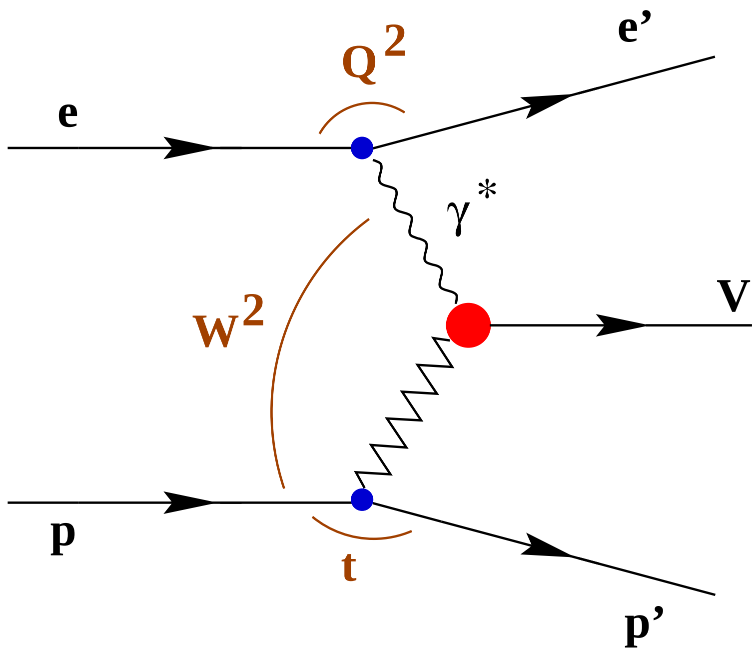
Spin-Density Matrix Elements in Exclusive VM-production at

hermes



$$\boxed{e + p \to e + p + VM}$$

- No hard scale (low Q^2, low mass VM (ρ^0, ω, ϕ))

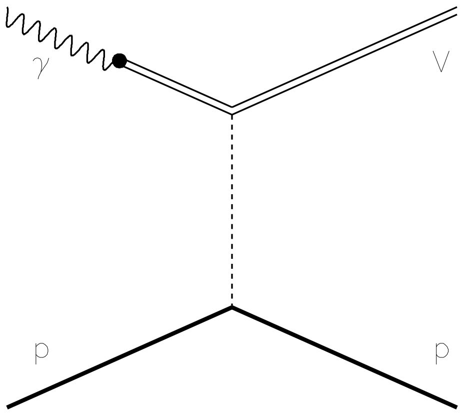
Soft process: VDM, Regge phenomenology

- Hard scale

pQCD description

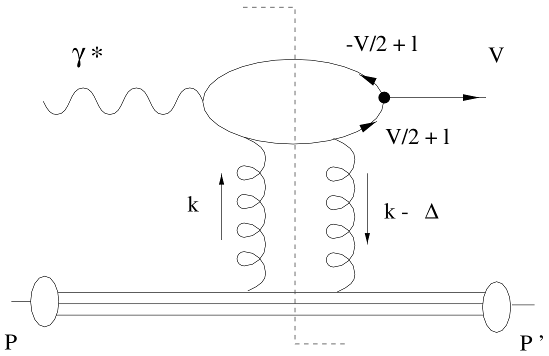
VM-production

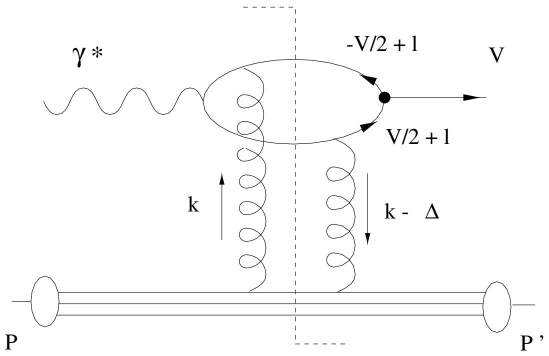
Low Q^2, low mass VM (ρ^0, ω, ϕ)
$\longrightarrow$ soft diffractive process (VDM, Regge phenomenology)



- e^{bt}
- weak W-dependence
- SCHC
- High W: Pomeron

Hard scale ($Q^2 > 1$, J/Ψ-production)
$\longrightarrow$ pQCD: Off-Forward Parton Distributions





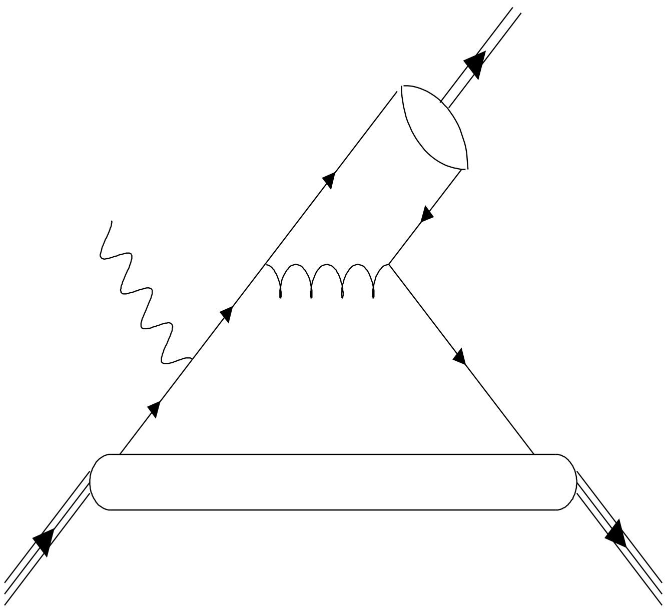
High W: 2-gluon exchange

OFPD

Off-Forward Parton Distributions aka Skewed Parton Distributions (SPD's)

