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Multipacting at the photocathode in the rf gun cavity

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DESY, PITZ
Erice, Italy, October 2005

- Experimental observation
- Secondary emission model and test with beam dynamics
- Simulation of the electron multiplication process
- Summary

Measurement setup

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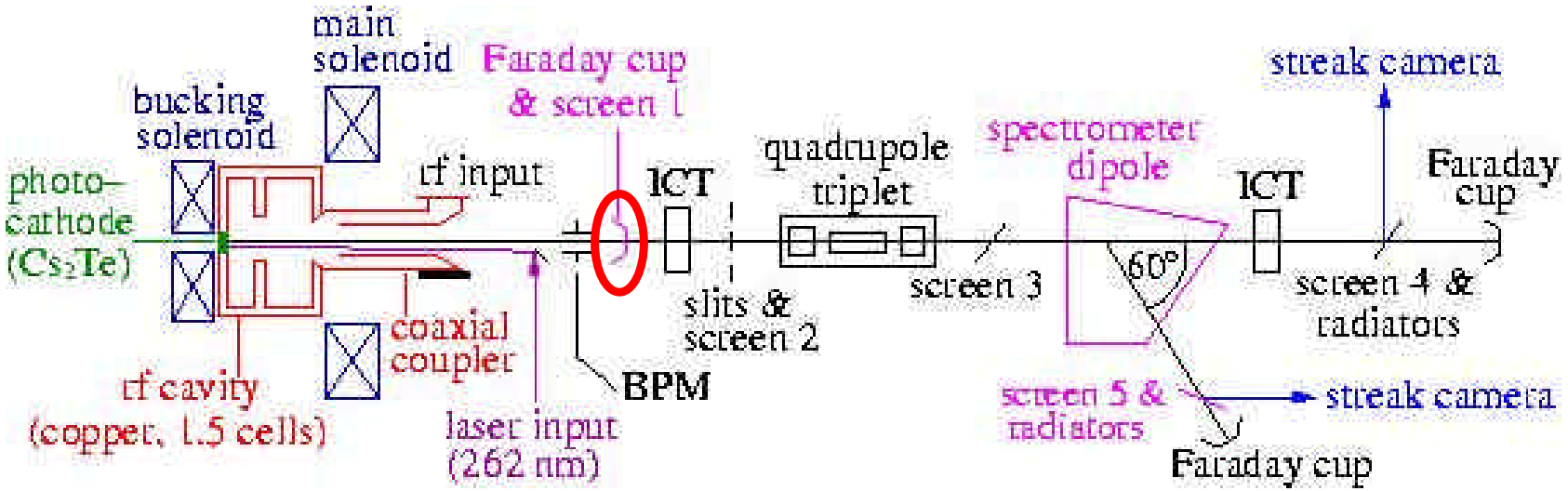

