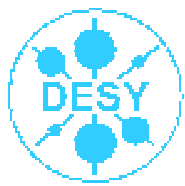
ANGULAR CORRELATIONS IN 3-JET EVENTS and SUBJET MULTIPLICITIES AT ZEUS

Thomas Schörner-Sadenius
Hamburg University

(for the ZEUS collaboration)



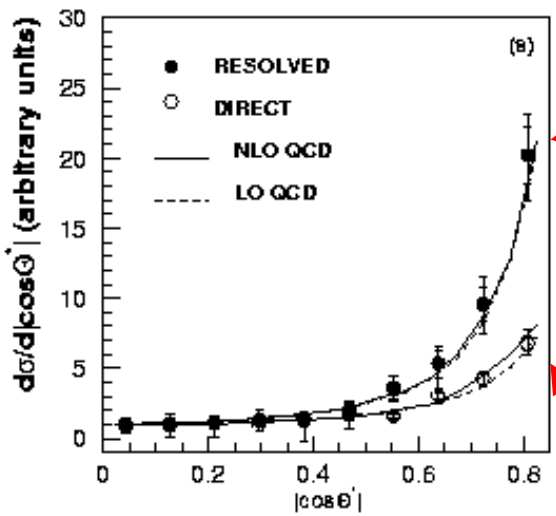
DIS 06
Tsukuba, April 19-24, 2006

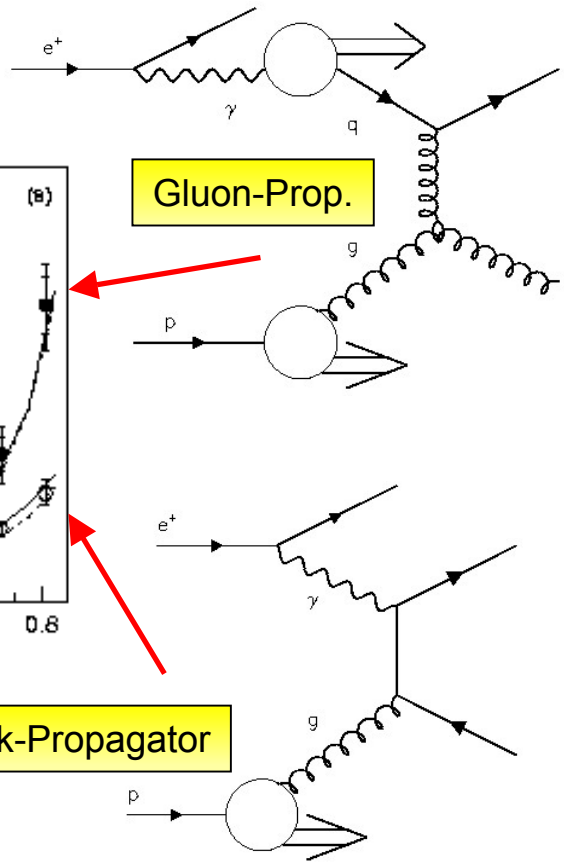
ANGULAR CORRELATIONS

Motivation: Is it really QCD?

¶ QCD: accepted effective theory of strong interactions.

¶ But – do we really see $SU(3)_C$?
- spin-1/2 (1) quarks (gluons)?
- Color factors?

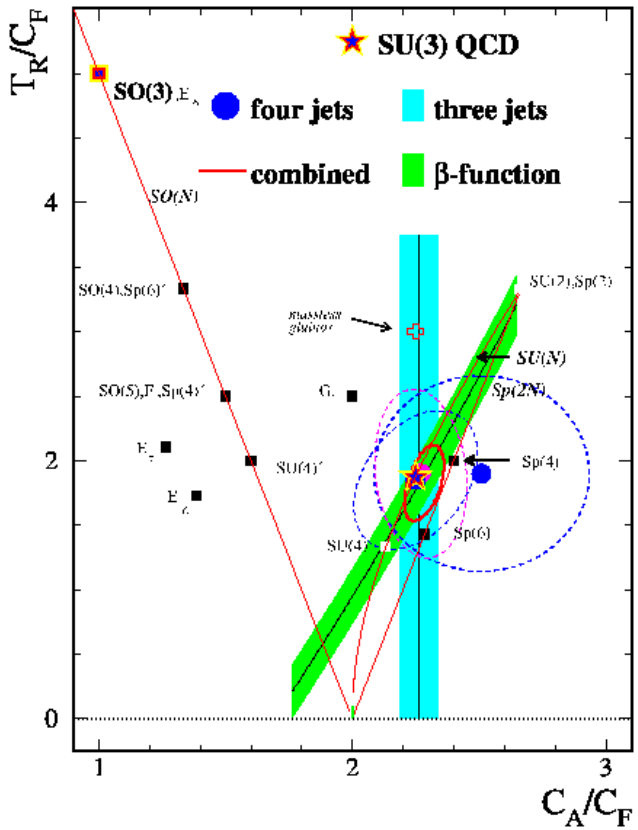




Gluon-Prop.

Quark-Propagator

¶ Several tests of both the color factors and the spin structure in e+e– and ep:



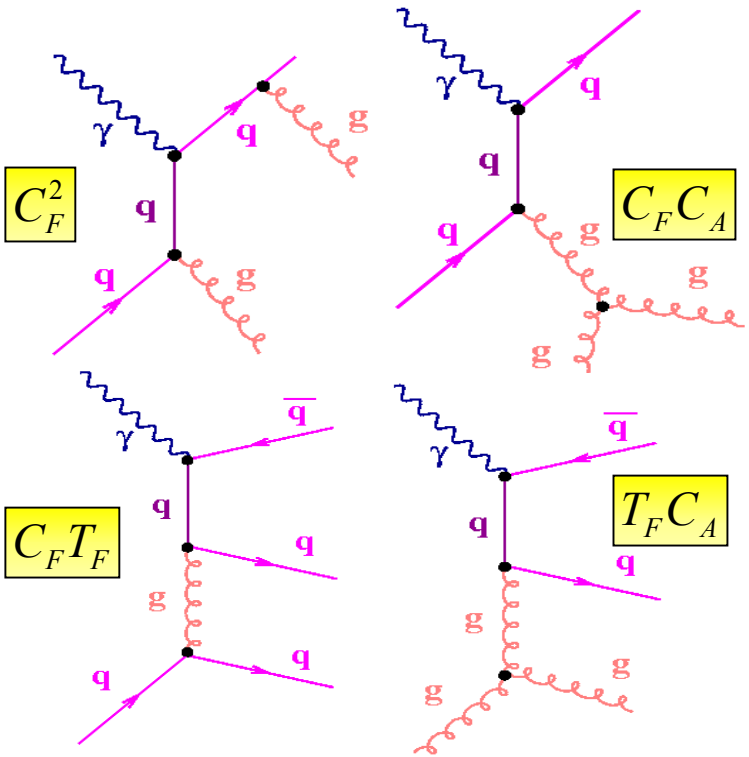
It seems to be QCD!

