Focus on $H \times V$ and OH Efficiencies for FOCUS Experiment

Fabiola Vázquez* Hector Méndez
CINVESTAV

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Abstract

The OH and $H \times V$ one and two body trigger efficiency has been measured using photon beam. We discuss all the steps to obtain these numbers, such as the arrays reconstructed geometry, alignment and counter efficiency. These latest measurements were done using muon beam and a special trigger to illuminate a big portion of these planes.

1 Introduction

The H, V and OH are 3 set of scintillator counters placed transversally to the incident beam. They are part of the first level trigger or Master Gate. The main purpose of these arrays of counters is to reject the electromagnetic interactions of photons and to select hadronic events.

The $H \times V$ array is located down stream of the proportional wire chamber number 4 (P4), in front of the Inner Electromagnetic Calorimeter (IE), where the e^+ e^- pairs are refocalized by the combined action of the magnets M1 and M2; it is used to detect charged tracks outside the pair region and it consist of two adjacent planes of scintillators: The H plane (Fig. 1) and the V plane (Fig. 2). Both planes are divided in two halves positioned side by side of a vertical separation or gap called the pair region.

OH is a plane of scintillators covering the upstream face of the outer electromagnetic calorimeter (OE). It is designed to detect wide angle charged particles outside the center gap; besides the central hollow region, it has also a vertical central gap which allows the $e^+ e^-$ pairs to pass undetected.

Signals coming from these two detector arrays, OH and $H \times V$, are organized in a suitable logic to define a pair of particles both of which were out of the central gap and therefore much more likely to be from a hadronic interaction than a purely electromagnetic one.

2 Geometry and Alignment

We took specials muon runs to investigate the geometry of these planes. Our main method was to project the reconstructed pwc tracks to the plane under analysis.

In order to reconstruct the geometry of the H, V and OH detectors we analized MUON runs (see Table 1.) with the following characteristics:

- Trigger: $AM \cdot AMD \cdot RF(IM + OM1)$
- Magnets off
- Cuts:
  - Number of tracks = 1 (we reconstruct only pwc tracks)
  - We call P1P2P4 (an special routine that finds tracks passing through P1 and P2, then on to P4; the tracks must not pass thru P0, but are allowed to go on thru P3) to illuminate the outer part of the detectors, since with the normal reconstruction program we didn't see, for example, $H1$, $H2$, $H11$, $H12$, $H13$, $H14$, $H23$, $H24$
  - We request that the reconstructed track starts at the first plane of P0 or first plane of P1.

We made the profile when the counter is on (this information comes from the Fermilab-latches), and we measure the edge of the counter in x and y projection. As we can see in Fig. 4.

The mesures appearing next are these averages with some improvements to fit as best as possible the geometry to the signal from our reconstruction.

The reference system is right-handed.

RUNS ANALIZED:

type	run	tape	date	time	2nd. lavel trig.
μ	6398	FD0475	sep/24/96	22:15	HDWSTUDY
μ	7659	FD1398	nov/14/96	02:23	HDWSTUDY
μ	9079	FD2440	jan/21/97	23:53	HDWSTUDY
μ	9114	FD2458	jan/23/97	22:12	HDWSTUDY
μ	9115	FD2458	jan/23/97	22:40	HDWSTUDY
μ	9116	FD2459	jan/23/97	22:52	HDWSTUDY
μ	9117	FD2459	jan/23/97	23:04	HDWSTUDY
μ	9118	FD2453	jan/23/97	23:15	HDWSTUDY
μ	9119	FD2453	jan/23/97	23:26	HDWSTUDY
μ	9320	FD2611	jan/31/97	11:25	HDWSTUDY
μ	9321	FD2611	jan/31/97	11:31	HDWSTUDY
μ	9322	FD2611	jan/31/97	11:36	HDWSTUDY
μ	9323	FD2611	jan/31/97	11:42	HDWSTUDY
μ	9324	FD2611	jan/31/97	11:46	HDWSTUDY
μ	9325	FD2611	jan/31/97	11:51	HDWSTUDY
γ	9808	FD3024	feb/25/97	09:33	L2 photon set32

Table 1: Runs analized

2.1 The H detector

The H detector is formed by 24 counters placed horizontally. Each counter has an average width of 20.55 cm and an average length of 66.85 cm. They form two arrays of 12 counters each, that cover a region of 246.6 cm. $\times$ 66.85 cm. each, separated by a vertical gap of $\approx$ 9.5 cm. wide, see Fig. 1. The center of the plane is 0.7 cm. off in x and 1.5 cm. off in y with respect to the reference system (center of M2). The Z position of this detector is 1095 cm. with respect to the center of M2.

2.2 The V detector

The V detector is formed by 12 counters placed vertically. Each counter has an average width of 22.6 cm and an average length of 114.95 cm. They form two arrays of 6 counters each, that cover a region of 229.9 cm. $\times$ 67.8 cm. each, separated by a verticla gap of $\approx$ 9.9 cm. wide, see Fig. 2. Note that the gap is 0.4 cm. larger than the one measured on the H plane. The center of the plane is 0.3 cm. off in x and 0.87 cm. off in y with respect to the reference system. We assumed the Z position of this detector to be the same as for the H plane. The correct label for each counter is as in the figure, but the phisical label for the $V1$ and $V3$ counters is swapped, the same happen for the $V4$ and $V6$ counters.

