LETTER of INTENT

DOUBLE-LAr: Liquid Argon Imaging Chambers at FNAL

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Abstract.

In this Letter of Intent an experiment searching for sterile neutrinos in the LSND region at the FNAL Booster neutrino beam facility is proposed. The experiment exploits two LAr-TPC detectors, the first of about 150 tons at 100 m from the proton target, the second one of about 600 tons placed at 540 m. Both detectors have identical structure and closely resemble the ICARUS T600 detector, which is presently under installation in the LNGS underground Laboratory of INFN.

This project will benefit of the already developed and well tested technology of ICARUS T600, without the need of any major R&D activity. The superior quality of the LAr imaging TPC and its unique $e\text{–}\pi^0$ discrimination allows full rejection of the NC background, without efficiency loss for electron neutrino detection. In addition, the simultaneous use of a near and a far detector will allow to perform an almost Montecarlo independent experiment, while minimizing the systematic uncertainty associated to the neutrino beam and interaction cross-sections.

Both features will permit to investigate with improved sensitivity the $\nu_\mu \rightarrow \nu_e$ oscillations in the LSND region.

(May 7, 2008)

1 Introduction.

The development of the Liquid Argon Imaging TPC [1] has been actively pursued by the ICARUS Collaboration during the last two decades. The technology has reached its fully mature level and a first underground experiment with some 600 tons of sensitive mass, the ICARUS T600 [2] detector —comprehensively tested on surface in Pavia during 2001 — is now in its final phase of installation underground at the LNGS. First of its kind, it will become fully operational during 2008 and initiate in Hall B the first full scale underground physics experiment based on LAr-Imaging technology (CNGS-2).

A continuously sensitive, bubble chamber like detector of such a magnitude (see Figure 1) will not only provide an operational, "on the floor" demonstration of the LAr TPC technique but also produce an important amount of new physics results both with cosmic rays and the CNGS neutrino beam. It will also realistically open the way to future more massive detectors for accelerator and without accelerator driven phenomena [3]. The accelerator neutrino rate in T600 is of about 1200 ev/year for an integrated beam intensity of 4.5 x 10^{19} POT, with the 400 GeV neutrino beam from the CERN-SPS as "proton provider".

Amongst the main aims of the scheduled 5 years CNGS physics programme are the (1) direct observation of the $\nu_\mu \rightarrow \nu_\tau$ conversion in the electron channel and (2) a search for sterile neutrinos from a sizable excess of ν_e CC events, possibly modulated by the oscillation frequency L/E in order to probe the existence of LNSD-like effects [4].

The present LOI describes another very important physics domain in which the LAr Imaging should be extended with a detector of the approximate size of the T600, associated with availability of a low energy neutrino beam (with L/E ~ 1 Km/GeV) from the very intense FNAL Booster presently exploited by the MiniBoone Collaboration. At a distance of about 540 m from the FNAL target and for 2 x 10^{20} POT/year, a detector of the dimensions of the T600 will accumulate more than 200'000 unbiased, "bubble chamber like" neutrino events each year. A LAr TPC may accumulate such a very large statistics with the very high spatial and energy resolutions of the LAr and the clear identification of all NC and CC channels. These results will be complementary to the one from ICARUS T600, exposed at CNGS, which will detect $\nu_\mu \rightarrow \nu_e$ oscillations at much larger L/E but with smaller statistics and therefore larger $\sin^2(2\theta_{e\mu})$, with an enhanced sensitivity toward low Δm^2 values.

The most relevant physics issues in this configuration relate to the possible existence of sterile neutrinos. The LSND experiment at LANSCE in Los Alamos [5] took data from 1993–1998 and observed an excess of (87.9 ± 22.4 ± 6.0) events in the $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance channel, corresponding to a transition probability (P = 0.264 ± 0.067 ± 0.045 %), ~ 3.3 σ away from zero. To explain this signal with neutrino oscillations requires a mass-squared difference $\Delta m^2 \approx 1$ eV^2. Such a value is inconsistent with the mass-squared differences required by the standard atmospheric and long-baseline experiments. Moreover, the KARMEN experiment [6] at the neutron spallation source, ISIS, at the Rutherford Appleton Laboratory studied the same appearance channel ($\bar{\nu}_\mu \rightarrow \bar{\nu}_e$) between 1997 and 2001 at a slightly different baseline than LSND, but did not observe a positive signal.

