Performance of the ATLAS Trigger for the High Luminosity LHC era

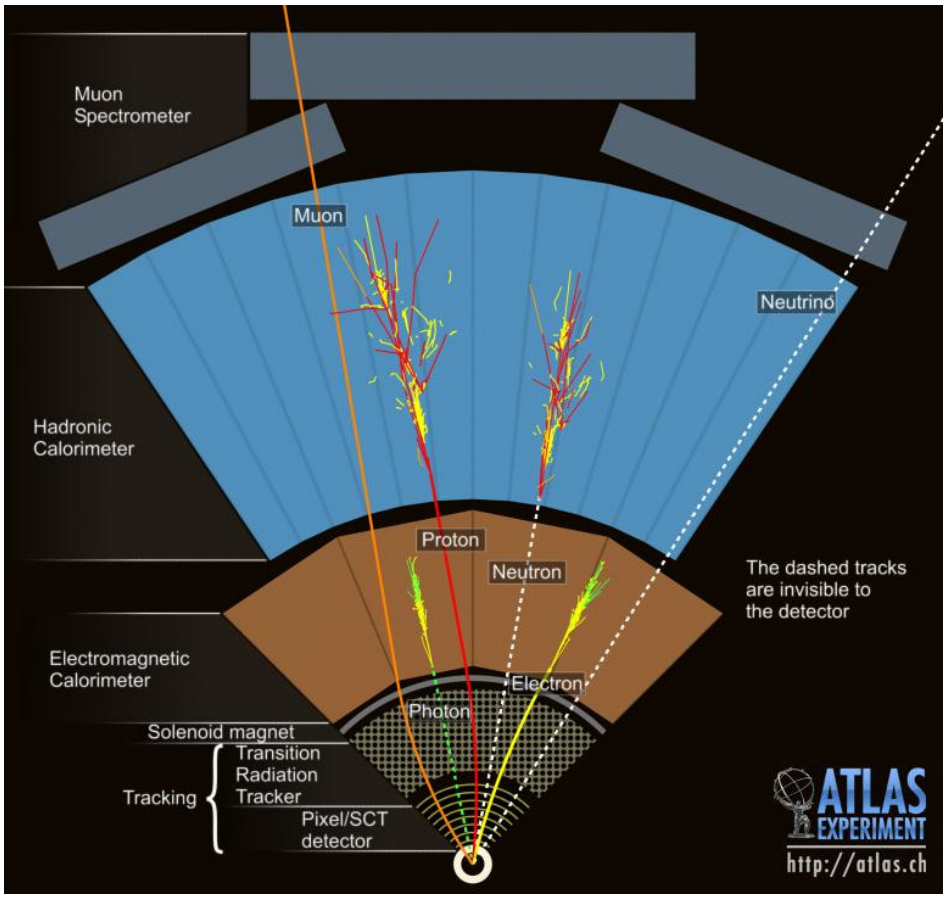
Filipe Cruz

Supervisors:
Ana Luísa de Carvalho
Ricardo Gonçalo
Patrícia Conde

LIP Summer Student Program

August 29, 2019

Sections of ATLAS



Tracking Chamber:

- Detects charged particles
- Charged particles exit the detector with about the same energy and direction

Electromagnetic calorimeter:

- Measure the energy of charged and neutral particles
- Absorbs the full energy of e^+, e^- and γ

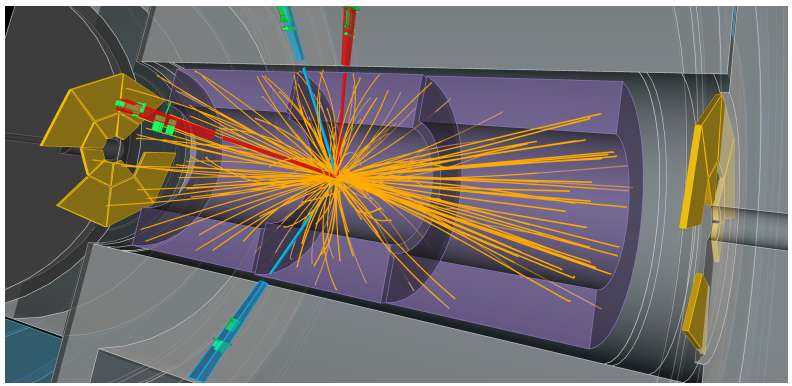
High Luminosity LHC era

Trigger System

It is not possible to select all data for offline analysis.

