A proposed trigger scheme for $p\bar{p} \to \phi\phi \to 4K$

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1 Introduction

We have investigated the feasibility of a trigger for the channel $p\bar{p} \to \phi\phi \to 4K$.

This channel constitutes the only other decay mode, (other than $\gamma\gamma$) that we may hope to detect for η_c and η_c'.

The ability to measure both decay modes would certainly be a major improvement for the experiment since the measurements would be largely independent: the analysis for the $\gamma\gamma$ is based on the calorimeter (and ignores the charged tracking), while the analysis for the $\phi\phi$ would be based only on the charged tracking (ignoring the calorimeter). Of course systematic errors from luminosity and C.M. energy measurements would be the same.

The feasibility of a hardware trigger does not guarantee, however, the possibility to actually make a measurement, since there are uncertainties in the estimates of peak cross section and background levels, both physical (interesting by itself) and non physical. This problem was discussed in previous memos [1][2]: the measurement of the η_c mass and width in this channel seems possible even without Kaon identification; the measurement of η_c' is more problematic.

$E835$ charged tracking detectors provide a fast z information (scintillating fibers) that can be used in the 1^{st}-level trigger and a highly segmented $\phi - z$ information (Silicon Barrel) that can be used in a processor to check (roughly) the compatibility with the $\phi\phi$ hypotesis.

The Silicon Barrel information can not be used at 1^{st}-level. If the 1^{st}-level trigger rate can be kept low enough, the Silicon Barrel hits will be crucial for the software trigger to reduce the rate of events written on tape. It is unlikely that we can find the money and the manpower required to build a dedicated 2^{nd}-level trigger, and we did not take into account this possibility.

We have studied a trigger scheme for the 1^{st}-level that only requires few additional modules of the same kind of those already used in $E760$ charged trigger.

Our aim is to present a configuration that will allow to define a trigger using all the significant information from the counters.

We made Montecarlo simulations of many background reactions that could give a significant contribution to the trigger rate to compare the performance of this trigger scheme with the one studied in 1991.

We use the simulation to show that a significant rate reduction can be achieved by some appropriate logic that can be built in the proposed layout.

2 Rate constraints vs instantaneous luminosity

The major concern is for the scan in the η_c mass region, i.e. the more interesting one, where the trigger rates are higher.

In the present simulation we assumed that in the next run the value of the instantaneous luminosity will be $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$, a factor 5 increase over the maximum recorded in the 1991 scans in the η_c mass region (run 1799).

We have chosen this value mainly because of the limits of the DAQ, independently on the improvements in the gas jet/accelerator performances.

2.1 Limits set by the DAQ

The total input rate to the event building (and filtering) processors must be kept below $10\,KHz$ in order to have tolerable dead time, the total rate of events to tape (recorded rate) should be kept below $\sim 1.2\,KHz$ ($400\,Hz$ for each tape).

If we want to write different set of triggers to different tapes, this implies that $ETOT$ (written to tape) must not exceed $800\,Hz$ (or $400\,Hz$ if the "charmonium trigger", i.e. $MLU1$ and "2γ's" rates require more than 1 tape)

In the 1991 run we have taken data with and without $ETOT$ (see tab.1).

The difference in $MLU4$ rate and in the recorded rate between run 1799 and 1801 is mainly due to $ETOT$, and only in part (for the rate to tape) to the different prescaling of minumum bias (prescaled by 10^4 in run 1799 and by 10^5 in run 1801). From these numbers we can estrapolate the rates to $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$ and $\mathcal{L} = 5 \cdot 10^{31} cm^{-2} s^{-1}$ (see tab. 2).

The foreseen improvements in the hardware of the $ETOT$ trigger (no overlaps) will not affect the estimate on the recorded rate of $ETOT$ since the ACP already made a check on the software sum. They will only reduce the Gatemaster input rate. As a consequence the maximum tolerable 1^{st}-level trigger rate that we quote for the $\phi\phi$ channel is probably underestimated.

