$Z \rightarrow \tau\tau$ (electron, τ-had) analysis with mc08 data

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Analysis with mc08 datasets

- Analysis first done with release 13 and csc data -> 14 TeV, 100 pb^{-1} scenario
  - documented in ATL-PHYS-INT-2009-019
- Redo this analysis on release 14 new simulation and reconstruction samples and observe an impact of 14->10 TeV centre-of-mass energy change
  - Analysis code rewritten in order to run on AODs
    - many thanks to Thomas Koffas and Lukasz Janyst
- Focus on aspects not studied in ATL-PHYS-INT-2009-019
  - trigger efficiencies
  - forward electrons, conversions…
- Revisit/optimize cuts used in the csc analysis
- Understand/study problems found during csc data analysis

Used mc08 samples

- Official AOD 14.2.20 samples
  - majority with HEC quadrant off (r541) but some with this region on (r604)
  - LO xsections used so far
    - should change to NLO where available in next step

xsec = used xsections, after filter

mc08.106052.PythiaZtautau.recon.AOD.e347_s462_r541 xsec:$1.13*10^3$ pb events: $1.4*10^5$

mc08.106052.PythiaZtautau.recon.AOD.e347_s462_r604 events: $9*10^4$

mc08.106050.PythiaZee_1Lepton.recon.AOD.e347_s462_r541 xsec: $1.09*10^3$ pb events: $8*10^5$

mc08.106050.PythiaZee_1Lepton.recon.AOD.e347_s462_r604 events:$10*10^5$

mc08.106022.PythiaWtaunu_1Lepton.recon.AOD.e352_s462_r541 xsec:$3.6*10^3$ pb events: $5.4*10^5$

mc08.106020.PythiaWenu_1Lepton.recon.AOD.e352_s462_r541 xsec:$10.3*10^3$ pb events: $6*10^5$

mc08.106020.PythiaWenu_1Lepton.recon.AOD.e352_s462_r604 events: $8*10^5$

mc08.105200.T1_McAtNlo_Jimmy.recon.AOD.e357_s462_r541 xsec:$2.06*10^2$ events: $4*10^5$

mc08.106054.PythiaZee_Mll20to60_1Lepton.recon.AOD.e379_s462_r635

xsec:$6.63*10^2$ events: $5*10^4$

mc08.105802.JF17_pythia_jet_filter.recon.AOD.e347_s462_r604(617)

Selection cuts

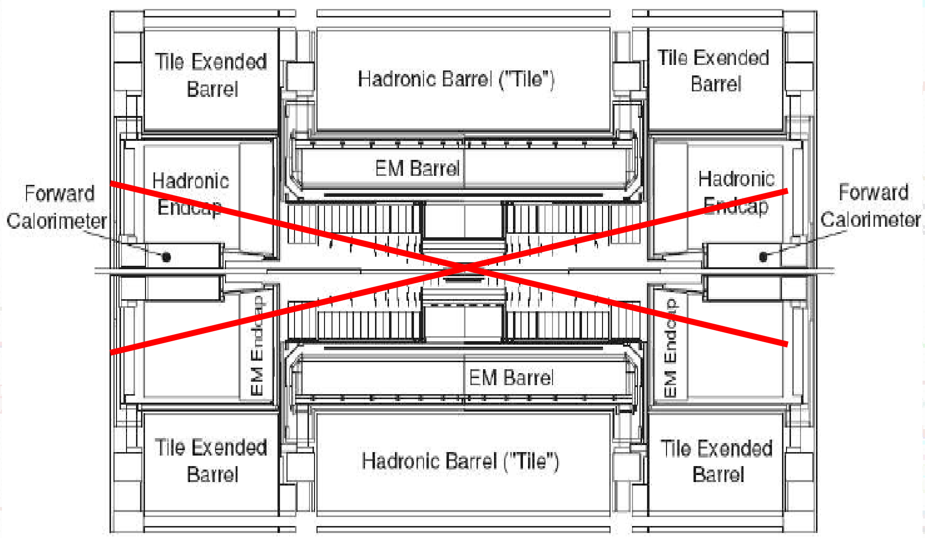
Basic selection

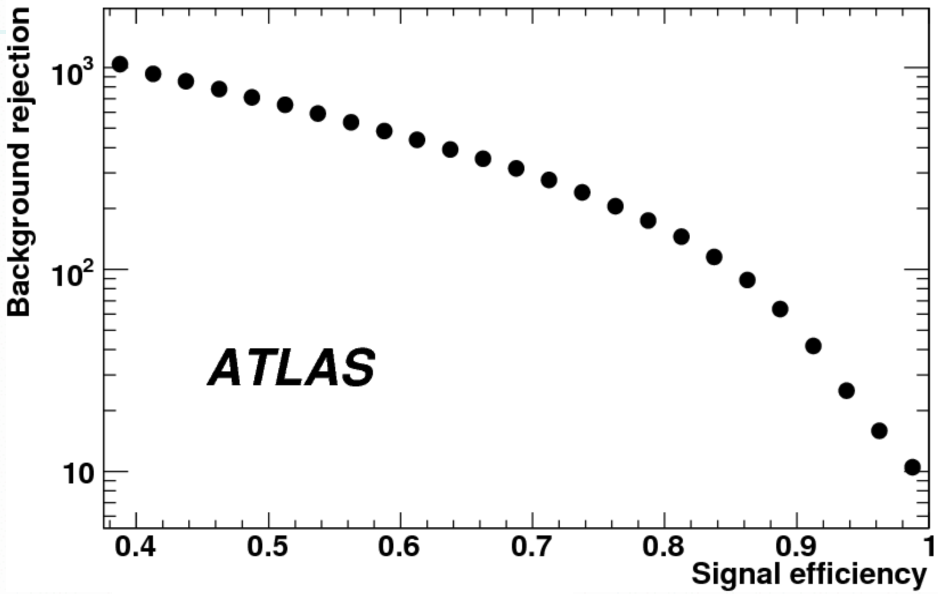
- *Tight* electron with $p_T(e)$ = 15-35 GeV [$p_T(e)$=15-40 GeV used for csc studies]
- *Medium* both-seeds tau, (NN), with $p_T(\tau)$ = 20 - 60 GeV
  - candidate has to be separated from already accepted electron by ΔR>0.2
  - veto on electon or muon using flags from tau object
  - [new] in addition 1P candidates with no reconstructed π^0 cluster are vetoed if E/p of the overlapping egamma object is > 0.9 or tau *sumEtCellsLArOverLeadTrackPt* > 0.9
- veto on p_T> 8 GeV other ele *medium* / *loose* (outside accepted ele/tau ROI) and any muon from Staco collection
- [new] veto forward electrons
  - find forward electron, try to reconstruct invariant mass with previously accepted electron and see if it is not close Z mass
- [new] veto *loose* photons
- $m_T(e, E_T^{miss})$ < 35 GeV
- isolation of electron in calorimeter and tracker

