τ Reconstruction ATLAS Run 1

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Overview

- overview of τ reconstruction and identification
- performance measurements in Run1
- brief outlook for Run2

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Basic τ Properties

τ^- Branching ratios (m_τ=1.78 GeV):

$e^-/\mu^- \upsilon_{e/\mu} \upsilon_\tau$ (35%)

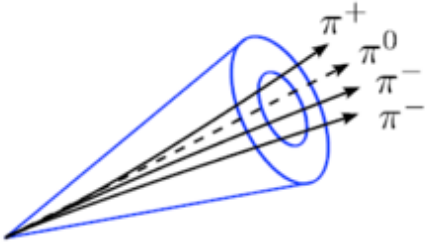
$\pi^- \upsilon_\tau$	(11%)	1-prong
$\rho^- \upsilon_\tau$	(25%)	
$\pi^- \pi^0 \pi^0 \upsilon_\tau$	(9%)	
$\pi^- \pi^0 \pi^0 \pi^0 \upsilon_\tau$	(1%)	
K^- + neutrals	(1.5%)	
$\pi^- \pi^+ \pi^- \upsilon_\tau$	(9%)	3-prong
$\pi^- \pi^+ \pi^- \pi^0 \upsilon_\tau$	(4.5%)	
$K^- \pi^+ \pi^- \upsilon_\tau$	(0.4%)	

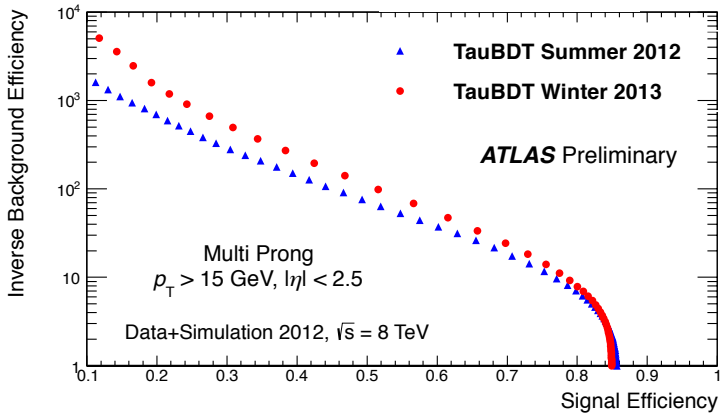
other modes (~3%)

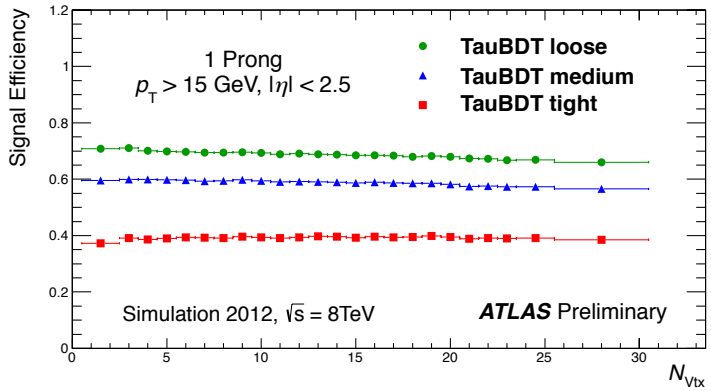
- properties of hadronically decaying τ's:
- very well collimated object of charged and neutral pions
- charged component of τ reproduces the direction of visible τ well (particularly leading pion)
- most τ's have one or three charged decay products (pions)
- modest but significant proper lifetime (87 microns)

τ Identification Run I

- reconstructed from antiKt 0.4 topojet seeds
- direction and p_T measured from LC calibrated clusters in 0.2 "core" cone
- τ-specific energy scale (TES) calibration from MC
- separate hadronically decaying τ's both from QCD jets as well as from electrons (muons too)
- two multivariate classifiers using tracking and shower shape info (BDT)
- TES uncertainties and scale factors for both BDT's from both single particle deconvolution as well as tag-and-probe (TP)

