ANGULAR CORRELATIONS IN 3-JET EVENTS *and* SUBJET DISTRIBUTIONS AT ZEUS

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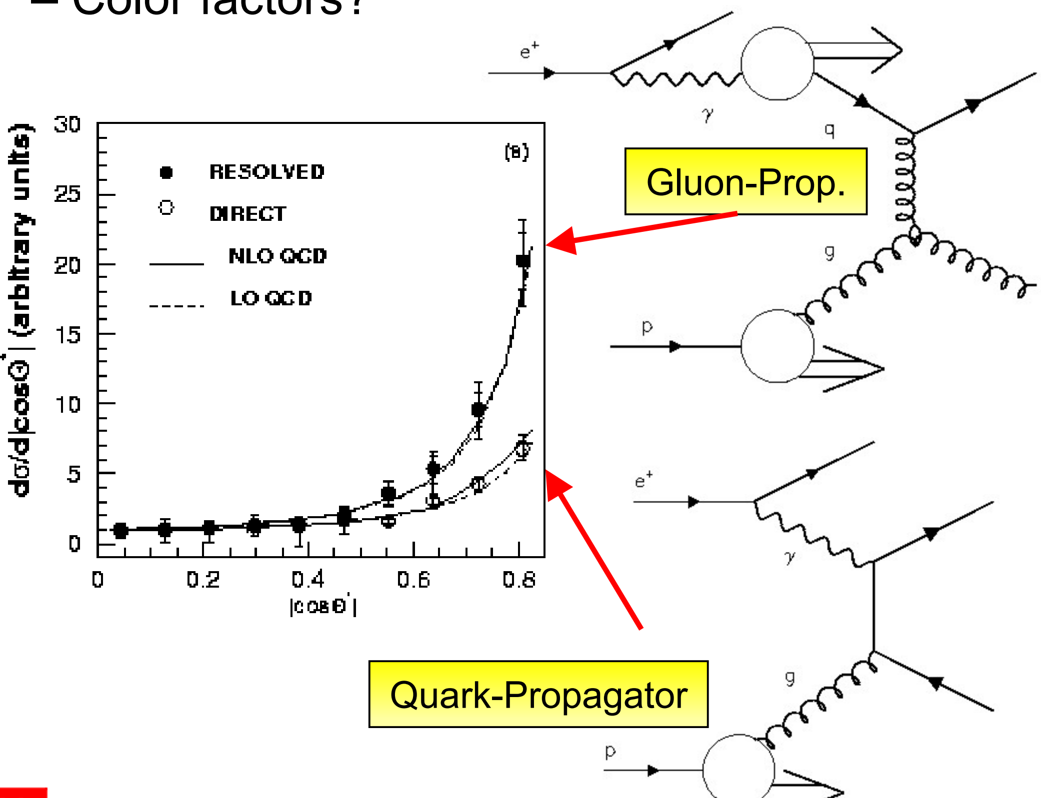
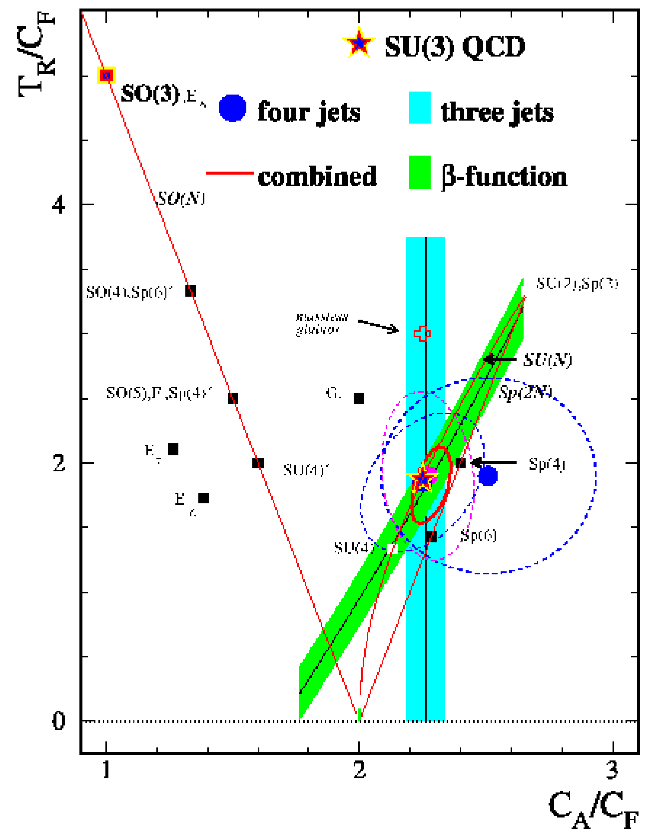
ANGULAR CORRELATIONS

