Substructure dependence of jet cross sections at HERA and determination of α_s

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(On behalf of the ZEUS collaboration)

- **Introduction**
- **Experimental analysis and results**
- **Summary**

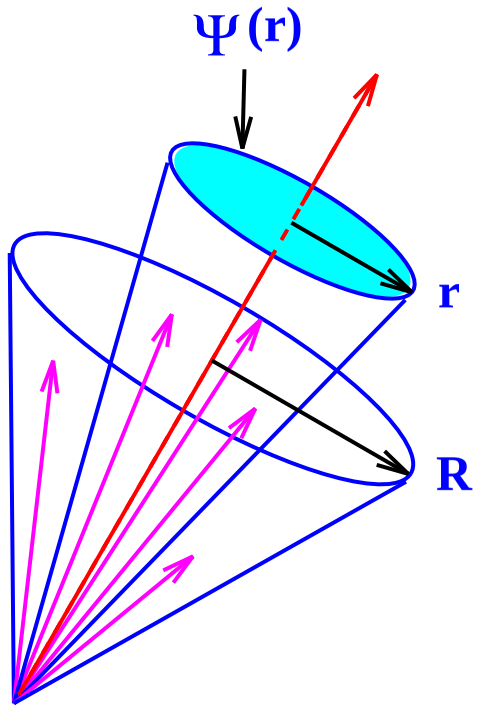
Introduction

The substructure of jets can provide:

- **information on the hadronisation process.**
- **separation of samples enriched in quark- and gluon-initiated jets**
- **separation of samples of different subprocesses**
- **information on the underlying parton dynamics**
- **an opportunity to extract α_s**

Jet substructure

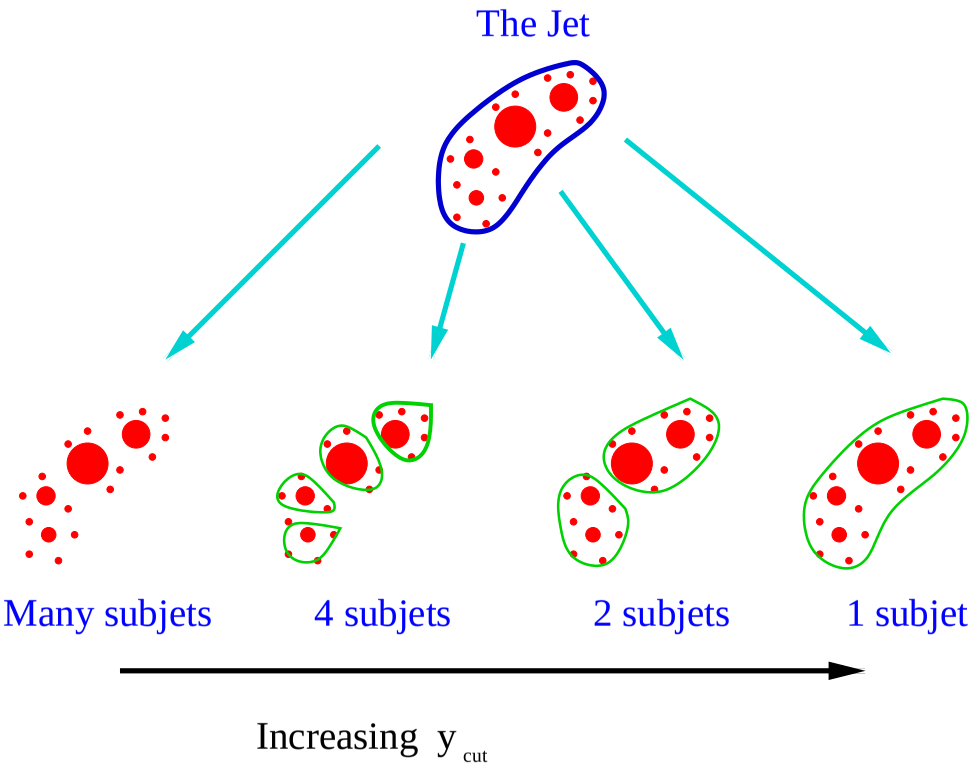
Integrated jet shape $\psi(r)$ is the average fraction of the jet's transverse energy that lies inside a cone in the $\eta - \phi$ plane of radius, r:



$$\psi(r) = \frac{1}{N_{\text{jets}}} \sum_{\text{jets}} \frac{E_T(r)}{E_T^{\text{jet}}}$$

Subjets resolved within a jet by considering all particles associated with the jet and reapplying the k_T algorithm until for all particle pairs, i, j,

$$d_{ij} > d_{\text{cut}} = y_{\text{cut}} \left(E_T^{\text{jet}}\right)^2$$



Kinematic ranges

Photoproduction sample

$Q^2 < 1\text{GeV}^2$

$142 < W_{\gamma p} < 293\text{GeV}$

Inclusive jet sample:

- $E_T^{\text{jet}} > 17\text{GeV}$
- $-1 < \eta^{\text{jet}} < 2.5$

Dijet sample:

- $E_T^{\text{jet1,2}} > 17, 14\text{GeV}$
- $-1 < \eta^{\text{jet1,2}} < 2.5$
- $M^{\text{jj}} > 52\text{GeV}$ & $|\cos\theta^*| < 0.8$

