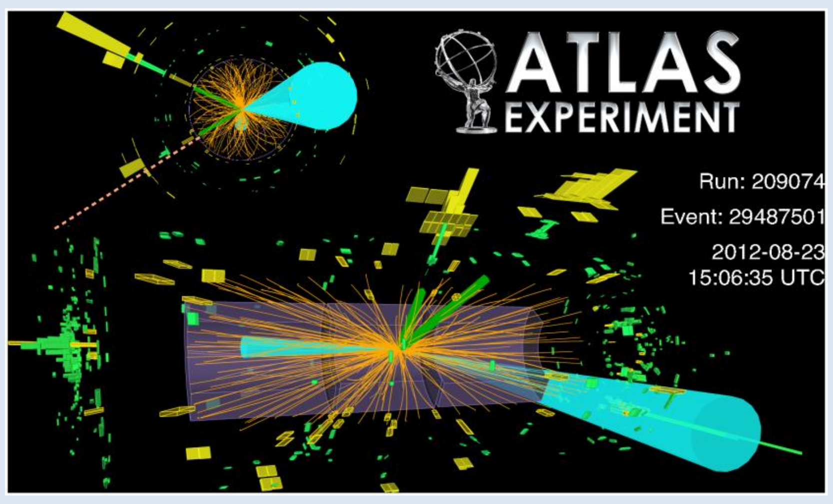
LHCC Poster Session - CERN, 5 March 2014

Performance of Tau Reconstruction and Identification for Run-1 in ATLAS

Taus in ATLAS

Display of an event selected by the H →ττ analysis in the channel with two hadronic tau decays in the VBF category. The tau candidates are indicated by green tracks. The S/B ratio in the BDT score bin of this event is 0.67.

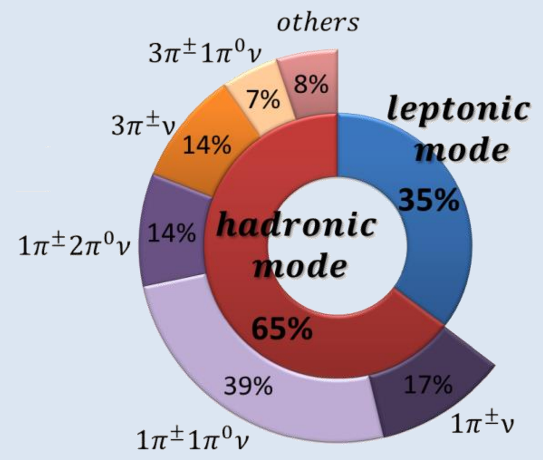


Introduction to Tau Leptons at ATLAS

- Mean lifetime: 291 fs. Proper decay length: 87 μm → taus **decay in the beam pipe and are reconstructed and identified from their decay products.**
- Taus in the p_T range of 20 GeV to >1 TeV are of interest for ATLAS analysis.

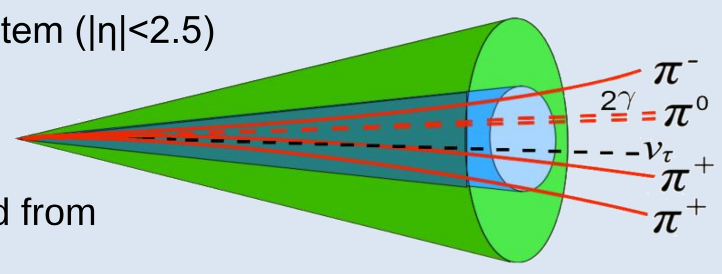
Signature of hadronic tau decays ("taus") in the ATLAS detector:
- Calorimeter: **Narrow shower**. Mix of particles that create hadronic and electromagnetic showers.
- Tracking: **One track or three tracks,** closely spaced with low transition radiation, displaced secondary vertex.

Main backgrounds for taus:
- Quark- or gluon-initiated jets ("**QCD jets**") have a **much larger cross section** than taus. They are usually **wider** than taus and have **larger particle multiplicities**.
- **Electrons** usually produce more **transition radiation** than hadrons from taus and they initiate purely **electromagnetic showers**.



