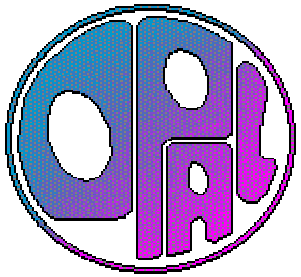
Abstract 376



# Isolated Prompt Photon Production in Photon-Photon Collisions at $\sqrt{s_{ee}}$=183-209 GeV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on behalf of the OPAL Collaboration



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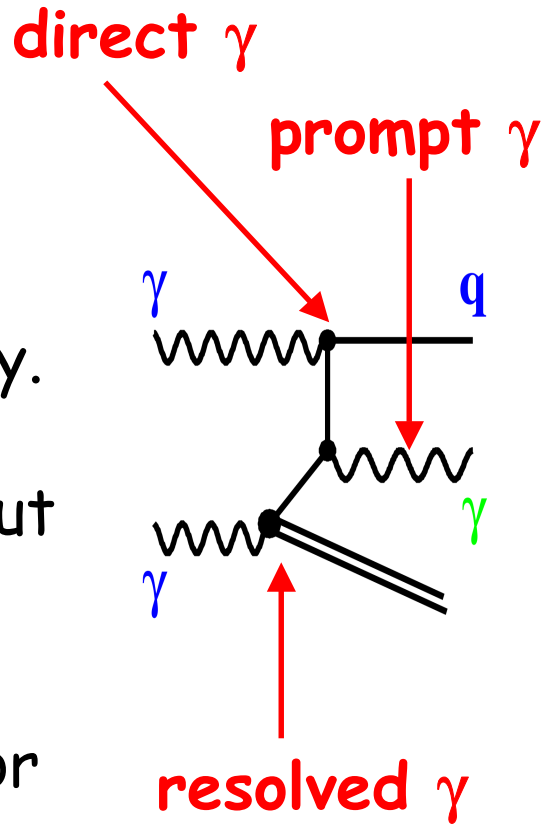
'Prompt' ≡ not coming from particle decays/fragmentation, but emitted from the hard underlying scattering.

# Prompt Photons in $\gamma\gamma \rightarrow \gamma + X$

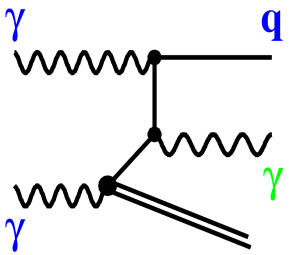
- Allow to study photon's hadronic structure and test QCD predictions:
  - Prompt $\gamma$ appear in resolved processes (in LO; in NLO also in direct events).
  - Small NLO corrections / scale dependency.
  - 'Cleaner' than dijets (hadrons, D*)
    → less uncertainty from hadronisation (but prompt $\gamma$ have smaller Xsection ~$O(\alpha_{EM})$).
- Might further be used for
  - studies of the underlying parton picture or
  - background studies in LHC Higgs searches.



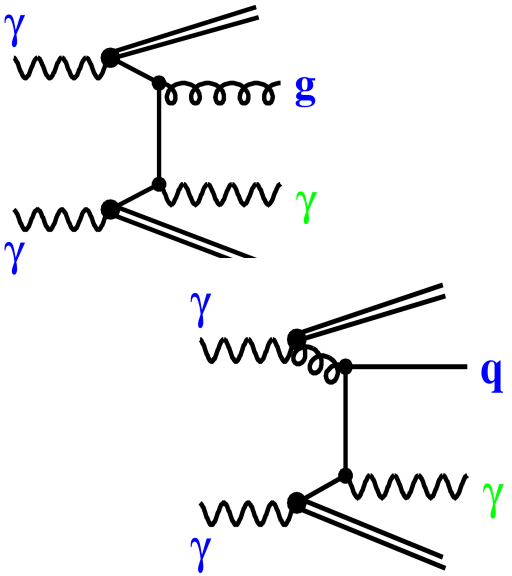
# Theoretical Predictions

- Fixed-order NLO QCD calculations (Fontannaz et al).
- PYTHIA 6.130 for signal $\gamma\gamma \rightarrow \gamma + X$
  - Distinct samples for single/double resolved for three energy points.
  - Sas-1D (LO) $\gamma$ PDF.
- Background with fake / real $\gamma$:
  - PHOJET 1.10 and HERWIG 5.9 for $\gamma\gamma$ background without prompt $\gamma$.
  - Also Vermaseren 1.0, PYTHIA 5.7, KORALZ, grc4f.

