Observation of the tt-bar dilepton channel with tau lepton in the early ATLAS data

ATLAS TAU WG MEETING July 24th

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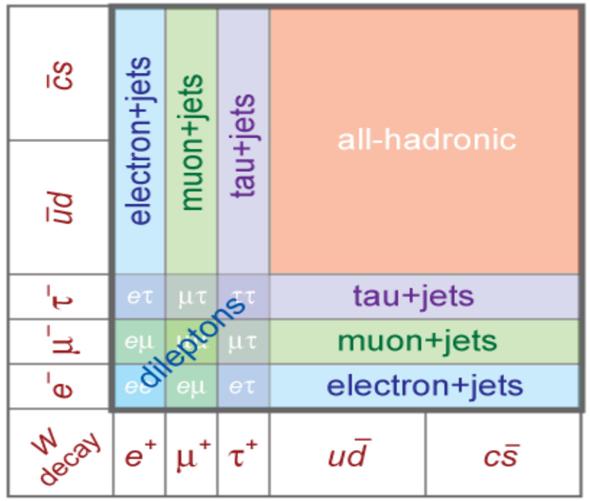
PHYSICS MOTIVATIONS

Category	Decay Mode	BR	
Dilepton	tt-bar →evb evb tt-bar →μvb μvb tt-bar →evb μvb	1/81 1/81 2/81	4/81 (5%)
τ-Dilepton	tt-bar →evb τvb tt-bar →μvb τvb tt-bar →τvb τvb	2/81 2/81 1/81	5/81 (5%)
Lepton+jets	tt-bar →evb qqb tt-bar →μvb qqb	12/81 12/81	24/81 (30%)
	tt-bar →τvb qqb	12/81	
All-hadronic	tt-bar →qqb qqb	36/81	36/81(44%)

Top Pair Decay Channels



➢Observation of the process: tt-bar →W(→l+ν_l)W(→τ+ν_τ)bb, l:e or μ in the early ATLAS data sample (100 - 1000 pb-1)

- ➢Background for SUSY, SM and MSSM Higgs.
- ➢Possible contribution to comissioning the ATLAS Tau reconstruction / Tau ID methods.

➢To complete the scan of the ttbar channels for cross section measurements:

- ➢Low yield of events, but independent sample, different sensitivity to new physics.

➢To search for beyond the Standard Model effects in the top quark decay:

- ➢Relative deviations in ratio of dilepton cross sections:

$$R = \frac{t \to \tau \nu_\tau b}{t \to \ell \nu_\ell b} (\ell = e, \mu) \qquad R > 1 \Rightarrow t \to bH^{\pm}$$

THE ANALYSIS TOOLS

CSC mc12 samples:

tt-bar signal

trig1_misal1_mc12.005200.T1_McAtNlo_Jimmy.recon.AOD.v12000601_tid005997

W(→e+ν_e)+≥3 jets background

trig1_misal1_mc12.008241.AlpgenJimmyWenuNp3_pt20_filt3jet.recon.AOD.v12000601

W(→μ+ν_μ)+≥3 jets background

trig1_misal1_mc12.008245.AlpgenJimmyWmunuNp3_pt20_filt3jet.recon.AOD.v12000601

Z(→ττ)+≥2 jets background

trig1_misal1_mc12.008156.AlpgenJimmyZtautauNp2LooseCut.recon.AOD.v12000601

1) Starting with "Alternative ntuples" proposed by the Top group:

-Ntupling package **12.0.6.TopQuarkAODtoROOTuple**

customized for this top analysis:

to include the TauJet(1p3p) AOD information

to include all the MC truth particle AOD container information in "event" block)

2) Ongoing cross-check with TopView ntuples.

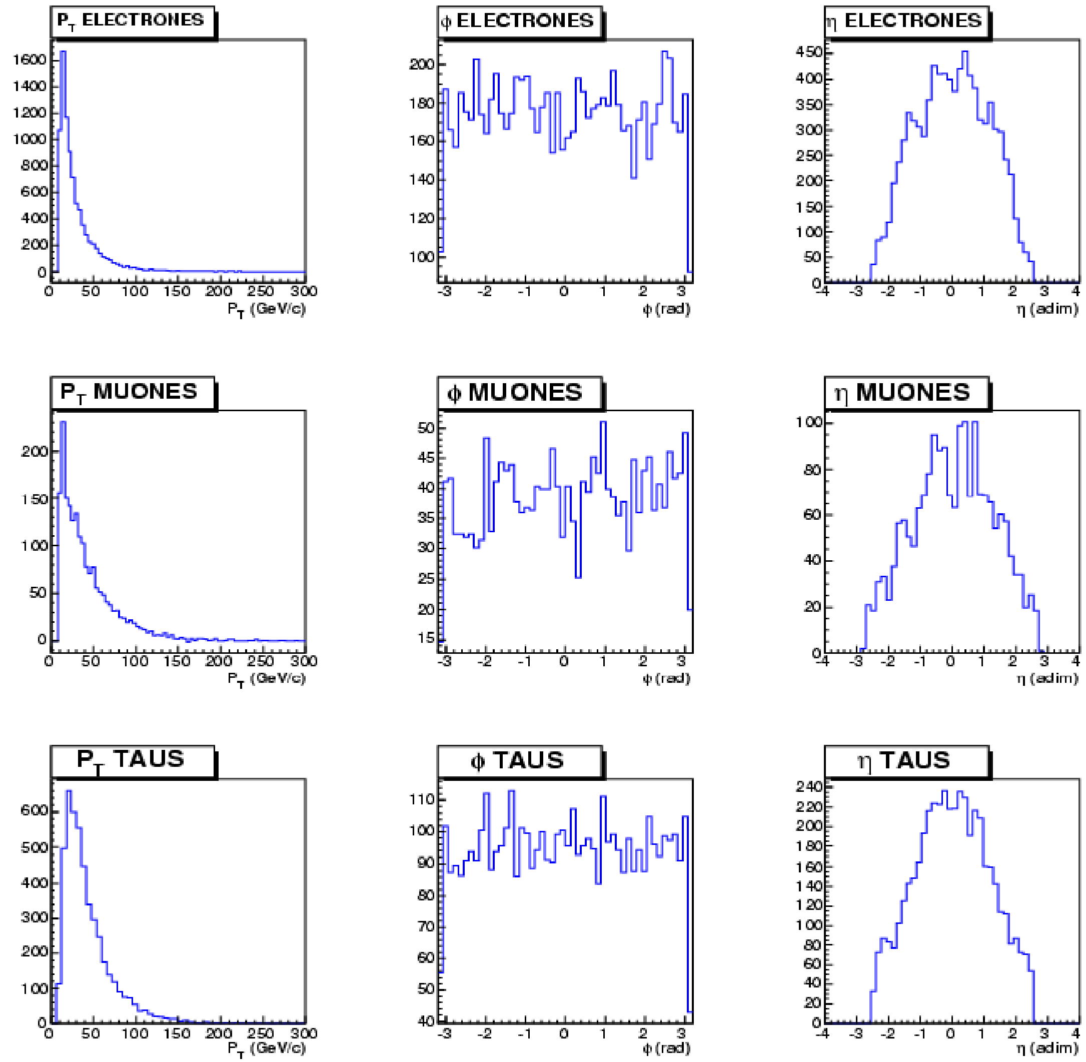
-Re-ntupling default´s Top group TopView ntuples 5200/8155/8241/8245 with TopView-121302 to remove lepton-preselection and overlap removal.

