Preliminary study of electrons / positrons identification with magnetised LAr

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Outline

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2. Details of the simulation
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Purpose of the work

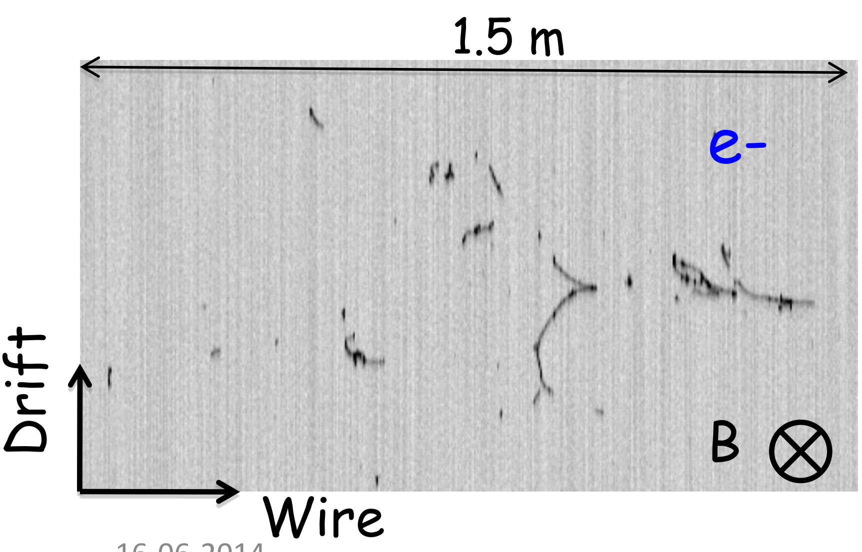
- A new phase of the ICARUS experiment foresees the addition of a magnetic field to perform charged particle identification and momentum measurement.
- In the hypothesis of magnetizing the active volume, it is necessary to determine automatically if the incoming particle is a neutrino or an anti-neutrino.
- In this framework, following an idea from P. Sala, a dedicated algorithm is under development to automatically recognize electrons and positrons produced in neutrino charged current interactions.

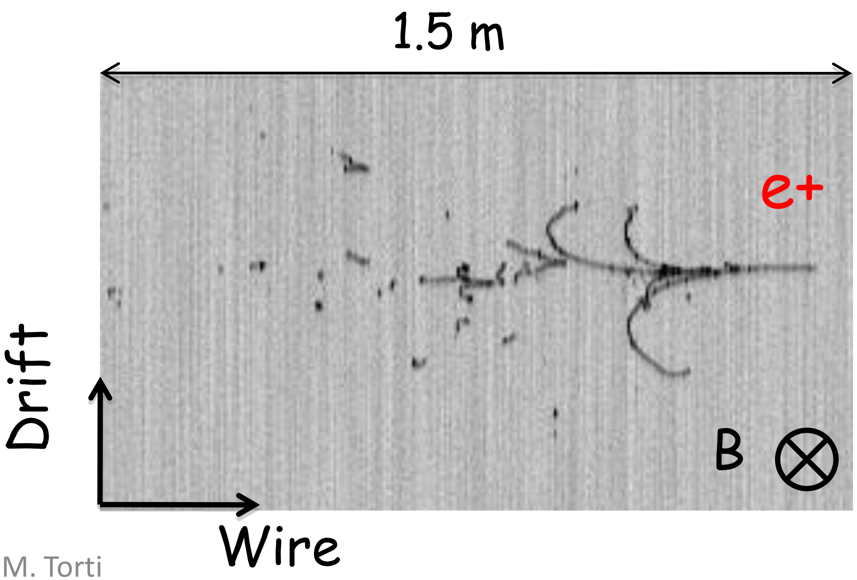
Details of the simulation

In order to test this algorithm, a Monte Carlo simulation has been carried on, with a 1 T magnetic field, perpendicular to the drift and beam directions, present in the active volume.

A total sample of 2000 events, equally divided between e+ and e-, is produced with the Fluka package (provided by P. Sala).

