The Photon Structure at medium x and Q^2 in Deep Inelastic $\mathrm{e}\,\gamma$ Scattering at $\sqrt{s_{\mathrm{ee}}}$ = 91—172 GeV

Richard Nisius (CERN) May, 11 '97

Photon '97 Egmond aan Zee

- Introduction

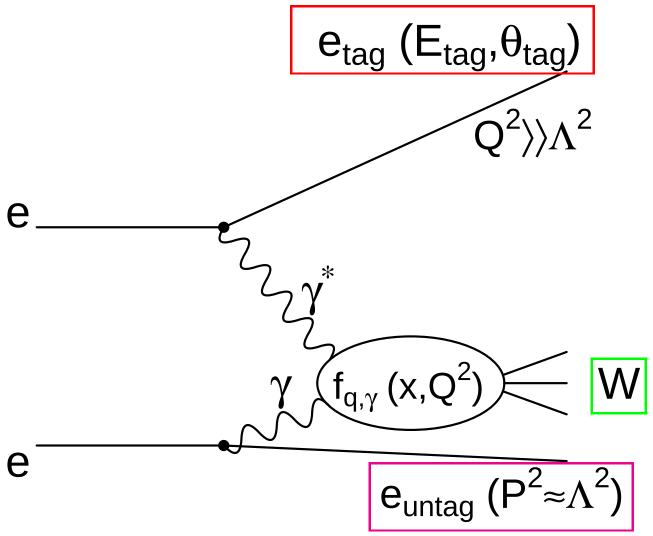
1. Hadronic final states

2. The structure function $F_2^\gamma(x, Q^2)$

- Conclusions

For the Collaboration

Electron-Photon Scattering



$$\frac{d^2\sigma_{e\gamma\rightarrow eX}}{dx dQ^2} = \frac{2\pi\alpha^2}{x\,Q^4}\cdot$$

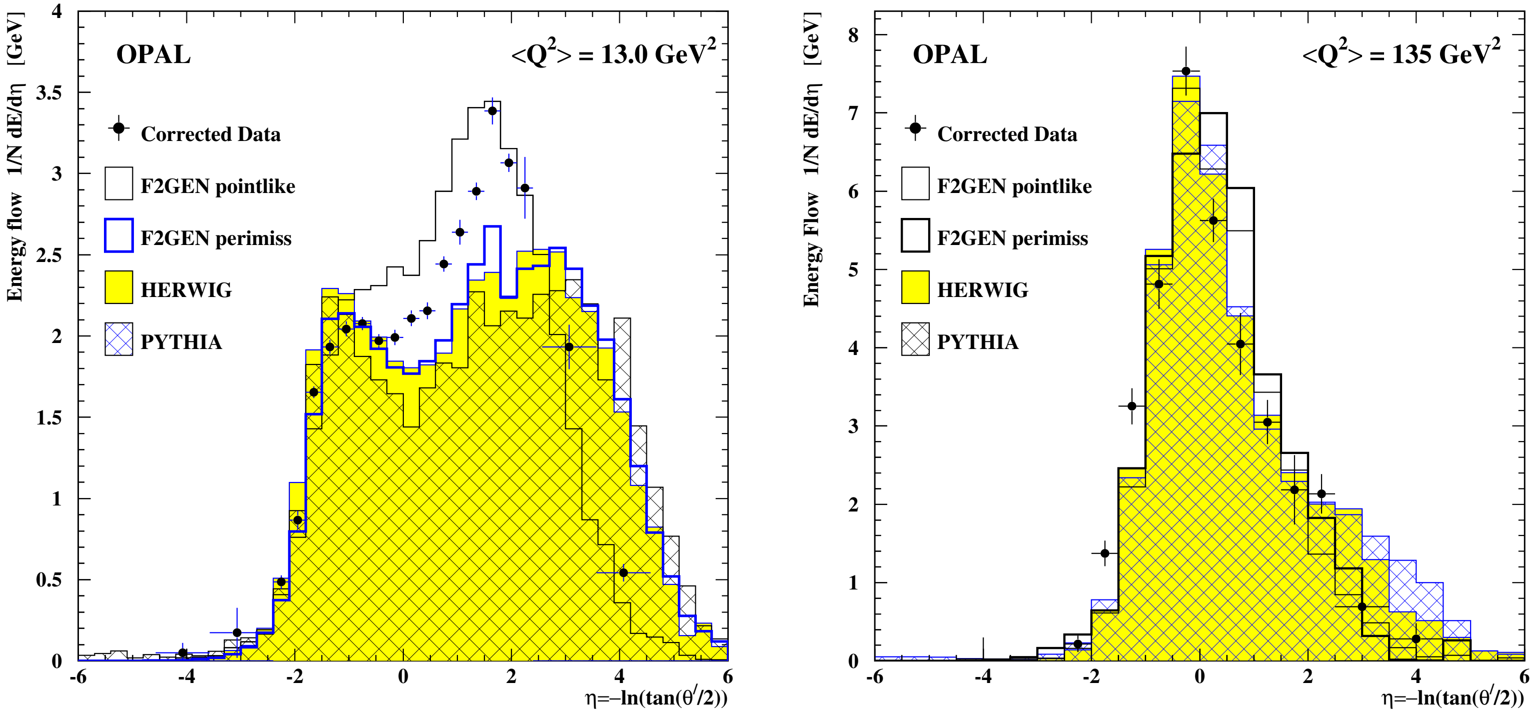
$$\left[(1+(1-y)^2)\,F_2^\gamma(x,Q^2) - \underbrace{y^2 F_L^\gamma(x,Q^2)}_{\rightarrow 0} \right]$$

$$Q^2 = 2\,E_\mathrm{b}\,E_\mathrm{tag}\,(1-\cos\theta_\mathrm{tag}) \gg P^2$$

$$x = \frac{Q^2}{Q^2+W^2+P^2}$$

$$y = 1-\frac{E_\mathrm{tag}}{E_\mathrm{b}}\cos^2(\frac{\theta_\mathrm{tag}}{2}) \ll 1$$

