Search for Monotop Production in Leptonic Decays of Top Quarks at $\sqrt{s}$=8 TeV Using the ATLAS Detector

Andrew Chegwidden

Michigan State University

DPF 2015

Outline

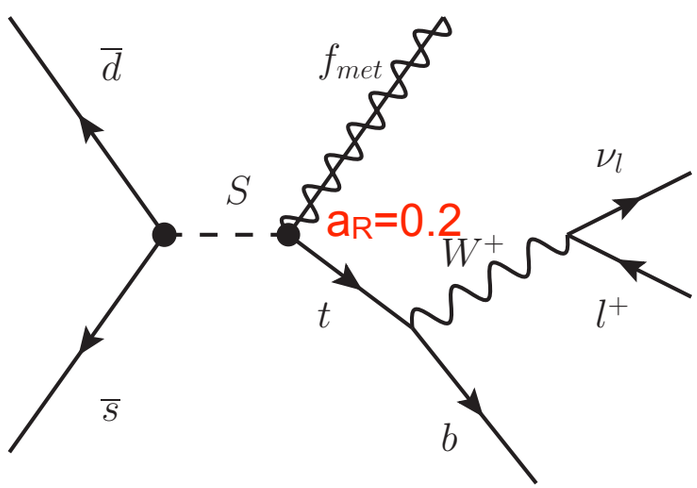
- Cut Based Analysis
  - Signal Models
  - Analysis Strategy
  - Kinematics
  - Expected / Observed Limits
- BDT Analysis
  - Input Variables
  - BDT Parameters
  - Expected Limits
- Future Plans

Cut Based Analysis

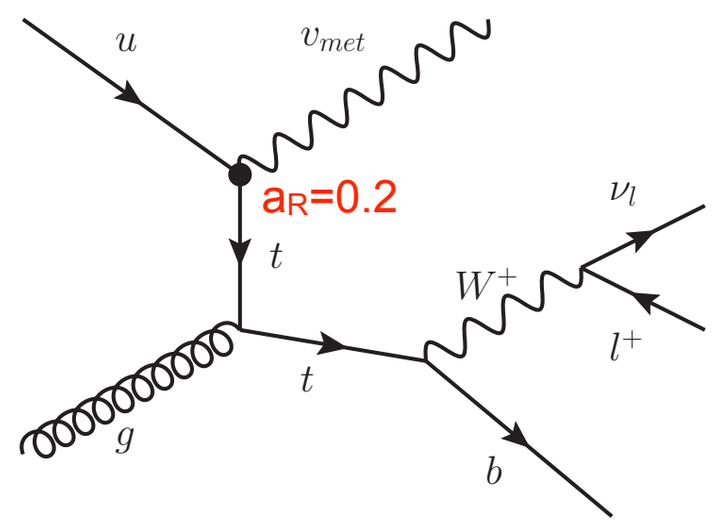
Signal Models

- Search for BSM production of top quark + Missing Transverse Energy (MET)
- Effective model:
  - J. Andrea, B. Fuks, F. Maltoni (Phys. Rev. D85 (2011) 074025
  - G. Cacciapaglia, A. Deandrea, B. Fuks (arXiv:1407.7529)
- Two benchmark models:
  - S1: scalar resonance decaying into one top quark and a neutral fermion (baryon number violating)
  - S4: associated production of a top quark with a neutral spin-1 particle (FCNC)
- Right-handed couplings only; required to respect electroweak gauge structure
- f_{met} (S1) and v_{met} (S4) can be considered dark matter candidates

$S1_R$



resonant production



non-resonant production

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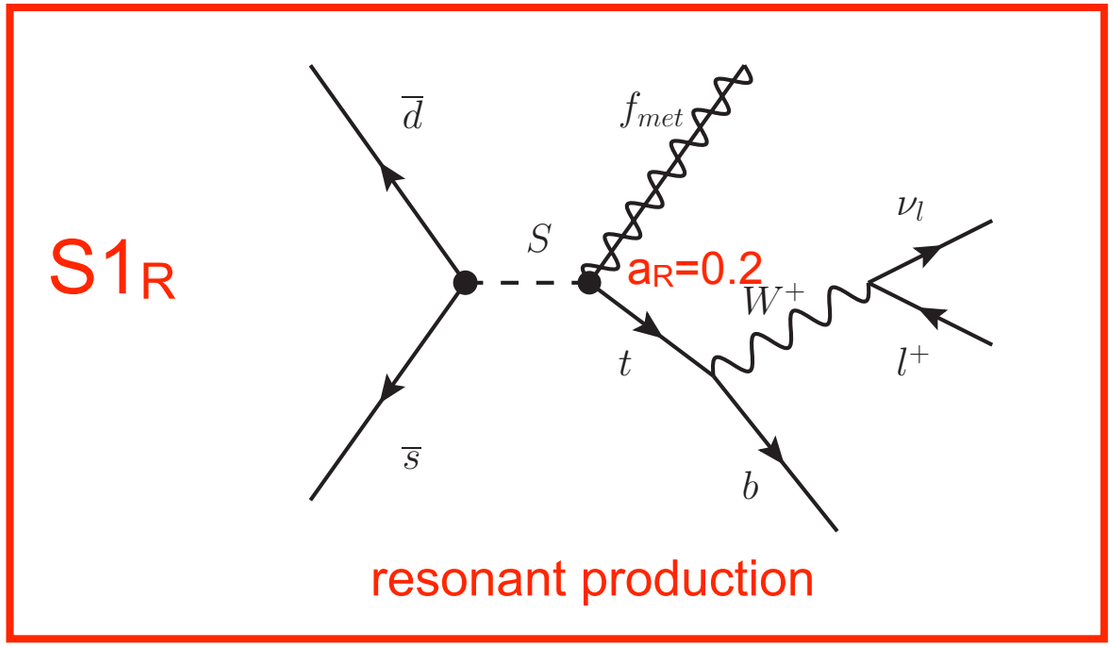

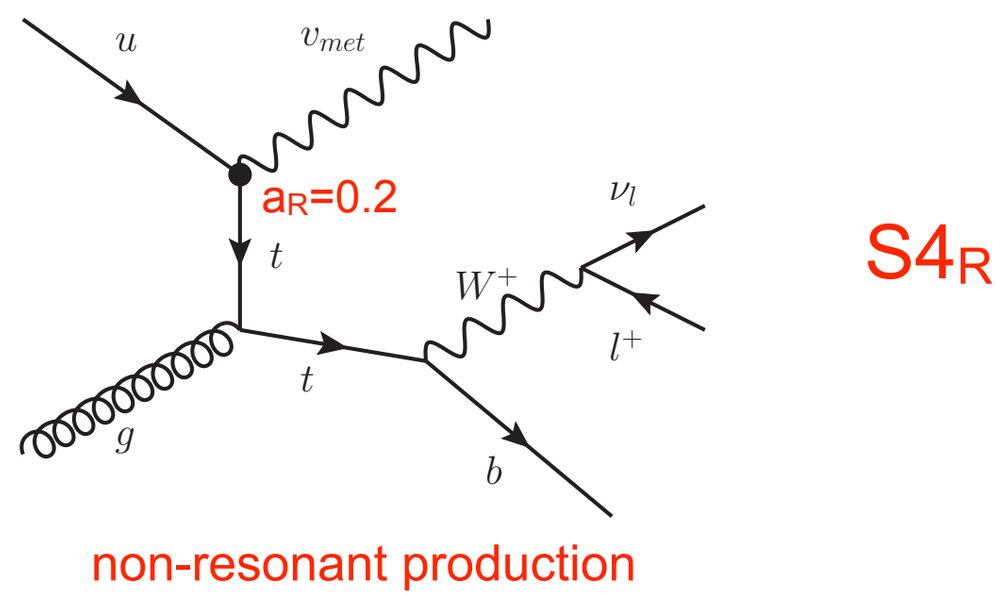

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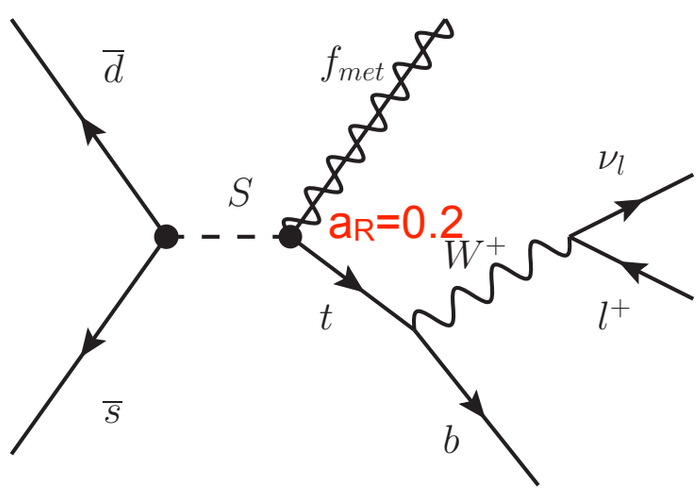

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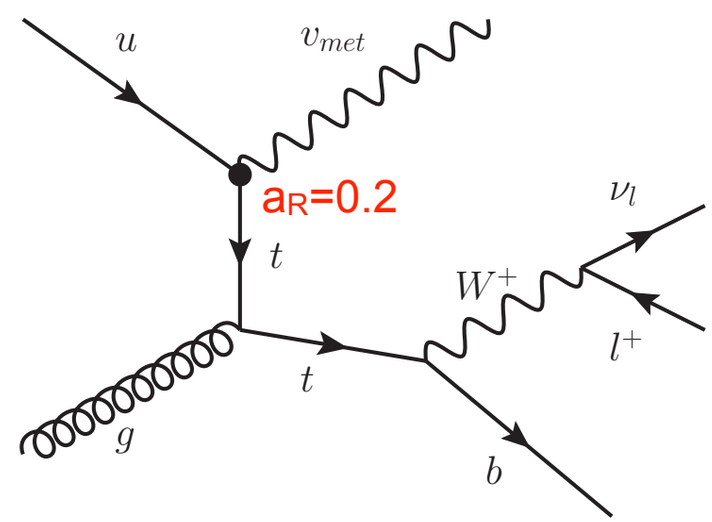

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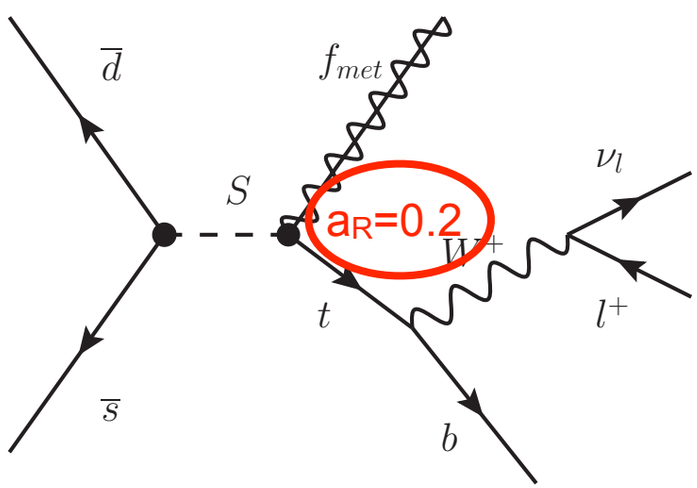

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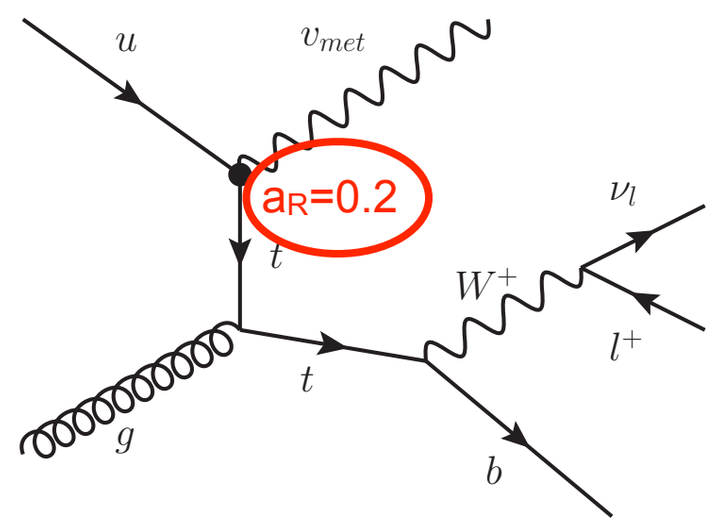

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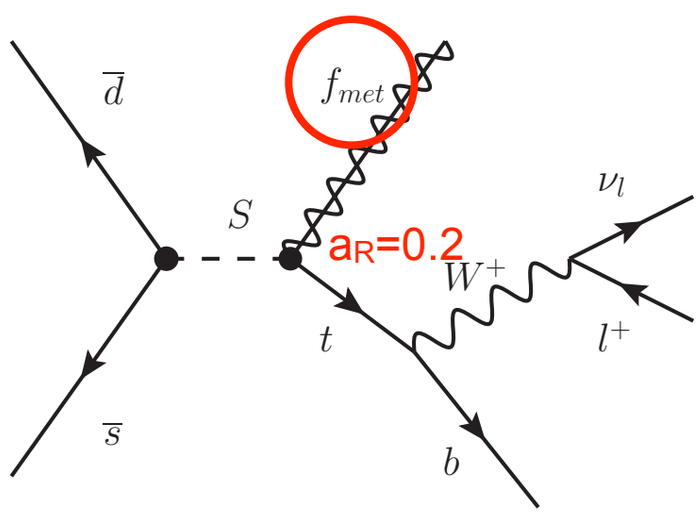

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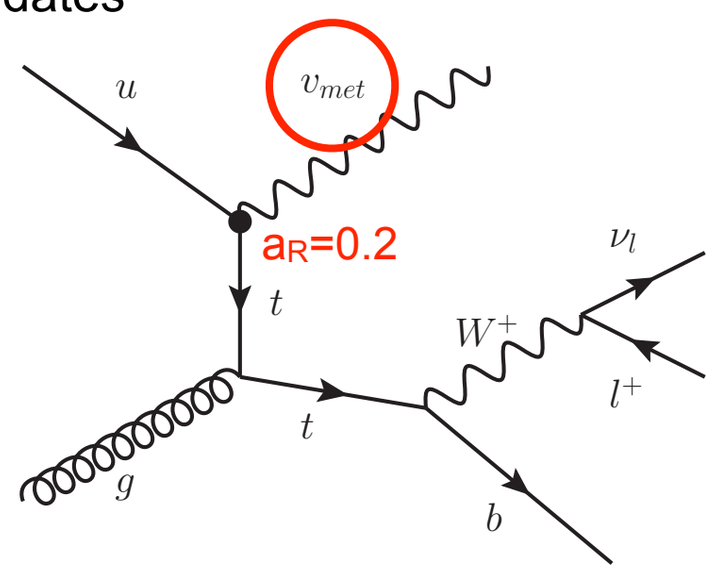

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Analysis Strategy

- Leptonic top decay topology:
  - 1 lepton, 1 b-jet, and Missing Transverse Energy (MET)
- Multijet rejection:
  - $p_T(l) > 30$ GeV, MET > 35GeV, MET+M_T(l,MET) > 60 GeV
- Control / Signal regions:
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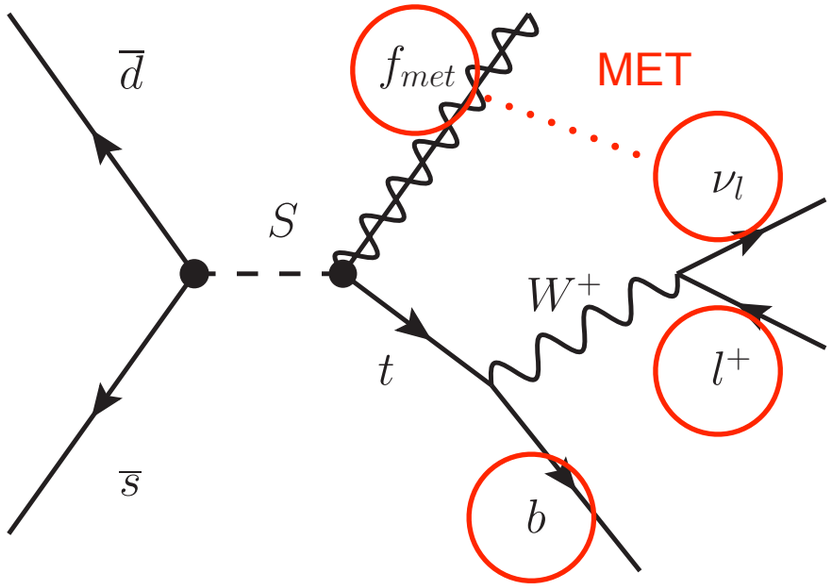

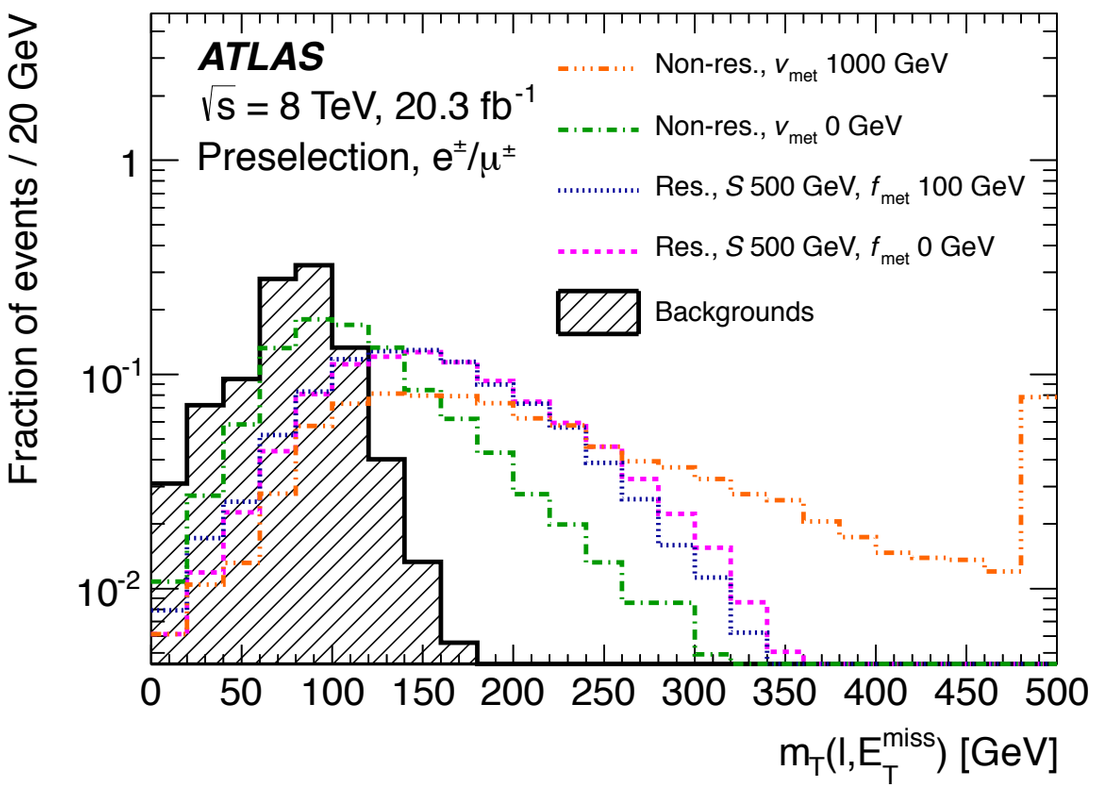

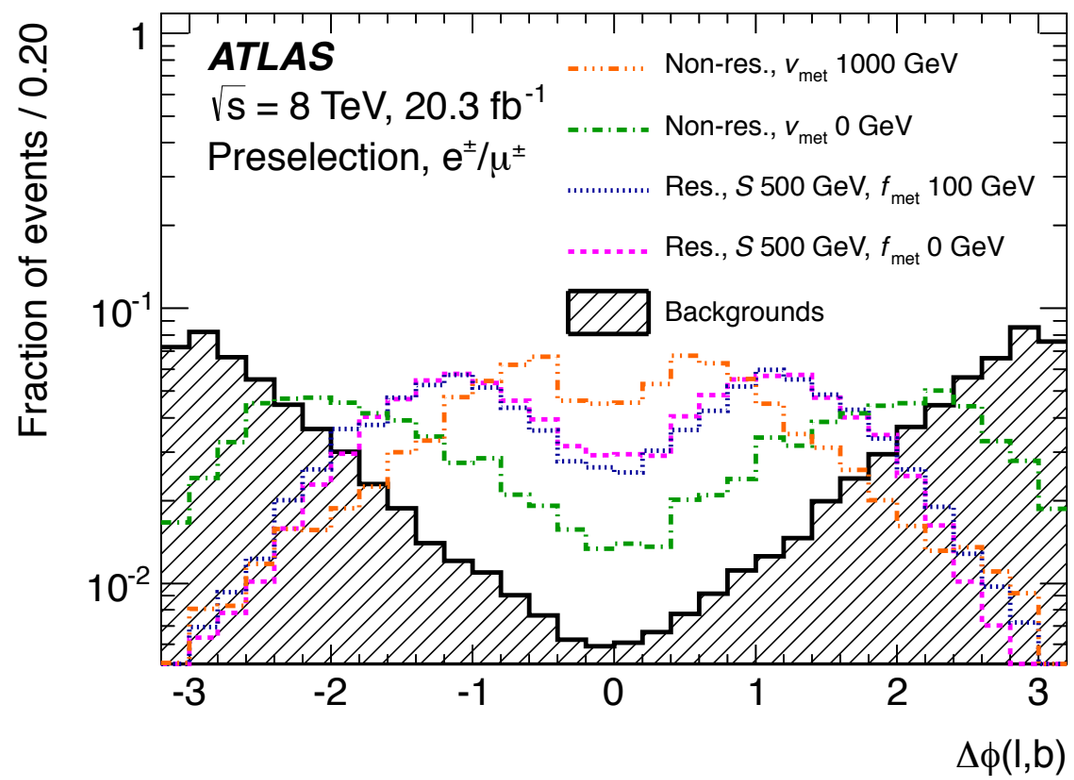

Eur. Phys. Jour. C 75 (2015) 79 (DOI: 10.1140/epjc/s10052-014-3233-4)