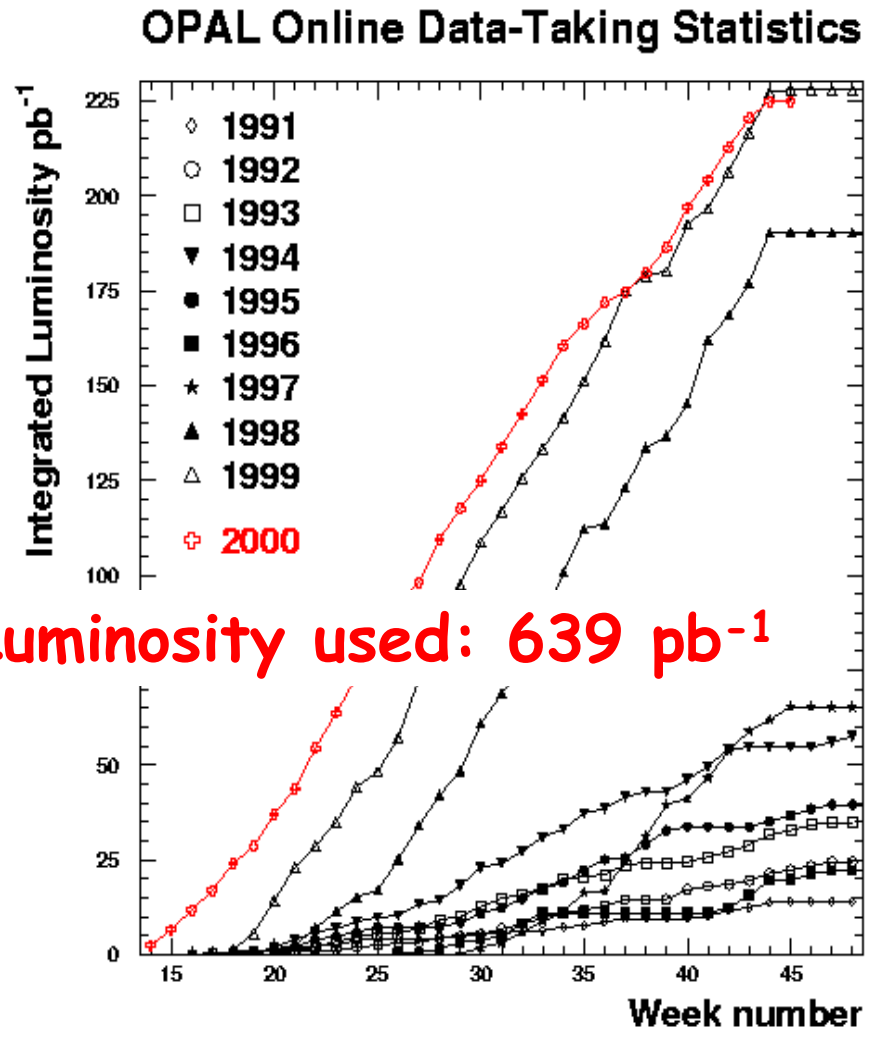
**Single-resolved**



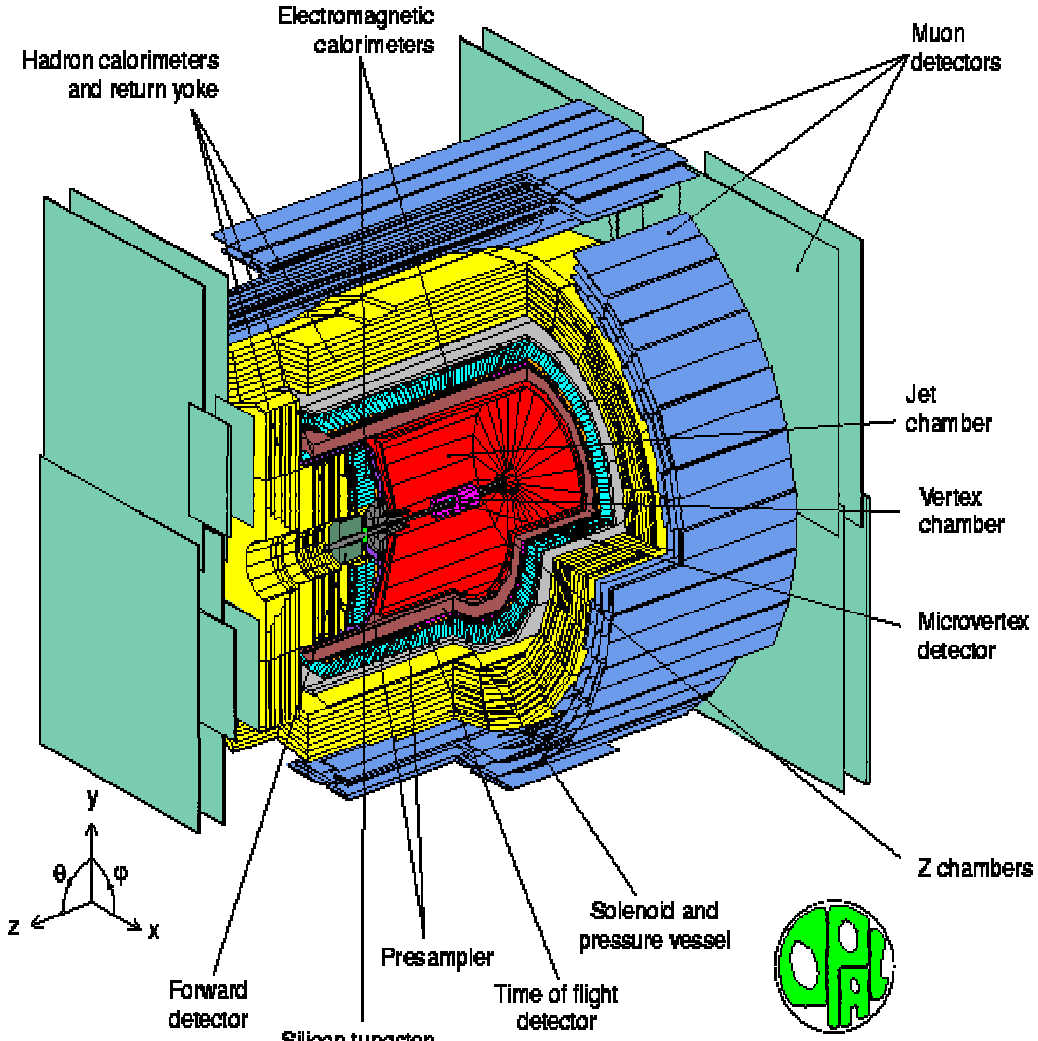

**Double-resolved**



# LEP and the OPAL Detector



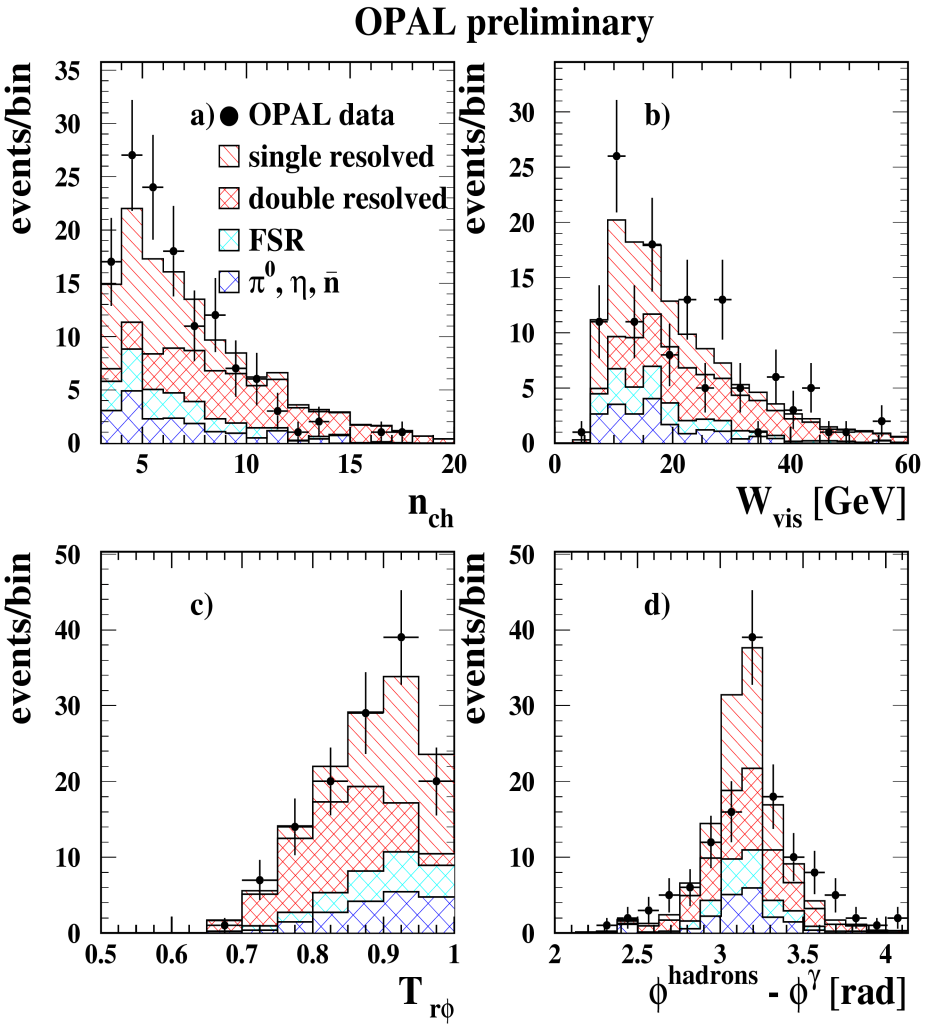

**Luminosity used: 639 pb$^{-1}$**




· Photons in γγ

