Pion production in neutrino reaction via GPDs

Ya-Ping Xie
Institute of Modern Physics, CAS

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Co-authors X. Chen, S. Kumano, R. Kunitomo and S. Wu

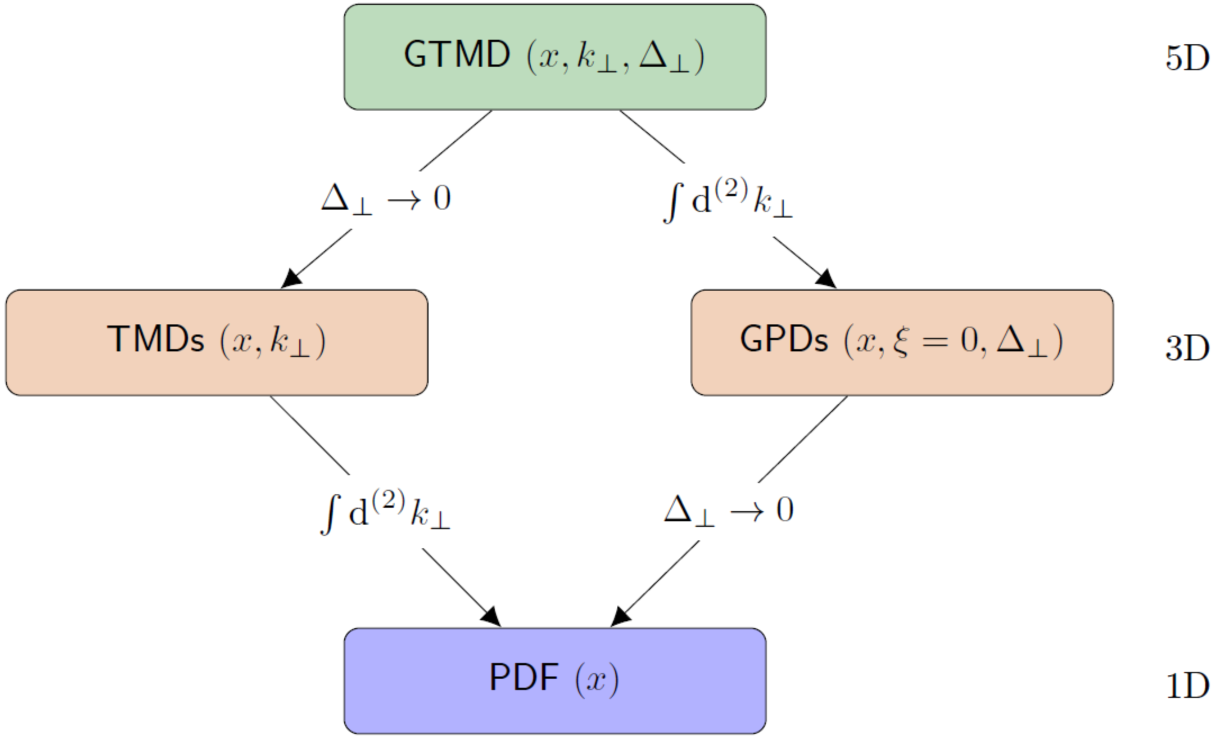
Outline

This talk includes follow

- GPD and model
- Pion production in neutrino reacatin
- Numerical results
- Summary

GPD and Models

General Parton Distribution (GPD) is important aspect of nucleon structure. It is 3-Dimension function of nucleon. It have relationship between GTMD and PDFs



