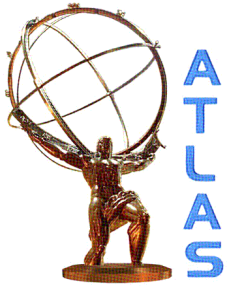


SUSY tau+X searches at ATLAS

Sourabh Dube
For the ATLAS collaboration

3rd May, 2012

BNL Workshop on SUSY with 5 / fb at the LHC

Lawrence Berkeley National Laboratory

Brookhaven, New York, USA

Outline

- Motivation for tau searches
- Tau reconstruction and Identification
- Looking for one τ
- Looking for two τ's

Motivation

- Leptons are important for searches; reduce background, clean signatures
- SM follows lepton universality, NP need not!
- There are regions of parameter space where production of taus is significantly enhanced over lighter leptons

Consider GMSB,

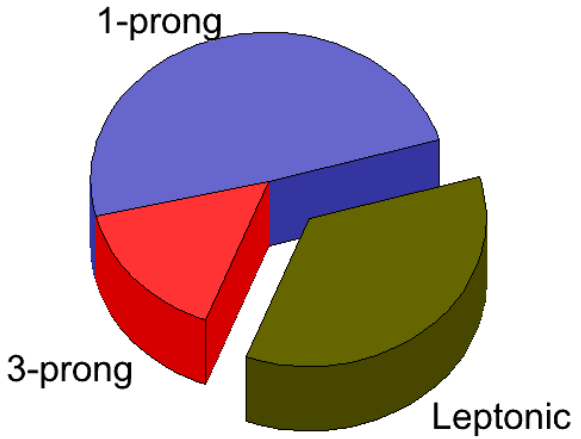
For larger tanβ, stau is NLSP for most of parameter space

Sparticles cascade decay to the stau followed by $\tilde{\tau} \rightarrow \tau \tilde{G}$

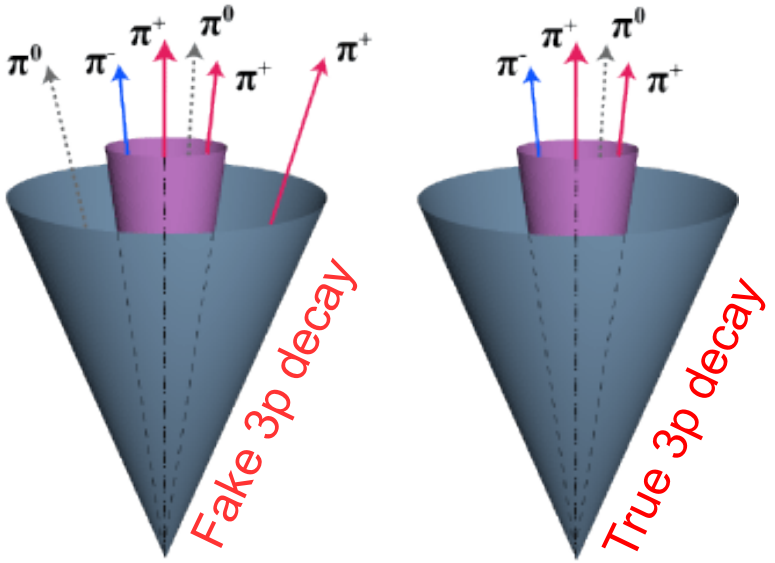
Tau Reconstruction

Tau mass = 1.8 GeV
~ 65% of tau decays are to hadronic final states

1-prong – 1 charged pion in final state
3-prong – 3 charged pions in final state

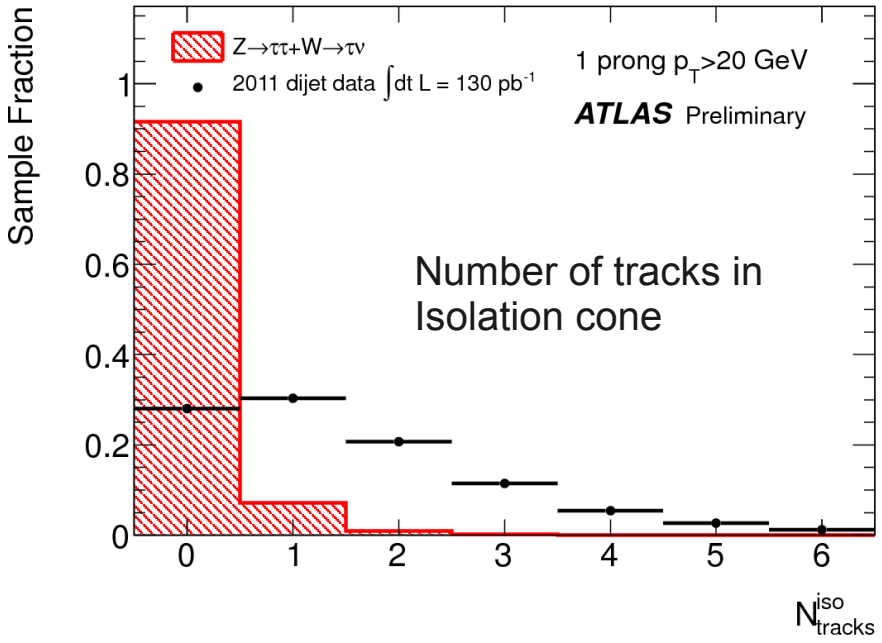


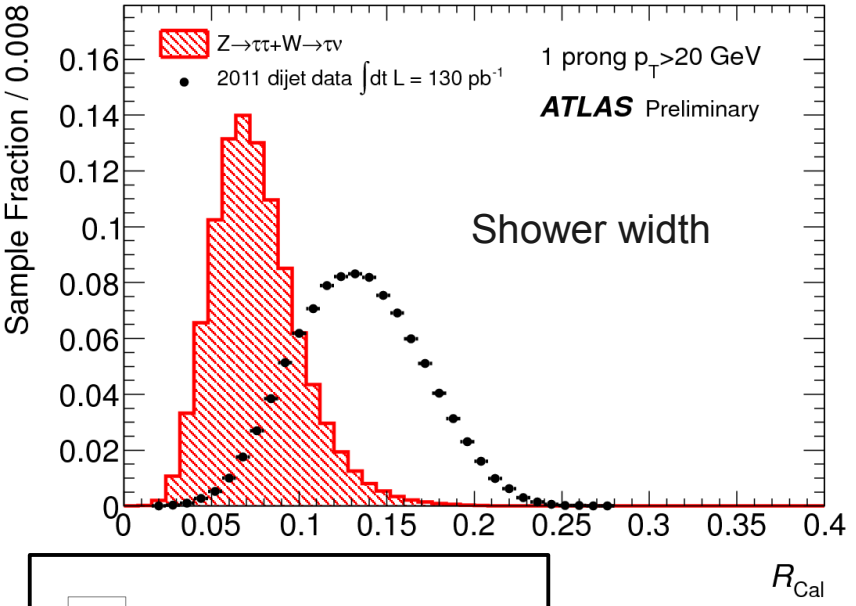
- Taus reconstructed from all jets with pT > 10 GeV (Jets using anti-kt algorithm with R = 0.4)
- Separate identification of 1p and 3p
- Multivariate discriminants based on tracking and calorimeter information
- Tau energy scale calibrated from MC based on visible energy, |η|, and number of prongs

