Cathodes for CTF3/CLIC

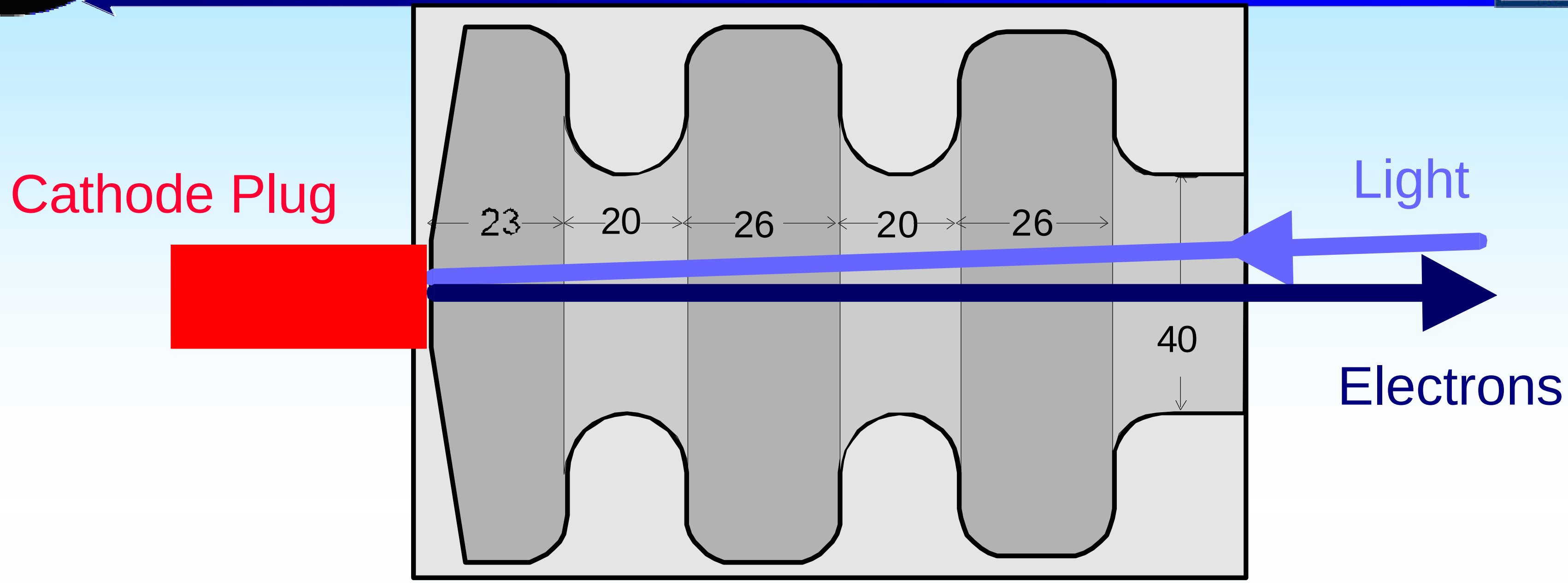
- RF- Gun
- Cathodes
- Conclusion

URL: www.cern.ch/photoemission

Requirements for the injector

- Reliability
- long pulse trains (92μs for CLIC, 1.54μs for CTF3) of short pulses (10 ps)
- average current 75mA (CLIC),
- pulse train shaping
- 469MHz (CLIC), 1.5GHz (CTF3) frequency
- 1/1000 energy stability
- jitter <1ps
- must use existing technology

The RF Gun for CTF3



P_{RF}	30 MW
beam energy	5.6 MeV
beam current	3.5 A
peak field on cathode	85 MV/m
unloaded Q	13000
coupling factor β	2.9
delay beam /RF	400 ns

Laser seems to be a minor technical challenge

What about the cathodes ?

