

CB NOTE 323

E decaying into  $\eta'\pi\pi$ .

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# 1 Pseudoscalars decaying into $\eta'\pi\pi$ .

We consider the  $0^{-+}$  decay into  $\eta'\pi\pi$ . We study 5-body annihilation

$$\bar{p}p \rightarrow \eta'4\pi, \quad (1)$$

where  $\eta' \rightarrow \eta\pi^+\pi^-$  or  $\eta' \rightarrow \eta\pi^0\pi^0$ . This needs to investigate the following final state

$$\bar{p}p \rightarrow \eta 2\pi^+ 2\pi^- 2\pi^0, \quad (2)$$

with  $\eta \rightarrow 2\gamma$ .

We use the 4-prongs and 6 or more  $\gamma^*$  sample of events which give a good 4C fit to the hypothesis  $\bar{p}p \rightarrow 2\pi^+ 2\pi^- 6\gamma$ : 7946 events with CL>10% [1]. These events are dominated by  $2\pi^+ 2\pi^- 3\pi^0$  and we removed them by applying a 1% CL cut on the hypothesis  $\bar{p}p \rightarrow 2\pi^+ 2\pi^- 3\pi^0$ . The remaining sample contains 1900 events. These events are: residual background of  $2\pi^+ 2\pi^- 3\pi^0$ , possible background due to split-offs which escaped the selection criteria and  $\eta 2\pi^+ 2\pi^- 2\pi^0$ . Fig.1 shows  $2\gamma$  invariant mass distribution (15 combinations per event) for these 1900 events. We see a clear  $\eta$  signal. Then 5C fit has been applied to select the reaction

$$\bar{p}p \rightarrow 2\pi^+ 2\pi^- \eta 4\gamma, \quad \eta \rightarrow 2\gamma \quad (3)$$

901 events survived over 10% CL cut. Fig.2 shows the distribution of PEDs and  $\gamma^*$  for these events. In practice, these 901 events are representing reaction 2.

Fig.3 presents  $\pi^+\pi^-\pi^0$  invariant mass distribution (8 combinations per event). One can see a clear  $\eta$  signal.

To study reaction (3) when it contains one  $\eta$  only, we remove those contributions from reactions

$$\bar{p}p \rightarrow \eta\eta\eta, \eta, \eta \rightarrow \pi^+\pi^-\pi^0, \eta \rightarrow 2\gamma, \quad (4)$$

$$\bar{p}p \rightarrow \eta\eta\pi^+\pi^-\pi^0, \eta \rightarrow \pi^+\pi^-\pi^0, \eta \rightarrow 2\gamma, \quad (5)$$

having both CL>10% . The final almost background free sample contains 625  $\eta 2\pi^+ 2\pi^- 2\pi^0$ . Fig.4 shows  $\eta 2\pi^0$  invariant mass distribution of these events. (1 combination per event), whereas fig.5 shows  $\eta\pi^+\pi^-$  distribution for the same sample (4 combinations per event). In both figures one can see a clear  $\eta'$  signal. We find 213  $\eta' \rightarrow \eta\pi^0\pi^0$  events and 412  $\eta' \rightarrow \eta\pi^+\pi^-$  events.

reaction	$n_{ev}$ observed	$\epsilon_s$ [%]	$\epsilon_t$	BR( $\bar{p}p$ ) [%]
$\bar{p}p \rightarrow E\pi^+\pi^-$	$124 \pm 15$	3.5	$0.55 \pm 0.20$	$0.15 \pm 0.06$
$E \rightarrow \eta'\pi^+\pi^-$				
$\eta' \rightarrow \eta\pi^0\pi^0$				
$\bar{p}p \rightarrow E\pi^+\pi^-$	$108 \pm 15$	3.2	$0.55 \pm 0.20$	$0.14 \pm 0.05$
$E \rightarrow \eta'\pi^0\pi^0$				
$\eta' \rightarrow \eta\pi^+\pi^-$				
$\bar{p}p \rightarrow E\pi^0\pi^0$	$130 \pm 15$	3.3	$0.55 \pm 0.20$	$0.16 \pm 0.06$
$E \rightarrow \eta'\pi^+\pi^-$				
$\eta' \rightarrow \eta\pi^+\pi^-$				

Table 1: Summary of results.  $n_{ev}$  is the number of observed events.  $\epsilon_t$  is the trigger efficiency as defined in CBNOTE324.

