Diffractive Photoproduction of J/ψ Mesons with Large Momentum Transfer

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On Behalf of the H1 Collaboration

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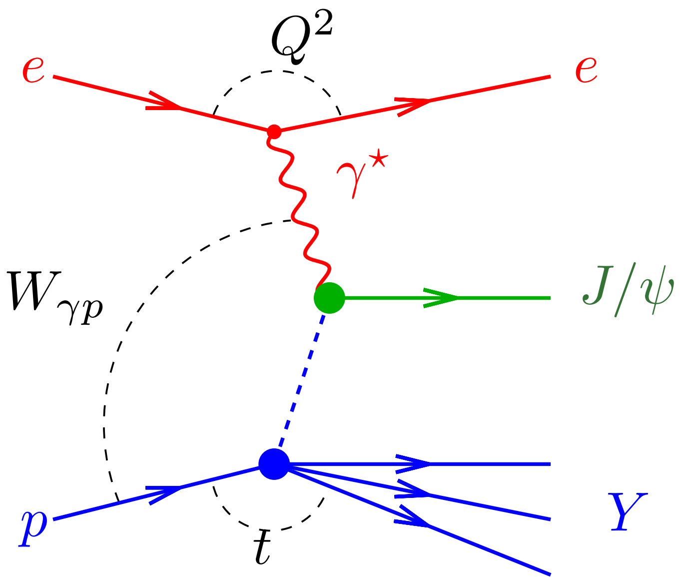
Diffractive J/ψ Production

At HERA:

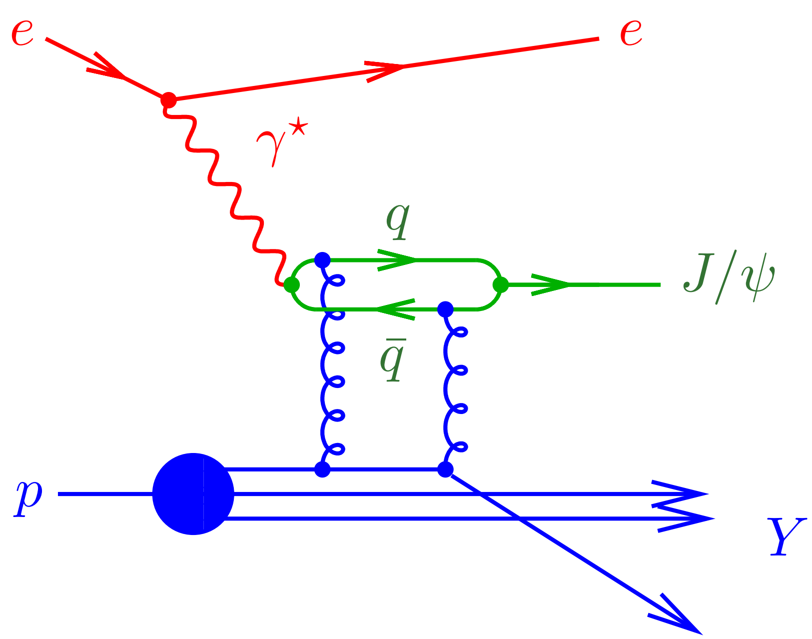
- For Large $|t|$ Proton Dissociation Dominates



Q^2	γ^* Virtuality
$W_{\gamma p}$	$\gamma^* p$ CMS Energy
$\lvert t \rvert$	(4-mtm. transfer)^2 at proton vertex

In Perturbative QCD:

- Require hard scale (Large M_V^2,$|t|$ and/or Q^2)