2.3 The OH detector

The OH detector is formed by 24 counters placed horizontally. It has two different sizes counters: 16 long counters with an average width of 20.65 cm. and an average length of 72.3 cm. and 8 short counters with an average width of 20.65 cm. and an average length of 52.43 cm. They are arranged in two groups following the next sequence: 4 long counters, 4 short counters (in the middle) and 4 long counters. These two groups of 12 counters each are separeted by a vertical gap of $\approx$ 9.41 cm. wide, and because of the way they are arranged, there is a square hole in the middle of the detector of 49.16 cm $\times$ 82.6 cm., see Fig. 3. The center of the plane is 1.0 cm. off in x and 4.0 cm. off in y with respect to the reference system. The Z position of this detector is -360 cm with respect to M2.

Note (from the figure) that the counters $OH23$ and $OH22$ are swapped.

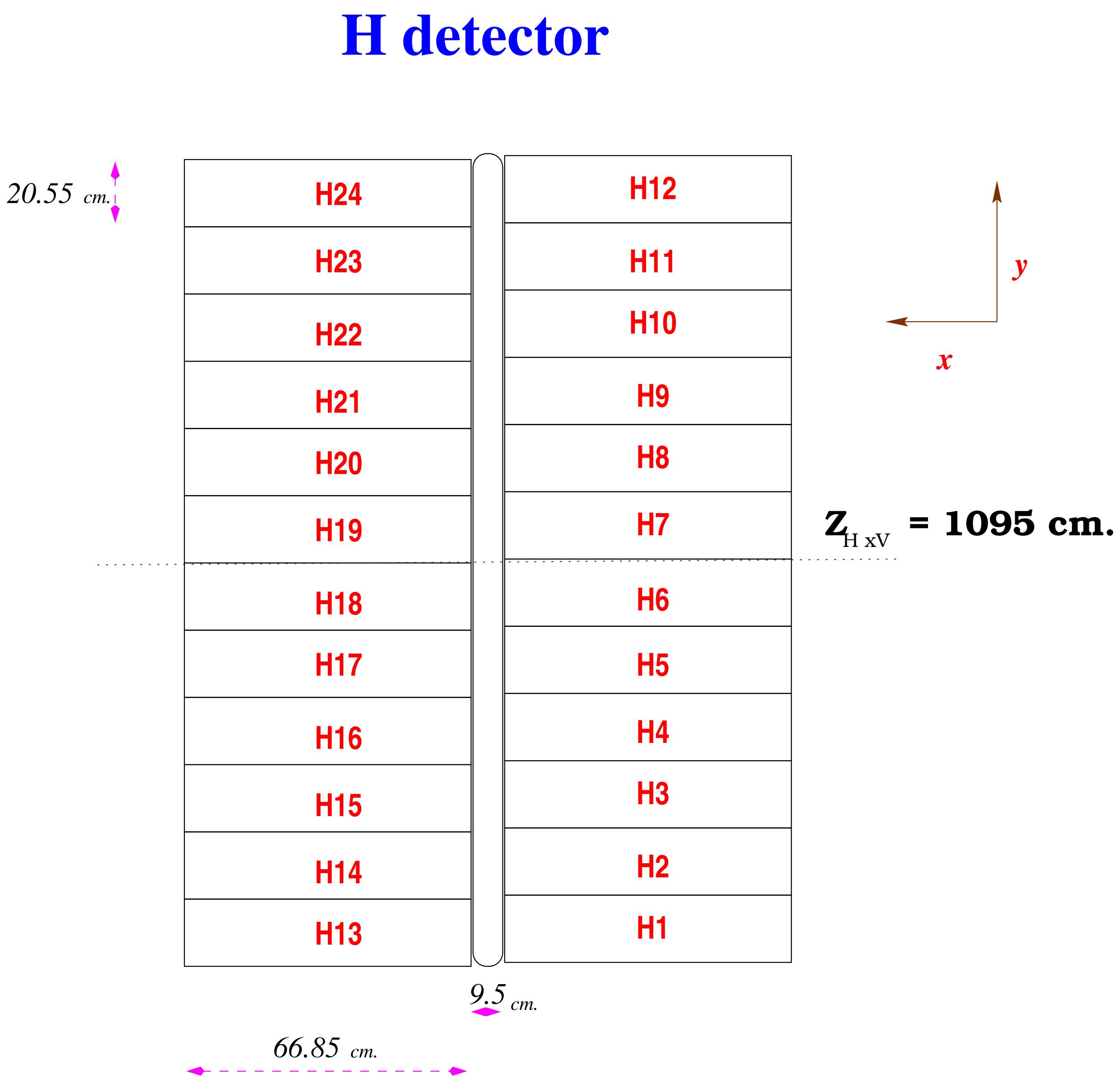

Figure 1: Display of the H counters

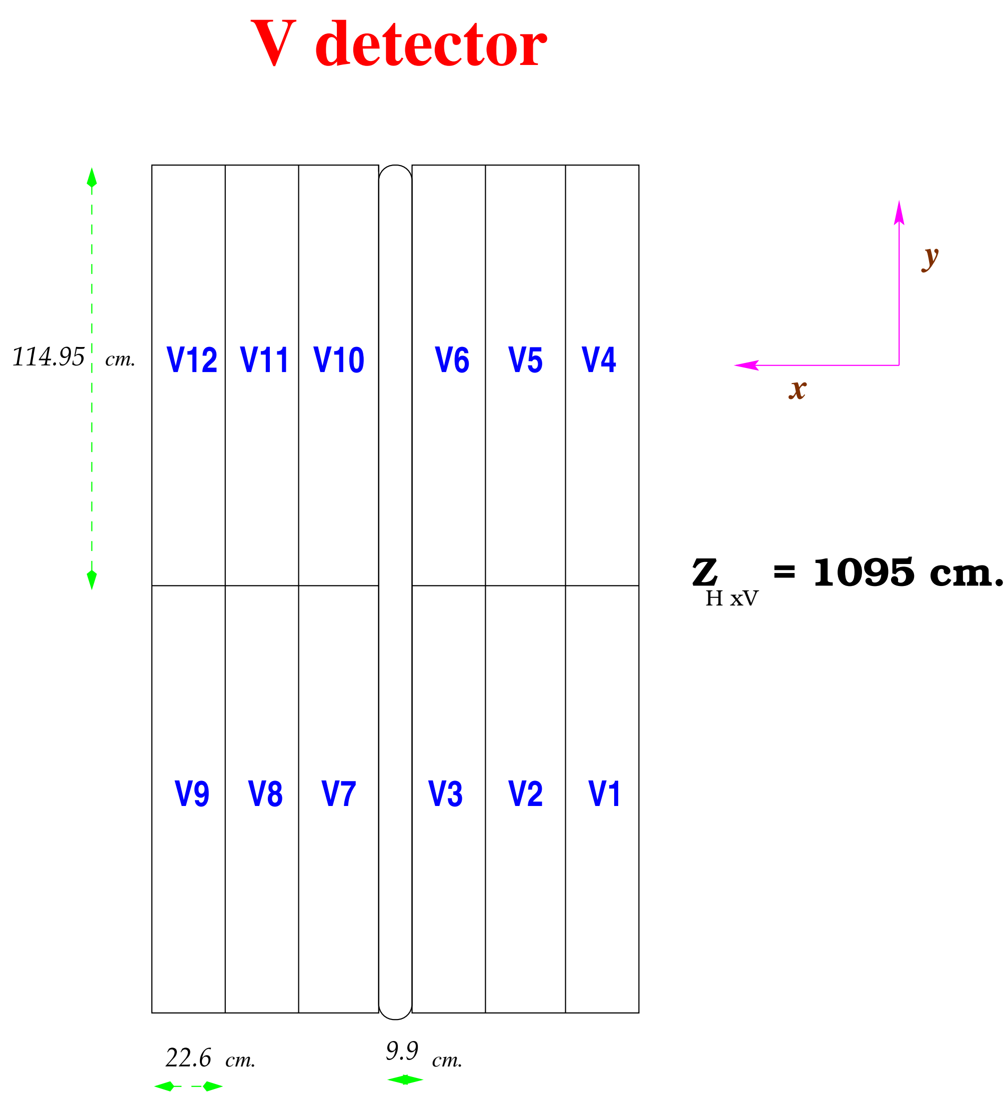

Figure 2: Display of the V counters

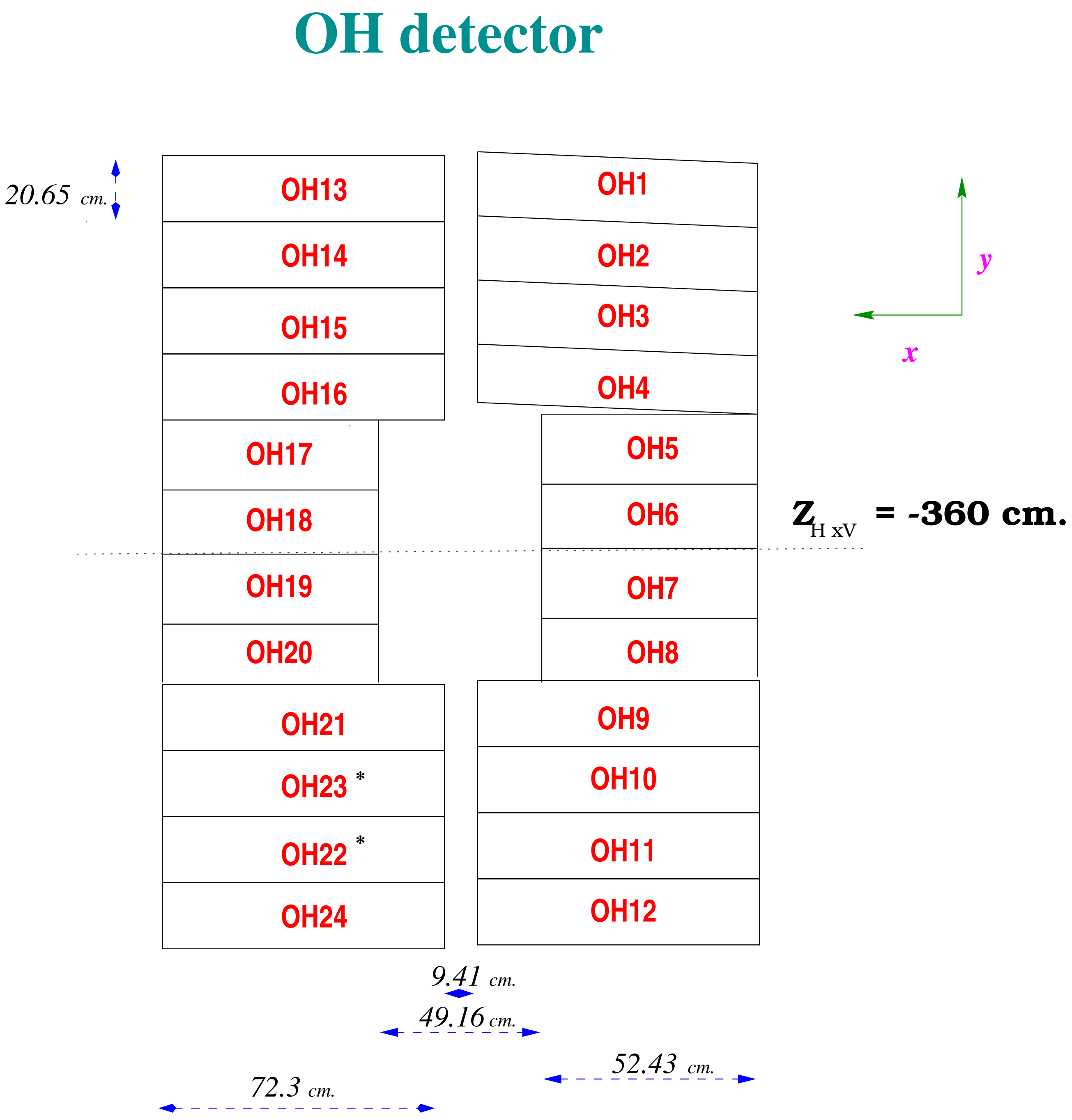

Figure 3: Display of the OH counters

The $OH1$, $OH2$, $OH3$ and $OH4$ counters are not placed horizontally but with a slightly angle of $\approx 0.7448°$ (exagerated in the figure) as we see on the counter profile (see Fig. 4) but big enough to be noted by the resolution of our reconstruction. Also the west side of the detector (counters 13 to 24) is shifted 0.5 cm. down with respect to the east side.

3 Efficiencies

Once we know the geometry of these detectors, we can measure how efficient those counters are.

If we made the following definitions:

a =	TOTAL number of tracks POINTING a given counter (no matter if it is on or off).
b =	TOTAL number of tracks (IN or OUT a given counter) when the counter is ON.
c =	number of tracks pointing to the counter when it is ON.
d =	number of tracks pointing to the counter when it is OFF.
e =	number of tracks NOT pointing to the counter when it is ON.

We can then define the following:

$$\text{Efficiency of a given counter} = \frac{c}{a}$$

$$\text{Noise} = \frac{e}{b}$$

These are the definitions of efficiency and noise we use in this work.
In order to improve the efficiencies we made the so called fiducial cuts, this means that we made a little cut all around the counter (so the counter looks slightly smaller than it is) to avoid the edges' error: tracks counted double because they are very near or over the frontiers (edge) of each counter.

We took the following fiducial cuts:

H, V and OH counters cut in x: 0.2 cm. cut in y: 0.2 cm.

