Measurement of Zγ Production at CDF

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Abstract

Diboson production provides a sensitive test of the Standard Model. We present an analysis of events with associated production of Z bosons and photons, using 127.8pb^{-1} of Run II data, taken by CDF at the Tevatron. Both the electron and muon channels of the Z boson are analysed. The data are compared to Standard Model expectation. In addition, the cross-section in both channels is presented and the sensitivity to anomalous couplings of the Z boson is discussed.

Introduction

The associated production of a vector boson and a photon is an ideal test of the Standard Model. Any deviation from the Standard Model prediction could indicate new physics, e.g. compositeness of vector bosons. Several measurements were performed by the LEP collaborations, the D0 experiment and the Run I CDF collaboration

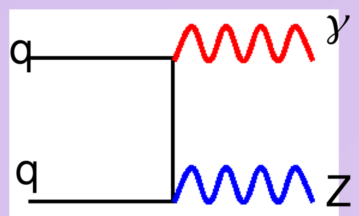

Figure 1A

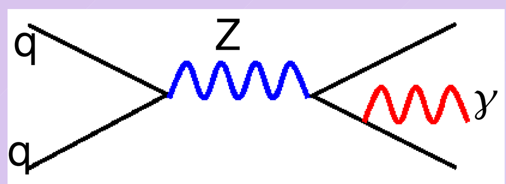

Figure 1B

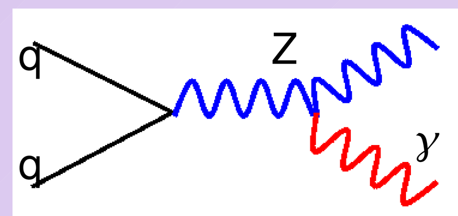

Figure 1C

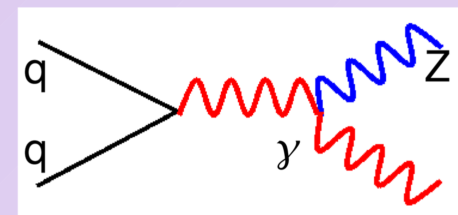

Figure 1D

Theory

The Standard Model Feynman diagrams for Zγ production are shown in figures 1A and 1B.

- Initial state radiation from the incoming quarks (1A).
- Final state radiation or inner Bremsstrahlung radiation from the lepton and is known as radiative Z decays (1B).
- Diagrams 1C and 1D represent direct Z+γ production, which is forbidden in the Standard Model, since it does not allow direct coupling between the Z and γ.

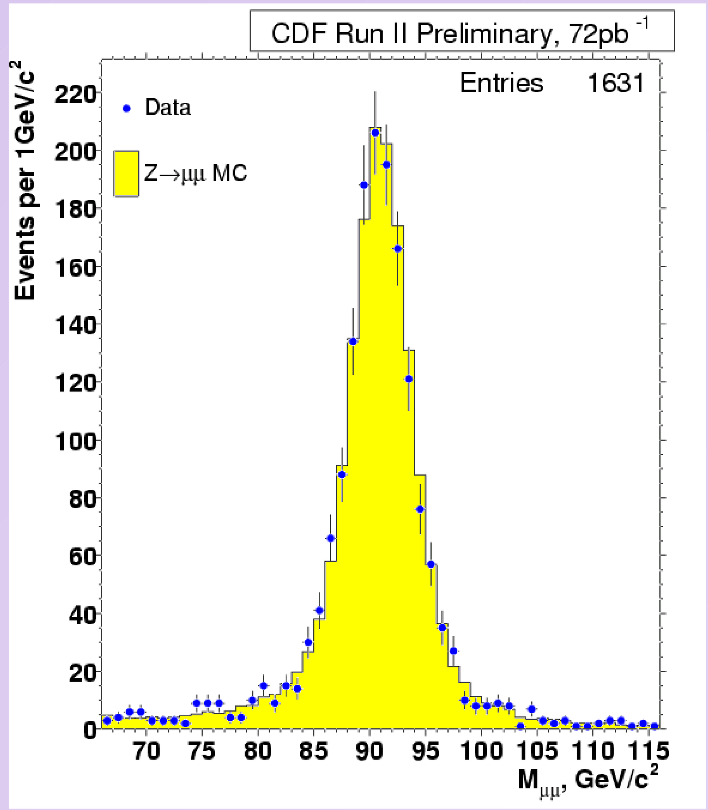

Figure 4: Invariant mass distribution of Z candidates

Signature

Events are triggered using high Pt lepton triggers.

