The studies of neutrino interactions and oscillations in the T2K experiment

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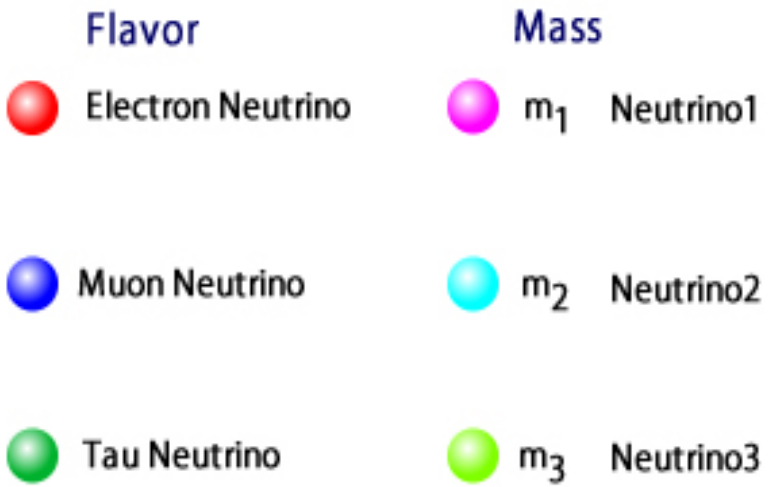
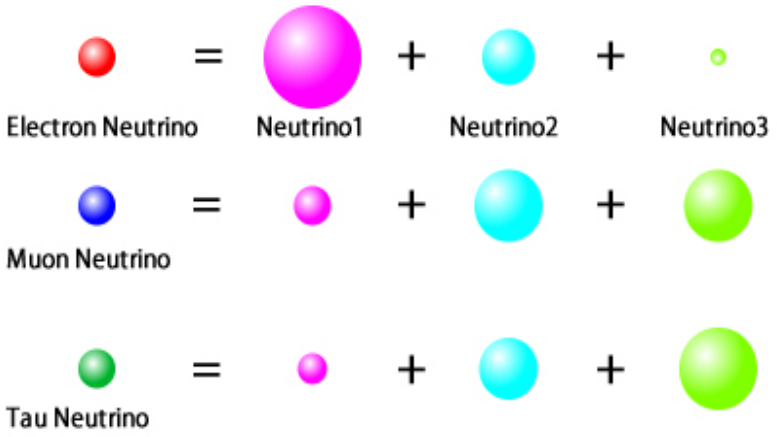
Neutrinos and neutrino oscillations

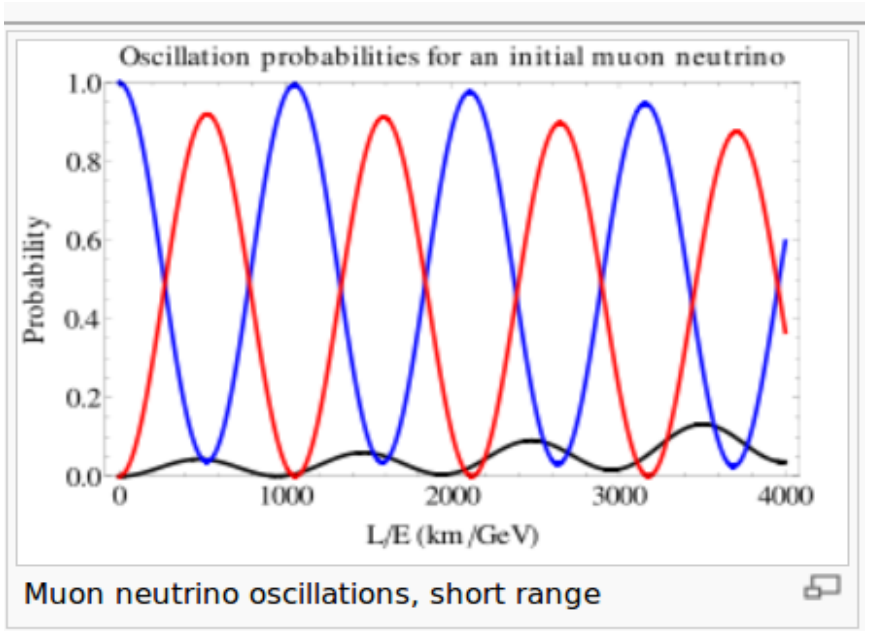


Neutrino:

- neutral, weakly interacting elementary lepton
- very light and difficult to detect
- 3 types of neutrino change to each other through oscillations

