High Et jets and α_s at HERA

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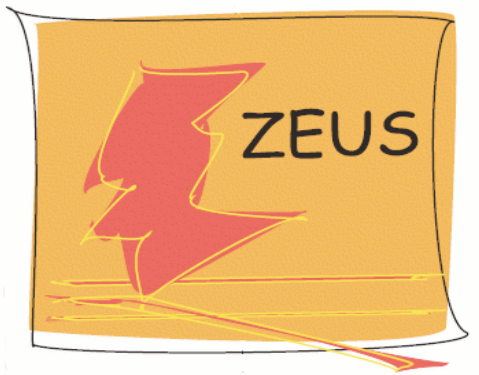
on behalf of the H1 and ZEUS Collaborations



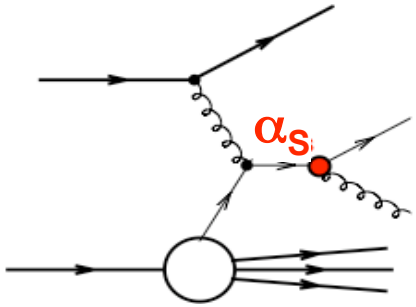
Abstracts covered

- **121 Measurement of the jet-radius dependence of inclusive-jet cross sections**
  DESY-06-241, Physics Letters B 649 (2007) 12-24
- **132 Measurement of multi-jet cross sections in charged current ep scattering**
  DESY-08-24, to be published in Physical Review D
- **137 Measurement of angular correlations in three-jet production**
  ZEUS **preliminaryDESY-08-100**
- **143 Measurement of dijet cross sections in deep inelastic ep scattering**
  ZEUS-prel-07-005
- **145 Measurement of jet substructure in neutral-current deep inelastic ep scattering at high Q2**
  ZEUS-prel-07-013
- **152 / 628 Precision measurements of alphas at HERA (H1 and ZEUS)**
  H1prelim-07-132 ZEUS-prel- 07-025
- **788 Measurement of Inclusive Jet Production in Deep-Inelastic Scattering at High Q2 and Determination of the Strong Coupling**
  DESY 07-073 , Phys.Lett.B653:134-144,2007
- **844 Inclusive and Multi-Jet Production at high Q^2 and determination of α_s using full HERA data**
  H1prelim-08-031
- **845 Measurement of jet production in deep-inelastic ep scattering at low Q2**
  H1prelim-08-031

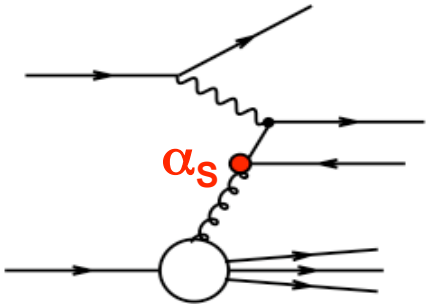
Jet production in electron-proton scattering

multi-jet states (> 1+1) = direct manifestation of QCD

Deep inelastic scattering (DIS)

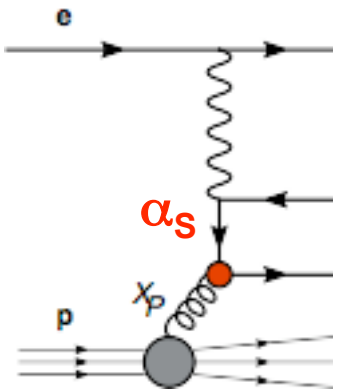


QCD Compton

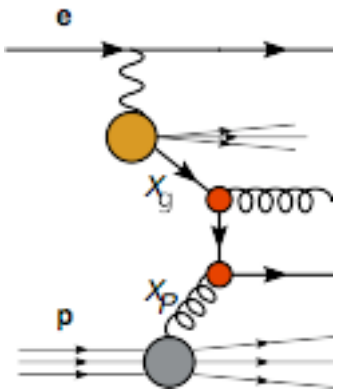


BGF

Photo-production ($Q^2 \approx 0$)



