Fast online reconstruction of short-lived particles with KF Particle Finder in the CBM experiment

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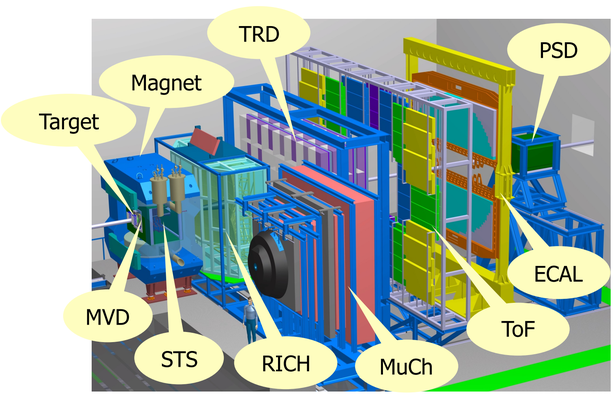
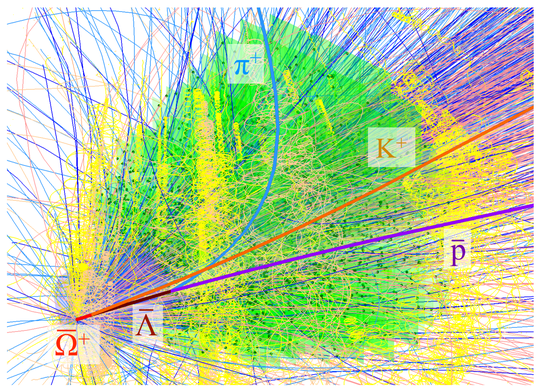
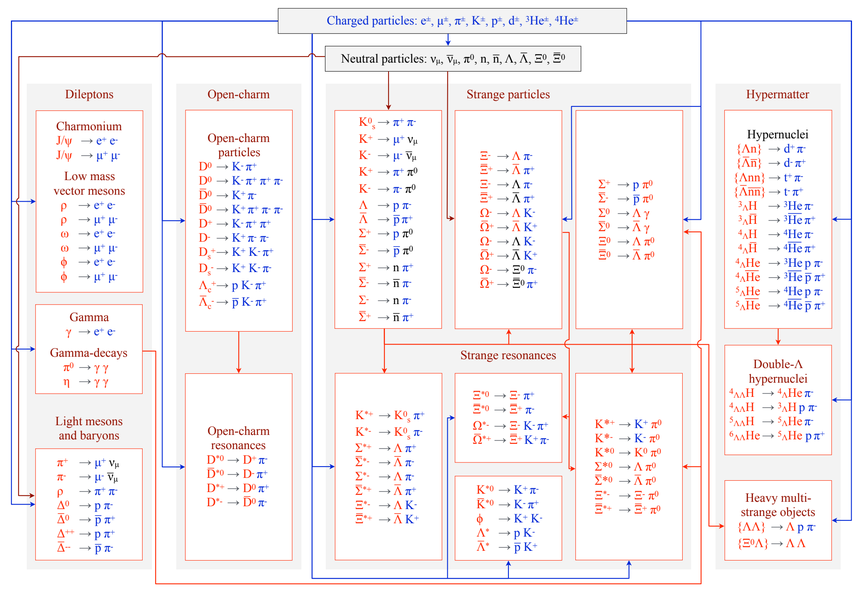
CBM Experiment at FAIR

