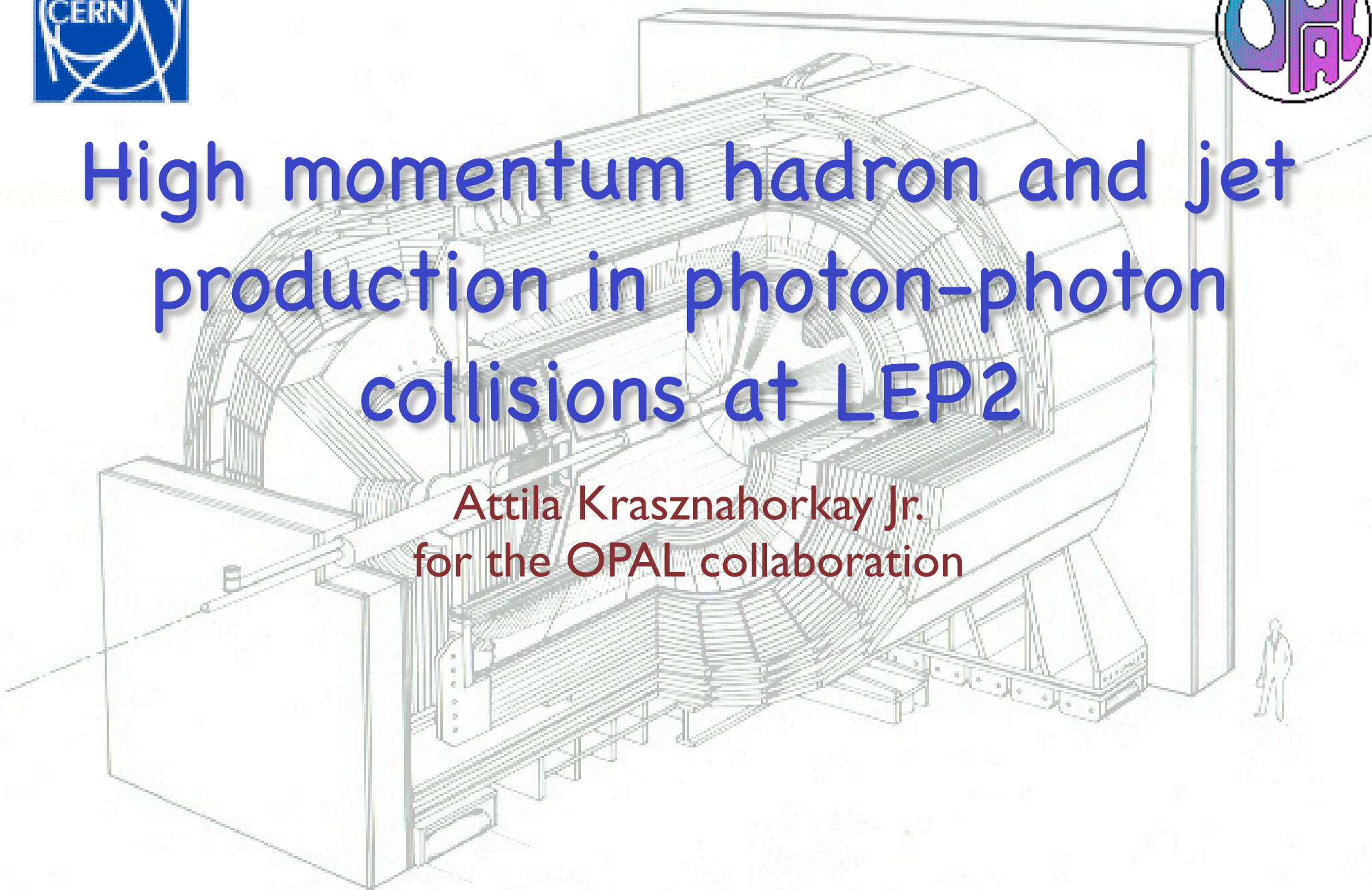


High momentum hadron and jet production in photon-photon collisions at LEP2

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for the OPAL collaboration

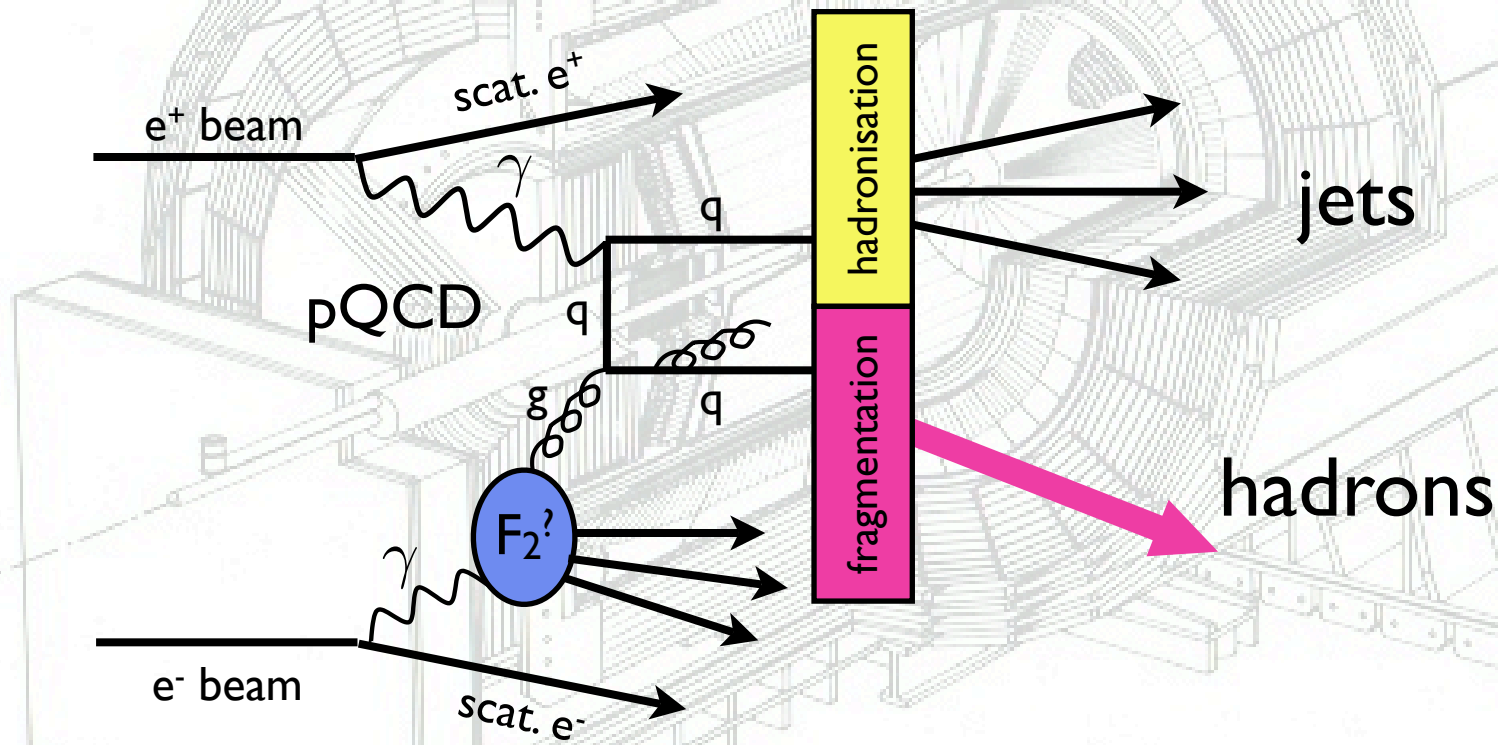


Contents



