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Lamarr: implementing a flash-simulation paradigm at LHCb

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In the LHCb experiment, during Run2, more than 90% of the computing resources available to the Collaboration were used for detector simulation. The detector and trigger upgrades introduced for Run3 allow to collect larger datasets that, in turn, will require larger simulated samples. Despite the use of a variety of fast simulation options, the demands for simulations will far exceed the pledged resources.
To face upcoming and future requests for simulated samples, we propose Lamarr, a novel framework implementing a flash-simulation paradigm via parametric functions and deep generative models.
Integrated within the general LHCb Simulation software framework, Lamarr provides analysis-level variables taking as input particles from physics generators, and parameterizing the detector response and the reconstruction algorithms. Lamarr consists of a pipeline of machine-learning-based modules that allow, for selected sets of particles, to introduce reconstruction errors or infer high-level quantities via (non-)parametric functions.
Good agreement is observed by comparing key reconstructed quantities obtained with Lamarr against those from the existing detailed Geant4-based simulation. A reduction of at least two orders of magnitude in the computational cost for the detector modeling phase of the LHCb simulation is expected when adopting Lamarr.

Significance

In this contribution we will provide an update on the models used to parametrize the tracking reconstruction, now entirely based on deep neural networks, and on a pioneering research on modeling particle-to-particle correlation effects, focusing on the electromagnetic calorimeter reconstruction as an application. An update on the software infrastructure to define low-latency pipelines of machine-learning models will also be discussed.

References

[1] L. Anderlini et al., "Lamarr: the ultra-fast simulation option for the LHCb experiment", PoS ICHEP2022 (2022) 233

[2] M. Barbetti, "Lamarr: LHCb ultra-fast simulation based on machine learning models deployed within Gauss", in 21th International Workshop on Advanced Computing and Analysis Techniques in Physics Research: AI meets Reality, 2023, arXiv:2303.11428

[3] L. Anderlini et al., "The LHCb ultra-fast simulation option, Lamarr: design and validation", in 26th International Conference on Computing in High Energy & Nuclear Physics, 2023, arXiv:2309.13213

Experiment context, if any

LHCb

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