

# Exclusive electroproduction of the $\rho^+$ on the proton at CLAS

**AHMED FRADI**  
**(CLAS collaboration)**

**Institut de Physique Nucléaire d'Orsay (France)**

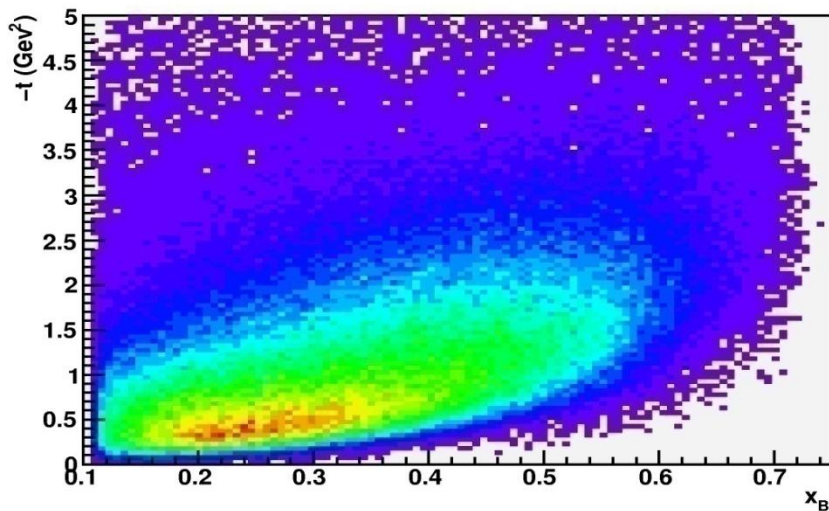
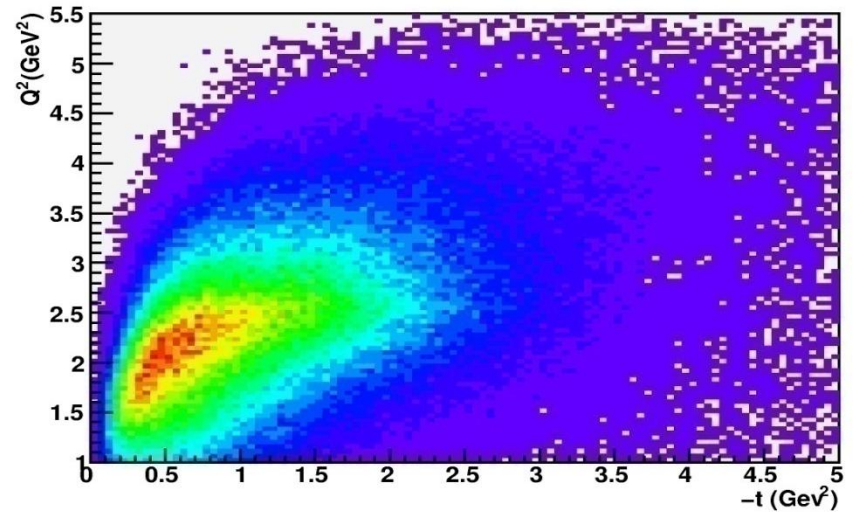
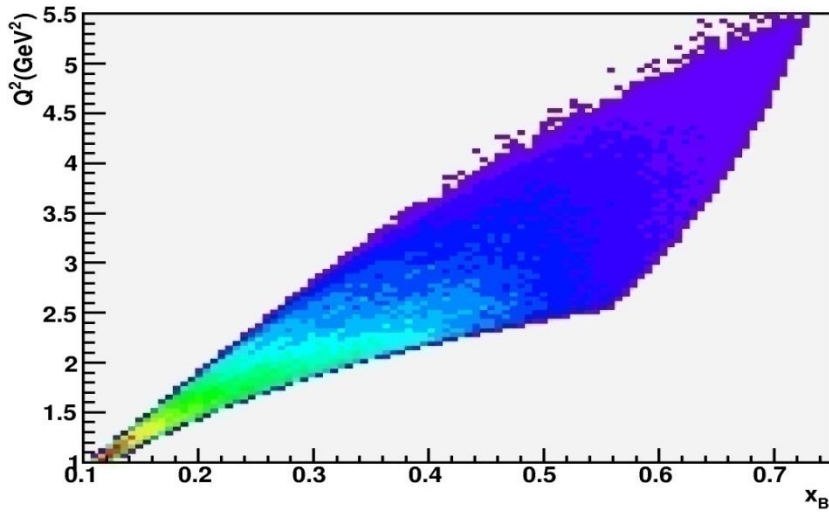
**MENU 10**  
**Williamsburg, 2 June 2010**

## **Outline:**

- Experiment
- Data analysis:  $\rho^+$  cross sections
- Interpretation

# The e1-dvcs experiment (March - May 2005)

$$e p \rightarrow e' n \rho^+ \rightarrow e' n \pi^+ \pi^0 \rightarrow e' n \pi^+ \gamma \gamma$$



