Experimental Proposal to FNAL

Search for short lived Particles using a high Precision Mini-Bubble-Chamber

B. Hahn, E. Hugentobler and E. Ramseyer

University of Berne, Department of High Energy Physics, Berne, Switzerland

Scientific Spokesman: E. Hugentobler tel: 031 65 40 62
Deputy Spokesman: B. Hahn tel: 031 65 40 65

May 1978

6 pgs.

Summary

A search for short lived particles produced in high energy hadron-nucleus collisions (such as charmed particles) by means of a small highly sensitive precision heavy liquid bubble chamber (C_3F_8) will be made. Such particles can be recognized by their decays near the production vertex. We operate the chamber at a bubble density of 300 bubbles/cm and an apparent bubble size of 30 μm in real space. This allows us to detect short lived particles if their decay length exceeds 0.3 mm independant of the decay mode. We will be able to set an upper limit of less than 5 μb to the production cross section of short lived particles produced in pairs if their lifetime is more than 10^{-13} sec.

The whole experimental equipment has been tested at CERN in a 70 GeV hadron beam and is ready to be shipped to Fermi Lab.

Setting up and testing period:	10 days
Data taking period:	20 days

1. Introduction

We constructed a small bubble chamber working at very high sensitivity of 300 bubbles/cm (Mini-Bubble-Chamber = MBC). This instrument could be useful to search for short lived charged or neutral particles produced in a primary interaction in the chamber liquid independent of the decay mode. The MBC is thought to fill the gap between normal bubble chambers and nuclear emulsions, but sharing the advantages of bubble chambers. Another technique is to use a pressure streamer chamber (FNAL-experiment E-490). The liquid volume of our chamber is cylindrical, 6 cm in diameter and 3.5 cm deep. It is photographed by two cameras. The chamber liquid is C_3F_8 or $CBrF_3$, which are both nontoxic and nonflammable.

2. Results of a Test Operation at CERN (see photograph)

Our MBC has been successfully tested in a 70 GeV hadron beam of the CERN SPS with the following results:

- The bubble density, as measured along primary tracks is around 300 bubbles/cm
- near the interaction vertex the spatial resolution for recognizing a decay or an interaction of a particle is as small as 0.3 mm in real space, if the multiplicity is low. Only for higher multiplicities the visibility is reduced within a forward cone of about 3^o - 5^o opening angle. The efficiency for short tracks decaying with high transverse momenta would thus not be reduced. In this connection we would like to stress, that a high

transverse momentum according to M.K. Gaillard et al. [1] is one of the characteristics of charmed particle production.

- The scanning of the pictures can be done in a short time and with immediate recognition of interesting events.

3. Proposed Experiment

Recent experiments at CERN [2, 3] and at FNAL [4] suggest a cross section of > 25 μb for charmed particle production by 400 GeV protons. We propose to expose our MBC to a 400 GeV proton beam in order to look for direct evidence of pair produced short lived particles.

With our equipment we are able to take one photograph per beam burst. In order to reach an upper limit of 4 μb with 90 % CL and 50 % detection efficiency we have to collect 40'000 interactions in our MBC. This roughly corresponds to 100'000 pictures which requires a data taking period of 20 days (average beam repetition time 13 sec, running efficiency 75 %). We estimate that our detection efficiency should be better than 50 % if the lifetime of pair produced short lived particles is higher than 10^{-13} sec.

4. Background

Pair production of short lived particles is essential in order to discriminate against secondary interactions near the vertex of the primary particle. The probability that in a given primary interaction two secondaries each produce a star within a distance of 2 mm and which both are misinterpreted as decays of particles is estimated to be $\lesssim 5 \cdot 10^{-5}$.

5. Requirements

Beam

400 GeV protons
30" bubble chamber beam with standard fast extraction (200 μs) using the first ping
Intensity: 50 particles per ping
Profile: vertical 2.5 cm
horizontal 0.5 cm

Power

about 5 kW (220 V)

Space

1,5 x 2,5 m^2 in front of the 30" bubble chamber (1.5 m in beam direction), accessible for film change every 2 to 3 hours.
Additional space for 2 racks of electronics and bottles of compressed air.

Compressed air supply

To operate the bubble chamber we need compressed air or nitrogen of 25 bar pressure (compressor or bottles).

The consumption would be about 10 bottles / day (200 bar pressure, 50 litres volume).

Personnel

Operation of MBC alone needs only one physicist on shift.

E. Hugentobler (private docent) Scientific spokesman
B. Hahn (full professor) Deputy spokesman
E. Ramseyer (graduate student)

A sufficient number of physicists of the University of Berne (the names will be indicated later) can come to Fermilab for running the experiment. We also would appreciate the collaboration of one or two FNAL staff physicists.

Costs for Fermilab

Only the cost of the electric power for the beam and our equipment.

References

1) M.K. Gaillard et al. Rev. of Mod. Phys. 47, 277 (1975)
2) BEBC CERN/EP/PHYS 78-2
3) CDHS CERN-PRE-78-02
4) Dr. Bodek FNAL, private communication