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Measurements of the Partonic Structure of Virtual Photons

Experimental results from H1 and ZEUS collaborations

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High Enery Physics 99

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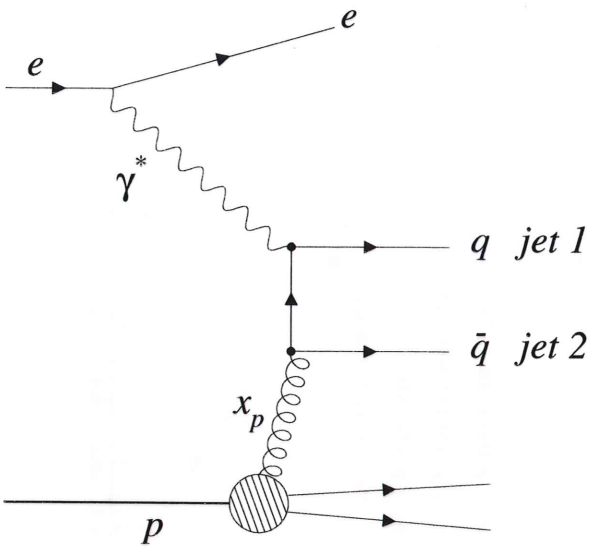
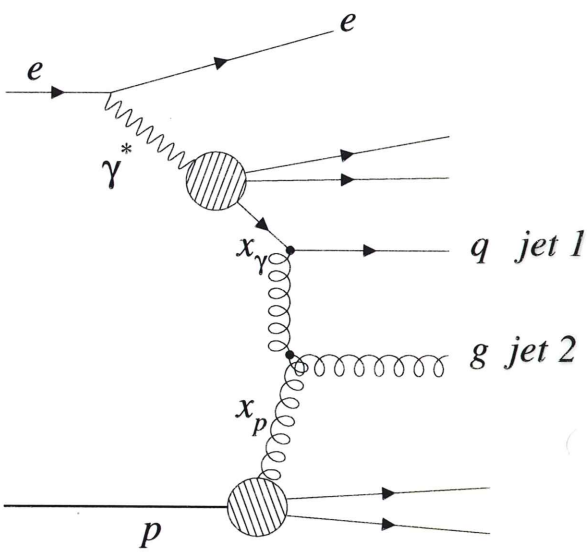
Introduction