Analysis in the $m_{Vis}(e,\tau)$ mass window $m_{Vis}(e,\tau)$ = 35-75 GeV

Analysis with requiring E_T^{miss} > 20 GeV

Identification of forward electrons





Based on Z→ee sample

- For |η|>2.5 no tracking possible
  - Analysis based only on calorimeters
  - no track, we can't distinguish between photon and electron + no charge information
- Coarser granularity
- Two eta bins
  - EMEC(|η|<3.2)
  - FCal (|η|>3.2)
- Used a topological clustering E_T > 15 GeV
- Sequential cuts on 7 discriminating variables (based on shower shape)
  - Energy fraction in the most energetic cell
  - Longitudinal and lateral moments
  - Energy density
  - Distance of each cell to the shower center
- For the analysis the private copy of the official egamma code is used

Electrons in QCD samples

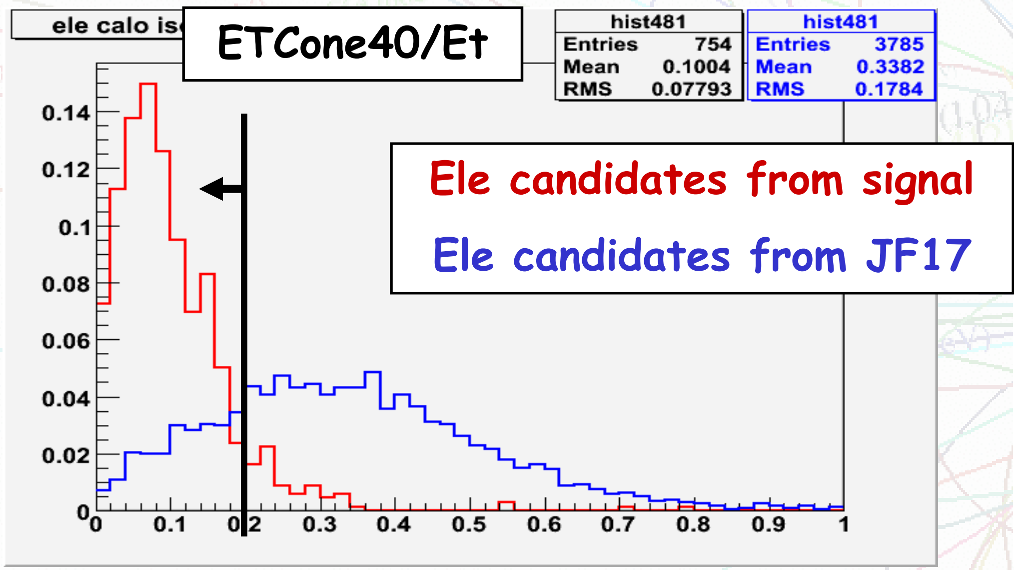
- Electrons from τ's in the $Z \rightarrow \tau\tau$ process are well isolated but:
  - Non-isolated electrons from semileptonic heavy quarks decays and background electrons from conversions and Dalitz decays mimic isolated ele of the signal
- Particles passing *tight* ele p_T=15-35 GeV and $|\eta|$<2.5 cuts in QCD full simulation dijet samples (r604) :

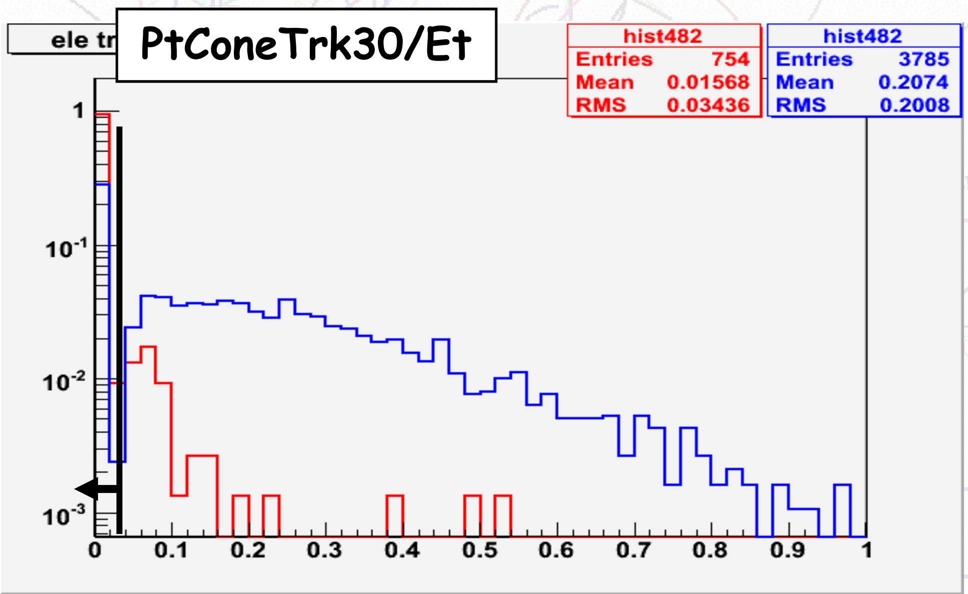
	QCD J1	QCD J2	QCD J3
hadrons	46%	22%	10%
Bkg ele(γ,Dalitz)	15%	8%	7%
Non-iso ele(b,c)	39%	70%	83%

- Main source of electrons in QCD background – electrons from semileptonic decays of heavy quarks
  - dedicated cuts on isolation in calo and tracker needed to suppress bkg from those electrons

Electrons in QCD samples - isolation cuts

- Isolation in calorimeter: requires energy in the isolation cone $\Delta R=0.4$, after subtracting electron E to contain < 20% of the ET of the electron candidate.
- Isolation in tracker: scalar sum of p_T's of all tracks with $p_T>1$ GeV in $0.03<\Delta R<0.3$ around electron track. To be less sensitive to tracks from conversions only tracks with hits in the B-layer are considered.