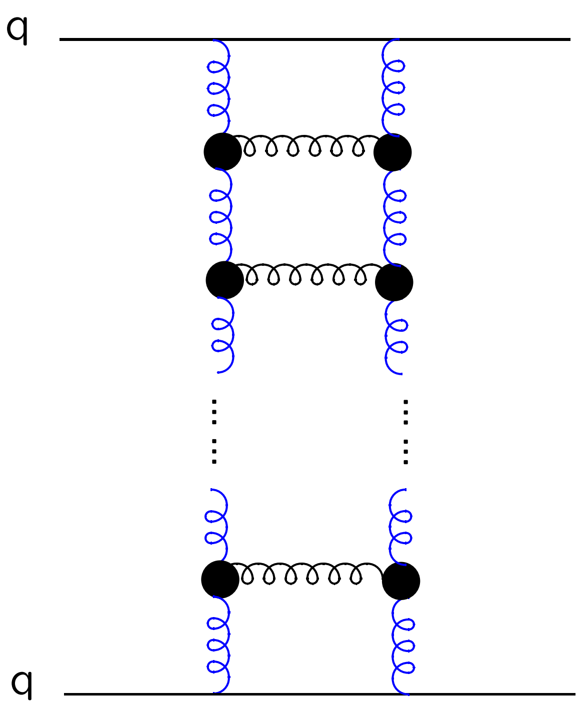
(1) Photon Fluctuates into $q\bar{q}$ Pair

(2) Lowest Order Exchange: 2 Gluons

(3) Need Meson Wavefunction to form J/ψ

pQCD Predictions For Large $|t|$

- Higher Order Exchange
- Non-Trivial Effective Gluonic Ladder (Reggeized gluon ladder)



- Leading Log Approximation

Predictions using BFKL Evolution

- Unordered momenta along gluon ladder

(1) Bartels, Forshaw, Lotter, Wüsthoff Phys. Lett. B375 (1996) 301
(2) Forshaw, Ryskin Z.Phys. C68 (1995) 137

- Number of recent extensions:

(1) **BFKL LL** (inc. higher conformal spin)
(2) **BFKL LL + NL** (estimate of Non-Leading corrections)
(3) **BFKL LL + NL + running α_s**

Enberg, Motyka, Poludniowski [hep-ph/0207027]

