PISA MEETING POSTER SESSION – La Biodola, May 2012

Tracking and calorimeter performance for tau reconstruction at ATLAS

The tau lepton at hadron colliders

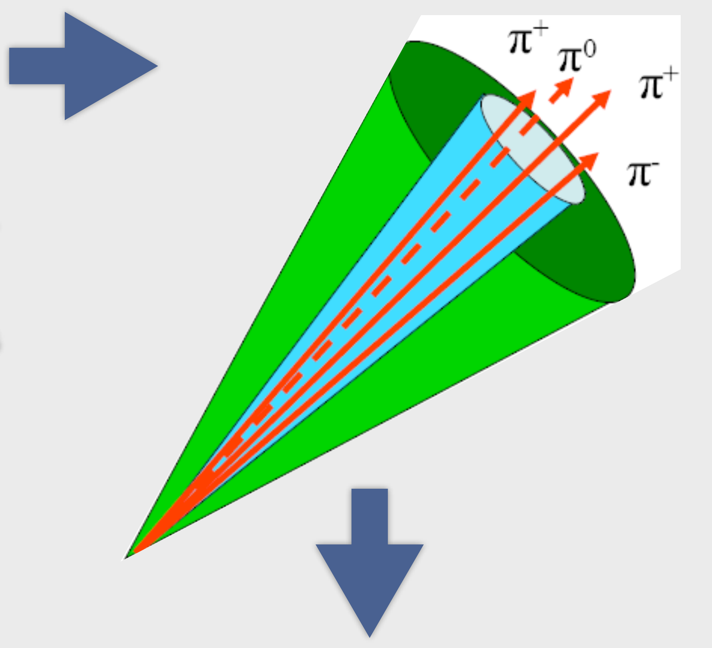
- m = 1776.82 ± 0.16 MeV
- τ = 290.6 ± 1.0 fs
- cτ = 87μm

Decays before leaving the beam pipe

Hadronic mode BR = 64.8%
1 prong or 3 prong

Leptonic mode BR = 35.2% → very difficult to distinguish from prompt leptons at colliders

Narrow low track multiplicity hadron jet



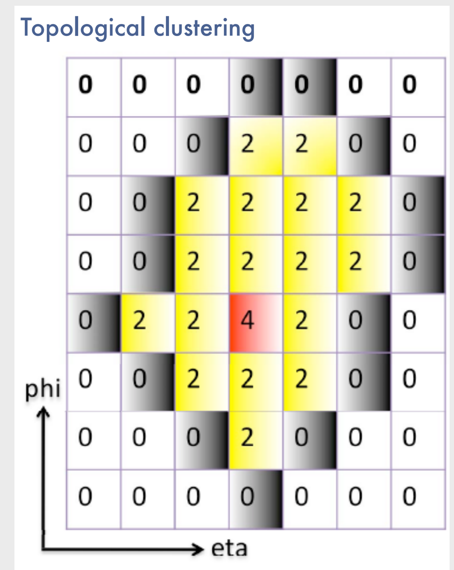
Calorimeter and tracking information is combined to reconstruct hadronically decaying taus

Taus have an important role in Higgs boson and Supersymmetry searches.

Physics requirements
- Discriminate from hadronic jets
- Discriminate from electrons and muons
- Good energy calibration: scale and resolution
- Reconstruction of single modes

Tau reconstruction at ATLAS

- Reconstruction seeded by anti-kt jets (R=0.4) from calorimeter calibrated 3D topological clusters, p_T > 10 GeV



- Tracks satisfying
  - p_T > 1 GeV
  - number of pixel hits ≥ 2
  - number of pixel + SCT hits ≥ 7
  - |transverse impact parameter| < 1.0 mm
  - |longitudinal impact parameter|< 1.5 mm

are associated if distance from tau axis
- ΔR < 0.2 → core tracks
- 0.2 < ΔR < 0.4 → isolation tracks

