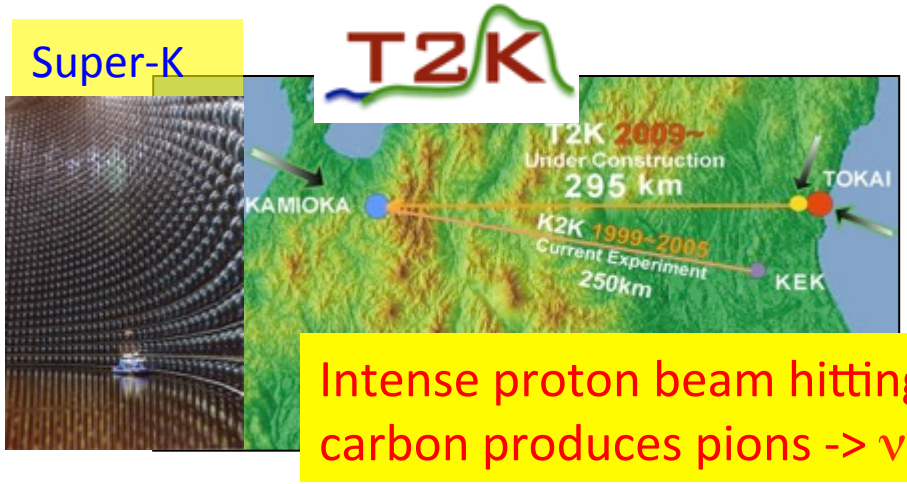
Neutrino Physics is a HOT topic

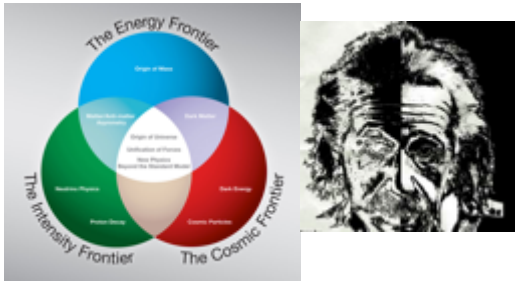


Intense proton beam hitting carbon produces pions -> ν_μ

First data Mar-June2010

Monitor proton beam: Optical Transition Radiation
- detector built by York U./ U.Toronto/TRIUMF
- installed and commissioned in Japan, 08/09 -

T2K (Tokai to Kamioka) is the premier experiment planning to measure a key parameter governing $\nu_\mu \rightarrow \nu_e$ oscillation using man-made neutrinos



Research associate: Arturo Fiorentini
Graduate student on York/T2K: M. Yu, E. Pinzon, M. McCarthy
Graduated from York/T2K: B. Kirby, L. Stawnyczy
T2K is international - CDN groups are from Toronto,TRIUMF, Regina, TRIUMF, UBC, Victoria, Winnipeg, York

