Study of tt-bar events in the dilepton channel with tau lepton in ATLAS

ATLAS Top Quark Physics Workshop

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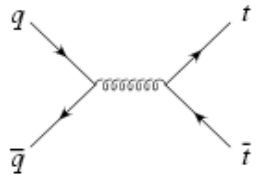
outline

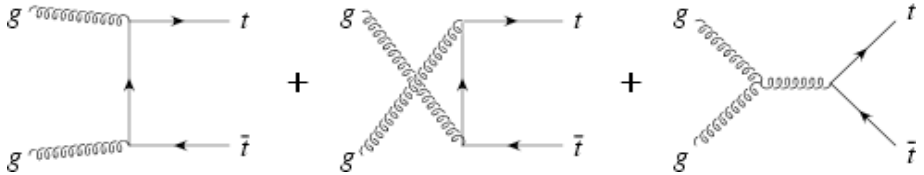
- **Physics motivations**
- **Offline tau reconstruction algorithms**
  - Tau1p3p
  - TauRec
  - Merged
- **Analysis at 14 TeV**
  - TopQuarkAODtoROOTuple/TopView
  - Selection criteria
  - Results
- **Prospects at 10 TeV**
  - ARATopQuarkAnalysis

INTRODUCTION

Top pair production through strong interactions

√s=1.96 (14) TeV:
85 (10) ±5% qq
15 (90) ±5% gg





TEVATRON $\sigma_{t\bar{t}}$ (QCD-NLO) ≅ 6.7 pb

LHC: $\sigma t\bar{t}$ (QCD-NLO) ≅ 840 pb

Electroweak decays ~100% BR(t→W⁺b)

tt → W(→lν)bW(→lν)b (e+μ: 5%)
→ DILEPTONIC

tt → W(→lν)bW(→qq)b (e+μ:35%)
⟶ 1 LEPTON PLUS JETS

tt → W(→qq)bW(→qq)b (45%)
→ FULL HADRONIC

Top Pair Decay Channels

W decay	e^+	μ^+	τ^+	$u\bar{d}$	$c\bar{s}$
$\bar{c}s$	electron+jets	muon+jets	tau+jets	all-hadronic	
$\bar{u}d$					
τ^-	eτ	μτ	ττ	tau+jets	
μ^-	eμ	μτ		muon+jets	
e^-	ee	eμ	eτ	electron+jets	

dileptons

Physics motivations: **tau lepton**

ttbar decaying modes/branching ratios

categoría	modo de decaimiento	branching ratio (BR)	
dileptónicas	$t\bar{t} \to e\nu b e\nu \bar{b}$	1/81	4/81 (5%)
	$t\bar{t} \to \mu\nu b \mu\nu \bar{b}$	1/81	
	$t\bar{t} \to e\nu b \mu\nu \bar{b}$	2/81	
	$t\bar{t} \to e\nu b \tau\nu \bar{b}$	2/81	5/81 (6%)
	$t\bar{t} \to \mu\nu b \tau\nu \bar{b}$	2/81	
	$t\bar{t} \to \tau\nu b \tau\nu \bar{b}$	1/81	
1 Leptón + jets	$t\bar{t} \to q\bar{q} b e\nu \bar{b}$	12/81	24/81 (30%)
	$t\bar{t} \to q\bar{q} b \mu\nu \bar{b}$	12/81	
	$t\bar{t} \to q\bar{q} b \tau\nu \bar{b}$	12/81	12/81 (15%)
Todo hadrónico	$t\bar{t} \to q\bar{q} b q\bar{q} \bar{b}$	36/81	36/81 (44%)

- **tau** lepton:
  - m = $1776.99^{+0.29}_{-0.26}$ MeV
  - τ = $(290.6 \pm 1.0) 10^{-15}$ s
  - $c\tau$ = 87.11 μm
- Standard Model(**SM**)
  - ttH → tt ττ (100-150 GeV)
  - qqH → qq ττ
- **New physics**
  - SUSY
  - Extra dimensions
  - MSSM Higgs
    - A/H → ττ
    - H^+ → τν

$$R = \frac{t \to \tau \nu_\tau b}{t \to l \nu_l b} \; (l = e, \mu)$$

Tau Physics

- Leptonic decay modes:

$\tau \rightarrow \nu_\tau + \nu_e + e$ (17.4%)
$\tau \rightarrow \nu_\tau + \nu_\mu + \mu$ (17.8%)
} ~35 %

- Hadronic decay modes:

~ 65 %

~77 %

1 prong

$\tau \rightarrow \nu_\tau + \pi^\pm$ (11.0%)
$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0$ (25.4%)
$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0 + \pi^0$ (10.8%)
$\tau \rightarrow \nu_\tau + \pi^\pm + \pi^0 + \pi^0 + \pi^0$ (1.4%)
$\tau \rightarrow \nu_\tau + K^\pm + n\pi^0$ (1.6%)

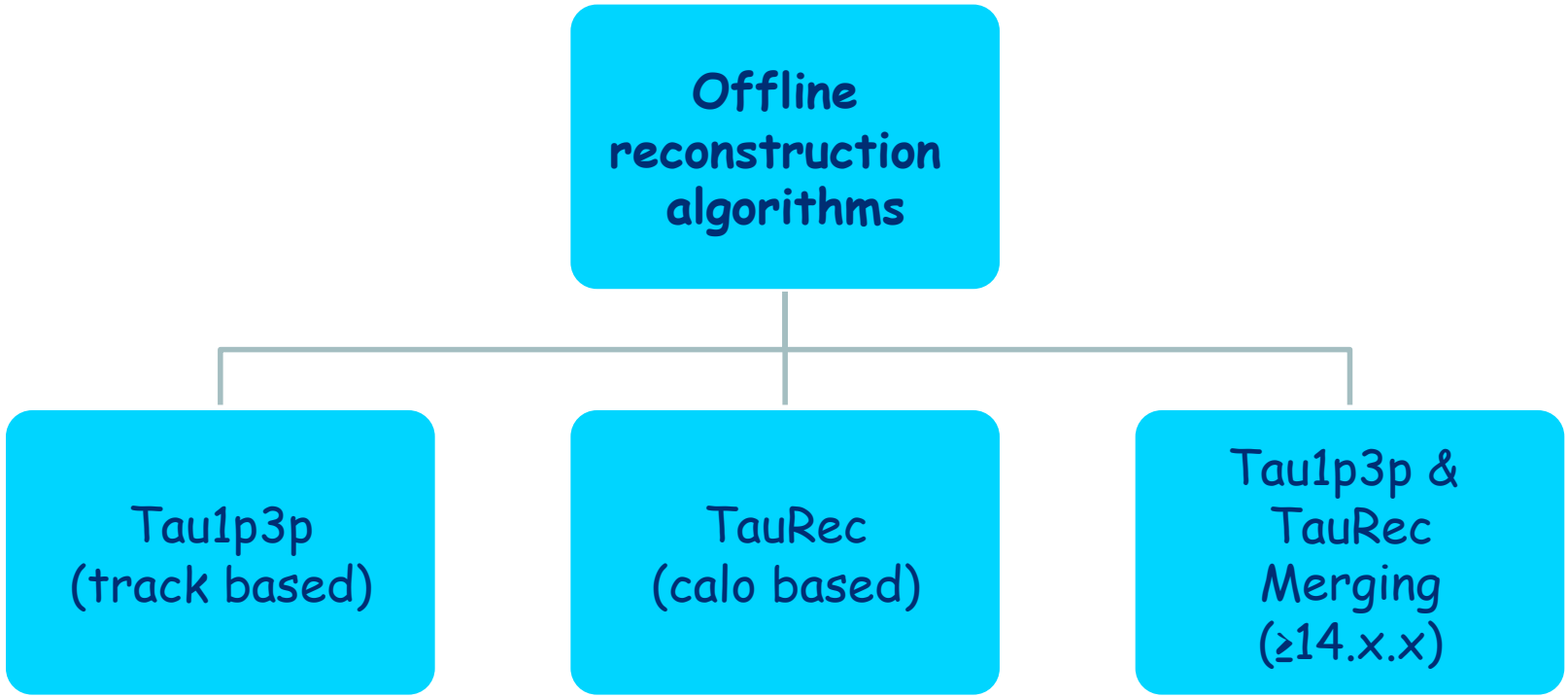
$\tau \rightarrow \nu_\tau + \pi^\pm$
$\tau \rightarrow \nu_\tau + \pi^\pm + n\pi^0$

~23 %

3 prong

$\tau \rightarrow \nu_\tau + 3\,\pi^\pm + r\pi^0$ (15.2%)

How do we identify them?


Offline reconstruction algorithms
Tau1p3p (track based)
TauRec (calo based)
Tau1p3p & TauRec Merging (≥14.x.x)

Offline reconstruction algorithms

variables

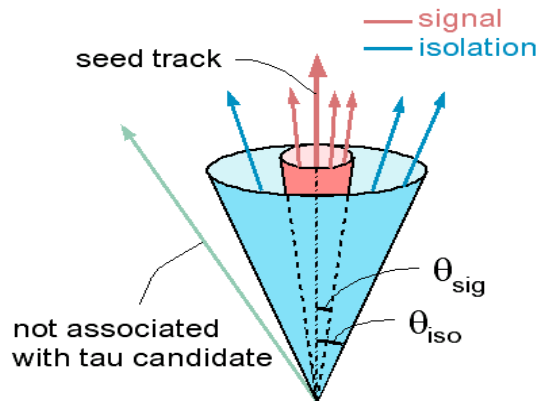
- Electromagnetic radius, R_{em}

$$R_{em} = \frac{\sum_{i=1}^{n} E_{Ti}\sqrt{(\eta_i - \eta_{cluster})^2 + (\varphi_i - \varphi_{cluster})^2}}{\sum_{i=1}^{n} E_{Ti}}$$

- Isolation fraction in the calorimeter

$$\Delta E_T^{12} = \frac{\sum_{j=1}^{n'} E_{Tj}}{\sum_{i=1}^{n} E_{Ti}}$$

- Number of tracks, N_{tr}
- Tau charge



- Transverse energy width in the η strip layer

$$\Delta\eta = \sqrt{\frac{\sum_{i=1}^{n} E_{Ti}\,(\eta_i - \eta_{cluster})^2}{\sum_{i=1}^{n} E_{Ti}}}$$

- Lifetime signed pseudo impact parameter

$$\sigma_{IP} = \frac{d_0}{\sigma_0} \times sign\left(\sin(\phi_{cl} - \phi_{tr})\right)$$

- E_T/p_T leading track
- Number of hits on the η strip layer

E_T ~ 20-70 GeV

Tau1p3p

1. 1 good quality track: **p_T> 9 GeV**
2. Search for tracks with **p_T> 2 GeV** in $\Delta R < 0.2$

τ_{1P}

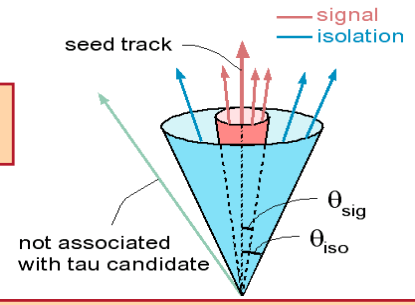
- NO near track
- (η,φ) from track at vertex

Energetic calibration

τ_{3P}

- 2 near tracks
- (η,φ) from bary centre of tracks
- $\sum$charge = +-1

Energetic calibration



build discriminant variables
use $\Delta R < 0.2$
$0.2 < \Delta R < 0.4$ for isolation only

τ_{1P} - single-prong candidates

τ_{3P} - three-prong candidates

TauRec

- Seed → TopoJets (clusters) reconstructed with E_t> 10 GeV y $|\eta| < 2.5$
- Search for tracks (from TrackParticle container) around the seed (topo jet) in a cone $\Delta R < 0.2$ → use information from the calorimeter and the inner detector
- Candidates with 1,2 & 3 tracks are selected
- Energy calibration (H1, cell weight assignment related to energy and η)
- Discriminant variable(**Likelihood**) build using tau identification variables

Tau Algorithm Merging

- **Seed**: tracks (E_t > 6 GeV) and TopoJets (E_t > 10 GeV)

- First **Tau1p3p**
  - for each tau1p3p seed, a TopoJet is searched for within 0.2 cone radius
  - if TopoJet is found, then **tauRec** reconstruction is also run on this
  - in this case, the candidate is an **overlap candidate**
  - protection against using the same jet twice (if matched to two good quality tau1p3p leading tracks)
  - if no TopoJet found within 0.2 of tau1p3p seed, **the candidate is tau1p3p-only**

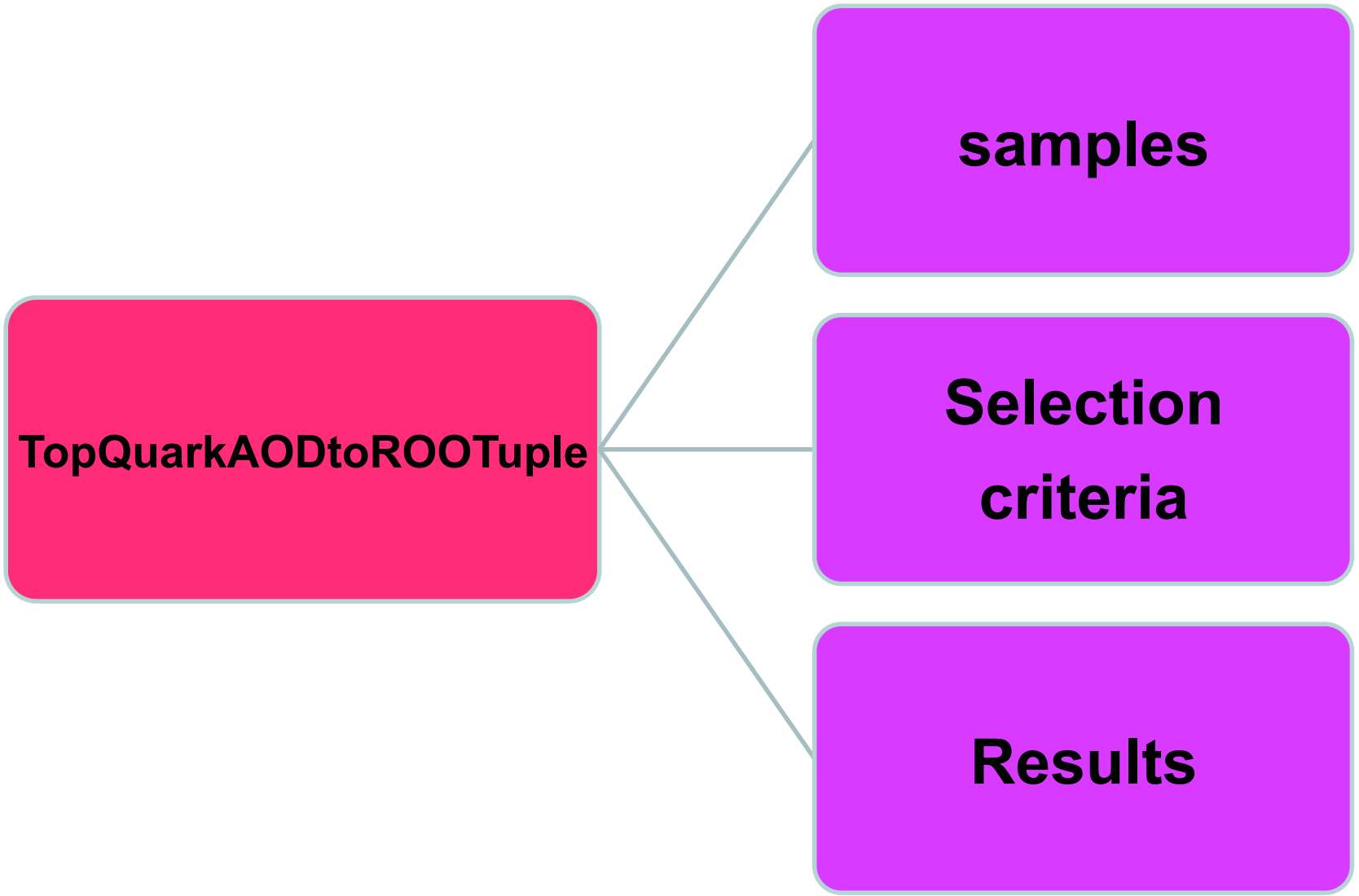
- Unused TopoJets are seeds for additional tauRec candidates
  - tauRec reconstruction run as normal
  - these candidates are **tauRec-only candidates**