High average current

High laser power

⇨? Damage

Test Conditions

Since the CLIC laser does not yet exist, try with another one:

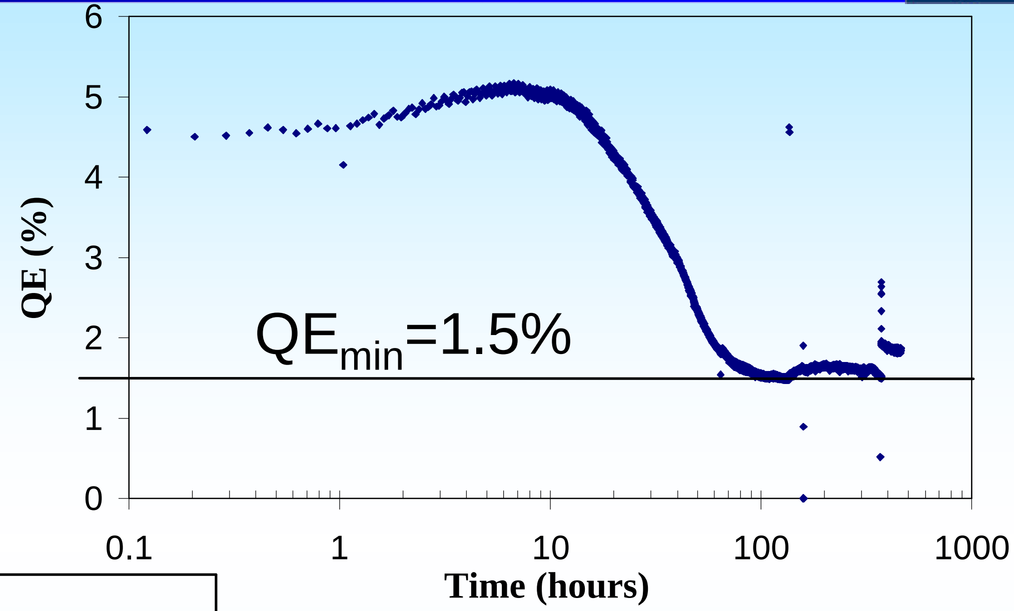
- Quadrupled Nd:YLF,
- Rep.Rate 1-15 kHz (used mainly 1kHz)
- Pulselength 100-150ns (used 100ns)
- Average Power up to 800mW

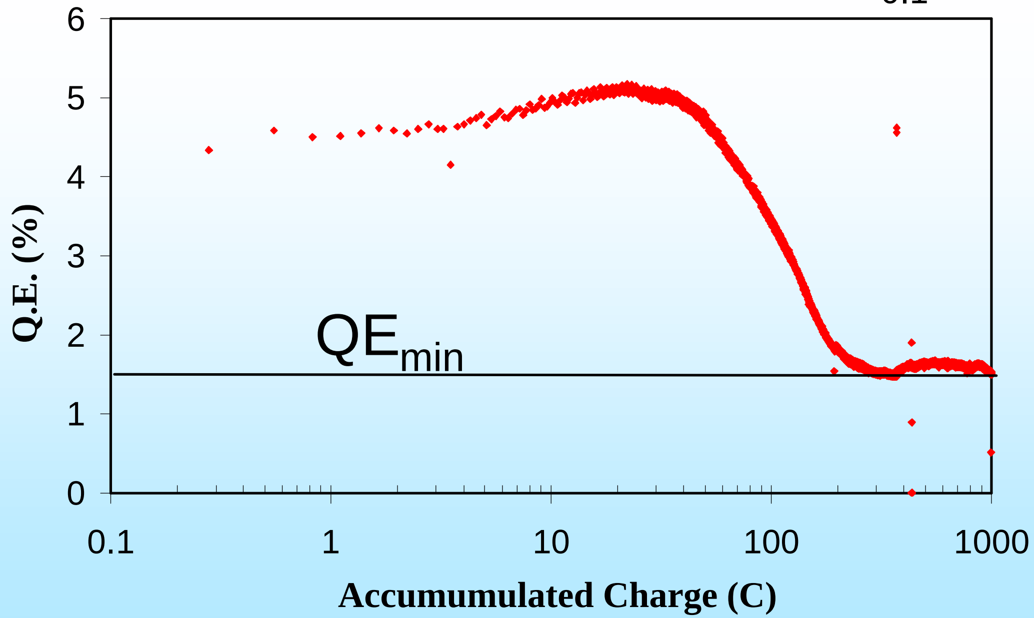
Goal: Show an average current of 1mA

Cathode test for high average current I

Reminder for CLIC:
1mC per macropulse,
75 mA on average
For CTF 3: 5.2 μC,26 μA

Cathode plug was cleaned
by Ar^{+} bombardement
Thickness Te: 10nm
Thickness Cs: 8nm





