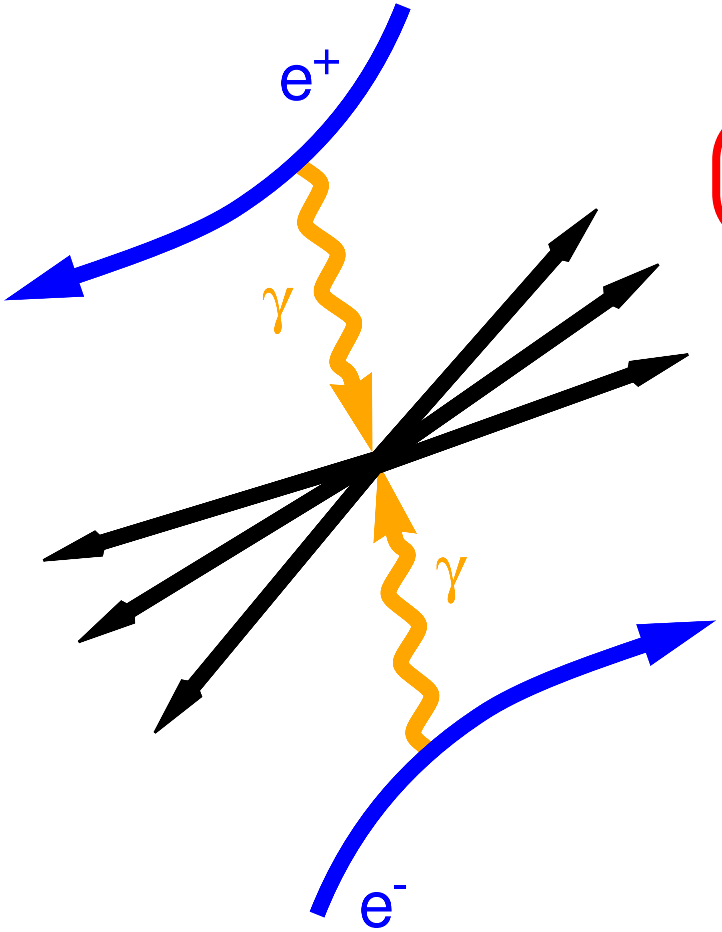
THE PARTON CONTENT OF THE PHOTON



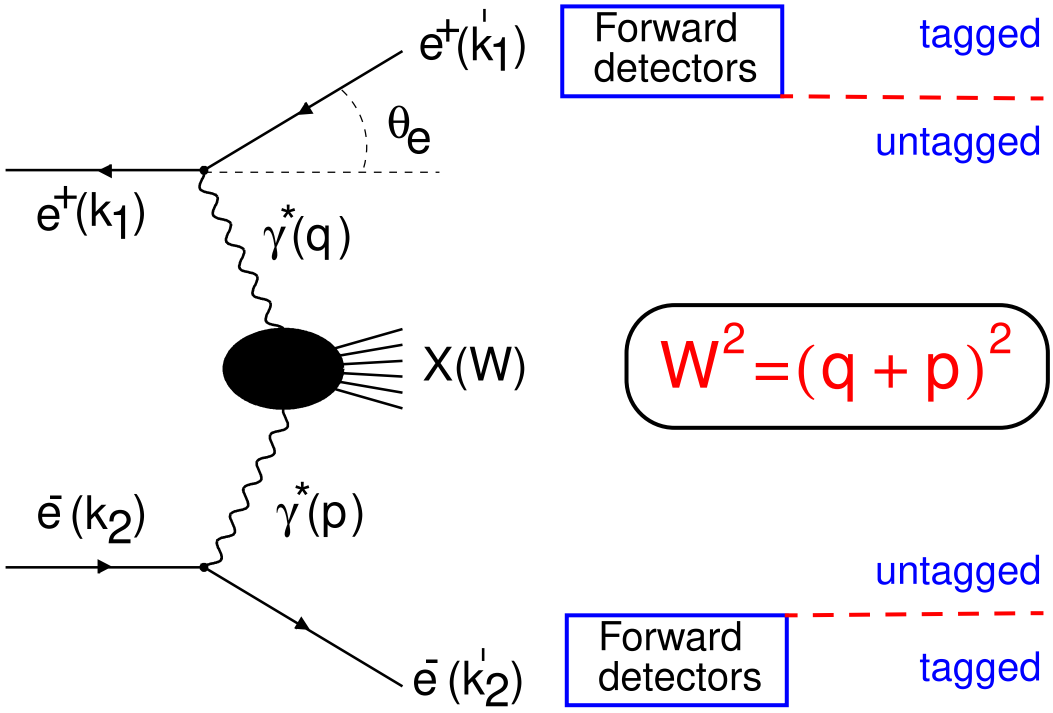
F_2^γ at low x

Heavy Quark Production

Thorsten Wengler, CERN
March 2000

XXXVth Rencontres de Moriond
Les Arcs, France

Kinematics



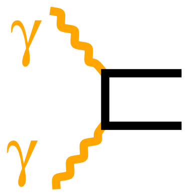
$$W^2 = (q+p)^2$$

$$Q^2 \equiv -q^2 = -(k_1 - k_1')^2 = 2\,E_b E_{tag}(1-\cos\theta_e)$$

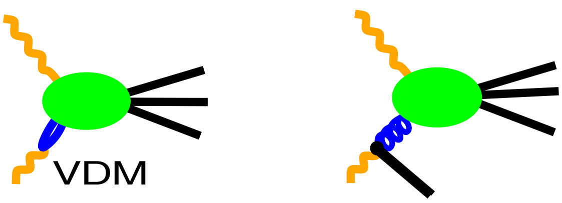
$$P^2 \equiv -p^2 = -(k_2 - k_2')^2$$

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

point-like



hadron-like



The Photon Structure Function

Determined from single tag events

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

Small contribution

$$y = 1 - \frac{E_{tag}}{E_b}\cos^2\theta_e$$

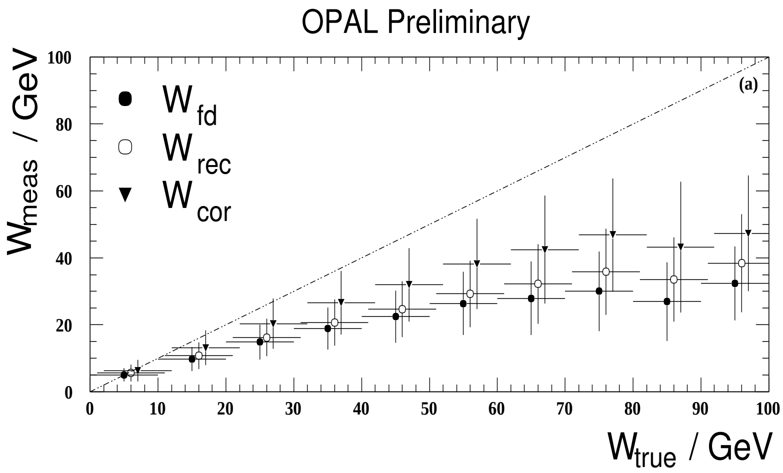
Small for $E_{tag} \geq 0.7\, E_b$ and small θ_e considered

