The Measurement of Hadronic Structure Function of the Electron $F_2^e(z)$.

DELPHI Collaboration

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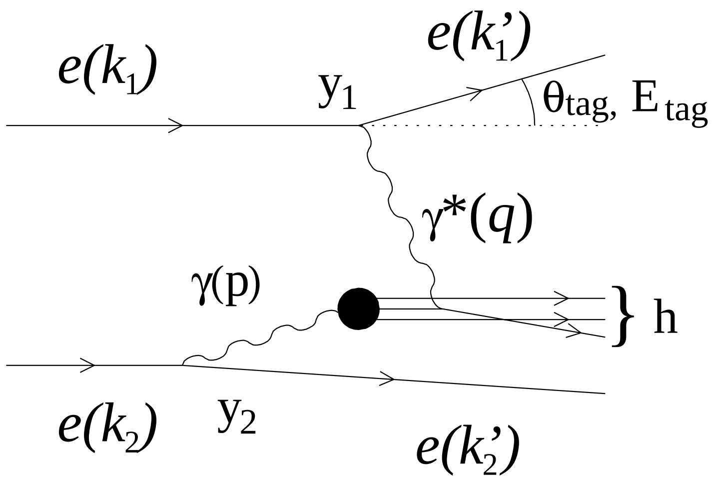
OUTLINE

- Deep Inelastic e-γ scattering
- Deep Inelastic e-e Scattering
- Analysis
- Measurement of the Electron Structure Function
- Conclusion



Electron-Photon Interactions

$$e^+e^- \to e^+e^-\gamma(q)\gamma(p) \to h + e^+e^-$$

Virtualities of the Photons

$$-q^2 = Q^2 \quad -p^2 = P^2$$

Scaling (dimensionless) variables:

$$y_1 = \frac{p\cdot q}{p\cdot k_1} \qquad y_2 = \frac{p\cdot q}{q\cdot k_2} \qquad x = \frac{Q^2}{2p\cdot q}$$

Total inclusive cross section:

$$\frac{d\sigma(ee\to h+ee)}{dy_1 dy_2 dP^2 dQ^2} \approx f_{\gamma|e}(y_2, P^2)\frac{d\sigma(e\gamma\to h+e)}{dy_1 dQ^2}$$

$f_{\gamma|e}(y_2, P^2)$ represents density of photons inside the electron and $\sigma_{e\gamma}$ describes the reaction $e\gamma \rightarrow hadrons$

After integration over P^2 one can obtain:

$$\int_{P^2_{min}}^{P^2_{max}} dP^2 f_{\gamma|e}(y_2, P^2) = f^{WW}_{\gamma|e}(y_2, P^2_{max}) =$$
$$\frac{\alpha_{em}}{2\pi}\left[\frac{1+(1+y_2)^2}{y_2} ln\frac{P^2_{max}}{P^2_{min}} - 2\frac{1-y_2}{y_2}\right]$$

(Weizsacker - Williams approximation)

If $P^2 << Q^2$, one can regard such a process as inelastic scattering of the electron on a quasi real photon target:

$$\frac{d\sigma(e\gamma \rightarrow h+e)}{dxdQ^2} = \frac{4\alpha^2_{em}\pi}{xQ^4}[(1 + (1 - y_1)^2)F^\gamma_2(x, Q^2)]$$

To obtain above cross section one has to measure both Q^2 and $W_{\gamma\gamma}^2$ what leads to indirect measurement of :

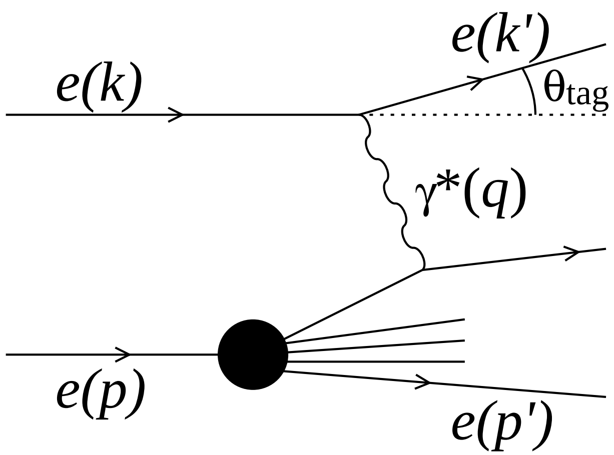
$$x = \frac{Q^2}{Q^2 + W_{\gamma\gamma}^2}$$

x is a momentum fraction of probed parton with respect to photon.

