NEUTRINO EXPERIMENTS WITH BUBBLE CHAMBERS AND HIGH-RESOLUTION VERTEX DETECTORS

P. Musset,
CERN, 1211-Genève-23, Switzerland.

ABSTRACT

In this note we will show that beam set-up and detectors have to be quite different from those used at present accelerators. Nevertheless, neutrino physics look quite accessible with a 20 TeV machine.

1. BEAM CONSIDERATIONS

In wide-band beams, the large muon flux, of the order of 10^5 particles, is unacceptable for bubble chambers. On the other hand, the neutrino interaction rate is very high in any materials, especially in the beam axis, of the order of 50 ev/t/10^{13} protons.

Consequently, the detector should be moved downstream by e.g. 3 km, to lower the muon background to an acceptable level. A small size detector can be used, and the neutrino beam can use only a part of the whole machine intensity.

A multi-fast ejection, with a spill of 10^{-4}s, would be needed for rapid-cycling bubble chambers.

2. INADEQUACY OF PRESENT LARGE BUBBLE CHAMBERS

The shape of existing chambers, almost spherical, is quite inadequate for the events of much higher energy. The large weight of such chambers would lead to a number of events per picture much too high. Finally, big chambers have intrinsically low resolution, and the secondary tracks, which are emitted in a very narrow cone, would not be separated.

3. PROPOSED CHARACTERISTICS OF BUBBLE CHAMBERS

Since bubble chambers must not be large, but have to be precise, we propose the use of small depth - typically 20 cm - and high resolution - typically 20μ - bubble chambers, with both hydrogen and heavy liquids. The weight could be in the range of 0.1 tons, to obtain of the order of ½ to 1 event per expansion. The chamber should be long enough, of the order of the metre, to separate muons, which would be identified in a dowstream absorber, from the hadrons. It should be possible in most cases to separate hadrons, which would be measured downstream. It is not realistic to envisage the measurement of magnetic curvature of secondaries inside the chamber unless very high magnetic fields become available by that time. The bubble chamber should then be hybridized, i.e. equipped with a spectrometer for secondaries. A total absorption calorimeter would be able to measure the total hadronic energy. Note that picture taking can be triggered according to an event selection in dowstream detectors.

Identification of electrons produced at the vertex which is of special importance in dump experiments, is difficult because of the high number of π^0 emitted, which give rise to Dalitz pairs.

The best approach for experiments in which the e identification is essential, is maybe to use a hydrogen bubble chamber followed by a very fine-grain shower counter. Since many tracks originate from the primary vertex at small relative angles, the shower counter has to be fine-grained in the plane perpendicular to the beam. It also has to be fine-grained in the beam direction, in order to distinguish showers produced by secondaries from showers produced in nuclear interactions of secondary hadrons.

Note that hadrons with low relative p_T would remain difficult to spatially separate.

4. REMARKS

Heavy bosons produced by neutrinos will decay with somewhat large (order of 10^o) angles. They will be produced with a partial rate of 10^{-3} of the total cross-sections and may constitute a subject of interest in themselves.

Heavy flavour particles (C, B, τ, or others) have decay lengths of the order of the cm, which may be directly measured in some cases.

An electronic detector of a moderate weight (ton) but with a very high resolution (20 μ) and triggerable is very desirable since it would open the field of rare processes and at the same time would have many of the advantages of the bubble chambers.

5. CONCLUSIONS

The study of neutrino interactions in the multi-TeV region requires different technical approaches than present neutrino experiments. These techniques do not seem to present basic difficulties. The main problem may be the separation of particles gathered in narrow jets, and this problem calls for very high resolution detectors.

Many of the topics considered in this note are the results of discussions with S. Mori and W. Venus.