Analysis of hadronic final states and the photon structure function $F_2^\gamma(x, Q^2)$ in deep inelastic $e\gamma$ scattering at LEP

Jan A. Lauber, UCL

for the OPAL collaboration

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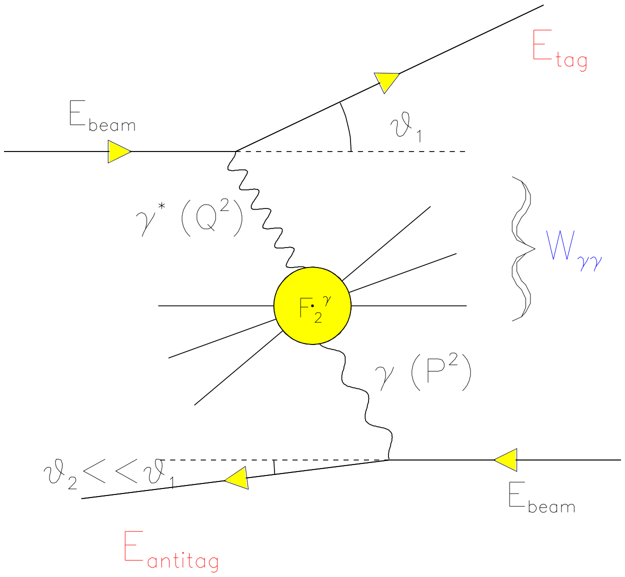
- Comparison to new models
- Energy flows in tagged $\gamma^*\gamma$ collisions
- Photon structure function F_2^γ
- Conclusion

PA03–007

Kinematics

Singly tagged $\gamma^*\gamma$ events:



$$\frac{d^2\sigma_{e\gamma\to eX}}{dx dQ^2} = \frac{2\pi\alpha^2}{xQ^4} \times \left[\left(1+(1-y)^2\right) F_2^\gamma(x,Q^2) - \underbrace{y^2 F_L^\gamma(x,Q^2)}_{\to 0}\right]$$

