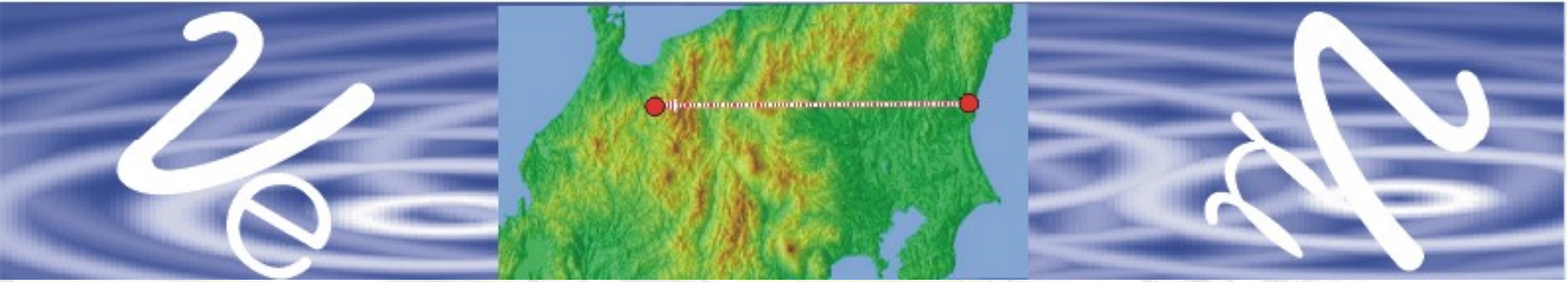


## *Characterising the T2K ν beam:*

# Status of the T2K Near Detectors

**Outline**

- T2K
- J-PARC and beamline
- Super-Kamiokande
- Near Detectors
  - INGRID
  - ND280

*Laura Kormos*

**Lancaster University**

385 members, 65 Institutes, 12 countries

**Canada**
TRIUMF
U. Alberta
U. B. Columbia
U. Regina
U. Toronto
U. Victoria
York U.

**France**
CEA Saclay
IPN Lyon
LLR E. Poly.
LPNHE Paris

**Germany**
U. Aachen

Japan
U. Hiroshima
ICRR
ICRR Kamioka
ICRR RCCN
KEK
Kyoto U.
U. Kobe
U. Miyagi
U. Osaka City
U. Tokyo

Switzerland
U. Bern
U. Geneva
ETH Zurich

Poland
IPJ Warsaw
IFJ PAN, Cracow
T. U. Warsaw
U. Silesia, Katowice
U. Warsaw
U. Wroclaw

S. Korea
N. U. Chonnam
U. Dongshin
N. U. Gyeongsang
N. U. Kyungpook
U. Sejong
N. U. Seoul
U. Sungkyunkwa

Spain
IFIC, Valencia
U. A. Barcelona

USA
Boston U.
B.N.L.
Colorado S. U.
Duke U.
Louisiana S. U.
Stony Brook U.
U. C. Irvine
U. Colorado
U. Pittsburgh
U. Rochester
U. Washington

Italy
INFN, U. Roma
INFN, U. Napoli
INFN, U. Padova
INFN, Pol. of Bari

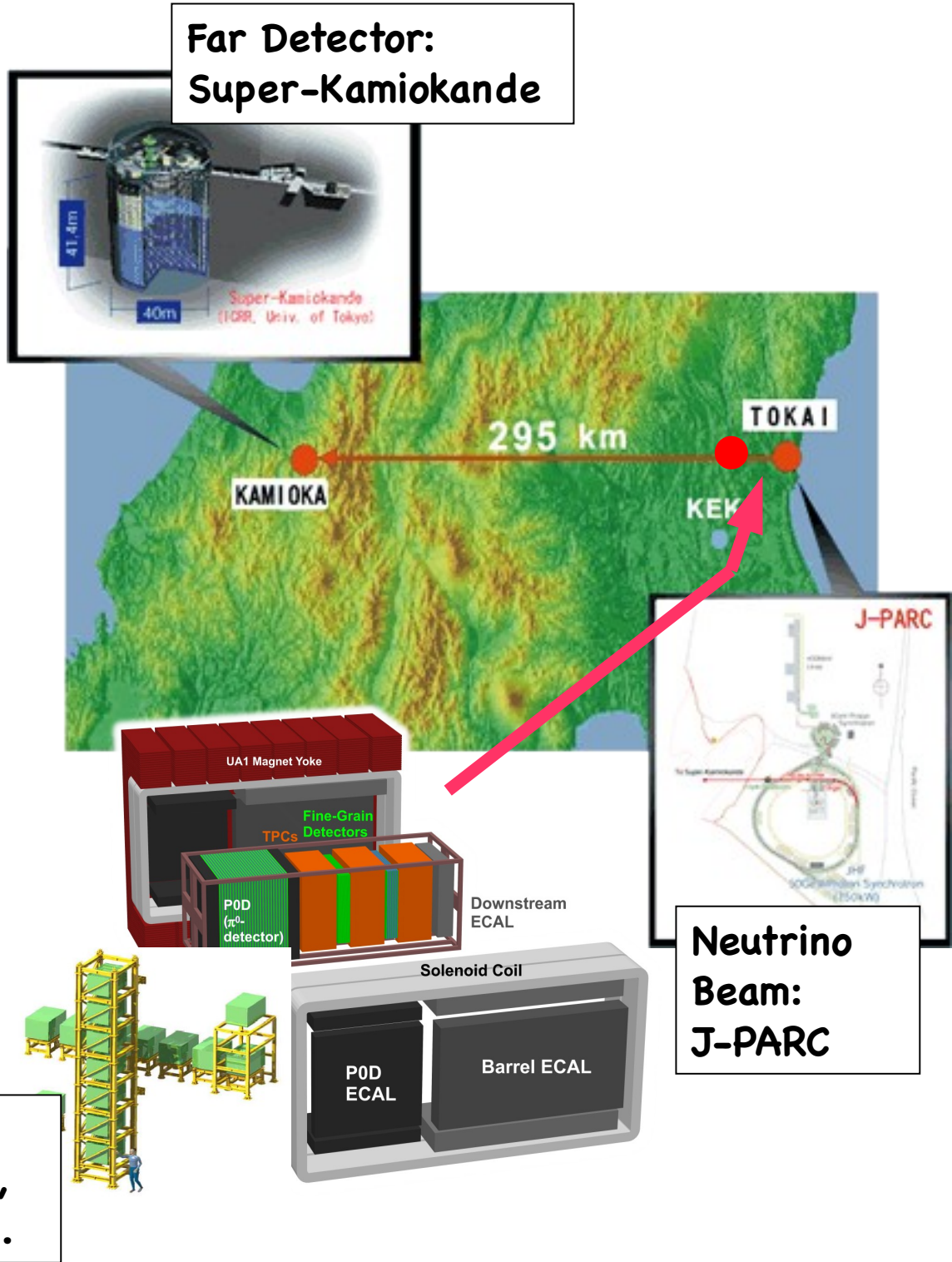
United Kingdom
Imperial C. London
Queen Mary U. L.
Lancaster U.
Liverpool U.
Oxford U.
Sheffield U.
Warwick U.
STFC, RAL
STFC, Daresbury

Russia
INR

# The T2K Collaboration

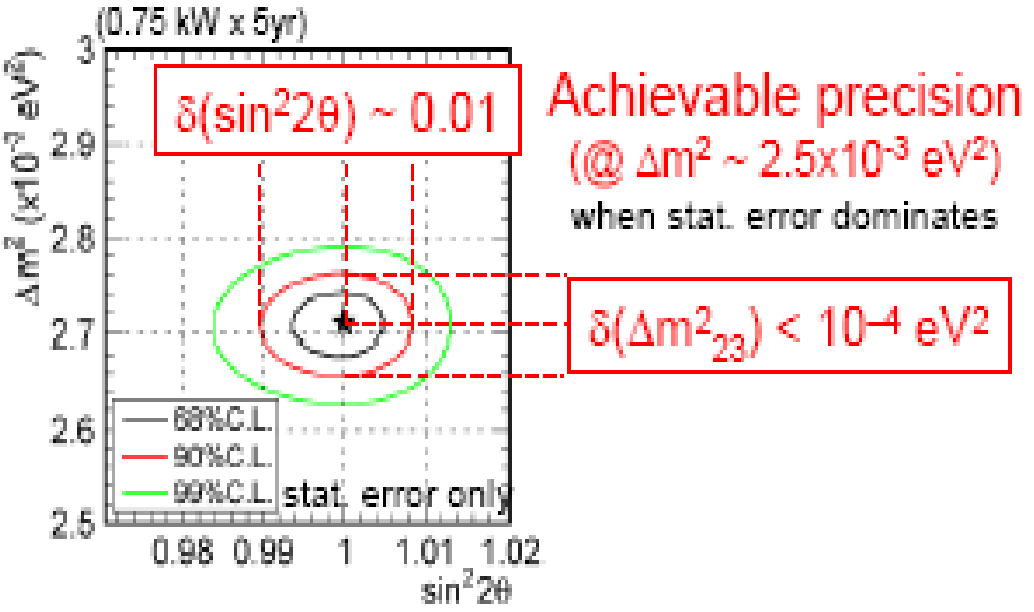
# The T2K Experiment

- Long baseline neutrino experiment
  - Baseline 295km
- Search for/measure neutrino oscillations:
  - $\nu_\mu \rightarrow \nu_e$
  - $\nu_\mu \rightarrow \nu_\tau$
- Improve measurement of $\theta_{23}$, $\Delta m^2_{23}$
  - Does $\theta_{23}$ represent maximal mixing?
- First measurement of $\theta_{13}$
  - How small is $\theta_{13}$?
- In phase 2, search for CP violation.