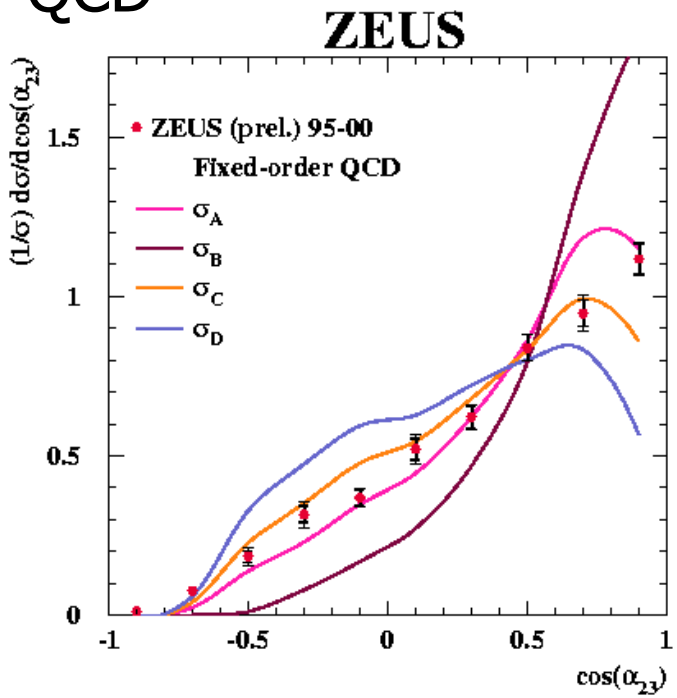
ANGULAR CORRELATIONS

Investigating the gauge structure of QCD

¶ In 3-jet production, several color factor combinations contribute to cross section:

$$\sigma_{ep\to 3jets} = C_F^2 \cdot \sigma_A + C_F C_A \cdot \sigma_B + C_F T_F \cdot \sigma_C + T_F C_A \cdot \sigma_D$$





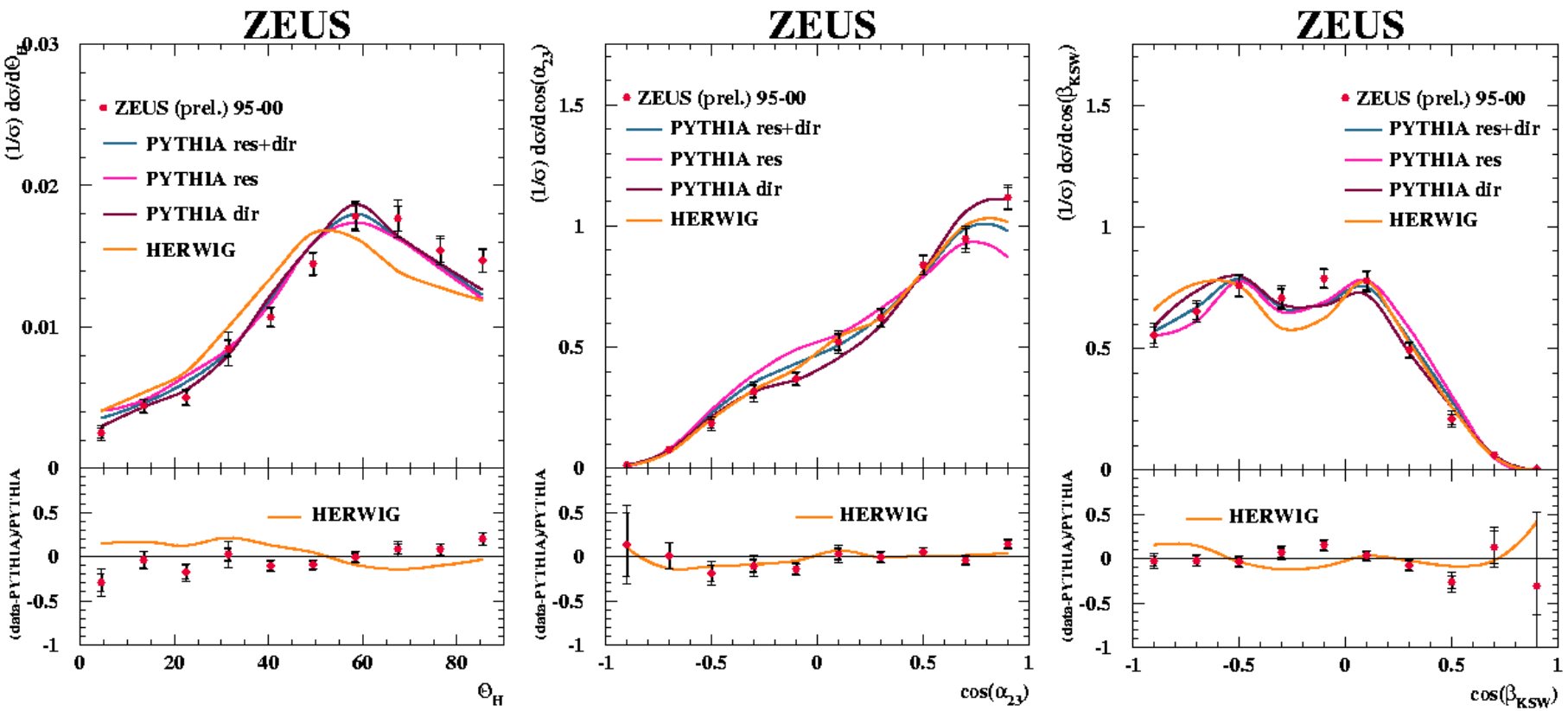
¶ Data sample: DIS: 98-00: 81.7pb^{-1},
γp: 95-00: 127pb^{-1};

¶ $Q^2 > 125$ GeV^2, $|\cos\gamma_h| < 0.65$;
($Q^2 < 1$ GeV^2), $0.2 < y < 0.85$;

¶ At least three jets (in Breit frame) with
– $E_T > 14$ GeV, $-1 < \eta < 2.5$, $x^{\gamma}_{obs} > 0.7$;
– $E_T > 8/5/5$ GeV, $-2 < \eta < 1.5$;

ANGULAR CORRELATIONS – PHOTOPROD.