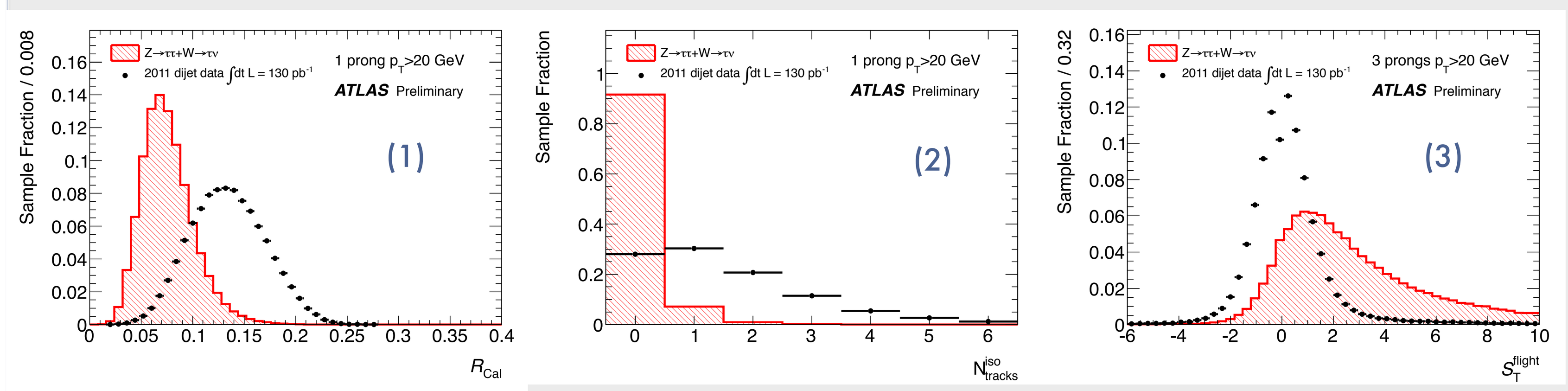
crucial role of tracking efficiency!

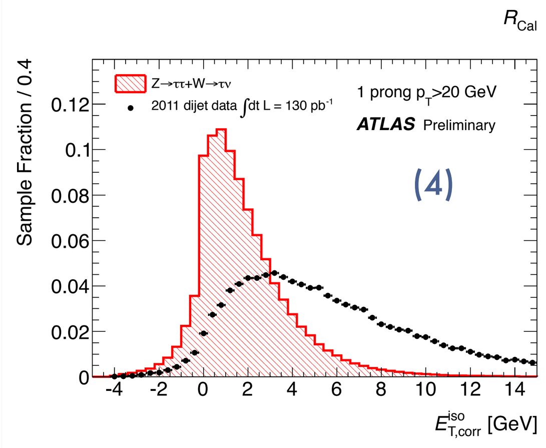
- Four-momentum from clusters in ΔR < 0.2 from the seed axis plus an additional correction is applied for the p_T
- Information from tracking and calorimetry combined to derive identification variables

Identification

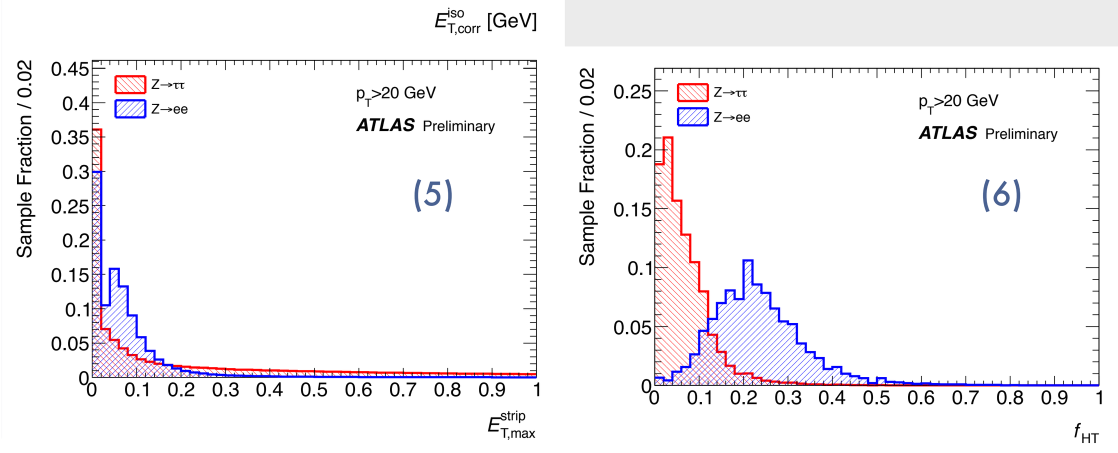
Decay products are collimated	Jet width in the tracker and calorimeter
Presence of leading charged hadron	Leading track information
No gluon radiation	Isolation variables
Low invariant mass	Invariant mass of tracks and clusters
Lifetime	Impact parameter, secondary vertexing
EM energy fraction different from electrons	Longitudinal position of energy deposits
EM component from π^0	ATLAS LAr strip information
Less transition radiation than electrons	ATLAS TRT information