Now we combine  $\eta' \rightarrow \eta\pi^0\pi^0$  with a  $\pi^+\pi^-$  pair (4 combinations/event). The  $\eta'\pi^+\pi^-$  invariant mass is shown in Fig.6a (histogram). The  $E$  meson signal is visible. The  $\eta' \rightarrow \eta\pi^+\pi^-$  is now combined with  $\pi^0\pi^0$  (dots) or with the remaining  $\pi^+\pi^-$  pair (full line). The  $E$  meson signal is visible in all distributions. Fig.6b shows the sum of these 3 distributions.

We find that 362  $2\pi^+2\pi^-\eta2\pi^0$  events are the result of the following annihilation:  $\bar{p}p \rightarrow E\pi\pi, E \rightarrow \eta'\pi\pi, \eta' \rightarrow \eta\pi\pi$ . The three different  $E$  signals are in fair agreement with what one would expect if all the 3 pairs of pions are scalars. Tab.1 summarizes the experimental results.

## 2 Branching ratios of $E$ decay into $\eta\pi\pi$ and $\eta'\pi\pi$

Using the results given in Table 2 of [1] and table 1 in this note, we get:

$$\frac{E \rightarrow \eta'\pi\pi}{E \rightarrow \eta\pi\pi} = \frac{362}{700} \times \frac{6.8}{3.3} \times \frac{1.0}{0.55} \times \frac{4/9}{12/45} \approx 3.3 \pm 1.2$$

