QE at FLASH and PITZ

S. Lederer

DESY

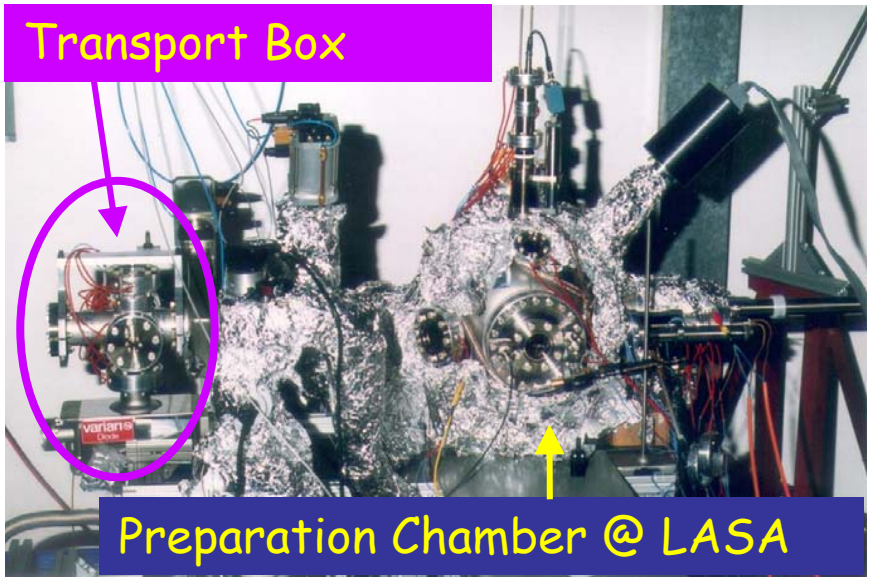
Characterization of High Brightness Beams May 28th, 2008

Overview

- Cs_2Te photocathode production
- Analysis at FLASH and PITZ
  - cw Quantum Efficiency (QE) measurements
  - pulsed QE measurements
  - QE maps
  - optical inspection
- Summary
- Outlook

Cs_2Te photocathodes

Cs_2Te photocathodes for FLASH and PITZ prepared at LASA, INFN Milano, Italy



- UHV Vacuum System - base pressure 10^{-10} mbar
- 6 sources slot available
- Te sources out of 99.9999 % pure element
- Cs sources from SAES®
- High pressure Hg lamp and interference filter for online monitoring of QE during production
- Masking system
- 5 x UHV transport box

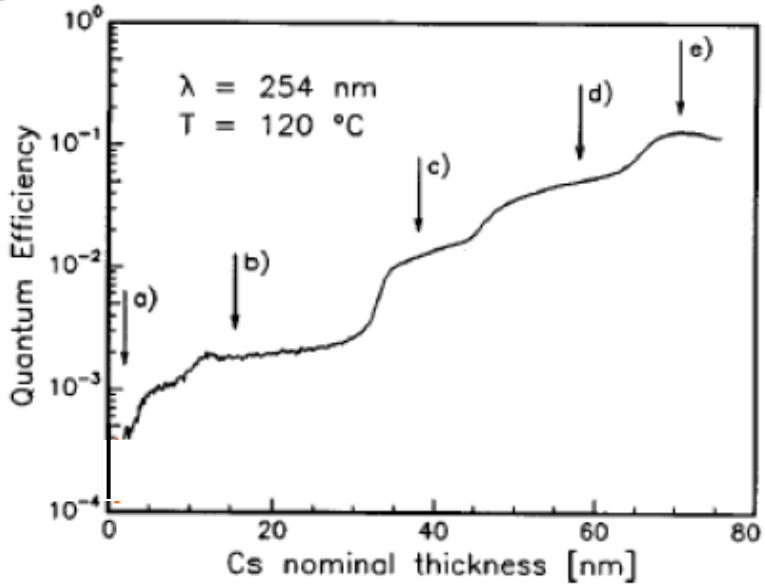
* *L. Monaco FLASH seminar, April, 2008*

After preparation transport to FLASH or PITZ under UHV conditions

Cs_2Te photocathodes

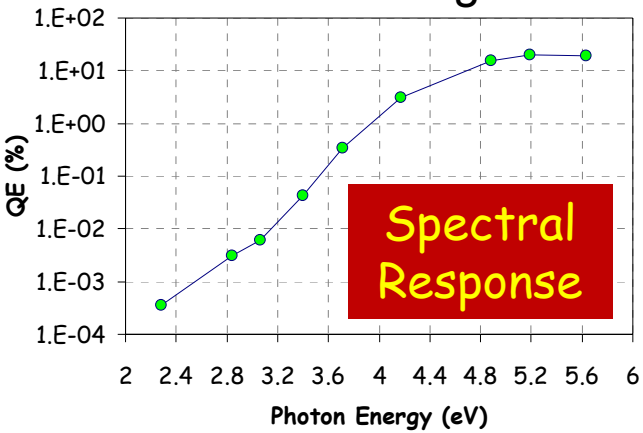
Preparation of the Cs2Te film

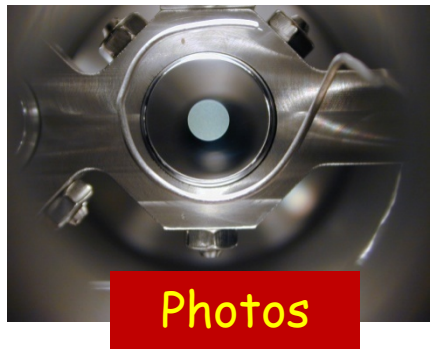
- substrate: polished Mo-plug
- during preparation plug stays at 120 deg C
- deposition of 10 nm Te
- starting Cs evaporation
- during Cs deposition monitoring of QE
- max. QE → Cs evaporation stopped

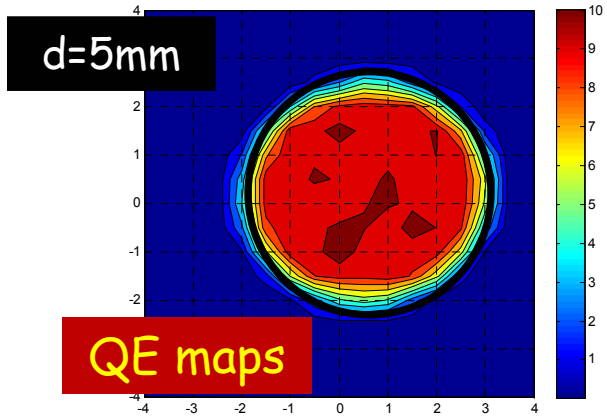


*P. Michelato et al., NIM A **393** (1997), 464*

for each cathode diagnostic after deposition:







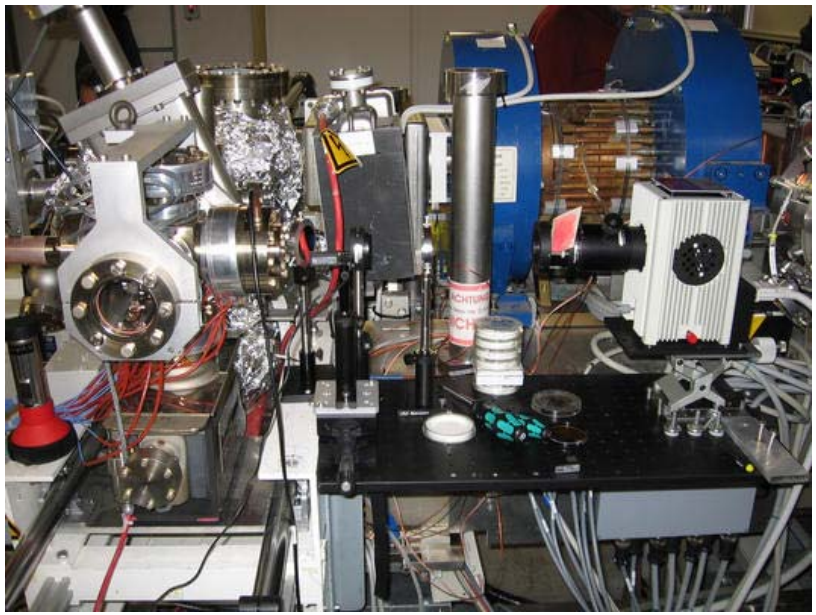
L. Monaco FLASH seminar, April, 2008

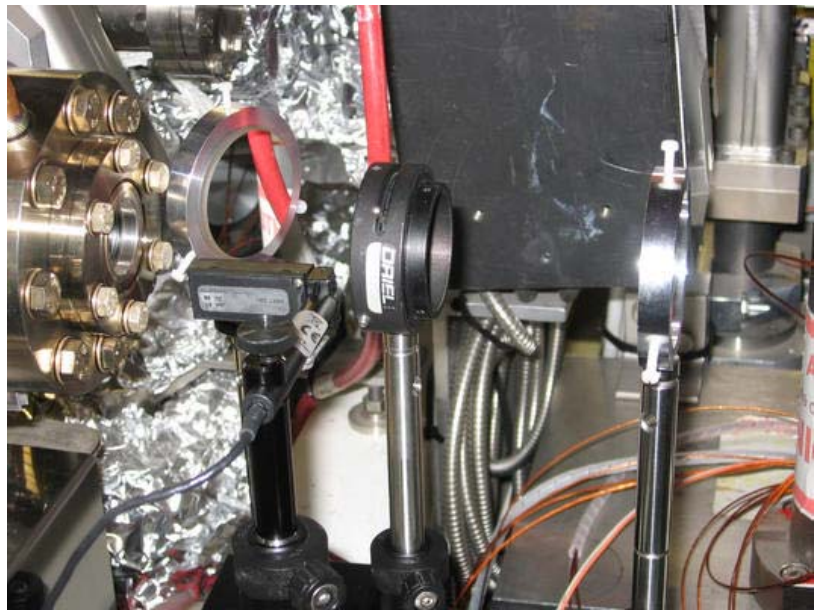
Analysis at FLASH and PITZ
1. cw QE measurements

Measurements of the spectral response of the Cs_2Te cathodes in the transport box

set-up (comparable to LASA)

- Hg lamp
- band pass filter for photon energy selection
- photodiode to determine light power
- Pico ammeter to measure current of emitted electrons
- some optics for focusing





Analysis at FLASH and PITZ
1. cw QE measurements

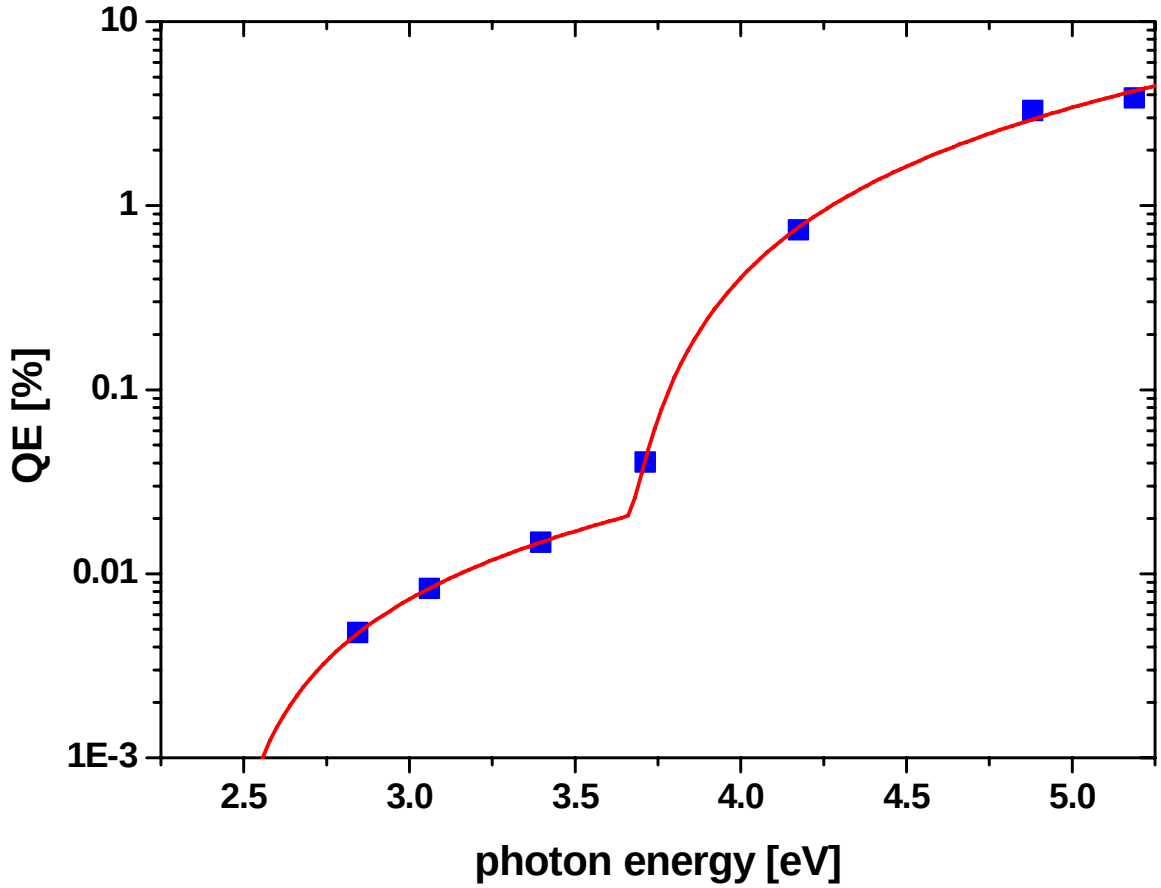
$$QE = A_1\left(h\nu - W_1\right)^{m_1} + A_2\left(h\nu - W_2\right)^{m_2}$$