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

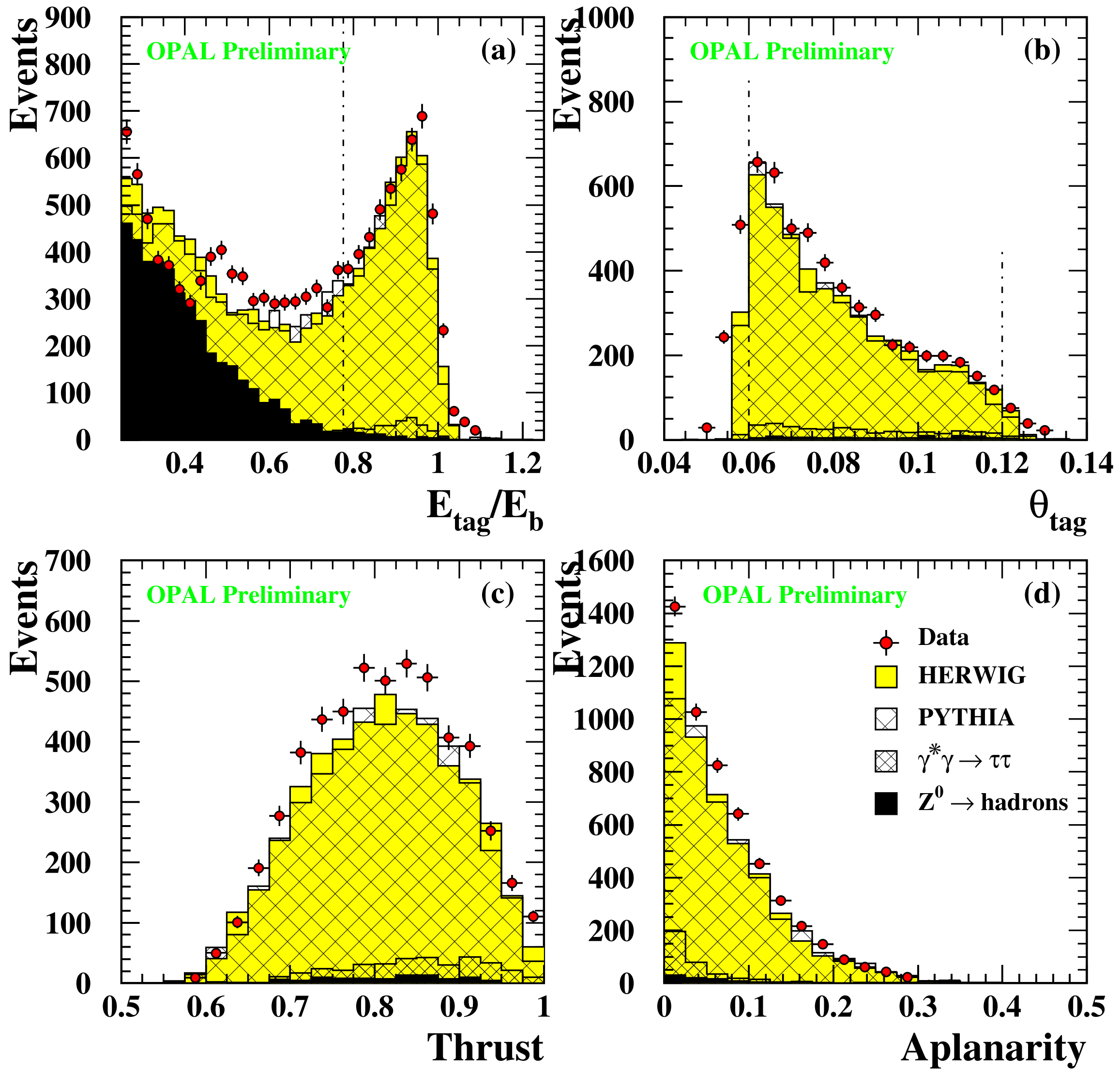
$$x = \frac{Q^2}{Q^2+W^2+P^2}$$

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

New Generators

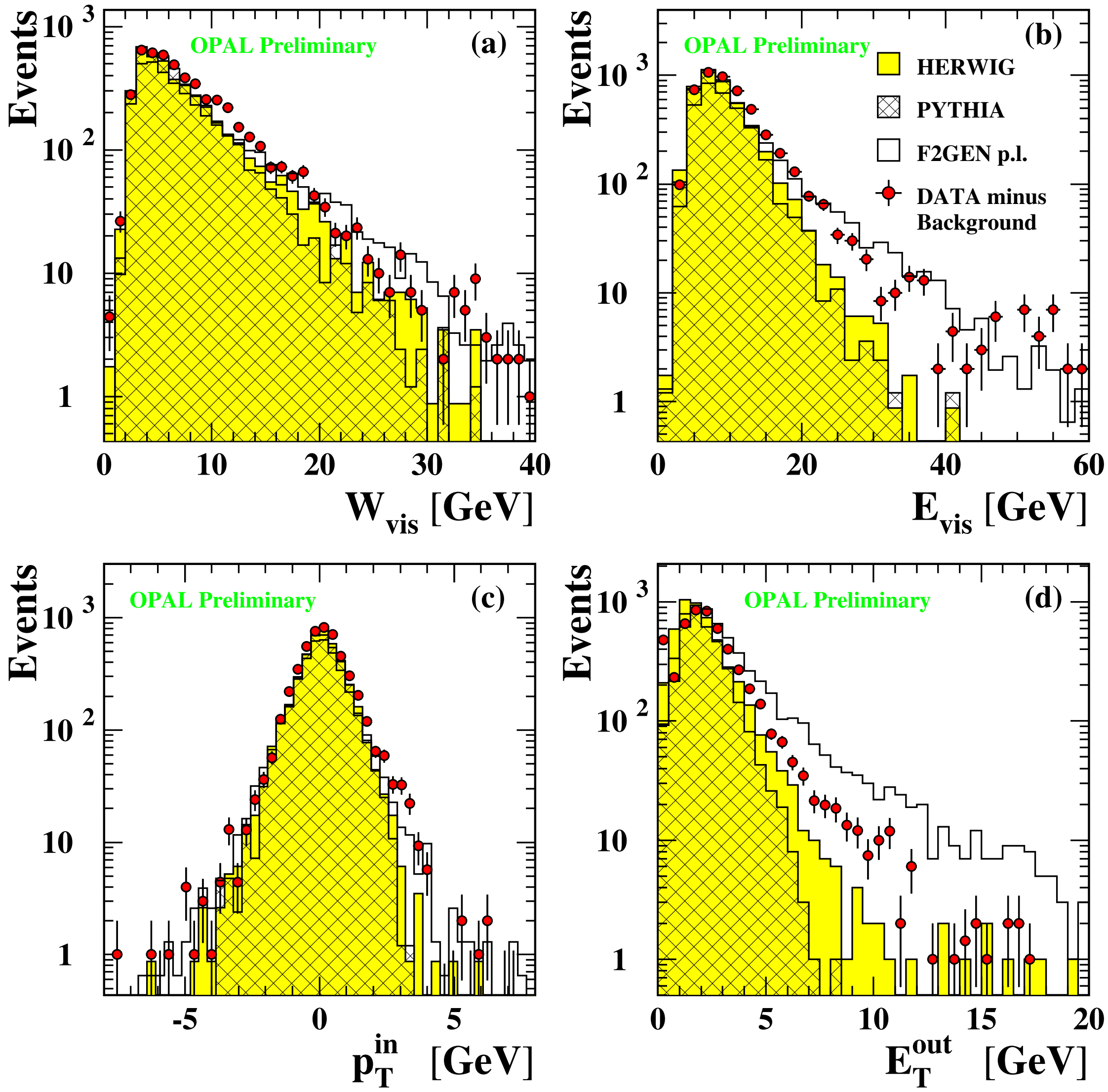
- Since last publication, HERWIG5.8d and PYTHIA5.718 became available with the deep inelastic $e\gamma$ scattering included
- Compare new generators (with GRV and SaS1D) with data distributions
- and F2GEN with all “pointlike” $q\bar{q}$ angular distribution in the $\gamma^*\gamma$ centre of mass, and JETSET
- PYTHIA and HERWIG use a QCD motivated $\gamma^*\gamma$ final state fragmentation

Comparison of event quantities – I



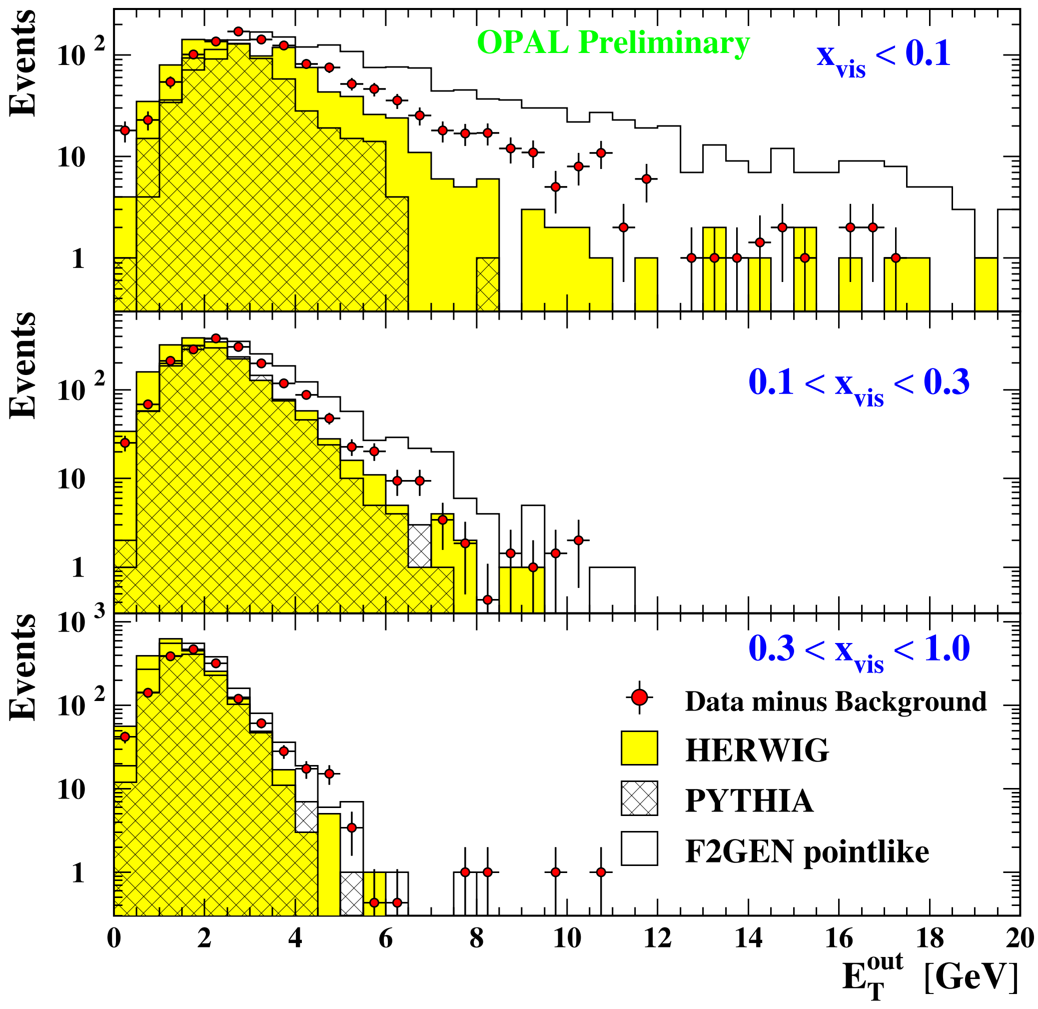
- Generally good agreement in shape, M.C. + GRV/SaS cross sections lower than data ($\sim 10\%$)