Selection criteria (CDF → ATLAS)

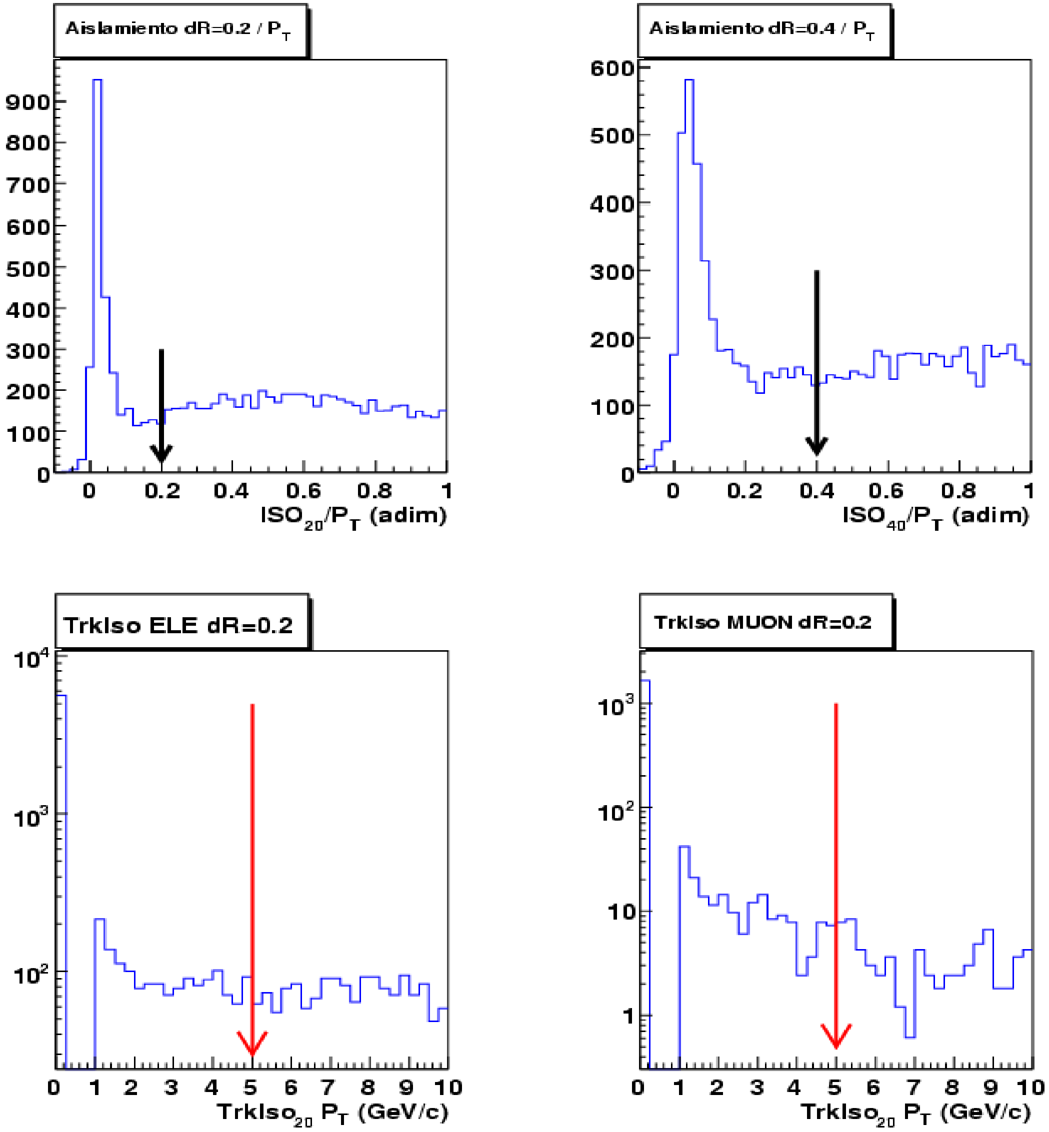
An isolated lepton (e o μ) with $P_T >$ 20 GeV (Triggering object)

- | η | < 1 (CDF)
- | η | < 2.5 (ATLAS)