$$with \quad W_i = E_{G_i} + E_{A_i}$$

cathode #123.1, unused
data taken 2008-05-20
at FLASH

W_1 = 2.4 eV
W_2 = 3.7 eV

QE @ 254 nm = 2.4 %



Analysis at FLASH and PITZ
1. cw QE measurements

$$QE = A_1\left(h\nu - W_1\right)^{m_1} + A_2\left(h\nu - W_2\right)^{m_2}$$

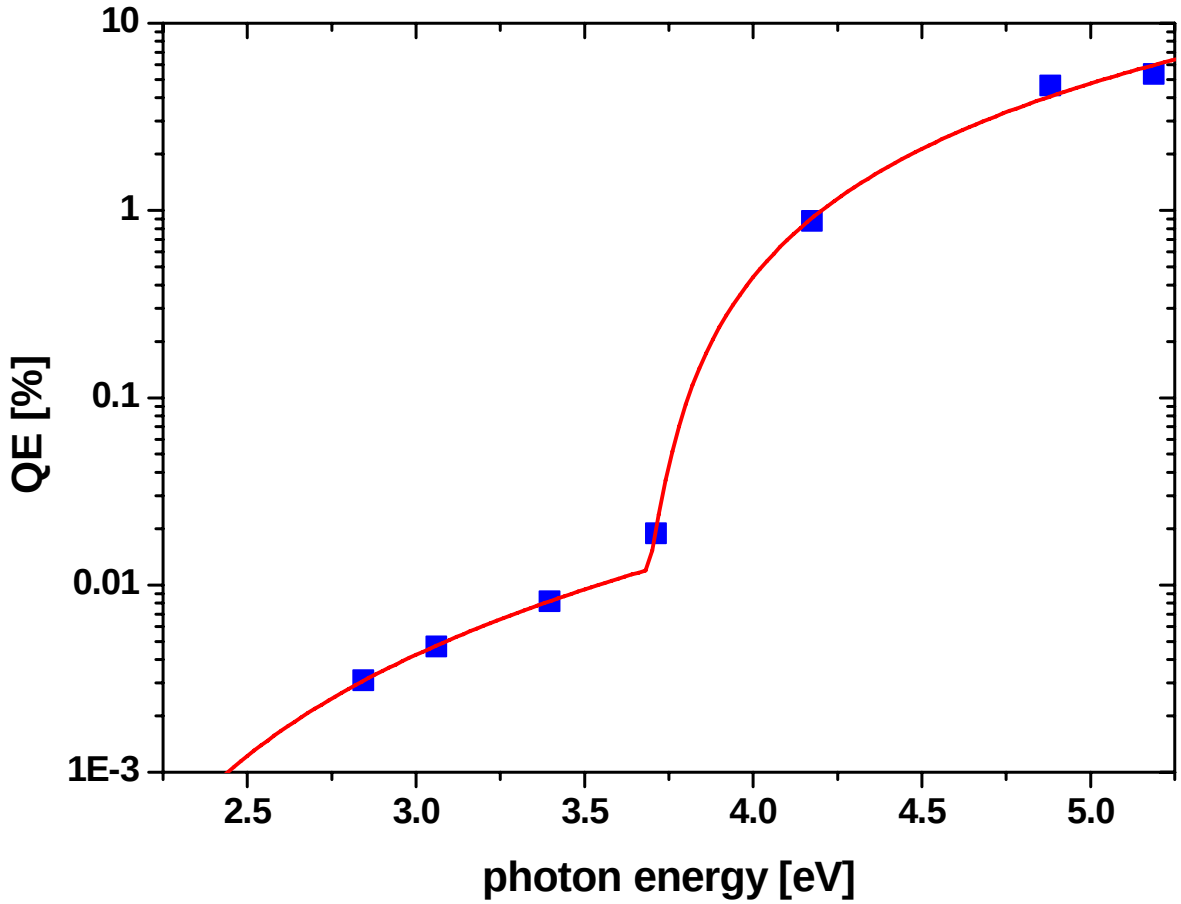
$$with \quad W_i = E_{G_i} + E_{A_i}$$

cathode #91.1, unused
data taken 2008-05-20
at FLASH

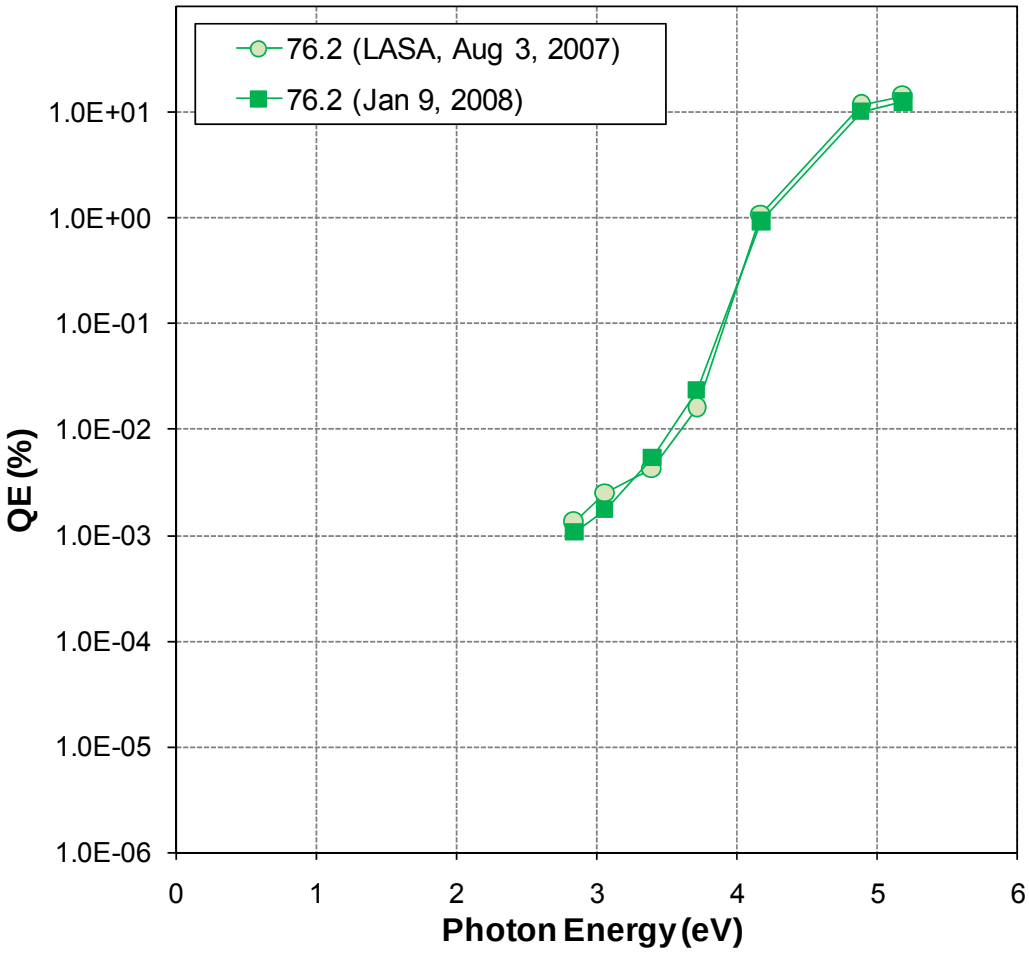
W_1 = 1.8 eV
W_2 = 3.7 eV

QE @ 254 nm = 3.2 %

at LASA:
QE @ 254 nm = 9.75 %



Analysis at FLASH and PITZ
1. cw QE measurements



	LASA 2007-07-02	FLASH 2008-01-09
QE@254nm	11.5%	10%
QE@262nm	6.8%	6.2%
E_G+E_A (eV) (low)	0.8	1.3
E_G+E_A (eV) (high)	3.6	3.6

Analysis at FLASH and PITZ
2. pulsed QE measurements

	FLASH	PITZ
charge measurement C[nC]	toroid (3GUN, 1.125 m downstream of cathode)	Faraday cup (FC1, 0.78 m downstream of cathode)
laser energy measurement E[μJ]	measured in laser hut	1) measured in laser hut or 2) on laser table in tunnel by energy meter or PM
laser energy at cathode E_{cath}[μJ]	calculated from measured transmission of laser beam line	in case of 1) calculated from measured transmission of laser beam line

Analysis at FLASH and PITZ
2. pulsed QE measurements

$$QE = \frac{n_{el}}{n_{ph}}$$

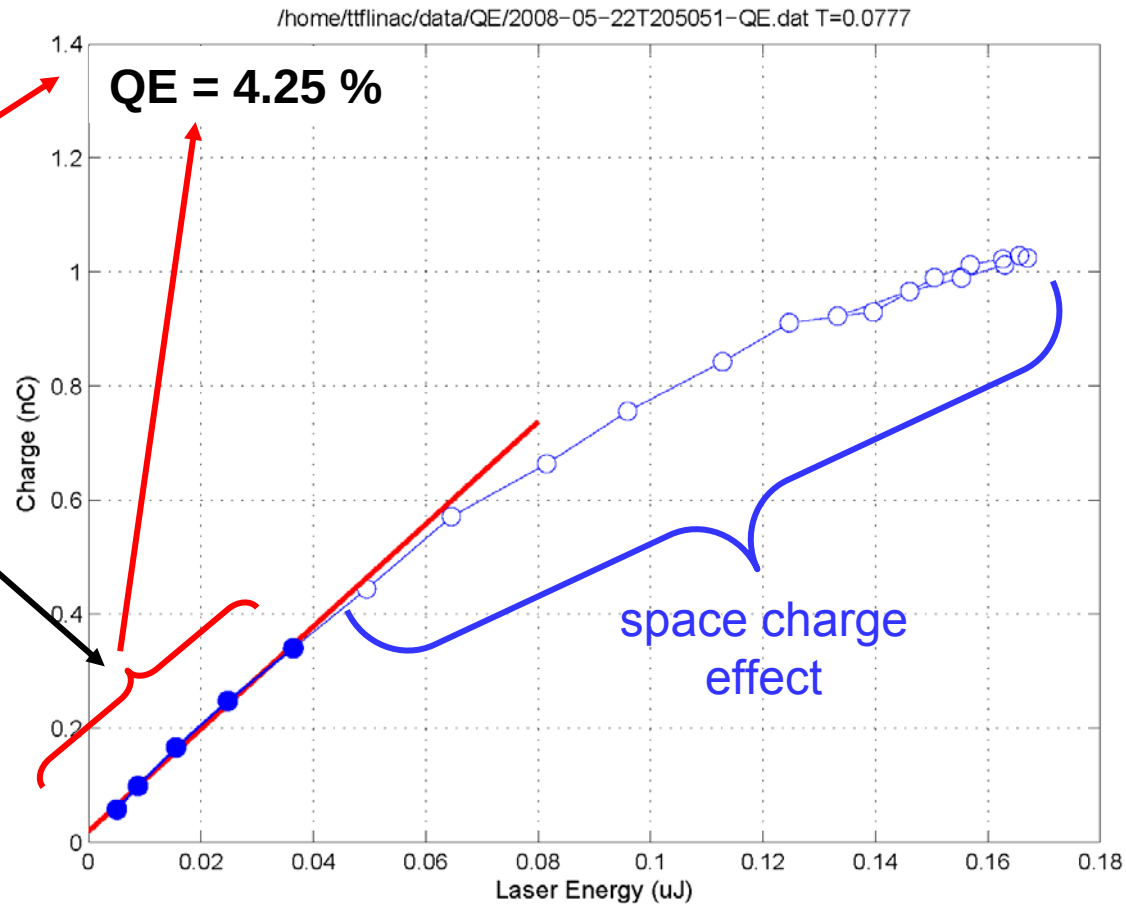
$$QE[\%] = 100 \frac{Q[C] E_{ph}[eV]}{E_{cath}[J]}$$

