Inclusive hadrons and pair production in γγ collisions at LEP

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L3 Collaboration

XXVIIIth Rencontres de Moriond – QCD

Outline

❑ ***Baryon pair production***

➔ ***$P\overline{P}$*** **[L3:submitted, OPAL:CERN-EP-2002-056]**

➔ ***$L\overline{L}$ and $S^0\overline{S^0}$*** **[L3: PLB 536 (2002) 24]**

❑ ***r^0r^0 pair production at high Q^2***

[L3:submitted]

❑ ***Inclusive hadrons production***

➔ ***$p^{\pm}$ and $K^{\pm}$*** **[L3:CERN-EP-2002-081, OPAL:Eur.Phys.J. C6 (1999) 253]**

➔ ***p^0 and K^0_S*** **[L3:PLB 524 (2002) 44, OPAL:Eur.Phys.J. C6 (1999) 253]**

National
Central
University

❑ **Test QCD calculations**

➔ Three-quark model

➔ Quark-diquark model
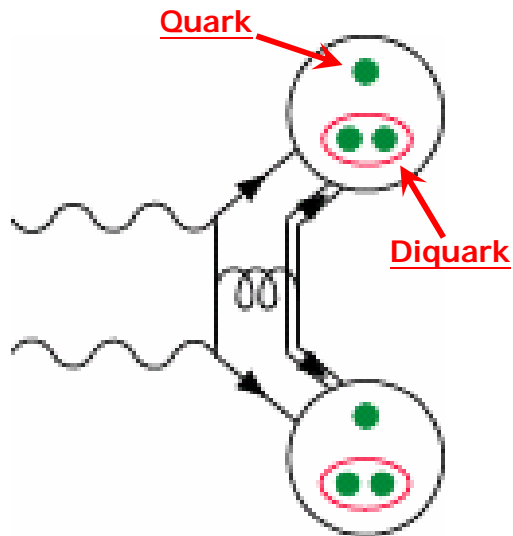
(1) C. Berger et al., hep-ph/0212066
(2) M. Anselmino et al., Int. J Mod. Phys A4, 5213
(3) G. Farrar et al., Nucl. Phys. B259 702

— Standard DA[1]

— Standard DA[2]
(Mp negelcted)

— Three quark[3]
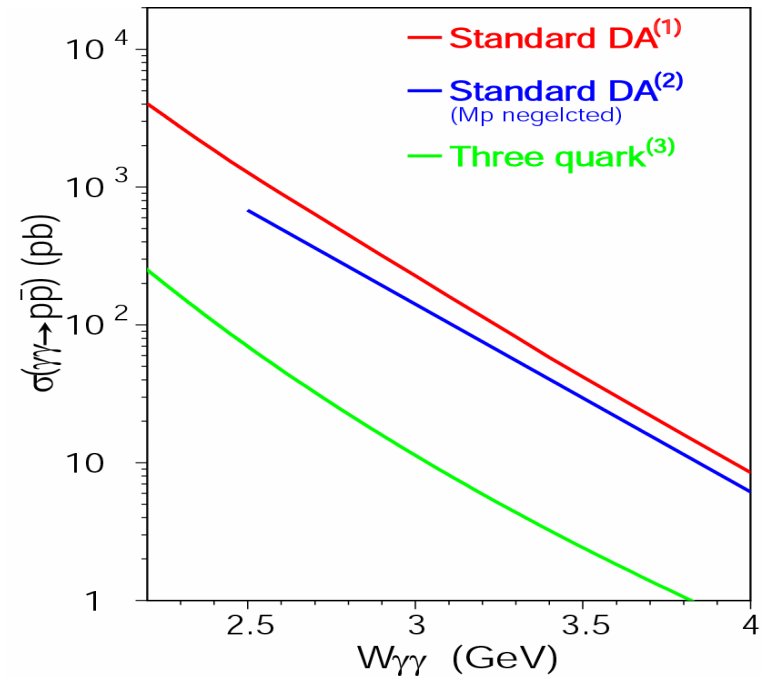
Baryon Decay Channel

❑ **Decay Channel:**

✓ $e^+e^- ® e^+e^-p\overline{p}$

✓ $e^+e^- ® e^+e^-L\overline{L}$

$$L ® p\pi^- \qquad \overline{L} ® \overline{p}\pi^+$$

✓ $e^+e^- ® e^+e^-S^0\overline{S^0}$

$$S^0 ® L\gamma \qquad \overline{S^0} ® \overline{L}\gamma$$

❑ **Select 2 or 4 tracks events.**

➔ Proton and Anti-proton identification.

Proton and Anti-proton Identification

❑ **L3:**
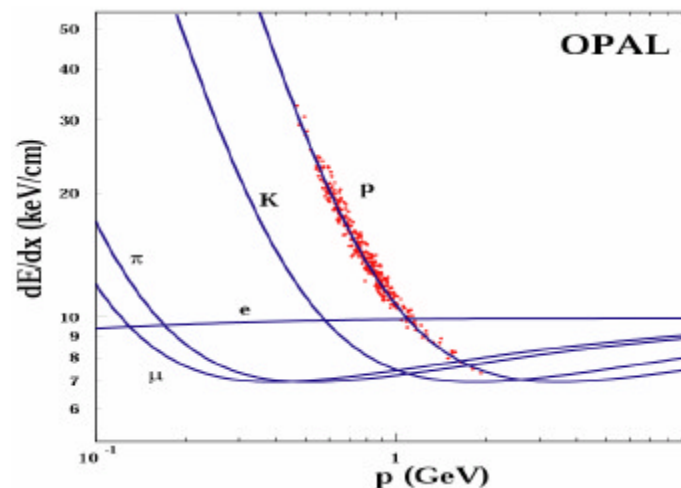
   ➔ Anti-Proton:

     ✓ Neural network
       P, dE/dx, E_t/P_t & Shower shape
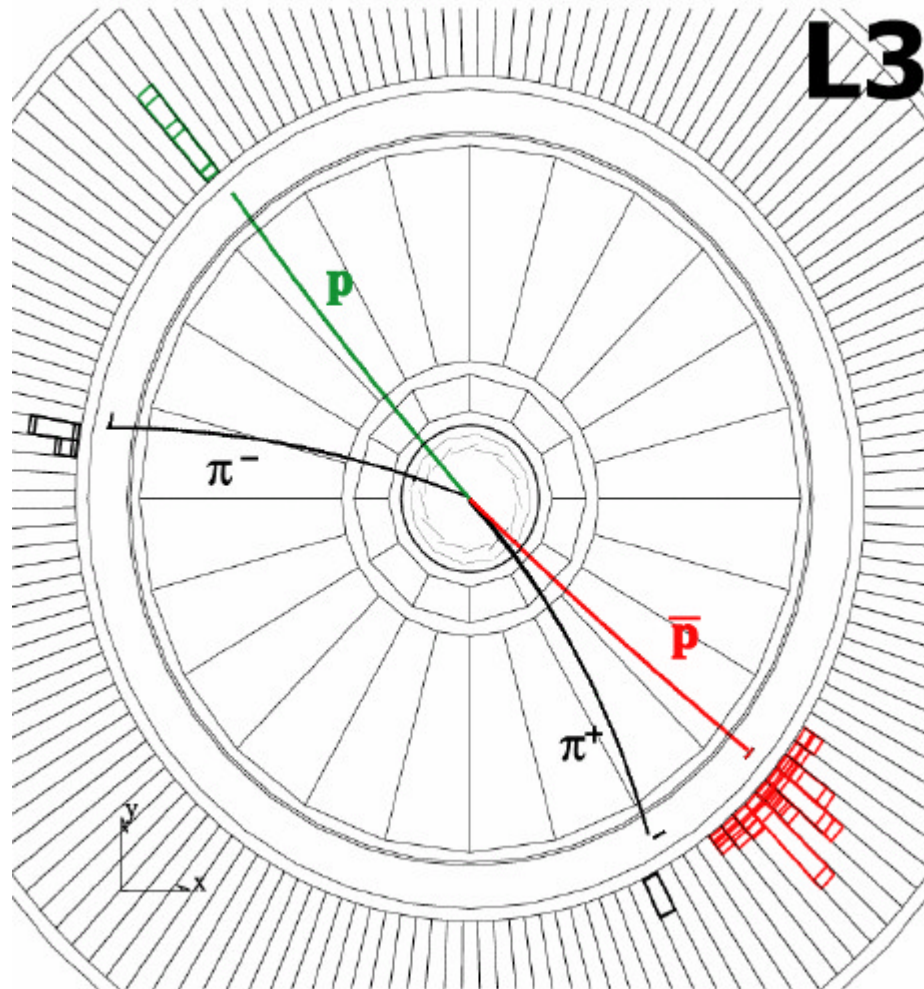
   ➔ Proton:
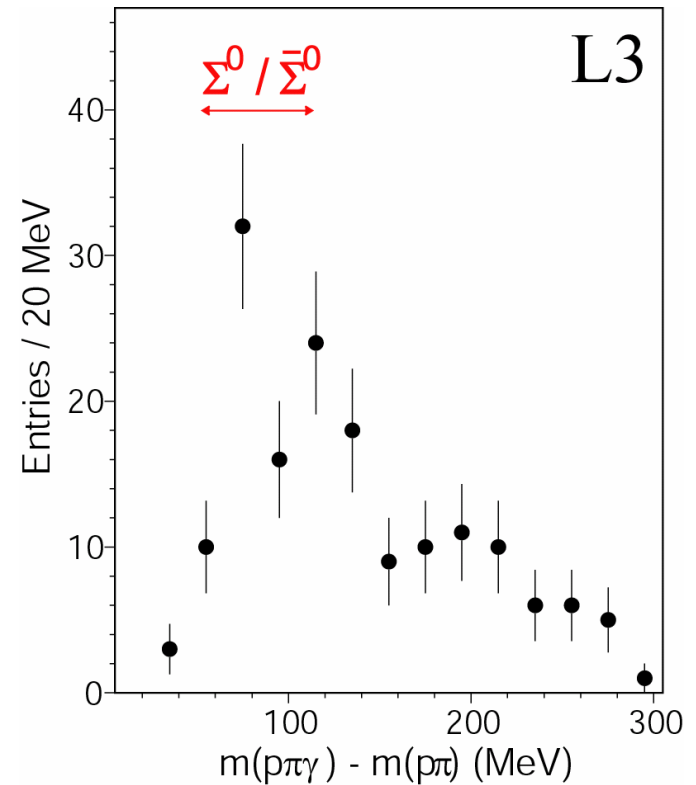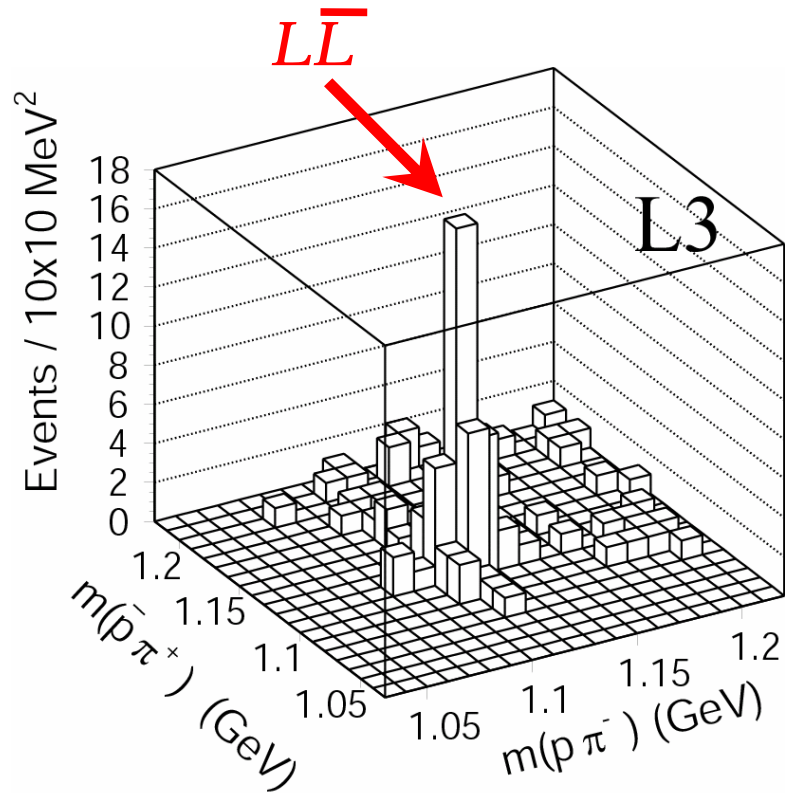
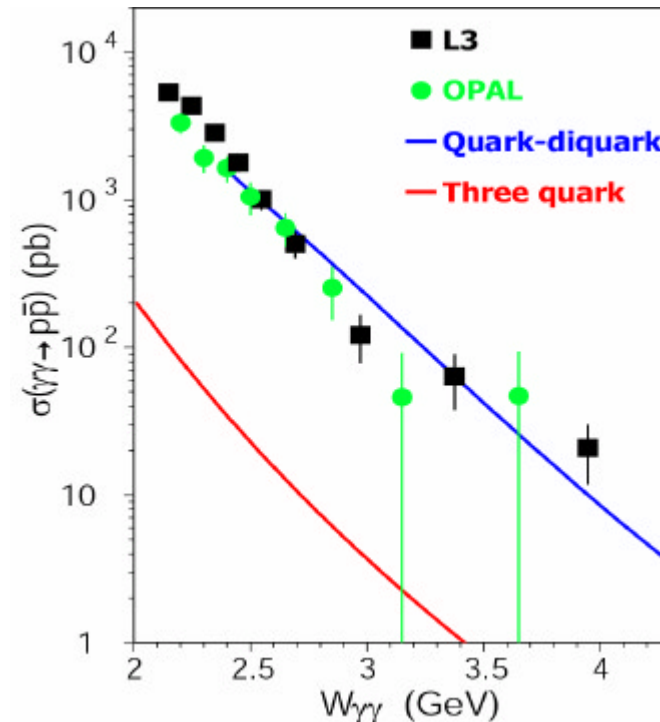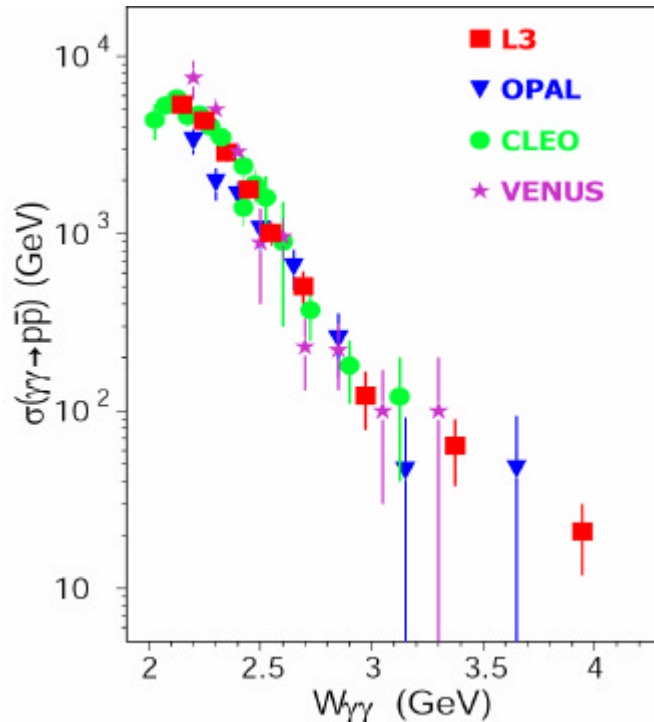   ✓ E_t/P_t and dE/dx
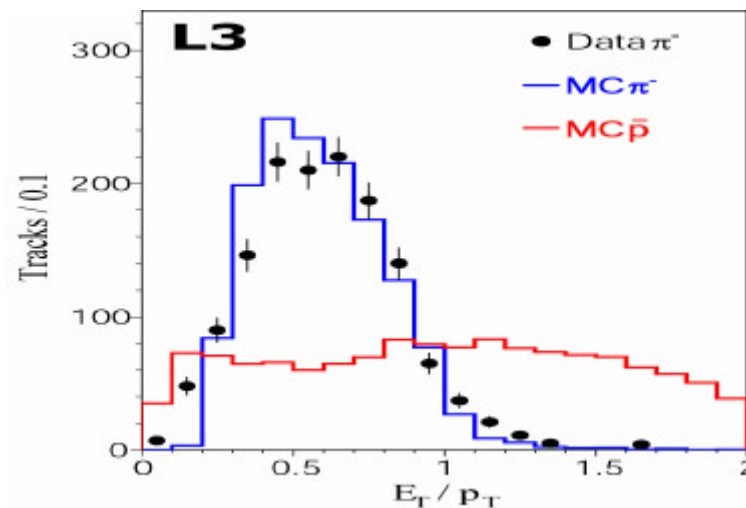
❑ **OPAL:**

