Event Shapes in DIS at H1

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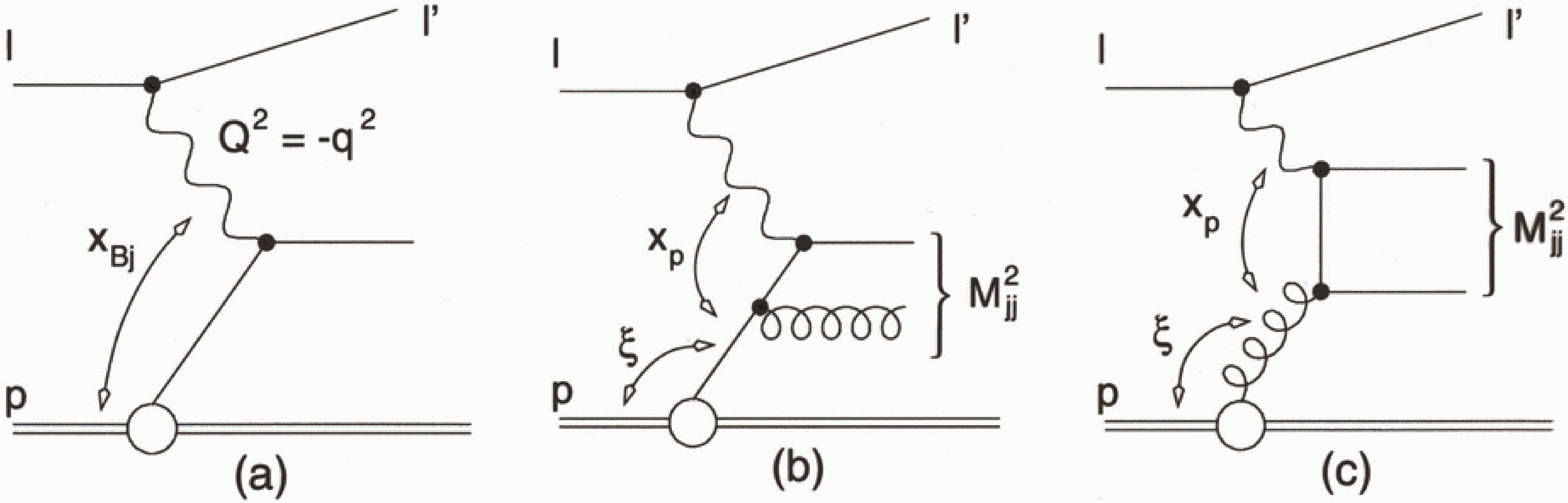
On behalf of H1 collaboration

- Deep Inelastic Scattering at HERA
- 2-jet event shape
- 3-jet event shape
- jet rate
- Summary

