# *Inclusive Jet Production in Deep Inelastic Scattering at high Q2 at HERA*

THE UNIVERSITY *of* LIVERPOOL


Steve Maxfield for H1

***Thomas Kluge***

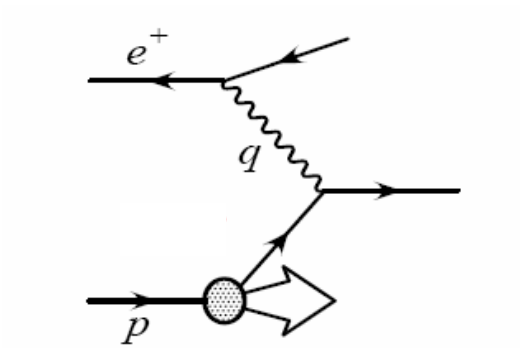
***Wenbiao Yan***


- Inclusive Jet production and $\alpha_S$
- Data Selection and cross section measurement
- QCD analysis and extraction of $\alpha_S$
- Conclusions

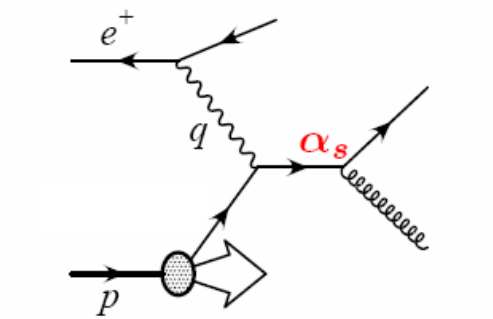
- Results are preliminary

# Inclusive Jet Cross-sections

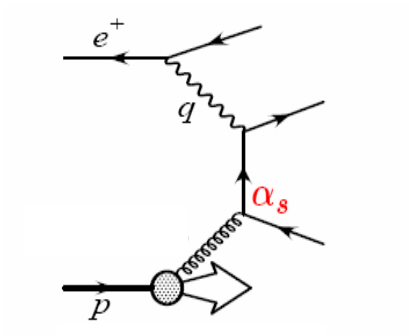
- Inclusive jet cross-section in NC DIS.
  - High statistics, IR safe source of information on QCD
  - Relatively small systematic uncertainties and few non-perturbative complications
  - Sensitivity at order $\alpha_S$




Born level




QCD Compton

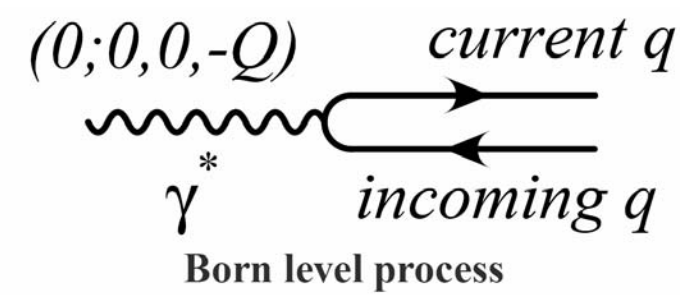



Boson gluon fusion

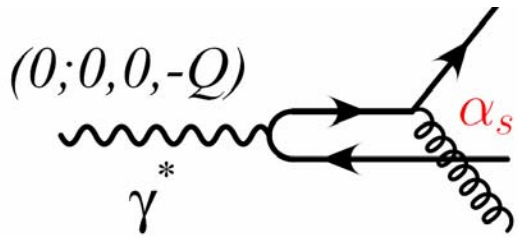
# Jet Definition

- Perform jet finding in *Breit Frame* so that:
  - Jet production cross section factorises
  - Lowest order with high $E_t$ jets is already $\mathcal{O}(\alpha_S)$.

B. R. Webber, J. Phys. **G19** (1993) 1567.



Born level process



QCD compton

- Use Longitudinally invariant, factorisable $k_t$ algorithm.

