AYSS-2023

Detection of the atmospheric neutrinos in the NOvA experiment

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The NOvA experiment

- **N**uMI **O**ff-Axis νe **A**ppearance;
- 14 mrad off-axis beam;
- 2 GeV peak energy;
- measure ν_μ ($\overline{\nu}_\mu$) disappearance and ν_e ($\overline{\nu}_e$) appearance;
- two detectors:

  - near detector (ND, 300 tons) at a distance of 1 km from target;

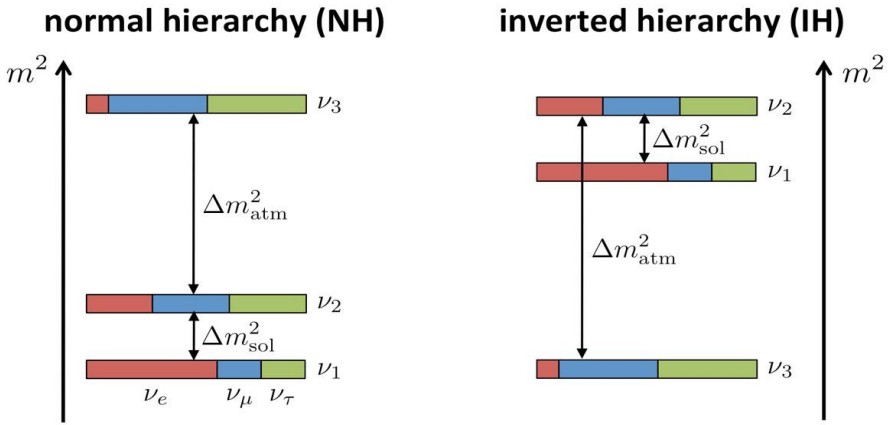
  - far detector (FD, 14 kilotons) at a distance of 810 km, in Ash River, MN;
- PVC tubes filled with liquid scintillator based on mineral oil.

NOvA physics goals

- determination of the neutrino mass hierarchy;
- definition of the octant θ_{23}, the refinement θ_{13};
- restrictions on the δ_{cp} ;

} main analysis

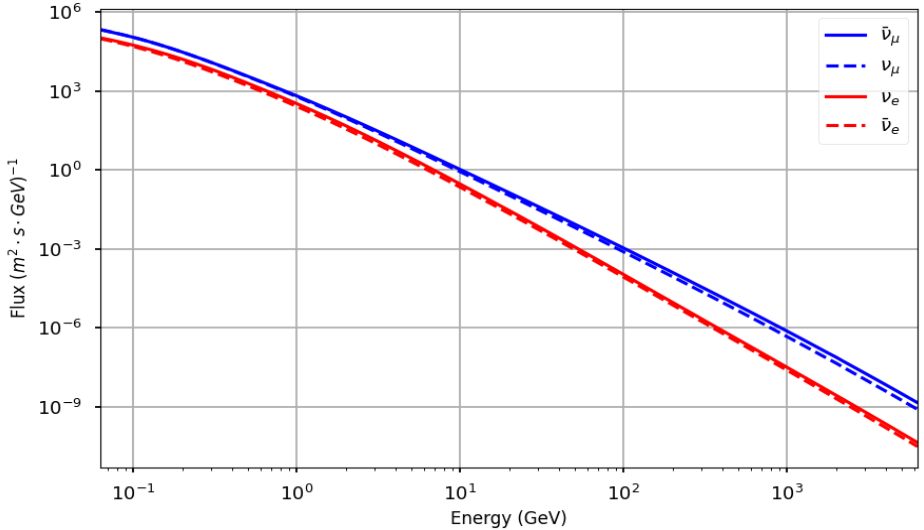
- sterile neutrinos, exotic searches, neutrino cross-sections.