- Efficiency of above cuts in full simulation QCD JF17 sample:

isolated electrons:	89%
Non-isolated electrons(from b,c):	4%
Bkg electrons(γ,Dalitz):	23%
Hadrons(jets):	14%

Results for nonQCD background

Events in 100 pb^{-1}	$Z \to \tau\tau$	$Z \to ee$ $\sqrt{\hat{s}} > 60$ GeV	$W \to \tau\nu \to lep\nu\nu$	$W \to e\nu$	$t\bar{t}$	$Z \to ee$ $\sqrt{\hat{s}}$ =20-60 GeV
e-tight, p_T=15-35 GeV	5012	30147	26214	257438	1702	8604
τ-medium, p_T=20-60 GeV	715	240	100	715	102	46
Veto mediumEle	685	113	94	674	62	26
Veto looseEle	668	102	92	667	51	25
Veto frwdEle	668	89	92	667	51	25
Veto loosePho	657	78	90	659	42	21
$m_T^{e,E_T^{miss}} < 35$ GeV	616	71	56	125	10	18
ele iso	543	62	47	114	7	17
OS events	500	43	15	45	4	3
OS events, ntrack=1,3	487	40	10	37	4	3
Basic sel + E_T^{miss} >20 GeV						
OS events	93	0	7	21	3	0
OS events, ntrack=1,3	90	0	4	15	3	0
Basic sel + $m^{e,\tau}$=35-75 GeV						
OS events	457	5	11	21	2	2
OS events, ntrack=1,3	445	5	6	19	2	2

