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TRIUMF shares the 2016 Breakthrough Prize in Fundamental Physics

(Vancouver, BC) – The *Breakthrough Prize in Fundamental Physics* for 2016 has been awarded jointly to the Daya Bay, Kamland, SNO, Super-Kamiokande (Super-K), and T2K/K2K collaborations "for the fundamental discovery of neutrino oscillations, revealing a new frontier beyond, and possibly far beyond, the standard model of particle physics." The award, honouring those at the forefront of fundamental physics, is shared by dozens of TRIUMF scientists involved in the SNO (Sudbury Neutrino Observatory) and T2K (Tokai to Kamioka) experiments. TRIUMF made significant contributions to these collaborations, with the efforts involving scientists, students, engineers, and technicians from the laboratory.

Founded by Russian entrepreneur, venture capitalist and physicist Yuri Milner, *The Breakthrough Prize in Fundamental Physics* is open to all physicists—theoretical, mathematical, and experimental—who have made profound contributions to human knowledge. The $3 million prize is awarded by the Breakthrough Foundation for "Outstanding contributions in Life Sciences, Fundamental Physics, and Mathematics."

Next to light, neutrinos are the most abundant particles in the universe, continuously showering the Earth after being created in the sun and by cosmic rays in the atmosphere. TRIUMF Researcher Emeritus Dr. Rich Helmer was involved in both SNO and T2K: "In the mid-1990s, there were tantalizing hints that neutrinos might have properties that would solve the twin mysteries of the solar and atmospheric observations. It has been quite a thrill to have taken part in the two experiments that showed unambiguously that neutrino oscillations were the solution." Recently, the 2015 Nobel Prize in Physics was awarded to Dr. Art MacDonald (for the SNO collaboration) and Dr. Takaaki Kajita (for the Super-K collaboration) for their discovery of neutrino oscillations, which proved definitively that neutrinos have a small mass.

The T2K experiment received key innovations from TRIUMF that enabled it to provide data with uncertainties smaller than otherwise possible. The experiment employs neutrinos created by the JPARC proton accelerator in Tokai, Japan and sent to the Super-K detector 300 km away in Kamioka. TRIUMF researchers developed an off-axis beam technique to provide a neutrino beam that is both more intense and better focused when being sent across such distances. TRIUMF Research Scientist Dr. Akira Konaka then presented the idea to the fledging collaboration, which subsequently adopted it. T2K ultimately observed neutrino oscillations from a man-made source for the first time, which led to the measurement dictating the rules for oscillations.

TRIUMF researchers and technical staff supplied several important components for the experiment. The fine-grained detectors and time projection chambers, which together comprise the tracker of the near detector, were designed and built at TRIUMF. The remote-handling equipment used to service radioactive components were also designed and built at the laboratory. In addition, the Optical Transition Radiation monitor proposed and built by TRIUMF, York University, and the University of Toronto (both TRIUMF member universities) played an important role in reducing the uncertainties and thus making the groundbreaking results more significant. The 2011 Physical Review Letters paper "Indication of Electron Neutrino Appearance from an Accelerator-produced Off-axis Muon Neutrino Beam," has received 1000 citations—twice the INSPIRE's threshold for renowned papers. Finally, TRIUMF also hosts the T2K Tier-1 analysis center.

The TRIUMF researchers involved in the SNO collaboration helped demonstrate that neutrinos change their identity type on their way to Earth from the Sun, a discovery that requires neutrinos to have a mass greater than zero. The results also confirmed the theories of energy generation in the sun with great accuracy. McDonald, who was the SNO Project Director, stated: "Our collaboration members are very pleased to receive this

testimony to the scientific significance of their work. Our findings are a result of many years of hard work and our full scientific author list includes over 270 scientists."

The *Breakthrough Prize* award was presented on the evening of Nov. 8 at a ceremony at the NASA Ames Research Centre in Moffett Field, California. Hosted by comedian Seth Macfarlane, the award ceremony was broadcast live in the U.S. on National Geographic Channel. A one-hour version of the broadcast is scheduled for Fox on Nov. 29, at 7 p.m. Eastern.

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About SNO (http://www.sno.queensu.ca)
The Sudbury Neutrino Observatory is a unique underground neutrino telescope near Sudbury, Ontario. Through its use of heavy water, the SNO detector provided unique ways to detect neutrinos from the Sun and other astrophysical objects and measure their properties. Measurements at the SNO Laboratory began in 1999 and the detector was in almost continuous operation until November 2006. SNO was constructed and operated by more than 200 scientists from Canada (Queen's University, Carleton University, Laurentian University, University of Guelph, University of British Columbia, TRIUMF, Chalk River Laboratories (to 1996), and University of Alberta (since 2007)), Portugal, the US, and the UK. TRIUMF researchers Rich Helmer and Reda Tafirout are members of the SNO Collaboration, while important technical expertise was provided by Jean-Michel Poutissou and Ewart Blackmore, in addition to the contributions of TRIUMF engineers, technicians, students and other researchers.

About T2K (http://t2k-experiment.org)
The T2K experiment is aimed at confirming hints of neutrino oscillations garnered from studies of neutrinos produced in the atmosphere. A neutrino beam is produced at the JPARC accelerator in Tokai, Japan, and after traveling through the Earth the neutrinos are detected with the Super-K detector near Kamioka. The experiment makes use of an off-axis beam technique developed at TRIUMF. The T2K experiment was constructed and is operated by an international collaboration, which now includes about 500 members from 59 institutes, including Japan, Canada, France, Germany, Italy, South Korea, Poland, Russia, Spain, Switzerland, the UK, and the US. The T2K-Canada collaboration consists of 40 scientists from eight institutions, including TRIUMF, the University of Victoria, the University of British Columbia, the University of Alberta, the University of Regina, the University of Winnipeg, York University, and the University of Toronto. TRIUMF researchers include Akira Konaka, Rich Helmer, Pierre Amaudruz, Shaomin Chen, Peter Gumplinger, Mark Scott, Kenji Hamano, Mark Hartz, Robert Henderson, Dean Karlen, Issei Kato, Sujeewa Kumaratunga, Thomas Linder, Kendall Mahn, Andy Miller (retired), Kentaro Mizouchi, Jean-Michel Poutissou, Renee Poutissou, Fabrice Retiere, Roman Tacik, Mike Wilking, and Stan Yen, in addition to the contributions of TRIUMF engineers, technicians, and students.

About TRIUMF (www.triumf.ca)
TRIUMF is Canada's national laboratory for particle and nuclear physics. Together with its partner AAPS, Inc., TRIUMF also seeks to commercialize its technologies for the benefit of all Canadians. Located on the south campus of the University of British Columbia, TRIUMF receives operating support from the Government of Canada through a contribution agreement via National Research Council Canada; the Government of British Columbia provides capital for new buildings. TRIUMF is owned and operated as a joint venture by a consortium of 19 Canadian universities. Connect with TRIUMF on Twitter, Facebook, and Instagram: TRIUMFLab

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