Track match between VC and ESC

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Abstract

Tracks between Vertex Chamber(VC) and Endcap Shower Counter(ESC) are matched to enlarge BES solid angle coverage, the matching is in good quality, and the matching efficiency is more than 90%. The codes will be incoorporated in BESLIB V101.

1 Introdution

The data quality of the original Central Drift Chamber(CDC) was too bad to be used, the relevent software in BESLIB was insufficient. After BES upgrading, CDC was replaced by VC, it's expected that VC can give good spatial resolution and enlarge the solid angle coverage.

The reconstruction quality and efficiencys for BES were determined by Main Drift Chamber(MDC). From the experience of physics analysis, it's expected that the reconstruction can give more accurate vertex and larger solid angle coverage. It's even suggested to calculate luminosity by using ESC, the key is to distinguish between charged and neutral tracks. The application of VC provides a way to satisfy needs from physics. Below is given the reconstruction procedure in BESLIB V100:

$$\boxed{\text{DCJULIE}}$$
$$\Downarrow$$
$$\boxed{\text{MDCPID}}$$
$$\Downarrow$$
$$\boxed{\text{SHANAL}}$$
$$\Downarrow$$
$$\boxed{\text{TOFID}}$$
$$\Downarrow$$
$$\boxed{\text{MUREDO}}$$
$$\Downarrow$$
$$\boxed{\text{VCJULI}}$$

Topologically, a physical track should have pieces from all possible subdetectors, in Table 1 is shown the relevent BES subdetectors and corresponding subtypes in TRKLST.

Table 1: BES subdetectors and corresponding subtypes in TRKLST

subtype	**3**	**4**	**5**	**6**	**7**	**13**
subdetector	**MDC**	**TOF**	**SC**	μ	**dE/dX**	**VC**

In BESLIB V100, track match between MDC and ESC has been carried out, but those between VC and MDC, VC and ESC havn't been reallized yet. One can't expect MDC-ESC match to do all things, in Fig.1 is shown the geometric configuration of VC,

MDC, and ESC. It's difficult for MDC to reconstruct with less than four layers of hits, and Bhabha events favors small angle on the other hand.