Beam energy = 5.75 GeV

Current: 20-25 nA

Integrated Luminosity  $\approx 40 \text{ fb}^{-1}$

$0.1 < x_B < 0.65$

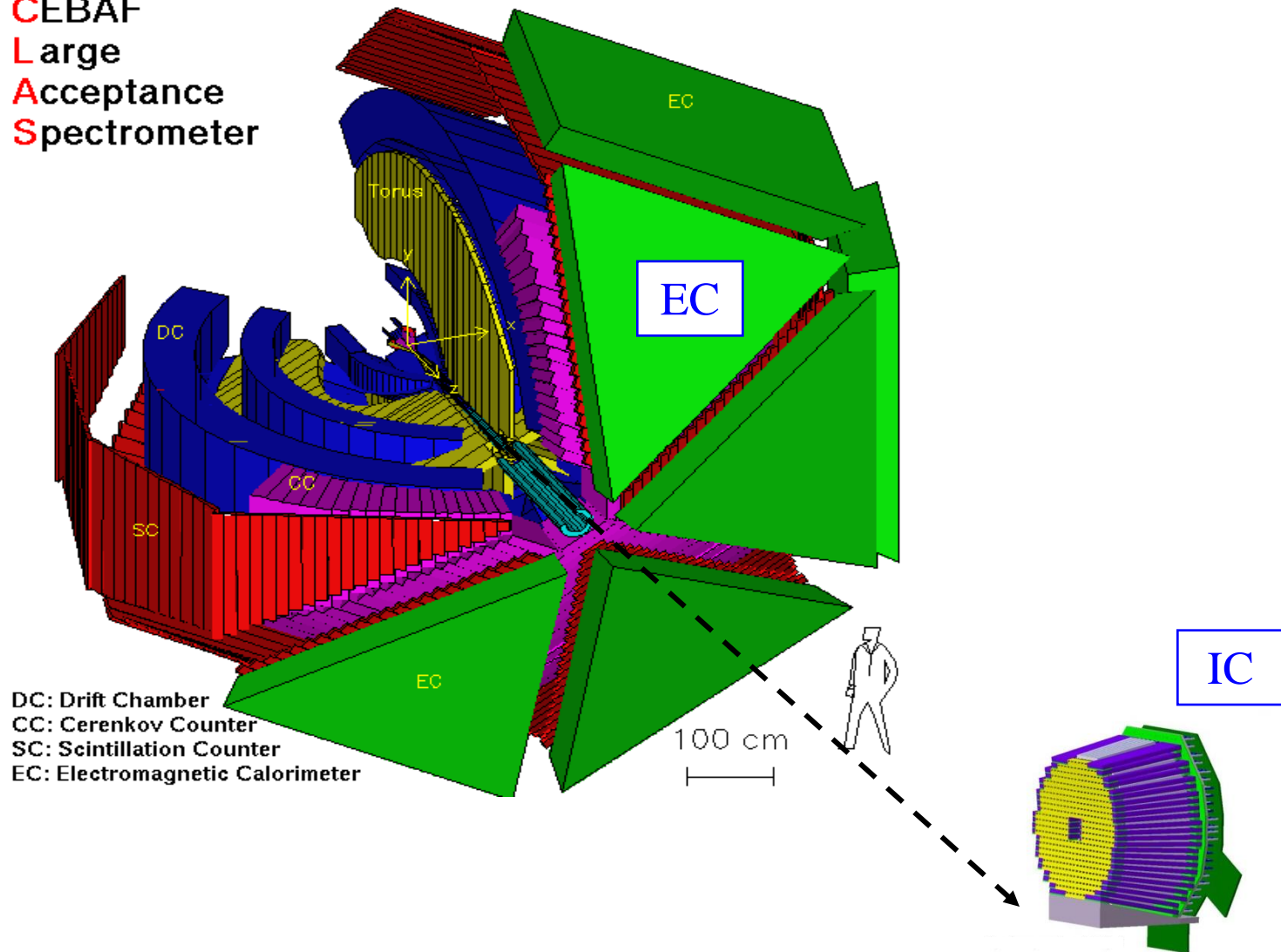
$Q^2$  up to 5 GeV<sup>2</sup>

$-t$  up to 3.5 GeV<sup>2</sup>

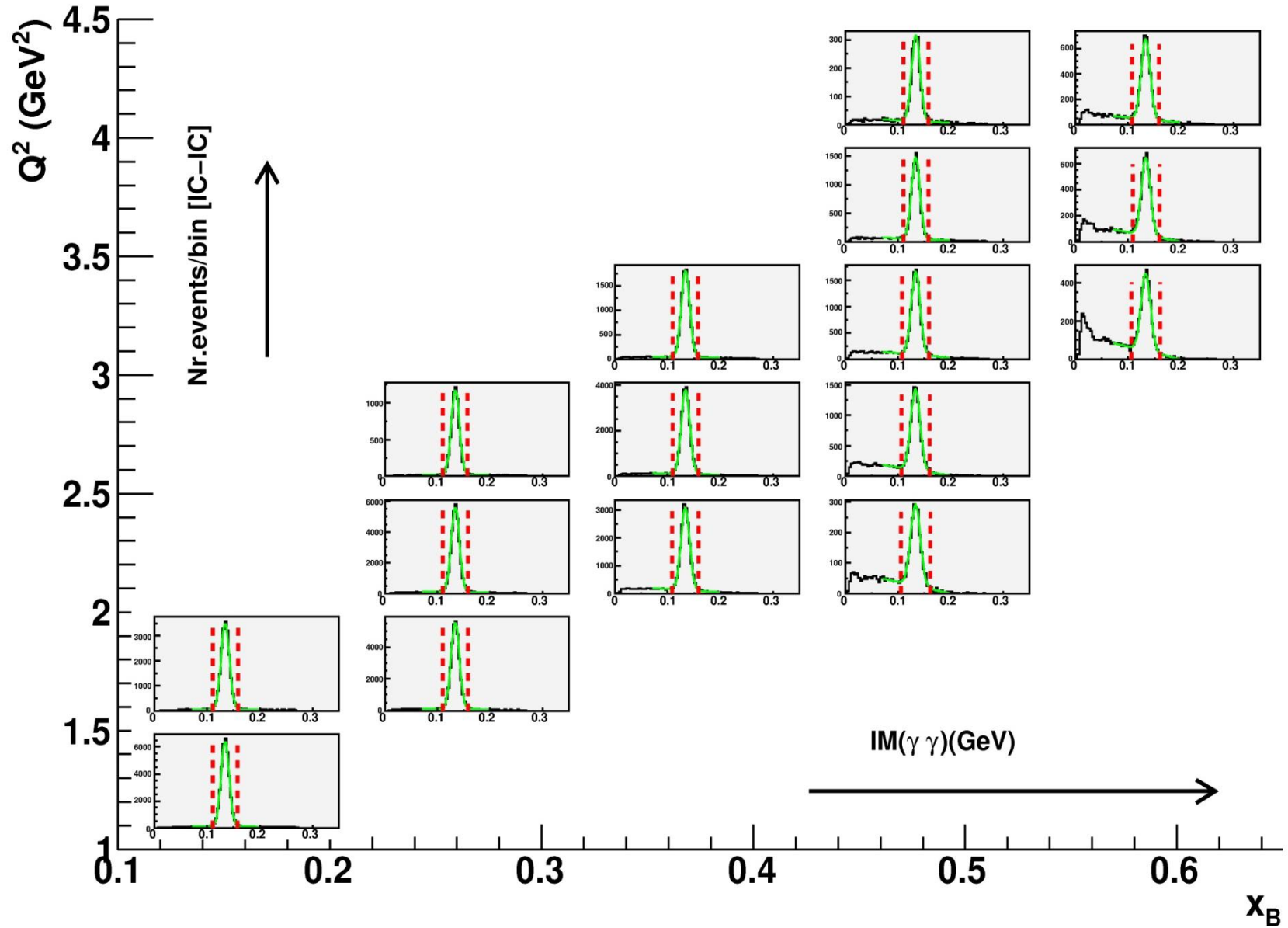
# Channel selection

$$e p \rightarrow e' [n] \rho^+ \rightarrow e' [n] \pi^+ \pi^0 \rightarrow \boxed{e'} [n] \boxed{\pi^+ \gamma \gamma}$$

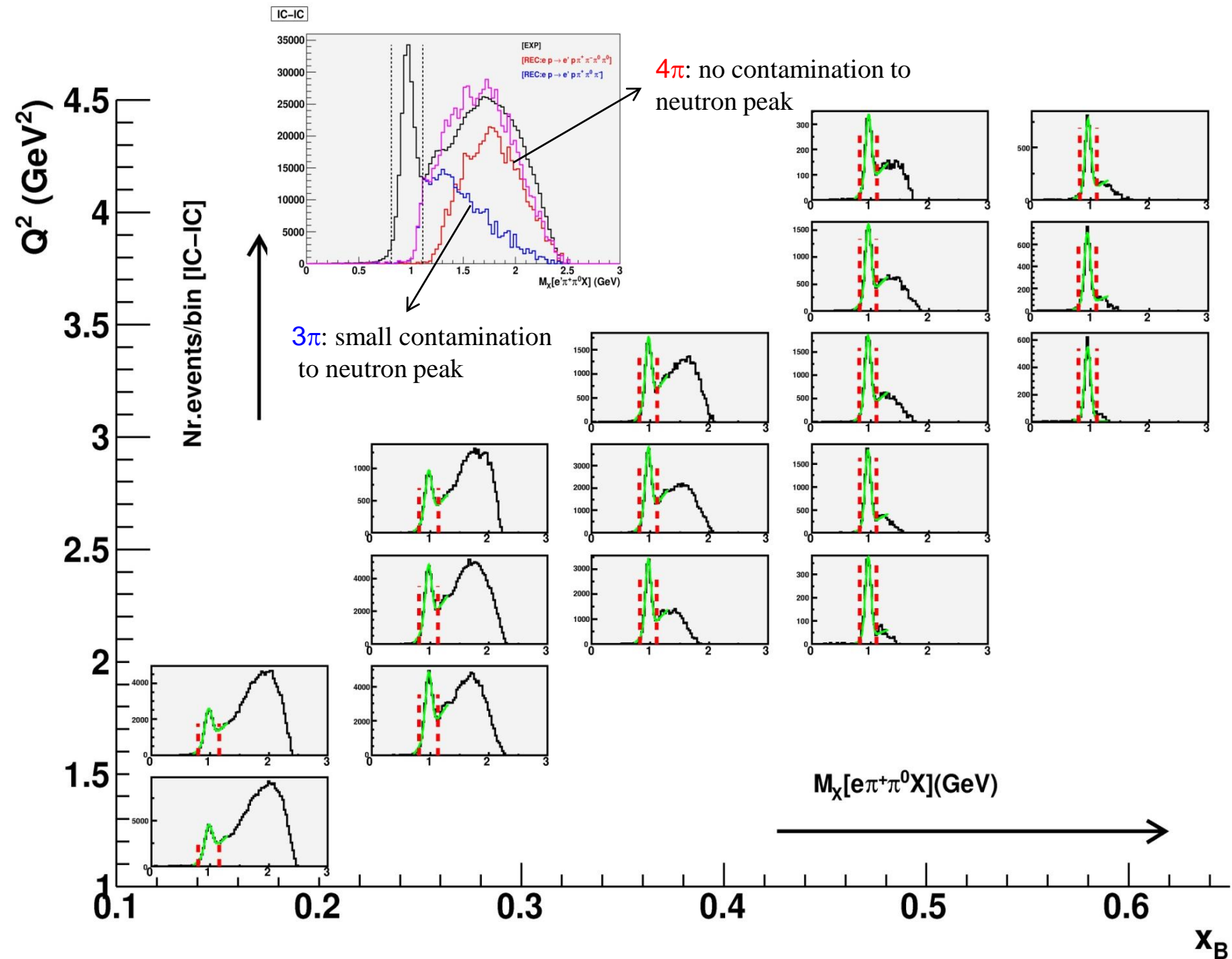
**C**EBAF  
**L**arge  
**A**cceptance  
**S**pectrometer