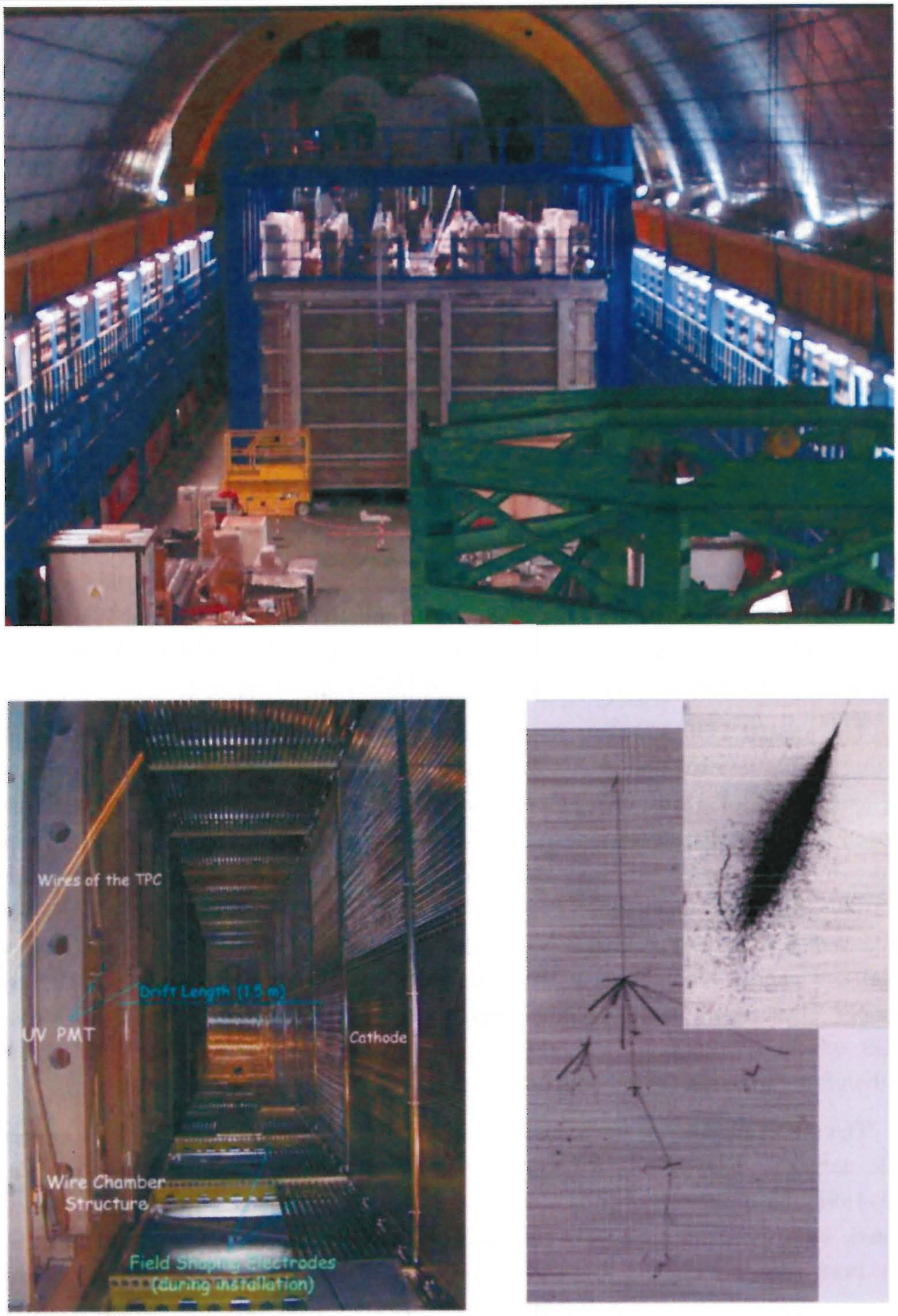

Figure 1. Top: ICARUS T600 installed in Hall B at LNGS. Bottom-Left: view of the one of the drift region of the T600 LAr-TPC. Bottom-Right: cosmic ray events recorded with the T600 in Pavia.

The MiniBooNE experiment at Fermilab has been designed to test the indication for oscillations reported by LSND. In April 2007 the MiniBooNE group announced the first oscillation analysis [7]. The results disfavour at 90% level the simplest sterile-neutrino schemes. However, a scheme, with two sterile neutrinos can accommodate different oscillation patterns for the ν and $\bar{\nu}$ and the scheme is not dead since the Miniboone is yet to present $\bar{\nu}$ data. Until Miniboone announces a negative result for $\bar{\nu}$, therefore, such a scenario is still acceptable. Furthermore, even if Miniboone announces a negative result for $\bar{\nu}$ in the future there still remains a possibility for sterile-neutrino scenarios in which the mixing angles are small enough to satisfy the Miniboone constraint, and the effect of these scenarios could be revealed as a violation of three-flavour unitarity in future neutrino experiments. Such scenarios are as probable as all other possibilities since there is no evidence as yet for any of them. So, from this point of view, it is useful to consider scenarios that seek to reconcile the evidence for $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance from LSND with other evidences for neutrino oscillations. Data taking is indeed vigorously continuing with MiniBooNE at FNAL, extended also to the anti-neutrino channel in which LSND was originally observed.

