Analysis of Hadronic Final States and the Photon Structure Function $F_2^\gamma(x, Q^2)$ in Deep Inelastic Electron-Photon Scattering at LEP

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DPF 96, Minneapolis

- Introduction

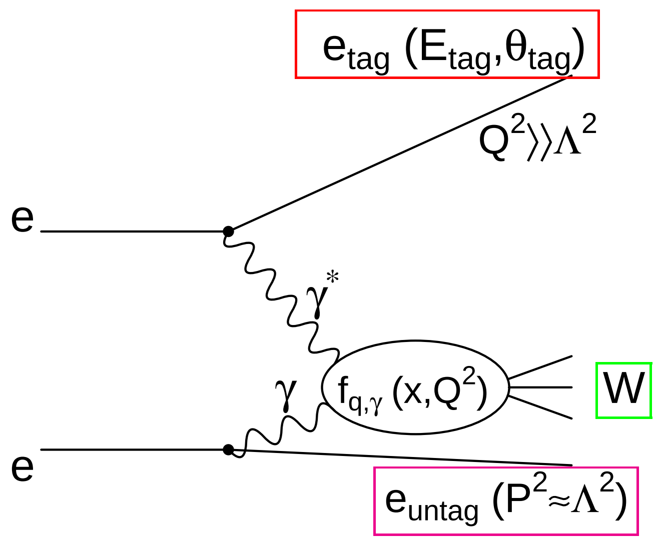
1. Hadronic final states

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

- Conclusions

For the OPAL Collaboration

Electron-Photon Scattering



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

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

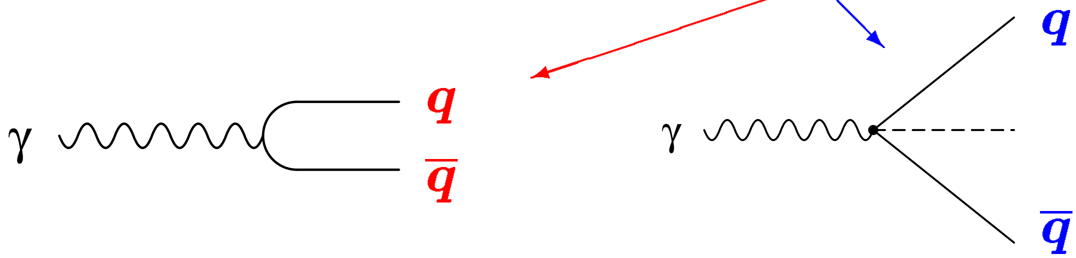
$$Q^2 = 2\,E_b\,E_{tag}\,(1-\cos\theta_{tag}) \gg P^2$$

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

$$y = 1-\frac{E_{tag}}{E_b}\cos^2\left(\frac{\theta_{tag}}{2}\right) \ll 1$$

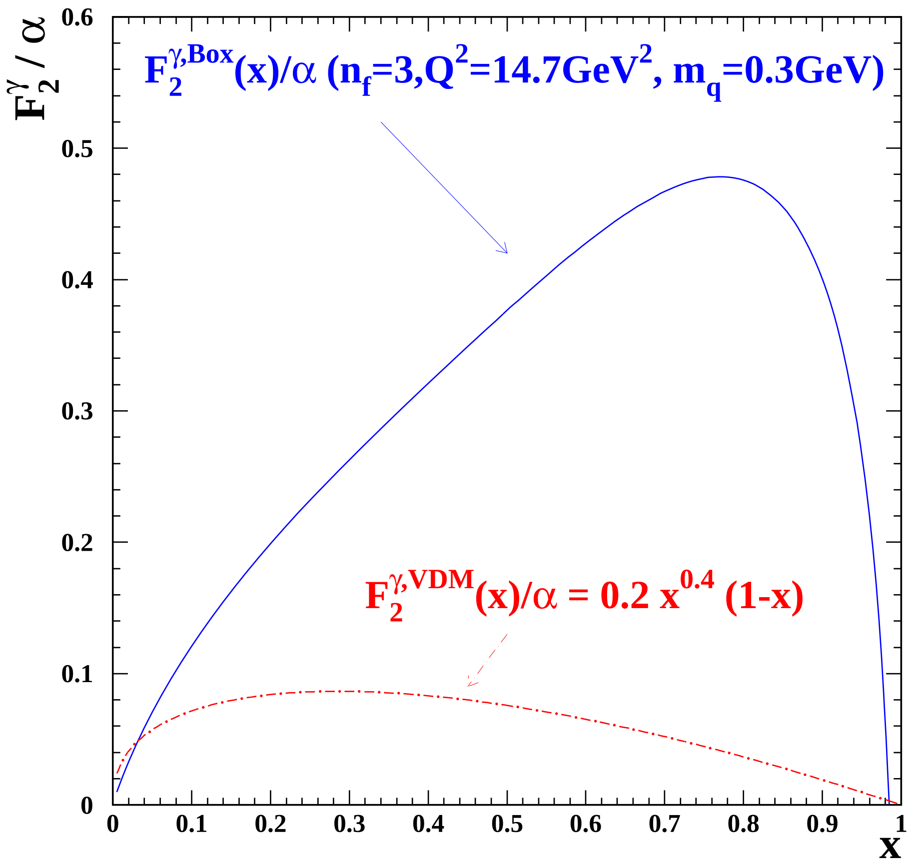
The contributions to $F_2^\gamma(x, Q^2)$