Comparison of event quantities – II



- Large model dependence in tails of distributions

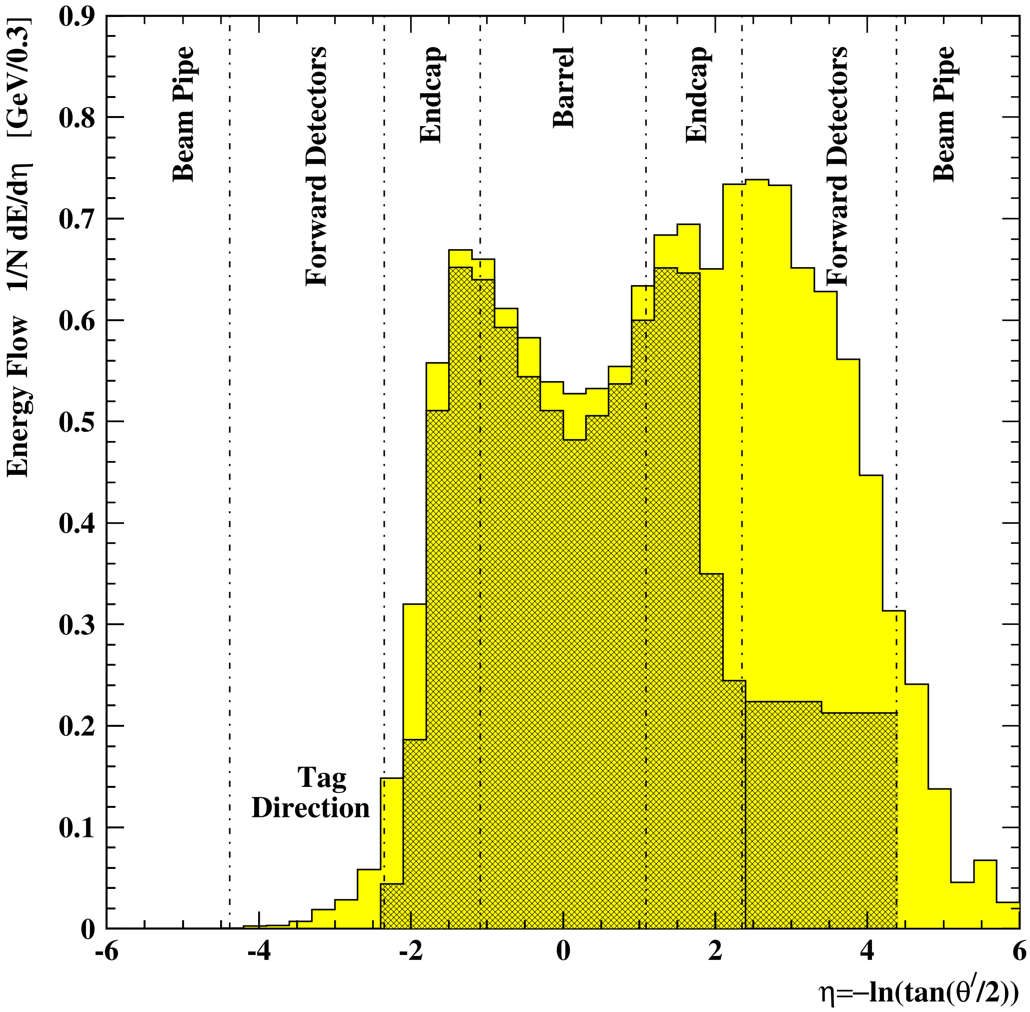
E_T vs. x_{vis}



- Larger discrepancies at low x_{vis}

