Home Work : Particle source Answer the following questions.

Q1. Fig.1 shows the polarization and quantum efficiency of a GaAs/GaAsP super-lattice photo-cathode prepared for the linear collider. The design team decided that the electron polarization must be 80% at the interaction point. Please specify the laser performance: wave length, bunch energy, bunch repetition, and average power in a macro-pulse. The ILC pulse contains 2625 bunches in 0.97ms. Bunch charge must be 3.2 nC at the interaction point. Please assume that 30% of the generated bunch charge at the cathode is lost before arriving at the interaction point. Any depolarization effects is not assumed.

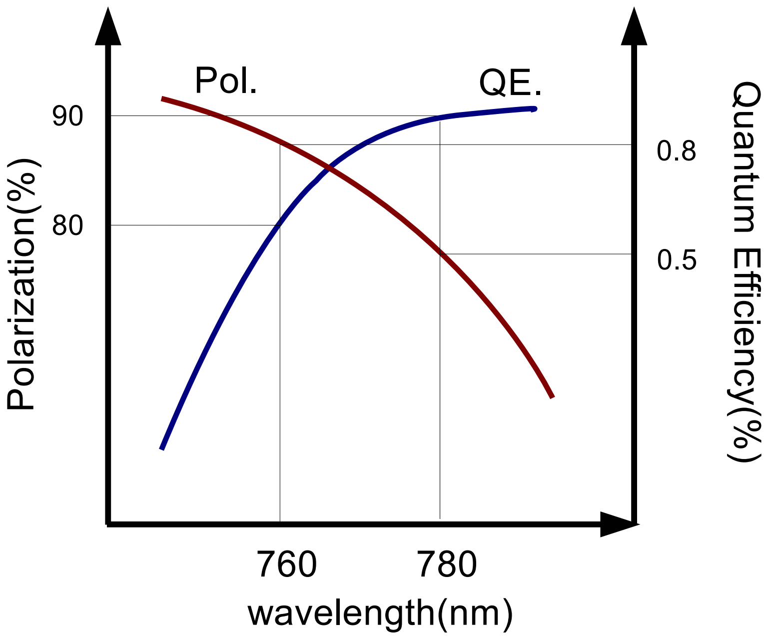

Figure 1: Polarization and quantum efficiency of GaAs cathode as a function of wavelength.

Q2. According to several technical limitations, the size of the cathode active area is 5mm in radius. The laser is illuminated on the cathode with the same area with flat intensity. To extract the beam, 200kV bias voltage is applied between the cathode and anode with 8.0cm gap. To extract the required bunch charge, how much is the appropriate laser bunch length? Please assume that the extractable current density from the gun is limited by space charge effect.

Q3. How much is γ and β (Lorentz factor) of the beam generated by the gun?

Q4. The generated bunch from the gun is too long for RF acceleration and has to be shorten by buncher. Choose appropriate frequency for energy modulation in bunching and answer the reason. Please assume that the accelerator RF is 1.3 GHz and the bunch repetition is 2.7MHz.

(a) 650.00 MHz

(b) 185.71 MHz

(c) 108.33MHz

Q5. Derive the condition for the perfect bunching,

$$d\tau = -\frac{LeV_0\omega}{c\gamma^2\beta^3 E}dt. \tag{1}$$

by considering drift time for a section length L and its energy derivative.

Q6. RF cavity for bunching section is designed with the frequency chosen in Q4. The shunt impedance of the cavity is 2.0×10^6ohm and available input RF power is 20kW. What is the distance from the cavity to the first accelerator, i.e. total length of the bunching section?

Q7. Positron is generated by cascade shower in material. Assume that the electron energy becomes half in each step by bremsstrahlung. Derive the following equation for the shower max length

$$x_{max} = X_0 \left[\frac{\ln\left(\frac{E_0}{E_c}\right)}{\ln 2} - \ln 2 \right], \tag{2}$$

where E_0 is initial electron energy, E_C is critical energy, X_0 is radiation length defined as

$$\frac{dE}{dx} = \frac{E}{X_0}. \tag{3}$$

Q8. Assuming W(Tungsten) target (Z=74, A=184, ρ =19.3 g/cm^3) and 2.0 GeV drive electron energy. What is the optimum thickness of the target in radiation length and cm?

Q9. For the undulator positron generation, the cut off energy of the gamma from undulator must be enough for pair-creation. How much is the electron drive beam energy for 10 MeV cut off energy of 1st mode in GeV? Undulator period λ_u is 1.1cm and K value is 0.9. Please assume gamma ray radiation angle θ is 0.

Q10. For the laser compton positron generation, the cut off energy of the gamma from laser compton must be enough for pair-creation. How much is the electron drive beam energy for 10 MeV cut off energy of 1st mode in GeV? The laser wavelength is 1053nm and the gamma ray is emitted to $\theta = 0$.