Predictions using DGLAP Evolution

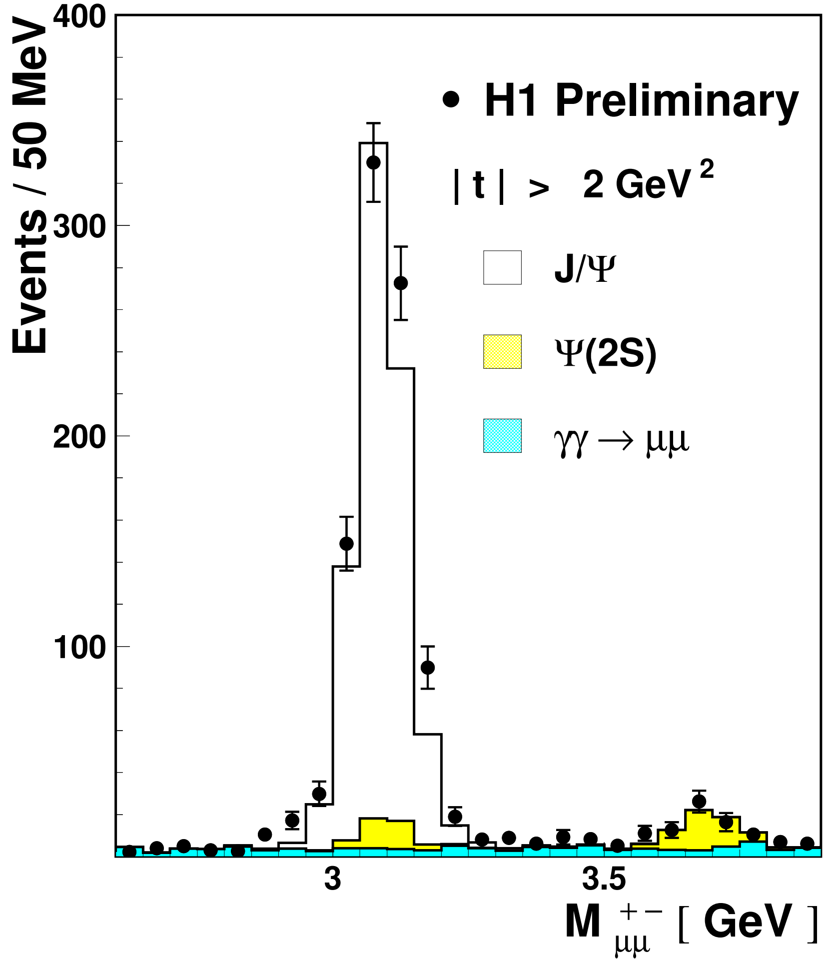
- Ordered momenta along gluon ladder

(1) **DGLAP LL** applicable for $|t| < M^2_{J/\psi}$

Gotsman, Levin, Maor, Naftali Phys. Lett. B352 (2002) 37

Event Selection:
HERA I Event Sample

H1 Detector : Integrated luminosity 78 pb^{-1}



H1 Preliminary Result:

$J/\psi \to \mu^+\mu^-$

$\sim 0 < Q^2 < 1\,\mathrm{GeV}^2$

$50 < W_{\gamma p} < 150\,\mathrm{GeV}$

$2 < |t| \simeq |p^2_{t,J/\psi}| < 30\,\mathrm{GeV}^2$