Deep Inelastic Scattering at HERA

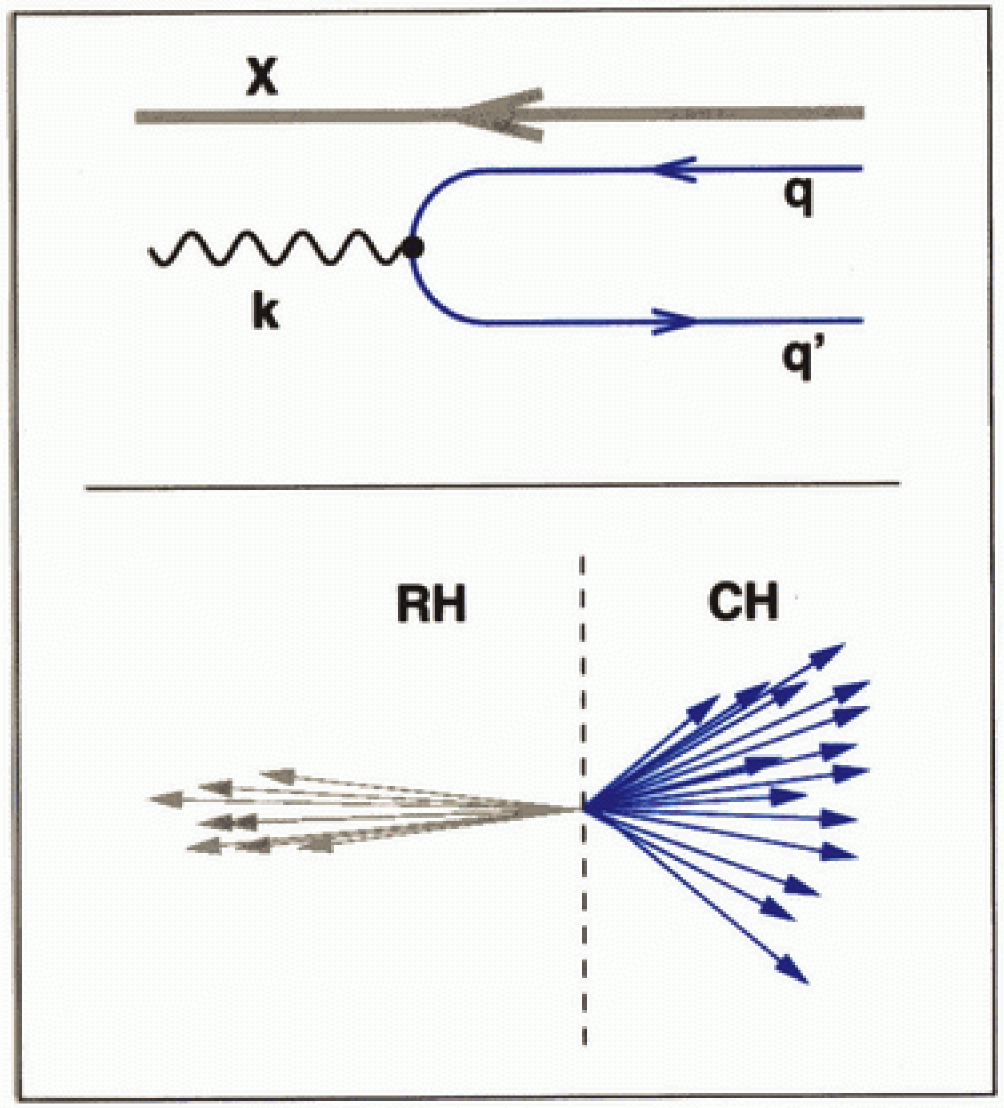


Born process: QPM — **QCD-Compton process** — **Boson-gluon fusion**

- **Study pQCD prediction and non-perturbative hadronization**
- **HERA-I data: 1995-2000, $\mathcal{L} =$ ~~115~~ 112 pb^{-1}, $\sqrt{s}$ =300/320 GeV**
- **Momentum transfer $Q^2 \in$ (196, 40000) GeV^2 and inelasticity y $\in$ (0.1, 0.7)**

Breit frame in DIS

$$2x\vec{P} + \vec{k} = 0$$



Advantage of Breit frame

- proton remnant hemisphere (RH) with $\eta > 0$
- Current hemisphere (CH) with $\eta < 0$
- Current hemisphere: similar to 1/2 e^+e^- collision

2-jet event shapes

- first non-zero contribution at order α_s
- 1 - Thrust: $\tau \equiv 1 - T = 1 - \frac{\sum_h |p_{zh}|}{\sum_h |p_h|}$
- 1 - Thrust related to the thrust axis: $\tau_C \equiv 1 - T_C = 1 - \frac{\sum_h |p_h \cdot n_T|}{\sum_h |p_h|}$
- Jet broadening: $\mathrm{B} = \frac{\sum_h |p_{\perp h}|}{\sum_h |p_h|}$
- Jet Mass (massless in the p-scheme): $\rho = \frac{(\sum_h p_h)^2}{(2\sum_h |p_h|)^2}$
- C-parameter: $\frac{3\sum_{h,i} |p_h||p_i| \sin^2\theta_{hi}}{2(\sum_h |p_h|)^2}$

These are defined for the particles in the current hemisphere (CH) alone.

2-jet event shapes

- Differential distribution of event shape F

  $\frac{d\sigma(F)}{dF} = \frac{d\sigma^{pQCD}(F - a_F\mathcal{P})}{dF}$

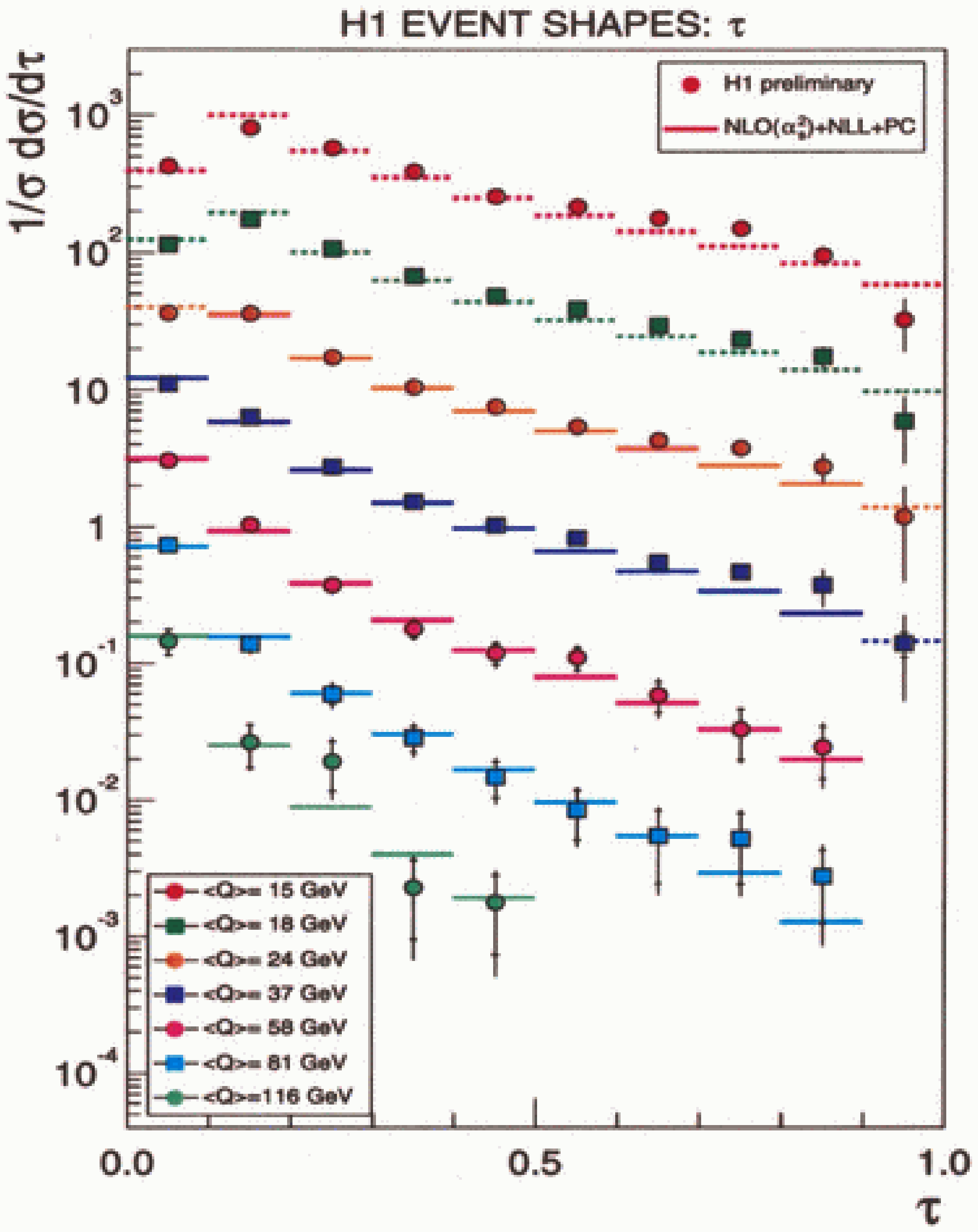
  $d\sigma^{pQCD}$ and a_F: pQCD calculation

