


# ***A Few Topics for Discussion***











*18 June 2014*

*Second EU Hyper-Kamiokande Open Meeting*

*CERN, Geneva*

# The T2K Collaboration



 <b>Canada</b> U. Alberta U. B. Columbia U. Regina U. Toronto TRIUMF U. Victoria U. Winnipeg York U.	 <b>Italy</b> INFN, U. Bari INFN, U. Napoli INFN, U. Padova INFN, U. Roma	 <b>Poland</b> A. Soltan, Warsaw H.Niewodniczanski, Cracow U. Silesia, Katowice T. U. Warsaw U. Warsaw U. Wroclaw	 <b>Spain</b> IFIC, Valencia U. A. Barcelona	 <b>USA</b> Boston U. Colorado S. U. U. Colorado Duke U. U. C. Irvine Louisiana S. U. U. Pittsburgh U. Rochester Stony Brook U. U. Washington
 <b>France</b> CEA Saclay IPN Lyon LLR E. Poly. LPNHE Paris	 <b>Japan</b> ICRR Kamioka ICRR RCCN KAVLI IPMU KEK Kobe U. Kyoto U. Miyagi U. Edu. Osaka City U. Okayama U. Tokyo Metropolitan U. Tokyo	 <b>Russia</b> INR	 <b>Switzerland</b> ETH Zurich U. Bern U. Geneva	 <b>UK</b> Imperial C. L. Lancaster U. Liverpool U. Queen Mary U. L. Oxford U. Sheffield U. STFC/RAL STFC/Daresbury Warwick U.

**Total:**  
~500 members  
59 institutes  
11 Countries

**Europe**  
8 Countries; 30 Institutes  
> 50% members are from Europe.  
Largest European neutrino experiment

Near & Far  
sites:



KEK/JAEA



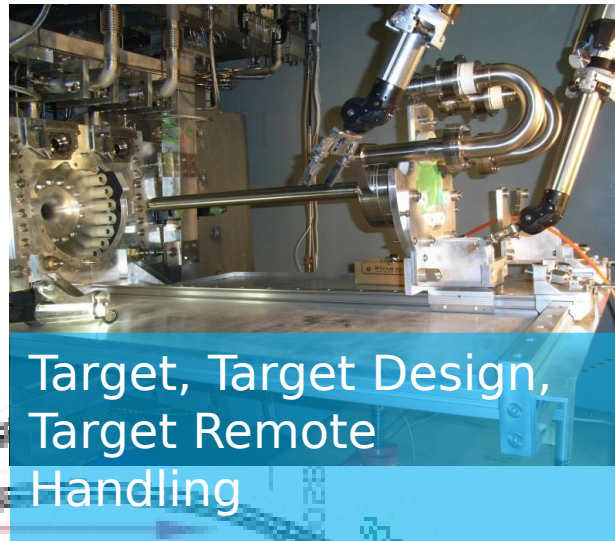
ICRR

# European Contributions to T2K Beamline

Dump Design



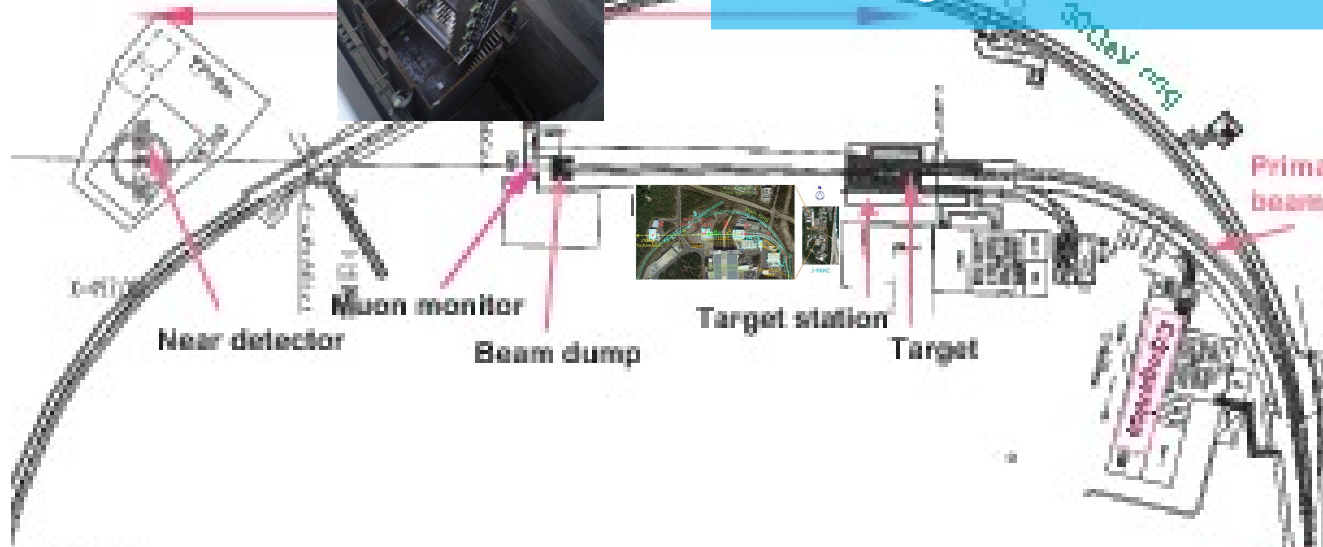
Target, Target Design, Target Remote Handling



