Jet Multiplicity and Background Extraction in Inclusive SUSY Analyses at the LHC

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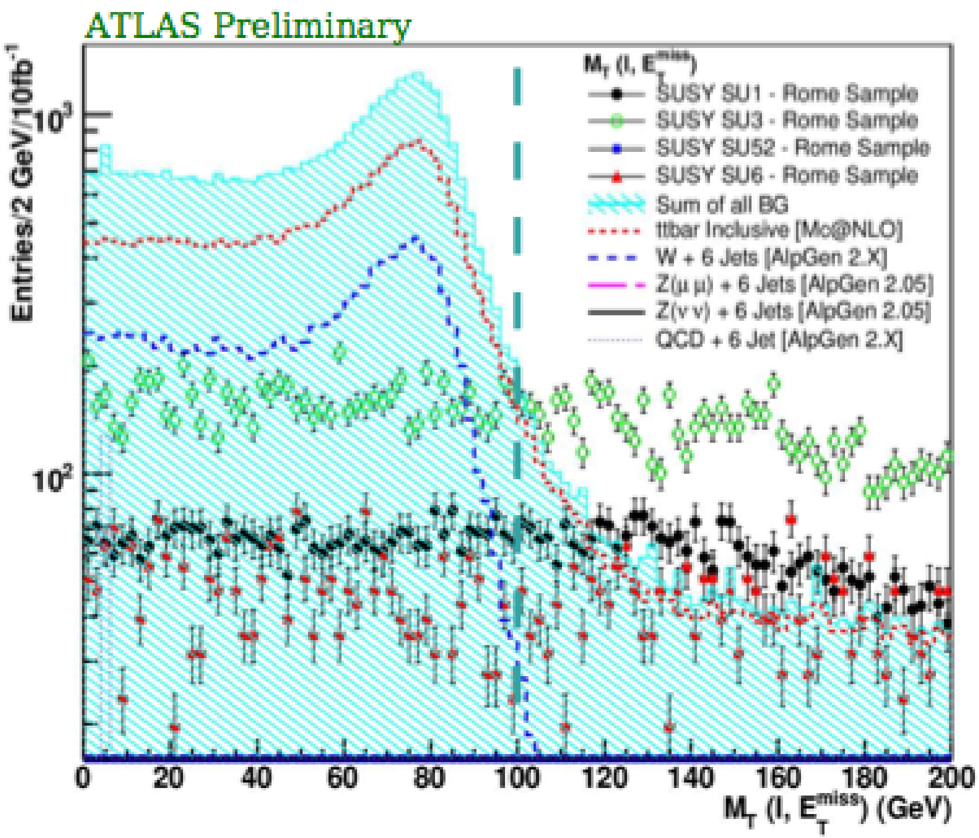
(University of Wisconsin. Not an ATLAS talk)

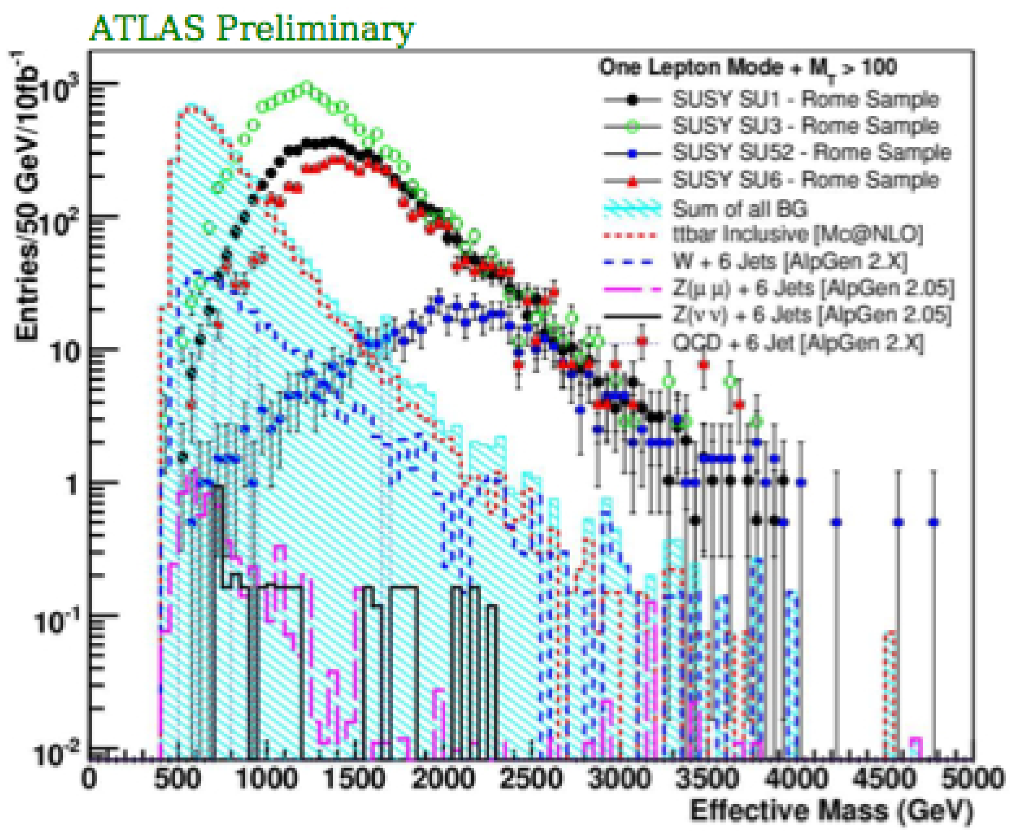
Many thanks to S.Dittmaier, L.Flores, F.Petriello and I.van Vulpen

Pheno 2007, Madison, 05/07/07

Motivation

- Contribution from tt is ubiquitous in SUSY(-like) searches in leptons+MET+jets final states. W+jets is also very important





Motivation (cont)

- We are evaluating the possibility of inclusive SUSY(-like) searches with various numbers of jet tags as means for establishing a deviation from the SM with the very first data at the LHC. In particular we are considering analysis scenarios in which we tag 2j or 3j in addition to 4j base-line analysis
  - In addition, we should take advantage of NLO computations once validated on control samples. Use NLO computations to reduce theoretical uncertainty of ratios

Availability of QCD NLO computations as of LHC turn on

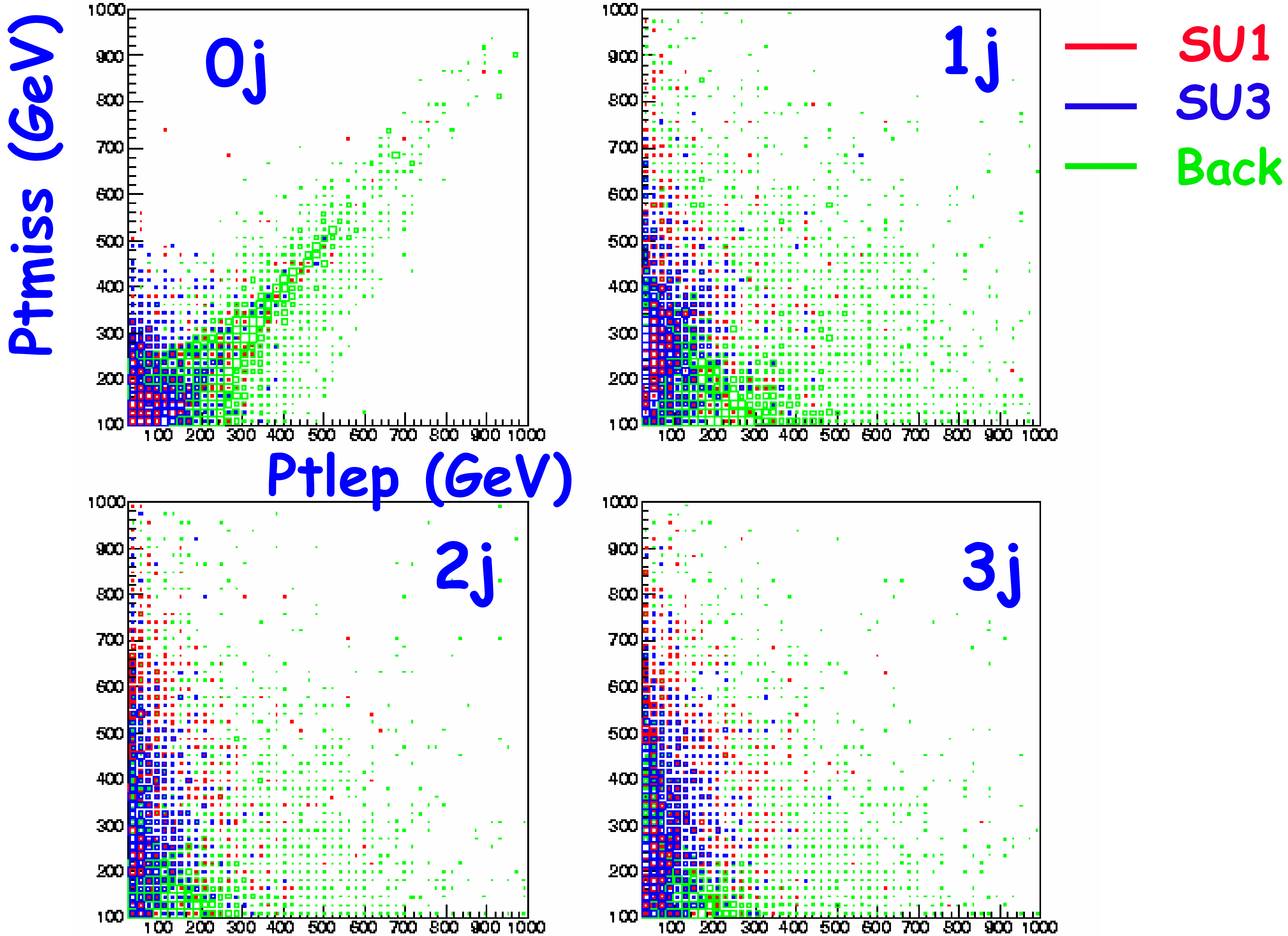
	0j	1j	2j	3j
W	Yes	Yes	Yes	?
tt	Yes	Yes	?	No

Pre-selection (l+MET+jets)

