The W $\rightarrow \tau\nu$ analysis

- update for MC08 10 TeV data -

Copenhagen Tau Workshop 2009

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with special thanks to
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Outline

- Physics motivation (CDF results)
- Selection “cut-flow”
  - Trigger selection
  - Estimation of non-QCD background rejection
- QCD background issues – Atlfast II and full-sim
  - QCD rejection studies
- Summary and plans

Motivation (CDF results)

The **$W \to \tau\nu$** process will provide most abundant source of taus in the first 100 pb^{-1} (10x larger σ than for $Z \to \tau\tau$)

Possible measurements:

- Cross-section:

$\sigma(pp \to W) \times BR(W \to \tau\nu)$

CDF: $2.62 \pm 0.07(stat) \pm 0.21(syst) \pm 0.16(lumi)$ nb

- Leptonic branching ratios of the W boson:

$BR(W \to \tau\nu)/BR(W \to e\nu)$

CDF: $0.99 \pm 0.03(stat) \pm 0.07(syst)$

- Ratio of the τ and electron electroweak coupling to charged current:

g_τ/g_e

CDF: $0.99 \pm 0.02(stat) \pm 0.04(syst)$

In ATLAS with 10 TeV:

$\sigma(W \to \tau\nu, \tau \to had)$ = 7.69×10^3 pb

σ(QCD jets) = 1.2×10^{10} pb

S:B = 7×10^{-7}

Such measurements have been performed by CDF – see: Nucl. Phys. B: Proc. Suppl. 144, 323-332 (spires-hep/6099807) – from Run II with 72pb^{-1}

At the LHC:

Signal cross-section: **~10x** higher

Background cross-section: **~100x** higher

Signal extraction will be much harder

Data samples in use

Number	Process	x-sec [nb]	Filter eff.	Events/100pb^{-1}	Events in fullsim	Prod. Tags
106023	$W \to \tau\nu$, $\tau \to$ had	7.69	1.00	7.69E+005	200k	e347_s462_r604
105009	QCD J0 (8 – 17 GeV)	1.18E+07	1.00	1.18E+012	400k	e344_s479_r604
105010	QCD J1 (17 – 35 GeV)	8.69E+05	1.00	8.69E+010	400k	e344_s479_r604
105011	QCD J2 (35 – 70 GeV)	5.59E+04	1.00	5.59E+009	400k	e344_s479_r604
105012	QCD J3 (70 – 140 GeV)	3.30E+03	1.00	3.30E+008	400k	e344_s479_r604
106020	$W \to e\nu$	11.91	0.85	1.01E+006	1M	e347_s462_r604
106021	$W \to \mu\nu$	11.91	0.85	1.01E+006	600k	e352_s462_r541
106052	$Z \to \tau\tau$	1.13	1.00	1.13E+005	200k	e347_s462_r604
106050	$Z \to ee$	1.14	0.96	1.09E+005	1M	e347_s462_r604
106022	$W \to \tau\nu$, $\tau \to$ lep	4.15	0.87	3.61E+005	200k	e352_s462_r541
105200	ttbar	0.37	0.55	2.05E+004	250k	e357_s462_r579

ATLFAST – 2 (Fast Calo Sim)

105009	QCD J0 (8 – 17 GeV)	1.18E+07	1.00	1.18E+012	40M	e344_a68
105010	QCD J1 (17 – 35 GeV)	8.69E+05	1.00	8.69E+010	40M	e344_a68
105011	QCD J2 (35 – 70 GeV)	5.59E+04	1.00	5.59E+009	40M	e344_a68
105012	QCD J3 (70 – 140 GeV)	3.30E+03	1.00	3.30E+008	10M	e344_a68

Top priority – replace the Atlfast II samples with new ones as soon as possible – **duplicate events bug**

See remarks on next slide

Data samples in use

- All datasets from official **mc08** production (AODs, rel 14.2.2X)
  - Where possible – using **14.2.25.3** production with HEC on and EF E_T^{Miss} bug corrected
  - For ttbar – r579 sample used with HEC on
  - Will update the results after “r635” processing is complete
- Signal sample is **not** filtered
- Processed with: **Athena-14.2.25.3** using:
  - GRID (Panda)
  - IFJ Tier3
- QCD full-sim samples **too small** for detailed rejection studies – need to use Atlfast II samples (14.2.20 official production, full tracking, fast Calo-Sim)
- Atlfast II samples do not contain trigger information – need a normalization factor for trigger efficiency
- Atlfast II samples are affected by the **duplicate events bug**. However – by the time of the workshop they were an only available option to make a full analysis
- All QCD plots and numbers are made with **x-sec weighted** sum of J0 – J3 samples

