Deep Vector Meson Electroproduction

M.Guidal & S. Morrow

IPN Orsay & SPhN/Saclay

1/ Data analysis of the $ep \to ep\rho^0$ reaction at CLAS with the 5.75 GeV beam (e1-6 experiment)

⇨ $\sigma_L\ (\gamma^*_L p \to p\rho_L^{\,0})$

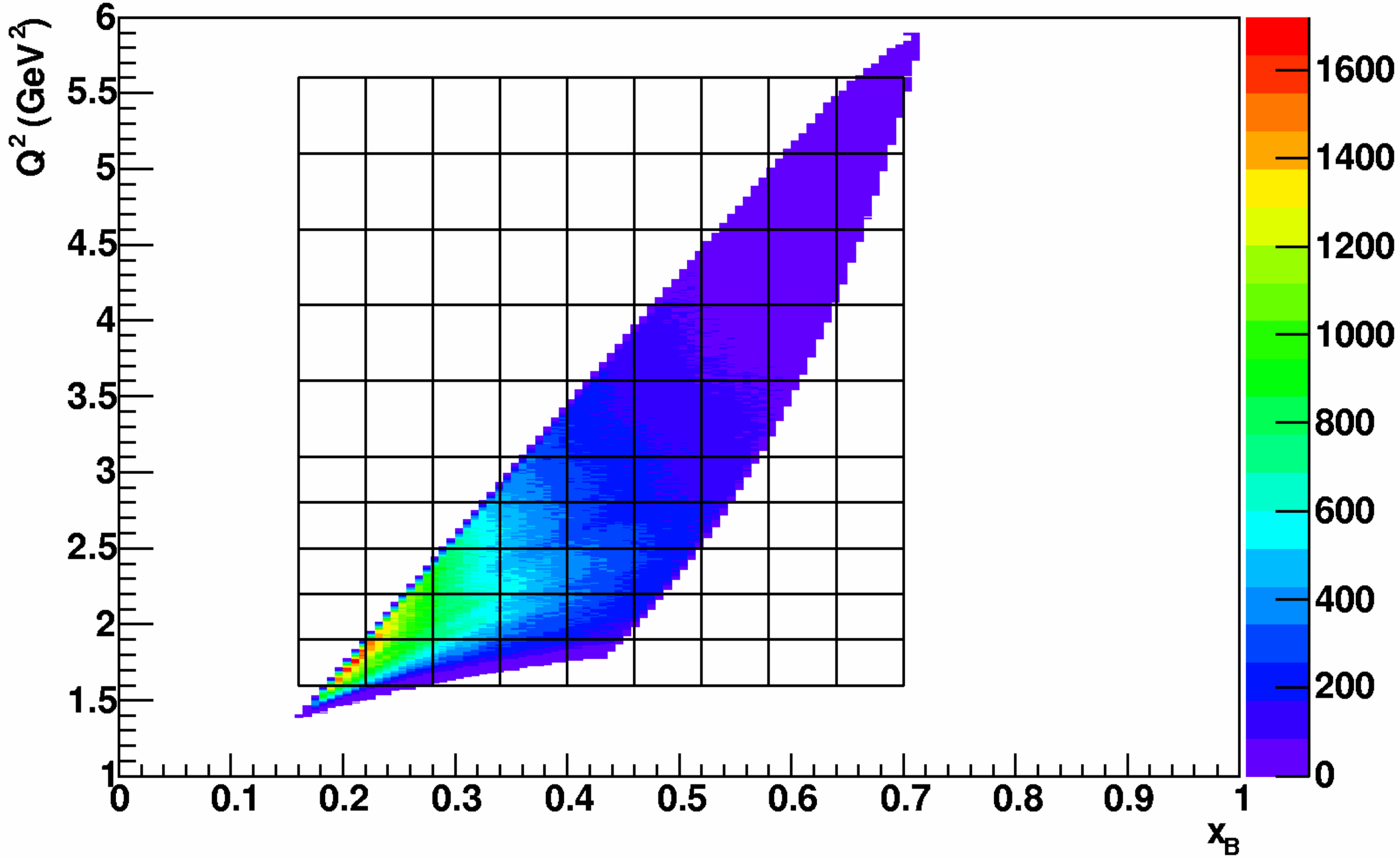
2/ Interpretation in terms of GPDs (& Regge : JML model)

⇨ Role of mesons in GPDs

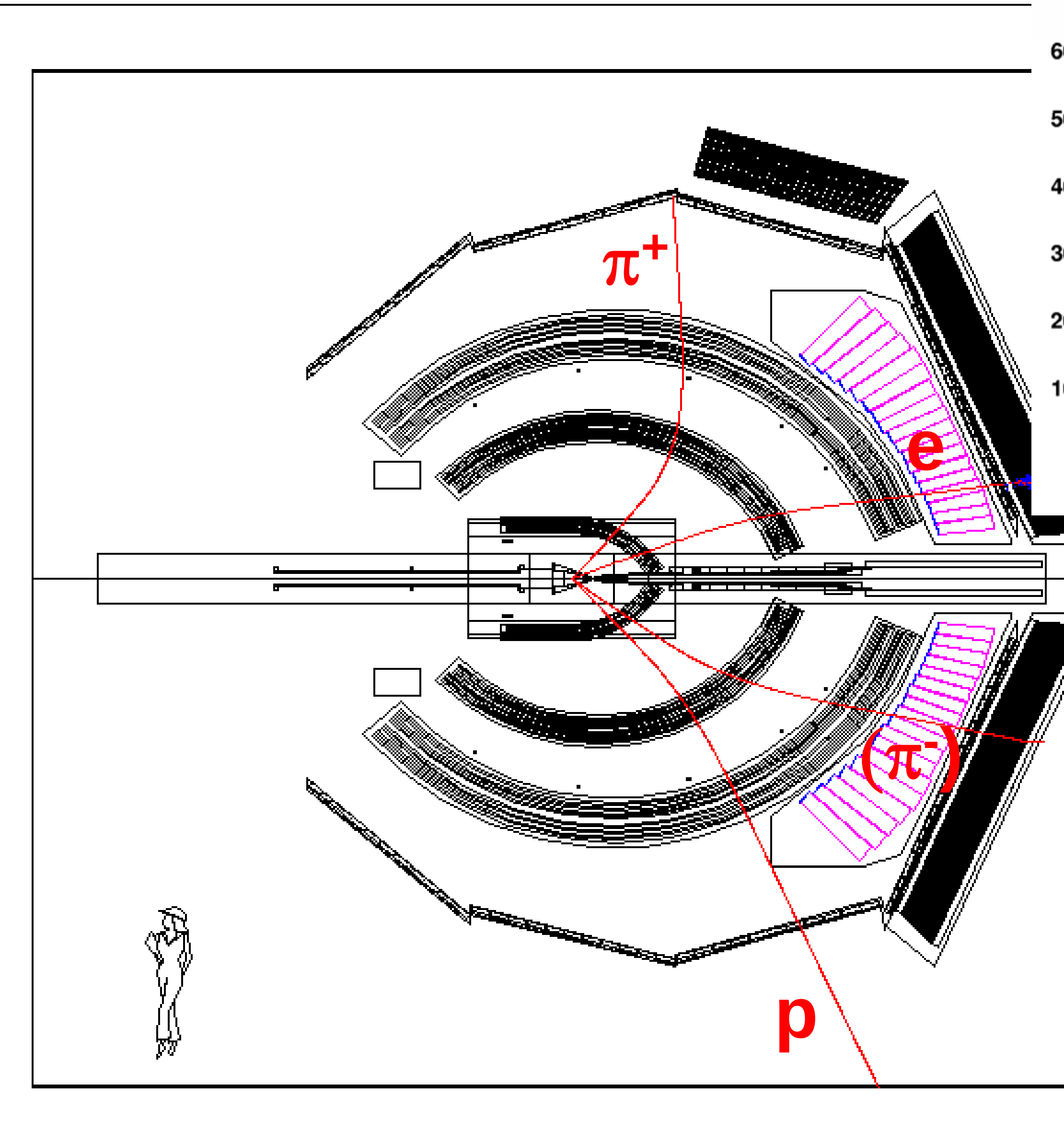
e1-6 experiment (5.75 GeV)

(CLAS detector)

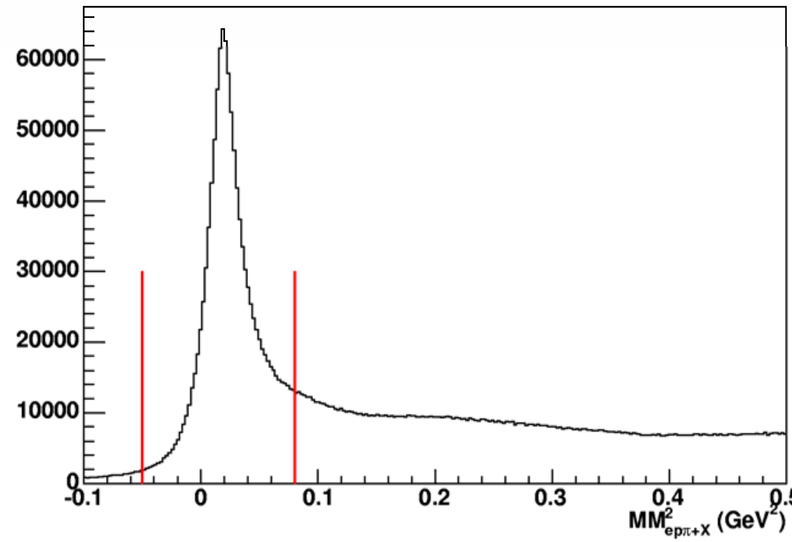
(October 2001 - January 2002)