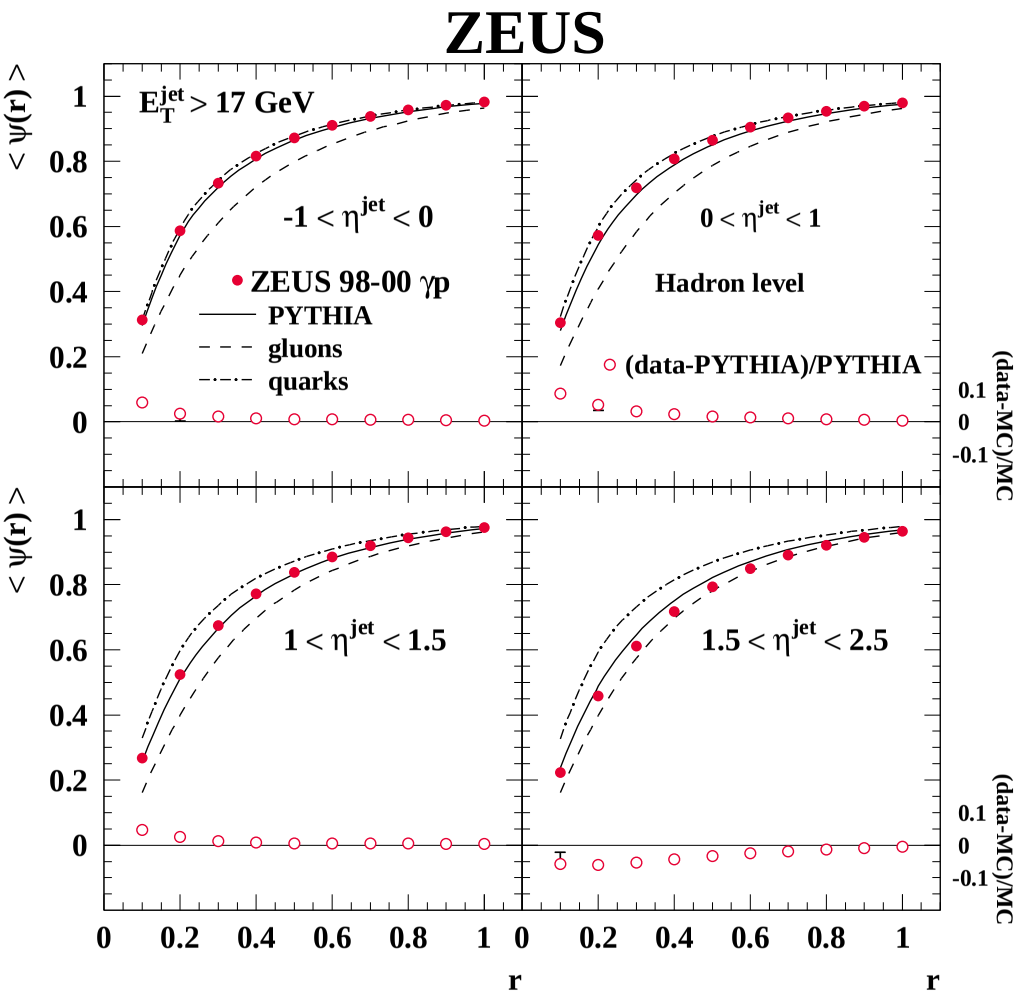
Deep inelastic scattering sample

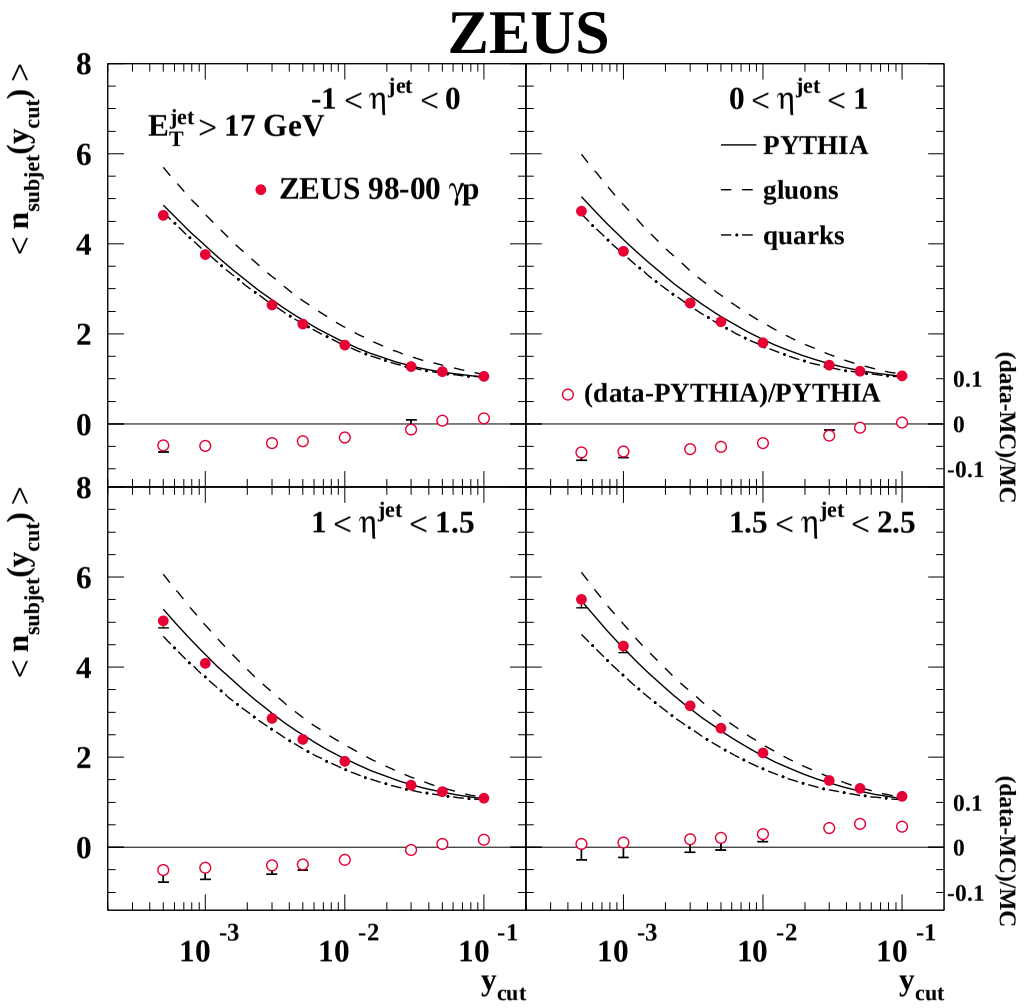
$Q^2 > 125\text{GeV}^2$

Inclusive jet sample:

- $E_T^{\text{jet}} > 17\text{GeV}$
- $-1 < \eta^{\text{jet}} < 2.5$

Measurements of jet substructure (γp)



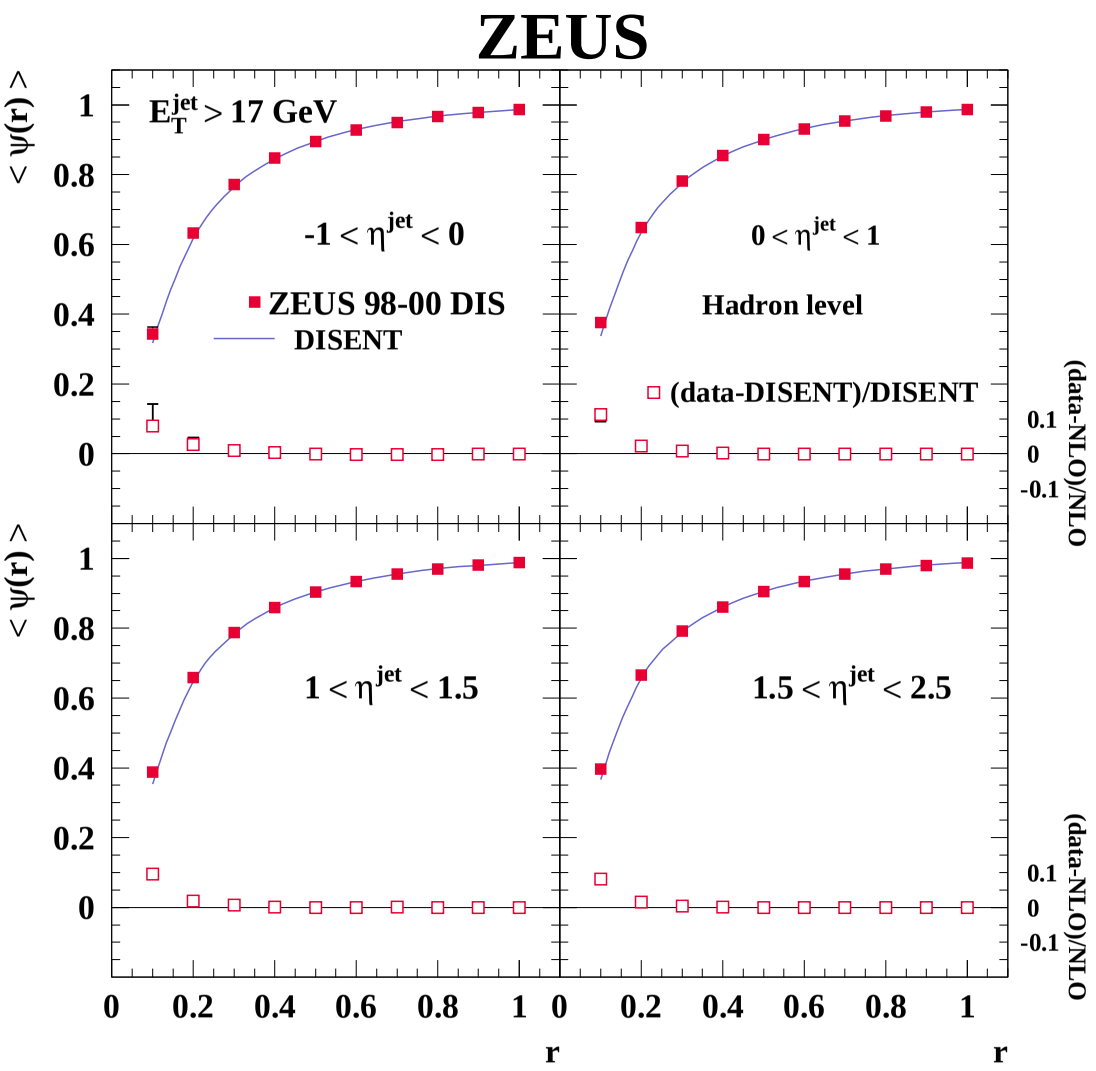


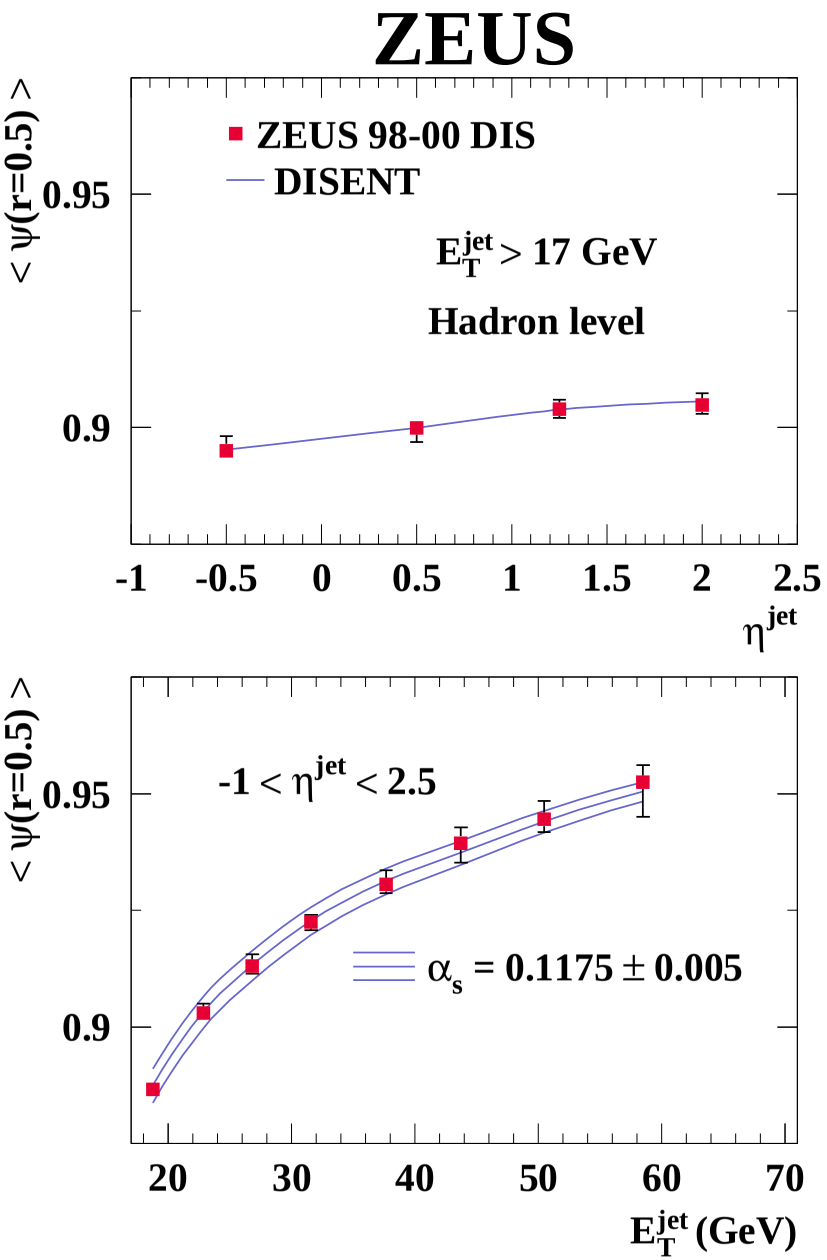
Difference between quark and gluon jets.

