

# Inclusive Production of Charged Hadrons in Photon-Photon Collision

Balázs Ujvári  
Debrecen University

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OPAL-week, CERN

- F Data set, MC's, cuts
- F Corrections
- F Bin-by-bin unfolding
- F Our results and comparison with L3 results
- F Systematic errors

## What do we use for the analysis?

F Data taken by the OPAL-detector at LEP  
in 1997, 1998, 1999, 2000. all:  $L=616\text{pb}^{-1}$

F Monte-Carlo simulations:

PHOJET 1.10, PYTHIA 5.722       $\gamma\gamma \rightarrow q\bar{q}$

PYTHIA 6.125     $Z \rightarrow q\bar{q}$

HERWIG 5.9     $\gamma\gamma^* \rightarrow q\bar{q}$

KORALZ 4.02     $Z \rightarrow \tau\tau$

VERMASEREN     $\gamma\gamma \rightarrow \tau\tau$

## The cuts for all energies 183-209 Gev

### Against the Z-events:

$$E_{\text{ECAL}} + E_{\text{HCAL}} < 50.0 \text{ GeV}$$

$$E_{\text{ECAL}} + E_{\text{HCAL}} < 60.0 \text{ GeV} \text{ (high-}P_t \text{ track)}$$

$$|P_{z,\text{hadronic final state}}| < 50.0 \text{ GeV}$$

### and the single-tag events:

$$E_{\text{FD+SW}} < 60.0 \text{ GeV}$$

### Quality cuts:

$$W_{\text{ECAL}} > 3 \text{ GeV}$$

$$\text{CThits} > 40$$

$$|\text{D}0| \text{ of tracks} < 0.15 \text{ cm}$$

### Against the beam-wall, beam-gas events:

$$z_{\text{primary-vertex}} < 5 \text{ cm}$$

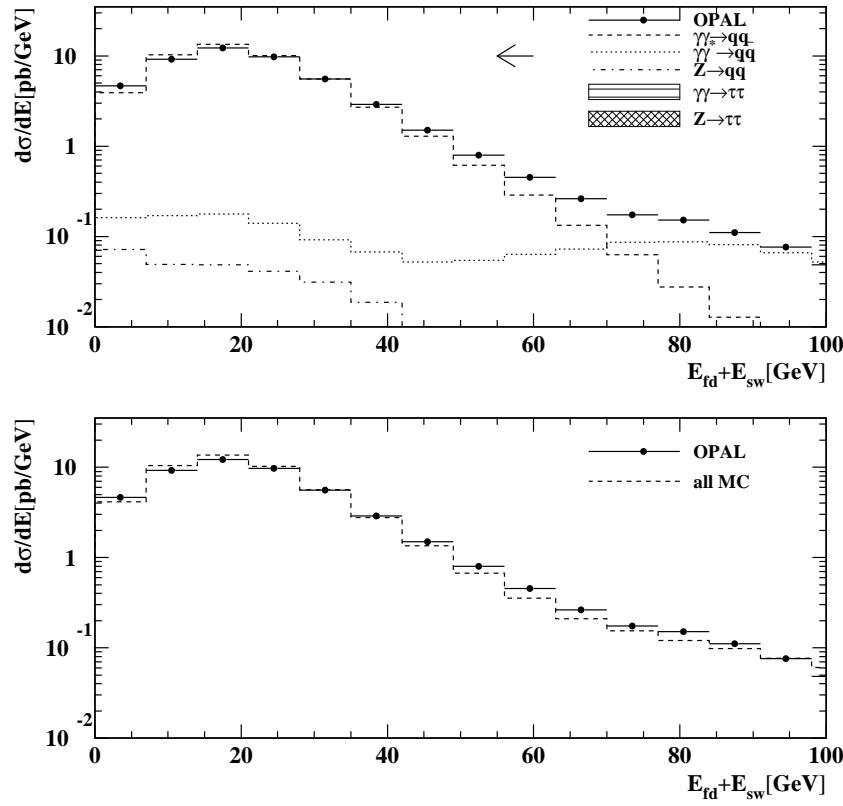
$$r_{\text{primary-vertex}} < 2 \text{ cm}$$

