Recent results on diffractive and forward physics at HERA

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on behalf of the H1 and ZEUS Collaborations

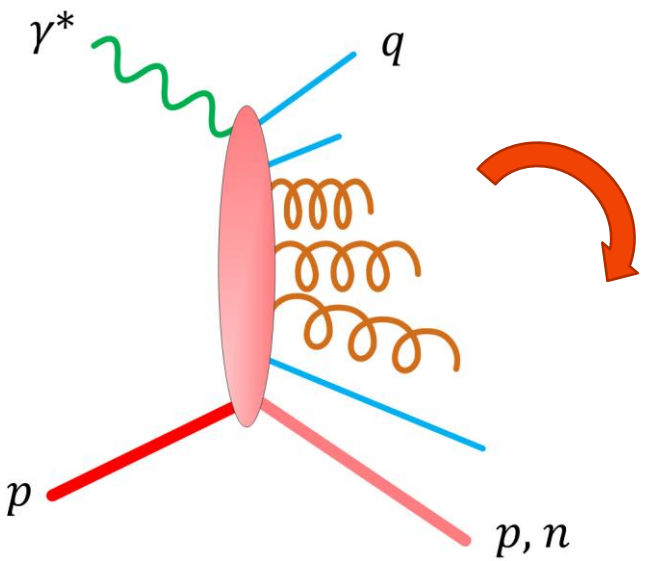
Outline

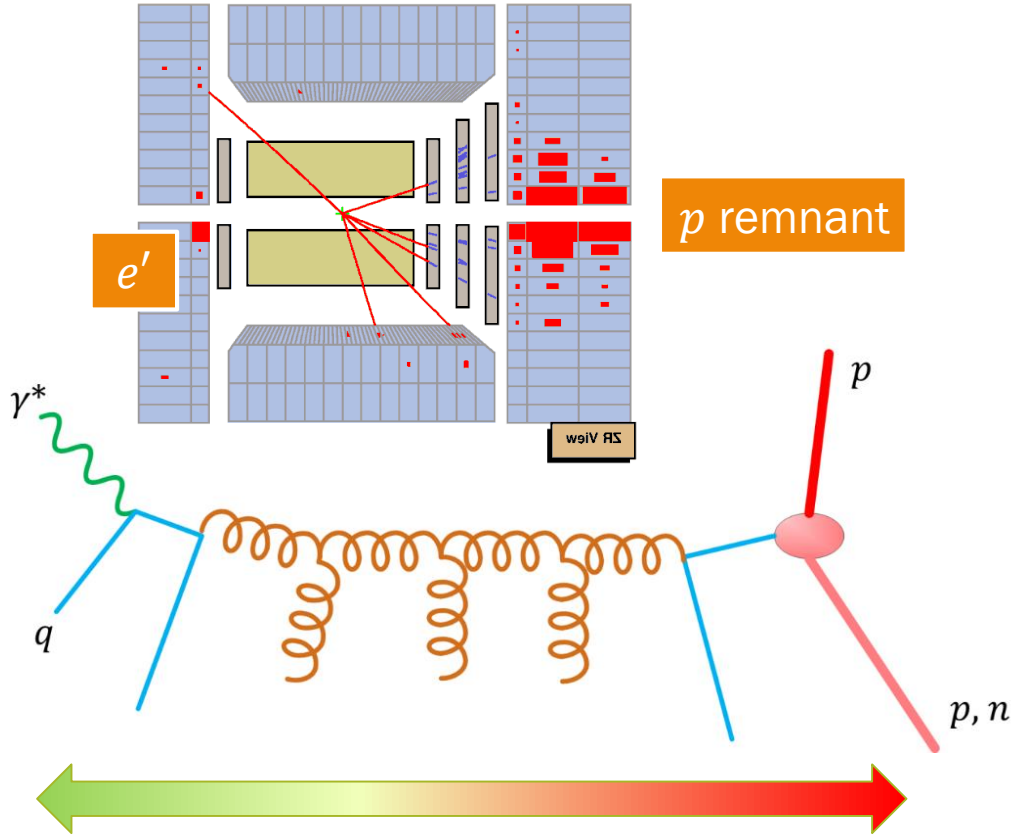
Short introduction to diffraction and forward physics in ep scattering at HERA

Recent results

- D* production in diffractive DIS
- Prompt photons in photoproduction
- Ratio of $\psi'/\psi(1S)$ in diffractive DIS
- ρ^0 production cross sections in diffractive production

DIS at HERA and forward particles





Large rapidity difference between γ^* and the leading particle

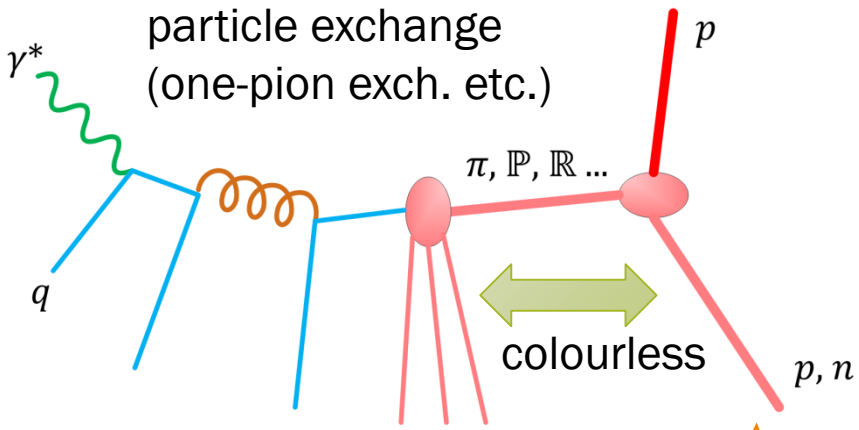
$Q^2 \gtrsim 4\ \mathrm{GeV}^2$
small x = hard

backward
$y \simeq -2$

$x \simeq 1, p_T \simeq \Lambda_{QCD}$
very large x = soft

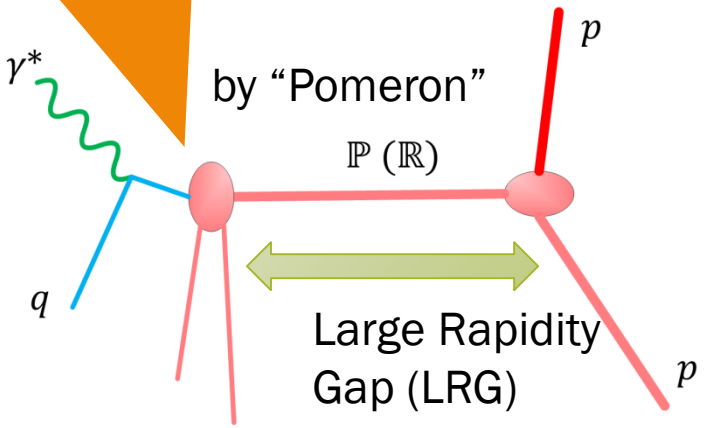
forward = 0 degree
$y \simeq 7$

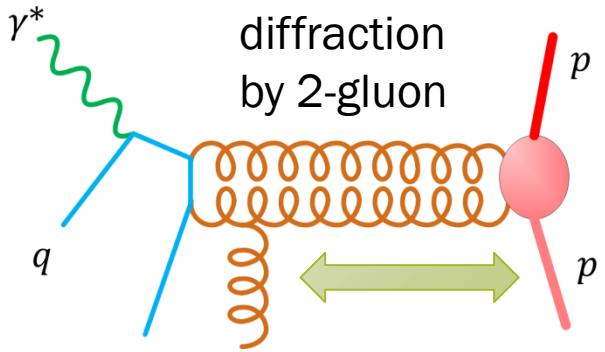
Diffraction and forward production in DIS



Production of
a leading baryon

Partonic structure?