To reduce the flow of data, ATLAS uses two-level online selection system:

- Level-1 hardware trigger
- High Level Trigger (HLT) CPU farm



Update of Trigger System

HL-LHC aims to provide an increase in instantaneous luminosity by a factor of 5-7.

- It increases the discovery potential
- But also increase pile-up of events μ

$\Downarrow\Downarrow$

Upgrade of the Trigger System with a hardware tracking pre-processor - the **Hardware Track Trigger** (HTT)

Theory and Objectives of the internship

Decay of Z boson

Z bosons are produced from proton-proton interactions.

$$m_Z = 91.2 \text{ GeV/c}^2$$

Z boson decays to:

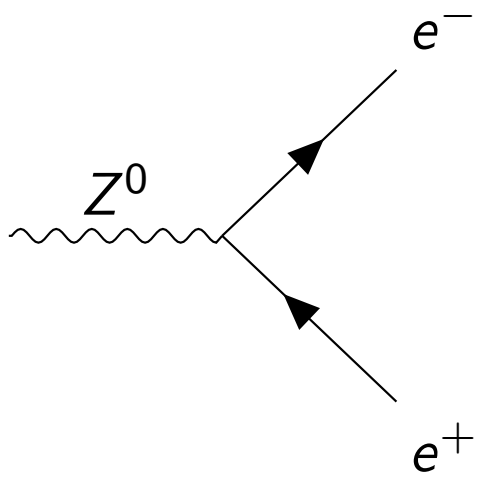
- Quark-antiquark (70%) - identified as jets.
- Neutrino-antineutrino (20%) - untouched by the detector
- Lepton-antilepton (10%) - electron, muon, tau

Jets are responsible for the background.

Objectives:

Study the performance of the future HTT:

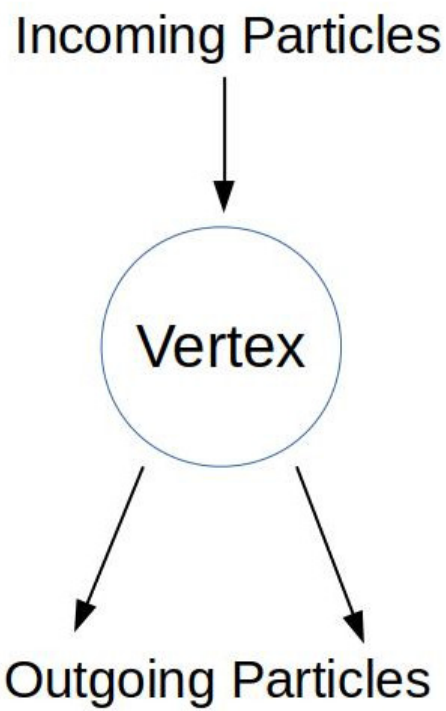
- At selecting the signal ($Z \rightarrow ee$), with the resolution of parameters
- At rejecting background



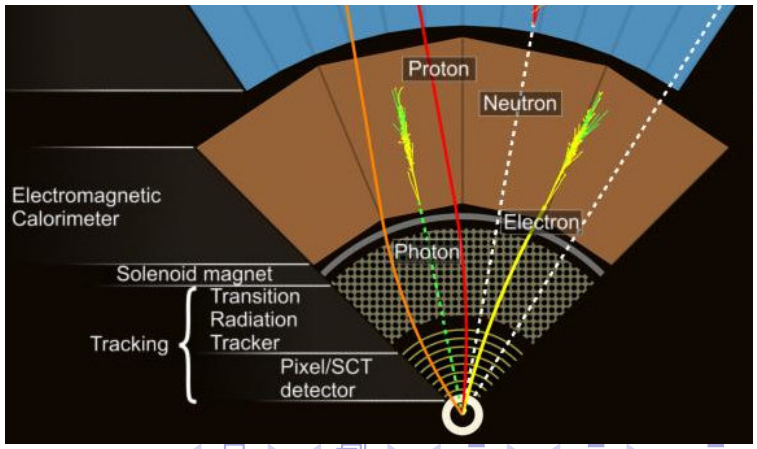
Methodology

Using simulated data and a start-up code:[1]

