Z→2lγ form-factor at 8 TeV analysis validation

Summer student report

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INTRODUCTION

LHC provides us a lot of pp collisions and one of the processes that can be studied is quark-antiquark annihilation into a Z boson which could decay to real lepton and virtual one (Fig.1). Z→2l vertex depends on lepton virtuality and this vertex is called form-factor V(Q) [1]. This function V(Q) is included into the expression (1) for Z→2l neutral current [2]. This form-factor function V(Q) is sensitive to interference effects from New Physics, because it is sensitive to loops. Also beyond SM vertex represented in Fig.2 could exist [3].

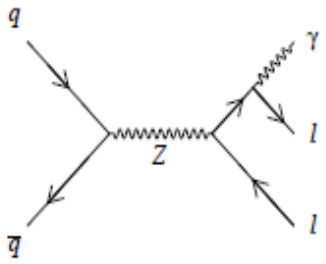

Fig.1. $q\bar{q} \to Z \to ll\gamma$ final state radiation Feynman diagram

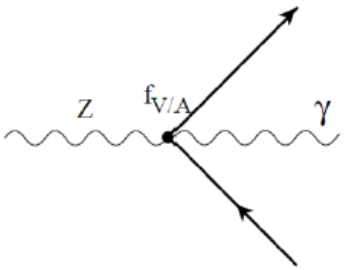

Fig.2. . $q\bar{q} \to Z \to ll\gamma$ direct photon emission Feynman diagram

$$\langle f\bar{f}|J_Z^\mu|0\rangle = V_f(q^2)\bar{u}_f\gamma_\mu\left[\frac{I_{3f}(1-\gamma_5)}{2} - \hat{k}_f(q^2)\hat{s}^2Q_f\right]v_f \qquad (1)$$

ANALYSIS VALIDATION

There are a lot of processes at pp collisions and it is necessary to select only Z→2lγ process. The selection criteria described in the note [1] were applied to the 2012 data and MC. These criteria are shown in Table 1.

According to Fig.3, 4 we choose only red region for analysis because these points are concentrated near the Z boson mass value. Background events are grouped at yellow region. It is Z→ll + some fake photon. In Fig. 5 the fit result of distribution over llγ invariant mass is shown, blue line is the fitting curve. From fit the number of background events is found. The M_{inv}(ll) (Fig.6) and M_{inv}(llγ) (Fig.7) is well described by the SM MC, the background contribution is very small. But the $M_{inv}(l^+\gamma)$ (Fig.8) reveals some difference between line and dots. This difference is the object of study.

	Z→ $ee\gamma$	Z→ $\mu\mu\gamma$
Triggers	EF_2e12Tvh_loose EF_e24vh_medium EF_e60_medium	EF_mu18_mu8_EFFS EF_2mu13 EF_mu24i_tight EF_mu36_tight
Events Preselection	Apply All_Good GRL for all final states; Remove all events that have LAr EventInfo error flag (larError==2 in D3PD); Remove all events that have titleError==2 in D3PD; Remove all events that have coreFlags&0x40000!=0 in D3PD; Remove Tile corrupted events passing other quality criteria in periods G-J using; Primary vertex with at least three tracks coming from a beam spot $\lvert d_0\rvert < 1\ mm; \lvert Z_0\rvert < 10\ mm$	
Photon Selection	Photon with the highest P_t; $P_t(\gamma) > 15\ GeV$ $\lvert\eta(\gamma)\rvert < 2.37$ excluding $1.37 < \lvert\eta(\gamma)\rvert < 1.52$; pass tight ID $\delta R(\gamma, l) > 0.4$; topoEtcone40($\gamma$) $< 4\ GeV$	
Lepton Selection	$P_t(e) > 10\ GeV$; loose e $\lvert\eta(e)\rvert < 2.47$ topoEtcone40(e)/$E_t < 0.3$	$P_t(\mu) > 10\ GeV$ $\lvert\eta(\mu)\rvert < 2.37$ topoEtcone40(μ)/$E_t < 0.2$
Invariant Mass	At least 1 photon + 2e with opposite sign $\max(P_{t_1}, P_{t_2}) > 25\ GeV$ $45\ GeV < M(ee) < 80\ GeV$ $80\ GeV < M(ee\gamma) < 100\ GeV$	At least 1 photon + 2μ with opposite sign $\max(P_{t_1}, P_{t_2}) > 25\ GeV$ $45\ GeV < M(\mu\mu) < 80\ GeV$ $80\ GeV < M(\mu\mu\gamma) < 100\ GeV$