Beam Baffle



Beam Window

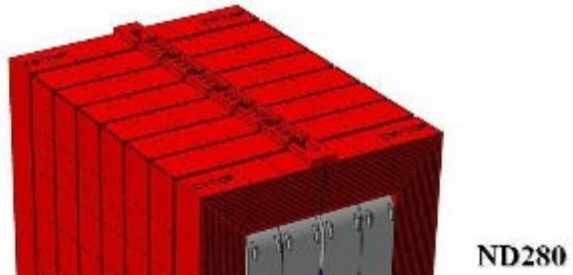
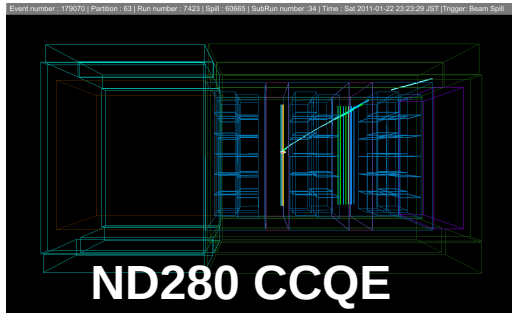


Demonstrates the ability of Europe to make significant contributions to facilities which are not in Europe!

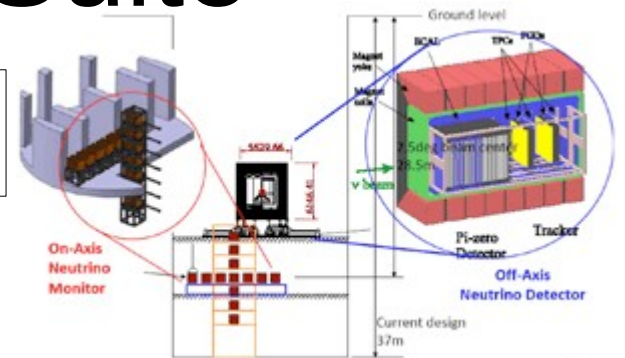
Ongoing work for the T2K upgraded beam power (up to 750MW) and for multi MW beams (HK) ⇒ see C. Densham's talk