Analysis

- ***TopQuarkAODtoROOTuple***
  - http://ghodbane.web.cern.ch/ghodbane/top/ntuple.12.0.6.html
  - ttbar, Ztautau, W+Njets, Wbb, SingleTop
  - Tau1p3p
  - MuonID

- ***TopView***
  - https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TopView
  - ttbar, Ztautau, W+njets, Wbb, SingleTop
  - QCD dijets
  - Tau1p3p + TauRec
  - MuonID + StacoMuon

- ***ARATopQuarkAnalysis***
  - https://atlas-france.in2p3.fr/cgi-bin/twiki/bin/view/Atlas/ARATopQuarkAnalysis
- ***TopPhysTools (¿&TauTools?)***
  - https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TopPhysTools
  - https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TauDPDMaker


TopQuarkAODtoROOTuple
samples
Selection criteria
Results

TopQuarkAODtoROOTuples MC samples

- **ttbar**

  trig1_misal1_mc12.005200.T1_McAtNlo_Jimmy.recon.AOD.v12000601

- **Ztautau**

  trig1_misal1_mc12.008156.AlpgenJimmyZtautauNp2LooseCut. recon.AOD.v12000601

- **Wbb**

  trig1_misal1_mc12.006281.AlpgenJimmyWbbNp1.recon.AOD.v12000605
  trig1_misal1_mc12.006282.AlpgenJimmyWbbNp2.recon.AOD.v12000605_tid015410
  trig1_misal1_mc12.006283.AlpgenJimmyWbbNp3.recon.AOD.v12000605_tid015411

- **Single Top**

  trig1_misal1_mc12.005500.AcerMC_Wt.recon.AOD.v12000604_tid009895
  trig1_misal1_mc12.005501.AcerMC_schan.recon.AOD.v12000604_tid009896
  trig1_misal1_mc12.005502.AcerMC_tchan.recon.AOD.v12000604_tid009897

TopQuarkAODtoROOTuples MC samples

- **W+Njets**
  - First only W+3jets:
    trig1_misal1_mc12.008241.AlpgenJimmyWenuNp3_pt20_filt3jet.recon.AOD.v12000601
    trig1_misal1_mc12.008245.AlpgenJimmyWmunuNp3_pt20_filt3jet.recon.AOD.v12000601
  - Finally W+Njets (N≤5)
    trig1_misal1_mc12.006101.AlpgenJimmyWenuNp0LooseCut.recon.AOD.v12000605_tid014144
    trig1_misal1_mc12.006102.AlpgenJimmyWenuNp1LooseCut.recon.AOD.v12000605_tid014147
    trig1_misal1_mc12.006103.AlpgenJimmyWenuNp2LooseCut.recon.AOD.v12000605_tid014150
    trig1_misal1_mc12.006104.AlpgenJimmyWenuNp3LooseCut.recon.AOD.v12000605_tid01415
    trig1_misal1_mc12.006105.AlpgenJimmyWenuNp4LooseCut.recon.AOD.v12000605_tid014156
    trig1_misal1_mc12.006106.AlpgenJimmyWenuNp5LooseCut.recon.AOD.v12000605_tid014159
    trig1_misal1_mc12.006107.AlpgenJimmyWmunuNp0LooseCut.recon.AOD.v12000605_tid018113
    trig1_misal1_mc12.006108.AlpgenJimmyWmunuNp1LooseCut.recon.AOD.v12000605_tid014165
    trig1_misal1_mc12.006109.AlpgenJimmyWmunuNp2LooseCut.recon.AOD.v12000605_tid014168
    trig1_misal1_mc12.006110.AlpgenJimmyWmunuNp3LooseCut.recon.AOD.v12000605_tid014171
    trig1_misal1_mc12.006111.AlpgenJimmyWmunuNp4LooseCut.recon.AOD.v12000605_tid014174
    trig1_misal1_mc12.006112.AlpgenJimmyWmunuNp5LooseCut.recon.AOD.v12000605_tid014177

Background

$$t\bar{t} \rightarrow bW(l+\nu_l)bW(\tau_{had}+\nu_\tau) \rightarrow l+\tau_{had}+2jets+\not{E}_T \qquad l := e,\mu$$

Z → ττ + 2 jets

- Physic background.

$$Z+2p \rightarrow \tau\tau+2p \rightarrow l+\nu_l+\nu_\tau+\tau_{had}+2p \rightarrow l+\tau_{had}+2jets+\not{E}_T \qquad l := e,\mu$$

- Reduction through kinematic and angular criteria

W + N jets, Wbb, SingleTop

- Instrumental background.
- Tau identification cuts for reduction.

$$W+3p \rightarrow l+\nu_l+3jets \neq l+2jets+\not{E}_T+\tau_{had} \qquad l := e,\mu$$

Selection criteria

1. Un isolated lepton (e o μ) with P_T >20 GeV (trigger object) and | η | < 2.5
2. tau identification:
   - One τ lepton: E_T> 15 GeV .
   - Tau1p3p: discriminant = 1
   - TauRec: Likelihood > 6 (TopWG recomendation)
3. At least 2 energetic jets with | η | < 2:
   - E_T(1er jet) > 50 GeV
   - E_T(2nd jet) > 30 GeV
4. Missing transverse energy $\not{E}_T$>25 GeV
5. $H_T := \not{E}_T + \Sigma E_{T(leptones)} + \Sigma E_{T(jets)}$ H_T>250 GeV
6. Z veto
7. Opossite sign (OS)
8. Btagging

Summary (e,τ_{had})

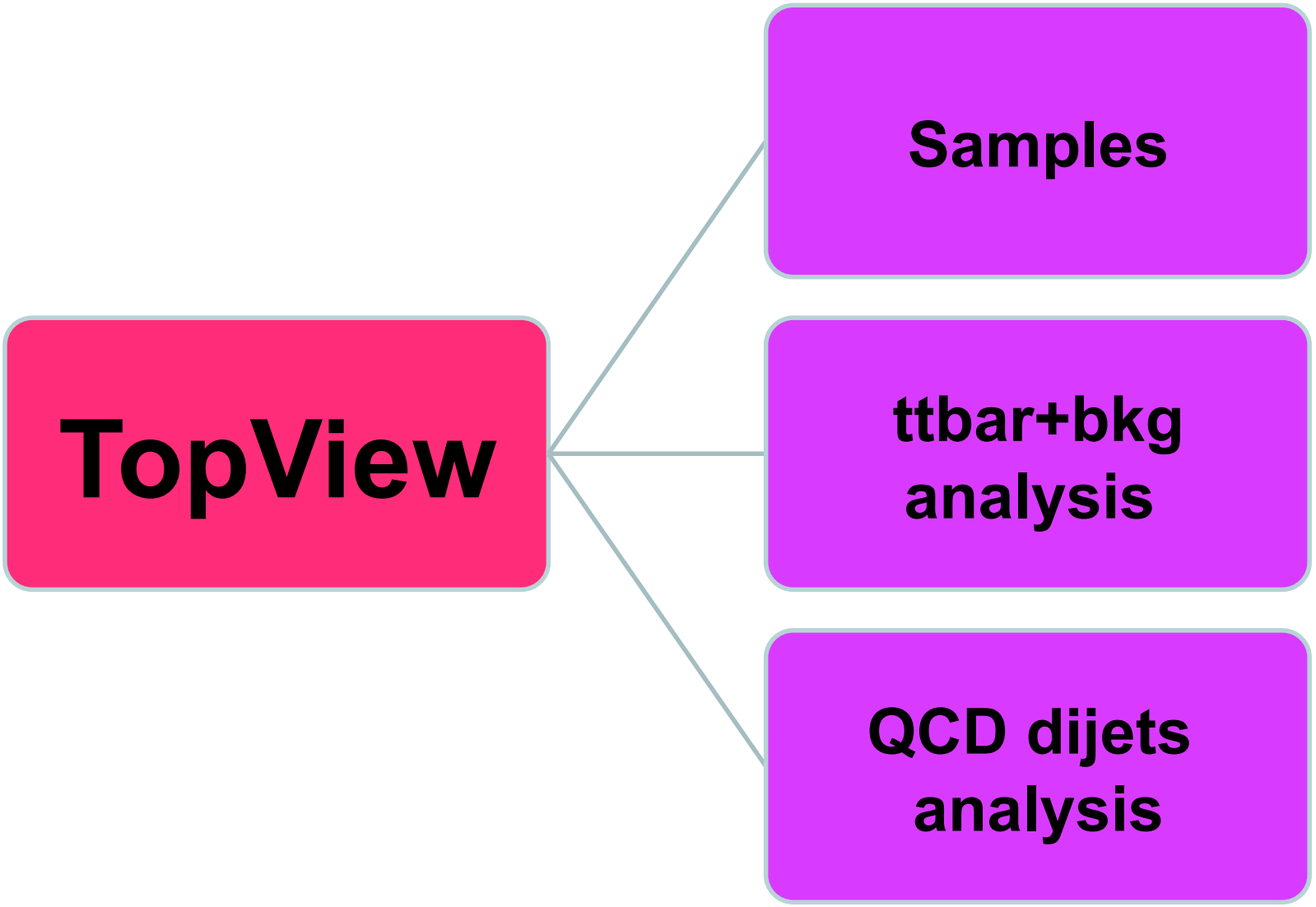
	N_{evt} $(100\ pb^{-1})$				
	$t\bar{t}(e\tau_h)$	$W(e\nu_e)+Np$	$W(e\nu_e)bb+Np$	$Single\ t$	$Z(\tau_e\tau_h)+2p$
	1140 ± 19	336559 ± 1365	488 ± 17	3371 ± 66	745 ± 14
1 e $P_T > 20\ GeV$	575 ± 13	170728 ± 958	203 ± 11	1857 ± 49	259 ± 8
1 τ $P_T > 15\ GeV$	222 ± 8	30775 ± 374	68 ± 6	590 ± 27	106 ± 5
Tau ID	80 ± 5	9594 ± 218	13 ± 3	91 ± 10	53 ± 4
$E_T^{1st\ jet} > 50\ GeV$	74 ± 5	4409 ± 139	8 ± 2	68 ± 9	22 ± 2
$E_T^{2nd\ jet} > 30\ GeV$	70 ± 5	2882 ± 107	8 ± 2	68 ± 9	15 ± 2
$\not{E}_T > 25$	62 ± 4	2458 ± 99	6 ± 2	58 ± 8	7 ± 1
$H_T > 250\ GeV$	63 ± 4	1241 ± 58	5 ± 1	46 ± 7	5 ± 1
Z veto	63 ± 4	1222 ± 58	5 ± 1	46 ± 7	2 ± 1
Opposite Charge	54 ± 4	583 ± 39	3 ± 1	24 ± 5	2 ± 1
1 btag w>3	32 ± 3	53 ± 11	2 ± 1	12 ± 4	1 ± 0
1 btag w>5	30 ± 3	30 ± 8	2 ± 1	12 ± 3	0 ± 0
1 btag w>7	28 ± 3	15 ± 4	2 ± 1	10 ± 3	0 ± 0
2 btags w>3	8 ± 2	2 ± 2	0 ± 0	5 ± 3	0 ± 0
2 btags w>5	7 ± 1	2 ± 2	0 ± 0	3 ± 2	0 ± 0
2 btags w>7	5 ± 1	0 ± 0	0 ± 0	2 ± 2	0 ± 0

Summary (μ,τ_{had})

	N_{evt} $(100\ pb^{-1})$				
	$t\bar{t}(\mu\tau_h)$	$W(\mu\nu_\mu)+Np$	$W(\mu\nu_{mu})bb+Np$	$Single\ t$	$Z(\tau_\mu\tau_h)+2p$
	1062 ± 18	287446 ± 1192	450 ± 16	3489 ± 68	764.4 ± 14.5
$1\ \mu\ P_T > 20\ GeV$	717 ± 15	218430 ± 1039	241 ± 12	2431 ± 56	374.7 ± 10.2
$1\ \tau\ P_T > 15\ GeV$	301 ± 10	40422 ± 422	75 ± 6	705 ± 29	147.3 ± 6.4
Tau ID	112 ± 6	12569 ± 244	18 ± 4	120 ± 12	69.6 ± 4.4
$E_T^{1st\ jet} > 50\ GeV$	107 ± 6	3321 ± 111	7 ± 2	106 ± 11	30.6 ± 2.9
$E_T^{2nd\ jet} > 30\ GeV$	101 ± 6	1141 ± 47	7 ± 2	106 ± 11	20.6 ± 2.4
$\not\!\!E_T > 25$	91 ± 5	943 ± 43	5 ± 1	86 ± 10	9.1 ± 1.6
$H_T > 250\ GeV$	90 ± 5	525 ± 25	5 ± 1	82 ± 10	5.5 ± 1.2
Z veto	86 ± 5	511 ± 25	5 ± 1	81 ± 10	3.6 ± 1.0
Opposite Charge	77 ± 5	270 ± 18	3 ± 1	30 ± 6	1.7 ± 0.7
1 btag w>3	51 ± 4	35 ± 6	3 ± 1	15 ± 4	0.6 ± 0.4
1 btag w>5	48 ± 4	20 ± 5	2 ± 1	13 ± 4	0.6 ± 0.4
1 btag w>7	39 ± 4	13 ± 4	2 ± 1	9 ± 3	0.3 ± 0.3
2 btags w>3	9 ± 2	1 ± 1	1 ± 1	1 ± 1	0.0 ± 0.0
2 btags w>5	6 ± 1	1 ± 1	1 ± 1	0 ± 0	0.0 ± 0.0
2 btags w>7	3 ± 1	1 ± 1	0 ± 0	0 ± 0	0.0 ± 0.0

