Inclusive Search for New Physics at CMS with Jets and Missing Momentum Signature

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5th Annual Workshop
of the Helmholtz Alliance
"Physics at the Terascale"

Published results ($1.1fb^{-1}$): PAS SUS-11-004

Bundesministerium
für Bildung
und Forschung

Outline

- **Introduction to Jets + MET analysis**
- **Overview data-driven background estimations**
- **Details on the lost lepton background**
- **Results and Outlook**

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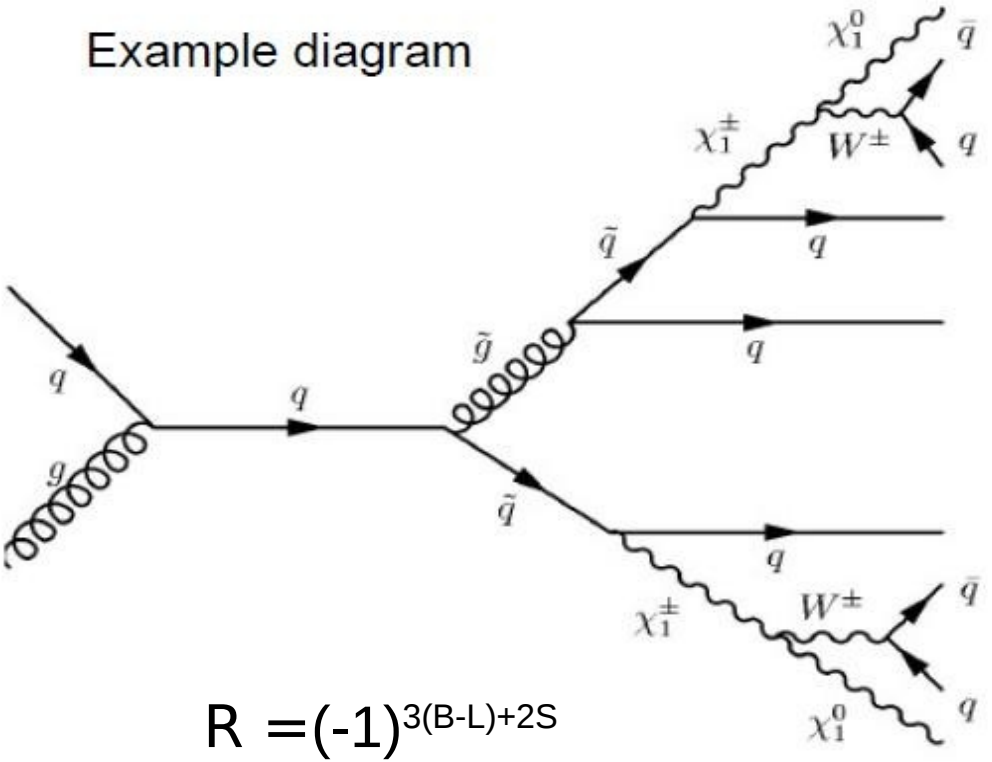
Supersymmetry

Search for new physics at the CMS experiment

- Search for R-parity conserving SUSY
  - Pair production of SUSY particles
  - pp-collider: production of gluinos squarks cascade to LSP
    - Detector: High number of jets
  - Stable LSP in final state
    - Detector: Missing Energy

Example diagram



$R = (-1)^{3(B-L)+2S}$

Generic search for new physics

Selection

- $N_{jet} \geq 3$ ($P_T > 50$ GeV, $|\eta|<2.5$) [central production]
- Require minimal $\Delta\phi$(MHT, $jet_{1,2,3}$) (reject events with aligned MHT and missmeasured jet)
  - Reduce QCD with mismeasured jet
- Veto on e/μ (reduce background from W+Jets & ttbar)
  - Dedicated lepton SUSY analyses

- **Baseline:**
- **HT > 350 GeV** ($\sum|P_T|$ of the jets)
- **MHT > 200 GeV** ($-\sum P_T$ of Jets $P_T > 30$ GeV, $|\eta|<5.0$)

- Search regions
  - High HT > 800 GeV
  - High MHT > 500 GeV (inc HT > 800 GeV)

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Data vs SM expectation (MC)

There are four main backgrounds from SM processes

- $Z \rightarrow \nu\nu$ (not reducible)
- QCD: Mismeasuret Jets
- TTbar/W + Jets: real MHT, hadronic tau
- TTbar/W + Jets: real MHT, lost lepton

