Inclusive π^0 and K^0_s in $\gamma\gamma$ reactions in L3

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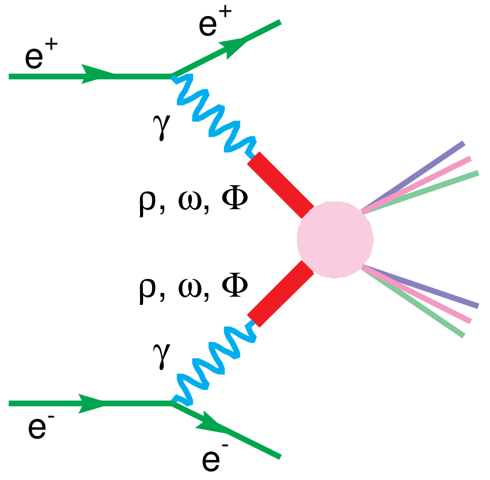
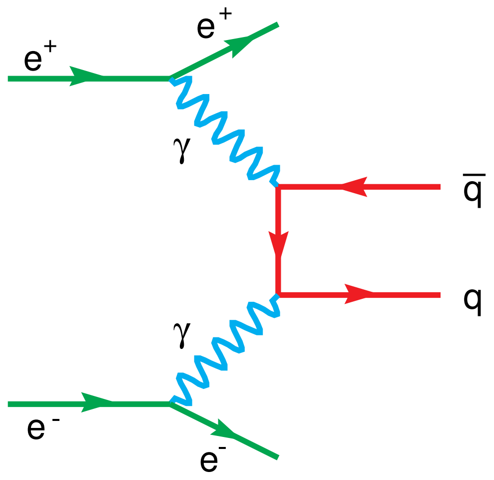
- $\gamma\gamma \rightarrow hadrons$ physics
- Event selection
- Comparison with OPAL
- Monte-Carlo comparisons
- The soft p_T region (VDM)
- The hard p_T region (QCD)
- Conclusions

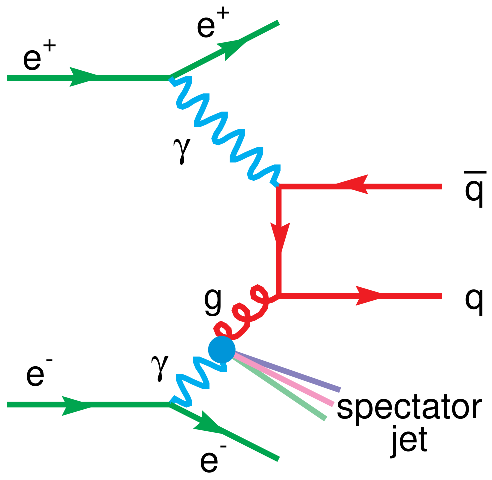
$\gamma\gamma \rightarrow hadrons$ processes



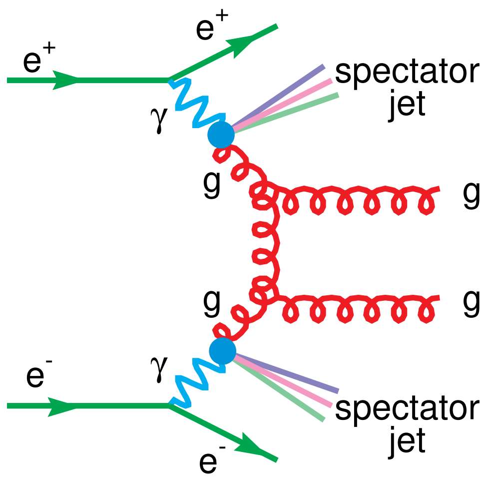
VDM



Direct



Single Resolved



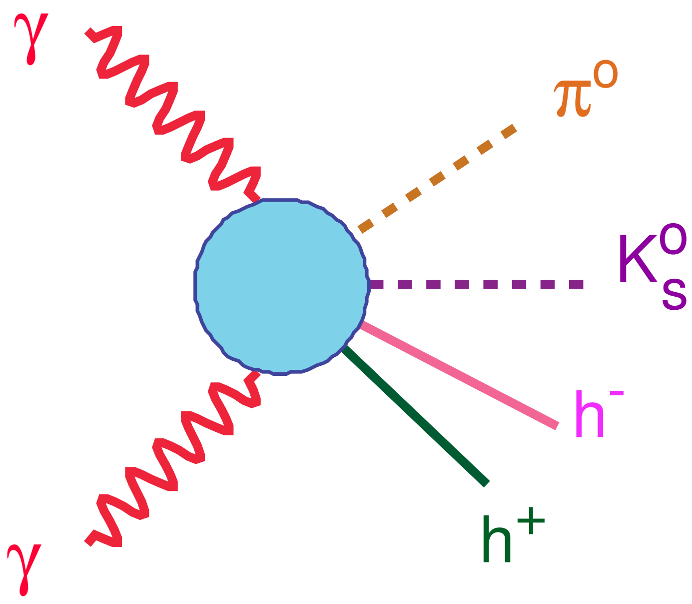
Double Resolved

What is the contribution of the different processes ?

What are the differences in event shapes ?

Inclusive particle production

⇨ Look at single particle inclusive production



Study differential cross-sections as function of

$$p_T = \sqrt{p_x^2 + p_y^2} \text{ and } \eta = -ln(\ tan \ \frac{\theta}{2})$$

.

Hadron selection

All 1998 and 1999 data are used:
$\int \mathcal{L}.dt \simeq 171.6 + 242.5 \simeq 414\ pb^{-1}$
$189 \leq \sqrt{s} \leq 202$ GeV

MC Phojet and Pythia are used
with $\int \mathcal{L}(Phojet).dt \simeq \int \mathcal{L}(Pythia).dt \simeq 384\ pb^{-1}$
at $\sqrt{s} = 189\ GeV$

The usual $\gamma\gamma \to hadrons$ cuts are:
- at least 6 particles
- $E_{BGO+HCAL} < .4\sqrt{s}$
- anti-tag: no cluster with $E > 70\ GeV$ and $\theta > 33\ mrad$

at generator level select:

		π^0	K_s^0
Q^2	$<$	$3\ GeV^2$	$8\ GeV^2$
$W_{\gamma\gamma}$	$>$	$5\ GeV$	$10\ GeV$

Particle selection

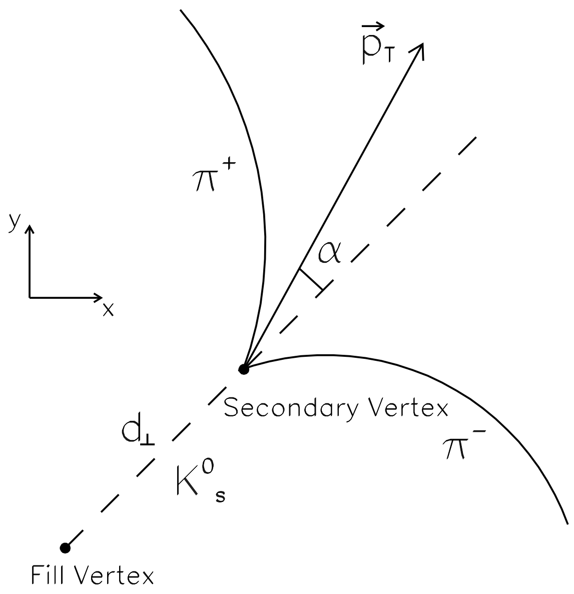
For π^0: at least 2 photons with:

- at least 2 crystals
- $E_\gamma > 100$ MeV
- angle with closest track > 200 mrad

⇨ 80 million 2 photon combinations !