TopQuarkAODtoROOTuple: Summary

- Need to use b-tagging to distinguish the tt-bar →bW(→τ_{had})bW(→e/μ) signal at 100 pb^{-1}
- Wbb insignificant when compared with W+jets & SingleTop
- Btagging
  - 1 ⟶ small S/B ratio
  - 2 ⟶ Dominant backgrounds (W+jets y SingleTop) drastically reduced, but we lost almost all the signal (3-5 events).
    - S/B ~2 (electronic channel) and ~ 3 (muonic channel).
- Contribution:
  - ATLAS note ATL-COM-PHYS-2008-068
  - ATLAS CSC note phys-int-2008-003


TopView
Samples
ttbar+bkg analysis
QCD dijets analysis

TopView MC samples

- ttbar

  trig1_misal1_mc12.005200.T1_McAtNlo_Jimmy.recon.AOD.v12000601_tid005997

- Ztautau

  trig1_misal1_mc12.008156.AlpgenJimmyZtautauNp2LooseCut.recon.AOD.v12000601_tid006628

- W+jets

  trig1_misal1_mc12.006101.AlpgenJimmyWenuNp0LooseCut.recon.AOD.v12000605_tid014144
  trig1_misal1_mc12.006102.AlpgenJimmyWenuNp1LooseCut.recon.AOD.v12000605_tid014147
  trig1_misal1_mc12.006103.AlpgenJimmyWenuNp2LooseCut.recon.AOD.v12000605_tid014150
  trig1_misal1_mc12.006104.AlpgenJimmyWenuNp3LooseCut.recon.AOD.v12000605_tid01415
  trig1_misal1_mc12.006105.AlpgenJimmyWenuNp4LooseCut.recon.AOD.v12000605_tid014156
  trig1_misal1_mc12.006106.AlpgenJimmyWenuNp5LooseCut.recon.AOD.v12000605_tid014159
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  trig1_misal1_mc12.006111.AlpgenJimmyWmunuNp4LooseCut.recon.AOD.v12000605_tid014174
  trig1_misal1_mc12.006112.AlpgenJimmyWmunuNp5LooseCut.recon.AOD.v12000605_tid014177

TopView MC samples

- Wbb
  - trig1_misal1_mc12.006281.AlpgenJimmyWbbNp1.recon.AOD.v12000605
  - trig1_misal1_mc12.006282.AlpgenJimmyWbbNp2.recon.AOD.v12000605_tid015410
  - trig1_misal1_mc12.006283.AlpgenJimmyWbbNp3.recon.AOD.v12000605_tid015411
- Single Top
  - trig1_misal1_mc12.005500.AcerMC_Wt.recon.AOD.v12000604_tid009895
  - trig1_misal1_mc12.005501.AcerMC_schan.recon.AOD.v12000604_tid009896
  - trig1_misal1_mc12.005502.AcerMC_tchan.recon.AOD.v12000604_tid009897
- QCD dijets
  - trig1_misal1_csc11.005009.J0_pythia_jetjet.recon.AOD.v12000604_tid010586
  - trig1_misal1_csc11.005010.J1_pythia_jetjet.recon.AOD.v12000601_tid006001
  - trig1_misal1_csc11.005011.J2_pythia_jetjet.recon.AOD.v12000503_tid005591
  - trig1_misal1_csc11.005012.J3_pythia_jetjet.recon.AOD.v12000604_tid009525
  - trig1_misal1_csc11.005013.J4_pythia_jetjet.recon.AOD.v12000605_tid009524
  - trig1_misal1_csc11.005014.J5_pythia_jetjet.recon.AOD.v12000601_tid006004
  - trig1_misal1_csc11.005015.J6_pythia_jetjet.recon.AOD.v12000601_tid005996
  - trig1_misal1_csc11.005016.J7_pythia_jetjet.recon.AOD.v12000601_tid006005

Summary (TauRec (e,τ_{had}))

	N_{evt} $(100\ pb^{-1})$				
	$t\bar{t}(e\tau_h)$	$W(e\nu_e)+Np$	$W(e\nu_e)+b\bar{b}$	$SingleTop$	$Z(\tau_e\tau_h)+2p$
	1210.23 ± 24.80	247486.51 ± 877.63	427.08 ± 6.16	3764.78 ± 35.71	746.69 ± 12.95
$1\ e/\mu\ P_T > 20\ GeV$	512.14 ± 19.24	112052.39 ± 589.42	151.46 ± 3.67	1901.22 ± 24.55	207.50 ± 6.83
$1\ \tau\ P_T > 15\ GeV$	173.90 ± 11.24	27438.88 ± 277.02	51.88 ± 2.15	865.59 ± 15.22	79.50 ± 4.23
Tau ID	32.67 ± 5.05	748.60 ± 46.91	0.81 ± 0.27	7.44 ± 1.63	13.92 ± 1.77
$E_T^{1st\ jet} > 50\ GeV$	29.65 ± 4.74	122.65 ± 12.10	0.48 ± 0.22	6.00 ± 1.47	8.53 ± 1.38
$E_T^{2nd\ jet} > 30\ GeV$	27.64 ± 4.69	83.88 ± 8.23	0.39 ± 0.19	5.53 ± 1.41	7.64 ± 1.31
$\not{E}_T > 25$	24.12 ± 4.29	64.44 ± 7.21	0.39 ± 0.19	3.18 ± 1.00	4.72 ± 1.03
$H_T > 250\ GeV$	20.10 ± 3.96	30.02 ± 4.16	0.39 ± 0.19	2.32 ± 0.86	2.92 ± 0.81
Z veto	13.57 ± 3.45	26.91 ± 4.06	0.39 ± 0.19	1.70 ± 0.72	0.67 ± 0.39
Opposite Charge	13.07 ± 3.48	21.01 ± 3.70	0.09 ± 0.09	1.70 ± 0.72	0.67 ± 0.39
1 btag w>3	7.04 ± 3.06	2.45 ± 1.37	0.09 ± 0.09	1.51 ± 0.70	0.22 ± 0.22
1 btag w>5	7.04 ± 2.97	0.36 ± 0.36	0.09 ± 0.09	1.51 ± 0.70	0.22 ± 0.22
1 btag w>7	5.53 ± 3.02	0.00 ± 0.00	0.09 ± 0.09	1.32 ± 0.67	0.22 ± 0.22
2 btags w>3	2.01 ± 1.67	0.00 ± 0.00	0.09 ± 0.09	0.26 ± 0.20	0.00 ± 0.00
2 btags w>5	1.51 ± 1.59	0.00 ± 0.00	0.09 ± 0.09	0.23 ± 0.19	0.00 ± 0.00
2 btags w>7	2.01 ± 1.23	0.00 ± 0.00	0.09 ± 0.09	0.19 ± 0.19	0.00 ± 0.00

Summary (TauRec (μ,τ_{had}))

	N_{evt} $(100\ pb^{-1})$				
	$t\bar{t}(\mu\tau_h)$	$W(\mu\nu_\mu)+Np$	$W(\mu\nu_\mu)+b\bar{b}$	$SingleTop$	$Z(\tau_\mu\tau_h)+2p$
	1223.30 ± 24.80	245558.02 ± 786.88	424.14 ± 6.14	3319.13 ± 34.53	759.04 ± 13.06
$1\ e/\mu\ P_T > 20\ GeV$	736.29 ± 19.24	180681.97 ± 676.28	217.54 ± 4.40	2165.92 ± 27.82	346.73 ± 8.82
$1\ \tau\ P_T > 15\ GeV$	251.29 ± 11.24	45158.13 ± 324.15	70.50 ± 2.51	639.13 ± 14.91	128.45 ± 5.37
Tau ID	50.76 ± 5.05	1788.54 ± 67.47	1.36 ± 0.34	18.95 ± 2.59	20.88 ± 2.17
$E_T^{1st\ jet} > 50\ GeV$	44.73 ± 4.74	467.57 ± 29.21	0.70 ± 0.25	14.50 ± 2.24	13.25 ± 1.72
$E_T^{2nd\ jet} > 30\ GeV$	43.73 ± 4.69	274.46 ± 19.06	0.45 ± 0.20	12.83 ± 2.10	11.23 ± 1.59
$\not{E}_T > 25$	36.69 ± 4.29	214.98 ± 15.84	0.35 ± 0.18	9.46 ± 1.83	7.86 ± 1.33
$H_T > 250\ GeV$	31.16 ± 3.96	106.66 ± 9.90	0.17 ± 0.12	7.69 ± 1.61	3.37 ± 0.87
Z veto	23.62 ± 3.45	100.52 ± 9.80	0.08 ± 0.08	6.88 ± 1.53	0.67 ± 0.39
Opposite Charge	24.12 ± 3.48	32.84 ± 4.83	0.00 ± 0.00	2.25 ± 0.86	0.45 ± 0.32
1 btag w>3	18.60 ± 3.06	2.07 ± 1.30	0.00 ± 0.00	1.00 ± 0.54	0.22 ± 0.22
1 btag w>5	17.59 ± 2.97	0.36 ± 0.36	0.00 ± 0.00	1.00 ± 0.54	0.00 ± 0.00
1 btag w>7	18.09 ± 3.02	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.54	0.00 ± 0.00
2 btags w>3	5.53 ± 1.67	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2 btags w>5	5.03 ± 1.59	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2 btags w>7	3.02 ± 1.23	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

TopView: Summary&Plans

- Results are consistent with TopQuarkAODtoROOTuple
  - Wbb insignificant when compared with W+jets & SingleTop
  - Need to use b-tagging to distinguish the tt-bar →bW(→τ_{had})bW(→e/μ) signal at 100 pb^{-1}
  - **Btagging** : with 1 btaggin we get S/B~1.5 in the electronic channel and S/B~ 6 in the muonic channel. (greater difference between channels than with TopQuarkAODtoROOTuple).
- Efficiency problems after OS cut applying Tau1p3p
  - Test with:
    - Tau1p3p/TauRec
    - MuonID/StacoMuon
- Pending of repeating the analysis with mc08 samples and release 14 (Tau1p3p &TauRec merged, 10 TeV)

QCD dijets: Motivations

- W+jets is the dominant “instrumental” background with jets misidentificated as tau leptons. (*ATL-COM-PHYS-2008-068*)

- We have estimated the W+jets background directly from our W+Njets samples, counting the number of events that pass the ttbar (lepton, τ_{HAD}) selection criteria.

- In order to make a more realistic estimation of the W+jets background, we have calculated fake rates using QCD dijets MC samples.

QCD dijets: selection criteria

- Events with Njets ≥ 2
- 2 more energetic jets (similar Pt)
- Back to back jets → $\Delta\varphi \geq (\pi - 0.3)$
- Randomly choose one as the "tag jet" and the other will be the "probe jet"
- tag jet
  - » $n_{trak\ min}$ = 4 ($p_T \leq$ 50 GeV) + 1 track for each additional 50 GeV interval in p_T

Probe jet = FR-Tau_Candidates

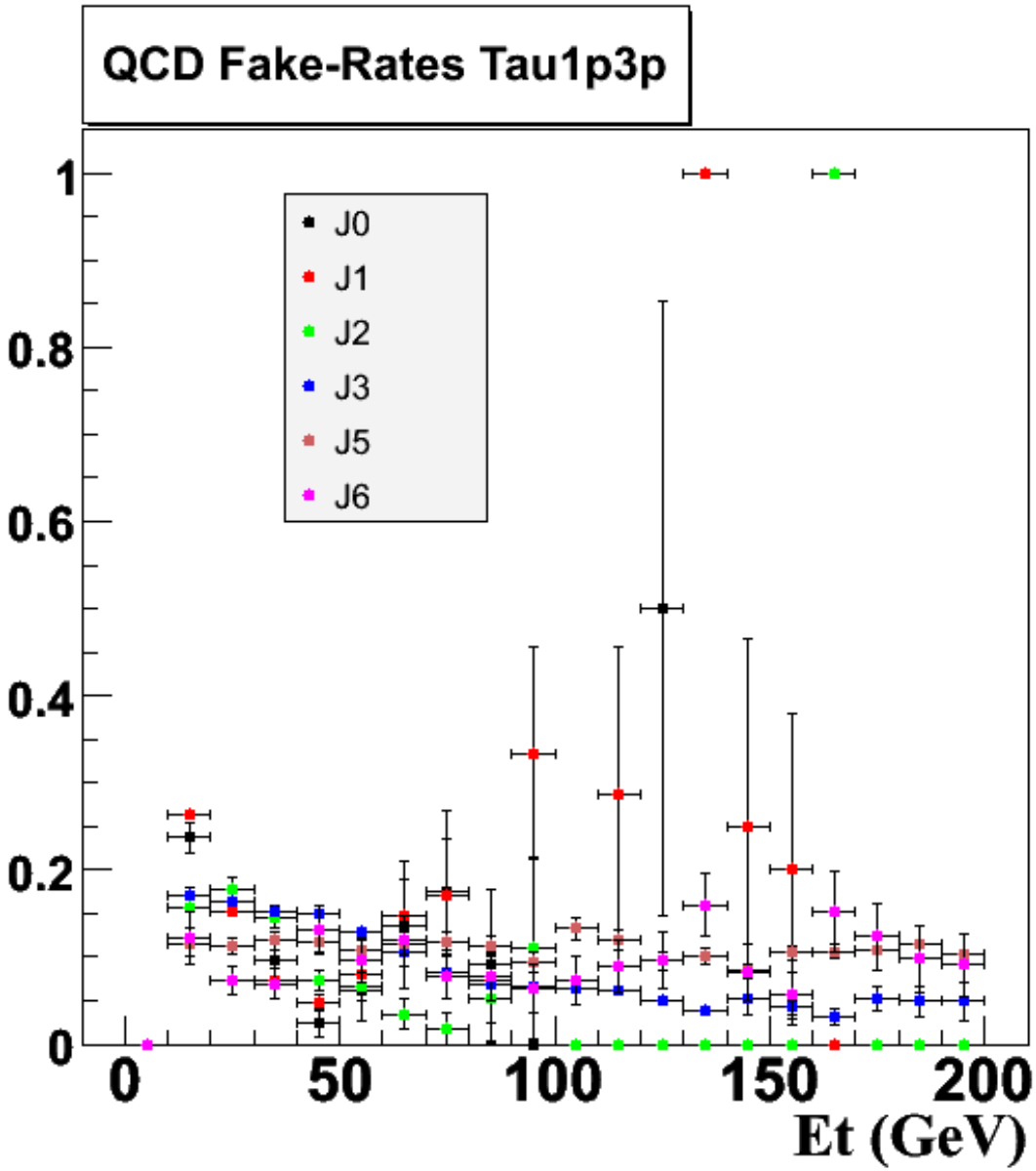
- Probe jet
  - Tau1p3p → Tau_Discriminant = 1
  - TauRec → Tau_logLikelihoodRatio > 4