$$QE[\%] \approx 0.5 \frac{Q[nC]}{E_{cath}[\mu J]}$$

@ 262 nm

Example QE measurement at FLASH
Cathode #123.1 2008-05-22

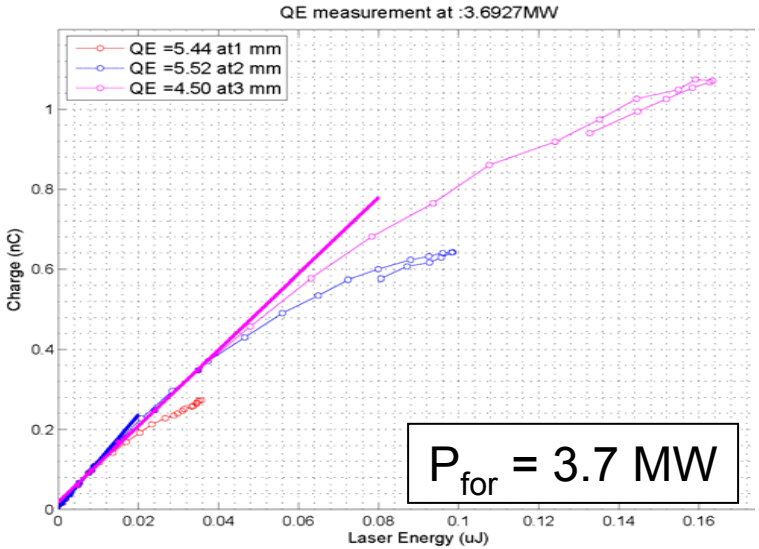
P_{for} = 3.3 MW Phase 38 deg, iris = 3 mm

