Measurement of the Inclusive Charm Production in $\gamma\gamma$ Collisions with the L3 Detector at LEP

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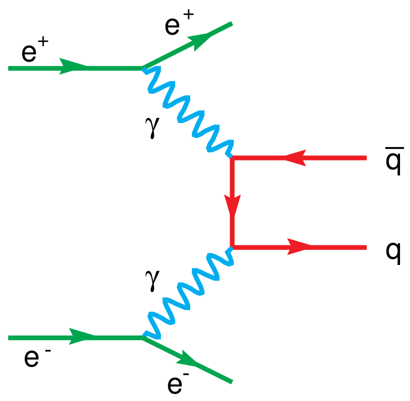
OUTLINE

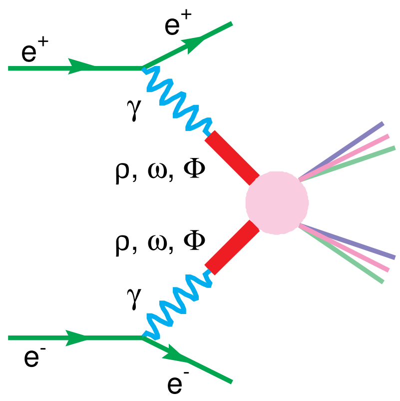
- **Motivation**
- **Data sample**
- **Hadrons selection, Charm tagging**
- **Cross section measurement**
- **Conclusion**
- **Outlook**

Motivation

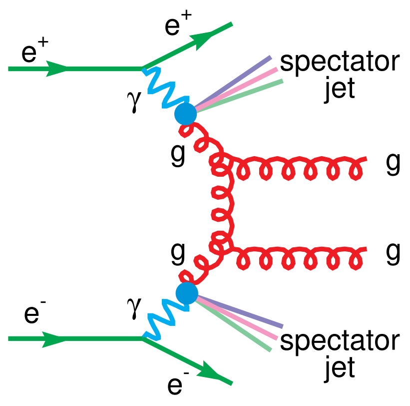
$$ee \to eeqq$$



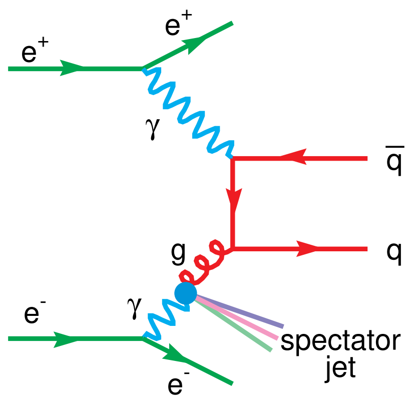
Direct



VDM



Double Resolved



Single Resolved

direct and single resolved processes dominate in the $ee \to eecc$ production

Motivation

$$ee \to eecc$$

- **theory gives firm prediction for heavy flavour production (perturbative calculations)**

- **at high energies the resolved processes are predicted to be at the same order as the direct one**

