

Tau fake rate determination from early data

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1 Introduction

- Method of tau fake rate determination

2 Results from preparatory studies

- Tau fake rates from MC samples
- Expected precision for 10 pb^{-1} of data
- Systematics

3 Outlook and further plans

Taus and QCD jets

- **Tau leptons**

Tau leptons short-lived: $\sim 65\%$ decay hadronically

Jet signature: diverging tracks and associated calorimetry entries

- **QCD jets**

Similar signature from QCD jets (fragmenting quarks and gluons)

Tau fake rate

- Rate of QCD jets misidentified as hadronically decaying tau leptons by the existing tau reconstruction algorithms

Global remarks/objectives

■ Motivation

The tau fake rate is a crucial number for all analyses relying on tau reconstruction, for QCD jets will be abundant in LHC data

■ Goals

- Determination directly from early data (independent of MC)
- Provide collaboration with corrections for reconstruction and systematic error estimation



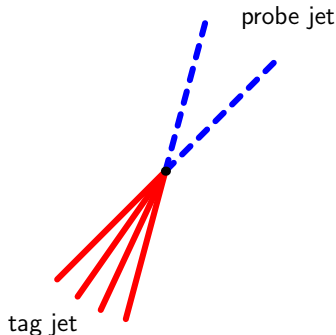
ATLAS-CSC-Note, 2008

Identification of hadronic τ decays with ATLAS detector

Tau fake rate determination from QCD dijet events

Method: tag and probe

- use back to back (in ϕ) dijet event of which one jet is randomly chosen and required to be a QCD jet (tag jet)
- the other is then known to be very likely another QCD jet (probe jet)
- subject probe jet to tau reconstruction algorithms



Tau fake rate f

$$f = \frac{\# \text{ probe jets identified as taus}}{\# \text{ all probe jets}}$$

Event topology cuts

- $|\eta| \leq 2.5$ for each jet
- $p_T \geq 15$ GeV for each jet
- $|\Delta\phi| = \pi \pm 0.30$ (back to back)
- $|\Delta p_T| < \frac{p_{T\max}}{2}$ (p_T balance)

Tag jet cuts

- # tracks ≥ 4
+ 1 track/50 GeV Δp_T
(removes most of the true taus)

Probe jet cuts

- no further cuts (to keep the whole spectrum)

Reconstruction algorithms

- TauRec (calorimetry based)
- Tau1P3P (track based)

Fake tau candidate criteria

- overlap: $|\Delta R| \leq 0.15$

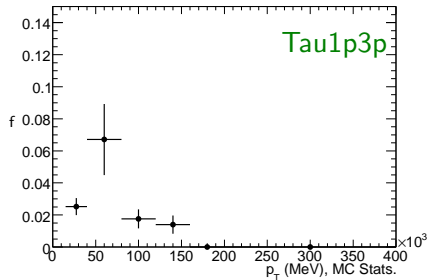
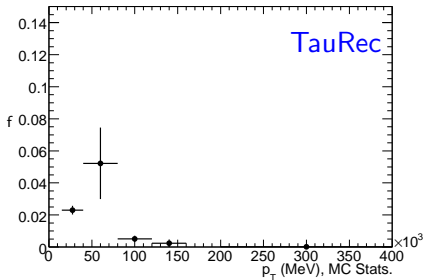
Preparatory studies using MC

Physics ID	Channel (p_T (GeV))	Cross section (nb) @ 14 TeV	Cross section (nb) @ 10 TeV
5009	Dijet J0(8-17)	17,600,000	11,700,000
5010	Dijet J1(17-35)	1,380,000	867,000
5011	Dijet J2(37-70)	93,300	56,000
5012	Dijet J3(70-140)	5,880	3,280
5013	Dijet J4(140-280)	308	152
5014	Dijet J5(280-560)	12.5	5.12
6023	$W \rightarrow \tau \nu$	17.3	12.0
6052	$Z \rightarrow \tau \tau$	1.58	1.13