GPD and model

GPD can be defined as off-diagonal matrix elements of a non-local operator in momentum space

$$\frac{1}{2}\int \frac{dz^-}{2\pi} e^{ixP^+z^-} \langle p', \lambda' | \bar{\psi}(-\frac{1}{2}z)\gamma^+ \psi(\frac{1}{2}z)|P,\lambda\rangle|_{z^+=0, z_T=0}$$
$$= \frac{1}{2P^+}\bar{u}(p',\lambda')\left[H^q\gamma^+ + E^q\frac{i\sigma^{+\alpha}\Delta_\alpha}{2m}\right]u(p,\lambda).$$

$$\frac{1}{2}\int \frac{dz^-}{2\pi} e^{ixP^+z^-} \langle p', \lambda' | \bar{\psi}(-\frac{1}{2}z)\gamma^+ \gamma_5 \psi(\frac{1}{2}z)|P,\lambda\rangle|_{z^+=0, z_T=0}$$
$$= \frac{1}{2P^+}\bar{u}(p',\lambda')\left[\widetilde{H}^q\gamma^+\gamma_5 + \widetilde{E}^q\frac{\gamma_5\Delta^+}{2m}\right]u(p,\lambda).$$

GPD and model

Form Factor can be computed via GPD as

$$\int dx H^q(x,\xi,t) = F_1^q(t), \qquad \int dx E_q(x,\xi,t) = F_2^q(t);$$

$$\int dx \tilde{H}^q(x,\xi,t) = G_A^q(t), \qquad \int dx \tilde{E}^q(x,\xi,t) = G_p^q(t).$$

Ji Sum rules is given as

$$\int x dx (H^q(x,\xi,0) + E^q(x,\xi,0) = 2J^q.$$

GPD and Models

GPD can be adopted to study proton spin, Energy momentum tensor, Form factor of Hadron and mass radius, mass distributions.

