Simulation of Radiative Effects for DVCS(BH)

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Introduction

Our goal is to simulate radiative effects for DVCS (BH) in a common framework of CLAS12 or CLAS MC reconstruction.

For the fixed kinematic point (Q^2, $x_{Bj.}$, $-t$, ϕ) the born and radiative cross sections together with the probabilities for two-photon emission were calculated by:

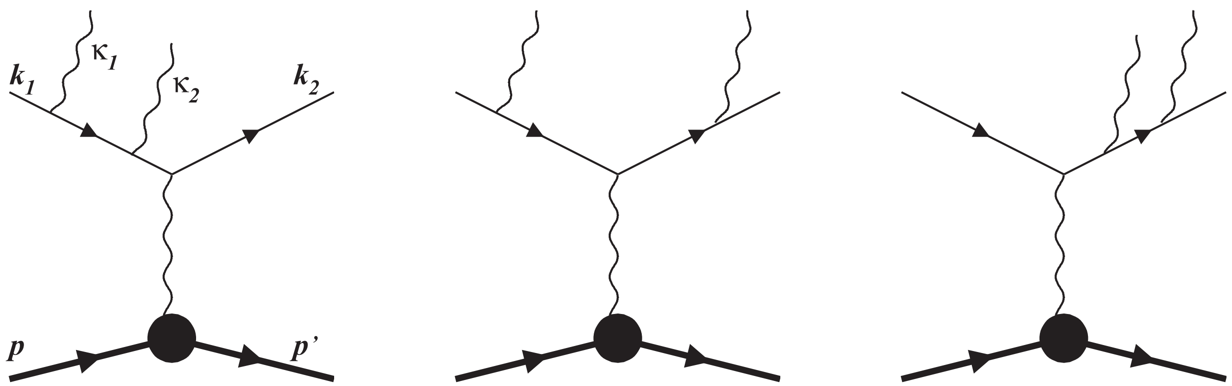
I. Akushivich, A. Ilyichev Phys. Rev. D85, 053008 (2012)

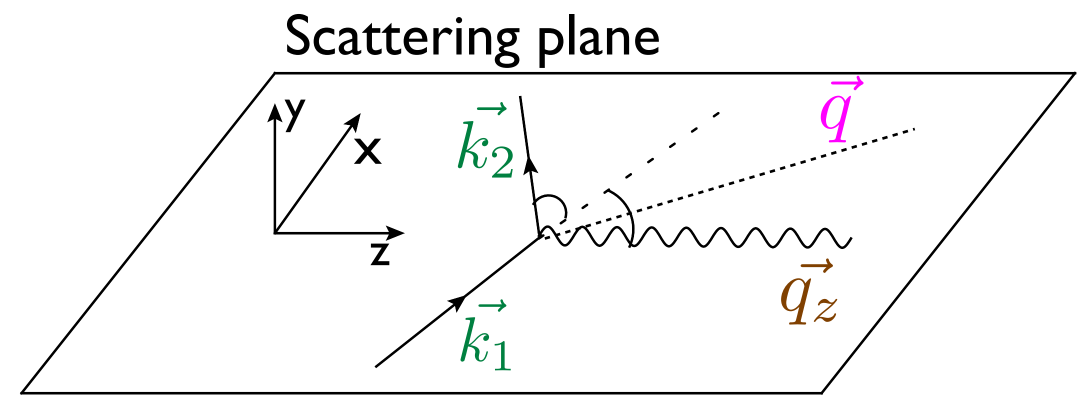
I. Akushivich, A. Ilyichev, M. Shumenko Phys. Rev. D90, 033001 (2014)

Implementation of radiative smearing for the final state particles.

Studies of the radiative smearing from the reconstructed MC sample.

Basic notations





The cross section of two photon emission is calculated under the assumption, that the second photon is unobserved (s & p peaks).

Second photon is collinear with either incoming or scattered electron.

$$\left.\begin{aligned}\gamma_{\mathbf{1}} &= \mathbf{k_1} - z_1\mathbf{k_1} \\ \gamma_{\mathbf{2}} &= \mathbf{k_2} z_2^{-1} - \mathbf{k_2}\end{aligned}\right\} \xrightarrow{\text{generalized notation}} \gamma = z_2^{-1}\mathbf{k} - z_1\mathbf{k} \quad \left\{\begin{aligned} z_1 &= 1 \ for\ the\ p\ peak \\ z_2 &= 1 \ for\ the\ s\ peak\end{aligned}\right.$$

