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ZEUS

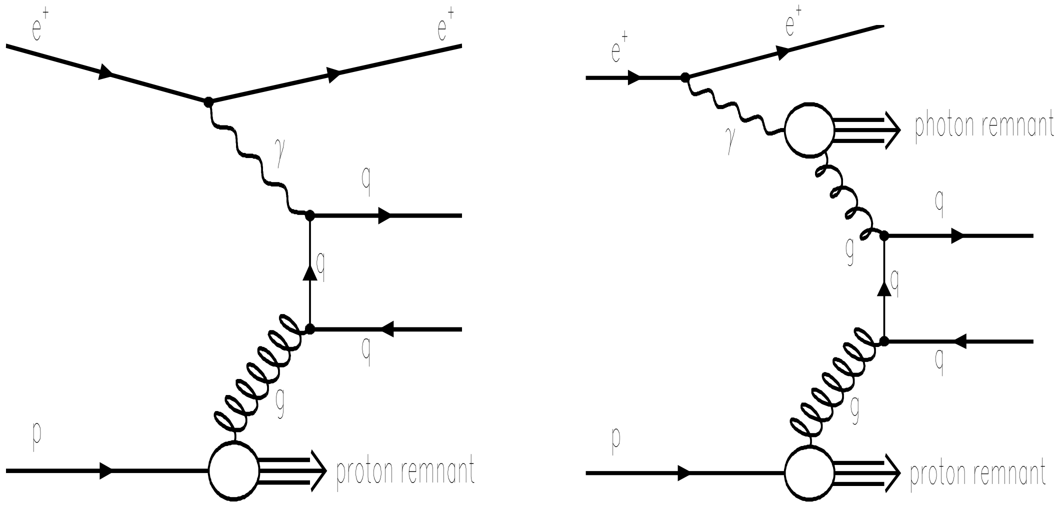
Virtual Photon Structure at HERA

- **direct and resolved interactions**
- **virtual photon structure**
- **suppression of the structure**
- **study of the two scales**
- **triple differential cross sections**
- **summary**

http://giroz.desy.de/~kcira/show.php3?p=talks

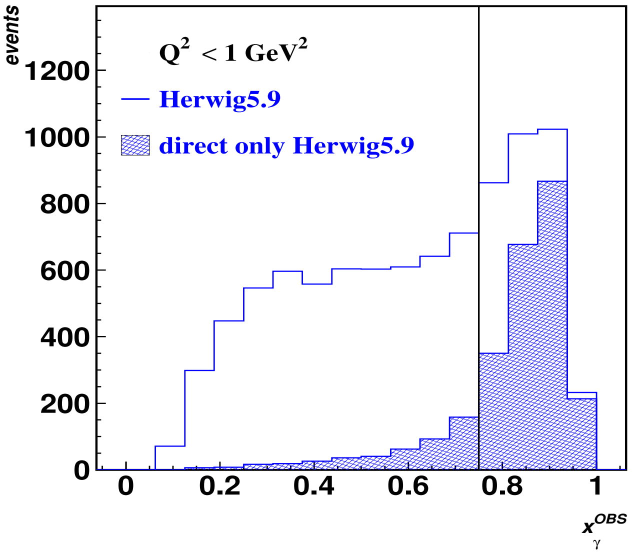
Direct and Resolved Interactions

In photoproduction ($Q^2 \simeq 0$), at LO-QCD:



Direct $x_\gamma = 1$ Resolved $x_\gamma < 1$

probing photon structure via the dijet system



$$x_\gamma^{OBS} = \sum_{jets} \frac{E_T e^{-\eta}}{2yE_e}$$

good separation - direct events concentrated at high x_γ^{OBS}

Virtual Photon Structure

Similarly to real photons, virtual photons interact via two components:

$$\boxed{|\gamma^* > = |DIR > + |RES >}$$

The direct component corresponds to the pointlike interactions of the photon.

The resolved component has a perturbative and a non-perturbative part. The perturbative part comes from $\gamma \leftrightarrow q\bar{q}$ (at HERA hard scale is $\mu^2 \approx E_T^2$.)

Both pQCD and non-pQCD components are suppressed with increasing photon virtuality Q^2.

Virtual Photons at HERA

In comparison to e^+e^- experiments at HERA:

- F_2^γ cannot be measured.

