Measurement of the tau lepton reconstruction and identification performance in the ATLAS experiment using pp collisions at $\sqrt{s}=13$ TeV

Michael Hübner (huebner@physik.uni-bonn.de)
Rheinische Friedrich-Wilhelms-Universität Bonn, Germany, on behalf of the ATLAS Collaboration

---

**Tau reconstruction & motivation**

The tau lepton offers access to a variety of physics analyses, ranging from BSM physics (e.g. SUSY searches) to SM analyses (e.g. Higgs coupling measurement). To be able to perform such measurements, a sophisticated reconstruction and calibration of the tau lepton was developed. Several algorithms target different aspects of hadronically decaying taus ($\tau_h$) and when combined deliver a precise picture.

**Common measurement strategy**

- **Concept:** select well-known Standard Model process $Z \rightarrow \tau\tau$
- **Tag** leptonically decaying tau into muon (trigger the muon), probe hadronically decaying tau
- **Use** common event selection to select $Z \rightarrow \tau\tau$ events

**QCD CR**

- **Estimation of QCD-induced multijet background (ABCD method):**
  - Obtain multijet template from same sign events
  - Scale template with normalisation factor calculated in QCD CRs

- **Estimation of W+jets:**
  - Shape/Norm taken from data – simulation in W CR
  - Normalisation transfer factors calculated from simulation in W CR and signal region

**Signal and other backgrounds from simulation**

**Goal:** measure scale factors to account for any remaining differences between data and simulation after tau energy calibration

**Common measurement strategy**

- **Goal:** apply tau trigger on probe tau in signal region and extract trigger efficiency (similar procedure as the tau identification measurement)
  - $N_{\tau_h} = R_{\text{pT}} \cdot N_{\text{tracks}} \cdot 10^{\text{bkg}} / 2 \cdot 10^{\text{trig}}$
  - $N_{\tau_h} = R_{\text{pT}} \cdot N_{\text{tracks}} \cdot 10^{\text{bkg}} / 2 \cdot 10^{\text{trig}}$
  - Extend $p_T$ range by using $Z \rightarrow \tau\tau$ for lower $p_T$ values, and $\tau$ events for high $p_T$

**Trigger efficiency**

- **Concept:** select common Standard Model process $Z \rightarrow \tau\tau$
- **Tag** leptonic tau decay into muon (trigger the muon), probe hadronically decaying tau
- **Use** common event selection to select $Z \rightarrow \tau\tau$ events

**QCD CR SS**

- **Estimation of QCD-induced multijet background (ABCD method):**
  - Obtain multijet template from same sign events
  - Scale template with normalisation factor calculated in QCD CRs

- **Estimation of W+jets:**
  - Shape/Norm taken from data – simulation in W CR
  - Normalisation transfer factors calculated from simulation in W CR and signal region

**Signal and other backgrounds from simulation**

**Goal:** derive scale factors accounting for differences between data and simulation in the efficiency of a candidate to pass a certain level of identification

**Scale factor definition:**

**QCD**

- **Tau energy scale**
  - **Goal:** measure scale factors to account for any remaining differences between data and simulation after tau energy calibration
  - **Fit** variable sensitive to TES shift: $\Delta E_T$
  - **TES shift parametrisation:** $E_T \rightarrow (1 + \alpha)E_T$
  - **Fit** by minimizing

  $\chi^2(\alpha, \beta) = \sum \left( \frac{N_{\text{obs}} - (N_{\text{pred}}(\alpha) - N_{\text{disc}})}{\sqrt{N_{\text{disc}}}} \right)^2$ $+ \beta \left( \frac{\Delta N_{\text{pred}}(\alpha)}{} \right)^2 + \left( \frac{\Delta N_{\text{disc}}}{\sqrt{N_{\text{disc}}}} \right)^2$

**Overall TES uncertainties**

**Overall identification unc. (2016 data)**

**References**


https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TauPublicResults