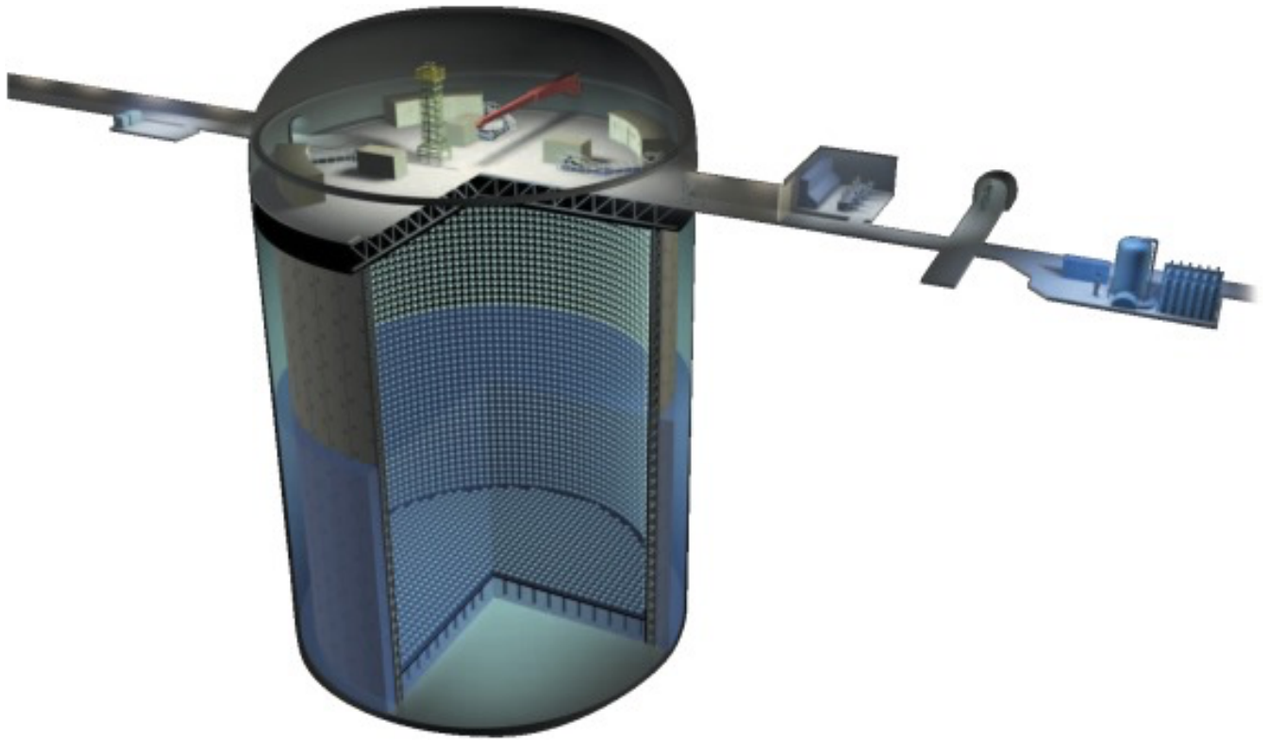
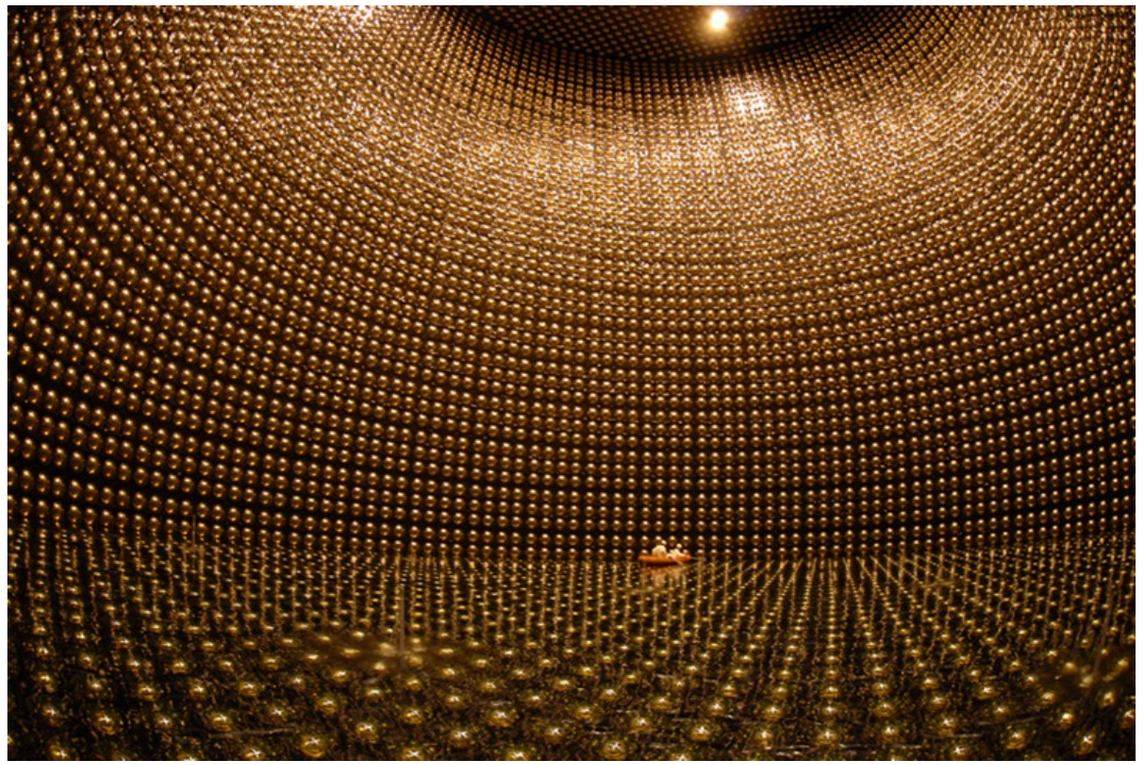
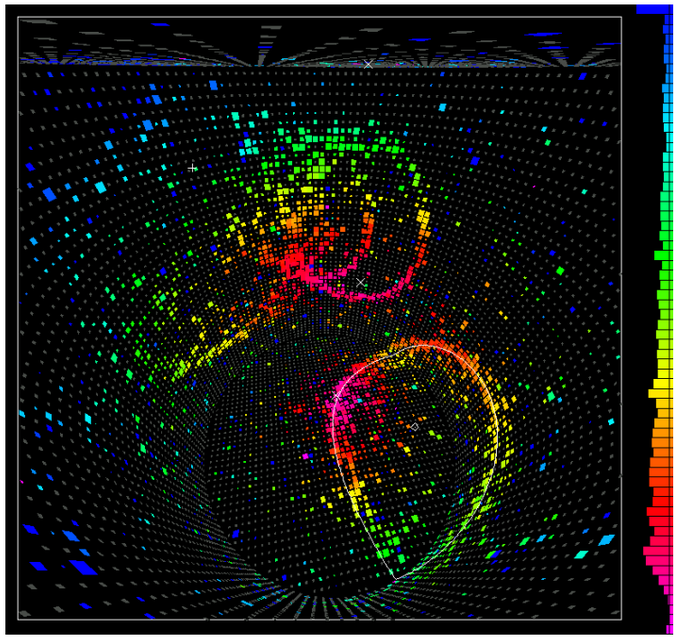
TOKYO/TORONTO PARTICLE PHYSICS RESEARCH AND GRADUATE EXCHANGE PRORAM