Tau Reconstruction

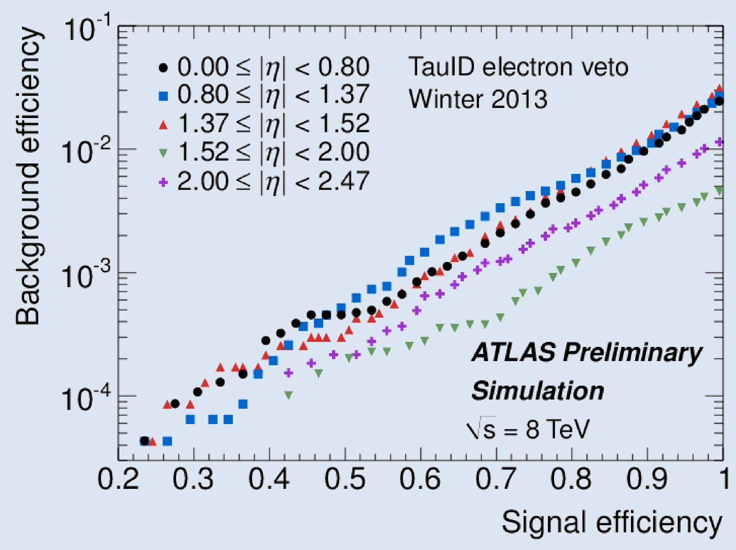
- Tau candidates are **seeded** by anti-k_t (R=0.4) calorimeter jets within the acceptance of the ATLAS tracking system (|η|<2.5)
- The **tau lepton production vertex** is identified using the tracks within ΔR<0.2 of the tau candidate
- The **tau visible 4-momentum** is reconstructed from the **calorimeter clusters** with ΔR<0.2
- **Tracks** within ΔR<0.2 and matched to the tau vertex are associated to the candidate
- Variables for **tau identification** are calculated from **tracks with ΔR<0.4** that are matched to the tau vertex and from **calorimeter cells and clusters with ΔR<0.2**



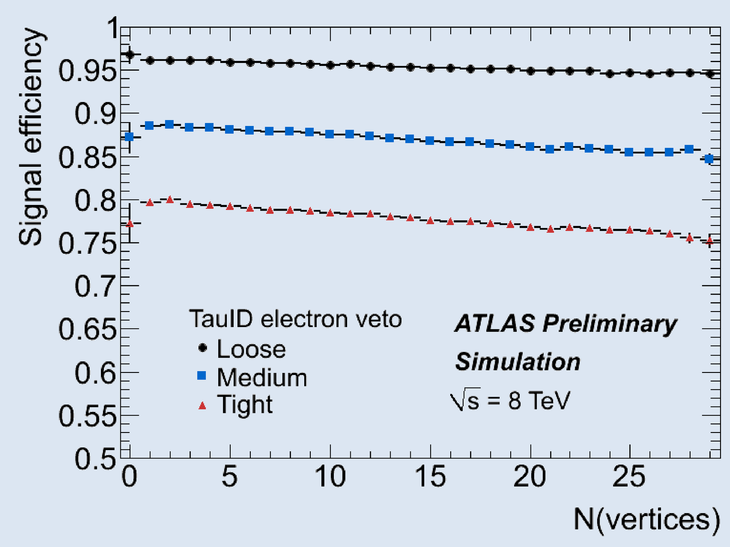
Tau Identification:
Discrimination against Electrons

- The signature especially of **1-prong taus** can be mimicked by electrons.
- A **BDT** classifier is trained on simulated electrons and taus. It explores information in the Transition Radiation Tracker and the shape of the energy distribution in the calorimeter.
- The efficiency of the electron identification has been **measured in data and simulation**.