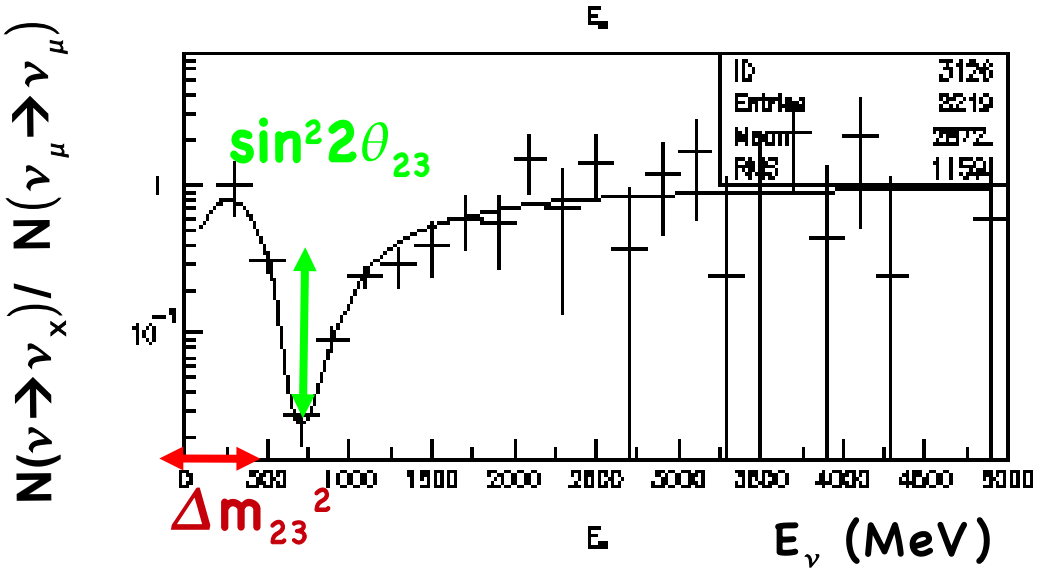


# Main T2K Measurements: $\sin^2 2\theta_{23}$, $\Delta m^2_{23}$

- **Phase 1:**
  - 5 years X 0.75 MW beam
  - $5 \times 10^{21}$ pot
  - Measurement of mixing angles

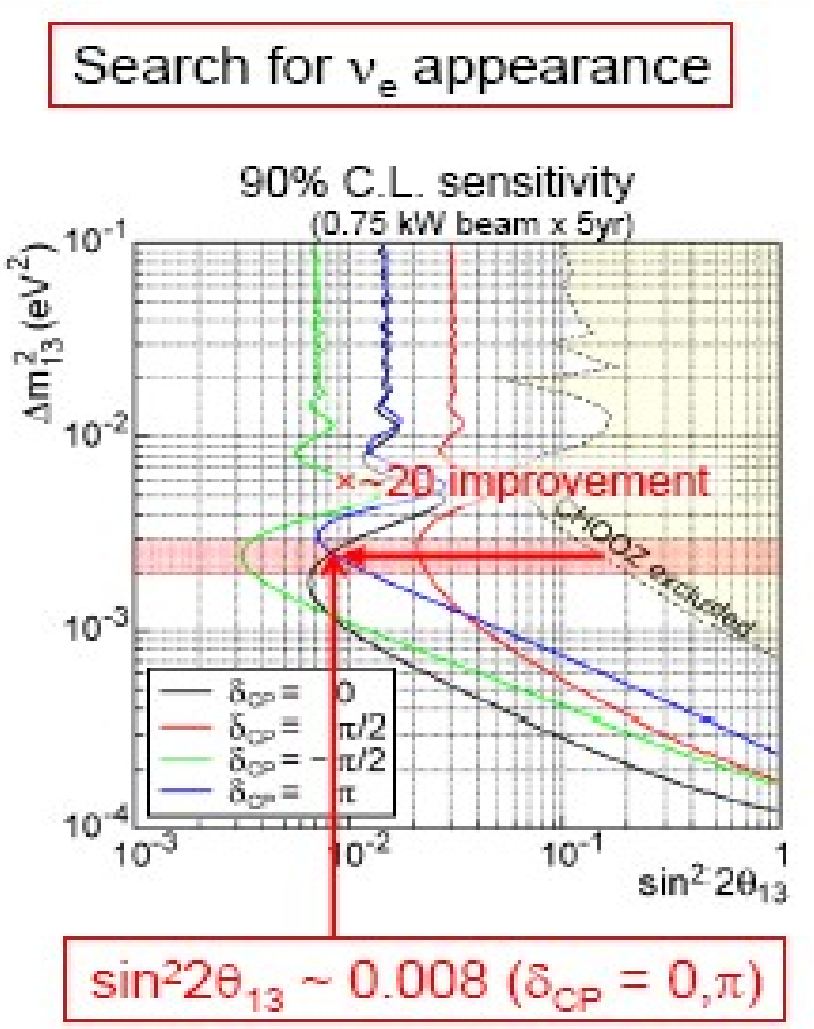


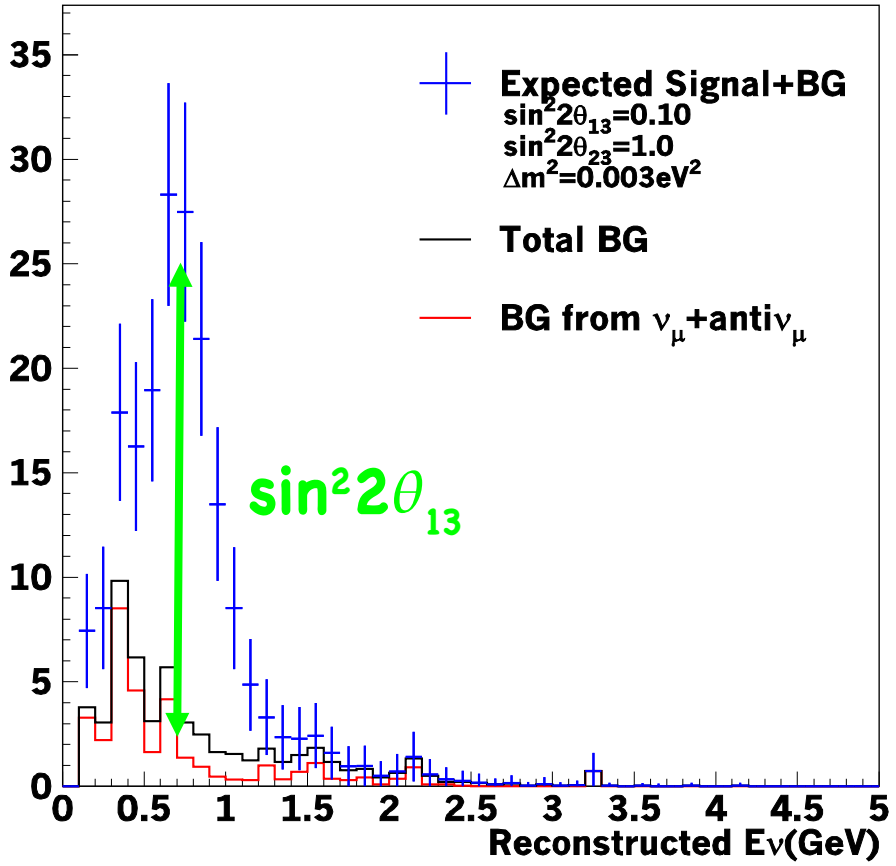

$\nu_\mu$ disappearance




- **Use CC Quasi Elastic Events**
  - Can reconstruct neutrino energy.
  - Background from non-CCQE interactions.