S. Catani, Yu.L. Dokshitzer, M.H. Seymour and B.R. Webber, C Nucl.Phys.B406(1993)187.

$E_t > 7$ GeV  $-1.0 < \eta^{Lab} < 2.5$

# Event Selection and Correction Procedure

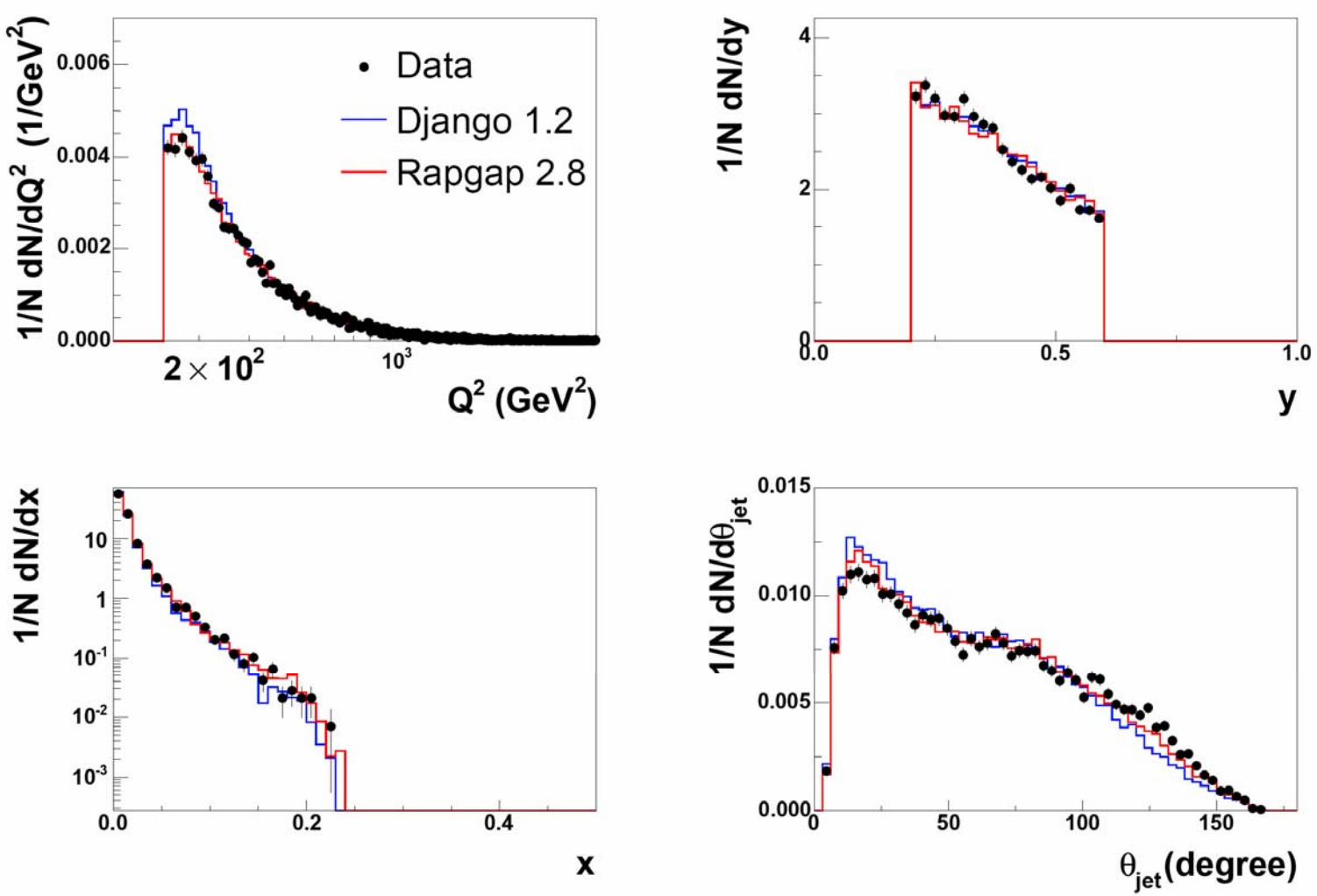
- 61.25 $pb^{-1}$ collected in 1999-2000 at cms energy $\sqrt{s}$ = 319 GeV
- Identify high $Q^2$ DIS events using scattered electron. Kinematic variables reconstructed using "electron-$\Sigma$" method
- Require:
  - $E_e' > 11$ GeV, $\theta_e < 153°$
  - $45 \text{ GeV} < \sum(E-p_z) < 65 \text{ GeV}$ (sum over hadrons + electron)

- $150 < Q^2 < 5000 \text{ GeV}^2$
- $0.2 < y < 0.6$
- ≥ 1 jet with $E_t > 7$ GeV and $-1 < \eta^{Lab} < 2.5$

