Obtaining Requirements for the Future ATLAS Event Filter Tracking System

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INTRODUCTION

The High-Luminosity LHC will provide a peak luminosity of 5×10^{34} cm^{-2}s^{-1}, which would result in 200 overlapping interactions (pileup). The high pileup poses a significant challenge for the ATLAS trigger and data acquisition system. The Event Filter Tracking system under design will allow both a regional reconstruction at 1MHz and the full event reconstruction at 150 kHz. The design challenge is to maximize the tracking performance of the algorithms while remaining within available resources. The results of studies to evaluate the minimal tracking performance required are presented. The dependence on tracking efficiencies, transverse momentum (p_T) resolution, and impact parameter resolution are shown for various lepton and multi-jet objects.

DEFINITION OF PERFORMANCE PARAMETERS

- ***Tracking efficiency***: the fraction of generated charged particles associated with a high-quality reconstructed track

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- ***Number of fake tracks:*** the number of reconstructed tracks not associated with generated particles
- ***Resolution on track parameters:*** the root mean square of the residual difference between the reconstructed and true values of the parameter.

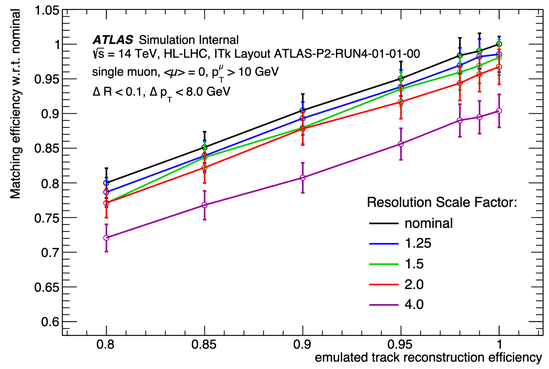
Changes in efficiency and rejection for:

- Track-muon matching
- Track to tau vertex association
- Tau track classification
- Multi-jet vertexing

are presented for various emulations of Event Filter tracks.

The track parameters will be multiplied by a Gaussian distribution with RMS corresponding to the resolution of the parameter.

PERFORMANCE STUDIES: MUONS



Efficiency of track-muon matching for various track reconstruction efficiencies and resolutions of track p_T and impact parameters.

- ***Track-muon matching was studied for possible Event Filter track qualities using single muon samples***

TRACK EMULATION AND PARAMETER SMEARING FRAMEWORK

The track parameter resolution functions are extracted from single muon events in a model of the HL-LHC ATLAS detector. An explicit function for the resolution is found by:

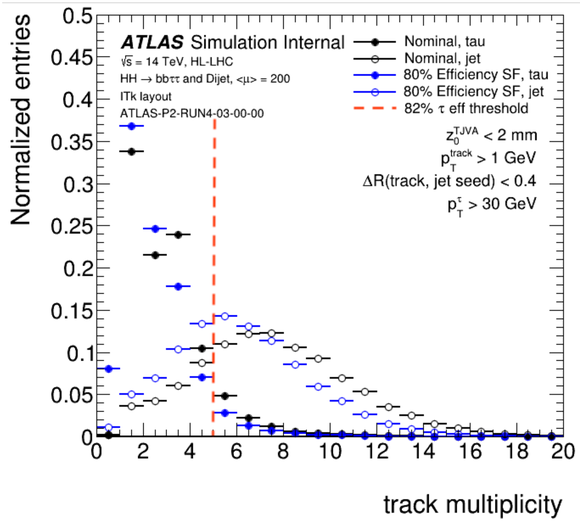
- Splitting offline track parameter resolution into 6 slices of track truth p_T
- Binning each p_T slice in $|\eta|$
- Fitting polynomial + gaussian function against $|\eta|$

This procedure is done for:

- Track p_T
- Track transverse and longitudinal impact parameters

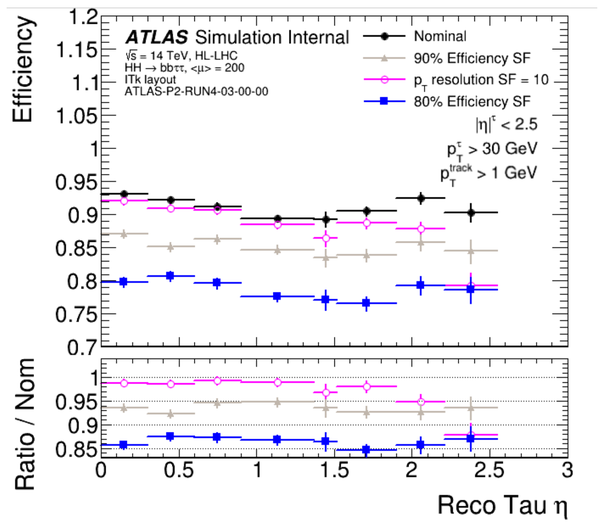
- ***Tracking inefficiency is emulated by dropping tracks at random***
- ***Fake tracks are not emulated. Limitations will be set implicitly.***
- ***Resolution on tracking parameters is emulated with scale factors (SF), which linearly scale track resolution functions***

PERFORMANCE STUDIES: HADRONIC TAUS



The number of tracks associated with the tau for both $\mathrm{HH} \rightarrow bb\tau\tau$ and dijet samples. The offline (nominal) and 80% tracking efficiency scenarios are presented.

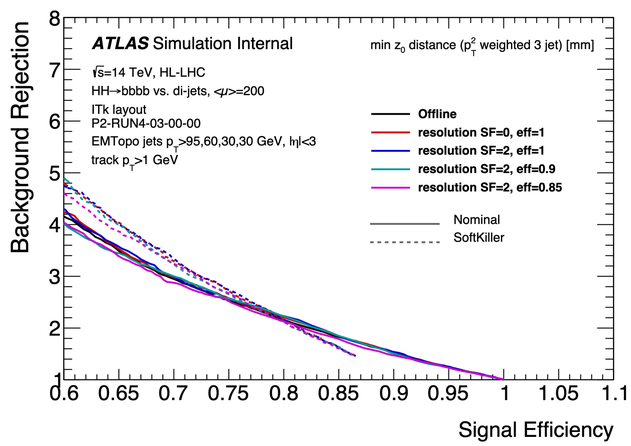
- ***Track to tau vertex association was studied on tau candidates in $HH \rightarrow bb\tau\tau$ and dijet samples***
- ***Implicit limits on the number of fake tracks allowed can be estimated***



Efficiency to correctly classify the prong of the tau using a Recurrent Neural Network. The network is retrained for each of the track emulation scenarios. Scenarios where the tracking efficiency and track p_T have been smeared are presented.

- ***Tau track classification efficiency was studied for possible Event Filter track qualities in $HH \rightarrow bbbb$ samples***

PERFORMANCE STUDIES: MULTI-JET



Efficiency to identify 4 jets as all coming from the primary vertex for two pileup suppression algorithms: a fast online vertexing algorithm (nominal) and a SoftKiller algorithm. The resolution of track p_T, impact parameters, and tracking efficiency is smeared.

- ***Multi-jet efficiency was studied for possible Event Filter track qualities using $HH \rightarrow bbbb$ samples***

CONCLUSIONS

- ***Performance studies were carried out in the context of single lepton and di-Higgs boson samples***
- ***The relationship between reconstruction of physics objects (muons, taus, and multi-jets) and track performance parameters was investigated***
- ***The results of these studies will guide the design of the Event Filter***