Full pQCD view
on diffraction

Gluon ladder may be colourful,

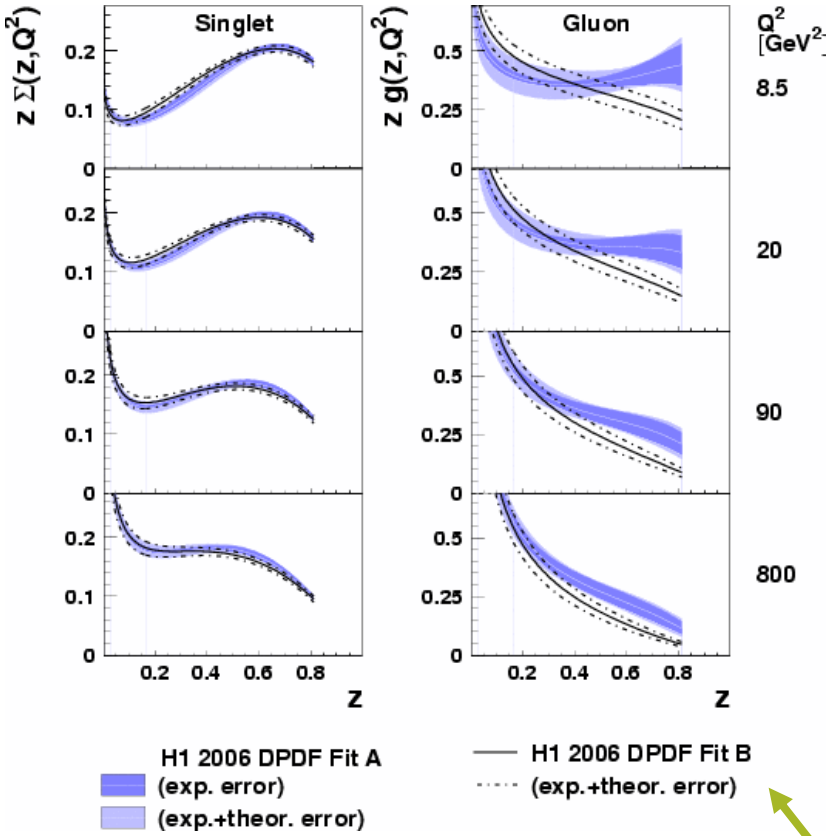
or colourless: via colourless exchange

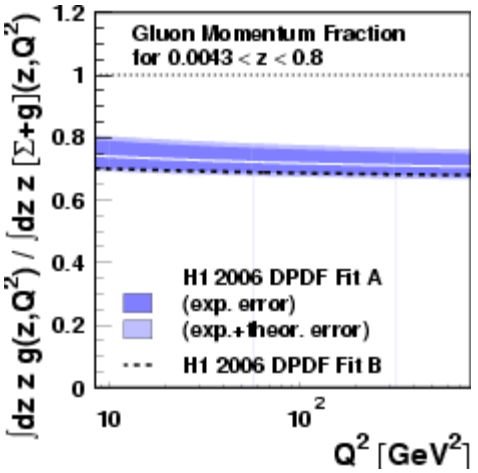
“Pomeron”, Reggeons and mesons (π, ρ ...)

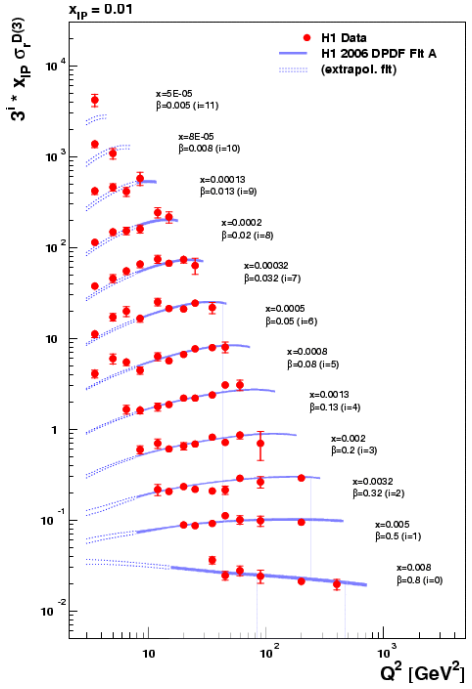
Diffractive parton densities

Diffractive PDFs: extracted by QCD fit

- gluons through slope of scaling violation







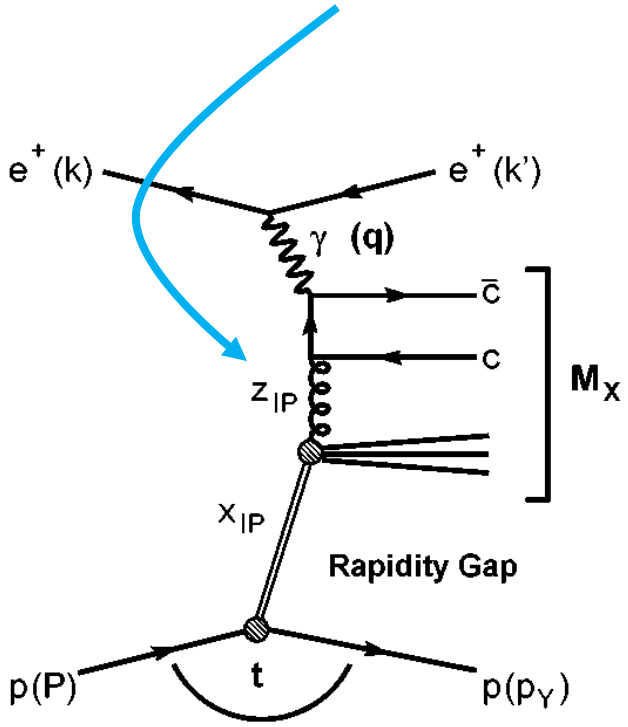
- Diffraction dominated by gluons
- Large uncertainties in the shape of gluon densities

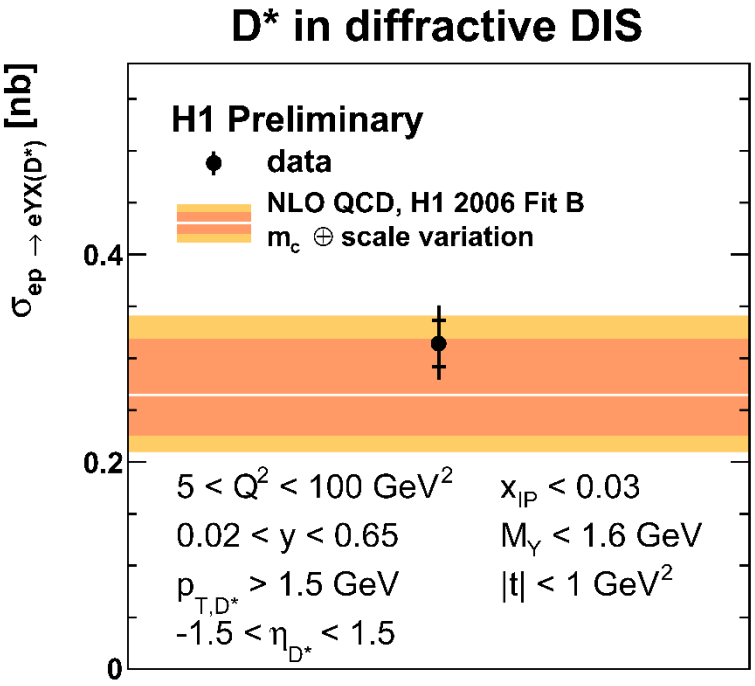
z: longitudinal fraction of the momentum of the parton to the diffractive exchange

used in theoretical predictions in comparison to the results shown later in this talk

D* production in diffractive DIS

Heavy flavour production:
sensitive to gluons





Integrated cross section is consistent with NLO prediction using HERA DPDFs

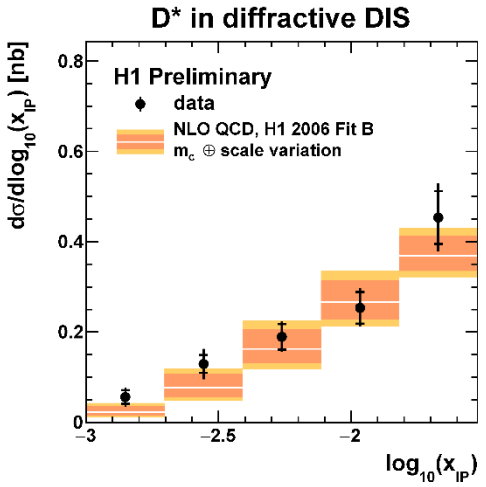
diffractive D*: differential cross sections