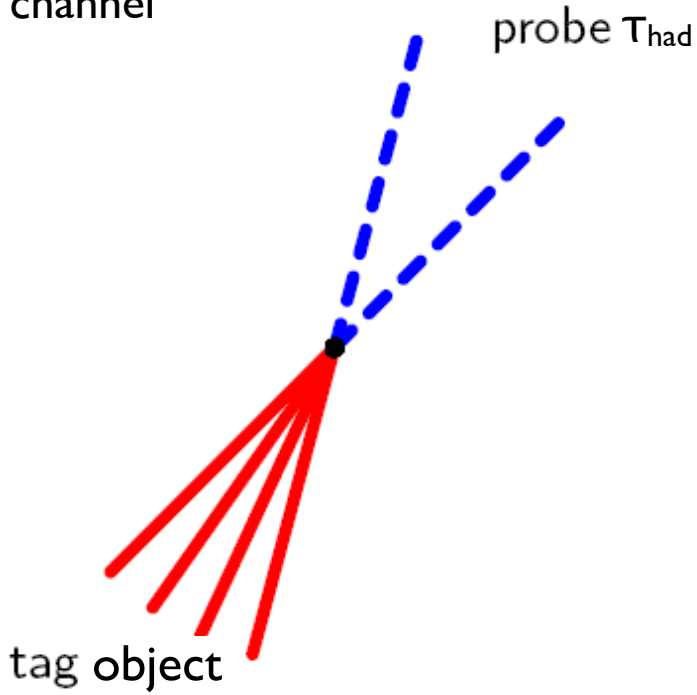






Tag-and-Probe Method

- Pick tag object that puts you in a well defined physics channel
- For signal Efficiency:
  - muon ($Z \rightarrow \tau_\mu \tau_{had}$)
- For background (BG) Efficiency:
  - hadronic jet (di-jet channel)
  - photon (phton+jet channel)
  - lepton pair in Z mass window (Z+jets channel)
- Use probe τ_{had} cand. in each channel to measure ε/f_{ID}



$$\varepsilon/f_{\mathrm{ID}} = \frac{\text{Number of probe objects identified as } \tau \text{ leptons}}{\text{Number of probe objects reconstructed as } \tau \text{ leptons}}$$

