Using a Vertex Fitting Routine for Beam-Associated Background Removal

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1 Introduction

Removing beam associated backgrounds from a hadronic event sample is the most difficult part of event selection for the R measurement. Two previous methods have been used: One involves scaling events from separated beam data [1] and the other fits a distribution of event vertices. [2]

In the latter case, a simplistic method was used, averaging the z values (at closest approach to the IP) of all MFIT=2, good hadronic tracks in each event. We hereafter refer to this method as the averaging method. In this memo, we examine an alternate method of obtaining the event vertex using routines in the BES library, hereafter referred to as the fitting method.

2 Fitting Method

The fitting method used in this analysis uses the routine `vxkwikj.f`. Originally written for MarkII, this routine was modified for MarkIII and later for BES with various stages of modifications and cleanup work to adjust it to the current BES environment. (Note: the modified routine and its subroutines are distinguished from their original versions by a 'j' at the end of the filename; i.e. `vxkwik.f` is the original, `vxkwikj.f` is the BES modified version.)

The fitting routine loops over all charged tracks in each event, selecting good candidate tracks. Good helix fits (MFIT=2) and non-loopers (radius of curvature must be greater than 60 cm) are required, as well as a user-selected fiducial cut: A loose cut takes tracks with $r < 15$cm while a tight cut requires the track to have $r < 1.5$cm and $z < 15$cm.

If zero or one candidate tracks survive, a vertex fit is deemed impossible, and a flag is set to indicate this failure. On the other hand, if two or more tracks survive, all combinations of two tracks are examined to see if they can form an intersection. If so, this intersection information is recorded.

After all pairs have been examined, a further determination is made: If one or more intersections were found, the average of all intersection points is used as input into a least squares fitting routine that attempts to find a point closest to all tracks. The result is given as the event vertex with a good status indicator. If the fit fails to converge, or if no intersections were found, the routine calculates the average values of closest approach to the IP of the candidate tracks and uses that as the event vertex. In the latter case, a status flag indicating a poor fit is set.

3 Comparison of Fitting Methods

Typically, when run on a selected hadronic sample set chosen for the R-scan analysis, the fitting method would obtain good status results for 98-99% of the events. The remaining 1-2% would be poor generally due to having too few tracks with MFIT=2 (the hadronic selection routine only requires a minimum of one MFIT=2 track) or being unable to find an intersection for tracks. Two alternatives were examined in order to provide some vertex information for all tracks: Either all status fits were used (`VS=A` indicated on the graphs) or only good status fits were used (`VS=1` on graphs), but a simple average of candidate tracks (as in the averaging method) was calculated as a fallback and added to the set (indicated as `fbck` on the graphs). Also, both fiducial cuts (`Loose` and `Tight`) were examined in fits separately.

Figure 1 shows a sample set of graphs for the 3.2 GeV data and Table 1 compares the number of events obtained with various fit parameters and compares the RMS of the z-vertex distributions for all six 98 R-scan data points. This initial comparison showed a signifgantly smaller RMS for z-vertex distributions with the fitting method, thus providing an impetus for further detailed examination.

	Simple avg		Loose cuts					
			VS=1		VS=A		VS=1,fbck	
ECM(GeV)	Nevt	RMS	Nevt	RMS	Nevt	RMS	Nevt	RMS
2.60	6486	0.126	6018	0.113	6486	0.108	6486	0.126
3.20	2343	0.125	2239	0.121	2343	0.118	2343	0.127
3.40	2663	0.160	2532	0.152	2663	0.148	2663	0.161
3.55	3338	0.153	3142	0.149	3338	0.145	3338	0.155
4.60	2380	0.221	2212	0.209	2380	0.202	2380	0.222
5.00	2872	0.241	2668	0.230	2872	0.221	2872	0.240

	Tight cuts					
	VS=1		VS=A		VS=1,fbck	
ECM(GeV)	Nevt	RMS	Nevt	RMS	Nevt	RMS
2.60	5292	0.0356	6486	0.104	6486	0.124
3.20	1966	0.0411	2343	0.114	2343	0.123
3.40	2031	0.0427	2663	0.143	2663	0.158
3.55	2512	0.0428	3338	0.139	3338	0.150
4.60	1402	0.0535	2380	0.197	2380	0.219
5.00	1509	0.0535	2872	0.216	2872	0.239

Table 1: Comparison of event numbers and RMS of z-vertex distributions for simple averaging method and vertex fitting method with different parameters.