- Generalization of standard PDF
- Appear in description of exclusive reactions

Low $W \Rightarrow$ high x_B: quark distributions



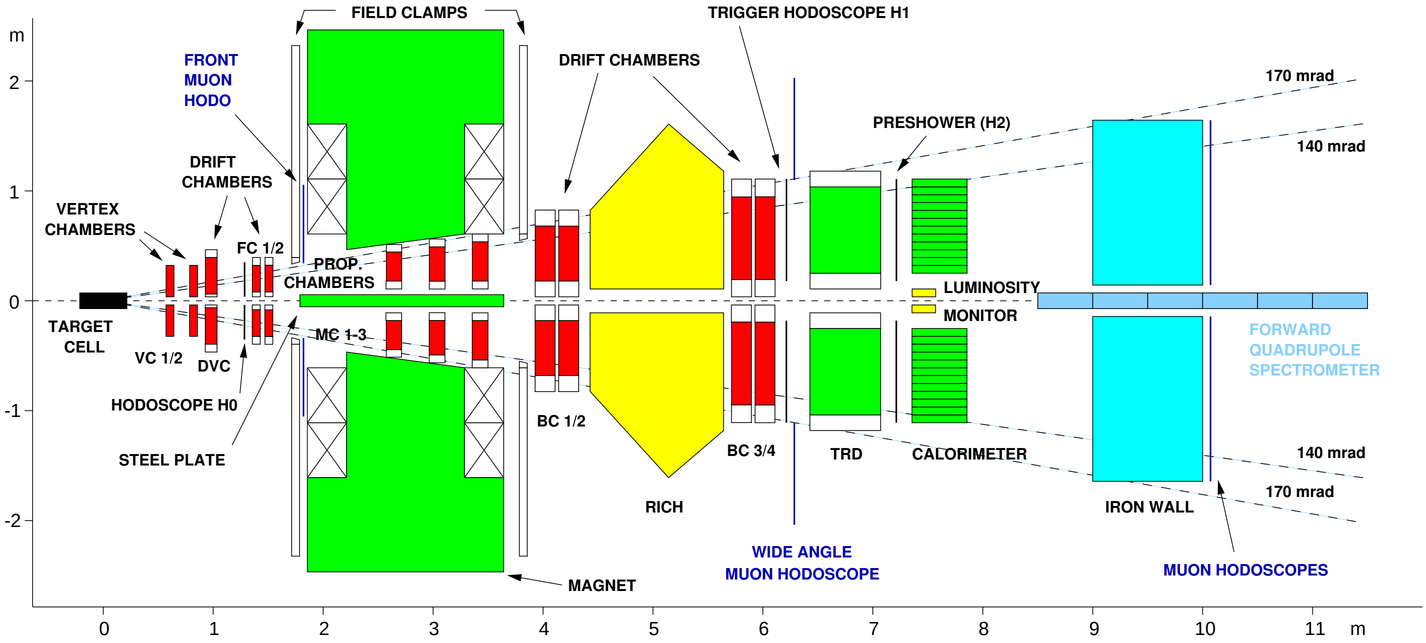
pQCD:

- Smaller b
- Helicity flip amplitudes
- Ratio of VM production cross sections $\rho^0 : \omega : \phi : J/\Psi$

HERMES

Fixed-target experiment at HERA-e ring

27.6 GeV longitudinally polarized e on ^{1}H



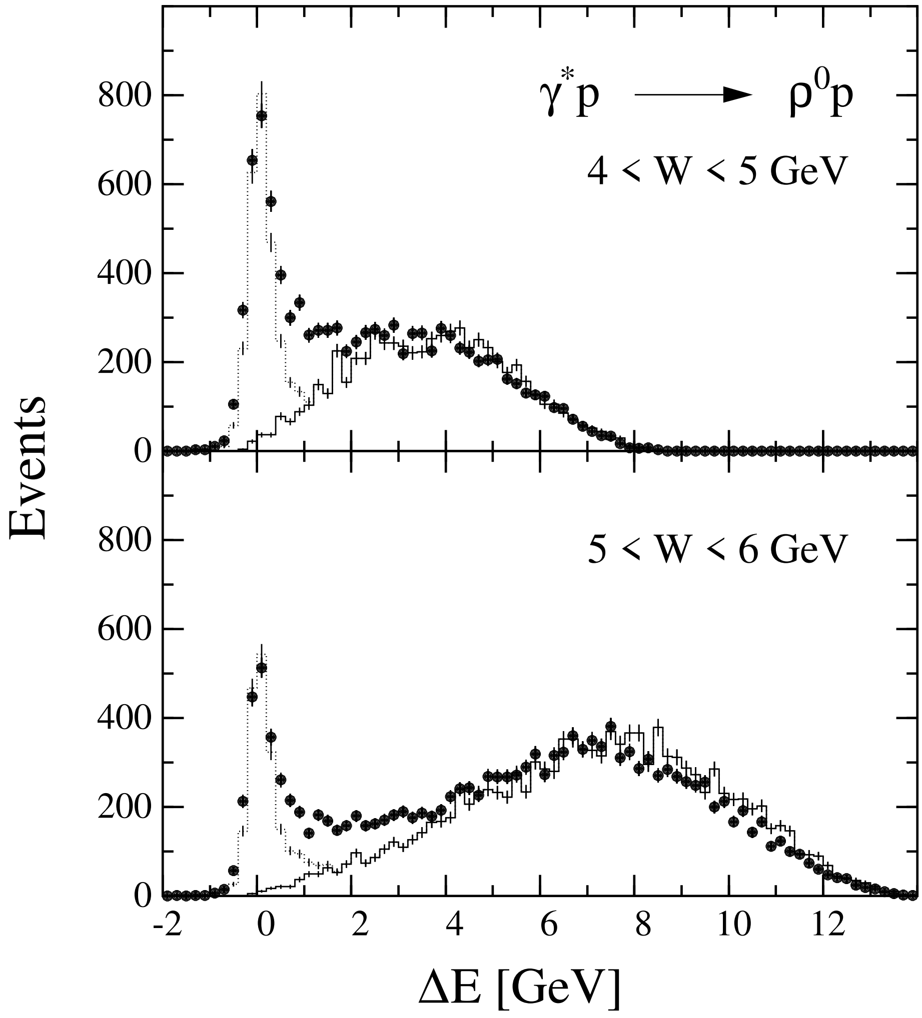
Detect:

•$\pi^+\pi^-$	ρ^0
•K^+K^-	ϕ
•$\pi^+\pi^-\pi^0$	ω
•l^+l^-	J/Ψ

$3.8 < W < 6.5$ GeV
$0.5 < Q^2 < 5$ GeV^2

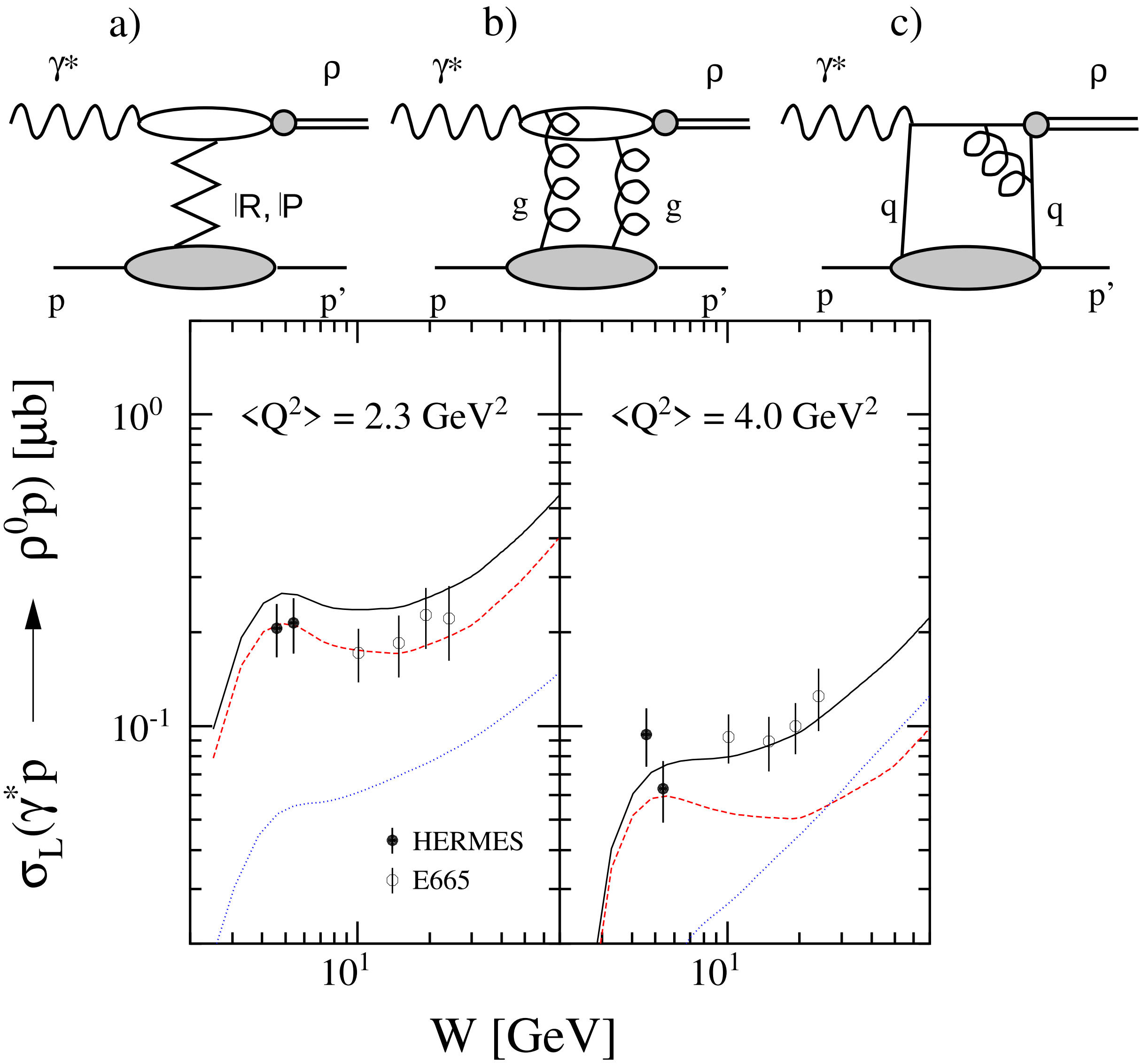
VM-production

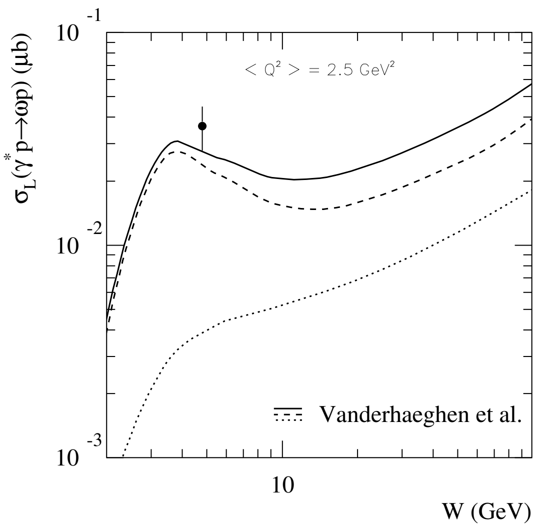
Exclusivity:



$\Rightarrow$ Good determination of exclusive channel
$\rightarrow$ DIS-"background" well described by Monte Carlo
$\rightarrow$ somewhat worse for ω and ϕ

VM-production





b) 2-gluon exchange: dots

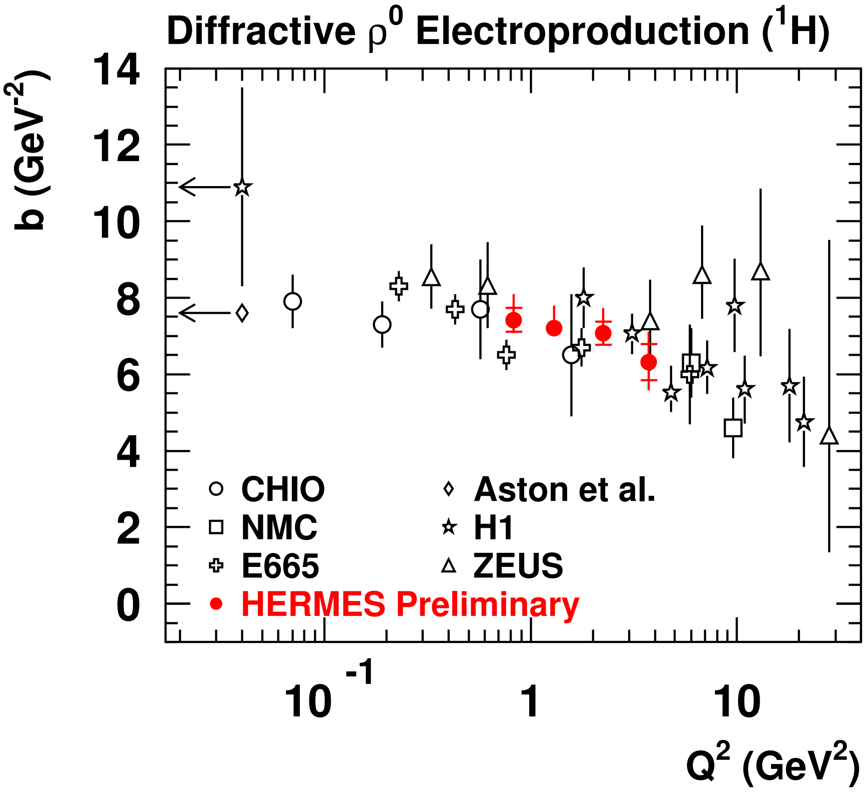
c) quark-exchange: dashes

Vanderhaeghen et al PRD60(1999)094017

t-dependence

Exponential decrease e^{bt}

ZEUS/H1: Photoproduction ρ^0: b increases with W
Electroproduction ρ^0: b decreases with Q^2



