ATLAS TAU COMBINED PERFORMANCE COSMICS RESULTS

The ATLAS Collaboration

Introduction

Cosmic rays are the first data available to ATLAS. These data have been used to examine the tau-jet reconstruction and identification algorithms. The purpose of this exercise has been to test the stability of the tau-jet algorithms with real data, as well as to systematically assess the algorithm performance on data and its comparison to Monte Carlo.

The reconstruction of hadronically decaying tau leptons can be separated into two categories as tau-jets can be seeded from either Inner Detector tracks, or from energy deposits in the calorimeters. The track-seeded algorithm requires a track with $p_T > 6$ GeV satisfying particular quality criteria, and then finds matching calorimeter clusters. The reconstruction of calo-seeded candidates starts from jets, reconstructed using a cone algorithm with $\Delta R < 0.4$ based on topological clusters, with $E_T > 10$ GeV. This algorithm then finds matching Inner Detector tracks.

Properties of taus and their shower behavior in material is the basis of tau-jet identification variables. These variables exploit the characteristics of a tau lepton decay, namely having 1 or 3 tracks and a narrow associated calorimeter cluster. In particular the tau working group has placed emphasis on having 'safe variables' available for first data, that is to say, variables that are simple and robust. Basic distributions used in the identification procedure are shown in the following pages.

The cosmic ray data from the Autumn 2008 combined runs used for this study consisted of events where both the solenoid and toroid magnetic fields were on. The data were divided into different trigger streams. The one used for this analysis contains events that passed any L1 Trigger accept, with the requirement that an Inner Detector track be reconstructed at L2. Two subsets of this stream were used, one requiring that each Inner Detector track has at least one associated pixel hit (PixComm), the other containing all events with an electron, photon or tau-jet at the reconstruction level (EGammaTau).

Introduction

In order to increase the number of reconstructed tau candidates in cosmic ray events, slight changes were made to the acceptance of the tau reconstruction algorithm. The impact parameter |d0| which was originally limited to 1 mm was extended to 40 mm, and similarly, |z0| was extended to 200 mm. Track quality criteria were loosened, only requiring at least one hit in the Pixel Detector. A requirement on the ratio of the transverse energy coming from the energy flow method and that coming from the calorimeter was removed from the track-seeded algorithm, as it was designed specifically to eliminate fake tau candidates originating from muons.

Data were compared to Cosmic Ray Monte Carlo samples simulated with Geant 4. In order to obtain a sufficient number of events for comparison, volume filters were applied at the simulation level. The first filter used requires a cosmic event to leave part of its signature within the Inner Detector. These Monte Carlo events were compared to the EGammaTau data. A second filter requiring a hit in the Pixel Detector was used to compare Monte Carlo and data from the PixComm stream.

In the following plots the reconstructed tau-jet candidates have been divided into two groups based on the seeding algorithm. Tau candidates seeded by tracks are referred to as “track-based” and those seeded by topojets as “calo-based”. The tau candidates with track and calorimeter seeds are included in both categories. In all plots the number of Monte Carlo events was normalized to data.