Trigger Selection

Trigger selection

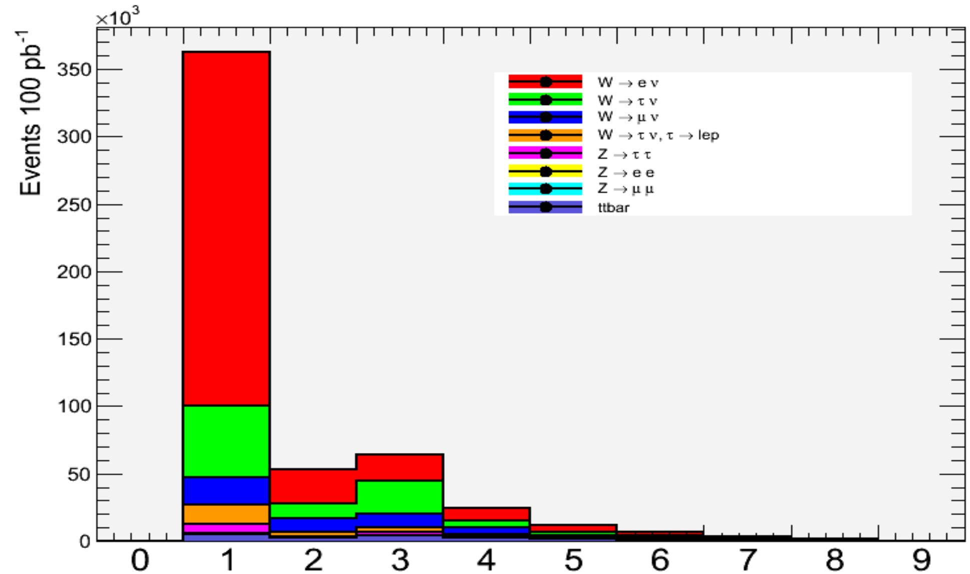
Base trigger menu: tau16i_loose_L1xe15_EFxe30

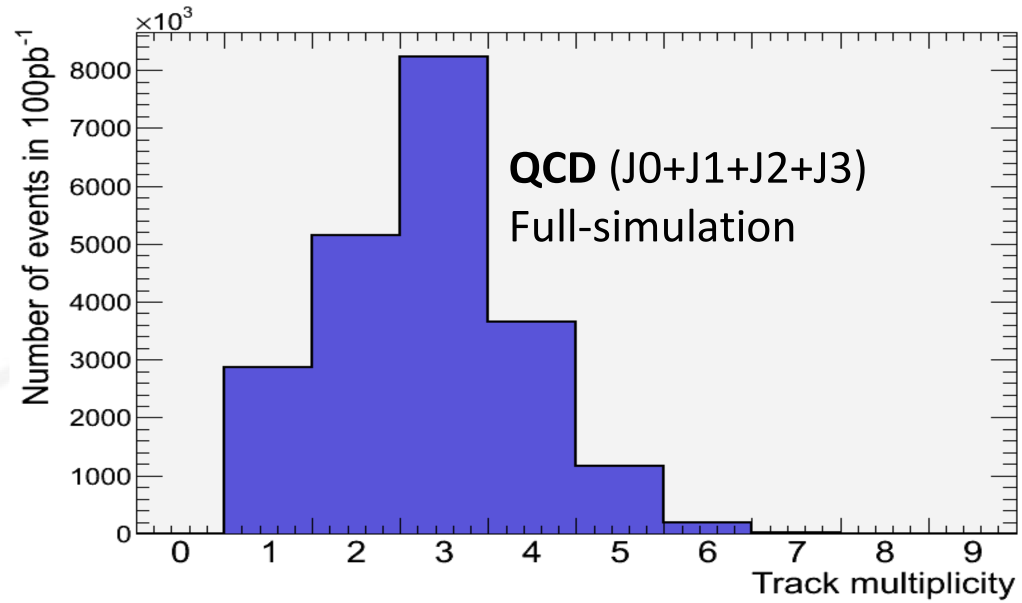
Process	#events in 100 pb^{-1}
W → τν, τ→had	105092
W → eν	418545
W → μν	44987
Z → ττ	10967
Z → ee	1913
Z → μμ	1568
W → τν, τ→lep	35587
ttbar	7170
QCD overall	2.1×10^7

Main non-QCD contribution after trigger selection:

→ W→eν – dominating 1p channel, exceeds the signal by factor **4**

This will be handled in the offline analysis.





