Identifying Elementary Particles From High Energy Collections Produced by The Large Hadron Collider at CERN
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The Large Hadron Collider
- The Large Hadron Collider (LHC), Fig. [A], is the largest particle accelerator in the world.
- LHC gives the scientific community a unique opportunity to study physics at the highest energy level achieved by mankind.
- Data from the LHC collisions, reconstructed by the Compact Muon Solenoid (CMS) detector (Fig. [B]), have already led to the discovery of the Higgs boson (Nobel Prize in physics in 2013) and many other discoveries are anticipated soon.
- In order to maximize the discovery potential of the CMS detector, it is crucial to fully capitalize on the hardware capability to reconstruct particles produced in the collisions.

Development of a New Algorithm
- Identification of electrons in a quark fragmentation environment (called jets) is highly challenging as other particles can mimic electron experimental signature. (1)
- We developed a new method to improve the identification of the low-energy electrons produced in heavy flavor quark decays and to properly account for the energy flow in the collision.
- We used both simple selection and multivariate techniques to vastly improve the performance of the electron reconstruction.
- This new algorithm was implemented in C++ and is now a part of the official CMS electron reconstruction software at CERN.

Electron Identification in CMS
In the CMS detector (Fig. [C]), the electrons are identified in the silicon tracker (labeled [D]) and the electromagnetic calorimeter (ECAL, labeled [E]). In low energy electron identification in jets, significant fake electron candidates arise from hadrons, such as pions. To reject the pions and to keep high electron detection efficiency, we use the two filters.

Filtering Criteria in New Algorithm
- The algorithm for electron identification is designed to find electrons which do not have photon emission within the silicon tracker detector volume. In this filter, we require good tracking quality, as well as good matching quality between reconstructed energy clusters and tracks. The electron identification strategy is shown in Fig. [F].

Filtering Criteria in New Algorithm
- One of the two filters responsible for electron identification is designed to find electrons which do not have photon emission within the silicon tracker detector volume. In this filter, we require good tracking quality, as well as good matching quality between reconstructed energy clusters and tracks. The electron identification strategy is shown in Fig. [F].

Filtering Criteria in New Algorithm
- The CMS detector is a general purpose particle detector designed to search for the Higgs boson and supersymmetric particle (SUSY) in addition Standard Model search. The CMS detector consists of the silicon pixel tracker, electromagnetic calorimeter (ECAL), hadron calorimeter, superconducting solenoid, and muon chambers. (2)

Filtering Criteria in New Algorithm
- The circumference of LHC is 27 km (Fig. [A]). Two proton beams circulate in opposite directions around the ring and collide at several points, the CMS detector is marked by the star in Fig. [A].

Filtering Criteria in New Algorithm
- The CMS is a detector which is designed to search for the Higgs boson and supersymmetric particles (SUSY) in addition to the Standard Model search. The CMS detector consists of the silicon pixel tracker, electromagnetic calorimeter (ECAL), hadron calorimeter, superconducting solenoid, and muon chambers. (2)

References & Acknowledgements


Summary
- A new method has been developed to identify electrons for the official reconstruction framework of the LHC collisions with the CMS detector.
- The new selection criteria offers a vast improvement over the old method: for the same reconstruction efficiency, the contribution from pions misidentified as electrons is reduced by a factor of two. This work directly impacts the discovery potential of future operations of the LHC complex in 2015. Being an official reconstruction method, 2500+ collaborators will benefit from better electron reconstructions.