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SINGLE SPECTROMETER STATION FOR NEUTRINO-TAGGING

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1. INTRODUCTION

The possibilities of generating beams of tagged neutrinos attract attention more and more. This is because ν-tagging has advantages in the TeV-energies, which are now attained with the Tevatron, or will be attained in a not remote future with the UNK-Serpukhov.

Up to now several methods for neutrino tagging are proposed[1-7]. Some of them are based on various three-particle decays: and others, on the two-particle decay $\pi(K) \to \mu + \nu$.

There is a proposition to use the $\pi(K) \to \mu + \nu$ decay in a ν-tagging station, which can be called a bispectrometer ν-tagging station[5-7] (Fig.1). It consists of two spectrometers - $S_{\pi,K}$ and S_{μ}, the first measuring the energy $E_{\pi,K}$ of the parent $\pi(K)$-mesons, and the second - the energy E_{μ} of the muons generated by the decay of the parent mesons. In the coordinate planes $C^{(1)}_{\pi,K}$, ..., $C^{(n)}_{\pi,K}$ and $C^{(1)}_{\mu}$,... $C^{(n)}_{\mu}$ the measurement of the coordinates of the $\pi(K)$, resp., μ-mesons, together with the measured values of $E_{\pi,K}$ and E_{μ} give the four-momenta $p_{\pi,K}$ and p_{μ} of the parent and the μ-meson. This makes it possible to calculate the neutrino four-momentum p_{ν} with the formula $p_{\nu} = p_{\pi,K} - p_{\mu}$.

The bispectrometer ν-tagging station gives an overdetermined set of measurements. Overdetermination is useful, because it offers the possibility of identifying the parent particles[6,7], but makes the device more complicated. For this reason it is

