

Analysis and interactive visualization of neutrino event topologies registered in the OPERA experiment

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Task 2

Downloading the OPERA datasets

Dataset × OPERA × zip ×

☐ include on-demand datasets

Filter by type

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Filter by file type

☐ csv

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Filter by event number

☐ 0--999

☐ 1000--9999

☐ 10000--99999

☐ 100000--999999

☐ 1000000--9999999

☐ 10000000--

Emulsion data for neutrino-induced charmed hadron production studies

The dataset was extracted from the official OPERA data repository. It contains 50 muon neutrino interactions with the lead target where a charmed hadron is reconstructed in the final state. Neutrino...

Dataset Derived OPERA

for the Task 1)

Emulsion data for track multiplicity

The dataset was extracted from the official OPERA data repository. It contains 817 muon neutrino interactions with the lead target where a muon was reconstructed in the final state. This happens in th...

Dataset Derived OPERA

for the Task 2)

Emulsion data for neutrino tau appearance studies

This dataset was extracted from the official OPERA data repository and it contains all the emulsion data information for the ten tau neutrino candidates, identified after an extensive analysis that...

Dataset Derived OPERA

for the Task 3)

Electronic detector data for tau neutrino appearance studies

This dataset was extracted from the official OPERA data repository and it contains all the data of the electronic detectors for the ten tau neutrino candidates, identified after an extensive analys...

Dataset Derived OPERA

for the Task 4)

How were these data validated?

During the data taking, all the runs recorded by OPERA are certified as good for physics analysis if the trigger and all sub-detectors show the expected performance. Moreover, the time stamp of the event should lie within the gate open by the CNGS beam signal. The data certification is based first on the offline shifters evaluation and later on the feedback provided by all sub-detector experts. Based on the above information, stored in a specific database, the Data Quality Monitoring group verifies the consistency of the certification and prepares an ascii file of certified runs to be used for physics analysis. For this specific data record, dedicated calibration procedures are performed to align the emulsion films each other and with the electronic detectors. These procedures with the corresponding results are saved in a dedicated database where data quality experts certify the results and prepare files to be used for the track and vertex reconstruction, thus being available for physics analysis.

Files

Filename	Size	
emulsion-data-for-track-multiplicity.zip	456.1 kB	Download

Disclaimer

The open data are released under the [Creative Commons CC0 waiver](#). Neither OPERA nor CERN endorse any works, scientific or otherwise, produced using these data. All releases will have a unique DOI that you are requested to cite in any applications or publications.



Task 2

2) Download OPERA emulsion dataset for the charged hadron multiplicity studies from the Open Data Portal. Develop a C++ program for analysis of the dataset. Read the positions of the primary neutrino-lead interaction vertices as well as the parameters of the secondary charged particle tracks. Find and save to histograms **a)** multiplicities of all produced charged particles and **b)** angles of the muon tracks. Save the histograms to a ROOT or to an image file. Compare the results with the ones published in the corresponding OPERA paper.

[\[Eur. Phys. J. C \(2018\) 78:62\]](#),
[\[Eur. Phys. J. C \(2018\) 78:747 \(erratum\)\]](#)

Total number of located ν events: 5603

**Events selected for the charged hadron multiplicity
analysis: 817 ν_{μ} interactions with the lead target
where a muon was identified**

Description of the variables from the *.csv files

Dataset semantics	
Variable	Description
evID	event Id (11-digit number)
globPosX	X position of a vertex in the OPERA detector system of reference (in cm)
globPosY	Y position of a vertex in the OPERA detector system of reference (in cm)
globPosZ	Z position of a vertex in the OPERA detector system of reference (in cm)
mult	number of ECC tracks attached to the vertex
posX	X position of a track/vertex in the OPERA brick system of reference (in micrometers)
posY	Y position of a track/vertex in the OPERA brick system of reference (in micrometers)
posZ	Z position of a track/vertex in the OPERA brick system of reference (in micrometers)
slopeXZ	tangent of a track angle in XZ view
slopeYZ	tangent of a track angle in YZ view
timestamp	time in milliseconds since 01/01/1970
trType	type of a track: 1 - <u>muon</u> ; 2 - <u>hadron</u> ; 3 - <u>electron</u> ; 4 - black; 5 - back black; 6 - gray; 7 - back gray

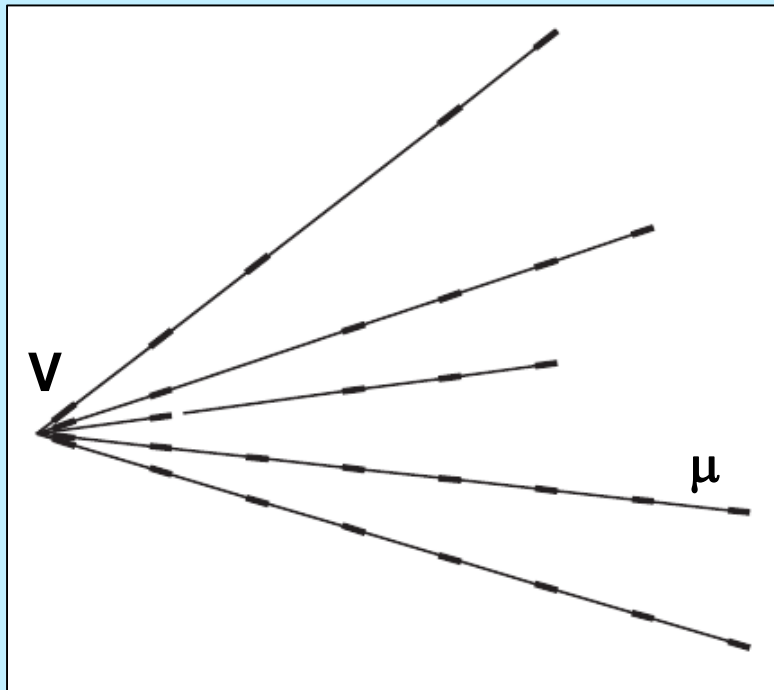
We will use these variables
to fill our histograms