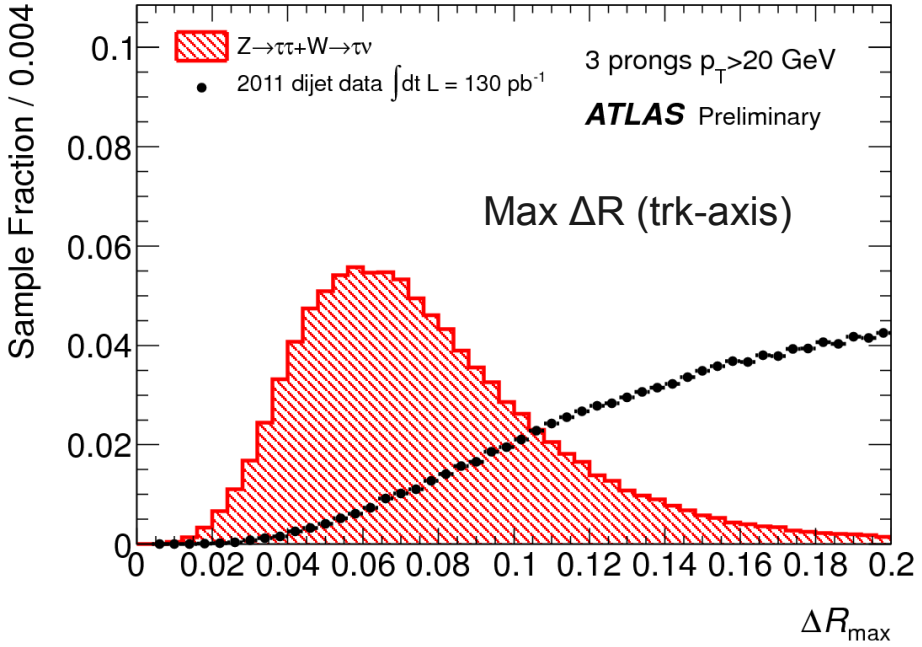


Tau Identification

ATLAS-CONF-2011-152







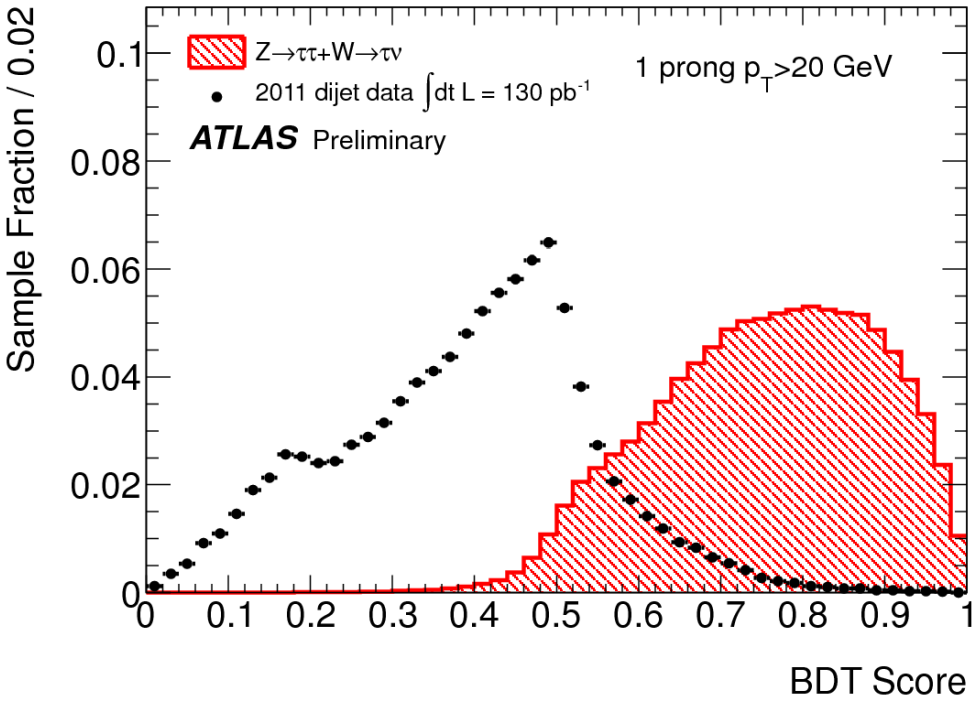
True τ (W/Z)

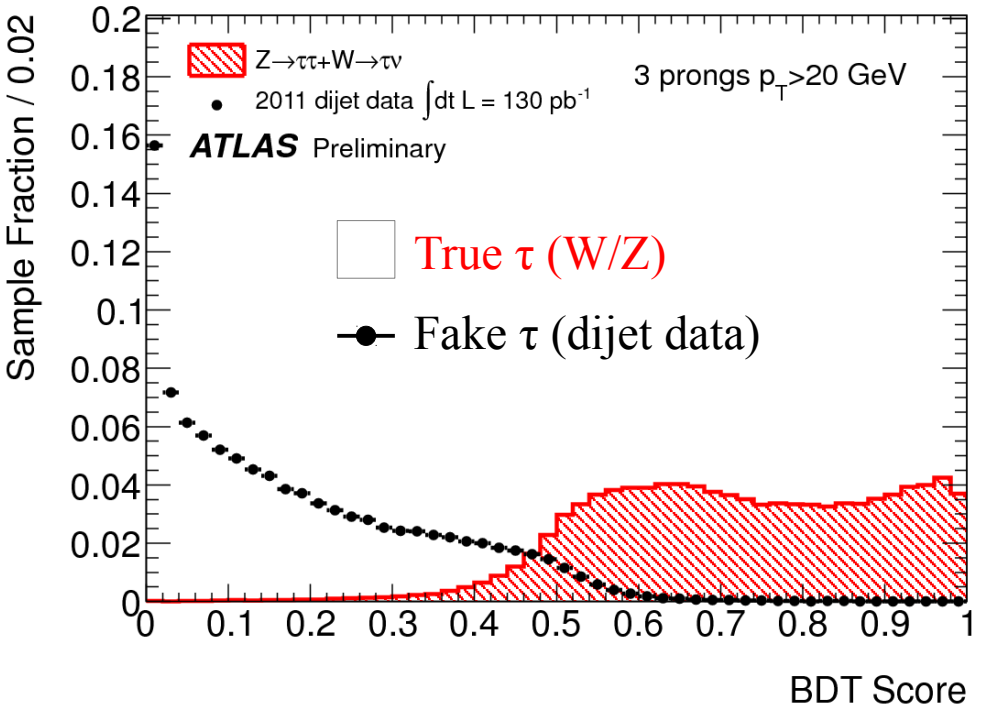
Fake τ (dijet data)

Other variables include
p_T weighted track width,
leading track momentum fraction,
core energy fraction,
cluster mass, track mass,
transverse flight path significance,
leading track IP significance...

