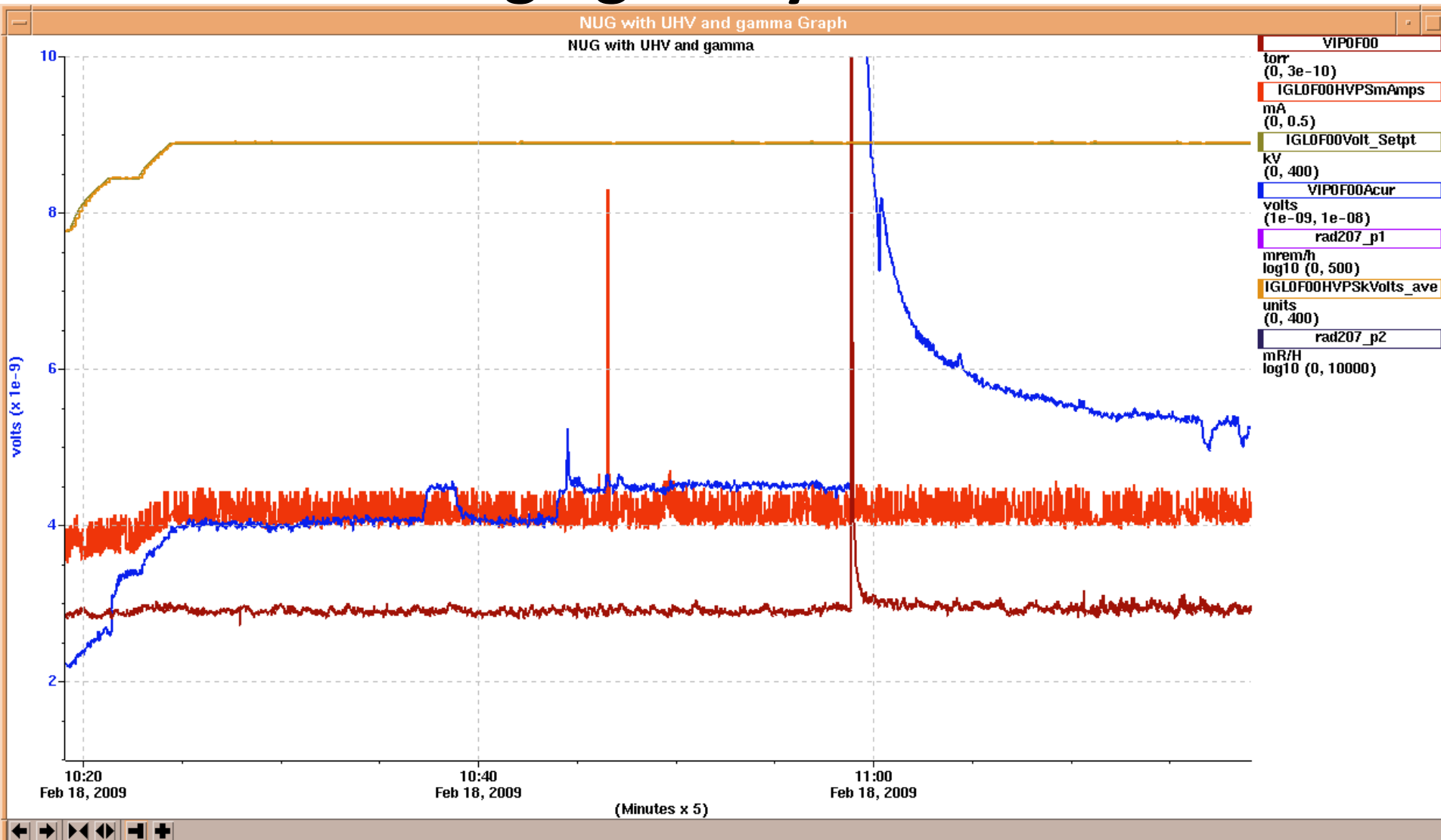


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# Gun vacuum degrades with voltage due to field emitter



