Search for direct Stau pair production

Supervisor: Stefan Guindon, Javier Montejo
Summer Student: Jiashen Tang

CERN

Direct stau search

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Interest SUSY scenario

EW production of τ̃ pairs, simplified SUSY model

$\tilde{\tau} \rightarrow \tau + \tilde{\chi}_1^0$(LSP) with 100% branching ratio

Hadronically tau decay 64.79% :
1 or 3 π^{+-} + π^0 + ν

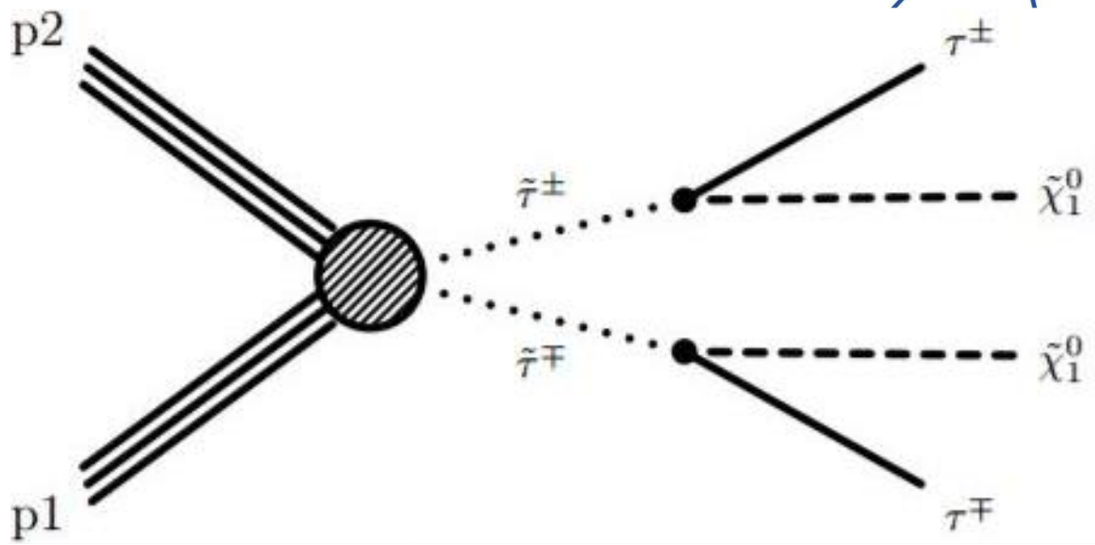
Leptonical tau decay 35.21% :
e/μ + ν

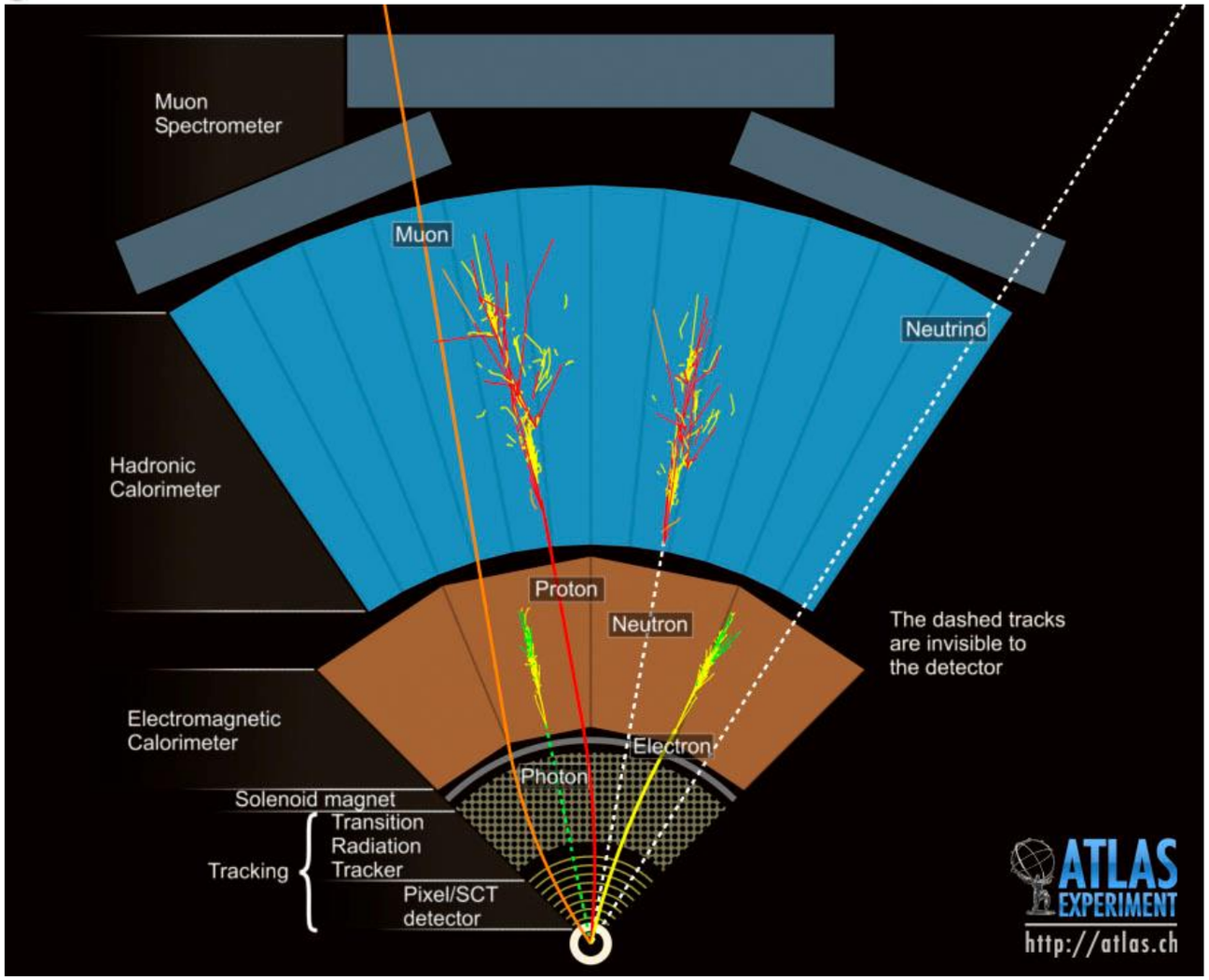
Jets(hadrons) reconstructed by anti-kt algorithm with calorimeter energy clusters

Electron reconstructed by ID and ECAL

Muon reconstructed by matching track in ID and MS

Hadronic tau is identified by clustering jets and matching tau decay mode with BDT





