GLADE Global **L**iquid **A**rgon **D**etector **E**xperiment

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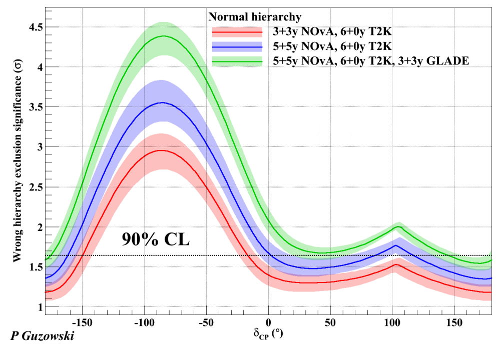
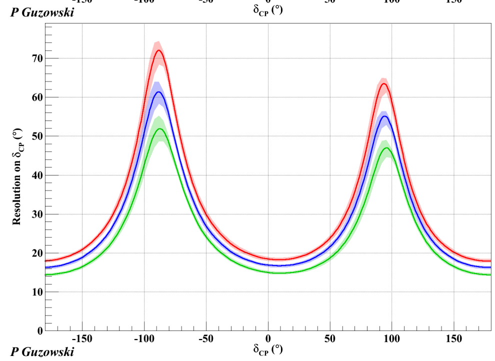
Overview We now know that $\theta_{13} \approx 9^\circ$, a relatively large value which will allow us to establish the neutrino mass hierarchy and measure the CP violating phase with a combination of long baseline, atmospheric and reactor neutrino experiments. When combined with data from double beta decay experiments, we may be able to determine if neutrinos are Dirac or Majorana particles. The NOνA and T2K long baseline experiments will have modest sensitivity to the mass hierarchy and may together be able to resolve it at 3σ for values of δ near $\pm 90^\circ$. We propose to extend the physics reach of this program in a phased way by constructing a Liquid Argon TPC at the NOνA far detector site, taking advantage of the 700 kW NuMI beamline, now being upgraded for NOνA, and the space available in the existing NOνA experimental hall. The proposed LArTPC, with a mass between 5 and 10 kton, will leverage the very successful LAr R&D program in the US and Europe and attract international cooperation. It will also serve as a stepping stone toward the construction of even larger LArTPCs, both in the technical sense, and by better establishing the physics mission need.

Physics Reach The figures show the projected physics reach for a scenario in which data from GLADE are collected for 3 years (6×10^{20} POT/yr) in neutrino mode and 3 years in anti-neutrino mode, and combined with 5+5 years of data from NOνA and 6 years of neutrino only data from T2K. The mass splittings and PMNS angles were taken from [1]. The lower figure assumes the mass hierarchy is known. The detector is assumed to perform as in the LBNE reconfiguration study [2]. The figures assume the normal hierarchy, but inverted hierarchy figures are similar after reflection about $\delta = 0^\circ$. GLADE substantially improves the probability of resolving the mass hierarchy, with $> 3\sigma$ resolution across a broad range of δ and $> 90\%$ resolution for almost the entire range. The run plan is flexible. For example, an exposure with GLADE and NOνA in only neutrino mode may allow for earlier determination of the hierarchy, but will reduce the reach in the resolution of δ. The GLADE performance will also benefit from excellent knowledge of the NuMI beam, provided by the on-





axis MINOS detector, the finer grained on-axis MINERνA detector, and the off-axis NOνA near detector (both of which can measure the beam ν_e content). We have not considered the impact of adding an off-axis LArTPC near detector, but note the synergy with the proposed LAr test beam experiment at Fermilab.

Detector, Timeline, Cost The available space for hosting the liquid argon volume is approximately 18 m x 18 m x 20 m. Accounting for structural support, insulation and secondary containment of the argon, the proposed volume of the active detector is 16 m x 16 m x 18 m. The cryostat would be made using a membrane cryostat as is currently suggested for LBNE. Based on the LBNE experience, we expect that a cryostat that could contain the volume of liquid argon described would cost approximately \$20M including a 30% contingency based on LBNE estimates. The active volume would be separated into four drift regions, with each reading out 13,200 channels, for a pitch of 4 mm between wires. If we were to reuse the electronics design for MicroBooNE or LBNE, we estimate the electronics cost to be \$23M including 30% contingency. A light detection system to facilitate operation on the surface is estimated to cost \$13M with a 30% contingency. The cryogenic filtration system is expected to cost \$25M, including contingency based on LBNE estimates. The labor costs associated with the construction would be a similar scale to the materials costs as indicated by MicroBooNE. Thus, we anticipate this detector could be built for between \$100M and \$200M. We anticipate that inception to completion of the project would take 5 years given the experience with design and construction of MicroBooNE and LBNE.

References

[1] G.L. Fogli *et al.*, Phys. Rev. D **86**, 013012 (2012), arXiv:1205.5254 [hep-ph].

[2] J. Appel *et al.*, "Physics Working Group Report to the LBNE Reconfiguration Steering Committee" `http://www.fnal.gov/directorate/lbne_reconfiguration/files/LBNE-Reconfiguration-PhysicsWG-Report-August2012.pdf`