   ➔ dE/dx and E/P

$e^+e^- \rightarrow e^+e^-L\bar{L}$ Event

L and S⁰ Mass Spectrum

Cross-section of **gg ® pp̄**

❑ Good agreement with previous experiments.

❑ Extended Wγγ range.

❑ Good agreement with the quark-diquark model.

❑ Three-quark model excluded.
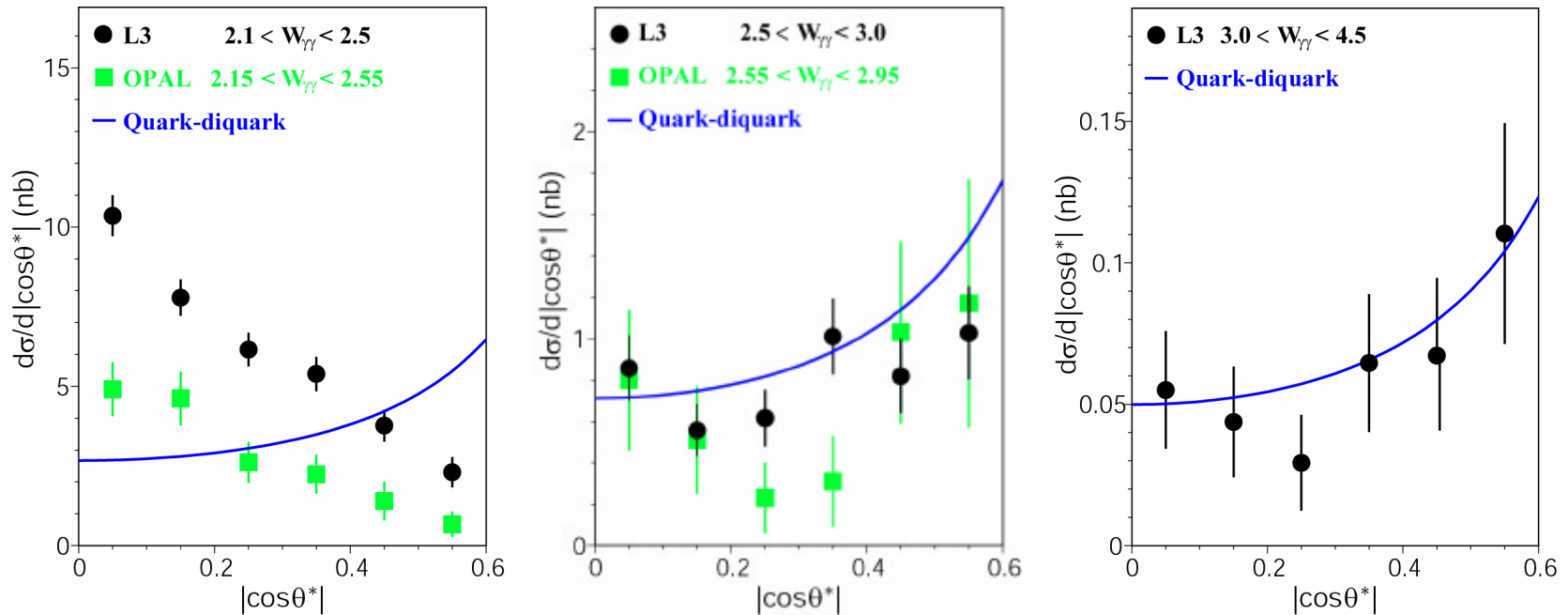
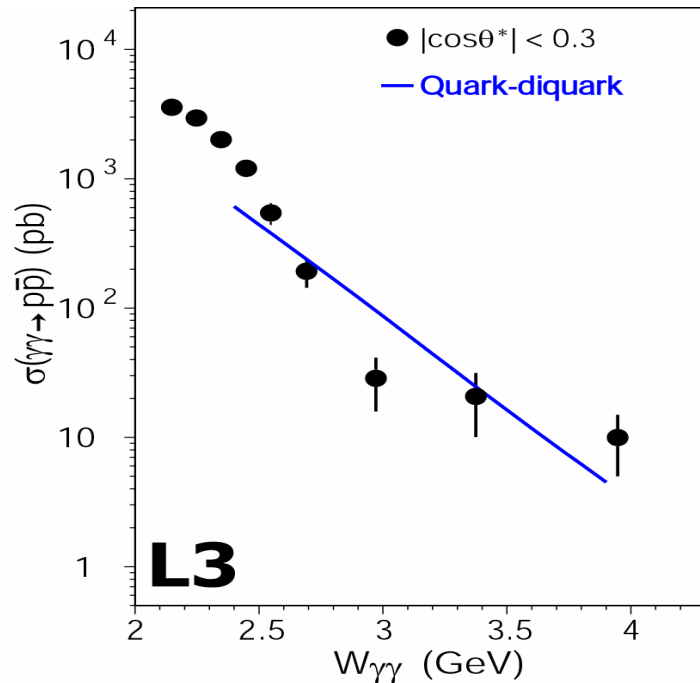❑ Different angular distribution in low $W_{\gamma\gamma}$ region.
❑ Disagree with the Quark-diquark model in low $W_{\gamma\gamma}$ region.