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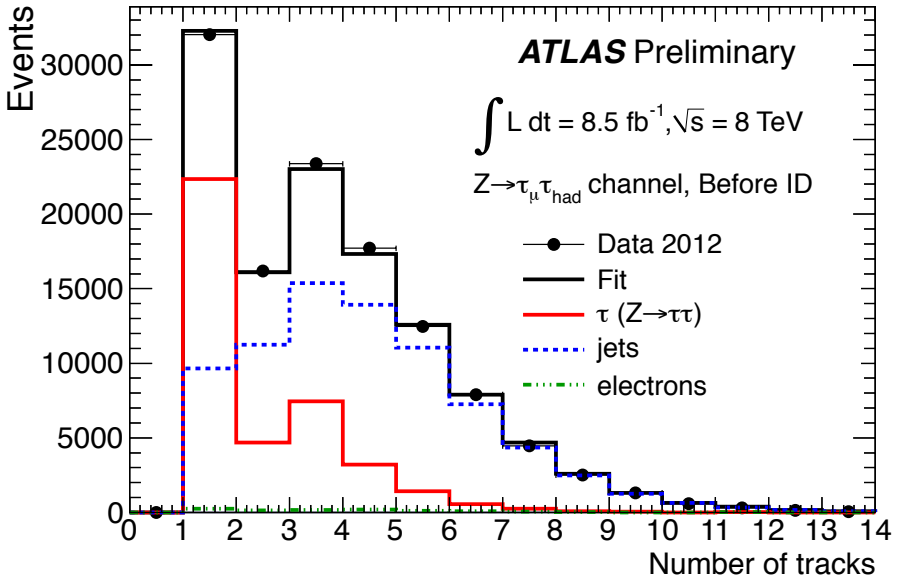
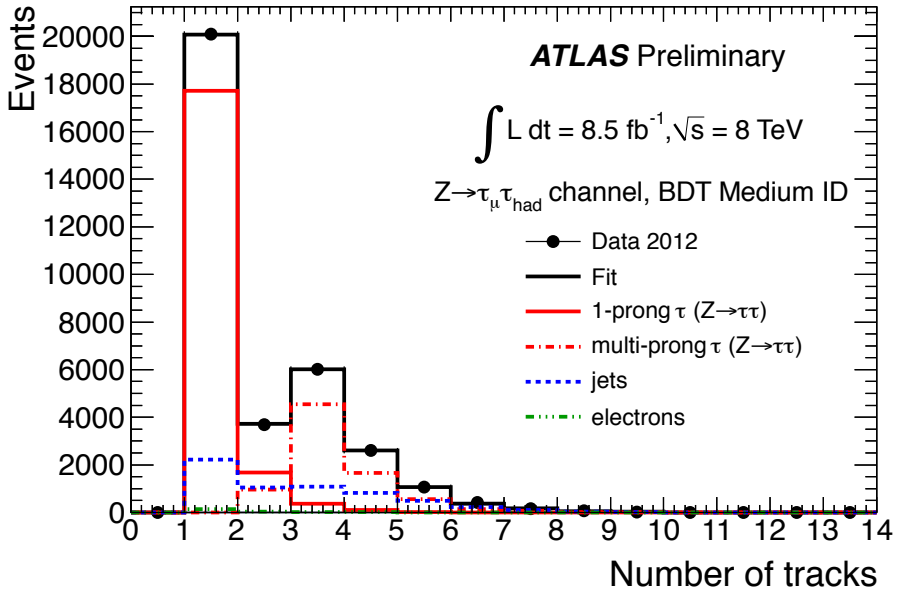
$Z \rightarrow \tau\tau$ Tag-and-Probe

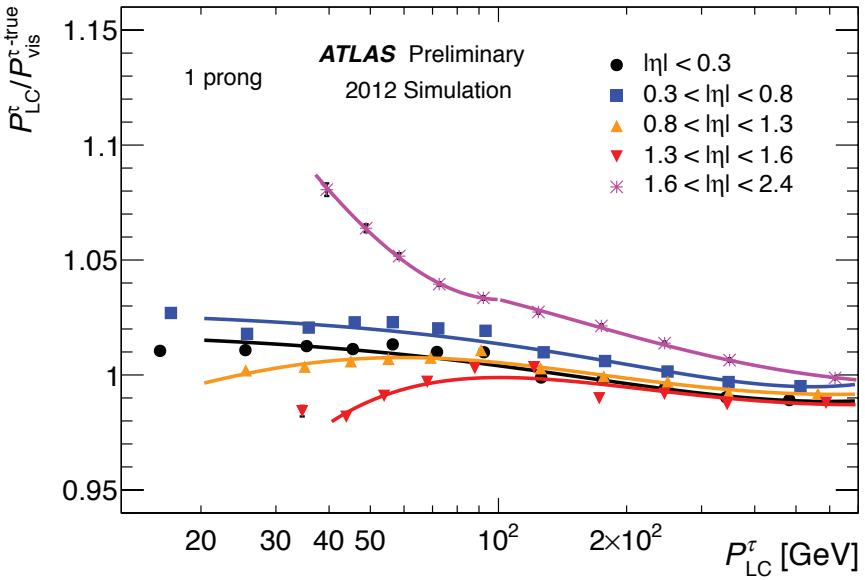
- Derive signal efficiency corrections and uncertainties in $Z \rightarrow \tau_\mu \tau_{had}$
- using tracks in isolation cone $0.2 < \Delta R < 0.6$
- for τ_{had} p_T > 20GeV uncertainties are ~3% for single- and ~5% multi-prong also stat. and syst. ~equal size
- for 15GeV < τ_{had} p_T < 20GeV uncertainties increase to 15-20%