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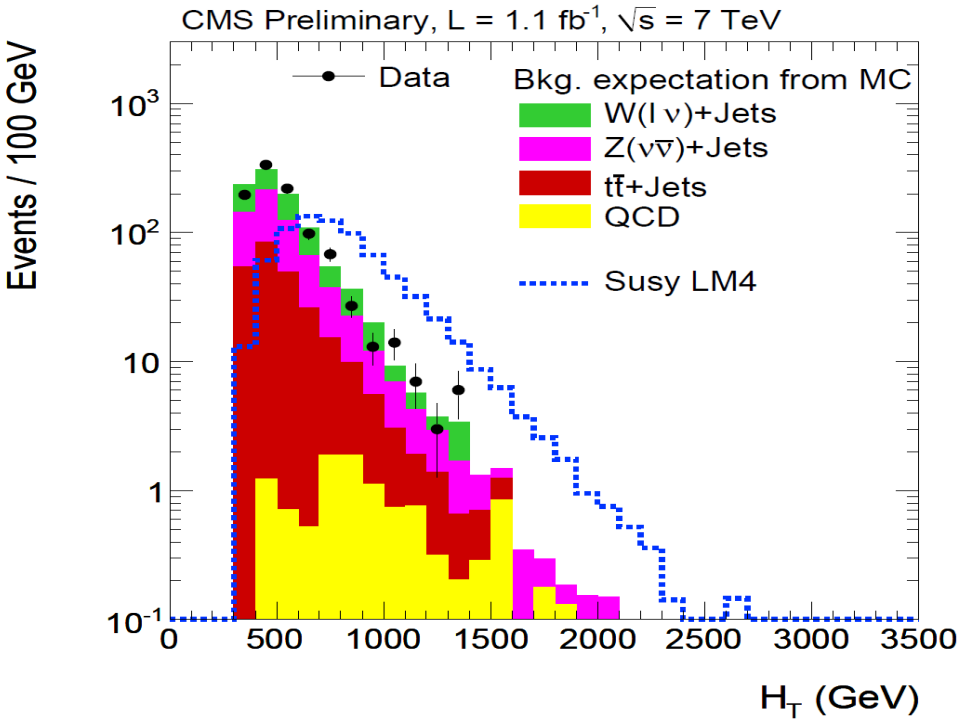
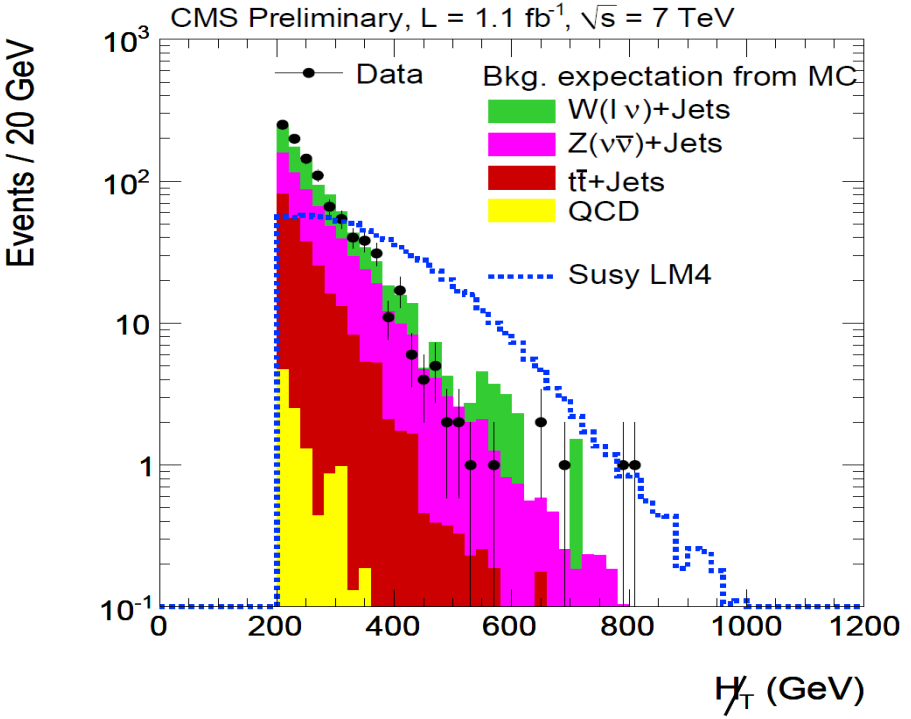
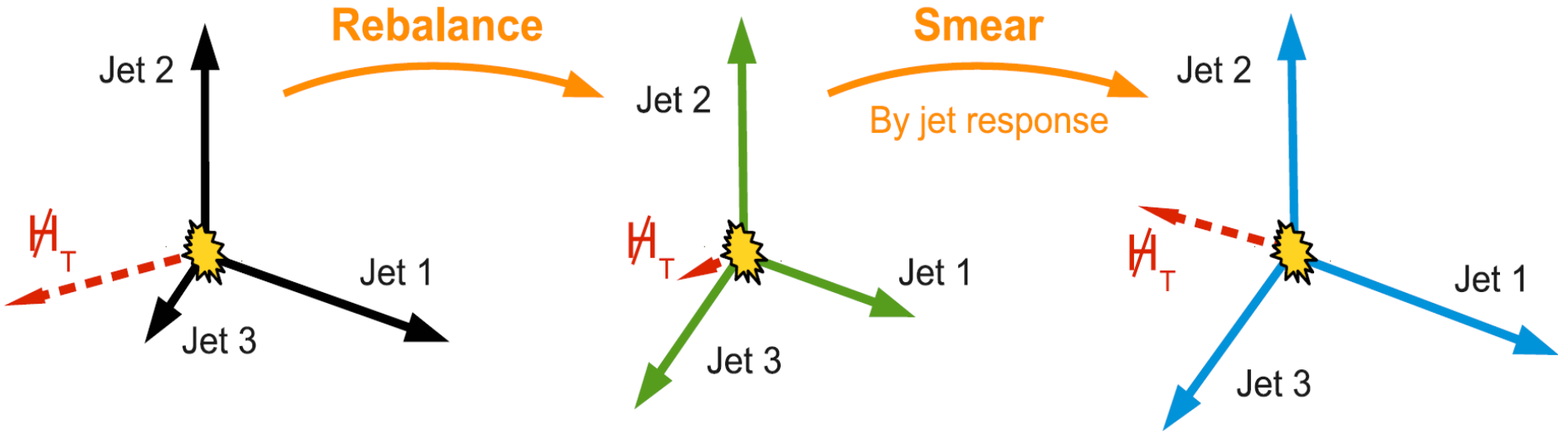




All backgrounds are data driven estimated!
No MC is used beyond this point, except for cross-check!

QCD Background estimations

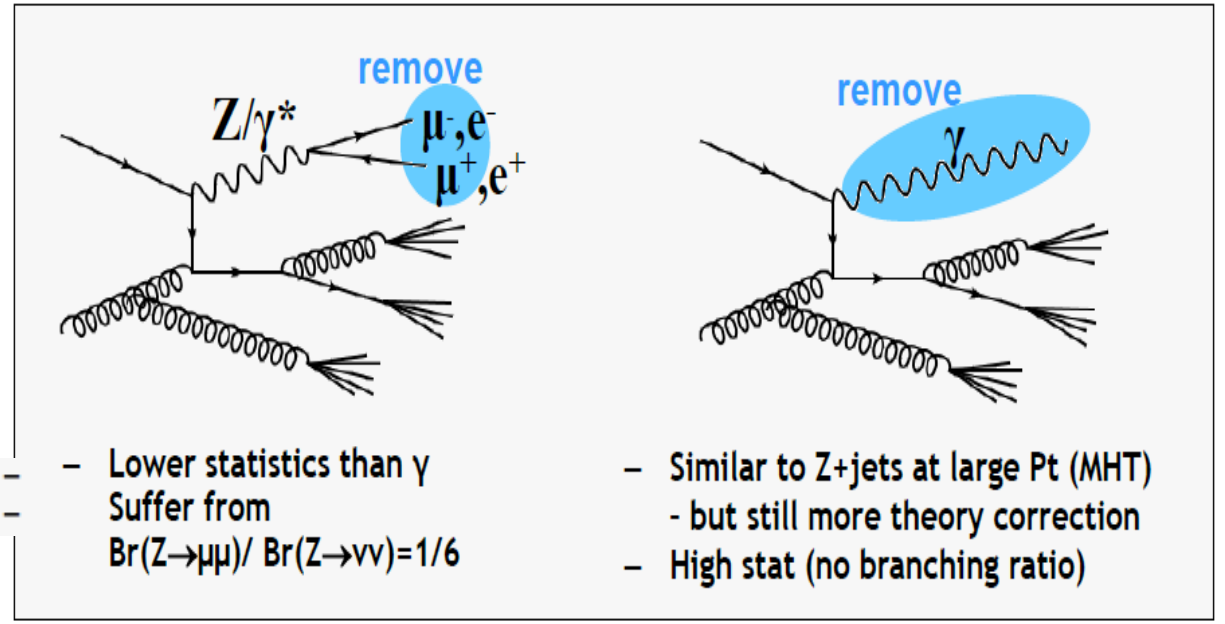
- QCD – rebalance and smear method
  - Predict MHT from jet resolution
  - Rebalance event by event
  - Smear by jet response