- AOD electron selection :
  - IsEm=0
  - ΣP_T (tracks, $\Delta R<0.2$) < 5 GeV
- AOD muons selection
  - MuonID muons
  - ΣP_T (tracks, $\Delta R<0.2$) < 5 GeV
  - $\chi^2>0$



e and μ Isolation

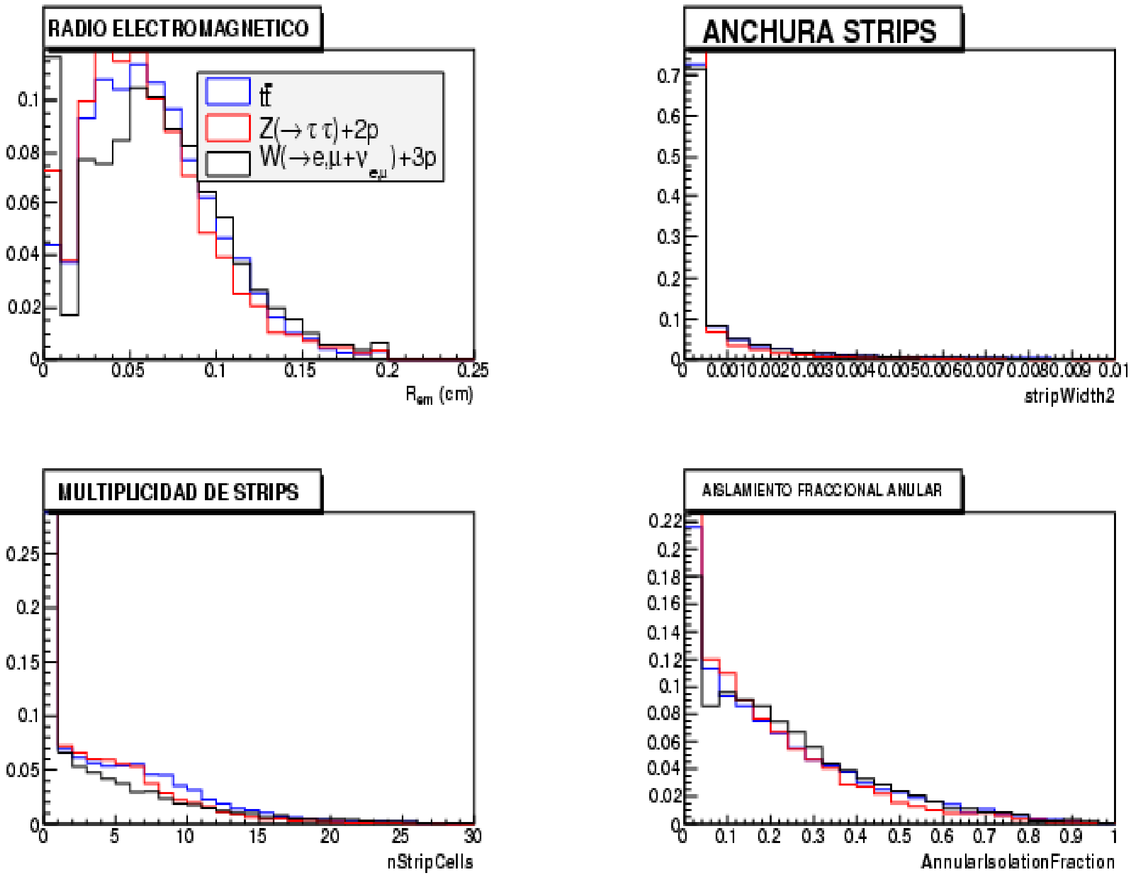


- Calorimeter ISO:
- ΣE_T (, $\Delta R<0.2,0.4$) / P_T

- Track isolation.
- ΣP_T (tracks, $\Delta R<0.2$) < 5 GeV

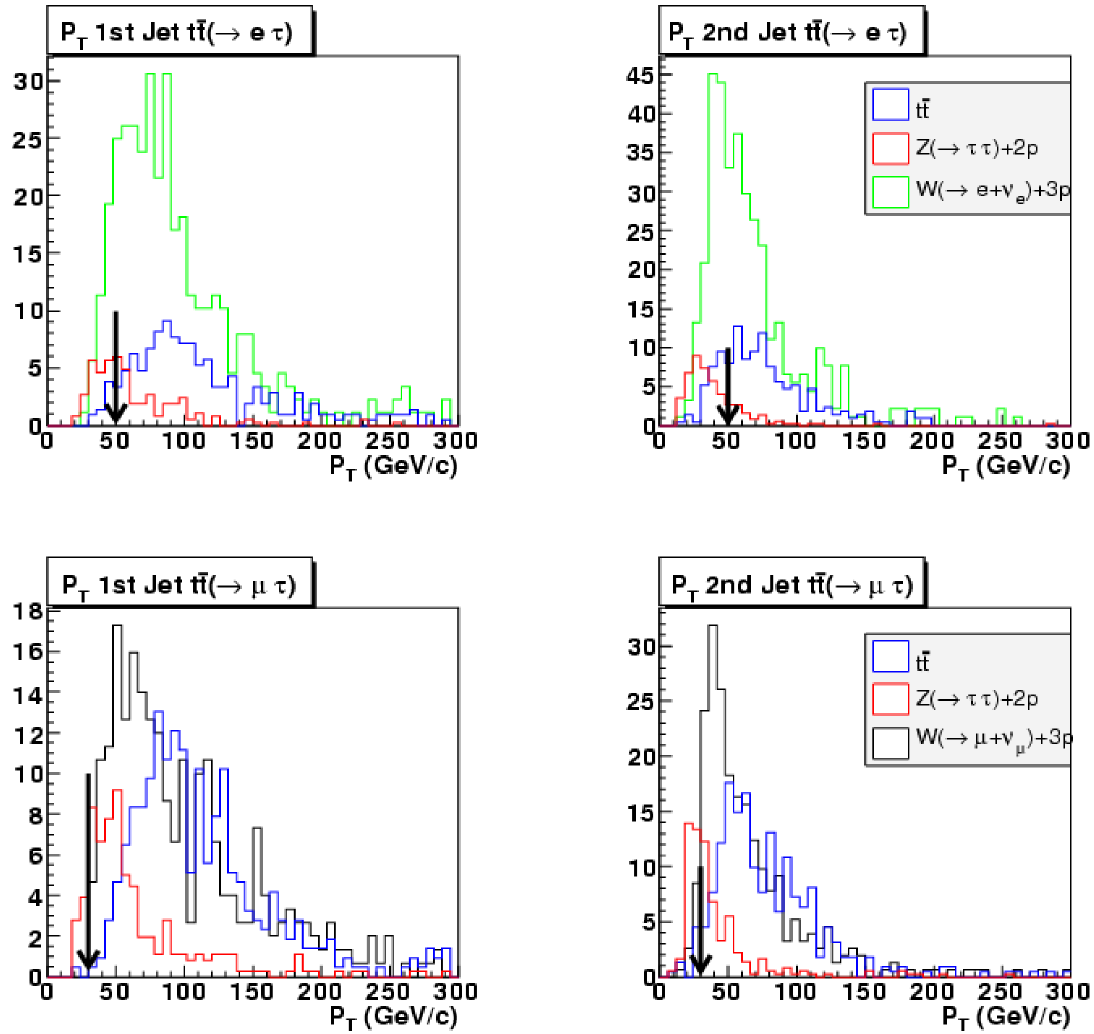
Tau ID

τ: E_T> 15 GeV .