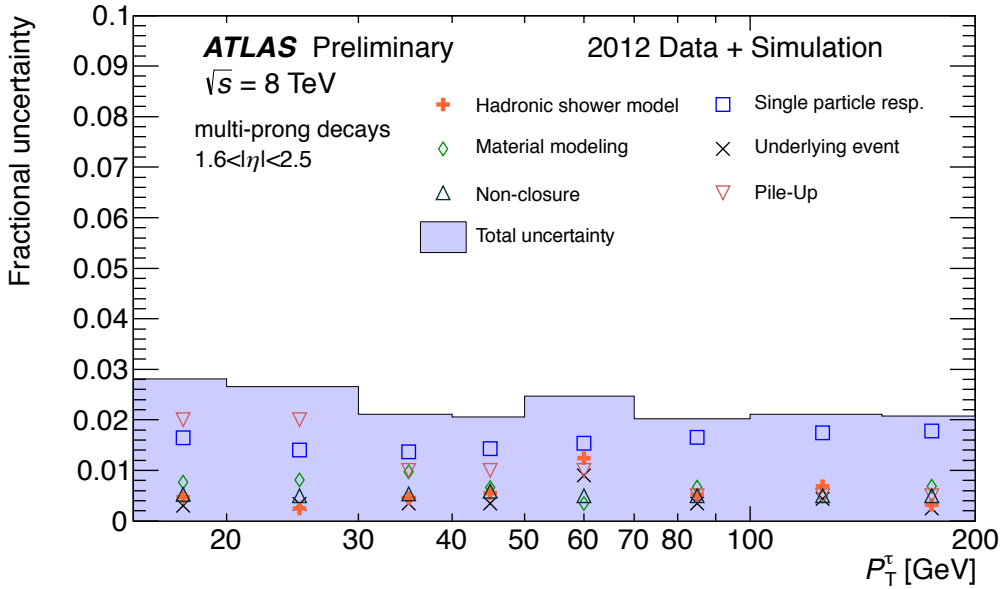




τ Energy Scale

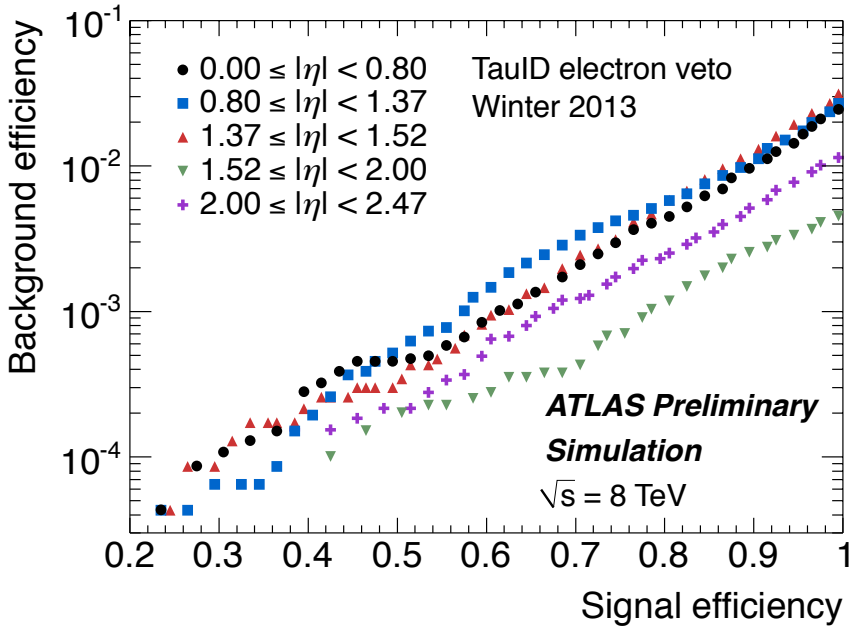
- Calibrated by numerical inversion of real τ response derived from simulation
- With pile-up correction this brings τ_{had} p_T to correct scale within 2-4% uncert.
- Uncertainties for τ_{had} p_T > 70GeV from single-particle convolution using test beam and E/p data
- below that using in situ calibration from visible mass in $Z \rightarrow \tau_\mu \tau_{had}$ TP