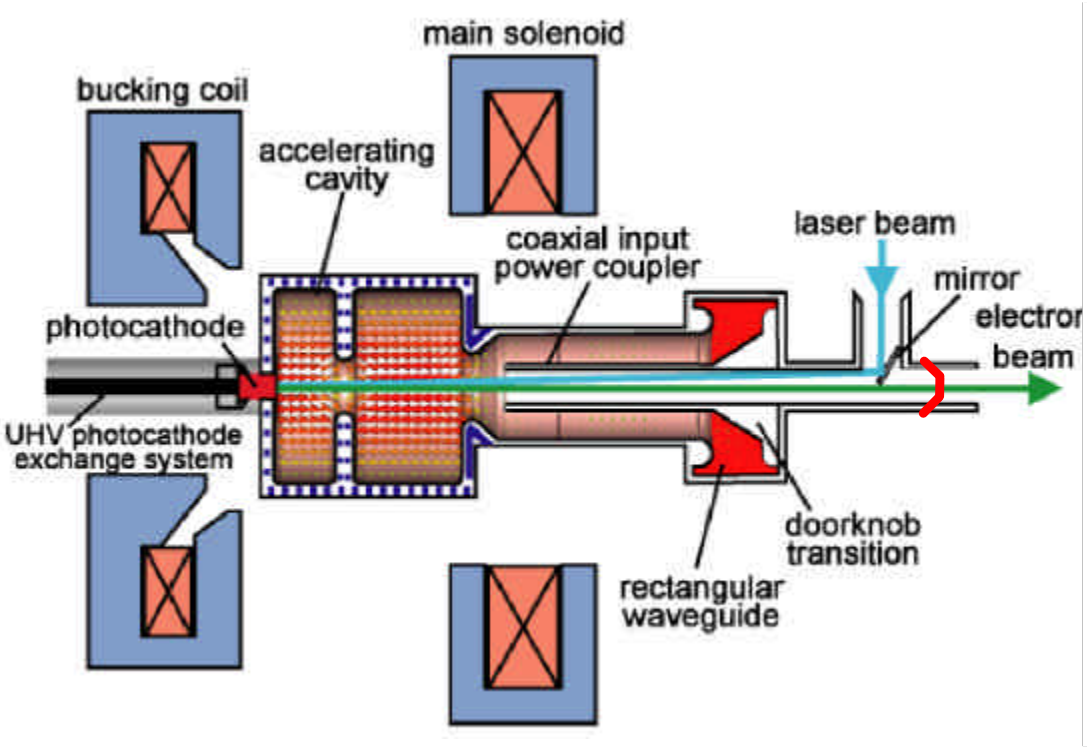

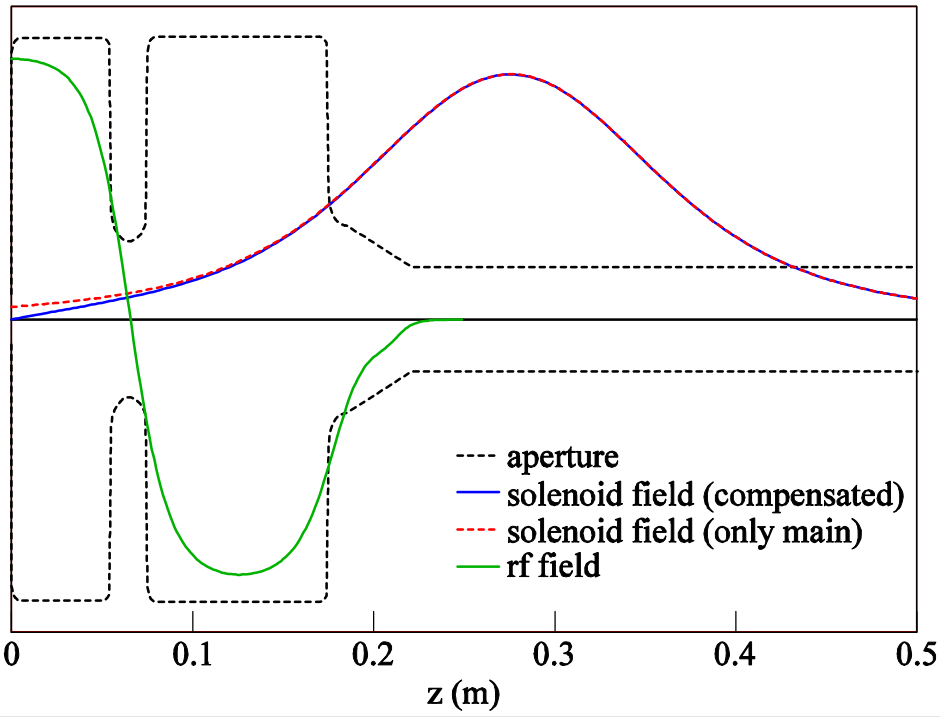

RF pulse and dark current

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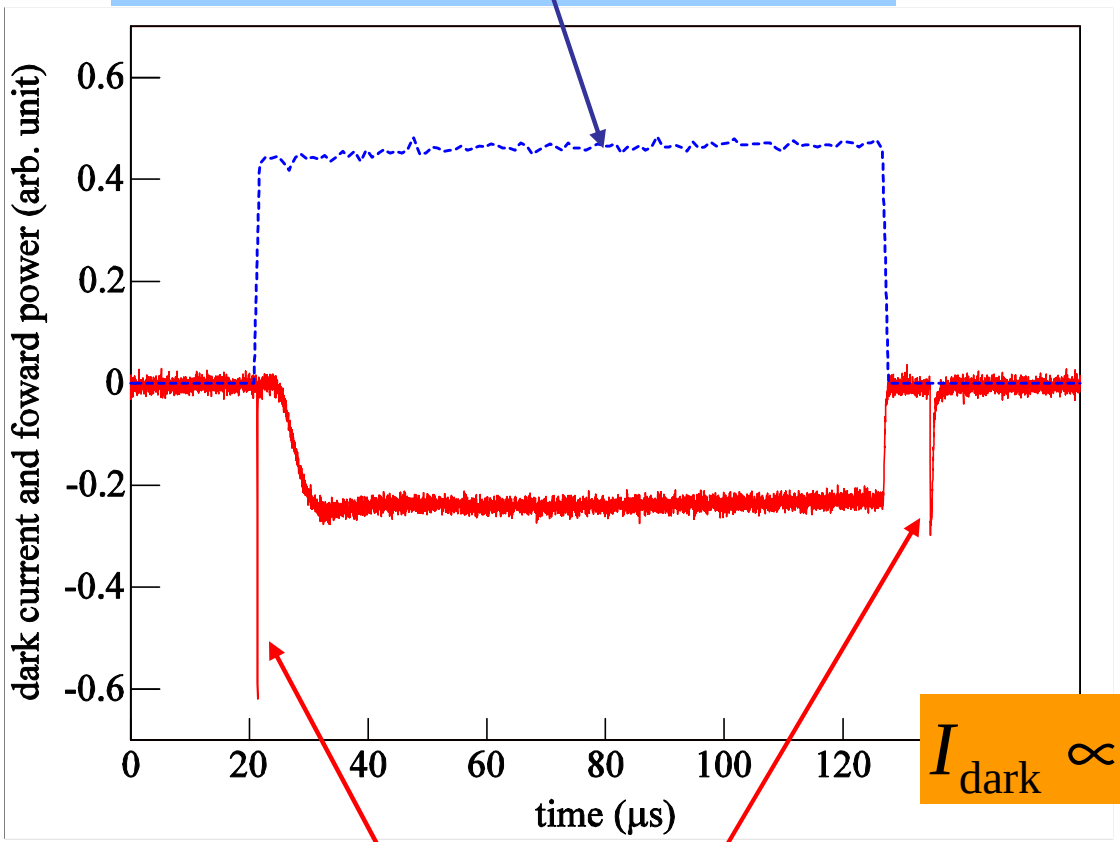
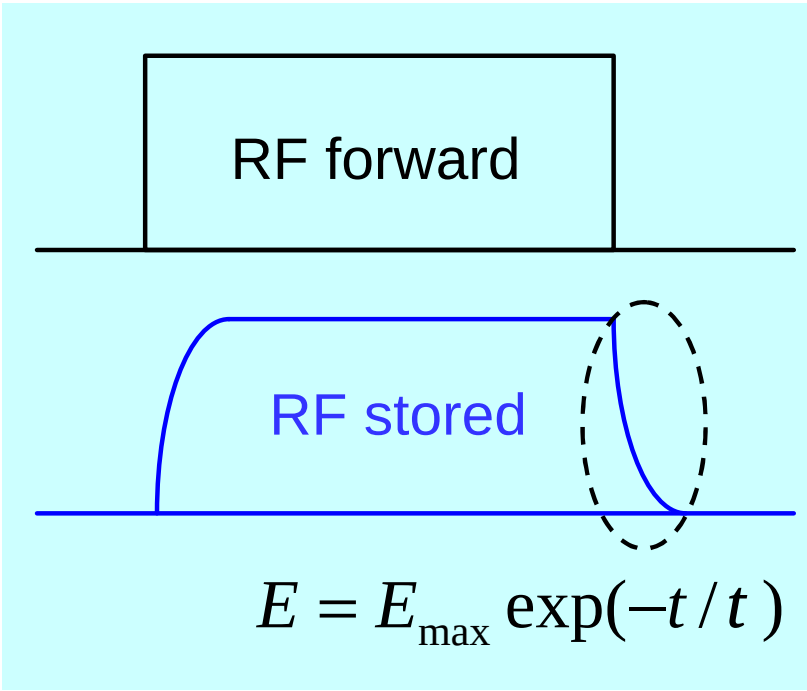
Dark current measured with the Faraday cup 0.78 m from the cathode

RF forward power to the gun





$$E = E_{\max} \exp(-t/t)$$

$$I_{\text{dark}} \propto E^2 \exp(-1/E)$$ (Fowler-Nordheim)

Peak caused by electron multiple impacting (multipacting) at the cathode

Description of multipacting

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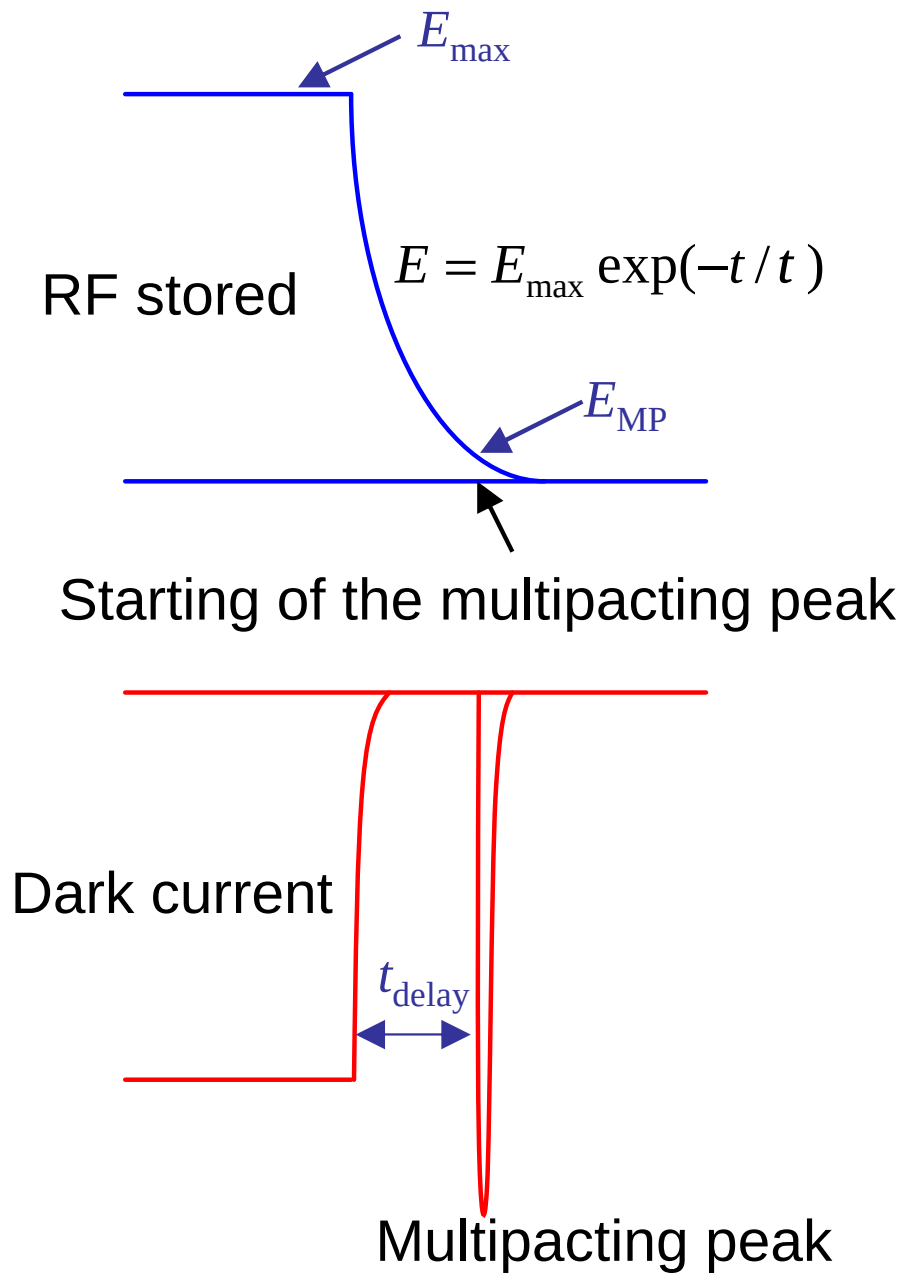

RF field when the multipacting starts

$$E_{MP} = E_{max} \exp(-t_{delay}/t)$$

E_{MP}: the RF field when the multipacting occurs

E_{max}: the maximum field of the RF pulse

t_{delay} : the delay between the end of the rf pulse and the beginning of the rear multipacting peak

t : the fill/decay time of the rf field in the cavity

Dark current and multipacting peaks

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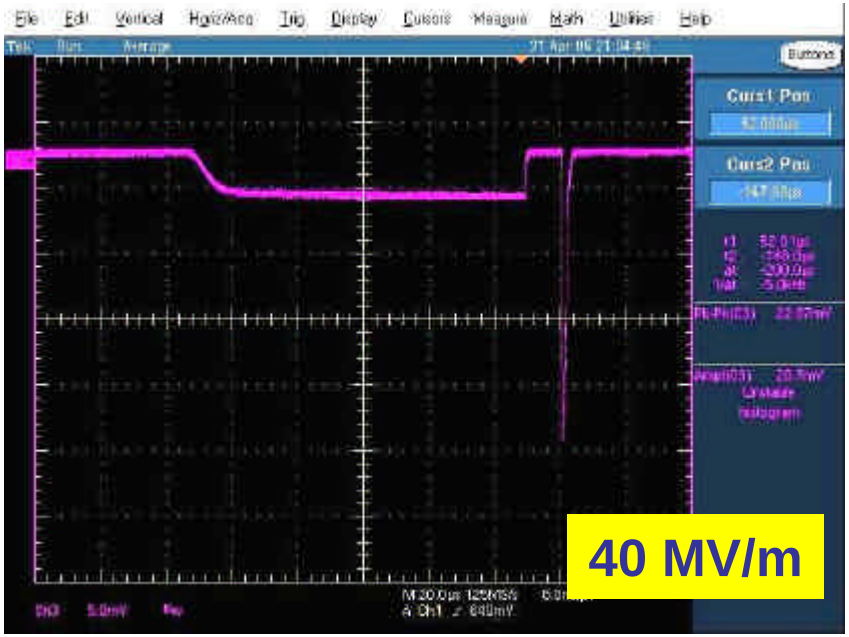

