4-Dimensional cellular automaton track finder for the CBM experiment*

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The CBM experiment at FAIR will focus on the measurement of rare probes at interaction rates up to 10 MHz. The beam will provide free stream of particles, so that some events may overlap in time. It requires the full online event reconstruction not only in space, but also in time, so-called 4D (4-dimensional) event building. A time-slice is reconstructed in parallel between cores within a CPU, thus minimising communication between CPUs. This is a task of the First-Level Event Selection (FLES) package.

The FLES reconstruction package consists of several modules: track finding, track fitting, short-lived particles finding, event building and event selection. The Cellular Automaton (CA) track finder is fast and robust and thereby will be used for the online track reconstruction. This method benefits from enumeration suppression by introducing a phase of building short track segments at an early stage before going into the main combinatorial search. The reconstruction efficiency for the primary tracks with momentum higher than 1 GeV/c in case of event-based analysis (see 3D column of Table 1) is 96.1%.

As a special study of the CA track finder stability the algorithm behavior was investigated with respect to the track multiplicity. For the study a super-event, which includes a number of minimum bias events, was reconstructed with no time information taken into account. In a super-event we combine space coordinates of hits from a number of Au+Au minimum bias events at 25A GeV and give it to the CA track finder as an input to reconstruct with a regular procedure. The reconstruction efficiency dependence is stable: the efficiency for all tracks changes by 4% only for the extreme case of 100 minimum bias events in the super-event (see (3+1)D column of table 1), comparing to the case of event-based analysis.

The time information was included to the algorithm. It has resulted in a higher reconstruction efficiency (see 4D column in table 1). In particular the time information drastically decreased ghost and made the reconstruction 3.7 times faster than without the time information ((3+1)D column of Table 1). The speed now is 8.5 ms and comparable with the event-based analysis. The CA track finder was fully parallelised inside the time-slice. The parallel version shows the same efficiency as a sequential one and achieves a speed-up factor of 10.6 while parallelising between 10 Intel Xeon physical cores with a hyper-threading.

The first version of event building based on 4D track finder was implemented. The hits time measurements distribution illustrating the complexity of defining event borders in a time-slice is shown Figure 1 with blue color, the resulting distribution of reconstructed track time – with black. Reconstructed tracks clearly represent event-corresponding groups. The FLES package is ready for the 4D reconstruction of time-slices in CBM.

Efficiency, %	3D	(3+1)D	4D
All tracks	83.8	80.4	83
Primary high-p	96.1	94.3	92.8
Primary low-p	79.8	76.2	83.1
Secondary high-p	76.6	65.1	73.2
Secondary low-p	40.9	34.9	36.8
Clone level	0.4	2.5	1.7
Ghost level	0.1	8.2	0.3
Time/event/core	8.2 ms	31.5 ms	8.5 ms

Table 1: Track reconstruction performance for 3D event-by-event analysis, super-event (3+1)D and time-based 4D reconstruction for 100 mbias Au+Au collisions at 25A GeV.

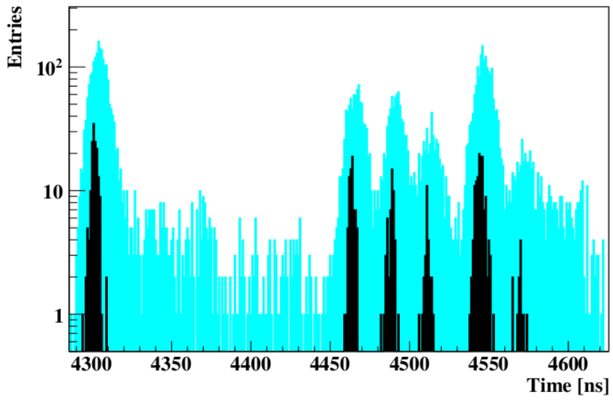

Figure 1: Distribution of time measurement in a part of a time-slice at the interaction rate of 10^7 Hz: hit time measurement (light blue), track time (black).

References

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* Work supported by HICforFAIR, FIAS and HGS-HIRe for FAIR.

DOI:10.15120/GR-2015-1-MU-NQM-CBM-04