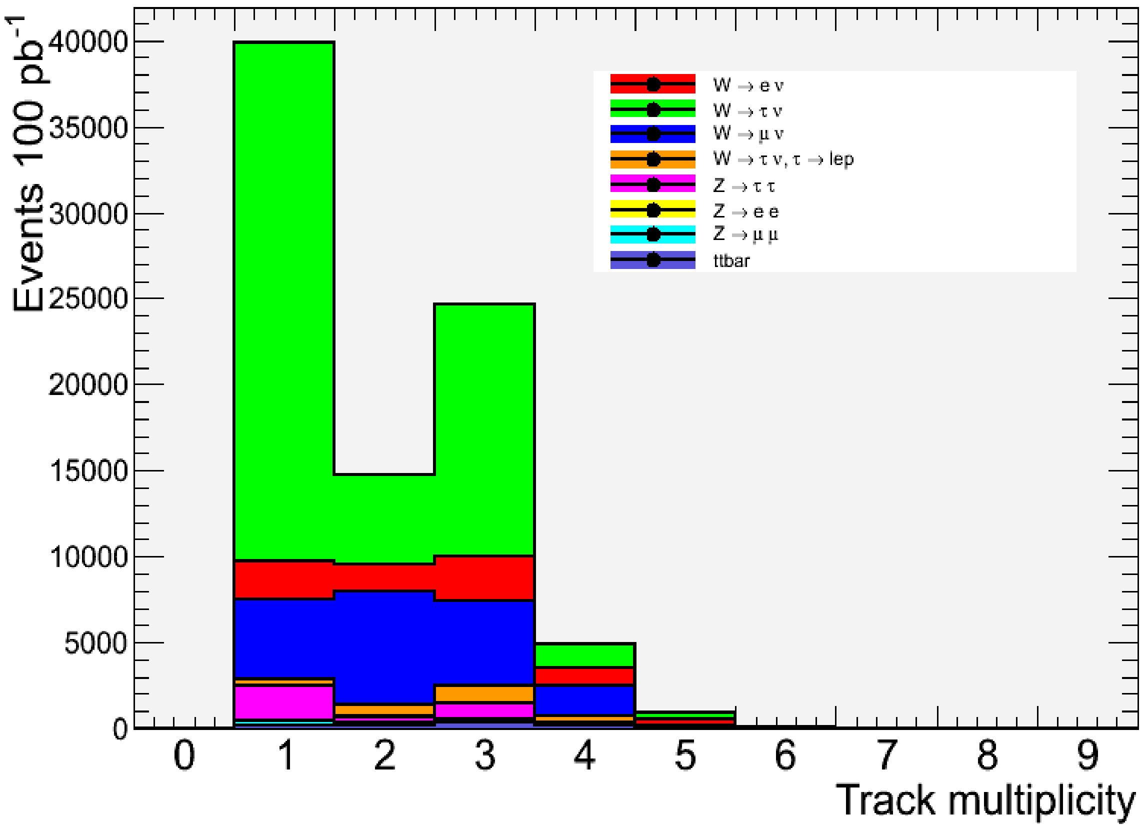
Offline Selection

Basic offline selection vs non-QCD

The "basic" tau selection involves:

- Offline E_T^{Miss} > 30 GeV
- Tau candidate from tau1p3p (track-seeded algorithm) with 20 GeV < p_T < 60 GeV
- Loose cut – based identification
- Basic μ/τ and improved e/τ separation

Process	#events in 100 pb^{-1}
$W \to \tau\nu$, $\tau \to$had	51703
$W \to e\nu$	7787
$W \to \mu\nu$	17348
$Z \to \tau\tau$	3419
$Z \to ee$	6
$Z \to \mu\mu$	706
$W \to \tau\nu$, $\tau \to$lep	3259
ttbar	1395



→Dominant background from $W \to$ lepton

→Need to veto events with muons ($W \to \mu\nu$ contritbution ~30%),

→Using an **improved** electron separation (see next slides)