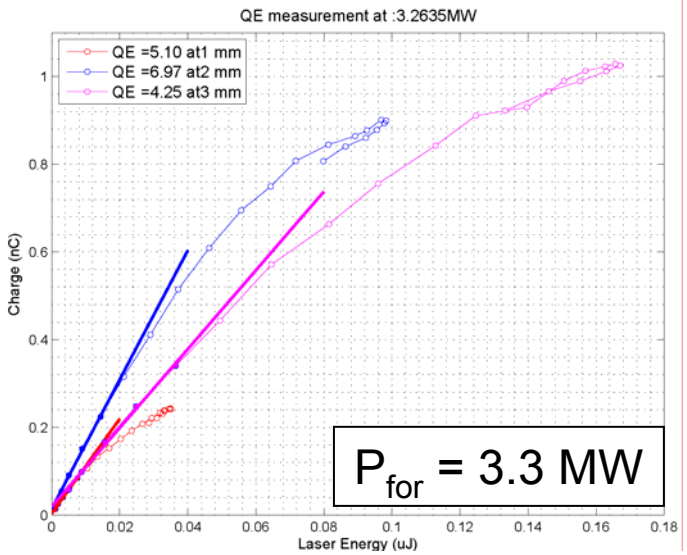


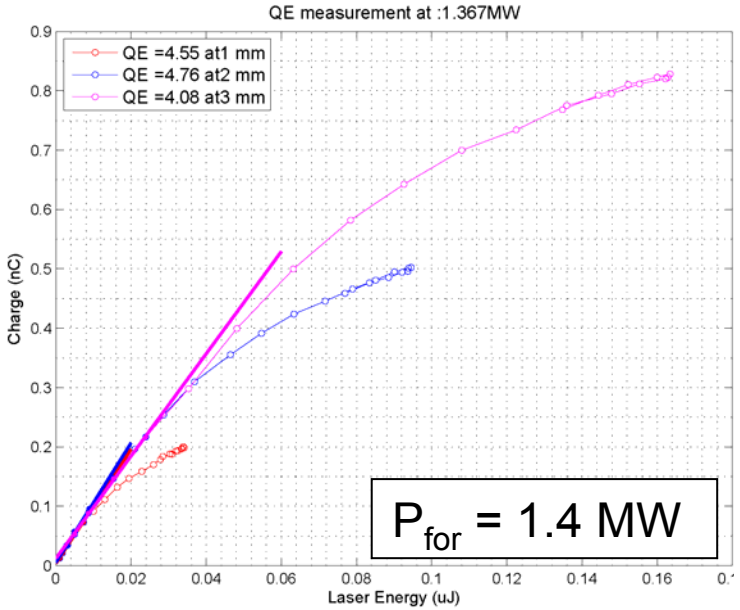
charge trend at low charge fitted

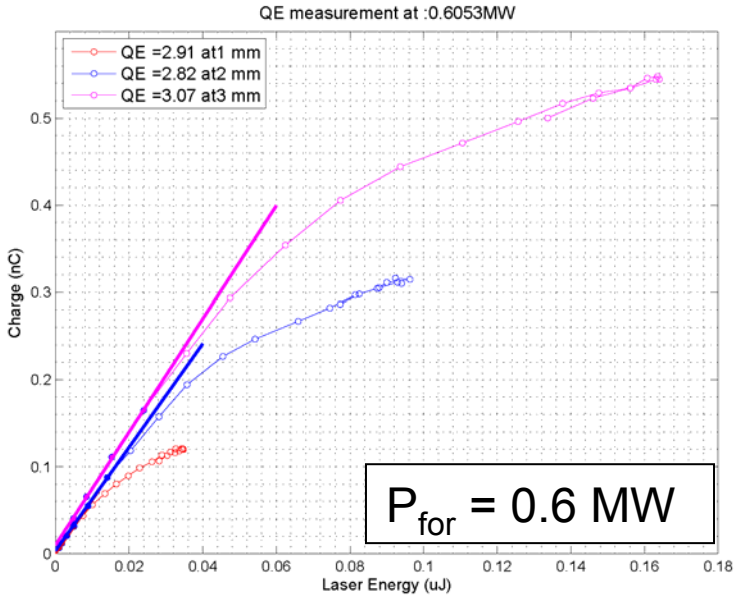
space charge effect

Analysis at FLASH and PITZ
2. pulsed QE measurements









Cathode #123.1

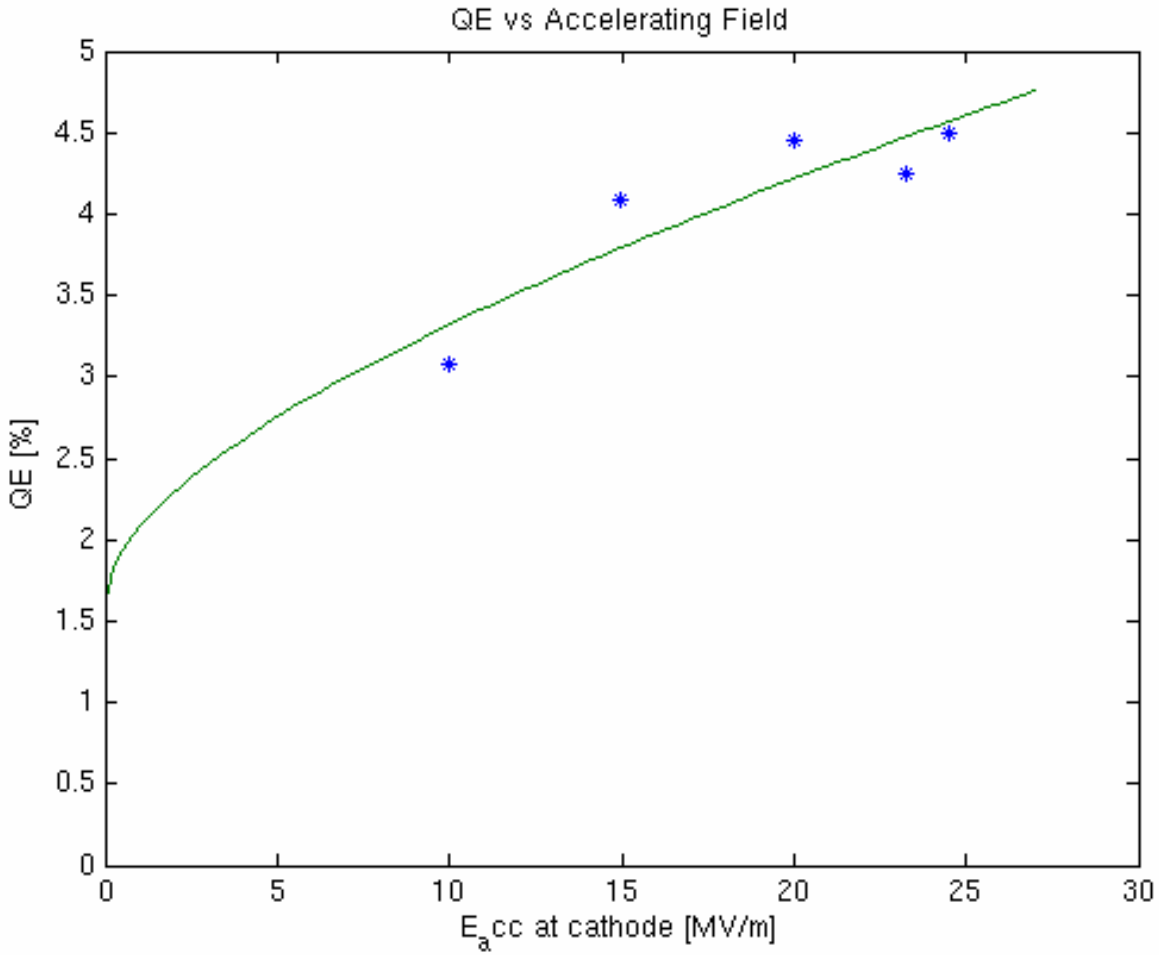
For each graph P_{for} was fixed and the iris varied

Analysis at FLASH and PITZ
2. pulsed QE measurements

$$QE = A\left(E_{ph} - W + q_e \sqrt{\frac{q_e \cdot \beta \cdot \varepsilon \cdot E_0 \cdot \sin\phi}{4 \cdot \pi \cdot \varepsilon_0}} \right)^m$$

From the fit of QE versus electric field at the cathode one gets information about the work function and the geometric enhancement factor

W = 3.65 eV
$\beta\varepsilon$ = 16
QE @ zero field =1.6 %



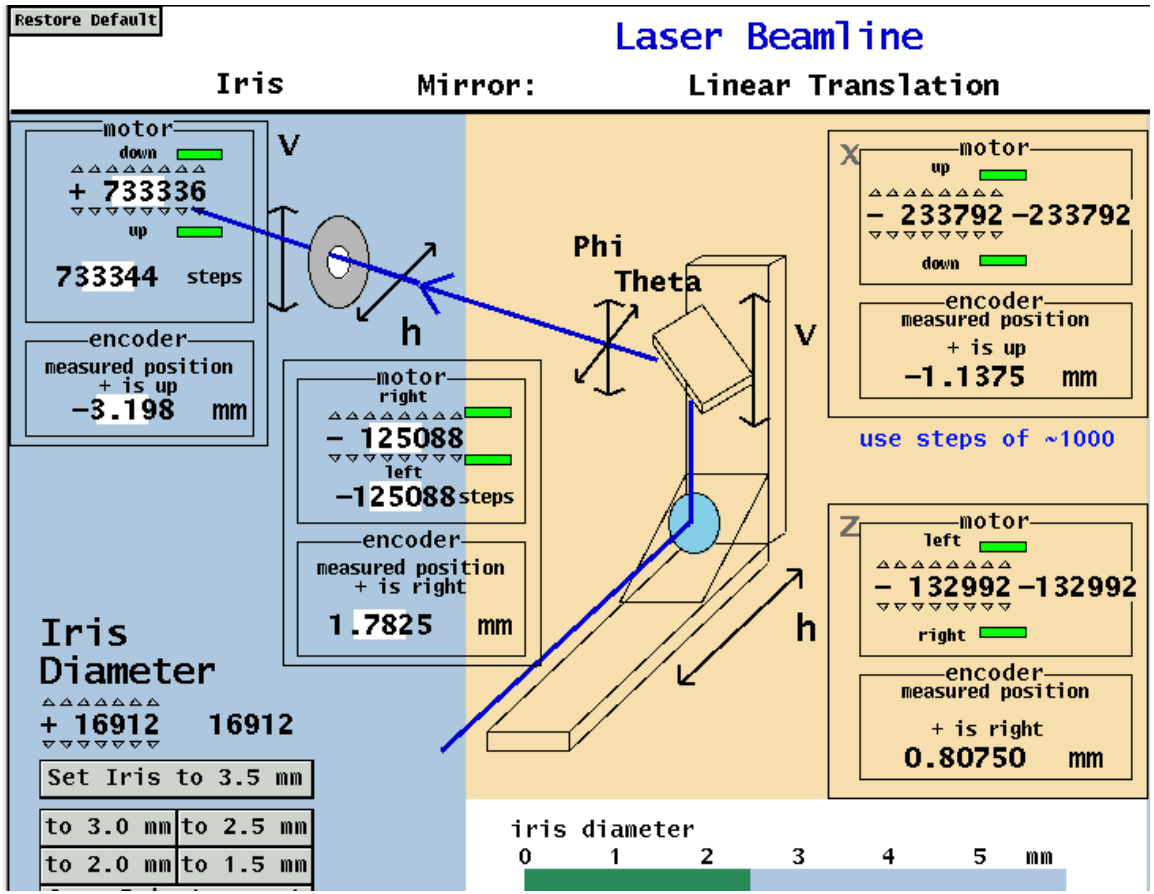
Analysis at FLASH and PITZ
3. QE maps

FLASH

1) charge measurement at first toroid

2) Iris 0.5 mm

3) scanning over cathode by moving iris and mirror together – the laser is also moved over the vacuum mirror