The corrected flow of hadronic energy

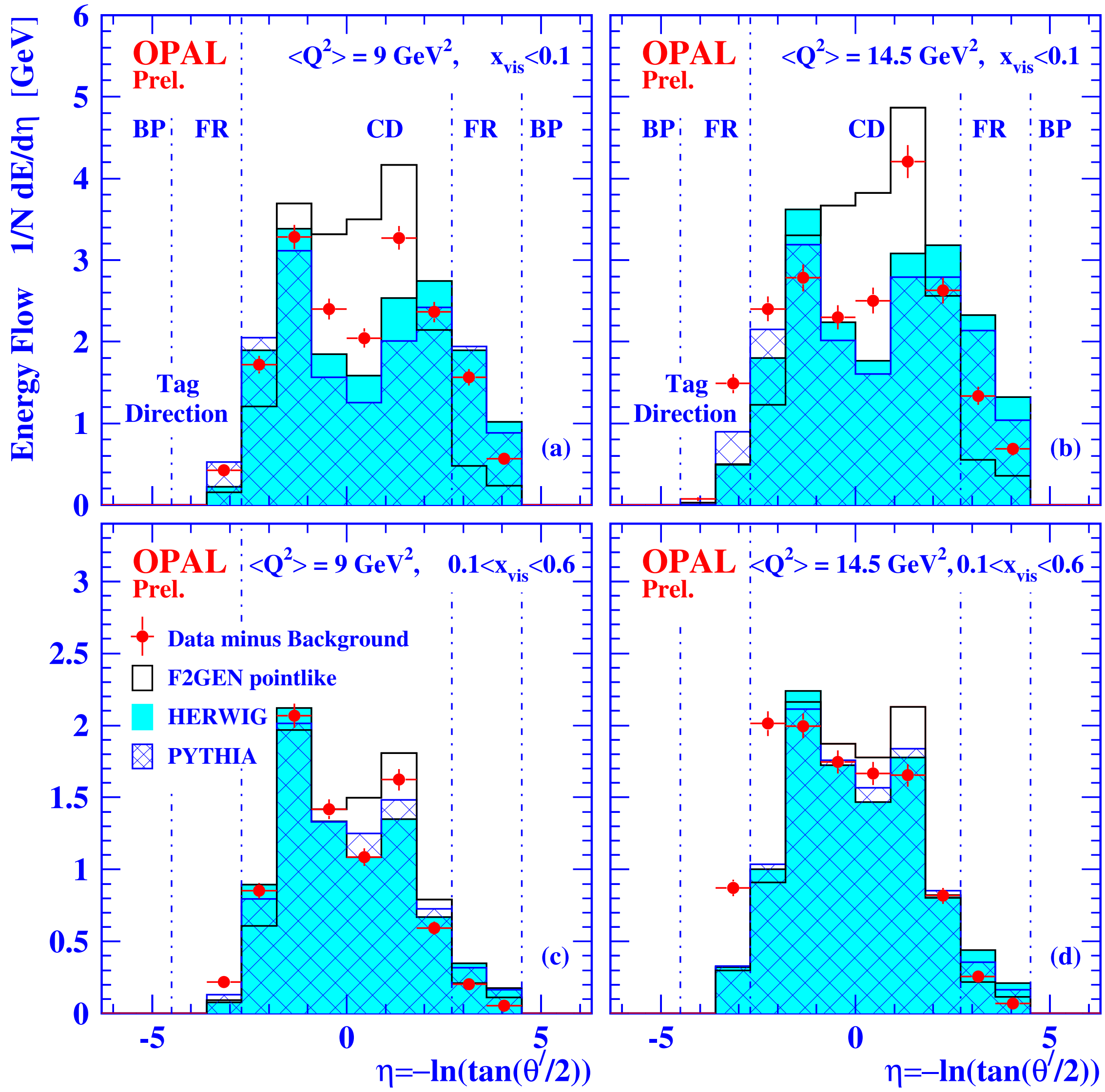


The description of the data by the Monte Carlo models is poor at low x and Q^2 and it improves for higher Q^2. The data, however, is precise enough to further constrain the models!

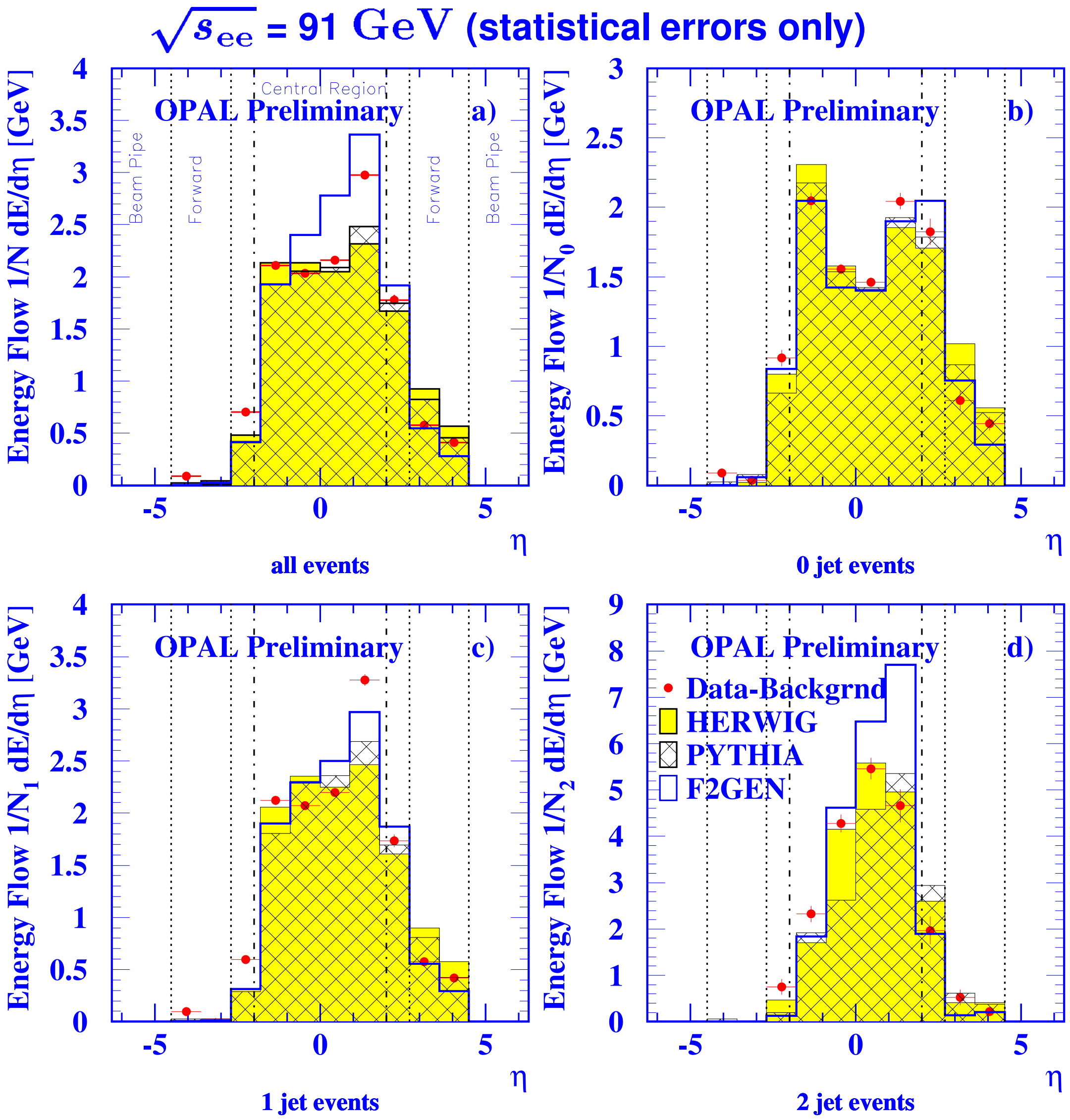
The hadronic energy flow

$\sqrt{s_{ee}}$ = 161 — 172 GeV (statistical errors only)

