Thermal Emittance in OPAL

February 3, 2009

Model [Flöttmann 1997, Clendenin 2000]

$$P(E_f, E_{ph} = \hbar\omega) \propto N_f(E_f) N_i(E_f - E_{ph} = \hbar\omega) \text{ with} \quad (1)$$

- $P(E_f, E_{ph} = \hbar\omega)$: probability for a photon of energy E_{ph} exiting an electron to a final state energy E_f.
- $N_f(E_f)$ is the density of final state
- $N_i(E_f - E_{ph})$ is the density of initial state

- Two cases, no-scattering (non-equilibrum) and scattering (equilibrium, e-e and e-phonon collisions) can be distinguished.
- A uniform radial distribution is assumed hence: $x_{rms} = \frac{r}{2}$.

Non-Equilibrum case

Photoemission from a metal involves fist the absorption of a photon with:

$$\hbar\omega > \Phi_e \tag{2}$$

where $\Phi_e = \Phi - \Delta$ is the reduced work function. The reduction is a function of the applied electric field E_c:

$$\Delta = e\sqrt{eE_c/4\pi\varepsilon_0}. \tag{3}$$

Electrons are emitted isotropic into the half-sphere with: $E_{kin} = \varepsilon_f + \hbar\omega$. Particles with angel φ larger than $\varphi_{max} = \arccos\sqrt{(\varepsilon_f + \Phi_e/E_{kin})}$ will pass the potential barrier.

$$p_x = p\sin\varphi\cos\theta,\ \varphi = [0\dots\varphi_{max}],\ \theta = [0\dots\pi] \tag{4}$$

and

$$p = m_0 c\sqrt{\gamma^2 - 1}. \tag{5}$$

Input Parameters for the simulation

- r_{rms} or distribution form virtual cathode!
- Cu, Fe, Cs2Te $\longrightarrow \Phi, \varepsilon_f$
- Laser: $\hbar\omega$
- Electric field: E_c Schottky effect

Question(s)

- Same model for Cu, Fe and Cs2Te?

no-scattering

Electrons are emitted isotropic into the half-sphere: $E_{kin} = E_f - E_{Gap}$
Particles with angel φ larger than $\varphi_{max} = \arccos\sqrt{(E_A/E_{kin})}$ will pass the potential barrier. E_A is the electron affinity ($E_A = E_T - E_{Gap}$).

$$p_x = p \sin\varphi \cos\theta,\ \ \varphi = [0 \ldots \varphi_{max}],\ \ \theta = [0 \ldots \pi] \qquad (6)$$

and

$$p = m_0 c \sqrt{\gamma^2 - 1}. \qquad (7)$$

scattering

Electrons are emitted isotropic into the half-sphere:
$E_{kin} = E_f - E_{Gap} - E_A$ with angel φ larger than $\varphi_{max} = \pi/2$.

- K. Flöttmann, Note on the thermal emittance of electrons emitted by Cesium Telluride photo cathodes
  TESLA FEL-Report, 1997-01.
- Reduction of thermal emittance of RF guns
  NIM A, 455 (2000) 198-201.