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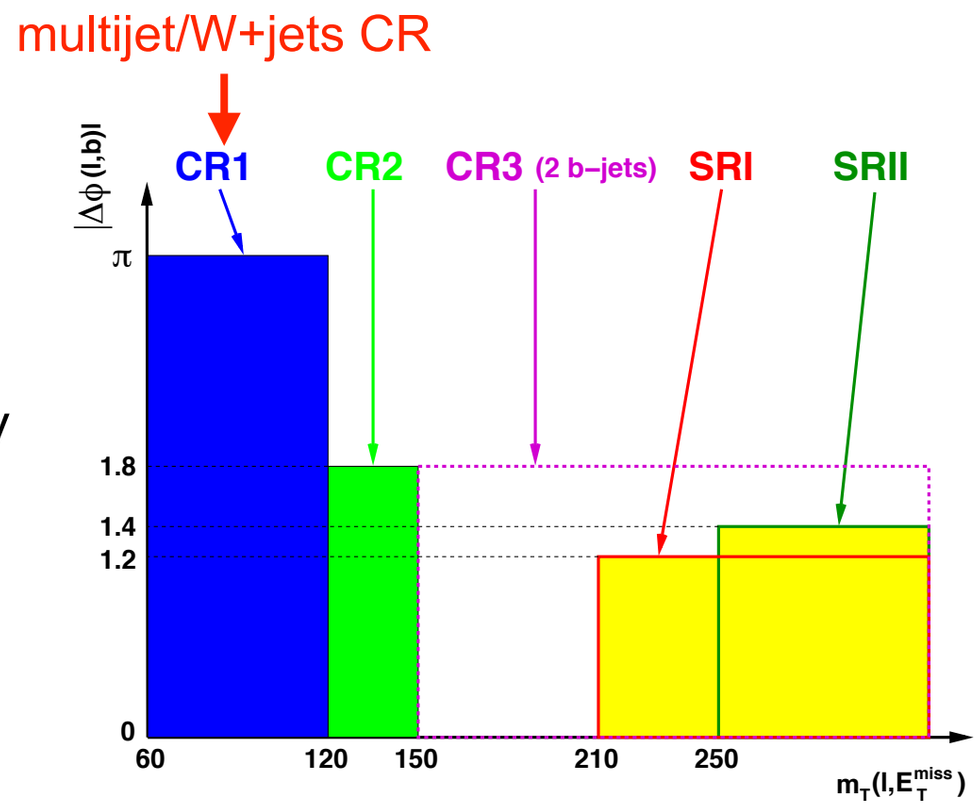

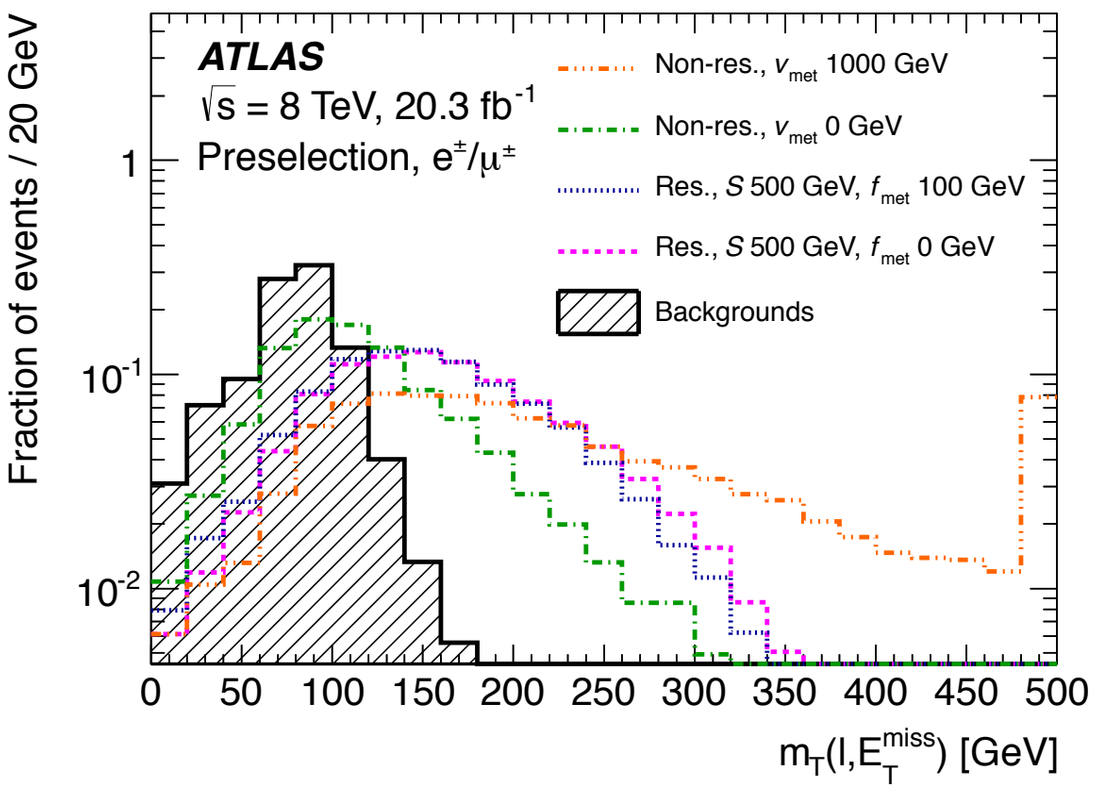

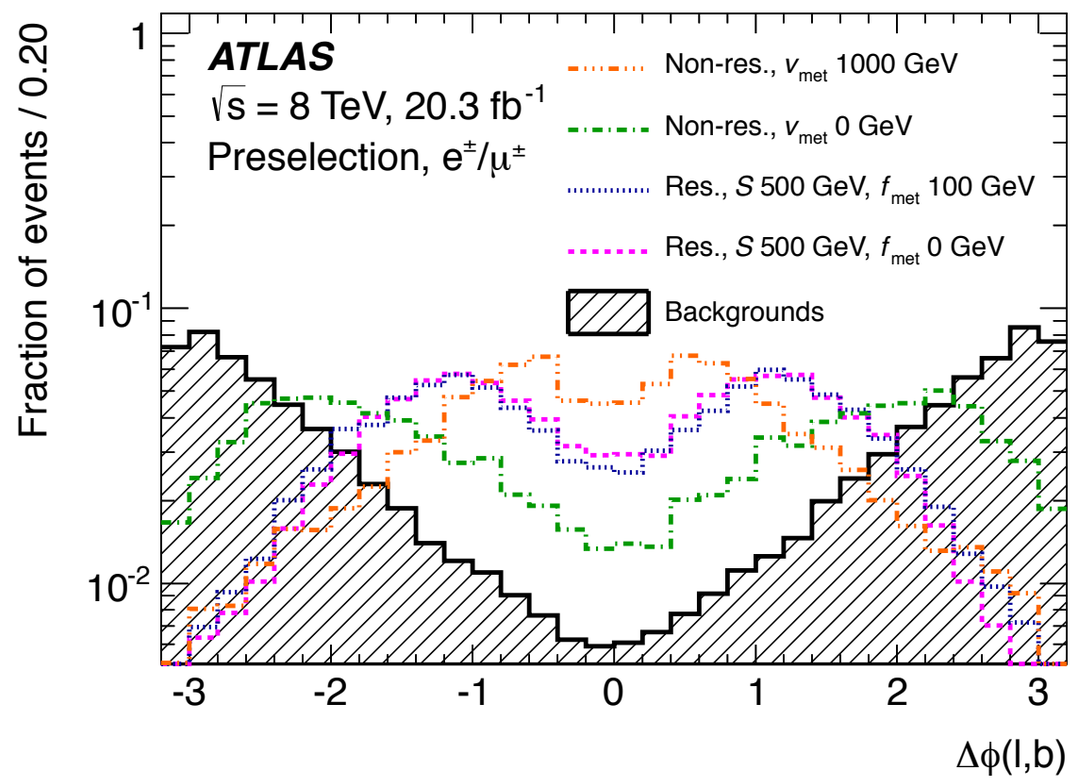

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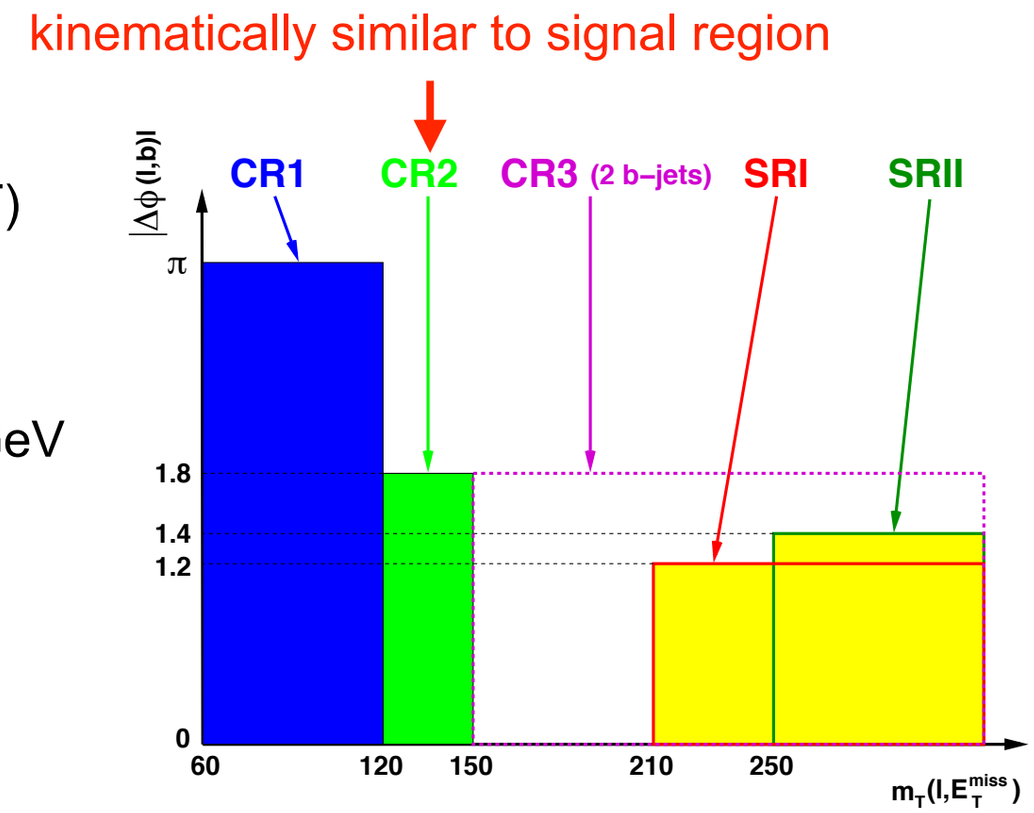

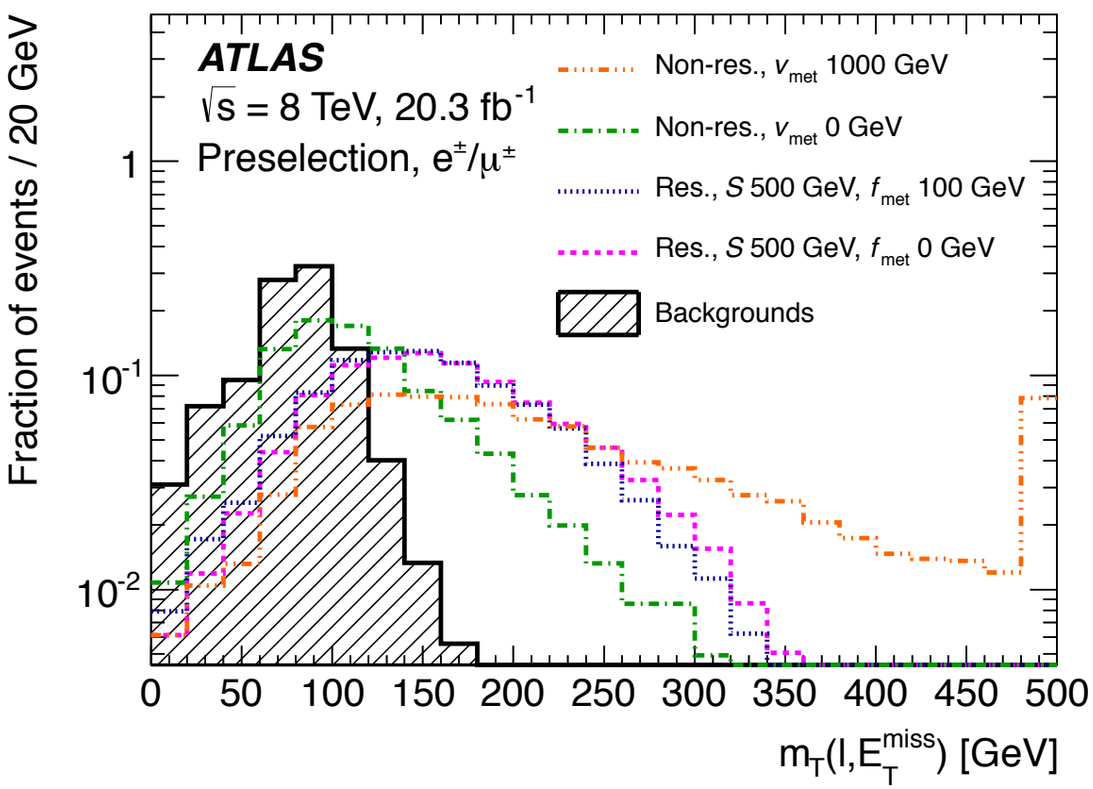

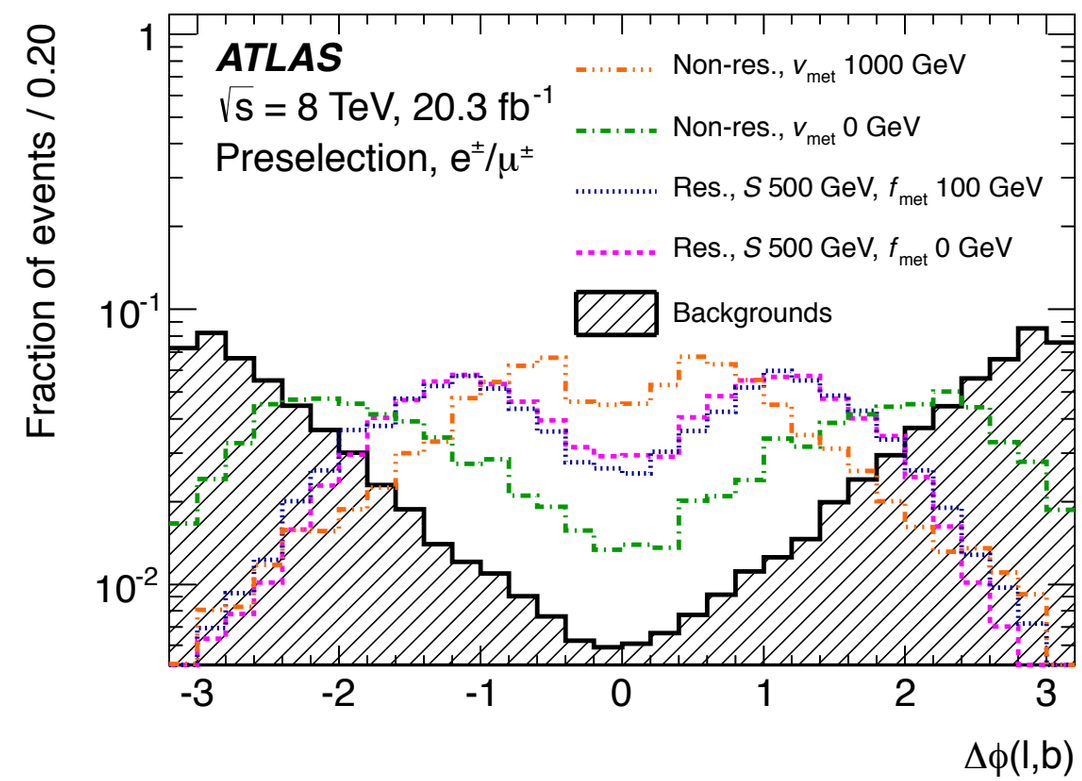

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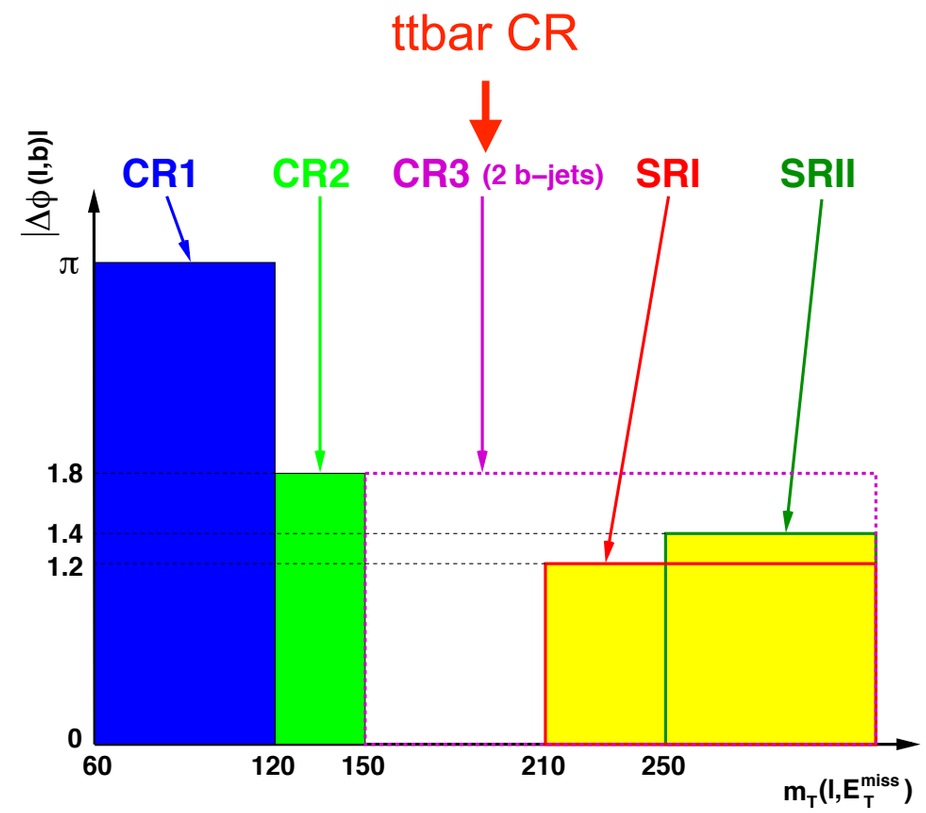