Cross-section of $\gamma\gamma \to p\bar{p}$

Large Angle

Small Angle
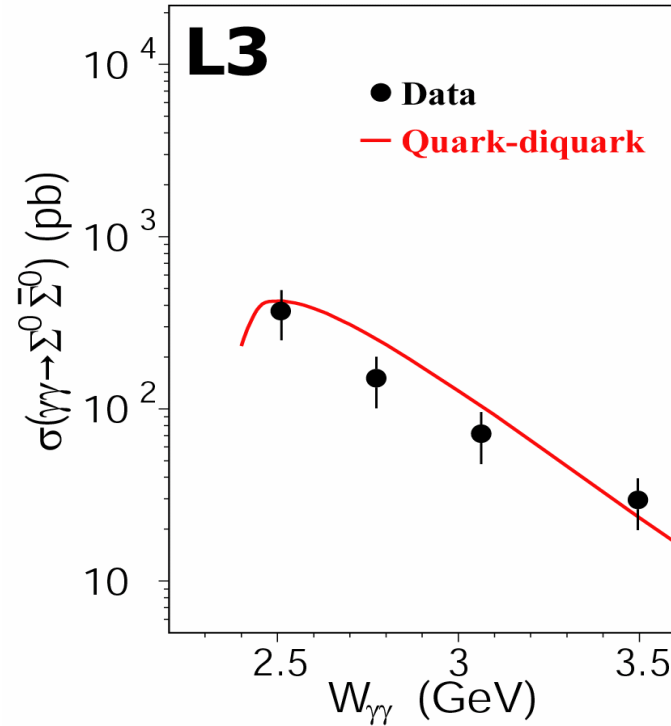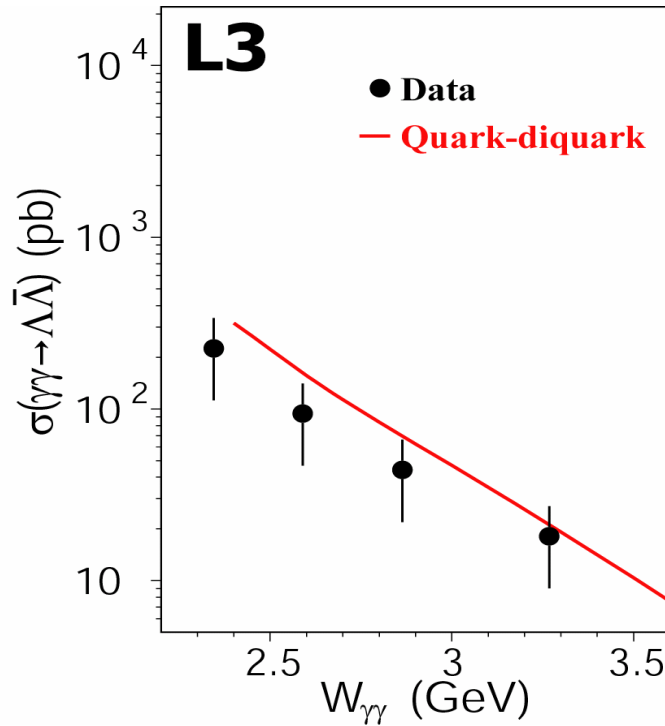

□ Shape changes at $W_{\gamma\gamma} \sim 3$ GeV

□ Disagree with quark-diquark model.
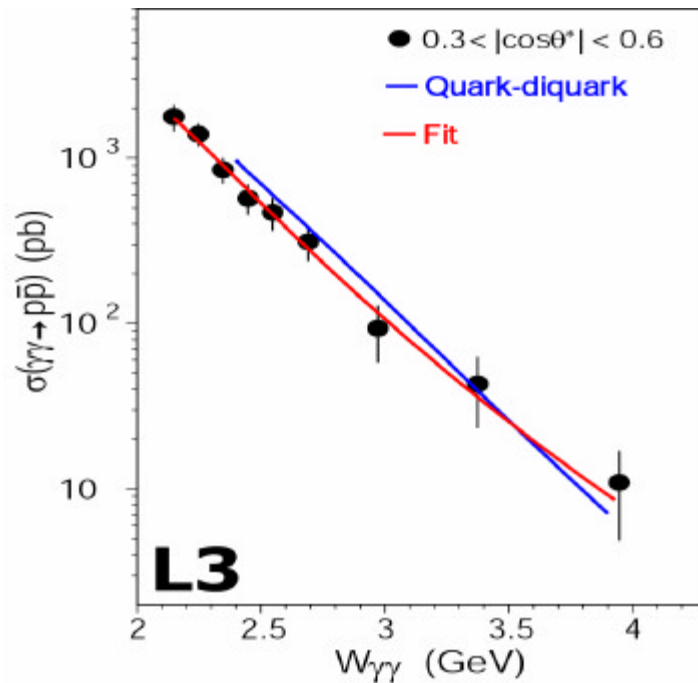
□ Agree with the quark-diquark model

□ Described by power law $\sigma \sim W^{-n}$, n=9.8±0.3

$gg \circledR L\bar{L}$ and $gg \circledR S^0\bar{S^0}$

□ Good agreement with the quark-diquark model.

□ Limited statistics.

$r^0 r^0$ *Pair Production*

- ❑ **$e^+ e^- ® e^+ e^- gg ® e^+ e^- r^0 r^0$**
  - ➔ It was studied at $Q^2 \sim 0$
    - ✓ Broad cross-section enhancement near threshold.
  - ➔ Events with $Q^2 \gg W^2$:
    - ✓ Verify the mechanism of the transformation qq (or gg) $\rightarrow$ meson pair [1].
    - ✓ $1.2\text{GeV}^2 < Q^2 < 30\text{GeV}^2$ (LEP1+LEP2)