Tau Identification

Boosted Decision Tree (BDT) trained for 1p and multi-prong

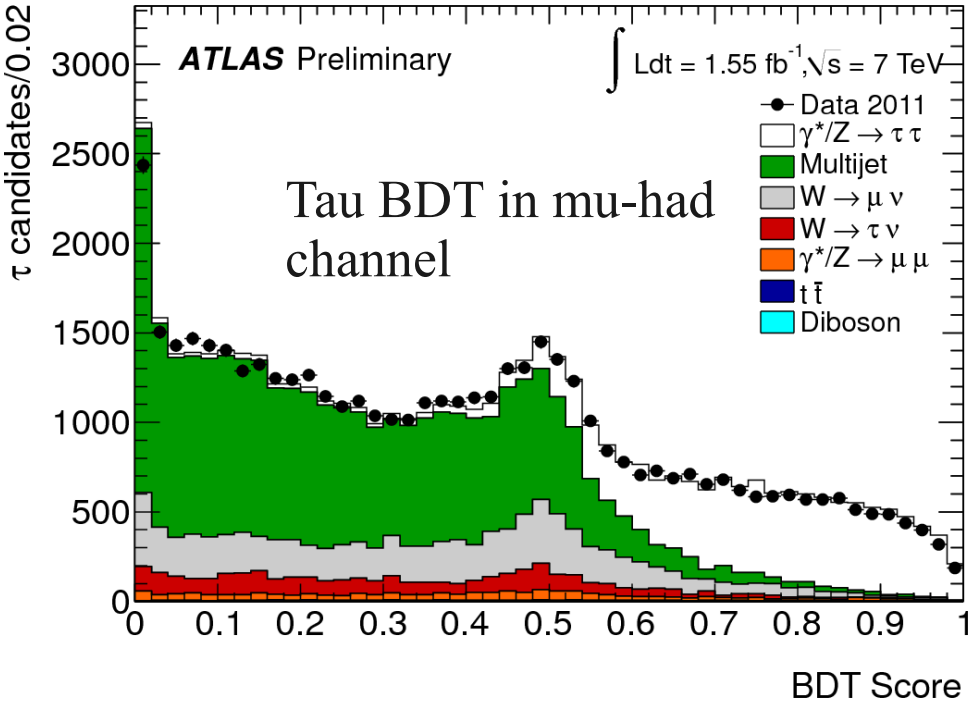


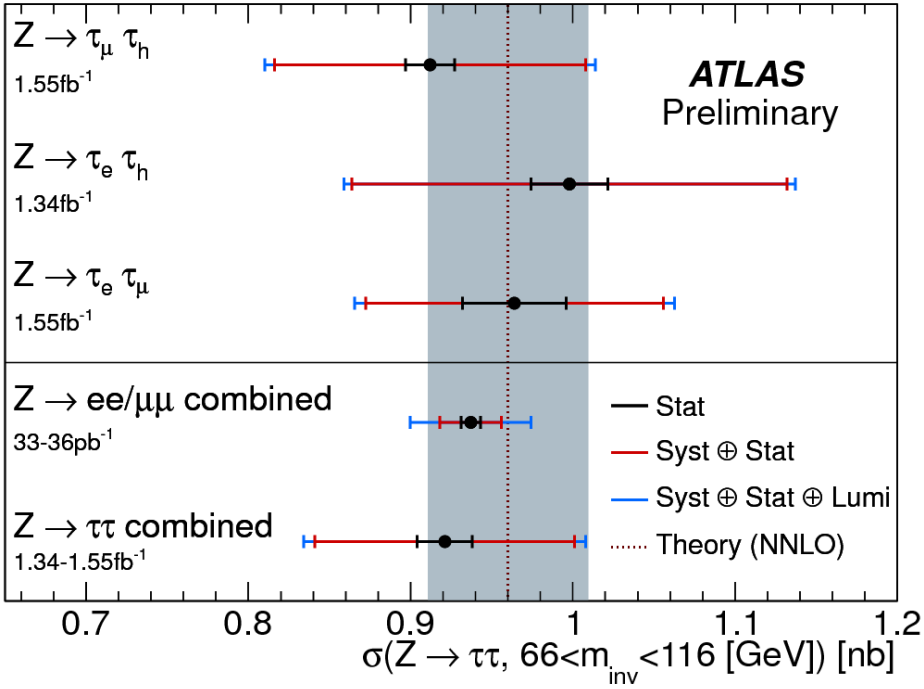


- Loose, Medium, Tight selections defined based on BDT score
- Each selection employs pT dependent cuts to compensate for pT dependence of BDT

Understand the SM before NP
Z→ττ cross section

ATLAS-CONF-2012-006





The Z→ττ cross section (lep-had) channel agrees very well with SM prediction.

$\geq 1\ \tau$ + jets + Etmiss

arXiv:1204.3852

$\geq 1\ \tau$ + jets + Etmiss (2.05 fb^{-1})

Event Selection

Trigger: 1 jet with $p_T > 75$ GeV, Etmiss > 45 GeV

1 tau with $p_T > 20$ GeV ($|\eta|<2.5$), BDTtight

2 jets with $p_T > 130$ GeV, 30 GeV respectively

Etmiss > 130 GeV

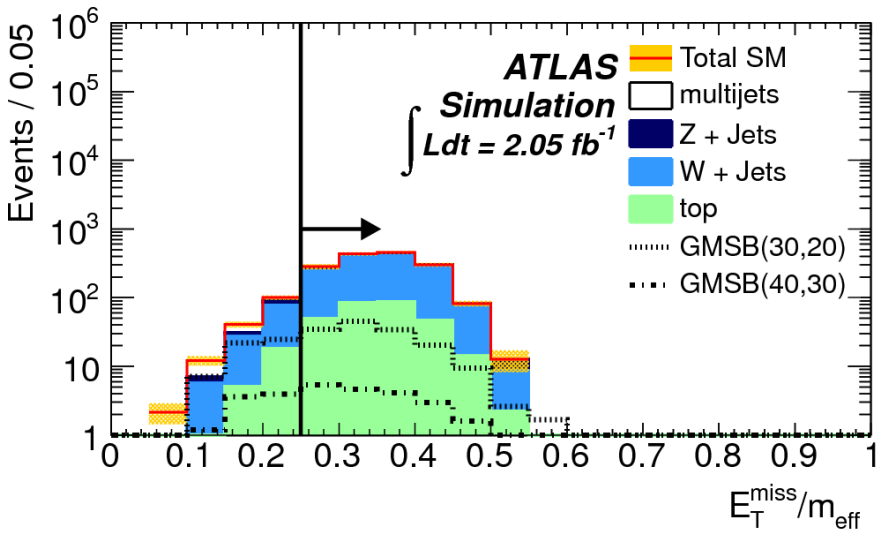
$\Delta\varphi$(jet-Etmiss) > 0.3 for both jets

$m_T > 110$ GeV

$M_{eff} > 600$ GeV ($\Sigma\ p_T$[tau,jets,Etmiss])

