Trilepton signal from chargino-neutralino production and decay at the focus point

An update

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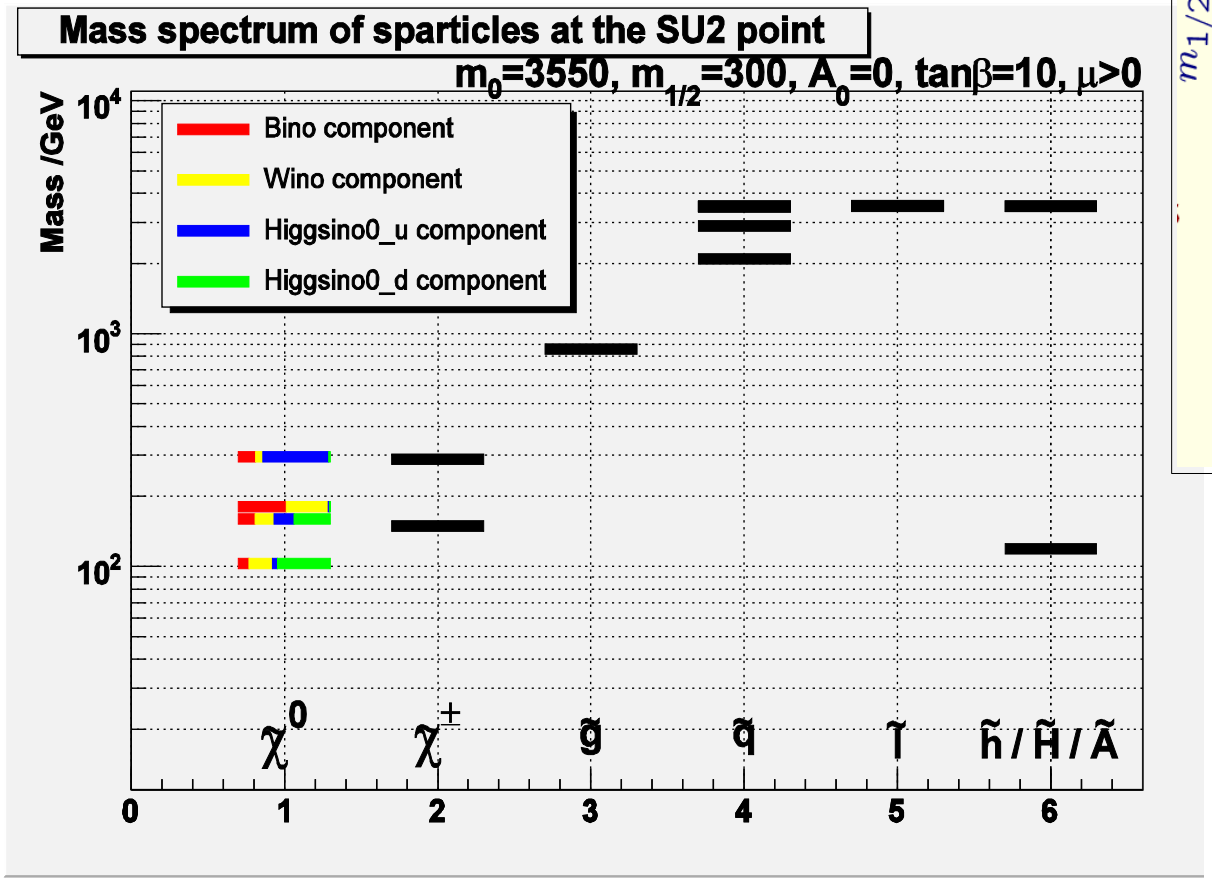
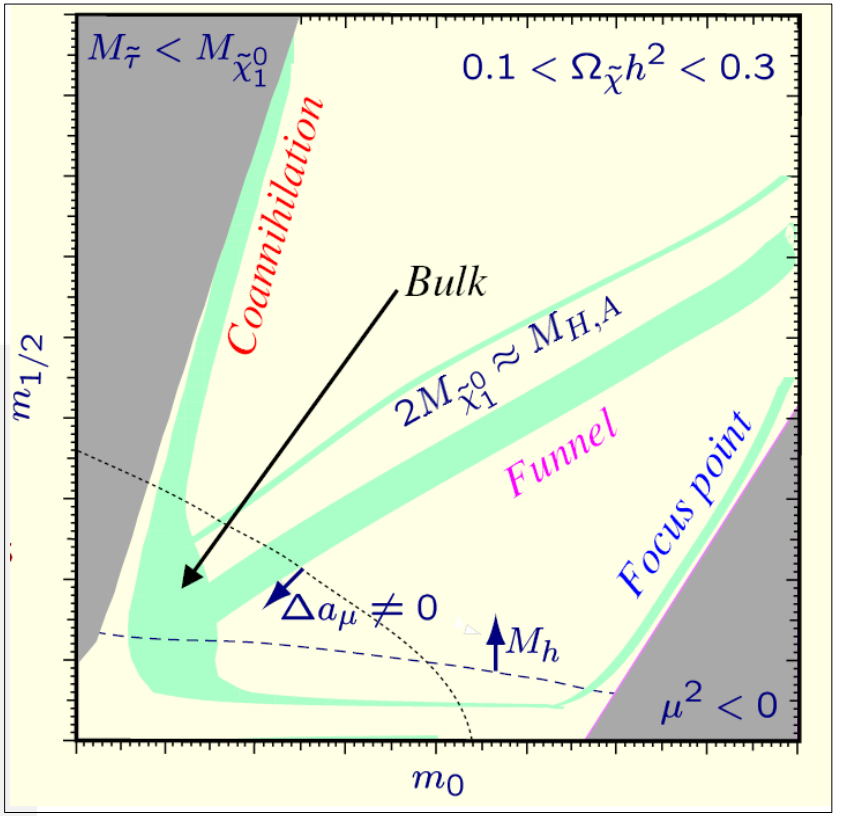
Focus point region, SU2 point

SU2 parameters

$m_0 = 3550\text{GeV}$
$m_{1/2} = 300\text{GeV}$
$A_0 = 0$
$\tan\beta = 10$
$\mu > 0$



SUSY parameter space



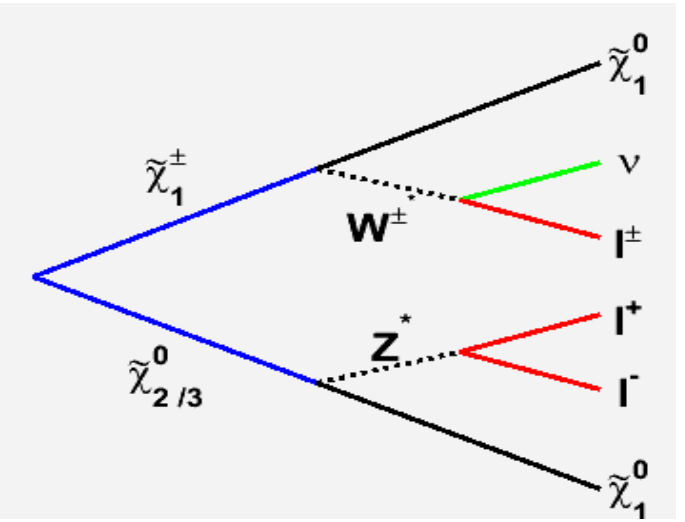
Heavy scalars are too massive so no decay through intermediate sleptons

Decay chains studied

$$\tilde{\chi}_2^0\tilde{\chi}_1^{\pm} \rightarrow l\,l\,l\,\nu\,\tilde{\chi}_1^0\tilde{\chi}_1^0$$

$$\tilde{\chi}_3^0\tilde{\chi}_1^{\pm} \rightarrow l\,l\,l\,\nu\,\tilde{\chi}_1^0\tilde{\chi}_1^0$$

chargino-neutralino production and decay to a trilepton final state with missing transverse energy



Sparticle	*Decay mode*	*BR (%)*
$\tilde{\chi}_2^0$	$\tilde{\chi}_1^0\ l\,l$	6.63%
	$\tilde{\chi}_1^0\ \tau\,\tau$	3.29%
	$\tilde{\chi}_1^0\ q\,q$	66.05%
	$\tilde{\chi}_1^0\ \upsilon\,\upsilon$	19.89%
	$\tilde{\chi}_1^{\pm}\ q\,q$	2.31%
	$\tilde{\chi}_1^{\pm}\ l\,\upsilon$	0.77%
	$\tilde{\chi}_1^{\pm}\ \tau\,\upsilon$	0.39%

Sparticle	*Decay mode*	*BR (%)*
$\tilde{\chi}_3^0$	$\tilde{\chi}_1^0\ l\,l$	6.55%
	$\tilde{\chi}_1^0\ \tau\,\tau$	3.26%
	$\tilde{\chi}_1^0\ q\,q$	65.35%
	$\tilde{\chi}_1^0\ \upsilon\,\upsilon$	19.55%
	$\tilde{\chi}_2^0\ q\,q$	0.07%
	$\tilde{\chi}_2^0\ \upsilon\,\upsilon$	0.02%
	$\tilde{\chi}_1^{\pm}\ q\,q$	3.45%
	$\tilde{\chi}_1^{\pm}\ l\,\upsilon$	1.15%
	$\tilde{\chi}_1^{\pm}\ \tau\,\upsilon$	0.57%

Sparticle	*Decay mode*	*BR (%)*
$\tilde{\chi}_1^{\pm}$	$\tilde{\chi}_1^0\ l\,\upsilon$	22.22%
	$\tilde{\chi}_1^0\ \tau\,\upsilon$	11.11%
	$\tilde{\chi}_1^0\ q\,q$	66.67%

where $l = e, \mu$

BR of decay modes for other charginos/neutralinos ~10^{-7} %

Production	*σ (fb)*	*Number of events expected for 10fb^{-1}*	*Number of tri-lepton events expected for 10fb^{-1}*
$q\bar{q}\rightarrow\tilde{\chi}_1^0\tilde{\chi}_1^{\pm}$	1296	12960	0
$q\bar{q}\rightarrow\tilde{\chi}_2^0\tilde{\chi}_1^{\pm}$	1137	11370	168
$q\bar{q}\rightarrow\tilde{\chi}_3^0\tilde{\chi}_1^{\pm}$	685	6850	100
$q\bar{q}\rightarrow\tilde{\chi}_4^0\tilde{\chi}_1^{\pm}$	53	530	0
$q\bar{q}\rightarrow\tilde{\chi}_1^0\tilde{\chi}_2^{\pm}$	4	40	0
$q\bar{q}\rightarrow\tilde{\chi}_2^0\tilde{\chi}_2^{\pm}$	62	610	0
$q\bar{q}\rightarrow\tilde{\chi}_3^0\tilde{\chi}_2^{\pm}$	61	610	0
$q\bar{q}\rightarrow\tilde{\chi}_4^0\tilde{\chi}_2^{\pm}$	311	3110	0

Cross-sections calculated using Isajet soft breaking parameters with Pythia (10^4 events)