Atmospheric neutrinos

Atmospheric neutrinos are the background for solving many additional physical problems:

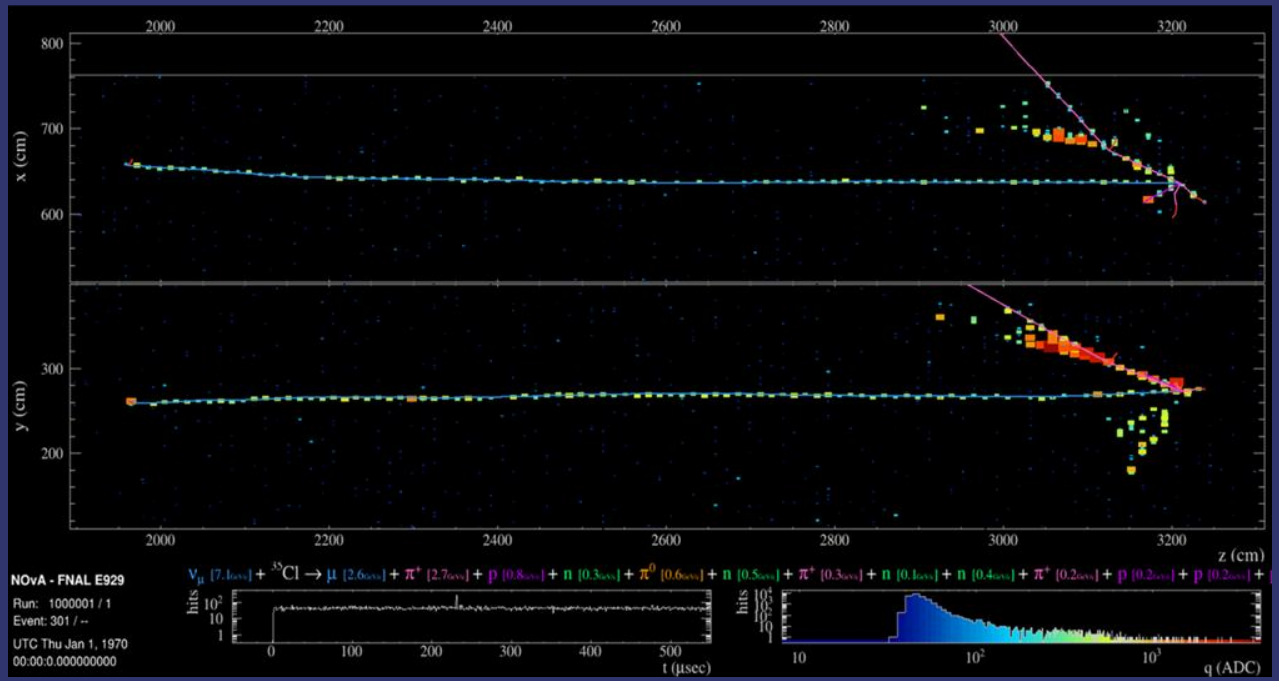
- the search for Dark Matter particles;
- studying of proton decay;
- registration of the shadow from the Moon and so on.



Atmospheric neutrino flux vs energy

The task was set to measure the atmospheric neutrinos spectrum in the NOvA.