Need distribution of events in Q^2 and x

Obtained from the scattered electron

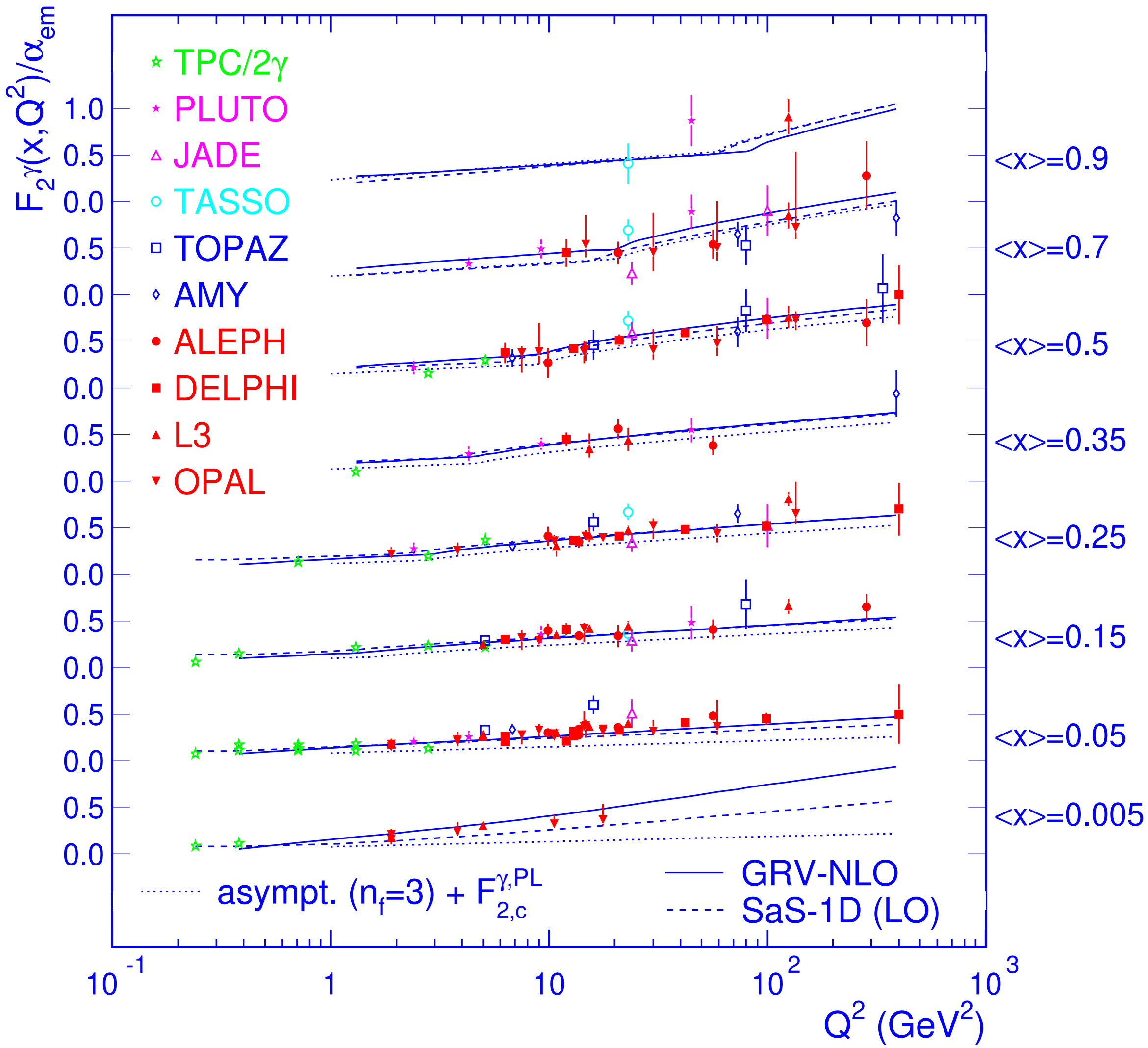
good resolution

Scattered electron & hadronic final state



Needs unfolding

An overview of F_2^γ results



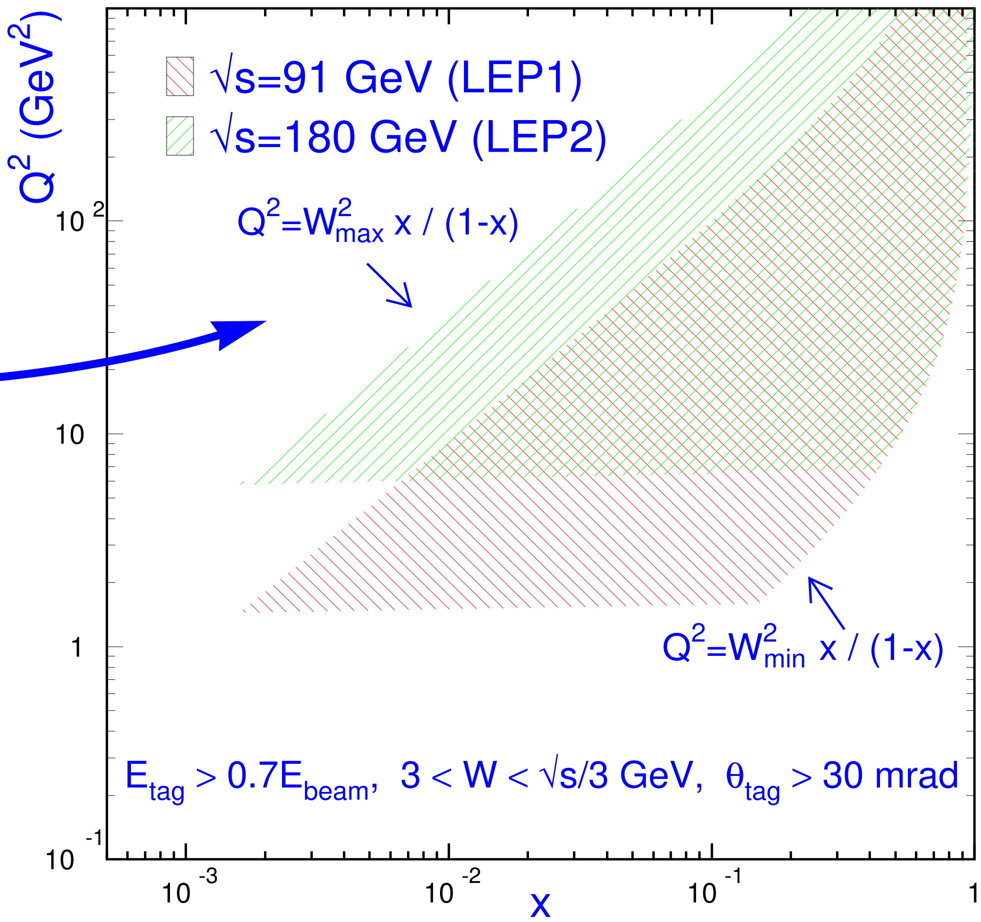
Rise with ln Q^2

Test of QCD !