- the photon can be probed at higher scales.
- already at LO there is sensitivity to the gluons in the photon.
- more suitability for study of photon structure versus photon virtuality.

HERA measurements are complementary to e^+e^- experiments and universality of the photon structure is tested.

Method

The ratio

$$R = \frac{\sigma(x_\gamma^{OBS} < 0.75)}{\sigma(x_\gamma^{OBS} > 0.75)}$$

is sensitive to resolved component and allows study of its suppression versus the photon virtuality Q^2.

Simulation

LO MCs and photon PDFs

Herwig5.9:

* MRSA for the proton
* SaS1D-LO parametrization of γ^* PDFs
* GRV-LO parametrization of γ PDFs
* ratio of direct and resolved components according to generated cross sections

In the SaS parametrization of the virtual photon pdfs, the two resolved components are suppressed as follows:

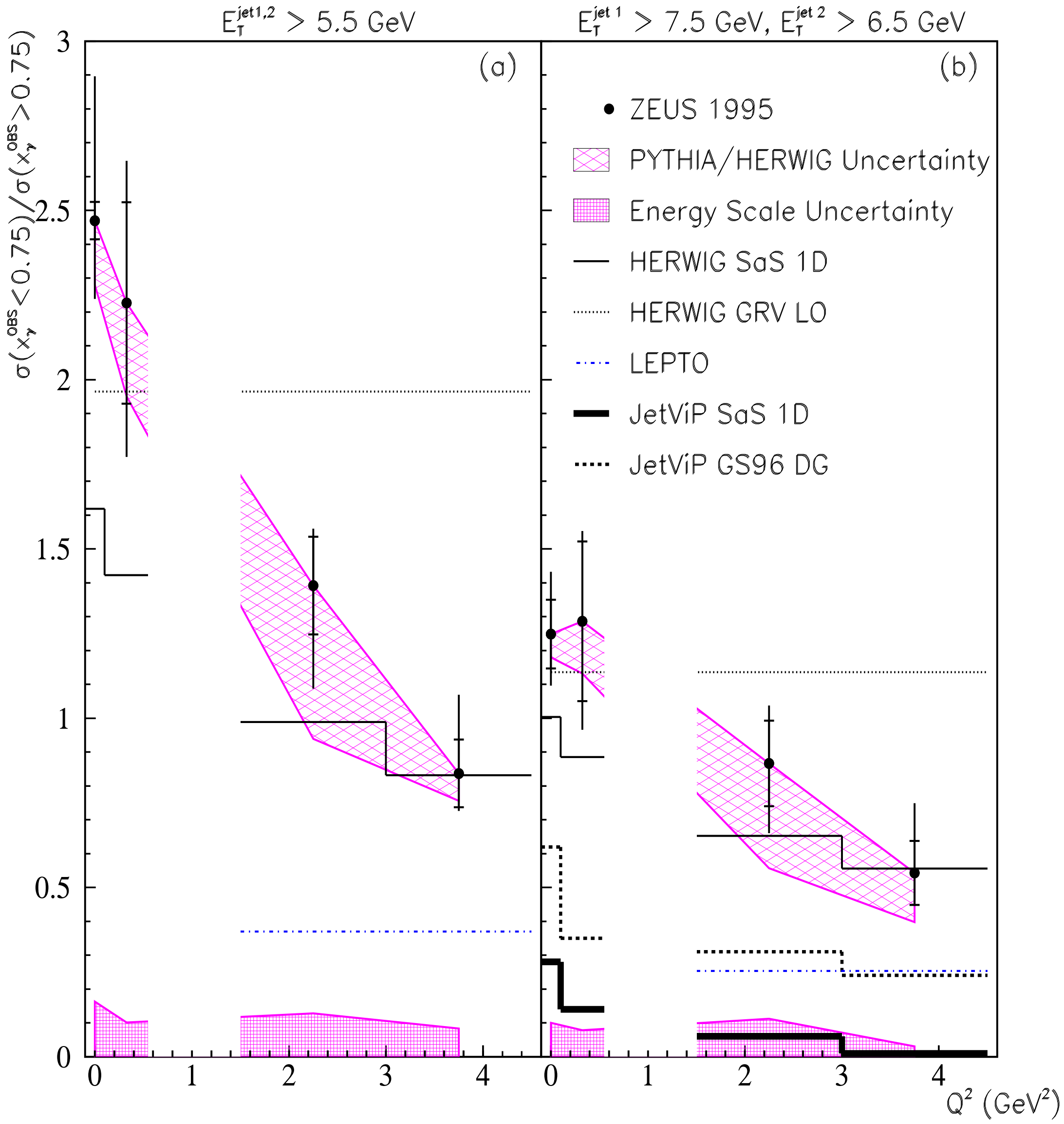
QCD: $\sim \ln(\mu^2/Q^2)$
non-pQCD $\sim Q^{-4}$