→Need tighter selection to suppress the background

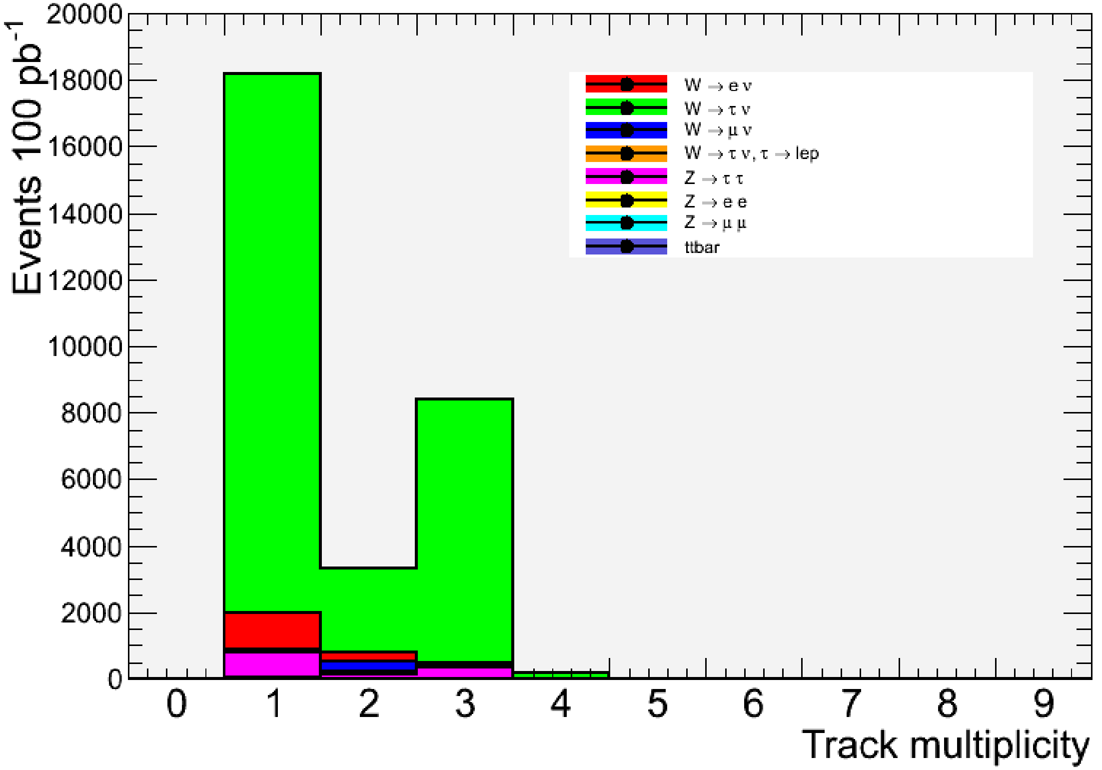
S:B$_{\text{non-QCD}}$ = 1.5

Tighter offline selection vs non-QCD

The "tight" tau selection involves:

- Basic selection cuts
- Tau with EfficNN > 0.3 (medium identification)
- No "loose" electron in $\Delta R > 0.4$ from tau
- No "loose" muon from STACO in $\Delta R > 0.4$ from tau

Process	#events in 100 pb^{-1}
$W \to \tau\nu$, $\tau \to$had	26748
$W \to e\nu$	1522
$W \to \mu\nu$	294
$Z \to \tau\tau$	1166
$Z \to ee$	0
$Z \to \mu\mu$	16
$W \to \tau\nu$, $\tau \to$lep	248
ttbar	74