# Main T2K Measurements: $\sin^2 2\theta_{13}$



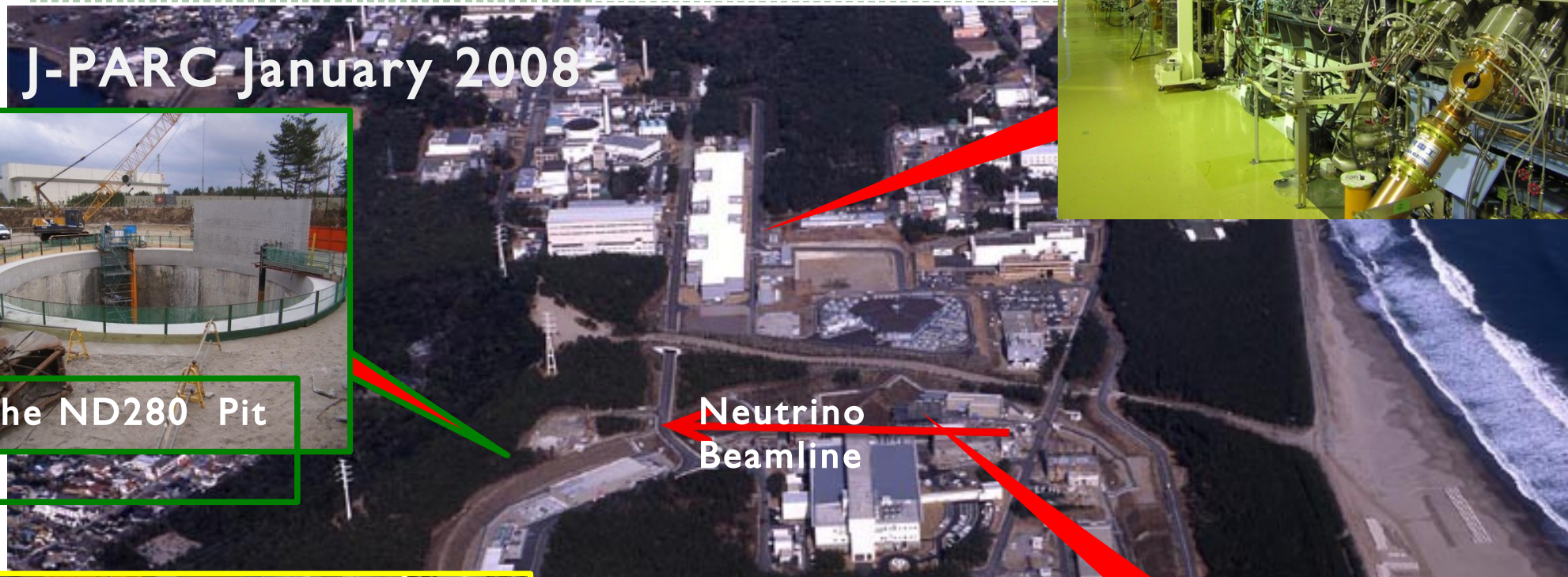




**Main Backgrounds:**

**Beam $\nu_e$ contamination**

**NC $\pi^0$ events**

# The J-PARC Facility

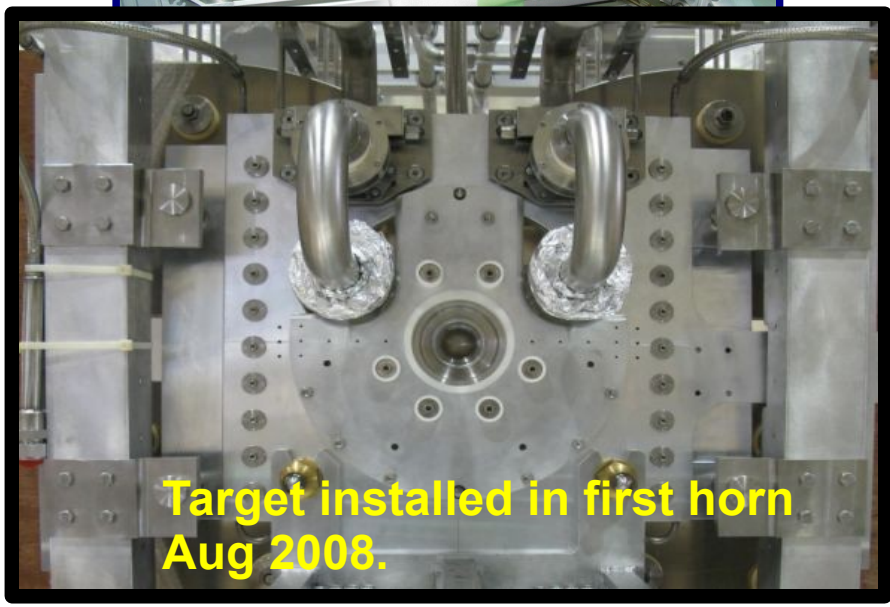


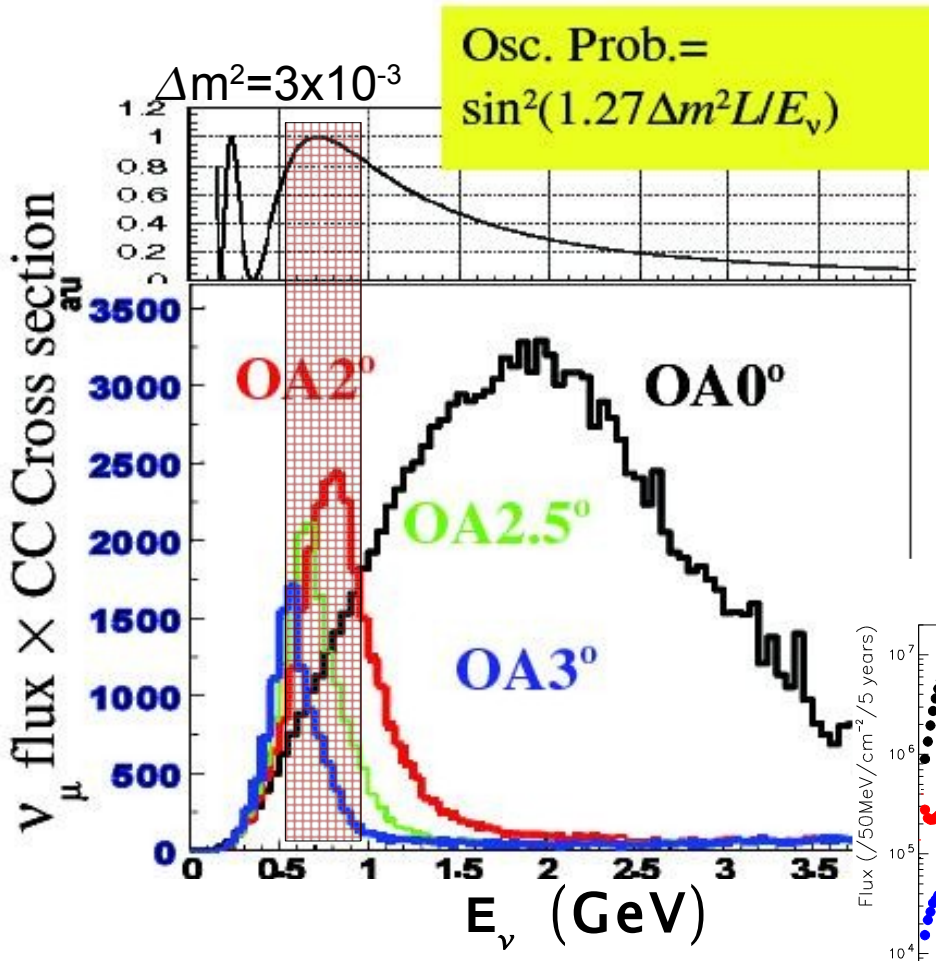


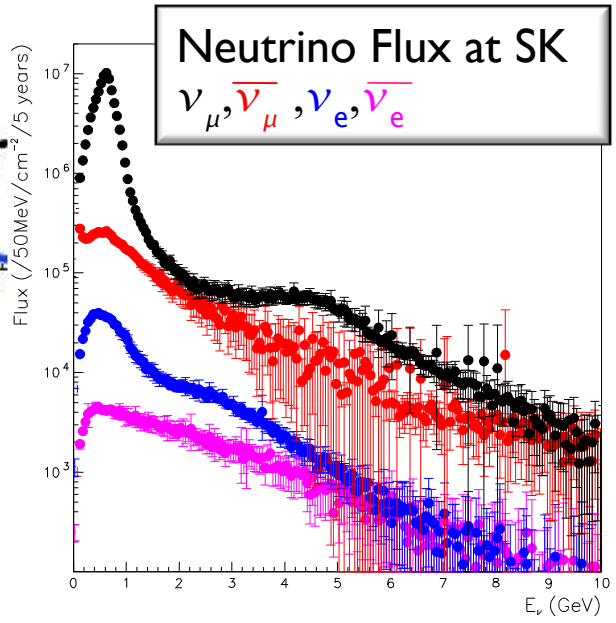

Phase 1: 0.75 MW

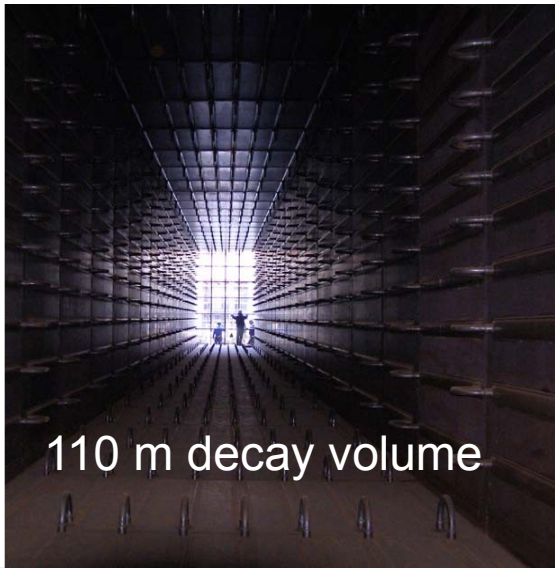
# The neutrino beamline

Off axis-beam ⇒ narrow band, just the $\nu$ we want.