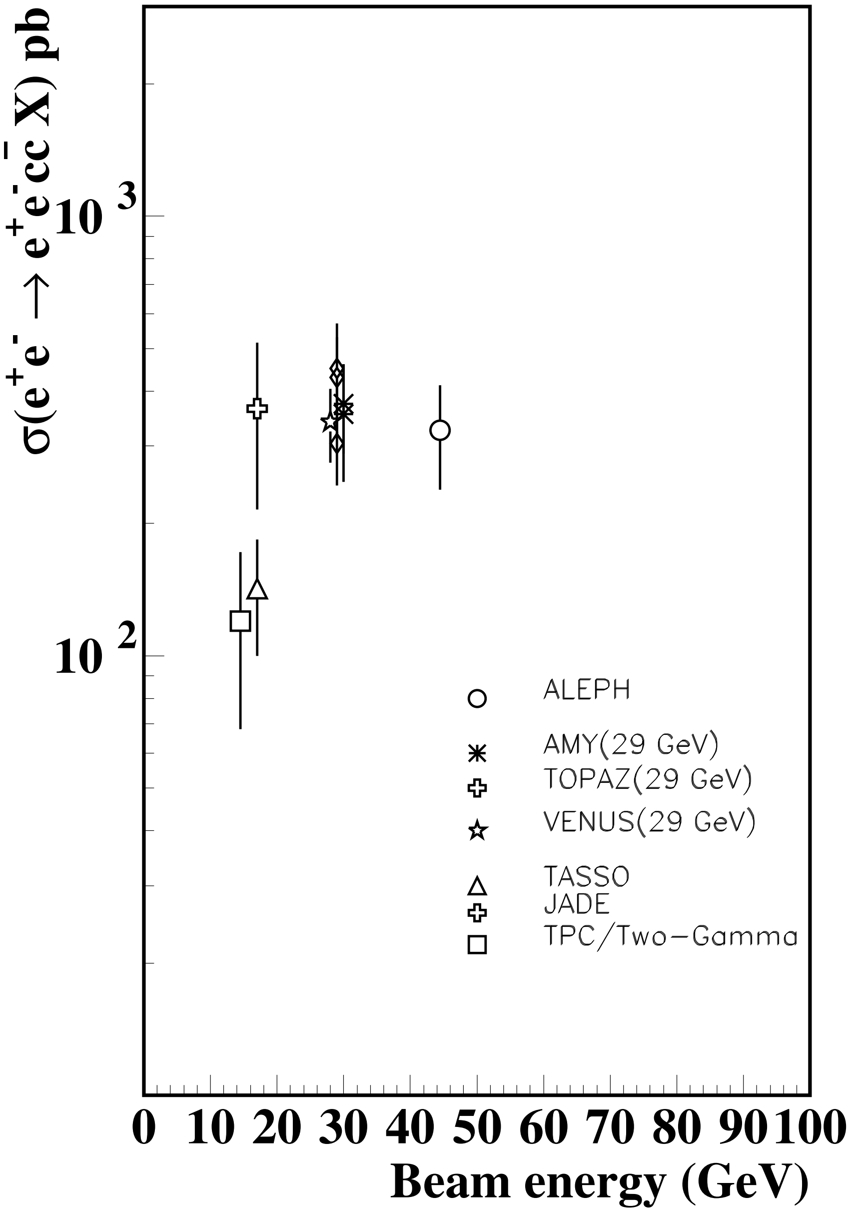
  - **thus a measurement of the** *gluon content of the photon* **(poorly known currently) might be feasible**

- *mass of a c-quark* **can be constrained from a precise measurement of charm production cross section**

Current experimental situation

$ee \to eeccX$

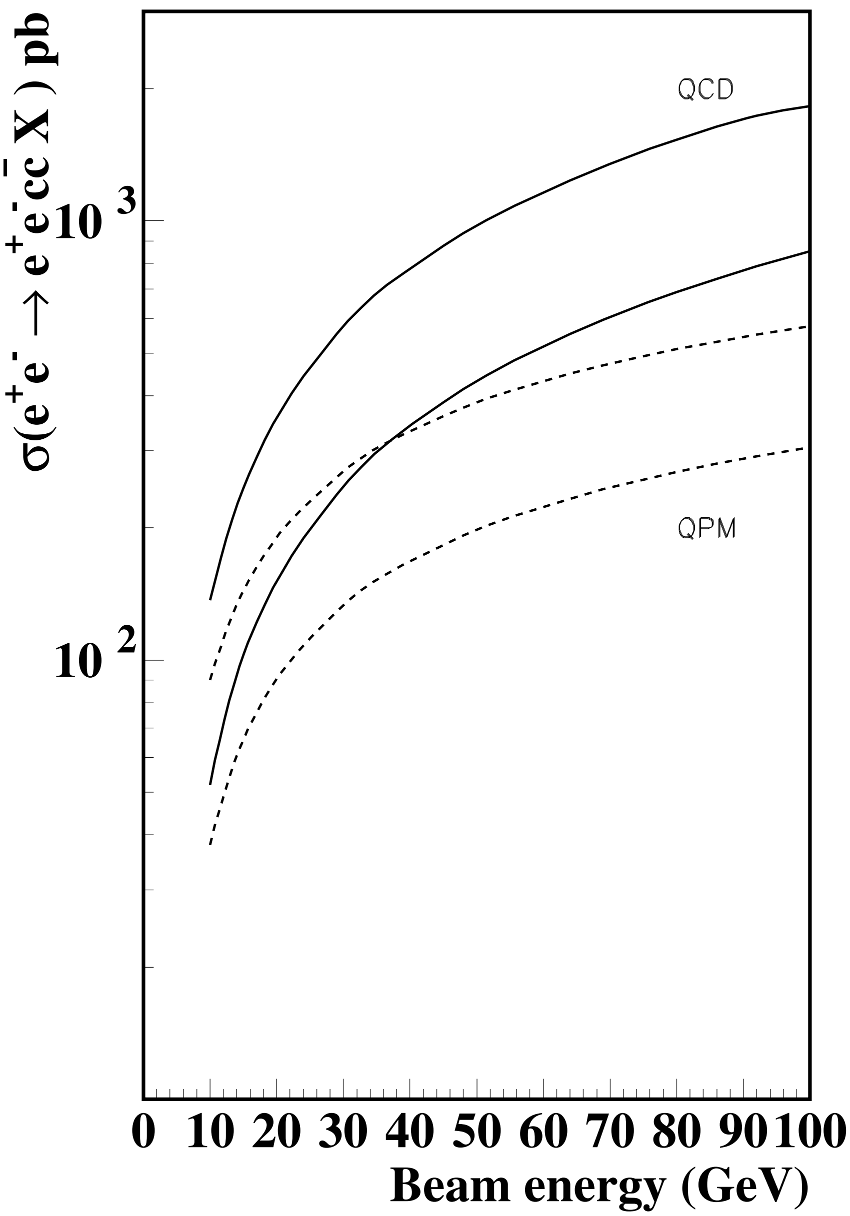
(as from yellow report 'Physics at LEP2', 1996,v1.,p.334)