Branching ratios calculated using Isasugra 7.71

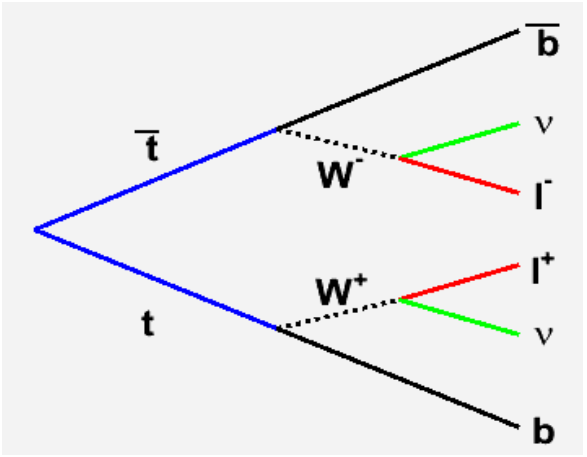
For signal analysis:

ATLFAST ntuples 10.02 version (from T.Lari – many thanks)

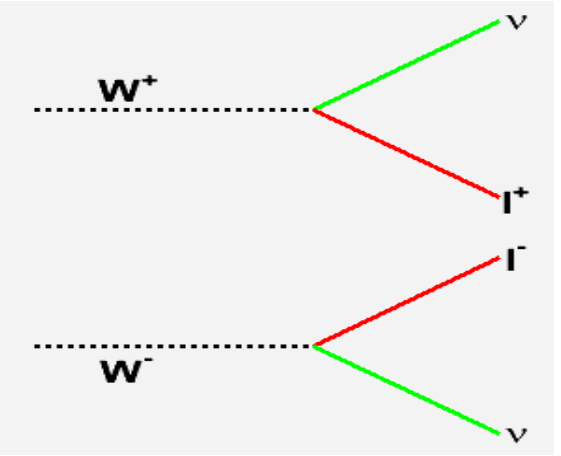
FULL SIM ntuples made from csc AOD and overlap removed using EventView 11.0.5

Some Standard Model backgrounds

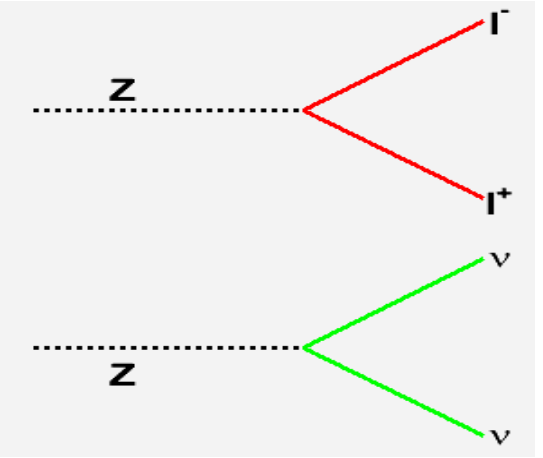
$t\bar{t}$



$W + light\ jets$



$Z + light\ jets$



ATLFAST				*FULL SIMULATION*			
Sample	***σ /pb***	***Expected no.events for 10fb^{-1}***	***No.events in sample***	***Sample***	***σ /pb***	***Expected no.events for 10fb^{-1}***	***No.events in sample***
SU2	4.9	5.0 x 10 ^{4}	1.0 x 10 ^{5}	SU2	4.9	5.0 x 10 ^{4}	5.6 x 10 ^{4}
ttbar mc@nlo	760	8.5 x 10 ^{6}	7.1 x 10 ^{6}	ttbar mc@nlo	461	4.6 x 10 ^{6}	2.0 x 10 ^{5}
W+jets low lumi	300	3.4 x 10 ^{6}	3.0 x 10 ^{6}	W+jets ALPGEN	1981		0
Z+jets	195	2.2 x 10 ^{6}	2.0 x 10 ^{6}	Z+jets ALPGEN	763		0
				WW	9.9		0
				ZZ	0.15		0
				WZ	1.8		0

Waiting for more statistics

Full Simulation samples used

Dataset 5402
SU2 (Jimmy)

11.4 fb^{-1} processed

Dataset 5200
Ttbar (mc@nlo+Jimmy) at least one top decaying to e, mu or tau (filter eff 0.54)

0.44 fb^{-1} processed

Datasets 5223-6, 8202-8205, 8208-11
W+jets (ALPGEN+Jimmy) 4j pt>40, pt_j1>80, Met > 80 GeV

Datasets 5132-6, 8101-5, 8113-7
Z+jets (ALPGEN+Jimmy) 4j pt>40, pt_j1>80, Met > 80 GeV

Not included in full sim study yet due to low statistics available

Datasets 5921-9
WW No filter

Datasets 5930-2
ZZ No filter

Datasets 5940-2, 5970-2
ZW No filter

Not included in full sim study yet due to on shell bosons problems

Z+b-jets

Not yet included due to low stats available

Full Simulation Particle Definitions

Used default EventView particle definitions

Variable	*Electron*	*Photon*	*Muon*	*B-tagged jet*	*Jet*
Et cut /GeV	15	15	15 (10)	15	15
Delta R cut	0.1	0.1	0.1	0.7	0.5
egamma electron	Yes	n/a	n/a	n/a	n/a
isEM Track and Shower Shape cuts	must pass *	n/a	n/a	n/a	n/a
Isolation Cone cuts	delta R =0.45, abs E=15GeV	delta R =1.0	n/a	n/a	n/a
Chi-squared Ndof	n/a	n/a	20	n/a	n/a
weight cut	n/a	n/a	n/a	4	n/a

* ClusterEtaRange
ClusterHadronicLeakage
ClusterMiddleSampling
ClusterFirstSampling
TrackEtaRange
TrackHitsA0
TrackMatchAndEoP
TrackTRT

Lepton Reconstruction Efficiencies

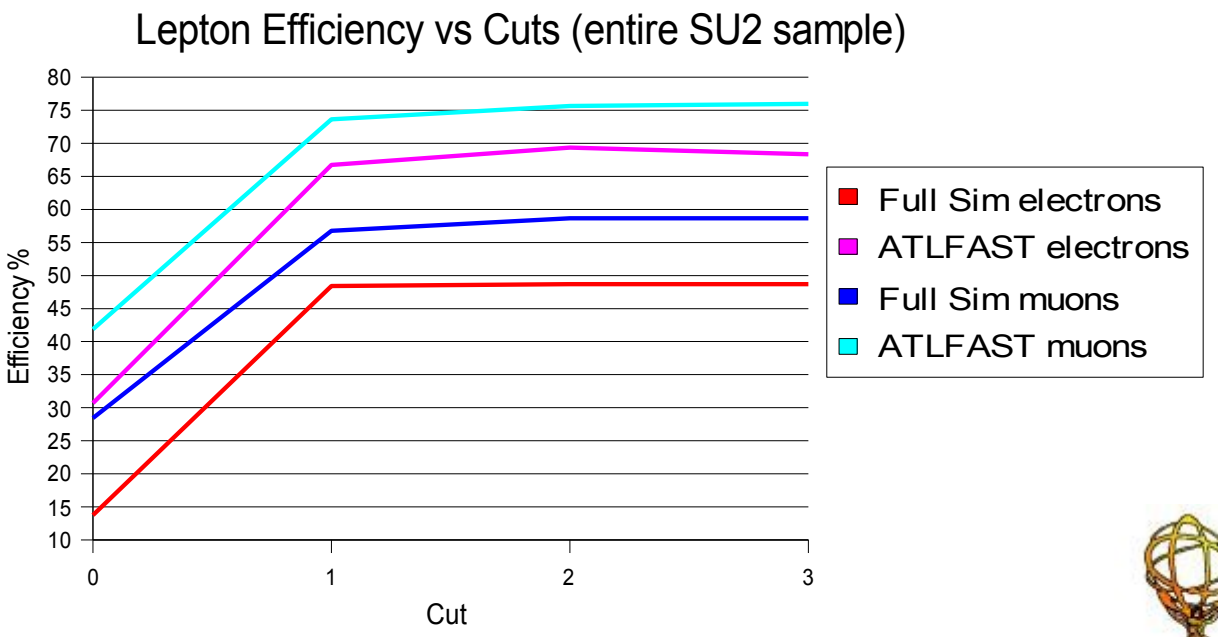
	FULL SIM (55900 events)				ATLFAST (109500 events)			
	TRUTH		RECON		TRUTH		RECON	
	No. e	No. mu	No. e	No. mu	No. e	No. mu	No. e	No. mu
No Cuts	39676	24046	5449	6837	74665	47915	22915	20072
			13.73	28.43			30.69	41.89
NLEP>=3	764	840	370	477	3612	2820	2410	2077
			48.43	56.79			66.72	73.65
2 SFOS	663	757	323	444	3012	2359	2090	1785
			48.72	58.65			69.39	75.67
2e15i or 2e10i	663	757	323	444	2564	2109	1753	1603
			48.72	58.65			68.37	76.01
Reconstruction Efficiencies(%)								

Efficiency definition:

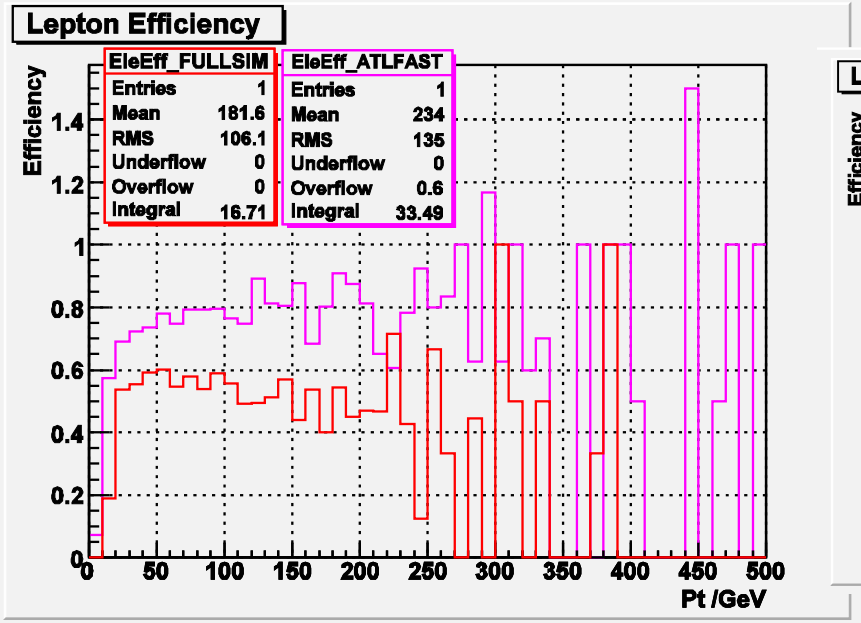
ε_e = (# recon e)/ (# truth e)