True Kinematics:

$$\mathbf{q_z} = z_1\mathbf{k_1} - z_2^{-1}\mathbf{k_2}$$

$$Q^2_{true} = \frac{z_1 Q^2}{z_2} \qquad x_{true} = \frac{Q^2_{true}}{2M(z_1 E_{beam} - E' z_2^{-1})} \qquad \nu_{true} = \frac{Q^2_{true}}{2M x_{true}}$$

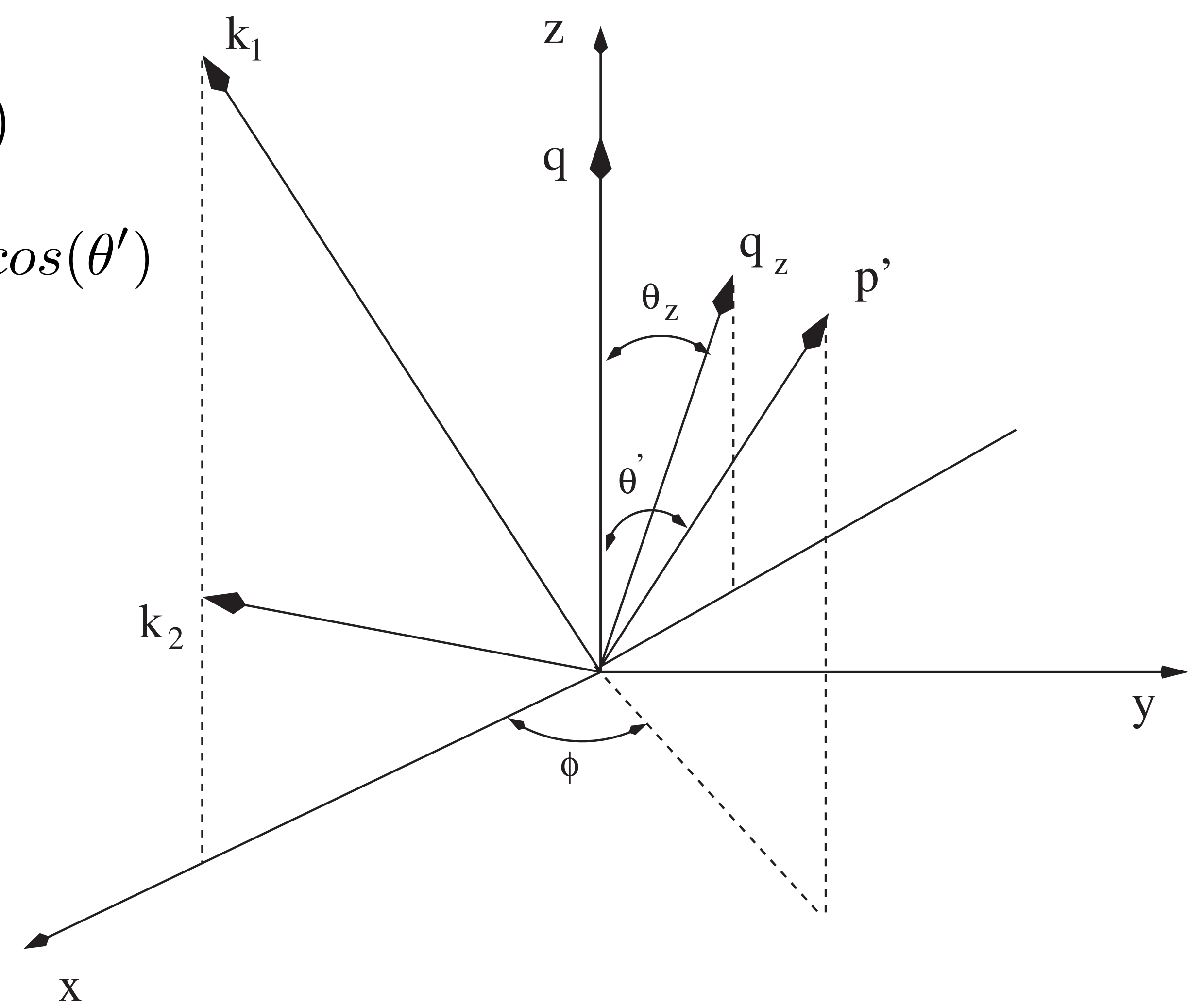
Definition of final state particles

Direction of $\vec{q_z}$ defines true polar (θ_{true}) and azimuthal (ϕ_{true})angles for the recoil proton.

$$cos(\theta_{true}) = cos(\theta')cos(\theta_z) - sin(\theta')sin(\theta_z)cos(\phi)$$

$$cos(\phi_{true})sin(\theta_{true}) = cos(\theta_z)sin(\theta')cos(\phi) + sin(\theta_z)cos(\theta')$$

$$sin(\phi_{true})sin(\theta_{true}) = sin(\theta')sin(\phi)$$



Proton energy is fixed by the squared four momentum transfer **t**.