### and agains the $\tau\tau$ events:

$$n_{\text{track}} \geq 6$$

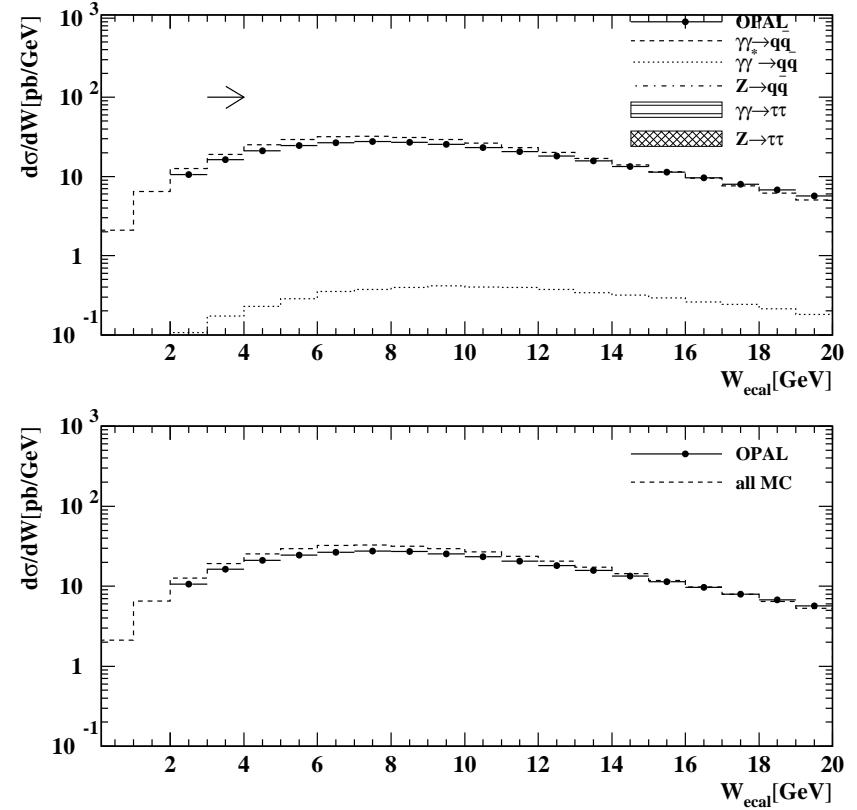
## Control plots

Total energy measured in FD and SW



MC fits the data well.

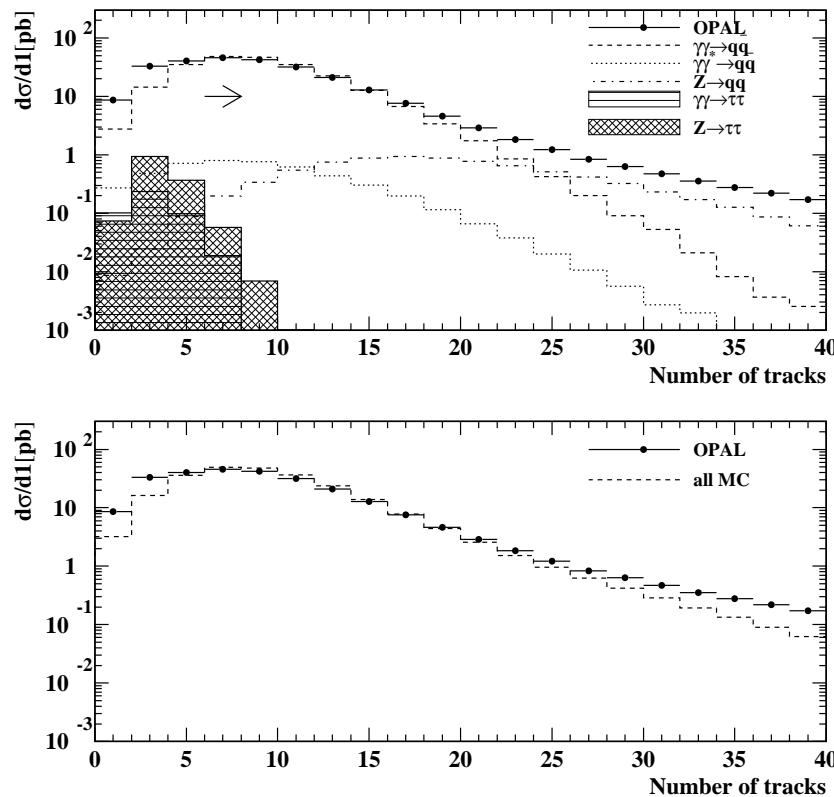
The invariant mass measured in ECAL



There is also a good agreement.

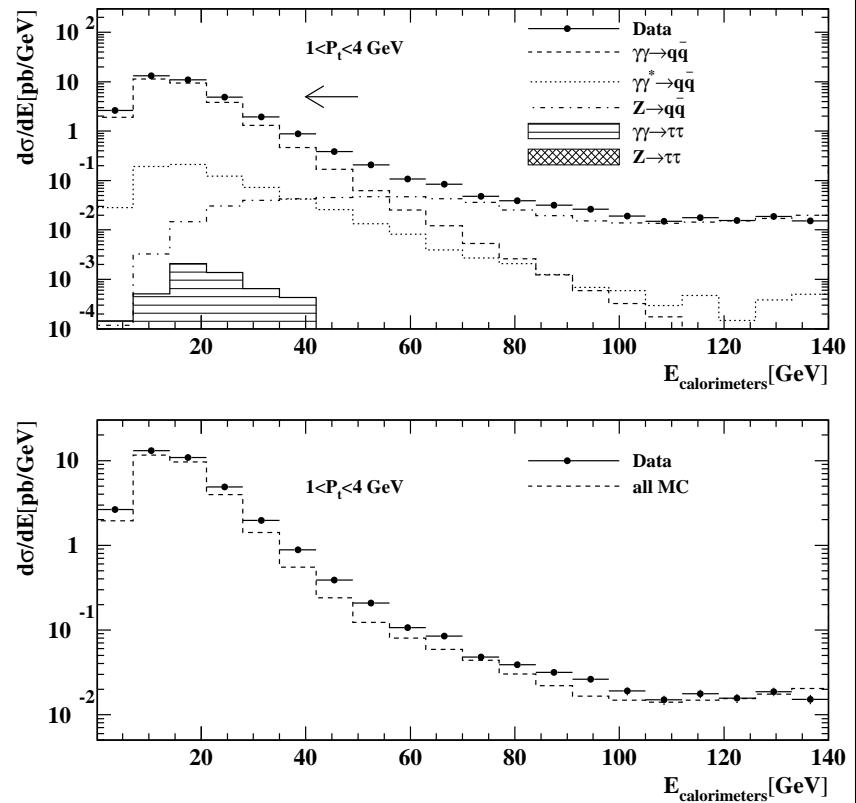
## Control plots

The number of tracks in an event



Discrepancy in tail (as in previous two-photon papers) but still acceptable.