Comparisons to MC models

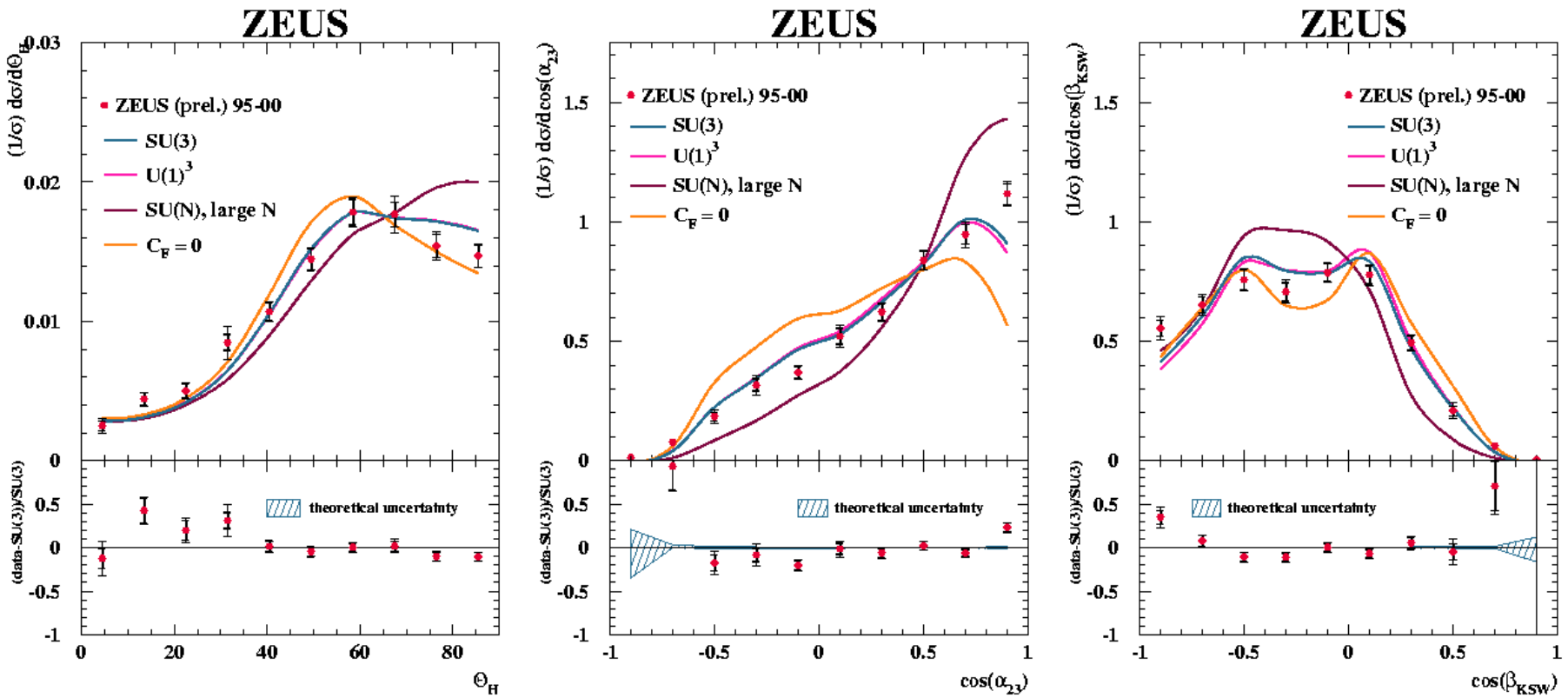


¶ PYTHIA provides better description of the data than HERWIG.

¶ Keep in mind: quark-induced contribution with triple-gluon vertex, σ_B, has significantly different shapes than others, but typically small.

ANGULAR CORRELATIONS – PHOTOPROD.

Comparisons to different theories



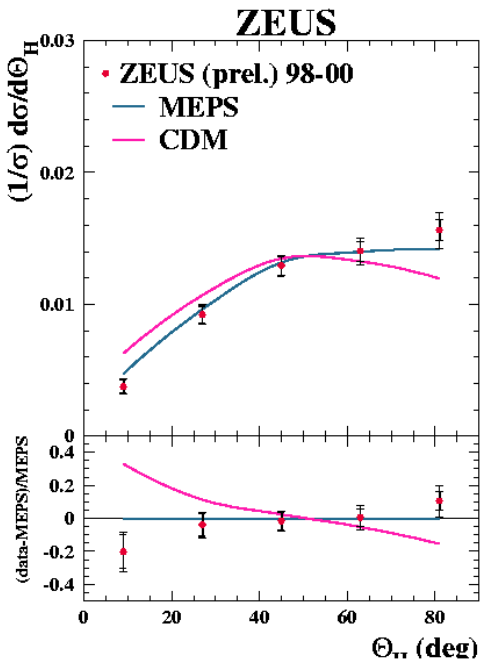
¶ Calculation based on SU(3) shows good description of data.