Data becomes increasingly more gluon-like with increasing η^{jet}.

Similar quality of description as a function of E_T^{jet}.

Measurements of jet substructure (DIS)





Good description by NLO calculation (with hadronisation).

Sensitivity to α_s

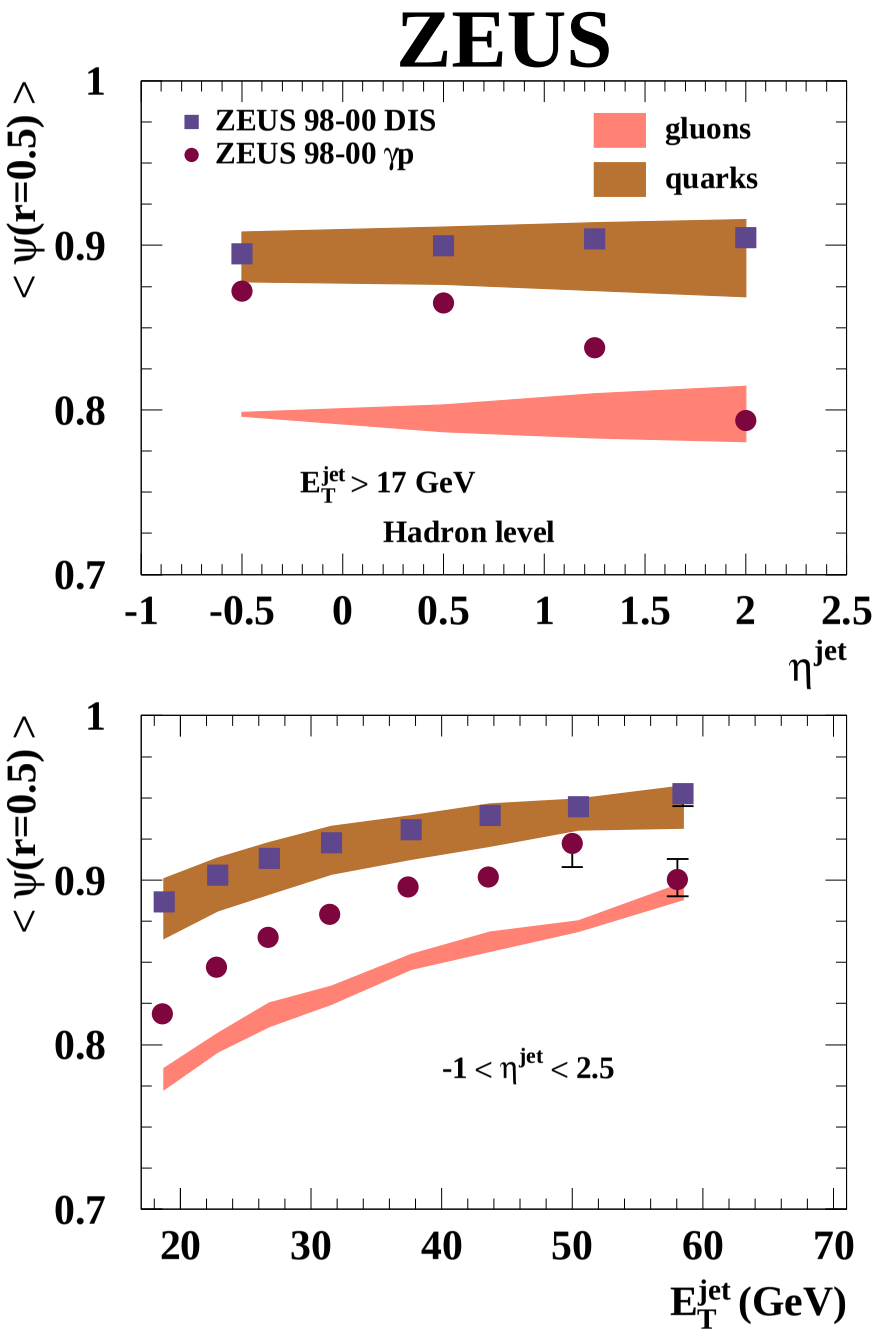
Jet substructure in γp and DIS

Jets in DIS consistent with being dominated by q-jets

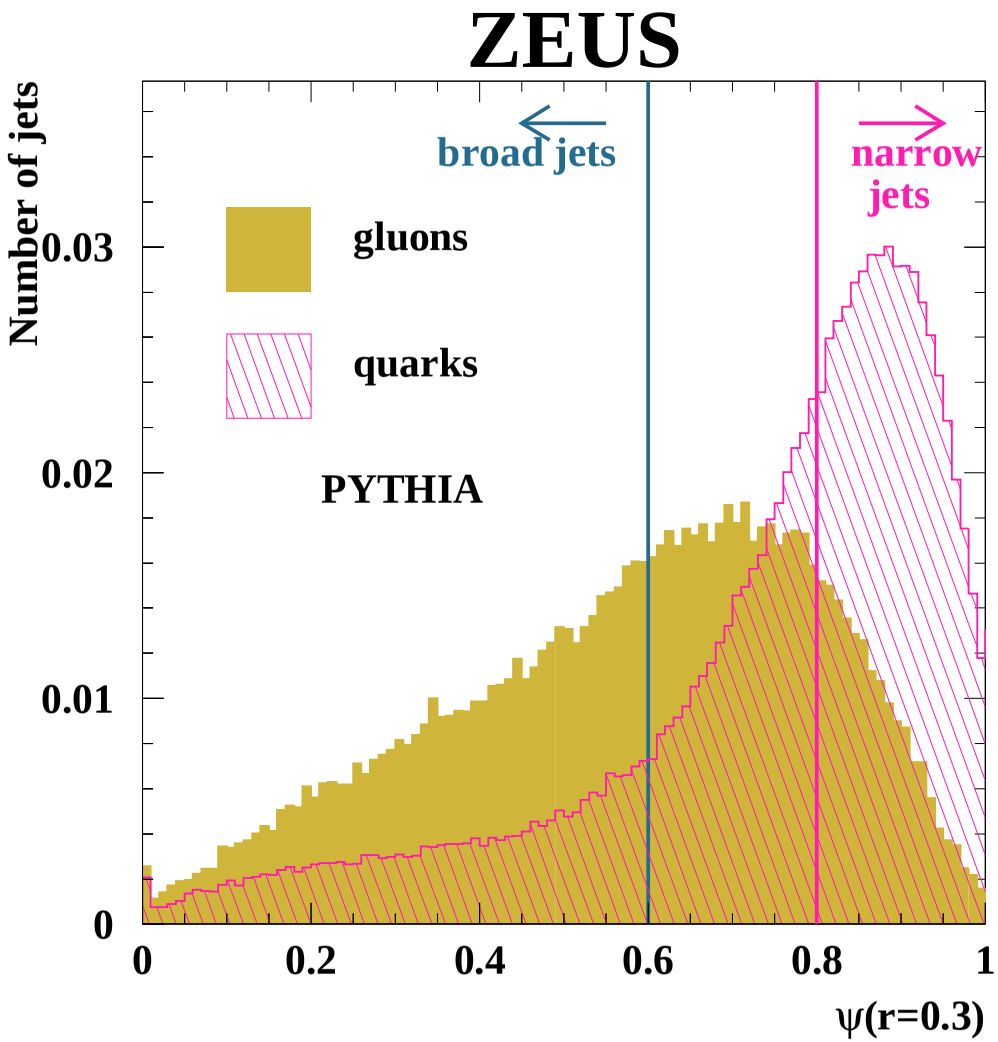
Jets in photoproduction and DIS similar in the rear direction

