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MEMORANDUM

A/To: SPSC

De/From: The I217 Collaboration

Concerne/Subject: I217 Update

In this document we summarise briefly the recent developments relevant to our stated interest [1] to perform a Jura Oscillation Experiment (JOE).

1) We have re-examined the physics case for JOE in the light of the recent results which no longer allow the atmospheric and LSND results to be explained in terms of oscillations with the same $\Delta \mathrm{m}^2$. A full description of this work is available in ref.[2]. The main points are:

i) three flavour neutrino oscillation phenomenology is quite adequate to describe all observed phenomena

ii) the $\Delta \mathrm{m}^2$ associated with the LSND result can only lie in the range $0.3 < \Delta \mathrm{m}^2 < 3.0 eV^2$

iii) the amplitude for $\nu_\mu \rightarrow \nu_\tau$ transitions $A_{\mu\tau}$ is larger than that for $\nu_\mu \rightarrow \nu_e$ transitions $A_{e\mu}$. In the $\Delta \mathrm{m}^2$ range above, the scale factor is given approximately by $4/A_{ex}$, $A_{ex} = A_{e\mu} + A_{e\tau}$. A_{ex} is limited by reactor results to $A_{ex} < 0.04$. Thus the $A_{e\mu}$ observed in the LSND experiment translates into $A_{\mu\tau} = 100 \times A_{e\mu}$. This result is shown in fig. 1.

2) Studies of the possibilities to measure directly $\nu_\mu \rightarrow \nu_e$ transitions with an apparatus capable of simultaneous muon and electron identification (such as for instance Noe [3]) are underway. However, the magnitude and the reliability of the expected $A_{\mu\tau}$ indicate that the LSND result could be profitably examined in a ν_μ disappearance experiment. We envisage to carry out the first round of data taking in the existing beam at WANF. The advantages of such an approach are the following:

i) disappearance experiments are known to be dominated by beam systematics and the WANF beam is very well understood

ii) for the appropriate range of L/E, the choice of the high energy option allows an effective discrimination between NC and CC events

iii) the L/E range in which a measurement of Δm^2 is possible is considerably narrower than the one in which oscillation can be observed (see for instance ref.[4] fig. 7). Thus, if a positive effect is established in the first round of measurements, more experimentation at lower energy to measure Δm^2 may become mandatory. Through the implementation at WANF of the NGS low energy beam optics, the energy can be lowered by as much as a factor of four, thus allowing a measurement of Δm^2 down to the lowest value in the allowed range above

iv) in a third round of experimentation a τ appearance experiment at an appropriately chosen energy becomes possible

v) the whole proposed program is not in competition with any other existing or planned activity in the world.

3) We are considering several options for the experimental apparatus, but no final decision has been made yet. To assess what kind of set-up would be needed and what kind of results could be reached by JOE we have used the results of the MINOS proposal [4].

The MINOS experiment, which consists of a near and a far detector, will work in an energy range very close to that of JOE so that the event topologies in two experiments will be very similar. Assuming for JOE a detector with the same performances of MINOS, the 90% C.L. limits for JOE can be determined by an appropriate scaling of those expected for MINOS (see ref.[4], fig. 7) as follows:

i) to ensure the collection of the same number of events in beams with different fluxes F, the MINOS exposure (20 kt-yr) is scaled by the factor ($F \times E/L^2$ of MINOS)/($F \times E/L^2$ of JOE). The results for the different beams considered [5] are:

	Beam	E (GeV)	Exposure ($ton \times 10^{19} pot$)
a)	WANF	24.7	71
b)	NGS 'reference'	21.5	37
c)	NuMI @CERN	15.5	51
d)	NGS le1	10	152
e)	NGS le2	6.4	358

ii) to account for the different most probable event energy E and distance L, the JOE Δm^2 scale is obtained by renormalizing that of MINOS by the factor (L/E of MINOS)/(L/E of JOE)

These results are shown in Fig. 1. For very large Δm^2 the curves are clearly incorrect as they actually re-intercept the vertical axis at a point which depends on the position of the near detector (l). For example for the Nomad position ($l = 0.625 Km$) curve c) crosses the $A_{\mu\tau} = 1$ axis for $\Delta m^2 = 20 eV^2$. A near detector in the present Nomad position would clearly correspond to the widest Δm^2 coverage, but other locations (such as e.g. the old Gargamelle building) are also quite acceptable.