$$F_2^\gamma(x,Q^2) = x \sum_{c,f} e_q^2 \, f_{q,\gamma}(x,Q^2)$$

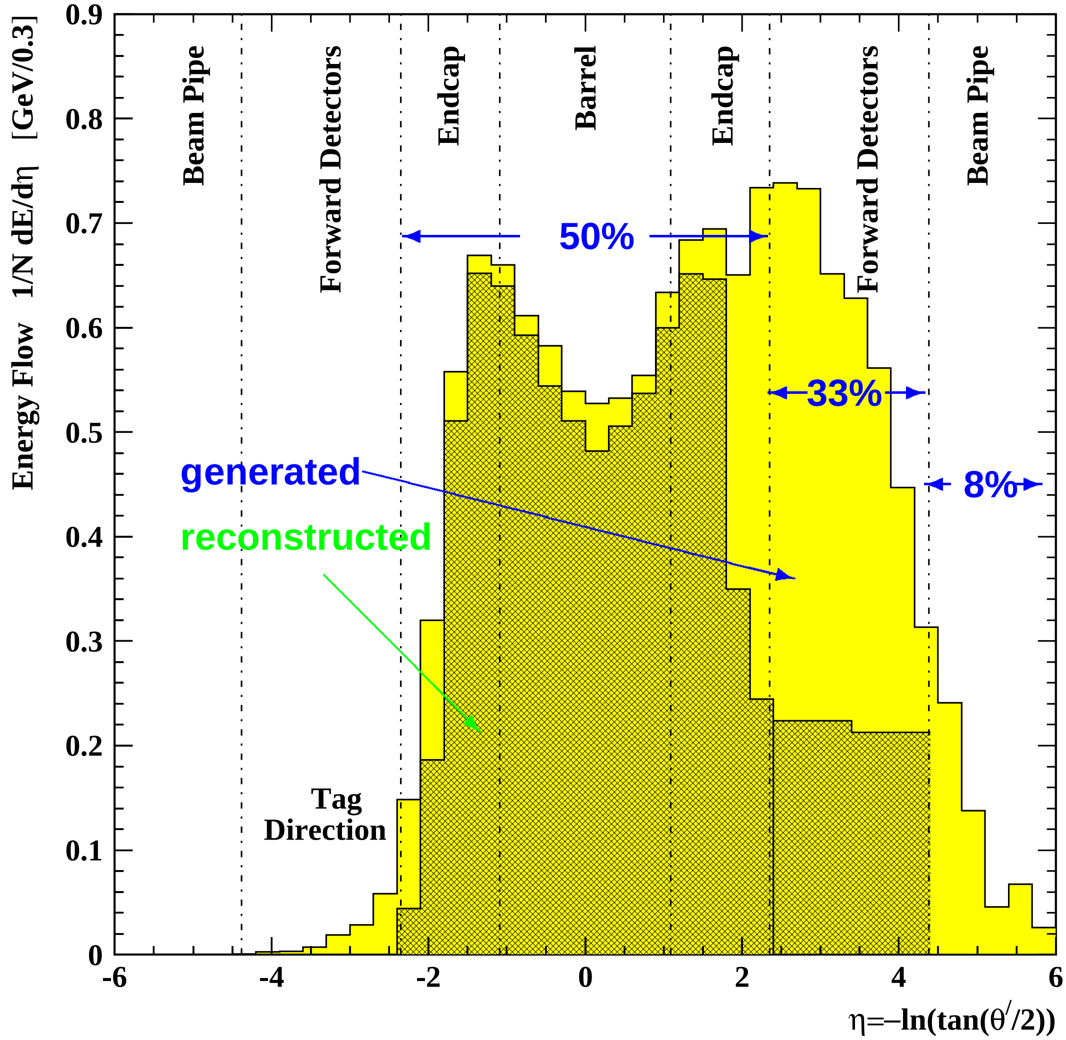


hadronic, VDM, p_T = "small" — **pointlike, p_T = "large"**

ρ, ω, ϕ, *non–perturbative* — *perturbative*

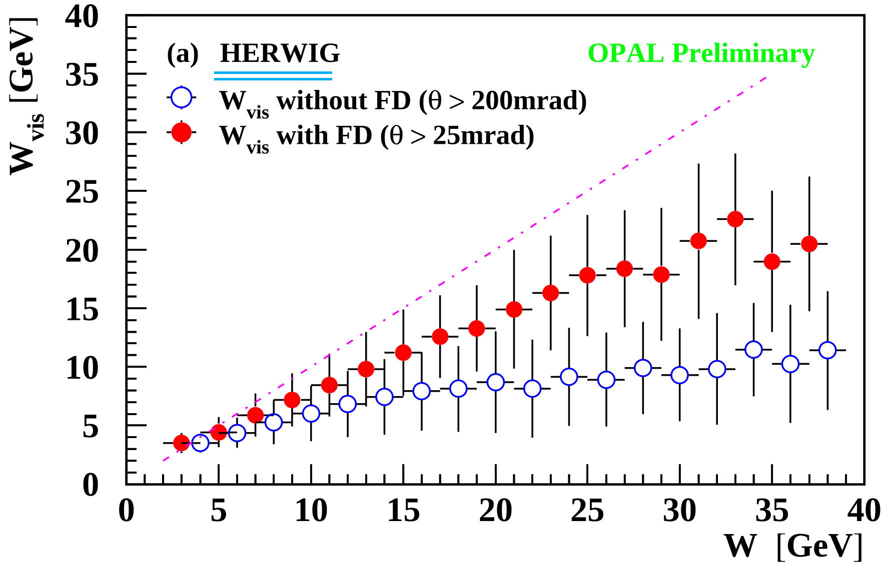