According to the present LOI, the high spatial resolution and the unique electron-π^0 discrimination achievable with the use of LAr will allow to further study $\nu_\mu \rightarrow \nu_e$ oscillations in the region of the LSND anomaly, looking for the presence of possible sterile neutrino with improved sensitivity with respect to MiniBooNE.

MiniBooNE has also observed a significant discrepancy between data and Montecarlo predictions at small energies, also under investigation. In order to remove the dependence from the model-dependent effects the LOI will be based on the simultaneous use of <u>two</u> different detectors, at the "far" and the "near" locations, respectively at 540 m and 100 m away from the source. This has the powerful advantage of eliminating — or at least of strongly reducing — the effect of the Montecarlo calculations, since the two results will be essentially identical in absence of neutrino oscillations. Indeed the use of two similar detectors at different distances is mandatory in order to reduce the systematic errors in the search for $\nu_\mu \rightarrow \nu_e$ oscillations; the data from the far detector should be compared to the event rates in the closer position. The near, small mass detector has therefore to be implemented in order to explicit the effect of the oscillations from other backgrounds.

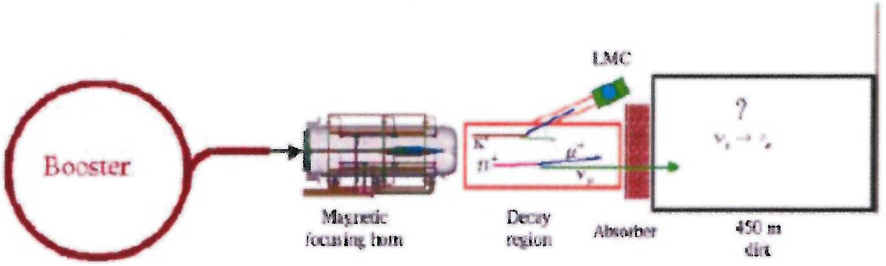

Figure 2. Experimental neutrino beam setup at the FNAL Booster presently in use by the MiniBooNE experiment.

Because of the evident advantages of the LAr TPC, the exposure could also be used for precise measurements of neutrino cross-sections in the low energy range, useful to improve the future neutrino oscillation experiments in the low energy region up to a few GeV. Moreover a LAr-TPC will permit to prove on a very large statistics the identification and rejection capabilities of all the NC backgrounds in LAr, which is a fundamental item for a large LAr detector in any future long baseline $\nu_\mu \rightarrow \nu_e$ oscillation search in the ~ GeV energy range.

2 The DOUBLE-LAr physics programme

The FNAL booster neutrino layout is shown in Figure 2, taken from Ref. [8, 9]. The magnetic horn is designed to focus secondary particles of momentum around 1.5 GeV/c. The decay tunnel is about 50 m long, followed by an iron beam stopper. The resulting neutrino beam spectrum is peaked at 0.5 GeV.

The beamline is already equipped with two experimental areas, one at 550 m from the beam target, presently hosting MiniBooNe detector, and the other at 100 m from target, where, at the moment, the SciBoone test facility is located. We assume that the two LAr-TPC detectors could be located in the vicinity of each of these these two locations.

As already pointed out, the simultaneous presence of two similar LAr-TPC detectors at the two different positions strongly reduces the dependence from the Montecarlo calculations (Figure 3) and any sizeable difference of the spectra in the near and far position may be directly and unambiguously related to the presence of neutrino oscillations. The far detector, at the 550 m location, will have almost the same size as the T600 to minimize the design effort while keeping an active mass (~500 tons) suitable for the proposed oscillation search. The near detector will be a scaled down version, large enough (~150 tons) not to affect the overall statistical error of the relative measurements.

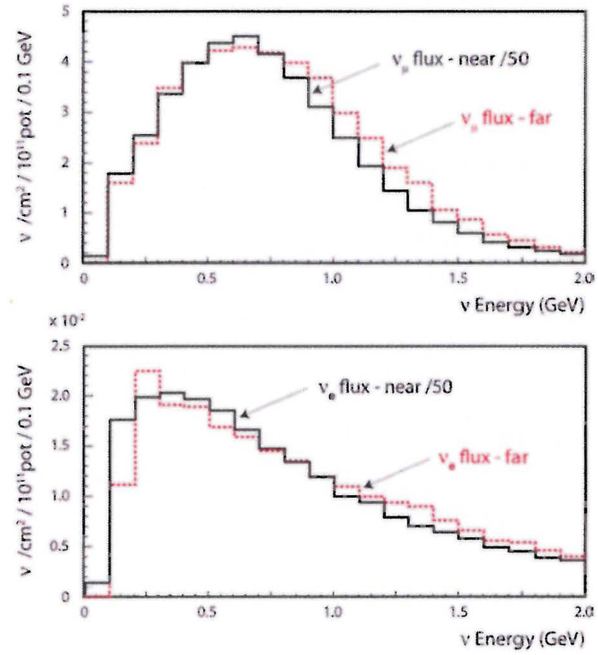

Figure 3. The expected ν_e and ν_μ fluxes at the near (100 m from target) and far (550 m from target) locations [8,9], in case of no oscillations. The fluxes at the near location have been downscaled by a factor 50, which is the ratio of the square of the distances from the centre of the decay tunnel.

