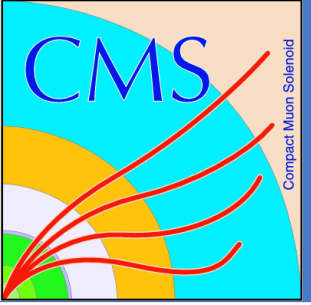

Soft Single Lepton SUSY Search using α_T at CMS

Z. Hatherell

Imperial College London

Imperial College London

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Introduction

- Supersymmetry Searches at LHC
- α_T variable
- Hadronic channel results
- Soft Single Lepton Strategy
  - Low p_T Leptons(10 – 25 GeV)
  - Use Hadronic Search plus Lepton
- Background Estimation Method
  - HT control regions
- Future Plans with 2011 Data

Supersymmetry Searches

Supersymmetry models predict the existence of a heavy, stable final state super-partner which will not interact with the detector

❖ SUSY production mechanisms at the LHC

$$pp \to \tilde{q}_R \tilde{q}_L \to \left\{ \begin{array}{l} q\tilde{\chi}_1^{\,o} \\ q\tilde{\chi}_1^{\,\pm} \to \left\{ \begin{array}{l} qq\bar{q}'\tilde{\chi}_1^{\,o} \quad (\text{all} - \text{hadronic}) \\ q\ell^{\pm}\tilde{\nu}_\ell\tilde{\chi}_1^{\,o} \quad (1 - \text{lepton mode}) \end{array} \right\} \end{array} \right\}$$

Typical Experimental signature:

- *Large missing transverse energy plus final state objects*

Searches are inclusive - remain model independent

- allows sensitivity to New Physics (SUSY or not SUSY)

Use benchmark points in popular models to assess sensitivity and set limits (notably CMSSM)

QCD Control variable – α_T

Dominant background from QCD - must be controlled.

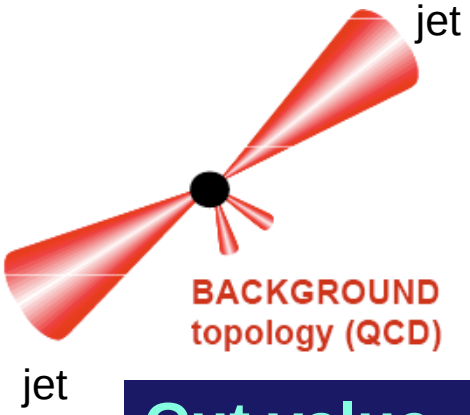
Search variable α_T originally proposed for di-jets (hep-ph 0806/1049)

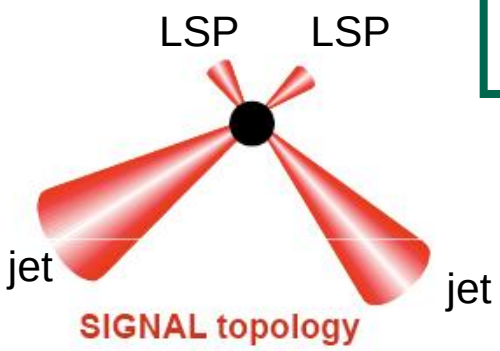
Extend the α_T variable for a N-Jet QCD system:

- Construct 2 Pseudo-jets to resemble QCD di-jet system
- Pseudo-jets balance in HT

$$\alpha_T = \frac{1}{2}\frac{H_T - \Delta H_T}{M_T} = \frac{1}{2}\frac{H_T - \Delta H_T}{\sqrt{H_T^2 - MH_T^2}}.$$

$$H_T = \sum_{jets} E_T \quad \not{H}_T = |\sum_{jets} \vec{P}_T|$$





Cut value - $\alpha_T > 0.55$ selects events with real missing energy.

