Rapidity Distribution of Υ(1S,2S,3S) Photoproduction in pPb Ultraperipheral collisions at 8.16 TeV

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Photoproduction of vector mesons in ultra-peripheral collisions (UPCs) of protons and ions provide unique opportunity to extract potential information about the parton distribution function (PDF) in proton and nucleus at small Bjorken x. In this work, we have investigated the exclusive Υ(nS) photoproduction in pPb UPC collisions at $\sqrt{s_{NN}} = 8.16$ TeV, the collision scenario at LHC in Run2 during Nov. 2016. The rapidity distribution of Υ(1S,2S,3S) photoproduction cross section with different gluon PDF of proton and nucleus considering photon flux suppression due to strong interactions, are being presented.

The rapidity distribution of vector meson (Υ) in proton-nucleus UPC interaction with proton from the right and Pb nucleus from the left, is given by the sum of the two terms:

$$\frac{\sigma_{pPb\to pPb\Upsilon}(y)}{dy} = N_{\gamma/Pb}(y)\sigma_{\gamma p\to\Upsilon p}(y) + N_{\gamma/p}(-y)\sigma_{\gamma Pb\to\Upsilon Pb}(-y) \quad (1)$$

Here $N_{\gamma/Pb(p)}(y)$ is the photon flux of proton or nucleus; $y = \ln(2\omega/M_\Upsilon)$ is the rapidity of Υ where ω is the photon energy and M_Υ is the mass of the Υ. As the photon flux $\propto Z^2$ the first term in r.h.s. (γp contribution) dominates and peaks at positive rapidity while the second term (γPb contribution) peaks at negative rapidity.

The photon flux of the proton (nucleus) of charge Z can be expressed as the convolution over the impact parameter b [1]:

$$N_{\gamma/Z}(\omega) = \int_0^\infty d^2\vec{b}\; \Gamma_{pA}(\vec{b}) N_{\gamma/Z}(\omega,\vec{b}) \quad (2)$$

where $N_{\gamma/Z}(\omega,\vec{b})$ is the photon flux in the transverse distance $\vec{b}$ away from the proton (nucleus) and $\Gamma_{pA}(\vec{b})$ is the probability to suppress the proton-nucleus strong interaction (SI) at small impact parameter b. In Fig. 1 we

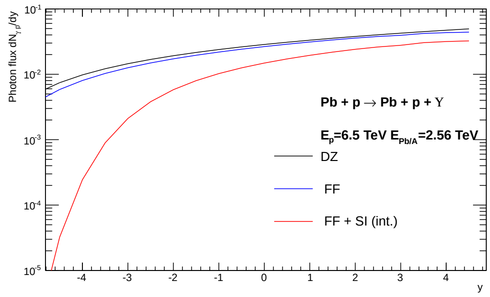

FIG. 1: The flux of photons from proton $N_{\gamma/p}$ as a function of Υ(2S) rapidity y in proton-Pb UPC at $\sqrt{s} = 8.16$ TeV.

compare the photon flux from the proton for the Υ (2S) photoproduction, evaluated from the exact expression Eq. 2 (red curve), the generally used DZ expression (black curve) and the FF (blue curve) is without SI suppression ($\Gamma_{pA}(b) = 1$). It is observed that, the SI reduce the photon flux substantially at large -ve rapidities (high photon energies).

The cross section of exclusive photoproduction of Υ on H ($H \equiv p, A$) can be written as

$$\sigma_{\gamma H\to\Upsilon H}(y) = \frac{d\sigma_{\gamma H\to\Upsilon H}}{dt}|_{t=0} \int dt |F_H(t)|^2$$

where $d\sigma_{\gamma H\to\Upsilon H}/dt|_{t=0}$ is the forward scattering amplitude and $F_H(t)$ is the charge form factor of the hadron (nucleus). Using leading order (LO) approximation, the scattering am-

