# Improvements in Hadronic Event Selection

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## 1 Introduction

The criteria for hadronic event selection had been carefully studied (see Ref. [1]) with the first R-scan run data collected in Spring '98. There are still rooms left for further improvements. Beam-associated background is always a troublesome problem, and the ratio of such kind of events can be up to ~30% at center-of-mass energy 5.0 GeV. With special treatment, beam-gas events are suppressed more effectively. The old selection mainly uses information in MDC, now an independent way which uses BSC and VC information is introduced.

## 2 Beam-associated background suppression

The salient feature of the beam associated background are that their tracks are very much along the beam pipe direction, the energy deposited in ECAL is small, most of the tracks are protons, and the tracks have no definite vertex. Although most of the background events can be rejected by track level and event level selection, there are still some events survived.

Another feature of beam-gas events is the unbalance of momentum and energy, that is to say, the tracks in such an event fly in the same direction, and usually they are near the beam pipe. However, it was not easy to find suitable cuts corresponding to the feature.

Now a very simple method is applied to reject most-likely beam-gas events: if all the tracks (no matter it is a charged one or neutral one) in an event are in the same side relative to the interaction point, then the event is regarded as beam-associated event. Obviously, the key problem is how to determine which side a track belongs to. For charged track, its vertex position along beam axis is usually used, but here we want to know which side the main body of the track is in, so it is more reliable to determine which side by the projected position to BSC from helix track fitting. For neutral track, its entrance position into BSC is enough for the determination.

Fig. 1 shows the suppression effect of the balance requirement, and the first subfigure represents all the separated-beam data in Spring '98. It can be seen that beam-gas events can be suppressed by a factor of 30 $\sim$ 40%, whereas efficiency loss is less than 2%, as given in Table 1.

With the balance requirement, it is not necessary again to remove those events with all tracks carry positive charge.