- Introducing the process
- Motivation for the analysis
- Selecting the events
- Results

The processes in question

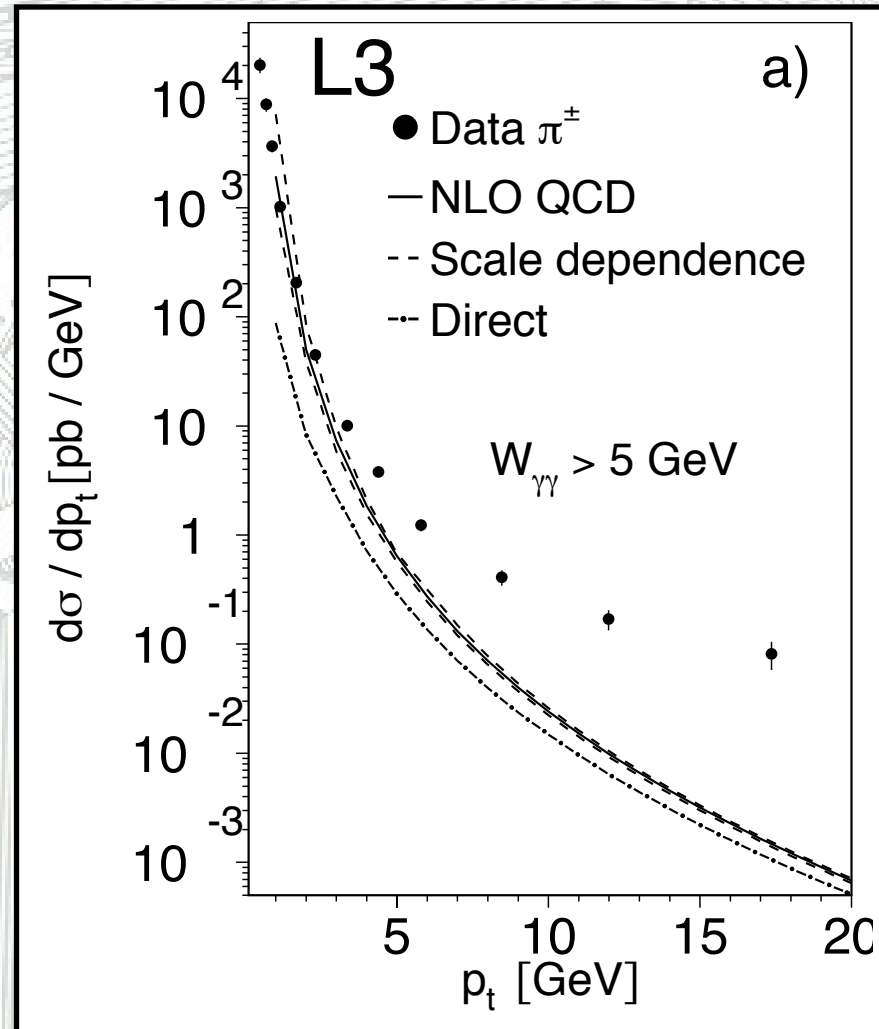


Many separate models needed to describe photon-photon interactions.

Motivation (1)



Problem with
pQCD?