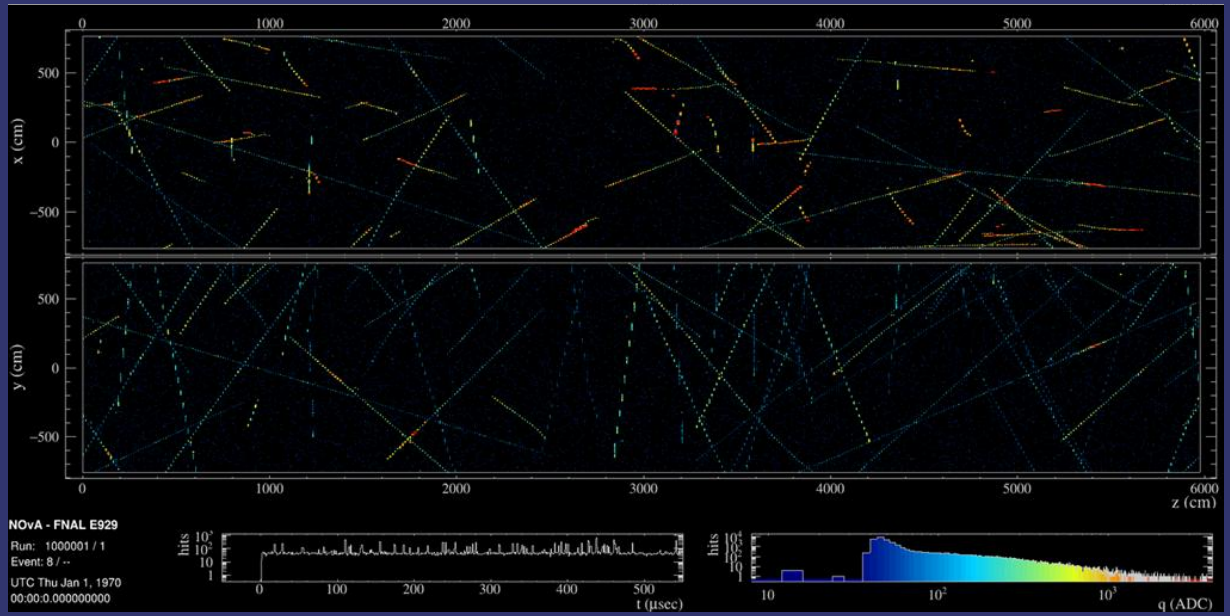
Simulated signal sample



Signal event from the atmospheric neutrinos

- simulated using GENIE software package;
- 10k signal events from all directions (2.3 year, ~ 4300 events/y).

Simulated background sample

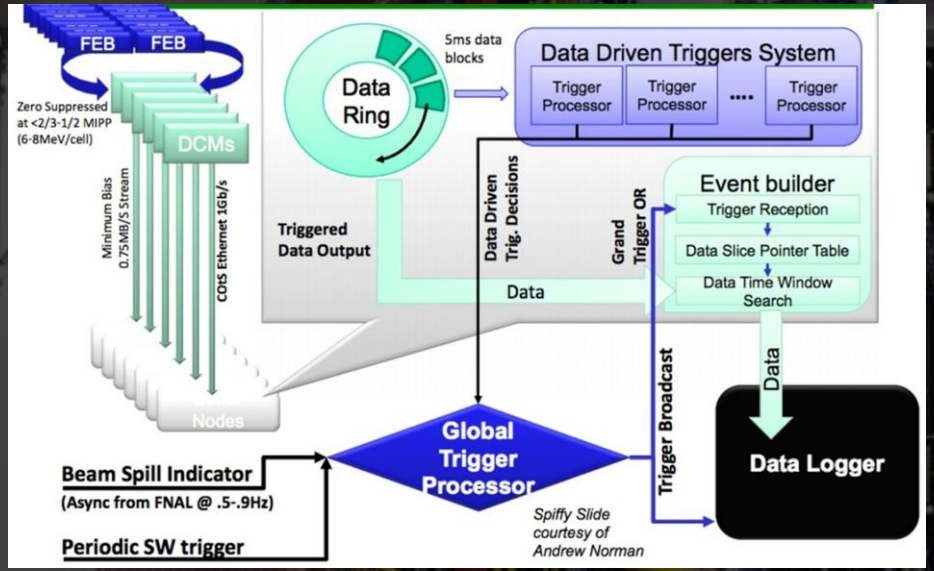


Background event from the cosmic rays (for 550 μs)

- mostly atmospheric muons and other activity induced by cosmic rays (150k μ per sec in FD);
- simulated using CORSIKA (COsmic Ray Simulations for KAscade).

The propagation of particles inside the detector is performed by GEANT4.

DDTriggers: description



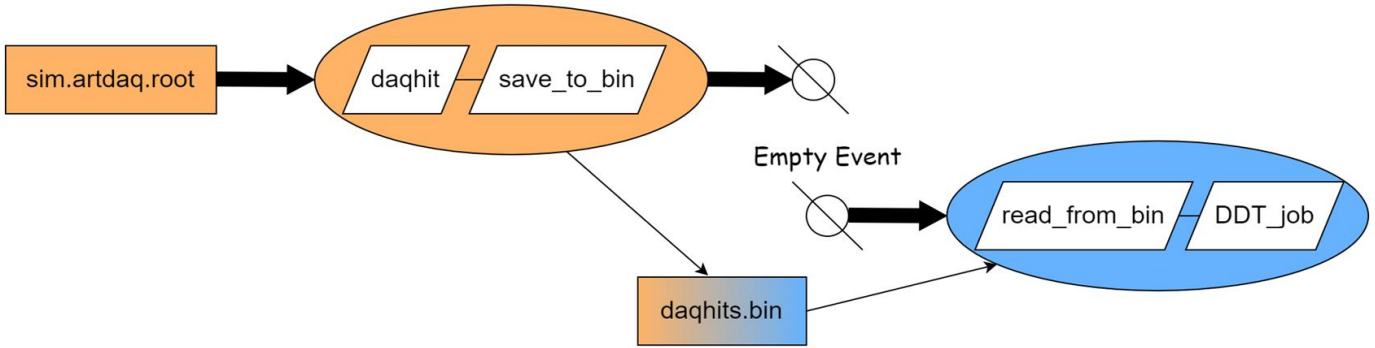
Data Acquisition System in NOvA

- By default, events are selected that coincide in time with the beam.
- All data is written to a circular buffer and analyzed by fast algorithms that allow you to save the necessary data for later offline analysis.
- It's a system of software triggers - Data Driven Triggers (DDT) data.