SUPER-KAMIOKANDE

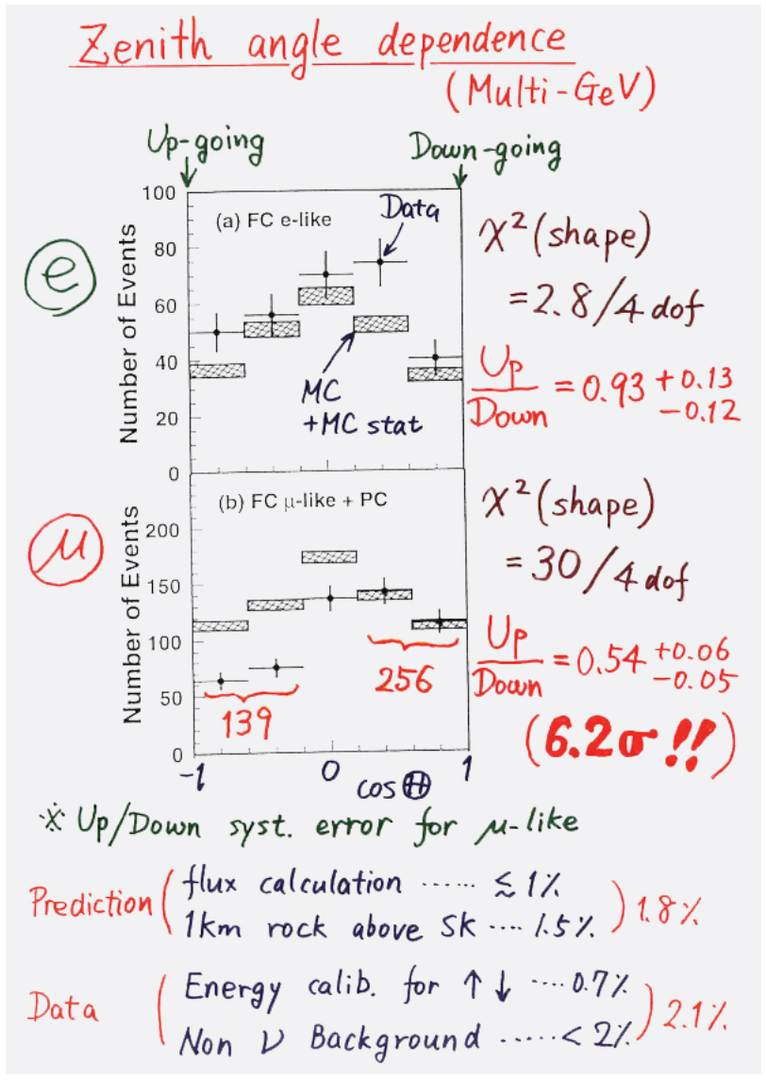


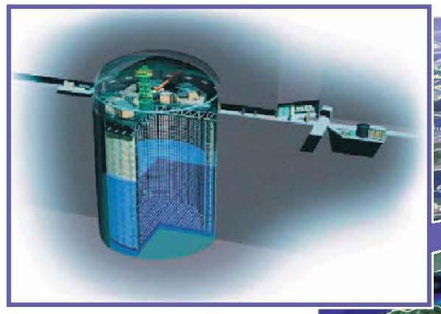




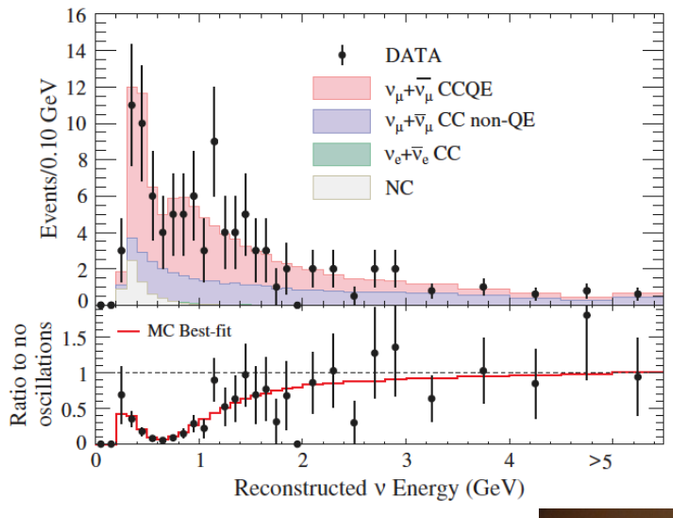
- 50 kT water Cherenkov (WC) detector
  - Inner volume instrumented with >11000 20″ photosensors
  - Outer volume with 1885 8″ photosensors
- Neutrino interaction detection via Cherenkov radiation emitted by charged particles

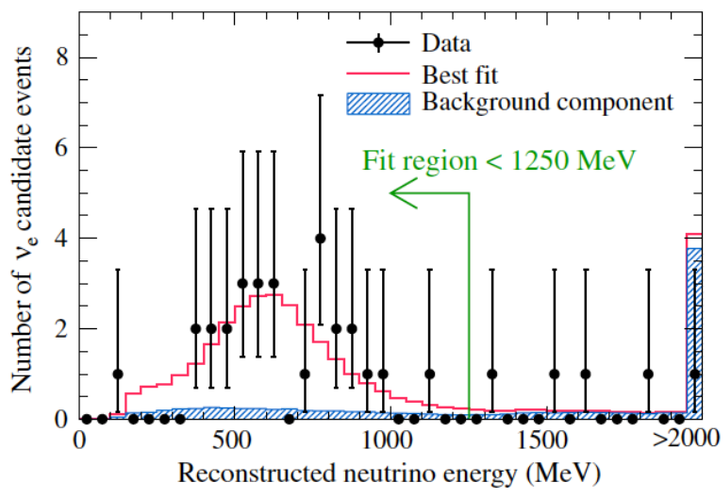
SK AND NEUTRINO PHYSICS





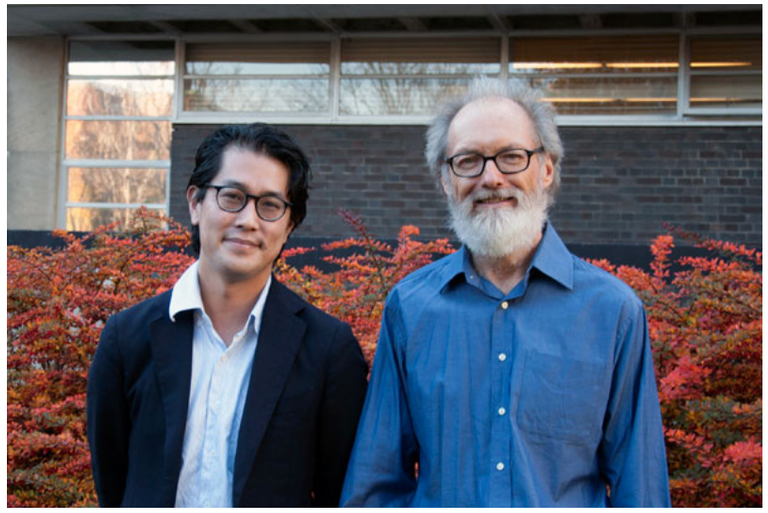
Super-Kamiokande
(ICRR, Univ. Tokyo)