(EWK,TOP,SUSY)

Hadronic α_T Search

❖ Hadronic α_T analysis published : Physics Letters B 698 (2011) (arXiv:1101.1628v1)

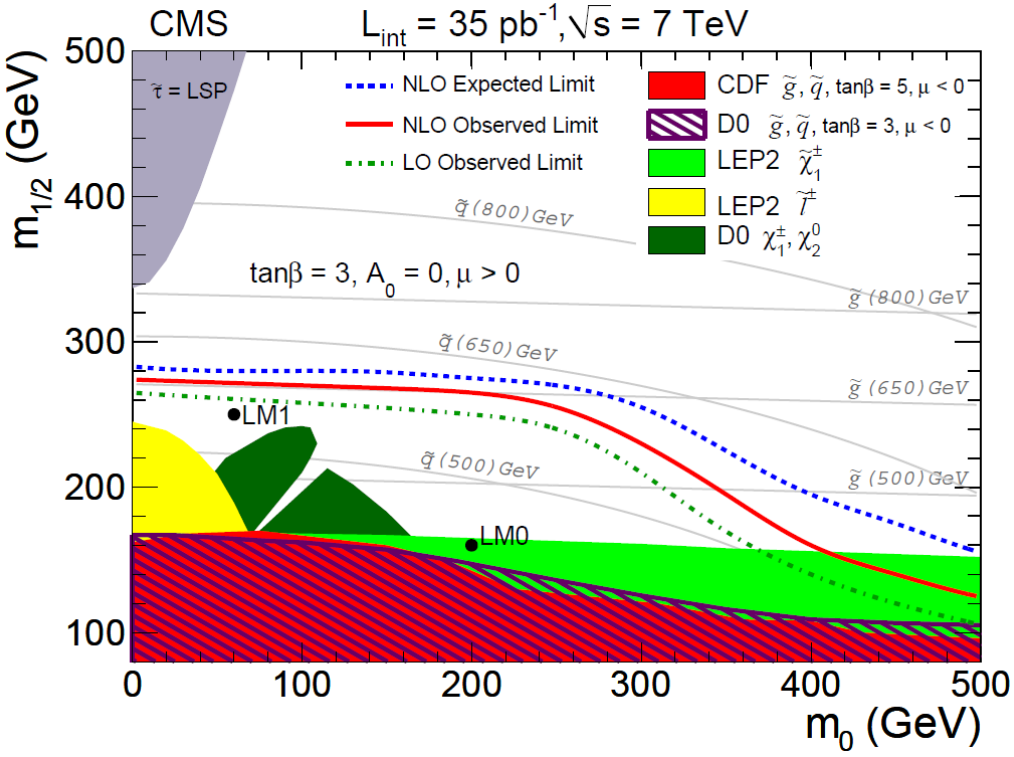
HT Trigger (100/120/140/150 HT)

At least 2 jets (p_T >50, $|\eta|$ < 2.4)

Veto leptons (p_T> 10 GeV), photons (p_T> 25GeV)