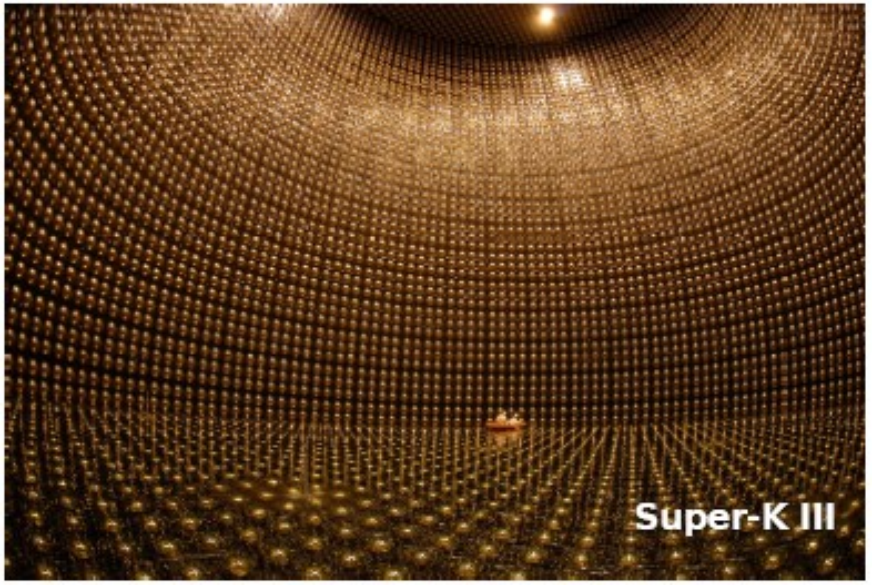




Beam predictions to be tested:
Near detectors : $\nu$s
NA61: Hadrons

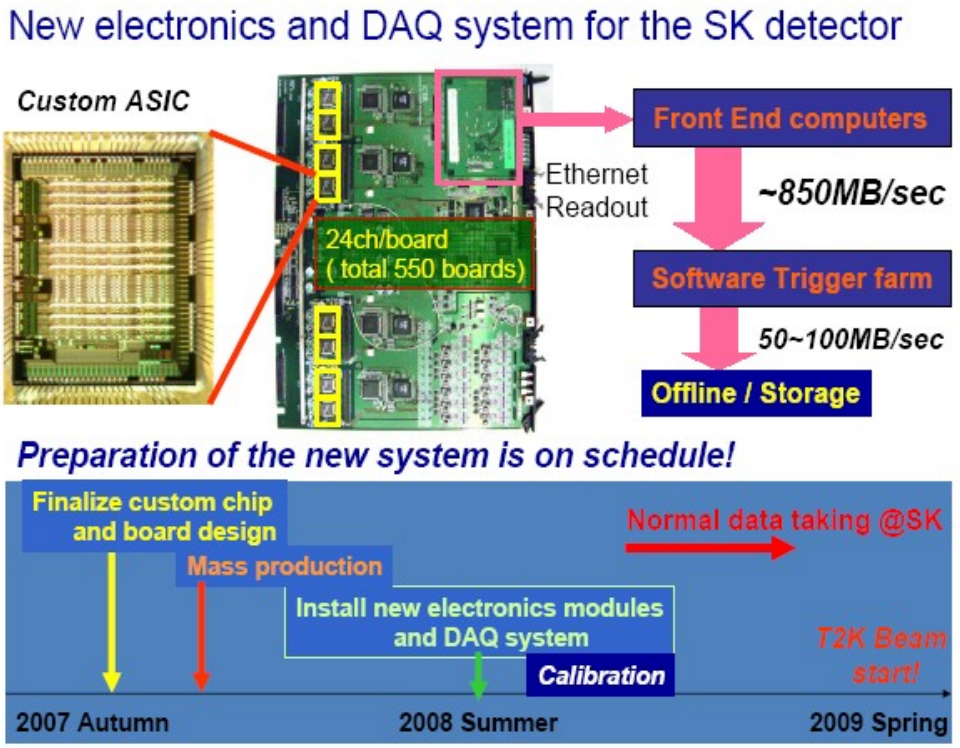
# Super-Kamiokande

- Lots of experience detecting neutrinos.
- Recent results covered earlier in this session.



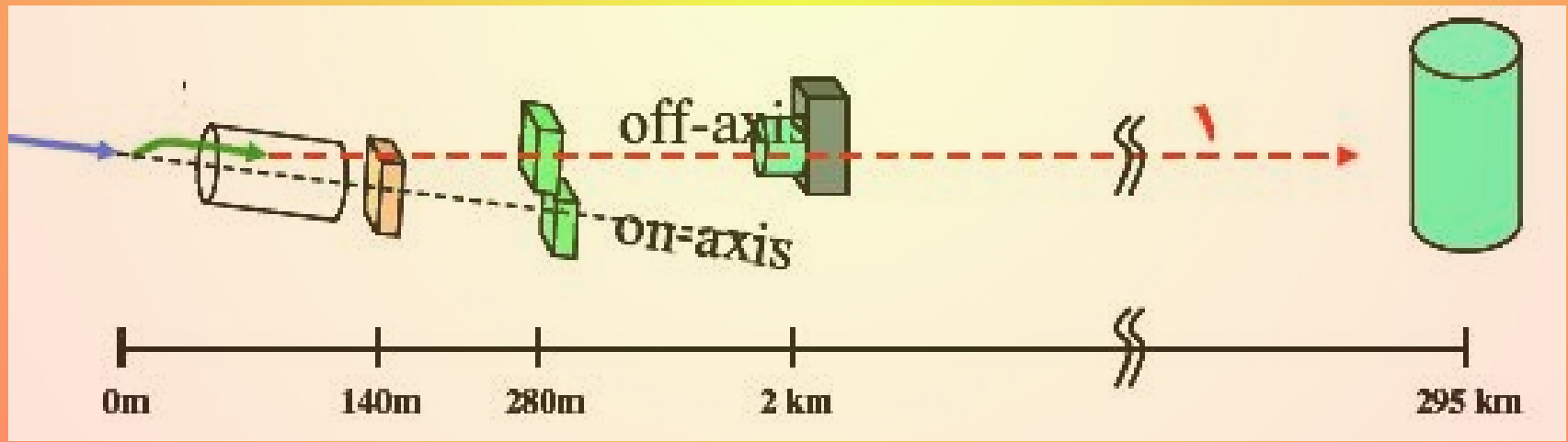

## Preparations underway to improve for T2K.

- Upgrade of old electronics and DAQ to new system:
  - Work underway.
  - Full system commissioned this year, in time for T2K beam.