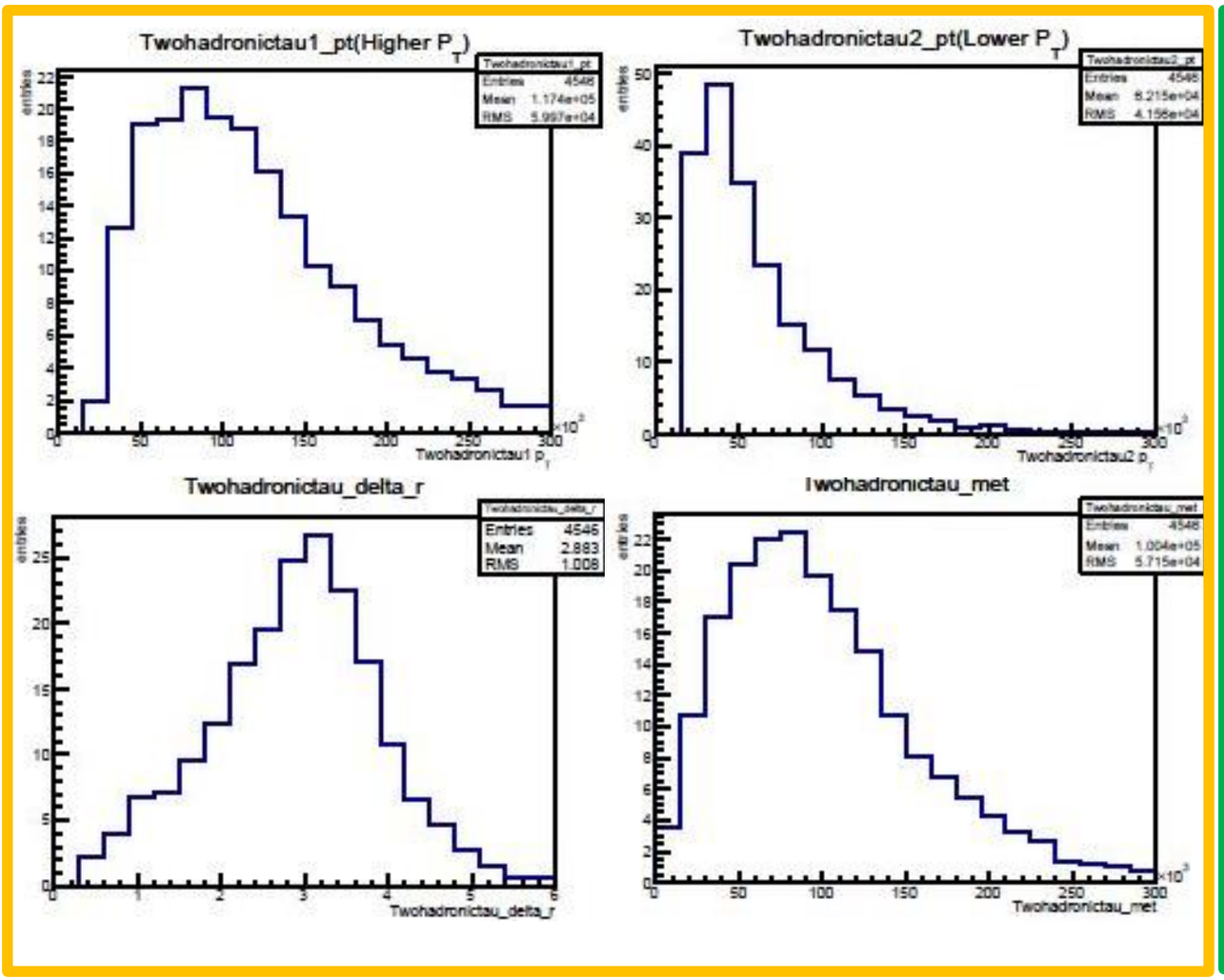
Kinematics and trigger

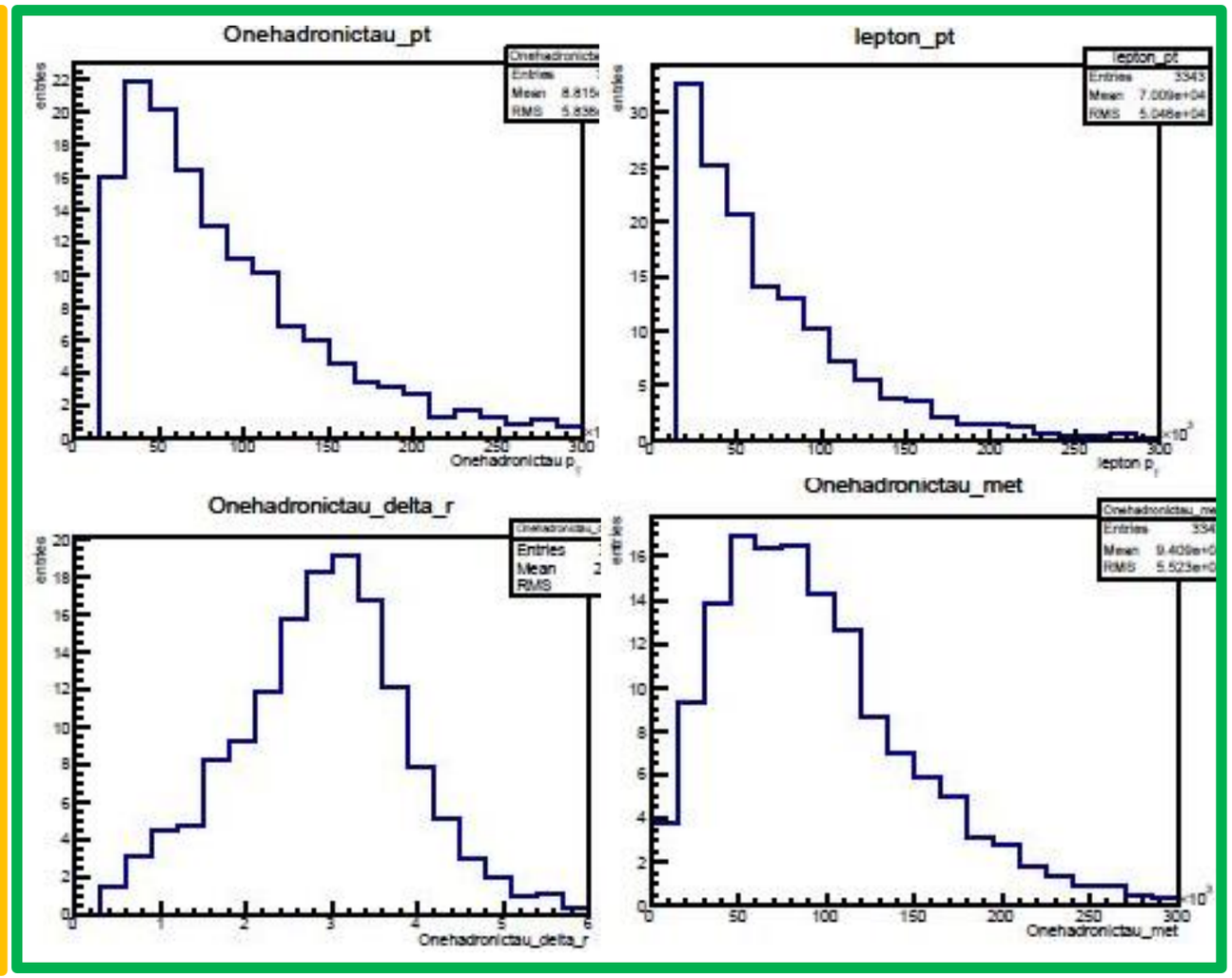
τ̃ mass 180 GeV, $\tilde{\chi}_1^0$ mass 1 GeV

HADHAD Channel: High leading Pt and MET **LEPHAD Channel: Lep + high Pt**

Pt: transverse momentum

MET: magnitude of missing transverse momentum due to neutrino (ν), neutrolino ($\tilde{\chi}_1^0$)





Delta_r: Angular separation between two objects $\Delta R = \sqrt{\Delta\varphi^2 + \Delta\eta^2}$; η pseudo-rapidity = *-ln(tan(θ/2))*

Kinematics and trigger

$m\tilde{\tau}$ 180 GeV $m\tilde{\chi}_0$ 1 GeV

Signal Acceptance

All possible lowest unscaled triggers

HADHAD Channel: ditau + met

(trigger efficiency plateau requires **MET ~ 130GeV)**

>>>>>>>>>>>>>>>>>>	HAD + HAD CHANNEL	<<<<<<<<<<<<<
Count event with n_tau = 2	2 Tau Triggers Tau1>120GeV;Tau2>80GeV	
Without Selection - Events	71	
With Selection - Events	13	
KeepingRatio = With/Without	18.310%	
	2 Tau + DR Tau1>55GeV;Tau2>40GeV;DeltaR<2.6	
Without Selection - Events	71	
With Selection - Events	13	
KeepingRatio = With/Without	18.310%	
	Tau + MET Tau1>55GeV;MET>100GeV	
Without Selection - Events	71	
With Selection - Events	28	
KeepingRatio = With/Without	39.437%	
	Tau + MET Tau1>55GeV;Tau2>40GeV;MET>75GeV	
Without Selection - Events	71	
With Selection - Events	29	
KeepingRatio = With/Without	40.845%	
	Tau + MET Tau1>55GeV;MET>150GeV	
Without Selection - Events	71	
With Selection - Events	12	
KeepingRatio = With/Without	16.901%	
	Tau + MET Tau1>55GeV;Tau2>40GeV;MET>125GeV	
Without Selection - Events	71	
With Selection - Events	13	
KeepingRatio = With/Without	18.310%	

LEPHAD Channel:

single lepton trigger is very efficient

<<<<<<<<<< >>>>>>>>>>>>>>>>>> <<<<<<<<<< >>>>>>>>>>>>>>>>>>	LEP + HAD CHANNEL
Count event with n_tau = 1 && n_lep = 1	Leptonic Triggers Electron>27GeV||Muon>27GeV
Without Selection - Events	86
With Selection - Events	69
KeepingRatio = With/Without	80.233%
	Tau + Lepton Tau1>120GeV;Electron>19GeV
Without Selection - Events	86
With Selection - Events	9
KeepingRatio = With/Without	10.465%
	Tau + Lepton Tau1>55GeV;Muon>15GeV
Without Selection - Events	86
With Selection - Events	30
KeepingRatio = With/Without	34.884%
	Leptonic + MET Tau1>40GeV;Electron>19GeV;MET>80GeV
Without Selection - Events	86
With Selection - Events	18
KeepingRatio = With/Without	20.930%
	Leptonic + MET Tau1>40GeV;Muon>15GeV;MET>80GeV
Without Selection - Events	86
With Selection - Events	21
KeepingRatio = With/Without	24.419%
	Leptonic + MET Tau1>40GeV;Electron>19GeV;MET>130GeV
Without Selection - Events	86
With Selection - Events	8
KeepingRatio = With/Without	9.302%
	Leptonic + MET Tau1>40GeV;Muon>15GeV;MET>130GeV
Without Selection - Events	86
With Selection - Events	10
KeepingRatio = With/Without	11.628%

Kinematics and trigger

$m\tilde{\tau}$ 120 GeV $m\tilde{\chi}_0$ 1 GeV

>>>>>>>>>>>>>>>>>>	HAD + HAD CHANNEL	<<<<<<<<<<<<<<
Count event with n_tau = 2	2 Tau Triggers Tau1>120GeV;Tau2>80GeV	
Without Selection - Events	428	
With Selection - Events	31	
KeepingRatio = With/Without	7.243%	
	2 Tau + DR Tau1>55GeV;Tau2>40GeV;DeltaR<2.6	
Without Selection - Events	428	
With Selection - Events	44	
KeepingRatio = With/Without	10.280%	
	Tau + MET Tau1>55GeV;MET>100GeV	
Without Selection - Events	428	
With Selection - Events	81	
KeepingRatio = With/Without	18.925%	
	Tau + MET Tau1>55GeV;Tau2>40GeV;MET>75GeV	
Without Selection - Events	428	
With Selection - Events	86	
KeepingRatio = With/Without	20.093%	
	Tau + MET Tau1>55GeV;MET>150GeV	
Without Selection - Events	428	
With Selection - Events	25	
KeepingRatio = With/Without	5.841%	
	Tau + MET Tau1>55GeV;Tau2>40GeV;MET>125GeV	
Without Selection - Events	428	
With Selection - Events	25	
KeepingRatio = With/Without	5.841%	