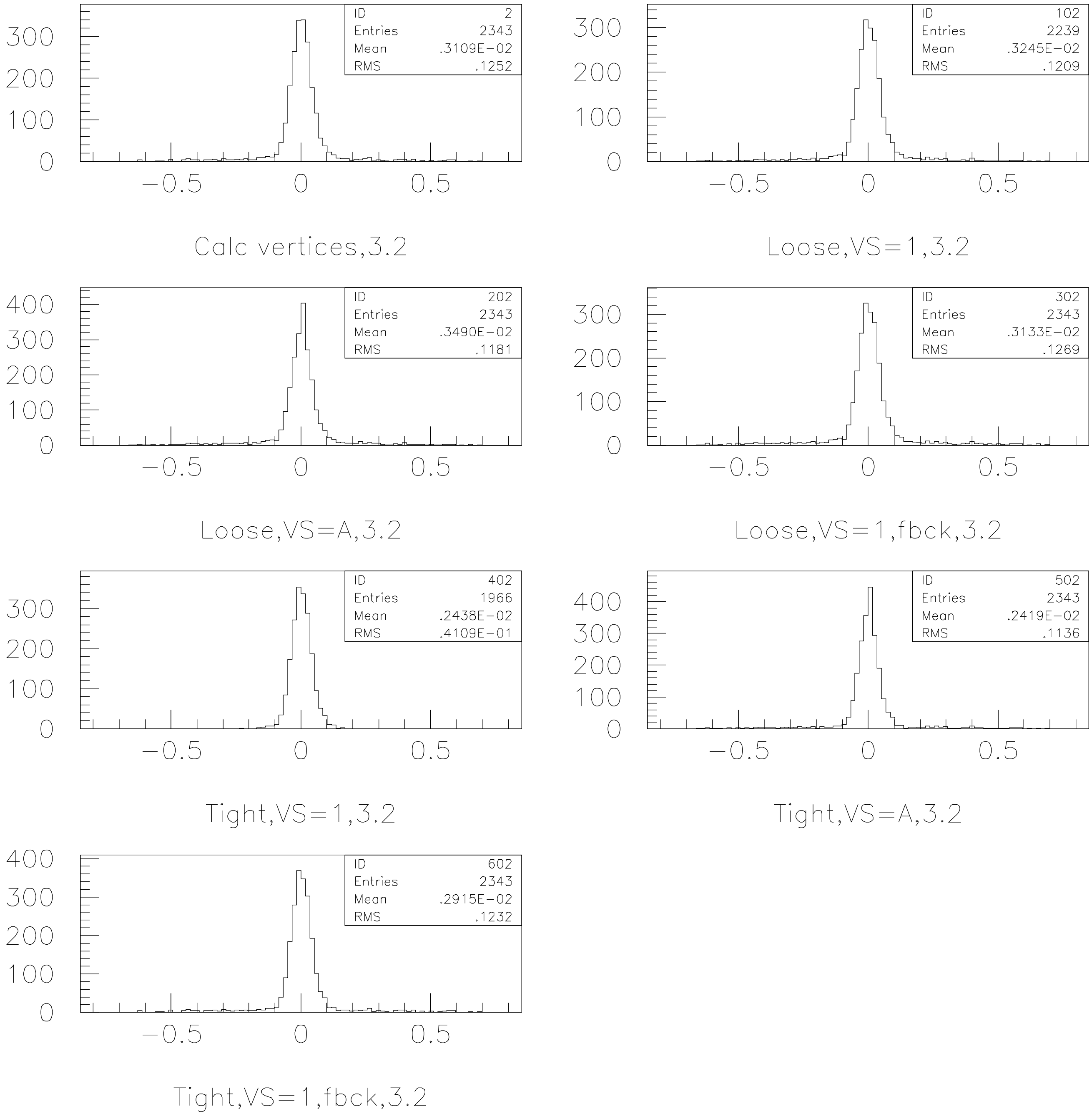

Figure 1: Comparison of event numbers and RMS of z-vertex distributions for simple averaging method (upper left) and vertex fitting method with different parameters for 3.2 GeV data.

4 Fit Quality

While the RMS of the distributions via vertex fitting was smaller than the averaging method, a proper determination of the quality of the routines would be a comparison of χ^2 values of the z-vertex distribution fits to the theoretical z distribution of a Gaussian plus background. In our case, we used a 2nd order polynomial for the background and fit within paw the averaging method as well as 4 different parameter sets for the vertex fitting method. A sample set of graphs can be seen in Figure 2. Note that case of `VS=1` is omitted as vertex information is not available for all events, making comparisons of total event numbers impossible.

5 98 Data

A comparison of χ^2 values as well as signal (Gaussian) areas for the 6 data points of the 98 R-scan is provided in table 2. Note that hadronic selection for this comparison was done with the 1998 selection routines. The area under the Gaussian is calculated to be

$$\text{Area} = \frac{A\sigma\sqrt{2\pi}}{\text{Bin width}}, \tag{1}$$

where A and σ are normalization and width parameters given in the fit and the bin width on all plots is 0.017.