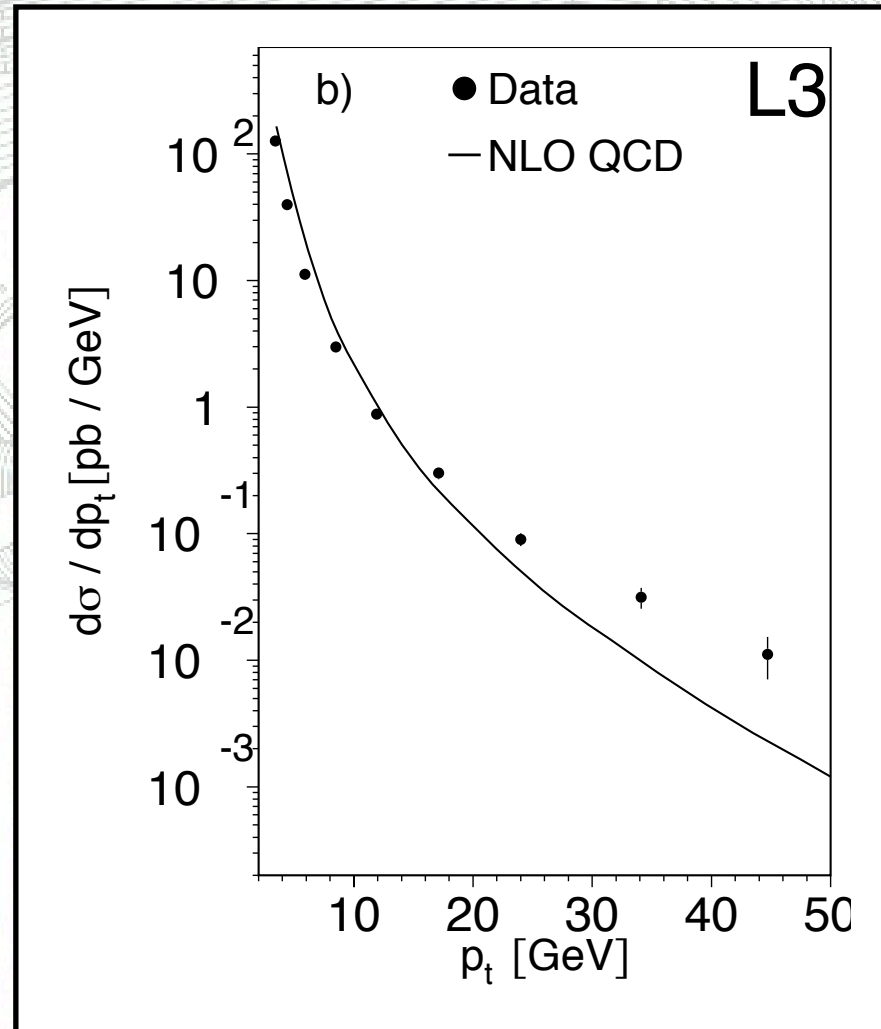


Problem with
fragmentation
function?

Motivation (2)



Problem with
pQCD?



Problem with
hadronisation?

The data sets



	hadron x-section	jet x-section
data taking period	1997 - 2000	1998 - 2000
$\sqrt{s_{ee}}$	183 - 209 GeV	189 - 209 GeV
luminosity	612.8 pb ⁻¹	593 pb ⁻¹
data set characteristics	hadron track, $p_T > 0.12$ GeV, $ \eta < 1.5$	one k_t jet with $p_T > 5$ GeV, $ \eta < 1.5$

Selecting charged hadron events



- Used cuts on various reconstructed parameters
 - Number of tracks
 - Visible invariant mass
 - Missing transverse energy
 - ...
- All cuts leave 1 144 035 events
- Overall background is below 2%, increasing to 50% for the highest p_T bin

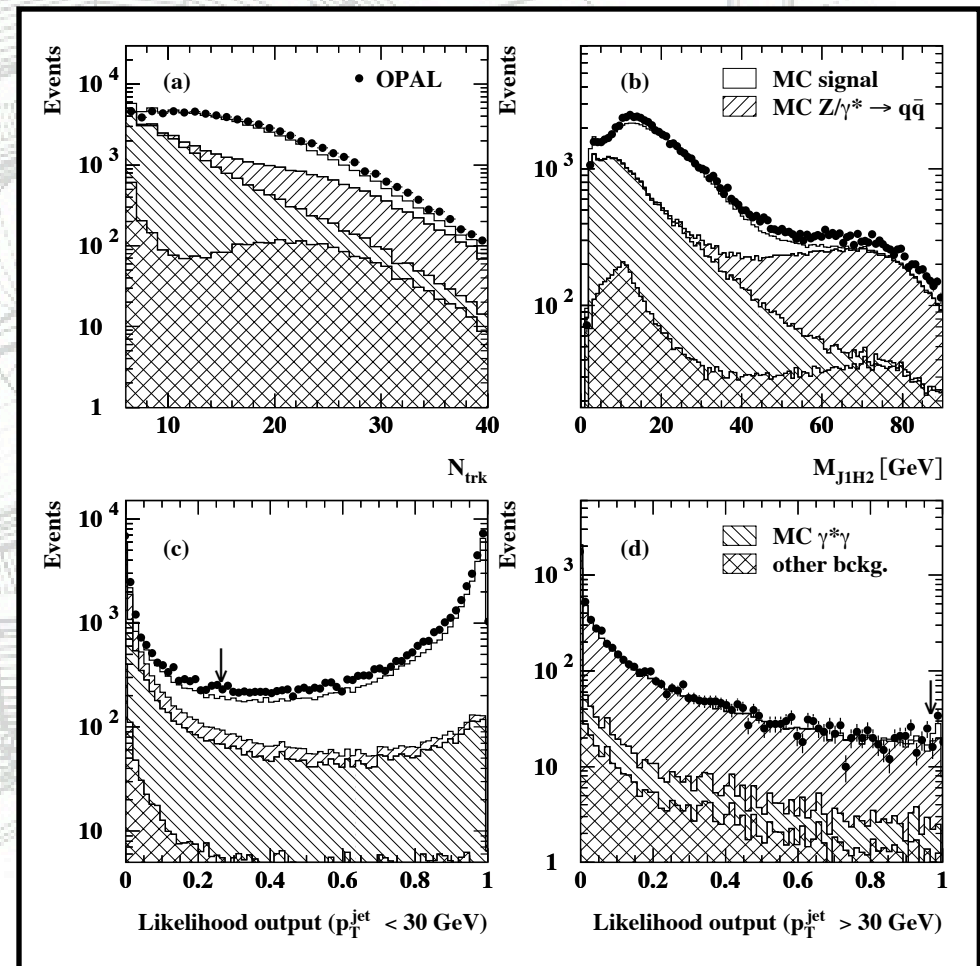
Selecting inclusive jet events (1)