1. Get electron truth particles originated from Z boson.



2. Apply parameterized efficiency of the detector
3. Associate tracks to truth particles
   - Considers a close track with highest momentum
4. Match EM clusters to tracks
   - Rejects clusters not candidates for the electrons

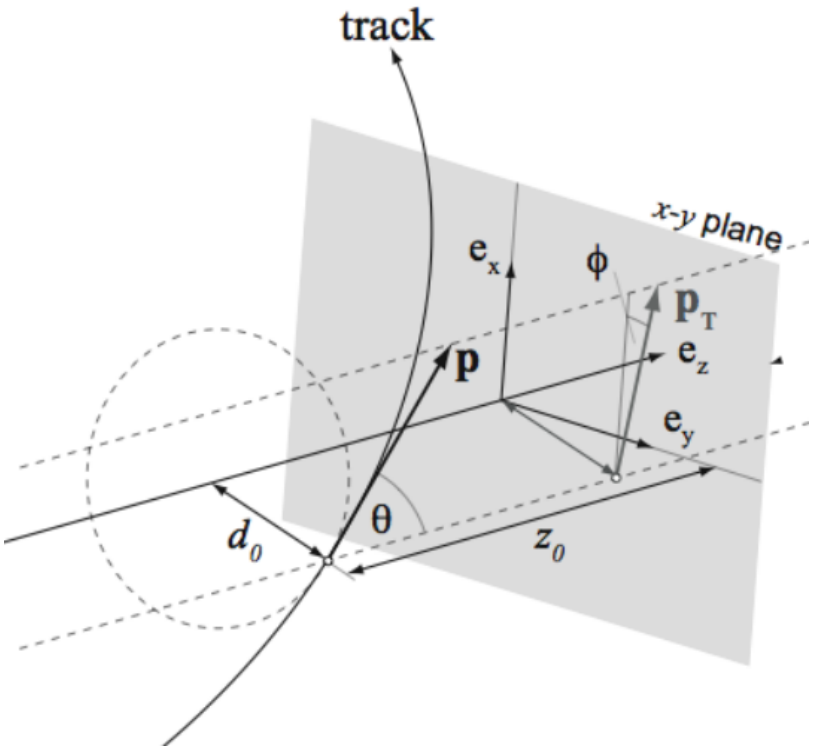


[1] made by Lewis Wilkins, RHUL

Perigee

Perigee Parameters:

$d_0, z_0, \theta, \phi, q/p$



http://physik.uibk.ac.at/hephy/theses/diss_as.pdf

Smeared Parameters

p_T - Tranverse momentum

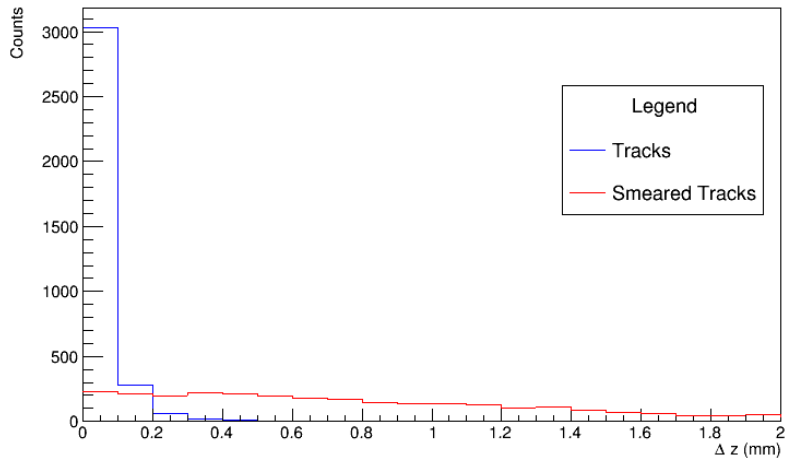
$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$ - pseudorapidity