GPD can be measured in different processes

Deep Virtual Compton Scattering

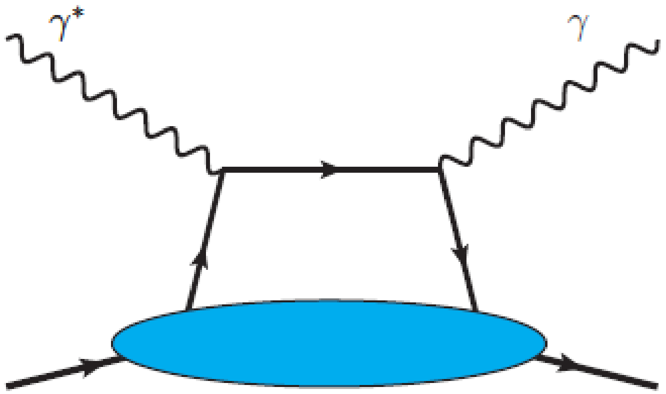
Deep Virutual Meson production

Time-like Compton Scattering

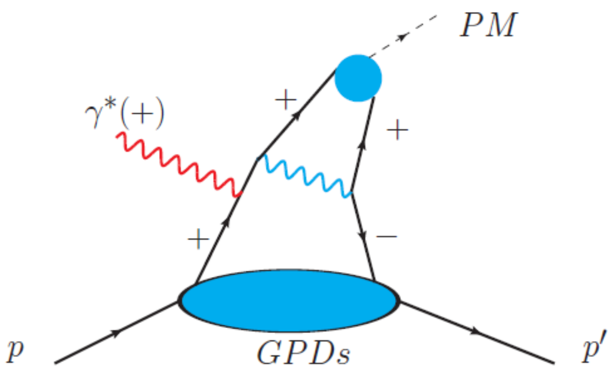
Neutrino reaction process

DVCS, DVMP and TCS processes

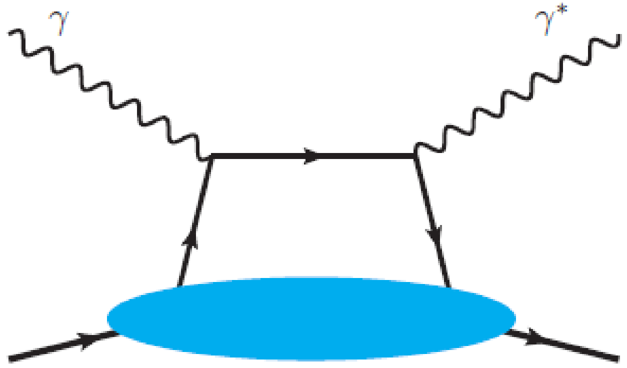
DVCS process



DVMP process

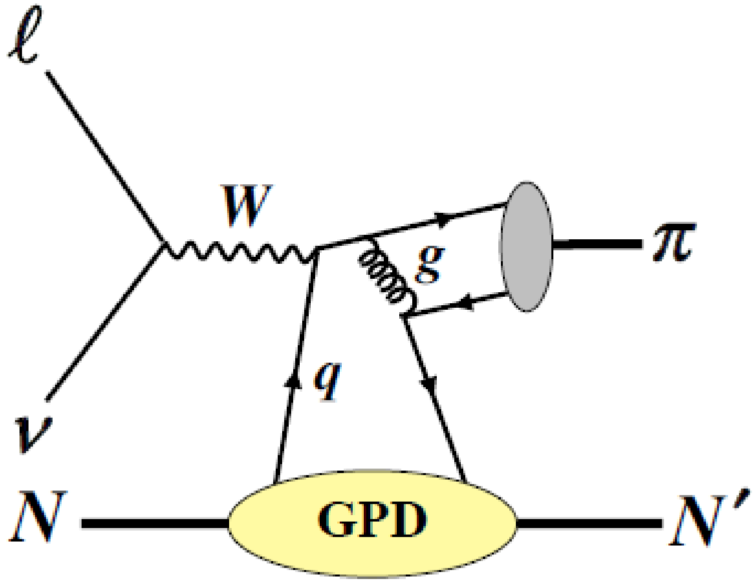


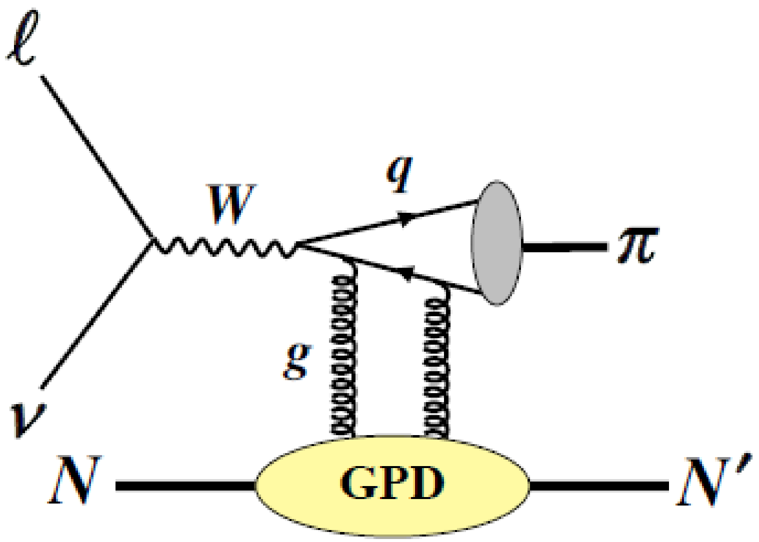
TCS process



Neutrino reaction

Neutrino reaction via GPD can be studied in the pion production





Neutrino reaction cross section of pion meson

The pion cross section in neutrino reaction cross sections can be writte

$$\frac{d^4\sigma(\nu N \to \ell N'\pi)}{dy\, dQ^2\, dt} = 2\pi \bar{\Gamma} \varepsilon \sigma_L .$$

t

$$\bar{\Gamma} = \frac{G_F^2 Q^2}{32(2\pi)^4 y \sqrt{1 + 4x_B^2 m_N^2 / Q^2}(s - m_N^2)^2 (1 - \varepsilon)}$$

$\varepsilon \approx \frac{1-y}{1-y+y^2/2}$. $y = Q^2/(x_B s)$ with $x_B = Q^2/(2pq)$.