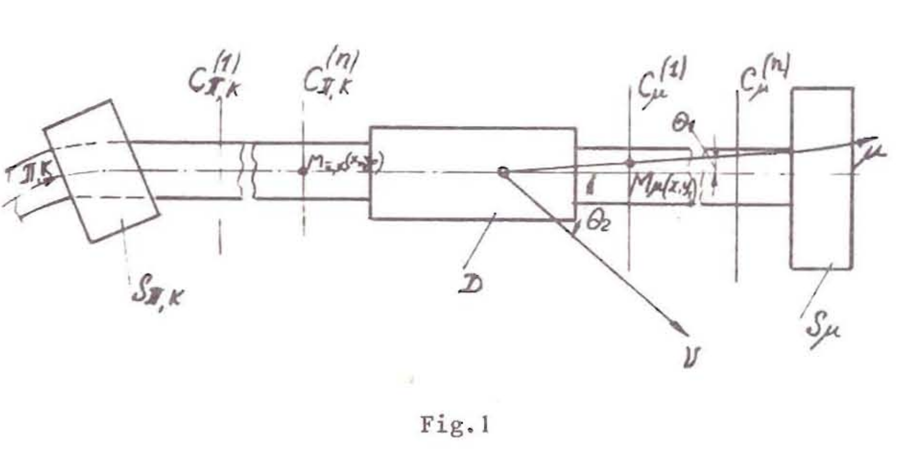

Fig.1

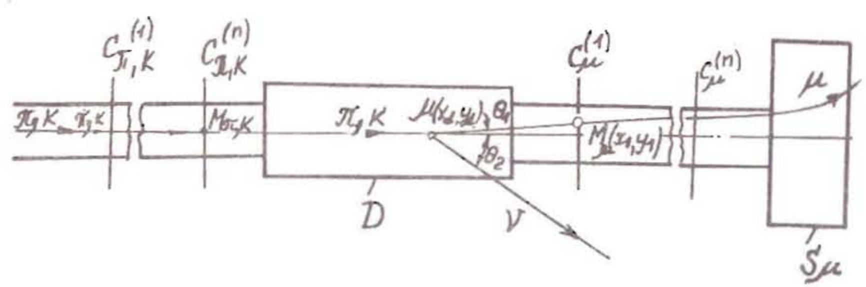

Fig.2

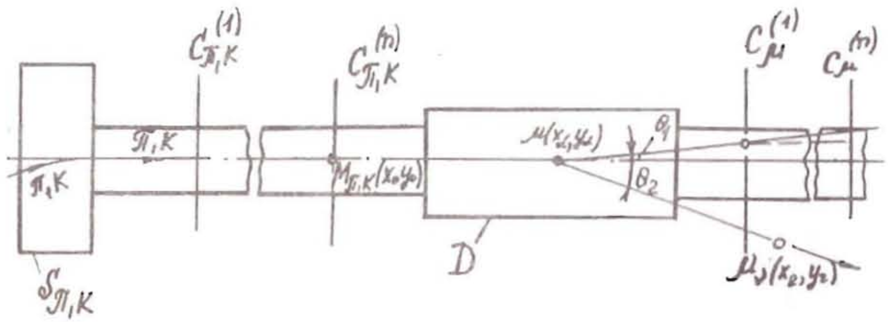

Fig.3

interesting to investigate similar tagging stations, which have simpler construction, for example, the one shown in Fig.2 [4].

Unlike the station in Fig.1, it has only one spectrometer - S_μ. So it will be called single-spectrometer ν-tagging station. There may be various versions of the single spectrometer ν-tagging station. Here we shall consider five of them, the Version A being shown in Fig.2; and Version D, which seems to be the best, in Fig.3.

In Fig.3 a point with the coordinates x_2, y_2 is shown. These are the coordinates x_2, y_2 of a neutrino event in the ν-detector.

In this paper five versions, A,B,C,D, and E of the single spectrometer tagging station will be described.

The single-spectrometer ν-tagging station is described in more details in Sec.2 as a realization of the fourth method of tagging. In order to see its place among other devices with a similar function, the other four methods of tagging, which are known to the author, are also briefly discussed.

It will be shown that single (and bispectrometer) tagging stations may use a small part of the primary proton-beam. This means that only a small portion of the capacity of the accelerator is used for neutrino experiments, the main part of its resources being engaged for other experiments.

2. METHODS OF NEUTRINO TAGGING

To our knowledge thus far five methods of tagging the neutrinos have been proposed. All the five are reduced to the use one way or another of the law of conservation of four momenta.

Two devices for neutrino tagging are described, in which averaged values of the four momenta of parent mesons and muons in the one case, or of parent mesons in the other case are measured. These devices and the corresponding methods are sufficiently specific to be considered separately as methods for neutrino tagging of the first kind. In the remaining three methods - the methods of the second kind - no average values are measured.

A) Methods of the First Kind

The First Method [1]. It is based on the decay $\pi \to \mu + \nu$. It is supposed that the pions and muons form a monochromatic and collimate beam with averaged four momenta, $\bar{p}_\pi$ and $\bar{p}_\mu$, respectively. The averaged four momentum of the neutrino is calculated by the formula $\bar{p}_\nu = \bar{p}_\pi - \bar{p}_\mu$. The energy E_ν of the tagged neutrino is determined by a relative error of 12.5 per cent.

The Second Method [2]. This method will be called Serpukhov's. It uses the decay $K \to \mu + \nu$ to obtain muon neutrinos and the decay $K \to e + \nu + \pi^\circ$ as a source of electron neutrinos. In the case $K \to \mu + \nu$, p_ν is calculated by the formula $p_\nu = \bar{p}_K - p_\mu$ the bar denoting averaging. The energy and direction of the neutrino are obtained from more information than in the first method: besides the averaged four momentum of the beam of parent mesons, the coordinates of the muon interaction, the energy and direction of the individual muon and the coordinates of the neutrino interaction are also available. Another advantage is the possibility existing here to sort out the decays whose parent particles are kaons. In other words, the problem of the kind of parent particle is solved here successfully. The success is due to the fact that the $\pi + K$-meson beam is monochromatic and collimated thereby the decay cone of the π-mesons, i.e., the cone in which the decay muon fly, is with a much smaller aperture than the K-meson decay cone. Due to this, if the muon flies between the large and small cone, it has originated from the $K \to \mu + \nu$ decay.