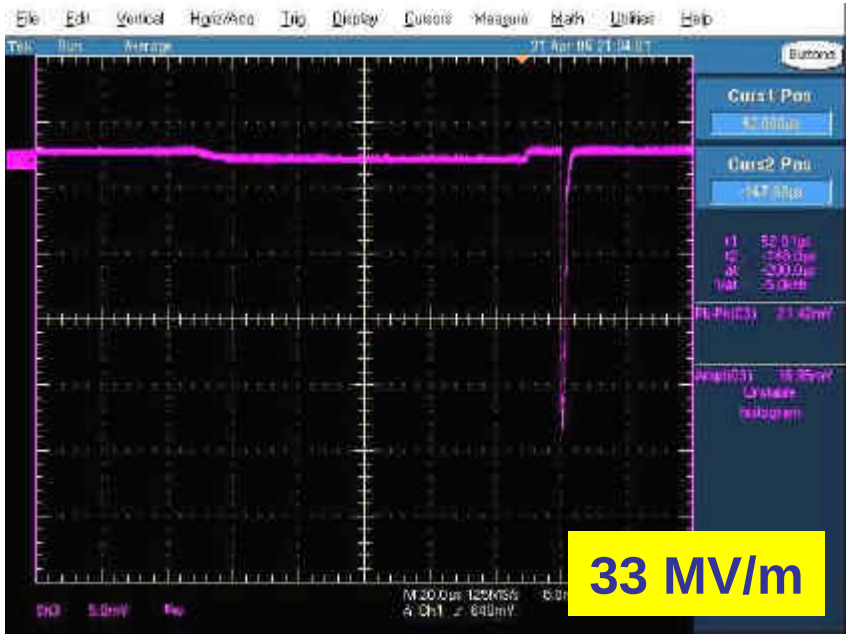

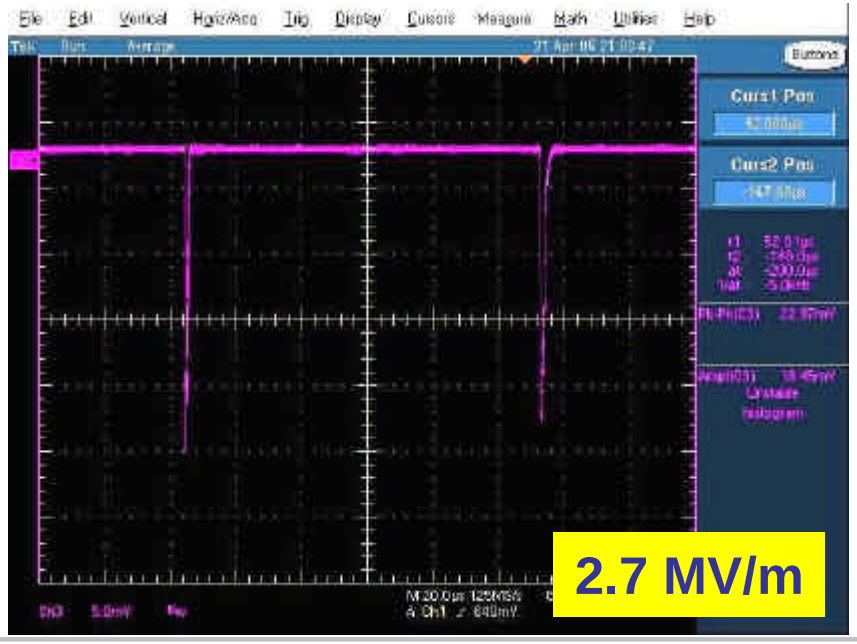

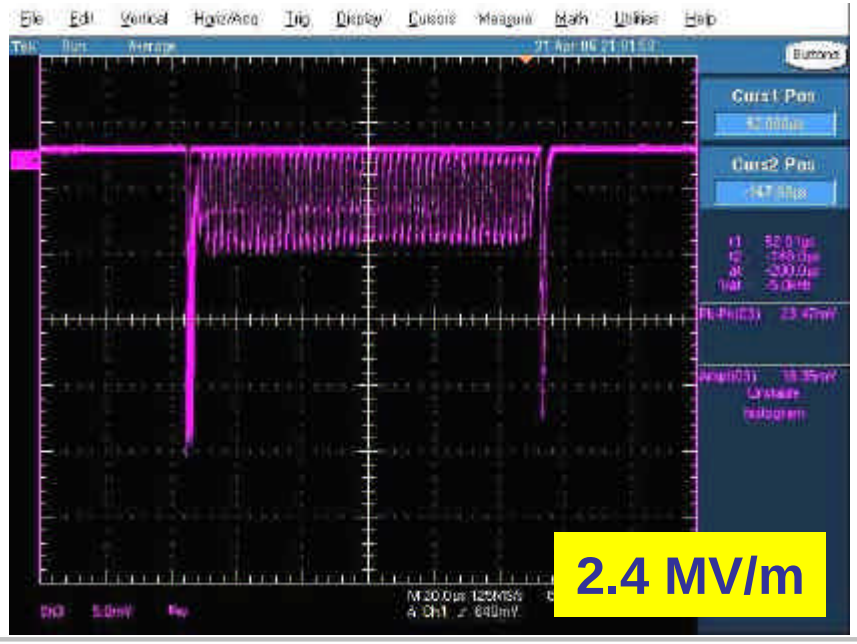

Measurement of the delay time

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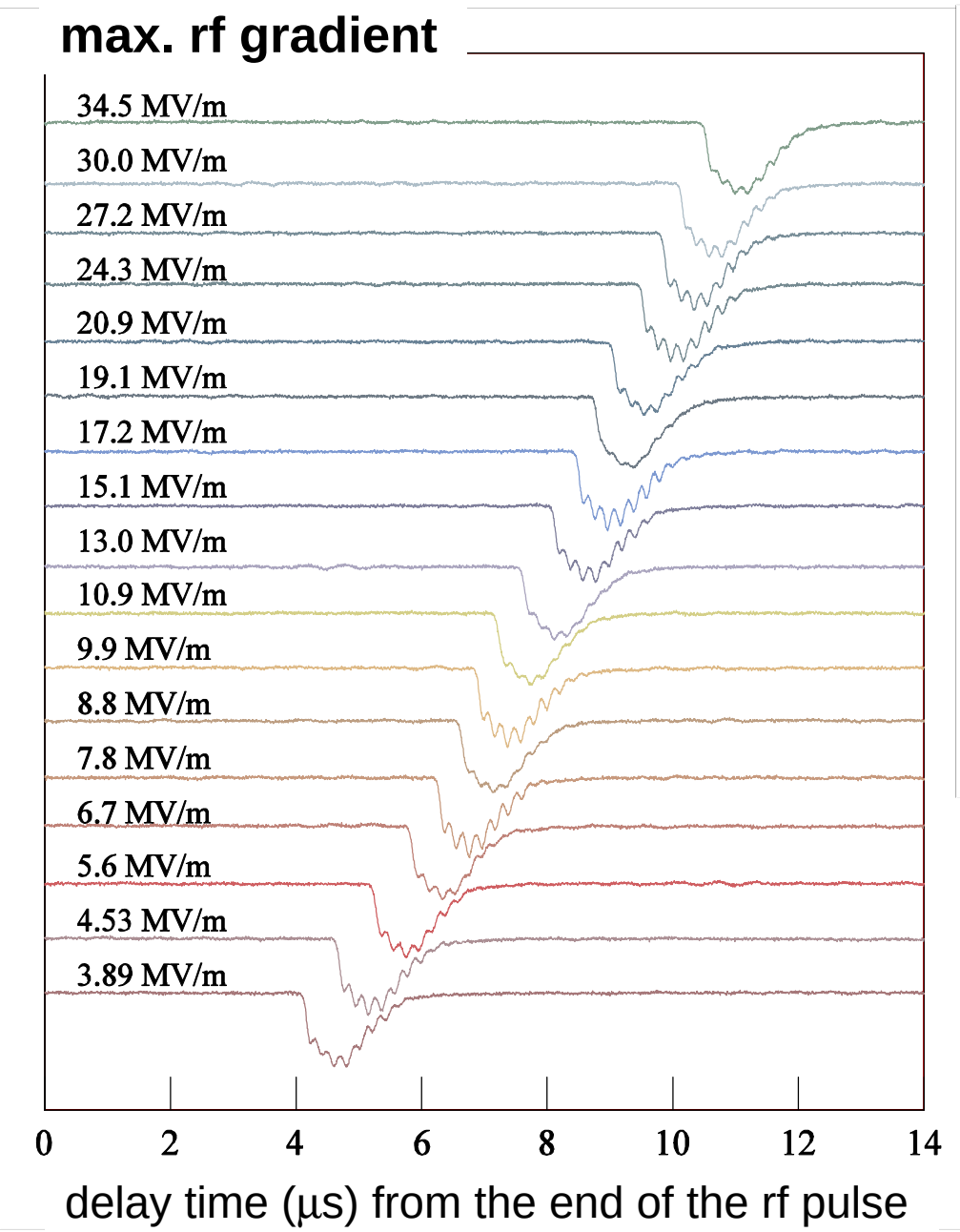