For analysis based on stored data, two existing triggers were considered: «Upmucontained» and «Neutronosc», allowing to separate ν CC events and ν NC, respectively.

Running DDT jobs on simulation

– We tried different ways to pass the data from offline to DDT:
  - standard methods fail because of different versions of ART and ROOT;
  - saving and reading in binary format → it worked!

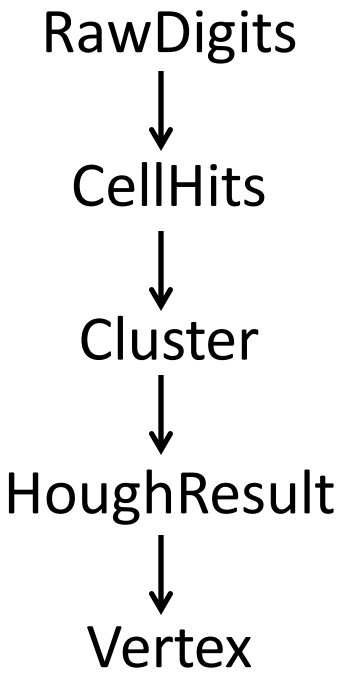


Saving all the DAQHits to binary file in a simple custom format:
independent of ROOT or ART versions

– <u>Now it's possible to run a DDT job on the offline data!</u>

Work in progress…

Reconstruction steps



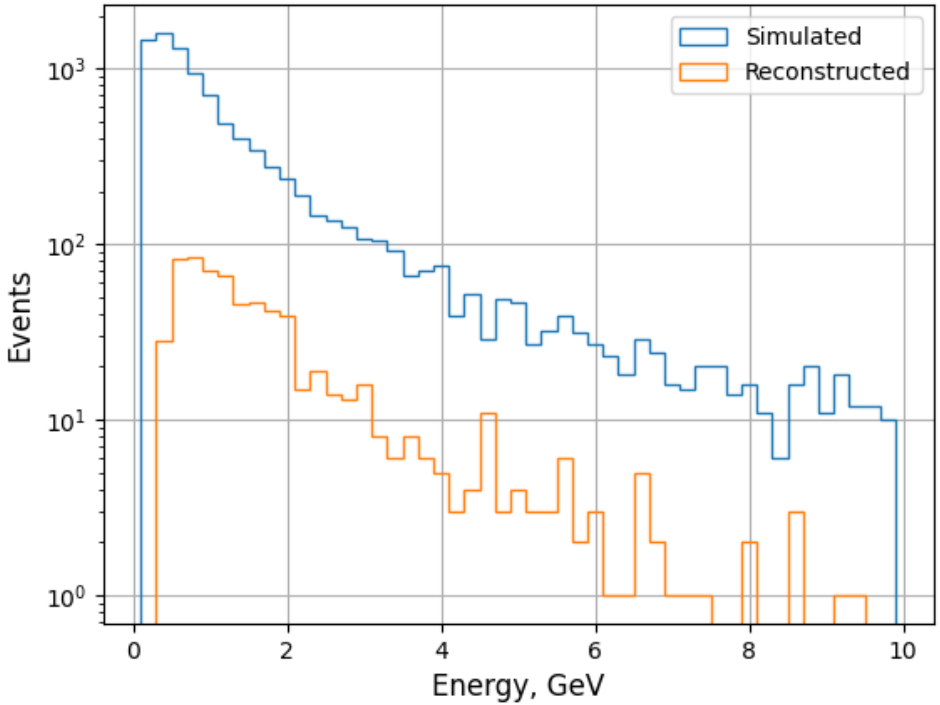
Apply calibrations, look up geometry information

