Charm and beauty inclusive production in two photon collisions at LEP

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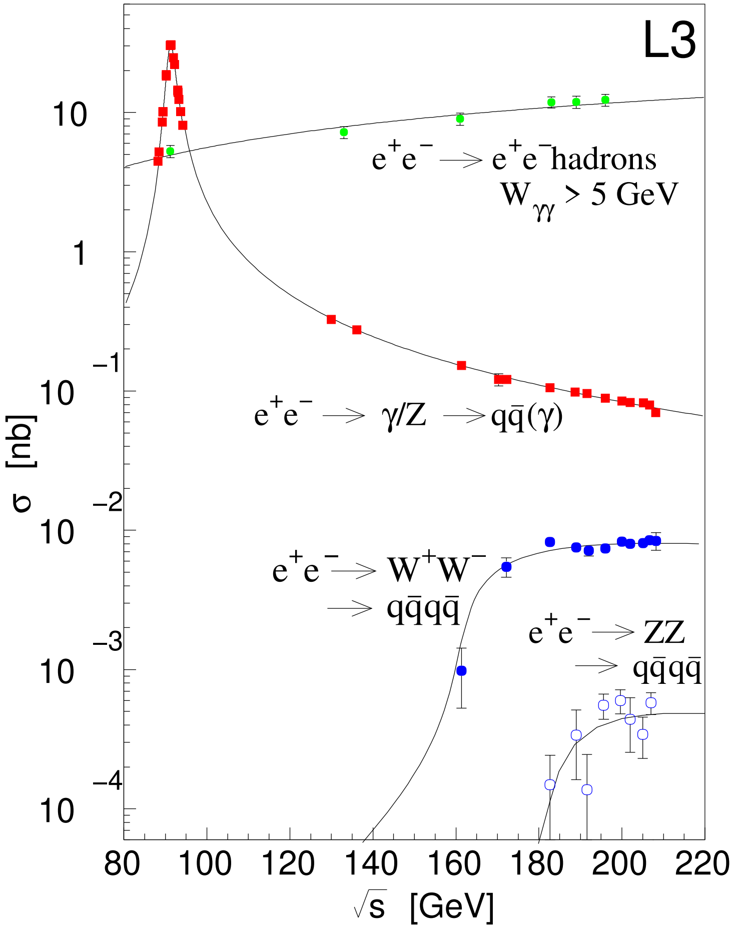
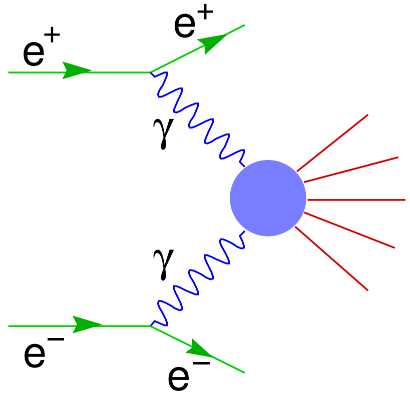
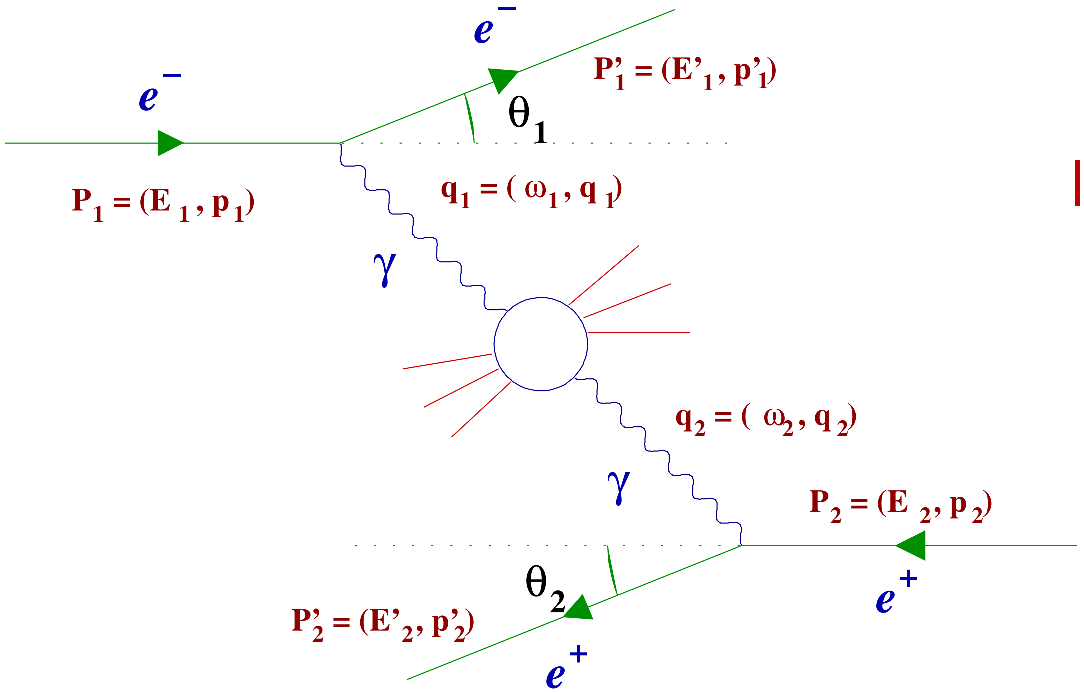
Hadron production at LEP





Two photon collisions are the main hadron source at LEP2.