Lepto:

* MRSA for the proton
* direct photons only

Ratio in the LAB frame (hep-ex/0002010)

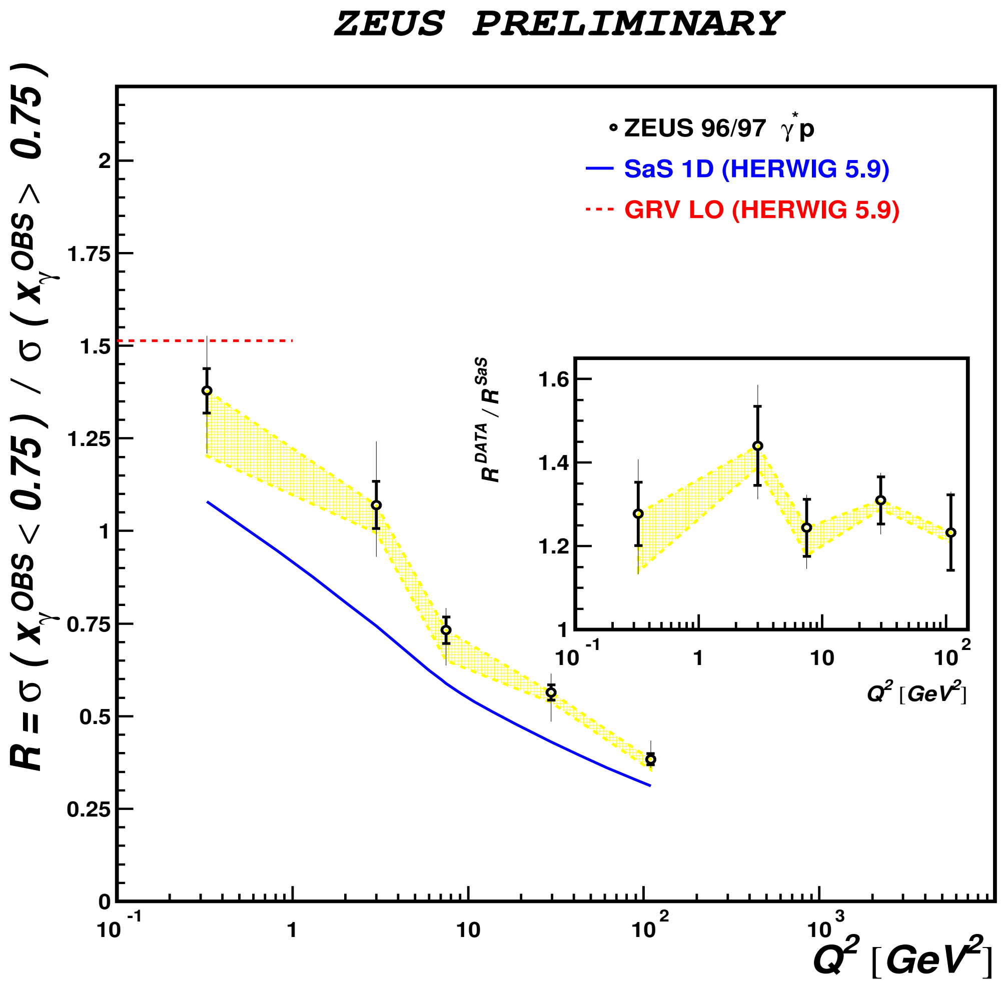
- restricted Q^2 range.
- laboratory frame.
- two different E_T cuts



- suppression seen up to $Q^2 = 4.5\mathrm{GeV}^2$.
- fall more pronounced for smaller jet E_T.