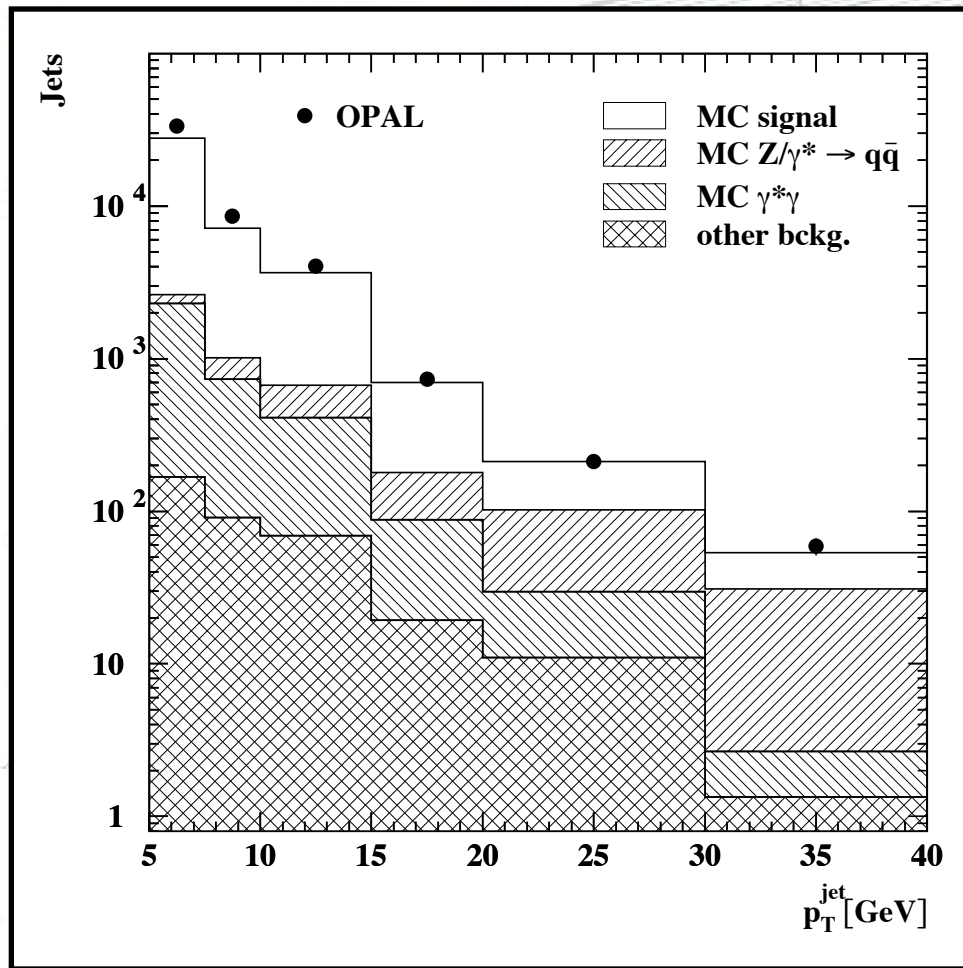
- Problem with S/B at high jet p_T



- Use likelihood selection
- Used 7 input variables
 - number of tracks
 - visible hadronic invariant mass
 - missing transverse energy
 - ...



Selecting inclusive jet events (2)

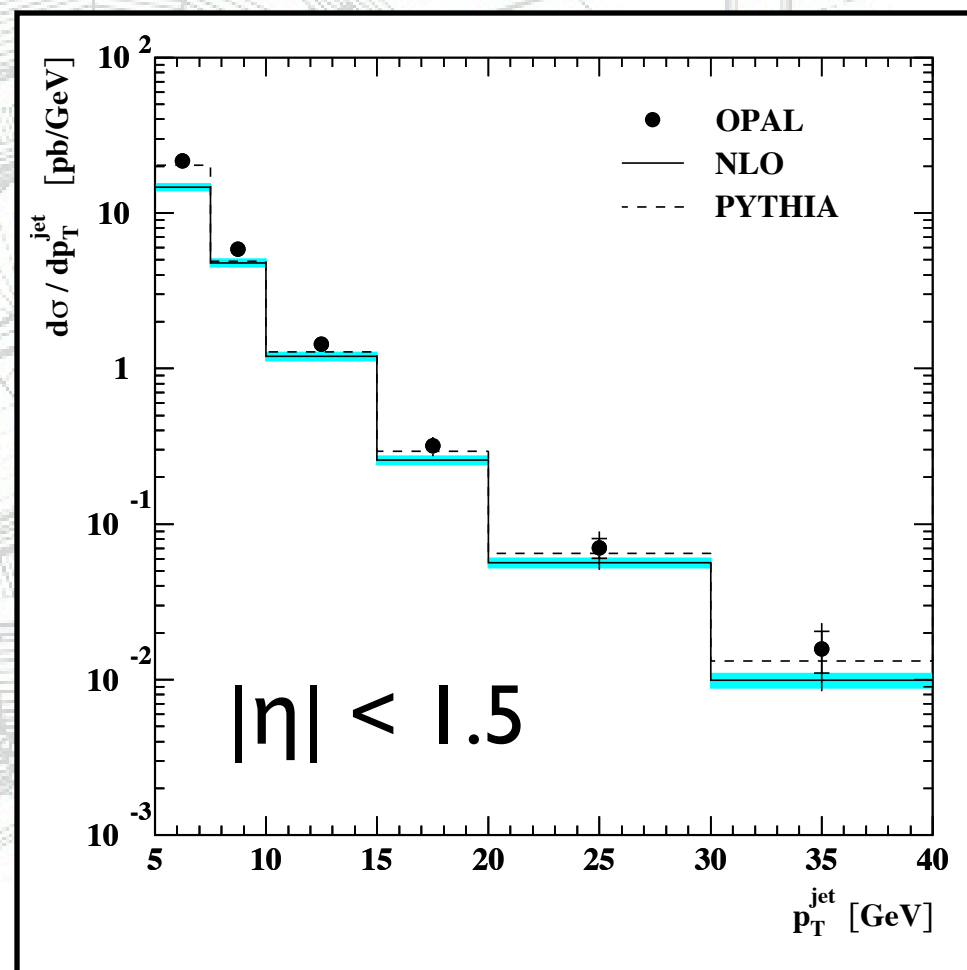


- Good S/B at low p_T
- About 50% background at 40 GeV
- Reliable measurement not possible above 40 GeV

Inclusive jet cross-section (1)