Etmiss/$M_{eff} > 0.25$

No electrons/muons above 20 GeV

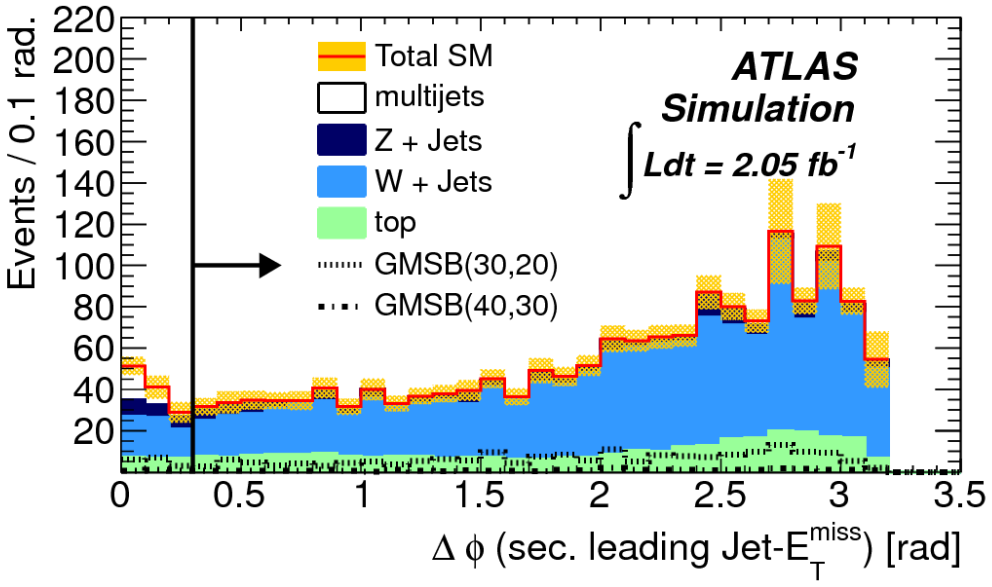


$\geq 1\ \tau$ + jets + Etmiss

Backgrounds W+jet, Z+jet, top-pair, single-top

Background estimated from 3 control regions

1. Real taus from W, Z, top
2. Fake taus from W, top
3. Fake taus from multijet

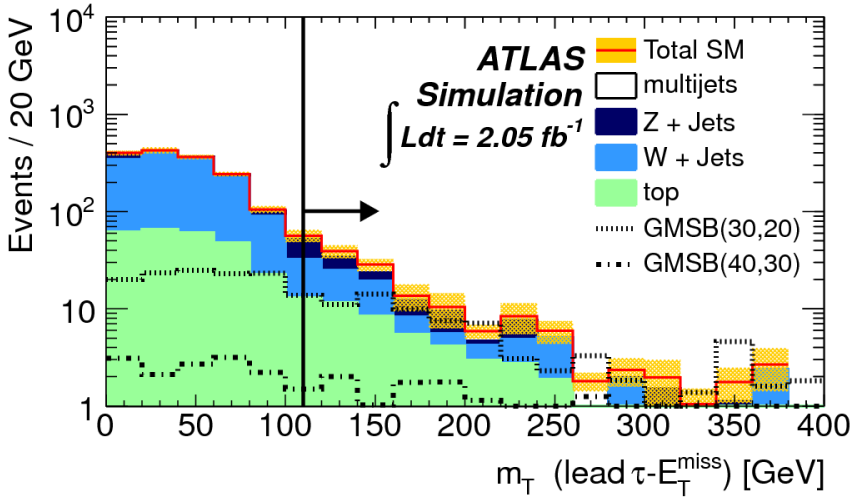


Control region: Multijets

Etmiss/M_{eff} < 0.25 or Δφ(jet-met)<0.3

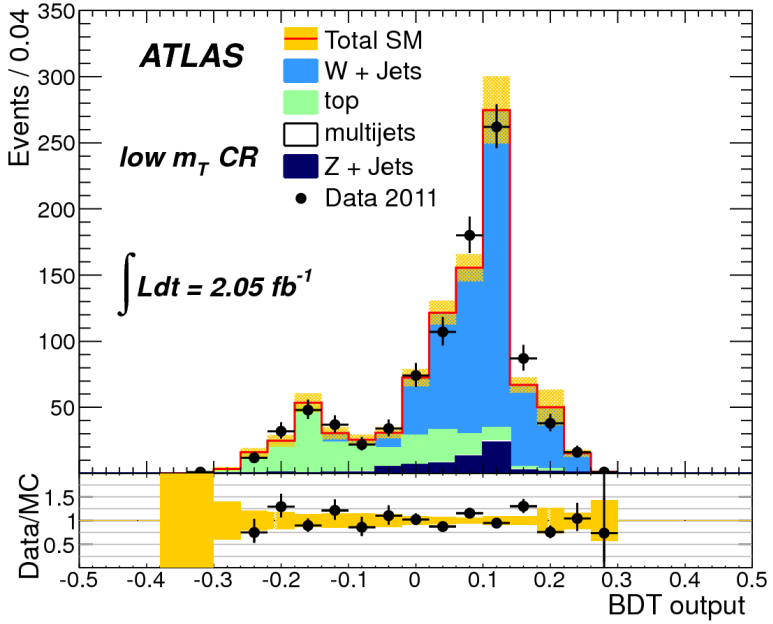
- Measure probability for jet to fake tau
- Apply to jets in signal region.
- Very small background

≥ 1 τ + jets + Etmiss



Control region: True taus - m_T < 70 GeV
Estimate W+jet and top predictions
(Z+jets from MC, multijet described above.)

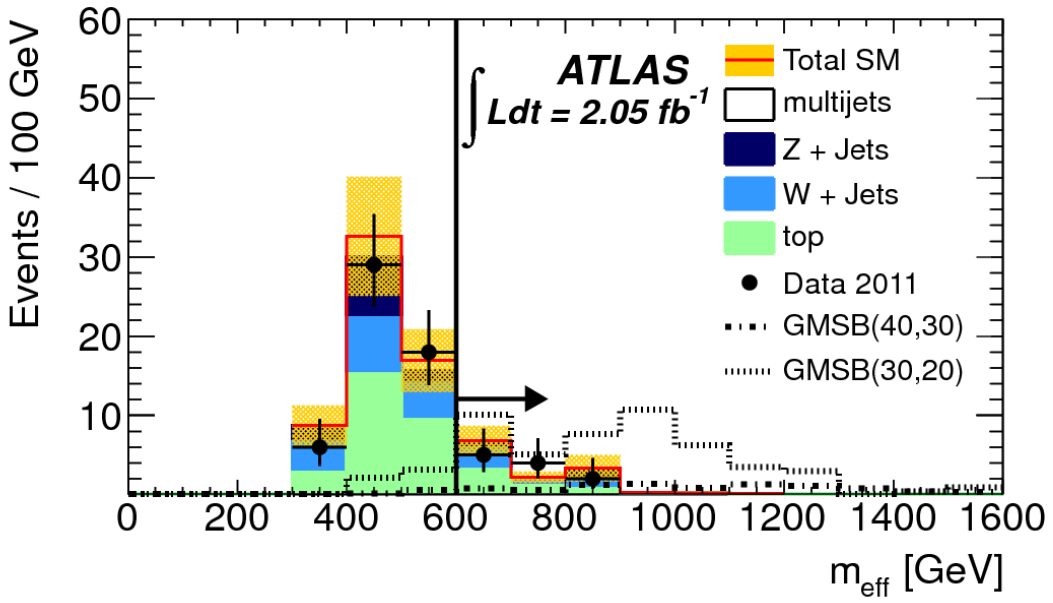
BDT based on Nb-jets, Njets, pT j2,
transverse thrust to get relative contributions.

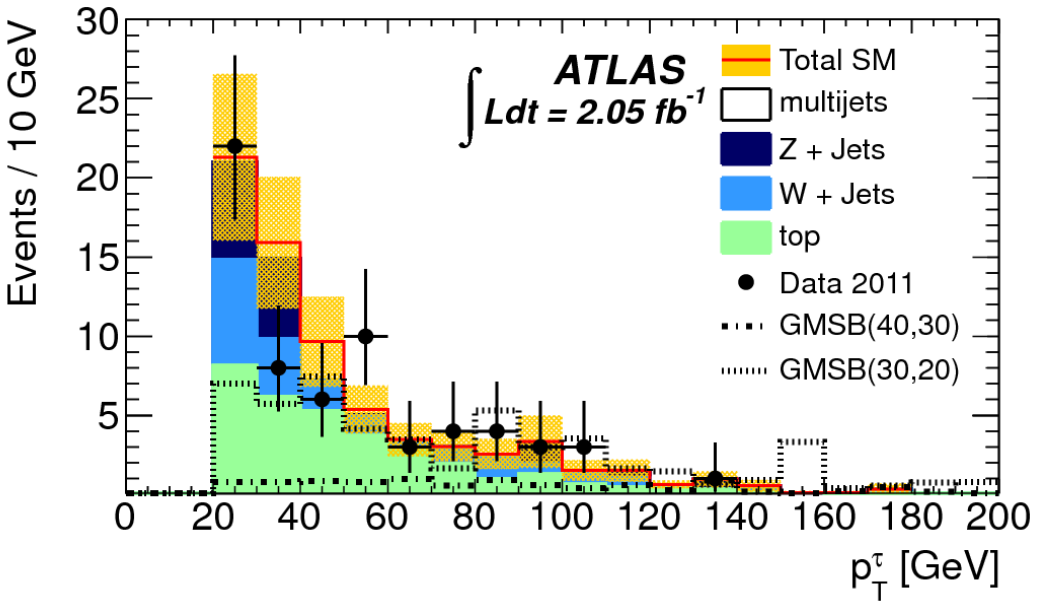


Control region: Fake taus (W/top)
m_T > 70 GeV
& (M_{eff} < 600 GeV Or m_T < 110 GeV)
normalize MC for fake taus from W, top here.

$\geq 1\ \tau$ + jets + Etmiss

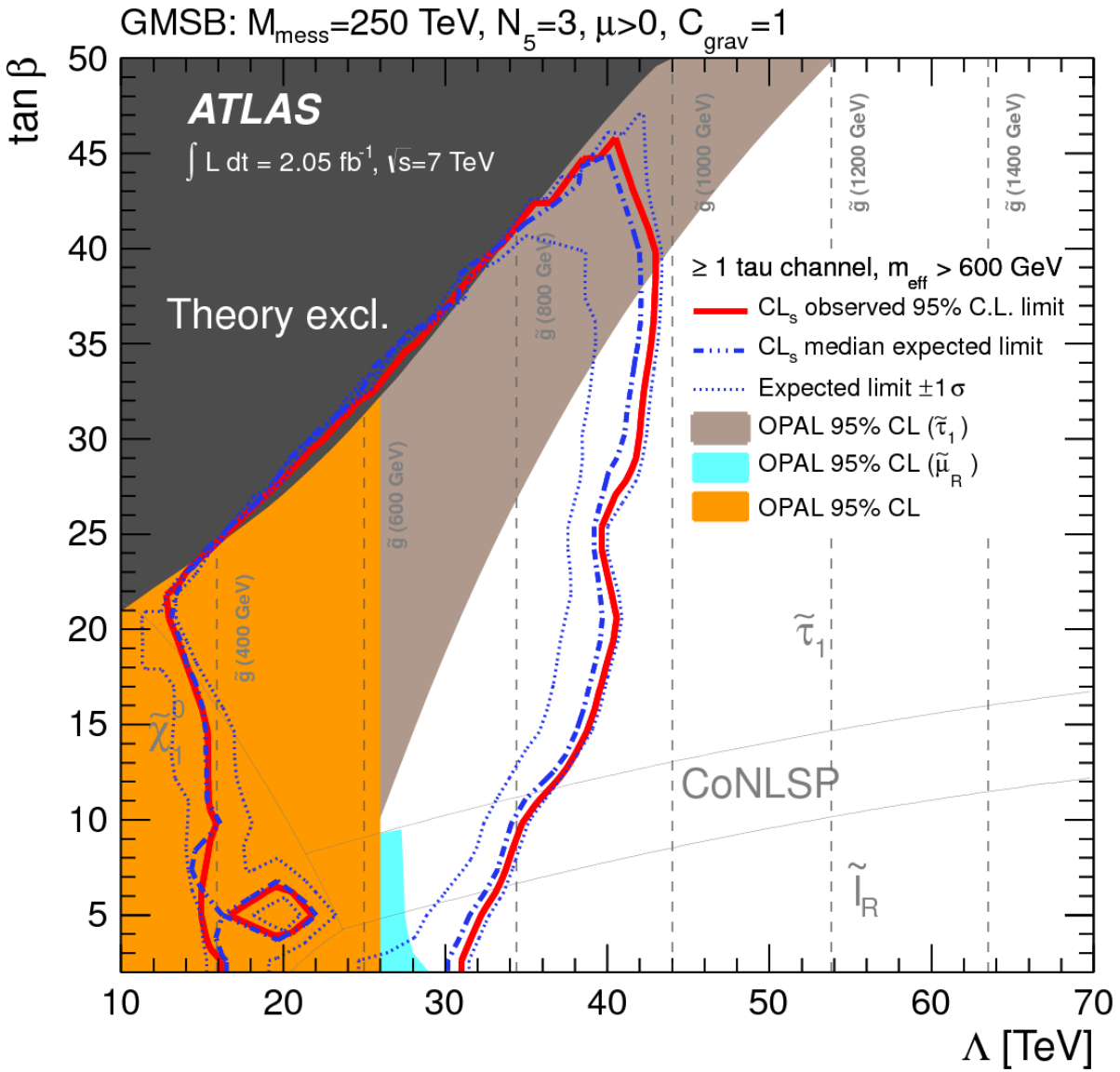
Top	W+jets	Z+jets	Mutijet	Σ_{SM}	Data
5.6 ± 1.4	4.7 ± 1.5	2.4 ± 0.7	0.5 ± 0.6	13.2 ± 4.2	11