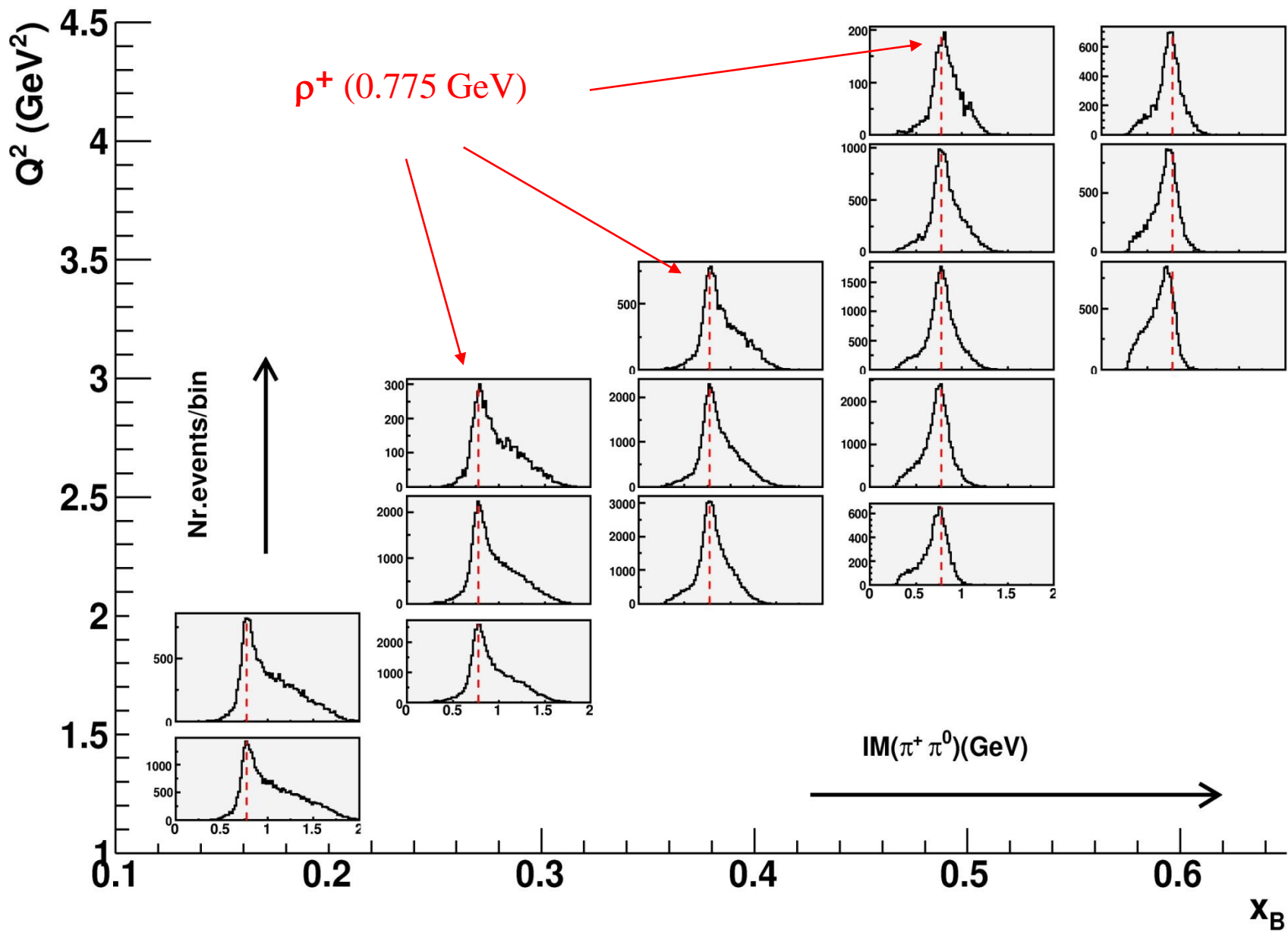
# $\pi^0$ selection



# Neutron selection



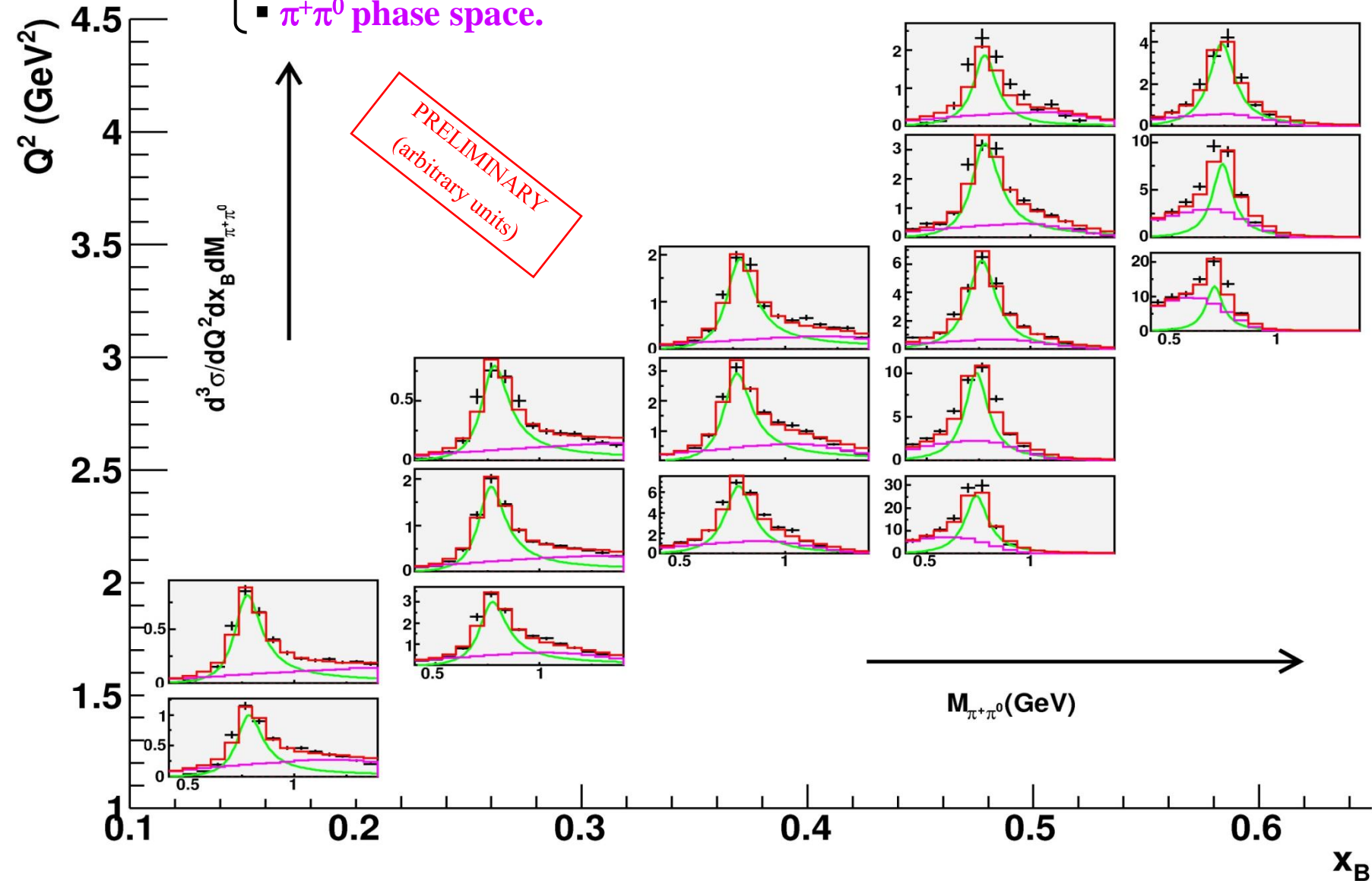
# $\pi^+\pi^0$ invariant mass



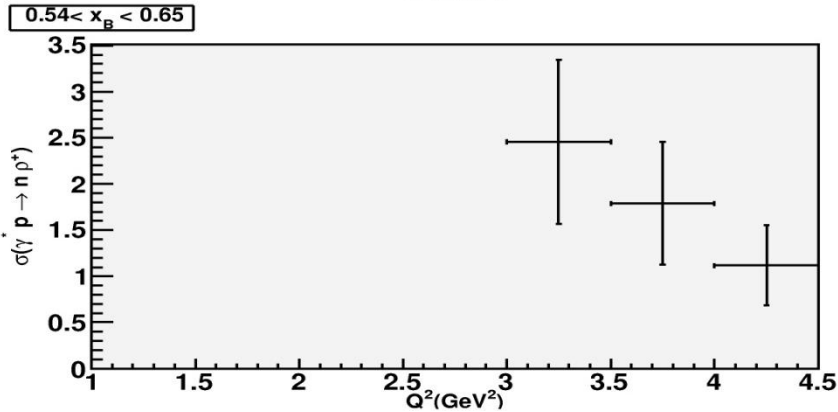
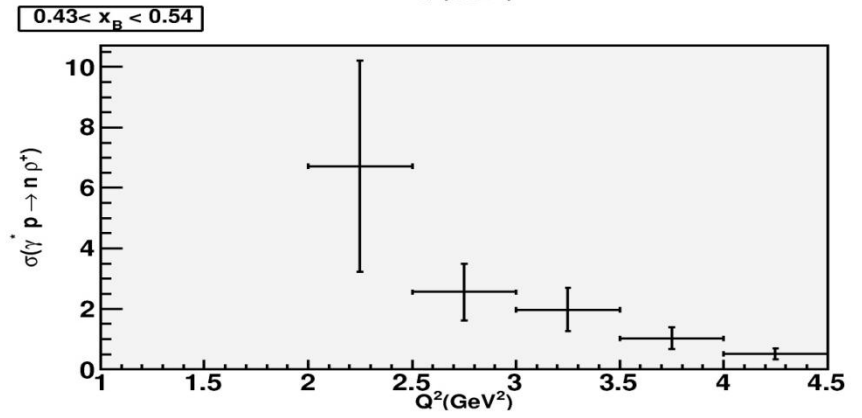
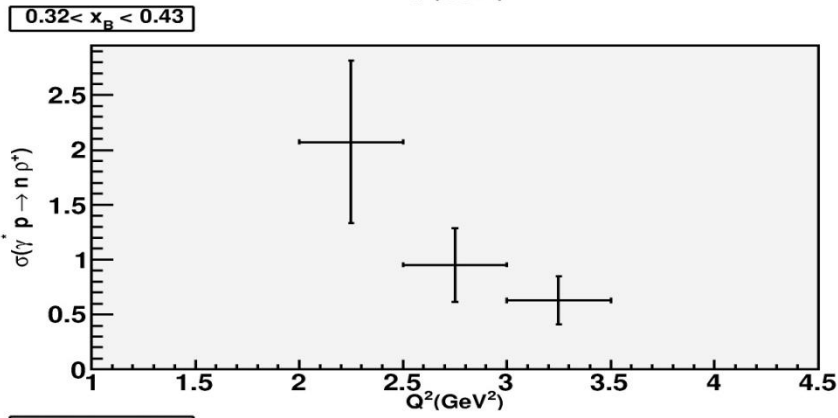
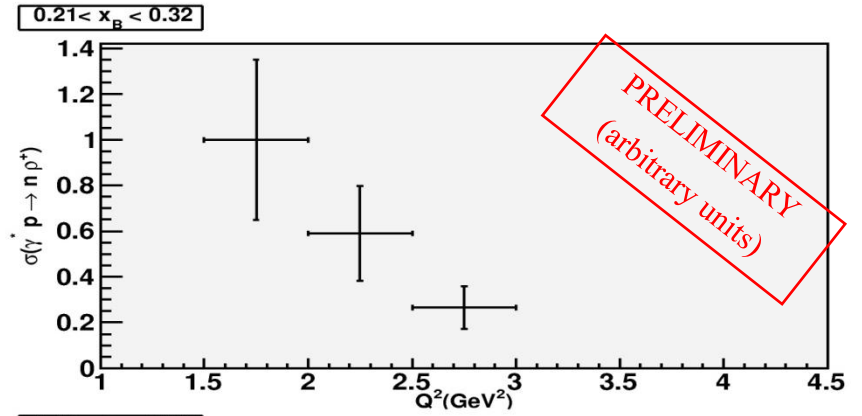
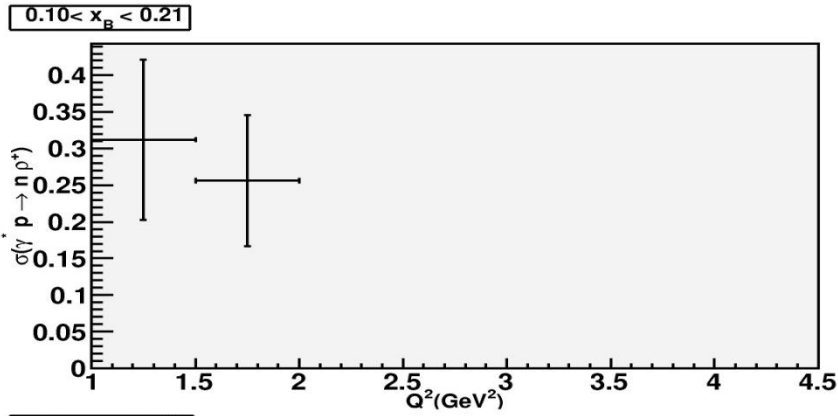
# Background subtraction

$$\frac{d\sigma_{\gamma^* p \rightarrow n\rho^+}}{dQ^2 dx_B d\tau} = \frac{1}{\Gamma_V L_{\text{int}} \text{Acc.