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Search for Physics Beyond the Standard Model in Z + MET + Jets events at the LHC

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Introduction

We present a search for **Physics beyond the Standard Model** (SM) in final states with a Z boson, jets and missing transverse energy, using a data sample collected in 2011 by the CMS detector at the Large Hadron Collider corresponding to an integrated **luminosity of 2.1 fb^{-1}**. This final state is predicted in several models of Physics beyond the SM, including supersymmetry. A **novel analysis method** is exploited, the Jet-Z Balance method, and a precise determination of the total SM background is obtained using a **control sample from data**. In the absence of any significant excess beyond the SM background, upper limits are set on simple models of supersymmetry, and further information is provided to allow confrontation of other models to these results.

Motivation

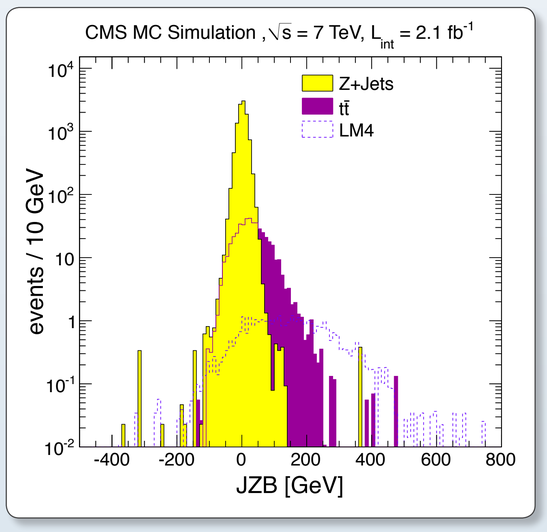
- Search for Physics beyond the Standard Model in final states containing **Z + Jets + missing ET** (Z decaying leptonically)
- Clean signature for New Physics searches
- Two major backgrounds:
  - Z+Jets with artificial MET
  - Top decays with accidental dilepton mass
- **Employ a new method: "Jet-Z Balance" (JZB)**

Defining JZB

- Define a new variable, the "Jet-Z balance":

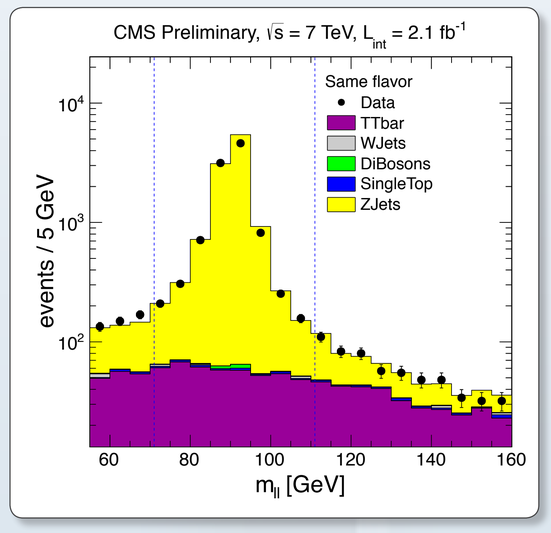
$$JZB = |\sum_{\text{jets}} \vec{p}_T| - \vec{p}_T^{\,Z}$$

- JZB distribution has **high discriminative power for signal**
- Use distribution to the left of the peak to predict distribution to the right (for Z+Jets)
- Use **data control samples to predict backgrounds**



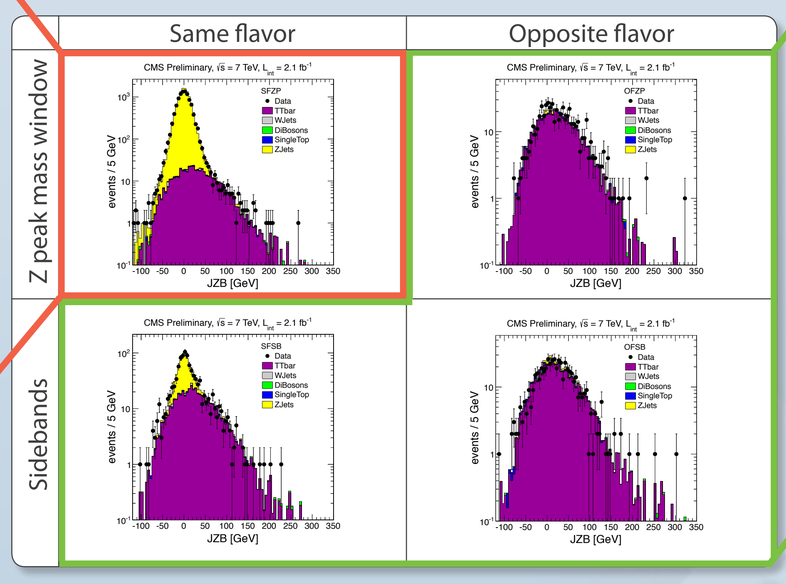
Event Selection

- We select events with:
  - 2 good opposite sign leptons with $p_T \geq 20$ GeV
  - 3 or more good jets with $p_T \geq 30$ GeV
  - invariant dilepton mass of the leptons in the Z mass window defined by $|m_{ll}-m_Z| \leq 20$ GeV



Background Prediction: Overview

- Consists of two components: **TTbar** and **Z+Jets**
- Define **four regions**, according to the relative flavor and the invariant dilepton mass of the two leptons
- Define **sidebands** (SB) and a **Z peak window** (ZP)
- Define **same flavor** (SF) and **opposite flavor** (OF)
- Same flavor events in the mass peak window are our signal region, rest are control regions