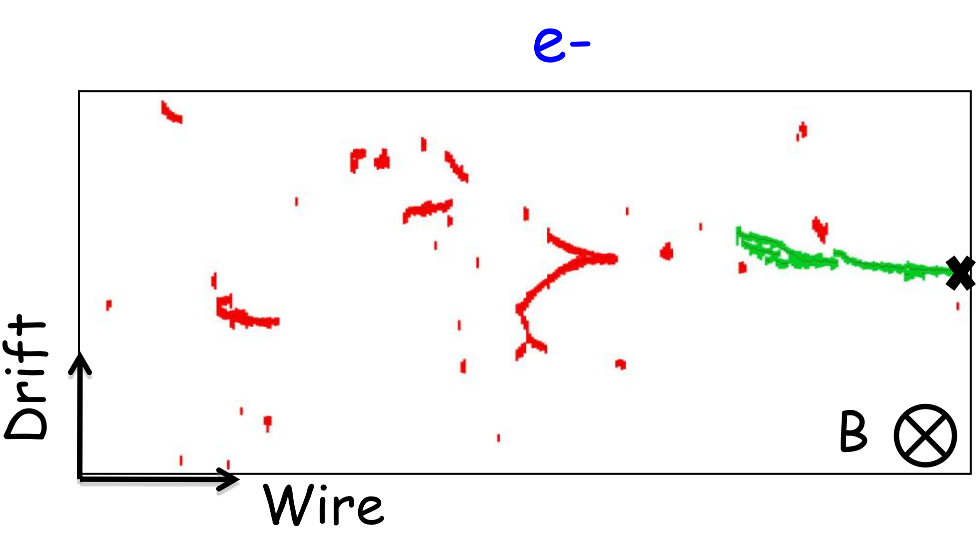
Electronic neutrinos and anti-neutrinos, with a fixed energy of 500 MeV, are generated and made to interact within the detector .

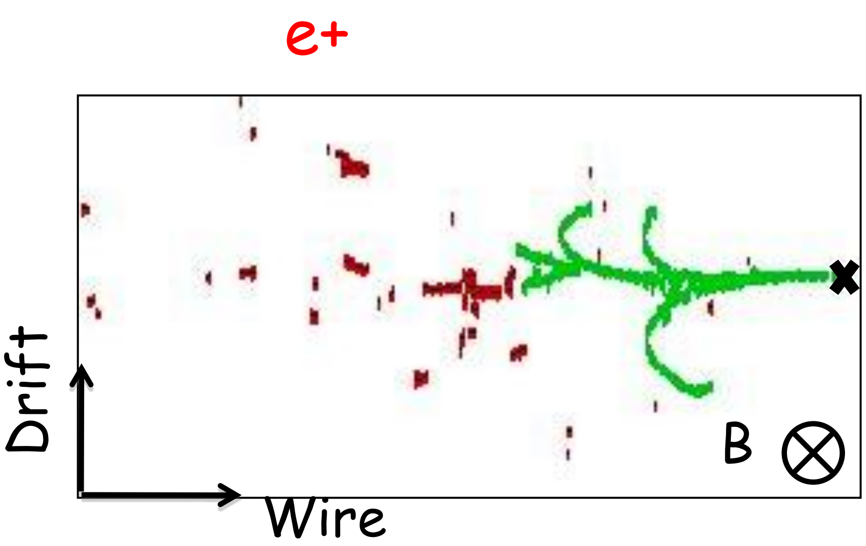




Procedure step by step (1)

Automatic identification is achieved through several steps. First, the information on the primary vertex position, included in the simulation, is retrieved (the primary vertexes are the black crosses in the images below).
Then, the cluster containing the primary vertex is selected (green hits) considering only neighbouring hits, due to the requirement of having particles coming from the original one.