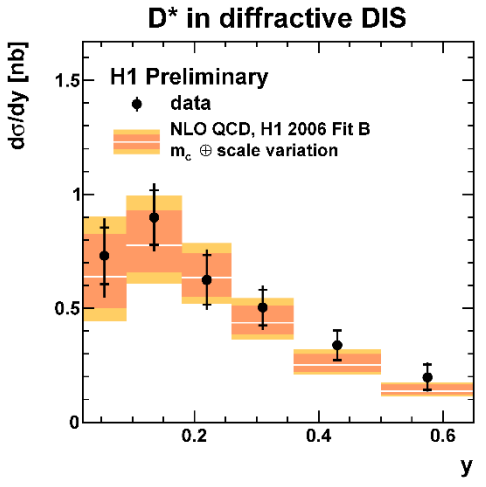
Good description
by the NLO calculation

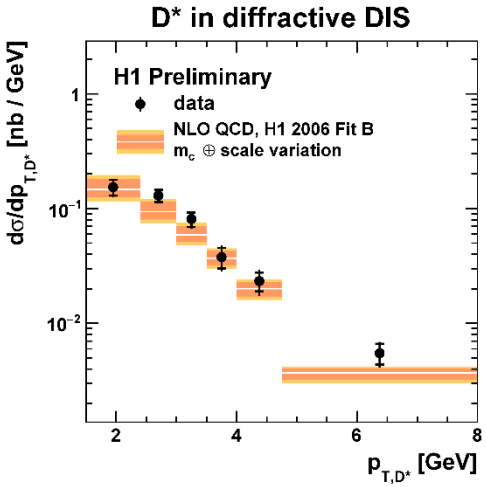
DPDF is “universal”
for this process

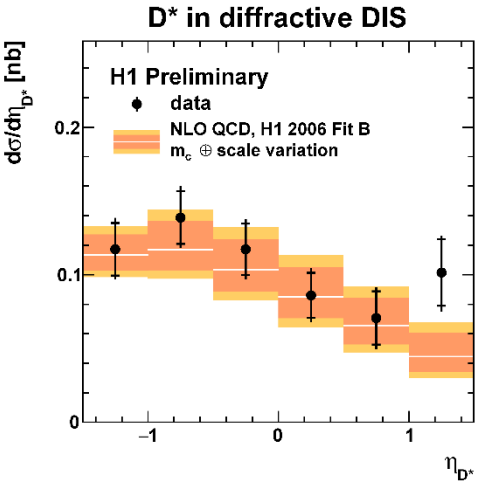
x_{IP}: longitudinal fraction of the momentum of the diffractive exchange to the incoming proton

y: Bjorken variable $y = \frac{p \cdot q}{p \cdot k}$



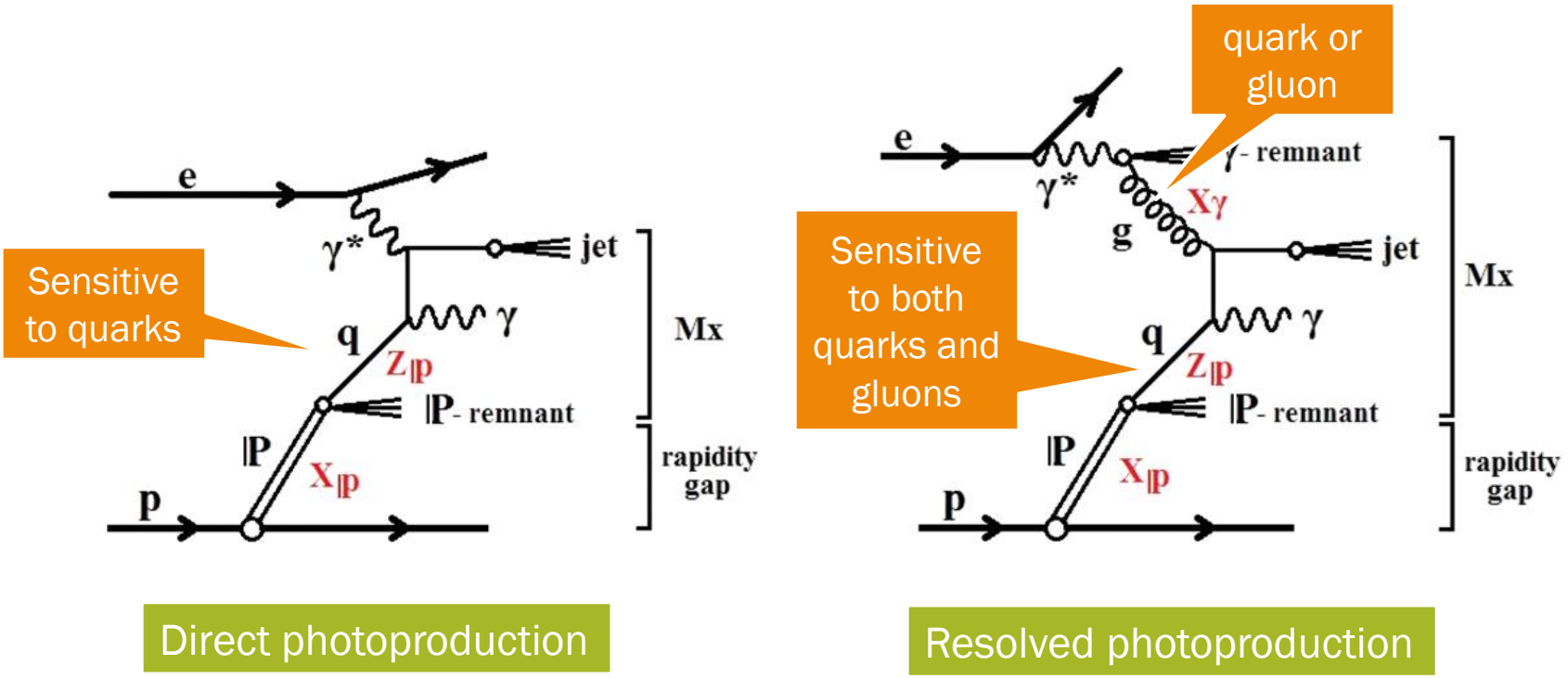






Data consistent with factorisation in diffractive DIS

Prompt photon in diffractive photoproduction



Direct photoproduction

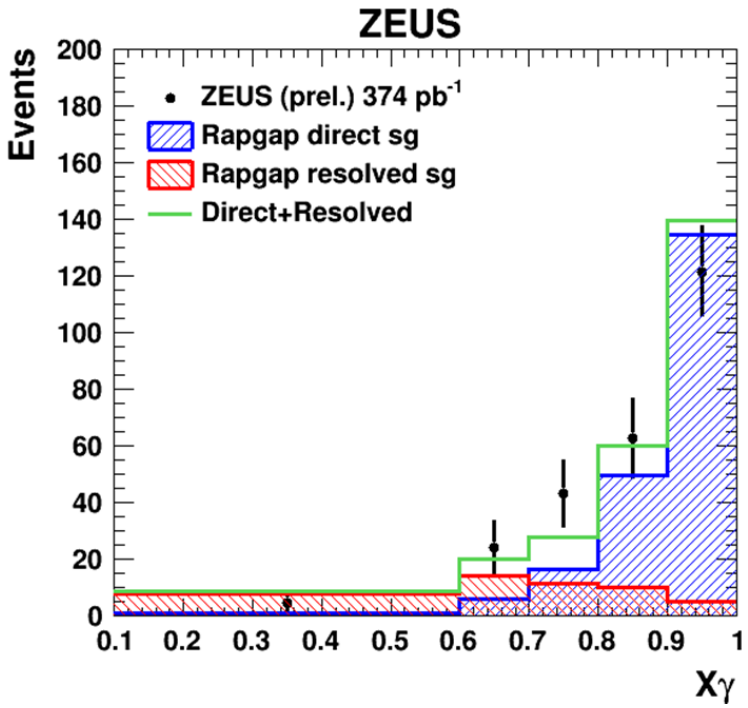
Resolved photoproduction

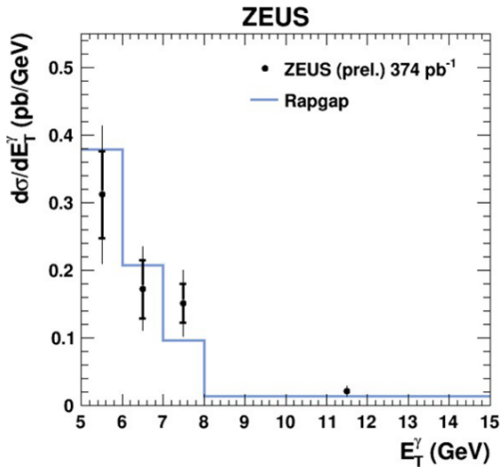
Smaller sensitivity to fragmentation than (di-)jet measurements

