The T2K Experiment

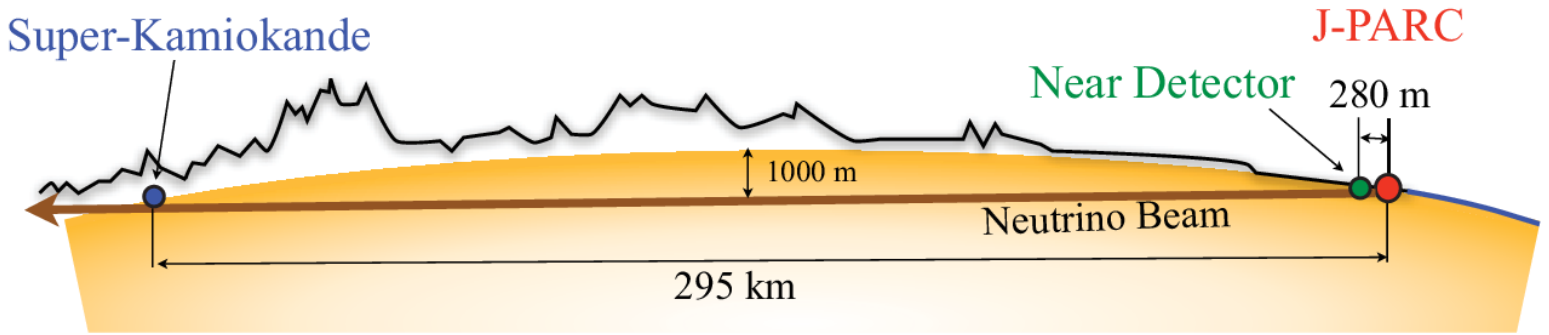
Daniel Scully

NuInt
22.10.2012

On behalf of

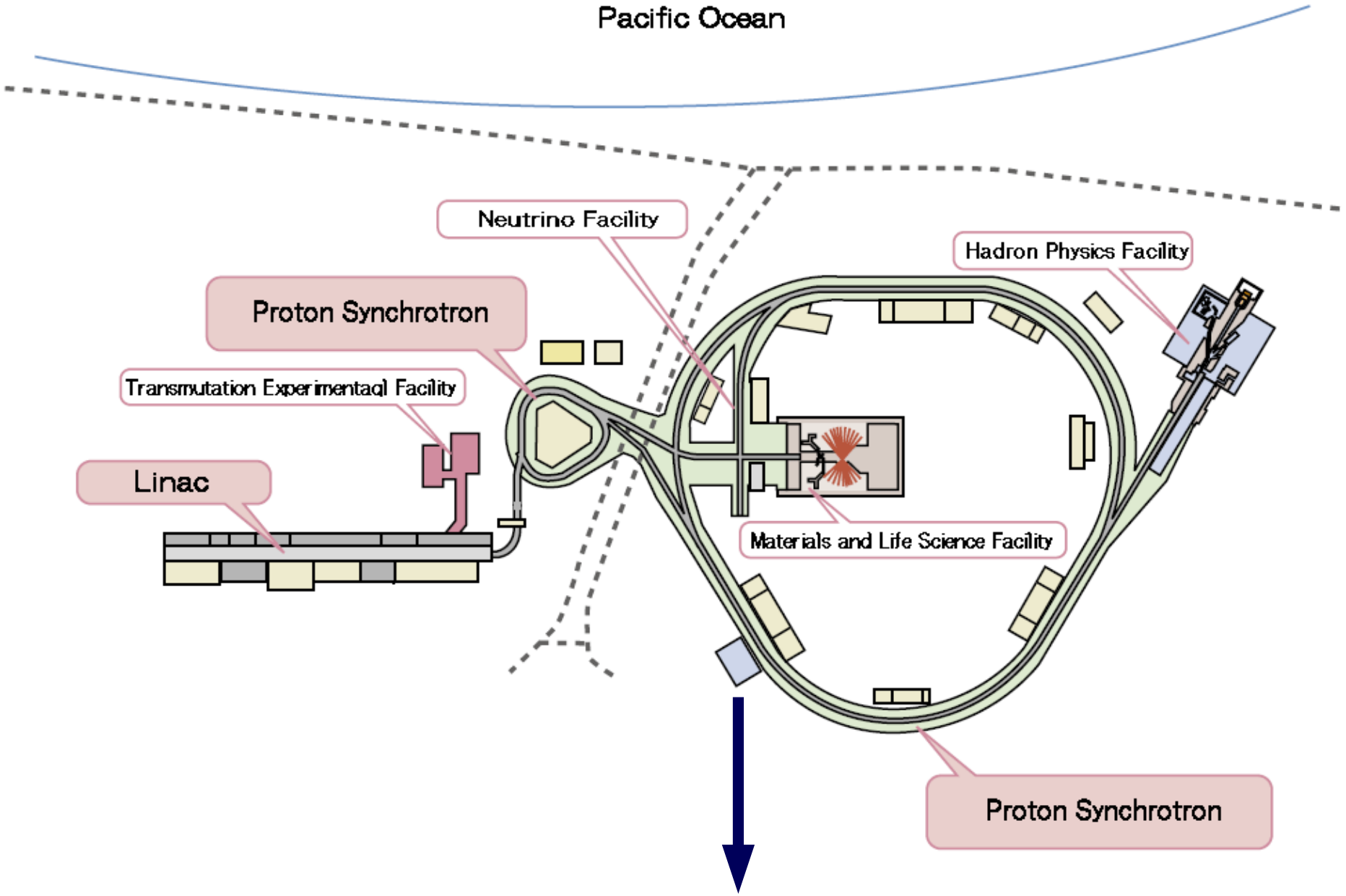
504 people, From 59 institutes, In 12 countries

The T2K Experiment



- Long-baseline neutrino oscillation experiment
- J-PARC produces off-axis neutrino beam
- Near Detectors for flux and cross-sections
- Far Detector at Super-Kamiokande
- Precision measurements of θ_{23}, θ_{13}, Δm^2_{32} and neutrino interaction cross-sections