Leading twist cross section

Leading twist cross section is calculated as

$$\sigma_L = \frac{1}{Q^2}\Bigg\{ \left[|C_q \mathscr{H}^q + C_g \mathscr{H}^g|^2 + |C_q \tilde{\mathscr{H}}^q|^2 \right] (1-\xi^2) + \frac{\xi^4}{1-\xi^2}\left[|C_q \mathscr{E}^q + C_g \mathscr{E}^g|^2 + |C_q \tilde{\mathscr{E}}^q|^2 \right] - 2\xi^2 \,\mathrm{Re}\left[(C_q \mathscr{H}^q + C_g \mathscr{H}^g)(C_q \mathscr{E}^q + C_g \mathscr{E}^g)^* \right] - 2\xi^2 \,\mathrm{Re}\left[(C_q \tilde{\mathscr{H}}^q)(C_q \tilde{\mathscr{E}}^q)^* \right] \Bigg\}.$$

$$\mathscr{F}^q = 2 f_\pi \int_0^1 dx' \frac{\Phi_\pi(x')}{1-x'} \int_{-1}^1 dx \frac{F^q(x,\xi,t)}{x-\xi+i\epsilon},$$ as

$$\mathscr{F}^g = \frac{8 f_\pi}{\xi} \int_0^1 dx' \frac{\Phi_\pi(x')}{x'(1-x')} \int_{-1}^1 dx \frac{F^g(x,\xi,t)}{x-\xi+i\epsilon},$$

$$\int_{-1}^1 dx \frac{F(x,\xi,t)}{x-\xi+i\epsilon} = \mathscr{P}\int_{-1}^1 dx \frac{F(x,\xi,t)}{x-\xi} - i\pi F(\xi,\xi,t),$$

Quark GPD

Quark GPD, for π^+

$$F^q(x,\xi,t) = F^d(x,\xi,t) - F^u(-x,\xi,t)$$

For π^0, It is given as

$$F^q(x,\xi,t) = \frac{1}{\sqrt{2}}\left[F^u(x,\xi,t) - F^d(x,\xi,t) + F^u(-x,\xi,t) - F^d(-x,\xi,t)\right]$$

GK model for GPD

GK model is popular model for GPDs

$$F^i(x,\xi,t) = \int_{-1}^{1} d\rho \int_{-1+|\rho|}^{1-|\rho|} d\eta\, \delta(\rho+\xi\eta-x)\, f^i(\rho,\eta,t)$$

$$\begin{aligned} f^i(\rho,\eta,t) &= F^i(\rho,\xi=0,t)\, w_i(\rho,\eta), \\ F^i(\rho,\xi=0,t) &= F^i(\rho,\xi=0,t=0)\, \exp\big(t\, p_{fi}(\rho)\big), \\ p_{fi}(\rho) &= -\alpha'_{fi} \ln\rho + b_{fi}, \\ w_i(\rho,\eta) &= \frac{\Gamma(2n_i+2)}{2^{2n_i+1}\Gamma^2(n_i+1)} \frac{[(1-|\rho|)^2-\eta^2]^{n_i}}{(1-|\rho|)^{2n_i+1}}. \end{aligned}$$

