

Pandora Frequently Asked Questions

Inside Pandora, is there a different algorithm for cluster merging, vertex finding, etc.?

Pandora actually uses more than 80 different algorithms, and **most steps in the pattern recognition process are performed not by a single algorithm but by a set of several algorithms**. For example, when comparing different 2D Clusters to assess whether they should be merged together, different algorithms are run independently, analysing the problem from different points of view in order to make the best decision.

What is the difference between pandoraNu and pandoraCosmic?

They are two different passes in the reconstruction, which use different Pandora algorithm configurations specified via XML files, available [here](#) and [here](#). Some algorithms are common to both whilst others are specific to cosmic-ray reconstruction or to e.g. identifying a neutrino interaction vertex. Whereas **pandoraCosmic is strongly track oriented, optimised for reconstruction of cosmic rays** (find muon tracks and delta-ray daughters), **pandoraNu is optimised for the reconstruction of a neutrino interaction** and therefore it looks to identify the neutrino interaction vertex, carefully protecting the different particles emerging from it, and reconstructing track-like and shower-like objects differently.

Why might there be more than one neutrino in an event?

In between the two passes of the reconstruction, pandoraCosmic and pandoraNu, a process external to Pandora tags and removes clear cosmic tracks. However, cosmic-ray remnants are typically still present after this subtraction process and their Hits are given to pandoraNu. To avoid merging cosmic remnants with the neutrino interaction, an algorithm in pandoraNu creates different *slices*. A subset of algorithms perform a “fast” reconstruction and the results are used to divide the input Hits into separate collections. Depending on how many cosmic remnants are still present when running pandoraNu, more than one slice may be created. One neutrino will be reconstructed for each slice: **one should truly represent the neutrino interaction, whilst other(s) will be cosmic remnants**.

How many vertices do I get from Pandora?

Pandora produces **exactly one vertex for each output PFParticle**. This includes the neutrino PFParticle in the pandoraNu pass. The vertex attached to a cosmic-ray particle represents the track position at the high-y coordinate.

How is the neutrino interaction vertex found?

The vertex identification is done in two steps. **Firstly, large numbers of 3D vertex candidates are created** by using the 2D Clusters constructed in the first stage of the pandoraNu reconstruction. The endpoints and crossing points of 2D Clusters are examined and pairs of 2D Clusters, from two different views, are used to motivate 3D candidate positions. **Then, the suitability of candidates is assessed by taking into account topological and calorimetric information:** the best vertex candidate is selected by calculating the transverse components of Cluster energies with respect to the candidate positions (*energy kick score*), the energy asymmetry (to discard candidates that bisect straight clusters), and candidate positions with respect to the beam direction.

What is the meaning of the PDG code given by Pandora to the PFParticles created?

The PDG code assigned by Pandora, either code 13 (track, also applied to e.g. protons) or 11 (shower), indicates whether the particle has been **created by algorithms designed to construct track-like or shower-like particles** respectively. The track/shower identification is now under active development (including assessment of the final output Particles) and significant improvements are expected. Right now, further characterisation is required at the analysis stage.

How is correct defined according to Pandora metrics?

With the Pandora *pattern-recognition metrics*, an event is deemed correct when there is **exactly one reconstructed particle matched to each and every primary MC particle**.

More details to answer the questions above can be found in the Pandora public note [here](#).