Event Shapes at HERA with ZEUS

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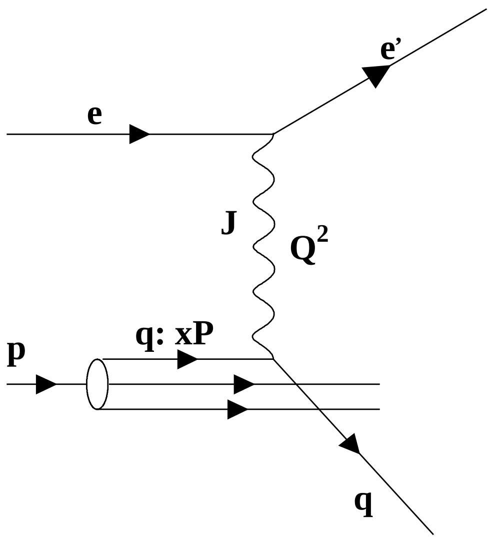
HERA Kinematic Variables

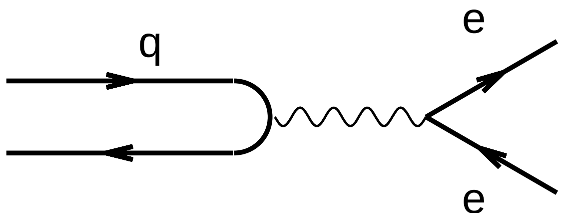
- **•920 GeV p^+**
  (820 GeV before 1999)
- **•27.5 GeV e^- or e^+**
- **•318 (300) GeV cms**

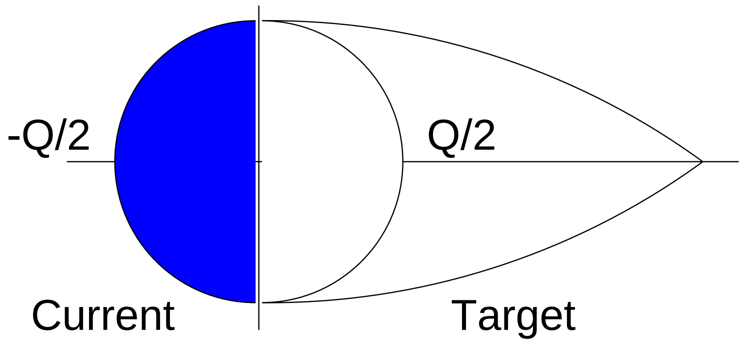


Q^2, x_{Bj}, y

Breit Frame Definition:

$$q + 2x_B P = 0$$

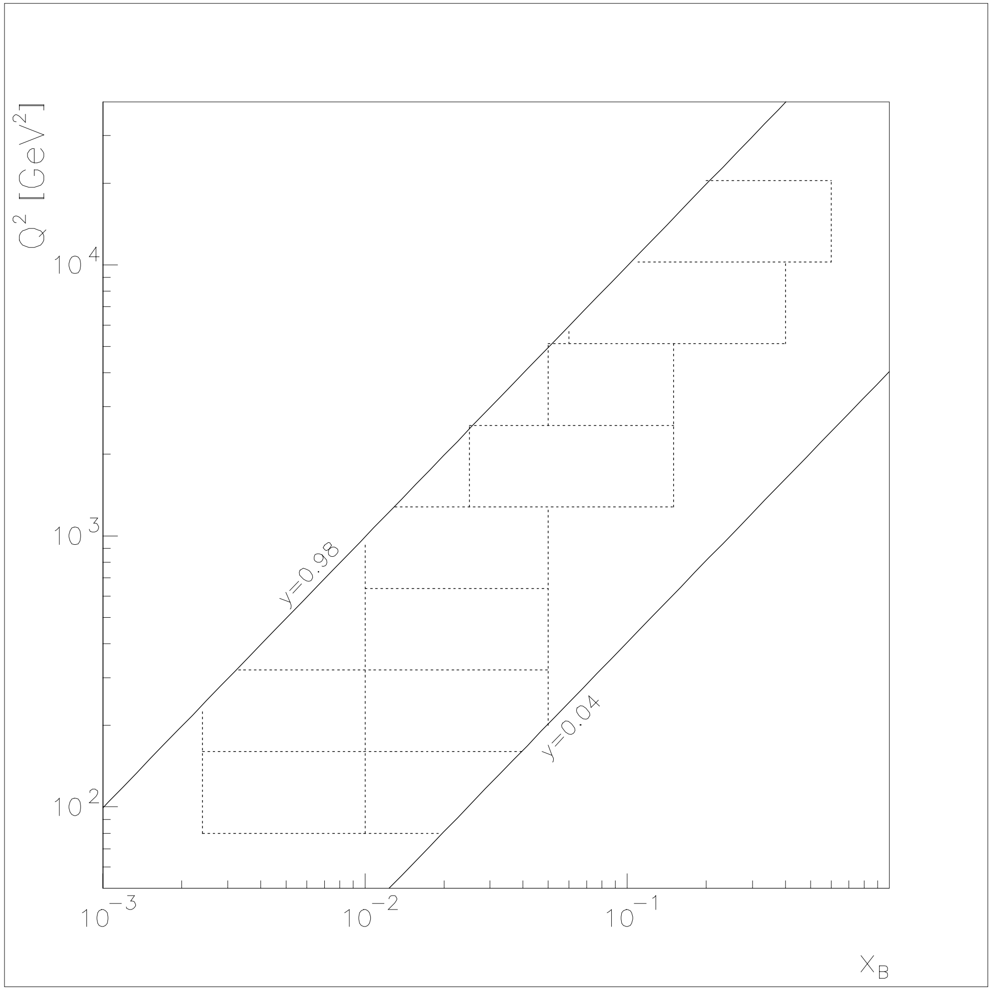




Similar to hemisphere in e^+e^-

Kinematic Bins

- Analysis conducted in 8 bins of Q^2
- Lowest two Q^2 bins are divided into two bins of x
- Two studies:
  - Means of each variable in each bin
  - Differential distributions of each variable in each bin



NOTE: multiple x bins at low Q^2

Approach to Non-perturbative Calculations

pQCD prediction → measured distribution

- **Correction factors for non-perturbative (soft) QCD effects**

Proposed theory*: Use power corrections to correct for non-perturbative effects in infrared and collinear safe event shape variable, F:

Used to determine the hadronization corrections

$$\langle F \rangle = \langle F \rangle_{perturbative} + \langle F \rangle_{power\ correction}$$

$$\langle F \rangle_{pow} = a_V \frac{3MA_1(\alpha_s, \overline{\alpha_0})}{\pi Q}$$

Valid for event shape means and differential distributions

Power correction

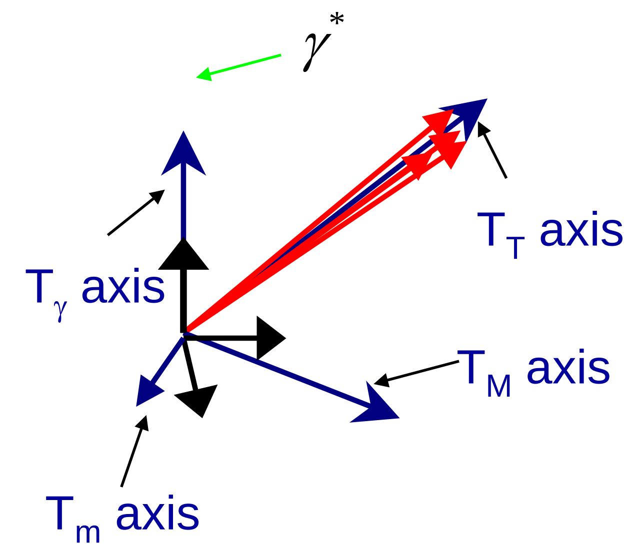
- **Independent of any fragmentation assumptions**

$\overline{\alpha_0} =$ **Universal "non-perturbative parameter"**

*** – (Dokshitzer, Webber, phys. Lett. B 352(1995)451)**

Combination of the hard and soft scales

Axis Dependent: T_T, B_T, T_γ, B_γ



Thrust

$$T = \frac{\sum_i |\vec{p}_i \cdot \hat{n}|}{\sum_i |\vec{p}_i|}$$

Broadening

$$B = \frac{\sum_i |\vec{p}_i \times \hat{n}|}{\sum_i |\vec{p}_i|}$$

Axis Independent: C, M^2

C Parameter

$$C = \frac{3\sum_{ij} |\vec{p}_i||\vec{p}_j| \sin^2(\theta_{ij})}{2\left(\sum_i |\vec{p}_i|\right)^2}$$

Jet Mass

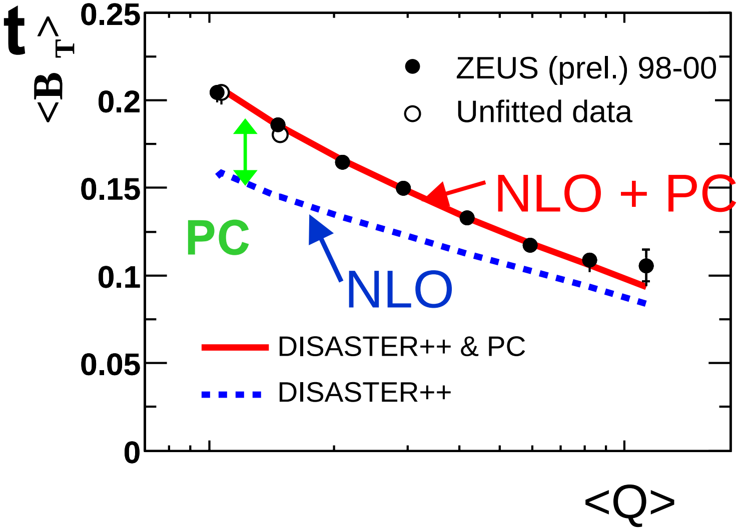
$$M^2 = \frac{\left(\sum_i p_i^\mu\right)^2}{\left(2\sum_i E_i\right)^2}$$