◇ Q^2 is measured directly $Q^2 = 4E_B E_{tag} sin^2\left(\frac{\theta_{tag}}{2}\right)$

◇ Challange of $W_{\gamma\gamma}^2$ determination

* Only small part of hadronic state is measured (polar angle distributions, Lorentz boost along the beam).
* To reconstruct hadronic invariant mass one has to correct the measured one taking into account particles that have escaped detection - strongly MODEL DEPENDENT!



Scattering on Electron

$$e^+e^- \to \gamma(q)e^+e^- \to h + e^+e^-$$

Scaling Variables

$$y_1 = 1 - \frac{E_{tag}}{E_B} cos \frac{\theta_{tag}}{2}$$

$$z = xy_2 = \frac{sin^2\left(\frac{\theta_{tag}}{2}\right)}{\frac{E_B}{E_{tag}} - cos^2\left(\frac{\theta_{tag}}{2}\right)}$$

z is considered as a momentum fraction of probed parton with respect to the electron momentum

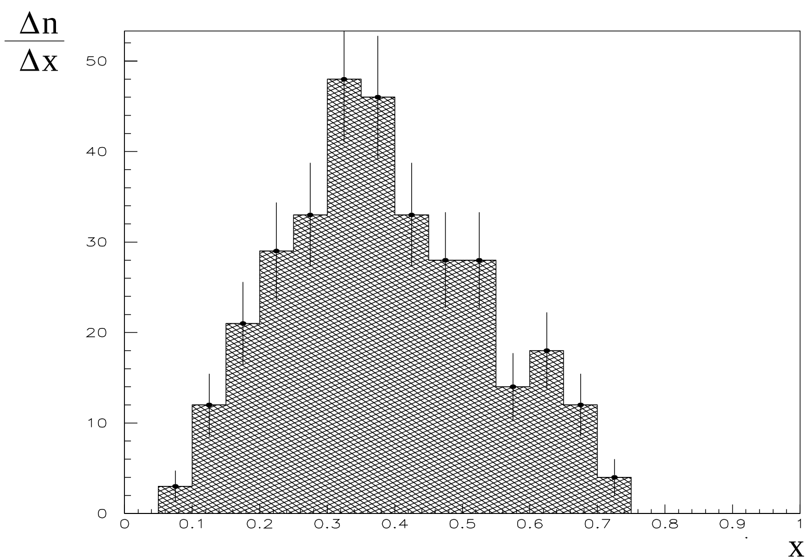
$$\frac{d\sigma(ee \to h + ee)}{dz dQ^2} = \frac{2\pi\alpha^2_{em}}{zQ^4}[(1 + (1 - y_1)^2)F_2^e(z, Q^2)]$$

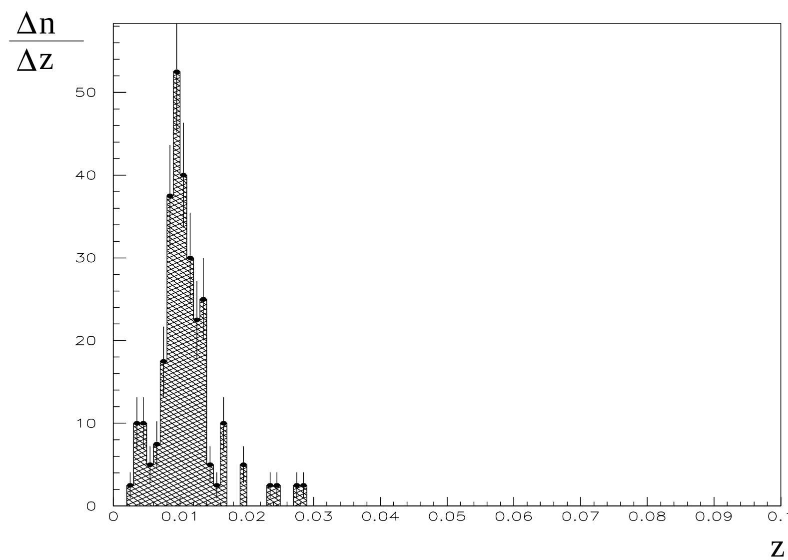
In analogy to *ep* scattering, we can introduce electron structure function $F_2^e(z, Q^2)$ [W.Słomiński,J.Szwed]. For $P^2 << Q^2$

$$\frac{1}{z}F_2^e(z, Q^2) = f^{WW}_{\gamma|e}(y_2, P^2_{max}) \otimes \frac{1}{x}F_2^\gamma(x, Q^2)$$

To determine $F_2^e(z, Q^2)$ one has to measure polar angle θ_{tag} and energy E_{tag} of the scattered electron - both directly measured!