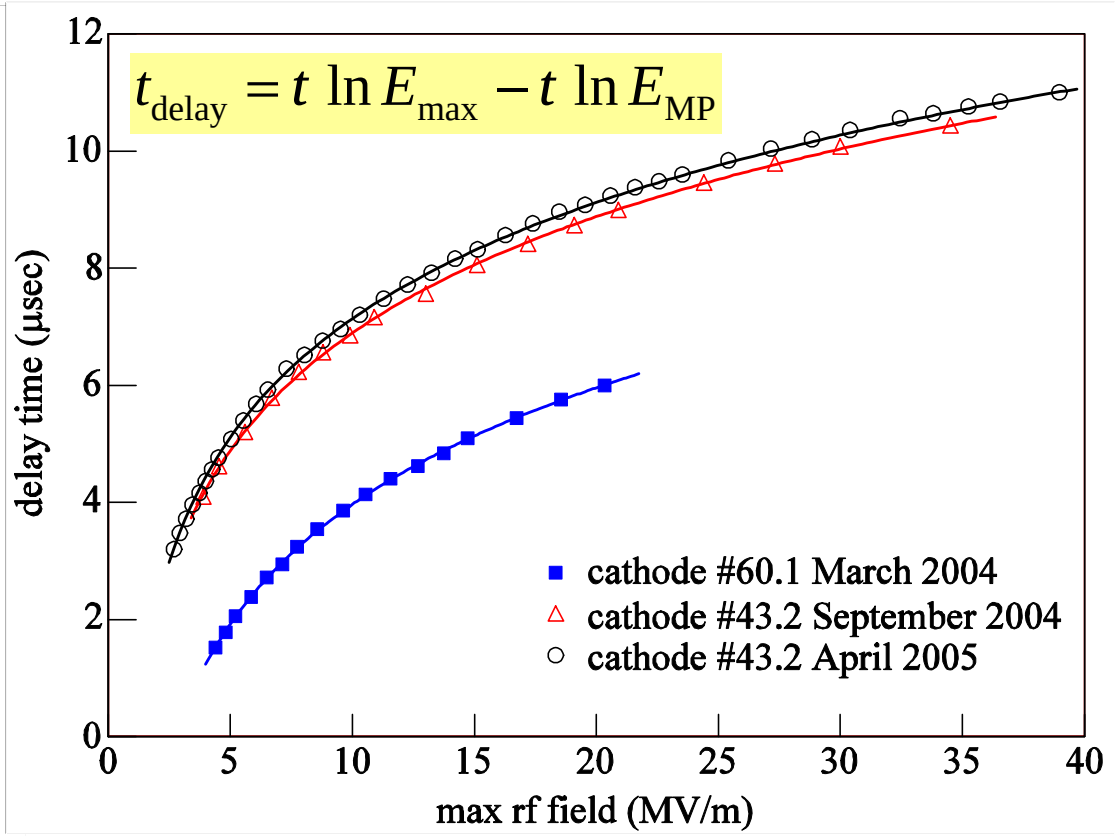

cathode	#60.1	#43.2	
Meas. time	Mar.04	Sep.04	Apr.05
E_{MP} (MV/m)	2.70	1.04	1.07
t (µs)	2.80	2.83	2.83

RF measurement in the cavity: 2.78 (µs)

Dependence on solenoid profile

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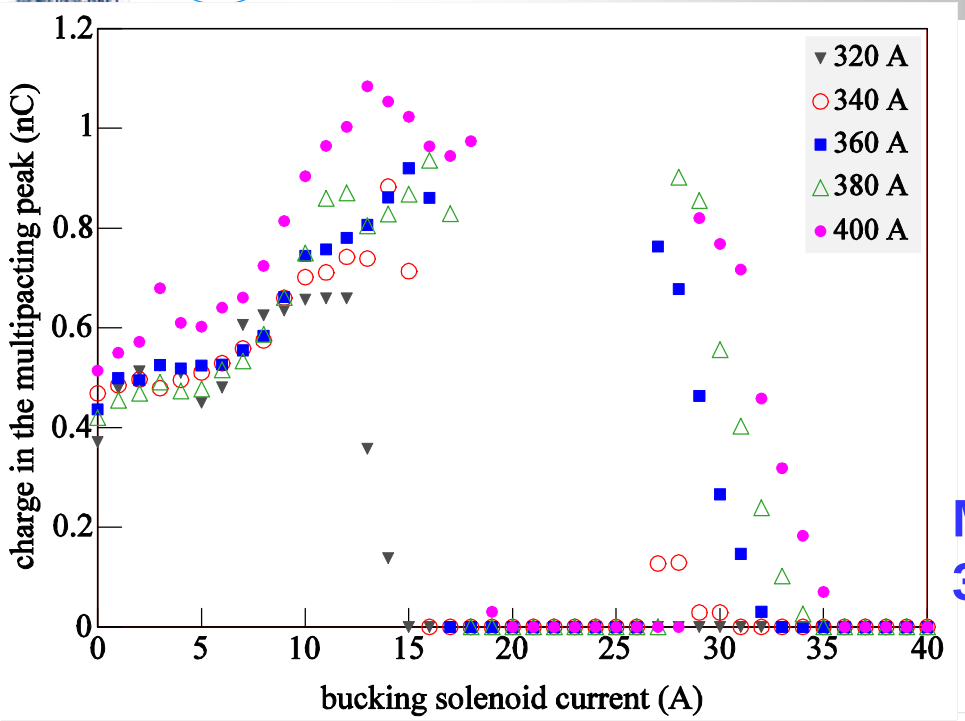
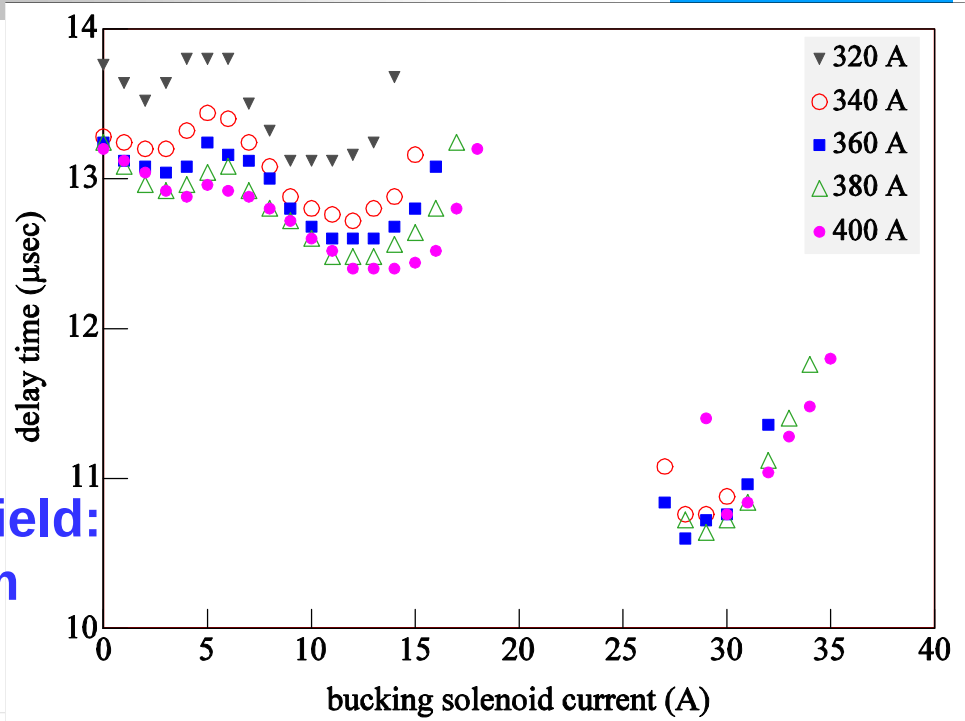
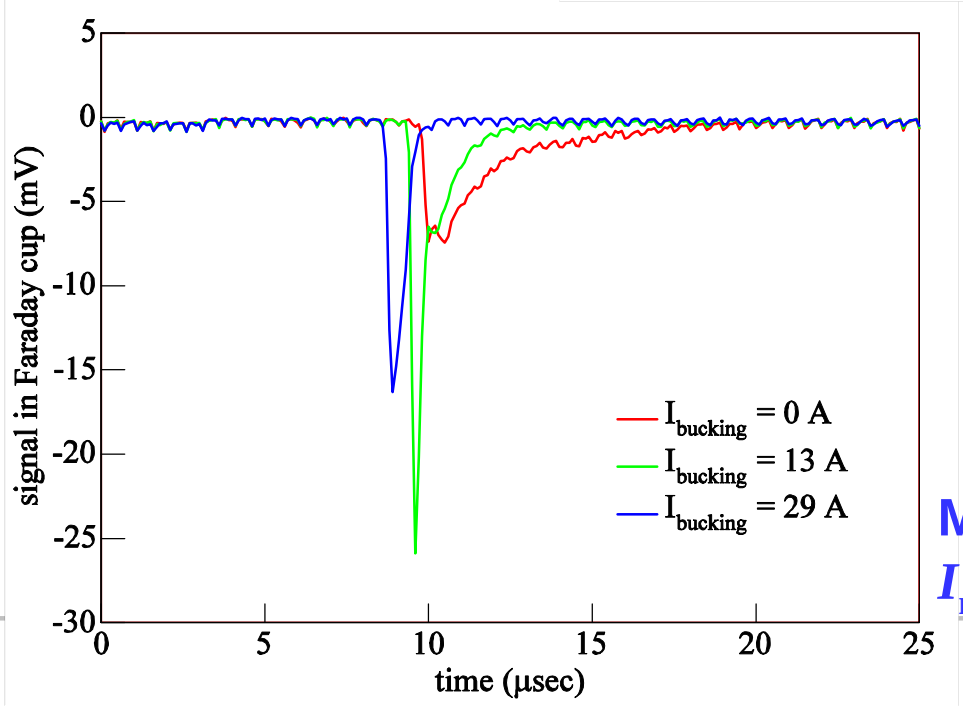