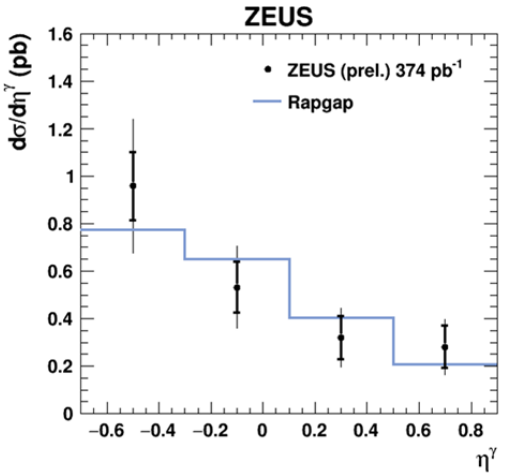
Jet + photon: reconstructing x_γ (resolved vs direct)

and z_{IP} (longitudinal distribution of partons in the “Pomeron”)

x_γ spectrum: resolved vs direct







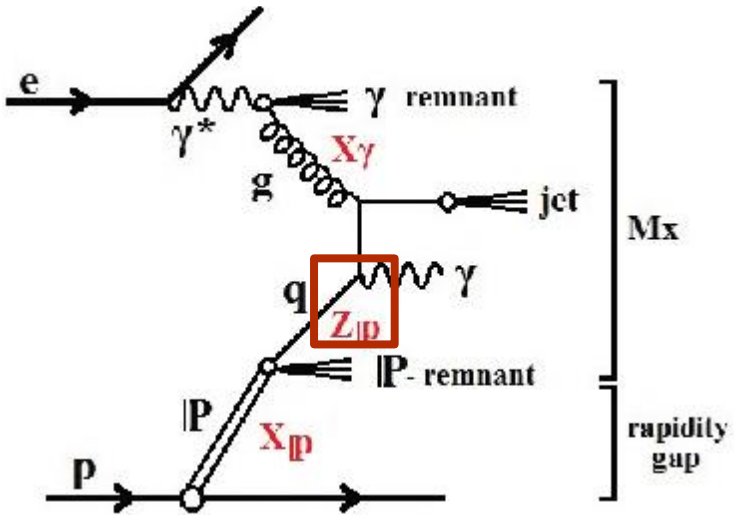
Prediction: RAPGAP LO+PS Monte-Carlo
with LO photon PDF (SaSG 1D)
and DPDF (H1 2006 Fit B)

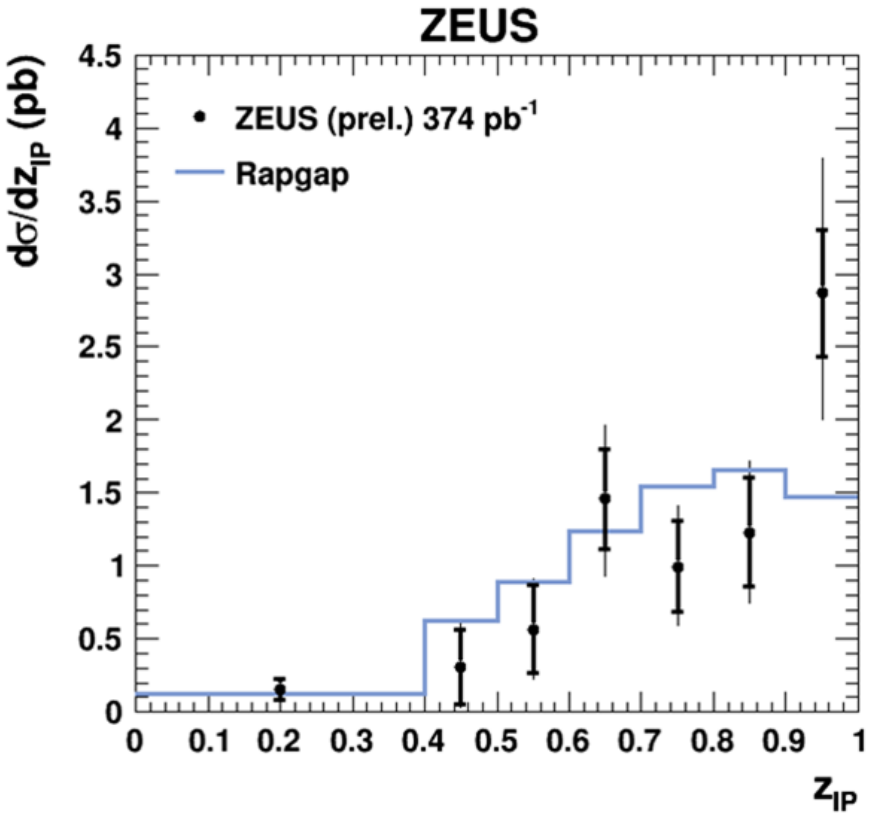
Resolved:Direct = 19:81 to describe the data

– default RAPGAP predicts higher resolved fraction

Good description on data after resolved / direct reweight

Z_{IP} distribution



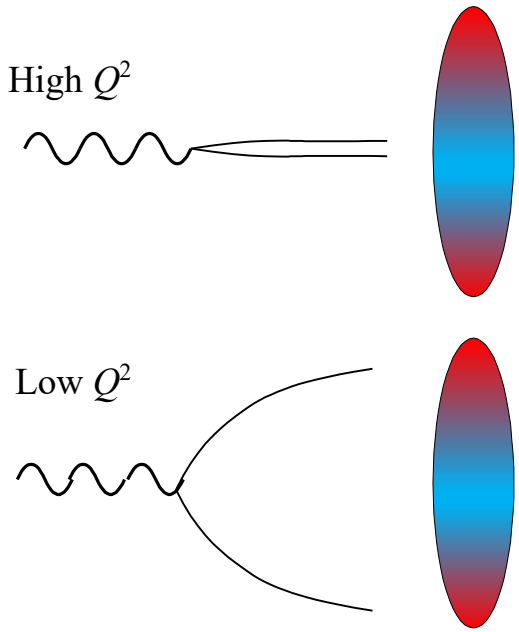


Peak near unity

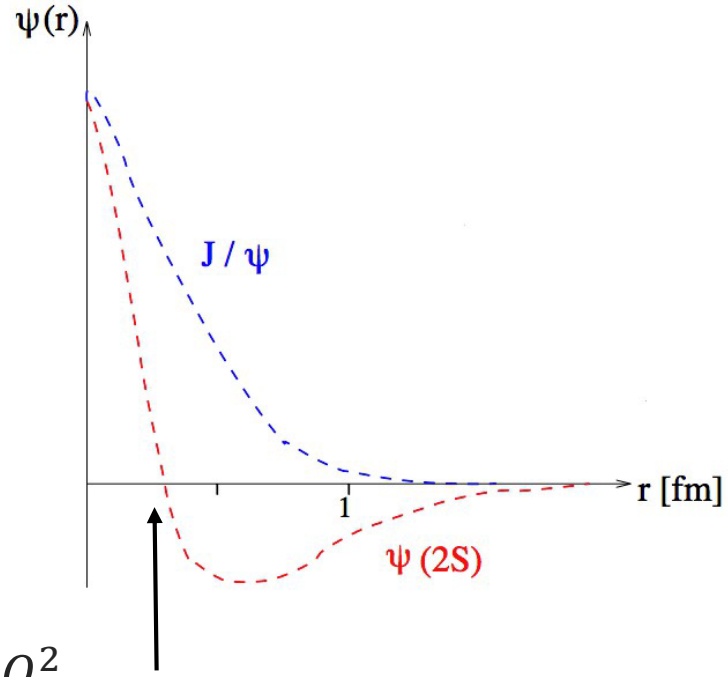
- no background source identified

“Super-hard” component in Pomeron?