One of the most important differences is smearing of the x and z variables





This is strong argument to apply bin by bin correction

NO UNFOLDING NEEDED

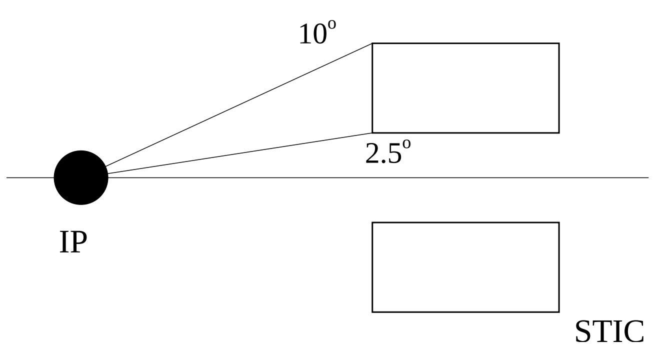
LESS MODEL DEPENDENT!

Data Selection

Set of cuts.

LEP1 and LEP2

- ◇ $E_{tag} > 0.65 E_B$
- ◇ $W_{\gamma\gamma} > 3\ GeV$
- ◇ charged multiplicity > 3
- ◇ $E_{atag} < 0.25 E_B$-antitag
- ◇ some additional cleaning cuts



◇ Data sets

$\mathcal{L}$ $[pb^{-1}]$	$\sqrt{s}$ [GeV]	year
111	91.2	1994-95
254	192-200	1999
233	200-209	2000