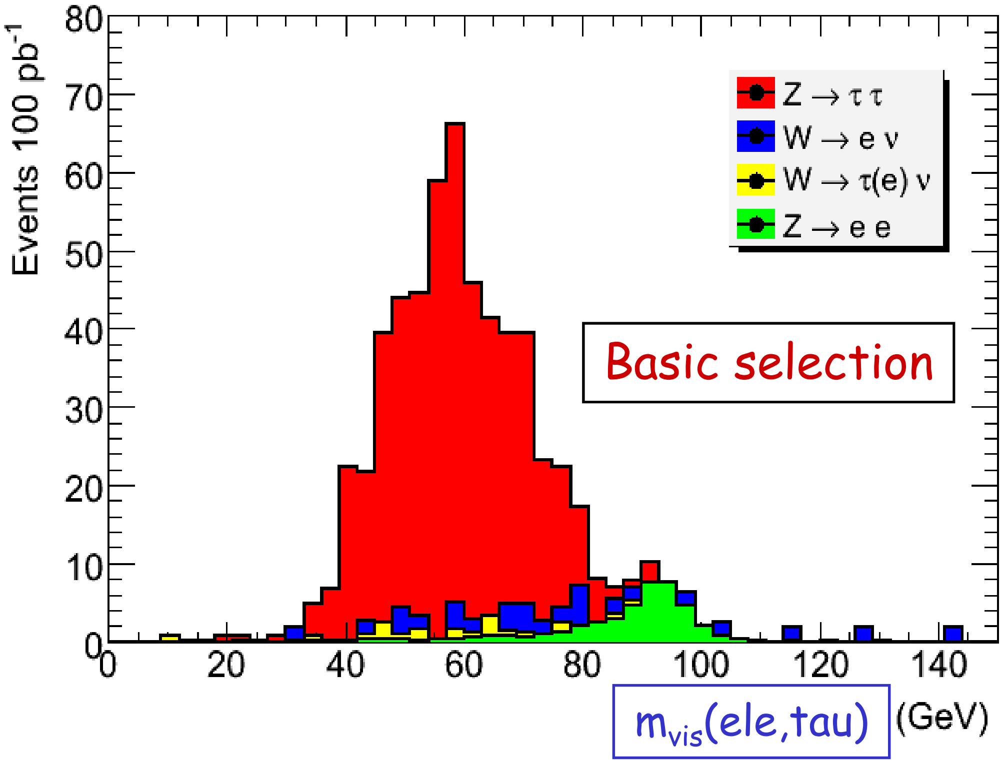
S/B=5

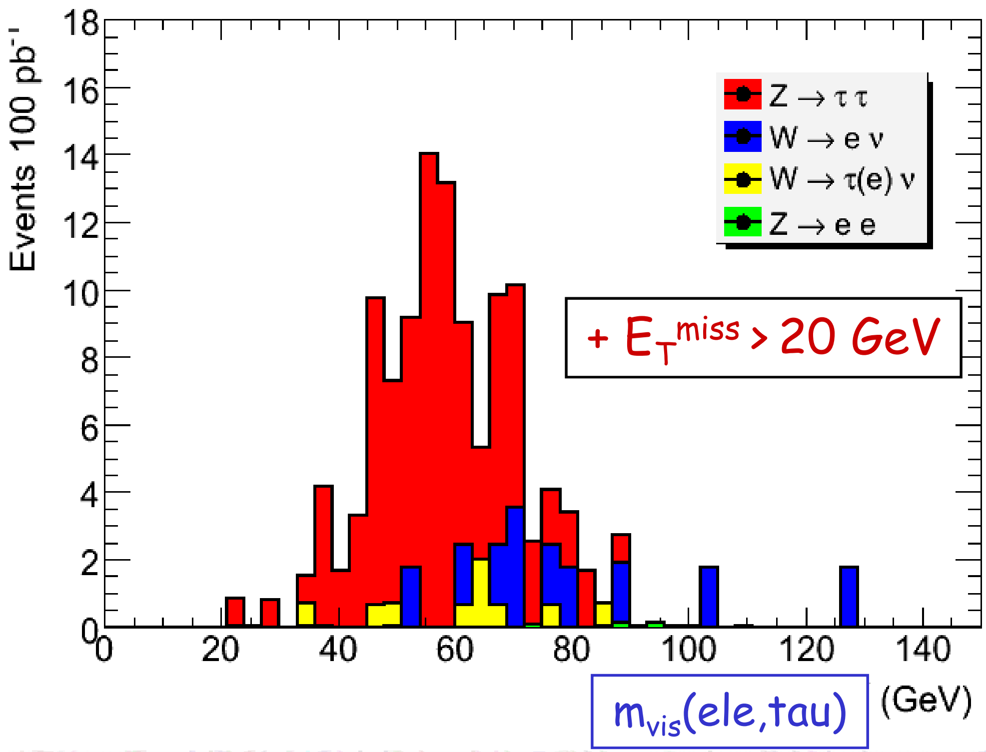
S/B=4

S/B=13

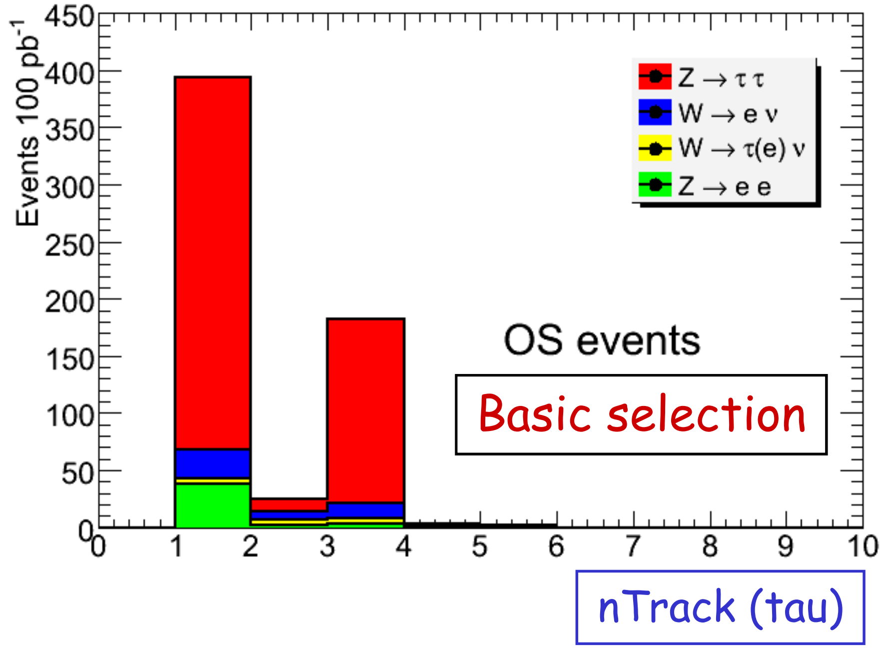
Much better S/B(nonQCD) obtained than for csc data analysis