List of input datasets

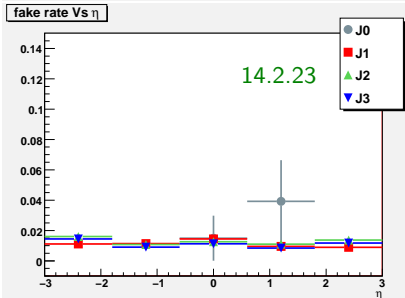
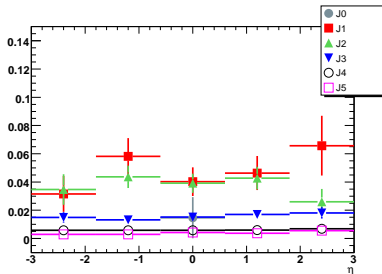
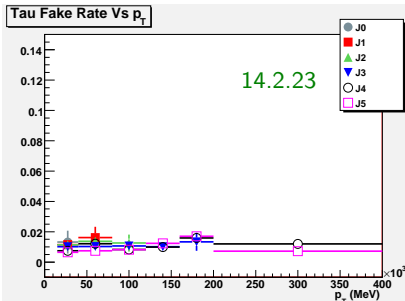
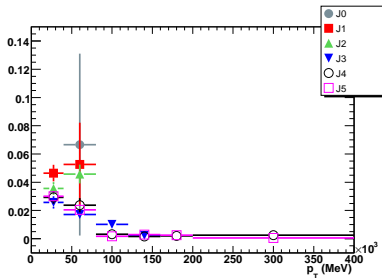
- Cross sections in leading order
- Event generator: Pythia

Preparatory studies using MC: Results

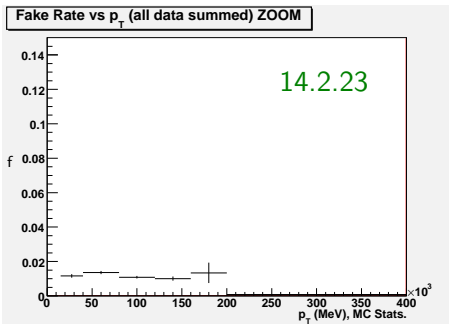
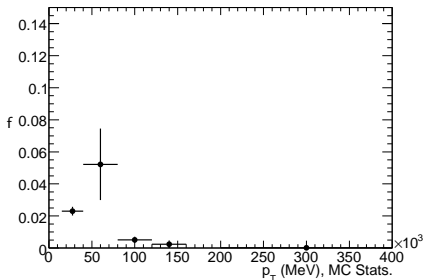


p_T range (GeV)	TauRec		Tau1p3p	
	MC stat. (%)	exp. prec. dat. 10 pb^{-1} (%)	MC stat. (%)	exp. prec. dat. 10 pb^{-1} (%)
15-40	2.3 ± 0.3	± 0.07	2.5 ± 0.5	± 0.07
40-80	5.2 ± 2.2	± 0.03	6.7 ± 2.2	± 0.04
80-120	0.5 ± 0.2	± 0.004	1.8 ± 0.6	± 0.008
120-160	0.2 ± 0.2	± 0.005	1.4 ± 0.6	± 0.01

Comparison Plots TauRec: Fake Rate vs p_T and η

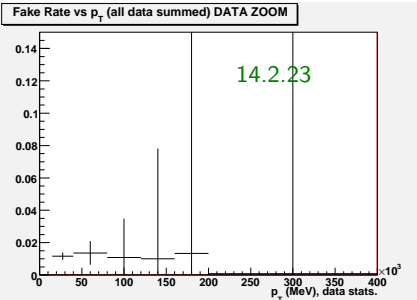
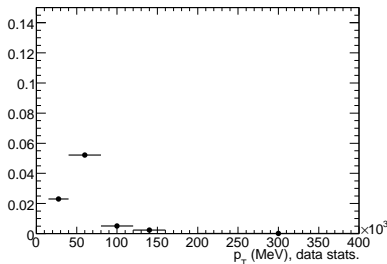
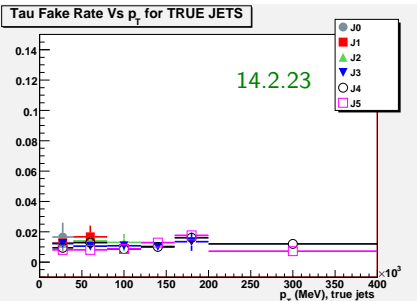
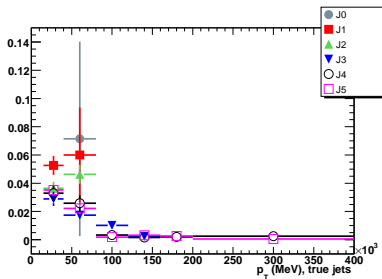


