

Data-driven Prediction of Invisible Z Background using Photons for Inclusive Jets plus Missing Momentum New Physics Search



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Inclusive Jets plus Missing Momentum New Physics Search

A search for New Physics in the CMS 2010 pp data [1] is based on:

- at least **three jets** accompanied by
- large **missing transverse momentum**.

This analysis is **inclusive**: the search is not optimized for any (SUSY) model or specific event kinematics. The strategy and methodology are appropriate for an **early search** in the 2010 pp data:

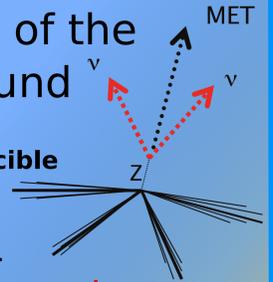
- a **counting experiment**;
- **data-driven background** estimations.

The **three main backgrounds** are QCD, vector bosons and $t\bar{t}$ with lost leptons or hadronic τ , and Z decaying to neutrinos.

[1] The CMS Collaboration, "Inclusive search for new physics at CMS with the jets and missing momentum signature", CMS PAS SUS-10-005 (2011).

Data-driven Prediction of the Invisible Z background

Z decaying to neutrinos constitutes an **irreducible background**. Three different **data-driven methods** are available, each with different strengths and weaknesses. $\gamma + \text{jets}$ is pursued.



$Z \rightarrow \mu\mu + \text{jets}$

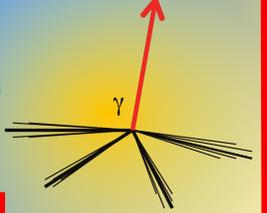
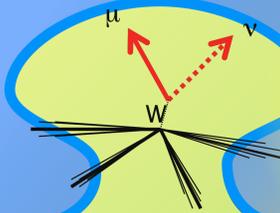
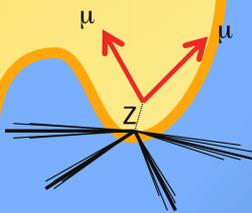
- + very clean
- + same topology
- low statistics

$W \rightarrow \mu\nu + \text{jets}$

- + large statistics
- + similar topology
- SM background
- Signal Contamination

$\gamma + \text{jets}$

- + large statistics
- + very clean
- phenom. correction



Phenomenological Correspondence

Photons and Z bosons exhibit similar characteristics at high energy. Differences are due to:

- the masslessness of the photon, while Z is massive;
- the Z boson couples also to the weak force, while the photon couples only to the electromagnetic force.

The correction factor will only contain the electroweak coupling differences if $p_T^\gamma \gg m_Z$. Since the 2010 pp data is not yet probing this regime, a **global correction factor** for a counting analysis was derived with detector simulation and reconstruction.

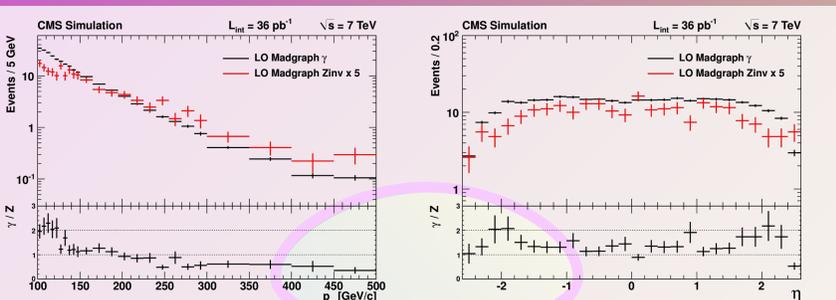
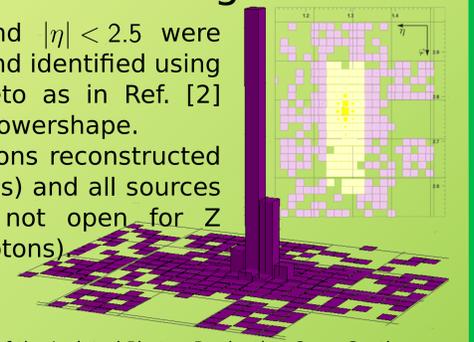


Figure 1: Generator Boson p_T spectrum (left) and η spectrum (right) for events with $\nu\nu + \text{Boson } p_T > 100 \text{ GeV}/c$ and with 3 or more jets for LO Madgraph $Z \rightarrow \nu\nu + \text{jets}$ and $\gamma + \text{jets}$.

Photon Selection & Backgrounds

Photons with $p_T > 100 \text{ GeV}/c$ and $|\eta| < 2.5$ were isolated in a $\Delta R < 0.4$ cone and identified using Had/Em energy and pixel veto as in Ref. [2] combined with a cut on the showershape.

Backgrounds are neutral mesons reconstructed as photons (secondary photons) and all sources of photons using channels not open for Z production (fragmentation photons).



[2] The CMS Collaboration, "Measurement of the Isolated Photon Production Cross Section in pp Collisions at $\sqrt{s} = 7 \text{ TeV}$ ", Phys. Rev. Lett. 106, 082001 (2011).