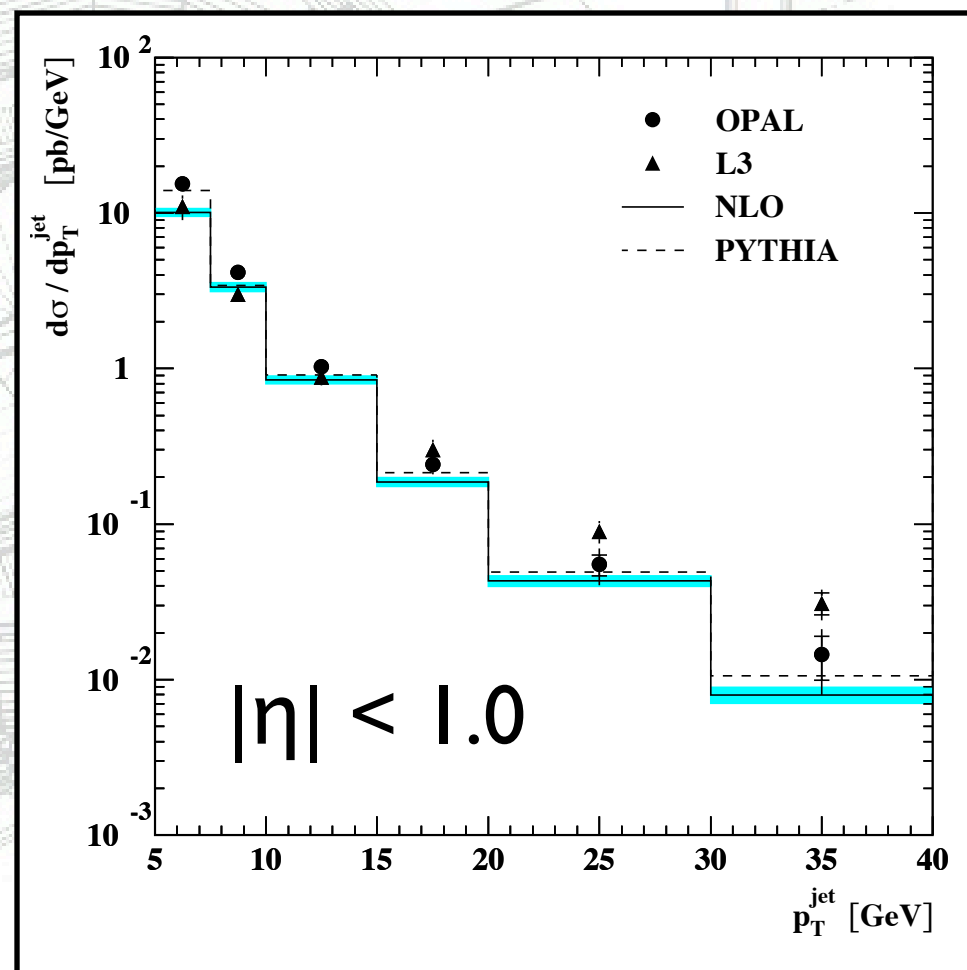
- Data in nice agreement with MC and NLO at high jet p_T
- NLO is only underestimating the cross-section in the lowest bin



Inclusive jet cross-section (2)



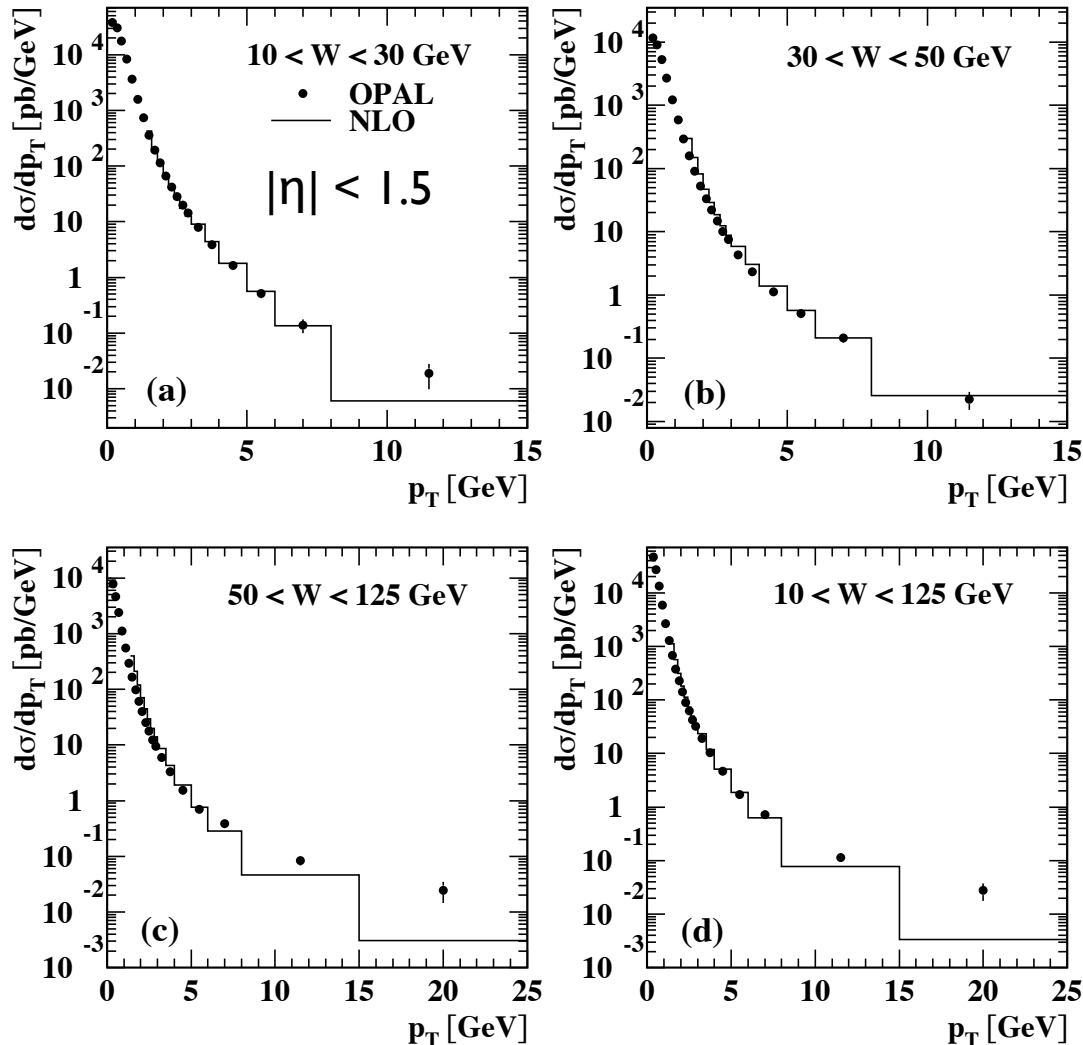
- Repeated analysis with L3's kinematic conditions
- Calculation still in good agreement with the measurement
- No measurement in OPAL for $p_T > 40$ GeV



