Helicity flip transitions and the t-dependence of exclusive photoproduction of rho meson

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17th International Workshop on Meson Physics
Krakow, 22-27 June 2023

Outline

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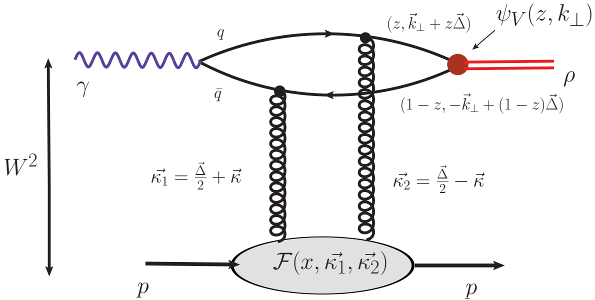
  Phys. Lett. **B836** (2023) 137595

Introduction

- The exclusive photoproduction of vector mesons is one of the intensively studied processes at high energies
- For the light vector mesons, the energy dependence displays a "soft pomeron" behaviour and follows the one of the total γp photoabsorption cross section
- Our work was motivated by a recent measurement of the differential cross section $d\sigma/dt$ (CMS and H1) for diffractive ρ^0 production
- The t-dependence of the cross section has been advocated as a probe of gluon saturation effects
- We include different contribution of helicity: $T \to T, T \to L, T \to T'$

Exclusive production of vector meson in photon-proton collisions



- $\psi_v(z, k^2) \rightarrow$ wave function of the vector meson
- $\mathcal{F}(x, \kappa^2) \rightarrow$ unintegrated gluon distribution function

The production amplitude for $\gamma p \to \rho p$

The imaginary part of the amplitude can be written as:

$$\Im m\,\mathcal{M}_{\lambda_V,\lambda_\gamma}(W,\boldsymbol{\Delta}) = W^2 \frac{c_v\sqrt{4\pi\alpha_{em}}}{4\pi^2} \int \frac{d\kappa^2}{\kappa^4}\alpha_S(q^2)\mathcal{F}(x,\frac{\boldsymbol{\Delta}}{2}+\boldsymbol{\kappa},\frac{\boldsymbol{\Delta}}{2}-\boldsymbol{\kappa}) \times \int \frac{dz d^2\boldsymbol{k}}{z(1-z)} I(\lambda_V,\lambda_\gamma;z,\boldsymbol{\kappa},\boldsymbol{k},\boldsymbol{\Delta})\psi_V(z,k)$$

The s-chanel helicity conserving $T \to T$ transition, where $\lambda_\gamma = \lambda_V$

$$I(T,T)_{(\lambda_V=\lambda_\gamma)} = m_q^2\Phi_2 + \left[z^2+(1-z)^2\right](\boldsymbol{k}\boldsymbol{\Phi}_1) + \frac{m_q}{M+2m_q}\left[(\boldsymbol{k}^2\Phi_2 - (2z-1)^2(\boldsymbol{k}\boldsymbol{\Phi}_1)\right]$$

The helicity flip

The helicity flip by one unit, from the transverce photon $\lambda_\gamma = \pm 1$ to the longitudinally polarized meson, $\lambda_V = 0$

$$I(L,T) = -2Mz(1-z)(2z-1)(\boldsymbol{e}\boldsymbol{\Phi}_1)\left[1 + \frac{(1-2z)^2}{4z(1-z)}\frac{2m_q}{M+2m_q}\right] + \frac{Mm_q}{M+2m_q}(2z-1)(\boldsymbol{e}\boldsymbol{k})\Phi_2$$

The helicity flip by two units, from the transverse photon $\lambda_\gamma = \pm 1$ to the transversely polarized meson with $\lambda_V = \mp 1$

$$I(T,T)_{(\lambda_V = -\lambda_\gamma)} = 2z(1-z)(\Phi_{1x}k_x - \Phi_{1y}k_y) - \frac{m_q}{M+2m_q}\left[(k_x^2 - k_y^2)\Phi_2 - (2z-1)^2(k_x\Phi_{1x} - k_y\Phi_{1y})\right]$$

