The hadronic structure function F_2^γ for quasi-real photons

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Representing the ALEPH collaboration

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In this talk . . .

EPS-HEP99 2_16, The LEP Two-Photon Working Group, Comparison of deep inelastic electron photon scattering events with predictions from the HERWIG and PHOJET Monte Carlo models

EPS-HEP99 2_17, OPAL, Measurement of the low-x behaviour of the photon structure function F_2^γ

EPS-HEP99 2_271, L3, Study of the hadronic photon structure function F_2^γ at LEP

EPS-HEP99 2_272, L3, The Q2 evolution of the hadronic photon structure function F_2^γ at LEP

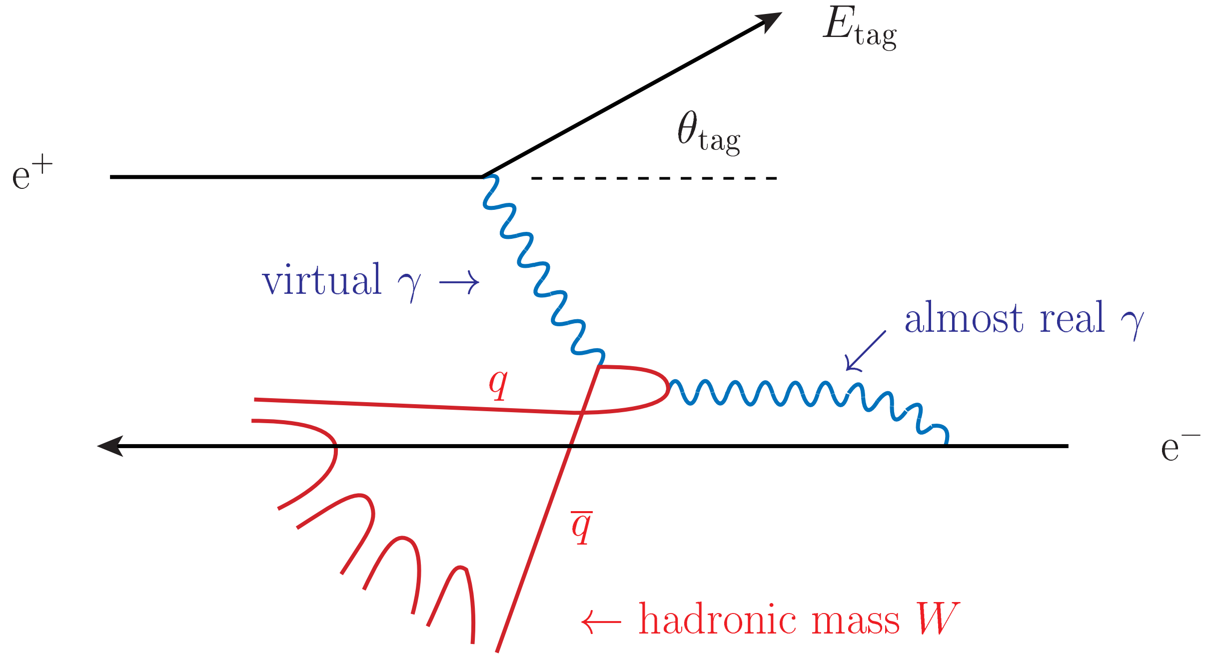
EPS-HEP99 2_617, ALEPH, A study of the photon structure function $F_2^\gamma(x, Q^2)$ using two-dimensional unfolding

NEW

- New LEP2 data
- Progress on models
- New unfolding techniques
- Kinematic info from tag used to reconstruct W