Charged hadron cross-section (1)

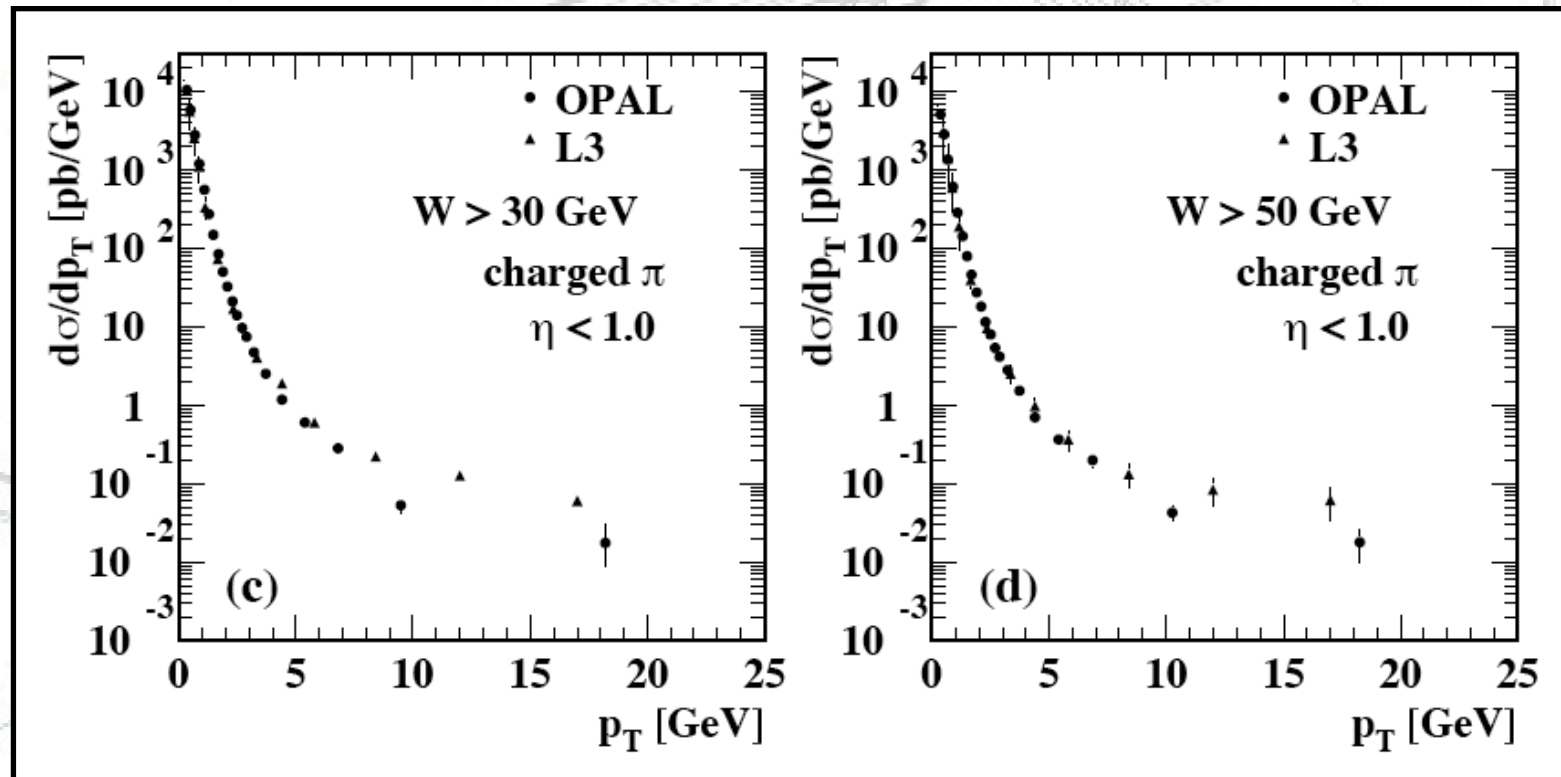


OPAL



- Calculation underestimates cross-section at high invariant mass, high p_T
- Otherwise description is good

Charged hadron cross-section (2)