Kinematic

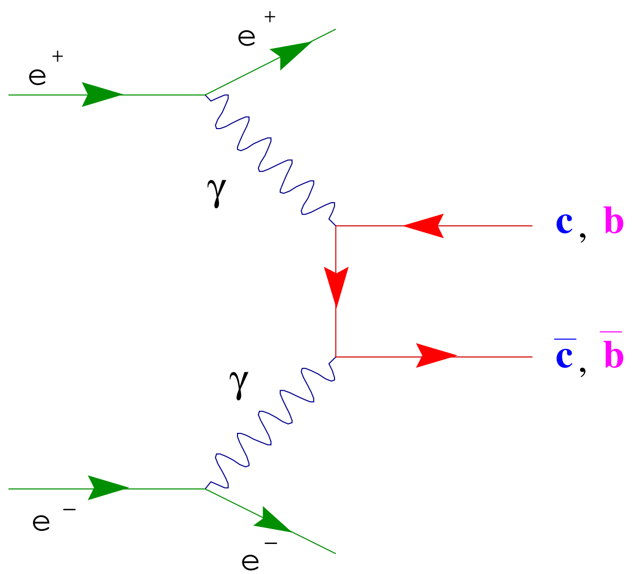


Anti-tag ensures
low photon virtuality (q^2)

High quark masses
set high energy scales
⇨ perturbative
regime of QCD

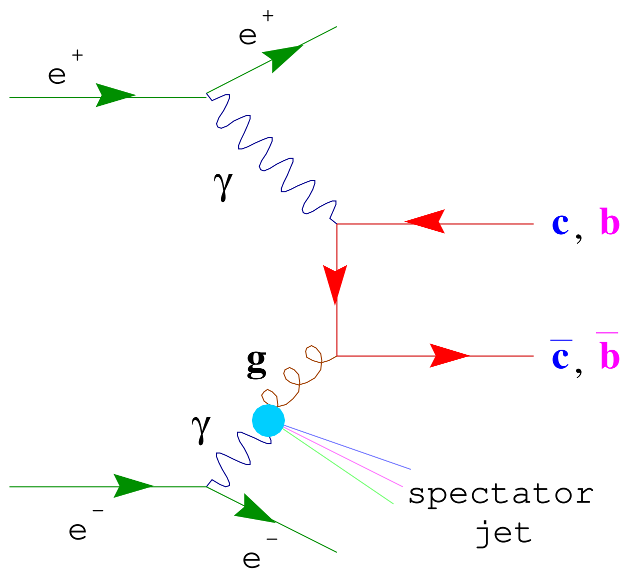
Heavy flavour in $\gamma\gamma$ collisions

At LEP2, direct and resolved processes are equally important



Direct (QED)

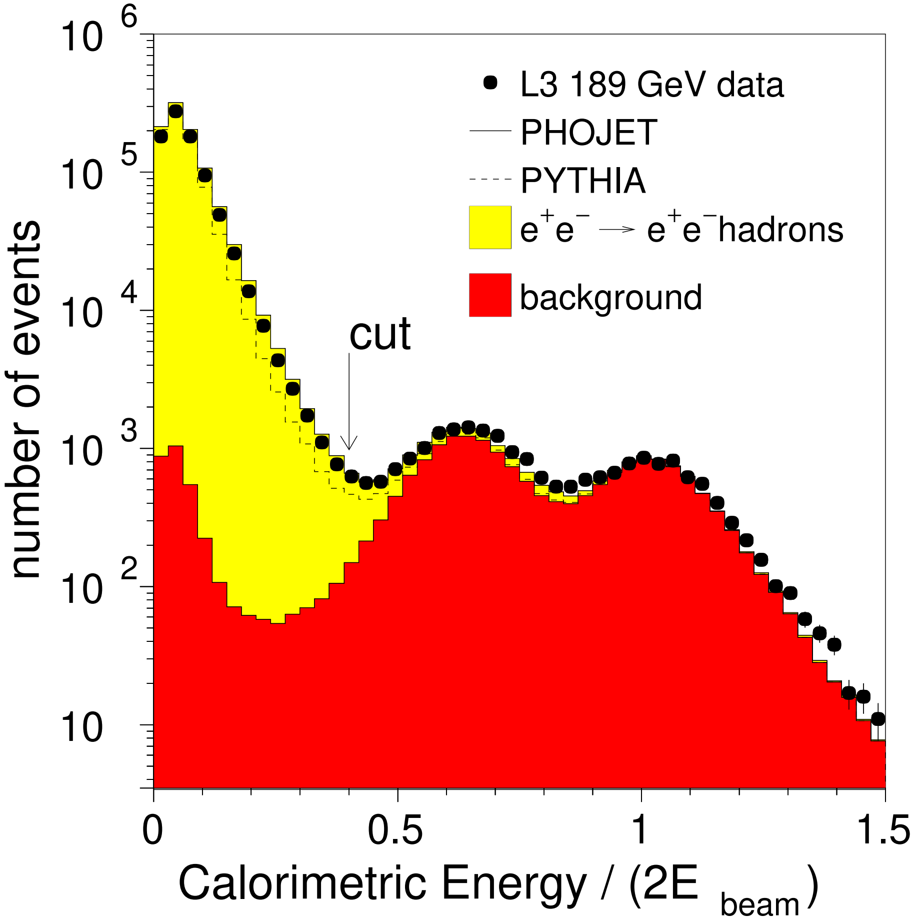
depends only on
quark masses and α_S
(radiative QCD corrections)