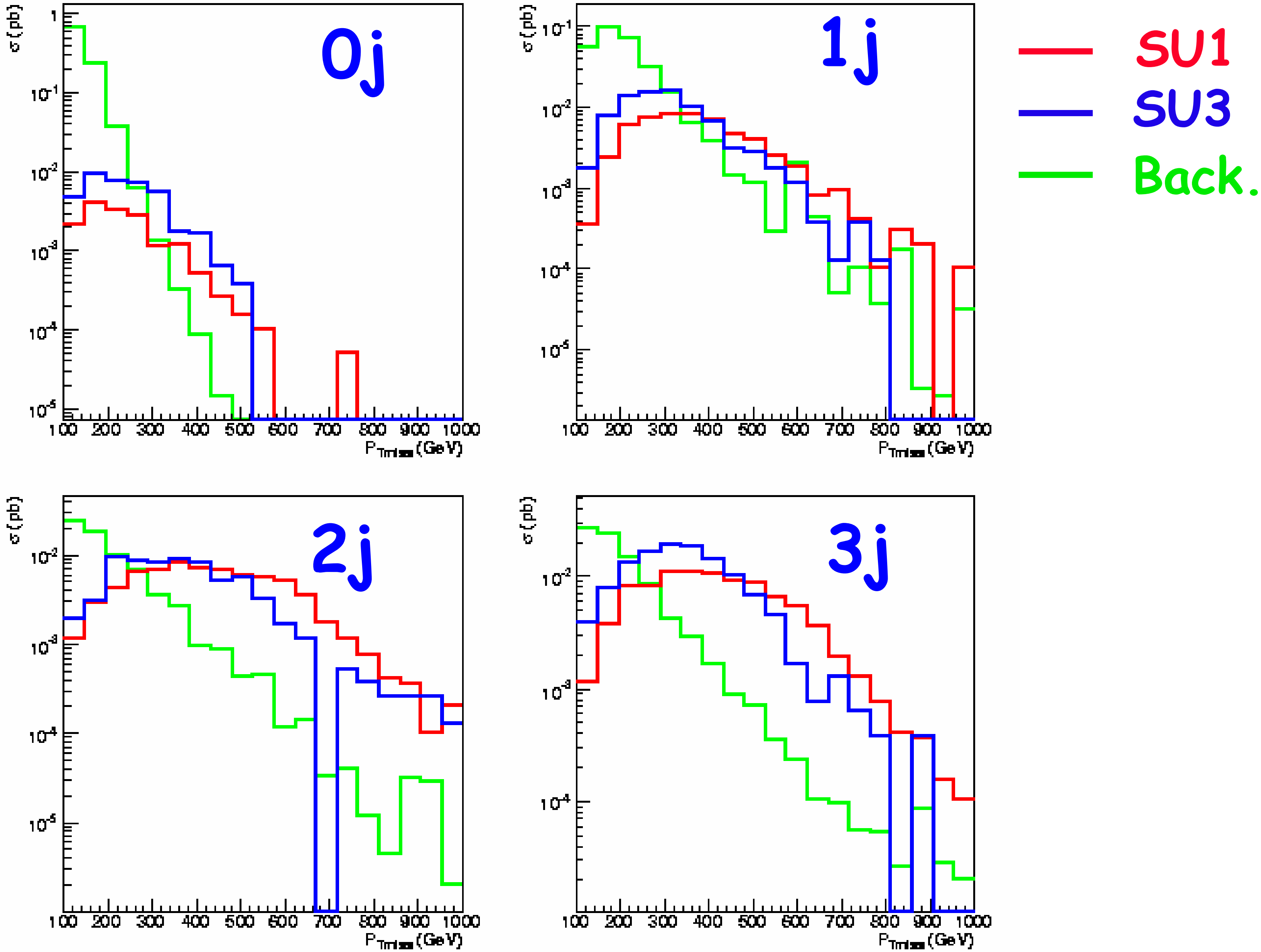
1. Only one lepton with P_{Tl}>20 GeV. Do not accept events in which a second lepton is found with P_T>6 GeV (will increase that to 10 GeV)
2. Missing E_T>100 GeV
3. M_T(lepton MET)>100 GeV

   Events with M_T<100 GeV are used as control samples.
4. Classify events according to the following jet thresholds P_{TJ1}>150, P_{TJ2}>100, P_{TJ3}>50, P_{TJ4}>50
   - These thresholds need to be optimized
   - <u>What happens when we consider events that do not have four jets that pass the above thresholds?</u>

These are events that do not pass the requirement of at least 4 hard jets



R=PTlep/Ptmiss<0.3



Cross-sections in pb and luminosity in pb^{-1}

Analysis with ≥4 jets

Cut (GeV)	SU1			SU2			SU3		
	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$
$\not{p}_T > 100$	0.220	0.77	183.55	0.042	0.15	4333.97	0.352	1.23	79.54
$\not{p}_T > 150$	0.206	1.57	111.85	0.036	0.27	2807.99	0.314	2.40	55.38
$\not{p}_T > 250$	0.163	4.80	69.54	0.020	0.59	2489.57	0.217	6.40	46.50
$\not{p}_T > 300$	0.135	7.14	69.18	0.013	0.69	3396.33	0.161	8.52	53.59
$\not{p}_T > 350$	0.109	10.05	72.49	0.008	0.77	4840.22	0.117	10.83	67.72
$\not{p}_T > 400$	0.083	13.39	85.71	0.005	0.77	8307.65	0.078	12.62	90.64

Analysis with 3 jets, exclusive (R<0.5)

Cut (GeV)	SU1			SU2			SU3		
	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$
$\not{p}_T > 100$	0.110	0.68	404.07	0.002	0.01	-	0.157	0.97	216.39
$\not{p}_T > 150$	0.107	1.21	264.32	0.001	0.02	-	0.149	1.69	150.70
$\not{p}_T > 250$	0.089	3.62	156.26	0.001	0.04	-	0.111	4.54	107.98
$\not{p}_T > 300$	0.078	5.67	138.82	0.001	0.06	-	0.088	6.42	114.32
$\not{p}_T > 350$	0.063	7.92	135.76	0.001	0.08	-	0.061	7.64	154.34
$\not{p}_T > 400$	0.051	10.95	157.77	0.000	0.09	-	0.040	8.61	218.15

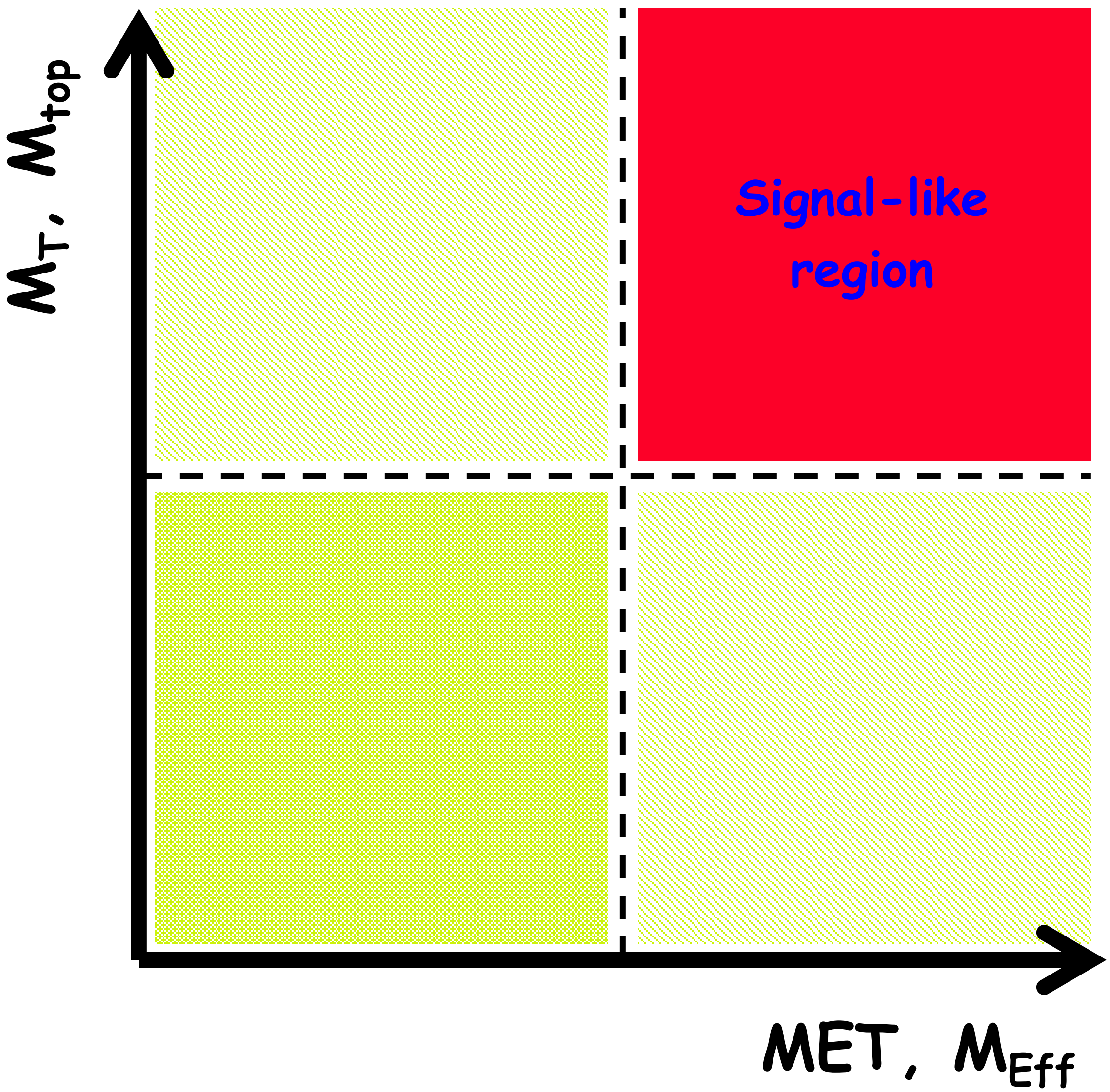
Cross-sections in pb and luminosity in pb^{-1}

Analysis with 2 jets, exclusive (R<0.5)

Cut (GeV)	SU1			SU2			SU3		
	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$
$\not{p}_T > 100$	0.081	0.59	625.41	0.000	0.00	-	0.088	0.65	528.34
$\not{p}_T > 150$	0.077	1.13	380.91	0.000	0.00	-	0.083	1.20	342.12
$\not{p}_T > 250$	0.066	3.24	215.06	0.000	0.01	-	0.062	3.02	239.17
$\not{p}_T > 300$	0.057	5.08	199.44	0.000	0.01	-	0.049	4.34	244.42
$\not{p}_T > 350$	0.049	8.01	176.43	0.000	0.01	-	0.038	6.25	264.18
$\not{p}_T > 400$	0.040	11.93	178.03	0.000	0.01	-	0.027	8.14	315.65

Analysis with 1 jets, exclusive (R<0.5)