For K^0_s: at least one secondary vertex with:

- $|\alpha| < .075$ rad
- $d_\perp > 3$ mm

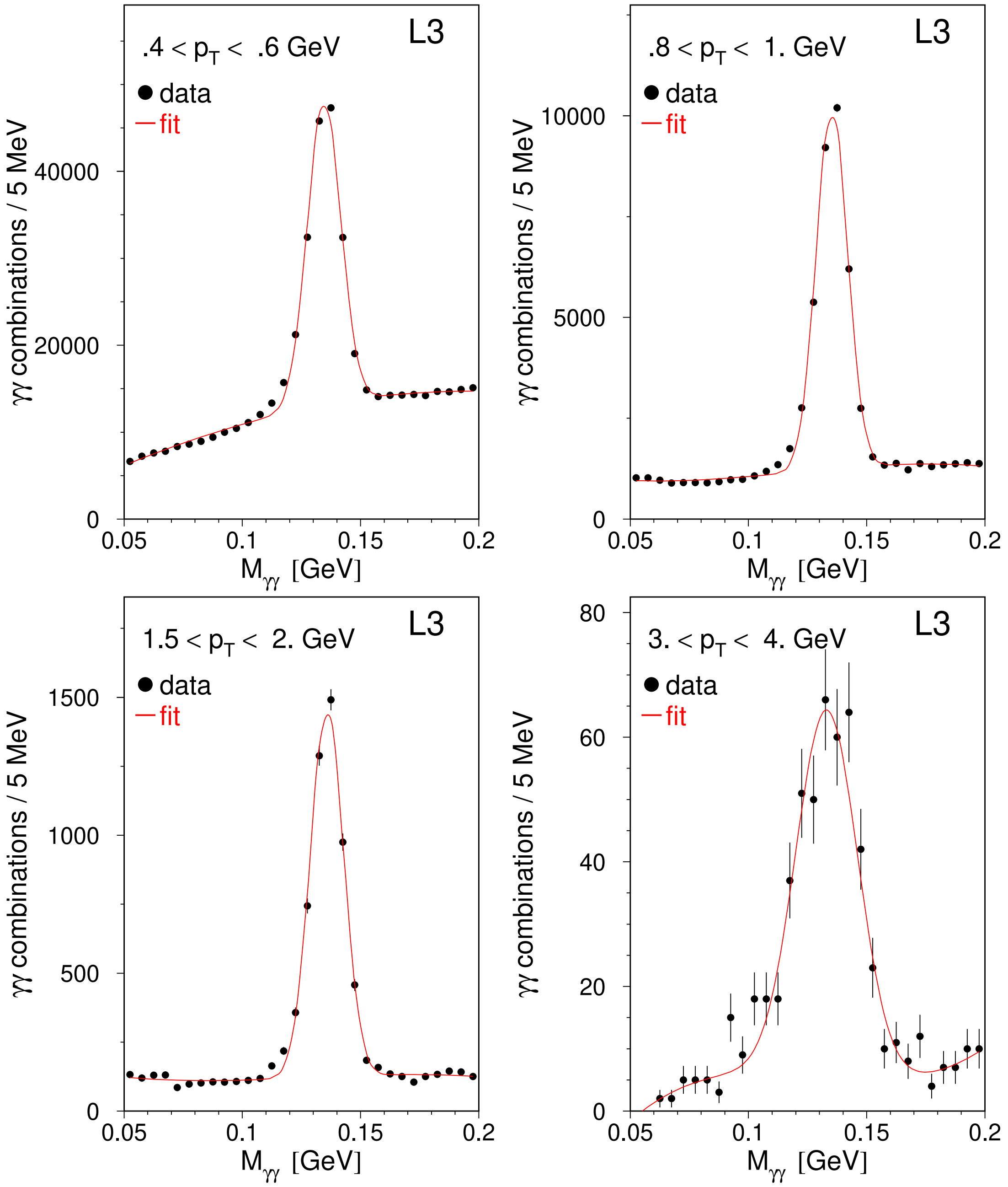


⇨ 500000 events selected

π^0 *mass distribution*

$|\eta| < 0.5$ for different p_T ranges

fit: gaussian + Chebychev polynomial

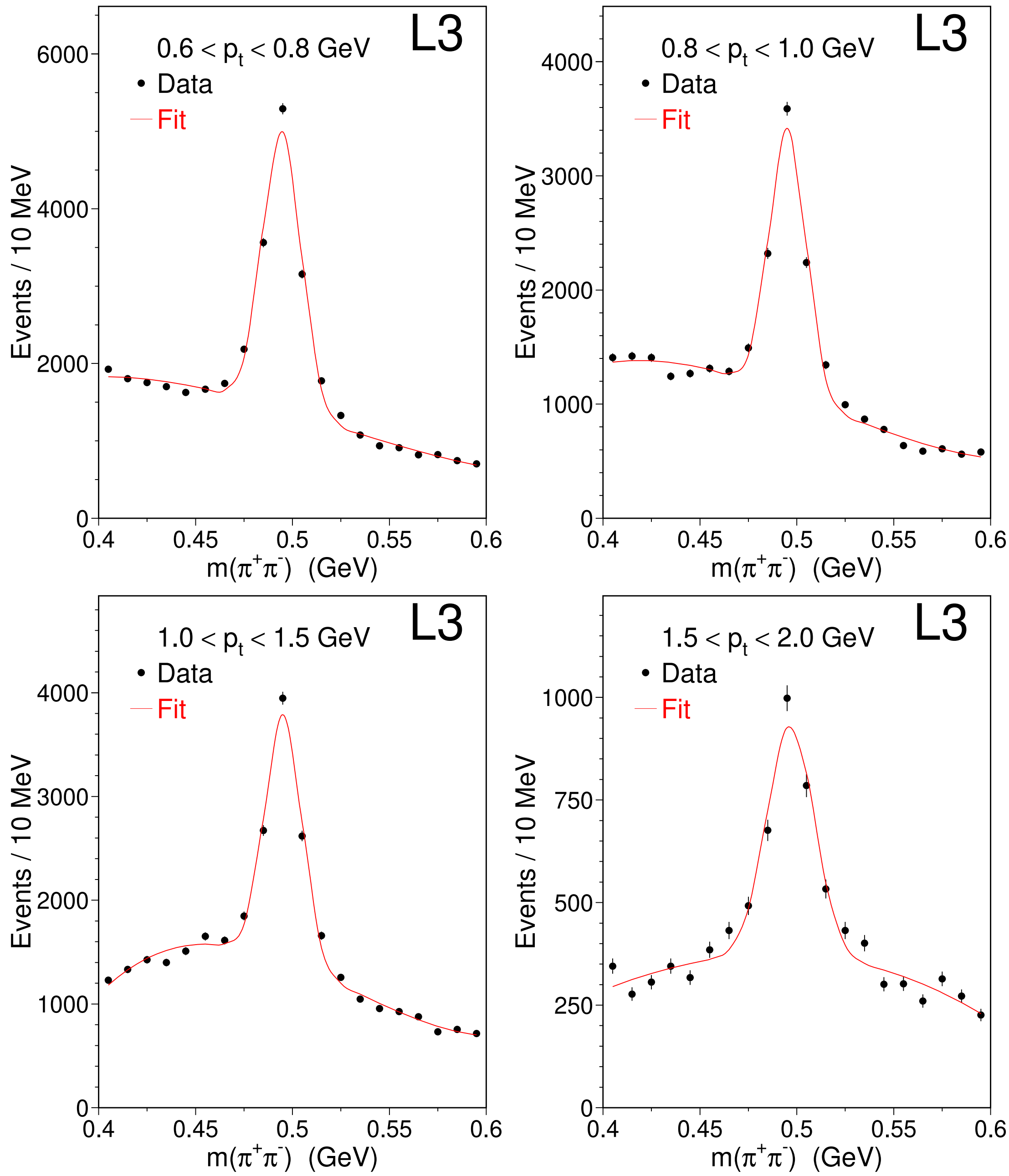


Mass resolution $\simeq$ 7 MeV