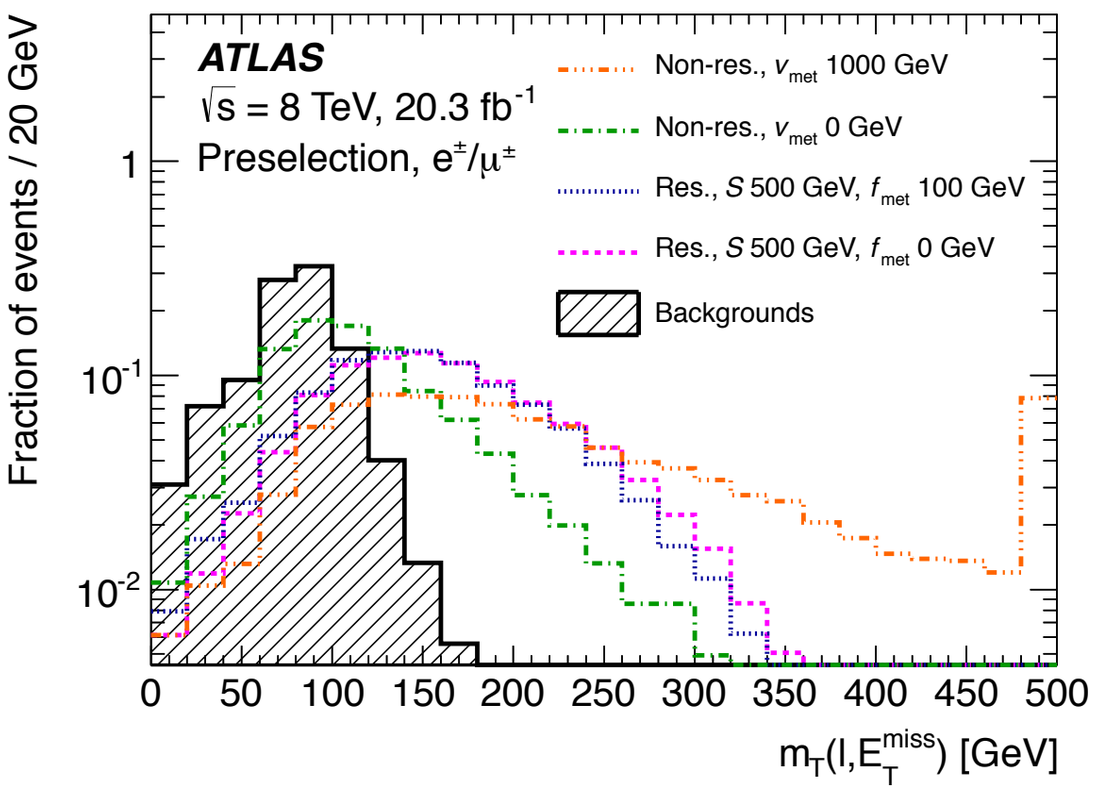

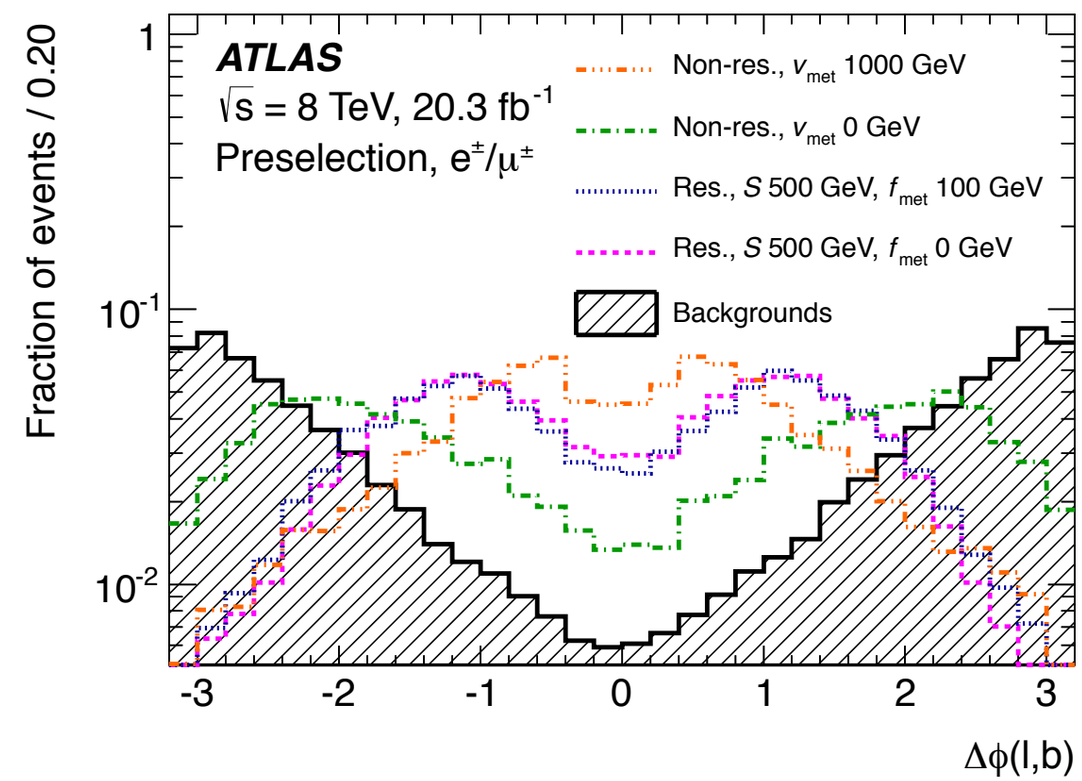

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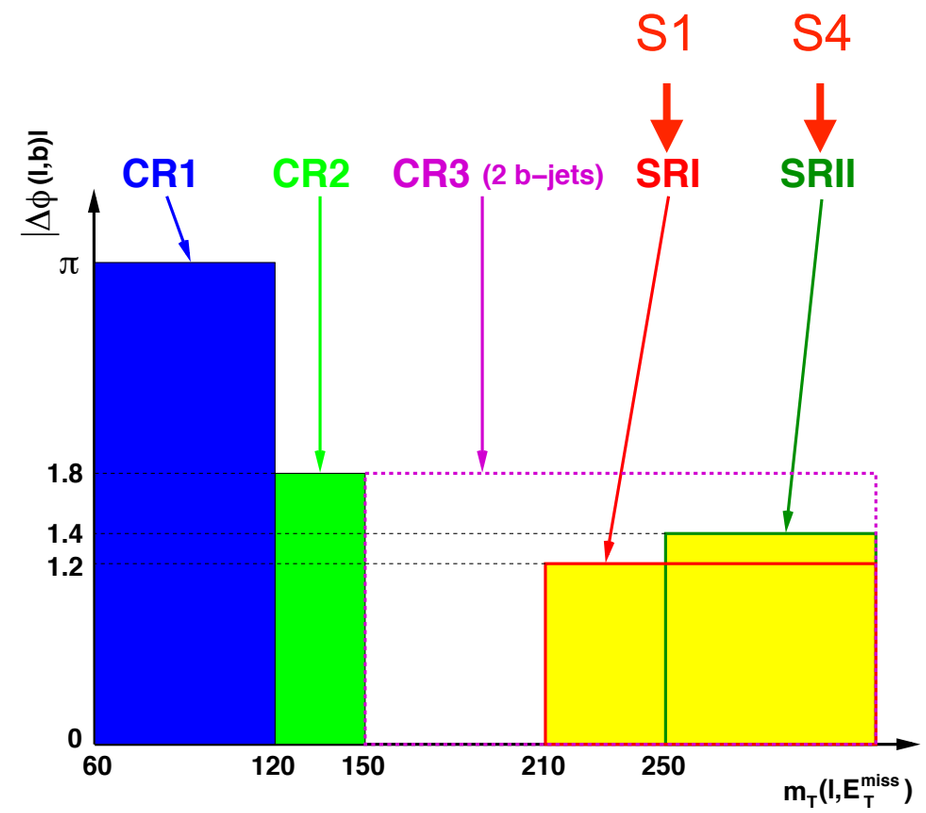

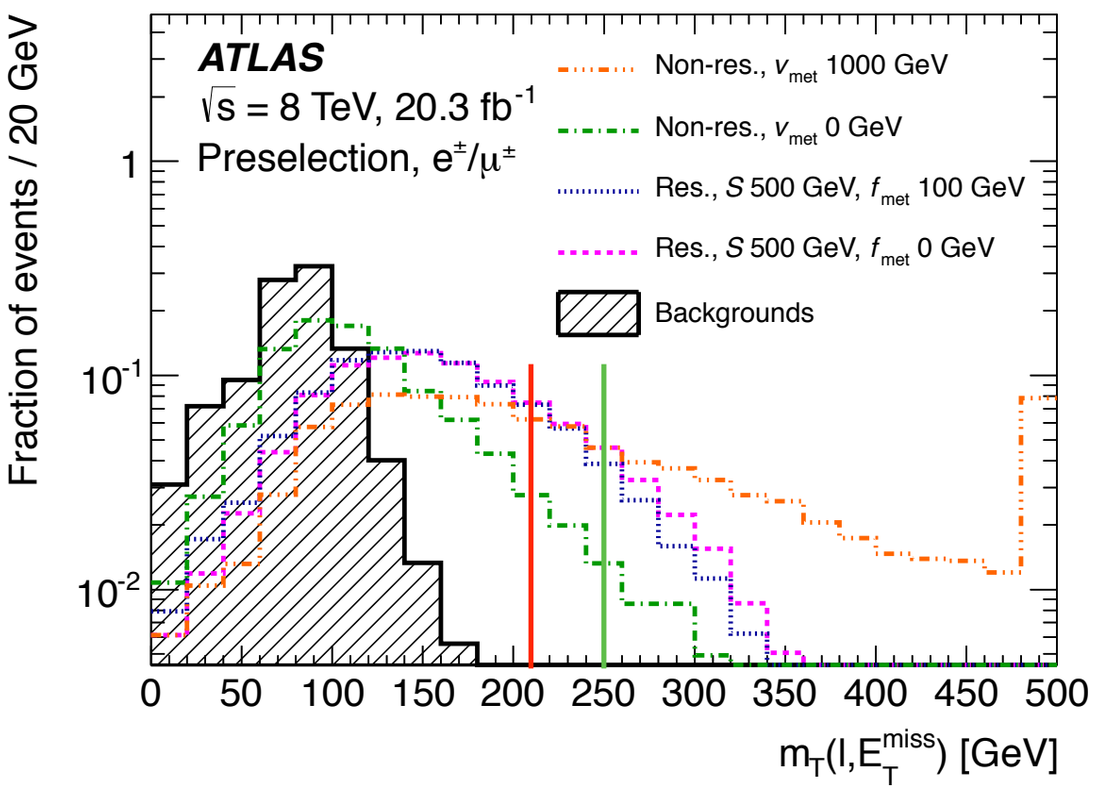

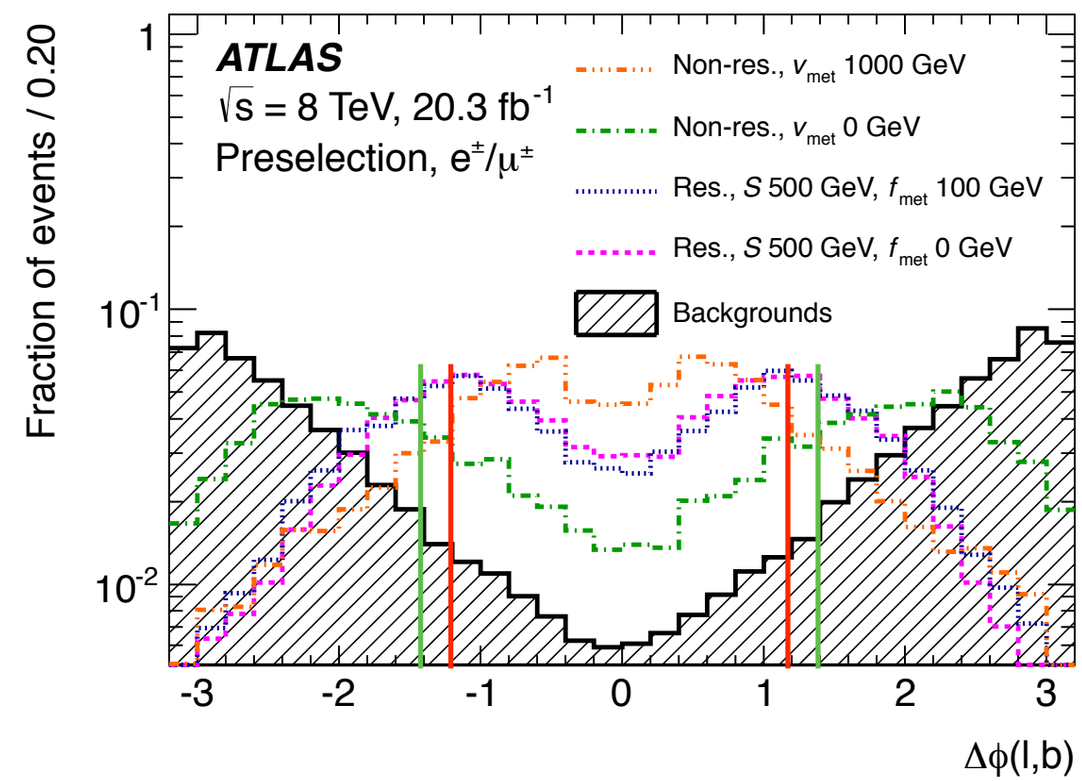

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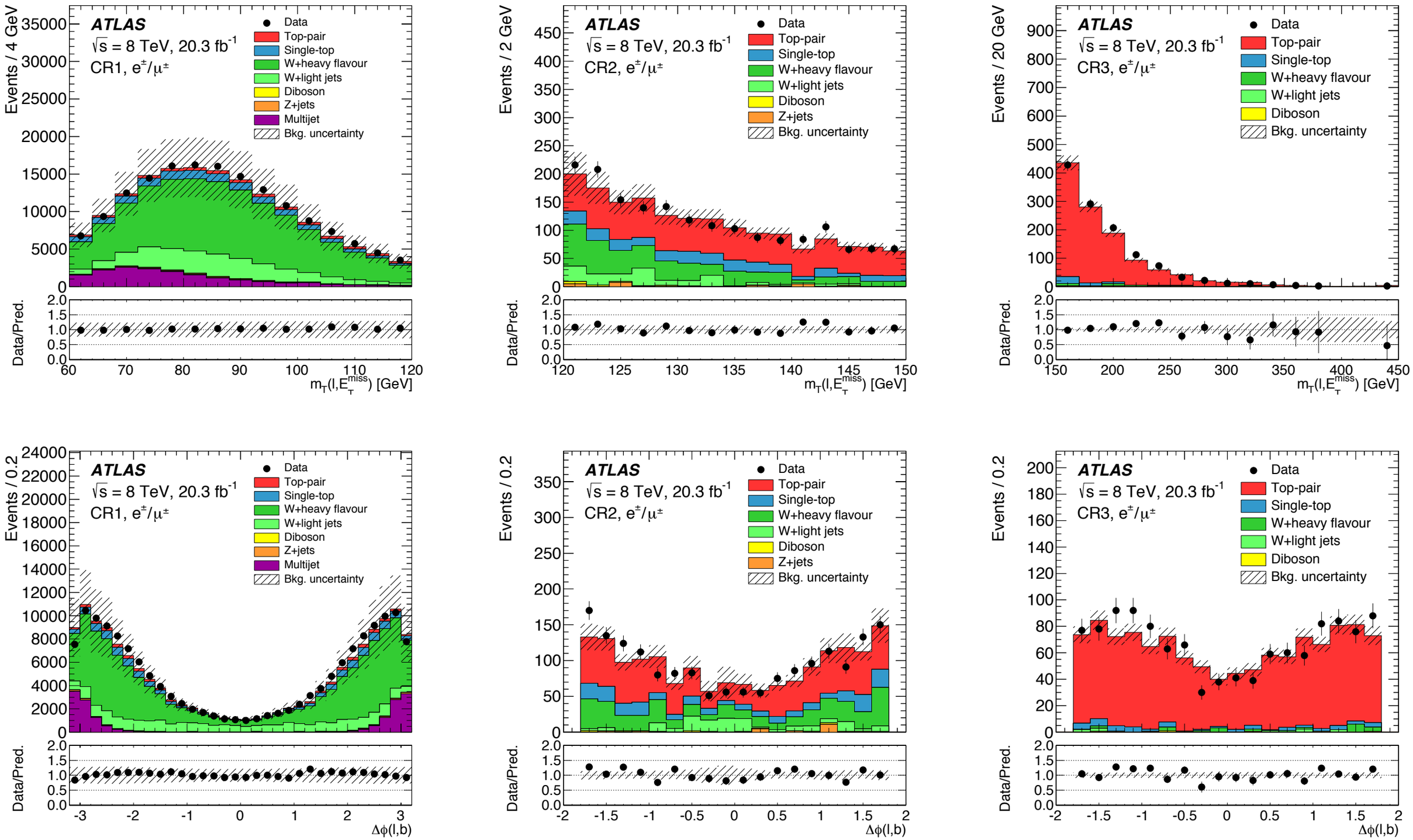
Control Region Plots



