Production of e^+e^- in proton-lead collision at the LHC energy

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New Vistas in Photon Physics in Heavy-Ion Collisions

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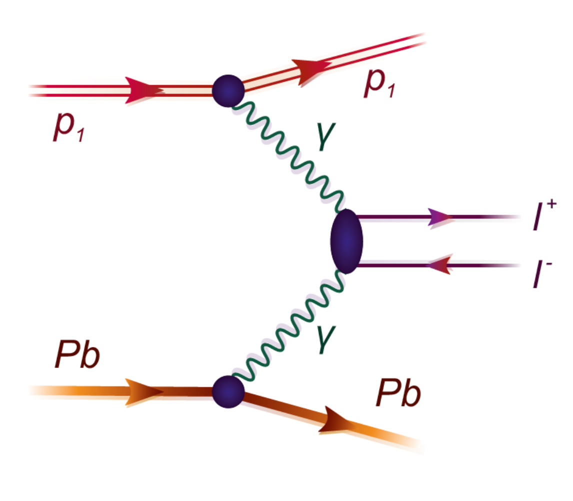
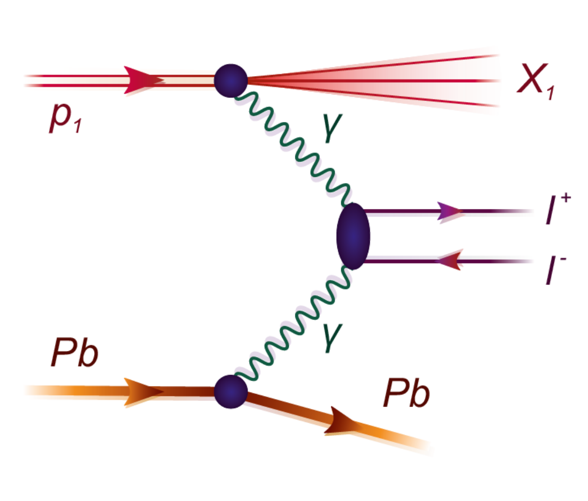
Introduction

- I would like to talk about photon initiated e^+e^- production in proton-lead collisions;
- We compared our results with experimental data;
- The formalism that we used is k_T-factorization approach;
- Our analysis covers four approaches to structure function;

$\gamma\gamma \rightarrow l^+l^-$ mechanism and k_T – factorization approach





The cross section for production of l^+l^- in proton-lead collisions in the k_T – factorization approach can be written as:

$$\sigma = S^2 \int dx_p dx_{Pb} \frac{d^2\overrightarrow{q_T}}{\pi} \left[\frac{d\gamma_{el}^{p}(x_p, Q^2)}{dQ^2} + \frac{d\gamma_{inel}^{p}(x_p, Q^2)}{dQ^2} \right] \gamma_{el}^{Pb}(x_{Pb}, Q^2)\, \sigma_{\gamma^*\gamma \rightarrow l^+l^-}(x_p, x_{Pb}, \overrightarrow{q_T})$$

Photon fluxes

The proton elastic flux is expressed by the proton electromagnetic form factor:

$$\frac{d\gamma_{el}^{p}(x_p, Q^2)}{dQ^2} = \frac{\alpha_{em}}{\pi}\left\{\left(1-\frac{x}{2}\right)\frac{4m_p^2 G_E^2(Q^2) + Q^2 G_M^2(Q^2)}{4m_p^2 + Q^2} + \frac{x^2}{4} G_M^2(Q^2)\right\}$$

For the nucleus elastic flux the following is repleaced:

$$\frac{4m_p^2 G_E^2(Q^2) + Q^2 G_M^2(Q^2)}{4m_p^2 + Q^2} \to Z^2 F_{em}^2(Q^2), \qquad F_{em}(Q^2) = \frac{3}{(QR_A)^3}\left[\sin(QR_A - QR_A\cos(QR_A)\right]\frac{1}{1+a^2Q^2}$$

The inelastic flux is expressed by the proton structure functions $F_2(x_{Bj}, Q^2)$ and $F_L(x_{Bj}, Q^2)$:

$$\frac{d\gamma_{inel}^{p}(x_p, Q^2)}{dQ^2} = \frac{1}{x}\int_{M_{thr}^2} dM_X^2\, \mathcal{F}_{\gamma^*\leftarrow p}^{in}(x, \vec{q}_T^{\,2}, M_X^2)$$

$$\mathcal{F}_{\gamma^*\leftarrow p}^{in}(x, \vec{q}_T^{\,2}, M_X^2) = \frac{\alpha_{em}}{\pi}\left\{(1-x)\left(\frac{\vec{q}_T^{\,2}}{\vec{q}_T^{\,2} + x(M_X^2 - m_p^2) + x^2 m_p^2}\right)^2 \frac{F_2(x_{Bj}, Q^2)}{Q^2 + M_X^2 - m_p^2} + \frac{x^2}{4x_{Bj}^2}\frac{\vec{q}_T^{\,2}}{\vec{q}_T^{\,2} + x(M_X^2 - m_p^2) + x^2 m_p^2}\frac{2x_{Bj}F_1(x_{Bj}, Q^2)}{Q^2 + M_X^2 - m_p^2}\right\}$$

Structure functions arguments

- Photon virtuality:

$$Q^2 = \frac{\vec{q}_T^{\,2} + x\left(M_X^2 - m_p^2\right) + x^2 m_p^2}{1 - x};$$

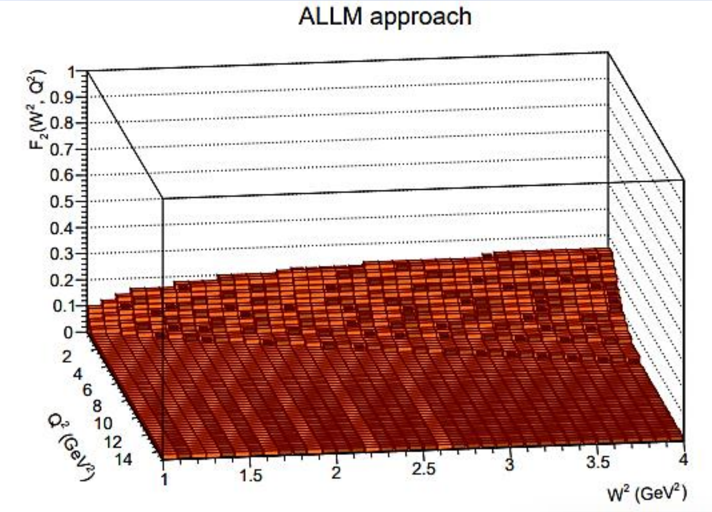
- Bjorken-x:

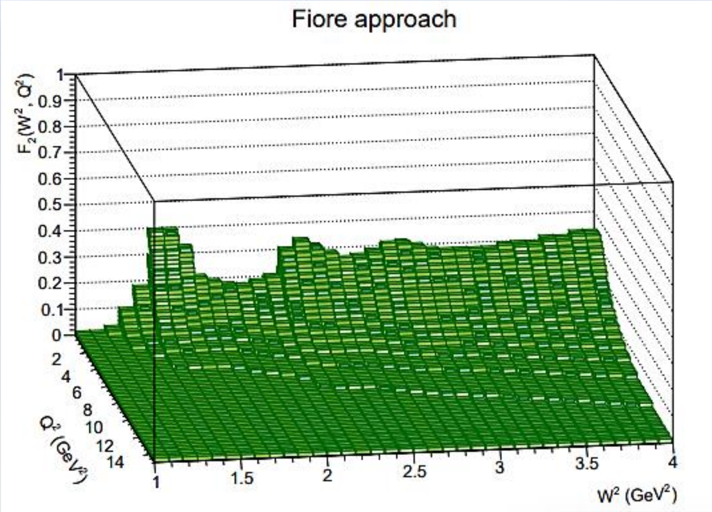
$$x_{Bj} = \frac{Q^2}{\left(Q^2 + M_X^2 - m_p^2\right)};$$

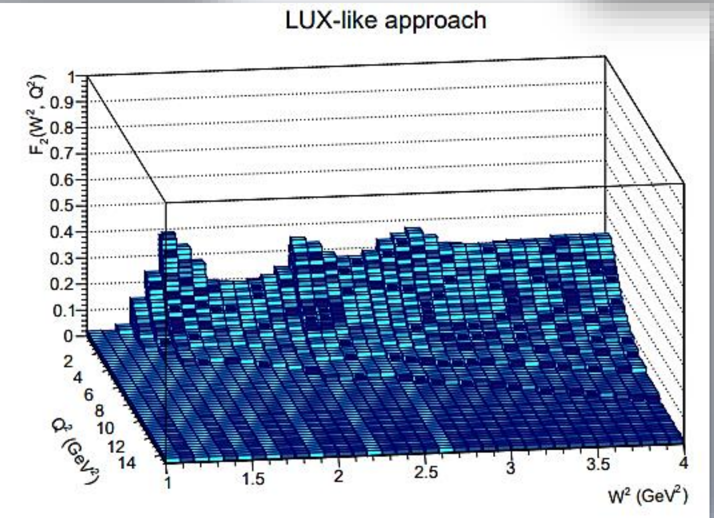
- Invariant mass of the hadronic final state:

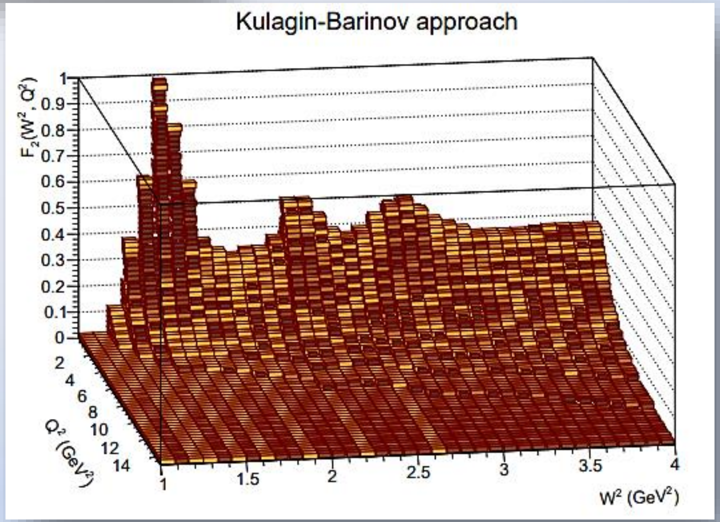
$$W^2 = \frac{1 - x_{Bj}}{x_{Bj}} Q^2 + m_p^2;$$