$$x_{vis} = \frac{Q^2}{Q^2 + W_{vis}^2}$$

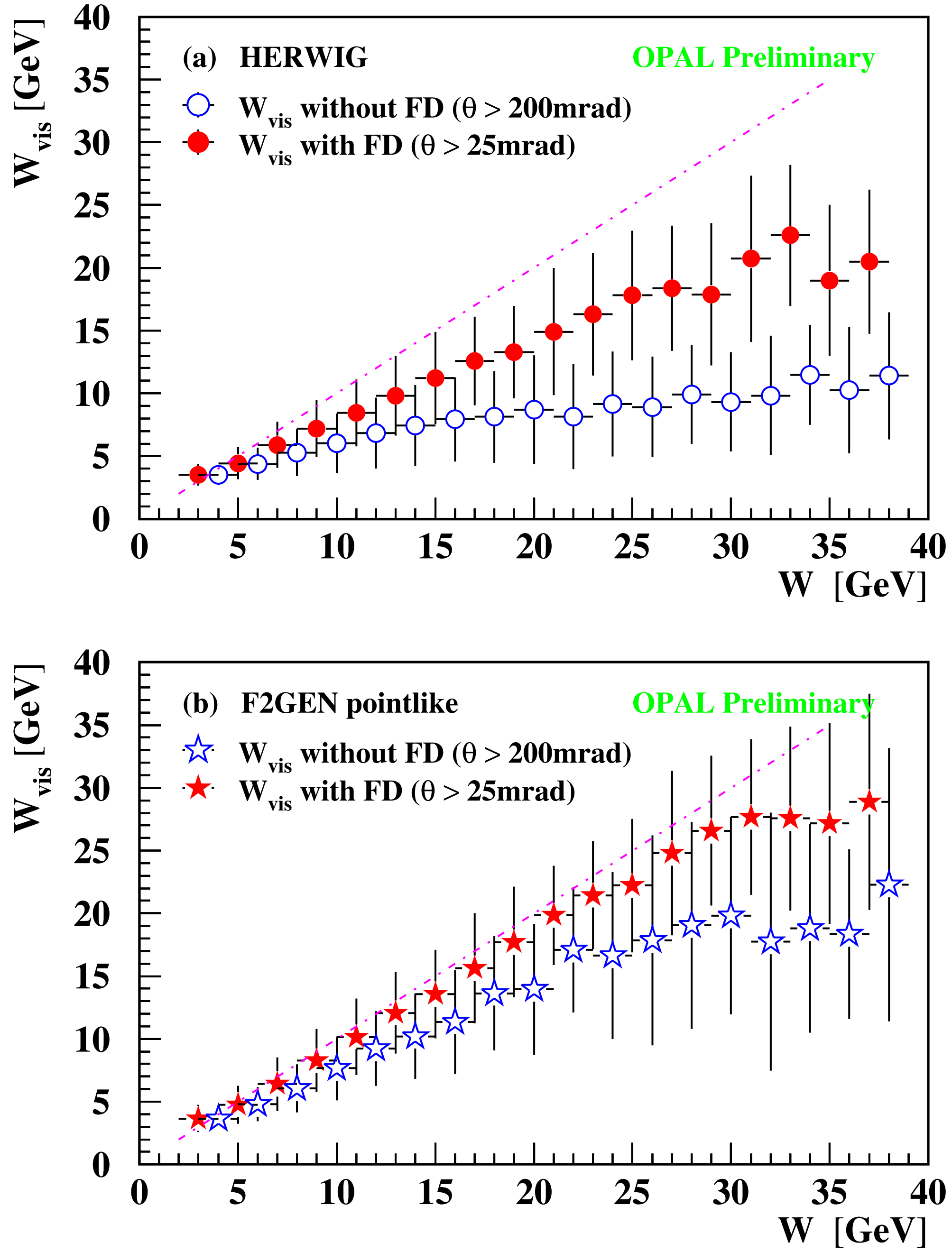
The hadronic Energy Flow for HERWIG



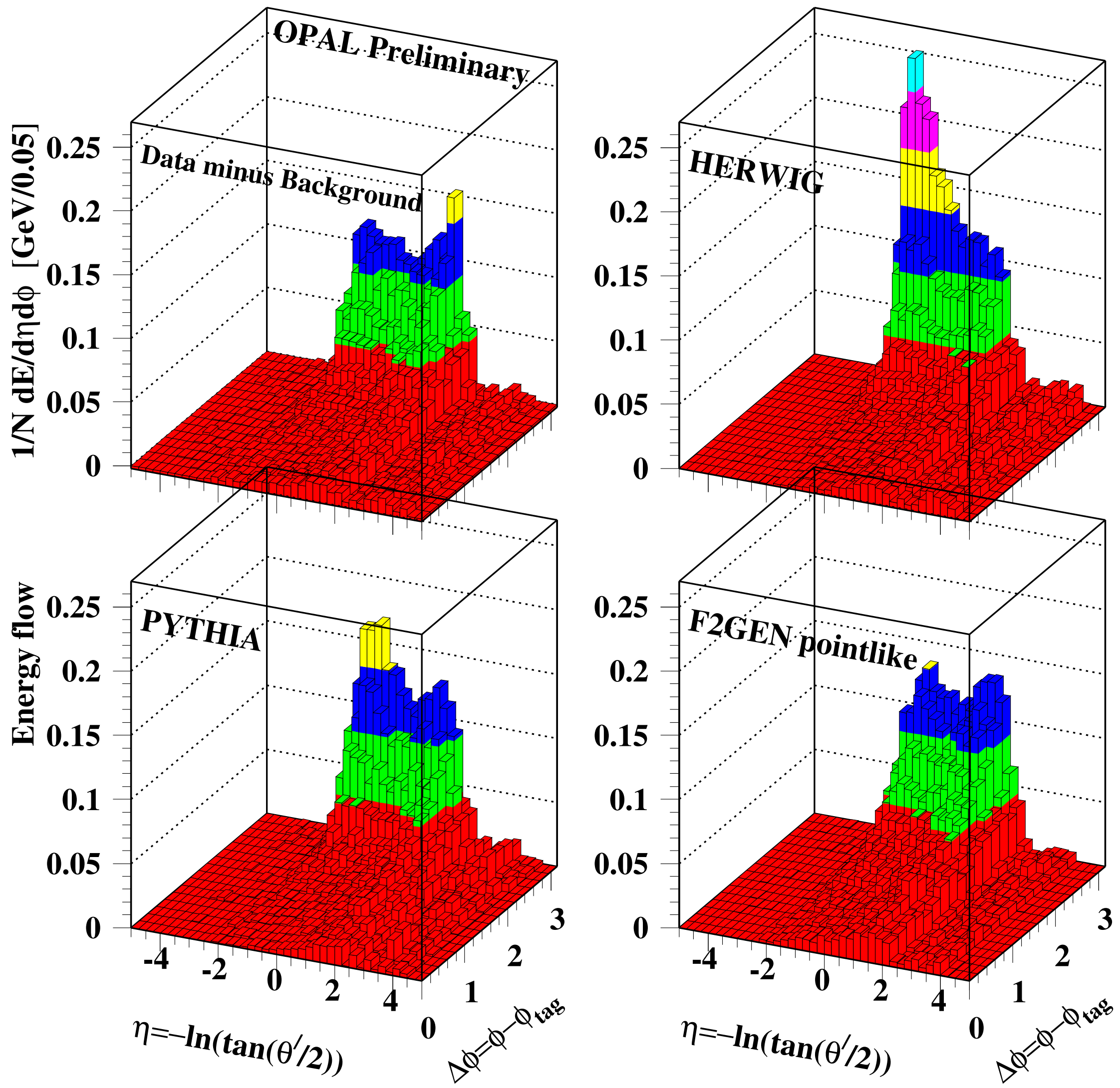
□ Generator level Energy Flow

