STATE UNIVERSITY OF NEW YORK
STONY BROOK
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June 10, 2007

Dr. Young-Kee Kim
Chair of the Steering Group
Deputy Director of Fermilab

Dear Young-Kee,

I am writing to you in response to your call for community input to your Fermilab Steering Group (FSG). I urge the FSG to consider possibility of Fermilab taking a leading role in evaluating, designing and constructing a large multi-purpose water Cherenkov detector, such as Underground Nucleon decay and Neutrino Observatory (UNO) [1]. In addition, I also urge the FSG to consider possibility of Fermilab engaging ***more deeply*** in the non-accelerator particle physics experiments, such as neutrinoless double beta-decay, dark matter search and dark energy search. These engagements will diversify the Fermilab's program beyond the traditional accelerator based particle physics research and will strengthen the overall future Fermilab program. In this letter, I, however, limit my discussion to the large multi-purpose detector, UNO.

UNO was first proposed by ckj in September 1999 [2] at the inaugural "Next generation Nucleon decay and Neutrino detector" (NNN) series workshop held at Stony Brook, and now there is a ~100 member UNO collaboration with active support from both the U.S. and abroad. The NNN workshop series [3] is well established as an international forum where possibilities of next generation large multi-purpose underground detectors are discussed. The workshop is held annually: in Aussois, France in 2005; in Seatle, U.S.A. in 2006 and in Hamamatsu, Japan in October 2007 [4]. In the following, I provide a short overview and status of UNO.

Overview of the UNO Experiment

The UNO detector is proposed as a next-generation underground water Cherenkov detector that probes physics far beyond the reach of the highly successful Super-Kamiokande (SuperK) detector while using the same well-tested technology. The baseline concept of the detector is a "Multi-Cubical" design with outer dimensions of $60\times60\times180$ m^3. The detector has three optically independent cubical compartments; the central cube has a photocathode coverage of 40%, while the side cubes have 10% coverage. This design optimizes the physics reach for nucleon decay searches and a variety of neutrino physics studies while keeping the detector cost at a minimum. The total (fiducial) mass of the detector is 650 (440) kton, which is about 13 (20) times larger than the SuperK detector. The UNO collaboration as well as some others has considered other detector configurations such as completely separate multiple detectors (as many as 10 independent cavities) with various photo-cathode coverage. We found that the baseline design is still the most optimal in terms of cost and time for us to reach physics goals of the next generation large multi-purpose detector.

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In terms of underground location the optimal depth of the detector is about 4000 m.w.e. A deeper location would reduce cosmogenic backgrounds, but may introduce additional complexity such as higher rock temperature and rock instability, and add cost to the construction and operation.

The discovery potential of the UNO detector is multifaceted and we only list the main physics topics.

UNO will be capable of observing proton decay through the vector boson mediated $e^+\pi^0$ mode in ~50% of the lifetime ranges predicted by the current Grand Unification Theories (GUTs). This mode of proton decay is considered the most model independent. Water Cherenkov technology is the only realistic detector technology option presently available that permits a search for this decay mode for proton lifetimes up to 10^{35} years.

UNO as an astrophysical neutrino observatory will greatly extend our capabilities in this important and timely field. In the case of a Galactic supernova explosion at the benchmark distance of 10 kpc, UNO will collect ~140,000 neutrino events, from which the millisecond neutrino flux timing structure can be extracted. The expected supernova rate within 1 Mpc is about one every 10 years. UNO would also be able to detect neutrinos from identified supernovae in galaxies out to several Mpc. In this case, backgrounds can be suppressed by demanding a coincidence of at least two neutrino events within 10 s or at least one neutrino event and an optical supernova within 1 day.

Discovery of the Diffuse Supernova Neutrino Background (DSNB), which is also known as Supernova Relic Neutrinos (SRN), is within the reach of UNO. The values of the DSNB flux predicted by various theoretical models, when taken most conservatively, are at most six times smaller than the current SuperK limit. UNO's much larger fiducial mass and lower cosmogenic spallation background will enable it to cover the entire predicted flux range. For the most recent predictions for the DSNB flux based on the latest astronomical data, the expected high statistics observation by UNO would allow exploration of the DSNB spectrum shape.

UNO is an ideal distant detector for a long-baseline neutrino oscillation experiment with neutrino beam energies below 10 GeV, providing a synergy between accelerator and non-accelerator physics. Thus it can play a crucial role in precision measurements of neutrino oscillation parameters and eventual discovery of CP violation in the lepton sector. Recent study jointly conducted by FNAL and BNL [5] has shown that a large water Cherenkov detector placed at a DUSEL site over ~1000 km from Fermilab can be used as a far detector for the measurements mentioned above using a conventional neutrino super beam generated at Fermilab. A method pioneered by the Stony Brook Nucleon decay and Neutrino group has also shown that the issue of π^0 background to the ν_e appearance can be managed effectively [6].