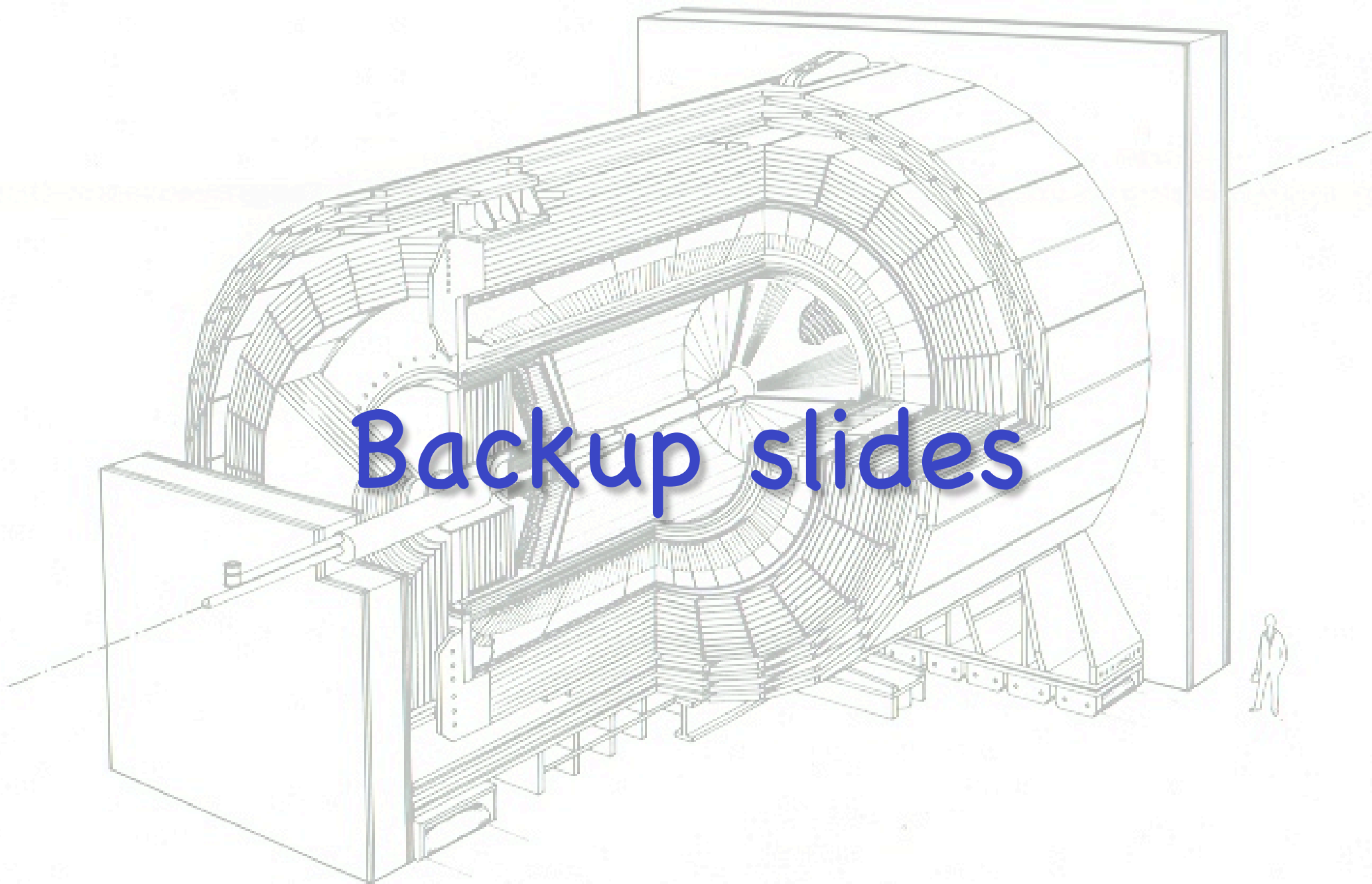


Results below L3 measurement at high $p_T \rightarrow$
closer to NLO

Conclusions



- The charged hadron and inclusive jet production cross-sections in photon-photon interactions have been measured in OPAL
- High p_T region dominated by background
- Found good agreement between measurement and calculation (except possibly for charged hadrons at largest p_T)



Backup slides

Likelihood input variables



- Visible invariant mass measured in the ECAL only
- Visible invariant mass from entire hadronic final state
- Number of tracks
- Energy deposits in ECAL
- Energy deposits in HCAL
- Missing transverse momentum
- Invariant mass calculated from jet with highest p_T and hadronic final state in the opposing hemisphere

Charged hadron selection



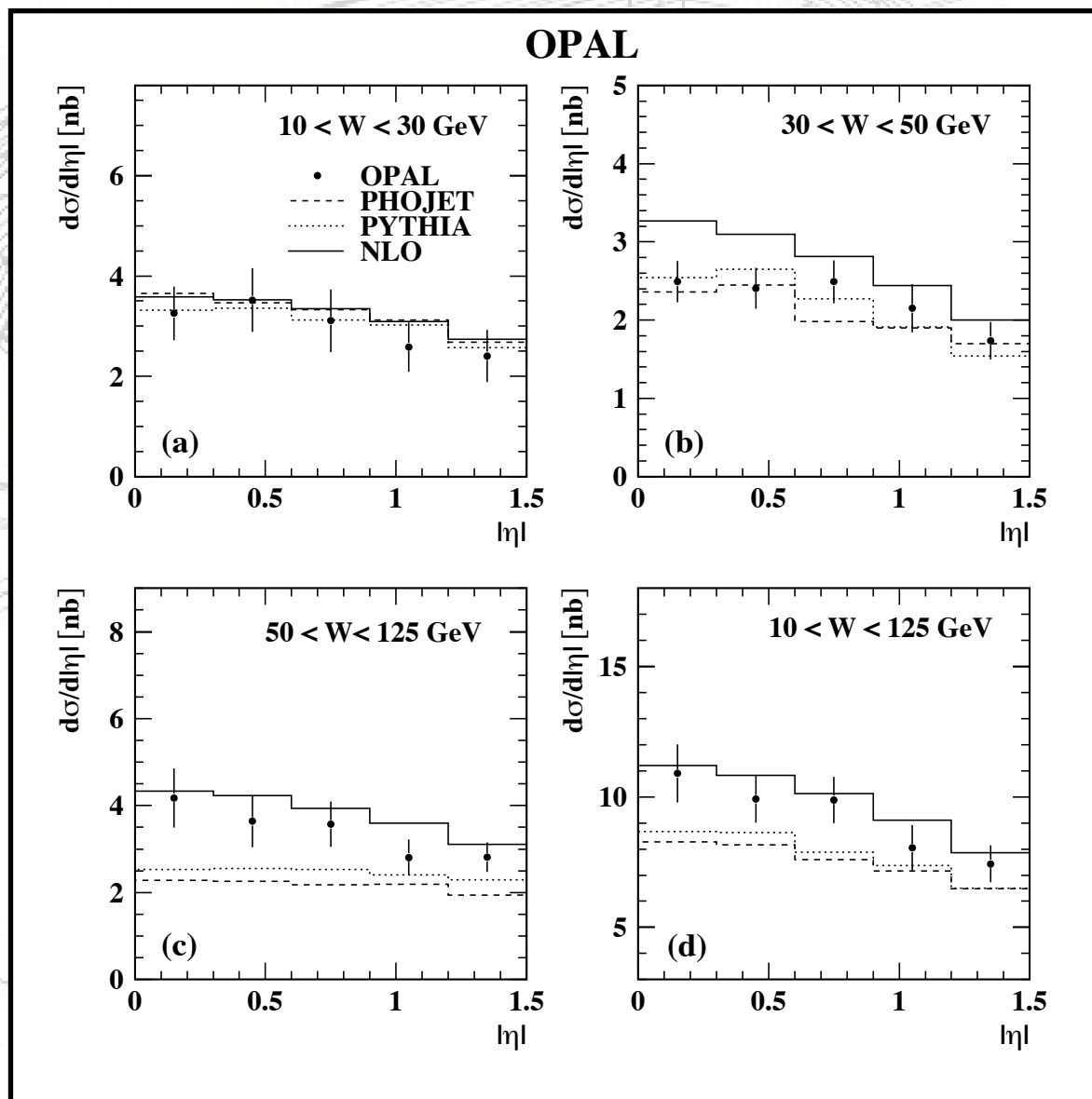
- At least six tracks must have been found in the tracking chambers. A track is required to have a minimum transverse momentum of 120 MeV with respect to the z axis and at least 40 hits in the central jet chamber. The number of measured hits in the jet chamber must be more than half of the number of possible hits given the track direction. The radial distance of nearest approach of the track to the primary vertex has to be less than 0.15 cm.
- The visible invariant hadronic mass calculated from the position and the energy of the clusters measured in the ECAL has to be greater than 3 GeV.
- The sum of all energy deposits in the ECAL and the HCAL has to be less than 50 GeV to remove background from hadronic Z decays in events with a radiative return to the Z peak.
- The missing transverse momentum of the event measured in the ECAL and the FD has to be less than 8 GeV.
- To reject events with scattered electrons in the FD or SW, the total energy sum measured in the FD and SW has to be less than 60 GeV.
- The background due to beam-gas or beam-wall interactions is reduced by requiring the radial distance of the primary vertex from the beam axis to be less than 2 cm and the distance from the nominal vertex position along the z direction to be less than 3 cm.