# T2K Near Detector Suite

ND280  
off-axis



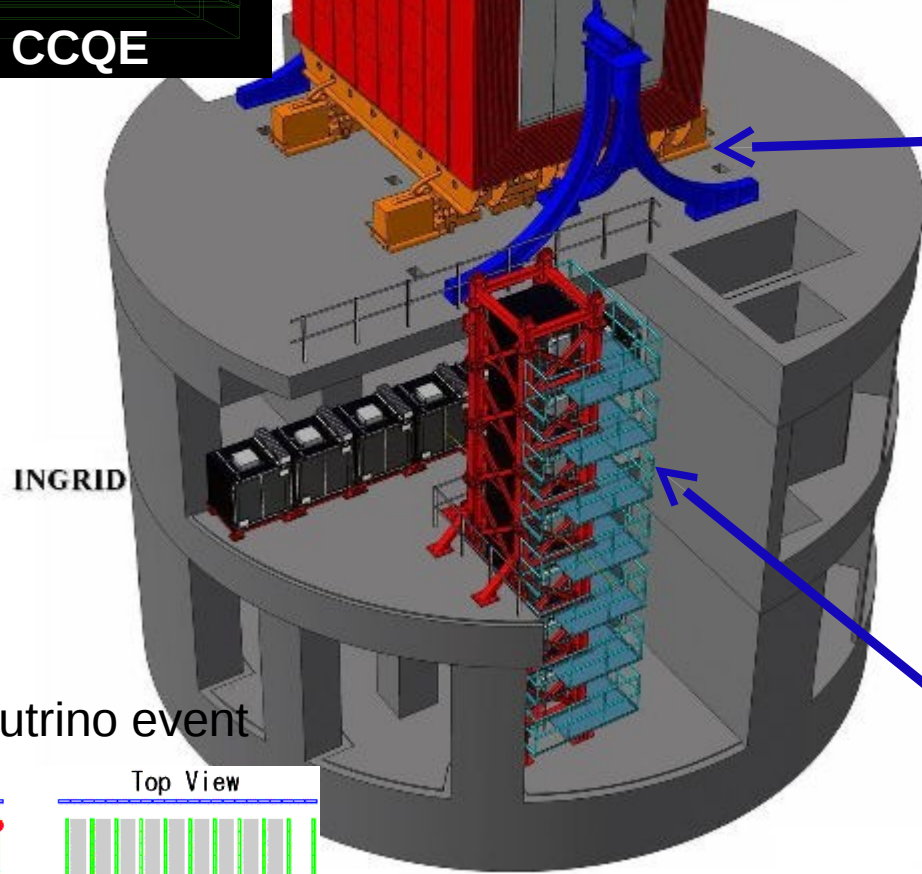
INGRID  
on-axis



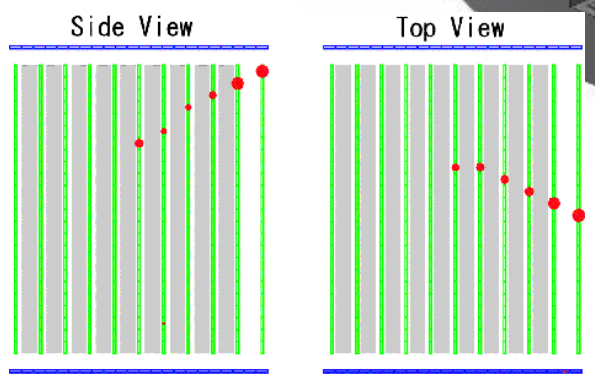
CERN directly contributed to ND280



- European Contributions:**
- UA1/NOMAD Magnet
  - TPC MicroMegas
  - TPC/FGD Electronics
  - Contributions to INGRID
  - ECAL
  - SMRD
  - Trip-T electronics
  - DAQ
  - Software
  - Analysis