K_S^0 mass distribution

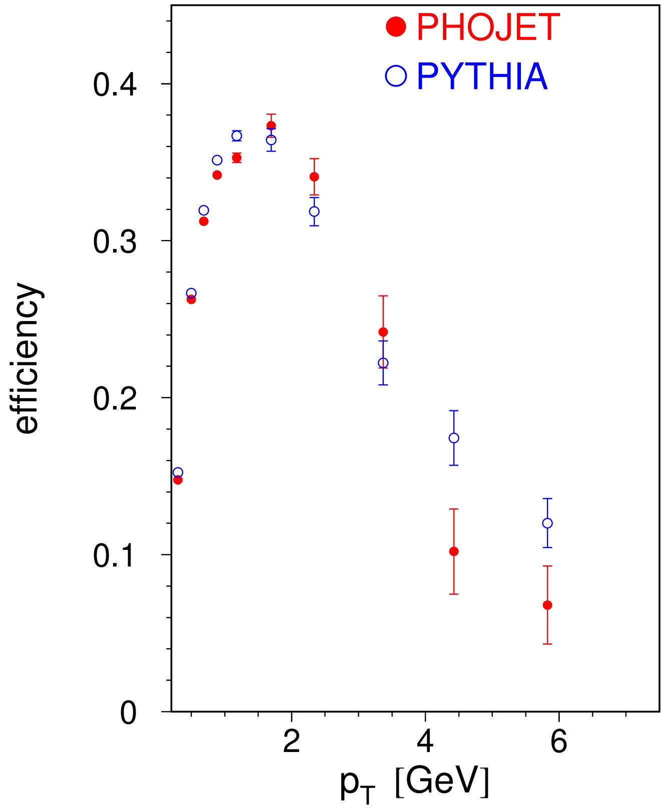
$|\eta| < 1.5$ for different p_T ranges

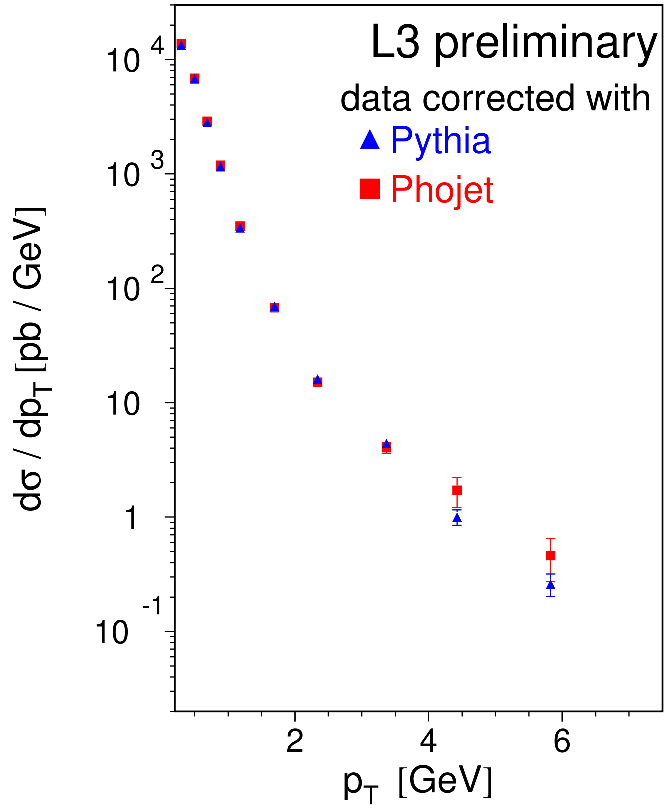
fit: gaussian + Chebychev polynomial



Mass resolution $\simeq$ 10 MeV

π^0: $\frac{d\sigma}{dp_T}$ for $|\eta| < .5$



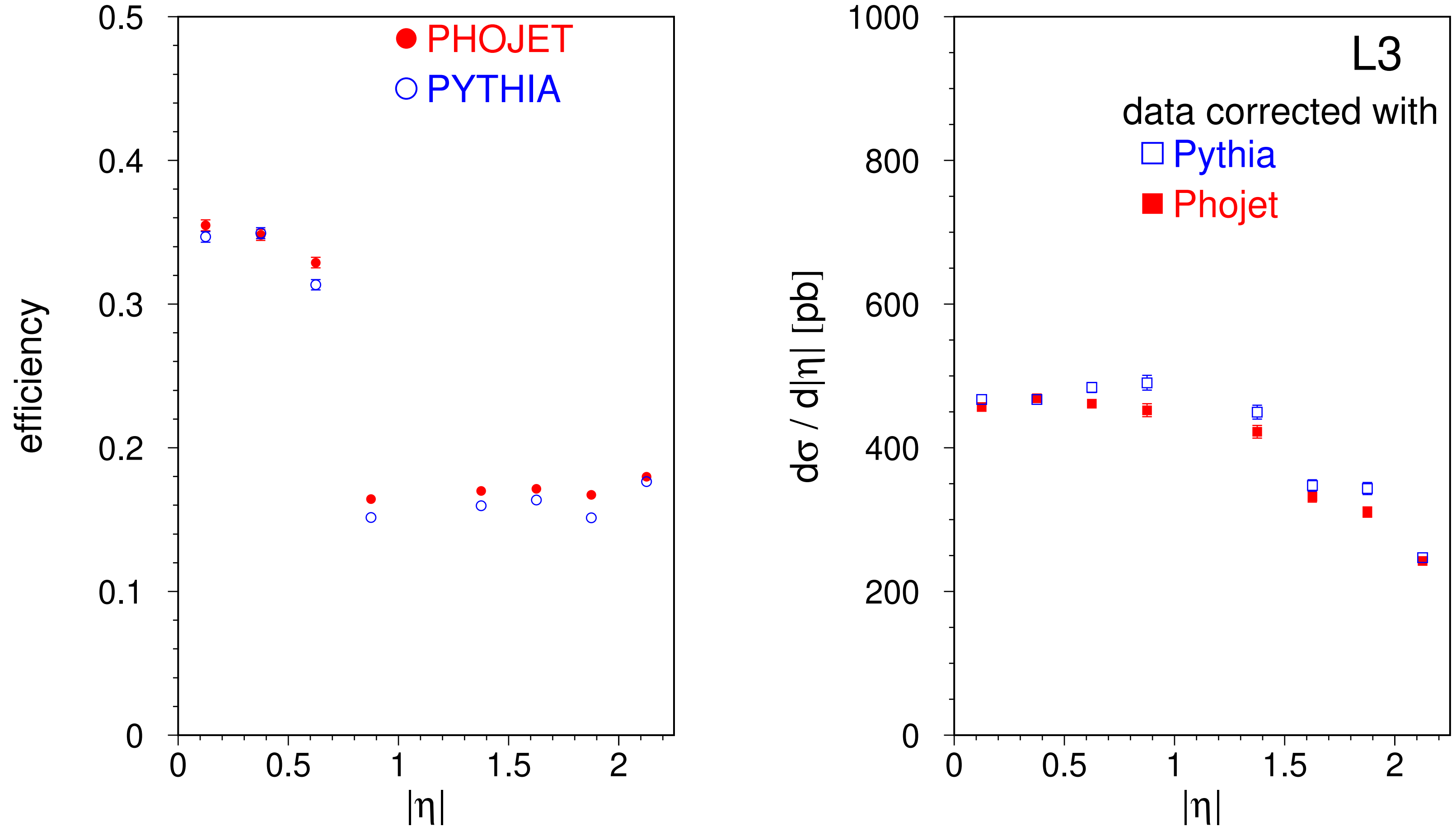