A $\phi\phi$ 1^{st}-level trigger of $2.5\,KHz$ at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$ will be compatible with the limits set by the DAQ, independenly on the prescaling of $ETOT$ only if

Table 1: Measured trigger rates (Hz) at the η_c energy in 1991

Run	E_{cm} GeV	$\mathcal{L}$ $10^{30}\,cm^{-2}\,sec^{-1}$	G.M. in Hz	Tape Hz	MLU1 Hz	MLU2 Hz	MLU4 Hz
1748 $(ETOT)$	2.975	4.2	742	170	5.7	~ 16	702
1799 $(no\ ETOT)$	3.005	4.9	63	47	7.1	~ 20	17
1801 $(ETOT)$	3.005	3.9	766	160	5.3	~ 16	755

Table 2: Expected rates (Hz) at the η_c

Trigger	$\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} sec^{-1}$		$\mathcal{L} = 5 \cdot 10^{31} cm^{-2} sec^{-1}$	
	G.M.in Hz	Tape Hz	G.M.in Hz	Tape Hz
MLU1	36	36	72	72
"2γ's"	87	87	175	175
MLU2 (pre:200)	52	10 (?)	105	20 (?)
Min.Bias (pre:10^5)	15	15	30	30
ETOT	4800	800-900	9600	1600-1800
TOTAL (ETOT not presc.)	5000	150+800	unpossible	
Max $\phi\phi$	~ 5000	~ 250		
TOTAL (ETOT presc.=2)	2500	150+400	5100	300+800
Max $\phi\phi$	~ 7500	~ 400	~ 5000	~ 100
TOTAL (ETOT presc.=4)	1350	150+200	2700	300+400
Max $\phi\phi$	~ 8500	~ 400	~ 7000	~ 400

Table 3: Measured rates (Hz) at the η_c energy in 1991 for the C_MLU outputs

Run	E_{cm} GeV	$\mathcal{L}$ $10^{30} cm^{-2} sec^{-1}$	C_MLU1 Hz	C_MLU2 Hz
1748	2.975	4.2	1100	5.5
1799	3.005	4.9	1360	6.9
Estimated		25	7000	35
Estimated		50	14000	70

the software trigger can reduce the $\phi\phi$ rate to $< 250\, Hz$.

An increase in luminosity by a factor 2 will certainly require a prescaling of $ETOT$ by at least a factor 2. In this case a 1^{st}-level of $5\, KHz$ is still acceptable only if the software trigger can reduce the $\phi\phi$ rate to $< 100\, Hz$, and this is certainly not trivial.

From the numbers in tab.2, it seems difficult to avoid a prescaling of $ETOT$ by a factor 2 even at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$, while at $\mathcal{L} = 5 \cdot 10^{31} cm^{-2} s^{-1}$ we will probably be forced to prescale it by a factor 4. In this case the only practical limit for the $\phi\phi$ trigger is given by the maximum rate that can be written to a single tape ($400\, Hz$).

2.2 Limit on Silicon Barrel Strobe rate

There is also a limit on the maximum strobe rate that is acceptable for the Silicon Barrel. There is no quoted value for the ICAR chip that reads out the Silicon pads, but a limit of $10\, KHz$ is conservative.

The problem comes from the fact that the strobe for the Silicon Barrel (that has to be delivered to the R/O chip within $300\, ns$) will probably be given by the charged MLU alone (i.e. will not require $PBG1$ for timing reasons). That means that in order to read out the silicons for $MLU1$ triggers we are forced to use C_MLU1 ("0e" and "1e") and C_MLU2 ("2e") as a strobe. Silicons will not receive the strobe (i.e. will not digitize hits) on neutral triggers.

By scaling from the measured values (tab.3), we could expect a contribution to the Silicon Barrel strobe from the $MLU1$ events of $\sim 7\, KHz$ for $\mathcal{L} \sim 2.5 \cdot 10^{31} cm^{-2} sec^{-1}$, that sets a limit of $\sim 3\, KHz$ for the 1^{st}-level $\phi\phi$ trigger rate.

It must be noticed that the main contribution to C_MLU1 comes from the "0e" trigger, that needs not to be included in the Silicon Barrel strobe (this trigger is used only to measure the "1e" and "2e" efficiencies). Excluding the "0e" from the

Table 4: Background reaction considered in the simulation. The values of the cross section are to be considered as estimates based on measured values to C.M. energies as near as possible.