$(6 < Q^2 < 11)\,\mathrm{GeV}^2$ $(11 < Q^2 < 20)\,\mathrm{GeV}^2$



Energy flow for different jet classes



Sample	All Events	0 jet	1 jet	2 jet
OPAL	2516±53	773±30	1605±42	135±13
HERWIG	2288±32	777±19	1455±25	55± 5
PYTHIA	2154±27	706±16	1411±22	37± 4
F2GEN	2363±30	596±15	1435±24	332±11

Some words about unfolding

The Principle:

$$g^{\mathrm{det}}(u) = \int A(u,\omega)\, f^{\mathrm{part}}(\omega)\, d\omega + B(u)$$

1. Our case:
   $g^{\mathrm{det}}(u) = g^{\mathrm{det}}(x_{\mathrm{vis}}),\ \ x_{\mathrm{vis}} = f(E_{\mathrm{tag}}, \theta_{\mathrm{tag}}, W_{\mathrm{vis}})$
   and $f^{\mathrm{part}}(\omega) = f^{\mathrm{part}}(x)$ which is related to F_2^{γ}, $B(u)$ denotes the background events.

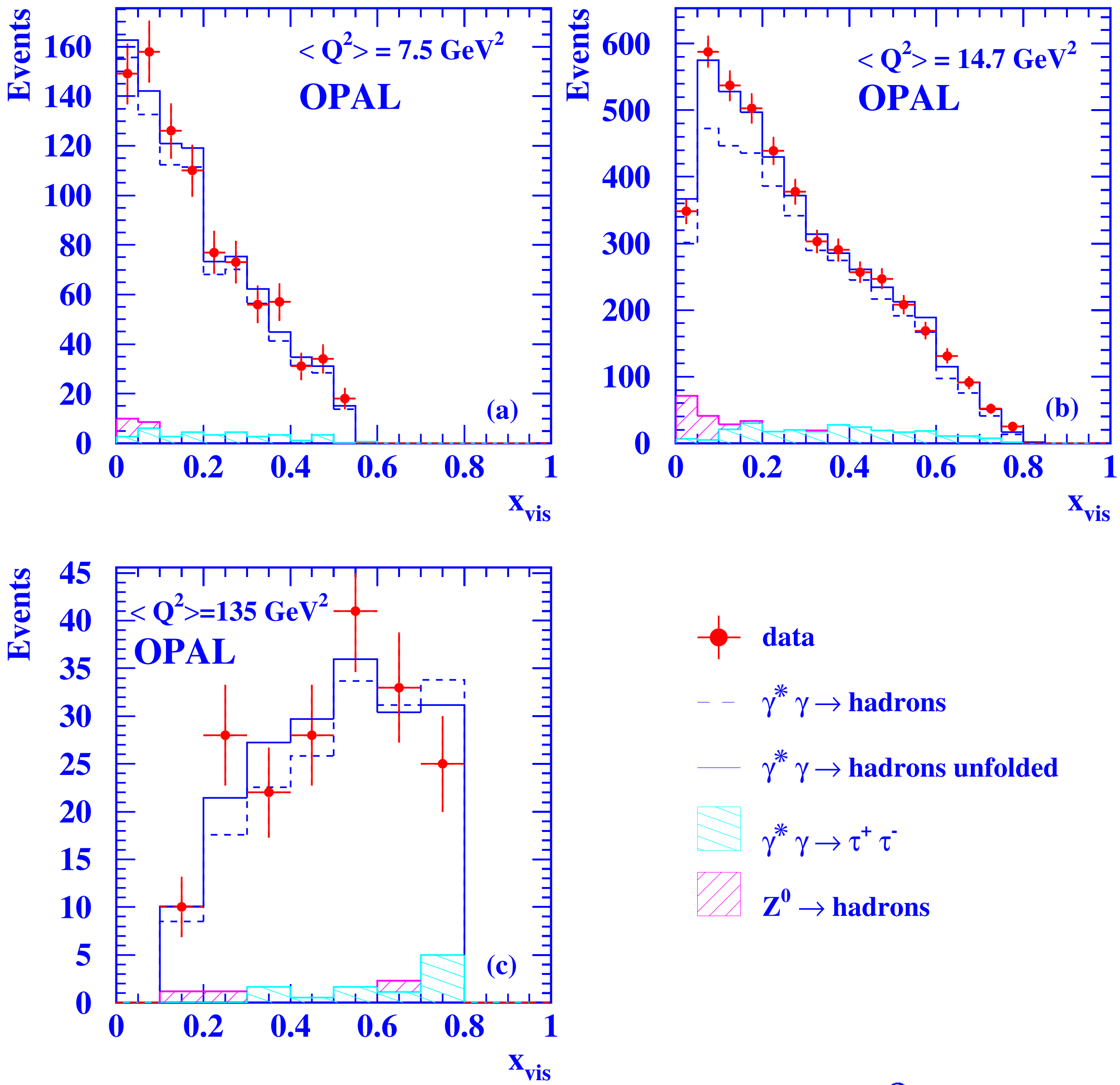
2. $A(u,\omega)$ has to be obtained from the Monte Carlo Models
   $\Rightarrow$ Model Dependence, consider all reasonable models.

3. The g^{det} (x_{vis}) distribution from the Monte Carlo is changed during unfolding, by assigning weights to each Monte Carlo event, in order to match the g^{det} (x_{vis}) distribution of the data.

   - After the unfolding the g^{det} (x_{vis}) distributions of data and Monte Carlo agree on a statistical basis.
   - Other distributions have to be used in order to check whether the unfolding has also improved on them, without using explicitly this variable.

4. The unfolding result should be independent of the F_2^{γ} used in the Monte Carlo. This is not true if F_2^{γ} and the $\gamma^{\star}\gamma$ fragmentation do not factorize.