→Non-QCD background is well suppressed

→Highest contribution from $W \to e\nu$ (6% of signal, mostly in 1p taus),

→$Z \to \tau\tau$ also non-insignificant

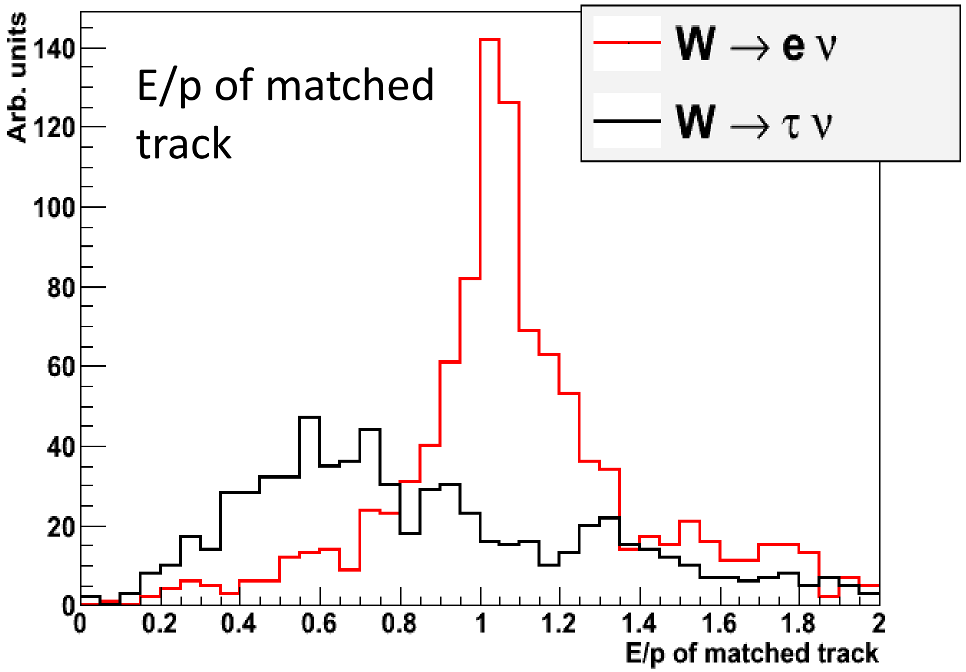
S:B$_{\text{non-QCD}}$ = 8.1

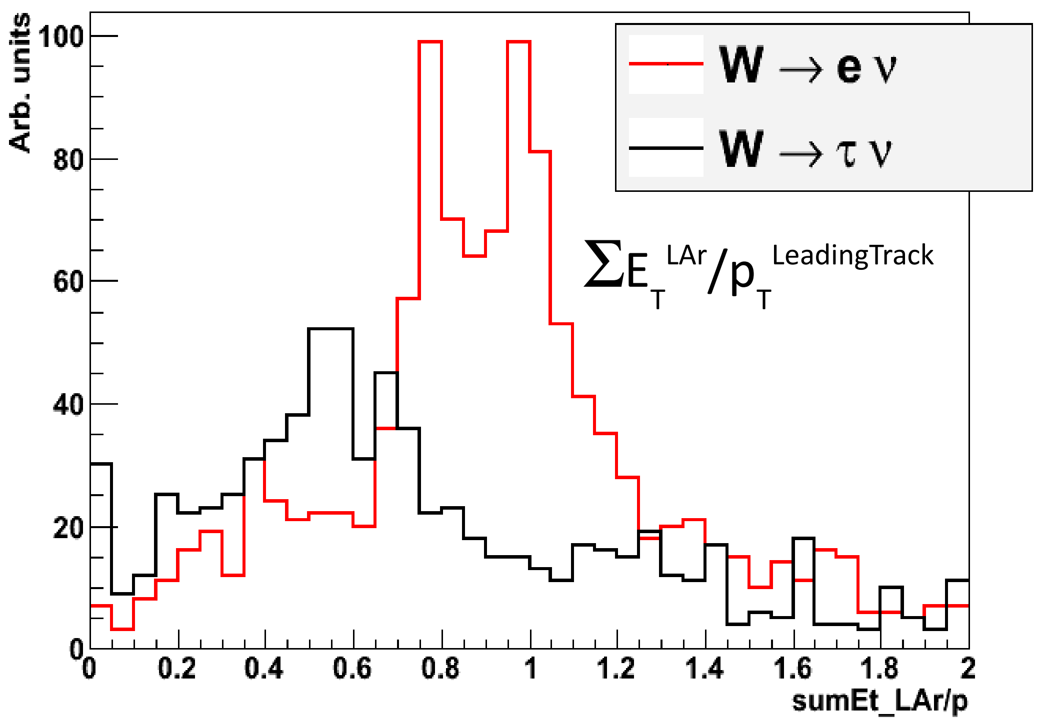
Improved electron veto

The electron rejection in single-prong tau candidates is greatly improved by adding the following cuts:

- $E/p > 0.9$ – from a track matched to tau-candidate
- $\Sigma E_T^{LAr}/p_T^{LeadingTrack} > 0.9$ – from tau-details