direct

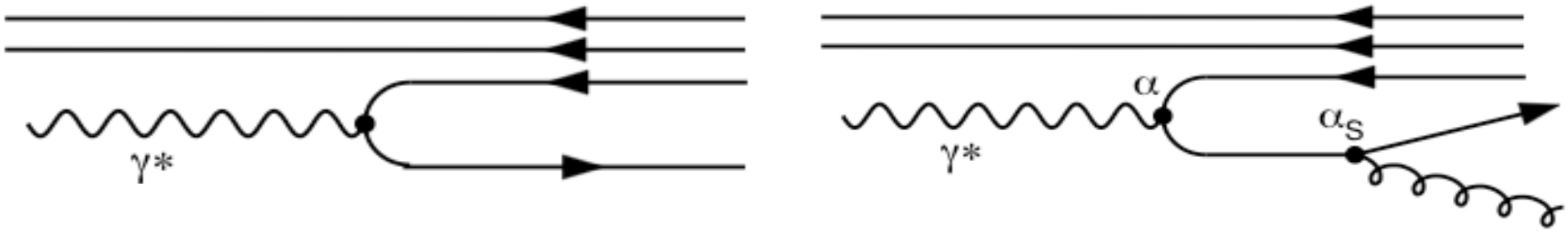


resolved

comparison with & fit to pQCD predictions ⇒ access to:

- parton distribution functions (gluon pdf)
- precision measurement of **strong coupling constant α_S**

Jet Finding: k_T Algorithm in the Breit Frame



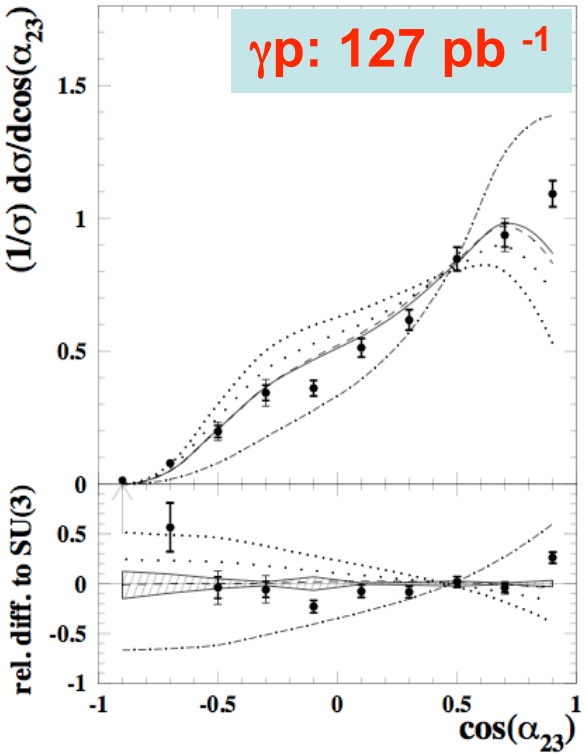
- **Breit frame: proton and virtual photon collide head-on,** in the naïve quark parton model the quark bounces off from the photon like from a "brick wall"
- **transverse momentum in Breit frame stems mainly from QCD process**
- **longitudinally invariant kT jet-algorithm in the Breit frame**
  - collinear and infrared safe
  - iterative clustering: $d_{i,j}^2 = min(E_{T,i}^2, E_{T,j}^2) \cdot \left[(\eta_i - \eta_j)^2 + (\varphi_i - \varphi_j)^2\right]$
  - result: n jets with $d_{i,j} > R$ where $R = 1$
- **observables: $\sigma(\geq n$ jets) single and double differential**
  as functions of: E_T, Q^2, x_B, η, parton momentum fraction ξ , invariant mass m

Checking the Gauge: 3-Jet Angular Correlations

$$\sigma_{ep\to 3jet} = C_F^2 \left| \text{(A)} \right|^2 + C_F C_A \left| \text{(B)} \right|^2 + C_F T_F \left| \text{(C)} \right|^2 + T_F C_A \left| \text{(D)} \right|^2$$

angle between 2 lowest E_T jets

« Körner,Schierholz,Willrodt »