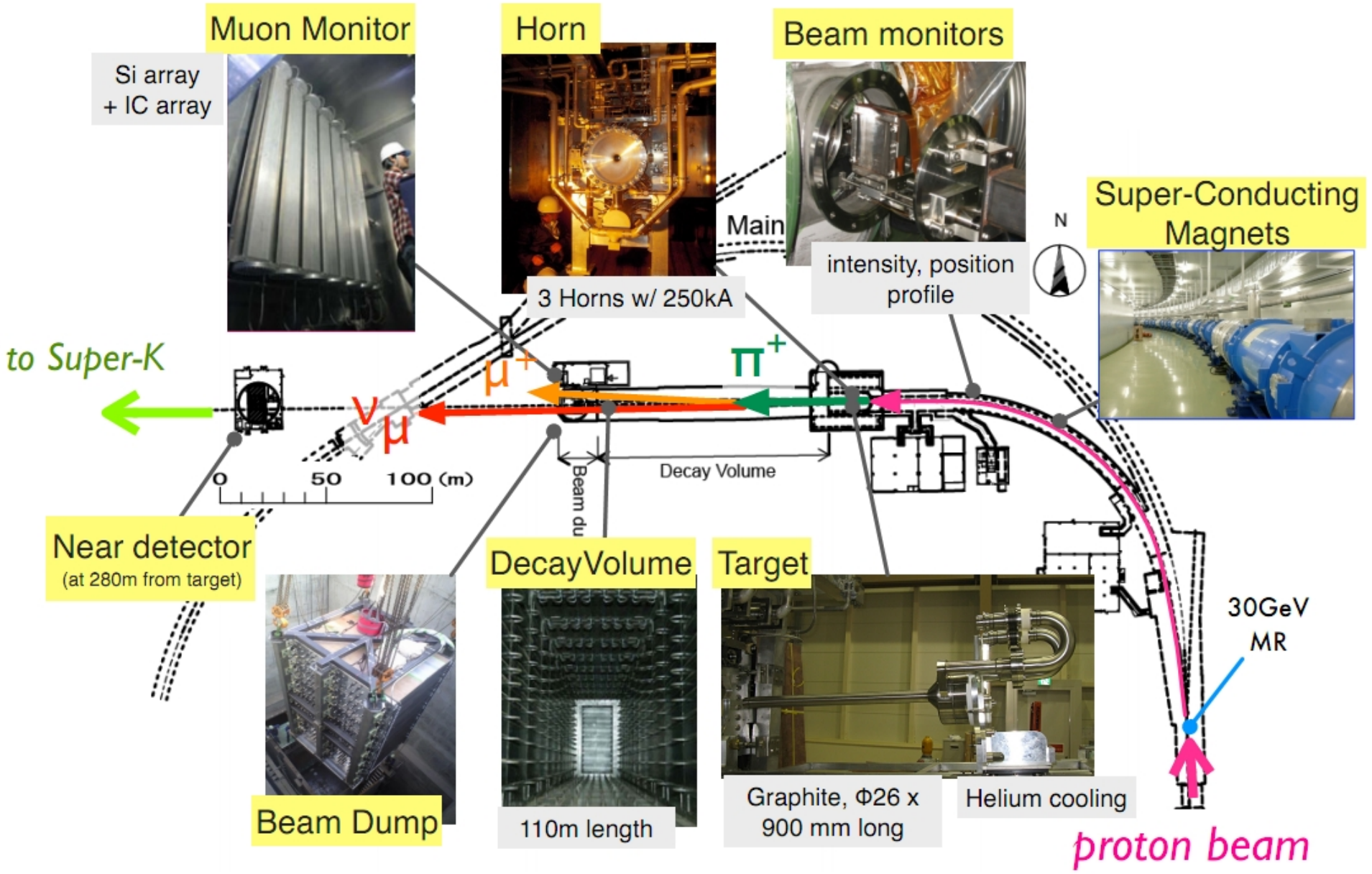
J-PARC



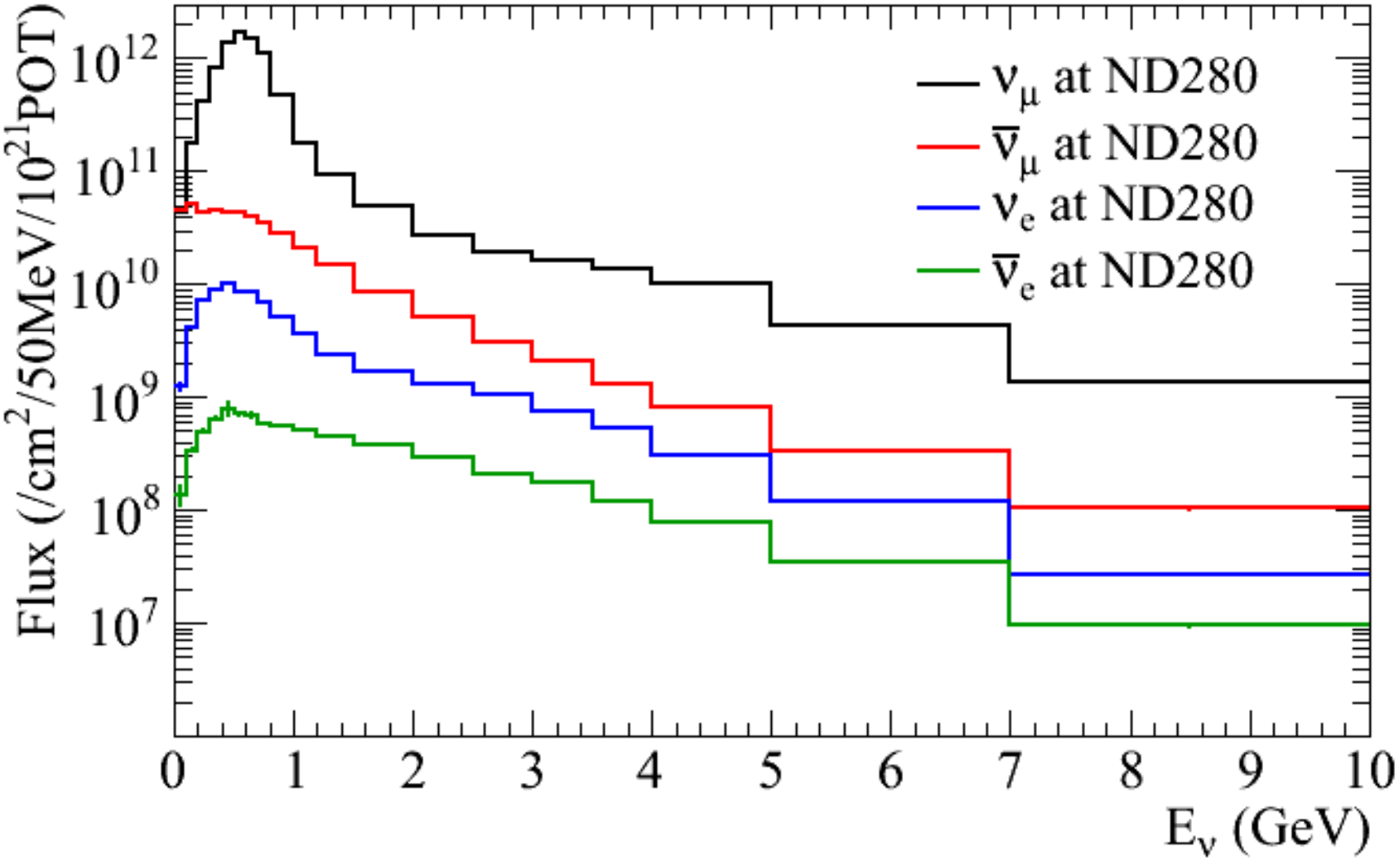
Daniel Scully

University of Warwick

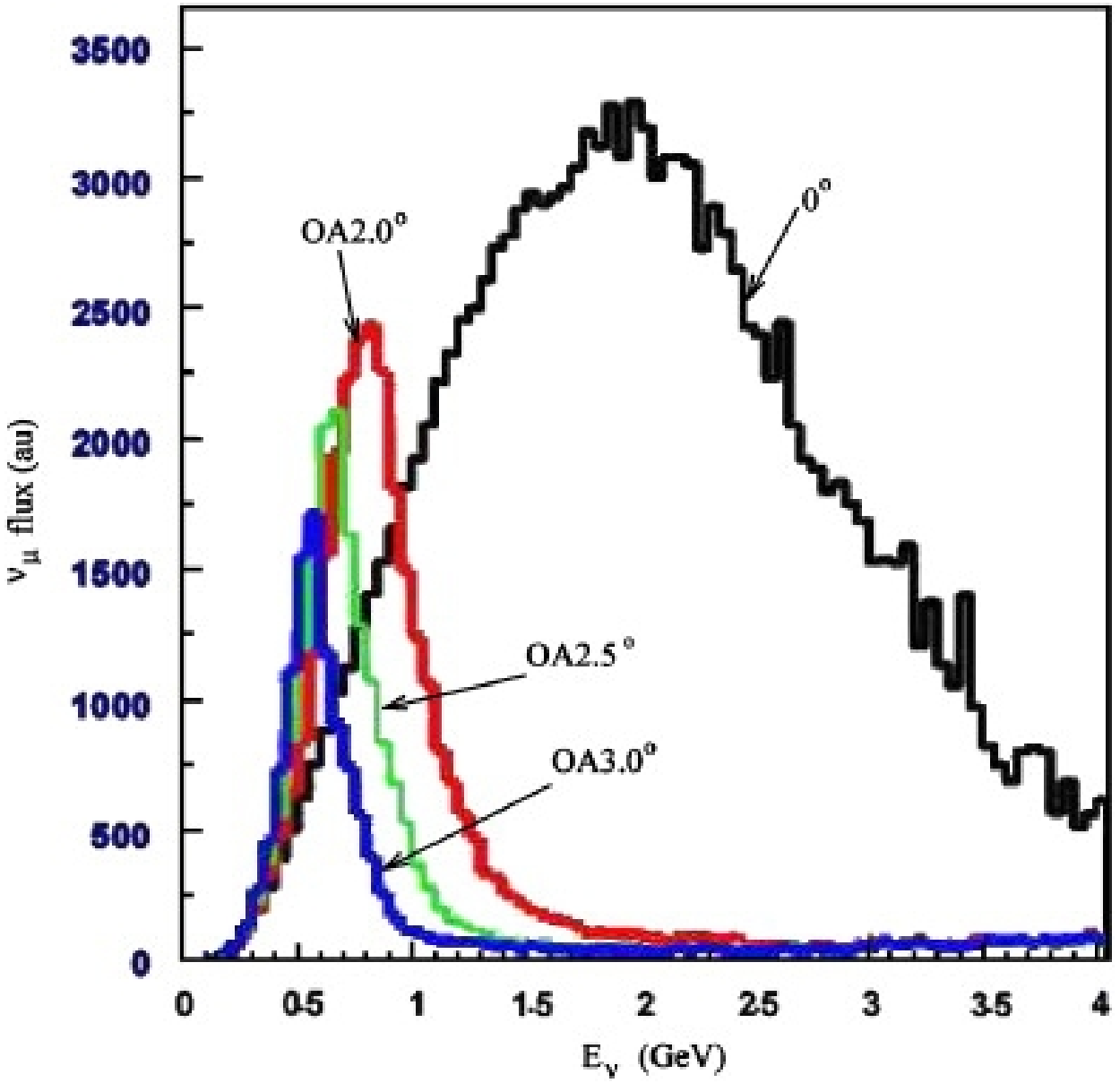
Beamline


Muon Monitor
Si array
+ IC array
Horn
3 Horns w/ 250kA
Beam monitors
intensity, position
profile
Super-Conducting
Magnets
N
Main
to Super-K
μ^+
π^+
ν_μ
0 50 100 (m)
Decay Volume
Beam du
Near detector
(at 280m from target)
DecayVolume
Target
Beam Dump
110m length
Graphite, Φ26 x
900 mm long
Helium cooling
30GeV
MR
proton beam