HT > 350 GeV , α_T > 0.55

Dead ECAL dR > 0.3 && MHT/MET < 1.25



Limits set in CMSSM m_0-$m_{1/2}$ plane

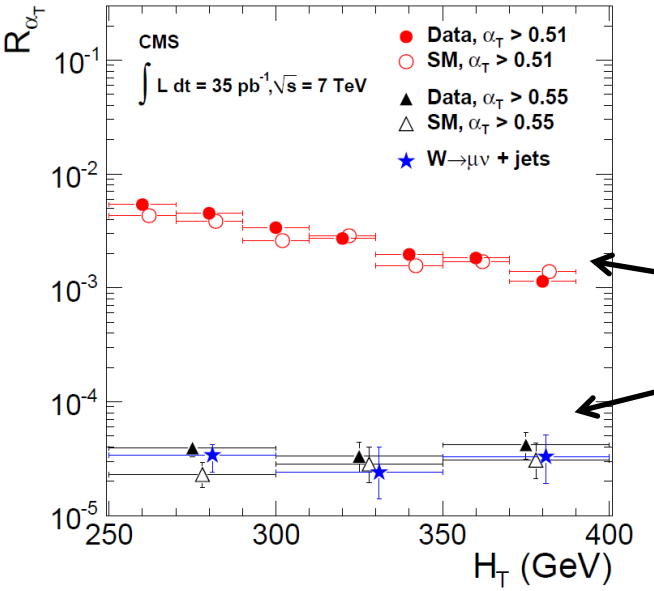
Upper limit on Signal of 13.4

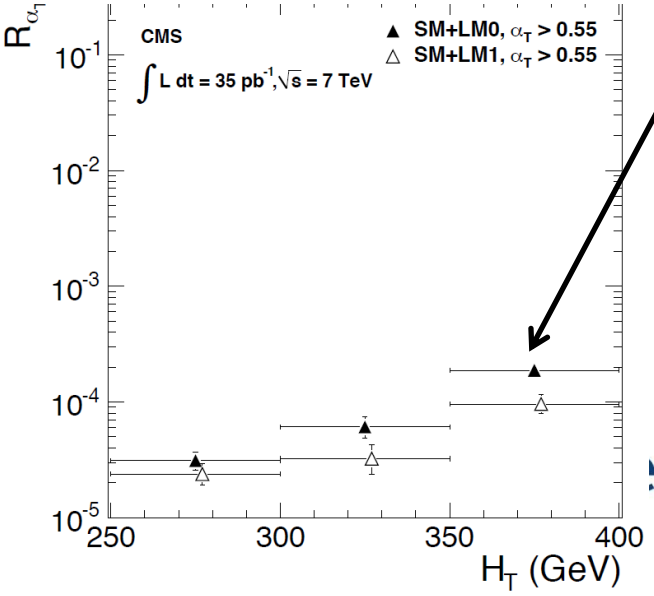
(very little dependence on tanβ)

Significant extension to excluded region over previous experiments!

Combined Background Estimation Hadronic Channel

Use lower HT regions to predict total background in signal regions





- Scale jet p_T thresholds in HT regions
- Define $R\alpha_T$ as the ratio of events pass/fail α_T

$R\alpha_{T(0.51)}$ expected to fall with increasing HT (QCD)

BUT $R\alpha_{T\ (0.55)}$ expected to be flat (EWK,Top)

(rises with increasing HT in presence of SUSY)

- **Fit in Control Region to obtain $R\alpha_{T\ (0.55)\ control}$**

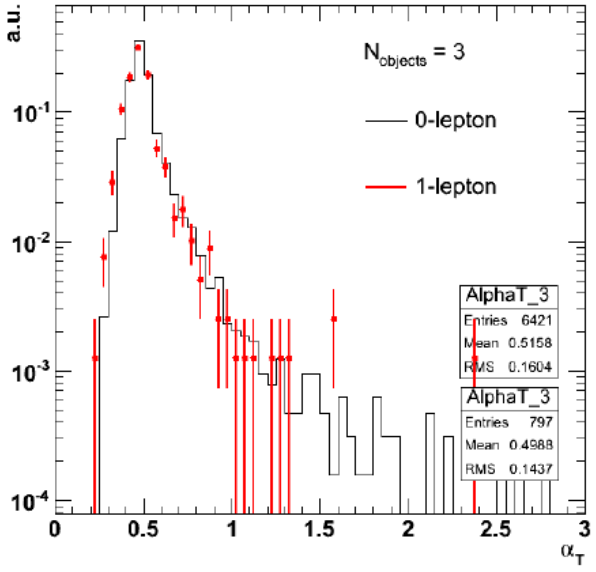
$$Expected\,Events(aT>0.55)=\frac{NControl\,(aT>0.55)}{NControl\,(aT<0.55)}*NSig\,(aT<0.55)$$

Predicts $9.4^{+4.8}_{-4.0}(\text{stat.}) \pm 1.0\ (\text{syst.})$ background events for 35pb^{-1} 2010 7TeV Data. There were 13 data events.

Adding a Soft Lepton

- **Requiring 1 lepton provides a cleaner signature;**
  - QCD background is significantly suppressed
  - EWK backgrounds dominate
- **BUT: SUSY leptons appear at the end of long decay chains**
  - Mass differences between SUSY particles can be small
  - SUSY lepton p_T can be significantly lower than in EWK/tt decays
  - Use exclusive low- p_T lepton selection -> EWK depleted search

SO QCD Dominant – as in hadronic – motivates using α_T approach



Replace N-Jet system with 1-lepton + (N-1)Jet system

1-lepton & N-Jet = 2 kinematically similar to 0-lepton in N-Jet = 3

Use leptonic versions of kinematic quantities -(HT, α_T, etc) where lepton included as a jet.