*_Vertex.csv

*_Tracks.csv

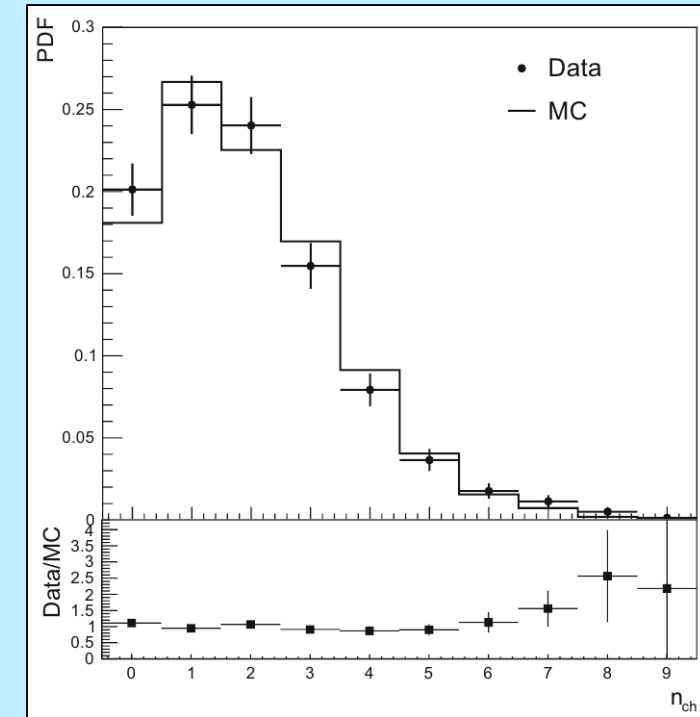
Track multiplicity and track slopes

Track multiplicity is a number of tracks (of charged particles) associated with a given vertex (in our case – with the ν_μ primary interaction vertex).



In the multiplicity sample each track is defined by its starting point (a 3D point near the vertex) and two slopes: slopeXZ and slopeYZ (i.e., tangents of angles with respect to the Z axis in the ZX and ZY views).

Track multiplicity distribution from the OPERA paper



In this task we will save the track multiplicities to a 1-dimensional (TH1I) histogram, while the two angles of muons - to a 2-dimensional (TH2D) histogram.

Backup slides

Histograms in ROOT

A very comprehensive description:

<https://root.cern/doc/master/classTH1.html>

A ROOT Guide For Beginners (Chapter 5 is about the histograms):

<https://root.cern.ch/root/html/doc/guides/primer/ROOTPrimer.pdf>

ROOT histogram tutorials:

https://root.cern/doc/master/group__tutorial__hist.html

ROOT TH2D (2D histogram) class reference:

<https://root.cern.ch/doc/master/classTH2D.html>

Example of creation and filling of a 2D histogram

```
void Hist2()  
{  
    Double_t MaxX = 10;  
  
    TH2D* H2 = new TH2D("H2",  
                        "H2 title",  
                        30, 0, MaxX,      // Number of bins and range for the X axis  
                        50, 0, MaxX*MaxX); // Number of bins and range for the Y axis  
  
    H2->SetTitle("X title");  
    H2->SetTitle("Y title");  
    H2->SetTitle("Z title");  
  
    H2->GetXaxis()->SetTitleOffset(1.4); // Sometimes the title is too close to the axis  
    H2->GetYaxis()->SetTitleOffset(1.4);  
    H2->GetZaxis()->SetTitleOffset(1.4);  
  
    Int_t N = 1000000;  
  
    TRandom* rand = new TRandom();  
  
    for (Int_t i = 0; i < N; i++)  
    {  
        Double_t x = i*MaxX/N;  
  
        Double_t y = x*x + rand->Uniform(-10, 10); // a parabola with random noise  
  
        H2->Fill(x, y);  
    }  
  
    H2->Draw("lego2");  
  
    // or H2->Draw("colz");  
}
```


Requirements to the final report

<http://interest.jinr.ru/index.php> (the FAQ section):

1. The report should include an abstract that will be published on the website.
2. The abstract must be written in English and should contain not more than 150 words.
3. The language of the main part can be English or Russian.
4. The volume of the main part should be 10-15 pages (including figures and references), font size 12-14.
5. The contents of the main part should include the following sections: introduction (main problem, background, findings), project goals, scope of work, methods, figures/diagrams/plots, results, conclusion (discussions, prospects), references, acknowledgments.

Frontpage template

6. The report should be uploaded not later than 1 week after the Wave has ended.
 7. After uploading, the report should be approved by the project supervisor. The supervisor does that by pressing the APPROVE button on the website. After that the report is considered officially submitted.
 8. The format of the uploaded report should be doc or pdf.
 9. To upload the report, go to your project page and press "Add report".
- After the report is uploaded and approved, you will receive a participation certificate.