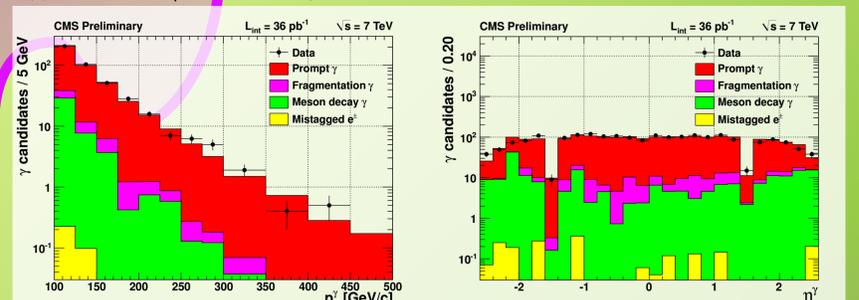


Figure 2: Photon p_T spectrum (left) and η spectrum (right) for events with 2 or more jets. The Monte-Carlo events were normalized to the number of entries in the data histograms.

HT & MHT Computation

Transverse Momentum (H_T) is the scalar sum of the transverse momentum of jets with $p_T > 50 \text{ GeV}/c$ and $|\eta| < 2.5$.

Missing Transverse Momentum (\cancel{H}_T) is the vector sum of the transverse momentum of jets with $p_T > 30 \text{ GeV}/c$.

$$H_T = \sum_{i \in \text{jets}} |\mathbf{p}_T^i| \quad \cancel{H}_T = \left| - \sum_{i \in \text{jets}} \mathbf{p}_T^i \right|$$

H_T and \cancel{H}_T are computed after removal of the Photon Jet inside a $\Delta R < 0.1$ cone around the reconstructed Photon.

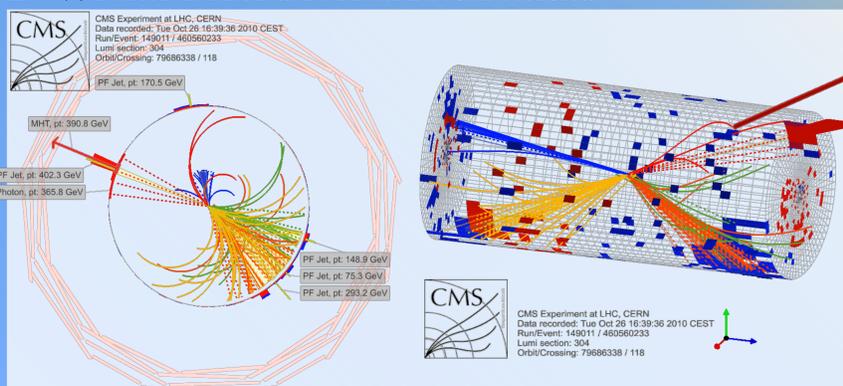


Figure 3: Display of an event with a $366 \text{ GeV}/c$ Photon. After removal of the Photon jet, \cancel{H}_T was computed to be $390 \text{ GeV}/c$, while H_T equals $688 \text{ GeV}/c$.

Results

A validation region is defined by the baseline cuts of $H_T > 300 \text{ GeV}/c$ and $\cancel{H}_T > 150 \text{ GeV}/c$. Two search regions were chosen on top of the baseline selection: $H_T > 500 \text{ GeV}/c$ and $\cancel{H}_T > 250 \text{ GeV}/c$. The invisible Z background for these three regions is estimated.

Table 1: Overview of all correction factors and corresponding systematic uncertainties. The 7 – 10% theoretical uncertainty on the Z to γ correspondence is treated as a uniform uncertainty, hence the RMS is tabulated.

	Baseline	High- H_T	High- \cancel{H}_T
Fragmentation	0.95±1%	0.95±1%	0.95±1%
Photon purity	0.94±8.8%	0.90±8.9%	0.97±10%
Photon mistag	1.00±1.4%	1.00±1.4%	1.00±1.4%
±scale	±6%	±4%	±6%
Z/ γ correction±acceptance	0.41±5%	0.44±5%	0.48±5%
±MC stat	±7%	±13%	±13%
ID data/MC ratio	1.01±2.4%	1.01±2.4%	1.01±2.4%
Total correction	0.37±14%	0.38±17%	0.45±18%

Table 2: Estimation of $Z \rightarrow \nu\nu$ using a correction factor obtained after detector simulation and reconstruction correcting for the differences in γ and Z phenomenology.

Selection Cuts	Data Events	Corrected Data Events	MC Truth (NLO)
Baseline:	72±8.5	26.3±3.2(stat)±3.6(syst)	21.2±1.4
High H_T Search:	22±4.7	8.4±1.8(stat)±1.4(syst)	5.76±0.74
High \cancel{H}_T Search:	16±4.0	7.1±1.8(stat)±1.3(syst)	6.34±0.78

A cross check was performed predicting $Z \rightarrow \mu\mu + \text{jets}$ and $W \rightarrow \mu\nu + \text{jets}$ and the result agrees within errors.