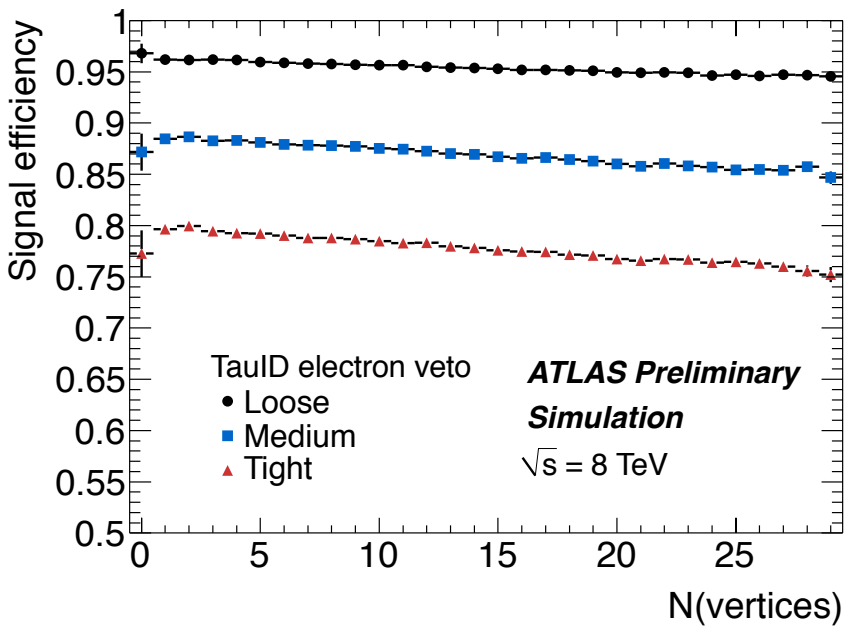




Z→ee Tag-and-Probe

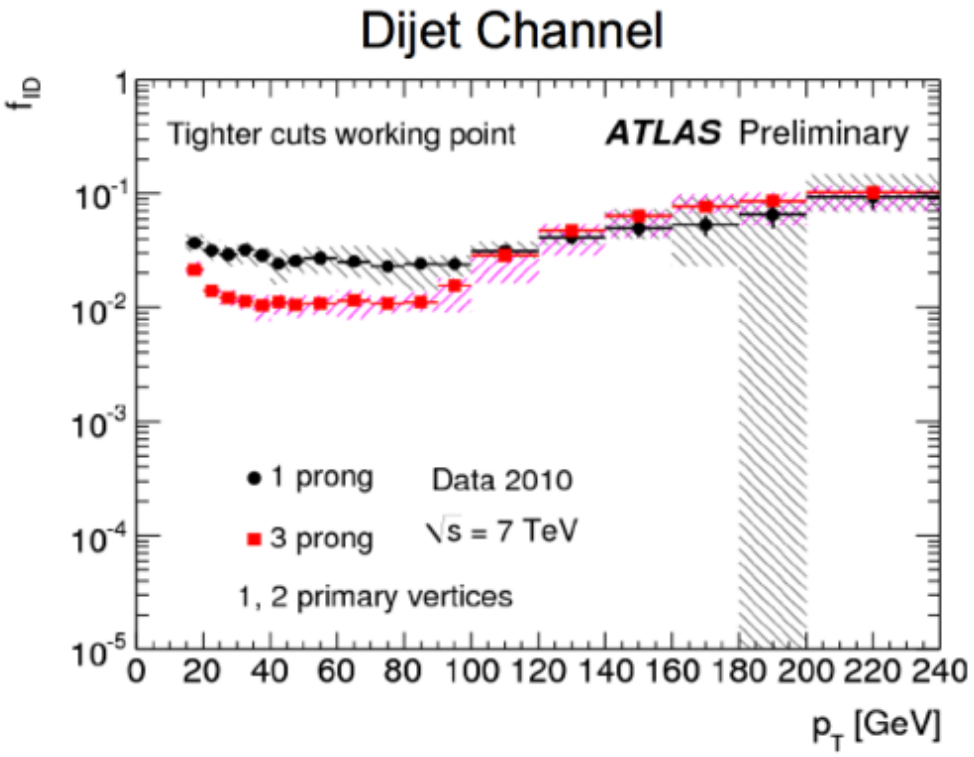
- Derive electron background efficiency corrections and uncertainties
- using one identified electron and one track that combine to Z mass
- uncertainties are ~10% for loose electron rejection algorithm (veto) and can range up to 30%