$$z = \frac{p{\cdot}p_{J/\psi}}{p.q} > 0.95$$

- Signal sample ~ 850 J/ψ events
- Signal MC uses BFKL LL model

- Non-resonant background at large $|t|$ is small
- Contribution from $\psi(2S)$

Differential Cross Section in $|t|$

- Dependence at large $|t|$: $\propto (-t)^{-n}$

  $\Rightarrow n = 3.00 \pm 0.08(stat.) \pm 0.05(syst.)$

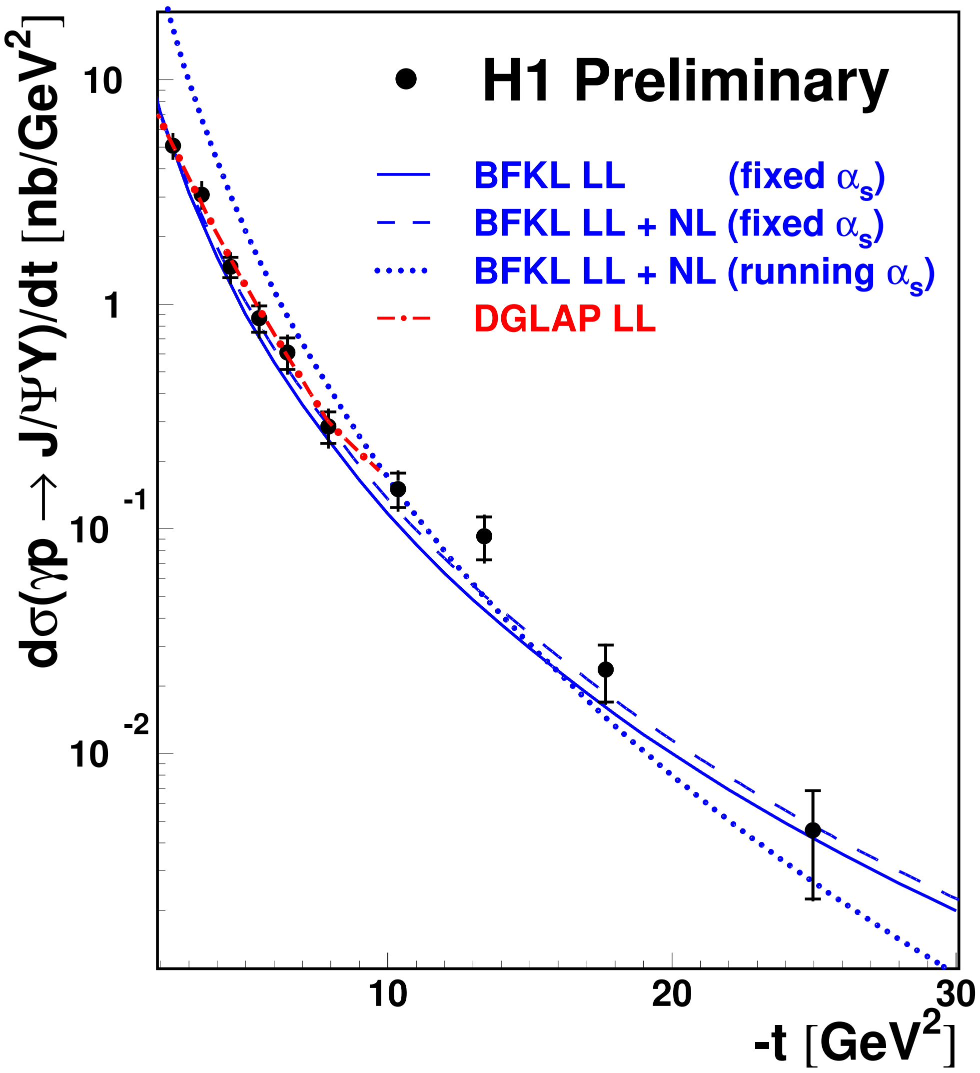
  for $|t| > 3.5\ \mathrm{GeV}^2$
- Increase $|t| \Rightarrow$ sys. increase in n
- $n \simeq 3$ similar to ρ,ϕ (ZEUS)

