Interactions in ICARUS

Francesca Pucci
Supervisor: Minerba Betancourt

Final Reports

25 September 2019

ICARUS

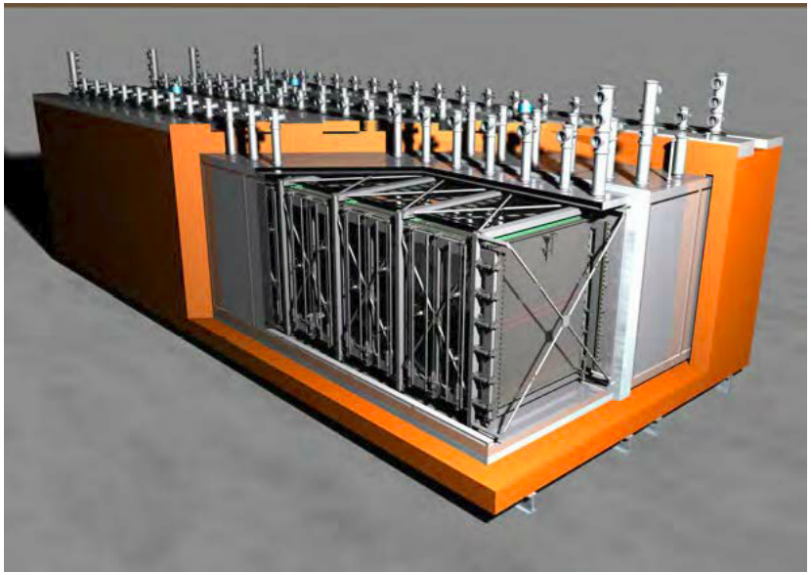
The ICARUS neutrino detector began its life in the Gran Sasso Laboratory in 2010.

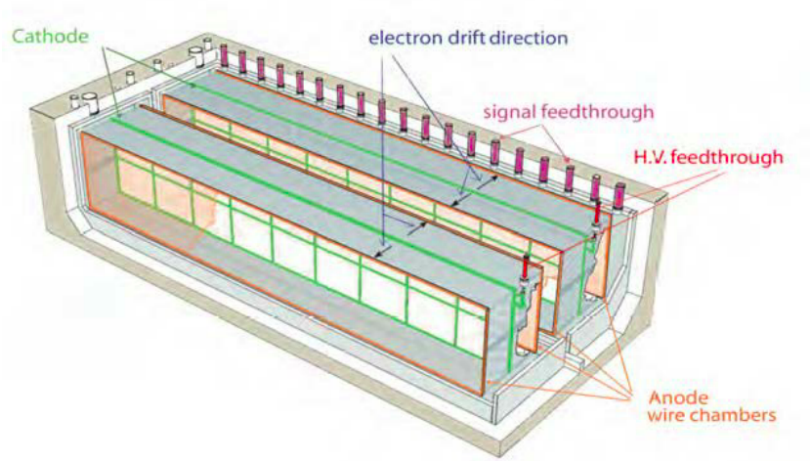
In 2014 it was moved to CERN, where it was updated and improved.

In 2017 it was moved to Fermilab and in 2018 its installation began.

Commissioning will begin at the end of 2019

How it works





The detector is 65 feet long and it is composed by two symmetric modules, with two TPCs each. It is filled with 600 tons of Liquid Argon.

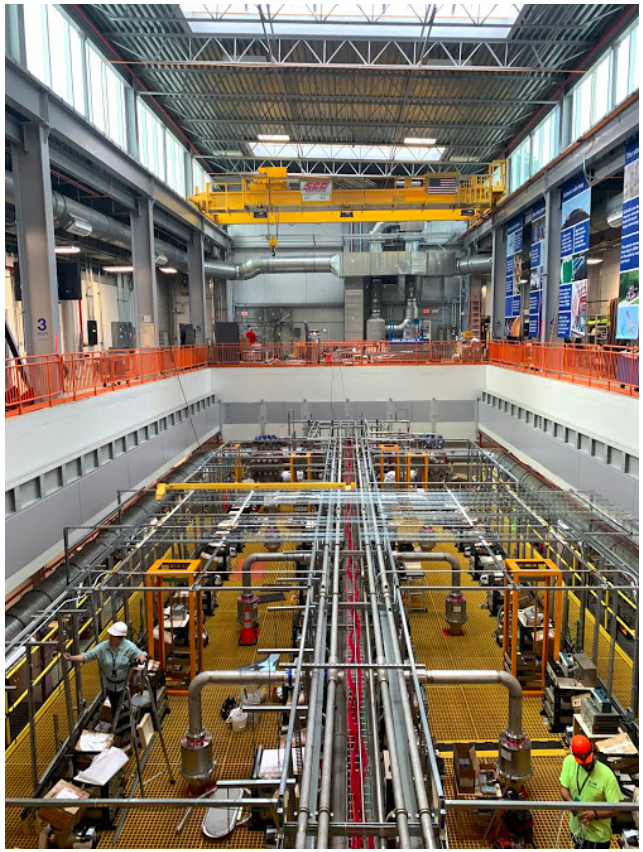
Neutrino interactions create new particles, which release electrons from the argon atoms.

Electrons drift to wire planes.

Events can be fully reconstructed and informations on neutrinos can be obtained.

Summary of my work until the midterm

- Installation of some cable trays
- Test of a code for particle identification
- Study of the particles track length and angular distributions
- Display of purity and data sending to database
- Creation of a link on the website

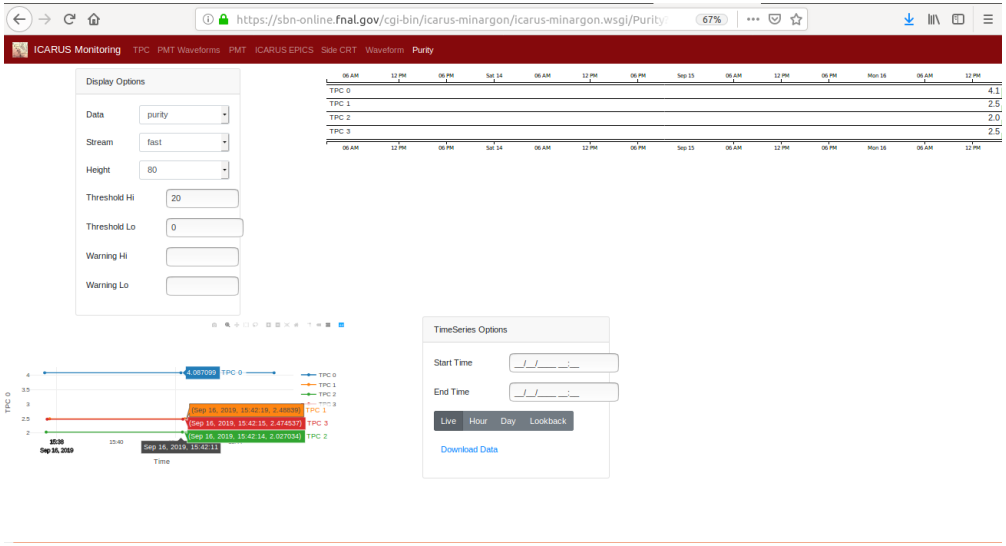


My work since then

Two main areas:

- Hardware

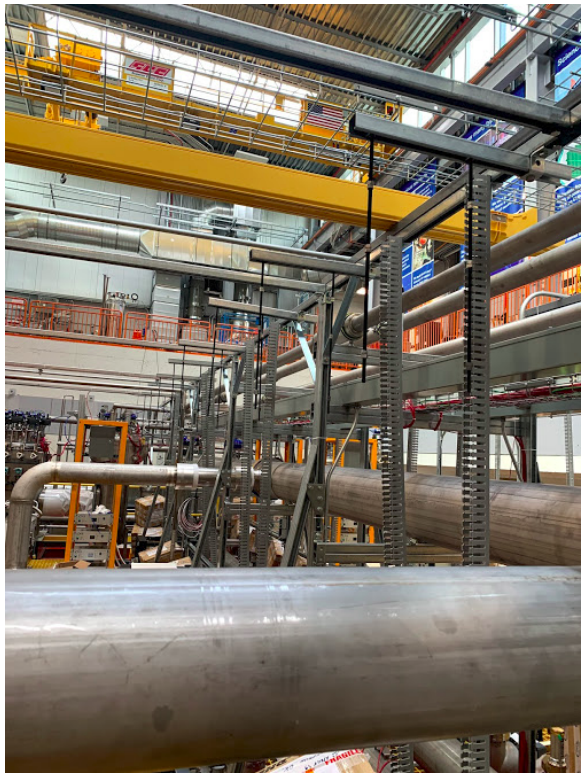
- Software



Fermilab

Hardware

- Installation of some more cable trays and of nuts for the threaded rod



- Final cabling of the 2 PS mini-racks on top of the Icarus detector:

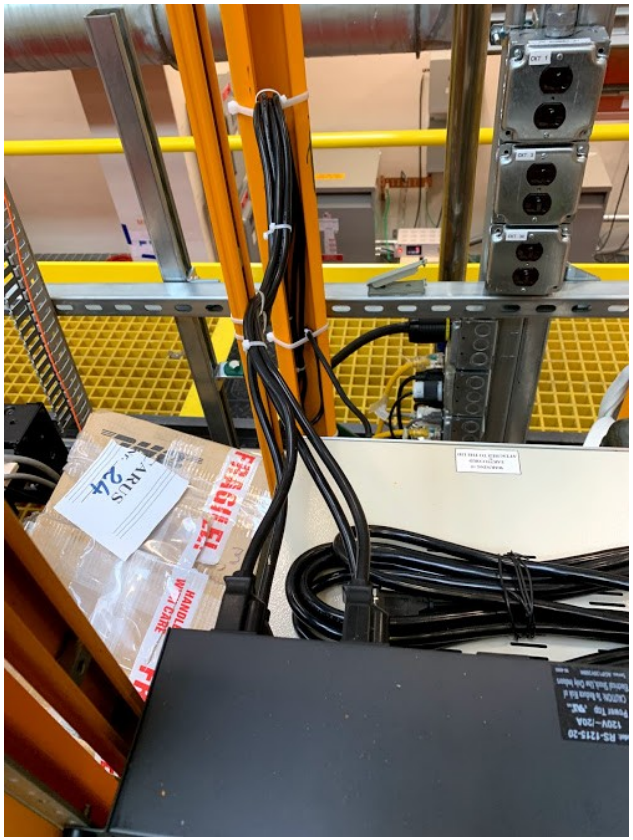
  -Work plan definition

  -Connect the cables from the power supply to the power cord on the top of the rack

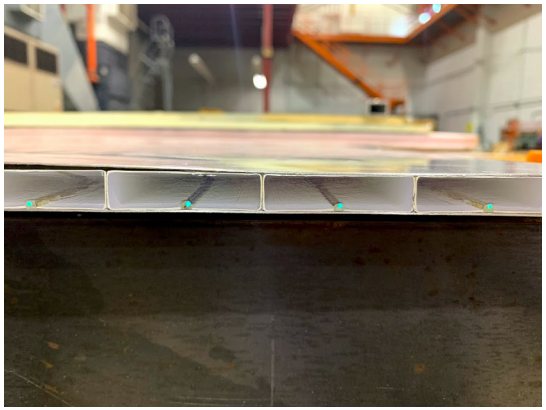
-Install the bar with the modem on the back of the mini rack and connect it to the power supply.

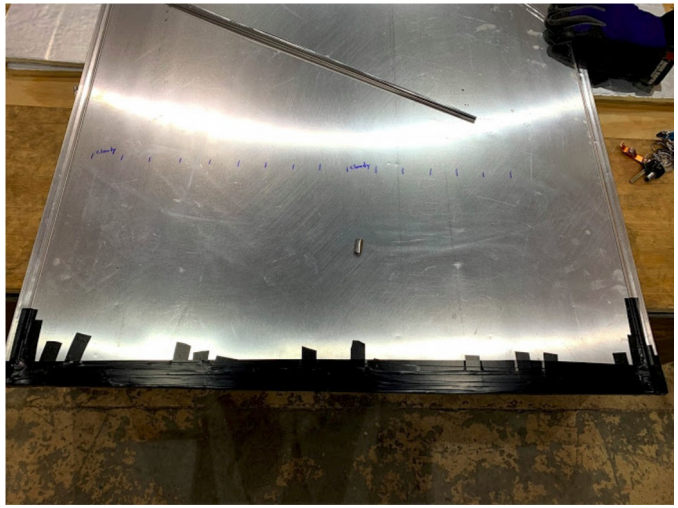
-Connect the Ethernet cables from the switch to the back of the power supply.

- Final cabling of the racks on top of the Icarus detector.



- Preparation and testing of the scintillator for the cosmic background rejection.





Software: Purity

Having high purity is essential for a successful operation of a LAr TPC. Purity of the TPCs can be measured based on the drift electron lifetime, using the following formula:

$$Q(t) = Q_0 e^{-\frac{(t_{hit}-t_0)}{\tau}}$$

This parameter can be extracted studying a sample of cosmic muon tracks and averaging on the values extracted track by track.

Purity studies

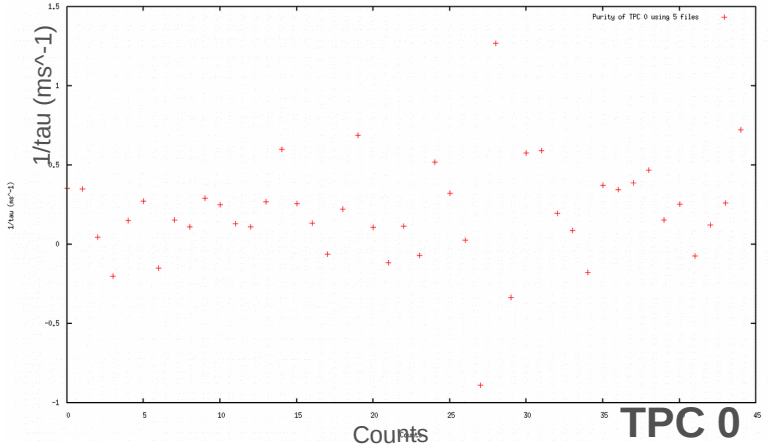
In order to obtain the purity values, the code analyses the tracks in the following way:

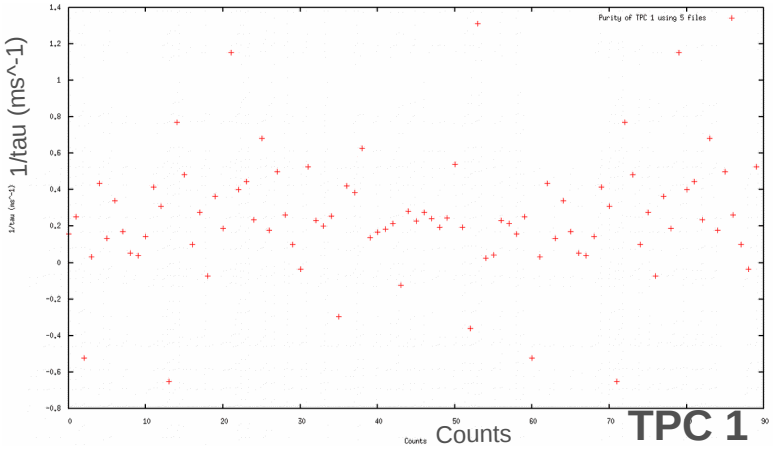
- The physical signals (hits) are extracted from the signals recorded on the wire using fast identification method
- The hits are grouped in clusters based on the relative distance of different point and on intensity of the hits on the wire
- Selection of tracks “good for purity measurement”
- Single fit of the hit area vs hit time to extract 1/τ ele