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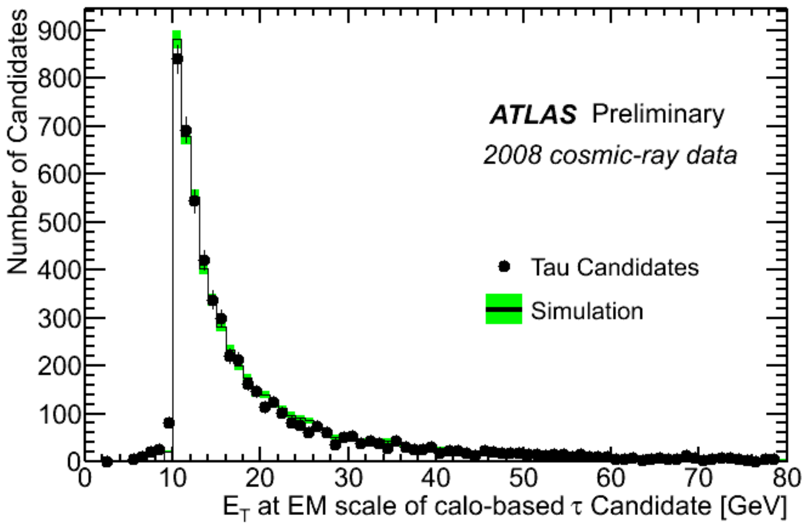
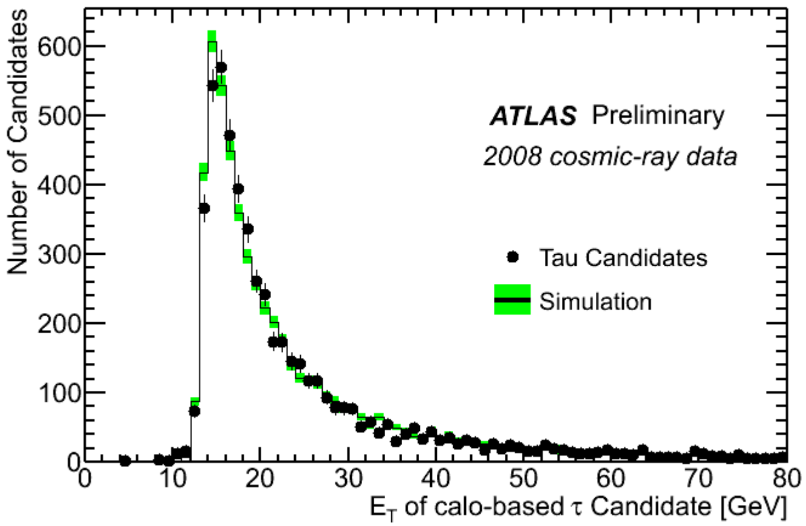
Tau-jet Reconstruction

Calo-based tau candidates



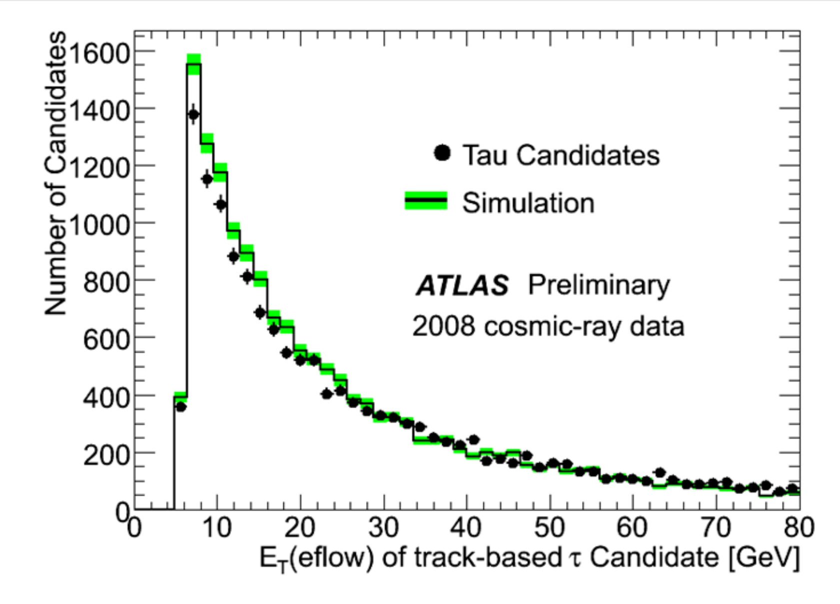
Transverse energy of calo-based tau-jet candidates at the electromagnetic scale (no hadronic calibration applied). The E_T at the EM scale is a safe variable used for identification in first data.

Calo-based tau candidates



Transverse energy of calo-based tau-jet candidates. Seed topojets must have $E_T > 10$ GeV and $|\eta| < 2.5$. Cell energies in the hadronic calorimeter are calibrated to the hadronic scale.