Positive scaling violations at all values of x

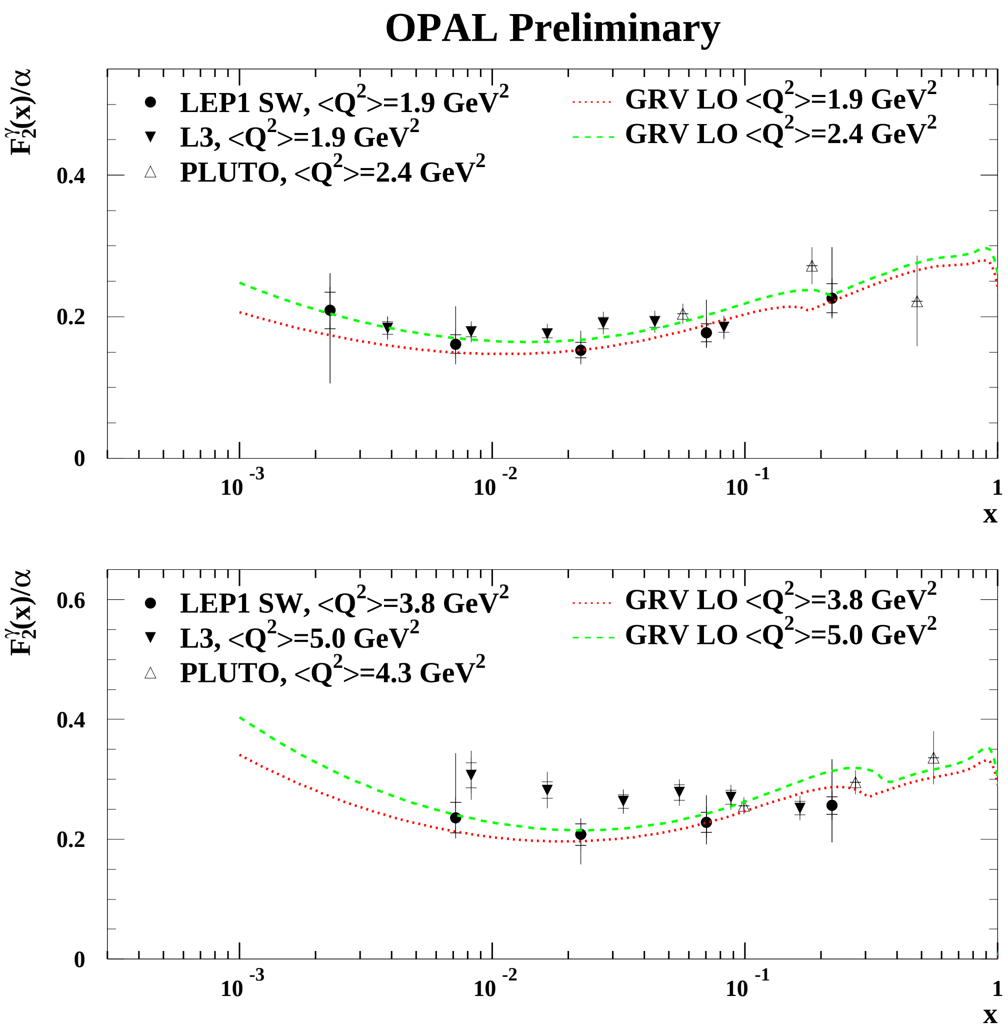
The accessible kinematic range

(low x, high Q^2)
cannot be reached



Presently explored is x
down to about 10^{-3} at LEP

A closer look at F_2^γ at low x



Low x rise cannot be ascertained with present data

The "one-more-point" situation

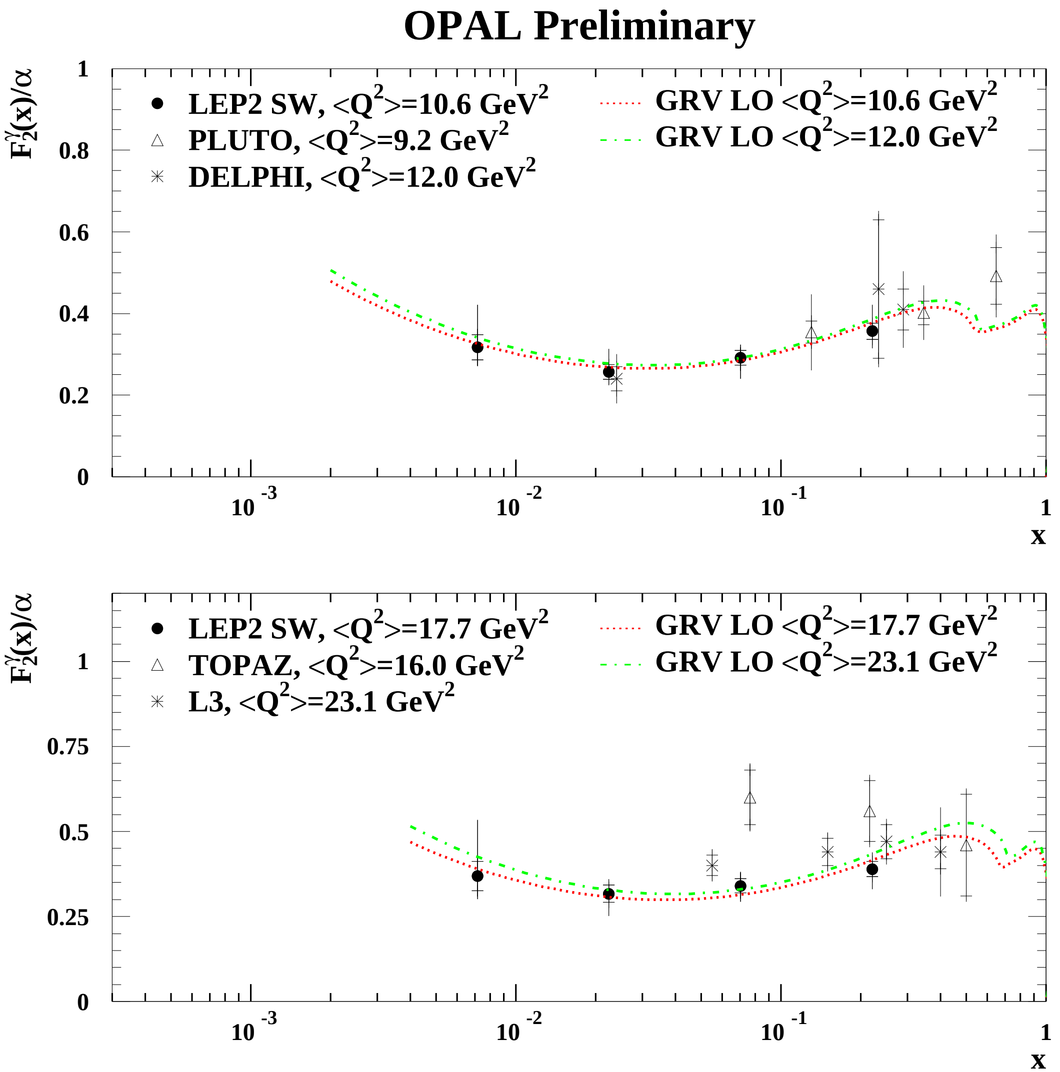
But will we get it ?