} \Delta Q^2 \Delta x_B \Delta \tau} \frac{N_{\gamma^* p \rightarrow n\rho^+}}{F_{\text{corr}}}$$

- Ross-Stodolsky B-W for  $\rho^+(770)$  with variable skewedness parameter.
- $\pi^+\pi^0$  phase space.

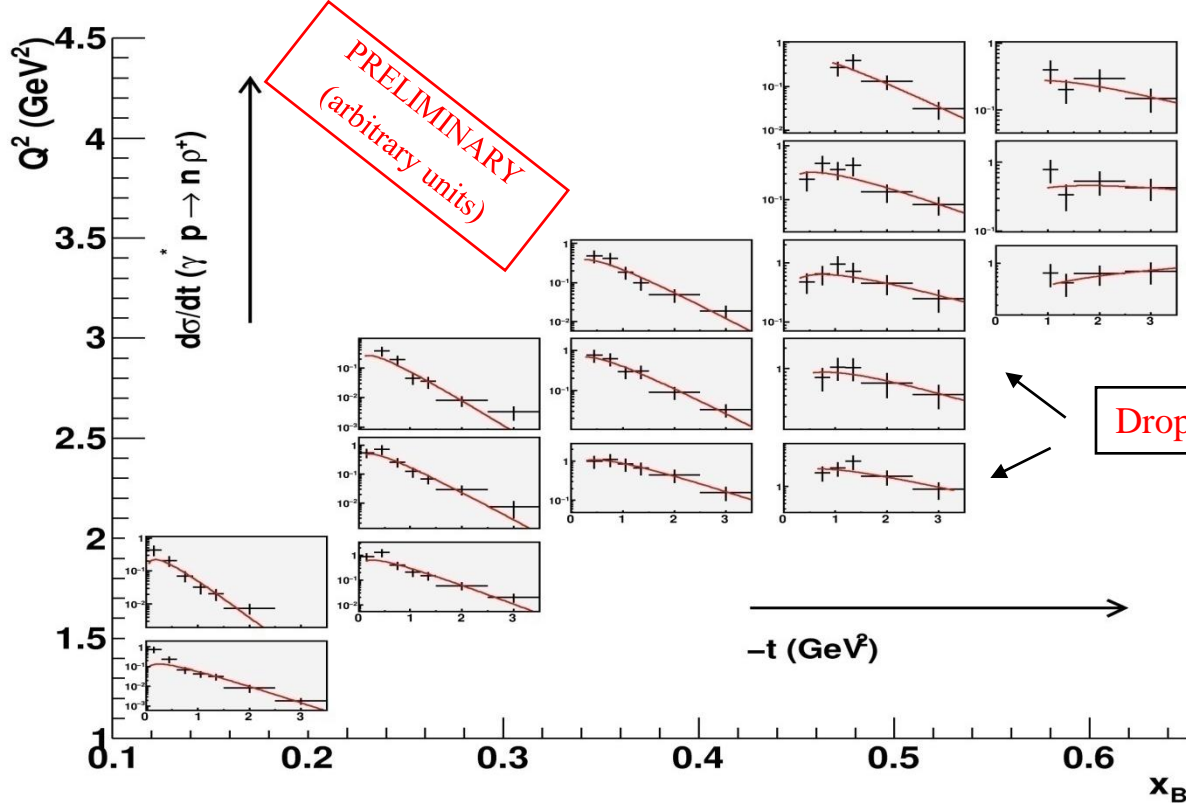


# Total cross section $\sigma(\gamma^* p \rightarrow n \rho^+)$



World's first-ever measurement



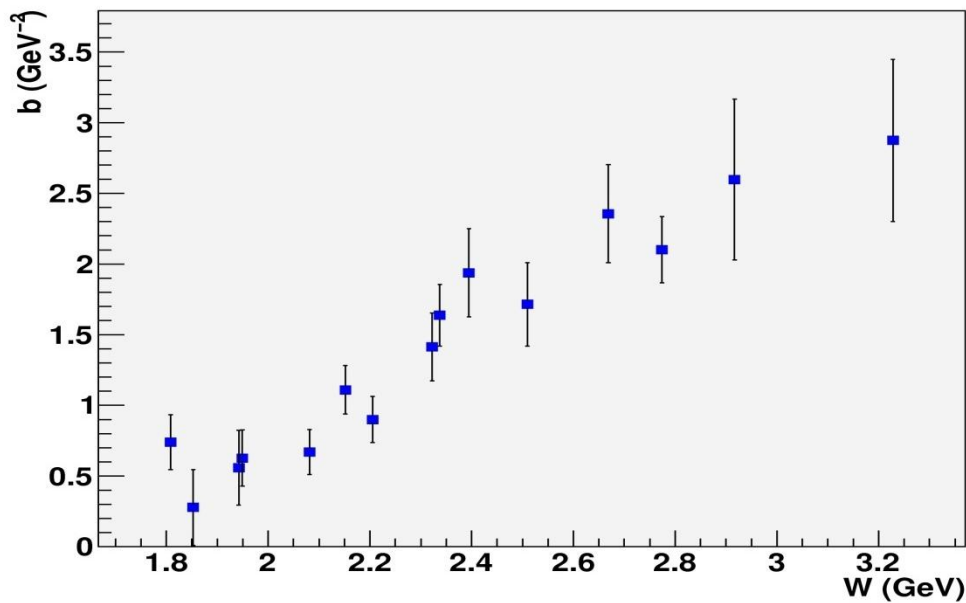


$\frac{d\sigma}{dt} (\gamma^* p \rightarrow n \rho^+)$

Drop of  $d\sigma/dt$  for  $t \rightarrow 0$

Fit function:

$$A\sqrt{-t}e^{-bt}$$

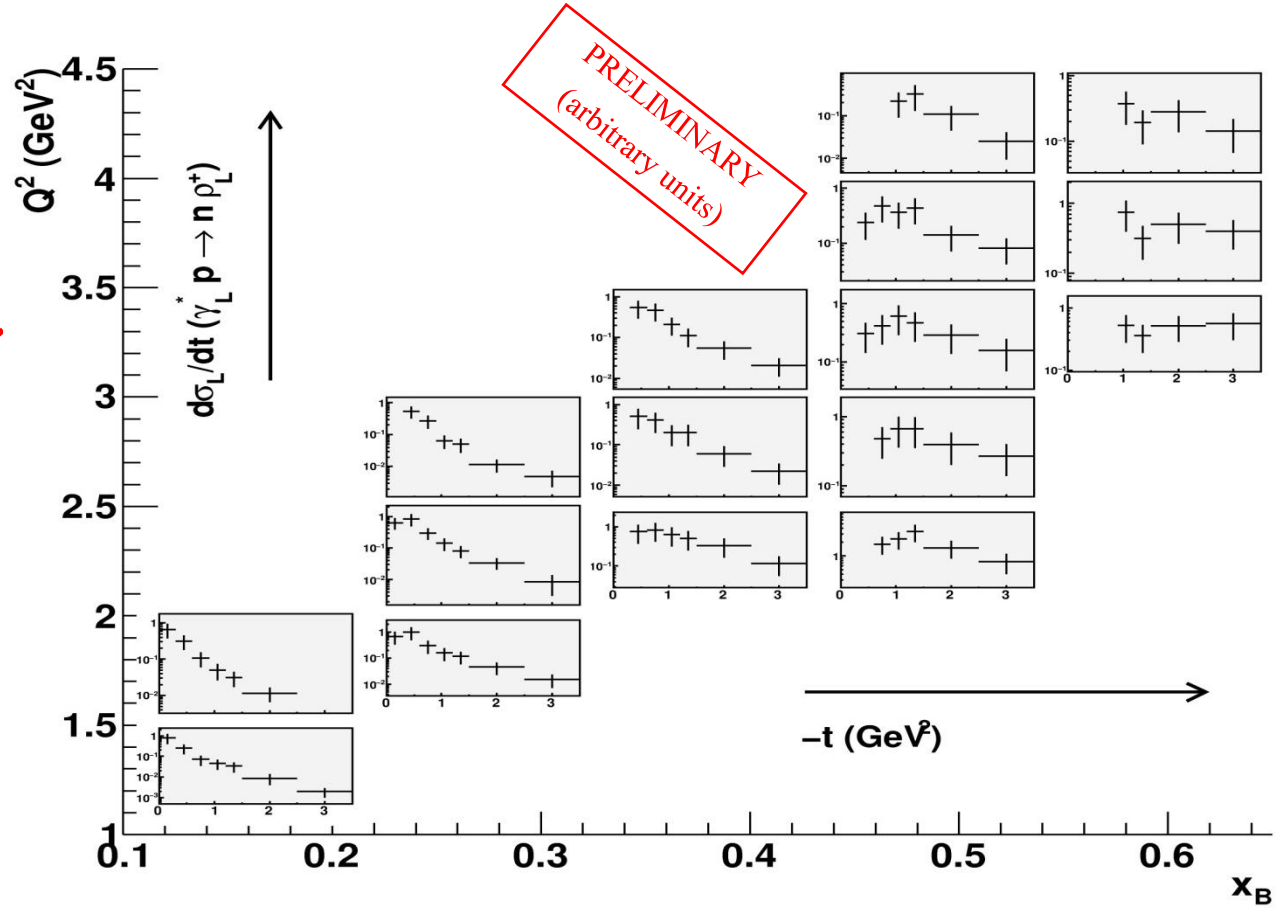
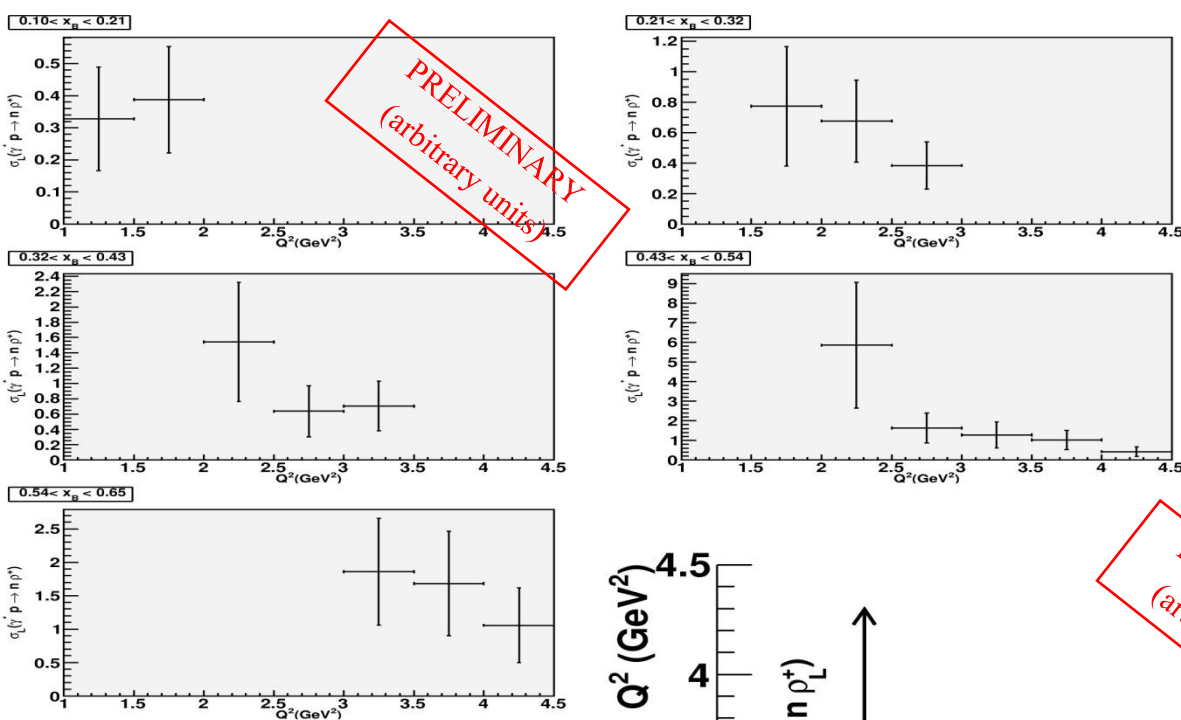


# Longitudinal cross sections

Longitudinal/Transverse separation:

➤ Analysis of the pion decay angles of the  $\rho^+$  ( $\cos\theta_{HS}$ )

➤ SCHC

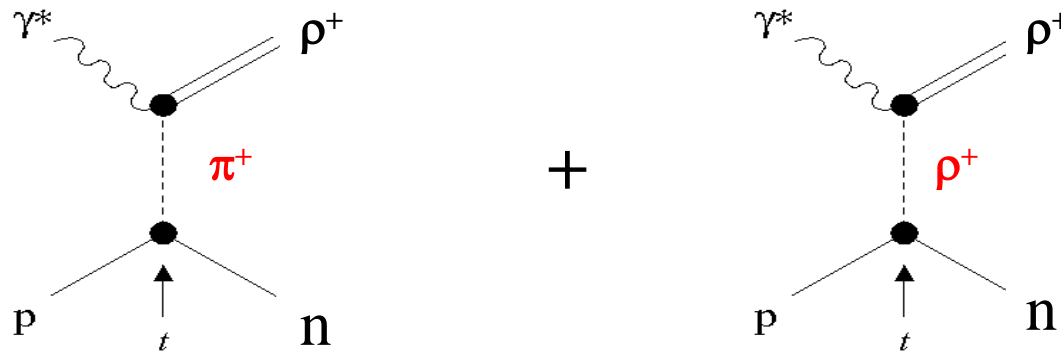


$\sigma_L(\gamma^* p \rightarrow n \rho^+)$

$d\sigma_L/dt(\gamma^* p \rightarrow n \rho^+)$

Low  $Q^2$

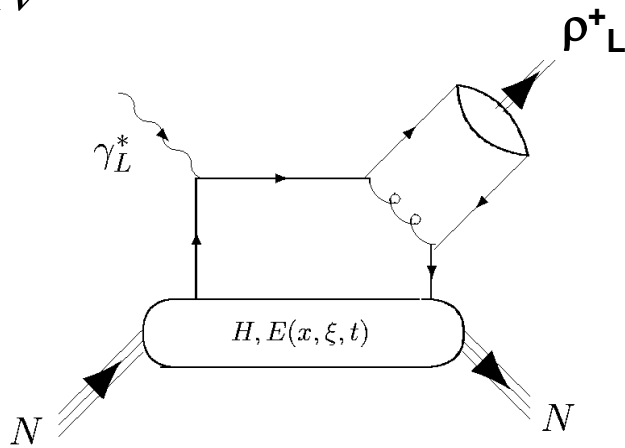
# Regge “hadronic” approach



Bjorken limit:

# GPD “partonic” approach

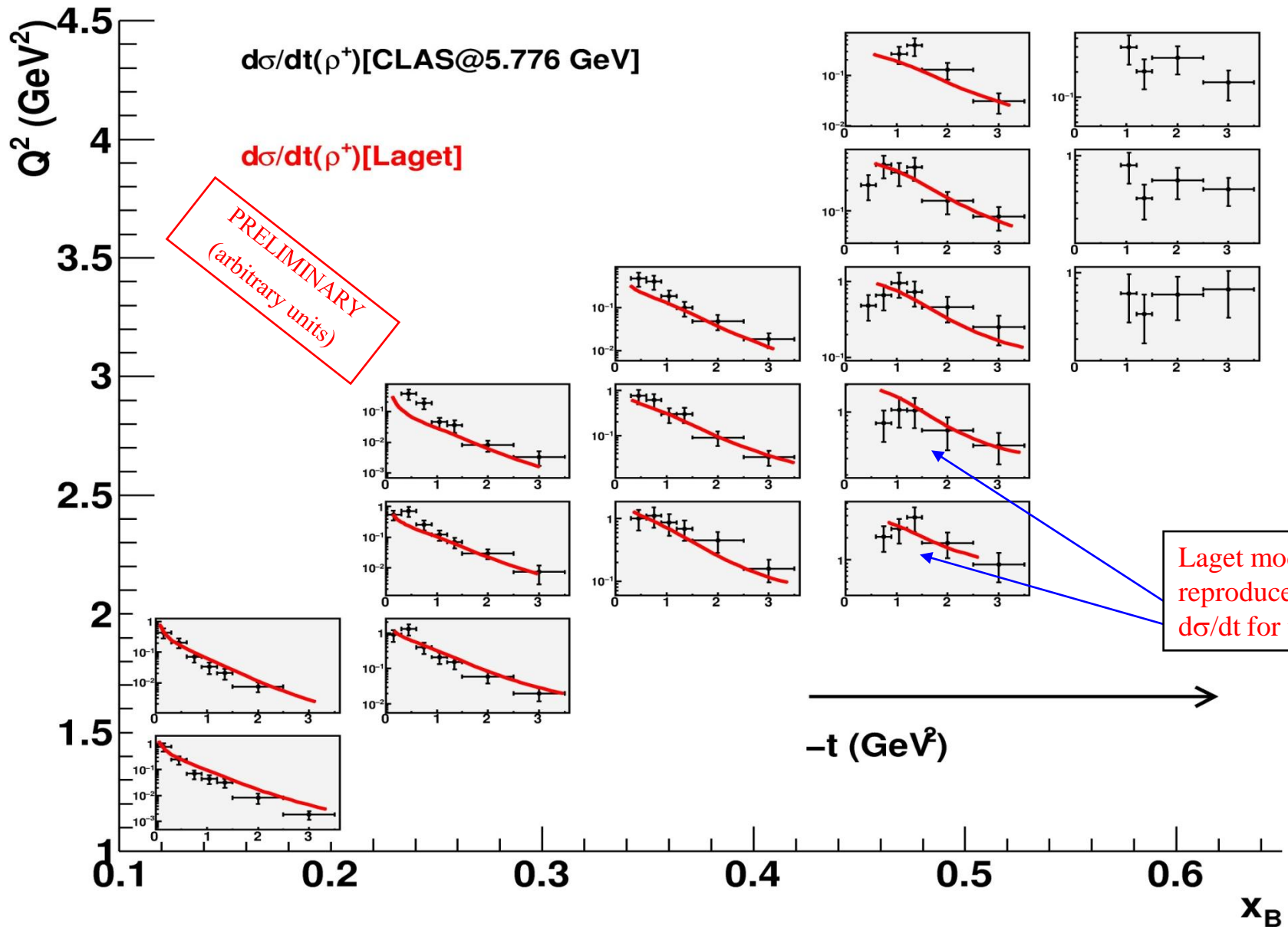
$$\begin{cases} Q^2, \nu \rightarrow \infty \\ x_B = \frac{Q^2}{2M\nu} \text{ finite} \end{cases}$$

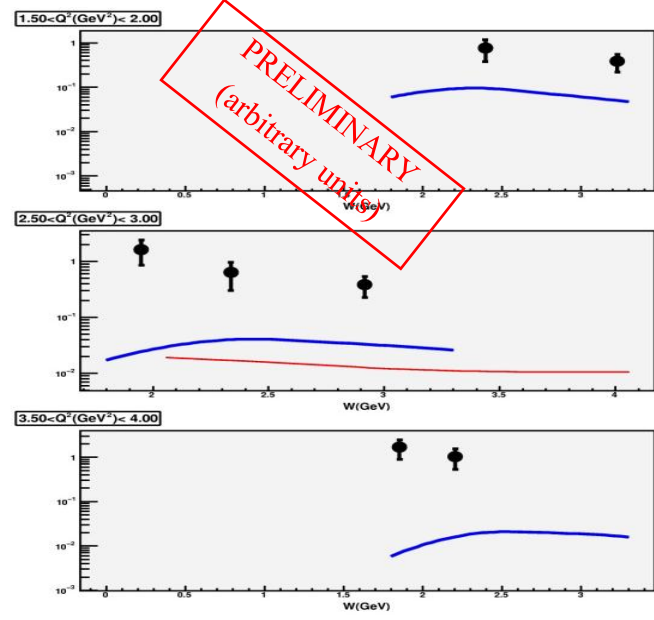
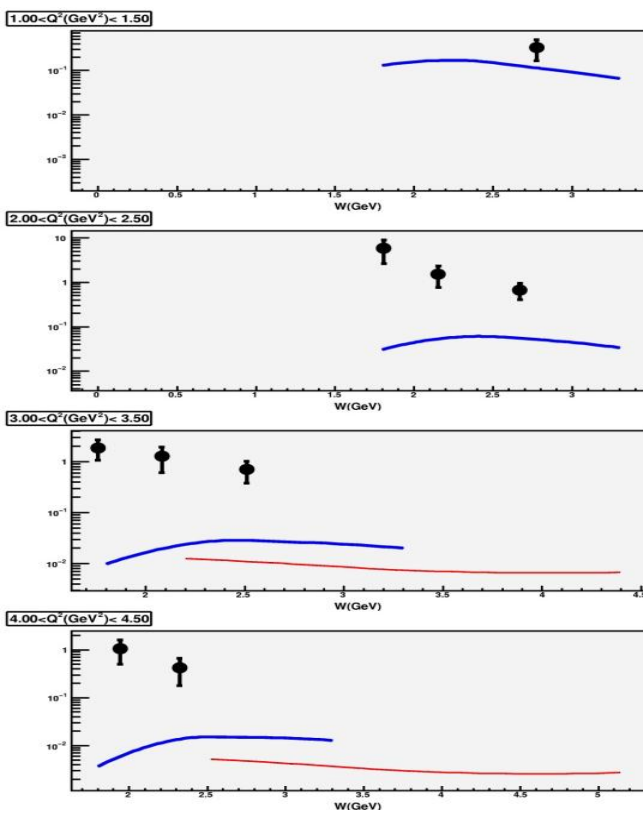


$\rho^0$	$e_u H^u - e_d H^d$ $e_u E^u - e_d E^d$
$\omega$	$e_u H^u + e_d H^d$ $e_u E^u + e_d E^d$
$\rho^+$	$H^u - H^d$ $E^u - E^d$