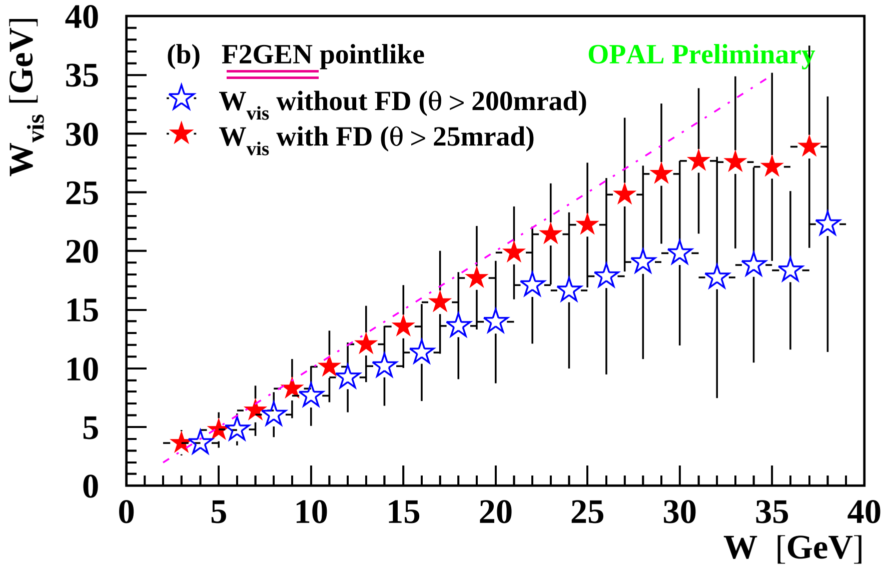
The hadronic Energy Flow from HERWIG



Only about 10% of the energy is deposited outside of the detector acceptance

The W – W_{vis} correlation



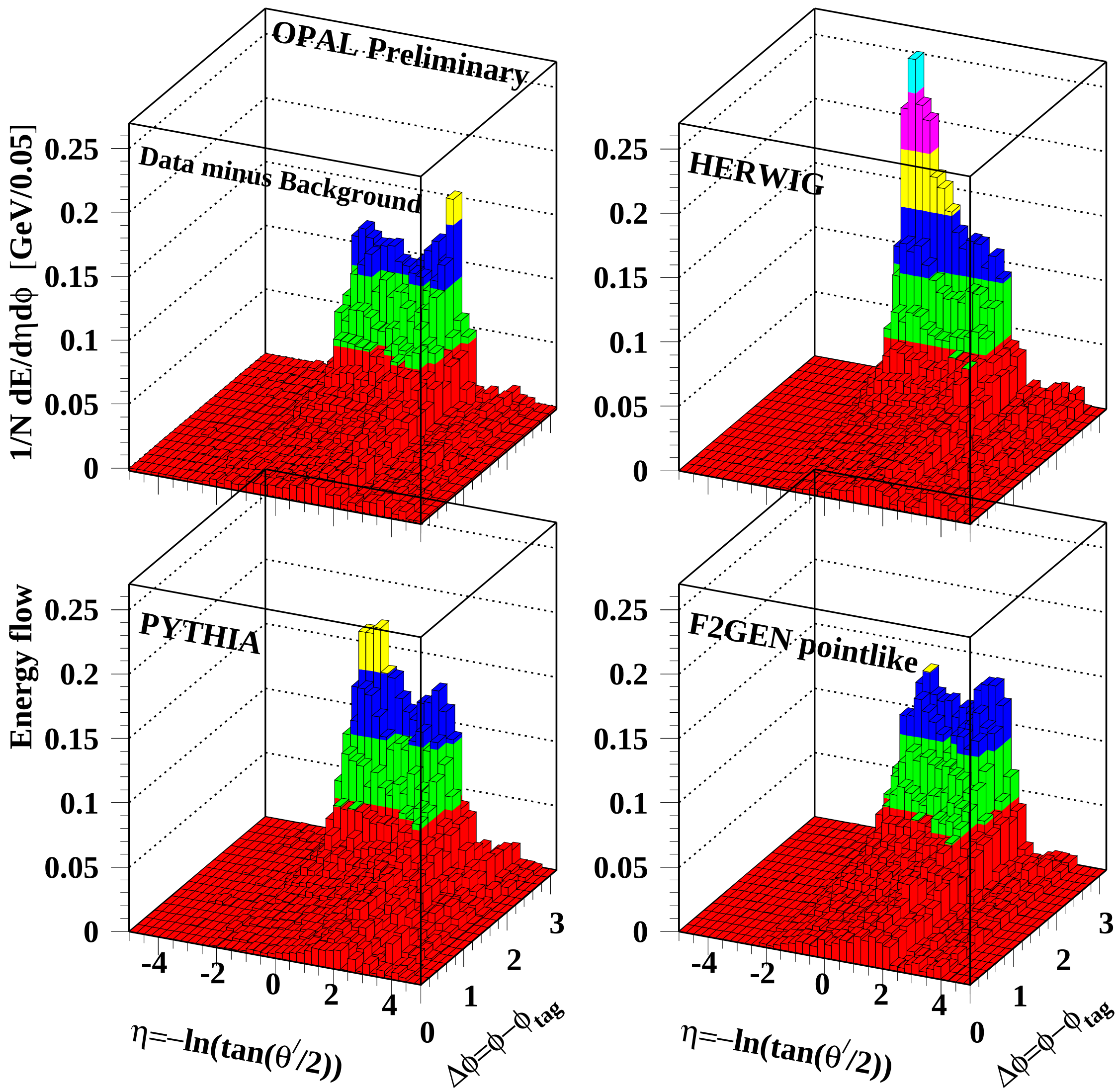


The correlation based on F2GEN is much stronger