DIRECT



RESOLVED



$Q^2 = 4E'_e/E_e \cos^2(\theta'/2)$ - **virtuality**

$y_e = 1 - E'_e/E_e \sin^2(\theta'/2)$ - **inelasticity**

$\bar{E}_t = (E_t^{jet1} + E_t^{jet2})/2$ - **hardness**

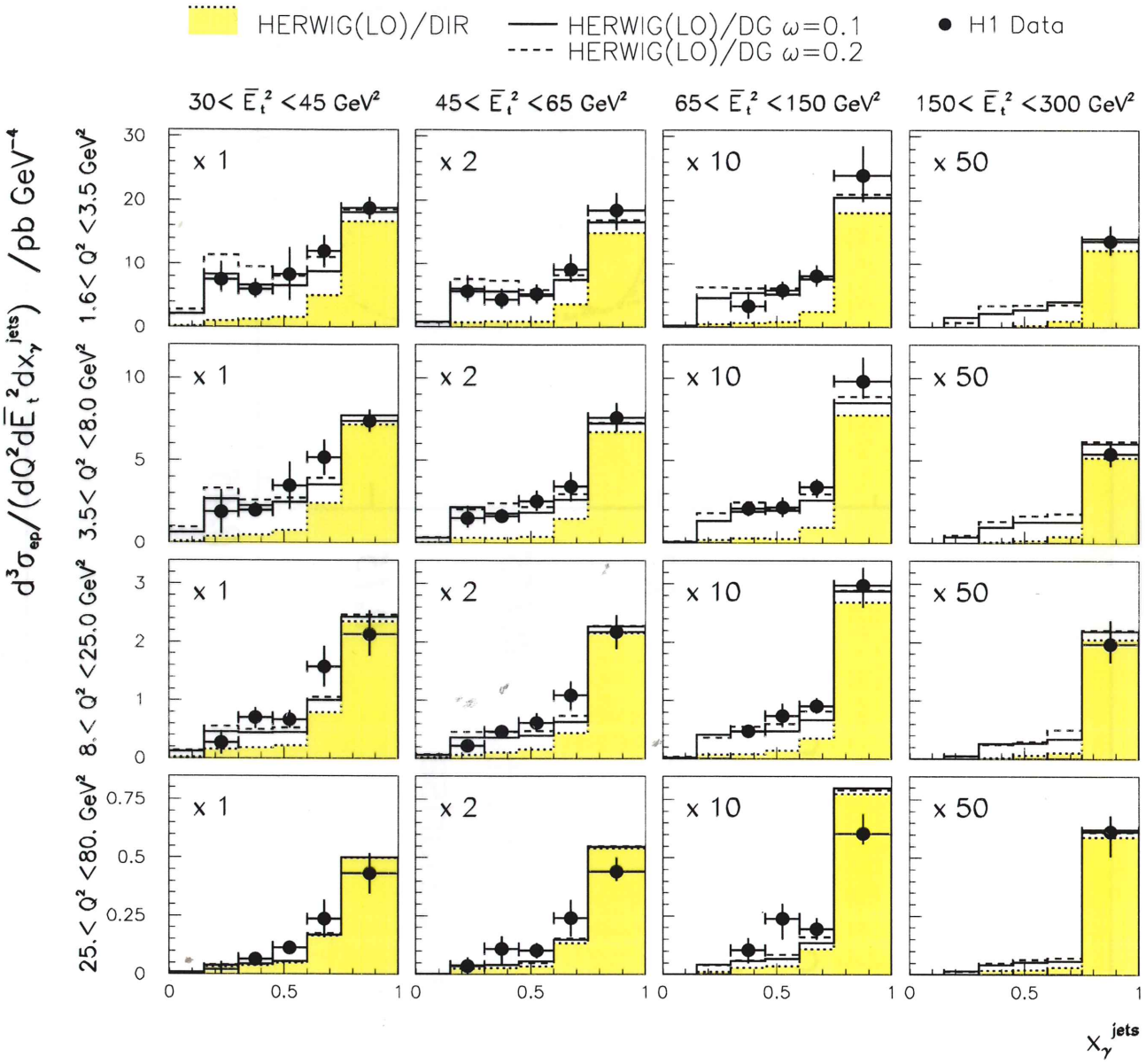
$Q^2 < \bar{E}_t^2$

If $Q^2 > \bar{E}_t^2$, the photon can not be resolved.