- 2 leptons with high Et.
- Leptons of opposite charge
- M_{INV}(l,l) >40 GeV/c^2
- Central photon with Et>7GeV
- ΔR(closest lepton,γ)>0.7

Figure 4 shows the invariant mass distribution for Z→$\mu\mu$ candidates peaking at 91GeV/c^2. The excellent agreement between data and simulation demonstrates good understanding of the lepton energy scales, before the additional photon requirement.

Particle Identification

Many subdetectors are used for particle identification in this analysis (Figure 2).

Muons

- Signals from the central muon systems.
- High quality tracks from the drift chamber and silicon trackers (P_T>20GeV).
- Cosmic rejection.

Central electrons

- Deposit in the central calorimeter (E_T>25 GeV).
- High quality tracks from the drift chamber and silicon trackers.

Central photons

- Deposit in the central calorimeter (E_T>7GeV).
- Lack of track from the drift chamber.

Plug Electrons

- Deposit in plug calorimeters (E_T>20GeV).
- Track in silicon tracking detectors.

Figure 3 shows a Zγ→$\mu\mu\gamma$ candidate event, illustrating graphically the signals from the muon systems, central calorimeters, drift and silicon tracking systems.

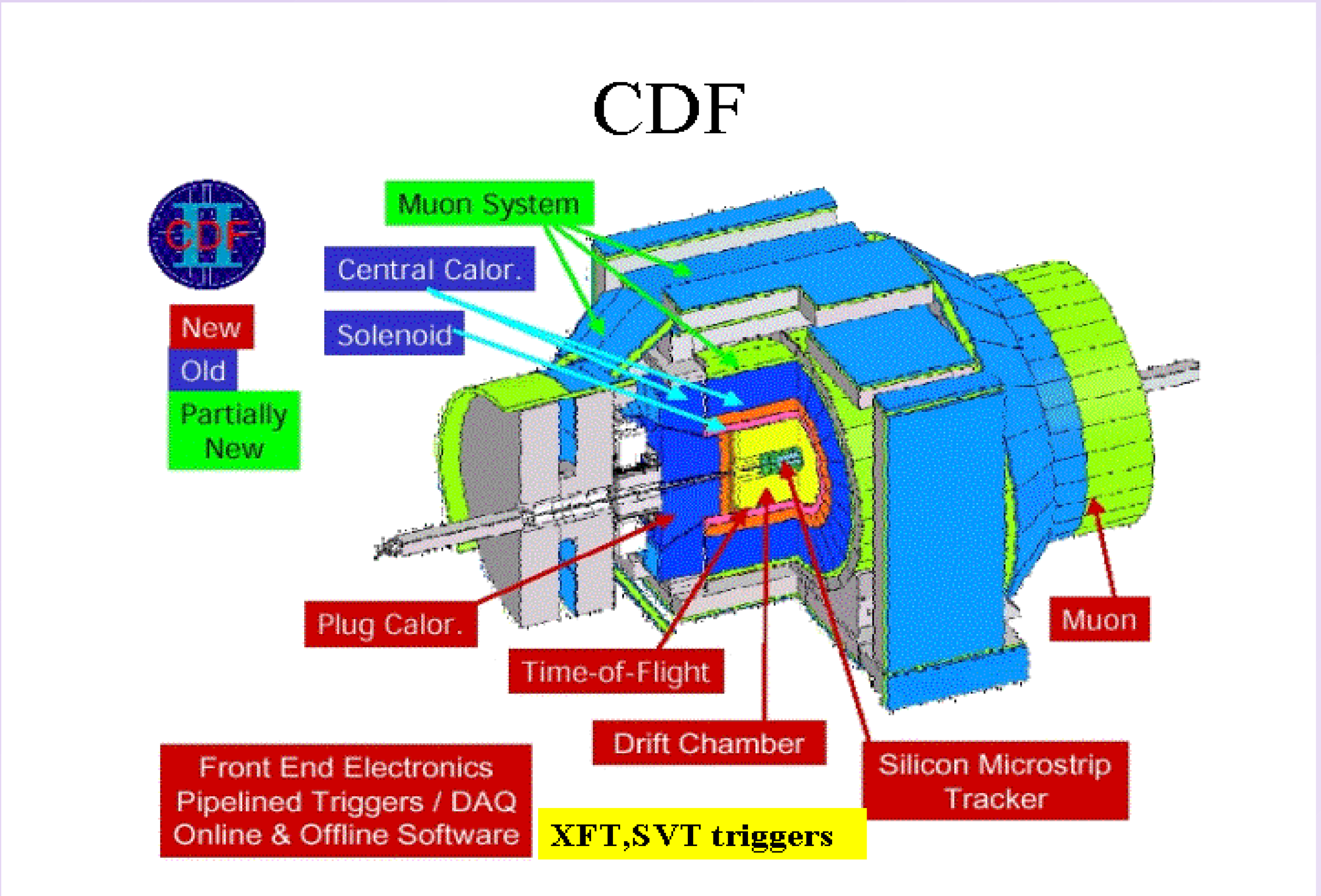

Figure 2: The CDF detector

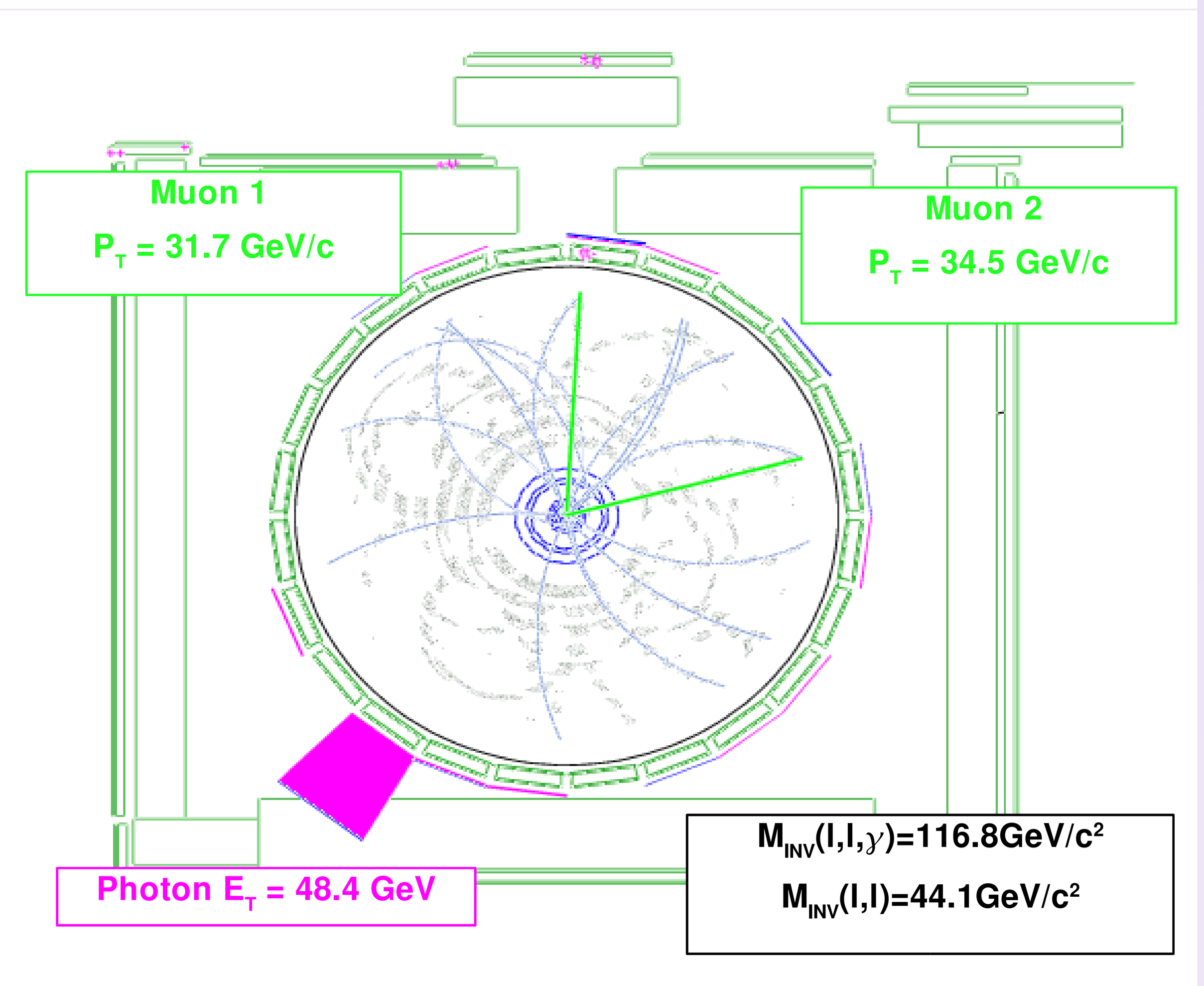

Figure 3: An event display of the highest photon E_T event

Results

The number of expected and observed events for 127.8pb^{-1} are shown in table 1. The errors shown are the experimental systematic uncertainties (sys), the uncertainty due to the 6% luminosity error (lum) and the theoretical uncertainty on the cross-section (th) of 7%. The major source of background is the misidentification of a hadronic jet as a photon.