$$E_{prot} = M - \frac{t}{2M}$$

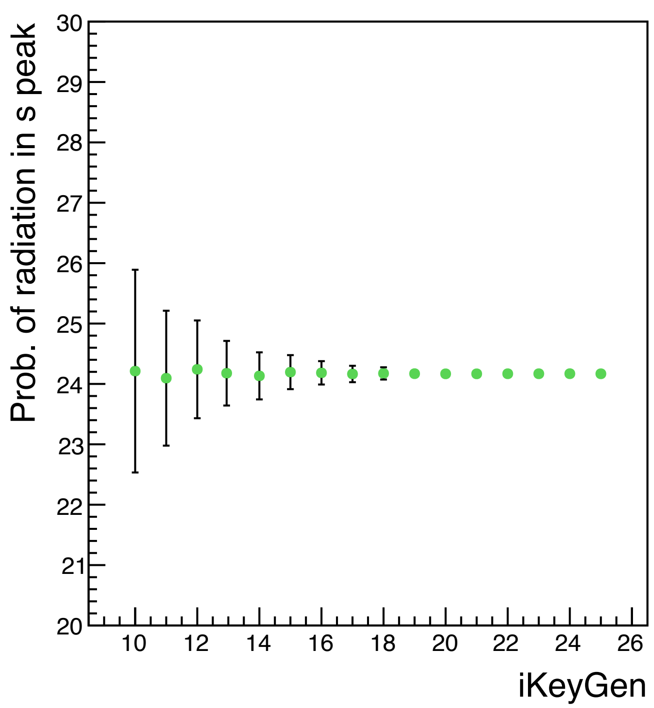
Photon energy is calculated using true energy transfer to the reaction.

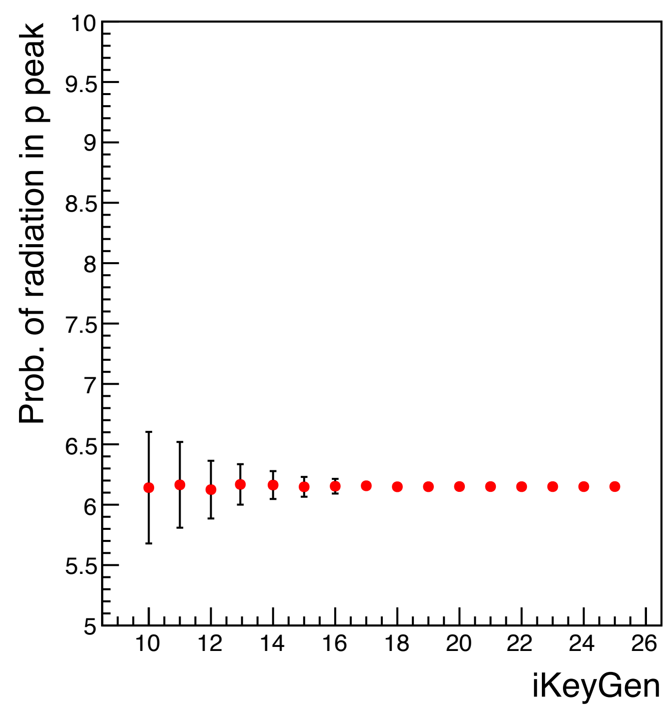
$$E_{\gamma} = \nu_{true} + \frac{t}{2M}$$

Precision of calculations

Radiative cross section is an integral over the phase-space of the photon in s & p peaks.

Accuracy of the calculation can be controlled by an external parameter (iKeyGen), that defines also the probabilities of second photon radiation.

