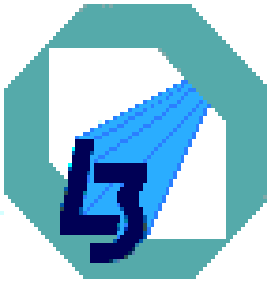


RHEINISCH-
WESTFÄLISCHE
TECHNISCHE
HOCHSCHULE
RWTH

$\gamma\gamma$-Production of Heavy Flavour at LEP

Stefan Roth

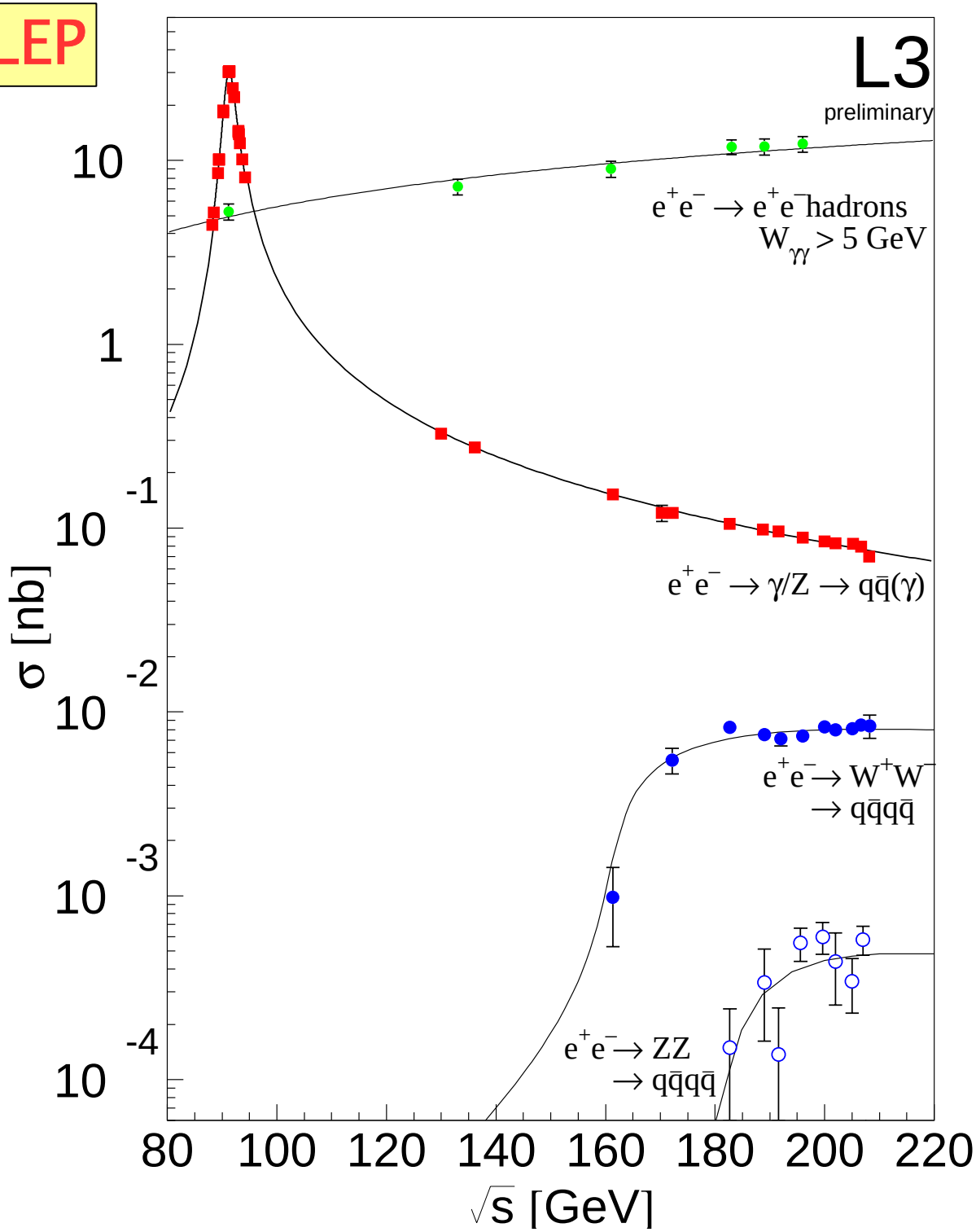
RWTH Aachen
L3 Collaboration

Hadron Production at LEP

Two photon collisions

are the dominant source

of hadrons at LEP2



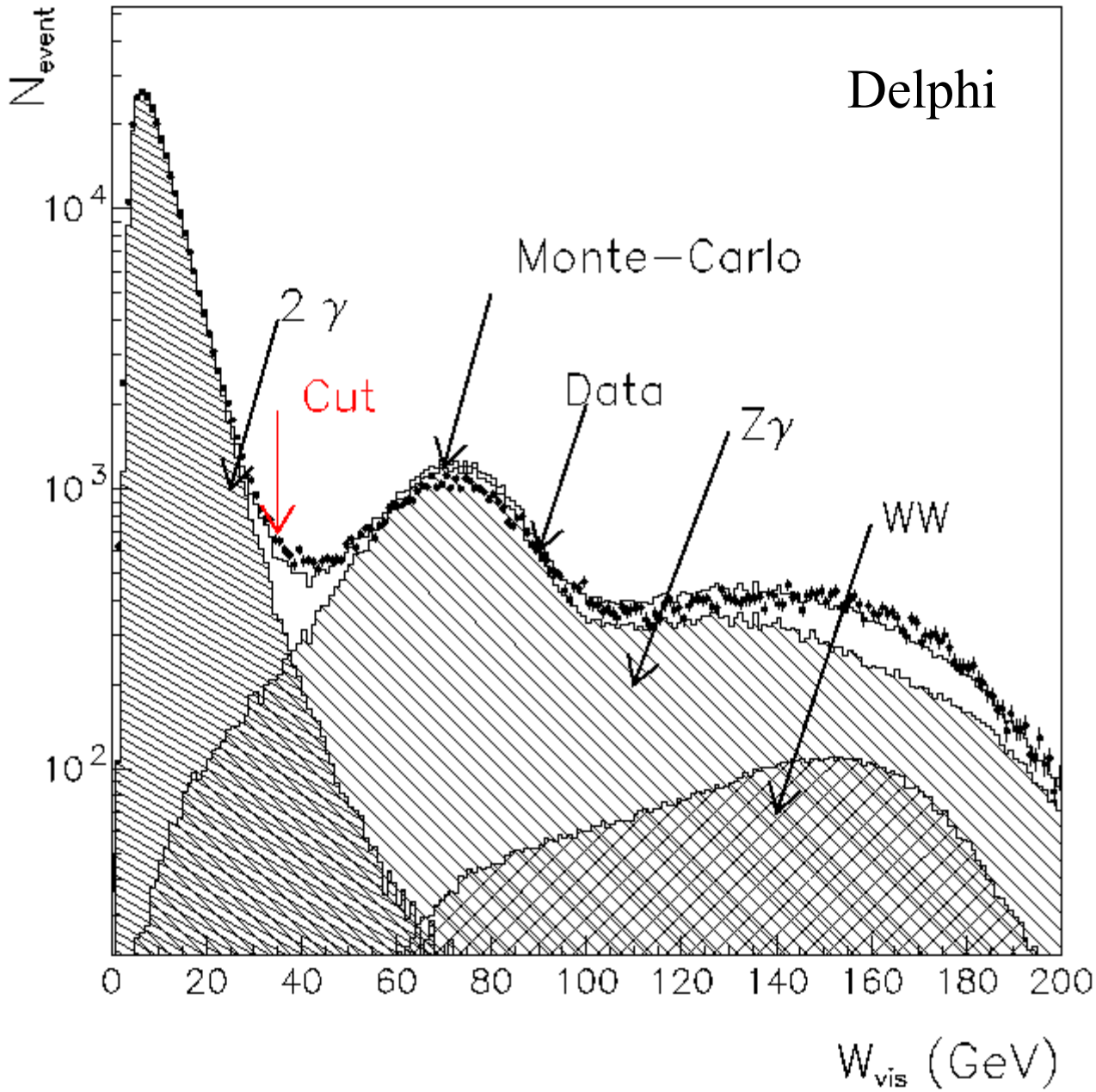
Selection of two photon events

Two photon selection uses the low visible mass W_{vis} of the hadronic system

Here:

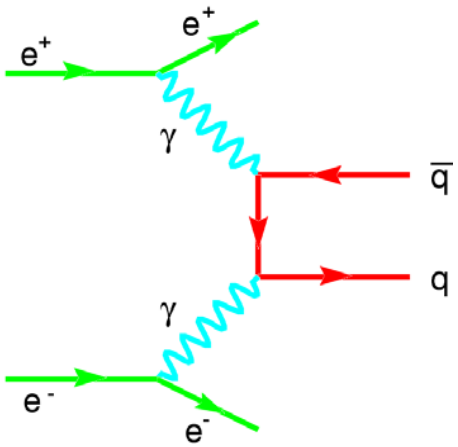
Use antitagged events

(beam electrons escape)

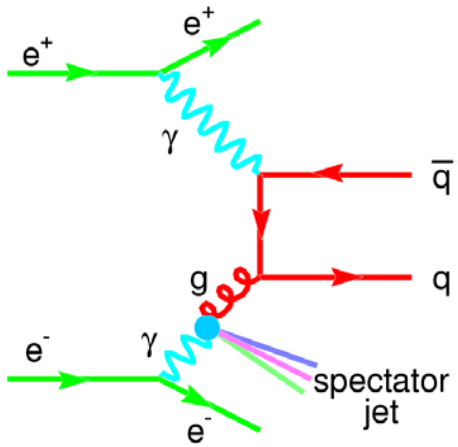


Hadronic Final State in $\gamma\gamma$ collisions

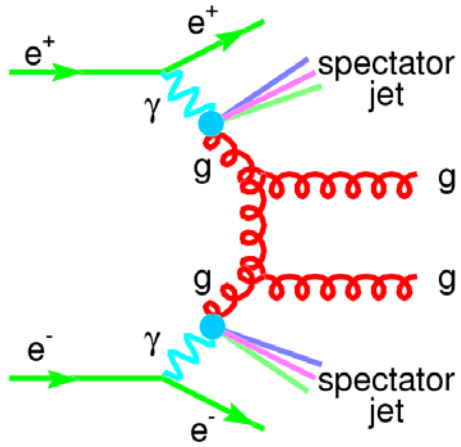
Hadronic final states from produced four processes



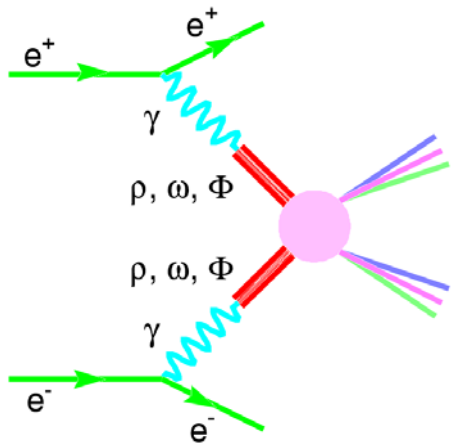
Direct



Single Resolved



Double Resolved



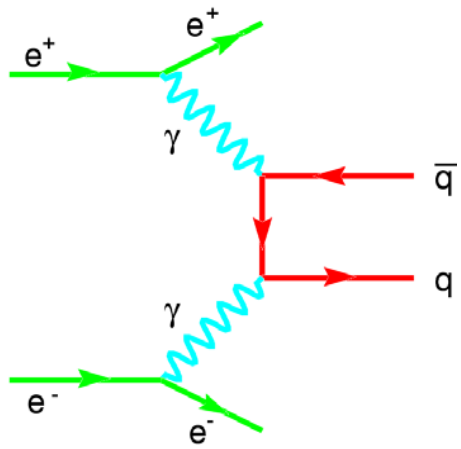
VDM

Heavy flavour production is
dominated by the first two processes

Heavy flavours in $\gamma\gamma$ collisions

Test of perturbative QCD:

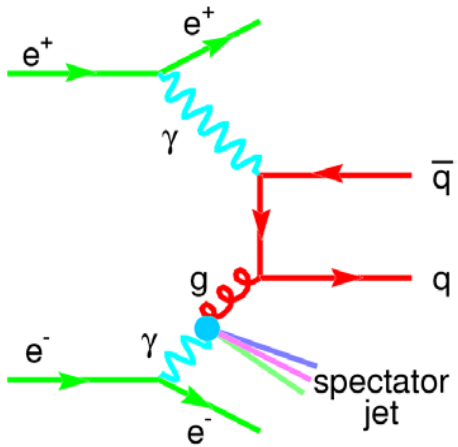
- Quark masses set high energy scale
- Direct Process depends on m_c (m_b) and α_s



- At LEP2 energies:

  Resolved process of the same order as direct
- Resolved process depends on gluon content

  of the photon



D* Identification of Charm

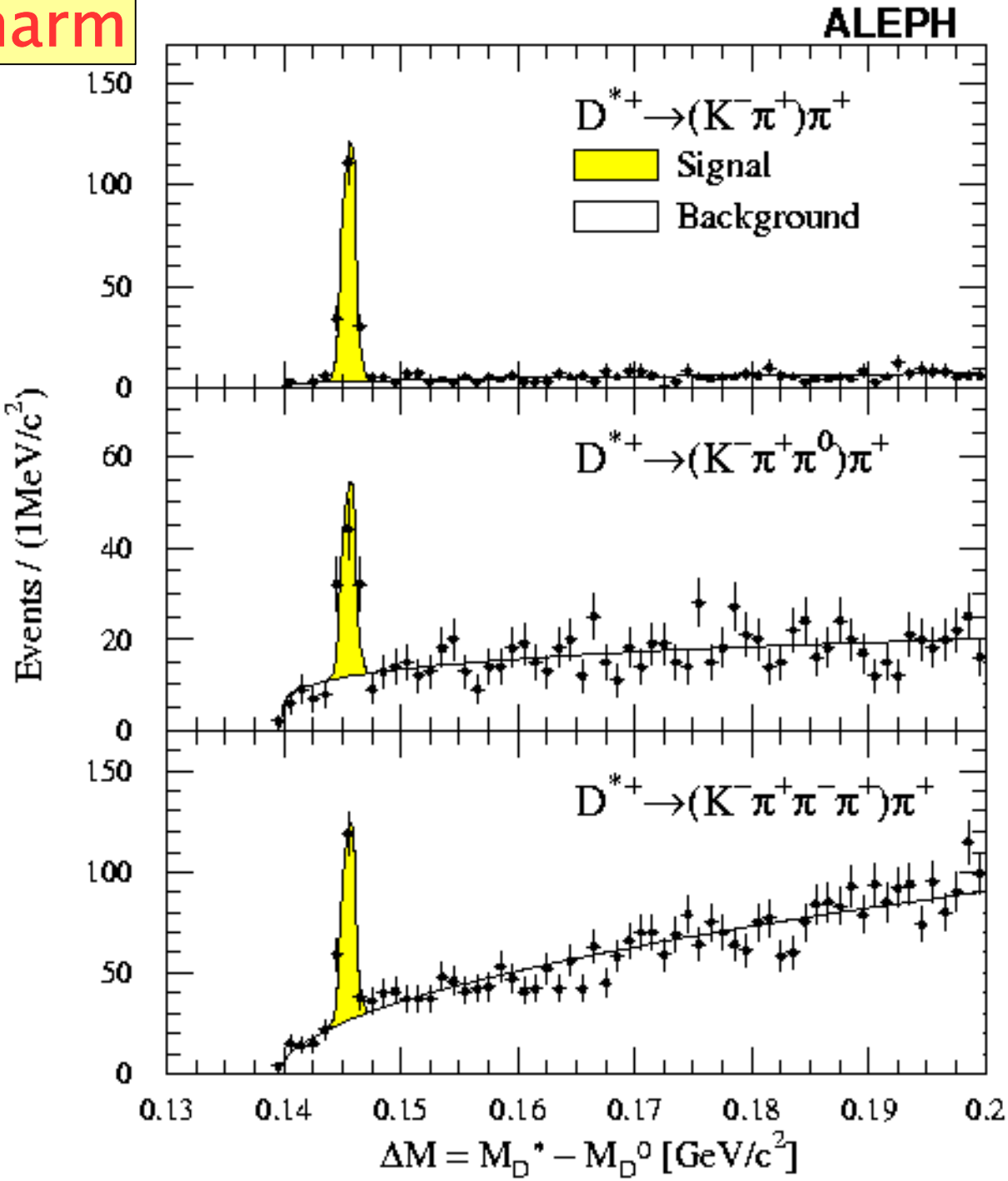
Charm tag from decay:

$D^{*\pm} \rightarrow D^0 \pi^{\pm}_s$

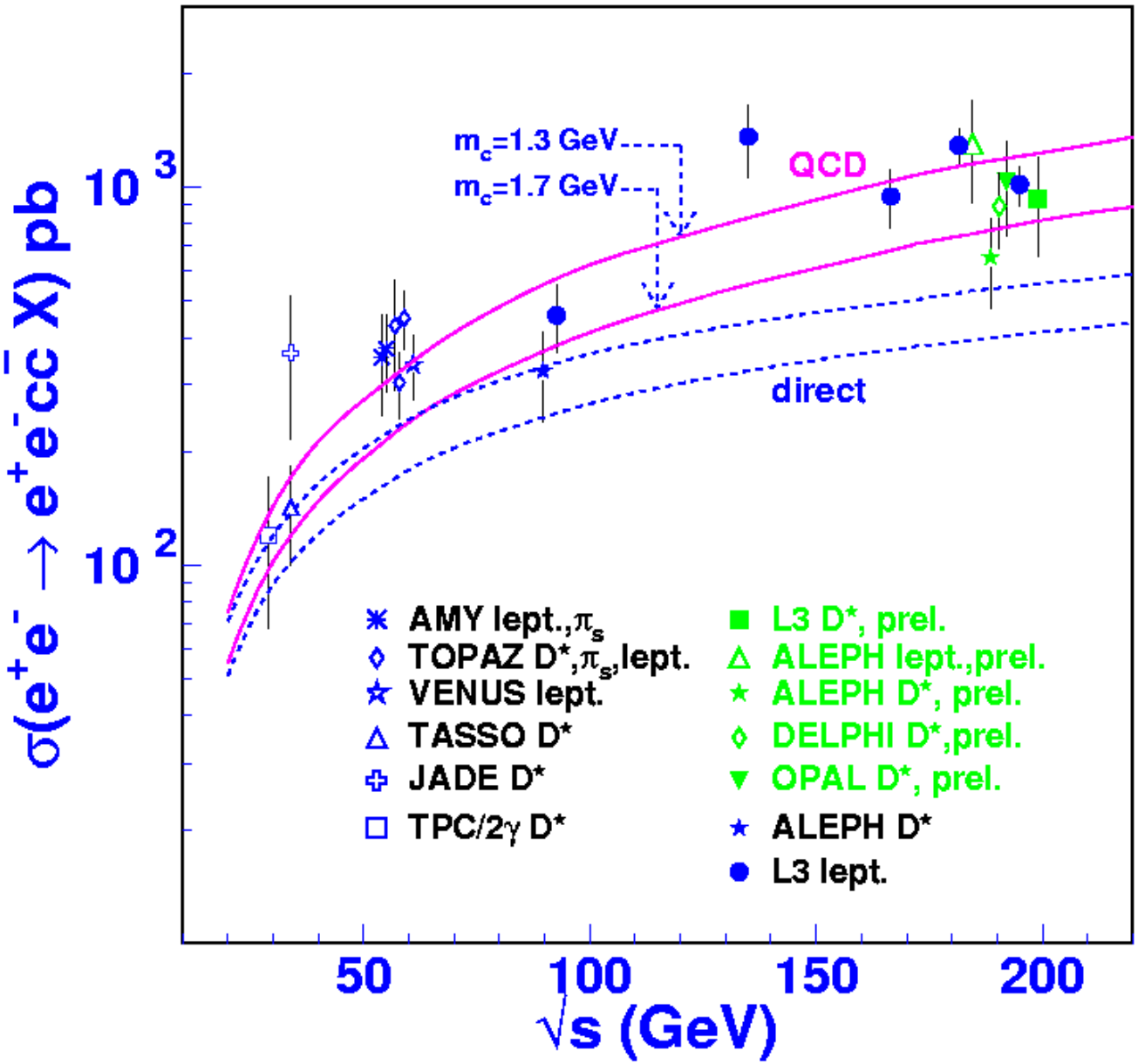
Peak in mass difference:

$\Delta m = m(D^*) - m(D^0)$
$= 145$ MeV

$\Rightarrow$ 6 MeV kinetic energy for slow pion $\pi^{\pm}_s$



Charm production cross section



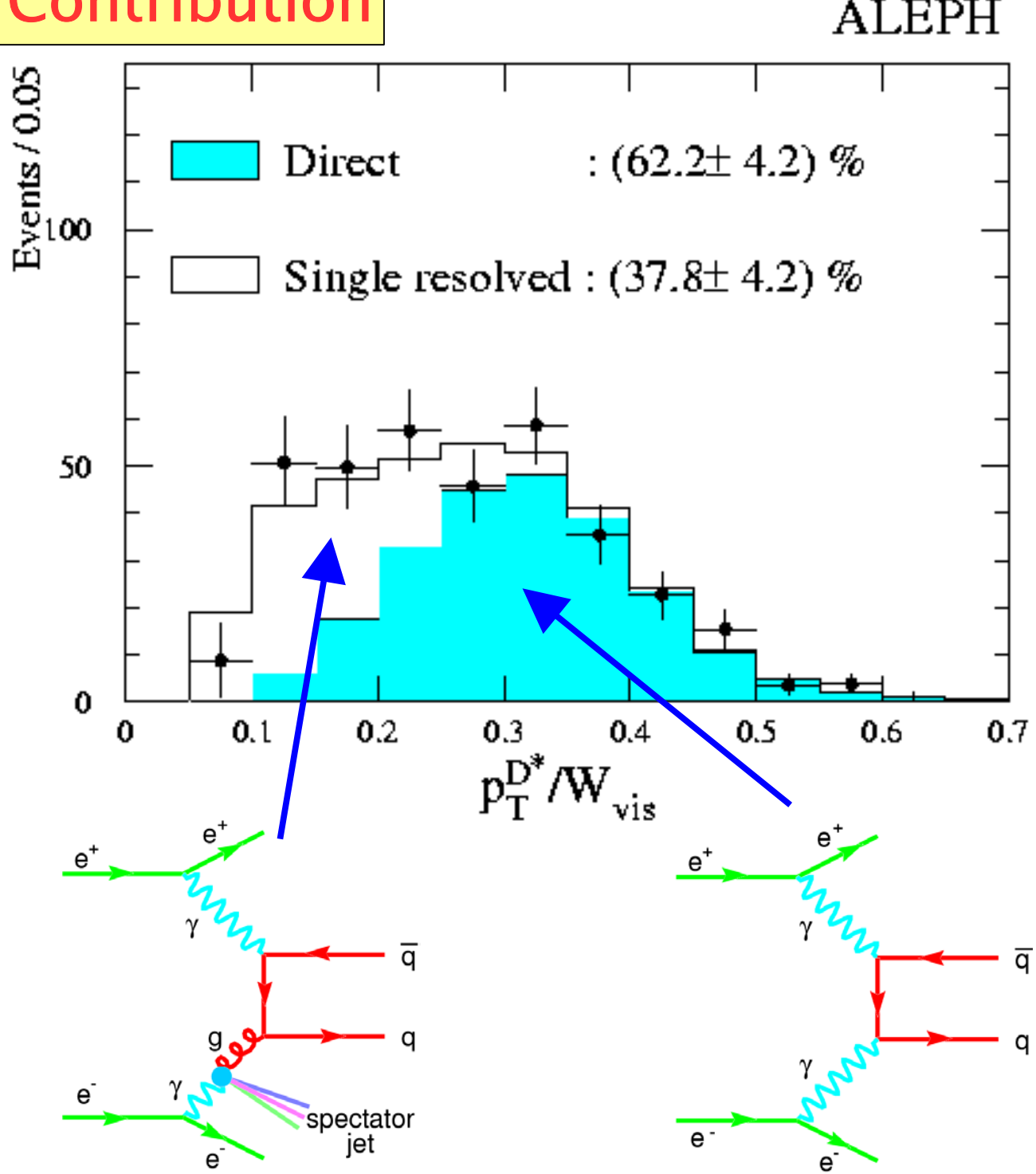
Evidence for gluon content of photon !