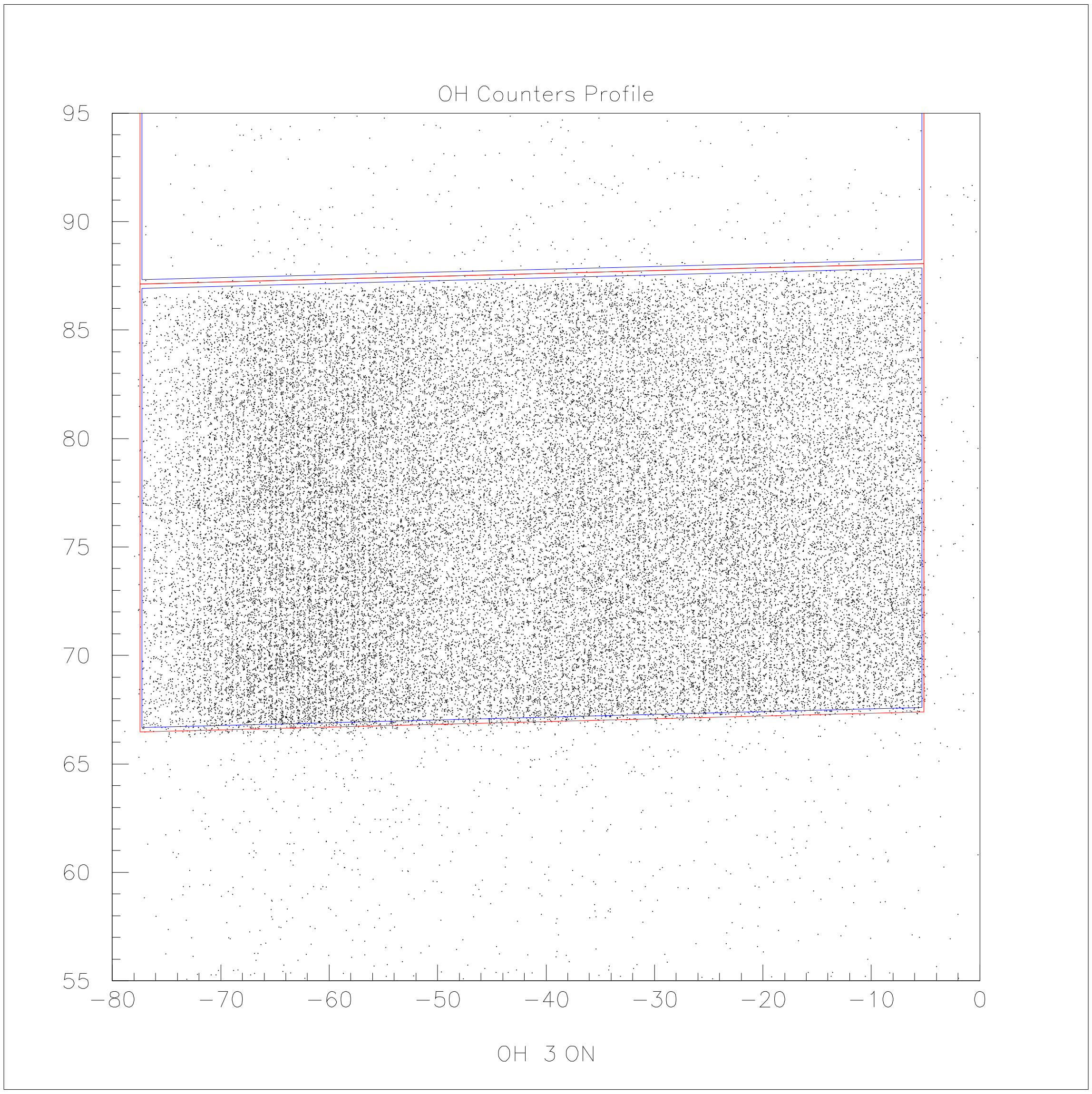

Figure 4: $OH3$ Counter profile

In order to calculate the efficiencies for the H and V detectors, we accept only 5 chamber tracks (we request that the last plane used is the last plane of P4 (plane 20)). For the OH we accept 3 or 5 chamber tracks (we request that the last plane used is the last plane of P2 (plane 12) or P4 (plane 20)).

The efficiencies obtained for the Run 6398 were reported on the oct/4/1996 E831 meeting. The conclusions given that day were that the possible causes for the low efficiencies in both detectors could be (in that order):

- geometry
- timing
- fermilab latch efficiency
- unpacking routine

Further investigation found no error in the unpacking routine.

The next step was to improve the geometry and make a study of the timing for these detectors. Also we began to study the OH detector.

In the jan/18/97 E831 meeting, for the Run 7659, we report better efficiencies for the H and the V detectors, but we found a certain problem of timing for the last 8 H counters ($H17$ to $H24$) and for the first 8 V counters ($V1$ to $V8$). For the rest of these counters the efficiency were above 85 % . Also we present the efficiencies for the OH counters, with some problems that need more work in geometry(since we found that the first 4 counters ($OH1$ to $OH4$) were out of the horizontal and the east/west halves of the detector were approx. 0.5 cm. shifted to respect to each other), timing and set of discriminator thresholds.

In the Run 9079 the problem of timing for the $H \times V$ were fixed, the gate for the H17 to H24 and V1 to V8 were changed from 20 ns. to 50 ns. and the efficiencies obtained were above 90 % for all the counters except for the $V1$.

The efficiencies for the OH counters were improved setting the discriminator threshold to 30 mV. for all the counters, but still the efficiencies appeared low. So the next step was to make a High Voltage study for each OH counter and also for the V1. (Luigi Moroni's idea)

For different muon runs (Runs: 9114 to 9119) we made a plateau study changing the High Voltage for all the OH counters going from -1900 V. to

-2400 V. in steps of 100 volts (see Fig. 5). Setting then the High Voltage of the OH counters to its best values (see OH log-book) the efficiencies were improved a lot: above 85 %. Still there were problems for the $OH4$ and $V1$.

On jan/28/97 the $OH4$ photo-tube was changed and again a new High Voltage study was made for this and also for the $V1$ (Muon Runs: 9320 to 9325). The efficiency of the $OH4$ was improved but not to much: about 60 % . And the efficiency of the $V1$: about 73 % .

These last results were presented in the 28/feb/1997 E831 meeting. And you can see in the Figure 6 the final values of the efficiencies for each counter for the corresponding run (See Appendix A for a more detailed history of the efficiencies).

3.1 Master Gate

For the study of the Master Gate or $((H \times V)_1 \cdot OH + (H \times V)_2)$ Efficiency we read the signal from the Bus-line for $(H \times V)_1$, $(H \times V)_2$ and OH in order to compare these signals with our reconstructed data.

BUS-LINE:

- $(H \times V)_1$ - Bit # 3
- $(H \times V)_2$ - Bit # 4
- OH - Bit # 5

We also try to reconstruct the trigger with the bus-line but it was not possible always. A rough estimation is 5 % error.