Theoretical predictions

(as from M.Drees,M.Krämer,J.Zunft and P.M.Zerwas,Phys. Lett. B306 (193) 371)

scale: $\sqrt{2}m_c$,
uncertainty: $1.3 < m_c < 1.7$ **GeV**$/c^2$



Charm tagging techniques used

- D^* **tagging**
  - **exclusive** $D^{*\pm} \rightarrow D^0\pi^\pm$ **(TPC/2γ,TASSO,JADE ,TOPAZ,AMY,ALEPH)**
  - **slow pion: inclusive** $D^{*\pm} \rightarrow D^0\pi^\pm$ **(TOPAZ,AMY)**

- **Kaons:** $K_s^0 \rightarrow \pi^+\pi^-$ **(TOPAZ)**

- **Leptons: semileptonic decays (TOPAZ,AMY,VENUS,** *L3 - this talk*)

Event Selection

SELECTION of $ee \rightarrow eeqq$

- **Visible Energy:**
  $2 < E_{vis} < 60$ **GeV (40 GeV at LEP1)**
- **Number of tracks:**
  $\#_{tracks} \geq 4$
- **Visible Mass:**
  $W_{vis} > 3$ **GeV**
- **Antitag Condition:**
  $E_{LuminosityMonitor} < 0.44 E_{beam}$

... **a few more cuts for LEP1.**

CHARM TAG

- **Muons in L3 Muon Chambers**
- **muon momentum:**
  $2 < P_{\mu} < 15$ **GeV/c (7 GeV/c at LEP1)**

Data Sample

LEP1 Data

- $\sqrt{s}$ = 91 GeV
- Luminosity = 80 pb^{-1} (94+95 years)

LEP2 Data

- $\sqrt{s}$ = 161, 172 GeV
- Luminosity = 21 pb^{-1} (96 year)

After all the cuts

LEP1 Data

↓

- **43 inclusive muon events observed**
- **27 ev. expected, eeqq(PYTHIA) + bkgd**