Cut (GeV)	SU1			SU2			SU3		
	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$	S	S/B	$L(5\sigma)$
$\not{p}_T > 100$	0.067	0.13	2964.88	0.004	0.01	-	0.108	0.21	1169.22
$\not{p}_T > 150$	0.066	0.19	2165.15	0.004	0.01	-	0.104	0.30	894.61
$\not{p}_T > 250$	0.053	0.66	864.90	0.001	0.01	-	0.070	0.88	519.28
$\not{p}_T > 300$	0.043	1.25	643.33	0.001	0.02	-	0.048	1.40	529.80
$\not{p}_T > 350$	0.032	1.73	696.69	0.000	0.02	-	0.028	1.51	866.31
$\not{p}_T > 400$	0.023	2.41	751.05	0.000	0.01	-	0.016	1.65	1403.09

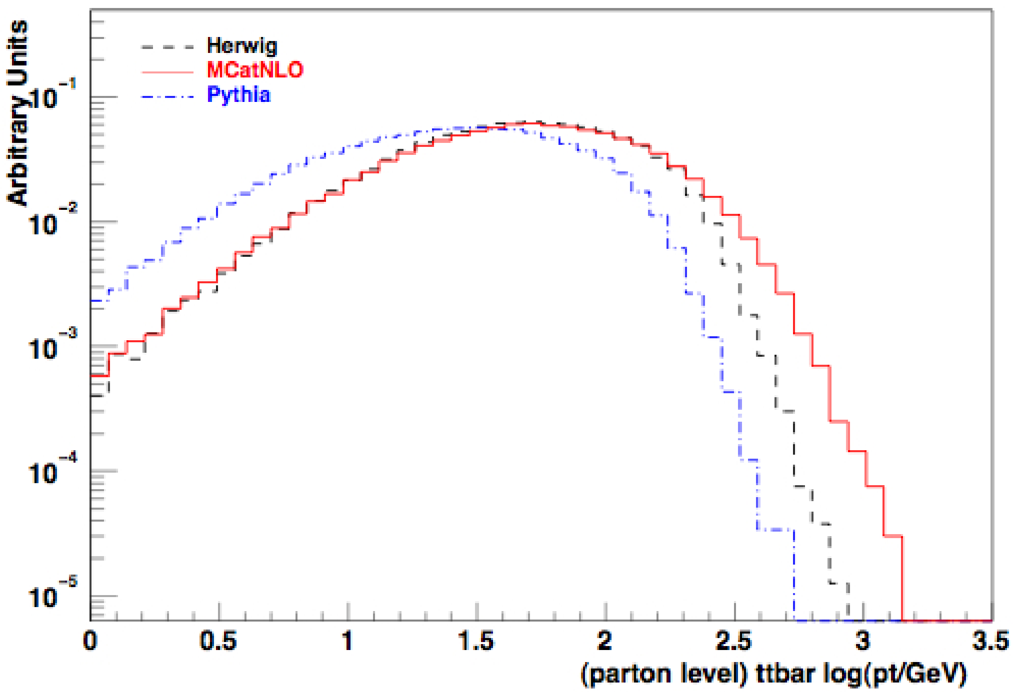


- The search for a deviation over the SM will be performed in certain regions of the phase space.
- Control samples will be used to validate MC and normalize backgrounds in the signal-like region
- It is crucial to study the composition of tt events in different regions of the phase space
  - Need to evaluate theoretical errors of extrapolations

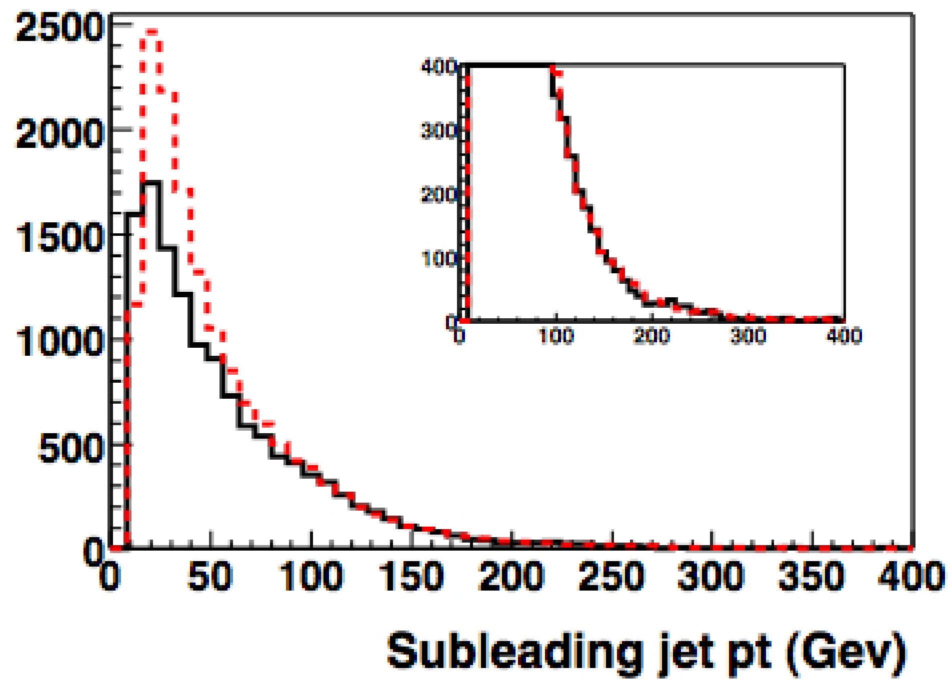
Looking into tt with MC@NLO

- MC@NLO has tt to NLO. Description of Pt of tt system and leading jet to LO. Sub-leading jet with Parton shower, but does not disagree too much from Madgraph tt+2jet