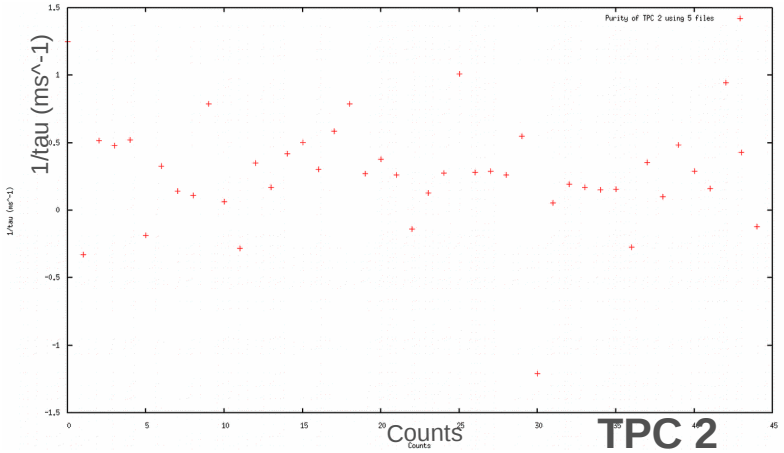
Tests

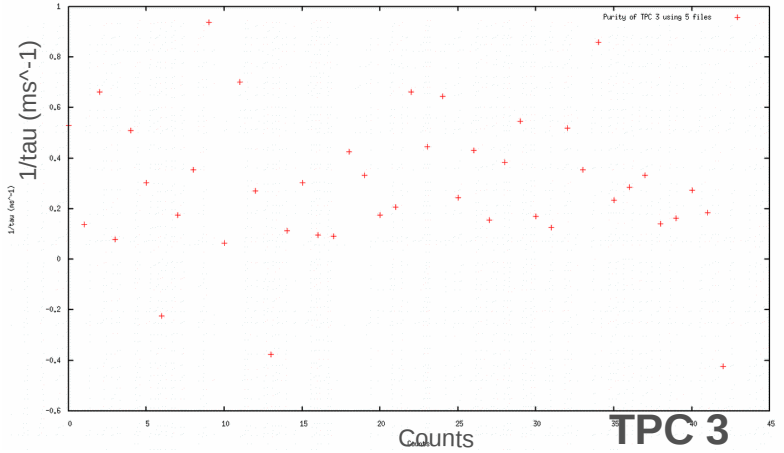
Tests on the 4 TPCs, with the information contained in 5 cosmics MC files:

pnfs/icarus/scratch/users/icaruspro/dropbox/mc1/poms_production/MCC1_1_poms_icarus_prod_purity_v08_22_00_4ms/detsim/detsim-*.root







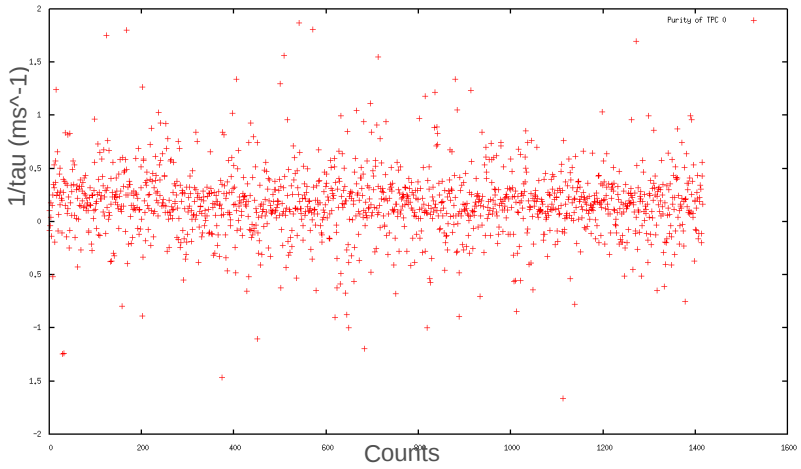


Fermilab

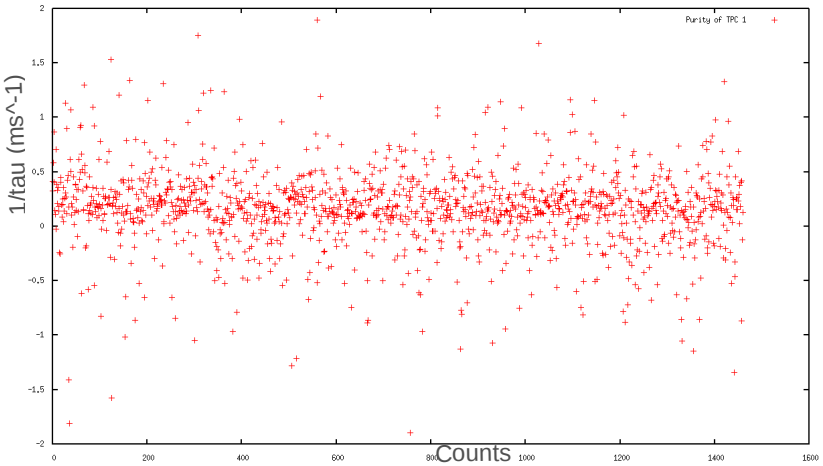
Tests

Tests using more statistics:

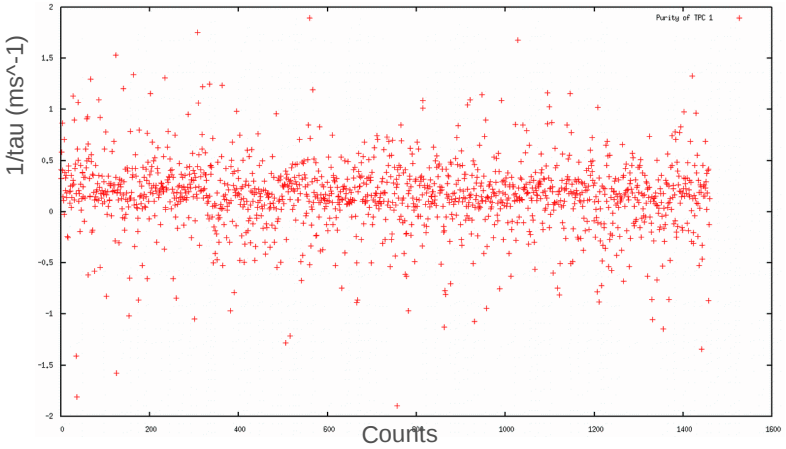
TPC 0-106 MC files



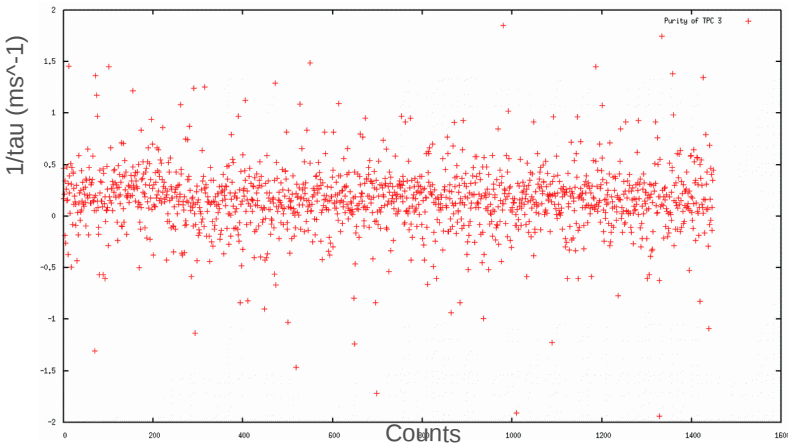
TPC 1- 64 MC files



TPC 2-64 MC files

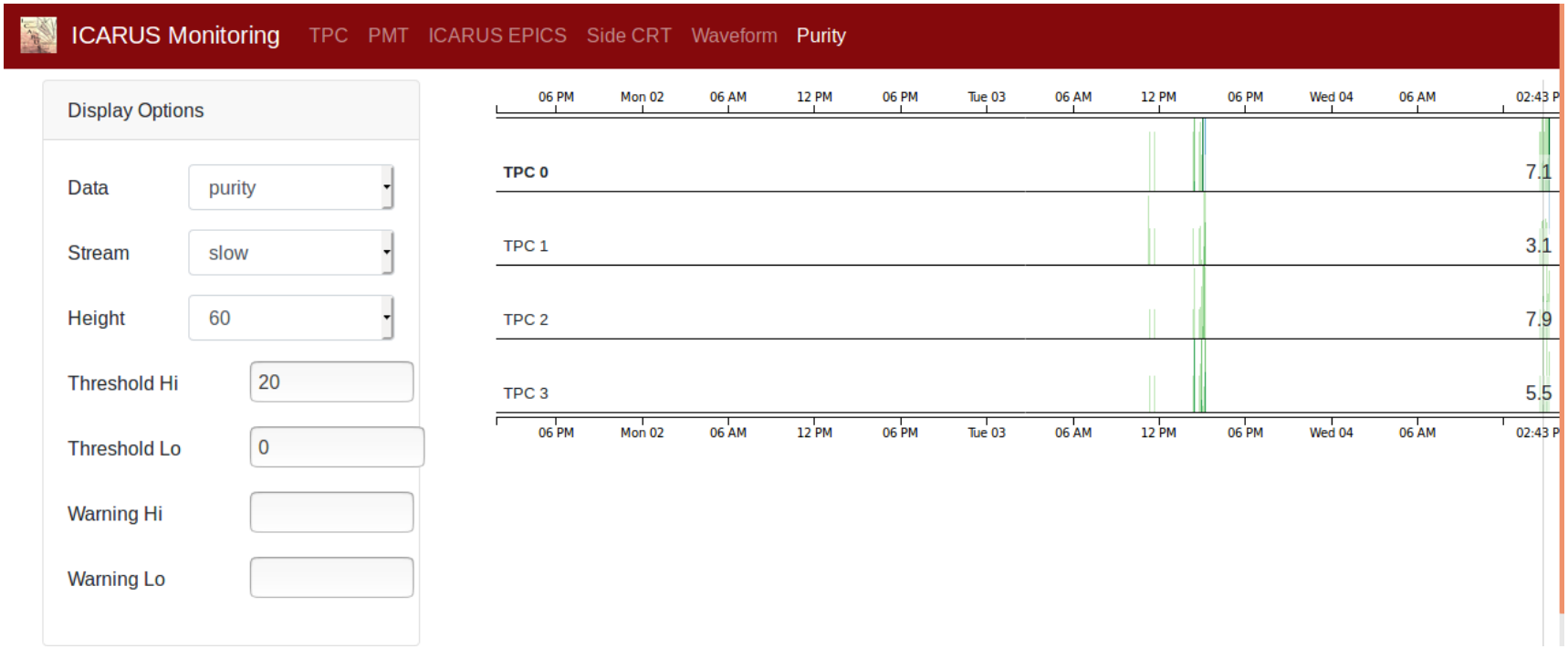


TPC 3- 106 MC files



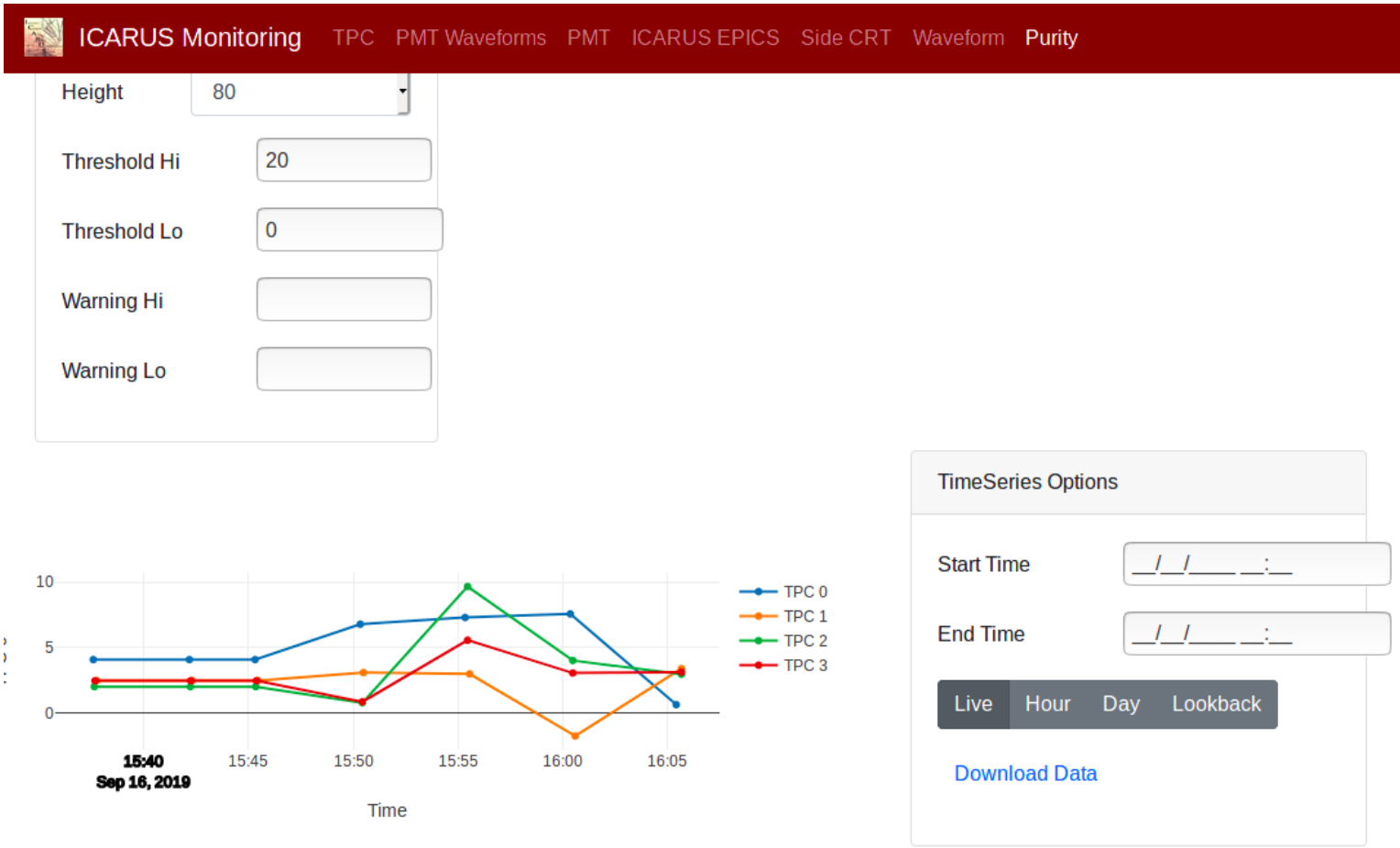
Fermilab

Online Monitoring



Display of a single value of purity per TPC every 5 minutes.

Online Monitoring



Display of purity as a function of time.

Many thanks to Gray for the help in setting up all of that!

Fermilab

Purity tests

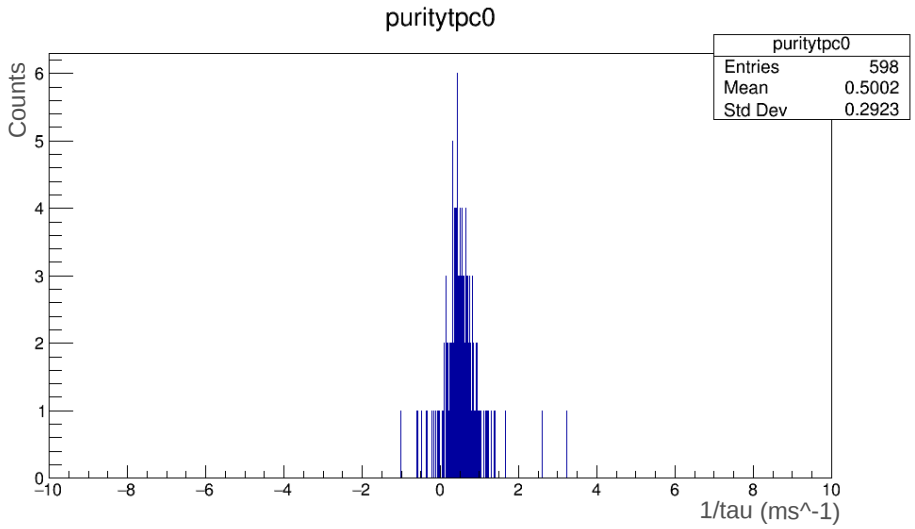
In order to check the validity of this study, I used MonteCarlo files with a known mean electron lifetime and tested the code with those.