QCD calculation:
M.Drees et al,
Phys. Lett. B 306 (1993) 371

Direct and Resolved Contribution

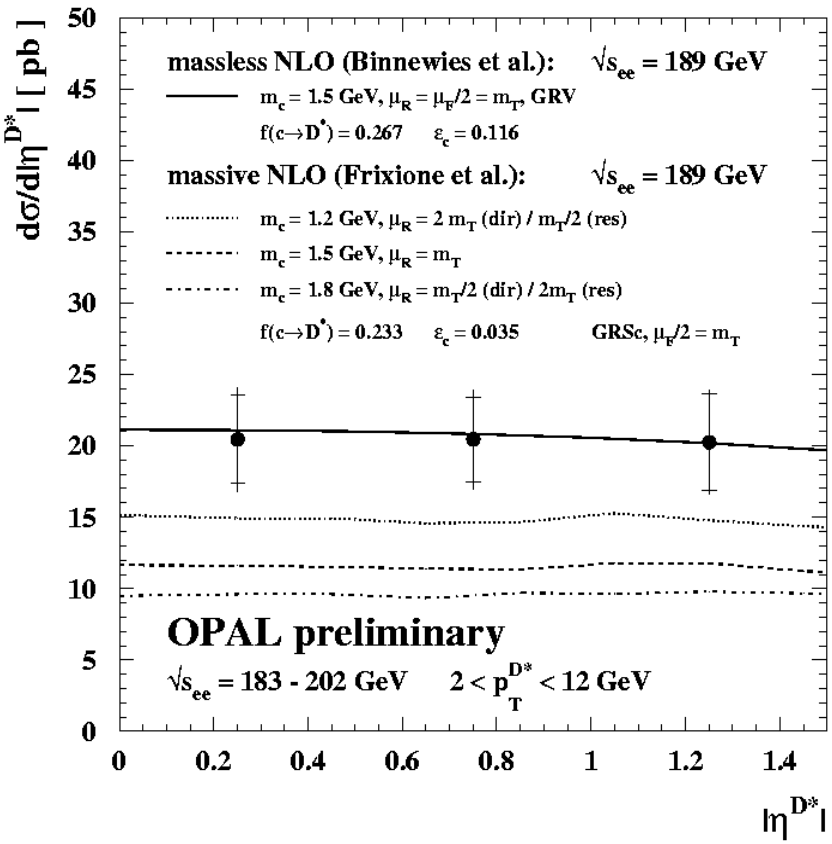
Use transverse momentum of D*

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

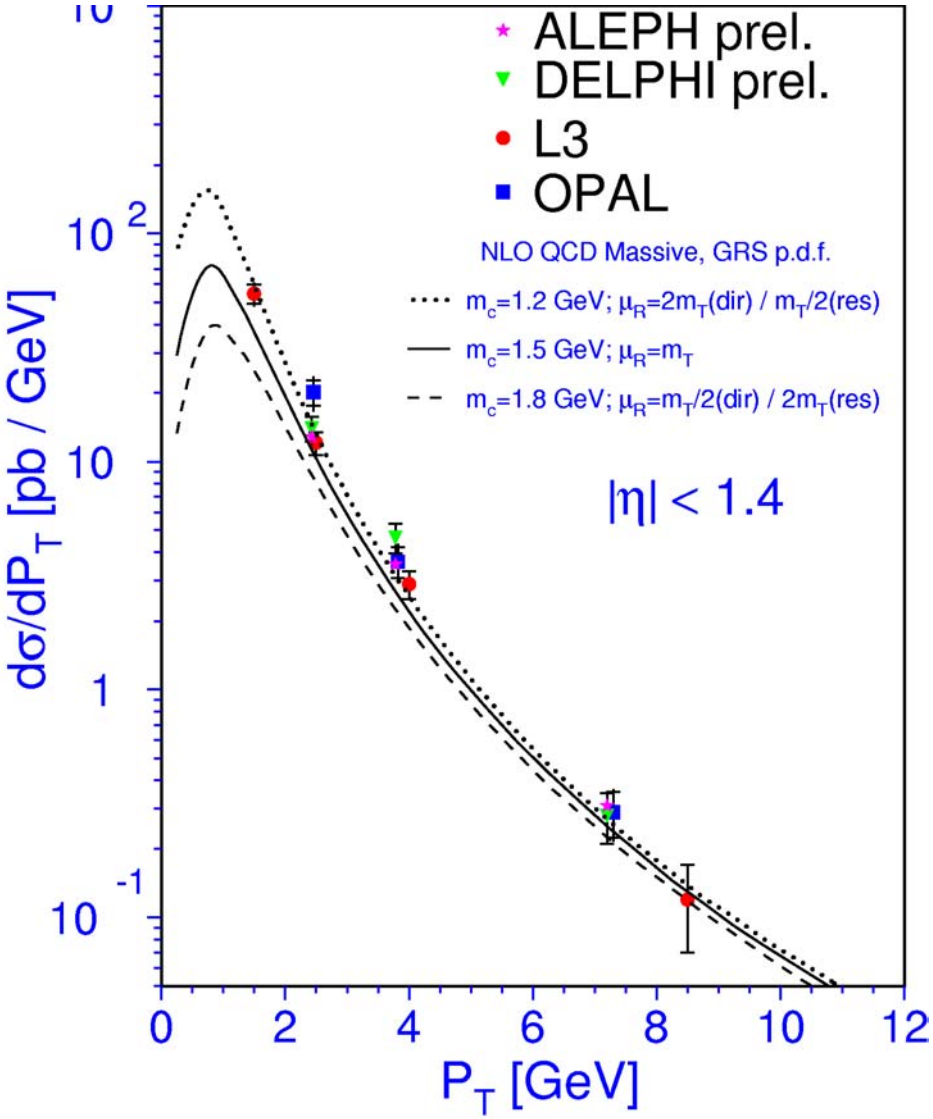


Charm production: Differential cross sections

Pseudorapidity



Transverse Momentum



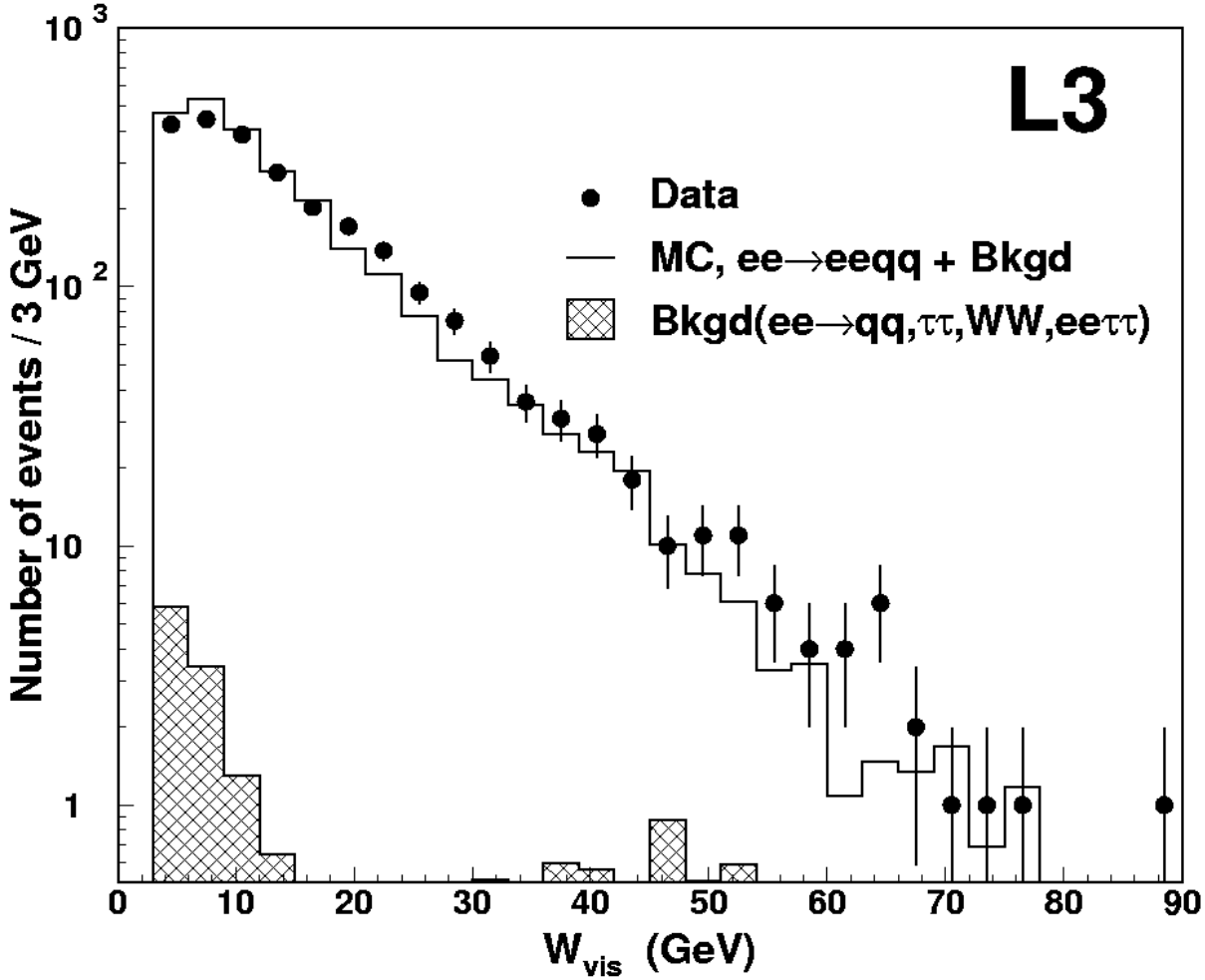
Agreement between data and NLO calculations

Charm production vs W_{vis}

Data are in excess of Pythia MC for visible masses $W_{vis} > 15$ GeV

Extraction of $\sigma(\gamma\gamma \to ccX)$

- Correction of detector acceptance
- Unfolding of detector resolution
- Unfolding of photon luminosity spectrum