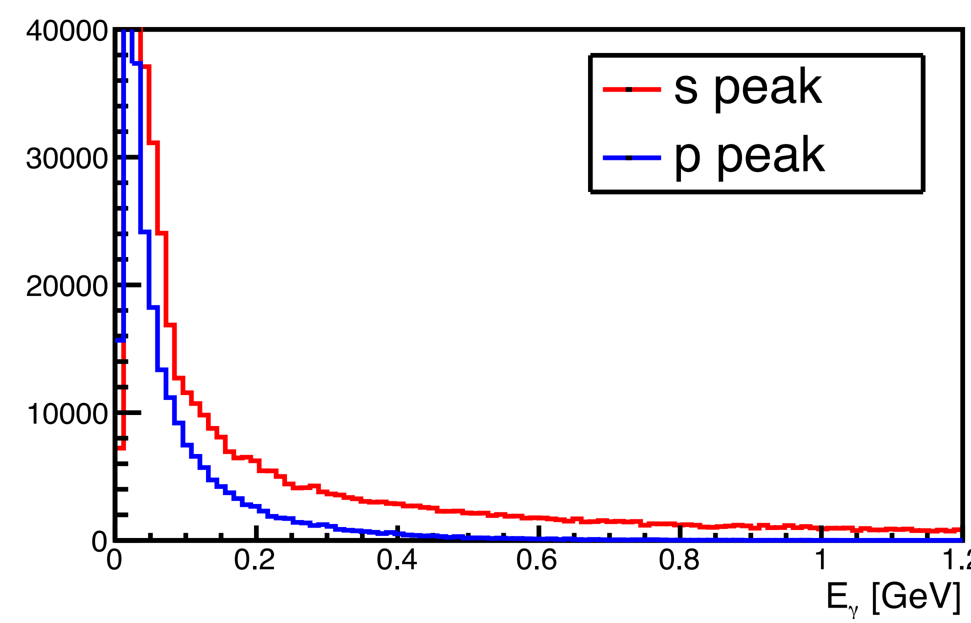




The size of the loop in MC integration: pow(2,iKeyGen)

Energy distributions of generated photons in the s & p peaks.

$$E_\gamma = \begin{cases} E_{Beam} - z_1 E_{Beam} \\ z_2^{-1} E' - E' \end{cases}$$