x_γ - **fractional momentum of parton in photon**

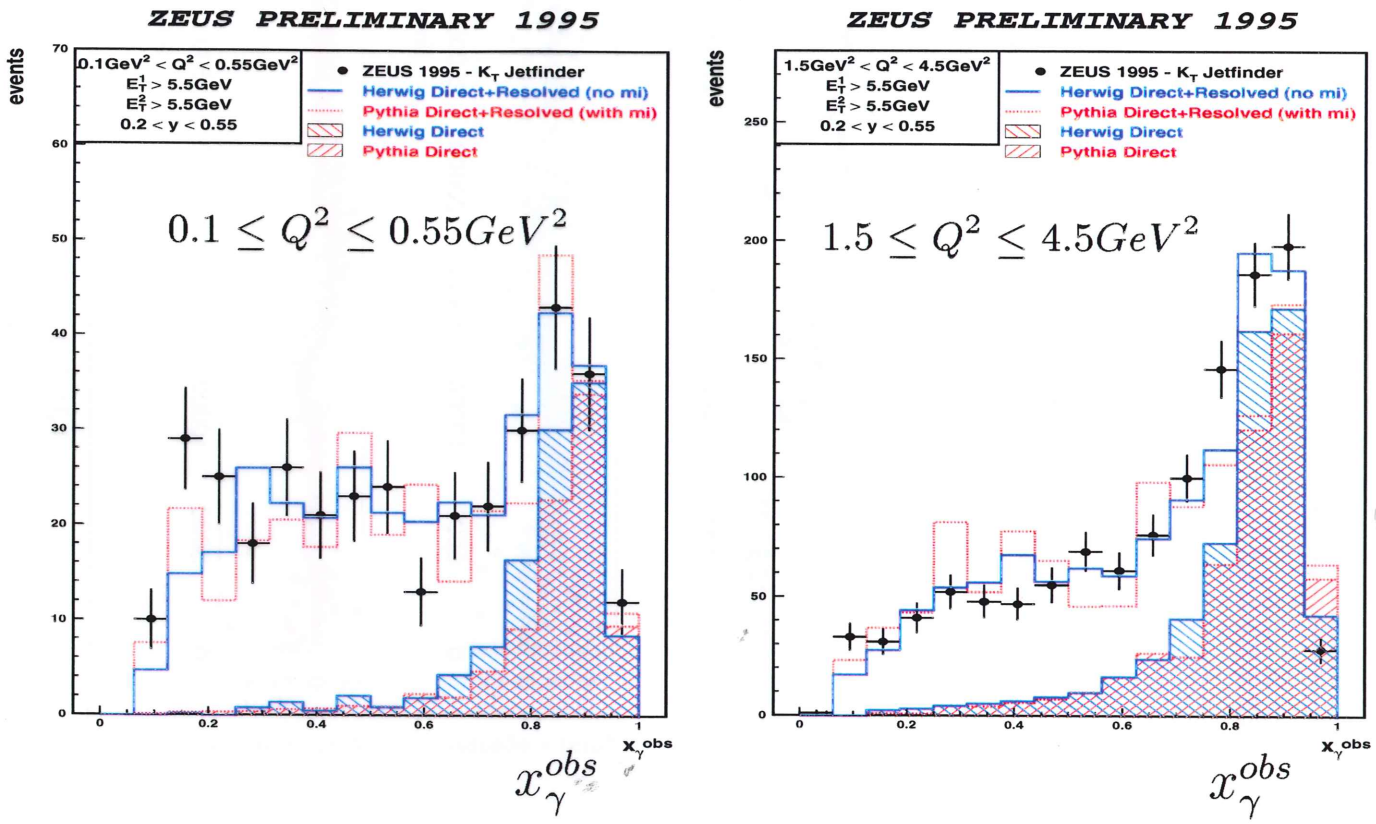
($x_\gamma = 1$ for *direct* process)

