Standard Model Electroweak Cross Section (ZGamma) Measurement

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Introduction & Motivation

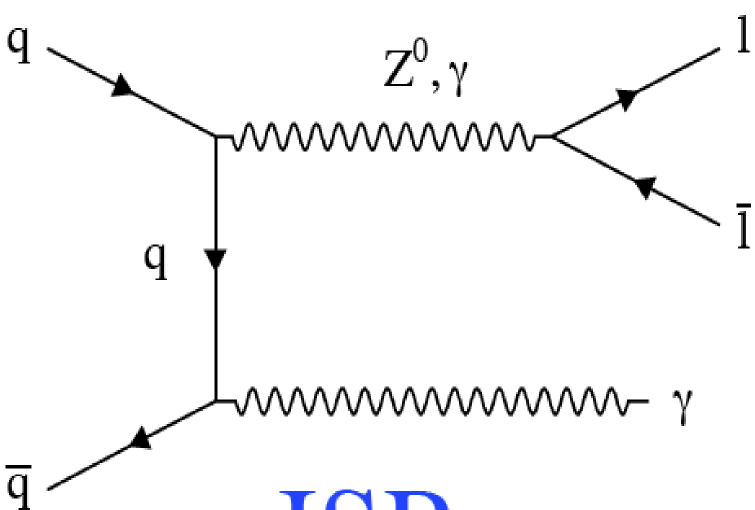
- $Z\gamma$ Final State is an important state of Standard Model in High Energy Physics
- Signature for new Physics
- Background for new Physics
- Background of Higgs Production
- Background of e* Production

Measurement of Zγ Cross Section

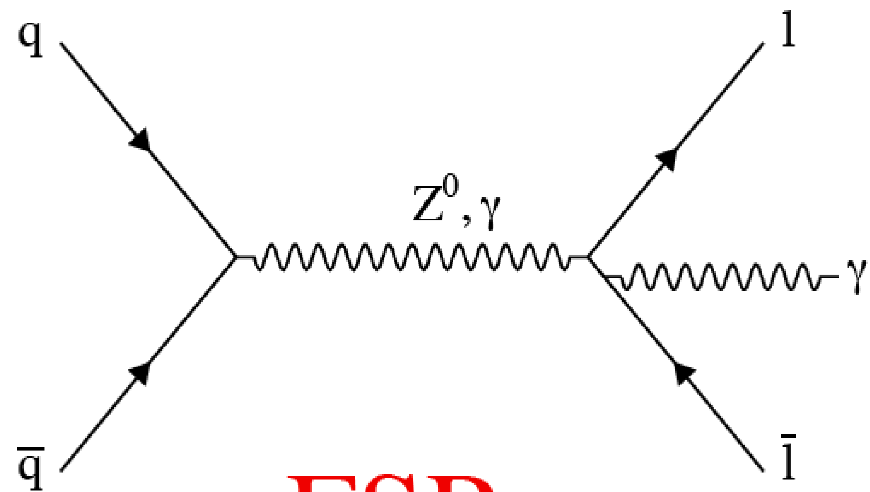
$$\sigma_{Z\gamma\rightarrow ll\gamma} = \frac{N_{observed} - N_{background}}{A \cdot \epsilon_{MC,Z\gamma\rightarrow ll\gamma} \cdot \rho_{eff} \cdot \int \mathcal{L}\, dt},$$

- ➡ $N_{observed}$: the number of observed yields
- ➡ $N_{background}$: the number of background yields
- ➡ $\mathcal{A}$: the fiducial and kinematic acceptance
- ➡ ε_{MC}: the selection efficiency from MC simulation
- ➡ ρ_{eff}: the correction factor on MC efficiency
- ➡ $\int\mathcal{L}$dt: integrated luminosity

ISR and FSR



ISR



FSR

Electron Selection

https://twiki.cern.ch/twiki/bin/viewauth/CMS/SimpleCutBasedEleID2011

❖ In order to minimize the effect from pileup

- ✦ H/E is removed
- ✦ HCAL isolation is computed with solid cone
- ✦ Isolation is applied pileup subtraction from fastjet information ($\Delta R = 0.3$)
  - Barrel: $(\max(0, \mathrm{IsoECAL} - 1) + \mathrm{IsoHCAL} + \mathrm{IsoTRK} - \rho \times \pi \times \Delta R^2)/P_T$
  - Endcap: $(\mathrm{IsoECAL} + \mathrm{IsoHCAL} + \mathrm{IsoTRK} - \rho \times \pi \times \Delta R^2)/P_T$
- ✦ $|d0| < 0.02$ cm (w.r.t. PV)
- ✦ $|dz| < 0.1$ cm (w.r.t. PV)