Efficiency decreases at low p_T (1 photon undetected)
at high p_T (2 photons merged)

Similar results by correcting with Pythia and Phojet

⇨ the average is used and half the difference is taken as systematic error.

π^0: $\frac{d\sigma}{d|\eta|}$ for $|p_T| > 1\ GeV$

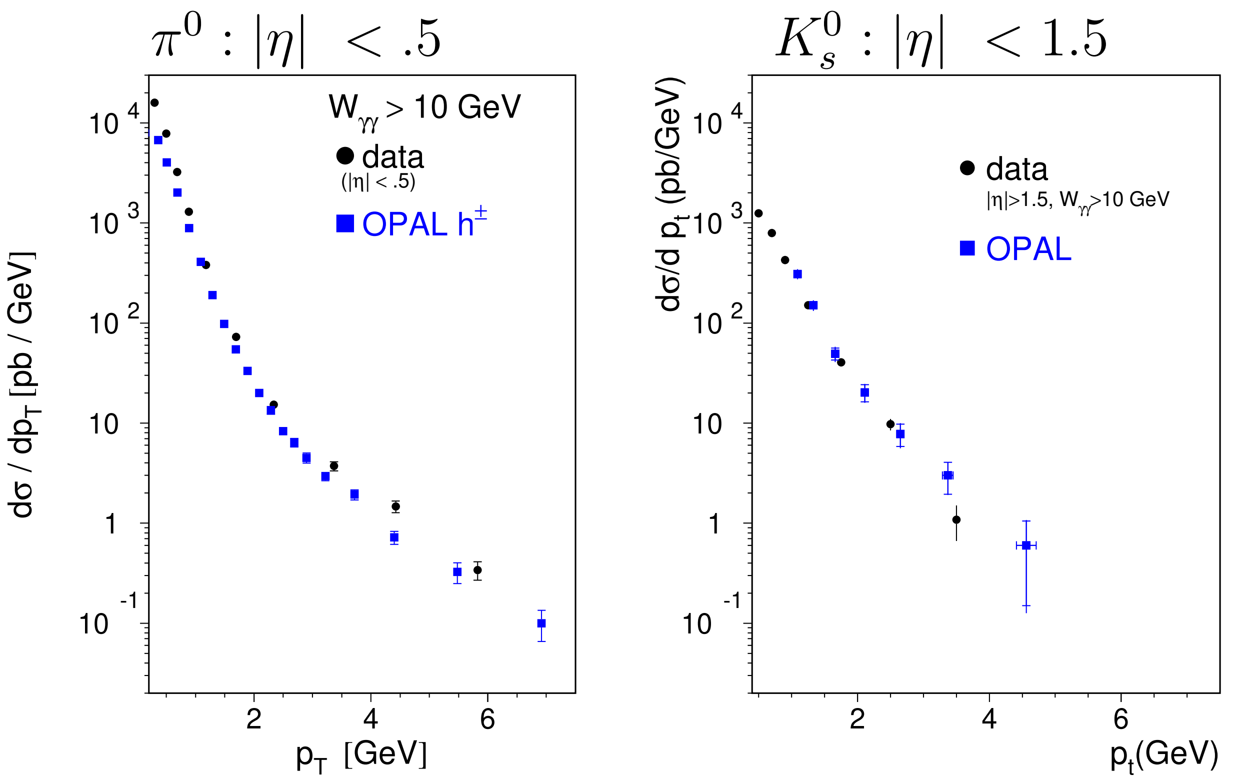


Efficiency is higher in the barrel.