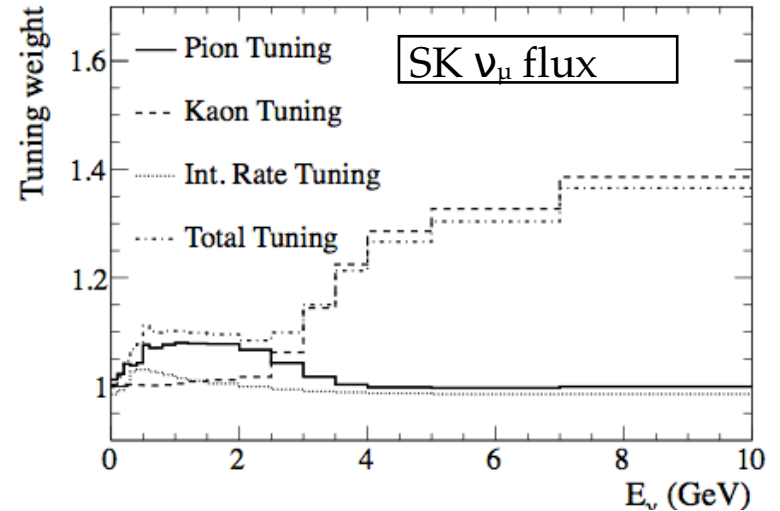
INGRID neutrino event



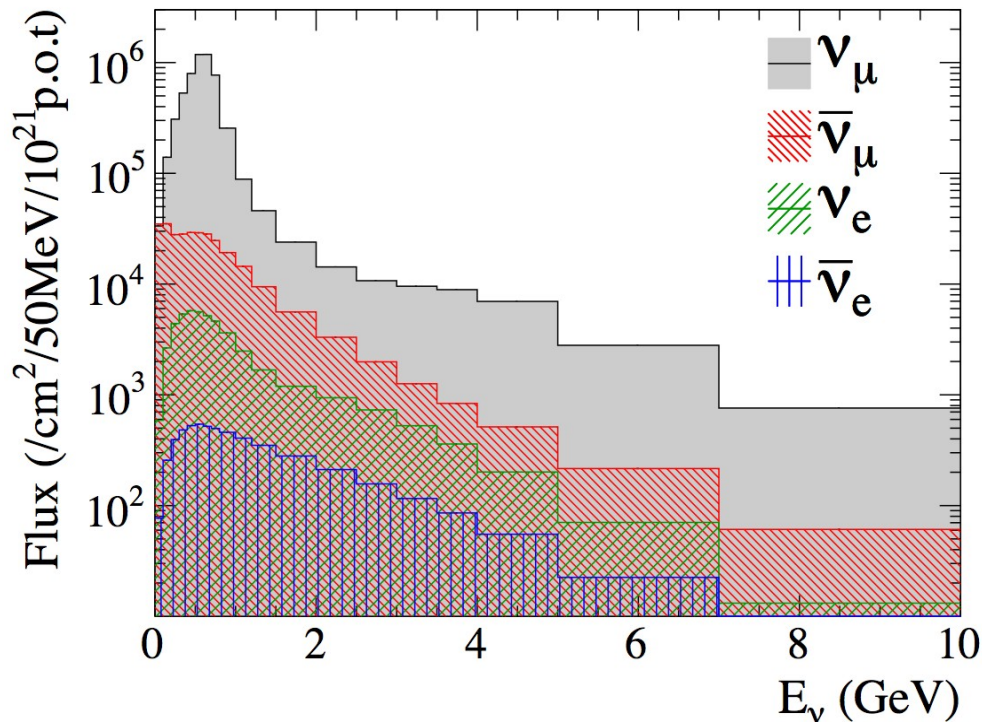
- ND280: neutrino spectrum, neutrino interaction properties
- INGRID: beam energy and profile

# Beam flux prediction

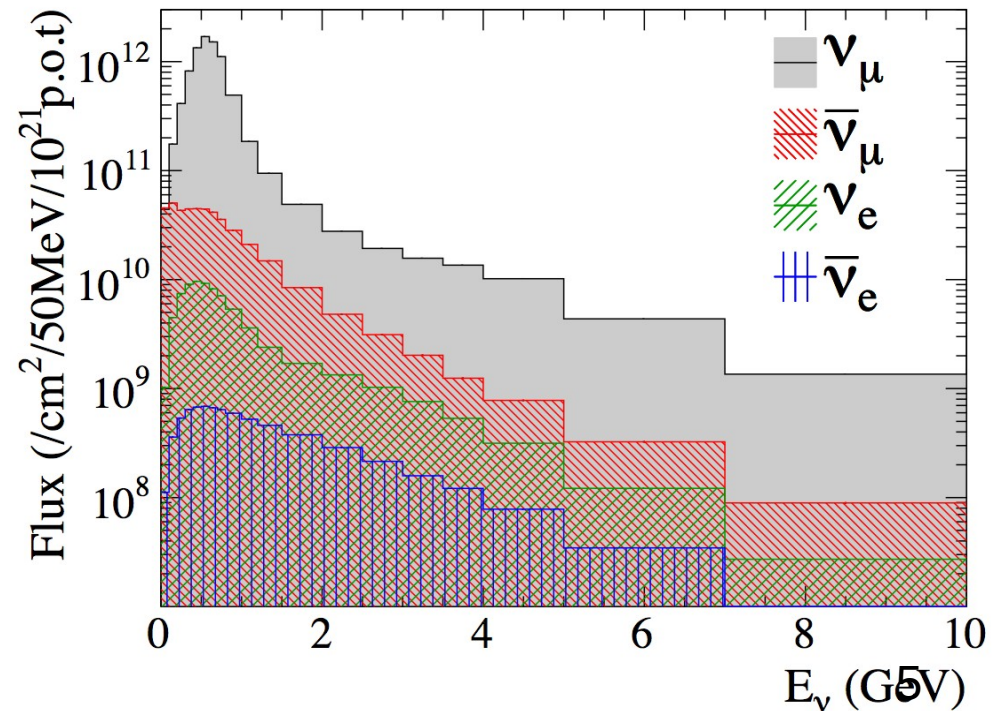
Beam flux is predicted based on **NA61/SHINE**  $\pi$ , K production measurements and T2K proton beam measurements