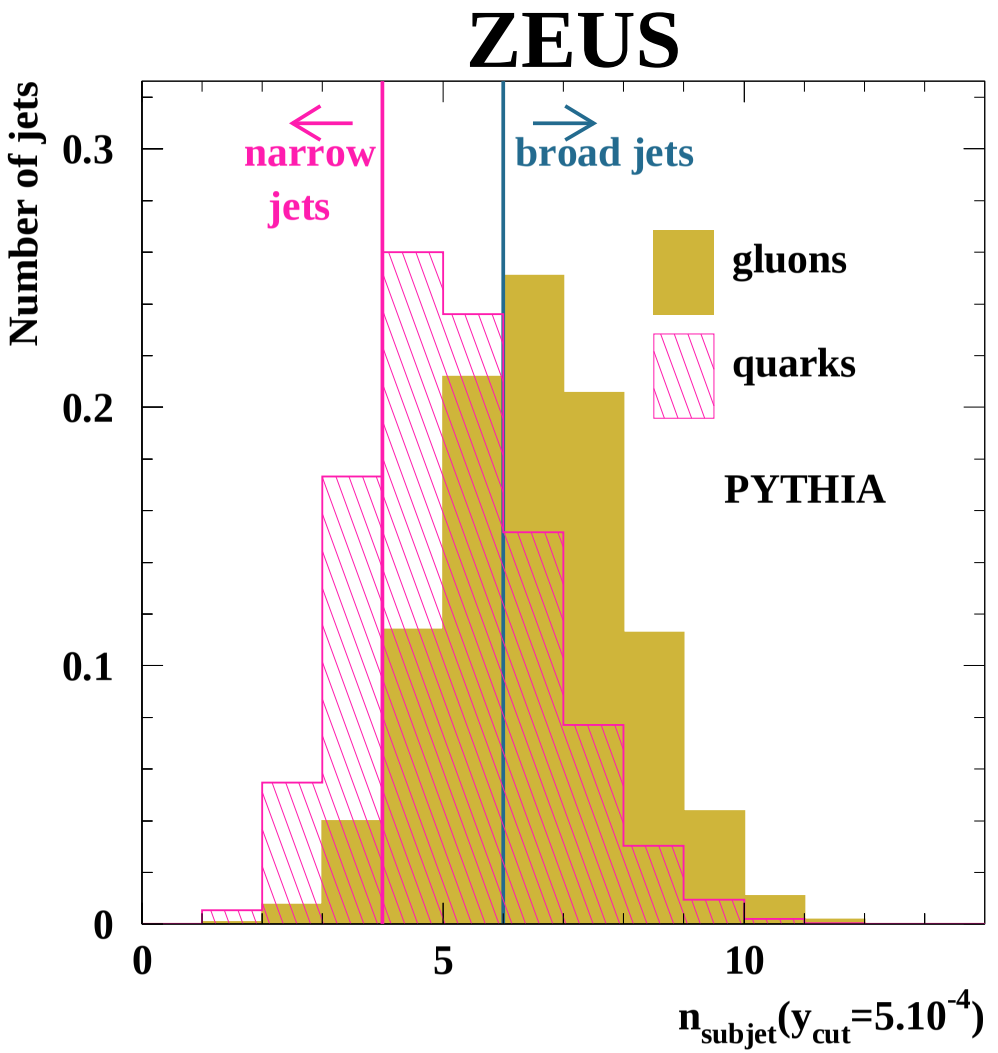
Jets in photoproduction become more gluon like with:

- **increasing η^{jet}**
- **decreasing E_T^{jet}**



Separation of quark and gluon jets

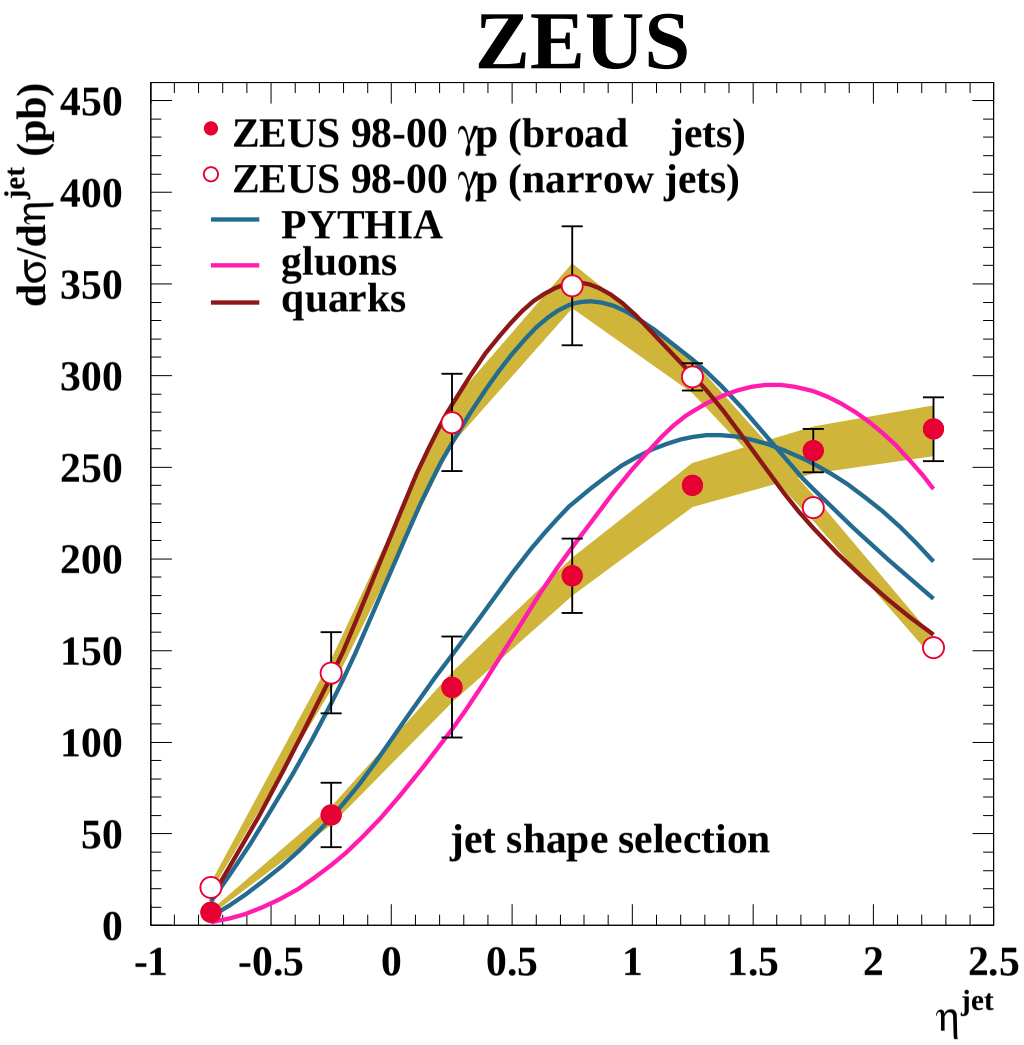


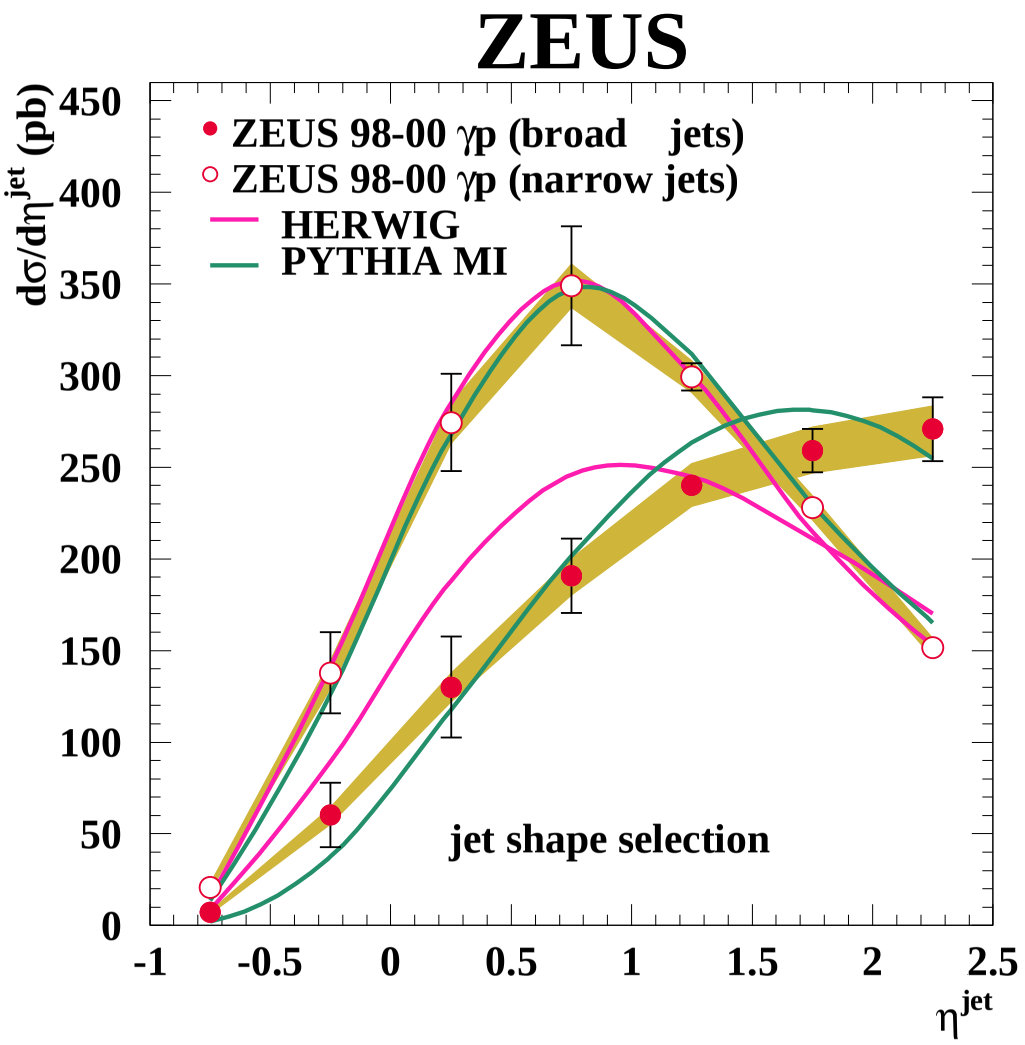


Gluon-enriched (broad jets): $\psi(r = 0.3) < 0.6$ **and/or** $n_{\text{subjet}}(y_{\text{cut}} = 5 \cdot 10^{-4}) \geq 6$

Quark-enriched (narrow jets): $\psi(r = 0.3) > 0.8$ **and/or** $n_{\text{subjet}}(y_{\text{cut}} = 5 \cdot 10^{-4}) < 4$

Measurements of $d\sigma/d\eta^{\text{jet}}$ in γp

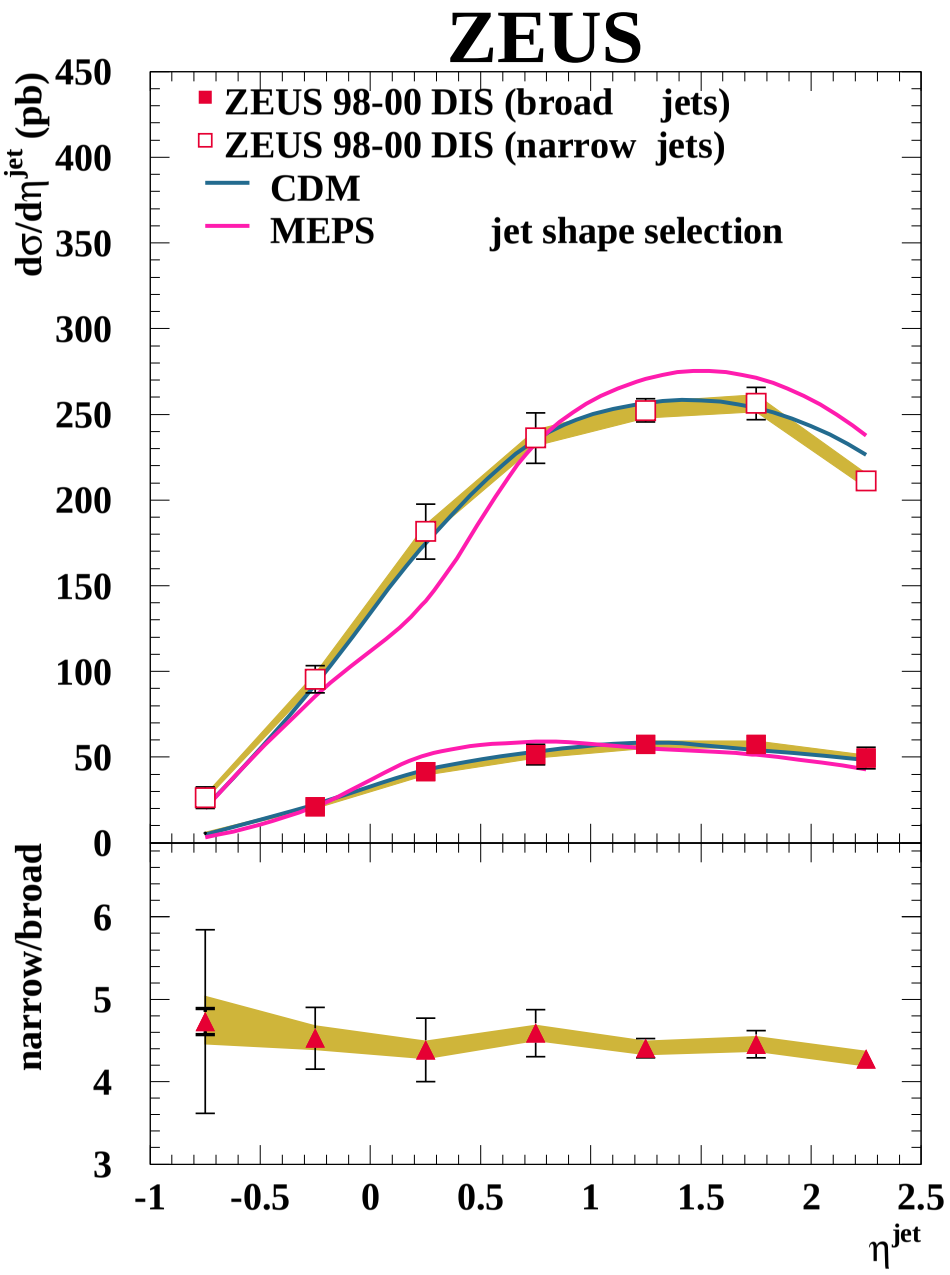


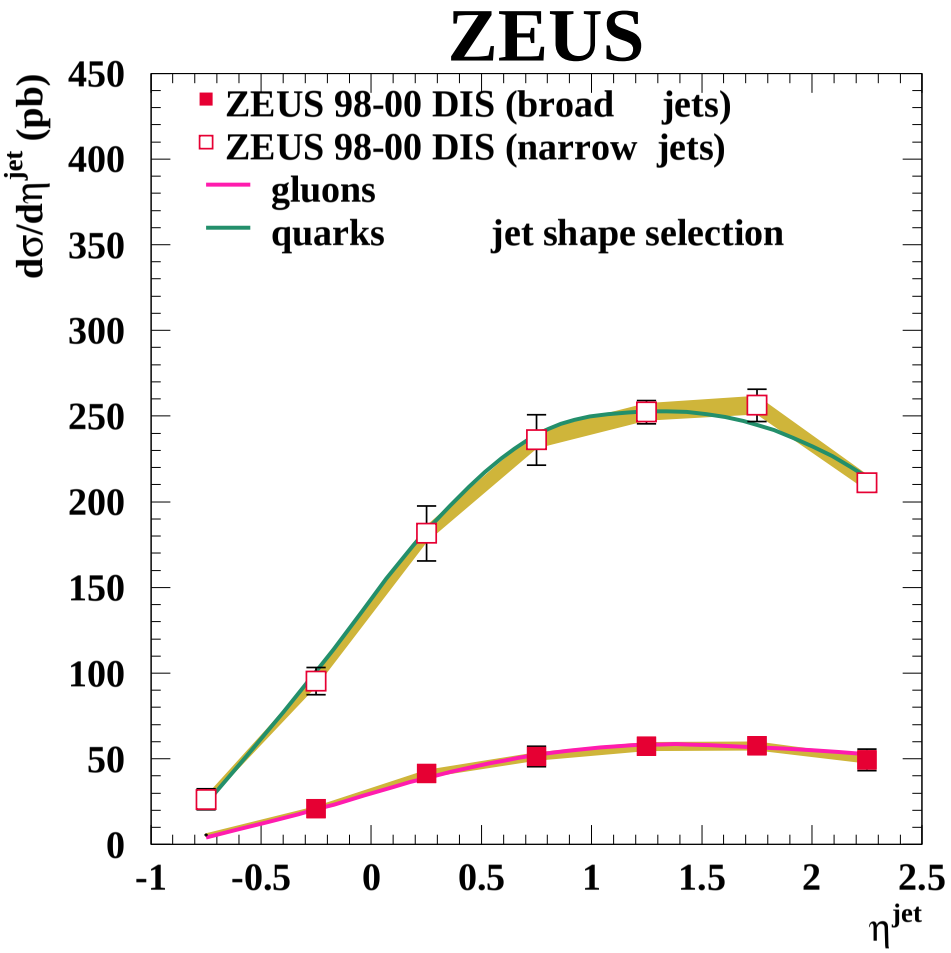


Broad jets: 15(12)% gg, 50(47)% qg, 35(41)% qq from PYTHIA (HERWIG)