Performance of the electron veto. Candidates do not overlap with any reconstructed electrons passing tight identification



Signal efficiencies of the three working points as a function of the number of average pileup interactions per bunch crossing

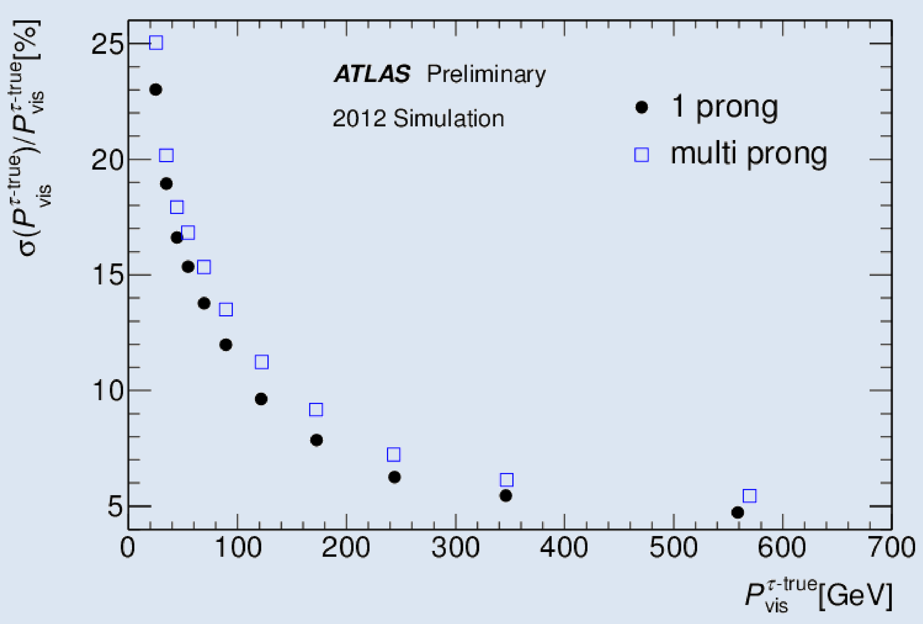


Tau Energy Calibration

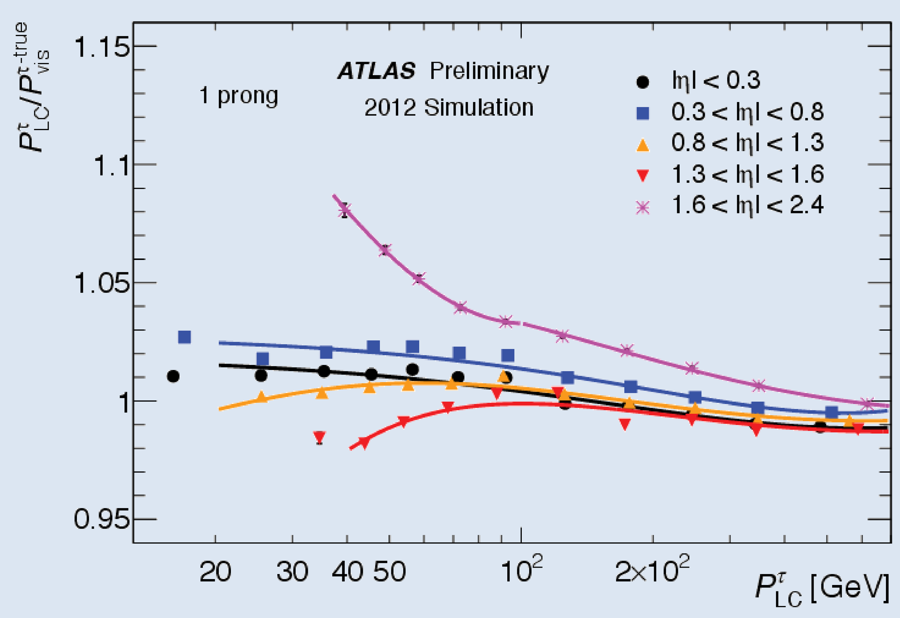
- The tau energy scale (TES) is calibrated dependent on p_T, |η| and differently for 1- and multi-prong candidates based on the **response in simulated events**.
- A dedicated **pileup correction** dependent on the number of reconstructed proton-proton vertices is applied.

- The **TES uncertainty** is **decomposed** into the uncertainties on the **response to the individual decay products**
  - Charged pions: isolated pions in data (E/p), combined test beam data (CTB) or simulation dependent on the kinematic region,
  - Neutral pions: well known line shape of Z→ee decays (e/γ).
- The TES is **checked** using an **in-situ analysis** of the visible mass in reconstructed Z→ττ events.