Pileup independence major requirement → tradeoff between tracking and calorimetry:
- tracking less sensitive thanks to shorter integration time
- calorimetry sensitive to full object energy





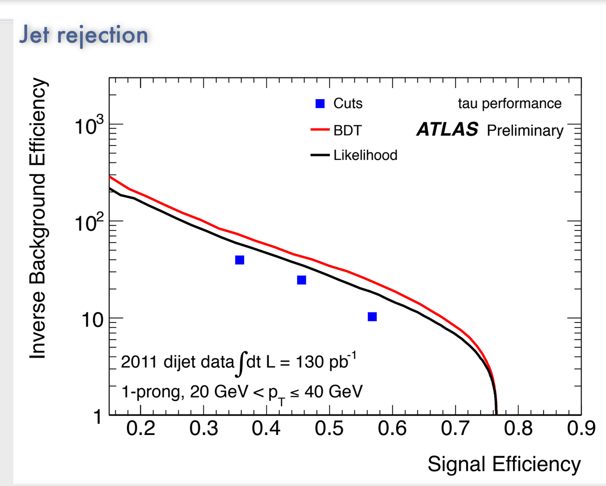
Examples of jet rejection variables: shower width in the electromagnetic and hadronic calorimeter weighted by the transverse energy of each calorimeter part (1), number of tracks in the isolation annulus (2), decay length significance of the secondary vertex for multi-prong tau candidates in the transverse plane (3), pileup corrected transverse energy of isolated clusters (4).

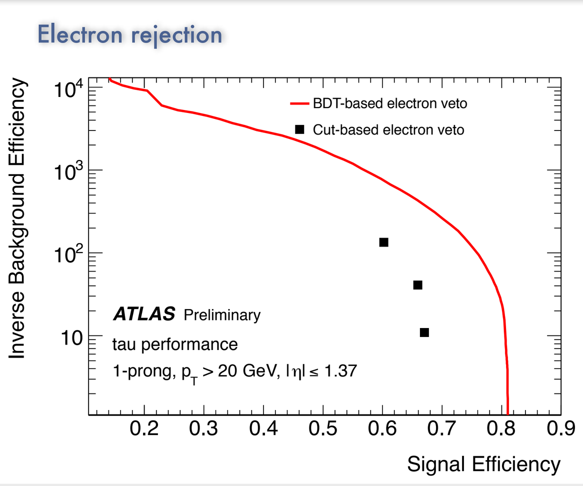


Examples of electron rejection variables: maximum transverse energy deposited in a cell in the pre-sampler layer of the electromagnetic calorimeter, which is not associated with that of the leading track (5), ratio of high-threshold to low-threshold hits (including outlier hits), in the Transition Radiation Tracker (TRT), for the leading p_T core track (6)

Identification performance

Examples of identification performance of inverse background efficiency as a function of signal efficiency for different estimators built from identification variables and based on a set of cuts, a projective log-likelihood ratio or a Boosted Decision Tree (BDT) algorithm.