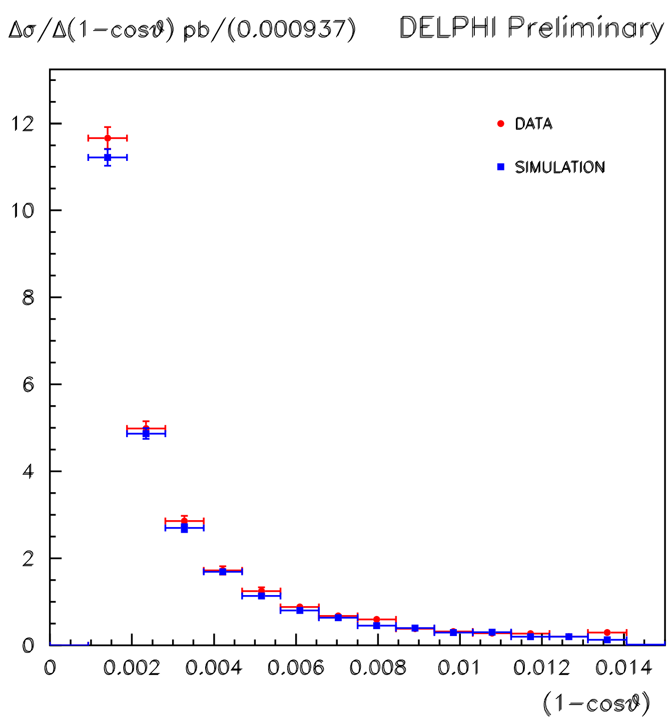
$\int Ldt$=598 pb^{-1}

◇ STIC Detector Resolution

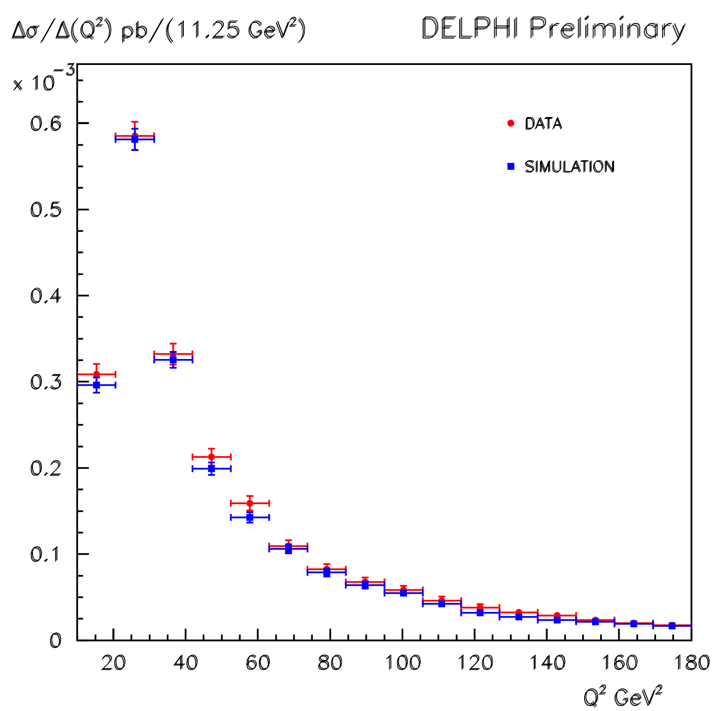
$\Delta\theta_{tag} \approx 1.2\ [mrad]$

$\frac{\Delta E_{tag}}{E_B} \approx 0.9\ \%$

Comparision of the data and simulated events (TWOGAM model).

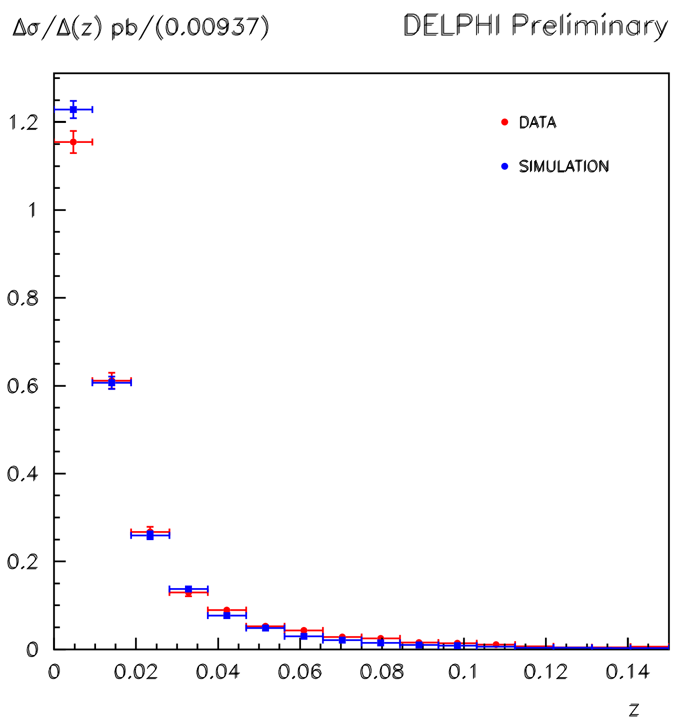


Angle of scattered electron.

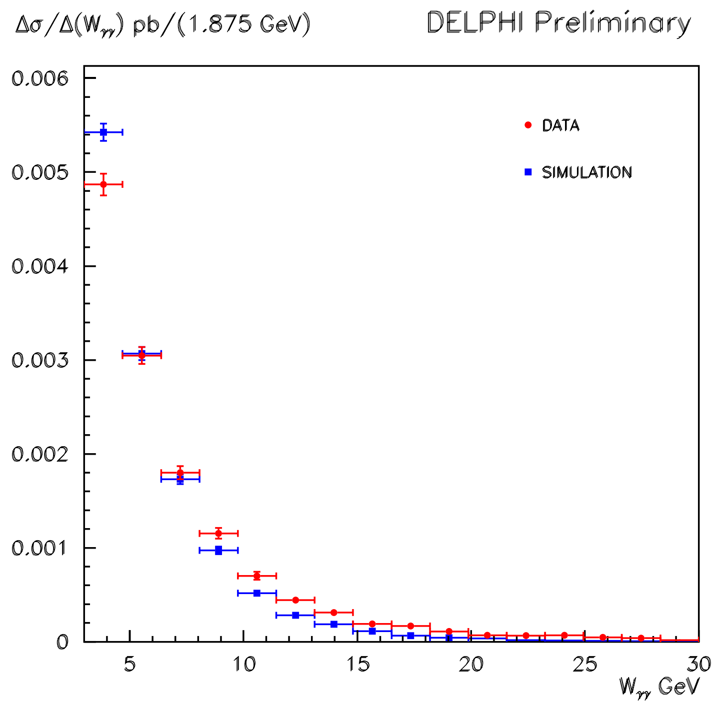


Q^2 of scattered electron.