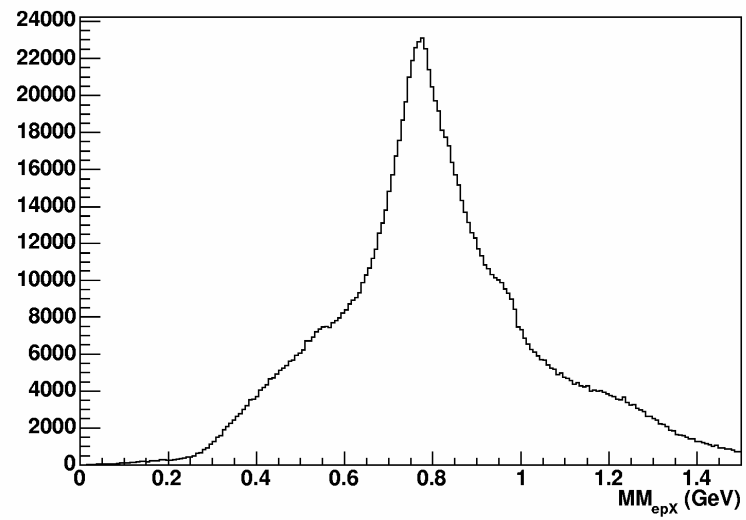
$ep \to ep\,\pi^+(\pi^-)$



$Mm(ep\pi^+ X)$



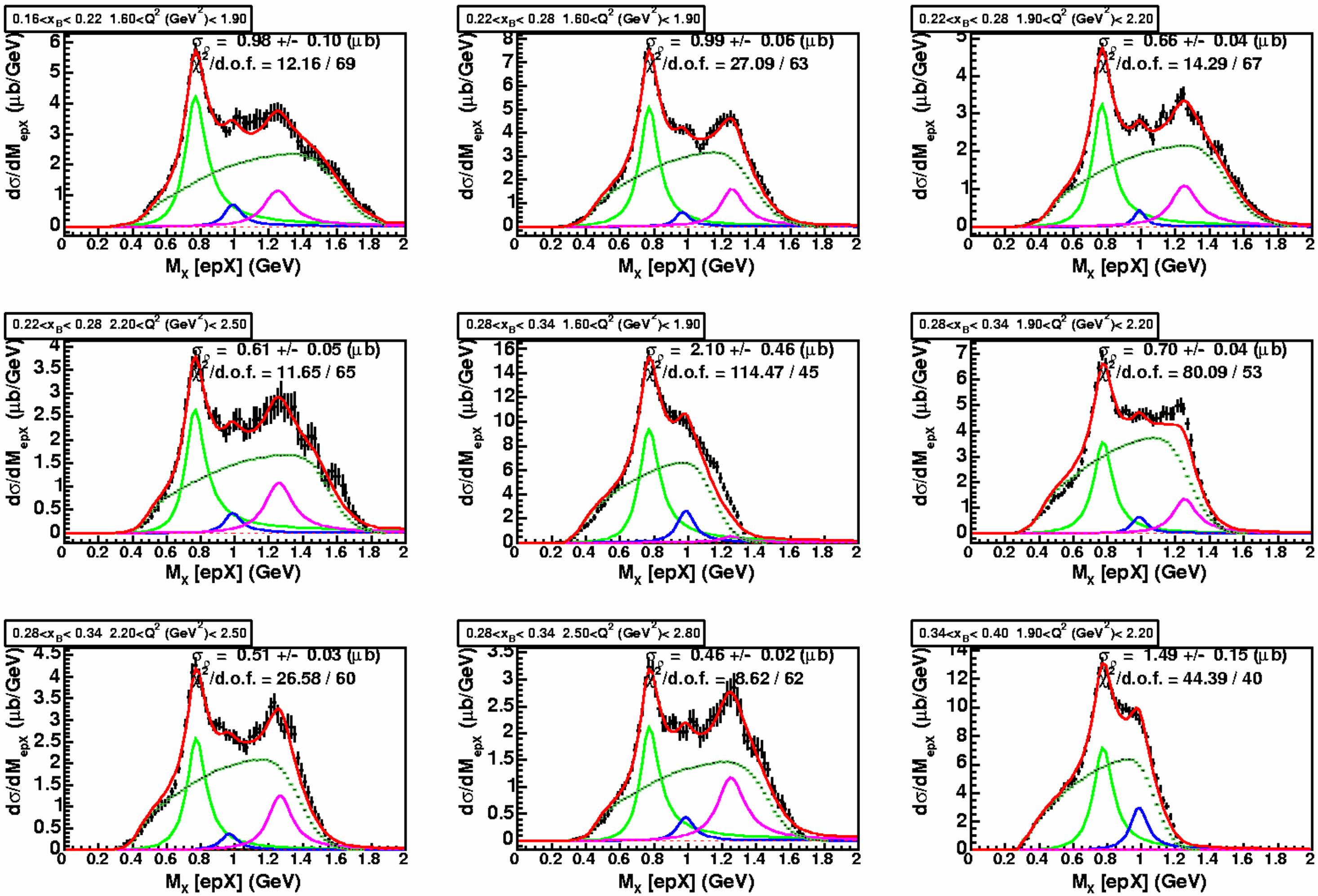
$Mm(epX)$



Background Subtraction

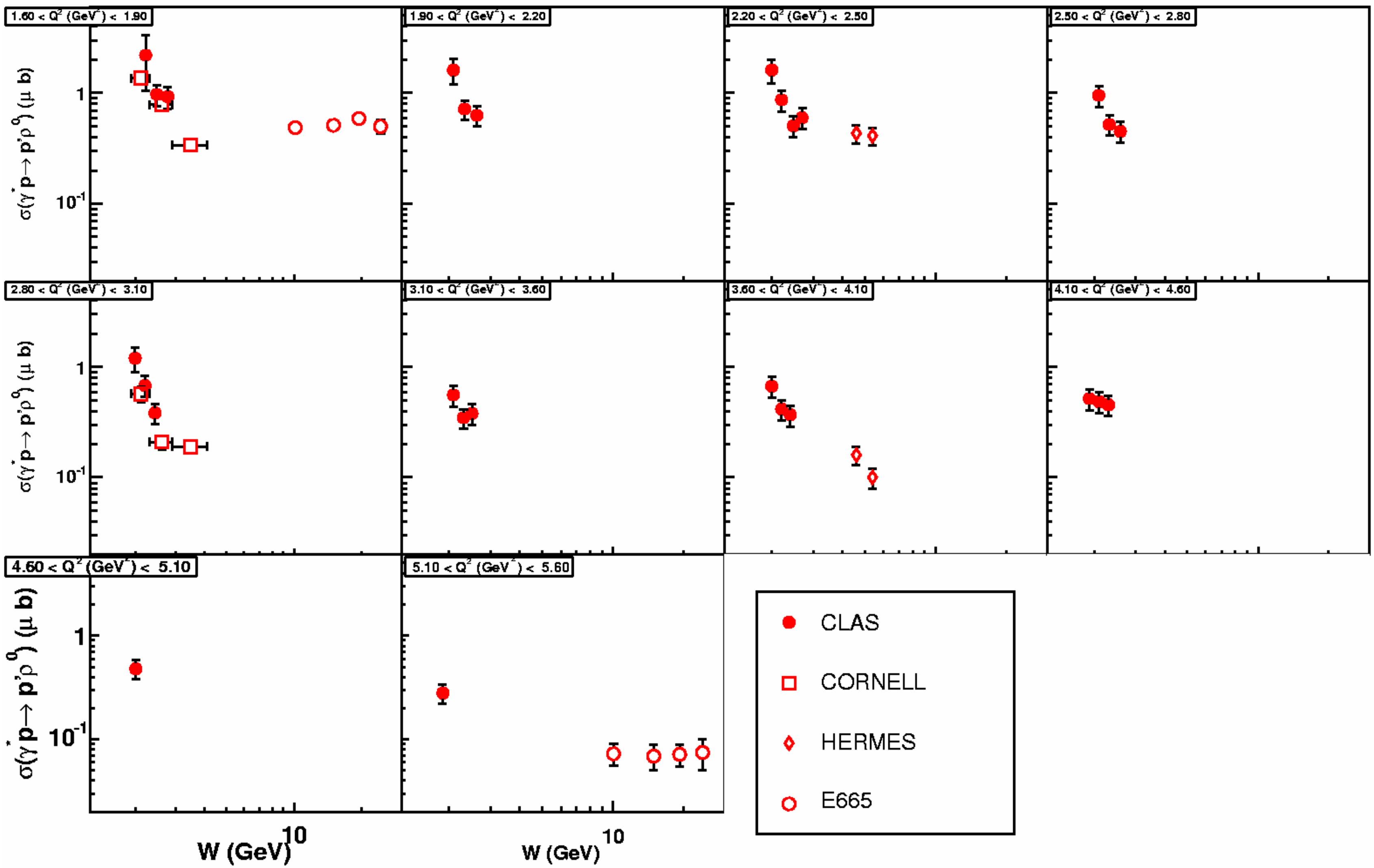
1) Ross-Stodolsky B-W for $\rho^0(770)$, $f_0(980)$ and $f_2(1270)$ with variable skewedness parameter,

2) $\Delta^{++}(1232)$ $\pi^+\pi^-$ inv.mass spectrum and $\pi^+\pi^-$ phase space.



