University of Notre Dame collaborates on muon detector development project

Most particle physicists think that the International Linear Collider (ILC) could revolutionise our understanding of the universe, and will challenge inquisitive minds of particle physics. This is a field where University of Notre Dame in Notre Dame, Indiana, US, has been actively participating, particularly in muon detector research and in organising outreach activities between students, high school teachers and physicists.

“The Notre Dame High Energy Physics group has a long history of working scintillating fiber tracking and calorimetry with fiber readout, so the ILC muon collaboration was a natural fit for the group,” said Mitchell Wayne, professor and department chair in the physics department at University of Notre Dame.

ILC prototype crew at University of Notre Dame gathered around the muon detectors built on-site.

One way that University of Notre Dame participates in muon research is through its active role as part of the Muon Detector Group. It is comprised of over 30 universities and research institutes including Colorado State University, Wayne State University, Northern Illinois University, University of Wisconsin at Madison and others in the US, and international ones such as the Università di Udine and Università degli Studi di Trieste, both situated in Italy. This group focuses their efforts on scintillator-based muon detector tests, seeking to develop an improved area of resistive plate chamber (RPC) detectors and simulation with integrated muons and calorimeters. More specific to these efforts, they also use test beam results performed at Fermilab to understand the issues in applying RPCs and strip-scintillators to linear collider muon systems.

But, the efforts towards the ILC do not stop here. In fact, every summer, University of Notre Dame sees the arrival of high school teachers, students and physicists who collaborate together in an annual programme sponsored by the National Science Foundation (NSF) and the Department of Energy (DOE) called QuarkNet. Here, they all can foster relationships with universities and research institutes across the country. It supports science education in schools by establishing a nation-wide science teacher network and its mission is to investigate particle physics through live, online data, learning fundamental physics from energy and momentum. “QuarkNet brings teachers into the research environment where they can experience how science is done,” said Wayne, “and students develop scientific knowledge and habits by working alongside scientists to make sense of the world using real experimental data.” This educational effort likewise involves muon detector construction and working together with Fermilab on prototypes using scintillators and fibres.

The ILC will actually include a detector system whose primary function will be to identify and measure muons. However, due to the thinness of the calorimeters, some hadronic showers will escape into the muon system. If the muon system can successfully detect this hadronic energy, it will improve the resolution of the calorimeters. Muons are, in fact, one of a group of three elementary particles known as the charged leptons (the others are the better known electron and the tau) and the presence of one or more of these muons among the final particles produced in an ILC collision can even be a sign of an interesting event.

The general layout of the muon detectors consists of planes of scintillator strips which are placed in gaps between 10 centimetre-thick plates that make up octagonally-shaped barrels around the beamline. Each strip contains a "wavelength shifting" fiber down its length. When a muon goes through the strip, a tiny fraction of its energy is left behind in the form of ultraviolet scintillation light which is later absorbed in the fiber and re-emitted at a longer (green) wavelength. The green light then travels down the fiber to a photodetector at the end of the strip. This octagonal shape is useful as it will facilitate making additional layers of muon detectors and, in such a case, only muons will be able to pass through and scientists can reconstruct the path of the muon.

Over the summer during the next few months, QuarkNet will recruit and train students to find answers to the above challenging questions... and they take part in what will hopefully be a successful learning experience and will arouse interest in particle physics for new participants as well. High school students will have, in other words, the unique opportunity to make history in taking part in the ILC detector and work "behind the scenes" on the workings of the muon detector.

As for the plans for the coming months, Wayne said that they would start to look at silicon photomultiplier types and test prototype strips for muon detectors.

“This ongoing research on muon detectors is clearly a very important step for the field of physics,” said Wayne.

-- Andre Sulluchuco