Max rf field:
39 MV/m





Max rf field: 39 MV/m
I_{main}: 400 A

Geometry of Cs_2Te cathode

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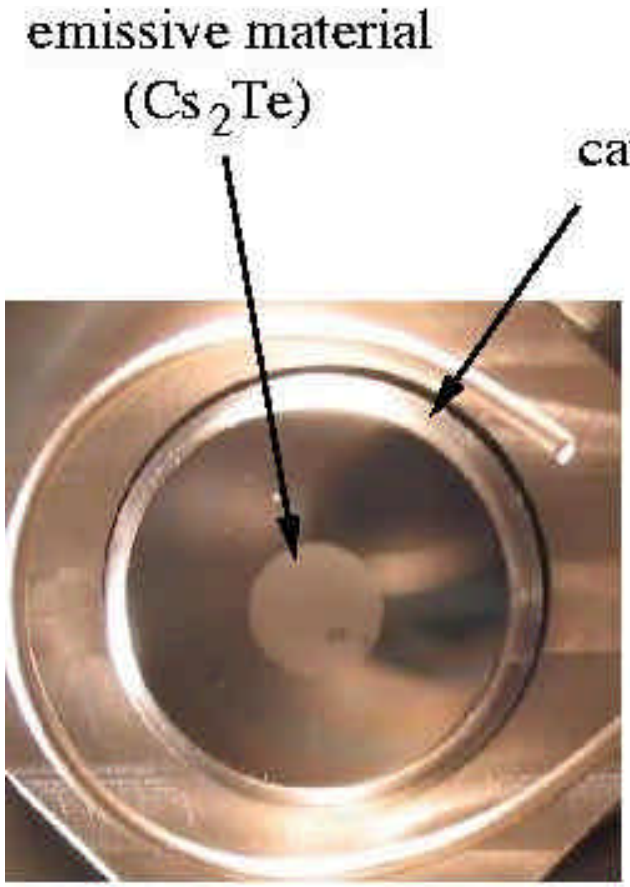
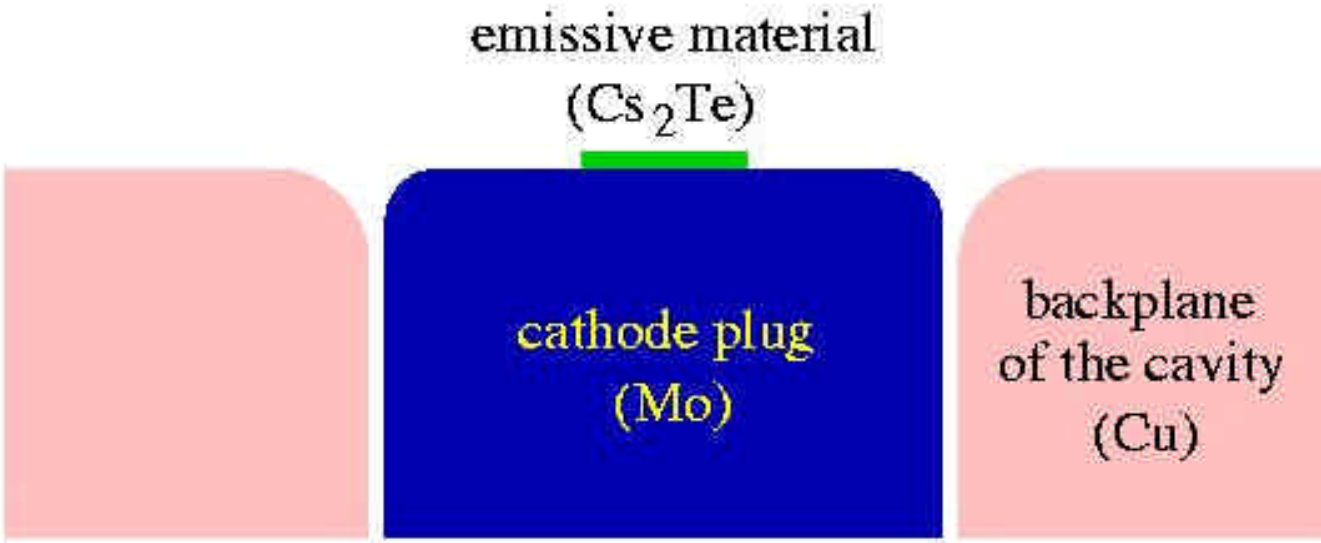
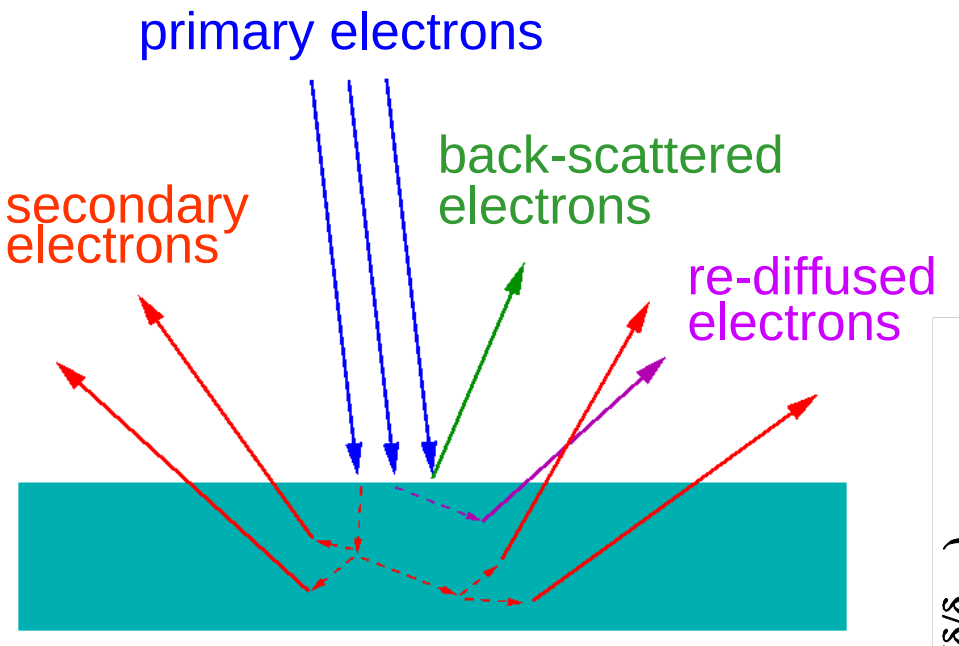


