The measurement of trigger efficiency for the new J/ψ data and the the study of BSC energy threshold

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Part I

The measurement of trigger efficiency for the new J/ψ data

1 Motivation and introduction

The measurement of trigger efficiency is very necessary, because it directly influences the accuracy of physical analysis.

The data (Run13931 to Run13939) for calculating trigger efficiencies were collected on Jan. 11, 2000.

2 Principle for calculating trigger efficiency

The trigger efficiency is measured in an experimental way, which is simple but effective.

Sample data for trigger efficiency measurement were acquired using special trigger condition table which is different from the trigger condition table for J/ψ data acquisition.In this table, each sub-detector corresponds to a trigger channel (such as MDC), in which trigger conditions relevant to this sub-detector are not used.

For calculating the efficiency of a certain trigger condition relevant to a sub-detector, the sample events must pass the trigger channel corresponding to this subdetector. And the ratio between the number of sample events that satisfy this trigger condition and the number of all sample events is the trigger efficiency of this condition.

3 Offline event selection

Trigger efficiencies for different event types (such as Bhabha, Dimuon, and Hadron events) are different, so offline event cut is necessary.

Let's take the MDC trigger channel (for calculating the efficiencies of trigger conditions related to MDC) and Bhabha event as an example.

The process of offline selection is given below:

1. Reconstruct raw data.

2. Pick out the events that pass the MDC trigger channel (the first column in table 1) as a sample.

3. Select Bhabha events and count the event number N_{bb}.

4. From Bhabha events, select events that satisfy $N_{trk\geq1}$ and $N_{trk\geq2}$ which are relevant to the detector MDC, and respectively count their numbers N_1 and N_2. The trigger efficiencies of $N_{trk\geq1}$ and $N_{trk\geq2}$ for Bhabha are calculated as follows:

$$\varepsilon^{bb}_{Ntrk\geq1} = N_1/N_{bb}$$

$$\varepsilon^{bb}_{Ntrk\geq2} = N_2/N_{bb}$$

Using this method, trigger efficiencies of all trigger conditions can be calculated.

The key for cut is, to calculate trigger efficiencies relevant to a certain subdetector, cut conditions related to this subdetector can't be used.

The cut conditions to select Bhabha, Dimuon and Hadron is according to Huang guangshun's fortran subroutines.

4 Results

Three trigger channels (CHARGED, CHAR2, NUTRAL) were opened for the barrel detectors in the trigger table for J/ψ. According to the trigger table for J/ψ, the trigger efficiencies for different trigger channels were calculated with the formula below:

$$Eff_{charged}(e1) = Eff_{Ntof\geq1} \bullet Eff_{Nvc\geq1} \bullet Eff_{Ntrk\geq1} \bullet Eff_{Etot-l}$$

$$Eff_{char2}(e2) = Eff_{Ntof\geq2} \bullet Eff_{Nvc1} \bullet Eff_{Ntrk\geq2}$$

$$Eff_{neutral}(e3) = Eff_{radial} \bullet Eff_{Etot-h}$$

These formula are according to the trigger table for J/ψ: The trigger efficiencies of different event types were calculated in the following formula:

$$\begin{gathered} Eff_{total} = Eff_{Ntof\geq1} \bullet Eff_{Nvc\geq1} \bullet Eff_{Ntrk\geq1} \bullet Eff_{Etot} \\ +(1 - Eff_{Etot-l}) \bullet Eff_{Ntof\geq2} \bullet Eff_{Nvc\geq1} \bullet Eff_{Ntrk\geq2} \\ +(1 - -Eff_{Ntof\geq1} \bullet Eff_{Nvc\geq1} \bullet Eff_{Ntrk\geq1} \bullet Eff_{radial} \bullet Eff_{Etot-h} \end{gathered}$$

Trigger Condition Table for measuring trigger efficiencies

\ TYPE CONDTN\	MDC	VC	BSC	TOF	ESC	ETOF	ENDVC	NML
active?	Y	Y	Y	Y	Y	Y	Y	Y
TOF B–B	–	–	–	–	–	–	–	–
$N_{tof} \geq 1$	–	–	Y	–	–	–	–	Y
$N_{tof} \geq 2$	Y	Y	–	–	–	–	–	–
RADIAL.	–	–	–	–	–	–	–	–
$N_{vc} \geq 1$	Y	–	Y	Y	Y	–	–	Y
Eradial	–	–	–	–	–	Y	–	–
ETOF B–B	–	–	–	–	Y	–	Y	–
ETOF$\geq$1	–	–	–	–	–	–	–	–
$N_{vc} \geq 2$	–	–	–	–	–	–	–	–
$N_{trk} \geq 1$	–	–	–	–	–	–	–	Y
$N_{trk} \geq 2$	–	Y	Y	Y	–	–	–	–
$N_{trk} \geq 4$	–	–	–	–	–	–	–	–
MUON–OR	–	–	–	–	–	–	–	–
E_{trk}	–	–	–	–	–	–	–	–
ESC-E_{tot}	–	–	–	–	–	Y	Y	–
E_{tot-l}	Y	Y	–	Y	–	–	–	Y
E_{tot-h}	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–