Triple Differential Dijet Cross-Section



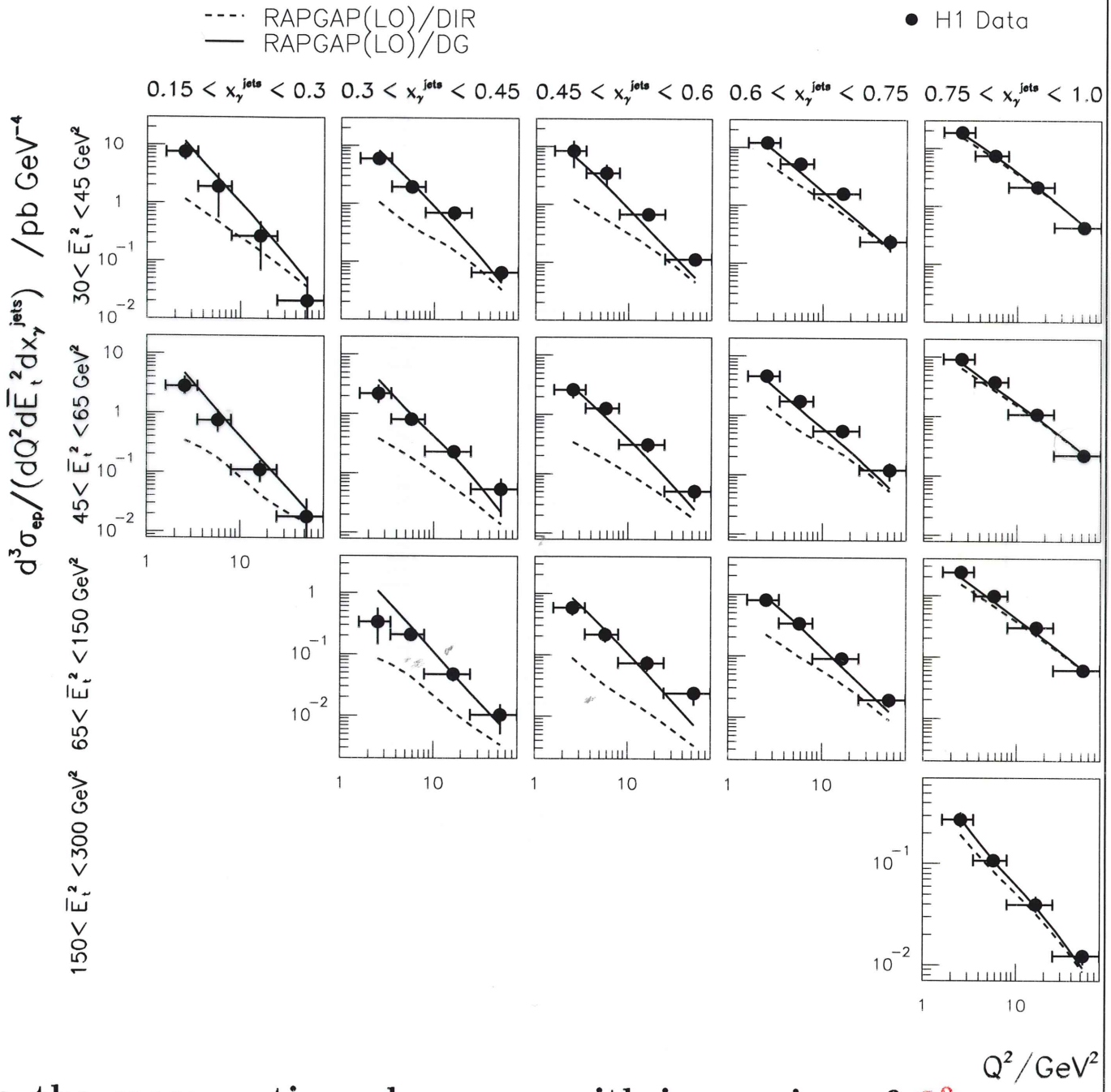
- cross-section decreases strongly with increasing Q^2 and $\bar{E}_t^2$
- significant resolved component is seen at $x_\gamma^{jets} < 0.75$
- as Q^2 increases the resolved component decreases
- there is a peak towards $x_\gamma^{jets} = 1$ (*direct* process)
- HERWIG (with suppres. factor L) describes the data

x_γ^{obs} vs Q^2



- At small Q^2 a significant resolved component should be included
- HERWIG and PYTHIA describe data satisfactorily with both component only
- the value $x_\gamma^{jets} = 0.75$ gives the optimal separation between the leading order *direct* and *resolved* events

Triple Differential Cross-Section



- the cross-sections decreases with increasing of Q^2
- the rate of decreasing is higher then expected for *direct* process
- observed dependence of cross-section is cosistent with that predicted for resolved virtual photon by QCD motivated models

Effective Parton Density for Virtual Photons

Single Effective Subprocess (SES) Approximation

$$\frac{d^5\sigma}{dy\,dx_\gamma\,dx_p\,d\cos\theta^*\,dQ^2} \sim$$

$$\sum_{k=T,L} \frac{f^k_{\gamma/e}(y,Q^2)}{y} \sum_{ij} \frac{f^k_{i/\gamma}(x_\gamma,P_t^2,Q^2)}{x_\gamma} \frac{f_{j/p}(x_p,P_t^2)}{x_p} |M_{ij}(\cos\theta^*)|^2$$

- $qg \to qg, gg \to gg, qq \to qq$ **have similar shapes**
- **differ mainly by colour factors**

The sum can be replaced by:

$$\frac{d^5\sigma}{dy\,dx_\gamma\,dx_p\,d\cos\theta^*\,dQ^2} \sim$$

$$\frac{f^T_{\gamma/e}(y,Q^2)}{y} \frac{\tilde{f}_\gamma(x_\gamma,P_t^2,Q^2)}{x_\gamma} \frac{\tilde{f}_p(x_p,P_t^2)}{x_p} |M_{SES}(\cos\theta^*)|^2$$