Front view of the cathode in the cathode chamber

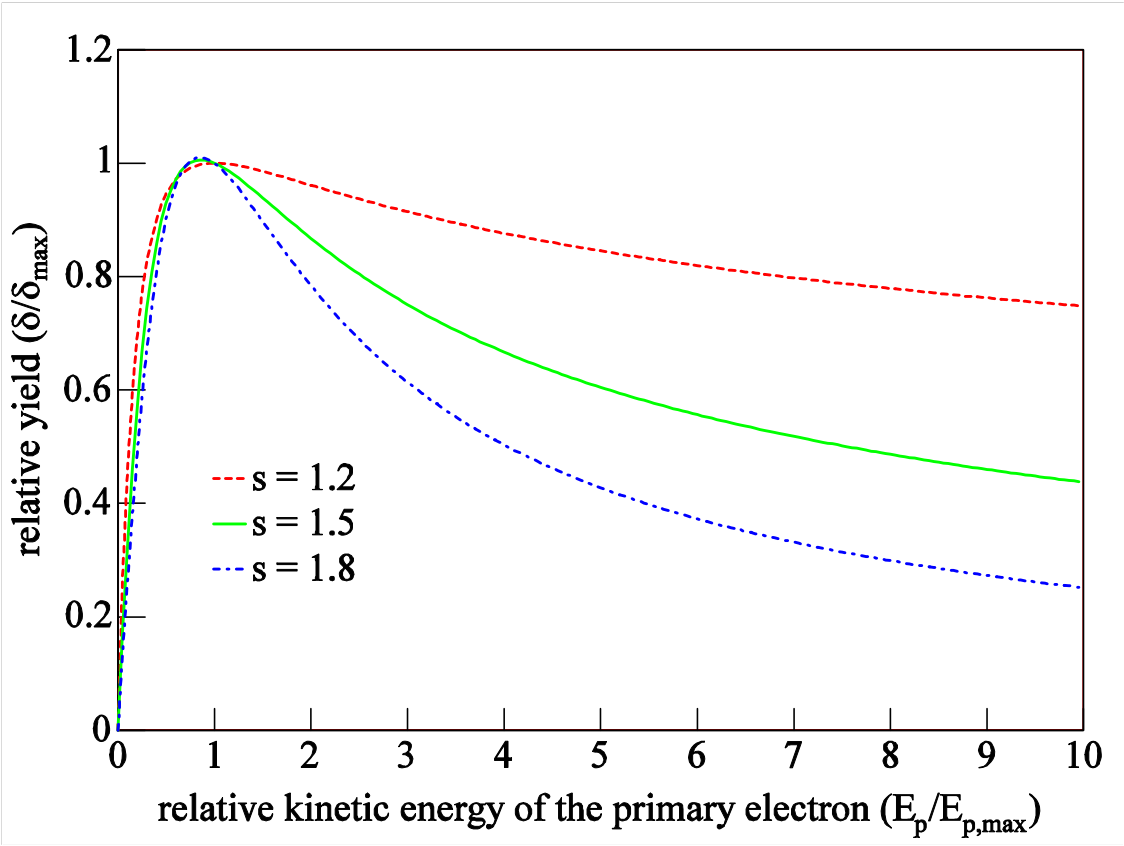


Schematic cross section of the cathode and the backplane of the Cu cavity

Numerical model of SE



$$d(E_p) = d_{\max} \frac{E_p}{E_{p,\max}} \cdot \frac{s}{s - 1 + \left(E_p / E_{p,\max}\right)^s}$$



This secondary emission model has been implemented into ASTRA

SE in the RF gun

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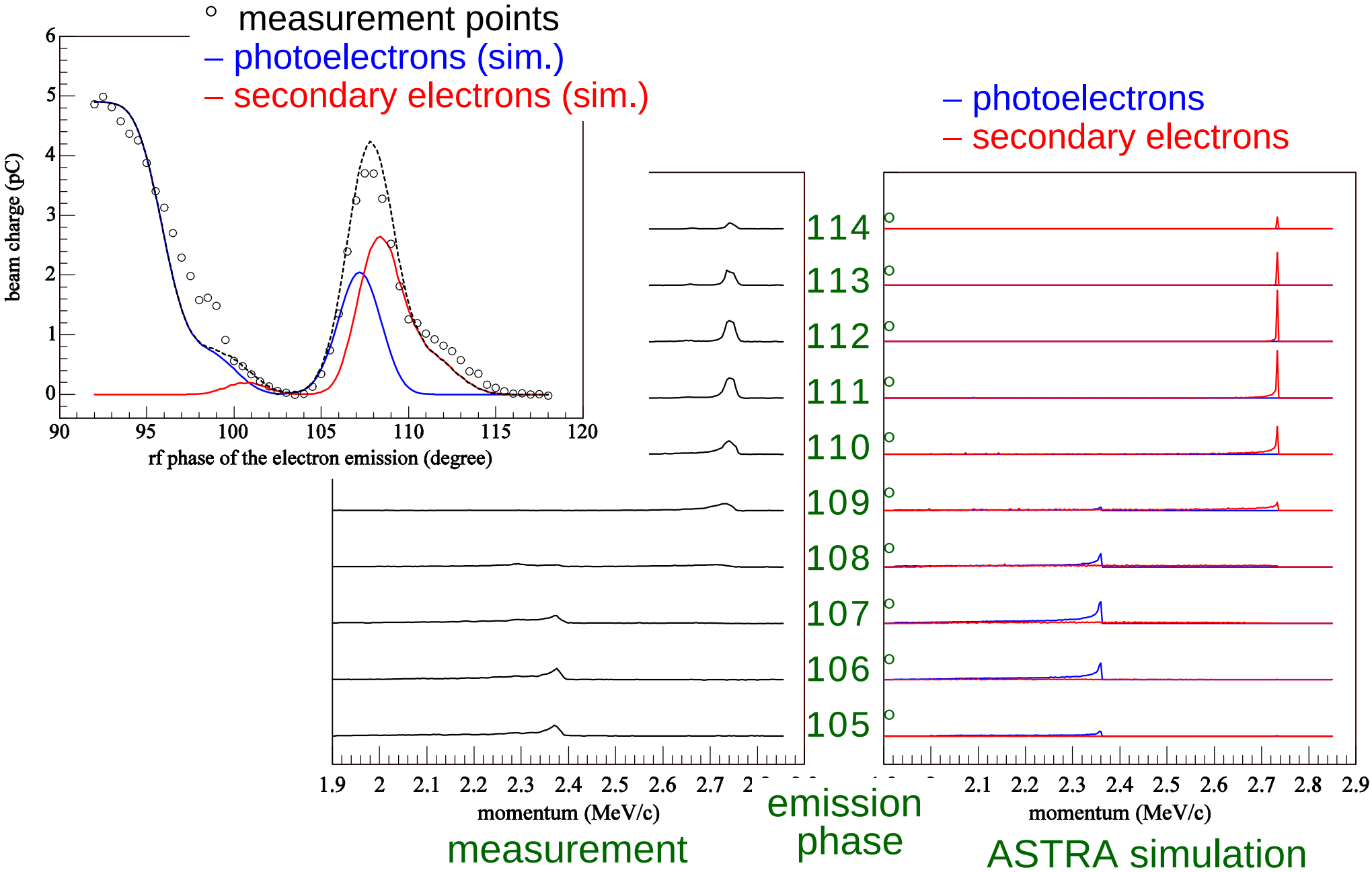
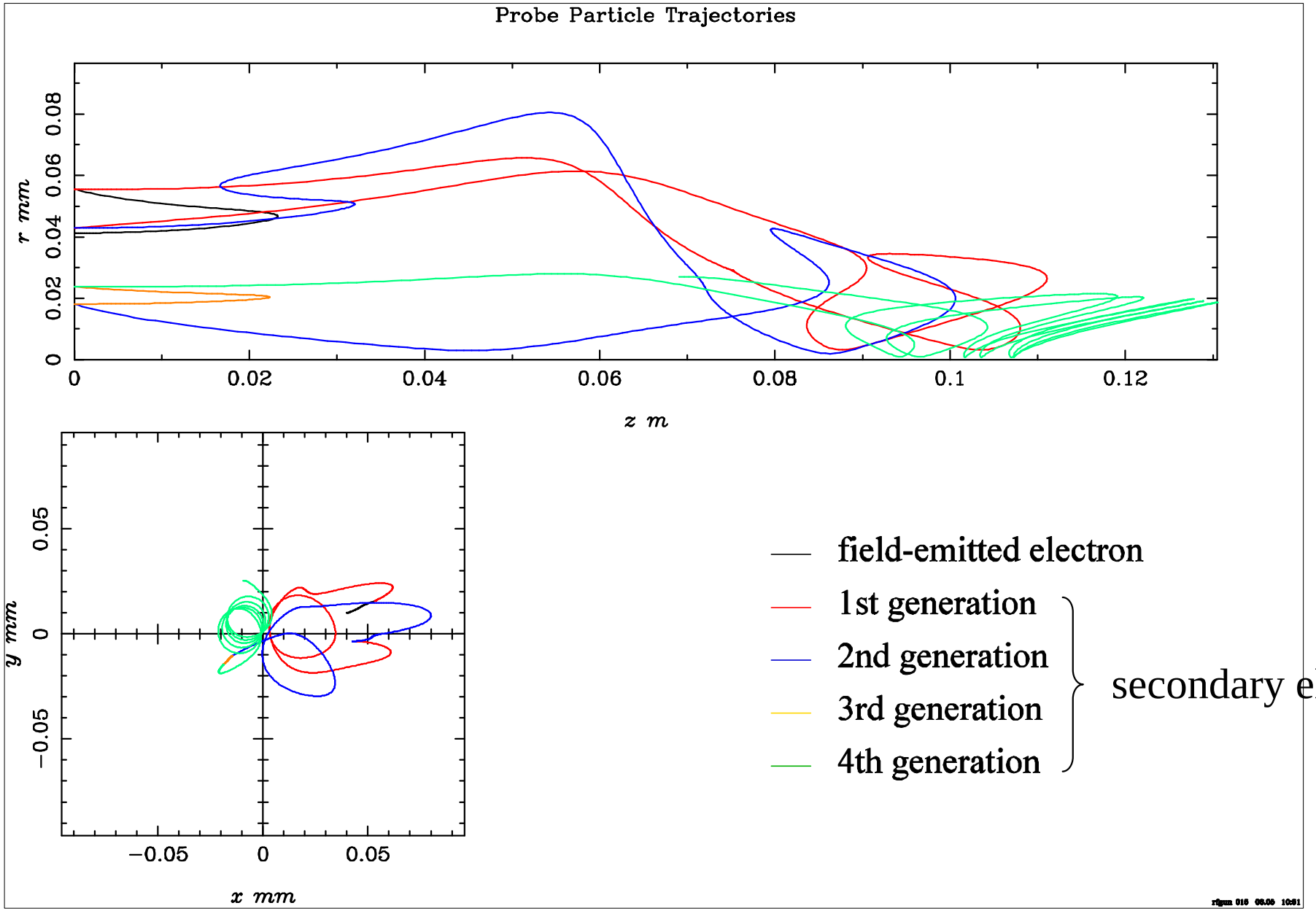


