# MS49 - **Algorithms for specific analysis and tracking**

The implementation of a track parameter finder for timing detectors with good or moderate position resolution has been performed in ENSARRoot [1], based on the TimTrack tracking method, described in Section 1. The second section of this report includes a method based in ANN models for the reconstruction of the γ-ray spectrum recorded by highly segmented, including a first evaluation of the background rejection capabilities.

*Section 1: Implementation of the TimTrack Tracking Method*

In every experiment it is important to have information about the kinematical parameters of the particles crossing our experimental setup. Traditionally, the analysis of the trajectories begins with the conversion of signals provided by our detectors into space coordinates. After the spatial analysis is done, the time corrections are introduced in several steps. The TimTrack method (short name of Timing Tracking) [2] is able to determine the kinematical parameters in one step taking as input the information from the detectors. TimTrack is based on the Least Squares Method (LSM) and therefore it is possible to make a full matrix description.

The implementation of the TimTrack in ENSARRoot requires the definition of new data levels in the analysis of the TRAGALDABAS detector [3] and a Task that fills the data levels performing the parameters calculation. The classes describing the data levels (*TraRPCSaeta)* and the Task to fill the data levels (*TraRPCHit2Saeta)* are available at the ENSARRoot distribution. The new data level is filled directly by calling the TraRPCHit2Saeta Task, as it is implemented in the simulation scripts (*macros/tragsim.C* and *macros/tragall.C*). The user can decide the number of planes that are going to be used for the reconstruction of the saetas. This implementation allows different combination of tracks in other higher-level data structures defined from combinations of *saetas* [3].

*Section 2: Gamma Reconstruction Using Artificial Neural Network (ANN)*

ANNs are computer models that attempt to mimic the processing capability of the nervous system. By reproducing the high interconnectivity of neurons, it allows for a fast reactivity due to parallel processing and thus it leads to an unprecedented ability to solve complex problems almost instantaneously [4].

The highly segmented detector CALIFA is foreseen as the calorimeter for the detection of photons and light-charged particles, mainly protons, in the future R3B experimental setup at FAIR in Darmstadt (Germany). The most challenging requirement on individual CALIFA detector elements will be the wide dynamic range they have to cover, from low-energy (100 keV) photons to high-energetic (300 MeV) protons [5].

We have adapted an ANN to the intelligent reconstruction of events by fitting the size of the cluster as a function of the total energy (Etot). The network considered to model the response of the CALIFA barrel to the interaction with photons, is based on three parameters: the *crystal multiplicity*, which describes the number of crystals that provided a signal for a particular event; the *total energy*, which corresponds to the sum of all energies measured by the individual crystals; and the *maximum energy*, which corresponds to the highest energy value measured by a single unit.

The network training, that is, the determination of the various network coefficients have been performed with simulations carried out with the CALIFA barrel. Different energy ranges, multiplicities and polar angle runs have been used to train and subsequently test the method under different circumstances.

The results demonstrate an improvement of the photo-peak to background ratio in a factor varying from 2.6 to 4.5 with respect to standard “calorimetric” sum of the energies of the individual crystals, but the ANN reduces the photo-peak efficiency. The improved photo-peak-to-background ratio for the ANN reconstruction are promising as it is indicative that the separation of true events from background noise or incorrectly reconstructed events may become easier, and analysis with fewer events may be possible. However, the reduction in the photo-peak (correctly reconstructed events that have been assigned as incorrect events) needs to be looked at and improved. Complex ANN with additional level of complexity (number of hidden layers, topology of the network, different activation functions in the neurons, …) have been proposed and should be implemented, trained and evaluated based on a larger input space parameters.

References

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[5] CALIFA BARREL Technical Design Report, November 2010 (http://www.fair-center.eu/for-users/experiments/nustar/documents/technical-design-reports.html).