Largest uncertainties from statistics in data control regions, extrapolation from control region to signal region using MC, jet energy scale and resolution.

≥ 1 τ + jets + Etmiss



$\geq 2\ \tau$ + jets + Etmiss

arXiv:1203.6580

$\geq 2\ \tau$ + jets + Etmiss (2.05 fb^{-1})

Event Selection

Trigger: 1 jet with pT > 75 GeV, Etmiss > 45 GeV

2 tau with p_T > 20 GeV (|η|<2.5), BDTloose

2 jets with p_T > 130 GeV, 30 GeV respectively

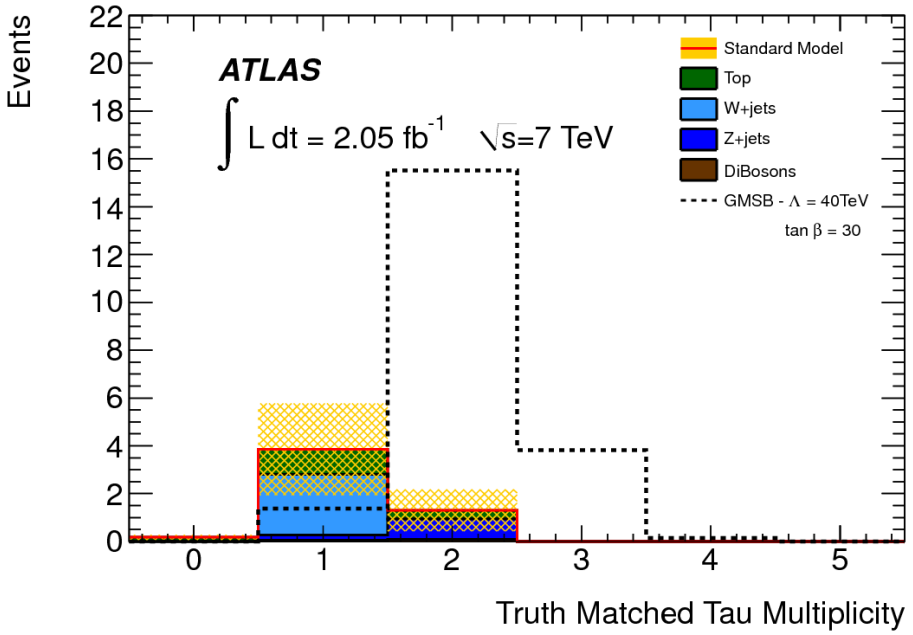
Etmiss > 130 GeV

Δφ(jet-Etmiss) > 0.4 for both jets

$m_T^1 + m_T^2 > 80$ GeV

M_{eff} > 700 GeV (Σ p_T[taus,jets,Etmiss])