Narrow jets: 4(3)% gg, 34(36)% qg, 62(61)% qq from PYTHIA (HERWIG)

Measurements of $d\sigma/d\eta^{\text{jet}}$ in DIS

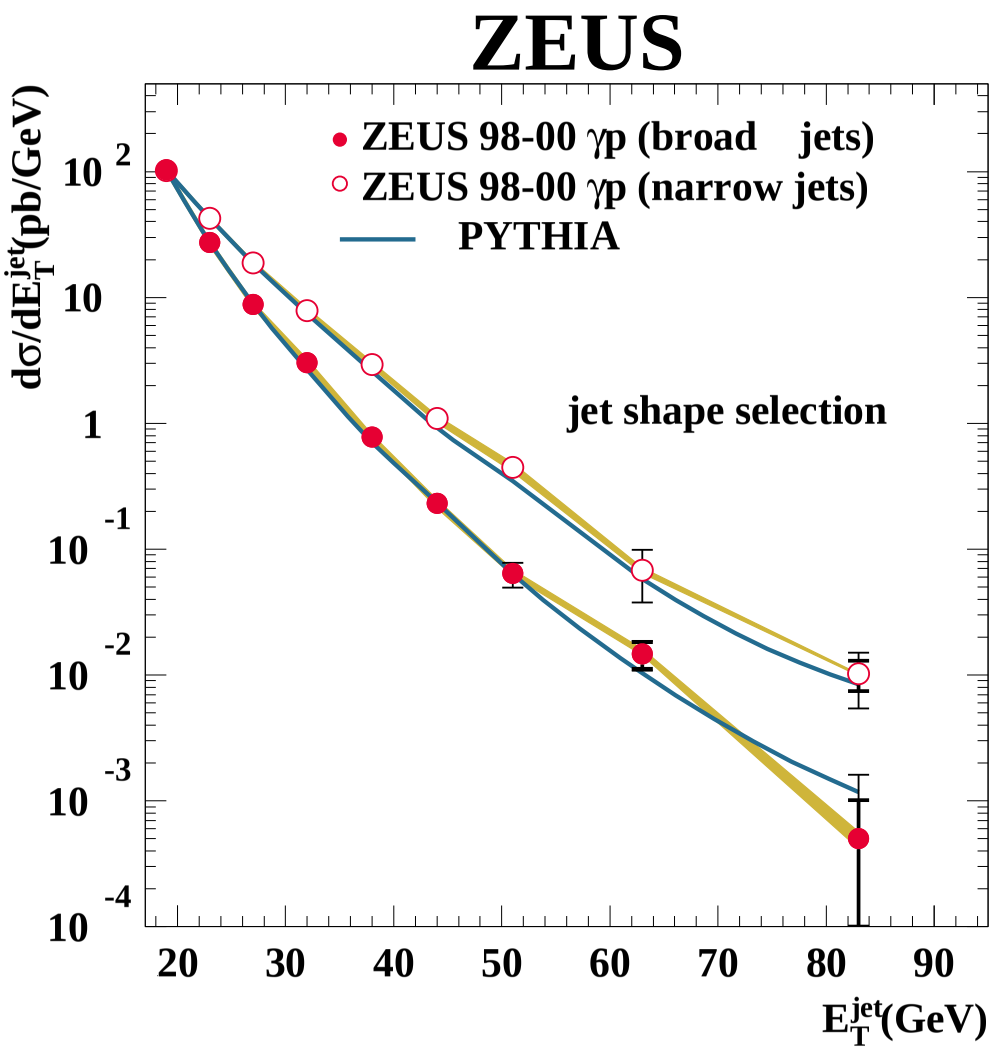




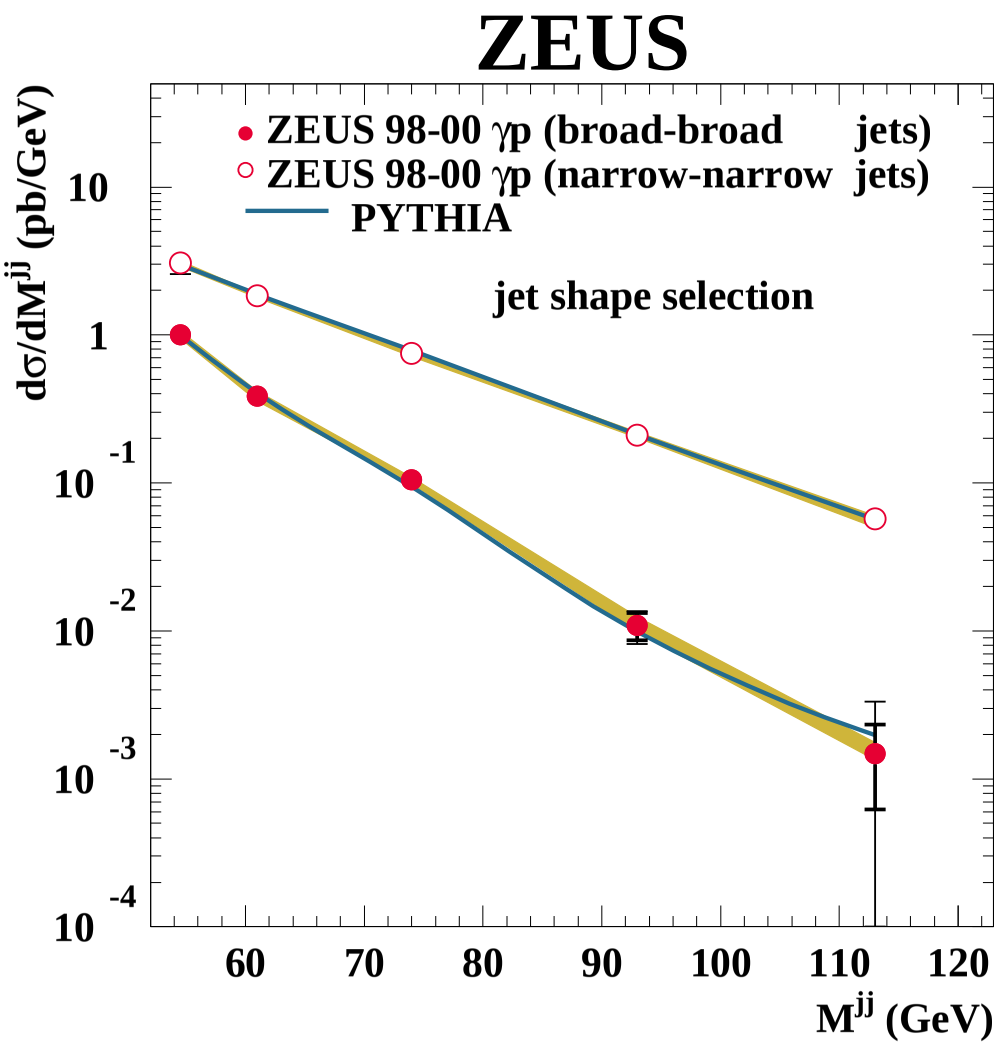
Variation with η^{jet} the same.