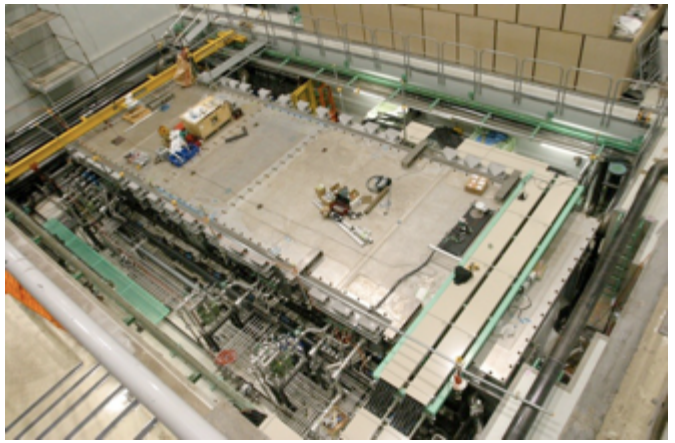
CP Violation

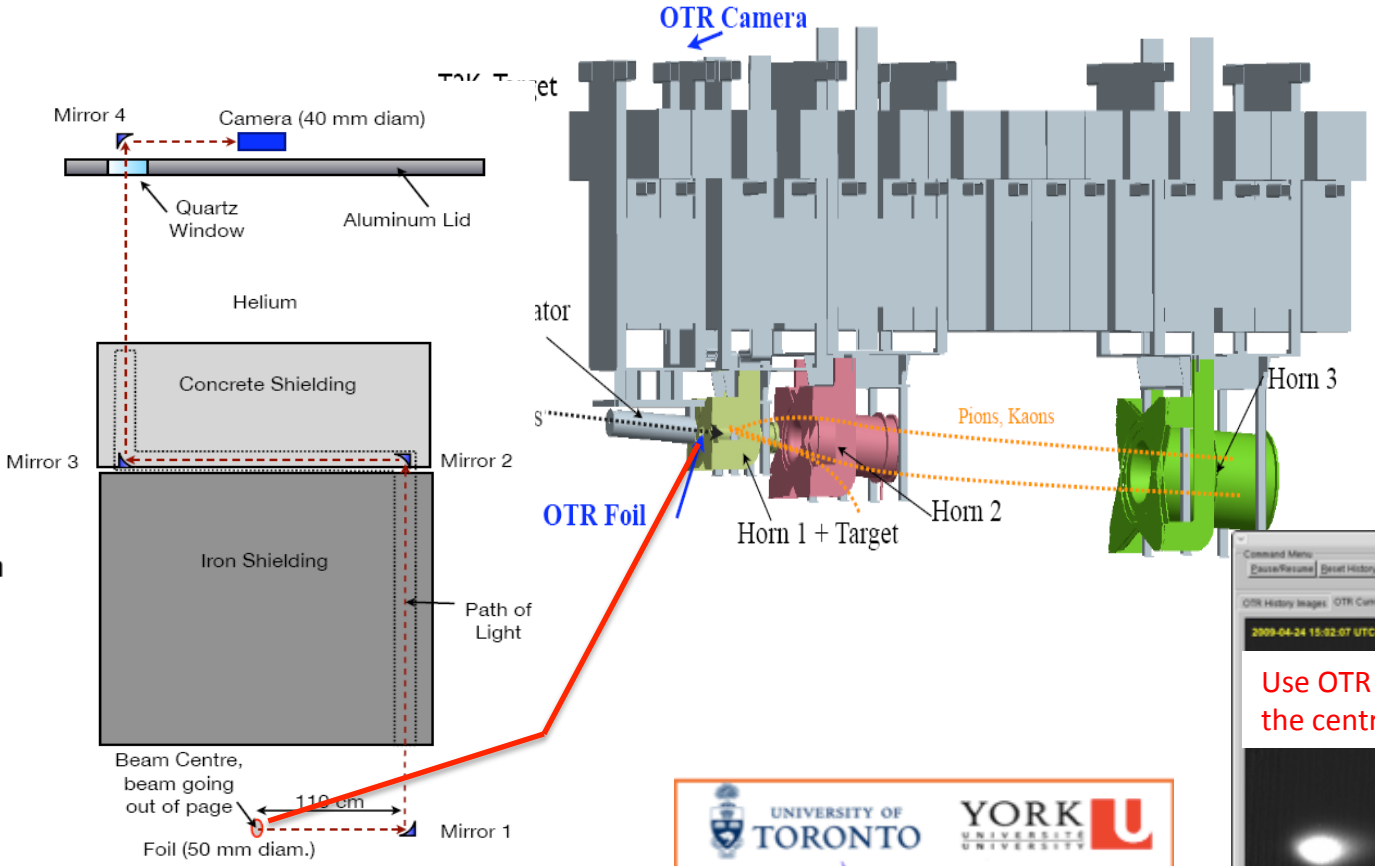
Optical Transition Radiation Detector:

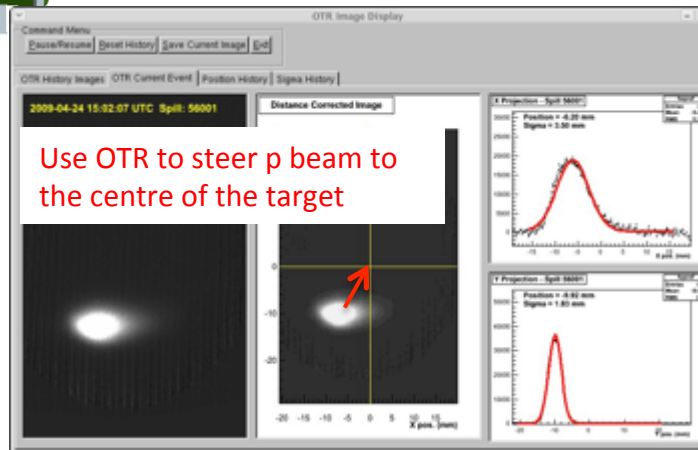
to monitor the proton beam position at the target