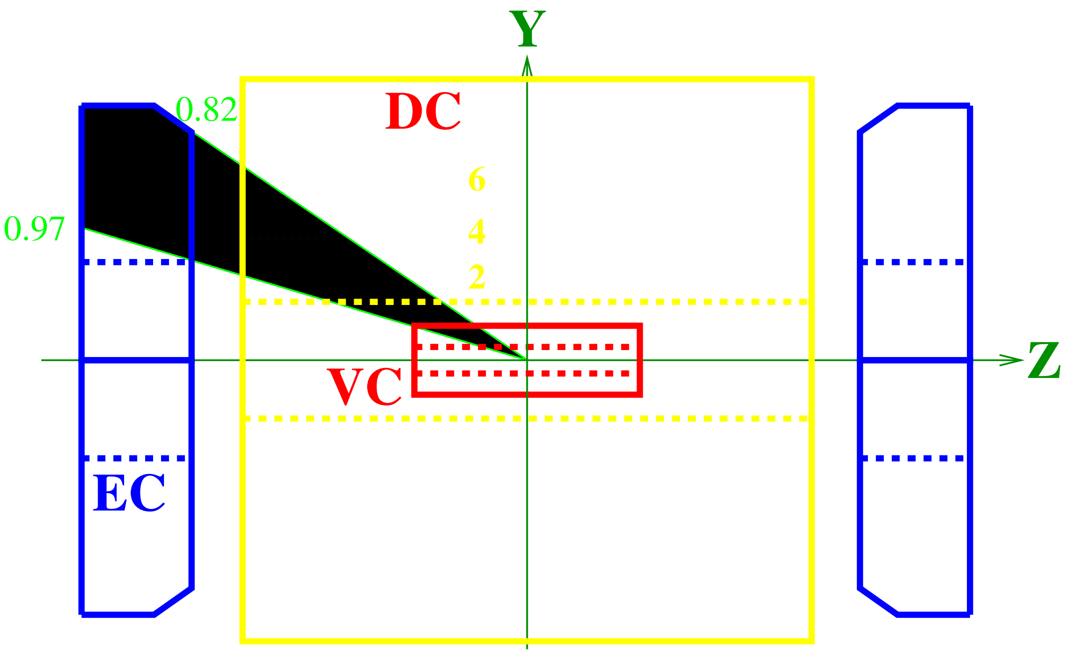

Figure 1: Geometric configuration of VC, MDC, and ESC

2 Track Match

Position correspondence is the basic principle of track match. However, both the VC Z and ESC reconstructions are bad in spatial resolution, one can't extralate VC track to ESC, or intrapolate ESC track to VC. The solution here is to make full use of th e high position precision in $r - \phi$ plane. In Fig.2 is shown the schematic diagram of track match between VC and ESC. We have the $r - \phi$ projection of VC track from trklst subtype 13, the entry point $(X_{\mathrm{VC}}, Y_{\mathrm{VC}})$ of VC track at ESC plane, the position $(X_{mboxEC}, Y_{\mathrm{EC}})$ of ESC cluster at first hit layer. DCA here is the distance between $(X_{\mathrm{EC}}, Y_{\mathrm{EC}})$ and the track projection.

To match the track and the cluster, it's required that

- **DCA $\leq$ 20cm,**

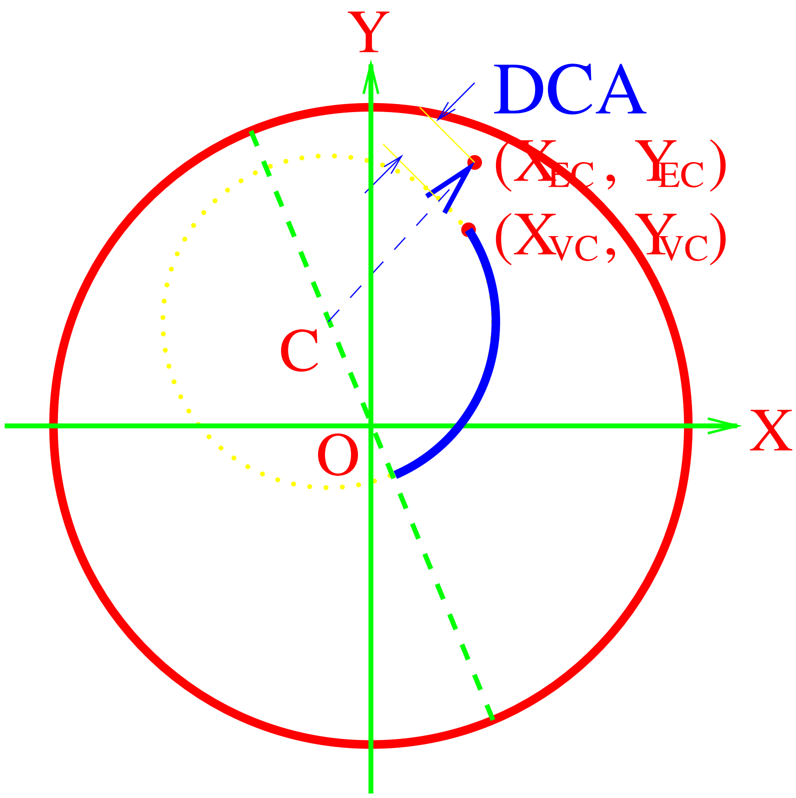

Figure 2: Schematic diagram of track match between VC and ESC

- $\left|X_{\mathrm{VC}} - X_{\mathrm{EC}}\right| \leq$ 15cm,
  $\left|Y_{\mathrm{VC}} - Y_{\mathrm{EC}}\right| \leq$ 20cm,
  $Z_{\mathrm{VC}} \cdot Z_{\mathrm{EC}} > 0$.
- **Compare MDC-SC match**
  - **If this track matches a BSC cluster already, compare the distances between clusters to track, the closer one has the privilege**
  - **If the cluster matches a MDC track, but the MDC track is a bad one, the VC track will take place it.**

3 Results

To tune and test the codes, data samples from both Monte-Carlo and real data are applied here. 10000 Monte-Carlo events of $e^+e^- \rightarrow e^+e^-\gamma$(bhagen–event type 20) are generated; the real data is the .nu data from Run 11034 to 11049(J/ψ scan). First of all, one has to find the matching efficiency, which is defined as

$$\epsilon = \frac{\text{Number of Matched VC-ESC Trks}}{\text{Number of Charged ESC Trks}}.$$

However, it's difficult to distinguish between charged and neutral ESC tracks. One solution is to find the angle θ_{iso} between the ESC track and the closest charged track.

