Lifetime of Cs_2Te Cathodes Operated at the FLASH Facility

FLASH
Free-Electron Laser in Hamburg

FLASH – The Free-Electron Laser at DESY, Hamburg, Germany
flash.desy.de

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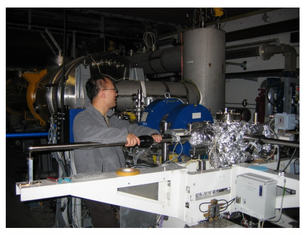
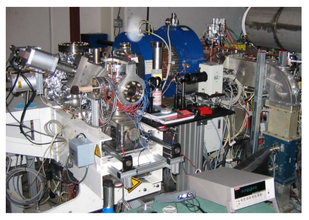
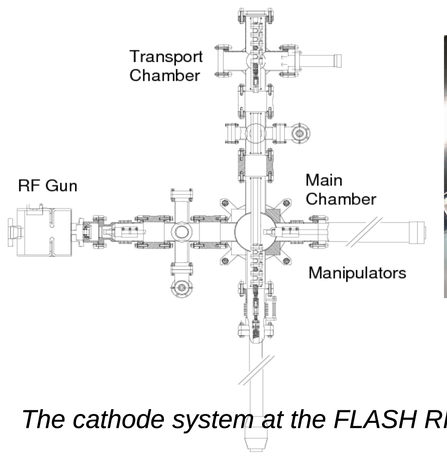
Summary

- The photoinjector of FLASH uses Cs_2Te photocathodes.
- Since 2005, FLASH is operating as a user facility (>7500 h per year)
- Cathodes are prepared at LASA, Milano, Italy and DESY (DESY cathode numbers start with 6xx)
- Recently, cathode 618.3 has been used during regular FLASH operation for a **record of 439 days at a good QE of ~3 %** with a total charge of 3.2 C extracted
- The present cathode 73.3 is in for 6 months now



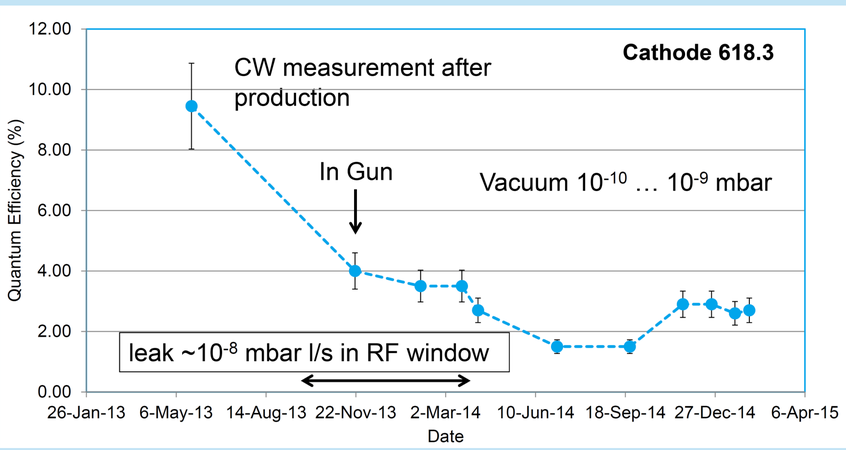




The cathode system at the FLASH RF-gun.

Cathode plug extracted from the carrier.

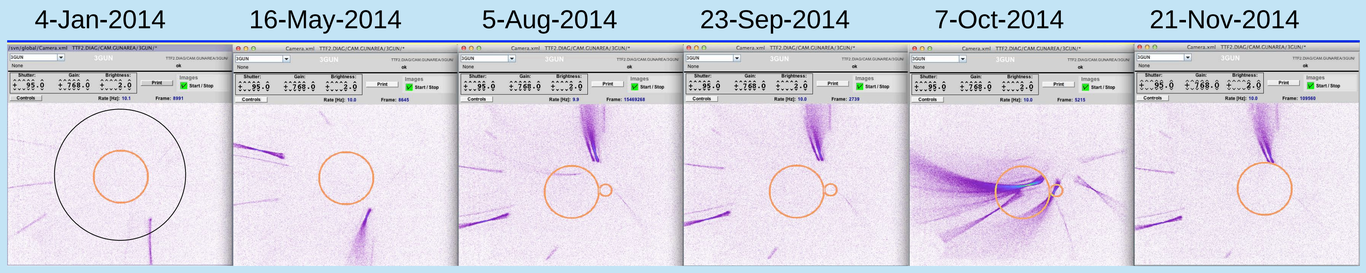
Lifetime



Operational lifetime of Cs_2Te cathode 618.3 at FLASH.