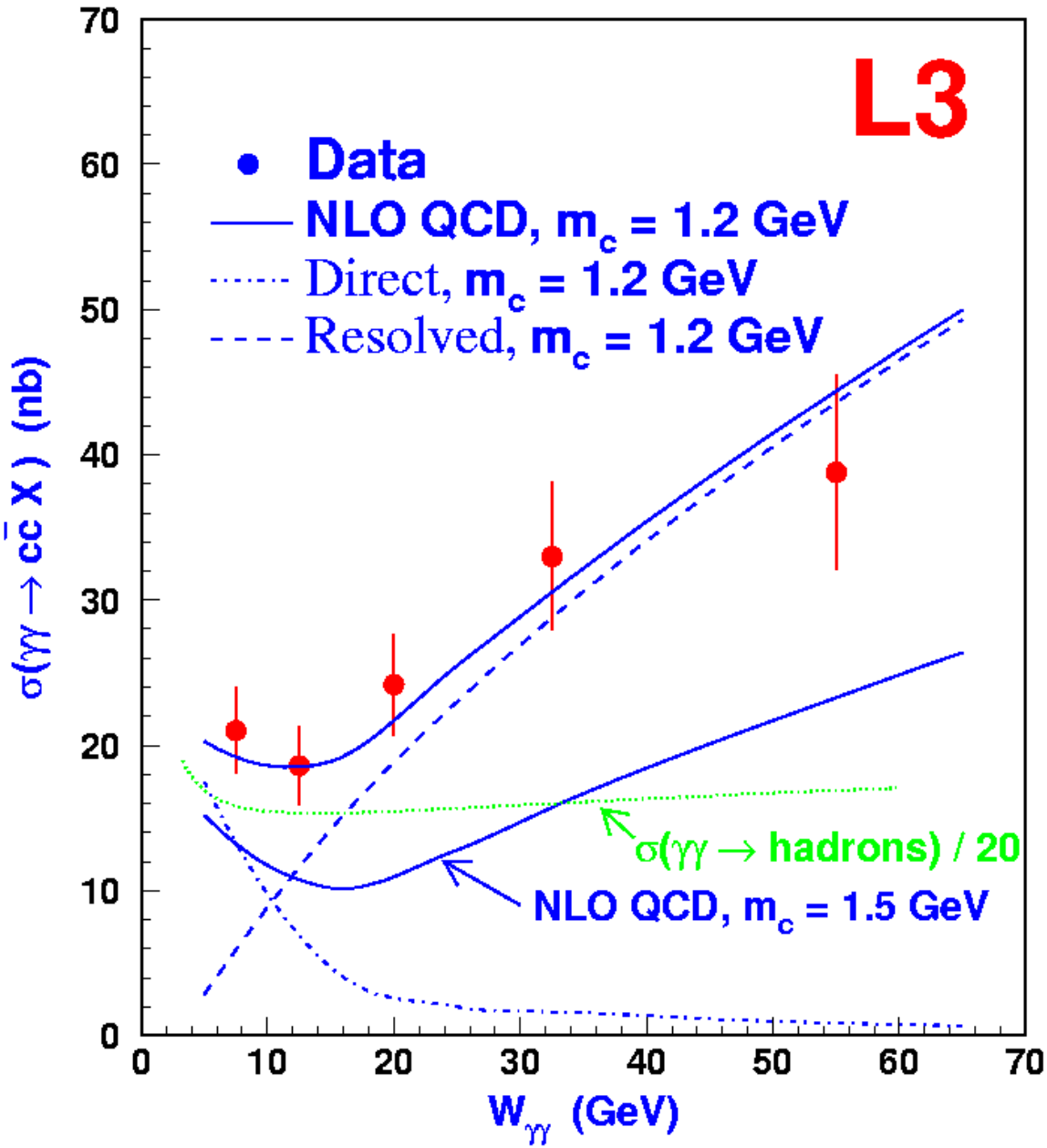


Cross section of $\gamma\gamma \to ccX$

$W_{\gamma\gamma}$ dependence of direct and resolved part are seen in data

Agreement with NLO calculations only for small charm quark masses

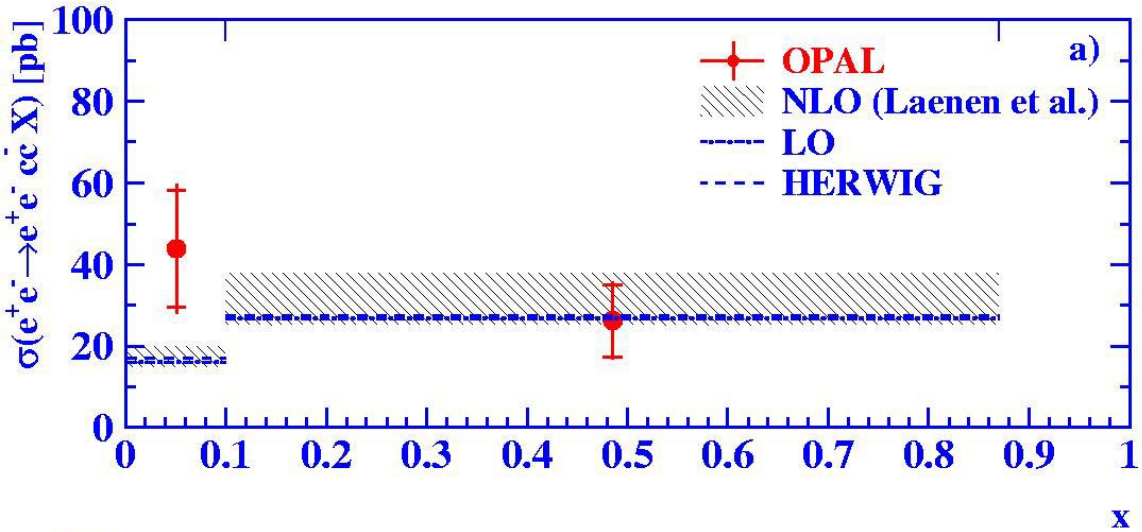
Steeper rise with visible mass as compared to $\sigma(\gamma\gamma \to \text{hadrons})$

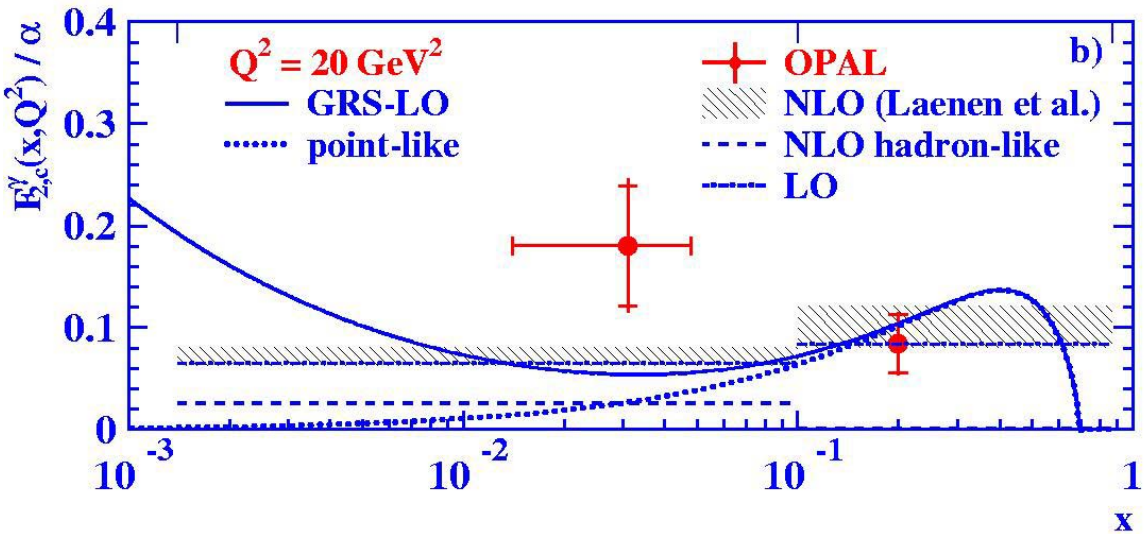


Charm structure function

Measurement of $F^{\gamma}_{2,c}$ using single-tag events with inclusive D*