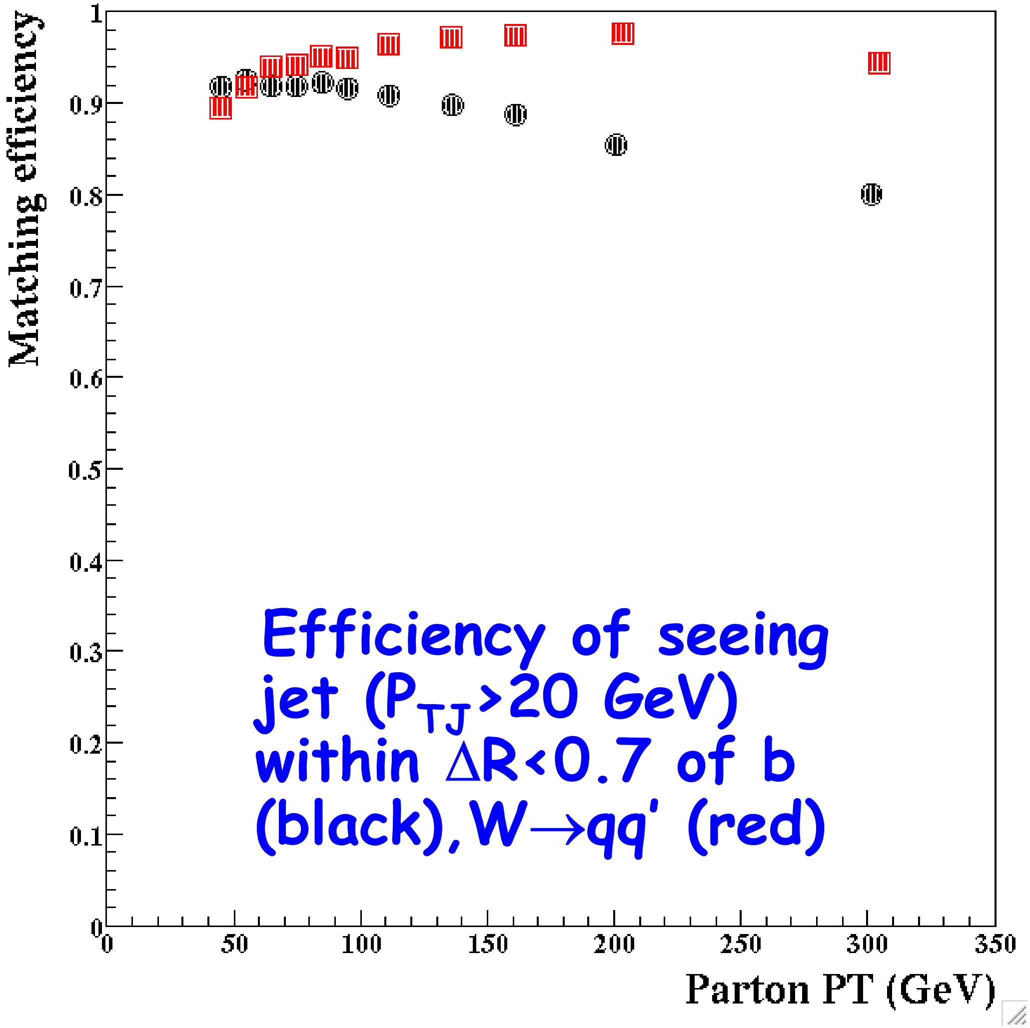
ATL-PHYS-2004-035

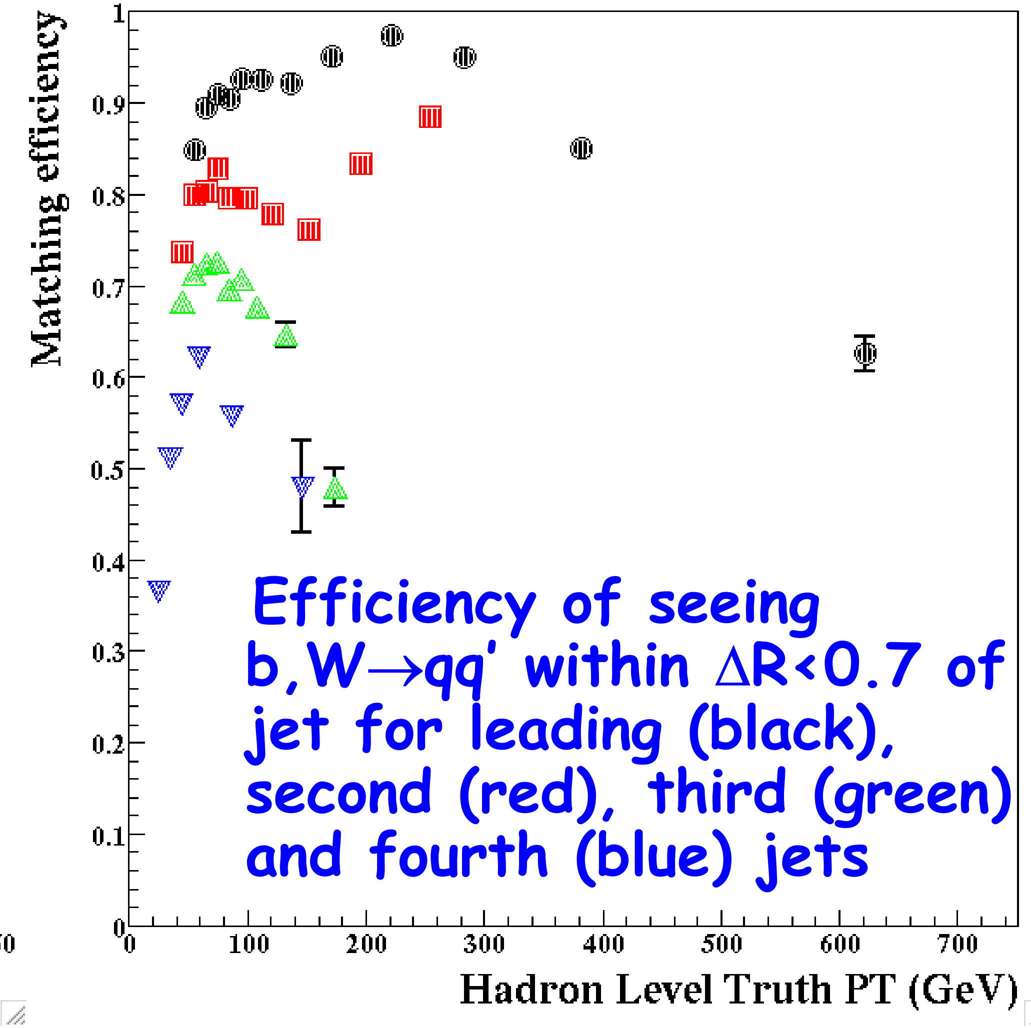


Red Madgraph tt+2j
Black MC@NLO



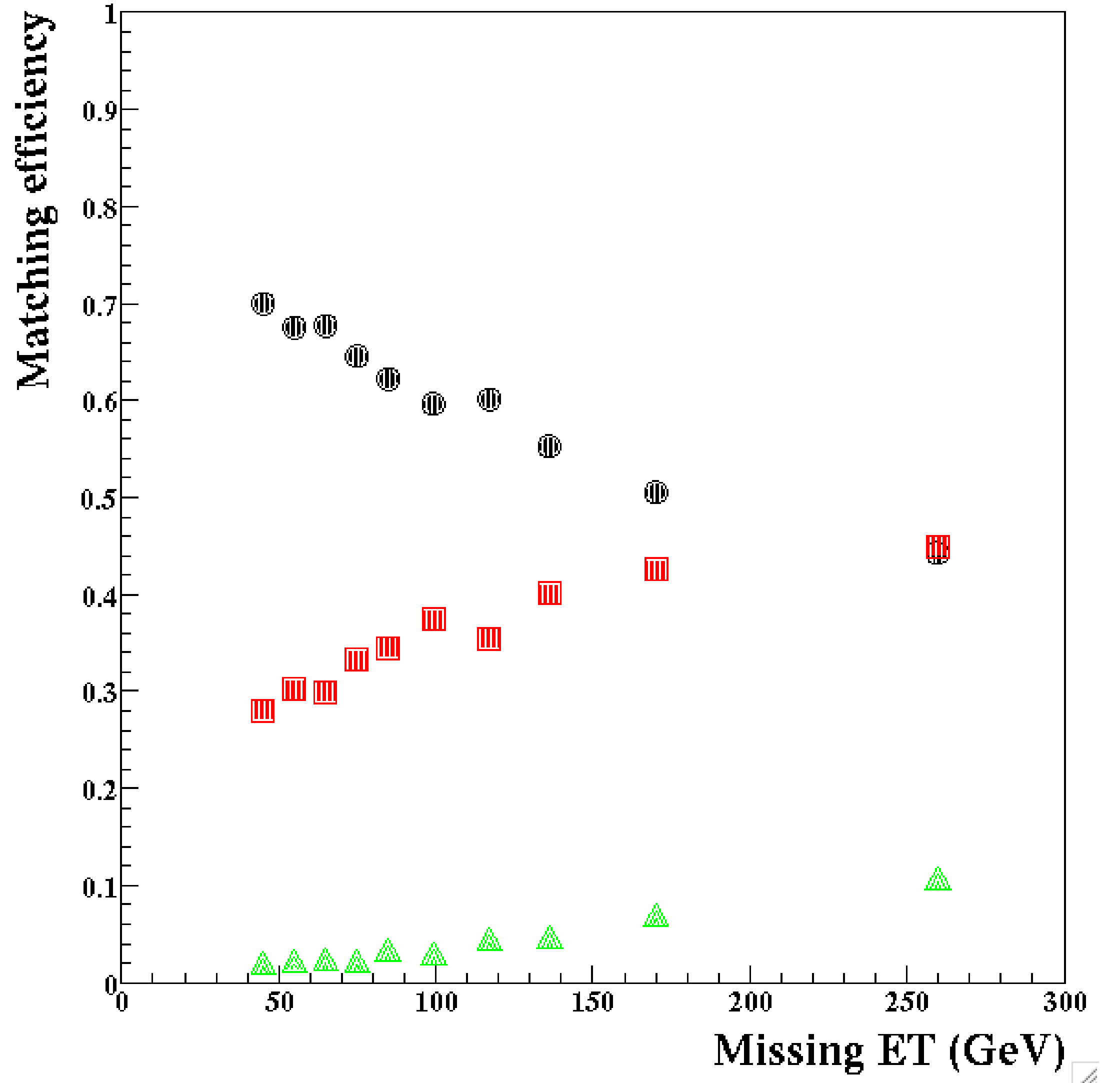
- Looking into truth hadron-level jets (cone ΔR=0.7) and checking the fraction of those jets that match top decay products (study 1 lepton analysis)





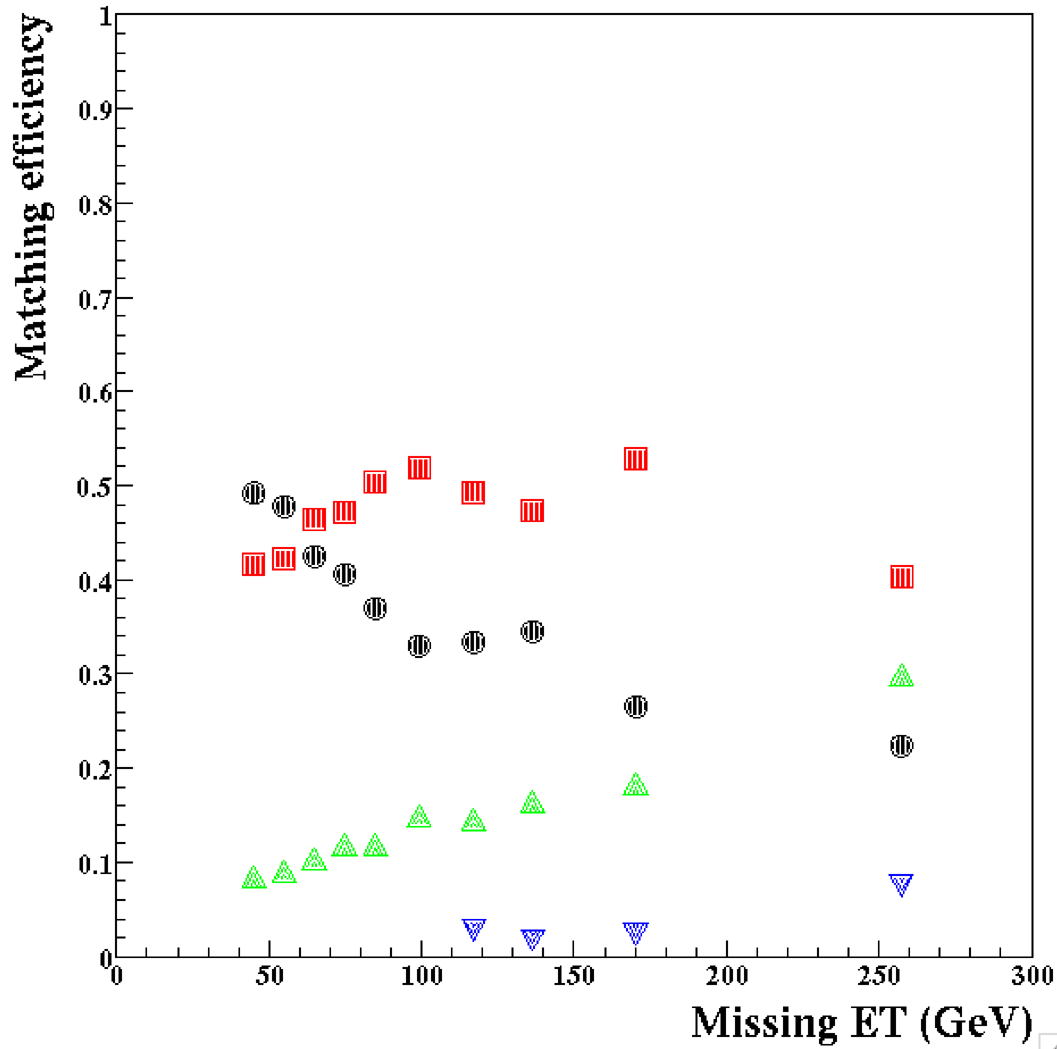
- Fraction of events with two tagging jets (P_{TJ1}>50 and P_{TJ2}>40 GeV) in which 2 (black), 1 (red) and 0 (green) jets are matched to top decay products