Measurements of $d\sigma/dE_T^{\text{jet}}$ and $d\sigma/dM^{\text{jj}}$ in γp

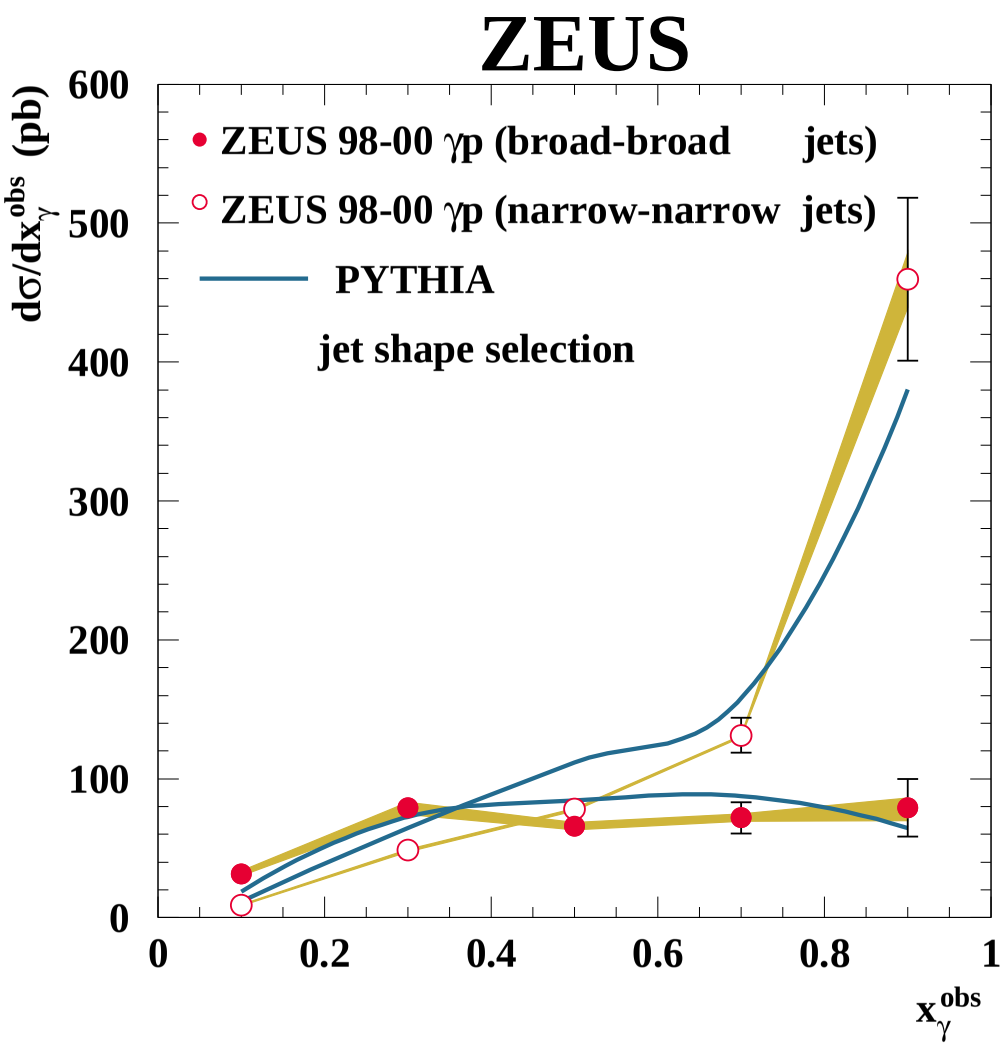
Inclusive jets

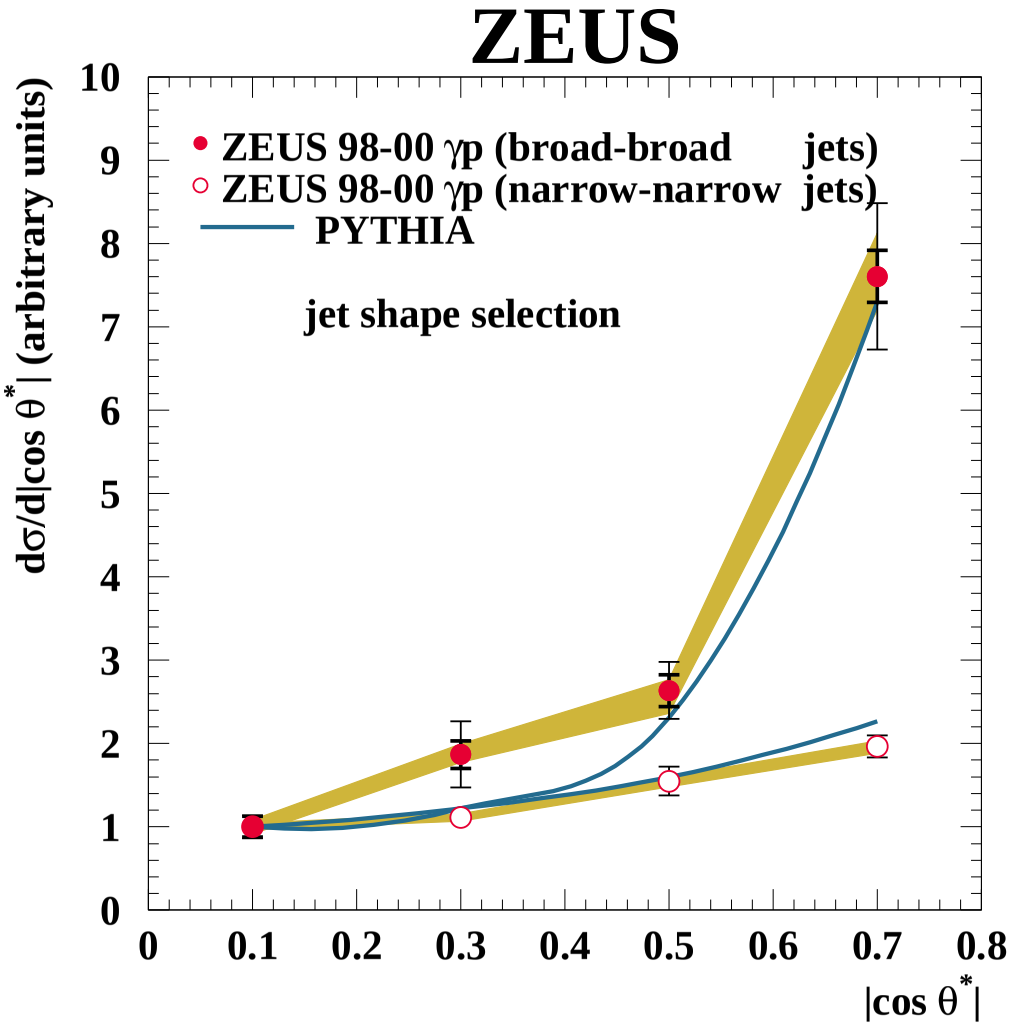


Dijets



Broad-broad and narrow-narrow jets



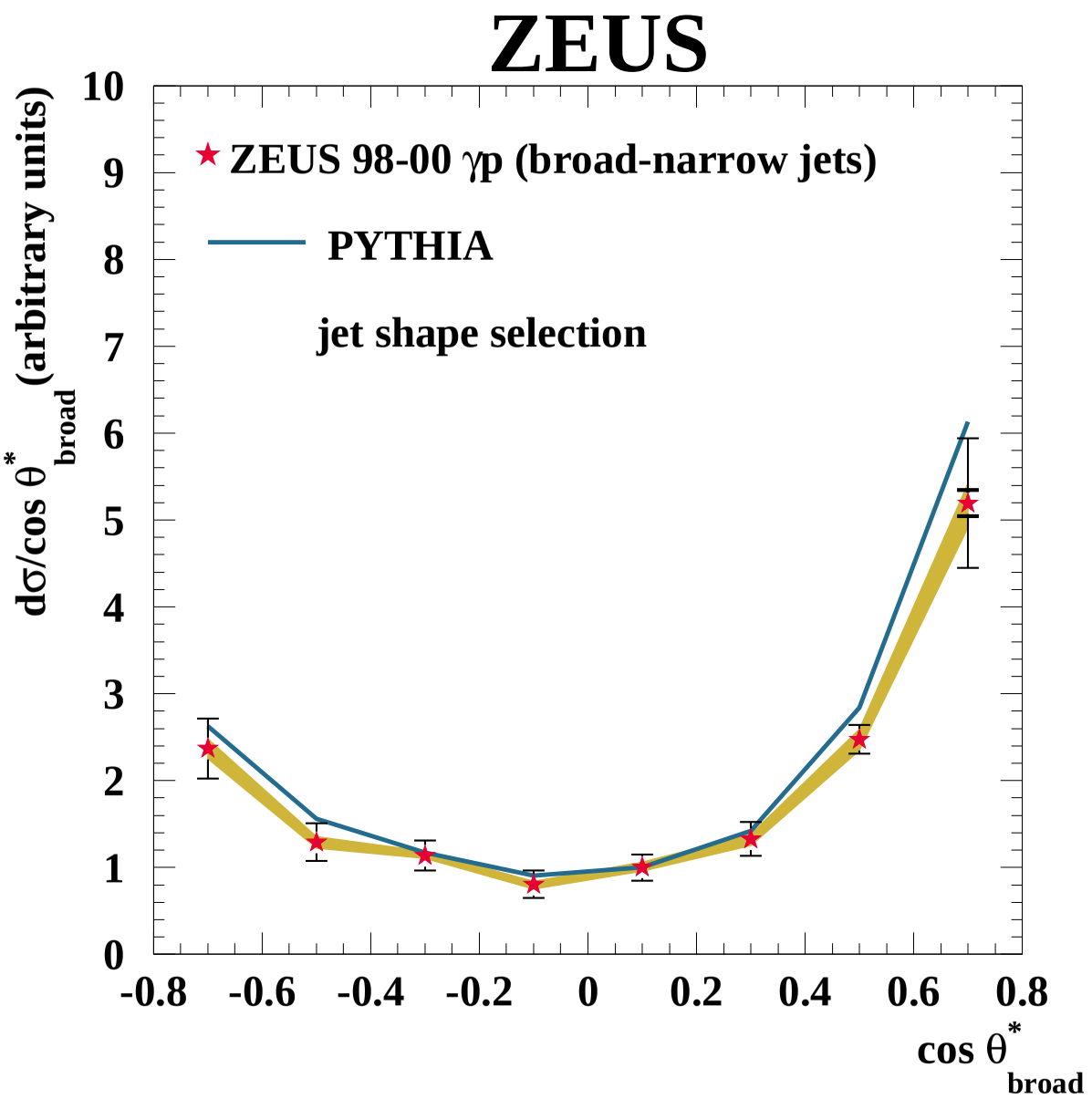


$$x_\gamma^{\text{obs}} = \frac{E_T^{\text{jet1}} e^{-\eta^{\text{jet1}}} + E_T^{\text{jet2}} e^{-\eta^{\text{jet2}}}}{2yE_e}$$