Different parametrizations of structure functions depending on W^2 and Q^2

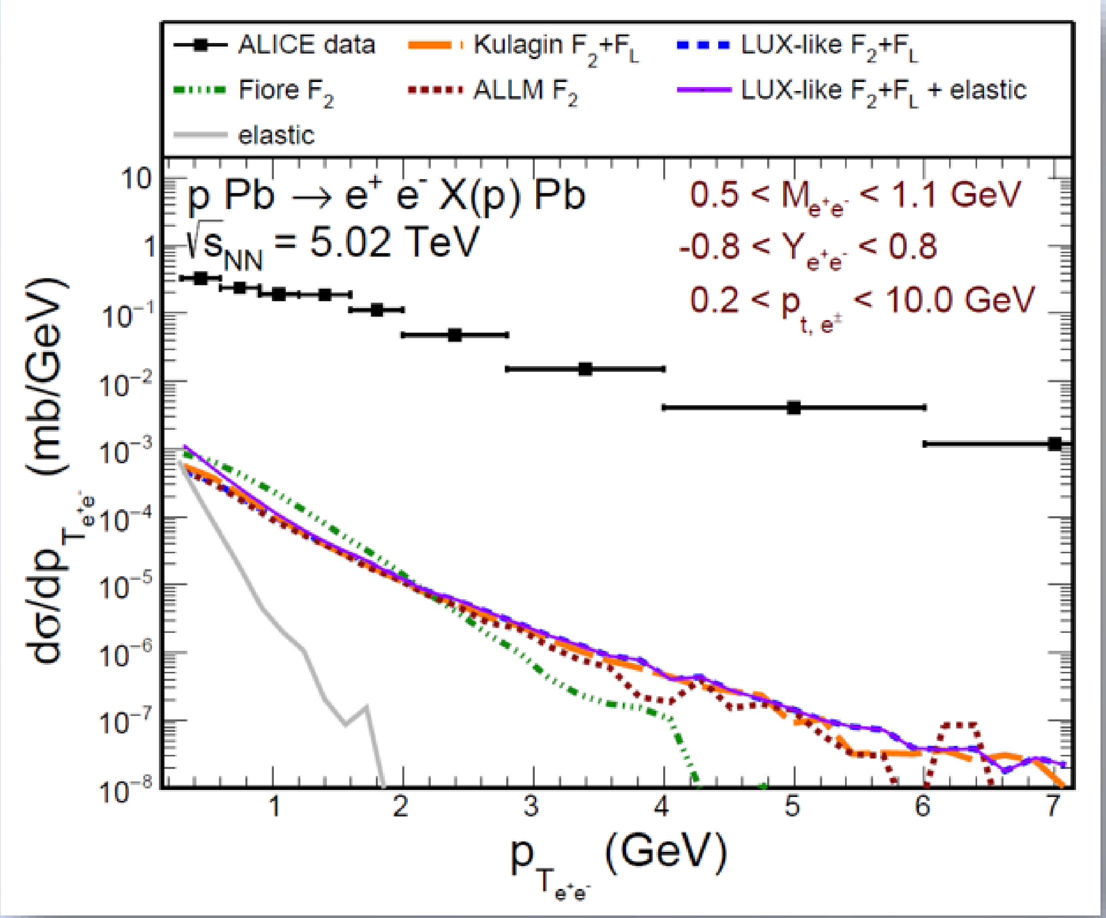


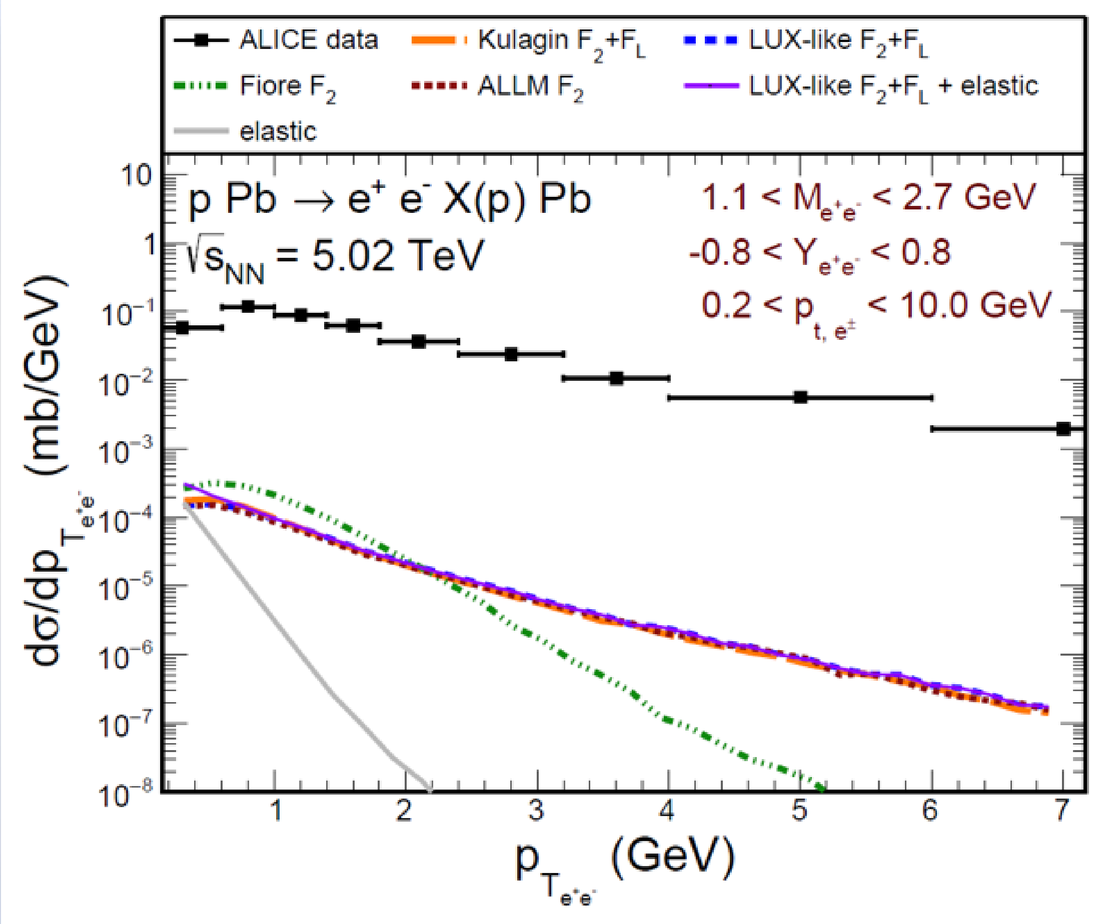