Sums are over all momenta in the current hemisphere of the Breit frame

Extraction of α_0 and α_S

Apply Power Corrections to Event Shape Means vs. Q^2

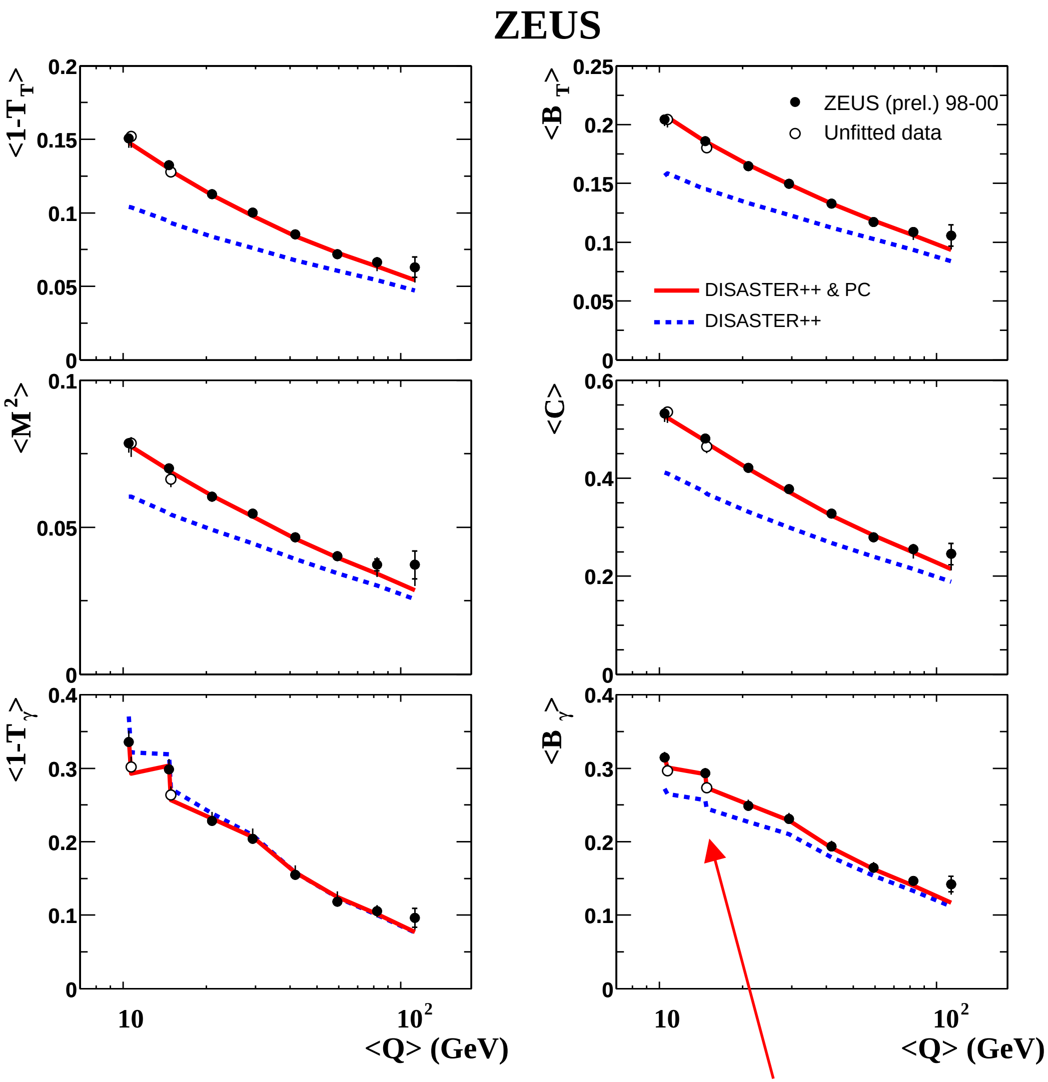
- Measure <F> and compare to NLO + PC
- Extract α_0 and α_S from fits to means
- (First group of slides)



Apply Power Corrections to Event Shape Differential Distributions

- Measure F and compare to NLO + Resummation + PC
- Extract α_0 and α_S from these distributions
- Results new for this meeting
- New Event Shape
- (Second group of slides)

Mean Event Shapes



Recall: multiple Q^2 bins at low x

Add PC to NLO in order to agree with data

2-parameter NLO + PC fit

- Simultaneous fit for α_s and α_0
- Each shape fit separately

Fits use Hessian method for statistical and systematic errors

NLO calculation using DISASTER++

ZEUS 98-00 (82.2 pb^{-1})