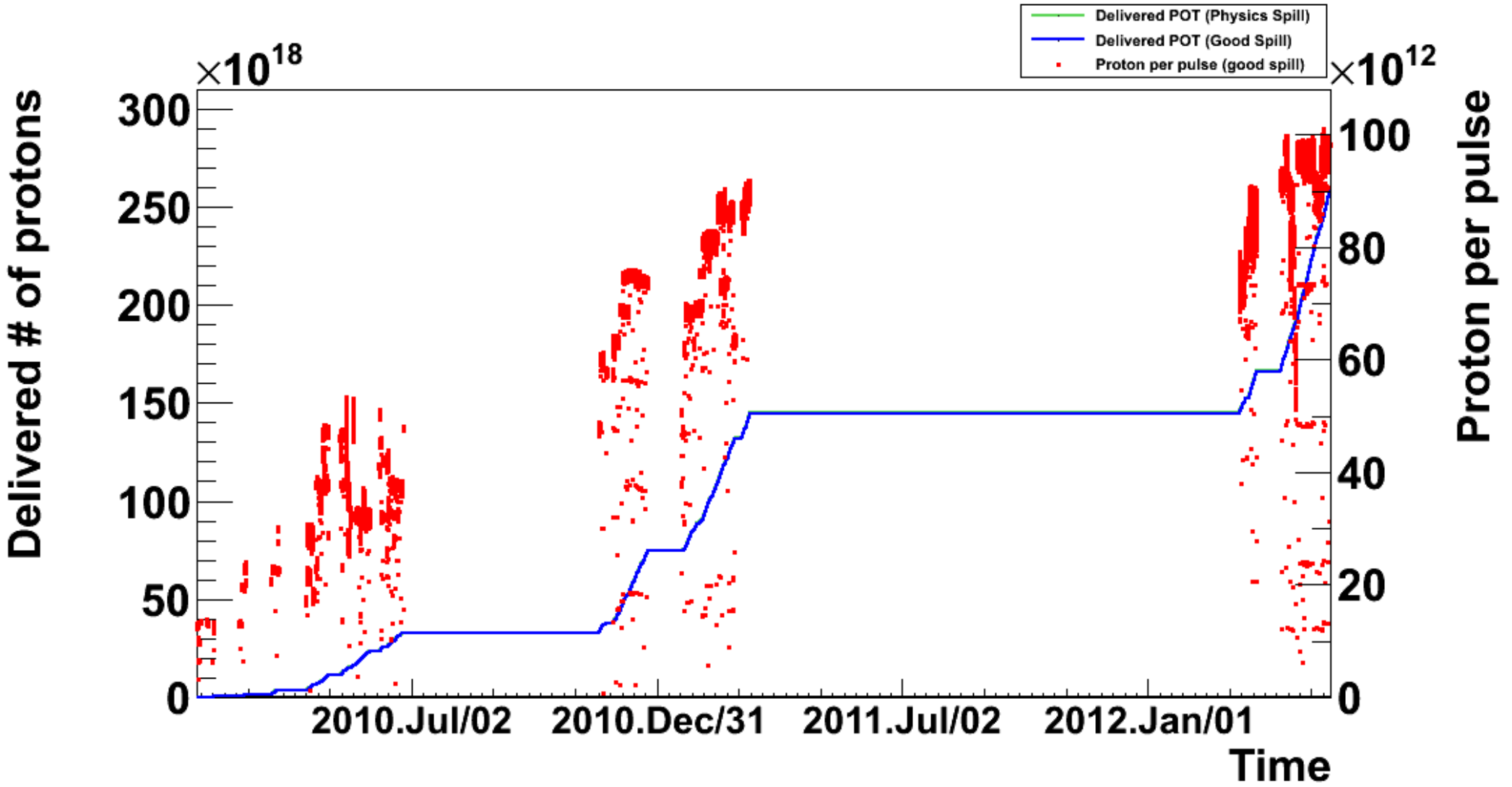
Beam Content



Off-Axis Beam



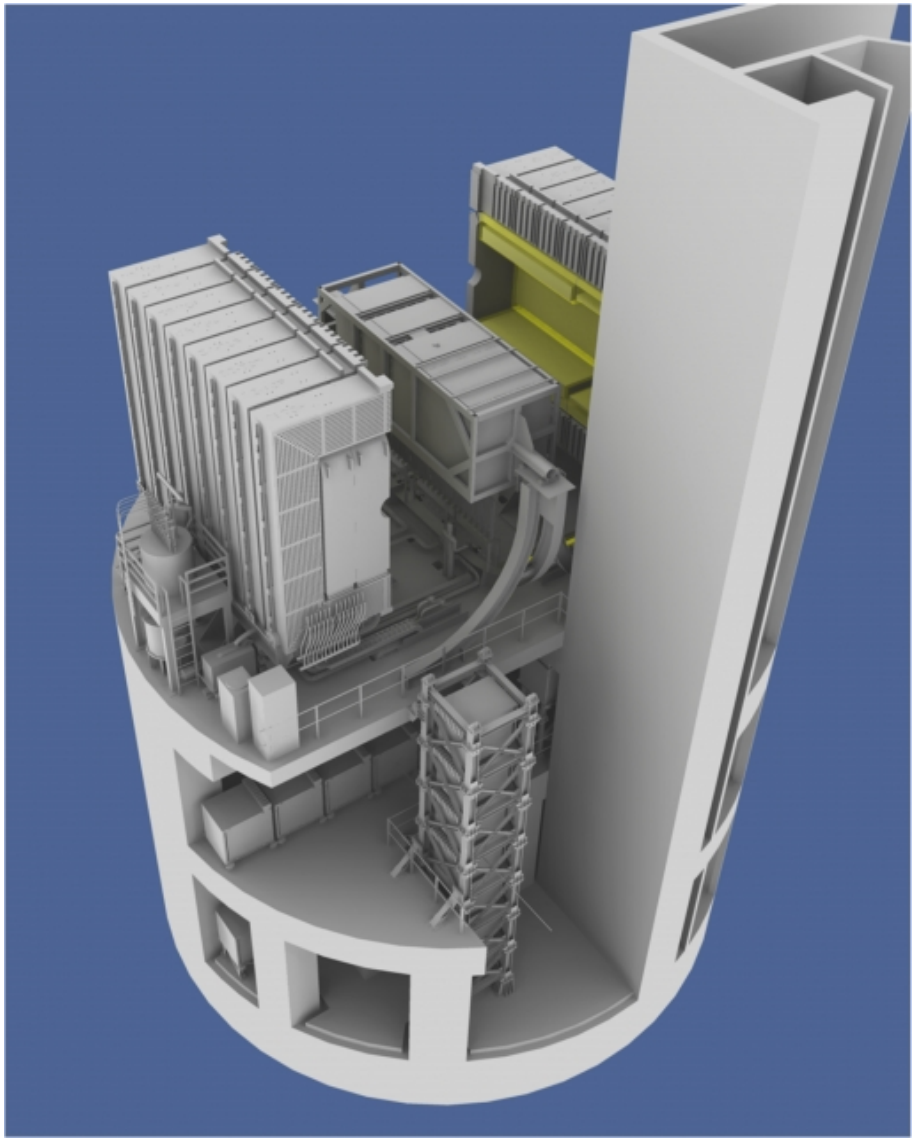
Beam Performance



Total Delivered: 3 x 10^{20} POT

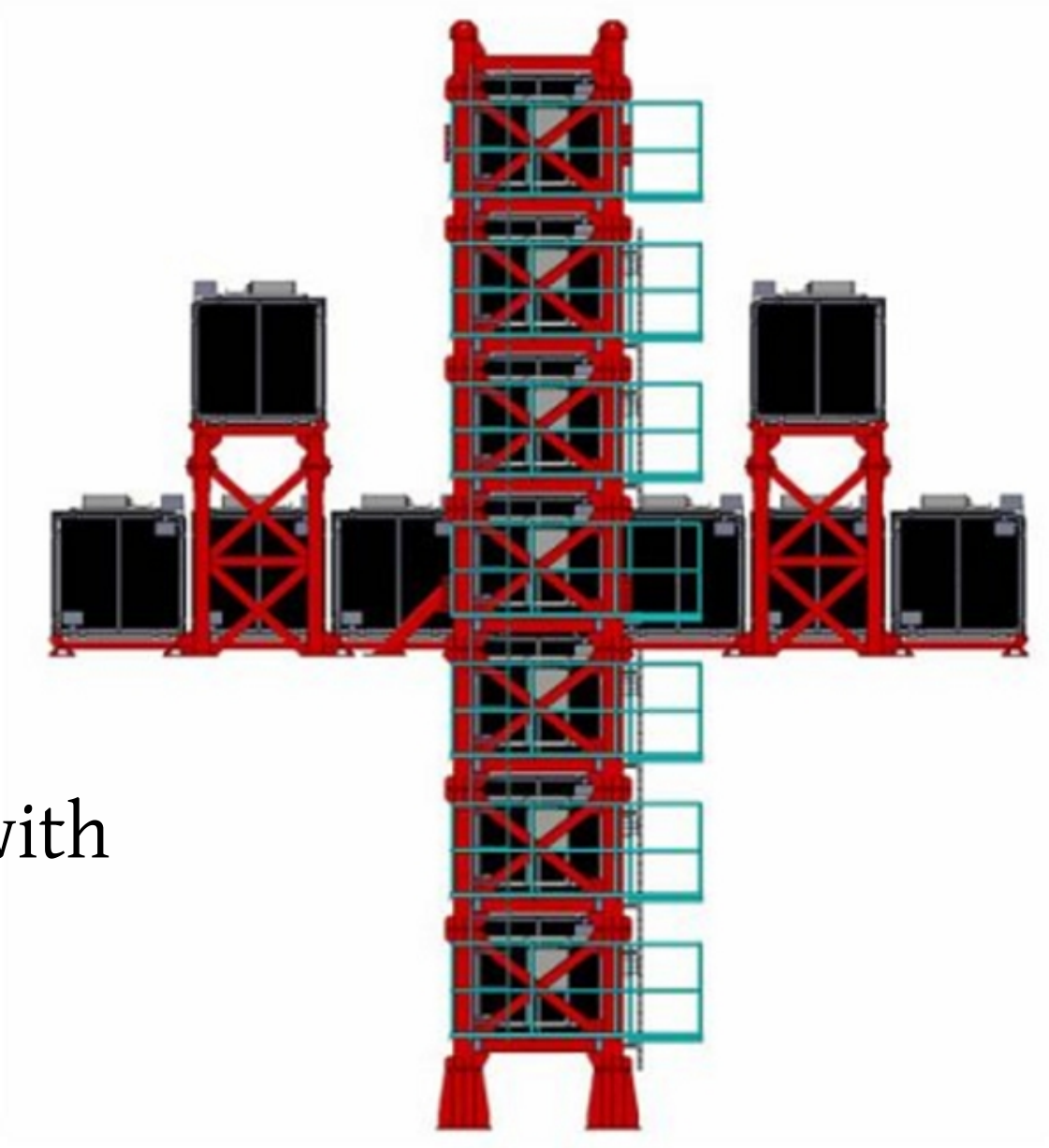
Near Detectors

- 280m downstream
- On-axis detector: INGRID
  - Flux normalisation
  - Beam direction
- Off-axis detector: ND280
  - Flux composition
  - Flux energy spectrum
  - Interaction cross-sections



INGRID

- 16 Modules
  - 7 Horizontal
  - 7 Vertical
  - 2 off-axis
- Plastic scintillator & steel
- 1 additional module with scintillator only



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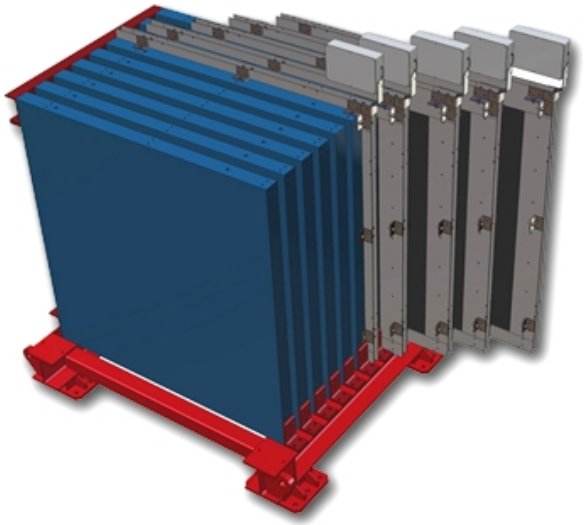

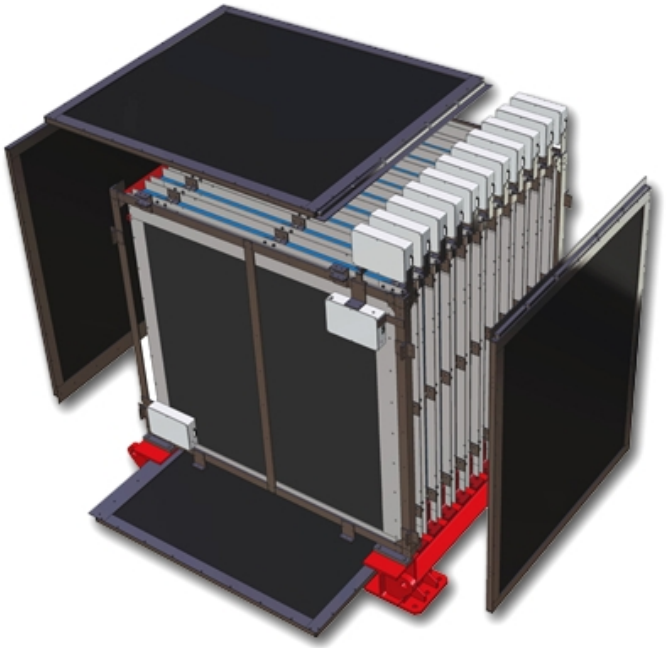

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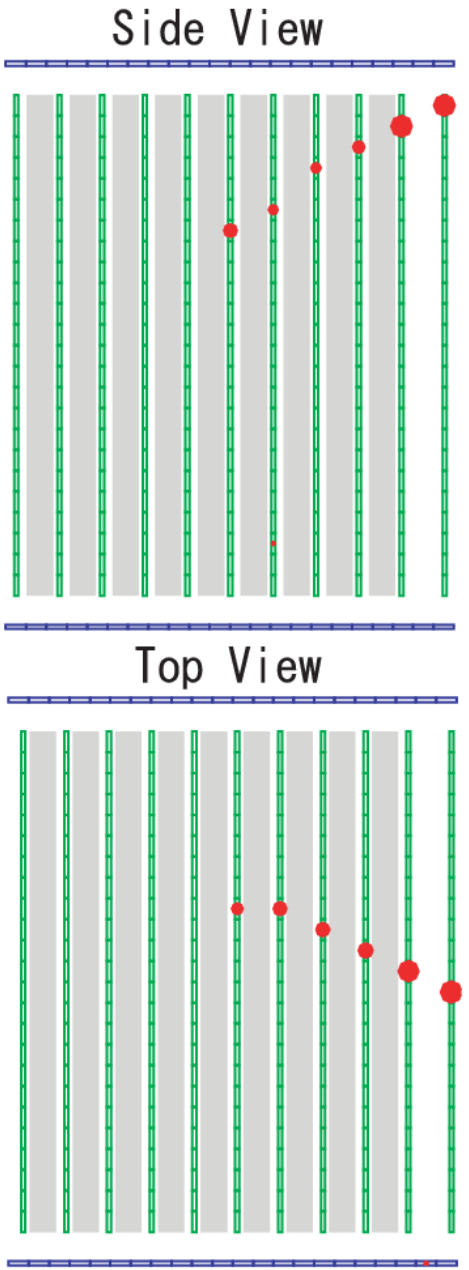
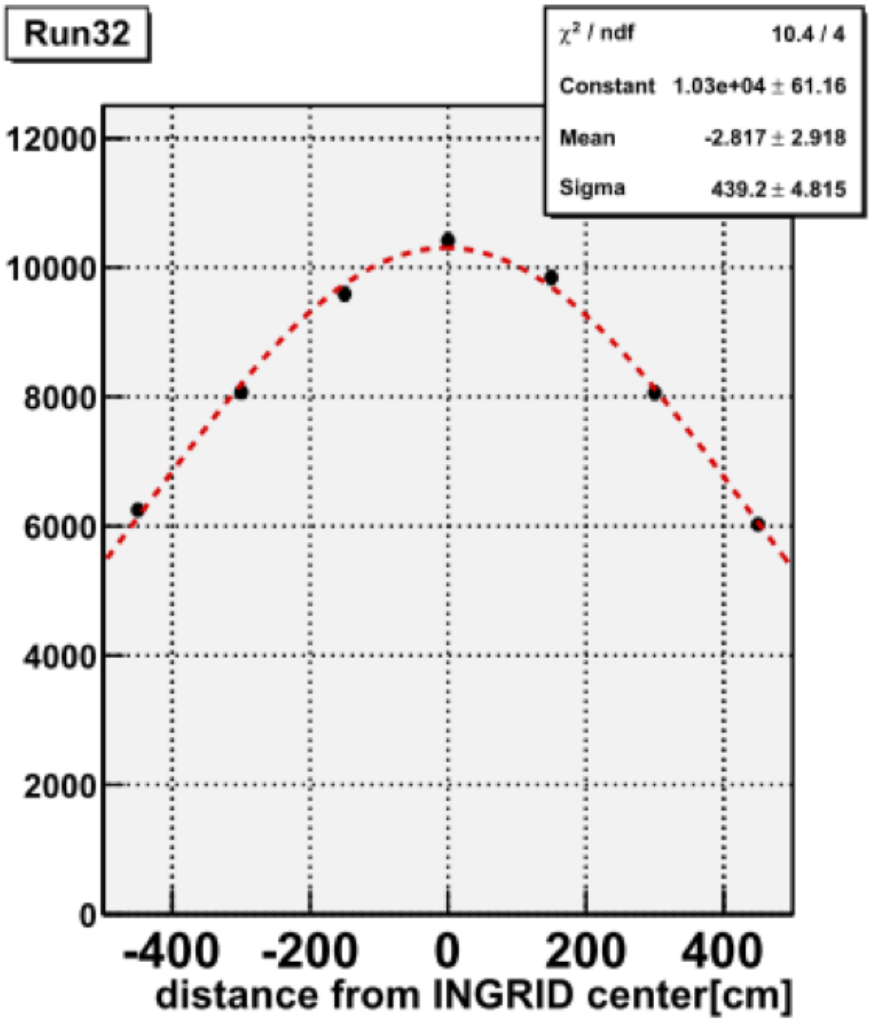
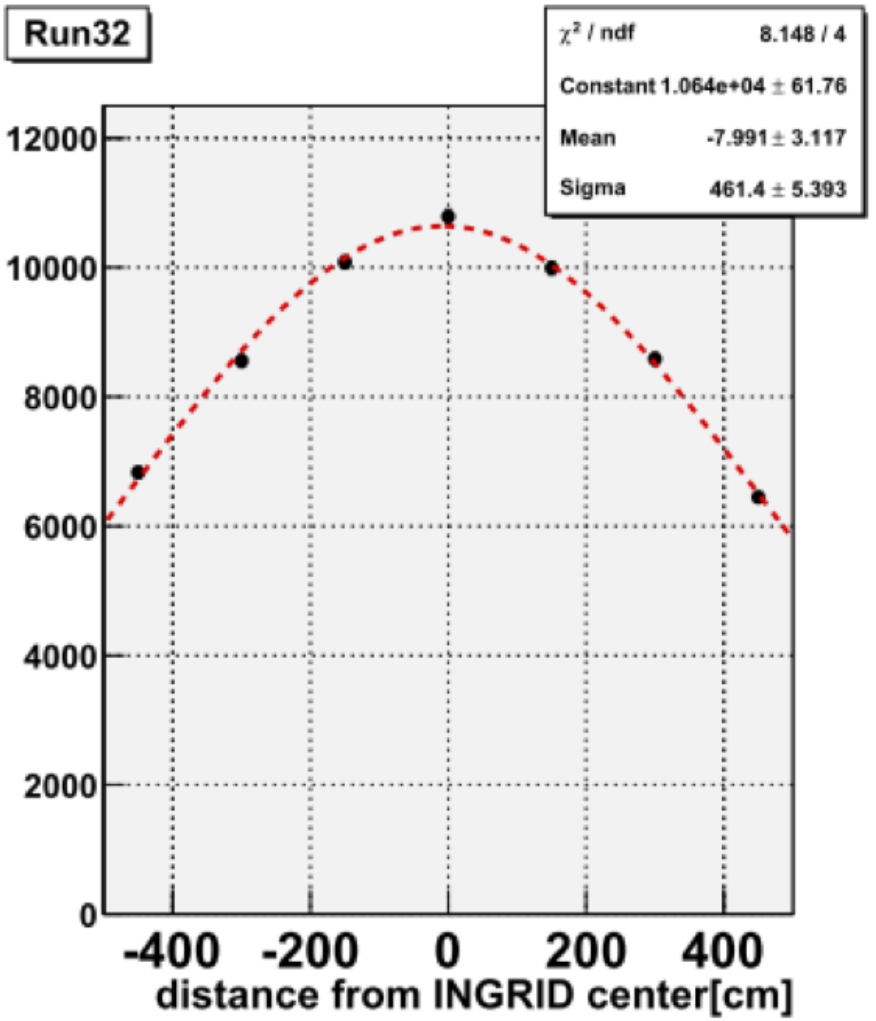