- **33 mrad < θ_e < 120 mrad**
- **$P_T(D^*) > 1$ GeV**
- **$\Rightarrow \langle Q^2 \rangle = 20$ GeV^2**





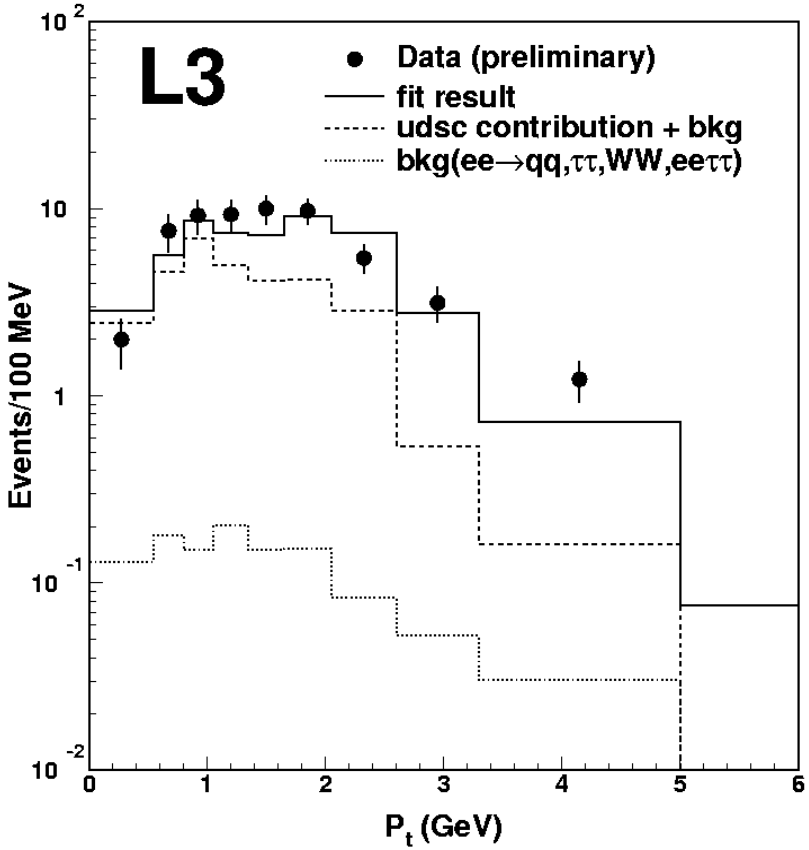
Result for $F^{\gamma}_{2,c}$

- x>0.1 pointlike part calculable in QCD
- x<0.1 hadron-like component

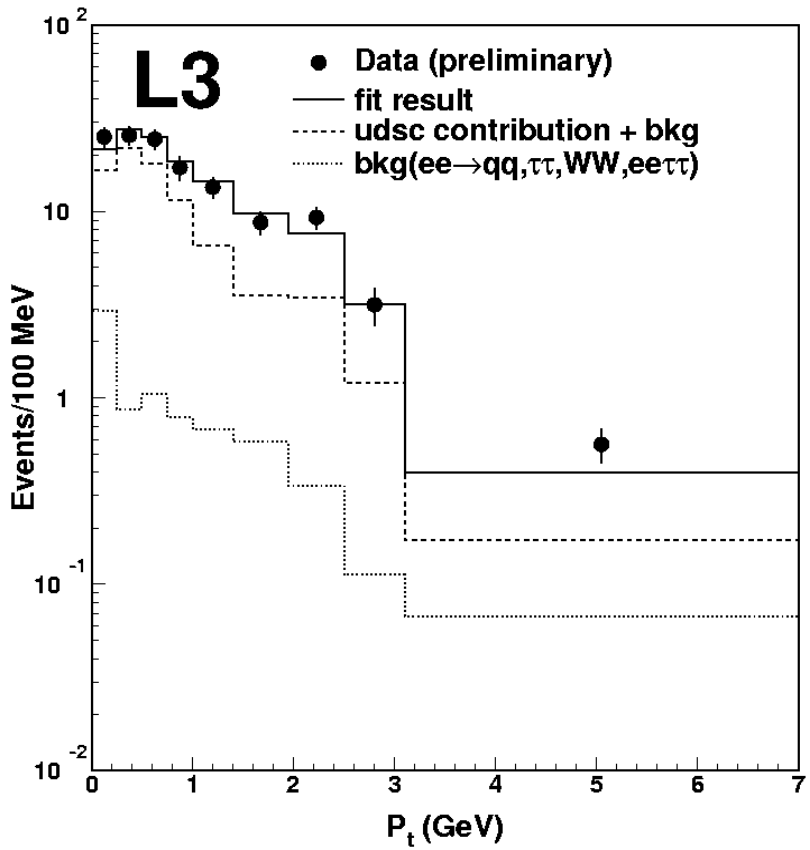
Search for Beauty in Two Photon Events

- Select leptonic decays of c or b quark
- Calculate P_t of lepton with respect to the nearest jet
- Fit resulting spectrum with uds, c and b content as free parameters