The circumstance that the neutrino parameters are defined on the basis of more information and that there is an effective way of solving the dilemma whether the parent meson is a pion or kaon, highly improves the qualities of the Serpukhov method of tagging.

B) Methods of the Second Kind

The Third Method[3]. It is based on the decays $\pi(K) \to \mu + \nu$ and $K_L^0 = \pi \pm \ell \mp \bar{\nu}_\ell$, where ℓ denotes a lepton.

We are interested only in the decay $\pi(K) \to \mu + \nu$. In this decay the tagging of the neutrino, i.e., the determination of the energy and direction of a separate particle occurs by using information on the neutrino coordinates and muon interaction and direction of the $\pi + K$ meson beam which is supposed to be well collimated.

If this method is perfected sufficiently, removing at first place the uncertainty originating from the lack of knowledge whether the parent is pion or kaon, most probably it may have cosiderable advantages.

The Fourth Method. This method and its implementation as the single-spectrometer ν-tagging station is described in more detail in the next paragraph.

The Fifth Method. It is implemented as the bispectrometer ν-tagging station described above (Fig.1).

The device shown in Fig.1 measures the world line $L_{\pi,K}$ of each parent meson and the world line L_μ of the muon generated by the decay of the parent meson. (For the designations $L_{\pi,K}$ and L_μ see the next paragraph).

In a second version of the bispectrometer station an additional channel of information is available - the world point $W_\nu(M_\nu, t_\nu)$ of the neutrino interaction in the detector[7] (Fig.4). (For the designations W, M and t, see the next paragraph).

3. THE FOURTH METHOD. THE SINGLE-SPECTROMETER ν-TAGGING STATION

The Fourth Method[4]. It is realized in the single-spectrometer station, which was briefly considered above. Some more details will be added here.

A beam of π or K mesons, or a mixture of π and K mesons, enters an evaluated tube where it is monitored by the coordi-