Preparatory studies using MC: TauRec Results

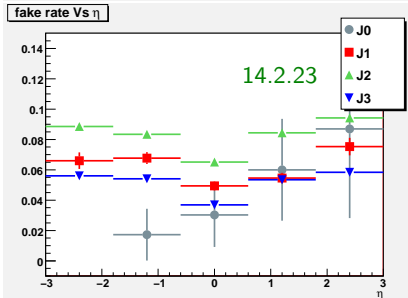
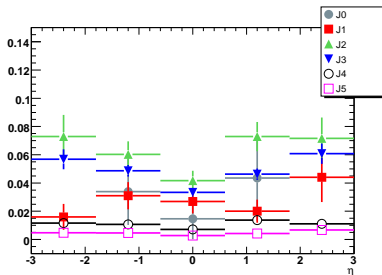
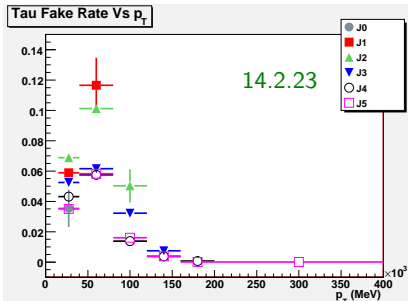
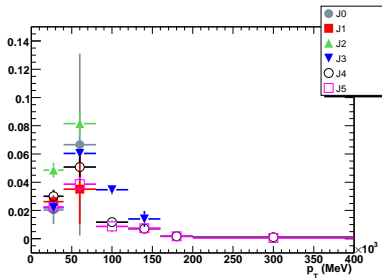


p_T range (GeV)	TauRec old		TauRec new	
	MC stat. (%)	exp. prec. dat. 10 pb^{-1} (%)	MC stat. (%)	exp. prec. dat. 10 pb^{-1} (%)
15-40	2.3 ± 0.3	± 0.07	1.2 ± 0.1	± 0.2
40-80	5.2 ± 2.2	± 0.03	1.4 ± 0.1	± 0.7
80-120	0.5 ± 0.2	± 0.004	1.1 ± 0.1	± 2.4
120-160	0.2 ± 0.2	± 0.005	1.0 ± 0.1	± 6.8

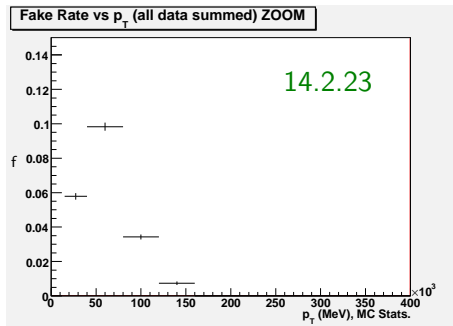
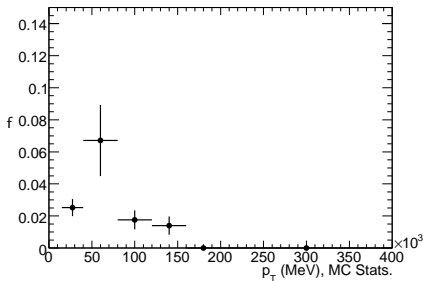
TauRec: Fake Rate (true jets) and expected precision



Comparison Plots Tau1P3P: Fake Rate vs p_T and η

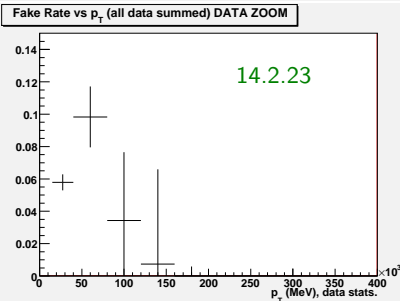
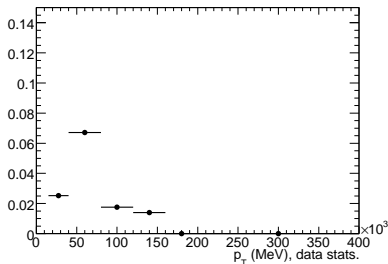
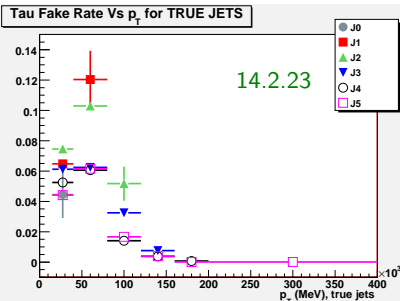
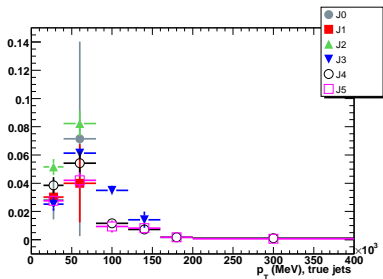


