Kinematic Searches for Missing Energy at CMS

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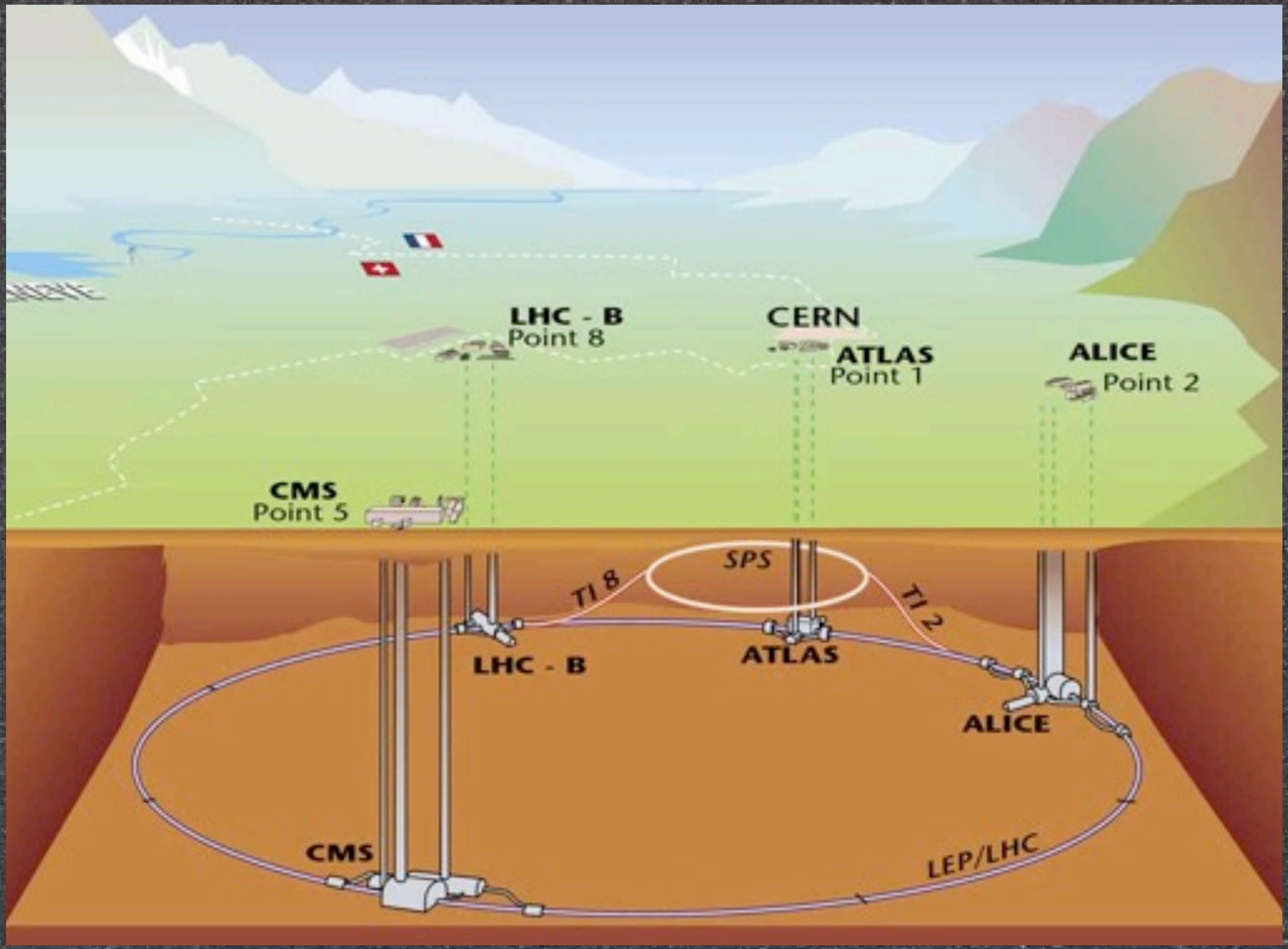
Contents

The Large Hadron Collider



Design

$$\mathcal{L} \approx 10^{34}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1}$$