1. **$\theta_{\mathrm{iso}} = 0$: It's a charged track**
2. **$\theta_{\mathrm{iso}} < 0$: It's an unmatched ESC track, but the closest charged track has no SC companion.**
3. **$0^\circ < \theta_{\mathrm{iso}} \leq 90^\circ$: It's an unmatched ESC track, the closest charged track has SC companion.**
4. **$90^\circ < \theta_{\mathrm{iso}} \leq 180^\circ$: It's an unmatched ESC track, the closest charged track has SC companion, but the back to back companion of this charged track is missing.**
5. **$\theta_{\mathrm{iso}} = 360^\circ$: No charged track at all.**

In Fig.3 is shown the distribution of this angle and the scattering plots of the ESC energydeposite versus the angle.

It's clear that cases $0^\circ < \theta_{\mathrm{iso}} \leq 90^\circ$ and $\theta_{\mathrm{iso}} = 360^\circ$ are for neutral tracks, the rests are for charged ones. Hence one can get the matching efficiencies for both MDC-ESC and VC-ESC track matches. In Tab.3 is shown the MDC-ESC and VC-ESC track matching efficiencies for both Monte-Carlo and real data.

The MDC-ESC track matching efficiency for real data is pretty much large, the reason is that the ESC tracks in real data have relatively large angles. VC-ESC matching quality can be expressed by spatial correlation. In Fig.4 is shown the di fference between x of track entry points at ESC plane and that of ESC tracks, if the first ESC hit layer isn't layer one, it's extended to layer one according to shower development direction.

From Tab.3, one can see that:

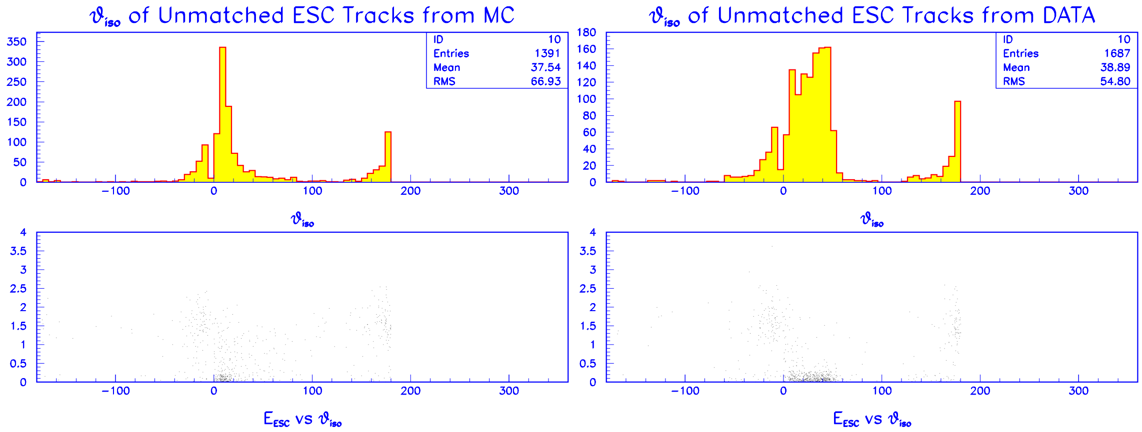

Figure 3: Angle between ESC track and it's closest charged track

Table 2: Track matching efficiencies

Sample		MC	Data
ESC	$N_{\mathbf{ESC}}$	**14800**	**7398**
MDC	$N_{\mathbf{MDC}}$	**2696**	**3354**
	ϵ	**18.2%**	**45.3%**
VC	$N_{\mathbf{VC}}$	**14241**	**6909**
	ϵ	**96.2%**	**93.4%**

Table 3: Matching resolution

	σ(cm)	Monte-Carlo	Data
MDC	$\sigma_{\mathbf{x}}$	**1.87**	**2.25**
	$\sigma_{\mathbf{y}}$	**2.85**	**3.96**
VC	$\sigma_{\mathbf{x}}$	**1.72**	**2.16**
	$\sigma_{\mathbf{y}}$	**2.66**	**4.28**

