Multi-peak Structure of the LPM shower in the dense media

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Abstract: The LPM showers have strong fluctuation in their development. Their fluctuation become effective rapidly in high density material, such as lead and tungsten, as the primary energies increase. The multi-peak structure in the LPM shower appears at extremely high energies in high density material. We discuss the characteristics of multi-peak structure in the present paper.

1. Introduction

The characteristics of the LPM shower is as follows [2][3][4][5]: (a) The average behavior of the LPM shower is quite different from that of the BH(Bethe-Heitler) shower. (b) The behavior of individual LPM shower deviate greatly from the average behavior of the LPM shower. The first "observation" of the multi-peak structure of the LPM shower in computer numerical experiment is found in [1]. The multi-peak structure in the electromagnetic cascade shower is the proper characteristics of the LPM shower and it could not be observed in the BH showers where the LPM effect could be neglected. The LPM effect become strongly effective in both higher primary energies and the dense media, such as lead and tungsten. In Figure 1, we give the differential cross sections with the LPM effect for the bremsstrahlung in tungsten. It is clear from the Figure 1 that the probability to emit lower energy photon decrease as their primary energy increase In Figure 2, we give the differential cross section with the LPM effect for pair creation in the same substance. It is understood from the figure that in addition to too longer mean free path with increasing energy non-uniform energy distribution energy between electron and positron attains at maximum at about 10 to 15 eV. In Figure 3, we give the mean free paths of the electrons due to the bremsstrahlung with the LPM effect in tungsten and lead. In Figure 4, we give the corresponding ones for the photons due to the pair creation with the LPM effect. It is clear from those figures that the mean free paths of shower particle increase rapidly as their primary energies increase.

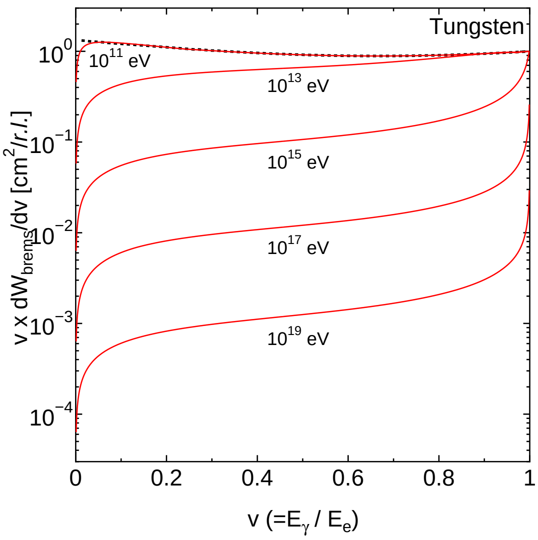

Figure 1: Differential cross sections for the bremsstrahlung with the LPM effect in tungsten for different primary electron energies.

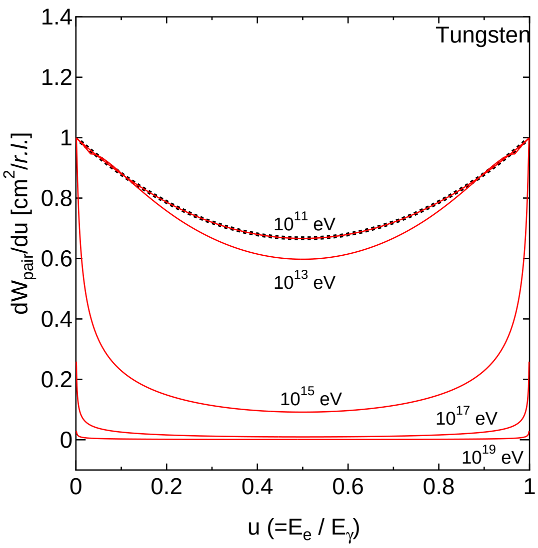

Figure 2: Differential cross sections for the pair creation with the LPM effect in tungsten for different primary photon energies.

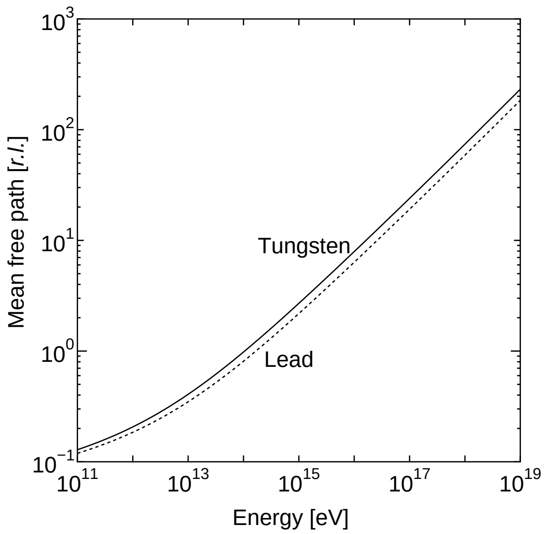

Figure 3: The mean free paths of the electron due to the bremsstrahlung with the LPM effect in lead and tungsten.