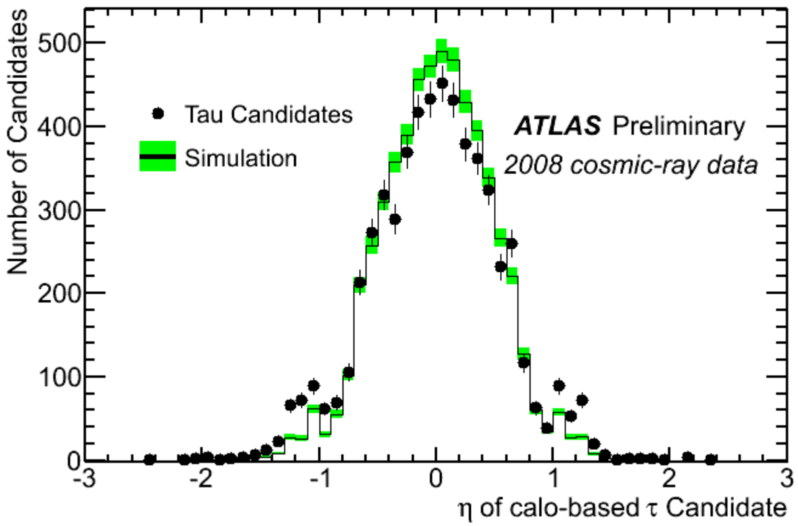
Track-based tau candidates



Transverse energy of track-based tau-jet candidates. The energy is determined using an energy flow algorithm. In this method the energy deposit in cells is divided into two categories, as coming from the neutral and charged components of a tau-jet. After calculation of the component energies, the energy coming from the track is replaced by the transverse momentum of that track from the Inner Detector.

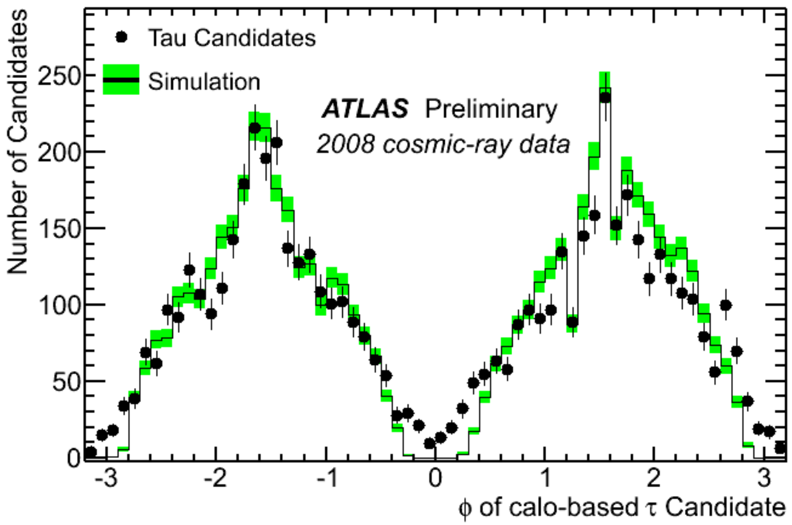
In case of cosmic events the energy calculated by this method is dominated by the transverse momentum of the muon track. Discrepancies between data and simulation are due to trigger effects not modeled in Monte Carlo.

Calo-based tau candidates



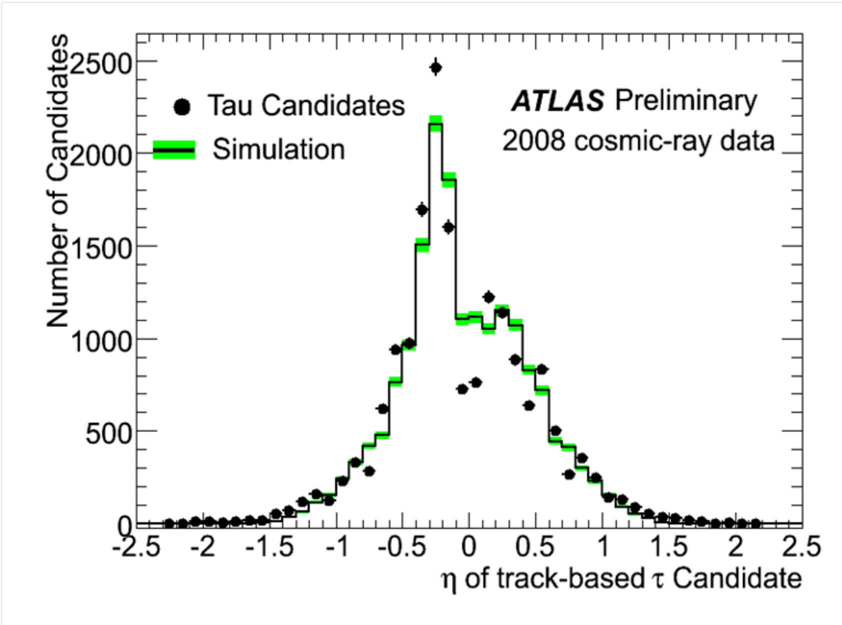
Pseudorapidity of calo-based tau-jet candidates. The majority of events are from seed jets that have a large energy deposit in a single cell; this cell defines the direction of the tau candidate.