*"Slight not what's near,*
*while aiming at what's far."*

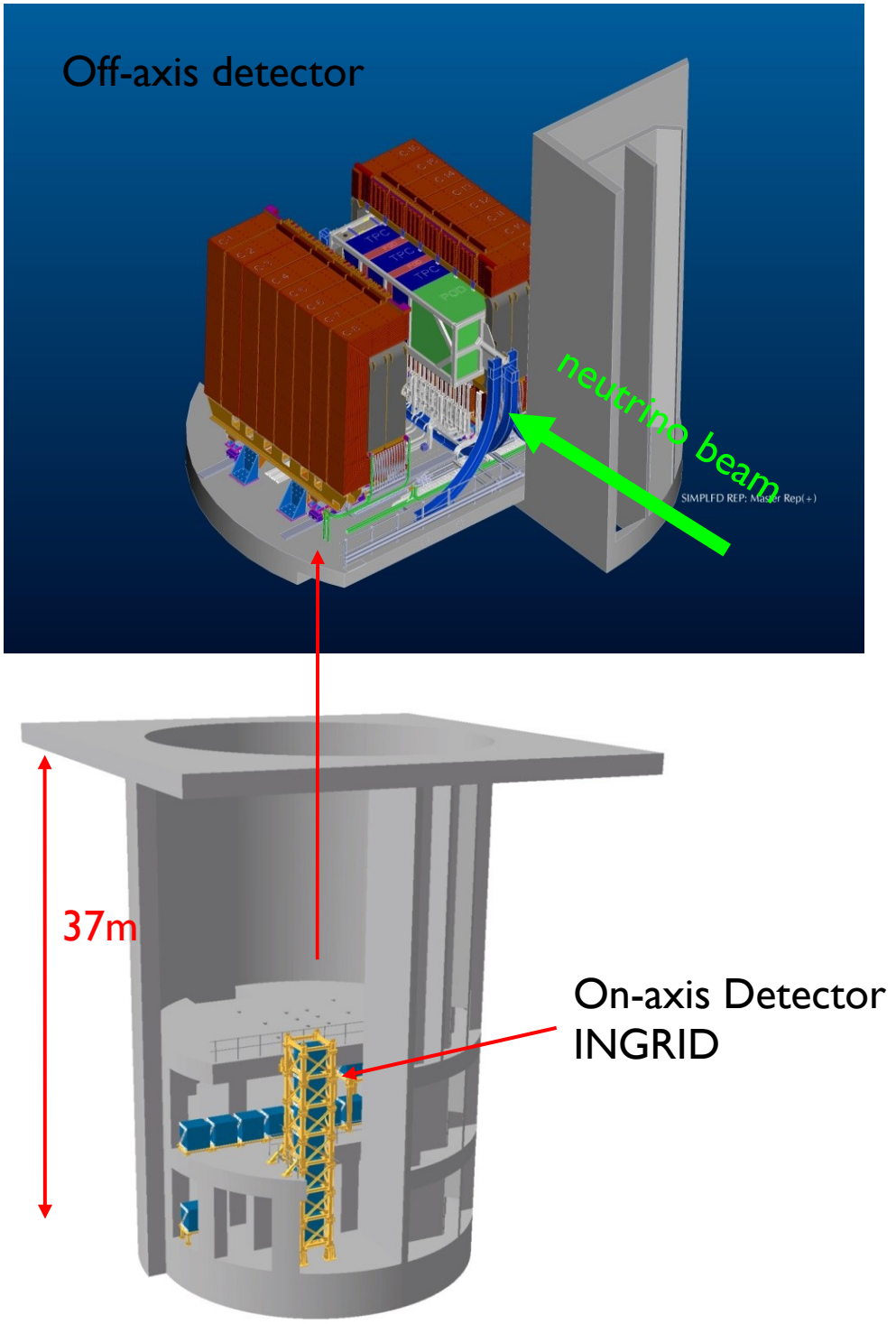
*-Euripides (~450 BC)*



# The T2K near detector suite.

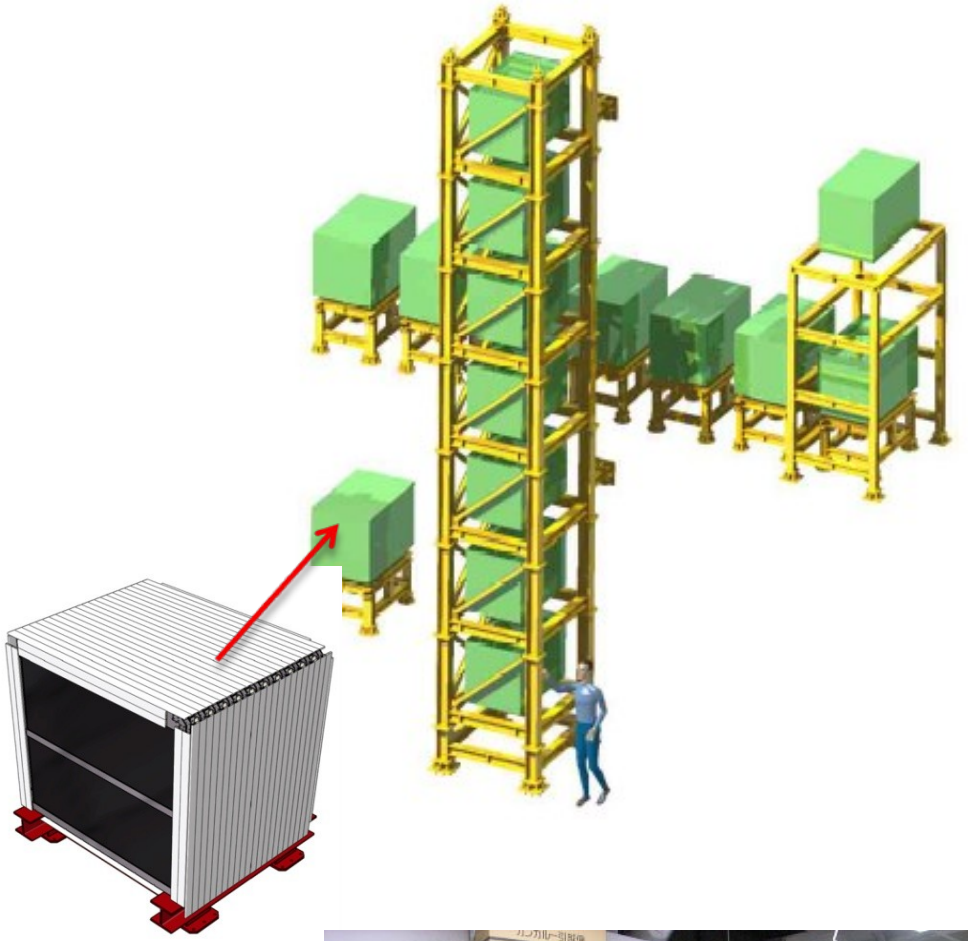
Understand the neutrino beam.

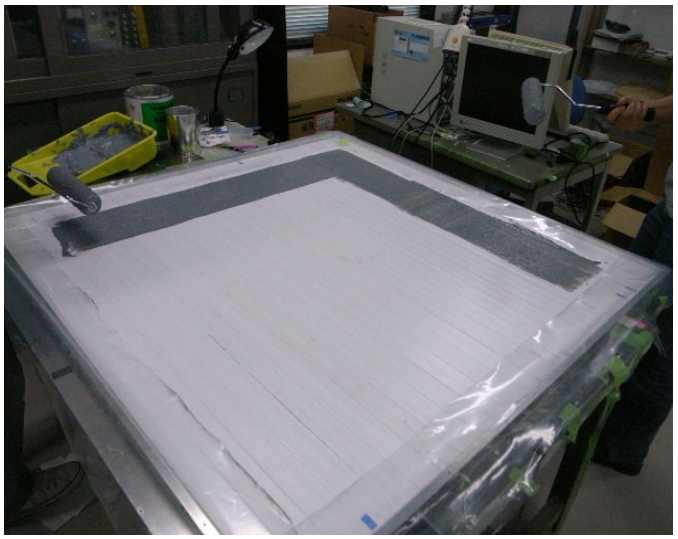
- **On – Axis Detector**
  - Beam monitoring.
  - Beam direction.
- **Off – Axis Detector**
  - Understand the neutrino beam to SK.
  - Beam flux.
  - Beam $\nu_e$ contamination.
  - Background processes.
  - Cross sections.



# On Axis – The INGRID Detector

- Modular Detector
  - 16 Modules.
- Each Module
  - 10 Scintillator Bar Layers
  - 9 Iron Layers.
  - 2 Surrounding Veto Planes
  - Wavelength Shifting Fibre → Hamamatsu MPPCs.

