MUON DETECTION WITH A PLATE INSIDE THE 15-FT NAL BUBBLE CHAMBER

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ABSTRACT

We shall consider here the use of a thick metal plate inside the 15-ft bubble chamber for the detection of muons, the alternative being a system of plates and counters placed outside the bubble chamber. In either case, a track is identified as a muon if it passes through the plate and is detected on the other side. No identification can result if the track does not pass through the plate. False identification arises if the track, being a pion, decays unobserved in flight and the resultant muon is seen to pass through the plate, or if the track, being a hadron, makes an interaction in the plate but a secondary emerges in the forward direction, or, of course, if the initial hadron makes no interaction and emerges. We shall consider these difficulties in order and compare the plate inside with a plate outside the chamber.

A. Probability of a Track Not Passing Through the Plate

Let us consider a 2-m diameter plate approximately 2-m downstream inside the chamber and compare this with a semicircular array of plates outside the chamber 10-m wide and 4-m high. These two systems subtend similar solid angles to the fiducial volume center. However, the distances from that center to the outside plates would have to be approximately 4 m (the vacuum tank is 22 ft in diameter) compared with 1 m for the inside plate. As a consequence of this and the 30-kG chamber field, tracks with momenta less than 2 GeV would never even enter the outside plate, and the system is not likely to be efficient for tracks less than 3 GeV. The plate inside the chamber, however, would be effective down to 1 GeV. This is important since in W production and other highly inelastic processes near threshold, the μ^- is constrained by kinematics to be slow.

B. Probability of a π Decaying, Undetected, Before the Plate

The mean decay path of a pion of momentum p GeV is approximately 56 p meters, and the probability of a decay in 1 m before a plate inside the BC is thus 2% for a 1-GeV pion and only 0.5% for a 4-GeV pion. In a bubble chamber, however, the decay of a pion, whose momentum is below 4 GeV, is usually made visible by the change of momentum of the track. Thus the probability of a pion decaying, unobserved, is not greater than 0.5% up to 4 GeV and proportionately less at higher momenta. If a plate outside the chamber is used, tracks of 4 GeV have a 2% probability of decay before the plate with essentially no means of observing the decay by charge of momentum, and only above 16 GeV is the probability down to 0.5%.

C. Hadron Interactions Giving A Forward Track That Emerges From the Plate, Or Hadrons That Pass Through the Plate

From results of tests for the ν spark-chamber experiment at CERN, it appears that between 50% and 60% of hadron interactions yields just one visible outgoing track so well aligned with the primary track that it could be mistaken for that track. This outgoing track does not, however, have the same momentum as the incoming track and thus if there is field after the plate, as in the bubble chamber, such interactions can, in general, be detected. As a result, nearly twice as many interaction lengths are required in a plate outside the chamber than in a plate inside the chamber. Thus, a pion has only 0.5% probability of passing undetected through 60 cm of tungsten inside the chamber while nearly 1.2 m would be required outside for the same separation. However, the much greater area of plate outside makes the use of tungsten impossibly expensive, and as a result, as much as 5 meters of concrete might be required for the same separation. Such a "plate" would weigh over 400 tons and compel considerable modification of the bubble-chamber house to accommodate it.

D. Summary

1. An outside plate array capable of 0.5% separation is very large and very massive.

2. An outside array can give 0.5% separation only at energies above 16 GeV and can only give 2% separation at 4 GeV.

3. The outside plate array can give no separation below about 3 GeV since the particles below this momentum will, in general, not pass through the plate.

4. In contrast, the tungsten plate inside the chamber can give 0.5% separation at all energies down to about 1 GeV.

The advantage, then, of the plate inside the chamber is its much better separation of μ's from π's at lower energies. Its only disadvantages are 1) the reduction in useful chamber volume, and 2) the fact that its presence would rule out the use of a quantameter outside the chamber.