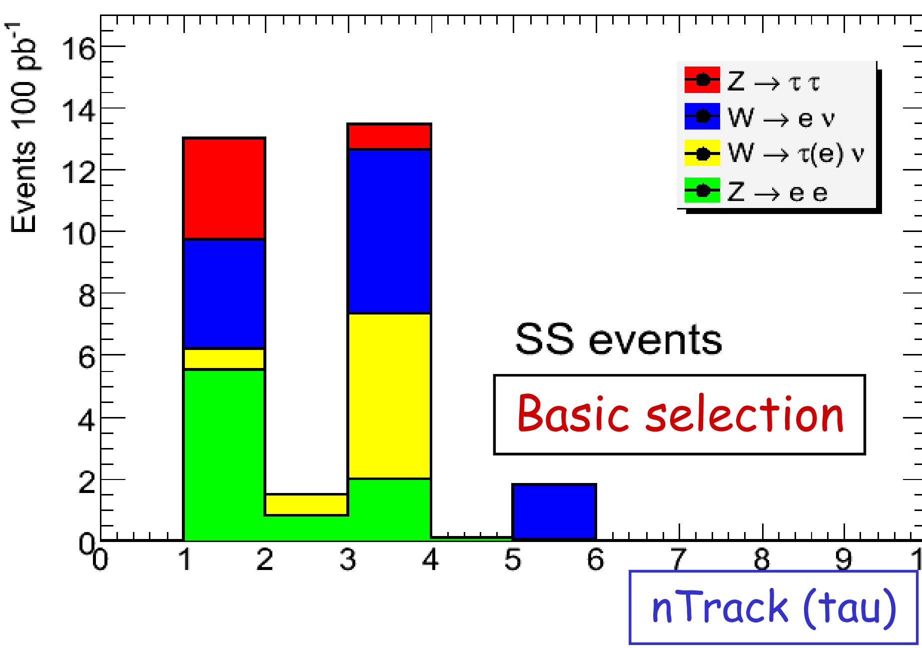
Results for nonQCD bkg - visible mass

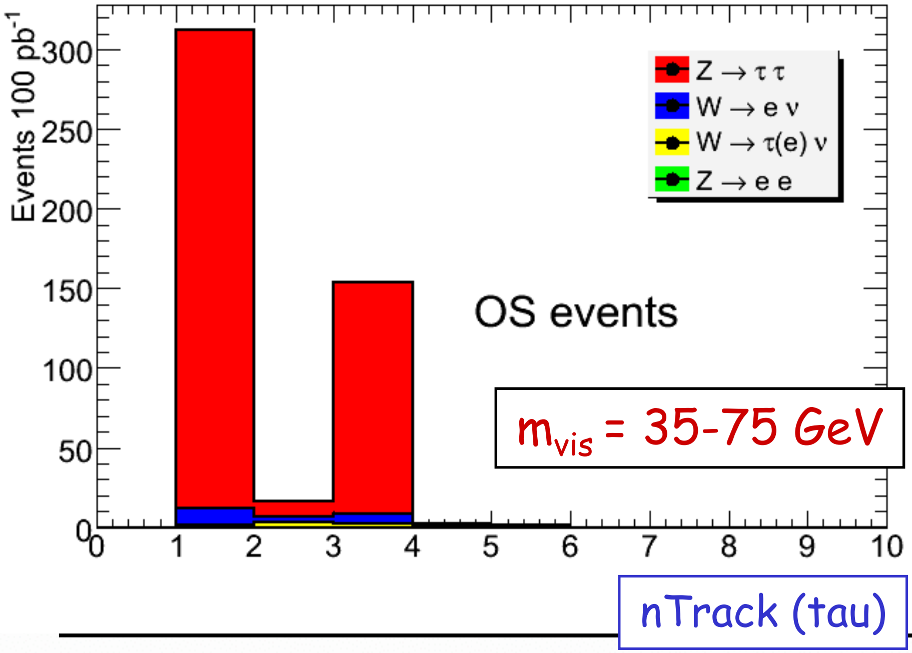


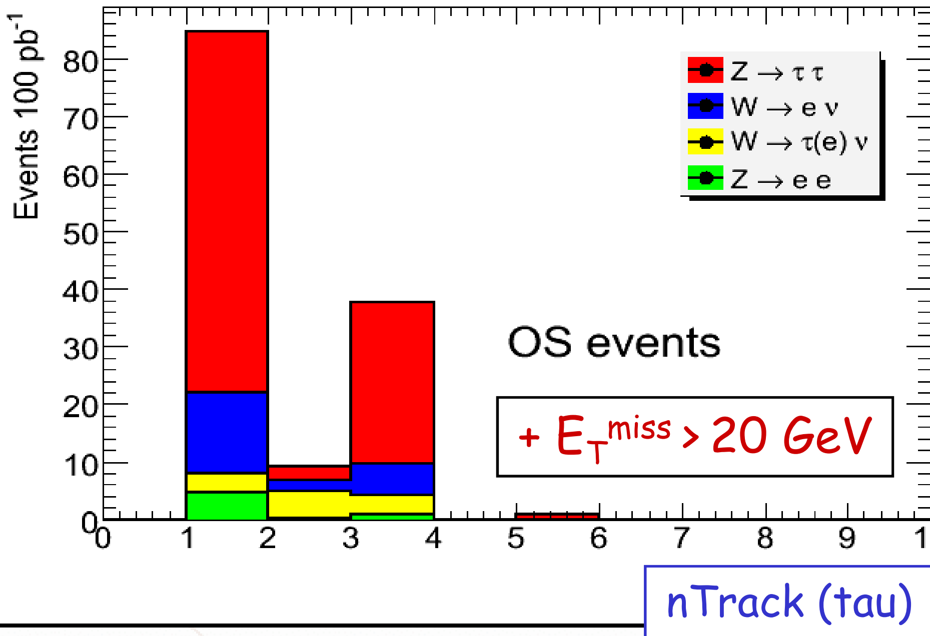


Results for nonQCD bkg - ntrack spectra









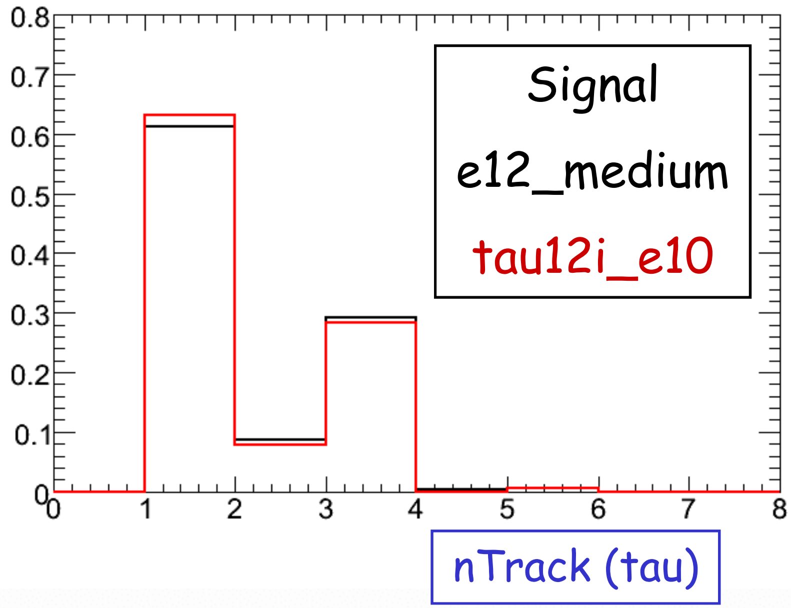
Trigger studies (1)

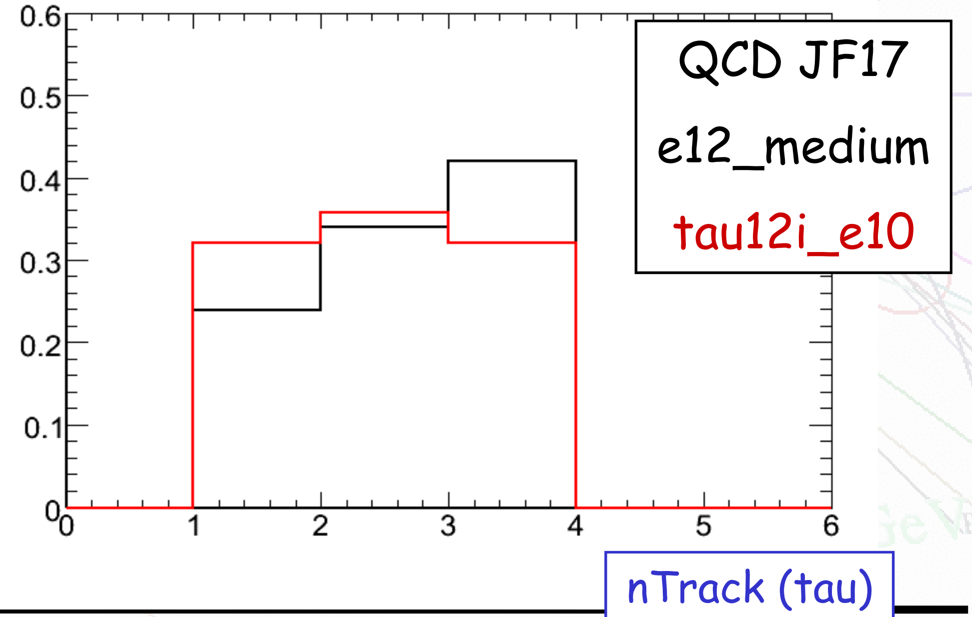
- Trigger efficiencies wrt off-line – signal sample

r541 – HEC quadrant off + electron trigger problems (L2 tracking is not correctly accounting for beam spot displacement)

	e10med	e12med	e15med	e20loose	e25loose	tau12_e10	tau16i_e10
Trig. Eff.	88%	88%	85%	54%	36%	69%	62%