$\vdots$

Deep inelastic eγ scattering



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

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

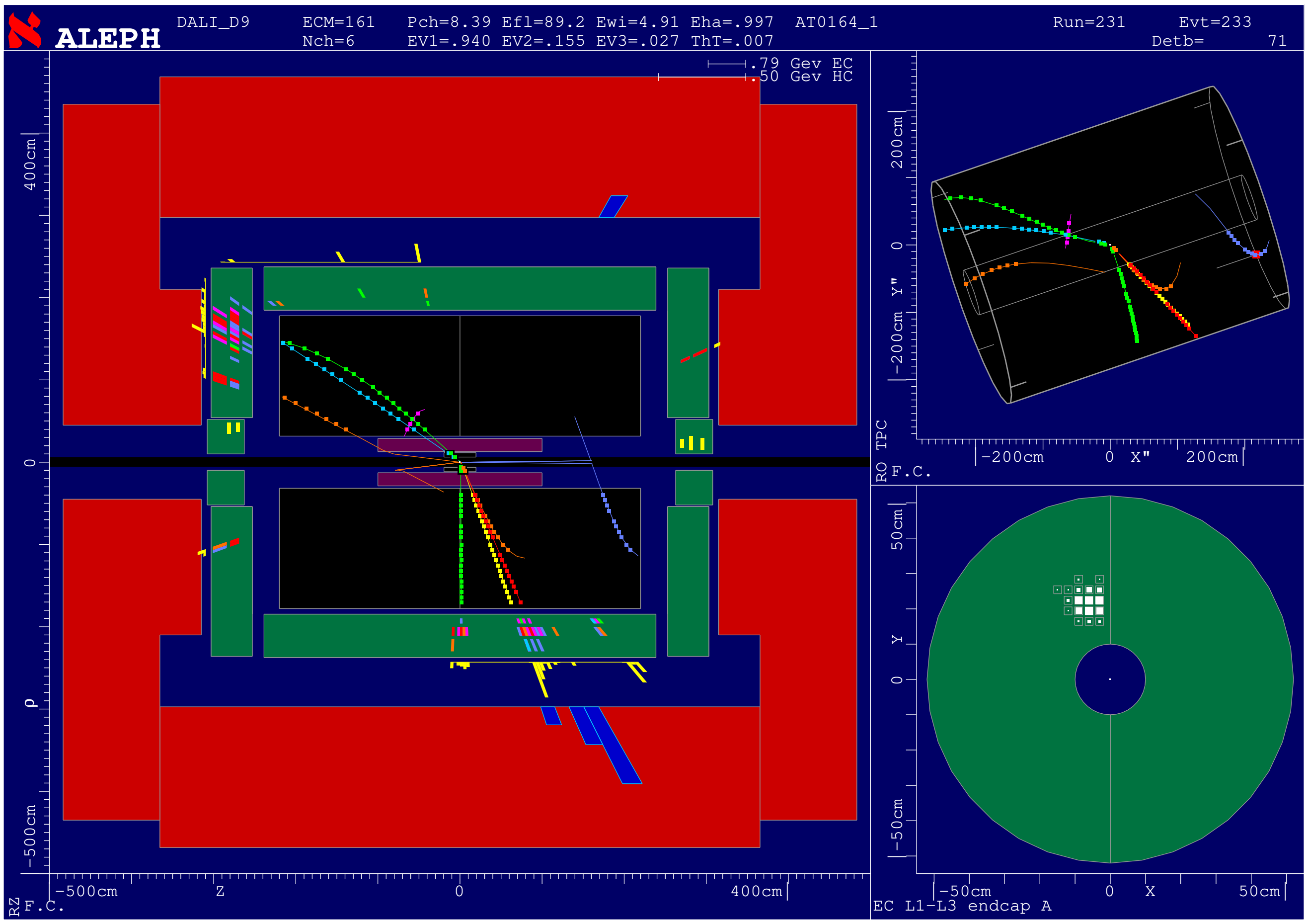
$$x = \frac{Q^2}{Q^2+W^2}$$

$$y = 1 - \frac{E_{\rm tag}}{E_{\rm beam}}\cos^2\theta_{\rm tag} \qquad (y \ll 1 \to \text{neglect } F_L^\gamma)$$

→ F_2^γ from $d^2\sigma_{{\rm ee}\to{\rm ee}X}/dx\,dQ^2$ and photon flux (EPA)

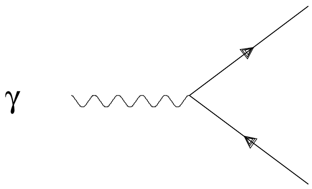
→ QCD test, predict photon cross sections

A single-tag event

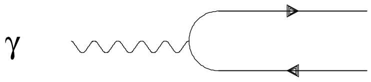


The physics involved in these events can be both

perturbative

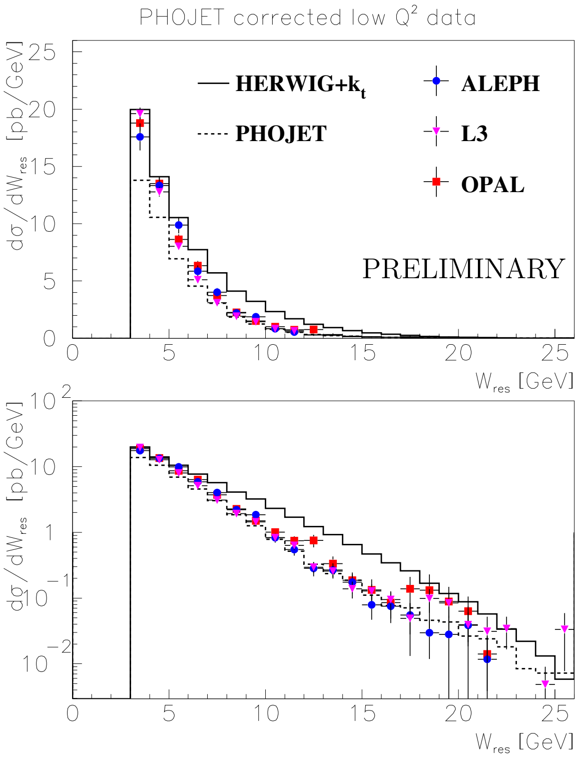


and non-perturbative



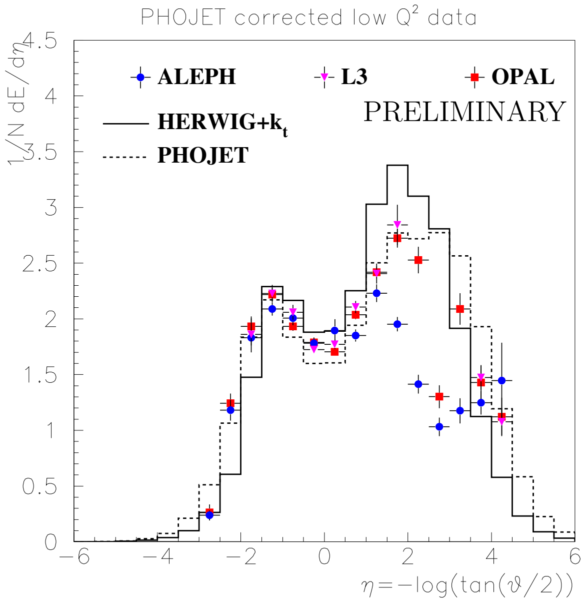
Models vs. data

Corrected distributions from LEP two-photon working group:



Hadronic mass in central rapidity region, $W_{\text{restricted}}$

Energy flow vs. rapidity (tag on left)

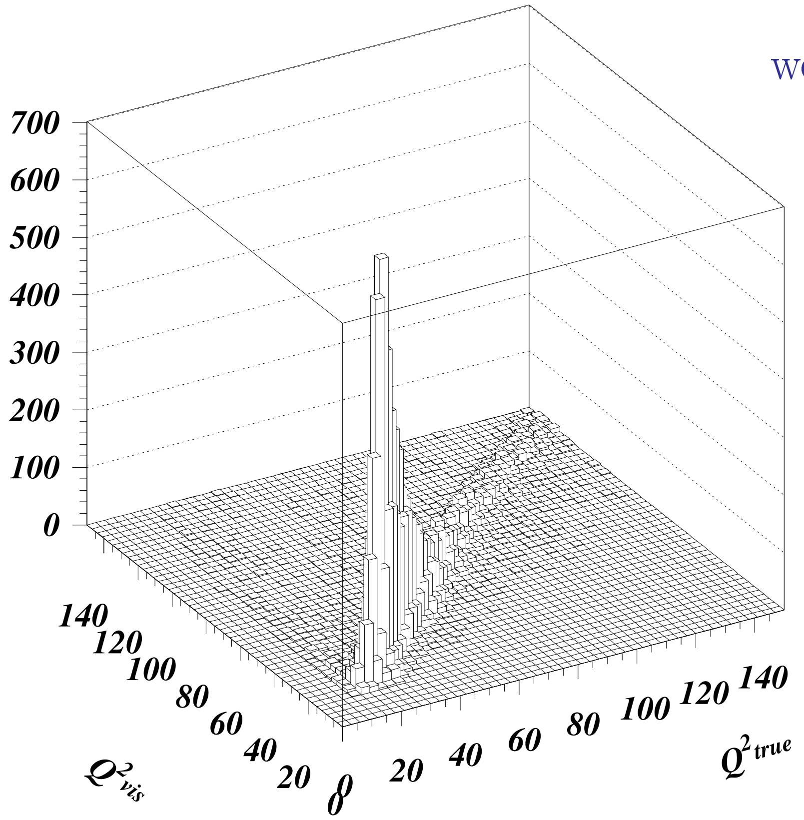


LEP averages $\rightarrow$ input for model builders

Measuring x and Q^2

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

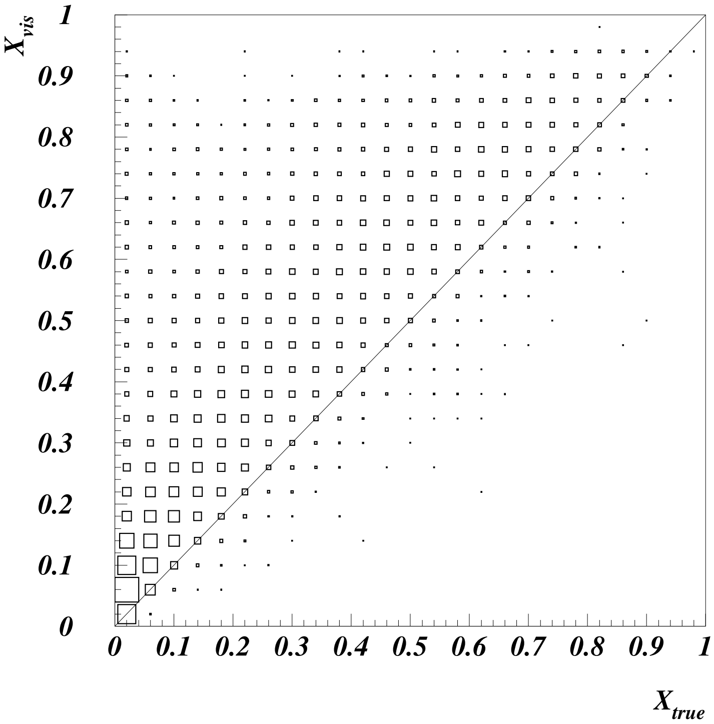
well measured



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

(often) poorly measured

→ unfolding

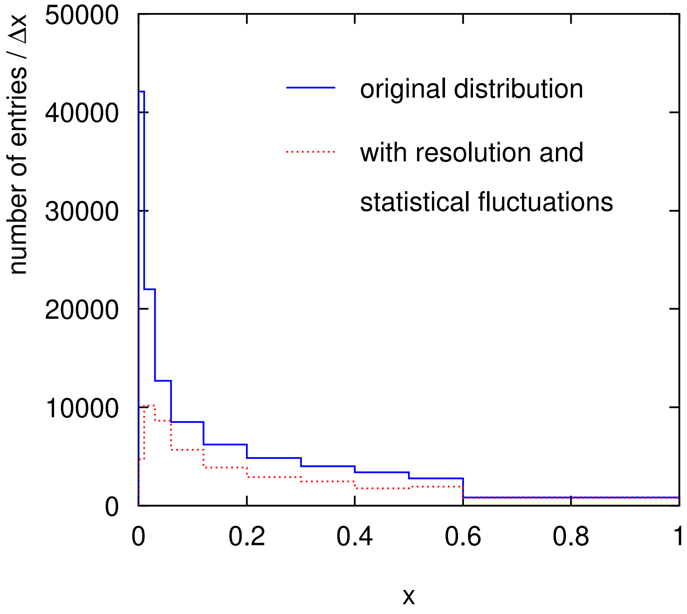


Unfolding

$$\begin{pmatrix} \text{observed } x \\ \text{distribution} \end{pmatrix} = \begin{pmatrix} \text{true } x \\ \text{distribution} \end{pmatrix} \otimes \begin{pmatrix} \text{response} \\ \text{matrix} \end{pmatrix}$$

Inverse problem:

Estimate $f(x)$ given data subject to effects of resolution and statistical fluctuations



ALEPH, OPAL: regularized unfolding, i.e. maximize

$$\varphi[f] = \underbrace{\alpha \ln L[f]}_{\text{likelihood function}} + \underbrace{S[f]}_{\text{regularization function}}$$

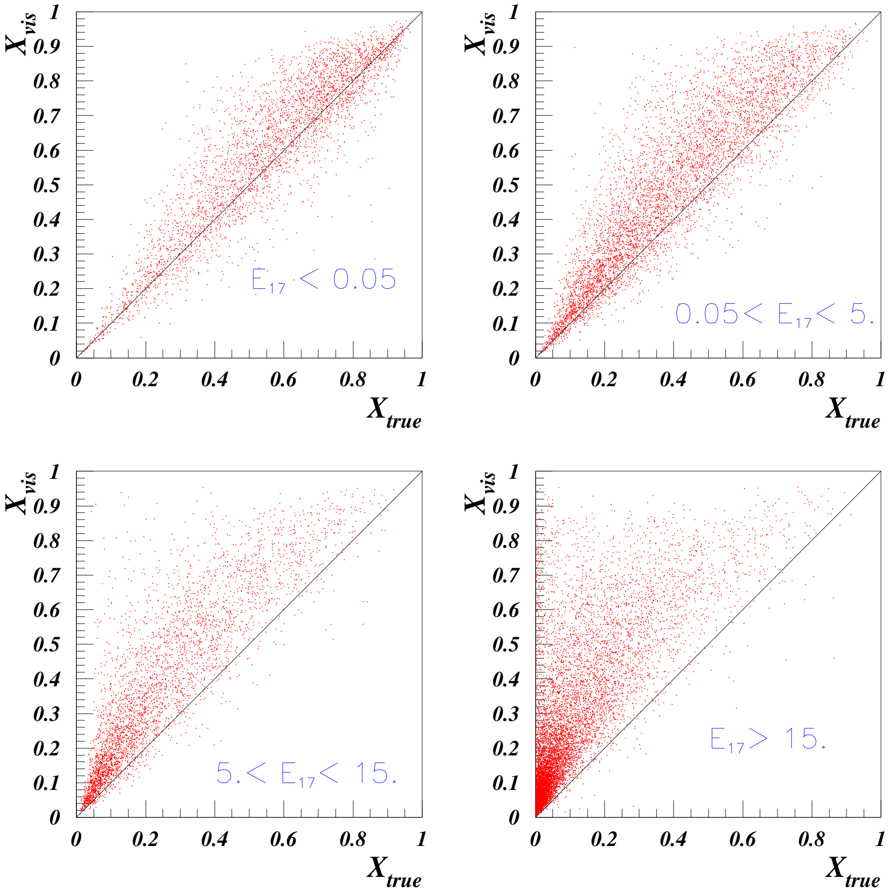
L3: iterative method based on Bayes' theorem:

G. D'Agostini, NIM A 362 (1996) 489.

Response matrix from Monte Carlo model + detector simulation

Model dependence of response matrix

x resolution depends on whether hadrons emitted at low angles:



E_{17} = energy with $\theta < 17°$ wrt beam

Solution: measure x and another variable related to x resolution

→ two-dimensional unfolding (ALEPH, OPAL)

