Probing lepton flavour violation in
\( \nu_\mu + N \to \tau + \ldots \) scattering and \( \mu \to \tau \) conversion
on nucleons.

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**Abstract**

We study lepton flavour-violating interactions which could result in the \( \tau \)-lepton production in the \( \nu_\mu N \) scattering or in \( \mu \to \tau \) conversion on nucleons at high energies. Phenomenological bounds on the strength of \( \bar{\tau} \nu_\mu \bar{q} q' \) interactions are extracted from the combined result of the NOMAD and CHORUS experiments on searching for \( \nu_\mu \to \nu_\tau \) oscillations. Some of these bounds supersede limits from rare decays.

We also propose a “missing energy” type experiment searching for \( \mu \to \tau \) conversion on nucleons. The experiment can be performed at a present accelerator or at a future neutrino factory.

**1 Introduction**

In the standard model of strong and electroweak interactions (SM) with massless neutrinos lepton flavour is conserved. However many extensions of the SM including the simplest extension with massive neutrinos predict flavour-violating interactions. For instance leptoquarks which occur naturally in all unified models such as \( SU(5) \) [1] or Pati-Salam \( SU(4) \) [2], in models with quark-lepton substructure [3] and in supersymmetric models with R-parity violation [4]. In general leptoquarks have baryon or lepton number violating couplings and they must be very heavy in order to avoid rapid proton decay or large Majorana neutrino masses. However, in theories with conserved baryon and lepton number leptoquark masses and couplings satisfy much weaker bounds which come mainly from the analysis of flavour-violating processes. Many searches for specific reactions, namely \( \mu - e \) conversion on nuclei [7], \( \mu \to e \gamma \) [5] and \( \mu \to 3e \) [6] decays, rare \( K \) [8], \( D^- - B^- \) [9] and \( \tau^- \) decays [10]

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and also search for lepton flavour violation in $e - p$ collisions [12] and neutrino interactions [13] have been performed resulting in stringent limits on the coupling strength of lepton flavour violating four-fermion $\bar{l}'qq'$ interactions.

There are also projects to improve some of these bounds significantly, see e.g. [14,15] including experiments at a neutrino factory. The neutrino factory is a future powerful tool for investigation of the nature of neutrino, in particular neutrino oscillations. It could also be useful for investigation of other physics beyond the standard model, see e.g. [18] and references therein. This facility would be an intense source of muons and might enable to improve the current upper limits on flavour-violating transitions, involving in particular $\mu$'s or $\nu_\mu$'s, by several orders of magnitude.

In this note we have suggested to probe lepton flavour violation through $\tau$-lepton production in $\nu_\mu N$ scattering or $\mu + N \rightarrow \tau + N$ conversion on nucleons at high energies. It should be stressed that experiments on search for $\mu-\tau$ conversion will probe flavour-violating interactions, in particular like $L = \bar{\mu}\tau[G_1\bar{u}c + G_2\bar{d}b + G_3\bar{s}b]$. Due to trivial kinematical constraints (e.g. $\tau \rightarrow \mu + D$ decay cannot occur, because of $m_\tau < m_\mu + m_D$), there are no stringent bounds on such interaction from the existing experimental bounds on rare $\tau$-lepton, such as $\tau \rightarrow \mu + \gamma$ [10], and charm/beauty meson decay rates [9]. For investigation of such flavour-violating interactions to perform experiments on searching for $\mu-\tau$ conversion is important.

This paper is organised as follows. In Sec.2 we extract phenomenological bounds on the strength of $\bar{\tau}\nu_\mu \bar{q}q'$ interactions from the current experimental bounds on search for $\nu_\mu - \nu_\tau$ oscillations from the NOMAD and CHORUS experiments. These bounds can compete from bounds derived from $\tau$-decays. In Sec.3 we consider a "missing energy" type experiment to search for lepton flavour violation in $\mu - \tau$ conversion on nucleons at high energies. In Sec. 4 we present our conclusions.

## 2 Phenomenological bounds

The latest combined limit of the CHORUS and NOMAD experiments on the probability of $\nu_\mu \rightarrow \nu_\tau$ oscillations is [19]:

$$ P(\nu_\mu \rightarrow \nu_\tau) < 0.6 \cdot 10^{-4} \quad (1) $$
Using the bound of Eq.(1) one can find that NOMAD data lead to the bound
\[
P(\nu_\mu \to \tau) = \frac{\sigma(\nu_\mu N \to \tau + \ldots)}{\sigma(\nu_\mu N \to \mu + \ldots)} < 0.6 \cdot 10^{-4}
\] (2)
on flavour-violating cross section of \(\nu_\mu\), neutrino with isoscalar nucleon target.