Similar results by correcting with Pythia and Phojet

⇨ the average is used and half the difference is taken as systematic error.

π^0 and K_S^0: $\frac{d\sigma}{dp_T}$ compared with OPAL $h^\pm$ and K_S^0



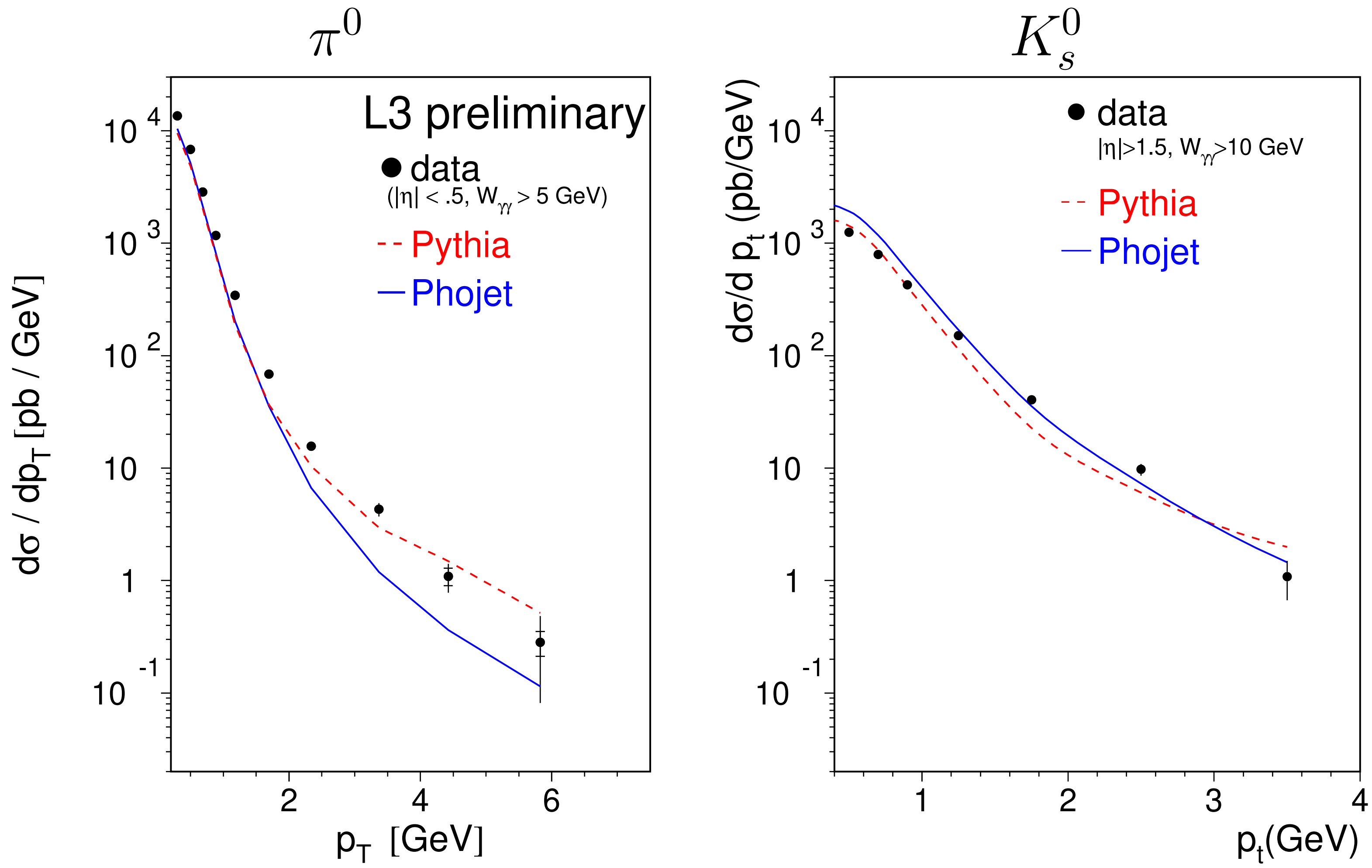
OPAL coll., Eur. Phys. J. C6(1999)253, at $\sqrt{s} = 161 - 172\ GeV$

Very good agreement

after correcting for difference in $\sqrt{s}$

and, in the $h^\pm$ case, for $|\eta|$ range and $\pi^0 = (h^+ + h^-)/2$.

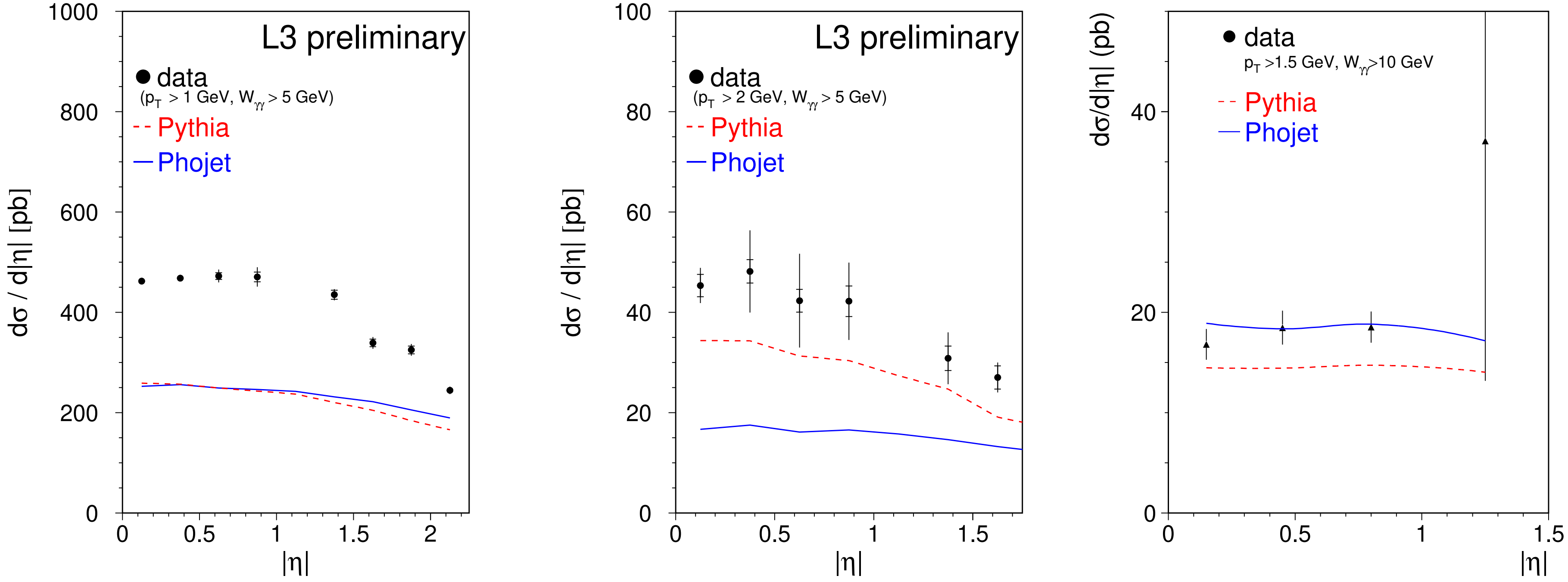
π^0 and K^0_S: $\frac{d\sigma}{dp_T}$ compared with LO MC



LO MC don't fit very well the data (logarithmic scale !)

