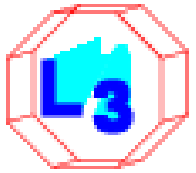
Baryon-Antibaryon Pair Production in Two-Photon Collisions at LEP



K. Freudenreich, ETH Zürich

DIS 2004, Štrbské Pleso, April 16, 2004

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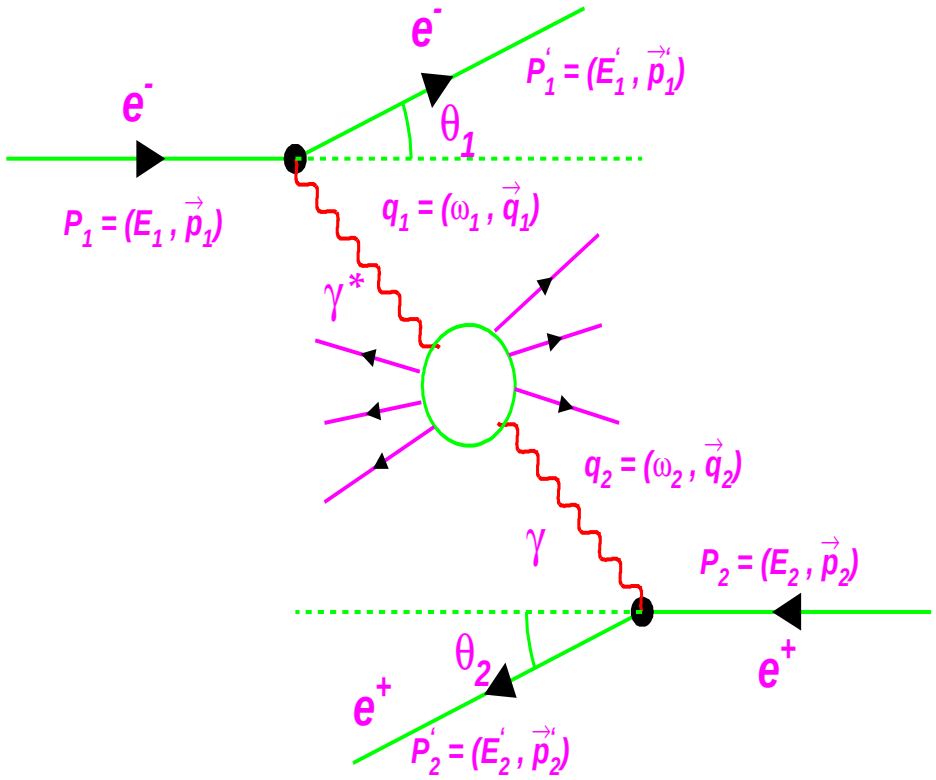
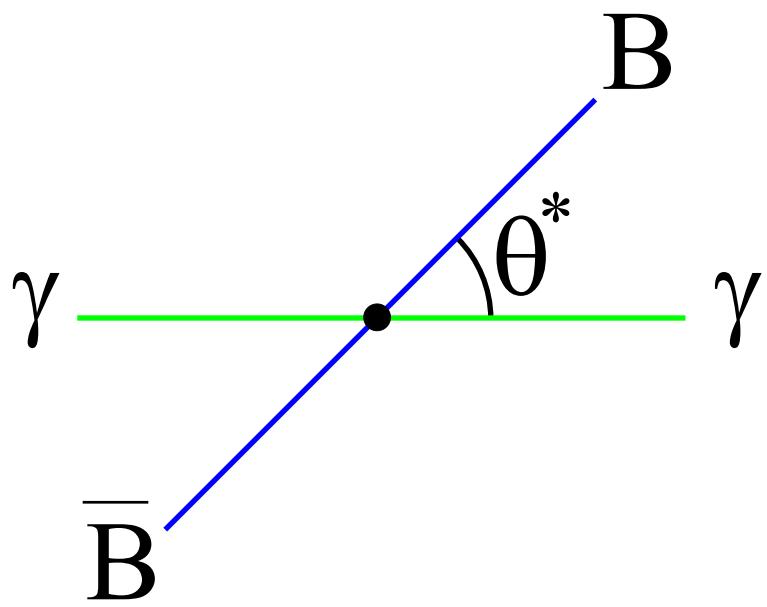
Overview

- Two-photon kinematics and theoretical models
- L3 subdetectors used in the analysis
- the data:
  P. Achard et al., Λ and Σ^0 pair production in two-photon collisions at LEP, Phys. Lett. B (2002) 24.
  P. Achard et al., Proton-antiproton pair production in two-photon collisions at LEP, Phys. Lett. B (2003) 11.
  B. Echenard, PhD thesis in progress, university of Geneva.
- comparison to models
- summary

Kinematics

$e^+e^- \rightarrow e^+e^- B\bar{B}$ with B ≡ baryon = p, Λ or Σ^0





$W_{\gamma\gamma}$ is the C.M.S. energy and Θ^* is the polar angle in the $\gamma\gamma$ C.M.S.

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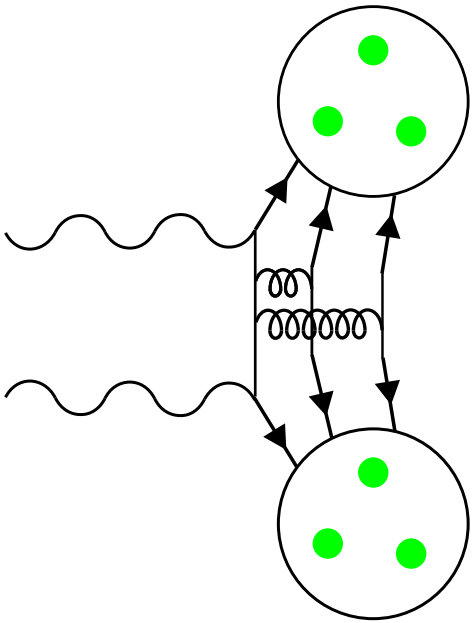
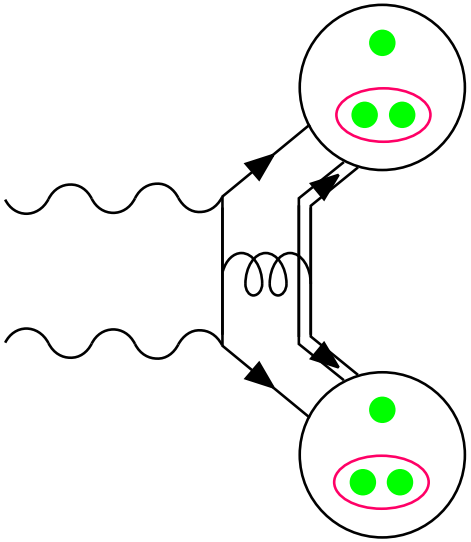
The Diquark Model

- Since perturbative QCD is inadequate at low p_T, models are needed for that region.
- Already M. Gell-Mann speculated in his 1964 quark paper about stable di-quarks.