Ratio $\psi(2S)/\psi(1S)$ in diffractive DIS



Ratio $R = \frac{\sigma(\gamma^* p \to \psi(2S) p)}{\sigma(\gamma^* p \to J/\psi p)}$



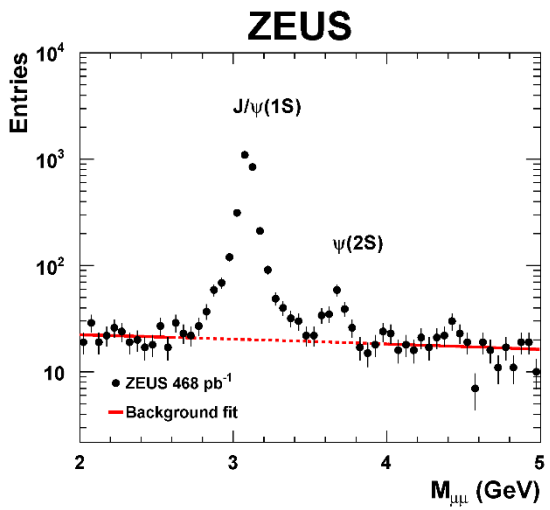
Node at ~0.35 fm

Photon "transverse size" decreases with Q^2

- Large for photoproduction $O(1\text{fm})$
- Small for high-Q^2 DIS $\ll 1\text{fm}$

Prediction: the ratio increases with Q^2

R vs Q^2 and comparison to models

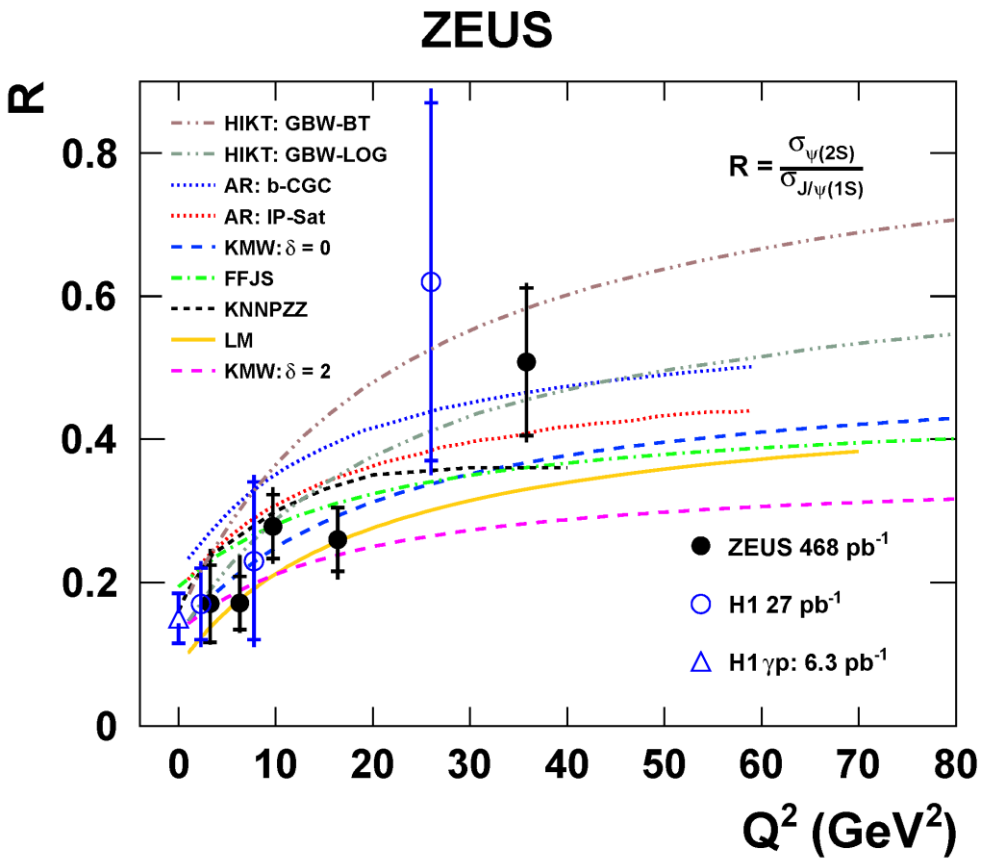


New data: 468 pb^{-1}

- Confirming earlier H1 result

Most of the models reproduces the behaviour

- Models with very slow increase not favoured



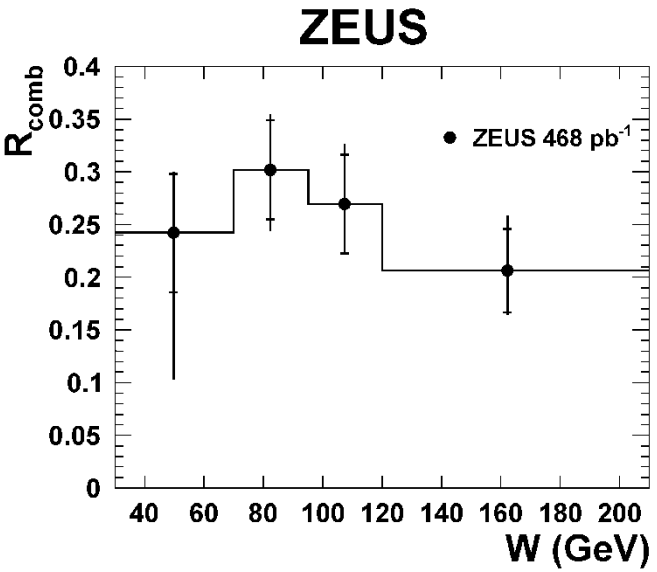
Steep increase with Q^2 from photoproduction to DIS regime

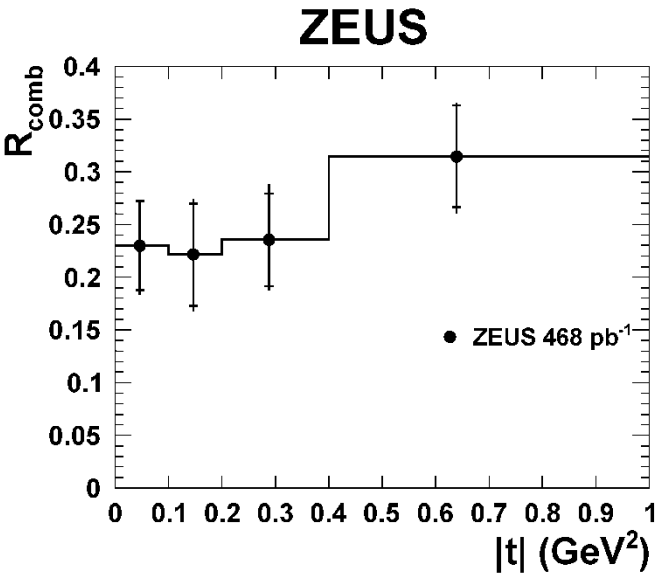
R dependence with other variables

No significant dependence on:

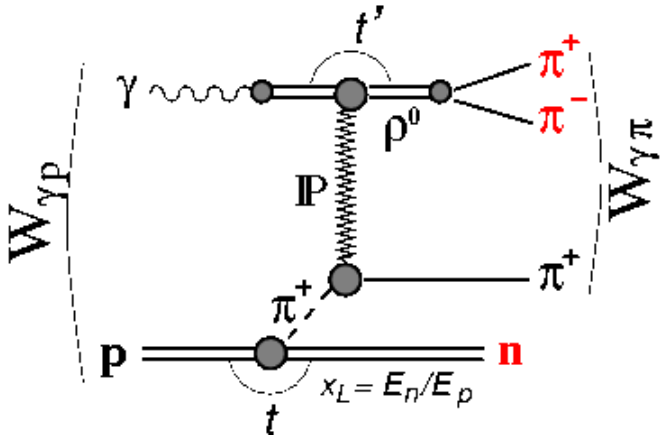
- W: $\gamma^* p$ centre-of-mass energy
- t: momentum transfer from the proton (that stays intact)