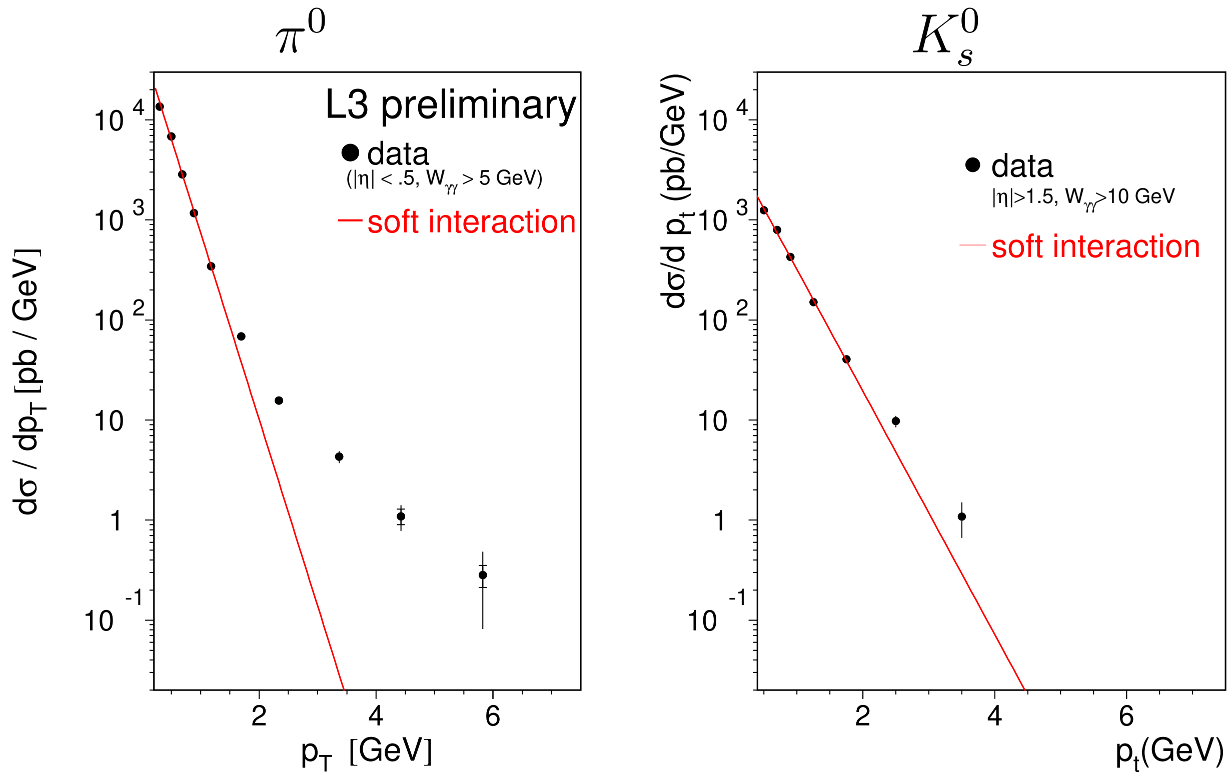
π^0 and K^0_S: $\frac{d\sigma}{d|\eta|}$ compared with LO MC

π^0 : p_T > 1 GeV π^0 : p_T > 2 GeV K^0_s : p_T > 1.5 GeV



Both MC are too low for π^0 but Pythia is better at high p_T
Both are quite good for K^0_s

π^0 and K^0_S: the soft interaction



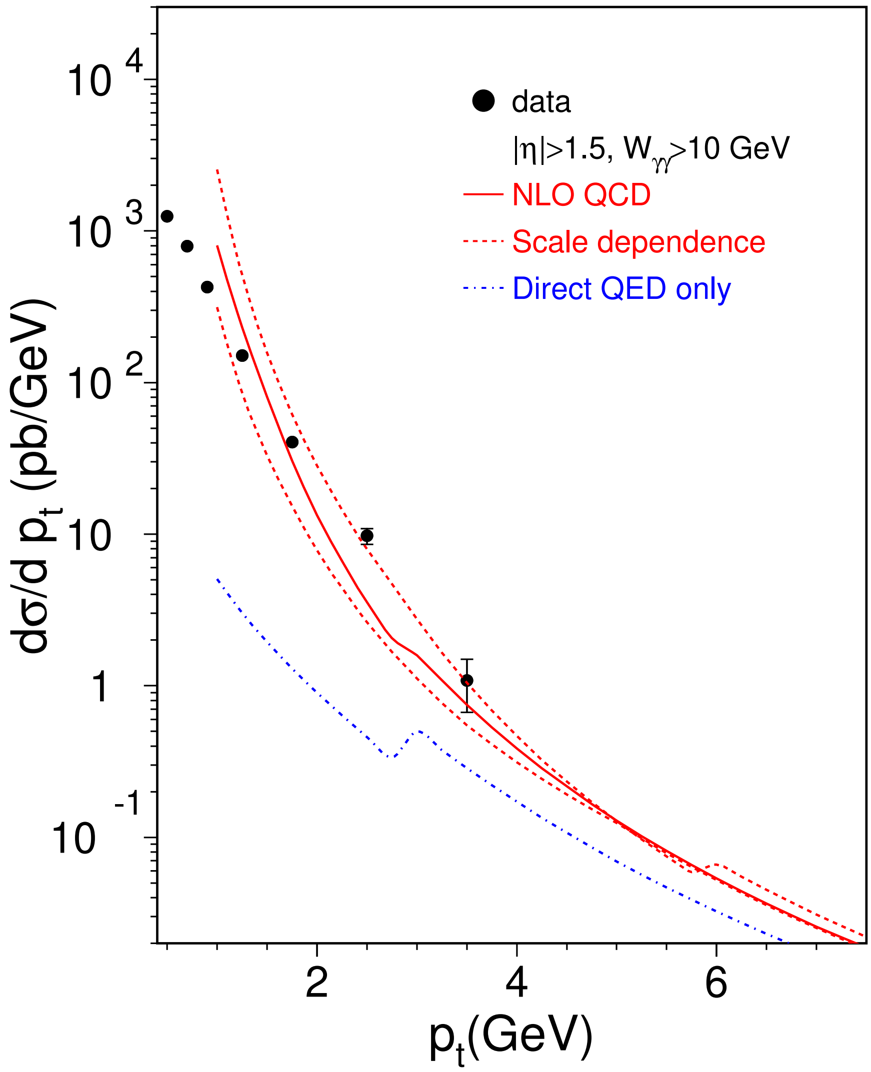
Exponential fit: $\frac{d\sigma}{dp_T} = Ae^{-p_T/<p_T>}$