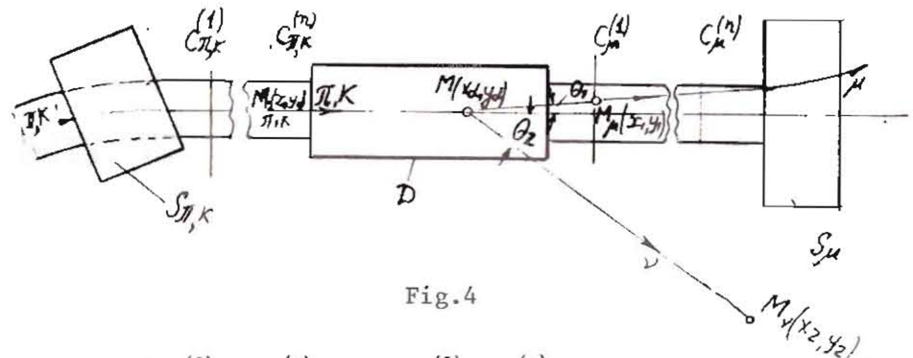

Fig.4

nate planes $C^{(1)}_{\pi,K}, \ldots C^{(n)}_{\pi,K}$ and $C^{(1)}_\mu, \ldots C^{(n)}_\mu$, (Fig.2). Hereby the direction of the trajectory of a given π or K meson, as well as the coordinates x_0, y_0 of a point $M_{\pi,K}$ of the trajectory and the time $t_{\pi,K}$ of its passage through $M_{\pi,K}$ are measured. After the parent meson decays in the decay tunnel D in μ and ν, one measures in the coordinate planes $C^{(1)}_\mu, \ldots C^{(n)}_\mu$ the direction of the muon, the coordinates x_1, y_1 of a point M_μ from the trajectory and the time t_μ of the passage through M_μ. The energy $E_\mu \simeq E_1$ of the muon is also measured in the magnetic spectrometer S_μ. In brief, the device in Fig.2 determines for each parent meson its trajectory in the three-dimensional subspace and a world point $W_{\pi,K}(M_{\pi,K}, t_{\pi,K})$ on this trajectory. After the decay of this parent meson in μ and ν the device determines the world line L_μ of the μ-meson, i.e., its four-momentum $p_\mu = (\vec{p}_\mu, E_\mu)$ and a world point $W_\mu(M_\mu, t_\mu)$ on its trajectory. The single-spectrometer ν-tagging stations may be fulfilled in various versions (see the Table).

Version A is described above. In fact, knowing the trajectory and the world point $W_{\pi,K}$ of the parent meson on the one side, and the world line L_μ of the muon, on the other side, one reconstructs on the base of the measurement data the world point W_d of the decay, angle θ_1 made by the $\pi(K)$-trajectory with the μ-trajectory and the energy of the muon E_1. An important role plays the two-valued function $M = (\frac{m_0}{m_1})^2 = M_\pi = (\frac{m_\pi}{m_\mu})^2$ and $M = (\frac{m_0}{m_1})^2 = M_K = (\frac{m_K}{m_\mu})^2$ if the parent meson is pion, resp., kaon, $m_0 = m_{\pi(K)}$ and $m_1 = m_\mu$ being the masses of the parent meson and of the muon respectively. In Version A the value of M is supposed to be determined. For sufficient low E_0 this can be effected by separating the $\pi + K$ mixture into one π-beam and one K-beam and then working either with the π-beam or with the K-beam, the procedure being equivalent to giving a fixed value to M. There exists another possibility for the pion/kaon identification (i.e., for the measurement of M)[8].

Table

Quan. / Vers.	x_0,y_0	ℓ_0	E_0	x_1,y_1	ℓ_1	E_1	x_2,y_2	ℓ_2	E_2	M	x_d,y_d	θ_1	θ_2
A	meas	meas	calc	meas	meas	meas	calc	calc	calc	meas	calc	calc	calc
B	meas	meas	meas	meas	meas	calc	calc	calc	calc	meas	calc	calc	calc
C	meas	meas	calc	meas	meas	meas	meas	calc	calc	calc	calc	calc	calc
D	meas	meas	meas	meas	meas	calc	meas	calc	calc	calc	calc	calc	calc
E [1)]	calc	calc	calc	meas	meas	meas	meas	calc or meas	meas	calc	calc	calc	calc

Quan. - quantity; Vers. - version; meas - measured; calc - calculated.

1) Remark. Behind the decay tunnel there is a device for muon identification.

Version B. It is similar to Version A except for the position of the spectrometer. In A the spectrometer S_μ is behind D and measures E_1, while in B there is a spectrometer S_μ in front of D, which measures $E_{\pi,K} = E_0$.

Version C and Version D are like Version A, resp. Version B with the additional possibility of measuring the cooordinates of the point M_ν of the neutrino interaction in the detector and the time t_ν it occurs, that is, the world point W_ν of the neutrino interaction. Having W_ν, it is possible on the base of the measured data to determine the angle θ_2 which the neutrino trajectory makes with the trajectory of the parent meson. M is calculated.

Version E. A glance at the Table shows that in Version E all measurements are made downstream of the decay tunnel. This makes it possible not to take into account the secondary protons and undecayed parent mesons which would be the vase if there were upstream measurements. So, one concentrates on the measurement of muons, generated in $\pi, K \to$ decays with the maximum possible velocity. This means that in Version D one would have a beam of tagged neutrinos with maximum intensity. However, without further investigations, it is not clear whether this possibility is feasible.

For several purposes Version D may be preferable. This is because the position of $S_{\pi,K}$ brings technical and economic advantages (smaller size and cost compared with S_μ) and because the additional information contained in W_ν is cheap and effective. Further on this Version will be considered in more detail.