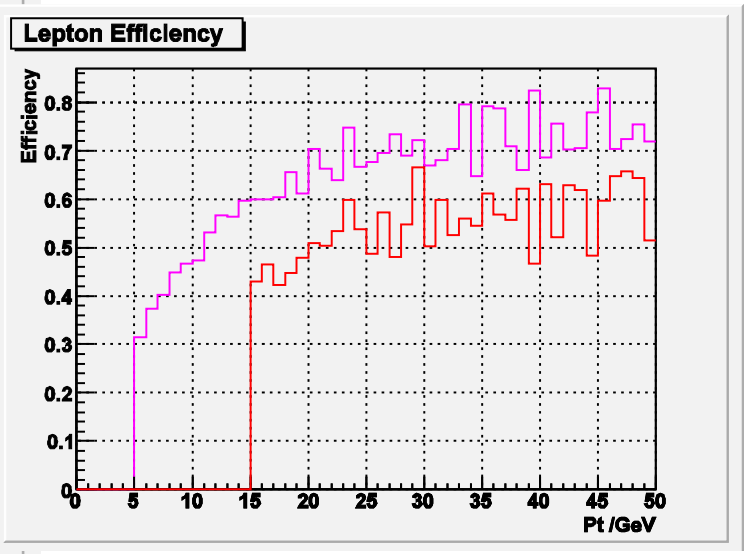
ε_μ = (# recon μ)/ (# truth μ)

For Full Sim, # recon e is the # of recon e with a good ΔR match (<1) with a truth e
For Fast Sim, no match is required (assume no fakes)

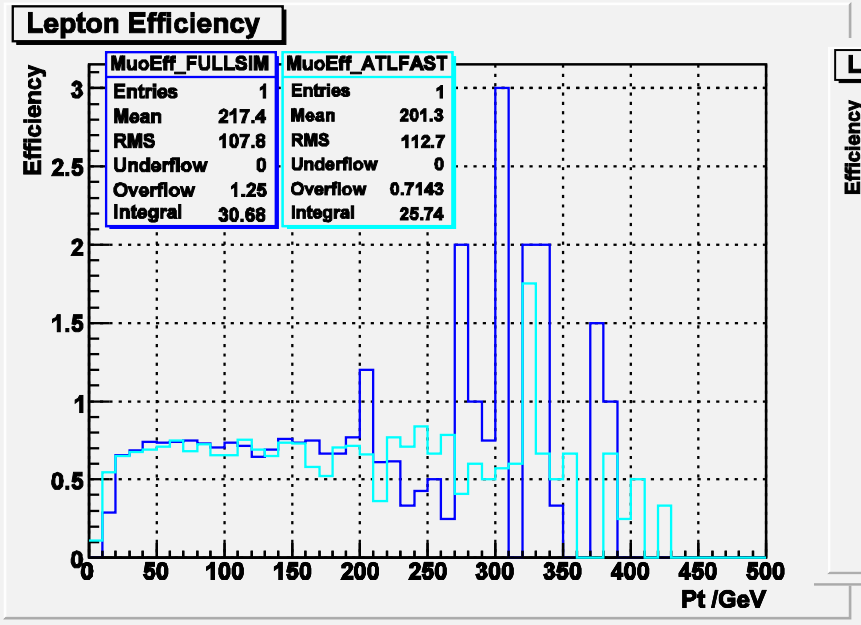


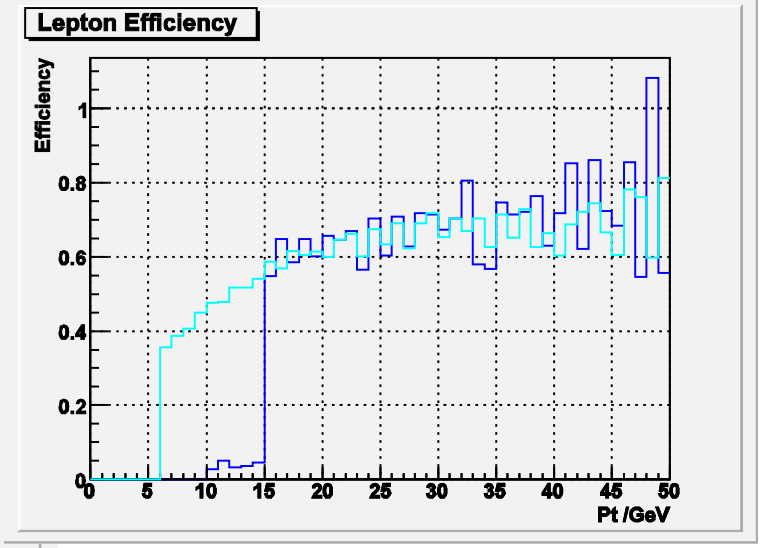
Lepton Reconstruction Efficiencies





Poor electron reconstruction in full simulation compared to ATLFAST



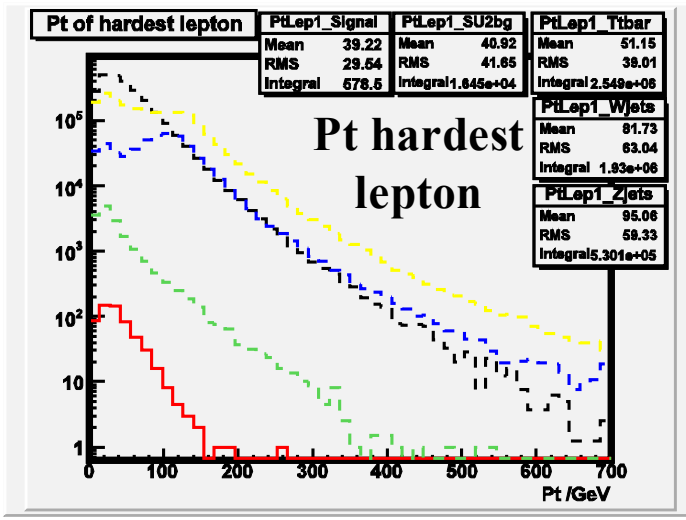


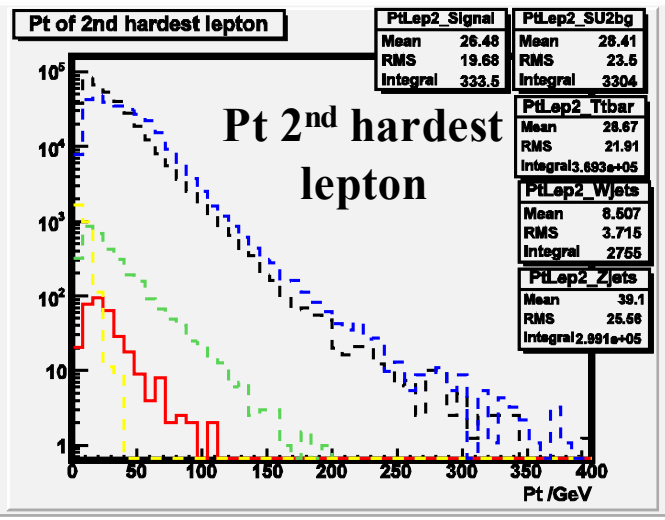
- Full Sim electrons
- ATLFAST electrons
- Full Sim muons
- ATLFAST muons

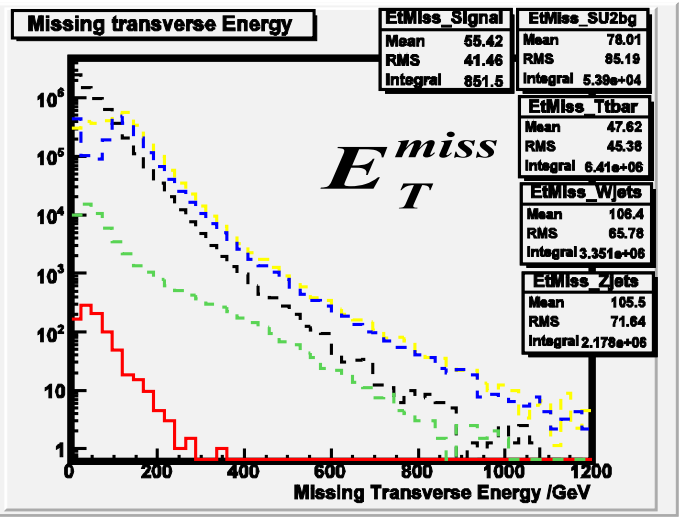
Muon reconstruction in full simulation is comparable to ATLFAST at Pt >15GeV