INGRID – Profile

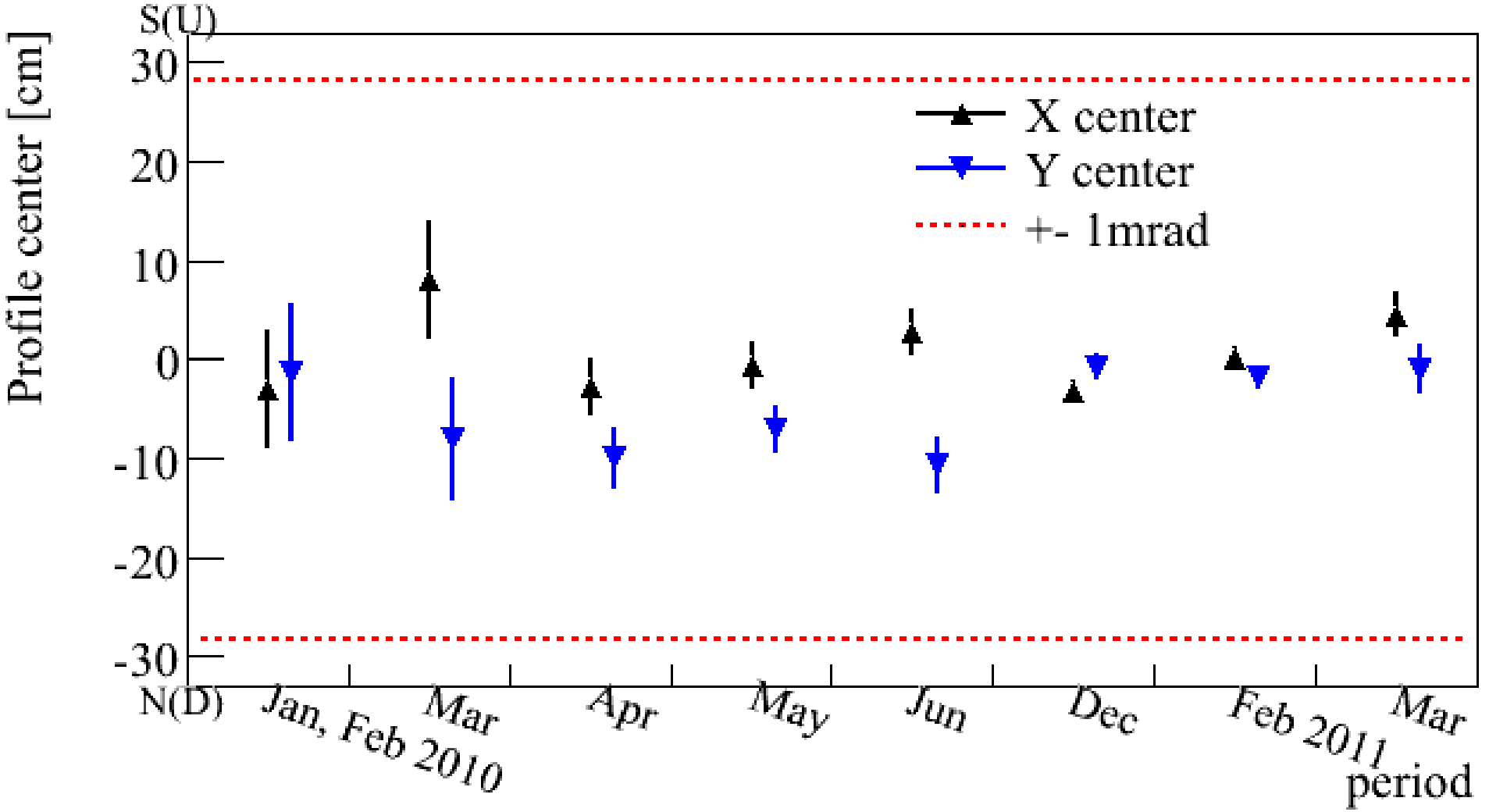
Horizontal



Vertical



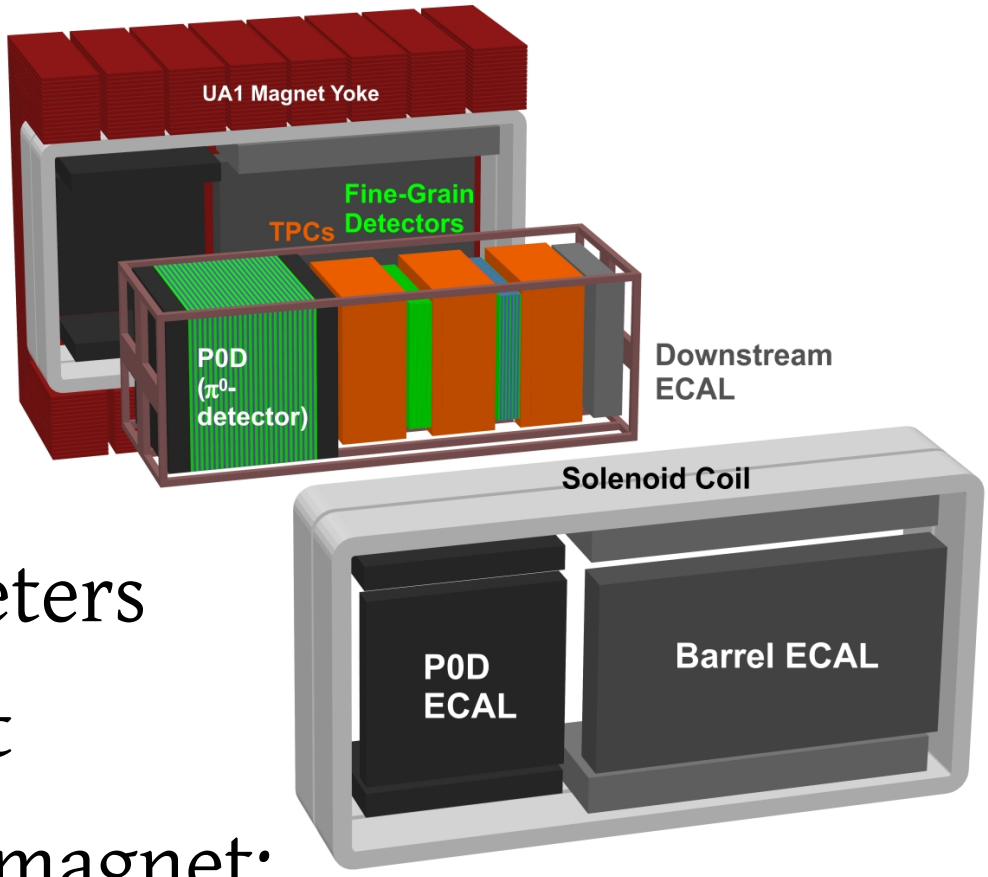
INGRID – Direction



1mrad shift gives ~2% energy shift at peak

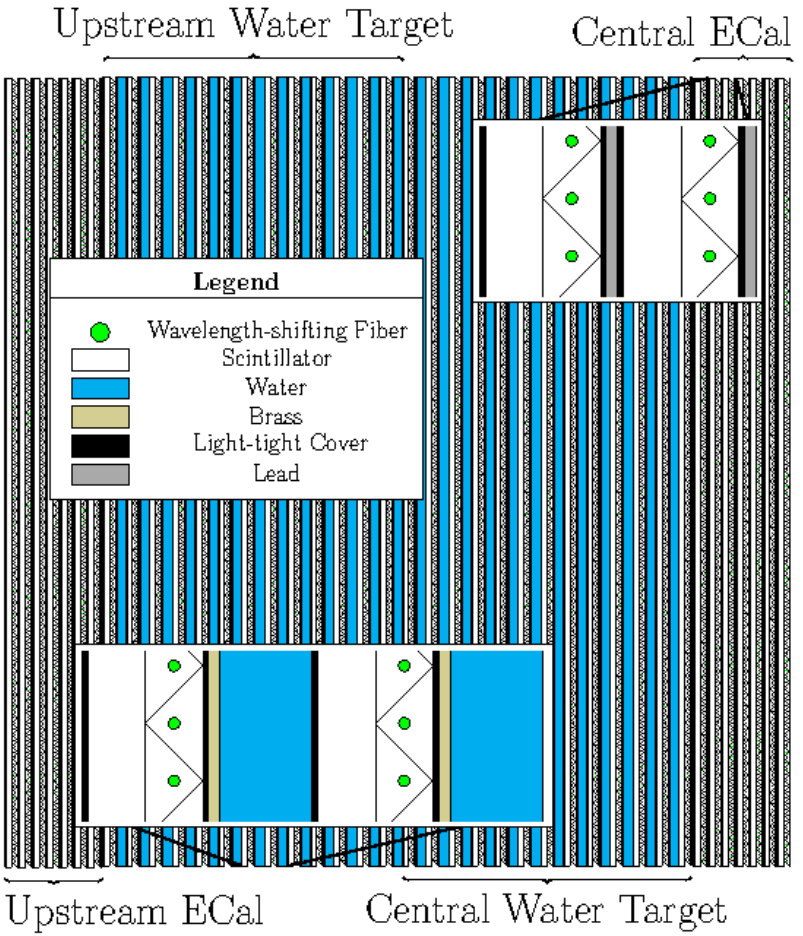
ND280

- Off-axis detector
- Central target region:
  - π^0 Detector (P0D)
  - Tracker (FGDs + TPCs)
- Surrounding EM Calorimeters
- UA1/NOMAD 0.2T Magnet
- Scintillator planes inside magnet:
  - Side Muon Ranging Detector (SMRD)



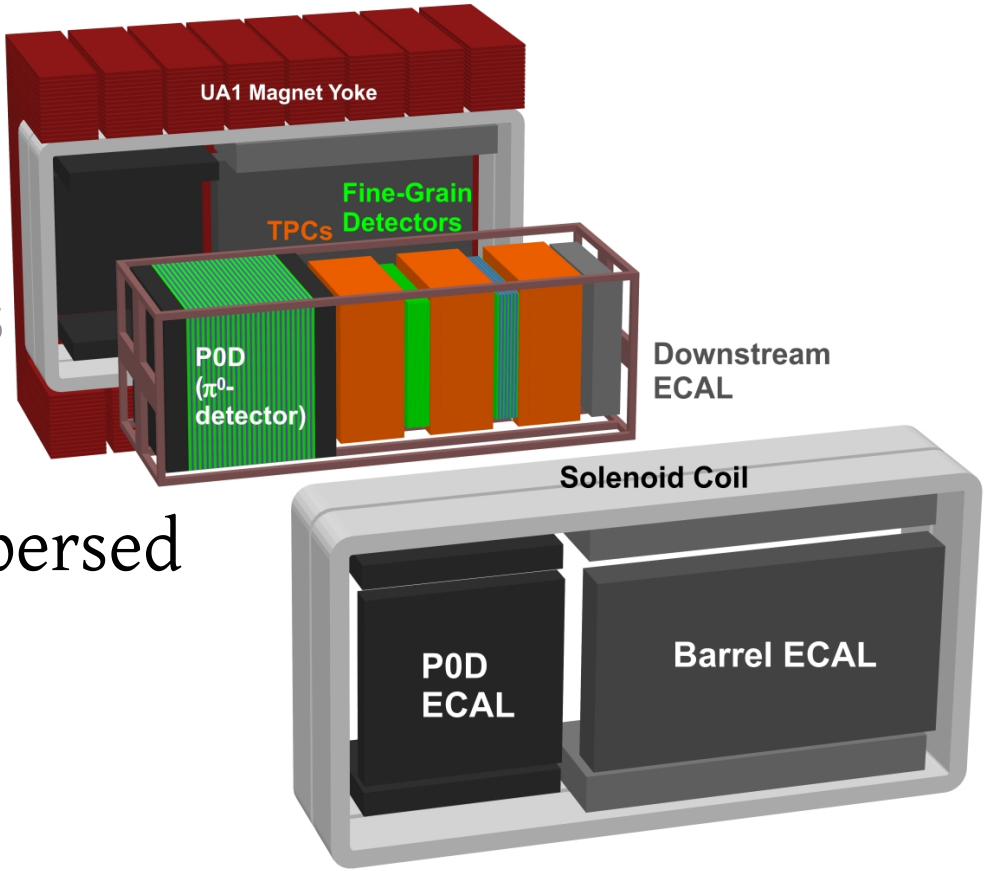
π^0 Detector – The P0D

- NC π^0 is a serious ν_e appearance background
- Central Target:
  - Water
  - Triangular scintillator bars
  - Brass foils
- Up and Downstream ECals
  - Triangular scintillator bars
  - Lead sheets
- Can be run with water in/out