In two jet analysis the large MET region is dominated by tt+0j and tt+1j



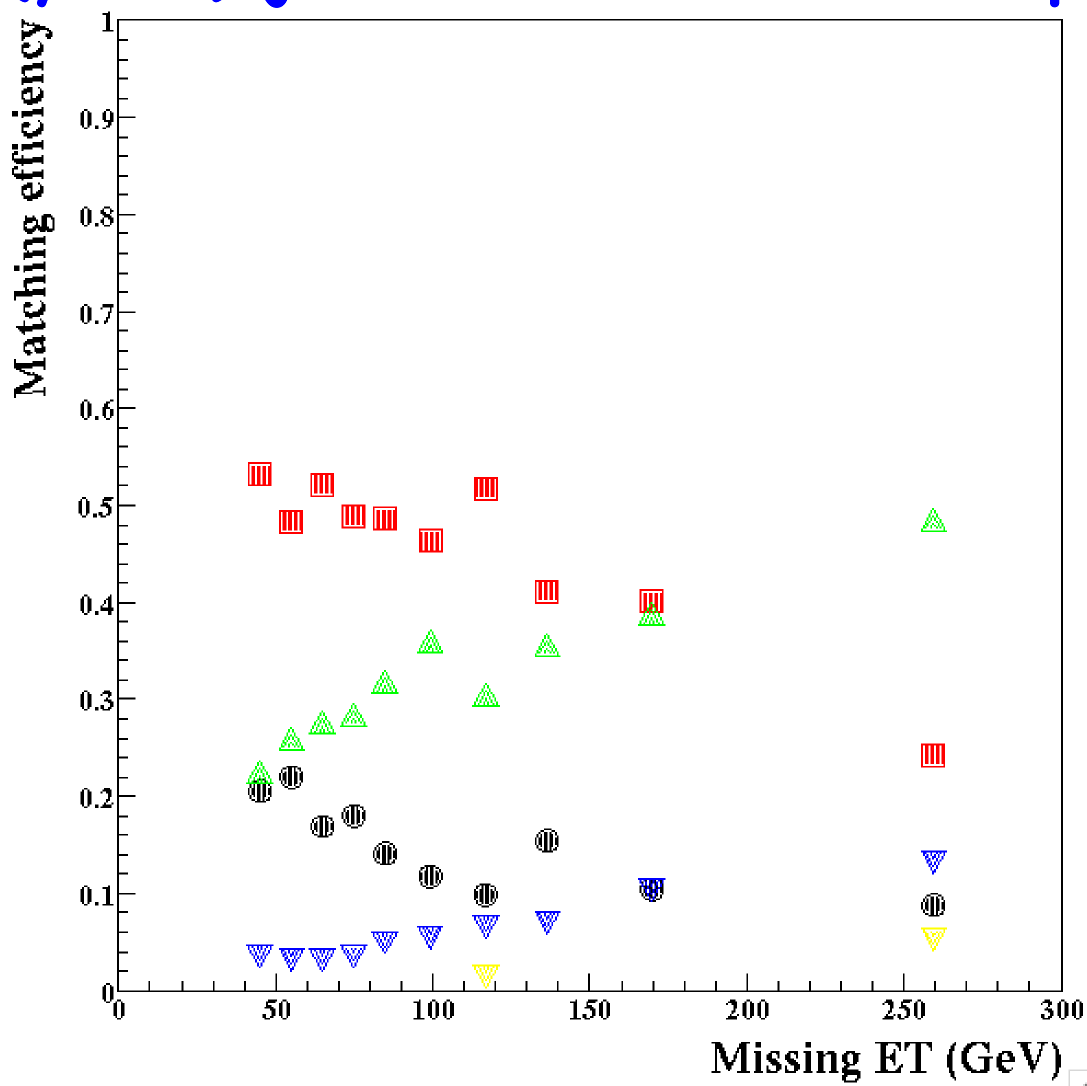
Fraction of events with three tagging jets (P_{TJ1}>50 and P_{TJ2}>40 GeV, P_{TJ3}>40 GeV) in which 3 (black), 2 (red), 1 (green) and 0 (blue) jets are matched to top decay products

In three jet analysis the large MET region is dominated by tt+0j and tt+1j with some contribution from tt+2j

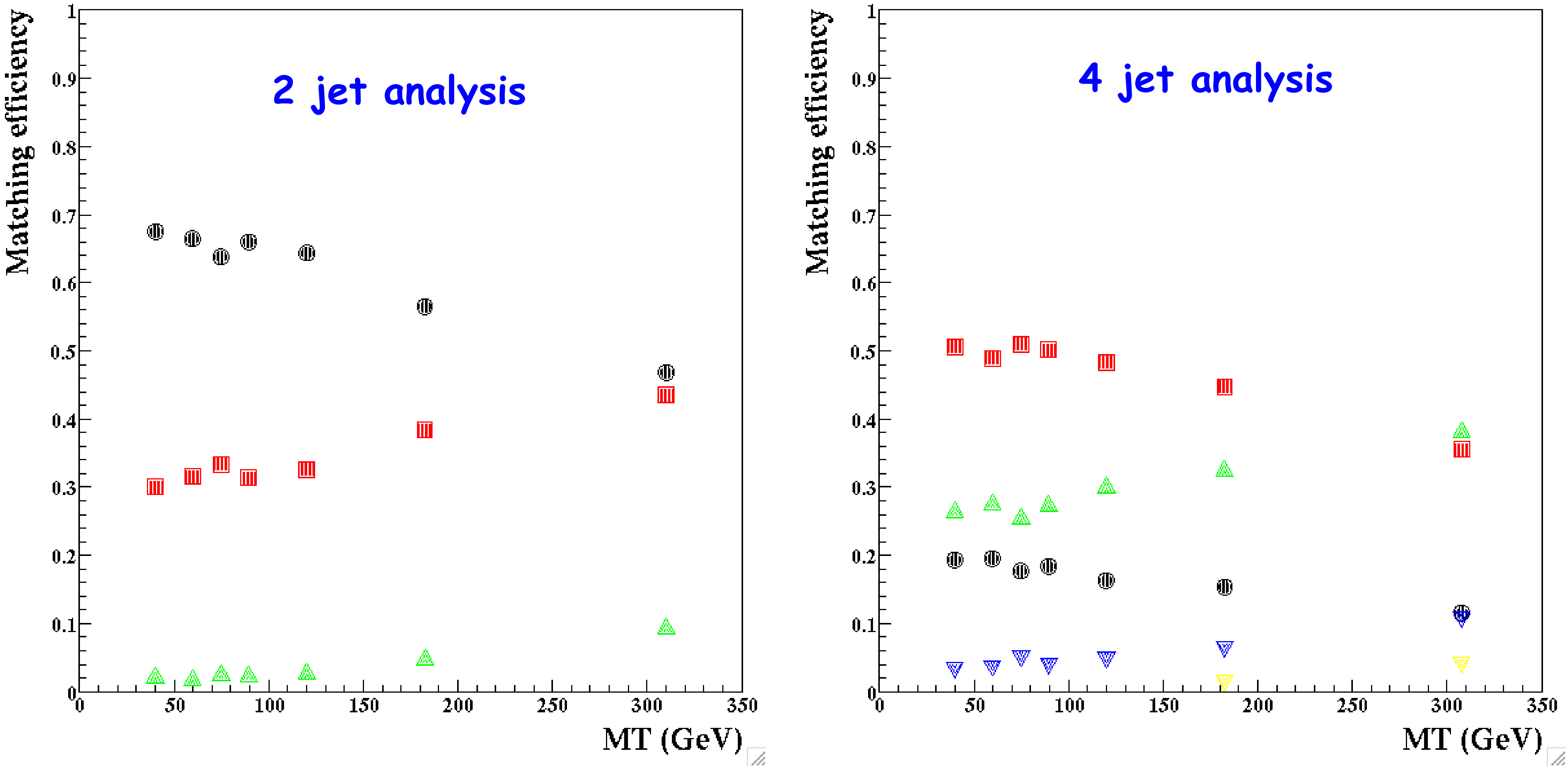


- Fraction of events with four tagging jets (P_{TJ1}>50 and P_{TJ2}>40 GeV, P_{TJ3}>40 GeV and P_{TJ4}>30 GeV) in which 4 (black), 3 (red), 2 (green), 1 (blue) and 0 (yelow) jets are matched to top decay products

In four jet analysis the large MET region is dominated by tt+1j and tt+2j with some contribution from tt+0j and tt+≥3j



- **Similar situation is observed when the matching efficiency is studied as a function of $M_T(l\nu)$**



Outlook

- We are exploring the discovery potential of SUSY signals for the ATLAS points in the l+MET final state for different jet multiplicities
  - For the SUSY points chosen, the final state with 4 jets carry most of the discovery potential, although final states with less jet multiplicity also carry similar discovery potential when combined.
    - This statement depends on the SUSY point
- Tagging 2 or 3 jets inclusively seems feasible and does not degrade discovery potential (for the SUSY points investigated). Tagging 2 or 3 jets brings significant benefits in terms of determination of background
- Working with theorists to evaluate theory errors for different analysis scenarios