Tau12_e10 worse than e15med but better than e20loose





Trigger studies (2)

- Trigger efficiencies wrt off-line – signal sample

r541 – HEC quadrant off + electron trigger problems (L2 tracking is not correctly accounting for beamspot displacement)

	e10med	e12med	e15med	e20loose	e25loose	tau12_e10	tau16i_e10
Trig. Eff.	88%	88%	85%	54%	36%	69%	62%

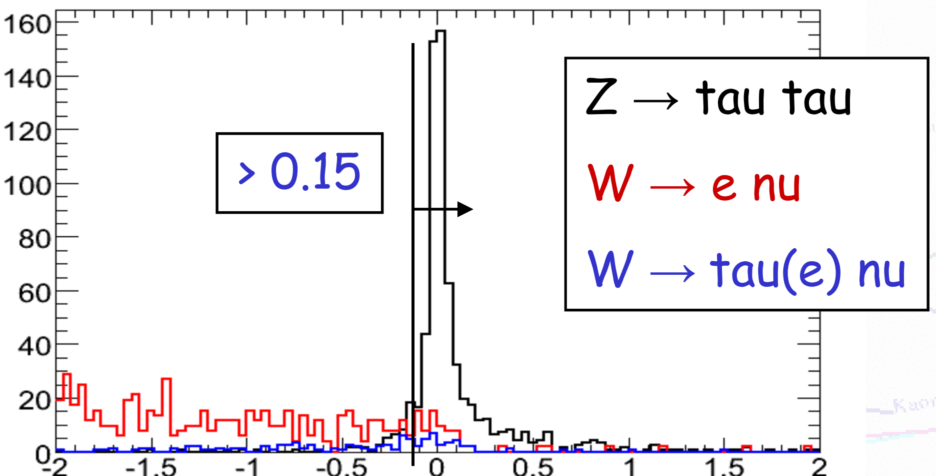
r604 – HEC quadrant on + fix of electron trigger problem

	e10med	e12med	e15med	e20loose	e25loose	tau12_e10	tau16i_e10
Trig. Eff.	98%	98%	96%	63%	33%	84%	79%

Angular correlations

- Instead of using standard cut on $m_T(ele, E_T^{miss})$ we tried Ryan's proposition of using angular correlation variable:

$$\cos(\varphi_{ele} - \varphi_{ETmiss}) + \cos(\varphi_{\tau} - \varphi_{ETmiss})$$



Events in 100 pb^{-1}	$Z \to \tau\tau$	$Z \to ee$ $\sqrt{\hat{s}} > 60$ GeV	$W \to \tau\nu \to lep\nu\nu$	$W \to e\nu$	$t\bar{t}$	$Z \to ee$ $\sqrt{\hat{s}}$ =20-60 GeV
e-tight, p_T=15-35 GeV	5012	30147	26214	257304	1702	8604
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Veto mediumEle	685	113	94	652	62	26
Veto looseEle	668	102	92	645	51	25
Veto frwdEle	668	89	92	645	51	25
Veto loosePho	657	78	90	637	42	21
Phi corr > 0.15	620	71	34	86	10	18
ele iso	548	62	34	78	7	17
OS events	505	43	12	30		3
OS events, ntrack=1,3	494	40	8	23		3
Basic sel + E_T^{miss} >20 GeV						
OS events	106	0	6	17	3	0
OS events, ntrack=1,3	102	0	2	11	3	0
Basic sel + $m^{e,\tau}$=35-75 GeV						
OS events	467	5	9	15	2	2
OS events, ntrack=1,3	457	5	5	13	2	2

+1%   -2%   -38%

First look at QCD background

- Running on ATLFAST2 QCD samples in GRID
  - a68 samples with duplicated events problem
  - not enough statistics to perform analysis -> parameterization is necessary

Events in 100 pb^{-1} (weight = 67303.23493)	all	5009	5010	5011	5012
e-tight, p_T=15-35 GeV	4493235	201909	2739528	1464300	87497
τ-medium, p_T=20-60 GeV	33569	0	8185	23502	1881
Veto mediumEle	31331	0	8185	21263	1881
Veto looseEle	30883	0	8185	20816	1881
Veto frwdEle	30883	0	8185	20816	1881
Veto loosePho	30883	0	8185	20816	1881
$m_T^{e,E_T^{miss}} < 35$ GeV	25378	0	5457	19920	0
OS events	4519	0	2728	1790	0
OS events, ntrack=1,3	223	0	0	223	0

Electrons in QCD samples

Full simulation

	All	5009	5010	5011	5012
ele tight pt (15-35) GeV	$5.2*10^6$	-	$(3.4\pm0.9)*10^6$	$(1.8\pm0.2)*10^6$	$(11\pm1.3)*10^4$

Atlfast 2

	All	5009	5010	5011	5012
ele tight pt (15-35) GeV	$4.5*10^6$	$2.0*10^5$	$2.7*10^6$	$1.5*10^6$	$8.7*10^4$

- Particles passing <u>medium</u> ele p_T=15-35 GeV and $|\eta|<2.5$ cuts in QCD full and atlfast2 dijet samples:

	QCD J2 full/atlfast2	QCD J3 full/atlfast2
hadrons	72% / 34%	62% /32%
Bkg ele(γ,Dalitz)	16% /15%	8% /15%
Non-iso ele(b,c)	12% / 51%	30% /53%