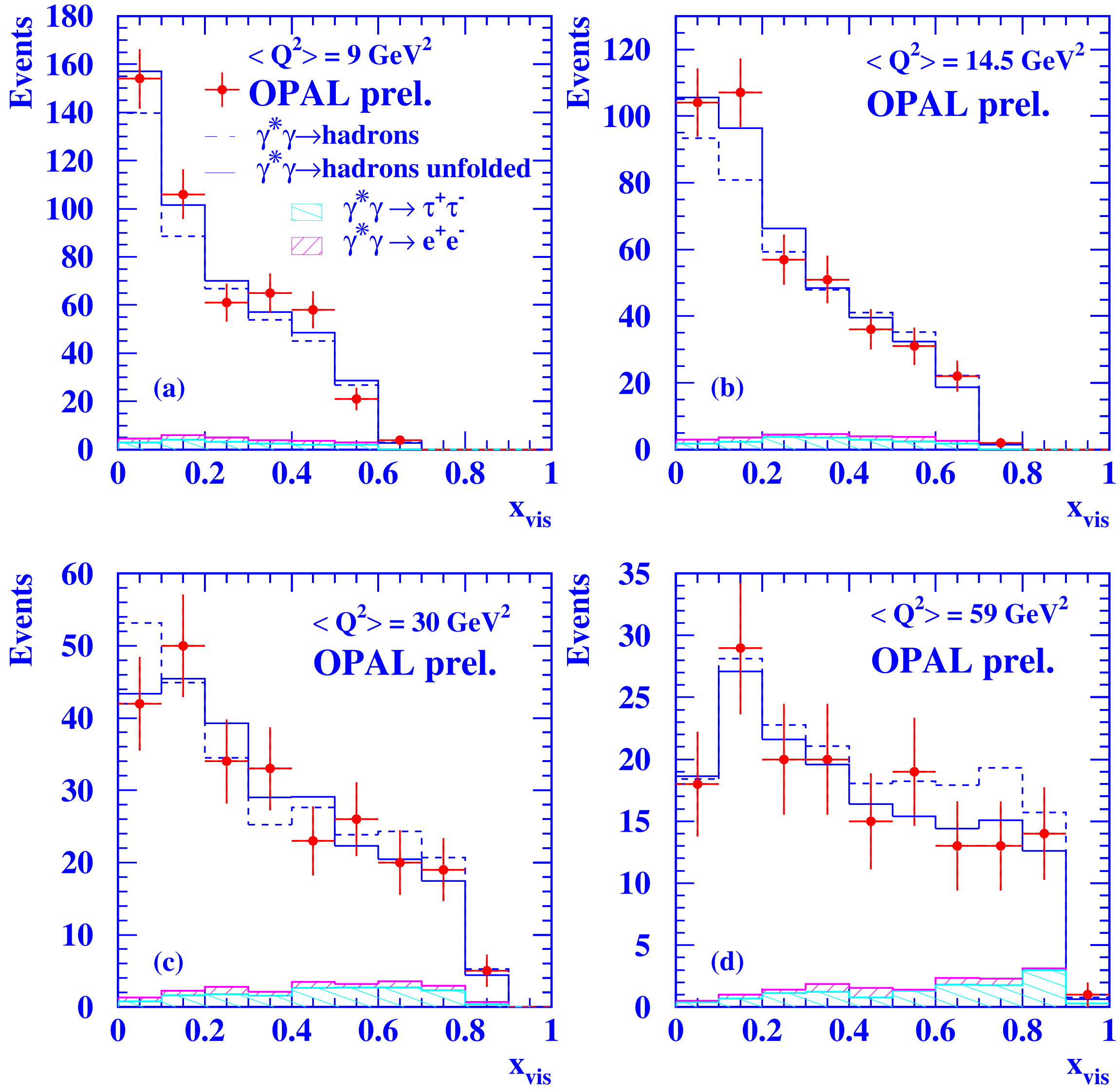
The $x_{\rm vis}$ distributions vs. HERWIG at $\sqrt{s_{\rm ee}}$ = 91 GeV



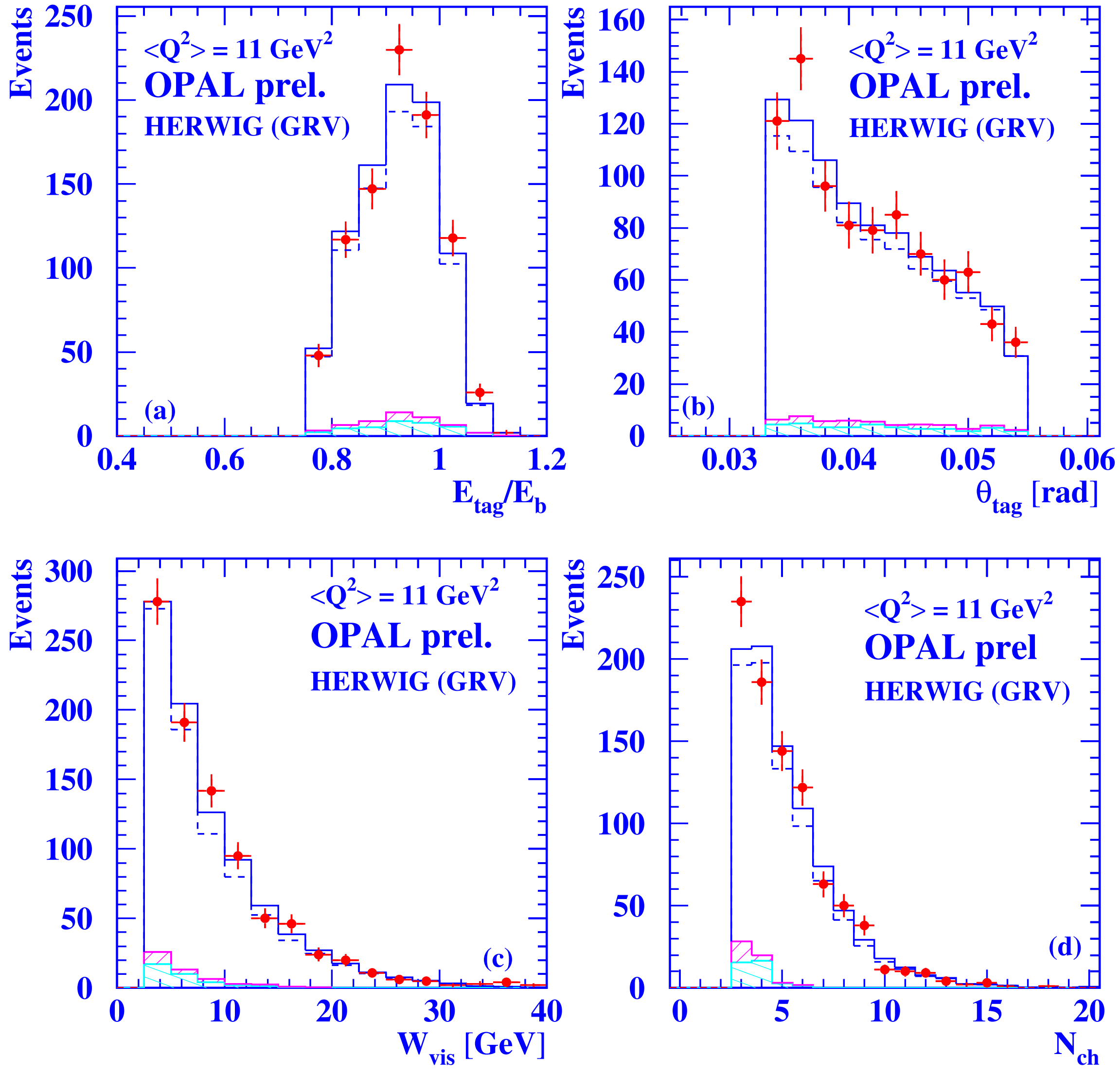
The mean $x_{\rm vis}$ increases with Q^2