- ❑ **Select 4 p + a tagged $e^\pm$ events**
  - ➔ $\gamma\gamma^* ® \rho^0 \rho^0$
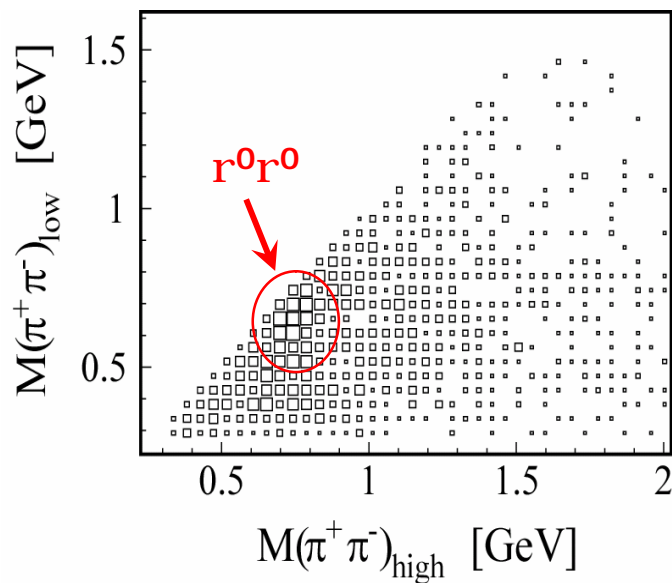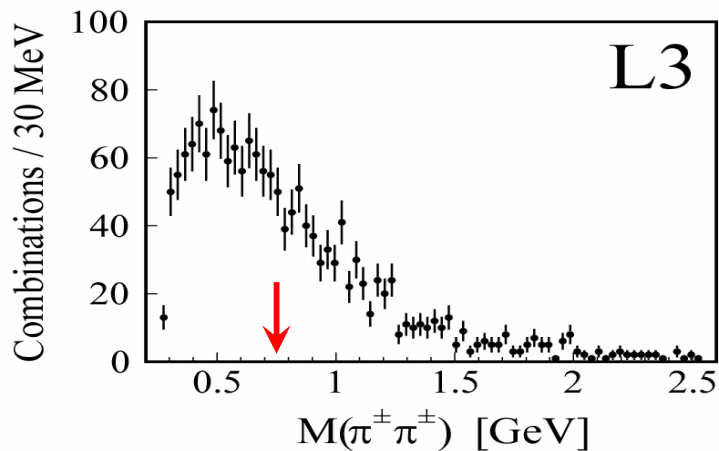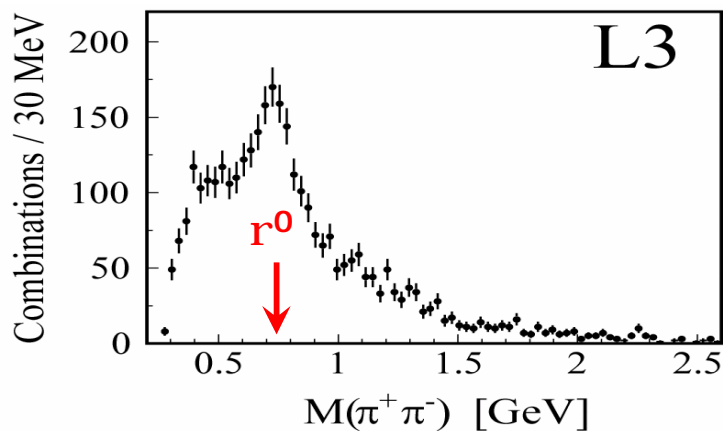 - ➔ $\gamma\gamma^* ® \rho^0 p^+ p^-$
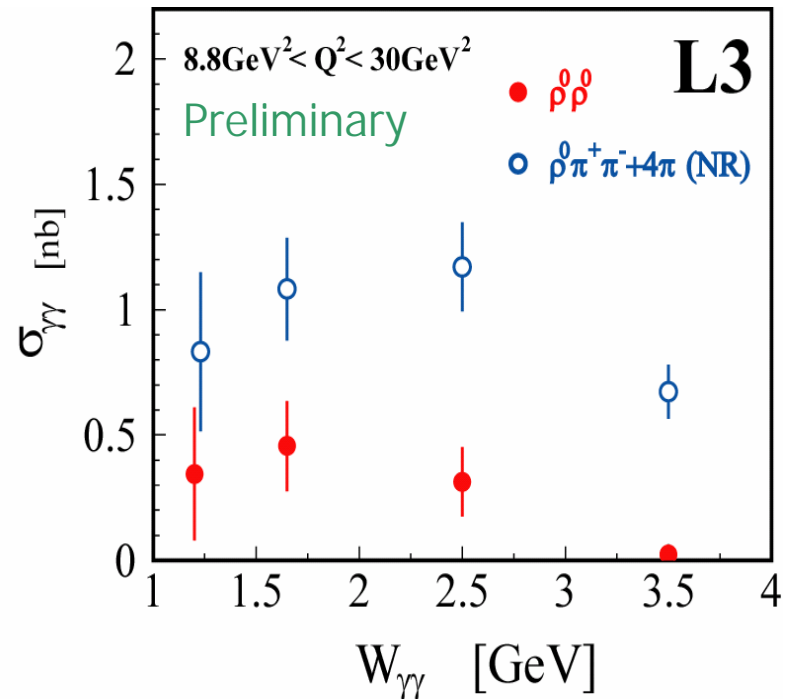 - ➔ $\gamma\gamma^* ® p^+ p^- p^+ p^-$ (non-resonant)
  - ➔ Separated by a box method.
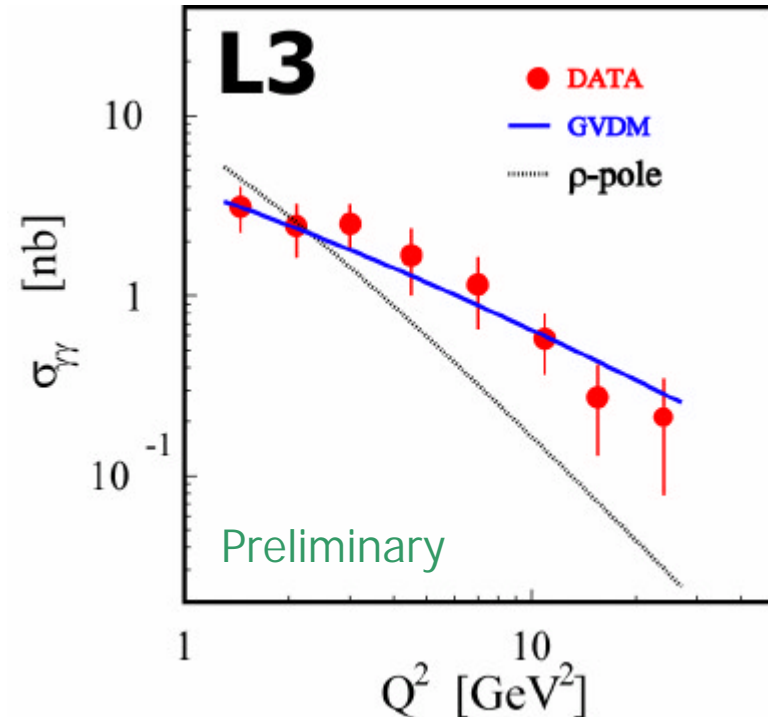
(1) M. Diehl et al., PRD 62 073014