$80 < Q^2 < 2 \cdot 10^4\ GeV^2$

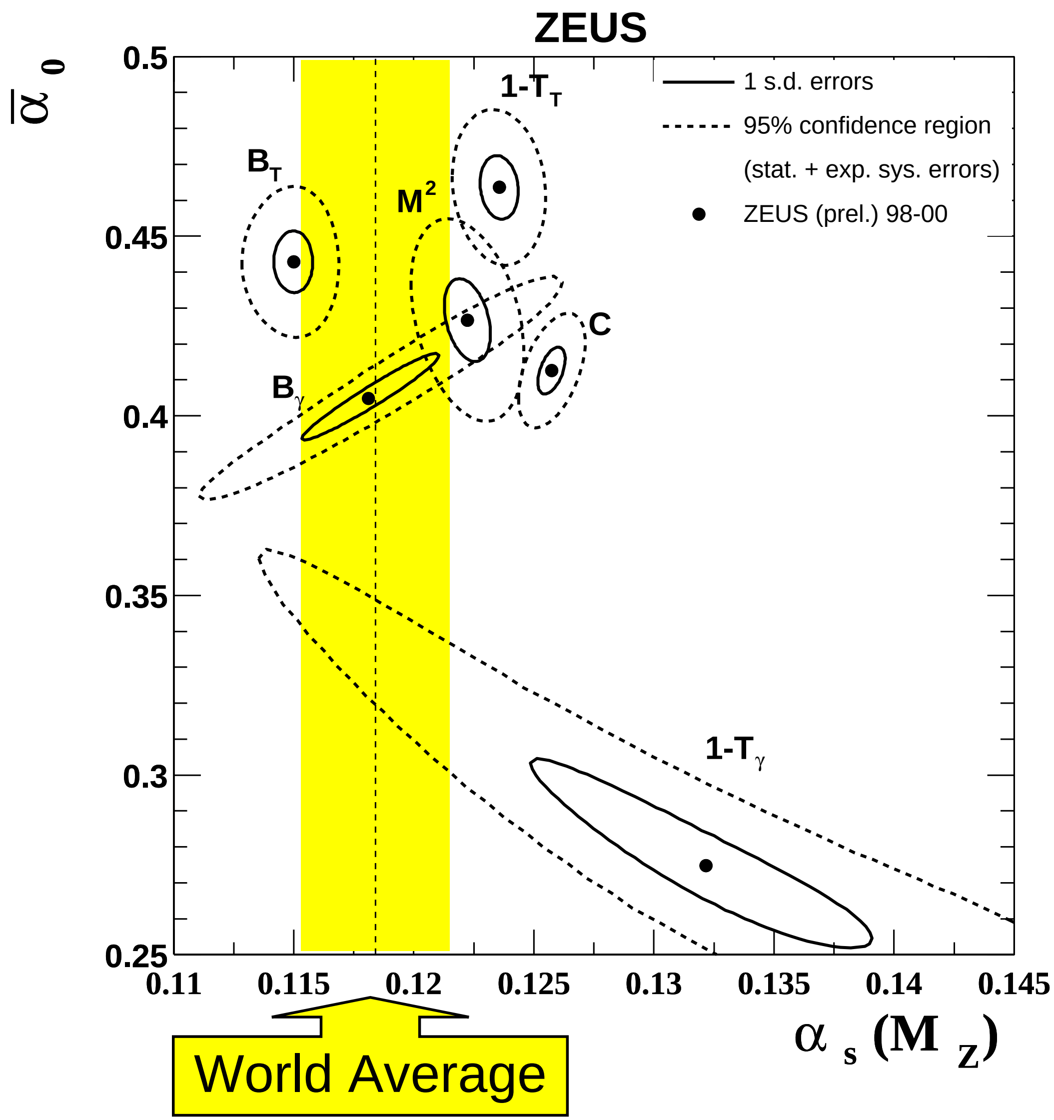
$2 \cdot 10^{-3} < x < 0.6$

Mean Parameters

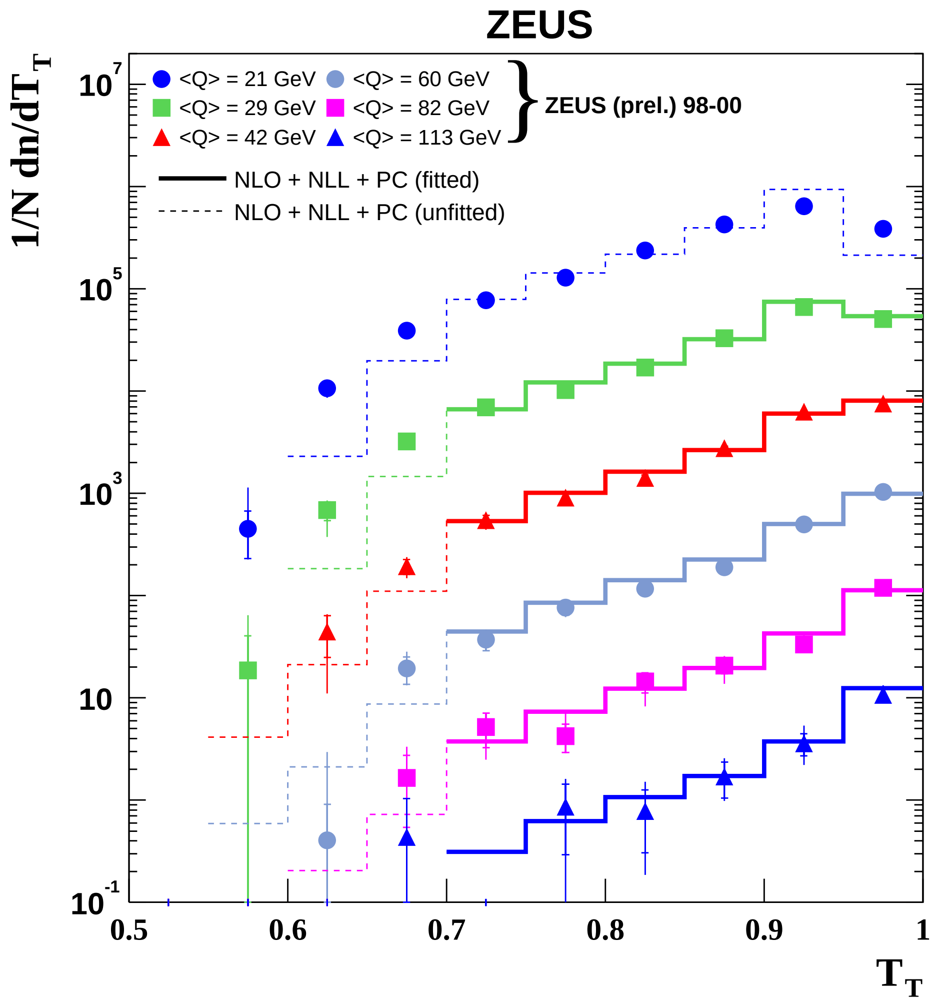
Extracted parameters for each shape

- **Fitted α_s values consistent to within 5%**
- **Fitted $\alpha_0 \approx 0.45$ to within 10%**
- **(excluding T_γ)**