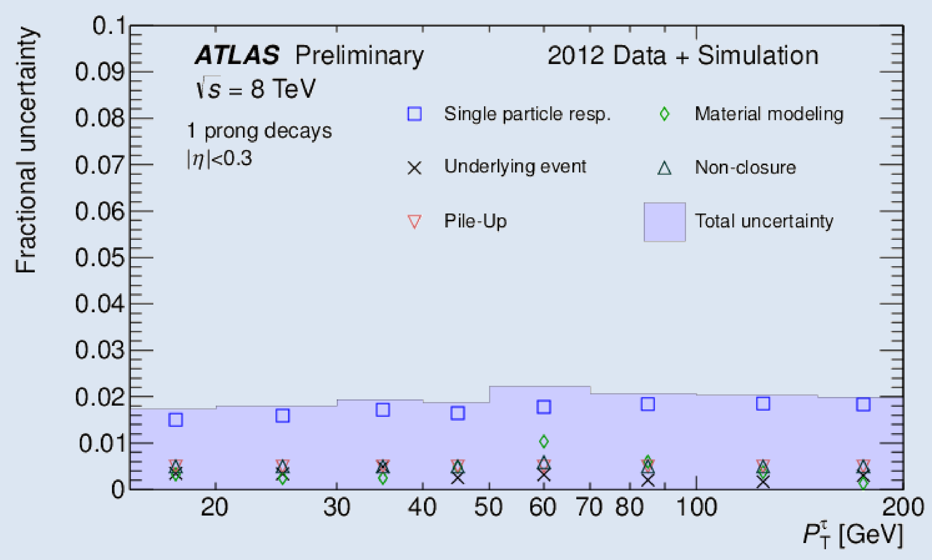
Tau momentum resolution as a function of the transverse momentum



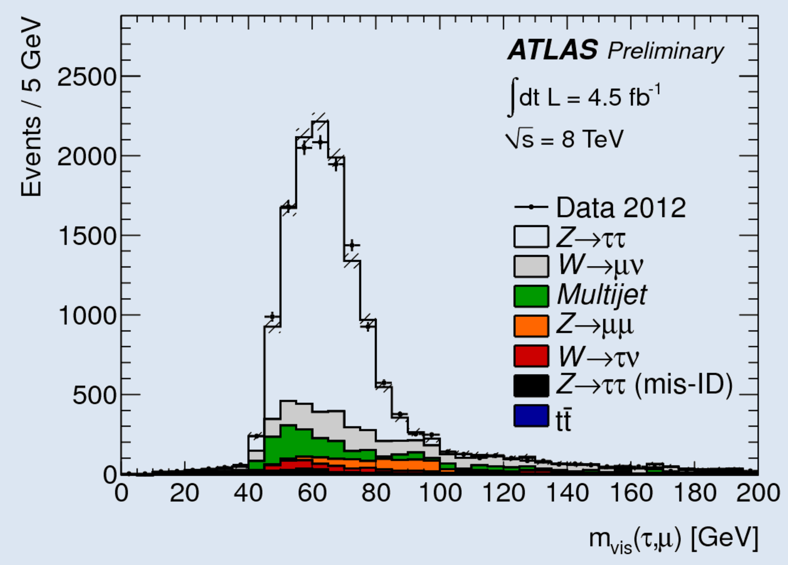
Response curves of the tau energy for reconstructed 1-prong taus



Fractional energy uncertainty for reconstructed 1-prong taus



In-situ cross check of the TES using the visible mass in reconstructed Z→ττ events