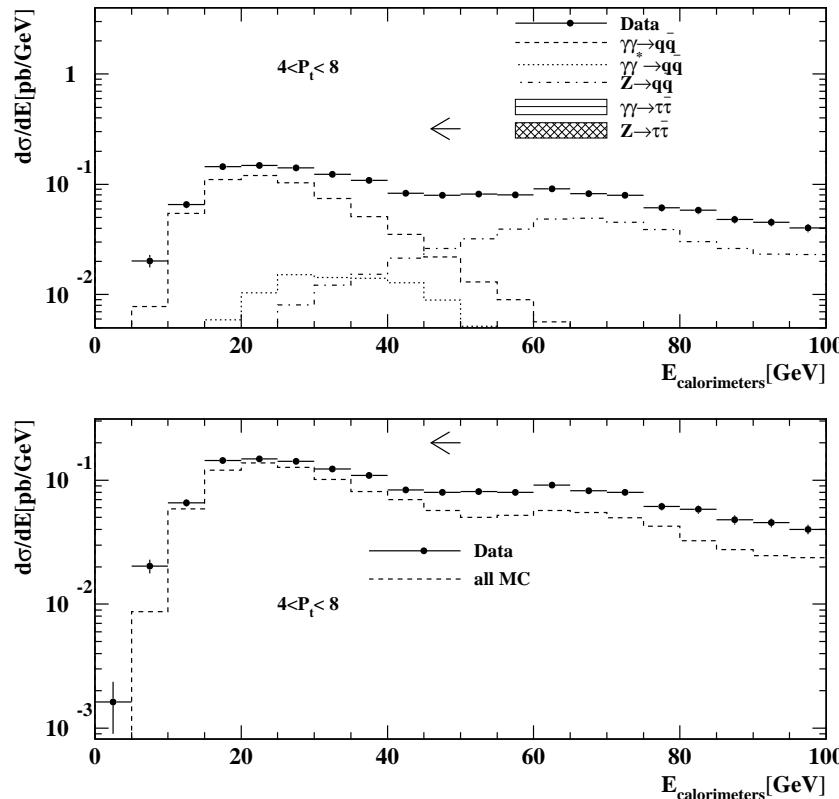
Total energy measured in ECAL and HCAL



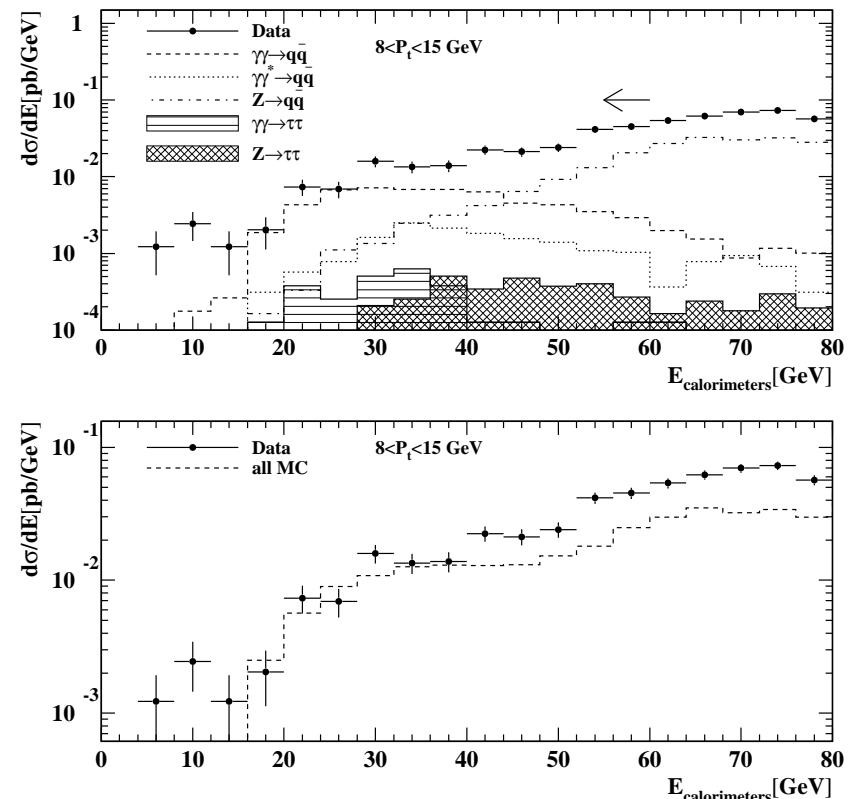
The low- $p_t$  range.