Theory errors dominate, except for γ axis shapes



Shape Distributions



Fit differential distributions over a limited range.

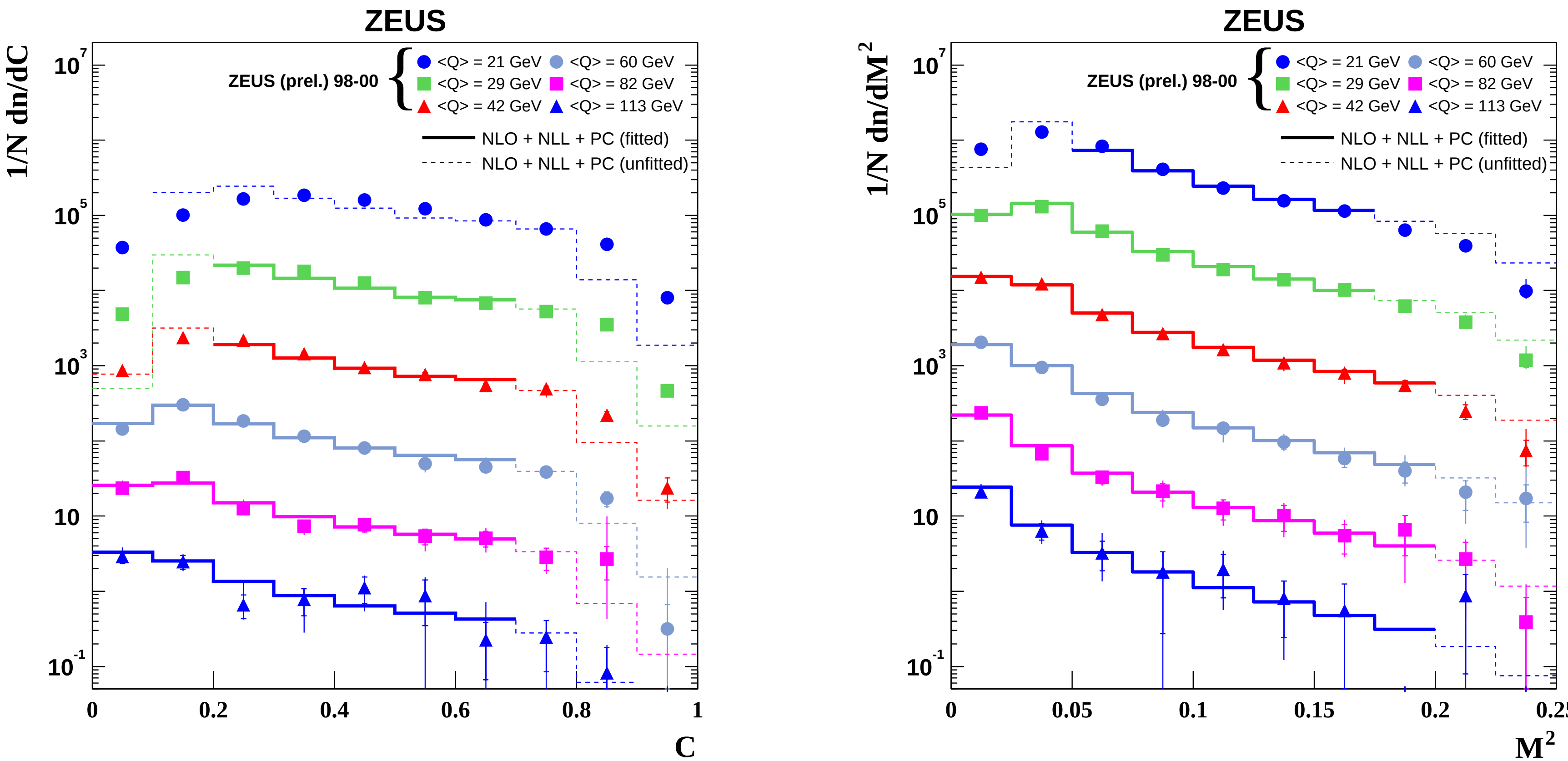
- **Bins for which theoretical calculations are expected to be questionable are omitted from fit.**
- **Resummation is applied with DISRESUM.**