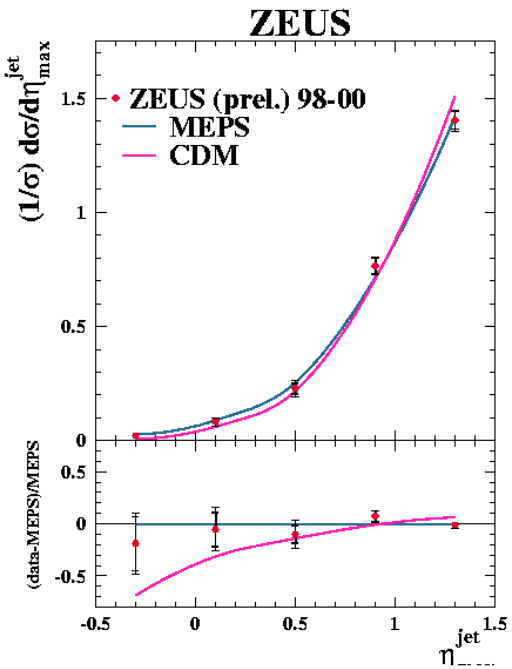
¶ Comparison to calculations based on other models (color factors) show similar / very different behaviour – sensitivity to color factors given!

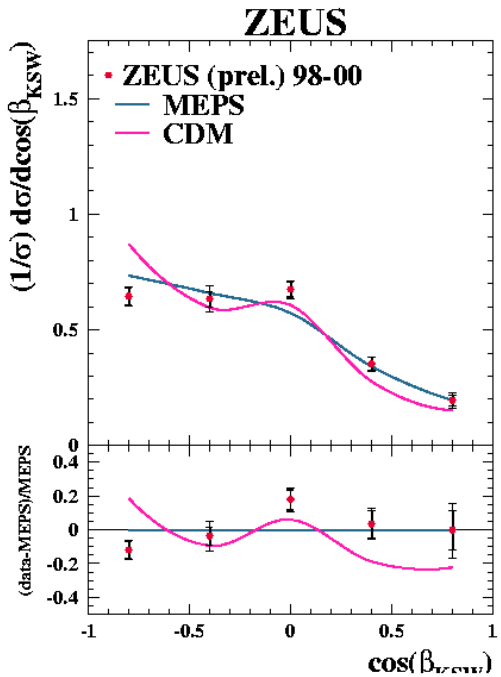
¶ SU(N) in large-N limit or for C_F=0 clearly disfavoured.

ANGULAR CORRELATIONS - DIS

Comparisons to MC models



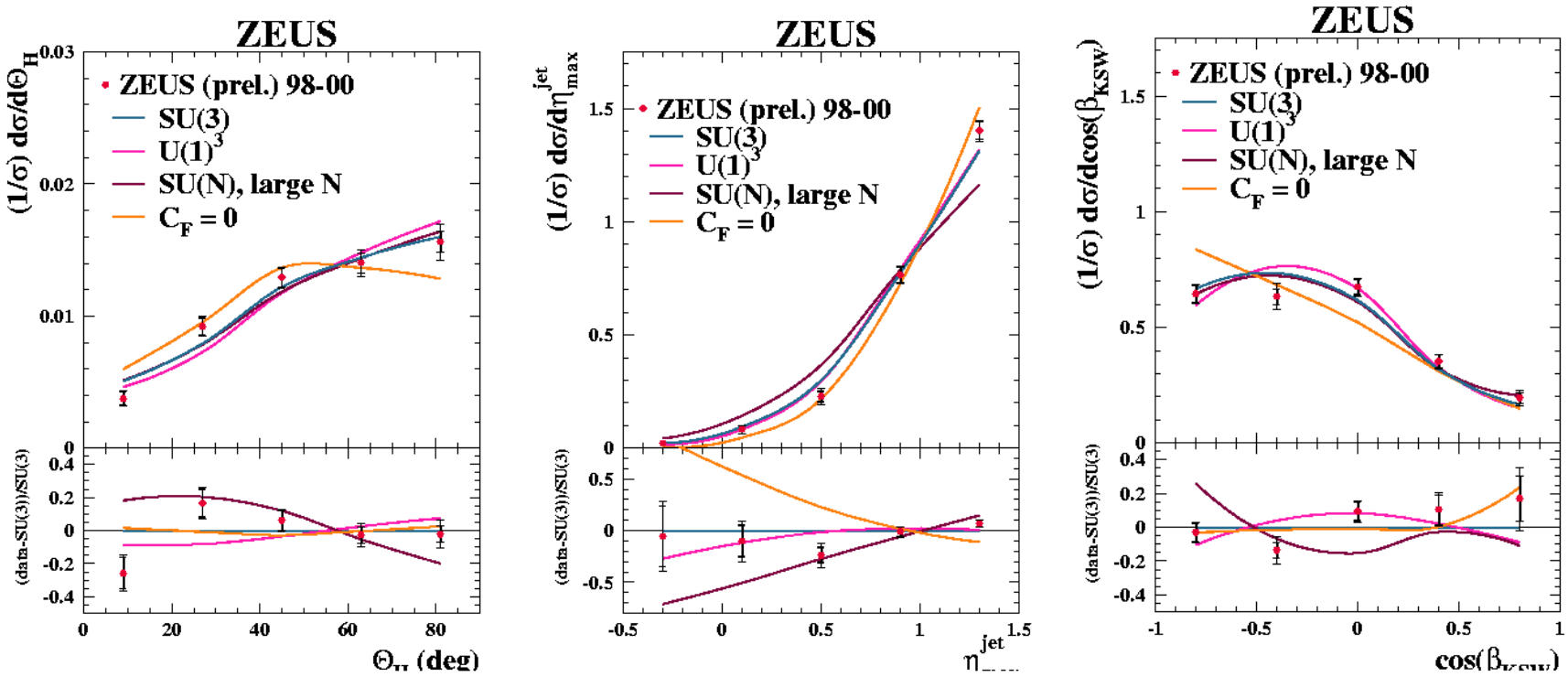




¶ MEPS MC model (LEPTO) provides better description of the data than CDM-based model (ARIADNE).

ANGULAR CORRELATIONS - DIS

Comparisons to different theories



¶ Calculation based on SU(3) shows good description of data.

¶ Comparison to calculations based on other models (color factors) show similar / very different behaviour – sensitivity to color factors given!

¶ $U(1)^3$ theory shows 10% differences to SU(3) – same order of stat. errors.

¶ SU(N) in large-N limit or for C_F=0 clearly disfavoured.