## Control plots

Total energy measured in ECAL and HCAL for events with at least one track  $4 < P_t < 8$  GeV



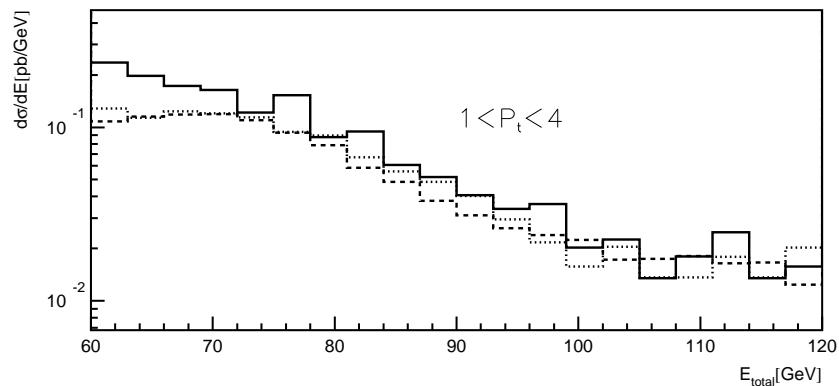
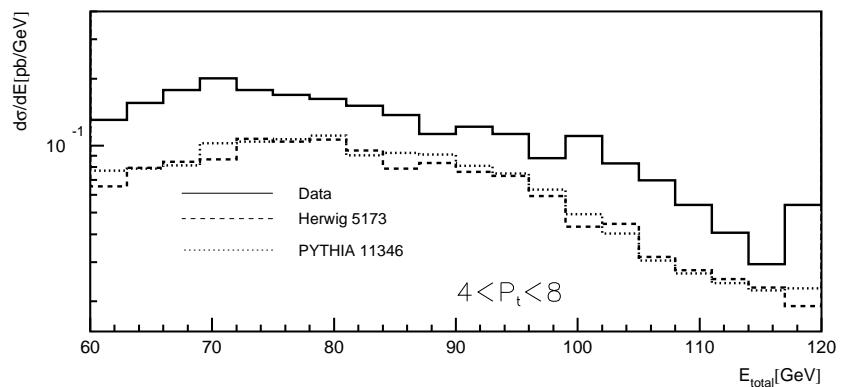
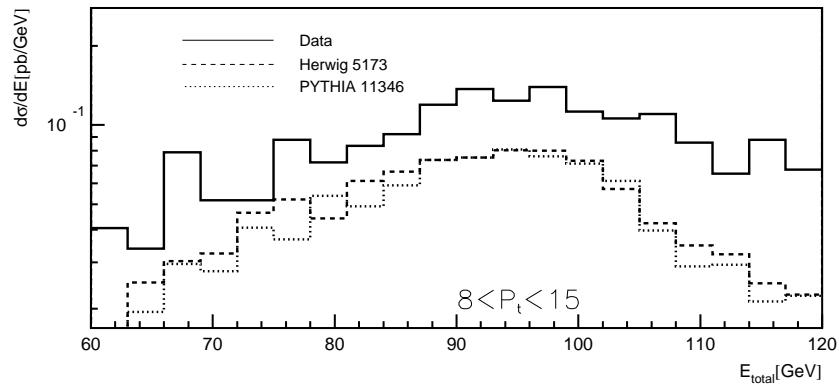
Total energy measured in ECAL and HCAL for events with at least one track  $8 < P_t < 15$  GeV



Large discrepancy for high energy  
(dominated by  $Z \rightarrow qq$  MC).

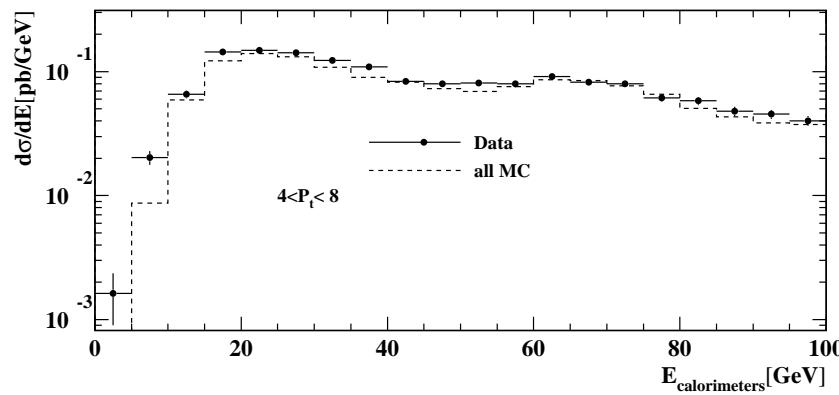
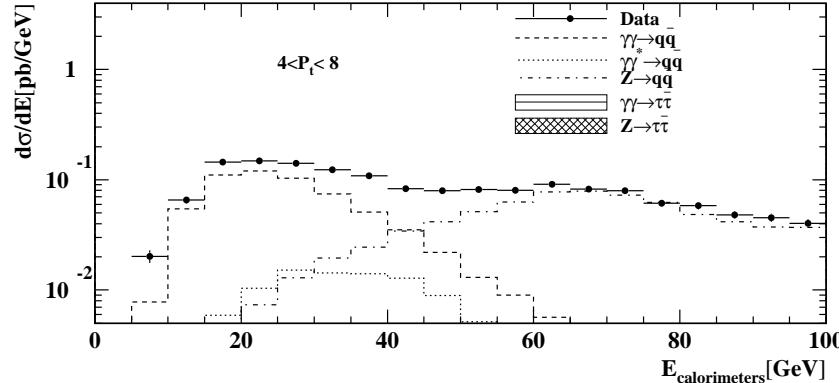
## Control plots (QCD)