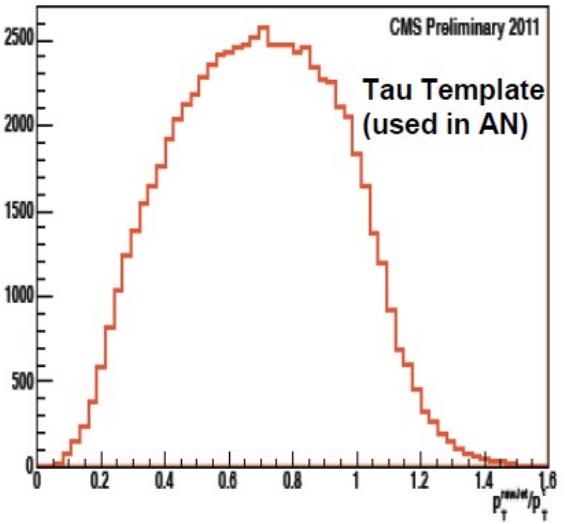
Details: PAS SUS-11-004

Z-> νν, hadronic tau Background estimations

- Z – estimation from photon + Jets
  - Remove photon



- W → tau
- Hadronic tau – replace muon with Jet from tau template



Tau response from MC

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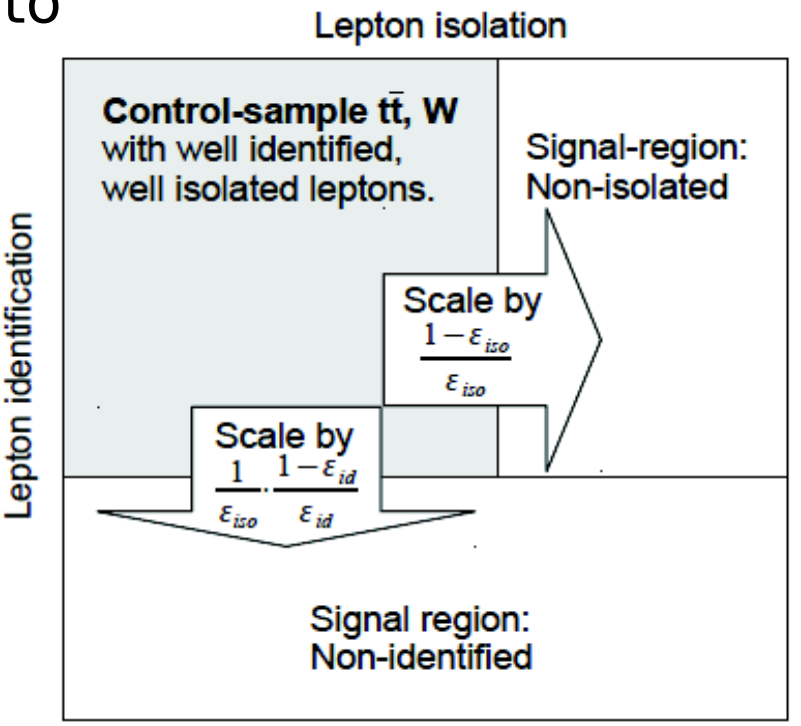
W/Top + (Lost Leptons) + ν + Jets

- Electrons & muons not removed by the lepton veto contribute to background
- There can be three reasons to lose leptons
  - the lepton is not reconstructed
  - not isolated
  - out of acceptance estimated from MC

W/Top + (Lost Leptons) + ν + Jets

- **Muon control sample** (CS):
  - All search cuts except lepton veto
  - Exactly one isolated muon,

    no electron
- Scale the control sample according to the measured (in)efficiencies
- Measure the identification and isolation (in)efficiencies from data with the “Tag & Probe” - method on the Z-resonance
- Parametrize ID-eff. in lepton P_T & η
- Isolation-eff. in ΔR(lep, jet) and P_T(lep)/P_T(jet)

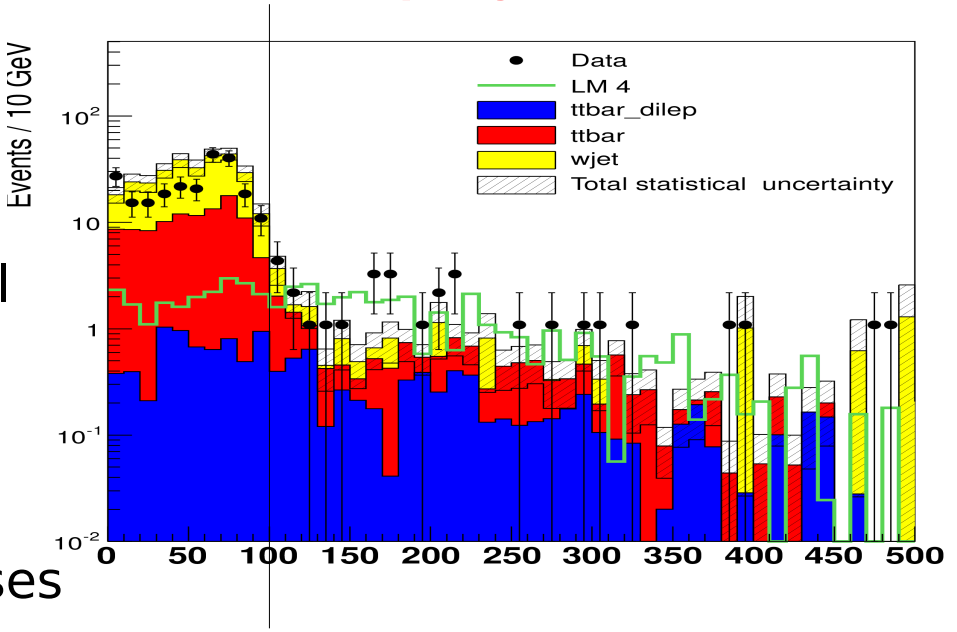


Signal Contamination in the background prediction

- Signal contamination decreases sensitivity
  - Transverse mass cut to reduce signal contamination
- MET in W & $t\bar{t}$ events
  - Muon and MET can be combined to m_T
  - Only dileptonic decays and mismeasured MET lead to tails
  - Apply cut at m_T=100 GeV
  - Removes 10% of CS but 50% signal for LM4 for the baseline selection
  - Even more eff. for higher MHT cuts
  - Fraction of signal contamination of the background estimation decreases
- m_T(W) cut improves sensitivity!