A1

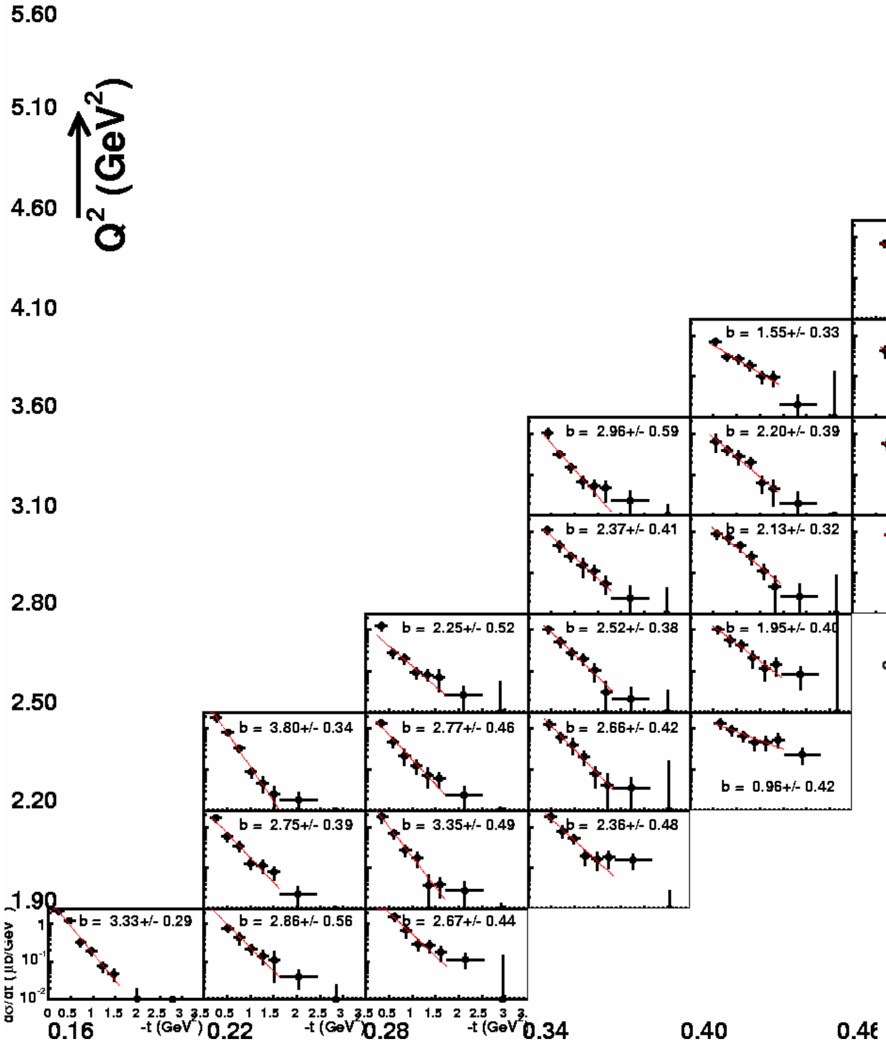
$\sigma_\rho\ (\gamma^* p \rightarrow p\rho^0)$ vs W



Slide 6

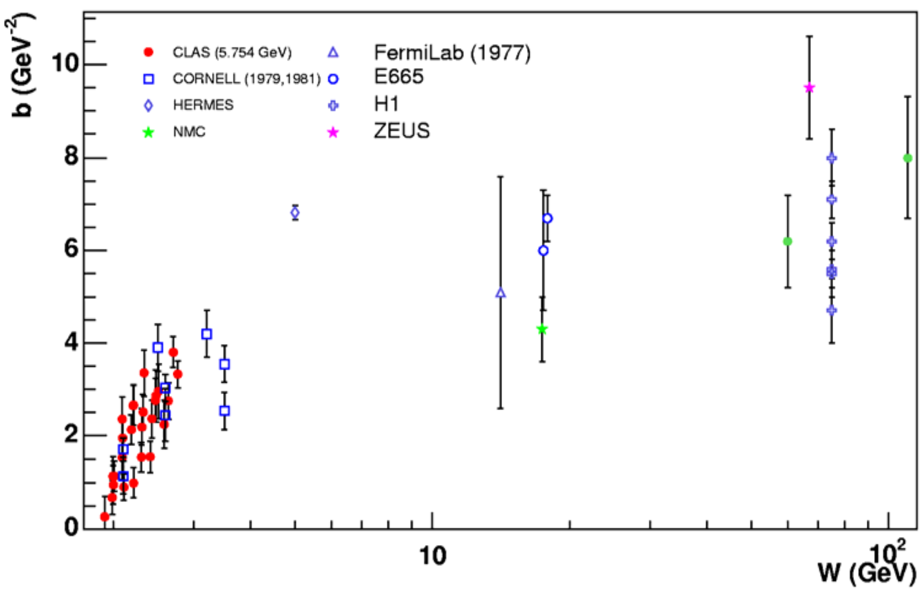
A1 Administrateur, 11/4/2005

dσ/dt ($\gamma^* p \to p\rho^0$)



Large t_{min} !
(1.6 GeV²)

Fit by e^{bt}

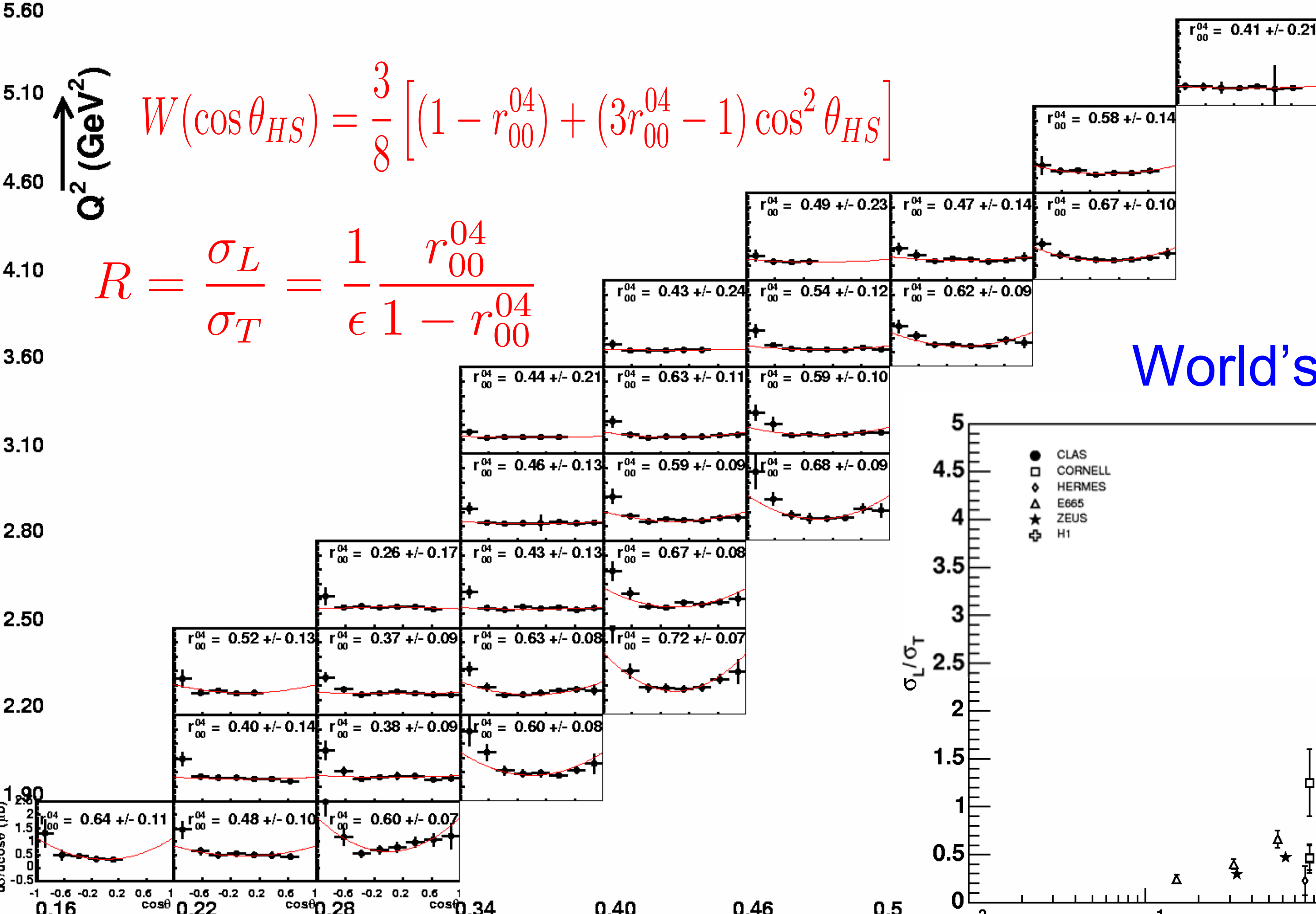


Angular distribution analysis, cos θ_{cm}

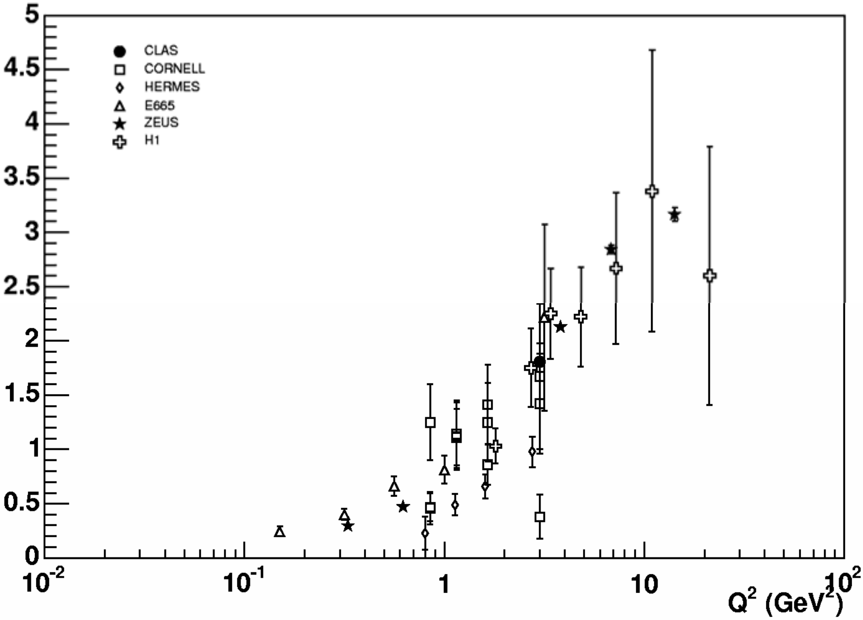
Relying on (and exp. checking) SCHC

$$W(\cos\theta_{HS}) = \frac{3}{8}\left[(1 - r^{04}_{00}) + (3r^{04}_{00} - 1)\cos^2\theta_{HS}\right]$$