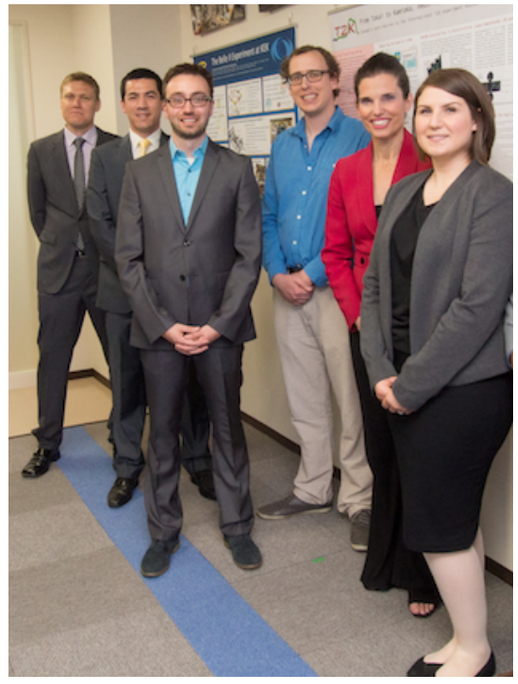
- Initial discovery of neutrino oscillations with atmospheric neutrinos (1998)
  - transmutation of neutrinos species (ν_e, ν_μ, ν_τ)
  - Nobel Prize in Physics 2015 to Takaaki Kajita (SK) and Art McDonald (SNO)
- Discovery of $\nu_\mu \rightarrow \nu_e$ oscillations
  - using accelerator-based neutrino beam (Tokai-2-Kamioka)
  - 2016 Breakthrough Prize in Fundamental Physics

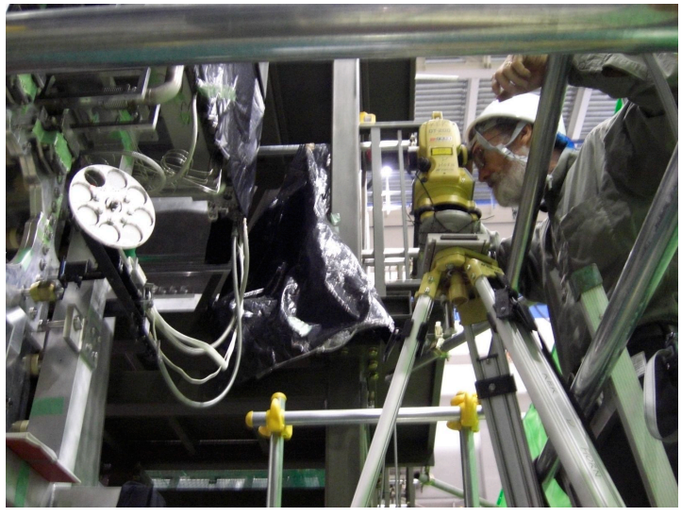
SK/T2K EFFORT AT TORONTO



- Contributions:
  - T2K Optical Transition Radiation Monitor
    - shared KEK Suwa Prize
  - Event reconstruction and analysis with HPC
    - heavily leverage Scinet
    - key for discovery of $\nu_\mu \rightarrow \nu_e$
- Other roles:
  - T2K Executive Committee
  - T2K Analysis Coordinator
  - SK “Tank Opening” Committee
  - PI for T2K/SK effort in T2K

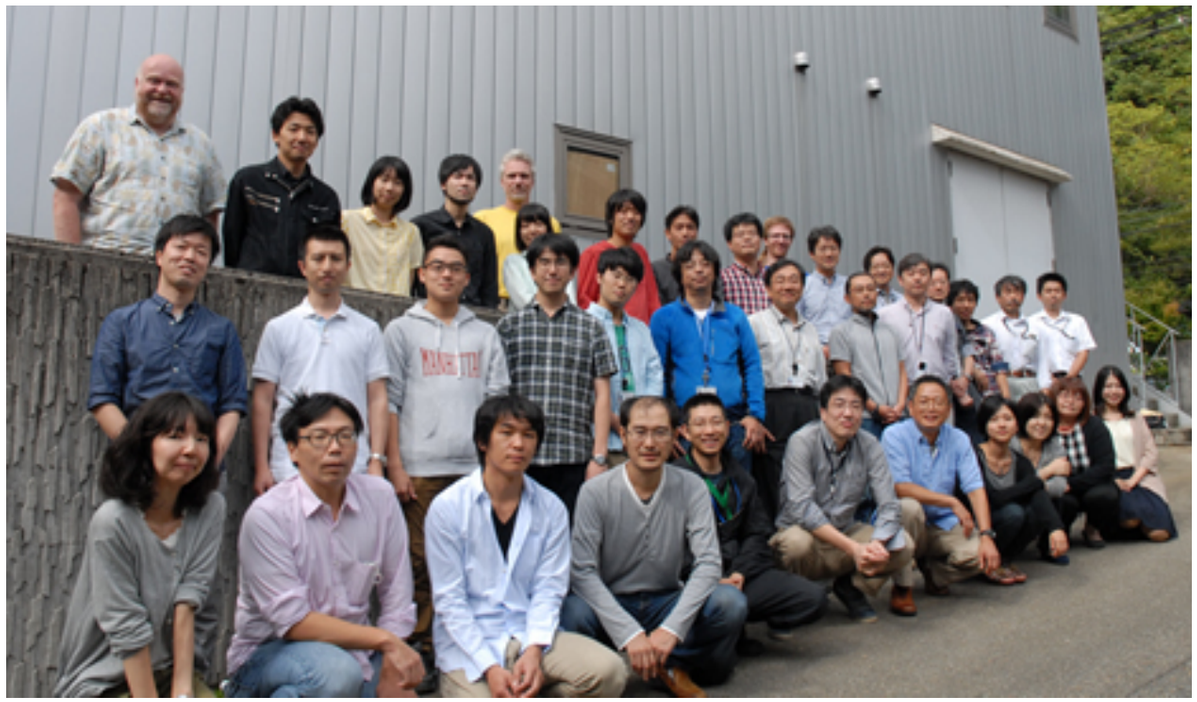
- Faculty:
  - J. F. Martin (Emeritus)
  - H. A. Tanaka (since 2015)
- Postdocs:
  - M. P. Hartz (now at Kavli IPMU)
  - A. Marino (now at Boulder)
- Graduate Students:
  - P. de Perio (2015, Vanier Fellow)
  - C. Nantais (CGSD)
  - T. Towstego