Table 1. Events selection criteria

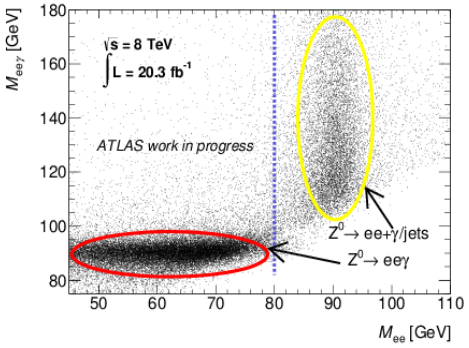

Fig.3. The eeγ invariant mass vs ee invariant mass

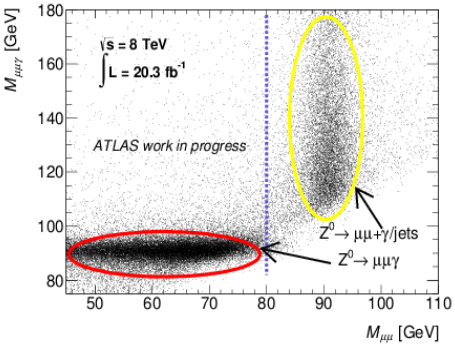

Fig.4. The μμγ invariant mass vs μμ invariant mass

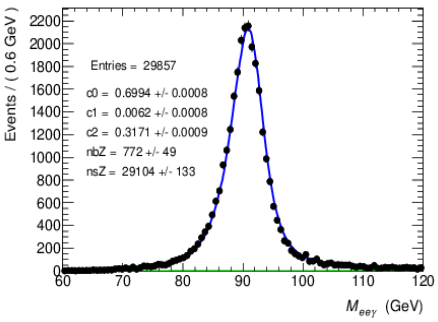

Fig. 5. The eeγ invariant mass fit. Green histogram is the background contribution

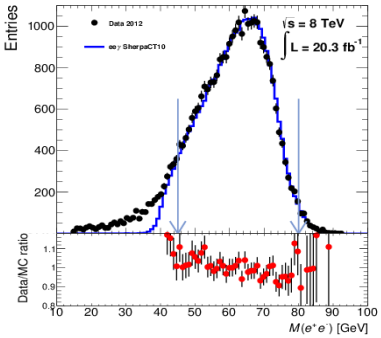

Fig.6. The ee invariant mass

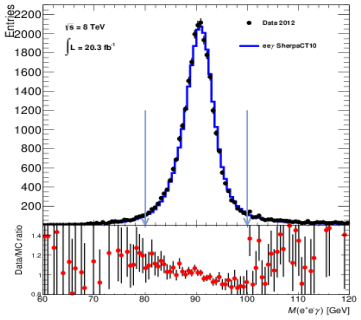

Fig.7. The eeγ invariant mass

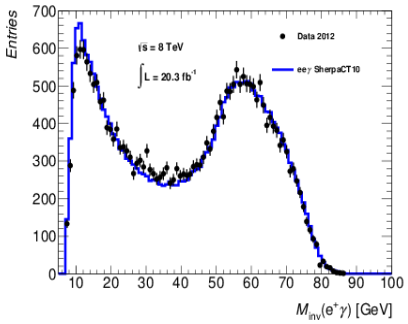

Fig.8. The $e^{+}\gamma$ invariant mass

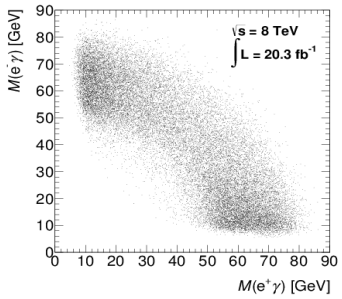

Fig. 9. $e^-\gamma$ invariant mass vs $e^+\gamma$ invariant mass

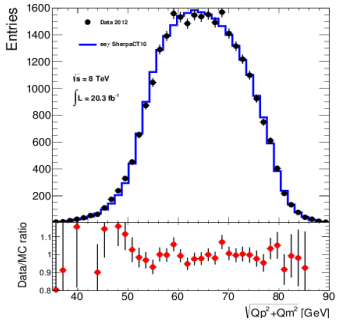

Fig.10. The $\sqrt{Qp^2 + Qm^2}$ quantity

According to Fig.9 there is the correlation between $M_{inv}(l^-\gamma)$ and $M_{inv}(l^+\gamma)$. Fig.10 shows that correlation is also well reproduced by the MC.

INSTRUCTION FOR PICTURES DRAWING

One of the main tasks was to automate the procedure of pictures drawing, which is necessary for analysis. The full instruction for pictures drawing procedure is represented below.

1. To login onto lxplus use command: ssh –Y <username>@lxplus.cern.ch;
2. To copy scripts: cp /afs/cern.ch/work/e/eganiev/public/Analysis/Z2lgPicturesDrawer.sh <directory path>
   cp /afs/cern.ch/work/e/eganiev/public/Analysis/InitBoth.C <directory path>
   Z2lgPicturesDrawer.sh launches drawing pictures scripts, InitBoth.C contains tree's initialization and cut's conditions;
3. To create directory for pictures: mkdir Pictures2lg;
4. To start drawing procedure of all pictures: source Z2lgPicturesDrawer.sh ;
5. To draw only one or few pictures you should open script Z2lgPicturesDrawer.sh: emacs Z2lgPicturesDrawer.sh&; then find script name that you like to draw, e.g. root –b –q Mmumu_DrawerWithRatio.C, copy it to linux shell;
6. To change selection criteria you should open script called InitBoth.C: emacs InitBoth.C& ; then find cut name you want to change and fix it.

SUMMARY

The selection criteria described in the note were applied to the 2012 data collected with ATLAS detector at 8 TeV pp collisions and to MC of the pp→Z+X→llγ+X process. Cut flow tables were checked. All pictures from the note were validated and ATLAS Style was applied to all of them. The procedure of picture drawing was automated.

REFERENCES

1. ATL-COM-PHYS-839;
2. A. Sirlin, A.Ferroglia. Rev.Mod.Phys., V85 (2013): eq. (59) p.273;
3. D. Bruss, O. Nachtmann, P. Overmann, Eur.Phys.J.C1:191-199,1998.