Bound of Eq.(2) allows to obtain restriction on flavour-violating interactions \(\bar{\tau} \nu_\mu \bar{q} q'\) which lead to nonzero cross section for the flavour changing reaction \(\nu_\mu N \to \tau + \ldots\). Let us consider the case of scalar leptoquarks. \(SU(3) \otimes SU(2) \otimes U(1)\) invariant Lagrangian of scalar and vector leptoquarks satisfying baryon and lepton number conservation has been written down in ref. [17]. For us the following interactions leading to flavour-violating reaction \(\nu_\mu N \to \tau + \ldots\) are interesting:

\[
L' = (g_{1L} \bar{q}_L \tau_2 l_L + g_{1R} \bar{u}_R \bar{e}_R e_R)S_1 + (h_{2L} \bar{u}_R l_L + h_{2R} \bar{q}_L \tau_2 e_R)R_2 + h.c.
\] (3)
\[-m_1^2 S_1^+ S_1 - m_2^2 R_2^+ R_2
\]

Here \(q_L, l_L\) are the left-handed quark and lepton doublets, and \(e_R, d_R, u_R\) are the right-handed charged leptons, down- and up-quarks, respectively; \(\psi^c = C\bar{\psi}^T\) is a charge-conjugated fermion field. The subscripts L, R of the coupling constants denote the lepton chirality. The indices of the LQ’s give the dimension of their \(SU(2)\) representation. Colour, weak isospin and generation(flavour) indices have been suppressed. After integration over heavy leptoquark fields one can obtain effective flavour-violating four-fermion interactions

\[
L_{4\Delta F} = \frac{g_{1L}^2}{m_1^2}(\bar{q}^c_l \tau_2 l_L^c)(\bar{q}^c_L i\tau_2 l_L) + \frac{g_{1L} g_{1R}}{m_1^2}(\bar{q}^c_L i\tau_2 l_L e_R^c) + \frac{g_{1L} g_{1R}}{m_1^2}(\bar{q}^c_L i\tau_2 l_L e_R^c) + \frac{h_{2L}}{m_2^2}(\bar{u}_R l_L \bar{e}_R i\tau_2 q_L) + \ldots
\] (4)

Especially interesting are couplings with the first and second quark generations:

\[
L_{4\Delta F}' = \frac{g_{1L} g_{1L} g_{1L}}{m_1^2}(\bar{s}^c_L \nu_\mu_L - \bar{c}^c_L \mu_L)(\bar{\nu}_\tau d^c_L - \bar{\nu}_\tau d^c_L - \bar{\nu}_\tau d^c_L - \\
\tau_L u^c_L) + \frac{g_{1L} g_{1L} g_{1R}}{m_1^2}(\bar{s}^c_L \nu_\mu_L \bar{\tau}^c_R c^c_R - \bar{c}^c_L \mu_L \bar{\tau}^c_R c^c_R) + \\
\frac{g_{1L} g_{1L} g_{1R}}{m_1^2}(\bar{c}^c_L \nu_\mu_L \bar{\tau}^c_R c^c_R - \bar{c}^c_L \mu_L \bar{\tau}^c_R c^c_R) + \frac{h_{2L}}{m_2^2}(\bar{\tau}_L d_L \bar{c}_R \nu_\mu_L - \bar{\tau}_R \mu L \bar{\tau} R u_L) + \\
+ \frac{h_{2L}}{m_2^2}(\bar{\tau}_R d_L \bar{c}_R \nu_\mu_L - \bar{\tau}_R \mu L \bar{\tau} R u_L) + h.c.
\] (5)