Cluster in space and time to isolate separate physics interactions

Search cluster for prominent straight line features

Using line features, look for major points of intersection

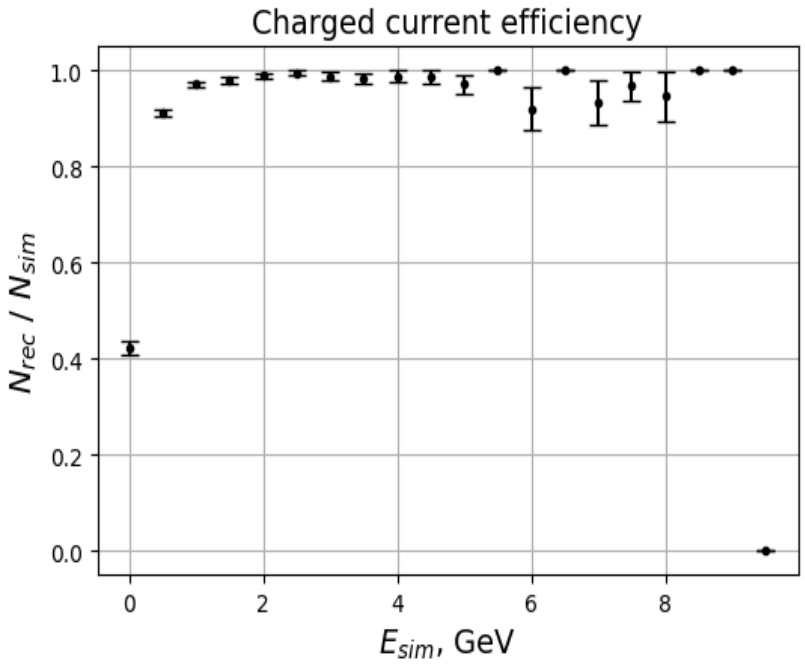
Reconstruction of the neutrino events

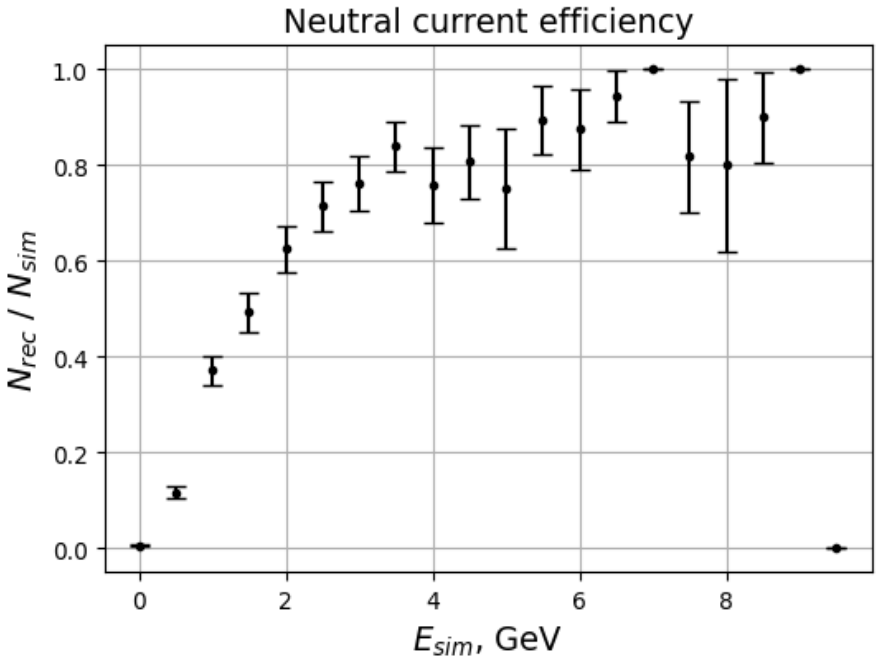


Energy spectrum: the blue color shows simulated neutrinos, the orange – reconstructed ones

Integral reconstruction efficiency - 45%.

Reconstruction of the neutrino events





For charged currents (CC) events the efficiency is stable, for neutral currents (NC) the more E_ν, the greater the efficiency

Summary

Status:

- created the signal and background samples;
- launched the reconstruction of the signal events and its integral efficiency was obtained;
- found the way to run a DDT job on the offline data

Plans:

- estimate the selection efficiency of the existing triggers;
- write the dedicated trigger for future data;
- create the procedure for the signal/background selection.

Thank you for your attention!