### Total energy using the ntuples of OPAL QCD-group

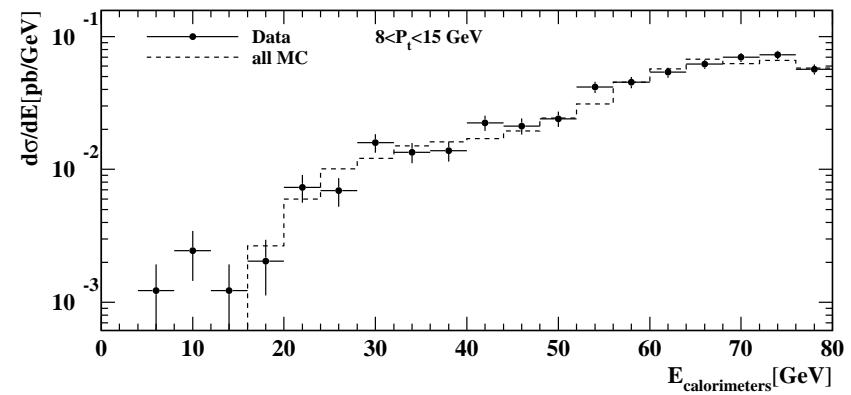
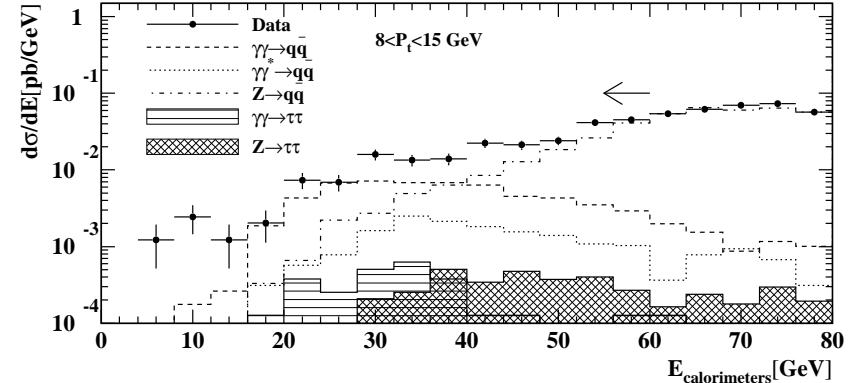


same effect is seen in QCD ntuples  
(completely separate code).