:<<<<<<<<<< >>>>>>>>>>>>>>>>>>>	LEP + HAD CHANNEL
Count event with n_tau = 1 && n_lep = 1	Leptonic Triggers Electron>27GeV||Muon>27GeV
Without Selection - Events	527
With Selection - Events	387
KeepingRatio = With/Without	73.435%
	Tau + Lepton Tau1>120GeV;Electron>19GeV
Without Selection - Events	527
With Selection - Events	30
KeepingRatio = With/Without	5.693%
	Tau + Lepton Tau1>55GeV;Muon>15GeV
Without Selection - Events	527
With Selection - Events	146
KeepingRatio = With/Without	27.704%
	Leptonic + MET Tau1>40GeV;Electron>19GeV;MET>80GeV
Without Selection - Events	527
With Selection - Events	60
KeepingRatio = With/Without	11.385%
	Leptonic + MET Tau1>40GeV;Muon>15GeV;MET>80GeV
Without Selection - Events	527
With Selection - Events	72
KeepingRatio = With/Without	13.662%
	Leptonic + MET Tau1>40GeV;Electron>19GeV;MET>130GeV
Without Selection - Events	527
With Selection - Events	24
KeepingRatio = With/Without	4.554%
	Leptonic + MET Tau1>40GeV;Muon>15GeV;MET>130GeV
Without Selection - Events	527
With Selection - Events	23
KeepingRatio = With/Without	4.364%

HADHAD Channel

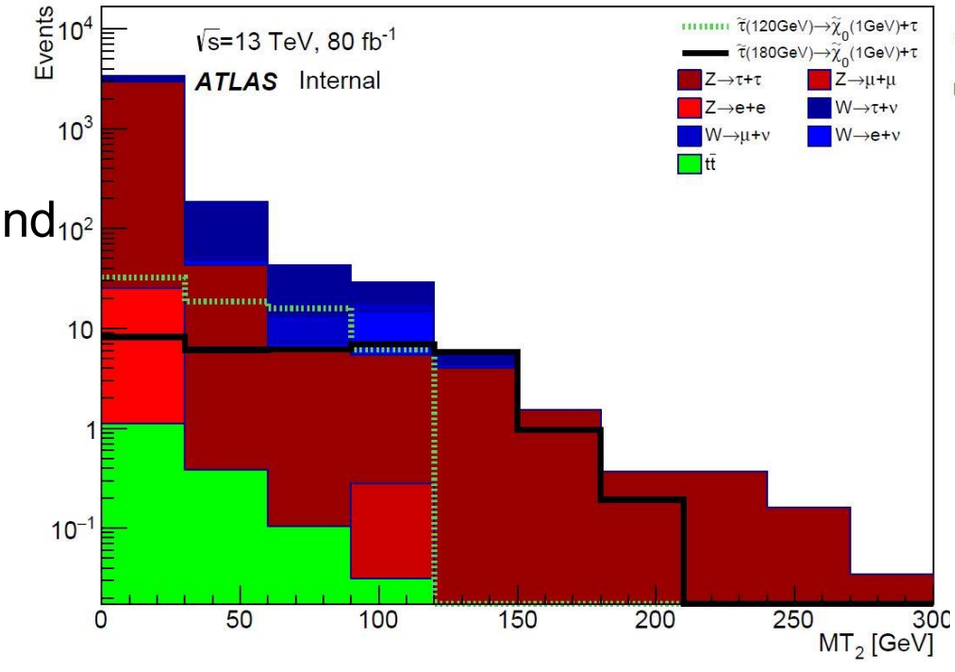
Trigger:

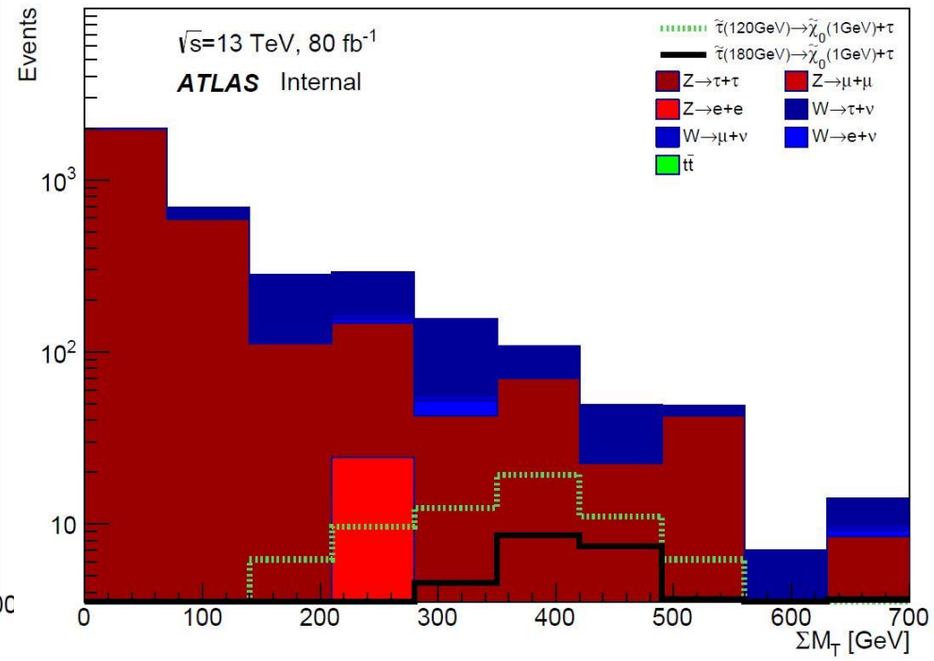
HADHAD: τ1_pt>40GeV; τ2_pt>30GeV; MET>130GeV

Thanks to Pieter for MT and MT2

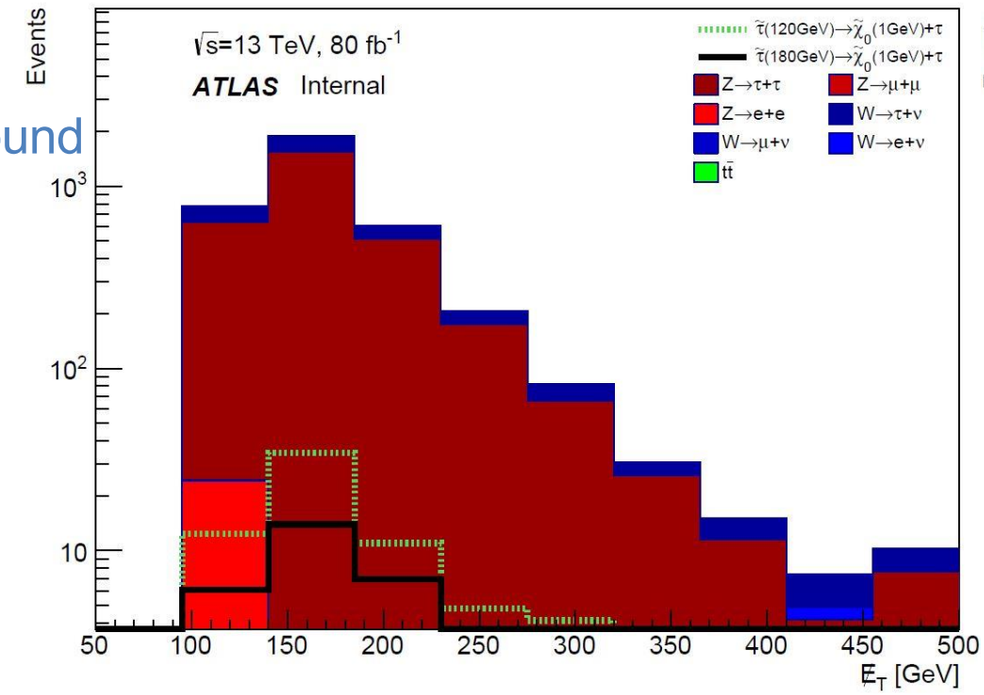
HAD HAD channel:

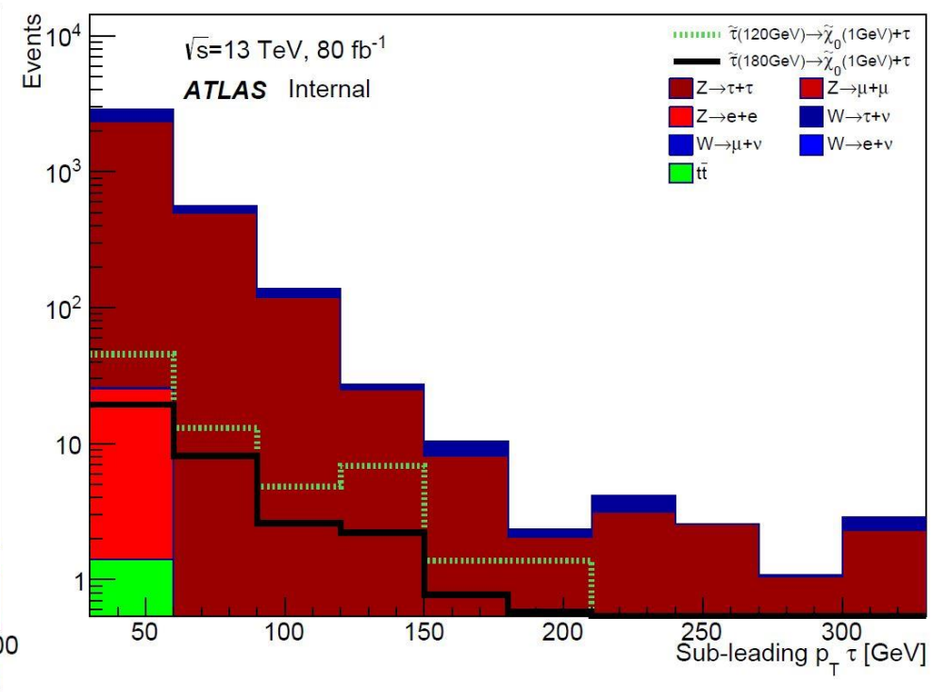
Large MT2:
Efficient in reducing background
Low signal acceptance
for **small stau mass**





Large ∑MT:
Efficient in reducing background
Low signal acceptance
for **large stau mass**





Search Region 1

Trigger: HADHAD: τ1_pt>40GeV; τ2_pt>30GeV; MET>130GeV

Selection: HADHAD: MT_2>90GeV; $\Delta\varphi(\tau 1, \tau 2)$>1.5

HAD HAD channel:

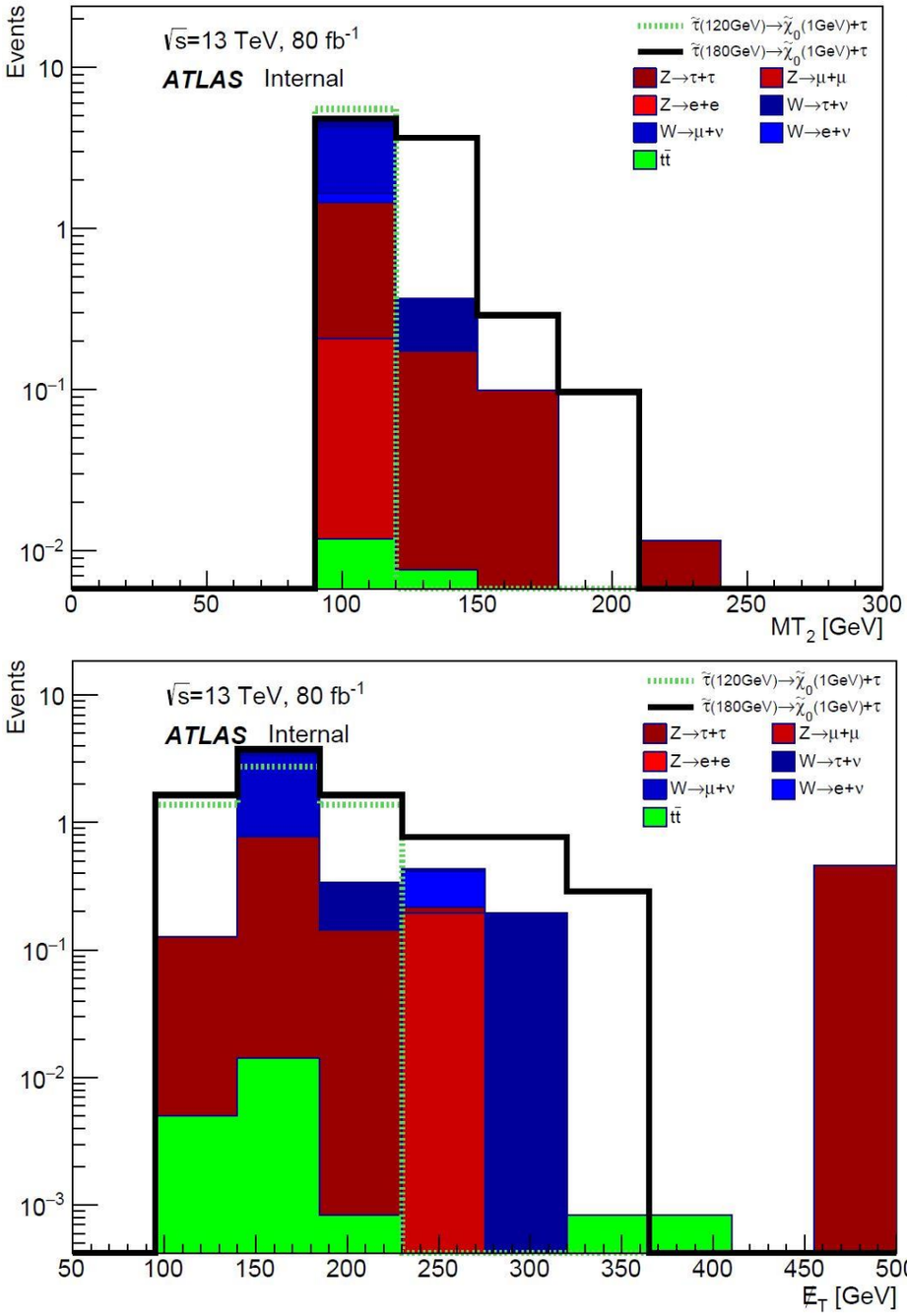
Target at high stau mass

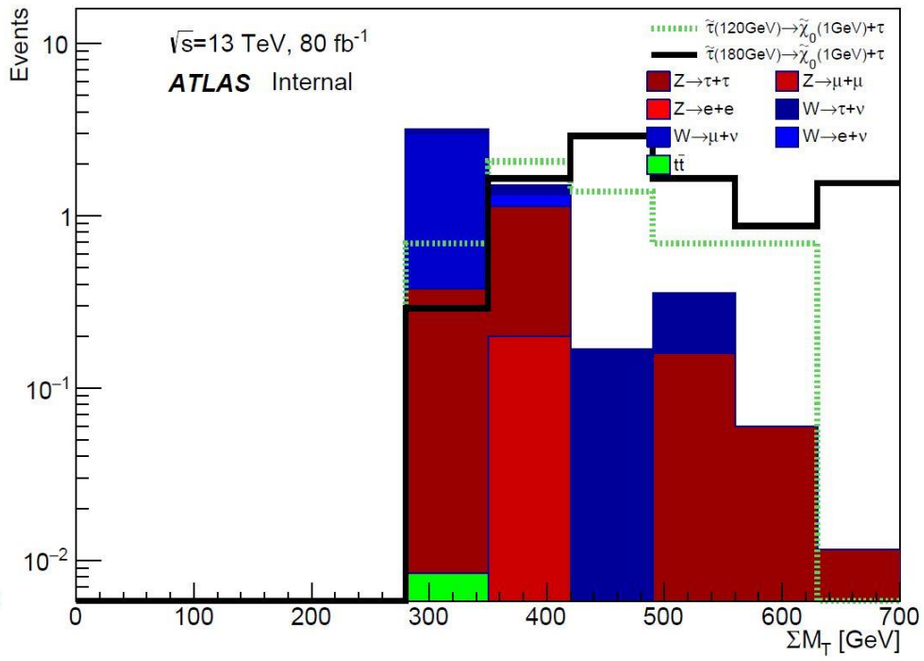
Stau 180GeV: ~9Events

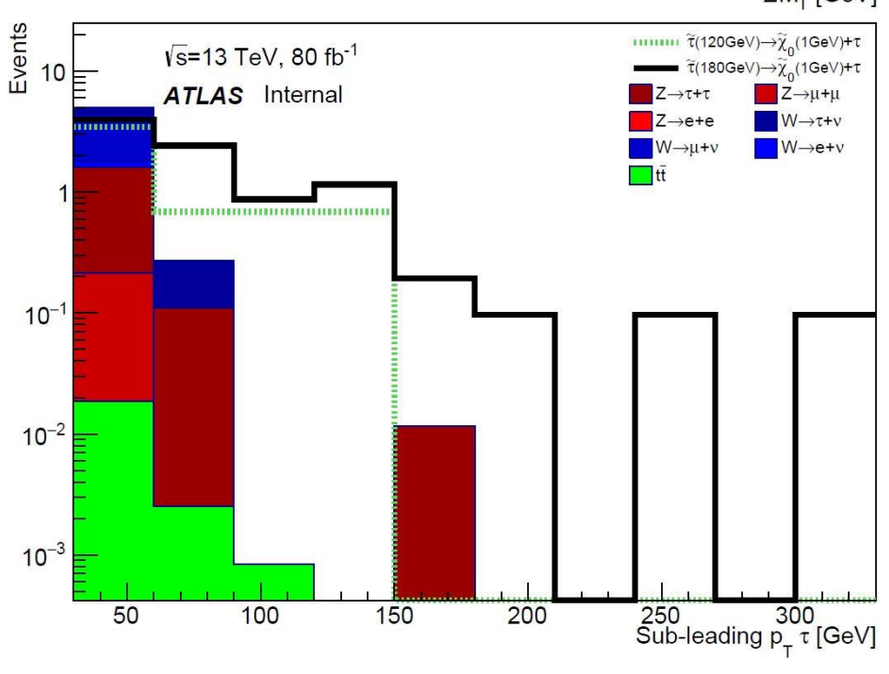
Stau 120GeV: ~6Events

BG total: ~5Events

Tight cut:
Not enough MC data for significance







Search Region 2

Trigger: HADHAD: τ1_pt>40GeV; τ2_pt>30GeV; MET>130GeV

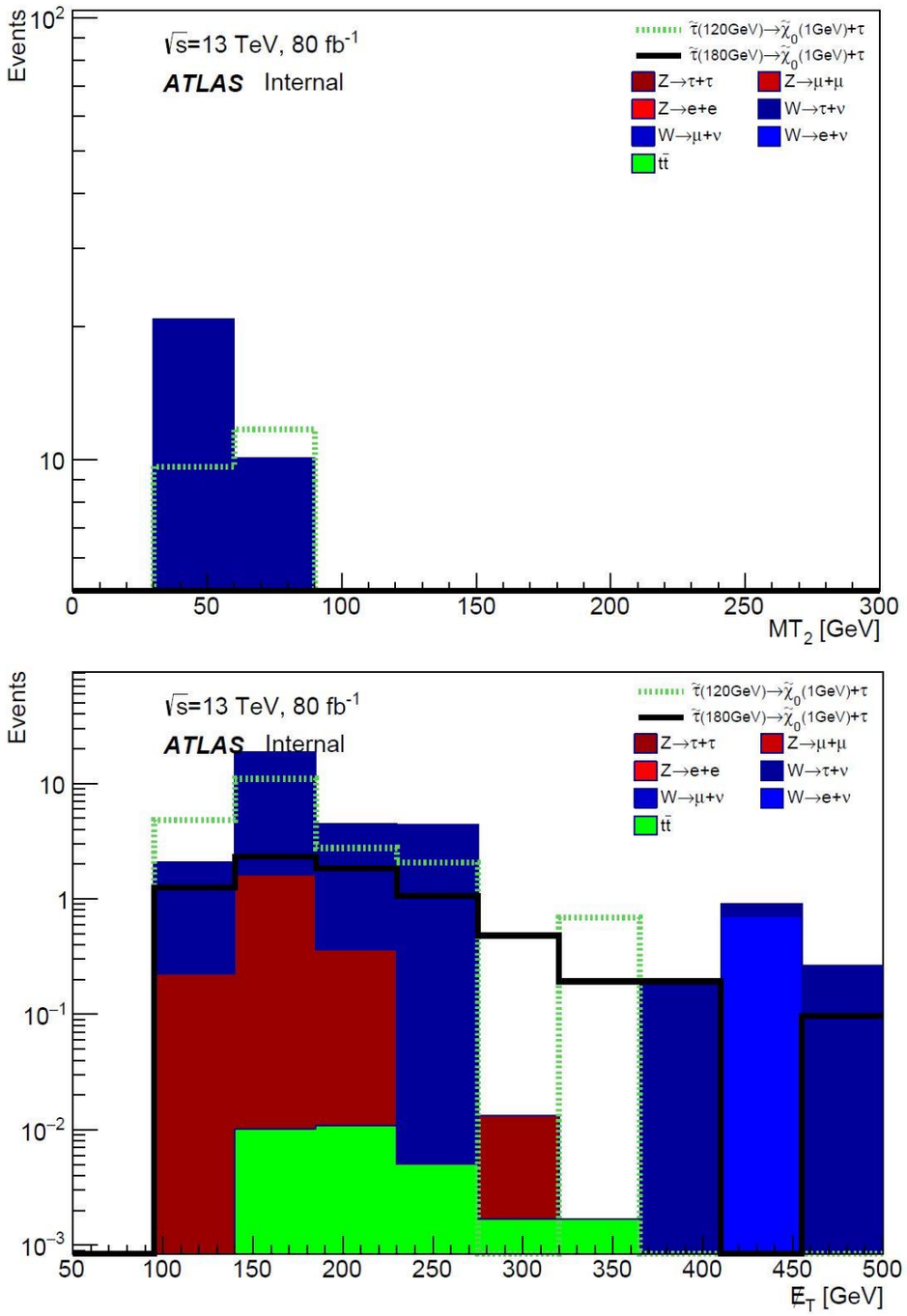
Selection: HADHAD: 40GeV<MT_2<90GeV; ΣM_T>350GeV; $\Delta\varphi(\tau 1, \tau 2)$>1.5

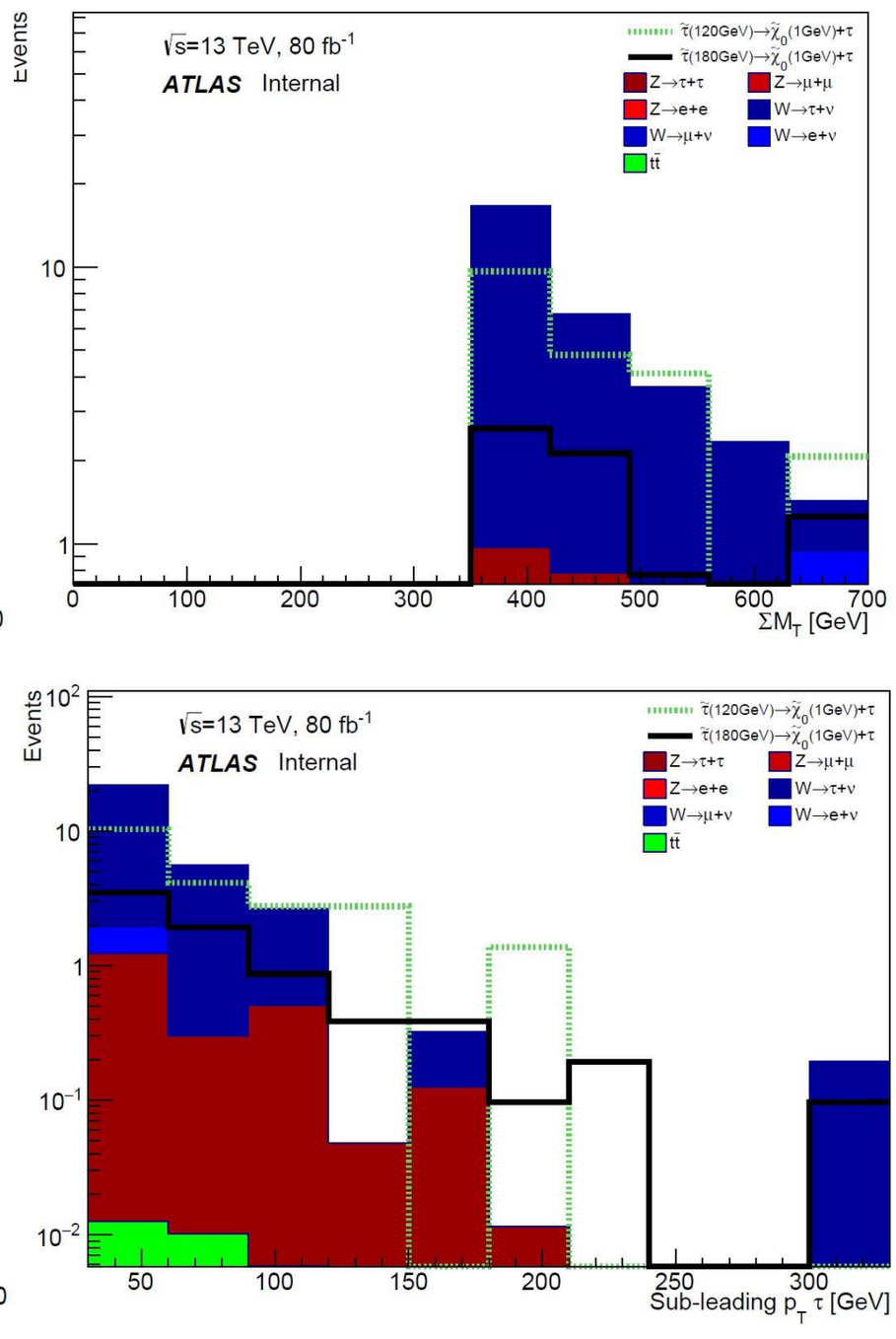
HAD HAD channel:

Stau 180GeV: ~2Events

Stau 120GeV: ~6Events

BG total: ~13Events





Search Region 3

Trigger: HADHAD: τ1_pt>40GeV; τ2_pt>30GeV; MET>130GeV

Selection: HADHAD: 40GeV<MT_2<90GeV; 300GeV<ΣM_T<350GeV; $\Delta\varphi(\tau 1, \tau 2)$>1.5