three quark model



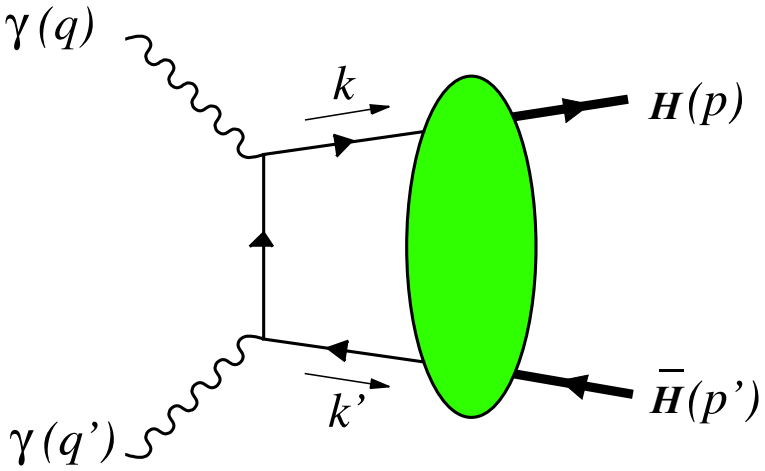
quark-diquark model

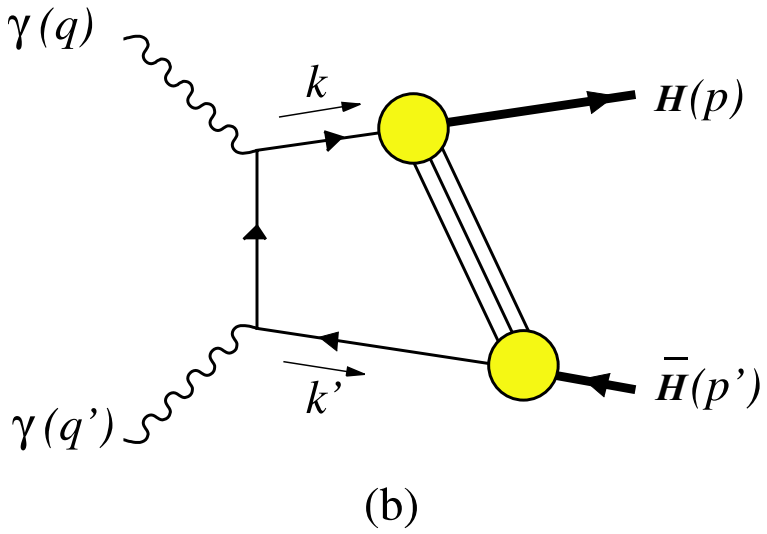


The Handbag Model

In the handbag model the amplitude for the annihilation of two photons into a baryon anti-baryon pair is factorized into a

hard $\gamma\gamma \rightarrow q\bar{q}$ subprocess and into a soft $B\bar{B}$ distribution amplitude:

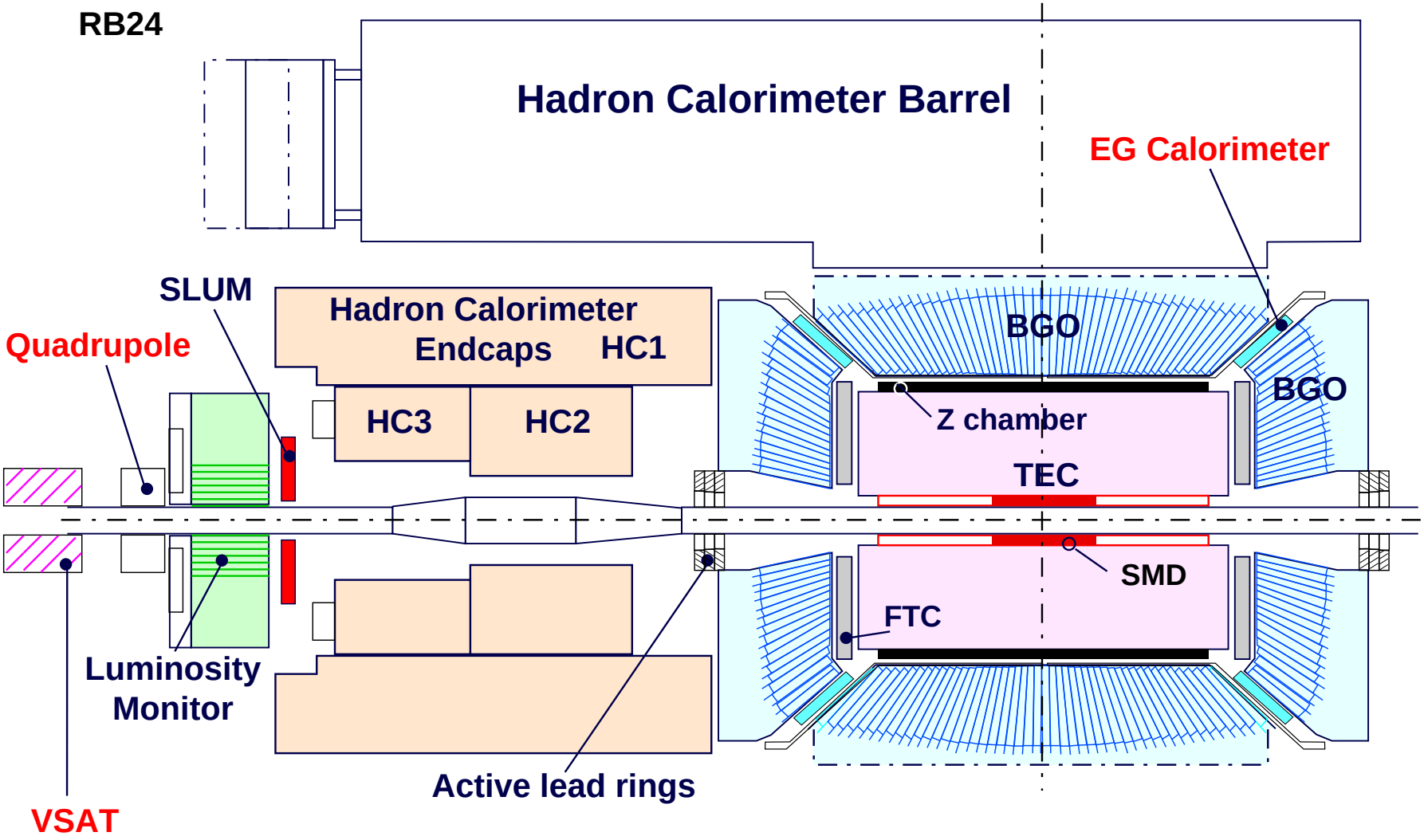




$$A(B\bar{B}) = r_B(\rho)\ A(p\bar{p}) \text{ with } \rho = \frac{F^{d,p}}{F^{u,p}}$$