## Solution: Reweight the $Z \rightarrow qq$ MC



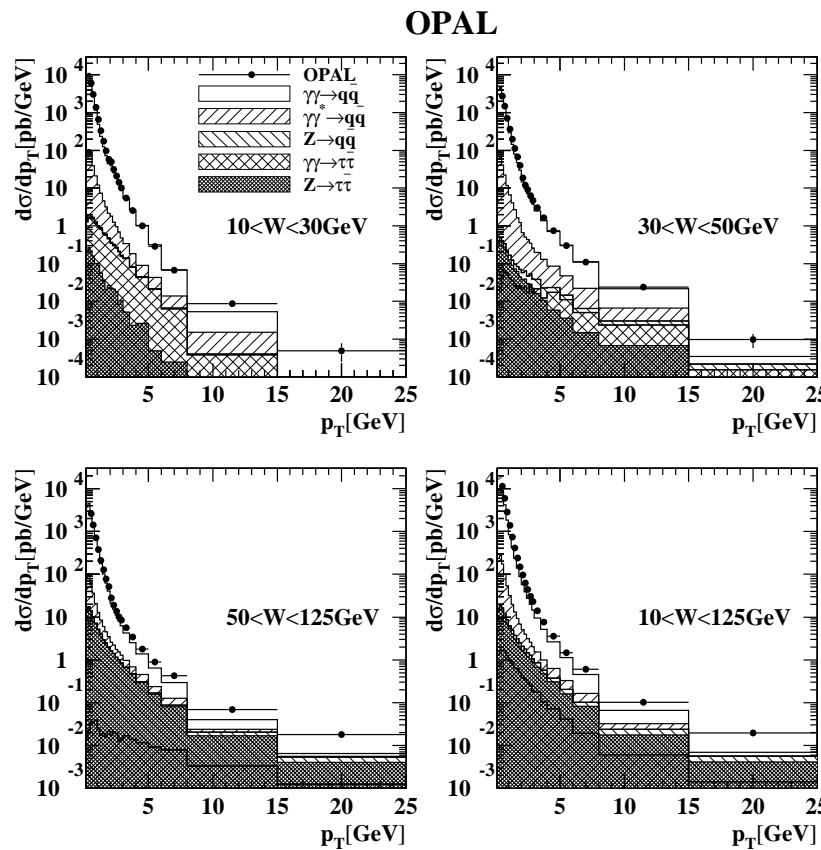
after reweighting with factor 1.6



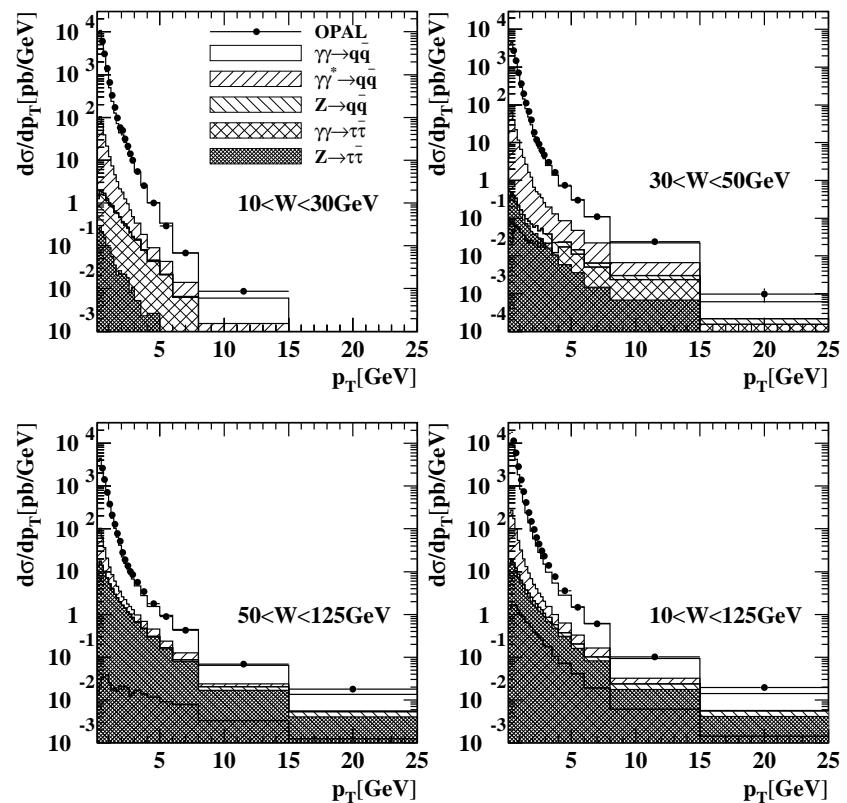
after reweighting with factor 2.0

## Reweighted signal MC

Uncorrected data



After reweight signal MC

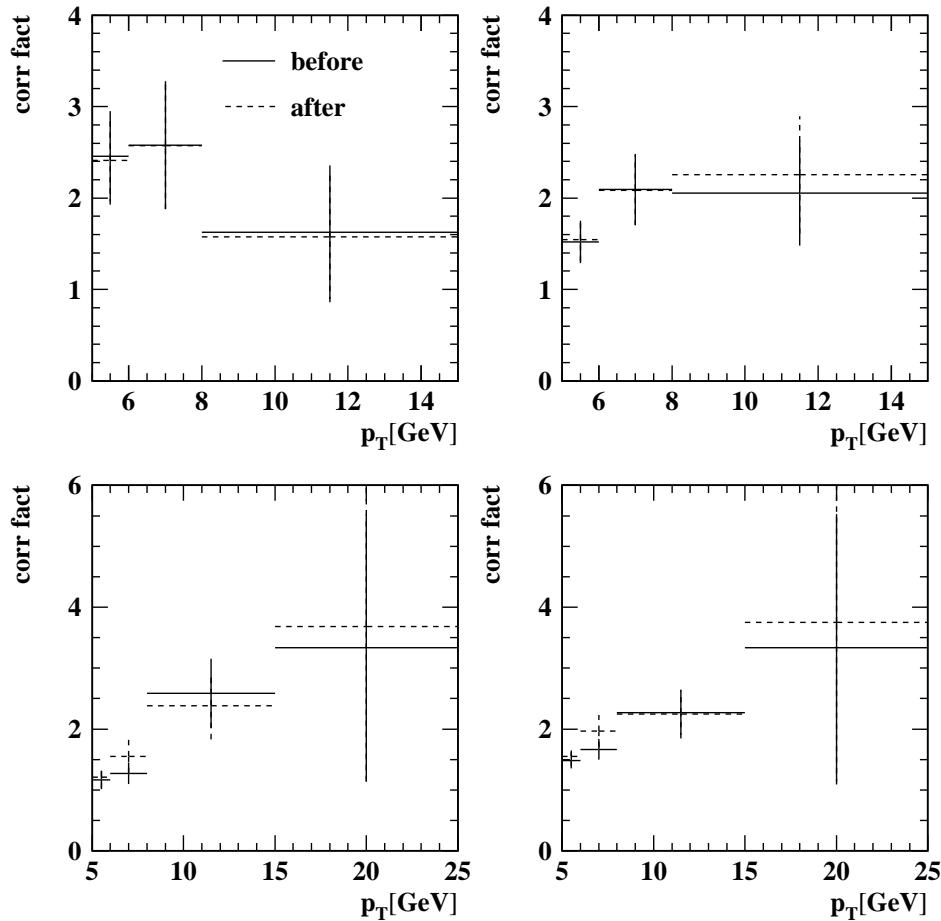


MC underestimate data at high  $p_t$

