EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CB-note 324

# 4-Prong Trigger Efficiency as Function of the Annihilation Channel

N.Djaoshvili, R.Landua, L.Montanet, R.Ouared

June 11, 1998

# 1 Introduction

We call annihilation channel the chain of $\bar{p}p$ annihilation and decay of narrow resonances as $\eta$, $\eta'$, $\omega$ etc..For instance:

$$\bar{p}p \rightarrow \eta'\pi^+\pi^- \rightarrow (\eta\pi^+\pi^-)\pi^+\pi^- \rightarrow ((\gamma\gamma)\pi^+\pi^-)\pi^+\pi^- \quad \equiv \quad 2\pi^+2\pi^-2\gamma \tag{1}$$

If $N_p$ is the number of produced events, the number of events observed in the "signal" is

$$N_{ob} = N_p \beta \epsilon_s \epsilon_t$$

where $\beta$ is the appropriate branching ratio, $\epsilon_s$ is the reconstruction and selection efficiency, and $\epsilon_t$ is the trigger efficiency. For channel (1) we have:

$$\beta = 0.437\ .\ 0.392 = 0.17; \epsilon_s = 6.8\%$$

$\epsilon_s$ is in this case the efficiency of reconstruction of 4 golden tracks multiplied by the detection efficiency of the two $\gamma^*$ and by a selection cut factor (10% probability for the 4C fit, rejection of the events with peds in Crystal-type-13, etc..[1].

$\epsilon_t$ is the efficiency for the 4-long-track trigger. It is found to be channel dependent.

# 2 Determination of $\epsilon_t$

For the determination of $\epsilon_t$ we compare a sample of 100000 "Triggered data" to a sample of 300000 "Minimum Bias data". We first consider channel (1), channel

$$\bar{p}p \quad \rightarrow \quad \eta 2\pi^+2\pi^- \tag{2}$$

and channel

$$\bar{p}p \quad \rightarrow \quad \pi^0 2\pi^+2\pi^- \tag{3}$$

for reference.

In both samples, we observe the $\eta'$ signal, with

$$\begin{aligned} \eta' &\rightarrow \eta\pi^+\pi^- \\ \eta &\rightarrow \gamma\gamma \end{aligned}$$

For the reference channel (3), we observe

$$\pi^0 \rightarrow \gamma\gamma$$

To obtain these signals we have applied the selection cuts described in [1]. The mass window cuts used for $\pi^0$, $\eta$ and $\eta'$ are:

$$\begin{aligned} m_{\pi^0} &\pm 20MeV \\ m_\eta &\pm 30MeV \\ m_{\pi^0} &\pm 25MeV \end{aligned}$$

$\pi^0$ and $\eta$ signals are both shown in figures 1a and 1b for "Triggered data" and "Minimum Bias data" respectively.

Table 1 summarizes the number of events for different channels and triggers:

| **Channel** | **4-Prong Trigger** | **Minimum Bias** |
|---|---|---|
| 3 ($\pi^0$) | 4324 | 3226 |
| 2 ($\eta$) | 110 | 90 |
| 1 ($\eta'$) | 22 | 30 |

Table 1: Number of events for different channels and triggers

One can note that the numbers of events include backgrounds under signals which appear in the same way for both "Triggered" and "Minimum Bias" data. This is particularly true for $\eta'$.

The relative number $\frac{\eta'}{\pi^0}$ is $(0.50 \pm 0.10)\%$ for "Triggered" data and $(0.93 \pm 0.18)\%$ for "Minimum Bias" data. Assuming $\epsilon_t$=1 for channel (3), we determine $\epsilon_t$ for channel (1):

$$\epsilon_t{}^{(1)} = \frac{0.50}{0.93} \quad = \quad 0.54 \pm 0.20$$

For reaction (2), one should take into account that fraction of $\eta$ coming out from the decay $\eta' \to \eta\pi^+\pi^-$ for which the trigger efficiency is now known ($\epsilon_t{}^{(1)}$). This effect alone explains the value of $\epsilon_t{}^{(2)}$, the trigger efficiency for channel (2) which is found equal to:

$$\epsilon_t{}^{(2)} \quad = \quad 0.91 \pm 0.09$$

Indeed, if one corrects for lost $\eta$'s correlated to the lost $\eta'$'s produced in the same trigger, one can find a good agreement with the "Minimum bias" data:

$$\frac{110 + (\frac{22}{0.54} - 22)}{4324} \quad \approx \quad \frac{90}{3226} \tag{4}$$

Consequently, $\epsilon_t{}^{(2)}$=1 for reaction (2) when the $\eta'$ signal is removed. This is precisely the case for reactions involving $E$-meson production. One can note that the number of "Minimum Bias" $\pi^0$ corrected for the appropriate channel selection efficiency $\epsilon_s$=6.4% ($\epsilon_t = 1$) gives a branching ratio for reaction (3)

$$BR(\bar{p}p \to 2\pi^+2\pi^-\pi^0) \quad = \quad (17.1 \pm 1.0)\%$$

in excellent agreement with bubble chamber result $(17.3 \pm 0.6)\%$ [2]. This clearly shows that our efficiency estimation ($\epsilon_s{}^{(3)}.\epsilon_t{}^{(3)} = 6.4\%$) is correct. Also, one can deduce that the four-prong trigger enrichment factor is 1.7.

We now consider the channel:

$$\bar{p}p \to 2\pi^+2\pi^-6\gamma \tag{5}$$

95% of these events are indeed

$$\bar{p}p \to 2\pi^+ 2\pi^- 3\pi^0 \tag{6}$$

The comparison of the ratio $\frac{Number\ of\ events\ for\ channel\ (6)}{Number\ of\ events\ for\ channel (3)}$ gives 15.4% for "4-Prong Trigger" data and 18.4% for "Minimum Bias" data. Therefore

$$\epsilon_t{}^{(6)} = \epsilon_t{}^{(5)} \quad = \quad 0.84 \pm 0.15$$

A similar comparison for the reaction

$$\bar{p}p \to 2\pi^+ 2\pi^- \eta 4\gamma \tag{7}$$

yields:

$$\epsilon_t{}^{(7)} \quad = \quad 0.55 \pm 0.20$$

For reaction

$$\bar{p}p \to \eta\eta\pi^0 \tag{8}$$

with both $\eta \to \pi^+\pi^-\pi^0$, we find $\epsilon_t{}^{(8)} \simeq \epsilon_t{}^{(5)}$ within statistics.
For Channels

$$\bar{p}p \to \eta'\pi^+\pi^-\pi^0\pi^0, \ \ \eta' \to \eta\pi^+\pi^- \tag{9}$$

$$\bar{p}p \to \eta' 2\pi^+ 2\pi^-, \ \ \eta' \to \eta\pi^0\pi^0 \tag{10}$$

$$\begin{aligned} \bar{p}p \to \eta'\eta\pi^0, \eta' \to \eta\pi^+\pi^- \\ with\ \eta \to \gamma\gamma\ and\ \eta \to \pi^+\pi^-\pi^0 \\ or \\ \eta \to \pi^+\pi^-\pi^0\ and\ \eta \to \gamma\gamma \end{aligned} \tag{11}$$

statistics are too small to allow precise quantitative estimates. For these reactions, one can assume that

$$\epsilon_t \approx \epsilon_t{}^{(7)} \quad = \quad 0.55 \pm 0.20$$

# References


[1] N.Djaoshvili *et al.*, *CB-note-318* (1998)