□ Detector level Energy Flow

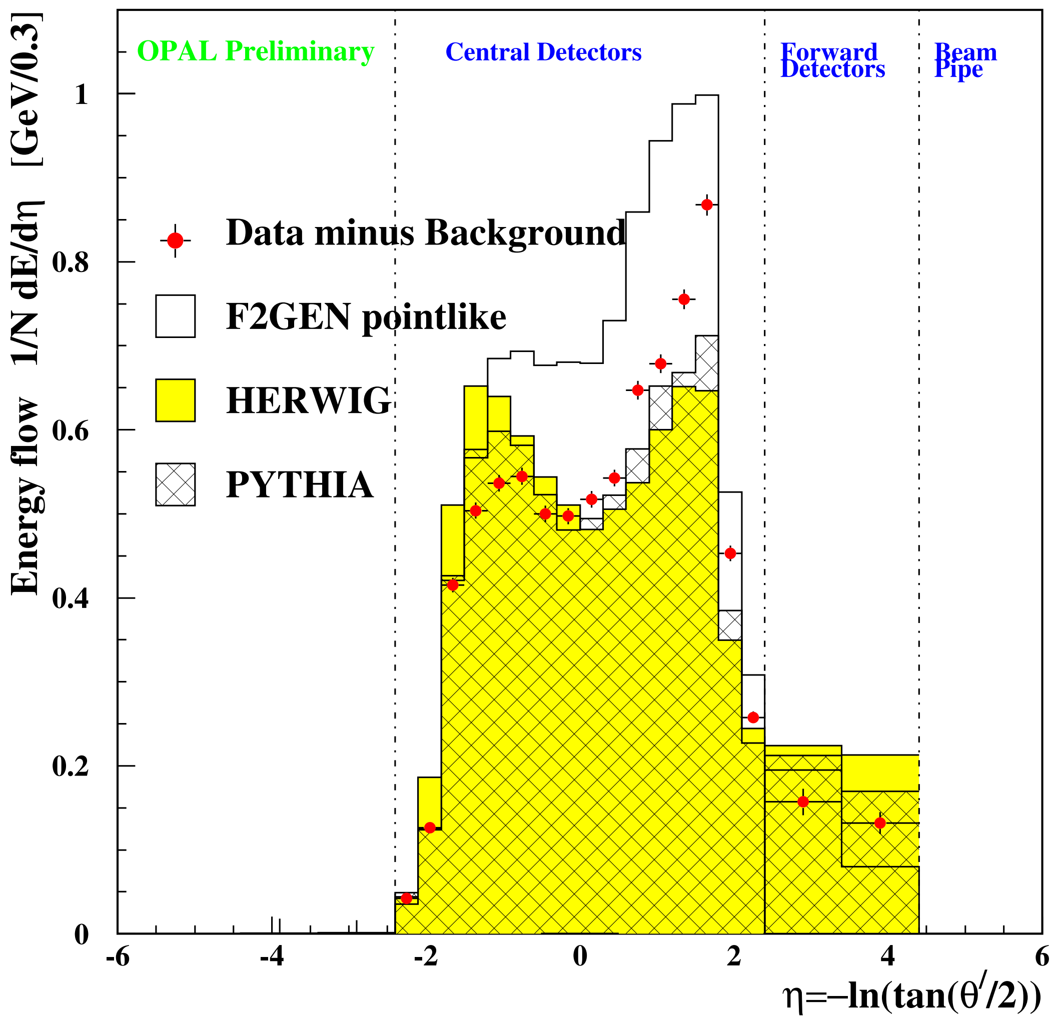
The $W - W_{vis}$ Correlation



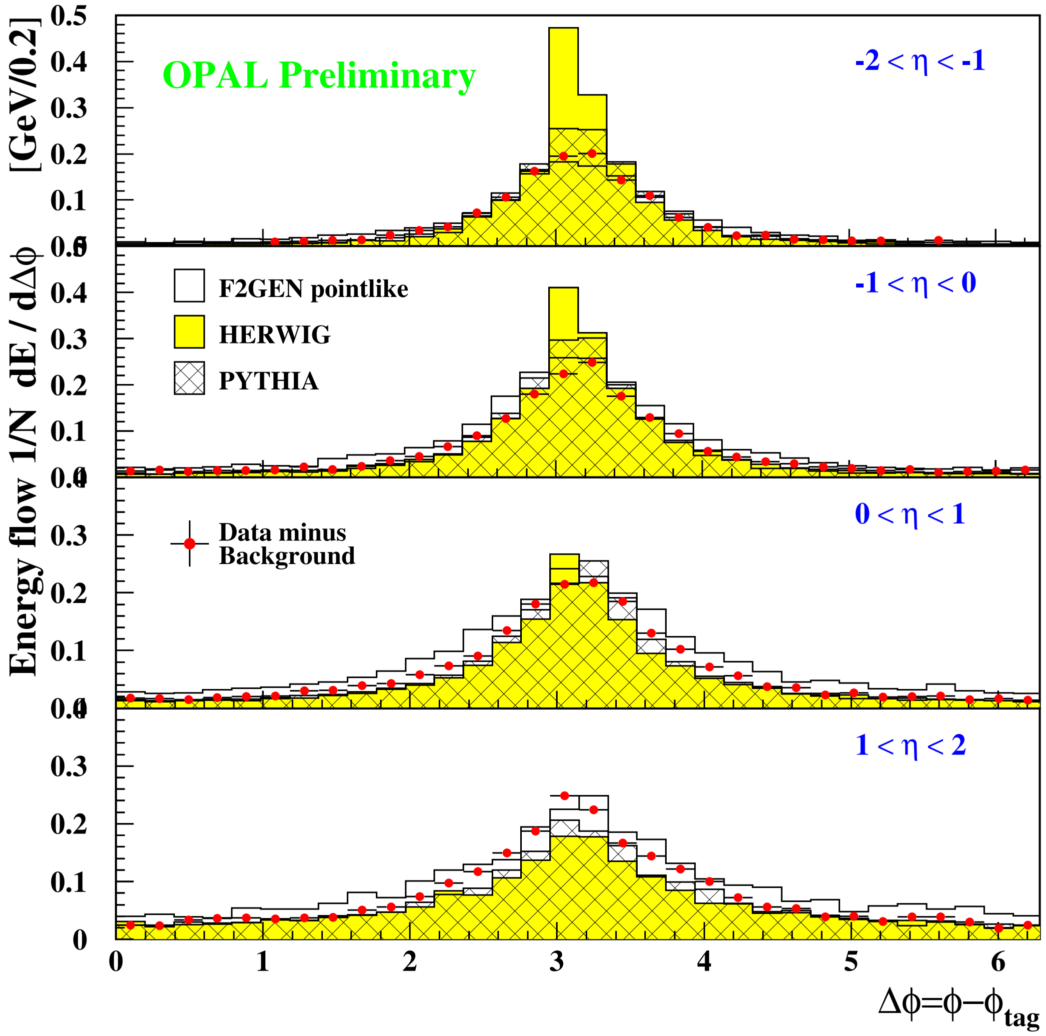
Two dimensional Energy Flow



Energy Flow vs. η