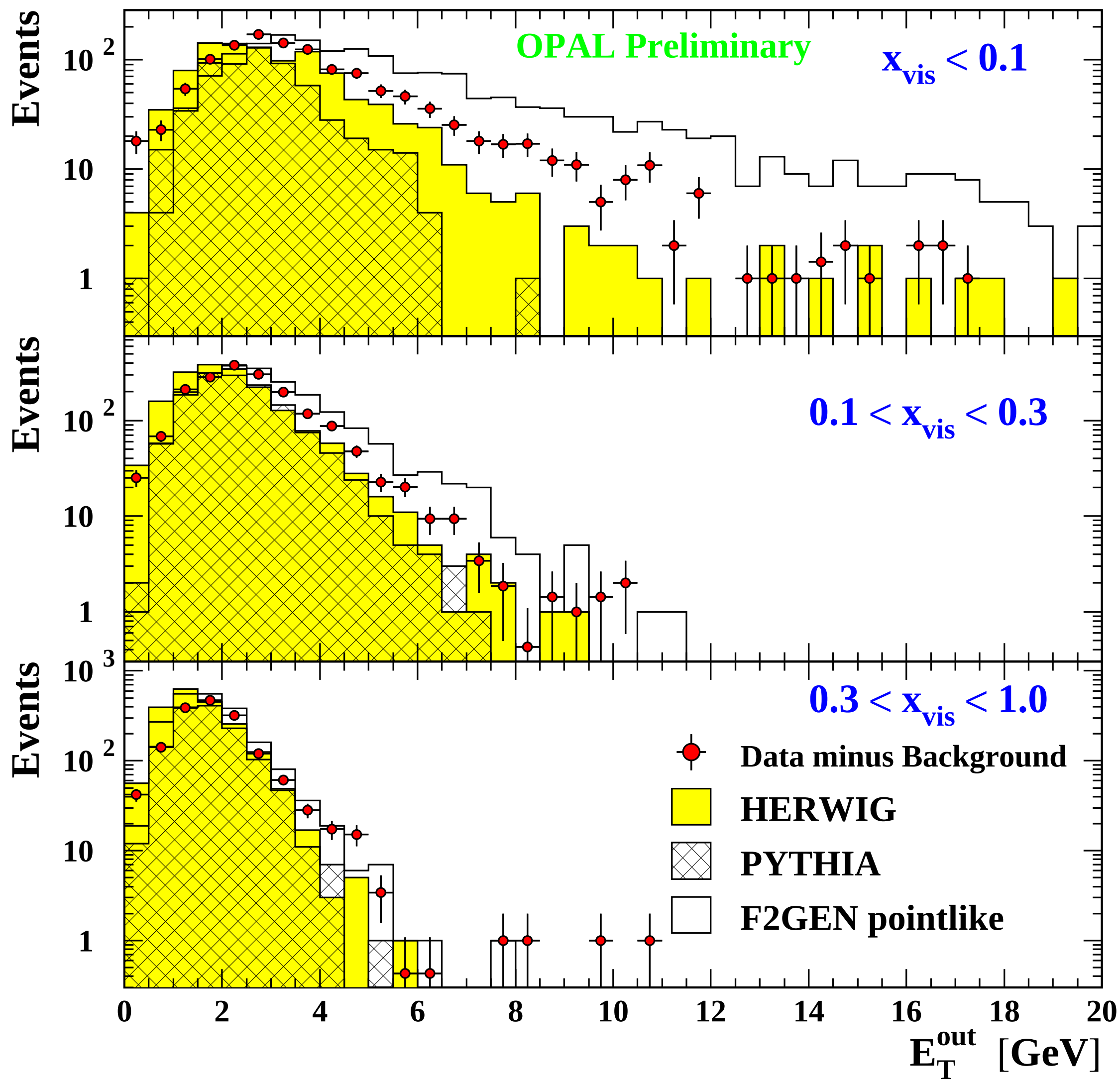
The inclusion of the Forward Detectors significantly improves the correlation

The two-dimensional Energy Flow

Very different deposition of energy in η and ϕ for the data and various Monte Carlo models