	Reaction		$\sigma\,(mb)$
1	$p\bar{p} \to p\bar{p}\pi^+\pi^-$	$(n.r.)$	1.4
2	$p\bar{p} \to \Delta\bar{\Delta} \to p\bar{p}\pi^+\pi^-$		2.35
3	$p\bar{p} \to 2\pi^+2\pi^-$		0.4
4	$p\bar{p} \to 2\pi^+2\pi^-\pi^0$		4
5	$p\bar{p} \to 2\pi^+2\pi^-2\pi^0$		6
6	$p\bar{p} \to 2\pi^+2\pi^-3\pi^0$		4.3
7	$p\bar{p} \to 2\pi^+2\pi^-4\pi^0$		1.7
8	$p\bar{p} \to 3\pi^+3\pi^-$		0.92
9	$p\bar{p} \to 3\pi^+3\pi^-\pi^0$		2.7
10	$p\bar{p} \to 3\pi^+3\pi^-2\pi^0$		2.4
11	$p\bar{p} \to p2\pi^+3\pi^-\bar{n}$	$(+c.c.)$	2.35

strobe will reduce its rate to less than $1\,Khz$ at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$, therefore posing no serious problem for any reasonable $\phi\phi$ 1^{st}-level trigger rate.

3 Montecarlo simulation

We have taken into account many reactions with 4 or 6 charged particle (tab.3) which have cross sections of the order of $1\,mb$ or more.

With the only exception of reaction 2. (for which we used the measured angular distribution in the simulation[4]) the events were generated according to phase space (CERNLIB GENBOD routine). Natural width of decaying particles (Δ,ϕ) is taken into account when generating the decay.

The simulation assumed perfect alignment and no cracks in the hodoscopes.

The interaction vertex is assumed to have $\sigma(x, y, z) = (2.5, 2.5, 3.0)\,mm$ (non pointlike source).

The scintillating fiber detector was simulated with a realistic geometry that takes into account layer separation, active fiber radius and pitch among fibers.

Photon conversion probability is taken into account when simulating the hit pattern in the hodoscopes and in the scintillating fibers, but no attempt is made to simulate the Cerenkov response (that in the real life will be used to reject these events).

The efficiency of the trigger is always based on $\phi\phi$ events having the 4 tracks in the acceptance of $H1$,$H2$ and scintillating fibers ($15^o < \theta < 63.9^o$ from $E760$ database and Scintillating fibers design). The acceptance (assuming a phase space distribution that might not be applicable in real life) is 57.9%. The probability that none of the Kaons decays within a radius of $60\,cm$ (see [1]) is 75%.

4 Conditions used to form the trigger

In order to design a trigger for this channel we can only use the topological and kinematical characteristics, no particle identification is possible without the Fitch counter.

The peculiar topology of the $\phi\phi$ channel, i.e. 4 charged tracks in which the opening angle of the Kaons from the same ϕ is "small", was the criterion on which was based the trigger tested in $E760$[3], e.g. run 1238 ($E_{cm} = 3.005\,GeV$), run 1341 ($E_{cm} = 3.525\,GeV$),

It had the following logic:

$$2h \times \overline{(1e)} \times (NH2 = 3,4) \times NH2_{Cluster} = 2 \times (NH1 = 2,3,4) \times H2\_COPL_{1/3}$$

$$\times\overline{(FCAL - OR)} \times \overline{(FCH - OR)}.$$

requiring 2 (or more) "tracks" (as defined by $H1 \times H2$), no electron, 2,3 or 4 hits in H1, 3 or 4 hits in H2, at least two of them back to back (1 vs 3 coplanarity) and nothing in the Forward Calorimeter or in the Forward Charged Hodoscope. The requirement of small opening angle between kaons was implemented by the condition that the $H2$ hits be grouped in 2 clusters of adjacent hits ($NH2_{Cluster} = 2$).

The efficiency was less than 30% (for η_c) and the trigger rate was $398\,Hz$ at $\mathcal{L} = 2.3 \cdot 10^{30} cm^{-2} sec^{-1}$, that scaled to the $E835$ luminosity would be too high ($> 4\,KHz$), unless we prescale $ETOT$.