Tracker

- 2 Fine Grained Detectors
  - Square plastic scintillator bars
  - FGD1 is pure scintillator
  - FGD2 has water targets interspersed
  - Provide interaction target
- 3 Time Projection Chambers
  - Predominantly Argon gas
  - Provide momentum (from curvature)
  - Provide Particle ID (from dE/dx)



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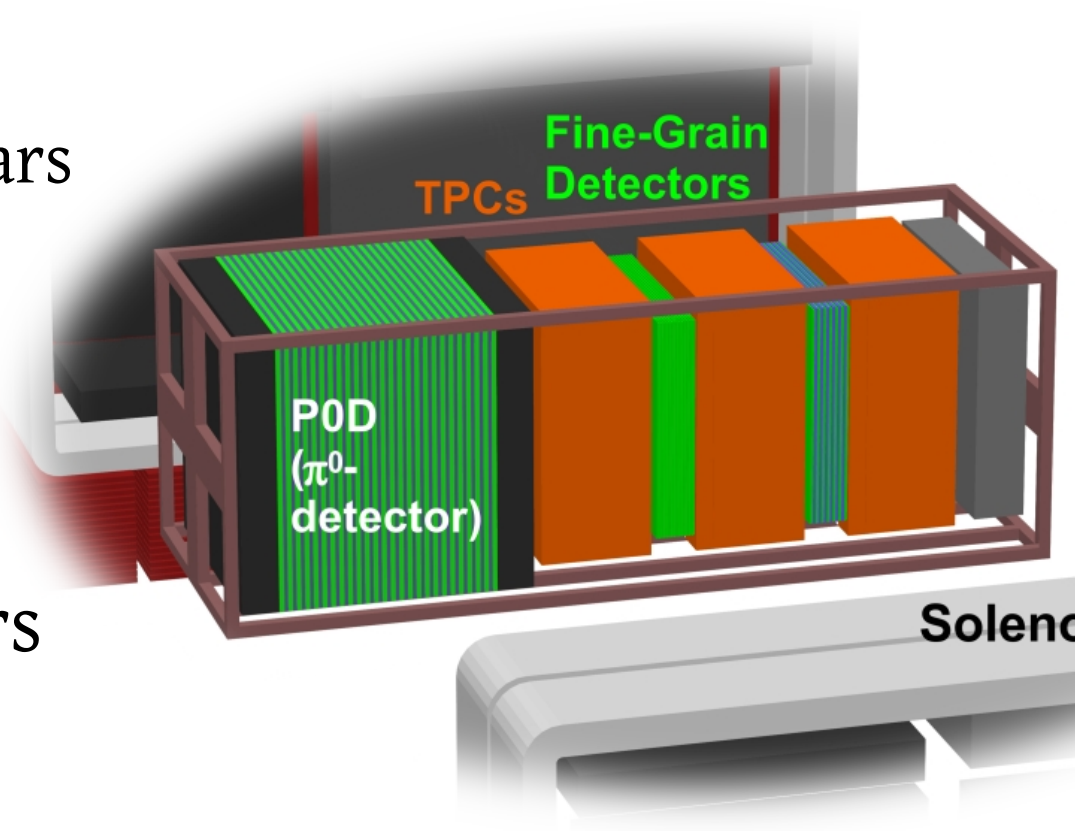
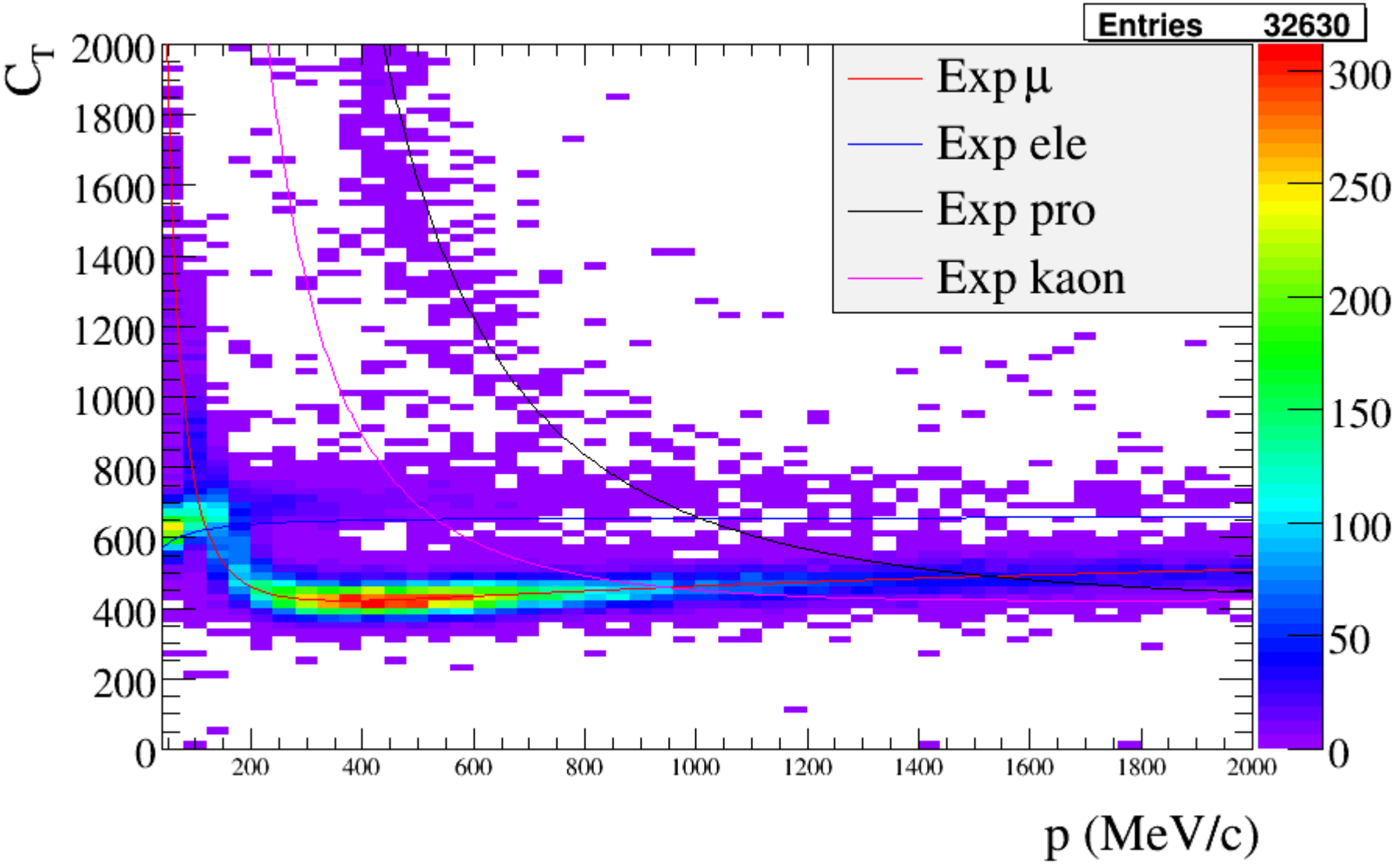
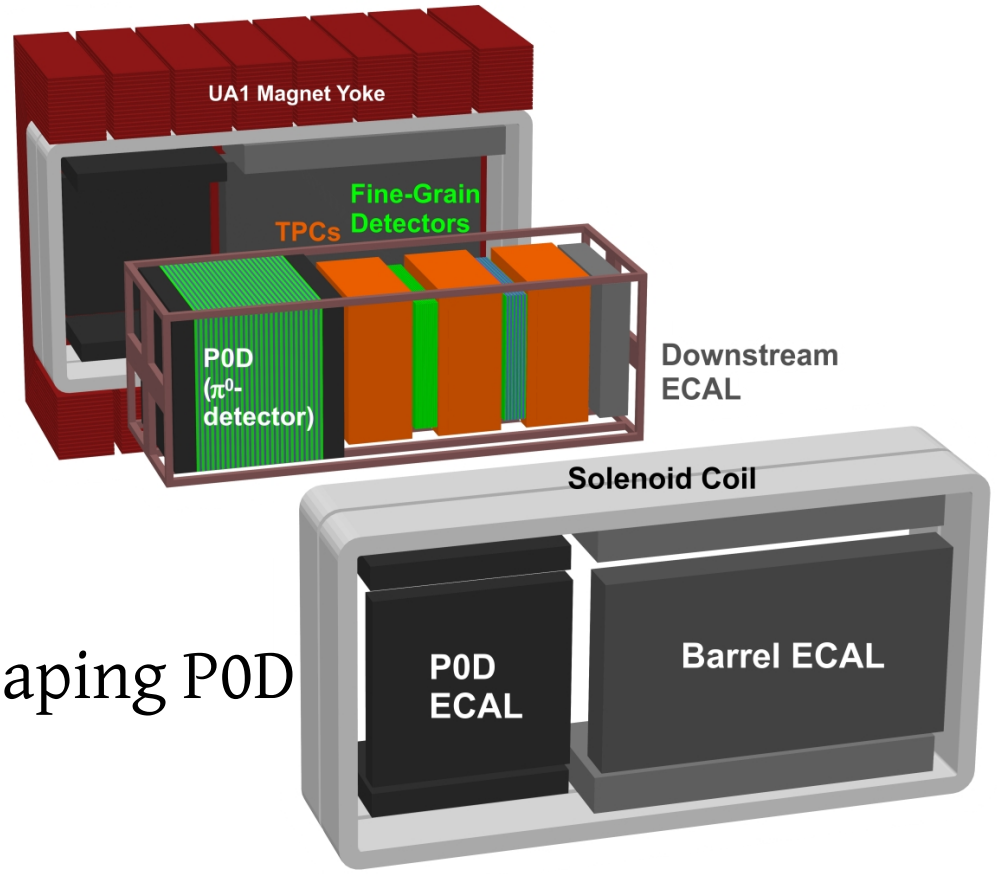


Tracker Particle ID



ECals

- 7 modules surround tracker:
  - Particle ID
  - EM Energy measurement
  - Photon conversion
- 6 modules surround the P0D:
  - Catch high-angle particles escaping P0D
  - Veto incoming backgrounds
  - Constructed at Warwick
- Rectangular plastic scintillator and lead



ECals

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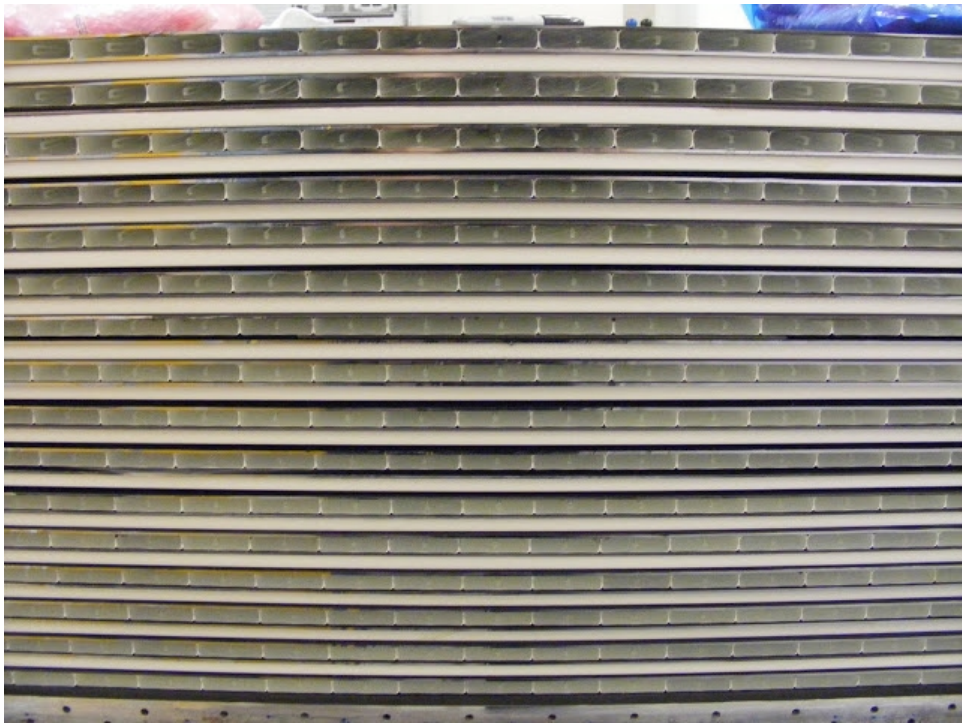