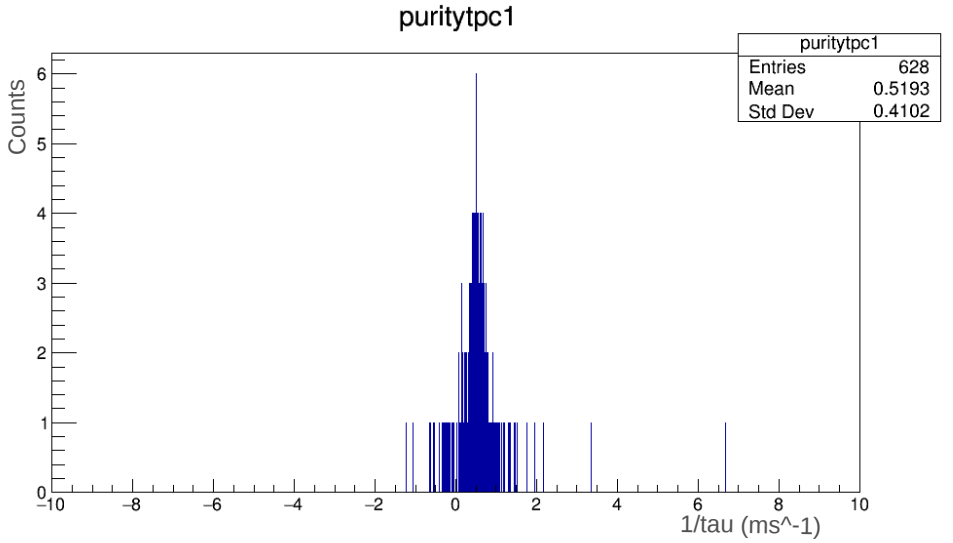
Based on our purity knowledge and on the validation of our results, I applied some cuts on the accepted purity values, so to make sure that only meaningful results are plotted and sent to the online monitoring system.

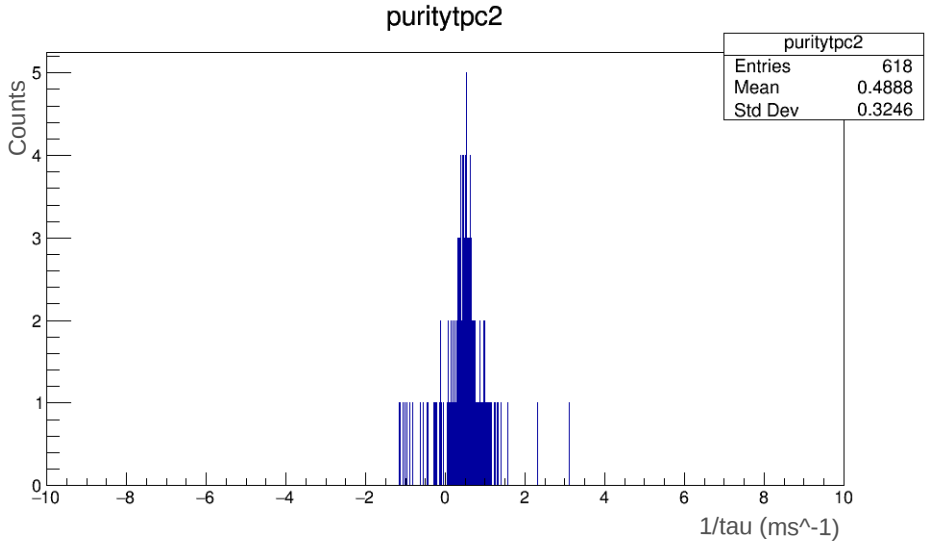
We only accept attenuation values between -10 and 10 ms^-1.

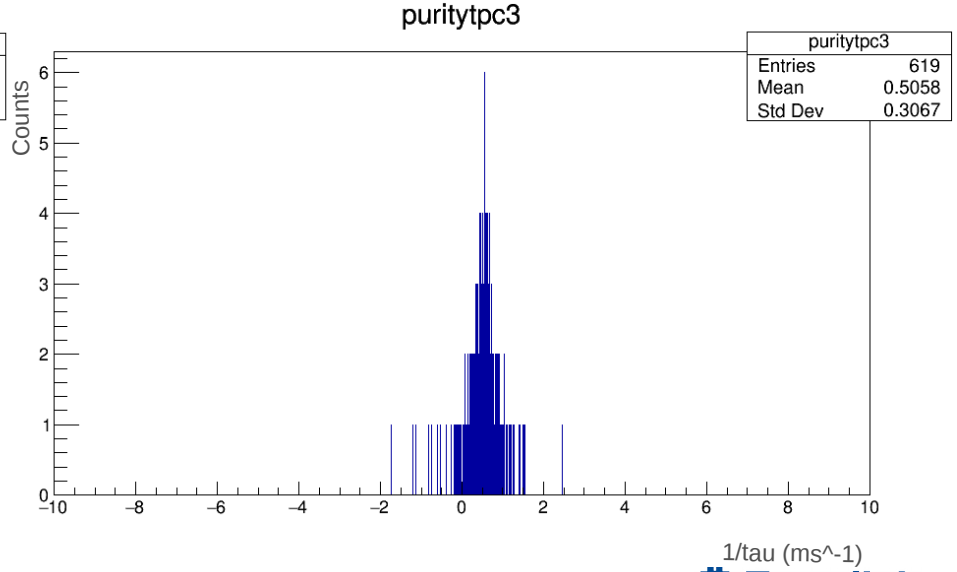
Tests

Histograms of the attenuation for MC files with mean electron lifetime 2ms:



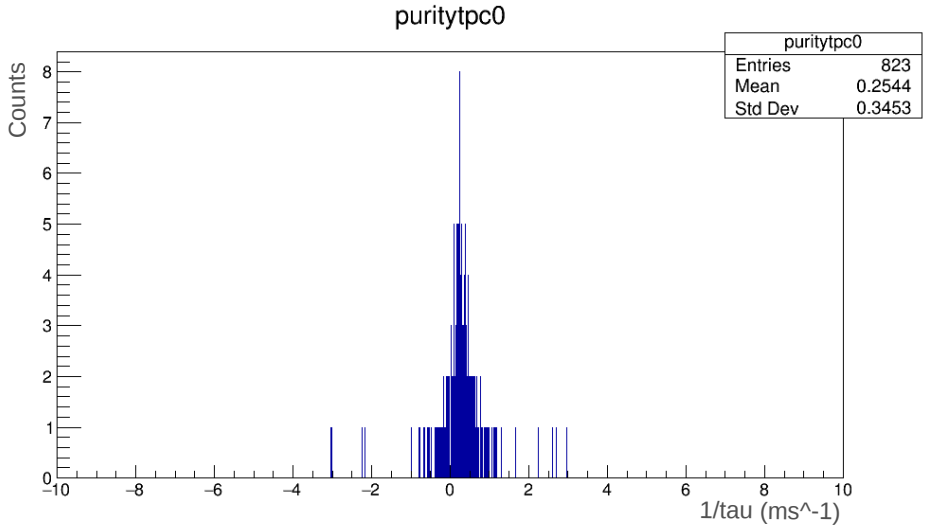


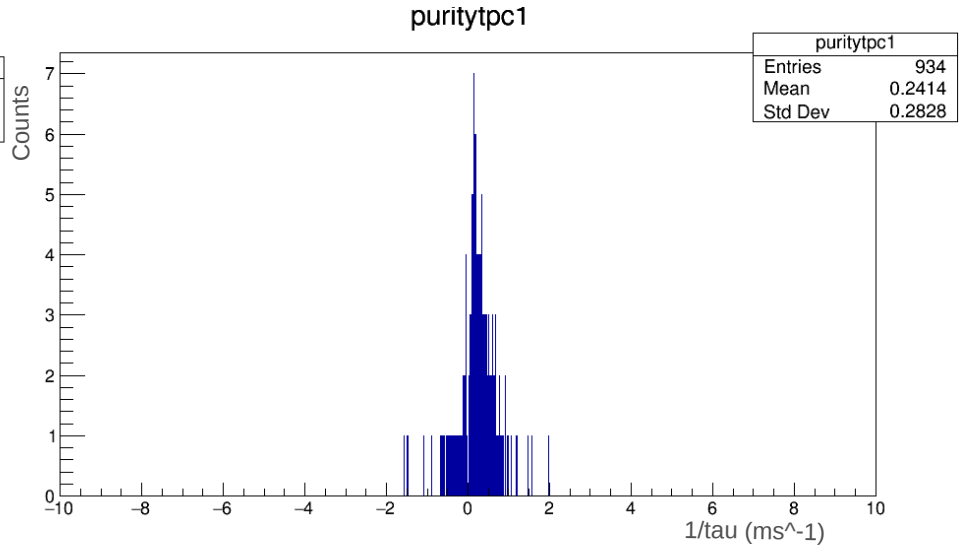


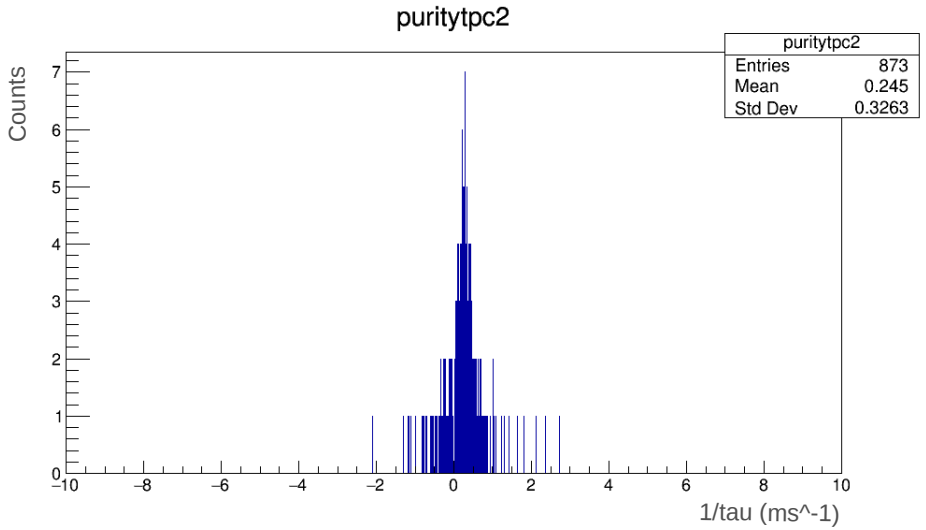


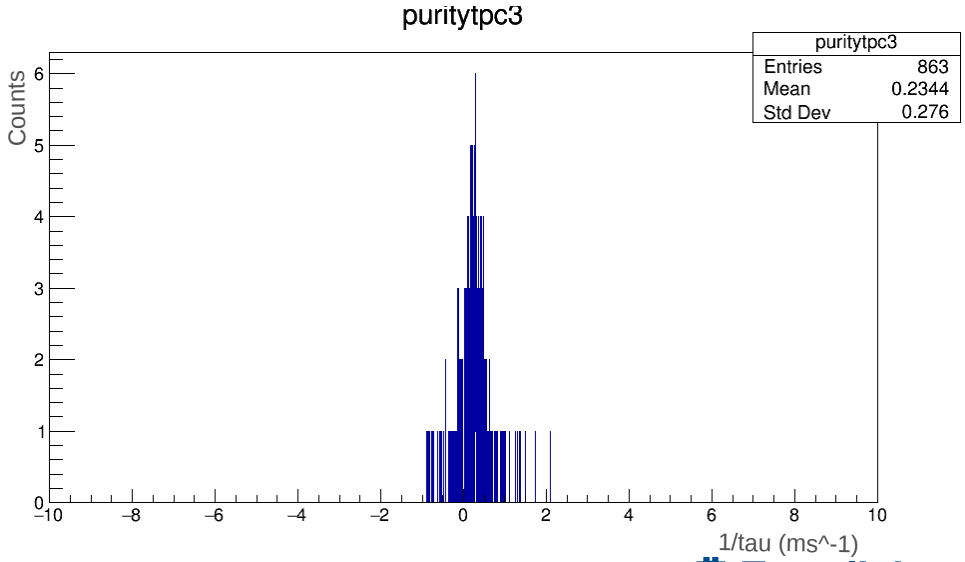
Tests

Histograms of the attenuation for MC files with mean electron lifetime 4ms:





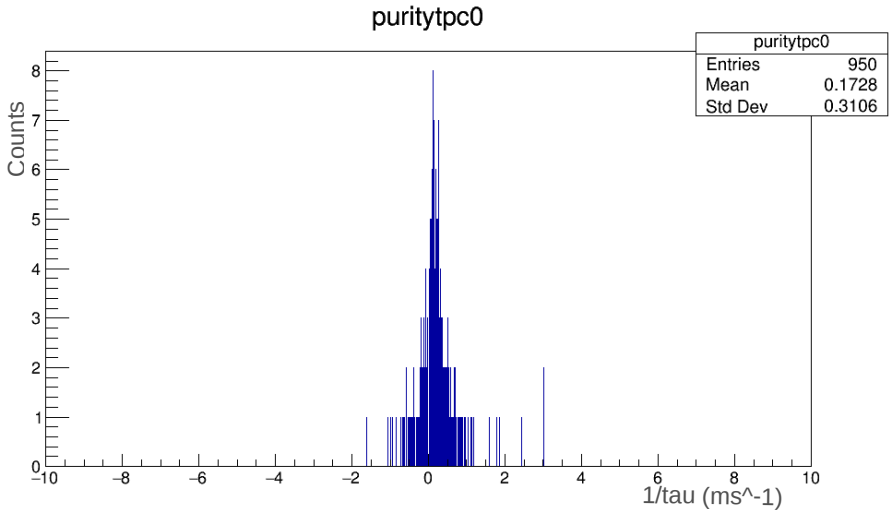


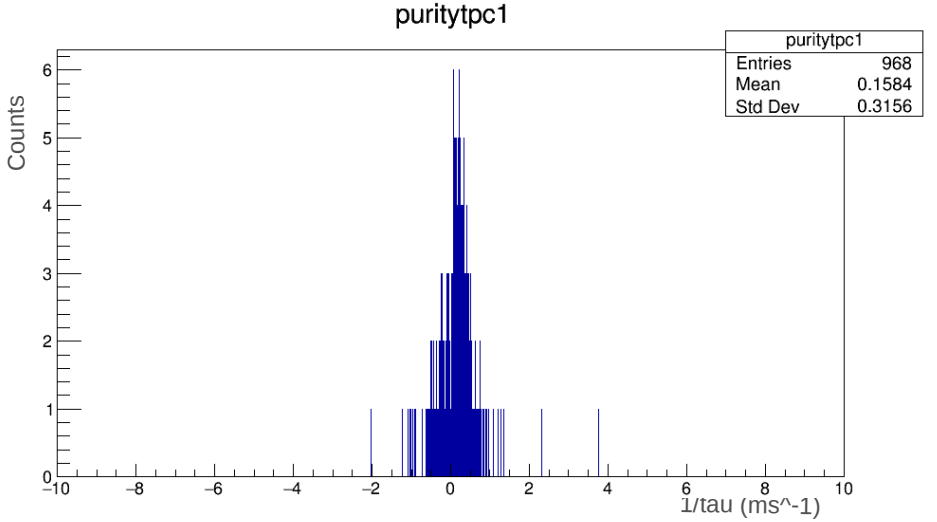


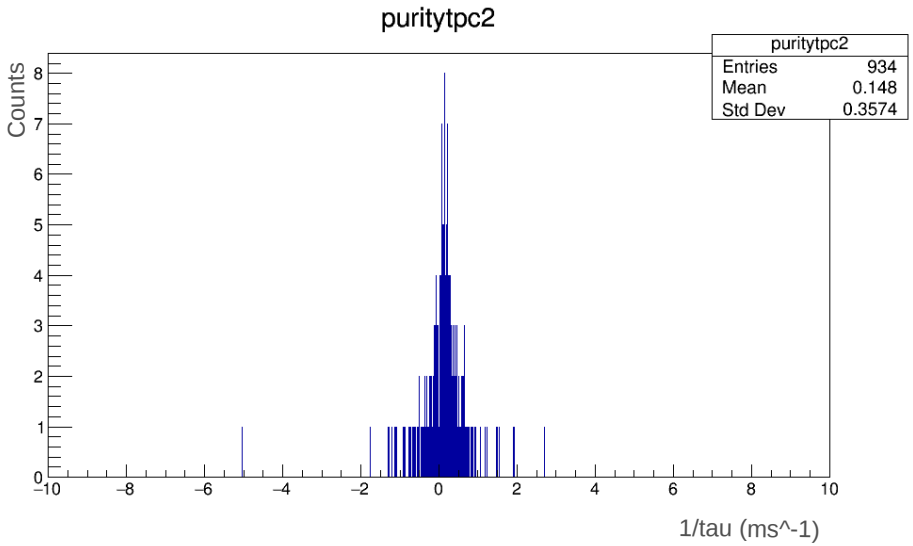
Fermilab

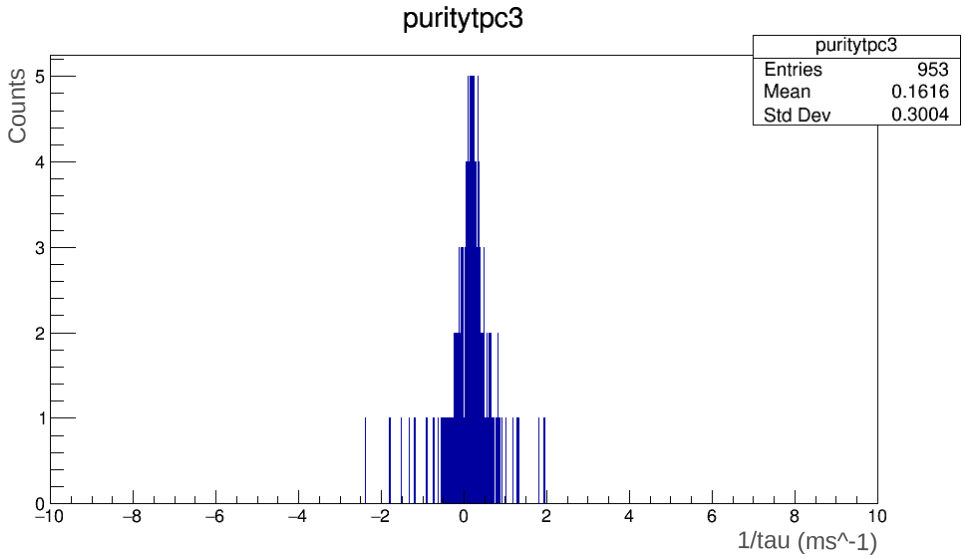
Tests

Histograms of the attenuation for MC files with mean electron lifetime 6ms:





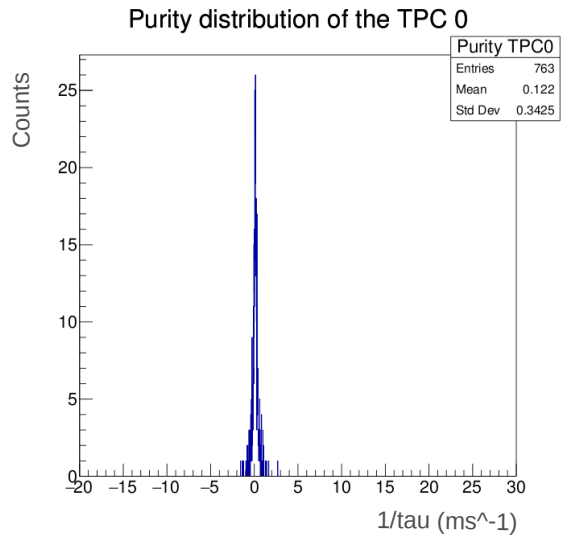


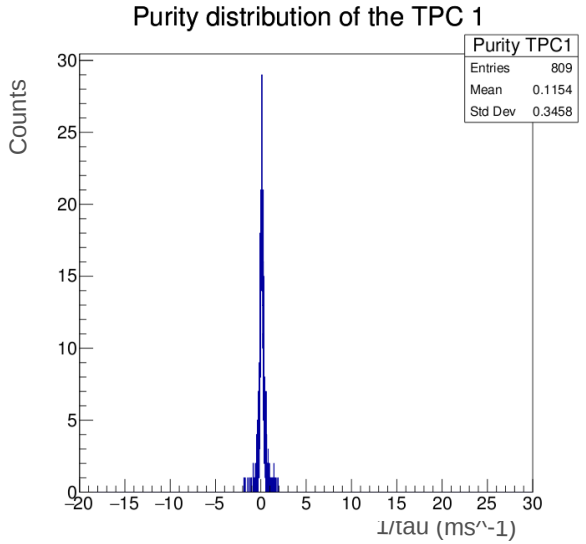


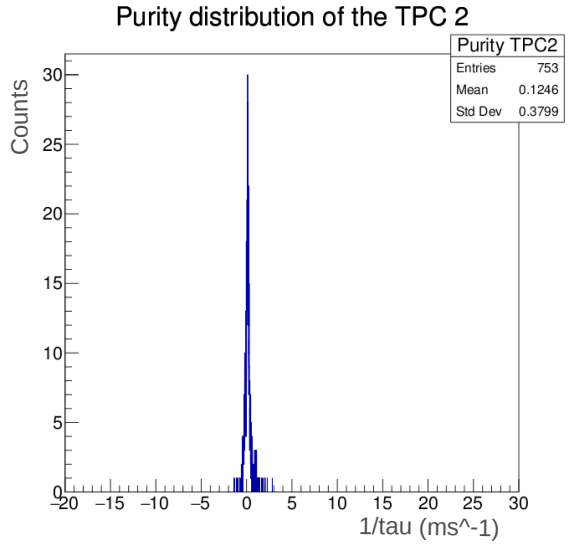
Fermilab

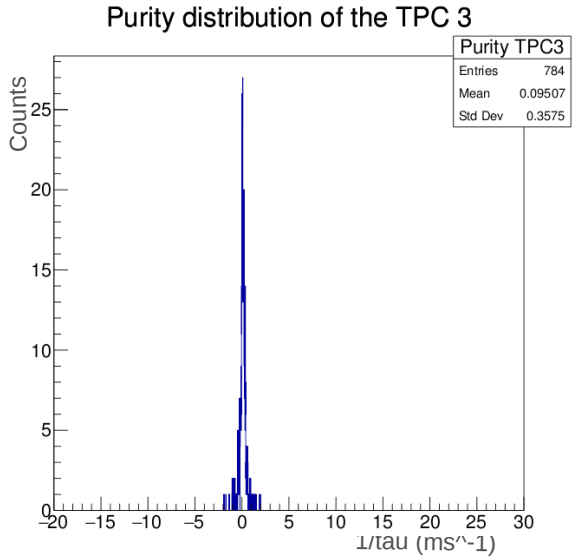
Tests

Histograms of the attenuation for MC files with mean electron lifetime 8ms:



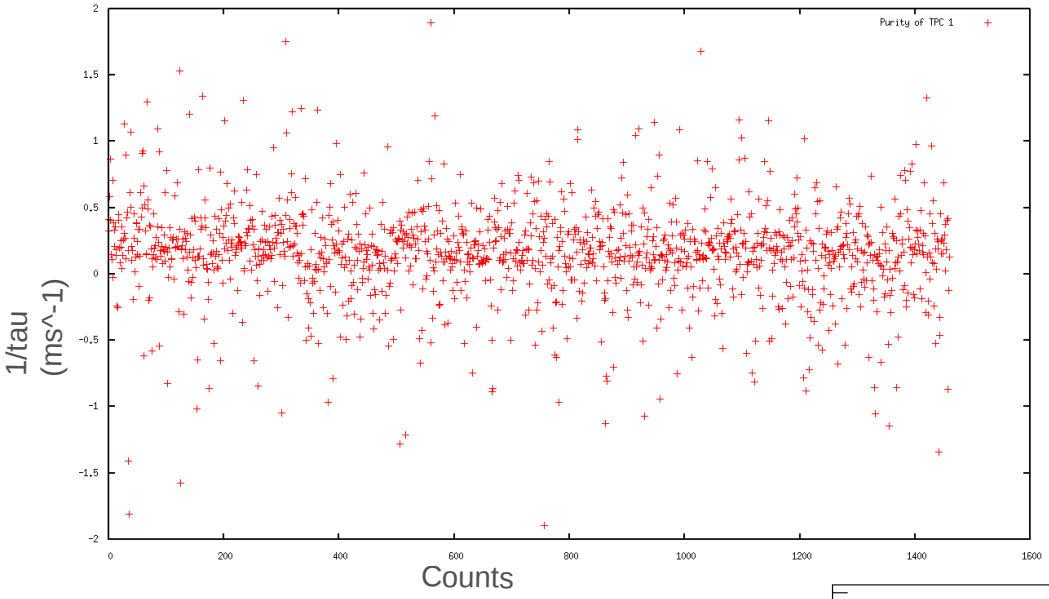




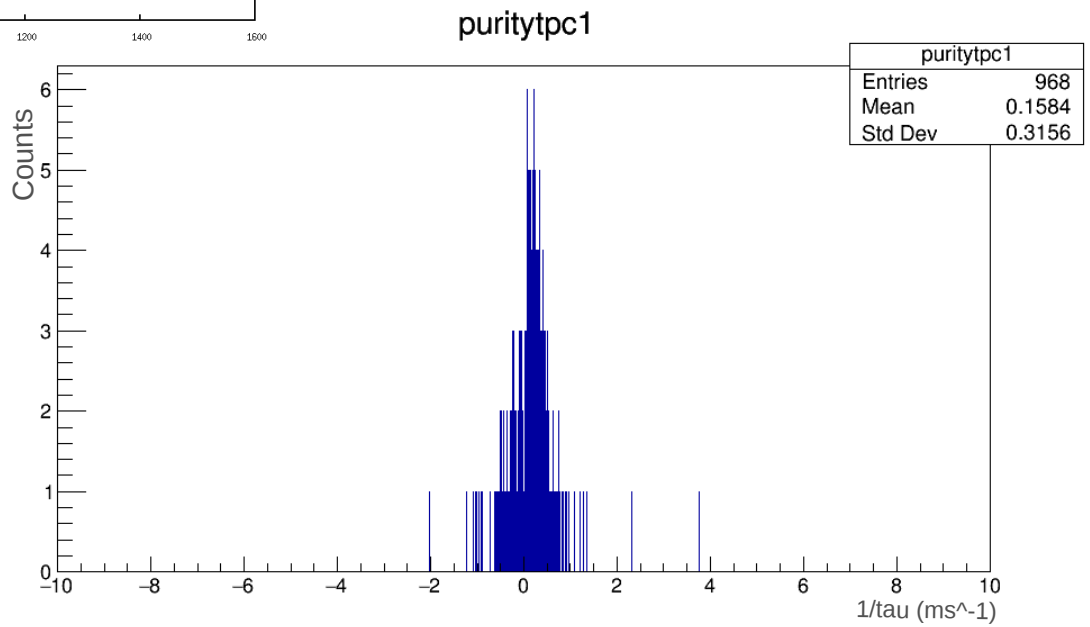


Fermilab

Results for 6ms electron lifetime

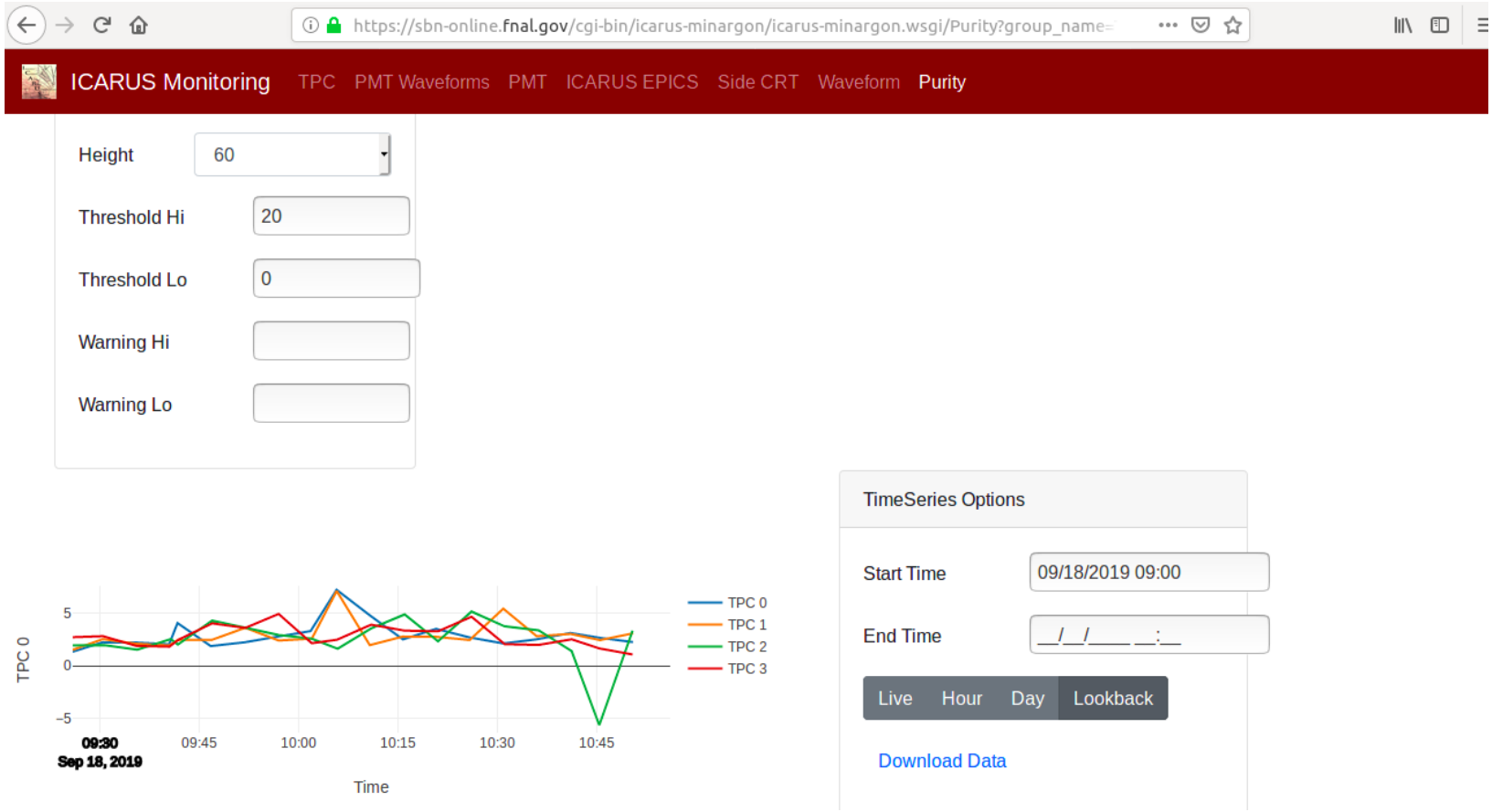


Purity of the TPC 1



Fermilab

Test of the results



Fermilab

Summary

- Development of tools for monitoring the purity of the detector
- Validation of the purity measurements in the online monitoring

Next steps for this project

- Identification of neutrinos and cosmics
- Implementation of the webpage

Thank you