Event Selection

Selection is taken from Hadronic search with the reversal of the lepton veto.

- Trigger - Lowest unprescaled of HT_100/120/140/150U#
- Jet p_T > 50 GeV , |η| < 3.0, Loose Jet ID
- First Jet |η| < 2.4
- 1 isolated lepton 10 < p_T < 25 GeV
- Veto on photons p_T > 25 GeV
- HT > 350 GeV
- Dead ECAL dR > 0.3
- MHT/MET < 1.25
- α_T > 0.55

Added single soft lepton requirement.

Use standard lepton ID variables
- from CMS Vector Boson Task Force.

Background Estimation Muon Channel – MC at 300pb^{-1}

Cutflow produced at 300pb^{-1} for MC Samples (samples shown in backup)
- Possible signal yield for 4 possible LM benchmark points also shown

Cuts	QCD Multijet	W + jets	Z + jets	$t\bar{t}$ + jets	All SM	LM0	LM1	LM01	LMTau
HT> 250	1067.5	555.1	43.8	317.2	1983.6	173.1	38.4	258.9	239.1
HT> 350	241.8	161.0	12.6	123.6	539.1	128.8	34.2	171.6	164.6
α_T>0.55	0	5.62	0	5.49	11.11	19.58	11.22	34.3	30.9

NB: 300pb^{-1} is a conservative estimate of data available for summer conferences

Benchmark Points exist to evaluate performance
- CMS LM0-9 'Low Mass' points close to exclusion levels

Created 2 points with a low- p_T lepton spectrum (valid MSSM):

- **'LM01'** (uses LM1 gaugino sector and LM0 ~q/~g mass spectrum)
- **'LMTau'** (enhances production of stau)

Leptonic **α_T** analysis is **designed** and thus **favoured** to perform optimally in such scenarios.

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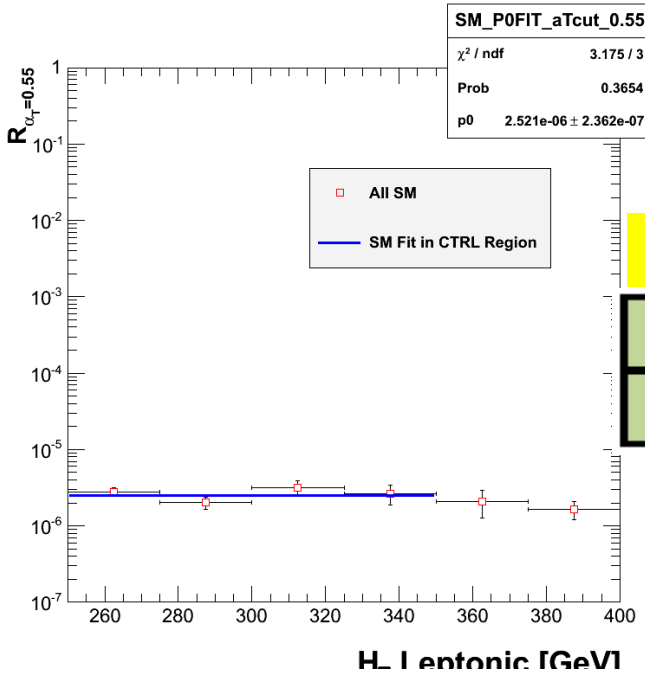
- Lepton requirement reduces statistic in denominator of Rα_T

-Therefore use hadronic selection in denominator (lepton veto)

- Use method in MC as a closure test:



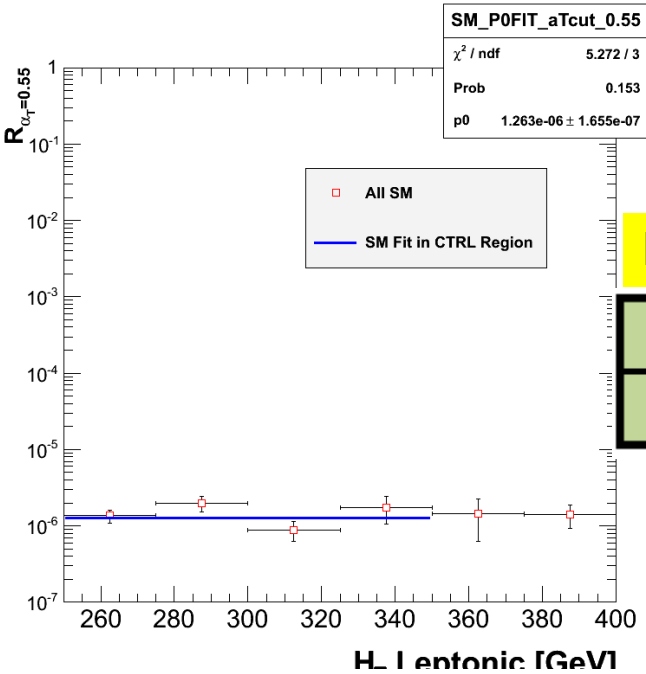
Monte Carlo 300 pb^{-1}

Predicted RAT	Actual N (aT<0.55)	Predicted N (aT>0.55)	Actual N (aT>0.55)
2.52E-06	6.10E+06	15.73 +/- 1.47	11.11 +/- 2.34

Background Estimation Electron Channel – MC at 300pb^{-1}

Cutflow produced at 300pb^{-1} for MC Samples (samples shown in backup)
- Possible signal yield for 4 possible LM benchmark points also shown

Cuts	QCD Multijet	W + jets	Z + jets	$t\bar{t}$ + jets	All SM	LM0	LM1	LM01	LMTau
HT> 250	701.5	312.7	25.3	183.5	1223.0	93.5	20.7	121.6	140.6
HT> 350	211.5	93.6	11.0	70.8	386.8	69.3	18.5	88.3	97.1
α_T>0.55	0	6.55	0	2.43	8.99	10.35	6.27	14.71	19.69



- Lepton requirement reduces statistic in denominator of Rα_T

- Therefore use hadronic selection in denominator (lepton veto)

- Use method in MC as a closure test:

Monte Carlo 300 pb^{-1}

Predicted RAT	Actual N (aT<0.55)	Predicted N (aT>0.55)	Actual N (aT>0.55)
1.26E-06	6.10E+06	7.86 +/- 1.03	8.99 +/- 2.49

Investigating 2010 Data – but not enough statistics with 35pb^{-1}

Plans for 2011 Datasets

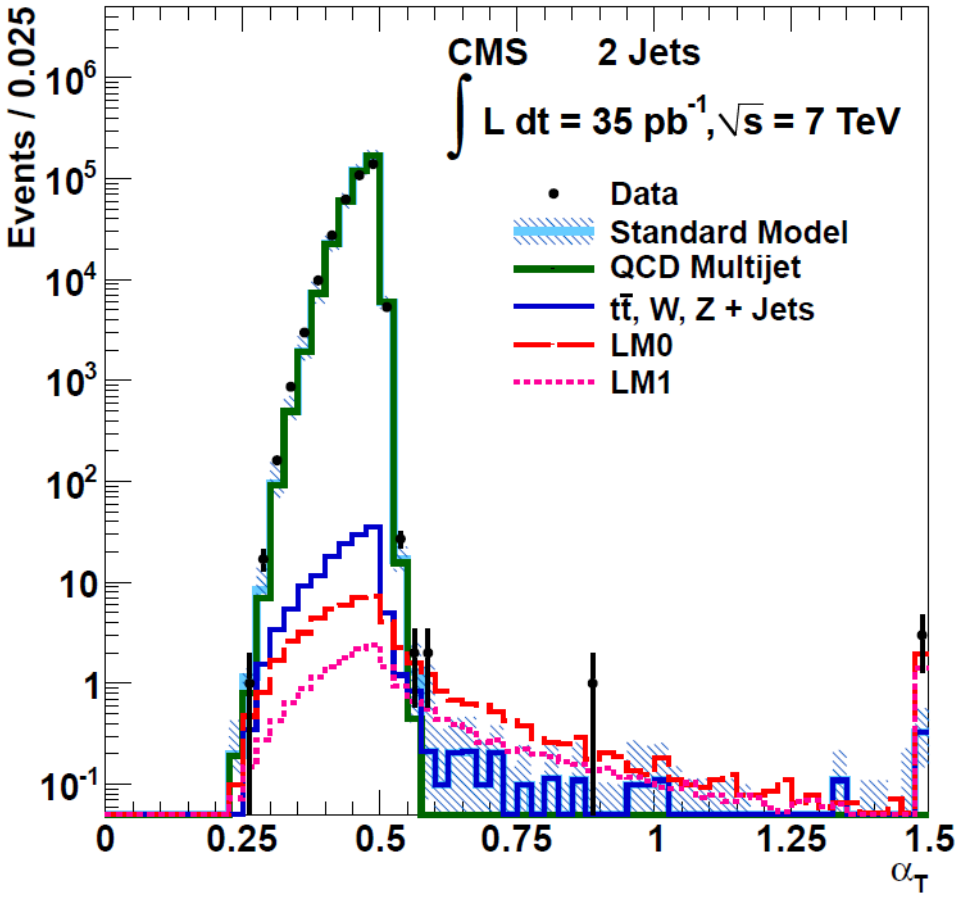
- Use 1-lepton α_T analysis on 2011 CMS Data
- Use α_T trigger for Signal Selection
  - also still need HT triggers for denominator
- Investigate other background estimation methods
- Publish results for Summer Conferences