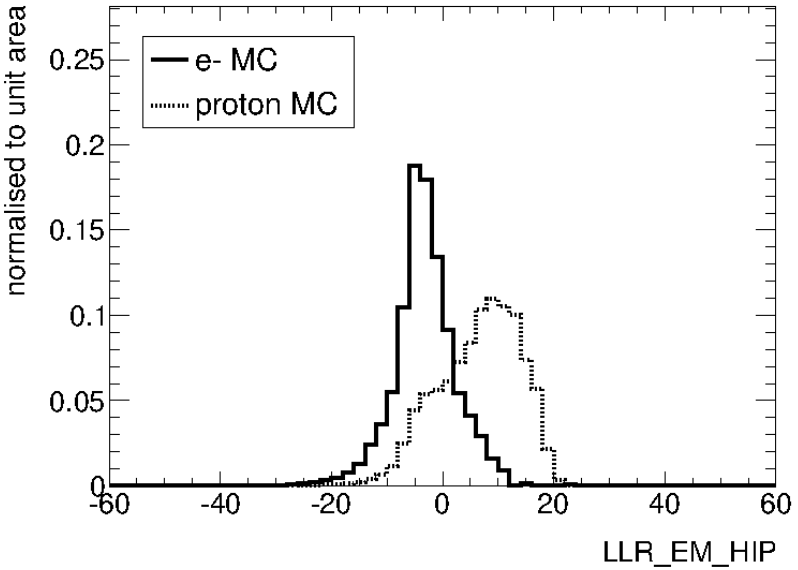
- Rectangular plastic scintillator and lead

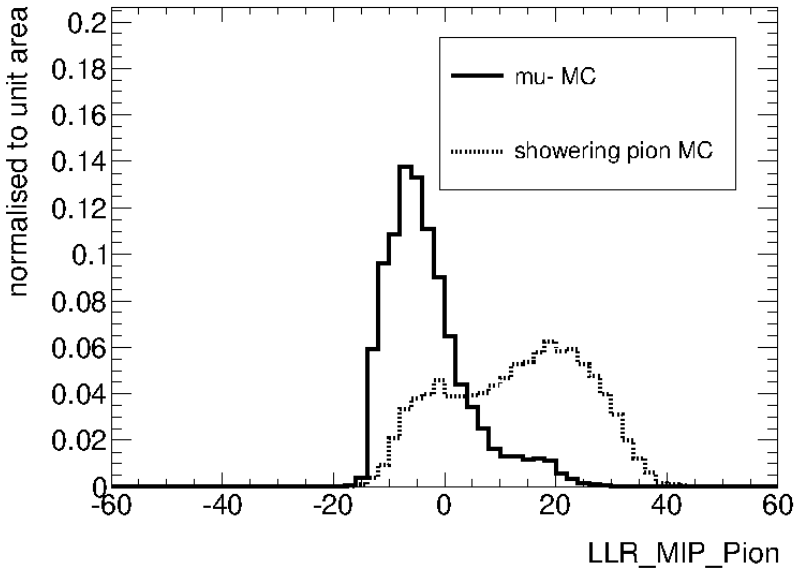
ECal Particle ID

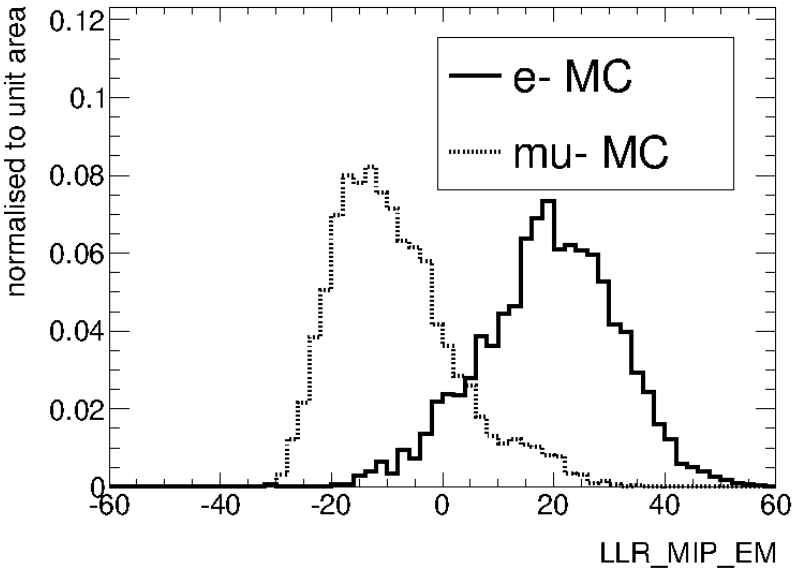
Electron – Proton

Muon - Electron

Muon – Pion



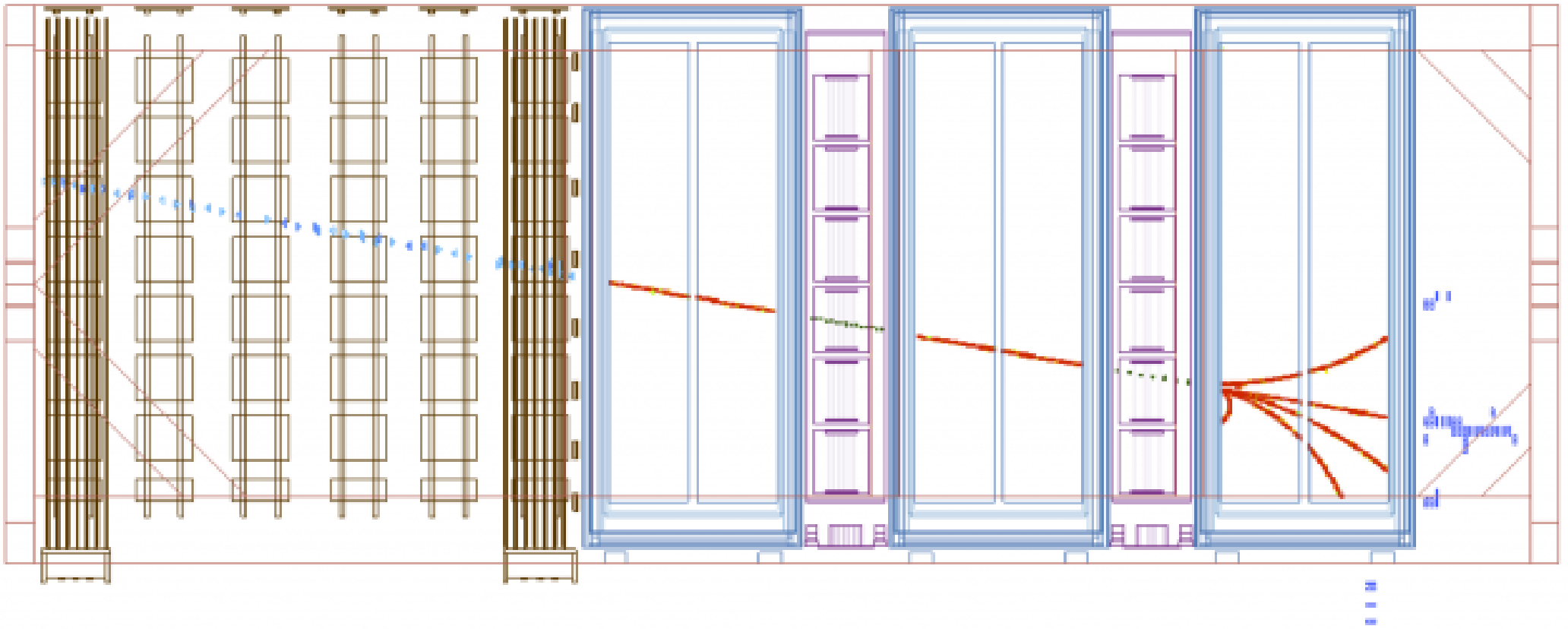




Daniel Scully

University of Warwick

ND280



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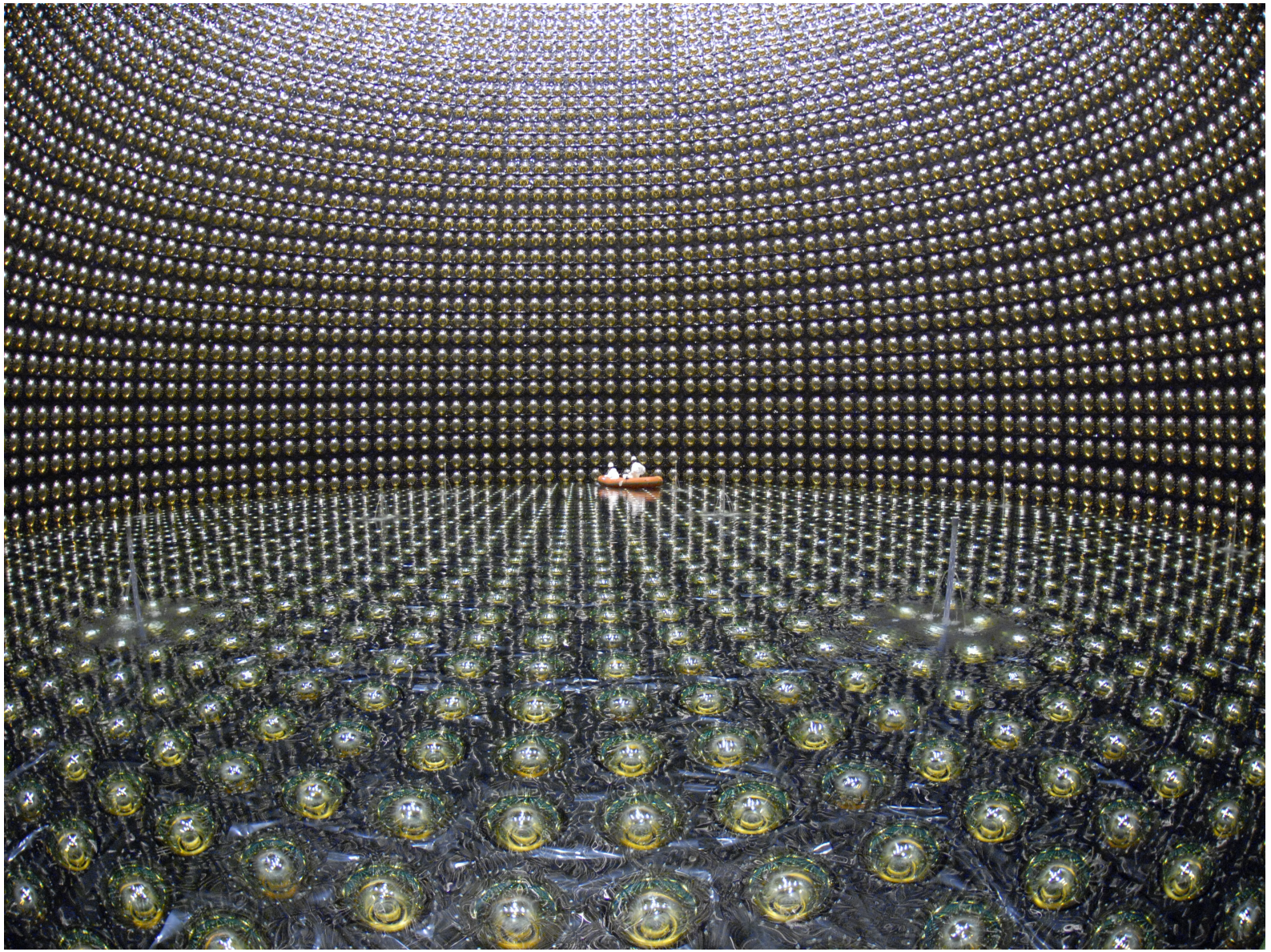
Super-Kamiokande