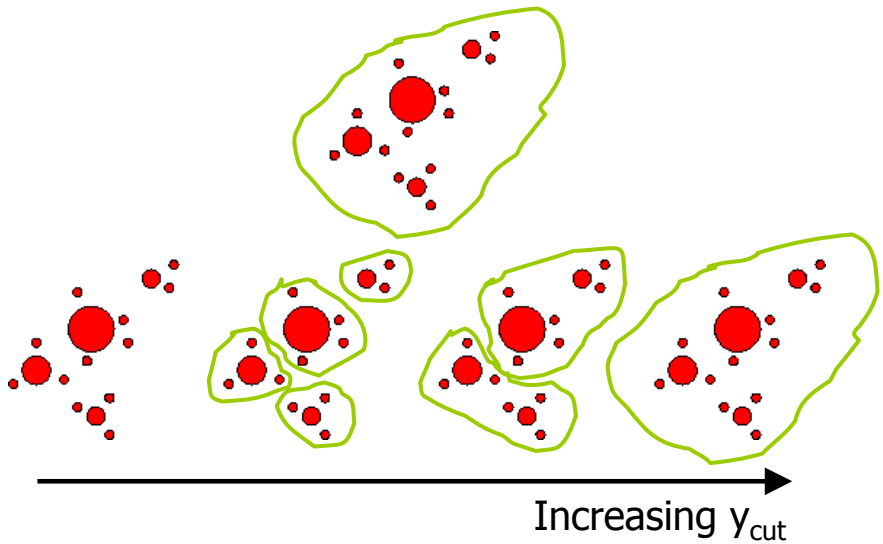
SUBJETS DISTRIBUTIONS IN DIS

Motivation: Study pattern of QCD radiation

¶ Tests of QCD radiation so far performed using measurements of
– integrated / differential jet shapes $\Psi(r)$ and
– subjet multiplicities
and using LO MC models with parton shower models.

¶ At sufficiently high transverse energies E_T fragmentation effects negligible
→ internal jet structure can be calculated perturbatively
→ stringent test of pQCD calculations.

¶ Used here: Distribution of subjets within jets.



SUBJETS DISTRIBUTIONS IN DIS

Event and Jet Selection

¶ Data sample: 98-00, 81.7pb^{-1};

¶ $Q^2 > 125$ GeV^2;

¶ standard cleaning cuts;

¶ longitudinally invariant k_T algorithm in lab frame on call cells;

¶ at least one jet with
- $E_T > 14$ GeV and
- $-1 < \eta < 2.5$

¶ Exactly two subjets resolved in a jet at $y_{cut} = 0.05$.

¶ Analysis performed in the lab frame:

– Current NLO calculations have ≤ 3 partons in final state; maximally two can be reconstructed in one jet – jet shape at $O(\alpha_S)$.

– In lab frame, up to 3 partons can be reconstructed in one jet – $O(\alpha_S^2)$.
→ significant test of pQCD!

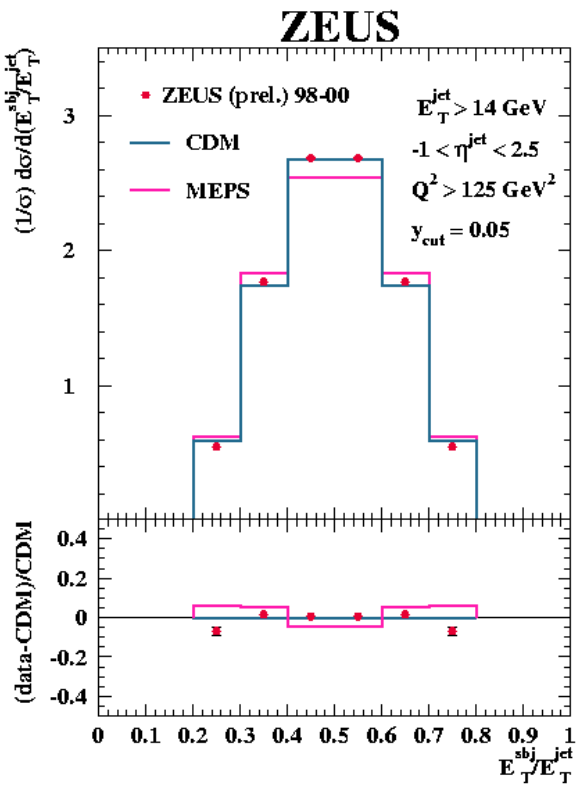
¶ Variables sensitive to subjet topology:
- $E_{T,sub}/E_{T,jet}$,
- $\eta_{sub}-\eta_{jet}$,
- $|\phi_{sub}-\phi_{jet}|$,
- α_{sub}.

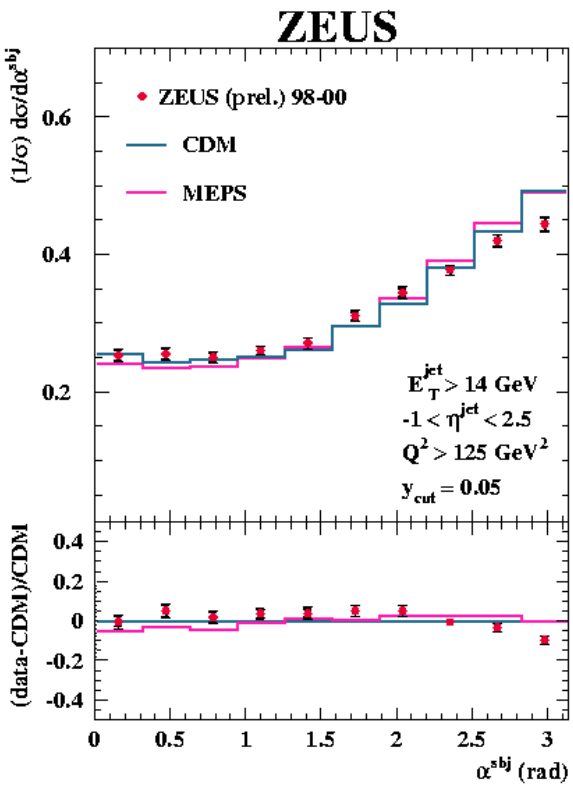
¶ Using normalized cross-sections.