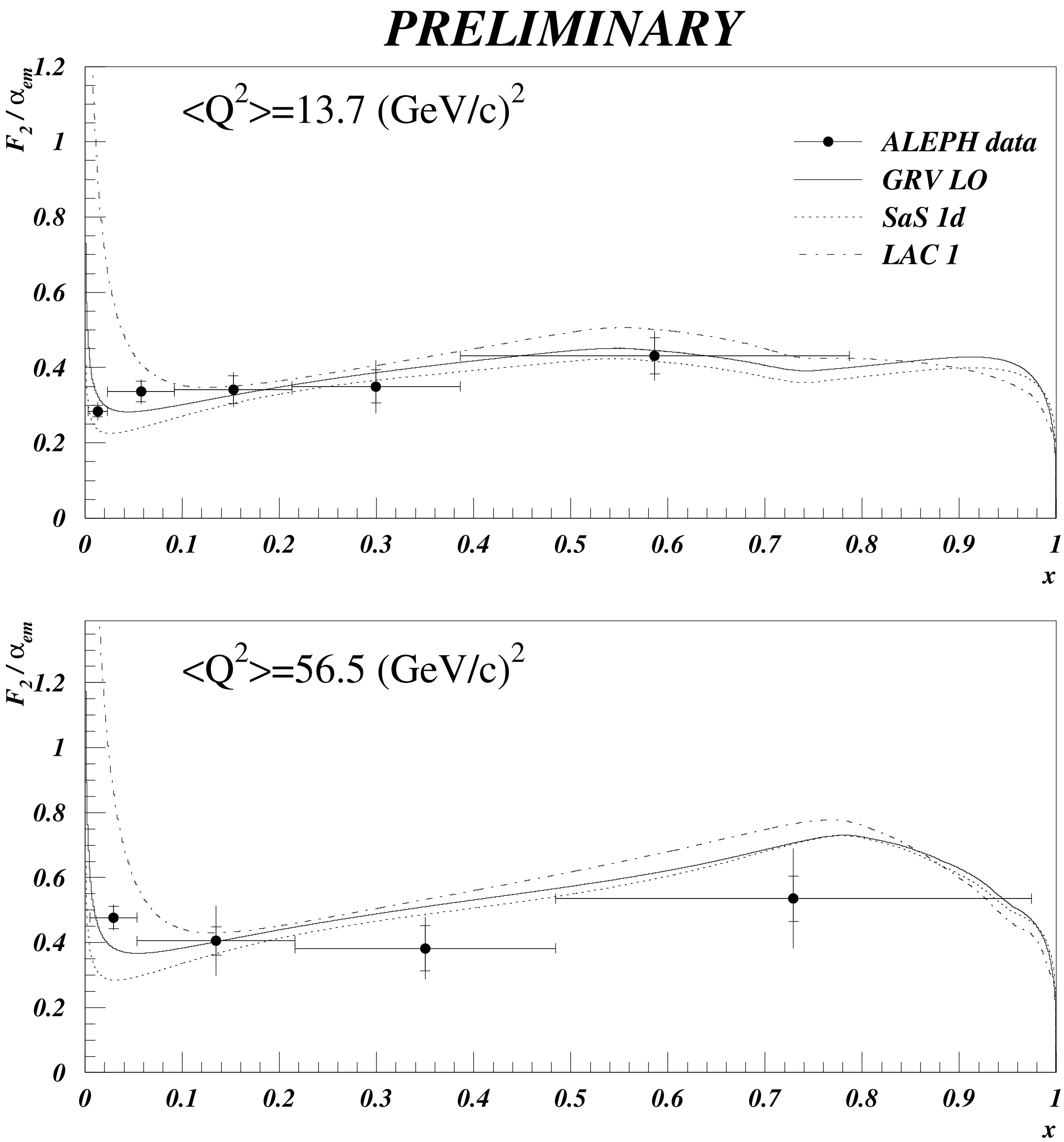
→ reduces model dependence

→ reduces statistical errors

cf. Affholderbach, Cowan et al., J. Phys. G24 (1998) 457.

