Photo-production of Upsilon (Υ) and dilepton continuum in Ultra Peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5$ TeV

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Introduction

Ultra-peripheral collisions (UPC_s) of heavy-ions involves long range electromagnetic interactions at impact parameters larger than twice the nuclear radius where no nucleon-nucleon collision can take place. At LHC (Large Hadron Collider) the strong electromagnetic field due to coherent action of Z=82 proton charges accelerated at TeV energies generates an equivalent flux of quasi real photons which can be used for high energy photo production studies. Exclusive photo-production of heavy quarkonia in high-energy ultra-peripheral collisions ($\gamma A \rightarrow V\, A$, where $V = J/\psi, \Upsilon$ and the nucleus A remains intact) offers a useful means to constrain the small-x nuclear gluon density. At LHC , due to center of mass energies 5.5 TeV/nucleon maximum photon energy can reach up to 100 GeV [1]. Which corresponds a photon-nucleus c.m. energy of the order of 1 TeV. Measurement of Υ photo-production in CMS at LHC can probe a x value of the order 10^{-4}. The CMS capabilities for the measurement of Υ family in $\mu^+\mu^-$ and e^+e^- decay modes using the tracker, the muon chambers and the ECAL in ultra peripheral PbPb collisions at $\sqrt{s_{NN}}$=5.5 TeV are studied. Input distributions are obtained using STARLIGHT generator, which is based on PHENIX UPC data. Full Simulation and Reconstruction of whole Υ family as well as dilepton-continuum is done. Standard HLT algorithms are used to select interesting events. Geometrical acceptance, Trigger and reconstruction efficiencies are calculated for Υ and dilepton continuum.

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Υ family and dimuon continuum

Upsilon family and dilepton continuum are reconstructed for CMS detector. In dimuon channel reconstruction efficiency (geometrical acceptance $\times$ reconstruction efficiency) is calculated for whole Υ family i.e. Υ(1s), Υ(2s) and Υ (3s). It is found that reconstruction efficiency increases 50 % for Υ(1s) to 57% for Υ (3s). Reconstruction efficiencies for dimuon continuum are found 8 %. Dependence of reconstruction efficiency on muon p_t is studied. It is found that dimuon continuum reconstruction efficiency decrease more rapidly than Upsilon with increasing muon p_t cut. In Dielectron channel Reconstruction efficiency (geometrical acceptance$\times$ reconstruction efficiency) for Υ family (dielec cont) is found 13% (1%). Also mass resolution is 200 MeV, so it is difficult to separate three states of family. We have worked on two aspects namely, increase electron reconstruction efficiencies using Particle Flow techniques and work on trigger strategies for UPC.

Electron reconstruction with Particle Flow (PF) Techniques

Electron reconstruction efficiency in CMS is nearly 90 % for electron $p_t \geq 5$ GeV [5]. But most of the electrons coming from Υ decay have p_t less than 5 GeV. Electrons coming from dielectron continuum ($\gamma\gamma \rightarrow e^+e^-$) also have small p_t values. Thus Υ reconstruction efficiencies are found very small in electron decay channel. As we get very small reconstruction efficiencies for low p_t electrons. We tried ParticleFlow tools for electron reconstruction. it is found that reconstruction efficiencies for low p_t electrons can be increases using Particle Flow Technique. These techniques are very new and in their early stage of being implemented in CMS software package (CMSSW). We successfully use these techniques in electron reconstruction and achieve a increase in reconstruction efficiencies. Using PF electrons, Upsilon reconstruction efficiency can be increased up to 19 % from 10 % (using standard GSF electron collection).

TABLE I: Single electron reconstruction efficiency using Particle Flow Collection (PF Coll) and Gaussian Sum Fitter collection (GSF Coll)

	GSF Coll	PF Coll
($\|\eta\|^e \leq 1.0$,$\|p_t\|^e >0$)	26%	63%
($\|\eta\|^e$ no cut ,$\|p_t\|^e > 0$)	22%	39%

Υ reconstruction with High Level Trigger

Ultra Peripheral Collisions have following characteristics which can be used for triggering them:
1. A large rapidity gap between the produced state and interacting nuclei.
2. Forward emission of neutron(s)
3. Very low global multiplicities, two back to back tracks (almost empty central detector)
4. Relatively narrower rapidity distribution centered at mid rapidity

On the basis of these basic characteristics following CMS L1 primitive triggers are proposed in CMS AnalysisNote [6] as part of Ultra Peripheral Trigger

i) Veto ('OR') on signals in forward hadron calorimeters towers ($3\leq |\eta| \leq 5$) above the default energy threshold (HF^+ .OR. HF^-) to insure a large rapidity gap in one or both hemisphere.

ii) Energy deposition in Zero Degree Calorimeter $^+$ or Zero Degree Calorimeter$^-$ above the default threshold in normal PbPb collisions to tag Coulomb break up via GDR neutron excitation .

iii) Hit(s) in muon RPCs ($|\eta| \leq 2.4$) or CSCs ($0.8\leq |\eta| \leq 2.4$), no minimum p_t cut for track as defined in standard PbPb dimuon trigger.

In this analysis we tried HLT paths HLTMu3 and HLTDoubleMu3. HLTMu3 (HLTDoubleMu3) required at least one (two) muon with p_t more than 3 GeV, present in event. Trigger efficiencies are calculated for Υ family and dimuon continuum. These efficiencies are tabulated in table II.

TABLE II: Trigger efficiency for HLTMu3 and HLTDoubleMu3

	HLTMu3	HLTDoubleMu3
$\Upsilon \rightarrow \mu^+\mu-$	42 %	17 %
$\gamma\gamma \rightarrow \mu^+\mu^-$	5 %	2 %

We can see from table II that for HLTMu3 Υ trigger efficiency is 42 % while for dimuon continuum it is very small only 5%. Thus a lot of dimuon continuum events get rejected in trigger. Total reconstruction efficiency (geometrical acceptance $\times$Trigger efficiency $\times$ reconstruction efficiency) is found 35 % for Υ family and 4% for dimuon continuum.

References

[1] K. Hencken *et al.*, Phys. Rep. to appear, arXiv:0706.3356 (2007).

[2] L. Gribov, E. M. Levin and M. G. Ryskin, Phys. Rep. **100**, 1 (1983);
A. H. Mueller and J. w. Qiu, Nucl. Phys. B **268**, 427 (1986)

[3] See e.g. E. Iancu and R. Venugopalan, in QGP. Vol 3, Eds: R.C. Hwa *et al.*, World Scientific, Singapore, hep-ph/0303204 (2003);
J. Jalilian-Marian and Y. V. Kovchegov, Prog. Part. Nucl. Phys. **56** 104 (2006).

[4] L. Frankfurt, M. Strikman and C. Weiss, Ann. Rev. Nucl. Part. Sci. **55**, 403 (2005)

[5] S. Baffioni *et al.* CMS Note AN-2006/40,

[6] David d'Enterria, Aurelien Hees CMS Note AN-2006/107,