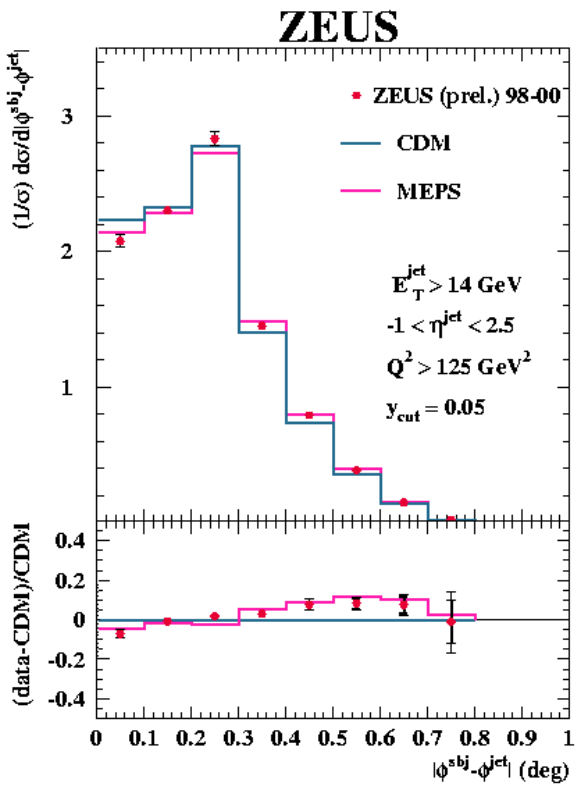
¶ Comparison to LO MC models and NLO QCD.

SUBJETS

Comparison to MC models 1





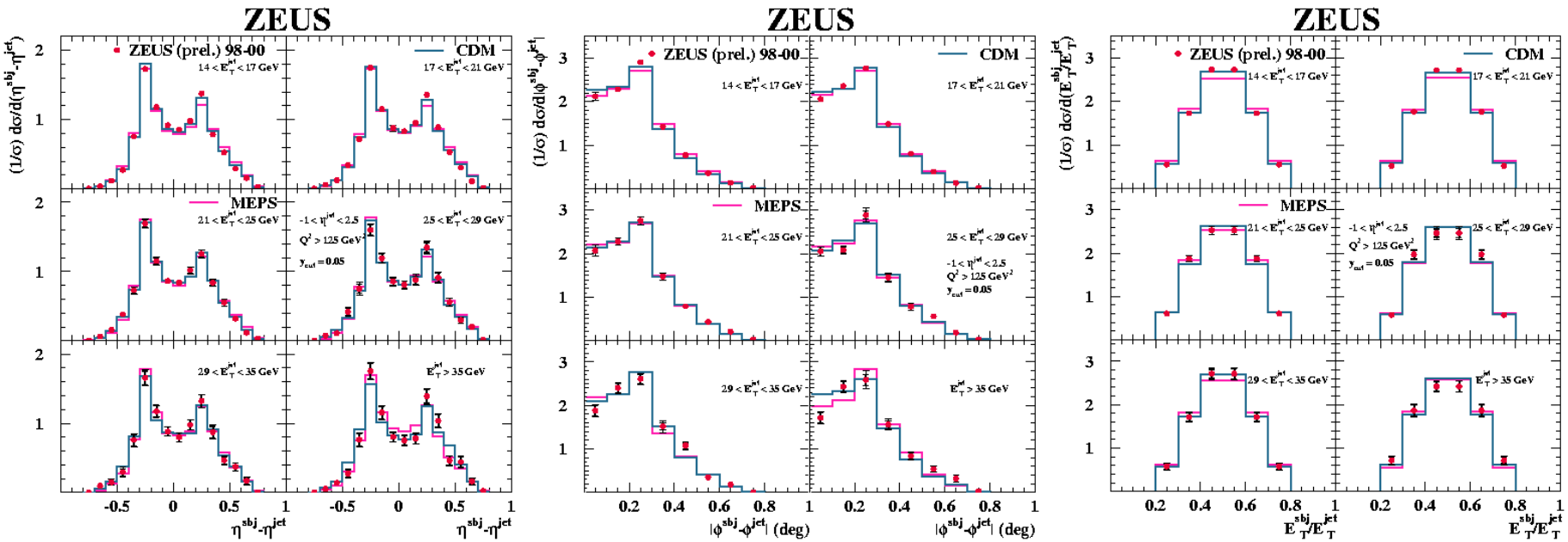


¶ Data show expected behaviour:
- Symmetric behaviour of E_T^{sub}/E_T; (two entries per event).
- No production of subjets close together in phase-space.
- The harder subjet tends to be in the backward direction.

¶ Both models describe the data reasonably well.