ECM (GeV)	Avg method		Loose fits				Tight fits			
			VS=A		VS=1,fbck		VS=A		VS=1,fbck	
	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof
2.60	5271	1.382	5248	4.244	5133	2.066	5561	2.665	5413	1.076
3.20	1915	1.298	1883	1.380	1841	1.151	1995	1.070	1961	1.123
3.40	1908	1.712	1853	1.716	1818	1.290	2009	1.427	1965	1.566
3.55	2392	1.499	2345	2.974	2311	1.951	2540	2.250	2496	1.239
4.60	1155	0.991	1179	2.389	1113	1.429	1296	1.964	1211	0.840
5.00	1210	1.365	1214	2.675	1149	1.305	1371	2.243	1273	1.221
Unwtd avg:		1.375		2.563		1.532		1.937		1.178

Table 2: Comparison of signal events (Gaussian area) and χ^2/dof for fits.

As can be seen from the table, using only good vertex fits (VS=1) with the simple averaging method as fallback gives fits that are comparable (with loose cuts) or better (with tight cuts) than the simple averaging method. Interestingly, the former results in fewer signal events, but the latter results in more.

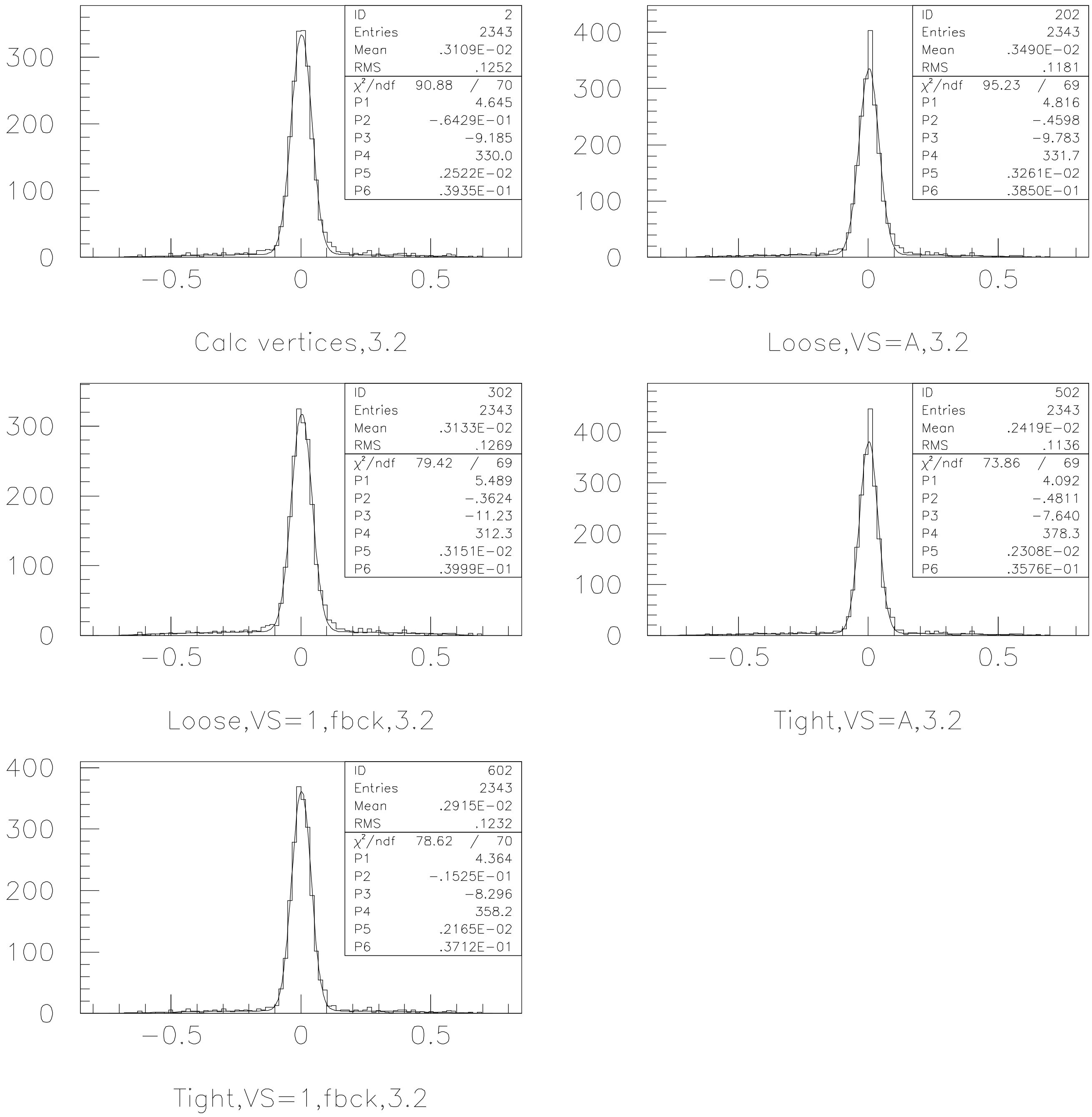

Figure 2: Fits for the averaging method (upper left) as well as different parameter sets for the fitting method for 3.2 GeV data.