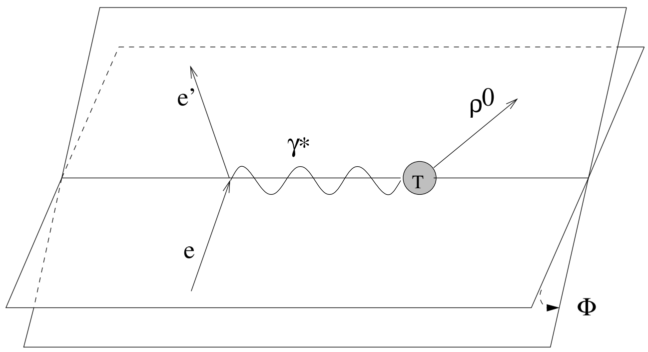
Q^2-dependence confirmed
W-dependence?

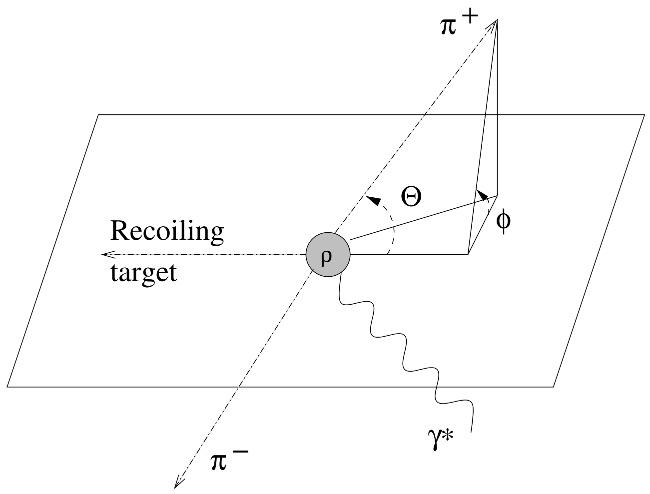
ρ^0	$7.08 \pm 0.14\ ^{+0.58}_{-0.08}$ GeV^{-2}
ω	$7.34 \pm 0.67\ ^{+1.59}_{-0.64}$ GeV^{-2}

SDME's

spin-density matrix elements

γ-helicity $\leftarrow$ meson-helicity $\leftarrow$ ang.dist. decay-mesons





- Helicity amplitudes: $T_{\lambda_V \lambda_{N'} \lambda_\gamma \lambda_N}$

$$\rho^{\alpha}_{\lambda_V \lambda'_V} \propto \sum_{\lambda_{N'}, \lambda_N, \lambda_\gamma, \lambda'_\gamma} T_{\lambda_V \lambda_{N'} \lambda_\gamma \lambda_N} \Sigma^{\alpha}_{\lambda_\gamma \lambda'_\gamma} T^{*}_{\lambda'_V \lambda_{N'} \lambda'_\gamma \lambda_N}$$

- 26 independent ρ SDME's
- No L/T separation: $\Rightarrow$ 23 independent r SDME's
- $W(\cos\theta, \phi, \Phi) = f(r^{\alpha}_{ij})$

SCHC

s-channel helicity conservation:
helicity of photon $\rightarrow$ helicity of meson

Parity conservation:
$T_{-\lambda_V - \lambda_{N'} - \lambda_\gamma - \lambda_N} = (-1)^{(\lambda_V - \lambda_{N'}) - (\lambda_\gamma - \lambda_N)} T_{\lambda_V \lambda_{N'} \lambda_\gamma \lambda_N}$

Natural Parity Exchange:
$T_{-\lambda_V \lambda_{N'} - \lambda_\gamma \lambda_N} = \pm(-1)^{(\lambda_V - \lambda_\gamma)} T_{\lambda_V \lambda_{N'} \lambda_\gamma \lambda_N}$

$$\boxed{T_{00}, T_{11}, T_{01}, T_{10}, T_{1-1}}$$

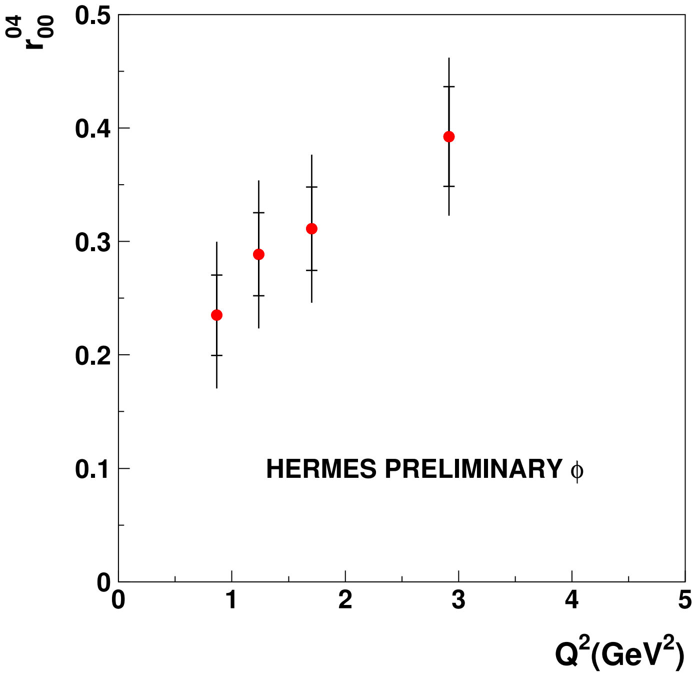
SCHC:
$T_{01} = T_{10} = T_{1-1} = 0$

$\Rightarrow$ most $r^\alpha_{ij} = 0$, e.g. r^5_{00}

$$\Rightarrow R = \frac{\sigma_L}{\sigma_T} = \frac{|\ T_{00}\ |^2}{|\ T_{11}\ |^2}$$