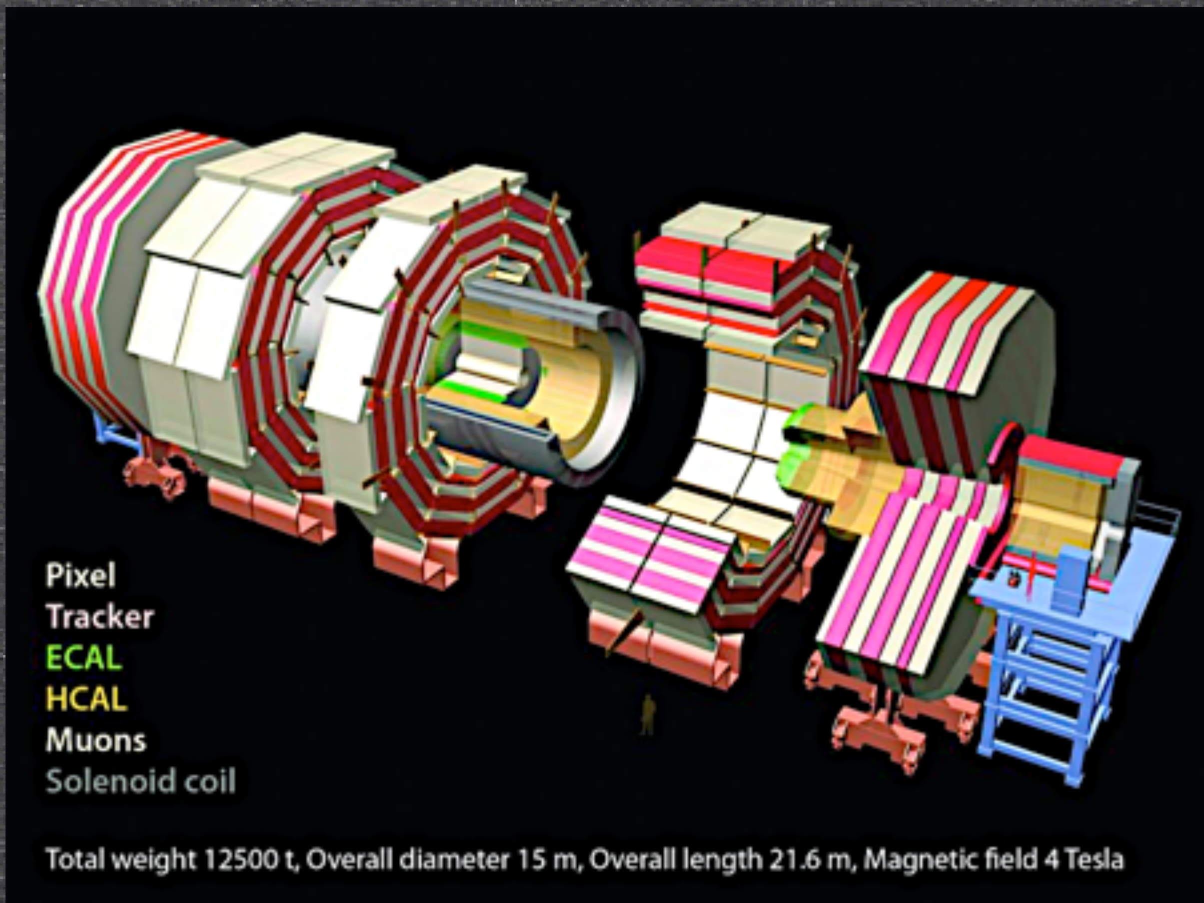
$$\sqrt{s} = 14\ \mathrm{TeV}$$

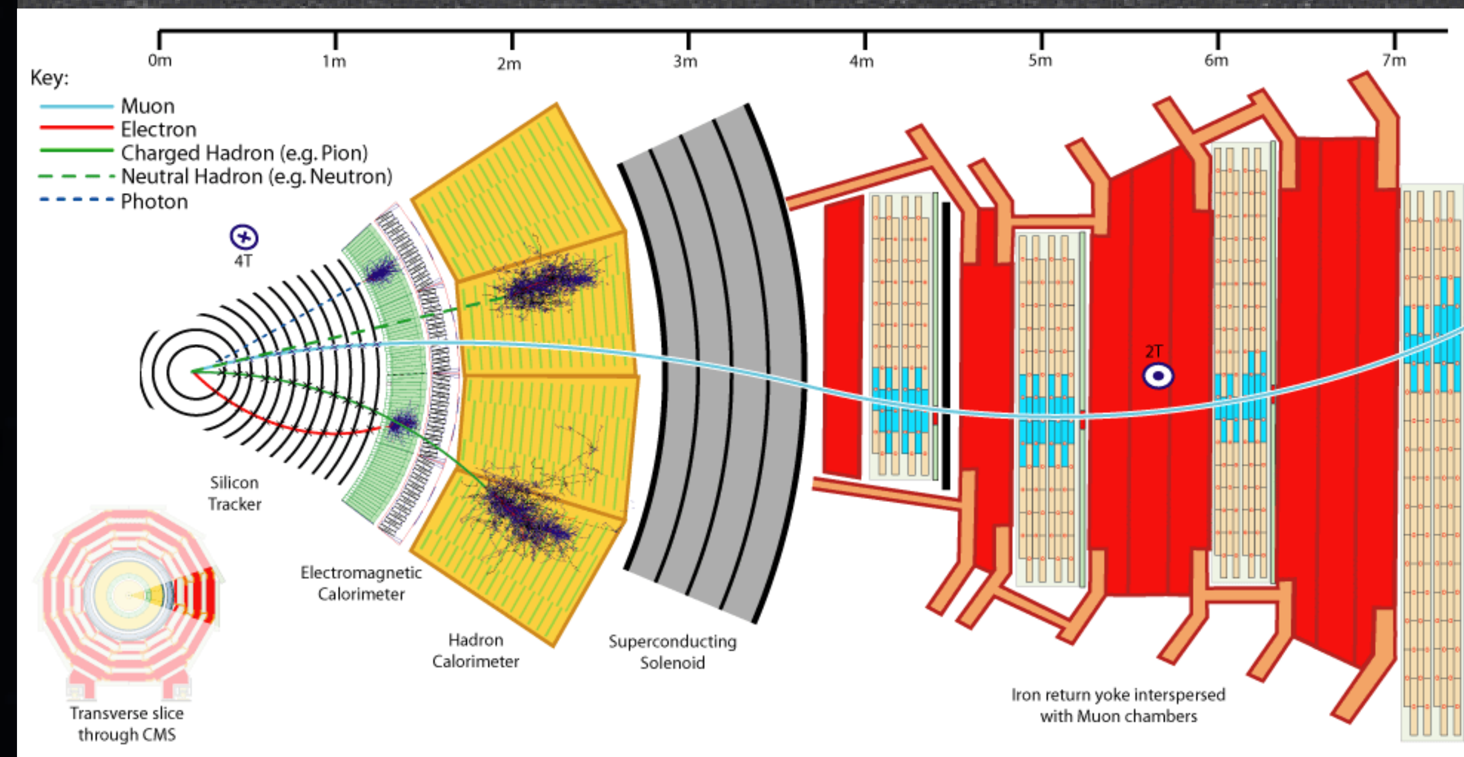
2010-2011

$$\mathcal{L} \approx 10^{32}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1}$$

$$\sqrt{s} = 7\ \mathrm{TeV}$$

The Compact Muon Solenoid





- Trigger on: calorimeter Deposits & Muon Chamber Hits
- Global Calorimetry Trigger selects Jet candidates and missing energy

SuperSymmetry

Motivations:

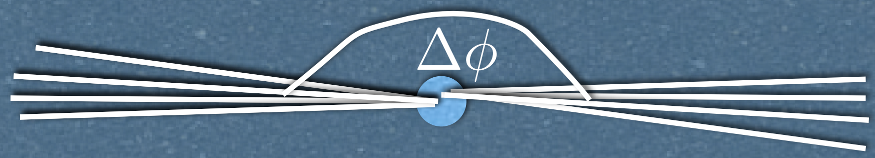
- Natural Extension to SM
- Light SUSY provides solution to hierarchy problem
- Provides a Dark Matter candidate

Predictions:

- Multitude of new particles
- If R-Parity conserving, large missing energy signature

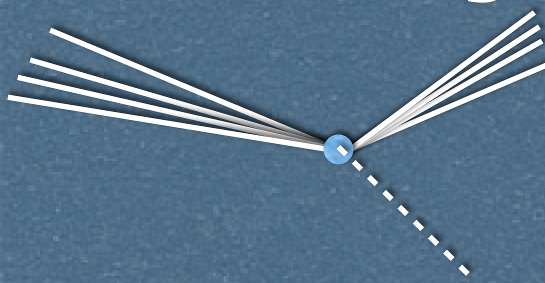
Kinematic Selection

Ideal Dijet



$$\sum_{jets} \mathbf{p}_T = 0$$

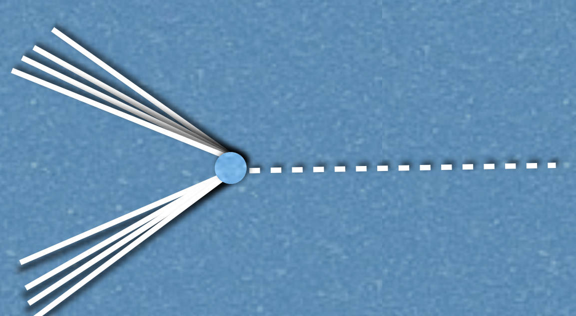
Miss-measured Dijet



Fake Missing $\mathbf{p}_T$

$$\sum_{jets} \mathbf{p}_T \neq 0$$

Real Missing $\mathbf{p}_T$



$$\sum_{jets} \mathbf{p}_T = -\not{p}_T$$

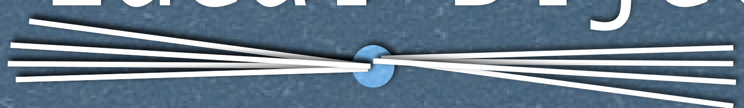
At LHC, primary background is QCD. How to reduce this background?