good agreement in control regions

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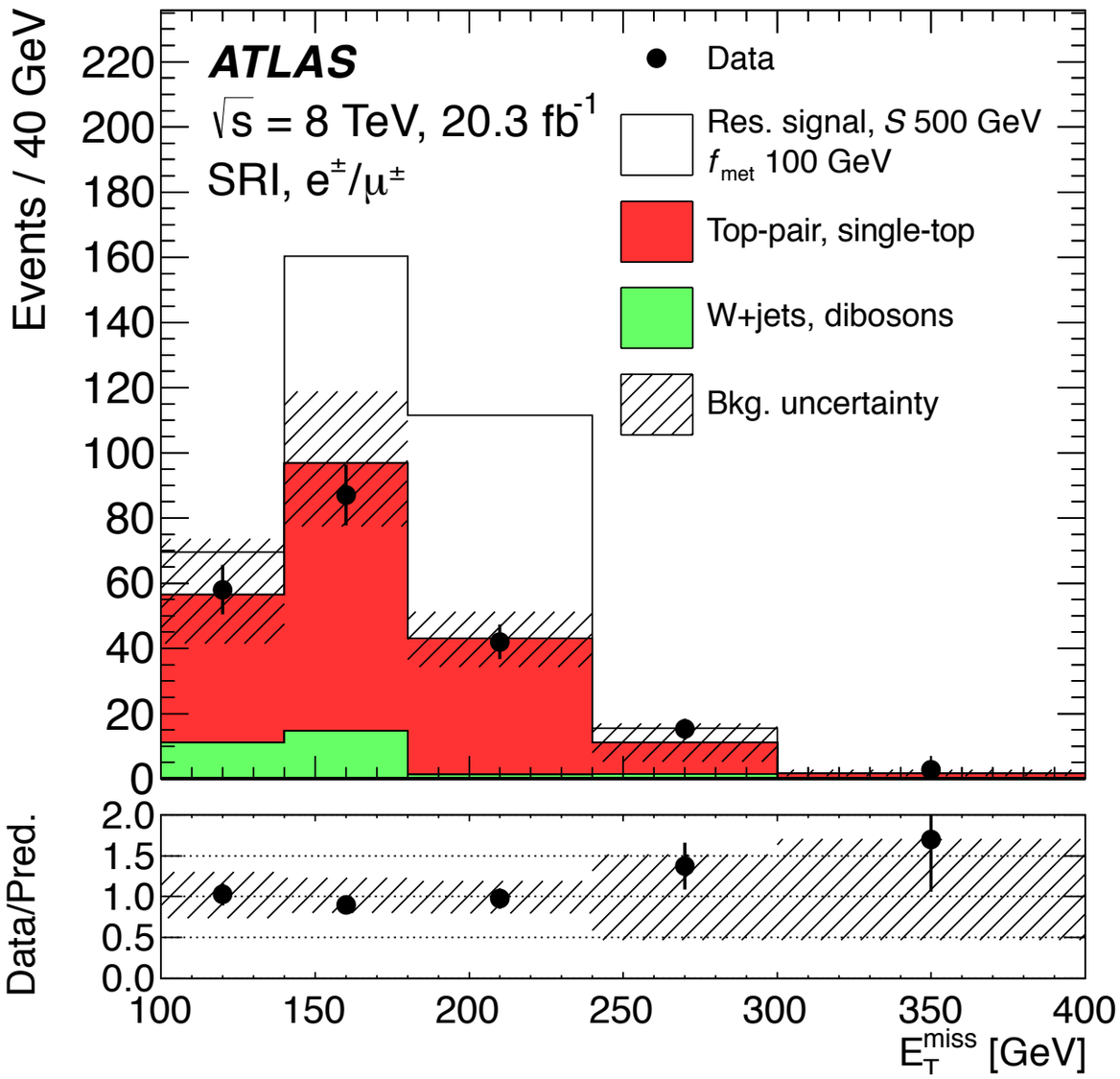
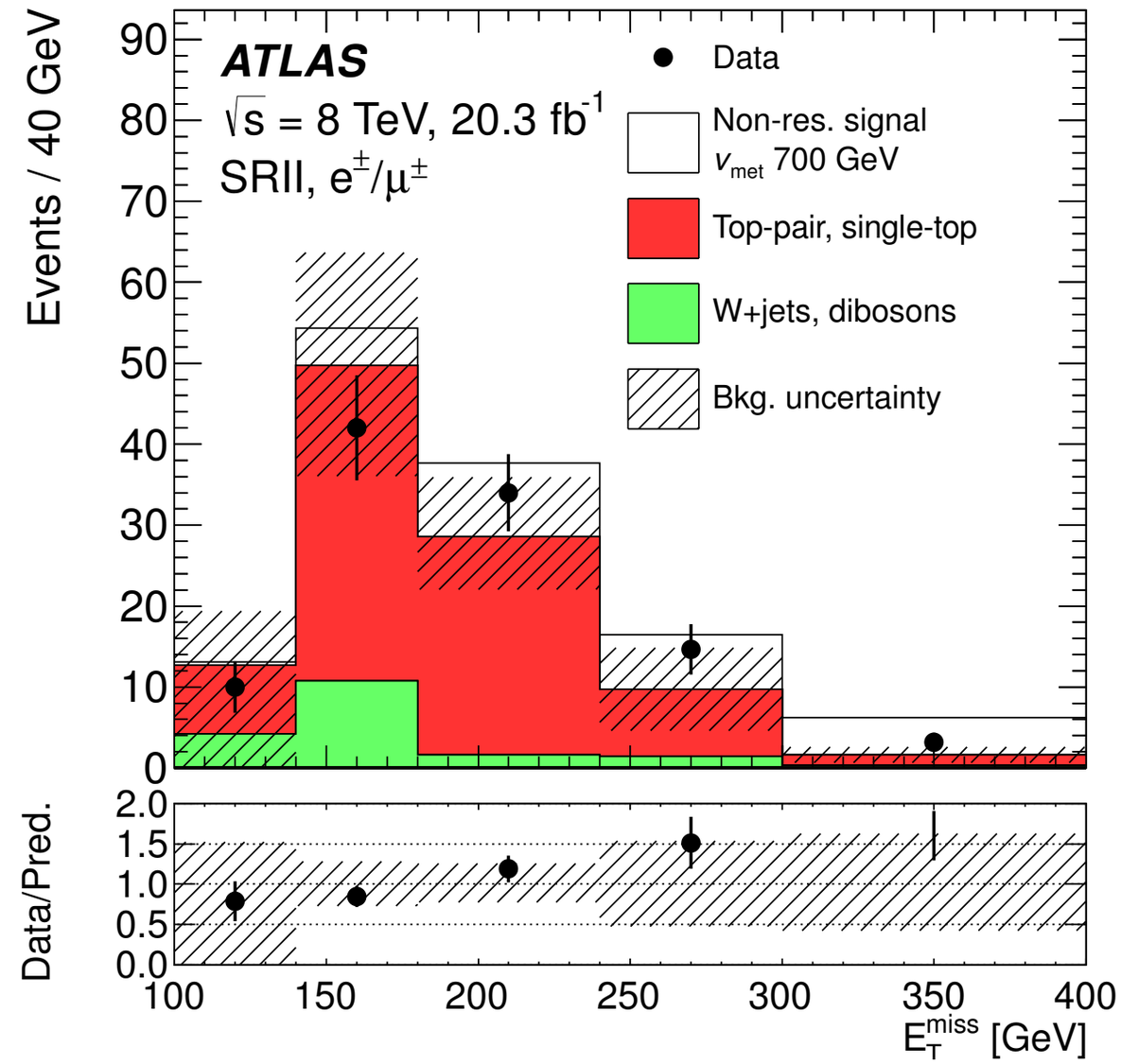
Signal Region Plots





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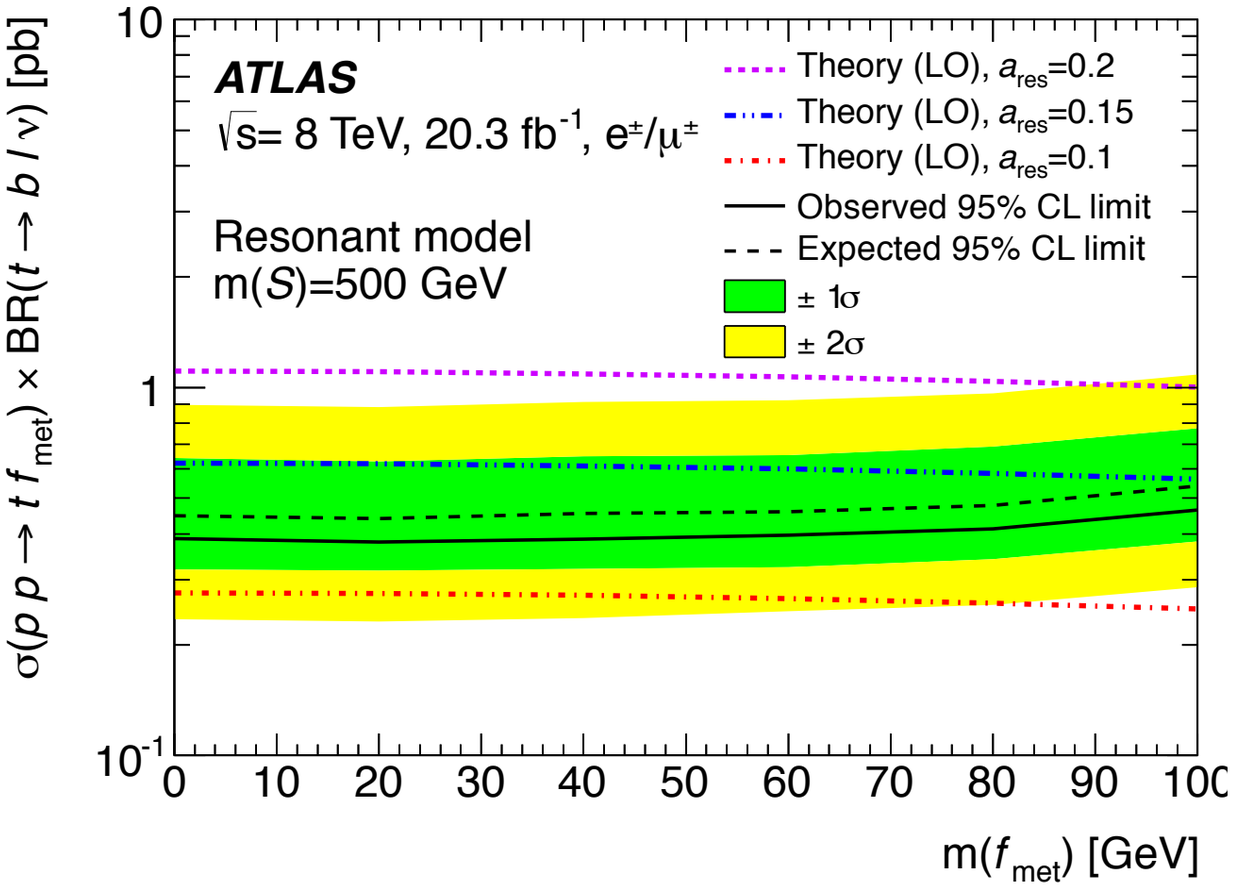
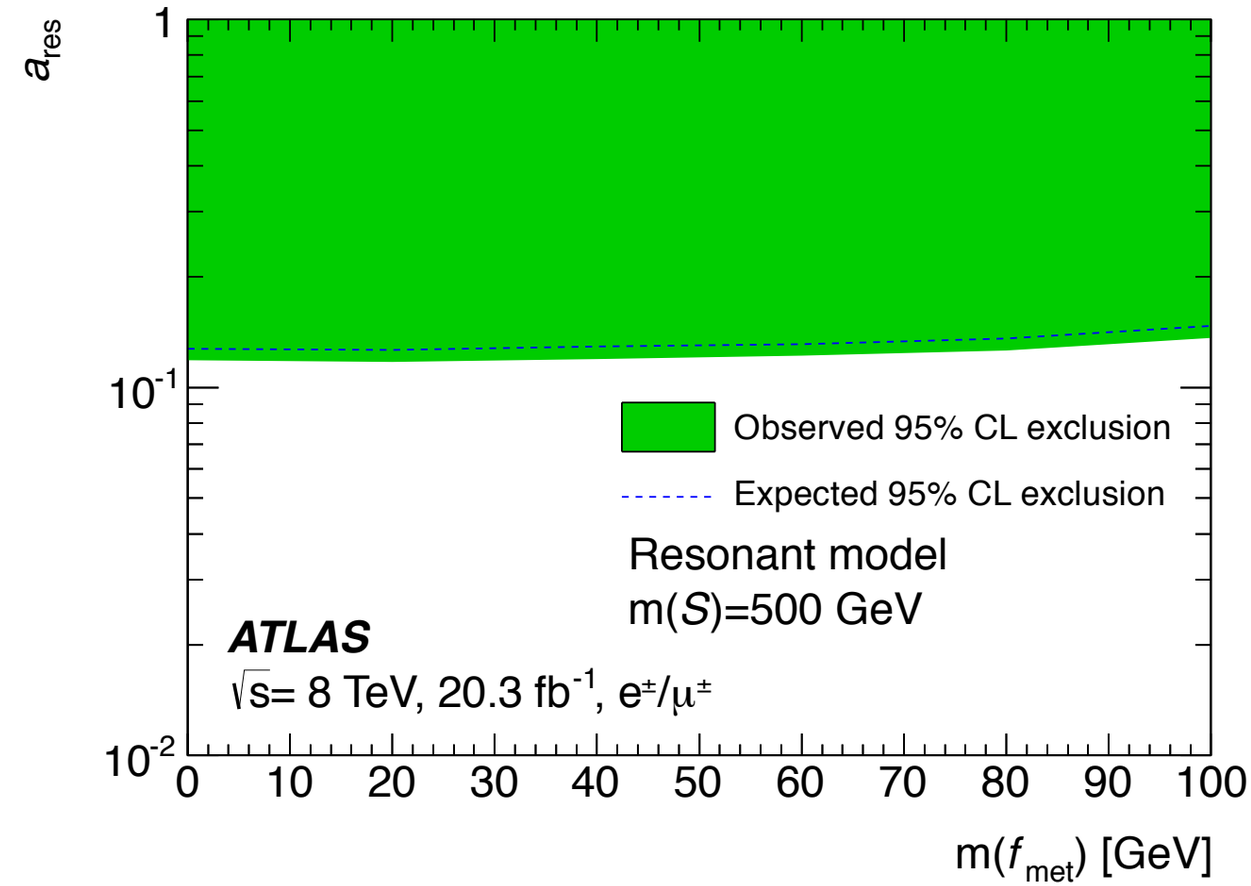
Observed and Expected Limits (Resonant)





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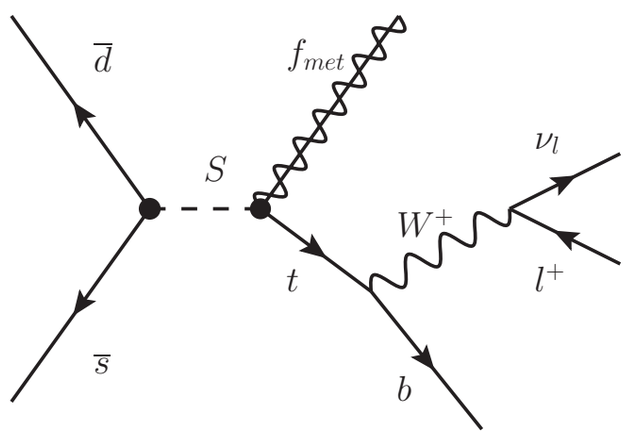

resonant production

for a_R=0.2 f_{met} is excluded at 95% CL for a mass of 0 to 100 GeV

$\sigma \propto a_R^2$ so limits on the coupling can be extracted as well

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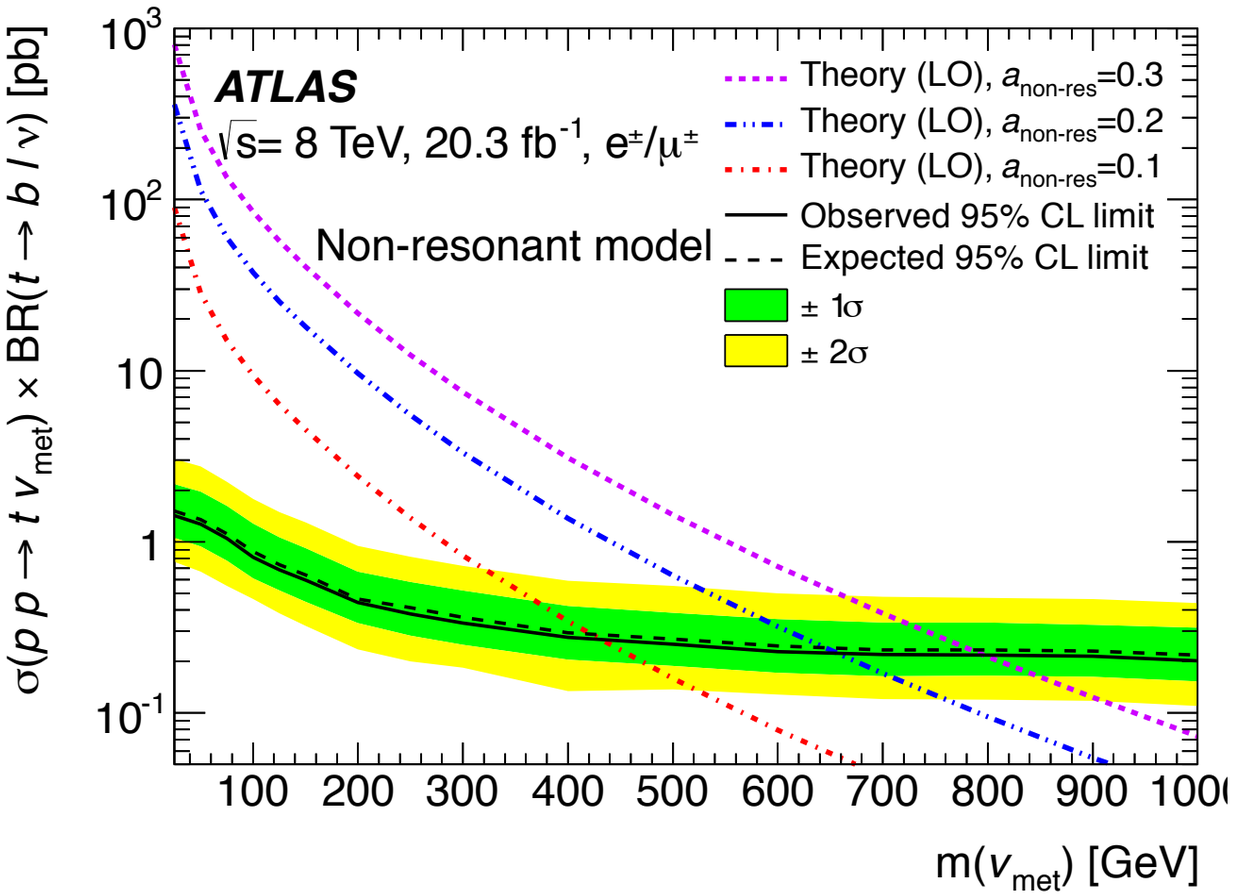
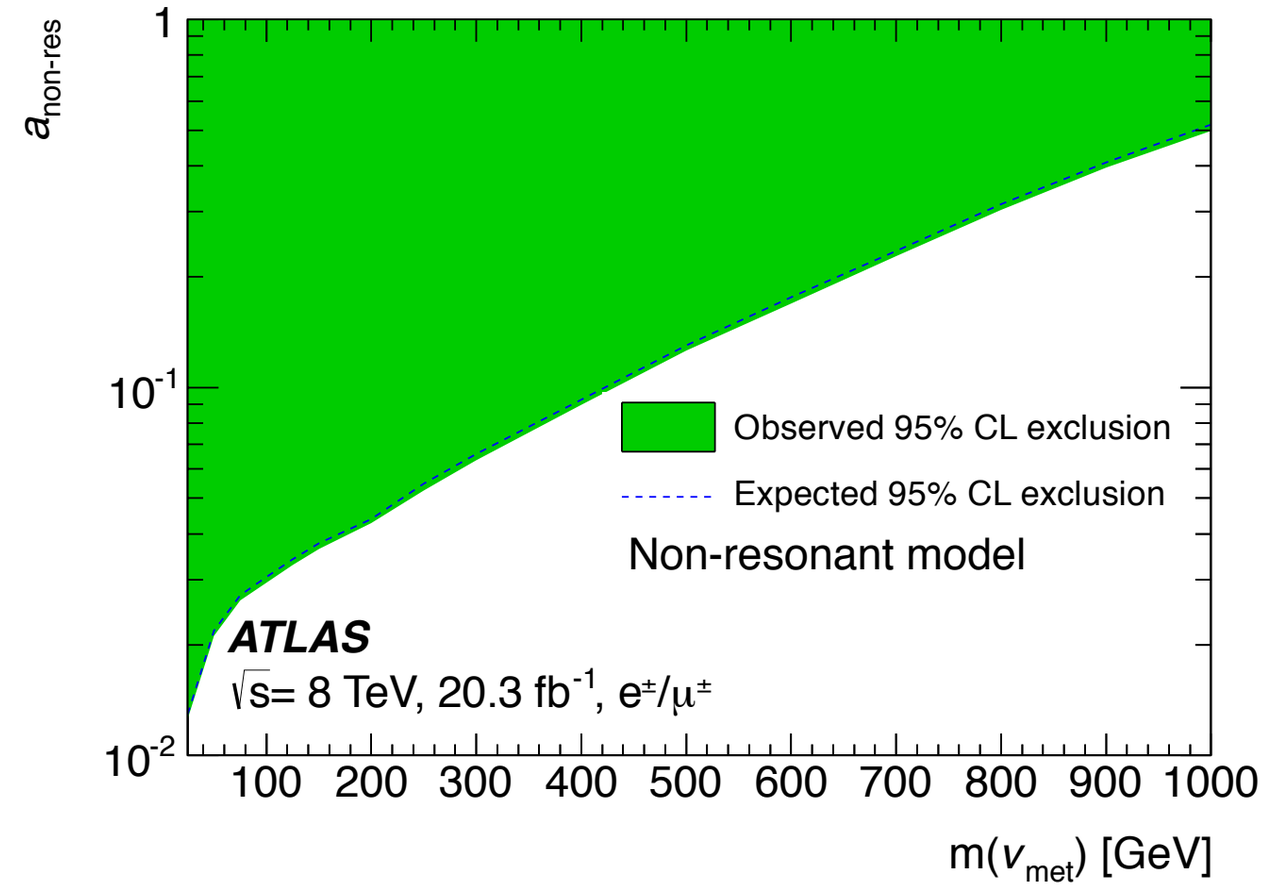
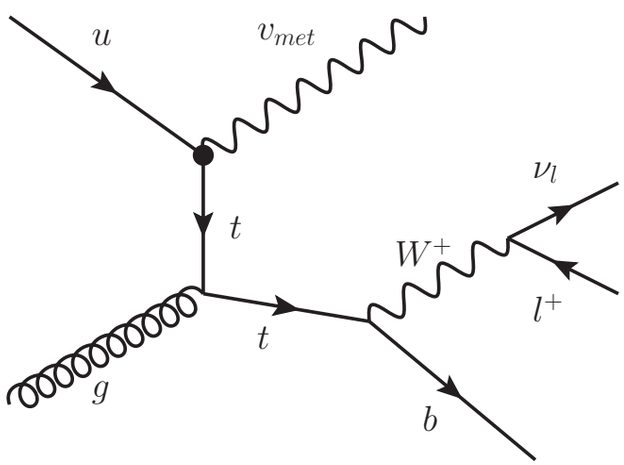