Distributions in $p_{T_{e^+e^-}}$





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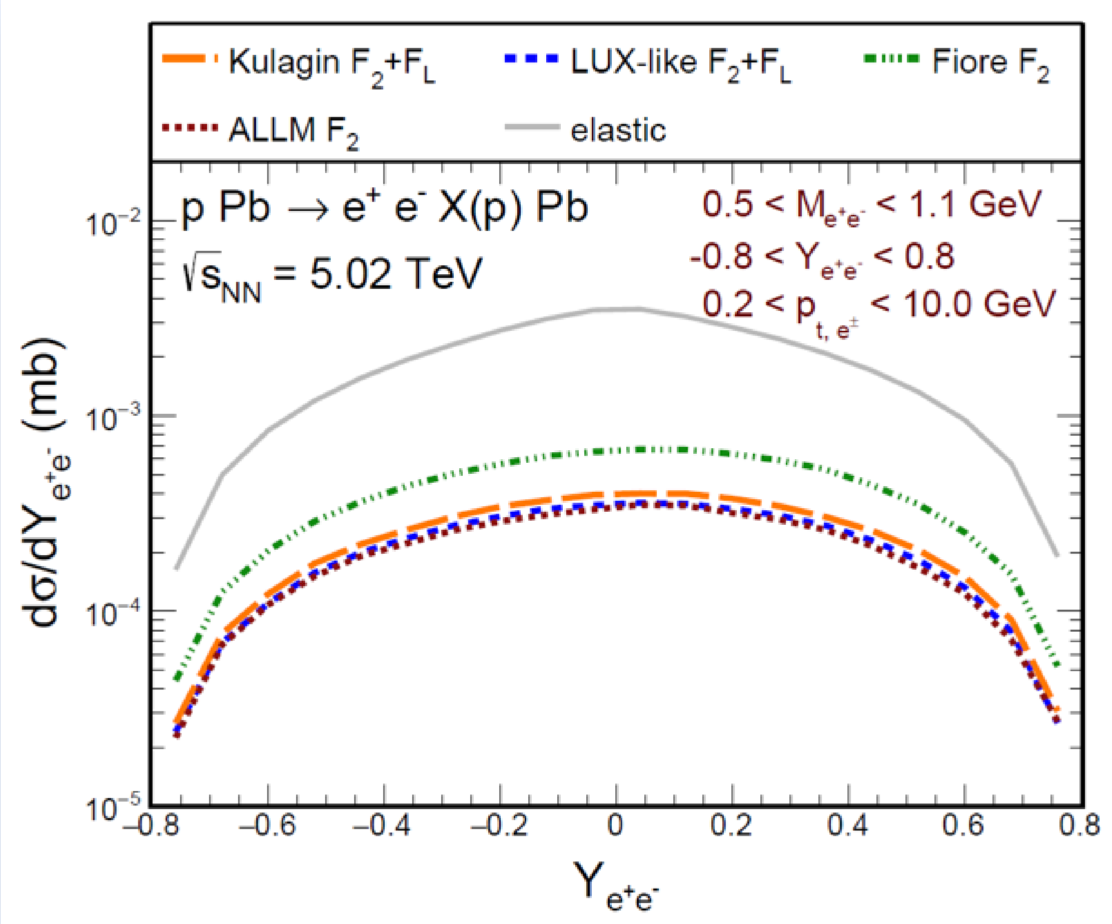