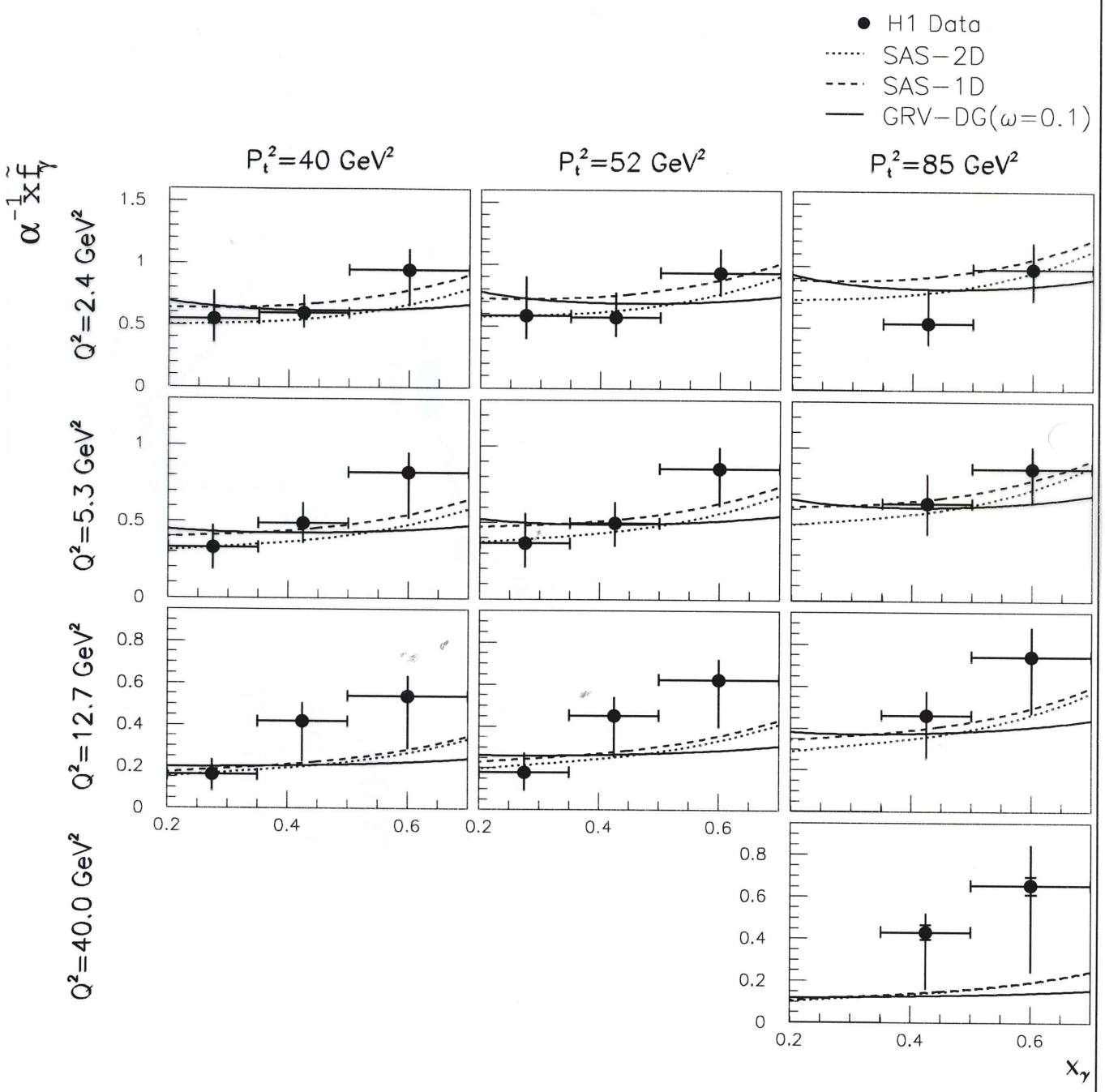
where the effective parton densities are :

$$\tilde{f}_\gamma(x_\gamma,P_t^2,Q^2) \equiv \sum_{n_f}(f_{q/\gamma}+f_{\bar{q}/\gamma}) + \frac{9}{4} f_{g/\gamma}$$