Motivation: Is it really QCD?

- QCD: accepted effective theory of strong interactions.
- But – do we really see $SU(3)_C$?
  - non-abelian → 3-gluon vertex?
  - spin-1/2 (1) quarks (gluons)?
  - Color factors?



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



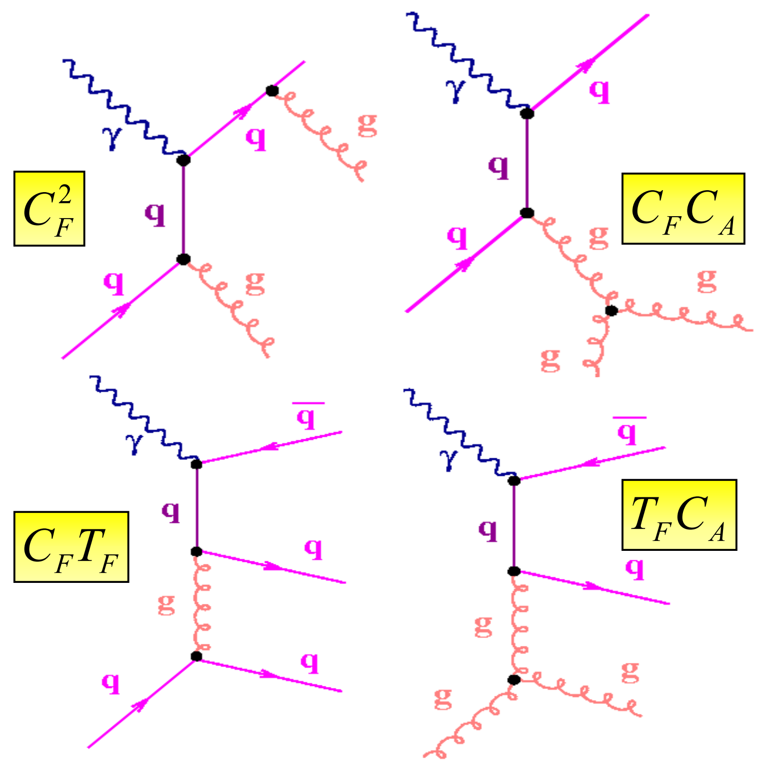
It seems to be QCD!
Strong interaction described by $SU(3)_C$!

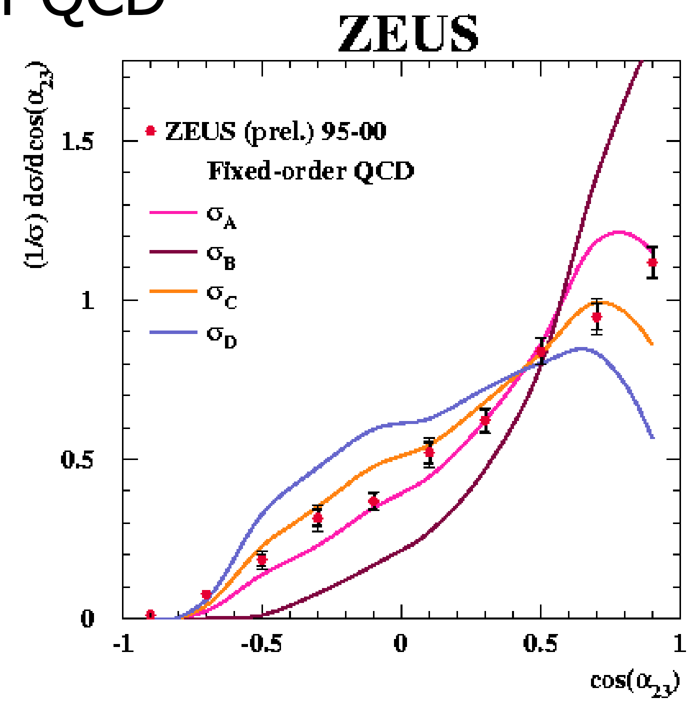
ANGULAR CORRELATIONS

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};