- BFKL LL and BFKL LL + NL (fixed α_s)

  $\Rightarrow$ both describe data
- Prescription for running α_s

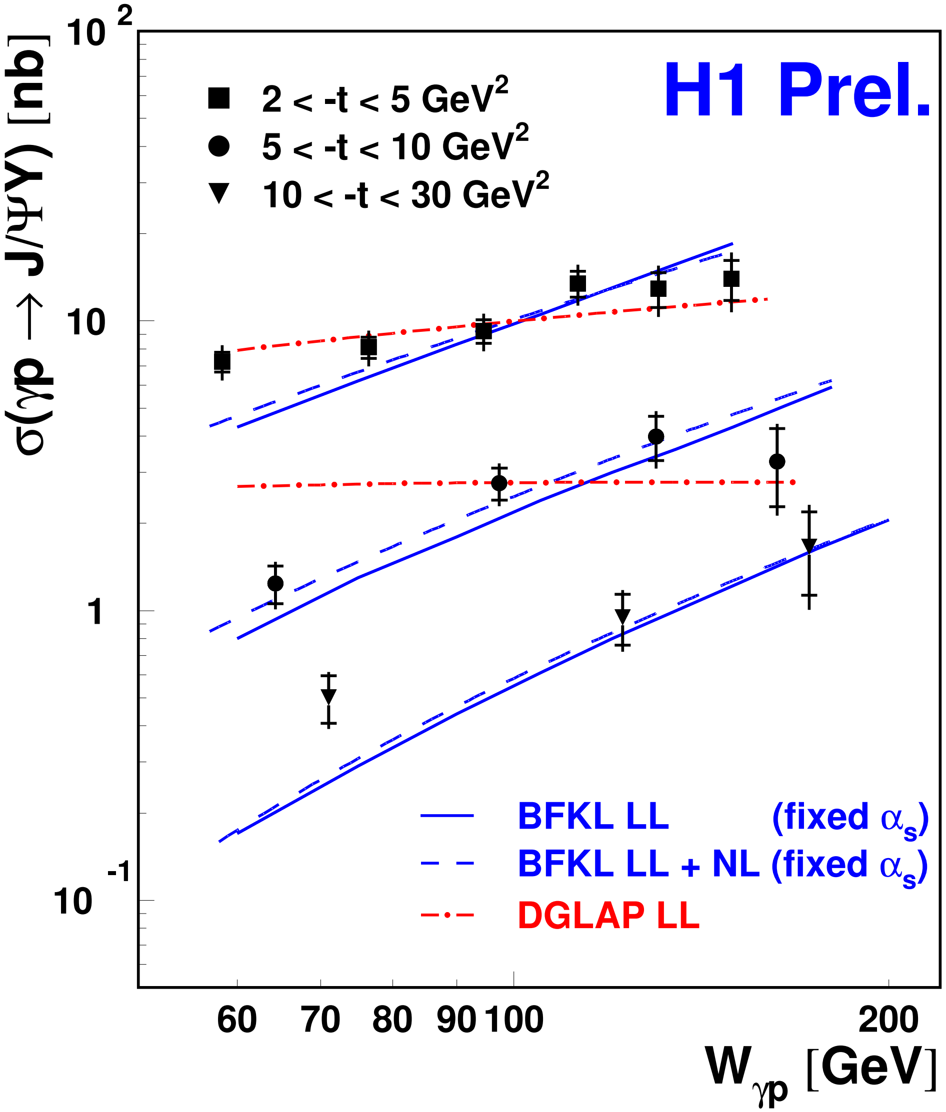
  $\Rightarrow$ steeper t-dependence
- DGLAP LL in range of model ($|t| \leq 10$ GeV^2)