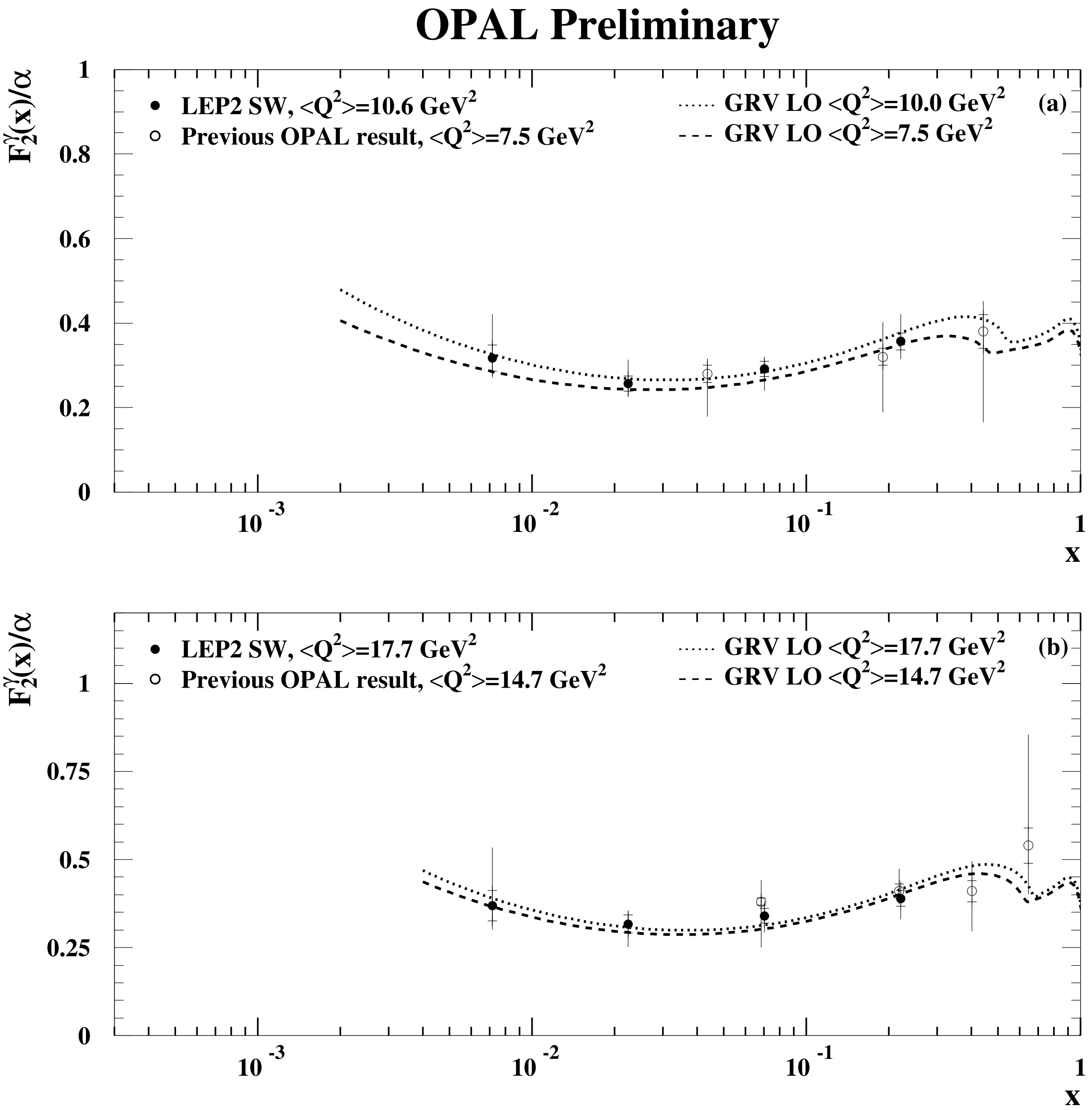
F_2^{γ} from ALEPH

$$E_{\mathrm{cm}} = 183 \text{ GeV}, \;\; \int L\,dt = 53 \text{ pb}^{-1}$$



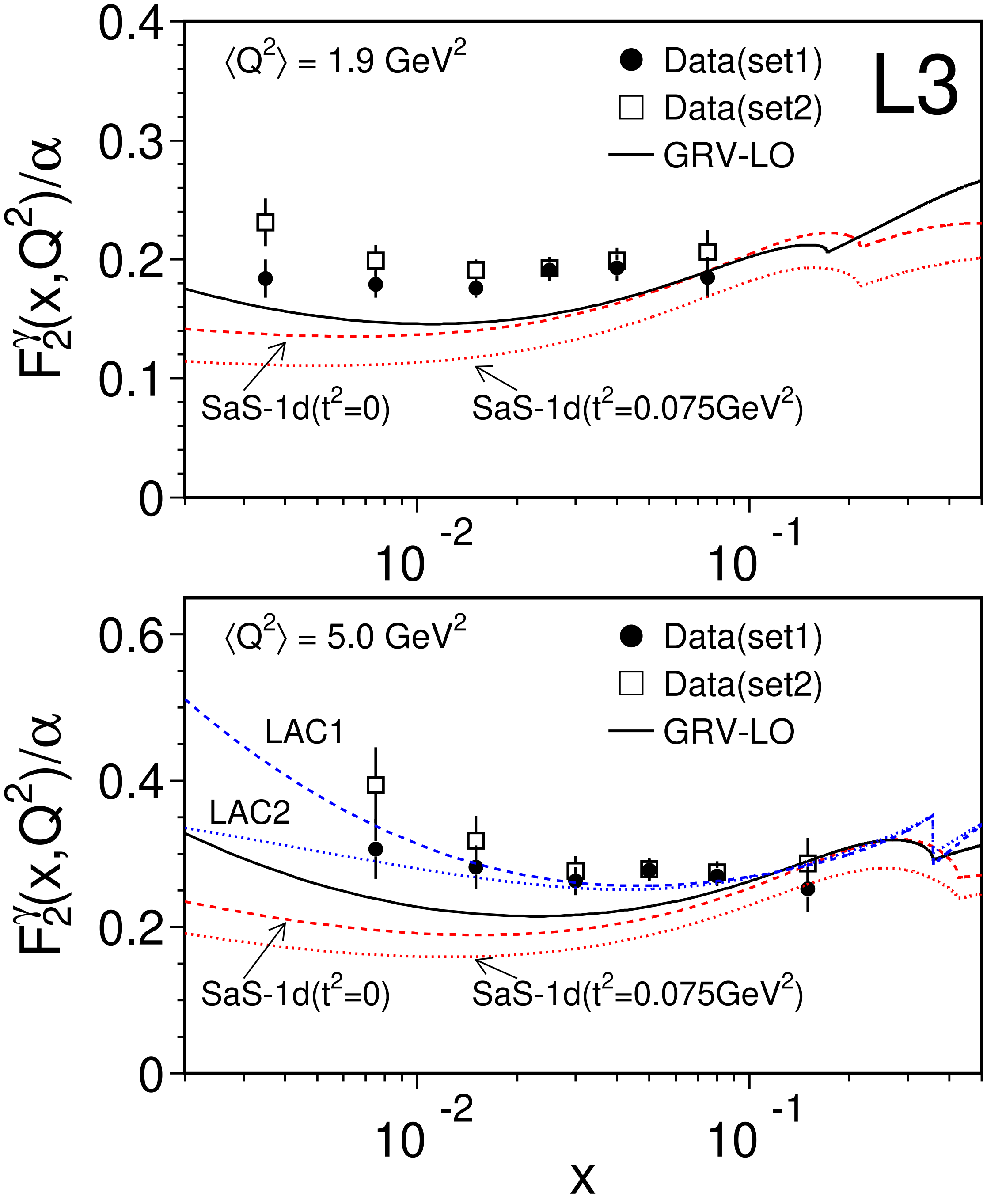
F_2^γ from OPAL

$$E_{\rm cm} = 189 \text{ GeV}, \quad \int L\,dt = 167 \text{ pb}^{-1}$$



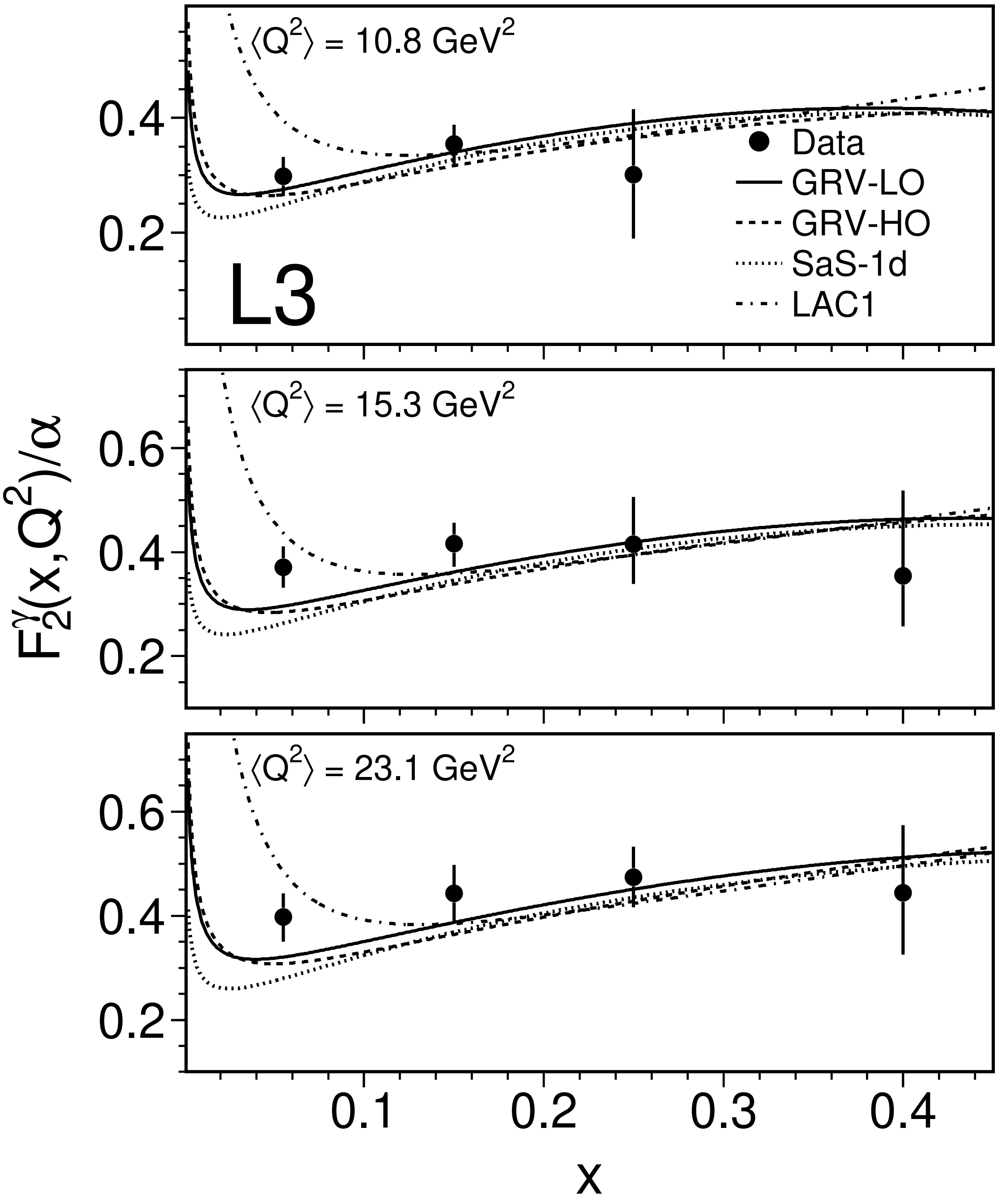
F_2^γ from L3

$$E_{\rm cm} = 91 \text{ GeV}, \;\; \int L\, dt = 140 \text{ pb}^{-1}$$