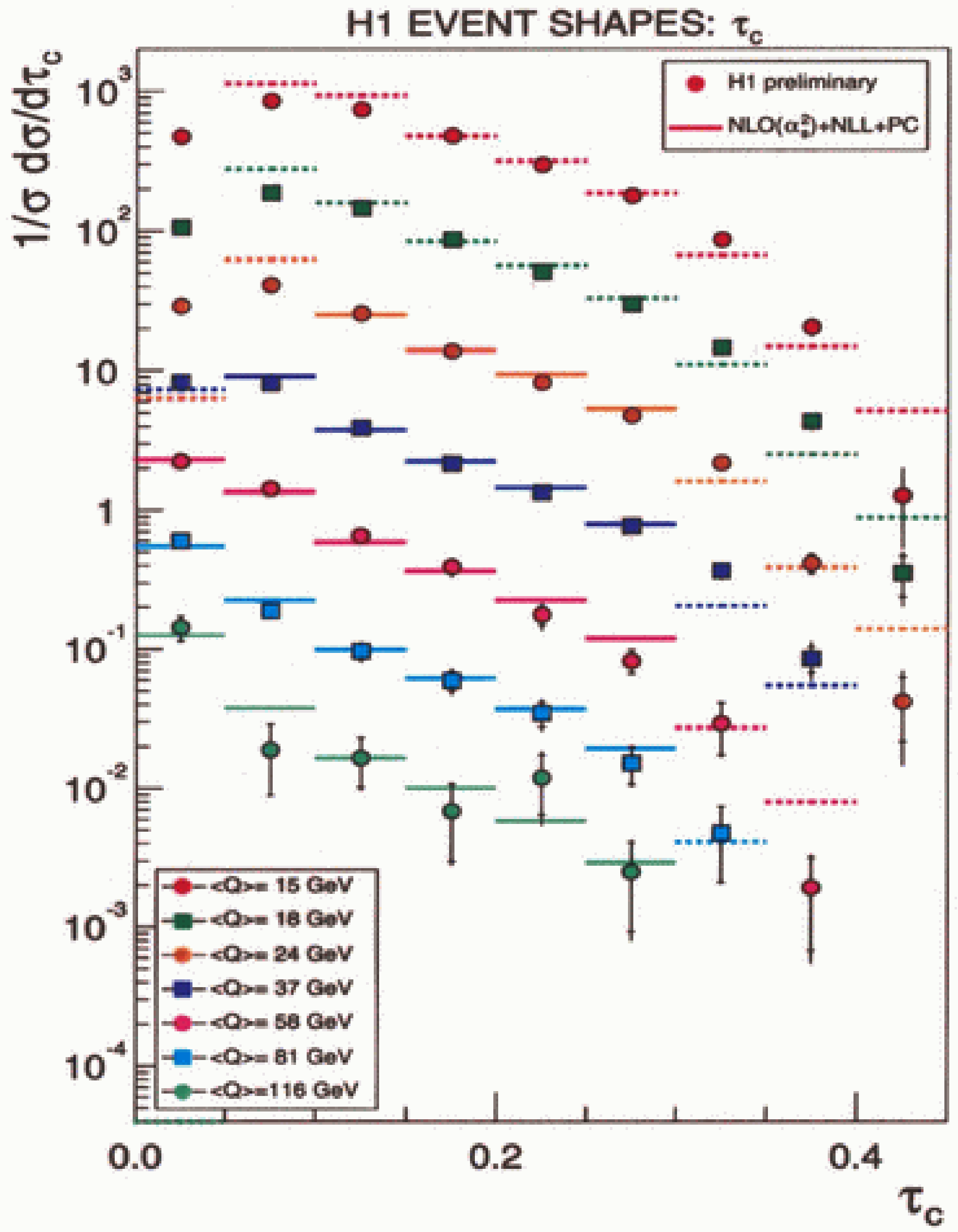
  $\mathcal{P}$: power correction, non-perturbative effects