The construction criteria of the T600 are perfectly adequate for the new proposed experiment. We have deliberately maintained the main features of the existing T600 in order to strongly reduce the time necessary for a faithful reproduction of the detector. The main modification of the far detector is the extension of the drift time from 1.5 to 3 m, as now widely proven by the progress in the technology. The near detector T150 is exactly equal to an half size of the T300, one of the two half-modules of the T600. In both detectors, the relevant elements of the wire planes, cryogenics, HV system, readout cabling and electronics and phototube readout are identical to the one of the existing T600. They can be duplicated with virtually no additional technical developments and at well known costs and short delivery times.

2.1 The search for "sterile" neutrino.

The Fermilab Booster neutrino beam is characterized by 4 x 10^{12} protons at 8 GeV incident on a beryllium target. The proton beam has a 1.6 μs beam spill at a rate of 4 Hz. The target is located inside a magnetic horn where the positively (or negatively) charged pions and kaons are focused to a 50 m long decay tunnel, 1.82 m diameter. It is expected that more than 2 x 10^{20} POT (protons on target) may be collected per year of data taking. The calculated ν_μ beam energy spectrum is peaked around ~ 0.5 GeV while the intrinsic ν_e contamination is expected at ~0.5 % level. Figure 3 shows the neutrino fluencies at near and far locations. The similarity of the ν_e spectra in two sites improves the search for ν_e appearance signal, since, as already pointed out, many uncertainties cancel out.

A full simulation of the expected neutrino events in the DOUBLE-LAr detectors has been performed within the FLUKA framework [10], where all interaction processes on Ar nuclei (QE, resonances, DIS [11]) as well as full particle transport are included. The expected numbers of events (with and without $\nu_\mu \leftrightarrow \nu_e$ oscillations) in the FNAL beam are shown in Table 1.

Table 1. Event rates for DOUBLE-LAr at FNAL for 6 10^{20} pot at the near (100 m from target) and far (550 m from target) sites. The oscillated signals are clustered below 1.5 GeV of visible energy (see Figure 4).

	far	*near*
Fiducial mass, t	500	100
Distance from target, m	540	100
ν_μ interactions ($E_\nu < 4$ GeV)	6.0 x 10^5	5.0 x 10^6
ν_μ interactions ($E_\nu < 2$ GeV)	5.6 x 10^5	4.7 x 10^6
Intrinsic ν_e from beam ($E_\nu < 4$ GeV)	4400	37000
Intrinsic ν_e from beam ($E_\nu < 2$ GeV)	3160	28000
ν_e oscillations: $\Delta m^2 = 2.0\ eV^2;\ sin^2 2\theta = 0.002$	902	400
ν_e oscillations: $\Delta m^2 = 0.4\ eV^2;\ sin^2 2\theta = 0.02$	1210	165

The recognition and the detection efficiency of ν_e interactions in the LAr TPC are expected to be very high. Events due to neutral currents are very well identified and they can be rejected to a negligible level. A minimal cut of 50 cm in the longitudinal direction and 10 cm cut on the sides of the sensitive volume is normally performed.

Electron identification is also assured under these geometrical cuts. Indeed, due to the directionality of the neutrino beam, the probability that an electron escapes from the instrumented volume before initiating a shower is extremely small: only 2 % of the electrons travel through a LAr-TPC thickness smaller than 3 X_0 and 0.3 % travel less than 1 X_0 in the instrumented volume.

Therefore we can safely assume to identify electrons with almost 100 % efficiency. A large improvement of the LAr discovering potential with respect to the other experiments is expected because of a better statistics, the exploitation of DIS and resonances events in addition to quasi-elastic events and by a much better ν_e selection efficiency.

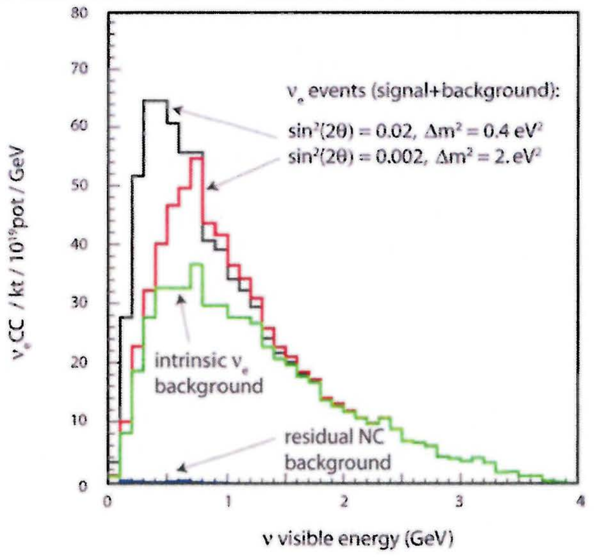

Figure 4. Expected excess of ν_e CC events in the DOUBLE-LAr far detector, compared to the ν_e background (mostly ν_e from beam).