No dependence apart from Q^2, i.e. the transverse size of $\gamma^{(*)}$

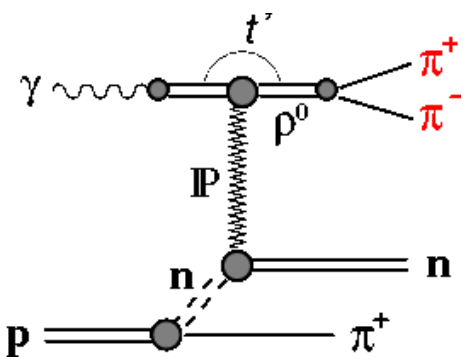




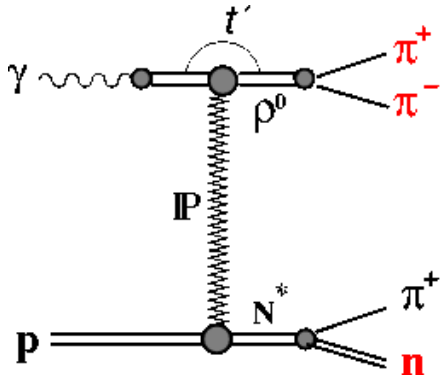
ρ^0 photoproduction with a neutron



(One-) Pion Exchange (OPE) dominant at high x_L



neutron exchange

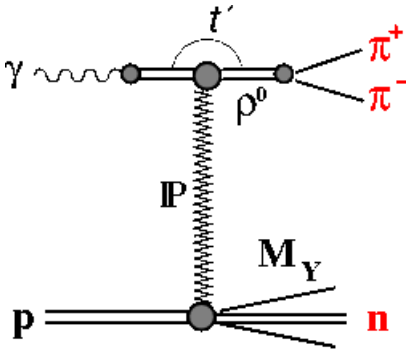


through decay of N*

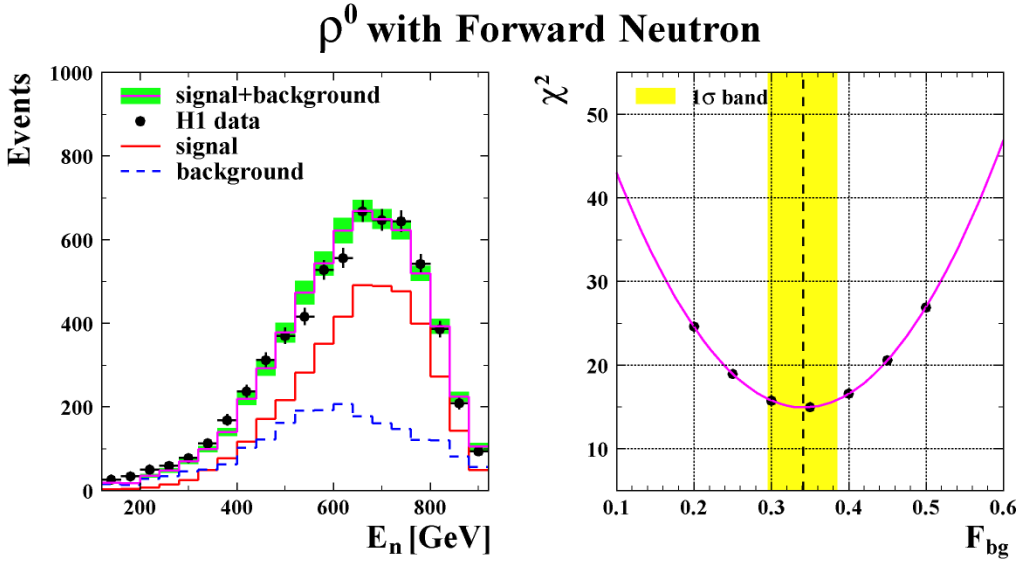
cancelling (opposite sign in amplitude)

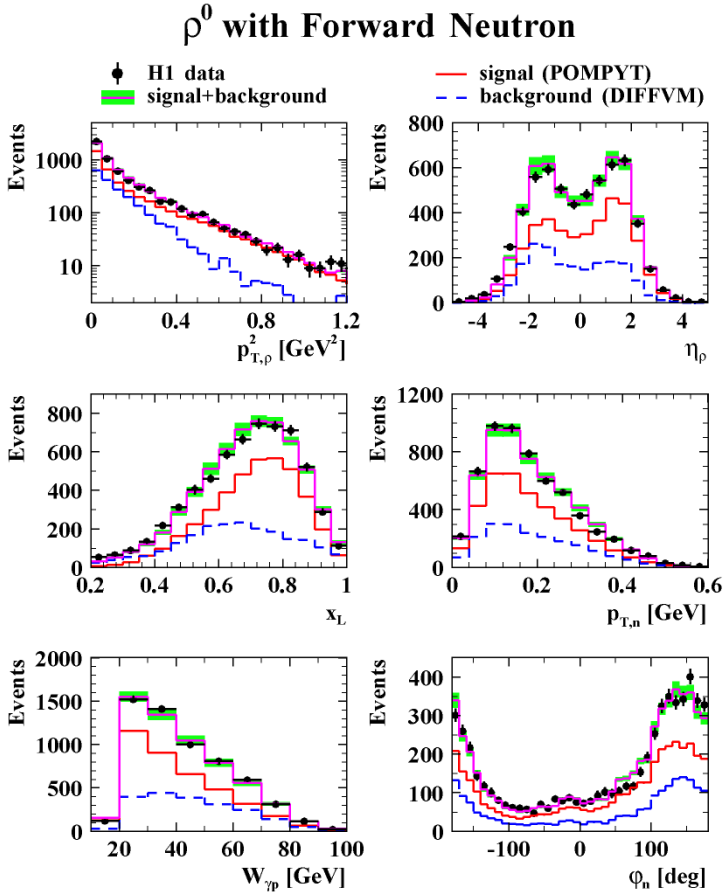
- Difference from inclusive neutron production
- Accessing $\gamma\pi$ diffraction

Background: neutron from proton-dissociated system Y



$\rho^0 + n$: Background subtraction





Using shape difference in x_L

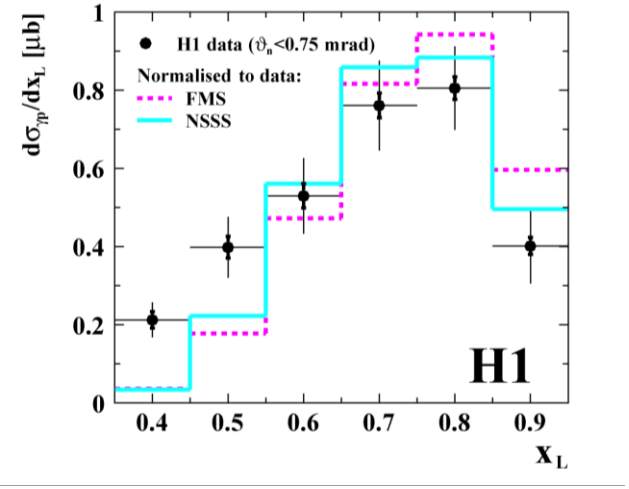
- OPE is dominant at high x_L $(0.65 < x_L < 0.95)$

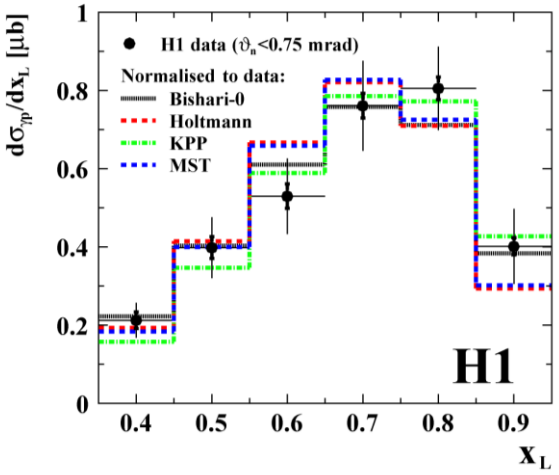
Proton dissociative background is subtracted hereafter