### **3 Figures**

#### **References**

- [1] N.Djaoshvili et al., CB-Note-318
- [2] N.Djaoshvili et al., CB-Note-324

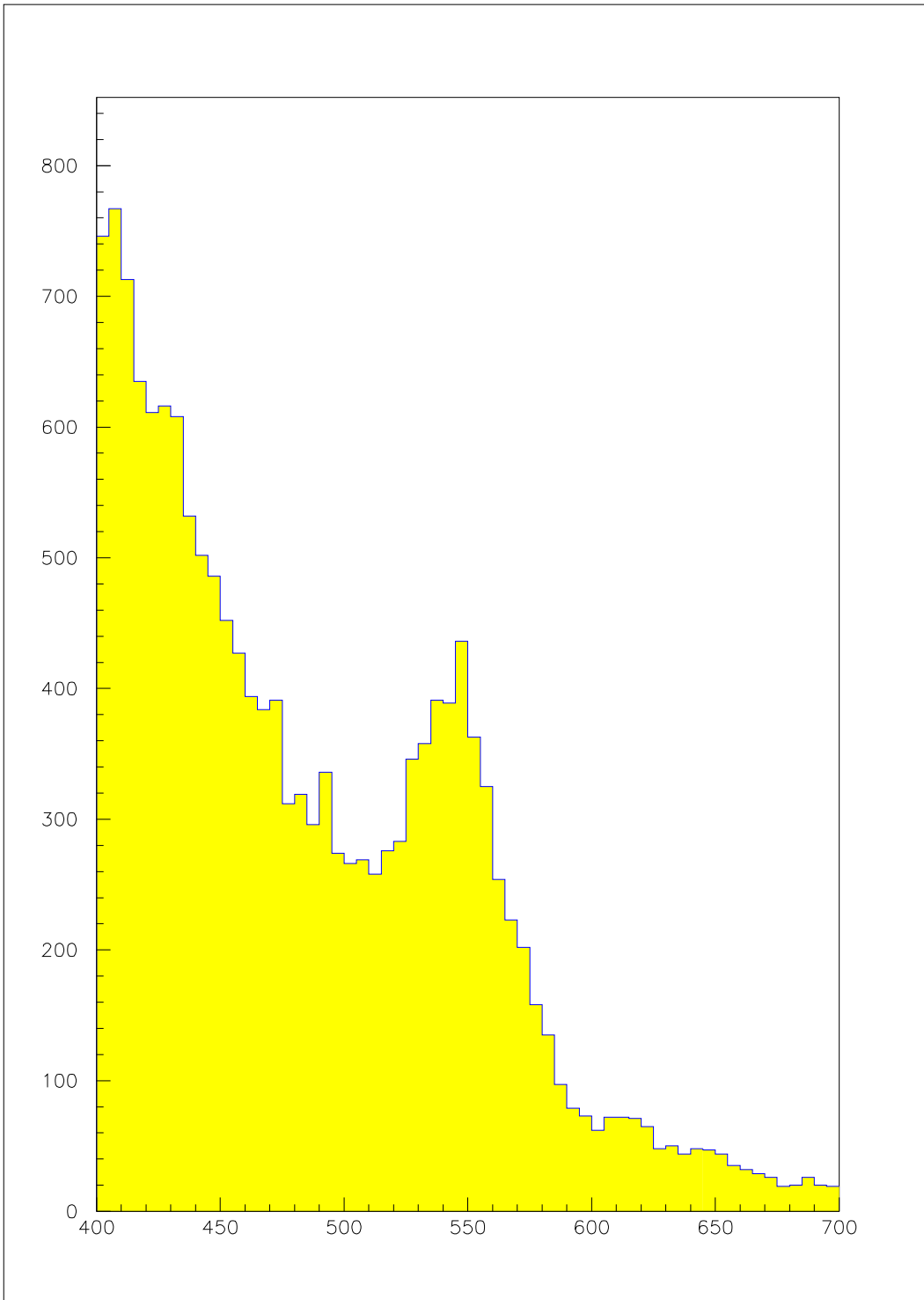


Figure 1:  $\gamma\gamma$  invariant mass distribution for 1900 events (12 comb).

