Two Methods for Ellipse Fitting in the CBM Experiment

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An ellipse fitting algorithm based on the Taubin method [7] was implemented for data handling in the RICH detector of the CBM experiment [1]. In this work we present comparative analysis of this method and a standard one based on the Kepler equation, whose performance yields to that of the Taubin method.

Recently the elliptic model of Cherenkov radiation rings in the RICH detector of the CBM experiment [1] was accepted instead of the previous circular one [4]. The method of ellipse fitting has been developed basing on the Kepler equation of ellipse and using minimization by well known MINUIT package [5, 6]. Further we call it Minuit Fitter. In this paper we propose an alternative approach, based on the direct Taubin method [7], referred further to as Taubin Fitter. It is important to stress that the Taubin method is direct (non-iterative) and, therefore is much faster than the method based on Minuit Fitter, besides it is statistically more accurate [7, 8].

For comparison of two ellipse fitting methods a set of points distributed along ellipses was simulated with different rotation angles of ellipse axes and various numbers of points. Each point was simulated with normally distributed errors in X and Y coordinates: $N(0, \sigma)$ with $\sigma = 0.3$. After testing we can conclude that Taubin Fitter is $5 \div 25$ times faster than Minuit Fitter, moreover Taubin Fitter is practically independent on the number of ellipse points (see Fig.1). As it is demonstrated in the Fig.2, Taubin Fitter gives also better estimated parameters of ellipse.

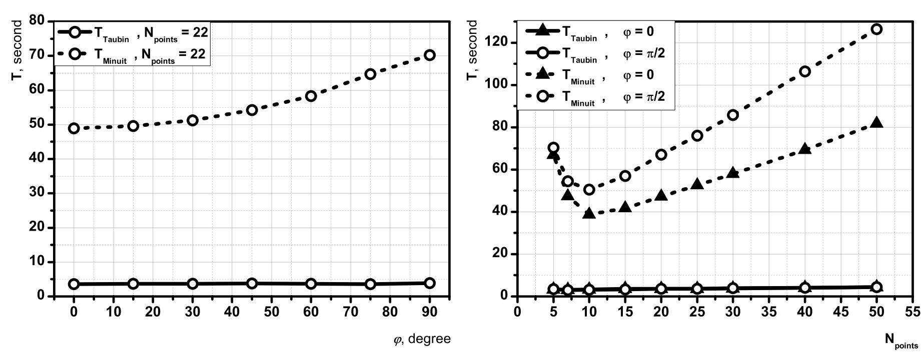

Figure 1: Calculation time for 10^5 ellipses vs. ellipse rotation angle (left) and number of points (right)

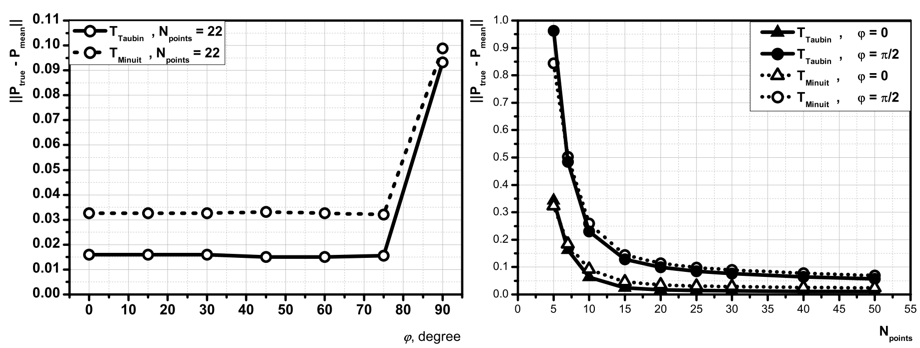

Figure 2: Euclid norm of mean errors of estimated parameters vs. ellipse rotation angle (left) and number of points (right)

For testing closer to reality, 500 UrQMD events Au+Au at 25 AGeV with additional 5e^- and 5e^+ per event were simulated and reconstructed to check the RICH ring finding efficiency. Ring finding efficiency is shown in Table 1. Taubin Fitter allows increasing efficiency by 2.69% and reducing number of fakes.

Table 1: *Ring finding efficiency*

Method	**Eff., %**	**Num. of Fakes per event**	**Num. of Clones per event**
Ring Finder with Minuit Fitter	90.33	6.75	0.42
Ring Finder with Taubin Fitter	93.02	5.99	0.70

The comparison of two ellipse fitting methods shows advantages of Taubin Fitter. On the basis of our study Taubin Fitter was chosen as default algorithm for ellipse fitting in RICH of the CBM experiment. However, because Taubin method is intended to fit a general conic section equation by points on a plane, in some very rare cases Taubin Fitter gives not an ellipse but a parabola or even a hyperbola while Minuit Fitter gives only ellipse solutions. Therefore, it is proposed to apply a hybrid approach in the CBM experiment, when ellipse is fitting by Taubin method in majority of cases, but if it is failed Minuit Fitter can be used. It was included in the CBM Framework [2, 3] and used now as the default method.

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