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Higgs boson production in photon-photon interactions with proton, light-ion, and heavy-ion beams at current and future colliders

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The production of the Higgs boson in photon-photon interactions with proton and nucleus beams at three colliders planned or proposed at CERN — the high-luminosity Large Hadron Collider (HL-LHC), the high-energy LHC (HE-LHC), and the Future Circular Collider (FCC) — is studied. The cross sections for the process A $\gamma\gamma$ A$\rightarrow$(A) H (A), with the ions A surviving the interaction and the Higgs scalar exclusively produced, are computed with Madgraph 5 modified to include the corresponding elastic γ fluxes, for Pb-Pb, Xe-Xe, Kr-Kr, Ar-Ar, O-O, p-Pb, and p-p over the nucleon-nucleon collision energy range $\sqrt{s_{\rm NN}} \approx 3$–$100$ TeV. Simulations of the $\gamma\gamma \rightarrow$ H $\rightarrow b\bar{b}$ decay mode — including realistic (mis)tagging and reconstruction efficiencies for the final-state b-jets, as well as appropriate kinematical selection criteria to reduce the similarly computed $\gamma\gamma \rightarrow b\bar{b}, c\bar{c}, q\bar{q}$ continuum backgrounds — have been carried out. Taking into account the expected luminosities for all systems, the yields and significances for observing the Higgs boson in ultraperipheral collisions (UPCs) are estimated. At HL-LHC and HE-LHC, the colliding systems with larger Higgs significance are Ar-Ar(6.3 TeV) and Kr-Kr(12.5 TeV) respectively, but 3σ evidence for two-photon Higgs production would require 200 and 30 times larger integrated luminosities than those planned today at both machines. Factors of ten can be gained by running for a year, rather than the typical 1-month heavy-ion operation at the LHC, but the process will likely remain unobserved until a higher energy hadron collider, such as the FCC, is built. In the latter machine, the 5σ observation of Higgs production in UPCs is feasible in just the first nominal run of Pb-Pb and p-Pb collisions at $\sqrt{s_{\rm NN}} = 39$ and 63 TeV respectively.

Summary

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