$$m_T = \sqrt{2 p_T^{\mu} \not{E}_T (1 - \cos(\Delta\phi))}$$

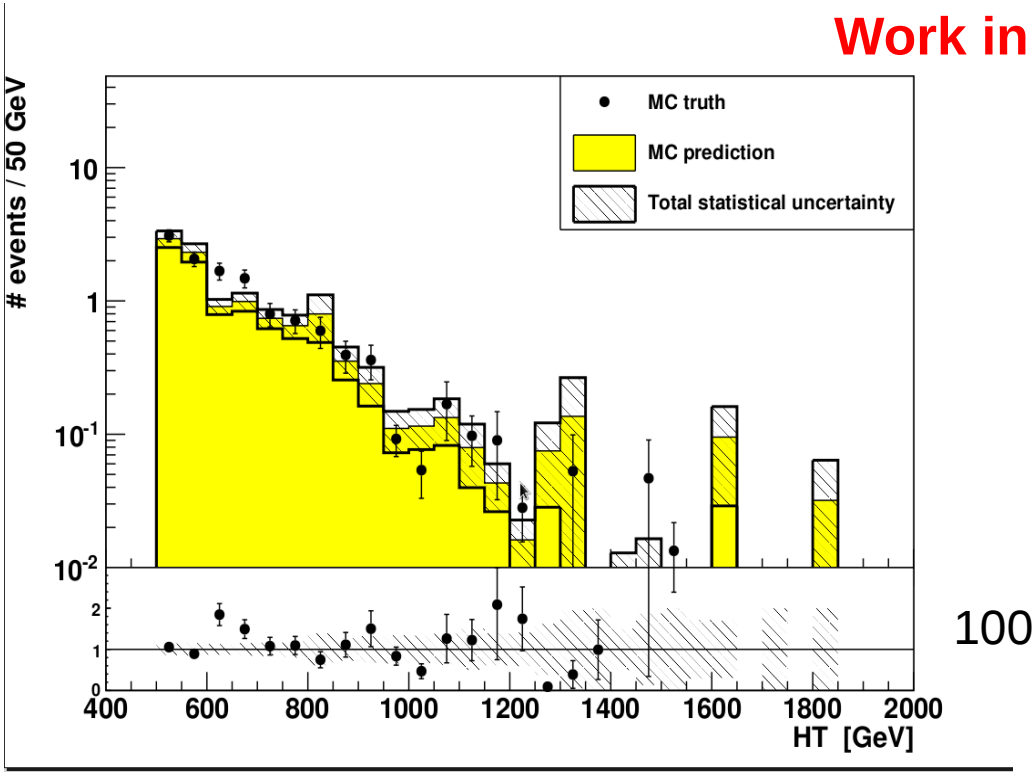
Work in progress

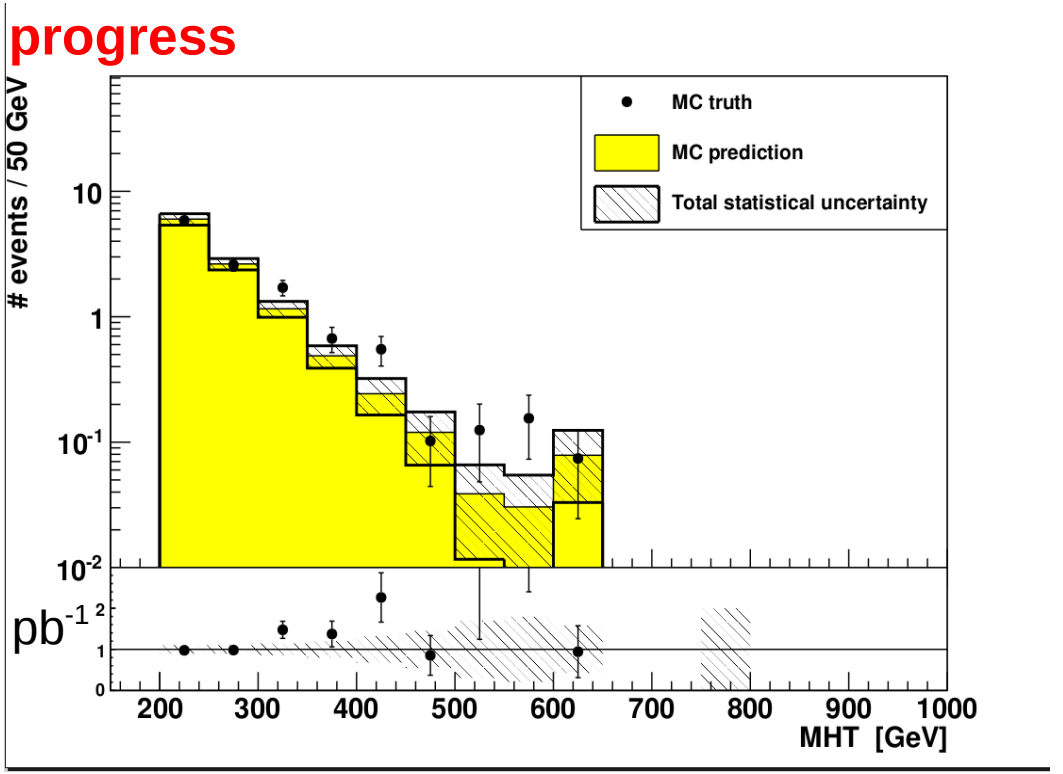


Closure Test: Lost Lepton Method

Closure Test: Compare MC truth (expectation) to prediction on MC

Work in progress





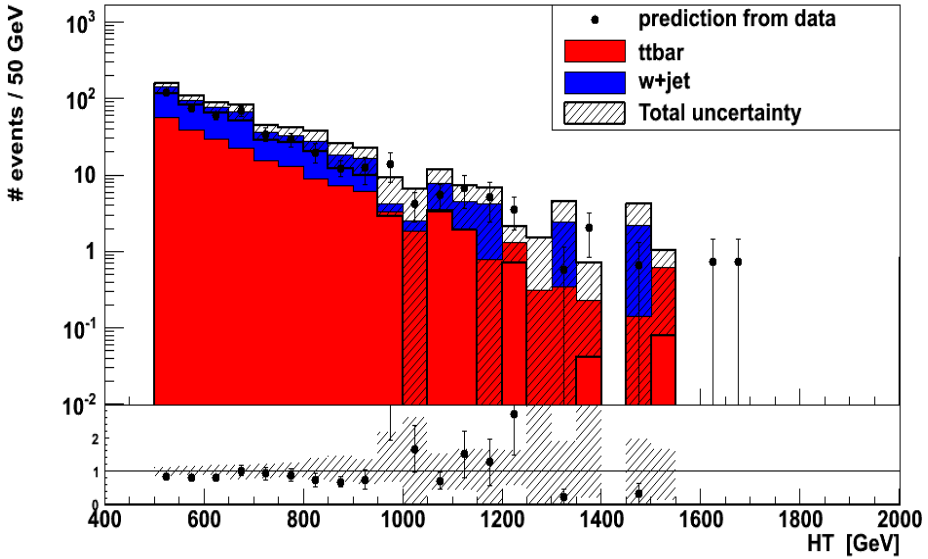
100 pb^{-1}

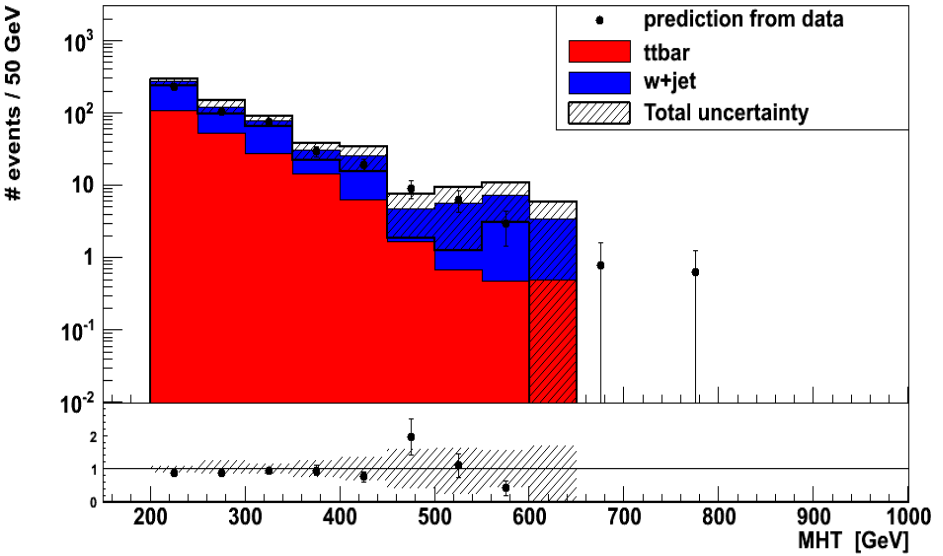
- Shape agrees for all studied distributions
- Only statistical uncertainties (closure test: no systematics)
- Slight underprediction (MC_{truth} = 11.8 ± 0.6 $MC_{predict}$ = 10.8 ± 0.7)
  - 9% correction on data due to non-closure

Prediction of the Lost Lepton Method

Predicted Events on data for the lost lepton method: 427 ± 60 @ 4.61/fb,
Plain MC simulation for the lost lepton from w+jet and ttbar : 545 ± 41

Baseline selection





Work in progress

Source	Systematic Uncertainties	
Statistics of control-sample	−18.2	+18.2
iso- & id- efficiencies (statistical)	−17.5	+23.7
Differences $t\bar{t}$, W, Z-samples and kinematic in control vs. signal region	−42.7	+42.7
SM background in control-region	−12.8	+0
MC use for acceptance calculation	−16.6	+16.6
transverse W-mass-cut	−17.2	+19.8
total, combined systematics	−53.7	+55.2