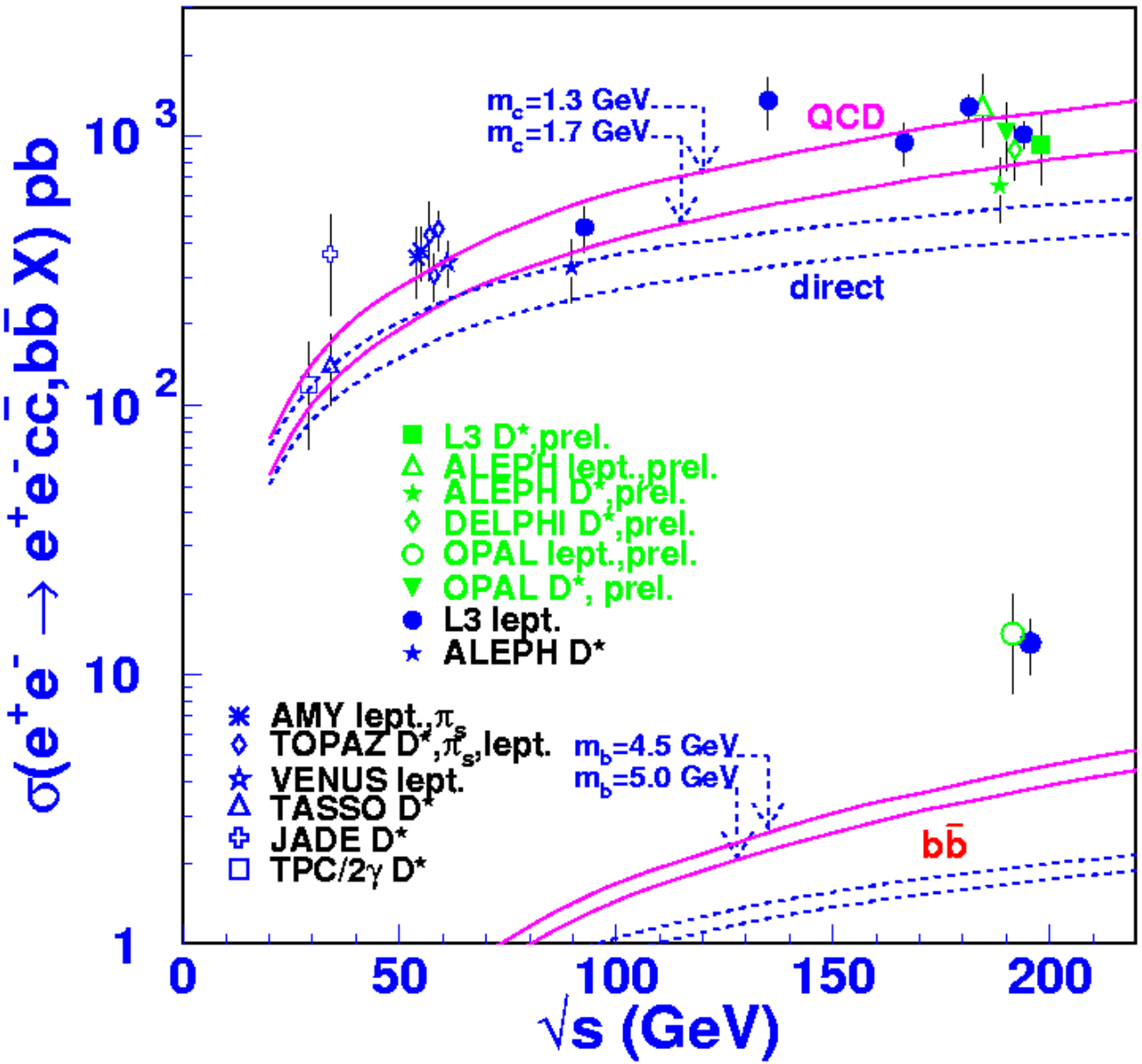
Electrons



Muons



Charm and beauty cross section



Charm cross section reproduces D* result

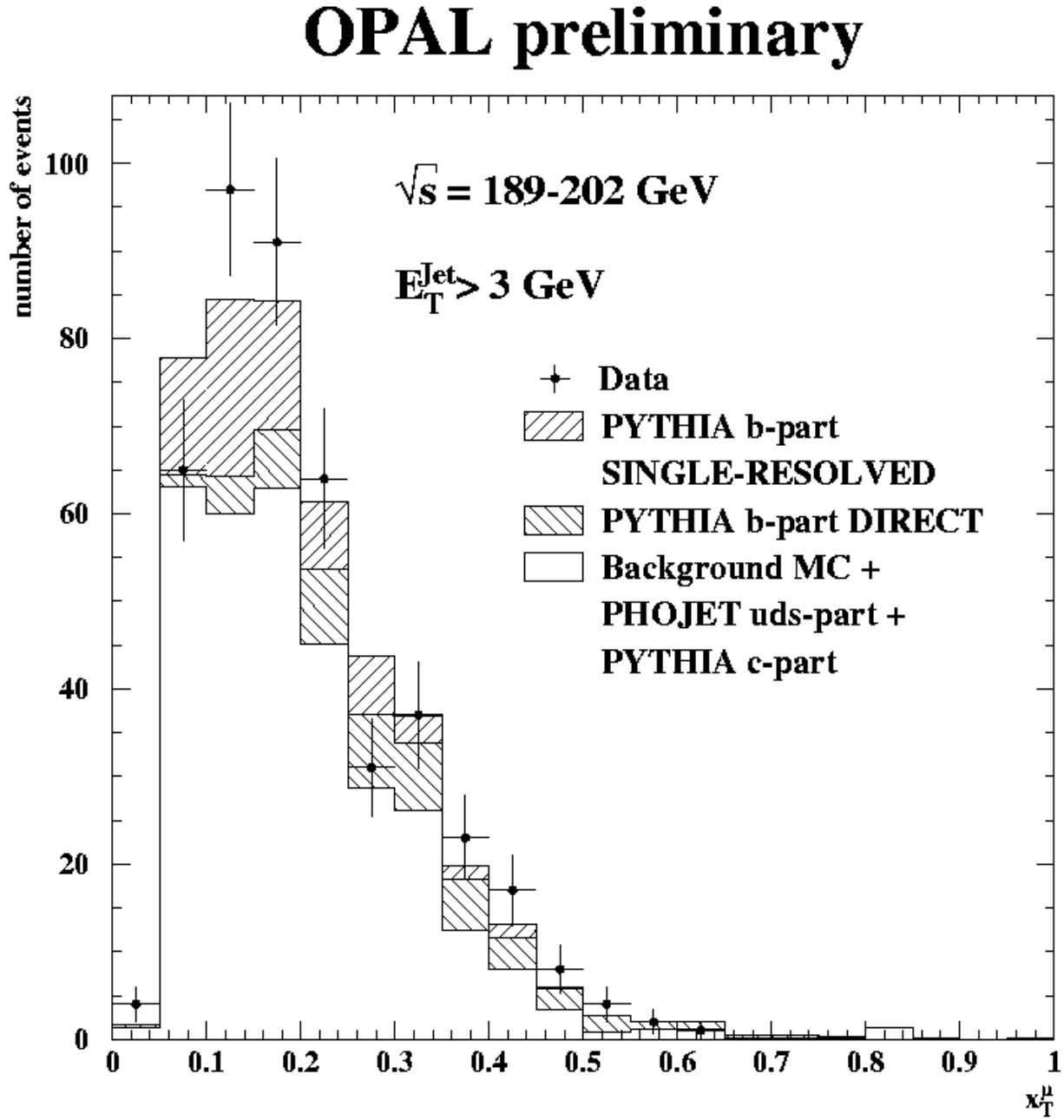
Beauty cross section in excess of QCD by 4 standard deviations

Source of beauty excess ?