  $\Rightarrow$ describes data



Extension of t range, since DIS 2001

Total Cross Section in $W_{\gamma p}$



$\delta = 0.770$
$\pm$ 0.139 (stat.)
$\pm$ 0.101 (sys.)

$\delta = 1.29$
$\pm$ 0.23 (stat.)
$\pm$ 0.16 (sys.)

$\delta = 1.30$
$\pm$ 0.39 (stat.)
$\pm$ 0.36 (sys.)

Extension of $W_{\gamma p}$ range with increasing $|t|$

- Fit form $\sigma \propto W_{\gamma p}^{\delta}$, $\delta = 4\alpha(t) - 4$

  $\Rightarrow$ Similar rise ($\delta \sim 1$) as elastic J/ψ

- Effective trajectory $\alpha_{IP} = \alpha(0) + \alpha' t$

  $\alpha' = -0.013 \pm 0.007_{stat.} \pm 0.007_{sys.}$

  $\alpha(0) = 1.17 \pm 0.05_{stat.} \pm 0.04_{sys.}$

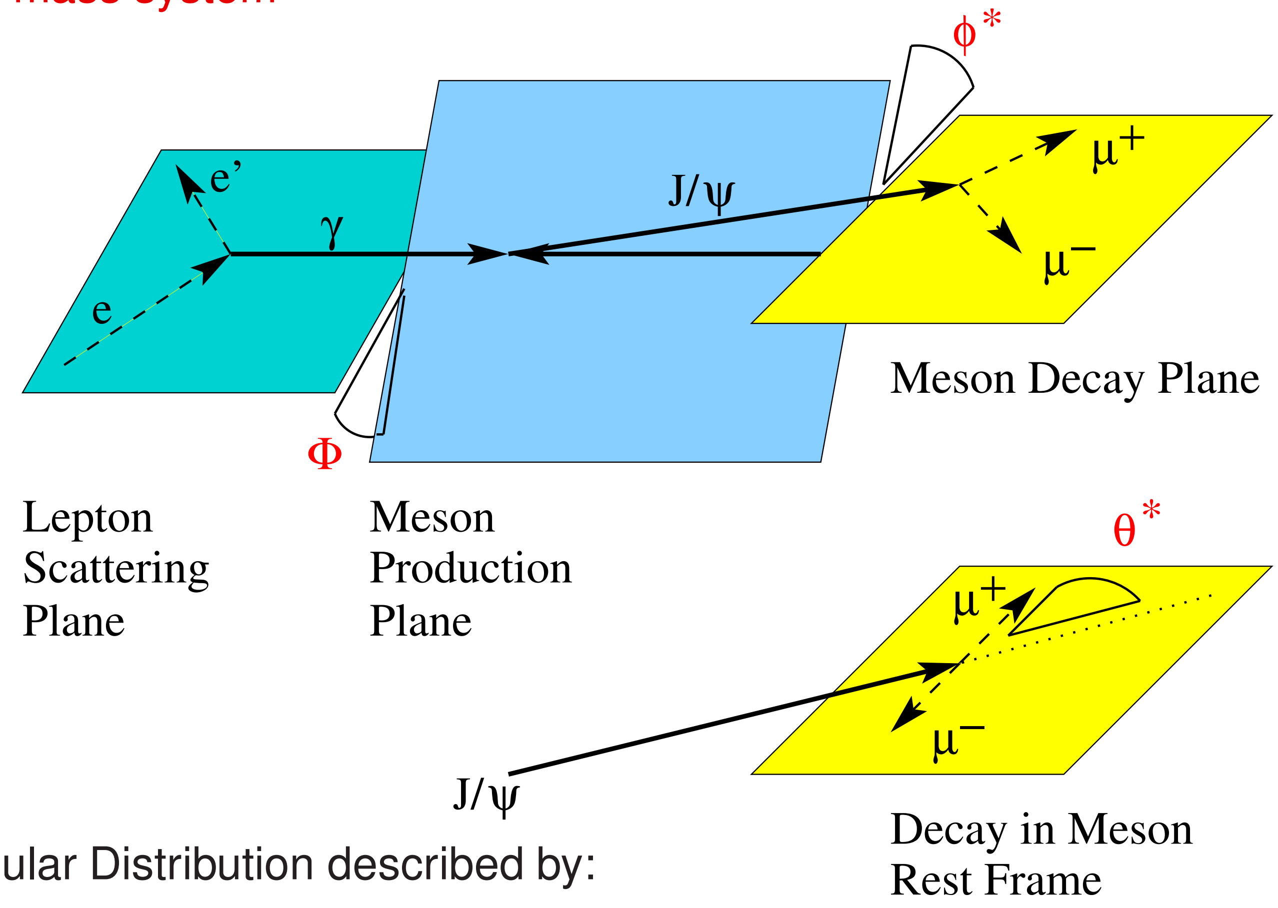
- BFKL LL and BFKL LL + NL (fixed α_s)
  $\Rightarrow$ reasonable description of data