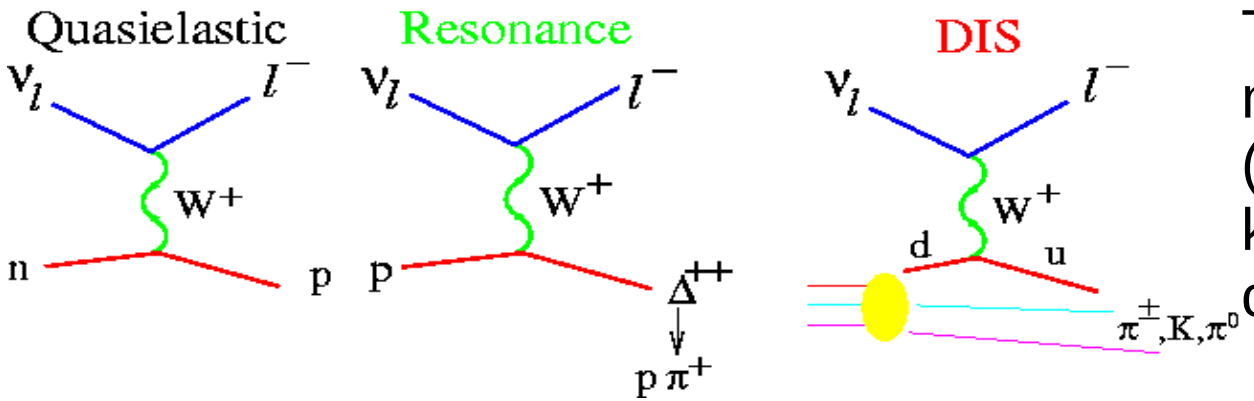


Img source: http://www.hyper-k.org/en/neutrino.html

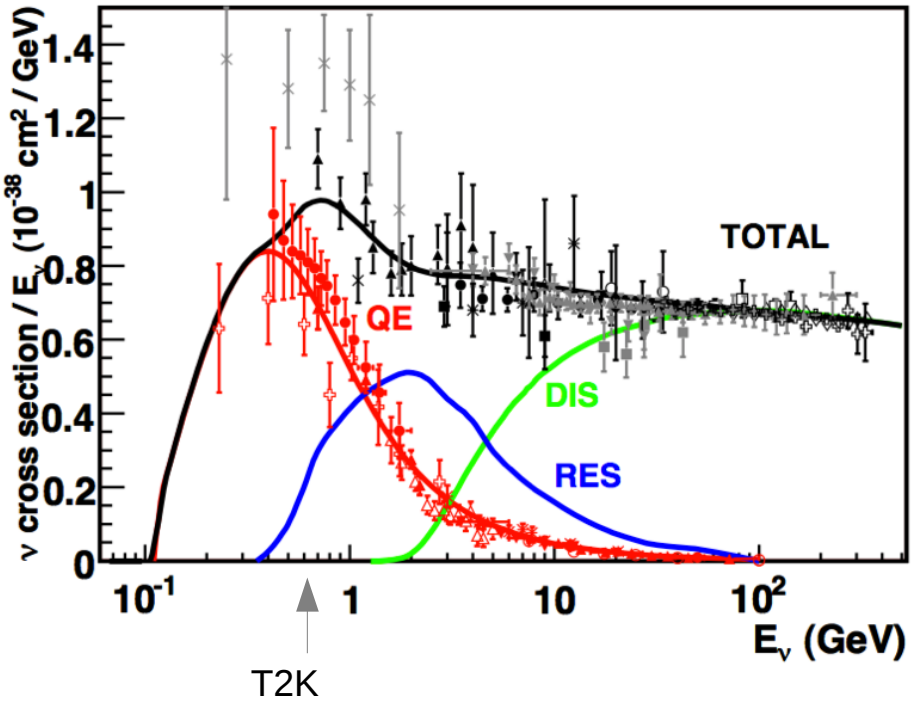


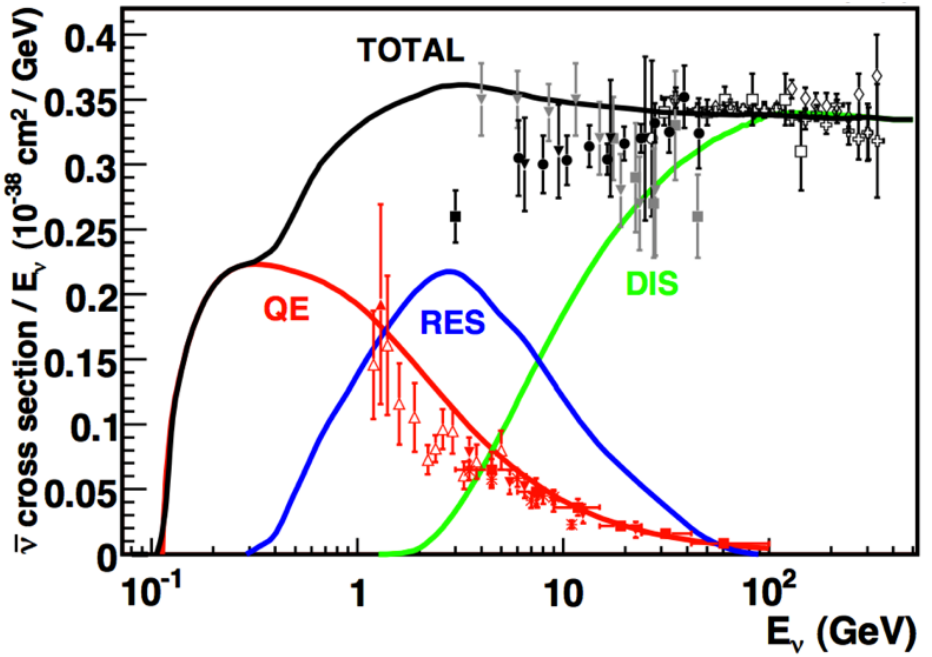
Img source: http://en.wikipedia.org