- Cathode 618.3: in use at FLASH 21-Nov-2013 to 4-Feb-2015
- These are 439 days of FLASH operation (>7500 h per year)
- Total charge extracted: 3.2 C
- QE dropped to 3 % due to a small vacuum leak at the RF window discovered and repaired April 2014
- Further drop probably due to conditioning of the new RF window to <2%
- Recovered later to 3% when vacuum condition became excellent again (<10^{-10} mbar)

Darkcurrent

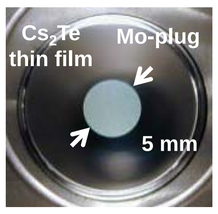


Darkcurrent with cathode 618.3 measured with a Ce:YAG powder screen 1.6 m downstream the cathode. The image from Oct. 2014 is with cathode 619.3.The red circle indicates the position of the Cs_2Te film, the black circle the rim of the cathode. Some emitters disappear, other show up.

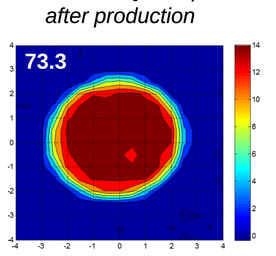
- L-band RF gun (1.3 GHz), dry ice cleaned, vacuum pressure < 10^{-10} mbar
- Fwd power 4.8 MW, 500 µs RF pulse length → max. gradient at cathode 52 MV/m, beam momentum 5.6 MeV/c
- Cathode 618.3: very small darkcurrent of 5 µA, measured at gun exit
- To reduce activation of beamline components and also the cryogenic load, a darkcurrent kicker close to the gun dumps most of the darkcurrent into a collimator
- Emitters appear partly at the rim of the thin film, partly at the rim of the plug or gun backplane
- Darkcurrent is constant with time, with one exception of a stronger emitter appearing and shortly disappearing again