# Event/γ Selection ($\sqrt{s_{ee}}$=183-209 GeV)

- Require ≥3 tracks. Reject events with scattered leptons above θ=33 mrad.
- Reject e+e- annihilations:
  - 5 GeV < $W_{vis}$ < 0.3$\sqrt{s_{ee}}$
  - $E_{cal}$ < 0.25$\sqrt{s_{ee}}$.
- Select isolated photons:
  - EM clusters with $|\eta| < 1$ and $p_T > 3$ GeV.
  - Photon and hadronic final state balanced in φ.



# Photon Selection ctd'

- Isolation criterion ($\delta$<R):

  $\Sigma_i E_{Ti} \cdot \Theta(\delta - R_{i\gamma}) \leq$
  $0.2 \cdot E_{T\gamma}(1-\cos\delta)/(1-\cos R)$

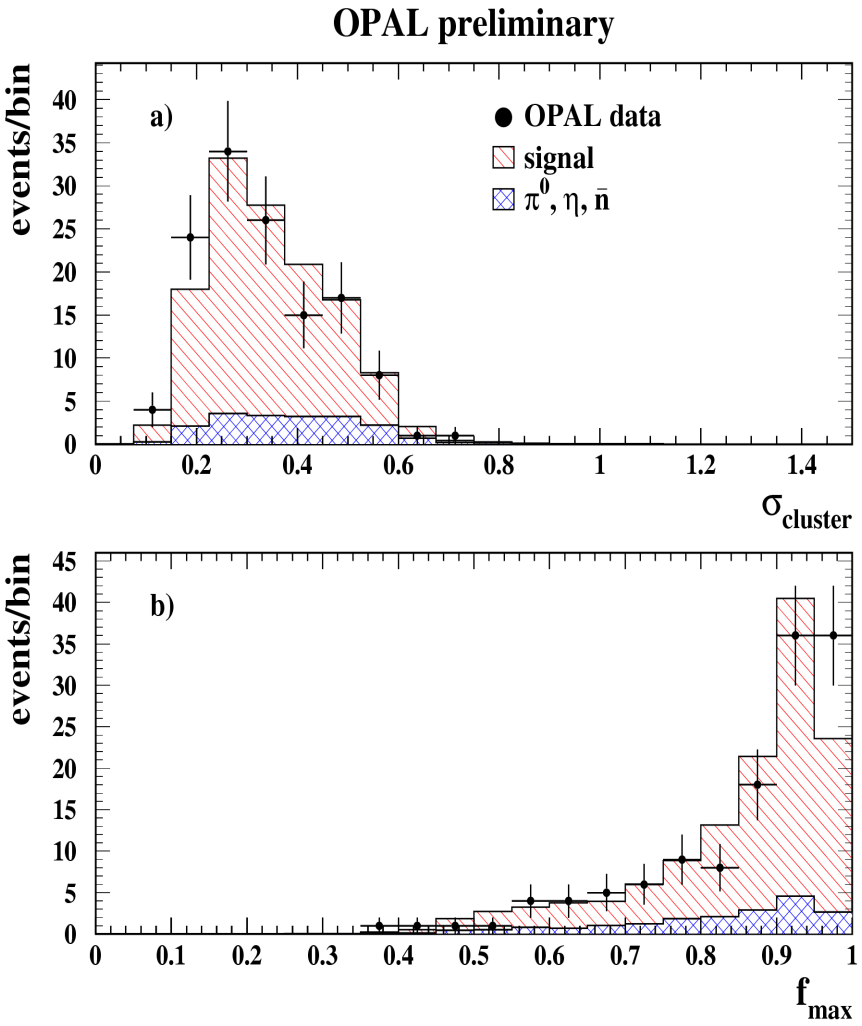
- Background: antineutrons, $\eta/\pi^0$ decays → shape analysis:

  $f_{max} = E_{max}/E_\gamma$

  $\sigma_c = (\Sigma_i E_i R_{i\gamma})/E_\gamma$

  $g(f, \sigma) = a g^\gamma + b g^\pi +$
  $(1-a-b)\cdot(c g^n + (1-c) g^\eta)$

- Fit: a = 0.85 ± 0.08 (stat)
  b = 0.11 ± 0.08 (stat)

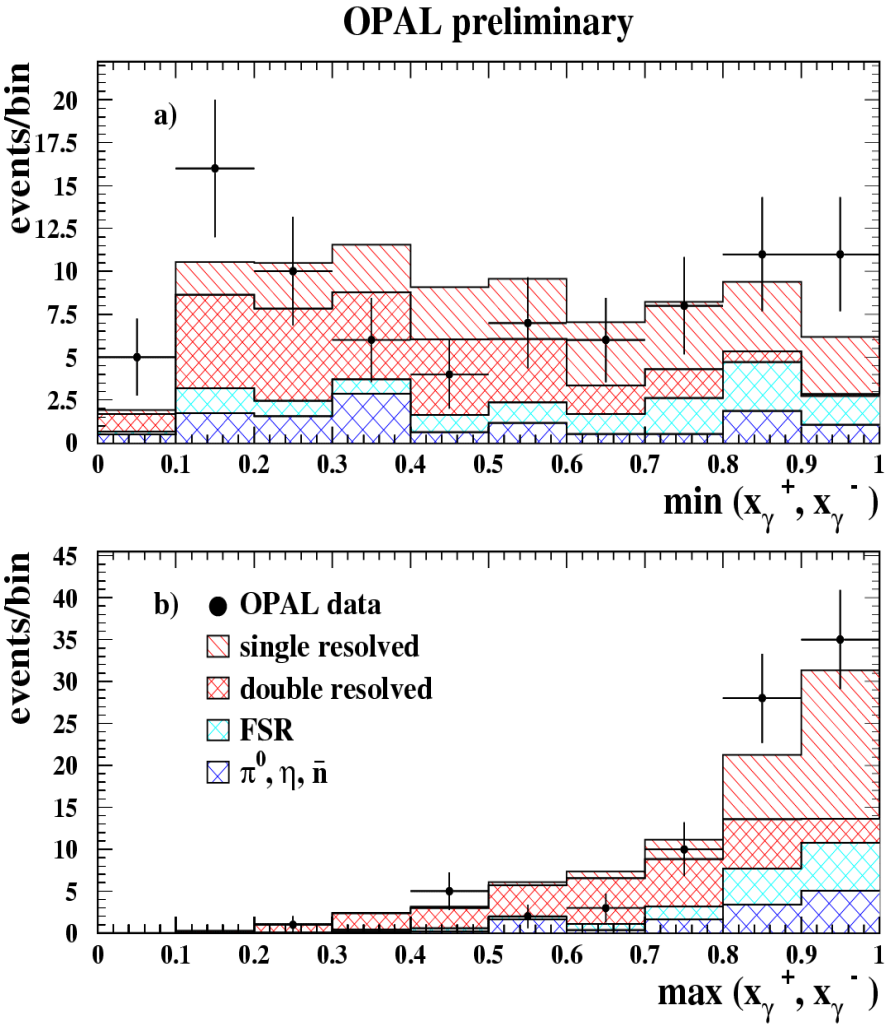


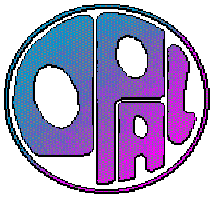
# Single/Double Resolved Ratio $r_{s/d}$