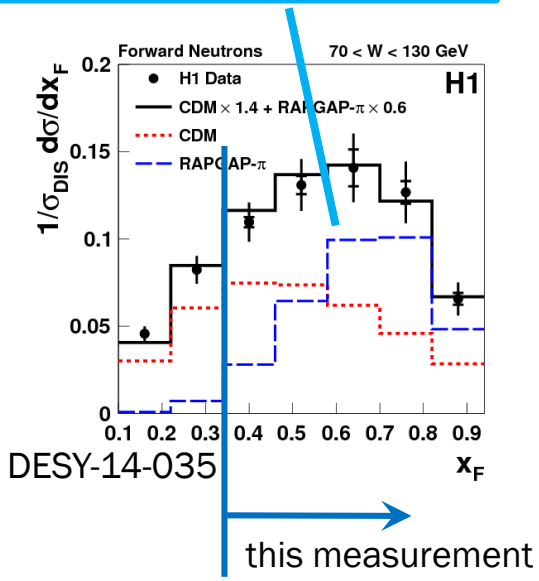
Good description of data with thus determined background fraction

$\rho^0 + n$: γp cross sections

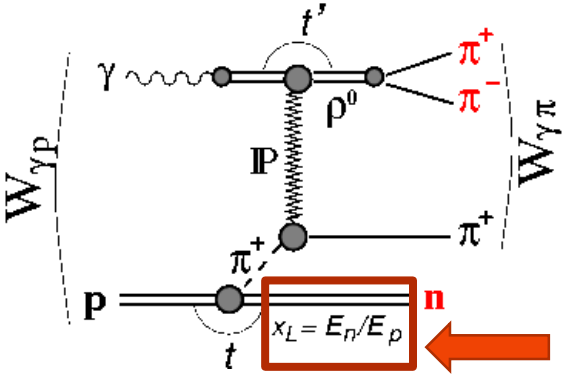
inclusive spectrum in DIS
(blue-dashed: OPE contribution)







$20 < W_{\gamma p} < 100$ GeV
$0.35 < x_L < 0.95$
$t' < 1$ GeV^2



Similar shape as the inclusive neutron

- factorisation at proton-neutron vertex

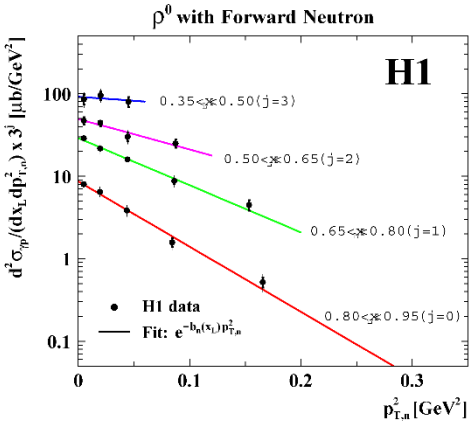
Well described by many of models

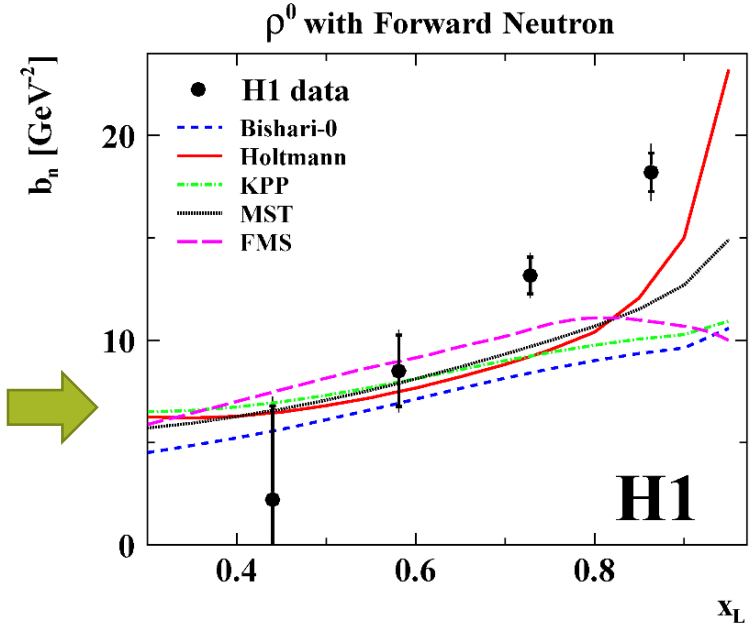
- except for FMS and NSSS

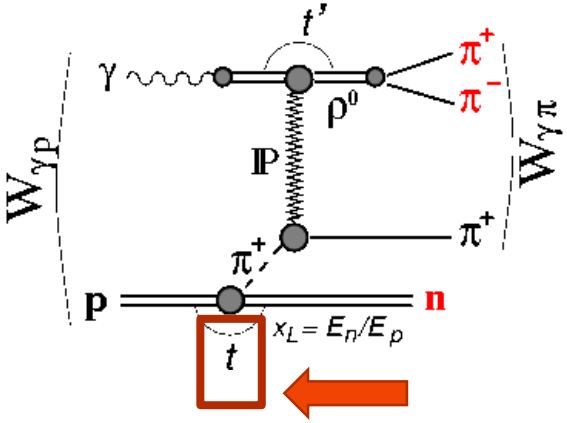
Absolute cross section: $\sigma_{\gamma\pi}/\sigma_{\gamma p} = 0.25 \pm 0.06$

- **smaller than additive quark model ($\simeq 0.6$)**
- **absorption?**

$\rho^0 + n$: t-distribution (neutron p_T)

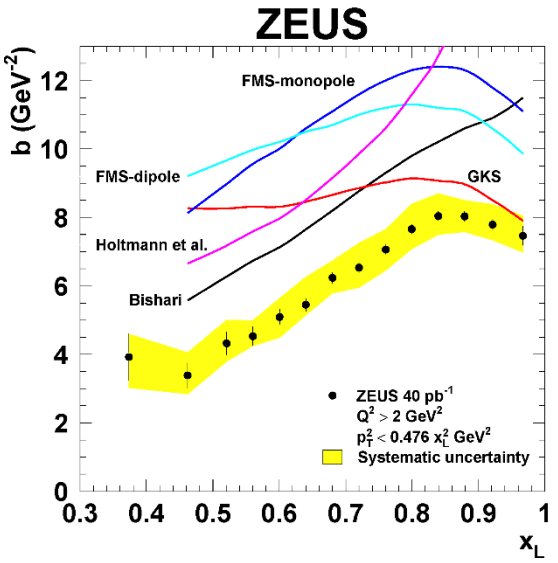






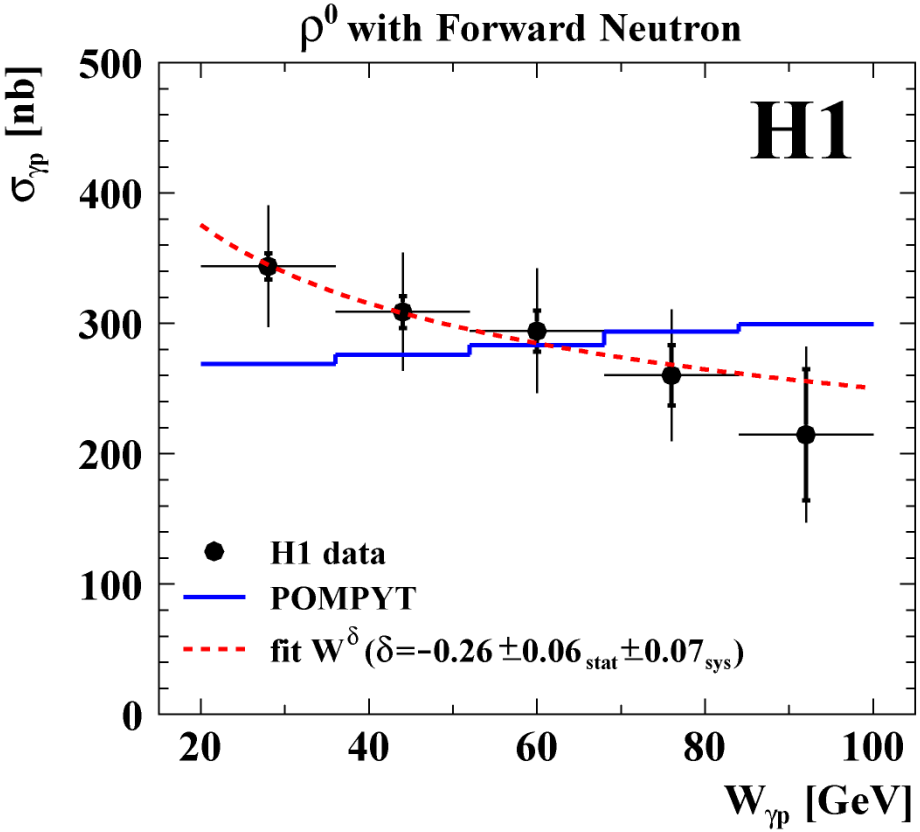
Steeply falling (i.e. high b parameter) at very high x_L