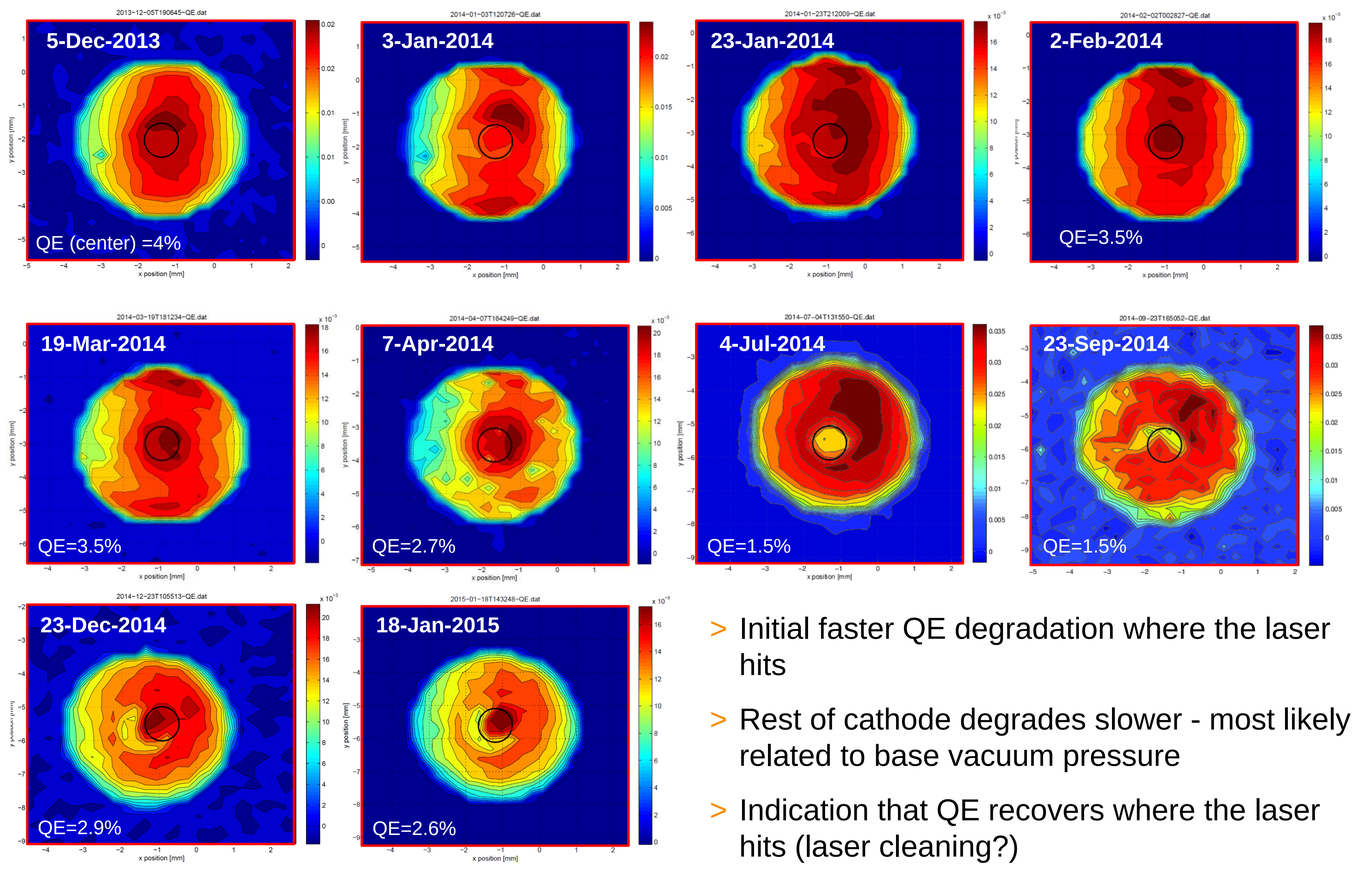
QE map evolution

- Cathode 618.3
- QE map with laser spot size 100 µm diam., step size 85 µm



Initial cw QE map after production



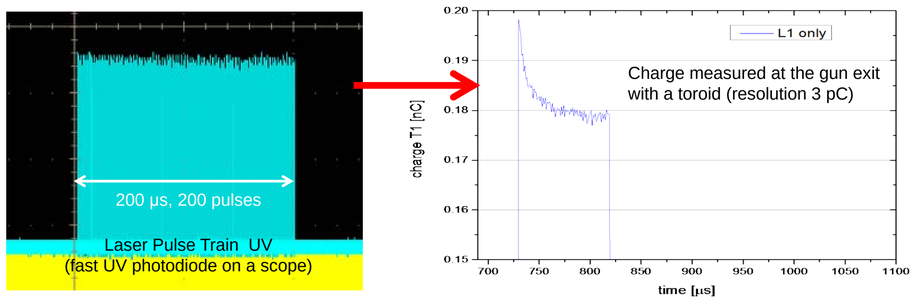


Note: the color code does not show absolute QE's, see scale

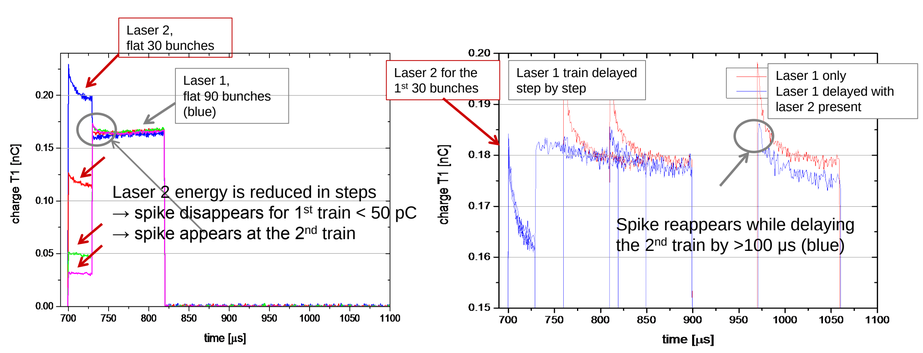
- Initial faster QE degradation where the laser hits
- Rest of cathode degrades slower - most likely related to base vacuum pressure
- Indication that QE recovers where the laser hits (laser cleaning?)

Emission issue of fresh cathode 73.3

- QE after preparation 12.4%
- Fresh in the gun 4-Feb-2015 QE=10%



- A flat energy distribution of the laser pulse train produces a 'spike' at the head of the electron bunch train emitted from a fresh cathode – that's not what one wants to have



- The spike is not produced by a spike in the laser train
- It originates from the cathode, for a field of >20 MV/m
- The decay time is ~30 µs, recovery time ~250 µs
- Spike strength depends on laser energy density and accelerating field on cathode
- The decay time decreases slowly with time over weeks

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