Due to the excellent imaging capability, π^0 from ν_μ NC events cannot be misidentified as electron because events where both photon conversion points are distinguished from the ν_μ interaction vertex can be rejected. i.e. photons converting at more than 2 cm from the ν_μ vertex. The remaining π^0 background is further reduced by discarding events compatible with a parent π^0 mass reconstructed within 10 % accuracy. Only 3 % of π^0 survive the cuts with vertex inside the fiducial volume. Finally the remaining photon can be discriminated from electrons on the basis of dE/dX analysis [12]. This method provides a 90 % electron identification efficiency with photon misidentification probability of 3 % at relatively low energies for tracks longer than 2.5 cm. The final π^0 mis-interpretation probability is 0.1 %, while the corresponding electron efficiency is 90 %.

Results of the simulation (Figure 4) indicate that the excess of ν_e events for different effective oscillation parameters, spanning over the whole LSDN allowed region, is generally well above the residual ν_e background, which is now due primarily to the intrinsic beam contribution. NC events are rejected to a negligible value.

While statistical contribution to the sensitivity to $\nu_\mu \rightarrow \nu_e$ oscillations is well controlled by the LAr detector performance, the systematic error associated to neutrino beam and cross-section can be almost cancelled out exploiting the two detectors configuration. Therefore the sensitivity to $\nu_\mu \rightarrow \nu_e$ oscillations has been calculated with the help of the quantity:

$$\Delta_e = \left(\frac{N_e}{N_\mu}\right)^{far} \Bigg/ \left(\frac{N_e}{N_\mu}\right)^{close} - C_e$$

where N_e/N_μ is the ratio of the event number with identified electron and muon as detected in the near and far location and C_e is a correction factor that takes into account the difference of the N_e/N_μ ratio in the two locations. For an identical ratio N_e/N_μ in the two positions, $C_e = 1$.

The actual distribution in C_e, derived from the actual distributions of Figure 3 is shown in Figure 5. One can see that the ideal case $C_e = 1$ is only slightly modified in the actual distribution.

Since the un-oscillated neutrino spectra in the close and far detectors have similar structure, the systematic errors related to the knowledge of the neutrino beam and cross-sections cancel out with this method. A value of $\Delta_c \neq 0$ is therefore the indication for neutrino oscillations. In Figure 6, the quantity Δ_c is plotted for two different values of oscillation parameters.

In Figure 7 we show our expectations from DOUBLE-LAr. The apparently negative MiniBooNE result is also shown with its 90% confidence level (1.6 s.d.). A higher statistical impact is definitely required to exclude such an important LNSD claim.

2.2 Neutrino cross-section measurements

Precise measurements of the neutrino cross-section in the 0-3 GeV energy range are needed by present and future neutrino oscillation experiments. Existing data on charged current quasi-elastic, deep inelastic, and single pion production are affected by a large uncertainty especially at the lower energies [13].

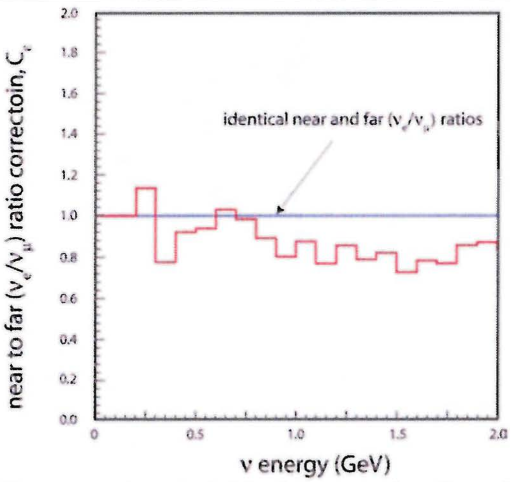

Figure 5. Actual distribution as a function of the neutrino energy of the distance correction factor C_e.

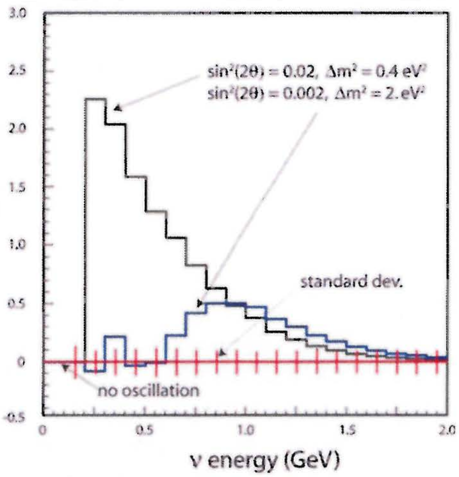

Figure 6. Expected behaviour of Δ_e, normalized to the ratio in the near position (N_e/N_μ), for two different values of oscillation parameters, derived from Figure 2.