The trigger table for J/ψ:

\ TYPE CONDTN\	BHABHA	CHARGED	2–MU	CHAR2	NEUTRAL	ENEU	EBB	BB2
active?	N	Y	N	Y	Y	Y	Y	N
TOF B–B	–	–	–	–	–	–	–	–
$N_{tof} \geq 1$	–	Y	Y	–	–	–	–	–
$N_{tof} \geq 2$	–	–	–	Y	–	–	–	Y
RADIAL.	–	–	–	–	Y	–	–	–
$N_{vc} \geq 1$	–	Y	–	Y	–	–	–	–
Eradial	–	–	–	–	–	Y	–	Y
ETOF B–B	–	–	–	–	–	–	Y	–
ETOF$\geq$1	–	–	–	–	–	–	–	–
$N_{vc} \geq 2$	–	–	–	–	–	–	–	–
$N_{trk} \geq 1$	–	Y	–	–	–	–	–	–
$N_{trk} \geq 2$	–	–	–	Y	–	–	–	–
$N_{trk} \geq 4$	–	–	–	–	–	–	–	–
MUON–OR	–	–	Y	–	–	–	–	–
E_{trk}	–	–	–	–	–	–	–	Y
ESC-E_{tot}	–	–	–	–	–	Y	Y	–
E_{tot-l}	–	Y	–	–	–	–	–	–
E_{tot-h}	–	–	–	–	Y	–	–	–
3	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–

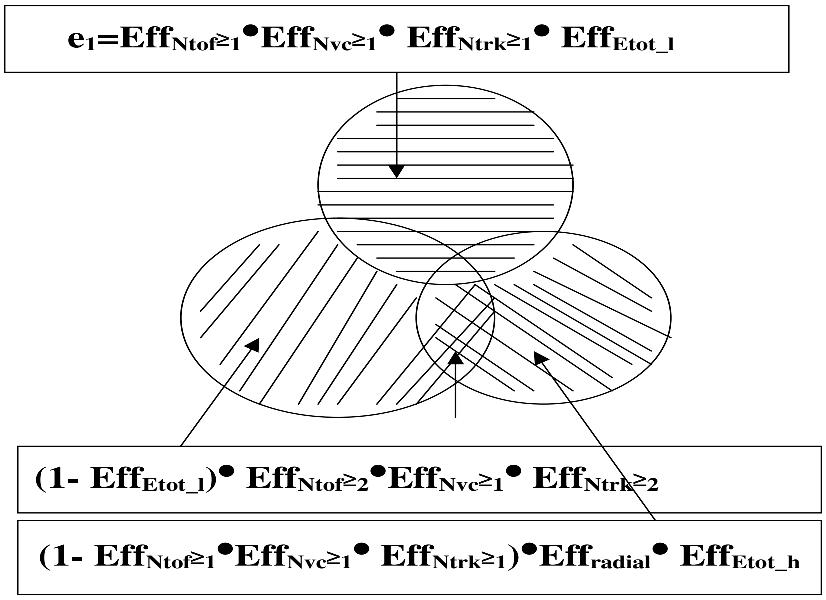


Figure 1:

5 Summary

The trigger efficiencies for different events are:

$$Eff_{Bhabha} = 0.99998$$

$$Eff_{Dimuon} = 0.99642$$

$$Eff_{Hadron} = 0.99619$$

The trigger efficiencies of the trigger system are high enough.

	Bhabha Events			Dimuon Events			Hadron Events		
Conditions	Passed	Total	Efficiency	Passed	Total	Efficiency	Passed	Total	Efficiency
TOF BB	4020	4404	0.91281	1716	1782	0.96296	17311	37152	0.46595
Ntof>=1	4400	4404	0.99909	1782	1782	1.00000	36973	37152	0.99518
Ntof>=2	4309	4404	0.97843	1733	1782	0.97250	36221	37152	0.97494
Nvc>=1	3878	3878	1.00000	1733	1737	0.99770	23531	23533	0.99992
Ntrk>=1	4355	4355	1.00000	1769	1769	1.00000	25296	25306	0.99960
Ntrk>=2	4309	4355	0.98944	1733	1769	0.97965	25095	25306	0.99166
Radial	3561	3613	0.98561	439	1832	0.23963	8841	23600	0.37462
Etot_l(20)	3613	3613	1.00000	1782	1832	0.97271	23568	23600	0.99864
Etot_h(55)	3602	3613	0.99696	28	1832	0.01528	18117	23600	0.76767
Charged			0.99909			0.97047			0.99336
Char2			0.96809			0.95052			0.96673
Neutral			0.98261			0.00366			0.28758
Eff_total			0.99998			0.99642			0.99619