and

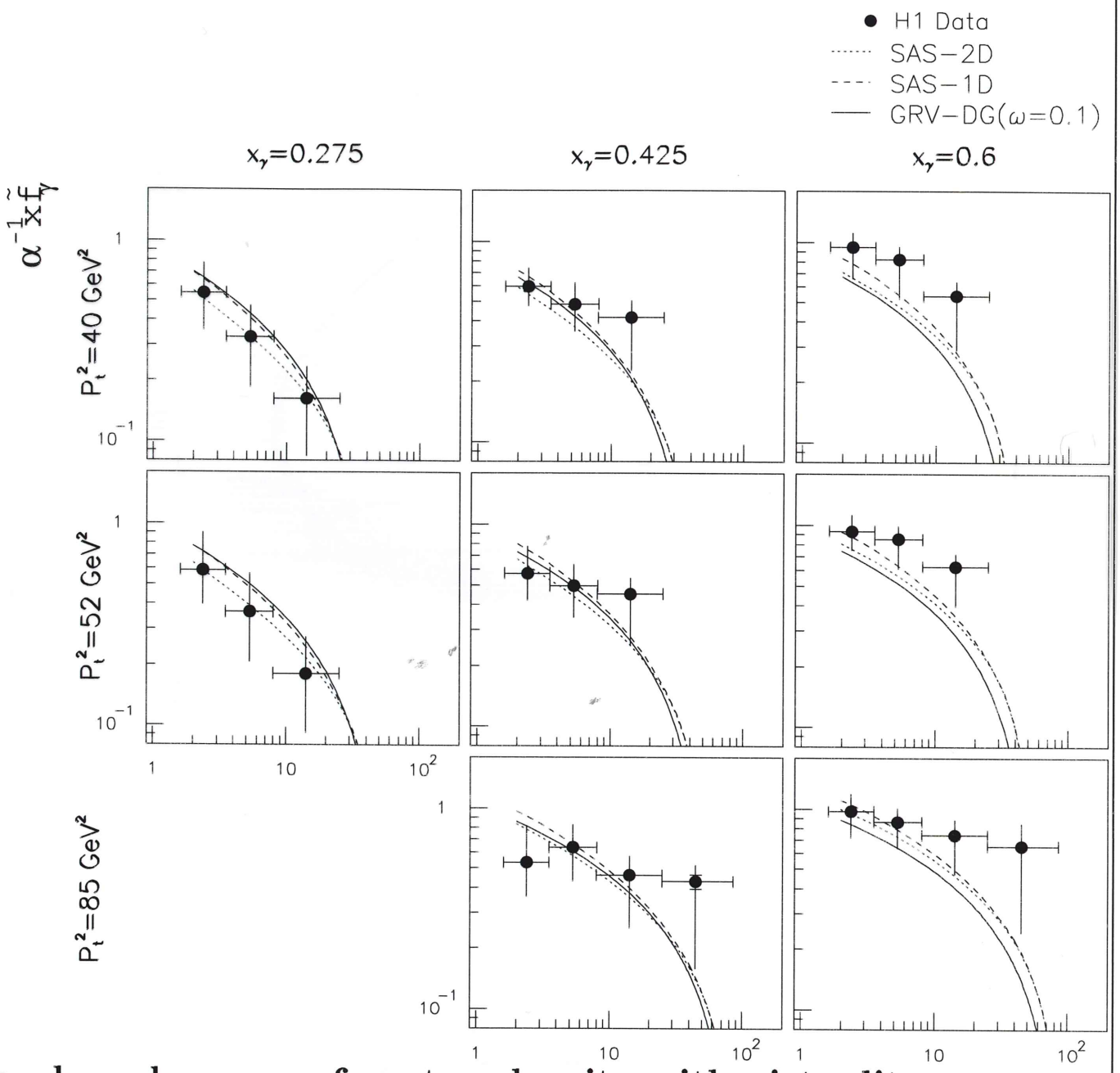
$$\tilde{f}_p(x_p,P_t^2) \equiv \sum_{n_f}(f_{q/p}+f_{\bar{q}/p}) + \frac{9}{4} f_{g/p}$$