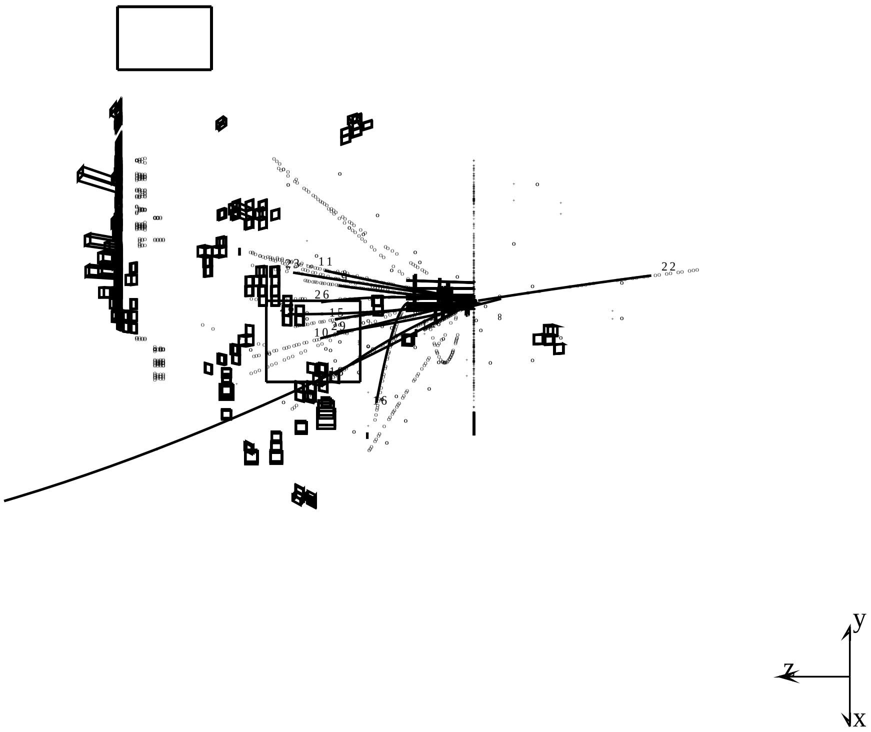
LEP2 Data

↓

- **29 inclusive muon events observed**
- **23 ev. expected, eeqq(PYTHIA) + bkgd**

Example of event
View from the top of detector (longitudinal)

Run # **658001** **Event #** **3689** Total Energy : 36.91 GeV



Transverse Imbalance :	.1674	**Longitudinal Imbalance :**	.5708		
Thrust :	.7686	**Major :**	.5903	**Minor :**	.0808
Event DAQ Time :	*960717 43936*				

Example of event

$r - \phi$ view (transverse)

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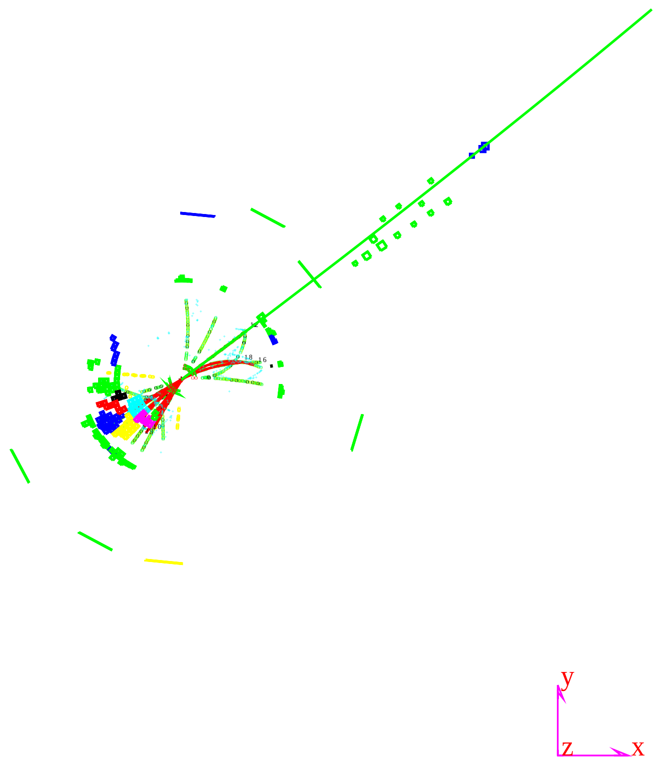

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Cross Section Measurement

$$\sigma = \frac{N_{ev} \cdot \pi_{c\bar{c}}}{\mathcal{L} \cdot \epsilon_{c\bar{c}} \cdot \epsilon_{trigger}}$$

N_{ev}	**# of $ee \to eeqq$ events background subtracted**
$\pi_{c\bar{c}}$	**fraction of $c\bar{c}$ events in $ee \to eeqq$**
$\mathcal{L}$	**integrated luminosity**
$\epsilon_{c\bar{c}}$	**$c\bar{c}$ selection efficiency**
$\epsilon_{trigger}$	**trigger efficiency**

RESULTS in:

$$\sigma_{LEP1}^{ee \to eeccX} = 553 \pm 142 \ \textbf{(stat)} \ \pm 141 \ \textbf{(syst) pb}$$

$$\sigma_{LEP2}^{ee \to eeccX} = 848 \pm 373 \ \textbf{(stat)} \ \pm 231 \ \textbf{(syst) pb}$$