Kinematic Selection 2

Define $\alpha = \frac{\mathbf{p}_{T2}}{m_{jj}}$ (L. Randall & D. Tucker-Smith)

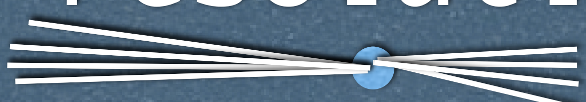
In the Massless limit + Hadron machine $\Longrightarrow$ $\alpha_T = \frac{\sqrt{E_T^{j2}/E_T^{j1}}}{\sqrt{2(1-\cos\Delta\phi)}}$

Ideal Dijet



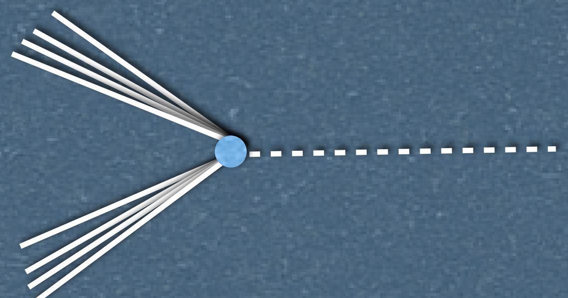
$\alpha_T = 0.5$

Poor energy resolution



$\alpha_T < 0.5$

Real Missing Energy

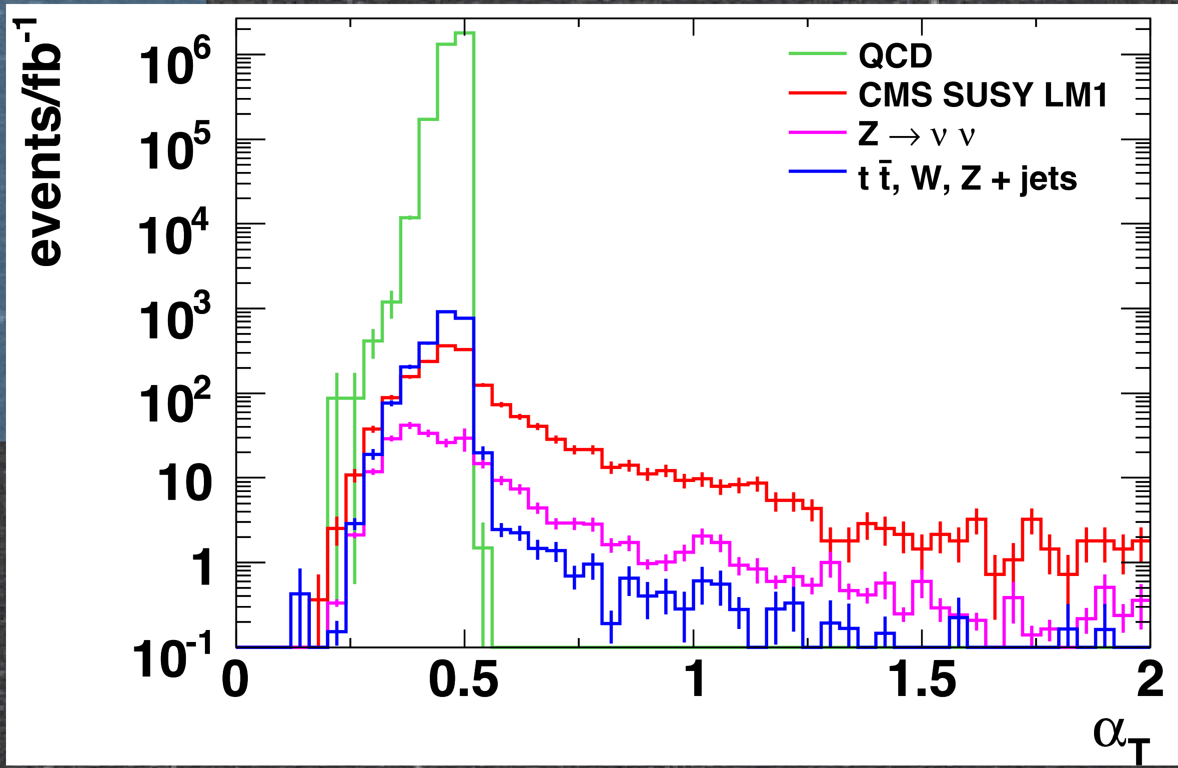


$\alpha_T > 0$

Cuts

$p_T > 100$ GeV

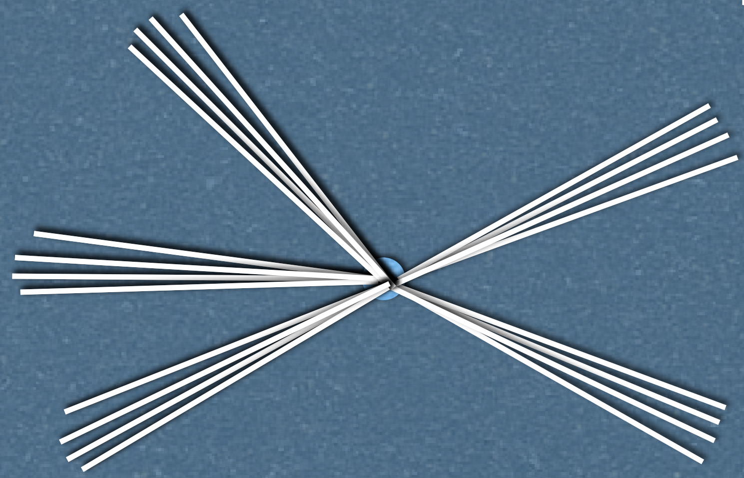
$|\eta_{j1}| < 2$



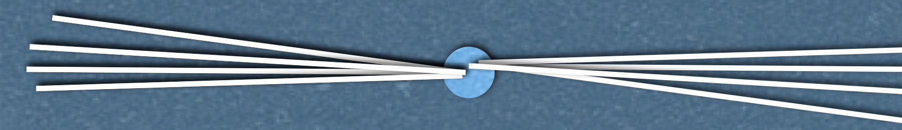
(CMS-AN 2008/114)