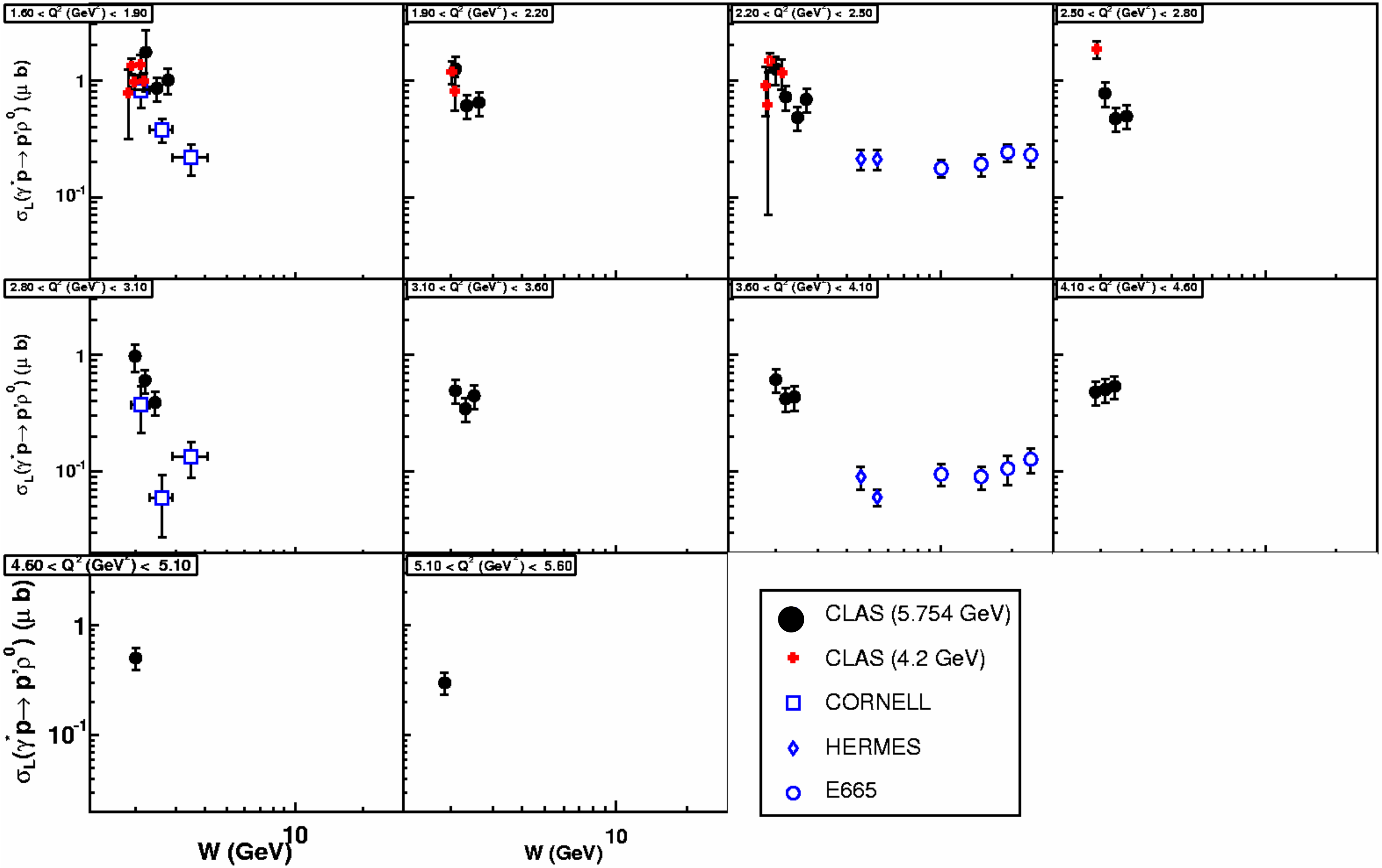
$$R = \frac{\sigma_L}{\sigma_T} = \frac{1}{\epsilon}\frac{r^{04}_{00}}{1 - r^{04}_{00}}$$



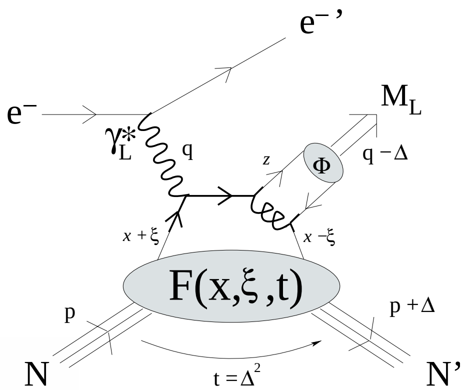
World's data for R



Longitudinal cross section σ_L ($\gamma^*_L p \rightarrow p \rho_L^0$)

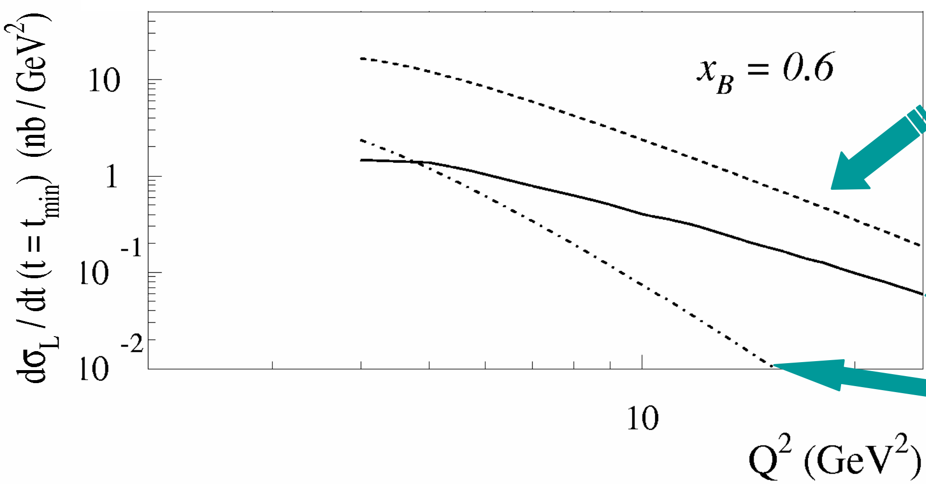


Interpretation in terms of GPDs ?



$$\mathcal{A}_L = -\frac{2ie}{9}\left(\int_0^1 dz \frac{\Phi(z)}{z}\right)\frac{4\pi\alpha_S(Q^2)}{Q}\int_{-1}^{+1} dx \left\{\left[\frac{1}{x-\xi+i\epsilon}+\frac{1}{x+\xi-i\epsilon}\right]F(x,\xi,t)\right\}$$

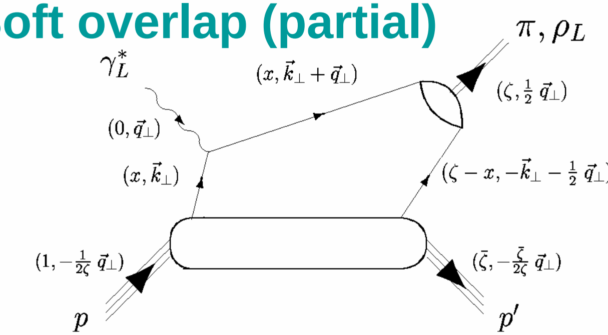
$$F(x,\xi,t) = H_M^N(x,\xi,t)\bar{N}(p')\gamma\cdot n N(p) + E_M^N(x,\xi,t)\bar{N}(p')i\sigma^{\kappa\lambda}\frac{n_\kappa\Delta_\lambda}{2m_N}N(p)$$



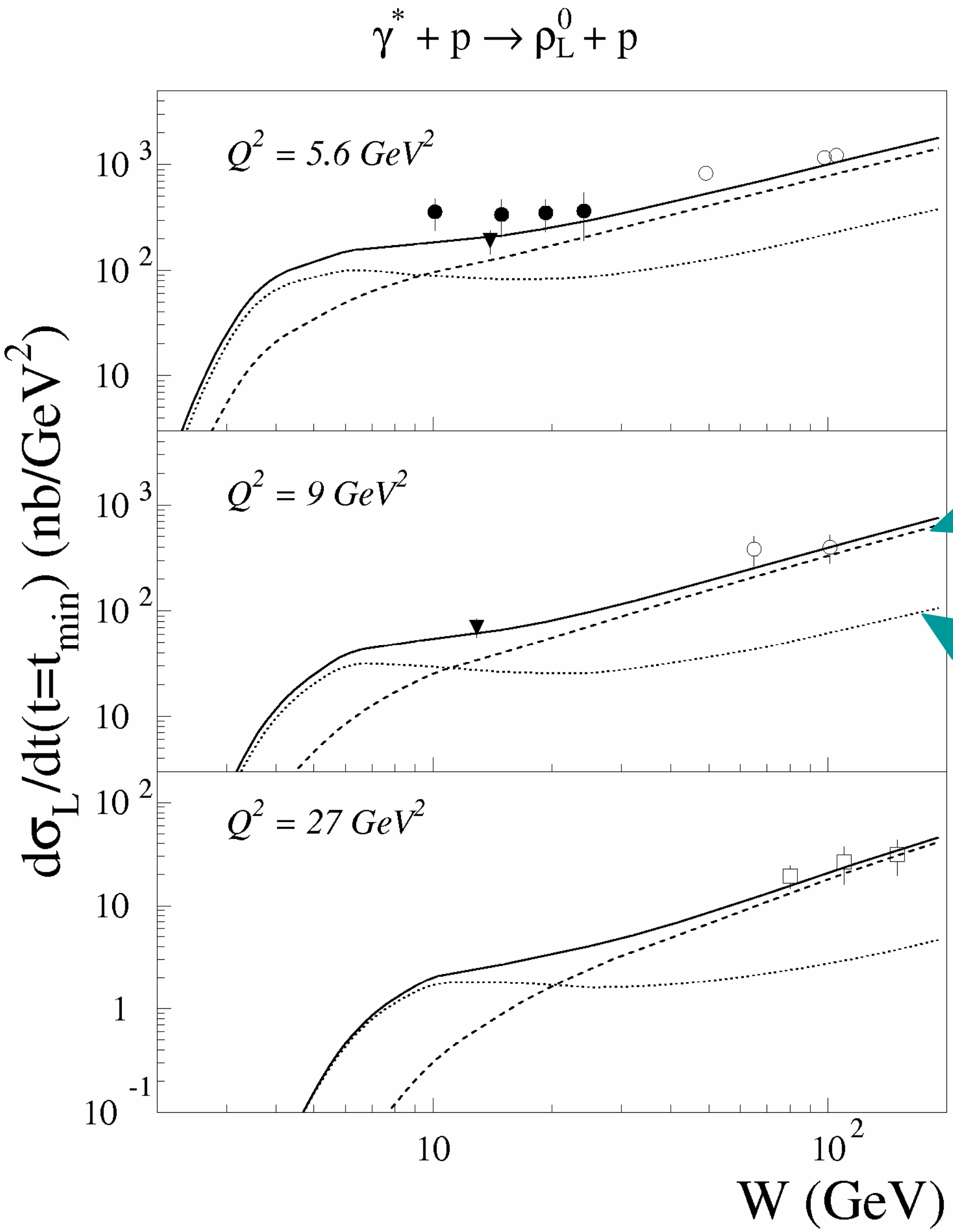
LO (w/o kperp effect)