Broad-broad: 16% gg, 52% qg, 32% qq

Narrow-narrow: 1% gg, 28% qg, 71% qq

Broad-narrow jets

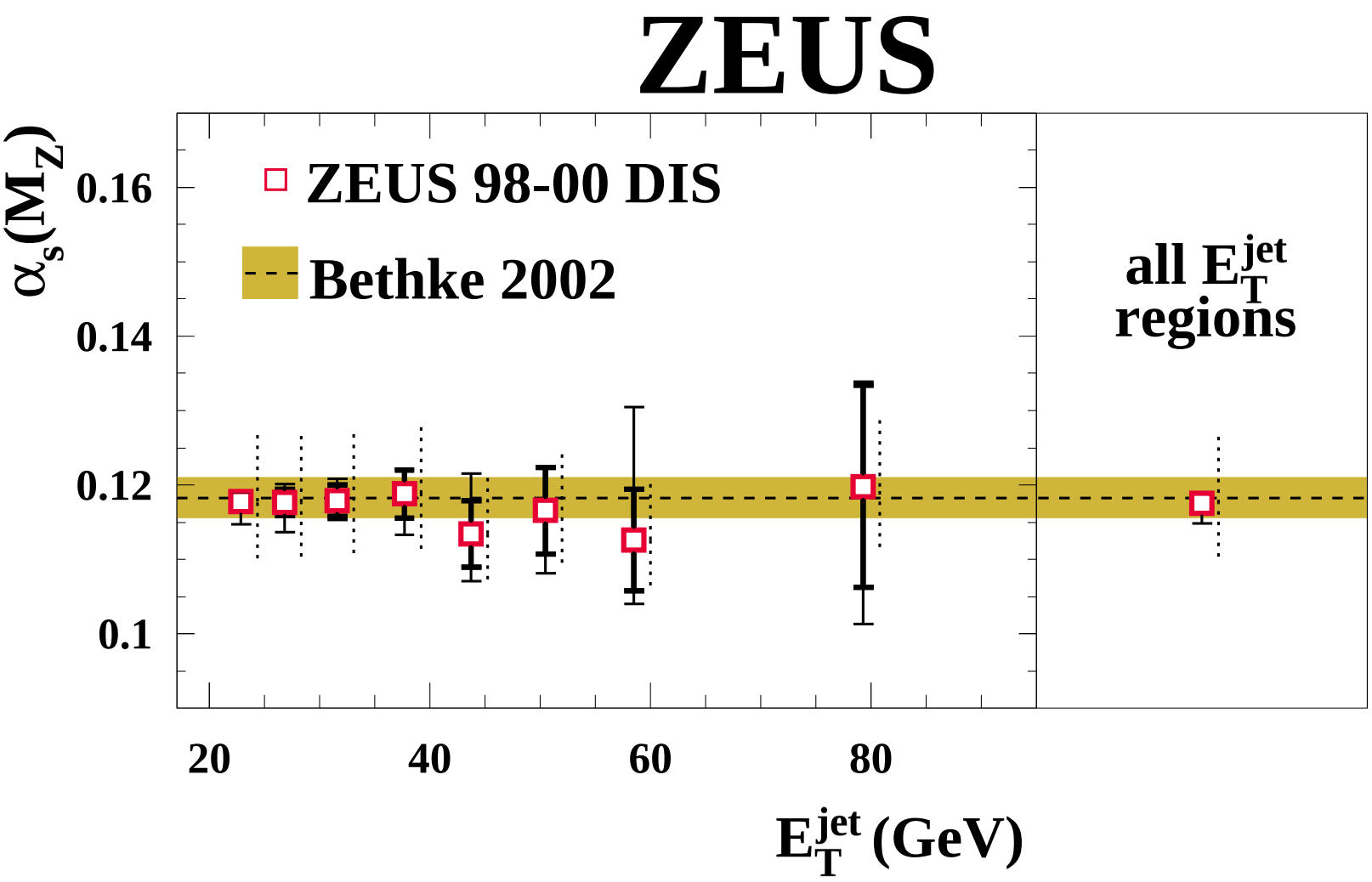


Broad-narrow: 52% qg**, 4%** gg**, 44%** qq**;** $q_\gamma g_p \to qg$**.**

Asymmetric distribution: t**-channel** g **exchange and** u**-channel** q **exchange.**

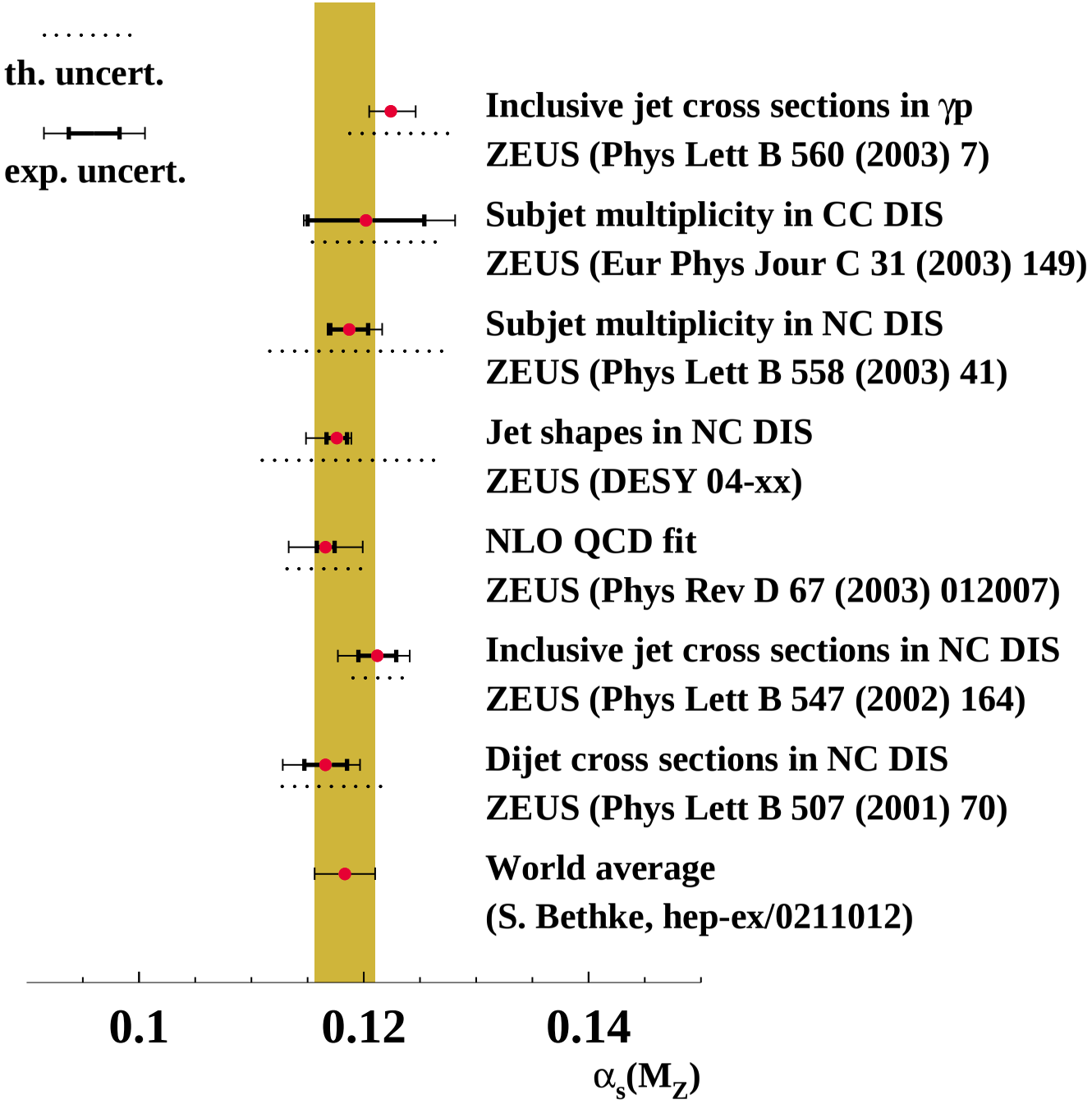
Extraction of α_s

$$\langle 1 - \psi(r) \rangle = \frac{\int dE_T (E_T / E_T^{\text{jet}}) [d\sigma(ep \to 2 \text{ partons})/dE_T]}{\sigma_{\text{jet}}(E_T^{\text{jet}})} \text{ (LO)}$$



$$\alpha_s = 0.1176 \pm 0.0009(\text{stat.})^{+0.0009}_{-0.0026}(\text{exp.})^{+0.0091}_{-0.0072}(\text{th.})$$

Summary of α_s from ZEUS



Summary

Method for enrichment of samples of quark and gluon jets has been demonstrated.

Cross section variables show characteristics of enrichment of particular sub-processes.

An accurate measurement of α_s has been performed.