No electrons/muons above 20/10 GeV

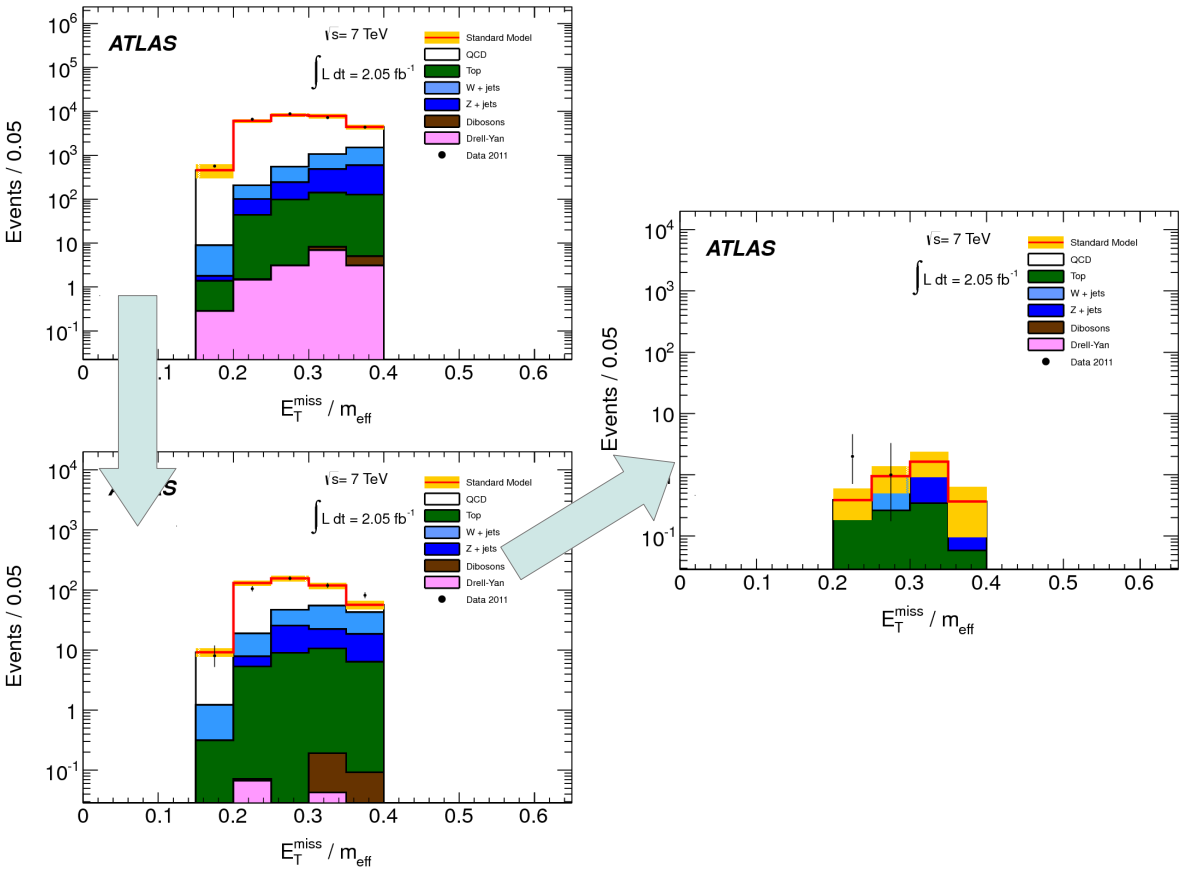


$\geq 2\ \tau$ + jets + Etmiss

Backgrounds Z+jet, top-pair, single-top

Background estimated from 2 control regions

1. Fake taus from W, top
2. Fake taus from multijet



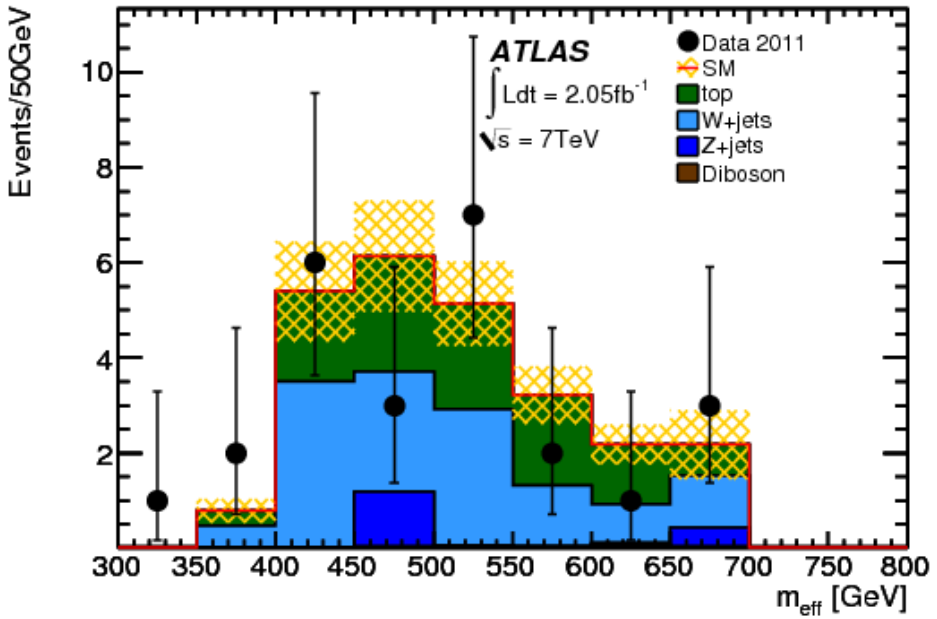
Control region: Multijets

Etmiss/M_{eff} < 0.4 or $\Delta\varphi$(jet-met)<0.4

Scale MC to data using events with 0 and 1 τ's.

This background is negligible.

$\geq 2\ \tau$ + jets + Etmiss



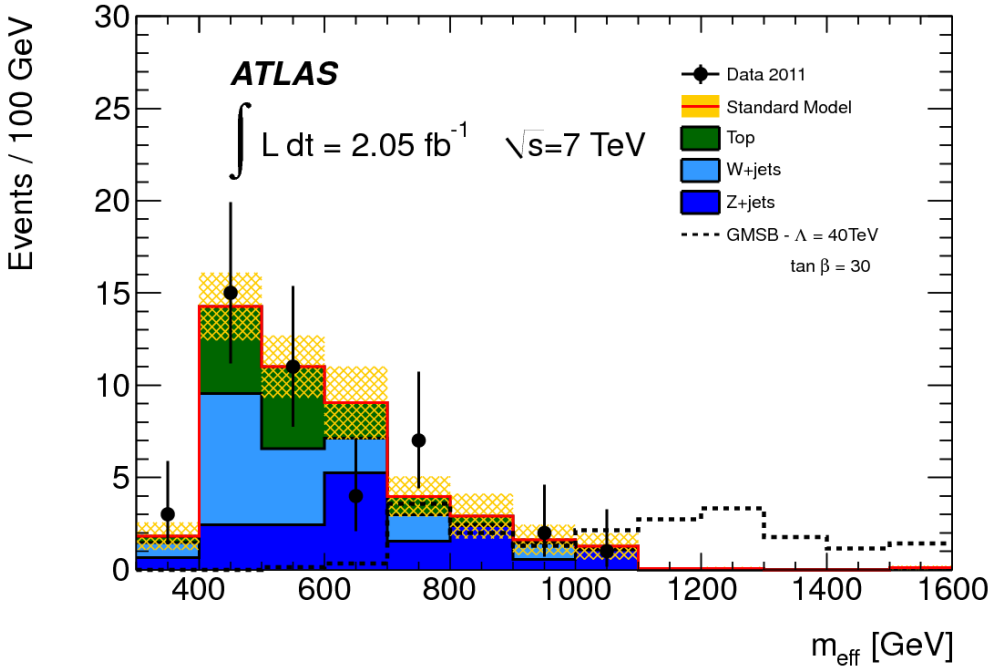
Control region: Fake taus (W/top)

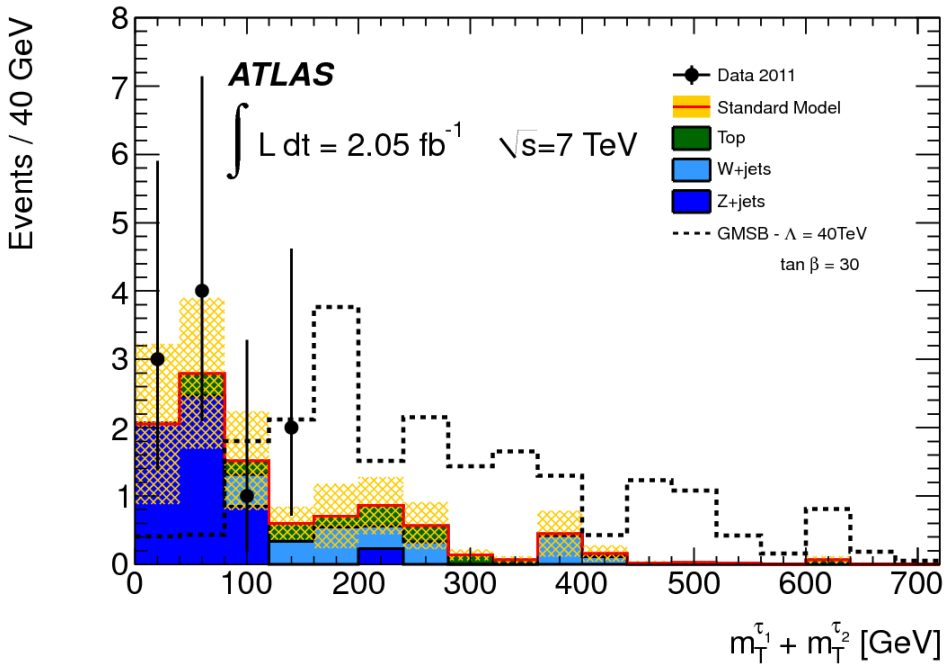
- $M_{eff} < 700$ GeV

- Total top/W MC is scaled in this region.
- Contributions are separated into top/W by splitting control region by number of b-jets.
- Z+jets estimated from MC