ZEUS 98-00 (82.2 pb^{-1})

$9 < Q < 141$ GeV

$2*10^{-3} < x < 0.6$

Shape Distributions



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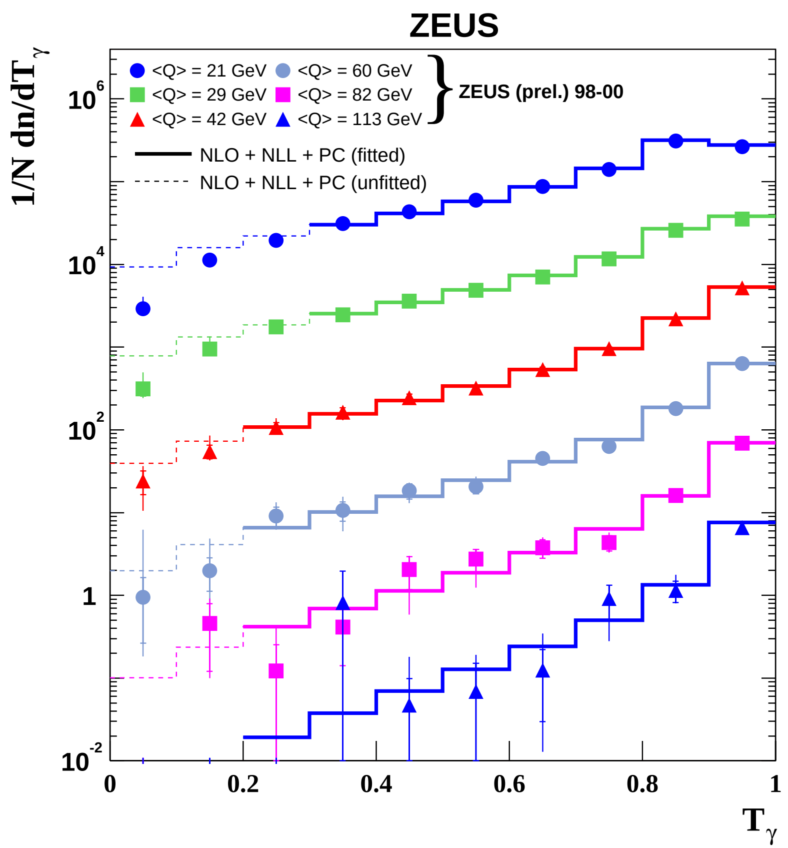

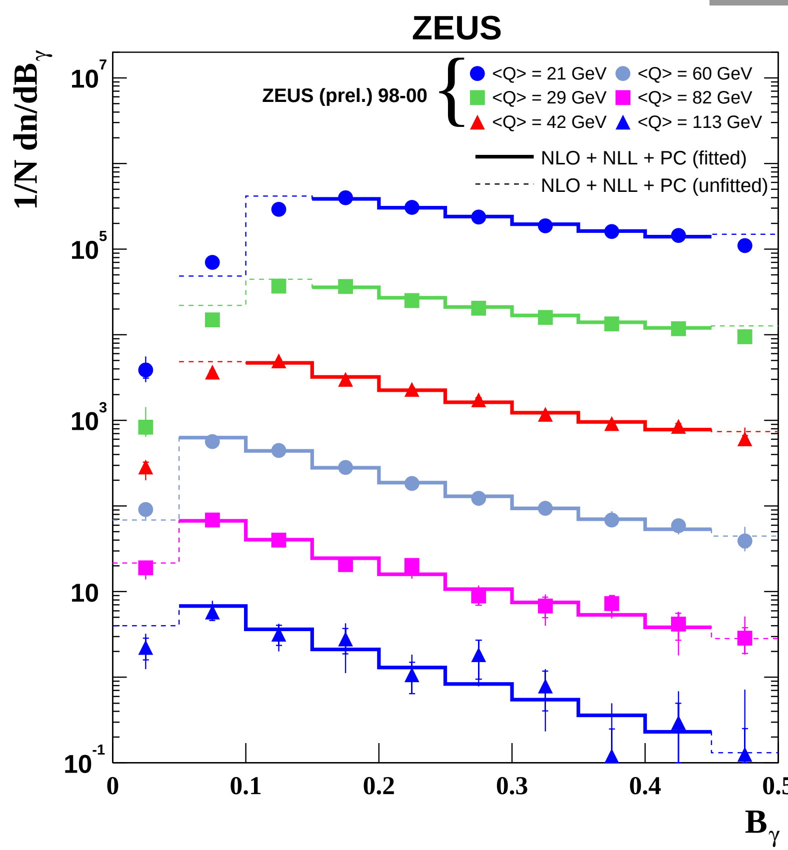

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Distribution Parameters

Fits use Hessian method for statistical and systematic errors.