M. Diehl, P. Kroll and C. Vogt, Eur. Phys. J., C26 (2003) 567.

L3 subdetectors used in the analysis



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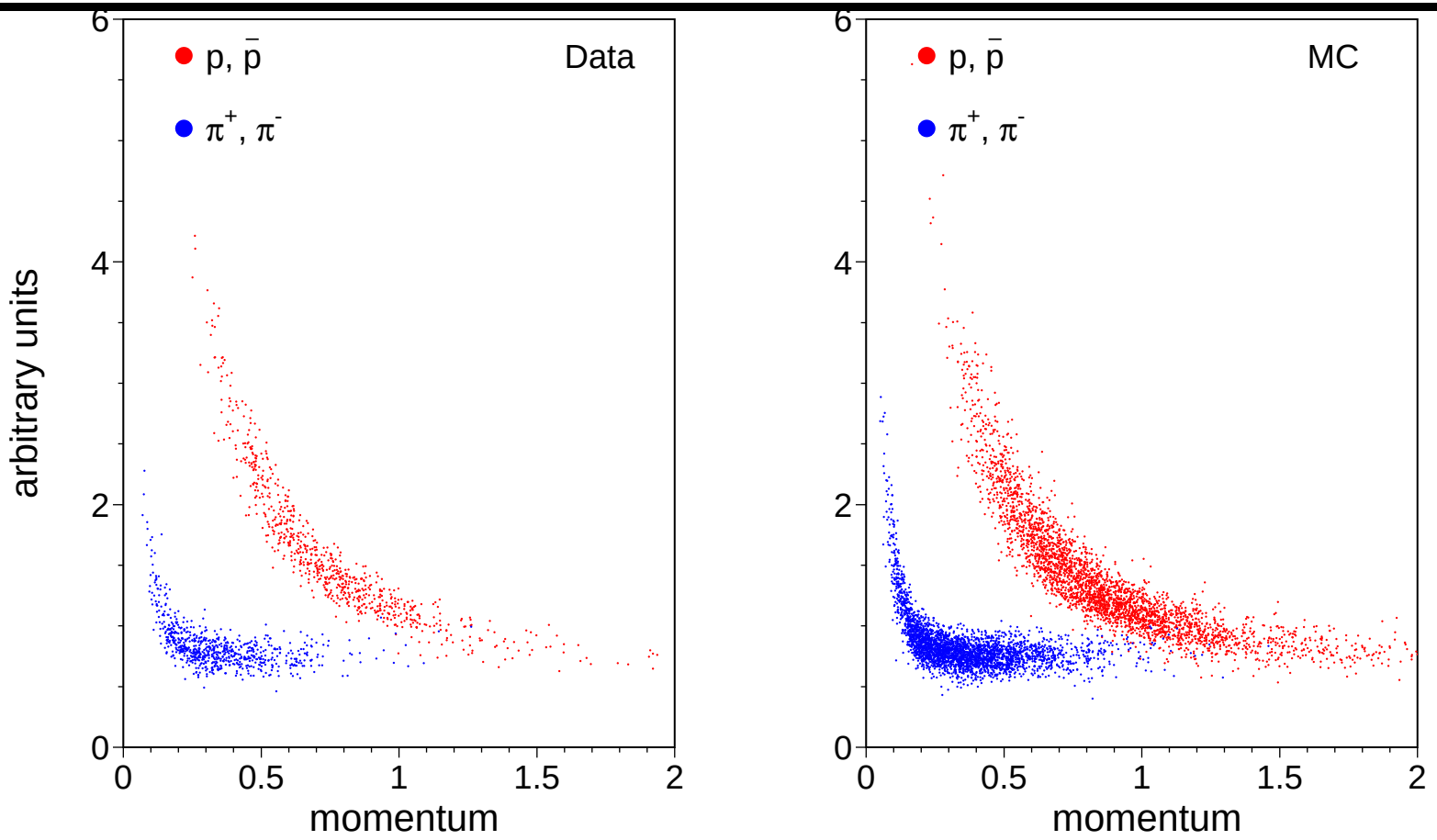
$\frac{d\,E}{d\,x}$ Measurement

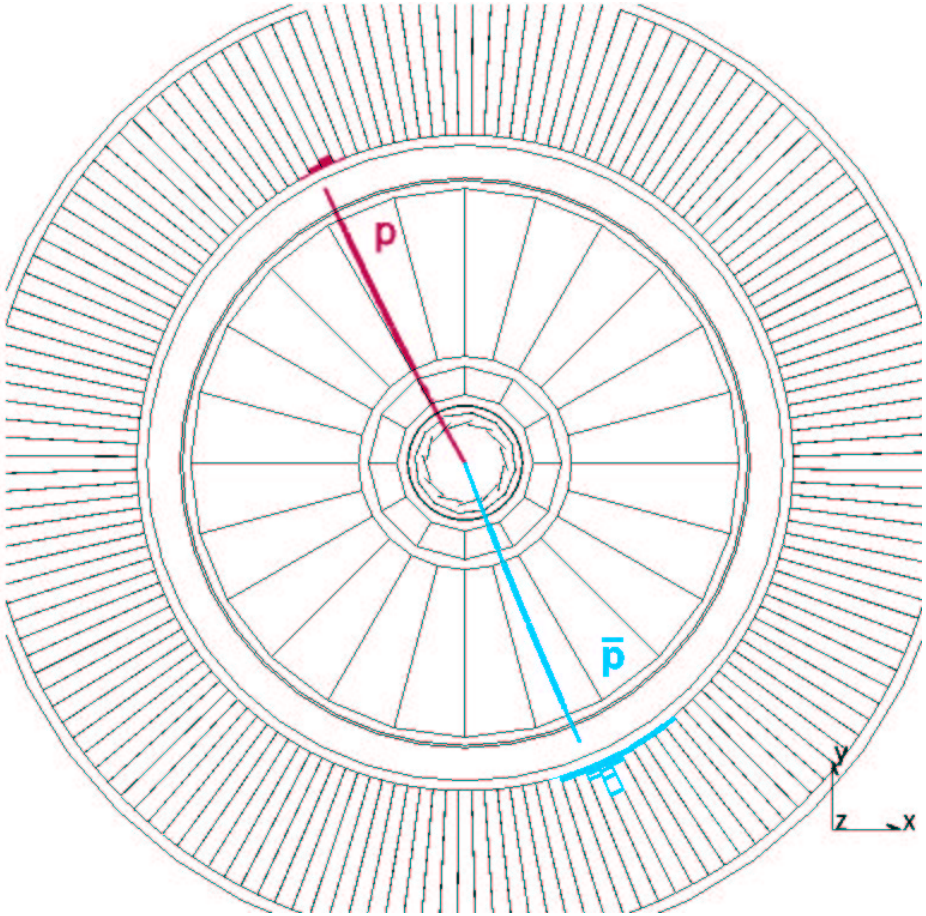


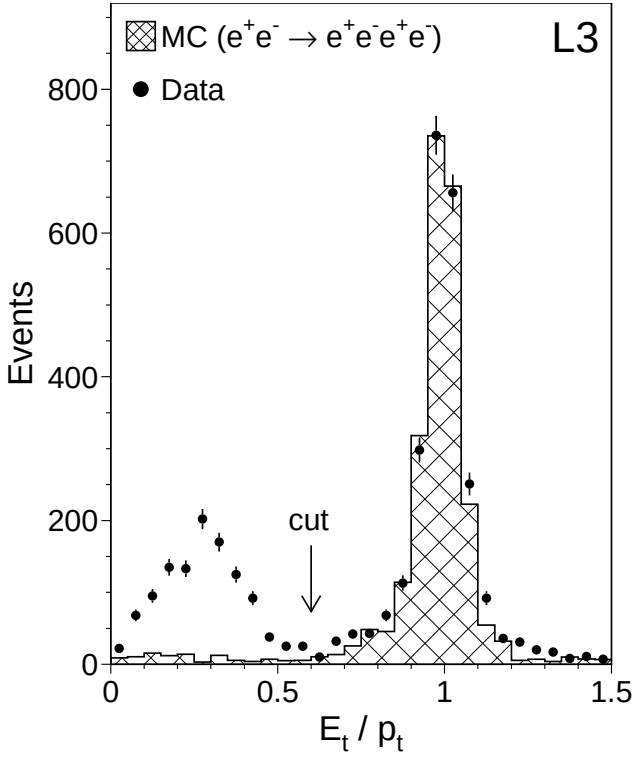
$\frac{dE}{dx}$ is used for the identification of protons and pions