Neutrino interactions



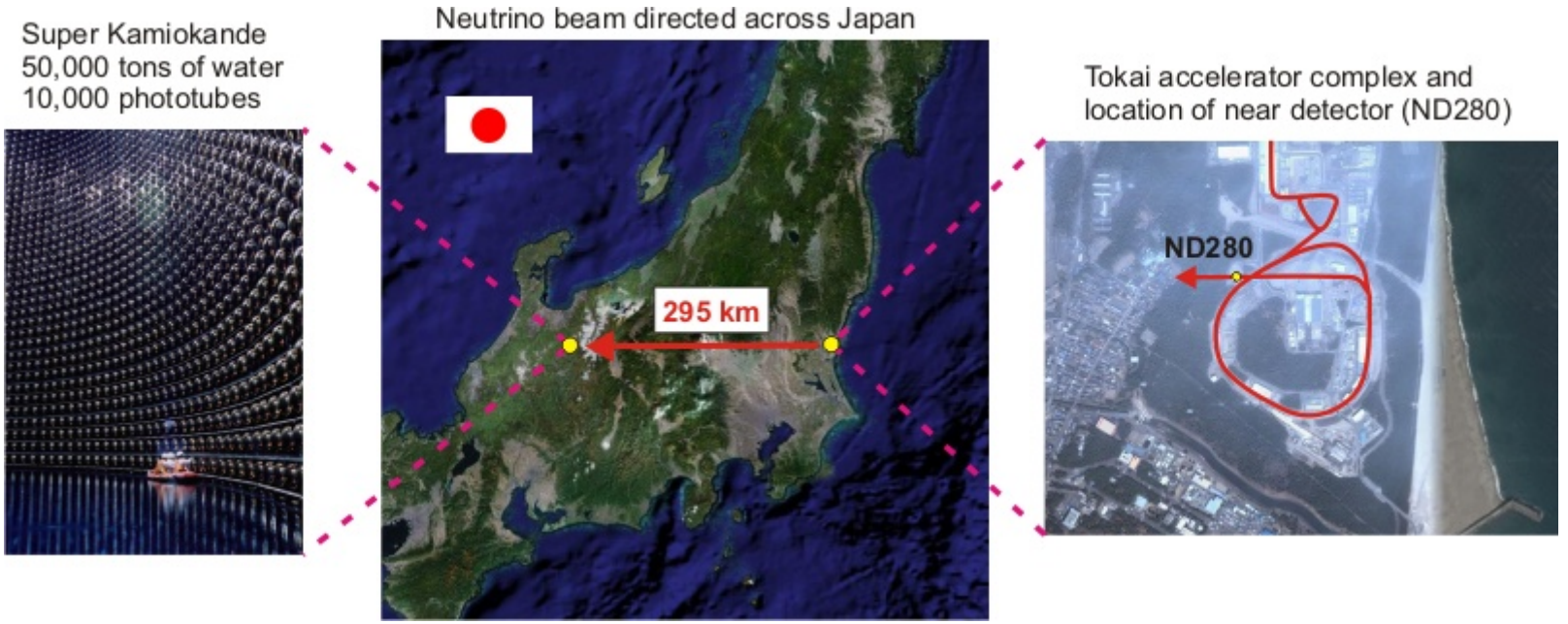
To understand and study neutrino properties (i. a. neutrino oscillations), knowledge about neutrino cross-sections is needed.



