Software developments and analysis in the ATLAS group

Software coordination

- Starting October 2021 G. Stavropoulos is appointed ATLAS muon software coordinator.

- Goal: Design, develop and maintain the ATLAS muon offline software all the way from DAQ byte-stream reading to muon reconstruction and identification.

- Muon software domain:
  - Data Access: Byte-stream Conversion - Cabling
  - Detector Description
    - **Task :** Development of an XML-based description of the ATLAS Muon Detector. Develop the necessary C++/OO and Python software to prepare the data for track reconstruction and muon identification.
  - Modelling of the Detector Response (Simulation, Digitization, ”Local” Reconstruction)
    - **Task :** Muon detector digitization development in the new ATLAS Run-4 software framework.
  - Track Reconstruction and Muon Identification
    - **Task : Develop track reconstruction algorithms in the new ATLAS Run-4 software framework.**
  - Conditions Database and Detector Control system
  - Detector Specific calibration procedures
  - Trigger
  - Offline Data Quality
  - Validation

An example: High radiation background in the New Small Wheel detector

- The precise reconstruction of the trajectories of muons created in proton–proton (pp) collisions is a key ingredient in many of the physics processes.

- In order to reconstruct muon trajectories, ATLAS uses energy deposits from charged particles (hits) recorded in individual detector elements of the New Small Wheel (NSW) and applies clustering algorithms to them.

- The purpose of the clustering algorithms is to group together these energy deposits. Based on those groups of hits called clusters in a number of the layers of NSW, the associated track parameters can be estimated.

- Therefore, the performance in the reconstruction of these clusters heavily affects with the associated tracks.

- In the context of this task, we work with Micromegas clusters, which are a collection of strips (sensitive element of the Micromegas detector).

Description of the task

- Muons with high transverse momentum undergo radiative energy losses.

- These may produce hits near the muon track and 'spoil' the shape of the cluster in the NSW.

- Goal: In order to accurately find the hit positions of the muon track along the detector layers, we would like to identify these problematic clusters.

- We refer to:
  - Signal: Clusters with simulated hits from muons.
  - Background: Clusters with simulated hits from electrons, photons apart from muons.

- This is a classification task with a binary (two level) qualitative response (Y=1 for signal, Y=0 for background).

- Someone can explore a number of methods like Boosted decision trees, Random Forests, Support Vector Machines etc.

Z boson precision measurement

- Our group is taking part in the precision measurement of the Z boson mass and specifically in the muon momentum calibration part.

- Last measurement from Large Electron–Positron Collider (LEP):
  $91.187{,}6 \pm 2{,}1(\mathrm{MeV})$.
  Given this precisely measured value of the Z boson mass and the clean leptonic final state of Z decaying into 2 leptons, these $Z \to ll$ processes provide the primary constraints for detector calibration, physics modeling as well as validation of an analysis strategy.

- Why? Prerequisite for a very precise measurement of the:
  - Higgs mass and width. Certain studies shows that the mass of the Higgs boson can be measured with a precision of 10-20 MeV.
  - W mass
  - and a self consistency check of the Standard Model.

- LHC can move from the 17 million Z bosons produced at LEP to 100 million Z leptonic decays at the end of Run3.