Average current: **750 μA**

Total charge: **1.2 kC**

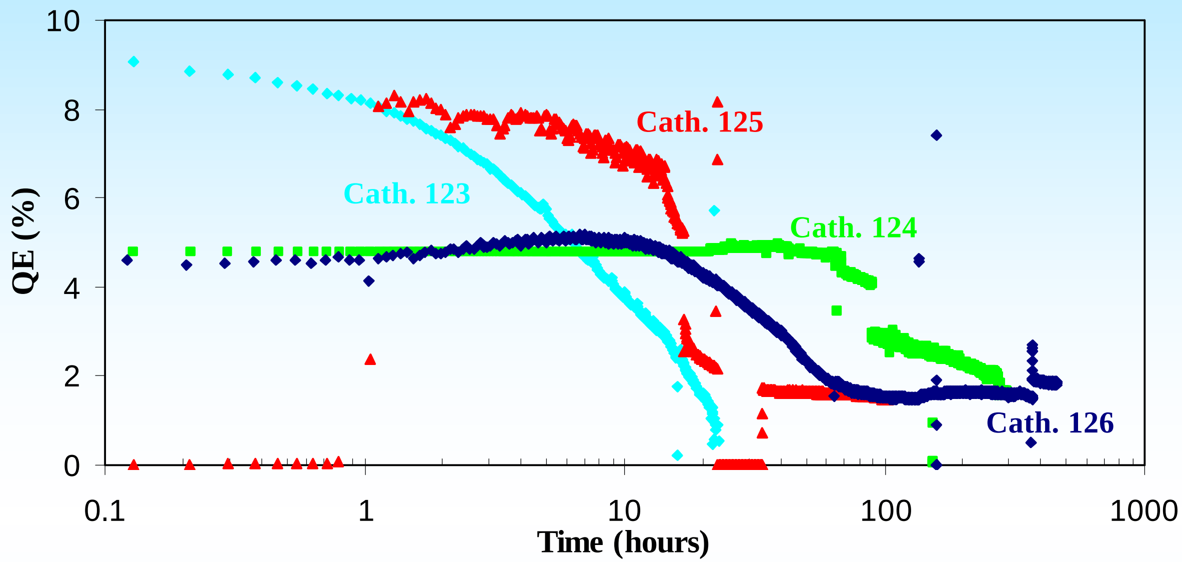
Current density: $\mathbf{21}\,\frac{mA}{cm^2}$

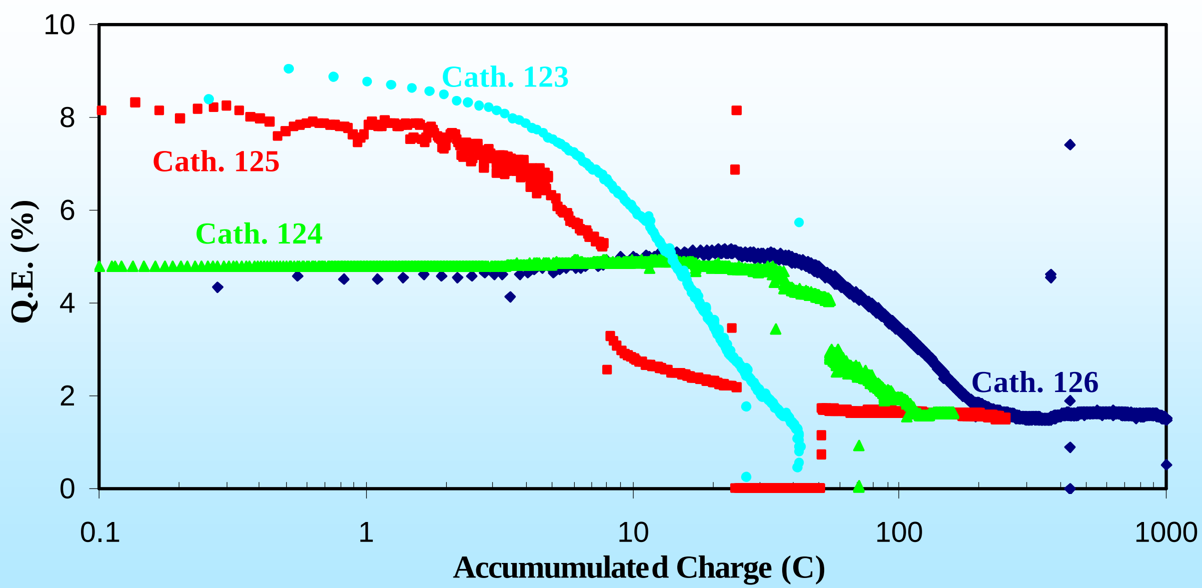
Laser power density: $\mathbf{6}\,\frac{W}{cm^2}$