Rho pole contributions

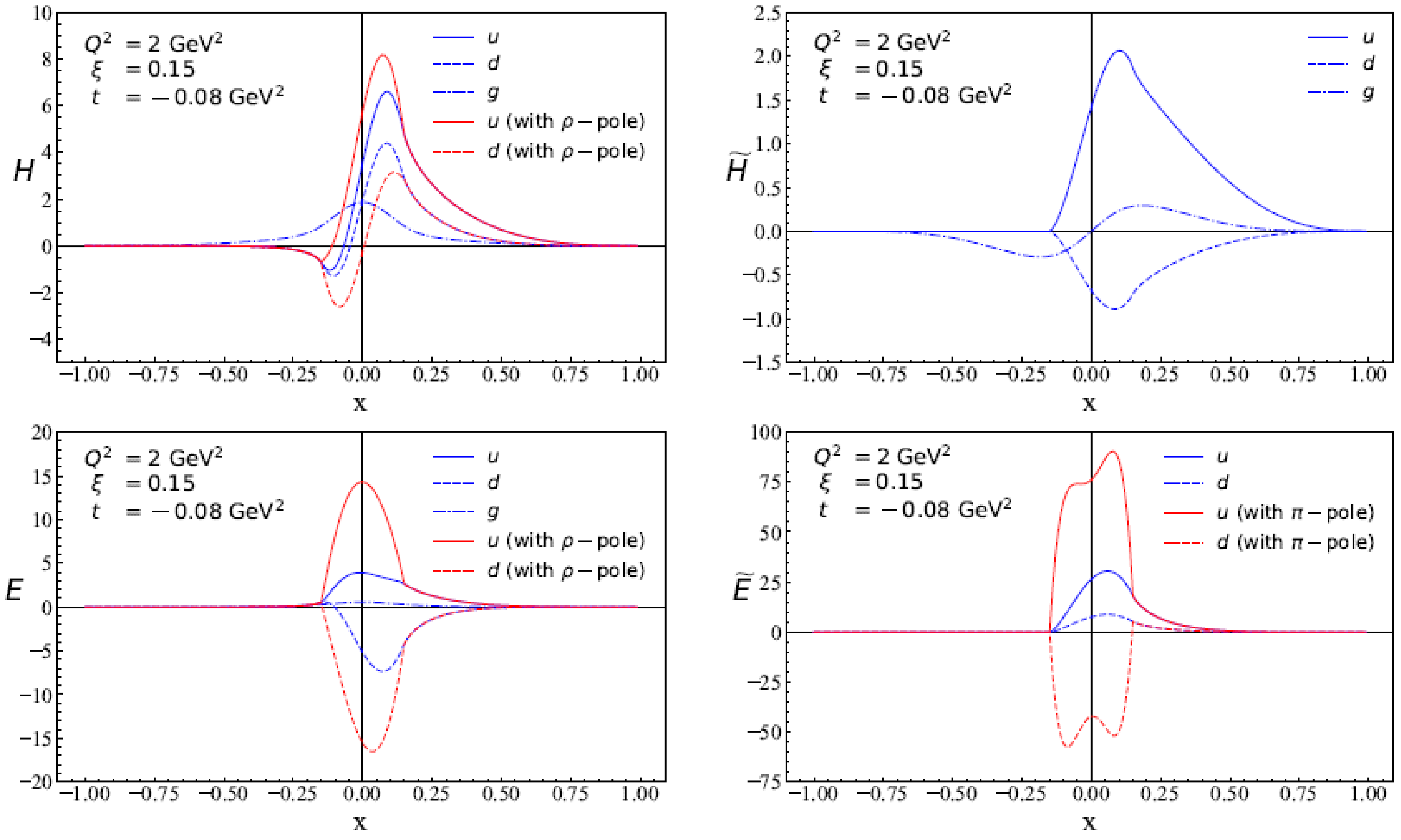
In pion production, there is pole contributions with GPD

$$H_\rho(z,\xi,t) = \frac{1}{1-t/m_\rho^2}\frac{C_1}{g_\rho}\frac{1}{2\xi}\Phi_\rho\left(x=\frac{z+\xi}{2\xi}\right)\theta(\xi-|z|),$$