- $\mathcal{P}$: universal for the observable and the process

- Power corrections have two free parameter α_s and $\bar{\alpha}_0(\mu_I = 2GeV)$

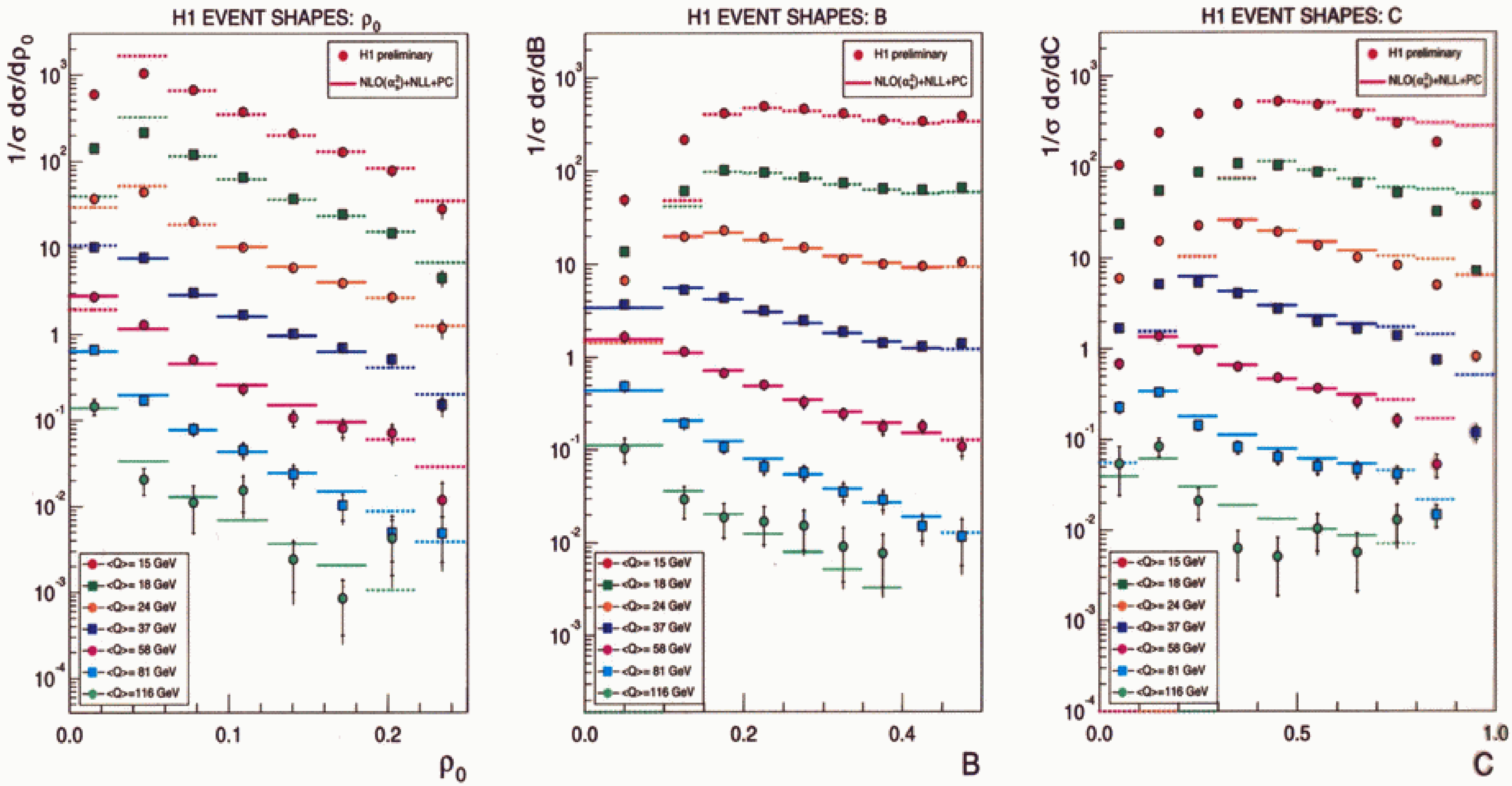
2-jet event shapes





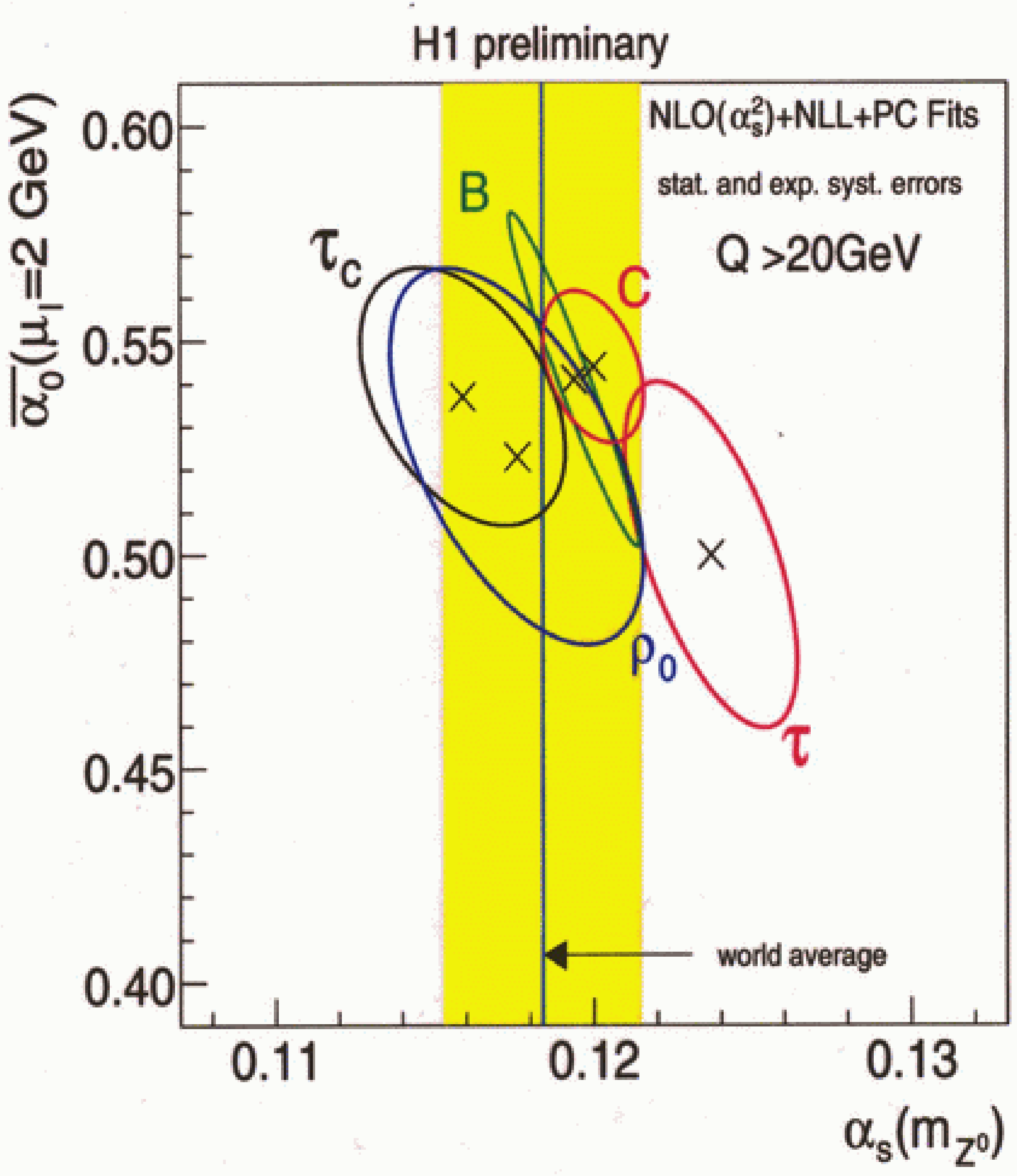
- **data fitted well by pQCD and power correction**

2-jet event shapes



- data fitted well by pQCD and power correction

2-jet event shapes