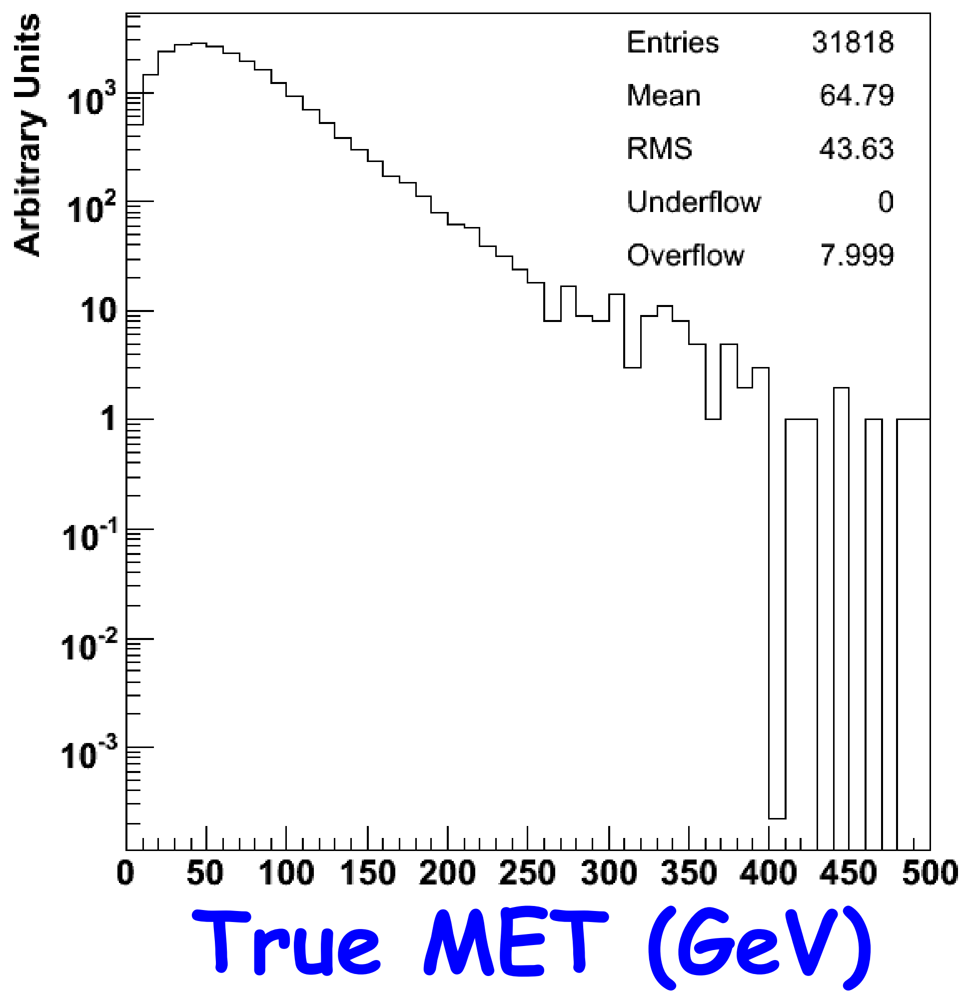
Back-up Slides

Cross-sections in pb

Cut (GeV)	$t\bar{t}$	W+jets	$Wb\bar{b}$+jets	WW+jets	ZW	Total	Fraction
				0j			
$\not{p}_T > 100$	2.270	5.105	0.103	0.096	0.085	7.658	0.81
$\not{p}_T > 150$	0.421	1.165	0.026	0.022	0.020	1.652	0.66
$\not{p}_T > 250$	0.012	0.197	0.004	0.002	0.003	0.217	0.52
$\not{p}_T > 300$	0.002	0.094	0.002	0.001	0.001	0.101	0.50
$\not{p}_T > 350$	0.001	0.053	0.001	0.000	0.001	0.056	0.50
$\not{p}_T > 400$	0.000	0.033	0.001	0.000	0.000	0.034	0.52
				1j			
$\not{p}_T > 100$	0.418	0.413	0.035	0.029	0.000	0.896	0.10
$\not{p}_T > 150$	0.215	0.240	0.015	0.019	0.000	0.488	0.19
$\not{p}_T > 250$	0.032	0.063	0.004	0.006	0.000	0.105	0.25
$\not{p}_T > 300$	0.012	0.031	0.002	0.003	0.000	0.048	0.24
$\not{p}_T > 350$	0.004	0.018	0.001	0.002	0.000	0.025	0.23
$\not{p}_T > 400$	0.002	0.011	0.001	0.001	0.000	0.014	0.21
				2j			
$\not{p}_T > 100$	0.140	0.099	0.023	0.009	0.000	0.271	0.03
$\not{p}_T > 150$	0.056	0.045	0.008	0.005	0.000	0.113	0.04
$\not{p}_T > 250$	0.009	0.016	0.002	0.002	0.000	0.029	0.07
$\not{p}_T > 300$	0.004	0.009	0.001	0.001	0.000	0.016	0.08
$\not{p}_T > 350$	0.002	0.006	0.000	0.001	0.000	0.009	0.08
$\not{p}_T > 400$	0.001	0.004	0.000	0.000	0.000	0.005	0.08
				3j			
$\not{p}_T > 100$	0.201	0.070	0.029	0.008	0.000	0.308	0.03
$\not{p}_T > 150$	0.088	0.031	0.010	0.005	0.000	0.134	0.05
$\not{p}_T > 250$	0.018	0.011	0.002	0.002	0.000	0.032	0.08
$\not{p}_T > 300$	0.009	0.007	0.001	0.001	0.000	0.017	0.09
$\not{p}_T > 350$	0.004	0.004	0.001	0.001	0.000	0.010	0.09
$\not{p}_T > 400$	0.002	0.003	0.000	0.001	0.000	0.006	0.09
				$\geq$ 4j			
$\not{p}_T > 100$	0.193	0.061	0.026	0.006	0.000	0.286	0.03
$\not{p}_T > 150$	0.090	0.027	0.010	0.004	0.000	0.131	0.05
$\not{p}_T > 250$	0.022	0.008	0.002	0.002	0.000	0.034	0.08
$\not{p}_T > 300$	0.011	0.005	0.001	0.001	0.000	0.019	0.09
$\not{p}_T > 350$	0.006	0.003	0.001	0.001	0.000	0.011	0.10
$\not{p}_T > 400$	0.003	0.002	0.000	0.001	0.000	0.006	0.09

Cut (GeV)	SU1			SU2			SU3		
	S	S/B	Frac.	S	S/B	Frac.	S	S/B	Frac.
				0j					
$\not\!\!E_T > 100$	0.062	0.01	0.11	0.023	0.00	0.32	0.122	0.02	0.14
$\not\!\!E_T > 150$	0.041	0.02	0.08	0.007	0.00	0.15	0.081	0.05	0.10
$\not\!\!E_T > 250$	0.013	0.06	0.03	0.001	0.00	0.03	0.028	0.13	0.05
$\not\!\!E_T > 300$	0.007	0.07	0.02	0.000	0.00	0.02	0.014	0.14	0.04
$\not\!\!E_T > 350$	0.004	0.08	0.02	0.000	0.00	0.02	0.007	0.13	0.03
$\not\!\!E_T > 400$	0.003	0.08	0.01	0.000	0.00	0.01	0.004	0.10	0.02
				1j					
$\not\!\!E_T > 100$	0.078	0.09	0.14	0.005	0.01	0.07	0.129	0.14	0.14
$\not\!\!E_T > 150$	0.075	0.15	0.14	0.004	0.01	0.08	0.119	0.24	0.15
$\not\!\!E_T > 250$	0.057	0.55	0.14	0.001	0.01	0.06	0.076	0.72	0.15
$\not\!\!E_T > 300$	0.046	0.96	0.14	0.001	0.01	0.05	0.051	1.07	0.14
$\not\!\!E_T > 350$	0.034	1.34	0.13	0.000	0.01	0.04	0.030	1.18	0.12
$\not\!\!E_T > 400$	0.024	1.72	0.12	0.000	0.01	0.02	0.017	1.21	0.10
				2j					
$\not\!\!E_T > 100$	0.090	0.33	0.16	0.001	0.00	0.01	0.104	0.38	0.12
$\not\!\!E_T > 150$	0.085	0.75	0.16	0.000	0.00	0.01	0.093	0.82	0.12
$\not\!\!E_T > 250$	0.071	2.43	0.18	0.000	0.01	0.01	0.066	2.27	0.13
$\not\!\!E_T > 300$	0.061	3.83	0.18	0.000	0.01	0.01	0.052	3.27	0.14
$\not\!\!E_T > 350$	0.051	5.51	0.19	0.000	0.01	0.01	0.039	4.19	0.15
$\not\!\!E_T > 400$	0.041	7.63	0.20	0.000	0.01	0.01	0.027	5.08	0.16
				3j					
$\not\!\!E_T > 100$	0.126	0.41	0.22	0.002	0.01	0.03	0.184	0.60	0.21
$\not\!\!E_T > 150$	0.119	0.89	0.23	0.002	0.01	0.04	0.169	1.26	0.22
$\not\!\!E_T > 250$	0.095	2.95	0.24	0.001	0.03	0.05	0.117	3.65	0.23
$\not\!\!E_T > 300$	0.082	4.75	0.25	0.001	0.05	0.06	0.092	5.31	0.25
$\not\!\!E_T > 350$	0.066	6.78	0.25	0.001	0.07	0.07	0.063	6.48	0.25
$\not\!\!E_T > 400$	0.052	9.21	0.26	0.000	0.08	0.08	0.041	7.17	0.24
				$\geq$ 4j					
$\not\!\!E_T > 100$	0.220	0.77	0.38	0.042	0.15	0.57	0.352	1.23	0.39
$\not\!\!E_T > 150$	0.206	1.57	0.39	0.036	0.27	0.73	0.314	2.40	0.41
$\not\!\!E_T > 250$	0.163	4.80	0.41	0.020	0.59	0.86	0.217	6.40	0.43
$\not\!\!E_T > 300$	0.135	7.14	0.41	0.013	0.69	0.86	0.161	8.51	0.44
$\not\!\!E_T > 350$	0.109	10.05	0.41	0.008	0.77	0.87	0.117	10.83	0.46
$\not\!\!E_T > 400$	0.083	13.37	0.41	0.005	0.77	0.88	0.078	12.60	0.47

Cut (GeV)	SU6			$SU8_1$		
	S	S/B	Frac.	S	S/B	Frac.
			0j			
$\not\!\!E_T > 100$	0.018	0.00	0.07	0.022	0.00	0.07
$\not\!\!E_T > 150$	0.012	0.01	0.05	0.015	0.01	0.05
$\not\!\!E_T > 250$	0.005	0.02	0.03	0.004	0.02	0.02
$\not\!\!E_T > 300$	0.003	0.03	0.02	0.002	0.02	0.01
$\not\!\!E_T > 350$	0.001	0.02	0.01	0.000	0.01	0.00
$\not\!\!E_T > 400$	0.001	0.02	0.01	0.000	0.01	0.00
			1j			
$\not\!\!E_T > 100$	0.026	0.03	0.10	0.042	0.05	0.14
$\not\!\!E_T > 150$	0.025	0.05	0.11	0.041	0.08	0.15
$\not\!\!E_T > 250$	0.019	0.18	0.11	0.033	0.32	0.16
$\not\!\!E_T > 300$	0.016	0.32	0.10	0.028	0.59	0.16
$\not\!\!E_T > 350$	0.012	0.48	0.10	0.021	0.83	0.15
$\not\!\!E_T > 400$	0.008	0.60	0.08	0.013	0.95	0.13
			2j			
$\not\!\!E_T > 100$	0.025	0.09	0.10	0.036	0.13	0.12
$\not\!\!E_T > 150$	0.024	0.21	0.10	0.034	0.30	0.12
$\not\!\!E_T > 250$	0.020	0.69	0.11	0.027	0.94	0.13
$\not\!\!E_T > 300$	0.017	1.10	0.11	0.023	1.47	0.13
$\not\!\!E_T > 350$	0.015	1.66	0.12	0.019	2.10	0.14
$\not\!\!E_T > 400$	0.013	2.37	0.13	0.015	2.84	0.15
			3j			
$\not\!\!E_T > 100$	0.048	0.15	0.19	0.058	0.19	0.20
$\not\!\!E_T > 150$	0.045	0.34	0.19	0.056	0.41	0.21
$\not\!\!E_T > 250$	0.038	1.17	0.20	0.044	1.36	0.21
$\not\!\!E_T > 300$	0.033	1.88	0.21	0.039	2.26	0.22
$\not\!\!E_T > 350$	0.027	2.73	0.21	0.032	3.28	0.23
$\not\!\!E_T > 400$	0.022	3.87	0.22	0.026	4.61	0.25
			$\geq$ 4j			
$\not\!\!E_T > 100$	0.134	0.47	0.53	0.138	0.48	0.47
$\not\!\!E_T > 150$	0.127	0.97	0.54	0.126	0.96	0.47
$\not\!\!E_T > 250$	0.102	3.01	0.55	0.098	2.90	0.47
$\not\!\!E_T > 300$	0.087	4.59	0.56	0.085	4.46	0.48
$\not\!\!E_T > 350$	0.071	6.52	0.56	0.066	6.09	0.48
$\not\!\!E_T > 400$	0.055	8.87	0.56	0.049	7.92	0.47