$<p_T> \; = \; 233 \; \pm 1 \; MeV$ for π^0 and $<p_T> \; = \; 357 \; \pm 9 \; MeV$ for K^0_S

Similar $<p_T>$ values as observed in hadron interactions

(A. Zieminski, proceedings of the 1977 European Conference on Particle Physics).

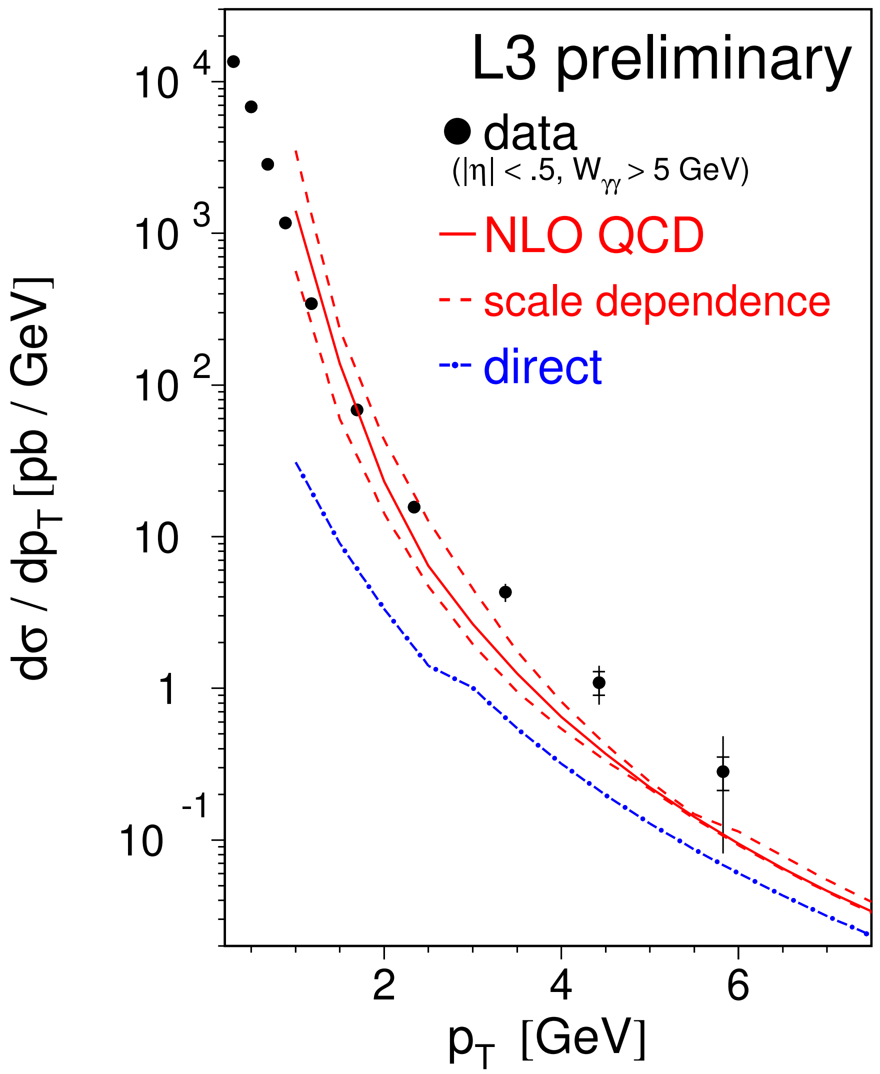
K_S^0: *the hard interaction*



Data are quite well reproduced by
NLO QCD-improved parton model
(Binnewies, Kniehl and Kramer, Phys. Rev. D53(1996)6110)

The direct process is not sufficient.
Kink from the $\gamma\gamma \rightarrow c\bar{c}$ threshold.
Scale $\mu = M = M_F = (0.5, 1, 2) \times p_T$.

π^0: *the hard interaction*



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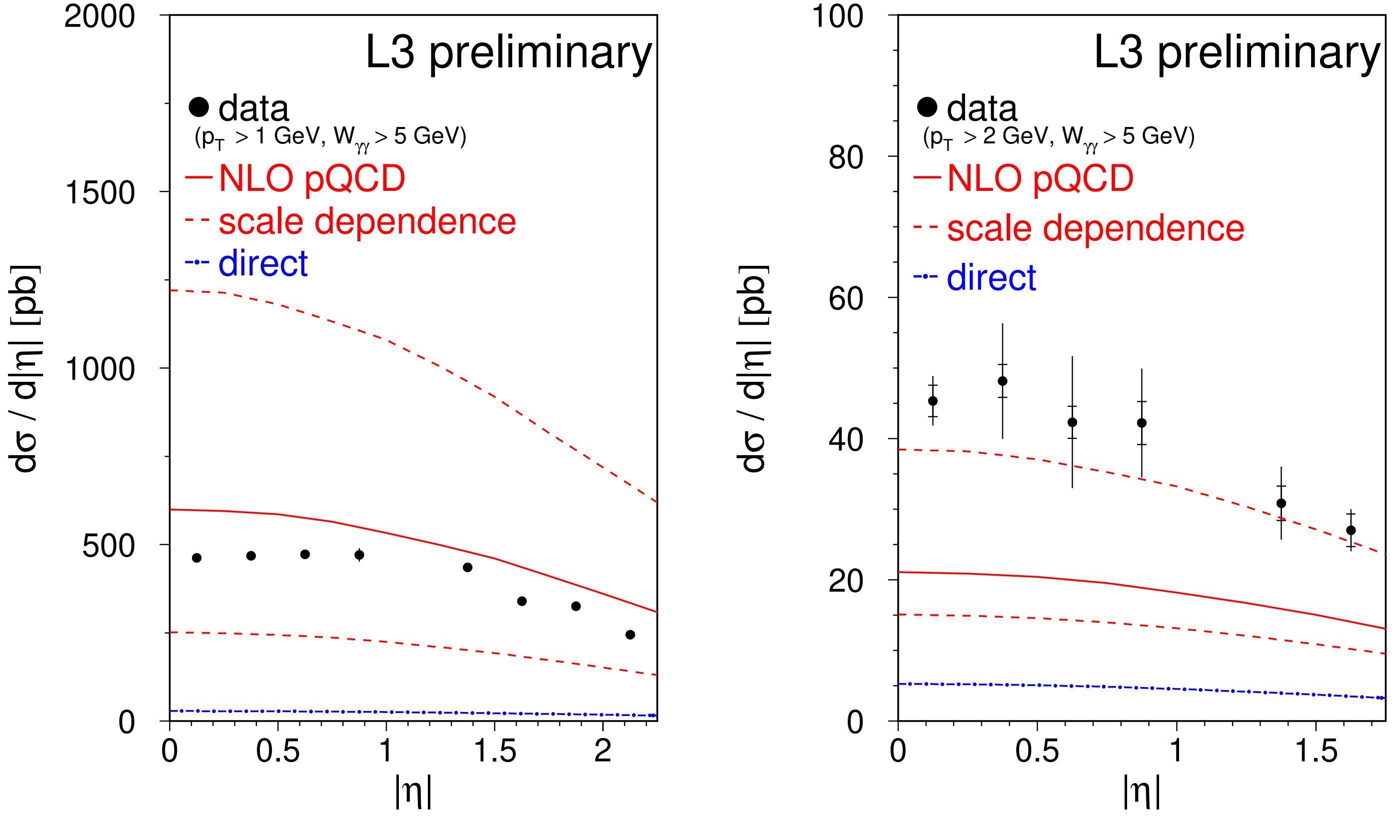
Scale $\mu = M = M_F = (0.5, 1, 2) \times p_T$.