For the couplings of Eq.(5) bounds resulting from flavour-violating \(\tau\)-lepton
decays bounds are absent. So, the CHORUS and NOMAD data are in fact the single ones that allow to extract the most stringent bounds on couplings of four-fermion interactions of Eq.(5). In quark-parton model the cross section of the inclusive $\nu_\mu N \to \mu + \ldots$ scattering on the isoscalar nucleon is determined by the formula\(^2\)

$$\sigma(\nu_\mu N \to \mu + \ldots) \equiv \frac{1}{2}(\sigma(\nu_\mu p \to \mu + \ldots) + \sigma(\nu_\mu n \to \mu + \ldots)) = \frac{G^2 s}{2\pi} ((Q + S) + \frac{1}{3}(\bar{Q} - \bar{S})) \approx \frac{G^2 s}{\pi} \cdot 0.22$$

where [16]

$$Q = U + D + S \equiv \int_0^1 [u(x) + d(x) + s(x)] dx \equiv \int_0^1 q(x) dx \approx 0.44 \quad (7)$$

and $G$ is the Fermi constant.

$$\bar{Q} = \bar{U} + \bar{D} + \bar{S} \equiv \int_0^1 [\bar{u}(x) + \bar{d}(x) + \bar{s}(x)] dx =$$

$$\int_0^1 \bar{q}(x) dx \approx 0.07$$

$$\bar{U} \approx \bar{D} \approx 0.03 \quad (9)$$

$$S \approx \bar{S} \approx 0.01 \quad (10)$$

$$U \approx 0.28 \quad (11)$$

$$D \approx 0.15 \quad (12)$$

Using the four-fermion flavour-violating interaction of Eq.(5) and quark-parton model one can find that

$$\sigma(\nu_\mu N \to \tau + \ldots) = \frac{s}{96\pi} \left[ g_{1L} g_{1L,2} \frac{m_1^2}{m_1^2} \left(3S + \frac{1}{2}(\bar{D} + \bar{U})\right) + g_{1L,2} g_{1R,2} \frac{m_1^2}{2} (3S) + g_{1L} g_{1R,2} \frac{m_1^2}{2} (U + D) + \frac{h_{2L,2} h_{2R,1}}{m_2^2} \left(\frac{3}{2}(U + D)\right) + \frac{h_{2L,1} h_{2R,2}}{m_2^2} (\bar{S} + \frac{3}{2}(\bar{U} + \bar{D})) \right]$$

\(^2\) Here we use notations of ref. [16]
From formulae of Eqs.(6-13) we find bounds

\[ \frac{g_{1L,2}g_{1L,2}}{m_1^2} < 0.4 \cdot G \quad (14) \]

\[ \frac{g_{1L,2}g_{1R,2}}{m_1^2} < 0.16 \cdot G \quad (15) \]

\[ \frac{g_{1L,2}g_{1R,1}}{m_1^2} < 0.08 \cdot G \quad (16) \]

\[ \frac{h_{2L,2}h_{2R,1}}{m_2^2} < 0.03 \cdot G \quad (17) \]

\[ \frac{h_{2L,1}h_{2R,2}}{m_2^2} < 0.16 \cdot G \quad (18) \]

Note that in supersymmetric models with R-parity violation [16] one of the possible R-violating terms in the superpotential has the form

\[ W' = g_{1L}L_i\tau_2q_Ld_R^c \quad (19) \]

After integration over right-handed down squarks we find in particular the effective interaction

\[ L'_\Delta F = \frac{g_{1L,12}g_{1L,23}}{m_{sq}^2}(-\bar{u}_L\mu_L + \bar{d}_L\nu_{\mu,L}) \cdot (\bar{c}_L\tau_L + \bar{s}_L\nu_\tau)^+ + ... \quad (20) \]

which in fact coincides with the first term of the interaction (5). Here \( m_{sq} \) is the mass of right-handed down-squark. So using the previous results we find that

\[ \frac{g_{1L,23}g_{1L,12}}{m_1^2} < 0.08 \cdot G \quad (21) \]

For \( g_{1L,23}g_{1L,12} = 1 \) we find that \( m_{sq} \gtrsim 1000 \text{ GeV} \).

One can extract bounds on effective coupling constants of the general four-fermion interaction describing the transition \( \nu_\mu N \rightarrow \tau + ... \)

\[ \text{Here we consider only interactions of the first and second quark generations with } \nu_\mu \text{ and } \tau \]

\[ \text{[3]} \]
In quark-parton model for the interaction of Eq. (22) the $\nu_\mu \to \tau$ inclusive cross section is determined by the formula

$$L_4 = \frac{4}{2^{1/2}} \left[ G_{1,11} \bar{u}_R \nu_\mu \bar{\tau}_R d_L + G_{1,12} \bar{u}_R \nu_\mu \bar{\tau}_R s_L + G_{1,21} \bar{c}_R \nu_\mu \bar{\tau}_R d_L + G_{1,22} \bar{c}_R \nu_\mu \bar{\tau}_R s_L \right]$$

