Trigger Efficiency Study for R Scan

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Abstract

The trigger efficiency for R Scan is measured in an experimental way. The design of trigger table, offline selection,calculation of efficiency and errors are described. The efficiencies of various trigger conditions and three types of events are given.

1 Introduction

In the experiments of High Energy Physics, events recorded in tapes must pass the selection of trigger system at first. So the status of trigger system influences the quality and quantity of data acquired.
And in the physics analysis of R value:

$$R = \frac{\sigma_{had}}{\sigma_{\mu\mu}} = \frac{N_{had}^{obs}}{\sigma_{\mu\mu} \cdot \varepsilon_{select} \cdot \varepsilon_{trg} \cdot (1+\delta) \cdot L}$$

Trigger efficiency of hadron is very important to increase the precision of R value. In a word, trigger efficiency study for R scan is very necessary.
According to the study on trigger efficiency before, the trigger efficiency is measured in an experimental way. This way is simple but effective.

2 Principle of Efficiency Measurement

The measurement is based on this idea: At first an event sample is selected. The sample is irrelevant to certain detector's trigger conditions, The ratio between the number of events which satisfy this detector's trigger condition and the number of all events in this sample is this trigger condition's efficiency.

3 Data Collection

To obtain the samples for trigger study, the trigger table (table I) is designed in this way according to basic principle:

Table I [1] Trigger Condition Table for Trigger Study

trigger type condition	MDC	VC	BSC	TOF	ESC	ETOF	ENDVC	NML
Active?	Y	Y	Y	Y	Y	Y	Y	Y
TOF BB	-	-	Y	-	-	-	-	-
$N_{TOF\geq1}$	-	-	-	-	-	-	-	Y
$N_{TOF\geq2}$	Y	Y	-	-	-	-	-	-
Radial	-	-	-	-	-	-	-	-
$N_{vc\geq1}$	Y	-	Y	Y	Y	Y	-	Y
$N_{etof\geq1}$	-	-	-	-	-	-	-	-
Etof B-B	-	-	-	-	Y	-	Y	-
$N_{trk\geq1}$	-	-	-	-	-	-	-	Y
$N_{trk\geq2}$	-	Y	Y	Y	-	-	-	-
$N_{trk\geq4}$	-	-	-	-	-	-	-	-
Muon-or	-	-	-	-	-	-	-	-
XXX	-	-	-	-	-	-	-	-
ESC-Etot	-	-	-	-	-	Y	Y	-
E_{tot-l}	Y	Y	-	Y	-	-	-	Y
E_{tot-h}	-	-	-	-	-	-	-	-

There are fourteen trigger conditions totally. $N_{trk\geq1}$, $N_{trk\geq2}$ and $N_{trk\geq4}$ means there are one or two or four tracks at least in MDC found by trigger tracking system. TOF BB, $N_{TOF\geq1}$ and $N_{TOF\geq2}$ are relevant to TOF. Radial, E_{tot-l} and E_{tot-h} are deposited energy cuts in BSC. $N_{vc\geq1}$ is relevant to VC. Etof B-B and $N_{etof\geq1}$ are relevant to Etof. ESC-Etot is deposited energy in ESC. On April 29, The data for trigger efficiency study were collected (RUN 11410-11419). The Center-of-mass energy (E_{cm}) is 3097MeV. Thresholds of Deposited Energy cuts in SC are: E_{tot-l}= 8, E_{tot-h}=25, ESC-Etot=8. (Same as R-scan data taking.)

4 Offline Selection of Events

Trigger efficiency for different event type(such as Bhabha, Dimuon, Hadron events) is different, and only the trigger efficiency of good events is useful for R Scan. So the offline cut is necessary. Now, we will take MDC as an example to illustrate offline selection.

1. Reconstruct raw data;

2. Check trigger type to obtain a sample which is irrelavant to MDC's trigger conditions ($N_{trk\geq1}$, $N_{trk\geq2}$), this means that the events passed first trigger type (first column in table I).

3. Select all types of events (Bhabha, Dimuon, Hadron) in this sample and count their number (N_{BB}, $N_{\mu\mu}$, N_h). The cut conditions were gived by R group.

[0]1 'Y' means this condition must be satisfied, 'N' means this condition must not be satisfied, '-' means this condition can be ignored.

4. Check trigger conditions ($N_{trk\geq1}$, $N_{trk\geq2}$) and count the number of events satisfying this condition. Supposing the number of events satisfying $N_{trk\geq1}$ is N_1, $N_{trk\geq2}$ is N_2, the trigger efficiency of $N_{trk\geq1}$ and $N_{trk\geq2}$ for Bhabha are:

$$\varepsilon^{BB}_{N_{trk\geq1}} = \frac{N_1}{N_{BB}} \qquad \varepsilon^{BB}_{N_{trk\geq2}} = \frac{N_2}{N_{BB}}$$

Same for Dimuon and Hadron,

$$\varepsilon^{\mu\mu}_{N_{trk\geq1}} = \frac{N_1^{\mu\mu}}{N_{\mu\mu}} \qquad \varepsilon^{\mu\mu}_{N_{trk\geq2}} = \frac{N_2^{\mu\mu}}{N_{\mu\mu}}$$

$$\varepsilon^{h}_{N_{trk\geq1}} = \frac{N_1^{h}}{N_{h}} \qquad \varepsilon^{h}_{N_{trk\geq2}} = \frac{N_2^{h}}{N_{h}}$$

Using this method, we can measure other trigger condition's efficiency.

