Search for Flavor Changing Neutral Currents (FCNC) at LHC with tagged neutrino beam directed into Lake Geneva

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Abstract
The possibility is studied that high energy neutrinos originating from K_{long} decays produced in 7 TeV proton-nucleus interactions could be tagged by Silicon detector equipped with extremely fast electronics. The neutrino beam would be directed along the Lake Geneva which could serve as a multi-kiloton Cherenkov detector. The aim would be the study neutrino-electron scattering with identified electronic and muonic neutrinos with known energy. One could distinguish with high precision the single particle final states containing electron or muon. Due to the exact timing the cosmic ray background is expected to be negligible. The nonzero muon/electron ratio would indicate directly the existence and the size of FCNC.

1 Introduction

Nowadays neutrino physicists are interested practically only in the neutrino oscillations at relatively low energy, which are promising a breakthrough if one can observe non-zero ϑ_{13} in the medium-term future. But there are other interesting theoretical possibilities where one can search with neutrinos for effects beyond the Standard Model. Here we should like to turn the attention toward the problem of Flavor Changing Neutral Currents (FCNC). In theoretical physics, FCNCs are expressions that change the flavor of a fermion current without altering its electric charge. If they occur in the Lagrangian, they may induce processes that have not been observed in experiment. Flavor changing neutral currents may occur in the Standard Model beyond the tree level, but they are highly suppressed (the GIM mechanism). Measurement of elastic neutrino-electron scattering is proposed identifying the flavor (electronic/muonic) of the outgoing charged lepton using LHC in the fixed target regime.

2 History

The concept of neutrino tagging is not a new idea B. Pontecorvo [1] already wrote in 1979:

"The possibility of using tagged–neutrino beams in high-energy experiments must have occurred to many people. In tagged-neutrino experiments it should be required that the observed event due to the interaction of the neutrino in the neutrino detector would properly coincide in time with the act of neutrino creation ($p \to \mu\nu$, $K \to \mu\nu$, $K \to e\nu\pi$, …). Of course, in tagged-neutrino experiments the properties of neutrino beams (types, direction and energy) will be much better known than in the experiments performed so far….In spite of the difficulties it seems that sooner or later such facilities will be available at various high-energy accelerators. Naturally such a "maximum" programme would provide extremely useful facility."

According to our knowledge the first concrete conceptual design is appeared in Russian in ref. [2] which is reproduced with added English text in Fig.1.