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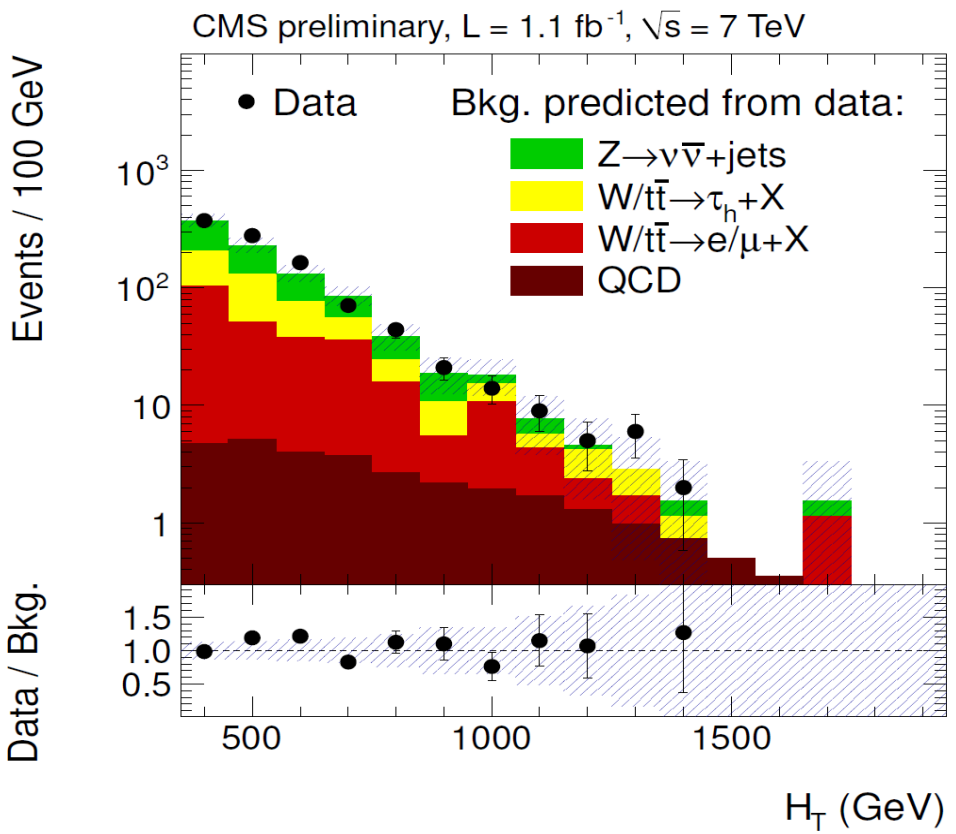
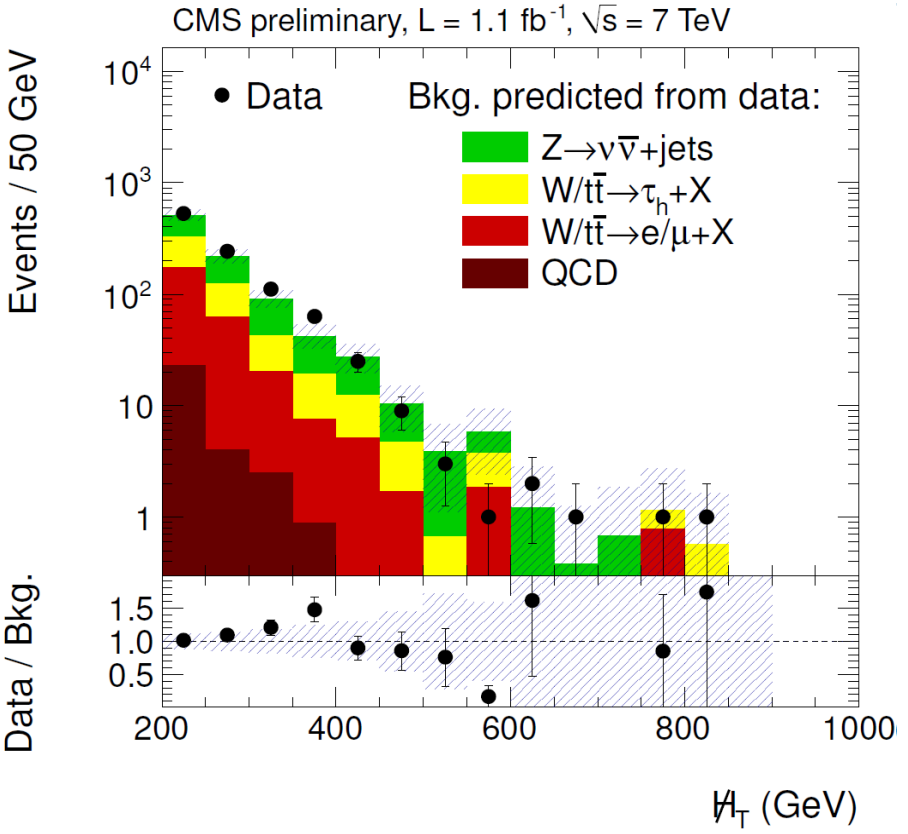
Total data-driven background prediction

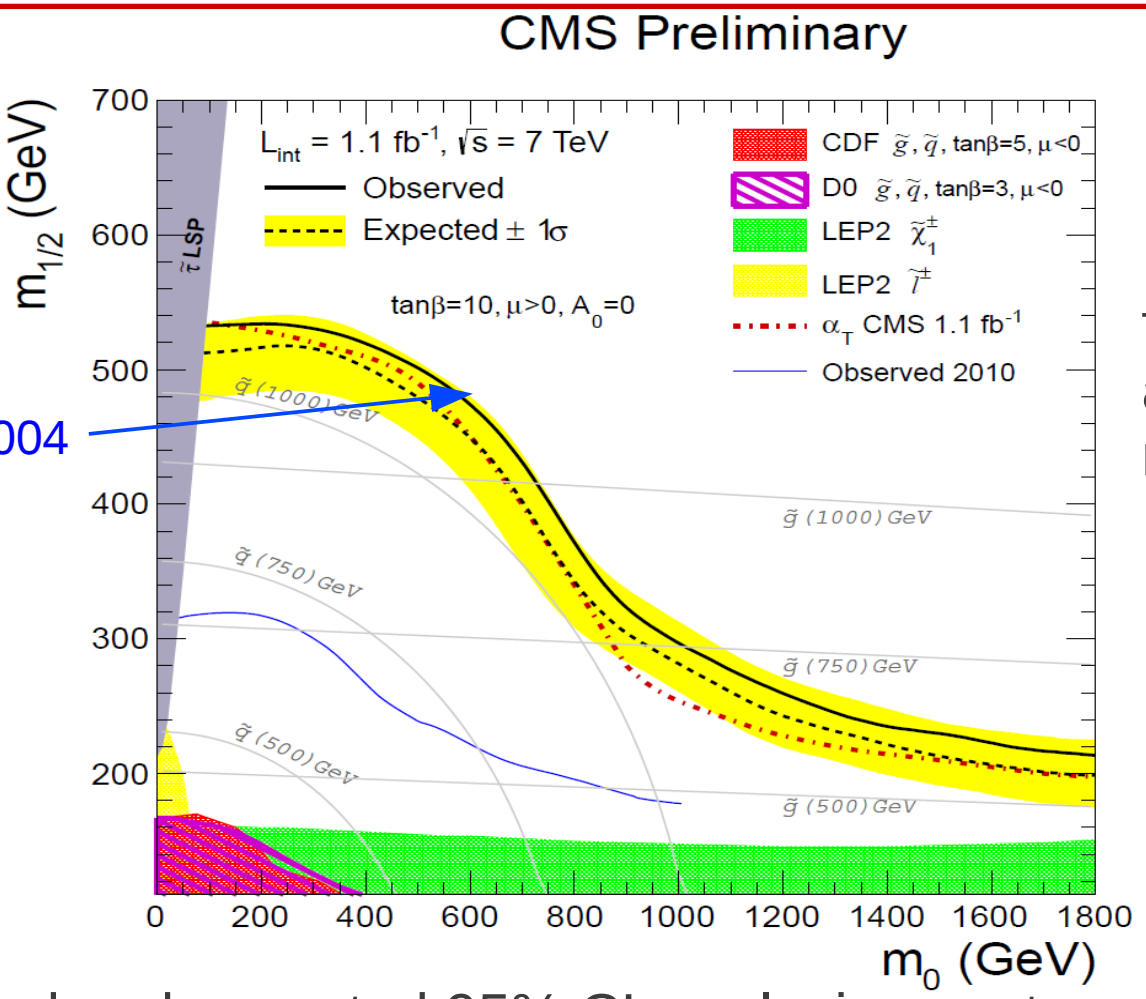




HT and MHT distributions in data compared to the combined data-driven background predictions.