M(p⁺p⁻) Spectrum

Cross-section of $\gamma\gamma \rightarrow \rho^0\rho^0$
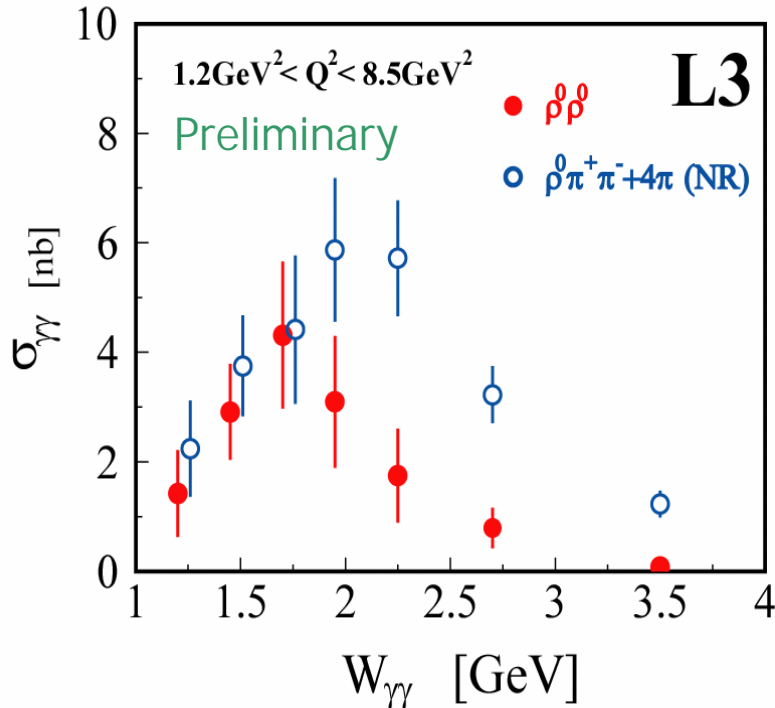
➔ Broad enhancement near threshold of $\gamma\gamma \rightarrow \rho^0\rho^0$ as seen in $Q^2 \sim 0$ measurements.
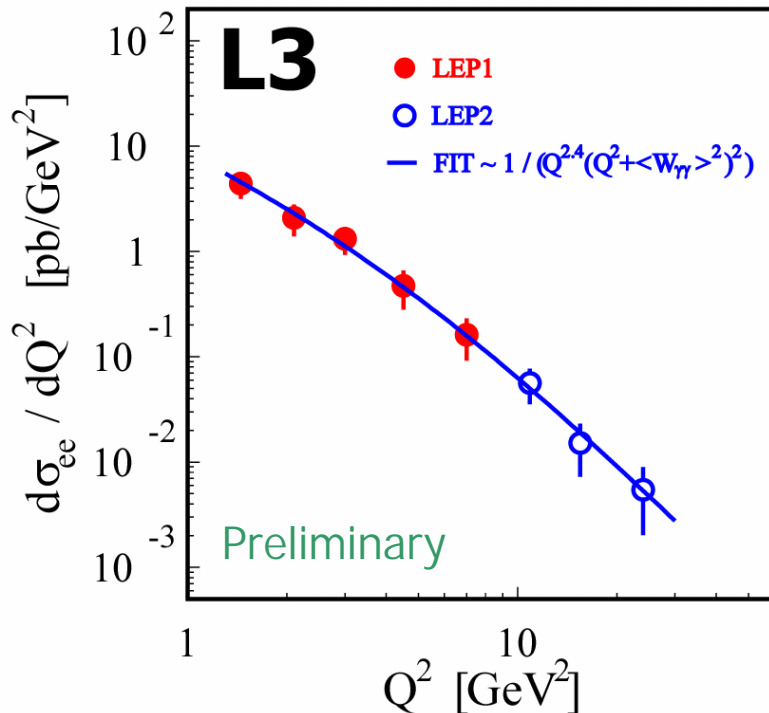
☐ Fit to $1/(Q^m(Q^2+<W>^2)^2)$

➔ $m = 2.4 \pm 0.3$ (<W> = 1.945)

➔ Agrees with the QCD
expectation, m = 2.

☐ Agrees with the GVDM
Form factor

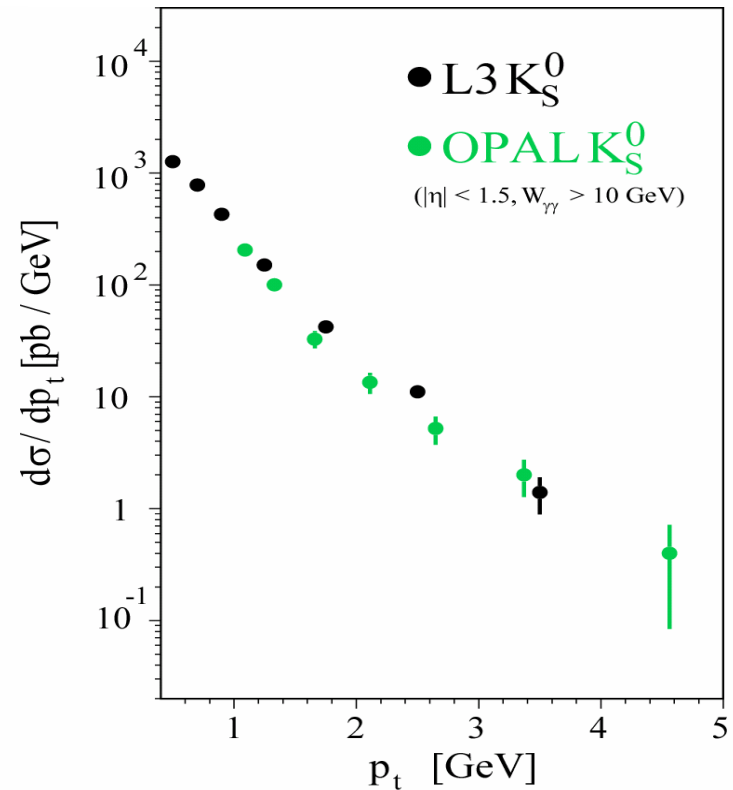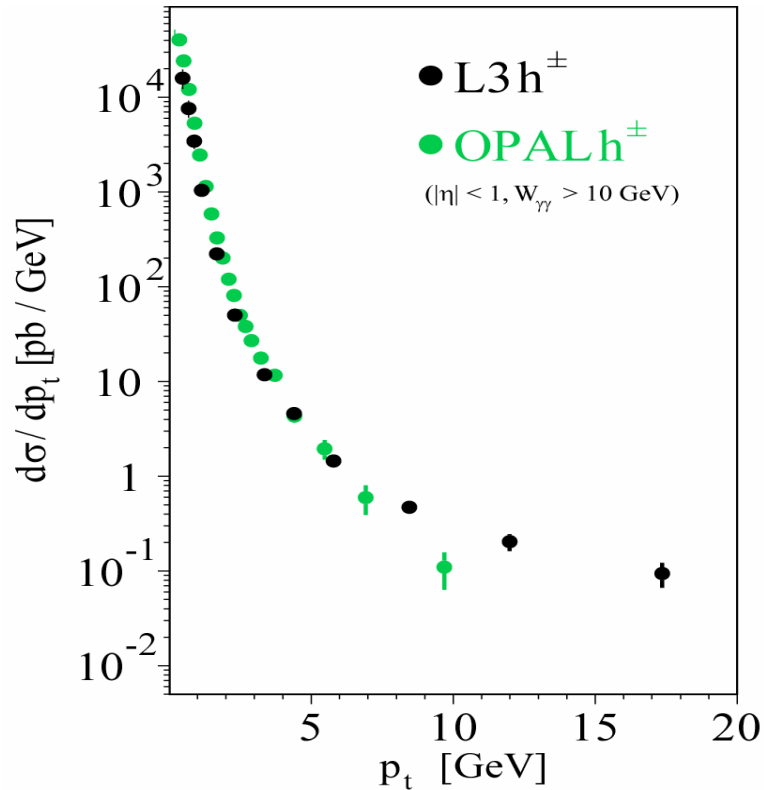# *Inclusive Hadron Production*

❑ **Inclusive hadron production:**

➔ Study the structure of photon (NLO QCD calculation available[1])

➔ Verify Monte Carlo models.

❑ **Use LEP2 Data:**

➔ Extend measurement to high P_t region. ($P_t \sim$ 20GeV).