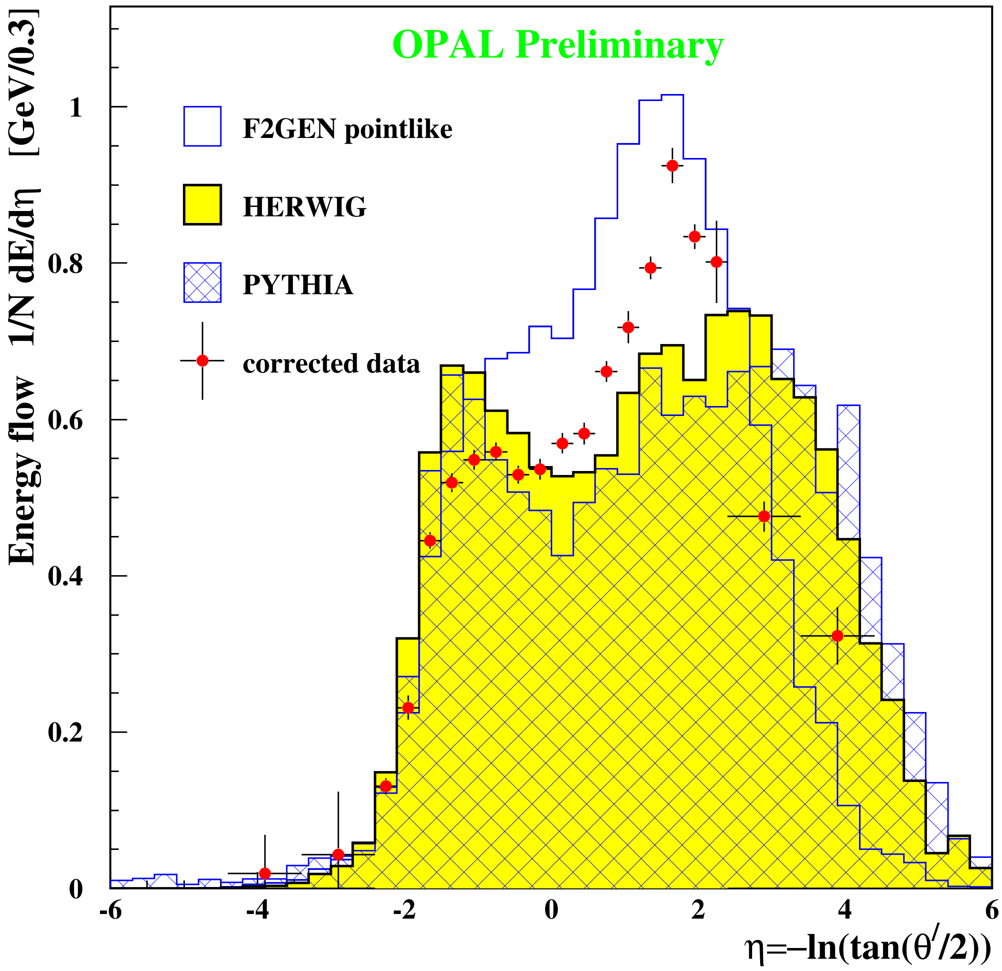


Energy Flow vs. $\Delta\phi$



The corrected Energy Flow

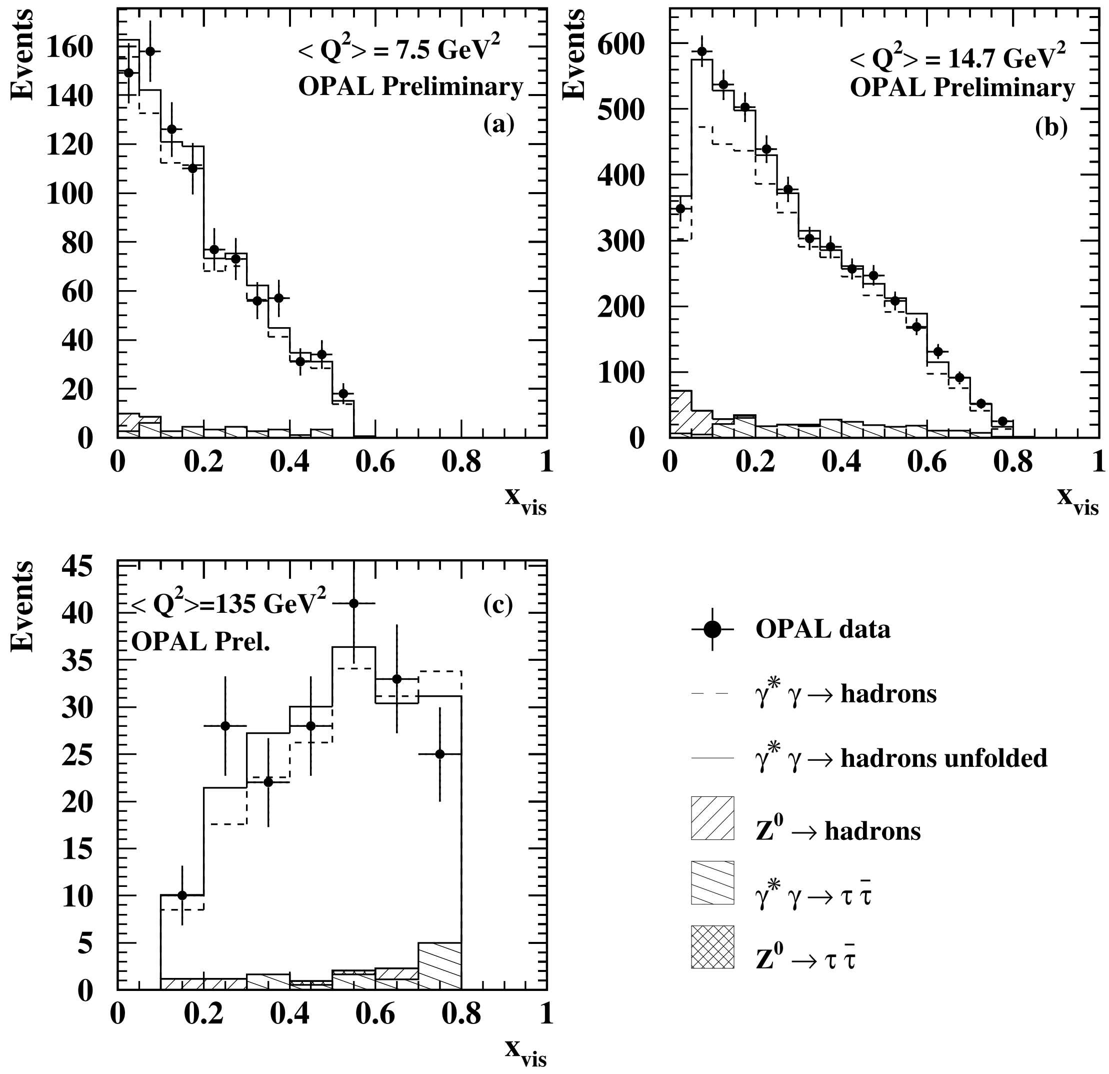
- The data energy flow is corrected for detector inefficiencies