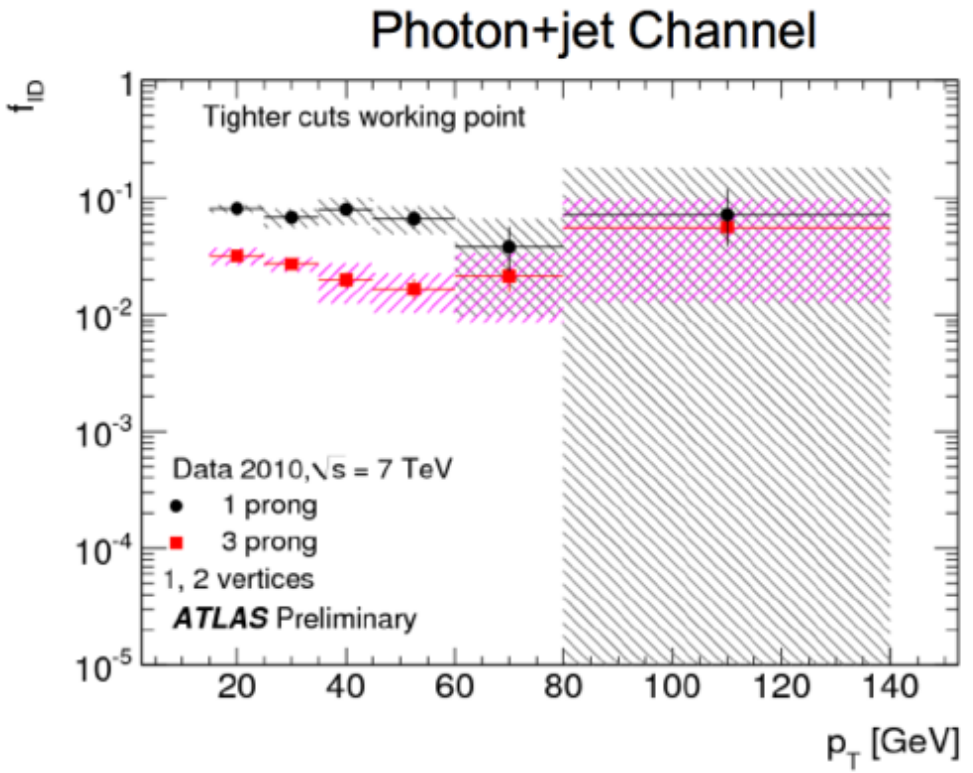




f_{ID}: Mis-ID probability

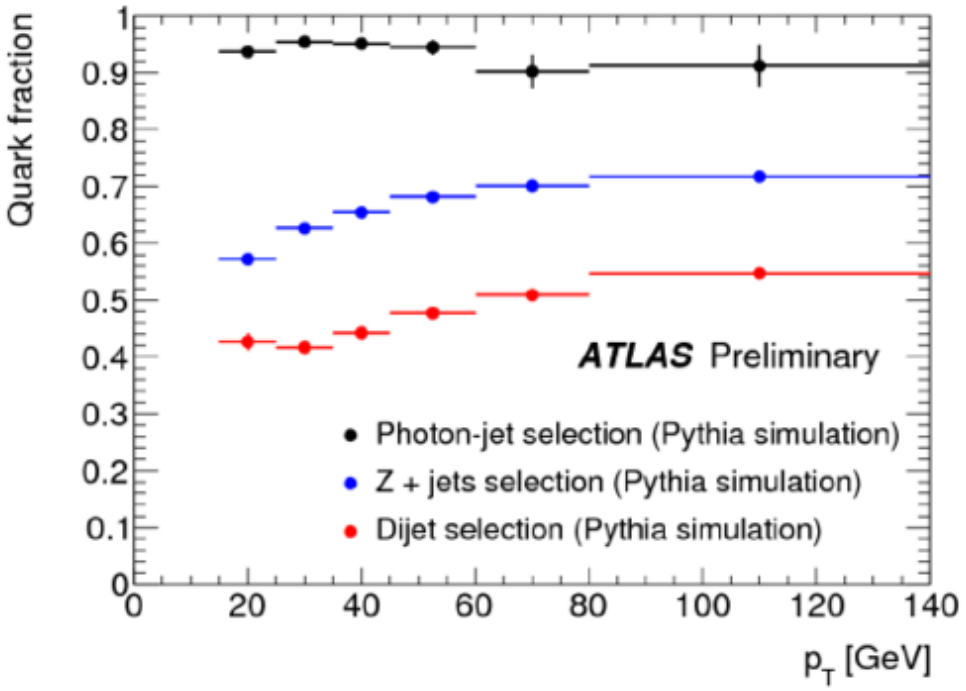
- Hadronic jets are tricky, since the jets are different in different channels
- In 2010: last public measurement in Z+jets, di-jet and photon+jet topologies