In order to calculate the efficiencies we used the last muon tape mention before: fd2611, Runs: 9320 to 9325. And a file from a photon run: 9808, trigger: Photon Data Set 14 Mu 1 Body off, taken on feb/25/97. These time the cuts were:

- No cut on the number of tracks
- Not calling P1P2P4 (for the photon run)
- Only 5 chamber tracks for the $H \times V$
- 3 and 5 chamber tracks for the OH

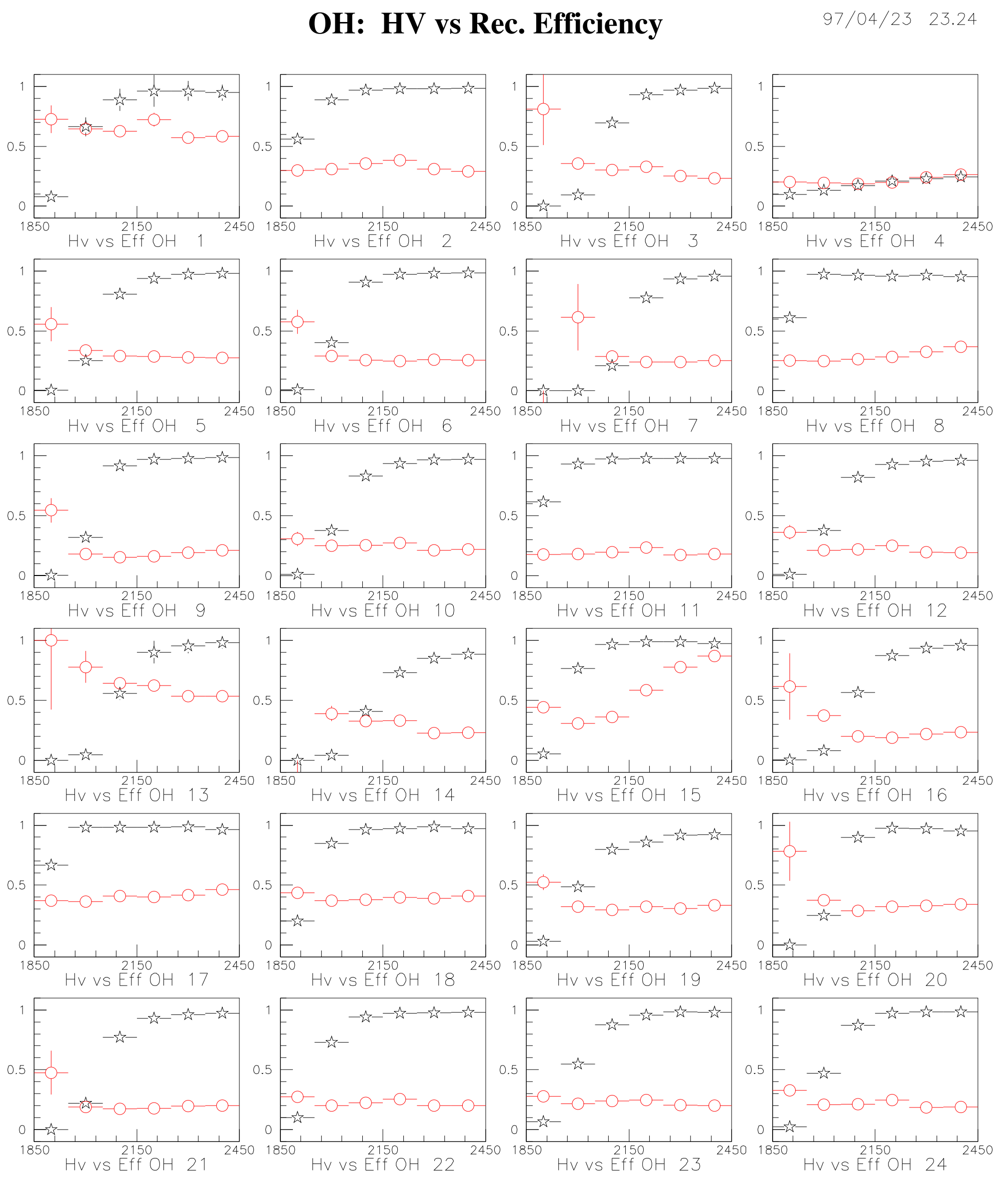

Figure 5: High voltage plateau study for the OH counters. The stars are the efficiencies and the circles are the noise