TAU ID →TAU1P3P
discriminant == 1



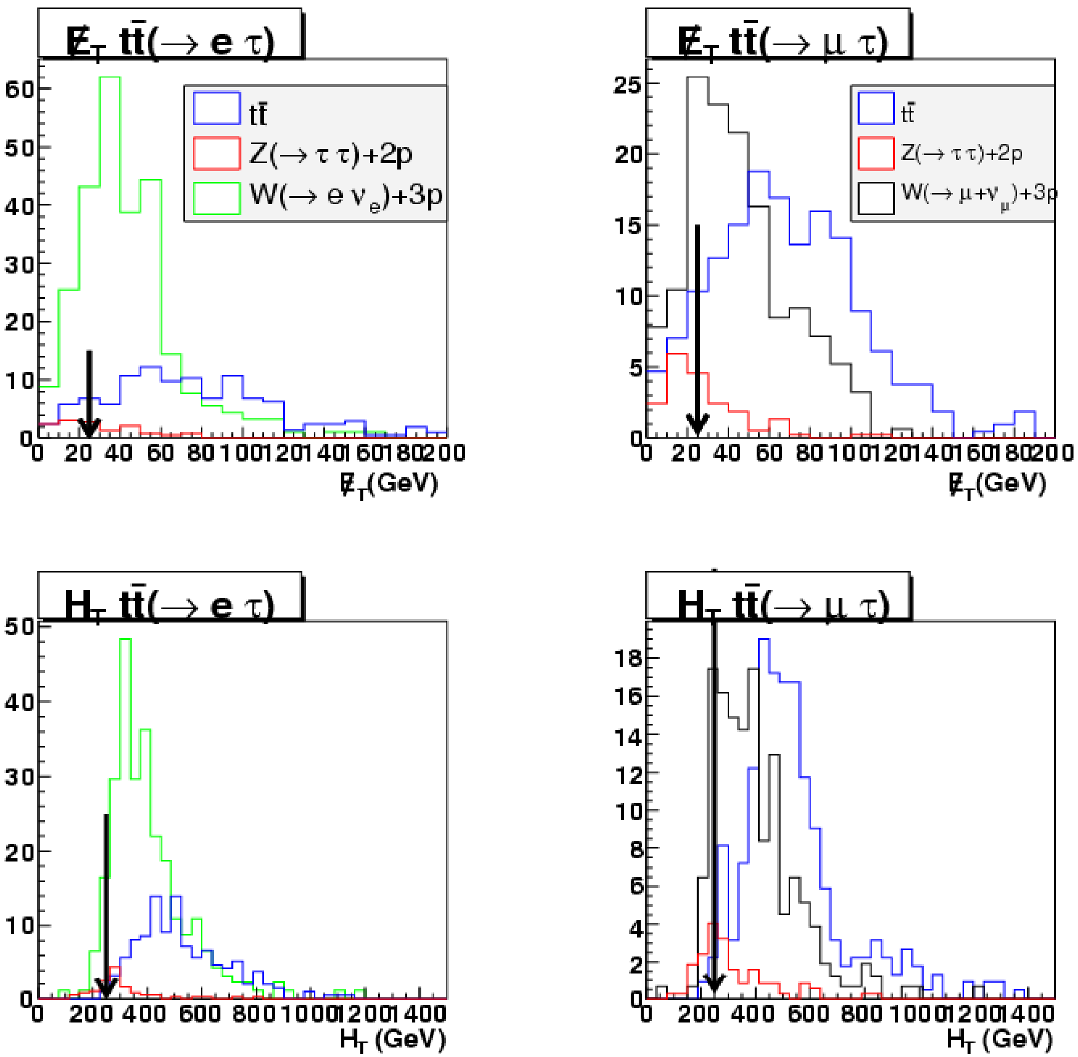
Jet selection criteria (CDF → ATLAS)

- At least two high E_T jets:
  - E_T(1st jet) > (25→50) GeV
  - E_T(2nd jet) > (15→35) GeV



MET and H_T (CDF → ATLAS)

- Energía transversa perdida:
  - $\not{E}_T > 20 \rightarrow 25$ GeV
- $H_T := E_T + \Sigma E_{T\,(leptones)} + \Sigma E_{T\,(jets)}$
  - $\not{H}_T > 205 \rightarrow 250$ GeV



Signal acceptance.