ICRR AND KAVLI IPMU

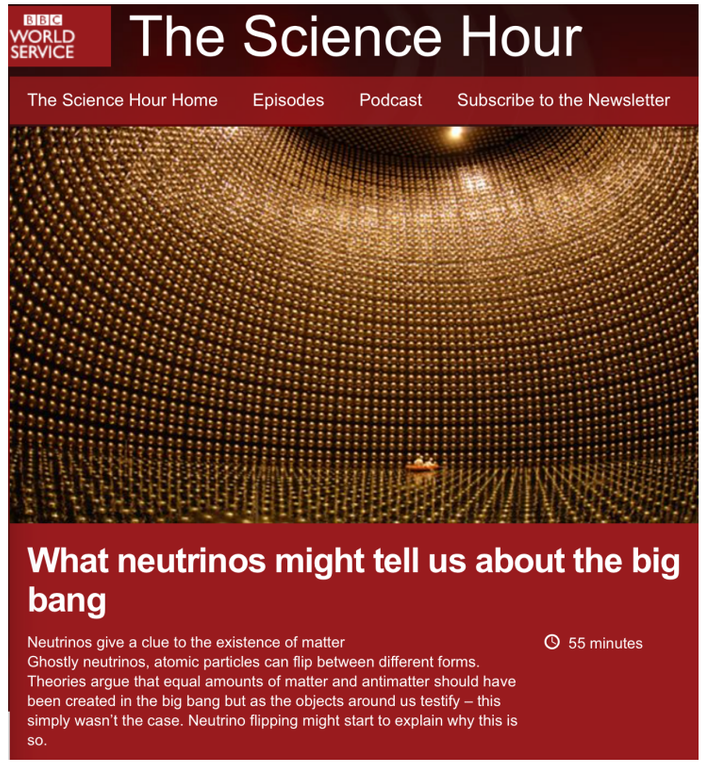
- Institute of Cosmic Ray Research (ICRR)
  - main office on Kashiwa Campus (Director: T. Kajita)
  - operates Kamioka Observatory (Director: M. Nakahata)
    - and the Super-Kamiokande detector
  - ~20 faculty members
- Kavli Insitute for the Physics and Mathematics of the Universe (Kavli IPMU)
  - Founded in 2007 as part of a “Word Premier International Research Centre"
  - main office on Kashiwa campus (Director: H. Murayama)
  - 3 faculty working on SK/T2K