SDME's for ϕ

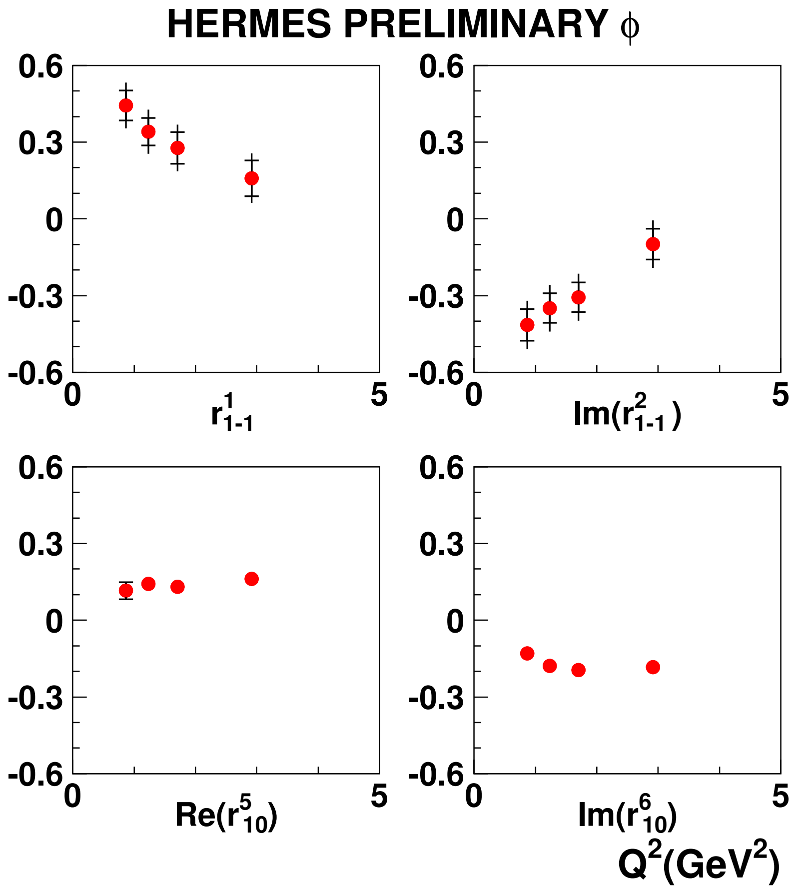
Longitudinal polarization of ϕ



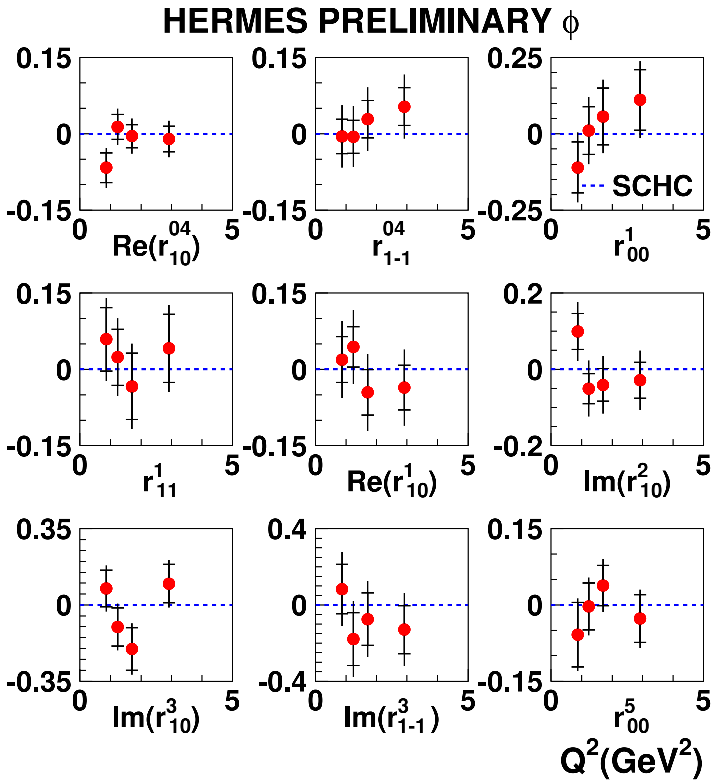
SCHC:

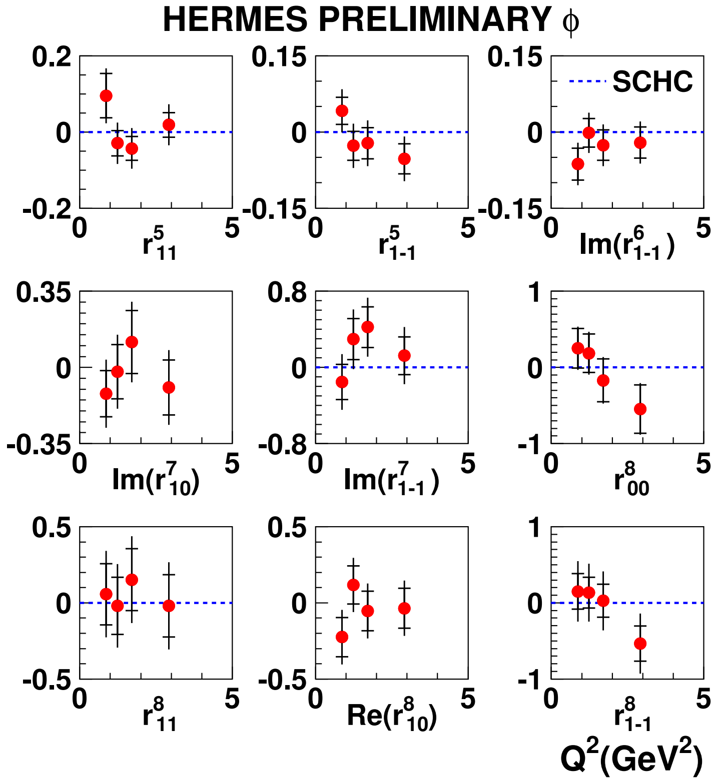
$r^1_{1-1} = -\mathrm{Im}(r^2_{1-1})$

$\mathrm{Re}(r^5_{10}) = -\mathrm{Im}(r^6_{10})$



SDME's for ϕ

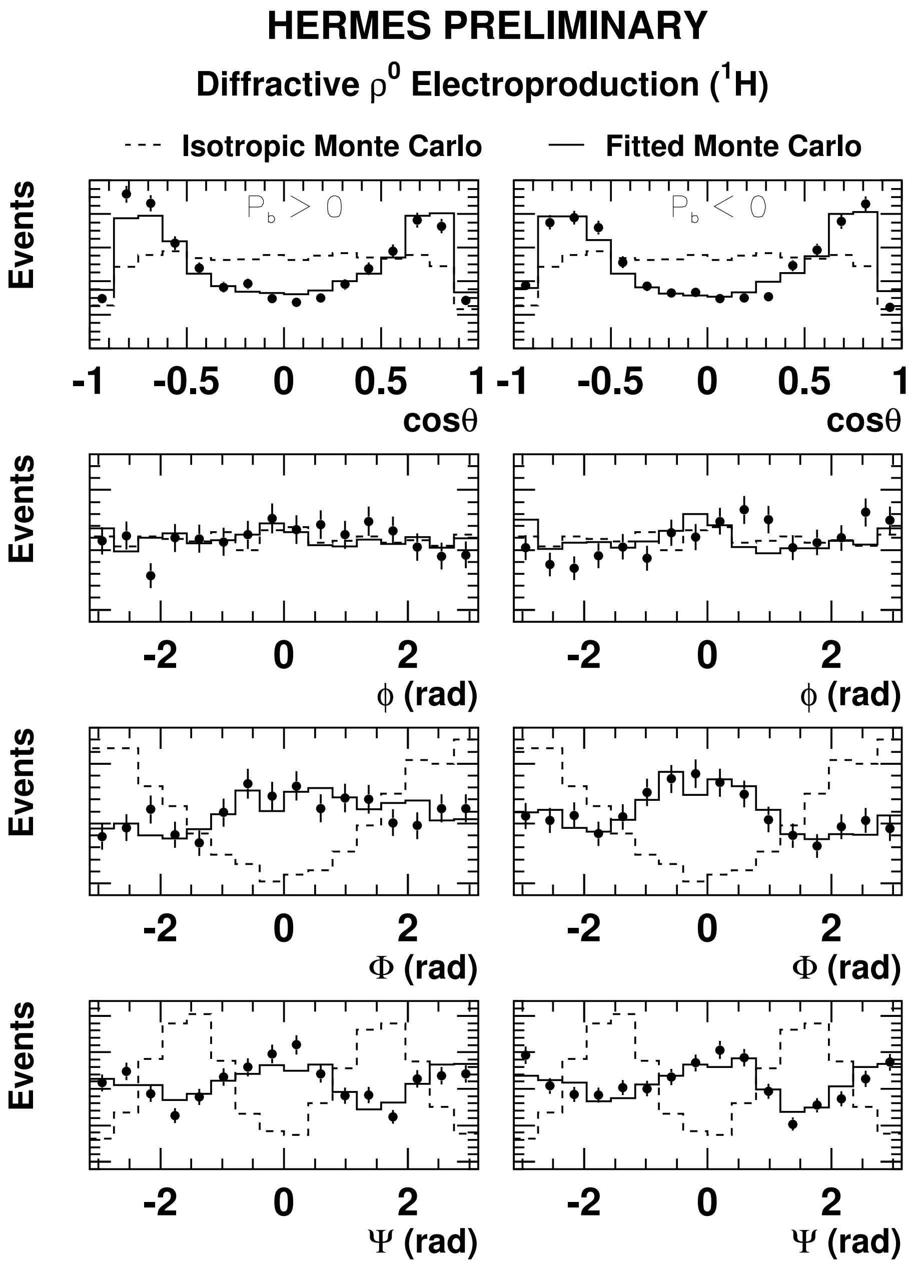




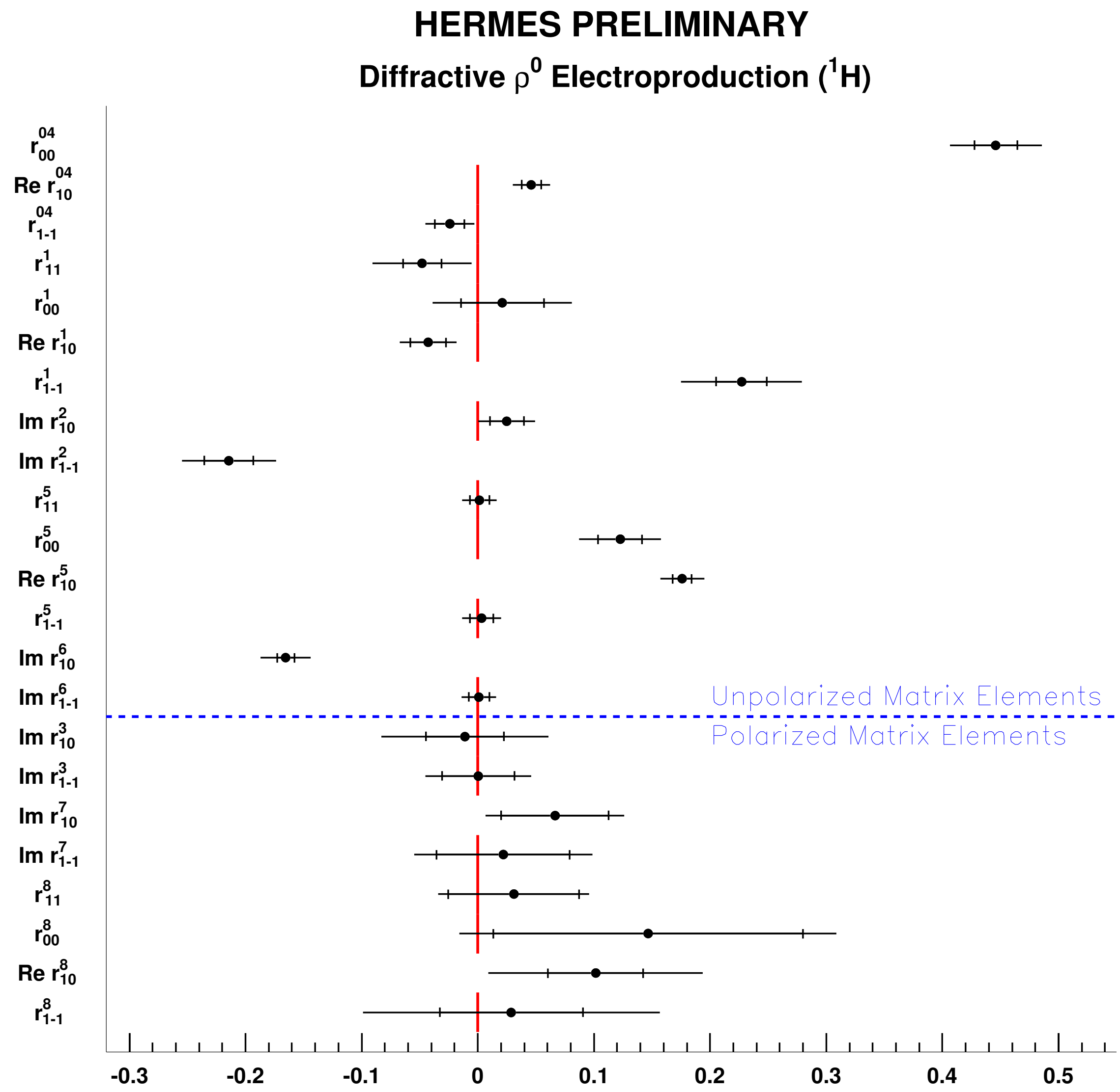
Compatible with SCHC

SDME's for ρ^0

Much higher statistics
Maximum Likelihood fit to 3-dimensional decay angular distributions