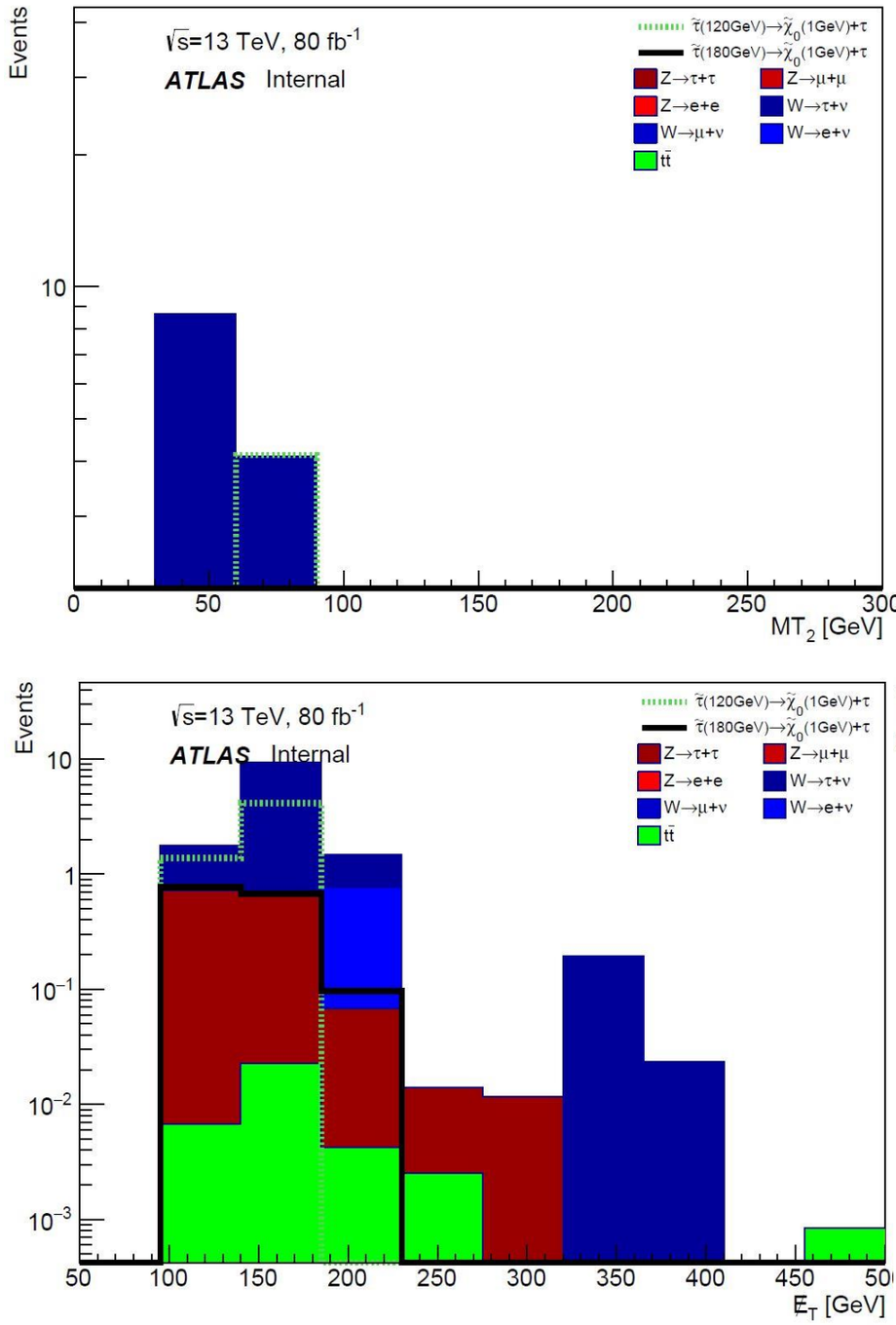
HAD HAD channel:

Target at high stau mass

Stau 180GeV: ~7Events

Stau 120GeV: ~21Events

BG total: ~31Events



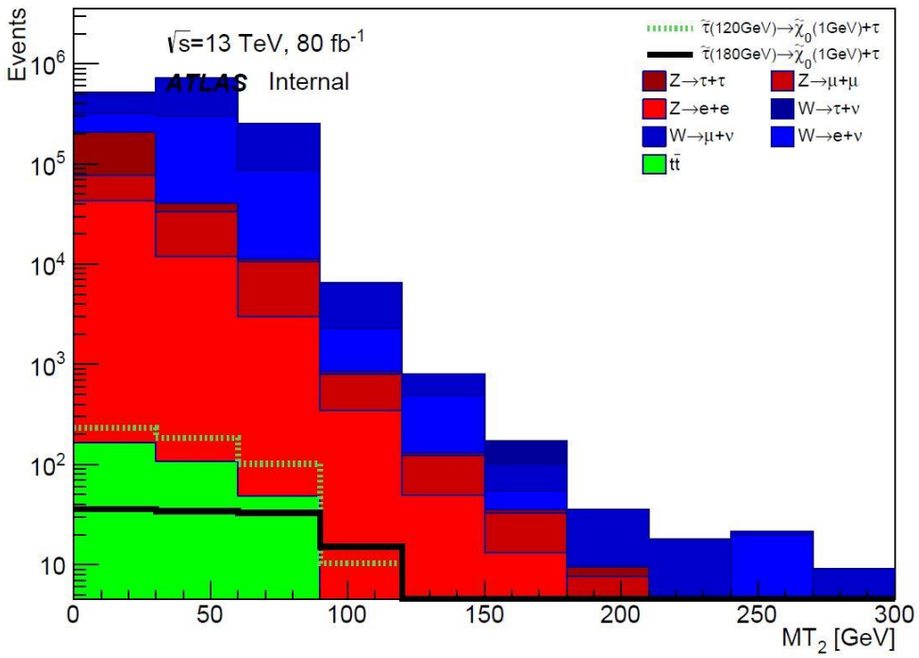
LEPHAD Channel

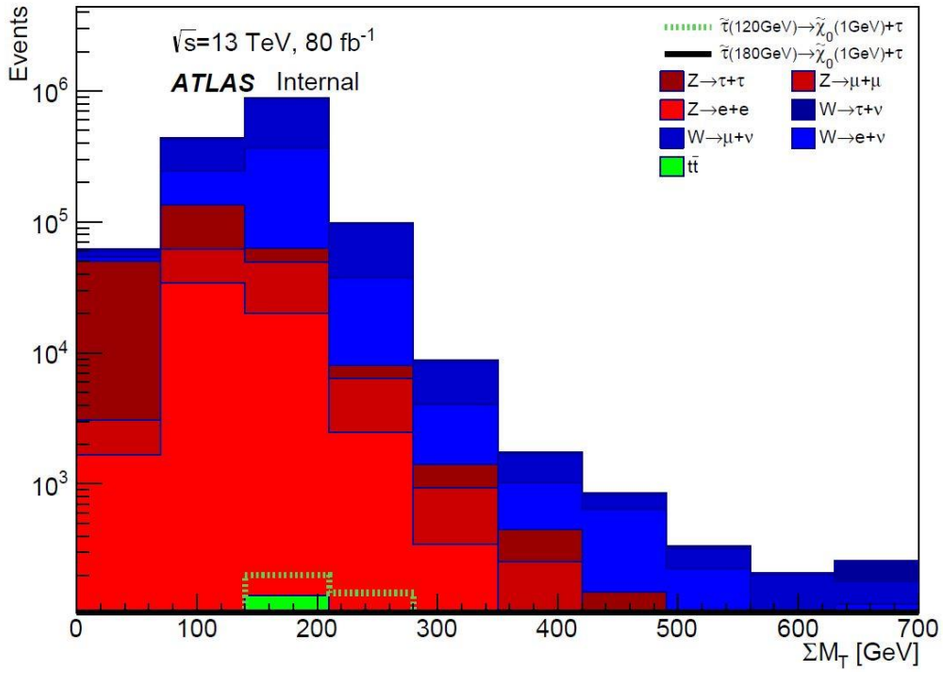
Trigger:

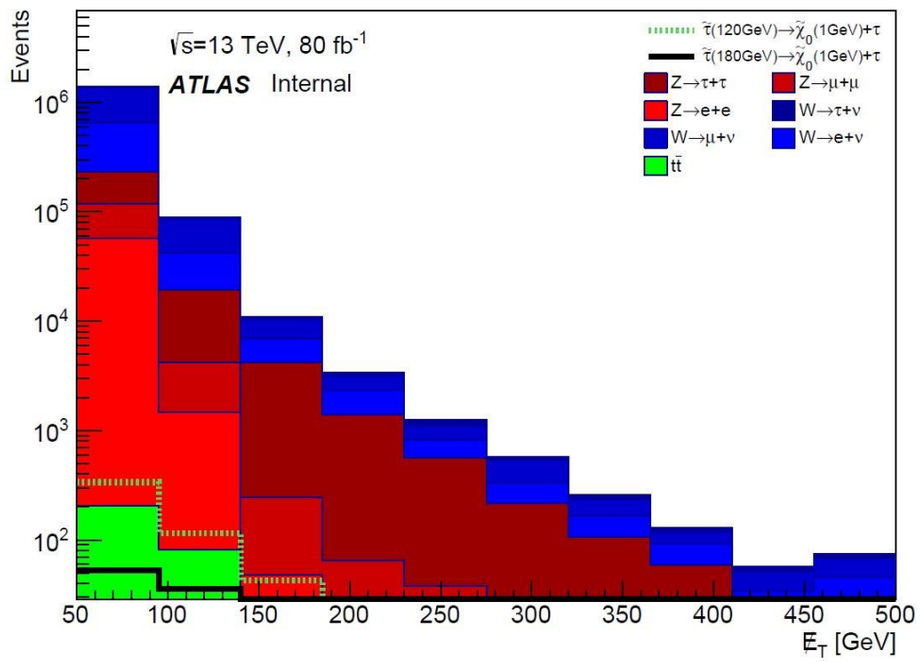
LEPHAD: τ_pt>20GeV; e/μ_pt>27GeV; MET>50GeV