[2] R. Bizzari *et al.*, *Nucl. Phys.* **B14** (1969) 169

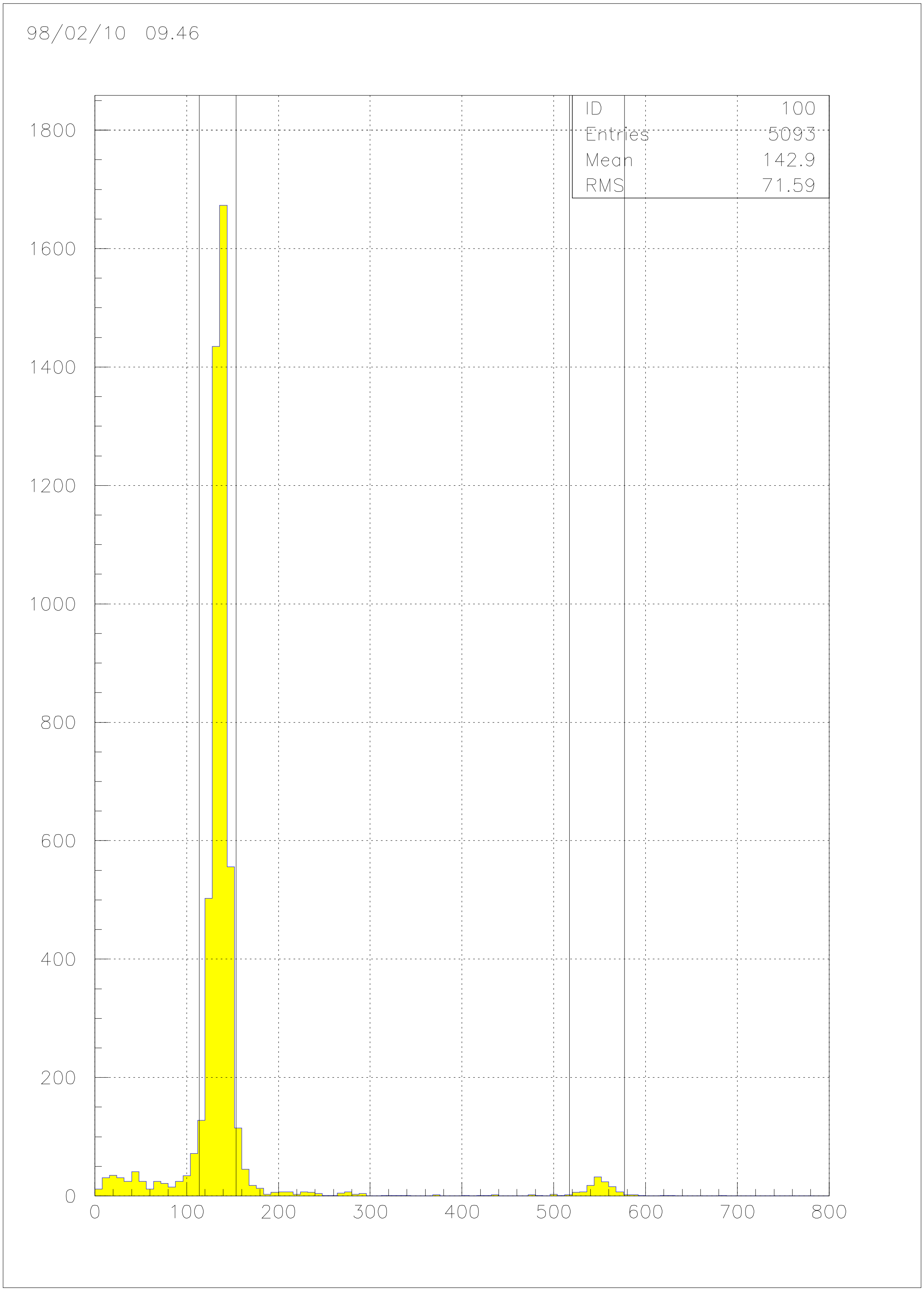


Figure 1: $\gamma\gamma$ invariant