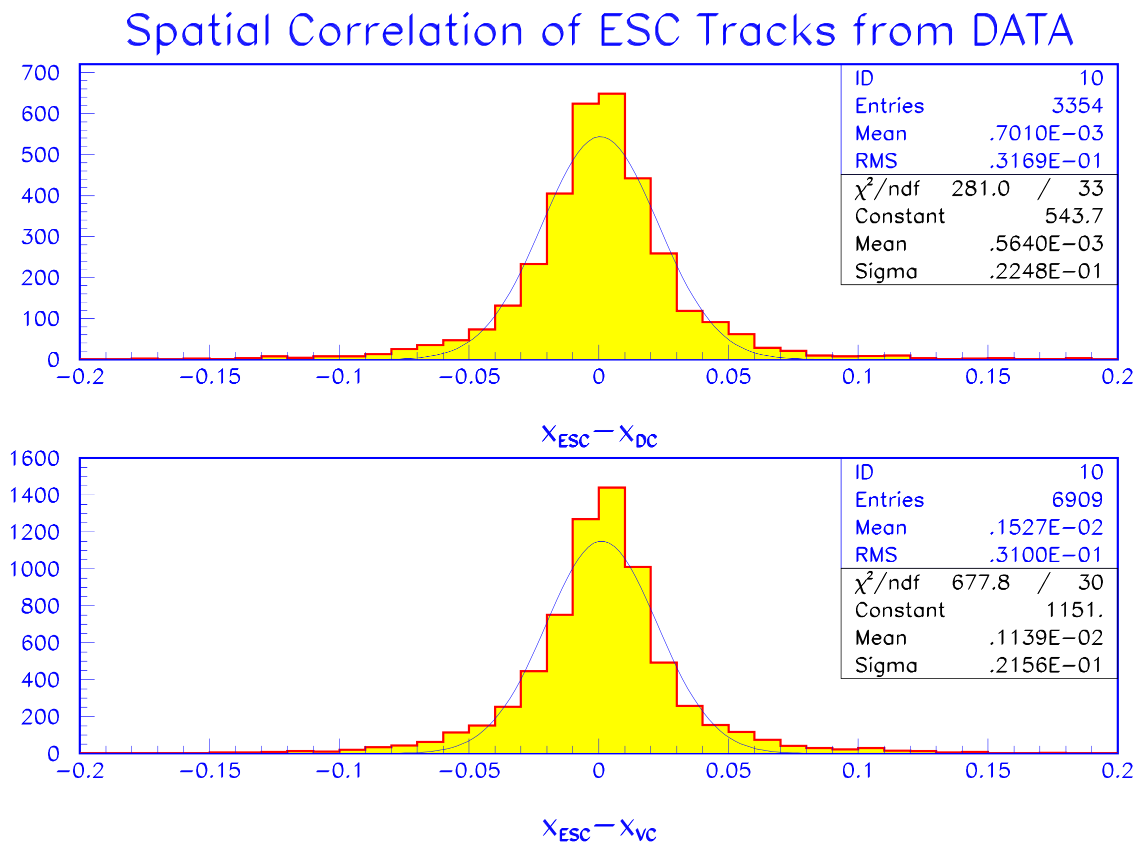

Figure 4: x difference between track entry points and ESC cluster position at first hit layer

- **Data is worse than Monte-Carlo**
- $\sigma_{\mathbf{y}} > \sigma_{\mathbf{x}}$
- **VC is a little bit better than DC, except $\sigma_{\mathbf{y}}$ of data**

The reason is that y of ESC clusters are obtained from charge division method, which has relativly large error. In Fig.5 is shown a displayed event. There are two charged tracks. Track one is got from MDC, it's matched by both VC and ESC; track two is a VC track, it's missing in MDC, but it's matched to ESC.

4 Summary

In BESLIB V101, the reconstruction procedure will be

$$\boxed{\textbf{DCJULIE}}$$
$$\Downarrow$$
$$\boxed{\textbf{VCJULI}}$$
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$$\Downarrow$$
$$\boxed{\textbf{MUREDO}}$$

The VC-MDC match is melted in VCJULI, and the VC-ESC match is put in SHANAL.