Plot transverse momentum of muon

Direct and Resolved part is needed to describe shape of data distribution

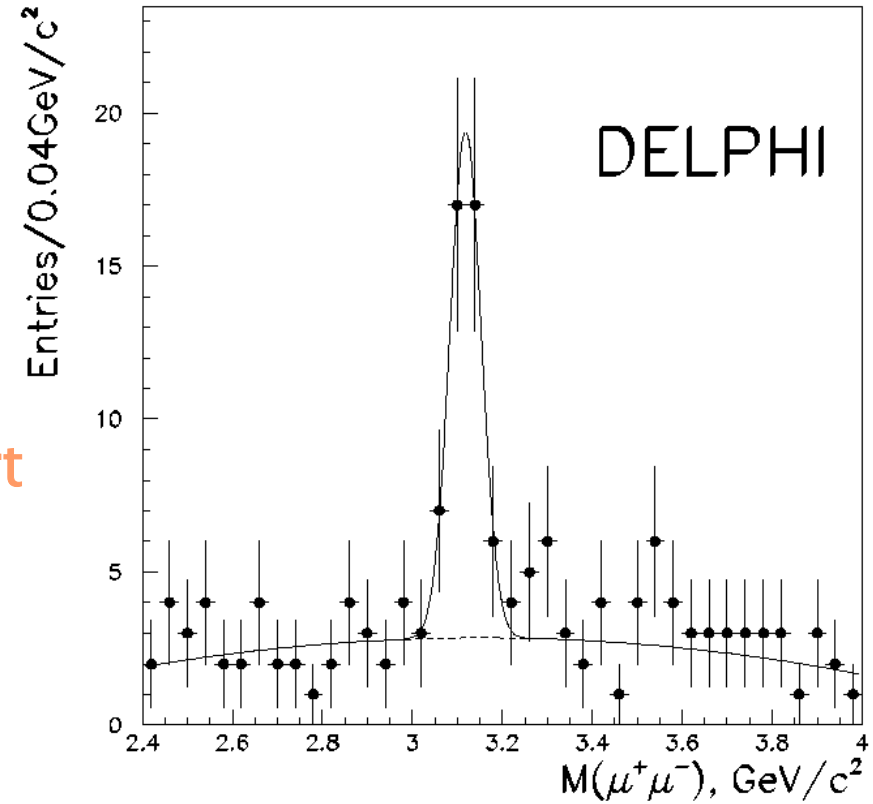
None of both can explain excess alone



Inclusive J/Ψ Production

Identification of $J/\Psi \to \mu^+\mu^-$

- DELPHI selects 36 events with nearly full LEP2 luminosity
- Distinguish diffractive/resolved part
- Measure cross section of resolved part ($\gamma g \to J/\Psi$)



Interpretation by M. Klasen et al. hep-ph/0112259

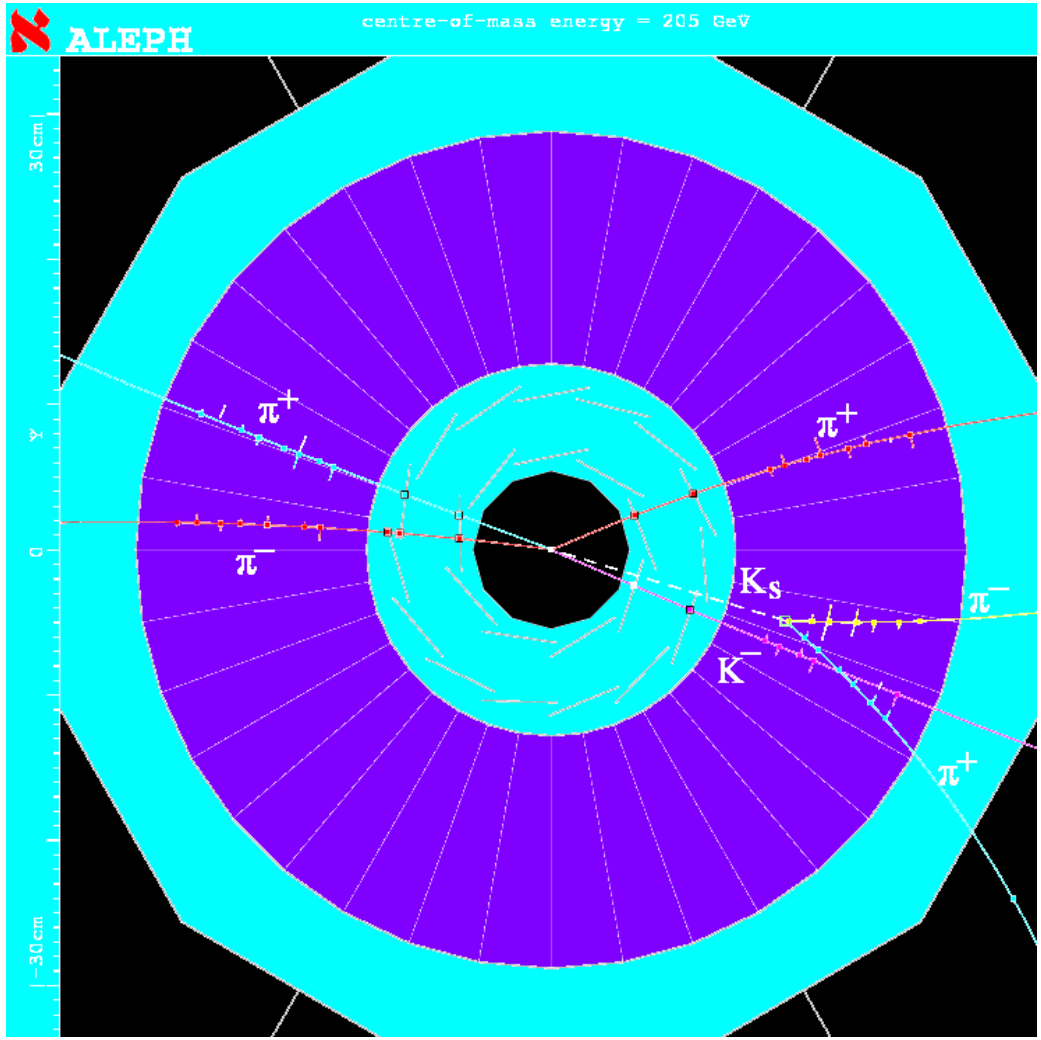
- Colour Octet Model favoured
- J/Ψ is produced in hard process as CO

  Converts into physical colour singlett quarkonia by nonperturbative emission of soft gluons.

Search for η_b

Exclusive production via $\gamma\gamma \rightarrow \eta_b$

- η_b still undiscovered
- Estimates for $\Delta m = m(\Upsilon) - m(\eta_b)$ from lattice are **O(100 MeV)**
- ALEPH: 1 candidate
- L3: 3 candidates



Mass from ALEPH event: $9.30 \pm 0.02 \pm 0.02$ GeV/c^2

Summary

Charm:

- Differential distributions agree with QCD calculations
- Total inclusive charm cross section agrees with NLO calculations, but low charm quark masses preferred
- Gluon content of photon is important
- Charm structure function of photon measured

Beauty:

- Cross section three times higher than NLO calculations
- Search for exclusive η_b still ongoing.