mass for 4-prong triggered data

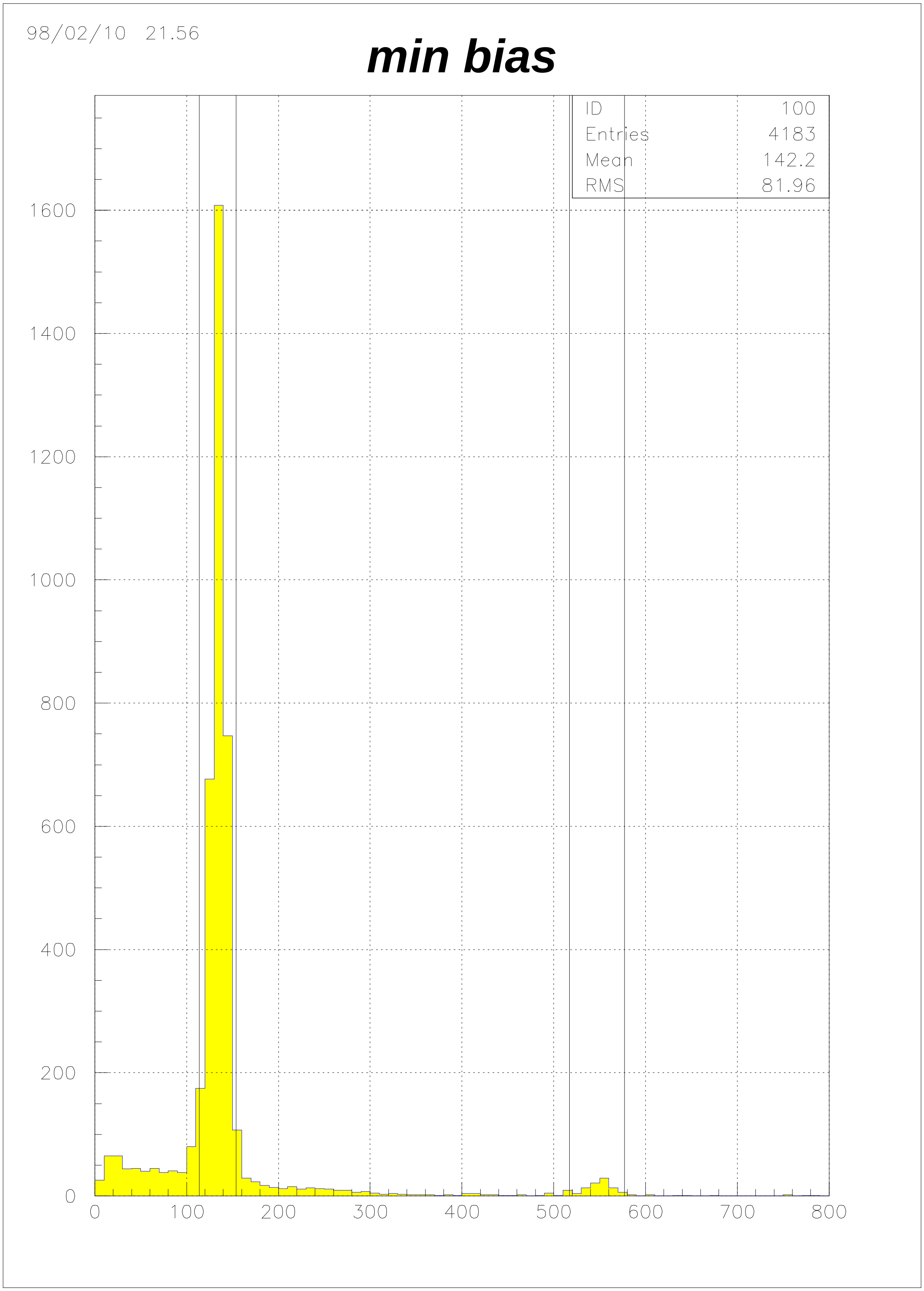


Figure 2: $\gamma\gamma$ invariant mass for minimum bias data