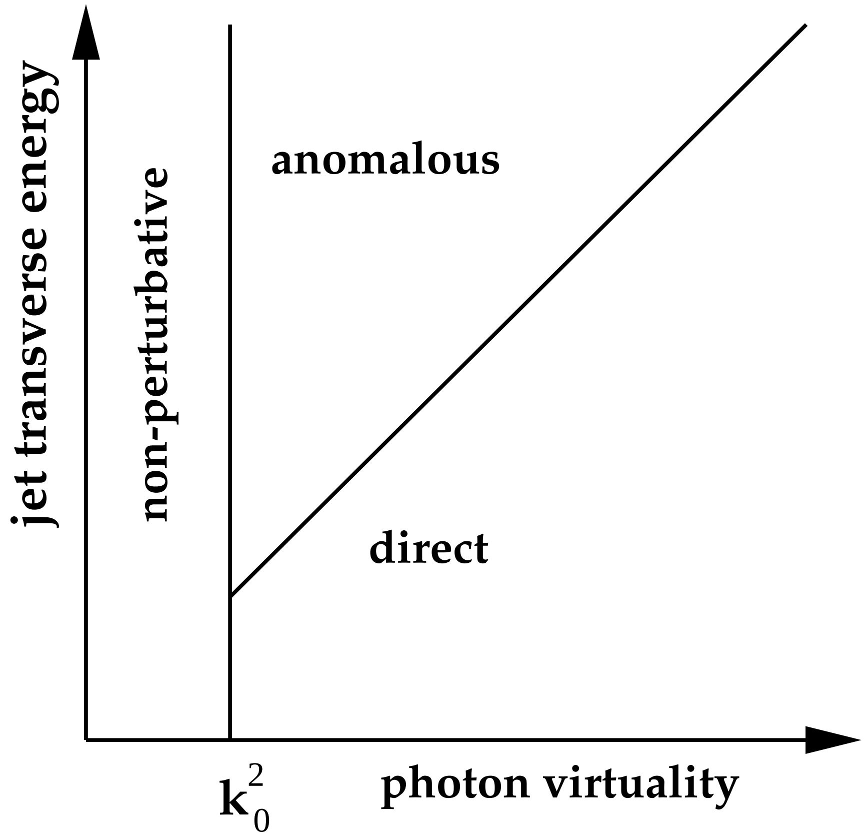
Suppression of Virtual Photon Structure

- $\gamma^{*}p$ frame - k_T dijets: $E_T^{jet} > 7.5, 6.5$ GeV, $-3.0 < \eta^{jet} < 0$
- $0.2 < y < 0.55$, $0.1 < Q^2 < 10^4\,\mathrm{GeV}^2$



- ratio of cross sections falls with increasing photon virtuality ⇒ suppression seen.
- rate of fall of SaS1D - ok, but seems not to have enough resolved.

The two scales



• if the photon virtuality is larger than the hard scale of the jets: $Q^2 > (\overline{E_T})^2$, then photon pointlike.

• if $Q^2 < (\overline{E_T})^2$, then photon develops partonic structure.

• at lower photon virtualities models must be used (VDM).

Cross Section Definition

$\gamma^* P$ c.m. frame

- inclusive dijets selected with k_T
- $E_T^{jet} > 7.5, 6.5$ GeV
- $-3.0 < \eta^{jet} < 0$
- $0.2 < y < 0.55$

Cross section $d^3\sigma/dQ^2 d(\overline{E_T})^2 dx_\gamma^{OBS}$ computed in bins of $(\overline{E_T})^2$ and Q^2:

$49 < (\overline{E_T})^2 < 85$ GeV^2

$85 < (\overline{E_T})^2 < 150$ GeV^2

$150 < (\overline{E_T})^2 < 700$ GeV^2

$0.1 < Q^2 < 0.55$ GeV^2

$1.5 < Q^2 < 4.5$ GeV^2

$4.5 < Q^2 < 10.5$ GeV^2

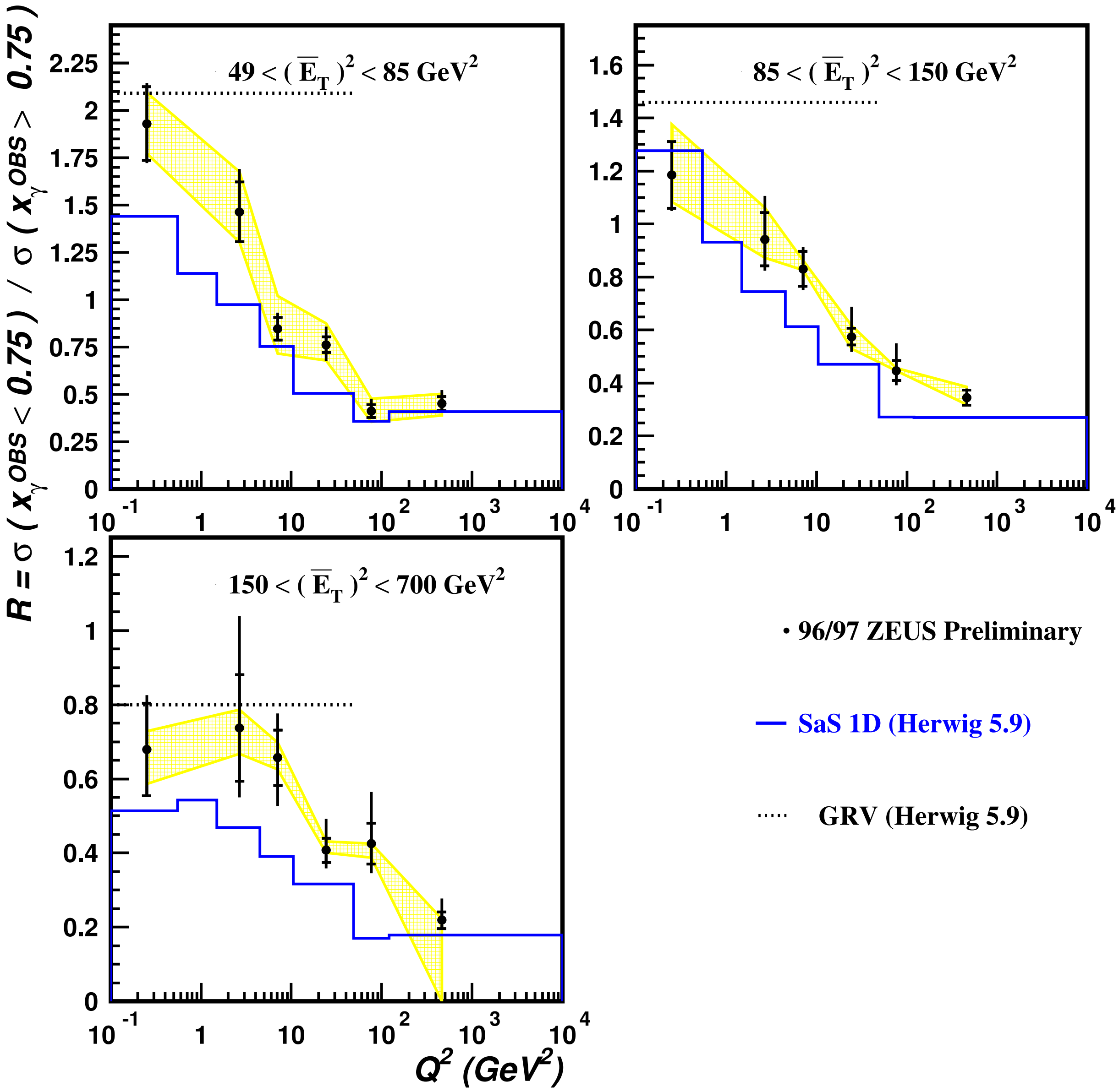
$10.5 < Q^2 < 49$ GeV^2

$49 < Q^2 < 120$ GeV^2