- For the $\gamma$ +jet sample:

$$x_\gamma^{\pm} = \frac{(E_\gamma \pm p_{z\gamma}) + (E_{jet} \pm p_{zjet})}{\Sigma_{hadrons,\gamma}(E \pm p_z)}$$

  using a cone jet finder with R=1, $E_T$ > 3 GeV.
- Fit $x_\gamma^{min}$ distribution to data → $r_{s/d}$ = 0.59 ± 0.12
- For the complete data set use also $x_T = 2p_T^\gamma / W_{vis}$ → $r_{s/d}$ = 0.41 ± 0.08,
- Average → $r_{s/d}$~0.5.





# The Total Cross-Section

For isolated prompt photons ($p_T > 3$ GeV, $|\eta^\gamma| < 1$):

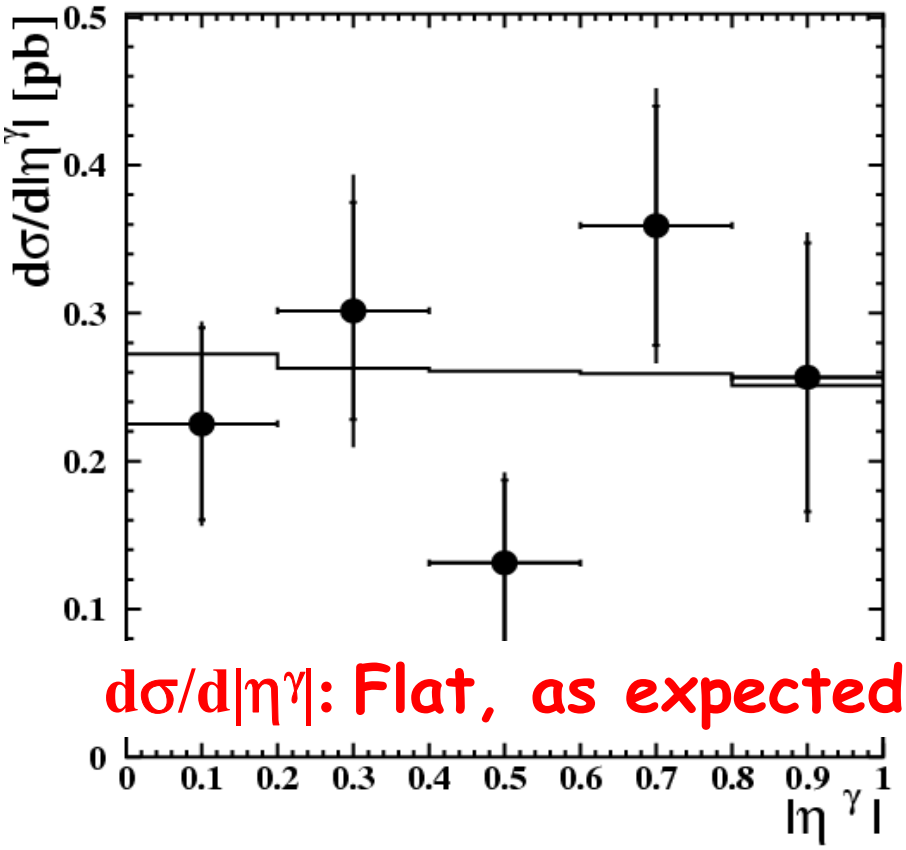
$$\sigma_{tot} = r \cdot N_{prompt}/\varepsilon_{single} L + (1-r) \cdot N_{prompt}/\varepsilon_{double} L$$

- $N_{prompt}$: 92.8, background subtracted (FSR, $\pi$, $\eta$, n).
- $r_{s/d}$: single / double resolved ratio.
- $\varepsilon$: Taken from PYTHIA MC (0.51 / 0.61).