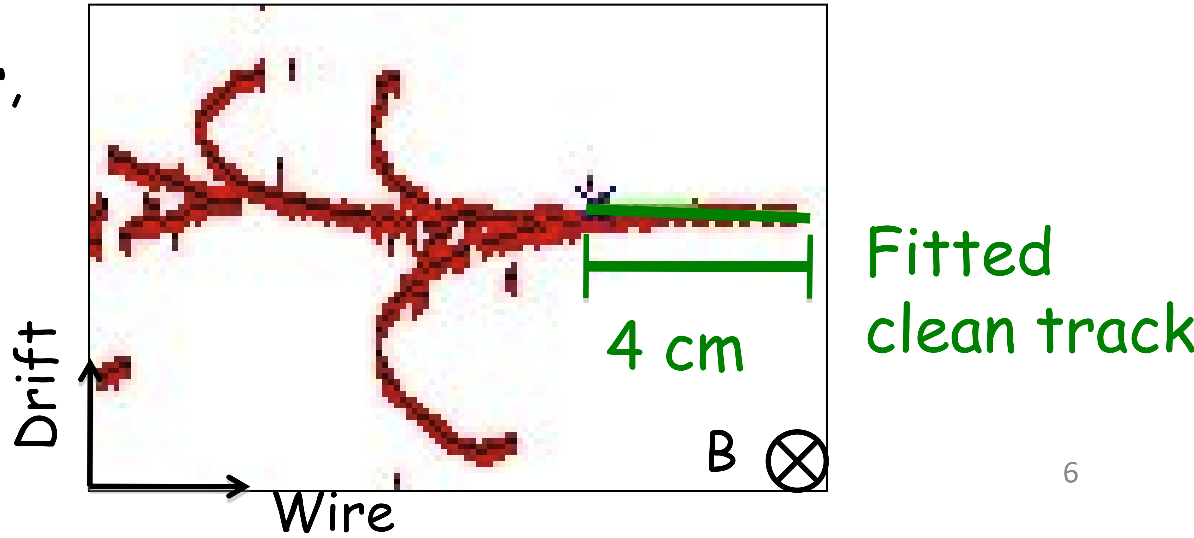


Procedure step by step (2)

After the identification of the cluster, a portion of the lepton track, free of interactions, is selected (the so called clean track).

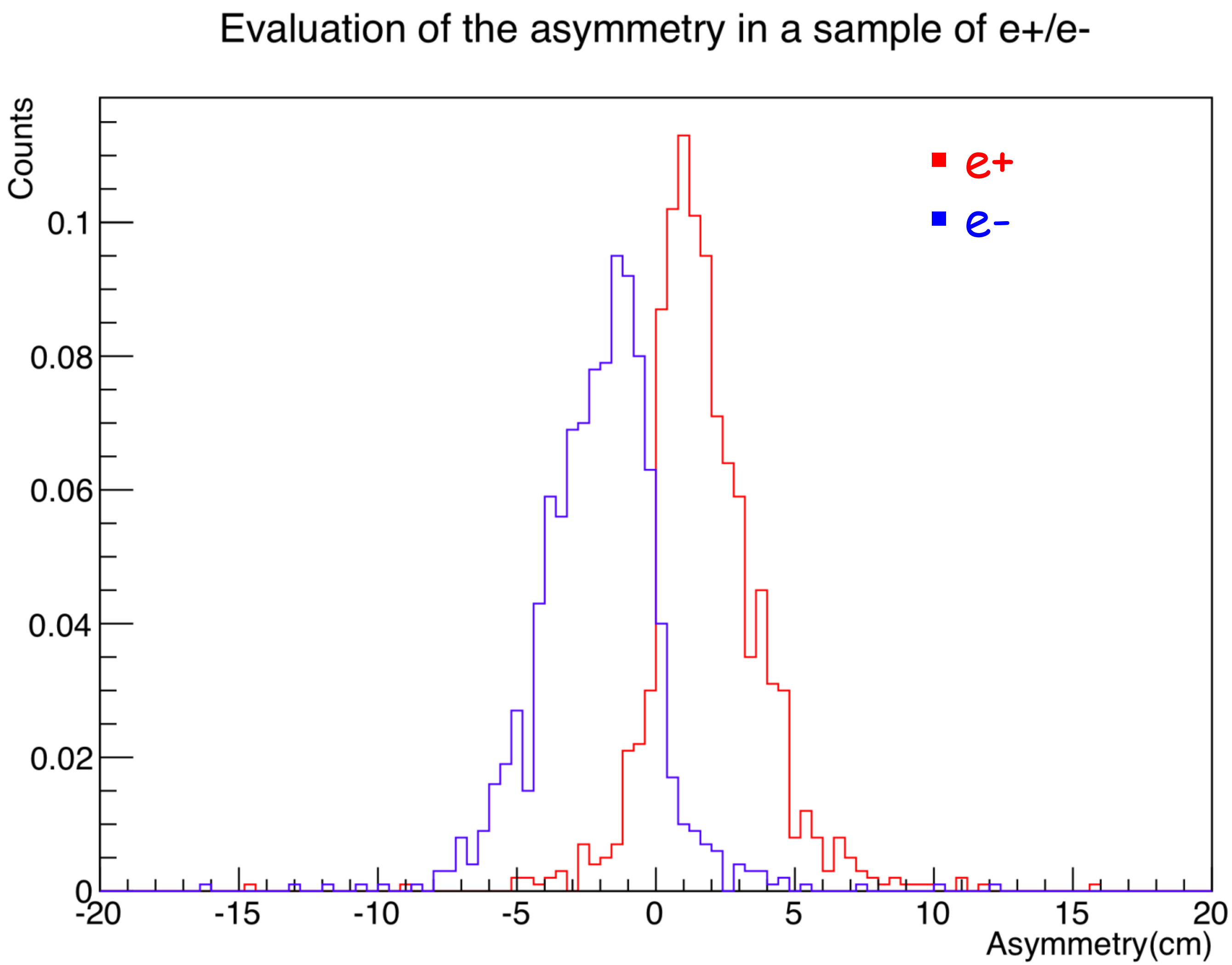
The sequence of hits of the clean track is then modeled with a straight line, with defined direction and orientation (green line in the image below).