F_2^γ from L3

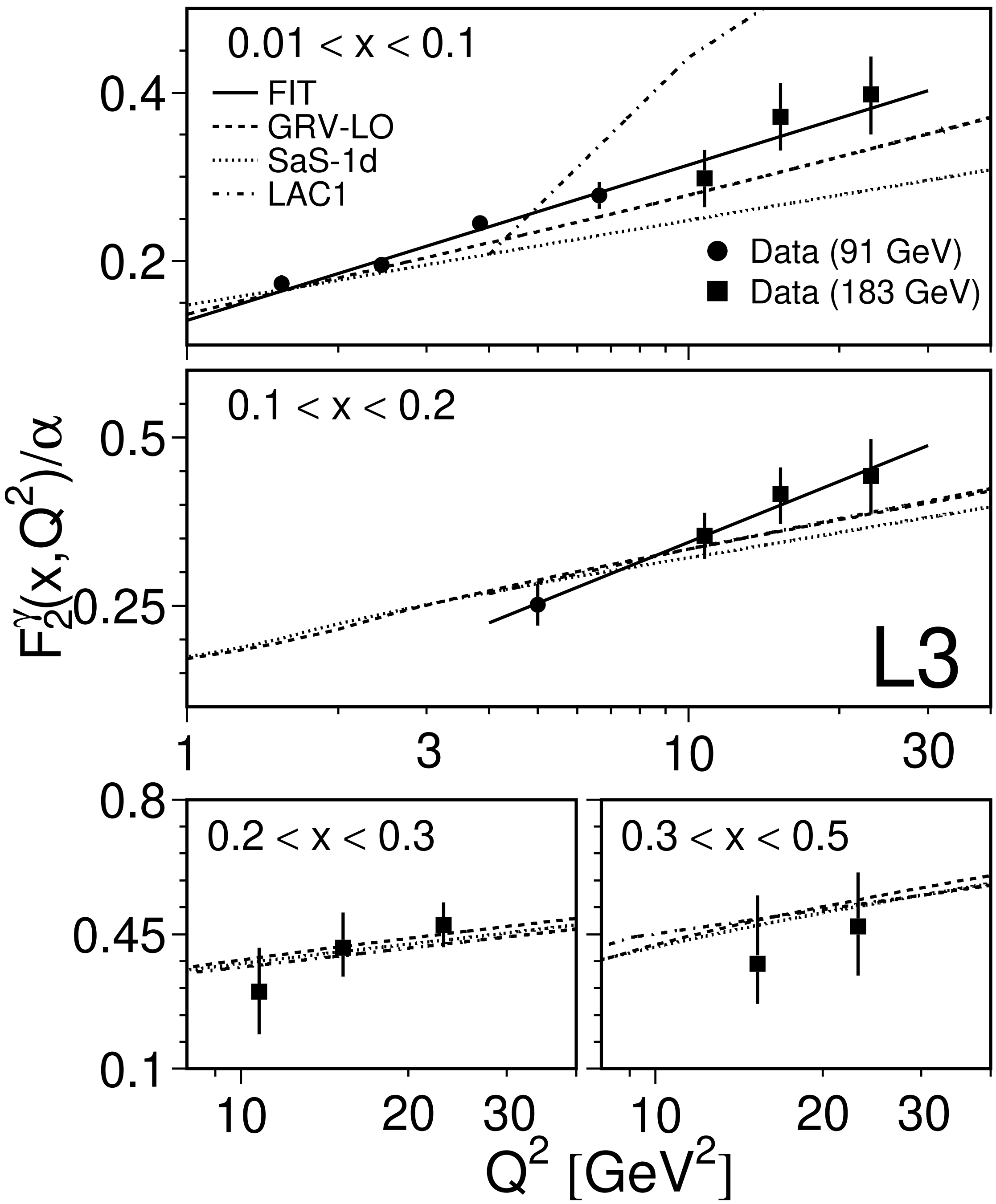
$$E_{\rm cm} = 183 \text{ GeV}, \quad \int L\, dt = 52 \text{ pb}^{-1}$$



L3: F_2^γ vs. Q^2

$$E_{\rm cm} = 91 \text{ GeV}, \ \int L\,dt = 140 \text{ pb}^{-1}$$

$$E_{\rm cm} = 183 \text{ GeV}, \ \int L\,dt = 52 \text{ pb}^{-1}$$



Conclusions

- Combined LEP distributions
  - → central rapidity region OK, problems in forward region
  - → input for model builders
  - → ongoing model studies by LEP $\gamma\gamma$ working group

- Improvements in unfolding
  - → 2-D reduces errors in F_2^γ

- Parametrizations of structure functions:
  - → OPAL, ALEPH: good agreement with GRV-LO
  - → L3 data higher than GRV-LO (low Q^2)
  - → SaS-1d too low at low x, LAC1 too high.

- Some LEP2 data analyzed, much more to come

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