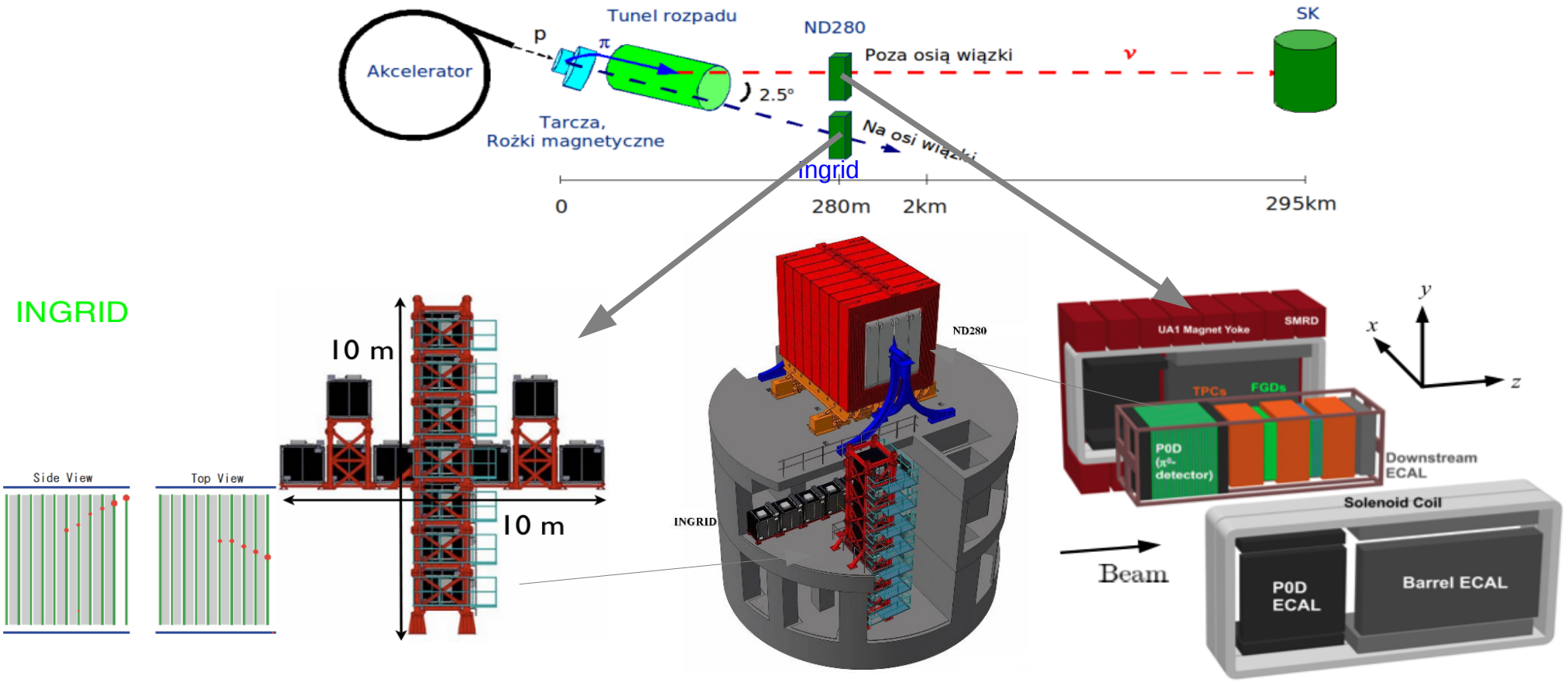


T2K Experiment

- Long baseline neutrino oscillation experiment
  - J-PARC accelerator complex: production of intense muon neutrino beam
  - Near detectors: measurement of the neutrino flux before oscillations and neutrino cross-sections
  - Far detector: measurement of the neutrino flux after oscillations



Near detectors: INGRID and ND280



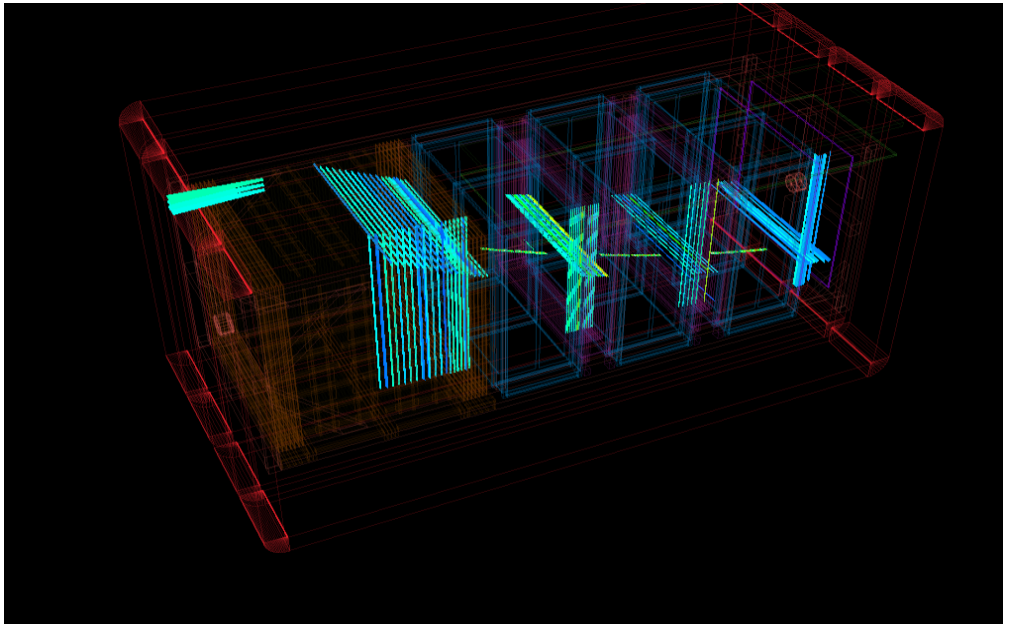
INGRID
in the center of the neutrino beam axis