Figures 5 to 9 show various kinematic properties of the candidate events. Figure 9 shows the kinematic difference between Zγ events from initial radiation (Figure 1A) and from radiative Bremsstrahlung decay (Figure 1B). In the case of the former, only the leptons contribute to the mass of the Z boson, were as in the latter, all three objects contribute.

For Zγ production in the kinematic range ΔR>0.7 and E_t^{γ}>7GeV, the cross-section is:

σ*BR = 5.8 ± 1.0(stat) ± 0.4 (sys) ± 0.4 (lum),

compared to a theoretical cross-section of 5.3 ± 0.4 (th).

	Number of Events with E_T^{γ}>7GeV	Number of Events with E_T^{γ}>25GeV
Z+γ MC	40.5 ±2.3(sys) ±2.4(lum) ±2.8(th)	5.0 ±0.3(sys) ±0.3(lum) ±0.4(th)
Z+jet fakes	2.5 ±0.8(sys)	0.1 ±0.1(sys)
Fake Z+γ	0.2 +0.3/-0.2(sys)	---
Total SM + BG	**43.2 ±2.3(sys) ±2.4(lum) ±2.8(th)**	**5.1 ±0.3(sys) ±0.3(lum) ±0.4(th)**
Data	**47**	**5**

Table 1: The number of expected and observed Zγ events for 127.8pb^{-1}

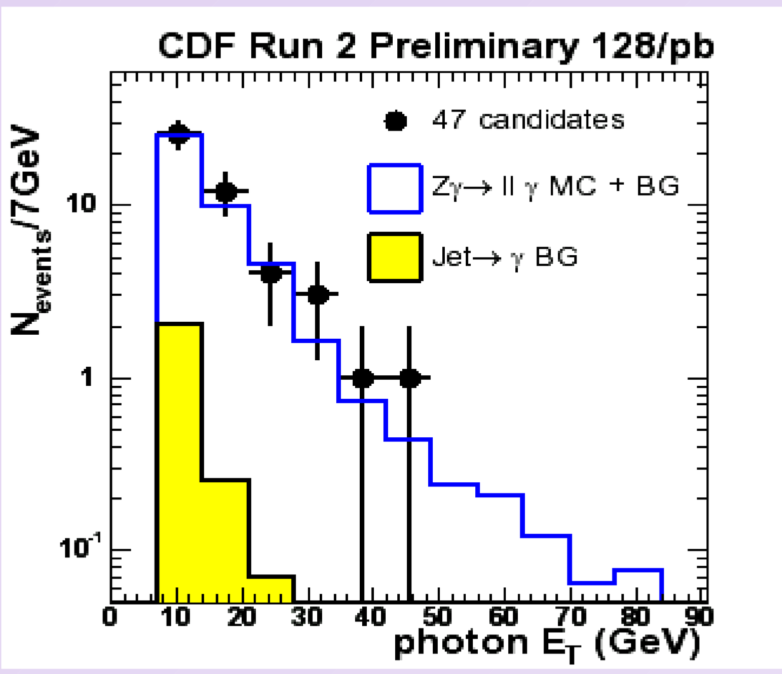

Figure 5.