Finally, the oriented distance between hits (in the selected cluster) actual position and its projection on the modeled straight line, is evaluated. The mean value of these distances, due to the magnetic field and then related to the particle charge, is taken as discriminating parameter, and called Asymmetry.



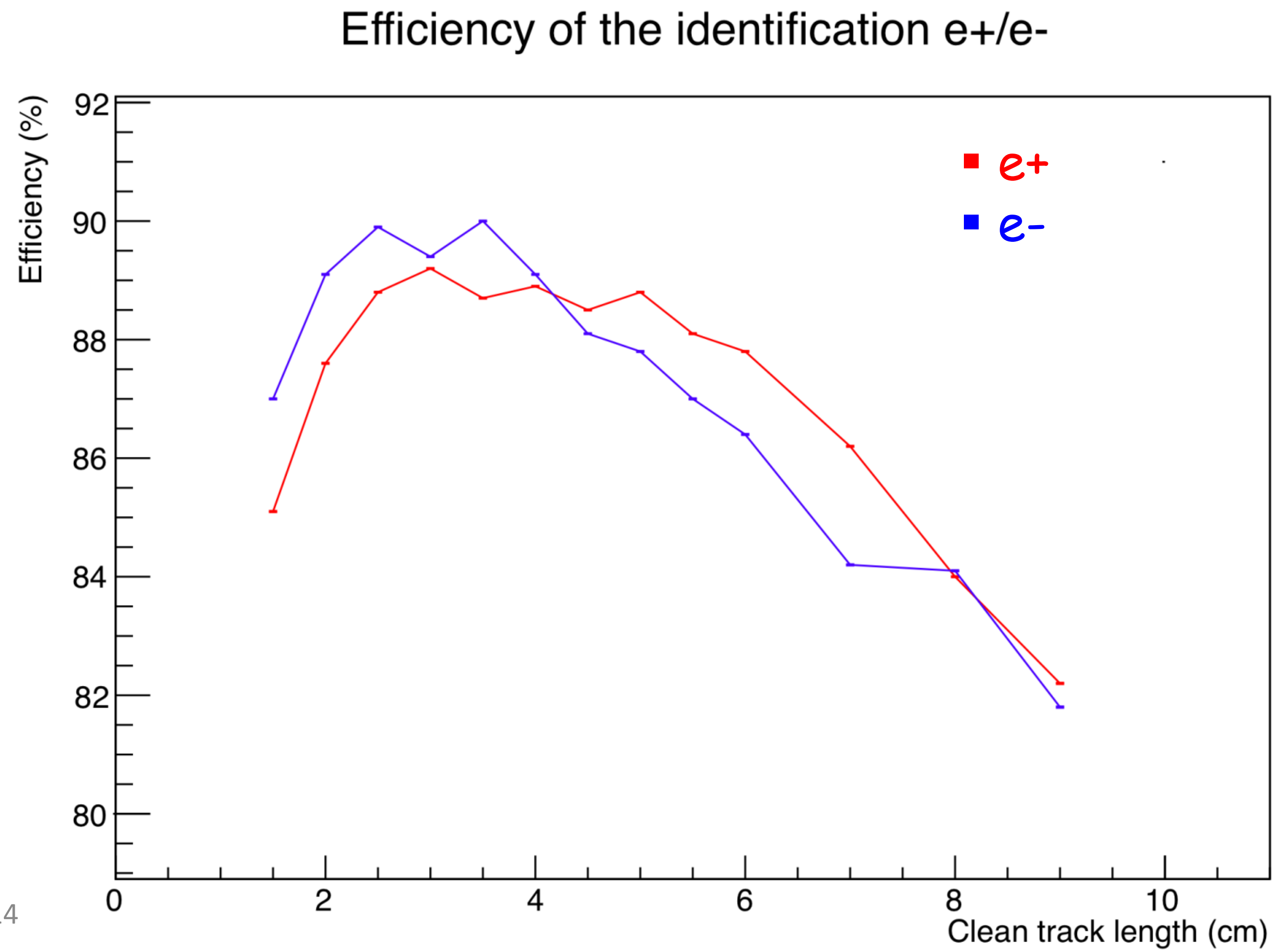
Results (1)