# The field emitter induces ceramic charging, discharging every 45 minutes



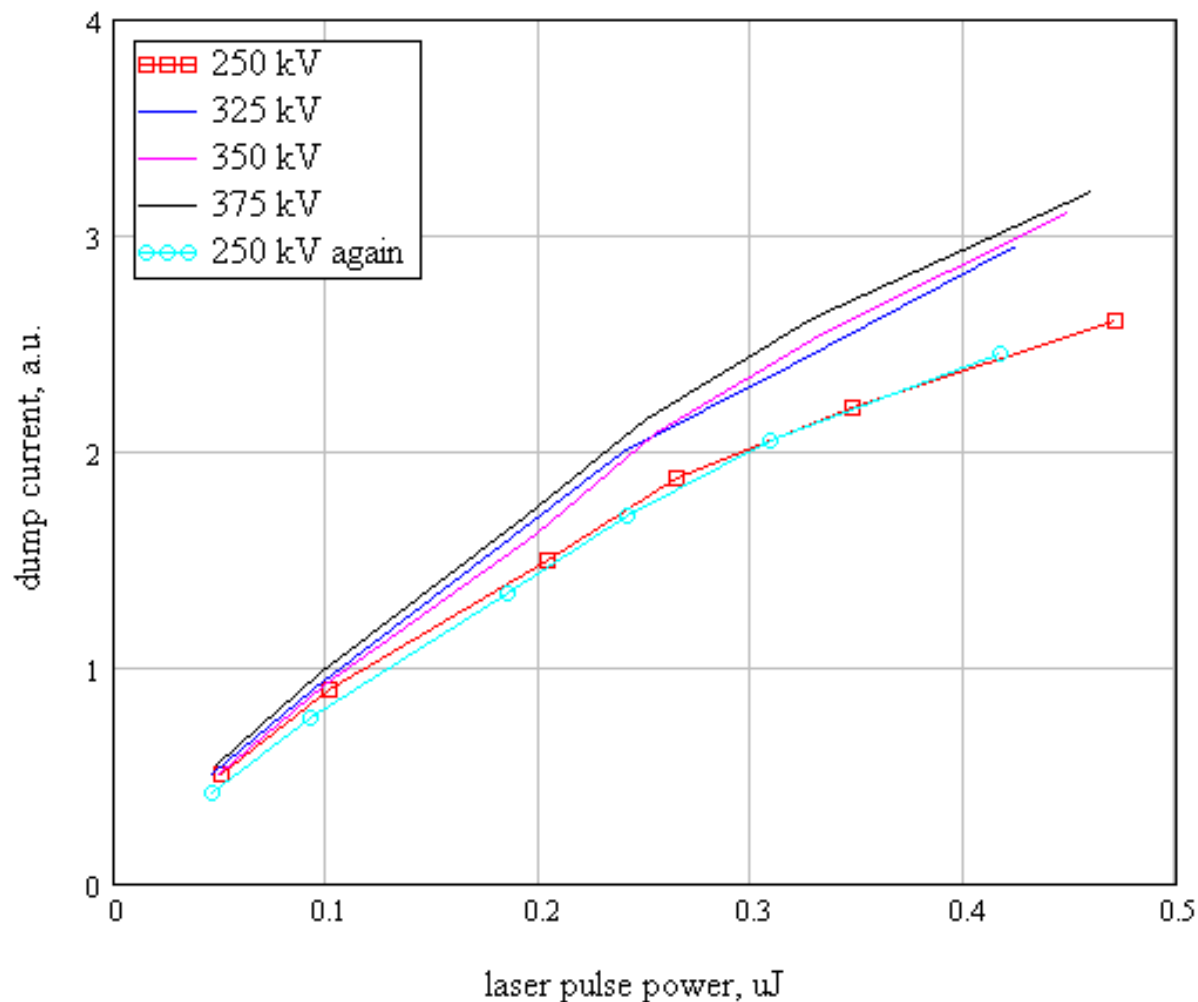
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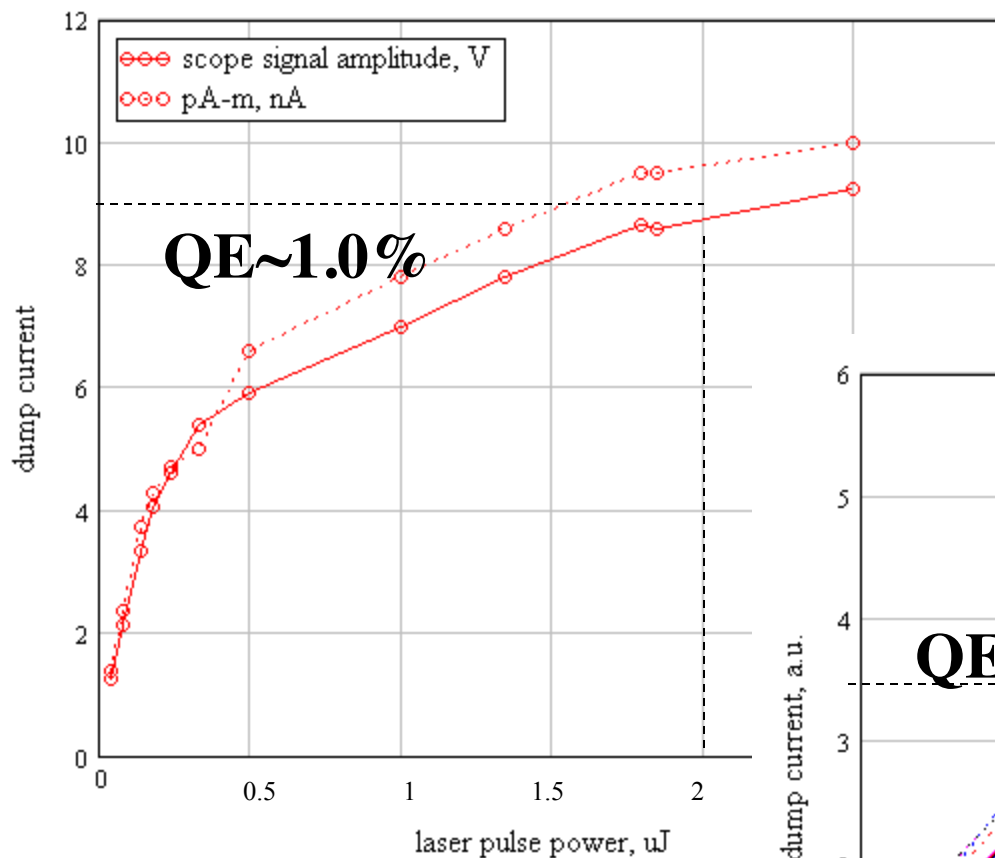
# Is it space charge limit, $I=KV^{3/2}$ ?