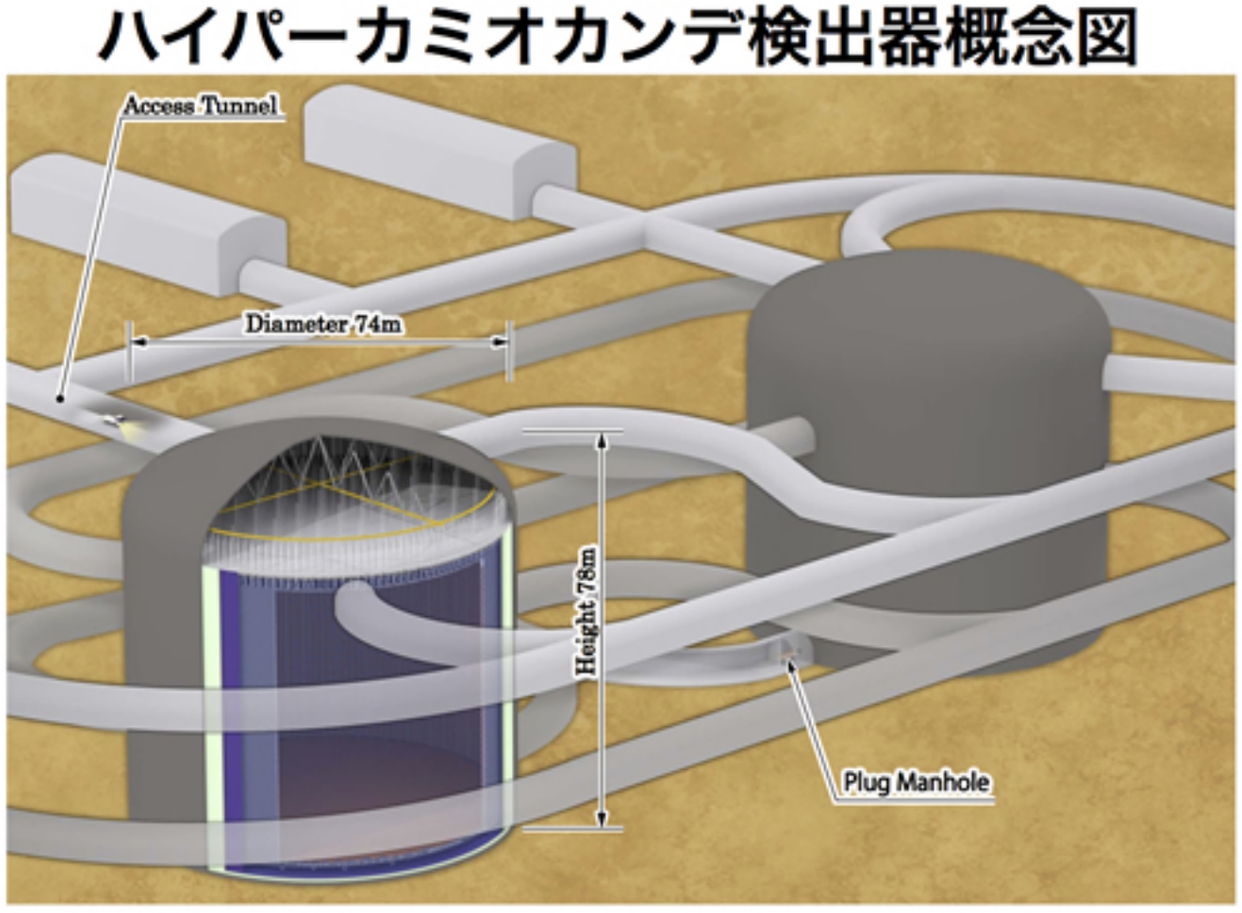


UPCOMING SCIENCE

- In 2016, T2K presented its first results comparing neutrino and antineutrino oscillations
  - Detecting an imbalance in these processes ("CP violation") is one of the most pressing issues in particle physics today
  - clues to why the universe is matter-dominated