Systematic uncertainties



p_T [GeV]	ECAL energy [%]	Background subtraction [%]	Cut selection [%]	Signal re-weighting [%]	Total [%]
5.0 - 7.5	3.2	4.4	0.1	2.6	6.0
7.5 - 10.0	3.5	4.6	0.2	2.2	6.2
10.0 - 15.0	3.6	5.3	0.8	1.4	6.6
15.0 - 20.0	3.7	6.2	1.7	3.1	8.0
20.0 - 30.0	9.1	7.7	3.7	4.0	13.2
30.0 - 40.0	12.2	8.6	4.7	5.0	16.5

η dependence of charged hadron x-section



L3 inclusive jet selection



p_t [GeV]	$\langle p_t \rangle$ [GeV]	Background [%]	Reconstruction efficiency [%]	Trigger efficiency [%]	$d\sigma/dp_t$ [pb/GeV]
3–4	3.4	4.6 ± 0.1	60.8 ± 0.2	95.8 ± 0.3	$(13 \pm 1 \pm 1) \times 10^1$
4–5	4.4	5.6 ± 0.1	57.2 ± 0.3	95.9 ± 0.5	$(40 \pm 1 \pm 3)$
5–7.5	5.9	7.8 ± 0.1	53.2 ± 0.3	96.2 ± 0.5	$(11 \pm 1 \pm 1)$
7.5–10	8.5	11.1 ± 0.1	48.9 ± 0.5	96.6 ± 1.0	$(30 \pm 1 \pm 2) \times 10^{-1}$
10–15	11.9	14.0 ± 0.2	44.9 ± 0.6	96.8 ± 1.4	$(88 \pm 3 \pm 7) \times 10^{-2}$
15–20	17.1	16.0 ± 0.4	39.2 ± 0.9	96.9 ± 2.0	$(30 \pm 2 \pm 3) \times 10^{-2}$
20–30	24.0	18.6 ± 0.8	31.6 ± 0.8	97.3 ± 2.1	$(90 \pm 7 \pm 8) \times 10^{-3}$
30–40	34.1	18.9 ± 1.5	20.5 ± 1.3	97.3 ± 2.5	$(31 \pm 5 \pm 2) \times 10^{-3}$
40–50	44.7	19.6 ± 1.6	15.2 ± 1.9	98.5 ± 2.8	$(11 \pm 3 \pm 2) \times 10^{-3}$

Jet cross sections



p_T^{jet} [GeV]	$\langle p_T^{\text{jet}} \rangle$ [GeV]	Background [%]	$d\sigma/dp_T^{\text{jet}}$ [pb/GeV]
$ \eta^{\text{jet}} < 1.0$			
5.0 – 7.5	5.9	13.8 ± 0.1	$(15.3 \pm 0.1 \pm 0.9)$
7.5 – 10.0	8.5	17.4 ± 0.3	$(41.5 \pm 0.8 \pm 2.4) \times 10^{-1}$
10.0 – 15.0	11.8	21.6 ± 0.4	$(10.3 \pm 0.3 \pm 0.6) \times 10^{-1}$
15.0 – 20.0	16.9	28.8 ± 0.9	$(24.1 \pm 1.6 \pm 1.6) \times 10^{-2}$
20.0 – 30.0	23.3	47.6 ± 1.8	$(55.0 \pm 8.4 \pm 6.2) \times 10^{-3}$
30.0 – 40.0	33.0	57.0 ± 3.6	$(14.5 \pm 4.5 \pm 2.0) \times 10^{-3}$
$ \eta^{\text{jet}} < 1.5$			
5.0 – 7.5	5.9	14.9 ± 0.1	$(21.7 \pm 0.2 \pm 1.3)$
7.5 – 10.0	8.5	19.3 ± 0.2	$(58.5 \pm 0.9 \pm 3.6) \times 10^{-1}$
10.0 – 15.0	11.8	22.5 ± 0.4	$(14.3 \pm 0.3 \pm 0.9) \times 10^{-1}$
15.0 – 20.0	16.9	28.9 ± 0.9	$(31.8 \pm 1.9 \pm 2.6) \times 10^{-2}$
20.0 – 30.0	23.5	47.1 ± 1.6	$(70.3 \pm 10.2 \pm 9.3) \times 10^{-3}$
30.0 – 40.0	33.0	57.1 ± 3.2	$(15.7 \pm 4.7 \pm 2.6) \times 10^{-3}$