## Correction factor

### Signal MC correction

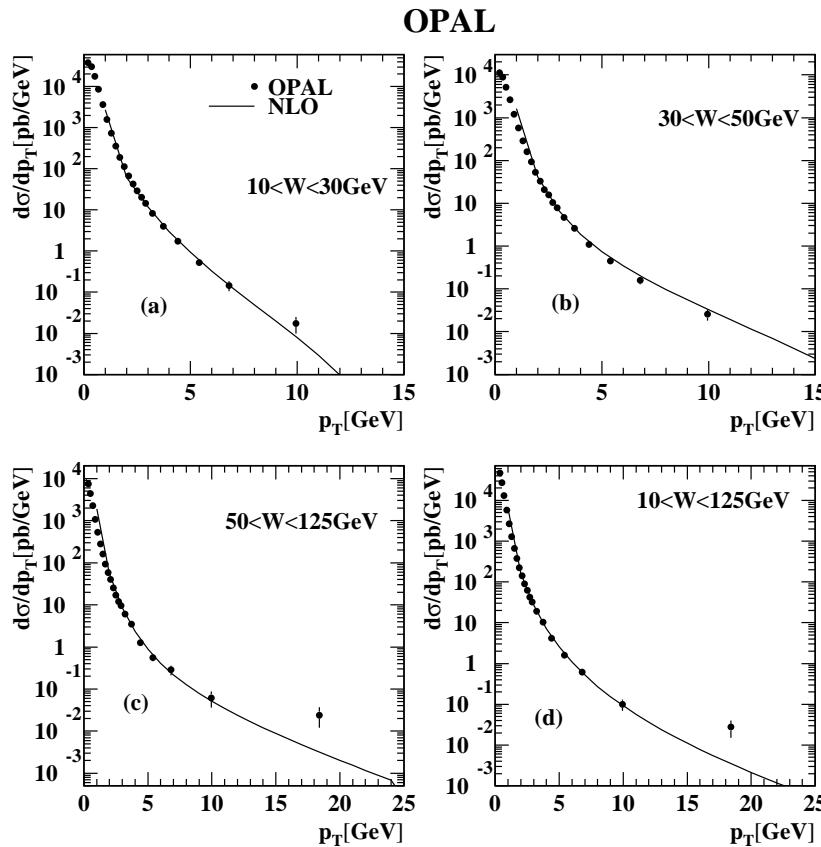
OPAL



Pythia is the standard signal MC

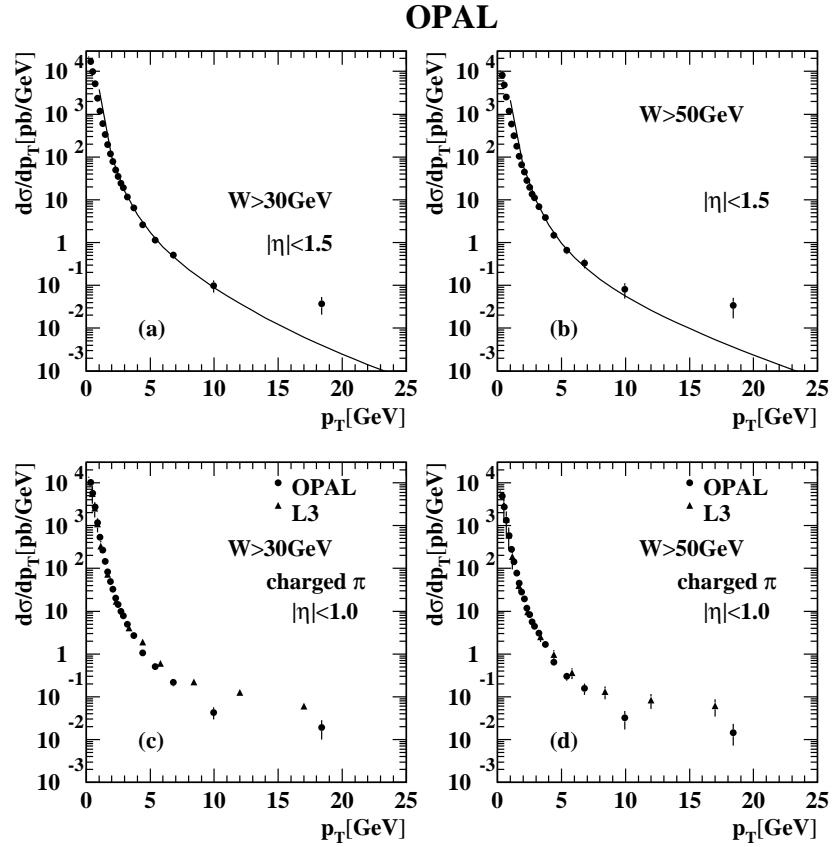
## Results

### Unfolded $p_t$ -distributions, full uncertainty



Now: Data points plotted at average of each bin. Will try to get NLO in our bins instead