UGDF function and $G(\boldsymbol{\Delta}^2)$

Unintegrated gluon distribution function

$$\mathcal{F}\left(x, \frac{\boldsymbol{\Delta}}{2} + \boldsymbol{\kappa}, \frac{\boldsymbol{\Delta}}{2} - \boldsymbol{\kappa}\right) = f(x, \boldsymbol{\kappa})\, G(\boldsymbol{\Delta}^2)$$

$$f(x, \boldsymbol{\kappa}) \to \frac{\partial xg(x, \boldsymbol{\kappa}^2)}{\partial \log \boldsymbol{\kappa}^2}$$

For the function $G(\boldsymbol{\Delta}^2)$ we have two options:

1. an exponential parametrization:

$$G(\boldsymbol{\Delta}^2) = \exp\left[-\frac{1}{2} B \boldsymbol{\Delta}^2\right]$$

2. a dipole form factor parametrization often used in nonperturbative Pomeron models (Donnachie, Dosch, Landshoff and Nachtmann book):

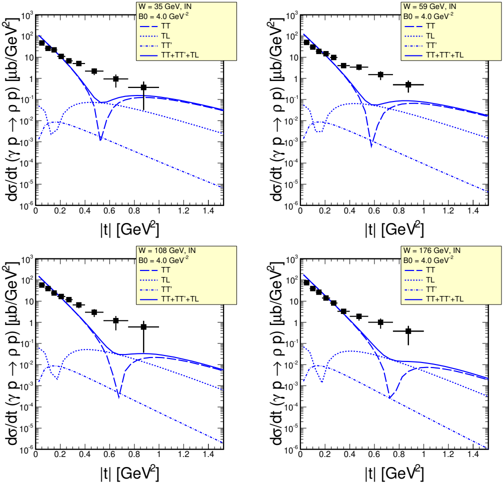
$$G(\boldsymbol{\Delta}^2) = \frac{4m_p^2 + 2.79\boldsymbol{\Delta}^2}{4m_p^2 + \boldsymbol{\Delta}^2} \frac{1}{\left(1 + \frac{\boldsymbol{\Delta}^2}{\Lambda^2}\right)^2}$$

Distribution in t for $\gamma p \to Vp$

$$\psi_V(z,k^2) = C\exp\left(-\frac{k^2a^2}{2}\right)$$

Ivanov - Nikolaev UGDF

$$G(\mathbf{\Delta}^2) = \exp\left[-\frac{1}{2}B\mathbf{\Delta}^2\right]$$



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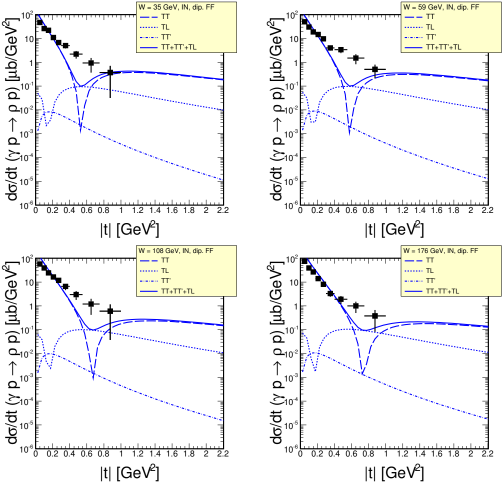

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Kimber-Martin-Ryskin UGDF

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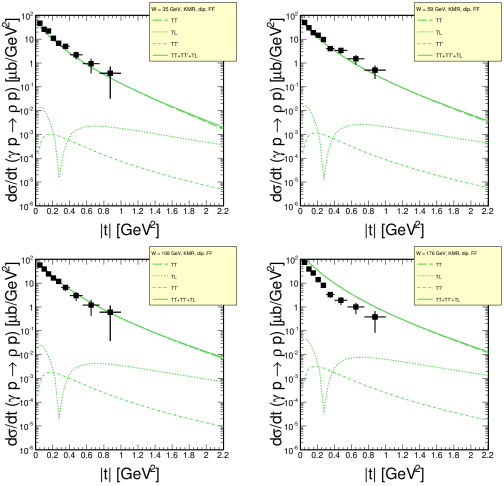