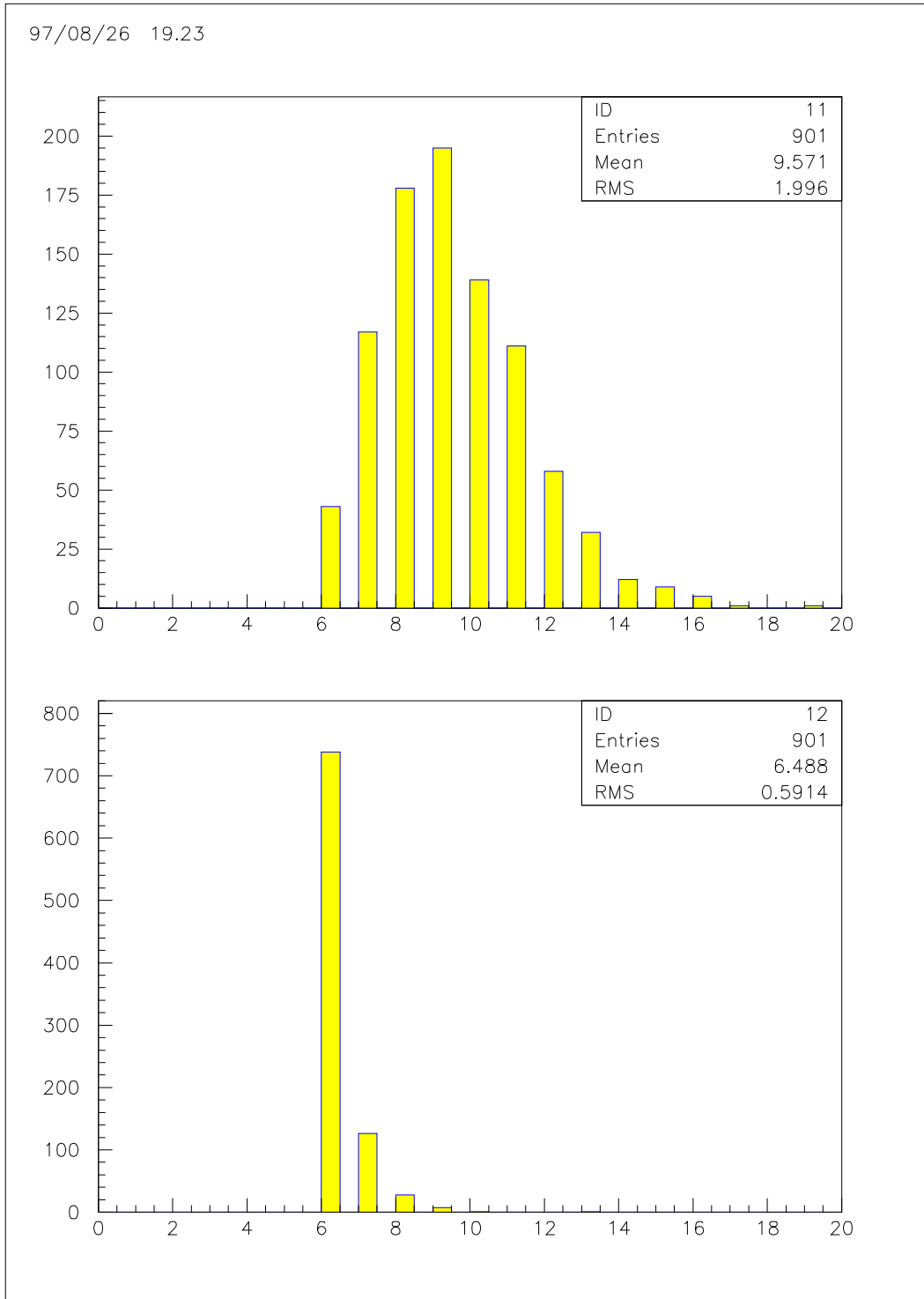


Figure 2: Number of peds and  $\gamma^*$  for the 901 events of reaction (3).