4. THE D-VERSION

The D-version of the single-spectrometer ν-tagging station, or in brief, the single-spectrometer station permits in principle the four-momentum p_ν of each neutrino, reacted in the detector, to be measured at a comparatively low price. Here we shall derive the underlying formulae.

Let the target, where the π, K mesons are generated, be the origin 0, at a coordinate plane XOY, which coincides with the plane of the $\pi(K) \to \mu + \nu$ decay (Fig.5). In this figure $M_{\pi,K}$ is a point of the trajectory of the parent meson, $\vec{\ell}_0$ is a unit vector characterizing its direction, M_μ is a point of the muon trajectory, M_2 is the locus of the neutrino event in the detector, and $\vec{\ell}_1$ is a unit vector, characterizing the direction of the muon trajectory.

In [5,7] $\vec{\ell}_0$ and $\vec{\ell}_1$ are supposed to be measured each one by two coordinate planes. In such case the error caused by the

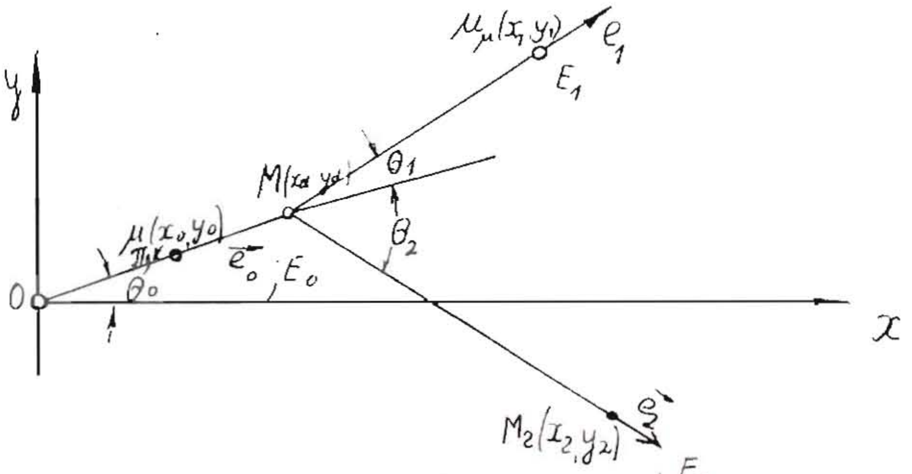

Fig.5

multiple scattering is minimum, but this is at the expense of worsening the effectiveness of the system. It is better to measure $\vec{\ell}_0$ and $\vec{\ell}_1$ each one with $n > 2$ coordinate planes. When n grows, the error due to the multiple scattering grows approximately by a factor of $\sqrt{n}$. But at the same time the same error is diminished approximately by a factor of $1/\sqrt{n}$ because one has to measure $\vec{\ell}_0$ and $\vec{\ell}_1$ by means of n random numbers corresponding to the n coordinate planes. The result is that when n grows, the error of measurement is approximately constant, while the effectiveness approaches monotonously to 1. However, n is not to be chosen too large, because other factors are limiting it.

As in[7], the timing can be achieved either by scintillation counters or by a special arrangement of the wires in the proportional or drift chambers. Analogously M_ν is the locus of the neutrino event. Having $M_{\pi,K}$, $\vec{\ell}_0$, M_μ and $\vec{\ell}_1$ one reconstructs the decay point M_D. If one then adds the information about M_2, one gets the angles θ_1 and θ_2, which make the trajectories of μ, resp., ν, with the trajectory of $\pi(K)$. As is seen from Fig.3, the energy E_0 of the parent meson is also known.

So, the problem now is: for a given $\pi(K) \to \mu + \nu$ decay one knows θ_1, θ_2 and E_0. Which is the energy E_2 of the neutrino?

This problem will be solved in the ultrarelativistic limit.