Smaller errors will help

Work is in progress

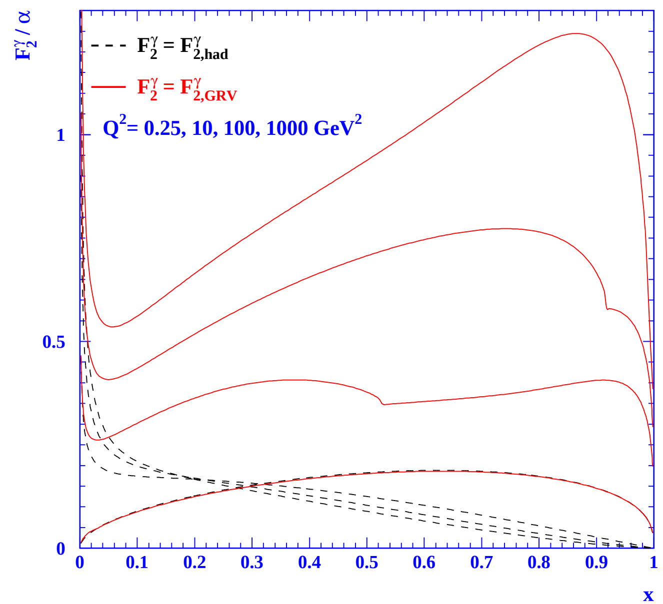
Further improvements expected soon !!