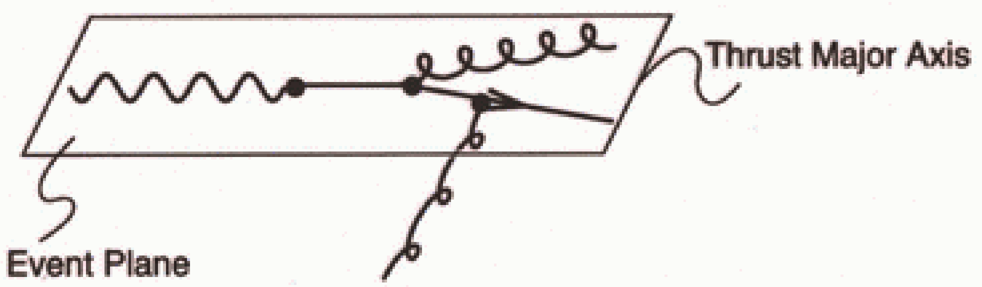
Fitted results from distributions

- **negative correlation between $\bar{\alpha}_0$ and $\alpha_s(M_{Z^0})$**
- **consistent with $\bar{\alpha}_0 = 0.5$, within 10%**
- **consistent value for $\alpha_s(M_{Z^0})$ with world average**

3-jet event shapes

- first non-zero contribution at order α_s^2
- K_{out} : out-of-event-plane momentum for hadrons with $\eta_{Breit} < 3.0$