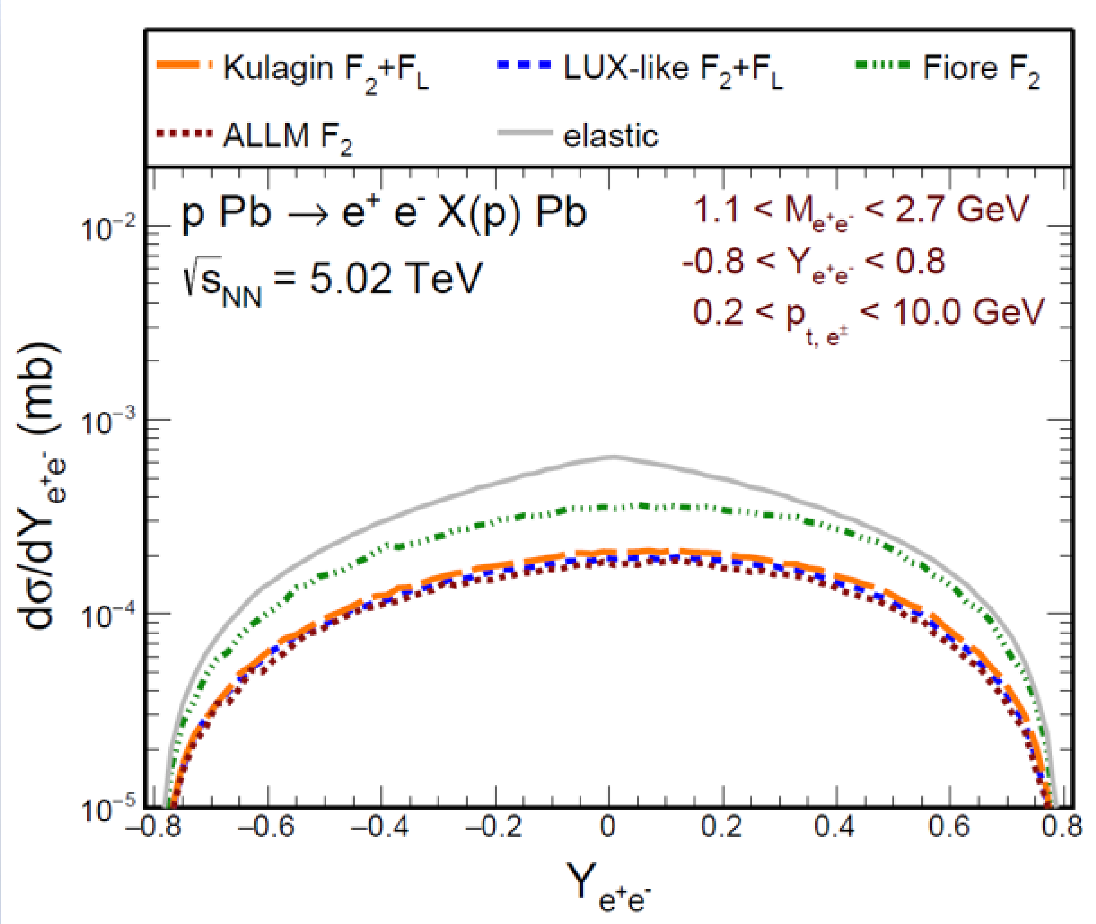
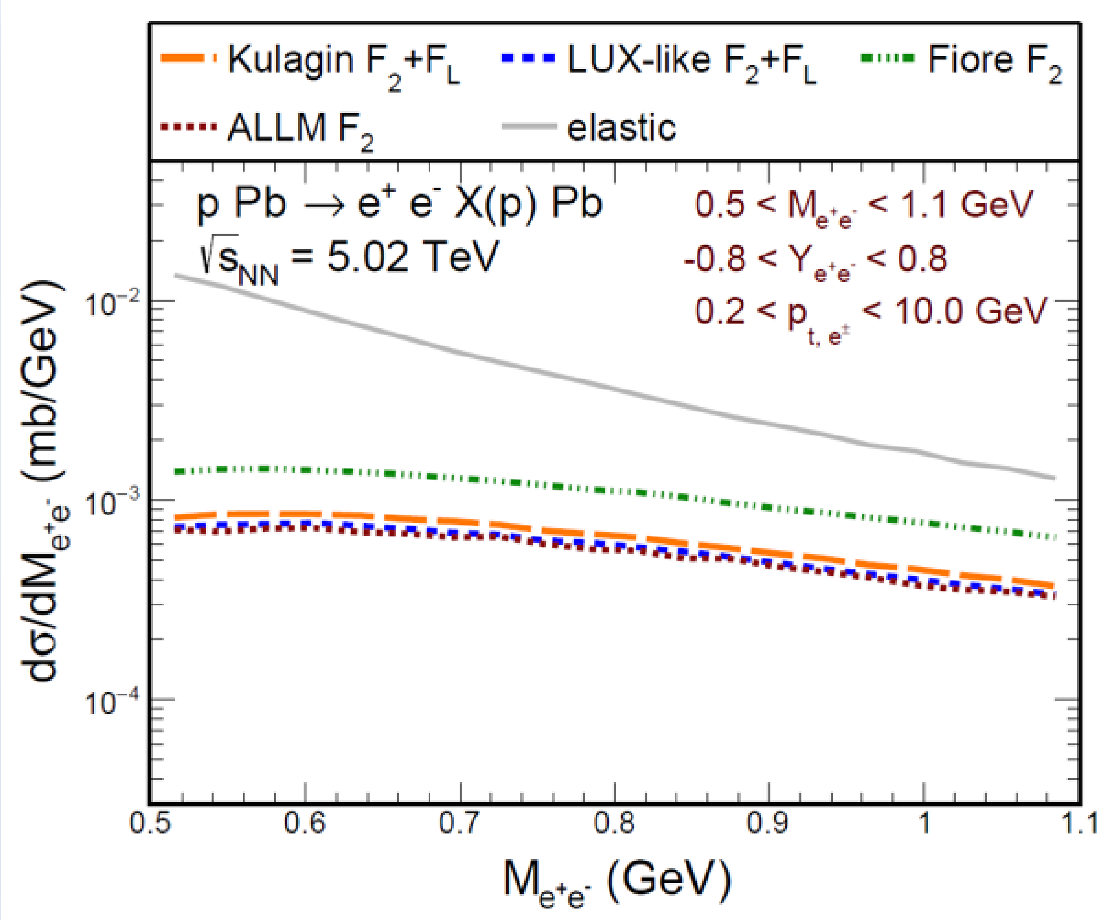
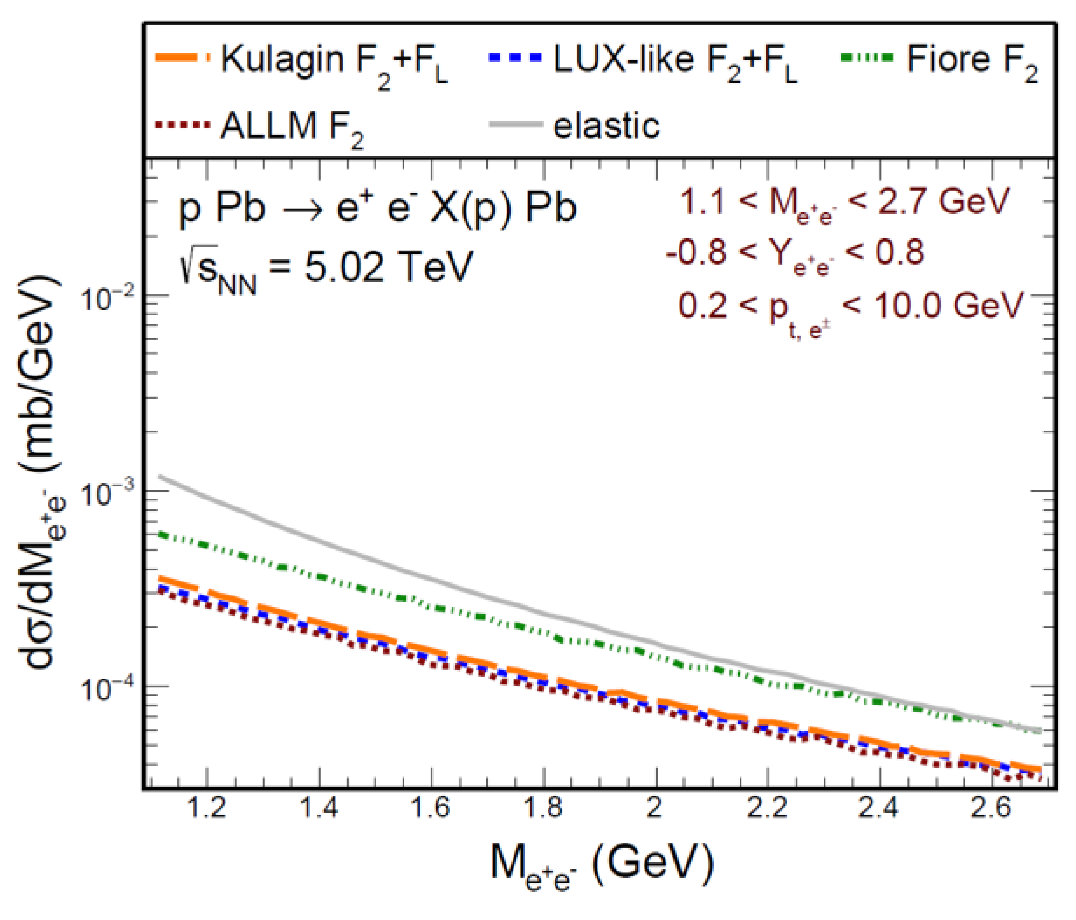
Distributions in $Y_{e^+e^-}$