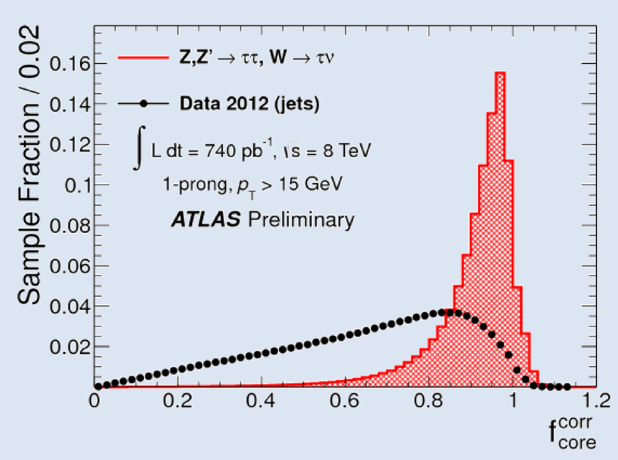


Tau Identification: Discrimination against QCD jets

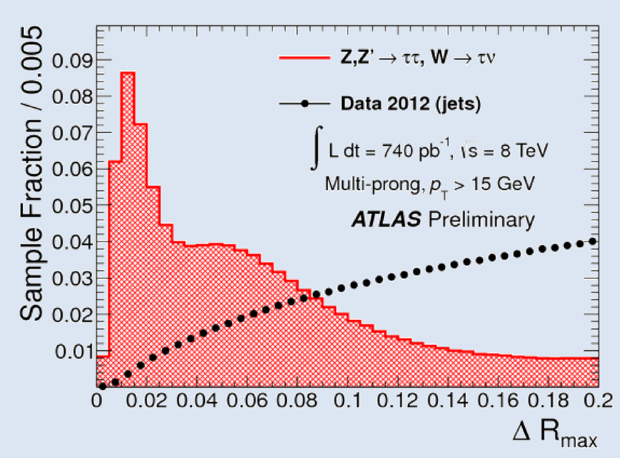
- Discrimination is provided by **Boosted Decision Trees** (BDT). They explore variables sensitive to
  - the particle multiplicity and the width of a candidate,
  - the displacement of the origin of the tracks from the primary vertex,
  - the kinematics of reconstructed neutral pions in the tau decay.
- For the variable selection, particular attention is paid to the **stability of the performance under pile-up**.

- The **modeling** of the tau identification in simulation is studied in Z→ττ decays with a "**tag and probe**" approach:
  - "Tag:" leptonically decaying tau,
  - "Probe:" hadronically decaying tau.
- The **number of tracks** is **fitted** before and after tau identification, to measure the efficiency in data and simulation.
- Additional studies have been performed using W→ τυ and tt̄ events.

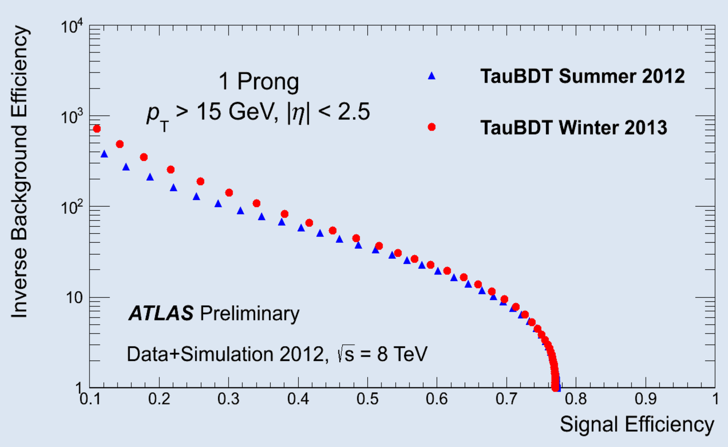
Fraction of calorimeter energy in ΔR<0.1 to ΔR<0.2



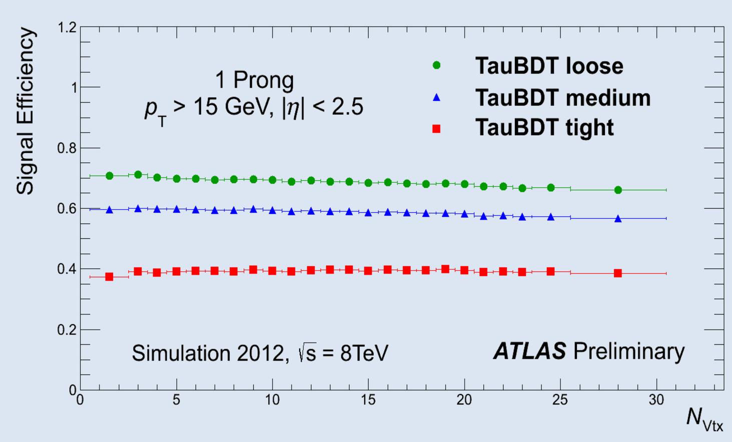
Maximal distance of track associated to the tau candidate