Owing to the very low detection threshold of the Liquid Argon technique, the exposure of DOUBLE-LAr at the FNAL-Booster neutrino beams could significantly improve the neutrino cross-section knowledge in the low energy range.

Approximately 8 10^5 and 10^5 charged current events per 10^{20} pot could be recorded from the Booster in the near and far detector respectively with similar neutrino spectrum peaked at ~ 0.7 GeV. Moreover DOUBLE-LAr could also measure neutral current cross-section, detecting 4 10^4 neutral current events.

The far detector also collects data from the off-axis NuMI beam [14] with rates comparable to that of the Booster (0.7 10^5 charged current events) but with a spectrum peaked at 0.25 GeV (neutrinos from pions) and 2 GeV (neutrinos from kaons). Combined with the Booster beam, this feature allows covering a wide energy range, particularly interesting for the future off-axis long base line neutrino experiments.

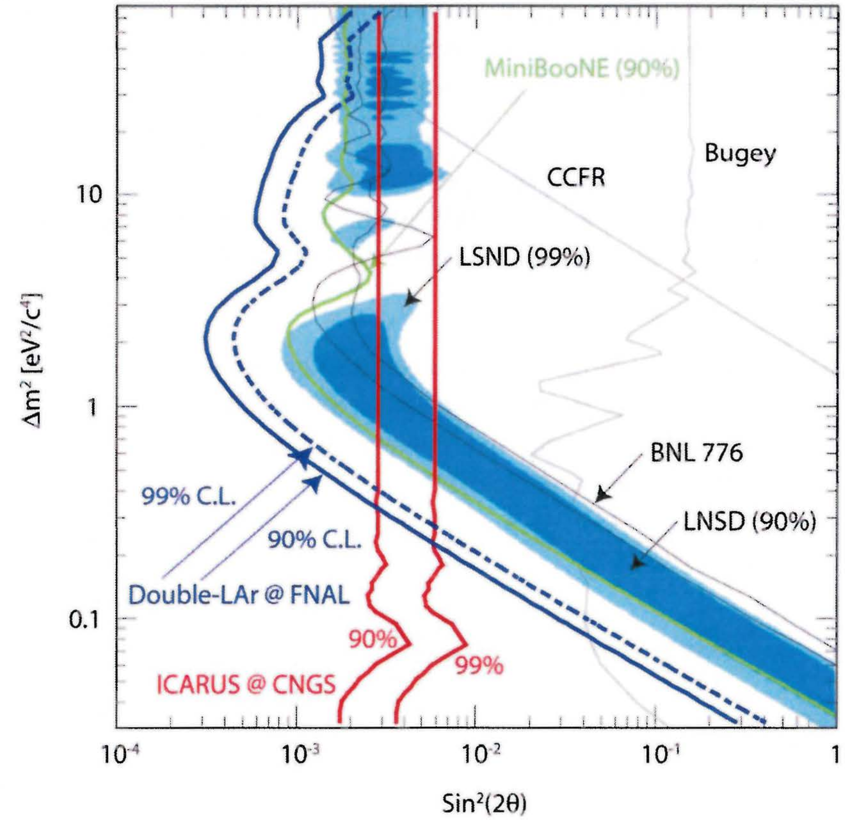

Figure 7. The expected sensitivity of DOUBLE-LAr exposed at the FNAL neutrino beam is shown at the levels of 90 % and 99%. A 4 % total systematic error was assumed for DOUBLE-LAr. The expected results of ICARUS T600 @ CNGS beam are also shown at the levels of 90 % and 99%. As a reference, the LSND result and the MiniBooNe and previous CCFR, Bugey and BNL776 negative results are also shown.

2.3 *Neutral current rejection power*

Beside the oscillation search, the DOUBLE-LAr experimental program is a powerful high-statistics validation test of the background rejection capability for the future neutrino oscillation experiments, which will exploit off-axis neutrino beams with energy spectra similar to that of the Booster neutrino beams.

The assumption that the NC background is negligible is supported by extensive studies performed by ICARUS collaboration [15] both for beam and atmospheric neutrinos.

The exposure of DOUBLE-LAr at FNAL beam will permit to easily experimentally validate this analysis with large statistics.

3 The DOUBLE-LAr detectors.

3.1 *The ICARUS T600 design and performance*

The ICARUS T600 detector [2] is the largest liquid Argon TPC ever built, with a size of about 600 tons of fully imaging mass. The design and assembly of the detector relied on industrial support and represents the application of concepts matured in laboratory tests to the kton-scale. The detector was developed to act as an observatory for astroparticle and neutrino physics at the Gran Sasso Underground Laboratory and a second generation nucleon decay experiment.

