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Interactive comment on "Evaluation of Monte Carlo tools for high energy atmospheric physics" *by* Casper Rutjes et al.

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We would like to thank the referee for his/her comments. We agree that further steps would be desirable in order to achieve full validation. The general purpose codes used in this benchmark (EGS5, FLUKA and Geant4) are in other physical contexts validated against experiments.

Two specific comments.

1. Referee #2 states: line 11, page 2: in the large-scale electric field theory, seed electrons might also originate from lightning leaders. See, e.g., section 4.6.2 of Dwyer, Smith and Cummer, Space Science Reviews, 2012.

Line 11, page 2 reads: The first electrons are typically supplied by cosmic particles

from the sun or from other galactic or extragalactic sources.

Or reply: We agree. We added the following line for more clarification: "High energy seed electrons might also origin from lightning leaders, from radioactive decay or from some mixed form of electron sources."

2. Referee #2 states: page 5, line 25. In the discussion of positronium, the lifetimes are for vacuum. Will any positronium be disrupted in 1 bar air before decaying? Which of the programs, if any, handle two versus three photon decay of positronium? This effects the magnitude of the 511 keV line in TGF photon spectra, produced in the atmosphere.

Line 25, page 5 reads: The standard implementation is that, when a positron drops below the low energy cut-off, it comes to rest immediately (in space and time). In reality the positron will come to rest over some distance and time, forming positronium (e.g. an e+e− bound state), before annihilation. The positronium has a lifetime depending on the spins of the positron and electron (Karshenboim, 2004), forming a singlet or triplet state with lifetimes of 124 ps or 139 ns (in vacuum), respectively.

Our reply: The positronium discussion was added to point out that reality is different than the standard implementation. We have added the following lines for more clarification; "If the triplet state is formed in a medium like air, the lifetime permits "pick-off" annihilation where an opposite spin electron from the medium will annihilate in singlet orientation before the triplet-oriented electron can collapse and annihilate with the positron, thus resulting in again 2 photons (instead of 3). Thus, besides a small time delay, the magnitude of 511 keV line in the photon spectrum is not changed. None of the codes with the settings used in this benchmark include positronium."

The typo has been corrected in the updated manuscript.

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