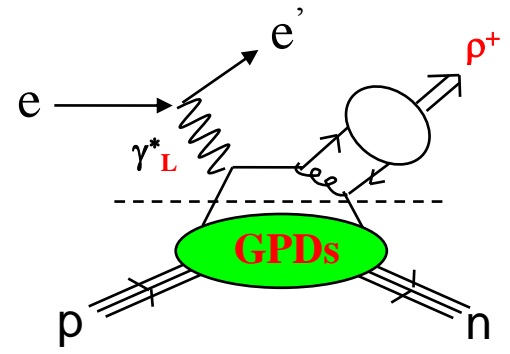


# Laget model for $\gamma^*p \rightarrow n\rho^+$





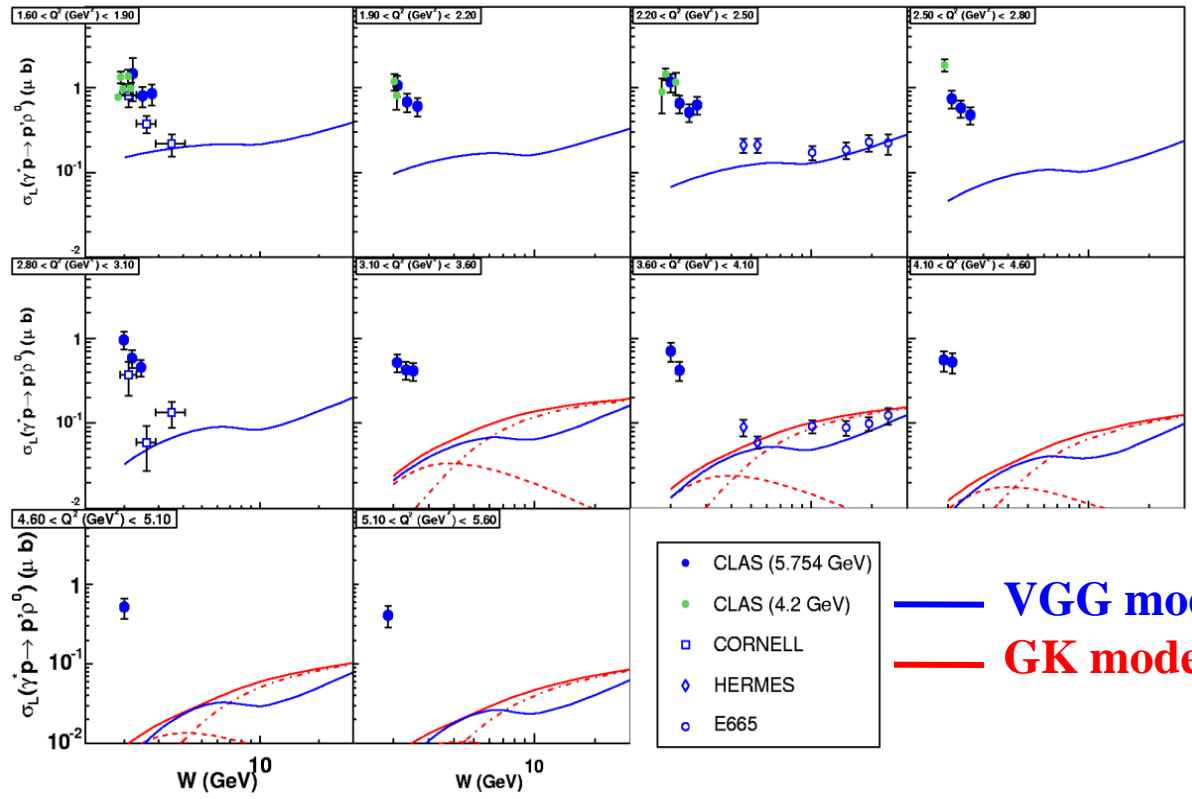
“Partonic approach”