$$G_{2,22} \bar{c}_L \nu_\mu \bar{\tau}_L c^e_L + G_{2,21} \bar{s}_L \nu_\mu \bar{\tau}_L u^e_L + G_{2,12} \bar{d}_L \nu_\mu \bar{\tau}_L u^e_L + G_{2,11} \bar{d}_L \nu_\mu \bar{\tau}_L u^e_L + G_{3,11} \bar{d}_L \nu_\mu \bar{\tau}_R u^e_L + G_{3,12} \bar{d}_L \nu_\mu \bar{\tau}_R c^e_L + G_{3,21} \bar{s}_L \nu_\mu \bar{\tau}_R u^e_L + G_{3,22} \bar{s}_L \nu_\mu \bar{\tau}_R c^e_L + h.c.]$$

Using NOMAD bound of Eq. (3) and Eq. (6) for inclusive $\nu_\mu \to \mu$ cross section we find bounds on parameters of flavour-violating four-fermion interaction of Eq. (24)

$$(G_{1,11}, G_{2,11}, G_{3,11}) < 3.3 \cdot 0.8 \cdot 10^{-2} G$$  \hspace{1cm} (24)

$$(G_{1,12}) < 5.5 \cdot 10^{-2} G$$  \hspace{1cm} (26)

$$(G_{1,22}) < 13.0 \cdot 10^{-2} G$$  \hspace{1cm} (27)

$$(G_{2,12}, G_{3,12}) < 2.6 \cdot 10^{-2} G$$  \hspace{1cm} (28)

$$(G_{2,12}, G_{3,12}) < 7.5 \cdot 10^{-2} G$$  \hspace{1cm} (29)

$$(G_{2,22}, G_{3,22}) < 7.5 \cdot 10^{-2} G$$  \hspace{1cm} (30)

It should be noted that in the search for $\mu$-$\tau$ conversion we probe in particular four-fermion flavour changing interactions. As it has been mentioned in the introduction bounds on the flavour changing interactions

$$\Delta L = \bar{\mu} \tau [G_1 \bar{u} c + G_2 \bar{b} d + G_3 \bar{s} b]$$  \hspace{1cm} (31)

are not very stringent due to trivial kinematical reasons. For instance $\tau$ lepton cannot decay to D-meson and muon, since $m_\tau < m_\mu + m_D$). So, bounds from
τ lepton decays do not lead to bounds on $G_i$. Due to the same reason bounds from rare D- and B-mesons are also not very stringent. The study of $\mu$-$\tau$ conversion will allow to obtain stringent bounds on coupling constants $G_i$.

3 Experimental search for the $\mu \rightarrow \tau$ conversion.

Here we describe the search for flavour-violating interactions of the $\mu \bar{\tau} q q'$ type by using the muon to tau-lepton conversion on nucleons at high energies. Note that the four-fermion interaction $\mu \bar{\tau} c u$ does not contribute to $\tau$-decay, since $D$-meson mass is bigger than $\tau$-lepton mass, so for such interaction the flavour-violating bounds resulting from $\tau$-decay modes are not applicable, hence the search for $\mu - \tau$ conversion is in fact the single way to probe such interactions.

As an example, we simulated the experiment on searching for $\mu \rightarrow \tau$ conversion performed with the NOMAD detector [20] at a high purity sign-selected 20 GeV muon beam. The experiment is based on searching for single muon events from the primary muon interactions with a target (see Figure 1) with considerable energy losses which are not detected. The simulation were partly based on the Monte Carlo program used at NOMAD for the standard neutrino interactions [21].

The NOMAD detector, see Figure 1, consists of a number of sub-detectors most of which are located inside a 0.4 T dipole magnet: drift chambers (DC) with an average density of 0.1 g/cm$^3$ and a total thickness of about one radiation length ($\sim 1.0X_0$) followed by a transition radiation detector and a preshower detector not shown in Figure 1, and a lead-glass electromagnetic calorimeter (ECAL). A hadron calorimeter (HCAL) and muon stations are located just after the magnet coils. For simplicity, we have assumed that the primary muon interactions occur in a fully active dense target which is a block of lead glass, so that the energy losses in the target are measured.