No Cuts

ATLFAST

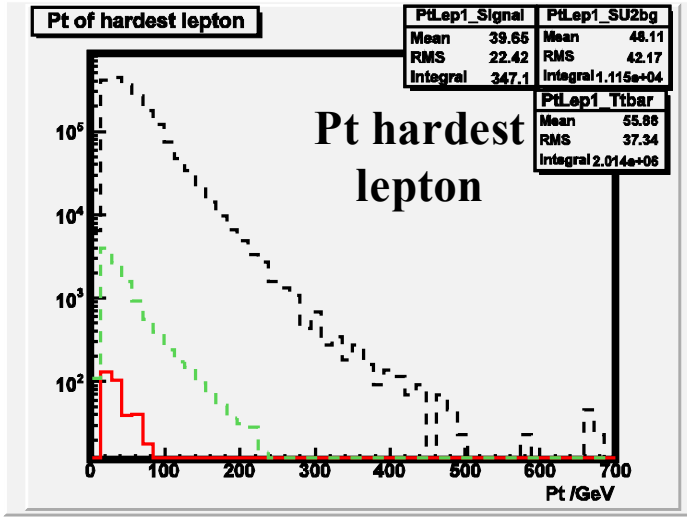


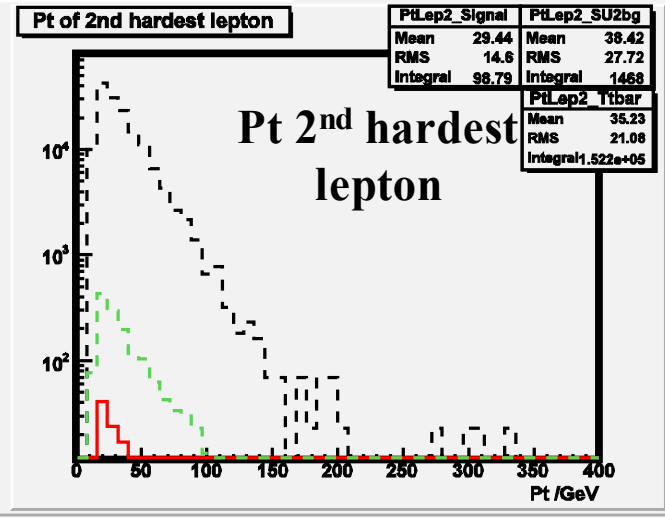


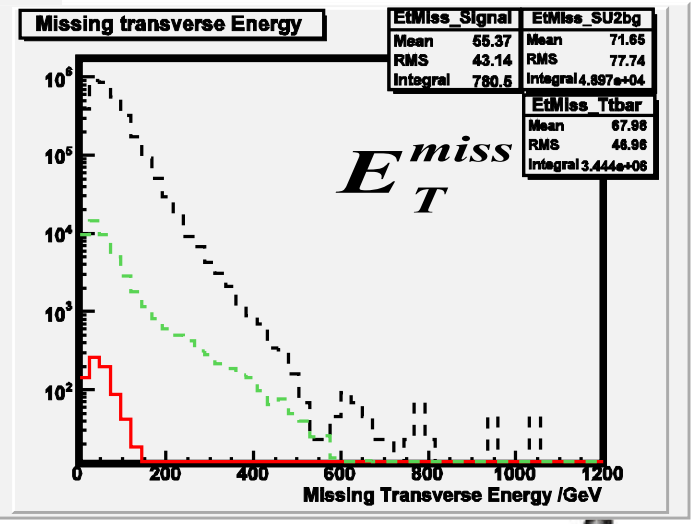


Signal
SU2 bkgnd
ttbar (mc@nlo)
Wjets
Zjets

FULL SIMULATION

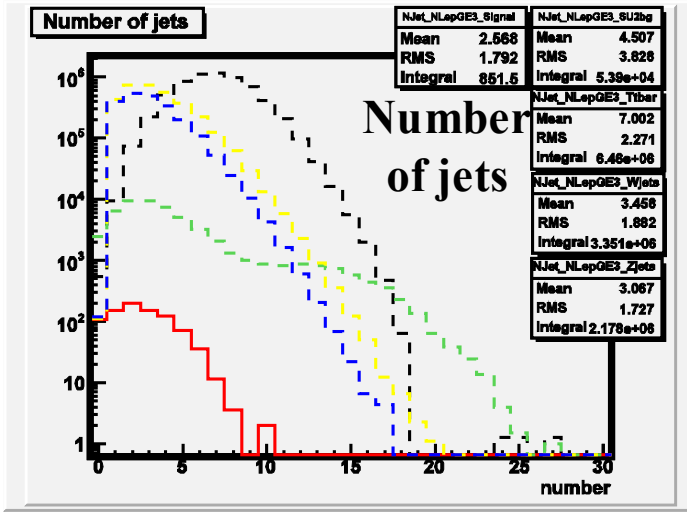


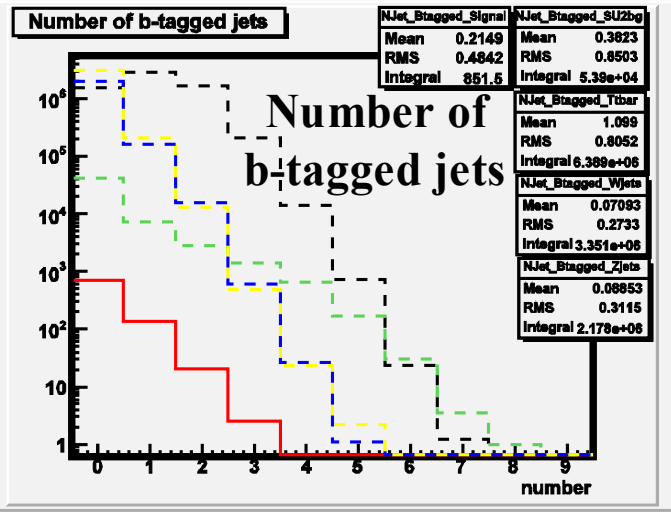


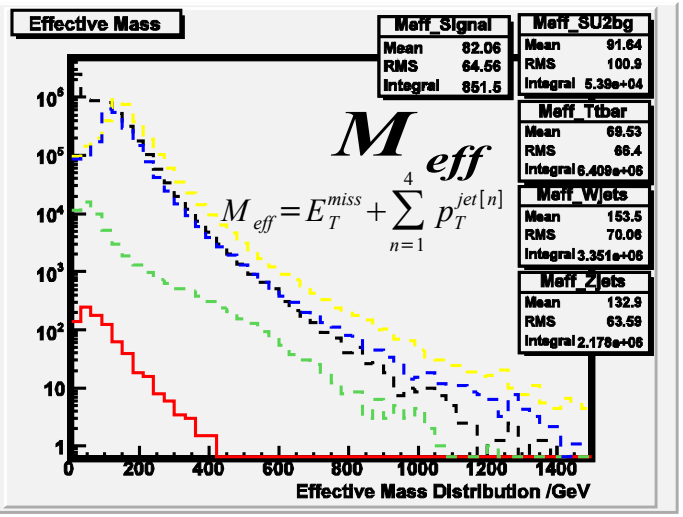


No Cuts

ATLFAST







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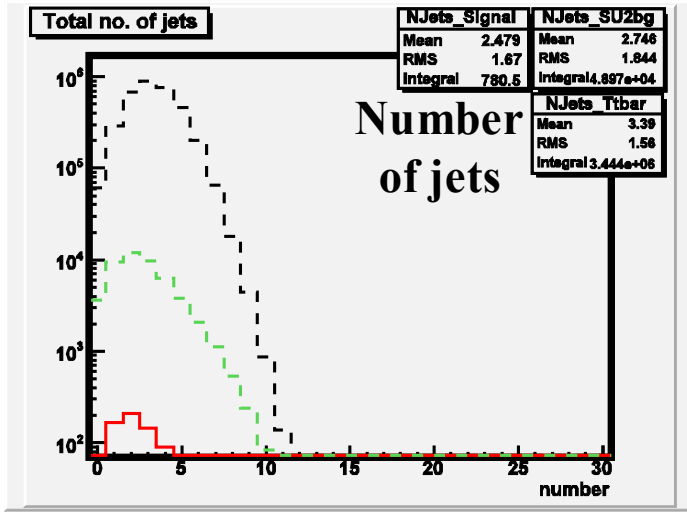
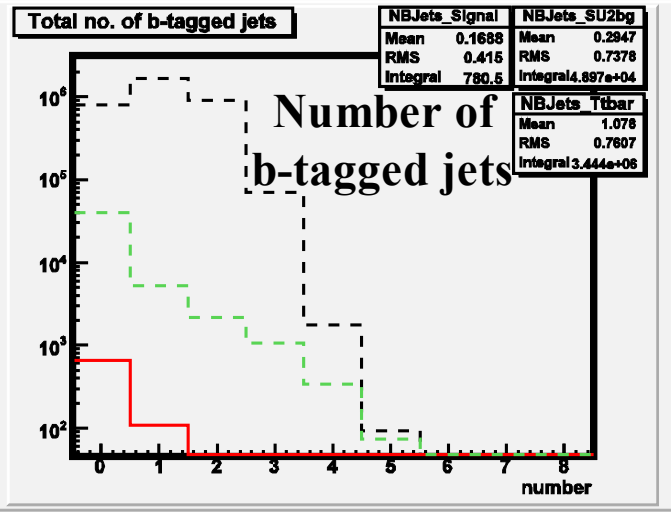
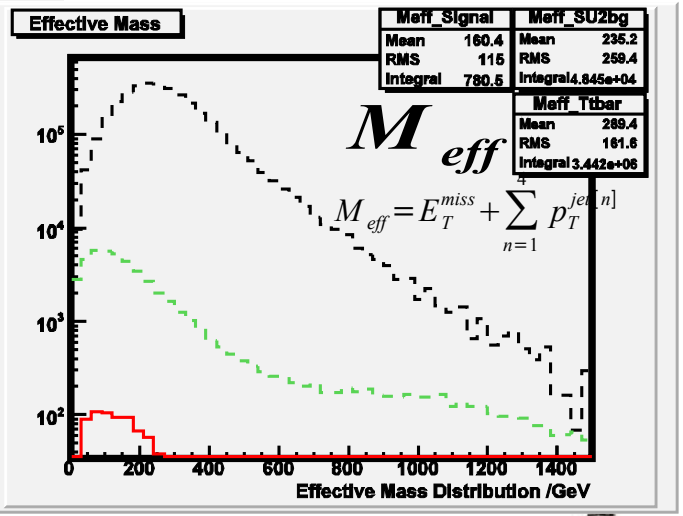
ttbar (mc@nlo)
Wjets
Zjets

