Performance of the ATLAS Trigger for the High Luminosity LHC era

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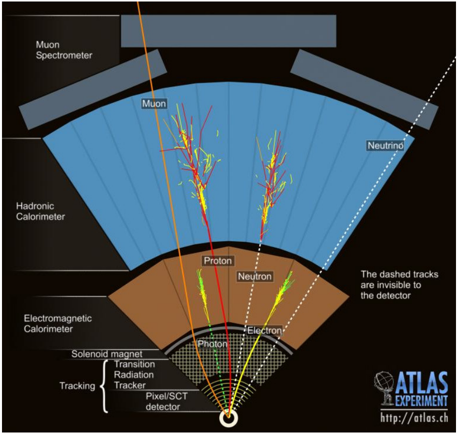
LIP Summer Student Program

September 5, 2019

ATLAS Experiment in LHC

Sections of ATLAS



Tracking Chamber:

- Detects charged particles
- Particles exit the detector with same energy

EM and Hadronic calorimeters:

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

Magnet System:

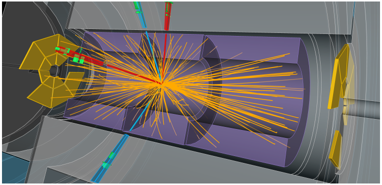
- Bends the trajectories of charged particles

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

$\Downarrow$

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.

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

Z boson decays to:

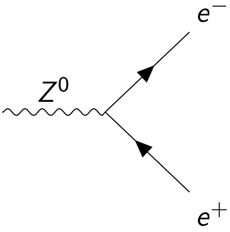
- Quark-antiquark (70%) - identified as jets.
- Neutrino-antineutrino (20%) - untouched by the detector
- Lepton-antilepton (10%) - electron, muon, tau

Jets are responsible for the background.

Objectives:

Study the performance of the future HTT:

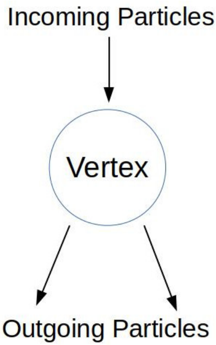
- At selecting the signal ($Z \to ee$), with the resolution of parameters
- At rejecting background, with different Δz cuts



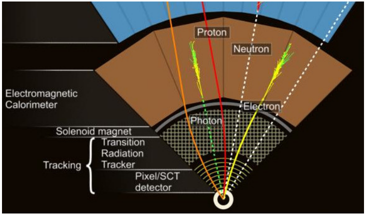
Methodology

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

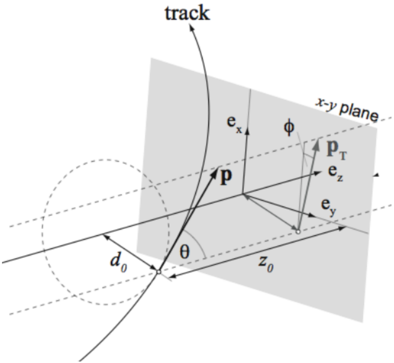


[1] made by Lewis Wilkins, RHUL

Perigee

Perigee Parameters:

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



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

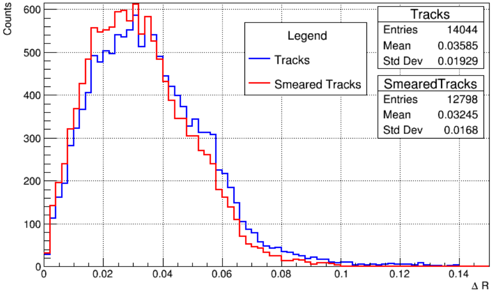
Smeared Parameters

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 clusters to new tracks.
   - Gaussian distribution
   - Recurring to specific smearing functions[1]
6. Calculate intended variables

[a] describe how the gaussian parameters change vs p_T and η

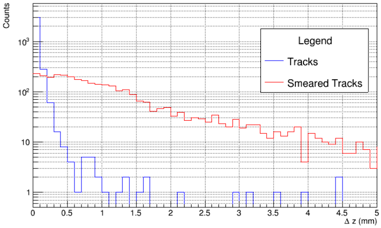
Control test

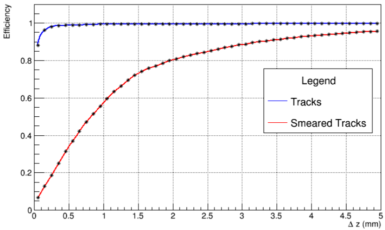


Minimum ΔR (between clusters and tracks) for offline tracks and HTT tracks:

Calculated by:

$$\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$$





Efficiency as a function of Δz cut is significantly smaller for HTT tracks than for offline tracks.

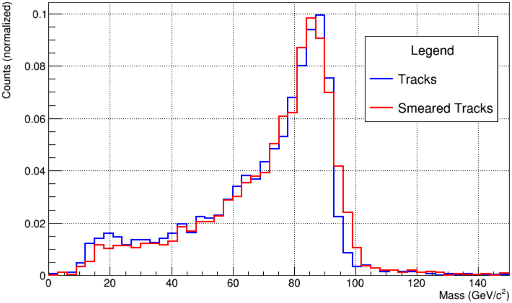
$\Downarrow$

Δz cut for pile-up rejection needs to be more loose in trigger than in offline analysis.

η range	η	ϕ	z0(mm)
$0.1 < \eta < 0.3$	0.004	0.003	2.9
$0.7 < \eta < 0.9$	0.004	0.003	4.5
$1.2 < \eta < 1.4$	0.011	0.013	19.3
$2.0 < \eta < 2.2$	0.014	0.012	22.1

Results - Z Boson invariant mass

Invariant mass of the parent Z boson of the par electron-positron:



Mass obtained using track values by expression:

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

- Loss of energy of electrons (by *Bremsstrahlung*) leads to the asymmetry of the calculated mass
- Wider gaussian for the smeared tracks

Conclusion

- Loss of efficiency for HTT tracks due to poorer resolution
- The invariant mass of the Z boson can be used as control for the HTT algorithm

Future steps

- Study of efficiency with pileup values for a given Δz value
- Continuation of the background rejection study