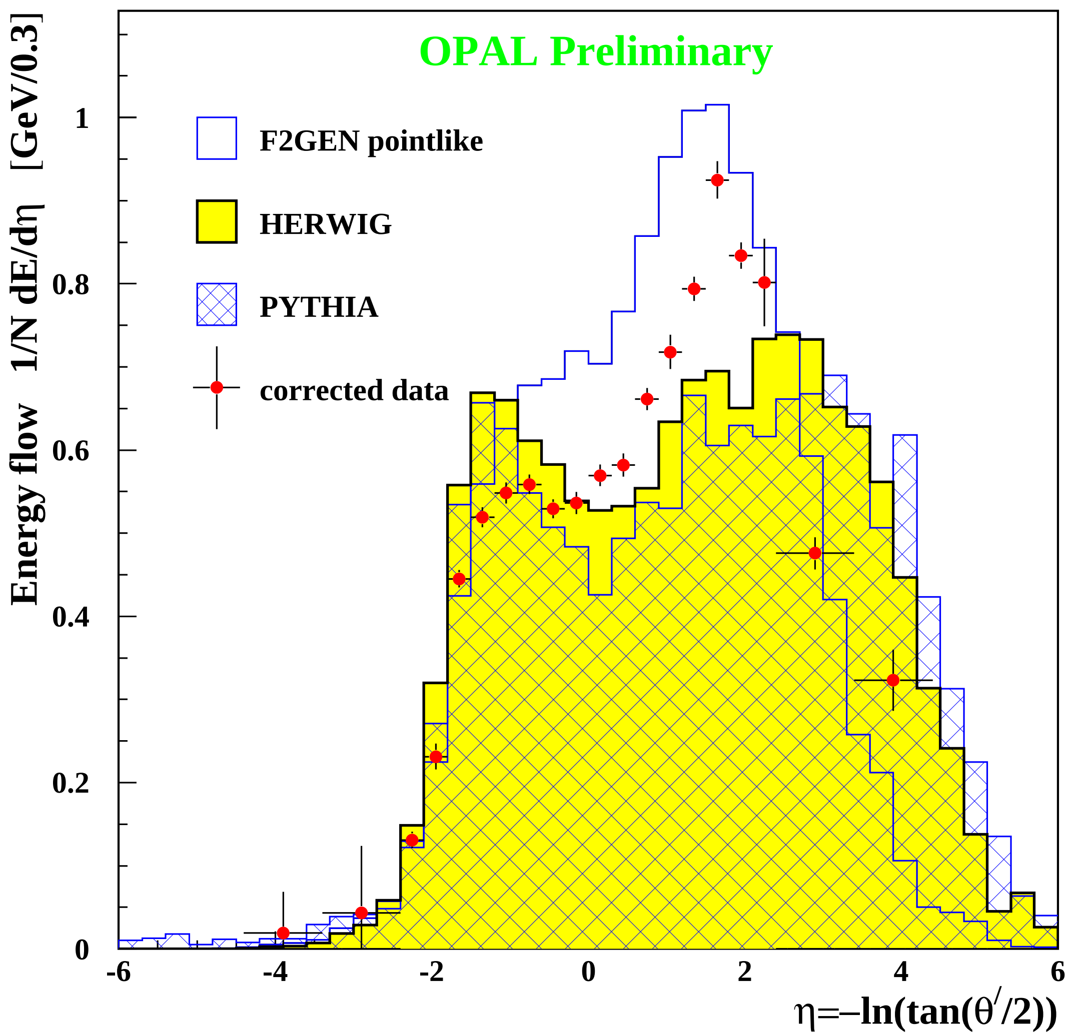


The model dependence as a function of x_{vis}



The agreement gets better for increasing x_{vis}

The corrected Energy Flow



The data can constrain the models much more

Some words about unfolding

The Principle:

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

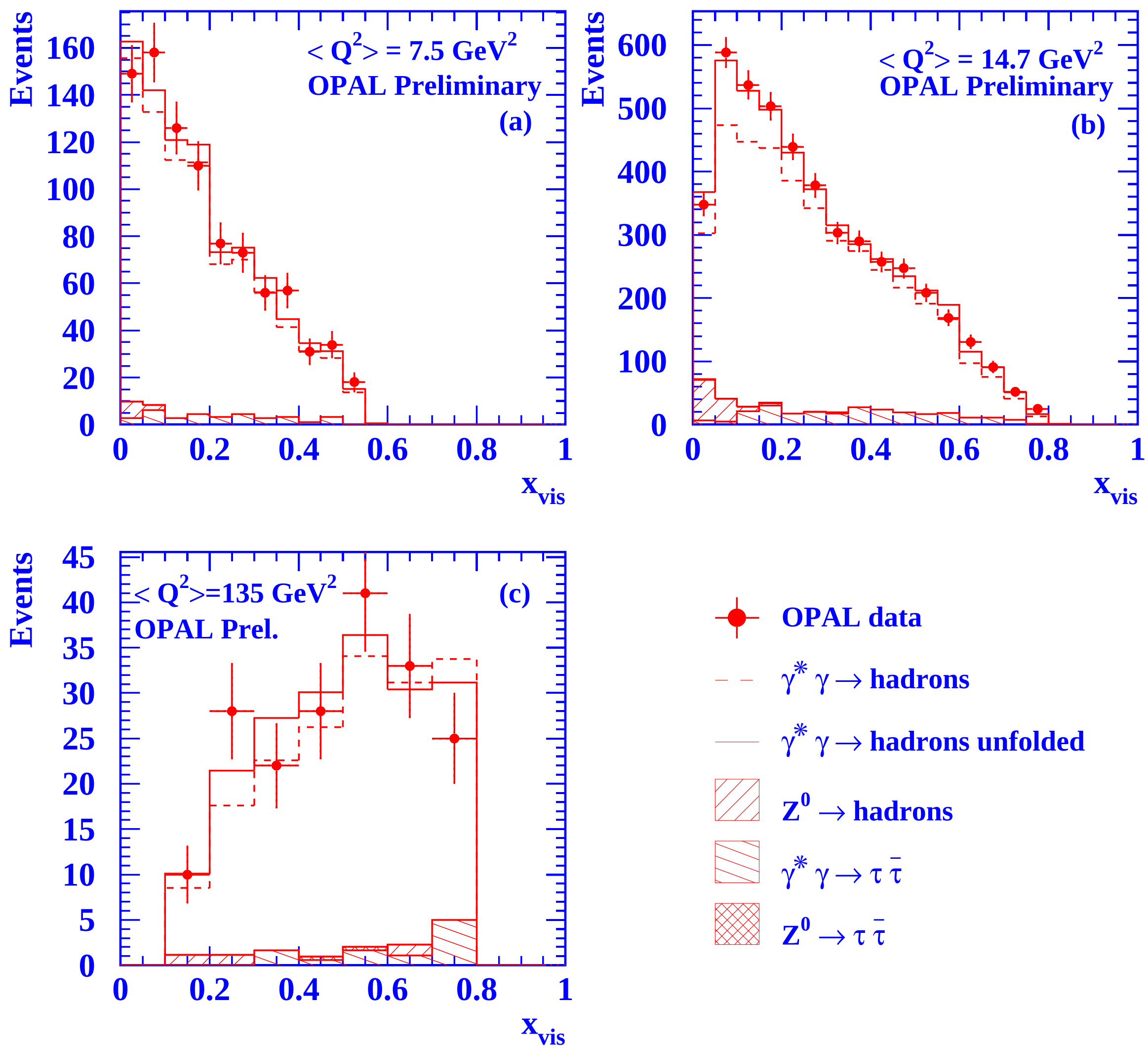
1. **Our case:**
   $g^{\mathrm{det}}(u) = g^{\mathrm{det}}(x_{\mathrm{vis}}),\ x_{\mathrm{vis}} = f(E_{\mathrm{tag}}, \theta_{\mathrm{tag}}, W_{\mathrm{vis}})$
   and $f^{\mathrm{part}}(\omega) = f^{\mathrm{part}}(x)$ which is related to F_2^γ, $B(u)$ is denotes the background events.

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

3. The $g^{\mathrm{det}}(x_{\mathrm{vis}})$ distribution from the Monte Carlo is changed during unfolding, by assigning weights to each Monte Carlo event, in order to match the $g^{\mathrm{det}}(x_{\mathrm{vis}})$ distribution of the data.
   - The $g^{\mathrm{det}}(x_{\mathrm{vis}})$ distributions of data and Monte Carlo agree afterwards by construction.
   - 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 $\gamma^*\gamma$ fragmentation do not factorize.

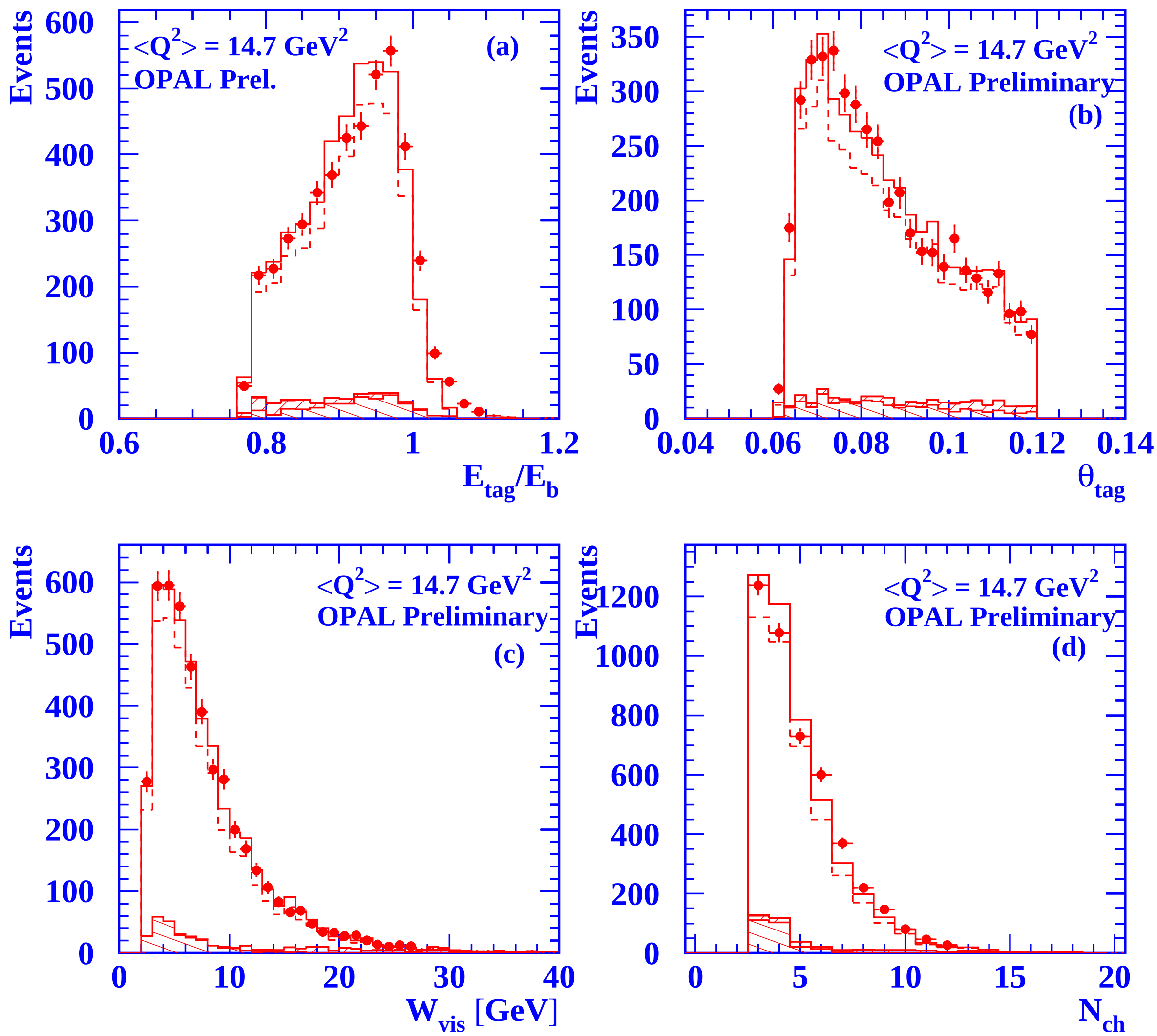
The $x_{\rm vis}$ distributions compared to HERWIG