Both cuts are applied for 1p candidates with 0 π^0

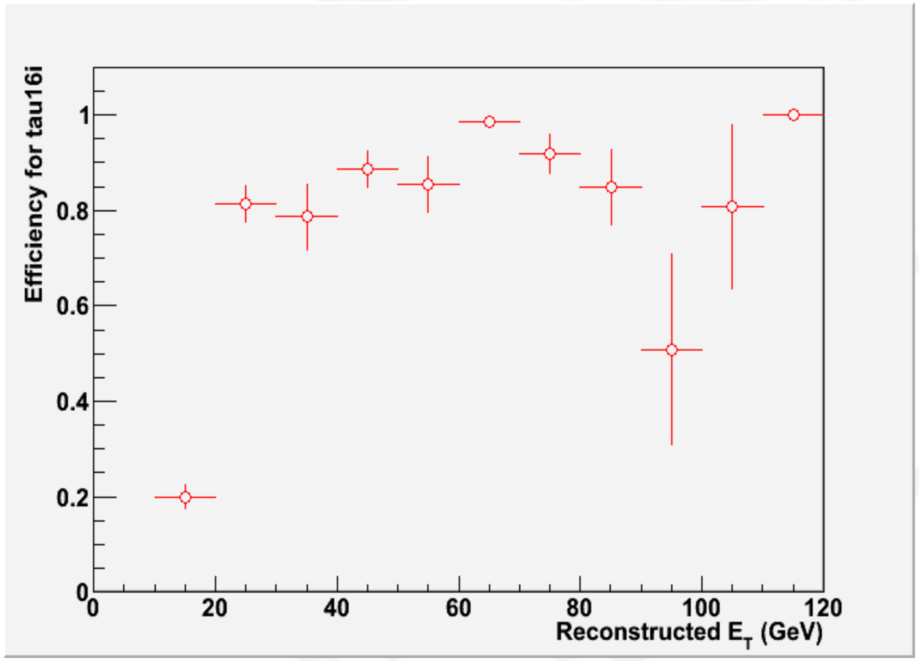




QCD background

Atlfast II vs full-simulation

1. Atlfast II has no trigger simulated – will apply a correction factor derived from full-sim comparisons

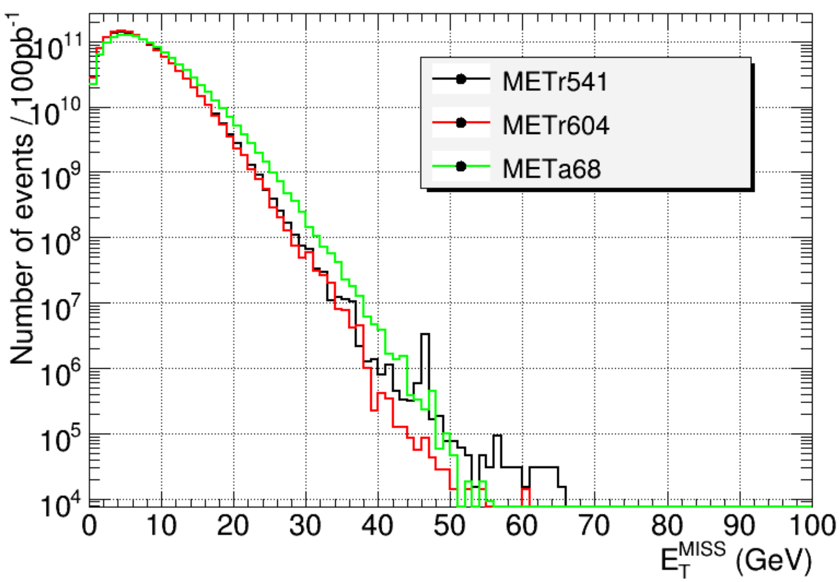


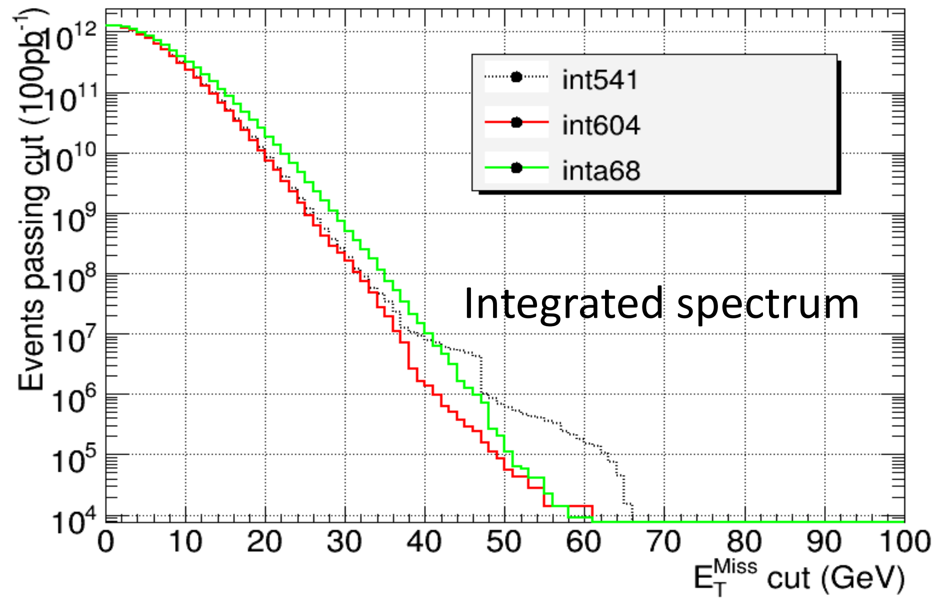
Thanks to **Pilar Casado** for the TOC Tau-trigger part only reproduced here.
MET – part – will be applied when ready.

Tau-trigger scaling factor is estimated to be **0.78** (using final QCD spectrum of tau p_T)

Atlfast II vs full-simulation

2. Differences in offline E_T^{Miss} distributions





Another correction factor due to discrepancies in missing E_T distributions between fast and full simulation – at 40 GeV the estimated scaling factor value would be **0.4**.

3. Tau-reconstruction & identification performance issues

	Full-sim	Atlfast II
No cut	1.27282e+12	1.27282e+12
Tau reco pt>20	6.95743e+09	7.35227e+09
Tau loose id pt<60	3.32725e+09	3.48246e+09
Tau medium ID	3.22918e+08	4.80934e+08

Rejection of EfficNN > 0.3 is slightly worse for Atlfast II samples – factor **0.67** will be applied

“Cut flow” vs QCD - I

Selection	$W \to \tau\nu$	Incl. QCD	Incl. QCD (scaled)
$E_T^{Miss} > 30$ GeV, Medium τ-ID	26748	8.41×10^5	90200
$E_T^{Miss} > 40$ GeV, Medium τ-ID	11086	30097	6300
$E_T^{Miss} > 50$ GeV, Medium τ-ID	1687	2123	900

Uncertainty estimation:

At 30 GeV the highest contribution comes from the J1 sample:

cut	J0	J1	J2	All
$E_T^{Miss} > 30$ GeV, Medium τ-ID	5.90e+04	5.52e+05	2.16e+05	8.41e+05

In **lower** $\mathbf{p_T}$ bins the E_T^{Miss} spectrum is also **lower** on average and with shorter tails

We can therefore neglect the J0 contribution to stat. uncertainty at 40 GeV and more.

cut	J0	J1	J2	All
$E_T^{Miss} > 40$ GeV, Medium τ-ID	0	15207	12018	30097

However at 50 GeV the dominating uncertainty term is related to J1 statistics.