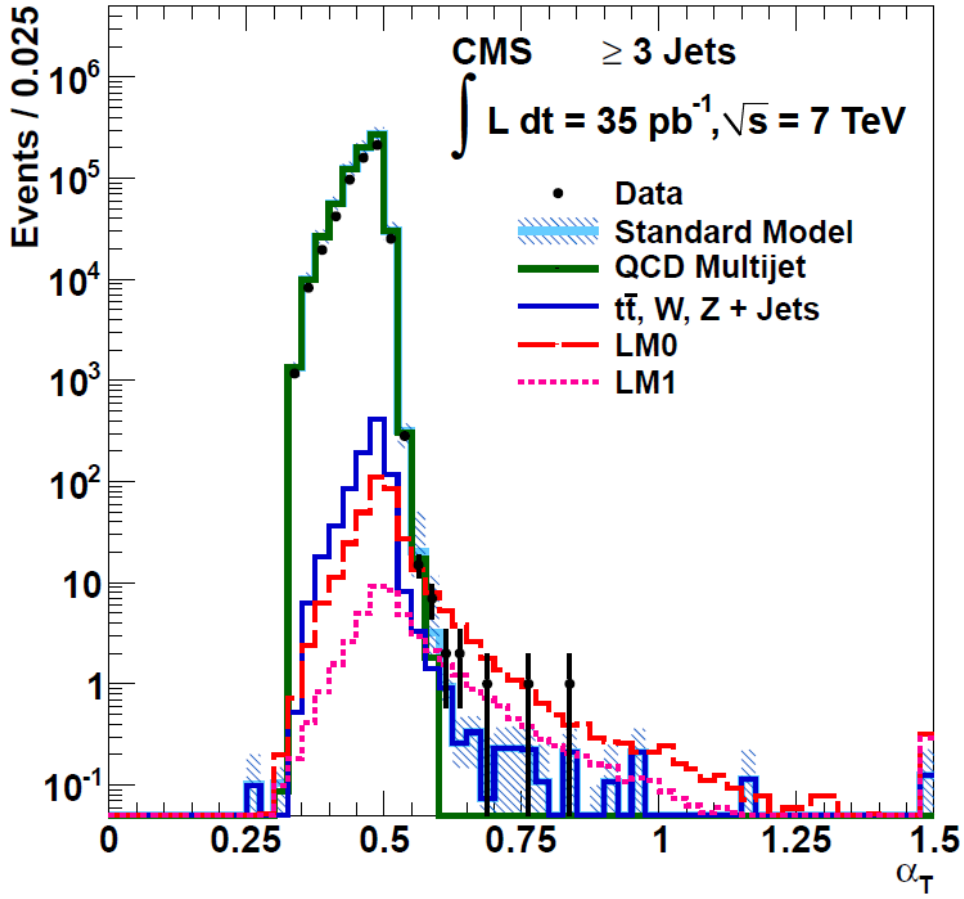
  - 0.5 – 1.0 fb^{-1} data at 7TeV

Backup Slides

Hadronic Analysis

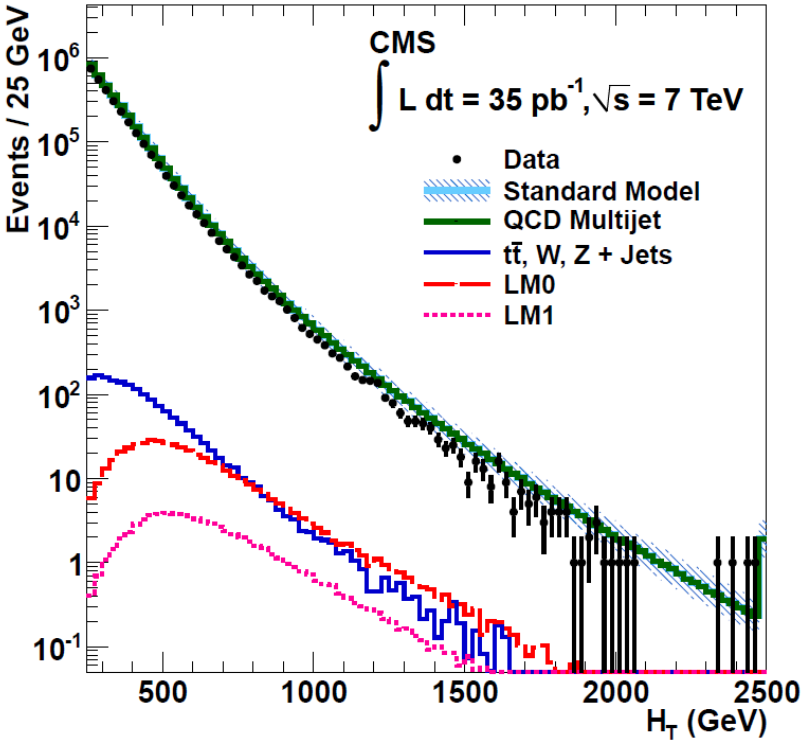
