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P1.36: Primary scintillation in Xe for electrons and alpha-particles

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Gaseous xenon (GXe) is playing an increasingly significant role in important areas of neutrino physics such as double beta decay and double electron capture experiments, and is a potential alternative to MeV-region γ-ray imaging. The capability for simultaneous readout of both ionization and scintillation signals and for topology reconstruction of the ionizing particle tracks are important advantages of GXe. In addition, GXe allows for improved energy resolution when compared to liquid xenon (LXe). The precise knowledge of the xenon response to radiation interactions in both scintillation and ionization channels is of utmost importance for the exact understanding and modulation of xenon radiation detectors.

The primary scintillation yield, i.e. the mean energy required to produce a scintillation photon, wsc, of GXe is far less understood than the ionization yield due to the limited number of studies in the literature. While for 5.5-MeV α-particle interactions the wsc-value was measured to be in the 34-60 eV range, for electrons, measuring the primary scintillation produced by x- and γ-ray interactions, the wsc-value was measured to be in the 61 - 111 eV range.

The average energy expended per excited atom in GXe is expected to be similar for x-, γ-rays or electrons and almost equal to that obtained for α-particles. However, the results presented in the literature are inconsistent with that expectation and not fully understood, as can be only partially ascribed to the different gas density and/or drift field conditions. One may also pose the question of a dependence of wsc with photon energy.

We carried out a systematic study on the absolute primary scintillation yield in Xe under reduced electric fields in the 70–300 V/cm/bar range and near atmospheric pressure, 1.2 bar, using a Gas Proportional Scintillation Counter. Our results are supported by a robust geometrical efficiency simulation model. Neglecting the 3rd continuum emission, a mean wsc-value of 38.7 ± 0.6 (sta.) +7.7 −7.2 (sys.) eV was obtained for x/γ-rays in the 5.9–60 keV energy range and for α-particles in the 1.5–2.5 MeV range, and no significant dependence neither on radiation type nor on energy has been observed. If the Xe 3rd continuum emission is to be considered, the average energy to produce a 2nd and 3rd continuum photon can be calculated as w2nd = 43.5 ± 0.7 (sta.) +8.7 −8.1 (sys.) eV and w3rd = 483 ± 7 (sta.) +110 −105 (sys.) eV, respectively, while the energy to produce a 3rd or 2nd continuum photon is w2nd+3rd = 39.9 ± 0.6 (sta.) +8.0 −7.4 (sys.) eV, assuming a 3rd to 2nd continuum yield ratio of 0.09, as recently reported.

The absolute electroluminescence yield was also measured in our setup for a wide range of electric fields, showing a mean disagreement of 7% with the simulation data. If we consider the El-yield as reference, the mean wsc-value corrected for this difference is wsc = 41.6 ± 0.6 (sta.) +6.2 −6.4 (sys.). Our experimental wsc-values agree with both state-of-art simulations and literature data obtained for α-particles. The discrepancy between our results and the experimental values found in literature for x/γ-rays is discussed and attributed to undressed large systematic errors.

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