Preparatory studies using MC: Tau1P3P Results

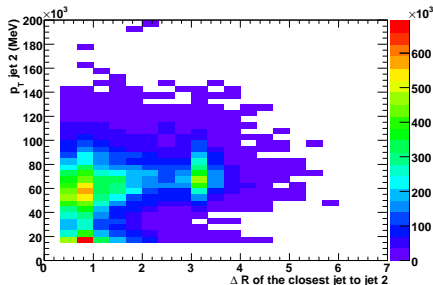


p _T range (GeV)	Tau1p3p old		Tau1p3p new	
	MC stat. (%)	exp. prec. dat. 10 pb ⁻¹ (%)	MC stat. (%)	exp. prec. dat. 10 pb ⁻¹ (%)
15-40	2.5 ± 0.5	± 0.07	5.8 ± 0.2	± 0.5
40-80	6.7 ± 2.2	± 0.04	9.8 ± 0.2	± 1.9
80-120	1.8 ± 0.6	± 0.008	3.4 ± 0.1	± 4.2
120-160	1.4 ± 0.6	± 0.01	0.7 ± 0.1	± 5.9

Tau1P3P: Fake Rate (true jets) and expected precision



Preparatory studies using MC



Jet environment

- back to back jets at $|\Delta R| = 3$
- many close jets at $|\Delta R| \approx 1$

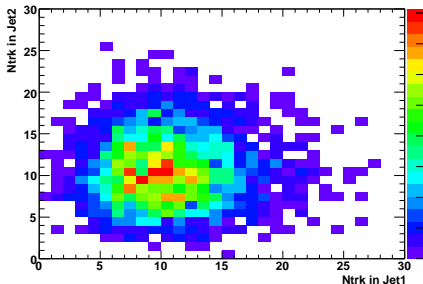
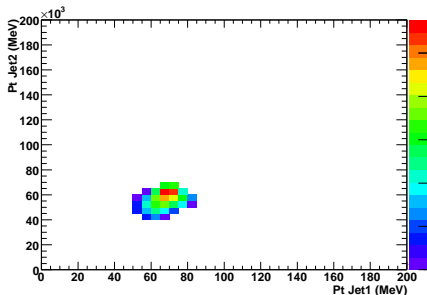
Method flexible

- Selection has to be adapted to the (jet) environment according to the signal of interest
- Method can mimic different environments using e.g. isolation cuts

Main sources of systematic errors

- Presence of real taus in the selected sample (negligible)
- Possible correlations between tag and probe side (partly addressed, low)
- Uncertainties from the definition of the overlap (negligible)
- Uncertainties from the origin of the jet
- Dependence on the type of the jet
- Trigger dependence
- Fake rate due to other particles (electrons, muons, etc.)

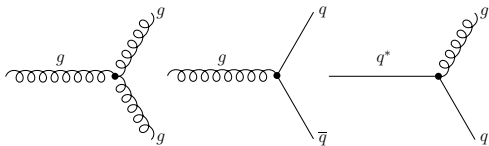
Correlations between tag and probe jet



Correlation of jet track number

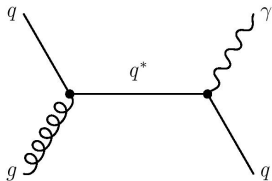
- Select jets out of certain p_T range, compare number of tracks
- → Correlation negligible ($\rho = 0.0049$)
- but other correlations possible: jet width, neutrals fraction ...

Dependency on jet type



Fake rate from dijets

- Study of back to back jets gives combined rate of misidentified quarks and gluons (gluons dominate)

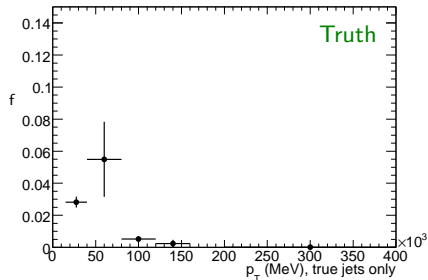
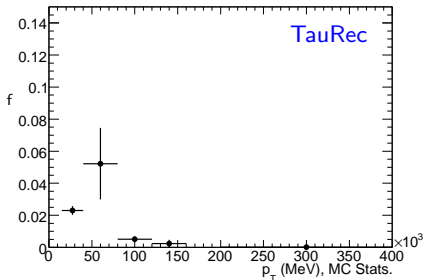


Fake rate from photon-jets

- Study of back to back jet and photon gives fake rate exclusively due to quarks

- Dijet events provide a way to evaluate tau fake rates from early data using a tag-probe method
- Tau fake rates expected to be at the $\mathcal{O}(1\%)$ level for low transverse momenta ($p_T < 200$ GeV)
- Significant measurement (precision at sub-percent level) possible with 10 pb^{-1} of data (?)
- Address remaining systematic error studies
- Can be used to tune/correct MC tau reconstruction and assign systematic uncertainties to analyses

Backup: truth match



Comparison with expectation (MC truth)

- Comparison for TauRec algorithm
- MC statistics shown
- → Agreement convincing