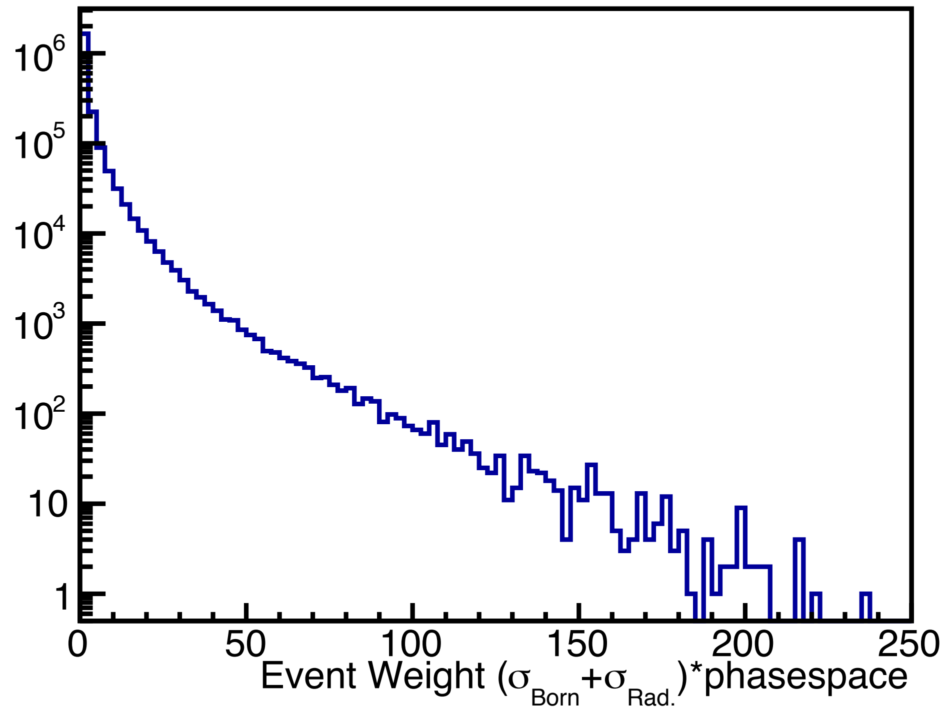


Generation of MC Sample

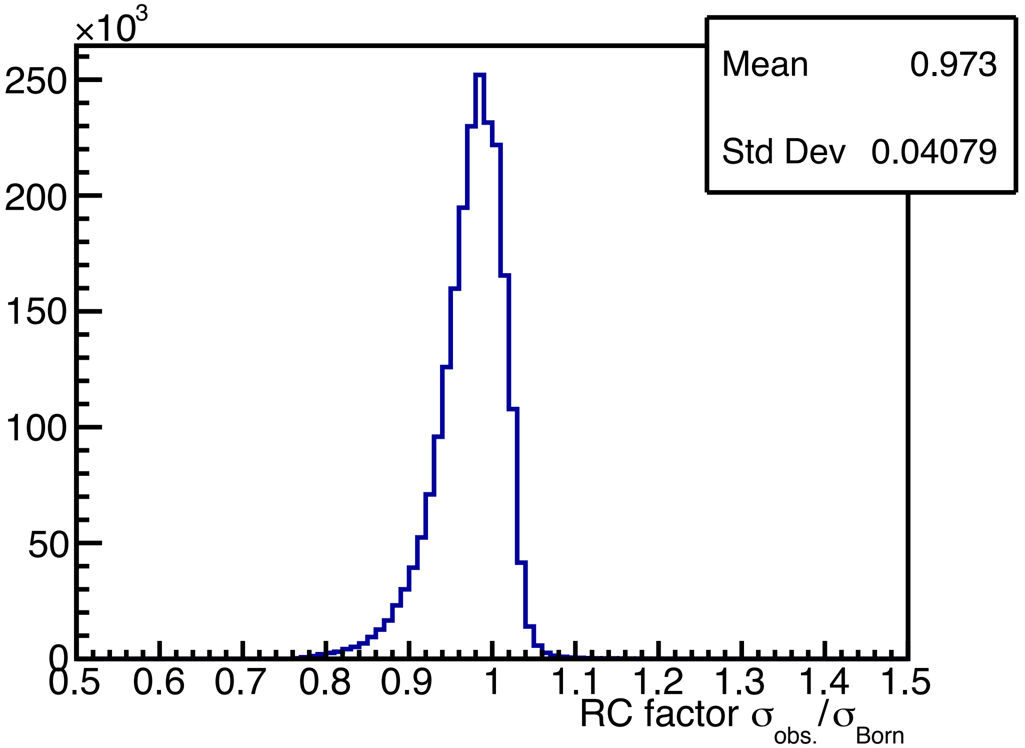
Event sample is generated using weighted MC method.

- Flat phase-space $X=(Q^2,\ x_{Bj.},\ -t,\ \phi)$ + MC weight
- MC weight = $(\sigma_{Born}(X) + \sigma_{Rad.}(X))$ * phase-space
- RC factor = $(\sigma_{Born}(X) + \sigma_{Rad.}(X)) / \sigma_{Born}(X)$