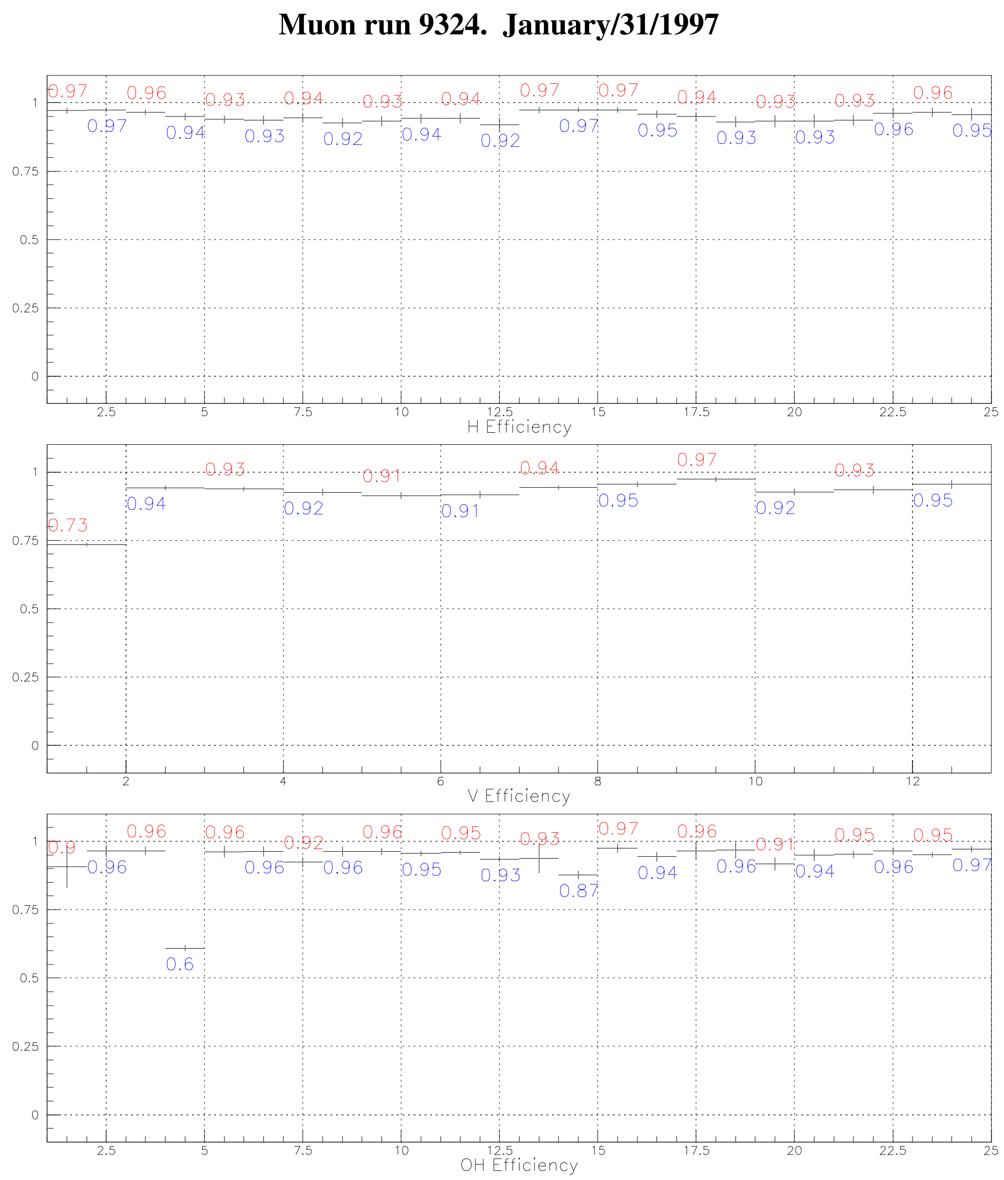

Figure 6: H, V and OH efficiencies for muon run 9324

- Well defined tracks.

In order to calculate the efficiencies of the Master Gate we need to understand the $H \times V$ trigger logic. Fig. 7 shows the arrangement of the counters to fit into the trigger logic. And Fig. 8 shows the logic itself.

The efficiencies obtained for the muon run and photon run were presented at the 28/feb/1997 E831 meeting and are listed in Table 2. The normalization is made by dividing the bus-line and reconstructed signal between the total number of events analized. The efficiencies are obtained by dividing:

$$Eff. = \frac{Normalization\ Recon}{Normalization\ Bus}$$

3.2 Conclusions

From this work we can conclude that the efficiencies for the H counters are above 91.5 %, for the V counter above 90.5 % (except for the $V1$: 73.4 %) and for the OH counters above 87.5 % (except for the $OH4$: 60.9 %).

As you can see from Table 2. the efficiency for the OH is grater than 100 % this is because the way we normalize: the number of events counted by the bus-line must have an error that we are not taking into account. Why these pattern doesn't occur for the $(H \times V)_1$ and $(H \times V)_2$, is not yet understood.