Short term plans

- Estimation of QCD background
  - run on a84 samples when available
    - check if parameterization at least for electrons needed
  - run on lepton filtered QCD full simulation samples
- Track isolation cuts – try to use official TrackIsolationTool
- Move from r541 to r635/r641/r642 (without problem with HEC and electron trigger + without duplication bug)
- Continue analysis towards cross-section and tau efficiency measurement
  - try to use common tool for benchmark analysis for Z xsection measurement

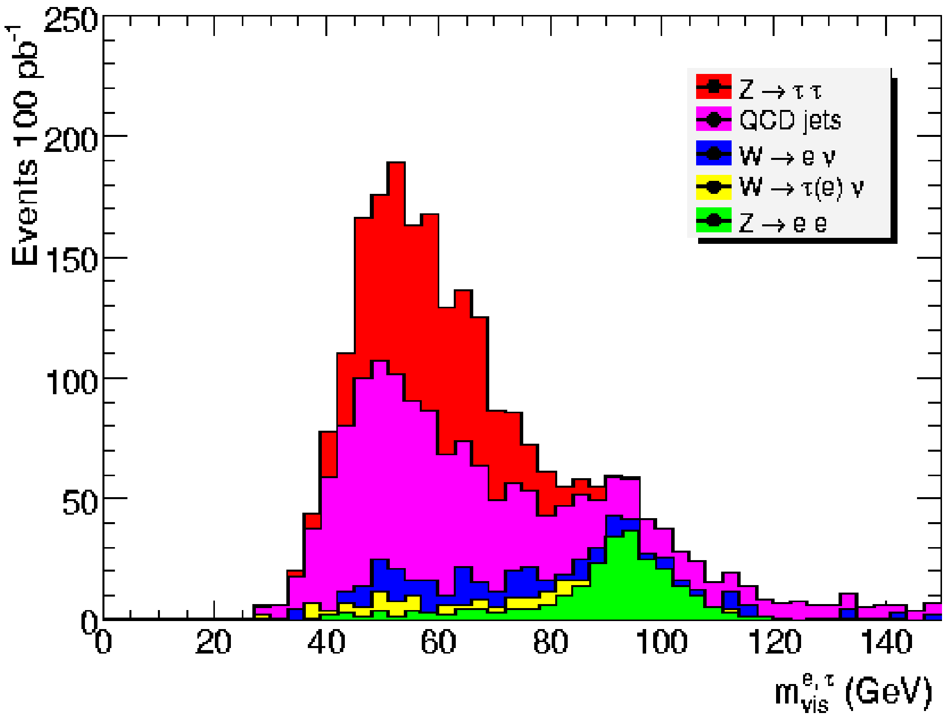
Backup slides

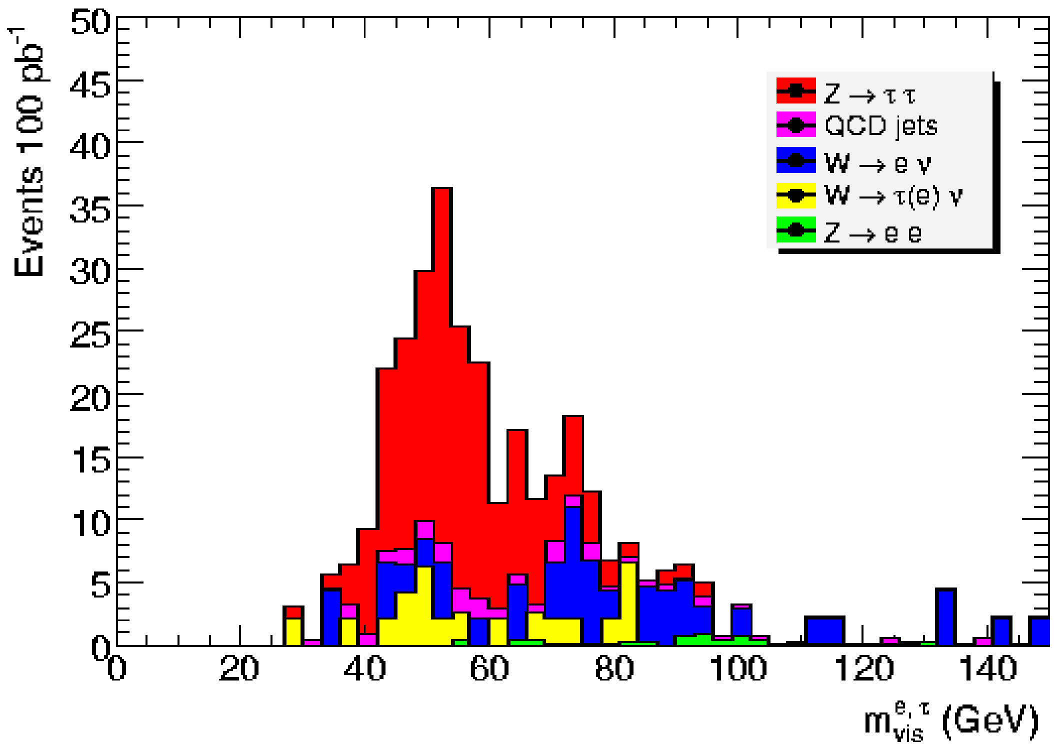
Check on W+jet samples

- W->tau + jet
  - mc08.106042.PythiaWtaunuJet_Ptcut.recon.AOD.e352_s462_r541
    - xsection $5.94*10^3$ pb
  - Basic selection, OS, ntrack=1,3: 17 events for 100pb-1
  - To compare with W->taunu: 13 events for 100pb-1
- W->e + jet
  - mc08.106040.PythiaWenuJet_Ptcut.recon.AOD.e352_s462_r541
    - xsection $5.94*10^3$ pb
  - Basic selection, OS, ntrack=1,3: 37 events for $100pb^{-1}$
  - To compare with W->e nu: 49 events for $100pb^{-1}$

Final results – $m_{vis}^{\tau,e}$ (ATL-PHYS-INT-2009-01)