p $\bar{p}$ selection

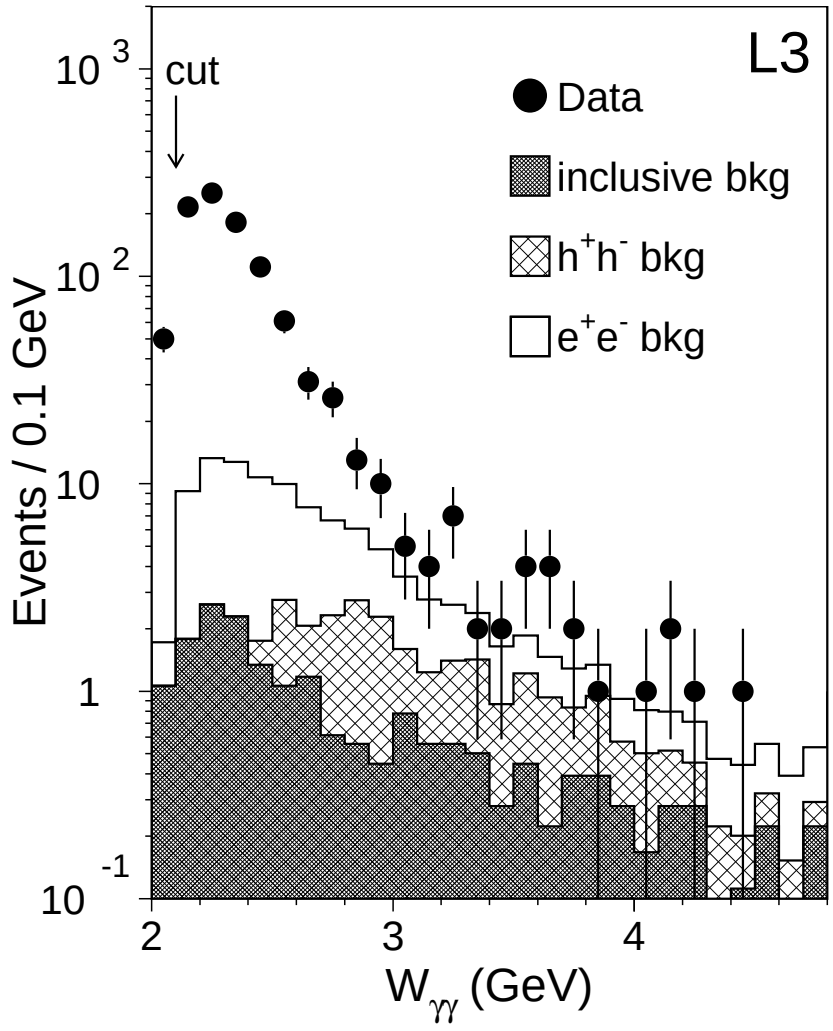
■ 2 tracks of opposite charge ■ $\bar{p}$ from neural net (p, $\frac{dE}{dx}$, $\frac{E_t}{p_t}$ + shower shape)

■ no photons ■ $(\sum \vec{p}_t(pair))^2 < 0.1$ GeV^2 ■ protons from $\frac{dE}{dx}$ and $\frac{E_t}{p_t} < 0.6$





effective mass $W_{\gamma\gamma}$ of the p $\bar{p}$ pair



989 events found for $\mathcal{L}$ = 667 pb^{-1}.

938 events selected with $W_{\gamma\gamma} > 2.1$ GeV.

since very small $\sqrt{s}$ dependence $\rightarrow$

combination into one $\sqrt{s}$ bin.

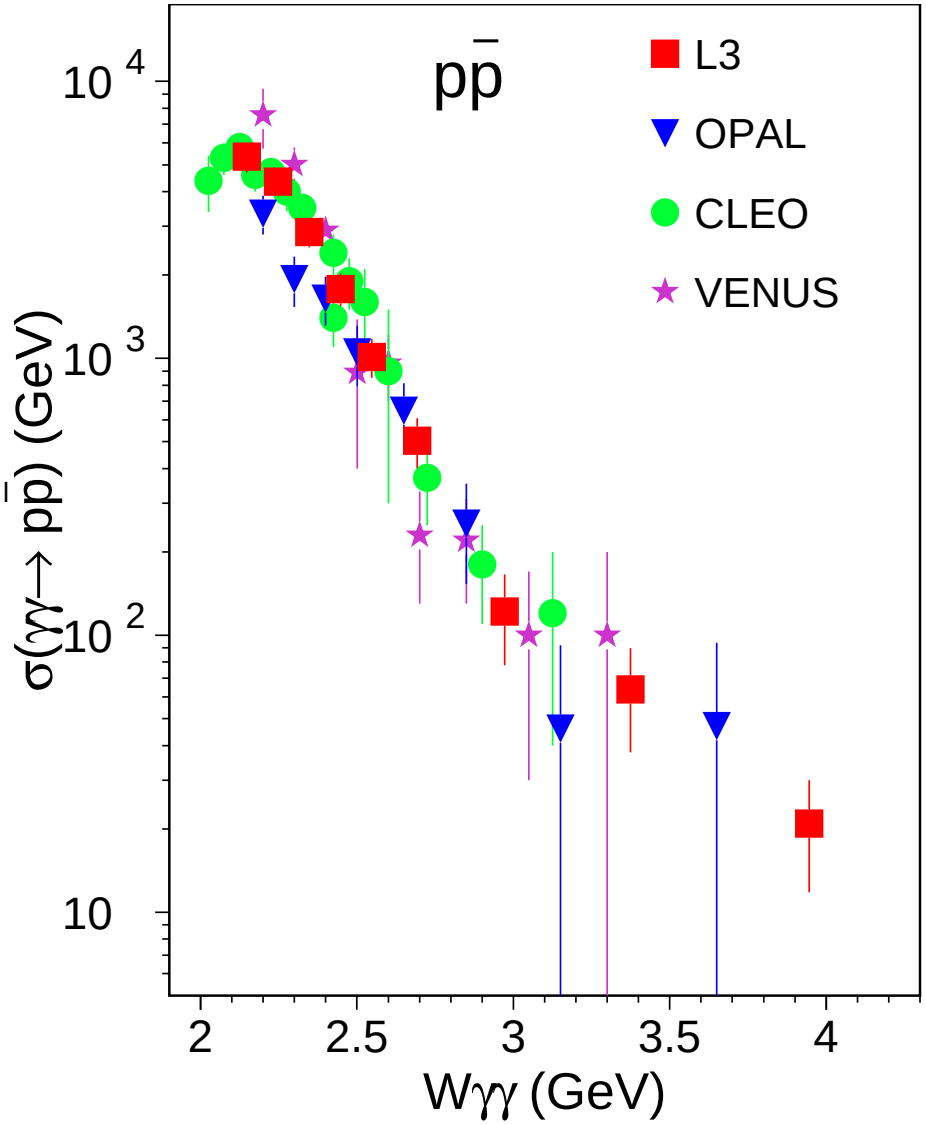
$\sigma(e^+e^- \rightarrow e^+e^- p\bar{p})$ =