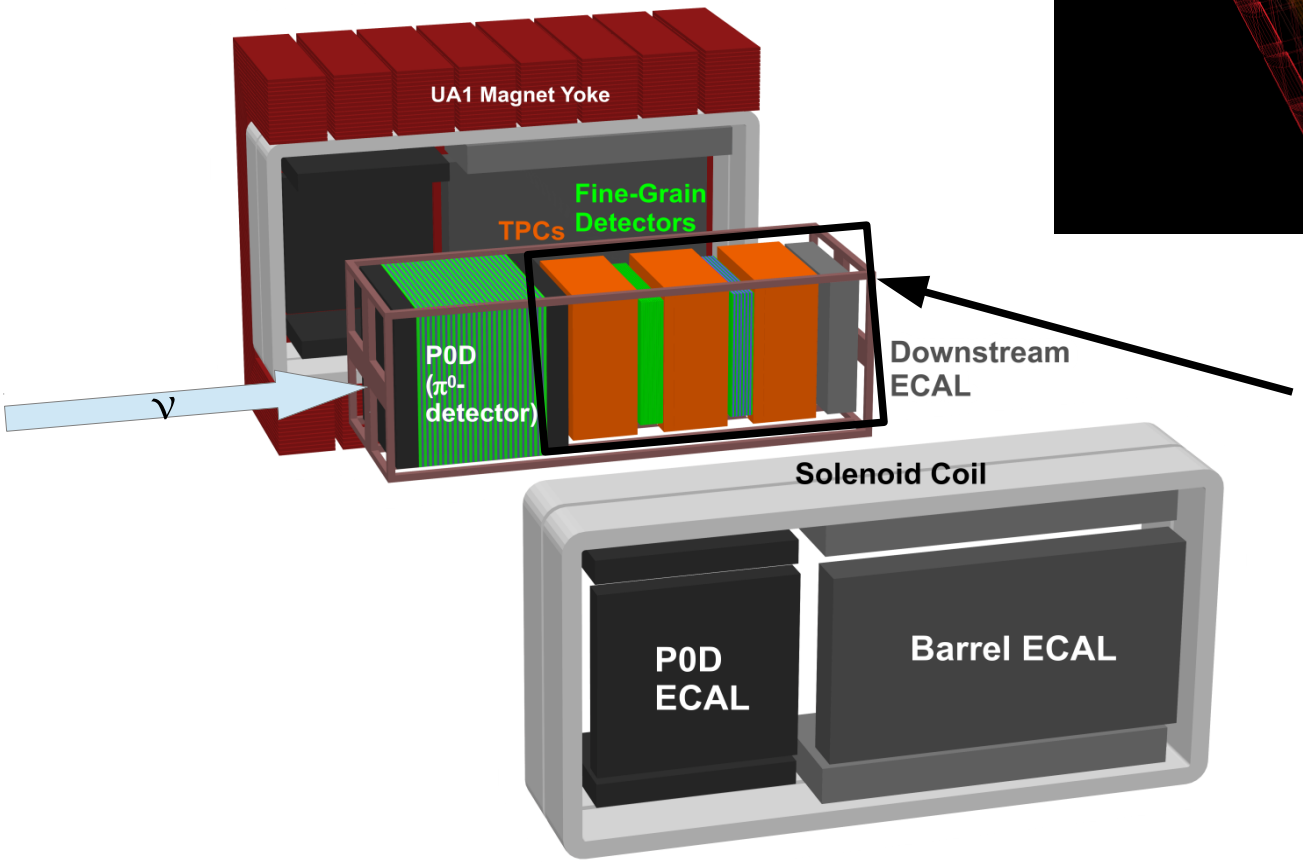
Kraków T2K group perform the analyses in ND280 detector