2016 interview with
BBC world service

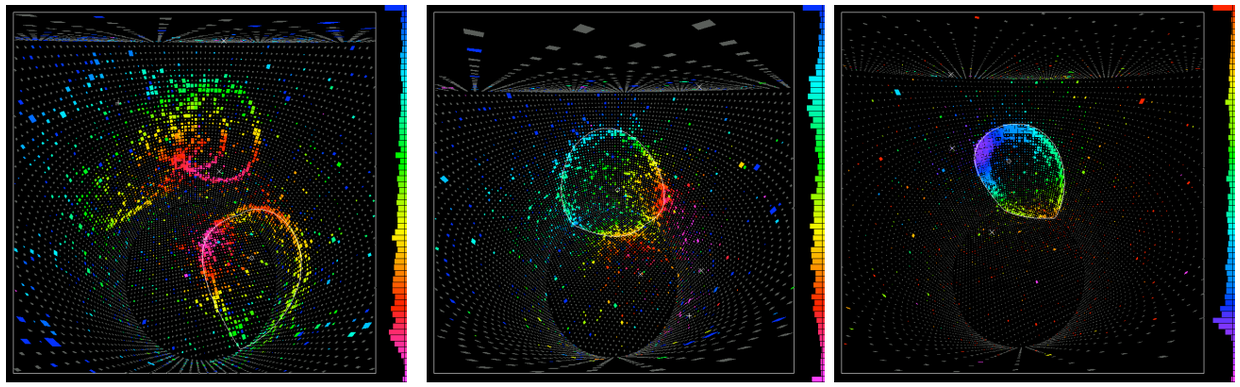


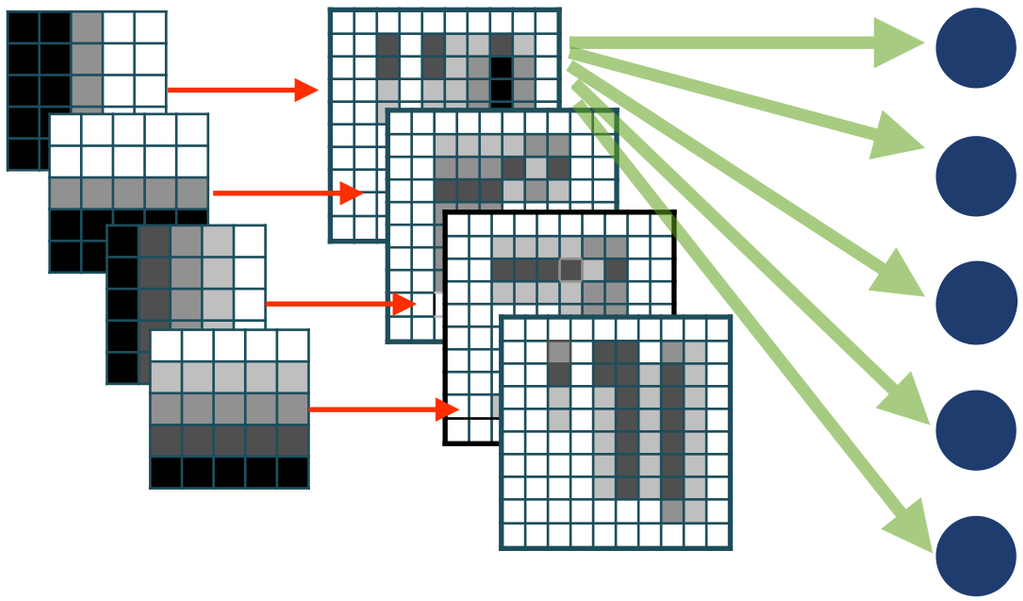


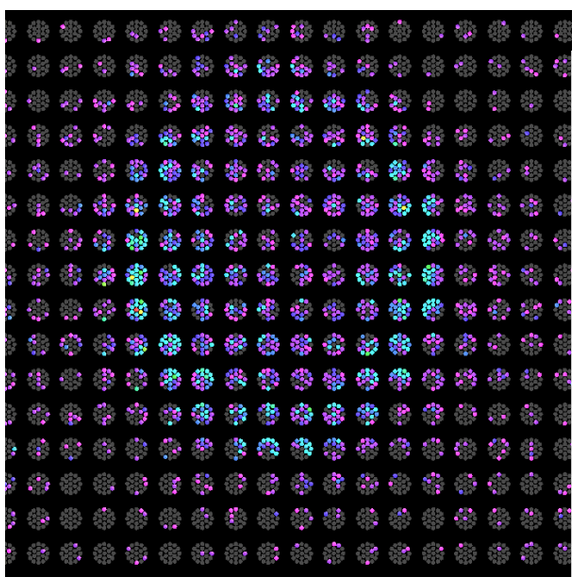
- Continued program at T2K to search for "CP violation"
  - ~now to 2025
  - if nature is kind, we may see it in this current generation experiment
- Next Generation: "Hyper-Kamiokande"
  - ~10x larger detector
  - greater sensitivity, broad program
  - now under consideration by MEXT
  - aim to start in 2026

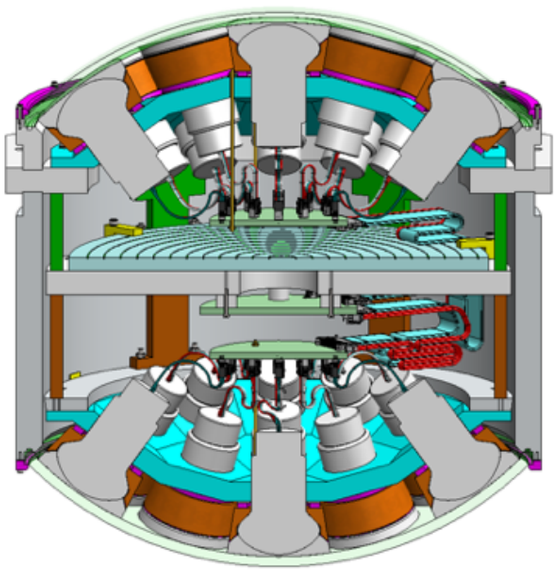