Final visible mass distributions for events with OS, ntrack(τ)=1,3 events





Basic selection with very tight (iso) ele ID

Analysis with E_T^{miss}

Motivation for $Z \rightarrow \tau\tau$ channel

- $Z \rightarrow \tau\tau$ channel will provide statistically significant sample of τ leptons for 100 pb^{-1}
  - measurement of the xsection and the τ-ID efficiency
  - selected by lepton trigger -> unbiased sample of τ(had) decays
    - measurement of the τ trigger efficiencies
  - detector calibration -> E_T^{miss} and τ-jet energy scale determination
- Different then Z->ee,μμ channels.
  - overwhelming QCD bkg, low momenta of visible τ-decays products
- Studied for the Tau CSC note and ATL-COM-PHYS-2008-127 (D. Cavalli, C. Pizio)
  - calo-based algorithm used for τ reconstruction
  - analysis of (e/μ,τ-had) channels
    - determination of the τ-jet energy scale and E_T^{miss} scale
  - clean sample obtained
    - ~500 signal evts + 10% bkg from $W \rightarrow l\nu$ + 5% bkg from QCD
- In presented analysis we concentrate on (e,τ-had) channel
  - track-based algorithm used for τ reconstruction
  - analysis tuned to obtain high statistics for signal
    - xsection and τ-ID measurement for 100 pb^{-1}

Analysis with csc data - reminder

Documented in ATL-PHYS-INT-2009-019

- Analysis done with release 13 and csc data -> 14 TeV, 100 pb^{-1} scenario
- Signal and nonQCD bkg - full simulation (50-614k events in each channel), QCD bkg from the non-official production with Atlfast-I (~8×10^7 events)
- Results without trigger efficiencies (trigger info not available in analyzed CBNTs)
- CBNT based analysis
  - Basic selection:

• *Tight* electron with $p_T(e) > 15$ GeV

• ID *medium* τ, (tau1p3p, NN), with $p_T(\tau) > 20$ GeV

• Veto events with *loose* e $p_T(e) > 8$ GeV or any μ with $\Delta R > 0.3$ from identified τ or e

• $m_T(e, E_T^{miss}) < 35$ GeV

• Electron and τ to be separated, with $\Delta R(e,\tau) > 1.5$

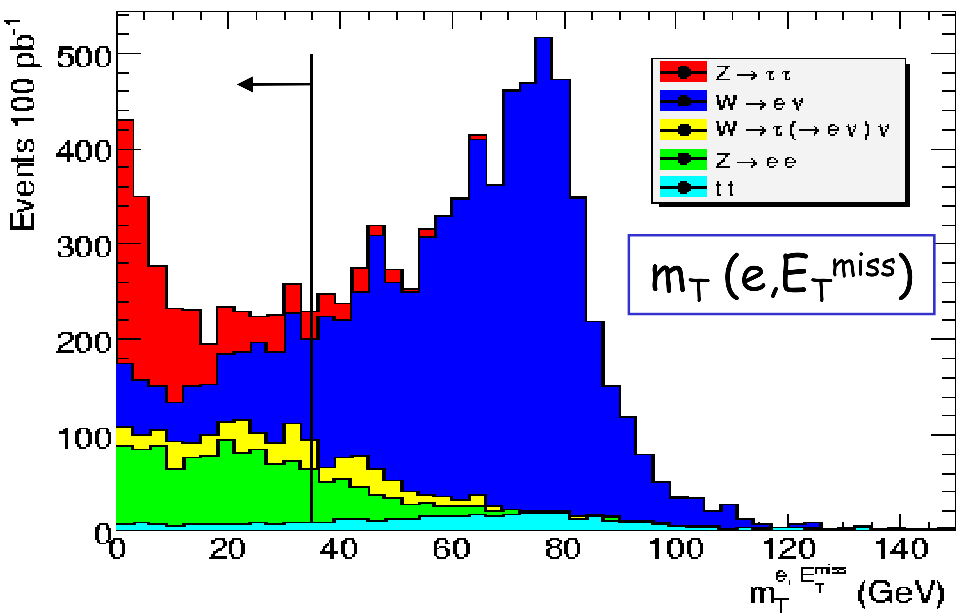
• p_T limited to $p_T(e) = 15 - 40$ GeV and $p_T(\tau) = 20 – 60$ GeV

  - After the basic selection, two possible scenarios:
    - Analysis in the $m_{Vis}(e,\tau)$ mass window $m_{Vis}(e,\tau) = 35\text{-}75$ GeV
    - Analysis with requiring $E_T^{miss} > 20$ GeV

Analysis with csc data (ATL-PHYS-INT-2009-01)

- Some changes/improvements done in the note reviewing phase for COM->INT
  - In addition sample $W \rightarrow \tau\nu$ with $\tau \rightarrow e$ studied and found to be significant source of the non-QCD background

Events in 100 pb^{-1}	$Z \rightarrow \tau\tau$	$W \rightarrow e\nu$	$W \rightarrow \tau_e \nu$	$Z \rightarrow ee$	$t\bar{t}$	QCD (true e)	QCD (fake e)	S/B
Basic kinematical selection								
Basic selection + p_T^e = 15 -40 GeV Ele isolation OS, τ_{Ntrack}=1,3	745±30	190±20	80±15	250±5	10±1	260	890	0.44
$m^{e,\tau_{had}}$=35-75 GeV	685±25	105±15	55±10	35±3	5±1	185±10	600±1	0.70
$E_T^{miss} > 20$ GeV	185±15	75±10	40±10	5±1	10±1	15±5	5±1	1.23



The $W \rightarrow \tau\nu$ with $\tau \rightarrow e$ background, although having much smaller cross-section than for $W \rightarrow e\nu$ is significant as the cut on $m_T(e,E_T^{miss})$ is not as efficient for that process as for $W \rightarrow e\nu$ events.

Analysis with csc data (ATL-PHYS-INT-2009-01)

• Studies of some features postponed to mc08 analysis: sharing between 1P and 3P for the W →eν bkg different for OS and SS events

- this effect is statistically significant.
- very likely fake tau's in SS sample are originating dominantly from gluon jet (larger tracks multiplicity), while in the OS sample from quark jet (lower tracks multiplicity)