	$t\bar{t} \rightarrow W(e,\nu_e)W(\tau_{had},\nu_\tau)b\bar{b}$		$t\bar{t} \rightarrow W(\mu,\nu_\mu)W(\tau_{had},\nu_\tau)b\bar{b}$	
	$N_{eventos}$	$\varepsilon_{ff} \pm \sigma$	$N_{eventos}$	$\varepsilon_{ff} \pm \sigma$
	3259	0.00 ± 0.00	3320	0.00 ± 0.00
1 e/μ $P_T > 20\ GeV$	1751	0.54 ± 0.01	2273	0.71 ± 0.02
1 τ $P_T > 15\ GeV$	686	0.39 ± 0.01	952	0.42 ± 0.01
Tau ID	246	0.36 ± 0.02	356	0.37 ± 0.02
$E_T^{1st\ jet} > 50\ GeV$	227	0.92 ± 0.06	340	0.95 ± 0.05
$E_T^{2nd\ jet} > 30\ GeV$	216	0.95 ± 0.06	322	0.95 ± 0.05
$\not{E}_T > 25$	189	0.87 ± 0.06	289	0.90 ± 0.05
$H_T > 250\ GeV$	191	1.01 ± 0.07	284	0.99 ± 0.06
Z veto	287	0.98 ± 0.07	275	0.97 ± 0.06
OS	162	0.87 ± 0.07	244	0.89 ± 0.06
B-TAGGING	131	0.81 ± 0.07	199	0.82 ± 0.06
Acceptance	0.07 ± 0.01		0.10 ± 0.01	

- tt-bar acceptance is mainly affected by lepton (e,μ,τ) identification, specially τ- lepton ID requirements.
- tt-bar acceptance is almost double in (μ-τ) channel w.r.t (e-τ) channel.
- The rest of cuts are 90-100 % efficient, preserving the tt-bar acceptance.

MAIN BACKGROUNDS

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

$Z \rightarrow \tau\tau$ + 2 jets

- Physics background.

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

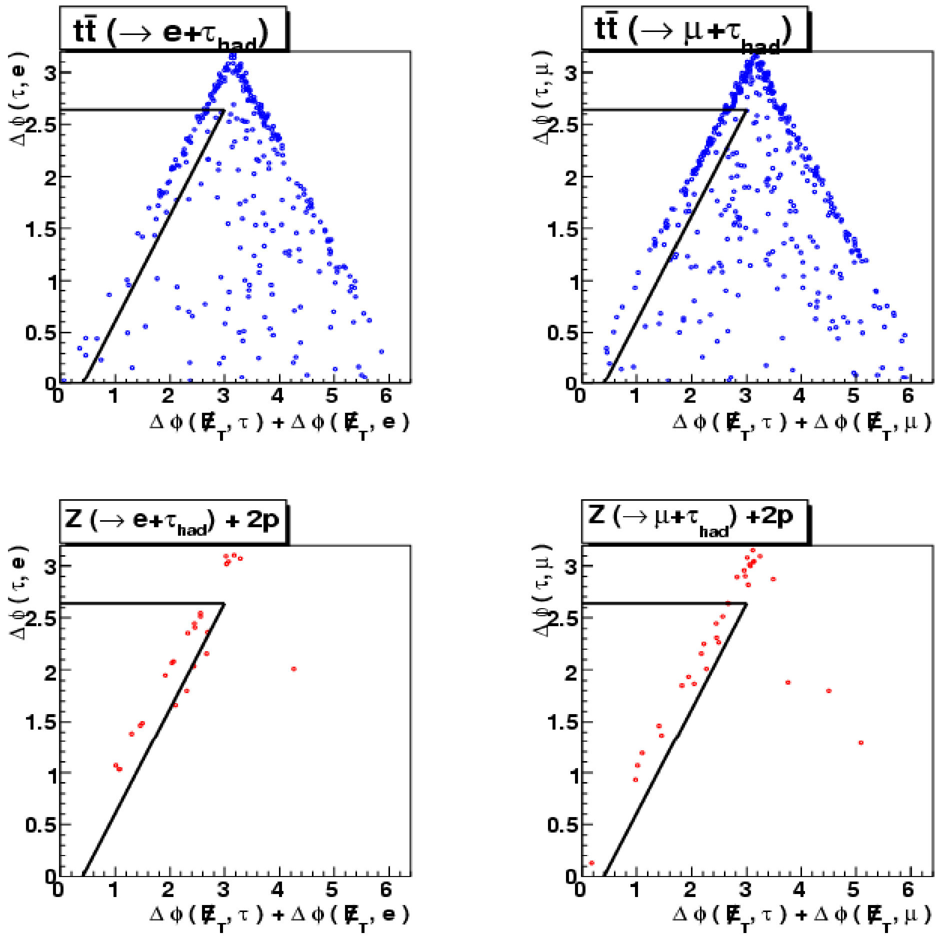
- Rejection by kinematic and angular criteria (next slide).

