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Exact Event Time Reconstruction for Time-of-Flight Particle Identification

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Precise determination of the event collision time $t_{\{0\}}$ is essential for particle identification with time-of-flight detectors. In the ALICE experiment, the event time can be reconstructed from measured TOF signals by comparing them with expected flight times under different particle-mass hypotheses [1,2]. The corresponding optimization problem is combinatorial, and practical reconstruction procedures therefore employ restricted hypothesis searches and rejection criteria.

We present an exact polynomial-time method for global minimization of the event-time objective function. The algorithm determines the optimal particle hypotheses together with the corresponding t_0 without exhaustive enumeration of all hypothesis assignments. The method was validated against brute-force enumeration at low multiplicity, where identical particle assignments, event times, and objective-function values were obtained. It was further benchmarked against the event-time reconstruction procedure implemented in the ALICE O2 framework [3,4] using simulated pp and Pb-Pb events. For typical events, the optimized O2 procedure remains highly competitive in execution time, while the exact method provides a guaranteed global optimum and can therefore serve as a reference for validating heuristic reconstruction approaches.

We also demonstrate ambiguous event configurations for which the restricted search converges to a suboptimal solution, producing a shifted reconstructed event time and incorrect particle assignments, whereas the exact algorithm recovers the global minimum. The proposed method can therefore be used both as a validation tool and as a component of future hybrid event-time reconstruction algorithms.

References

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