Arbitrary Units
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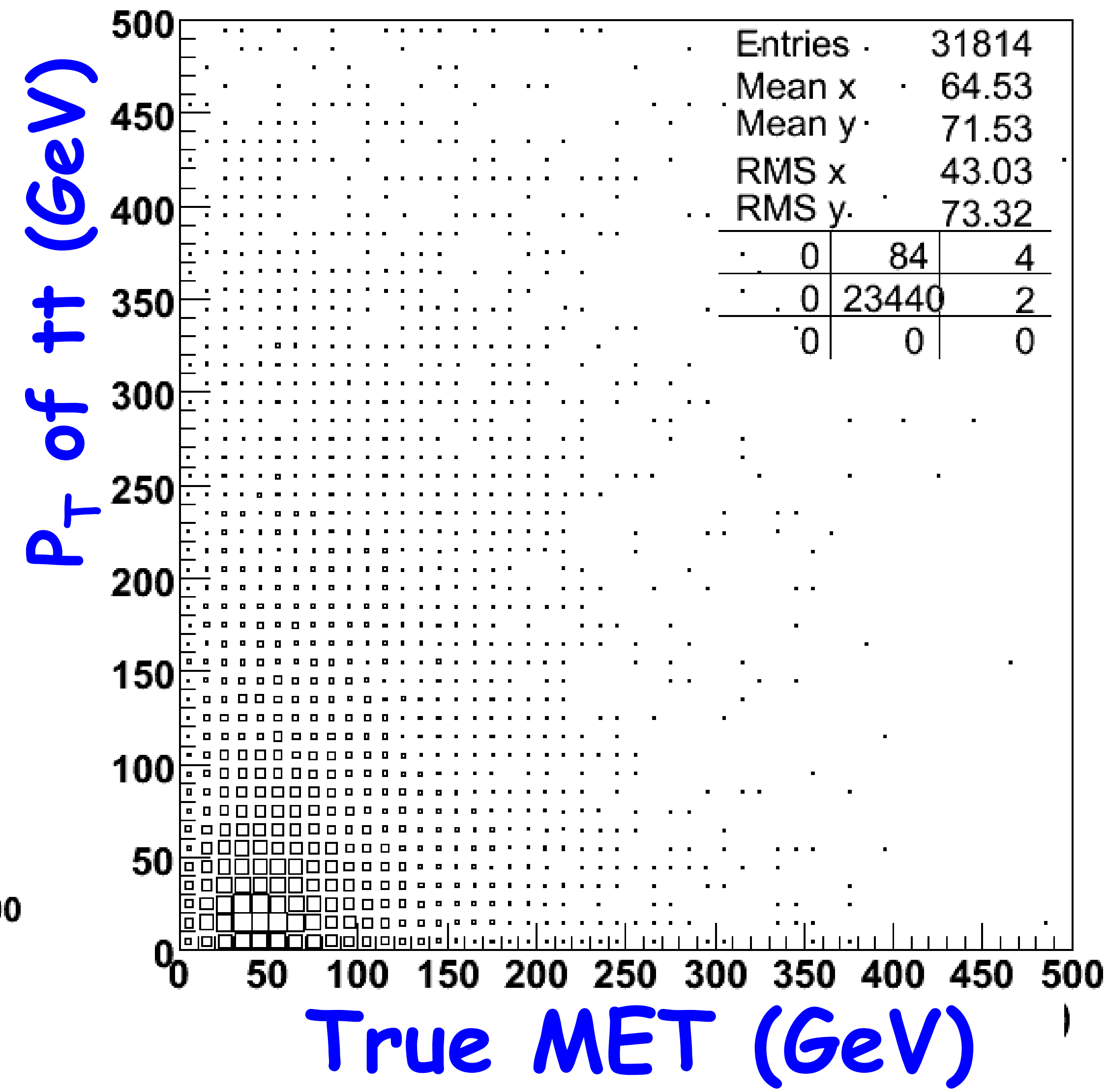
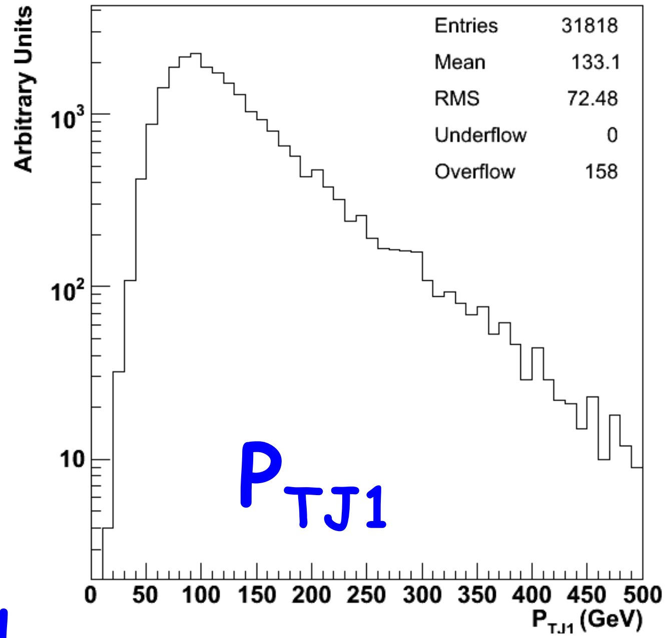
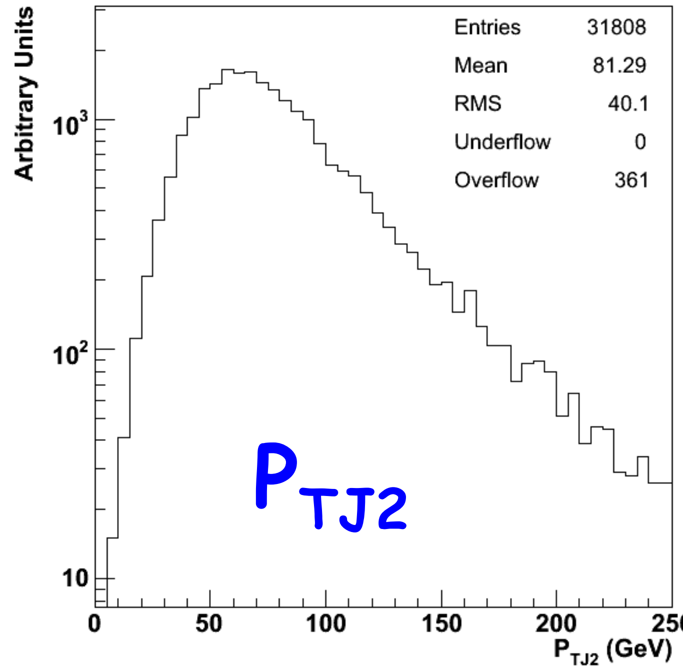
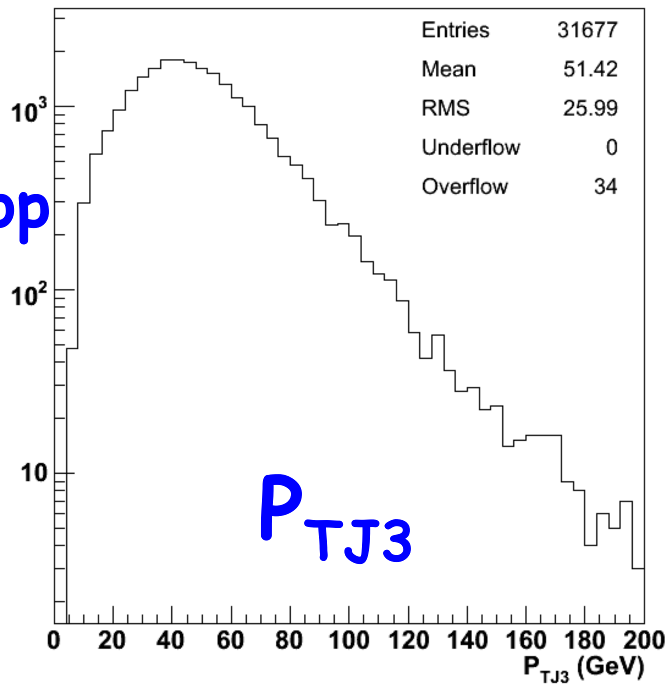
RMS 43.63
Underflow 0
Overflow 7.999
True MET (GeV)

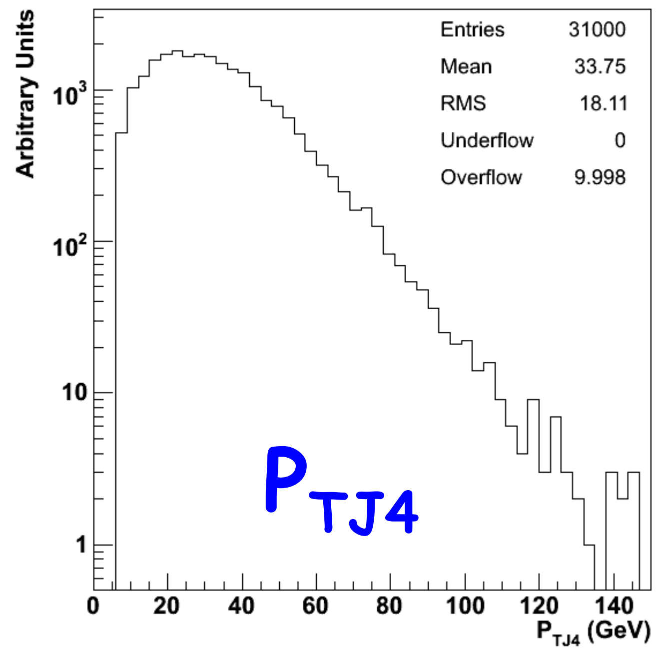

Entries 31814
Mean x 64.53
Mean y 71.53
RMS x 43.03
RMS y 73.32
0 84 4
0 23440 2
0 0 0
P_T of tt (GeV)
True MET (GeV)