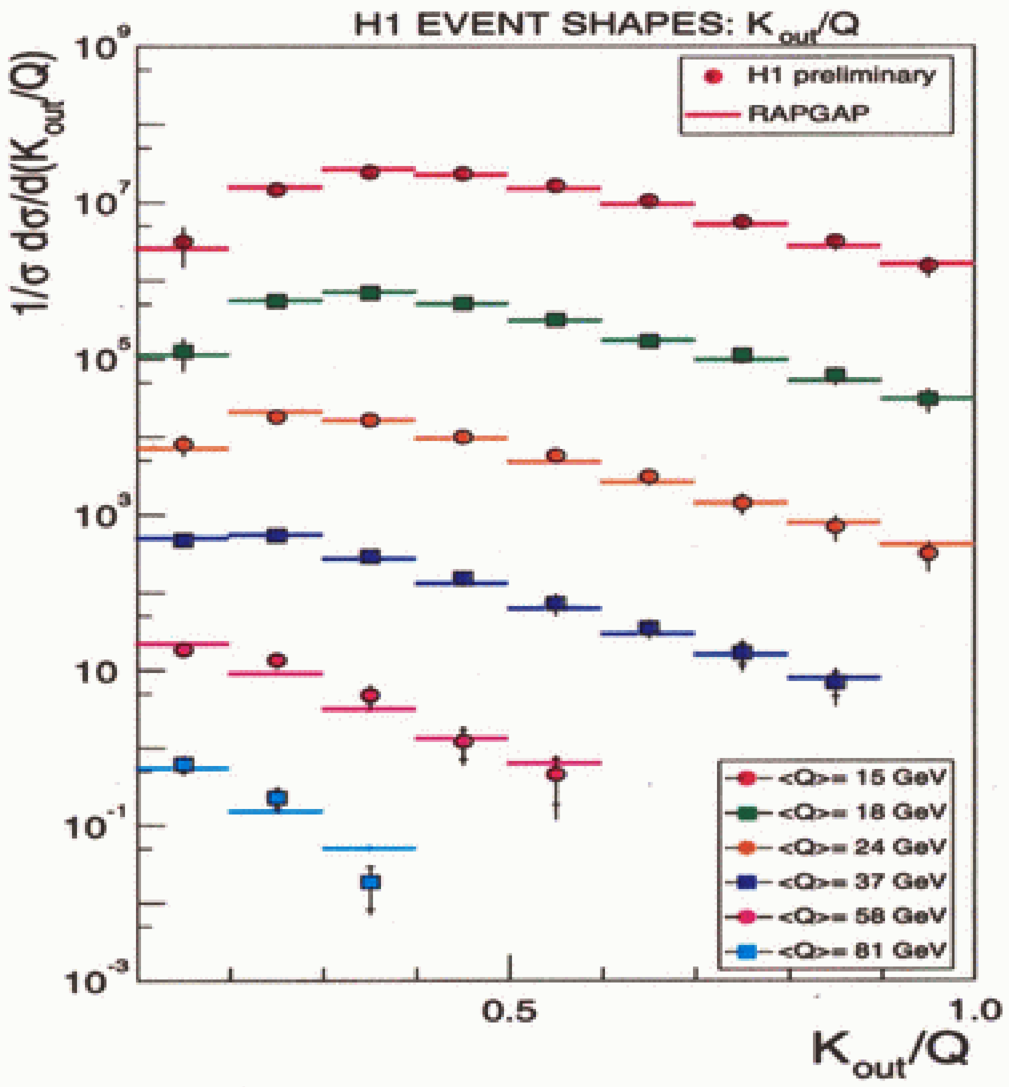
  $K_{out}/Q \equiv 1/Q \sum' |p_h^{out}|$