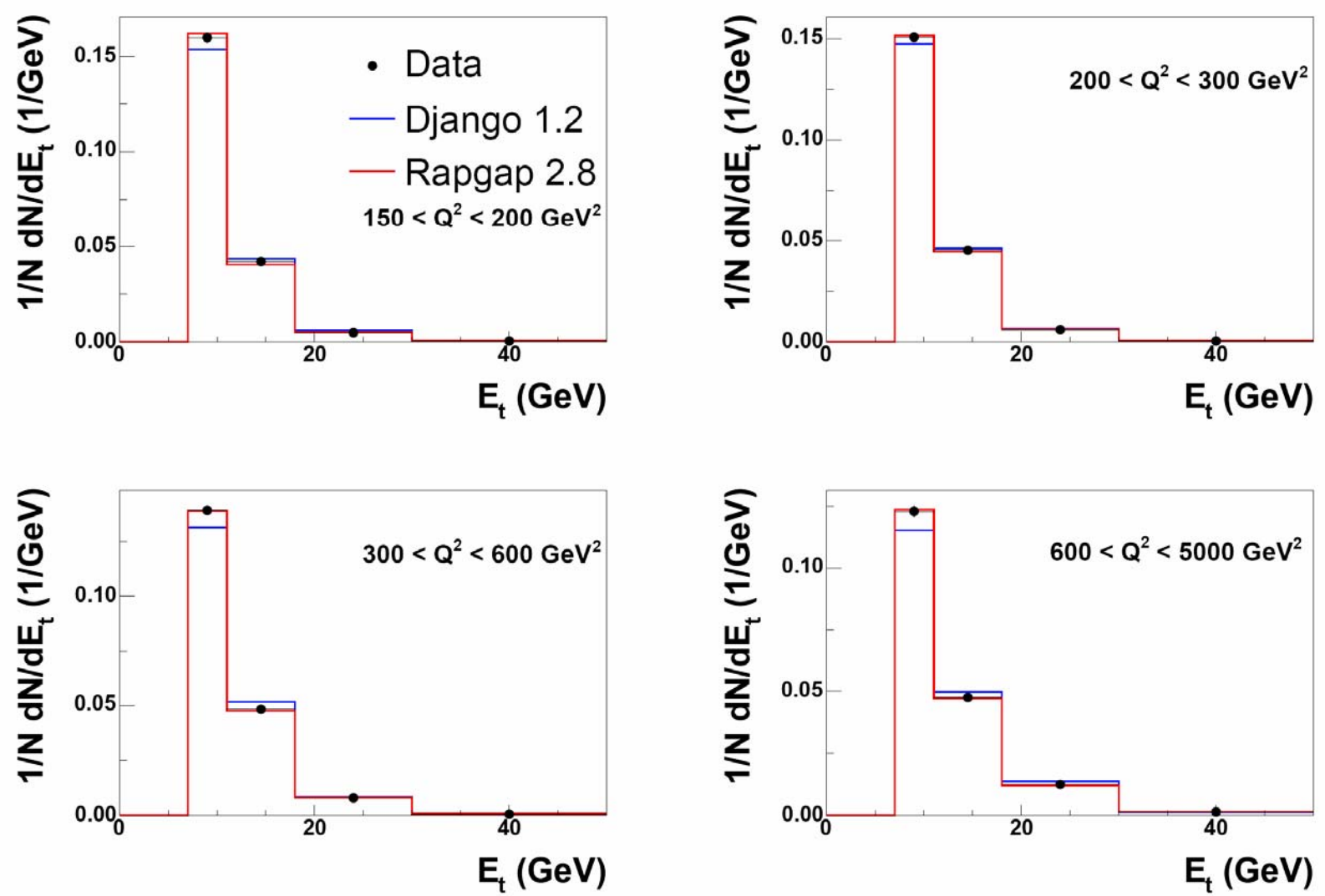
} Phase Space for cross sections

⇒ Correct data for detector resolution, acceptance losses and QED radiative effects

- DIS quantities in LO Monte Carlos compared to the data
- Distributions are normalised to 1.



- Jet $E_t$ distributions in LO Monte Carlos compared to the data.
- distributions are normalised to 1.



# Correction procedure continued…

- Bins chosen such that purities and stabilities > 50% justifying…
- …bin-by-bin correction procedure
- Correction factors determined from LO MC event generators
  - Django 1.2 (Ariadne, CDM)
  - Rapgap2.8 (LO ME + PS)
- $\Rightarrow$Factors within 20% of unity, model dependence < 10%.

$$C \equiv (C^{\text{Django}} + C^{\text{Rapgap}})/2$$
$$\delta C \equiv (C^{\text{Django}} - C^{\text{Rapgap}})/2$$