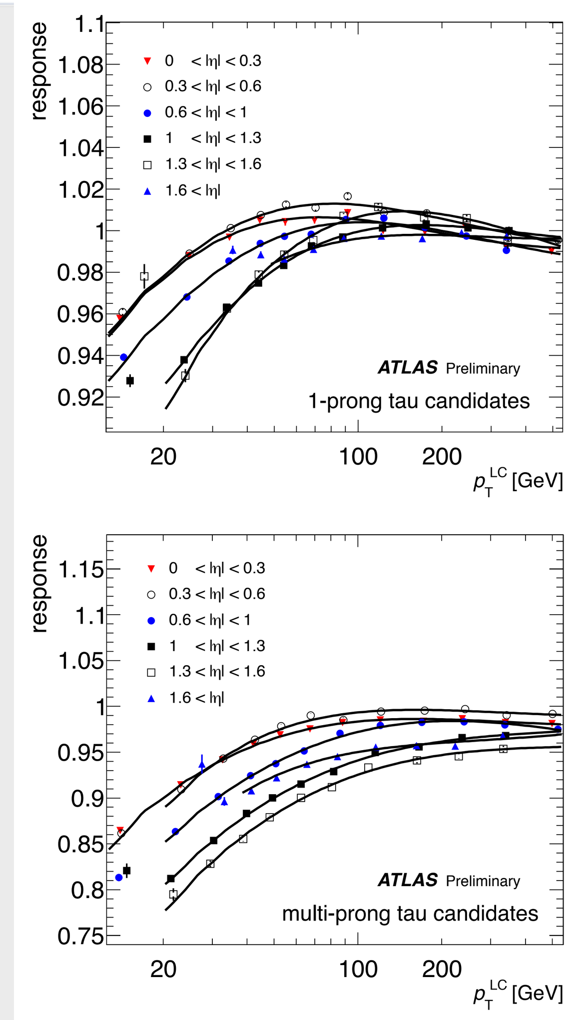




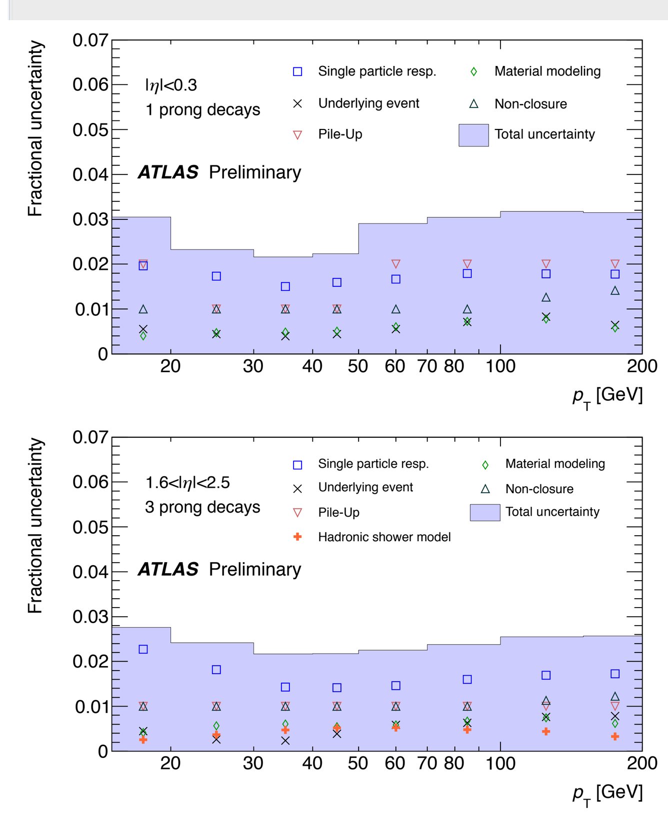
Each of the discriminants provides working points corresponding to approximately 60% (loose), 45% (medium), and 30% (tight) signal efficiencies.

Energy calibration

- Input clusters from Local Hadron Calibration (LC): topological clusters corrected for non-compensation losses due to noise threshold and dead material
- On top of tau energy scale (TES) correction applied to restore the true energy value
- TES determined using the response of MC simulated taus in bins of |η|, LC energy, and 1-prong or multi-prong category.



Response curves as a function of reconstructed tau p_T at LC scale for 1-prong (left) and multi-prong (right) tau candidates in various |η| bins