$120 < Q^2 < 10^4$ GeV^2

$\overline{E_T} = (E_T^{jet,1} + E_T^{jet,2})/2$

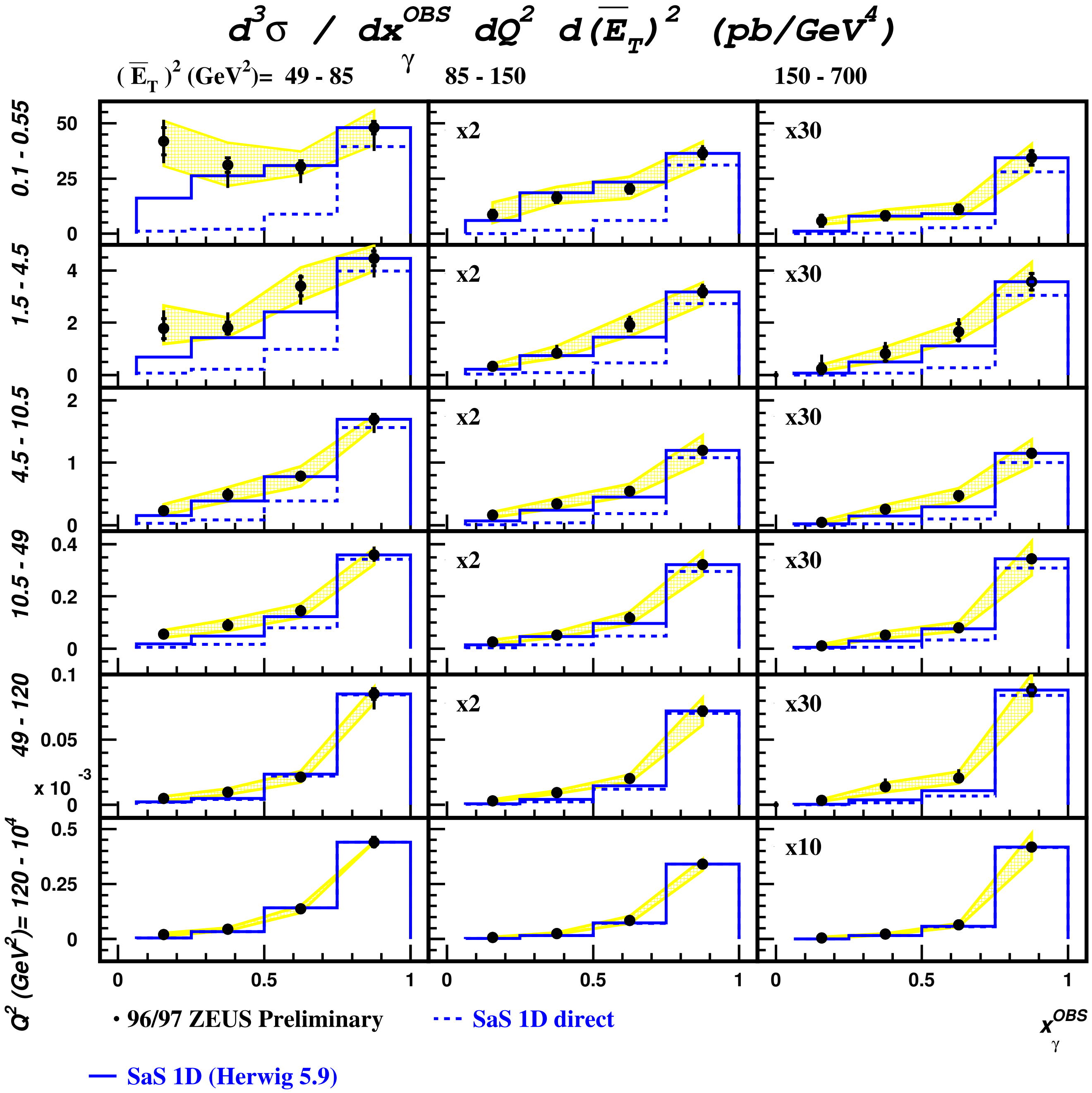
Ratios of Cross Sections



- ratios fall with $Q^2 \Rightarrow \gamma^*$-structure suppressed in each $(\overline{E_T})^2$ region.
- SaS1D below data ratio.