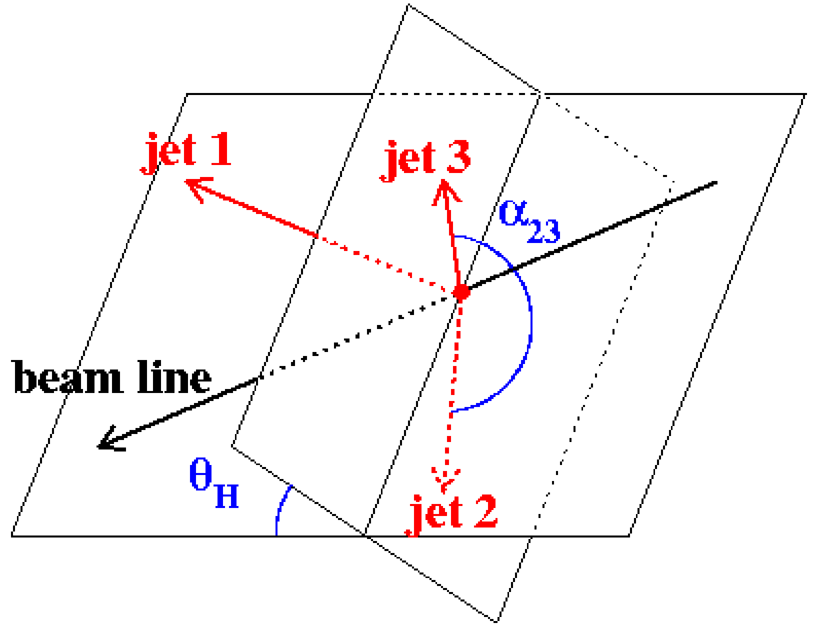
¶ $Q^2 > 125$ GeV^2, $|\cos\gamma_h| < 0.65$;
($Q^2 < 1$ GeV^2), $0.2 < y < 0.85$;