Cross section measurement
BREAK DOWN

$\sqrt{s} = 91$ GeV

$$N_{observed} = 43$$
$$N_{bkg} = \begin{cases} 5.4 \pm 2.7 & ee \rightarrow qq \\ 1.2 \pm 0.5 & ee \rightarrow \tau\tau \end{cases}$$
$$\pi_{c\bar{c}} = 0.70 \pm 0.09$$
$$\epsilon_{c\bar{c}} = (0.60 \pm 0.14) \cdot 10^{-3}$$
$$\mathcal{L} = 79.7 pb^{-1}$$
$$\epsilon_{trigger} = 95.7 \pm 1.2\%$$

$\sqrt{s} = 161 + 172$ GeV

$$N_{observed} = 29$$
$$N_{bkg} = \begin{cases} 7.0 \pm 0.8 & ee \rightarrow ee\tau\tau \\ 0.8 \pm 0.1 & ee \rightarrow \tau\tau \\ 0.6 \pm 0.3 & ee \rightarrow qq \\ 0.2 \pm 0.1 & ee \rightarrow WW \end{cases}$$
$$\pi_{c\bar{c}} = 0.60 \pm 0.08$$
$$\epsilon_{c\bar{c}} = (0.73 \pm 0.17) \cdot 10^{-3}$$
$$\mathcal{L} = 21.15 pb^{-1}$$
$$\epsilon_{trigger} = 93.5 \pm 0.7\%$$

Comments on cross section measurement

- charm selection efficiencies and purities have been estimated with PYTHIA Monte Carlo (mixture of direct and resolved processes)
- Vermaseren generator(direct process only) gives for efficiency estimate

$$\epsilon_{Verm} = (0.43 \pm 0.05) \cdot 10^{-3}$$

at LEP1

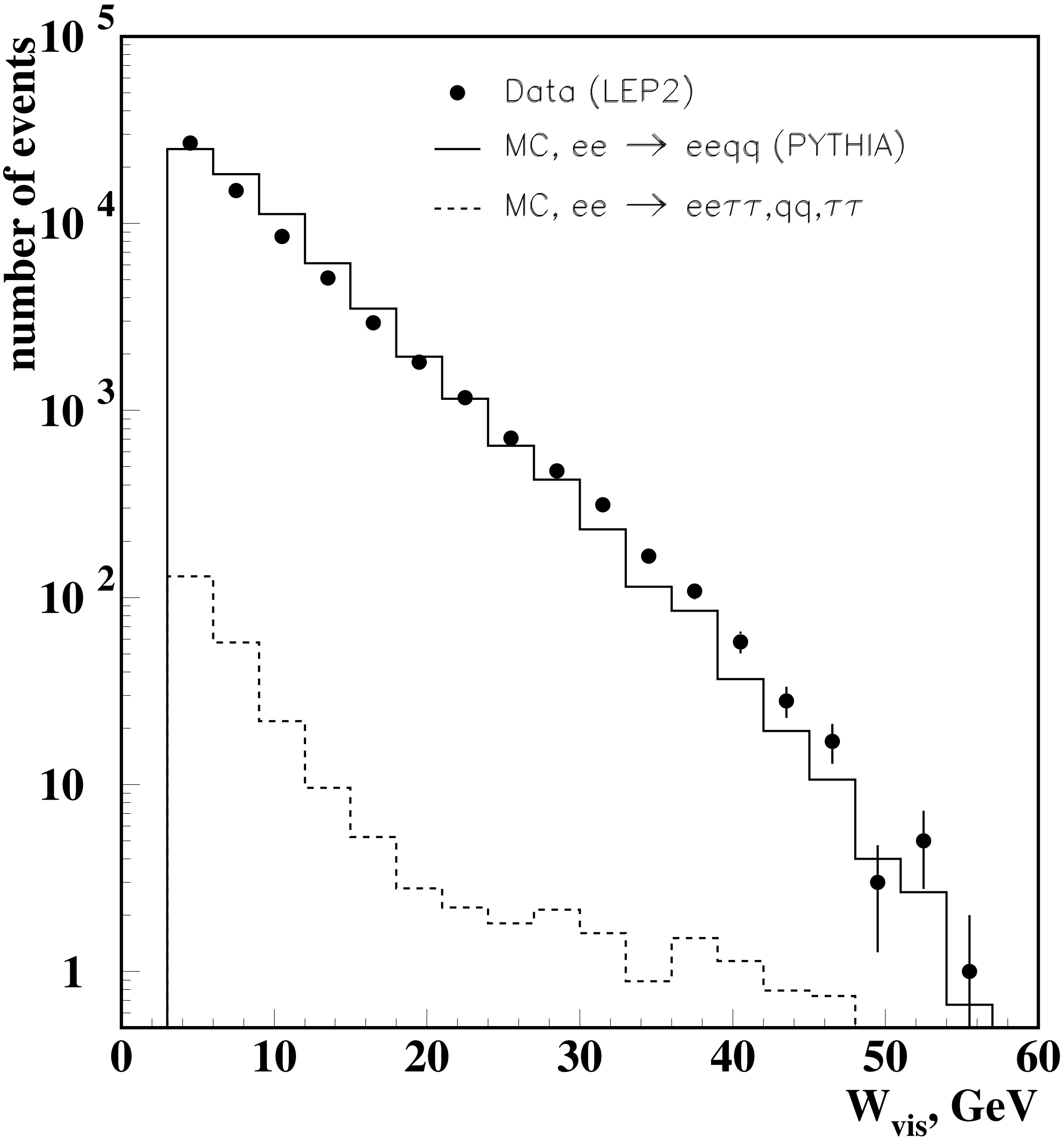
$$\epsilon_{Verm} = (0.79 \pm 0.11) \cdot 10^{-3}$$