S4R



non-resonant production

for a_R=0.2 v_{met} is excluded at 95% CL for a mass of 0 to 657 GeV

$\sigma \propto a_R^2$ so limits on the coupling can be extracted as well

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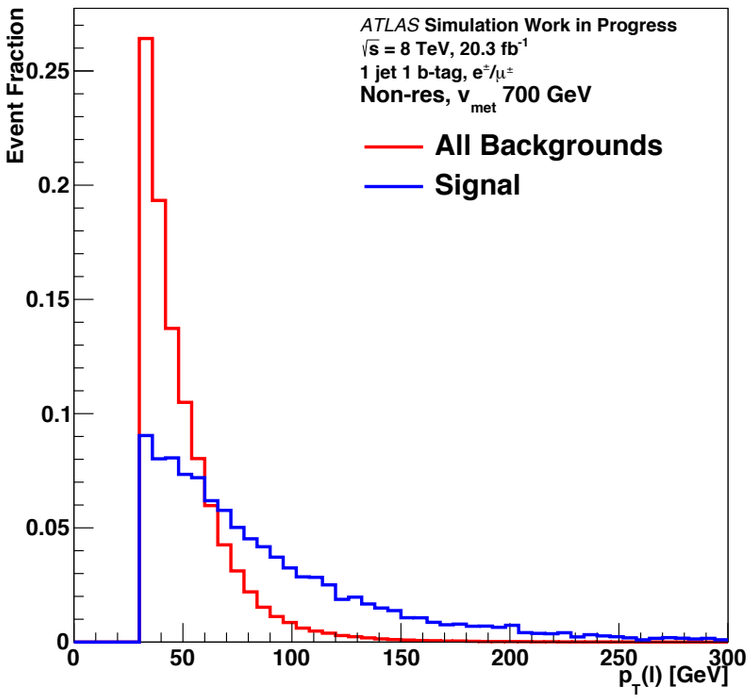
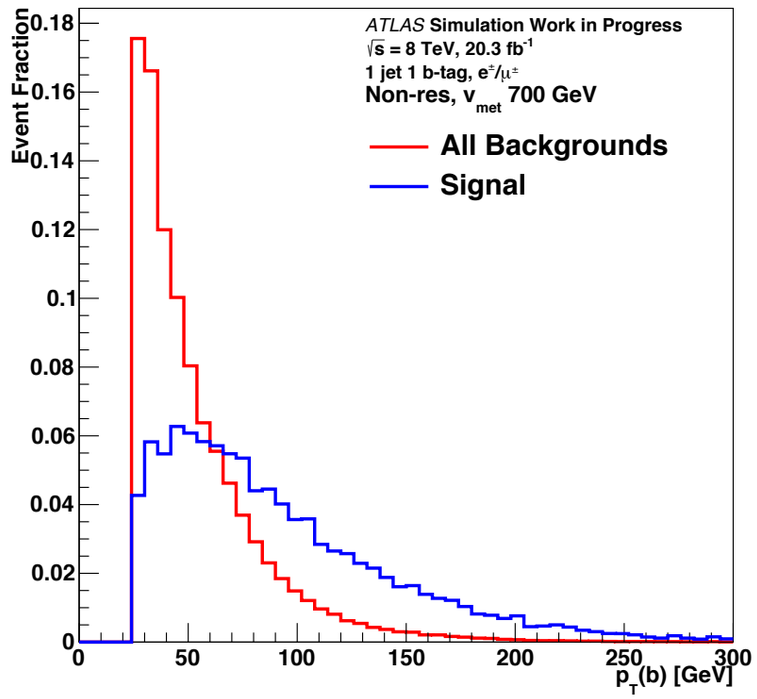
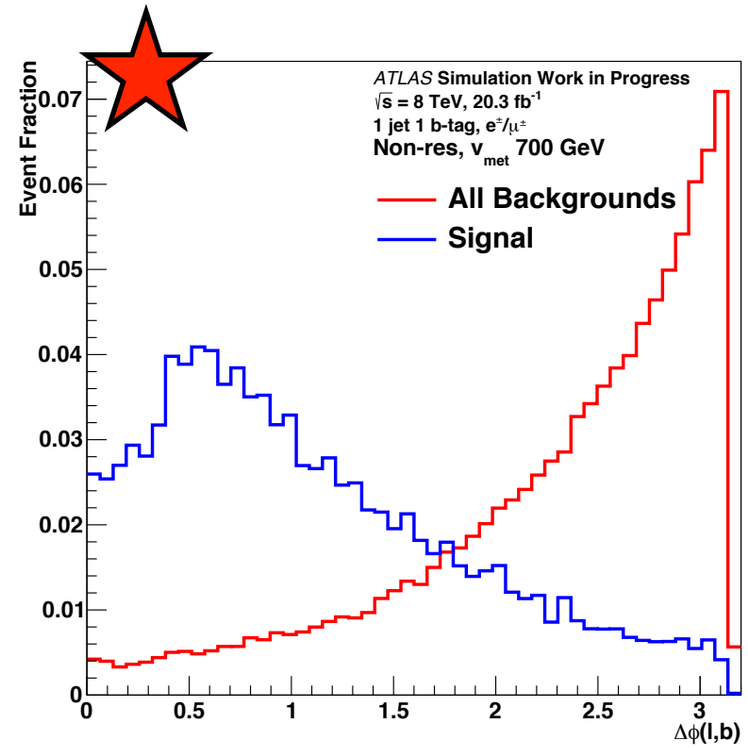
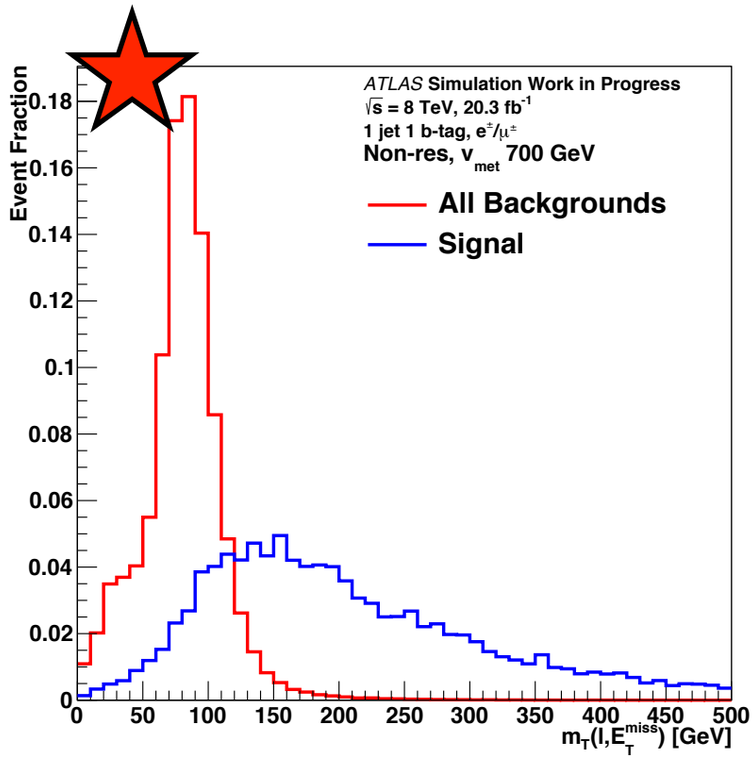
MULTIVARIATE ANALYSIS (BDT)