Distribution of event weights
for e16 kinematics

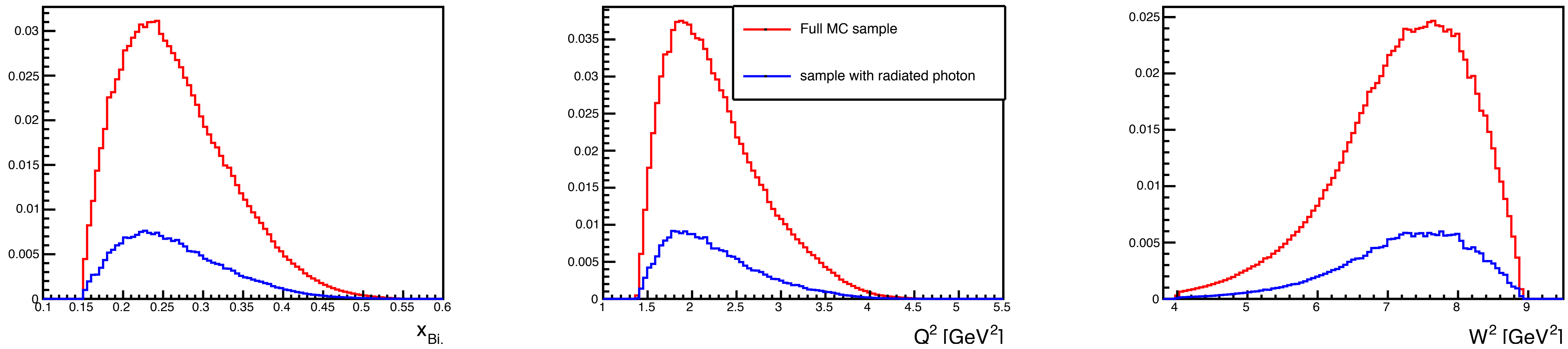


Distribution of RC factor
for e16 geometry

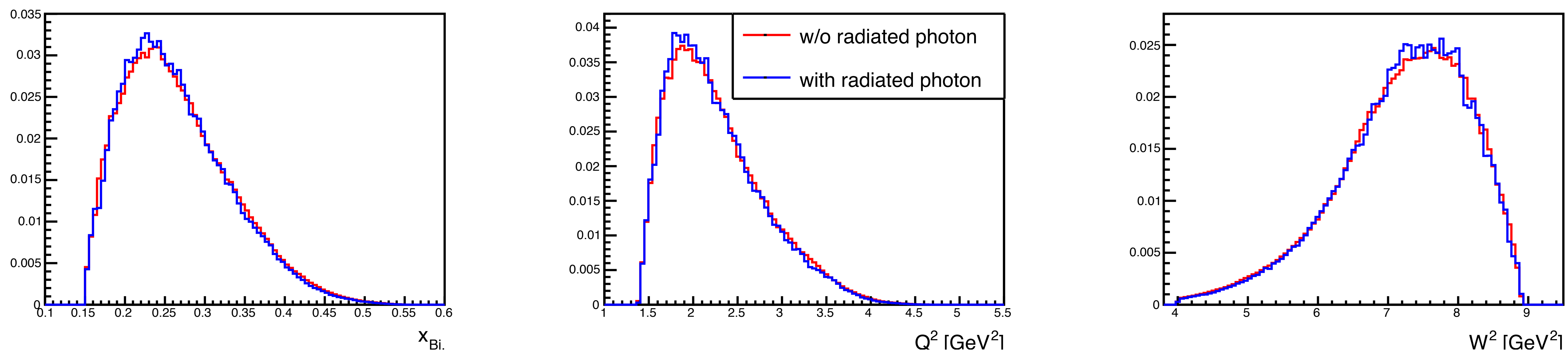


Inclusive kinematics

MC distributions of inclusive kinematics and the fraction of events with additional radiated photon.

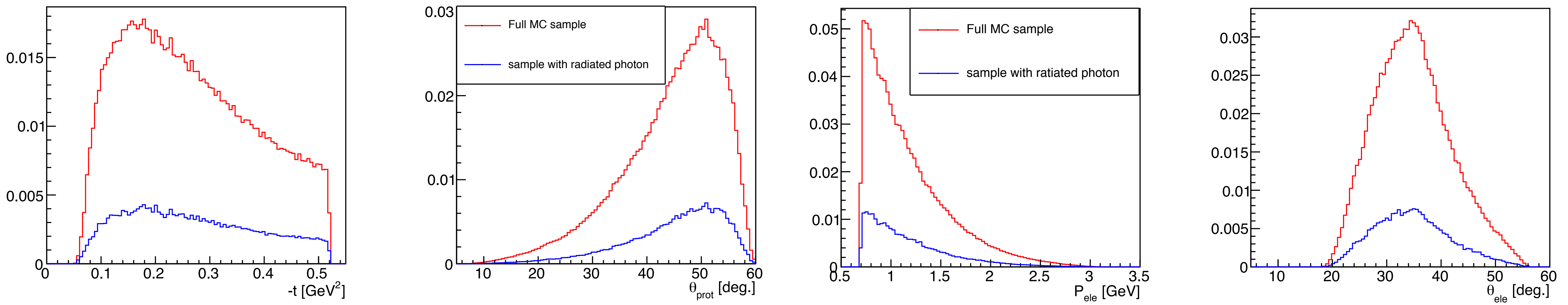


Comparison of the shapes of kinematic distributions for samples with and without radiated photon. Distributions are normalized to the area.



Kinematics of electron and proton

MC distributions of electron and proton kinematics and the fraction of events with additional radiated photon.