➔ $e^+e^- \circledR e^+e^- \mathbf{p^0} X$

$e^+e^- \circledR e^+e^- \mathbf{K^0_s} X$

$e^+e^- \circledR e^+e^- \mathbf{p^\pm} X$

$e^+e^- \circledR e^+e^- \mathbf{K^\pm} X$

(1) J. Binnewies et al., PRD 53 (1996) 6110.
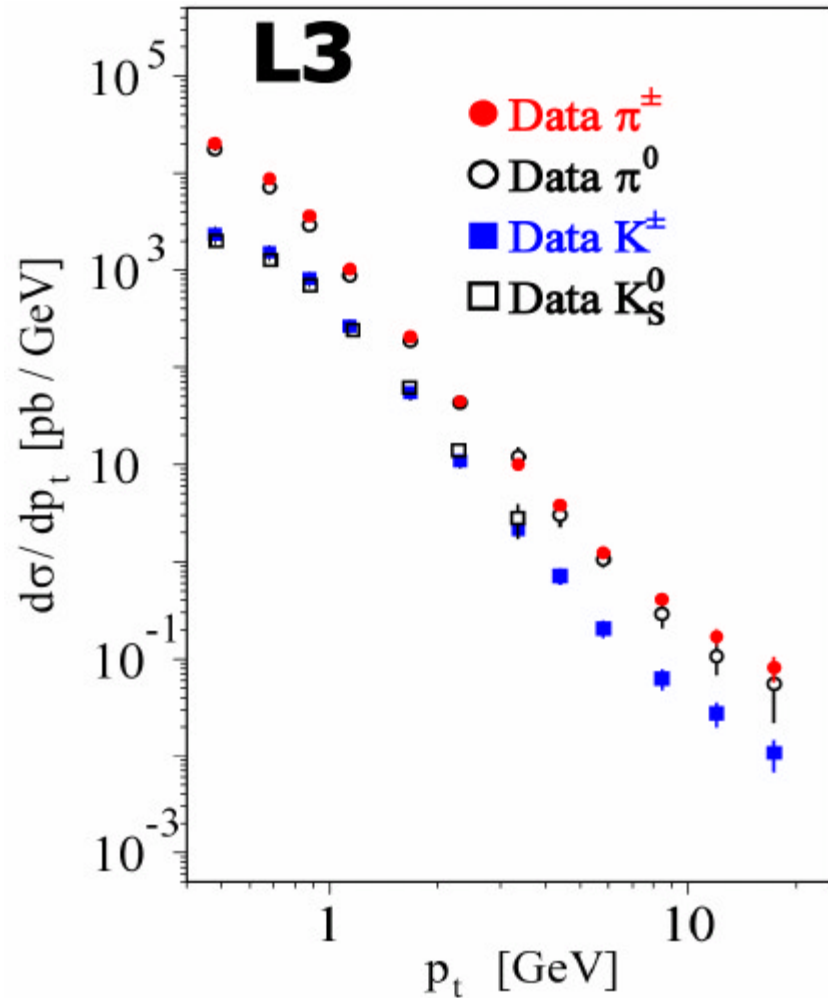
Cross-sections of inclusive hadrons

➔ Good agreement between experiments.
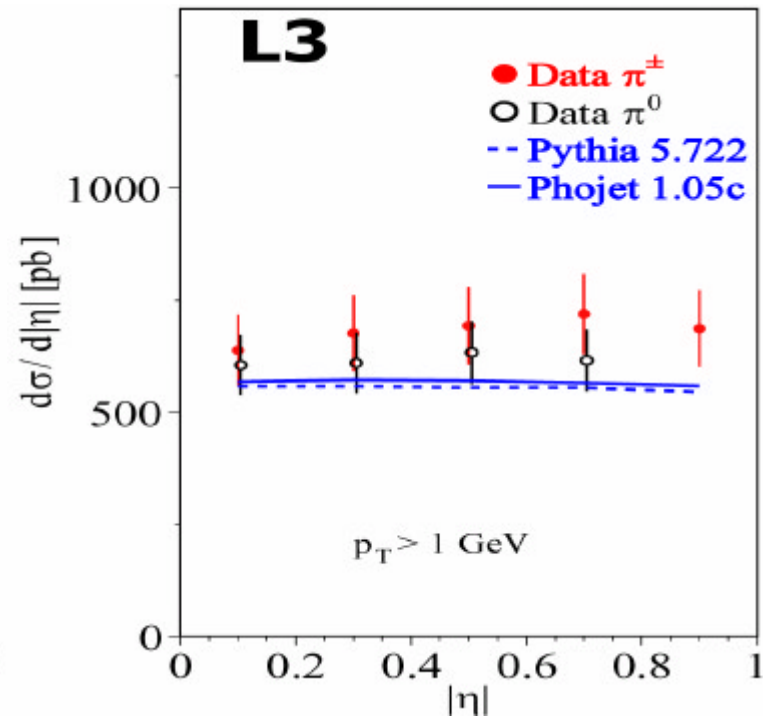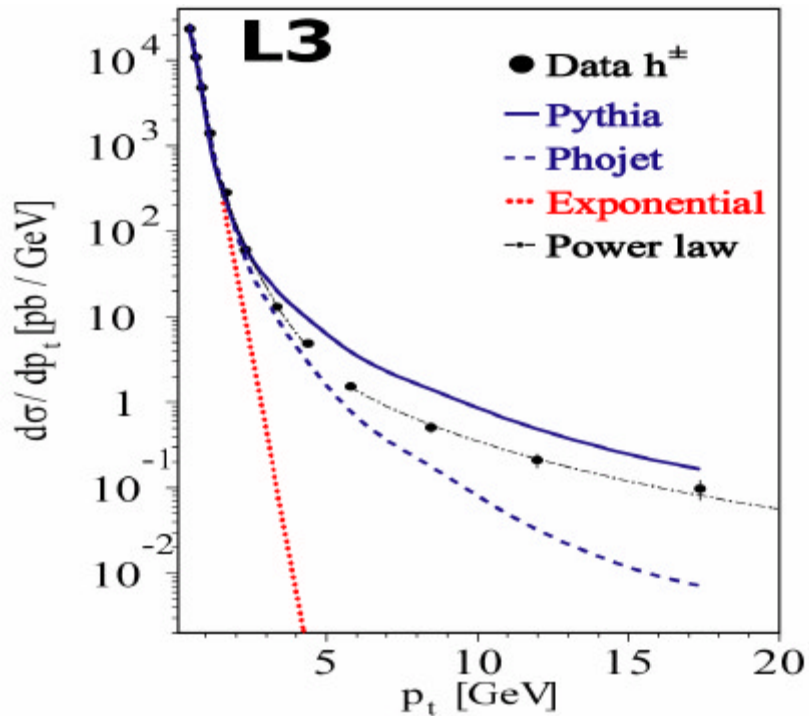
Comparison between different hadrons

❑ $\sigma(\pi^\pm)/\sigma(h^\pm)$ & $\sigma(k^\pm)/\sigma(h^\pm)$ are given by PYTHIA.