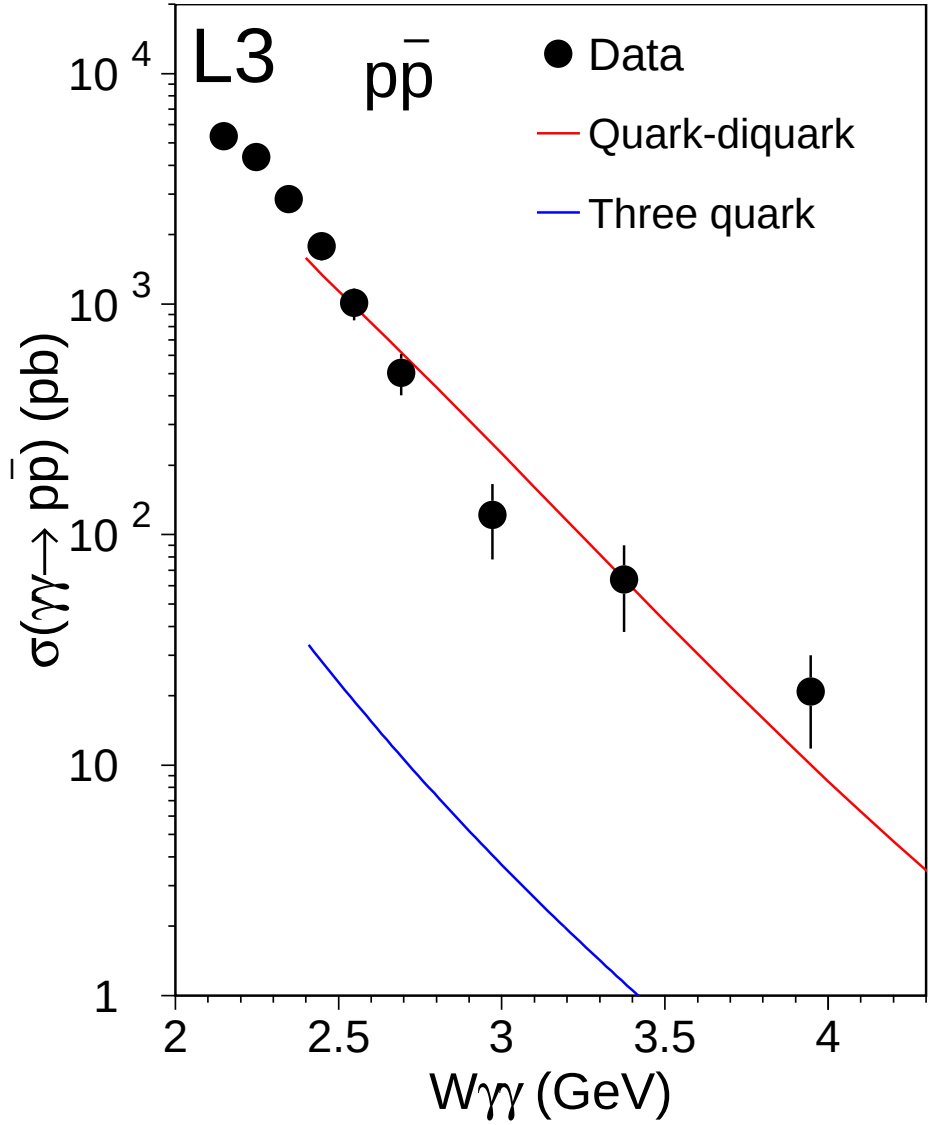
(26.7 $\pm$ 0.9 $\pm$ 2.7) pb

at $< \sqrt{s} >$ = 197 GeV

$d\sigma(\gamma\gamma \rightarrow p\bar{p})/d|\cos\Theta^*|$ is obtained by dividing out the two-photon luminosity function and extrapolation to Q^2 = 0 with a GVDM form factor.

$\sigma(\gamma\gamma \to p\bar{p})$ for $\cos\Theta^* < 0.6$





L3 data extend range in $W_{\gamma\gamma}$, agreement with prev. experim. + diquark model.

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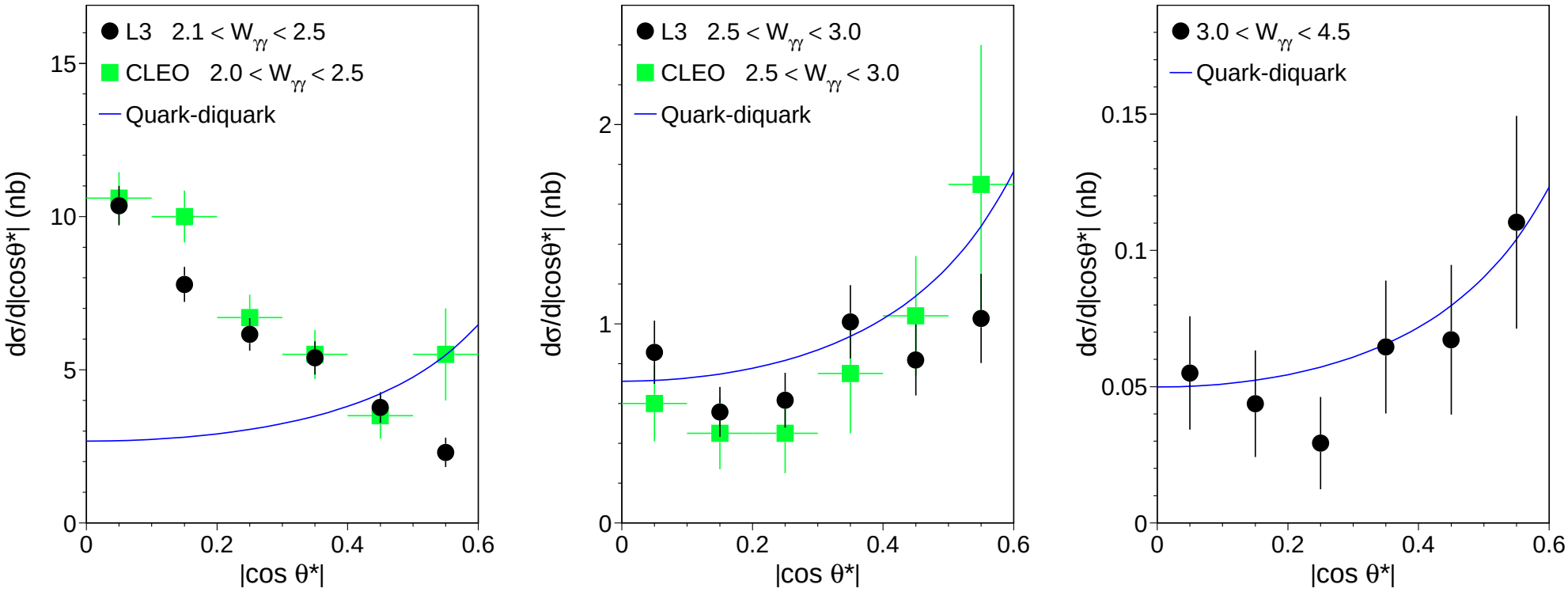
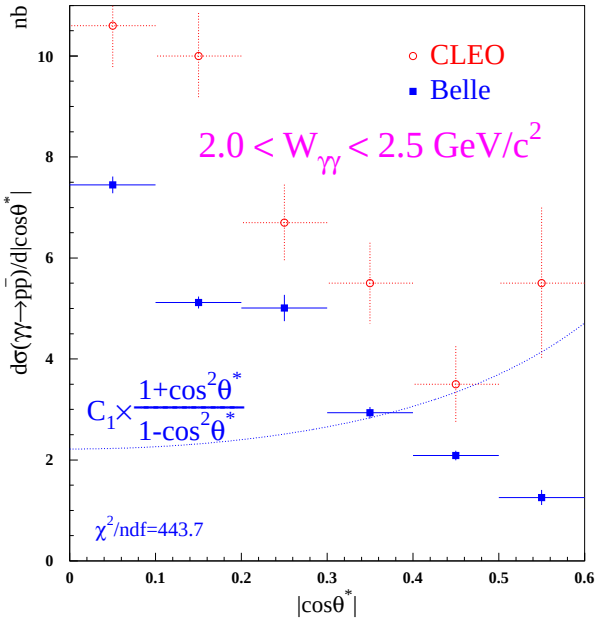
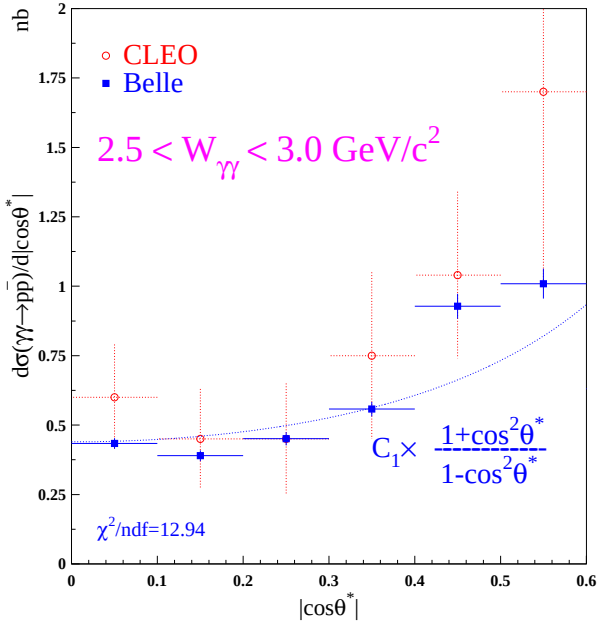
$d\sigma/d|\cos\Theta^*|$ in three bins of $W_{\gamma\gamma}$