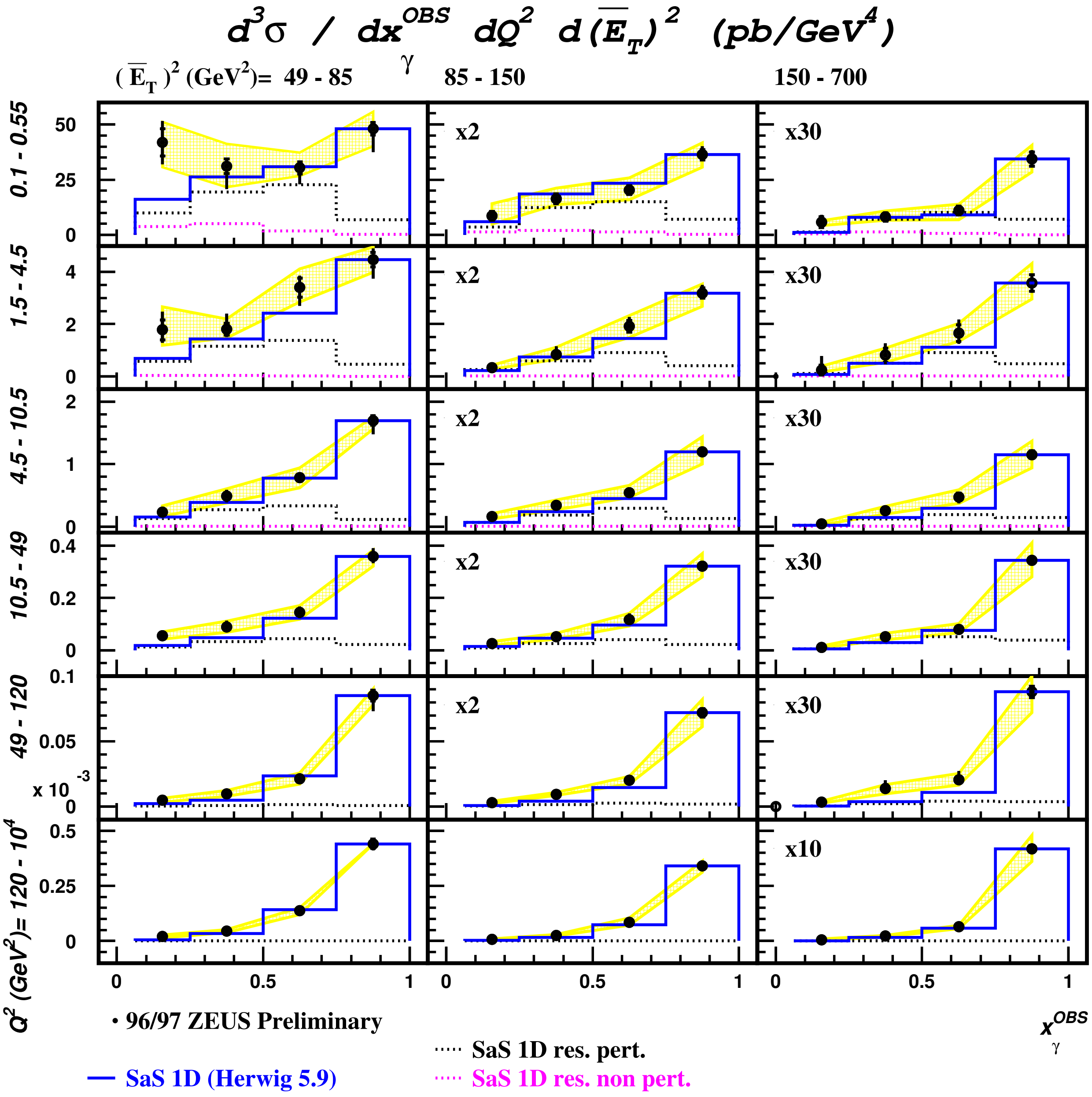
Triple Differential Cross Sections

- LO-MC normalized to highest x_γ^{OBS} data.