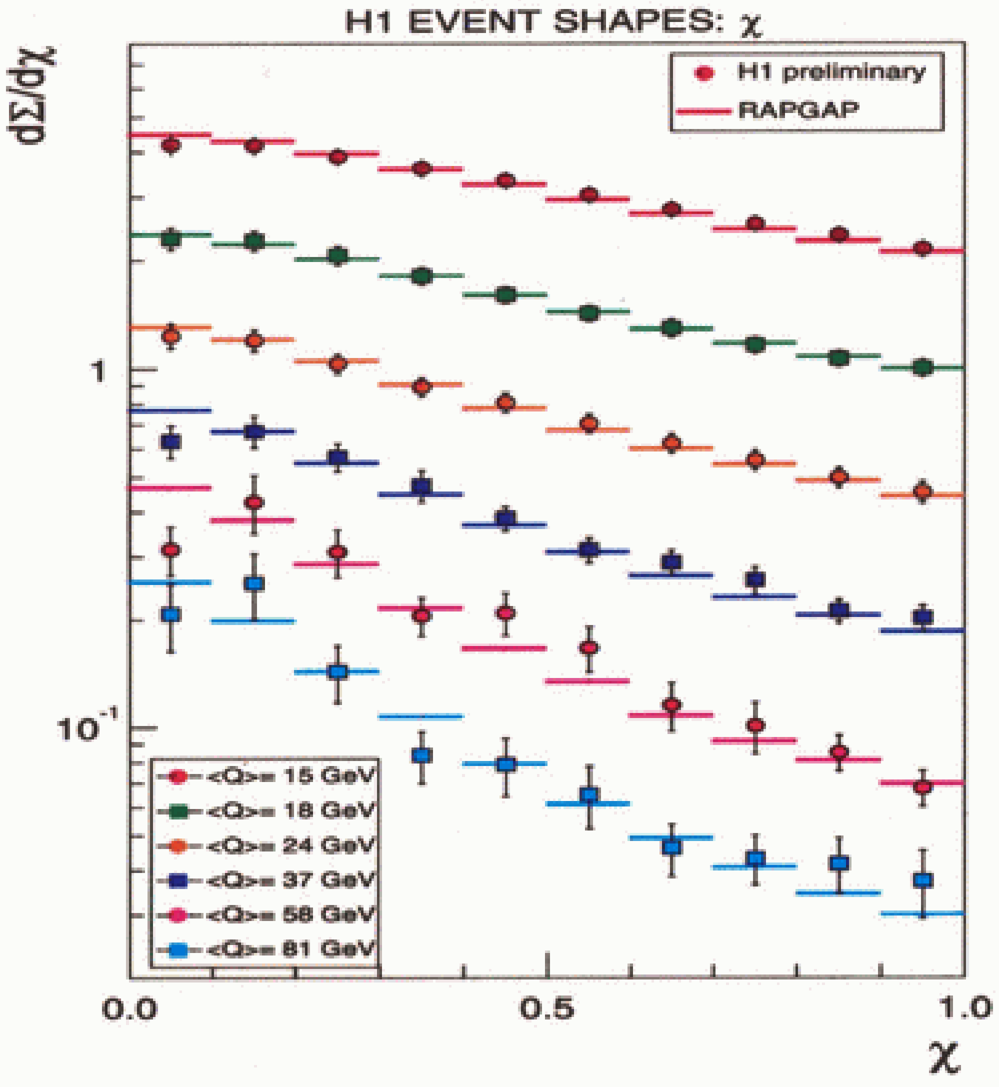


- χ : azimuthal correlation for hadrons with $\eta_{Breit} < 3.0$

  $\chi \equiv \pi - |\phi_h - \phi_{h'}|$, weighted by $w = p_{th} p_{th'}/Q^2$
- LO, next-to-leading-log resummation and power correction available from A. Banfi et al. JHEP 11 (2001) 066 & JHEP 04 (2002) 024

3-jet event shapes

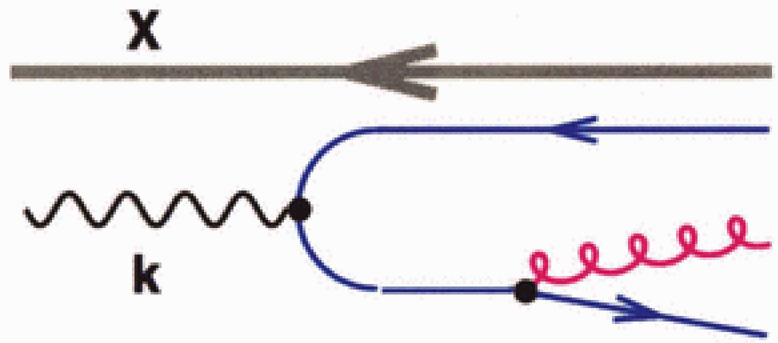




- RAPGAP Monte Carlo using LO matrix elements with parton showers
- K_{out} and χ are well described by RAPGAP