The operational principle of the LAr TPC is based on the fact that in highly purified LAr ionization tracks can be transported practically undistorted by a uniform electric field over macroscopic distances. Imaging is provided by a suitable set of electrodes (wires) placed at the end of the drift path continuously sensing and recording the signals induced by the drifting electrons. Non-destructive read out of ionization electrons by charge induction allows detecting the signal of electrons crossing subsequent wire planes with the wires running along different orientation. This provides several projective views of the same event, hence allowing space point reconstruction and precise calorimetric measurement.

The ICARUS T600 LAr detector consists of a large cryostat split in two identical, adjacent half-modules, with internal dimensions $3.6 \times 3.9 \times 19.9$ m^3 each (see Figure 1). Each half-module houses two Time Projection Chambers (TPC) separated by a common cathode, a field shaping system, monitors and probes, and two arrays of photo-multipliers, coated with TPB waveshifter. Externally the cryostat is surrounded by a set of thermal insulation layers. The detector layout is completed by a cryogenic plant, made of a liquid Nitrogen cooling circuit to maintain the LAr temperature uniform, and by a system of LAr purifiers. Each TPC is made of three parallel planes of wires, 3 mm apart. The first faces the drift region, with horizontal wires, the other two have the wires at ±60° from the horizontal direction. By appropriate voltage biasing, the first two planes (Induction planes) provide signals in non-destructive way, whereas the charge is finally collected on the last one (Collection plane). The maximum drift path, i.e. the distance between the cathode and the wire planes, is 1.5 m and the nominal drift field is 500 V/cm. The total number of wires in the T600 detector is about 55000. The signals coming from each wire are independently digitized every 400 ns. The electronics was designed to allow continuous read-out, digitization and independent waveform recording of signals from each wire of the TPC. The measurement of the absolute time of the ionizing event, the "T_0 time", can be determined via the prompt scintillation light produced by ionizing particles in LAr; together with the knowledge of the electron drift velocity, it provides the absolute position of the tracks along the drift coordinate.

The ICARUS T600 was commissioned in 2001 for a technical run performed at surface in the Pavia INFN site. All technical aspects of the system, namely cryogenics, LAr purification, read-out chambers, detection of LAr scintillation light, electronics and DAQ had been tested and performed as expected. Statistically significant samples of cosmic ray events (long muon tracks, spectacular high multiplicity muon bundles, electromagnetic and hadronic showers, low energy events) were recorded. The subsequent analysis of these events, carried out in 2002-03, has allowed the development and fine-tuning of the off-line tools for the event reconstruction and the extraction of physical quantities. It has also demonstrated the performance of the detector in a quantitative way, issuing in a number of published papers [16]. This test demonstrated the maturity of the project.

From 2005 to 2007 completion of the cryogenic system and remounting of the detector have been undertaken at LNGS (hall B). The final commissioning, in 2008, will be immediately followed by the exposure to cosmic neutrinos and to the CNGS neutrino beam.

In parallel with data analysis from the T600 test run, another important data set from a 50 liters ICARUS-like chamber located between the CHORUS and NOMAD experiments at the CERN West Area Neutrino Facility (WANF) has been exploited for the study of the LAr-TPC capability to identify and reconstruct low multiplicity neutrino interactions [17].

The ICARUS detector provides a measurement of ionization energy loss of a track similarly to a bubble chamber. A complete three dimensional spatial and calorimetric picture of events was built by extracting the physical information contained in the wire output signals, i.e. the energy deposition by the different particles and their hit position in the LAr. The measurement of the dE/dx and the related position for a large number of points along the track provide a way of estimating the particle momentum from range (for stopping particles) or multiple scattering, allowing, in addition, for a good particle identification.

3.2 *The DOUBLE-LAr TPC's.*

The proposed far detector closely resembles the two T600 half modules keeping unchanged the size of the external dewar and the mechanical design for a total LAr mass of about 600 tons (see Figure 8-left). Cryogenics and re-liquefaction systems of the T600 are also fully adequate. Internally the drift distance could be extended to 3 m, twice that of ICARUS T600, in order to simplify the structure of the LAr-TPC. The experience with the T600 shows that the required LAr purity level is achievable with the standard ICARUS purification system.

At the same time it has been demonstrated that doubling the high voltage on the cathode is perfectly feasible. The cathode plane is central with two sets of 3 anodic wire planes at the opposite sides of the cryostat. Both the cathode and wire chambers will be identical to that of the T600 detector.

As a consequence the number of the wire chambers is reduced by a factor two as well as the number of the read-out electronic channels. The TPC signals are extracted with the same T600 technique, using the well experiences feed-through system. Also the electronic chain is inherited from the ICARUS T600 detector as well as DAQ system, with a possible evolution based on an upgraded DAQ scheme that implements the same ICARUS T600 architecture with more performing new components and different modularity in view a multi-kton TPC with a number of channels in the order of $\sim n * 10^5$ [18].

