New approaches to Global Event Reconstruction in collider experiments

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Global Event Reconstruction consists in the reconstruction of final state particles crossing a detector. The idea is to combine information from different subdetectors (tracks, energy depositions, muon tracks, time information, ...) to extract particle properties. An example of such methods is the Particle Flow algorithm from CMS, that distinguishes between photons, electrons, charged and neutral hadrons and muons.

1 The Iterative CLustering framework in the CMS barrel calorimeters

In the High Luminosity phase of the LHC, CMS will face harsh environments, characterized by events with high pileup values, i.e. high number of simultaneous collisions happening in the same event, going up to 200 collisions per event. For CMS, these conditions will translate into more complex events, which are already a big challenges for the reconstruction, and higher trigger rates that, in addition, pose stricter timing requirements.

To face such conditions, numerous upgrades have been planned, both on the hardware and software side. On the hardware side, two novel detectors will be installed: the calorimeter endcaps will be replaced by the High Granularity CALorimeter (HGCAL) and a timing layer (MTD, MIP Timing Detector) will be placed between the tracker and the calorimeters.

Among the software updates, in the context of both HGCAL reconstruction and Particle Flow algorithms, The Iterative CLustering (TICL) has been developed. TICL is a reconstruction framework aimed at reconstructing physical objects starting from 5D hits (position, energy and time), returning particle properties and identification probabilities. My work within TICL focuses on its extension to the barrel calorimeters (ECAL and HCAL). As a start, since TICL has been developed for the HGCAL, the barrel calorimeters need to be layerized and considered as a whole: one layer for the electromagnetic section and four for the hadronic section. In the first place, energy depositions in the calorimeter cells are reconstructed (*hits*). Hits are then clustered together, layer by layer, in two dimensional objects called *LayerClusters*; subsequently, LayerClusters will be themselves clustered together, building *Tracksters*. Tracksters are three dimensional objects that represent showers in the calorimeter. From here linking to tracks and other tracksters (to recover inefficiencies) is performed, leading to the final candidates, from which particle properties can be extracted.

2 Redefining the target for full detector reconstruction algorithms

Truth information plays a major role in reconstruction since it impacts both how the algorithms are designed and how their performances are evaluated, therefore its definition is crucial and has to be well-defined. This role becomes even more important when talking about Machine Learning based reconstruction, since the algorithms are trained against it.

Therefore the truth information has to be "realistic" in the sense that it should represent what can be actually reconstructed in the detector. Hence, the idea behind this work is defining ParticleFlow-like objects that can be used to train the algorithms, using information from both tracks and calorimeter depositions.

In addition to this, reconstruction, in calorimeters but in other types of detectors as well, is limited by constraints such as granularity. For example, having a calorimeter with a non-infinite granularity, objects that are close together may look like one object, e.g. a shower in the calorimeter. The goal of this project is also to study how a redefinition of the targets of our reconstruction impacts the performances in terms of physics result. What is being done is the embedding of granularity information in the truth information, creating merged objects whenever the detector constraints do not allow for a well-defined object to be reconstructed. Also in this case, the algorithm has to be well understood since it is necessary for it to be infrared safe for it to give physical results.