$\rho^+$

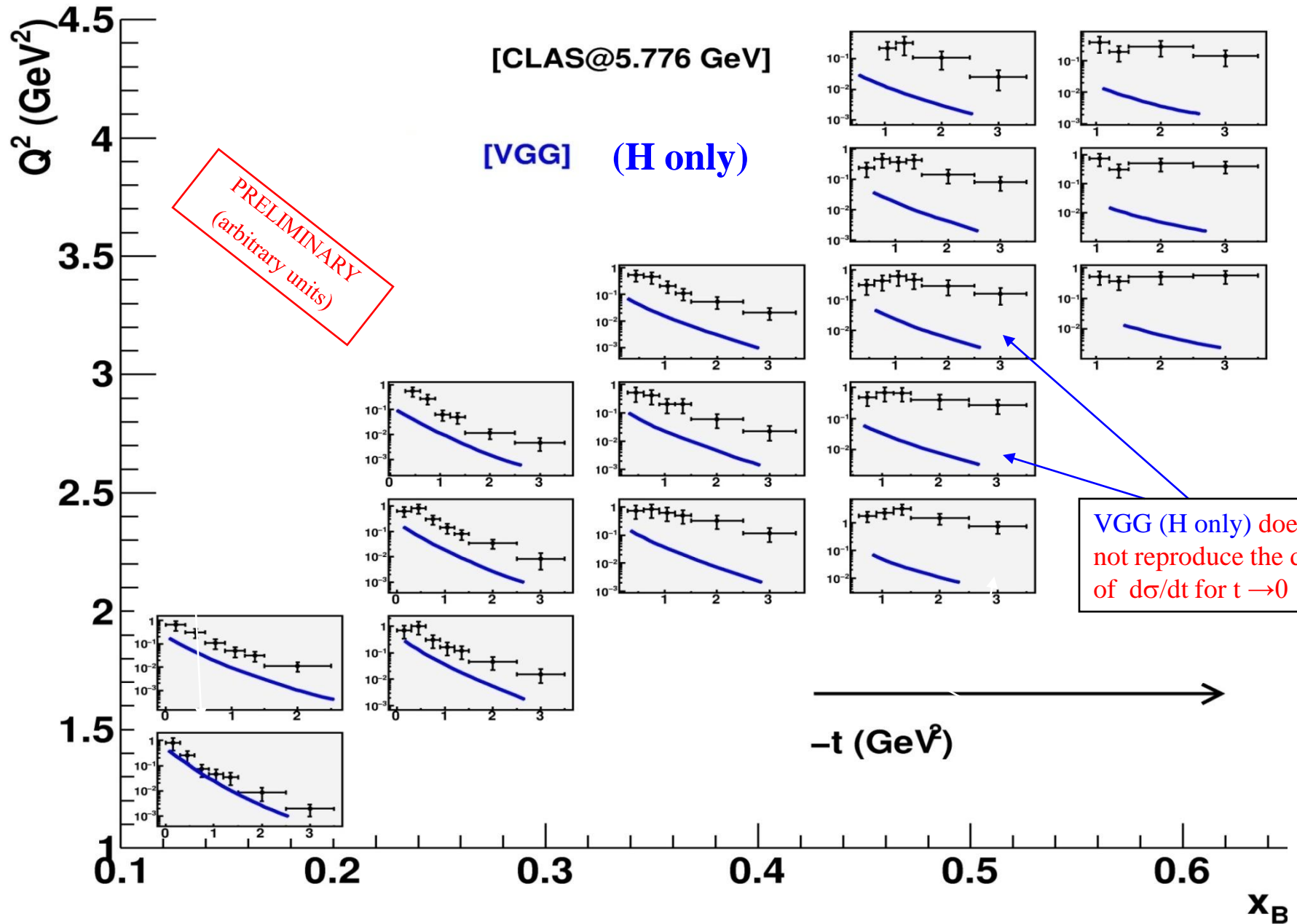
$\rho^0$

*S. Morrow et al.,  
Eur.Phys.J.A39:5-31,2009  
( $\rho^0$  @ 5.75 GeV)*

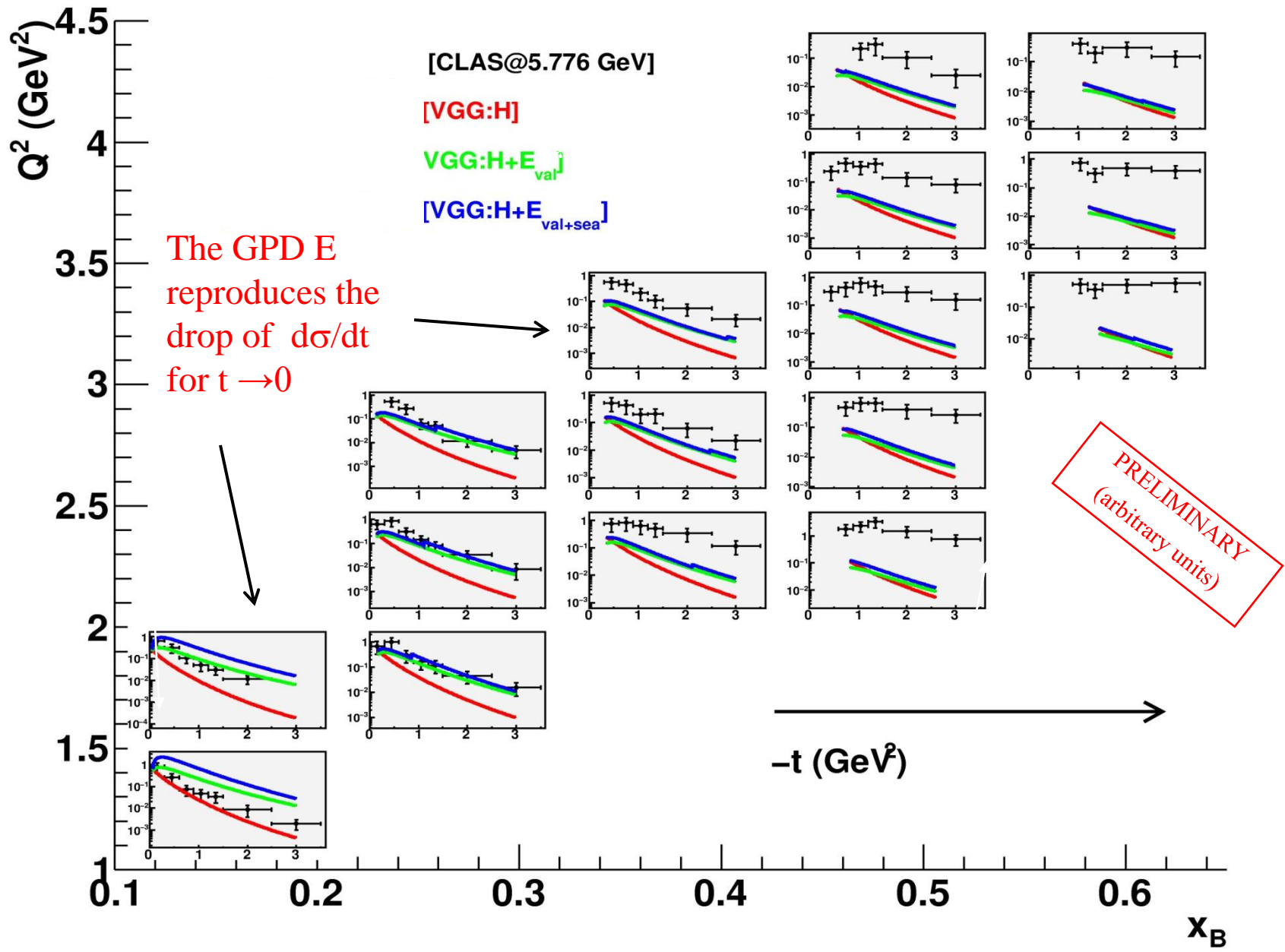


- CLAS (5.754 GeV)
  - CLAS (4.2 GeV)
  - CORNELL
  - ◇ HERMES
  - E665
- VGG model
- GK model

# $d\sigma_L/dt (\gamma^* p \rightarrow n \rho^+)$

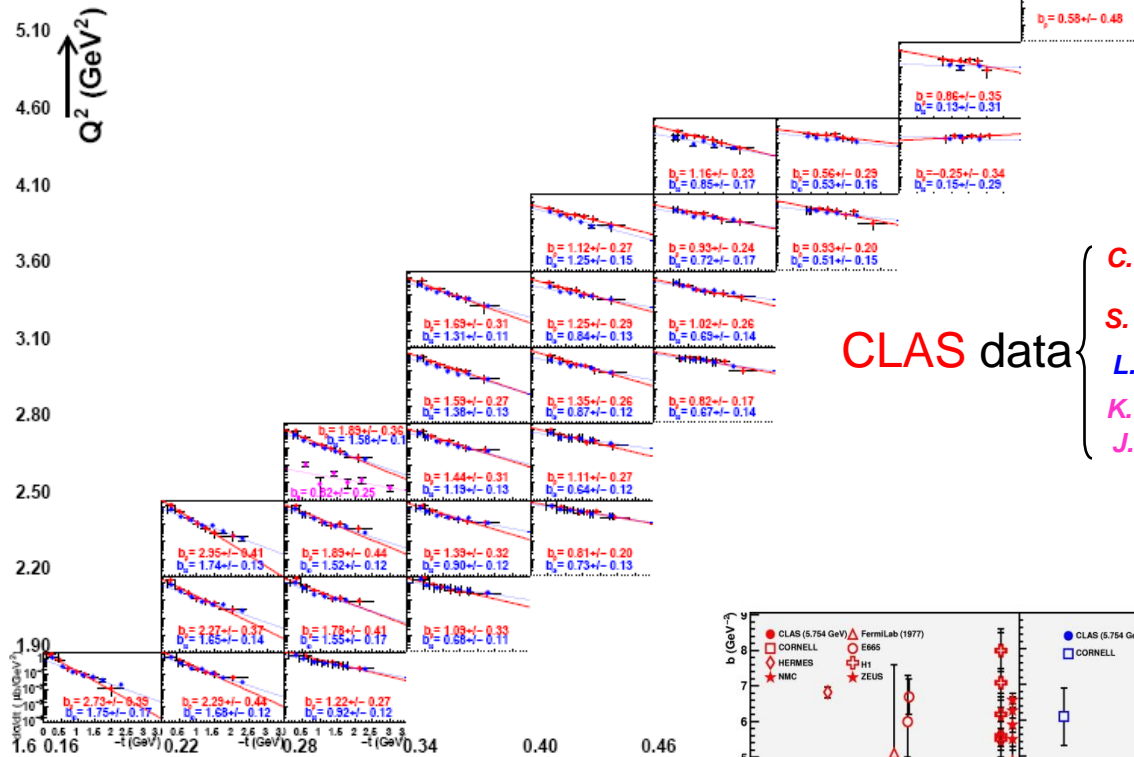


# $d\sigma_L/dt$ ( $\gamma^* p \rightarrow n \rho^+$ ): Hint of GPD E contribution ?





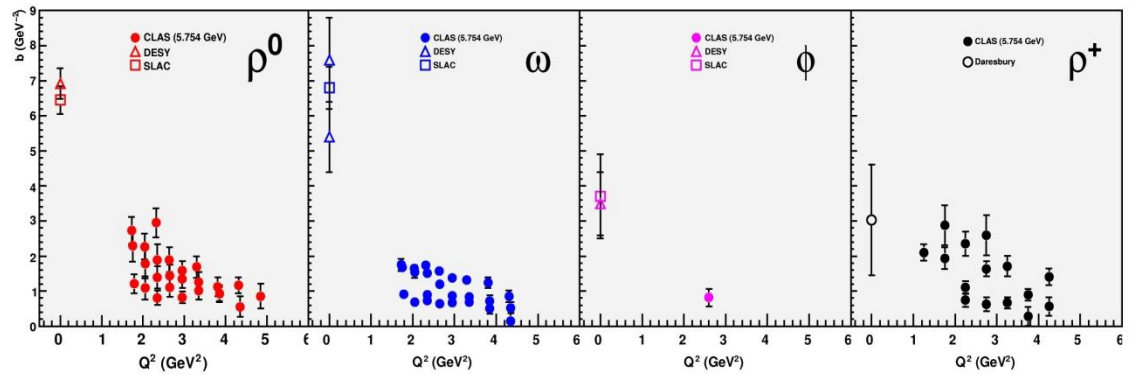
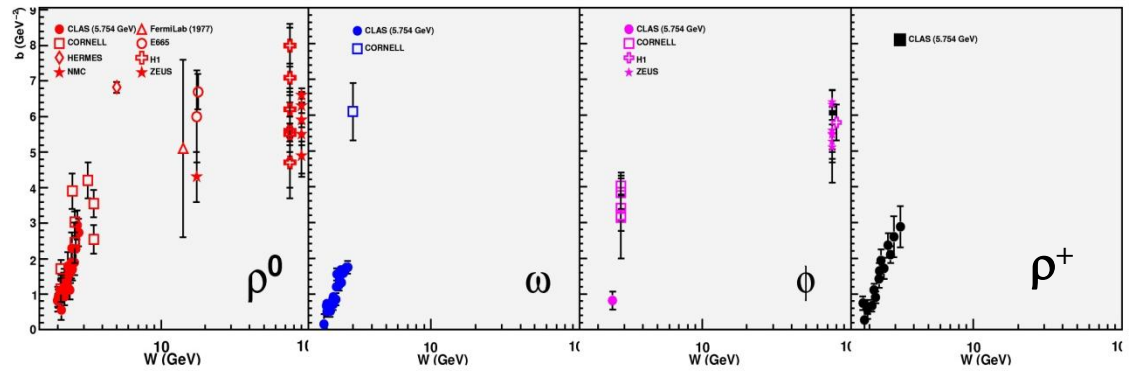
# $d\sigma/dt$ for $\rho^0$ , $\omega$ , $\phi$



CLAS data

- C. Hadjidakis et al., Phys.Lett.B605:256-264, 2005 ( $\rho^0$ @4.2 GeV)*
- S. Morrow et al., Eur.Phys.J.A39:5-31, 2009 ( $\rho^0$ @5.75GeV)*
- L. Morand et al., Eur.Phys.J.A24:445-458, 2005 ( $\omega$ @5.75GeV)*
- K. Lukashin, Phys.Rev.C63:065205, 2001 ( $\phi$ @4.2 GeV)*
- J. Santoro et al., Phys.Rev.C78:025210, 2008 ( $\phi$ @5.75GeV)*

Fit function:  $Ae^{-bt}$



$b$  reflects the size of the meson-nucleon system

# Conclusions

- World's first-ever measurement of exclusive  $\rho^+$  electroproduction.
- “Hadronic approach”: Laget Regge model describes well most of the features of  $\rho^+$  cross sections (total and diff., L and T) up to  $Q^2 \sim 4.5 \text{ GeV}^2$ .
- “Partonic approach”: GPDs model fails by large to describe longitudinal  $\rho^+$  cross sections especially for small  $W$  (valence region). We have to go to higher  $Q^2$  (but stay in valence region).
- Electroproduction of mesons is important to understand the transition between the soft description (hadronic approach) and the hard description (partonic approach).
- Comparison between  $(\rho^+, \rho^0, \omega, \phi)$  in progress: common features, ratios (cancel higher twists ?),...