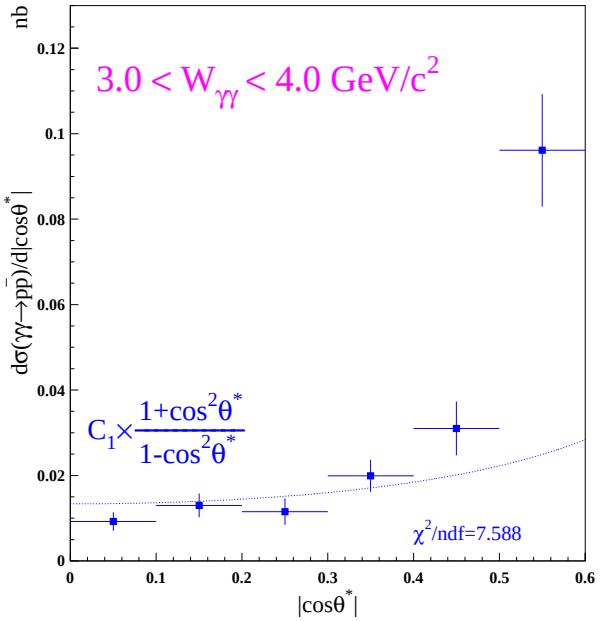


Diquark model starts to work for $W_{\gamma\gamma} > 2.5$ GeV

$d\sigma/d|\cos\Theta^*|$ in three bins of $W_{\gamma\gamma}$





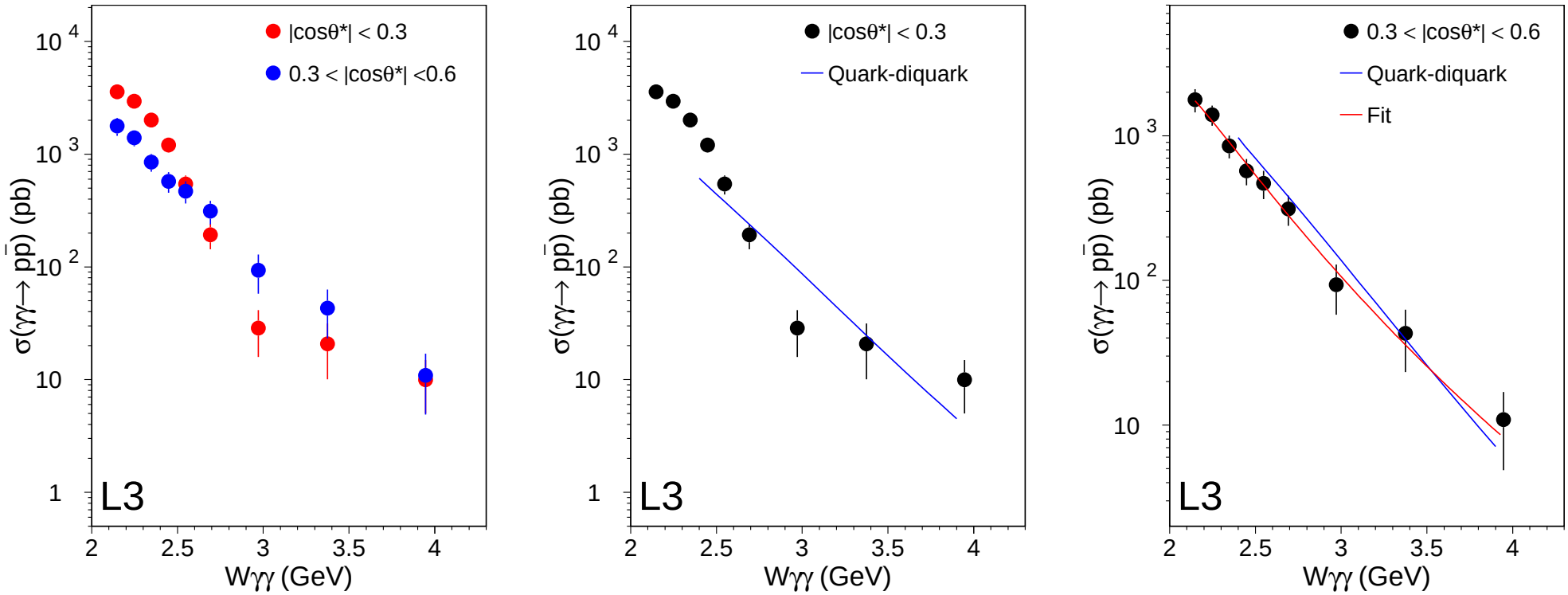


Preliminary data from the Belle colaboration, presented at Photon 03, Frascati, Italy. They show a similar behaviour.

In the meantime their data have changed in the lowest mass bin approaching both CLEO and L3.

Many thanks to Dr. C.-C. Kuo from Belle.

$\sigma(\gamma\gamma \to p\bar{p})$ vs. $W_{\gamma\gamma}$ in 2 bins of cos Θ^*



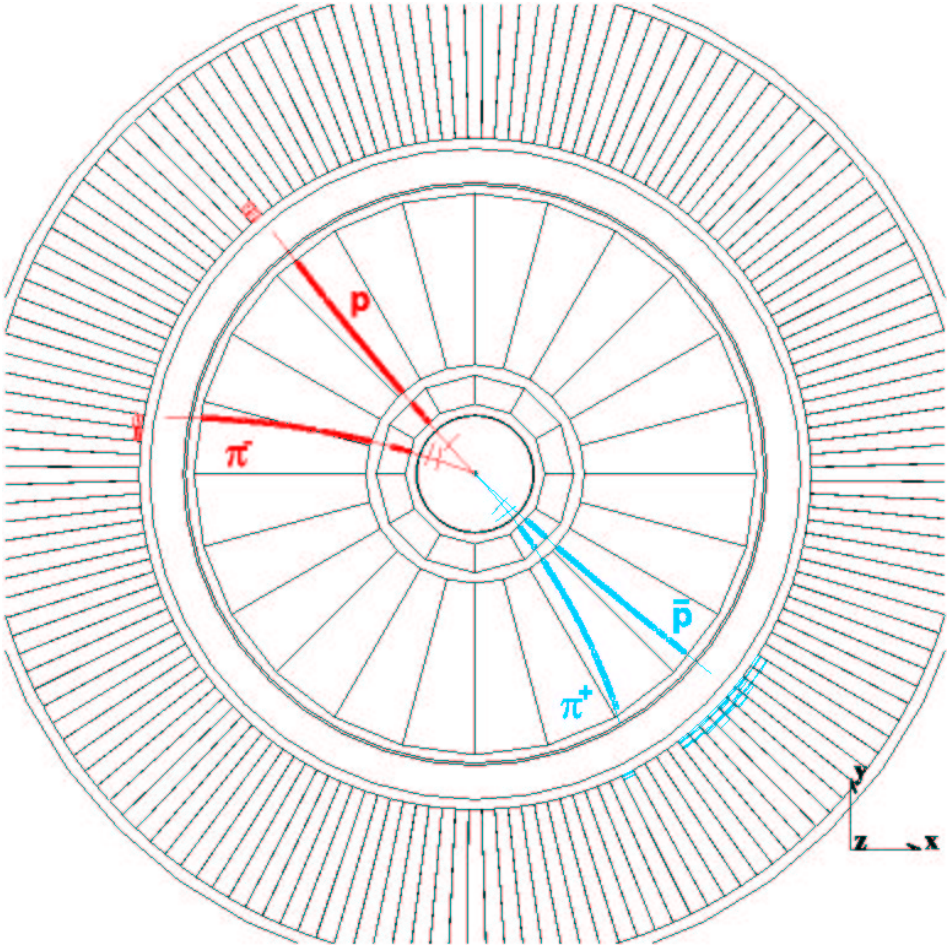
Change in slope at $W_{\gamma\gamma} \sim 3$ GeV for $|\cos\Theta^*| < 0.3$