Multi-jet Extension

Njets merged to form most conservative dijet



Ideal Dijet



$$\sum_{jets} \mathbf{p}_T = 0$$

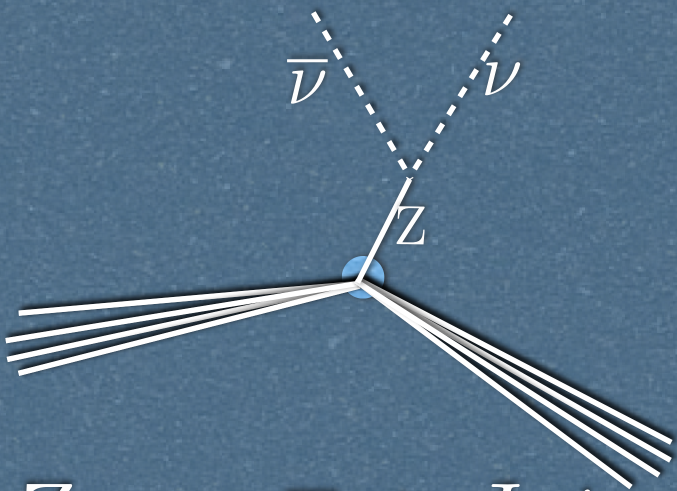
Extended up to 6 Jets

Most conservative combination selected

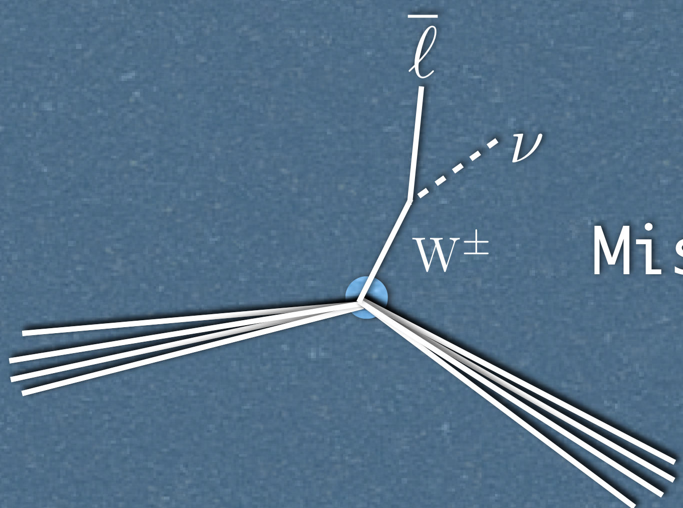
+ Additional Cut

$p_T(jet\ n > 2) > 50\ \mathrm{GeV}$

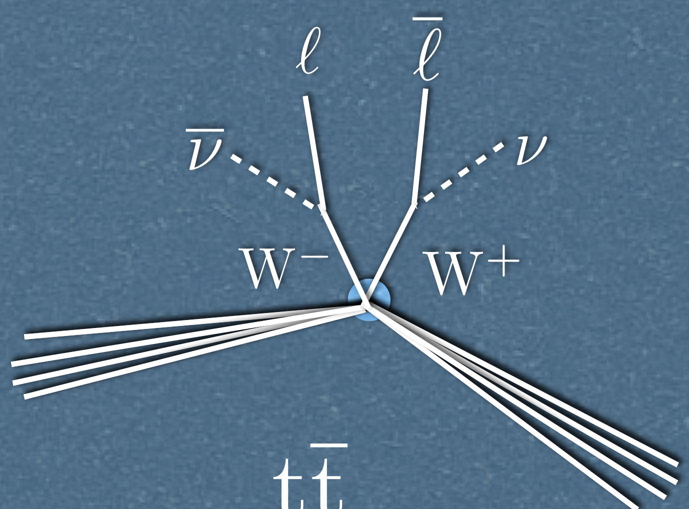
Standard Model Missing Energy Signals