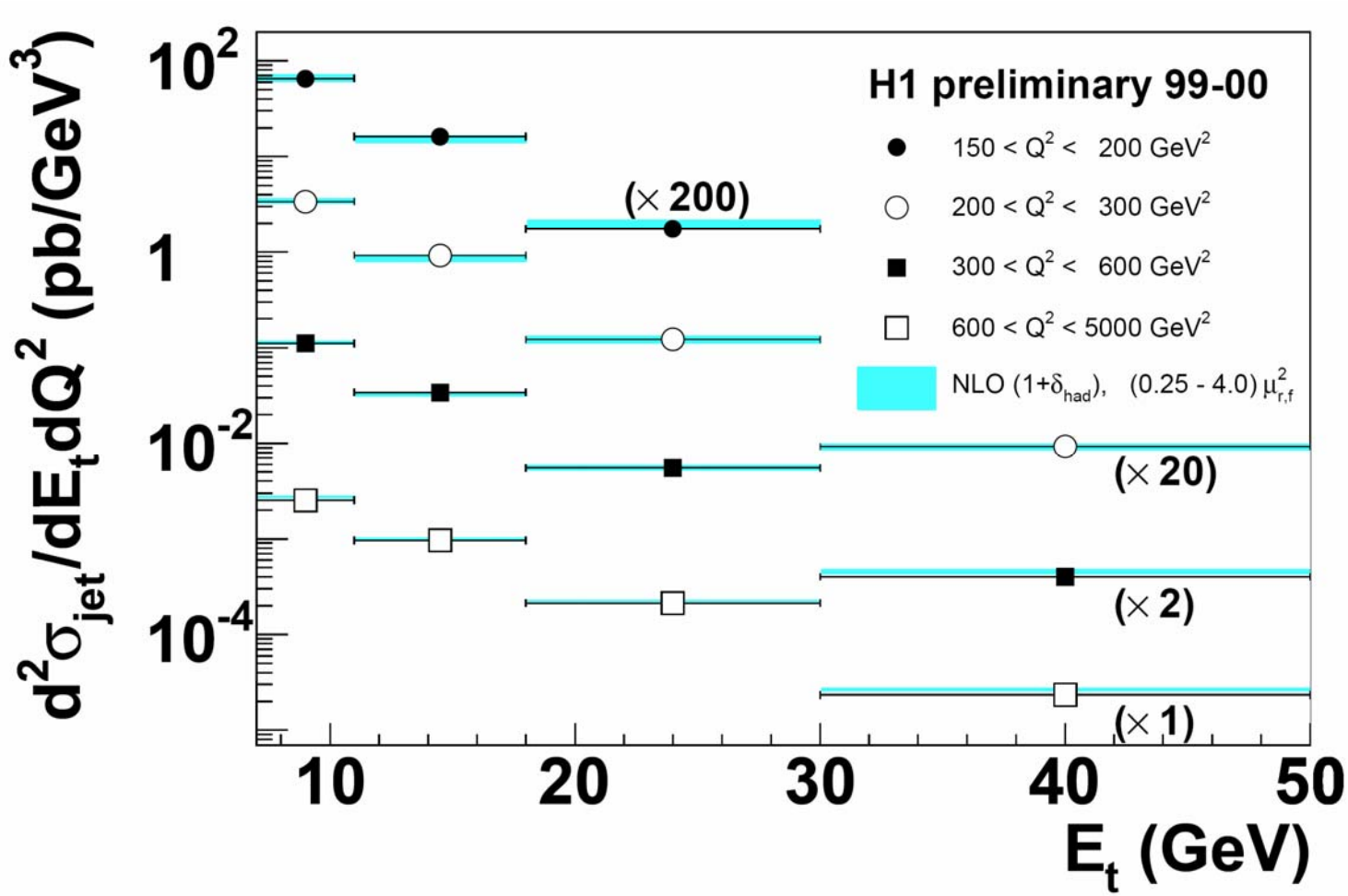
# NLO QCD Calculations

- NLOJET++ Z. Nagy and Z. Trocsanyi, Phys. Rev. Lett. 87 (2001)
  - $\overline{MS}$ Scheme
  - Renormalisation scale, $\mu_r = E_t^2$. Factorisation scale $\mu_f = Q^2$
  - 2-loop $\alpha_S(\mu_r)$ evolution, 5 active flavours. $\alpha_S(M_Z)$ fixed at 0.118
  - CTEQ5M1 PDFs for proton.
  - Estimate scale uncertainties by canonical variation: $0.25 < \mu_r^2 / E_t^2, \mu_f^2 / Q^2 < 4.0$
- Correct predicted parton level cross-sections for hadronisation

$$(1+\delta_{had}) = \sigma_{had} / \sigma_{part}$$

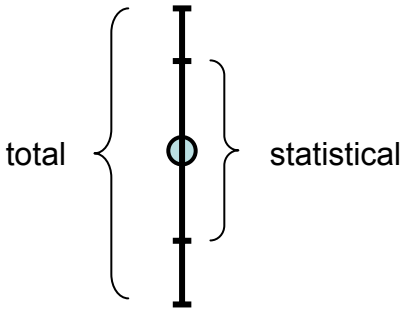
  - Use the LO MCs (without QED radiation) to determine corrections and uncertainties.
  - Corrections typically ~10%