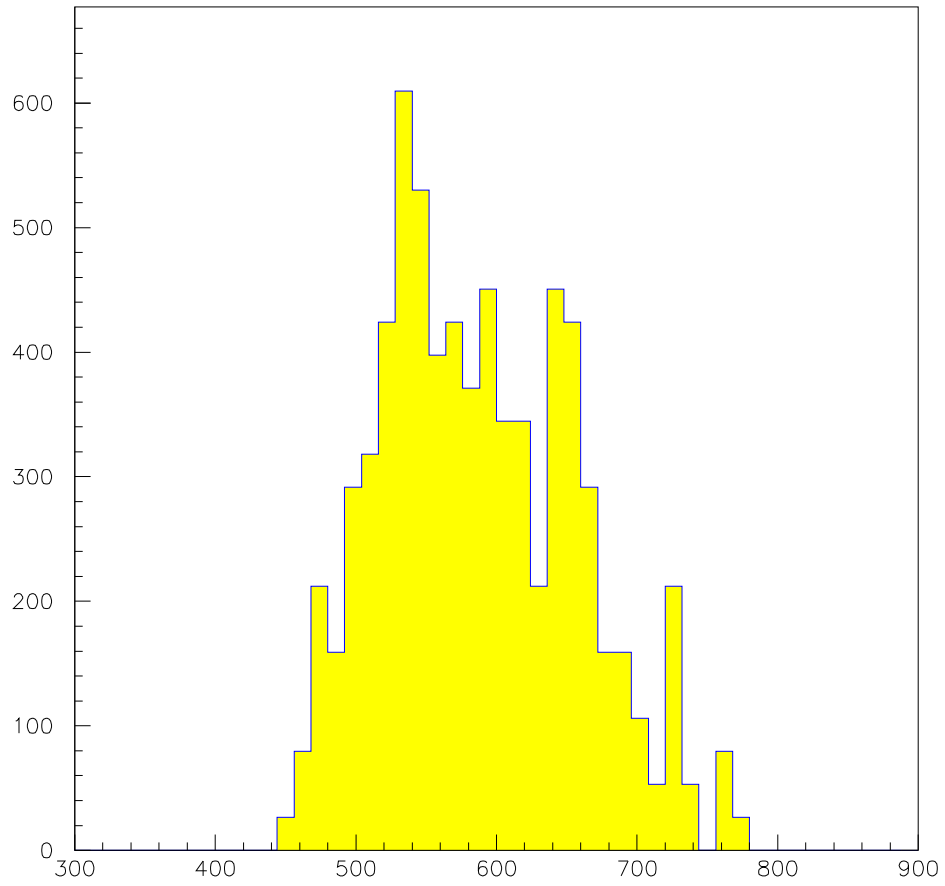
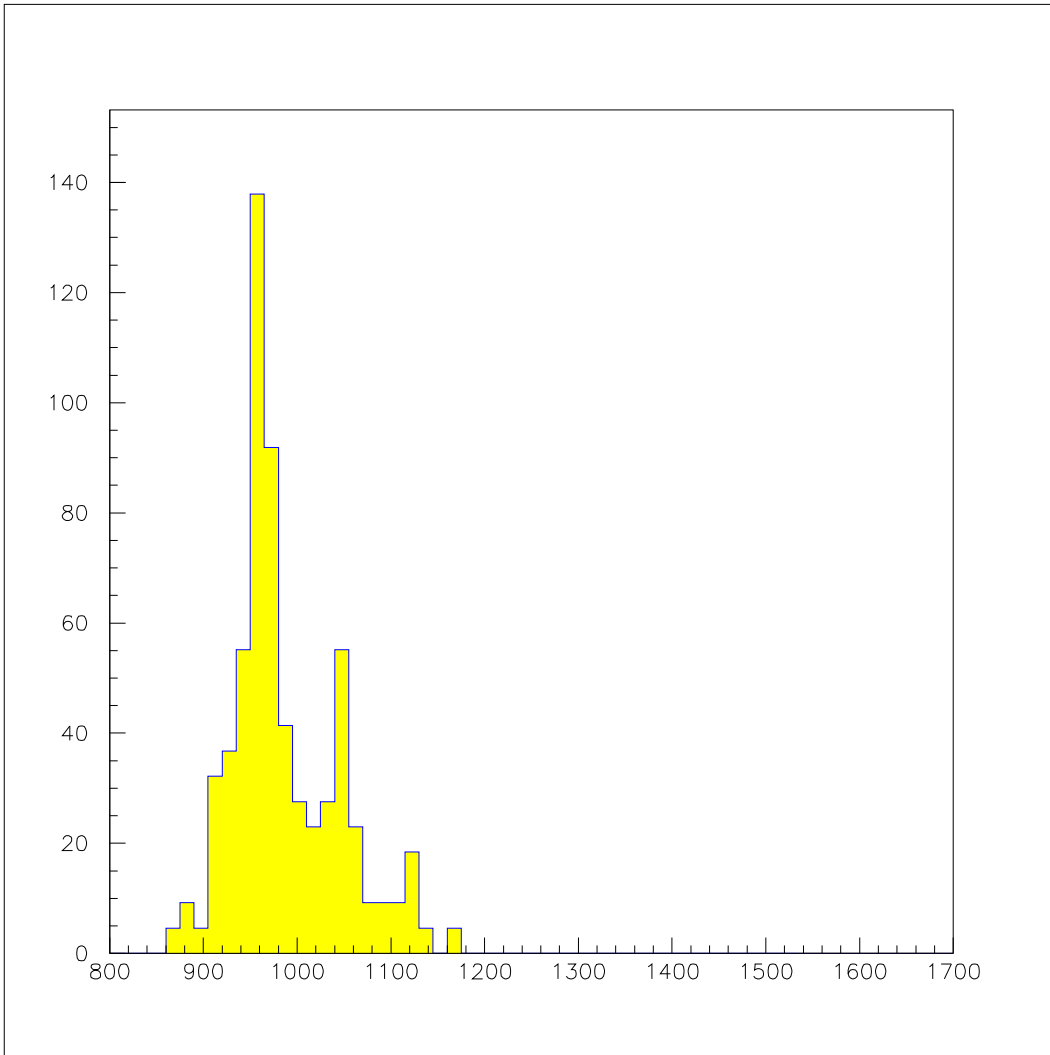