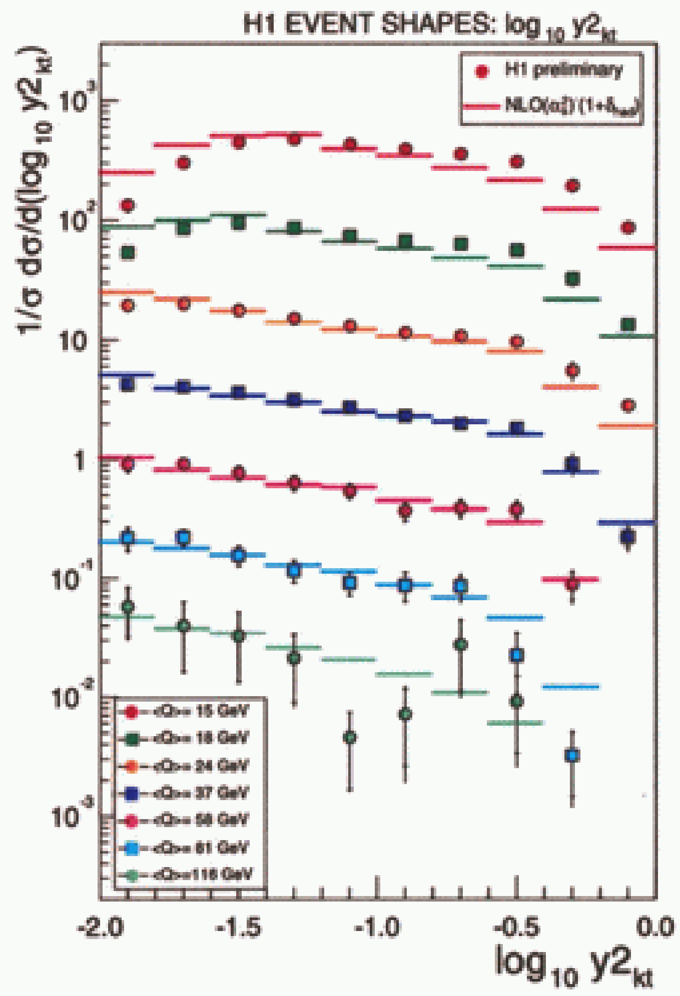
Jet rate

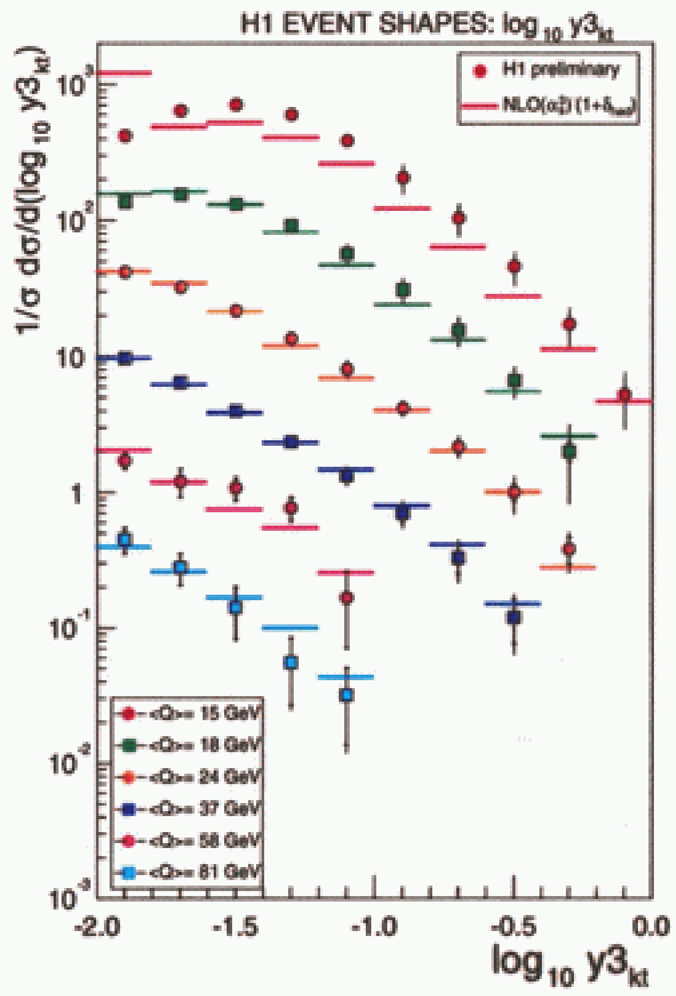
- Jet finder: exclusive k_t clustering algorithm
- y_2: the value of jet resolution parameter, where the transition 1+1 jets $\longrightarrow$ 2+1 jets occurs.

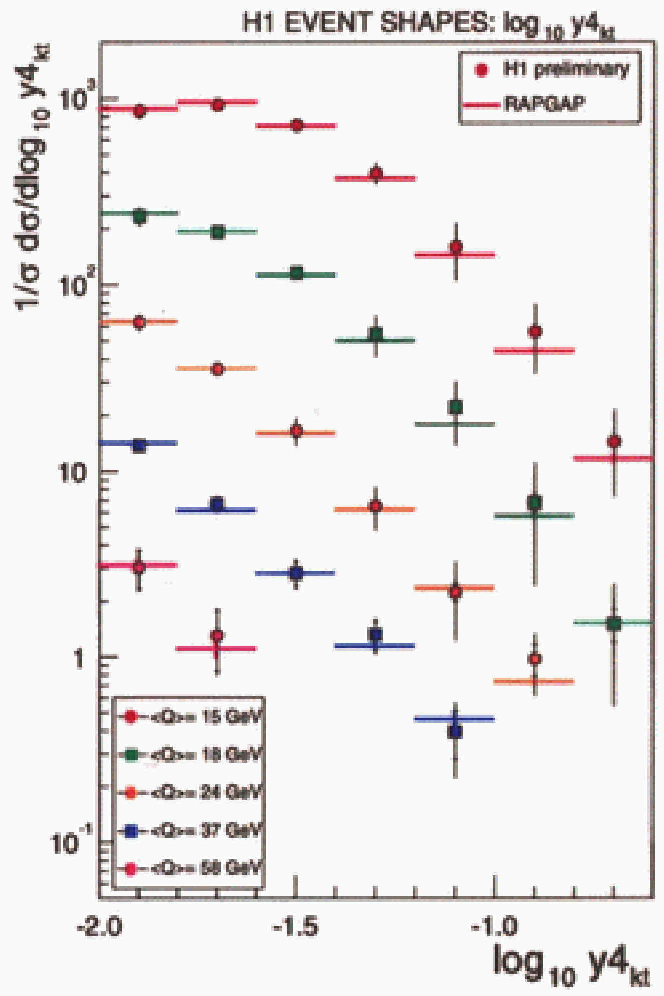


- Jet rate y_n: the same for the transition (n-1)+1 jets $\longrightarrow$ n+1 jets occurs.
- theory prediction:
  - Fixed order calculation in NLO for y_2 and y_3, LO for y_4
  - Resummation by A. Banfi et al.
  - Power corrections: not yet

Jet rate







- **NLOJET++ calculate (2+1)- and (3+1)-jet cross sections at NLO level and (4+1)-jet cross section at LO level.**
- **NLOJET++ give a good description of y_2 and y_3 for $Q^2 \geq 576$ GeV^2.**

Summary

- Precision measurements of event shape have been performed.
- pQCD and power correction well describes 2-jet event shapes.
- A first measurement of 3-jet event shapes (K_{out} and χ) in DIS. K_{out} and χ are described by Monte Carlo RAPGAP.
- NLOJET++ describes jet rate y_2 and y_3 for $Q^2 \geq 576$ GeV^2.