Efficiencies	95%	90%	85%	80%	70%	60%
Conversion Rejection						
missing hits ==	0	0	0	0	0	0
Dist	-	-	0.02	0.02	0.02	0.02
$\Delta cot\theta$	-	-	0.02	0.02	0.02	0.02
BARREL						
Combined Isolation						
	0.150	0.085	0.053	0.040	0.030	0.016
Electron ID						
$\sigma_{i\eta i\eta}$	0.012	0.01	0.01	0.01	0.01	0.01
$\Delta\phi$	0.800	0.071	0.039	0.027	0.020	0.020
$\Delta\eta$	0.007	0.007	0.005	0.005	0.004	0.004
ENDCAPS						
Combined Isolation						
	0.100	0.051	0.042	0.033	0.016	0.008
Electron ID						
$\sigma_{i\eta i\eta}$	0.031	0.031	0.031	0.031	0.031	0.031
$\Delta\phi$	0.7	0.047	0.028	0.021	0.021	0.021
$\Delta\eta$	0.011	0.011	0.007	0.006	0.005	0.004

Photon Selection

$$ISO^{new} = ISO^{original} - \rho_{event} \times \frac{nVtx}{<\rho>} \times \frac{<ISO>}{nVtx}$$

- ✦ No pixel seed matching
- ✦ H/E < 0.05
- ✦ Barrel (outer cone ΔR = 0.4):
  - IsoECAL - AeffxECAL×ρ < 4.2 + 0.006×E_T
  - IsoHCAL - AeffxHCAL×ρ < 2.2 + 0.0025×E_T
  - IsoTRK - AeffxTRK×ρ < 2.0 + 0.001×E_T
  - σiηiη < 0.011
- ✦ Endcap (outer cone ΔR = 0.4):
  - IsoECAL - AeffxECAL×ρ < 4.2 + 0.006×E_T
  - IsoHCAL - AeffxHCAL×ρ < 2.2 + 0.0025×E_T
  - IsoTRK - AeffxTRK×ρ < 2.0 + 0.001×E_T
  - $\sigma_{i\eta i\eta}$ < 0.03

Event Selection

❖ Good vertex selection:

✦ |d0| <= 2 cm, |dZ| <= 24 cm and n.d.o.f. >= 4

❖ Remove beam scrapping:

✦ At least 25% of all tracks should be of quality "highPurity"

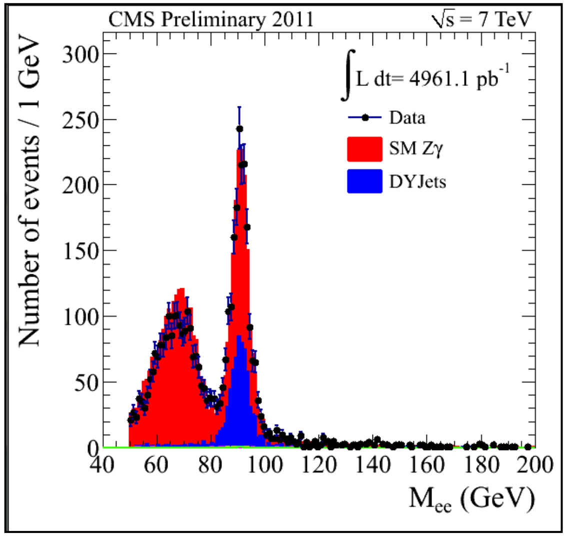
❖ HLT requirement:

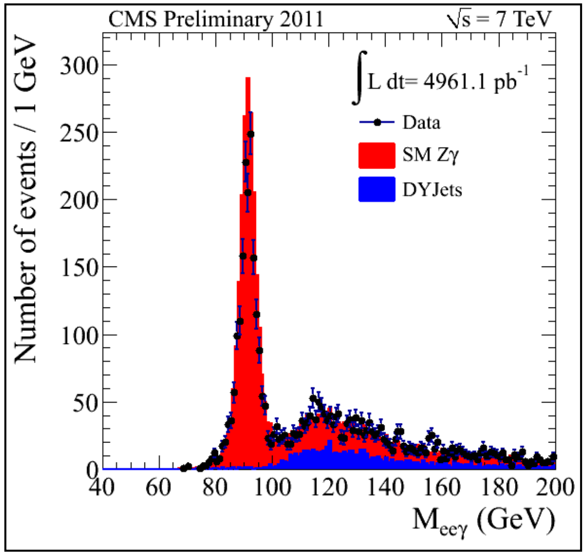
✦ Unprescaled double-electron triggers

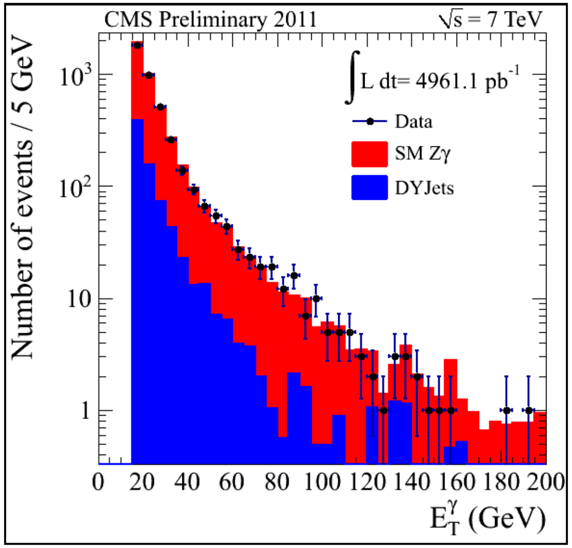
$Z\gamma$ Selection

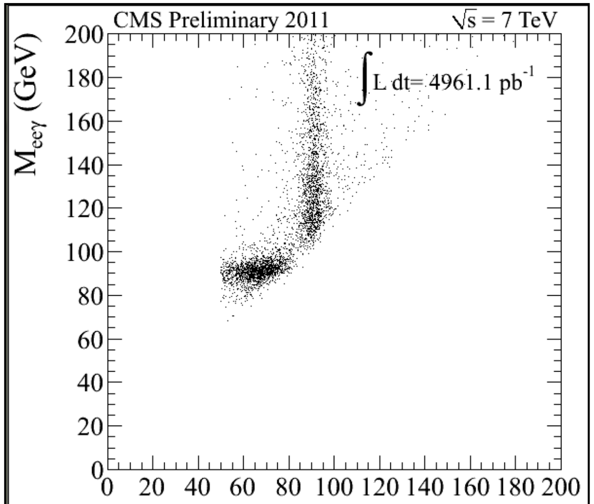
- Two good electrons:
  - Apply run-dependence energy scale correction
  - P_T > 20 GeV, in ECAL fiducial region
  - Pass WP85
- $M_{ll} > 50\ GeV$
- Select leading good photon:
  - Apply overall energy scale correction
  - E_T > 15 GeV, in ECAL fiducial region
  - Pass photon selection
  - $\Delta R(l, \gamma) > 0.7$

Data yeild









$$\sigma_{Z\gamma} \text{ -> } ll_{\gamma} = \frac{N_{observed} - N_{background}}{A \cdot \epsilon_{MC, Z\gamma \rightarrow ll_{\gamma}} \cdot \rho_{eff} \cdot \int L\, dt'}$$

$N_{observed} = 4113 \pm 64.1$

Acceptance & Efficiency

$$\sigma_{Z\gamma} \text{ -> } ll_{\gamma} = \frac{N_{observed} - N_{background}}{\boldsymbol{A \cdot \epsilon_{MC,Z\gamma \to ll_{\gamma}}} \cdot \rho_{eff} \cdot \int L\, dt'}$$

- $A \cdot \epsilon_{MC,Z\gamma \to ll_{\gamma}} = \frac{N_{accept}}{N_{gen,kin}}$
- N_{accept}= the number of events passing all selection cuts
- $N_{gen,kin}$= the number of generated events

with $E_{T\gamma}$ > 15 GeV, ΔR(l,γ) > 0.7, and M_{ll} > 50 GeV

- $A \cdot \epsilon_{MC,Z\gamma \to ll_{\gamma}} = 0.132$

Correction Factor

$$\sigma_{Z\gamma} \text{ -> } ll_\gamma = \frac{N_{observed} - N_{background}}{A \cdot \epsilon_{MC, Z\gamma \to ll_\gamma} \cdot \boldsymbol{\rho_{eff}} \cdot \int L\, dt\prime}$$

- Since efficiency is obtained from MC, the difference of efficiency between data and MC should be taken into account.
- Study the difference of:

  ① trigger,

  ② electron reconstruction,

  ③ electron/photon selection efficiencies

  between data and MC.
- $\rho_{eff} = \rho_{trigger} * \rho_{reco}{}^2 * \rho_{WP852}{}^2 * \rho_{pho} = 0.929$

Background Estimation

$$\sigma_{Z\gamma} \rightarrow ll_{\gamma} = \frac{N_{observed} - \mathbf{N_{background}}}{A \cdot \epsilon_{MC,Z\gamma \rightarrow ll_{\gamma}} \cdot \rho_{eff} \cdot \int L\, dt\prime}$$

- Template Method
- Signal templates (Use MC samples)
  - Use Zee candidates to extract shift correction
- Background templates
  - Use data samples, sideband region
- The fit is performed using a unbinned extended maximum likelihood
- Get the background distribution in signal range with Integrating $\sigma_{i\eta i\eta}$.
- $N_{background} = 895.7 \pm 28.9$

Result

- Theory: Zgamma Cross Section is 5.4 $\pm$ 0.2(stat.) $\pm$ (sys.)

$$\sigma_{Z\gamma} \text{ -> } ll_{\gamma} = \frac{N_{observed} - N_{background}}{A \cdot \epsilon_{MC,Z\gamma \rightarrow ll_{\gamma}} \cdot \rho_{eff} \cdot \int L\, dt'}$$

- $N_{observed}$ = 4113 $\pm$ 64.1
- $N_{background}$ = 895.7 $\pm$ 28.9
- A* $\epsilon_{MC,Z\gamma \rightarrow ll_{\gamma}}$ = 0.13
- ρ_{eff} = 0.93
- $\int L\, dt'$ = 4961.1

- The Zgamma Cross Section is 5.3 $\pm$ 0.1(stat.) $\pm$ (sys.)

Thanks for your attention!