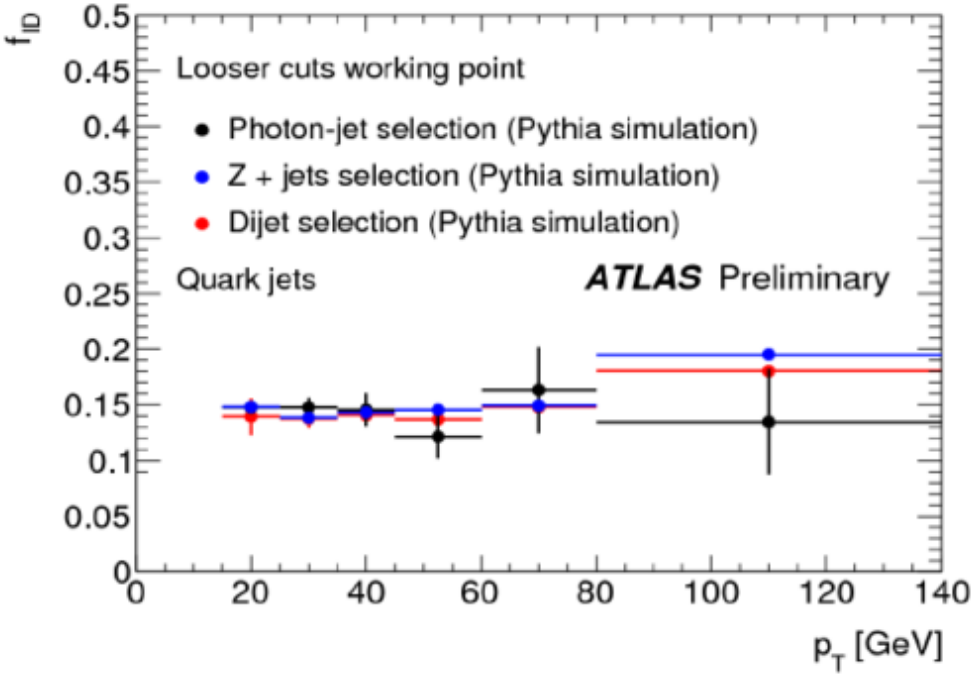




f_{ID}: Mis-ID probability

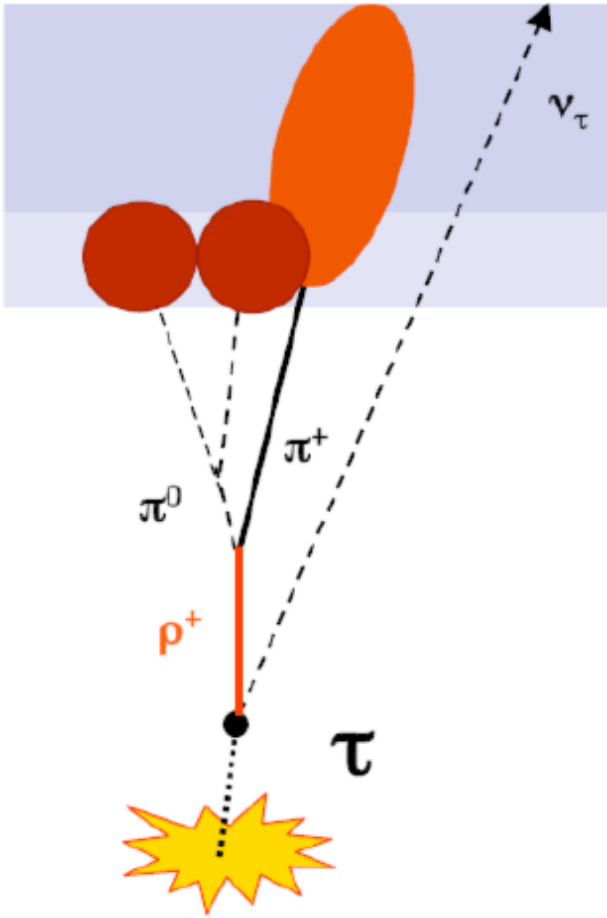
- Large differences across channels due to different quark/gluon origin of jets
- Verified consistent values for quark/gluon-only f_{ID} across channels
- Method needed to extract quark/gluon fraction from data





Improvements for Run2

- reconstruct individual charged and neutral pions
  - charged pions: tracks
  - neutral pions: EM topo-clusters
- alternative four vector taking advantage of better tracker p_T resolution at low p_T
- allows access to tau polarization
- incorporate more information like conversion tagging and shrinking cone
- harmonization between on- and off-line ID



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Summary and Outlook

- Presented principles of τ_{had} reconstruction at ATLAS in Run I
- Direction and momentum from calorimeter only
- ID using both shower shapes in calo and tracking information
- Signal efficiency and energy scale from $Z \rightarrow \tau_{\mu}\tau_{had}$ TP
- Electron BG efficiency from $Z \rightarrow ee$ tag-and-probe
- Can we also get universal measure of jet BG efficiency
- Many improvements for Run2 in preparation (see Benedict's talk)

Backup

$W \rightarrow \tau\nu$ Tag-and-Probe

- Derive signal efficiency corrections and uncertainties in $W \rightarrow \tau_{had}\,\nu$
- also using tracks in isolation cone $0.2 < \Delta R < 0.6$
- uncertainties similar in size to $Z \rightarrow \tau_{\mu}\tau_{had}$ measurement