Effective Parton Density of Photon vs x_γ



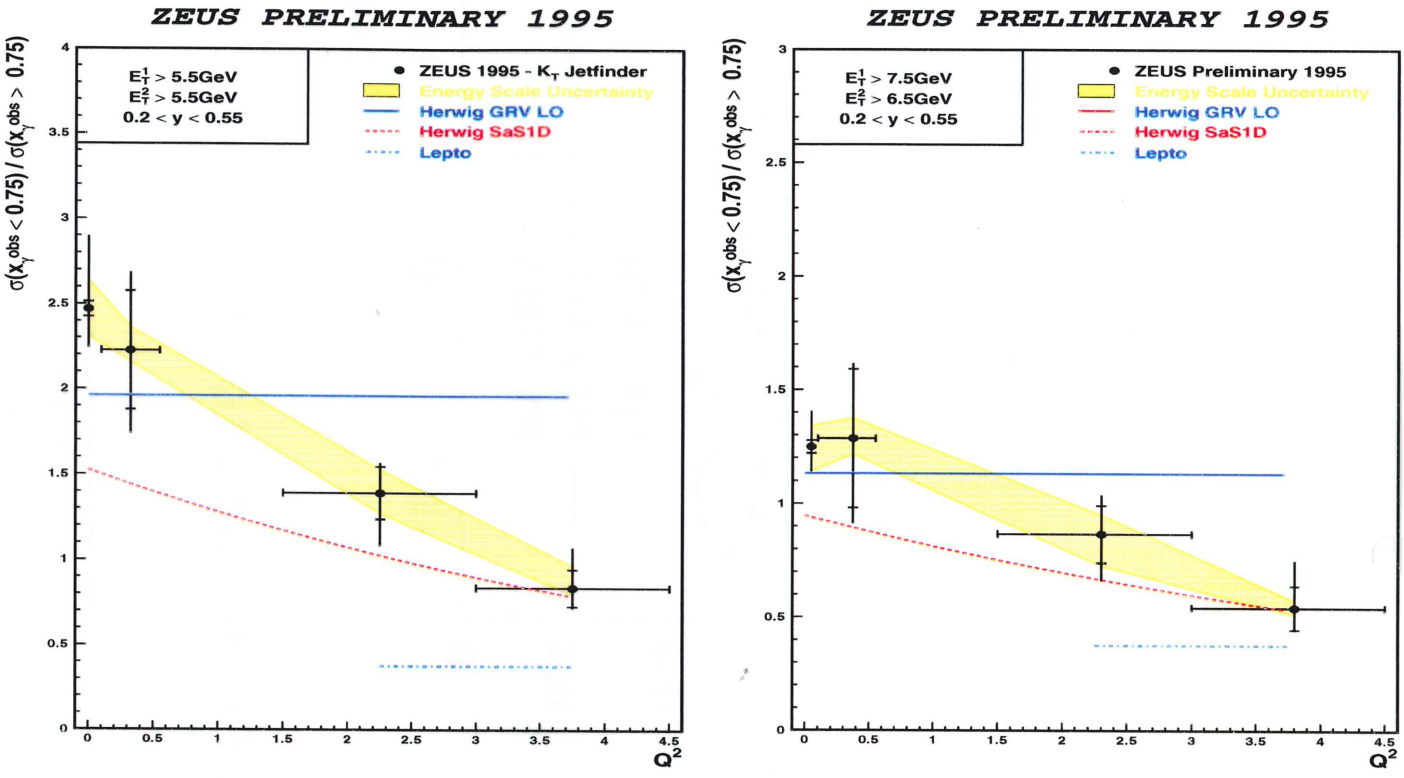
- effective parton density tends to rise with x_γ
- data are described by all models within errors except the highest Q^2

Effective Parton Density of Photon vs Q^2



- clear decrease of parton density with virtuality
- all models predict more rapid suppression with Q^2 as it seen in data
- when $Q^2 \to P_t^2$ non-leading terms expected to become more important

The ratio of *"resolved"* to *"direct"*



- x_γ < 0.75 - "resolved"
- x_γ > 0.75 - "direct"
- Some uncertainties are canceled in the ratio

Conclusion

- **Clear evidence is shown for virtual photon structure at $Q^2 < \bar{E}_t^2$ up to $Q^2 = 80\ GeV^2$**
- **Description of DIS events needs models where *resolved* processes are included**
- **The measurements are consistent with QCD prediction that as $Q^2 \to \bar{E}_t^2$ photon structure reduces to *direct* interaction**
- **Effective Parton Density of virtual photon is measured**