PhyStat-ν Workshop on Statistical Issues in Experimental Neutrino Physics

Mark Hartz
Kavli IPMU Assistant Professor

The PhyStat-ν workshop on statistical issues in experimental neutrino physics attracted over 90 particle physicists and statisticians from around the world to Kavli IPMU on May 30 - June 1, 2016. The workshop focused on the statistical methods used to interpret data from current and future neutrino experiments.

The discovery of neutrino masses through the phenomenon of neutrino oscillations opened a new window to physics beyond the standard model and led to the 2015 Nobel Prize awarded to Takaaki Kajita and Arthur B. McDonald. Neutrino experiments now aim to further understand the phenomenon of neutrino oscillations and the mechanism by which neutrinos obtain their very small masses. Outstanding questions include: do neutrinos and antineutrinos oscillate differently (so-called CP violation), is the neutrino its own anti-particle, what is the ordering of masses for the three neutrinos, will precision measurements of the parameters governing oscillations indicate an underlying symmetry involved in the generation of neutrino masses?

To study these outstanding questions, neutrino physicists are building ever more complex experiments that require significant human and monetary resources. Therefore, it is critical to maximize the information extracted from these experiments while also ensuring that inferred information on neutrino model parameters and choices between models are statistically sound. The PhyStat-ν workshop addressed three major statistical issues: event classification, parameter estimation and model selection.

Event classification refers to the process by which physicists interpret raw data observed in detectors as physical processes. For example, a pattern of light observed in a neutrino detector may be interpreted as one or more charged particles propagating through the detector medium and producing Cherenkov light. New techniques that can maximize the information extracted from the raw data were presented, including boosted decision trees and a non-parametric Bayesian event reconstruction.

Parameter estimation involves the inference of allowed values for model parameters given the data that is observed. Both classical and Bayesian methods were presented at PhyStat-ν with a focus on challenging cases such as parameters with physical bounds and deciding between a two-sided or one-sided interval for a parameter.

The topic of model selection received significant attention since the next generation of experiments will measure the hierarchy of neutrino masses, which has two options, normal or inverted hierarchy. Since this measurement involves a discrete choice rather than a continuous parameter, naive expectations for what constitutes a significant result can be wrong. The methods of model selection in both the classical and Bayesian approaches were discussed and comparisons were made to a similar discrete choice made with LHC data, the determination of the Higgs boson candidate spin-parity.

The PhyStat-ν workshop at IPMU was the first PhyStat workshop in the field of neutrino physics and laid the groundwork for future workshops on statistical methods in experimental neutrino physics. A second PhyStat-ν workshop will be held at Fermilab on September 19-21.