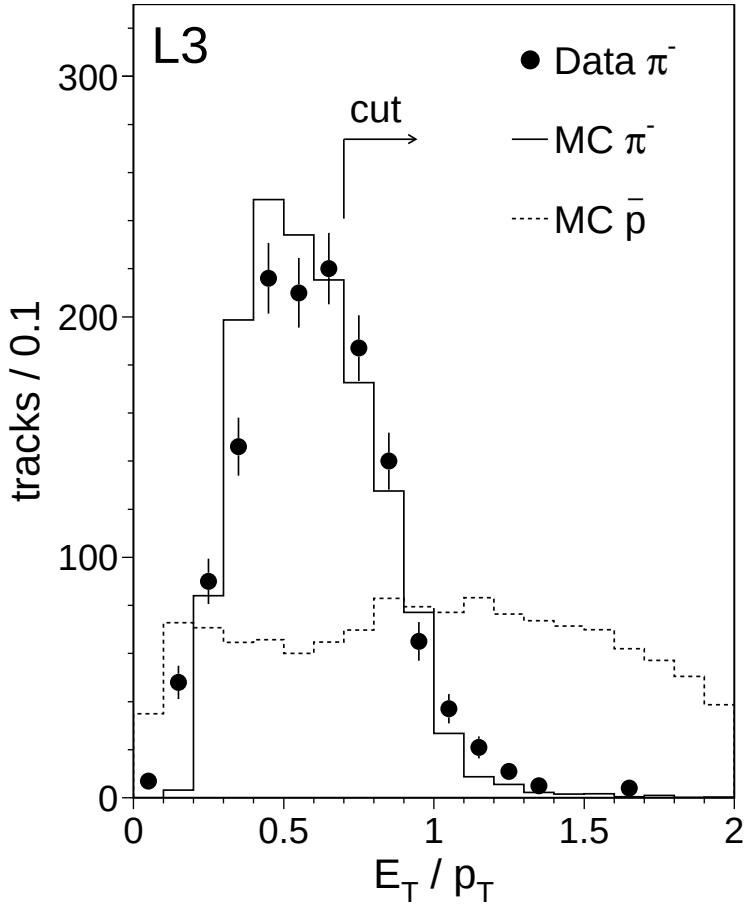
a fit with $\sigma \propto W^{-n}$ in $0.3 < |\cos\Theta^*| < 0.6$ yields $n = 9.8 \pm 0.3$

$\Lambda\ \bar{\Lambda}$ selection

■ 2 secondary vertices with $dca_{\perp} > 3$ mm ■ no photons ■ no K^0_s

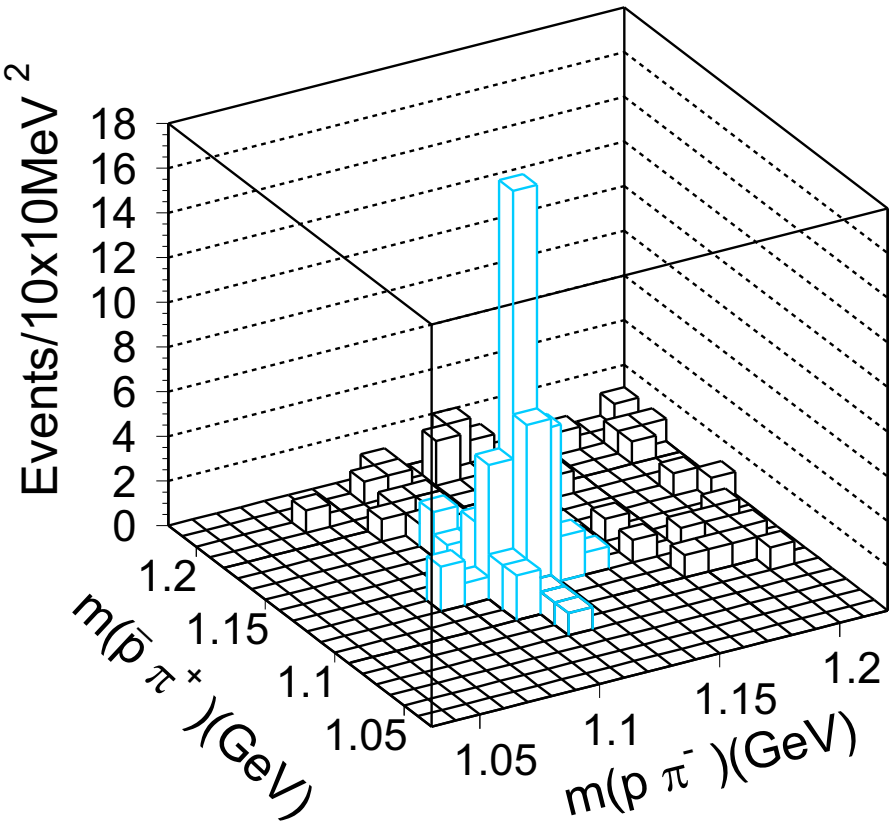
■ p and π identification via $\frac{dE}{dx}$ ■ $\bar{p}$ identification via $\frac{E_t}{p_t} > 0.7$