Good agreement between measurements

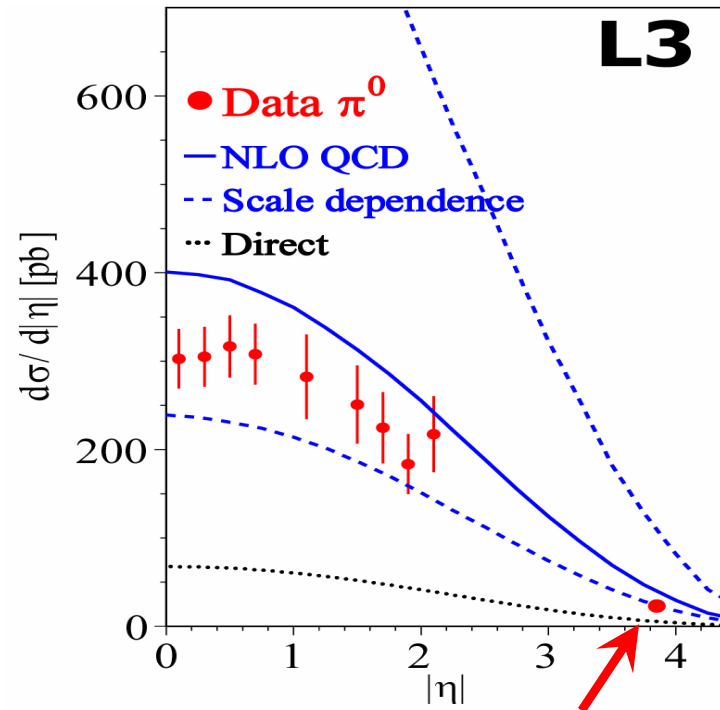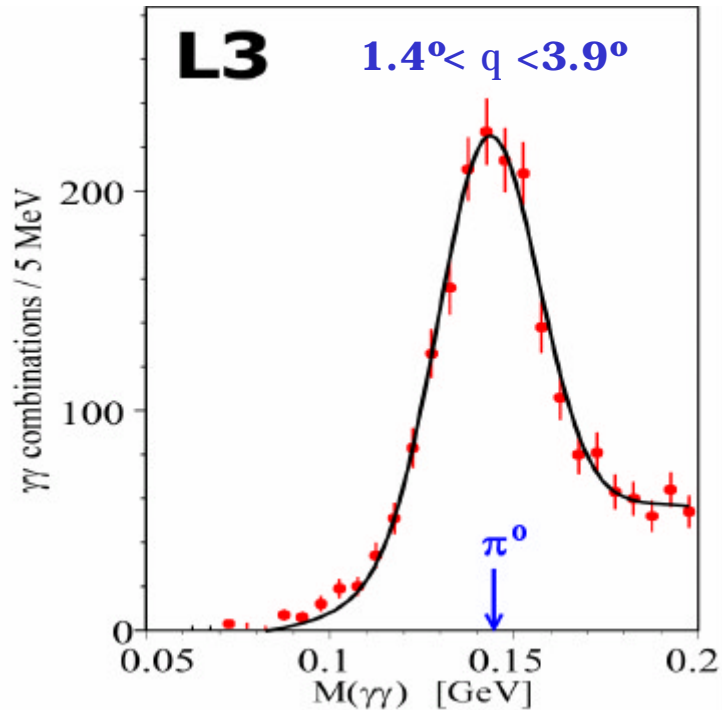**(Fragmentation functions in Monte Carlo is correct)**

Comparison between data and Monte Carlo models

- ❑ Low P_t: exponential form High P_t: Power law
- ❑ Pythia is above the data. Phojet is too low.

- ❑ Monte Carlo models describes well the uniform distribution
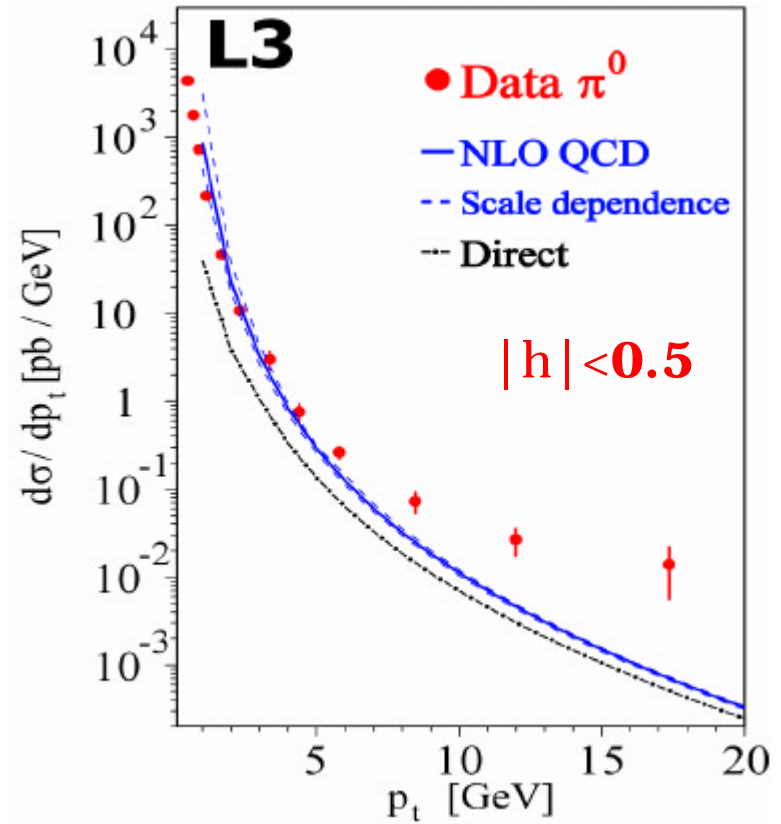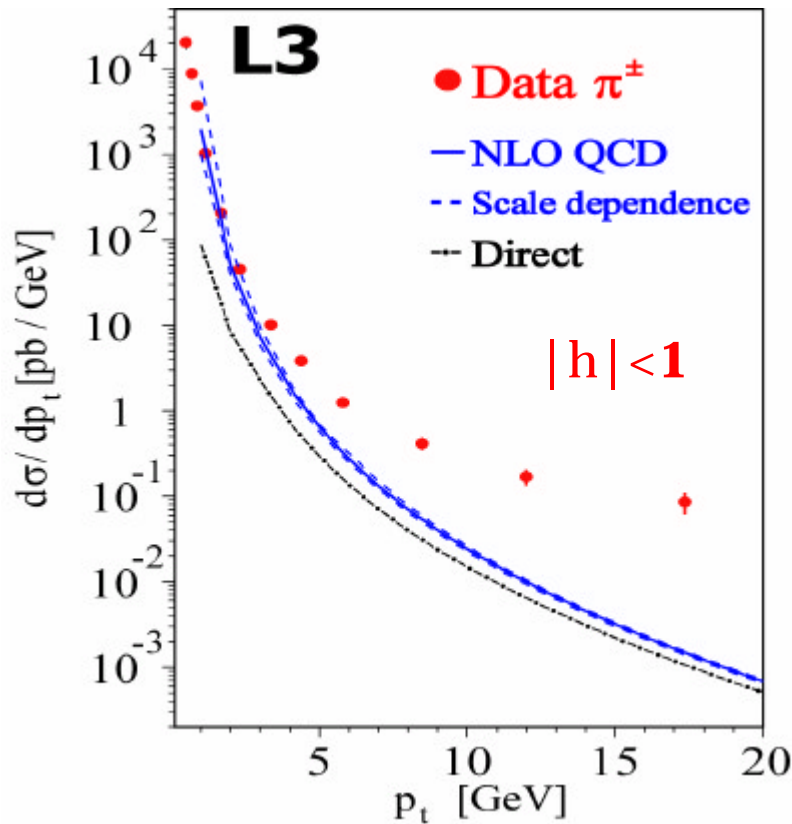- ❑ The agreement in the absolute rate depends on P_t cut.

Measure p⁰ in small angle detector

➔ The shape of the data is reproduced by NLO QCD predictions.

Comparison between data and NLO QCD

→ Exceed NLO QCD predictions at high P_t

Conclusion

❑ *Baryon pair production*:

→ The measurements agrees with the quark-diquark model.

→ The angular distribution at $W_{\gamma\gamma} < 2.5$GeV is different to one at $W_{\gamma\gamma} > 2.5$GeV.

❑ *High Q^2 r⁰r⁰ pair production*:

→ Broad enhancement of $\sigma(\gamma\gamma \to \rho^0\rho^0)$ near threshold.

→ The Q^2 dependence agrees with the QCD calculation.

❑ *Inclusive hadron production*:

→ Consistency of data.

→ Measurements exceed NLO QCD predictions at high P_t.