Good agreement between prediction and data!
No excess observed

Limits



PAS-SUS-11-004

Limits calculated from the hight HT and MHT search regions.

The observed and expected 95% CL exclusion contours in the CMSSM parameter m_0-$m_{1/2}$ plane.

The remaining CMSSM parameters are tan(β) = 10, μ > 0, and A_0 = 0

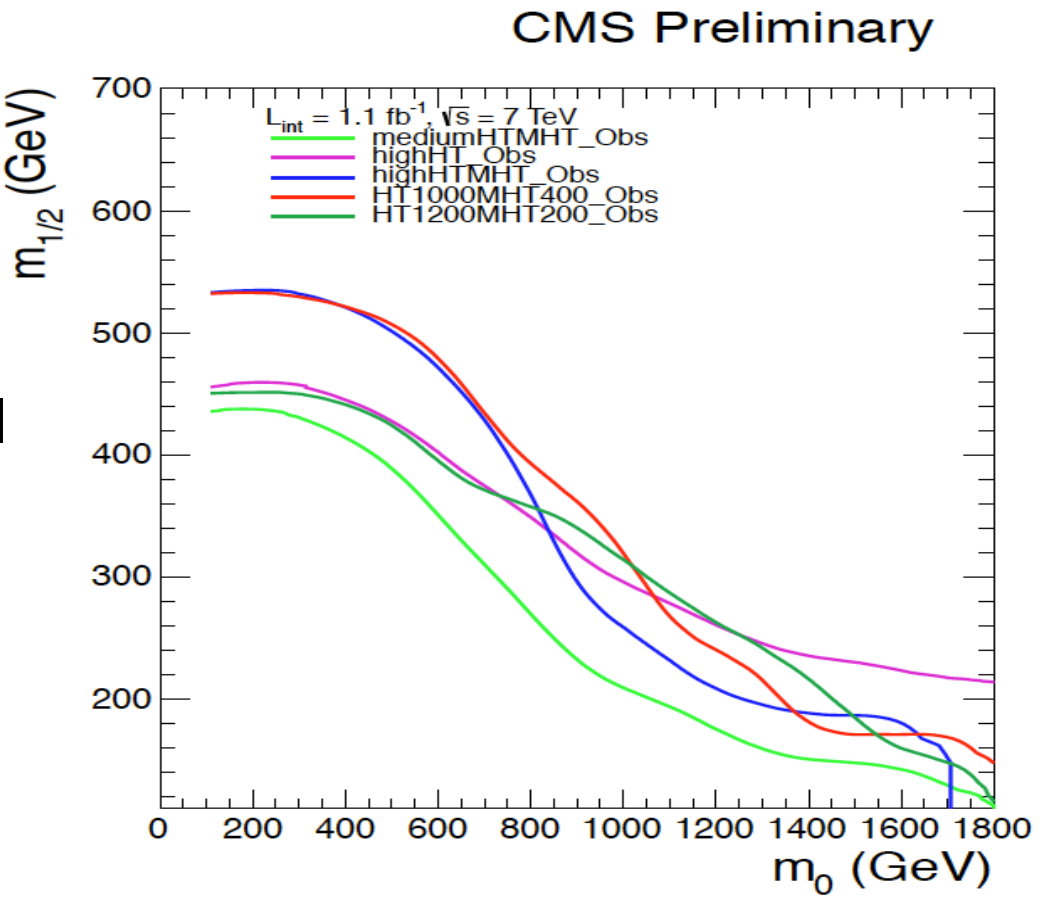
Outlook

For the limit setting only the best region is considered.

Future planes:

- Luminosity update to the full 2011 data set.
- Regions have been updated accordingly
- For the next publication 14 exclusive regions will be combined

Limit combination



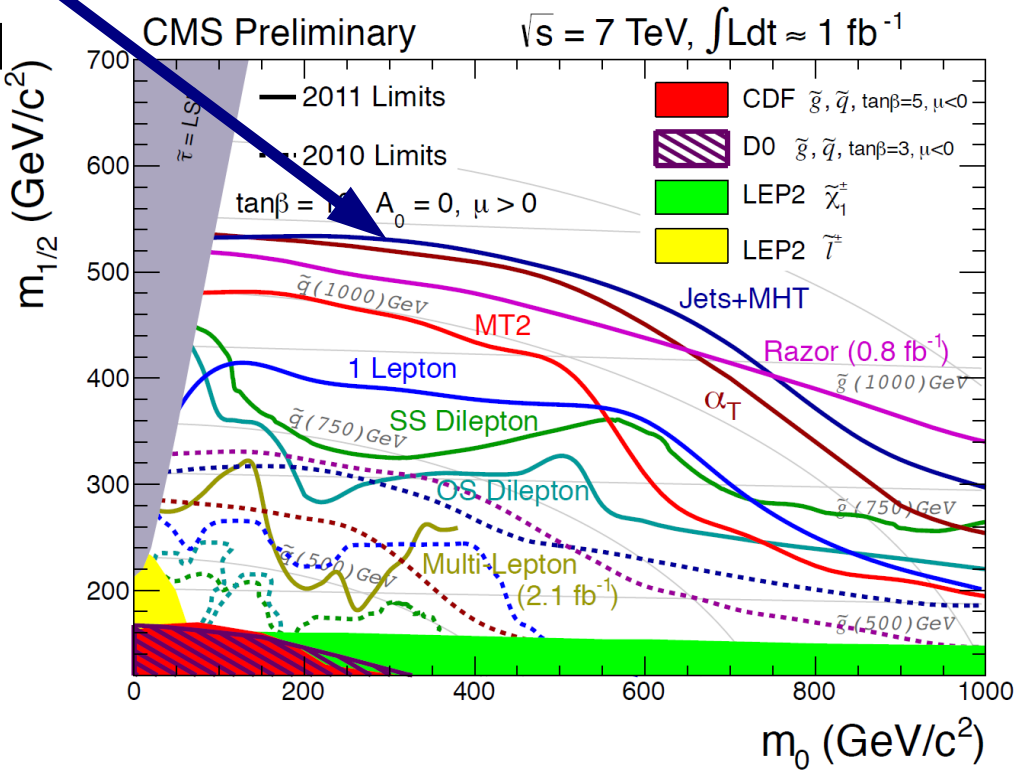
Conclusion

Conclusion

- Worlds best limits in CMSSM!
- Public result: PAS-SUS-11-004
- Very generic analysis
- All backgrounds data-driven estimated