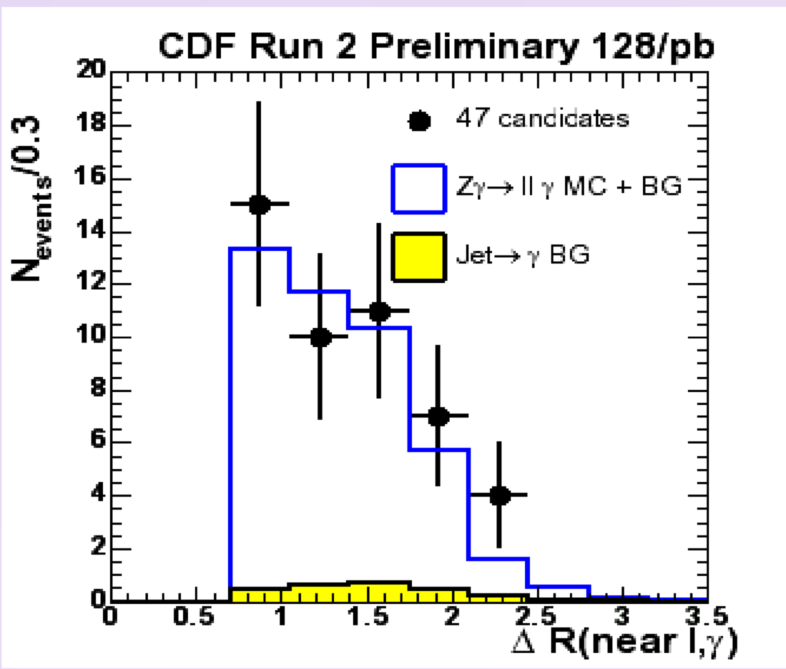

Figure 6.

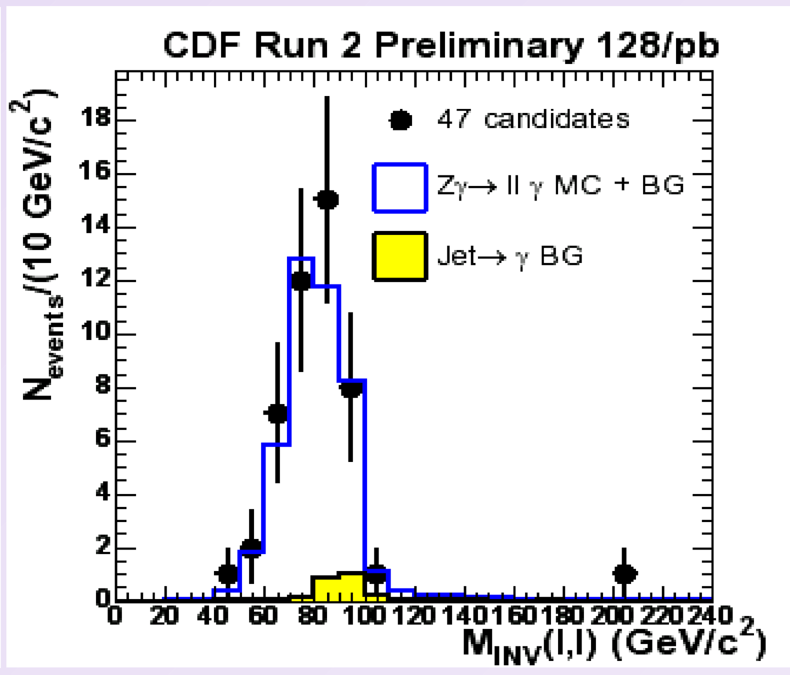

Figure 7.