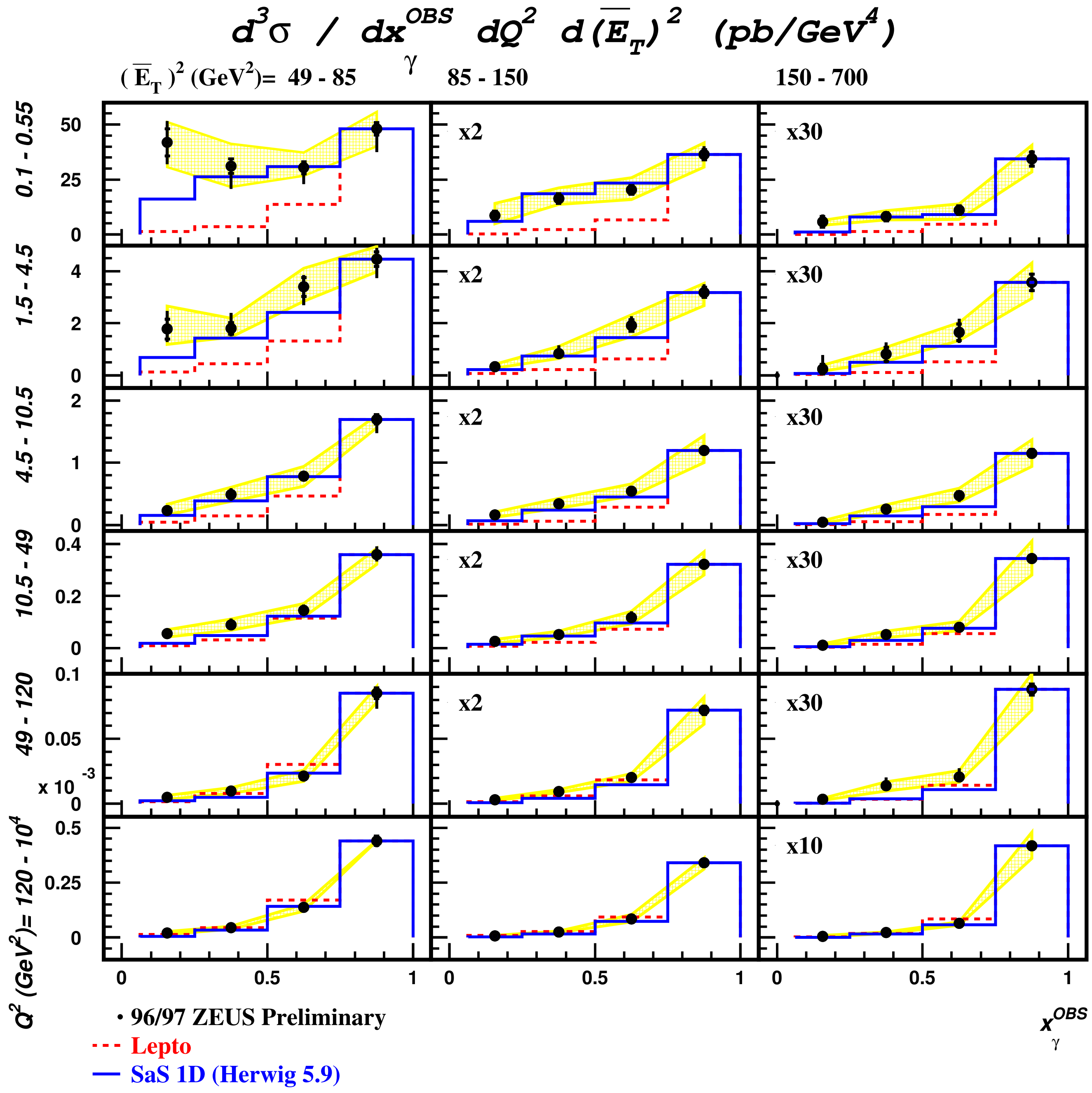
- lower x_γ^{OBS} cross section falls faster than higher x_γ^{OBS} one.
- $Q^2 < (\overline{E_T})^2$: direct-only not enough to describe data.
- $Q^2 > (\overline{E_T})^2$: no resolved, data described from direct.

Triple Differential Cross Sections



• in our kinematic region, within the SaS1D model most of the resolved component is perturbative.

Triple Differential Cross Sections



- Lepto similar to direct-only Herwig.
- data described for $Q^2 > (\overline{E_T})^2$.

summary

- ratio of cross sections $R = \sigma(x_\gamma^{OBS} < 0.75)/\sigma(x_\gamma^{OBS} > 0.75)$ falls with increasing Q^2 for each $(\overline{E_T})^2$ region. suppression of γ^* structure seen.
- ratio of Herwig using SaS1D lies below data.
- triple differential cross section measured $d^3\sigma/dQ^2 d(\overline{E_T})^2 dx_\gamma^{OBS}$ in bins of Q^2 and $(\overline{E_T})^2$.
- direct component is not enough to describe data for $Q^2 < (\overline{E_T})^2$ but does describe shape for $Q^2 > (\overline{E_T})^2$
- within the SaS1D model, most of the resolved component is perturbative in our region of kinematics.
- Lepto describes the data where it is supposed to: $Q^2 > (\overline{E_T})^2$.