$Z \rightarrow \nu\overline{\nu} + Jets$



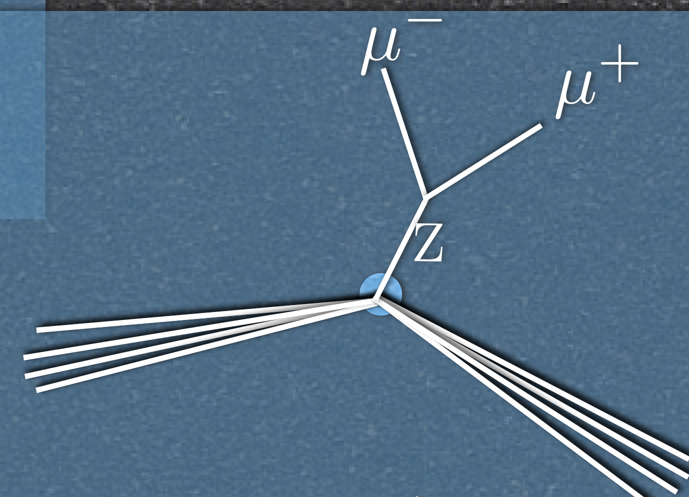
Miss Lepton



$t\overline{t}$

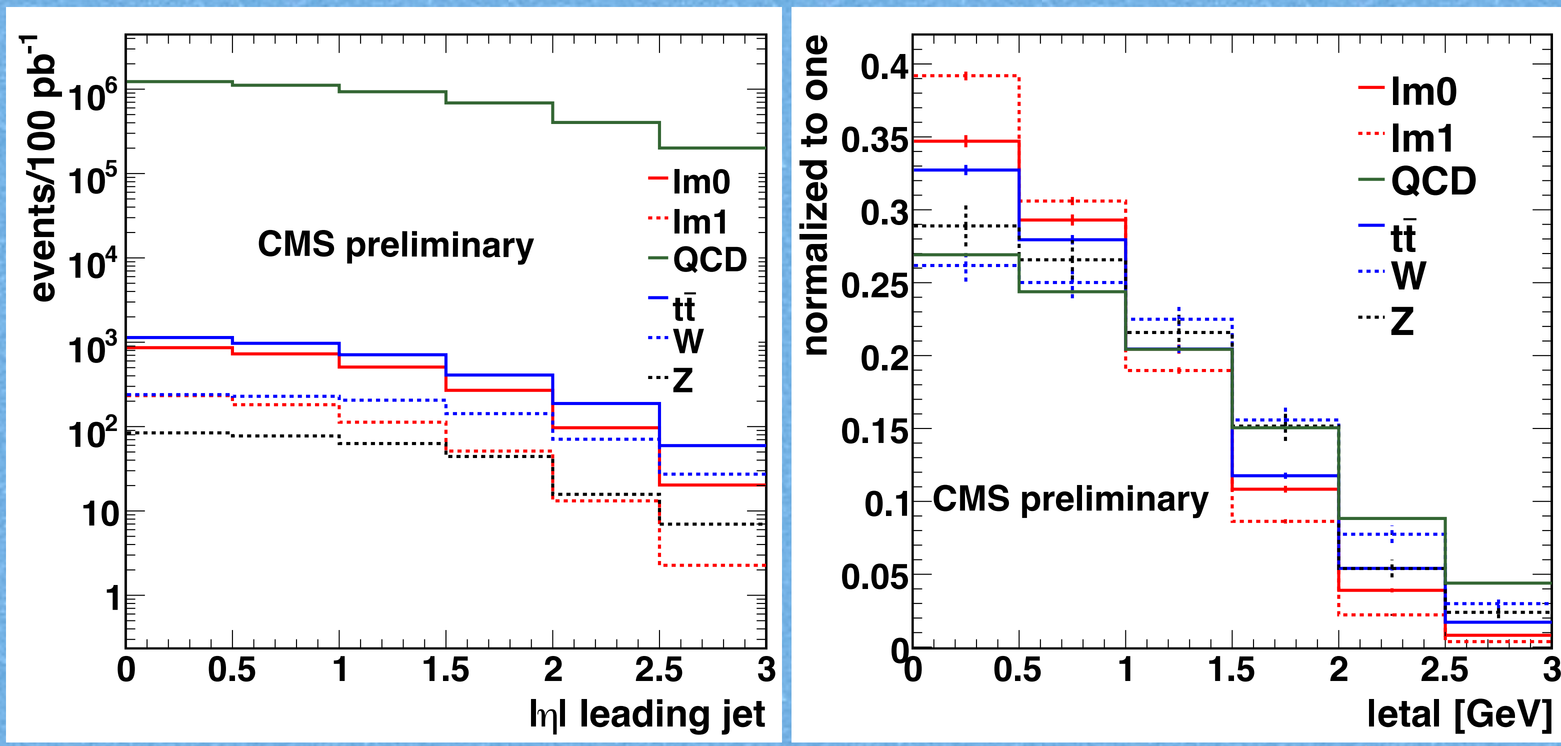
Miss one lepton/
No tau veto

Can we reduce these backgrounds?



$Z \rightarrow \mu^{-}\mu^{+} + jets$

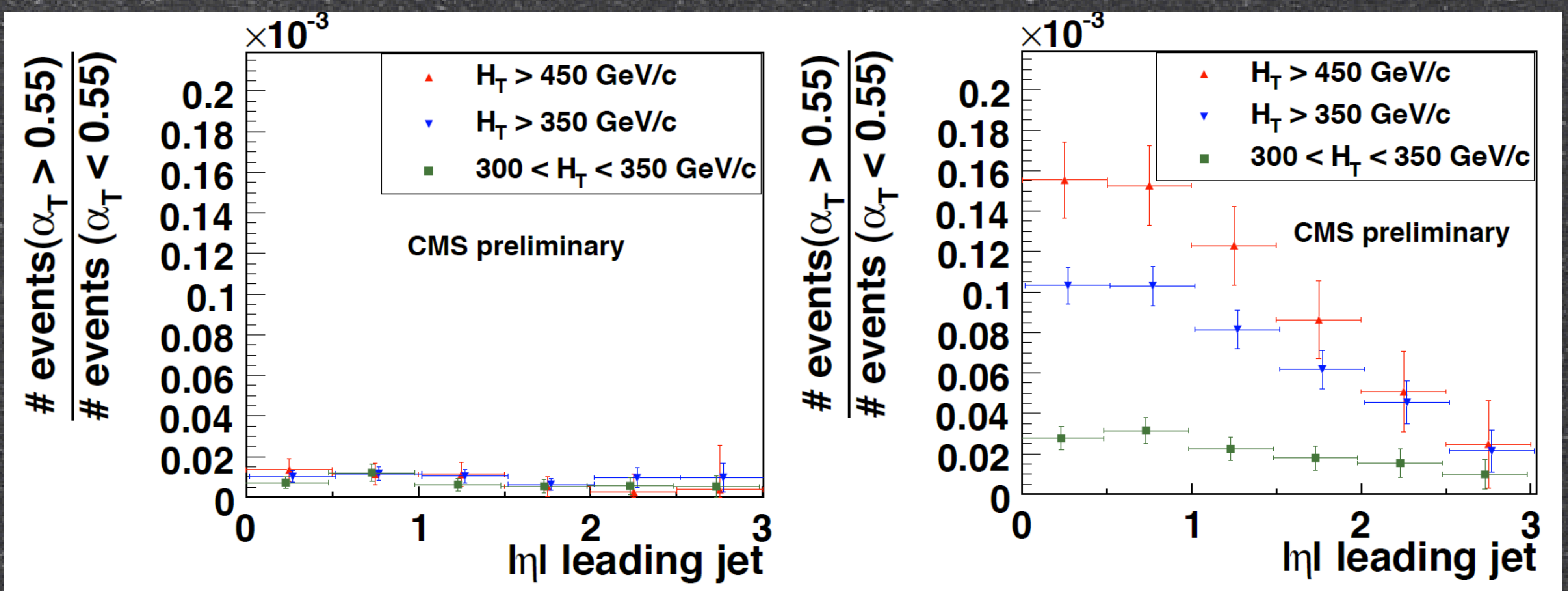
α_T discovery potential



(a) Distribution of the leading jet $|\eta|$ (b) Normalized distribution of the leading jet $|\eta|$