Figure 3:  $M(\pi^+\pi^-\pi^0)$  (8 comb)

Figure 4:  $M(\eta\pi^0\pi^0)$  (1 comb)



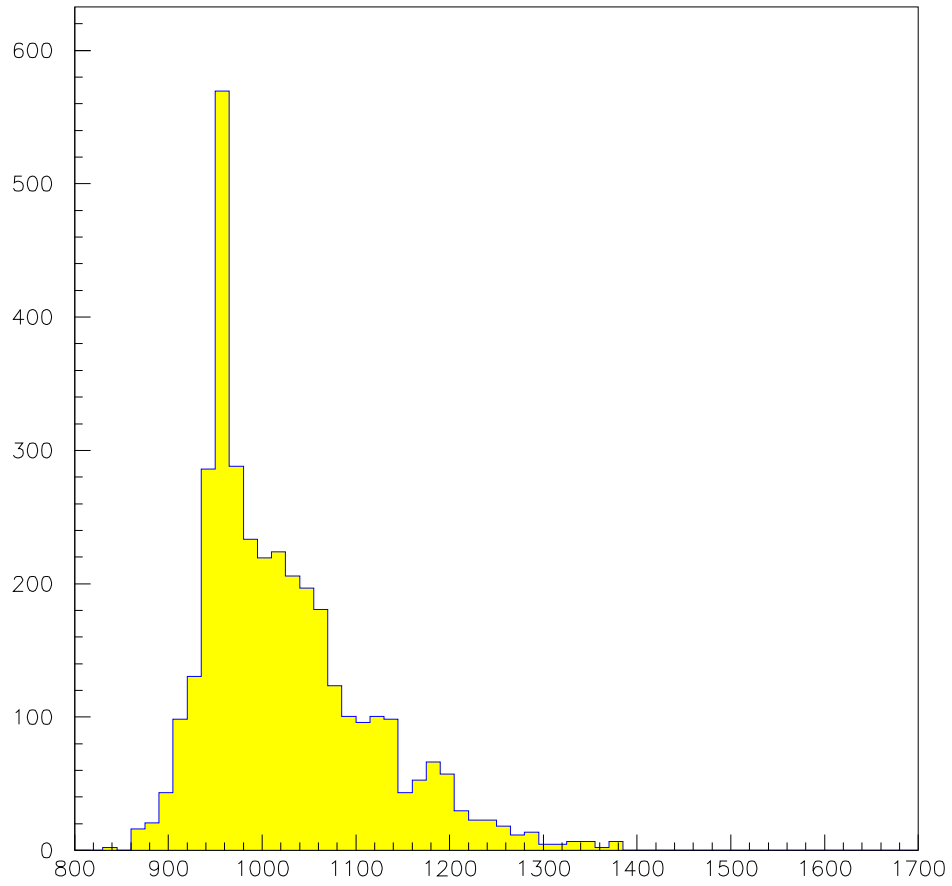