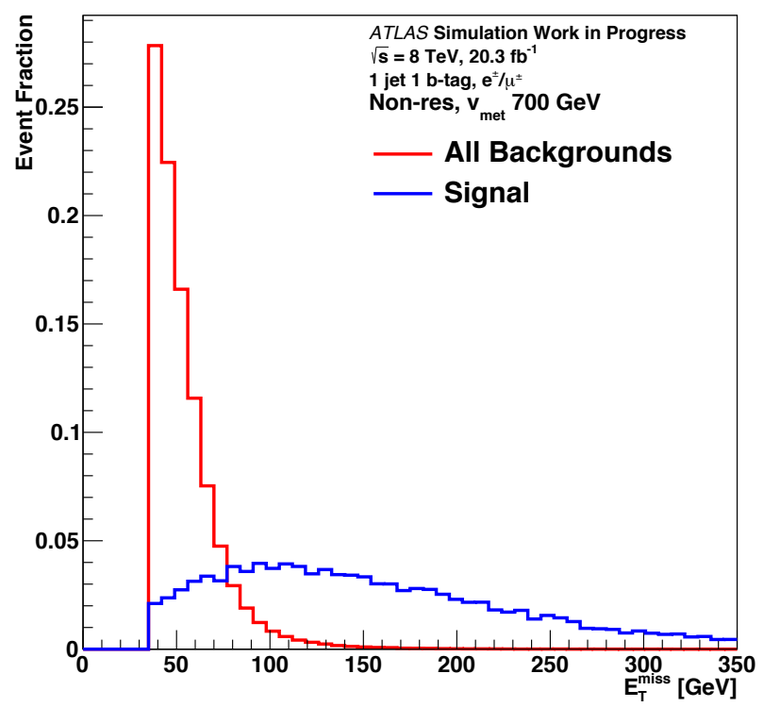
BDT Input Variables - Separation Power





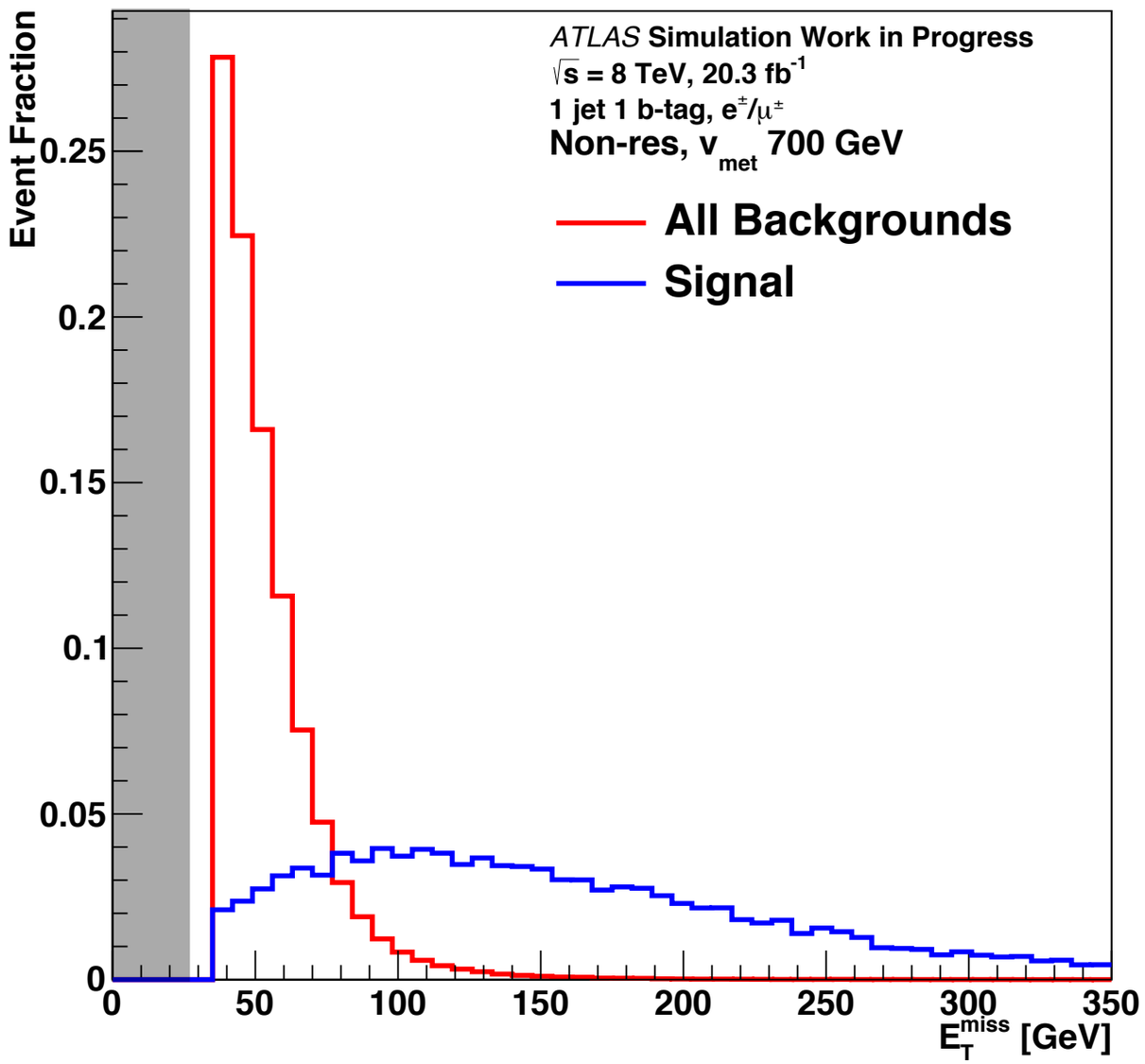


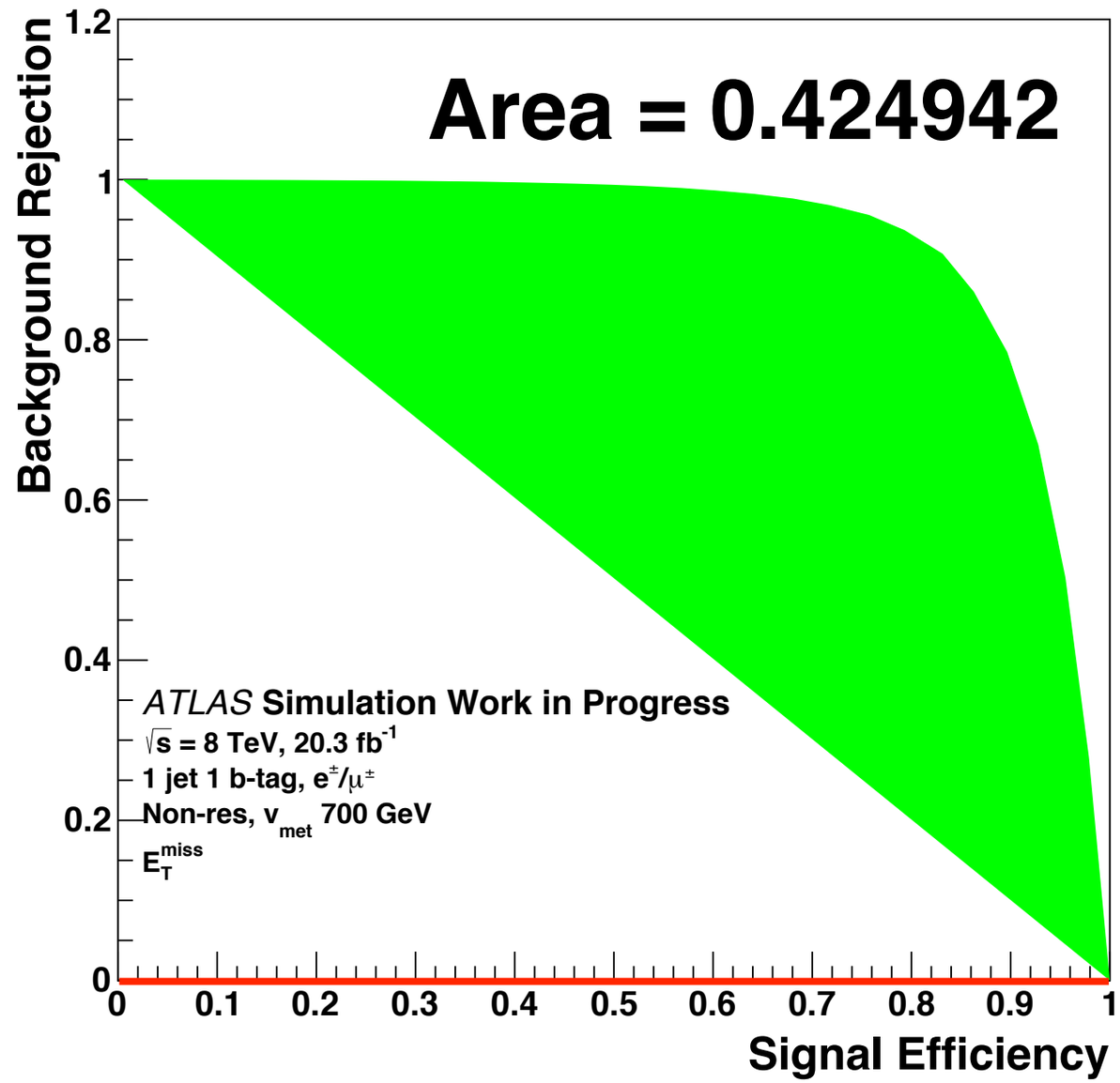




★ used in cut based analysis

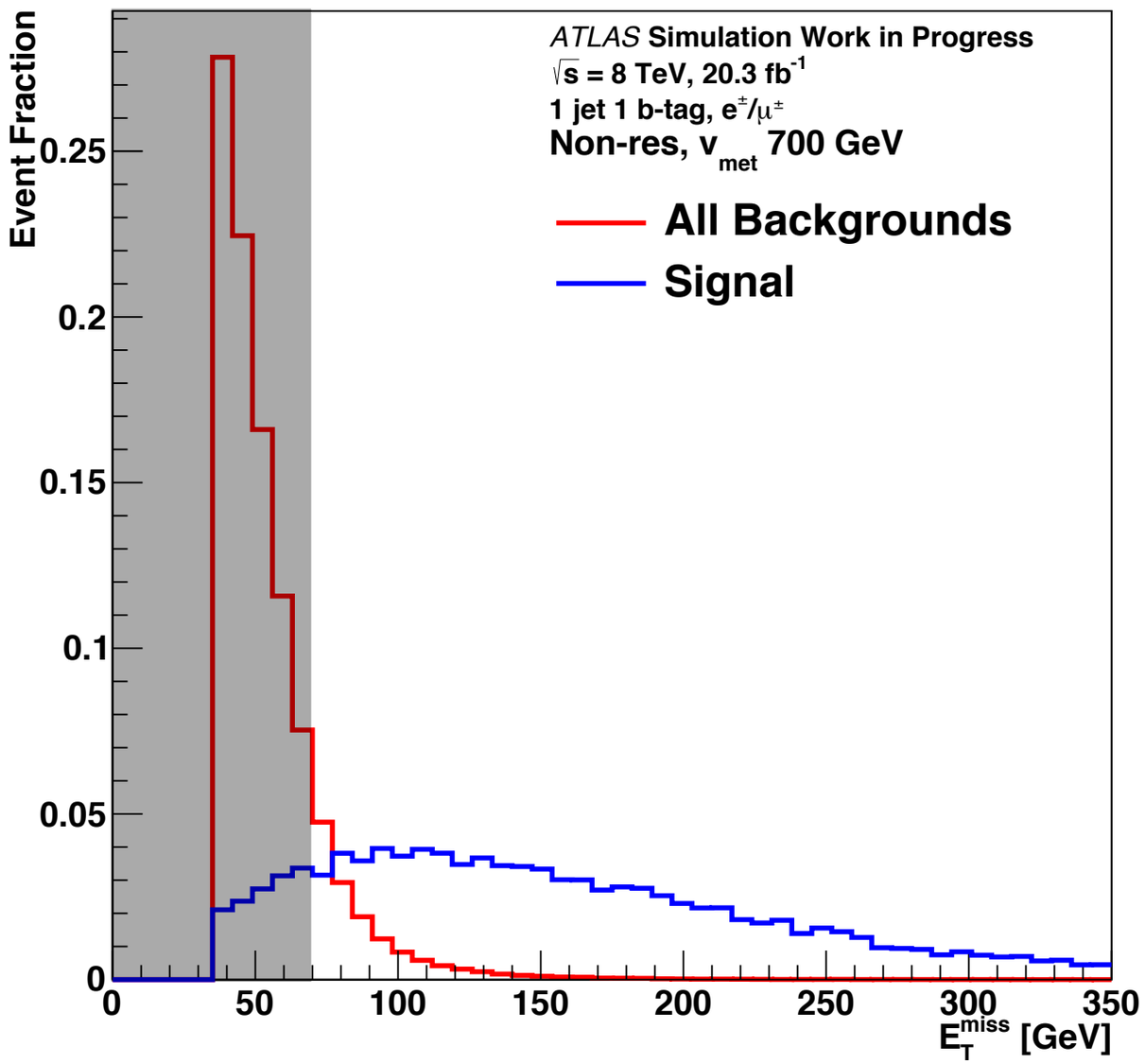
Ranking BDT Variables

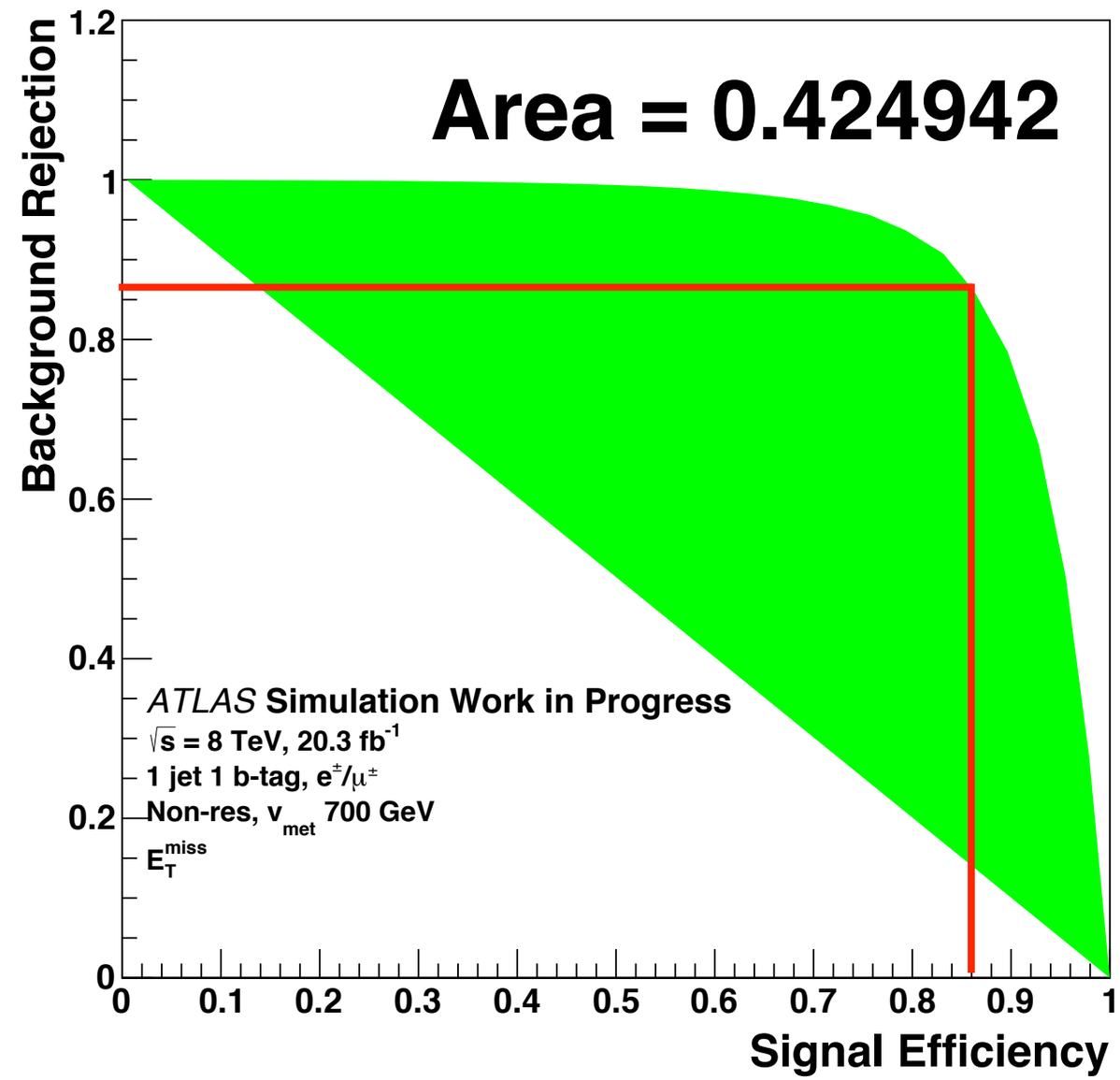




MET > 35 GeV

Ranking BDT Variables





MET > 70 GeV

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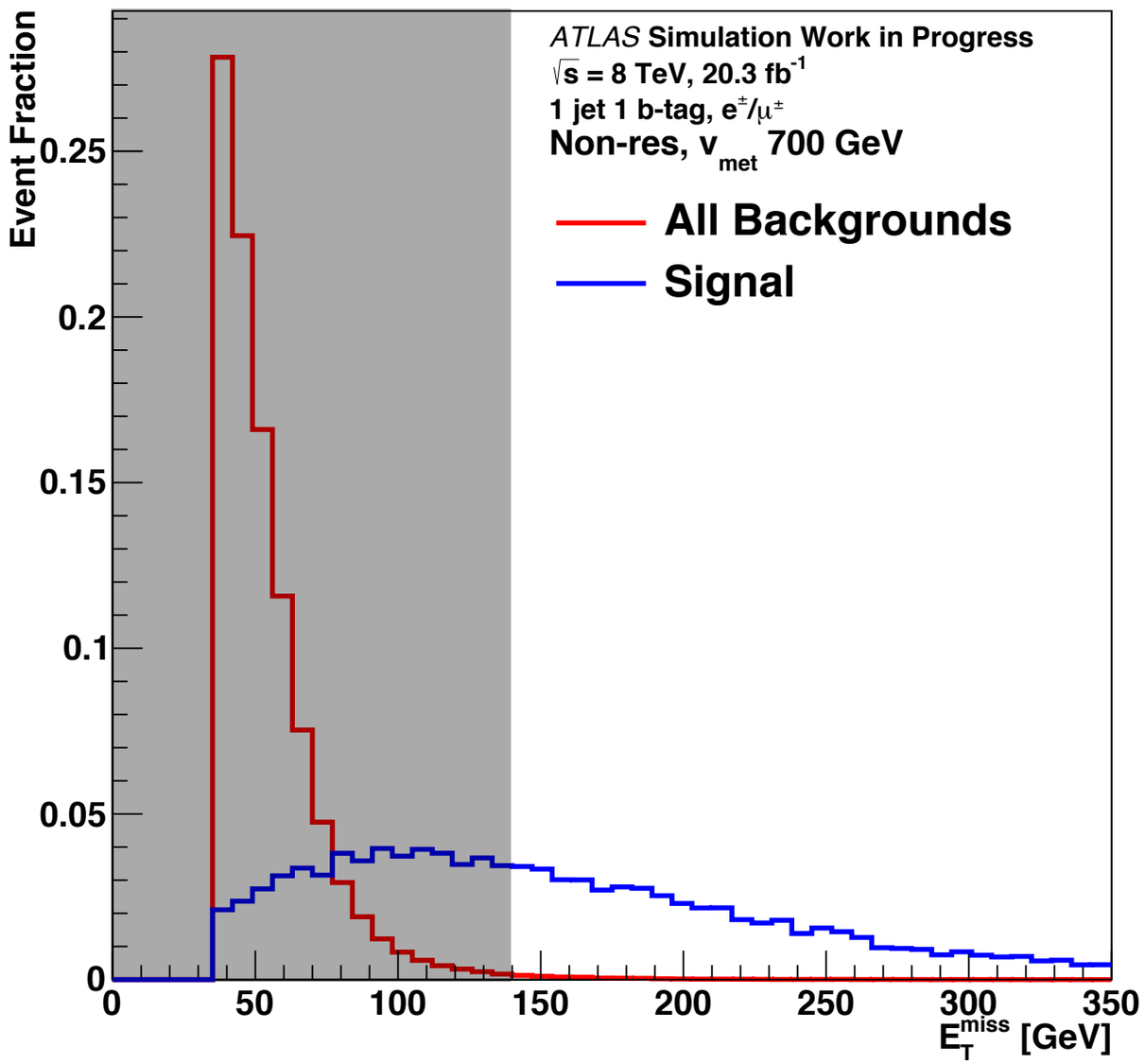
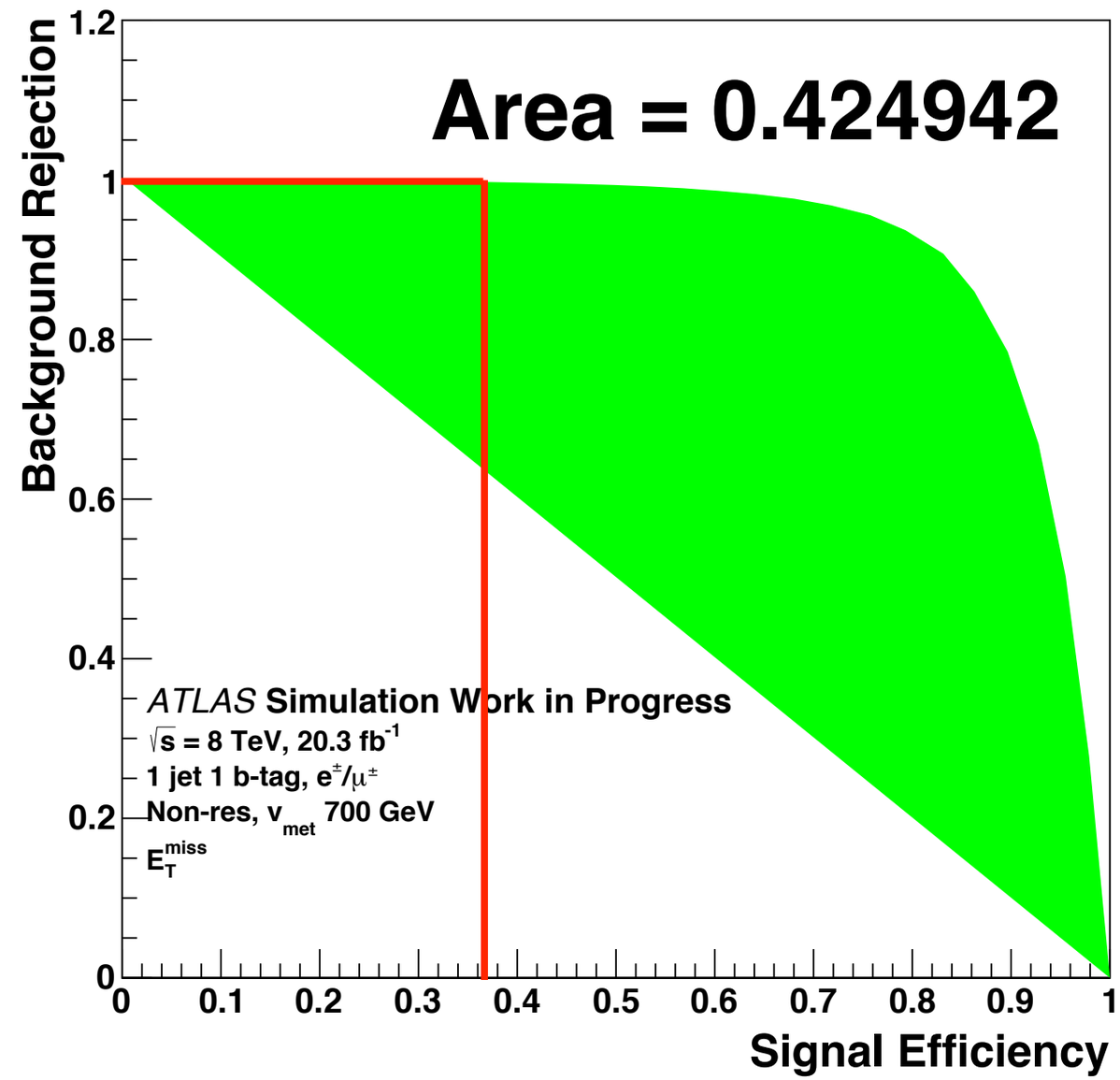
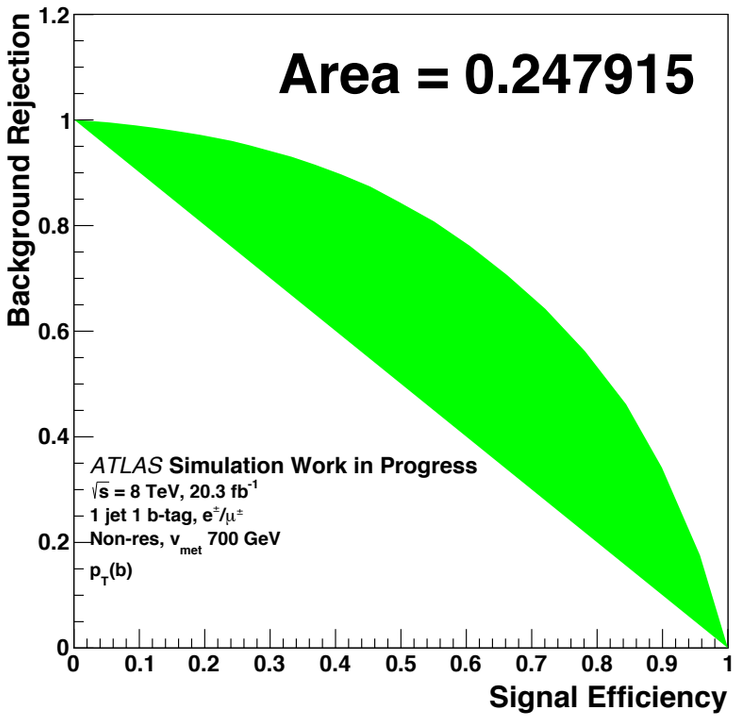
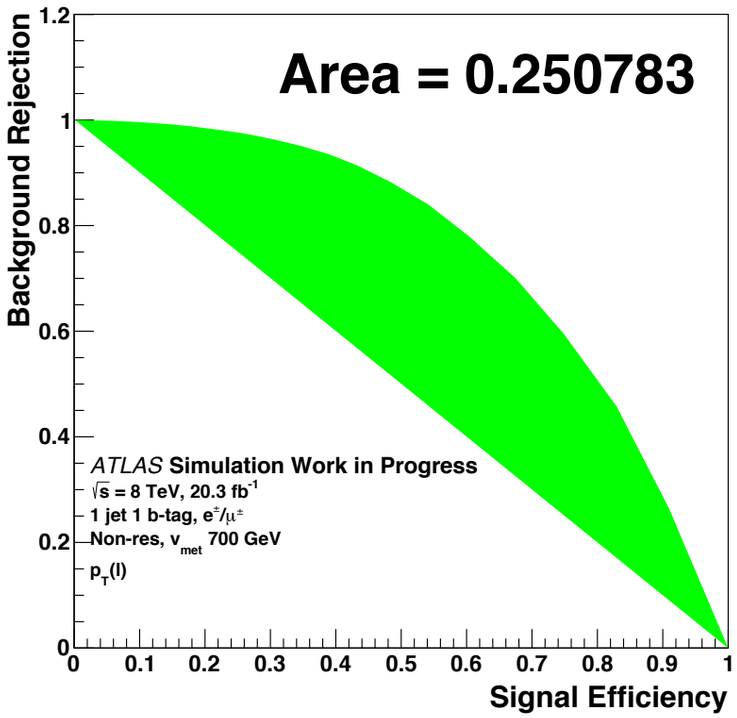