at LEP2

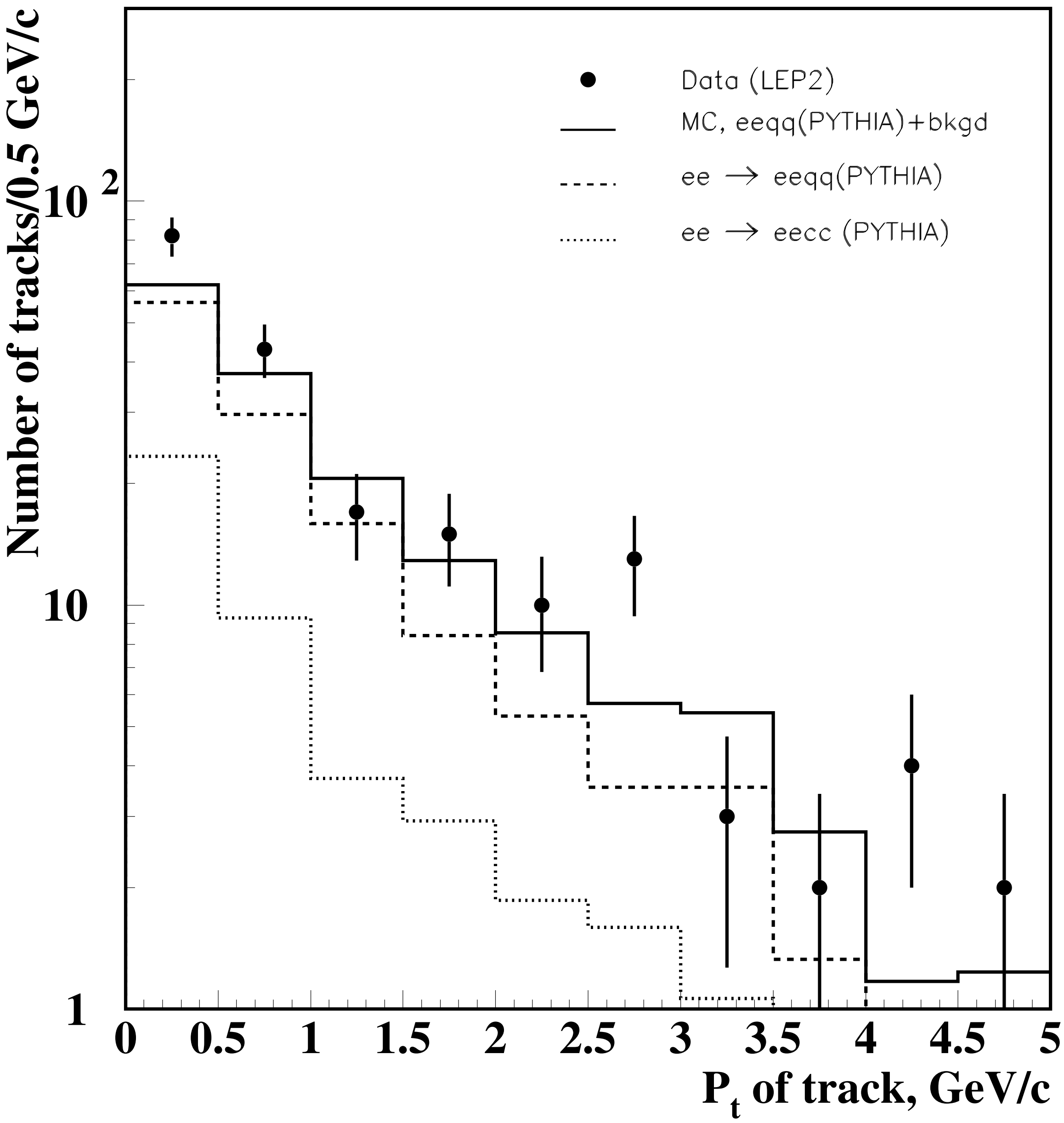
VISIBLE MASS

after hadronic