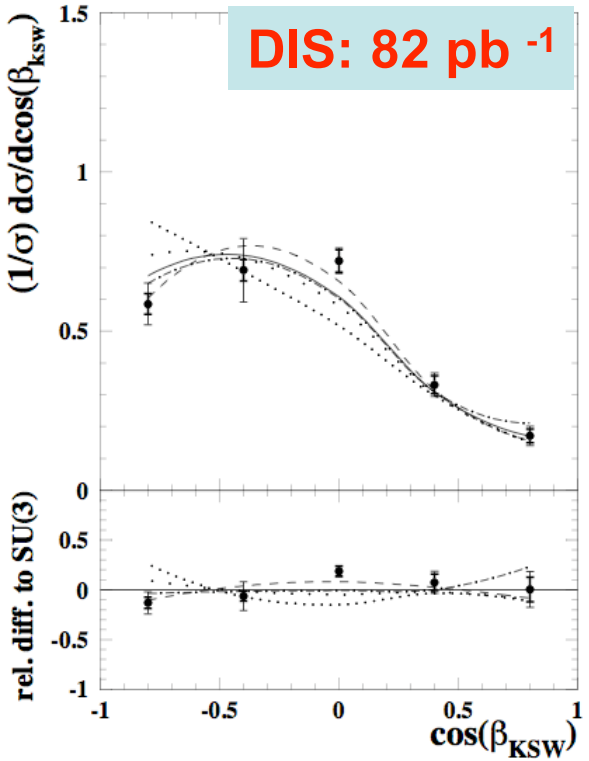
SU(3)

$U(1)^3$

SU(N), large N

$C_F = 0$

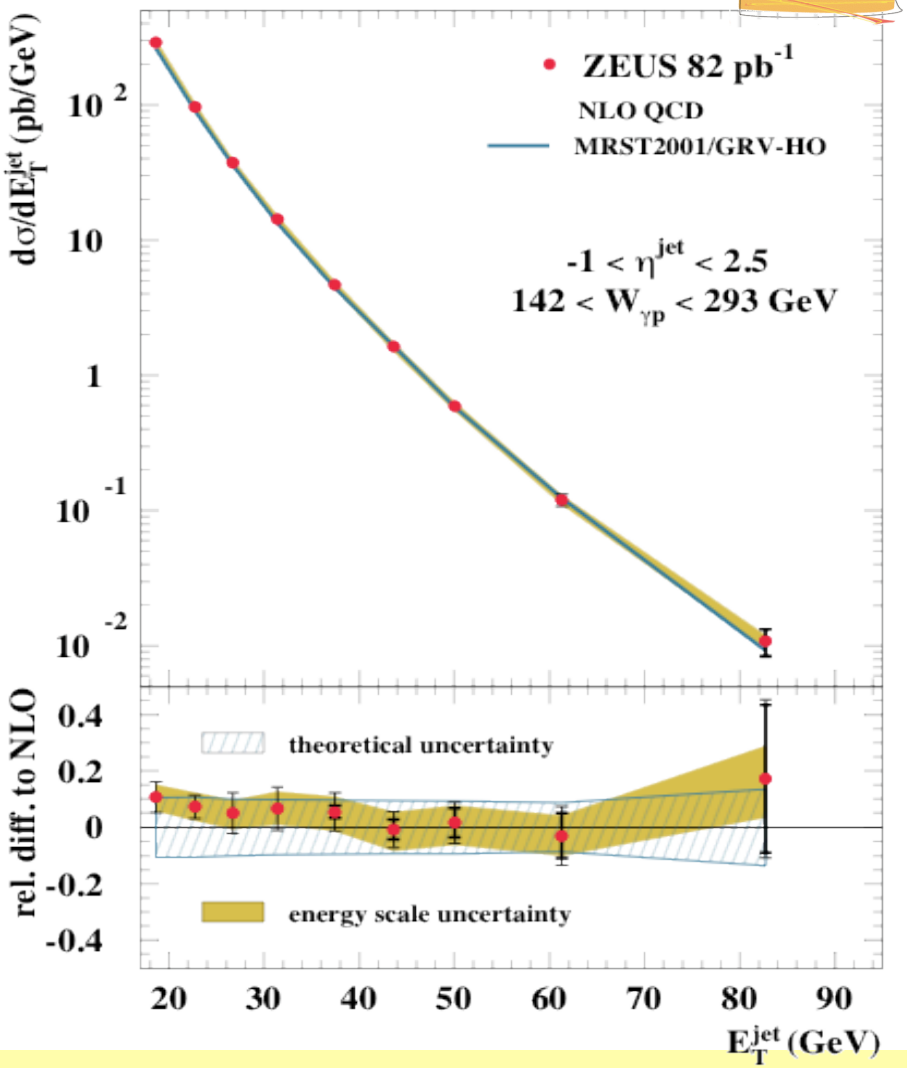
SO(3)