Caveat Emptor

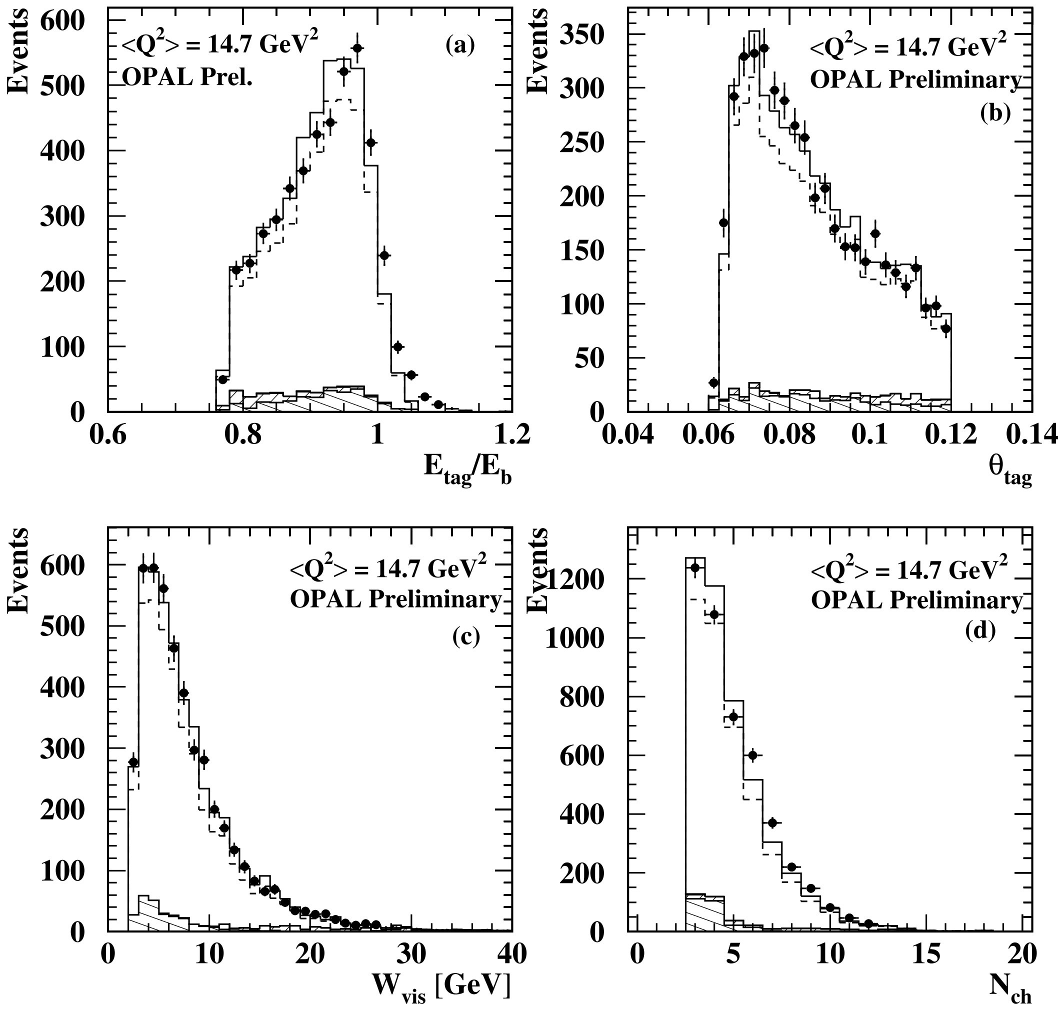
- None of the available models describe the data well
- The central and forward regions are sensitive to the modelling of $\gamma^*\gamma$ fragmentation
- Different $\gamma^*\gamma$ modelling changes the $x - x_{vis}$ correlation
- Using only one model to unfold does not account for $\gamma^*\gamma$ fragmentation modelling errors