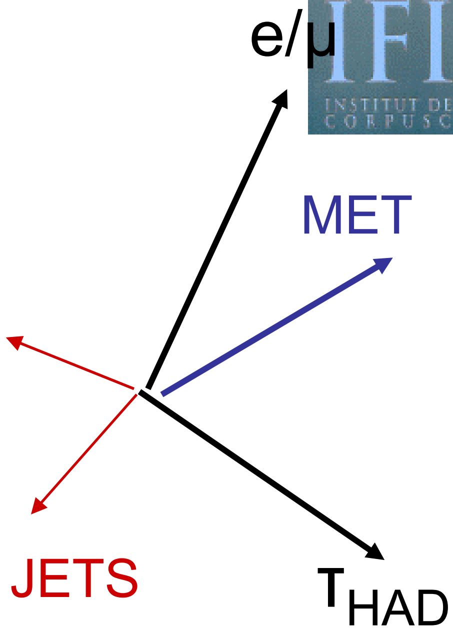
W +≥ 3 jets

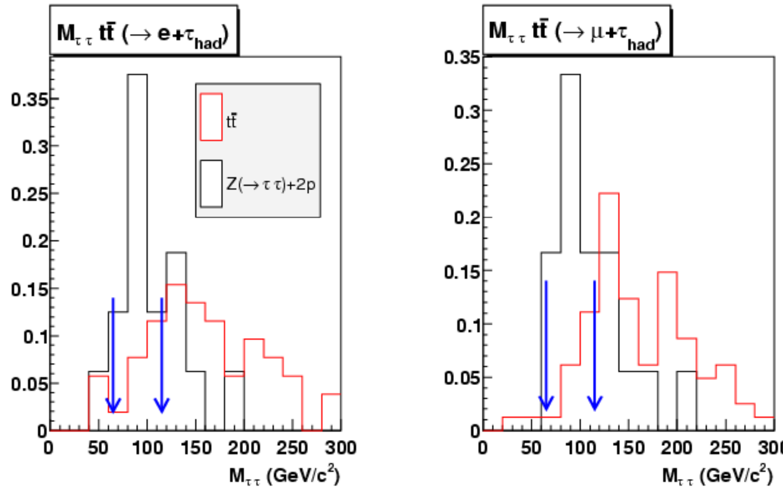
- Instrumental background
- Rejection by tau ID criteria

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

VETO Z→ττ+≥2 jets







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

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

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

Z→ττ+≥2 jets predictions.

	$Z(\tau \rightarrow e, \nu_e; \tau_{had}) + 2p$		$Z(\tau \rightarrow \mu, \nu_\mu; \tau_{had}) + 2p$	
	$N_{eventos}$	$\varepsilon_{ff} \pm \sigma$	$N_{eventos}$	$\varepsilon_{ff} \pm \sigma$
	2695	0.00 ± 1.88	2776	0.00 ± 1.88
1 e/μ $P_T > 20\ GeV$	910	0.34 ± 0.01	1371	0.49 ± 0.01
1 τ $P_T > 15\ GeV$	356	0.39 ± 0.02	540	0.39 ± 0.02
Tau ID	180	0.51 ± 0.04	253	0.47 ± 0.03
$E_T^{1st\ jet} > 50\ GeV$	79	0.44 ± 0.05	112	0.44 ± 0.04
$E_T^{2nd\ jet} > 30\ GeV$	53	0.67 ± 0.09	74	0.66 ± 0.08
$\not{E}_T > 25$	25	0.47 ± 0.09	33	0.45 ± 0.08
$H_T > 250\ GeV$	20	0.80 ± 0.18	20	0.61 ± 0.14
Z veto	13	0.65 ± 0.18	13	0.65 ± 0.18
OS	8	0.62 ± 0.22	7	0.54 ± 0.20
B-TAGGING	8	1.00 ± 0.35	7	1.00 ± 0.38

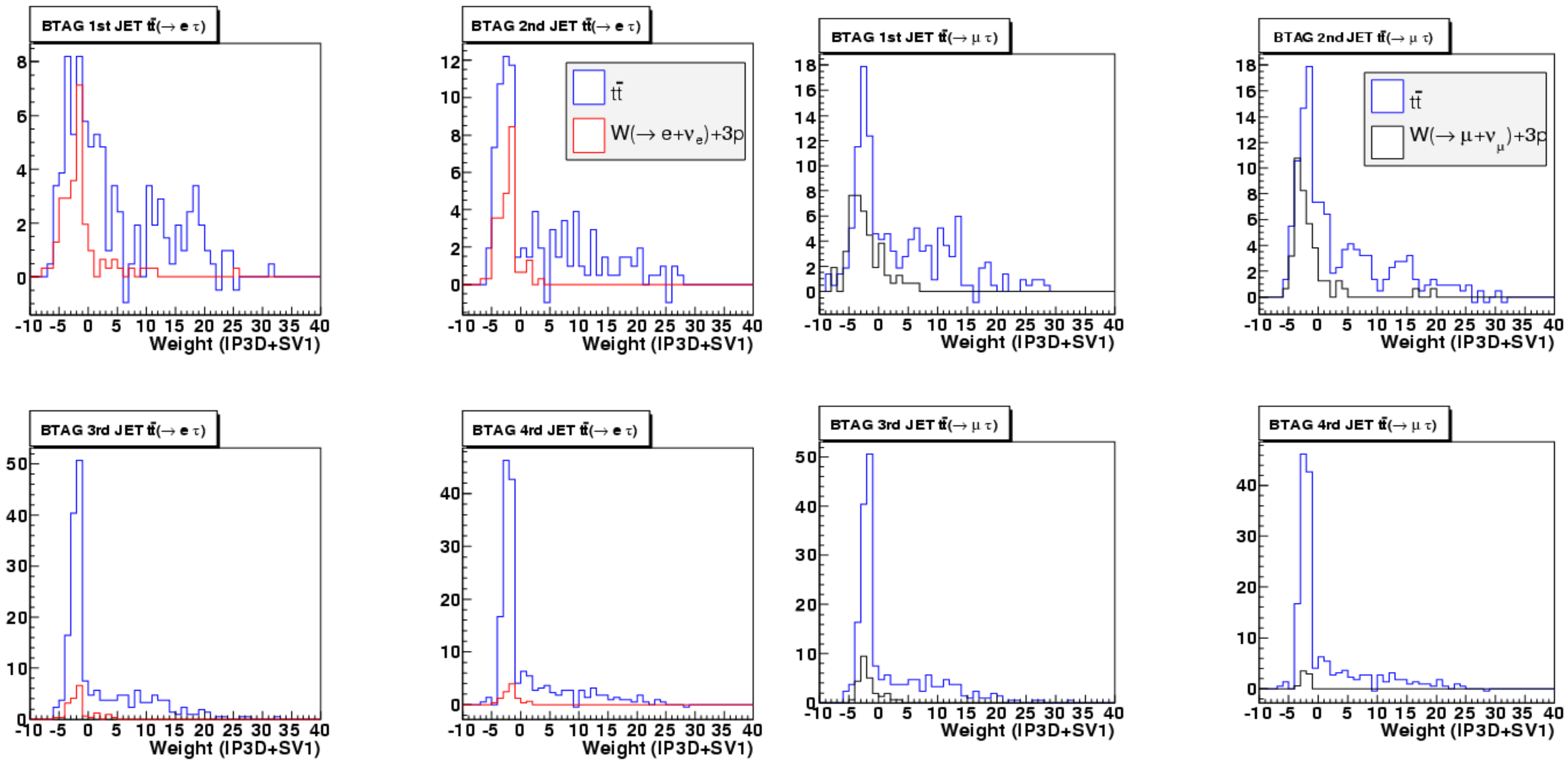
- Z veto rejects 65% Z→ττ+≥2 jets preserving 98% of the tt-bar signal.
- MC sample 8156, statistically limitted.