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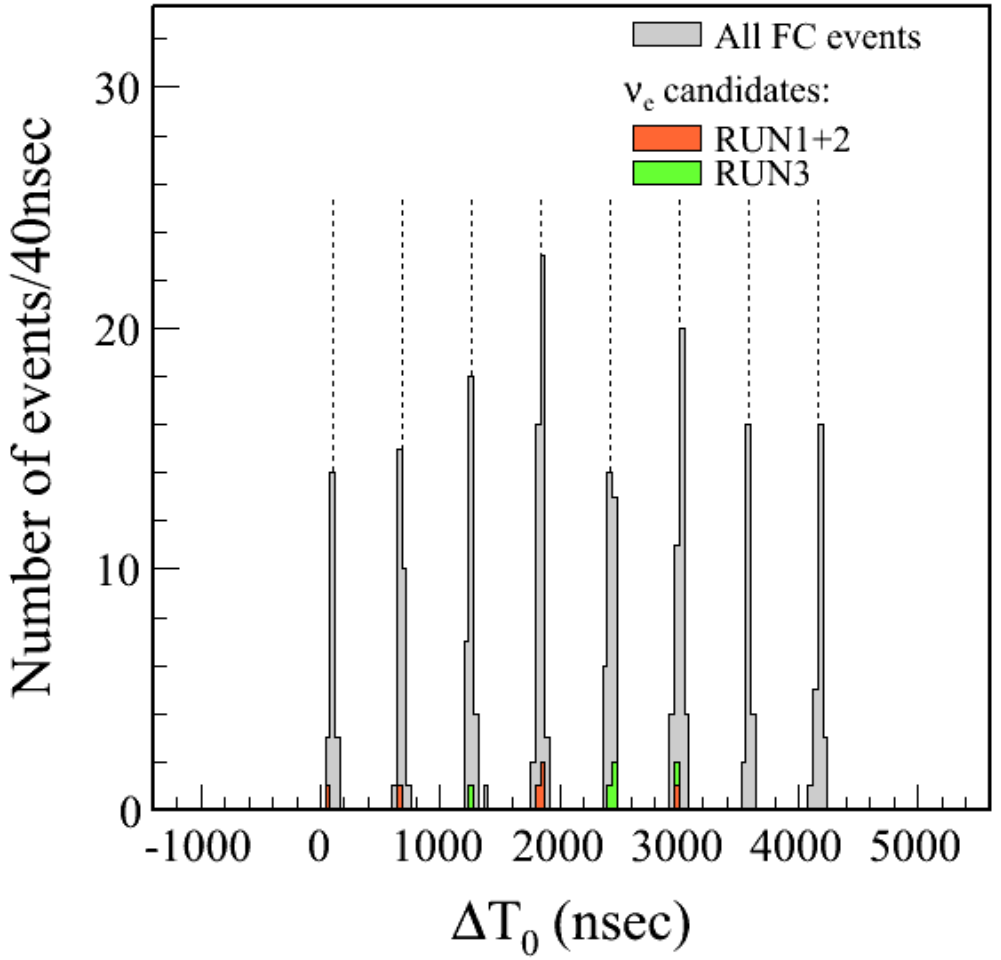
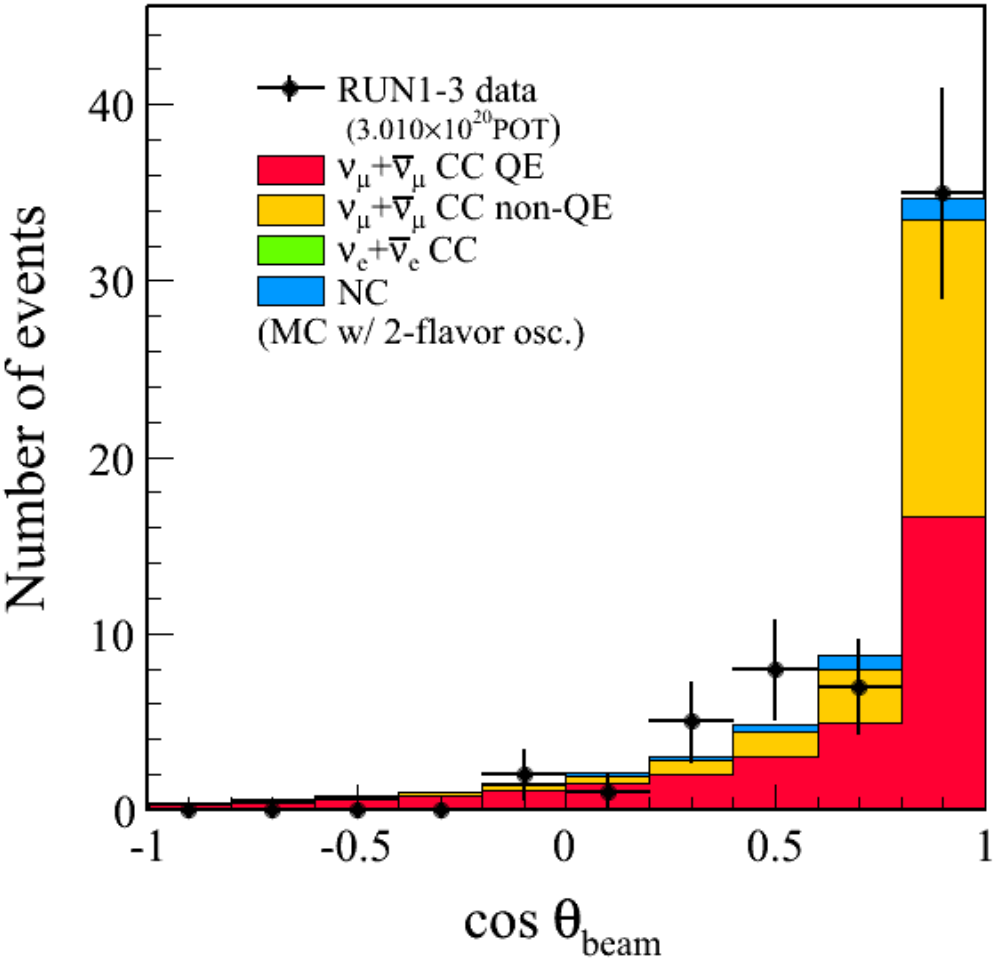
Super-Kamiokande

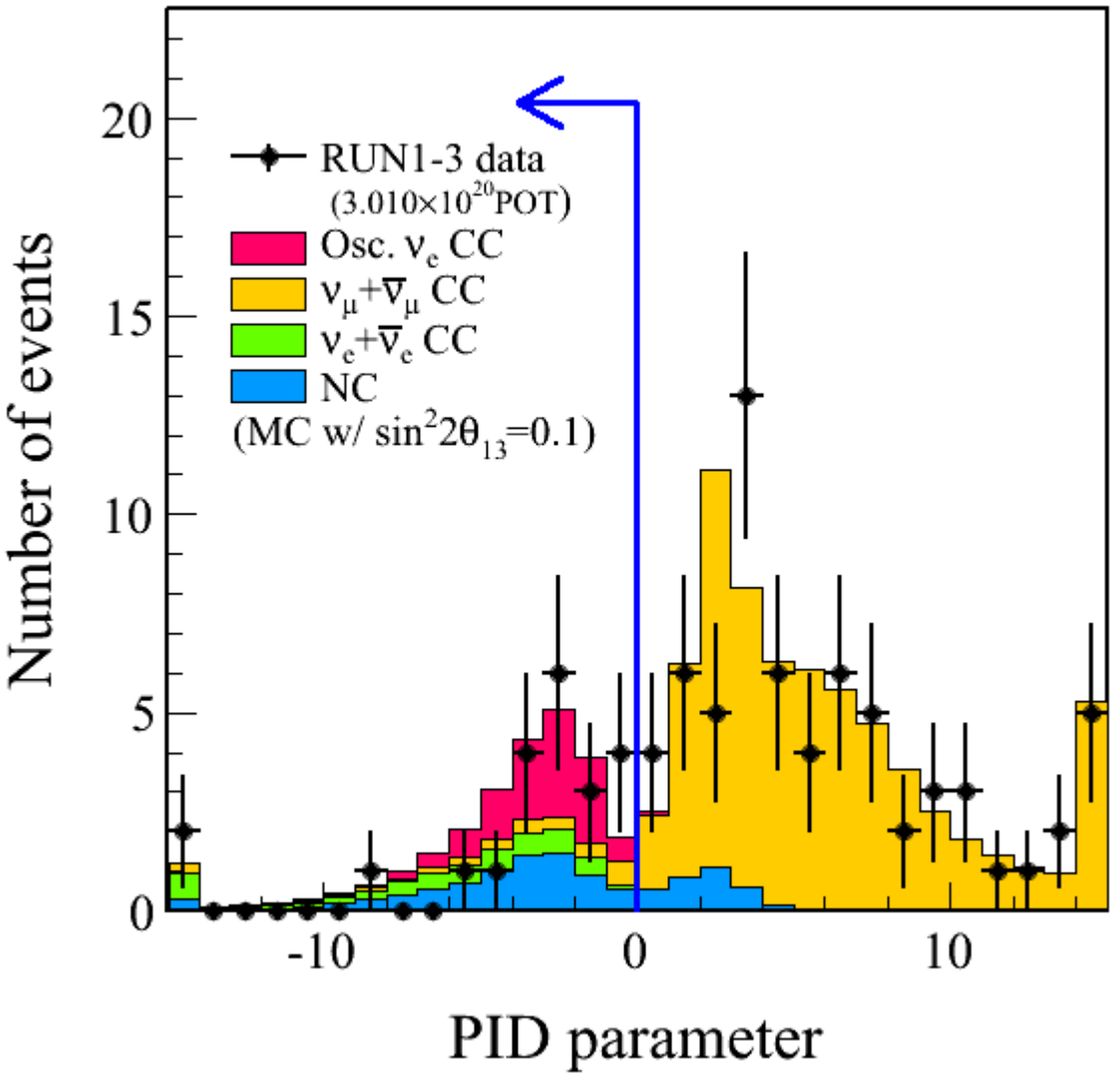
- 50kT water Cherenkov detector
- 22.5kT fiducial volume
- 295km from beam
- Can distinguish ν_e and ν_μ
- Can measure momentum and angle
- Good timing