T2K Run1-4 Flux at Super-K

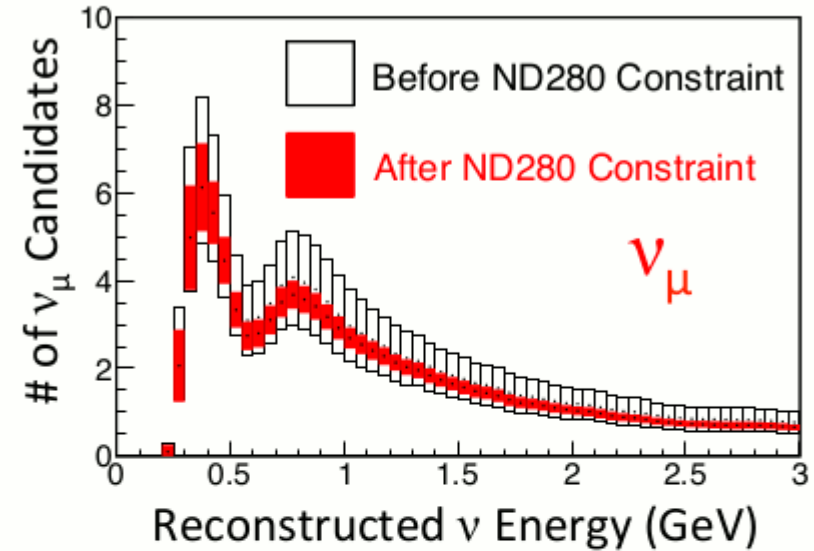
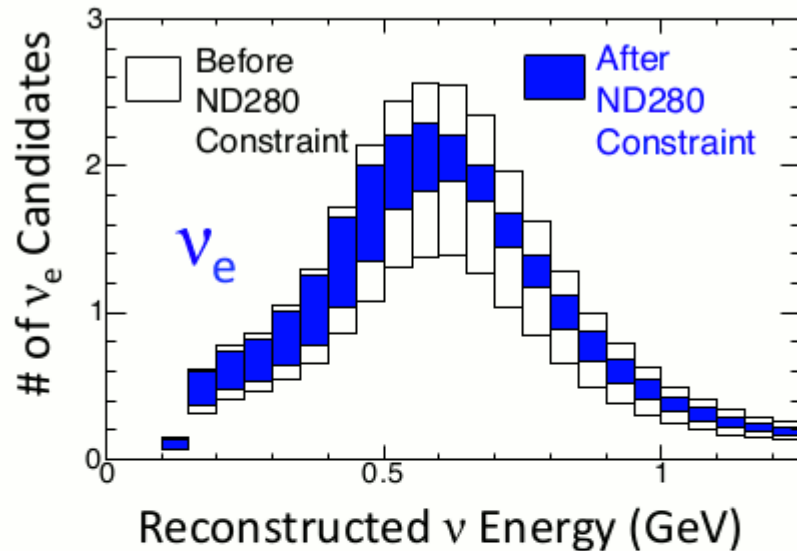


T2K Run1-4 Flux at ND280



# Flux and ND280 Constraints

## Resulting Systematic Errors



Systematic Source	Relative Uncertainty in # of $\nu_e$ Candidates (%)	Relative Uncertainty in # of $\nu_\mu$ Candidates (%)
Flux + cross section (ND280 constrained)	3.1	2.7
Cross section (ND280-independent)	4.7	5.0
$\pi$ Hadronic Interactions	2.3	3.5
SK Detector	2.9	3.6
<b>Total</b>	<b>6.8</b>	<b>7.6</b>

# Lessons Leant

Cern has been fundamental for T2K to:

- Refurbish and donate the UA1/NOMAD magnet
- Home for many test beams (TPC, ECAL, DAQ/electronic tests etc)
- Building and operating NA61/SHINE
- ...
- A home for EU contributions

# Hyper-K

Many contributions can happen. We would like to discuss the ones that are feasible. A few initial suggestions:

- Contributions to MW beam development
- Contributions to understanding neutrino interactions:
  - NuSTORM?
- Hardware development for Hyper-K (far and near detectors), complementary with Japan efforts:
  - photo-sensor accessories, i.e. cover+geomagnetic shield+electronics
  - photo-sensor calibration R&D. Eg a small package (LED, SiPM, and electronics) next to each PMT, to monitor gain, noise, and perhaps timing....
  - Other calibration tools to calibrate big detectors
- .....