An example of electron trajectories



Multiplication Process (I)

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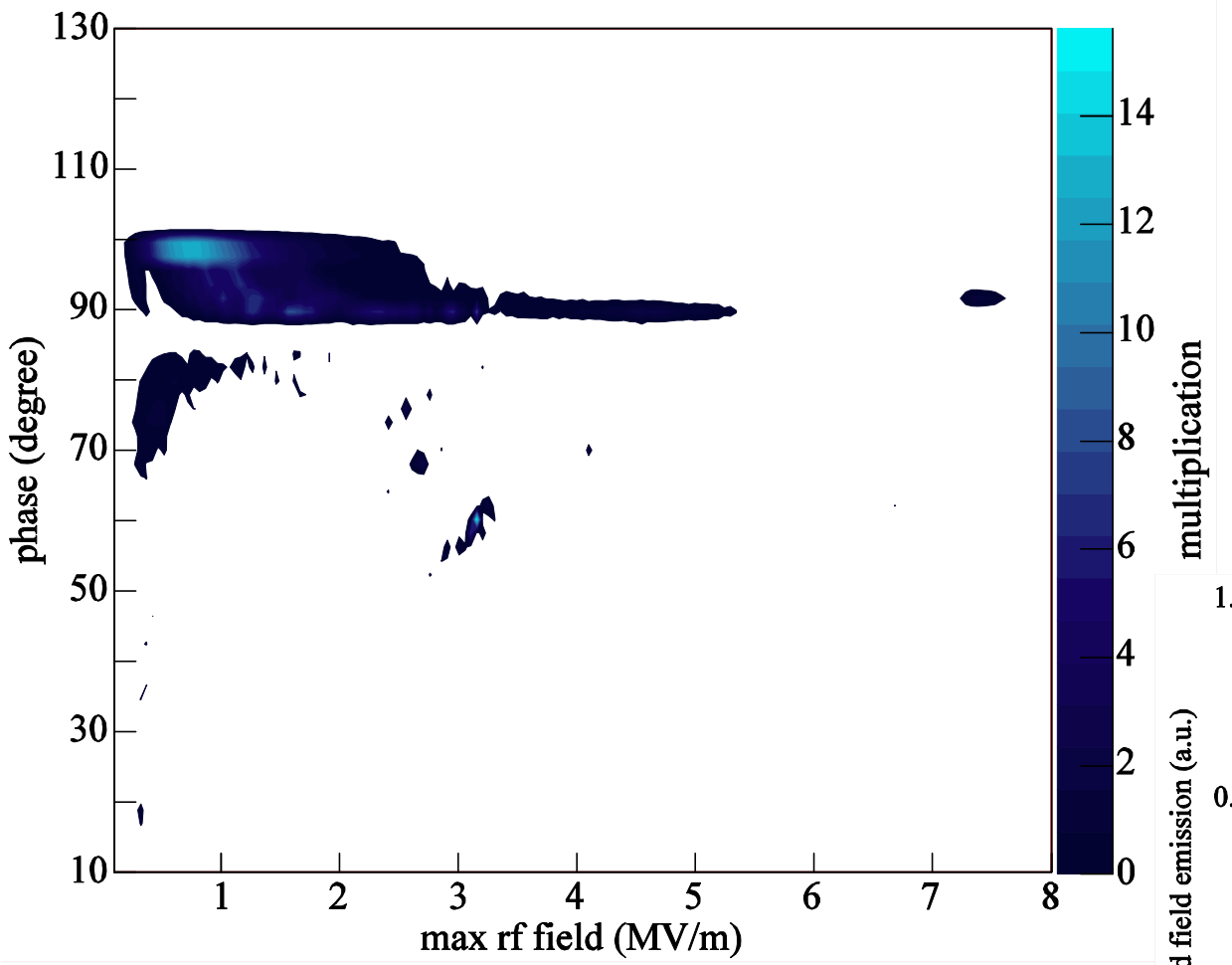
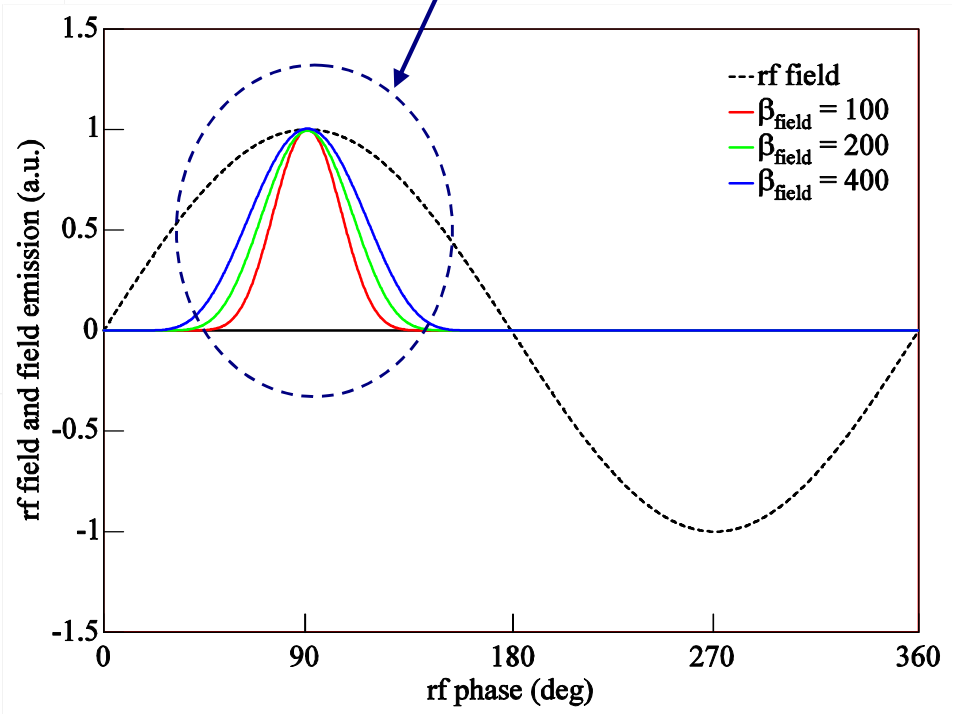
d_{max} = 20, E_{max} = 1 keV, s = 2.2



Most of dark current is emitted around 90 °



Electron multiplication as a function of the max rf field and the emission phase. Electron trajectories and secondary generation have been tracked for 100 rf cycles (~77 ns).

Multiplication Process (II)