The background contributions are small

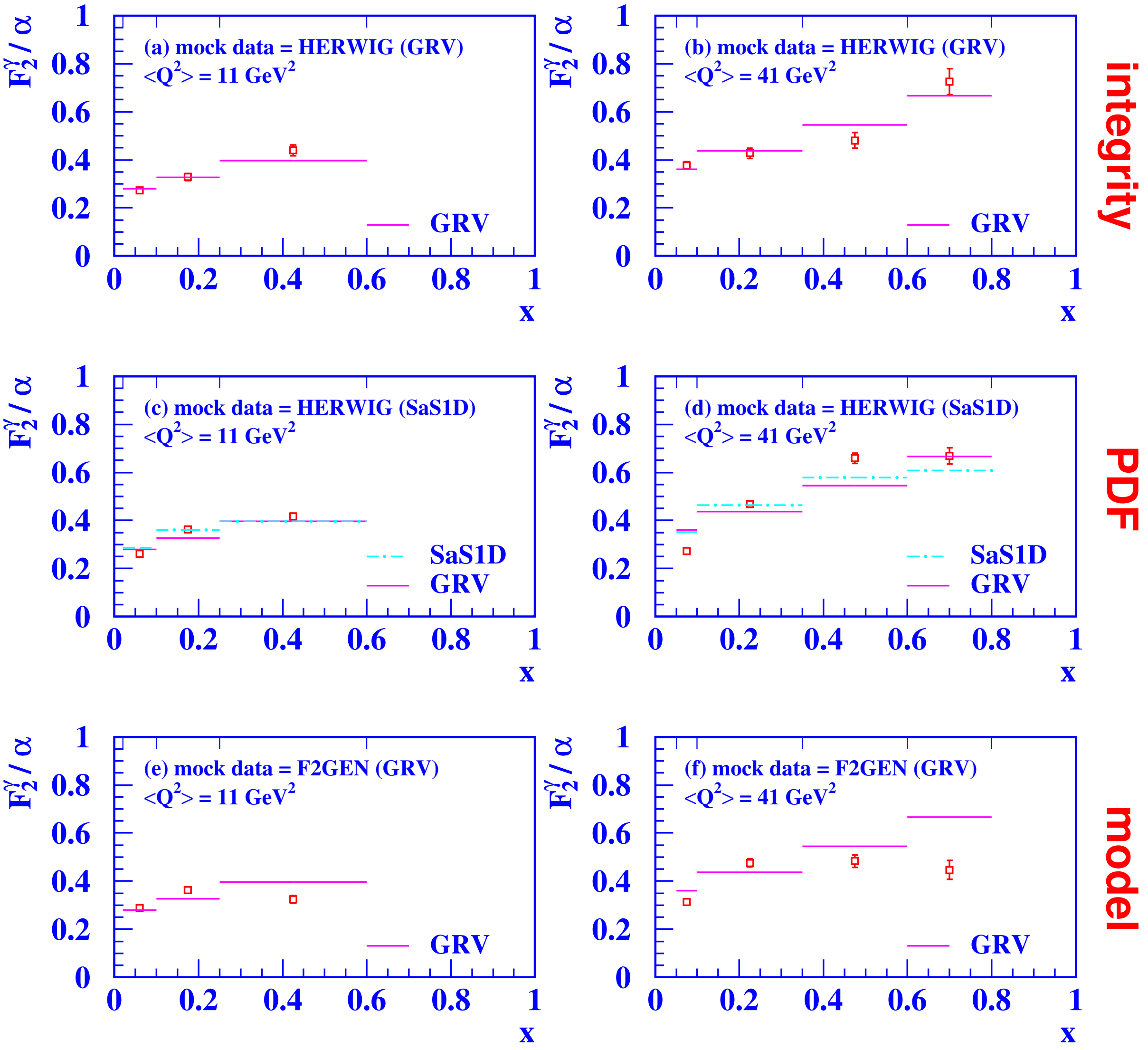
The $x_{\rm vis}$ distributions vs. HERWIG at $\sqrt{s_{\rm ee}}$ = 161—172 GeV