The main source of inefficiency is the requirement of $NH2_{Cluster} = 2$, because the opening angle distribution of the Kaon pair, almost flat up to 26^o (then falling down to zero at $\sim 30^o$) is large compared to the granularity of $H2$ (11.25^o).

The most important difference among $E760$ and $E835$ is given by the z information provided by the fibers, from which we will certainly define a multiplicity (NSF).

In devising a new trigger scheme we had the following guidelines:

- Find a more efficient way to implement the requirement of "small opening angle" in $H2$

- Use the z segmentation of the fibers to veto some polar angular regions, to pose condition on multiplicity, pose some loose condition on the $\phi\phi$ kinematics.

We therefore used the 1991 trigger logic as a starting point and made a study to identify other possible trigger conditions that could be used to reduce the rate and that are at the same time feasible with the existing logic (or at most require a duplication of some modules).

4.1 Multiplicity in $H2$ and SF

We are forced to require a multiplicity ≥ 3 to reject channels with only 2 charged tracks.

A powerful cut is the one on the combined multiplicity of $H2$ and scintillating fibers, i.e. $(NSF = 3,4) \times (NH2 = 3,4) \times (NH2 + NSF = 7,8)$, that kills all events with only 3 charged tracks in the acceptance.

4.2 Veto on polar angular regions

Kaons from $\phi\phi$ reaction at η_c, once the acceptance condition on all 4 kaons is met, have an angular distribution almost vanishing for angles above $\theta \sim 50^o - 55^o$, therefore we can use as a veto either the scintillating fibers (e.g. the $.OR.$ of the most upstream fibers in each layer) or the $.OR.$ of the Ring sums (that in the next configuration will be available, instead of the Super-Ring sums of $E760$) for ring 1 to 4 ($50.4^o < \theta < 70^o$) or both.

At the η_c and η_c' can use the Ring sums for ring 18-20 ($10.6^o < \theta < 14.4^o$) as a veto, since these rings cover an angular region not covered by the charged tracking.

At the $^1P_1$ it would be preferable to release the condition on the $CCAL$ (even at the price of less efficient requirements on counters) in order not to reduce the angular acceptance of the γ, whose angular distribution is certainly relevant for the analysis.

4.3 Hit pattern in $H2$

The topology of $\phi\phi$ events is characterized by the small opening angle among Kaons from the same ϕ, and as a consequence the two pairs of kaons are almost back-to-back in azimuth.

The condition on the "small" opening angle can be posed by a coincidence matrix among $H2$ elements used as a veto ($H2\_LOGIC$). This essentially requires to have hits exclusively back to back in a polar angular window of 80^o (1/7) or 55^o (1/5).

To strengthen the back-to-back requirement we can require $H2\_COPL_{1/3}$ that has $\sim$ 100% efficiency even if it is not very effective in reducing the rate, beeing strongly correlated with $H2\_LOGIC$.

Another condition that can be used to reduce the rate, even if strongly correlated with $H2\_LOGIC$, is given by the clusterization of $H2$ hits. With the existing electronics, we could have $H2$ hits clusterized in different ways:

- *majority* clusters (as in 1991 adjacent hits will count as 1)
- *alternated* clusters (same as *majority* clusters but on *odd* and *even* counters separately). This would allow to define as 1 $Alt-cluster$ two hits separated by 1 $H2$ element.

A possible choice for $H2_{cluster}-LOGIC$ is given by

$$(NH2 = 3 \times NH2_{Cluster} = 2 \times NH2_{Altclust} = 3).OR.$$

$$(NH2 = 3 \times NH2_{Cluster} = 3 \times NH2_{Altclust} = 2).OR.$$

$$(NH2 = 4 \times NH2_{Cluster} = 2 \times NH2_{Altclust} = 4).OR.$$

$$(NH2 = 4 \times NH2_{Cluster} = 3 \times NH2_{Altclust} = 3).OR.$$

$$(NH2 = 4 \times NH2_{Cluster} = 4 \times NH2_{Altclust} = 2,3)$$

Other more stringent choices are possible for the clusterization (like $NH2_{Cluster} = 2$ used in 1991), with some loss in efficency.