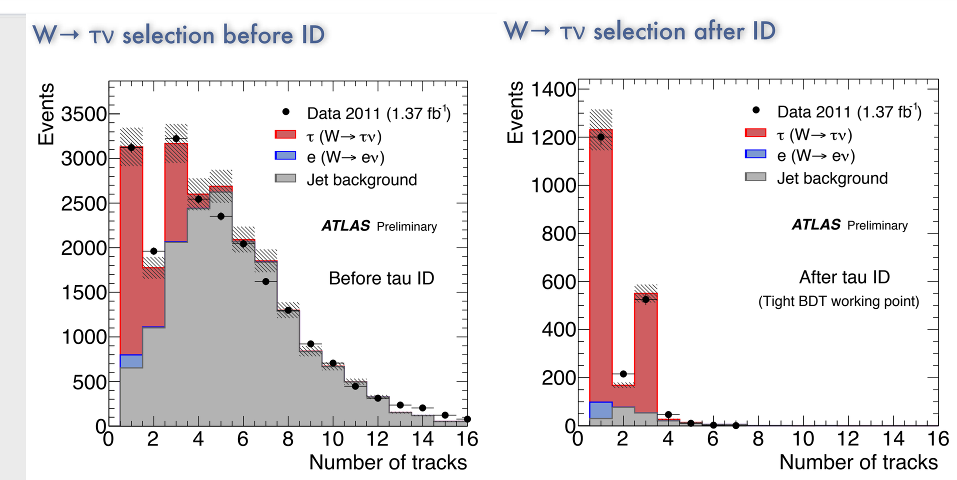


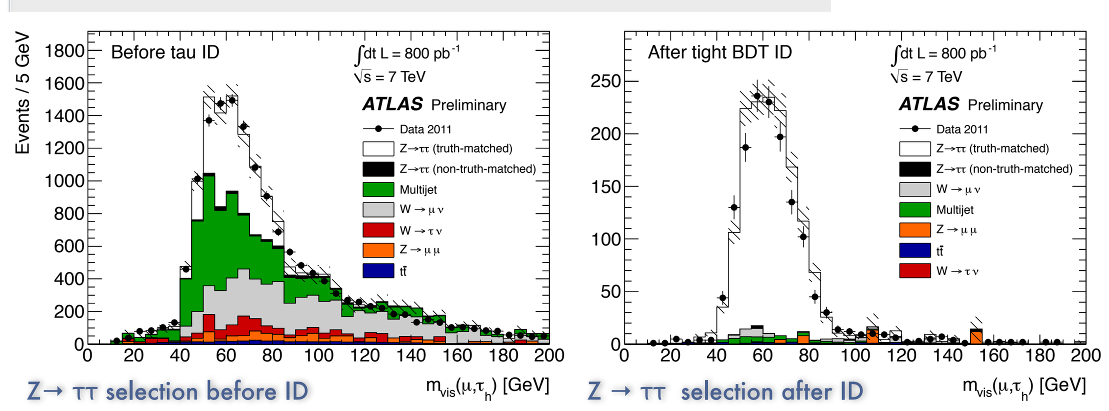
TES uncertainties:
- particle responses from isolated single hadrons measurements and combined test beam data
- Underlying event
- Pile-up
- Hadronic shower model
- Material in detector simulation

TES uncertainty for 1-prong (top, |η|<0.3) and multi-prong (bottom, 1.6<|η|<2.5) decays. The single contributions are shown as points and the combined uncertainty as the filled band.

In-situ identification efficiencies

- Identification efficiencies can be measured in data
- Method: select W→ τν or Z→ ττ events in data without applying tau identification and count the events that pass identification





Background is a major challenge: estimation exploting charge correlations for Z→ ττ and fitting track multiplicity for W→ τν

Identification efficiencies		Cuts	Likelihood	BDT
W→τν Results on 1.37 fb^{-1}, statistical uncertainty is given first and then the systematic	Loose	0.87 ± 0.02 ± 0.02	0.70 ± 0.02 ± 0.02	0.81 ± 0.02 ± 0.03
	Medium	0.79 ± 0.02 ± 0.03	0.46 ± 0.02 ± 0.03	0.63 ± 0.02 ± 0.03
	Tight	0.65 ± 0.02 ± 0.03	0.27 ± 0.01 ± 0.02	0.42 ± 0.01 ± 0.03
Z→ττ Results on 0.8 fb^{-1}, statistical uncertainty is given first and then the systematic	Loose	1.03 ± 0.05 ± 0.08	0.83 ± 0.05 ± 0.08	0.88 ± 0.05 ± 0.08
	Medium	0.80 ± 0.05 ± 0.07	0.56 ± 0.04 ± 0.05	0.61 ± 0.04 ± 0.06
	Tight	0.63 ± 0.04 ± 0.06	0.32 ± 0.02 ± 0.03	0.40 ± 0.03 ± 0.04

References

- The ATLAS collaboration, *Performance of the Reconstruction and Identification of Hadronic Tau Decays with ATLAS*, ATLAS-CONF-2011-152

Sofia Maria Consonni[1], on behalf of the ATLAS Collaboration
Contact: sofia.consonni@mi.infn.it
1) Università degli Studi di Milano & INFN

UNIVERSITÀ DEGLI STUDI DI MILANO · INFN · ATLAS EXPERIMENT