We shall use the formula [9]

$$E^2(q - V^2\cos\theta) - 2EE^*\sqrt{1 - V^2} + E^*(1 + V^2) + V^2m^2\cos^2\theta = 0, \quad (1)$$

where E, E*, θ and m can characterize either the muon with $E = E_1$, $E^* = \dfrac{m_0^2 + m_1^2 - m_2^2}{2m_0}$, $\theta = \theta_1$ and $m = m_1$ or the neutrino with $E^* = E_2$, $E^* = \dfrac{m_0^2 - m_1^2 + m_2^2}{2m_0}$, $\theta = \theta_2$ and $m = m_2 = 0$. As to V it is given by the formula $V = \sqrt{1 - \dfrac{m_0^2}{E_0^2}}$. Writing down (1) in the ultrarelativistic limit for neutrino, one has

$$E_2 = E_0\left(1 - \frac{m_1^2}{m_0^2}\right)\frac{1}{1 + \theta_2^2/\psi^2}, \quad (2)$$

where $\psi = m_0/E_0$.

However, (2) does not permit the calculation of E_2, because one does not know m_0, i.e., one does not know whether the parent is a pion or a kaon. To solve this dilemma let us write in an ultrarelativistic limit the perpendicular to $\vec{\ell}_0$ component of the momentum of the muon + neutrino system. This component must be zero.

$$E_1\theta_1 + E_2\theta_2 = 0. \quad (3)$$

Putting in (3) $E_1 = E_0 - E_2$ and substituting E_2 from (2) one has

$$\theta_1 = -\left(1 - \frac{m_1^2}{m_0^2}\right)\frac{\theta_2}{m_1^2/m_0^2 + \theta_2^2/\psi^2}, \quad (4)$$

which can be written down as

$$M = -\frac{\theta_1}{\theta_2}\left(1 + \frac{E_0^2}{m_1^2}\theta_2^2\right) + 1 \quad (5)$$

with

$$M = \frac{m_0^2}{m_1^2}. \quad (6)$$

As θ_1, θ_2 and E_0 are known from the measurements, one can calculate M. If one has measured the products of the reaction $\pi(K) \to \mu + \nu$, M should be very near to one of the two values [10] $M = \dfrac{m_\pi^2}{m_\mu^2} = \dfrac{m_0^2}{m_1^2}$ if the parent were pion, or $M = \dfrac{m_K^2}{m_\mu^2} = \dfrac{m_0^2}{m_1^2}$ if it were kaon.

After having found $m_0 = m_\pi$ or $m_0 = m_K$ then there is no obstacle to calculating E_2 from (2).

5. THE INTENSITY OF THE PROTON BEAM

The mixture of $\pi + K$ mesons, which enters the single-spectrometer station is produced from secondary particles from the proton-nucleon collisions. We shall estimate the intensity I_p of the proton beam which produces beams of positive secondary pions with intensity I_{π^+} and energy E_{π^+}, and of positive secondary kaons with intensity I_{K^+} and energy E_{K^+}. The estimation is very rough, because of the uncertainty of the formulae for the yield, but in our case a semiquantitative approach is sufficient. We shall use the production formulae [11]

$$\frac{d\sigma_{\pi^+}}{dE_{\pi^+}}(E_{\pi^+}, E_p) = (1 + \frac{E_0}{E_p}) \frac{A_{\pi^+}}{E_{\pi^+}} \exp(- \frac{B_{\pi^+} E_{\pi^+}}{E_p}) \quad (7)$$

and

$$\frac{d\sigma_{K^+}}{dE_{K^+}}(E_{K^+}, E_p) = \frac{A_{K^+}}{E_{K^+}}(1 - \frac{E_{K^+}}{E_p})^{B_{K^+}} , \quad (8)$$

where σ_{π^+} is the cross-section for the production of positive pions, σ_{K^+} is the cross-section for the production of positive kaons, $E_0 = 8$ GeV, $A_{\pi^+} = 32.2$ mbarn, $A_{K^+} = 3.4$ mbarn, $B_{\pi^+} = 5.8$ and $B_{K^+} = 2.8$.