5 Results on Trigger Efficiency

With the data for trigger efficiency study, we have got such results. Efficiency of trigger conditions for all kinds of events are listed in Table II.

Table II [2] Efficiency of Trigger Conditions

	BB Events		Dimuon Events		Hardron Events	
$C_{onditions}$	Event Num	Eff(%)	Event Num	Eff(%)	Event Num	Eff(%)
TOF BB	860/963	89.30	369/406	90.89	3625/7117	50.93
$N_{TOF\geq1}$	961/963	99.79	404/406	99.51	7114/7117	99.96
$N_{TOF\geq2}$	896/963	93.04	370/406	91.13	7049/7117	99.04
$N_{vc\geq1}$	895/897	99.78	370/370	100.0	7049/7050	99.99
$N_{trk\geq1}$	898/898	100.0	371/371	100.0	7049/7049	100.0
$N_{trk\geq2}$	896/898	99.78	370/371	99.73	6560/7049	93.06
Radial	857/860	99.65	123/374	32.89	1450/3627	40.00
$E_{tot-l}(8)$	860/860	100.0	369/374	98.66	3625/3627	99.94
$E_{tot-h}(25)$	860/860	100.0	23/374	6.15	3305/3627	91.12
ESC-Etot	3837/3837	100.0				
$N_{etof\geq1}$ [3]	1178/1178	100.0				
Etof B-B [3]	1133/1178	96.18				
$N_{Endvc\geq1}$	3837/3881	98.87				

Thresholds of Deposited Energy in BSC and ESC are shown in next page(Figure 1.)

$$E_{tot-l}(8) \approx 90MeV \qquad E_{tot-h}(25) \approx 750MeV \qquad ESC - Etot \approx 220MeV$$

[0]2 Events which don't pass E_{tot-l} was hand scanned

[0]3 From RUN11416 to RUN11419, the ETOF channel was closed.

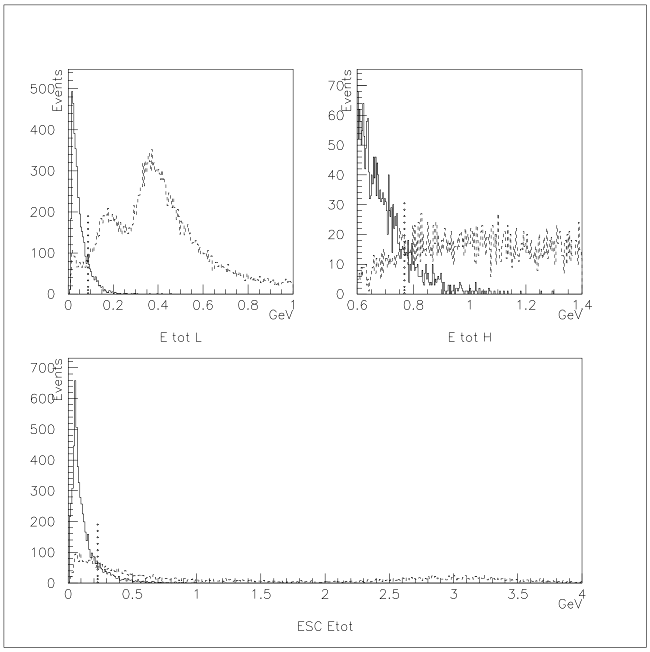

Figure 1: Thresholds of Deposited Energy in SC (Dash line means above threshold, solid line means below threshold.)

6 Trigger Efficiency for R Scan

To monitor the status of trigger system, we use the data for R scan to measure trigger efficiency according to the same idea and offline selection mentioned above. The trigger efficiency is measured beam energy by beam energy.

6.1 Trigger Table

The trigger table for R scan is shown in table III. This table is used when data for R scan were collected.

The data collected with this trigger table, we can select out two samples. First sample is composed of the events which pass channel Char2. In this channel, The trigger conditions which is relevant to BSC(E_{tot-l}, E_{tot-h} and Radial) are not required. Therefore with this sample, we can get trigger efficiency of conditions(E_{tot-l}, E_{tot-h} and Radial). The second sample is consisted of events which pass channel Neutral. Only the trigger conditions of BSC are used. So with this sample trigger efficiency of trigger conditions($N_{trk\geq1}$, $N_{trk\geq2}$, $N_{trk\geq4}$, $N_{vc\geq1}$, TOF BB, $N_{TOF\geq1}$ and $N_{TOF\geq2}$)can be obtained. The trigger efficiency of endcap trigger conditoions are not considered.