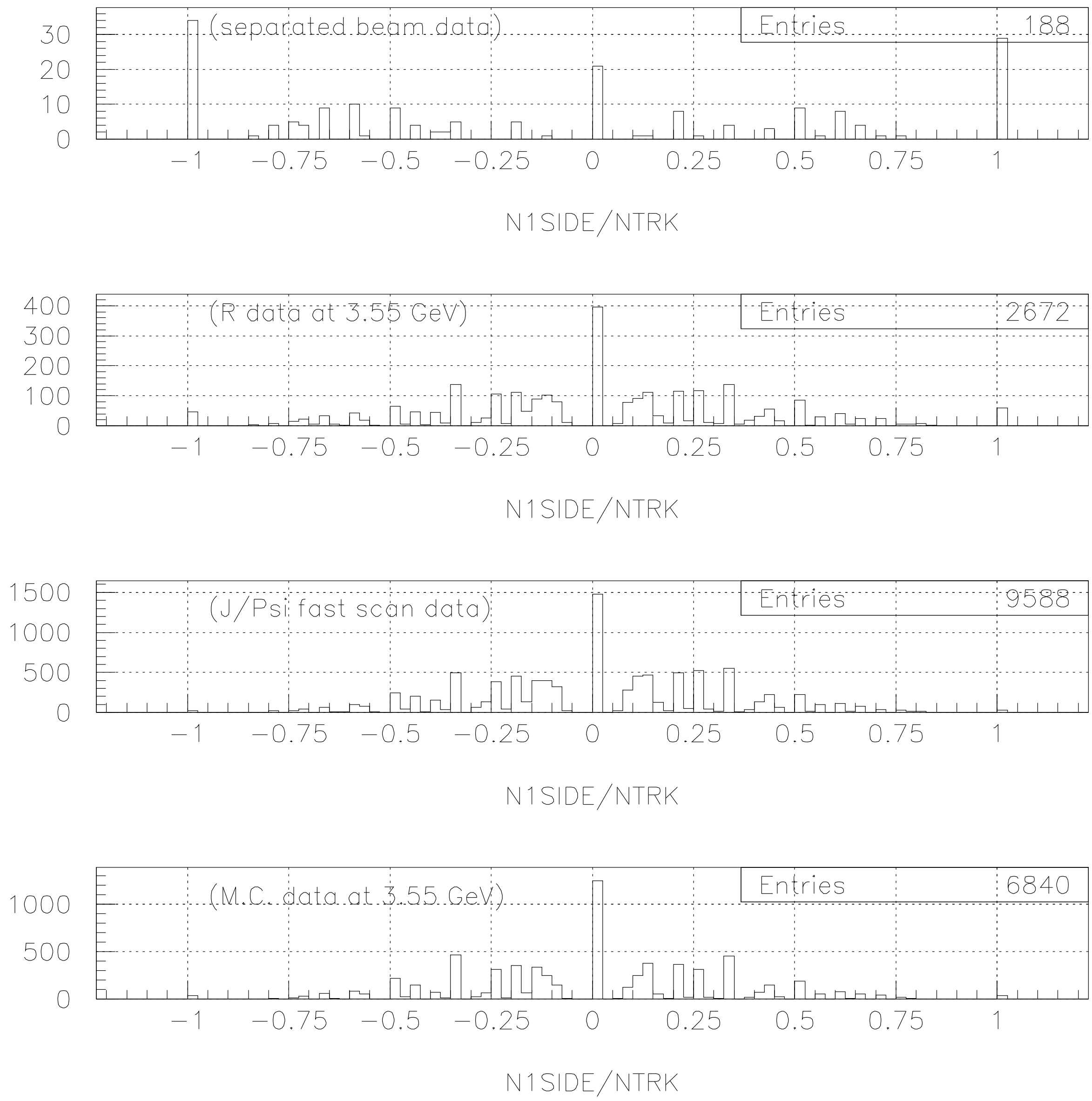


Figure 1: Beam-associated background suppression, events at $\pm 1$ are rejected

Table 1: Beam-gas suppression and efficiency loss

| $E_{cm}$ (GeV) | $N_{sep}$ (old) | $N_{sep}$ (now) | suppression ratio(%) | $\Delta\varepsilon/\varepsilon$ (%) |
|---|---|---|---|---|
| 3.2 | 10 | 7 | 30.0 | 1.25 |
| 3.4 | 46 | 28 | 39.1 | 1.91 |
| 3.55 | 50 | 33 | 34.0 | 1.02 |
| 4.6 | 48 | 37 | 22.9 | 0.56 |
| 5.0 | 26 | 16 | 38.5 | 0.49 |

# 3 Parallel selection by BSC+VC

In the old selection frame, MDC information is used to distinguish multi-prong hadron final states from various backgrounds, and other sub-detector information plays auxiliary role. Now a parallel way using mainly BSC information is introduced. If an event has more than 5 clusters in BSC, then it is regarded as hadron candidate. To make sure the cluster comes from a real track, it should have at least 3 hit-layers in BSC, the first hit-layer should be within the first 3 layers of BSC, and the deposited energy should be less than 0.8 GeV and greater than 0.08 GeV. Cosmic rays may have many hits in BSC, but good hadrons are produced at the interaction point, so it is reasonable to require that there is at least 1 VC-track with good tracking quality fulfills $V_r < 2$cm and $| V_z |< 18$cm; for 2 VC-tracks case, they should not be back-to-back: $|| \phi_1 - \phi_2 | - 180° |> 5°$.

The number of charged tracks has been used to represent the production multiplicity, since now 0-prong and 1-prong events may be included, the multiplicity distribution becomes like Fig. 2