FULL SIMULATION







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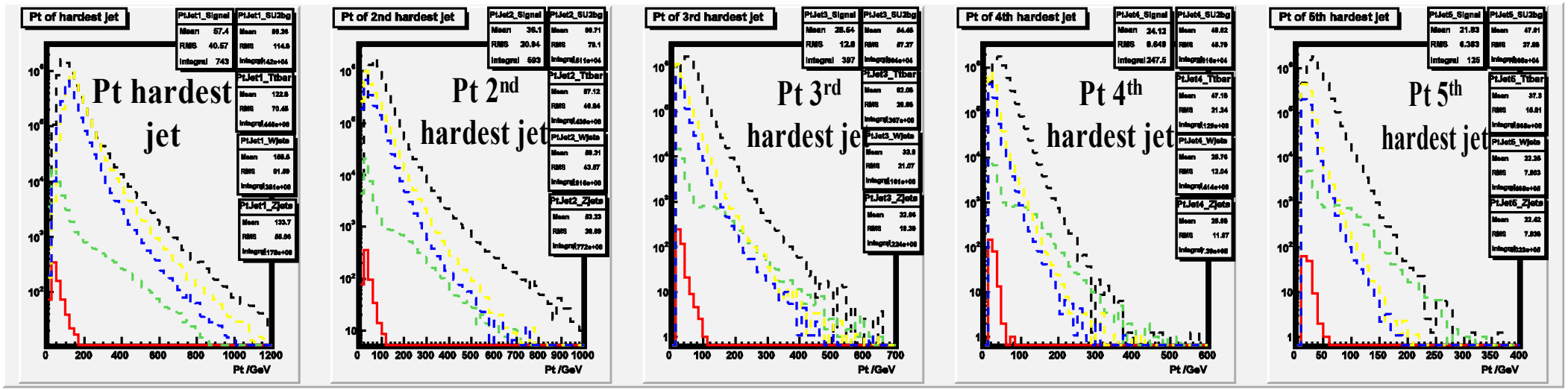
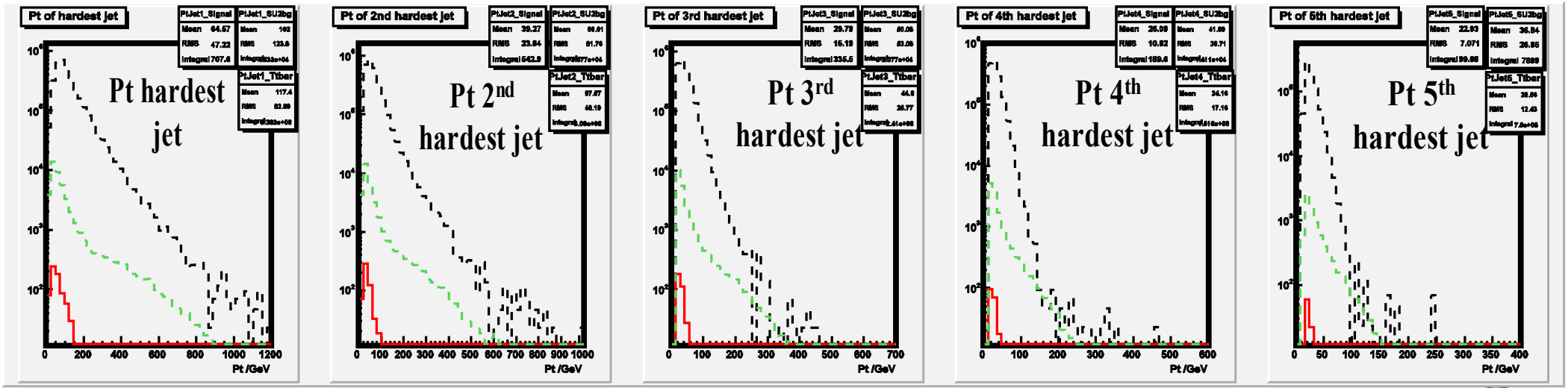
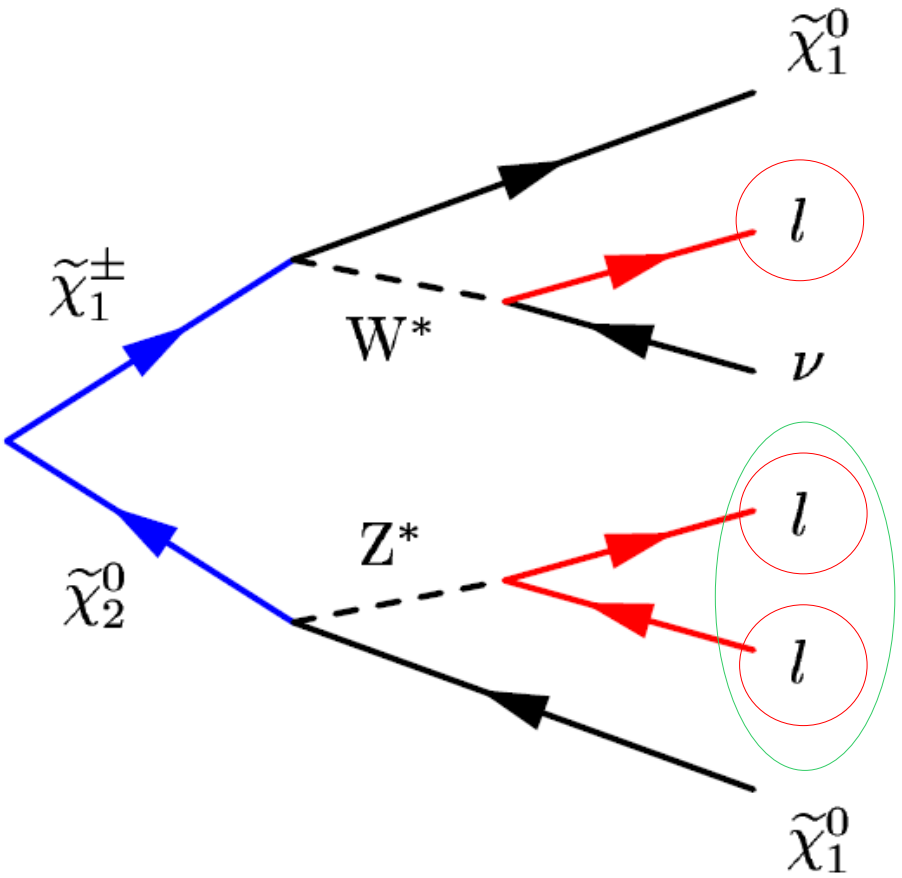


FULL SIMULATION



Leptonic cuts



Require:

Cut 1

3 leptons (e, μ)

Cut 2

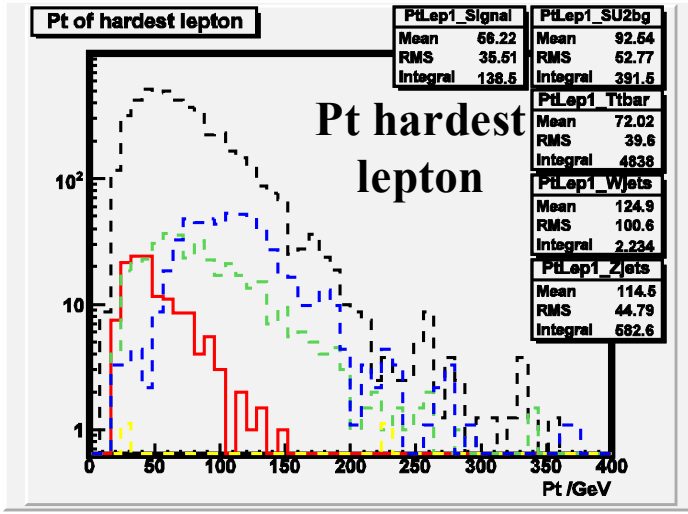
2 Same Flavour Opposite Sign leptons

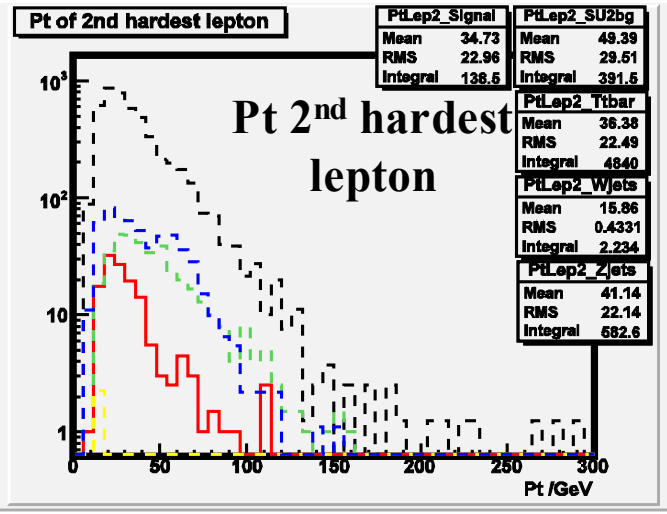
Cut 3

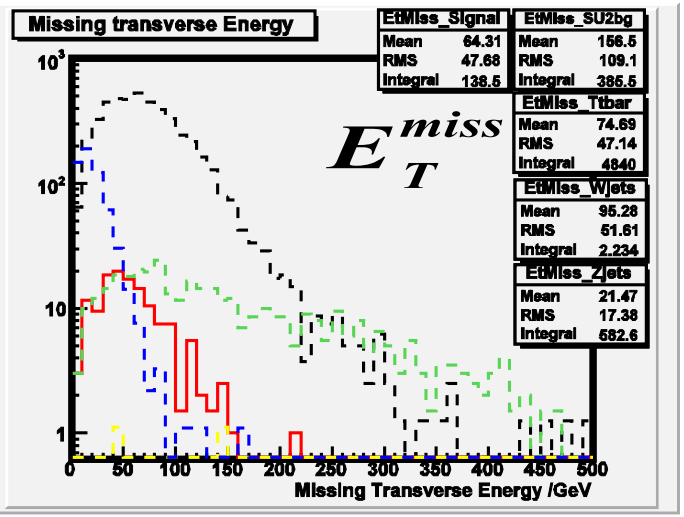
2e15i or 2mu10i (trigger menu cut)

After Leptonic cuts (1,2,3)

ATLFAST



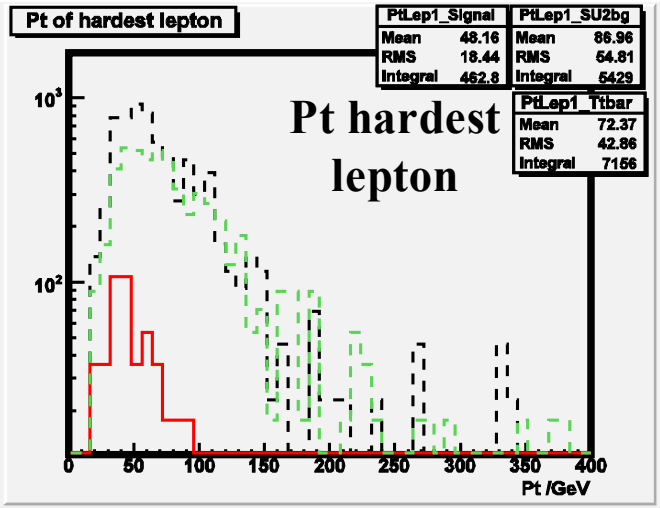


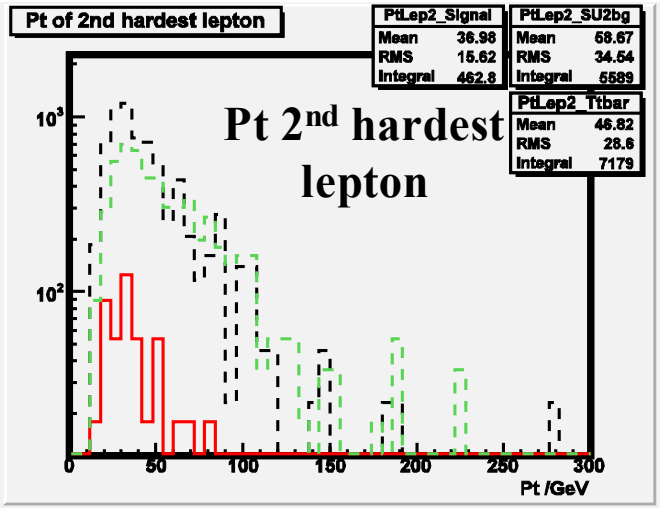


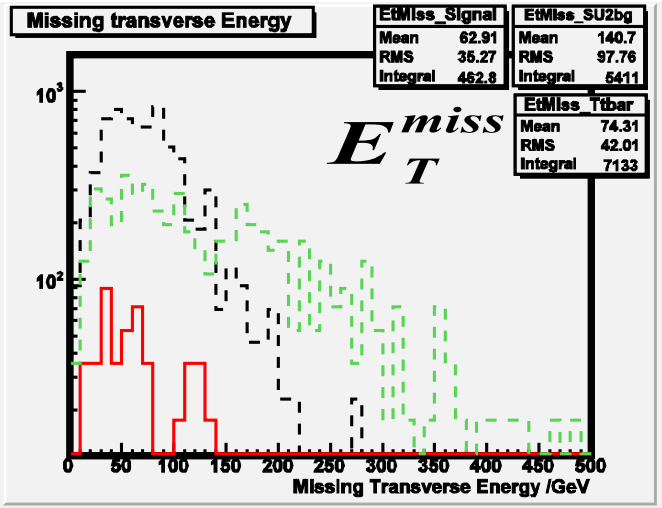
Signal
SU2 bkgnd
ttbar (mc@nlo)
Wjets
Zjets