The sensitivity to $\mu \rightarrow \tau$ conversion and background level were studied for events with a simple topology of the final state. Namely, we consider quasi-elastic (QE) $\mu \rightarrow \tau$ conversion $\mu + N \rightarrow \tau + N$ at a single nucleon $N$ with the subsequent $\tau$ decay in the target. For deep inelastic events the level of background was found to be considerably higher.

Consider the $\tau \rightarrow \mu \nu \nu$ decay of $\tau$’s produced in the $\mu \rightarrow \tau$ conversion. Since $\tau$-leptons are very short lived particles - even at energy of $\simeq 100$ GeV the average decay length of $\tau$ lepton is of the order of a millimetre - practically they are not detectable. The experimental signature of their presence in the beam would be a signal of fractional ”disappearance” of primary muon beam energy in the
Fig. 1. Schematic illustration of the "missing energy" type experiment on production of $\tau$ via $\mu \rightarrow \tau$ conversion in the active target and its detection via $\tau \rightarrow \mu\nu\nu$ decay. The experimental signature of the $\mu \rightarrow \tau$ conversion is a single muon in the final state with a catastrophic energy loss in the target. The muon momentum is measured by the drift chamber (DC) spectrometer. The muon is accompanied by no significant activity in the electromagnetic calorimeter (ECAL) and hadronic calorimeter (HCAL).

detector[4] Indeed, two neutrinos from the $\tau \rightarrow \mu\nu\nu$ decay would penetrate any type of calorimeter without significant attenuation and cannot be observed effectively in the detector via its interactions. Hence, the only visible energy is the energy associated with the decay muons. The experimental signature for the $\mu \rightarrow \tau$ conversion in the detector is a single muon of the same sign and with energy less than that from the primary muon beam, Figure 1.

The energy distribution of muons from $\tau \rightarrow \mu\nu\nu$ decays of $\tau$'s produced in the $\mu \rightarrow \tau$ conversion is shown in Figure 2. The total efficiency of single muon detection is about 11% and dominated by the branching ration of tau to muon decay mode of 17 % and by the muon momentum cuts.

There are several potential sources of the background for the experiment considered:

- low energy tail in the muon beam energy distribution, e.g. due presence of pions in the beam and their decays in flight;
- catastrophic muon energy loss in the target with poorly detected products of the reaction, e.g. deep inelastic muon scattering accompanied by neutrons

4 Another possible way of $\tau$ identification is based on the algorithms developed by NOMAD for searches for $\tau$’s produced through $\nu_\mu \rightarrow \nu_\tau$ oscillations [21].
Fig. 2. *Simulated muon energy distribution from* $\tau \to \mu \nu \nu$ *decay of* $\tau$ *'s produced in* $\mu \to \tau$ *conversion at energy* $E_\mu = 20$ *GeV.*

- or nuclei break-up;
- the detector is not hermetic in the forward direction;
- muon misidentification.

The largest contribution to the background is expected from muon inelastic photonuclear interactions in the target yielding a muon and neutral penetrating particles in the final state (e.g. neutrons, $K^0_L$, ..) which are not detected, e.g due to the fact that the detector is not fully hermetic, thus making hermiticity to be the crucial parameter. The effect of leakages depends on beam energy. According to the simulation, the probability for secondaries to be mismeasured decreases with the muon energy increasing. Additional way to improve the sensitivity is to use active target with a low threshold and detectors with rather good energy resolution capability. At higher energies when the $\tau$-decay length $L_\tau \gtrsim 1$ mm, the active target could be an instrumented target, e.g. silicon micro-strip detector, to measure a non zero impact parameter of the secondary tracks from $\tau$ decays with respect to the main vertex [23]. This technique being combined with the “missing energy” measurements will dramatically improve the sensitivity of the $\mu \to \tau$ conversion search. Note that the target could be the existing STAR detector (instrumented Silicon Target) which was built and installed in the NOMAD detector [24].

The distribution of the reconstructed energy for muon-nucleon inelastic reactions is shown in Figure 3. The muon produced in the $\mu \to \tau \to \mu \nu \nu$ chain is defined as a single track accompanied by no activity in others subdetectors by using the following selection criteria:
Fig. 3. Distribution of total reconstructed energy in the detector muon-nucleon inelastic interactions.