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plitude for elastic photoproduction of Υ from a proton or a nucleus reads [1]:

$$\frac{d\sigma_{\gamma H\to\Upsilon H}(W_{\gamma p},t=0)}{dt} = \frac{M_{\Upsilon}^3\Gamma_{ee}\pi^3}{48\alpha_{e.m.}\mu^8}\ (1+\eta^2)$$
$$R_g^2 F^2(Q^2)\ [\alpha_s(Q^2)\frac{xG_H(x,Q^2)}{A}]^2 \qquad (3)$$

x, is the fraction of nucleon momentum carried by gluons, $G_A(x,Q^2)$ is the gluon distribution in the proton or nucleus evaluated at momentum transfer $Q^2 = (M_\Upsilon/2)^2$. For gluon distribution in proton, we use recent LO and NLO parton distribution function (PDF), CTEQ6L1 and CTEQ6M respectively [2]. For nucleus, three nuclear modification sets are used: (i) LO and NLO EPS09 nuclear PDF [3] (ii) LO and NLO HKN07 [4] (iii) nCTEQ15 [5]. The factors $(1+\eta^2)$, R_g^2 corresponds to correction due to real part, skewness which are evaluated by fitting the CTEQ6L1 and CTEQ6M gluon distribution with $1/x^\lambda$. The NLO correction factor $F^2(Q^2)$ is phenomenologically determined from normalization while comparing the cross section $\gamma p \to \Upsilon(1S)p$ with available experimental data from HERA and LHCb.

TABLE I: Υ photoproduction cross-section of Υ (nS) in CMS acceptance for different nucleon and nuclear PDFs.

PDFs	Cross section (nb)		
	Υ(1S)	Υ(2S)	Υ(3S)
CTEQ6L1	171.8	60.5	36.6
CTEQ6L1+EPS09LO	159.2	56.0	33.9
CTEQ6L1+HKN07LO	161.4	56.8	34.4
CTEQ6M	148.9	51.1	31.4
CTEQ6M+EPS09NLO	140.4	48.2	29.6
CTEQ6M+HKN07NLO	140.9	48.3	29.7
CTEQ6M+nCTEQ15	136.6	46.9	28.8
STARLIGHT	156.2	70.2	50.6

Fig. 2 presents the rapidity distribution of Υ(nS) photoproduction cross section for pPb UPC collisions at $\sqrt{s}_{NN}$ = 8.16 TeV which is the LHC run 2 scenario, with different proton PDF and nuclear gluon shadowing parameterization. Photoproduction cross section for CMS acceptance $(-2.4 < y < 2.4)$ are given in Table 1. We also present the prediction

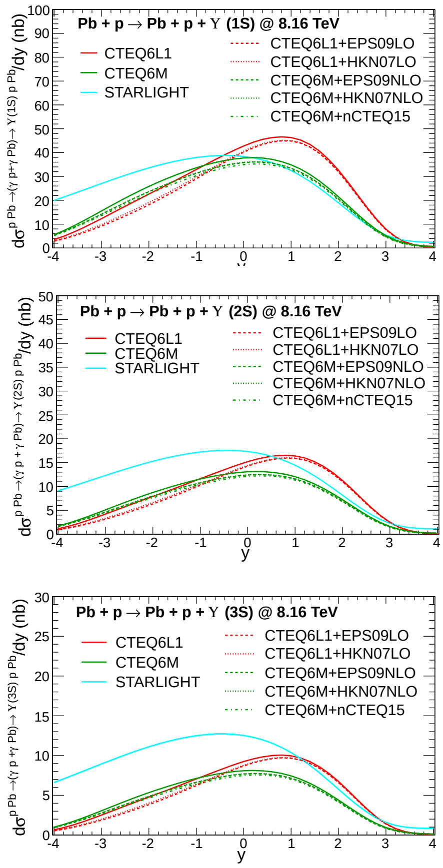

FIG. 2: The rapidity distribution of Υ (nS) photoproduction cross-section for pPb collisions at $\sqrt{s}$ = 8.16 TeV. (upper panel) Υ (1S), (middle panel) Υ (2S), (lower panel) for Υ (3S) respectively.

of cross section from STARLIGHT event generator [6]. The theoretical predictions can be compared with the experimental measurements of Υ photoproduction from Run2 LHC.

References

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