events selection

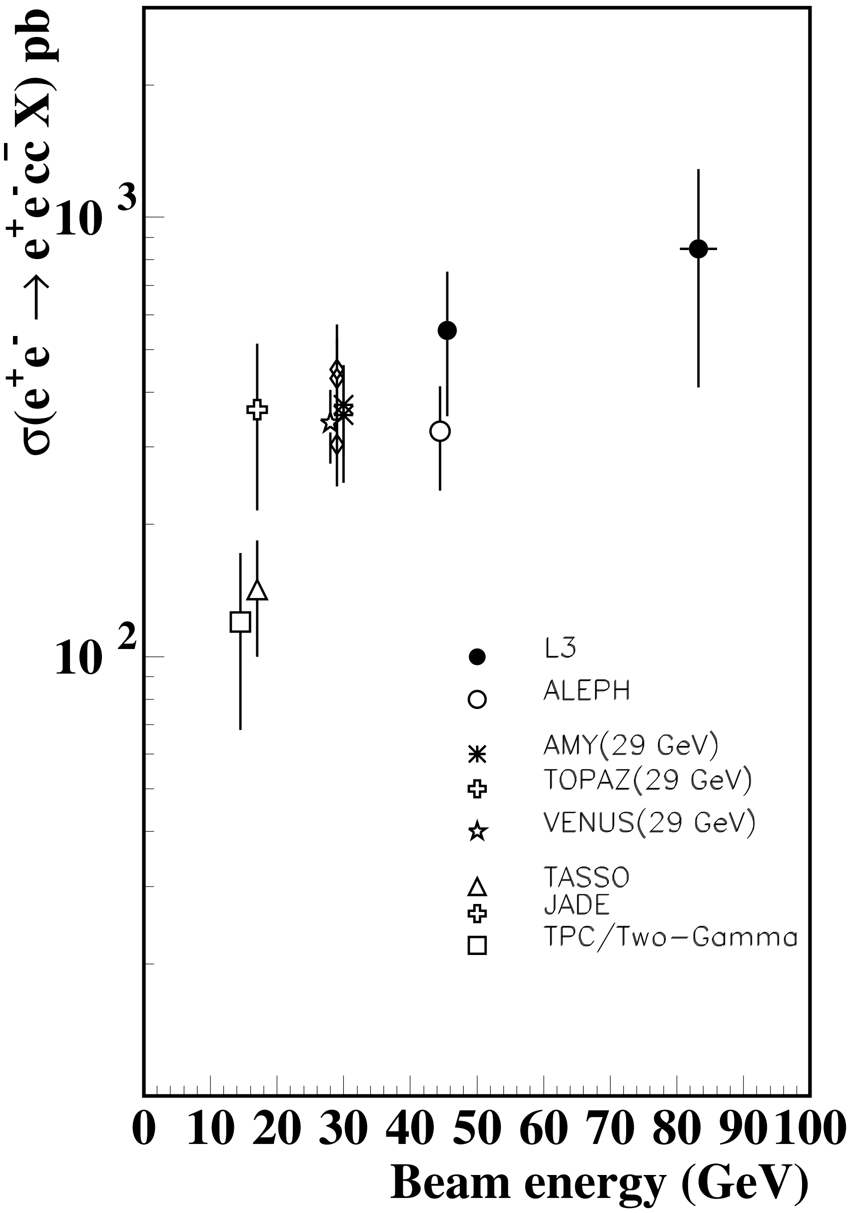
(Data / MC = 0.92)