- energy deposition in the target is consistent with the one deposited by a going through muon;
- single DC track with momentum $3 < P < 10$ GeV/c matched to the single track in the MUON stations;
- no $\gamma$'s in the ECAL with energy $E_\gamma > 0.4$ GeV;
- no HCAL activity: total HCAL energy $< 1.4$ GeV. This cut serves as an HCAL veto;

The probability $P(\mu \to \tau)$ for $\mu \to \tau$ conversion and the number $N(\mu \to \tau \to \mu\nu\nu)$ of signal events in the detector are related by

$$P(\mu \to \tau) = \frac{\sigma(\mu N \to \tau N)}{\sigma_{in}(\mu N \to \mu...)}$$

(32)

and

$$N(\mu \to \tau \to \mu\nu\nu) = N_\mu \cdot \sigma(\mu N \to \tau N) \cdot BR(\tau \to \mu\nu\nu) \cdot \epsilon \cdot \rho \cdot L \cdot N_A$$

(33)

where $N_\mu$ is the total number of muons, $\sigma_{in}(\mu N \to \mu...)$ $\approx 3\mu b$ for the energy range discussed [22] and $\sigma(\mu N \to \tau N)$ are the muon-nucleon inelastic cross section and cross section of $\mu \to \tau$ conversion per nucleon, respectively\textsuperscript{5}. $BR(\tau \to \mu\nu\nu)$ is the branching ratio for $\tau \to \mu\nu\nu$ decay mode, $\epsilon$ is overall

\textsuperscript{5} For simplicity we neglect the difference between cross sections on proton and neutron, shadow effect, etc..
Fig. 4. Simulation: 90% CL limit on probability of the $\mu \rightarrow \tau$ conversion in the target calculated as a function of total number of muons passing through the target. Solid line is a polynomial fit to the Monte Carlo points, dashed line is its extrapolation to the region of higher number of muons.

detection efficiency, $\rho$, $L$ are target related factors and $N_A$ is the Avogadro number.

Figure 4 shows estimated the 90% CL upper limit for the probability of $\mu \rightarrow \tau$ conversion calculated based on the expected number of background events as a function of the total number of muons passing through the target. The study of the background in the region of high sensitivity ($P(\mu \rightarrow \tau) \lesssim 10^{-6}$) requires simulation of a very large sample of events resulting in a prohibitively large amount of computer time. The maximum number of simulated events in our sample was about $10^6$ events. Assumption that the extrapolation shown in Figure 4 is valid down to $P(\mu \rightarrow \tau) \simeq 10^{-9}$ is probably too optimistic, however seems has some promise. More detail study of the simulated background shape is needed with significantly increased Monte Carlo statistics. In addition, the question how reliable are Monte Carlo predictions in the region of $P(\mu \rightarrow \tau) \lesssim 10^{-9}$ has also to be studied.

We note that direct experimental searches for a signal from the $\mu \rightarrow \tau$ conversion can be performed, for example, in the framework of the COMPASS experiment at CERN [25]. For muon beam energy region $E_\mu > 30$ GeV used in COMPASS the advantage is that the muon-nucleon inelastic cross section increases and the sensitivity to the $\mu \rightarrow \tau$ conversion rate might be expected to be of the order of magnitude high than shown in Figure 4. The search for
flavour changing reaction $\mu N \rightarrow \tau + \ldots$ will allow to test flavour changing interactions at the level $10^{-2}G$ in terms of the corresponding Fermi coupling.

4 Conclusion

In this note, we derive phenomenological bounds on the strength of $\bar{\tau} \nu_\mu \bar{q} q'$ four fermion flavour changing interactions. Such interactions can arise in models with leptoquarks, R-parity violating supersymmetry and additional flavour changing Higgs boson interactions.

The bounds are extracted from the combined result of NOMAD and CHORUS experiments on search for $\nu_\mu \rightarrow \nu_\tau$ oscillations, which constrains the rate of the $\tau$-lepton production in $\nu_\mu N$ scattering. Some of these bounds supersede limits from rare decays.

We also propose to probe flavour changing interactions by searching $\mu \rightarrow \tau$ conversion on nucleons in a “missing energy” type experiment. This experiment could be performed at present accelerator, e.g. at high energy at CERN in the framework of the COMPASS experiment [25] or at the future neutrino factory. The instrumented target could be the STAR detector which has been installed and successfully tested in the NOMAD detector [24]. The estimate shows that one might expect a sensitivity to the probability of $\mu \rightarrow \tau$ conversion on nucleons to be of the order of $10^{-9}$ or even better.

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