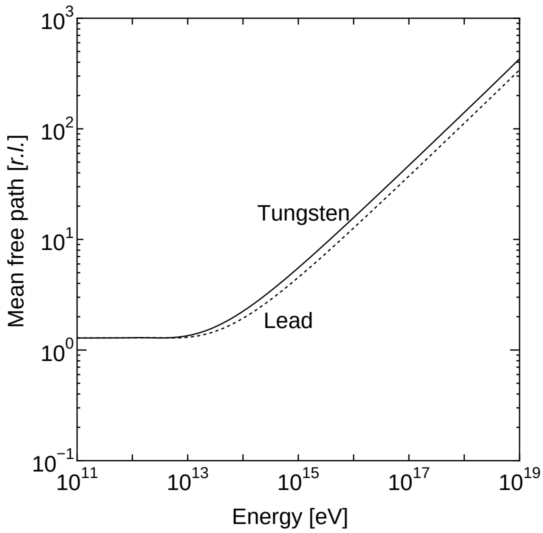

Figure 4: The mean free paths of the photon due to the pair creation with the LPM effect in lead and tungsten.

2. The behavior of the individual LPM shower

In Figure 5, we give the transition curves for electron initiated by primary electrons with 10 to 15 eV, in which the average picture from 100 sampling and three individual showers. The fluctuation effect appear in shower to shower. In Figure 6, we give case with primary energy 10 to 16 eV. The average picture is also obtained from 100 sampling. If we have enough sampling number, the averaged curve becomes more smooth. However, we could understand the big fluctuation in the showers, comparing individual shower with the averaged curve. In Figure 7, we give only three individual shower with primary energy 10 to 17 eV, which shows clear multi-peak structure in the electromagnetic cascade showers. The character of the multi-peak structure appear are supposed to appear at primary energy 10 to 17 eV in tungsten and lead.

3. Conclusion

LPM showers are strongly influenced by the fluctuation compared with the BH showers. Significant fluctuation in the LPM shower makes it to difficult

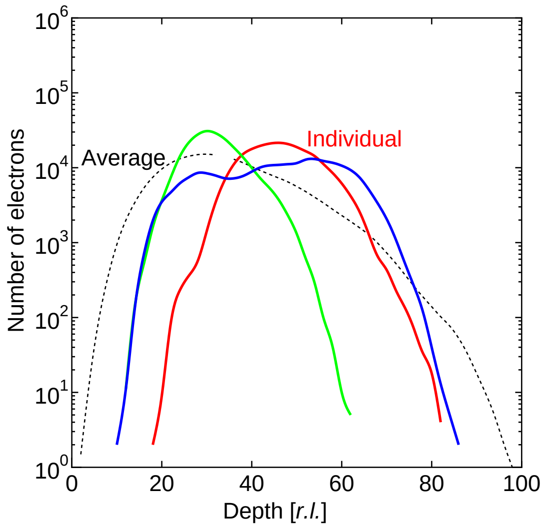

Figure 5: Average and three individual behavior of the LPM shower for electron numbers for 10^{15} eV due to primary photon.

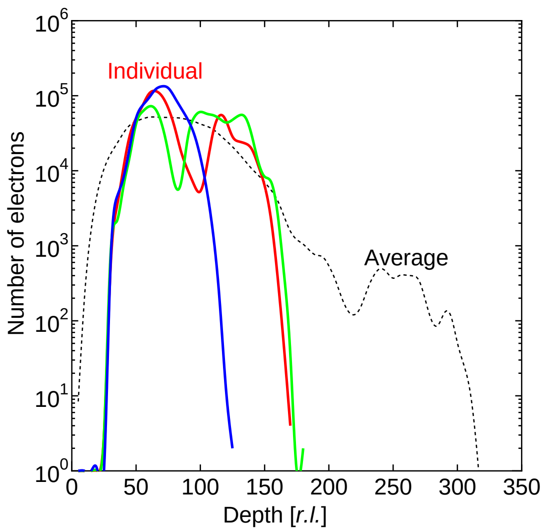

Figure 6: The corresponding ones for 10^{16} eV.

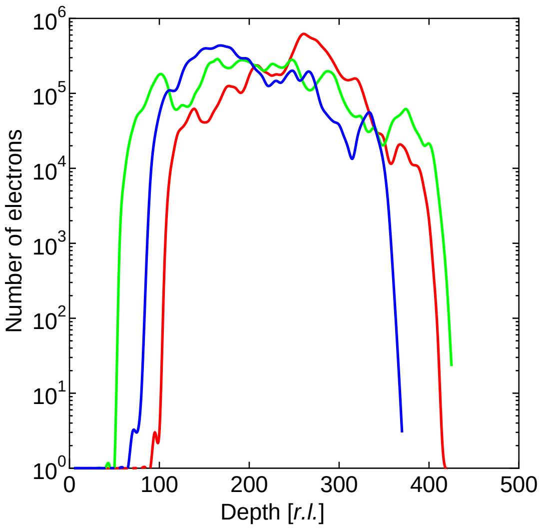

Figure 7: The corresponding ones for 10^{17} eV.

to determine its energy determination. Usually, we do not attribute the origin of the multi-peak structure of the shower to purely electromagnetic cascade shower, but to nuclear shower with unknown interaction. How to determine the energy of the LPM shower is an open problem for future.

References

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