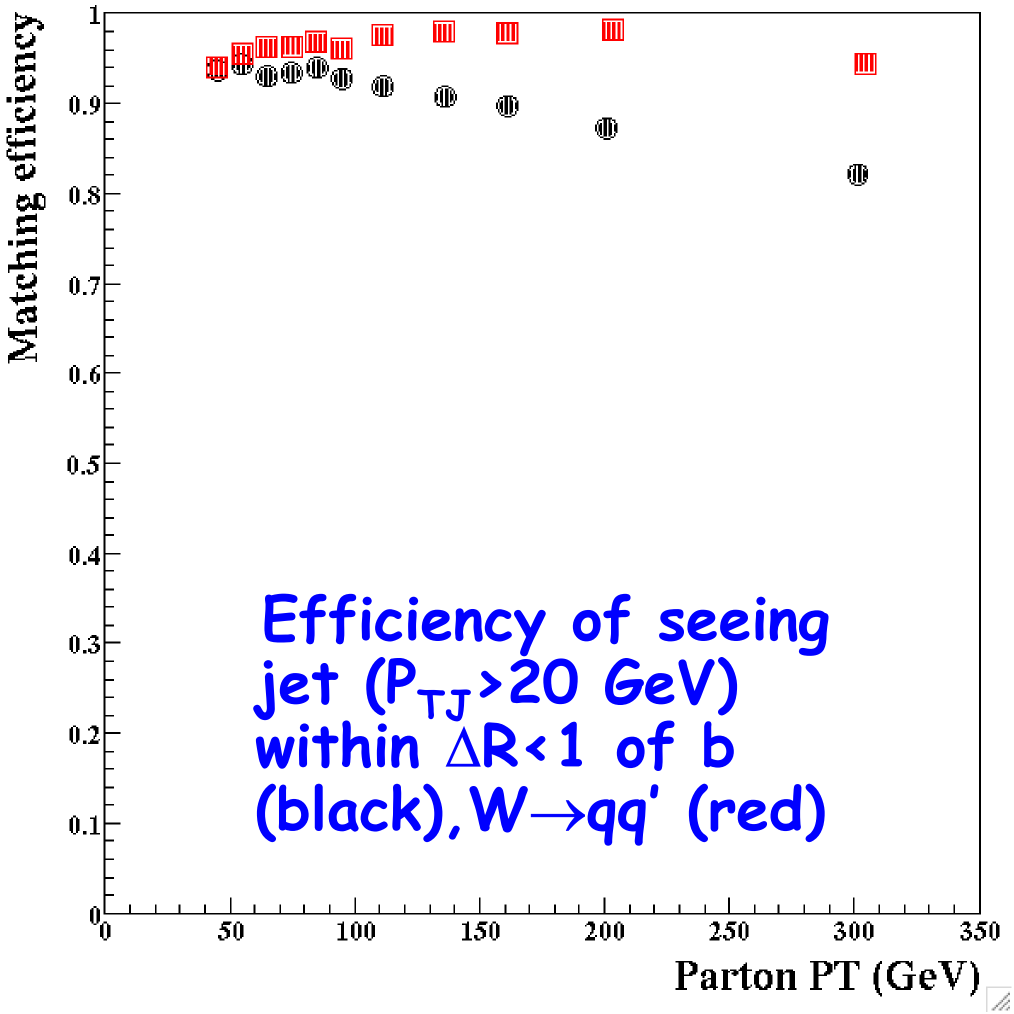
- Looking into truth hadron-level jets (cone $\Delta R=0.7$) and checking the fraction of those jets that match top decay products
  - Study 1 lepton analysis

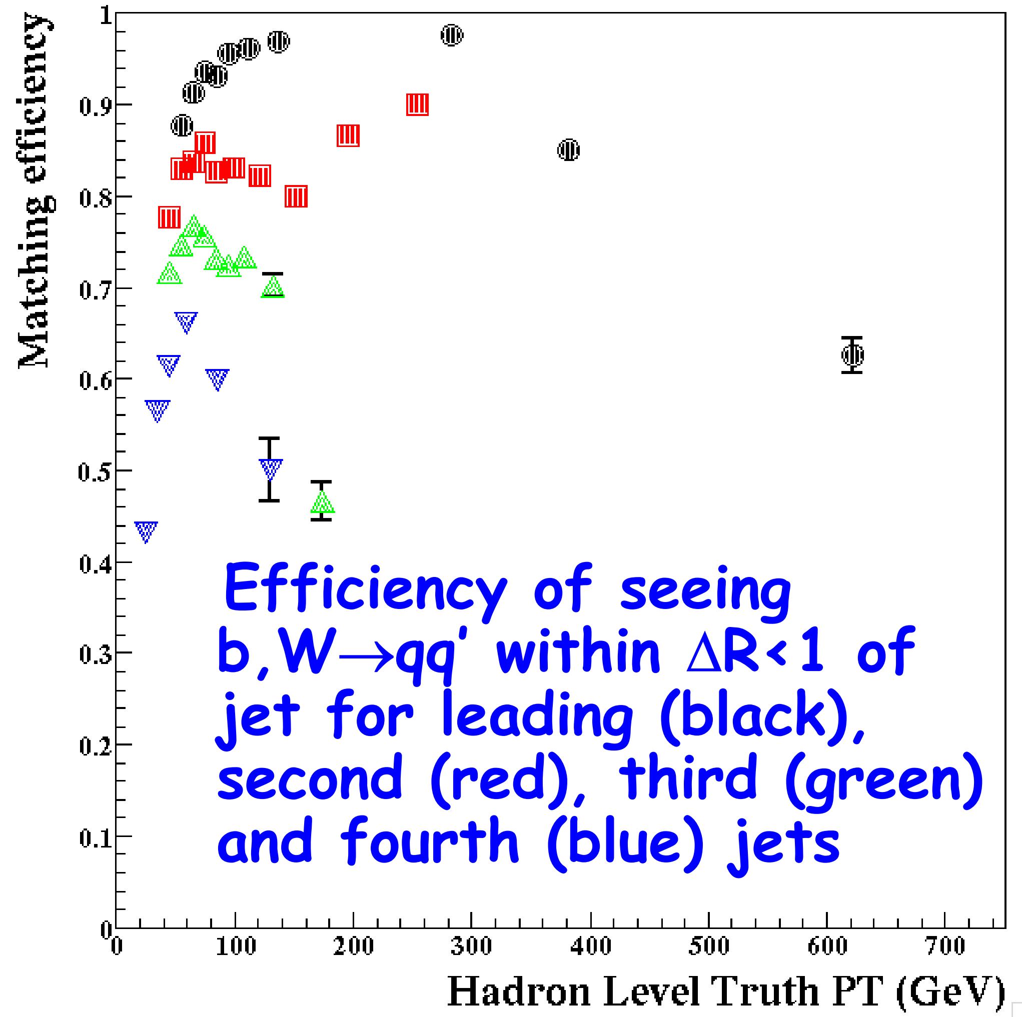






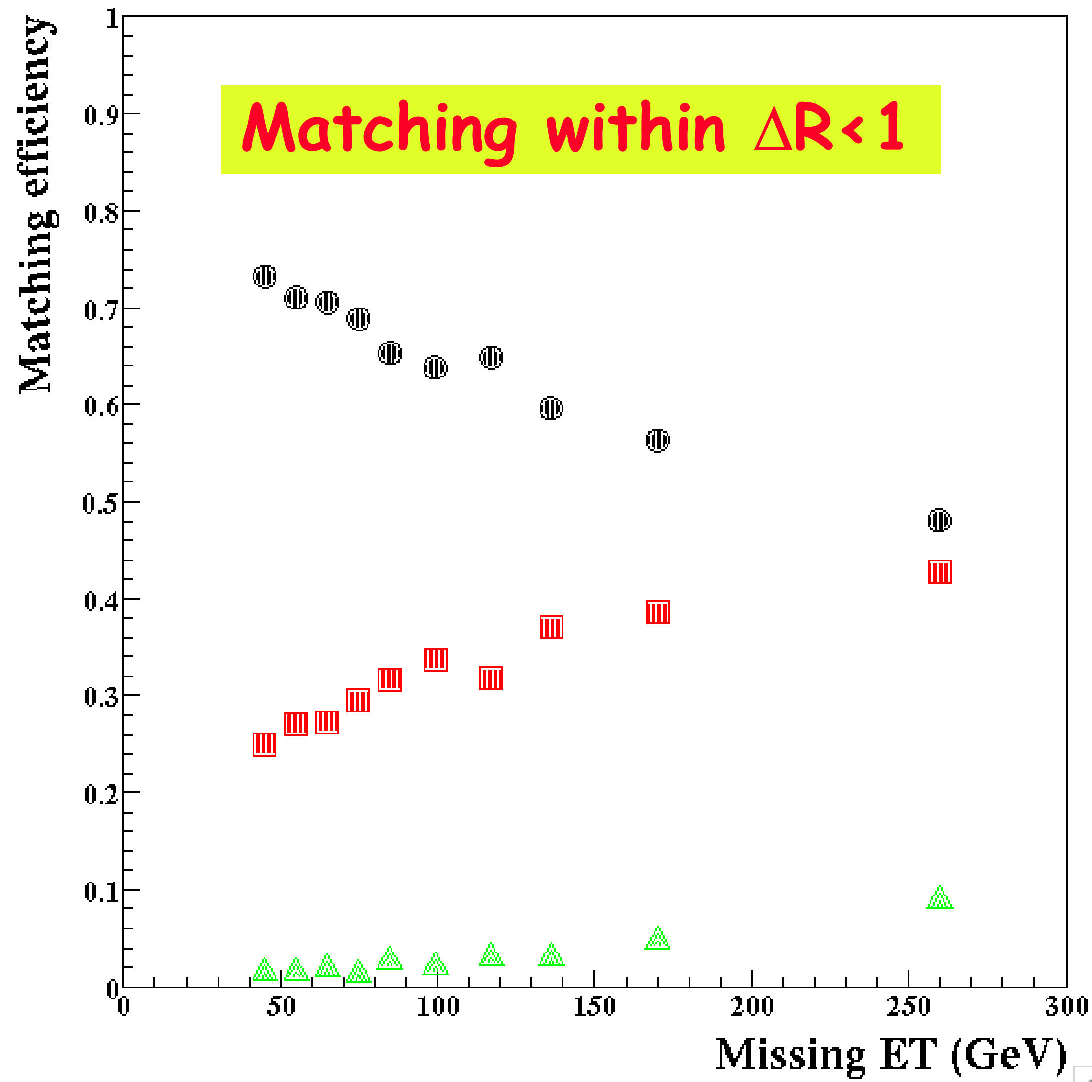



Matching efficiency
Parton PT (GeV)
Efficiency of seeing
jet (P_TJ>20 GeV)
within ΔR<1 of b
(black), W→qq' (red)


Matching efficiency
Hadron Level Truth PT (GeV)
Efficiency of seeing
b, W→qq' within ΔR<1 of
jet for leading (black),
second (red), third (green)
and fourth (blue) jets

- Fraction of events with two tagging jets (P_{TJ1}>50 and P_{TJ2}>40 GeV) in which 2 (black), 1 (red) and 0 (green) jets are matched to top decay products

In two jet analysis the large MET region is dominated by tt+0j and tt+1j



Fraction of events with four tagging jets (P_{TJ1}>50 and P_{TJ2}>40 GeV, P_{TJ3}>40 GeV and P_{TJ4}>30 GeV) in which 4 (black), 3 (red), 2 (green), 1 (blue) and 0 (yelow) jets are matched to top decay products

In four jet analysis the large MET region is dominated by tt+1j and tt+2j with some contribution from tt+0j and tt+≥3j