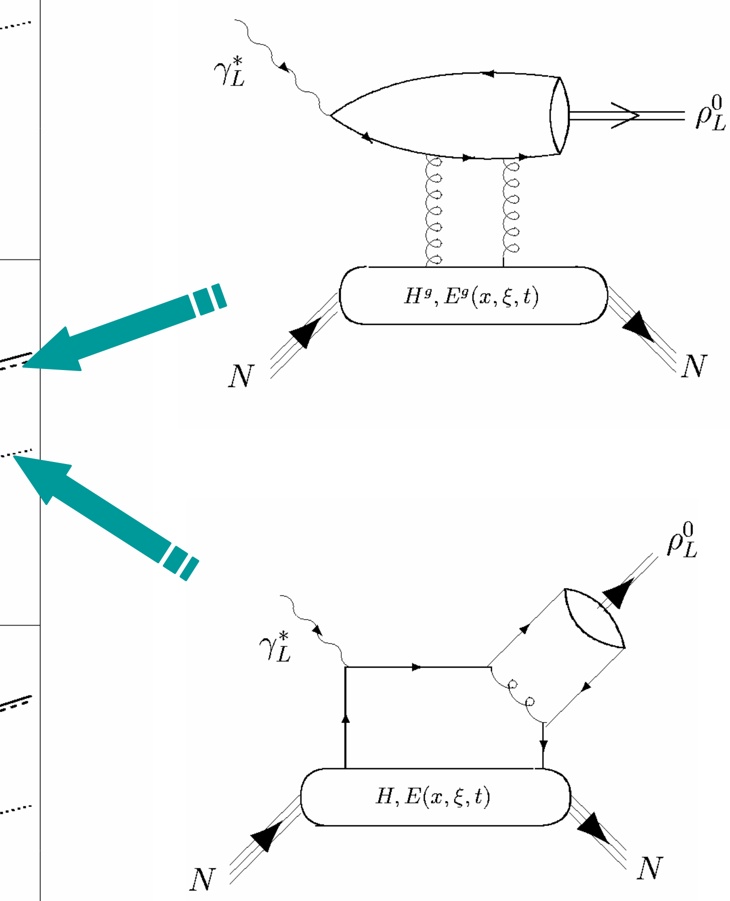
LO (with kperp effect)

Soft overlap (partial)



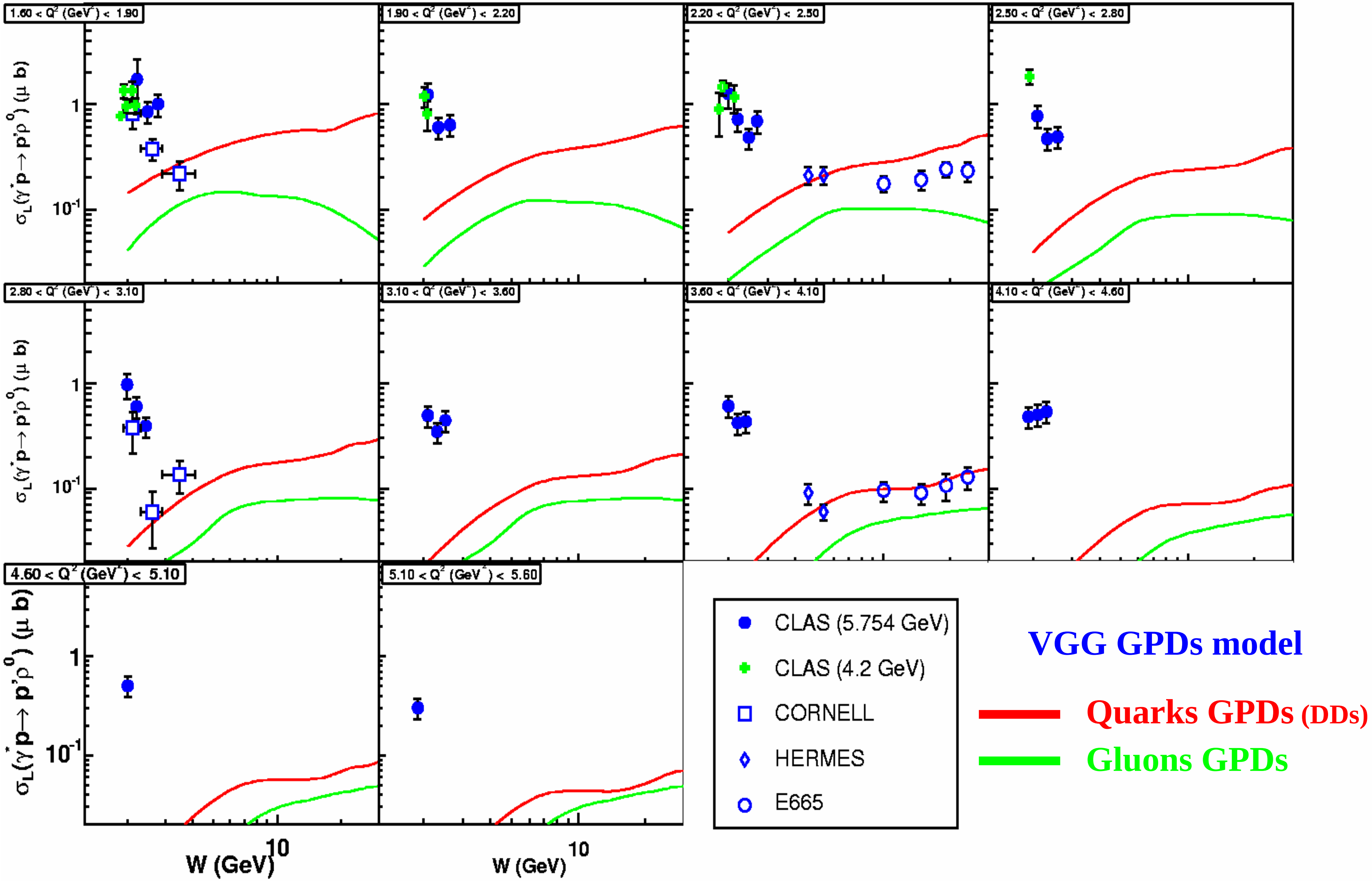
Handbag diagram calculation needs k_{perp} effects to account for preasymptotic effects



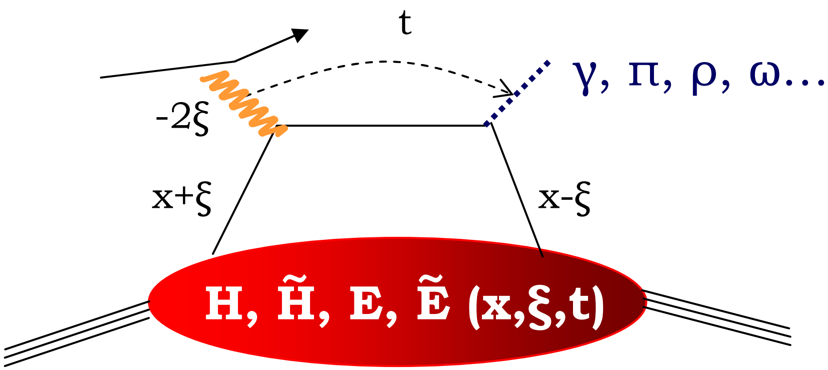


GPDs parametrization based on DDs (VGG model)

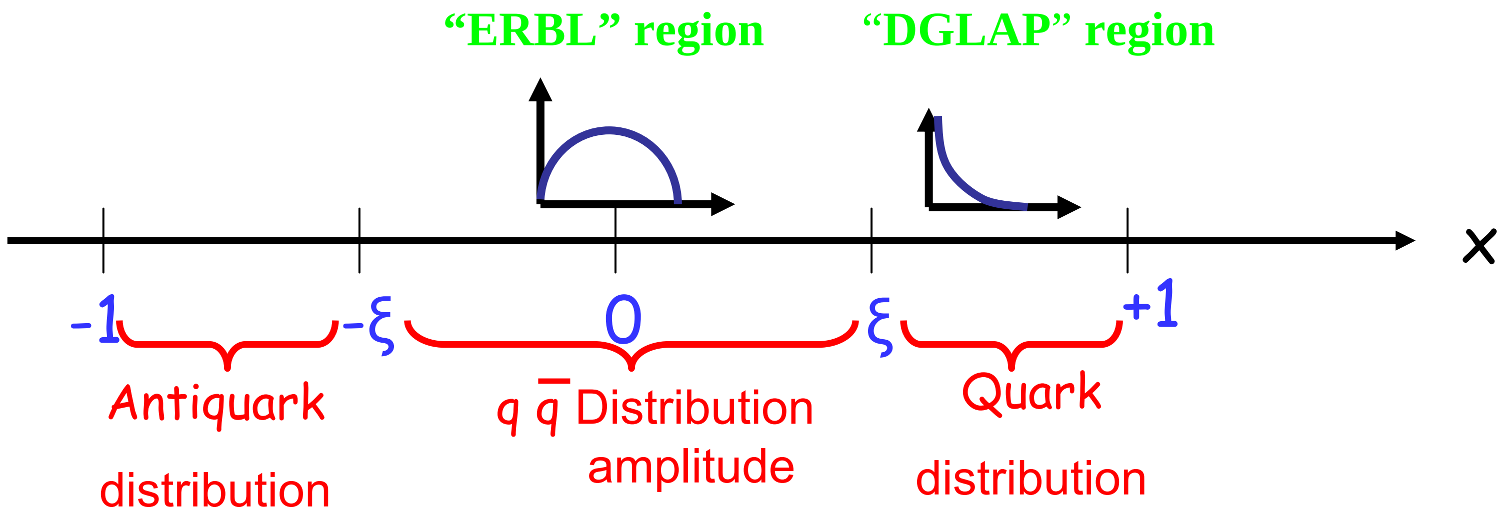
M. Vanderhaeghen, P. Guichon, M.G. (PRD 60:094017,1999)