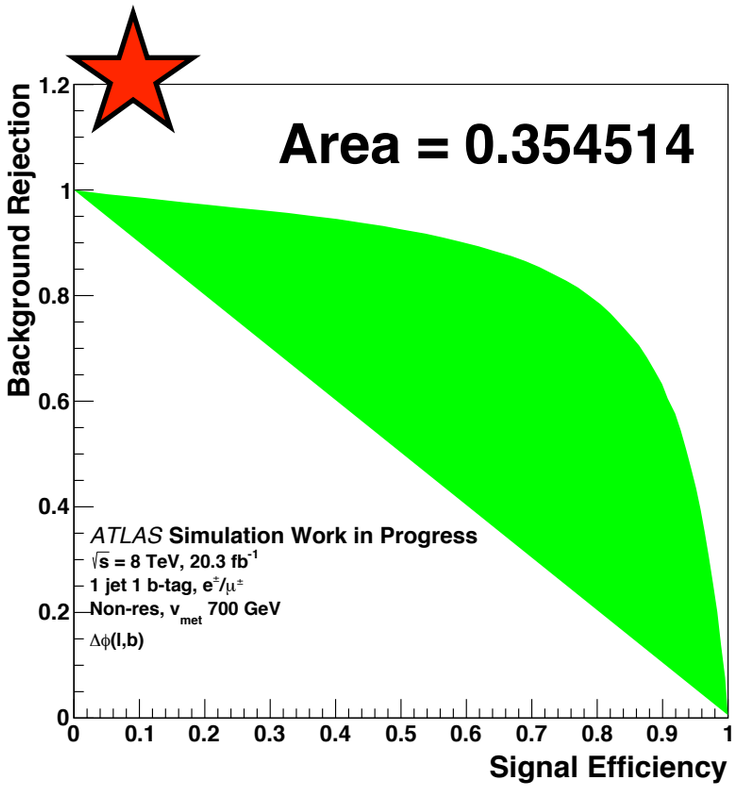


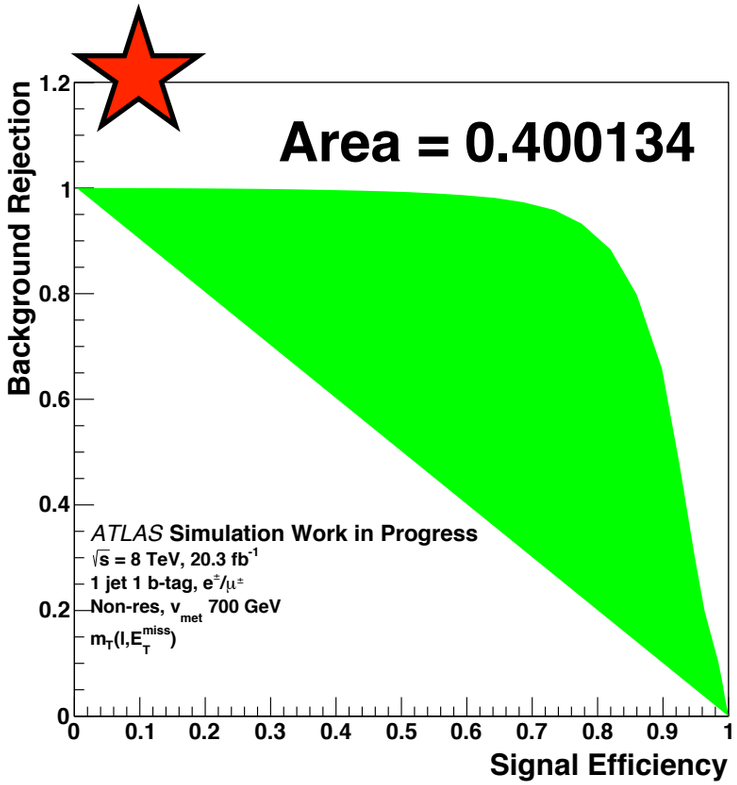
MET > 140 GeV

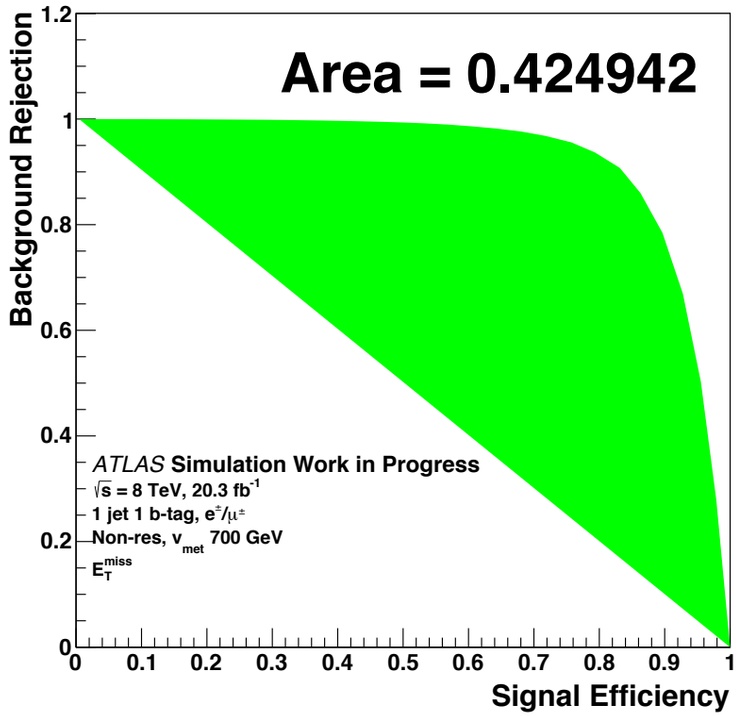
Background Rejection vs Signal Efficiency





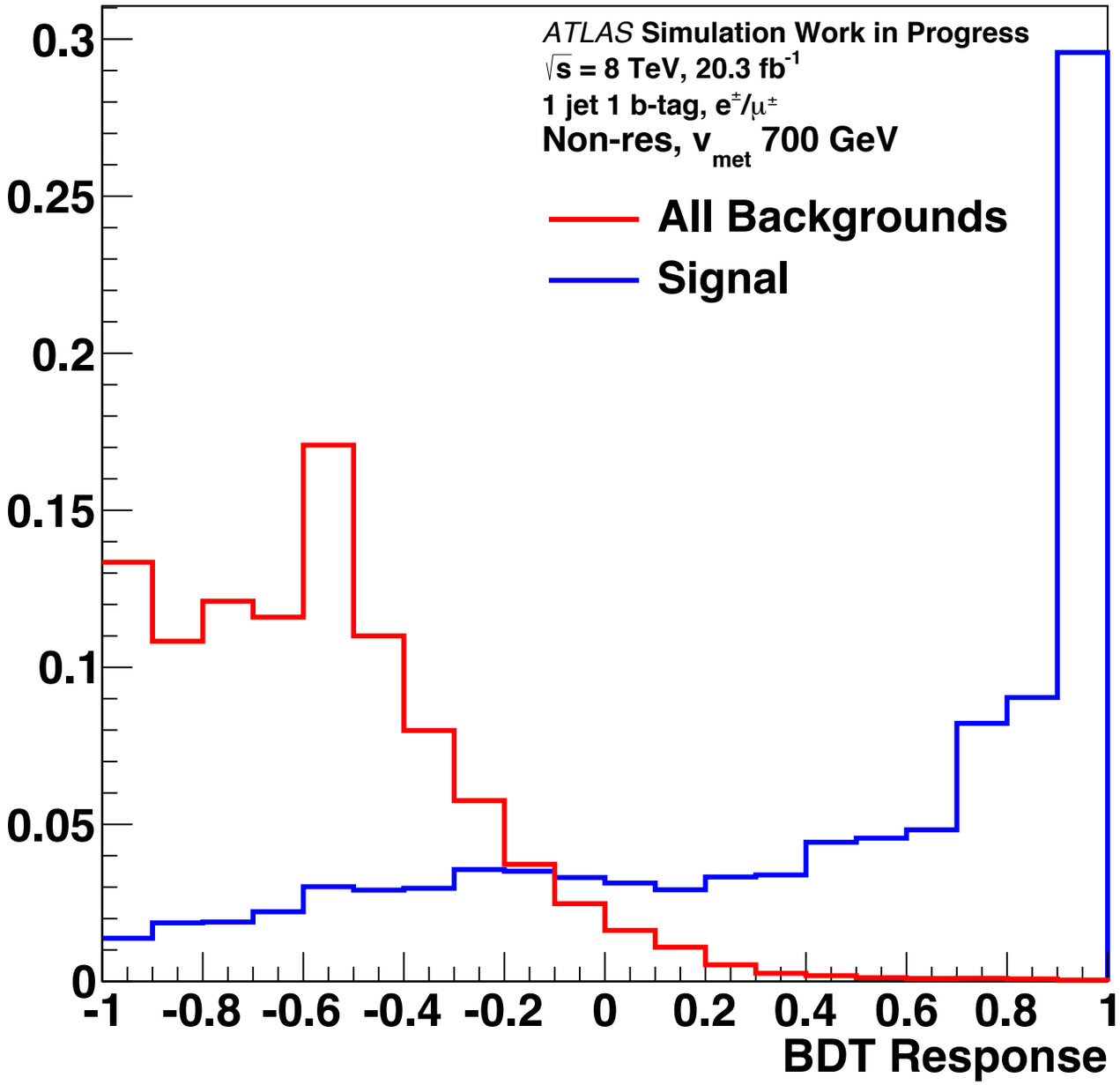






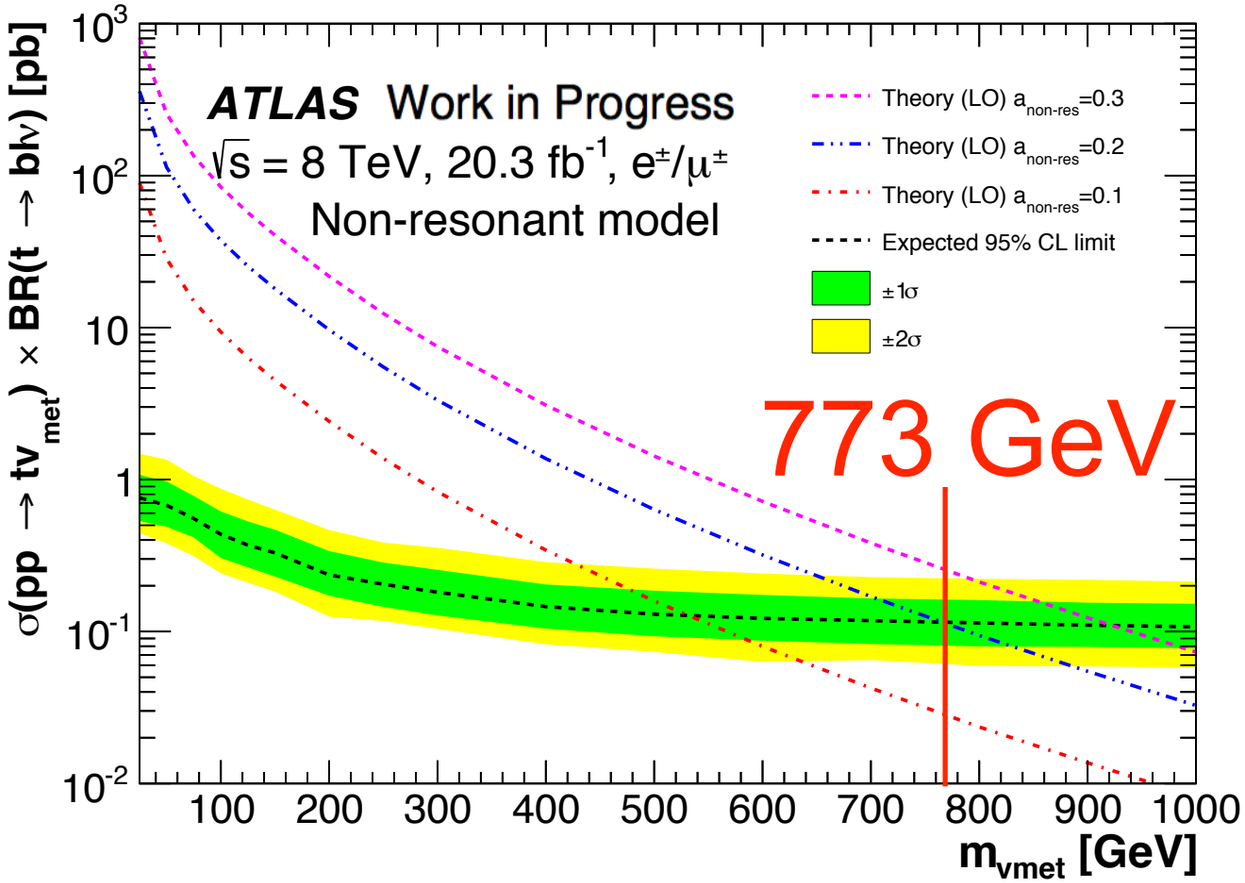
★ used in cut based analysis

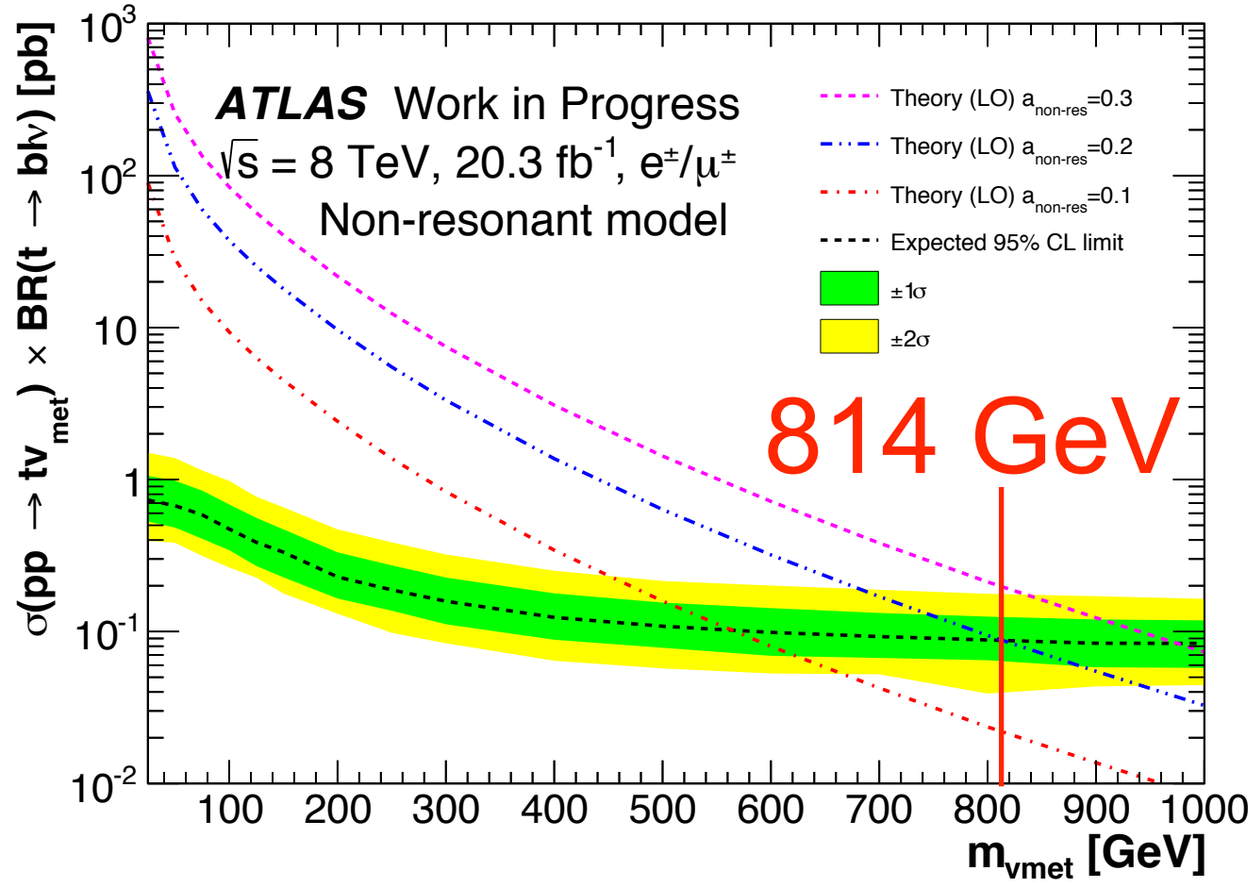
BDT Response



Parameter	Type/Value
Method	Gradient Boost
nTrees	500
nCuts	30
MaxDepth	4
Shrinkage	0.6
MinNodeSize	5%
% trained events	50%
%tested events	50%

Limits - Statistical Only





Cut-Based

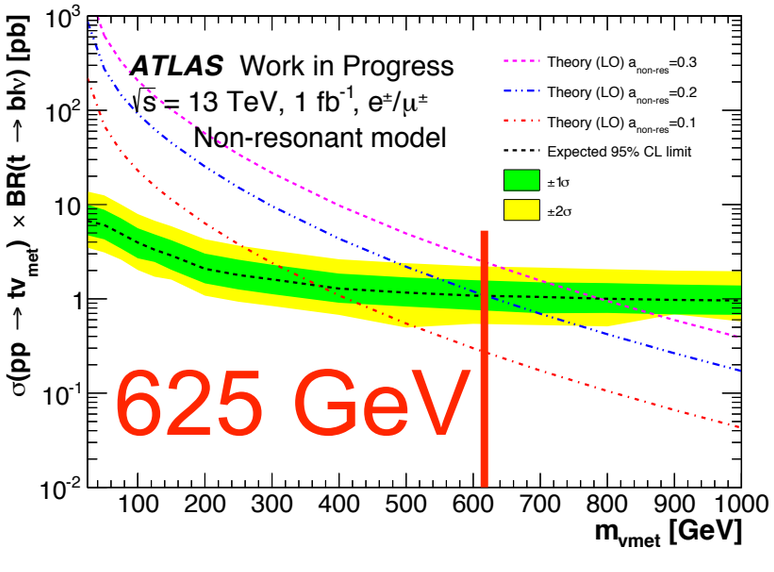
m_T(lep,MET) > 250 GeV
&&
| Δφ(lep,b) | < 1.4

