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Reconstruction of Charged Particle Tracks in Realistic Detector Geometry Using a Vectorized and Parallelized Kalman Filter Algorithm

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One of the most computationally challenging problems expected for the High-Luminosity Large Hadron Collider (HL-LHC) is finding and fitting particle tracks during event reconstruction. Algorithms used at the LHC today rely on Kalman filtering, which builds physical trajectories incrementally while incorporating material effects and error estimation. Recognizing the need for faster computational throughput, we have adapted Kalman-filter-based methods for highly parallel, many-core SIMD and SIMT architectures that are now prevalent in high-performance hardware.

Previously we observed significant parallel speedups, with physics performance comparable to CMS standard tracking, on Intel Xeon, Intel Xeon Phi, and (to a limited extent) NVIDIA GPUs. While early tests were based on artificial events occurring inside an idealized barrel detector, we showed subsequently that our "mkFit" software builds tracks successfully from complex simulated events (including detector pileup) occurring inside a geometrically accurate representation of the CMS-2017 tracker. Here, we report on advances in both the computational and physics performance of mkFit, as well as progress toward integration with CMS production software (CMSSW).

Recently we have improved the overall efficiency of the algorithm by preserving short track candidates at a relatively early stage rather than attempting to extend them over many layers. Moreover, mkFit formerly produced an excess of duplicate tracks; these are now explicitly removed in an additional processing step (note that mkFit builds all its tracks in parallel, so it cannot eliminate detector hits from further consideration as viable tracks are found). We demonstrate that with these enhancements, mkFit becomes a suitable choice for the first iteration of CMS tracking, and perhaps for later iterations as well. We plan to test this capability in the CMS High Level Trigger during Run 3 of the LHC, with an ultimate goal of using it in both the CMS HLT and offline reconstruction for the HL-LHC and Phase II CMS tracker.

Consider for promotion

Yes

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