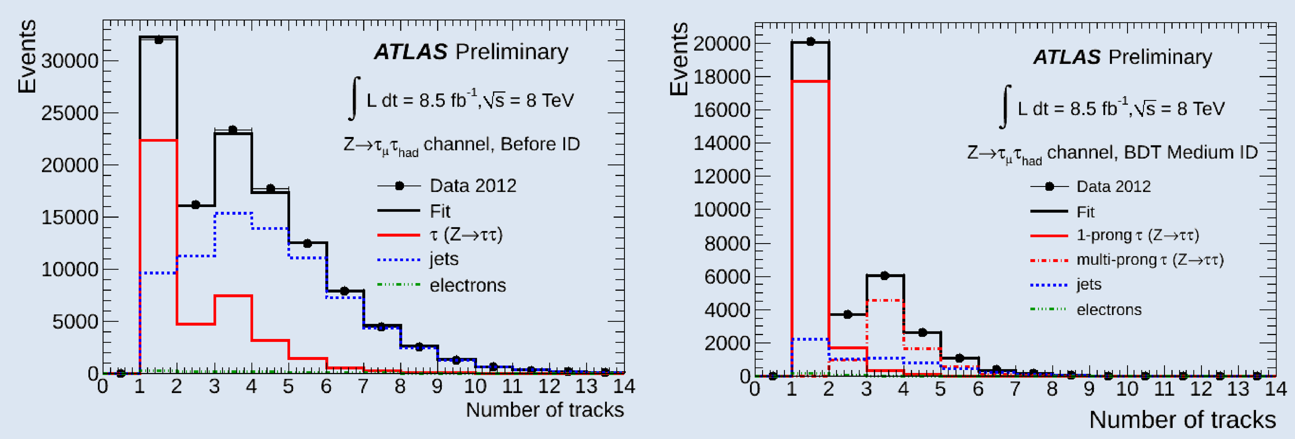
Performance of the tau identification for 1-prong tau candidates



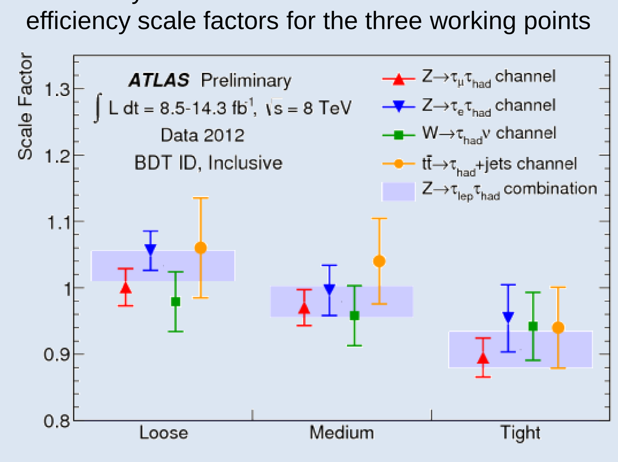
Identification efficiency of the three working points as a function of the number of vertices for 1-prong tau candidates



Fitted number of tracks before (left) and after (right) tau identification



Summary of the data/simulation tau identification efficiency scale factors for the three working points



Reference material: ATLAS Collaboration, Determination of the tau energy scale and the associated systematic uncertainty in proton-proton collisions at √s=8TeV with the ATLAS detector at the LHC in 2012, ATLAS-CONF-2013-044.
ATLAS Collaboration, Identification of Hadronic Decays of Tau Leptons in 2012 Data with the ATLAS Detector, ATLAS-CONF-2013-064.
ATLAS Collaboration, Evidence for Higgs Boson Decays to the tau+tau- Final State with the ATLAS Detector, ATLAS-CONF-2013-108

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