Optical transition radiation is emitted in a "cone" when a charged particle crosses a boundary between two media

OTR light is collected and transported through the shielding by a system of four parabolic mirrors area to be imaged with a camera







UNIVERSITY OF TORONTO YORK UNIVERSITÉ TRIUMF

Oscillation Analysis Flow

Flux Prediction
- Proton beam measurements
- Hadron production data

ND280 Measurement
- Inclusive ν_μ CC measurement
- Output: $R_{ND}^{\mu,Data} / R_{ND}^{\mu,MC}$
- Measure ν_e rate as cross-check

Neutrino Cross Sections
- Interaction models
- External cross section data

SK Measurement
- Develop ν_e CCQE candidate selection
- Simulate expectation: N_{SK}^{MC}
- Adjust normalization using ND280 measurement:

$$N_{SK}^{exp} = R_{ND}^{\mu,Data} \times N_{SK}^{MC} / R_{ND}^{\mu,MC}$$

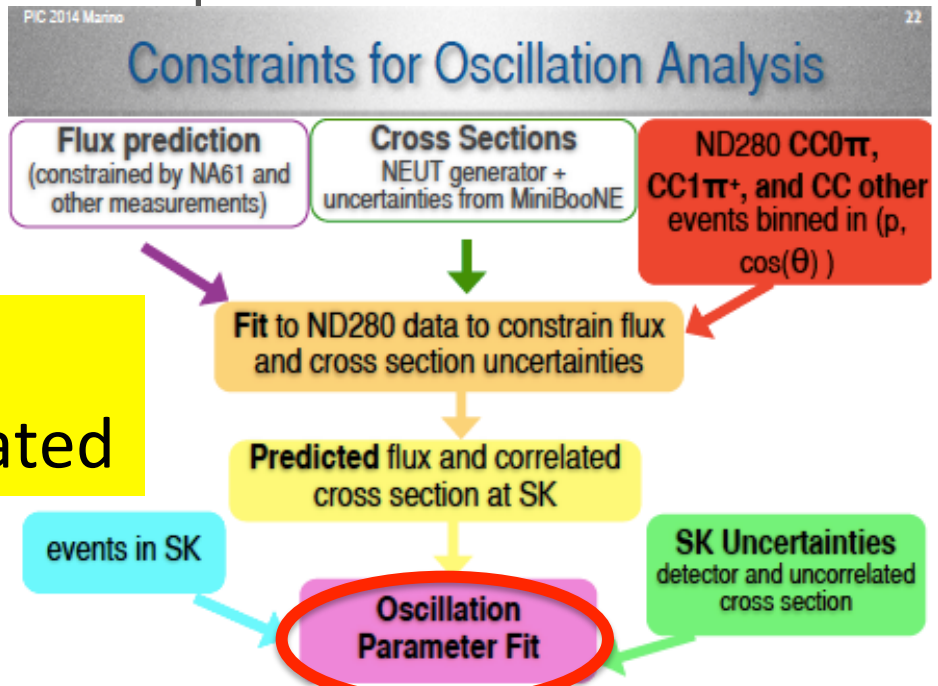
- Evaluate systematics
- Evaluate confidence intervals for data sample

M. Hartz, talk Fermilab 2011

Reducing the uncertainties on the Neutrino flux measurement is crucial for the oscillation analysis

Use many beam monitors
- Information feeds to the beam orbit

A. Marino, PIC, 2014



Join the beam line efforts!
New monitors being investigated

Students and post-docs and engineers working on the OTR whose families are originally from all over the world. Now in Canada/US

Peru

Russia

Japan

China

Colombia

US

Canada

Philippines

India

Romania

T2K Collaboration - North America

USA

Boston University (USA)
Colorado State University (USA)
Duke University (USA)
Louisiana State University (USA)
Michigan State University (USA)
Stony Brook University (USA)
University of California, Irvine (USA)
University of Colorado (USA)
University of Pittsburgh (USA)
University of Rochester (USA)
University of Washington (USA)

CANADA

TRIUMF (Canada)
University of British Columbia (Canada
University of Regina (Canada
University of Toronto (Canada)
University of Victoria (Canada)
University of Winnipeg (Canada)
York University (Canada)

Opportunities for young graduates for study abroad!