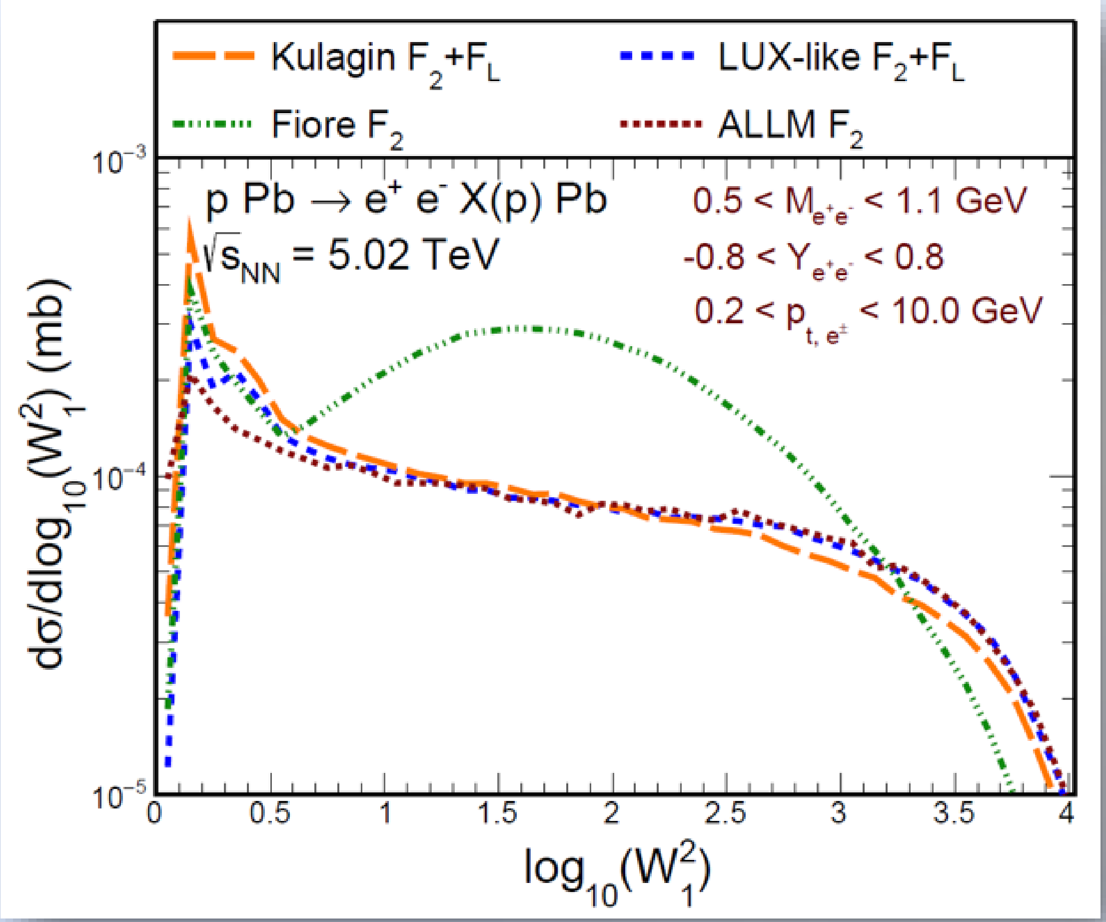


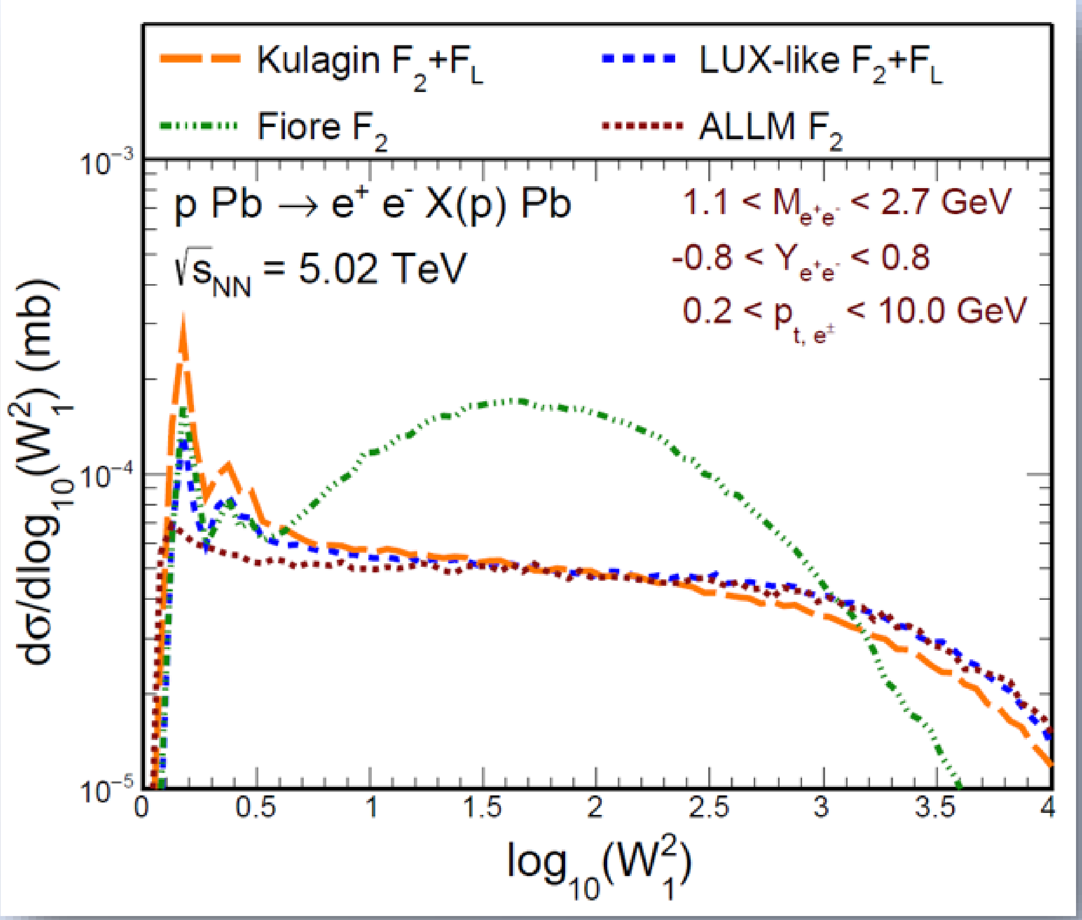
Distributions in $M_{e^+e^-}$



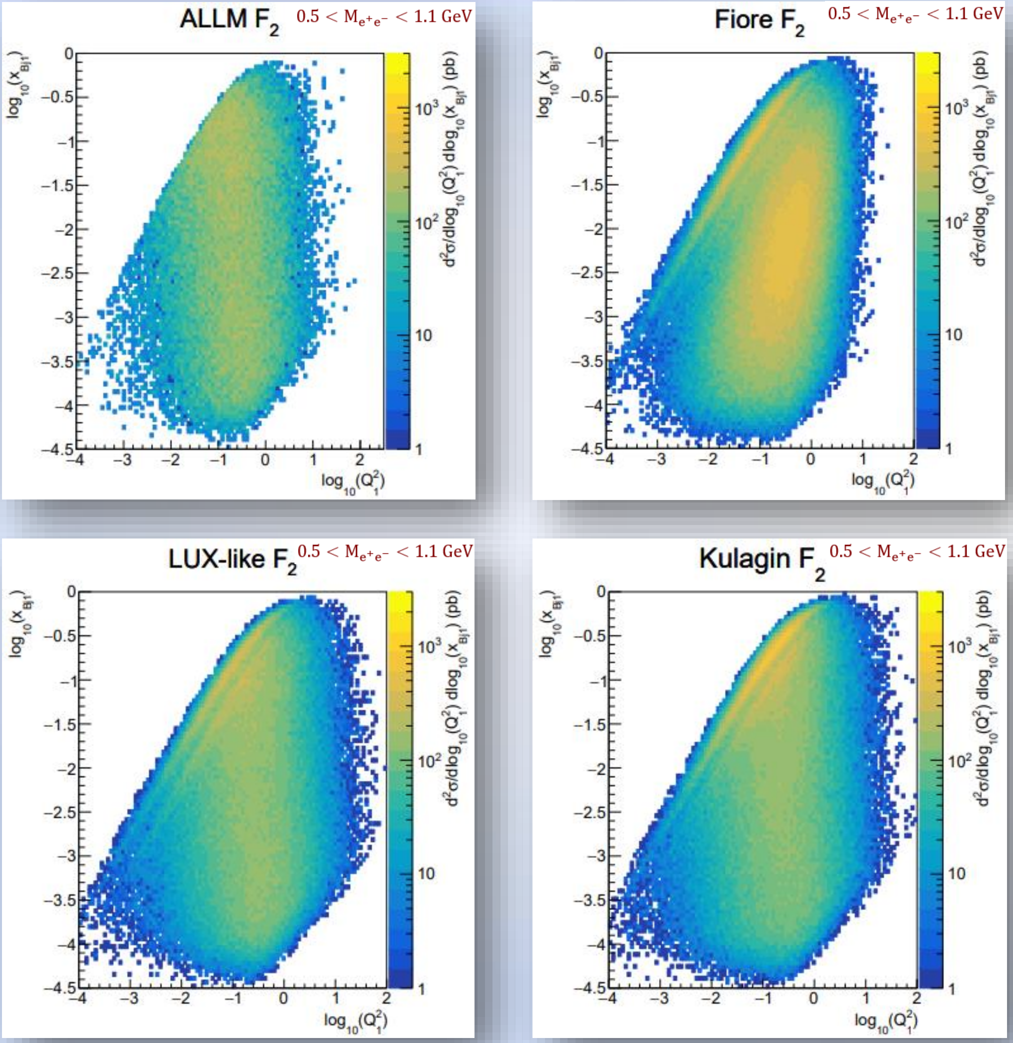


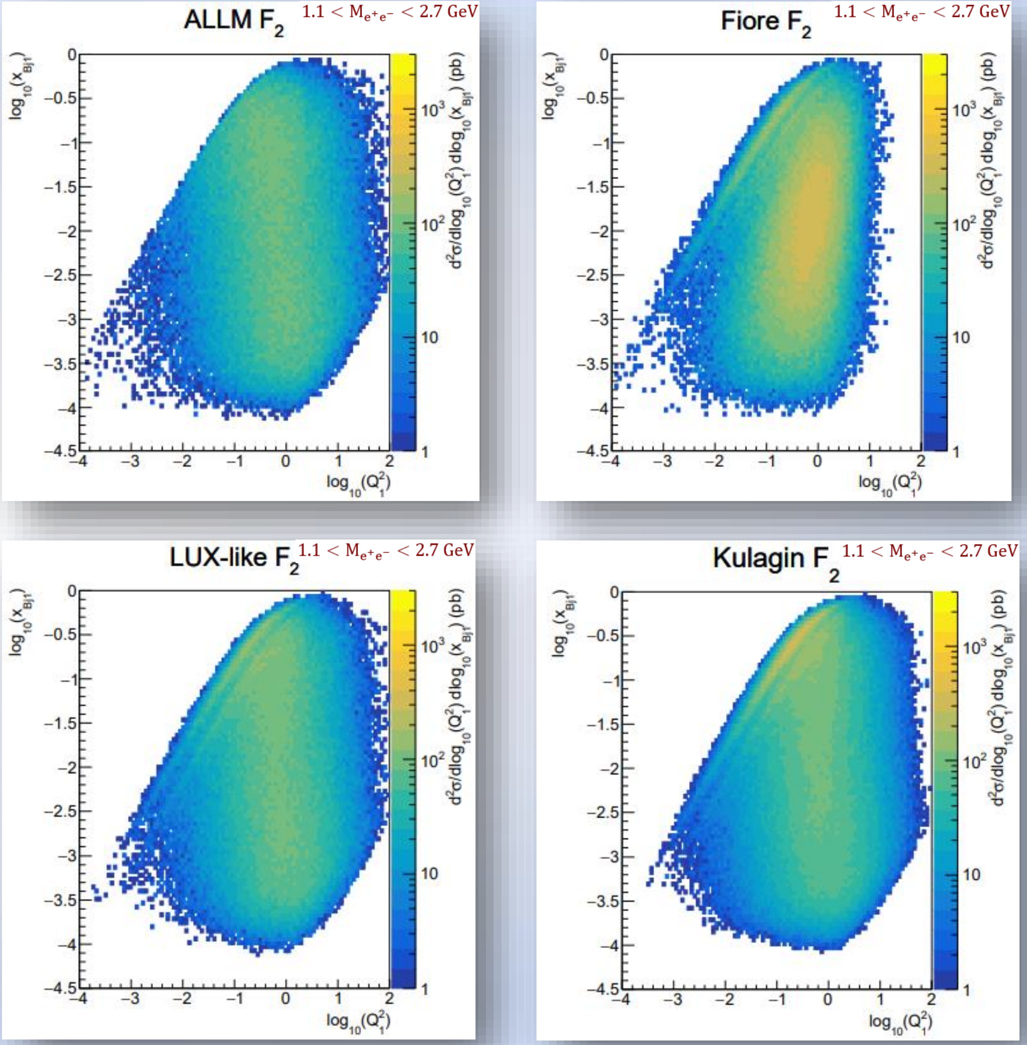
Distributions in $\log_{10}(W_1^2)$



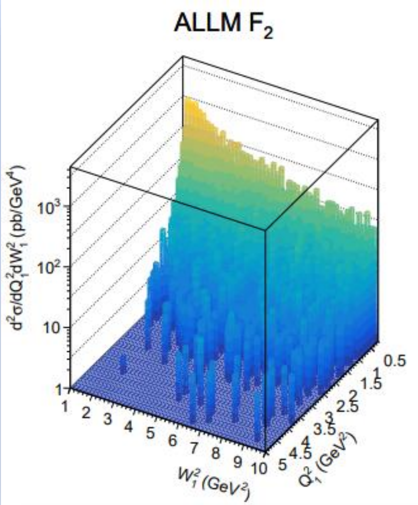


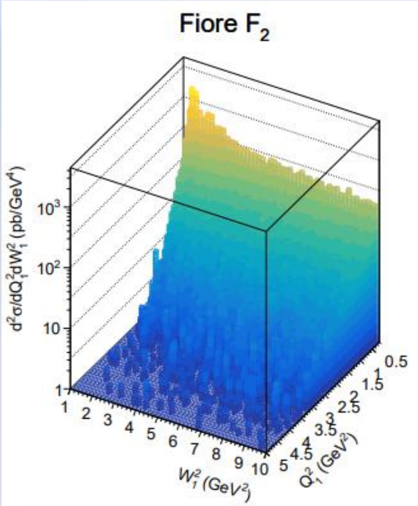
Distributions in $\log_{10} x_{Bj}$ and $\log_{10} Q^2$

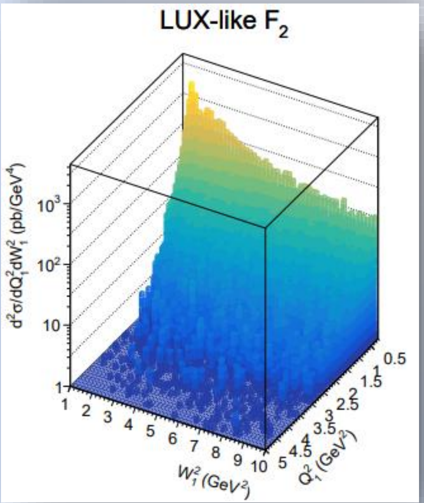


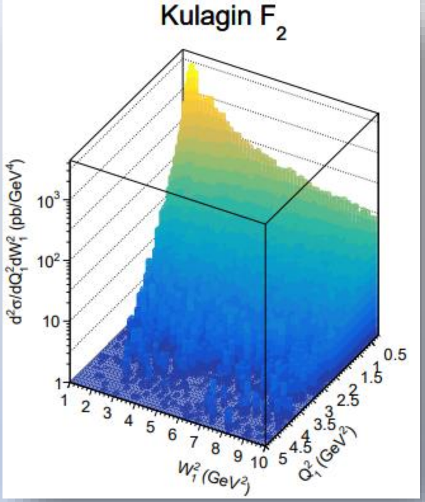


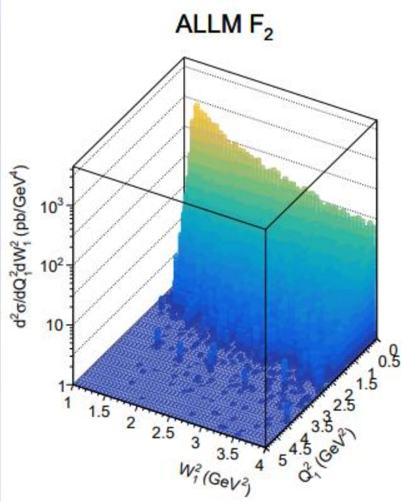