SUBJETS

Comparison to MC models 2 – double-differentially



¶ Data show expected behaviour:
- Symmetric behaviour of E_T^{sub}/E_T; (two entries per event).
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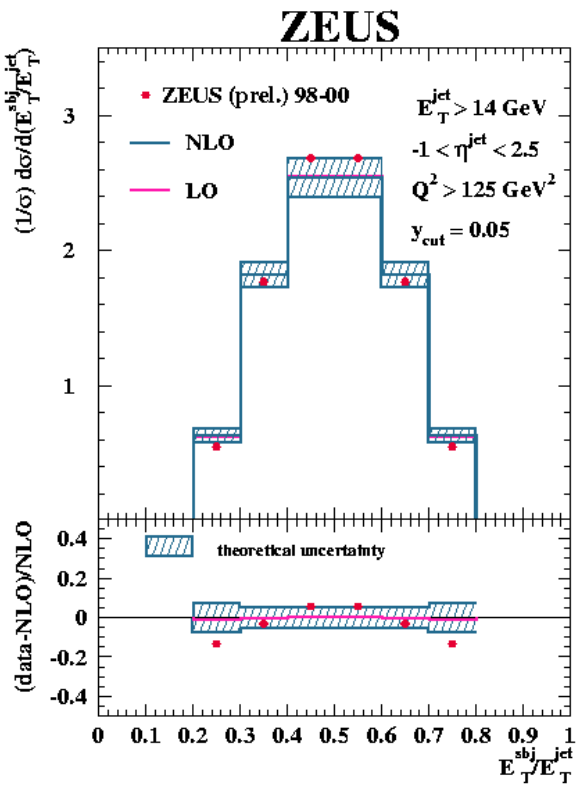
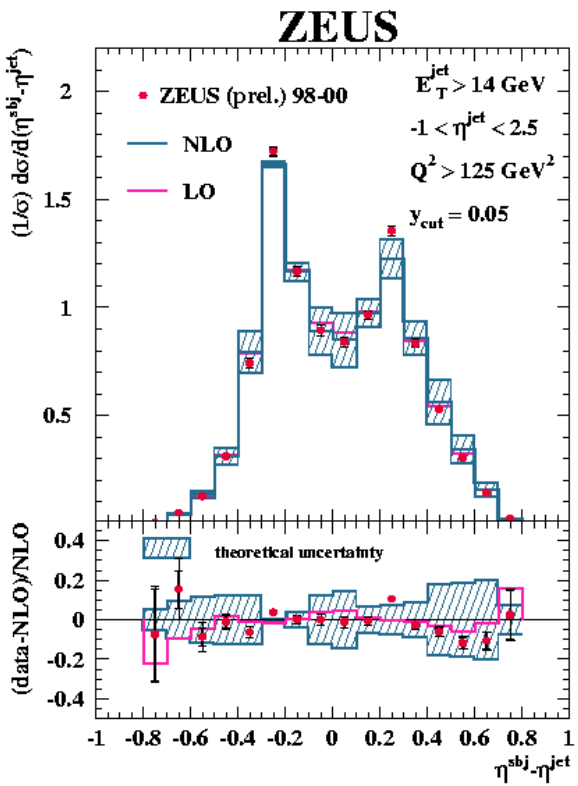
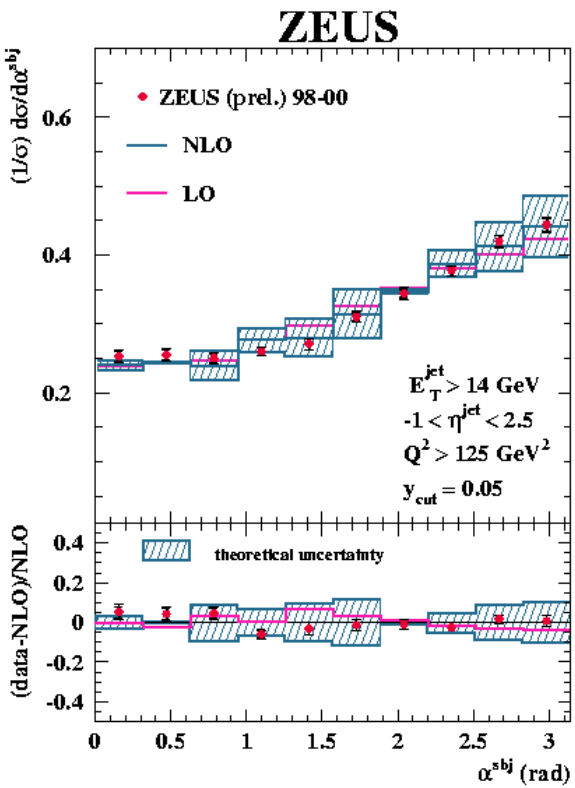
¶ Both models describe the data reasonably well.