¶ 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

Variables of interest

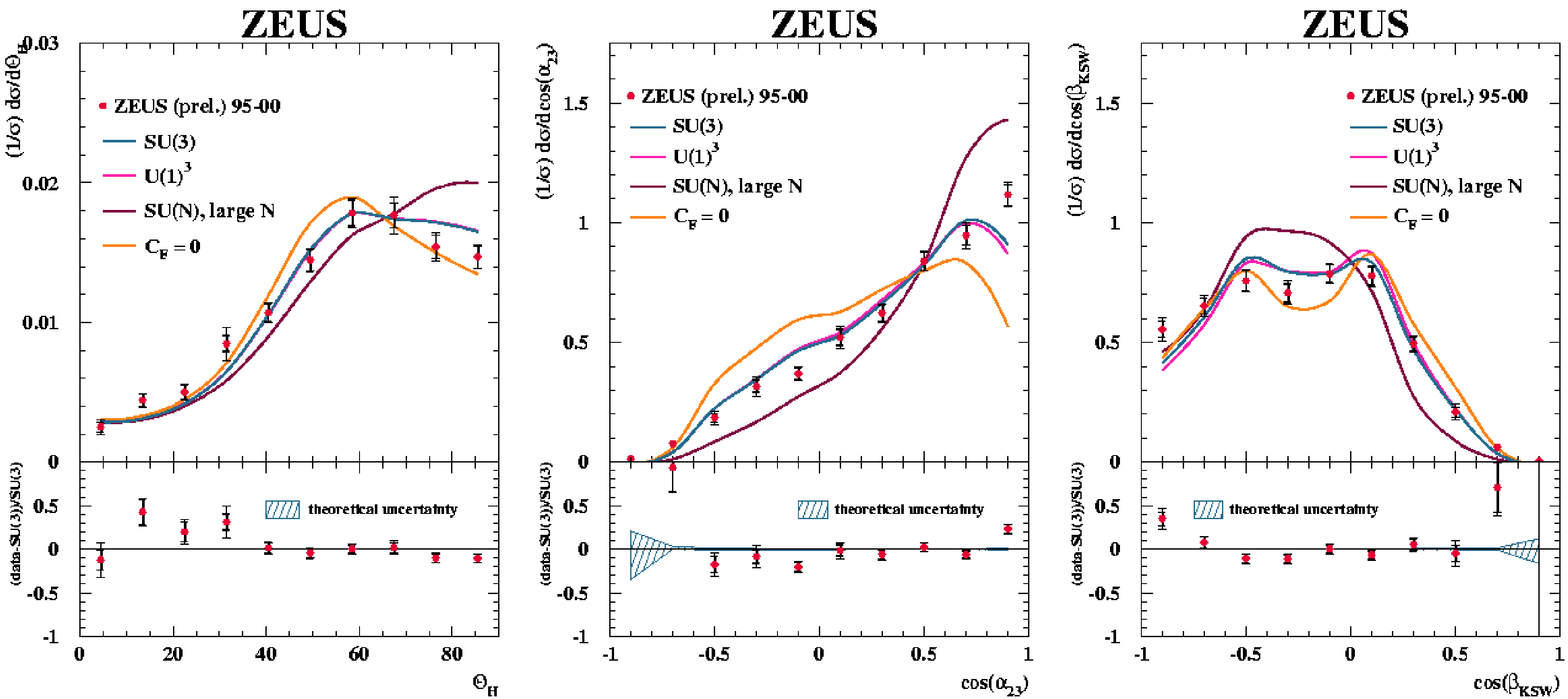
- ¶ θ_H: the angle between the planes determined by the highest E_T jet and the beam, and the two lowest E_T jets.
- ¶ α_{23}: the angle between the lowest E_T jets.



- ¶ $\cos(\beta_{KSW})$: $\cos\left[\frac{1}{2}\left(\angle[(\vec{p}_1 \times \vec{p}_3),(\vec{p}_2 \times \vec{p}_B)] + \angle[(\vec{p}_1 \times \vec{p}_B),(\vec{p}_2 \times \vec{p}_3)]\right)\right]$
- ¶ η^{jet}_{max}: the η of the most forward jet of the 3-jet system (only measured in DIS).

ANGULAR CORRELATIONS – PHOTOPROD.