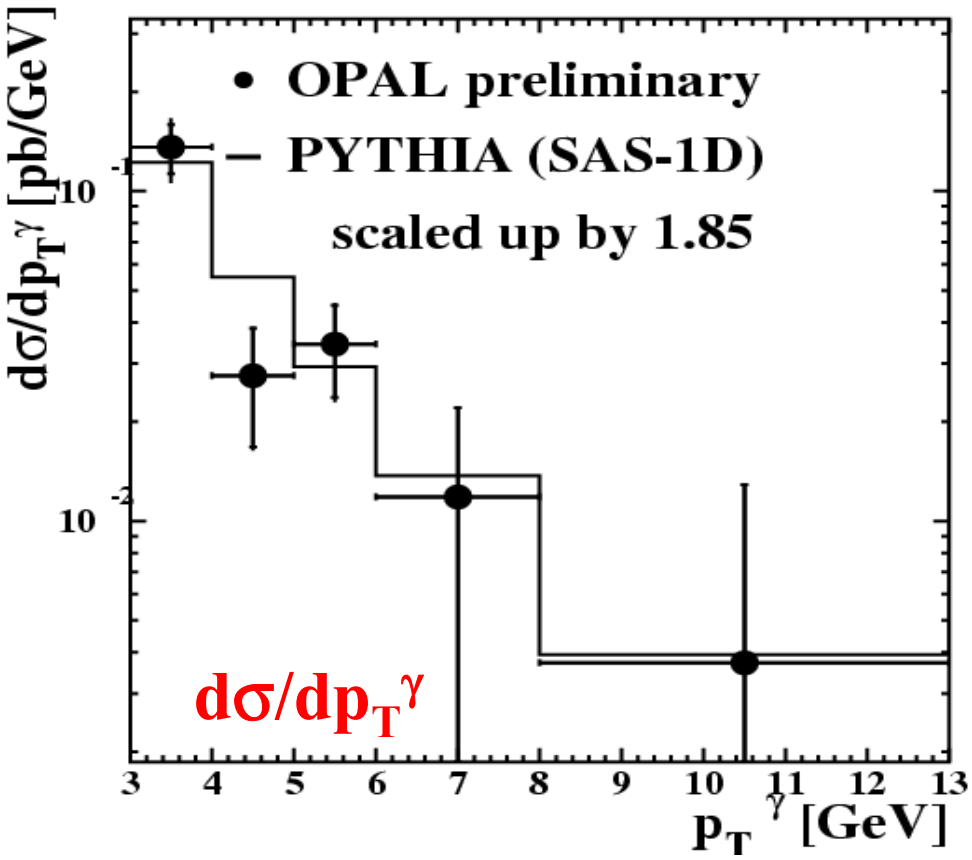
$$\sigma_{tot} = 0.26 \pm 0.04 \text{ (stat.)} \pm 0.03 \text{ (syst.) pb}$$

- Tristan: $\sigma(p_T > 2\text{GeV}) = 1.72 \pm 0.67$ pb at $\sqrt{s_{ee}} = 58$ GeV