Figure 2: Trigger efficiencies¡E$_{tot-l}$(20)≈150Mev,E$_{tot-h}$(55)≈950Mev¿

Part II

The study of BSC energy threshold

1 Introduction

In March 2000, the online event rate of BES became much higher and we found that the low energy threshold for BSC almost did not work. To find the reason, we focused on the BSC (Barrel Shower Counter) energy thresholds, which are two trigger conditions (E_{tot-h} and E_{tot-l}) in trigger condition table.

The higher event rate meant that the setup of high and low energy thresholds (E_{tot-h} and E_{tot-l}) had become relatively (this word means that not threshold setup itself varied) lower, thus more backgrounds came in. This was proved in this study.

We checked the shift of BSC thresholds' corresponding energy values, but did not find a feasible method to adjust the thresholds, because factors causing this phenomenon were complex and fickle.

2 How do we locate the energy thresholds

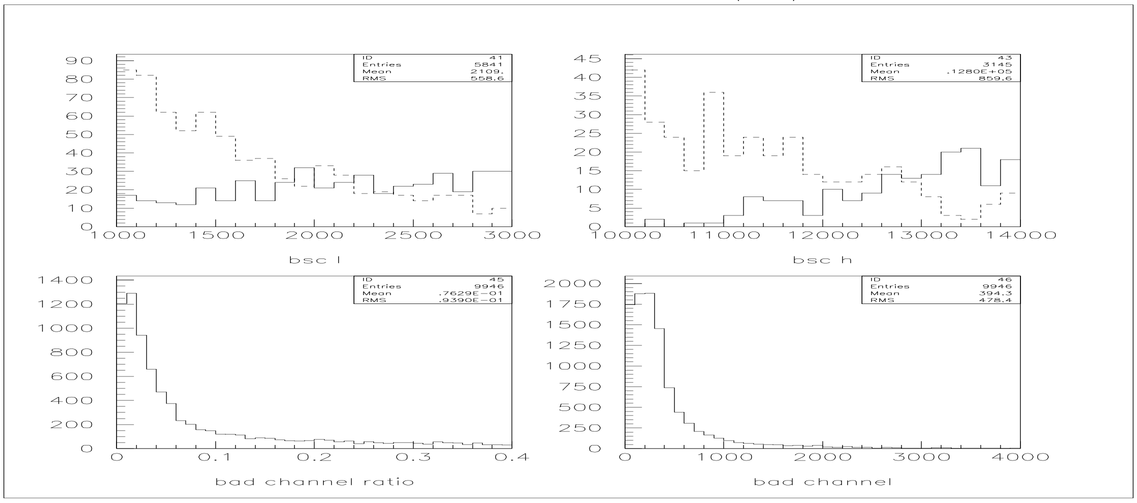
The energy threshold digital values E_{tot-h} and E_{tot-l} are set in a DAC, and converted to analog amplitude values. The BSC total energy output is compared with the analog values to judge whether it has passed the thresholds.

To find out the actual energy value a certain threshold setup corresponds to, we histogrammed the energy (digital accumulated ADC value or offline calibrated energy value) of each event that passed the thresholds (solid line in the following figure) or did not pass the threshold (dash line). Energy at the intersection point was considered as the corresponding energy of this threshold setup.

3 Result

We analyzed the data run13566 to run13573 (December 10, 1999) a the data run15427 to run15430 (March 8, 2000). These runs were collected for this study using special trigger condition table and the threshold setup for different runs is different.

The first picture "bsc l" is for low energy threshold, the second "bsc h" for high energy threshold, and the fourth is for false (bad) signals.