UNO provides a rich and flexible physics program, including additional topics such as the capability to observe multiple oscillation minima and ν_τ appearance in the atmospheric neutrinos; precision measurement of temporal changes in the solar neutrino fluxes; and searches for astrophysical point sources of neutrinos and dark matter in an energy range that is difficult to cover for larger, more coarse-grained undersea and under-ice detectors.

The detector technology proposed for UNO has been well tested over two decades in running experiments. No significant technical obstacles stand in the way of construction of the detector since all detector components can be obtained without further R&D. Rigorous professional civil and mechanical engineering design of the detector awaits choice of the final site.

We expect the detector could be completed within ten years of ground breaking. Preliminary cost estimates indicate the UNO detector would cost approximately $500M including a contingency estimate, but a substantial component (1/3-1/2) of this estimate is site dependent. The cost would be reduced considerably if the detector were built at an existing laboratory such as the Deep Underground Science and Engineering Lab (DUSEL) whose site decision by NSF is imminent.

The UNO collaboration is currently composed of 101 members from 43 institutions in 9 countries. The collaboration is supported by a Theoretical Advisory Committee, which is composed of 12 deeply interested theorists and an Advisory Committee, which is composed of 13 experimentalists including members from Japan and Europe.

Status of the UNO Project

The science case of UNO has been considered by many national committees during the last several years: HEPAP subpanel on long range planning in 2001, Committee of Physics of Universe "Quarks to Cosmos" in 2002, National Academy of Science Neutrino Facility Assessment Committee in 2002, and HEPAP Facilities Committee in 2003. UNO has received high marks for its scientific importance from these committees. In April 2004, there was an interagency working group report on "Physics of Universe" coordinated by National Science and Technology Council involving DOE, NASA, NSF, OMB and OSTP [7]. It made strong recommendations that include investments in the neutrinos and proton decay experiments. Recently, an APS joint neutrino study put R&D for the large multi-purpose underground detector among the highest priorities [8]. Most recently, a National Research Council Committee on Elementary Particle Physics in the 21th Century (EPP2010) [9] made the following recommendation in their report:

In their Finding 5: Neutrino and Proton Decay Probes
A program of neutrino physics, including, eventually, a detector large enough for sensitivity to proton decay, offers a probe of unification physics.
"In the past ten years, it has become clear that neutrinos have tiny but nonzero masses. This was a departure from the Standard Model and may be a signal of the unification of particle forces. There are now opportunities to extend this hint of unification. Proton decay experiments might show that the proton is unstable, a monumental discovery that would confirm one of the most basic predictions of unified theories."

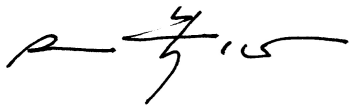
In their Action Item 5: A Staged Neutrino and Proton Decay Research Program
"Longer term goals should include experiments to unravel possible charge-parity violation in the physics of neutrinos and renewed searches for proton decay. There may be a valuable synergy between these important objectives, as the neutrino charge-parity violation measurements may require a very large detector that, if placed deep underground, will also be the right instrument for detecting proton decay."

About four years ago, while I was searching for an UNO site, it was clear that the Henderson mine was the best among all the sites. Subsequently, responding to NSF's solicitation for DUSEL site proposal, I led the Henderson Underground Science and Engineering Project (HUSEP) collaboration [10] to develop the Henderson mine into an underground experimental facility. The site is now proposed as a comprehensive DUSEL facility concentrating on the initial suite of experiments that include neutrino-less double beta decay and dark matter search. But, the design has a provision for a large detector like UNO, and I am as convinced as ever that this site is the best site for UNO both technically and practically. Although UNO is not part of the Henderson DUSEL proposal now under consideration by NSF, and it must be proposed and approved separately, the nation should seriously consider a possibility of constructing such a detector at a DUSEL site, especially at Henderson.

With encouraging national committee evaluations, theoretical developments, international interest and an excellent site in hand, I believe, it is the right time for Fermilab, the nation's flagship particle physics laboratory, to seriously consider the possibility of constructing a next generation large water Cherenkov detector such as UNO.

Thank you for your consideration and I wish you the best for fruitful discussions and findings for the future of Fermilab.

With warmest regards,



Chang Kee Jung
Spokesperson, UNO Collaboration
Spokesperson, HUSEP Collaboration

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