4.4 Hit pattern in the Scintillating Fibers

Beeing a cascade of 2-body decays, whith small opening angle between kaons from the same ϕ, we can require $NSF \geq 2$ upstream (where upstream is defined by the angle corresponding to $\theta_{cm} = 90^o$ corresponding to $\theta_{lab} \sim 30^o$ at η_c). This cut selects preferentially events with large p_t.

In a quite large fraction of events at least one of the kaons will be close enough to the direction of the "mother" particle, that can set a condition on the 2-body kinematics of the $\phi\phi$ to build an appropriate coincidence matrix among fiber bundles hits ($KIN2body$).

The most obvious grouping is given by an uniform spacing, but for trigger purposes a different choice might be more useful.

For this reasons we used in the simulation the fibers grouped in 16 fiber bundles (+1 used as a veto grouping the fibers at $theta > 55^o$), each one corresponding to an interval $\Delta\theta_{cm}(\phi) = 5^o$, that ideally would give a 1/1 coincidence in the matrix. We think to plug these signals into a PLU requiring a 1/3 coincidence (inclusive).

Similar results can be obtained with uniform spacing and 32+1 bundles, (of course with a different coincidence pattern).

The final choice on the grouping of SF will be done after a comparison of the performances of the trigger at ${}^1P_1$ and η_c'.

4.5 Rate reduction and efficiency

Many of the criteria described in this section are strongly correlated, both on $\phi\phi$ and on background. For this reason we show the matrices of combined efficencies (tab.5) and rate reduction factors (tab.6) of these criteria, calculated on the sample of MC events that satisfy the condition:

$$2h \times \overline{(1e)} \times (NH2 = 3,4) \times (NSF = 3,4)$$

$$\times \overline{(SF[> 55^o] - OR)} \times \overline{(FCAL - OR)} \times \overline{(FCH - OR)}.$$

i.e. a minimal necessary requirement for the $\phi\phi$ trigger, that has an efficiency (at η_c) of 85.1%.

5 Trigger scheme

The configuration we are proposing for the MLU dedicated to $\phi\phi$ would allow to combine all the conditions described in the previous section in an arbitrary way.

The 16 inputs are:

1. $NH2 = 3$
2. $NH2 = 4$
3. $NH2_{Cluster} \geq 3$
4. $NH2_{Altclus} \geq 3$
5. $NH2_{Altclus} \geq 4$
6. $NSF = 3$
7. $NSF = 4$
8. $NSF_{up} \geq 2$
9. $H2\_COPL$
10. $H2\_LOGIC$
11. $KIN2body$

Table 5: Correlated efficiencies (%) after minimal trigger

	$NSF{+}NH2{=}7,8$	$H2\_COPL_{1/3}$	$H2\_LOGIC_{1/7}$	$H2_{cluster}LOG$	$NSF_{up}{\geq}2$	$KIN2body_{1/3}$	$\overline{(CCAL[1{:}4])}$	$\overline{(CCAL[18{:}20])}$
$NSF{+}NH2{=}7,8$	91.1	91.1	91.0	80.5	84.3	79.4	82.6	91.8
$H2\_COPL_{1/3}$		100	99.9	88.5	92.6	87.1	91.0	100
$H2\_LOGIC_{1/7}$			99.9	88.5	92.6	87.1	91.0	99.9
$H2_{cluster}LOG$				88.5	82.0	77.2	81.1	88.5
$NSF_{up}{\geq}2$					92.6	81.2	84.3	92.6
$KIN2body_{1/3}$						87.1	79.3	87.1
$\overline{(CCAL[1{:}4])}$							91.0	91.0
$\overline{(CCAL[18{:}20])}$								100