- Inputs from simultaneous fit to ρ, ϕ, J/ψ data at lower $|t|$ (ZEUS)

- DGLAP LL:
  $2 < |t| < 5$ GeV^2: good description
  $5 < |t| < 10$ GeV^2: flatter dependence

Spin Density Matrix Elements

- Boost into γp centre of mass system

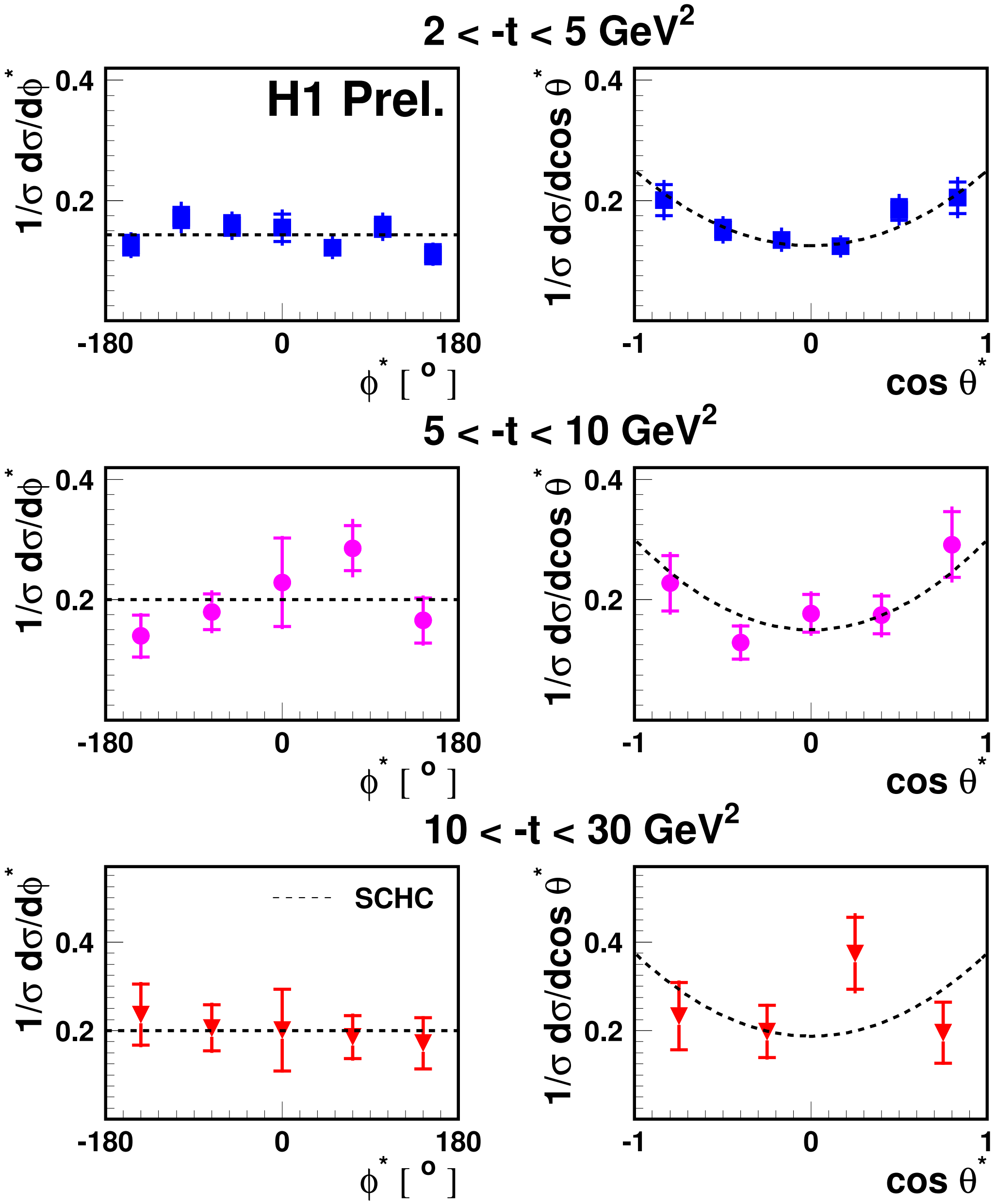


In Photoproduction:

- Normalised Decay Angular Distribution described by:
  - 2 Angles ϕ^* and θ^*
  - 3 Linear combinations of Spin Density Matrix Elements (SDMEs)
- s-channel helicity conservation (SCHC): J/ψ retains helicity of incident photon