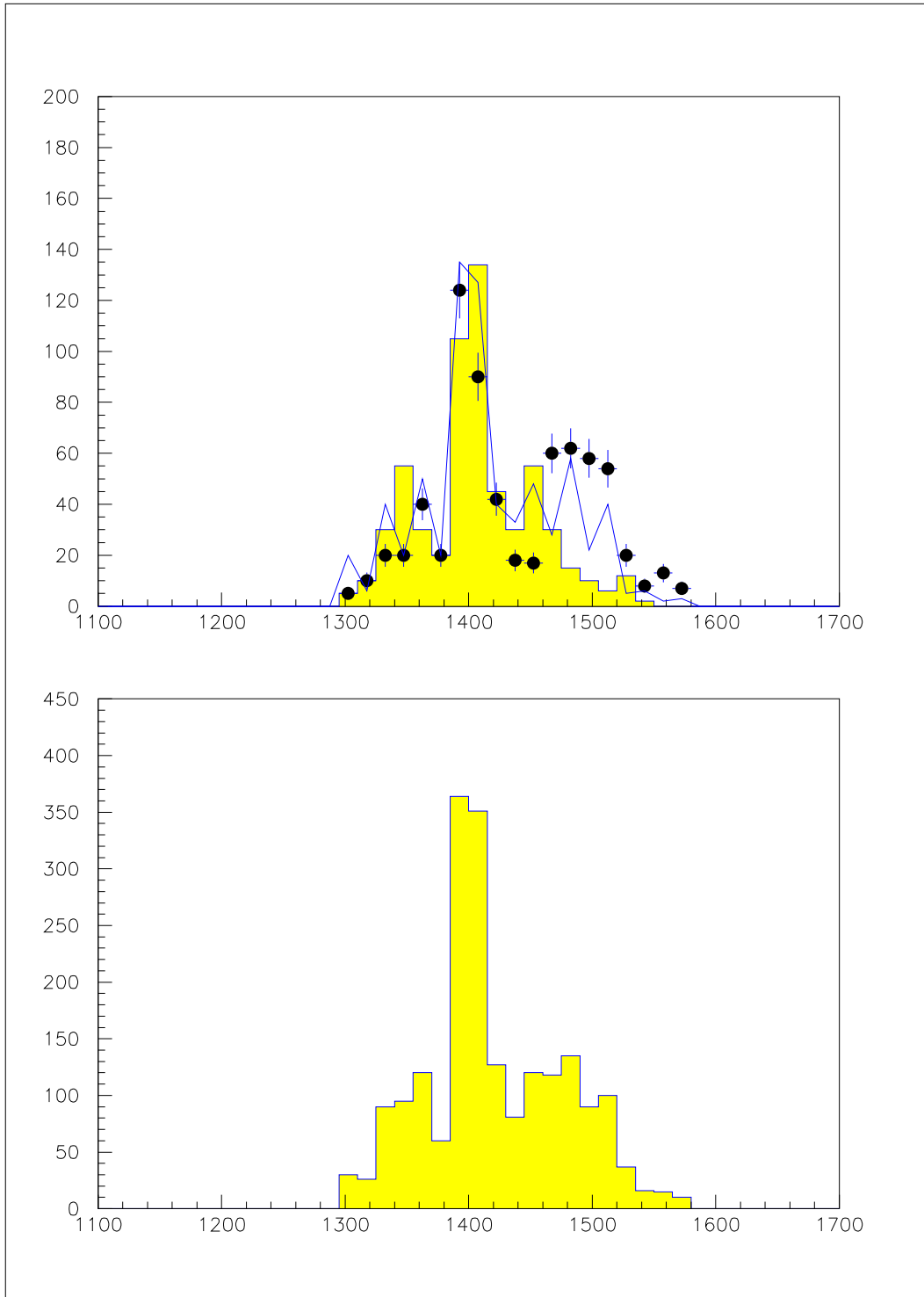


Figure 5:  $M(\eta\pi^+\pi^-)$  (*4 comb*)

Figure 6:  $M(\eta'\pi\pi)$  (*see text*)