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A MUON BEAM THROUGH THE NEUTRINO FILTER (AS A TEST BEAM FOR THE NEUTRINO DETECTORS)

I) PRINCIPLE

It is proposed to use the muon flux on the neutrino beam axis in the neutrino filter as a test beam for the neutrino detectors. For this purpose a beam pipe will be mounted on the axis of the neutrino filter [1]. In the pipe, which will normally be filled with mercury, the level of the mercury could be adjusted by compressed air such that the wanted number of muons reaches the neutrino detectors. Several metres of iron in front of the pipe will serve as hadron absorber and muon spectrum softener. This principle would represent three advantages:

- it resolves the difficulty of matching an inclined test beam channel to the different target positions considered;
- it yields - if the horn is switched off - positive and negative muons up to a certain maximum momentum; thus the track quality could be tested all over the bubble chamber;
- the neutrino filter would not be a completely impenetrable wall but might well serve as a collimator for other beams; it might for instance be important for the analysis of the neutrino events to study pion interactions in the H.L.B.C.

II) POSSIBLE MUON INTENSITIES

We assume :

1. 3.6 m iron (corresponding to 4.7 GeV energy loss of the muons) in front of the pipe;
2. that the angular distribution of the muons behind this absorber is given by multiple scattering only and that the mean square angle

$$\langle \theta_s \rangle^2 = \frac{0.021^2}{p_i p_f} \cdot \frac{X}{X_o}$$

p_i, p_f initial and final muon momentum,
X_o = 1.86 cm = radiation length in iron
X = 3.6 m
is a measure of the solid angle into which the muons would propagate without the pipe;

3. that the muon flux inside the pipe is attenuated only by the solid angle reduction factor

$$R = \frac{\Delta \Omega \text{ pipe}}{\pi \langle 0_s \rangle^2}$$

4. that the muon flux calculations - partly confirmed by measurements [2,3] - for 24 m decay path and 1964 magnetic horn as shown in fig. 1 - are a sufficiently good estimate of the order of magnitude

5. 10^{12} ejected protons, pipe diameter 6 cm, pipe length 16 m.

Then the muon flux spectrum shown in fig. 2 is obtained. The flux would be 4 to 5 times more intense if the pion decay path is 80 m long and if the pion flux is focused by three consecutive magnetic fields [4] corresponding to a total number of about 3.10^{-8} muons per protons. The flux intensity could be reduced by leaving mercury in the pipe.

It may be mentioned that :

- by reducing the absorber thickness in front of the pipe the intensity and peak energy would rise slightly;
- the pipe length could be as short as 11.2 m (see fig. 3) thus increasing the muon flux by a factor of 2;
- the pions could be focused more efficiently with respect to muons (according to the smaller decay angles larger decay paths could be admitted than for neutrinos, 95 m being the maximum possible in the new layout);

- a total muon flux of 10^{-7} per proton with 3 GeV peak energy, 6 mrad divergence over a surface of 28 cm^2 would consequently be conceivable.

Such a muon beam would have a smaller divergence but also a smaller intensity than the A.G.S. muon beam [5] which has 10^{-5} muons per proton over 700 cm^2 with 2.5 GeV peak energy and 35 mrad divergence.

III) TECHNICAL REMARKS

1. In order to avoid axial beam parallel slots due to the pipe the effective thickness of its wall should be changed a few times. This will be done by casting lead and arranging iron bars and bricks around the pipe, as shown in fig. 3.
2. The mercury pipe (inner diameter 6 cm) will consist of three parts (12.6 m in the stationary part, twice 1.8 m on two carriages of the filter). All three parts will belong to a system of communicating tubes whose upper ends consist of pressure pots placed on top of the filter (see fig. 4).
3. The mercury (about 700 kg, 270 kg from the previous neutrino beam) could be lifted by compressed air, and flux intensity and spectrum will be chosen within certain limits by adjusting the pressure separately in the three parts of the pipe (see fig. 4). An ionization chamber in front of the bubble chamber could serve as a testbeam flux monitor.

IV) COLLIMATOR FOR A POSSIBLE PION BEAM

A rough estimate shows that for instance an 18 GeV pion beam traversing the pipe could have a reasonable number of particles even with single bunch ejection. For this purpose the last part of the pipe in the stationary filter could be taken off thus leaving an 11.2 m long pipe and making room for a magnet to sweep away low-energy background produced in the pipe wall.

Assuming the beam to be momentum analysed ($\Delta p/p \approx 0.01$) and focused in the decay tunnel such that the beam waist comes to lie in the middle of the pipe one obtains roughly $\Delta p \cdot \Delta \Omega \approx 8.10^{-6}$ $\left[GeV/c \cdot sr \right]$. From extrapolation of pion production data [6] to 18 GeV/c a value $\partial^2 N / \partial p \, \partial \Omega = 10^{-3}$ may be estimated. For 7.10^{11} protons per pulse, 40 o/o target efficiency and single bunch ejection consequently about

100 pions per pulse

could be expected.

V) INFORMATION ABOUT THE FORWARD PRODUCTION OF PIONS IN THE TARGET

The quantitative measurement of the muon flux in the pipe (for zero current in the meson focusing devices) - for instance from an evaluation of the test beam pictures obtained with the H.L.B.C. - would allow to estimate the forward production of pions in the target. This would add further information to the one expected from muon flux measurements planned to be carried out in the neutrino filter [7]. Knowing the forward production of positive and negative pions one could calculate the fraction of negative pions being not defocused in the "positive" focusing channel; by calculating and looking for the corresponding μ^+/μ^- ratio on test beam pictures obtained when the focusing currents being switched on, these calculations could be verified.

This point might become important in view of the proposed test of the muon number conservation [8] since the non-defocused negative mesons produce the <u>direct</u> antineutrino background (the antineutrino background coming from mesons already defocused or produced in the tunnel wall might be much more numerous but could be assumed to be less energetic).

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REFERENCES

1) See NPA/Int. 65-29 (fig. 5) for details of the filter layout;

2) H.H. Bingham, L. Hoffmann, M. Nikolić - NPA/Int. 64-19, 64-20;

3) G. Plass and H.W. Wachsmuth - Informal Meeting on Neutrino Physics, CERN, 17 Jan. 1965;

4) A. Asner and Ch. Iselin - CERN 65-17;

5) R. Cool, A. Maschke, L. Lederman et al. - B.N.L. preprint;

6) B. Jordan - CERN 65-14;

7) H. Wachsmuth - CERN-NPA, Internal Note, 16 Dec. 1965;

8) H.J. Gerber et al. - Proposal to the E.E.C., 6 Dec. 1965.

FIGURE CAPTIONS

1) Muon flux on the axis of the neutrino filter in the 1964 layout;

2) Muon spectrum expected in the H.L.B.C. under the conditions stated in the text (24 m decay);

3) Details of the design of the neutrino filter;

4) Scheme of the test beam shutter.