Table III [4] Trigger Conditions Table for R Scan

trigger type condition	BB	Charged	2-mu	Char2	Neutral	Cosmic	Esc	BB2
Active?	N	Y	N	Y	Y	N	Y	N
TOF BB	-	-	-	Y	-	-	-	Y
$N_{TOF\geq1}$	-	Y	Y	-	-	-	-	-
$N_{TOF\geq2}$	-	-	-	-	-	-	-	Y
Radial	-	-	-	-	Y	-	-	-
$N_{vc\geq1}$	-	Y	Y	Y	-	Y	Y	-
$N_{etof\geq1}$	Y	-	-	-	-	-	-	-
Etof B-B	-	-	-	-	-	-	Y	-
$N_{trk\geq1}$	-	Y	-	-	-	-	-	Y
$N_{trk\geq2}$	-	-	-	Y	-	Y	-	-
$N_{trk\geq4}$	-	-	-	-	-	-	-	-
Muon-or	-	-	-	-	-	-	-	-
XXX	-	-	-	-	-	-	-	-
ESC-Etot	-	-	-	-	-	-	Y	-
E_{tot-l}	-	Y	Y	-	-	-	-	Y
E_{tot-h}	-	-	-	-	Y	-	-	-

6.2 Results with data for R scan

With the data for R scan in Ecm=3.550Gev, we got trigger efficiency in Ecm=3.550GeV. They are listed in Table IV.

Table IV [5] Efficiency of Trigger Conditions

	BB Events		Dimuon Events		Hardron Events	
$C_{onditions}$	Event Num	Eff(%)	Event Num	Eff(%)	Event Num	Eff(%)
TOF BB	9096/10178	89.37	69/77	89.61	334/622	55.70
$N_{TOF\geq1}$	10170/10178	99.92	73/73	100.0	621/622	99.84
$N_{TOF\geq2}$	9576/10178	94.09	72/77	93.51	614/622	98.71
$N_{vc\geq1}$	10133/10178	99.56	76/77	98.70	622/622	100.0
$N_{trk\geq1}$	10177/10178	99.99	77/77	100.0	622/622	100.0
$N_{trk\geq2}$	10130/10178	99.53	77/77	100.0	622/622	100.0
Radial	9117/9162	99.51	100/409	24.45	344/744	46.24
E_{tot-l}(8)	9162/9162	100.0	407/409	99.51	735/740	99.32
E_{tot-h}(25)	9162/9162	100.0	74/409	18.09	663/744	89.59

[0]4 'Y' means this condition must be satisfied, 'N' means this condition must not be satisfied, '-' means this condition can be ignored.

[0]5 Events which don't pass E_{tot-l} was hand scanned.

7 Summary

7.1 Trigger system is stable and effective.

7.2 Efficicency of three kinds of events.

Above 99.0% of good charged events can be collected from charged channel. Trigger efficiencies of events passing charged channel are:

$$\varepsilon = \varepsilon_{N_{tof}\geq 1} \cdot \varepsilon_{N_{trk}\geq 1} \cdot \varepsilon_{N_{vc}\geq 1} \cdot \varepsilon_{E_{tot-l}\geq 1} \cdot$$

Assuming that, we have
With trigger study data(Ecm=3.097GeV)

$$\varepsilon_{BB} = 99.57\%, \qquad \varepsilon_{\mu\mu} = 98.18\%, \qquad \varepsilon_h = 99.89\%$$

With R scan data(Ecm=3.550GeV)

$$\varepsilon_{BB} = 99.47\%, \qquad \varepsilon_{\mu\mu} = 98.22\%, \qquad \varepsilon_h = 99.17\%$$

Besides charged channel, some events can also pass other channels and thus be recorded, so their true value will be higher. The efficiency of other Center-of Mass can be measured in the same way when the data are available.

7.3 Statistical Errors

These statistics obey Binomial distribution. Each trigger condition efficiency's Variance(σ^2) can be calculated as below:

$$\sigma^2_{cond} = (1 - \varepsilon_{cond}) \cdot \varepsilon_{cond} \cdot N_0$$

Relative errors are:

$$\frac{\sigma_{cond}}{N_0}$$

Data for trigger test(Ecm=3.097GeV),

$$\varepsilon_{BB} = (99.57 \pm 0.22)\%, \varepsilon_{\mu\mu} = (98.18 \pm 0.69)\%, \varepsilon_h = (99.89 \pm 0.05)\%$$

Data for R scan(Ecm=3.55GeV),

$$\varepsilon_{BB} = (99.47 \pm 0.07)\%, \varepsilon_{\mu\mu} = (98.22 \pm 1.67)\%, \varepsilon_h = (99.17 \pm 0.34)\%$$