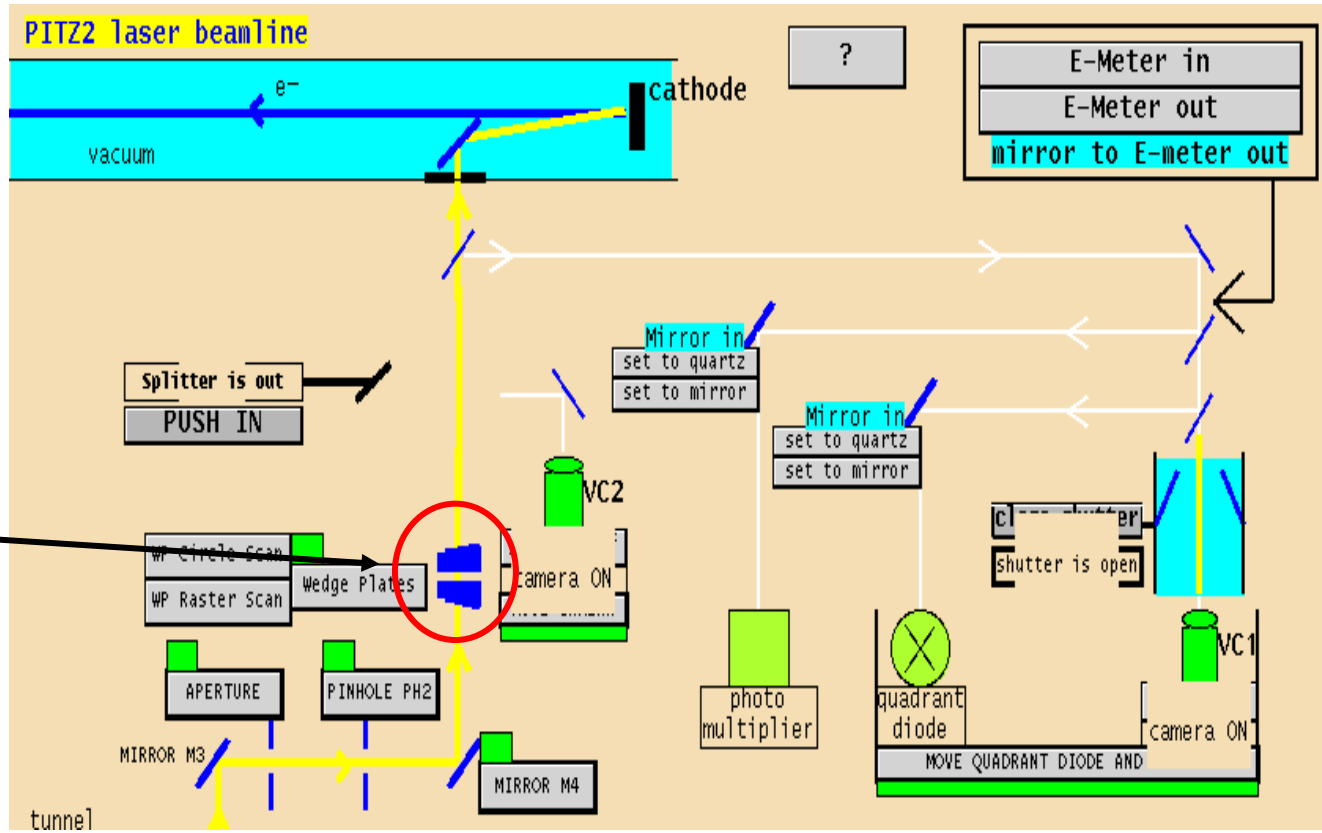
Analysis at FLASH and PITZ
3. QE maps

PITZ

1) charge measurement at first faraday cup

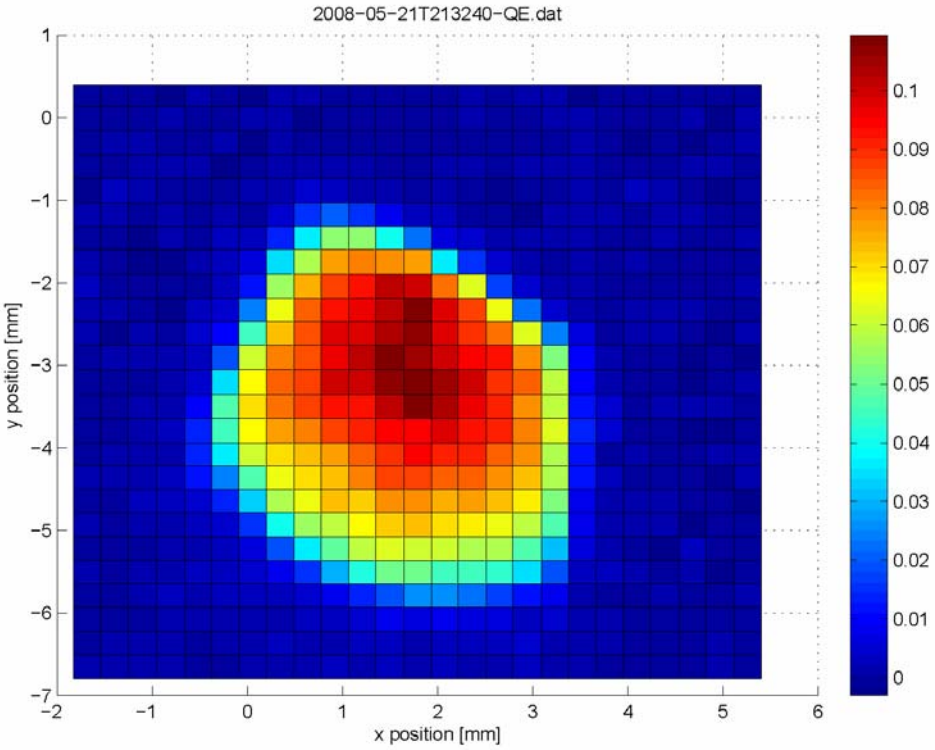
2) beam shaping aperture 0.2 mm

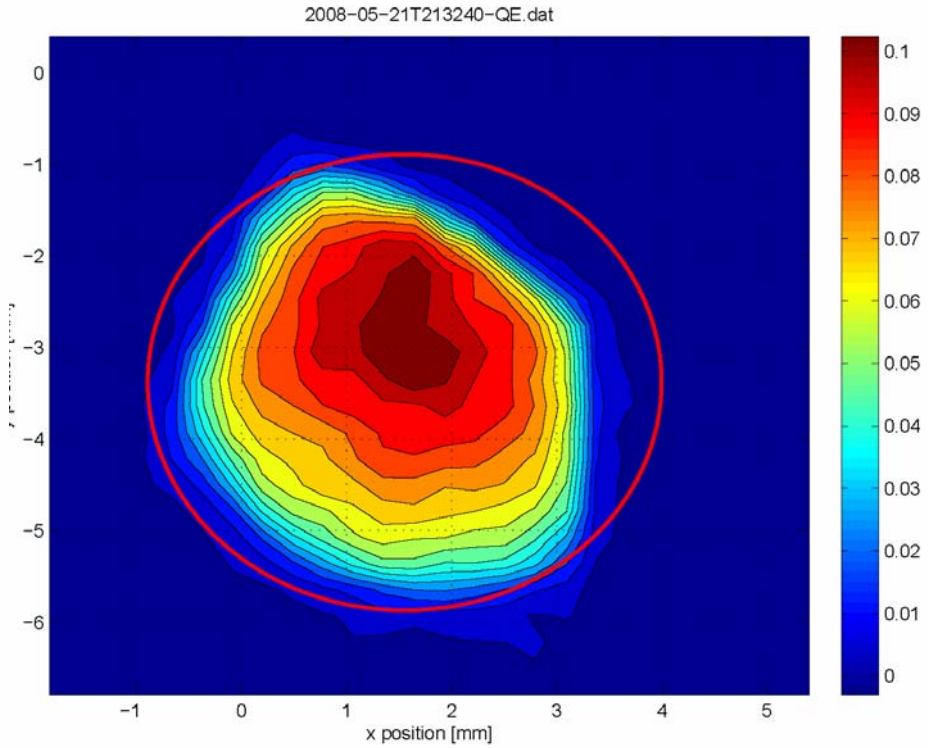
3) scanning over cathode by rotating the wedge plates – the laser is also moved over the vacuum mirror