6 99 Data

Further analysis was performed on a section of resonance region data from the 99 R-scan data set plus a few points above and below. The results are summarized in Table 3. As the event numbers and RMS values are not relevant to the fit, we omit that table. In general, results parallel that from the 98 data.

7 Conclusions

A rough indicator of the quality of fits is provided by the row of unweighted averages of χ^2/dof in Table 2. From this one can see that the vertex fitting method can provide comparable or better fits for the z-vertex distribution than the simple averaging method for a particular fitting scheme. Overall results give signal differences in the few percent range over the set of data points, consistent with all previous methods of statistical beam-gas background subtraction.

8 Bibliography

References

[1] Huang Guangshun and Qi Xiangrong, Hadronic Event Selection in the First R Scan Between 2-5 GeV, BES Analysis Memo.

[2] Huang Guangshun, The Subtraction of Beam Associated Background in Hadronic Event Sample, BES Analysis Memo.

ECM (GeV)	Avg method		Loose fits				Tight fits			
			VS=A		VS=1,fbck		VS=A		VS=1,fbck	
	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof	Area	χ^2/dof
2.200	1443	0.661	1463	0.989	1408	0.755	1540	0.533	1464	0.538
2.800	817	0.718	793	1.290	784	0.933	850	0.691	839	0.525
3.000	2051	0.984	2037	1.189	2011	1.050	2144	0.709	2114	0.599
4.027	950	0.628	931	0.740	915	0.676	974	0.810	959	0.773
4.030	766	0.436	743	0.447	735	0.408	786	0.476	776	0.501
4.033	935	0.535	913	0.711	907	0.603	972	0.596	963	0.547
4.040	1014	0.703	983	0.849	977	0.719	1033	0.808	1029	0.778
4.050	1041	0.674	1016	1.006	1007	0.942	1082	0.844	1069	0.636
4.060	914	0.622	886	0.534	880	0.501	938	0.555	932	0.639
4.070	691	0.436	674	0.335	668	0.330	712	0.390	701	0.558
4.080	585	0.432	582	0.508	570	0.460	618	0.379	605	0.365
4.090	980	0.406	940	0.656	935	0.597	1013	0.417	1005	0.384
4.100	876	0.531	855	0.600	848	0.589	895	0.525	896	0.524
4.110	887	0.656	868	0.598	858	0.588	929	0.472	914	0.580
4.120	445	0.635	428	0.820	424	0.624	469	0.521	460	0.474
4.130	1151	0.576	1126	0.845	1110	0.914	1186	0.560	1173	0.605
4.140	892	0.473	874	0.677	861	0.584	937	0.491	921	0.424
4.150	1062	0.533	1032	0.851	1021	0.675	1108	0.635	1088	0.567
4.160	1054	0.565	1035	0.757	1024	0.697	1100	0.609	1085	0.559
4.170	1050	0.558	1023	0.821	1018	0.758	1071	0.726	1062	0.704
4.180	1065	0.639	1029	0.976	1016	0.825	1097	0.792	1085	0.631
4.190	1177	0.579	1140	0.823	1128	0.700	1229	0.590	1217	0.499
4.200	861	0.528	829	0.664	823	0.634	886	0.692	885	0.546
4.210	573	0.466	559	0.590	548	0.556	600	0.429	584	0.532
4.220	1010	0.556	985	0.536	974	0.500	1054	0.387	1031	0.651
4.230	924	0.744	920	0.753	887	0.821	986	0.824	962	0.711
4.240	942	0.601	933	0.625	919	0.620	994	0.659	967	0.536
4.245	949	0.521	916	0.562	907	0.611	975	0.354	961	0.425
4.250	693	0.706	671	0.667	662	0.581	720	0.675	717	0.726
4.255	1043	0.809	1033	0.578	1017	0.531	1088	0.637	1075	0.688
4.260	995	0.556	984	0.640	972	0.498	1047	0.595	1031	0.399
4.600	1274	1.028	1254	0.899	1231	0.885	1336	0.747	1317	0.882
Unwtd avg:		0.609		0.735		0.661		0.598		0.578

Table 3: Comparison of signal events (Gaussian area) and χ^2/dof for fits.