Table 6: Correlated rejection factors after minimal trigger

	$NSF{+}NH2{=}7,8$	$H2\_COPL_{1/3}$	$H2\_LOGIC_{1/7}$	$H2_{cluster}LOG$	$NSF_{up}{\geq}2$	$KIN2body_{1/3}$	$\overline{(CCAL[1{:}4])}$	$\overline{(CCAL[18{:}20])}$
$NSF{+}NH2{=}7,8$	1.7	2.8	18.3	6.9	2.9	4.5	3.5	2.3
$H2\_COPL_{1/3}$		1.9	8.6	7.8	3.3	5.2	3.6	2.6
$H2\_LOGIC_{1/7}$			7.0	13.3	12.3	19.4	12.7	10.4
$H2_{cluster}LOG$				4.1	6.9	11.1	8.2	6.0
$NSF_{up}{\geq}2$					1.7	3.7	3.4	2.5
$KIN2body_{1/3}$						2.7	5.3	4.1
$\overline{(CCAL[1{:}4])}$							1.9	2.8
$\overline{(CCAL[18{:}20])}$								1.4

12. $CCAL[1:4]-OR$

13. $CCAL[18:20]-OR$

14. $FCH-OR$ .OR. $FCAL-OR$

15. $2h \times \overline{(1e)}$

16. $SF[>55^o]-OR$

We are confident that these inputs will give us an adequate level of flexibility to define a trigger logic for the $\phi\phi$ channel, whose actual scheme can only be established on real data, when rate measurements will be done in the set-up stage.

No condition on $H1$ multiplicity is used, but if needed it could be logically combined with $2h \times \overline{(1e)}$.

5.1 Hardware requirements

As already stated this trigger would require one additional MLU identical to the Charged MLU, that would work in parallel with it sending the output to the master MLU.

$H2\_LOGIC$ would require a duplicate of the PLU used to define $H2\_COPL$.

$KIN2body$ would require another PLU.

The $CCAL$ Ring-sums must be splitted,.OR.ed and discriminated.

To define a scintillating fiber multiplicity we have to build appropriate .OR. of fiber bundles to be fed into the trigger logic.

6 $\phi\phi$ trigger rate simulation

If we use in our simulation the 1991 trigger we find $\sim 500\,Hz$, that has to be compared with the measured value of $\sim 400\,Hz$. The 25% overestimate might possibly be explained by angular distributions (most of the reactions are forward-peaked) and also by the errors associated to extrapolation of cross sections from different E_{cm} values.

Our simulation show that a trigger defined by (tab.7, TR_A):

$$2h \times \overline{(1e)} \times (NH2 = 3,4) \times (NSF = 3,4) \times (NSF + NH2 = 7,8)$$

$$\times H2\_COPL_{1/3} \times H2\_LOGIC_{1/7}$$

$$\times \overline{(SF[>55^o]-OR)} \times \overline{(CCAL[1:4]-OR)} \times \overline{(CCAL[18:20]-OR)}$$

$$\times \overline{(FCAL-OR)} \times \overline{(FCH-OR)}.$$

has efficiency 70% and an estimated rate of $2.3\,KHz$ at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2}s^{-1}$.

Table 7: Vectors loaded in the $\phi\phi$ MLU for the proposed TR_A

Channel	Input	1	2	3	4	5	6	7	8
1	$NH2 = 3$	Y							
2	$NH2 = 4$		Y	Y					
3	$NH2_{Cluster} \geq 3$								
4	$NH2_{Altclus} \geq 3$								
5	$NH2_{Altclus} \geq 4$								
6	$NSF = 3$			Y					
7	$NSF = 4$	Y	Y						
8	$NSF_{up} \geq 2$								
9	$H2\_COPL$	Y	Y	Y					
10	$H2\_LOGIC$	Y	Y	Y					
11	$KIN2body$								
12	$CCAL[1:4] - OR$	N	N	N					
13	$CCAL[18:20] - OR$	N	N	N					
14	$FCH - OR.OR.FCAL - OR$	N	N	N					
15	$2h \times \bar{(}1e)$	Y	Y	Y					
16	$SF[> 55^o] - OR$	N	N	N					

Table 8: Estimated contribution to trigger TR_A rates from various background reactions. ($E_{cm} = 2.990\,GeV$, $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$)