Comparision of the data and simulated events (TWOGAM model).



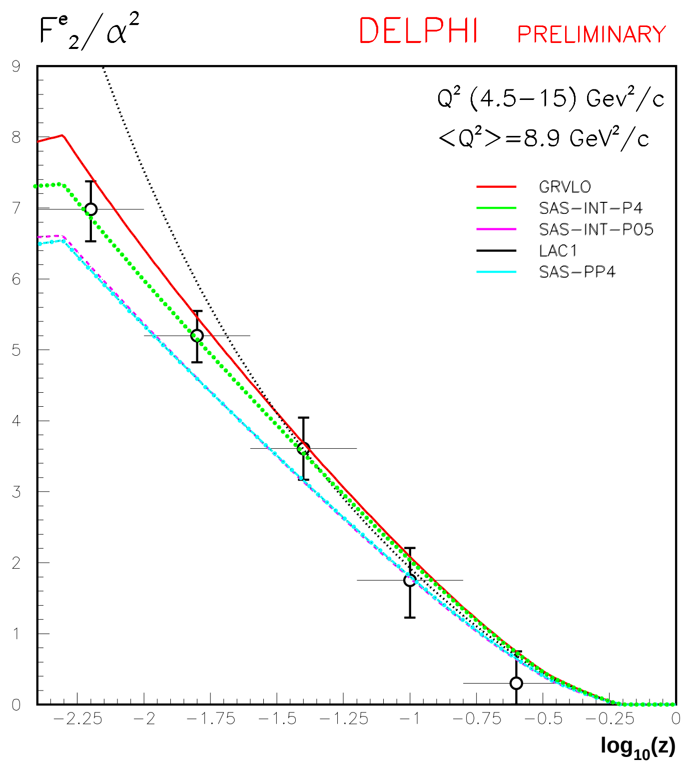
The z variable.



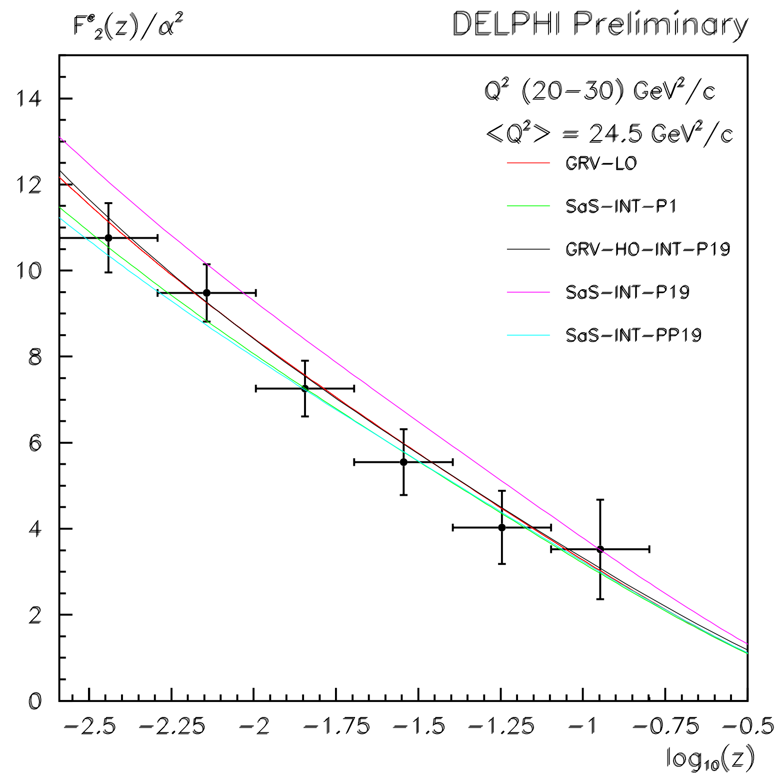
Invariant mass of hadronic state.

Measured electron structure function $F_2^e(z)$.