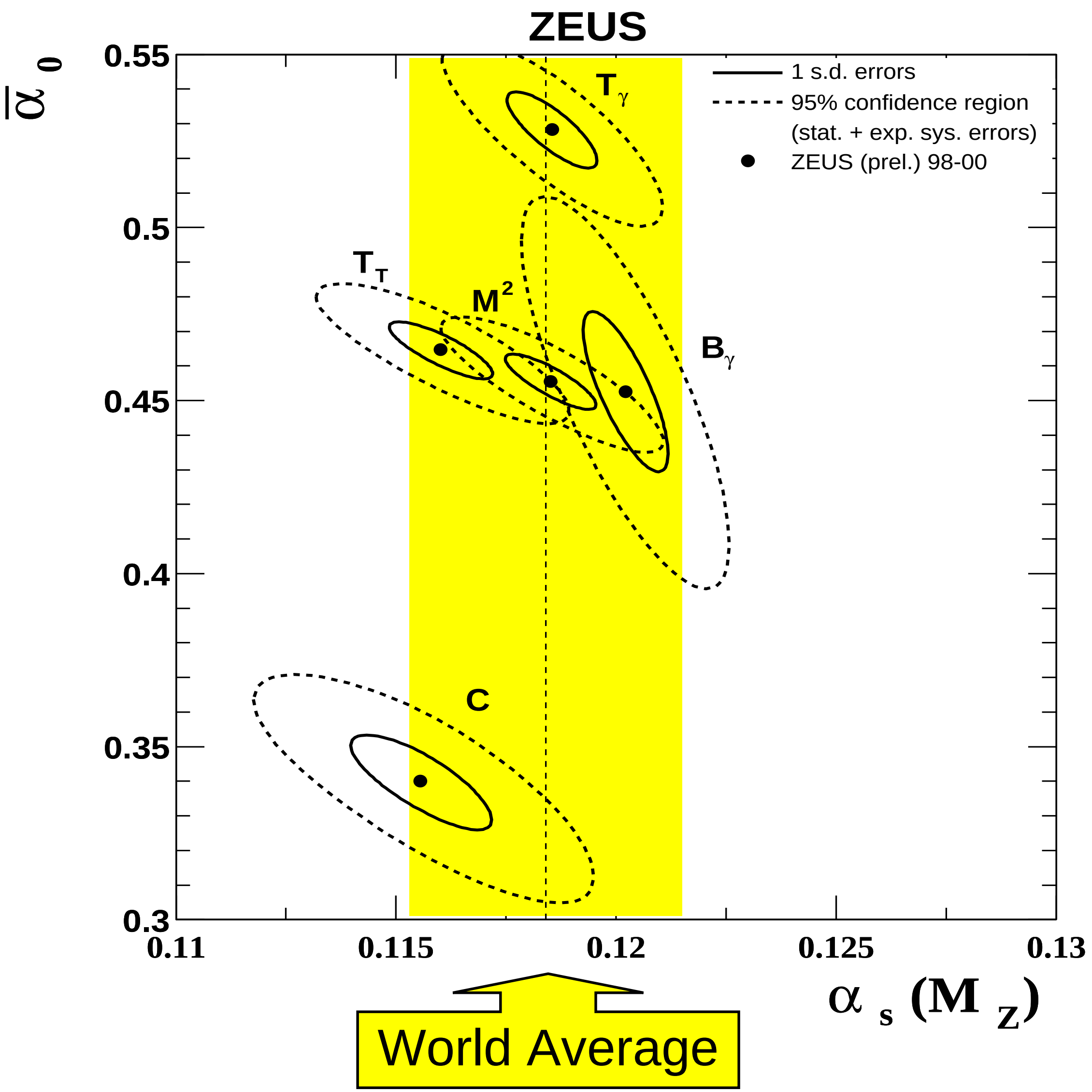
All variables with a good χ^{2}.

Fits are sensitive to matching method.

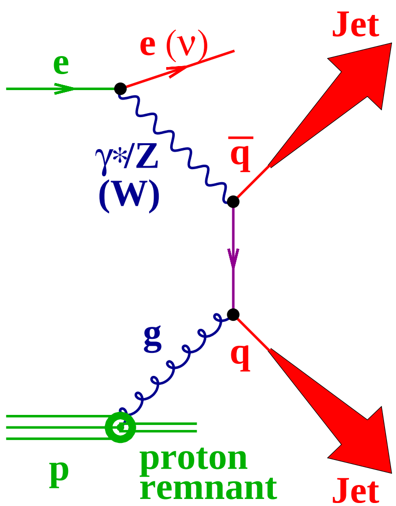
α_S agrees with world average

$\alpha_0 \approx 0.5$.