SDME's for ρ^0

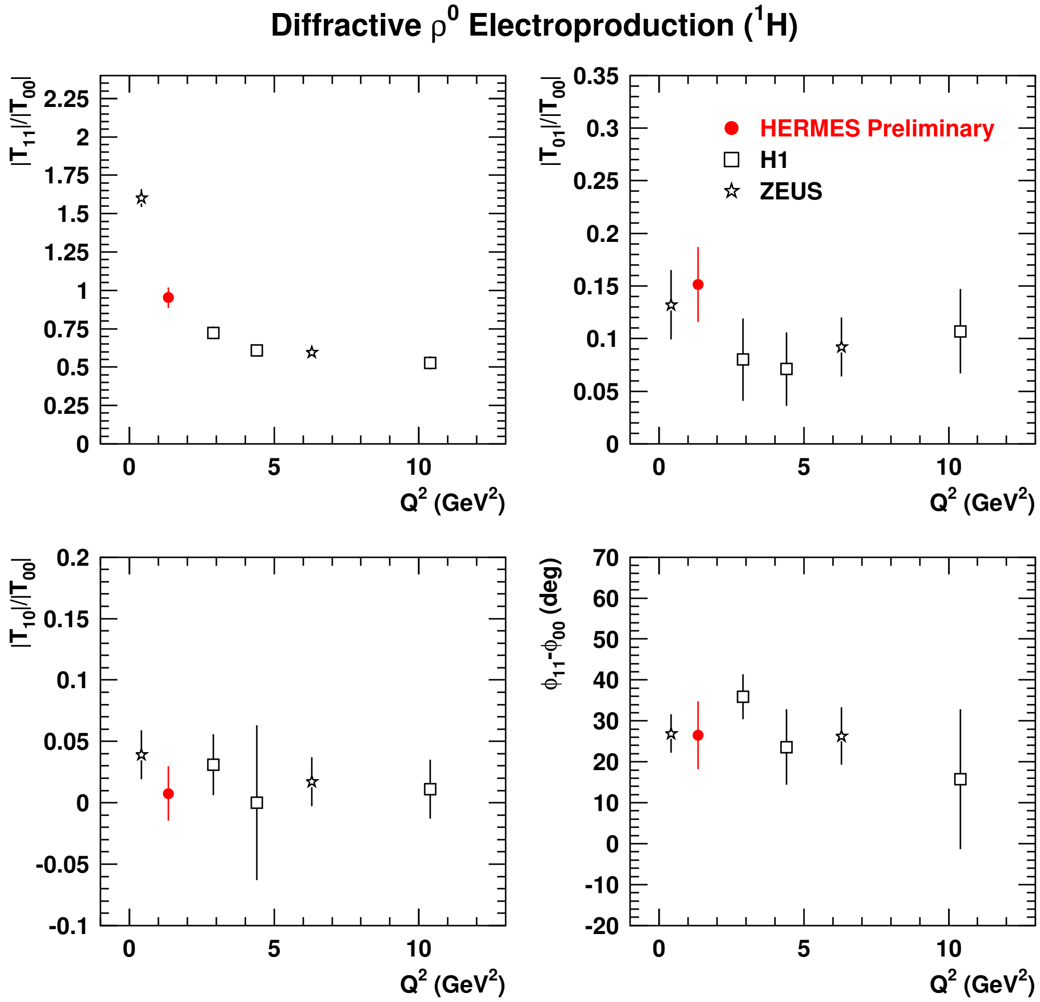


$\Rightarrow$ r^5_{00} significantly different from 0

$\Rightarrow$ Violation of SCHC

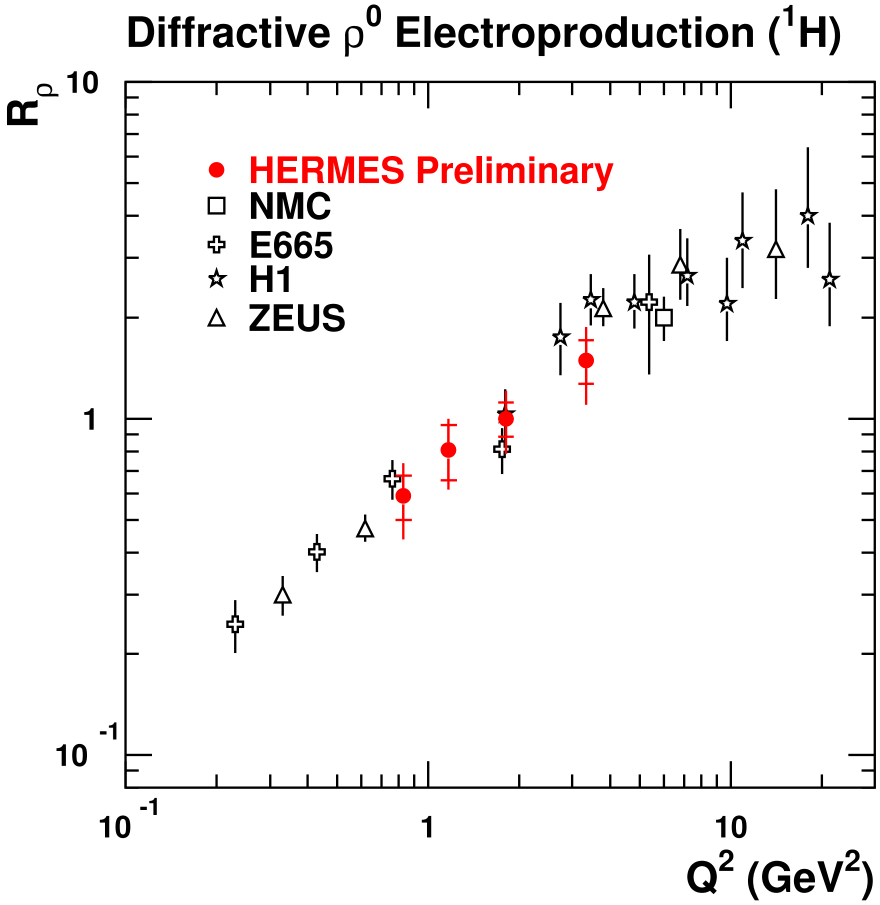
Helicity Amplitudes

assume Natural Parity Exchange



- Transverse $\rightarrow$ Longitudinal
- Clear evidence for helicity-flip T_{01}
- T_{10}, T_{1-1} compatible with 0
- No evidence for W-dependence