- 3-jet angular correlations in γp and DIS compatible with SU(3)
- SU(N_C=∞) and C_F=0 models are disfavored

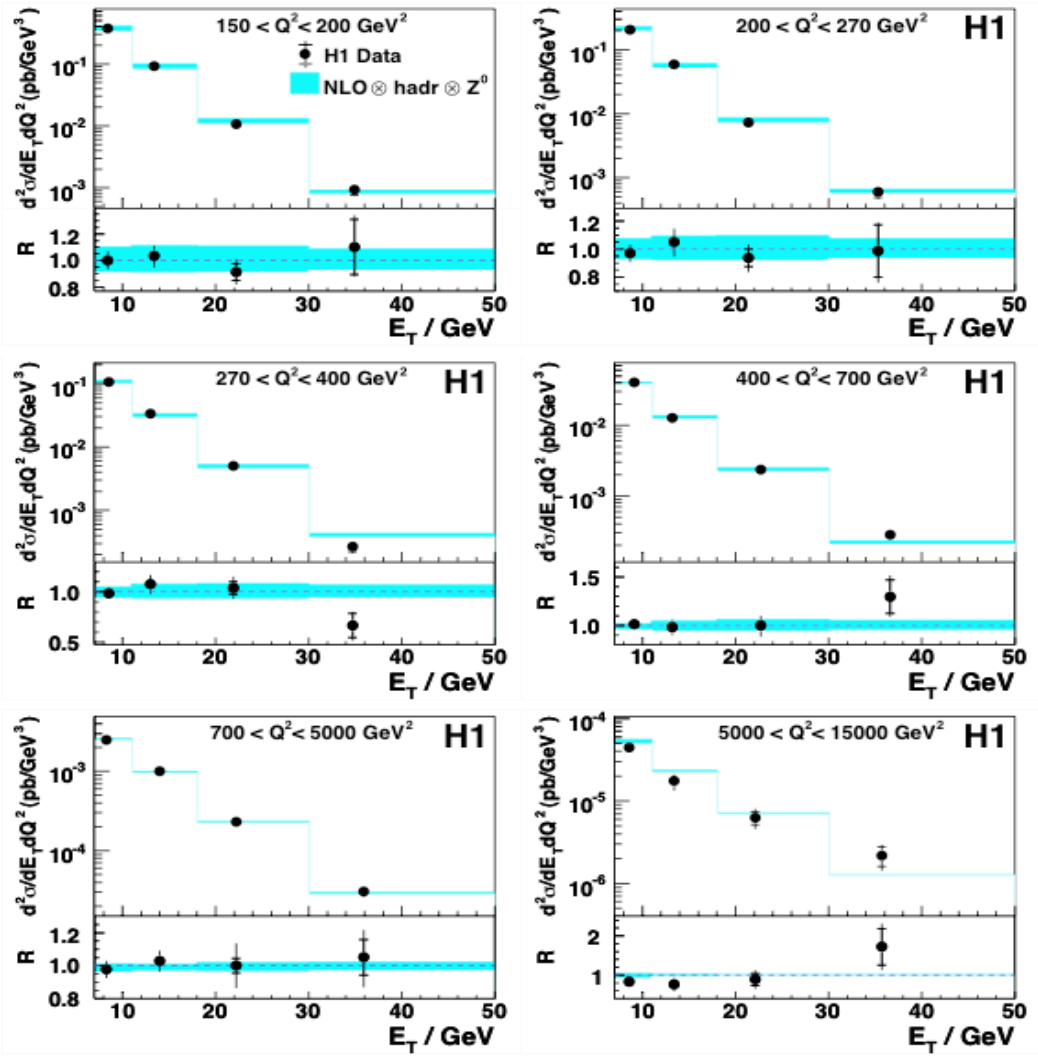
Inclusive Jet Production

in photo-production (ZEUS)



$\alpha_s(m_Z) = 0.1223 \pm 0.0001(stat) \pm 0.022(exp) \pm 0.030(th)$

in deep-inelastic scattering (H1)