Comparisons to different theories



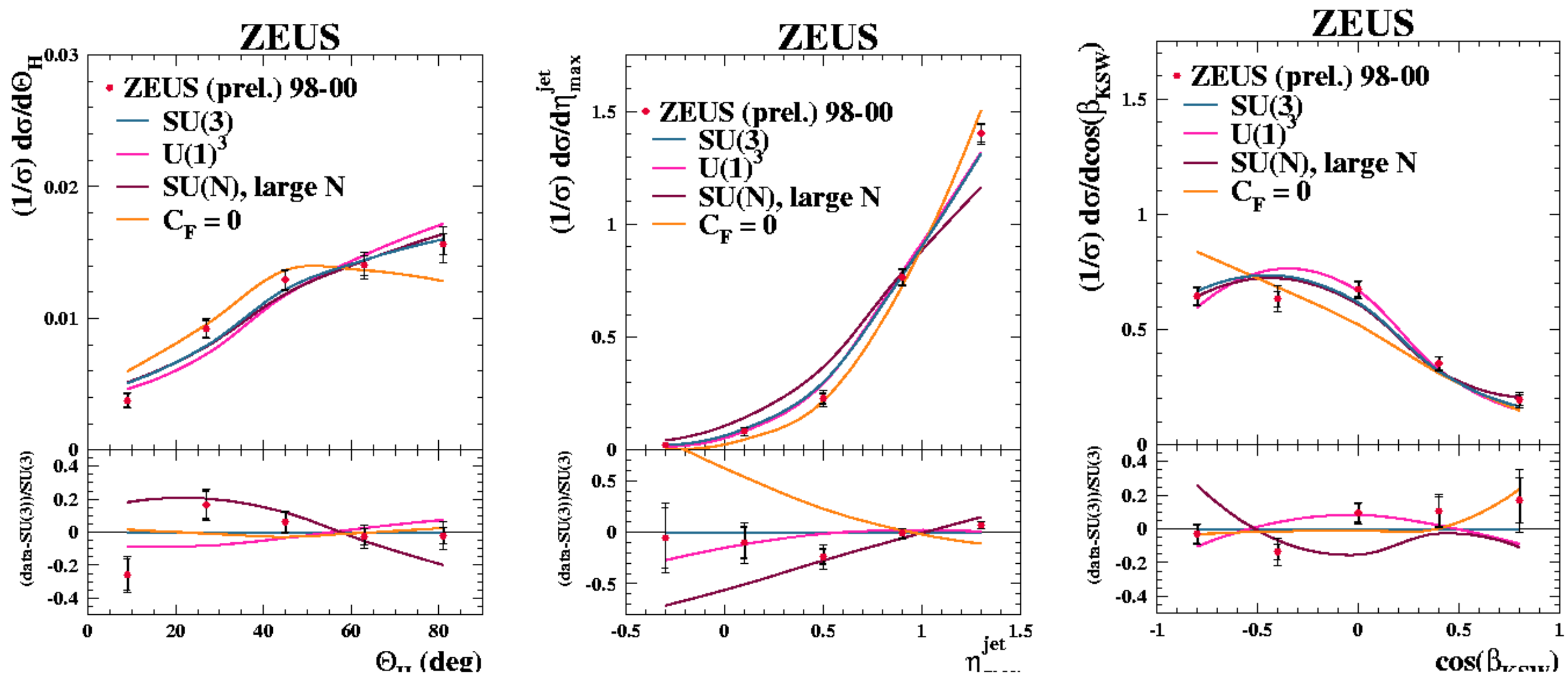
¶ Calculation based on $SU(3)_C$ shows good description of data (LO!).

¶ Comparison to calculations based on other models (adjustment of color factors) shows sensitivity to color factors!

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

ANGULAR CORRELATIONS - DIS

Comparisons to different theories



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

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

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

SUBJETS DISTRIBUTIONS IN DIS

Motivation: Study pattern of QCD radiation

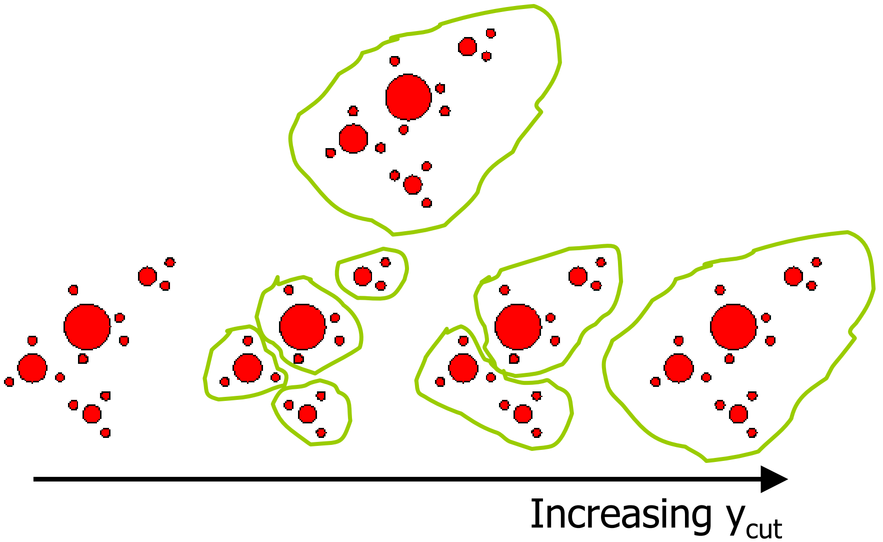
¶ Tests of QCD radiation so far performed using measurements of
– integrated / differential jet shapes $\Psi(r)$ and
– subjet multiplicities
and using LO MC models with parton shower models.