π^0: $\frac{d\sigma}{d|\eta|}$ for $|p_T| > 1 - 2\ GeV$

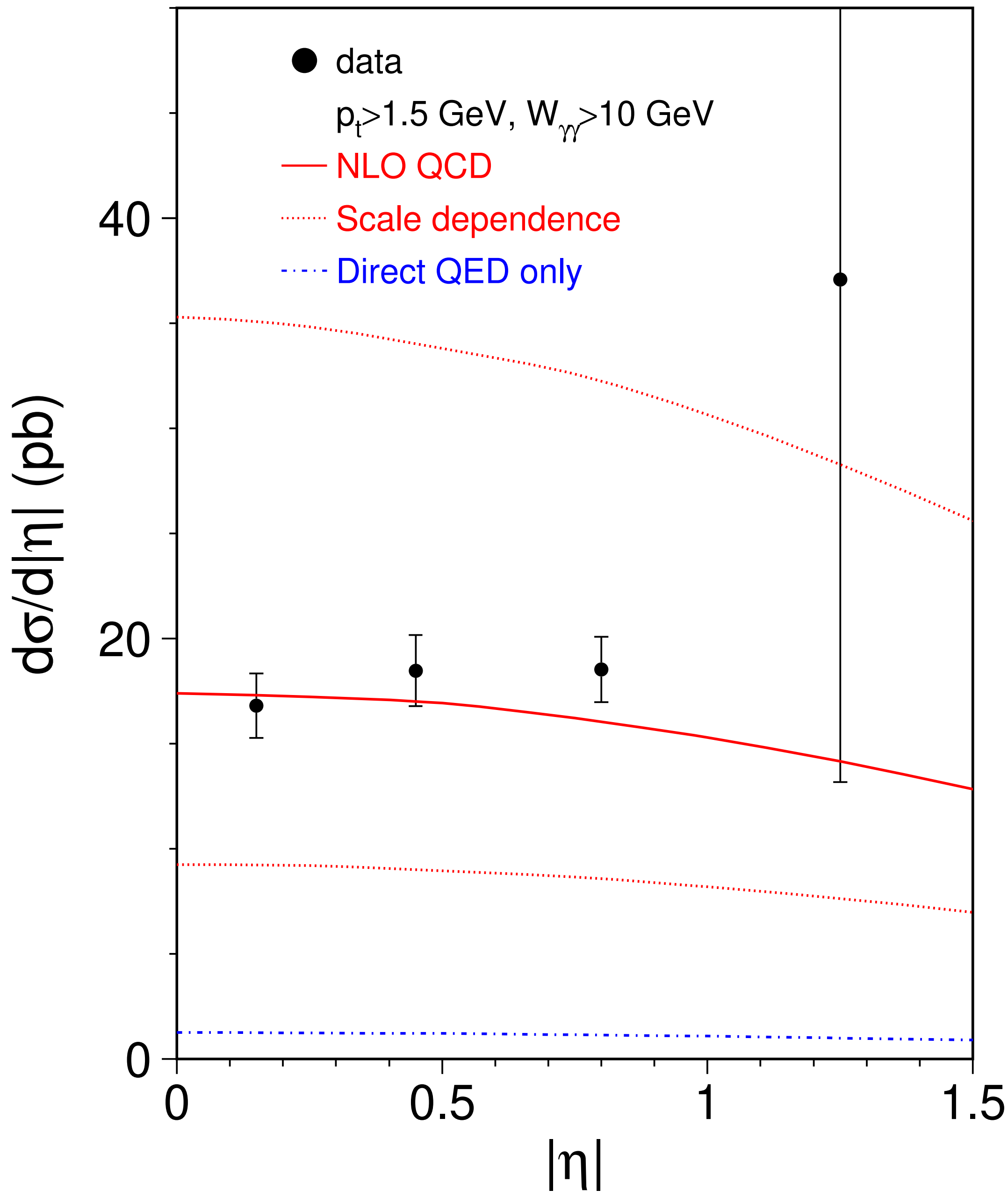
$p_T > 1\ GeV$ $\qquad$ $p_T > 2\ GeV$



At low p_T: good agreement.

At high p_T: somewhat low.

K_s^0: $\frac{d\sigma}{d|\eta|}$ for $p_T > 1.5\ GeV$



NLO QCD fits the data

Conclusions

- Clear π^0 and K_s^0 inclusive production

- First study at LEP of π^0 production

- At low p_T, exponential behaviour
  - ⇨ characteristic of soft interactions

- At high p_T, QCD behaviour
  - ⇨ starting at $p_T \simeq 2\ GeV$, characteristic of $\gamma\gamma$ collisions
  - ⇨ direct process only is not sufficient

- LO MC: not perfect agreement with data

- NLO QCD:
  - ⇨ K_s^0: good agreement
  - ⇨ π^0: lies below data for $p_T > 2\ GeV$

Good $\gamma\gamma$ data at LEP !

Improvements in
the MC and QCD calculations
are necessary to match
the data accuracy