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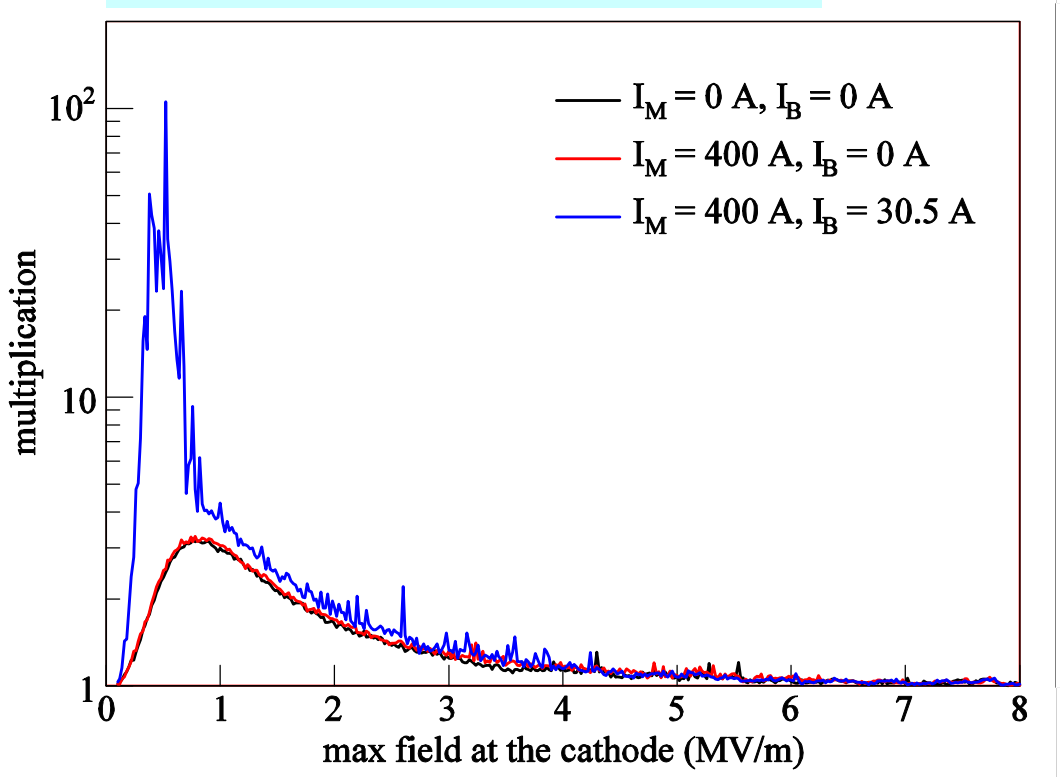
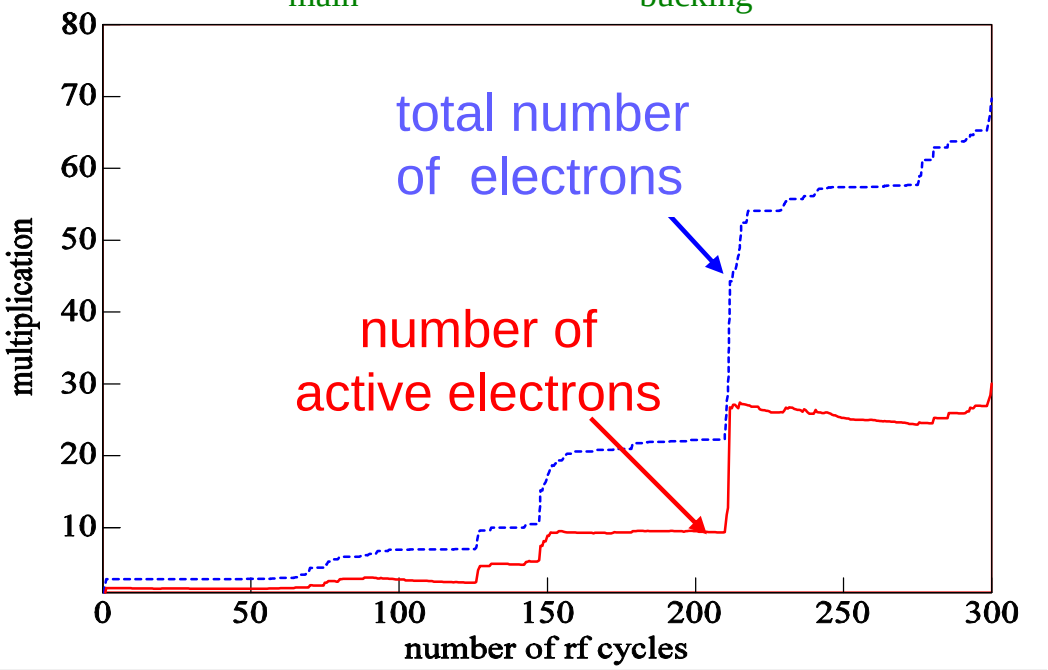
d_{max} = 20, E_{max} = 1 keV, s = 2.2



Multiplication after 140 rf cycles vs. the maximum field at the cathode for different main and bucking solenoid current

I_{main} = 400 A & $I_{bucking}$ = 30.5 A



Multiplication under the rf field decaying with a decay time of 2.78 μs starting from 0.6 MV/m of the maximum field strength. An exponential increase of the number of electrons is shown.

Summary (I)

- Multipacting takes place at the Cs_2Te photocathode at a low rf gradient (~1MV/m) with a strong influence of the solenoid field configuration.
- Due to the high SEY of the photocathode (Cs_2Te), the multipacting cannot be pressed out.
- The position and the field configuration of the solenoids has to be determined in order to prohibit the multipacting as well as to keep the emittance small.

Summary (II)

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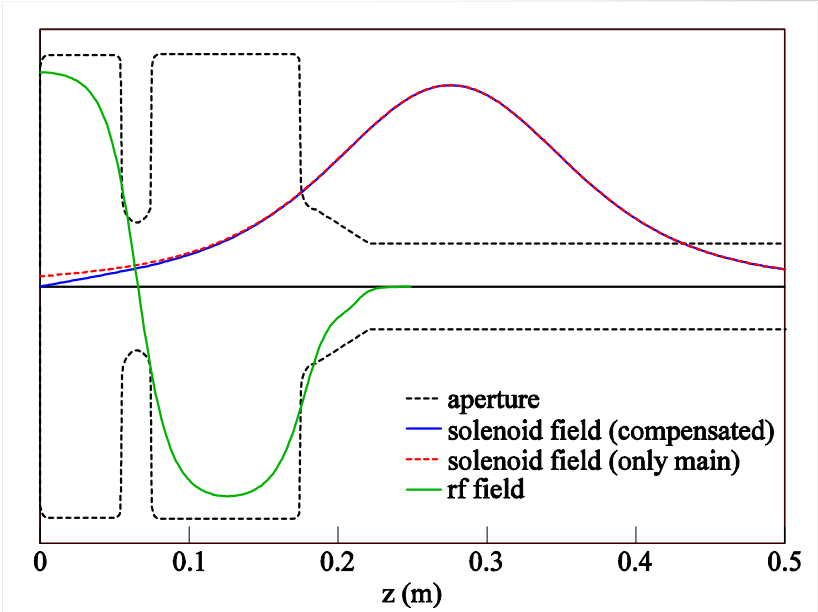
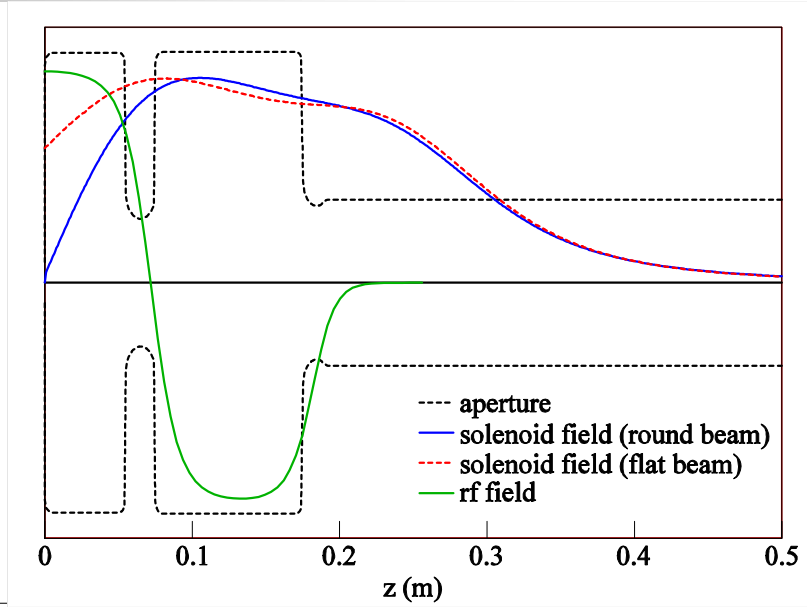
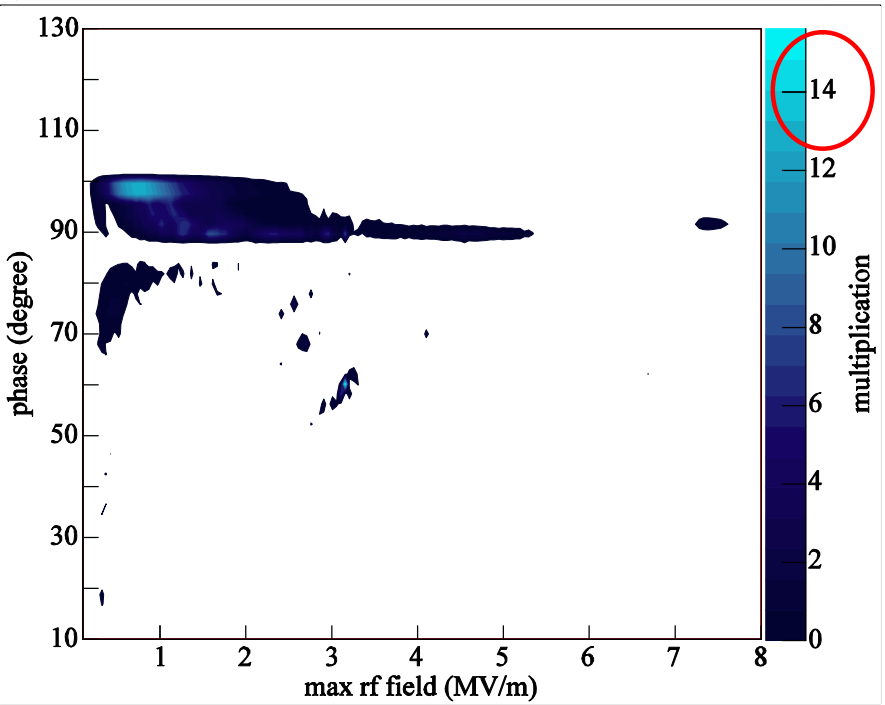


PITZ & VUV FEL





TTF phase1