The asymmetry parameter can be used to discriminate between electrons and positrons. The result of the computation is shown below for a fixed length of the clean track .



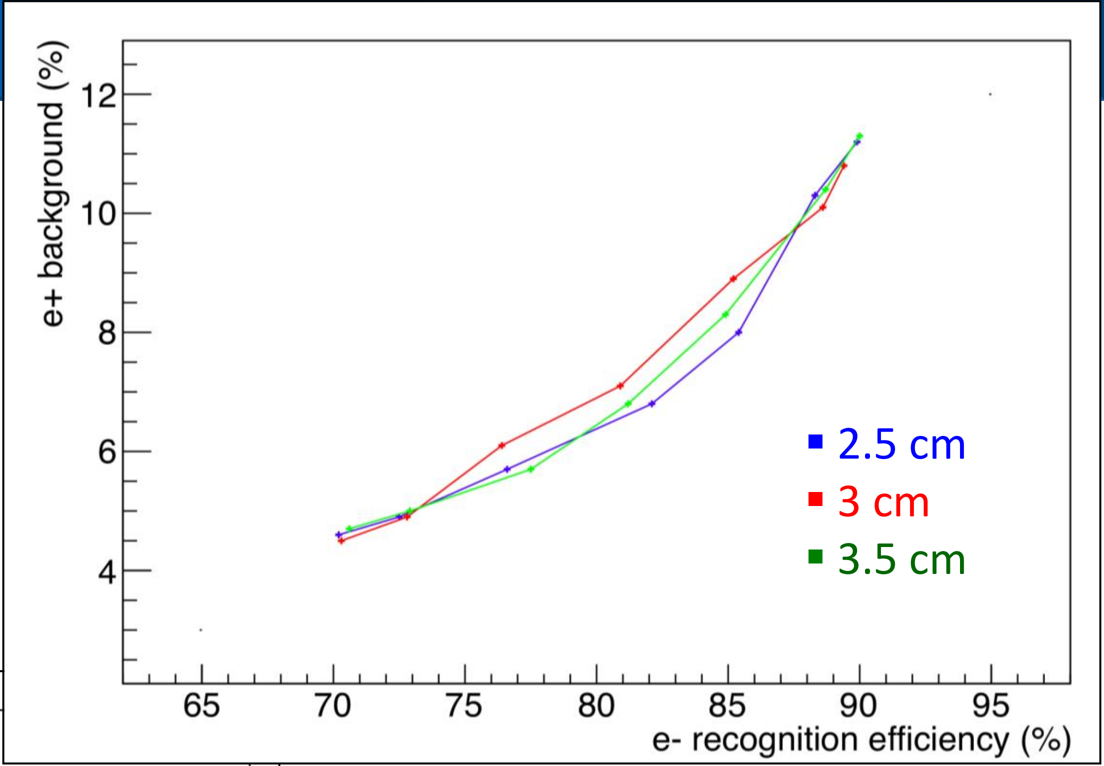
Results (2)