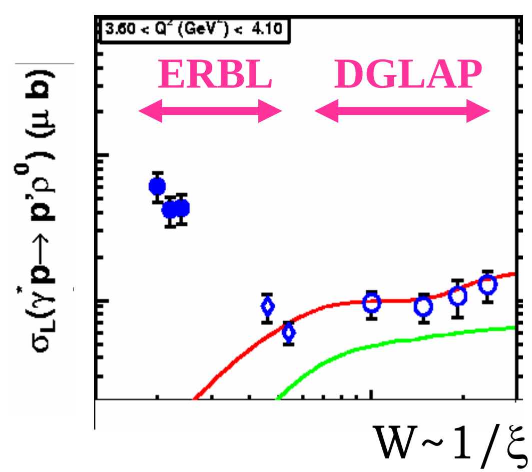
1.60 < Q² (GeV²) < 1.90
1.90 < Q² (GeV²) < 2.20
2.20 < Q² (GeV²) < 2.50
2.50 < Q² (GeV²) < 2.80
2.80 < Q² (GeV²) < 3.10
3.10 < Q² (GeV²) < 3.60
3.60 < Q² (GeV²) < 4.10
4.10 < Q² (GeV²) < 4.60
4.60 < Q² (GeV²) < 5.10
5.10 < Q² (GeV²) < 5.60
σL(γ*p → p'ρ0) (μ b)
W (GeV)
CLAS (5.754 GeV)
CLAS (4.2 GeV)
CORNELL
HERMES
E665
VGG GPDs model
Quarks GPDs (DDs)
Gluons GPDs



t
γ, π, ρ, ω…
-2ξ
x+ξ
x-ξ
H, H̃, E, Ẽ (x,ξ,t)



"ERBL" region
"DGLAP" region
x
-1
-ξ
0
ξ
+1
Antiquark
distribution
q q̄ Distribution
amplitude
Quark
distribution



3.60 < Q² (GeV²) < 4.10
ERBL
DGLAP
σL(γ*p→ p'ρ0) (μ b)
W~1/ξ

Out of ERBL region (W>5 GeV), decent agreement with data which thus seem to be interpretable in terms of (k_{perp} modified) LO handbag diagram and GPDs

In ERBL region, either :

BIG part is missing in GPDs parametrization (unconstrained meson exchange contributions in $-\xi<x<\xi$ region ?)

$H(x,0,0) = q(x)$

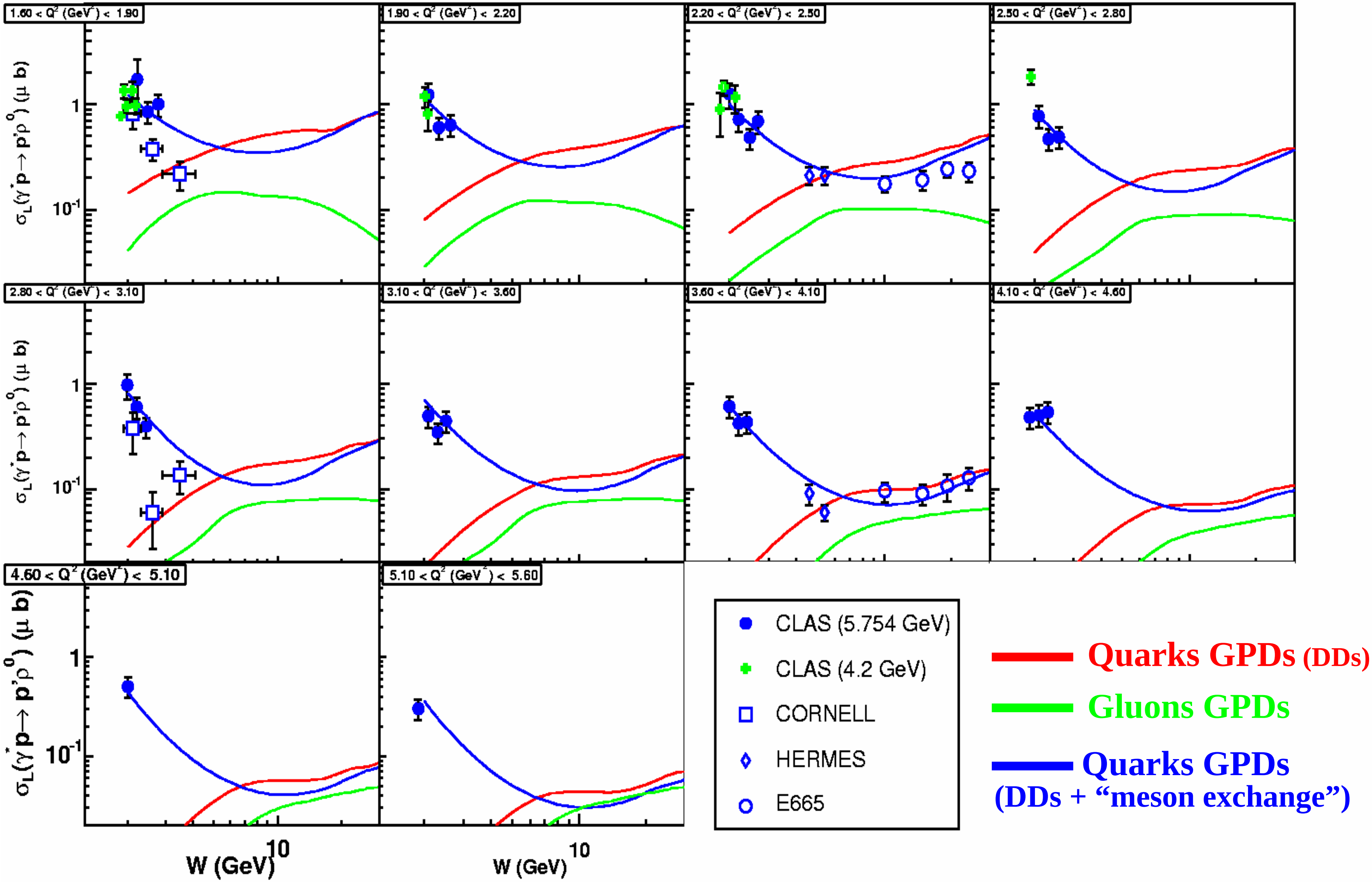
$\int H(x,\xi,t)dx = F(t)$

ERBL region is basically unknown and unconstrained, escapes all normalisation constraints

Add (in addition to DDs) (and fit) Gegenbauer (odd) polynomial to H (or/and E) GPD(s)

-Very Poor man's way of introducing $q\bar{q}$ correlations in the ERBL domain of GPDs-

Various GPDs contributions



***Out* of ERBL region (W>5 GeV), decent agreement with data which thus seem to be interpretable in terms of (k_{perp} modified) LO handbag diagram and GPDs**

***In* ERBL region, either :**

***BIG* part is missing in GPDs parametrization (*unconstrained* meson exchange contributions in $-\xi<x<\xi$ region ?)**

$$H(x,0,0) = q(x)$$

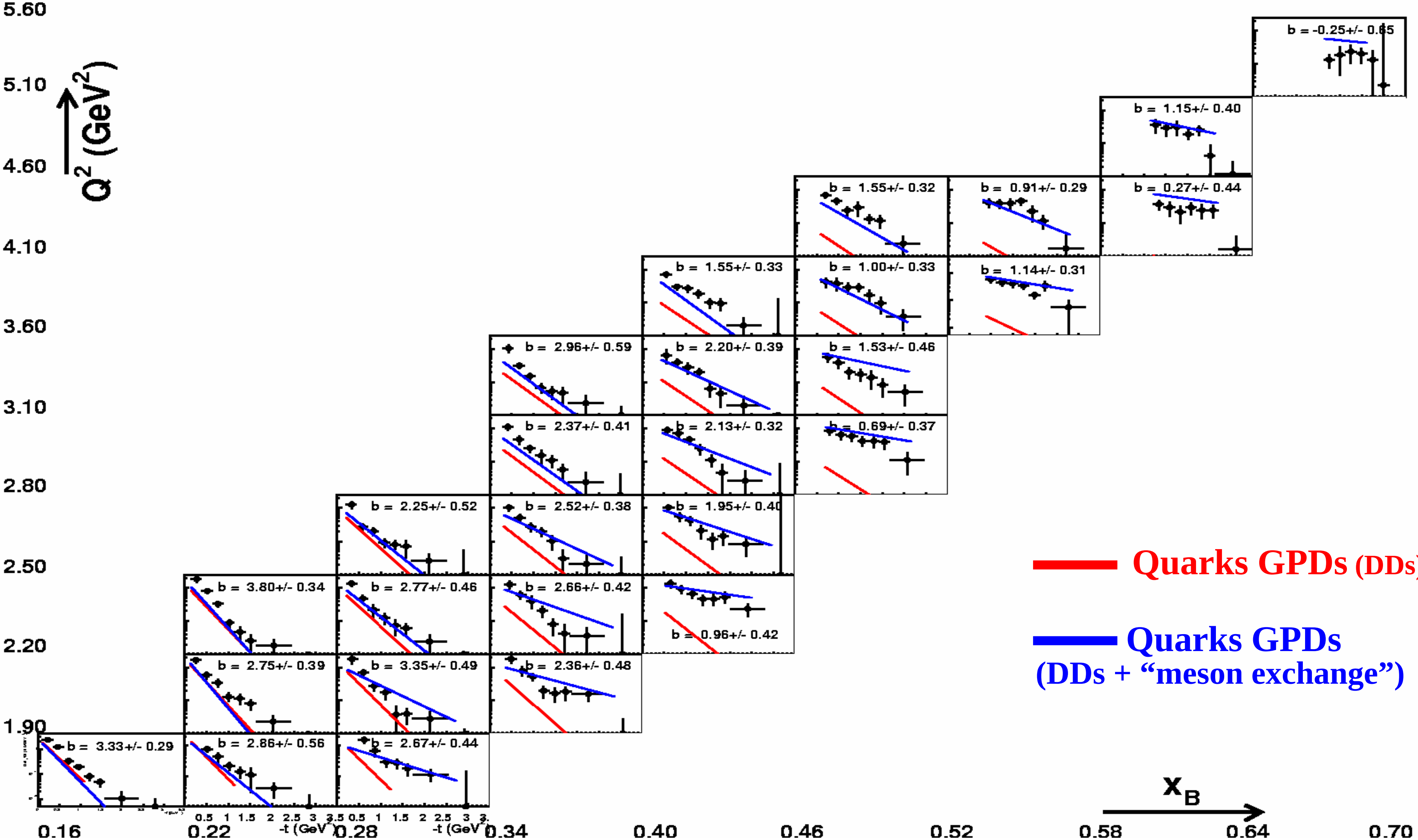
$$\int H(x,\xi,t)dx = F(t)$$

ERBL region is basically unknown and unconstrained, Escapes all normalisation constraints