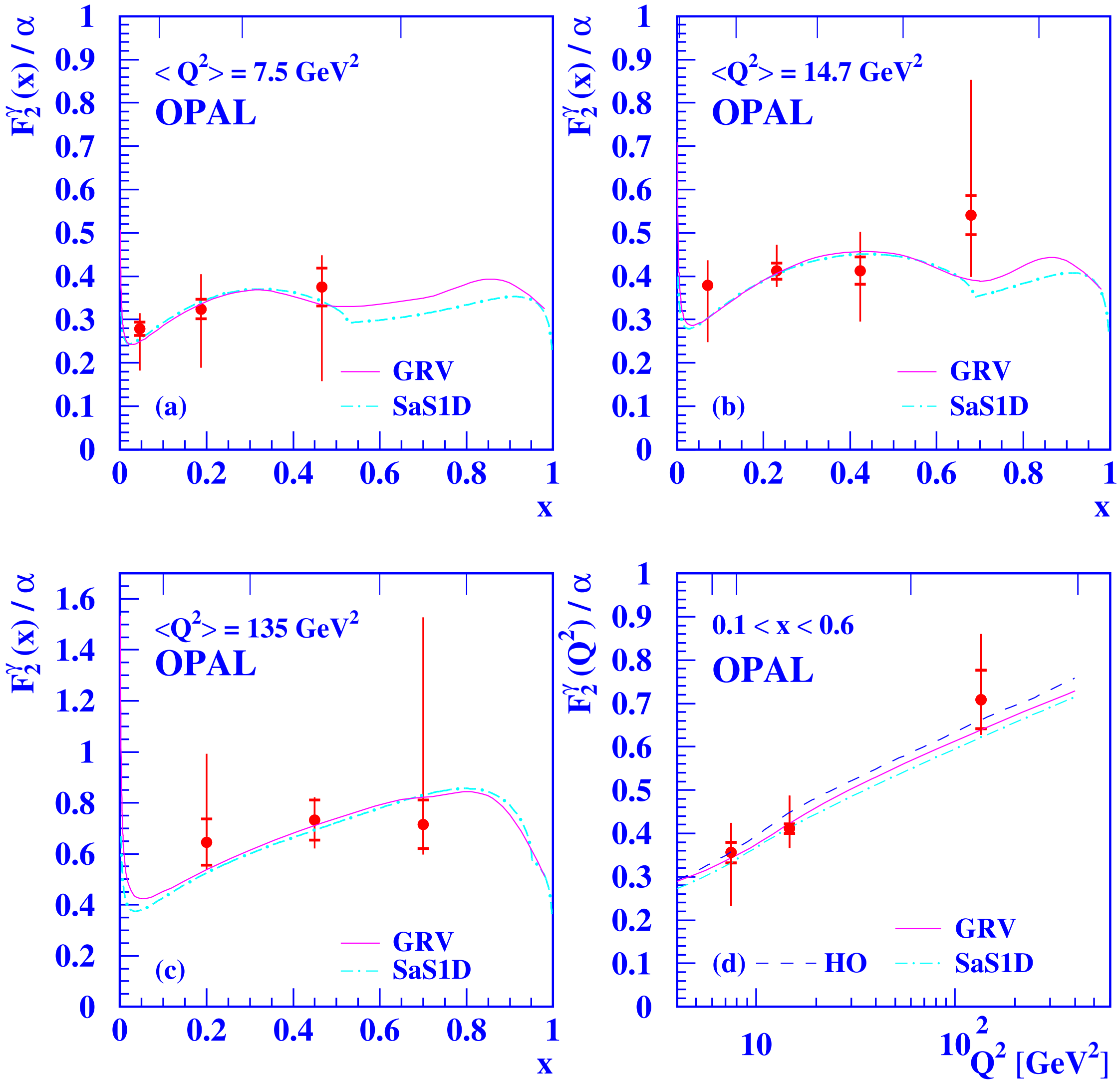
Global event kinematics



Some tests of the unfolding



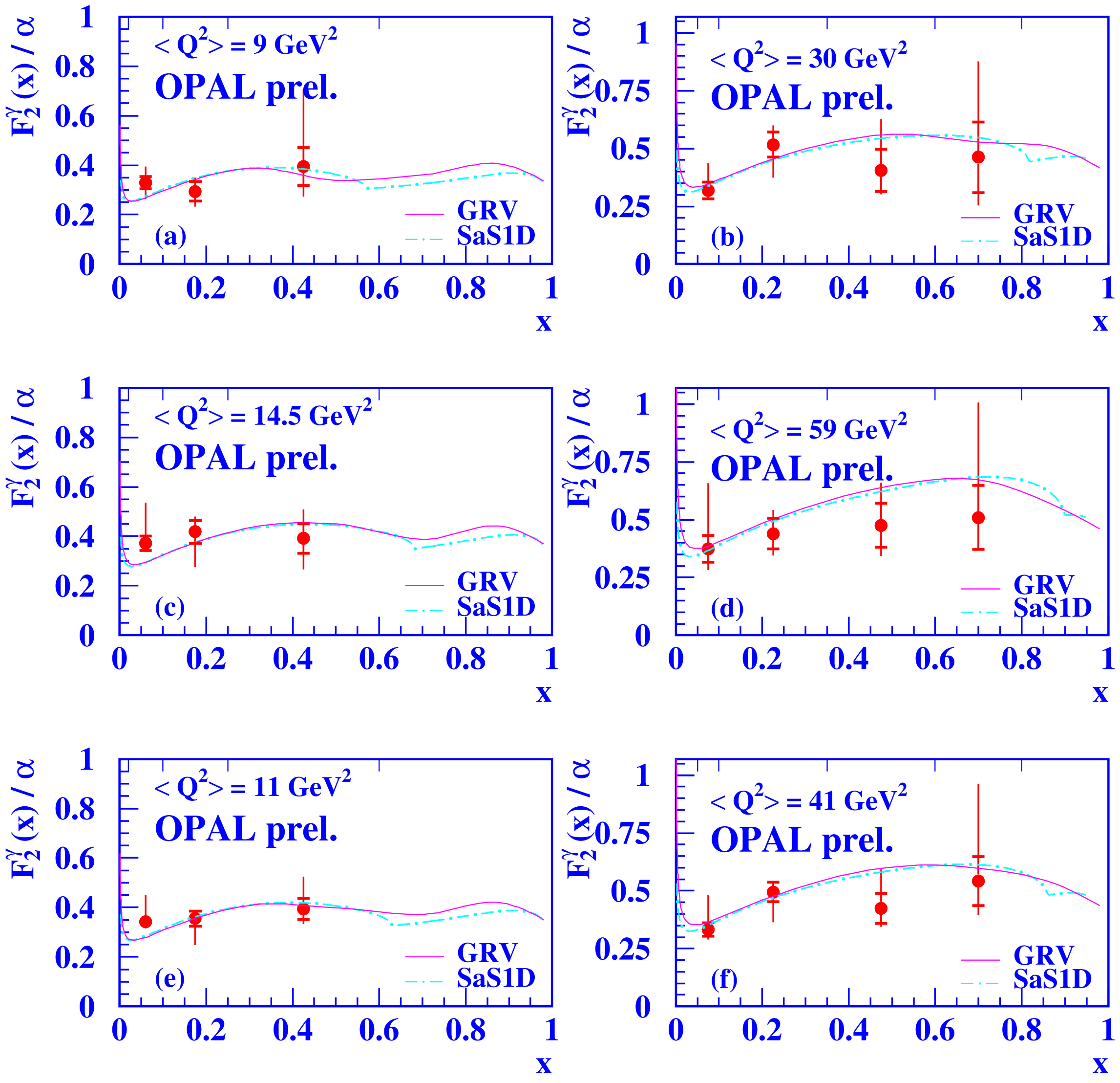
OPAL results on $F_2^\gamma(x, Q^2)$ at $\sqrt{s_{ee}} = M_{Z^0}$