Calo-based tau candidates



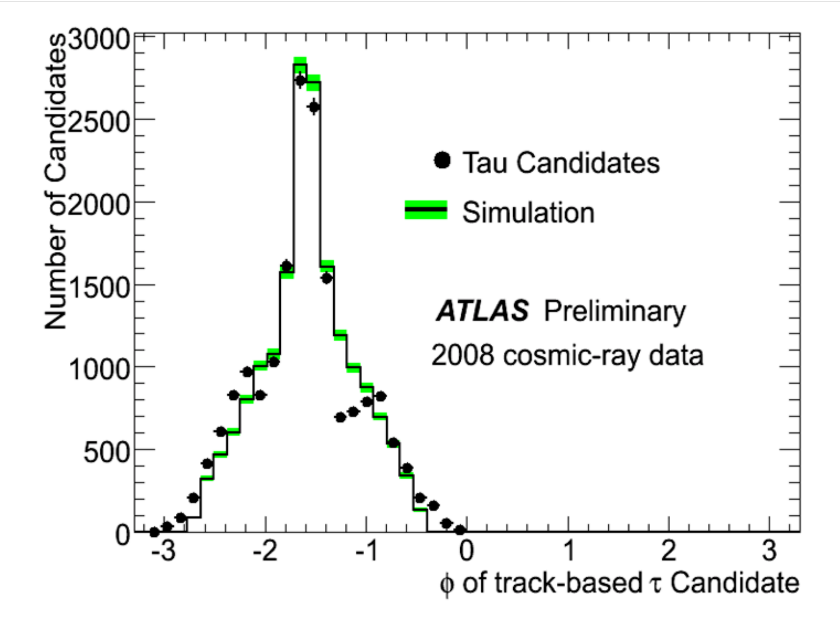
The phi direction of calo-based tau-jet candidates. The majority of events are from seed jets that have a large energy deposit in a single cell; this cell defines the direction of the tau candidate.

Track-based tau candidates



Pseudorapidity of track-based tau candidates. The double-peak structure is connected to the two construction shafts. The general distribution and basic features of the data agree with the simulation; smaller characteristics, however, are not reproduced as well. This plot identifies areas for improvement in the simulation.

Track-based tau candidates



The phi direction of track-based tau candidates. Cosmic rays that meet tau track requirements come in from surface levels down through the detector. Since the tau track-seeded algorithm uses the direction in which the momentum is pointing, such cosmics have a negative phi direction. Discrepancies between data and simulation are due to the elevator shafts to the pit which are not assumed in the simulation.