} FR-Tau_ID

QCD Results (I)

- Tau1p3p
- FR ~10%

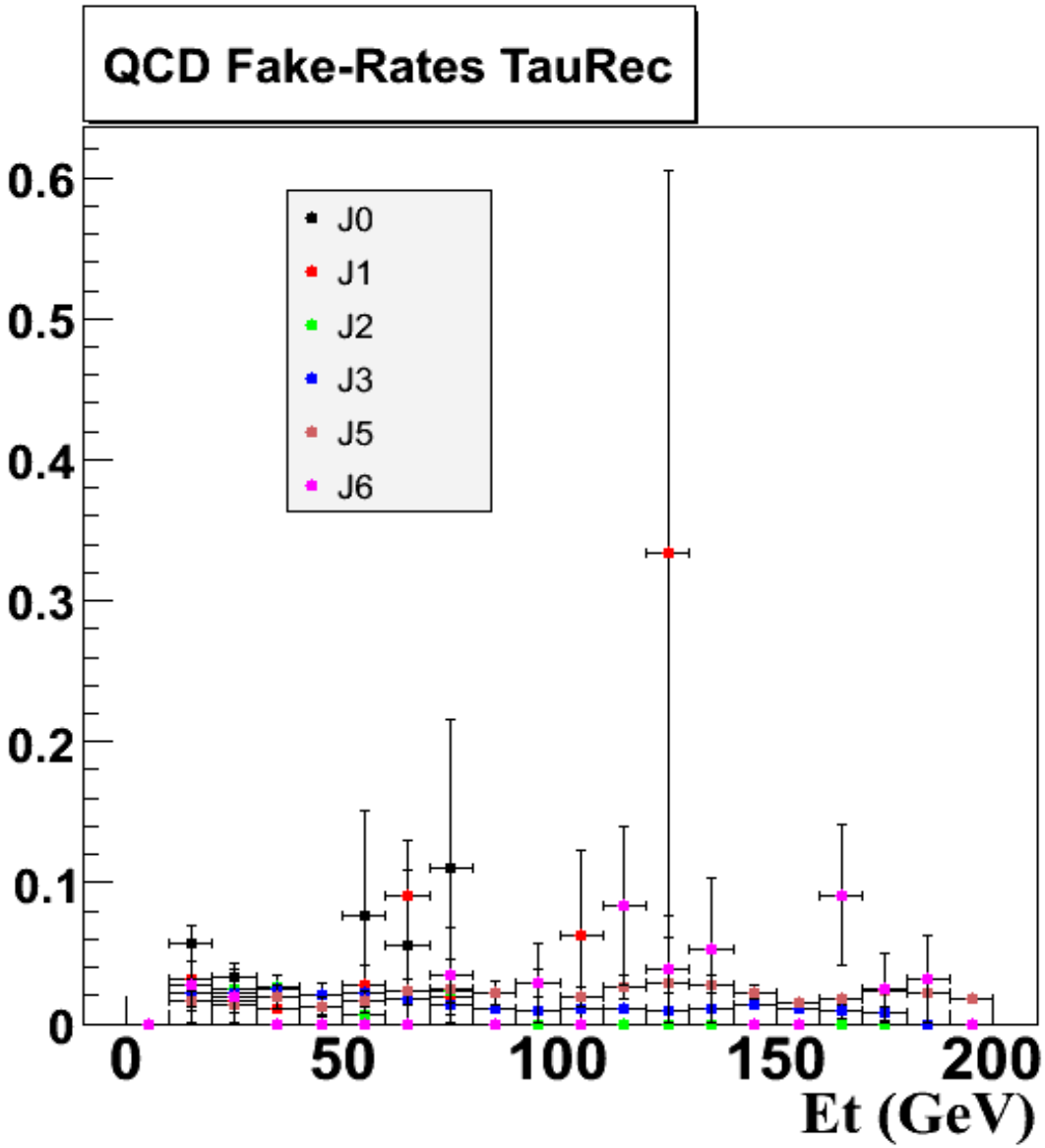
10% Discrepancy from
One sample to another



QCD Results (II)

- TauRec
- FR ~5%

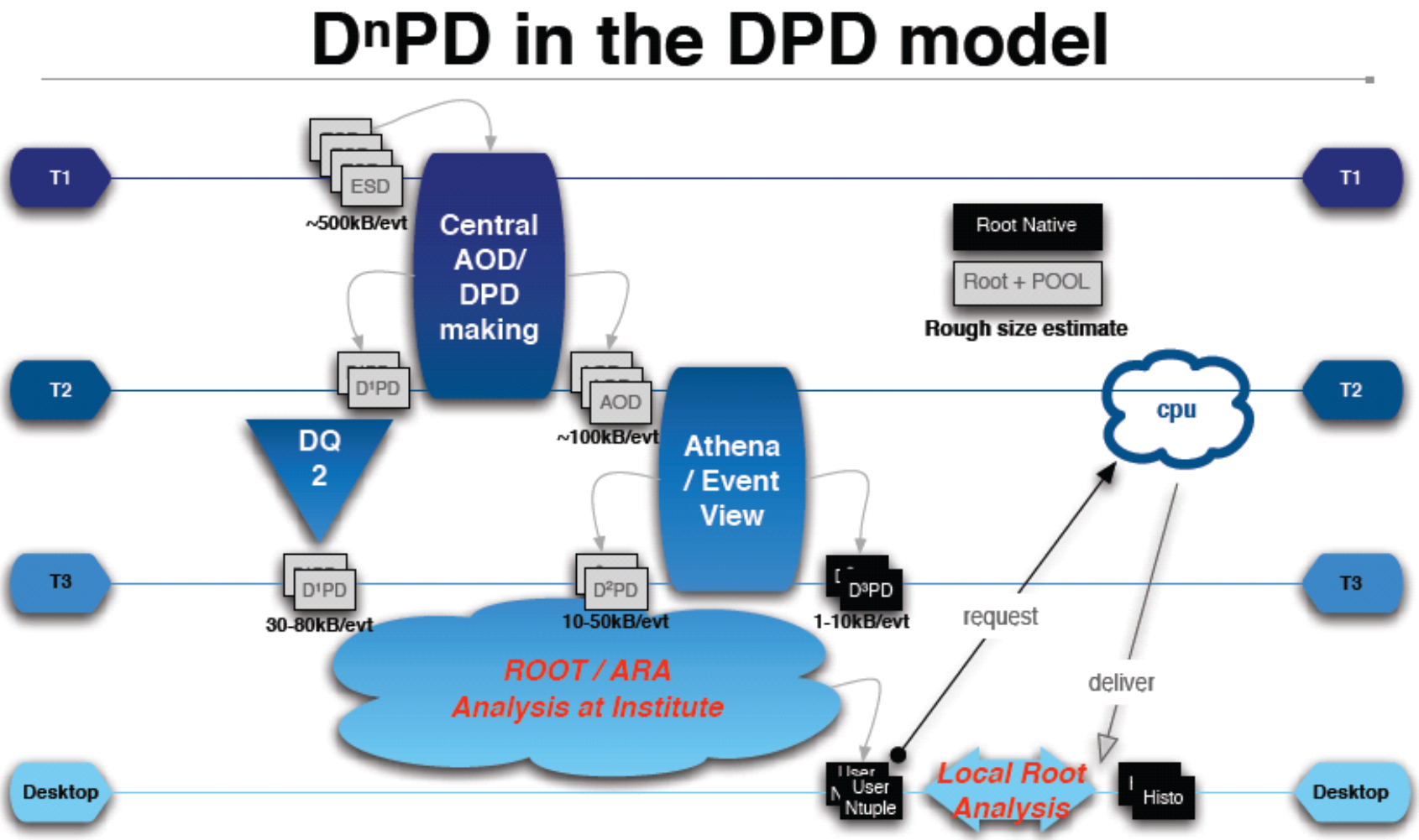
5% Discrepancy from
One sample to another

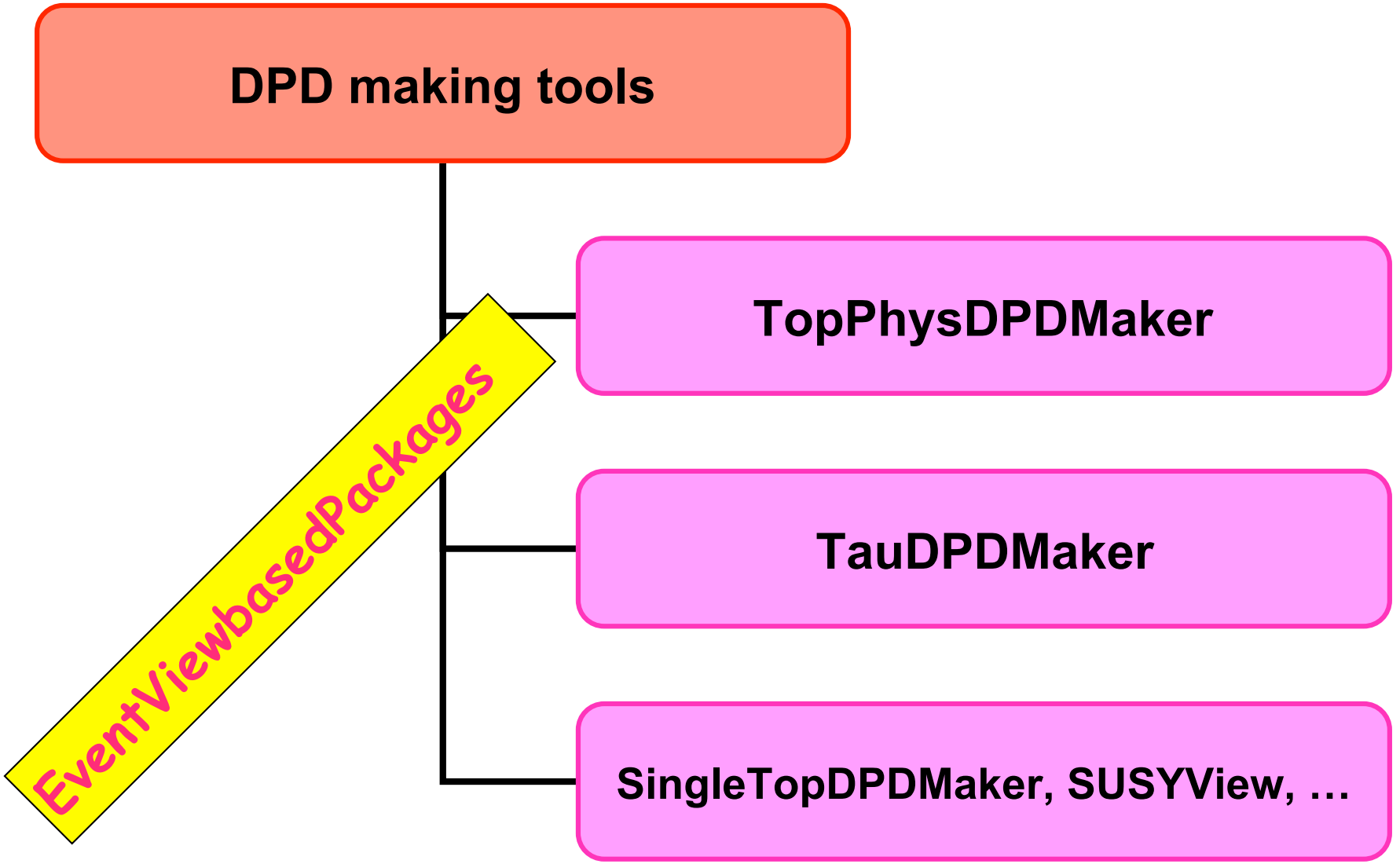


QCD dijets: Summary & plans

- QCD dijets
  - We have estimated FR from QCD dijets samples
  - Future:
    - apply to ttbar and W+jets
    - Parametrize FR as a function of ΣE_T

Release 14


DnPD in the DPD model
T1
T2
T3
Desktop
ESD
~500kB/evt
Central AOD/ DPD making
D1PD
DQ 2
AOD
~100kB/evt
Athena / Event View
D1PD
30-80kB/evt
D2PD
10-50kB/evt
D3PD
1-10kB/evt
ROOT / ARA Analysis at Institute
User Ntuple
Local Root Analysis
Histo
Root Native
Root + POOL
Rough size estimate
cpu
request
deliver


DPD making tools
TopPhysDPDMaker
TauDPDMaker
SingleTopDPDMaker, SUSYView, …
EventViewbasedPackages

ARATopQuarkAnalysis

- GOAL: repeat the analysis at 10 TeV to check if this channel will be observable at the beggining of the LHC

- 3 aims:
  - add tau monitoring variables
    - TauRec, Tau1p3p, merged details
    - https://twiki.cern.ch/twiki/bin/view/Atlas/TauDataQualityMonitoring
  - QCD fake rates calculation & aplication to ttbar+background samples
  - Top mixing sample analysis

  - **work in progress……..**

mc08 TopWG official samples

- Link Hypernews:
  - https://groups.cern.ch/group/hn-atlas-TopPhysicsWG/Lists/Archive/Flat.aspx?RootFolder=%2fgroup%2fhn-atlas-TopPhysicsWG%2fLists%2fArchive%2ftop%20mixing%20sample%20Jet%20stream%20registered&FolderCTID=0x012002001823315957BA9D4A9BED606ED727658E

- QCD dijets

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- ttbar

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  user.top.D3PD_rel14050006_MC08.mc08.105204.TTbar_FullHad_McAtNlo_Jimmy.recon.AOD.e363_s462_r563.20090121_GANGA

- Single top

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mc08 TopWG official samples

- W+jets

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- Wbb

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mc08 TopWG official samples

- **Top mixing**

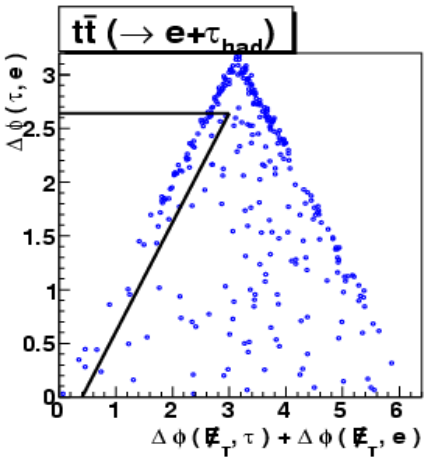
ttbar + Single top + W+jets + Z+jets + diboson (WW/WZ/ZZ)