LEP1

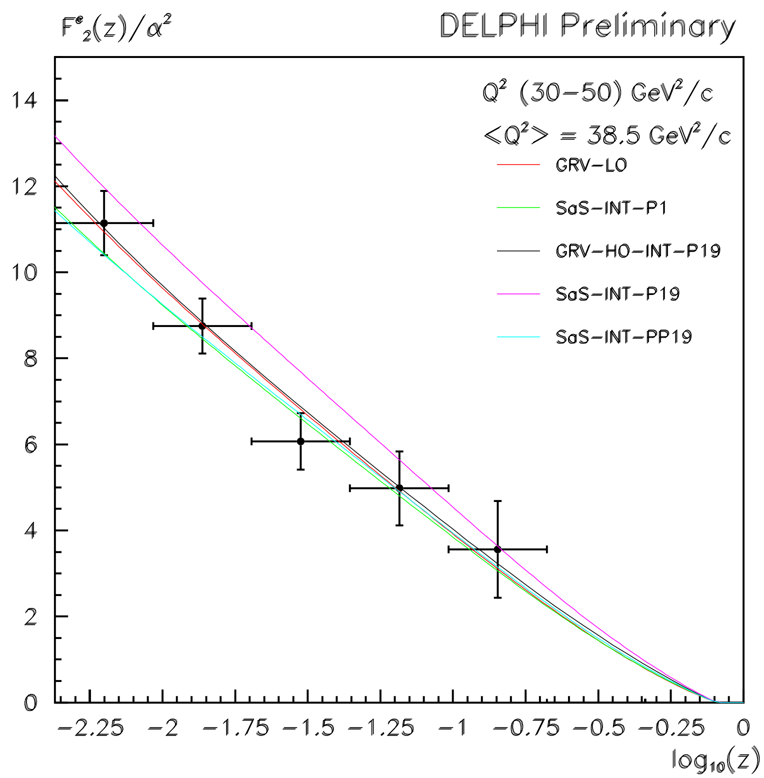


LEP2

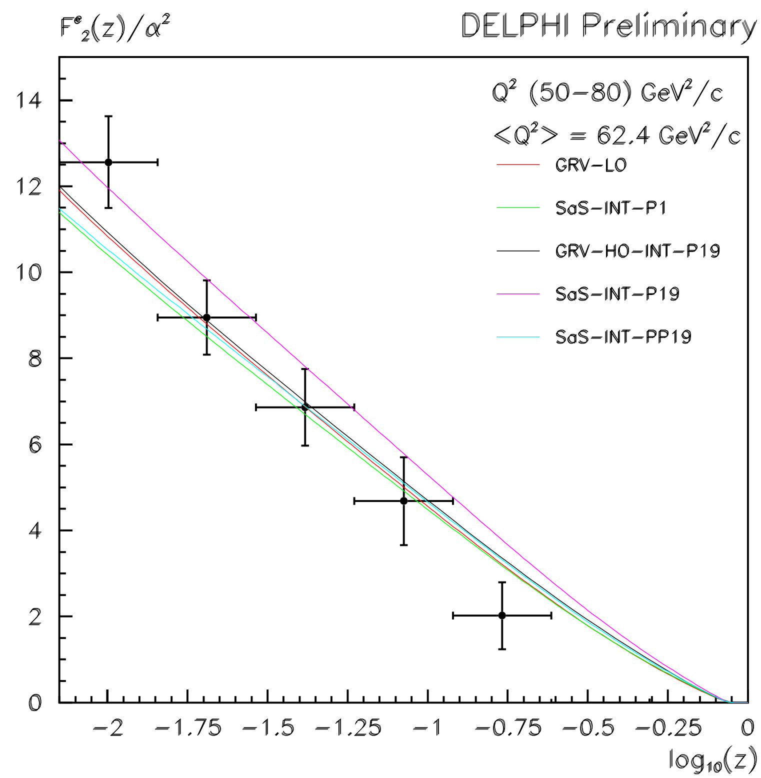


Measured electron structure function $F_2^e(z)$.

LEP2



LEP2



◇ CONCLUSION

1) First Measurement of the ESF

2) Simple method based on directly measured variables $\theta_{tag}, \ E_{tag}$

3) No unfolding

4) Errors well understood

5) Importance of photon virtuality

6) Agreement with GRV-LO model