$\geq 2\ \tau$ + jets + Etmiss

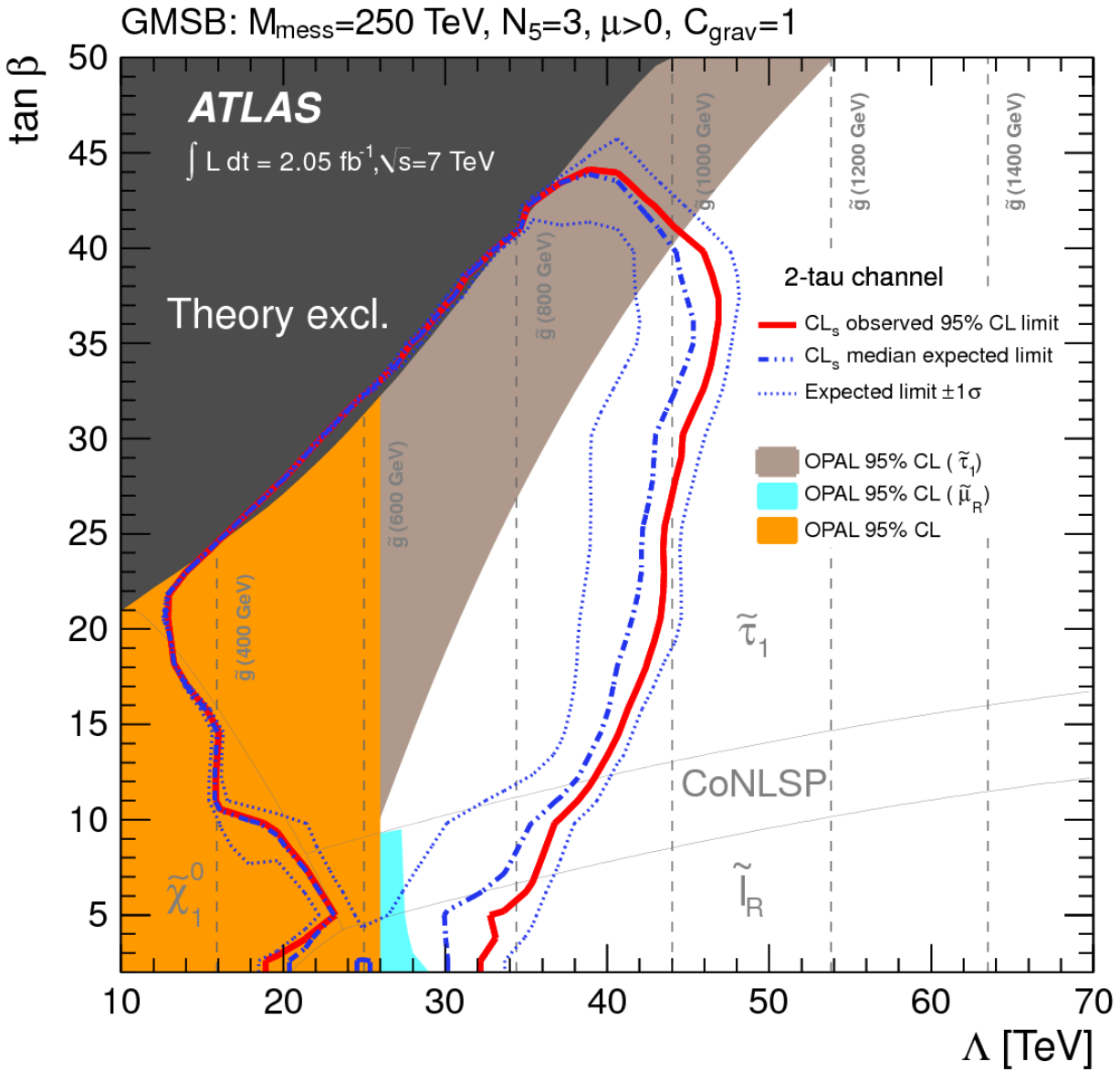
Top	W+jets	Z+jets	Diboson	Σ_{SM}	Data
1.6 ± 0.4	2.5 ± 1.0	1.1 ± 0.7	0.1 ± 0.05	5.3 ± 1.3	3





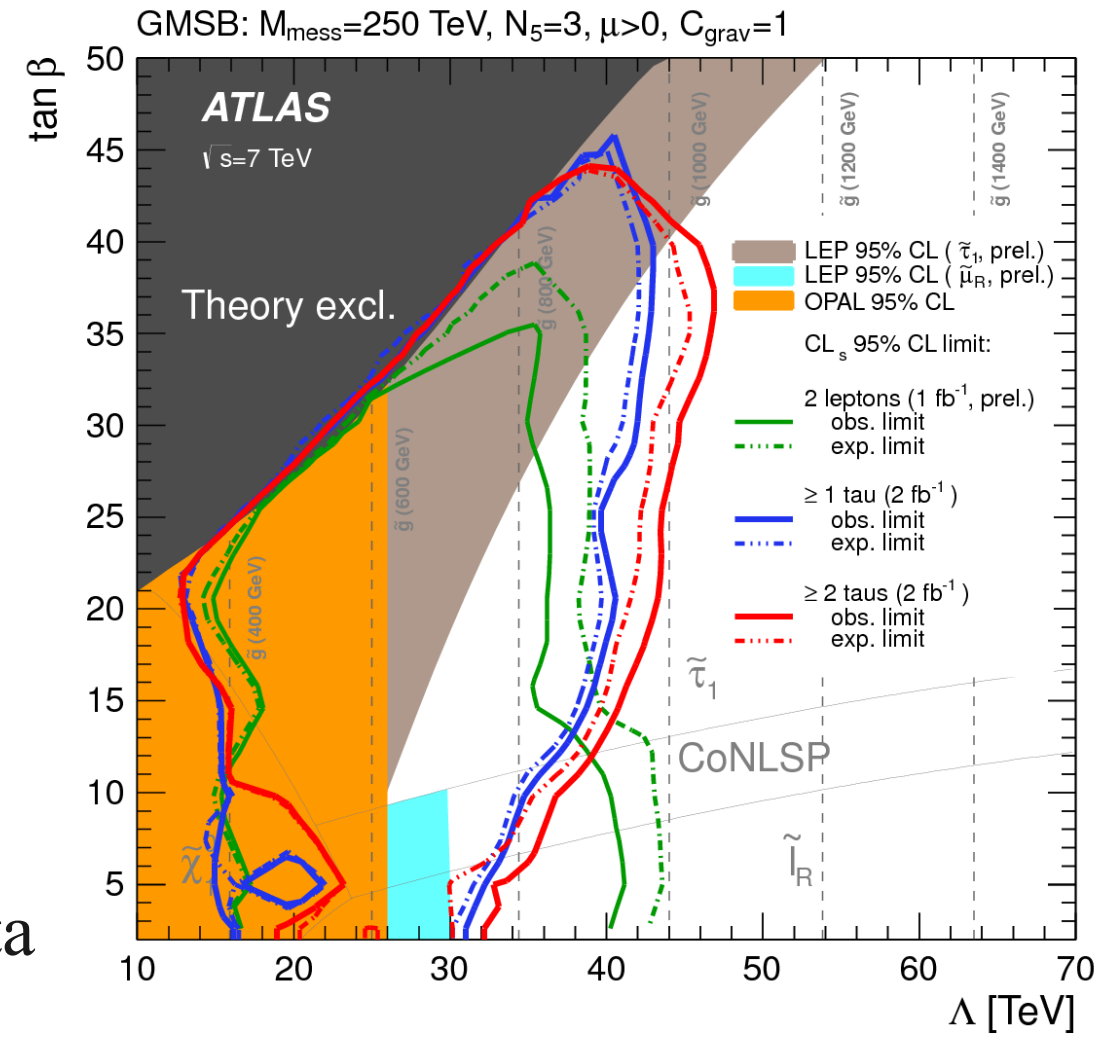
Largest uncertainties from statistics in data control regions, extrapolation from control region to signal region using MC, jet energy scale and resolution.

$\geq 2\,\tau$ + jets + Etmiss



Summary

- ATLAS SUSY with taus program is just warming up
- Current results will be updated to full 2011 dataset rapidly
- Additional searches in multilepton final states on the way
- And we have the 8 TeV data to look forward to!