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

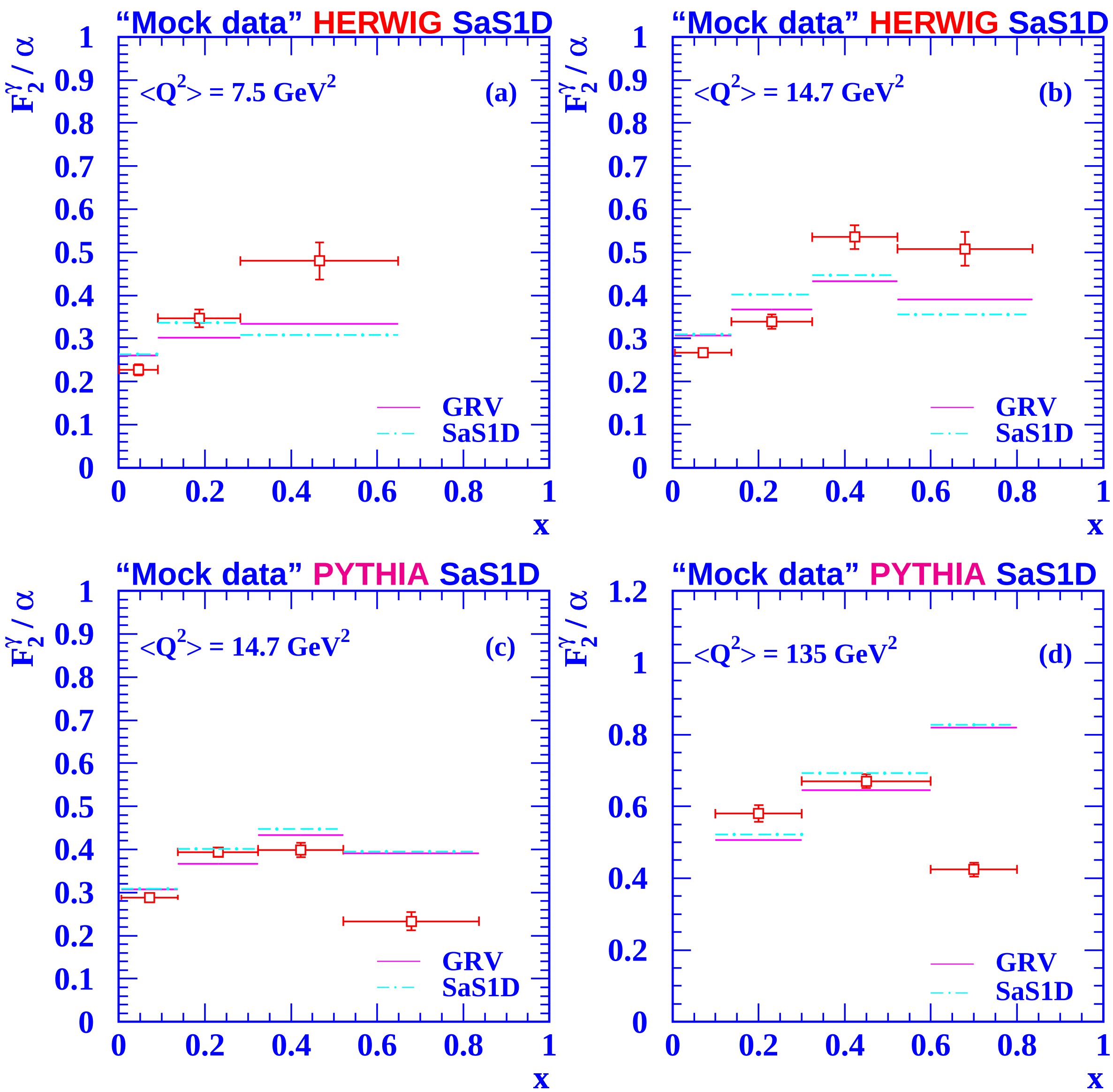
Background contributions are small

Some checks on global quantities



The unfolding significantly improves the agreement for various variables

Unfolding tests using HERWIG with GRV as unfolding MC

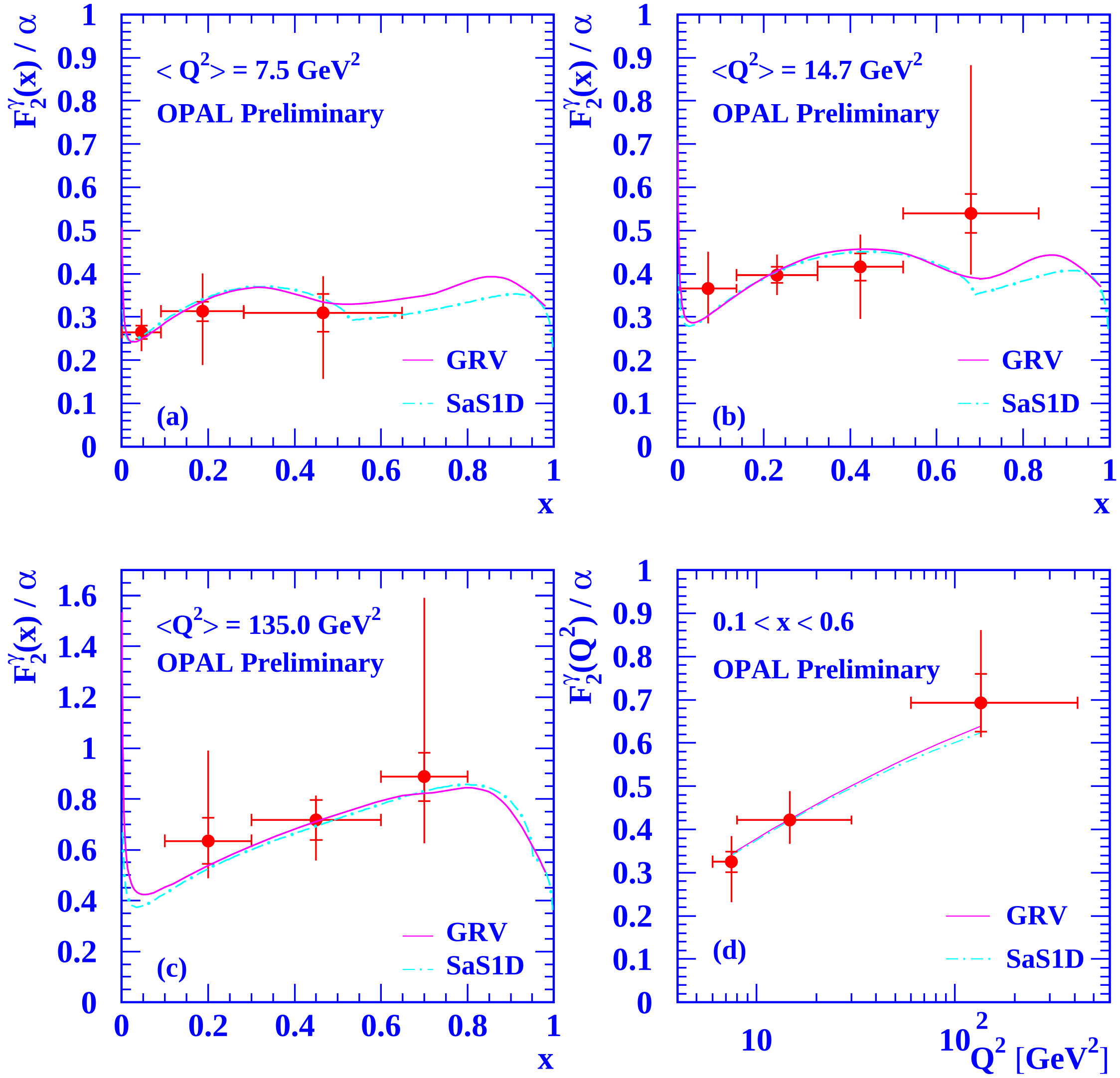


The error is dominated by systematic effects

The results on $F_2^{\gamma}(x, Q^2)$

$$F_2^{\gamma}(Q^2)/\alpha = (0.075 \pm 0.197) + (0.128 \pm 0.071)\ \ln Q^2$$

$$\chi^2/\mathrm{DOF} = 0.01 \quad Corr = -0.96$$



Conclusions

1. The hadronic final state depends on the chosen model, which need to be tuned to match the data distributions. The differences between the models are larger than the experimental errors, which means the data are precise enough to further constrain the models.

2. The values of the measured $F_2^\gamma(x, Q^2)$ are consistent with older analyses. The error on $F_2^\gamma(x, Q^2)$, which is increased compared to earlier investigations, will decrease when the Monte Carlo models are tuned to the data.

3. $\boxed{\mathrm{d}(F_2^\gamma/\alpha)/\mathrm{d}\ln Q^2 = 0.128 \pm 0.071}$ based only on OPAL data is not yet constrained to be significantly different from zero.

4. LEP II will give the opportunity to significantly enlarge the measured range in Q^2.