- New Results for full 2011 luminosity (4.61 fb^{-1}) aiming for publication

Paper 2010: JHEP **1108** (2011) 155



Backup

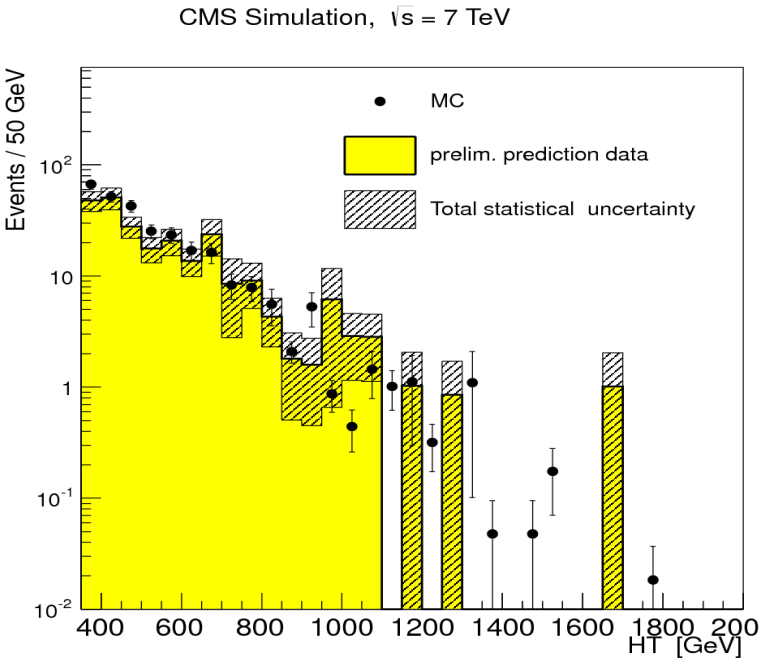
Isolation criteria

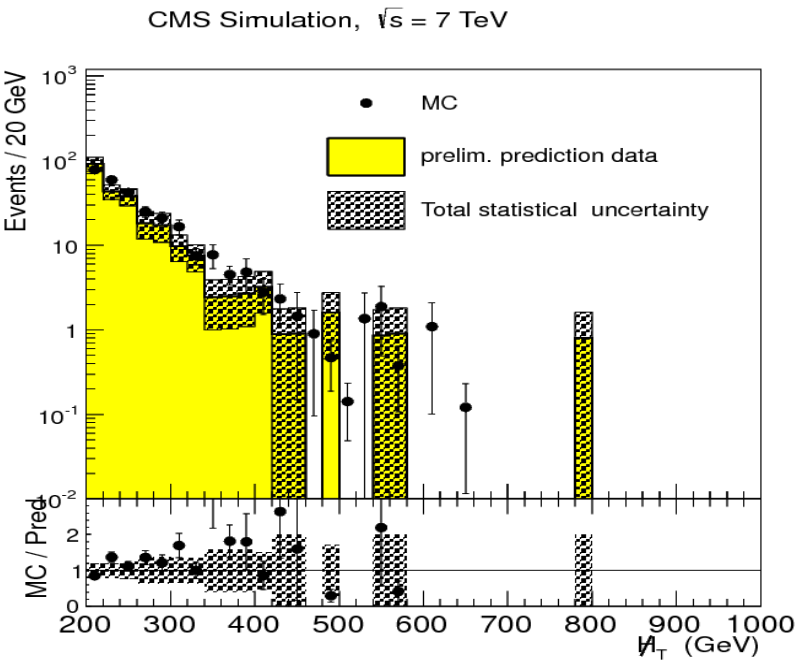
$$\mu_{Iso} = \frac{\sum_{trk}^{\Delta R=0.3} p_T^{chargedhadron} + \sum_{ecal}^{\Delta R=0.3} e_T^{neutralhadron} + \sum_{hcal}^{\Delta R=0.3} e_T^{photons}}{p_T}$$

Particle flow based relative isolation

Prediction with the Lost Lepton Method

Predicted Events from data: 244 ± 36.7 @ 1.14/fb,
Plain MC simulation: 279 ± 26.6 baseline selection





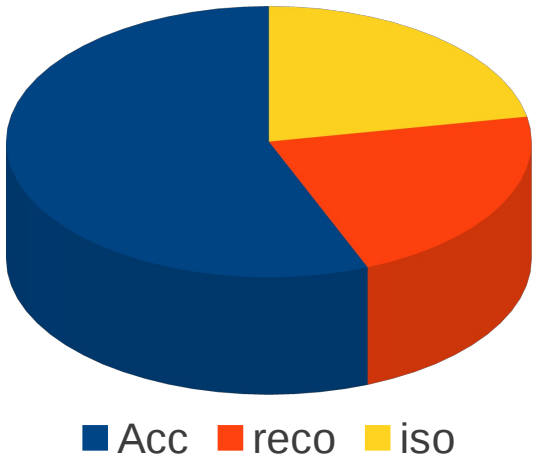
Source	Systematic Uncertainties	
Statistics of control-sample	−19.8	+19.8
Iso- & id- efficiencies (statistical)	−10.2	+10.2
Differences $t\bar{t}$, W, Z-samples and kinematic in control vs. signal region	−24.4	+24.4
SM background in control-region	−7.3	+0
MC use for acceptance calculation	−9.5	+9.5
Transverse W-mass-cut	−10.5	+10.5
Total, combined uncertainty	−36.7	+35.9

Details on the lost lepton background

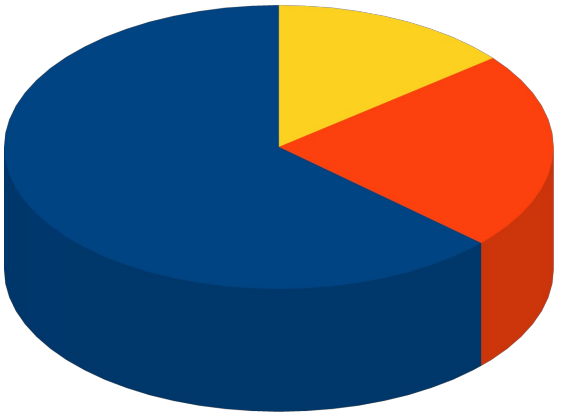
- Different topologies of Z, W, TTbar

Work in progress

Lost leptons from TTbar



Lost leptons from W+Jets



- Uncertainty on the acceptance arising from the PDF set
- Found to be less than 6 %