Single Resolved

depends mainly on
the gluon content
of the photon

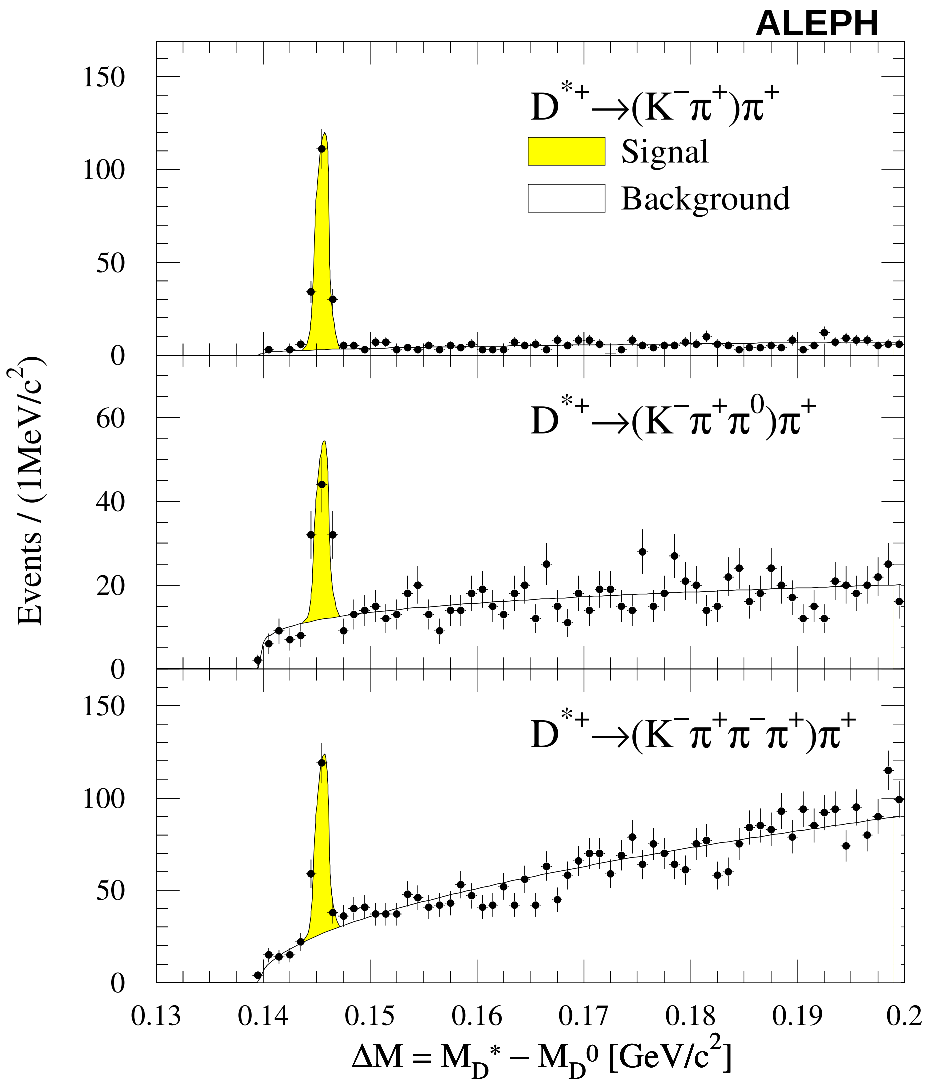
Selection of $\gamma\gamma$ events



Clear separation between $\gamma\gamma$ and annihilation events

The $\mathrm{e^+e^-} \longrightarrow \mathrm{q\bar{q}}(\gamma)$ and $\mathrm{e^+e^-} \longrightarrow \mathrm{e^+e^-}\tau^+\tau^-$ background is very low