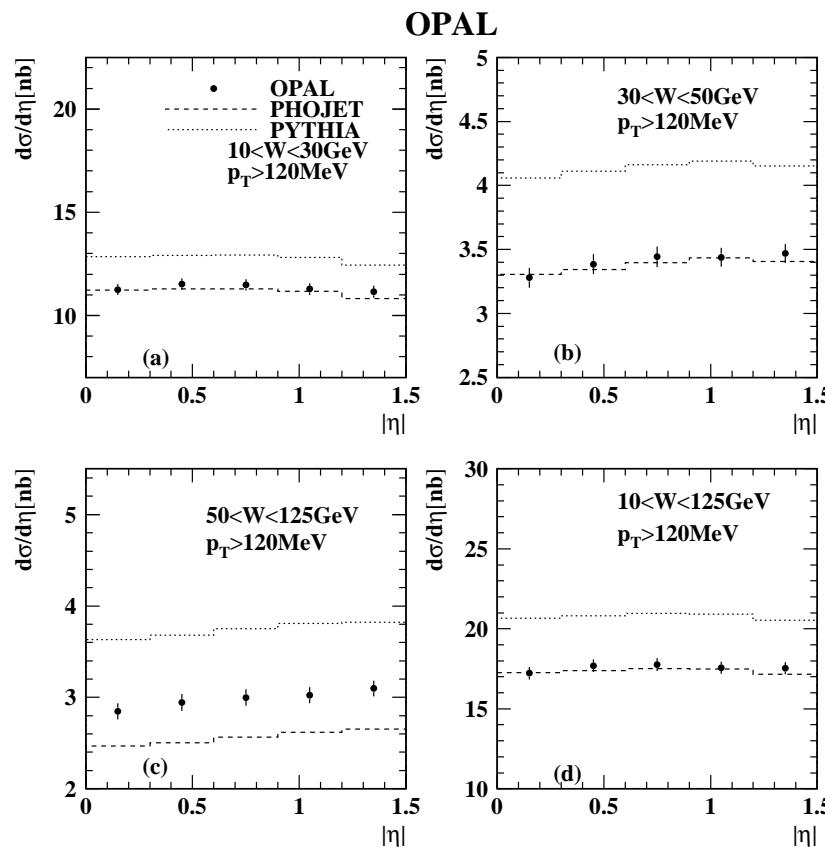
### $P_t$ -distributions, comparison to L3 results



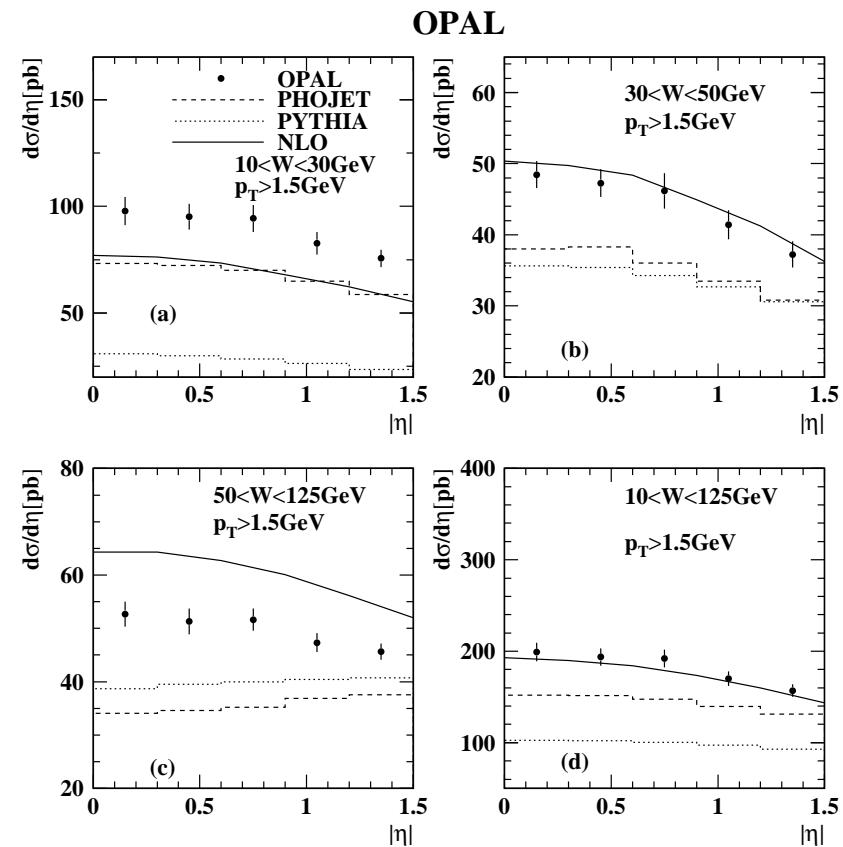
Extrapolation to  $\pi^\pm$  in  $|\eta| < 1.0$  by MC.

## Results

### $\eta$ -distributions



### $\eta$ -distributions



Will product MC lines with latest versions

NLO appear to have different slope in  $W$

**Systematic errors:**

- F PHOJET-PYTHIA unfolding results  $\pm 1 - 5\%$
- F calibration of ECAL  $1 - 20\%$
- F beam-wall, beam-gas events  $< 5\%$
- F cut variation  $1 - 30\%$

**Next steps:**

- F hadron level MC for comparison to data
- F get new NLO calculations
- F finish draft, EB, PR