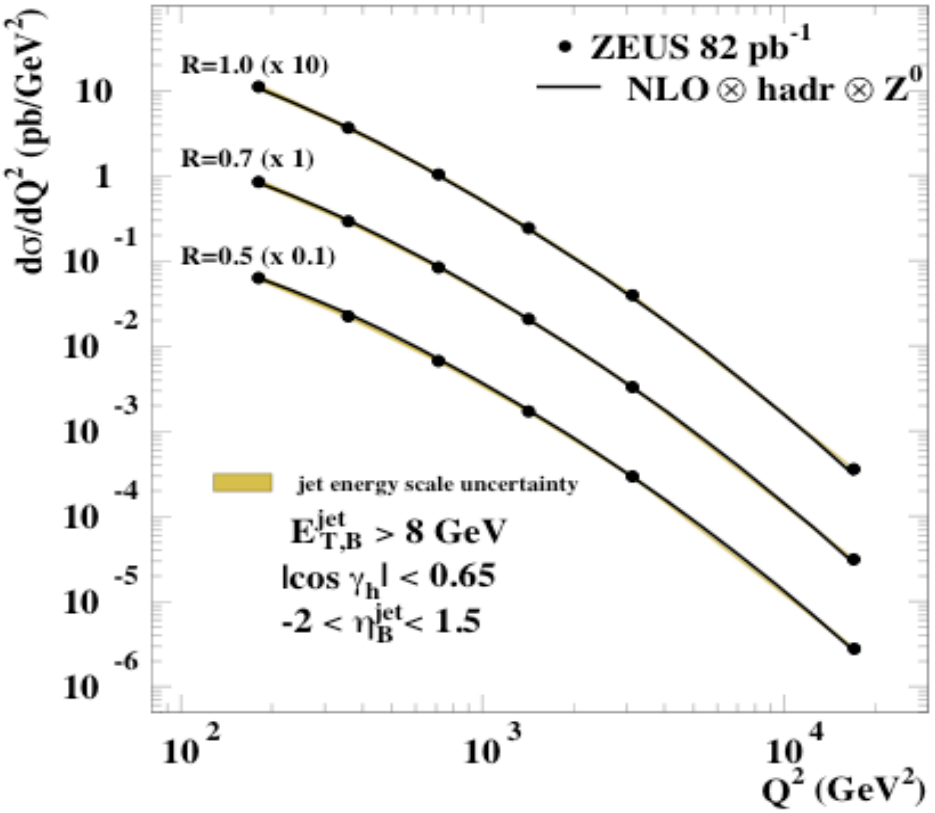


$\alpha_s(m_Z) = 0.1179 \pm 0.0024(exp)^{+0.0047}_{-0.0030}(th) \pm 0.016(pdf)$

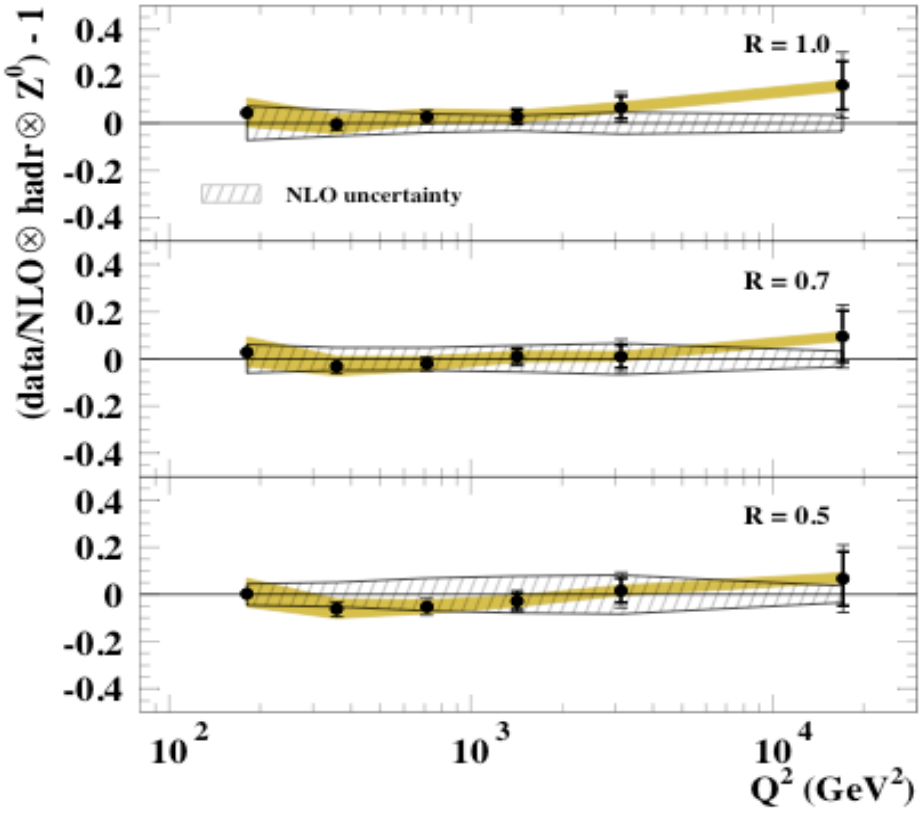
Influence of Radius on Jet Production

- k_T algorithm: $d_{i,j}^2 = min(E_{T,i}^2, E_{T,j}^2) \cdot \left[(\eta_i - \eta_j)^2 + (\varphi_i - \varphi_j)^2 \right] < R = 1$