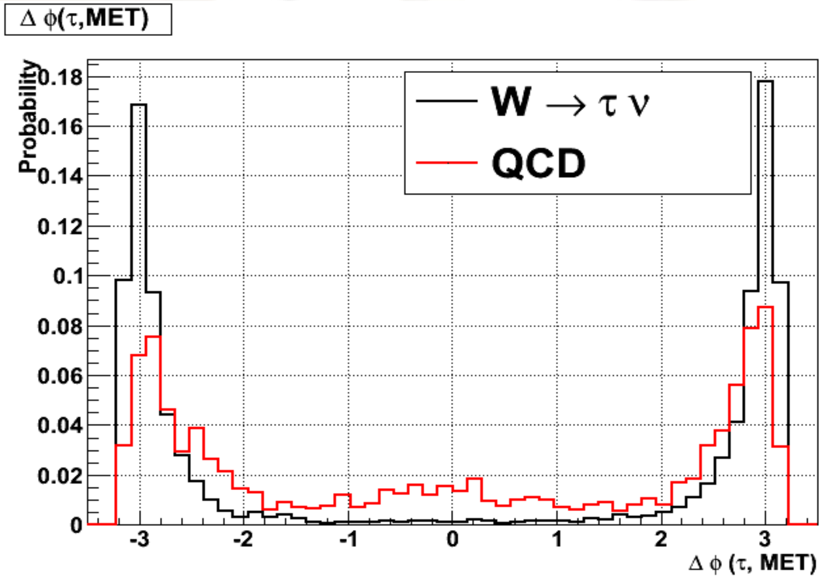
Uncertainty at 50 GeV level is 2172 (100%).

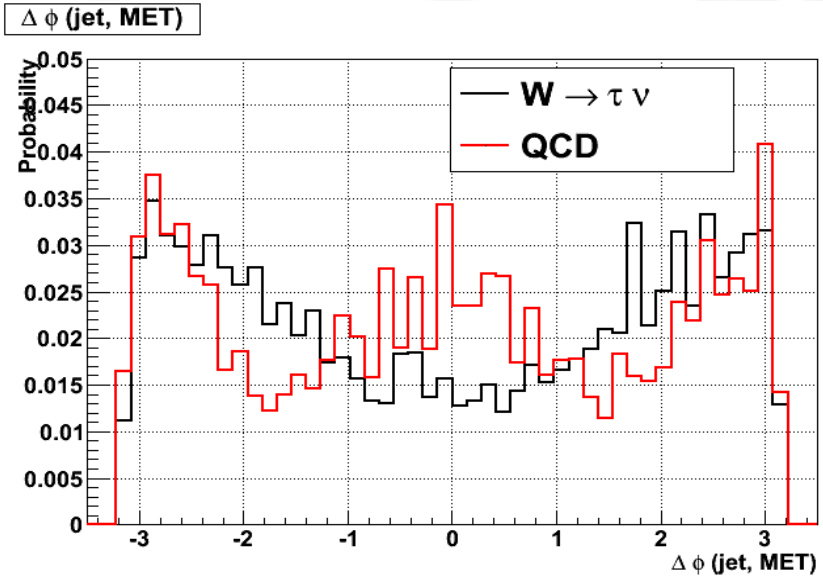
“Cut flow” vs QCD - II

Selection	$W \to \tau\nu$	Incl. QCD	Incl. QCD (scaled)
E_T^{Miss} > 40 GeV, Medium τ-ID	11086	30097	6300
E_T^{Miss} > 40 GeV, Medium τ-ID, veto fake-E_T^{Miss} topology	7536	6890	1440

At 40 GeV “for free” we can reduce background rate by **4.4** using E_T^{Miss} topology cuts (actually removing events with fake topology of E_T^{Miss} – see also ATL-PHYS-INT-2009-011 as a guideline

- $|\Delta\phi(\tau, E_T^{Miss})| > 2.0$ or
- $|\Delta\phi(\text{jet}, E_T^{Miss})| > 1.0$ for Cone4 – jets with p_T > 15 GeV not overlapping with τ-candidate