Introducing the variables $x_{\pi^+} = \frac{E_{\pi^-}}{E_p}$ and $x_{K^+} = \frac{E_{K^+}}{E_p}$ and neglecting $\frac{E_0}{E_p}$, then instead of (7) and (8) one gets

$$\frac{d\sigma_{\pi^+}}{dx_{\pi^+}} = \frac{A_{\pi^+}}{x_{\pi^+}} \exp(-B_{\pi} + x_{\pi^+}) , \quad (9)$$

$$\frac{d\sigma_{K^+}}{dx_{K^+}} = \frac{A_{K^+}}{x_{K^+}} (1 - x_{K^+})^{B_{K^+}} . \quad (10)$$

For the small increase $\Delta x = \Delta x_{\pi^+} = \Delta x_{K^+}$, the increases $\Delta\sigma_{\pi^+}$ and $\Delta\sigma_{K^+}$ will be calculated as differentials from (9) and (10). We are interested in the intensities $I_{\pi^+}(\Delta x)$ and $I_{K^+}(\Delta x)$ of pions and kaons in the energy range Δx.

If the cross-section σ_{pN} is 40 mbarn, then for $x_{\pi^+} = x_{K^+} = x = 1/2$, one gets

$$I_p = 10 \frac{I_{\pi^+}(\Delta x)}{\Delta x} = 10 \frac{I_{\pi^+}}{\Delta x} , \quad (11)$$

$$I_p = 40 \frac{I_{K^+}(\Delta x)}{\Delta x} = 40 \frac{I_{K^+}}{\Delta x} . \quad (12)$$

In other words, in order to have secondary mesons with given intensities I_{π^+} and I_{K^+}, we must use proton beams with intensities which are in an inverse proportion to the energy spread Δx. Thus, for the third method of tagging [2], in order to have well defined π^+ and K^+ ones, one has to choose $\Delta x \approx 0.01$.

If, as in [2], $I_{K^+} = 2\cdot 10^8$ $K^+\cdot sec^{-1}$, then $I_p = 1.2 \cdot 10^{13} p.sec^{-1}$ Because of the roughness of the estimation, this means that practically the whole proton beam of the accelerator is engaged.

Let us see what the conditions would be in the case of the single spectrometer-tagging station.

Here the K- and π-cone principle for selection [2] is unnecessary, hence Δx could be larger, for example, $\Delta x \approx 0.1$. According to (11), $I_p \approx 100 I_{\pi^+}$. For the D-version of the single spectrometer method the intensity $I_{\pi^+ + K^+}$ of the $\pi^+ + K^+$ beam in front of the decay tunnel is limited: $I_{\pi^+ + K^+} \lesssim I_\ell$, I_ℓ being at present of the order of 10^9 particles, sec^{-1} [12]. As the fraction of the K^+ in the $K^+ + \pi^+$ mixture is small, one can write $I_p \approx 100 I_{\pi^+} \approx 100 I_{\pi^+ + K^+} \leq 100 I_\ell \approx 10^{10} p.sec^{-1}$. In other words, the D-version of the single spectrometer station will use only a small part of the resources of the accelerator. But the beam of tagged neutrinos generated by it will be considerably less intense than that of the Serpukhov station [2], because in [2] undecayed pions, kaons, as well as secondary protons do not charge additionally the detectors, while in the case of the D-version they do. This drawback is perhaps removable in the E-version, if prospects for the realization of the idea of the E-version are good.

6. CONCLUSION

The preliminary analysis of the various versions of the single spectrometer ν-tagging stations indicates that the D-version may have some advantages. It is comparatively cheap and easy to build. It consists of part A in front of the decay-tunnel and another part A behind it (Fig.3). Part A comprises one magnetic spectrometer $S_{\pi,K}$, for example, one of the kind described in [13] and several coordinate planes $C^{(1)}, ..., C^{(n)} ...$, placed between $S_{\pi,K}$ and the decay-tunnel. Timing is achieved either in $S_{\pi,K}$ and $C^{(1)}, ..., C^{(n)}, ...$ or in special scintillation counters (see [7]).

