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Parallel implementation of the KFParticle vertexing package for the CBM and ALICE experiments

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Modern heavy-ion experiments operate with very high data rates and track multiplicities. Because of time constraints the speed of the reconstruction algorithms is crucial both for the online and offline data analysis. Parallel programming is considered nowadays as one of the most efficient ways to increase the speed of event reconstruction.

Reconstruction of short-lived particles is one of the most important tasks in data analysis of high energy physics experiments. The KFParticle package for short-lived particles reconstruction, based on the Kalman filter, is presented and described with mathematical apparatus. The package is actively used both in the CBM experiment at FAIR/GSI (Darmstadt, Germany) and the ALICE experiment at CERN (Geneva, Switzerland). The high computational speed of the KFParticle package in the CBM experiment is of the particular importance, because the full event reconstruction is required for the online event selection. Also in the ALICE experiment it is important for the analysis of the already collected data. The KFParticle package is geometry independent and can be used in other experiments too.

The package has rich functionality: the complete particle reconstruction with momentum and covariance matrix calculation; reconstruction of decay chains; daughter particles can be added one by one; simple access to parameters of the particle, such as mass, lifetime, decay length, rapidity, and their errors; transport of the particle; estimation of the distance between particles etc.

KFParticle has been vectorized using the SIMD instructions set. Since modern processors have SIMD units, vectoization is a simple and efficient way to increase the computational speed of the algorithms running on the same CPU. The package has been implemented in single precision for more efficient vectorization. The additional speedup factor of 3-5 has been achieved for the CBM and ALICE experiments. The Intel TBB library is used for parallelization between cores. The quality analysis of parameters, their errors and covariance matrix, which are obtained with KFParticle, has been performed using Monte Carlo simulated data. Results of the analysis are presented and discussed.

More sophisticated statistical methods for the particle analysis are under implementation within the KFParticle package. Implementation of the package using the parallel Intel ArBB library, as well as parallelization on GPU architectures are foreseen.

Primary author: Mr ZYZAK, Maksym (Goethe Universitaet Frankfurt)

Co-authors: Mr KULAKOV, Igor (Goethe Universitaet Frankfurt); Dr KISEL, Ivan (GSI, Gesellschaft fuer Schwerionenforschung mbH)

Presenter: Mr KULAKOV, Igor (Goethe Universitaet Frankfurt)

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