As in the T600, a set of few tens of PMT's, coated with TPB waveshifter, will be placed in LAr behind of the wire chambers to detect the prompt scintillation light for triggering purposes. The self-triggering system will be based on both the PMT and wire signals as it is foreseen in the T600 readout.

The near detector design (see Figure 8-right) will be similar to that of one T300 semi-module but with the length reduced by a factor 2, i.e. 10 m. for a total LAr mass of 150 tons, the cathode displaced to one side and just one set of wires at the opposite side. This solution permits to use the same mechanics of the wire chambers of far detector.

This design strategy allows exploiting the already developed and tested technology of ICARUS T600 without the need of any further R&D studies. Finally, the reconstruction and analysis tools developed for ICARUS to study neutrino physics both with cosmic rays and the CNGS beam, could also be exploited by DOUBLE-LAr.

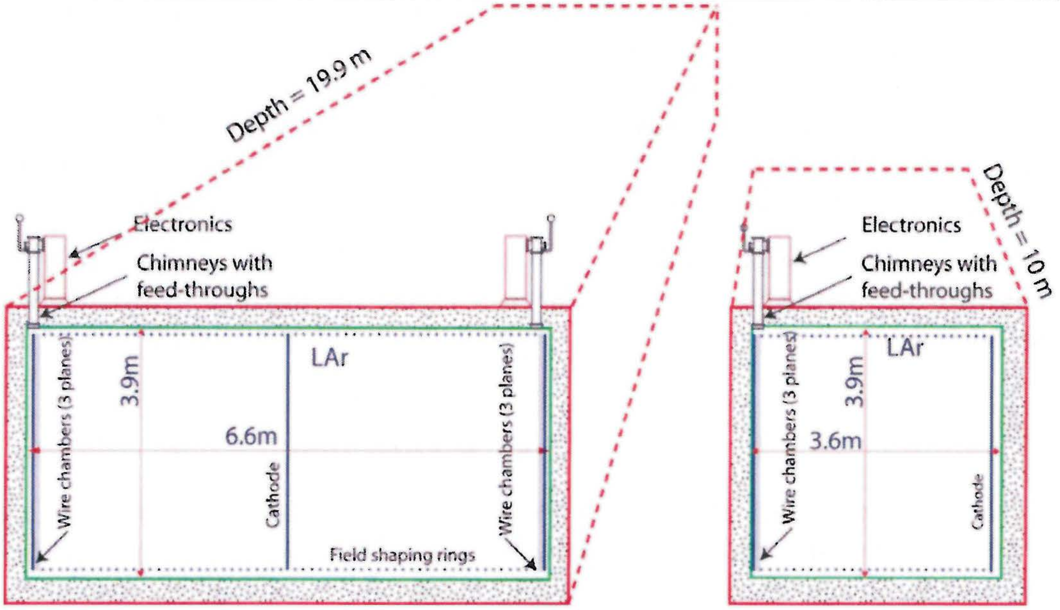

Figure 8. Artistic view of the proposed layout of the far (left) and near (right) LAr-TPC for the FNAL Booster neutrino beam.

We would like to remark that the near detector has a fiducial volume extremely close to the MicroBooNE detector, presently under active consideration by the US team [8]. An attractive possibility would then be the one of integrating the two programmes using the MicroBooNE detector instead of the near station based on the T150. This solution would have the advantage of embodying the future developments in which MicroBooNE is engaged with the now well established traditional ICARUS design.

The cryogenic infrastructure for the two detectors could be made in common, with significant reductions in overall cost and making use of the corresponding technological developments already carried out for ICARUS at the industrial level.

4 Conclusions.

The forthcoming operation of the ICARUS T600 detector at LNGS represents the completion of a development of the LAr-TPC technology over more than two decades.

It evidences that a number of important milestones have been successfully achieved, opening the way to the development of a new line of experiments, which can be extrapolated progressively to the largest conceivable LAr-TPC sensitive masses, suitable for accelerator and non accelerator driven physical phenomena.

In particular the exposure to a low energy neutrino beam at FNAL Booster of two LAr-TPC's, similar in size and design to the ICARUS T600, will allow investigating the existence of sterile neutrinos through the measure of $\nu_\mu \rightarrow \nu_e$ oscillations. The use of two LAr-TPC's at a near and a far location allows to minimize the effect of systematic uncertainty related the neutrino beam and neutrino cross-sections. The quality of the LAr-TPC as tracking and calorimetric detector is essential to reject at negligible level the contribution of neutral currents to the ν_e background. A sensitivity of $\sin^2(2\theta) < 3\ 10^{-4}$ (for $\Delta m^2 < 2\ eV^2$) and $\Delta m^2 < 0.02\ eV^2$ t 90 % C.L. will be at reach with three year exposure. In addition, a precise measure of the neutrino cross-sections in the 0-3 GeV energy range will also be possible.

The experience with the ICARUS T600 make us confident that such detectors could be constructed in a relatively short time and will feature the required characteristics and performances.

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