Parameter to test alpha T against

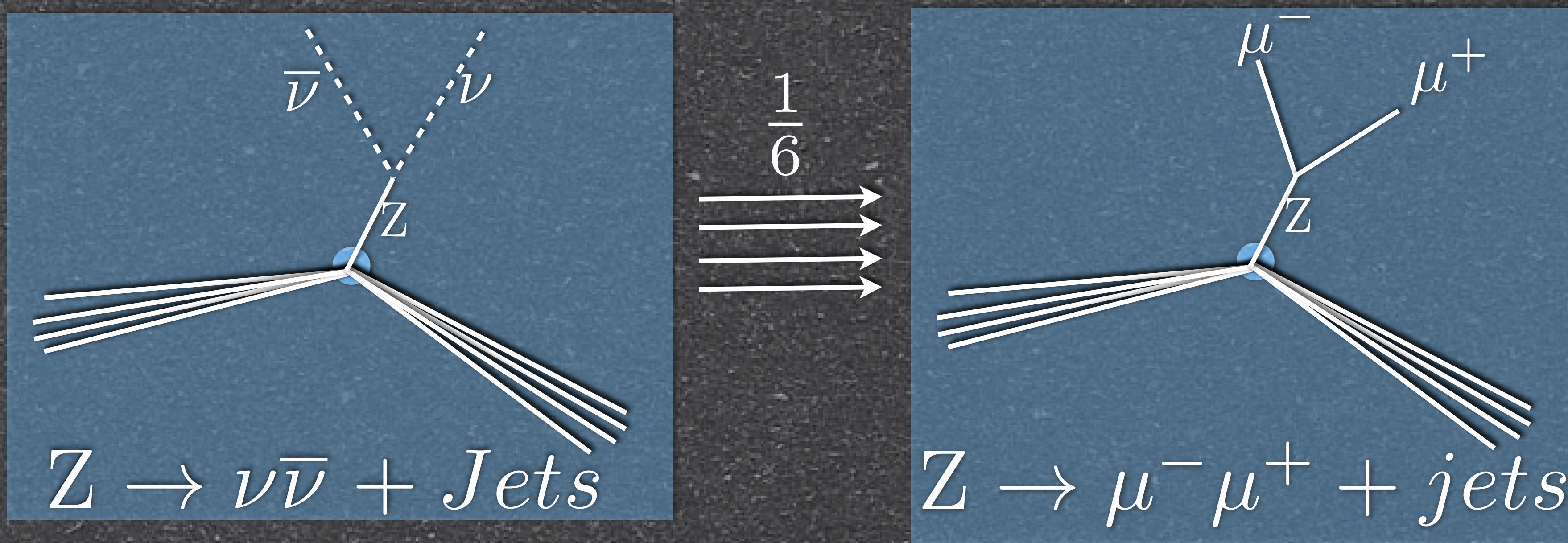
Distinguishing a non-SM signal



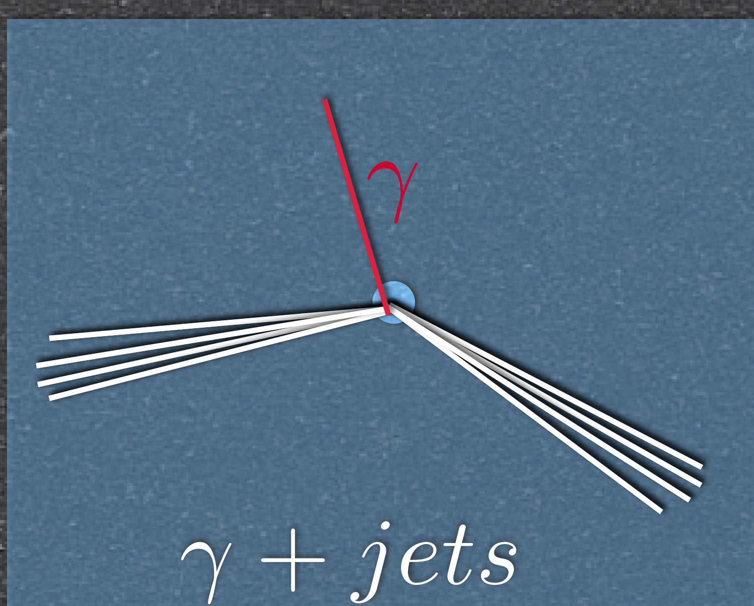
(b) SM background only (a) SUSY(LM0) + SM background

Questions?

Data Driven Background Estimation



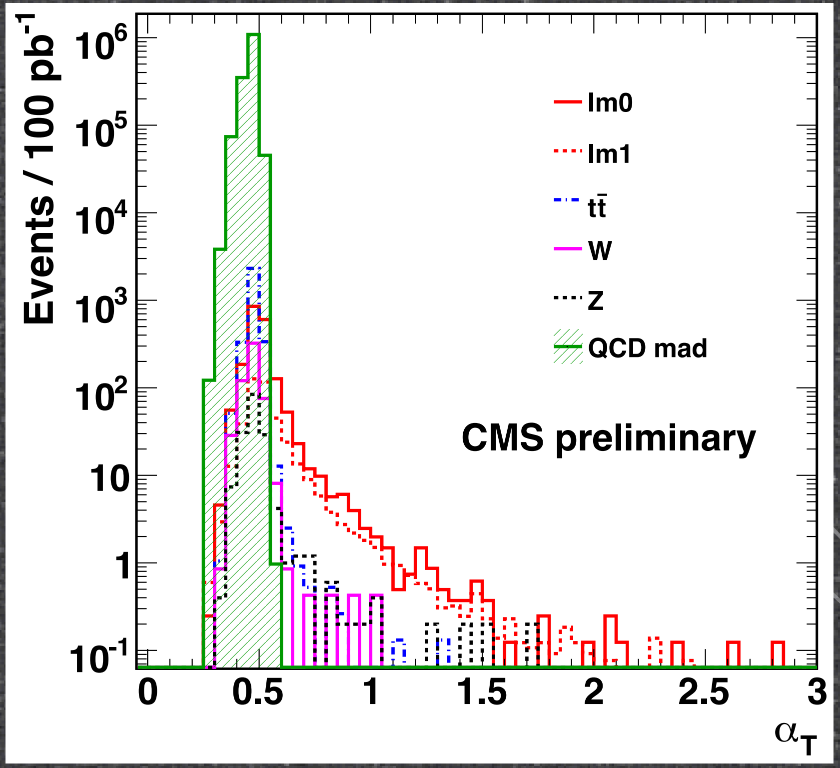
Repeat Analysis with muons ignored offline. Gives a clean signal, however low statistics with 100pb^{-1} of data.