IIT-Bombay students went to J-PARC to work on T2K and g-2 experiment

- Fantastic learning experience on hardware (Wagasci and g-2)

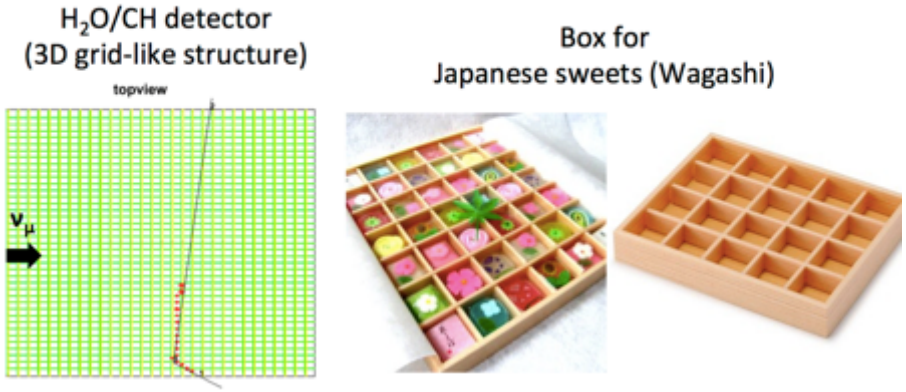
After graduation they will do their Ph.Ds at
University of Chicago and
Rutgers University

where they will continue to collaborate with Japan through their graduate work

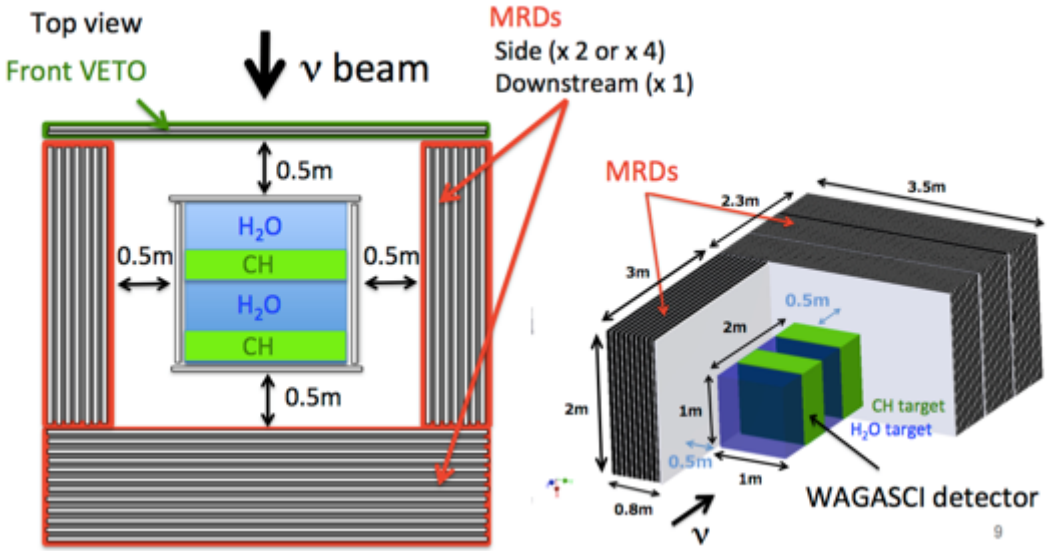
In the T2K oscillation analysis flux and cross section (model) parameters are largely constrained by the near detector (ND280) measurements

The largest systematic is a non-canceling uncertainty related to the cross section model and is caused by the difference in the target material between the near detector ND280 (hydrocarbon, CH, as the active target) and Super-K (H_2O)

WAGASCI



Water **G**rid **Sc**intillation Detector



T Ovsiannikova, IOP article
A. Minamino, Presentation at NuINT

from the IIT students:

"We had a very good experience working at J-PARC. The work at J-PARC was very helpful for gaining exposure to experimental HEP in general as well as for the Ph.D. application"

"The exchange program is indeed wonderful in providing hands-on experience and we benefited a lot from it."

Great opportunities for students in North america (US/Canada) to be involved in Japanese based neutrino experiments! Wealth of exciting new ventures in the works in the next decade.