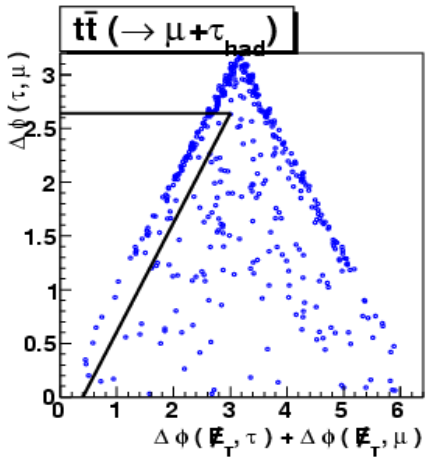
- user.RichardHawkings.0108172.topmix_Egamma.AOD.v1
- user.RichardHawkings.0108172.topmix_Muon.AOD.v1
- user.RichardHawkings.0108172.topmix_Jet.AOD.v1
- user.RichardHawkings.0108173.topmix_Egamma.AOD.v2
- user.RichardHawkings.0108173.topmix_Muon.AOD.v2
- user.RichardHawkings.0108173.topmix_Jet.AOD.v2
- user.RichardHawkings.0108174.topmix_Egamma.AOD.v2
- user.RichardHawkings.0108174.topmix_Muon.AOD.v2
- user.RichardHawkings.0108174.topmix_Jet.AOD.v2

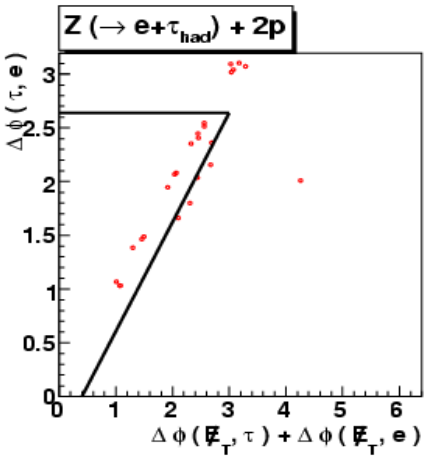
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TopMixingExercise

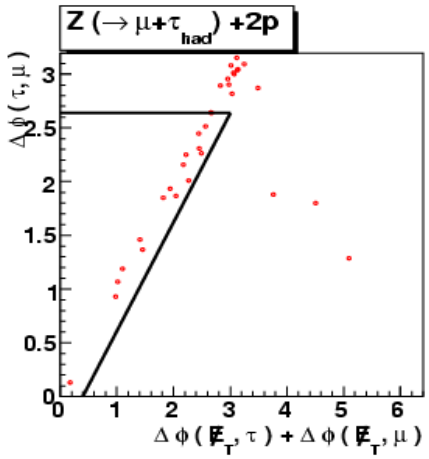
Backup Slides

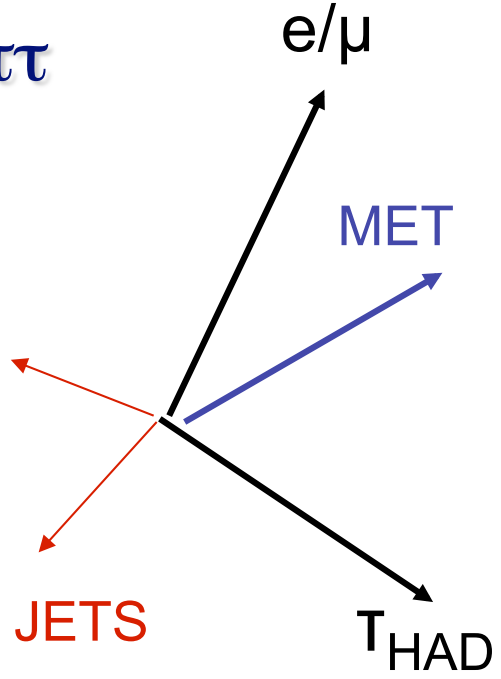
VETO DE BOSONES Z→ττ

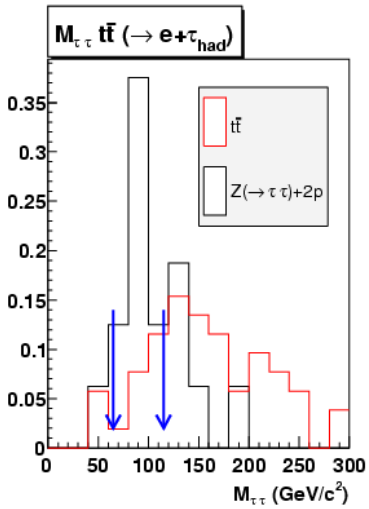


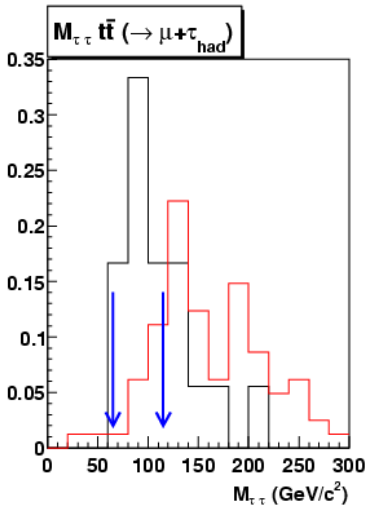












$$\Delta\phi_{\tau_{e/\mu},\not{E}_T} < \pi - 0.5$$

$$(\Delta\phi_{\tau_{e/\mu},\not{E}_T} + \Delta\phi_{had,\not{E}_T} - \Delta\phi_{\tau_{e/\mu},\tau_{had}}) < 0.4$$

$$65 < M_{\tau\tau} < 115 \quad GeV/c^2$$

TopQuarkAODtoROOTuple

W(→eν)+jets

	N_{evt} $(100\ pb^{-1})$							
	$W(e\nu_e)+0p$	$W(e\nu_e)+1p$	$W(e\nu_e)+2p$	$W(e\nu_e)+3p$	$W(e\nu_e)+4p$	$W(e\nu_e)+5p$	$W(e\nu_e)+Np$	$t\bar{t}(e\tau_h)$
	CSC	6101	6102	6103	6104	6105	6106	5200
	88436 ± 789	164993 ± 1044	58700 ± 371	17700 ± 112	4930 ± 31	1800 ± 19	336559 ± 1365	1140 ± 19
1 e/μ $P_T > 20\ GeV$	30969 ± 467	93146 ± 784	33133 ± 279	9778 ± 83	2728 ± 23	974 ± 14	170728 ± 958	575 ± 13
1 τ $P_T > 15\ GeV$	796 ± 75	16929 ± 334	8631 ± 142	3104 ± 47	952 ± 14	363 ± 9	30775 ± 374	222 ± 8
Tau ID	338 ± 49	5894 ± 197	2367 ± 75	752 ± 23	186 ± 6	57 ± 3	9594 ± 218	80 ± 5
$E_T^{1st\ jet} > 50\ GeV$	28 ± 14	2369 ± 125	1308 ± 55	506 ± 19	148 ± 5	50 ± 3	4409 ± 139	74 ± 5
$E_T^{2nd\ jet} > 30\ GeV$	0 ± 0	1353 ± 94	949 ± 47	403 ± 17	131 ± 5	46 ± 3	2882 ± 107	70 ± 5
$\not{E}_T > 25$	0 ± 0	1162 ± 88	798 ± 43	348 ± 16	109 ± 5	41 ± 3	2458 ± 99	62 ± 4
$H_T > 250\ GeV$	0 ± 0	304 ± 45	486 ± 34	305 ± 15	105 ± 5	41 ± 3	1241 ± 58	63 ± 4
Z veto	0 ± 0	304 ± 45	474 ± 33	301 ± 15	103 ± 5	40 ± 3	1222 ± 58	63 ± 4
Opposite Charge	0 ± 0	132 ± 30	232 ± 23	145 ± 10	52 ± 3	21 ± 2	583 ± 39	54 ± 4
1 btag w>3	0 ± 0	13 ± 9	9 ± 5	23 ± 4	6 ± 1	2 ± 1	53 ± 11	32 ± 3
1 btag w>5	0 ± 0	7 ± 7	5 ± 3	13 ± 3	5 ± 1	1 ± 1	30 ± 8	30 ± 3
1 btag w>7	0 ± 0	0 ± 0	2 ± 2	9 ± 3	3 ± 1	1 ± 0	15 ± 4	28 ± 3
2 btags w>3	0 ± 0	0 ± 0	2 ± 2	0 ± 0	0 ± 0	0 ± 0	2 ± 2	8 ± 2
2 btags w>5	0 ± 0	0 ± 0	2 ± 2	0 ± 0	0 ± 0	0 ± 0	2 ± 2	7 ± 1
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5 ± 1

W(→μν)+jets

	N_{evt} $(100\ pb^{-1})$							
	$W(\mu\nu_\mu)+0p$	$W(\mu\nu_\mu)+1p$	$W(\mu\nu_\mu)+2p$	$W(\mu\nu_\mu)+3p$	$W(\mu\nu_\mu)+4p$	$W(\mu\nu_\mu)+5p$	$W(\mu\nu_\mu)+Np$	$t\bar{t}(\mu\tau_h)$
	CSC	6107	6108	6109	6110	6111	6112	5200
	41397 ± 453	162987 ± 1031	58798 ± 372	17396 ± 111	5039 ± 32	1830 ± 19	287446 ± 1365	1062 ± 18
1 e/μ $P_T > 20\ GeV$	30641 ± 390	124473 ± 901	44883 ± 325	13251 ± 97	3817 ± 28	1364 ± 16	218430 ± 958	717 ± 15
1 τ $P_T > 15\ GeV$	978 ± 70	21901 ± 378	11539 ± 165	4186 ± 54	1319 ± 16	499 ± 10	40422 ± 374	301 ± 10
Tau ID	313 ± 39	7531 ± 222	3377 ± 89	995 ± 26	268 ± 7	85 ± 4	12569 ± 218	112 ± 6
$E_T^{1st\ jet} > 50\ GeV$	5 ± 5	1408 ± 96	1141 ± 52	521 ± 19	179 ± 6	68 ± 4	3321 ± 139	107 ± 6
$E_T^{2nd\ jet} > 30\ GeV$	0 ± 0	117 ± 28	501 ± 34	326 ± 15	138 ± 5	59 ± 3	1141 ± 107	101 ± 6
$\not\!\!E_T > 25$	0 ± 0	104 ± 26	416 ± 31	263 ± 14	111 ± 5	48 ± 3	943 ± 99	91 ± 5
$H_T > 250\ GeV$	0 ± 0	13 ± 9	169 ± 20	188 ± 12	106 ± 5	48 ± 3	525 ± 58	90 ± 5
Z veto	0 ± 0	13 ± 9	167 ± 20	182 ± 11	103 ± 5	46 ± 3	511 ± 58	86 ± 5
Opposite Charge	0 ± 0	7 ± 7	92 ± 15	98 ± 8	52 ± 3	21 ± 2	270 ± 39	77 ± 5
1 btag w>3	0 ± 0	0 ± 0	9 ± 5	13 ± 3	9 ± 1	3 ± 1	35 ± 11	51 ± 4
1 btag w>5	0 ± 0	0 ± 0	7 ± 4	6 ± 2	5 ± 1	2 ± 1	20 ± 8	48 ± 4
1 btag w>7	0 ± 0	0 ± 0	5 ± 3	4 ± 2	3 ± 1	1 ± 0	13 ± 4	39 ± 4
2 btags w>3	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	1 ± 2	9 ± 2
2 btags w>5	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	1 ± 2	6 ± 1
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	1 ± 0	3 ± 1

Wbb (e,τ_{had})

W(→eν)+bb :

1 e + MissingEt + 2 b-jets + 1 quark-gluon-jet passing tau ID cuts.

	N_{evt} (100 pb^{-1})						
	$W(e\nu_e)b\bar{b}+1p$		$W(e\nu_e)b\bar{b}+2p$		$W(e\nu_e)b\bar{b}+3p$		$W(e\nu_e)b\bar{b}+1,2,3p$
	258 ± 16	0.00 ± -0.60	125 ± 3	0.00 ± 0.00	105 ± 5	0.00 ± 0.00	488 ± 17
1 e $P_T > 20\ GeV$	113 ± 11	0.44 ± 0.04	50 ± 2	0.40 ± 0.02	40 ± 3	0.38 ± 0.03	203 ± 11
1 τ $P_T > 15\ GeV$	34 ± 6	0.30 ± 0.05	17 ± 1	0.34 ± 0.03	17 ± 2	0.42 ± 0.05	68 ± 6
Tau ID	6 ± 2	0.18 ± 0.07	4 ± 1	0.24 ± 0.04	3 ± 1	0.17 ± 0.05	13 ± 3
$E_T^{1st\ jet} > 50\ GeV$	3 ± 2	0.50 ± 0.29	3 ± 1	0.83 ± 0.14	2 ± 1	0.70 ± 0.26	8 ± 2
$E_T^{2nd\ jet} > 30\ GeV$	3 ± 2	1.00 ± 0.58	3 ± 1	1.00 ± 0.17	2 ± 1	1.00 ± 0.38	8 ± 2
$\not{E}_T > 25$	2 ± 1	0.67 ± 0.47	3 ± 1	0.85 ± 0.16	2 ± 1	0.86 ± 0.35	6 ± 2
$H_T > 250\ GeV$	1 ± 1	0.50 ± 0.50	3 ± 0	0.90 ± 0.18	2 ± 1	1.00 ± 0.41	5 ± 1
Z veto	1 ± 1	1.00 ± 1.00	3 ± 0	1.00 ± 0.20	2 ± 1	1.00 ± 0.41	5 ± 1
Opposite Charge	1 ± 1	1.00 ± 1.00	1 ± 0	0.54 ± 0.14	0 ± 0	0.17 ± 0.17	3 ± 1
1 btag w>3	1 ± 1	1.00 ± 1.00	1 ± 0	0.71 ± 0.23	0 ± 0	1.00 ± 1.00	2 ± 1
1 btag w>5	1 ± 1	1.00 ± 1.00	1 ± 0	0.57 ± 0.20	0 ± 0	0.00 ± 0.00	2 ± 1
1 btag w>7	1 ± 1	1.00 ± 1.00	1 ± 0	0.57 ± 0.20	0 ± 0	0.00 ± 0.00	2 ± 1
2 btags w>3	0 ± 0	0.00 ± 0.00	0 ± 0	0.07 ± 0.07	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>5	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0

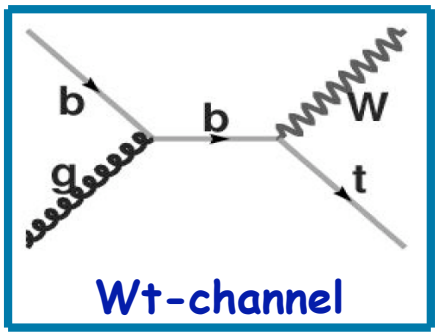
Wbb (μ,τ_{had})

W(→$\mu\nu$)+bb :

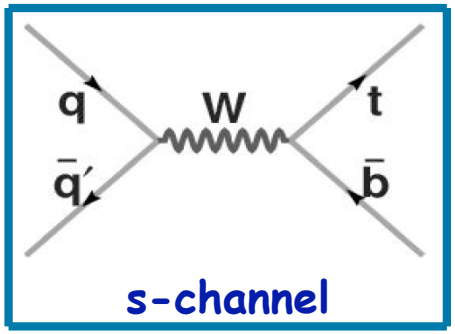
1 μ + MissingEt + 2 b-jets + 1 quark-gluon-jet passing tau ID cuts.