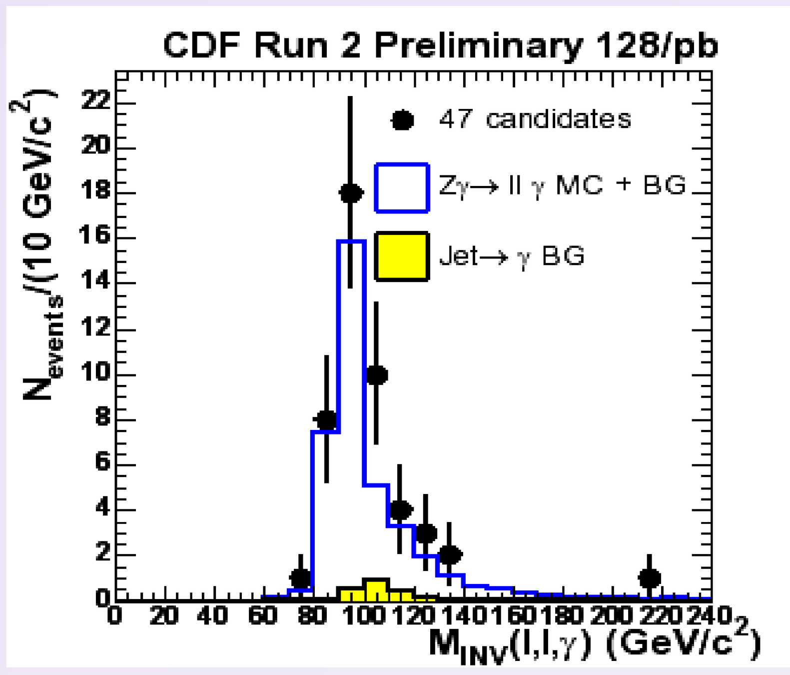

Figure 8.

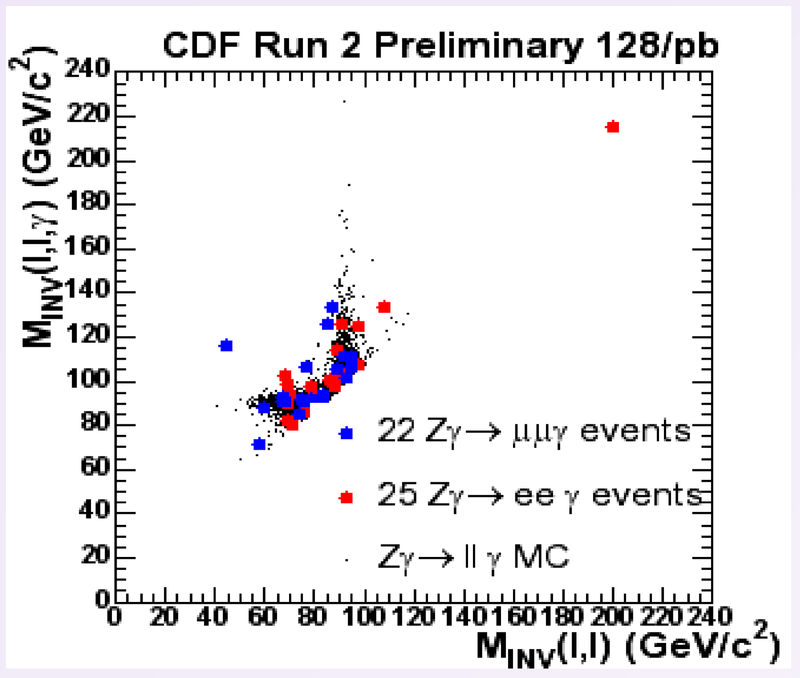

Figure 9.

Conclusions

The number of observed events, the cross-section measurement and the kinematic distributions of the 47 candidate events show excellent agreement with the Standard Model.
(Another related signal that is sensitive to diboson couplings is the measurement of W+γ production. Details can be found in the poster by Naho Tanimoto, Okayama University.)

Lepton-Photon 2003, Fermi National Accelerator Laboratory, Batavia, Illinois, USA, 11th-16th August 2003

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