Compressed Baryonic Matter experiment

Reconstruction challenge in the CBM Experiment





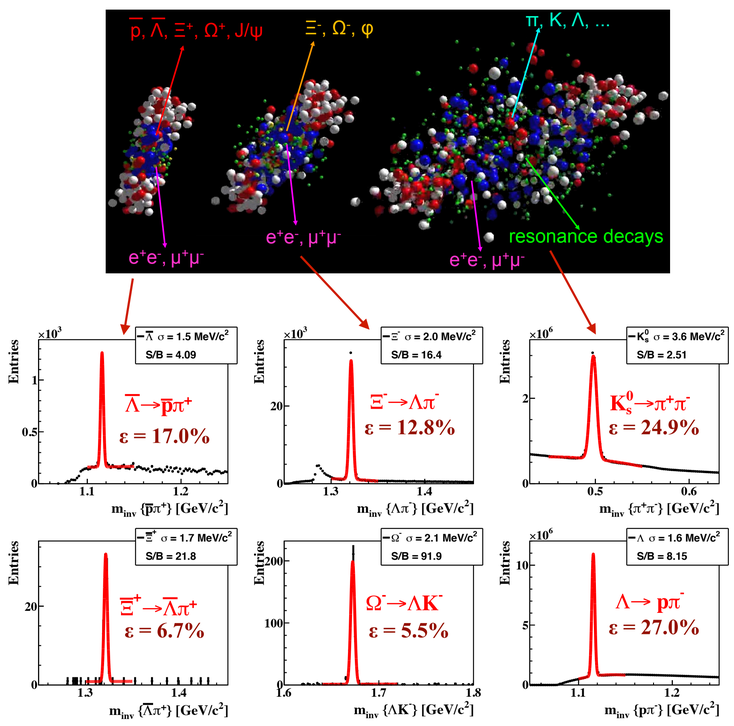


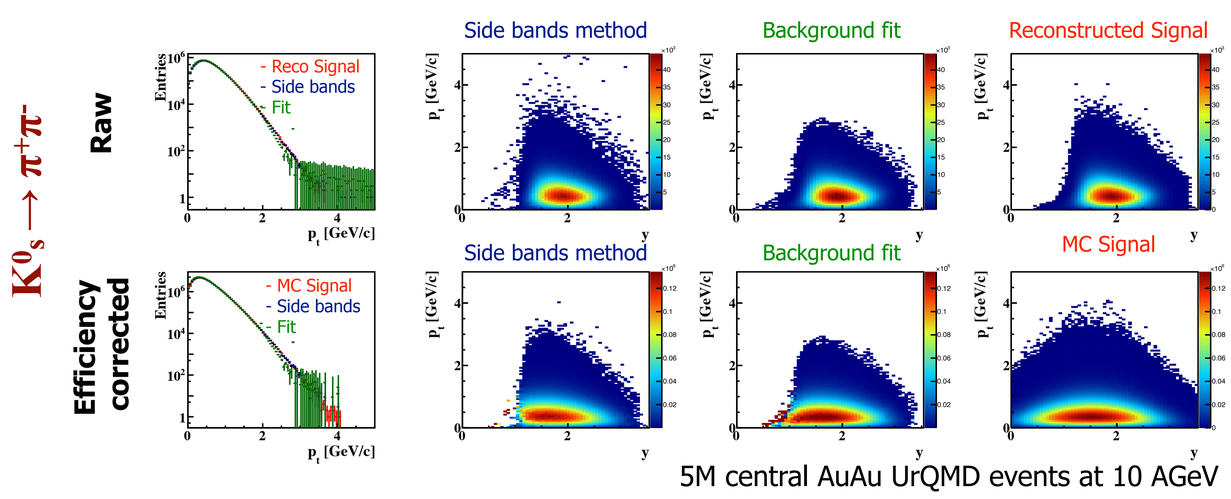
- CBM — future fixed-target heavy-ion experiment at FAIR, Darmstadt, Germany.
- 10^5-10^7 collisions per second.
- Up to 1000 charged particles/collision.
- Free streaming data.
- No hardware triggers.
- Online event reconstruction and selection is required in the first trigger level.

- Online reconstruction at the online farm.
- High speed and efficiency of the reconstruction algorithms are required.
- The algorithms have to be highly parallelised and scalable.
- CBM event reconstruction: Kalman Filter and Cellular Automaton.

- KF Particle Finder includes more than 100 decays, uses Kalman filter mathematics, geometry independent.
- Searches for short-lived particles combining tracks and reconstructed particles according to the PID hypothesis.
- The package is highly optimised and vectorised.