Part B consists of several coordinate planes $C^{(1)}, ..., C^{(n)}, ...$.

In Part A the four momentum $p_{\pi,K}$ of the parent meson, as well as its nature (whether it is a π or K-meson) are determined. Hereafter in Part B the four-momentum p_μ of the muon is calculated. The tagging, i.e., the determination of the four-momentum p_ν of the neutrino is performed by the formula $p_\nu = p_{\pi,K} - p_\mu$.

Version D compared with the Serpukhov device for ν-tagging [2] operates with a much smaller part of the proton beam of the accelerator, but gives a less intense beam of tagged neutrinos.

Version D and the Serpukhov device could be used, for example, in the following complementary way. The Serpukhov device works N months per year with the full intensity of the proton beam of the accelerator. In this time other experiments are switched off. Then, during the other $12\nu - N$ ($\eta \approx 0.5$) months of the year the D-version operates with, say, 5% of the resources of the accelerator, the other 95% being engaged for other experiments.

The alternation of the Serpukhov tagging station could proceed with the bispectrometer tagging station instead of with the single-spectrometer one.

The short-coming of the single-spectrometer method of giving less intensive neutrino beams can be moderated by suitable change of, for example, the percentage of K^+ mesons in the $\pi + K$ mixture. This can be achieved in the following way: Let 0 , r , θ, ϕ be a spherical coordinate system in the laboratory, the origin 0 and the axis 0Z of which coincide with the origin and the axis of the $\pi + K$ beam respectively. Let K_1 and K_2 be cones, the vertices and the axes of which coincide with 0 and 0Z respectively. Let the angles at the vertices of K_1 and K_2 be θ_1 resp. θ_2. Then, measures can be taken to absorb the $\pi + K$ beam inside of K_1 and outside of K_2. So, only that part of the $\pi + K$ beam will remain, which is enclosed in the annular region defined by the cones K_1 and K_2. Changing θ_1 and θ_2, in principle it is possible to change the percentage of K^+ in the $\pi + K$-mixture.

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Станция мечения нейтрино с одним спектрометром

Предлагается станция мечения нейтрино, построенная в соответствии со следующей принципиальной схемой. Пучок из мюонов и каонов проходит через магнитный спектрометр, в котором измеряется энергия $E_{\pi,K}$ каждой частицы. За спектрометром, в нескольких плоскостях расположены координатные детекторы, в которых определяется направление $\vec{\ell}_{\pi,K}$ движения частицы. Таким образом, в область распада мезоны поступают с известным 4-импульсом $p_{\pi,K}$. За областью распада измеряется направление $\vec{\ell}_\mu$ движения μ-мезона от распада. В работе показано, что этой информации достаточно для определения вида исходной частицы /пион или каон/, энергии E_ν и направления $\vec{\ell}_\nu$ движения нейтрино.

Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ.

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Single Spectrometer Station for Neutrino-Tagging

A neutrino tagging station built with respect to the following scheme is proposed. A beam of muons and kaons is passing through a magnetic spectrometer, where the energy $E_{\pi,K}$ of each particle is measured. There are coordinate detectors after the spectrometer in several planes, where the direction of the trajectory, $\vec{\ell}$, of a given particle is determined. Thus mesons enter into the decay domain with knowing 4-momentum $p_{\pi,K}$. Behind the decay domain the direction of the μ-meson generated by the decay of parent mesons, $\vec{\ell}$, is measured. It is shown this information is sufficient for determining the kind of the parent particle (pion or kaon), the energy E_ν and the direction of trajectory, $\vec{\ell}$, of the neutrino.

The investigation has been performed at the Laboratory of Computing Techniques and Automation, JINR.

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