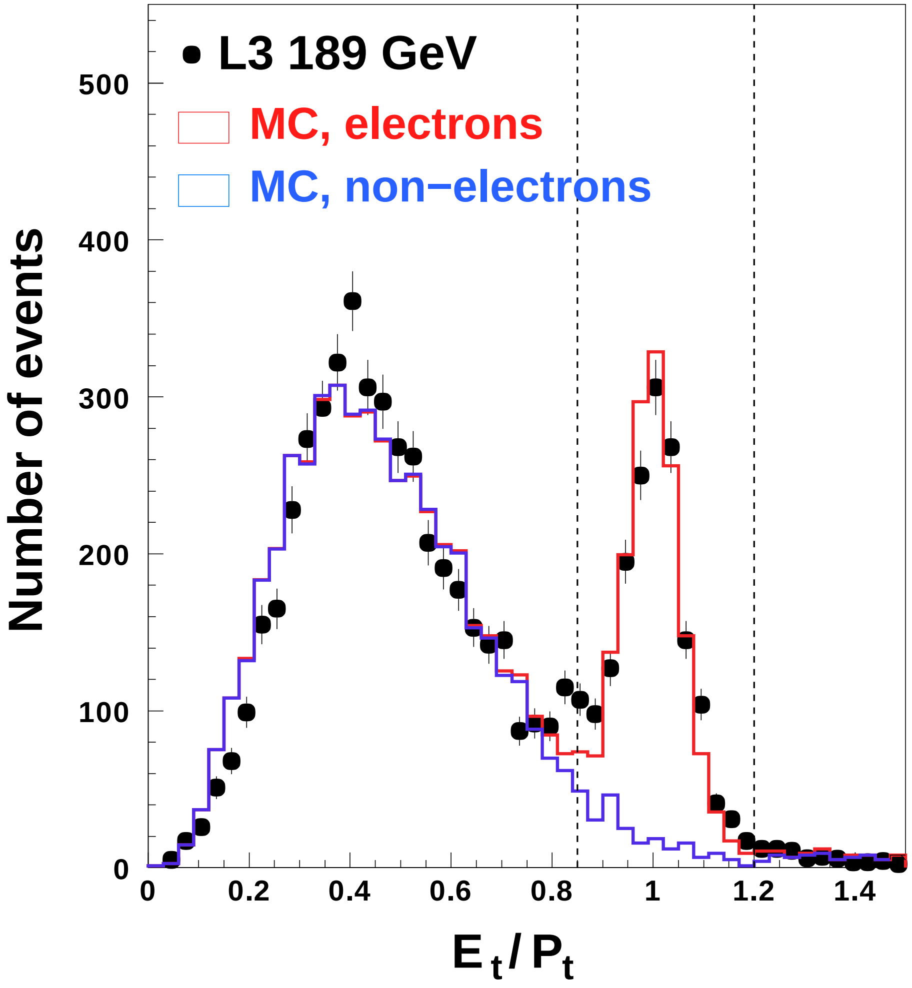
Heavy flavour tagging (I): D^* tag



$$D^{*\pm} \longrightarrow D^0 + \pi_S^\pm$$

See next talk for more details

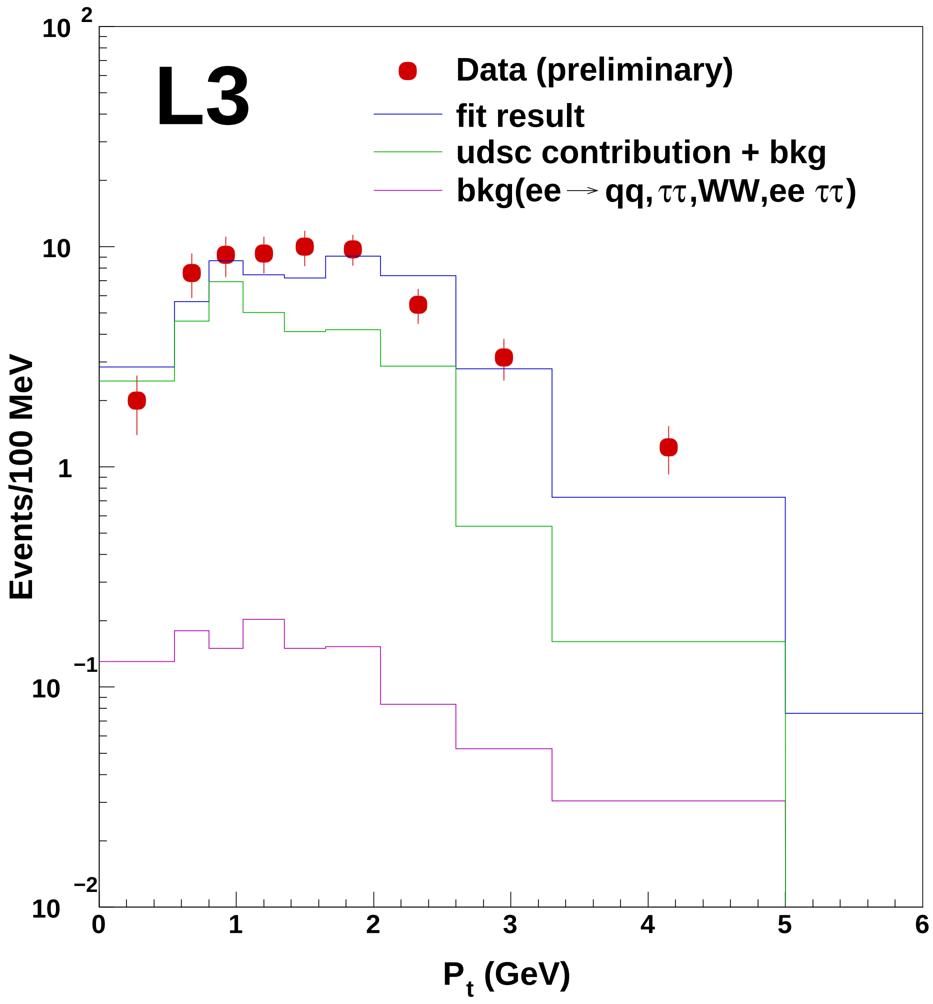
Heavy flavour tagging (II): lepton tag



Select leptonic decay (here e^- in L3) of c or b quark

Keep only electrons with momentum greater than 0.6 GeV (for c selection) or 2 GeV (for b selection)