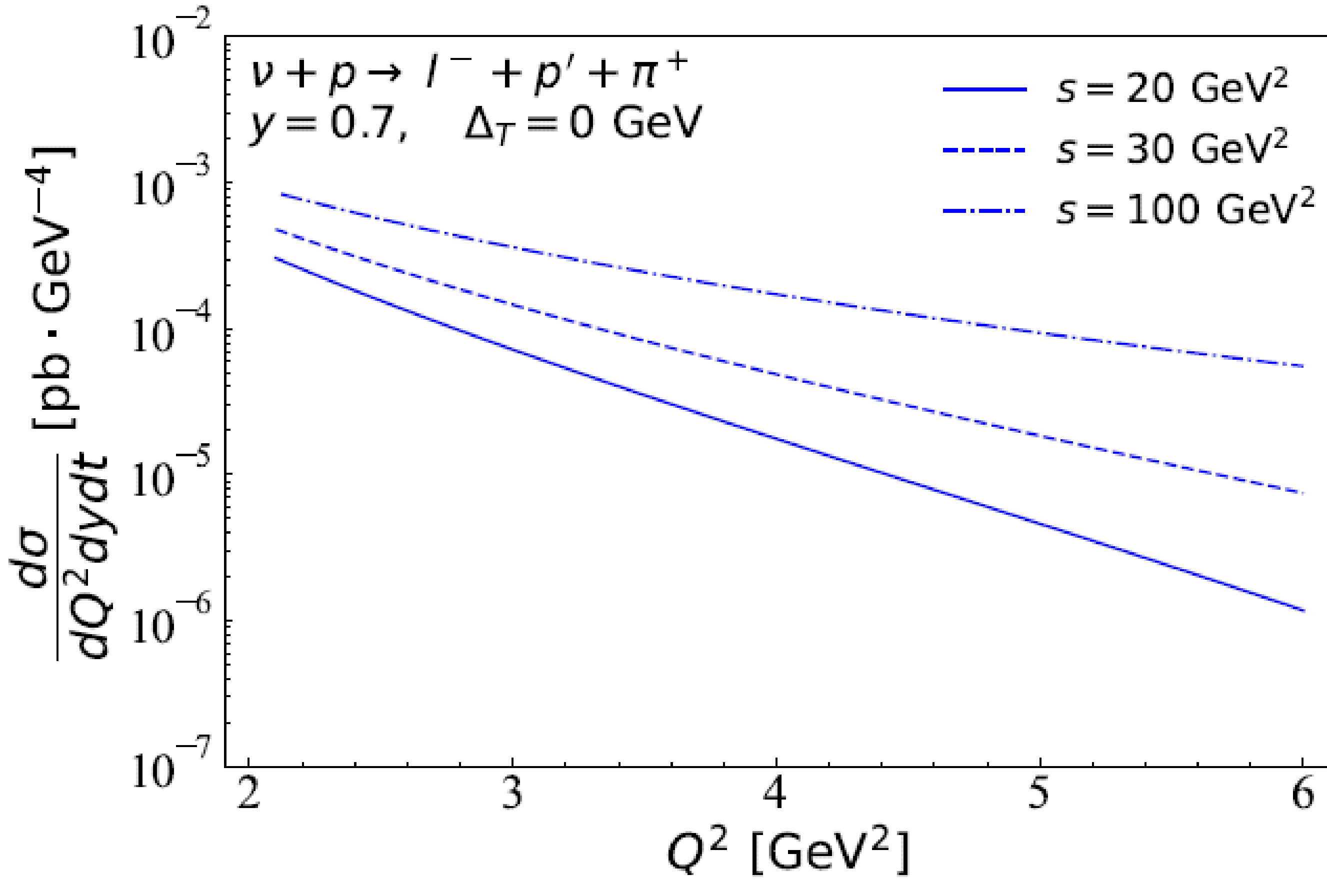
$$E_\rho(z,\xi,t) = \frac{1}{1-t/m_\rho^2}\frac{C_2}{g_\rho}\frac{1}{2\xi}\Phi_\rho\left(x=\frac{z+\xi}{2\xi}\right)\theta(\xi-|z|),$$