¶ 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. Specifically: Jets with two subjets at y_{cut}=0.05!

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

Angle (viewed from jet center) between hardest subjet and proton direction.



SUBJETS DISTRIBUTIONS IN DIS

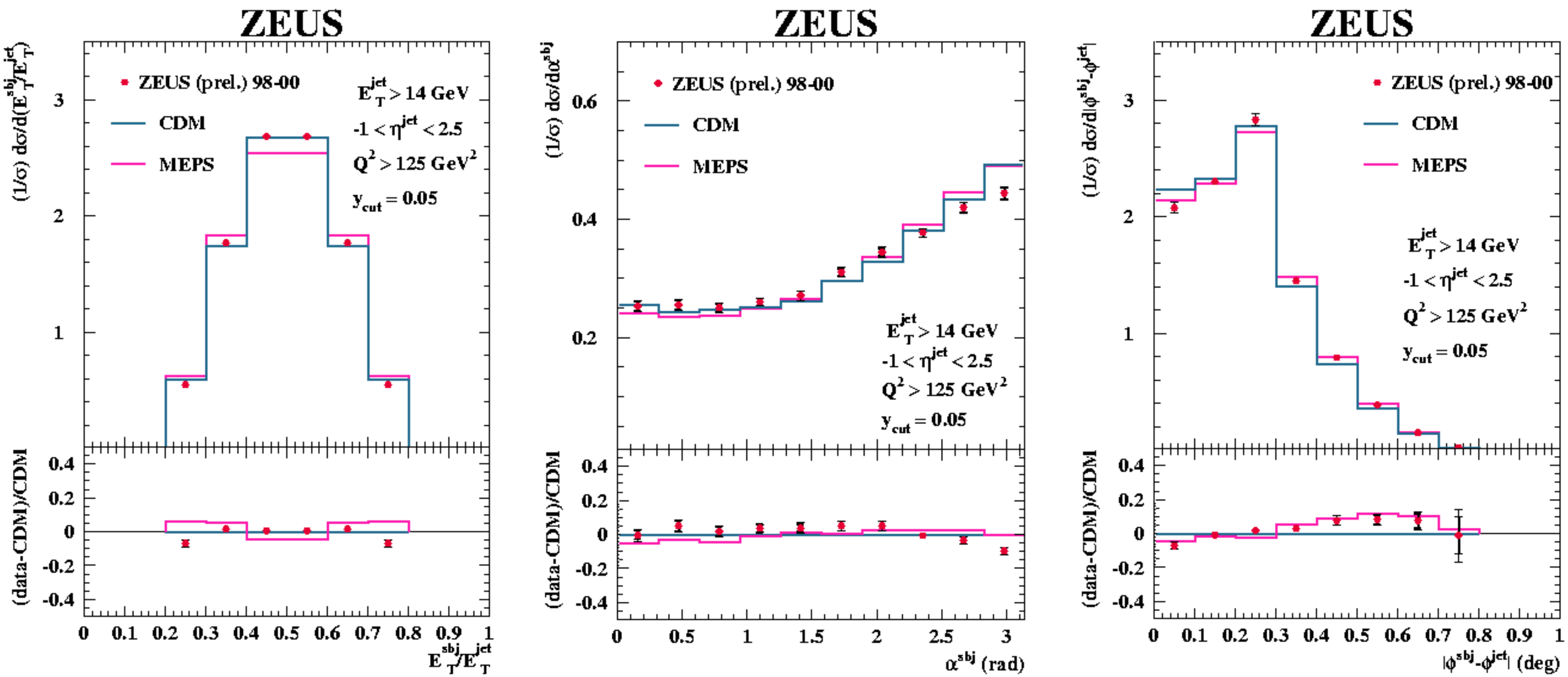
Event and Jet Selection

- Data sample: 98-00, 81.7pb^{-1};
- $Q^2 > 125$ GeV^2;
- standard cleaning cuts;
- longitudinally invariant k_T algorithm in lab frame on calorimeter cells;
- at least one jet with
  - $E_T > 14$ GeV and
  - $-1 < \eta < 2.5$
- Exactly two subjets resolved in a jet at $y_{cut} = 0.05$ (small hadronisation corrections).