Analysis at FLASH and PITZ
3. QE maps

FLASH





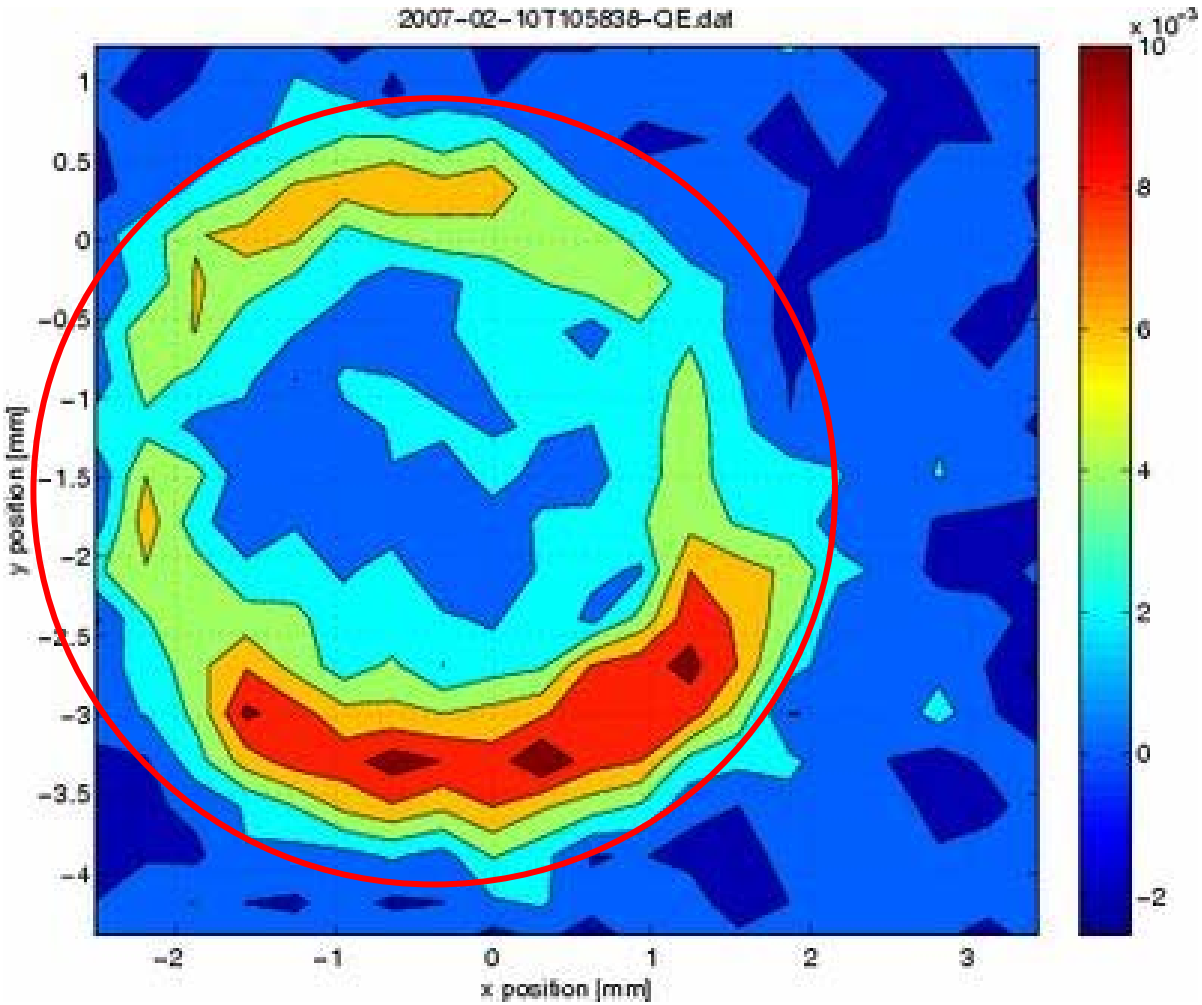
cathode #123.1 2008-05-21

Analysis at FLASH and PITZ
3. QE maps

FLASH

cathode #92.1

2007-02-10

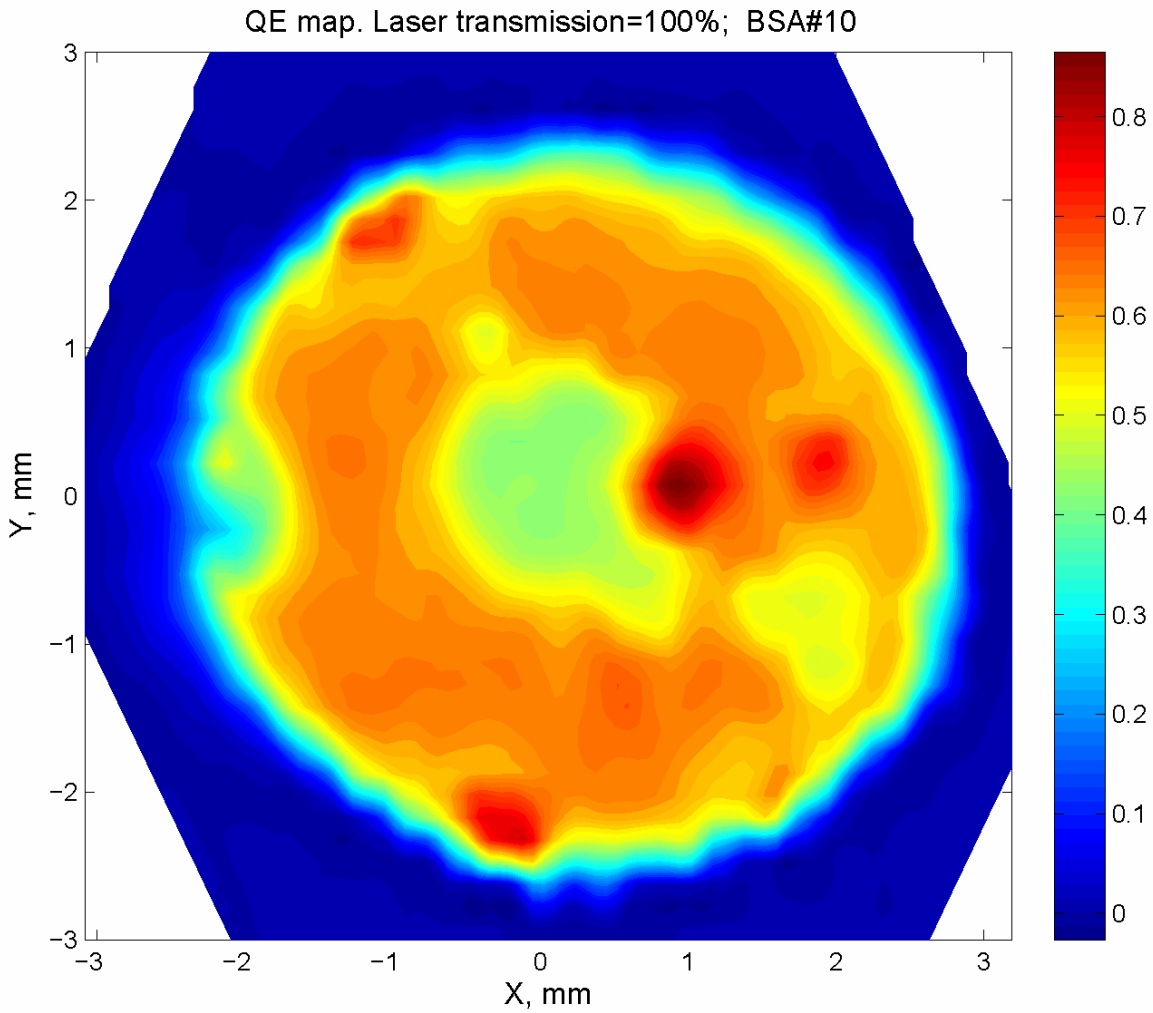


Analysis at FLASH and PITZ
3. QE maps

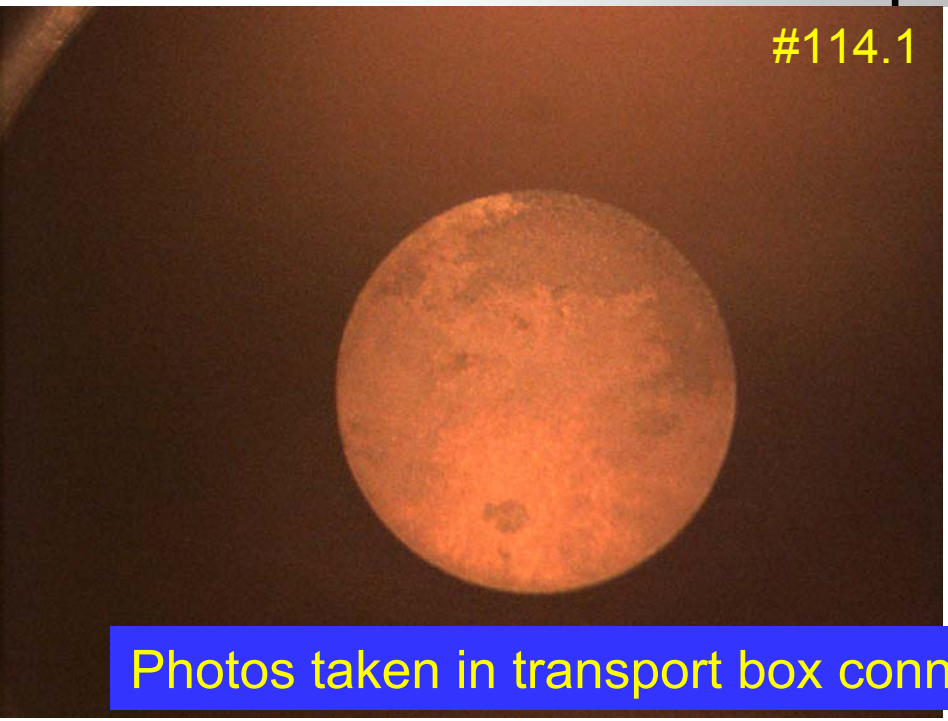
PITZ

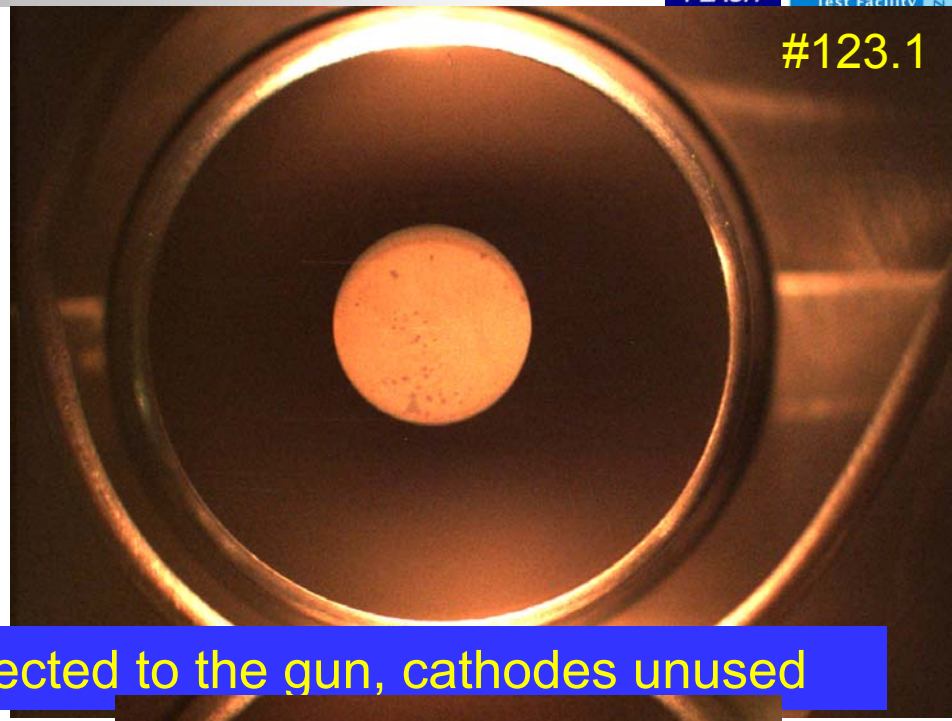
cathode #90.1

2007-08-20



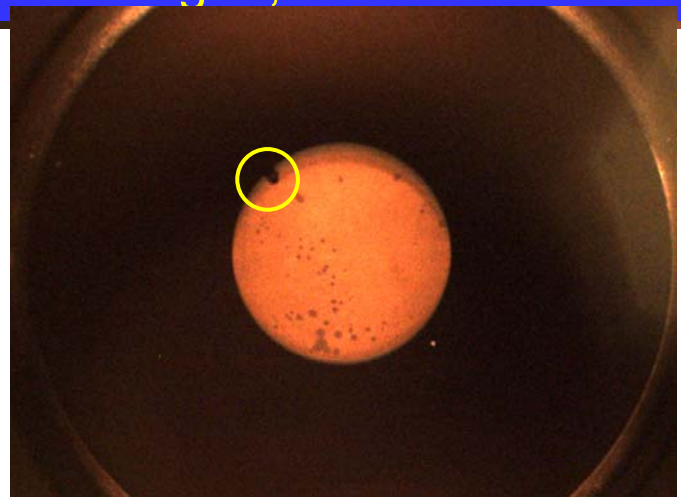
Analysis at FLASH and PITZ
4. photos



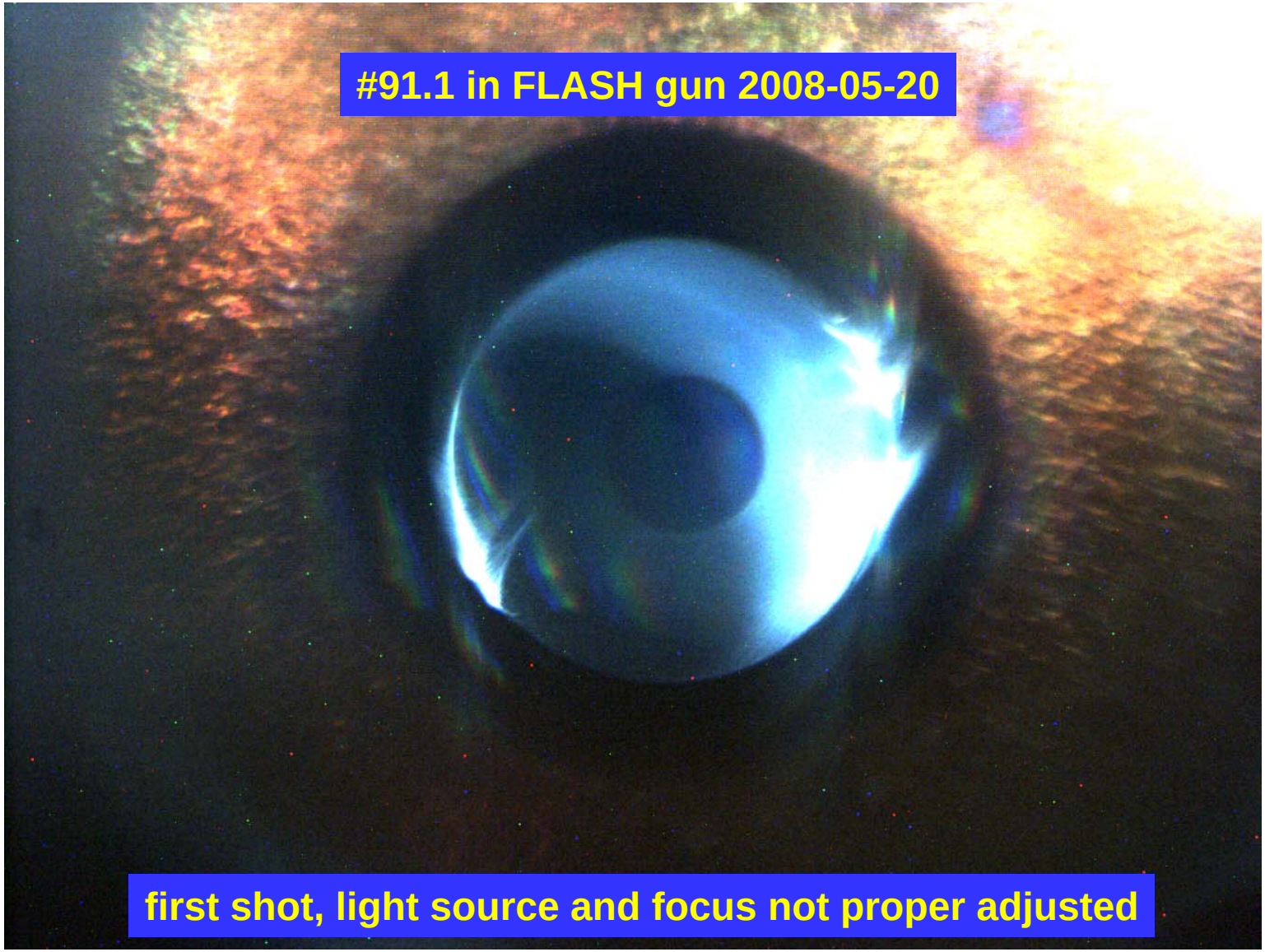


Photos taken in transport box connected to the gun, cathodes unused

cathode #123 after
6 days of usage



Analysis at FLASH and PITZ
4. photos



Summary

- Analysis after production at LASA
  - cw QE / spectral response
  - cw QE maps
  - Photos
  - → All after production and after usage
- Analysis at DESY
  - cw QE / spectral response
  - Pulsed QE
  - Pulsed QE maps
  - Photos
  - →All before during and after usage possible

Outlook

- Continued QE studies
- Cathode preparation at DESY
- Field emission microscope to identify field emitters right after cathode production
- XPS set-up for chemical analysis