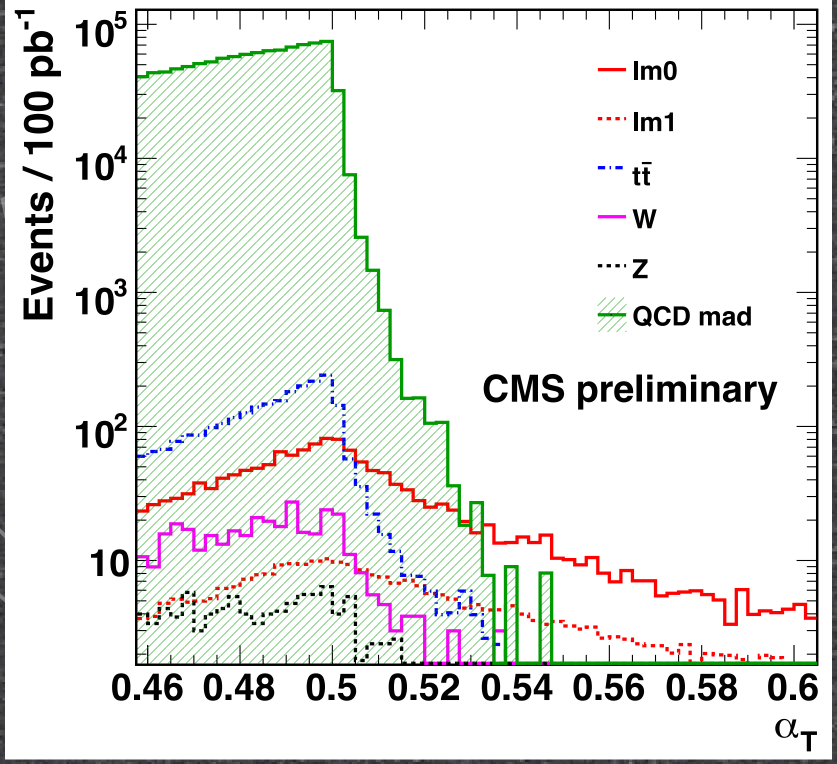


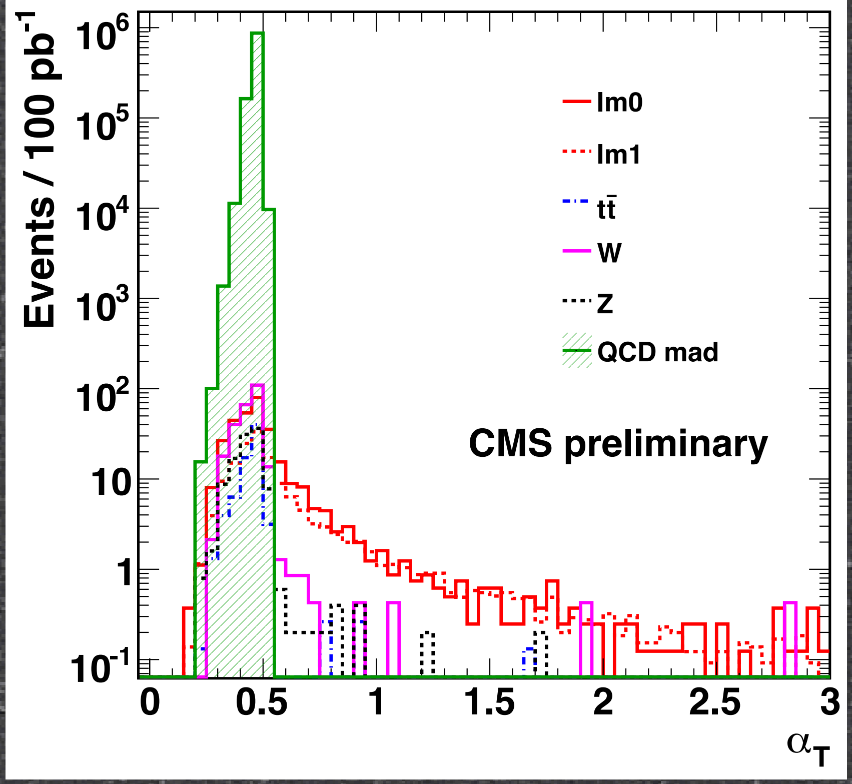
Clean signal above $E_\gamma = 100\,\mathrm{GeV}$

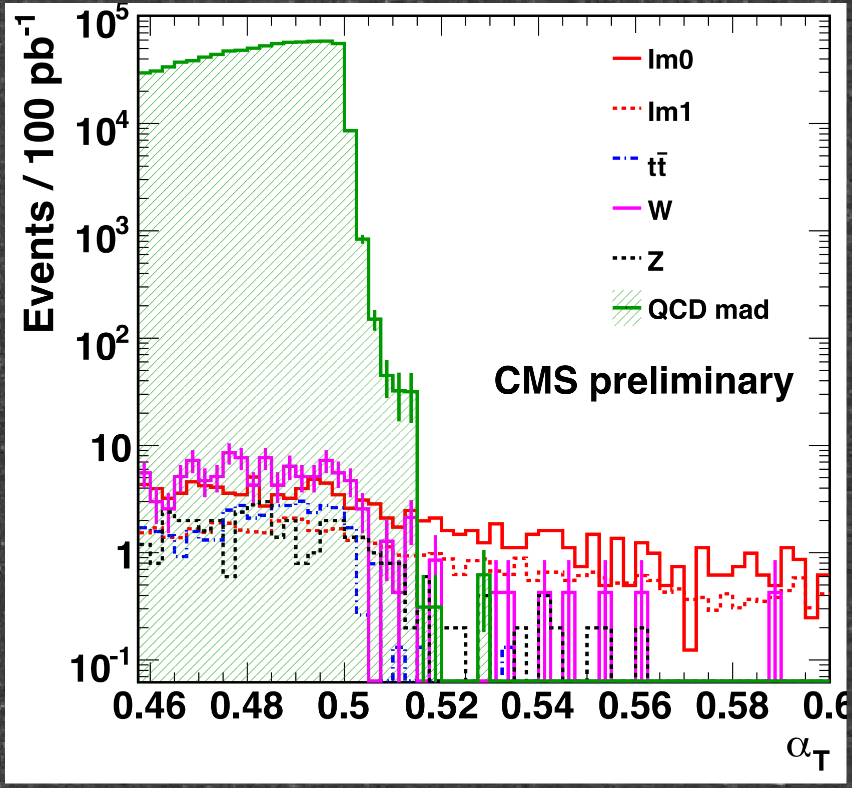
Back ups 1

Multi-Jet Events









Dijet Events

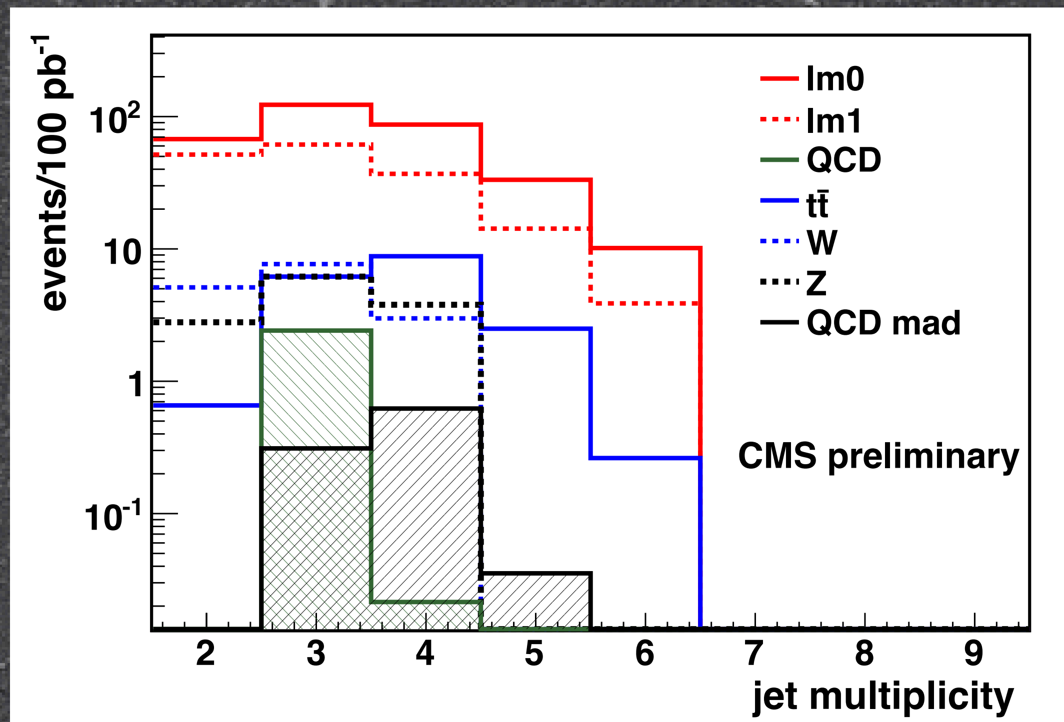
< 3. Right: a zoomed version for 0.46 < α_T < 0.6.