	N_{evt} $(100\ pb^{-1})$						
	$W(\mu\nu_\mu)b\bar{b}+1p$		$W(\mu\nu_\mu)b\bar{b}+2p$		$W(\mu\nu_\mu)b\bar{b}+3p$		$W(\mu\nu_\mu)b\bar{b}+1,2,3p$
	229 ± 15	0.00 ± 0.00	133 ± 4	0.00 ± 0.00	88 ± 5	0.00 ± 0.00	450 ± 16
$1\ \mu\ P_T > 20\ GeV$	121 ± 11	0.53 ± 0.05	72 ± 3	0.54 ± 0.02	48 ± 4	0.54 ± 0.04	241 ± 12
$1\ \tau\ P_T > 15\ GeV$	34 ± 6	0.28 ± 0.05	24 ± 2	0.33 ± 0.02	17 ± 2	0.36 ± 0.05	75 ± 6
Tau ID	12 ± 3	0.35 ± 0.10	4 ± 1	0.17 ± 0.03	2 ± 1	0.10 ± 0.04	18 ± 4
$E_T^{1st\ jet} > 50\ GeV$	3 ± 2	0.25 ± 0.14	3 ± 1	0.74 ± 0.13	1 ± 1	0.83 ± 0.37	7 ± 2
$E_T^{2nd\ jet} > 30\ GeV$	3 ± 2	1.00 ± 0.58	3 ± 1	1.00 ± 0.18	1 ± 1	1.00 ± 0.45	7 ± 2
$\not{E}_T > 25$	1 ± 1	0.33 ± 0.33	3 ± 1	0.90 ± 0.17	1 ± 1	1.00 ± 0.45	5 ± 1
$H_T > 250\ GeV$	1 ± 1	1.00 ± 1.00	3 ± 0	0.93 ± 0.18	1 ± 1	1.00 ± 0.45	5 ± 1
Z veto	1 ± 1	1.00 ± 1.00	2 ± 0	0.96 ± 0.19	1 ± 1	1.00 ± 0.45	5 ± 1
Opposite Charge	1 ± 1	1.00 ± 1.00	1 ± 0	0.44 ± 0.13	1 ± 0	0.60 ± 0.35	3 ± 1
1 btag w>3	1 ± 1	1.00 ± 1.00	1 ± 0	0.73 ± 0.26	1 ± 0	1.00 ± 0.58	3 ± 1
1 btag w>5	1 ± 1	1.00 ± 1.00	1 ± 0	0.55 ± 0.22	1 ± 0	1.00 ± 0.58	2 ± 1
1 btag w>7	1 ± 1	1.00 ± 1.00	1 ± 0	0.55 ± 0.22	1 ± 0	1.00 ± 0.58	2 ± 1
2 btags w>3	1 ± 1	1.00 ± 1.00	0 ± 0	0.27 ± 0.16	0 ± 0	0.00 ± 0.00	1 ± 1
2 btags w>5	1 ± 1	1.00 ± 1.00	0 ± 0	0.18 ± 0.13	0 ± 0	0.00 ± 0.00	1 ± 1
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.09 ± 0.09	0 ± 0	0.00 ± 0.00	0 ± 0

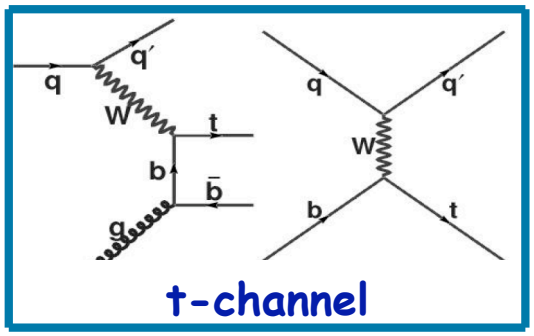
SingleTop Background



Wt-channel



s-channel



t-channel

- Wt:
  - W(→e/μ/+τ,ν),t→W(→qq´)b
  - 1lepton (e/μ) + 1 b-jets + 0,2 non-b jets + MET + 1 fake/real tau
- s-channel:
  - [t→W(→e/μ+ν)b]b
  - 1lepton (e/μ) + 2 b-jets + MET + 1 fake tau
- t-channel:
  - [t→W(→e/μ+ν)b]b,q´
  - 1lepton (e/μ) + 1,2 b-jets + 1 non-b jet + MET + 1 fake tau

SingleTop (e,τ_{had})

	N_{evt} $(100\ pb^{-1})$						
	$W(e\nu_e)t$		$s-$channel		$t-$channel		SingleTop
	972 ± 24	0.00 ± 0.00	120 ± 3	0.00 ± 0.00	2279 ± 62	0.00 ± 0.00	3371 ± 66
1 e $P_T > 20\ GeV$	564 ± 18	0.58 ± 0.02	56 ± 2	0.46 ± 0.02	1238 ± 46	0.54 ± 0.02	1857 ± 49
1 τ $P_T > 15\ GeV$	216 ± 11	0.38 ± 0.02	15 ± 1	0.28 ± 0.02	358 ± 25	0.29 ± 0.02	590 ± 27
Tau ID	38 ± 5	0.18 ± 0.02	2 ± 0	0.11 ± 0.02	50 ± 9	0.14 ± 0.03	91 ± 10
$E_T^{1st\ jet} > 50\ GeV$	31 ± 4	0.82 ± 0.11	1 ± 0	0.52 ± 0.16	35 ± 8	0.70 ± 0.15	68 ± 9
$E_T^{2nd\ jet} > 30\ GeV$	31 ± 4	1.00 ± 0.14	1 ± 0	1.00 ± 0.30	35 ± 8	1.00 ± 0.22	68 ± 9
$\not\!\!E_T > 25$	27 ± 4	0.87 ± 0.13	1 ± 0	0.91 ± 0.29	30 ± 7	0.86 ± 0.20	58 ± 8
$H_T > 250\ GeV$	26 ± 4	0.94 ± 0.14	1 ± 0	0.70 ± 0.26	20 ± 6	0.67 ± 0.19	46 ± 7
Z veto	25 ± 4	0.98 ± 0.15	0 ± 0	0.86 ± 0.35	20 ± 6	1.00 ± 0.29	46 ± 7
Opposite Charge	12 ± 3	0.47 ± 0.10	0 ± 0	0.33 ± 0.24	12 ± 4	0.58 ± 0.22	24 ± 5
1 btag w>3	7 ± 2	0.60 ± 0.17	0 ± 0	1.00 ± 0.71	5 ± 3	0.43 ± 0.25	12 ± 4
1 btag w>5	6 ± 2	0.55 ± 0.17	0 ± 0	1.00 ± 0.71	5 ± 3	0.43 ± 0.25	12 ± 3
1 btag w>7	5 ± 2	0.45 ± 0.15	0 ± 0	1.00 ± 0.71	5 ± 3	0.43 ± 0.25	10 ± 3
2 btags w>3	2 ± 1	0.15 ± 0.09	0 ± 0	0.50 ± 0.50	3 ± 2	0.29 ± 0.20	5 ± 3
2 btags w>5	1 ± 1	0.10 ± 0.07	0 ± 0	0.50 ± 0.50	2 ± 2	0.14 ± 0.14	3 ± 2
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.50 ± 0.50	2 ± 2	0.14 ± 0.14	2 ± 2

SingleTop (μ,τ_{had})

	N_{evt} $(100\ pb^{-1})$						
	$W(\mu\nu_\mu)t$		$s-$channel		$t-$channel		SingleTop
	979 ± 24	0.00 ± 0.00	112 ± 3	0.00 ± 0.00	2399 ± 64	0.00 ± 0.00	3489 ± 68
$\mu\ P_T > 20\ GeV$	730 ± 21	0.75 ± 0.02	65 ± 2	0.58 ± 0.02	1635 ± 52	0.68 ± 0.02	2431 ± 56
$1\ \tau\ P_T > 15\ GeV$	268 ± 12	0.37 ± 0.02	15 ± 1	0.23 ± 0.02	422 ± 27	0.26 ± 0.02	705 ± 29
Tau ID	48 ± 5	0.18 ± 0.02	2 ± 0	0.13 ± 0.03	71 ± 11	0.17 ± 0.03	120 ± 12
$E_T^{1st\ jet} > 50\ GeV$	42 ± 5	0.88 ± 0.10	1 ± 0	0.78 ± 0.18	62 ± 10	0.88 ± 0.14	106 ± 11
$E_T^{2nd\ jet} > 30\ GeV$	42 ± 5	1.00 ± 0.12	1 ± 0	1.00 ± 0.24	62 ± 10	1.00 ± 0.16	106 ± 11
$\not\!\!E_T > 25$	37 ± 5	0.88 ± 0.11	1 ± 0	0.61 ± 0.18	49 ± 9	0.78 ± 0.15	86 ± 10
$H_T > 250\ GeV$	34 ± 4	0.94 ± 0.12	1 ± 0	0.82 ± 0.27	47 ± 9	0.97 ± 0.18	82 ± 10
Z veto	33 ± 4	0.97 ± 0.13	1 ± 0	1.00 ± 0.33	47 ± 9	1.00 ± 0.19	81 ± 10
Opposite Charge	13 ± 3	0.40 ± 0.08	0 ± 0	0.00 ± 0.00	17 ± 5	0.36 ± 0.11	30 ± 6
1 btag w>3	6 ± 2	0.48 ± 0.14	0 ± 0	0.00 ± 0.00	8 ± 4	0.50 ± 0.22	15 ± 4
1 btag w>5	5 ± 2	0.35 ± 0.12	0 ± 0	0.00 ± 0.00	8 ± 4	0.50 ± 0.22	13 ± 4
1 btag w>7	4 ± 2	0.30 ± 0.12	0 ± 0	0.00 ± 0.00	5 ± 3	0.30 ± 0.17	9 ± 3
2 btags w>3	1 ± 1	0.04 ± 0.04	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	1 ± 1
2 btags w>5	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0

TopView

W+jets Tau1p3p

	N_{ent} (100 pb^{-1})							
	$W(e\nu_e)+Np0$	$W(e\nu_e)+Np1$	$W(e\nu_e)+Np2$	$W(e\nu_e)+Np3$	$W(e\nu_e)+Np4$	$W(e\nu_e)+Np5$	$W(e\nu_e)+Np$	$t\bar{t}(e\tau_h)$
	0 ± 0	164502 ± 832	58632 ± 266	17649 ± 80	4929 ± 28	1775 ± 10	247486 ± 878	1210 ± 24
1 e/μ $P_T > 20$ GeV	0 ± 0	74047 ± 558	26964 ± 180	7974 ± 54	2256 ± 19	812 ± 7	112053 ± 589	514 ± 16
1 τ $P_T > 15$ GeV	0 ± 0	10068 ± 206	5528 ± 82	2068 ± 27	654 ± 10	236 ± 4	18554 ± 223	181 ± 9
Tau ID	0 ± 0	3383 ± 119	1522 ± 43	486 ± 13	128 ± 4	46 ± 2	5564 ± 128	67 ± 6
$E_T^{1st\ jet} > 50$ GeV	0 ± 0	130 ± 23	543 ± 26	275 ± 10	99 ± 4	35 ± 1	1083 ± 36	59 ± 5
$E_T^{2nd\ jet} > 30$ GeV	0 ± 0	17 ± 8	335 ± 20	219 ± 9	92 ± 4	33 ± 1	695 ± 24	57 ± 5
$\not\!\!E_T > 25$	0 ± 0	8 ± 6	282 ± 18	179 ± 8	81 ± 4	29 ± 1	579 ± 21	49 ± 5
$H_T > 250$ GeV	0 ± 0	0 ± 0	83 ± 10	101 ± 6	68 ± 3	24 ± 1	276 ± 12	44 ± 5
Z veto	0 ± 0	0 ± 0	69 ± 9	92 ± 6	61 ± 3	22 ± 1	244 ± 11	35 ± 4
Opposite Charge	0 ± 0	0 ± 0	33 ± 6	43 ± 4	29 ± 2	10 ± 1	115 ± 8	26 ± 4
1 btag w>3	0 ± 0	0 ± 0	8 ± 3	7 ± 2	3 ± 1	1 ± 0	20 ± 4	17 ± 3
1 btag w>5	0 ± 0	0 ± 0	7 ± 3	3 ± 1	2 ± 1	1 ± 0	12 ± 3	14 ± 3
1 btag w>7	0 ± 0	0 ± 0	6 ± 3	1 ± 1	1 ± 0	0 ± 0	9 ± 3	12 ± 2
2 btags w>3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3 ± 1
2 btags w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1

	N_{ent} (100 pb^{-1})							
	$W(\mu\nu_\mu)+Np0$	$W(\mu\nu_\mu)+Np1$	$W(\mu\nu_\mu)+Np2$	$W(\mu\nu_\mu)+Np3$	$W(\mu\nu_\mu)+Np4$	$W(\mu\nu_\mu)+Np5$	$W(\mu\nu_\mu)+Np$	$t\bar{t}(\mu\tau_h)$
	0 ± 0	162529 ± 736	58797 ± 264	17389 ± 79	5037 ± 28	1806 ± 18	247531 ± 787	1231 ± 25
1 e/μ $P_T > 20$ GeV	0 ± 0	120208 ± 633	43126 ± 226	12533 ± 67	3573 ± 24	1242 ± 15	134521 ± 676	739 ± 19
1 τ $P_T > 15$ GeV	0 ± 0	79564 ± 515	28378 ± 177	7097 ± 51	1875 ± 17	611 ± 11	46029 ± 547	372 ± 14
Tau ID	0 ± 0	24414 ± 285	7532 ± 95	1882 ± 26	458 ± 9	136 ± 5	13392 ± 302	108 ± 7
$E_T^{1st\ jet} > 50$ GeV	0 ± 0	987 ± 57	2728 ± 57	1132 ± 20	358 ± 8	123 ± 5	4471 ± 84	88 ± 7
$E_T^{2nd\ jet} > 30$ GeV	0 ± 0	163 ± 23	1644 ± 44	917 ± 18	325 ± 7	118 ± 5	3021 ± 54	79 ± 6
$\not\!\!E_T > 25$	0 ± 0	110 ± 19	1288 ± 39	749 ± 16	262 ± 6	102 ± 4	2409 ± 47	73 ± 6
$H_T > 250$ GeV	0 ± 0	27 ± 9	515 ± 25	486 ± 13	220 ± 6	99 ± 4	1319 ± 30	65 ± 6
Z veto	0 ± 0	27 ± 9	501 ± 24	475 ± 13	216 ± 6	96 ± 4	1287 ± 30	55 ± 5
Opposite Charge	0 ± 0	0 ± 0	14 ± 4	23 ± 3	13 ± 1	6 ± 1	56 ± 5	7 ± 2
1 btag w>3	0 ± 0	0 ± 0	1 ± 1	3 ± 1	2 ± 1	1 ± 0	7 ± 2	5 ± 2
1 btag w>5	0 ± 0	0 ± 0	1 ± 1	3 ± 1	2 ± 1	0 ± 0	6 ± 2	5 ± 2
1 btag w>7	0 ± 0	0 ± 0	1 ± 1	1 ± 1	1 ± 0	0 ± 0	3 ± 1	6 ± 2
2 btags w>3	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	2 ± 1	1 ± 1
2 btags w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1