Add (in addition to DDs) (and fit) Gegenbauer (odd) polynomial to H (or/and E) GPD(s)

Or, NO such important contribution and keep "standard" (DDs based) GPDs but falls into "classical" problems of onset of factorization (CZ vs asympt. DA, Feynman mechanism, …)

$d\sigma_L/dt\ (\gamma^* p \rightarrow p\rho^0)$



Do t-channel meson exchange belong to GPDs ?

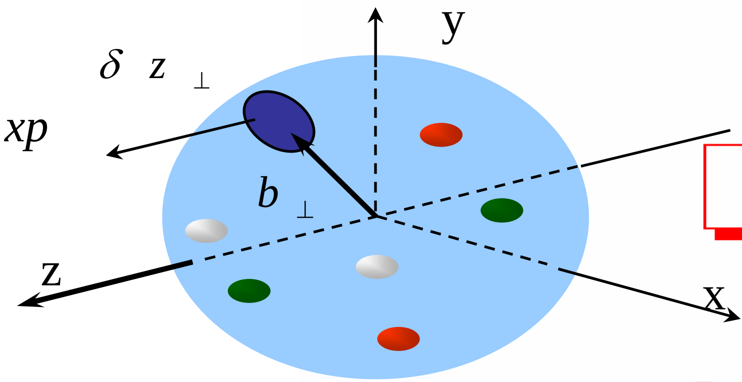
Do GPDs reflect nucleon structure or meson structure ?

At ξ=0,

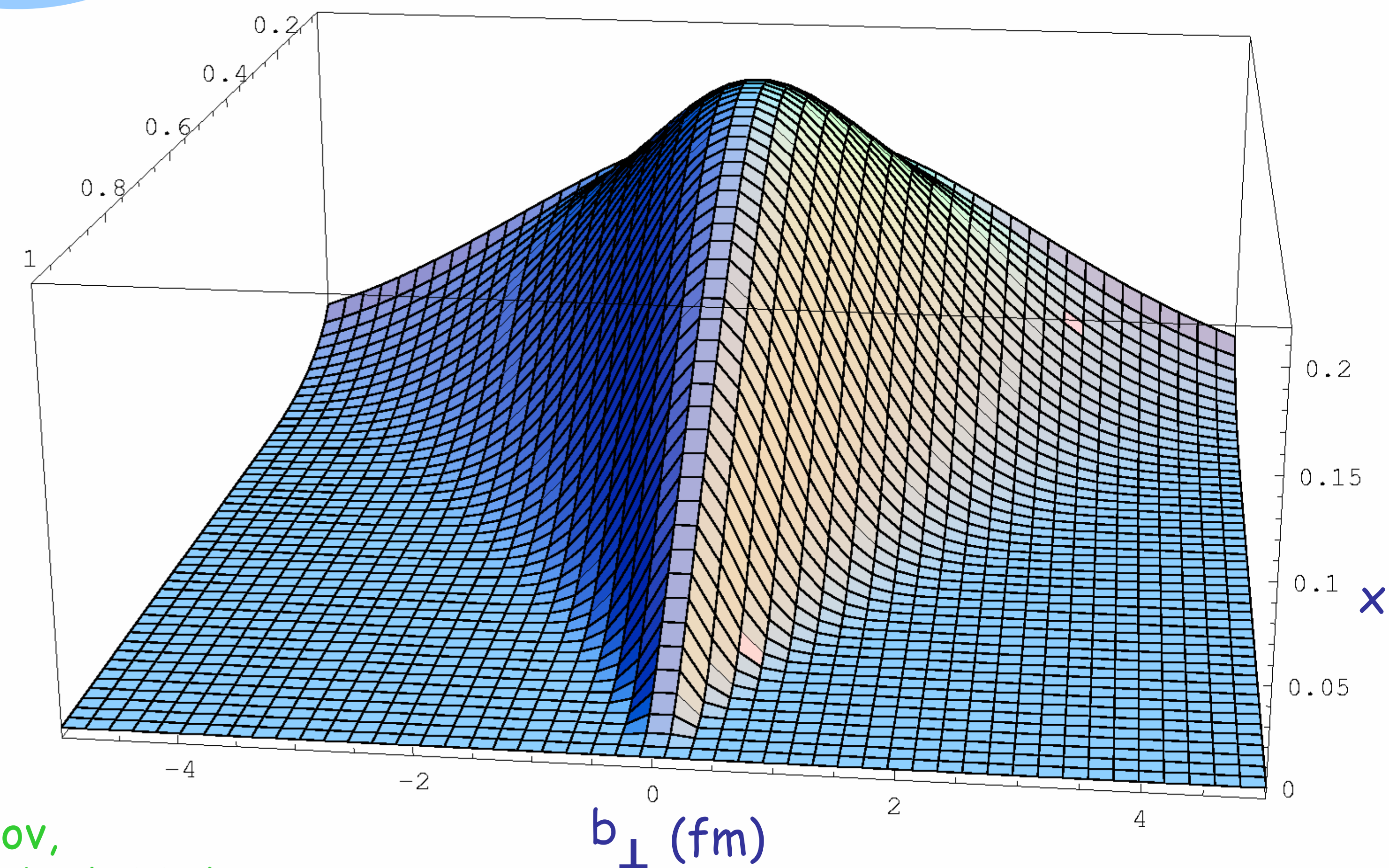
DGLAP regime

- **no correlations,**
- **diagonal configuration,**
- **probability interpretation,**
- **nucleon structure/imaging**

Image valid at $\xi=0$



$$H^u(x, \mathbf{b}_\perp)$$



Guidal, Polyakov,
Radyushkin, VdH (2005)

Do t-channel meson exchange belong to GPDs ?

Do GPD reflect nucleon structure or meson structure ?

At $\xi=0$,

DGLAP regime

- **no correlations,**
- **diagonal configuration,**
- **probability interpretation,**
- **nucleon structure/imaging**

At $\xi\neq0$,

ERBL regime

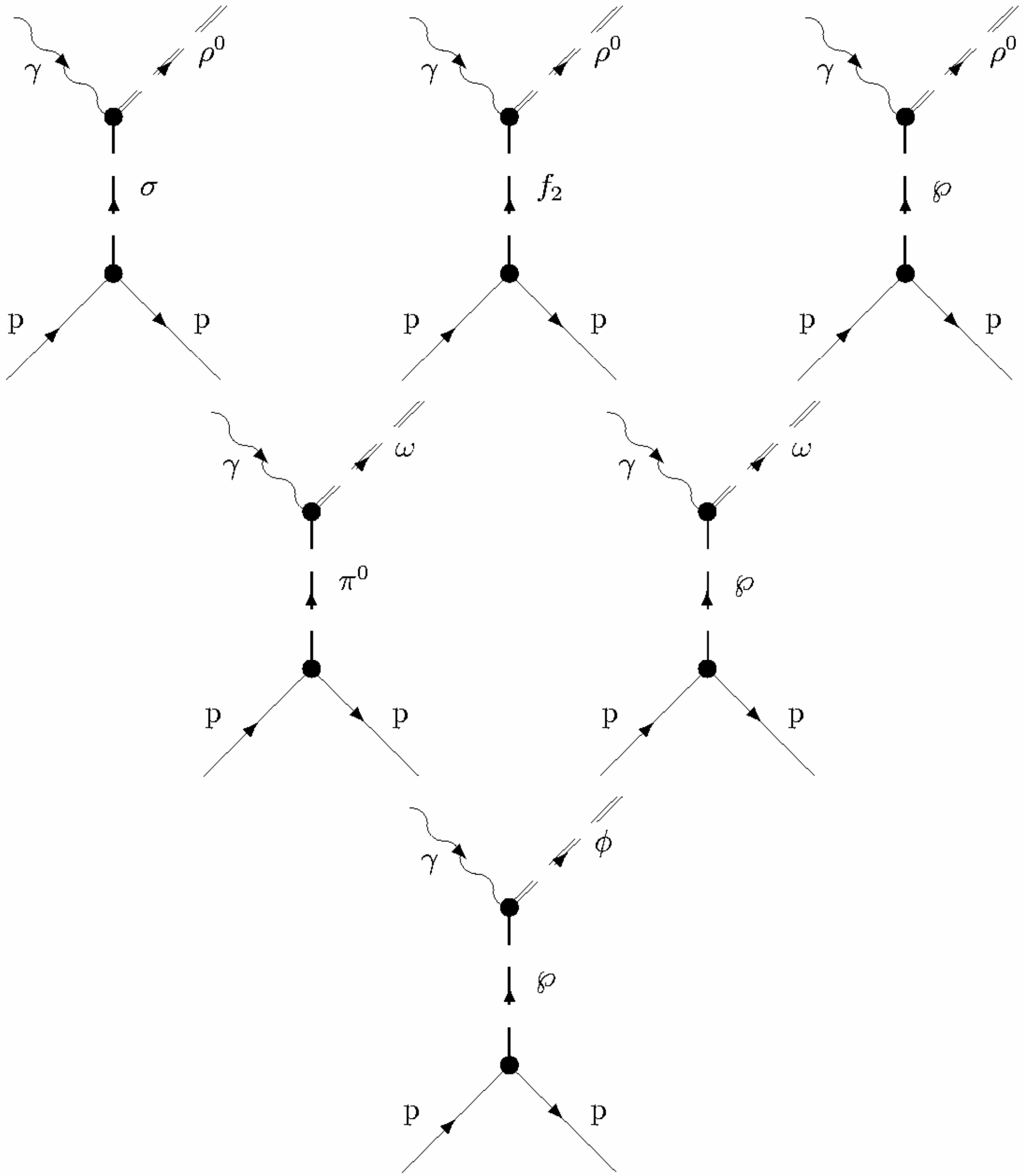
- **correlations,**
- **non-diagonal configuration,**
- **no probablity interpretation,**
- **nucleon interaction potential**