GK model of GPDs

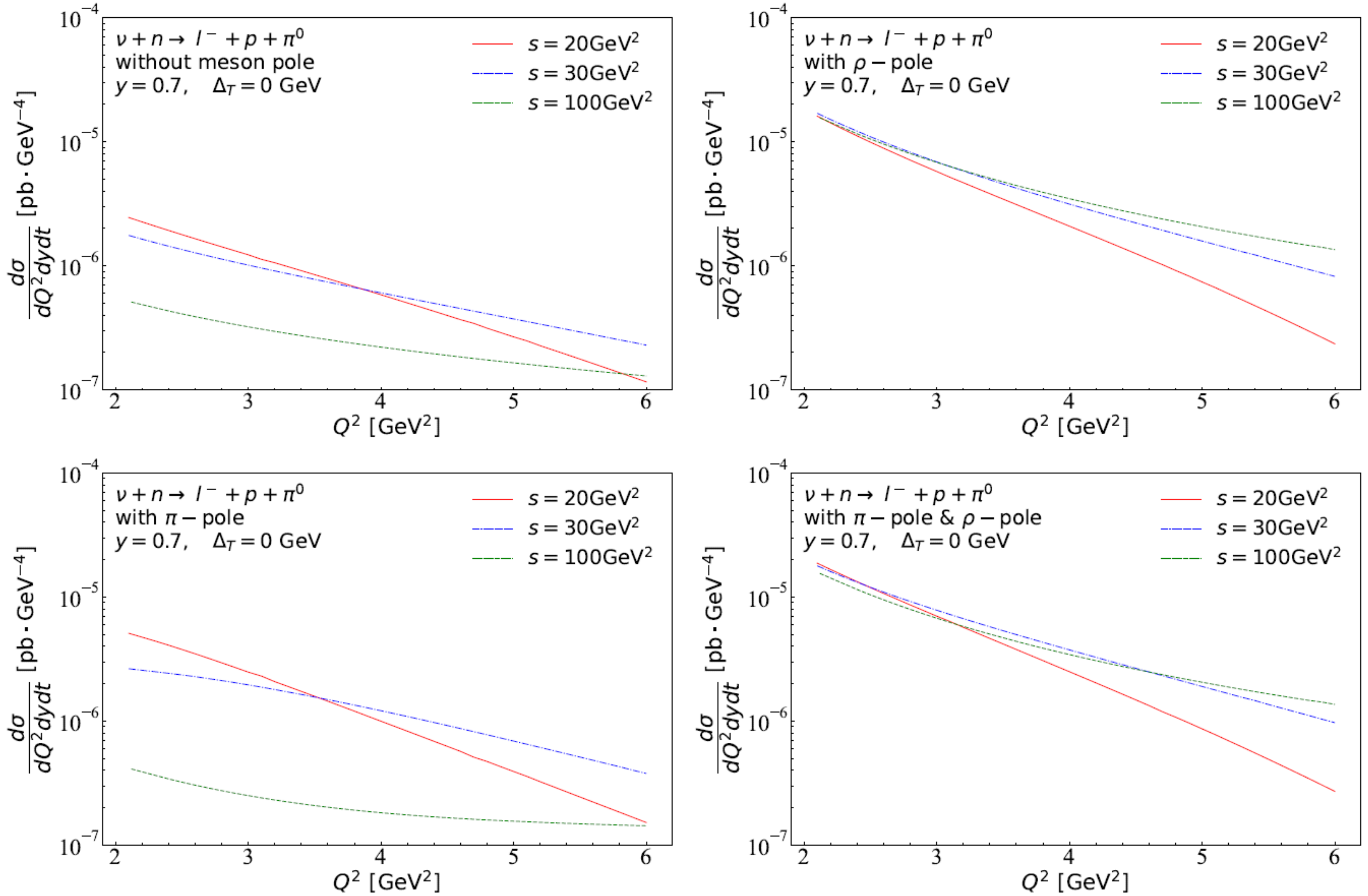
GK model of GPDs



Charged pion cross section



Neutral pion cross section



Summary

Pion production in neutrino reaction can be adopted to study GPD

Gluon GPD contribution is important in charged pion production.

Quark GPD can be extracted in neutral pion production

Meson pole contributions is also important in neutral pion production

The End

Thank you