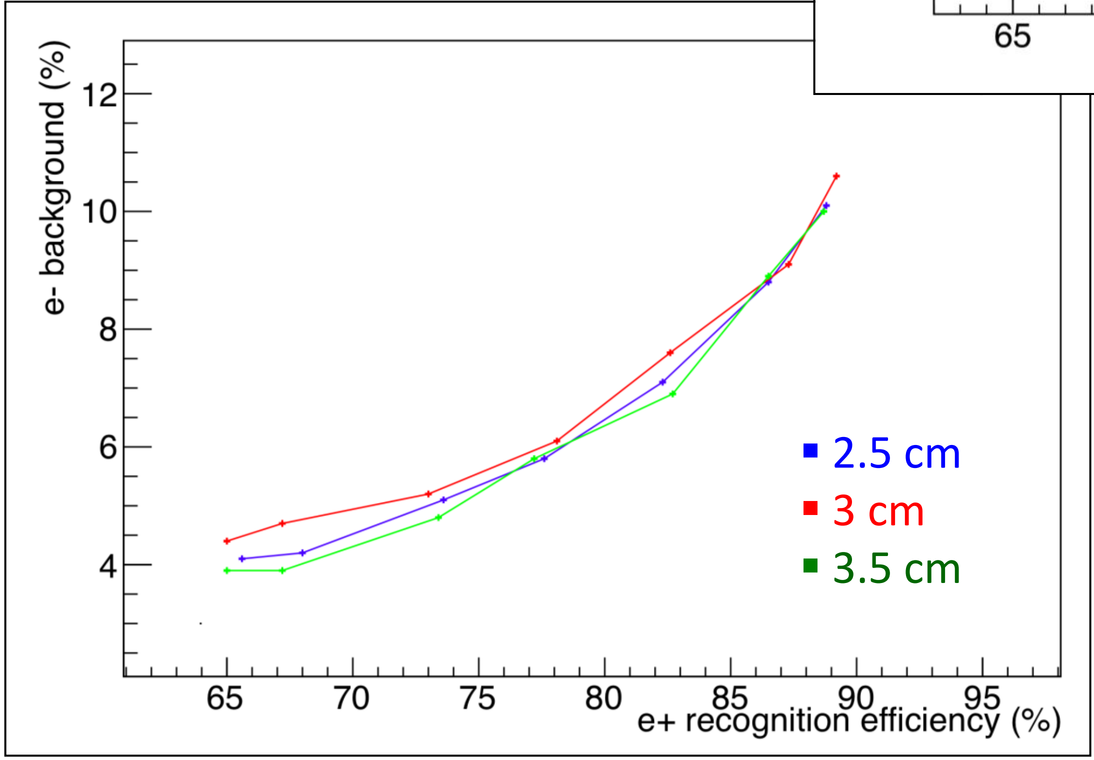
The power of the Asymmetry parameter to separate e- from e+, i.e. its Efficiency, depends on the length of the clean track. Varying this parameter, it is possible to select its optimal value, that lies in the range (2.5, 3.5) cm .



Results (3)

If the Asymmetry is too close to zero, separation capability drops. It is then necessary to choose a compromise value providing both good efficiency and acceptable background contamination.





For a given clean track length, the plots show the couple of values taken on by efficiency and background contamination, as a function of asymmetry.

Next steps

Before choosing the optimal compromise value for efficiency and background, and then applying the algorithm to real data, it is necessary to make some refinements:

• apply the algorithm on an improved samples, by (i) varying neutrino energy and (ii) adding vertex activity, due to other particles coming from primary interaction (this is expected to lower recognition efficiency);

• add possible magnetic field dis-uniformities, as expected from simulations of the field configuration;

• introduce new parameters to improve e+/e- discrimination. An hypothesis, still to be tested, is to combine the asymmetry information with the curvature of the track.

Conclusions

• In the hypothesis of magnetizing the active volume of the ICARUS T600 detector, a new algorithm that permits to distinguish automatically between electrons and positrons is being developed.

• Using a Monte Carlo simulation, the asymmetry parameter of the track is identified as a good parameter to separate these two classes of particles.

• The optimization of the parameters is under development, accounting the foreseen improvements and the future application on real data .

Thank you!