$$\Rightarrow r_{00}^{04} = r_{1-1}^{04} = \mathrm{Re}\{r_{10}^{04}\} = 0$$

J/ψ Decay Angular Distributions



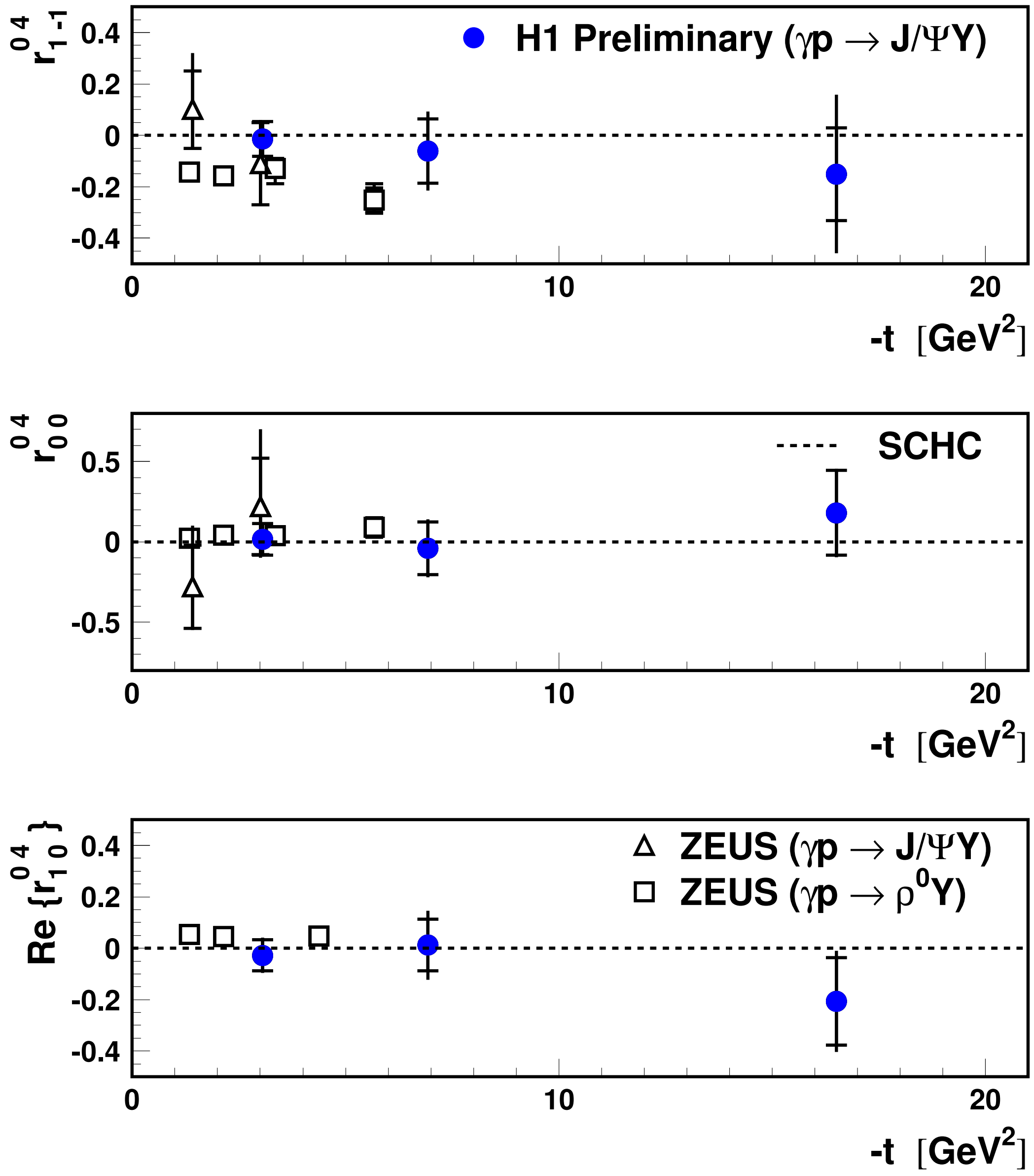
- Normalised 1D distributions measured in ϕ^* and $\cos\theta^*$ (three $|t|$ regions)
- In SCHC expect:
  Constant ϕ^* dependence
  Dependence in $\cos\theta^*$:
  $$\propto 1 + \cos^2\theta^*$$
- SCHC reasonable description of data

J/ψ SDMEs vs. t

● 2D fit used to extract SDMEs simultaneously

● Measured J/ψ SDMEs consistent with zero

$\Rightarrow$ Consistent with s-channel helicity conservation



Conclusions

- H1 Diffractive J/ψ measurement extended to much larger $|t| = 30\ \mathrm{GeV}^2$
- Dependence in $W_{\gamma p}$ now measured in three $|t|$ regions
- Total cross section in $W_{\gamma p}$:
  - Similar rise compared to elastic J/ψ (low $|t|$)
  - Smaller α'_{IP} than elastic J/ψ (low $|t|$)
- Spin Density Matrix Elements for J/ψ now extracted in three $|t|$ regions:
  - SCHC expectation consistent with data
- DGLAP LL model is:
  - Describing $|t|$ dependence for $|t| < 10\ \mathrm{GeV}^2$
  - Describing $W_{\gamma p}$ dependence : $2 < |t| < 5$ GeV^2
- BFKL LL and BFKL LL + NL (fixed α_s) models are both able to...
  - Describe $|t|$ dependence
  - Describe $W_{\gamma p}$ dependence

... over full $|t|$ range.