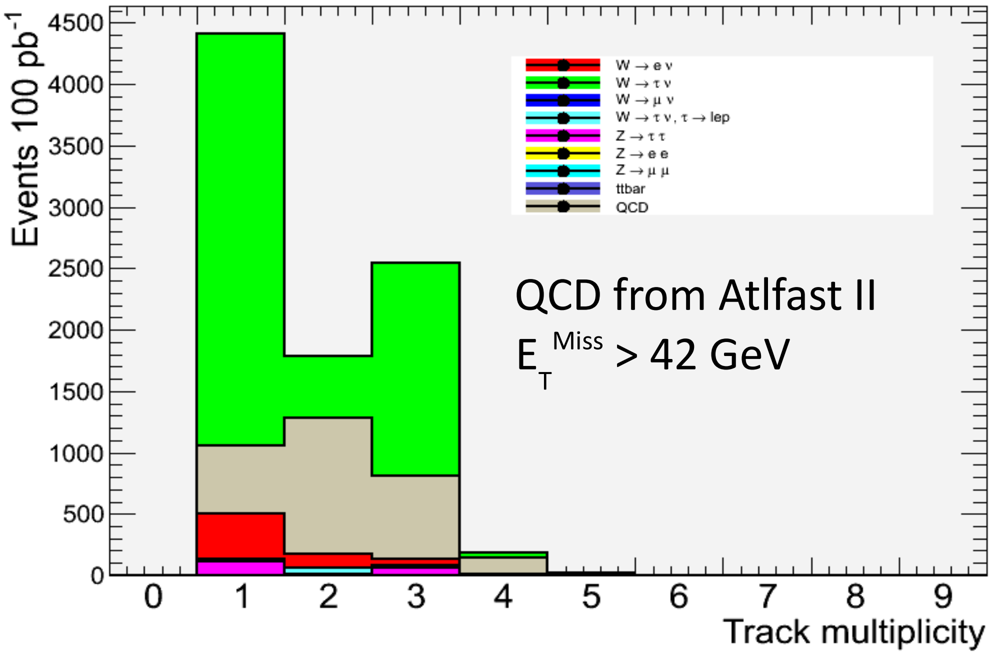


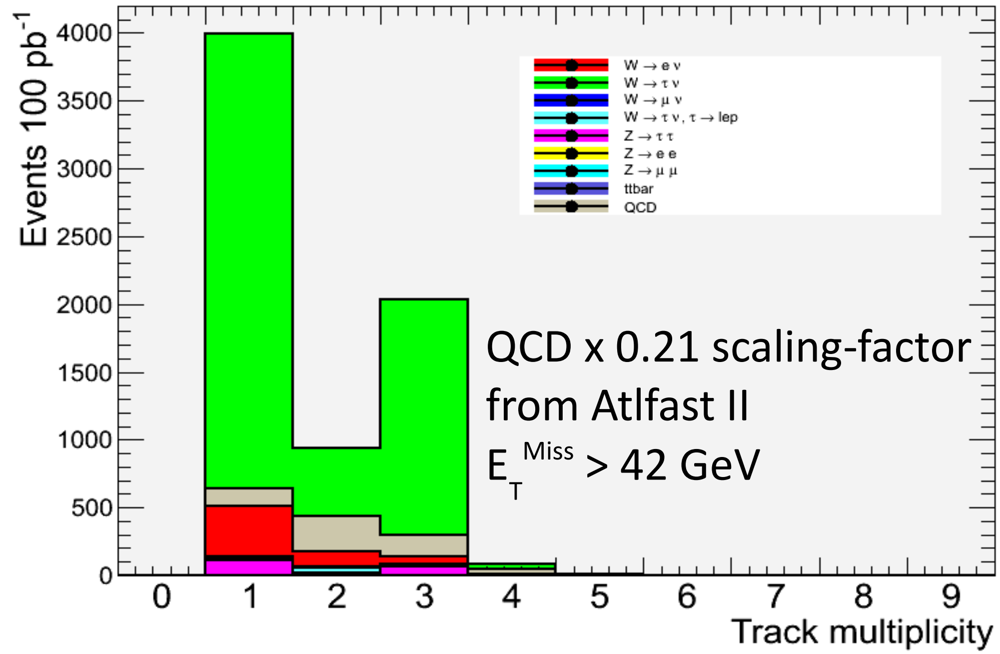
“Cut flow” vs QCD - III

Selection	$W \rightarrow \tau\nu$	Incl. QCD	Incl. QCD (scaled)
E_T^{Miss} > 42 GeV, Medium τ-ID	7357	10753	2250
E_T^{Miss} > 42 GeV, Medium τ-ID, veto fake-E_T^{Miss} topology	5629	2501	520

- At 42 GeV E_T^{Miss} threshold **S:B > 2** with no scaling factors applied
- Scaling factor might be wrongly estimated but **obviously it is lower than 1**
- Jets with **no associated tracks** are still present, mostly in J2 & J3 samples, but amount of such events is below 10%
- Higher E_T^{Miss} thresholds would result in significant reduction of signal events, with no improvement of S:B ratio (difficult to estimate due to low statistics)
- Requiring additional jet accompanying the identified tau does not improve S:B ratio at this E_T^{Miss} threshold level
- Vetoing the jet might be considered but the impact cannot be estimated due to low statistics, however it will yield a 30% signal rate reduction

Final results





Not sure about the estimation of the scaling factor uncertainty – anyway its influence can only improve the S:B ratio.

Currently:

- No scaling S:B = 1.51
- With scaling S:B = 3.1

Duplicate events bug may cause a reduction in statistics in high-E_T^{Miss} region – need to check that with new samples

Summary

- The $W \to \tau\nu$ process will be the first evidence for taus in Atlas
- Cross-section measurements should be possible, more precise (g_τ/g_e) unlikely
- Non-QCD background contribution: 15%
- QCD contribution acceptable event without the scaling factor
- The $W \to e\nu$ will be a good control sample for event kinematics at given E_T^{miss} threshold. studing events from the same tau stream but with identified tight-electron

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Plans for the near future

- Instead of scaling – use AOD to AOD corrections
- Replace the data with HEC problem (r541, r579) with newer productions
- Replace the Atlfast II samples with new ones with no bug **(Top priority)**