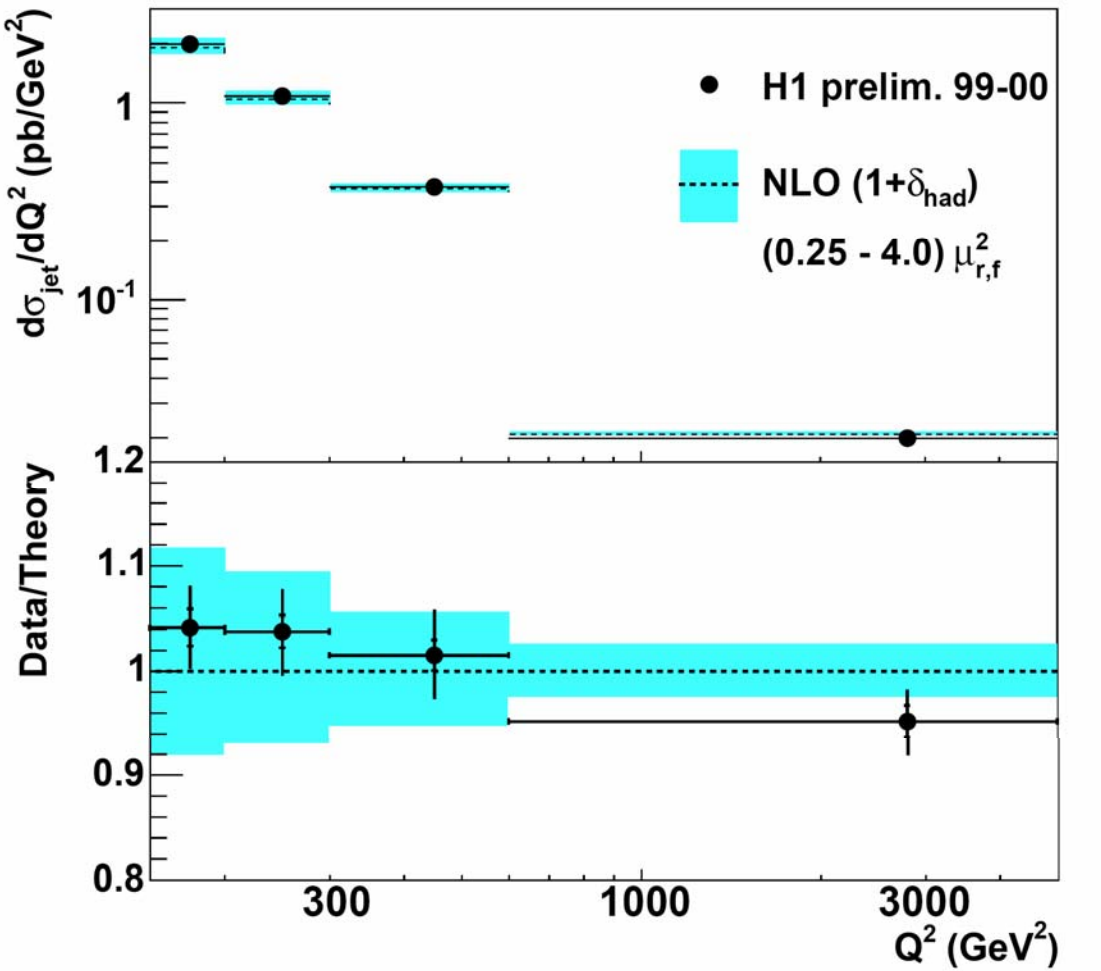
# Results I




***Good description of data over full $E_t$ range and all $Q^2$ ranges***

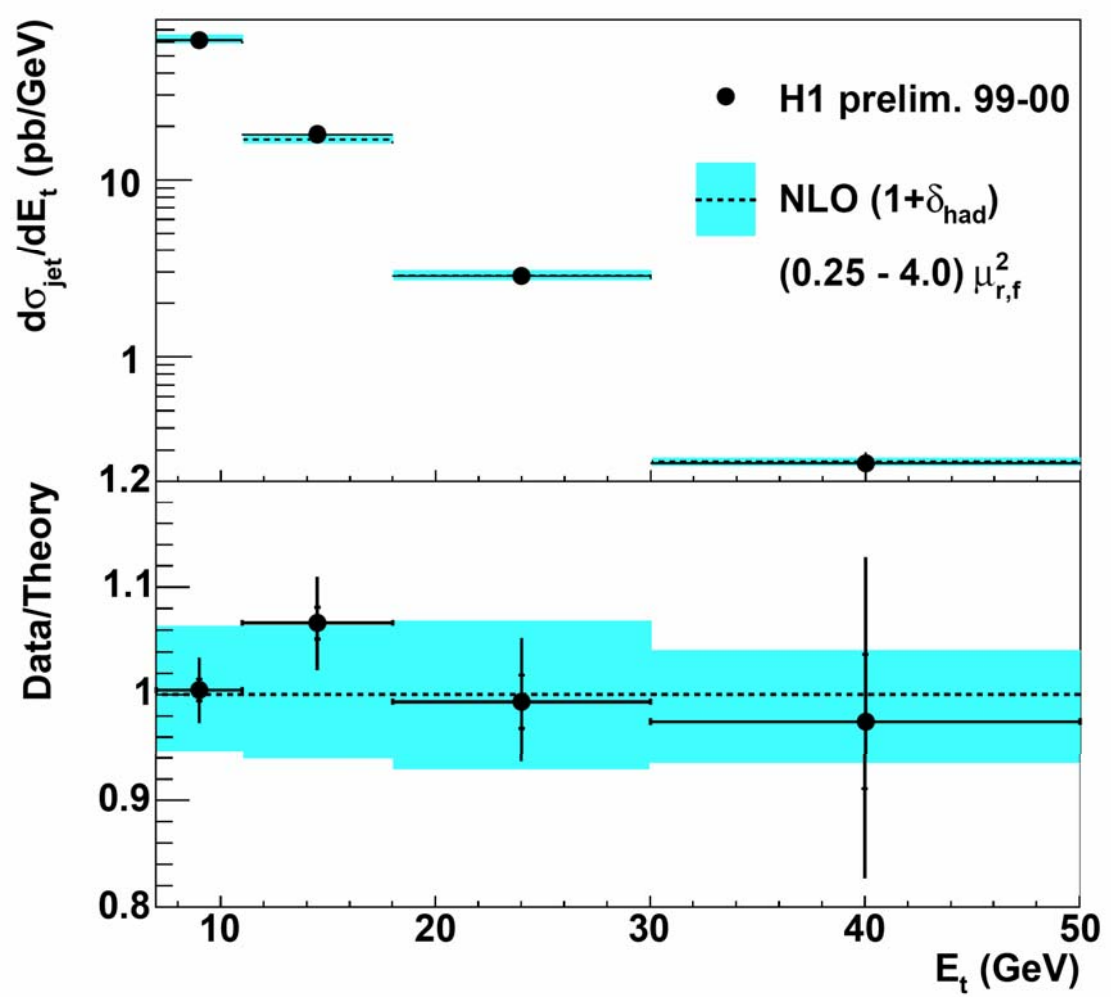
# Results II




***Good description of data over full $Q^2$ range***

# Results III



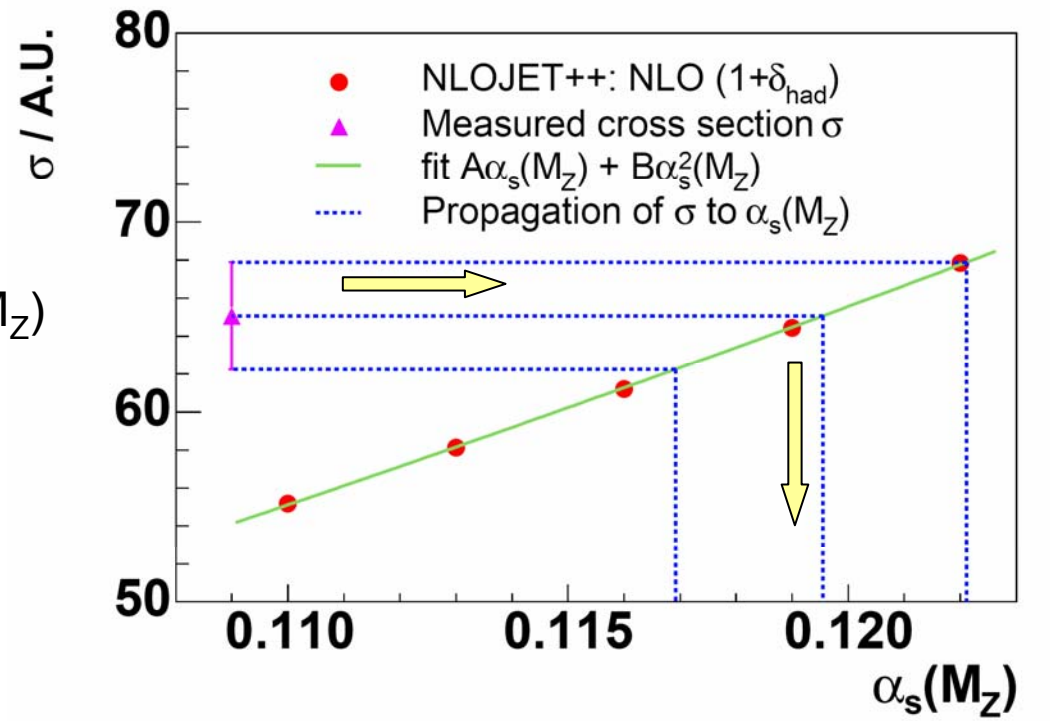