W ($\rightarrow$e,μ+$\nu_{e,\mu}$)+≥3 jets predictions

	$W(e,\nu_e)+3p$		$W(\mu,\nu_\mu)+3p$	
	$N_{eventos}$	$\varepsilon_{ff}\pm\sigma$	$N_{eventos}$	$\varepsilon_{ff}\pm\sigma$
	11248	0.00 ± 0.00	9999	0.00 ± 0.00
$1\ e/\mu\ P_T > 20\ GeV$	5047	0.45 ± 0.01	5737	0.57 ± 0.01
$1\ \tau\ P_T > 15\ GeV$	1659	0.33 ± 0.01	2007	0.35 ± 0.01
Tau ID	342	0.21 ± 0.01	350	0.17 ± 0.01
$E_T^{1st\ jet} > 50\ GeV$	270	0.79 ± 0.05	262	0.75 ± 0.05
$E_T^{2nd\ jet} > 30\ GeV$	244	0.90 ± 0.06	217	0.83 ± 0.06
$\not{E}_T > 25$	194	0.80 ± 0.06	174	0.80 ± 0.06
$H_T > 250\ GeV$	182	0.94 ± 0.07	151	0.87 ± 0.07
Z veto	180	0.99 ± 0.07	147	0.97 ± 0.08
OS	78	0.43 ± 0.05	69	0.47 ± 0.06
B-TAGGING	30	0.38 ± 0.07	30	0.43 ± 0.08

- More efficient cuts rejecting W+jets are due to:
  - Electron and muon selection.
  - Tau ID
- But additional criteria are needed to obtain S/B > 1 :
  - Opposite charged for leptons
  - B-tagging