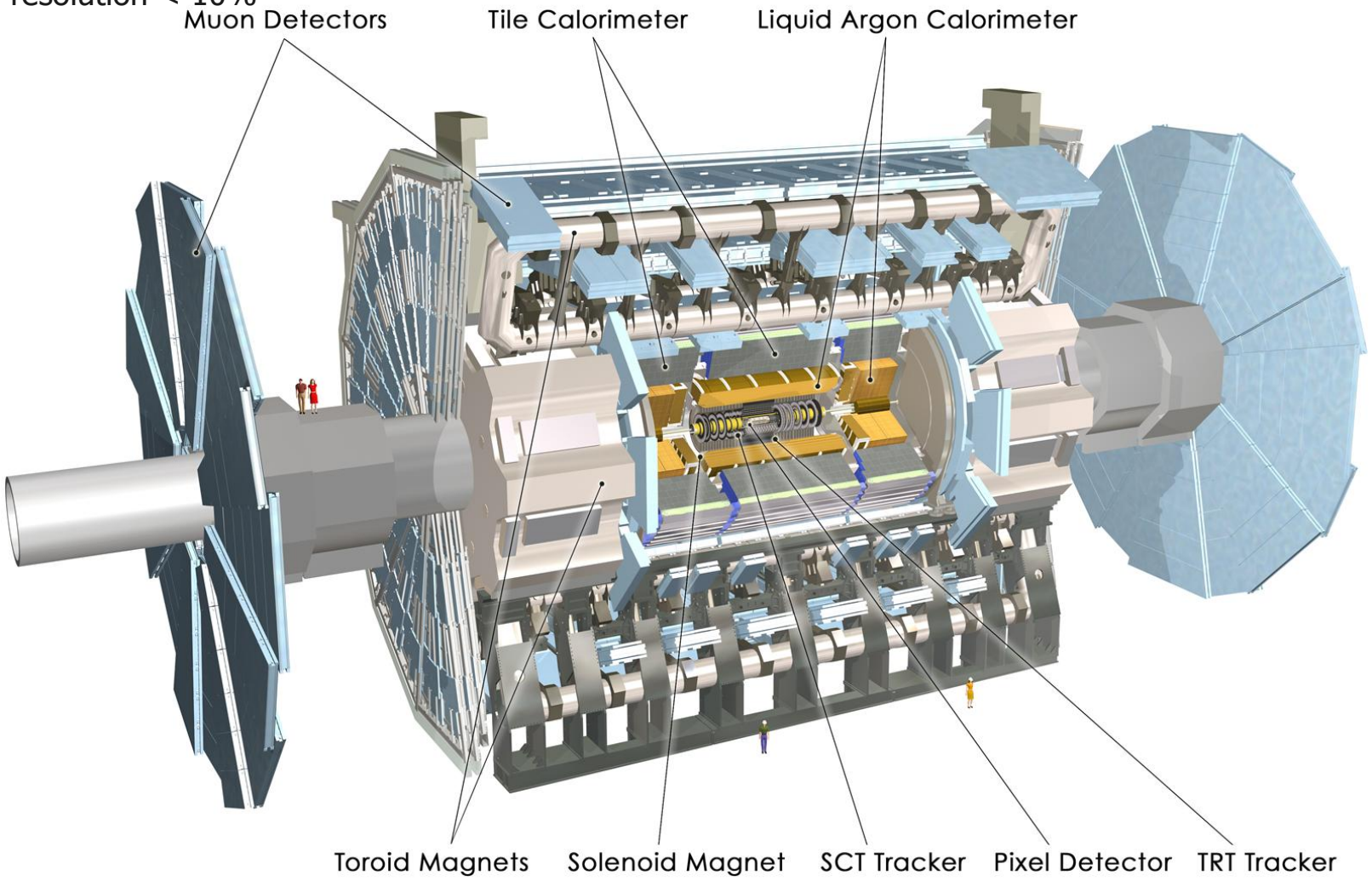


Supplementary slides

The ATLAS Detector

Muon Coverage: |η|<2.7
pT resolution < 10%

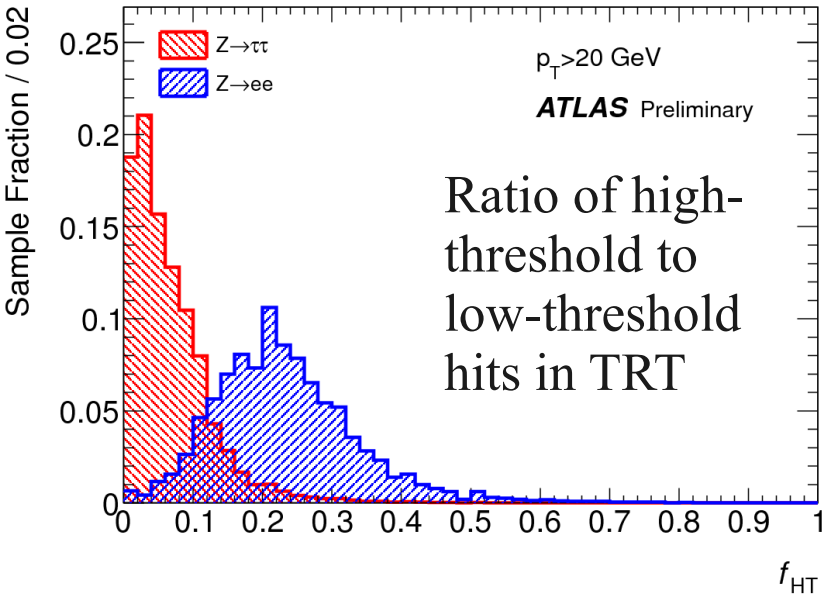
EM: |η|<3.2, σ/E~10%/√E
Had: |η|<5, central σ/E~50%/√E⊕0.03, forward σ/E~90%/√E⊕ 0.07

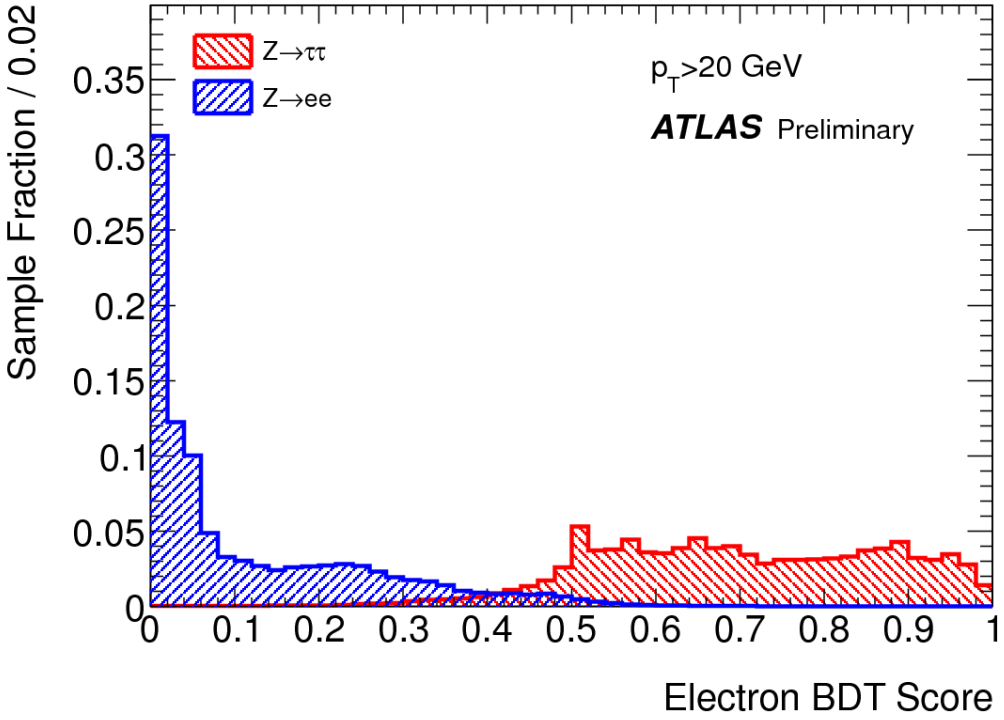


Tracker Coverage: |η|<2.5
$\sigma/pT \sim 3.8 \times 10^{-4}\ pT(GeV) \oplus 0.015$

Rejecting electrons

BDT trained to reject electrons





Other variables such as ratio of hadronic energy to track momentum, EM energy to track momentum, transverse energy in pre-sampler layer, ET weighted shower width in hadronic calorimeter....

$\geq 1\ \tau$ + jets + Etmiss

Systematic [%]	GMSB 30 20	GMSB 40 30	top	W	Z	Multijet
Jet energy scale	5.2	2.1	5.5	3.9	3.7	–
Jet energy resolution	10.0	4.5	6.2	9.3	6.1	–
τ energy scale	1.6	3.4	3.8	6.0	9.8	–
τ efficiency	11.6	11.9	0	0	0	–
Cluster energy scale	0.9	0.2	1.0	1.9	2.6	–
W/top fit statistical	–	–	9.0	4.8	–	–
W/top fit systematic	–	–	10.9	3.5	–	–
Fake τ CR statistical	0.5	0.2	9.7	8.0	15.4	–
Fake τ extrapolation to SR	–	–	1.9	1.9	1.9	–
Multijet CR	–	–	–	–	–	120
Theory	8.6	10.2	6.3	4.7	–	–
Monte Carlo statistics	7.0	7.1	9.2	26.7	21.2	–
Total	20	19	23	32	30	120

$\geq 2\,\tau$ + jets + Etmiss

Systematic Variation	Number of events	Relative deviation
Nominal	5.31	
Theory	6.06	14.2%
Scaling	6.53	23.1%
JER	4.34	-18.1%
JES	6.24	17.6%
Pileup	5.35	0.9%
TauID	5.44	2.5%
TauFake	5.28	-0.5%
TES	5.65	6.6%
Luminosity	5.35	0.8%
Total		40.7%