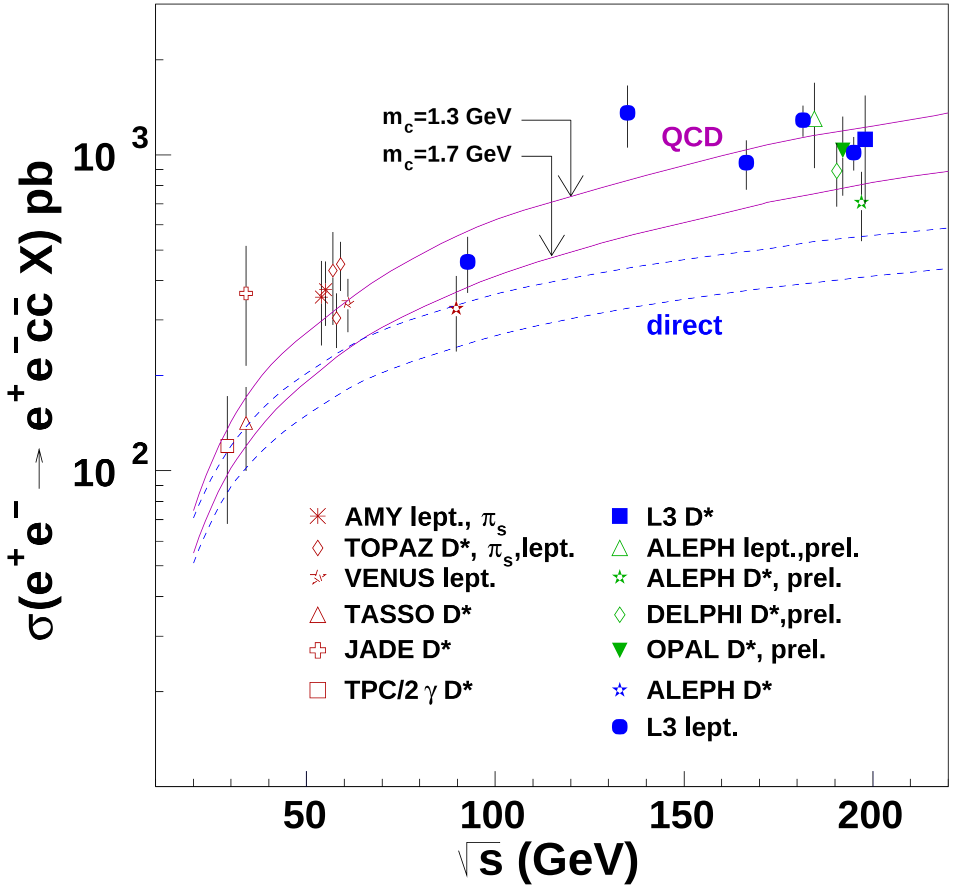
Heavy flavour tagging (II): lepton tag



Calculate p_t of the lepton with respect to the nearest jet

Fit resulting spectrum with uds, c and b content as free parameters

Charm cross-section



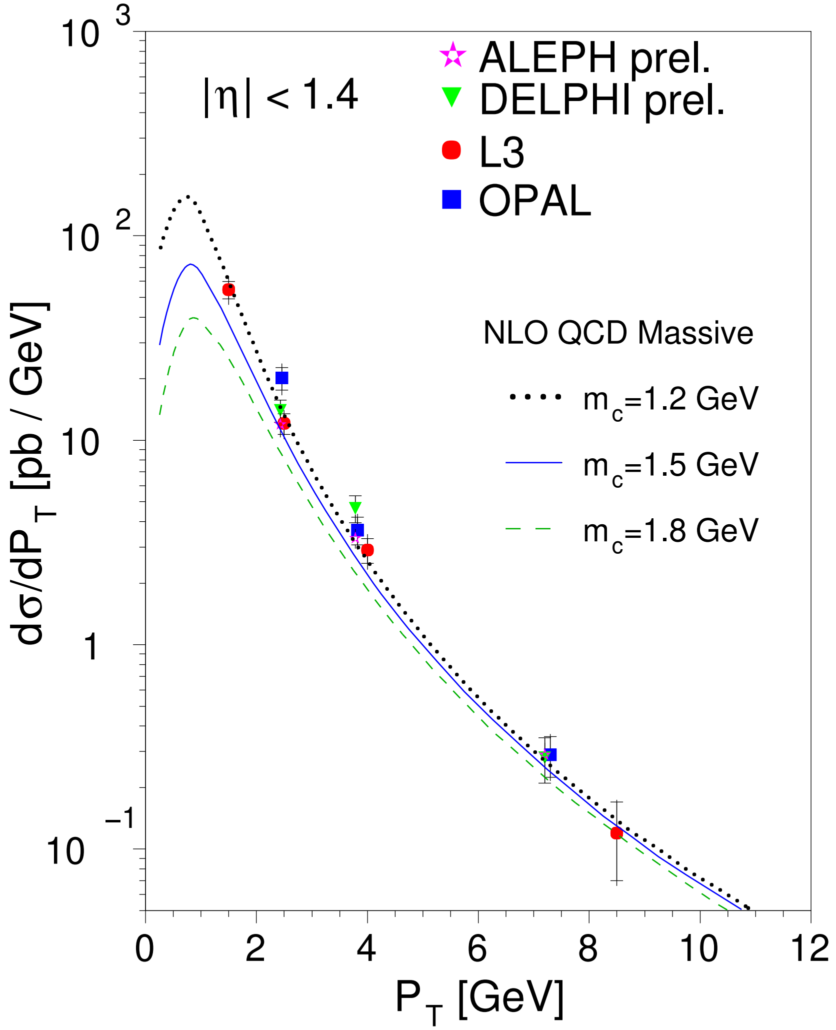
LEP explored
high energies with
high statistics

Direct is not sufficient

Evidence for gluon
content of the photon

NLO calculations: M. Drees et al., Phys. Lett. B306 (1993) 371

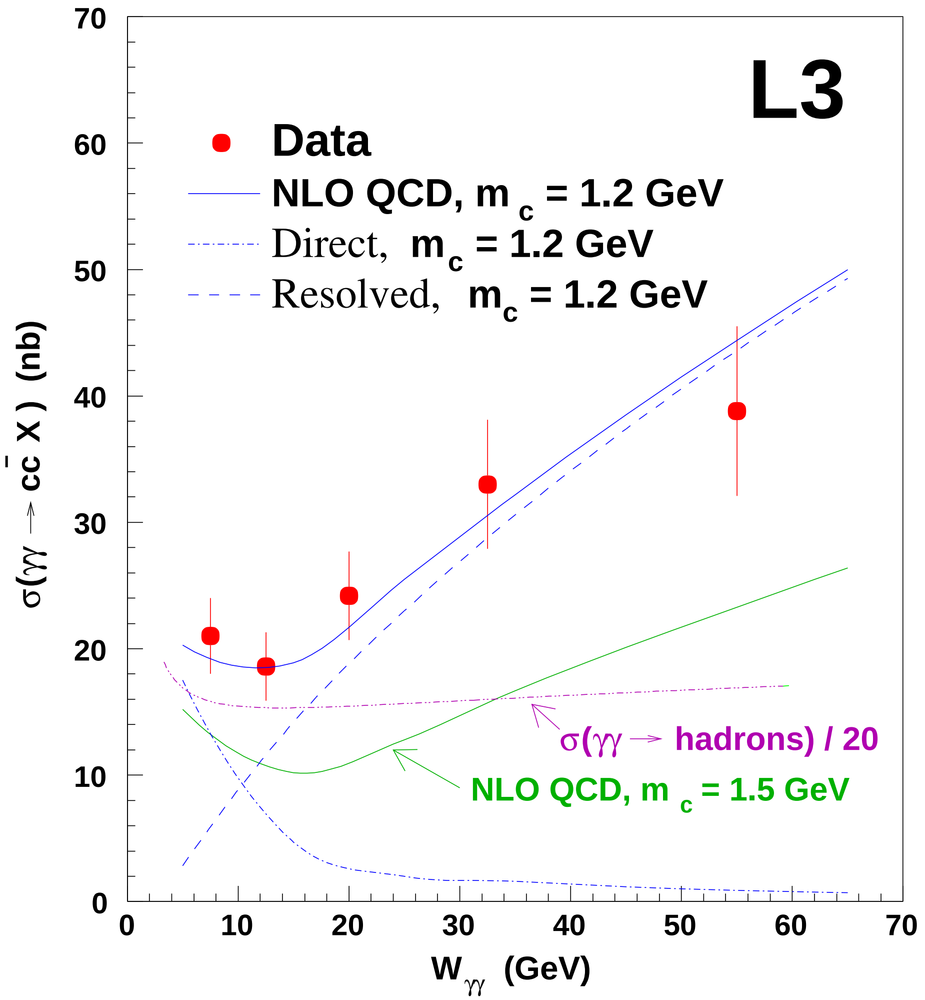
Charm differential cross-section (I)