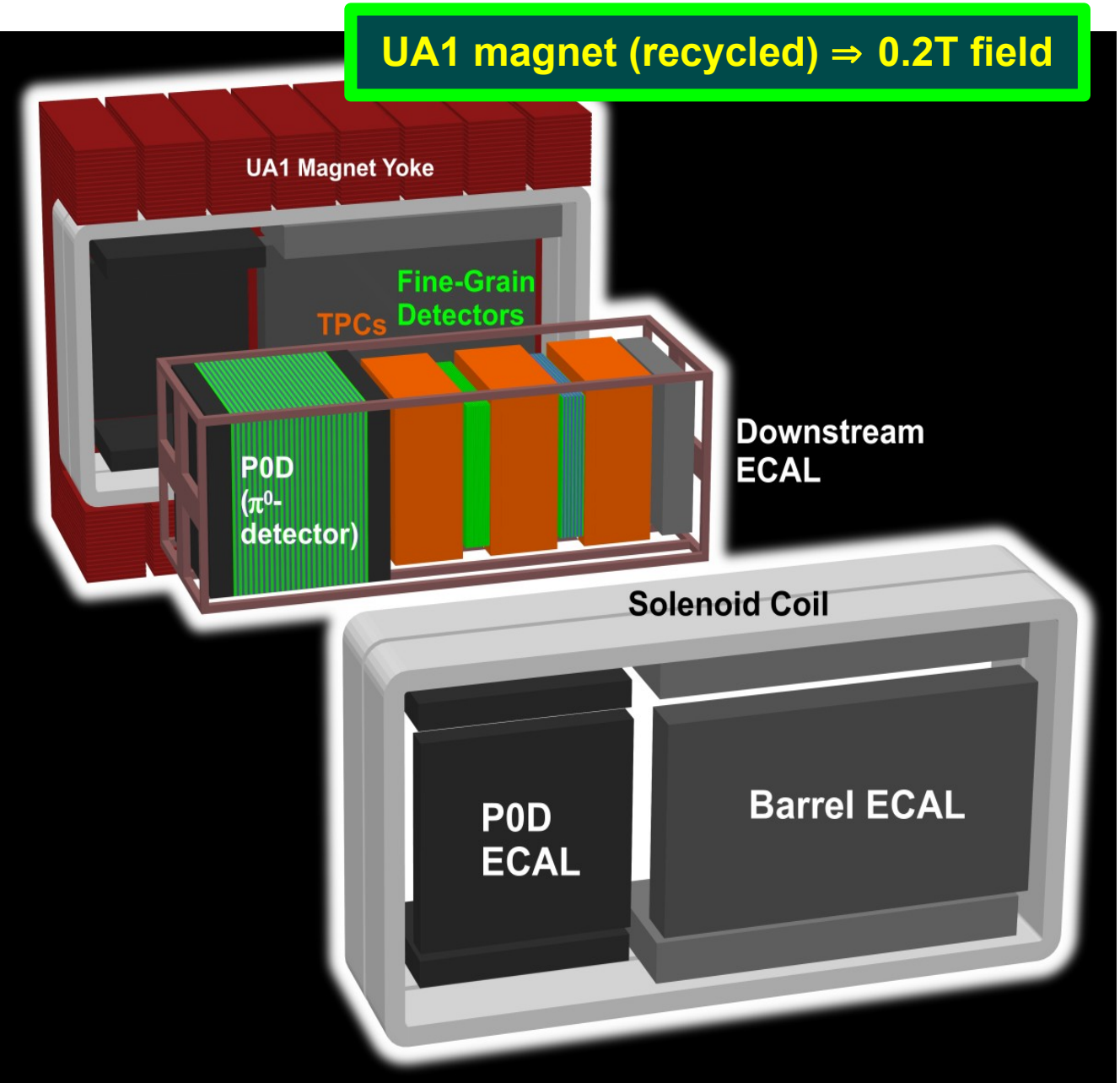





**INGRID Module Construction Underway**

# The Off-Axis Detector

Detailed understanding of beam to SK




## P0D: $\pi^0$ Detector

Layers of lead/water and plastic scintillator.

## 3 TPCs: Time Projection Chambers

High-resolution tracking chambers with Micromegas readout.

## 2 FGDs: Fine-Grained Detectors

High-granularity layers of water and plastic scintillator.

## ECal: Electromagnetic Calorimeter

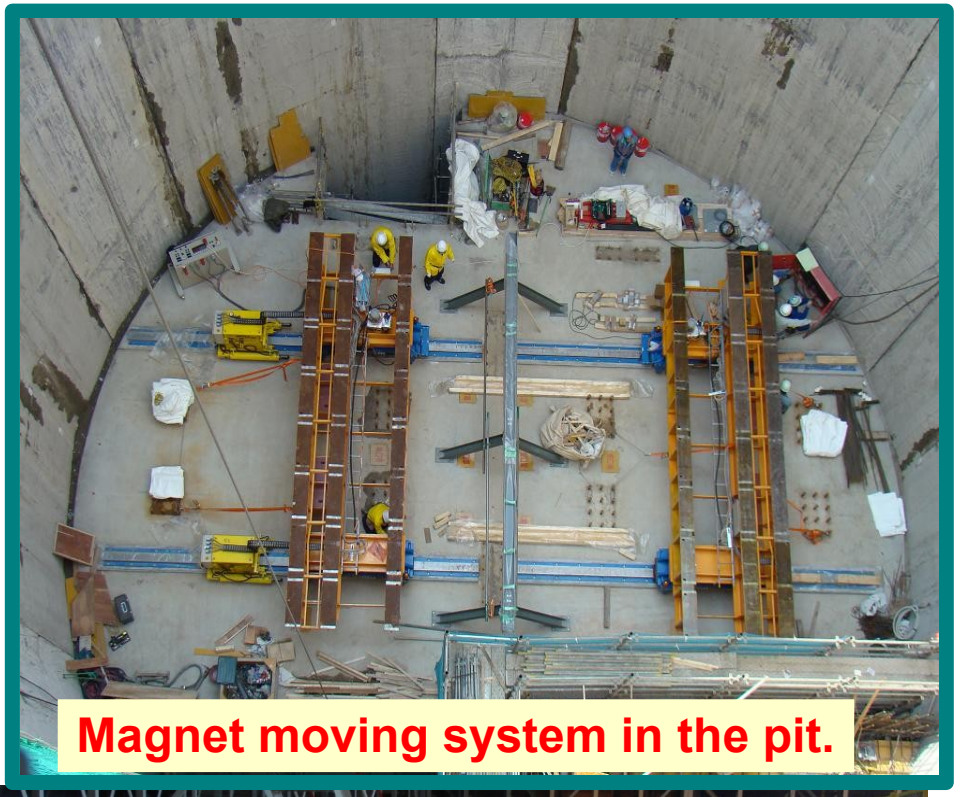
Layers of lead and plastic scintillator.

## SMRD: Side Muon Range Detector

Slabs of plastic scintillator inside iron magnet yoke.

# ND280 Magnet & Basket

Installation of the coils



Magnet moving system in the pit.

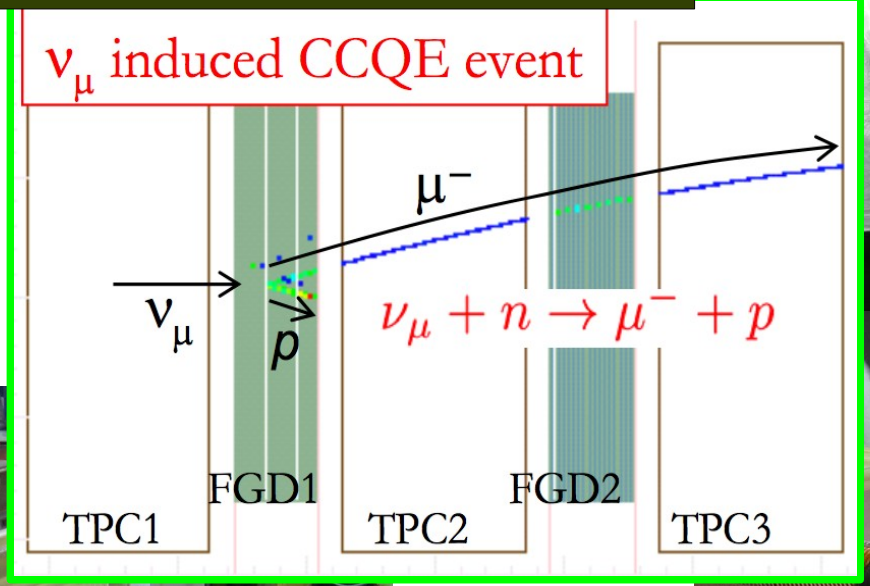
Magnet yokes in the pit

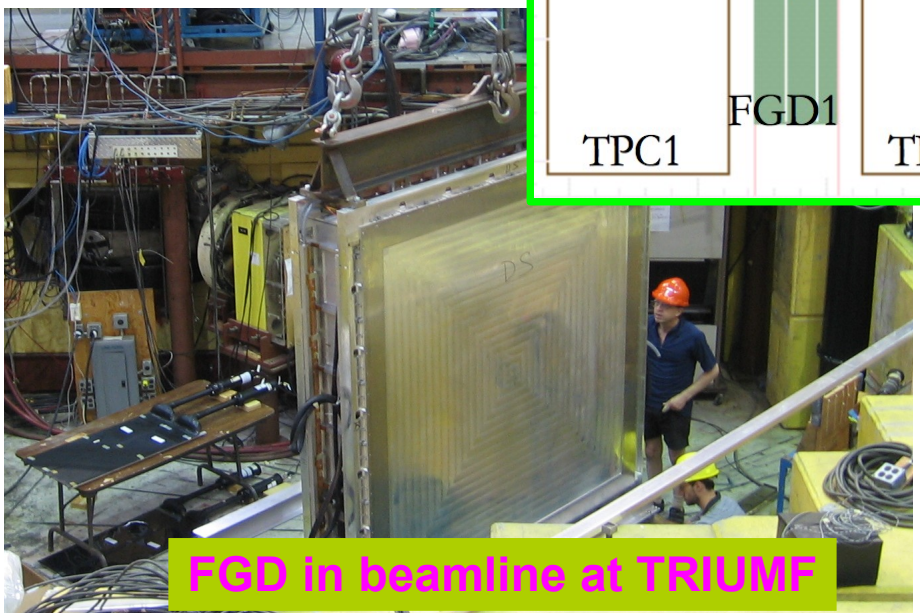
Delivery of the basket for testing.

