# 1 Photon Flux

In the electroproduction when the virtuality of the transferred photon is small $Q^2 \sim 0$, the electroproduction cross-section can be parametrized as a product of the photoproduction cross-section and the virtual photon flux.

$$\sigma_e = N_\gamma(E_\gamma)\sigma_\gamma \tag{1}$$

where $\sigma_e$ is the electroproduction cross-section, $\sigma_\gamma$ is the photoproduction cross-section, and the $N_\gamma(E_\gamma)$ is a flux of virtual photon, that represents number of virtual photons in the unit range of photon energy. This is known as Equivalent Photon Approximation (EPA).

In the electroproduction experiments, beam electrons will produce Bremsstrahlung photons in the target also, the flux of that photons is proportional to the target length. When the target length is not very small (w.r.t radiation length of the target), then real photon flux can be significant and one needs to consider that also.

The effective flux of photns therefore will be the sum of quasi-real (Virtual photon) and real (Bremsstrahlung) photon fluxes.

The virtual photon flux is calculated using the following equation [1]

$$N(E_\gamma) = \frac{1}{E_b}\frac{\alpha}{\pi \cdot x} \cdot \left( (1 - x + \frac{x^2}{2}) \cdot log(\frac{Q^2_{max}}{Q^2_{min}}) - (1-x) \right) \tag{2}$$

where $E_b$ is the beam energy, $E_\gamma$ is the photon energy, $x = \dfrac{E_\gamma}{E_b}$, $Q^2_{min}$ is kinematically allowed minimum value of $Q^2_{min}$, and $Q^2_{max}$ is the cutoff value on $Q^2$.

When electron passes a matter of the length $dx$, the number of Bremsstrahlung photons with a good approximation can be calculated using the following formula [2] (section: passage of particles through the matter).

$$N(E_\gamma) = \frac{dx}{X_0}\frac{1}{E_\gamma} \cdot \left( \frac{4}{3} - \frac{4}{3}\frac{E_\gamma}{E_b} + \frac{E^2_\gamma}{E^2_b} \right) \tag{3}$$

Here $X_0$ is the radiation length.

In the Bremsstrahlung case, when the photon is produced at x distance from the beginning of the target, then it will travel only $l - x$ distance in the target ($l$ is the target length). Taking into account this, in the luminosity calculation one need to take the integral $\int_0^l N(E_\gamma) \cdot (l-x)dx$. After calculating the integral, one finds that the effective flux will be

$$N(E_\gamma) = \frac{l}{2 \cdot X_0}\frac{1}{E_\gamma} \cdot \left( \frac{4}{3} - \frac{4}{3}\frac{E_\gamma}{E_b} + \frac{E^2_\gamma}{E^2_b} \right) \tag{4}$$

In. Fig.1 shown virtual (red) and real (blue) photon fluxes as a function of photon energy. Note that in the calculations target langth was taken 15 $cm$ and the $Q^2_{max} = 0.1\ GeV^2$. For the total integrated flux in the $E_\gamma \in (9. - 11)\ GeV$ range, we estimated $N = 0.00241179$ (virtual) + $0.00153735$ (real) $= 3.949 \times 10^{-3}$ photons per electron.

# References


[1] http://lss.fnal.gov/archive/other/lpc-94-35.pdf

[2] Chin. Phys. C, 38, 090001 (2014)

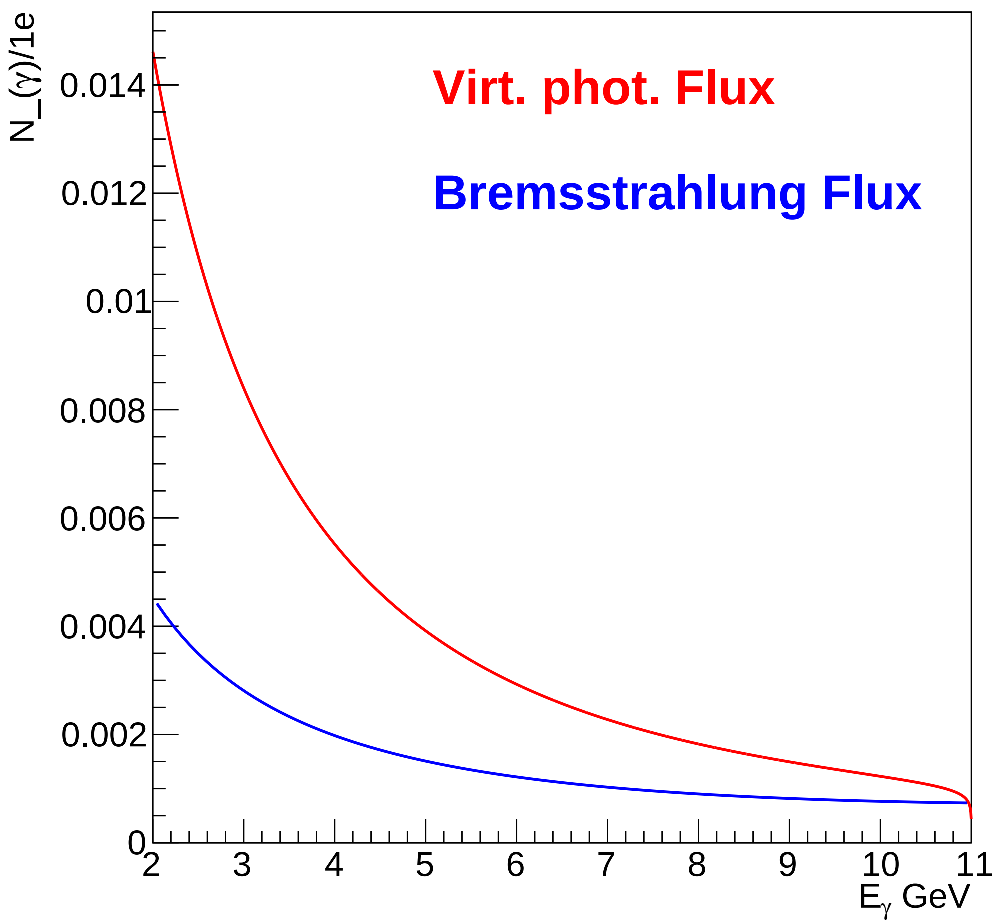


Figure 1: Virtual (red) and Real (blue) photon fluxes as a function of photon energy.