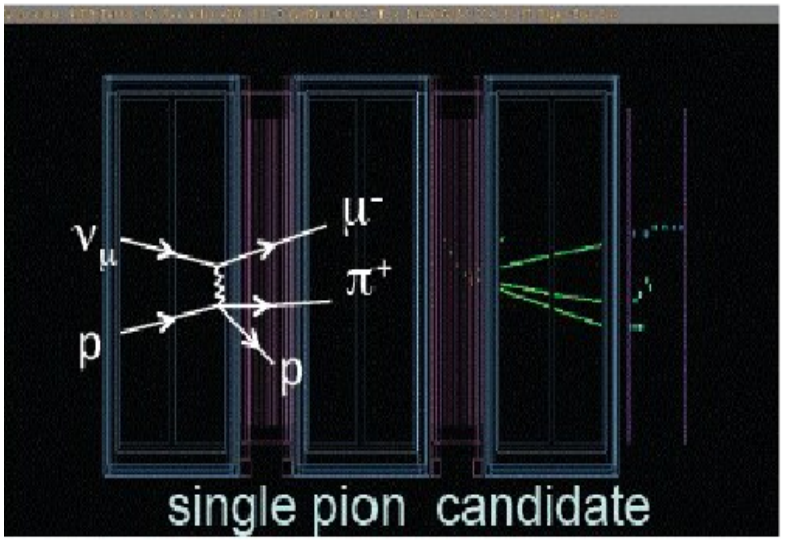
ND280
out of the neutrino beam axis

Events in ND280 detector

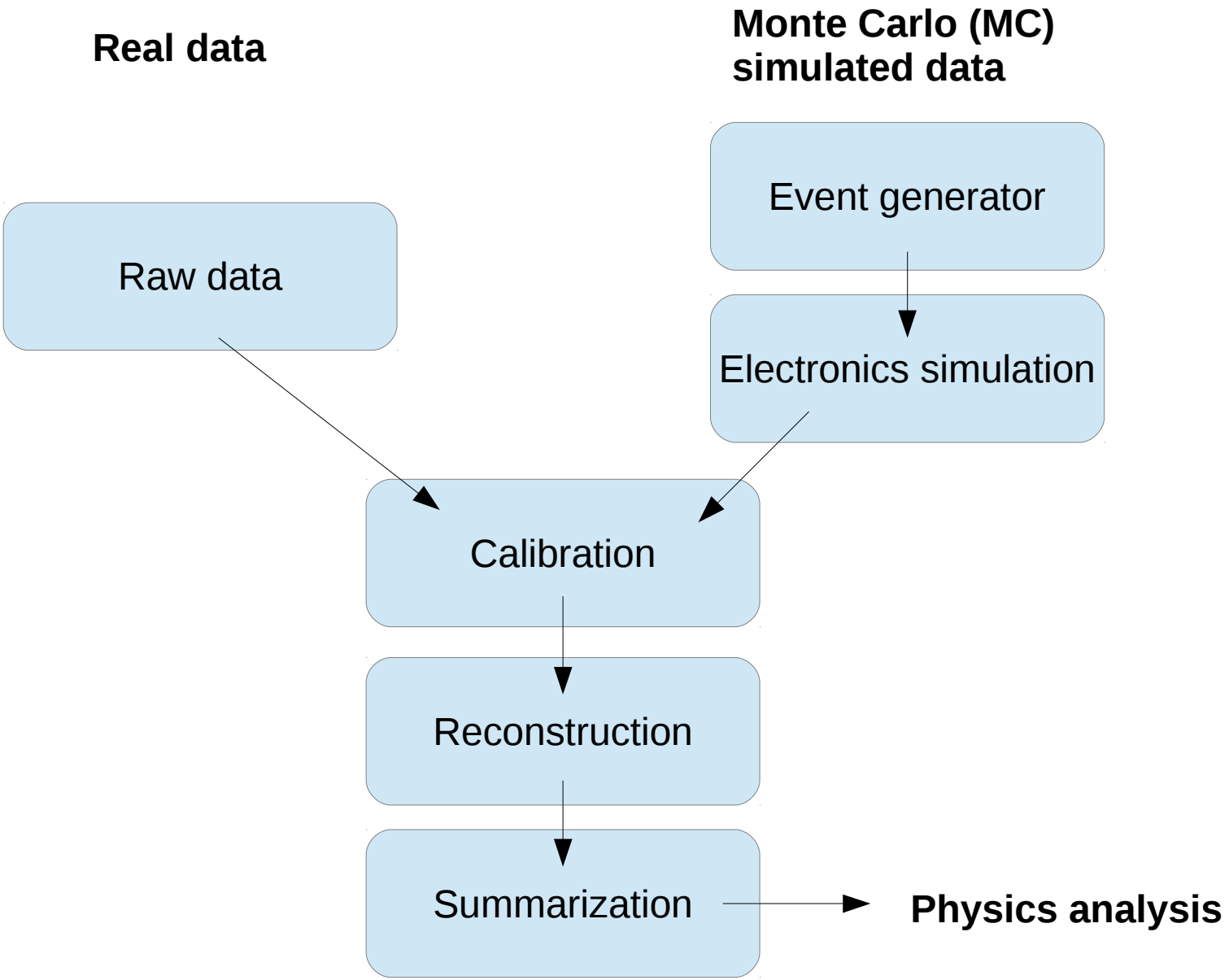
- Event analysis:
  - identify particles, neutrino type and type of interaction.