TORONTO ACTIVITIES

- **Algorithms**
  - developed maximum-likelihood-based algorithm that affords x2-3 improvement in some key metrics
  - now exploring deep learning techniques for Ĉ-ring identification and counting



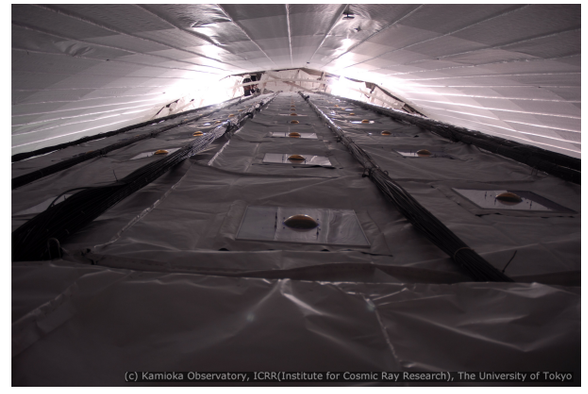




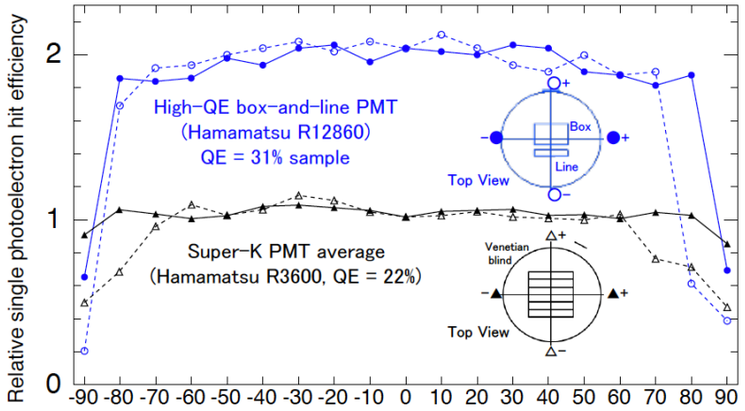


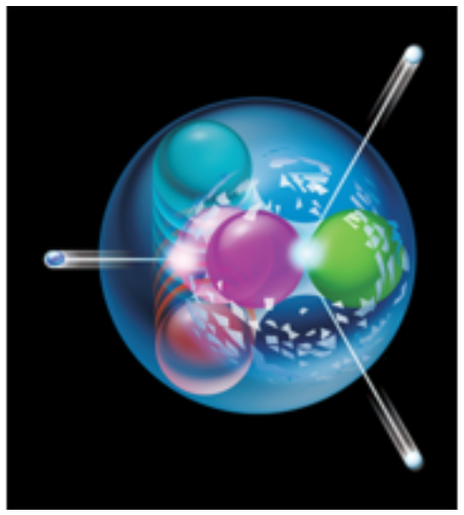
- **Photosensors:**
  - Increasing imaging granularity with smaller photosensors
  - “multi-PMT”
    - array of small 3” PMTs packaged into watertight module