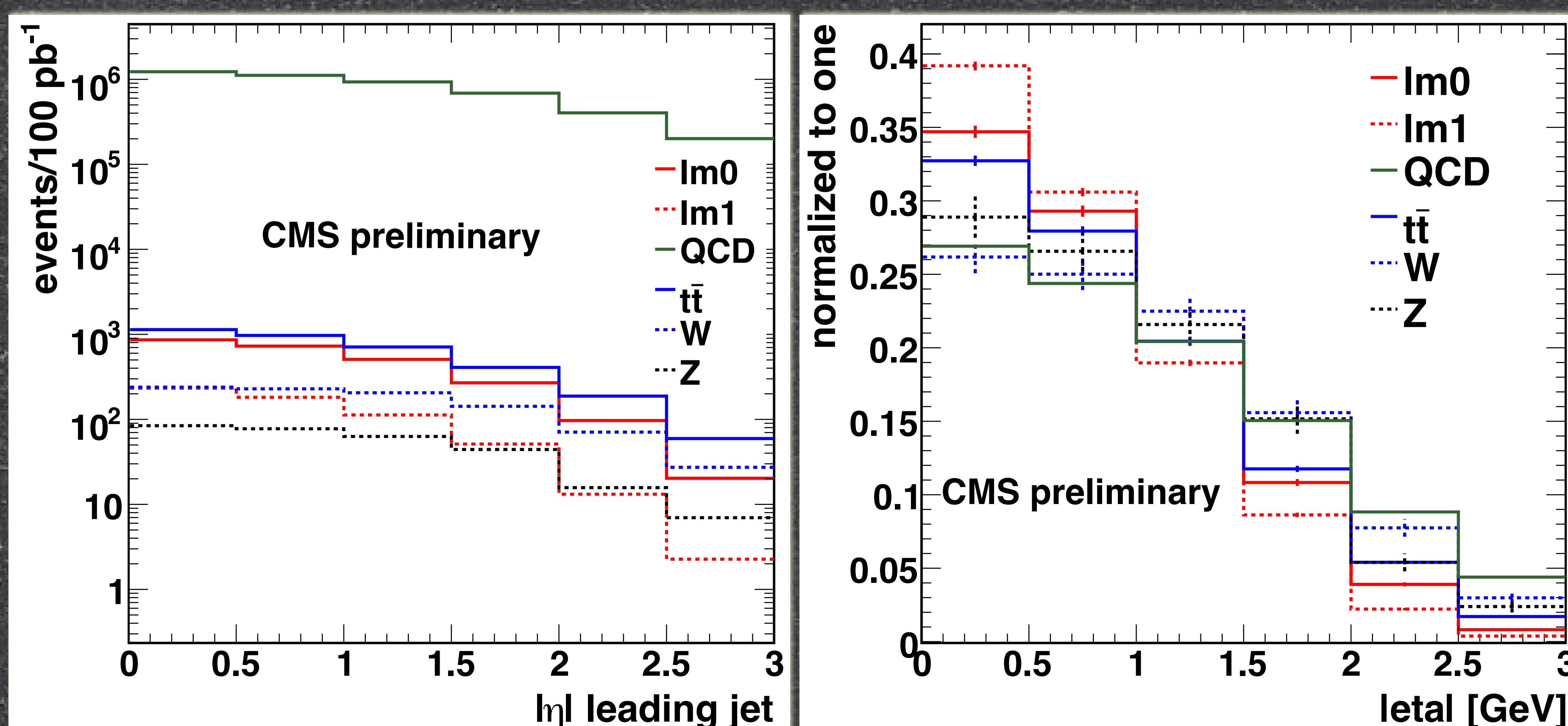
Event Selection

- Preselection cuts & Trigger (still from 10 TeV studies)
  - Trigger: jet110.
  - Define clean jet environment:
  - Veto electrons or global muons with $P_T > 10$ GeV
  - Veto Photons with $P_T > 25$ GeV
  - Jets $P_T > 50$ GeV, $|\eta|$ jets < 3 ($F_{em} < 0.9$)
  - No jet candidate with $P_T > 50$ GeV which was not selected. We cannot affort to have unidentified high p_T objects in the detector => MET!
  - Two jets with $p_T > 100$ GeV.
  - $|\eta|$ leading jet < 2.

$$H_T = \sum_{i=1}^{n} p_T^{\mathrm{jet}_i} > 350\ \mathrm{GeV}$$

This selection also defines the jet multiplicity.





(a) Distribution of the leading jet $|\eta|$

(b) Normalized distribution of the leading jet $|\eta|$

Sample	m_0 (GeV)	$m_{1/2}$ (GeV)	A_0	$\tan\beta$	sign(μ)	σ NLO (pb)	(LO) (pb)	lightest $\tilde{q}$ (GeV)	χ_1^0 (GeV)
LM1	60	250	0	10	+	54.86	(43.28)	410 ($\tilde{t}_1$)	97
LM2	185	350	0	35	+	9.41	(7.27)	582 ($\tilde{t}_1$)	141
LM3	330	240	0	20	+	45.47	(34.20)	446 ($\tilde{t}_1$)	94
LM4	210	285	0	10	+	25.11	(19.43)	483 ($\tilde{t}_1$)	112
LM5	230	360	0	10	+	7.75	(5.96)	603 ($\tilde{t}_1$)	145
LM6	85	400	0	10	+	4.94	(3.84)	649 ($\tilde{t}_1$)	162
LM7	3000	230	0	10	+	6.79	(3.82)		
LM8	500	300	-300	10	+	12.19	(8.81)	546 ($\tilde{t}_1$)	121
LM9	1450	175	0	50	+	39.79	(23.28)		

Robustness

One random jet in each event rescaled