FOR FULL SIM,
***signal & su2bg x20** for clarity*

FULL SIMULATION

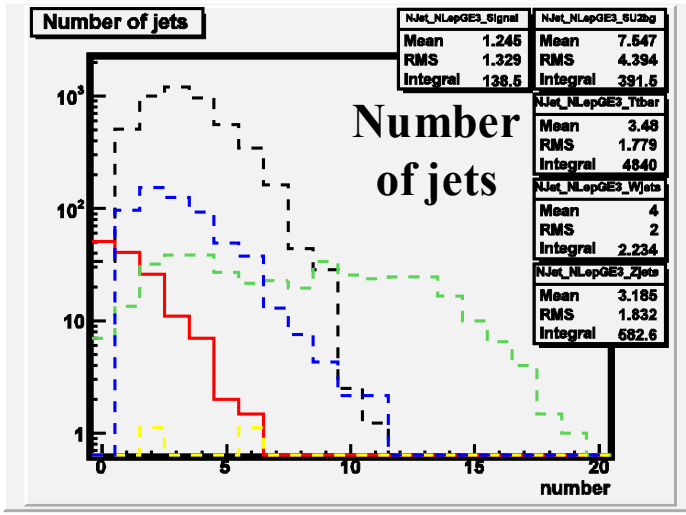


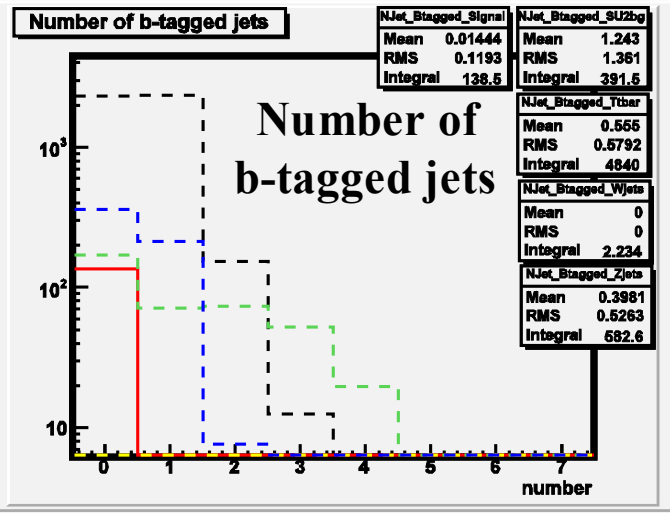


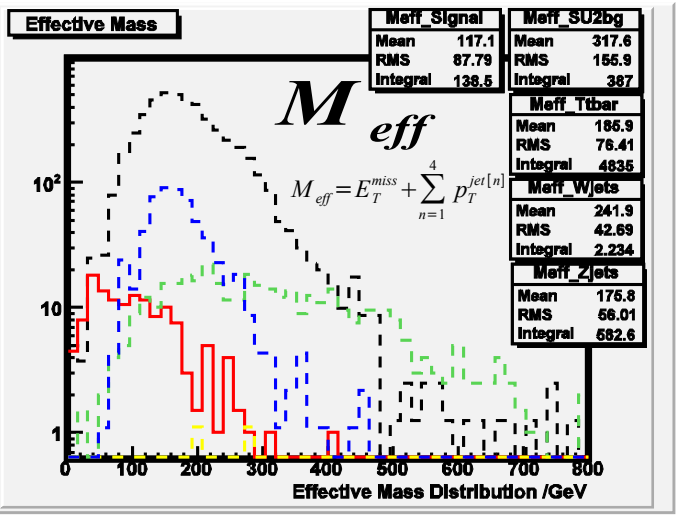


After Leptonic cuts (1,2,3)

ATLFAST







Signal
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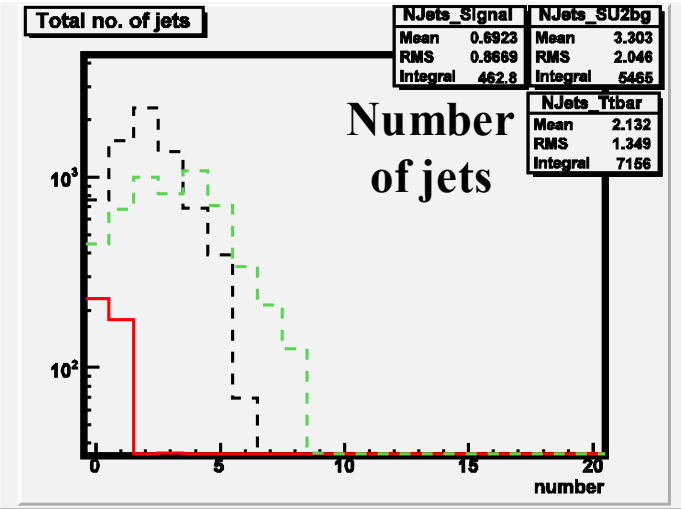
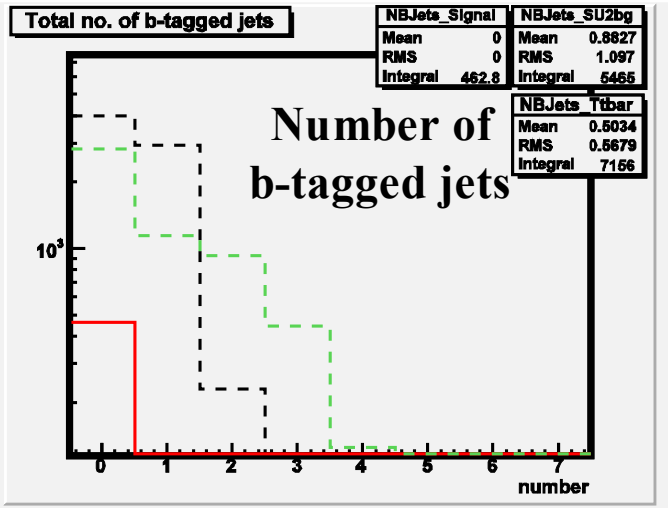
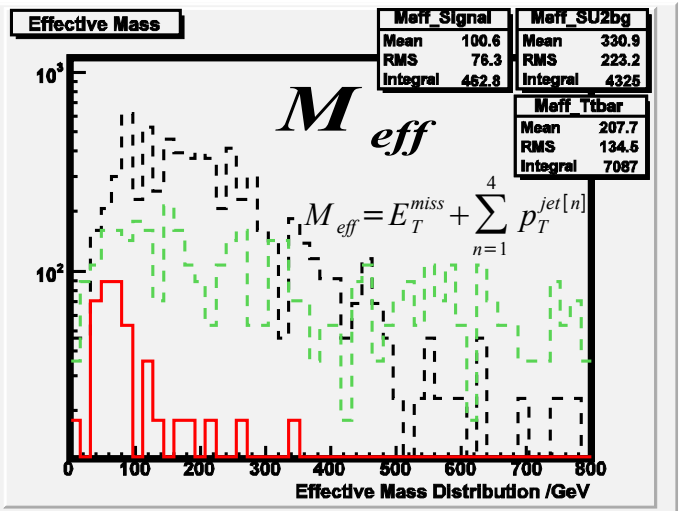
FULL SIMULATION

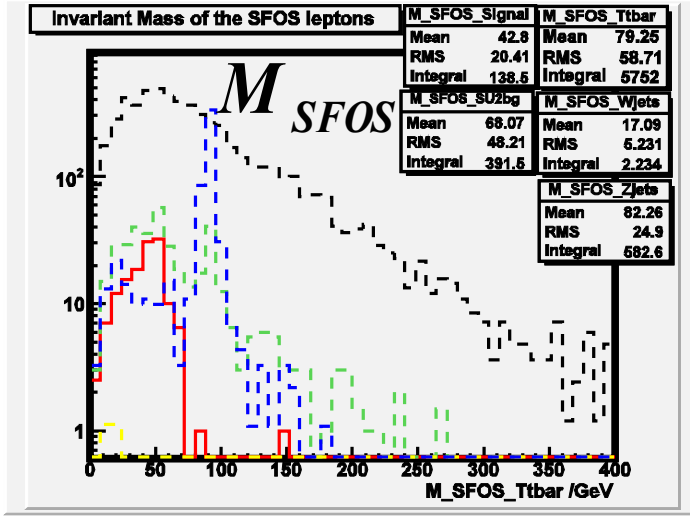


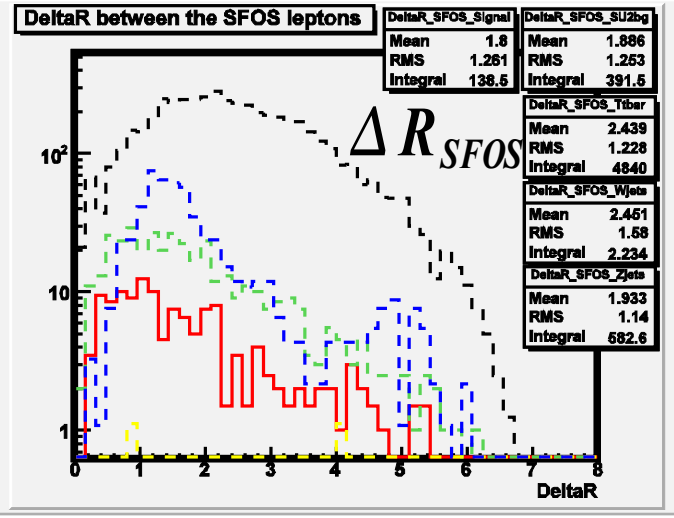


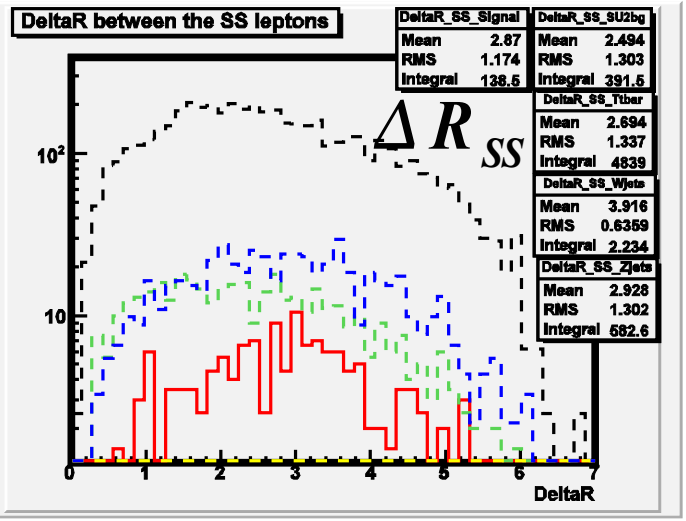


After Leptonic cuts (1,2,3)