Efficiency W+jets Tau1p3p

	efficiencies					
	$W(\mu\nu_\mu)+Np0$	$W(\mu\nu_\mu)+Np1$	$W(\mu\nu_\mu)+Np2$	$W(\mu\nu_\mu)+Np3$	$W(\mu\nu_\mu)+Np4$	$W(\mu\nu_\mu)+Np5$
	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
1 e/μ $P_T > 20\ GeV$	0.00 ± 0.00	0.74 ± 0.00	0.73 ± 0.00	0.72 ± 0.00	0.71 ± 0.00	0.69 ± 0.00
1 τ $P_T > 15\ GeV$	0.00 ± 0.00	0.66 ± 0.00	0.61 ± 0.00	0.57 ± 0.00	0.52 ± 0.00	0.49 ± 0.01
Tau ID	0.00 ± 0.00	0.31 ± 0.00	0.29 ± 0.00	0.27 ± 0.00	0	0.22 ± 0.01
$E_T^{1st\ jet} > 50\ GeV$	0.00 ± 0.00	0.04 ± 0.00	0.36 ± 0.01	0.60 ± 0.01	0	0.91 ± 0.01
$E_T^{2nd\ jet} > 30\ GeV$	0.00 ± 0.00	0.17 ± 0.02	0.60 ± 0.01	0.81 ± 0.01	0	0.96 ± 0.01
$\not\!\!E_T > 25$	0.00 ± 0.00	0.67 ± 0.07	0.78 ± 0.01	0.82 ± 0.01	0	0.87 ± 0.01
$H_T > 250\ GeV$	0.00 ± 0.00	0.24 ± 0.07	0.40 ± 0.01	0.65 ± 0.01	0	0.97 ± 0.01
Z veto	0.00 ± 0.00	1.00 ± 0.00	0.97 ± 0.01	0.98 ± 0.00	0.98 ± 0.00	0.97 ± 0.01
Opposite Charge	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.01	0.05 ± 0.01	0.06 ± 0.01	0.07 ± 0.01
1 btag w>3	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.08	0.14 ± 0.04	0.17 ± 0.04	0.09 ± 0.05
1 btag w>5	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.08	0.11 ± 0.04	0.15 ± 0.04	0.06 ± 0.04
1 btag w>7	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.08	0.05 ± 0.03	0.09 ± 0.03	0.00 ± 0.00
2 btags w>3	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.08	0.00 ± 0.00	0.01 ± 0.01	0.03 ± 0.03
2 btags w>5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00
2 btags w>7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00

W+jets TauRec

	N_{evt} (100 pb^{-1})							
	$W(e\nu_e)+Np0$	$W(e\nu_e)+Np1$	$W(e\nu_e)+Np2$	$W(e\nu_e)+Np3$	$W(e\nu_e)+Np4$	$W(e\nu_e)+Np5$	$W(e\nu_e)+Np$	$t\bar{t}(e\tau_h)$
	0 ± 0	164502 ± 832	58632 ± 266	17649 ± 80	4929 ± 28	1775 ± 18	247487 ± 878	1210 ± 25
1 e/μ $P_T > 20$ GeV	0 ± 0	74047 ± 558	26964 ± 180	7974 ± 54	2256 ± 19	812 ± 12	112052 ± 589	512 ± 16
1 τ $P_T > 15$ GeV	0 ± 0	15689 ± 257	7945 ± 98	2696 ± 31	817 ± 11	292 ± 7	27439 ± 277	174 ± 9
Tau ID	0 ± 0	454 ± 44	220 ± 16	58 ± 5	12 ± 1	4 ± 1	749 ± 47	33 ± 4
$E_T^{1st\ jet} > 50$ GeV	0 ± 0	13 ± 7	66 ± 9	32 ± 3	8 ± 1	4 ± 1	123 ± 12	30 ± 4
$E_T^{2nd\ jet} > 30$ GeV	0 ± 0	0 ± 0	47 ± 8	25 ± 3	8 ± 1	4 ± 1	84 ± 8	28 ± 4
$\not{E}_T > 25$	0 ± 0	0 ± 0	36 ± 7	19 ± 3	6 ± 1	3 ± 1	64 ± 7	24 ± 3
$H_T > 250$ GeV	0 ± 0	0 ± 0	10 ± 3	12 ± 2	6 ± 1	3 ± 1	30 ± 4	20 ± 3
Z veto	0 ± 0	0 ± 0	10 ± 3	10 ± 2	5 ± 1	2 ± 1	27 ± 4	14 ± 3
Opposite Charge	0 ± 0	0 ± 0	8 ± 3	7 ± 2	4 ± 1	1 ± 0	21 ± 4	13 ± 3
1 btag w>3	0 ± 0	0 ± 0	1 ± 1	1 ± 1	0 ± 0	0 ± 0	2 ± 1	7 ± 2
1 btag w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	7 ± 2
1 btag w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	6 ± 2
2 btags w>3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1
2 btags w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1

	N_{evt} (100 pb^{-1})							
	$W(\mu\nu_\mu)+Np0$	$W(\mu\nu_\mu)+Np1$	$W(\mu\nu_\mu)+Np2$	$W(\mu\nu_\mu)+Np3$	$W(\mu\nu_\mu)+Np4$	$W(\mu\nu_\mu)+Np5$	$W(\mu\nu_\mu)+Np$	$t\bar{t}(\mu\tau_h)$
	0 ± 0	162529 ± 736	58797 ± 264	17389 ± 79	5037 ± 28	1806 ± 18	247531 ± 787	1223 ± 25
1 e/μ $P_T > 20$ GeV	0 ± 0	120208 ± 633	43128 ± 226	12533 ± 67	3573 ± 24	1242 ± 15	134521 ± 676	736 ± 19
1 τ $P_T > 15$ GeV	0 ± 0	28438 ± 297	12694 ± 123	4290 ± 39	1273 ± 14	463 ± 9	34409 ± 324	251 ± 11
Tau ID	0 ± 0	1197 ± 63	430 ± 23	123 ± 7	31 ± 2	8 ± 1	1046 ± 67	51 ± 5
$E_T^{1st\ jet} > 50$ GeV	0 ± 0	183 ± 25	176 ± 14	76 ± 5	25 ± 2	7 ± 1	297 ± 29	45 ± 5
$E_T^{2nd\ jet} > 30$ GeV	0 ± 0	57 ± 14	122 ± 12	66 ± 5	22 ± 2	7 ± 1	218 ± 19	44 ± 5
$\not{E}_T > 25$	0 ± 0	30 ± 10	107 ± 11	55 ± 4	17 ± 2	6 ± 1	185 ± 16	37 ± 4
$H_T > 250$ GeV	0 ± 0	10 ± 6	40 ± 7	37 ± 4	13 ± 1	6 ± 1	[illegible]	[illegible]
Z veto	0 ± 0	10 ± 6	40 ± 7	33 ± 3	12 ± 1	5 ± 1	91 ± 10	24 ± 3
Opposite Charge	0 ± 0	0 ± 0	15 ± 4	11 ± 2	5 ± 1	2 ± 1	33 ± 5	24 ± 3
1 btag w>3	0 ± 0	0 ± 0	1 ± 1	1 ± 1	0 ± 0	0 ± 0	2 ± 1	19 ± 3
1 btag w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	18 ± 3
1 btag w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	18 ± 3
2 btags w>3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	6 ± 2
2 btags w>5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5 ± 2
2 btags w>7	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3 ± 1

Wbb Tau1p3p

	N_{evt} (100 pb^{-1})						
	$W(e\nu_e)b\bar{b}+1p$		$W(e\nu_e)b\bar{b}+2p$		$W(e\nu_e)b\bar{b}+3p$		$W(e\nu_e)b\bar{b}+1,2,3p$
	205.2 ± 4.1	0.00 ± 0.00	125.5 ± 3.5	0.00 ± 0.00	96.3 ± 3.0	0.00 ± 0.00	427 ± 6
1 e/μ $P_T > 20$ *GeV*	72.9 ± 2.4	0.36 ± 0.01	42.5 ± 2.0	0.34 ± 0.01	36.0 ± 1.8	0.37 ± 0.01	151 ± 4
1 τ $P_T > 15$ *GeV*	19.1 ± 1.2	0.26 ± 0.01	13.3 ± 1.1	0.31 ± 0.02	11.6 ± 1.0	0.32 ± 0.02	44 ± 2
Tau ID	4.3 ± 0.6	0.23 ± 0.03	3.0 ± 0.5	0.23 ± 0.04	1.6 ± 0.4	0.13 ± 0.03	9 ± 1
$E_T^{1st\ jet} > 50$ *GeV*	2.2 ± 0.4	0.51 ± 0.07	2.3 ± 0.5	0.74 ± 0.08	1.1 ± 0.3	0.71 ± 0.11	6 ± 1
$E_T^{2nd\ jet} > 30$ *GeV*	1.9 ± 0.4	0.85 ± 0.07	2.0 ± 0.4	0.87 ± 0.07	1.0 ± 0.3	0.92 ± 0.08	5 ± 1
$\not{E}_T > 25$	1.5 ± 0.4	0.83 ± 0.08	1.4 ± 0.4	0.70 ± 0.10	0.7 ± 0.3	0.73 ± 0.13	4 ± 1
$H_T > 250$ *GeV*	1.1 ± 0.3	0.68 ± 0.11	1.3 ± 0.4	0.93 ± 0.07	0.7 ± 0.3	1.00 ± 0.00	3 ± 1
Z veto	1.0 ± 0.3	0.92 ± 0.07	1.3 ± 0.4	1.00 ± 0.00	0.6 ± 0.2	0.88 ± 0.12	3 ± 1
Opposite Charge	0.3 ± 0.2	0.33 ± 0.14	0.7 ± 0.3	0.54 ± 0.14	0.4 ± 0.2	0.57 ± 0.19	1 ± 0
1 btag w>3	0.3 ± 0.2	1.00 ± 0.00	0.4 ± 0.2	0.57 ± 0.19	0.3 ± 0.2	0.75 ± 0.22	1 ± 0
1 btag w>5	0.2 ± 0.1	0.75 ± 0.22	0.4 ± 0.2	0.57 ± 0.19	0.3 ± 0.2	0.75 ± 0.22	1 ± 0
1 btag w>7	0.2 ± 0.1	0.50 ± 0.25	0.4 ± 0.2	0.57 ± 0.19	0.3 ± 0.2	0.75 ± 0.22	1 ± 0
2 btags w>3	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	0.14 ± 0.13	0.1 ± 0.1	0.25 ± 0.22	0 ± 0
2 btags w>5	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	0.14 ± 0.13	0.1 ± 0.1	0.25 ± 0.22	0 ± 0
2 btags w>7	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	0.14 ± 0.13	0.1 ± 0.1	0.25 ± 0.22	0 ± 0

	N_{evt} (100 pb^{-1})						
	$W(\mu\nu_\mu)b\bar{b}+1p$		$W(\mu\nu_\mu)b\bar{b}+2p$		$W(\mu\nu_\mu)b\bar{b}+3p$		$W(\mu\nu_\mu)b\bar{b}+1,2,3p$
	200.9 ± 4.0	0.00 ± 0.00	133.4 ± 3.6	0.00 ± 0.00	89.8 ± 2.9	0.00 ± 0.00	424 ± 6
1 e/μ $P_T > 20$ *GeV*	103.7 ± 2.9	0.52 ± 0.01	66.6 ± 2.6	0.50 ± 0.01	47.2 ± 2.1	0.53 ± 0.02	218 ± 4
1 τ $P_T > 15$ *GeV*	58.3 ± 2.2	0.56 ± 0.01	34.4 ± 1.8	0.52 ± 0.02	24.4 ± 1.5	0.52 ± 0.02	117 ± 3
Tau ID	14.7 ± 1.1	0.25 ± 0.02	8.2 ± 0.9	0.24 ± 0.02	5.4 ± 0.7	0.22 ± 0.03	28 ± 2
$E_T^{1st\ jet} > 50$ *GeV*	7.0 ± 0.8	0.48 ± 0.04	5.8 ± 0.8	0.70 ± 0.05	5.0 ± 0.7	0.93 ± 0.03	18 ± 1
$E_T^{2nd\ jet} > 30$ *GeV*	5.2 ± 0.7	0.74 ± 0.05	5.1 ± 0.7	0.88 ± 0.04	5.0 ± 0.7	1.00 ± 0.00	15 ± 1
$\not{E}_T > 25$	4.4 ± 0.6	0.84 ± 0.05	4.2 ± 0.6	0.83 ± 0.05	4.2 ± 0.6	0.83 ± 0.05	13 ± 1
$H_T > 250$ *GeV*	2.8 ± 0.5	0.63 ± 0.07	3.6 ± 0.6	0.86 ± 0.05	3.9 ± 0.6	0.93 ± 0.04	10 ± 1
Z veto	2.5 ± 0.5	0.91 ± 0.05	3.4 ± 0.6	0.95 ± 0.04	3.5 ± 0.6	0.90 ± 0.05	9 ± 1
Opposite Charge	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	0.03 ± 0.03	0.6 ± 0.2	0.18 ± 0.06	1 ± 0
1 btag w>3	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0.3 ± 0.2	0.43 ± 0.19	0 ± 0
1 btag w>5	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0.2 ± 0.1	0.29 ± 0.17	0 ± 0
1 btag w>7	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0.2 ± 0.1	0.29 ± 0.17	0 ± 0
2 btags w>3	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
2 btags w>5	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
2 btags w>7	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0