α_T distributions – dijet and >2jets





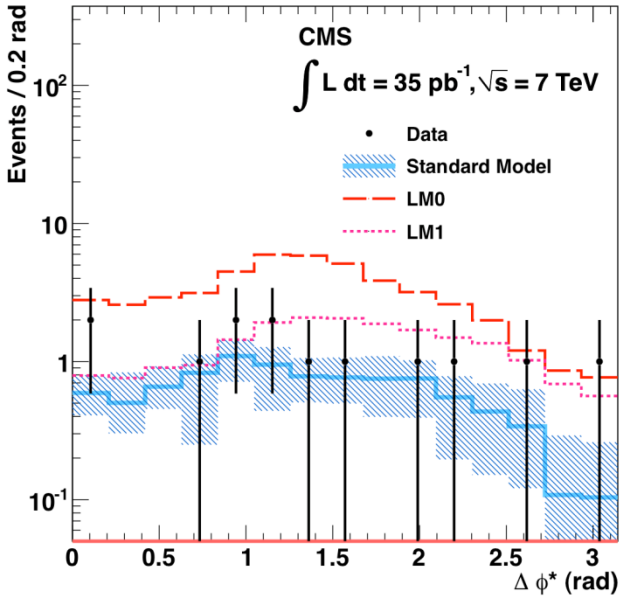
Hadronic Analysis

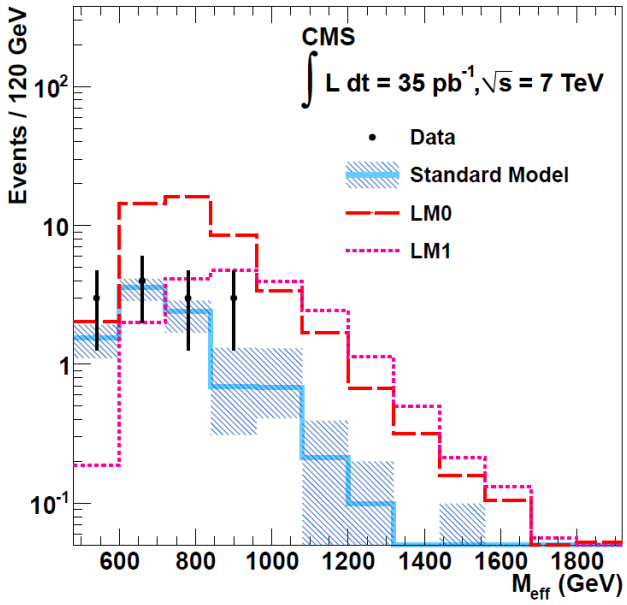
HT Distributions