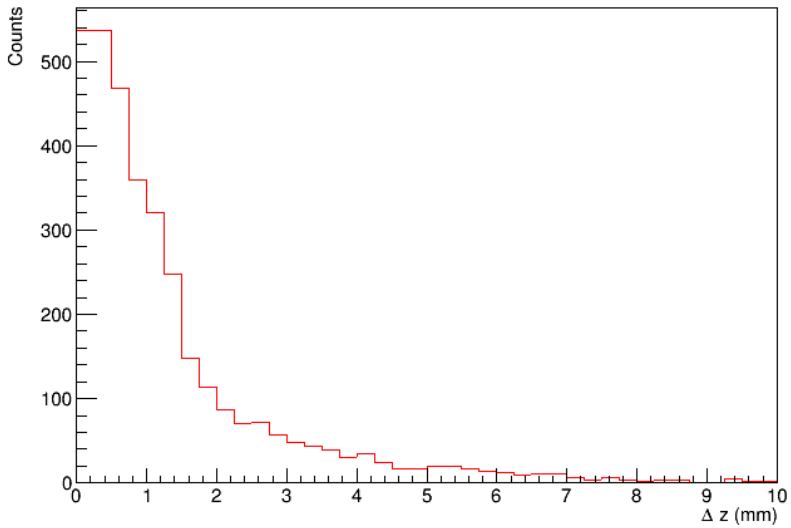
ϕ_0 - Azimutal angle on x-y plane

z_0 - distance in z axis to point of reference

5. Apply smearing to tracks parameters and associate truth particles to new tracks.
   - Gaussian distribution
   - Recurring to specific smearing functions
6. Calculate pretended variables

Results - Δz between tracks



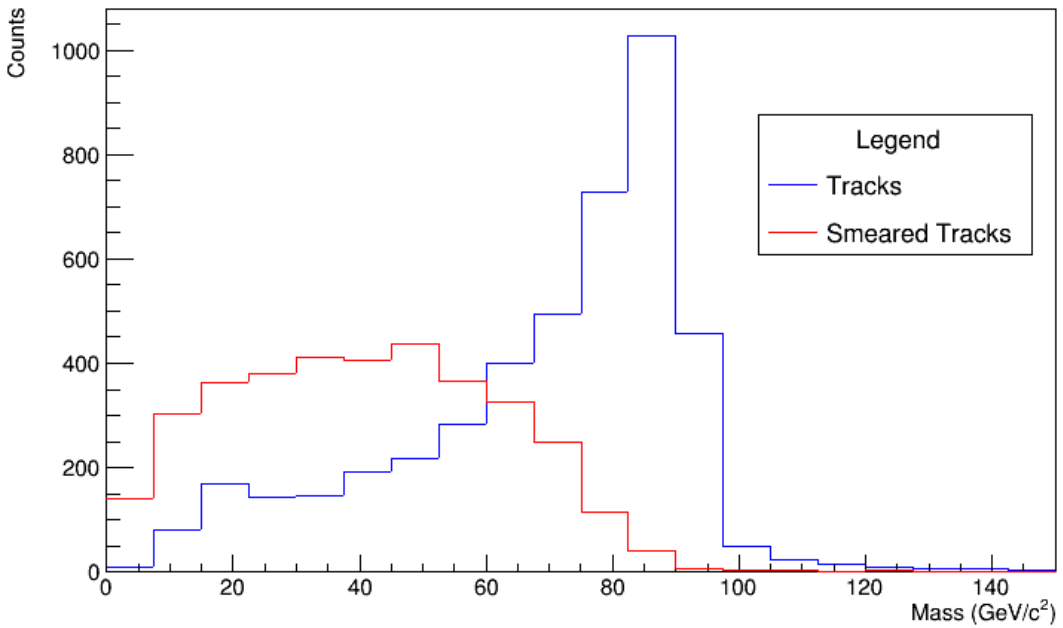


Δz referring to the tracks associated with the par of truth pairs.

Resolution of Δz, for the smearing tracks doesn't corresponds to the expected resolution ($\Delta z \sim 0.02$ mm).

Results - Z Boson mass

Mass of the parent Z boson of the electrons:



Mass obtained with track values by:

$$m_Z = \sqrt{(E_1 + E_2)^2 - (\overrightarrow{p_1} + \overrightarrow{p_2})^2}$$

- Loss of energy of electrons (by *Bremsstrahlung*) leads to asymmetry of Z mass for the tracks
- Shaped unexpected of the smeared tracks, caused by the smearing functions

Conclusion

Next steps:

- Correction of the smearing functions
- Study the variation of efficiency with pileup values
- Continuation of the background rejection study