SUBJETS

Comparison to NLO QCD 1





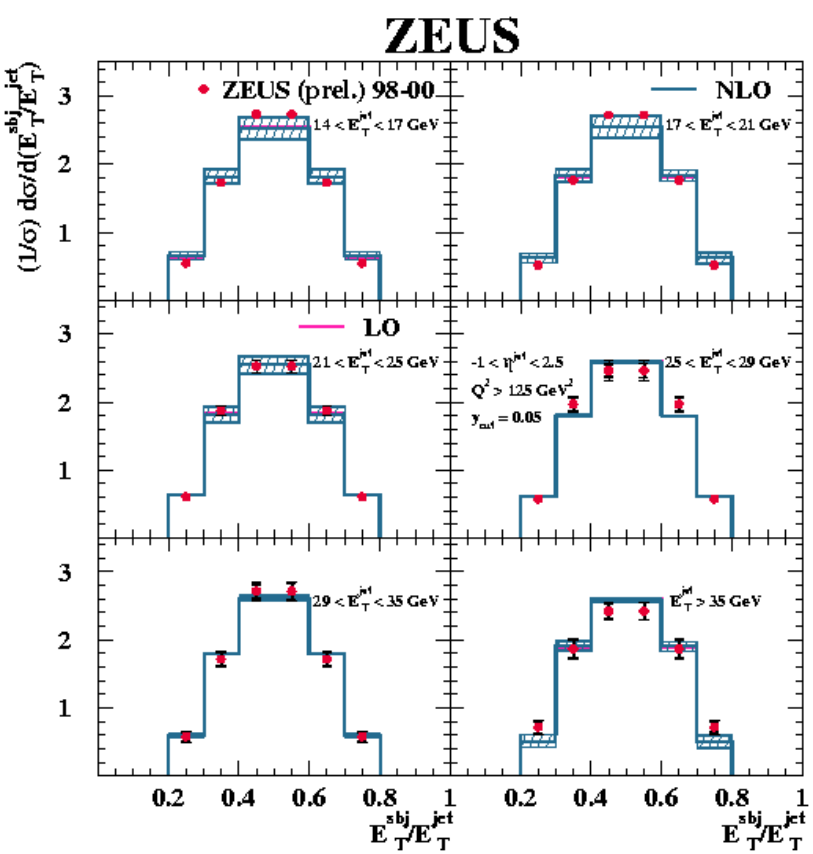


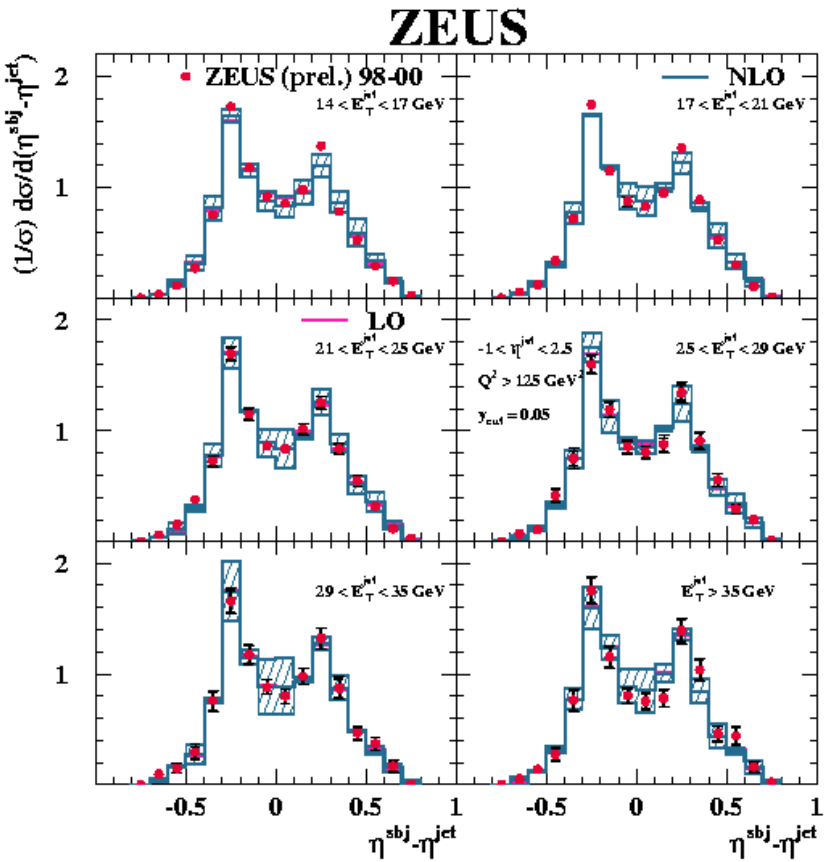
¶ NLO theory with up to three partons in a jet can reproduce data shapes very well.

¶ Theory supports hypothesis of hardest subjet being in backward direction.

SUBJETS

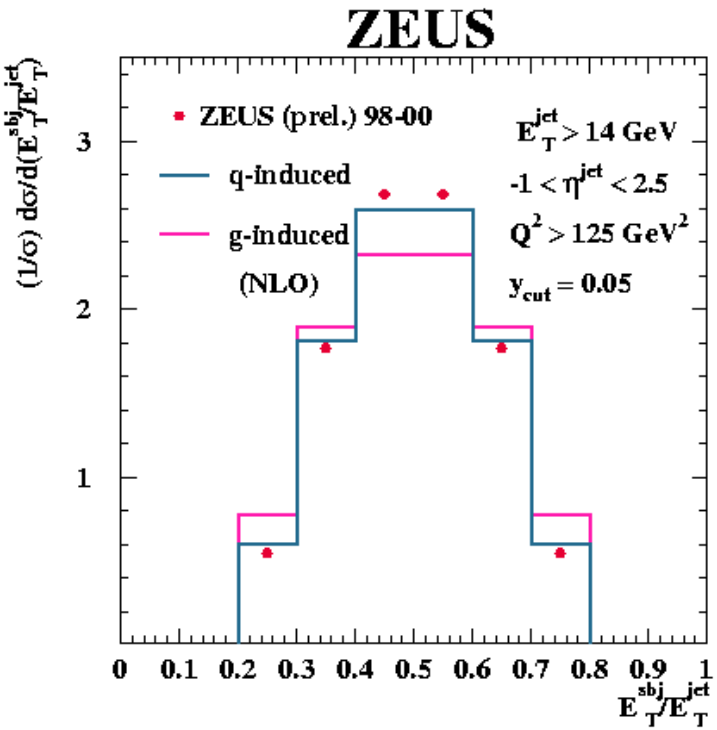
Comparison to NLO QCD 2 – double-differentially …

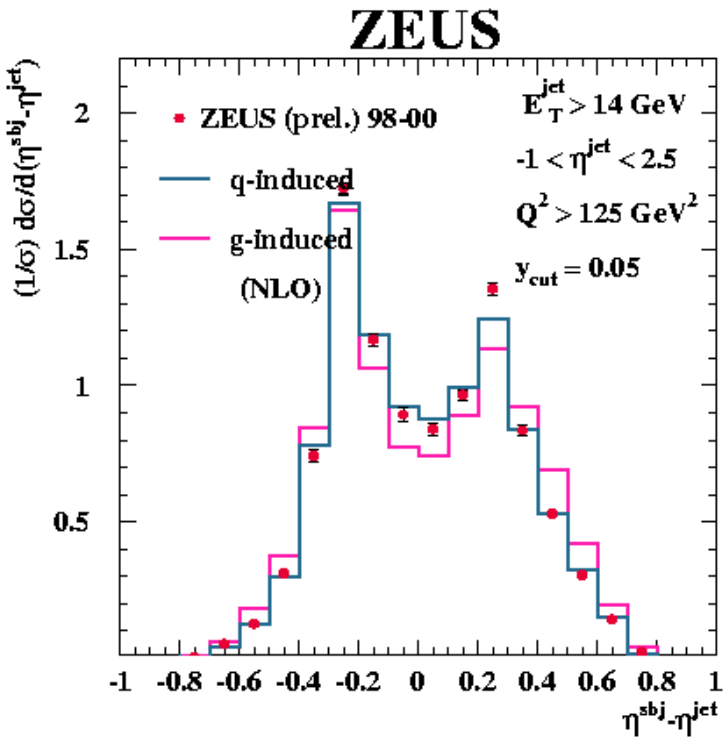




SUBJETS

Gluon-induced contribution





¶ Slightly different shapes of quark- and gluon-induced contributions to the NLO cross section.

¶ Data better described by quark-induced contribution which in the phase-space considered amounts to 82%.

¶ Subjets arising from qg pairs seem to be more balanced in ET and closer together than those from $q\bar{q}$ pairs.

SUMMARY

¶ HERA offers good opportunity to test QCD dynamics and radiation pattern.

¶ ZEUS three-jet angular correlations
– supply access to underlying gauge group via color factor analysis
– provide discriminating power between $SU(3)_C$ and other theories
– do not falsify $SU(3)_C$. although other groups also not excluded.

¶ ZEUS subjet distributions
– allow study of QCD radiation pattern within jets in perturbative regime
– are nicely described by NLO QCD calculations with up to three partons in one jet
- are dominated by quark-induced contributions for the phase-space region in question (and provide discrimination power between gluon- und quark-induced contributions).