Ring Recognition in the CBM RICH Detector

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One of the main problems of data handling obtained from the the RICH (Ring Imaging CHerenkov) detector of the CBM (Compressed Byronic Matter) [2] experiment is the recognition of Cherenkov radiation rings produced on the RICH photodetector. The problem is hindered veru much due to presence of noise and many interfering rings produced by secondary particles.

Two algorithms for ring finding in RICH were developed [1]:
1. based on information obtained by propagating tracks from the STS detector,
2. standalone approach is based on the Hough Transform (HT) [3, 4] combined with preliminary area clustering to decrease combinatorics.

Both ring-finders are working with good efficiency, however, there is a considerable number of fake rings present after ring finding. Routines have to be developed to reject them. A typical fake ring is formed by "stealing" hits from neighboring rings which seriously disturbs ring parameters. In order to reliably reject these fake rings, a set of parameters of found rings had to be selected which could be used for fake rejection. For this task, parameters had to be found which differ for fake and true rings as much as possible. Then, a set of cuts based on these parameters was developed to reject fake rings, however, trying not to drop down the ring finding efficiency for "good" rings. Finally, 7 parameters were selected: the number of hits in a narrow corridor around the ring; the number of hits in the ring; the distance between closest track projection and ring center; the biggest angle between neighboring hits; the χ^2 - criterion, and the radial position of the ring on the photodetector plane.

The first attempt of using a set of 1-dimensional cuts on each of these parameters resulted in an insufficient rejection of fakes and a large loss in efficiency. Therefore, in a second attempt, a set of 2 dimensional cuts was developed. Here, each 2D cut is a combination of two 1D cuts. Pairs of parameters are combined and filled in 2D histograms for fake rings, true electron and pion rings separately. Then, cuts are made in this 2D space, which remove the main part of the fake rings.

An alternative approach to a reliable rejection of fake rings is the application of an artificial neural network (ANN). By input values of ANN its necessary to define whether the ring is correctly found or not. We used the standard ROOT class TMultylayerPerceptron, which is an implementation of multilayer perceptron. In our case, the ANN consists of 7 input neurons corresponding to the 7 parameters which were described above, 30 hidden neurons and one output neuron. In the ANN training, the output value of fake rings was set to "one" and true, i.e. correctly found rings to "zero". The training of the ANN was based on the back propagation error method and used 20000 samples for training (10000 true rings and 10000 fake rings). For testing we used 300000 rings, 150000 fake and 150000 true rings. Note that the output neuron value is not binary: for fake rings this value lies in the region around 1, and for correctly found rings it concentrates around 0. Therefore, it is necessary to make a cut on the output value, here we choose 0.6 for separating good and fake rings.

First version of software were developed for Protvino prototype PMT (mean number of hits per electron ring = 40) and later was optimized for Hamamatsu PMT (22 hits per electron ring). At the moment the Hamamatsu PMT is using by default. All

	HT+no cut	HT+ANN cut=0.6
Electrons, %	91.9	89.37
Fakes/event	7.01	0.75
Clones/event	0.27	0.14

Table 1: Integrated ring finding efficiency for electrons from the primary vertex (HT algorithm, Hamamatsu PMT)

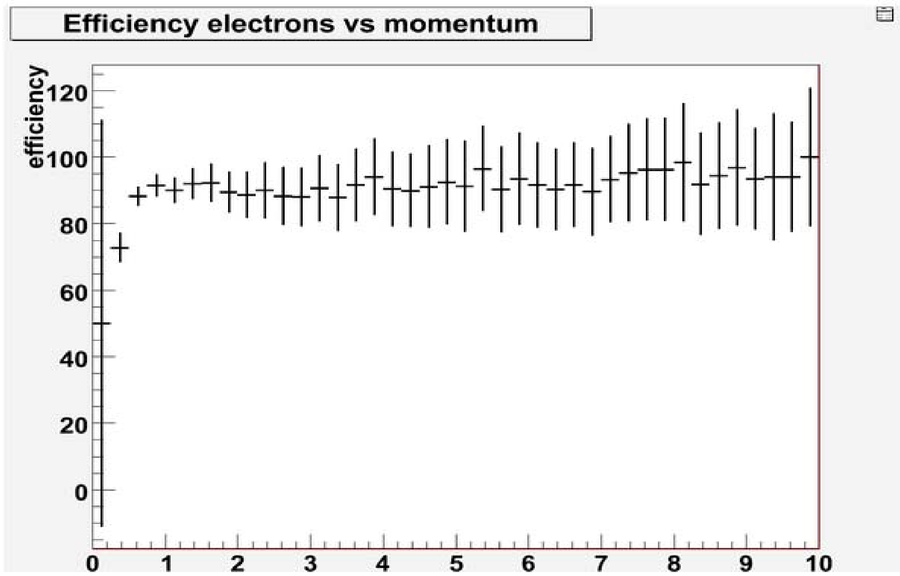

Fig. 1: Ring finding efficiency for electrons from the primary vertex in dependence on momentum (HT algorithm, ANN cut = 0.6, Hamamatsu PMT)

developed algorithms were tested on large statistics of simulated events and were then included into the CBM framework for common use. The algorithms can be used to test the RICH performance if implementing different photodetectors, e.g. the proposal from IHEP Protvino or a MAPMT from Hamamatsu (default). The routines can be further used for optimization of the detector setup. Also, they were used to establish electron identification routines which were applied for a rather realistic simulation of the di-electron spectra including full event reconstruction. The feasibility of both, a measurement of the low-mass vector meson and also the J/ψ could be shown.

All results presented above were extracted for central Au+Au collisions at 25 AGeV with additionally added 5e+ and 5e- at the main vertex in order to enhance electron statistics over the full phase space.

References

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