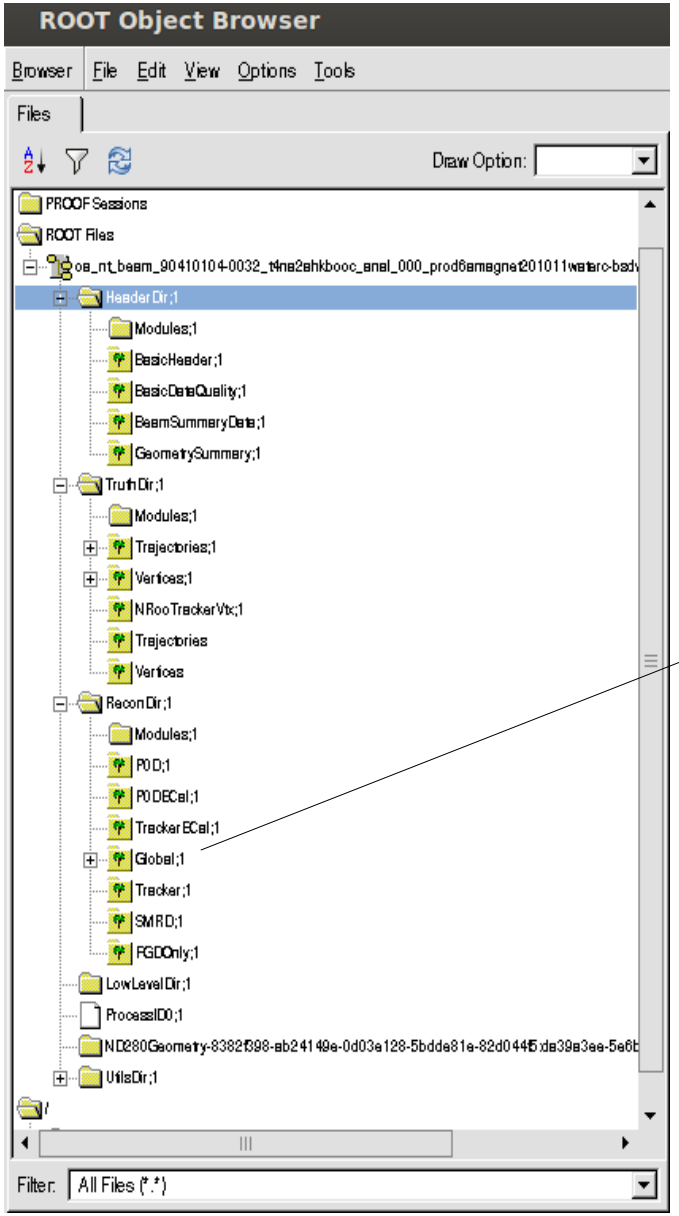




Event reconstruction

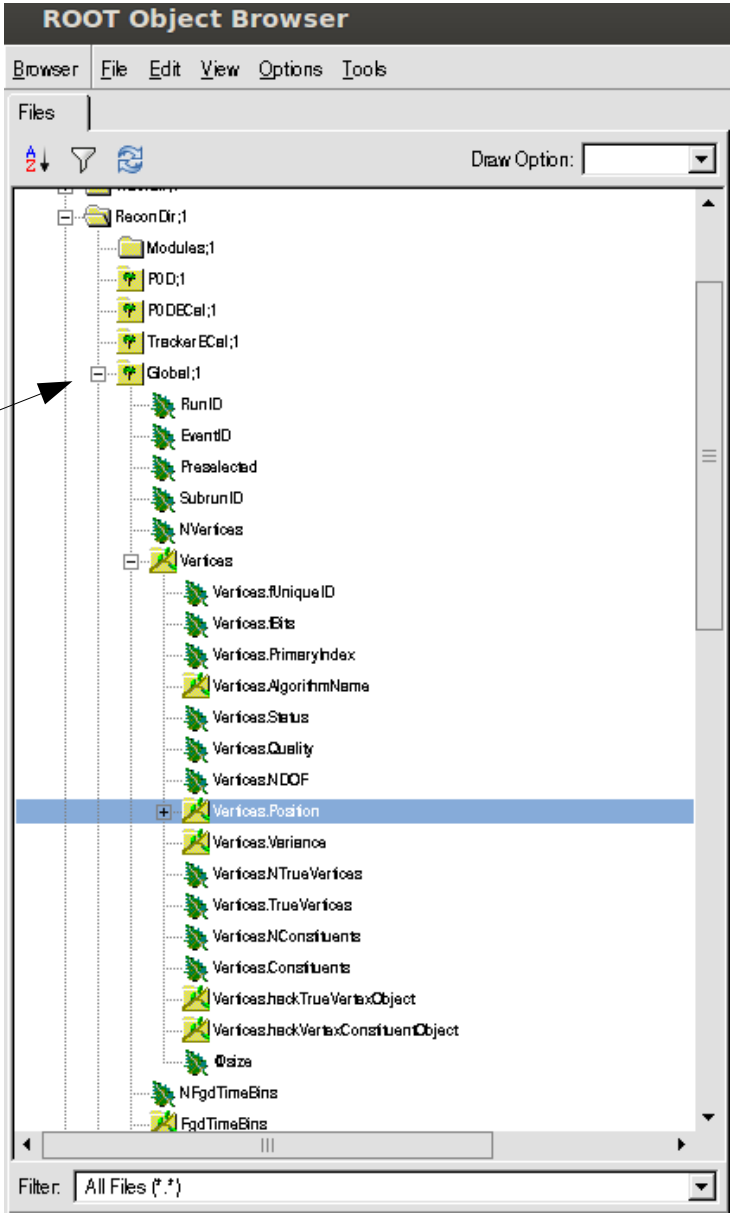


Input data structure



- Hierarchic root file containing information about reconstructed tracks and (in MC data) true trajectories