It's a good news for BES physics analysis that, after a combined VC-DC-ESC match, the BES solid angle coverage now is enlarged from $\cos\theta = 0.82$ to $\cos\theta = 0.97$. The VC-ESC track match is in good quality, and the efficiency is greater than 90

However, the VC track has no dE/dX information, it causes problem for particle ID, hopefully, there are two solutions: using DC hits, or makeing full use of VC TDC information from trailing edges.

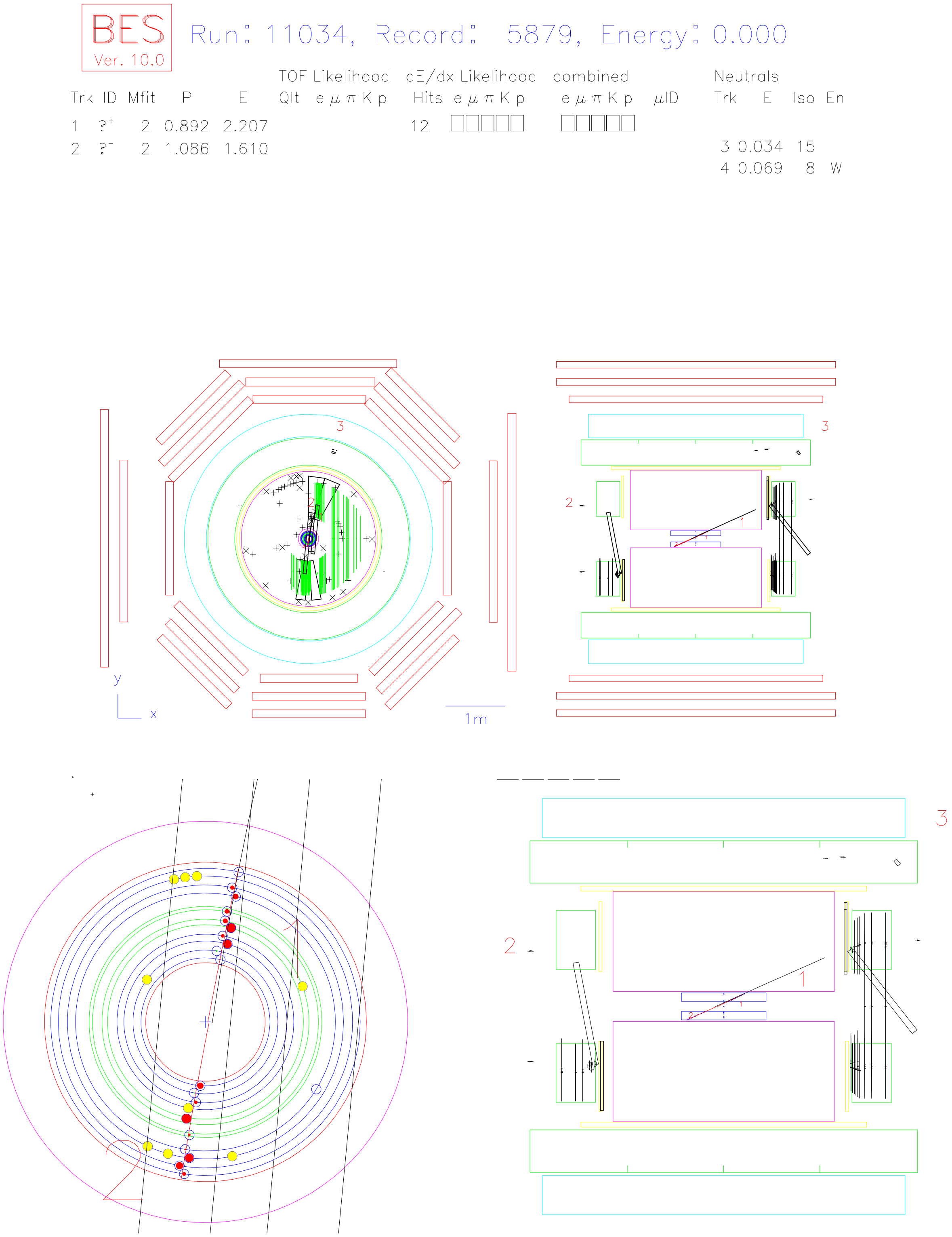

Figure 5: Event display