inclusive jet cross-section in DIS



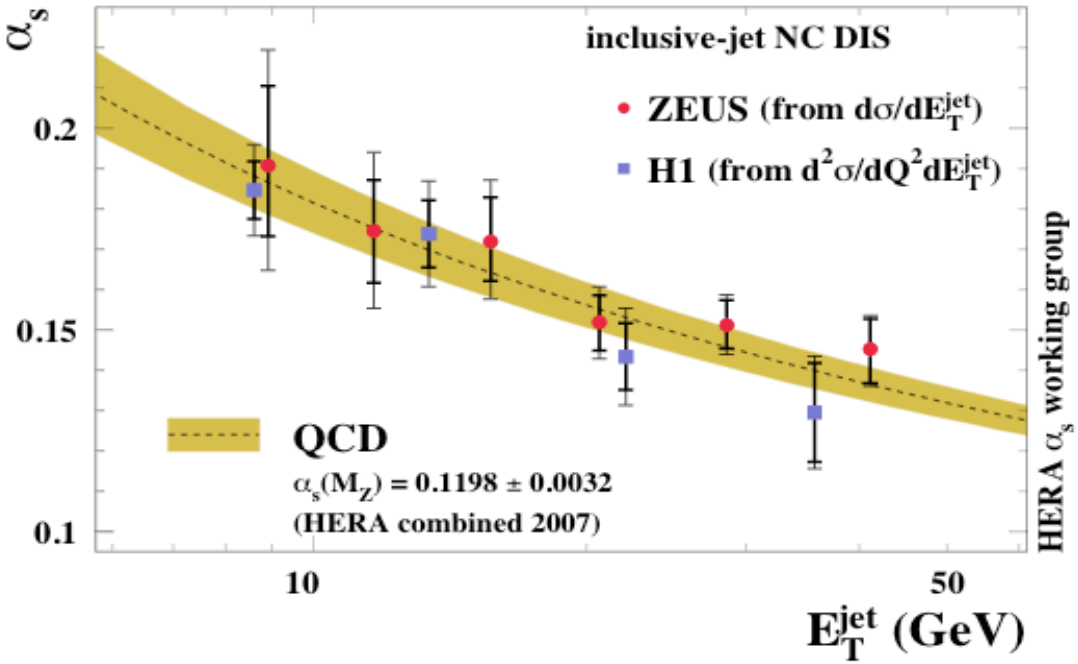
exp. & theory uncertainties

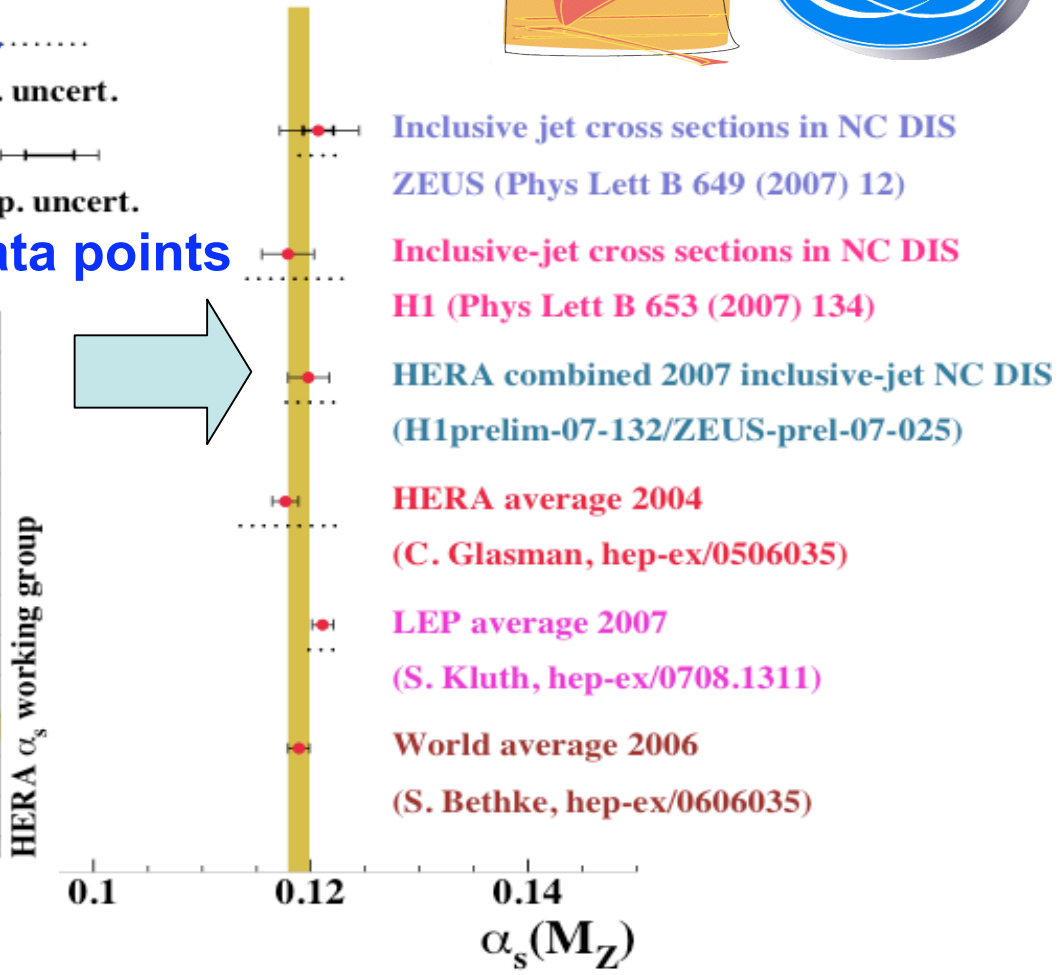


- NLO describes well jet productions for radius parameter down to 0.5
- for R=1: $\alpha_s(m_Z)$ = 0.1207 ± 0.0014 (stat.) ± 0.0034 (syst.) ± 0.022(th.)

HERA α_s determination: H1 and ZEUS

- HERA I incl. jet cross-sections in DIS
- syst. exp. uncertainties partially uncorr'd between experiments
- simultaneous fit of $\alpha_s(m_Z)$ to 24 +6 data points