F_2^γ at low x continued



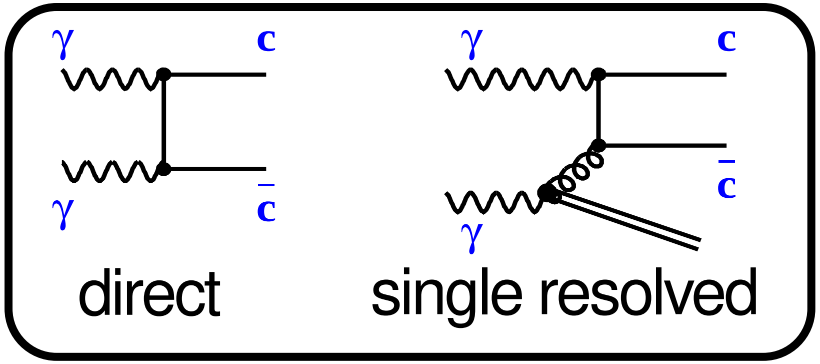
Good agreement between the experiments

GRV LO describes the data well



Heavy quark production in photon-photon collisions

Sensitive to gluon content of the photon



test QCD predictions

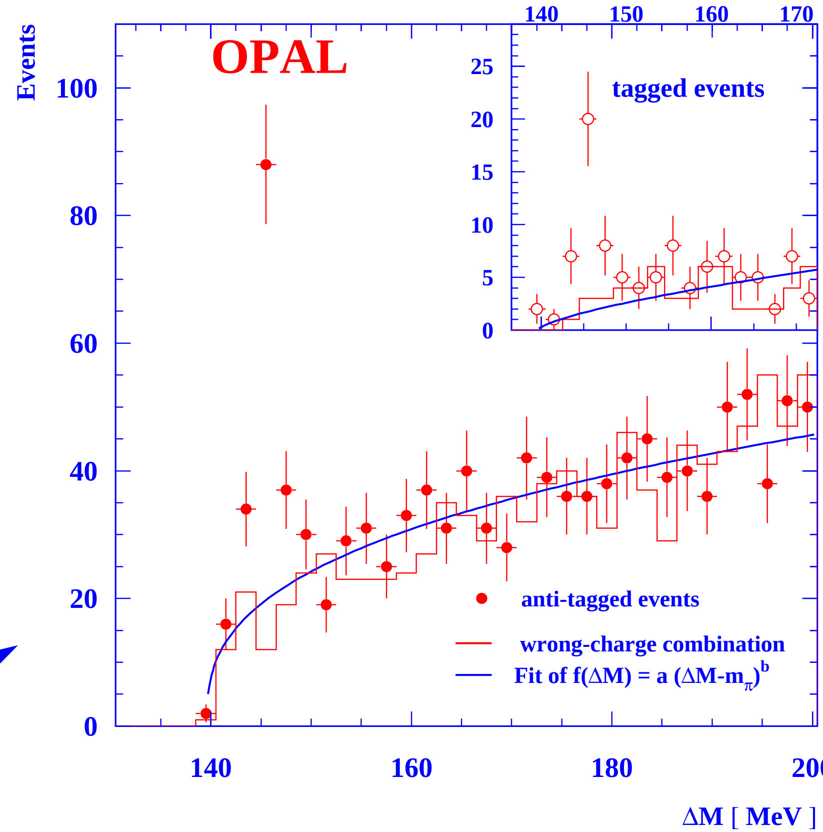
charm tag via $D^{\star}$:

$$D^{\star +} \rightarrow D^0 \pi^+$$

$$D^0 \rightarrow K^- \pi^+$$

$$D^0 \rightarrow K^- \pi^+ \pi^- \pi^+$$

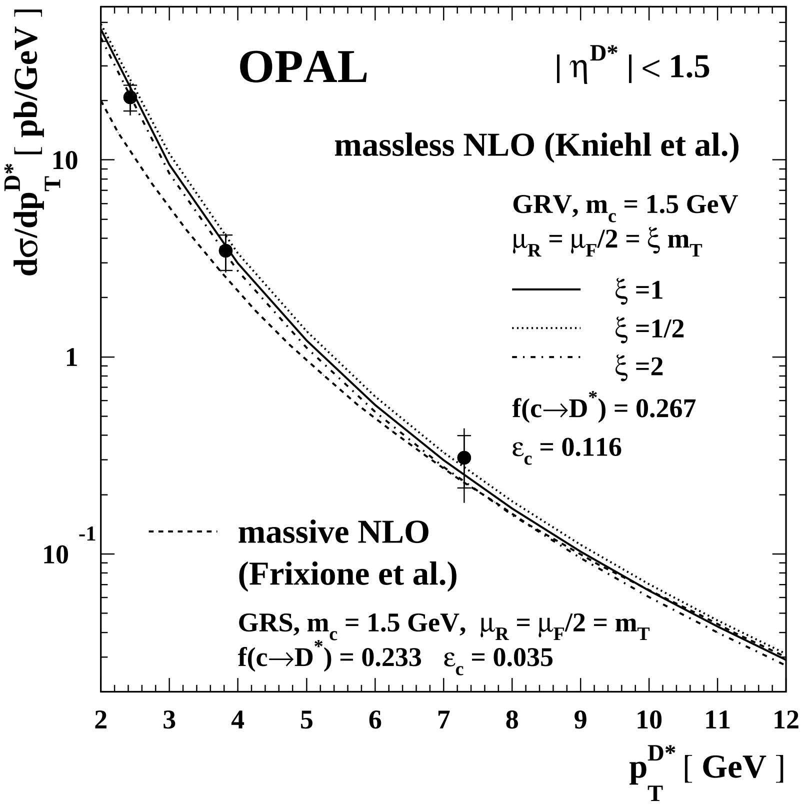
$\Delta M (D^{*}, D^0)$

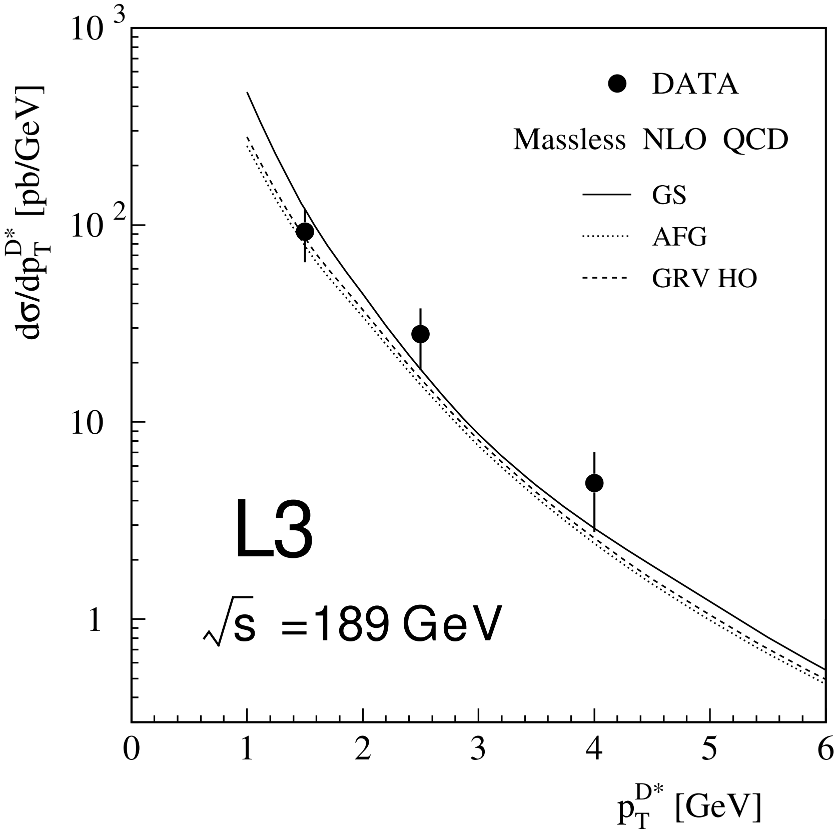


e.g. OPAL:

- ~ 210 pb^{-1} data
- ~100 events untagged
- ~ 30 events single-tag

Differential D* cross sections (untagged)