## No, there is no voltage

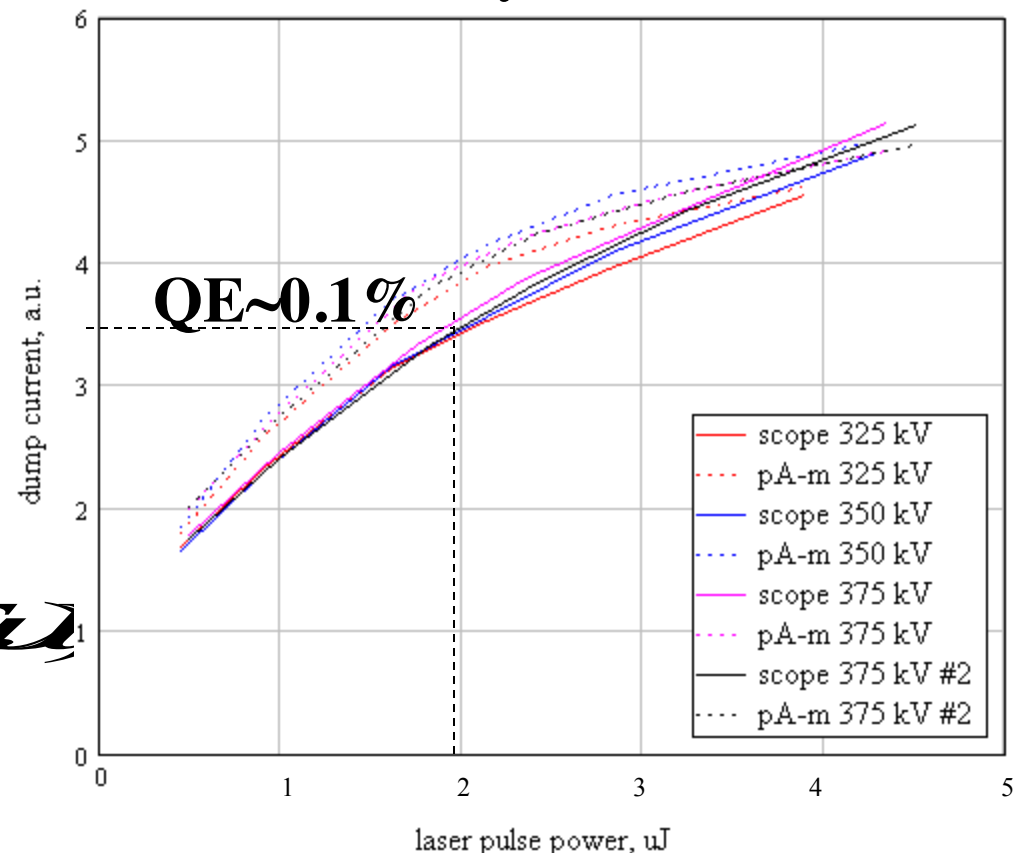




# But it might be Surface Charge Limit



When the photocathode is excited with high densities of light (near the bandgap), the total photoemitted charge is **not proportional to the light intensity**



$$QE = \frac{Q_{P/A}}{124 \cdot I_{L/A}}$$