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THE EXTERNAL MUON IDENTIFIERS (EMI) AT CERN

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Summary

For the two big bubble chambers BEBC and Gargamelle (GGM), detectors for external muon identification had been requested. Choice was given to multiwire proportional chambers behind additional iron absorbers. 71 chamber modules (each $1 \times 3 \text{ m}^2$) with two independent anode wire planes and one cathode strip plane have been built. To record the particle hits without deadtime during the spill length of 3 ms the development of a read-out system quite different from standard systems was necessary. The chambers, the electronics and the performance of both systems will be described.

Introduction

The use of the two large bubble chambers at CERN, GGM and BEBC, in the SPS West Area neutrino beam line, made external equipment for muon identification necessary. The principle used is the same as at FNAL⁽¹⁾. Two detector planes, with additional absorber before and between them, are placed behind the bubble chambers. The trajectory of a leaving particle is followed through the absorbers. If the trajectory coincides with a hit on the detector planes within a certain multiple scattering radius, the candidate is considered to be a muon.

The Detectors

Without going into details, we summarize the demands on the detector:

- (d) it should have large angular acceptance
 - (e) it should be modular with variable space resolution
 - (f) it has to work in inhomogeneous magnetic stray fields
 - (g) it has to monitor its running conditions itself as there is no feedback from other detectors.
- These requirements could be fulfilled by multiwire proportional chambers using a read-out technique which differs from usual read-out systems. The two EMI's at GGM and BEBC differ only in their geometrical arrangement. Fig. 1 shows the Gargamelle set-up with the veto counter, picket fence, calorimeter and the EMI.

Fig. 1

Gargamelle set-up with veto counter, picket fence and two detector planes

Figs 2 and 3 showing BEBC and its two EMI planes; a veto counter is under construction.

	EMI-BEBC	EMI-GGM
Chamber modules (each $1 \times 3 \text{ m}^2$)	55	16
Surface	$150 + 18 \text{ m}^2$	$24 + 24 \text{ m}^2$
Wires (Anodes)	84.500	24.500
Strips (Cathodes)	7.000	2.000
Electronic Channels	18.000	6.700
Memory (Bits)	806 K	260 K
Max. number of events (total)	1.023	1.023
Max. number of events per chamber	39(79)	39(79)

Fig. 2

BEBC set-up showing the two EMI planes

Fig. 3

BEBC with the outer EMI plane

Chambers

The size of each chamber module is $1 \times 3 \text{ m}^2$. A cross section is shown in fig. 4. The chambers are self supporting using rigid honeycomb sandwich panels. Thin frames glued onto those panels define the gaps.

Fig. 4

Chamber cross section

Each chamber contains two independent anode wire planes (oriented $\pm 30^\circ$ to the 1 m axis) and two cathode strip planes (0° and 90°). The wire diameter is 20 μm , the spacing 4 mm and the gap 2 x 8 mm. To get different space resolution groups of 2, 4 or 8 wires are put together to one electronics channel. The cathodes are made from painted silver strips (14 mm wide with 2 mm spacing) on the inner surface of the 6 cm thick honey-comb panels. The choice of this construction together with the above parameters made it possible to work without any support lines or spacers which results in full efficiency over the whole surface. The self supporting structure has the advantage of relatively low weight. The realisation of readable cathodes is rather simple.

Great care was taken to keep all tolerances small in order to achieve uniform working conditions over a big surface. Test results from the chambers have been published earlier⁽²⁾. Even though the chambers are used in a difficult environment (no air conditioning, no humidity control, the shaking from the bubble chamber expansion system, etc.), we can state that the chamber construction proved to be very reliable.

Electronics

The requirements mentioned before made a direct read-out of each hit to the Nord-10 computer impossible. Instead a special buffer was necessary to store all hits during the 2 to 3 ms long beam spill, and to transfer the data afterwards. MOS-shift registers are used as the basic elements for storing. These replace the flip-flop memories used in conventional MWPC systems. In order to minimize the recording of "zero" bits, the buffers are organized in two levels as shown in fig. 5. Each chamber module has a buffer with one input per channel and space for 39 events (or 79 for regions with high hit densities). The main buffer has one input per chamber and space for 1023 events on the whole EMI. The last location of both buffer types is used for transfer. For each event that occurs, the hit pattern for each chamber is stored in the chamber buffers, while the pattern of chambers hit is stored in the main buffer. A synchronisation scheme (fig. 6) ensures that no hits are missed, (at the expense of some overlap of events very close in time).

Fig. 5

Correlation between chamber buffers and main buffer

The minimum time resolution is 300 ns. The overall recording speed is 2 MHz. When data taking is finished, all data are pushed to the right end of the shift registers to fill up the unused locations and to facilitate access for read-out (fig. 5(b)).

Fig. 6

Synchronisation between chamber buffers and main buffer

The read-out itself is handled by a CAMAC interfaced control unit, which sequentially scans the event entries in the main buffer. For each entry, it addresses the chamber seen to have been hit, and outputs the number of channels involved. Fig. 7 shows the data format. Different words are identified by flags. To facilitate later access to the data, event and chamber word counts are added.

Fig. 7

EMI data format

Operation

As there is no feedback from the bubble chambers to tell about the performance of the wire chambers, great attention was given to various possibilities of continuously testing and monitoring the chambers and the auxiliary units. A number of hardware features have been incorporated into the system. The electronics can be tested digitally without using chambers, the chambers can be pulsed to fire all channels at once,

and finally a test mode is available permitting the sampling of cosmic ray data, which are histogrammed for each chamber individually. All tests can be used between beam spills. In addition, all voltages, chamber currents and gas fluxes are monitored.

Performance

The BEBC-EMI has been running continuously since the beginning of 1977. The Gargamelle-EMI was used up to now for test runs, as the bubble chamber itself has only just started up. The BEBC-EMI was first used with a narrow-band neutrino beam of low intensity and since the end of July with a 350 GeV wide-band neutrino beam, where the background rates reached the design limits. Up to now, nearly 500.000 pictures have been taken. Operational reliability has been very satisfactory since the beginning. The first experiment⁽³⁾ had good EMI data for 95% of the pictures taken. The overall EMI efficiency for detection of muons with momentum greater than 5 GeV/c was 98%.

References

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