- Not observed in inclusive neutron production
- Absorption of “large configuration” ?
- Some models predicted qualitatively



inclusive DIS

$\rho^0 + n$: W-dependence



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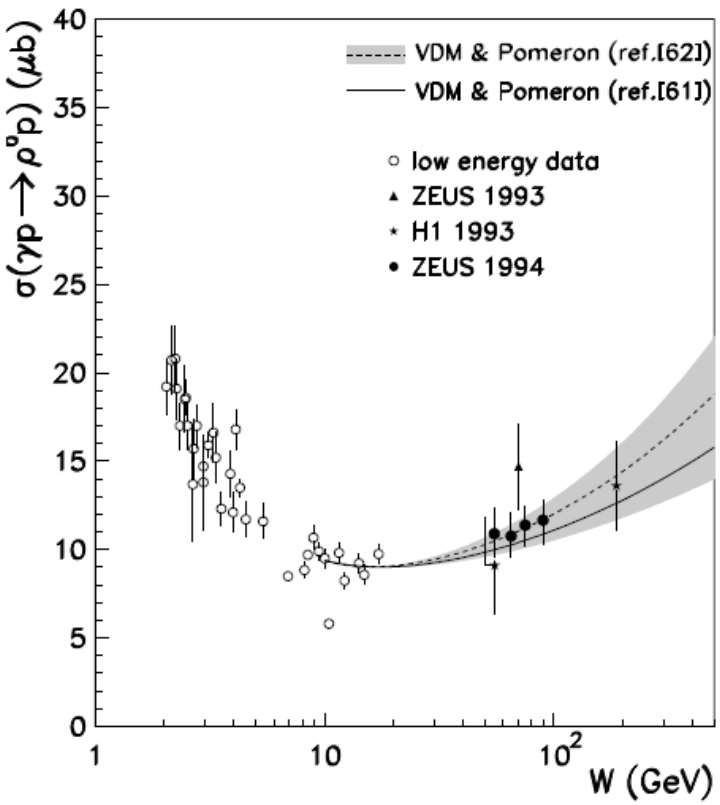
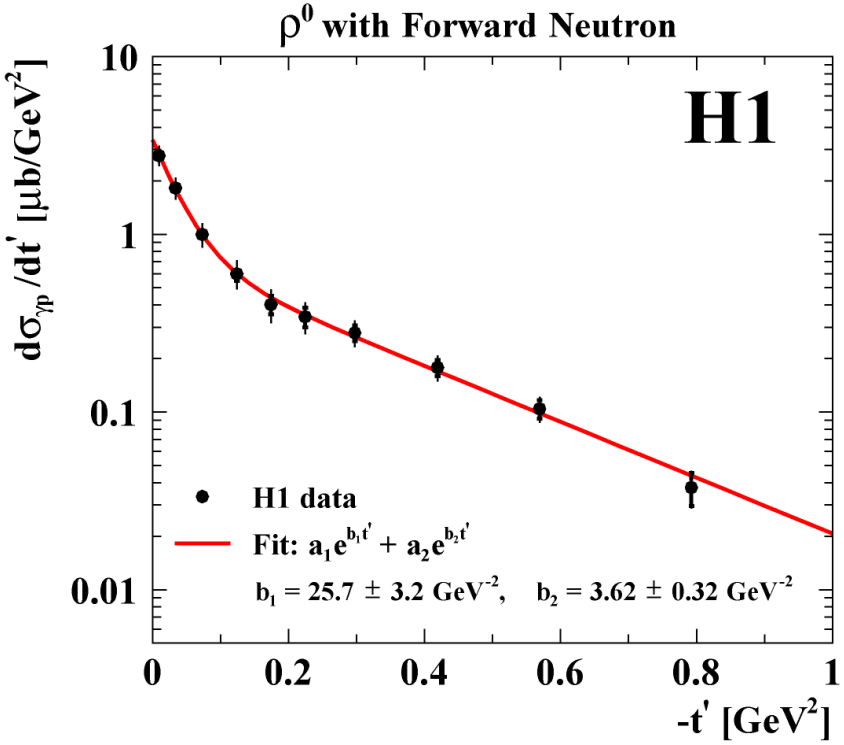


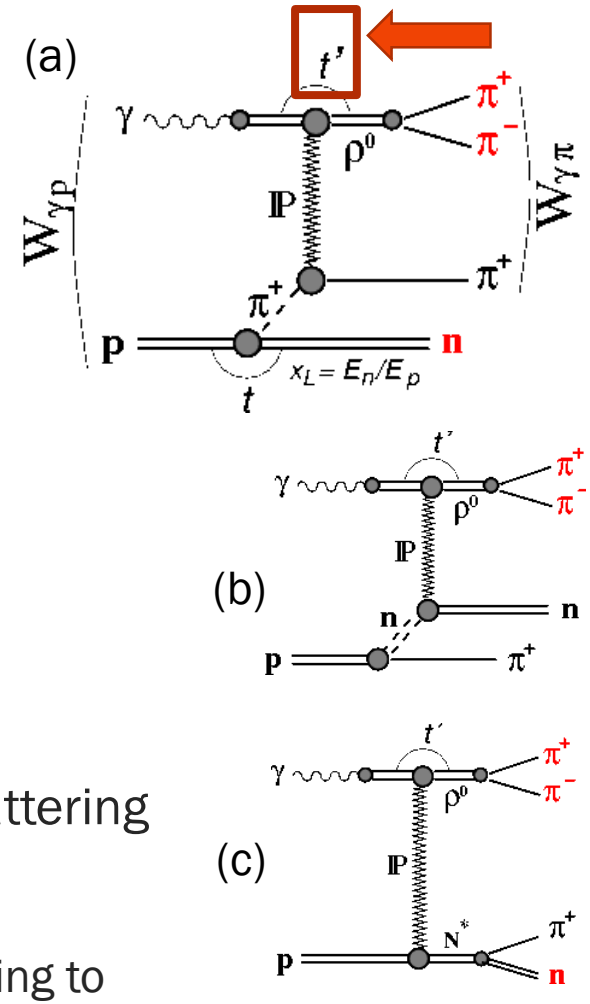
Pomeron trajectory: $\delta \simeq 0.08$

$\gamma p \to \rho^0 p$ at HERA prefers to increase with W

Different for $\gamma\pi \to \rho^0\pi$?

t'-dependence ($\gamma\pi$ scattering mom. transf.)





$b_1 \sim 25\ \mathrm{GeV}^{-2}$: diffractive peak - very peripheral scattering

$b_2 \sim 3.5\ \mathrm{GeV}^{-2}$:

- Interference between various diagrams (a)–(c) according to double-peripheral process (π, $\mathbb{P}$) ?
- "Pion dissociation" component?

Summary

D* in DIS:

- Diffractive factorisation in DIS further supported

Jet + direct γ in photoproduction:

- Hard (quark) component in diffraction?

ψ'/ψ in DIS:

- Insight to charmonium production

$\rho^0 + n$: diffractive "$\gamma\pi$" scattering

- Factorisation between γ and proton vertex
  One-pion exchange describes most of the feature of the data
- Absorption?

Hope to have combined LHC+HERA analyses on dPDF soon!