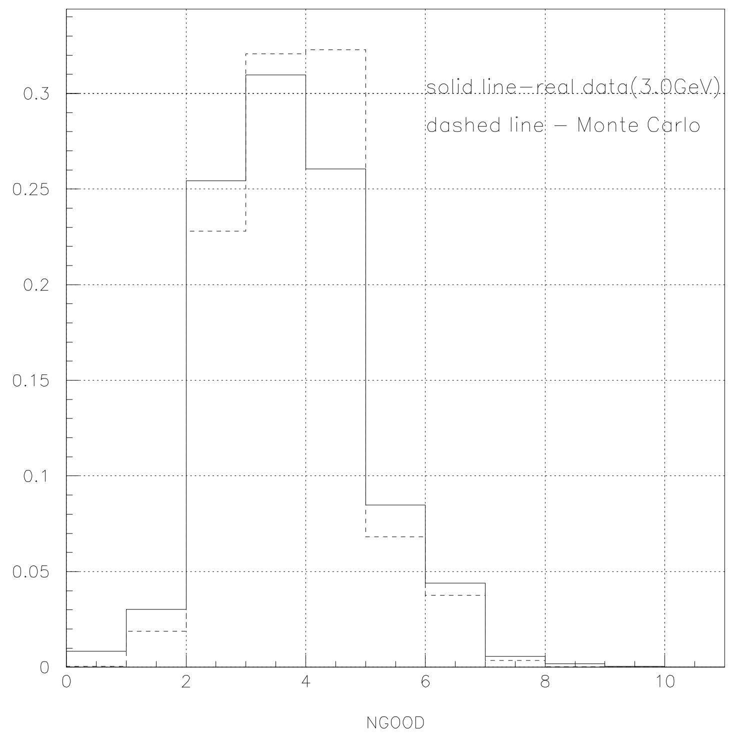


Figure 2: new multiplicity distribution

# 4 Considerations over 2-body final states

There are some real 2-prong hadron events like $\pi\pi, KK$ and $pp$. At high energies, the cross section is small, so such kind of events can be neglected. While at low energies, the cross section becomes larger, it would be good to increase the statistics if those events could be distinguished out.

To find definite final states, particle identifications are necessary. For BES detector, the ability of particle ID is not good enough, especially at high momentum. It is relative easy to select 2-body final states at low energy points, since a large portion of center-of-mass energy converts into particle mass, so that the momentum separation between different particles is far away enough for particle ID. Fig. 3 and Fig. 4 give the particle bands of $\pi, K$ and $p$, the distribution center of $e$ and $\mu$ at Ecm=2.2GeV, and the track momentum range of 2-body final states with $3\sigma$ deviation from its nominal value, from which one can see that the track momentum of $pp$ events is far away from other particles, while the track momentum of other 2-body events is close to each other. So it is convenient to distinguish $pp$ events by track momentum, difficult for other events. For $\pi\pi$ and $KK$ events, no good ways to tell them from Bhabhas and dimuons.

So far for 2-body final states at low energy points, we are confident only on $pp$ selection. The work has been done [2] with Ecm=2.6GeV data collected in Spring '98, and 11 $pp$ events was found. A new study on the same data set find 3 more $pp$ events. Comparing with the total hadron events - 5617, the 14 $pp$ events [3] is too few, less than 0.3%, no substantial effect to the result. To keep the selection simple, 2-body events are still not included.

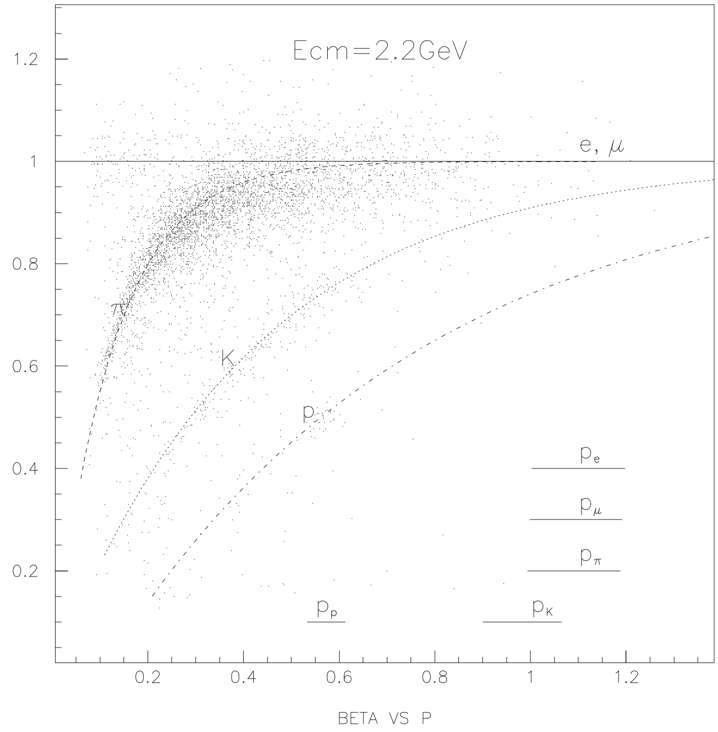


Figure 3: particle bands by TOF information, momentum range $p_f$ represents that of $f\bar{f}$ tracks

# 5 Comparisons between old and new selection

The improvements in hadronic event selection are checked with '98 and '99 R-scan data. Since VC information was missing in '98 ndst data, the independent selection by BSC+VC can not be tested. The previous R values and the ones with beam-gas suppression are listed in table 2.