- Analysis performed in the lab frame:
  - Current NLO calculations in Breit reference frame have ≤ 3 partons in final state; two at most 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!
- Using normalized cross-sections.
- Comparison to LO MC models and NLO QCD.

SUBJET DISTRIBUTIONS

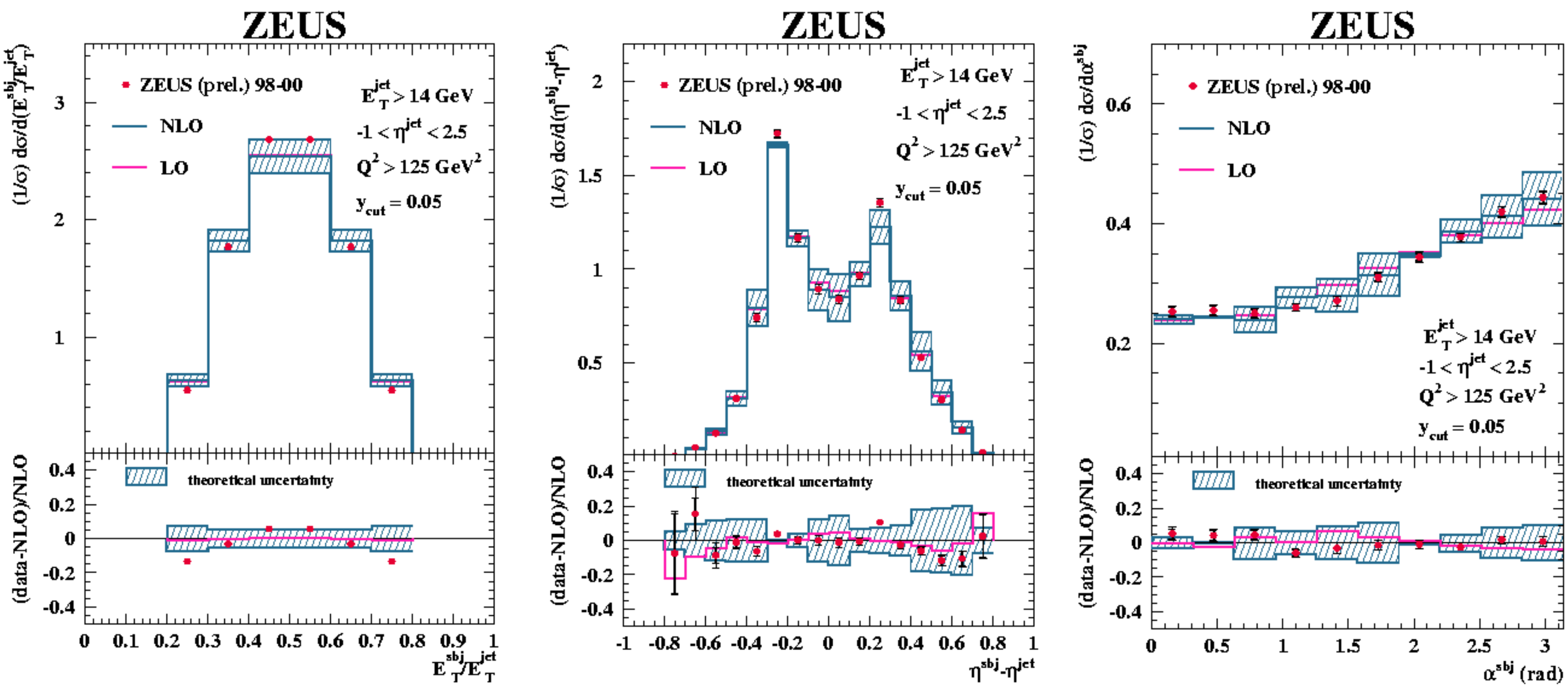
Comparison to MC models



- Data show expected behaviour:
  - Symmetric behaviour of E_T^{sub}/E_T by construction (two entries per event). Subjets tend to have similar E_T values.
  - 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 (also double-diff. distributions).