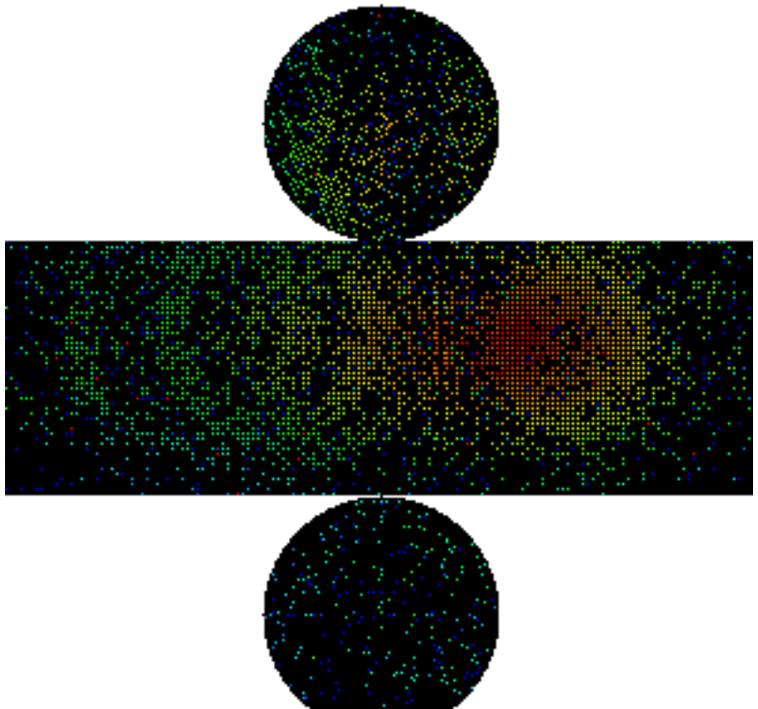
KAMIOKA/KAVLI IPMU



- **2018 Detector Maintenance:**
  - Replacement of outer detector PMTs
    - large failure rate due to age
    - ~200 new PMTs will be installed in the outer detector
  - New improved 20” “box and line” PMTs
    - improved in just about all aspects
    - ~100 new PMTs will be installed in the inner detector







- **Kamioka is the HQ for SK**
  - on-site calibration activities for understanding and improving detector performance
  - exploring full range of scientific program
    - e.g. proton decay, neutrino astrophysics.

PROPOSED ACTIVITIES

Graduate Student Exchange:

Two University of Toronto graduate students to visit Kamioka/Kavli IPMU for four months.

1. Four month fellowships ($33,000/annum prorated to four months)
2. Travel to Japan ($2000 for round trip ticket)
3. Travel within Japan ($600 to get to/from Toyama and a visit to Hamamatsu Photonics)
4. Accommodations at Kamioka Observatory ($30/night)
5. Attendance at AEPSHEP (Asia-Europe-Pacific School of High-Energy Physics) sponsored by particle physics laboratories around the world including CERN and KEK.

Postdoc Exchange:

Four month visit from a University of Toronto postdoc supported to supervise the graduate students.

Undergraduate Fellowship:

Counterpart to the graduate student exchange that funds one undergraduate student to participate

Faculty Travel

One faculty member to travel to Kamioka Observatory for four months

Equipment

This part of the budget provides for 25 Hamamatsu 8” PMTs to be purchased and tested prior to installation into the Super-Kamiokande detector with testing equipment (pulsed lasers, power supplies, readout electronics, etc.)

PROPOSED BUDGET

		T2K Grant	Dept/FAS	VPI	Kamioka/ Kavli IPMU	Total
Grad. Student Exchange	Toronto student fellowships	$ 6000	$ 8000	$ 8000		**$ 22000**
	Travel to Japan			$ 4000		**$ 4000**
	Travel within Japan			$ 1200		**$ 1200**
	Accommodations			$ 7200		**$ 7200**
	AEPSHEP School			$ 6000		**$ 6000**
Postdoc Exchange	4 months PDF support	$ 22000				**$ 22000**
	Travel to Japan	$ 2000				**$ 2000**
	Accommodations	$ 2400				**$ 2400**
Undergraduate Fellowship	Stipend		$ 8000			**$ 8000**
	Travel within Japan		$ 600			**$ 600**
	Travel to Japan		$ 2000			**$ 2000**
	Accommodations		$ 3600			**$ 3600**
Faculty	Travel to Japan				*$ 2000*	**$ 2000**
	Travel in Japan			$ 1200		**$ 1200**
	Accommodations/expenses			$ 3600	*$ 3000*	**$ 6600**
Equipment	Photomultipliers	$ 50000				**$ 50000**
	Testing Equipment				$ 30000	**$ 30000**
Total		**$ 82400**	**$ 22200**	**$ 31200**	**$ 35000**	**$ 170800**