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Golec-Biernat–Wüsthoff UGDF

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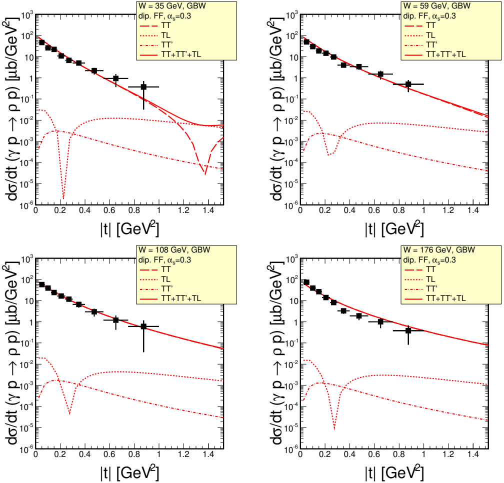

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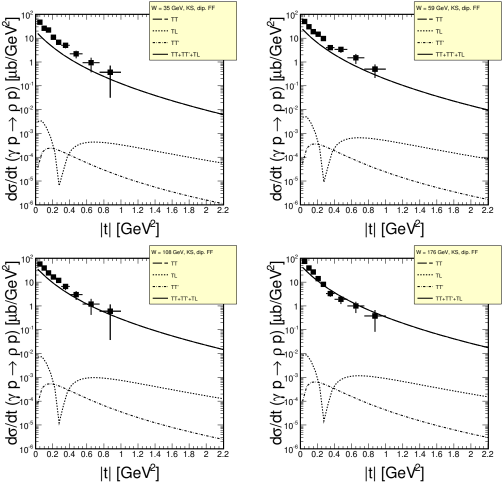
Kutak - Staśto nonlinear UGDF

$$G(\mathbf{\Delta}^2) = \frac{4m_p^2 + 2.79\mathbf{\Delta}^2}{4m_p^2 + \mathbf{\Delta}^2} \times \frac{1}{\left(1 + \frac{\mathbf{\Delta}^2}{\Lambda^2}\right)^2}$$



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Moriggi - Pecini - Machado UGDF

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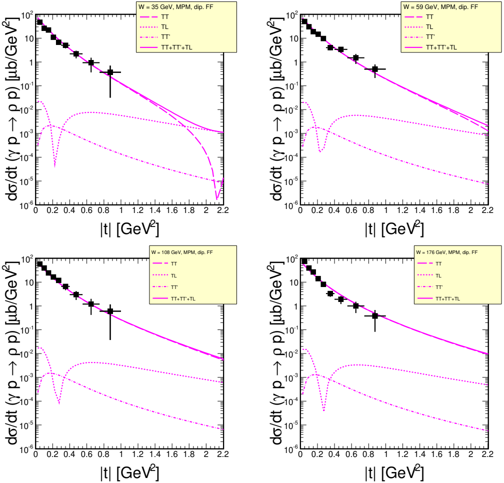

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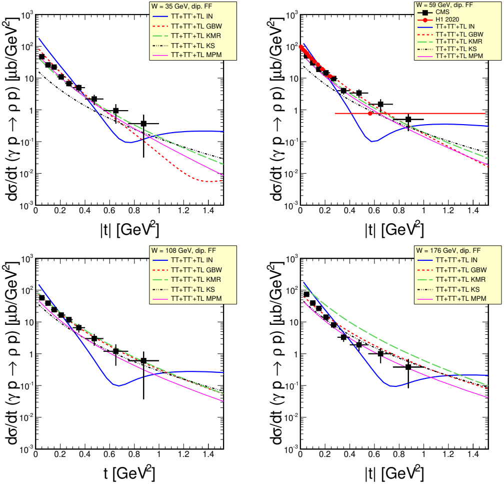

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Conclusions

- We have studied the role played by the often neglected helicity-flip amplitudes, which can contribute at finite t
- We have found that the large $|t|$-behaviour $d\sigma/dt$ depends on the form factor describing the coupling of the pomeron to the $p \to p$ transition, while the dip-bump structure depends rather on the UGD used
- We have included traditional $T \to T$ contribution as well as somewhat smaller $T \to L$ and $T \to T'$ (double spin-flip) contributions. The relative amount and differential shape of the subleading contributions depends on the UGD used
- Some of the UGDs generate dips for $T \to T$ transition. A good example is the Ivanov-Nikolaev UGD. All UGDs generate dips for $T \to L$ transition