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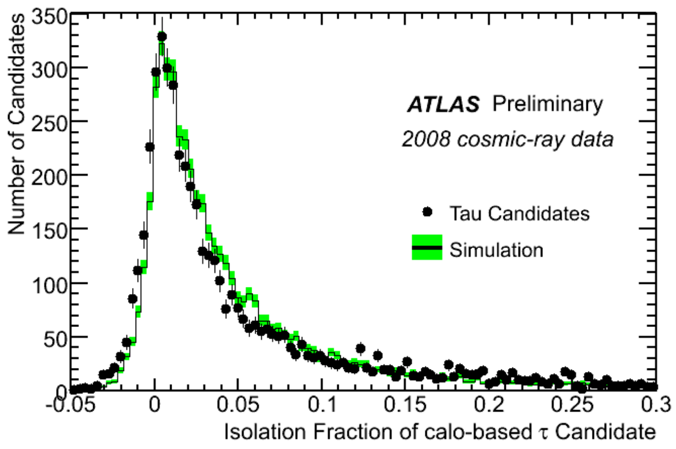
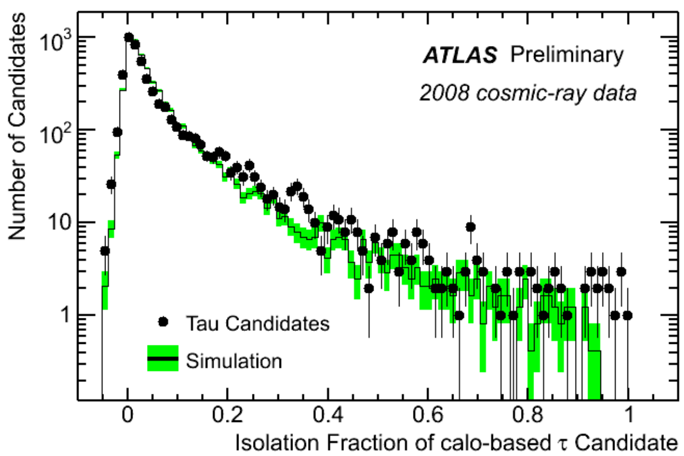
Tau Identification Variables

Calo-based tau candidates

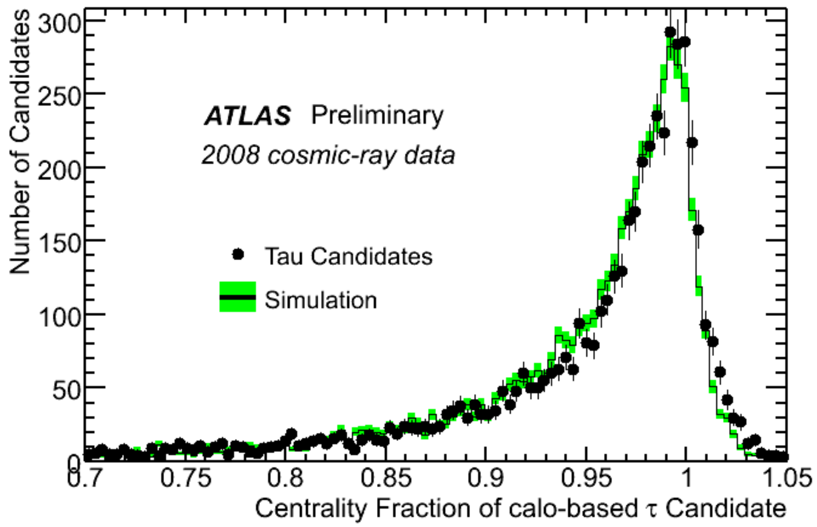




The fraction of the uncalibrated transverse energy deposited in the electromagnetic calorimeter in a cone $0.1 < \Delta R < 0.2$ around the direction of the tau candidate with respect to the total energy in the cone of $\Delta R < 0.4$.

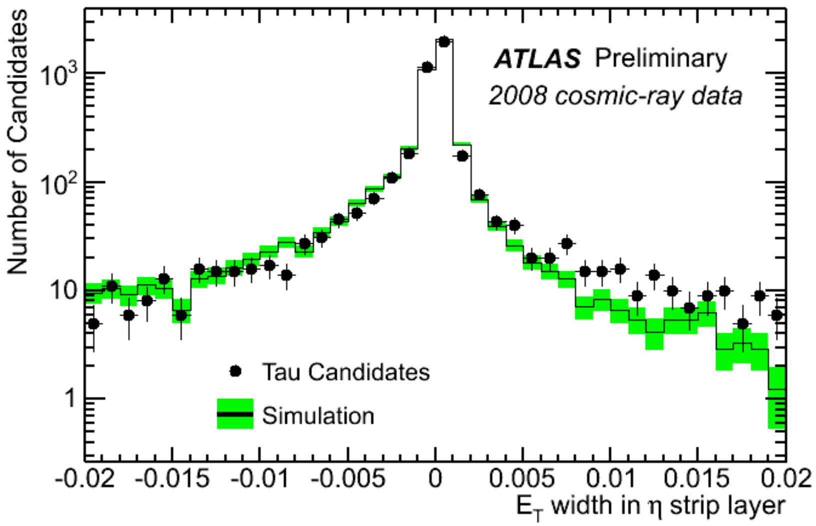
The top plot shows the peak region. The bottom plot displays the full range on a log scale, explicitly verifying the modeling of the tails.