light m_c are favoured

NLO QCD: S. Frixione et al.,
Nucl. Phys. B 571 (2000) 169

Charm differential cross-section (II)



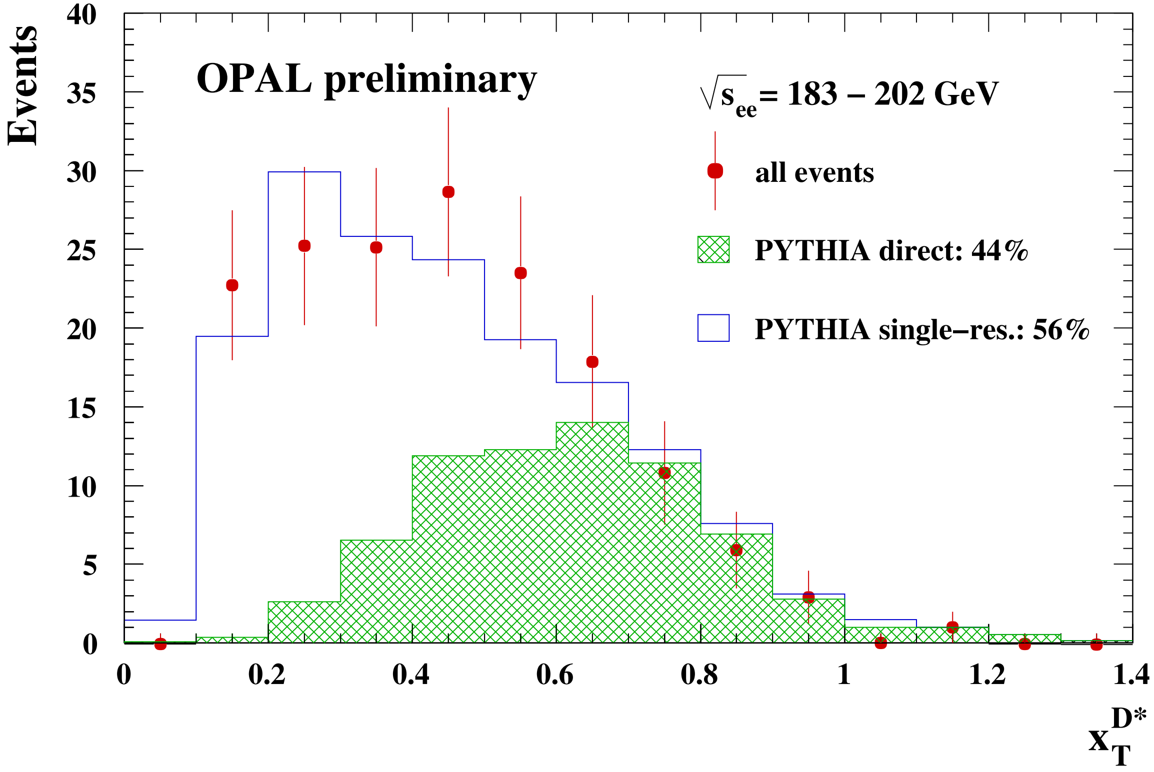
good agreement
for $m_c = 1.2$ GeV

sensitivity to
direct vs. resolved

steeper rise than
$\sigma(\gamma\gamma \to \mathrm{hadrons})$

NLO QCD: S. Frixione et al., J. Phys. G26 (2000) 723

Separation of $\gamma\gamma$ processes



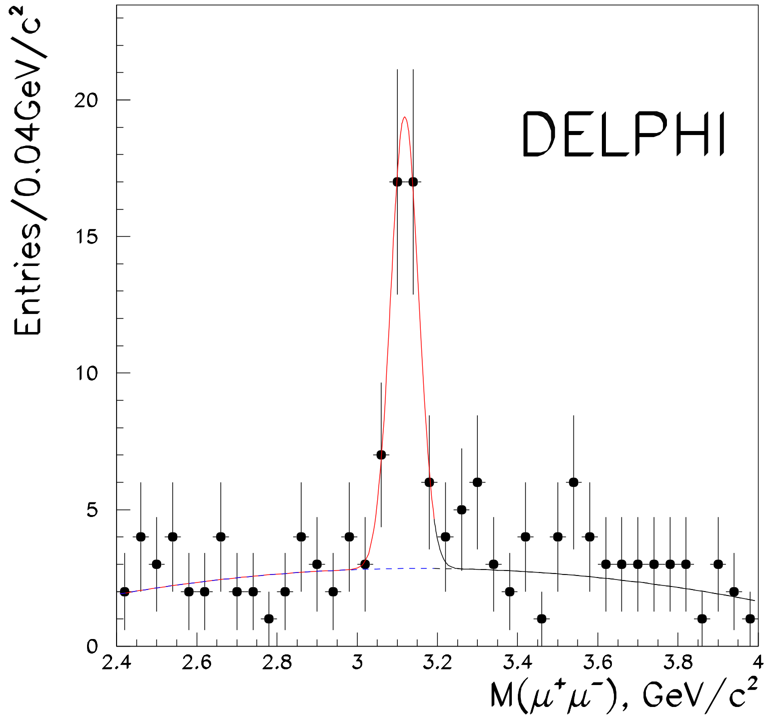
ALEPH (prel.):