Longitudinal/Transverse



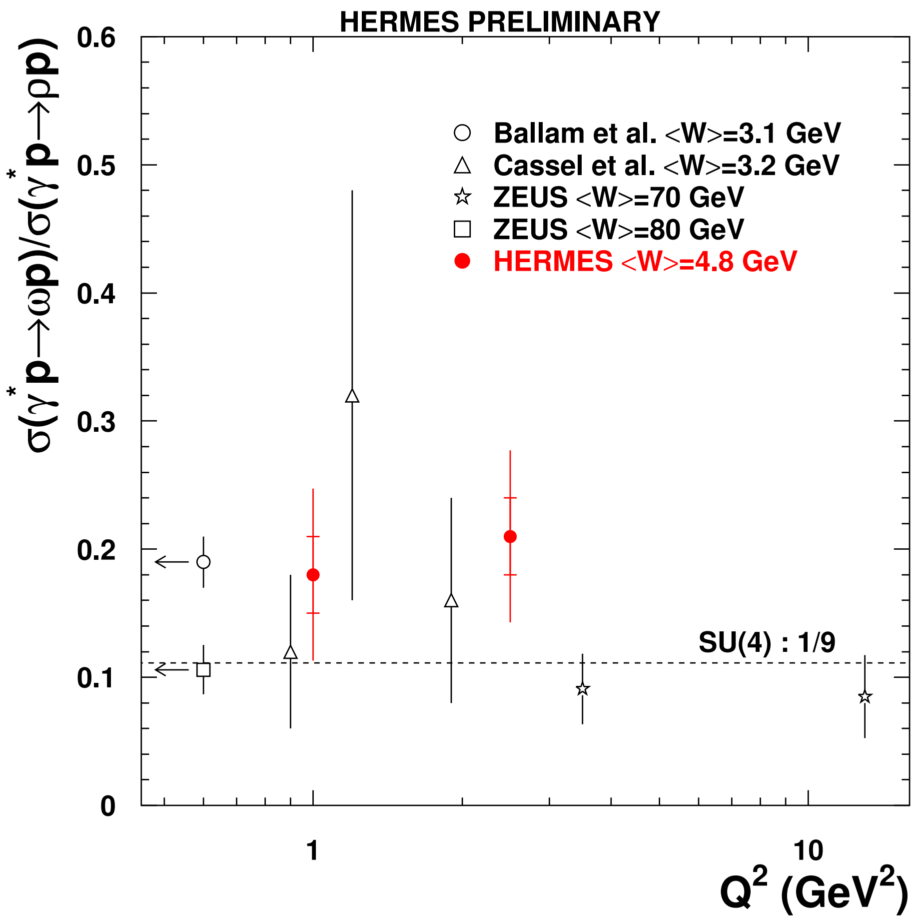
Effect of SCHC-assumption: $< 10\%$

Used to determine σ_L

Cross section ratios

Asymptotic: SU(4) pQCD prediction:

$$\rho^0 : \omega : \phi : J/\Psi = 9 : 1 : 2 : 8$$

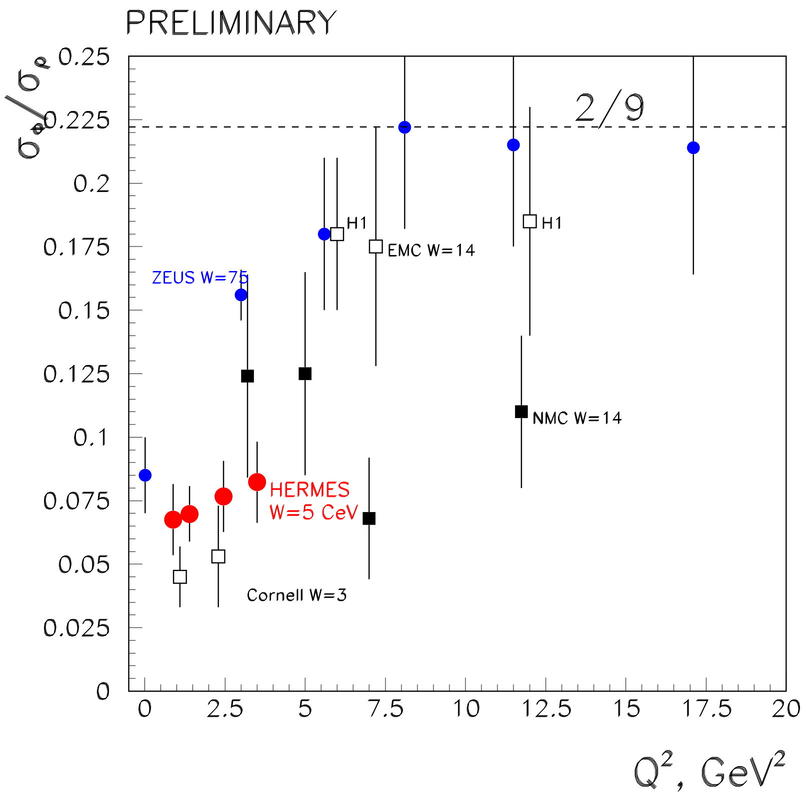


No indication of Q^2 dependence.
W-dependence?

Cross section ratios

Asymptotic: SU(4) pQCD prediction:

$$\boxed{\rho^0 : \omega : \phi : J/\Psi = 9 : 1 : 2 : 8}$$



Approaching asymptotic value at high Q^2
Slower approach at lower W

Conclusions

New results from HERMES in own kinematic domain:

- Intermediate Q^2
- Low W

Exponential t-dependence:

- decreases with Q^2
- consistent with values at higher W

SDME:

- transition T $\rightarrow$ L
- small single-flip amplitude observed

Cross section ratios:

- approach SU(4) values at high Q^2
- slower approach at low W?