T2K at Super-K

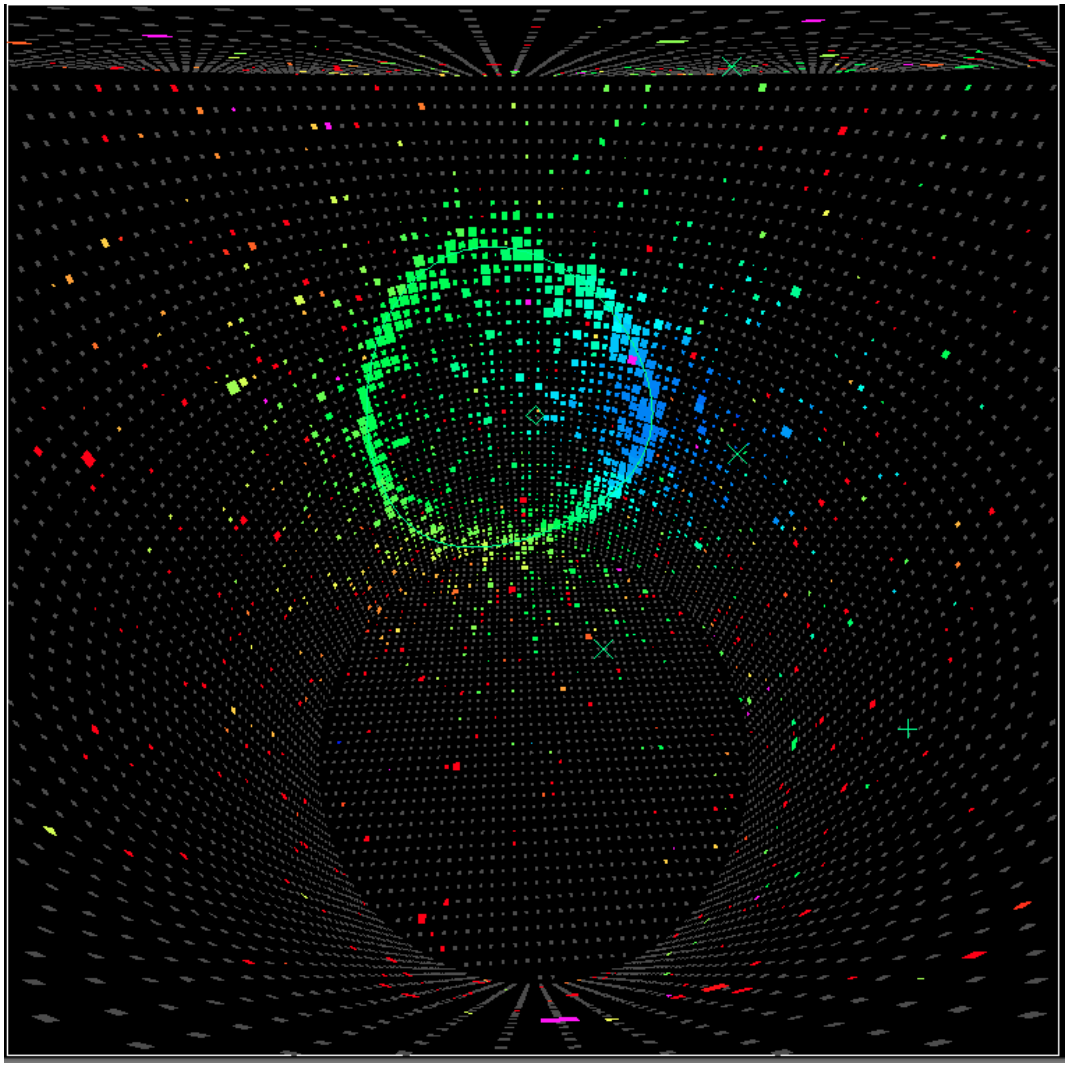




T2K at Super-K



T2K at Super-K



ν_e Candidate

The T2K Experiment

Physics

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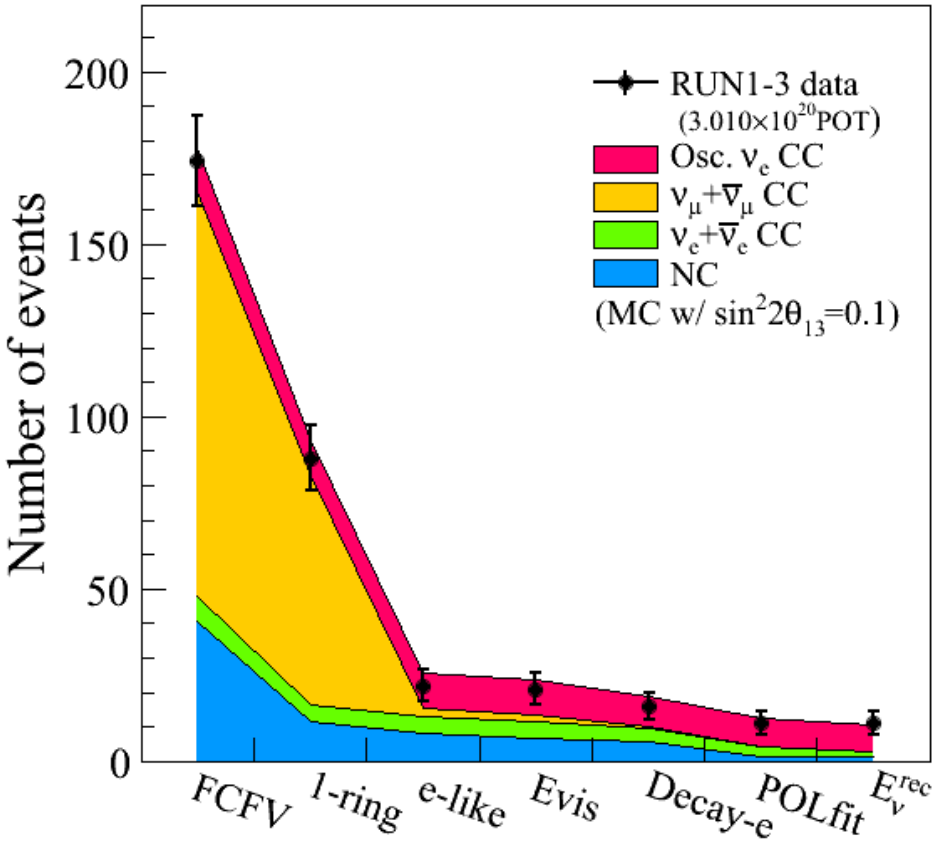
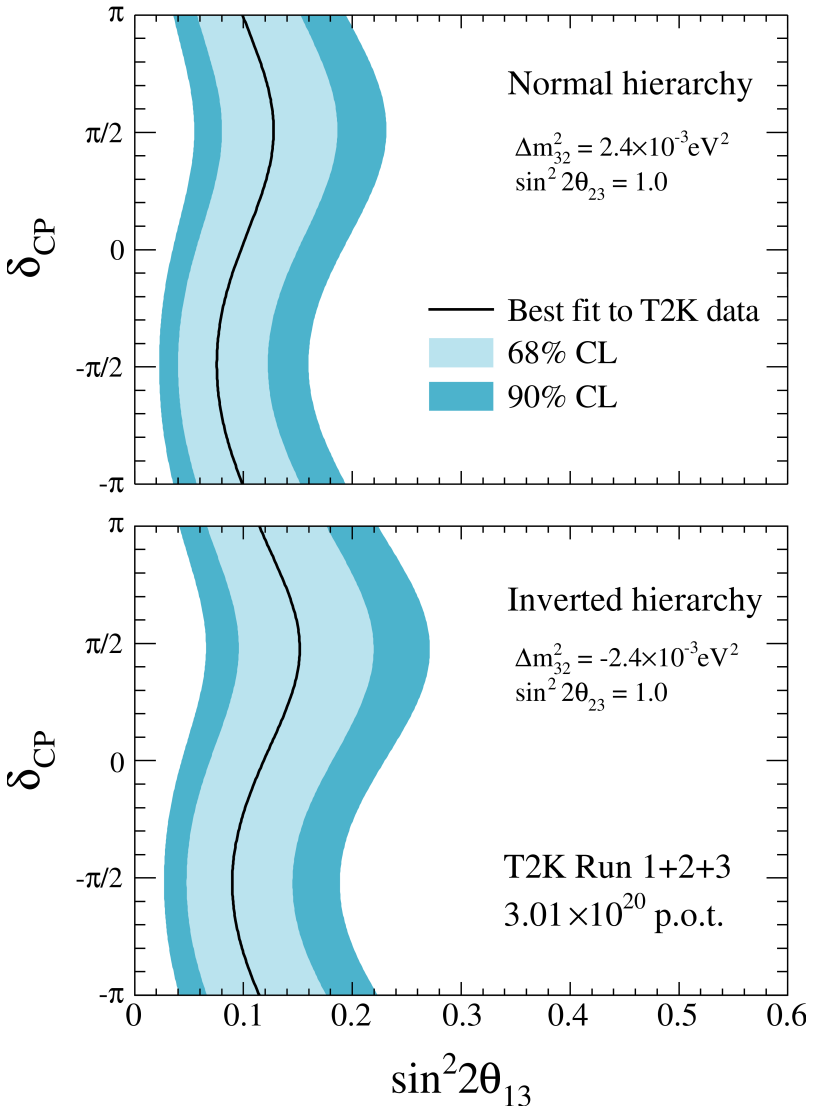
ν_e Appearance





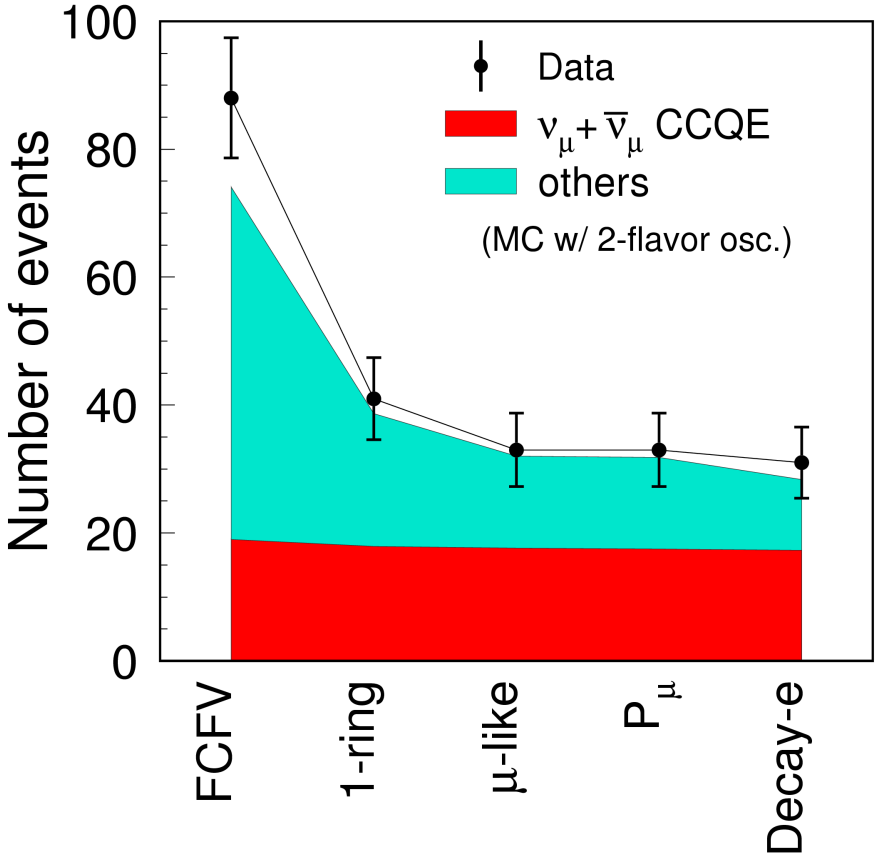
11 candidate ν_e events selected

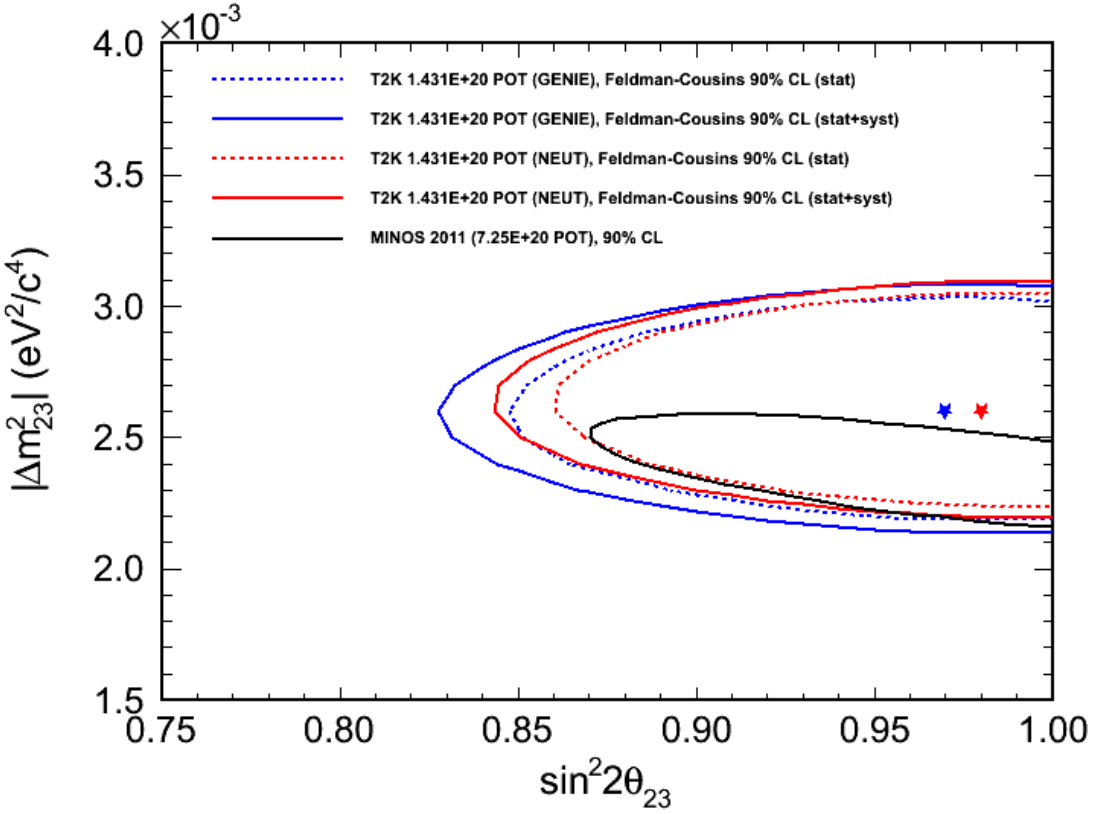
3.2 expected if $\theta_{13} = 0$

$\theta_{13} > 0$ at 3.2σ

3.01 x 10^{20} POT

ν_μ Disappearance





31 candidate ν_μ events selected

103 expected with no oscillations

1.4×10^{20} POT

From Summer 2011

New Result Soon!

Cross-Sections

ν_μ: **Inclusive (Monday)**

Quasi-Elastic (Thursday)

Single π (Thursday), Multi π, etc.

ν_e: Inclusive

$\bar{\nu}_\mu$: Inclusive

Quasi-Elastic

NC: Inclusive

Elastic

Single π^0 (Thursday)

Cross-Sections

- Multiple Target Materials:
  - Plastic scintillator — P0D, FGDs, ECals
  - Water — P0D, FGD2
  - Lead — P0D, ECals
  - Steel — INGRID
  - Brass — P0D
- Sometimes exclusive, sometimes in combination

Conclusions

- T2K: neutrino oscillations with an off-axis beam
- Making precision measurements of θ_{13}, θ_{23}, Δm^2_{32}
- Near Detectors:
  - Will make a broad range of interaction measurements
  - Capable of multiple event topologies
  - Containing many target materials

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