ATLFAST







Signal
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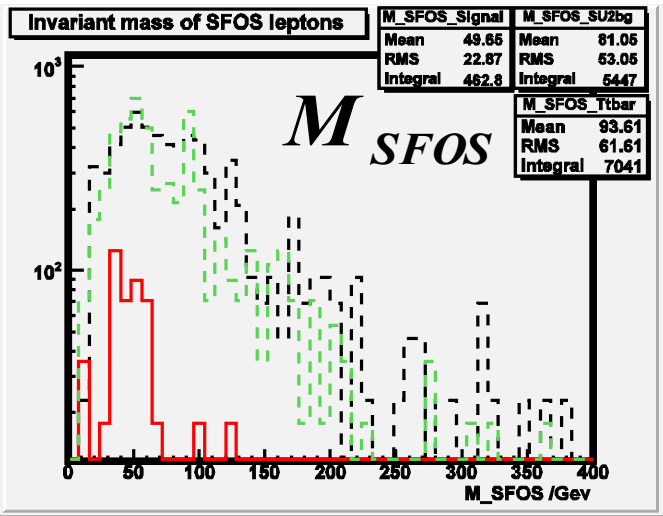
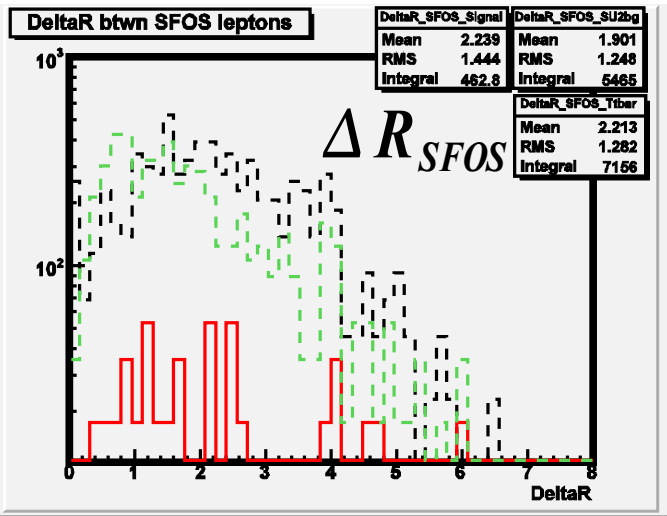
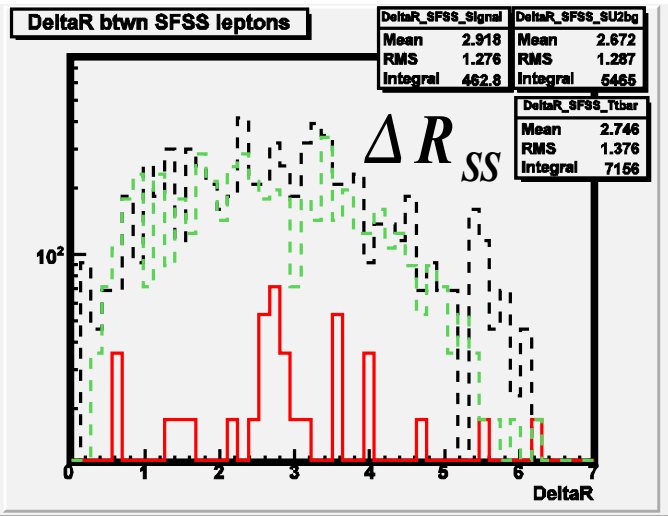
ttbar (mc@nlo)
Wjets
Zjets

FOR FULL SIM,
***signal & su2bg x20** for clarity*

FULL SIMULATION

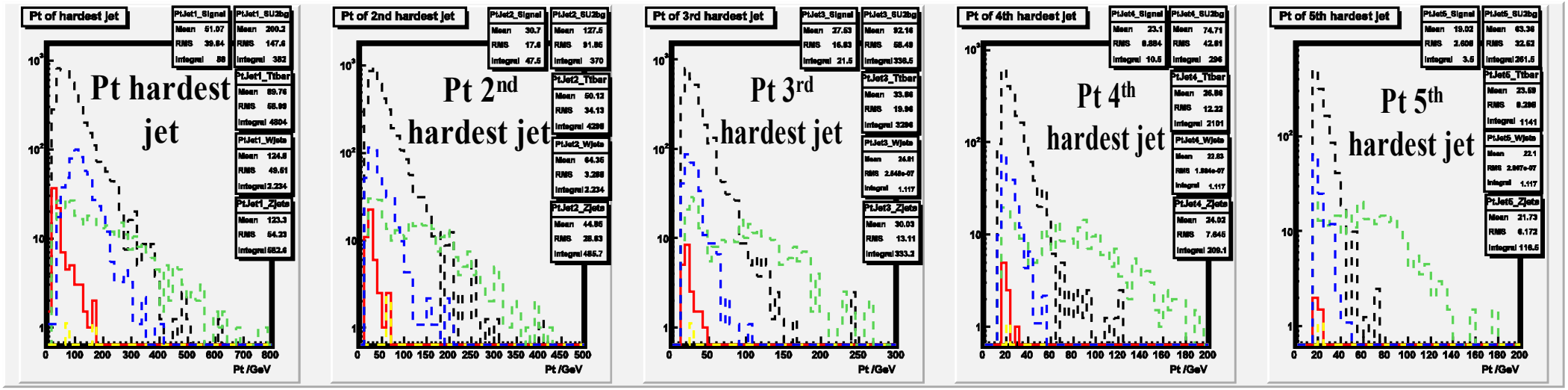






After Leptonic cuts (1,2,3)

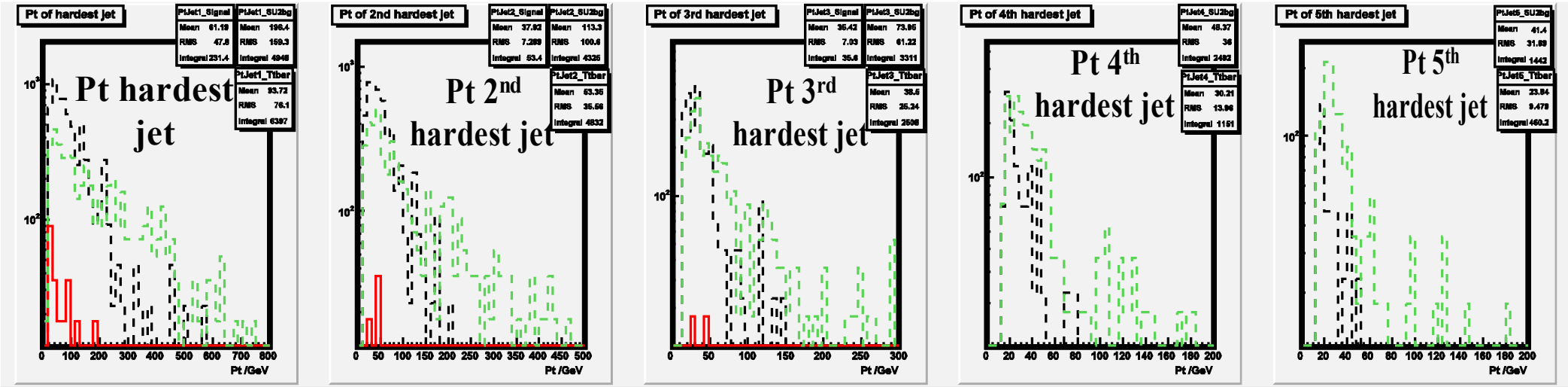
ATLFAST



Signal
SU2 bkgnd
ttbar (mc@nlo)
Wjets
Zjets

FOR FULL SIM,
***signal & su2bg x20** for clarity*

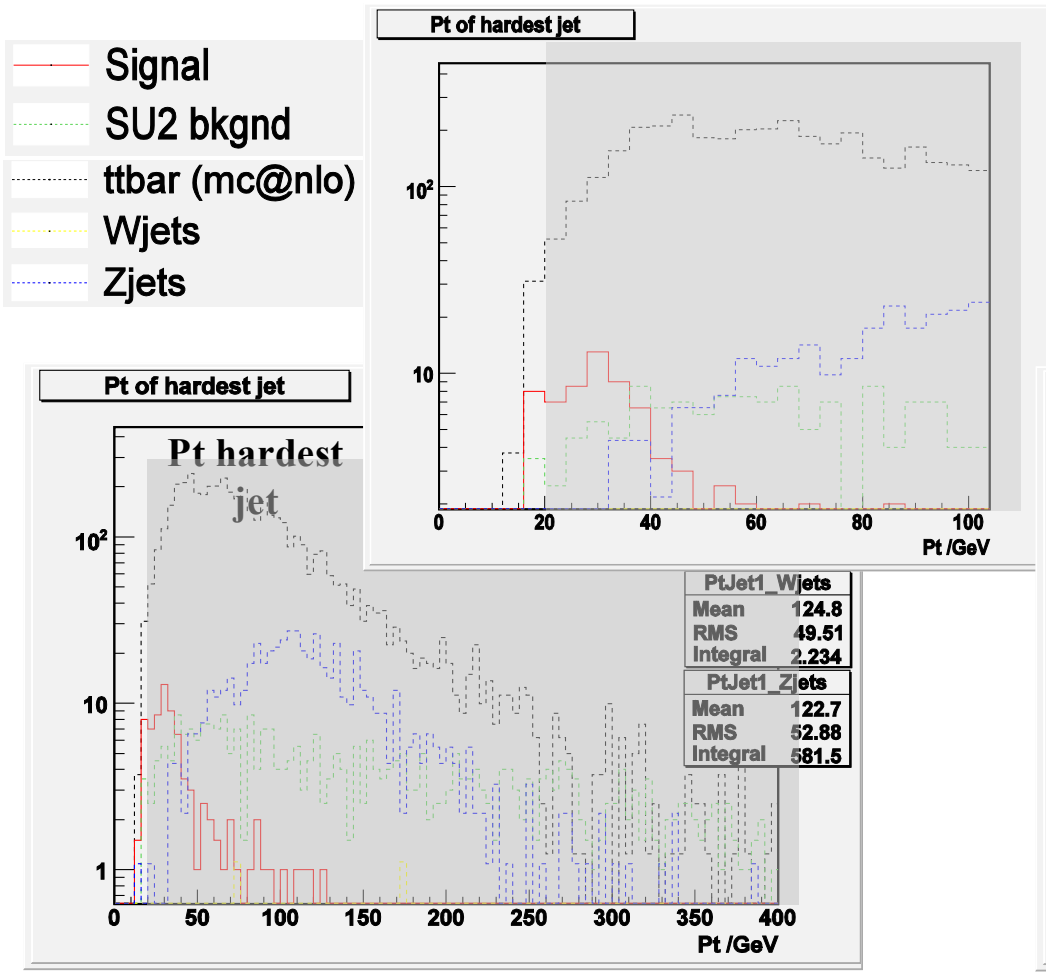
FULL SIMULATION



Jet Pt cut (4)