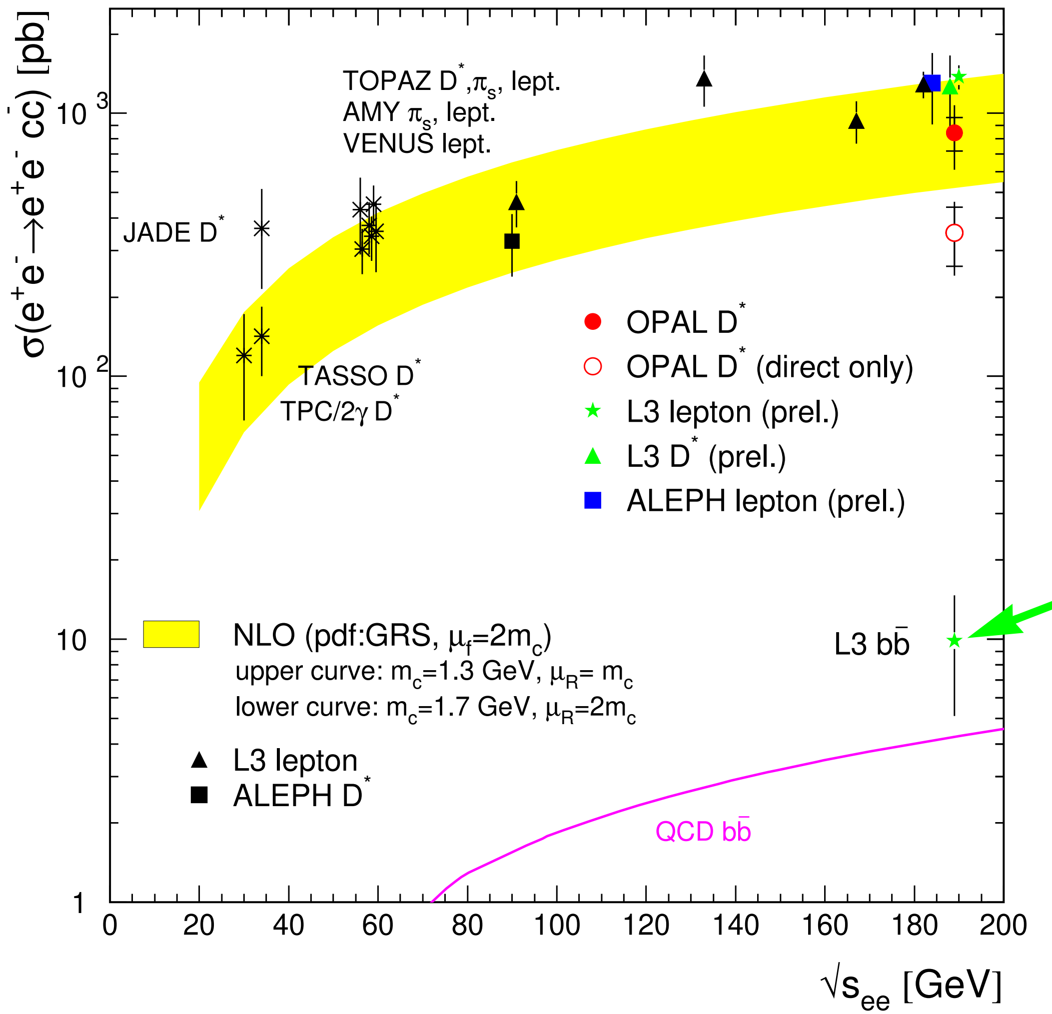




QCD at NLO works well

Surprisingly still good description for massless approach at low p_T

The total $c\bar{c}$ and $b\bar{b}$ cross-section

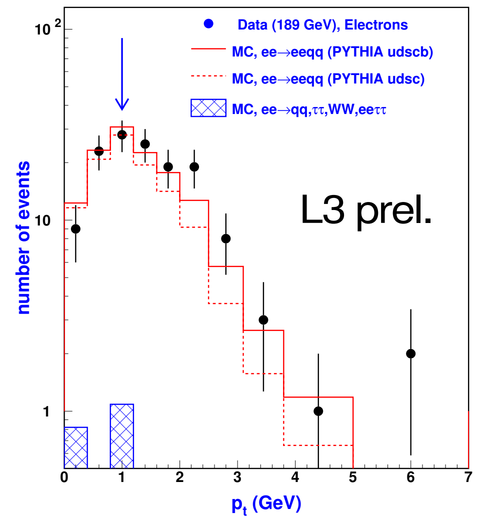


Extrapolated to full phase space using MC

New results from ALEPH, L3, OPAL

Good experimental agreement on $c\bar{c}$ cross-section

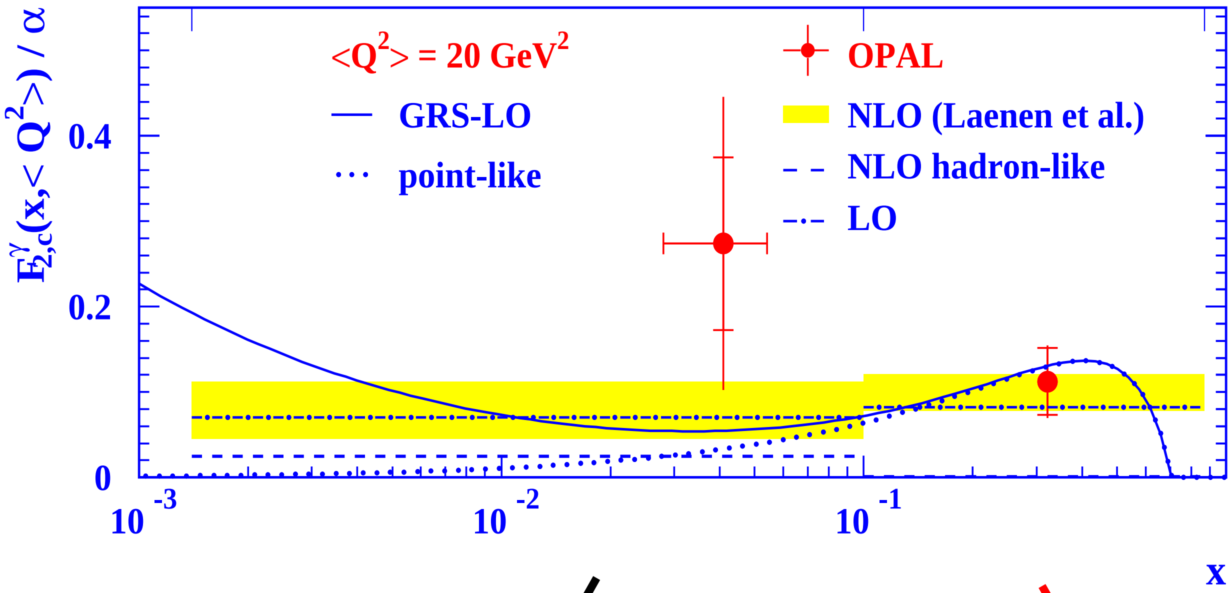
Well described by QCD



First sign of $b\bar{b}$ in $\gamma\gamma$ (L3):

$$\sigma^{b\bar{b}} = 9.9 \pm 2.9(\text{stat}) \pm 3.8(\text{syst})\ \text{pb}$$

First determination of $F_{2,c}^{\gamma}$



- Determined from ~30 single tagged $c\bar{c}$ events (identified D*)
- Large uncertainty for x<0.1 mostly due to model uncertainty (invisible part of cross-section in extrapolation to full phase space)

$\Rightarrow$ progress is expected

For x < 0.1 data suggest hadronic component

(but large uncertainties)

For x > 0.1 purely perturbative NLO QCD in good agreement with data

Summary

F_2^γ at low x

- F_2^γ determined down to x ~10^{-3}
- Good agreement of the available measurements
- A rise at low x cannot be established with present data
- Work is under way to reduce the uncertainties on F_2^γ
- Parameterizations like GRV LO are able to describe the data well

Heavy Quark Production

- New measurements of charm production in $\gamma\gamma$
- The experimental results are in good agreement
- NLO QCD provides a satisfactory description of the data
- First sign of $b\bar{b}$ in $\gamma\gamma$
- First determination of $F_{2,c}^\gamma$ in two bins of x
- $F_{2,c}^\gamma$ for $x > 0.1$ is well described by NLO QCD,
- $F_{2,c}^\gamma$ for $x < 0.1$: data suggest hadronic component