20th International Conference on Computing in High Energy and Nuclear Physics (CHEP2013)

Contribution ID: **340** Type: **Oral presentation to parallel session**

FLES: First Level Event Selection Package for the CBM Experiment

Monday 14 October 2013 15:45 (20 minutes)

The CBM (Compressed Baryonic Matter) experiment is an experiment being prepared to operate at the future Facility for Anti-Proton and Ion Research (FAIR, Darmstadt, Germany). Its main focus is the measurement of very rare probes, which requires interaction rates of up to 10 MHz. Together with the high multiplicity of charged tracks produced in heavy-ion collisions, this leads to huge data rates of up to 1 TB/s. Most trigger signatures are complex (short-lived particles, e.g. open charm decays) and require information from several detector sub-systems.

First Level Event Selection (FLES) in the CBM experiment will be performed on-line on a dedicated processor farm. This requires the development of fast and precise reconstruction algorithms suitable for on-line data processing. The algorithms have to be intrinsically local and parallel and thus require a fundamental redesign of traditional approaches to event data processing in order to use the full potential of modern many-core CPU/GPU architectures. Massive hardware parallelization has to be reflected in mathematical and computational optimization of the algorithms.

The Cellular Automaton (CA) algorithm is used for track reconstruction. The CA algorithm creates short track segments (triplets) in each three neighboring stations, then links them into track-candidates and selects them according to the maximum length and minimum chi^2 criteria. The algorithm is optimized with respect to time, vectorized, fully implemented in single precision and robust with respect to the detector geometry and inefficiency. Reconstruction of minimum-bias heavy-ion collisions shows 98% efficiency for most of signal particles and speed of 11 ms per event per core. The Kalman filter (KF) based track fit is used for precise estimation of track parameters.

The KFParticle package for short-lived particles reconstruction, based on the Kalman filter, 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. The KFParticle package has been also vectorized using the SIMD instructions set.

An overview of the on-line FLES processor farm concept, different levels of parallel data processing in the farm from the supervisor down to the multi-threading and the SIMD vectorization, implementation of the algorithms in single precision, memory optimization, scalability on up to 80 CPU cores, efficiency, precision and speed of the FLES algorithms with respect to track multiplicity are presented and discussed.

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Session Classification: Event Processing, Simulation and Analysis

Track Classification: Event Processing, Simulation and Analysis