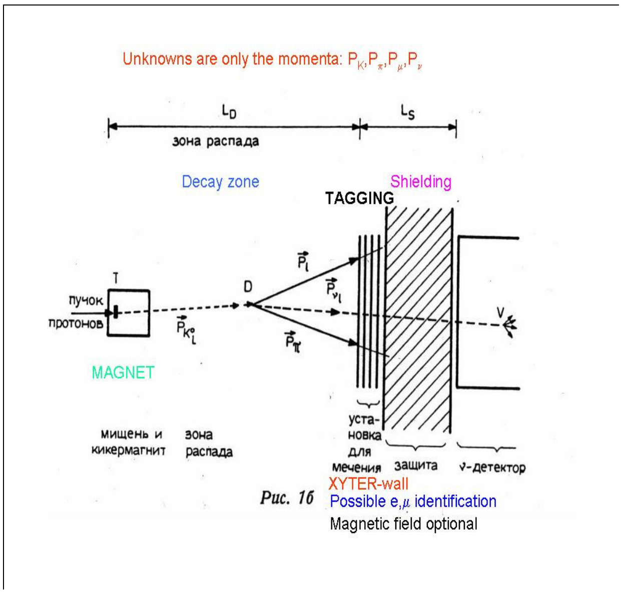


Fig. 1 First "tagging design" in 1981

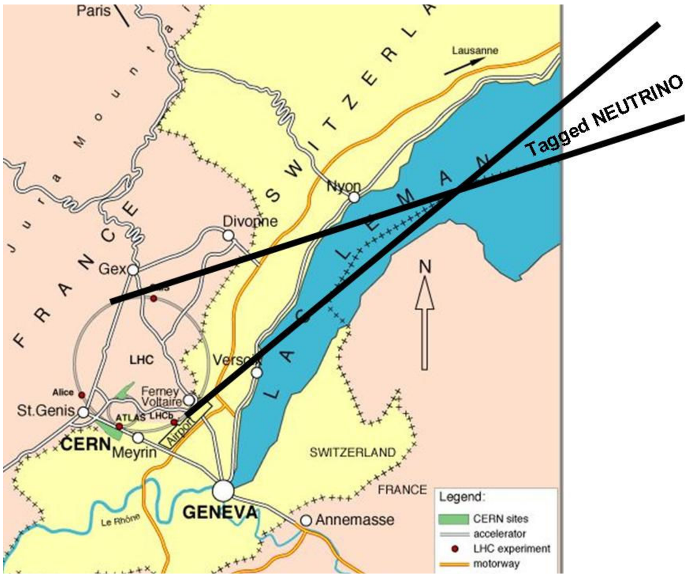


Fig. 2 Possible beam directions in Lake Geneva

The tagging neutrino idea emerged also in the SSC design phase. L. Nodulman proposed in the Snowmass PDF meeting [3] in 1982:

"A neutral channel at a 2O-TeV fixed-target proton accelerator could be used to provide a tagged neutrino bean using K. decays. Muon and electron neutrinos and antineutrinos are identified and energy tagged up to above 2 TeV, allowing excellent systematics and good statistics in studying their interactions. "

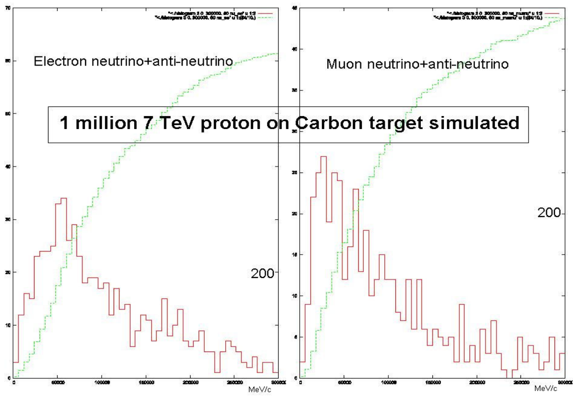
Real attempt was made in the frame of Serpukhov-152 experiment to perform neutrino tagging [4], but no physics results were published so far.

3 LHC site

In case of LHC one can take up the SSC line with a special advantage, that instead of a few ten meters detector one can use large parts of Lake Geneva as target material and detector up to the length of about 50 km. Possible beam lines are indicated in Fig. 2. The advantage and disadvantage of the neutral K_{0L} parent beam, that one doesn't need horn-focusing magnets. There can be different versions for the tagging device in the decay tunnel depending on the length. In case of long decay length one can use distributed tagging system with smaller lateral dimensions which could be more cost effective if one counts the number of tagged neutrinos per Euros. For simplicity, 1 km decay length was used in the simulation shown in Fig. 3. It is remarkable that one can see reasonable number of tagged neutrinos up to 300 GeV, the average neutrino energy is around 100 GeV.

4 Rate estimates

According to this simulation, including all neutrino types, one can get more than one tagged neutrino per 1000 incoming 7 TeV protons. If one uses the electronics proposed for FAIR-CBM detector [5], then one can achieve 10^9 tagging/sec rate. The key element of this electronics is the XYTER readout chip which produces for each hit analog and timing information with 1 nanosec accuracy providing a triggerless data-driven DAQ system.



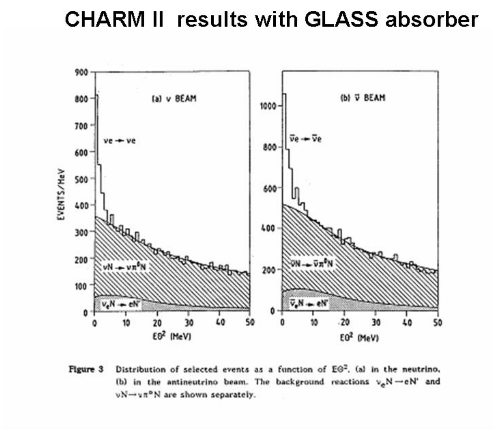


Fig. 3 Simulated ν spectra at LHC

Fig,4 Measured ν-e scattering at SPS ref. [6]

At this preliminary stage it is hard to present precise numbers about the number of ν-e elastic scattering events, but one can be sure that it should be many thousand times higher than in the CHARM-II experiment.

5 Summary

It is demonstrated that using Lake Geneva as target for high energy neutrinos originating from K_{0L} decays produced in 7 TeV proton-nucleus interactions one can measure large number of tagged ν-e interactions. Though one can reach considerable improvements compared to previous experiments, it remains open whether this will be enough to discover FCNC. More experimental and theoretical work is required. One should remark, however, that the tagging facility itself could be a gold-mine for the study of rare neutral kaon decays.

Acknowledgement

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References

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