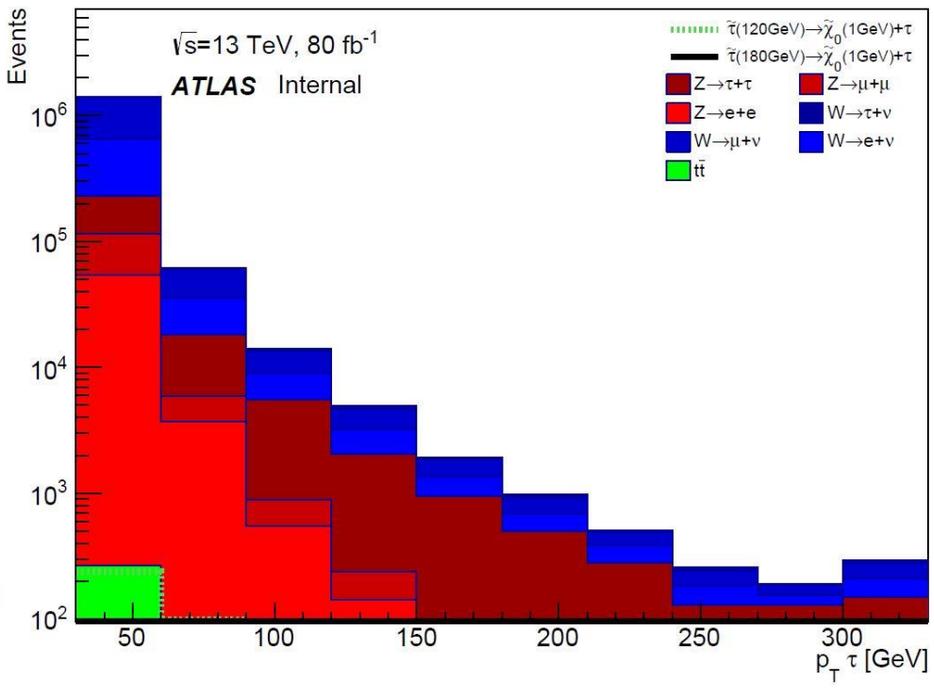
LEP HAD channel:

Much more backgrounds





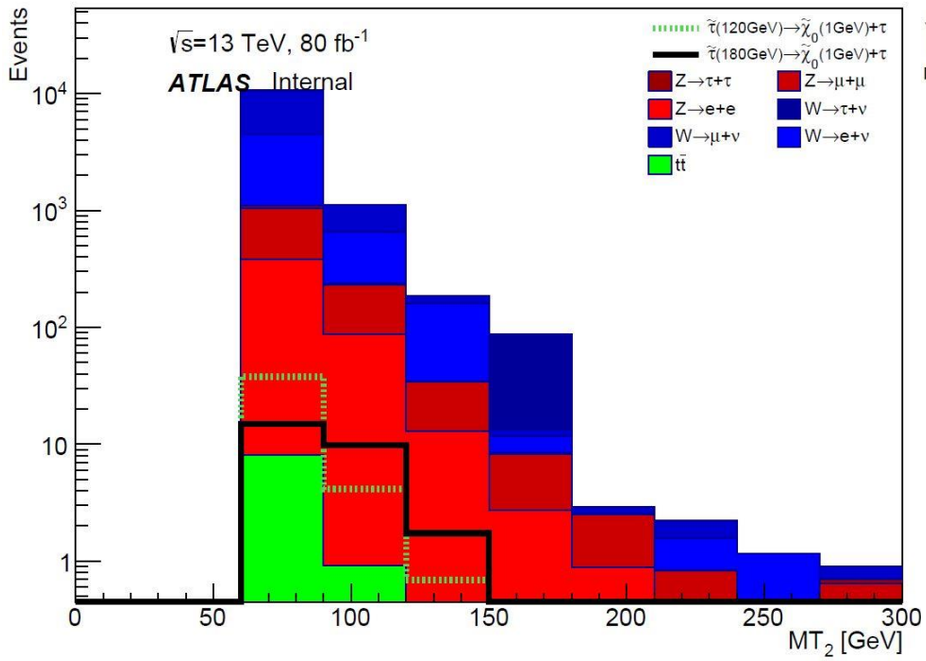


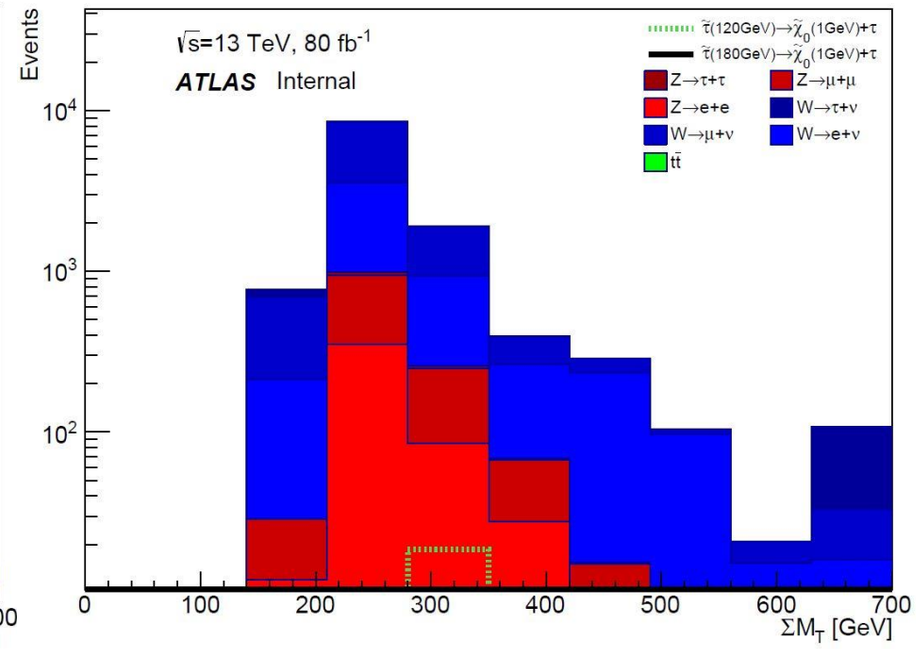


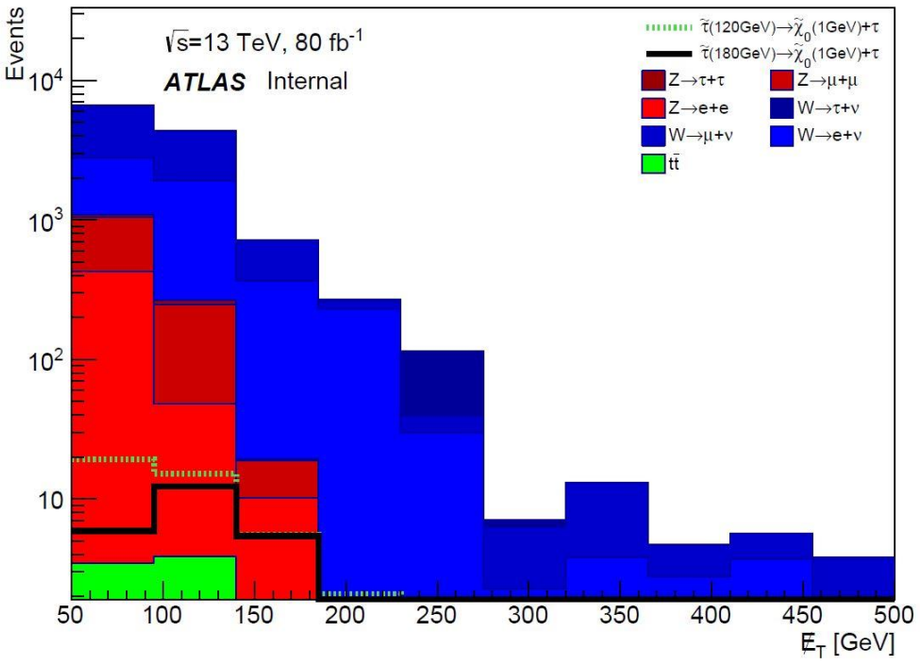
Search Region 1

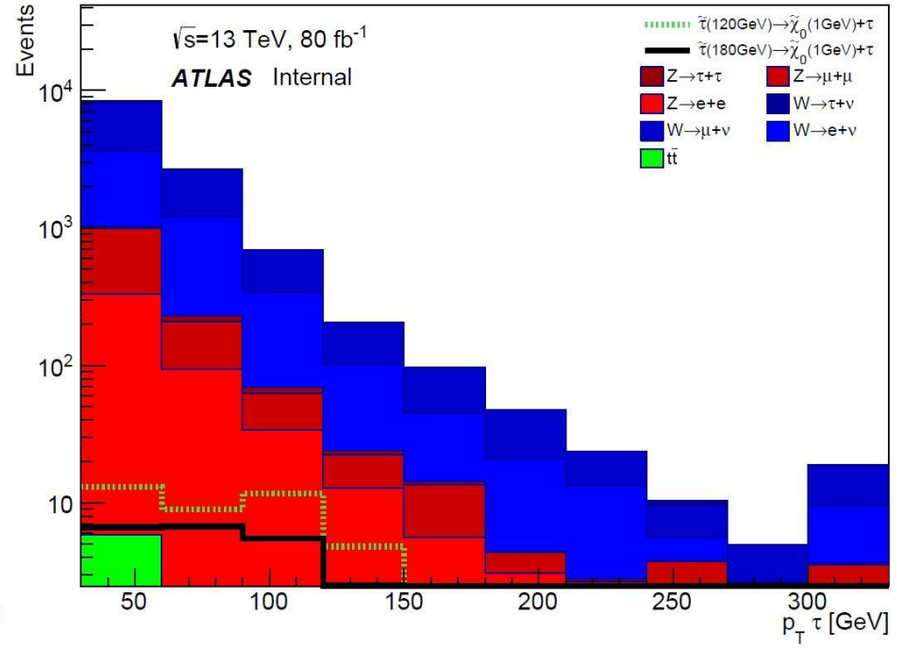
Trigger: LEPHAD: τ_pt>20GeV; e/μ_pt>27GeV; MET>50GeV