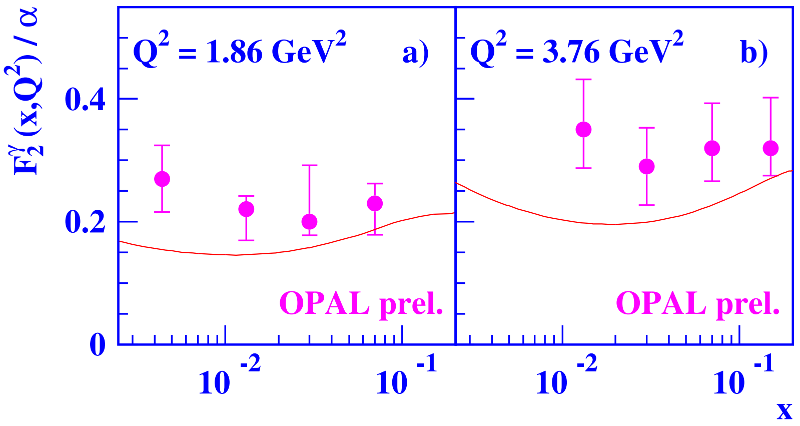
$$F_2^\gamma(Q^2)/\alpha = (0.08\,^{+0.13}_{-0.18}) + (0.13\,^{+0.06}_{-0.04})\ \ln Q^2$$

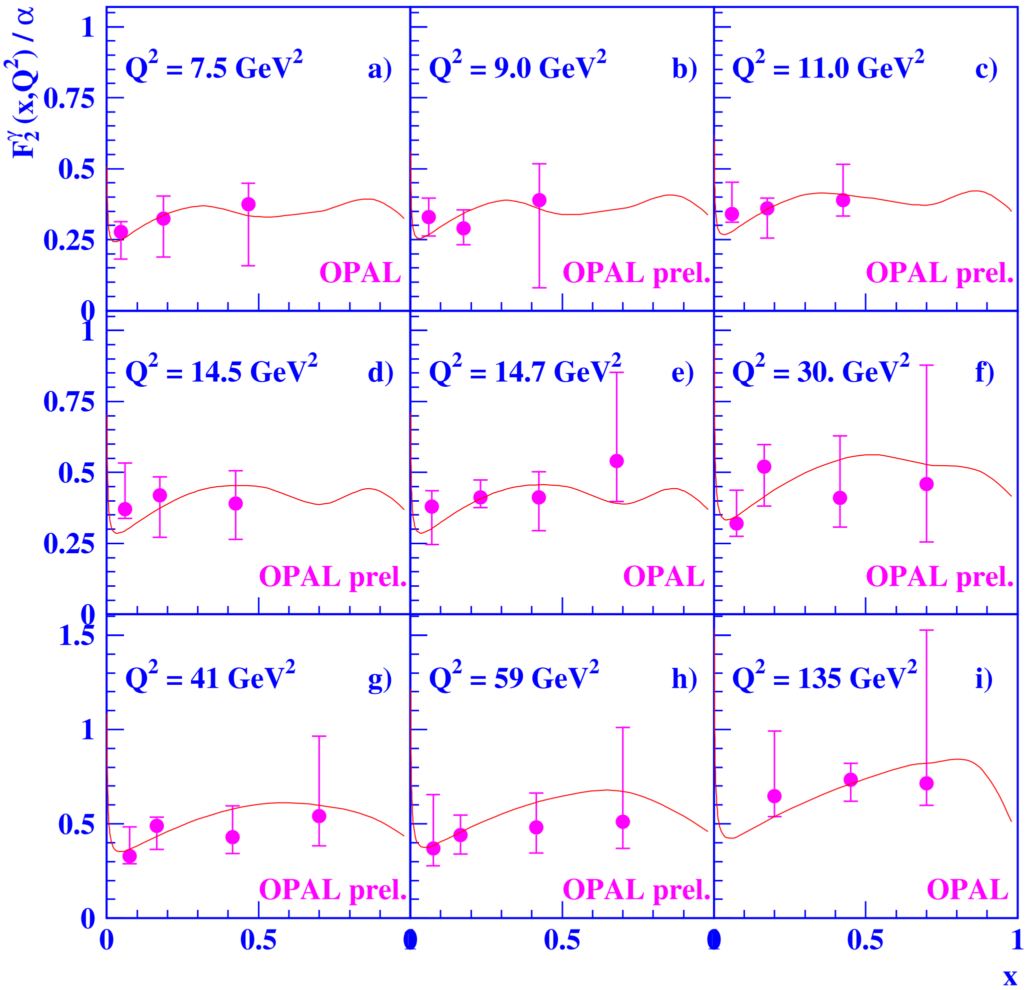
$\chi^2/\mathrm{dof} = 0.05 \quad Corr = -0.95$