Calo-based tau candidates



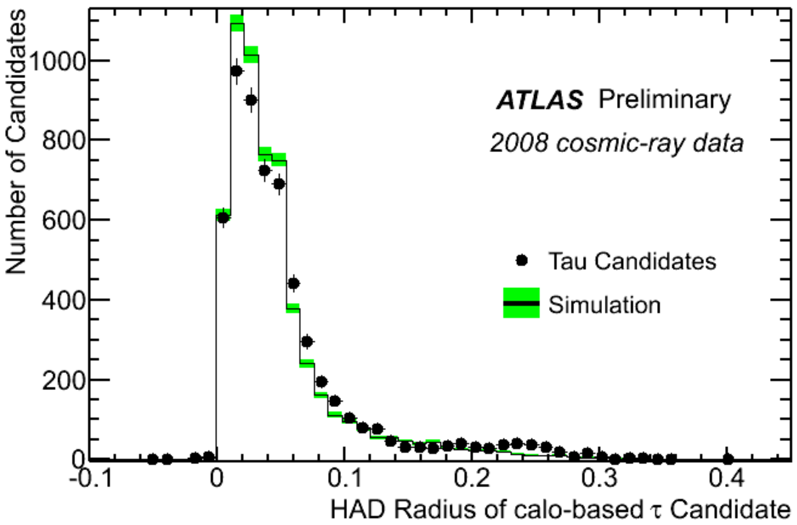
The ratio of the transverse energy of calo-based tau-jet candidates within a cone of $\Delta R < 0.1$ to their transverse energy within a larger cone of $\Delta R < 0.4$

Calo-based tau candidates



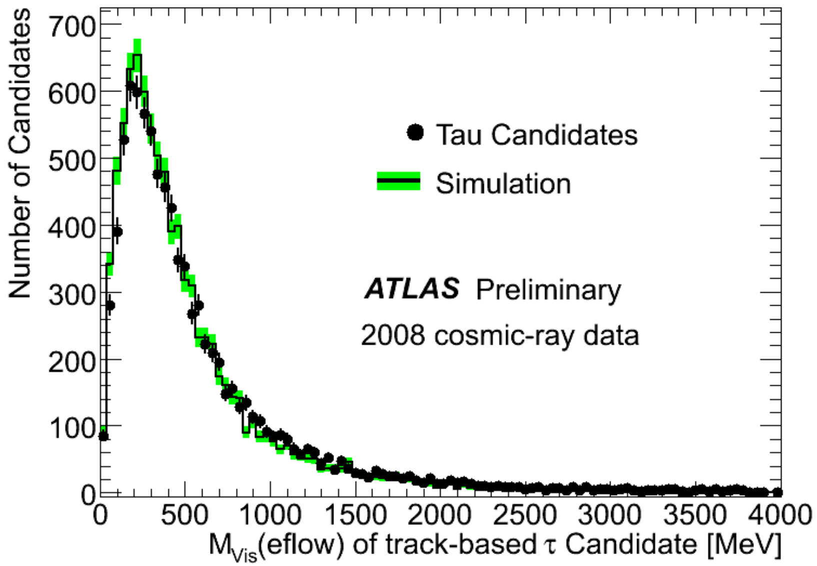
The transverse energy weighted width of tau candidates in the η direction in the first layer of the electromagnetic calorimeter.

Calo-based tau candidates



The radius of energy deposits in hadronic calorimeters for calo-based tau-jet candidates. This variable corresponds to the lateral development of hadronic showers.

Track-based tau candidates



The invariant mass of the charged and neutral decay products where the energy deposits associated to tracks have been replaced by the track momenta as measured in the Inner Detector.

The M_{Vis} is used in tau-jet identification. As in case of the energy, this variable is dominated by the momentum of the muon track.