Selection: LEPHAD: MT_2>70GeV; ΣM_T>200GeV; $\Delta\varphi(\tau, l)$>1.5





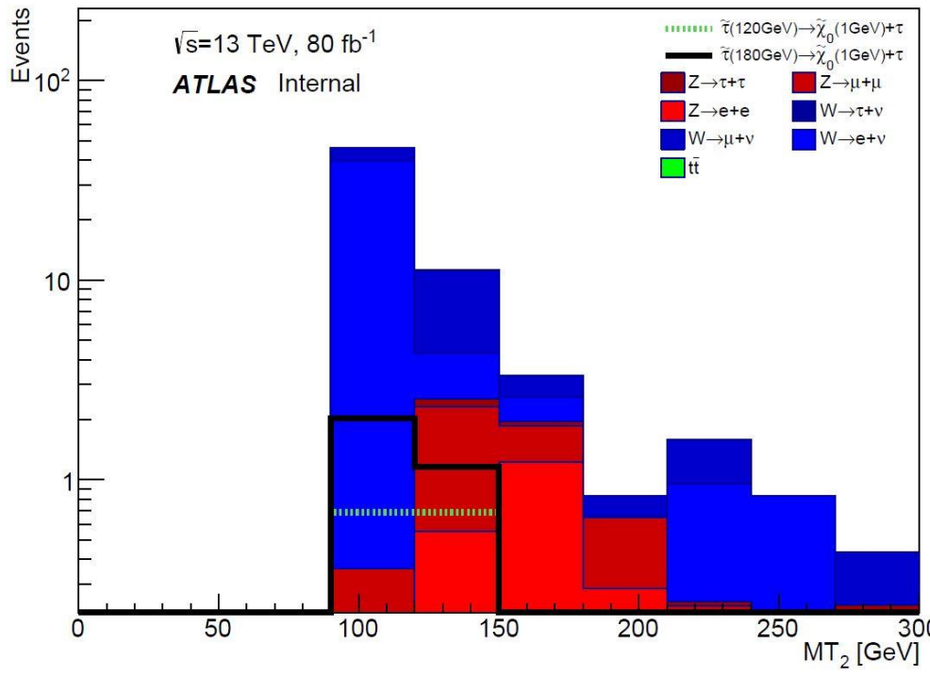


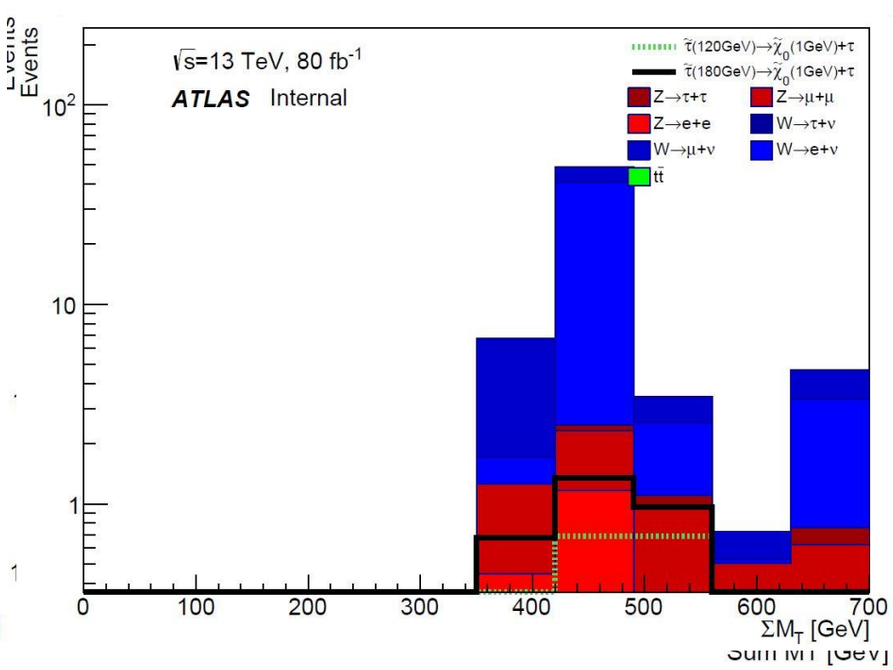


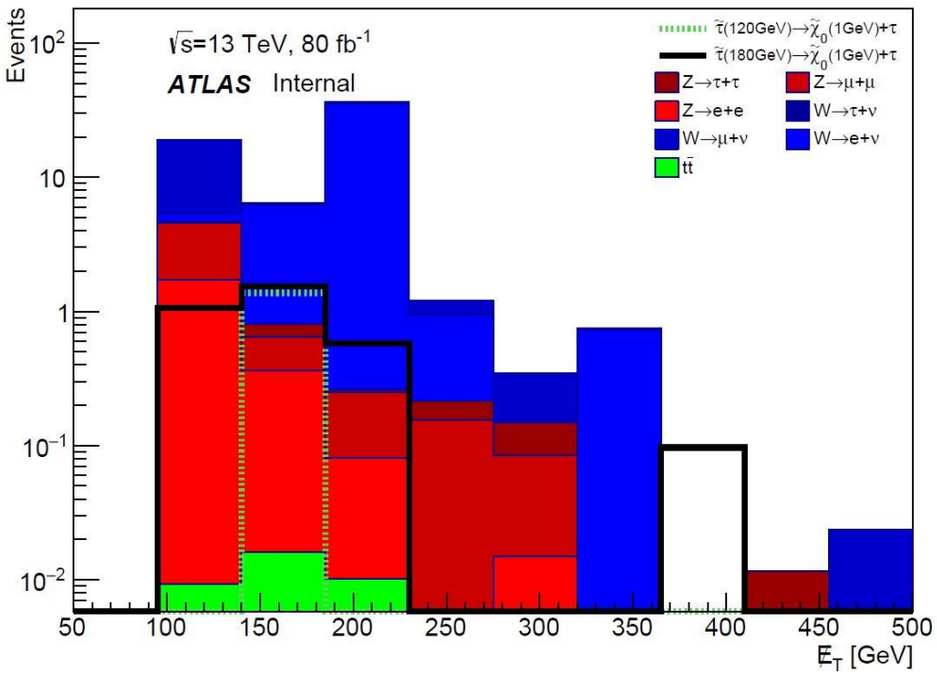
Search Region 2

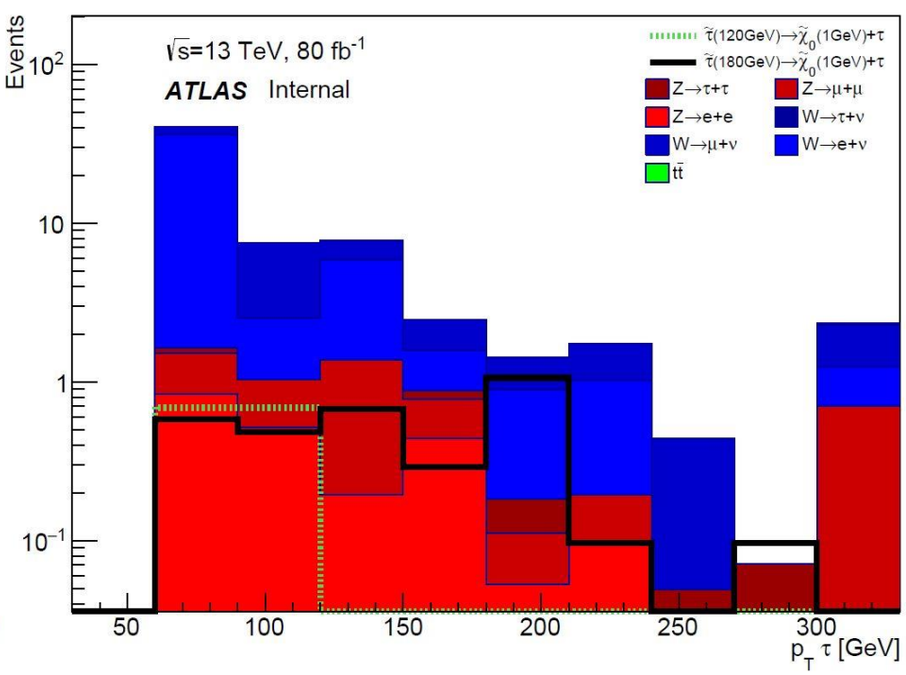
Trigger: LEPHAD: τ_pt>70GeV; e/μ_pt>50GeV; MET>100GeV

Selection: LEPHAD: MT_2>90GeV; ΣM_T>400GeV; $\Delta\varphi(\tau, l)$>1.5









Outlook:

HAD HAD channel:

Initial study has high sensitivity $\frac{S}{\sqrt{B}} \approx 4$

QCD backgrounds and fake tau rates need to be incorporated

Not enough MC data to distinguish signal or fluctuation

Move to Optimization framework

LEP HAD channel:

Need further optimization to reduce background

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