Reconstruction of short-lived particles with KF Particle Finder



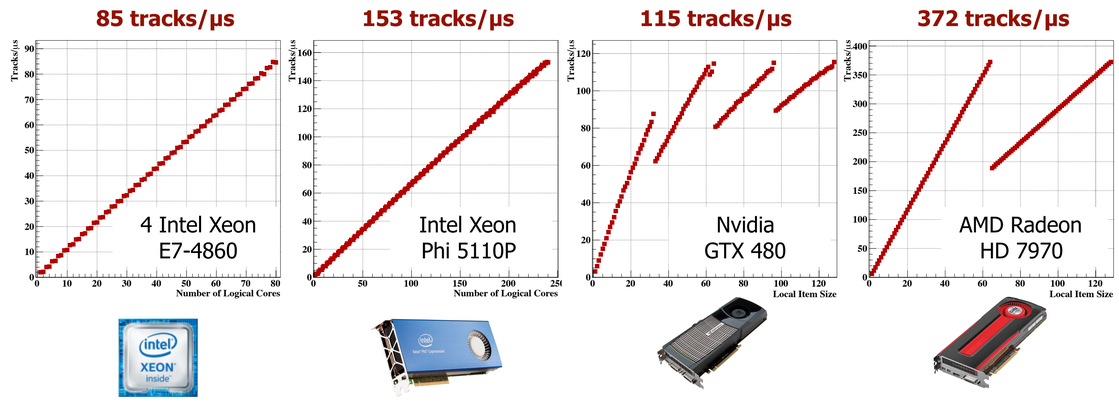


5M central AuAu UrQMD events at 10 AGeV

- Use of the Kalman filter with covariance matrices allow reconstruction of particles with high precision, high significance, signal to background ratio, and efficiency.
- Uniform approach for reconstruction of different particles together with wide coverage of possible decays provide perfect tools for studying different stages of the collision.

Scalability of the reconstruction algorithms

KF track fit

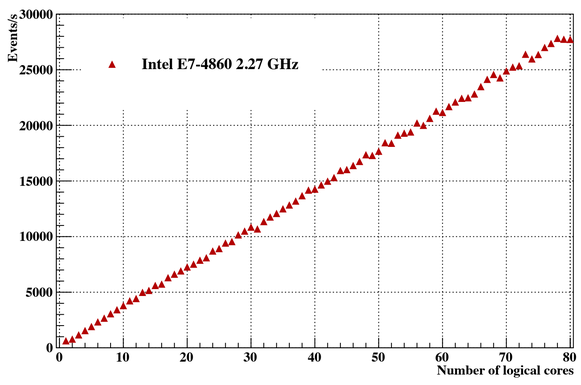


- CPU-like approach
- Steps due to the hyper-threading

- GPU-like approach
- Jumps due to the partial load of compute units

- Kalman filter based track fit is used for reconstruction of the track parameters — the input for short-lived particles reconstruction with KF Particle Finder.
- The fit is fully vectorised and parallelised, scales linearly at many-core architectures.

KF Particle Finder



- KF Particle Finder is fully vectorized and parallelized.
- KF Particle Finder shows strong scalability on many-core machines (the scalability on a computer with 40 physical, 80 logical cores is shown).
- Up to 1.5 ms/event/core for simulated AuAu collisions at 25 AGeV.

Conclusions

✓ KF Particle Finder based on the Kalman filter method provides accurate and mathematically correct procedures for reconstruction of particles with high precision and efficiency. Utilisation of the covariance matrices gives an advantage to extract effectively 2 times more signal.

✓ High quality clean reconstruction will provide tools for studying different stages of the collision.

✓ KF Particle Finder is highly optimised and vectorised for fast online operation.

✓ Online reconstruction will require alignment and calibration of the offline quality.

✓ Online operation will allow to perform real time physics analysis. Individual events can be studied just after collection, the integrated spectra will be available already at the finish of the run.

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