***Good description of data over full $E_t$ range***

# Determination of $\alpha_S(M_Z)$

- Use NLOJET++ to predict dependence of cross-section on $\alpha_S(M_Z)$ through matrix element and PDF in each measurement bin.
- Parameterize as $\sigma_{bin}\left(\alpha_S\left(M_Z\right)\right) = A_{bin} \cdot \alpha_S\left(M_Z\right) + B_{bin} \cdot \alpha_S^2\left(M_Z\right)$

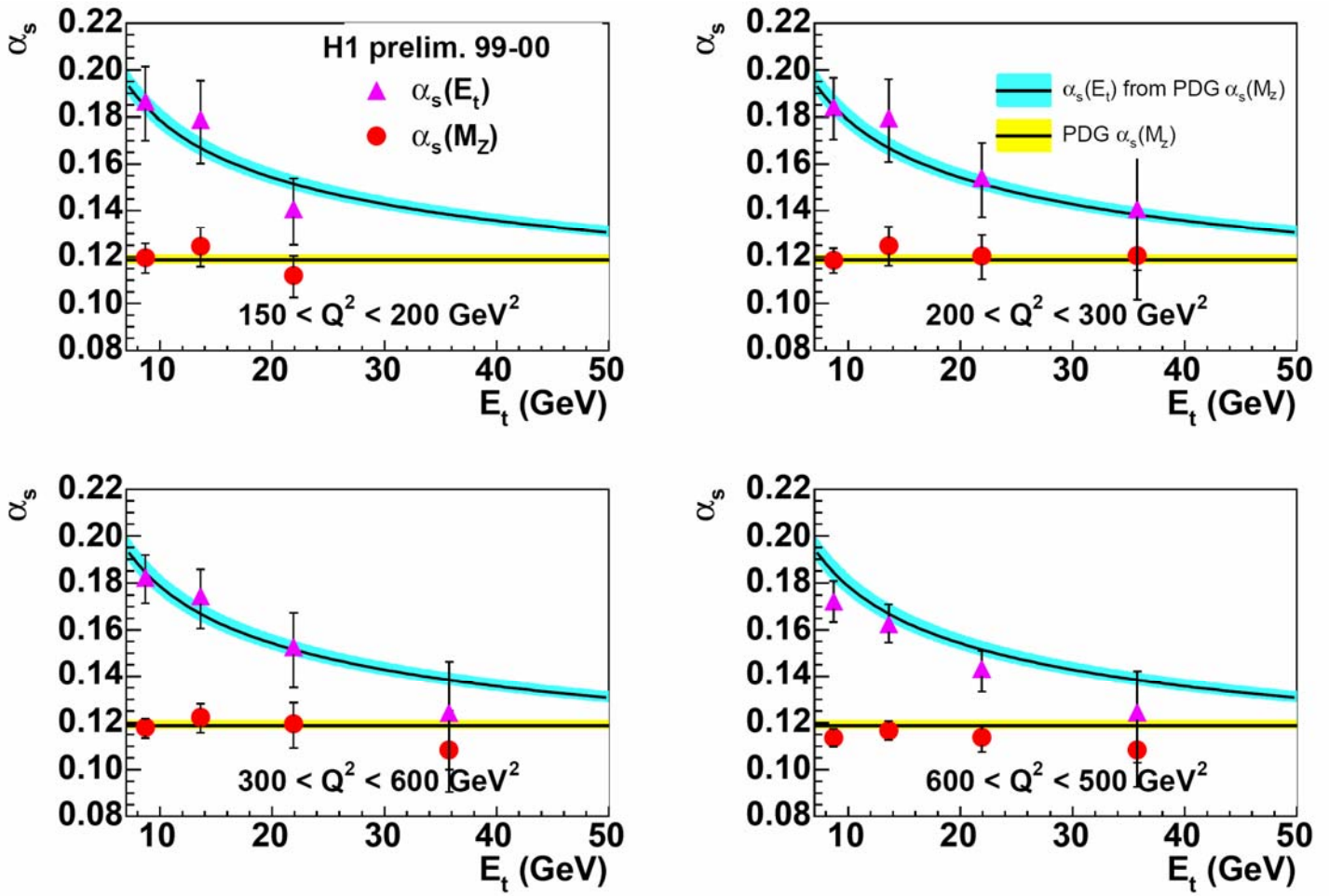
(cf ZEUS Physics Letters B 507 (2001) 70-88Z; Enrico Tassi (Hamburg U.),. DESY-THESIS-2001-059, Dec 2001.)