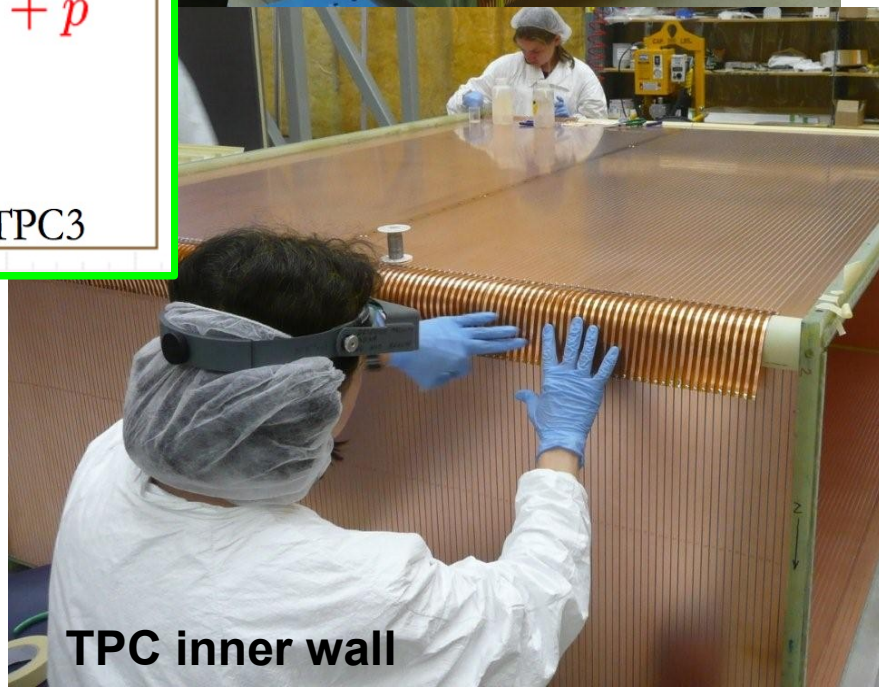
# Constructing the ND280: Tracking region

TPCs and FGDs

- Measure the CCQE events ($\nu_e$ & $\nu_\mu$ flux, E-spectrum).
- Measure $\nu$ cross-sections and kinematics.
- Measure nuclear recoil.
- PID.

# Constructing the ND280: P0D, ECal, SMRD

P0D

- $\pi^0$ detector.
- Measure $\nu_e$-appearance backgrounds, especially $\pi^0$ production rates, kinematics.
- Water-in vs water-out subtraction for cross-sections.

ECal

- Surrounds P0D and trackers to capture EM energy.
- $\pi^0$ reconstruction and PID.

SMRD

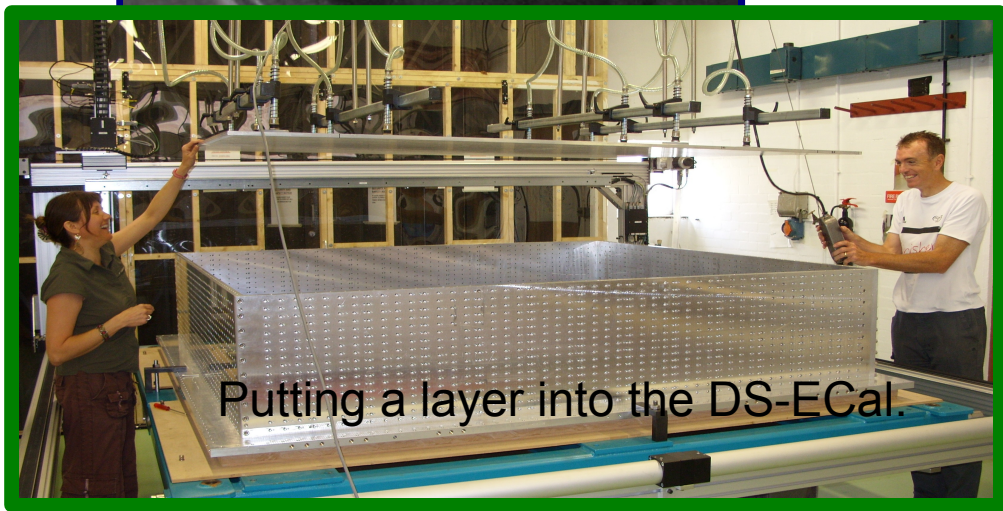
- Muon-ranging instrumentation in magnet yoke.


SMRD Bars


ECal scanner in operation.

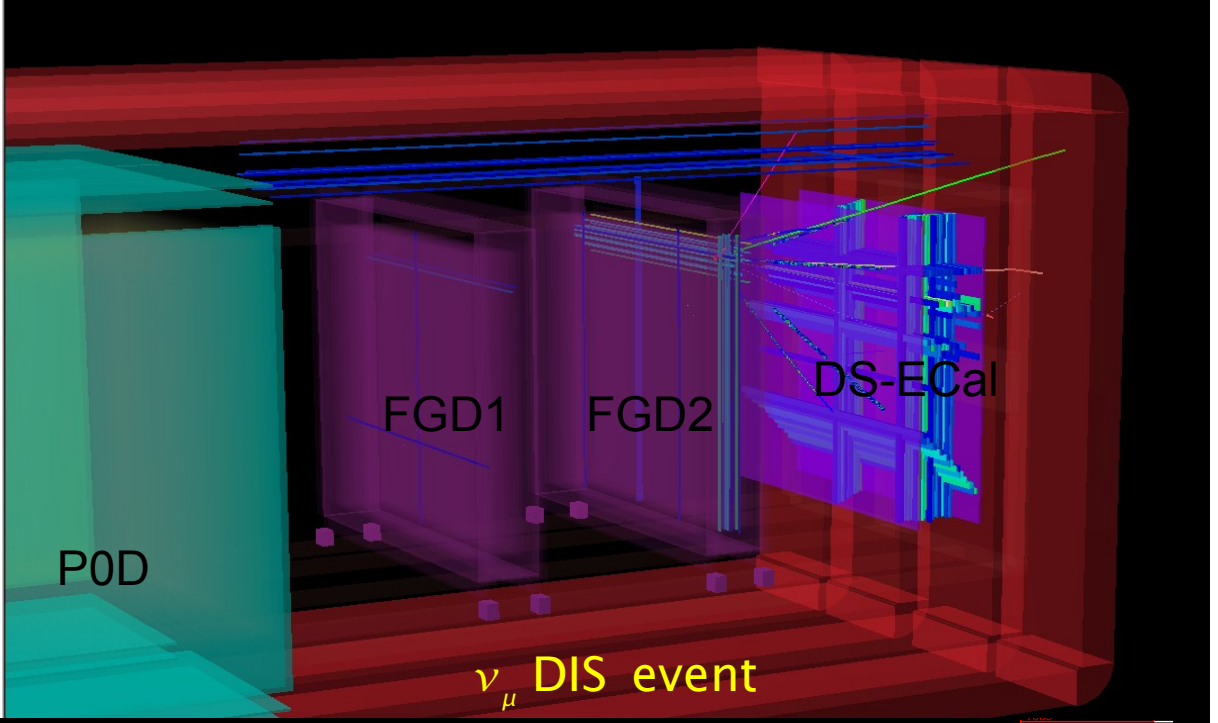

23 P0Dules in storage frame.

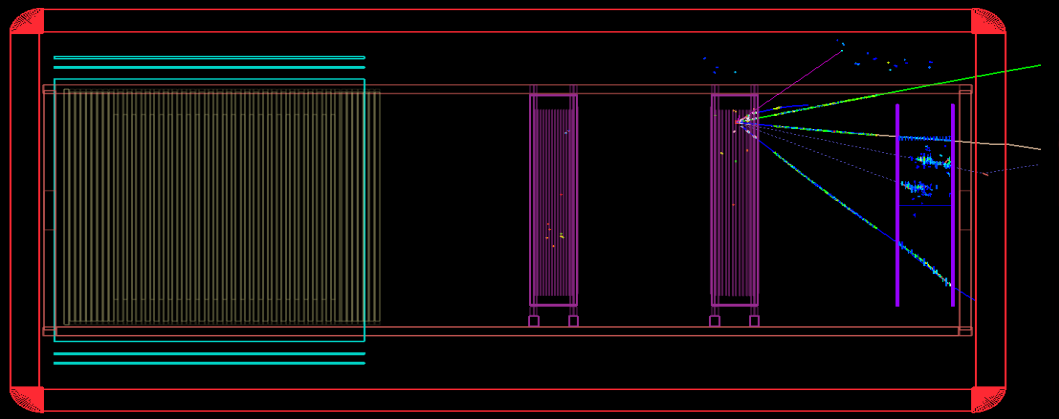

P0D bars


Putting a layer into the DS-ECal.