# Comparisons with PYTHIA



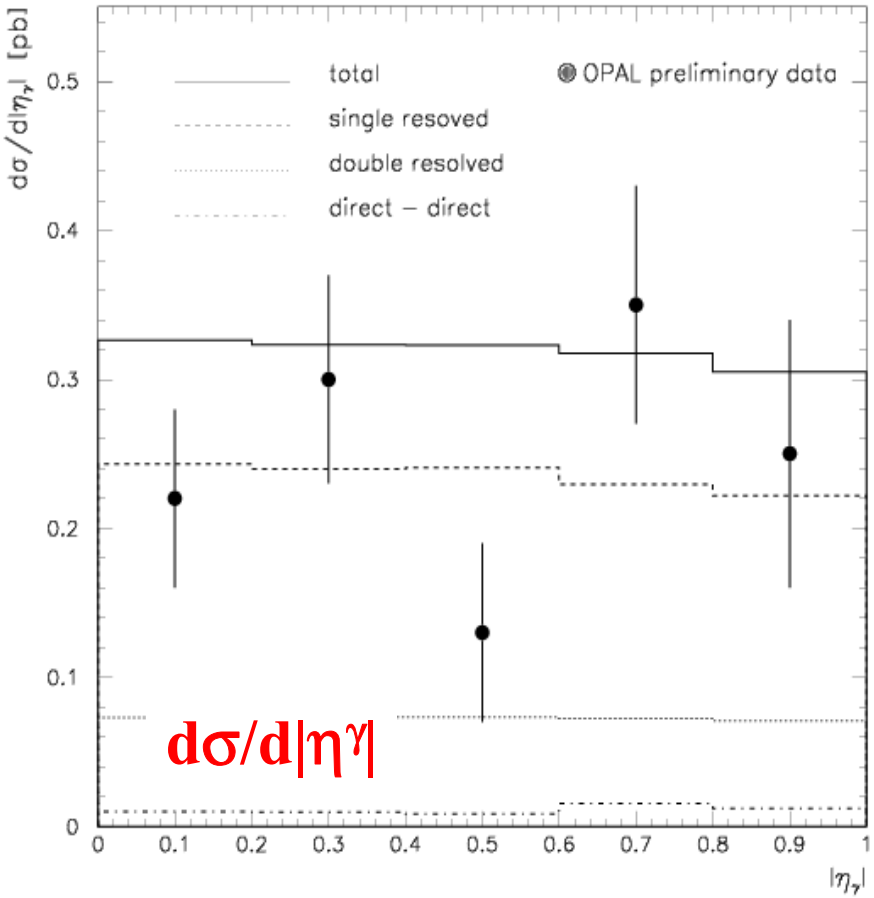

**$d\sigma/d|\eta^\gamma|$: Flat, as expected!**

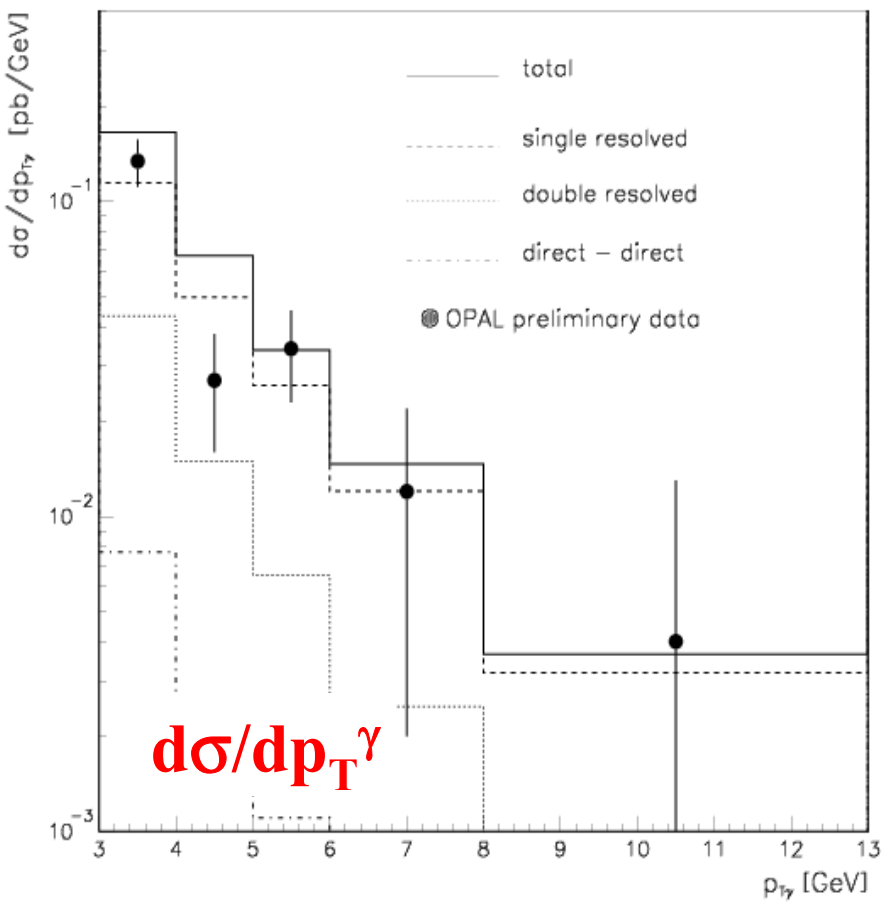



**$d\sigma/dp_T^\gamma$**

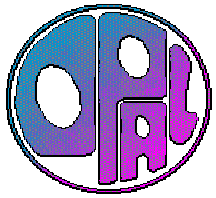
→ Shape of distributions well described, but normalisation off (1.85; in case of TOPAZ ~3, MC also low for ZEUS)

# Comparisons with NLO Calculations




- Shape and normalisation correct (Fontannaz et al)!



# Summary

- Prompt photons provide means to test QCD and to determine hadronic structure of photon.

  $\sigma = 0.26 \pm 0.04\ (\text{stat.}) \pm 0.03\ (\text{syst.})\ \text{pb}$

- PYTHIA badly normalized; good agreement of differential cross-sections with NLO QCD calculations.
- Looking forward to final result:
  - Test of different photon PDFs (GRV, LAC1).
  - Investigate including FSR in signal → better NLO description?