Invert measured $\sigma \rightarrow \alpha_S(M_Z)$



# Results IV

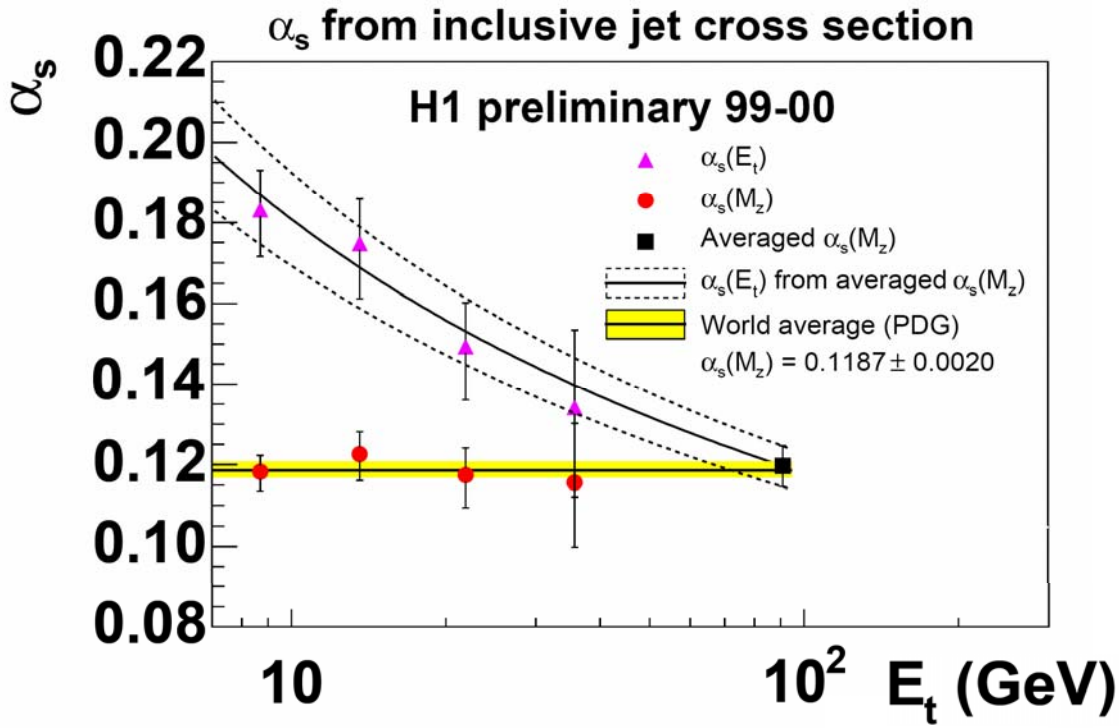
- Extracted values of $\alpha_S(M_Z)$
- Evolve with two-loop RG equation to $\alpha_S(E_t)$

# Results V

- Values consistent

  $\Rightarrow$ average




- Make combined fit to single $\alpha_S(M_Z)$ value ($\chi^2$ ndf =20.14/14) $\Rightarrow$

$$\alpha_s(M_Z) = 0.1197 \pm 0.0016(\text{exp.})^{+0.0046}_{-0.0048}(\text{th.})$$

**Largest contributions to errors:**

Expt. LAr energy scale, model dependence

Theory. Renormalisation and factorisation scales

# Conclusions

- H1 has measured the inclusive jet cross section in DIS $e^+p$ scattering in the range $150 < Q^2 < 5000\ \text{GeV}^2$ for jets with transverse energy > 7 GeV.
- NLO QCD predictions provide a sound description of the data.
- The strong coupling constant $\alpha_S(M_Z)$ has been measured:

$$\alpha_s(M_Z) = 0.1197 \pm 0.0016(\text{exp.})^{+0.0046}_{-0.0048}(\text{th.})$$

consistent with the world average.