Direct $=$ (62.2 ± 4.2) %

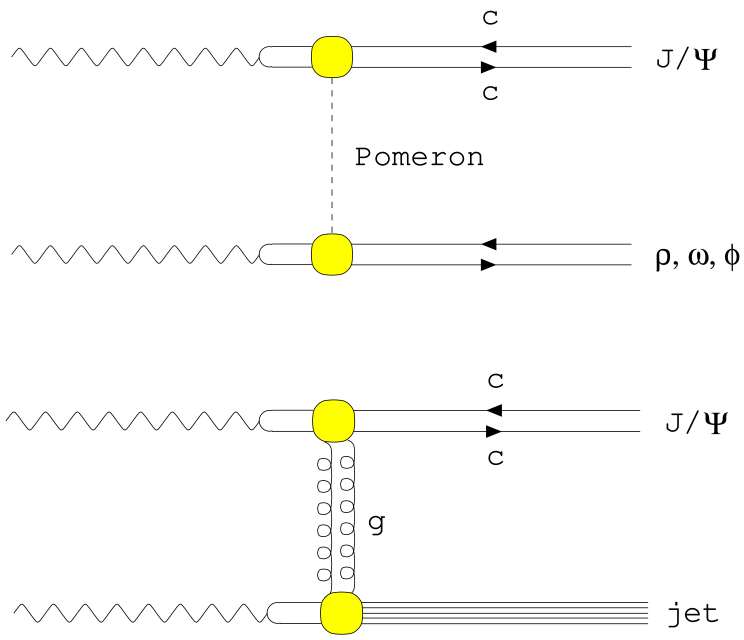
Single-resolved $=$ (37.8 ± 4.2) %

$$x_T^{D^*} = 2\ p_T^{D^*}\ /\ W_{vis}$$

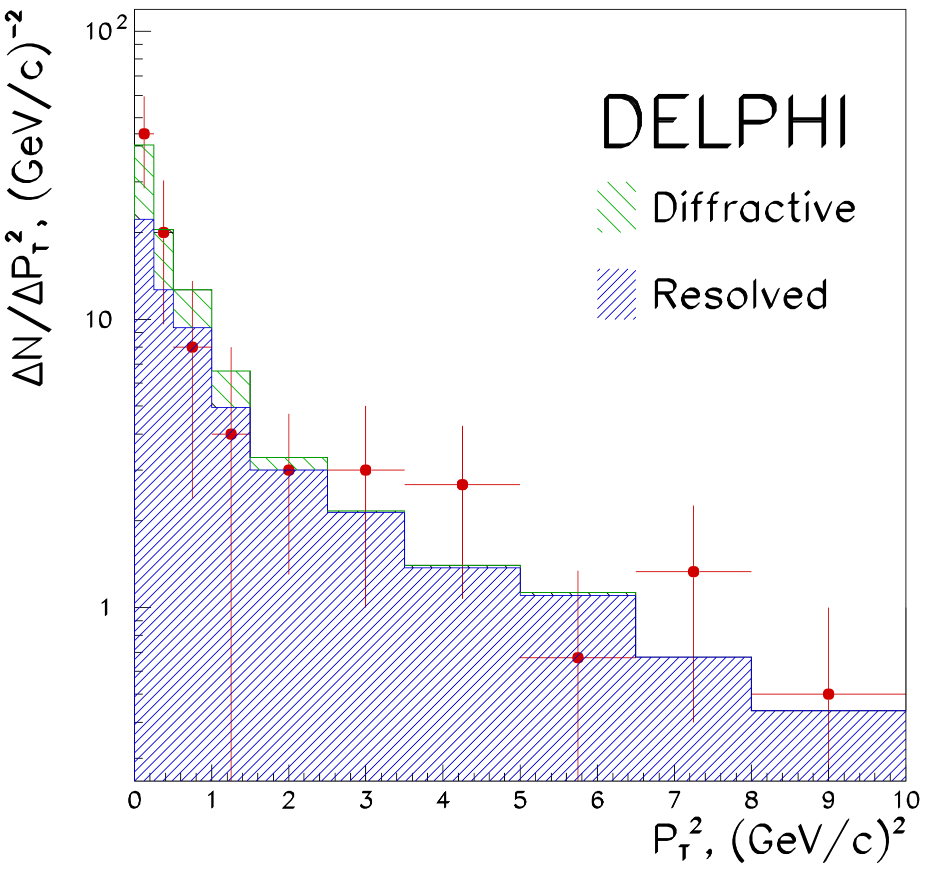
Inclusive J/Ψ production



Diffractive vs. Resolved



Separation of processes with J/Ψ

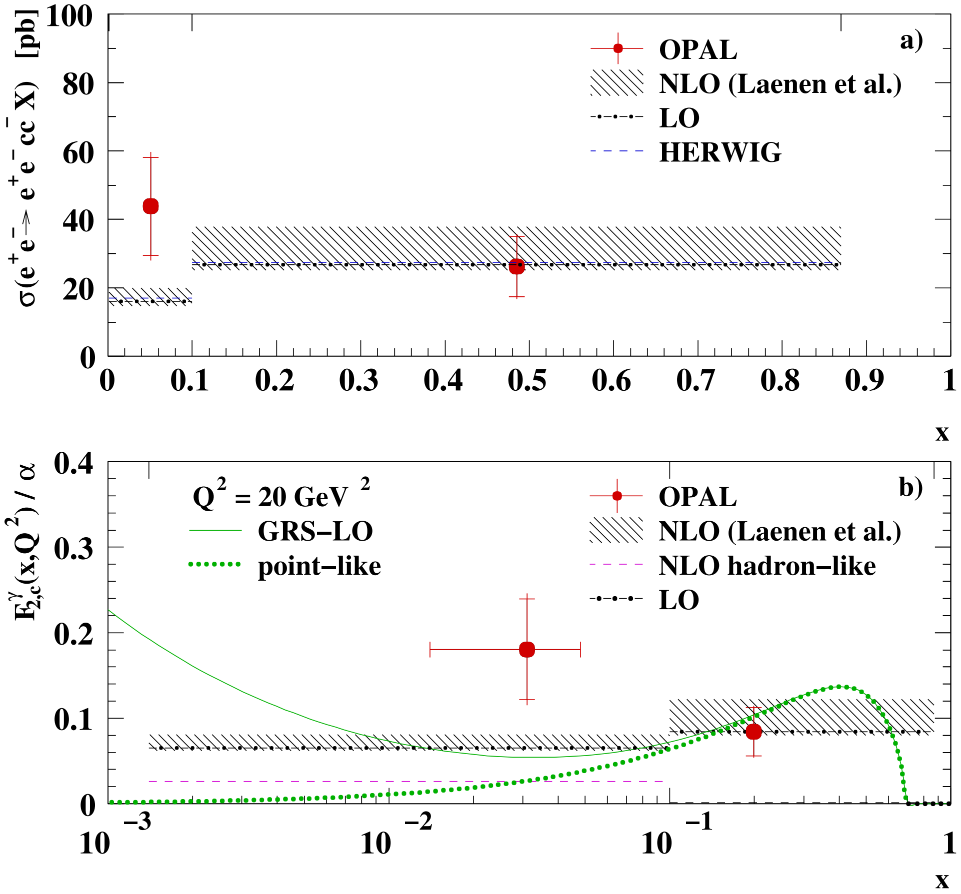


$$\text{diffractive} = 26 \pm 22\%$$
$$\text{resolved} = 74 \pm 22\%$$

$$\sigma_{J/\Psi X} = 45 \pm 19 \text{ pb}$$

$$\sigma_{diffr.} = 24 \text{ pb}$$
$$\sigma_{resolved} = 20 \text{ pb}$$

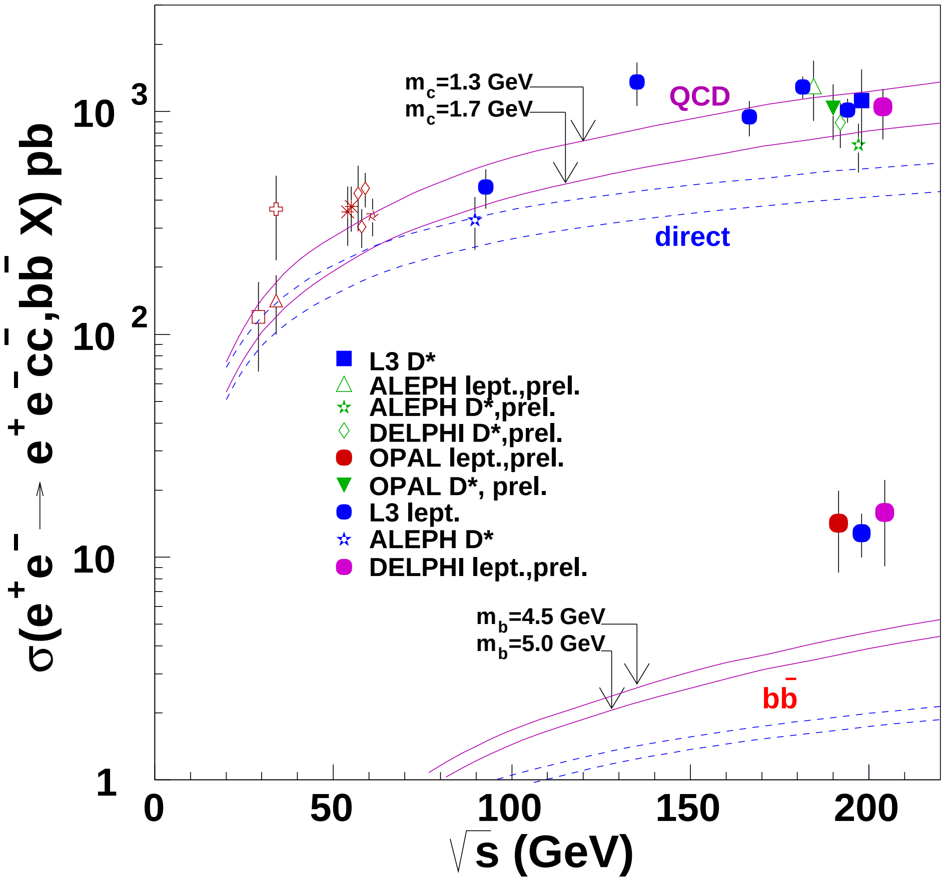
Charm structure function



$$0.0014 < x < 0.1,$$
$$0.1 < x < 0.87$$
$$\langle Q^2 \rangle = 20 \text{ GeV}^2$$

Hadron-like (resolved) component of $F^{\gamma}_{2,c}$ is probably underestimated

Beauty cross-section



Good agreement
experiments

Data $\simeq$ 3 times
higher than theory

5 σ deviation

Higher order QCD ?
or Integral Charge Quarks ?
or Susy ?
or ...

Conclusions

- heavy quark production in $\gamma\gamma$ collisions is widely studied:
  - ⇨ different tagging methods
  - ⇨ (differential) cross-sections
  - ⇨ ratio of the $\gamma\gamma$ processes
  - ⇨ photon structure function $(F^{\gamma}_{2,c})$

- evidence for $\gamma g \to \mathrm{q\bar{q}}$

- agreement data / NLO QCD is:
  - ⇨ good with charm mass $\simeq$ 1.2 GeV
  - ⇨ bad for beauty production