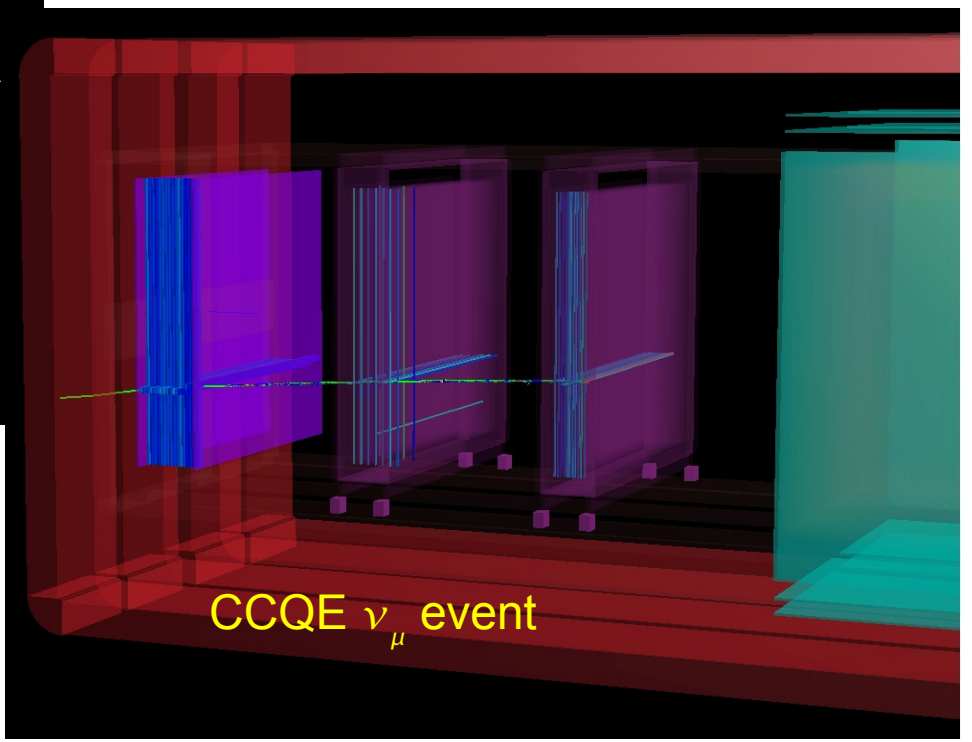
# ND280 event

- As ND280 is being physically integrated, it is also being virtually integrated!
- Software team is working on matching subdetector information at boundaries.
- A "Physics Book" is being created.



The reconstructed tracks overlay the MC "truth" tracks.

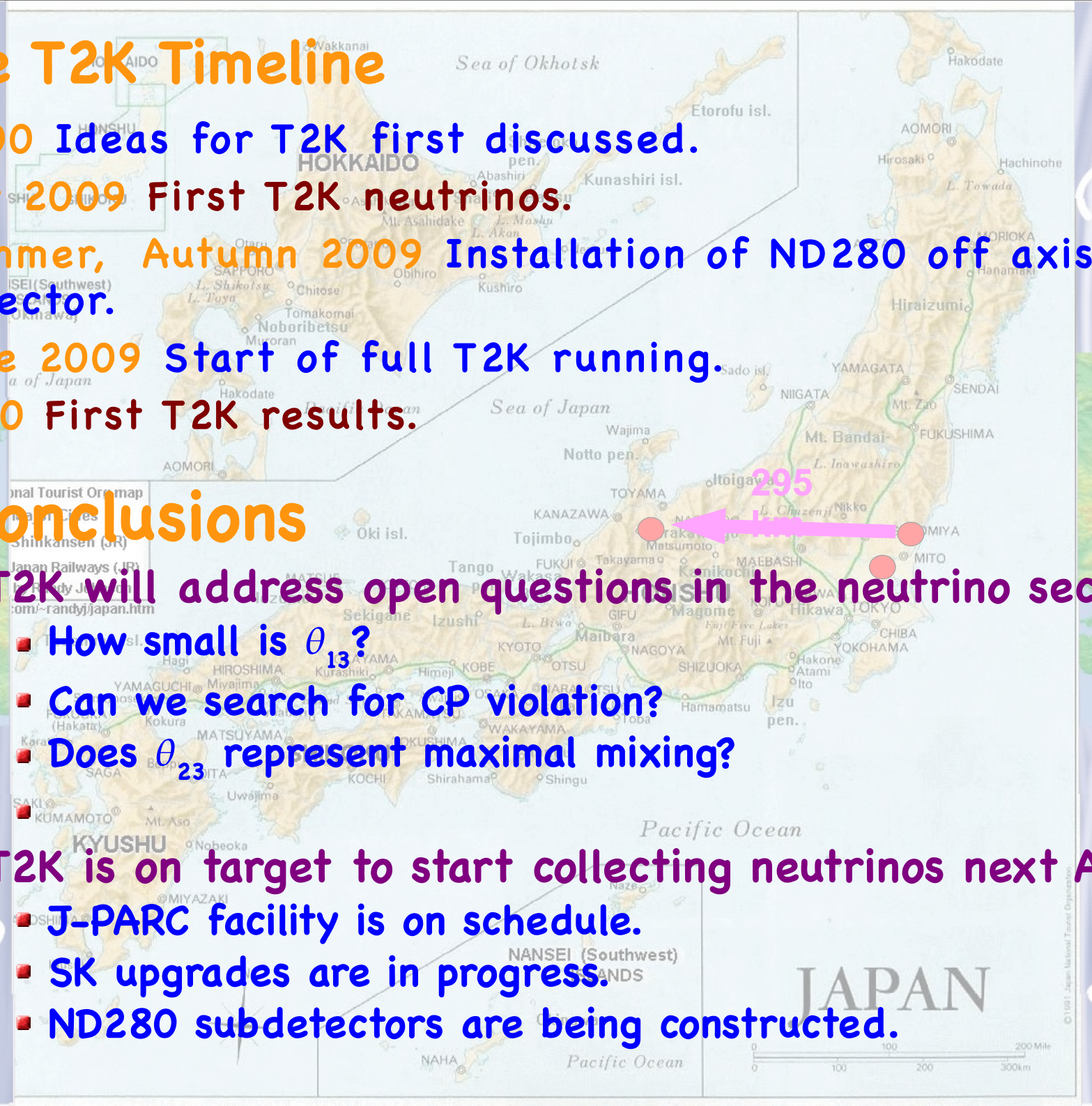


# The T2K Timeline

- 2000 Ideas for T2K first discussed.
- Apr 2009 First T2K neutrinos.
- Summer, Autumn 2009 Installation of ND280 off axis detector.
- Late 2009 Start of full T2K running.
- 2010 First T2K results.

# Conclusions

- T2K will address open questions in the neutrino sector.
  - How small is $\theta_{13}$?
  - Can we search for CP violation?
  - Does $\theta_{23}$ represent maximal mixing?
- T2K is on target to start collecting neutrinos next April.
  - J-PARC facility is on schedule.
  - SK upgrades are in progress.
  - ND280 subdetectors are being constructed.



# BACKGROUND SLIDES

# J-PARC Milestones and Timeline

- The Accelerator Group at JPARC is meeting their milestones.

- Linac : Fully Commissioned
  - 181 MeV (day 1 beam energy) achieved Jan 2007
  - Good beam stability
- 3 GeV Synchrotron (RCS) : Fully Commissioned
  - 3 GeV acceleration and extraction Oct 2007
  - $4.4 \times 10^{12}$ particles per bunch
  - Aiming for 100 kW operation at 25 Hz
- Main Ring Synchrotron
  - Beam has been captured and circulated from RCS May 2008
  - Acceleration to 30 GeV after the summer.
  - Extraction to neutrino beamline **Apr 2009**