The measurement of $F_2^\gamma(x,Q^2)$ at $\sqrt{s_{ee}}$ = 161—172 GeV

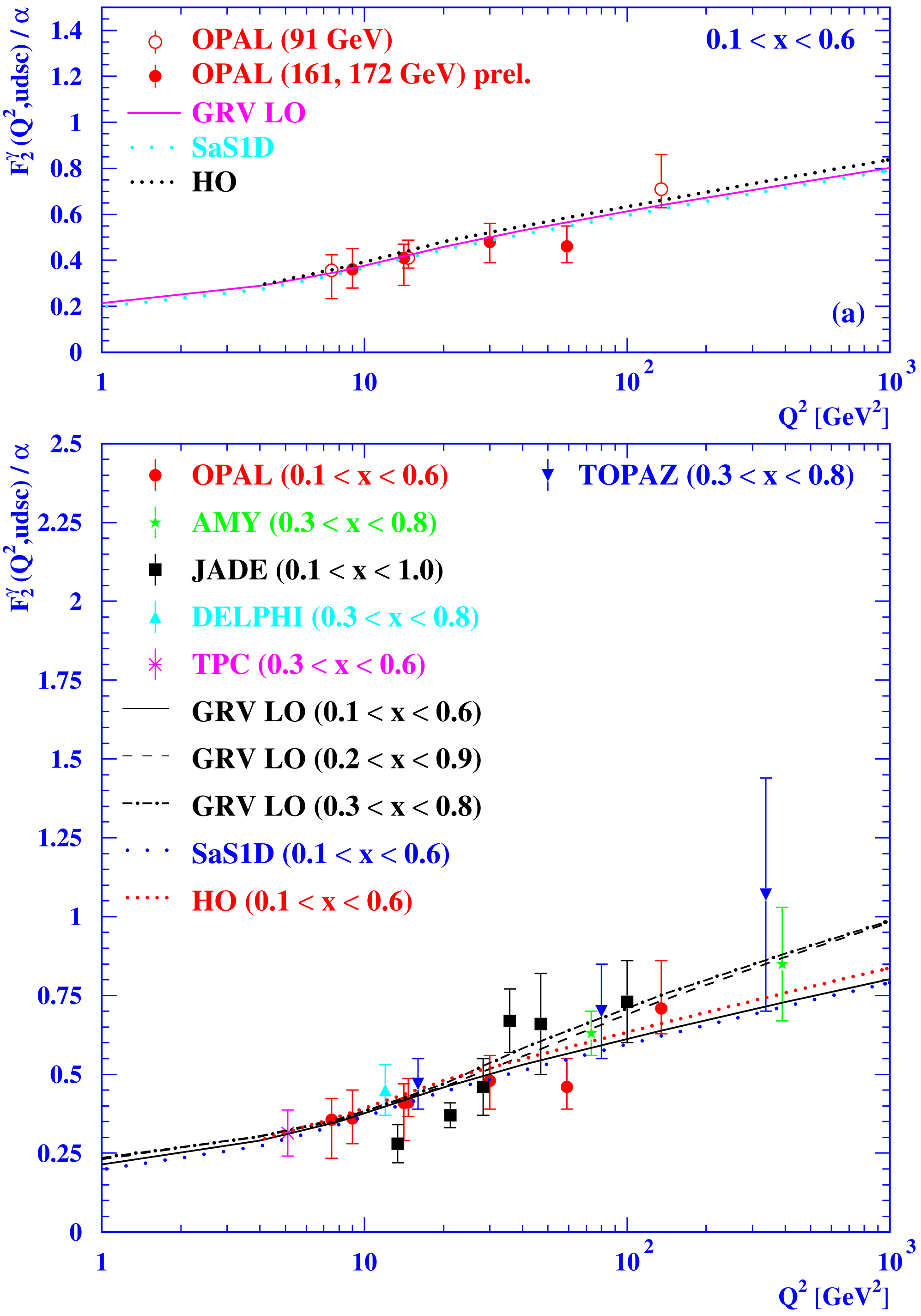


OPAL results on F_2^γ vs. GRV (LO)

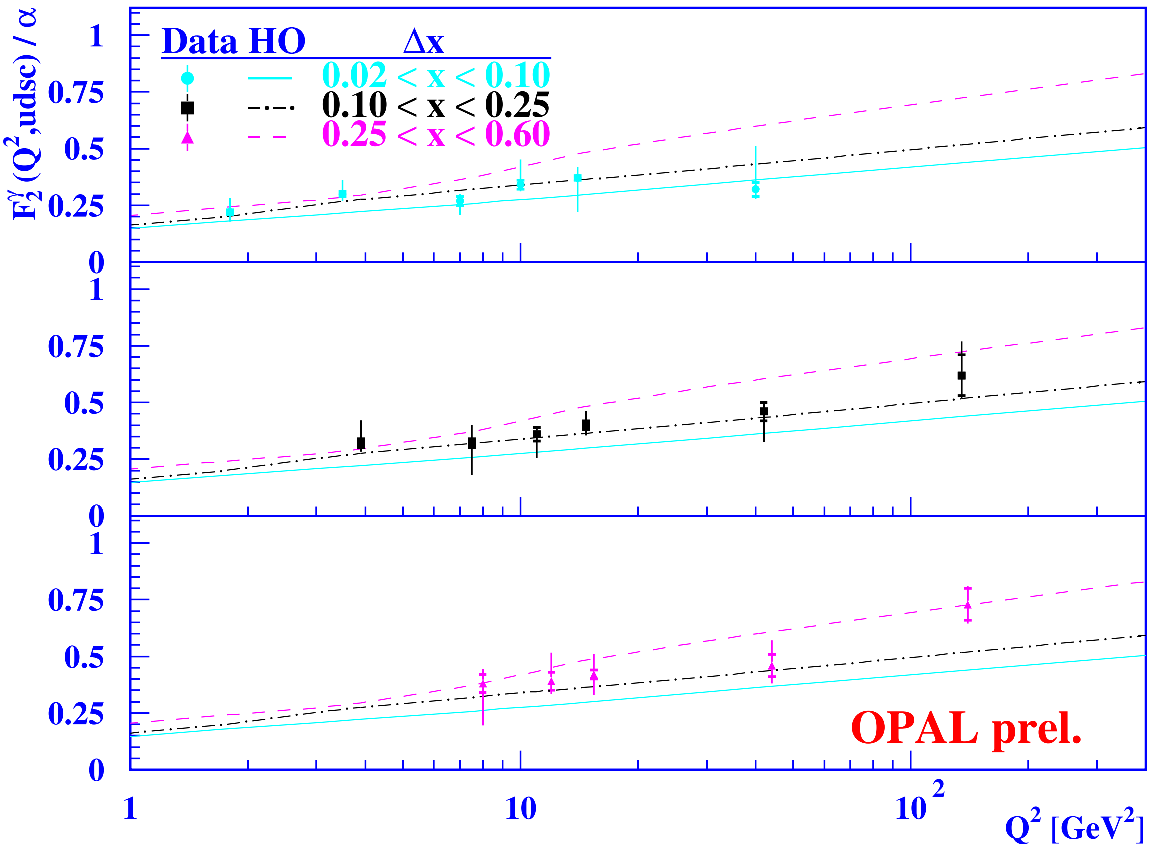




The Q^2 evolution of F_2^γ



Scaling violation as a function of x



Fit for: $0.1 < x < 0.6$ **and** $7.5 < \langle Q^2 \rangle < 135$

$\Downarrow$

$$F_2^\gamma(Q^2)/\alpha = (0.16 \pm 0.05^{+0.17}_{-0.16}) + (0.10 \pm 0.02^{+0.05}_{-0.02}) \ln \frac{Q^2}{\mathrm{GeV}^2}$$

Conclusions

1. For the hadronic final state significant differences are observed between the energy flow and jet rates of the data and the predictions of the Monte Carlo models.

2. The dependence of $F_2^\gamma(x, Q^2)$ on x has been measured in seven bins in Q^2 with mean values ranging from 7.5 to 135 GeV^2. In this range the F_2^γ based on the GRV and SaS1D parametrisations are found to be consistent with the OPAL data.

3. Using the OPAL data alone the evolution of F_2^γ with Q^2 was measured. The result
$$\boxed{\mathrm{d}(F_2^\gamma/\alpha)/\mathrm{d}\ln Q^2 = 0.10 \pm 0.02^{+0.05}_{-0.02}}$$
shows a slope significantly different from zero. At present the accuracy of the data is insufficient to observe a variation of the scaling violation with x.

...and

Outlook for

Photon '99

1. LEP2 data with $\mathcal{L}_{int} \geq 200\,\mathrm{pb}^{-1}$

2. $F_2^\gamma(x, Q^2)$ for $Q^2 \geq 500\,\mathrm{GeV}^2$

3. ...?

slides:
http://wwwcn1.cern.ch/~nisius/talks/EGMD110597/index.html