Interpretation "a la Regge" : Laget model

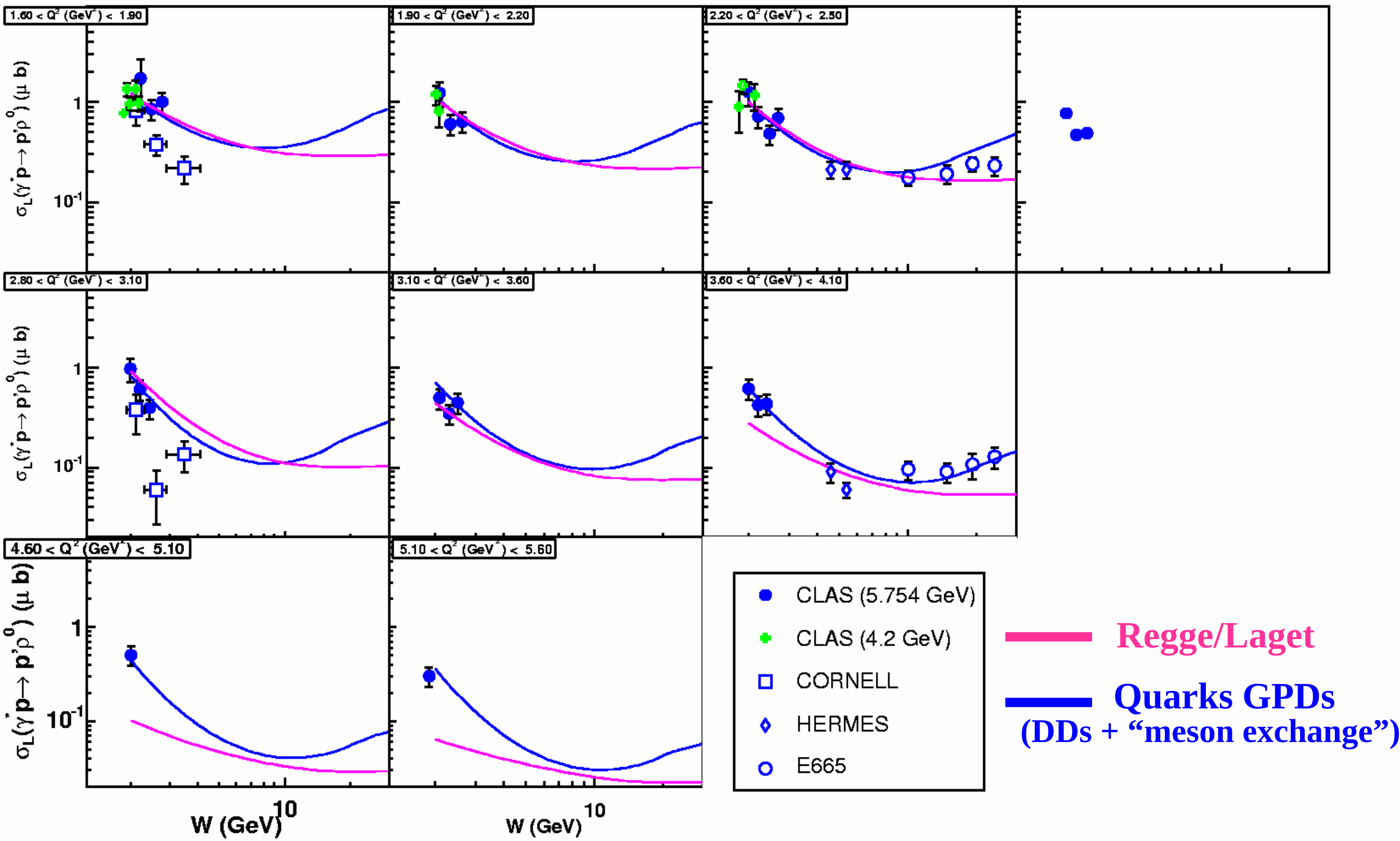
$\gamma^{*}p \rightarrow p\rho^{0}$

$\gamma^{*}p \rightarrow p\omega$

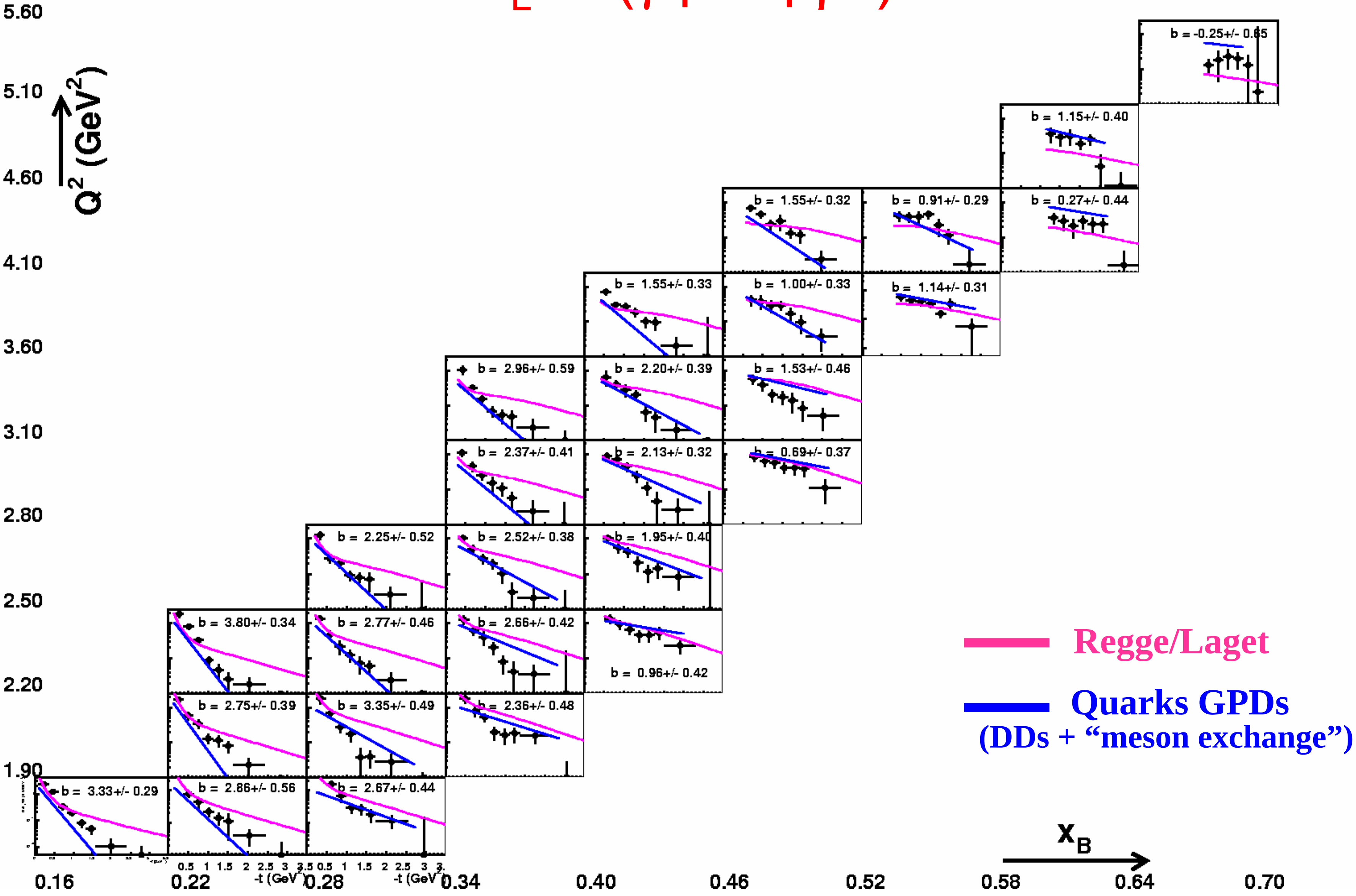
$\gamma^{*}p \rightarrow p\phi$



$\sigma_L\ (\gamma^*_L p \rightarrow p\rho_L^0)$



$d\sigma_L/dt\ (\gamma^* p \rightarrow p\rho^0)$



Summary

- ***Largest set ever of data for VM (ρ^0,ω,ϕ) production in the valence region ($\sigma_{L,T}$, $d\sigma/dt$,…)***

- ***Out of ERBL region (W>5 GeV), decent agreement with data which thus seem to be interpretable in terms of (k_{perp} modified) LO handbag diagram and GPDs***

- ***In ERBL region, either :***

  ⇨ ***BIG part is missing in GPDs parametrization (unconstrained meson exchange contributions in $-\xi<x<\xi$ region ?) –Hints from JLab DVCS data that something is missing in GPD parametrisation ?-***

  ⇨ ***Or, NO such important contribution and keep "standard" (DDs based) GPDs but falls into "classical" problems of onset of factorization,… (CZ vs asympt. DA, Feynman mechanism, …)***

  –Also, large tmin at large x ; important higher twists effects ?-

Cross section σ_L ($\gamma^* p \rightarrow \mathbf{p}\omega$) –Theory GPDs-

● JLab/CLAS: $\sigma_T+\varepsilon\sigma_L$ (μb), -2.7 GeV^2 < t < t_0

Calcul VGG: $\varepsilon\sigma_L$, $t(10^o) < t < t_0$