The KF Particle Finder package for short-lived particles reconstruction for CBM*

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Today the most interesting physics is hidden in the properties of short-lived particles which can not be registered directly by a detector system but only reconstructed from their decay products. Also, short-lived particles which have a very small production probability are of the particular interest. Thus, a statistically significant result can be obtained only in case of the operation with a high rate of collisions up to 10^7 Hz. This raises the problem of data processing and storage. Therefore only those events are selected for the further analysis that can potentially contain interesting particles. The CBM experiment requires the full reconstruction of events, including reconstruction of short-lived particles, already at the selection stage.

A fast and efficient KF Particle Finder package for short-lived particles reconstruction and selection is developed for the CBM experiment. A search for about 50 decay channels has been currently implemented. At first, all tracks are divided into groups of secondary and primary tracks for further analysis. Primary tracks are those, which are produced directly in the collision of beam and target ions. Tracks from decays of resonances (strange, multi-strange and charmed resonances, light vector mesons, charmonium) are also considered as primaries since they are produced directly at the point of the primary vertex. Secondary tracks are produced by the short-lived particles, which decay not in the primary vertex point and can be well separated. These particles include strange particles (K^0_s and Λ), multi-strange hyperons (Ξ and Ω) and charmed particles (D^0, $D^{\pm}$, $D^{\pm}_s$ and Λ_c).

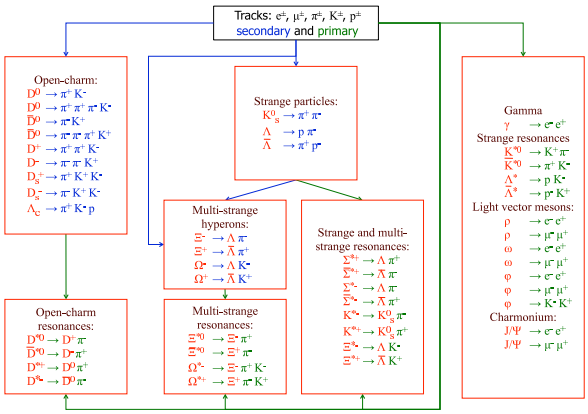

Figure 1: Block diagram of the KF Particle Finder algorithm.

Then tracks are combined according to the block diagram in Figure 1 and particle-candidates are produced from these combinations. The particles are reconstructed with the KF Particle package [1], which is based on the Kalman filter (KF) method and finds parameters of the particle, such as decay vertex, momentum, energy, mass, etc., together with their errors. All particles of the event are reconstructed at once that makes the algorithm local with respect to the data and therefore very fast.

KF Particle Finder achieves a high efficiency of the particle reconstruction. For example, efficiencies of K^0_s, Λ, Ξ^- and Ω^- reconstruction are 15.3%, 17.8%, 5.0% and 2.5% respectively for 240 000 of minimum bias Au+Au collisions at 25 AGeV. The corresponding signal to background ratios are 3.5, 5.1, 42.2 and 4.3.

In order to utilize all possible resources of modern CPUs and to achieve the highest possible speed KF Particle Finder is based on the SIMD instructions. Also, the algorithm has been parallelized between cores of the modern CPUs and demonstrates a strong linear scalability on many-core servers with respect to the number of cores (see Figure 2).

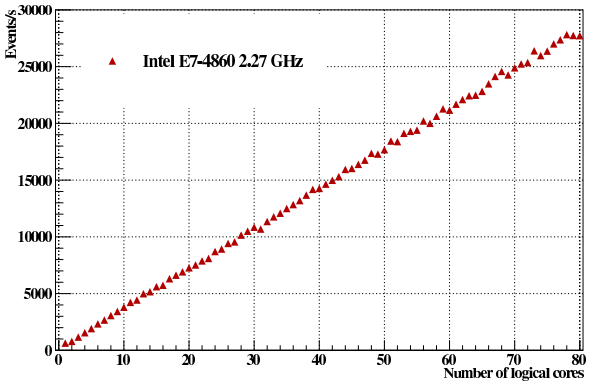

Figure 2: Scalability of the KF Particle Finder package with minimum bias Au+Au events at 25 AGeV on a many-core server lxir075 equipped with four Intel E7-4860 (2.27 GHz) CPUs.

Summarizing, the KF Particle Finder package reconstructs about 50 of the most important decay channels for the CBM experiment with a high efficiency and a high signal to background ratio achieving speed of 1.5 ms per Au+Au minimum bias collisions at 25 AGeV on a single core.

References

[1] S. Gorbunov and I. Kisel, Reconstruction of decayed particles based on the Kalman filter. CBM-SOFT-note-2007-003, 7 May 2007.

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