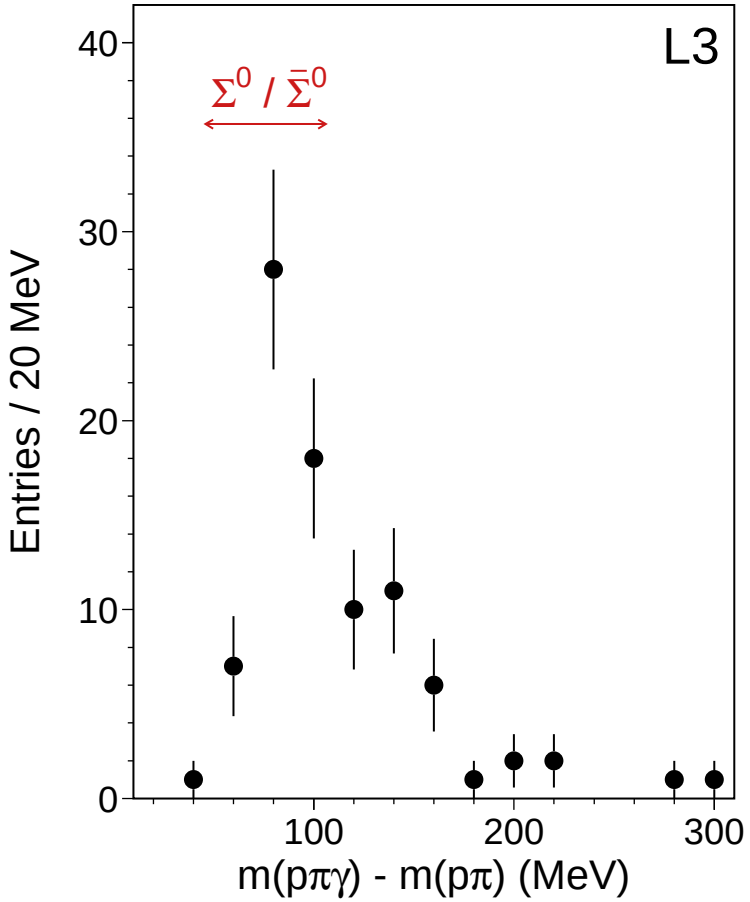




$e^+e^- \to \Lambda\bar{\Lambda}, \Sigma^0/\bar{\Sigma}^0$ selection

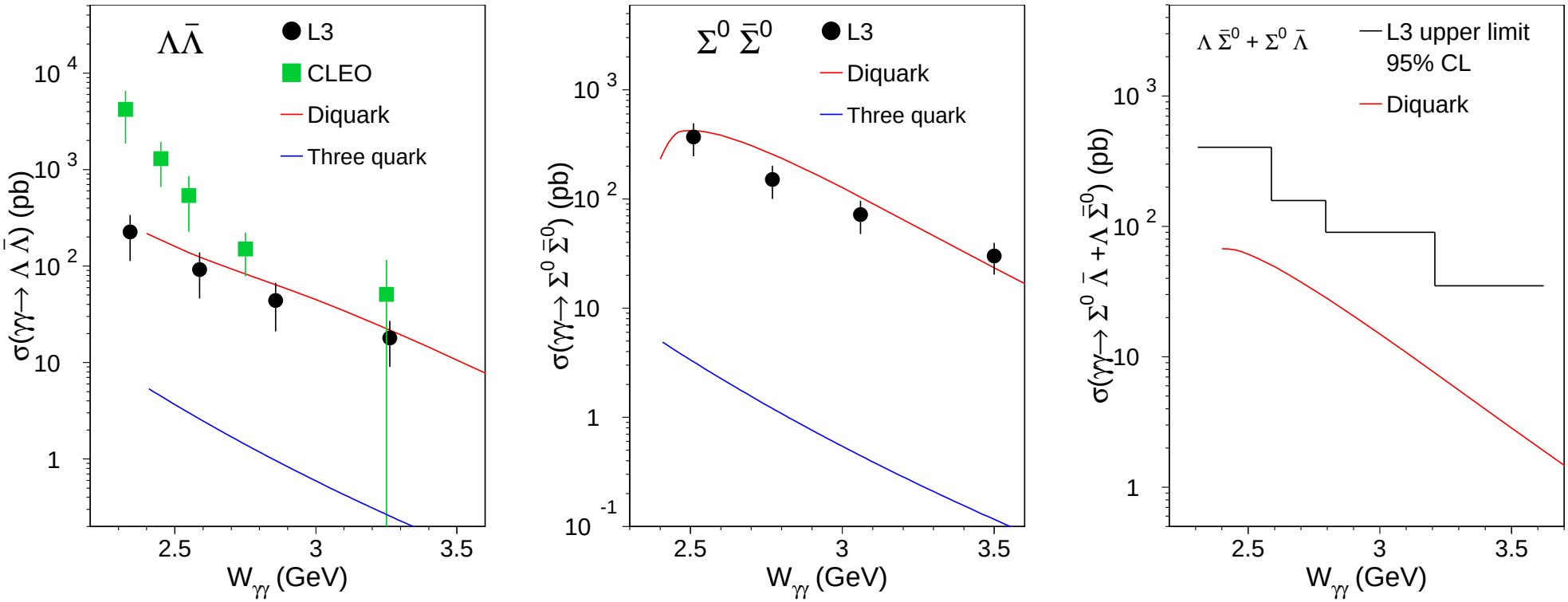
- Selection of decays $\Lambda \to p\pi^-$ $\bar{\Lambda} \to \bar{p}\pi^+$ $\Sigma^0 \to \Lambda\gamma$





- likelihood fit yields 12.5 ± 6.1 $\Lambda\bar{\Lambda}$ and 20.5 ± 6.5 $\Sigma^0\bar{\Sigma}^0$ events

$\sigma(\gamma\gamma \to \Lambda\bar{\Lambda},\ \Sigma\bar{\Sigma},\ \Lambda\bar{\Sigma}^0 + \bar{\Lambda}\Sigma^0)$



Limited statistics. Disagreement with CLEO at low $W_{\gamma\gamma}$.

Agreement with diquark model predictions.
Three quark model again much too low.

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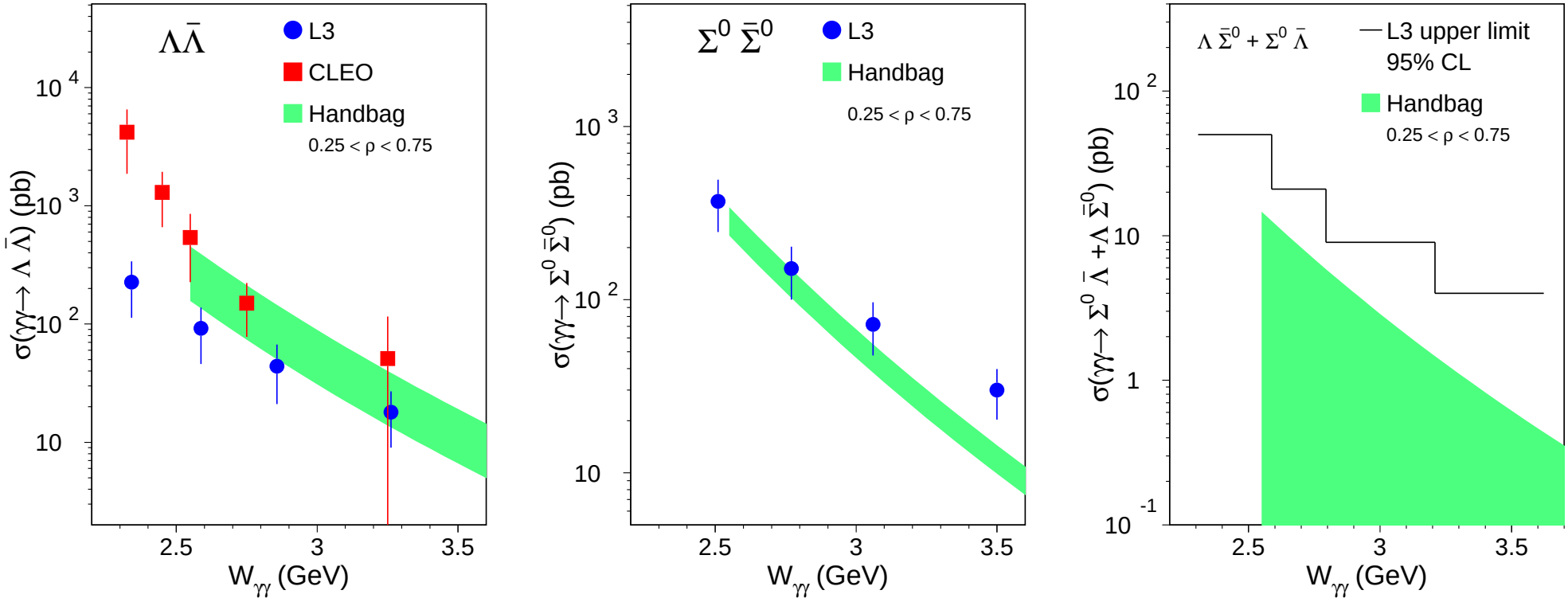
$\sigma(\gamma\gamma \to \Lambda\bar{\Lambda},\ \Sigma\bar{\Sigma},\ \Lambda\bar{\Sigma}^0 + \bar{\Lambda}\Sigma^0)$



Agreement with the handbag model (M. Diehl et al.) which uses a single model parameter ρ determined from $\gamma\gamma \to p\bar{p}$ data.

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Summary

$\gamma\gamma \to p\bar{p}$

- Diquark model agrees with data for $W_{\gamma\gamma} > 2.5$ GeV
- Three quark model predictions much too low
- Small and large angles have different $W_{\gamma\gamma}$ dependence

$\gamma\gamma \to \Lambda\bar{\Lambda} \quad \gamma\gamma \to \Sigma\bar{\Sigma}$

- Disagreement with three quark model
- Agreement with diquark and handbag models
- The Belle experiment will increase statistics by a lot