Wbb TauRec

	N_{evt} (100 pb^{-1})						
	$W(e\nu_e)b\bar{b}+1p$		$W(e\nu_e)b\bar{b}+2p$		$W(e\nu_e)b\bar{b}+3p$		$W(e\nu_e)b\bar{b}+1,2,3p$
	205.2 ± 4.1	0.00 ± 0.00	125.5 ± 3.5	0.00 ± 0.00	96.3 ± 3.0	0.00 ± 0.00	427 ± 6
1 e/μ $P_T > 20$ *GeV*	72.9 ± 2.4	0.36 ± 0.01	42.5 ± 2.0	0.34 ± 0.01	36.0 ± 1.8	0.37 ± 0.01	151 ± 4
1 τ $P_T > 15$ *GeV*	24.4 ± 1.4	0.33 ± 0.02	14.5 ± 1.2	0.34 ± 0.02	13.0 ± 1.1	0.36 ± 0.02	52 ± 2
Tau ID	0.3 ± 0.2	0.01 ± 0.01	0.4 ± 0.2	0.03 ± 0.01	0.1 ± 0.1	0.01 ± 0.01	1 ± 0
$E_T^{1st\ jet} > 50$ *GeV*	0.0 ± 0.0	0.00 ± 0.00	0.4 ± 0.2	1.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
$E_T^{2nd\ jet} > 30$ *GeV*	0.0 ± 0.0	0.00 ± 0.00	0.3 ± 0.2	0.75 ± 0.22	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
$\not{E}_T > 25$	0.0 ± 0.0	0.00 ± 0.00	0.3 ± 0.2	1.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
$H_T > 250$ *GeV*	0.0 ± 0.0	0.00 ± 0.00	0.3 ± 0.2	1.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
Z veto	0.0 ± 0.0	0.00 ± 0.00	0.3 ± 0.2	1.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
Opposite Charge	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
1 btag w>3	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
1 btag w>5	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
1 btag w>7	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
2 btags w>3	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
2 btags w>5	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
2 btags w>7	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0

	N_{evt} (100 pb^{-1})						
	$W(\mu\nu_\mu)b\bar{b}+1p$		$W(\mu\nu_\mu)b\bar{b}+2p$		$W(\mu\nu_\mu)b\bar{b}+3p$		$W(\mu\nu_\mu)b\bar{b}+1,2,3p$
	200.9 ± 4.0	0.00 ± 0.00	133.4 ± 3.6	0.00 ± 0.00	89.8 ± 2.9	0.00 ± 0.00	424 ± 6
1 e/μ $P_T > 20$ *GeV*	103.7 ± 2.9	0.52 ± 0.01	66.6 ± 2.6	0.50 ± 0.01	47.2 ± 2.1	0.53 ± 0.02	218 ± 4
1 τ $P_T > 15$ *GeV*	30.1 ± 1.6	0.29 ± 0.01	23.9 ± 1.5	0.36 ± 0.02	16.5 ± 1.2	0.35 ± 0.02	71 ± 3
Tau ID	1.0 ± 0.3	0.03 ± 0.01	0.3 ± 0.2	0.01 ± 0.01	0.1 ± 0.1	0.01 ± 0.01	1 ± 0
$E_T^{1st\ jet} > 50$ *GeV*	0.4 ± 0.2	0.42 ± 0.14	0.2 ± 0.1	0.67 ± 0.27	0.1 ± 0.1	1.00 ± 0.00	1 ± 0
$E_T^{2nd\ jet} > 30$ *GeV*	0.2 ± 0.1	0.40 ± 0.22	0.2 ± 0.1	1.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
$\not{E}_T > 25$	0.2 ± 0.1	1.00 ± 0.00	0.1 ± 0.1	0.50 ± 0.35	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
$H_T > 250$ *GeV*	0.1 ± 0.1	0.50 ± 0.35	0.0 ± 0.0	0.00 ± 0.00	0.1 ± 0.1	1.00 ± 0.00	0 ± 0
Z veto	0.1 ± 0.1	1.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
Opposite Charge	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
1 btag w>3	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
1 btag w>5	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
1 btag w>7	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
2 btags w>3	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
2 btags w>5	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0
2 btags w>7	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0.0 ± 0.0	0.00 ± 0.00	0 ± 0

SingleTop Tau1p3p

	N_{evt} (100 pb^{-1})						
	$W(e\nu_e)t$		$s-$ channel		$t-$ channel		SingleTop
	978 ± 15	0.00 ± 0.00	121 ± 2	0.00 ± 0.00	1960 ± 29	0.00 ± 0.00	3059 ± 2194
1 e/μ $P_T > 20$ GeV	471 ± 10	0.48 ± 0.01	48 ± 1	0.40 ± 0.01	841 ± 19	0.43 ± 0.01	1360 ± 965
1 τ $P_T > 15$ GeV	147 ± 6	0.31 ± 0.01	10 ± 1	0.21 ± 0.01	193 ± 9	0.23 ± 0.01	349 ± 242
Tau ID	23 ± 2	0.16 ± 0.01	1 ± 0	0.14 ± 0.02	23 ± 3	0.12 ± 0.02	48 ± 33
$E_T^{1st\ jet} > 50$ GeV	19 ± 2	0.83 ± 0.04	1 ± 0	0.70 ± 0.08	22 ± 3	0.94 ± 0.03	42 ± 29
$E_T^{2nd\ jet} > 30$ GeV	17 ± 2	0.92 ± 0.03	1 ± 0	0.85 ± 0.07	20 ± 3	0.90 ± 0.04	38 ± 26
$\not\!\!E_T > 25$	14 ± 2	0.81 ± 0.04	1 ± 0	0.86 ± 0.07	18 ± 3	0.89 ± 0.05	33 ± 23
$H_T > 250$ GeV	12 ± 2	0.82 ± 0.05	0 ± 0	0.68 ± 0.11	13 ± 2	0.71 ± 0.07	25 ± 17
Z veto	11 ± 2	0.98 ± 0.02	0 ± 0	0.85 ± 0.10	12 ± 2	0.93 ± 0.05	24 ± 16
Opposite Charge	5 ± 1	0.47 ± 0.07	0 ± 0	0.55 ± 0.15	6 ± 2	0.52 ± 0.10	12 ± 8
1 btag w>3	3 ± 1	0.56 ± 0.10	0 ± 0	0.67 ± 0.19	4 ± 1	0.64 ± 0.13	7 ± 5
1 btag w>5	3 ± 1	0.52 ± 0.10	0 ± 0	0.67 ± 0.19	3 ± 1	0.57 ± 0.13	6 ± 4
1 btag w>7	3 ± 1	0.52 ± 0.10	0 ± 0	0.50 ± 0.20	3 ± 1	0.57 ± 0.13	6 ± 4
2 btags w>3	0 ± 0	0.08 ± 0.05	0 ± 0	0.00 ± 0.00	0 ± 0	0.07 ± 0.07	1 ± 1
2 btags w>5	0 ± 0	0.08 ± 0.05	0 ± 0	0.00 ± 0.00	0 ± 0	0.07 ± 0.07	1 ± 1
2 btags w>7	0 ± 0	0.08 ± 0.05	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0

	N_{evt} (100 pb^{-1})						
	$W(\mu\nu_\mu)t$		$s-$ channel		$t-$ channel		SingleTop
	956 ± 14	0.00 ± 0.00	117 ± 2	0.00 ± 0.00	1966 ± 29	0.00 ± 0.00	3040 ± 2190
1 e/μ $P_T > 20$ GeV	654 ± 12	0.68 ± 0.01	70 ± 2	0.60 ± 0.01	1266 ± 23	0.64 ± 0.01	1990 ± 1427
1 τ $P_T > 15$ GeV	354 ± 9	0.54 ± 0.01	44 ± 1	0.62 ± 0.01	792 ± 19	0.63 ± 0.01	1190 ± 869
Tau ID	97 ± 5	0.27 ± 0.01	11 ± 1	0.26 ± 0.01	224 ± 10	0.28 ± 0.01	332 ± 244
$E_T^{1st\ jet} > 50$ GeV	82 ± 4	0.85 ± 0.02	7 ± 1	0.65 ± 0.03	175 ± 9	0.78 ± 0.02	265 ± 194
$E_T^{2nd\ jet} > 30$ GeV	74 ± 4	0.90 ± 0.02	6 ± 0	0.81 ± 0.03	157 ± 8	0.90 ± 0.01	238 ± 174
$\not\!\!E_T > 25$	60 ± 4	0.81 ± 0.02	5 ± 0	0.84 ± 0.03	132 ± 8	0.84 ± 0.02	197 ± 145
$H_T > 250$ GeV	49 ± 3	0.82 ± 0.02	3 ± 0	0.58 ± 0.04	99 ± 7	0.75 ± 0.02	151 ± 111
Z veto	48 ± 3	0.97 ± 0.01	3 ± 0	0.96 ± 0.02	96 ± 6	0.97 ± 0.01	147 ± 107
Opposite Charge	2 ± 1	0.05 ± 0.01	0 ± 0	0.01 ± 0.01	0 ± 0	0.00 ± 0.00	2 ± 2
1 btag w>3	1 ± 0	0.45 ± 0.15	0 ± 0	1.00 ± 0.00	0 ± 0	0.00 ± 0.00	1 ± 1
1 btag w>5	1 ± 0	0.45 ± 0.15	0 ± 0	1.00 ± 0.00	0 ± 0	0.00 ± 0.00	1 ± 1
1 btag w>7	1 ± 0	0.45 ± 0.15	0 ± 0	1.00 ± 0.00	0 ± 0	0.00 ± 0.00	1 ± 1
2 btags w>3	0 ± 0	0.09 ± 0.09	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>5	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0

SingleTop TauRec

	N_{evt} (100 pb^{-1})						
	$W(e\nu_e)t$		$s-$channel		$t-$channel		SingleTop
	1264 ± 16	0.00 ± 0.00	121 ± 2	0.00 ± 0.00	2380 ± 32	0.00 ± 0.00	3765 ± 2698
1 e/μ $P_T > 20$ *GeV*	831 ± 13	0.66 ± 0.01	48 ± 1	0.40 ± 0.01	1022 ± 21	0.43 ± 0.01	1901 ± 1318
1 τ $P_T > 15$ *GeV*	572 ± 10	0.69 ± 0.01	11 ± 1	0.24 ± 0.01	283 ± 11	0.28 ± 0.01	866 ± 638
Tau ID	2 ± 1	0.00 ± 0.00	0 ± 0	0.01 ± 0.01	5 ± 1	0.02 ± 0.01	7 ± 6
$E_T^{1st\ jet} > 50$ *GeV*	2 ± 1	0.73 ± 0.13	0 ± 0	1.00 ± 0.00	4 ± 1	0.83 ± 0.11	6 ± 5
$E_T^{2nd\ jet} > 30$ *GeV*	2 ± 1	1.00 ± 0.00	0 ± 0	0.75 ± 0.22	4 ± 1	0.90 ± 0.09	6 ± 4
$\not{E}_T > 25$	1 ± 1	0.88 ± 0.12	0 ± 0	1.00 ± 0.00	2 ± 1	0.44 ± 0.17	3 ± 2
$H_T > 250$ *GeV*	1 ± 0	0.71 ± 0.17	0 ± 0	0.67 ± 0.27	1 ± 1	0.75 ± 0.22	2 ± 2
Z veto	1 ± 0	0.80 ± 0.18	0 ± 0	1.00 ± 0.00	1 ± 1	0.67 ± 0.27	2 ± 1
Opposite Charge	1 ± 0	1.00 ± 0.00	0 ± 0	1.00 ± 0.00	1 ± 1	1.00 ± 0.00	2 ± 1
1 btag w>3	1 ± 0	0.75 ± 0.22	0 ± 0	1.00 ± 0.00	1 ± 1	1.00 ± 0.00	2 ± 1
1 btag w>5	1 ± 0	0.75 ± 0.22	0 ± 0	1.00 ± 0.00	1 ± 1	1.00 ± 0.00	2 ± 1
1 btag w>7	0 ± 0	0.50 ± 0.25	0 ± 0	1.00 ± 0.00	1 ± 1	1.00 ± 0.00	1 ± 1
2 btags w>3	0 ± 0	0.25 ± 0.22	0 ± 0	1.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>5	0 ± 0	0.25 ± 0.22	0 ± 0	0.50 ± 0.35	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>7	0 ± 0	0.25 ± 0.22	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0

	N_{evt} (100 pb^{-1})						
	$W(\mu\nu_\mu)t$		$s-$channel		$t-$channel		SingleTop
	817 ± 12	0.00 ± 0.00	117 ± 2	0.00 ± 0.00	2386 ± 32	0.00 ± 0.00	3319 ± 2524
1 e/μ $P_T > 20$ *GeV*	559 ± 10	0.68 ± 0.01	70 ± 2	0.60 ± 0.01	1537 ± 26	0.64 ± 0.01	2166 ± 1637
1 τ $P_T > 15$ *GeV*	196 ± 6	0.35 ± 0.01	17 ± 1	0.24 ± 0.01	426 ± 14	0.28 ± 0.01	639 ± 469
Tau ID	6 ± 1	0.03 ± 0.01	0 ± 0	0.03 ± 0.01	13 ± 2	0.03 ± 0.01	19 ± 14
$E_T^{1st\ jet} > 50$ *GeV*	5 ± 1	0.83 ± 0.07	0 ± 0	0.92 ± 0.08	10 ± 2	0.73 ± 0.08	14 ± 11
$E_T^{2nd\ jet} > 30$ *GeV*	4 ± 1	0.96 ± 0.04	0 ± 0	0.55 ± 0.15	8 ± 2	0.86 ± 0.07	13 ± 9
$\not{E}_T > 25$	3 ± 1	0.65 ± 0.10	0 ± 0	0.50 ± 0.20	6 ± 2	0.79 ± 0.09	9 ± 7
$H_T > 250$ *GeV*	3 ± 1	1.00 ± 0.00	0 ± 0	0.67 ± 0.27	5 ± 1	0.73 ± 0.11	8 ± 6
Z veto	2 ± 1	0.87 ± 0.09	0 ± 0	1.00 ± 0.00	4 ± 1	0.91 ± 0.09	7 ± 5
Opposite Charge	1 ± 0	0.38 ± 0.13	0 ± 0	0.00 ± 0.00	1 ± 1	0.30 ± 0.14	2 ± 2
1 btag w>3	1 ± 0	0.60 ± 0.22	0 ± 0	0.00 ± 0.00	0 ± 0	0.33 ± 0.27	1 ± 1
1 btag w>5	1 ± 0	0.60 ± 0.22	0 ± 0	0.00 ± 0.00	0 ± 0	0.33 ± 0.27	1 ± 1
1 btag w>7	1 ± 0	0.60 ± 0.22	0 ± 0	0.00 ± 0.00	0 ± 0	0.33 ± 0.27	1 ± 1
2 btags w>3	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>5	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0
2 btags w>7	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0	0.00 ± 0.00	0 ± 0