ATLFAST

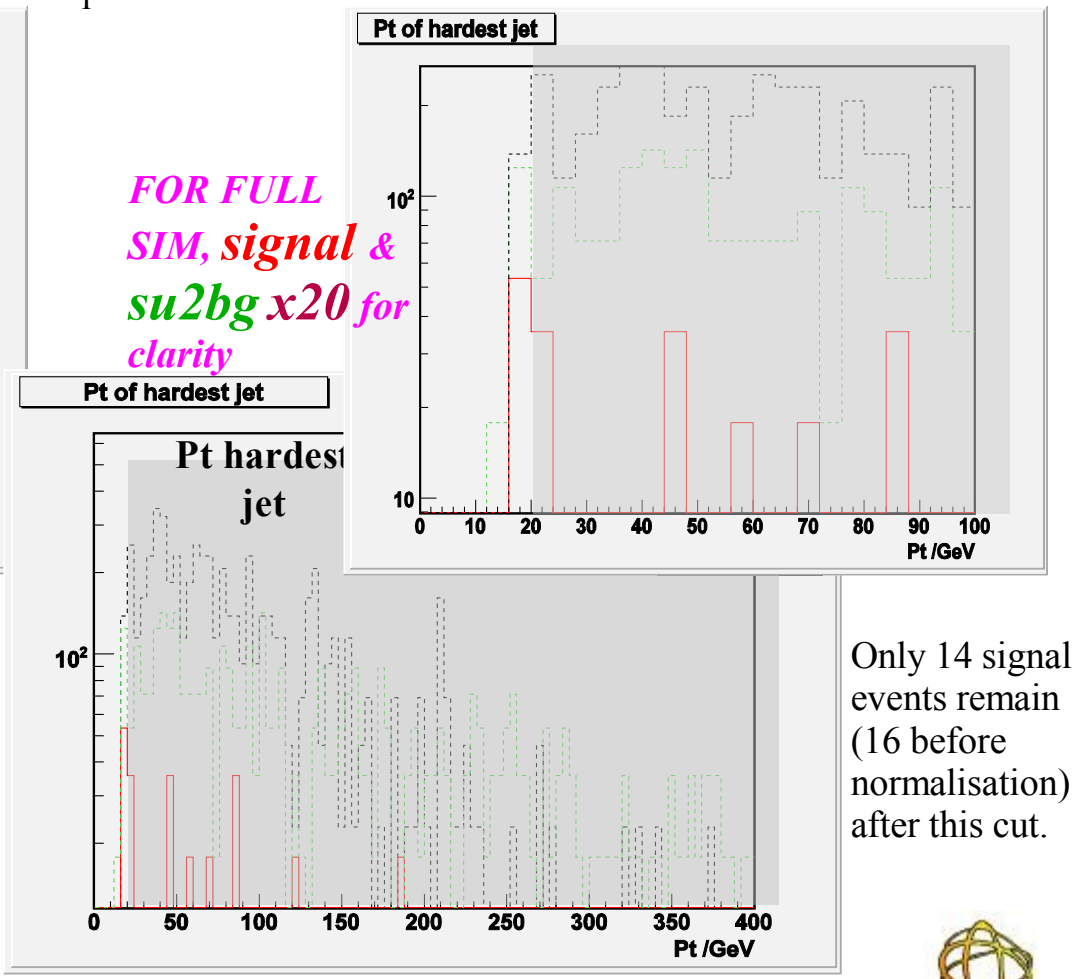
Fast simulation: no optimal Jet Pt cut found



FULL SIMULATION

Full simulation: optimal Jet Pt cut found at $p_T^{\text{all jets}} < 20\text{GeV}$ *In agreement with Rome analysis (Cedric Serfon)*

FOR FULL SIM, signal & su2bg x20 for clarity



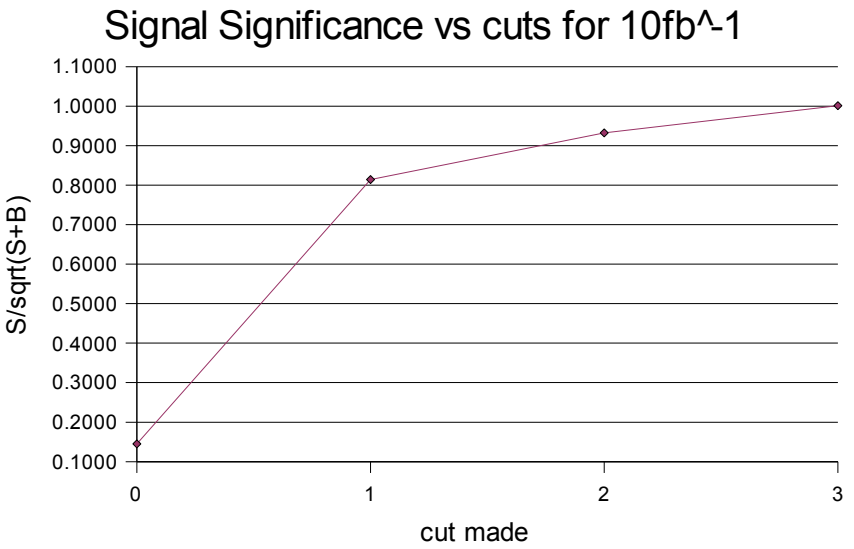
Only 14 signal events remain (16 before normalisation) after this cut.

Jet P_T cut is only effective for full simulation study. This is an important difference between jet reconstruction in ATLFAST and Full Simulation

Signal Significance for 10 fb^{-1}

ATLFAST

	No Cuts	Nleps >=3	2 SFOS Leptons	Pt Leps Trigger cut
Signal	852	169	167	139
SU2 background	53899	541	449	392
ttbar high lumi	8515800	13679	10131	5889
ttbar low lumi	8490900	13528	9962	5792
ttbar mcnlo	8489650	14180	10486	6331
W+jets high lumi	3351250	39	24	5
W+jets low lumi	3351000	41	26	2
Z+jets	2178000	657	649	583
S/sqrt(S+B)	0.1451	0.8142	0.9323	1.0013

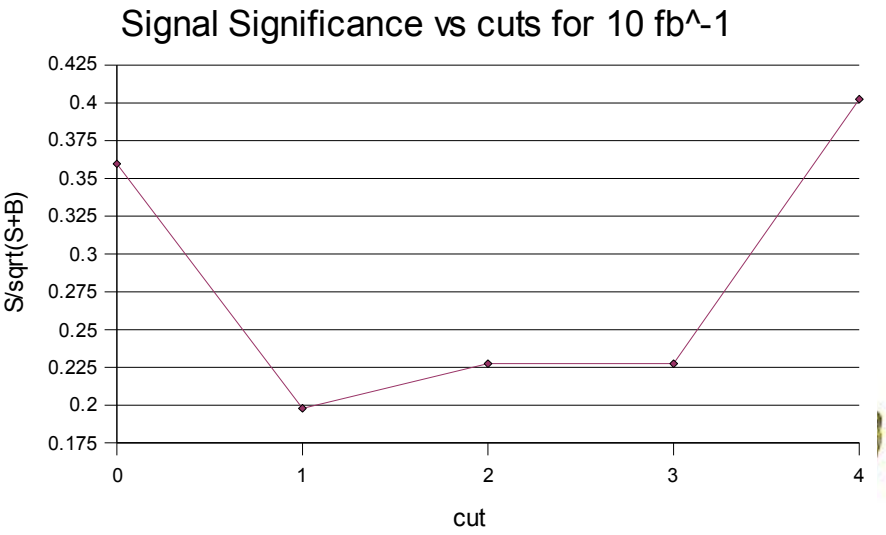


FULL SIMULATION

These numbers are different due to the way the signal was selected. Unable to use Truth Mother variables in full sim (problem in EventView).

Low number due to electron reconstruction efficiency

	No Cuts	Nleps >=3	2 SFOS Leptons	Pt Leps Trigger cut	Pt Jets <20GeV
Signal	784	23	23	23	14
SU2 background	49196	308	274	274	30
ttbar mcnlo	4702200	13461	10148	10148	1220
S/sqrt(S+B)	0.3597	0.1979	0.2275	0.2275	0.4025



Comparison of fast and full simulation

	ATLFAST	FULL SIMULATION
Electron Efficiency	Higher	Lower
Muon Efficiency	Similar	Similar
Lepton Pt	Higher	Lower
Jet Pt	Higher	Lower
Number of jets	Higher	Lower
E_t^{miss}	Higher	Lower
M_{eff}	Higher	Lower
M_{SFOS}	Similar	Similar
ΔR_{SFOS}	Similar	Similar
ΔR_{SS}	Similar	Similar

Needs to be increased for better statistics

Differences in jet reconstruction in fast and full simulation.

Possibilities for improving signal selection

FOR FULL SIMULATION

The cut that reduces the signal most dramatically is Nlep>=3.
This is due to poor lepton reconstruction efficiency.

Could be improved by...
-Changing the way leptons are identified to improve efficiency.
-Reconstruct leptons identified by ANY of the lepton authors.
-Find events with one good lepton and look closer, applying less stringent requirements for lepton identification rather than a global requirement.
-Requiring 2SFOS leptons + 1 well reconstructed track.
(preliminary investigations show that this makes very little impact)

Possibility of selecting only low E_T^{miss} events, although this is dependent on LSP mass.

Plans for the future

Obtain more csc data for backgrounds

Di-boson data available at present is all on-shell bosons.

W+jets and Z+jets ALPGEN data, limited statistics available – more expected with time.

Z+b-jets will also be included.

Improve lepton efficiency (with more signal events, event selection will be more accurate).

Investigate jet veto further – restrict jet veto to central region?

Investigate jet/electron ambiguities.

Estimation of di-boson and ttbar backgrounds from real data.

BACKUP SLIDES

Overlap Removal using EV

EVENTVIEW..

- standardises they way in which overlaps between reconstructed particles are removed
- enables users to create different EventViews for an event depending on how a particle is reconstructed.

It was used in the full simulation study to reconstruct the event with overlaps removed.

EventView inserts particles into an event, checking for any overlap in ΔR at the same time as applying tighter reconstruction definitions of particles.

e.g. an event may have an electron that was loosely reconstructed by both the electron and jet algorithms. In this case EventView would insert the electron container, see that the electron has also been reconstructed in the jet container using a delta R match and (hopefully) decide that it is an electron based on the kinematic definition of an electron and a jet.

Releases Used

Full Simulation

Sample	*Generated with*	*Reconstructed with*	*Overlap removed with*
SU2	Herwig/Jimmy	v11.0.42	EventView 11.0.5
ttbar mc@nlo	McAtNlo	v11.0.42	EventView 11.0.5
W+jets	ALPGEN	v11.0.42	not yet processed
Z+jets	ALPGEN	v11.0.42	not yet processed

Fast Simulation

Sample	*Generated with*	*Reconstructed with*
SU2	Pythia 9.04	v10.0.1
ttbar (high lumi)	Pythia 9.03	v10.0.1
ttbar (low lumi)	Pythia 9.03	v10.0.1
ttbar mc@nlo	McAtNlo	v10.0.1
W+jets (high lumi)	Pythia 9.04	v10.0.1
W+jets (low lumi)	Pythia 9.04	v10.0.1
Z+jets	Pythia 9.04	v10.0.1