SUBJET DISTRIBUTIONS

Comparison to NLO QCD



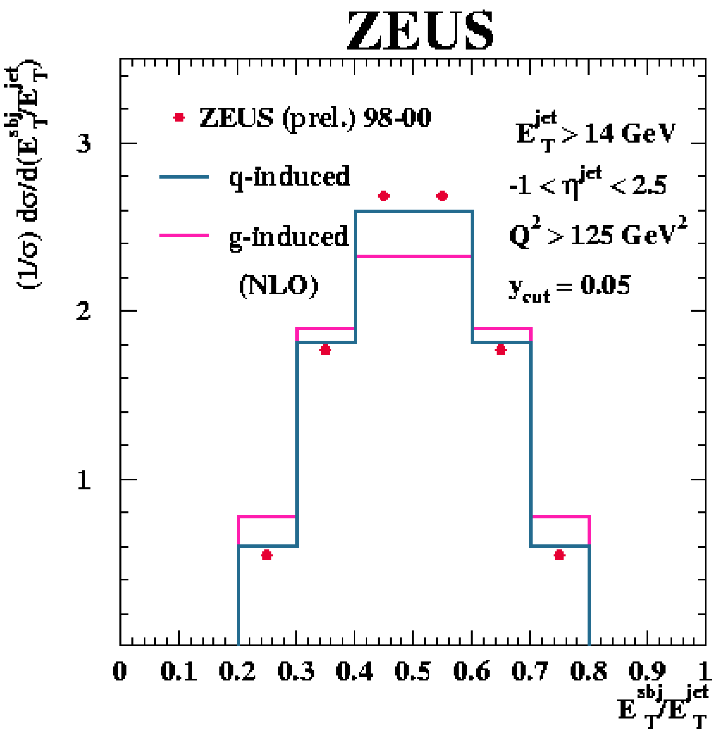
¶ NLO theory with up to three partons in a jet can reproduce data shapes well.

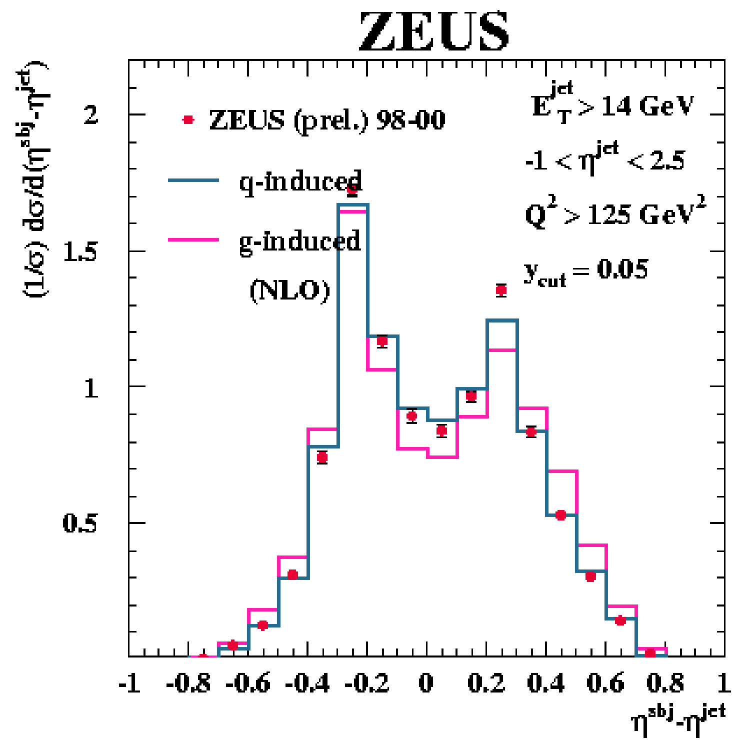
¶ Theory supports hypothesis of hardest subjet being in backward direction.

¶ Also double-differential distributions nicely described.

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 E_T 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).