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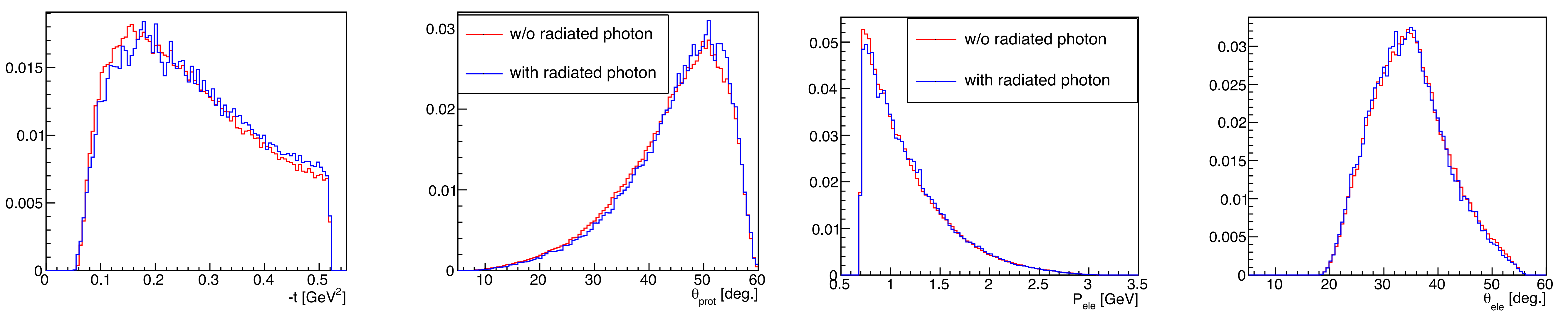
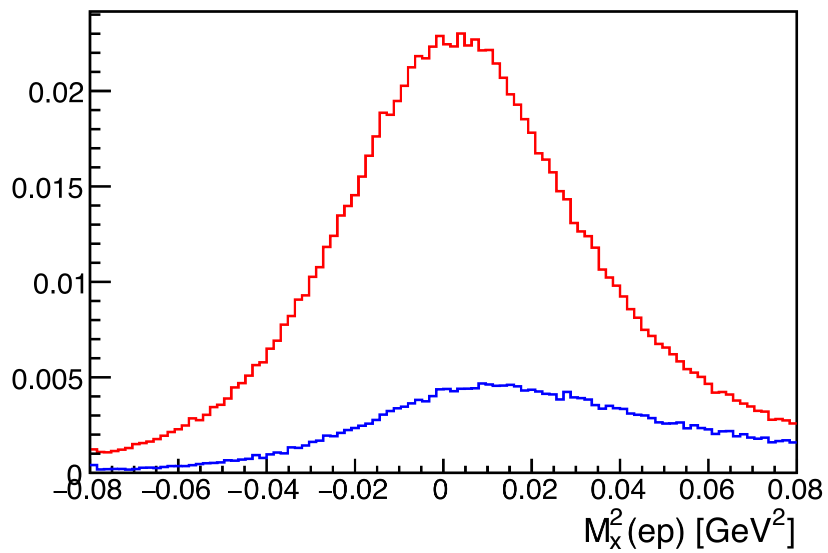
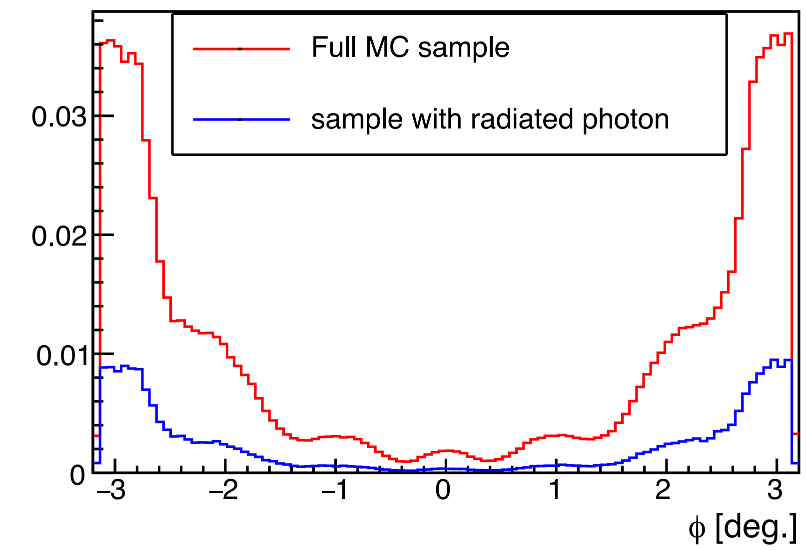