Cathode test for high average current II

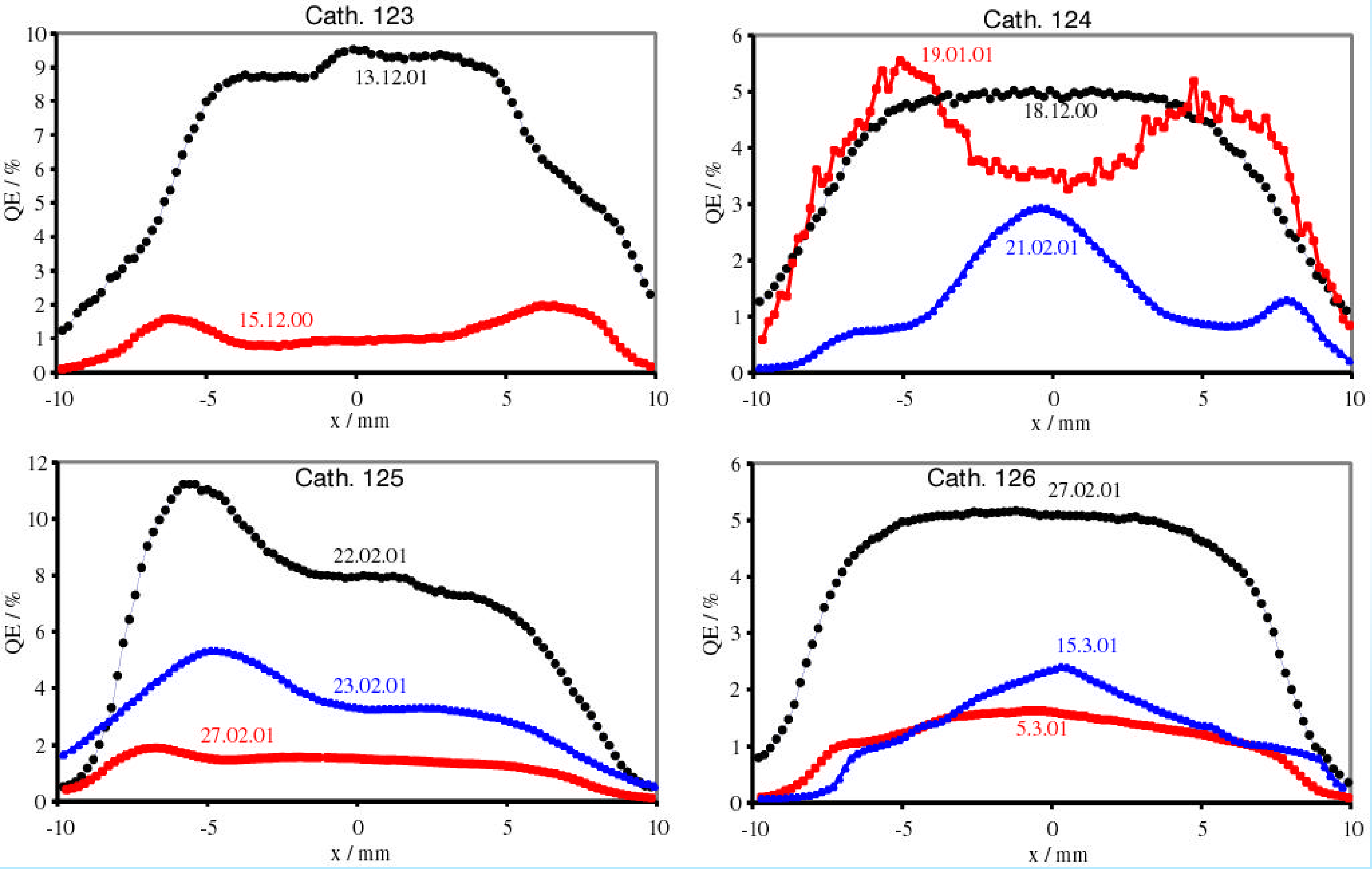
Cathodes 124, 126:
treated with ICE

Cathodes 123,125:
on Gold (50 / 100 nm)



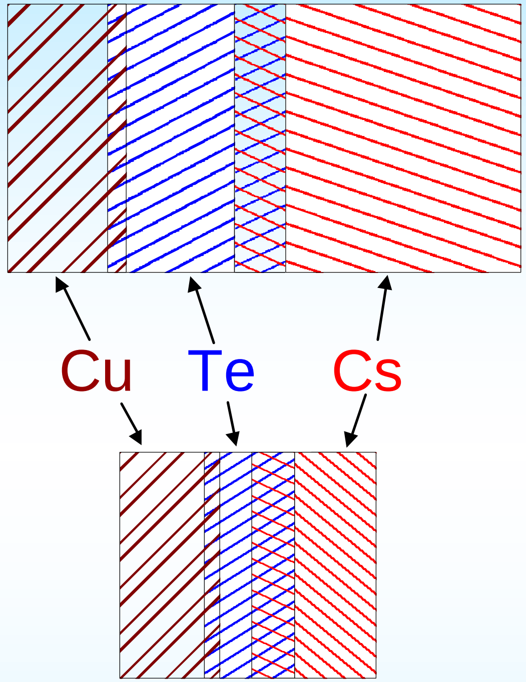


Spatial repartition of QE over the cathodes



Experiences:

Cs-Te cathodes with
10nm Te,15nm Cs:
Qe »10% → »1.5%

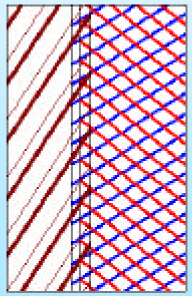


Cs-Te cathodes with
2nm Te, 6nm Cs:
Qe » 10% → »1.5%

Only a thin (some nm) active interface really consisting of photoemitting Cs_2Te ?

Solution:

Evaporate both elements at the same time

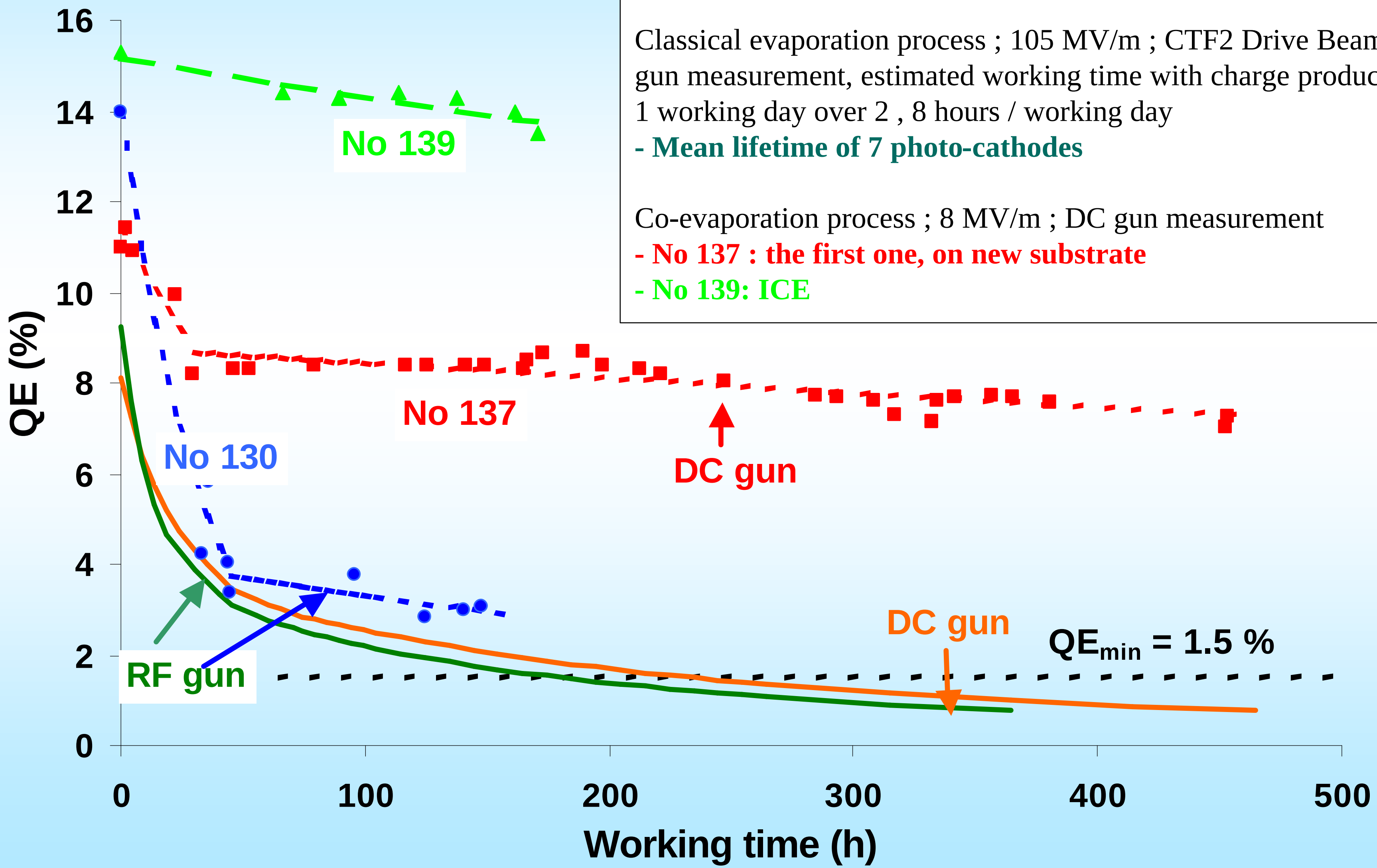


Gain in QE

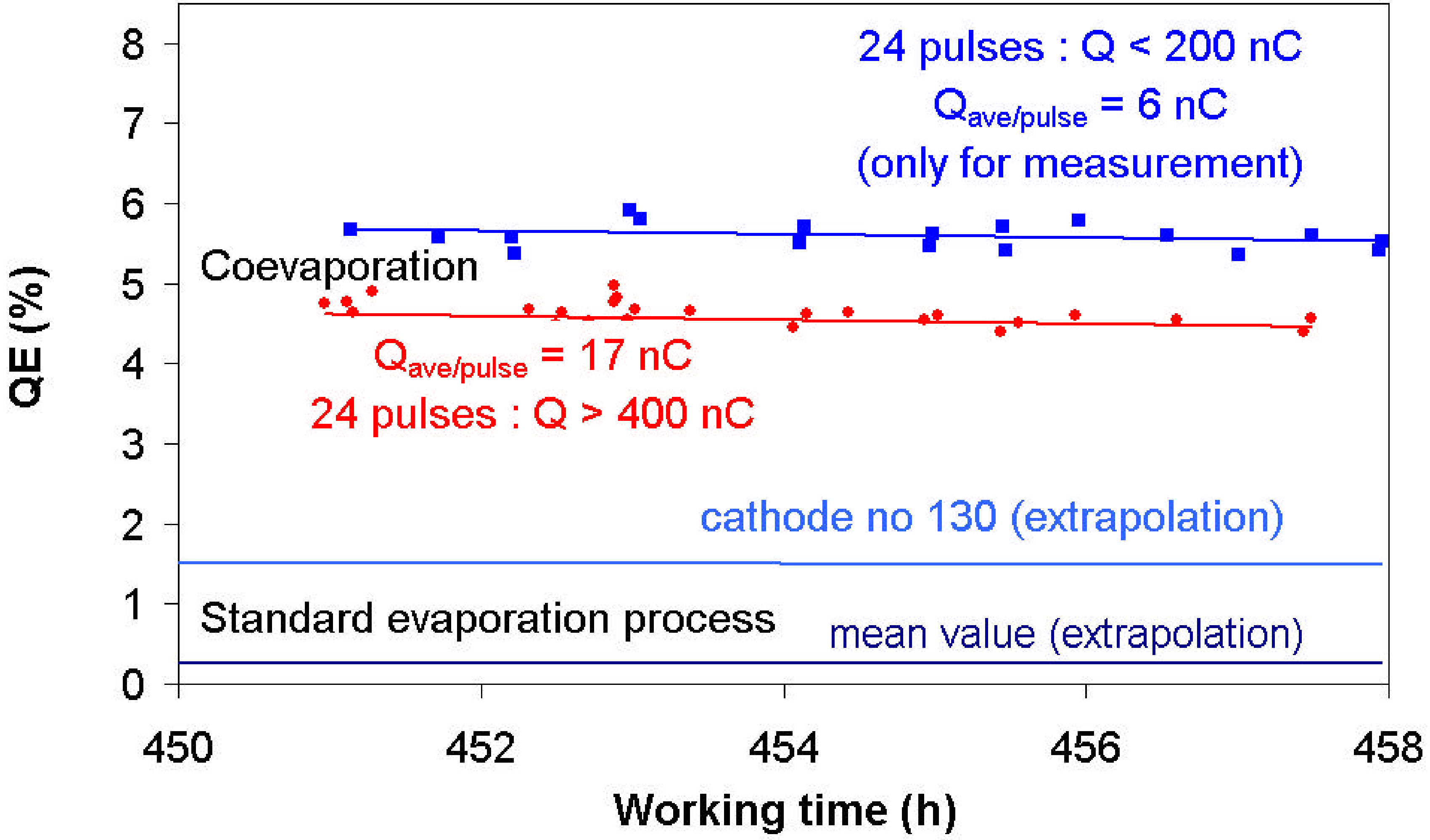
Classical evaporation process ; 8 MV/m ; DC gun measurement
- Mean lifetime of 6 photo-cathodes, including high charge test

Classical evaporation process ; 105 MV/m ; CTF2 Drive Beam RF gun measurement, estimated working time with charge production : 1 working day over 2 , 8 hours / working day
- Mean lifetime of 7 photo-cathodes

Co-evaporation process ; 8 MV/m ; DC gun measurement
- No 137 : the first one, on new substrate
- No 139: ICE



Behavior in the RF gun



Cesium Telluride Performances

Performances obtained at CTF or during the High Q test :

- **Working wavelength < 270 nm**
- **High peak current : 10 kA**
- **Maximum electric field : at least 125 MV/m**
- **Low dark current : similar to copper**
- **Measured response time £ 2-3 ps, limited by instrumentation**
- **Macro-pulse charge : 750 nC in 48 pulses, spacing 333 ps**
- **Mean current : » 1 mC x 1 kHz = 1 mA**
- **Lifetime : QE > 1.5 % during 460 h @ 750 mA, 1.4×10^{-9} mbar**

With coevaporation: >4.5 %

- **Mean current density : 21 mA/cm^2**
- **Resistance to laser damage: at least 6 W/cm^2 @ 262 nm**

Summary and Outlook

- No technological problem for RF gun
- Laser is feasible with some technical challenges
- Cathodes are able to produce the required current density
- Cathodes resist the laser intensity

A photoinjector seems to be feasible and to be a good technical solution:

- Better emittance
- No satellites
- Lower costs
- Less Radiation