	Reaction		Rate (Hz)
1	$p\bar{p} \to p\bar{p}\pi^+\pi^-$	$(n.r.)$	500
2	$p\bar{p} \to \Delta\bar{\Delta} \to p\bar{p}\pi^+\pi^-$		530
3	$p\bar{p} \to 2\pi^+2\pi^-$		70
4	$p\bar{p} \to 2\pi^+2\pi^-\pi^0$		410
5	$p\bar{p} \to 2\pi^+2\pi^-2\pi^0$		370
6	$p\bar{p} \to 2\pi^+2\pi^-3\pi^0$		140
7	$p\bar{p} \to 2\pi^+2\pi^-4\pi^0$		30
8	$p\bar{p} \to 3\pi^+3\pi^-$		80
9	$p\bar{p} \to 3\pi^+3\pi^-\pi^0$		90
10	$p\bar{p} \to 3\pi^+3\pi^-2\pi^0$		40
11	$p\bar{p} \to p2\pi^+3\pi^-\bar{n}$	$(+c.c.)$	10

The contribution to the rate from each of the background channels is listed in tab.8.

If the rates obtained in our simulation are underestimated by more than a factor 2 (even if the comparison with the 1991 data suggests that they are overestimated by 25%), we will be forced to choose between the prescaling of $ETOT$ (if not already prescaled for independent reasons) and more severe conditions in the trigger, at the price of some inefficiency.

7 Software trigger

The $\phi\phi$ trigger rate must be reduced by the software trigger to $< 400\,Hz$ in order to write events to tape. If $ETOT$ is not prescaled this limit is considerably reduced.

We have only studied the following algorithm:

- $\alpha(i,j) < 45^0.AND.\alpha(k,l) < 45^o$
- $AKIN < 6^o$

where i, j, k, l are any combination of any set of four tracks in the event, α is the opening angle between two tracks, $AKIN$ is the difference between the θ of one ϕ candidate (estimated by the average θ of the two tracks) and the predicted θ from the other ϕ candidate.

This criterion would reduce the $\phi\phi$ trigger rate to $\sim 280\,Hz$ at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$ with an efficiency of 99.6%. This rate is not compatible with the DAQ limits unless $ETOT$ is prescaled by a factor 2. At $\mathcal{L} = 5 \cdot 10^{31} cm^{-2} s^{-1}$ the $\phi\phi$ trigger rate would force a prescaling of a factor 6 in $ETOT$

Other selection criteria can be investigated in order to see if the conflict with $ETOT$ can be avoided or at least reduced.

8 Conclusions

A $\phi\phi$ 1^{st}-level trigger with acceptable rates, efficiencies and costs can be built for $E835$.

The simulation can reproduce the 1991 measured trigger rates within 25%.

The estimated trigger rate at $\mathcal{L} = 2.5 \cdot 10^{31} cm^{-2} s^{-1}$ is a factor 2 less than the maximum tolerable Gatemaster input rate even if $ETOT$ is not prescaled and a factor 1.5 less than the maximum strobe rate for the Silcon Barrel, even if the strobe on $MLU1$ events is given by C_MLU1.

The $\phi\phi$ 1^{st}-level trigger rate is adequate to strobe the Silicon Barrel, even taking into account the C_MLU1 rate.

Considering that an adequate prescaling of $ETOT$ (factor 2 or 4 depending on the luminosity) seems necessary independently on the rate of the $\phi\phi$ trigger and also that the strobe to the Silicon Barrel from $MLU1$ events can be safely reduced by a factor at least 5, we can expect that the proposed $\phi\phi$ trigger will give no rate problems to the Gatemaster input or to the S.B. strobe even at a luminosity of $\mathcal{L} = 5 \cdot 10^{31} cm^{-2} s^{-1}$.

The problem of the filtering of $\phi\phi$ triggers in the processors needs to be futher studied, but a rate reduction by a factor ~ 10 can be obtained with simple algoritms. The estimated $\phi\phi$ rate written to tape is not compatible with the DAQ limits unless $ETOT$ is prescaled by a factor 2 or 6.

Depending on the effective reduction factor achieved in the software trigger (with some other set of more selective criteria), we can be forced to take a decision on the relative priorities of $ETOT$ and $\phi\phi$ triggers.

References

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