Dphi/Meff of 13

passed events

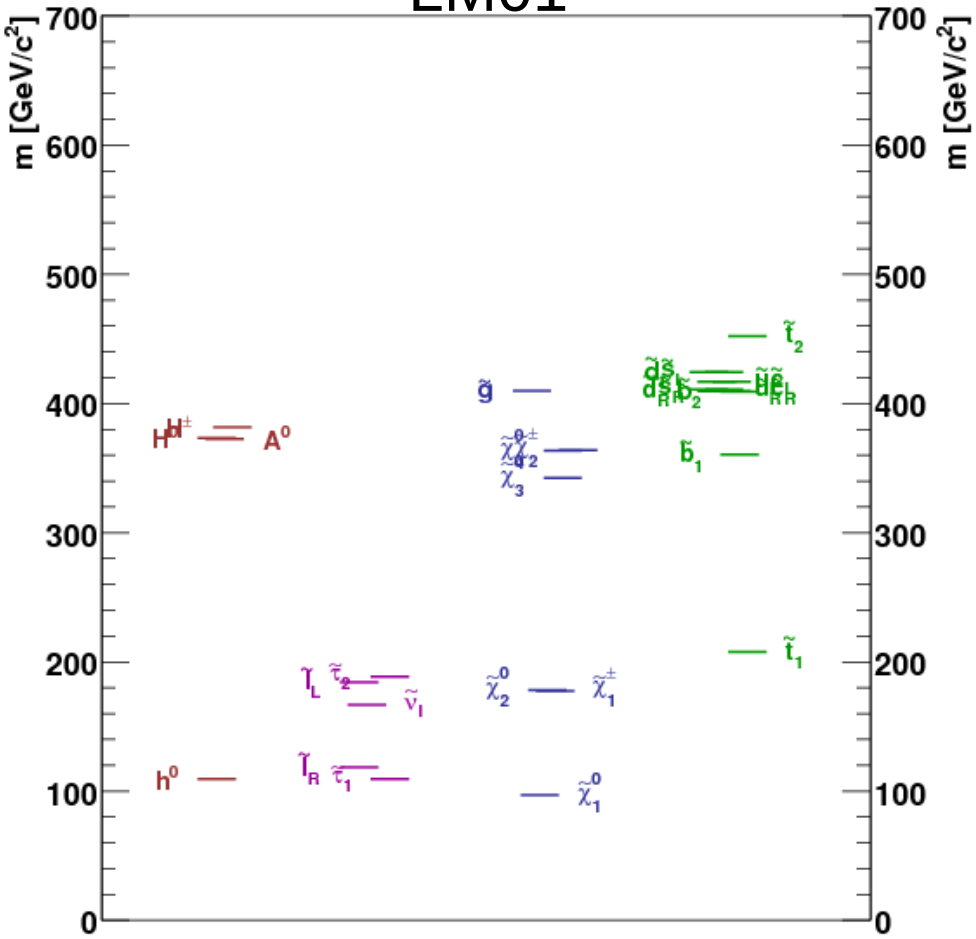




New LM Benchmark Points

Mass Hierarchies in the new benchmark points.

LM01



LMTau