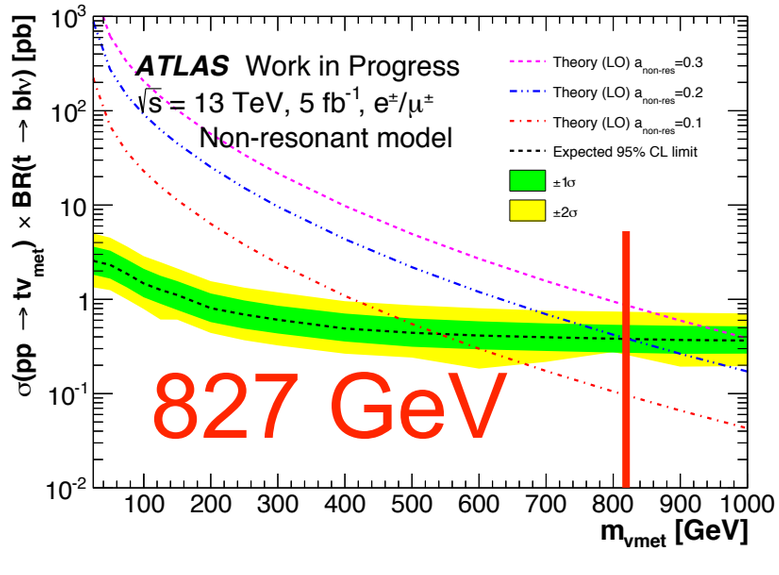
BDT-Based

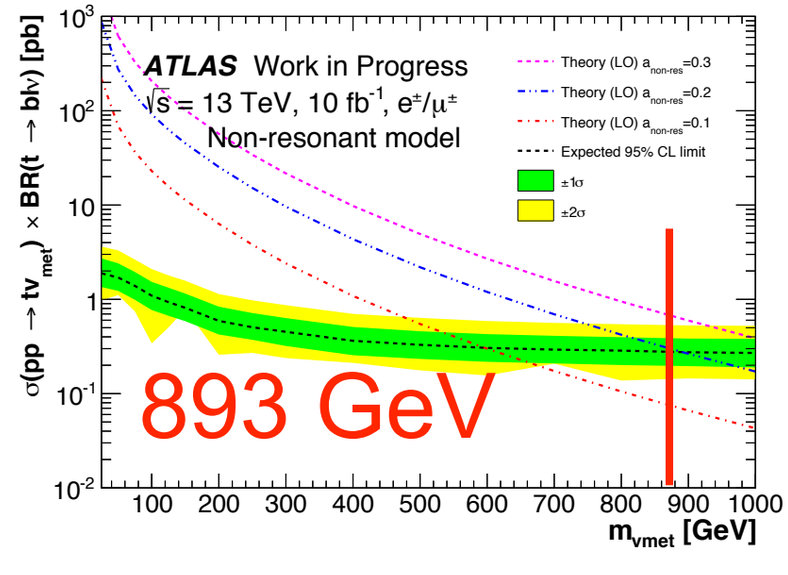
BDTResponse > 0.953

13 TeV Extrapolation

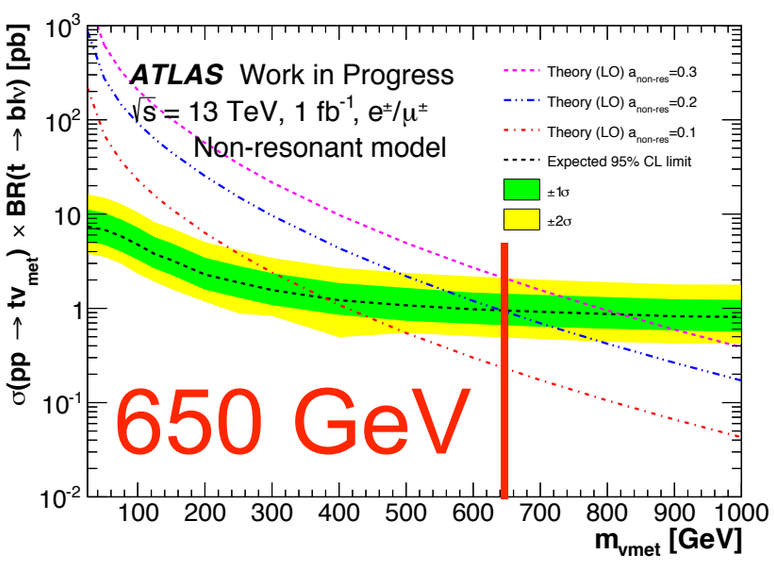
Cut Based

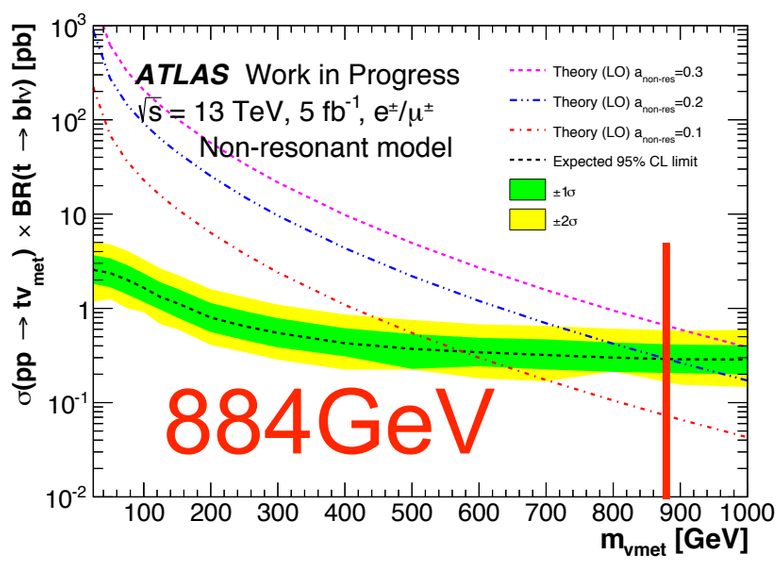


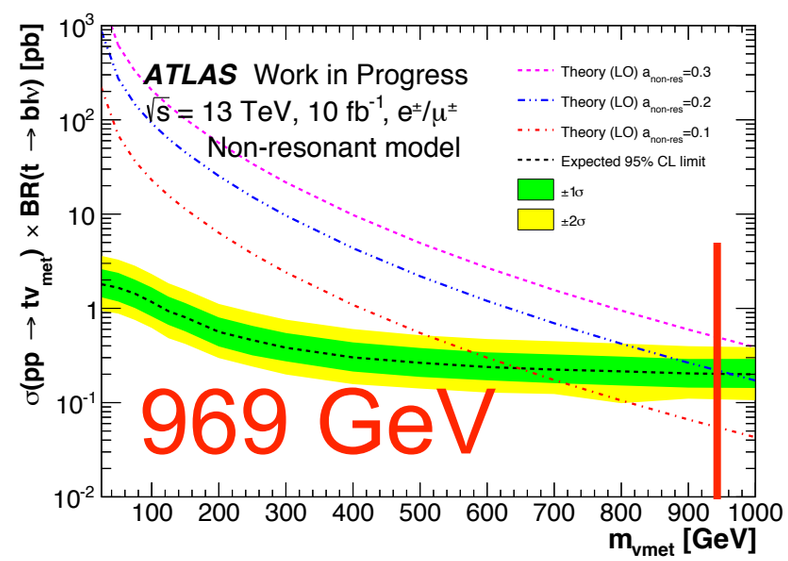




BDT



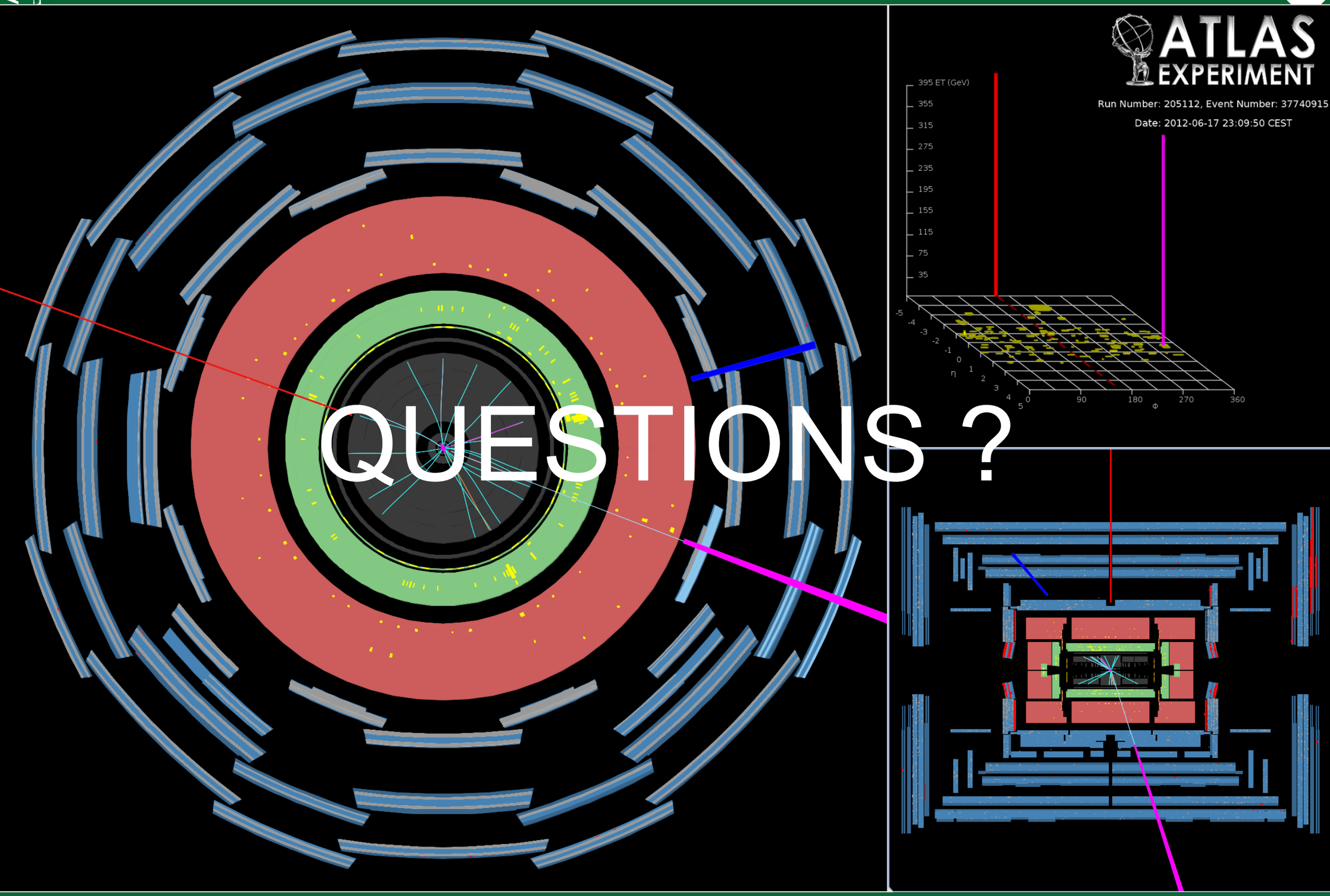




1 fb^{-1} 5 fb^{-1} 10 fb^{-1}

Conclusions

- Able to improve the limits with an MVA
- Might be statistically limited at 8TeV
- Looking forward to extending the analysis at 13 TeV
- Possible hadronic analysis to improve limits


ATLAS EXPERIMENT
Run Number: 205112, Event Number: 37740915
Date: 2012-06-17 23:09:50 CEST
395 ET (GeV)
355
315
275
235
195
155
115
75
35
η
Φ
0
90
180
270
360

QUESTIONS ?

BACKUP SLIDES

Event Yields - Cut Based

	SRI	SRII
Resonant signal, $m(S) = 500$ GeV, $m(f_{\mathrm{met}}) = 0$ GeV	$253 \pm 5 \pm 34$	–
Resonant signal, $m(S) = 500$ GeV, $m(f_{\mathrm{met}}) = 100$ GeV	$186 \pm 4 \pm 24$	–
Non-resonant signal, $m(v_{\mathrm{met}}) = 0$ GeV	–	$2430 \pm 130 \pm 210$
Non-resonant signal, $m(v_{\mathrm{met}}) = 1000$ GeV	–	$8.4 \pm 0.1 \pm 0.8$
$t\bar{t}$	$190 \pm 7 \pm 40$	$94 \pm 5 \pm 19$
Single-top s-channel	< 0.05	< 0.05
Single-top t-channel	< 0.10	< 0.10
Single-top Wt	$19 \pm 4 \pm 14$	$10 \pm 3 \pm 11$
W+light-quarks	$2 \pm 2 \pm 4$	$3 \pm 3 \pm 4$
$W+bb$	$10 \pm 3 \pm 5$	$9 \pm 3 \pm 7$
$W+cc$	$5 \pm 3 \pm 3$	$2 \pm 7 \pm 2$
$W+c$	$12 \pm 5 \pm 8$	$4 \pm 2 \pm 4$
Diboson	$1.3 \pm 0.6 \pm 0.7$	$1.0 \pm 0.5 \pm 0.5$
Z+jets	< 4	< 4
Multijet	< 0.6	< 1.3
Total background	$240 \pm 10 \pm 50$	$124 \pm 11 \pm 27$
Data	238	133

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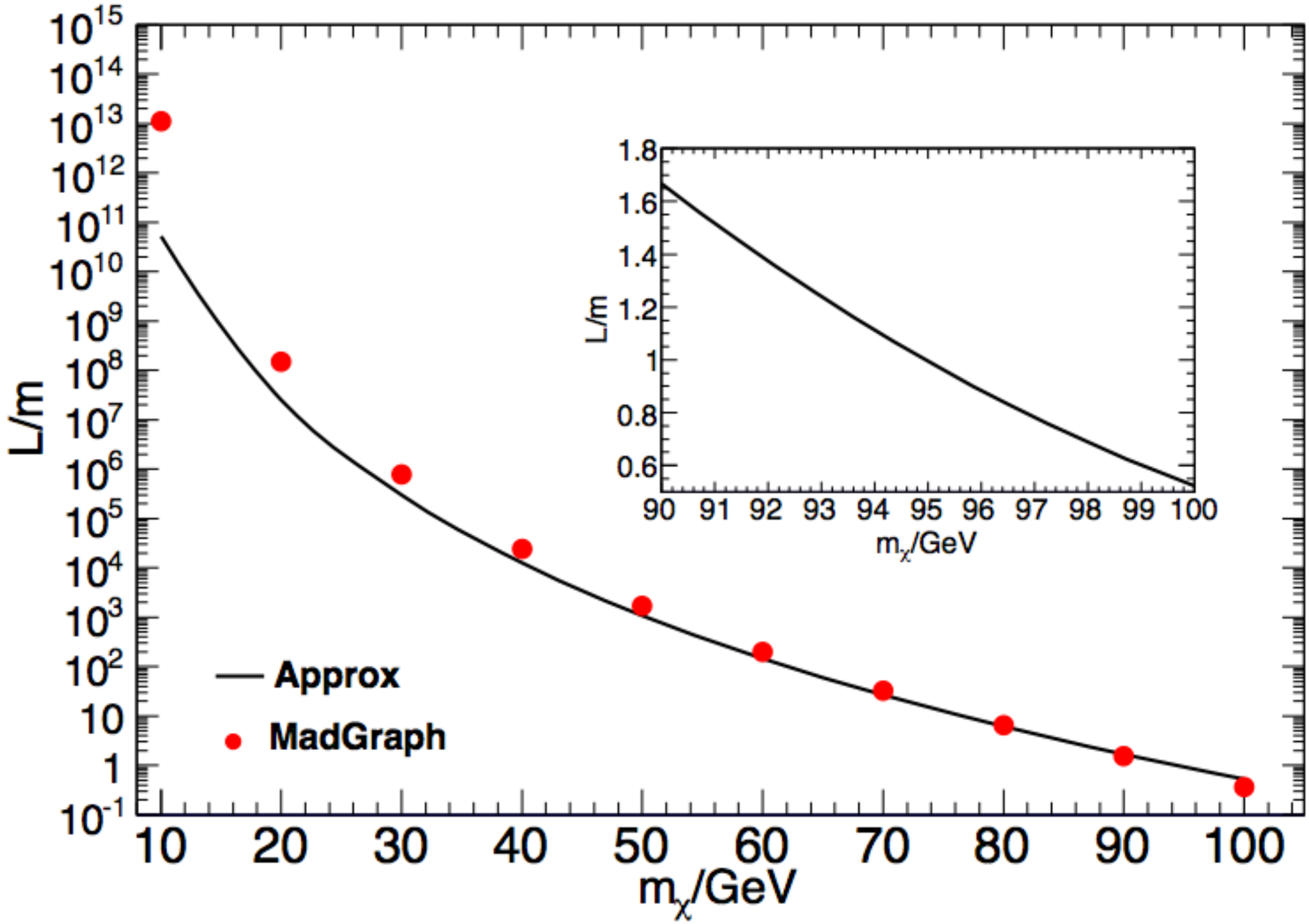
Resonant Model - DM Candidate Decay Length vs Mass



Phys. Rev. D 86, 034008 (2012) arxiv:1109.5963 [hep-ph]

Backgrounds

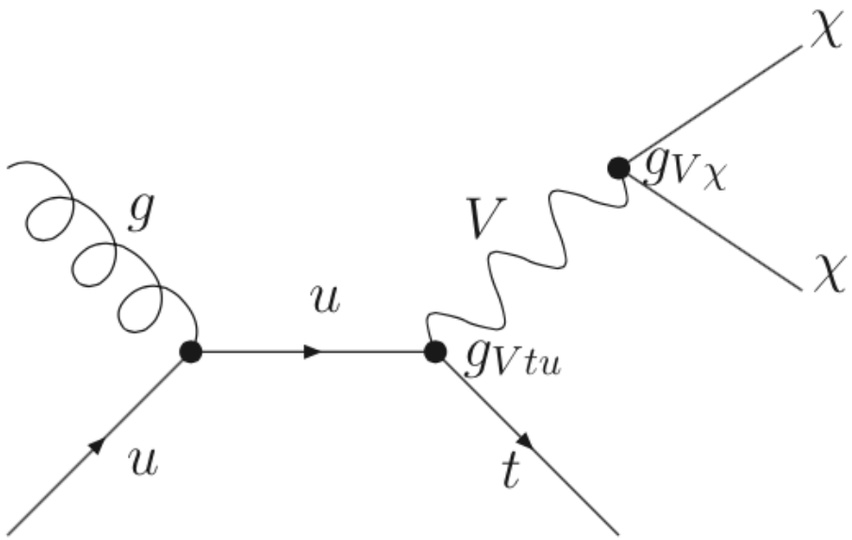
- Multijets are estimated with a data-driven matrix method
- Remaining backgrounds are normalized to theoretical cross-sections and modeled with MC simulation

Background	Generator	Xsec Order
ttbar	Powheg	NNLO+NNLL
single top	Powheg(s-chan,Wt) AcerMC (t-chan)	NNLO
W + jets	Alpgen+Pythia	NLO
Z + jets	Alpgen+Pythia	NLO
Diboson	Herwig	NLO

Systematics

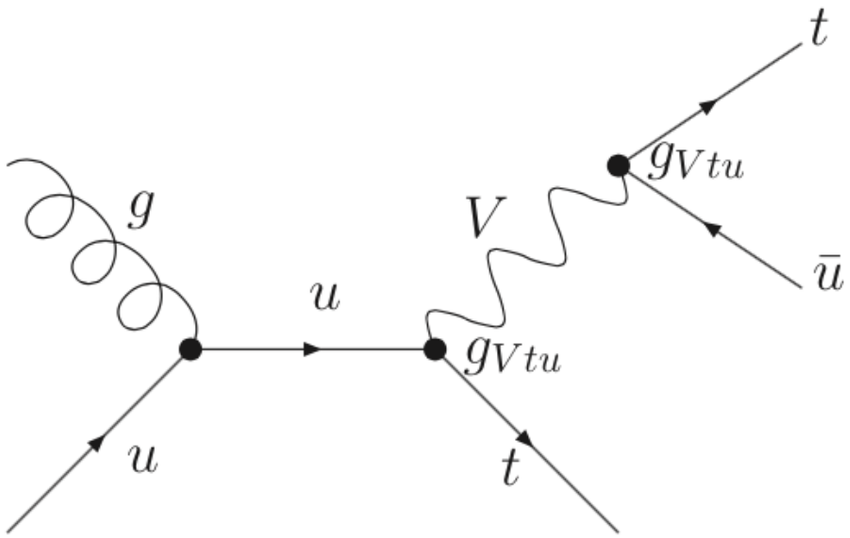
	SRI Resonant signal $m(f_{\mathrm{met}}) = 100$ GeV	SRI Background	SRII Non-resonant signal $m(v_{\mathrm{met}}) = 700$ GeV	SRII Background
Electron				
Trigger, reconstruction, identification	1.3	1.1	1.3	1.3
Energy scale and resolution	1.1	2.3	0.9	3.1
Muon				
Trigger, reconstruction, identification	1.0	1.1	1.1	1.2
Energy scale and resolution	0.4	1.8	0.3	4.1
Jet				
Energy scale	1.6	9.6	4.5	10.0
Energy resolution	1.9	2.1	3.0	0.9
Reconstruction	0.5	0.3	0.2	2.6
Vertex fraction	2.7	4.7	3.1	6.1
b-tagging and mis-tagging	3.5	4.7	4.3	4.8
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft terms	0.4	1.5	0.4	4.6
Acceptance				
PDF	11.2	5.6	4.0	6.2
$t\bar{t}$ generator	–	11.4	–	5.6
Wt generator	–	3.3	–	5.3
Wt diagram removal scheme	–	4.1	–	6.4
$t\bar{t}$ ISR/FSR	–	5.3	–	8.5
Cross-sections				
$t\bar{t}$	–	4.5	–	4.3
Wt	–	0.5	–	0.5
Diboson	–	0.1	–	0.2
W+light	–	0.2	–	0.7
W+hf	–	3.4	–	4.2
Luminosity	2.8	2.8	2.8	2.8
Total systematics	12.7	19.7	9.2	21.0
Statistics	2.0	1.8	1.8	9.2
Total	12.9	20.3	9.49	22.9

- V→dark matter



- ⇒ Monotop

- V→tu



- ⇒ SS Top (with other diagrams)

- BR[V→χχ] = 1 for monotop and < 1 for same-sign top analysis

courtesy of Théo Megy, LPC Clermont-Ferrand