H1 also studies Event Shape differential distributions

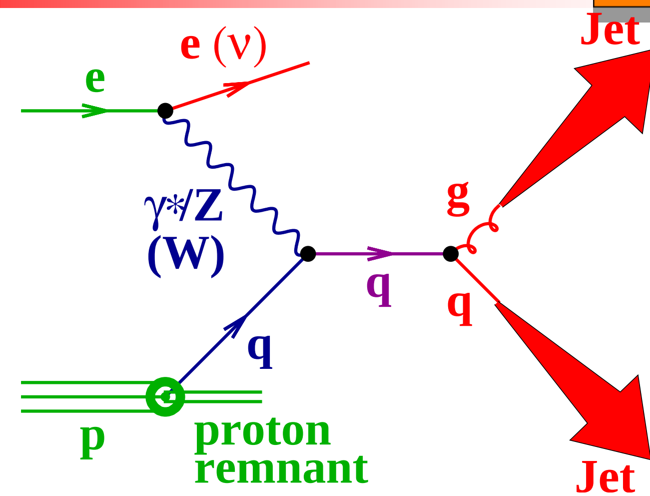


Event Shapes With Jets



$$O(\alpha^1 \alpha_S^1)$$

2 jets



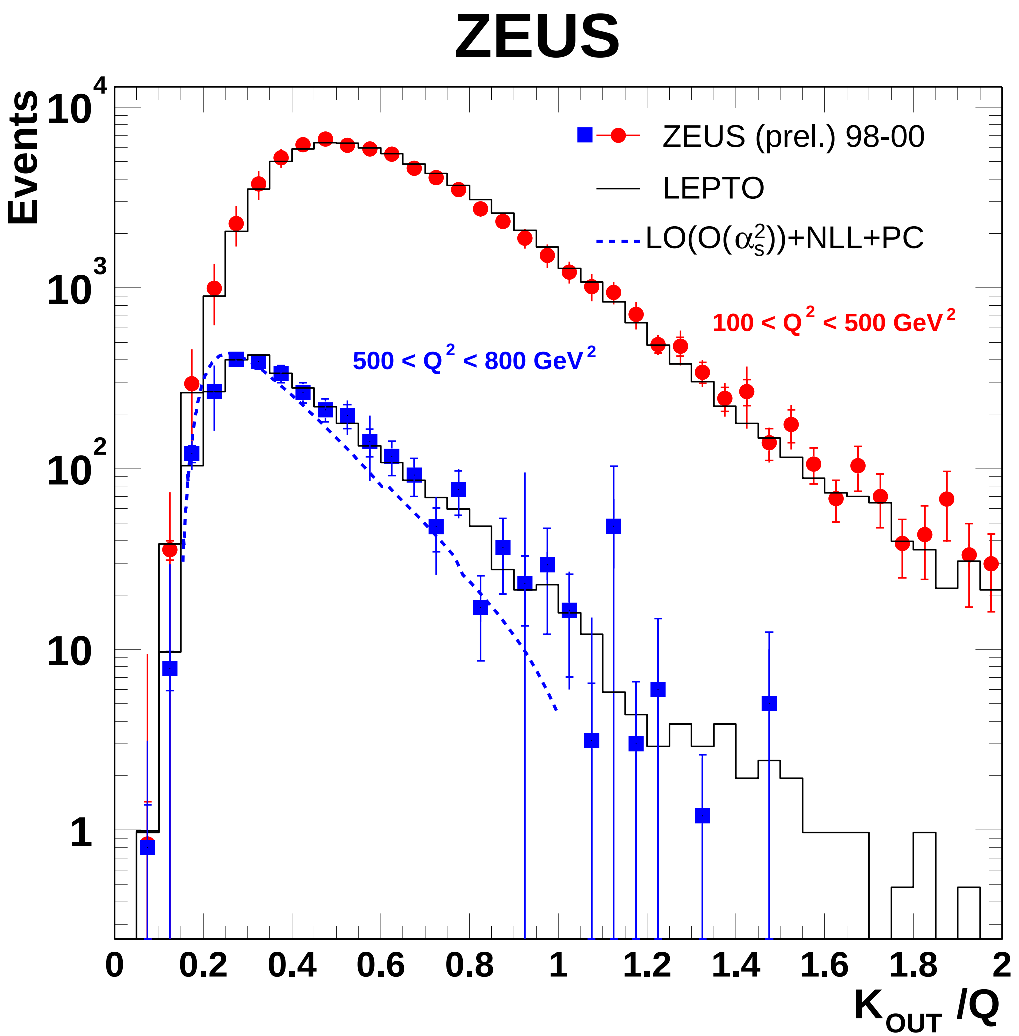
Momentum out of plane

$$K_{out} = \sum_i |\vec{p}_i|$$

Energy flow out of event plane defined by proton direction and thrust major axis

- **Sensitive to perturbative & non-perturbative contributions**
- **Dijet event:**
  - LO dijet pQCD calculation gives $K_{out} = 0$
  - First contribution to K_{out} is from non-perturbative part or from NLO dijet pQCD calculation

3-jet Event Shape Variable



No fits performed up to now

First comparison with LO+NLL+PC is shown

- $\alpha_s(M_Z) = 0.118$
- $\alpha_0 = 0.52$

Waiting on generalized resummation program

ZEUS 98-00 (82.2 pb^{-1})

$Q^2 > 100\ GeV^2$

Summary

- **Precise measurement of different event shapes**
  - Means, Differential Distributions, and new event shapes for jet events
- **α_0 extraction from Event Shapes mean and Event Shape differential distributions are consistent**
  - $\alpha_0 \approx 0.45 - 0.5$
- **Need some theoretical input if we want to proceed with the jets Event Shapes**