Run	Threshold low	Correspond E value	Correspond ADC value	Threshold high	Correspond E value	Correspond ADC value
13566	20	0. 095	2200	55	0. 72	13400
13567	25	0. 22	4200	60	0. 8	14600
13568	30	0. 32	5800	65	0. 83	15600
13569	35	0. 39	7500	70	0. 93	17000
13570	40	0. 5	9000	75	1. 03	18800
13571	45	0. 54	10200	80	1. 07	19600
13572	50	0. 64	12000	85	1. 12	20800
13573	55	0. 72	13000	90	1. 23	22200
15427	20	0	0	35	0. 21	4450
15428	25	0. 02	800	55	0. 56	11000
15429	30	0. 095	2300	65	0. 7	14400
15430	35	0. 2	4000	75	0. 88	17000

Figure 3:

As you can see, the same threshold setup corresponds to different energy values in the two groups of runs. For the same threshold setup, the corresponding energy values of run13566 to run13573 are greater than those of run15427 to run15430 by more than 2000 (ADC value), or more than 200 Mev energy shift.

This table has well accounted for the rise of event rate from December 1999 to March 2000.

The trigger table for BSC threshold study:

\ TYPE CONDTN\	BHABHA	CHARGED	2–MU	CHAR2	NEUTRAL	ENEU	EBB	BB2
active?	Y	Y	N	Y	Y	N	N	N
TOF B–B	–	–	–	–	–	–	–	–
N_{tof} ≥1	Y	Y	Y	–	Y	–	–	–
N_{tof} ≥2	–	–	–	Y	–	–	–	Y
RADIAL.	–	–	–	–	–	–	–	–
N_{vc} ≥1	Y	Y	–	Y	Y	–	Y	–
Eradial	–	–	–	–	–	Y	–	Y
ETOF B–B	–	–	–	–	–	Y	–	Y
ETOF≥1	–	–	–	–	–	–	–	–
N_{vc} ≥2	–	–	–	–	–	–	–	–
N_{trk} ≥1	Y	Y	–	–	Y	–	–	–
N_{trk} ≥2	–	–	–	Y	–	–	–	–
N_{trk} ≥4	–	–	–	–	–	–	–	–
MUON–OR	–	–	Y	–	–	–	–	–
E_{trk}	–	–	–	–	–	–	–	Y
ESC-E_{tot}	–	–	–	–	–	Y	Y	–
E_{tot-l}	–	Y	–	–	–	–	–	–
E_{tot-h}	–	–	–	–	Y	–	–	–
3	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–

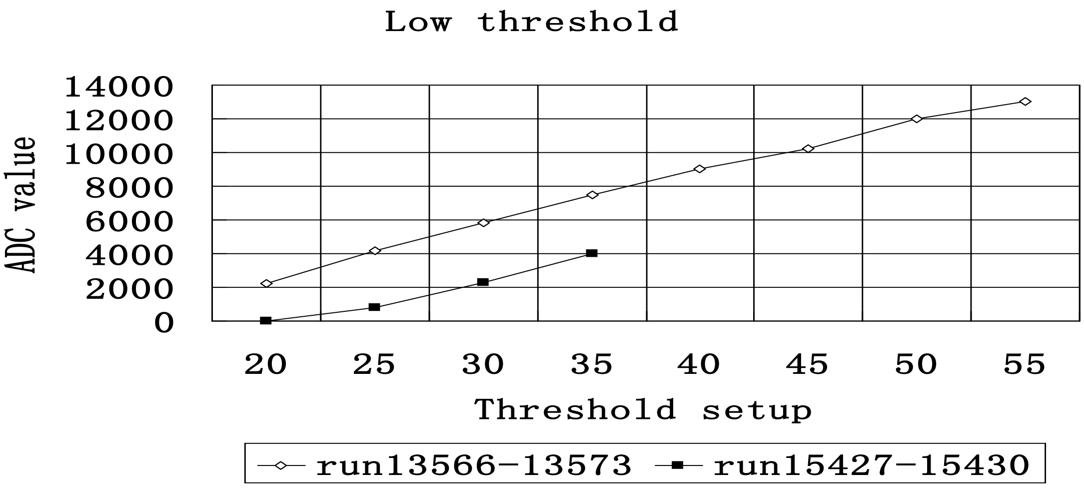


Figure 4:

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Run13566-13573	416	421	422	418	411	414	409	419	417	403	403	419
Run15427-15430	447	457	466	448	451	435	452	448	462	454	450	452

Figure 5:

4 Discussion

Though we have had an explanation for the rise of online event rate, the most basic reason causing this threshold shift is still unknown. Along with the analysis of these data, we also analyzed some other data, and the result suggests that the reason is very complex.

Three points I want to mention here:

1. The parameters of BSC certainly contribute to this shift, but the electronic and trigger systems' influence can not be excluded.

2. Our analysis also suggests that there is no definite tendency for this shift, which may fluctuate as time flows.

3. Since the setup of the thresholds was low, the trigger efficiency was still high enough. As more backgrounds were brougt in, the quality of raw data might degrade a little.