Distributions in W^2 and Q^2

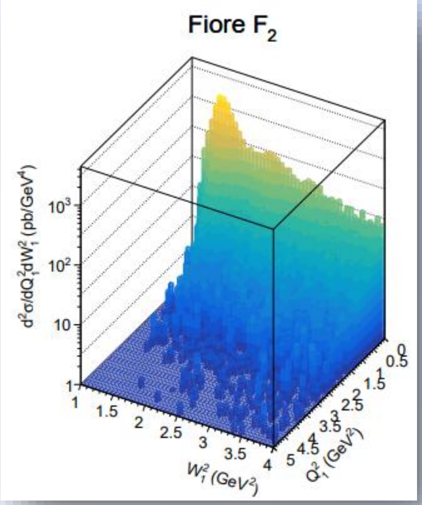


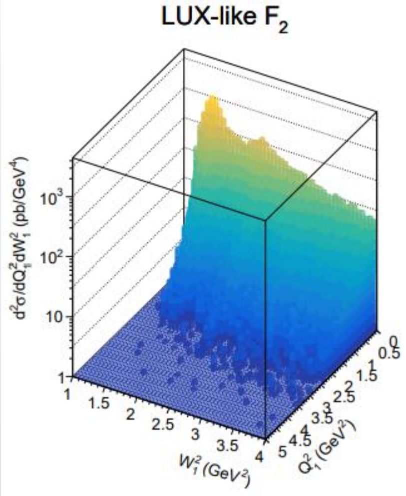


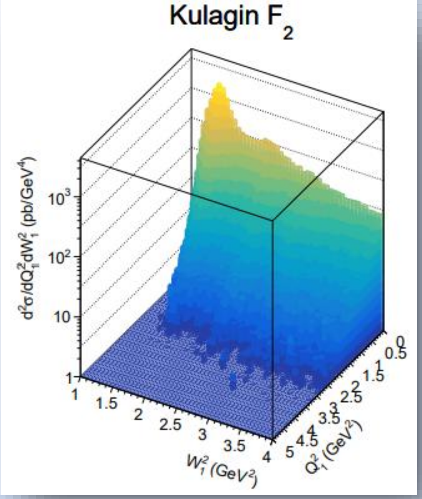












Total cross section for different approaches

Structure function approaches	$\sigma_{LMR}\ (nb)$	$\sigma_{IMR}\ (nb)$
elastic	2938.72	507.04
LUX-like	346.53	191.40
Kulagin-Barinov	387.93	205.27
Fiore et al.	653.07	347.08
ALLM	329.72	179.07

Conclusions

- We have calculated the photon-photon contribution to the inclusive production of e^+e^- pair in proton-lead collisions;
- Our results are compared to the existing data measured by ALICE collaboration;
- Although the contribution of two-photon processes is negligible, however it is interesting and could be experimentally tested in the future;
- It was shown the sensitivnes to the nonperturbative regions and broad range of Bjorken-x
- Various parametrizations used treat this area of structure functions slightly differently, but only Fiore et al. parametrization siginificantly differs from the others;

Thank you for your attention