Canada’s Role in Major International Projects: T2K and ILC
Particle Physics accelerator laboratories

- distributed around the world
Canada has a strong history of partnering in major international PP projects.

For more information: www.ipp.ca
In related areas of science, Canada provides world-class facilities which attract international research teams

- TRIUMF – radioactive ion beams
- SNOlab – deep underground laboratory for neutrino and dark matter experiments
Canada in international PP projects

- Canada has a modest size research community in Particle Physics
  - 250 subatomic physics faculty/staff
- To maximize Canadian impact:
  - focus on a limited number of projects
  - build large teams that work together
- Project selection
  - long term planning through community consensus
  - national funding for “projects” not for “groups”
  - funding decisions by international peer review, based on science and strength of team

In 2006, major funding for the T2K/Canada project was secured
T2K experiment

- Scientific objective: to uncover the mysterious nature of neutrinos
  - in particular: understand the way in which they change their identity from one kind to another (known as “oscillation”)

- Neutrinos ($\nu$): “ghost-like” particles
  - everywhere (300/cc)
  - can pass through walls (or the earth!)
    - very difficult to see
  - produced in nuclear reactions
  - very light – generally travel near the speed of light
Neutrino oscillations

- Discovered by experiments studying neutrinos from extraterrestrial sources:
  - Super Kamiokande (in Japan) was used to study neutrinos produced by cosmic ray interactions in the atmosphere

50 kton $H_2O$
Neutrino oscillations

- The effect was confirmed by the SNO experiment (in Canada) that studied neutrinos produced in the Sun
Technique:
- produce a pure beam of neutrinos (one type and with the same energy) and see what fraction change into a different type when observed at a later time

Challenges:
- producing an intense neutrino beam (so that a reasonable number can be detected)
- measuring the properties of the neutrinos at the time of production
- measuring the properties of the neutrinos after they have had a chance to oscillate
**T2K experiment**

- The new J-PARC facility is used to produce the intense neutrino beam.
- Super Kamiokande is used to measure the neutrinos after they travel 295 km through the earth (in 0.001 s).
- A new detector complex is under construction to measure the neutrinos right after they are produced.
T2K experiment

- Neutrino production and near detectors
T2K experiment – Canada’s role

- proton beam

remote manipulator system

proton monitor stack
proton beam
  ◦ OTR monitor – just in front of target
T2K experiment – Canada’s role

- Near detector tracker
T2K near detector tracker

- Canada has led the design and construction of the tracker to measure beam energy and composition:
  - 2 active neutrino targets (FGDs)
  - 3 gaseous time projection chambers (TPCs)
Fine grained detectors (FGDs)

- Consist of 8000 special plastic bars that produce a small amount of light when a neutrino interacts
  - light detected by miniature photosensors called MPPCs (Hamamatsu) provided by Kyoto University
  - first deployment of this new technology
Time projection chambers (TPCs)

- A 3D “digital camera” that images the products of the neutrino interactions in the FGDs
  - first deployment of micropattern TPC technology
TPC images

- Tests with cosmic rays at TRIUMF
Canadian T2K team

- TRIUMF and 6 University groups
  - University of Victoria, University of British Columbia, University of Alberta, University of Regina, University of Toronto, York University
    - 11 TRIUMF physicists
    - 9 University faculty
    - 25 staff
    - 10 postdocs
    - 11 graduate students
  - makes up about 15% of the T2K collaboration
  - Canada was the first foreign partner of T2K and the only nation to sign the original Letter of Intent
T2K collaboration

- Photo from inaugural collaboration meeting in January 2004

- now – more than 400 collaborators, from 65 institutes in 12 countries
T2K timeline

- Schedule from approval to operation much shorter than most accelerator Particle Physics experiments

- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

• approval in Japan
  • ND280 conceptual design
    • Canadian funding approved

Construction in Canada

• successful beam start
  • start of experimental program
Looking into the future

- The future direction of neutrino research will be guided by the outcomes of T2K
  - possibly a second phase for T2K with even more intense neutrino beams

- For particle physics as a whole, a consensus in its future direction emerged:
  - high energy proton–proton collider (LHC at CERN)
  - high energy electron–positron collider (ILC)
  - guided by the outcomes of the LEP program at CERN
    - Canada and Japan were major partners in the OPAL experiment at LEP, and are partnering in the ATLAS experiment at LHC
ILC

- Scientific objective: to uncover new laws of nature
  - in particular the way that particles attain mass and the laws that give rise to hidden matter/energy in our Universe

- Technique: produce new forms of matter by colliding electrons and positrons at the highest possible energies
  - circular colliders are impractical for the energy required – a linear collider is the only option
Accelerator and particle physicists around the world are working together to complete the design of the ILC and its detectors.
In Canada the initial ILC R&D focus has been on detector technology

- in particular: micropattern TPCs were developed in this research program – now being deployed in T2K

- ILC detector R&D work underway in global collaborations

- The LCTPC group (Japan, Canada, US, and Europe) are constructing and testing a large prototype micropattern TPC.
  - magnet provided by Japan
Recently Canada has become involved in ILC accelerator technology R&D
  ◦ focus area: superconducting RF cavities used to accelerate the ILC beams

Our funding request to build a low–energy, high–current electron accelerator at TRIUMF was approved last month
  ◦ the accelerator will use the ILC cavity design and qualify Canadian industry for ILC cavity production
ILC and Canada

- With this new accelerator project, Canada will develop expertise in ILC accelerator technology.

- At the same time the new accelerator will:
  - expand the science program at TRIUMF, by providing more radioactive isotope beams (produced through photo-fission) for existing experiments that study fundamental nuclear science and materials science.
  - act as a demonstration machine for the production of medical isotopes that are currently produced with aging nuclear reactors.
Summary

- Through partnerships, Canada plays significant roles in many international research projects
  - T2K and ILC are just 2 examples

- These partnerships benefit Canada and the other nations involved:
  - sharing knowledge
  - cooperative development of future technologies
  - enhanced opportunities for our students

- I look forward to continued Canada/Japan collaboration on T2K and on the ILC
Thank you