The results of figure 1 clearly show that the program outlined above can be achieved through a gradual build-up of the detector mass. Even in the most unfavourable case, a JOE of 100 ton target mass (1% of MINOS !) can obtain the results shown in Fig. 1 in about one year of running.

References

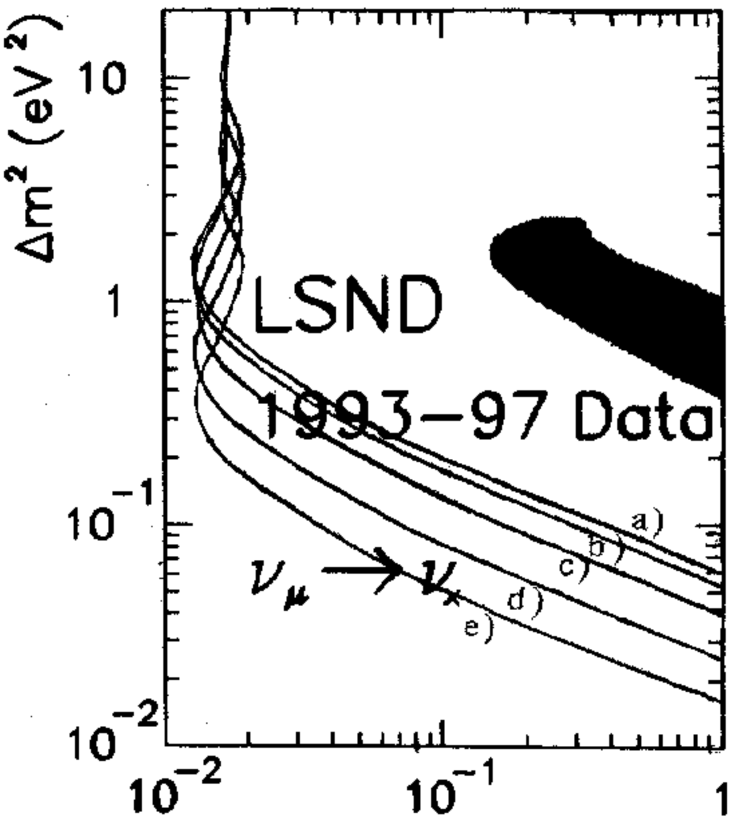
[1] D. Autiero et al, CERN-SPSC/97-23

[2] G. Conforto et al, hep-ph/9809501, Phys. Lett., to be published

[3] CERN-SPSC/98-32

[4] NuMI-L-375 and references therein

[5] CERN-SPSC/98-35



$$(A_{\mu\tau})_1 = 4 \sin^2\theta_{23} \cos^2\theta_{23} \cos^4\theta_{13} \cong$$

$$\cong 4 (A_{e\mu})_1/(A_{ex})_1$$

Figure 1: Estimated exclusion plots for JOE. The dark area on the r.h.s. is the translation into the $\nu_\mu \rightarrow \nu_x$ channel of the 99% C.L. LSND result. The a) to e) curves are the 90% C.L. limits calculated assuming a detector with the same performances of MINOS for different beams and exposures as follows: **a) existing WANF beam -** $71 ton \times 10^{19} pot$, **b) NGS 'reference' beam -** $37 ton \times 10^{19} pot$, **c) NuMI beam -** $51 ton \times 10^{19} (CERN) pot$, **d) NGS le1 beam -** $152 ton \times 10^{19} pot$, **e) NGS le2 beam -** $358 ton \times 10^{19} pot$