PERFORMANCE OF THE BEBC INTERNAL PICKET FENCE

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The Internal Picket Fence (IPF) for BEBC (Big European Bubble Chamber) is a proportional tube counter system mounted in the bubble chamber vacuum tank close to the liquid hydrogen. Its purpose is to give a timing signal for all events where a charged particle leaves the chamber. The system was installed and tested early this year. We report on performance as seen during several weeks of BEBC operations at cryogenic temperatures with a 3.5 T magnetic field.

Introduction

Neutrino experiments with BEBC require muon identification by some downstream detector. Such a device, the External Muon Identifier (EMI) has been built. It uses the principle that after several interaction lengths of absorber only muons will remain close to the extrapolated track. If a hit on the EMI is actually found within some multiple scattering circle around one of these crossing points, the track is considered to stem from a muon. We reported about this detector which consists of a large array of multi wire proportional chambers (each covering $1 \times 3 \text{ m}^2$) at this conference in 1977¹.

The high muon background is a problem. Although typically only one neutrino event occurs per several expansions, there are several hundred particles per beam spill hitting the EMI. This background is due to muons from the filter upstream BEBC, to interactions of neutrinos in the material of the BEBC structure, and to cosmic rays.

The performance of the EMI was improved by installation of a second detector plane, inside the BEBC shield, and by a veto plane in front. The latest and final (at least concerning muon identification) addition is the IPF, consisting of a ring of detectors directly adjacent to the bubble chamber body. Why this most obvious possibility of improvement took so long will be explained in the following.

The Internal Picket Fence

The IPF is a device giving identification for all bubble chamber events producing tracks which leave the chamber, whether or not those tracks stem from muons. Even if the IPF is meant to identify and to suppress background, its construction is further justified by physics arguments, and it provides valuable information in the following areas:

- association of reinteracting neutrals (which would not be recognised otherwise);
- vetoing of incident neutral hadrons (generated by neutrino interactions in the magnet coils or other material upstream);
- use as an off-line event trigger;
- improvement of the EMI efficiency for muons of low momenta.

The idea of an IPF has been discussed since the EMI came into operation. Several studies and proposals had been made but it became obvious rather soon that

no simple solution to the problem avoiding the dismantling of BEBC was possible. Only the big 1980/81 shutdown of the SPS (modifications for anti-proton experiments) made it finally possible to dismantle BEBC and to install a useful device around the chamber body. The only practical space available is the gap between the bubble chamber body and the outer vacuum tank wall. The IPF detector has to operate therefore in the high magnetic field (3.5 Tesla), inside the BEBC vacuum tank and near the cold chamber. It has to withstand 10 bar of accidental over pressure, and also the vibrations of the expansion system. The whole system has to conform with hydrogen safety regulations. Since it is hardly accessible when once installed, it has to operate essentially maintenance free. The aim was to achieve a high detection efficiency with a time resolution matched to that of the EMI. And finally, the IPF should cover most of the visible volume of BEBC.

Mechanics

Keeping the boundary conditions in mind the IPF modules are based on proportional tubes. A cross section containing 24 stainless steel tubes (316 L) is shown in fig. 1. Each tube is 2200 mm long and

Fig. 1: Cut through one picket (active width is 10 cm).

has an inner diameter of 7 mm with a wall thickness of 0.5 mm. The tubes are glued together in a two-step operation on a flat table. As a result we have rather rigid units with a sagitta of less than $1/10 \text{ mm}$. The double layer arrangement results in high efficiency per unit as the tubes are staggered to avoid the dead space between the tubes due to the walls. In addition, a high overall geometrical efficiency is obtained, as the displacement of the layers allows close spacing between neighbouring units. To keep the $50 \mu\text{m}$ wires (gold plated tungsten) in position, each tube contains a spacer. The spacers in the two layers are displaced to avoid dead regions near the centre.

Each unit is placed individually inside a steel container (1.5 mm wall thickness) to separate it from the BEBC vacuum as indicated in fig. 1. Gas pipes and cables are brought to the outside through corrugated tubes. Fig. 2 shows the schematic layout

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Fig. 2 Schematic layout of the EMI and Picket Fence in BEBC.

of the EMI with the Picket Fence in BEBC, while fig. 3 gives a birds-eye view into the BEBC vacuum tank, with the modules mounted on the outer wall.

Electronics

Due to multiple scattering the space resolution required is modest we therefore grouped six wires in parallel onto one amplifier. The four preamplifiers (simple ECL gates) are mounted on the top of the units inside the steel containers.

As the aim was to have as few active components as possible inside the inaccessible region, further amplifiers including discriminators and line drivers

Fig. 3 Birds view into the BEBC vacuum tank with the modules mounted on the walls of the vessel.

are installed in units at the top of the BEBC shield. All electrical connections are made via an 18 wire twisted-pair cable, and a 1.9 mm diameter coaxial cable for the high voltage. The logical signals are brought to the control room via 80 m long twisted pairs where they enter into the standard EMI read-out electronics².

Heating

The Pickets are installed between the cold (liquid H₂) chamber body and the cryostat of the superconducting magnet. As the units stop working at about 0 C (due to discharge caused by phase separation of the gas mixture) and as they would certainly be destroyed by excessive temperature changes in either direction, great care was given to active temperature control. Each unit is equipped with a platinum resistor at the bottom to monitor the temperature of the gas entering the tubes. The incoming gas passes resistive heating wires which are glued onto both sides of the units as indicated in fig. 1. The maximum heating power per unit is 3 W. A micro processor based system (fig. 4) turns

Fig. 4 Block diagram of the temperature measurement and regulation system

permanently to adjust the temperature to a given preset value (20 C). Due to the careful insulation of the chamber body (2 x 20 layers of super insulation) this heating power was fully sufficient. The choice of such a servo system is dictated by the fact that the temperature must also be controlled outside physics runs, when operators for the EMI and the IPF are absent.

Performance

Due to the hydrogen safety regulations the proportional tubes have to be operated with an inert gas. Therefore we are using the standard EMI gas mixture 70/30 A/CO₂. This mixture results in a high voltage working plateau of typically 150 V around 2.0 kV with an amplifier threshold of 200 μ V (at a 1.8 k Ω working resistor).

Once installed inside the BEBC vacuum no on-line efficiency measurement can be done. The only performance monitor for the system is the counting of cosmic ray rates. We observed no dependence of cosmic rates on the magnetic field. Also the BEBC expansions have no effect on the Pickets.

The time resolution of the Pickets is 230 ns full width, which fits well to the resolution of the EMI electronics (300 ns). The recording of data during the beam spill (3-4 ms) is dead time free as for the data from the EMI². After the long shut-down which started in the summer 1980, BEBC with the IPF installed was operational for a technical run in May 1981. The physics program started in August. Until today we could not yet get a precise determination of the efficiency for measured throughgoing tracks. Instead we used coarse cuts using the EMI chambers as reference. This gives for the forward as well as for the backward sector of the IPF an inefficiency of 6.5%. This is to be compared with a minimum design inefficiency figure of 5.8%, due to residual gaps between pickets (4.5%), wall thickness of individual tubes (1%), and spacer effects (0.3%).

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References

1. R.C.A. Brown et al., IEEE Transactions of Nuclear Science, Vol. NS-25, No. 1, (1978), 130.
2. C. Brand et al., Nucl. Instr. and Methods 136 (1976) 485.