Z+Jets Prediction

- Start with JZB distribution from same flavor events
- Use the fact that Z+Jets events evenly populate the left (JZB<0) and right (JZB>0) side
- Therefore **use left side to predict right side** (get Z+Jets prediction from left side)

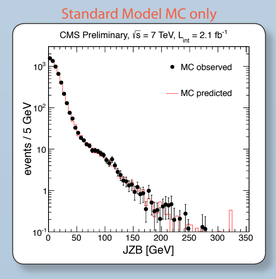
TTbar Prediction

- Ttbar events don't populate left and right side with equal probability (therefore not covered by DY prediction)
- **Extract a ttbar estimate for each control region** by taking the positive side (JZB>0) and subtracting the negative side (JZB<0) from it (to account for double counting)
- Average over all control regions to get final ttbar estimate

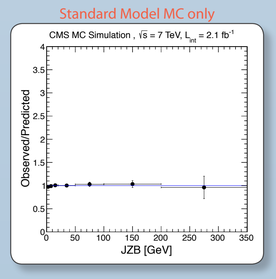
Results

- Final prediction obtained from Z+Jets and ttbar prediction
- Plot predicted and observed distribution using only Standard Model MC samples (below, left) and their ratio (below, right)
- Find a **flat line when using only Standard Model MC**

Standard Model MC only

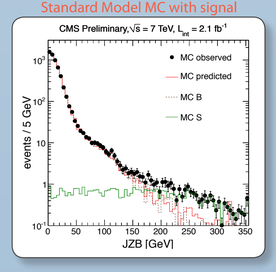


Standard Model MC only

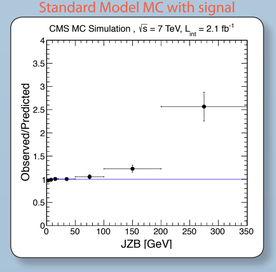


- Plot prediction and observation (below, left) and their ratio for Standard Model MC including a signal (LM4) (below, right)
- Ratio **deviates from 1 in the presence of signal**

Standard Model MC with signal

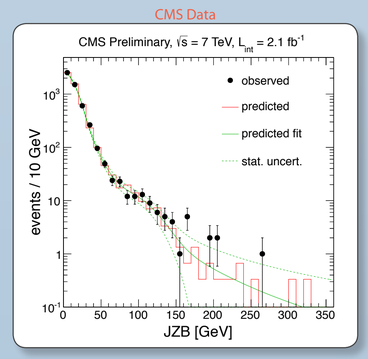


Standard Model MC with signal

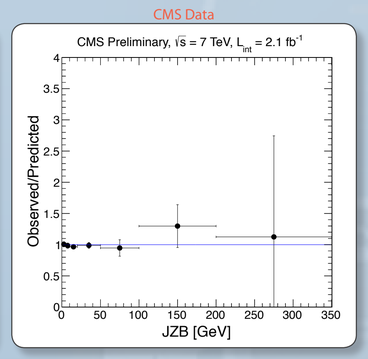


- Prediction and observation plotted using CMS data (below, left)
- Plot ratio of observed divided by predicted (below, right)

CMS Data



CMS Data



- Define **three signal regions**: JZB>50 GeV, JZB>100 GeV, and JZB>150 GeV, for which the predicted and observed yields are compared:

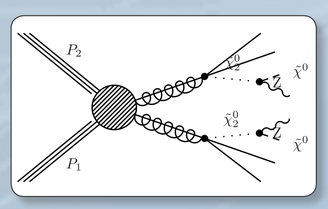
Region	Observed events	Background prediction
JZB > 50 GeV	168	164 ± 10 (stat) ± 42 (sys)
JZB > 100 GeV	48	37 ± 4 (stat) ± 10 (sys)
JZB > 150 GeV	11	7.0 ± 1.5 (stat) ± 2.1 (sys)

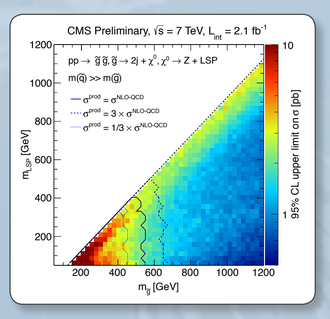
Interpretation

In the absence of any significant excess, **upper limits** on the cross section of two benchmark points are quoted (loss of discovery potential due to signal contamination in the background control regions is fully accounted for) :

Scenario	JZB > 50 GeV	JZB > 100 GeV	JZB > 150 GeV	Cross section
LM4	7.4 pb	3.8 pb	1.9 pb	2.53 pb
LM8	7.9 pb	4.2 pb	2.0 pb	1.03 pb

We also interpret our results in the context of **simplified models**:





Conclusions

We have presented a new method, which was commissioned in 2010 using 34 pb^{-1} and updated in 2011 with 191 pb^{-1} and 2.1 fb^{-1}.
We do not see any significant excess and have thus set limits on simplified models of supersymmetry.

References

PAS-SUS-11-019: Search for Physics Beyond the Standard Model in Z + MET + Jets events at the LHC
PAS-SUS-11-012: Search for supersymmetry in events with a Z boson and missing energy
PAS-SUS-10-010: Search for new physics in Z + MET + Jets events at the LHC

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