after all the cuts



Charm production in $\gamma\gamma$ collisions as up-to-date



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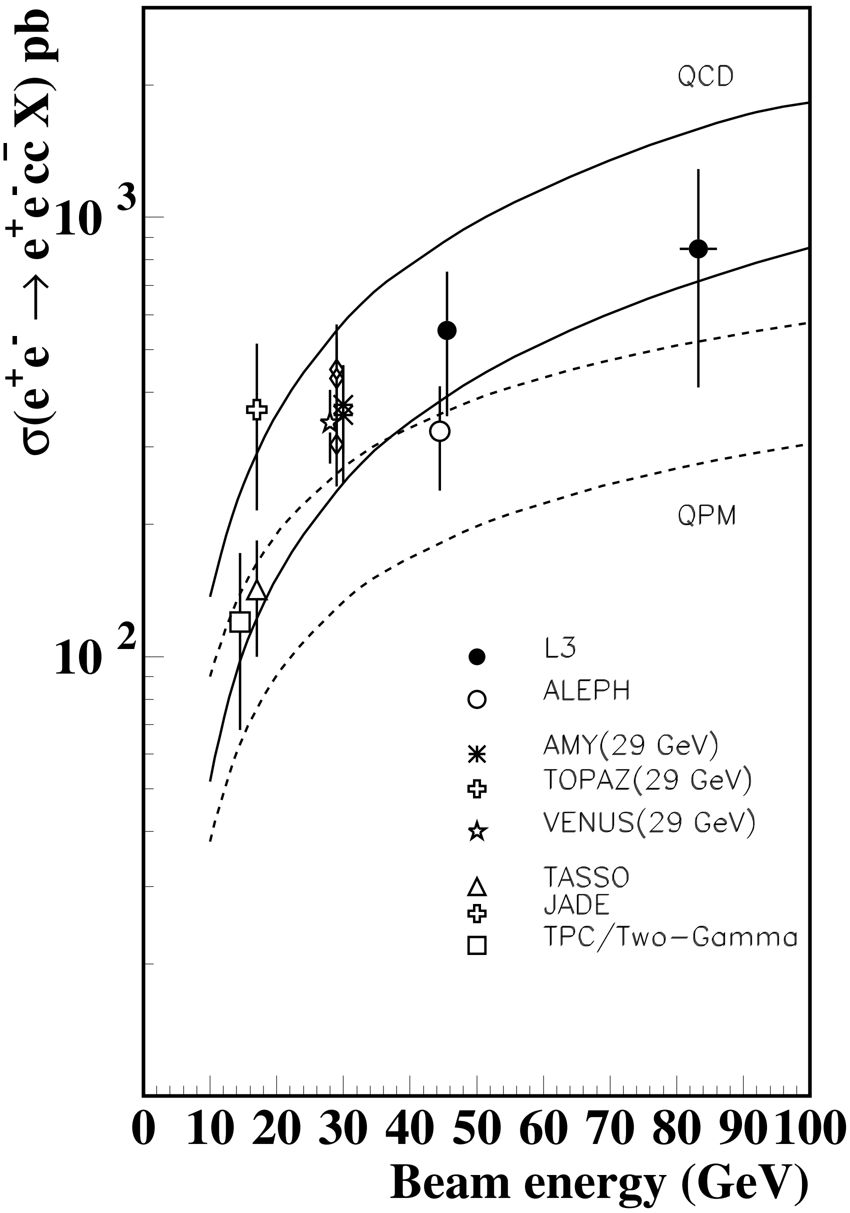

Conclusion

- **Cross sections of inclusive charm production in $\gamma\gamma$ collisions has been measured with L3 detector at LEP1 and LEP2 to be**

$$\sigma_{LEP1}^{ee\to eeccX} = 553\pm142\ \textbf{(stat)}\ \pm141\ \textbf{(syst) pb}$$

$$\sigma_{LEP2}^{ee\to eeccX} = 848\pm373\ \textbf{(stat)}\ \pm231\ \textbf{(syst) pb}$$

- **Results are in agreement with QCD predictions**
- **Results are preliminary**

Outlook

- there are good prospects for measurements at LEP2 energies
  - provided larger statistics available a shape of distributions can be studied (direct vs resolved)
- more analyses (other charm tags) are in progress