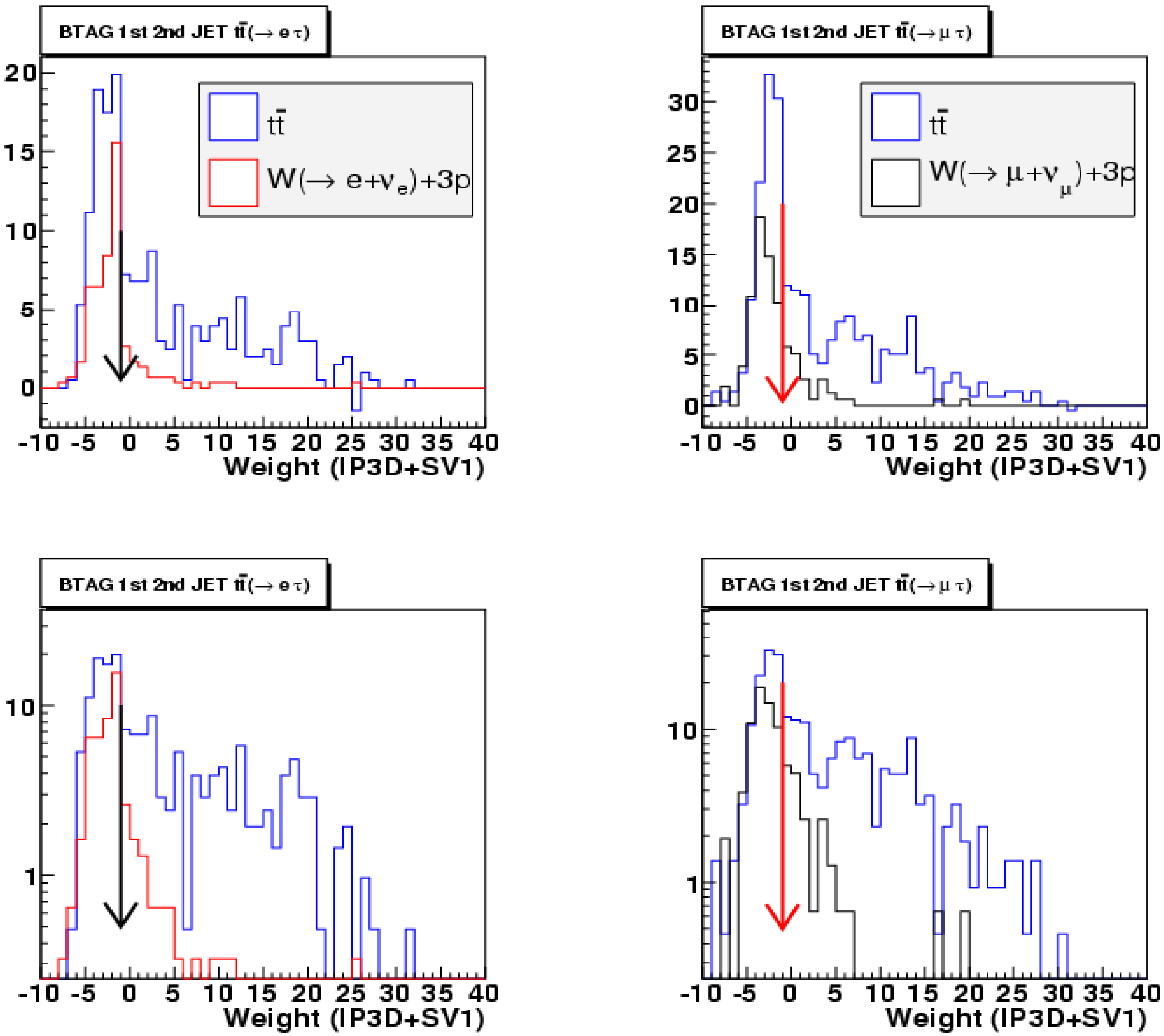
B-tagging: IP3D+SV2 weights from AOD



B-tagging for tt-bar dileptons with tau.

1 B-TAGG:

Weight (1er JET) > -1
OR
Weight (2nd JET) > -1



RESULTS in L=100 pb^{-1}

$$L_{MC} = \frac{N_{EVT}^{MC\ TOTAL}}{\sigma_{THEO}}$$

$$N_{EVT}^{100\ pb^{-1}} = N_{EVT}^{MC} \times \frac{100\ pb^{-1}}{L_{MC}}$$

$$\sigma_{THEO}^{t\bar{t}} = 872.8 \times 0.56\ \ pb^{-1}$$

$$\sigma_{THEO}^{W \to \mu\nu_\mu + 3p} = 771 \times 0.301 \times 0.534\ \ pb^{-1}$$

$$\sigma_{THEO}^{W \to e\nu_e + 3p} = 771 \times 0.304 \times 0.276\ \ pb^{-1}$$

$$\sigma_{THEO}^{Z \to \tau\tau + 2p} = 153 \times 0.403 \times 0.346\ \ pb^{-1}$$

	$N_{eventos}\ (\mathcal{L}=100\,pb^{-1})$			$N_{eventos}\ (\mathcal{L}=100\,pb^{-1})$		
	$t\bar{t}(e,\tau)$	$W(e,\nu_e)+3jets$	$Z(\tau \to e,\nu_e;\tau_{had})+2p$	$t\bar{t}(\mu,\tau)$	$W(\mu,\nu_\mu)+3jets$	$Z(\tau \to \mu,\nu_\mu;\tau_{had})+2p$
	1193 ± 11	12390 ± 123	741.9 ± 7.5	1213 ± 11	6468 ± 52	764.2 ± 7.6
$1\ e/\mu\ P_T > 20\ GeV$	602 ± 8	5560 ± 82	250.5 ± 4.4	783 ± 9	3711 ± 39	377.4 ± 5.3
$1\ \tau\ P_T > 15\ GeV$	232 ± 5	1827 ± 47	98.0 ± 2.7	327 ± 6	1298 ± 23	148.6 ± 3.4
Tau ID	83 ± 3	377 ± 21	49.5 ± 1.9	124 ± 4	226 ± 10	69.6 ± 2.3
$E_T^{1st\ jet} > 50\ GeV$	77 ± 3	297 ± 19	21.7 ± 1.3	119 ± 4	169 ± 8	30.8 ± 1.5
$E_T^{2nd\ jet} > 30\ GeV$	73 ± 3	269 ± 18	14.6 ± 1.1	112 ± 3	140 ± 8	20.4 ± 1.2
$\not{E}_T > 25$	65 ± 3	214 ± 16	6.9 ± 0.7	101 ± 3	113 ± 7	9.1 ± 0.8
$H_T > 250\ GeV$	65 ± 3	200 ± 16	5.5 ± 0.6	99 ± 3	98 ± 6	5.5 ± 0.6
Z veto	64 ± 3	198 ± 16	3.6 ± 0.5	95 ± 3	95 ± 6	3.6 ± 0.5
OS	55 ± 2	86 ± 10	2.2 ± 0.4	84 ± 3	45 ± 4	1.9 ± 0.4
B-TAGGING	44 ± 2	33 ± 6	2.2 ± 0.4	68 ± 3	19 ± 3	1.9 ± 0.4

CONCLUSIONS & FUTURE PLANS.

- We have performed a feasibility study on the observation of the tt-bar dilepton channel with tau lepton in the early ATLAS data L = 100 pb^{-1} using CSC samples.

- In the channel (e,τ): S/B ≈ 0.6 (S/B ≈ 1.3) without (with) b-tagging.
  - With current selection, the use of b-tagging is necessary for observation in first 100 pb^{-1}

- In the channel (μ,τ): S/B ≈ 1.9 (S/B ≈ 3.6) without (with) b-tagging.

- Future plans:
  - Short term: document this feasibility study.
    - Contribution to tau CSC note (~3 pages) by next Monday.
    - ATLAS note related this contribution by end of august.
  - Comparative studies TAUREC versus TAU1P3P
  - In absence of b-tagging: to go inside the tau id algorithms and to work on tighten the τ ID in the channel (e,τ)
  - More realistic estimate of $W(\rightarrow e+\nu_e)$ +≥3 jets background:
    - Parameterize jet→τ fake rate as a function of jet E_T, MET and ΣE_T from multijet data.
    - Apply $F_R(jet\rightarrow\tau)$ to fakeable events in “signal” sample.