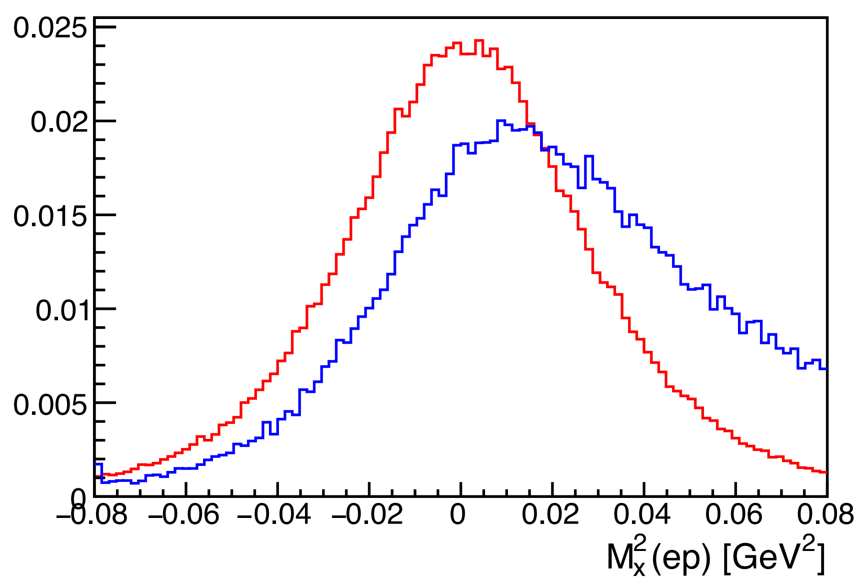
Exclusive kinematics

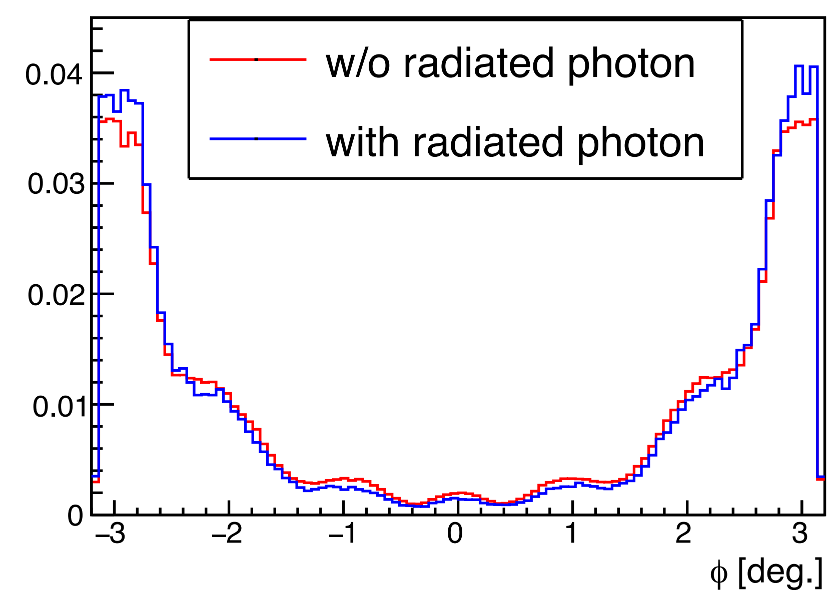
MC distributions of M_x^2 & ϕ and the fraction of events with additional radiated photon.





Comparison of the shapes of M_x^2 & ϕ distributions for samples with and without radiated photon. Distributions are normalized to the area.





Conclusion & Outlook

Monte Carlo generator with radiative effects for BH process can be used in the ongoing DVCS analysis.

Performance can be improved and controlled by the analyzers.

Possibility to add polarization dependences.

Possibility to add DVCS contribution together with Interference terms (for different GPD models).

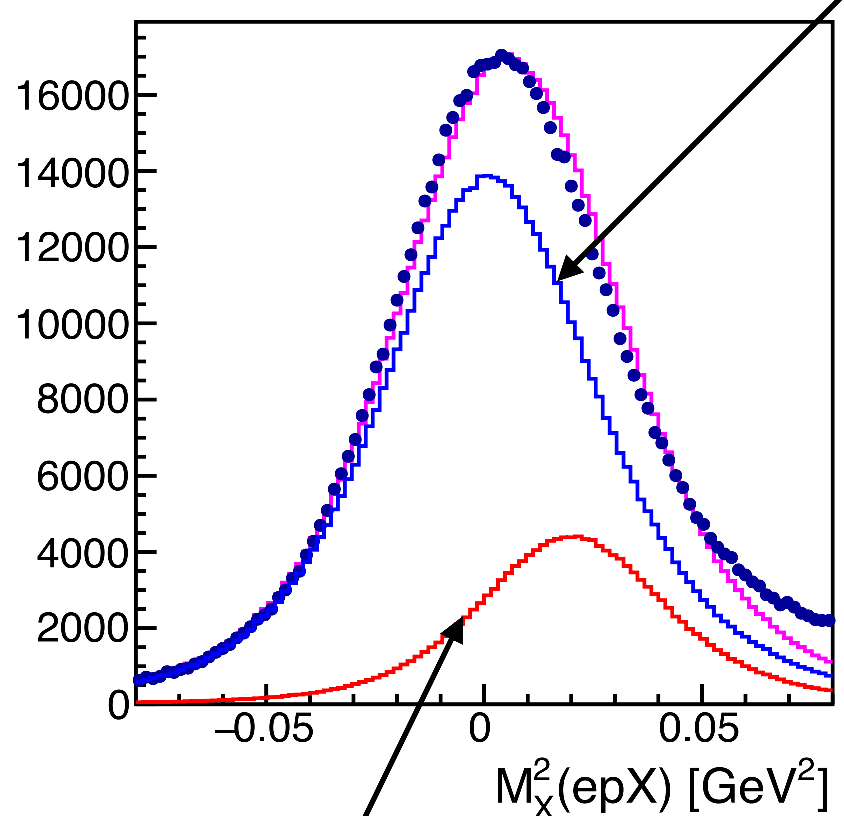
The source codes are available both in ForTran and C.

Thank you!

Backup

Backup

DVCS contribution
w/o radiative effects



Exclusive pion
contribution