Unfolding the x_{vis} Distributions



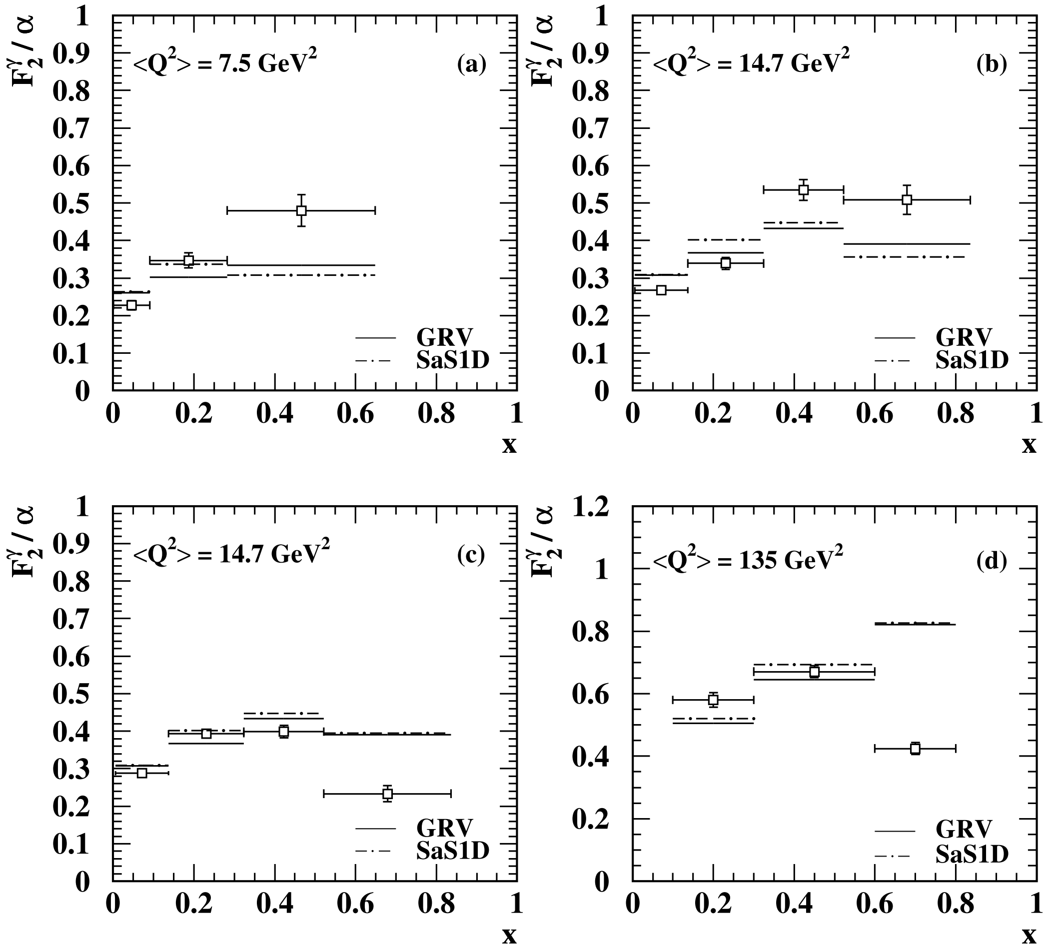
Unfolding Tests – 1

- Checking other variables after reweighting



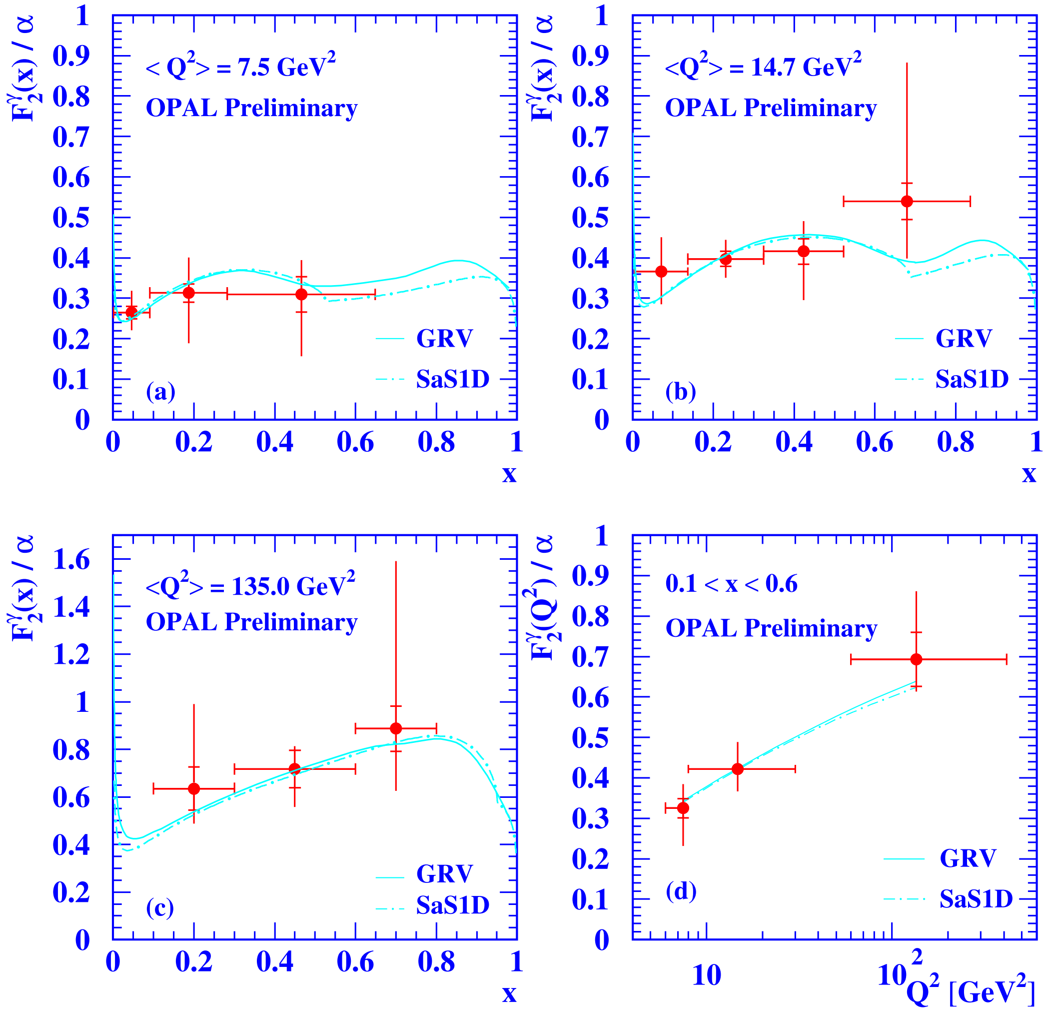
Unfolding Tests – 2

Using Monte Carlo as *mock* data to try and recover the F_2^γ used to generate the sample



The Results on $F_2^\gamma(x, Q^2)$

- Unfolding x_{vis} with all models



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

Conclusions

- This analysis uses hadronic energy measured in the forward region of the detector
- The data energy flow distributions are in clear disagreement with all available models
- The $\gamma^*\gamma$ fragmentation depends on the chosen model which need to be tuned to match the data distributions
- The photon structure function F_2^γ was measured, the systematic errors are dominated by the model dependences
- $F_2^\gamma(Q^2)/\alpha = (0.075 \pm 0.197) + (0.128 \pm 0.071) \ln Q^2$ rising with lnQ^2 as predicted by QCD
- Our measurement of F_2^γ and our understanding of the fragmentation process will both depend upon improving the models – especially at low x.