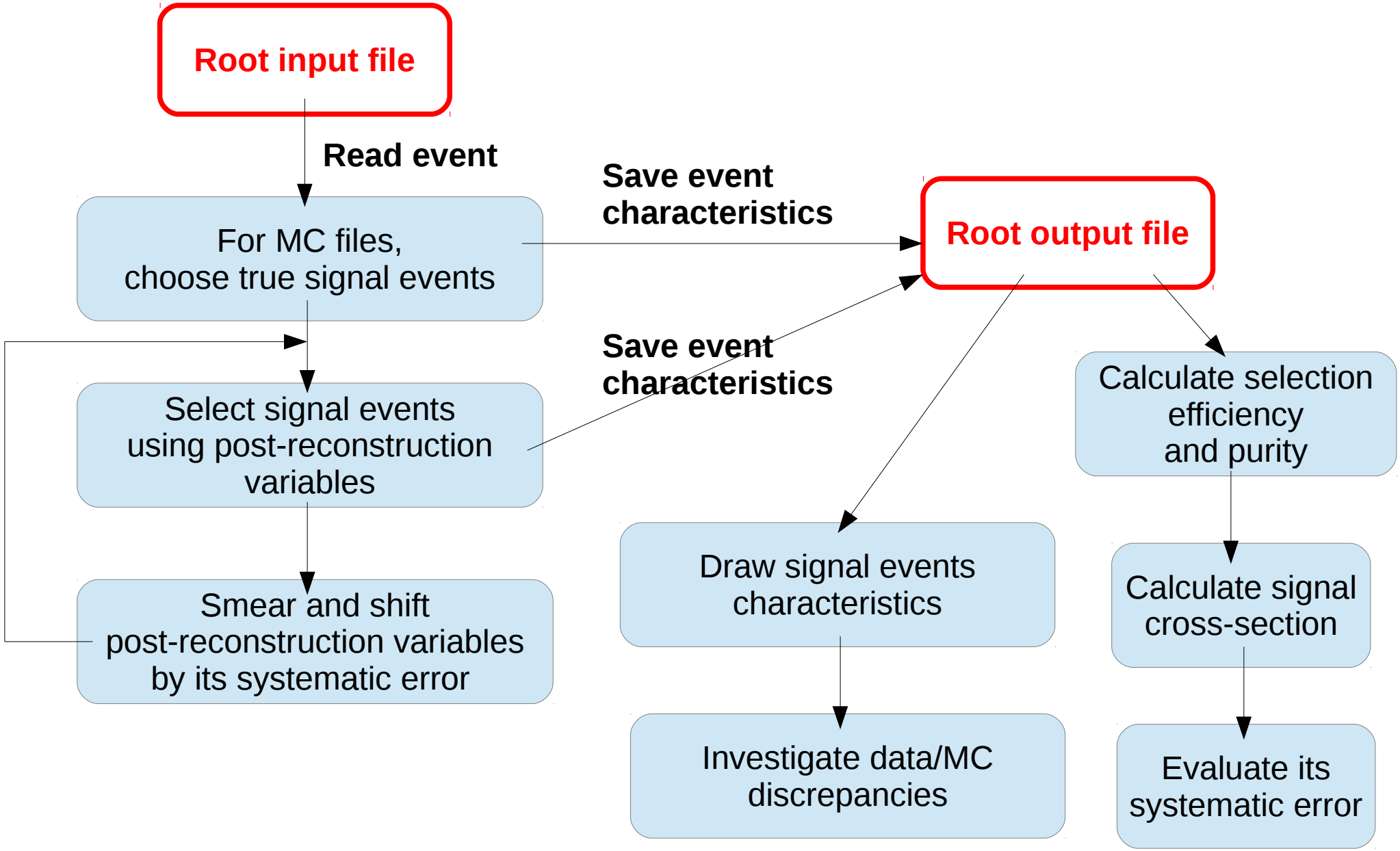
- Currently the size of the input data is about 15 TB
- And it's growing



T2K Cracow group analyses

- Reconstruction validation
- Implementation and validation of new reconstruction algorithms
- Systematic errors calculation
- Neutrino cross sections measurements

Event-by-event physics analysis



Hardware and software used

- **Hardware**:
  - ~25 TB of disc space
  - frequent input/output operations
  - simple, repetitive calculations using ~100 cores
- **Software:**
  - C++
  - root
  - ND280 dedicated libraries
- **Parallel computing**:
  - division of input files into subsets
  - running the same analysis program on each subset
  - adding the output root files using hadd (function for merging root files)
  - jobs do not communicate with each other
- **Grid computing**:
  - contact with other grid centres during downloading input data files only
  - local calculations using locally stored input data

Problems solved/to be solved

- Difficulty in making available the input data and validation plots – **VeilFS service**
- The T2K input data are stored in the LUSTRE file system, because of frequent I/O operations.
  But are these operations in fact frequent?
- Graphical interface for running and monitoring jobs would be useful – **CYFRONET tutorials**
- It would be useful to delete from a queue jobs with IDs from a certain range – **qsub -t array_range, qdel -t array_range**

Summary

- The cross section measurements are in progress and the results will be published
- The reconstruction validation will start soon
  - It requires more disc space and more CPU
- The prospect of adding Zeus to the grid centres used by T2K is investigated by the T2K Katowice group
  - VO T2K requires 300TB disc space and 300k hours CPU time / year