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} with the number of overlapping interactions (pileup) increasing from ~60 to 200. In this context, the high pileup poses a significant challenge for the ATLAS trigger and data acquisition system. The Event Filter Tracking system under design will provide online track reconstruction for the trigger system with a combined rate of 1MHz for regional tracking and 150 kHz for full scan tracking. The objective of this design stage is to define an efficient and sustainable implementation of the Event Filter Tracking system while simultaneously optimizing performance. In these studies, the minimal tracking performance required is studied using simulated HL-LHC events with future detector geometries. Examples of relations among design parameters and event features are presented for lepton and multi-jet reconstruction contexts.

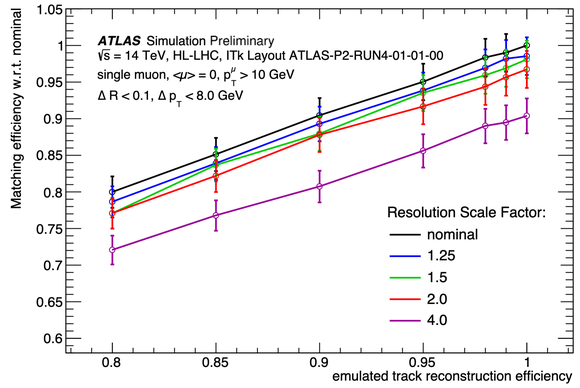
DEFINITIONS AND EMULATION OF PERFORMANCE PARAMETERS

- ***Tracking efficiency***: the fraction of generated charged particles associated with a high-quality reconstructed track.
  - Emulated by dropping tracks at random
- ***Number of fake tracks:*** the number of reconstructed tracks not associated with generated particles.
  - Not emulated; limits are set implicitly
- ***Resolution on track parameters:*** the standard deviation of the distribution of residual differences between the reconstructed and true values of the parameter.
  - Emulation done by smearing offline tracks, more details in section “Track Parameter Smearing Framework”

Working points, composed of tracking efficiency and resolutions values, are used to quantify emulations of the Event Filter Tracking system. We present the impact that various working points have on efficiency and rejection for several algorithms:

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

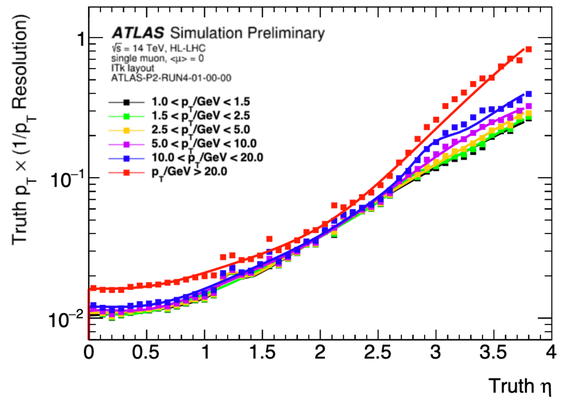
PERFORMANCE STUDIES: MUONS



Efficiency of track-muon matching as a function of the track reconstruction efficiency, for various resolutions of track p_T and impact parameters.

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

TRACK PARAMETER SMEARING FRAMEWORK

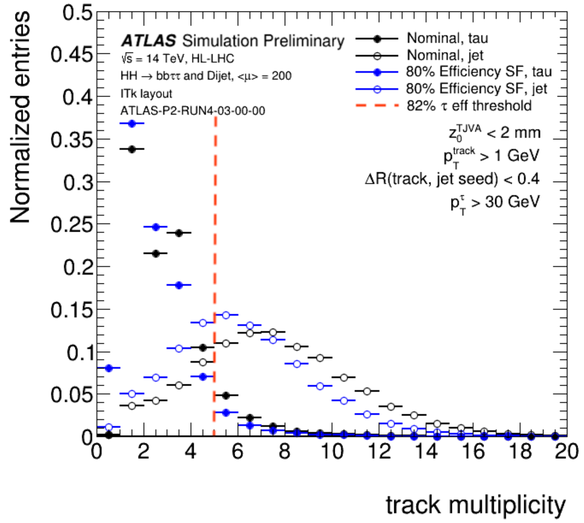


The resolution of track p_T as a function of track truth p_T and $|\eta|$. The longitudinal and transverse impact parameter resolutions are extracted using the same procedure and vary from O(10) – O(1000) μm over track truth p_T and $|\eta|$.

- ***Resolution on track parameters:*** emulated by the application of multiplicative scale factors (SF) onto the extracted resolution curves.

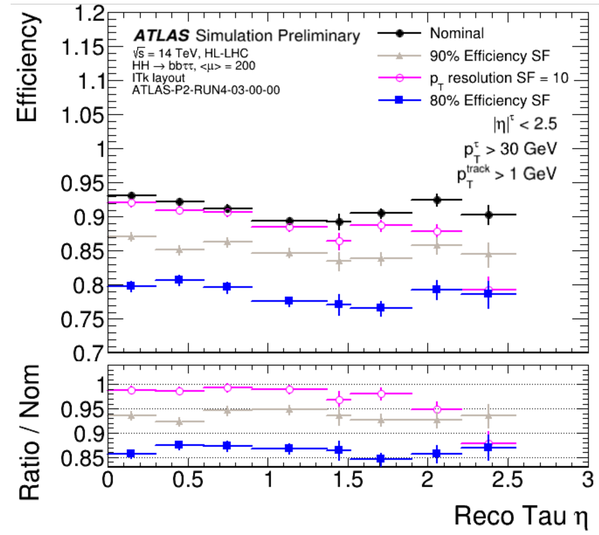
Track parameters are then recalculated from the emulated resolution by sampling a Gaussian distribution with mean equal to the offline value and standard deviation corresponding to the emulated resolution.

PERFORMANCE STUDIES: HADRONIC TAUS



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

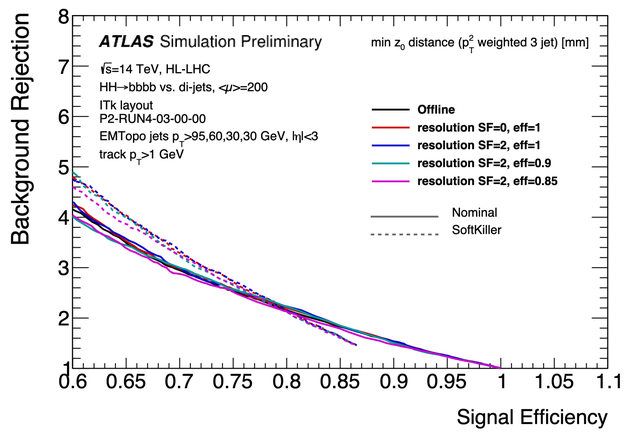
- ***Track to tau vertex association was studied on tau candidates in $HH \rightarrow bb\tau\tau$ and dijet samples***
- ***Implicit limits on the number of fake tracks allowed can be estimated***



Efficiency of tau track classification 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 working points 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 are smeared.

- ***Multi-jet efficiency was studied for possible Event Filter track working points 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 Tracking system***