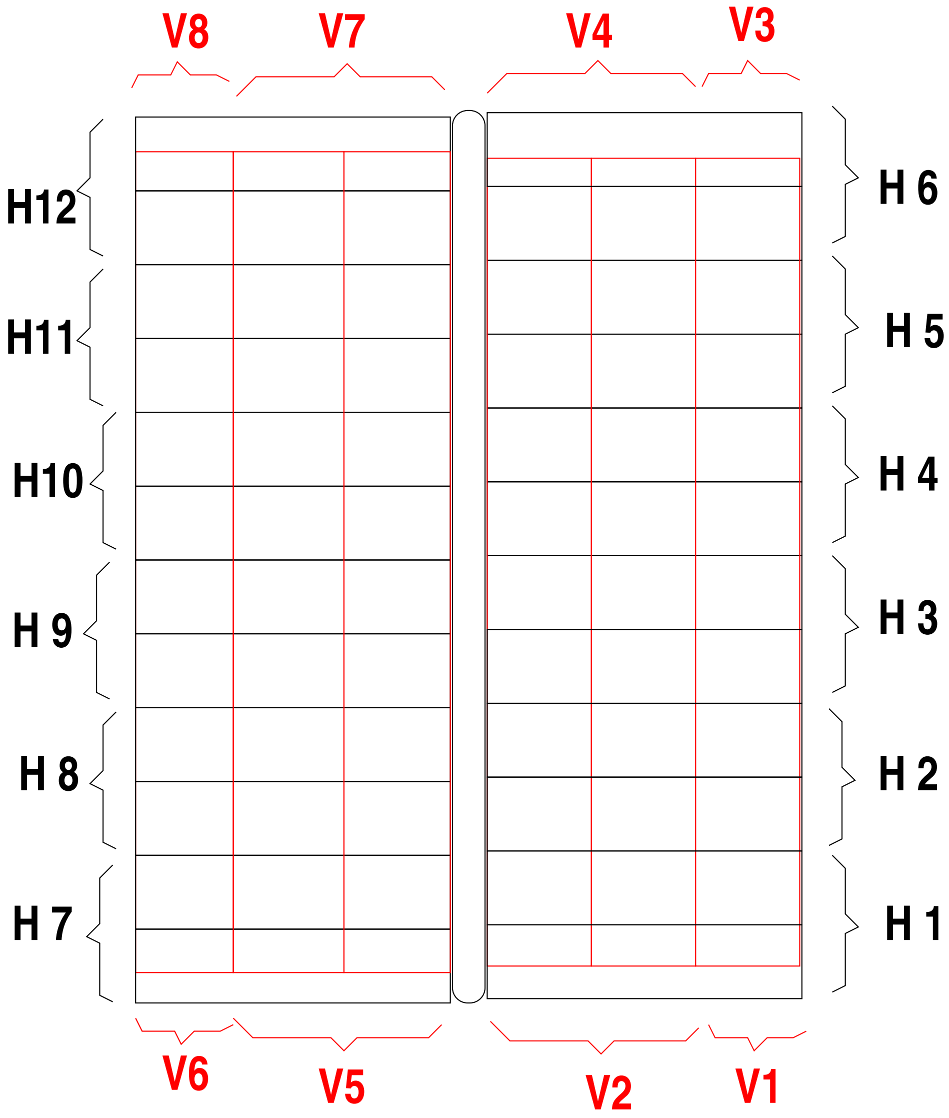

Figure 7: Display of $H \times V$ arrangement

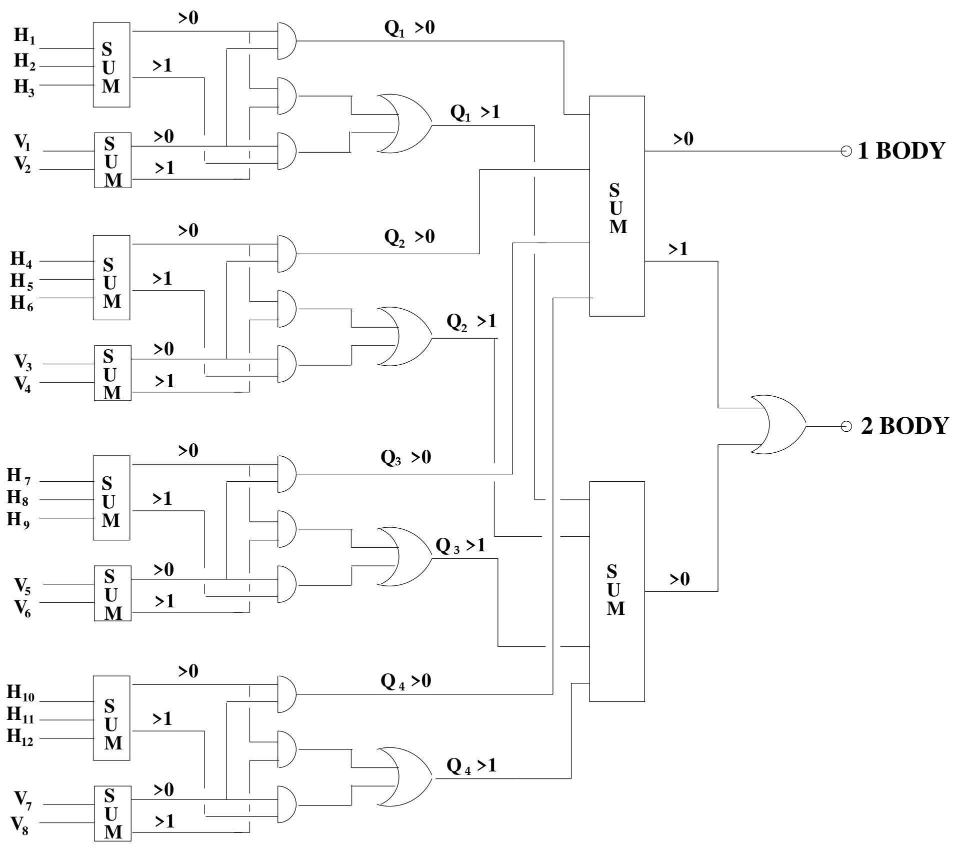

Figure 8: $H \times V$ trigger logic

MUON RUN: (fd2611)
total number of events analized = 1,826,020.

	Bus-line	Reconstructed	Normalization	
			Bus	Recon
$(H \times V)_1$	1,306,179	1,191,003	0.715	0.652
$(H \times V)_2$	95,982	1,290	0.053	0.0007
OH	1,527,338	1,456,426	0.836	0.798

Efficiencies:	$(H \times V)_1$	91.2 %
	$(H \times V)_2$	Not Applicable
	OH	95.5 %

PHOTON RUN: 9808
total number of events analized = 36,112.

	Bus-line	Reconstructed	Normalization	
			Bus	Recon
$(H \times V)_1$	32,550	29,076	0.901	0.805
$(H \times V)_2$	28,444	22,764	0.788	0.630
OH	24,593	25,679	0.681	0.711

Efficiencies:	$(H \times V)_1$	89.3 %	
	$(H \times V)_2$	79.9 %	
	OH	104.4 %	??

Table 2: Efficiencies for $((H \times V)_1 \cdot OH + (H \times V)_2)$