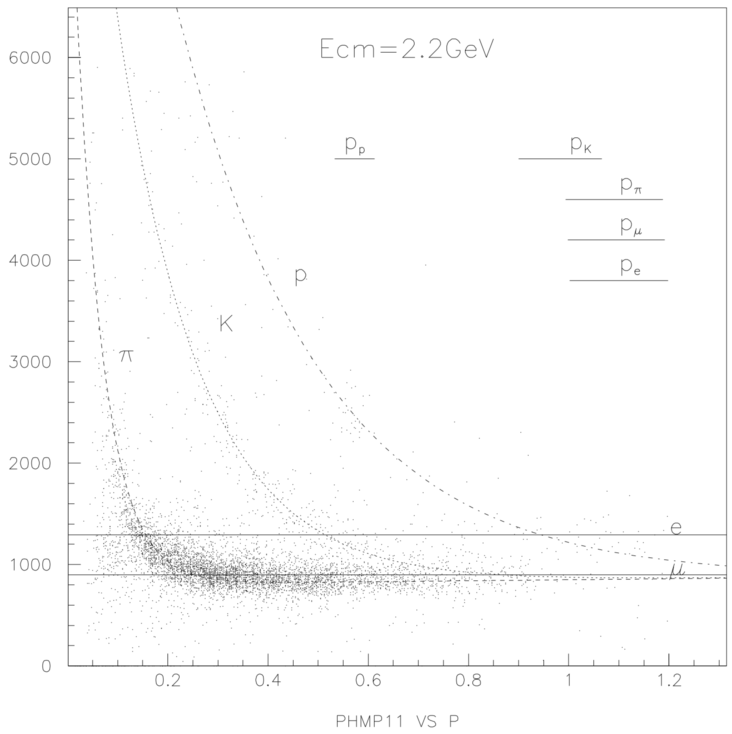


Figure 4: particle bands by dE/dx information, momentum range $p_f$ represents that of $f\bar{f}$ tracks

Table 2: R values without (old) and with (new) beam-gas suppression, '98 data

| $E_{cm}$(GeV) | 3.2 | 3.4 | 3.55 | 4.6 | 5.0 |
|---|---|---|---|---|---|
| R(old) | 2.25 | 2.36 | 2.29 | 3.53 | 3.42 |
| R(new) | 2.22 | 2.37 | 2.28 | 3.55 | 3.62 |
| diff.(%) | 1.3 | 0.4 | 0.4 | 0.6 | 5.9 |

The table tells that the R values are quite stable before and after special treatment to beam-associated backgrounds except Ecm=5.0GeV point, where the scale factor $f_{bg}$ is too large (17.82) so that R is very sensitive to $N_{sep}$. At the point, the number of total observed hadrons is only 1648, so $N_{sep}$ changes by 1 would result the final R changes more than 1%. But the new value seems more reasonable than the old one.

As for '99 data, Ecm=3.0GeV data is used to tested the new selections. From table 3, one can see that the R values using improved methods are very close to the old one.

Table 3: Comparisons at 3.0 GeV, '99 data. (new1 represents results only with beam-gas suppression, new2 represents results with also independent selection by BSC+VC.)

| | $N_{obs}$ | $N_{sep}$ | $\varepsilon$ | R |
|---|---|---|---|---|
| (old) | 2223 | 11 | .7019 | 2.23 |
| (new1) | 2173 | 8 | .6902 | 2.22 |
| (new2) | 2276 | 12 | .7138 | 2.24 |

# 6 Conclusion

Hadronic event selection criteria can possibly be improved from two sides described in section 2 and 3. Considering the parallel selection by BSC+VC brings more complication to selection and the gain is little, finally we decide only adopt the first improvement.

# References

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

[2] Yuan Changzheng, Observation of $ee \to pp$ at $\sqrt{s} = 2.6$ GeV, BES analysis memo

[3] http://hpws3.ihep.ac.cn/~huanggs/ps/ppbar_2.6GeV98.ps