$\alpha_s(m_Z) = 0.1198 \pm 0.0019\ (exp.) \pm 0.0026\ (th.)$

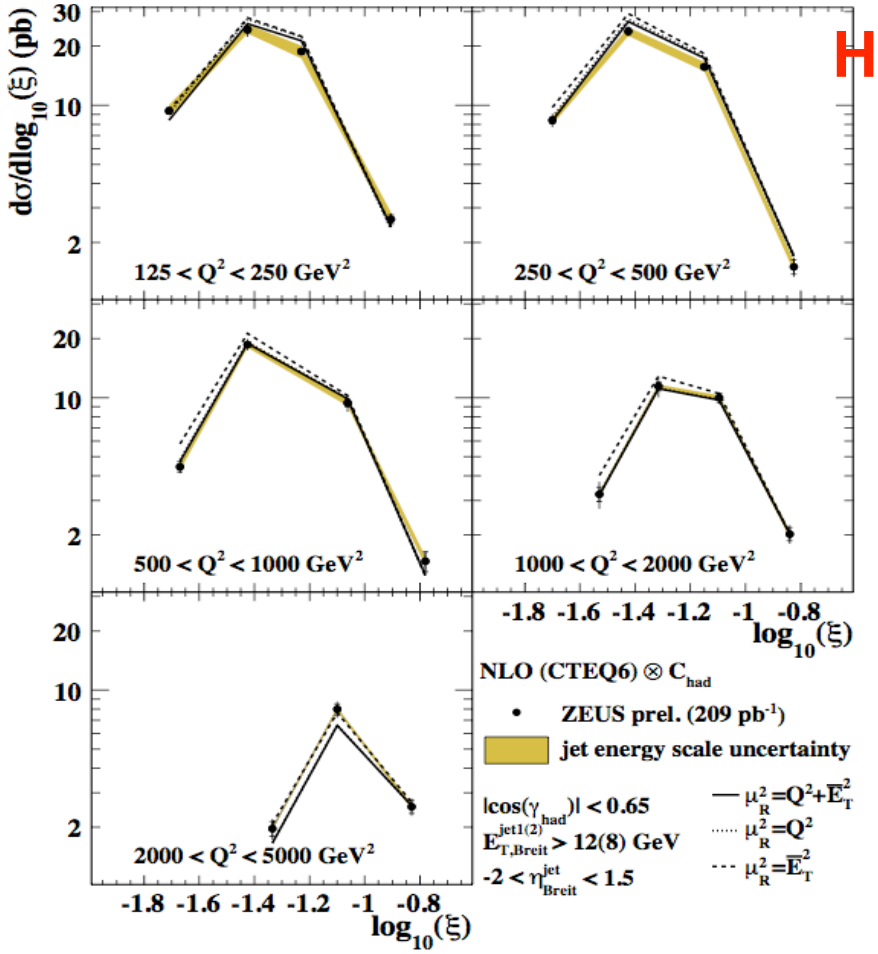
HERA I (2007) average competitive with LEP average

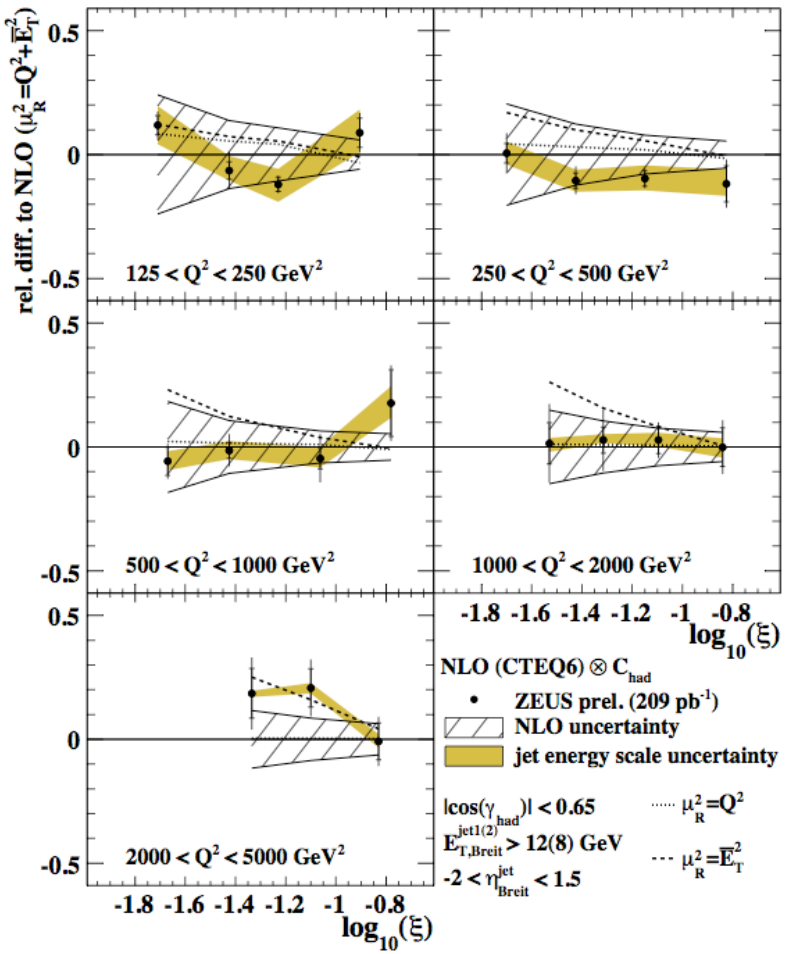
Dijet Production in DIS

parton momentum fraction $\xi = x_B \cdot (1+M^2/Q^2)$

HERA II

(data-NLO)/NLO





differential 2-jet cross-sections (E_T, Q^2, x_B, η^*, ξ, m_{12}) well described by NLO pQCD, theory uncertainty dominates

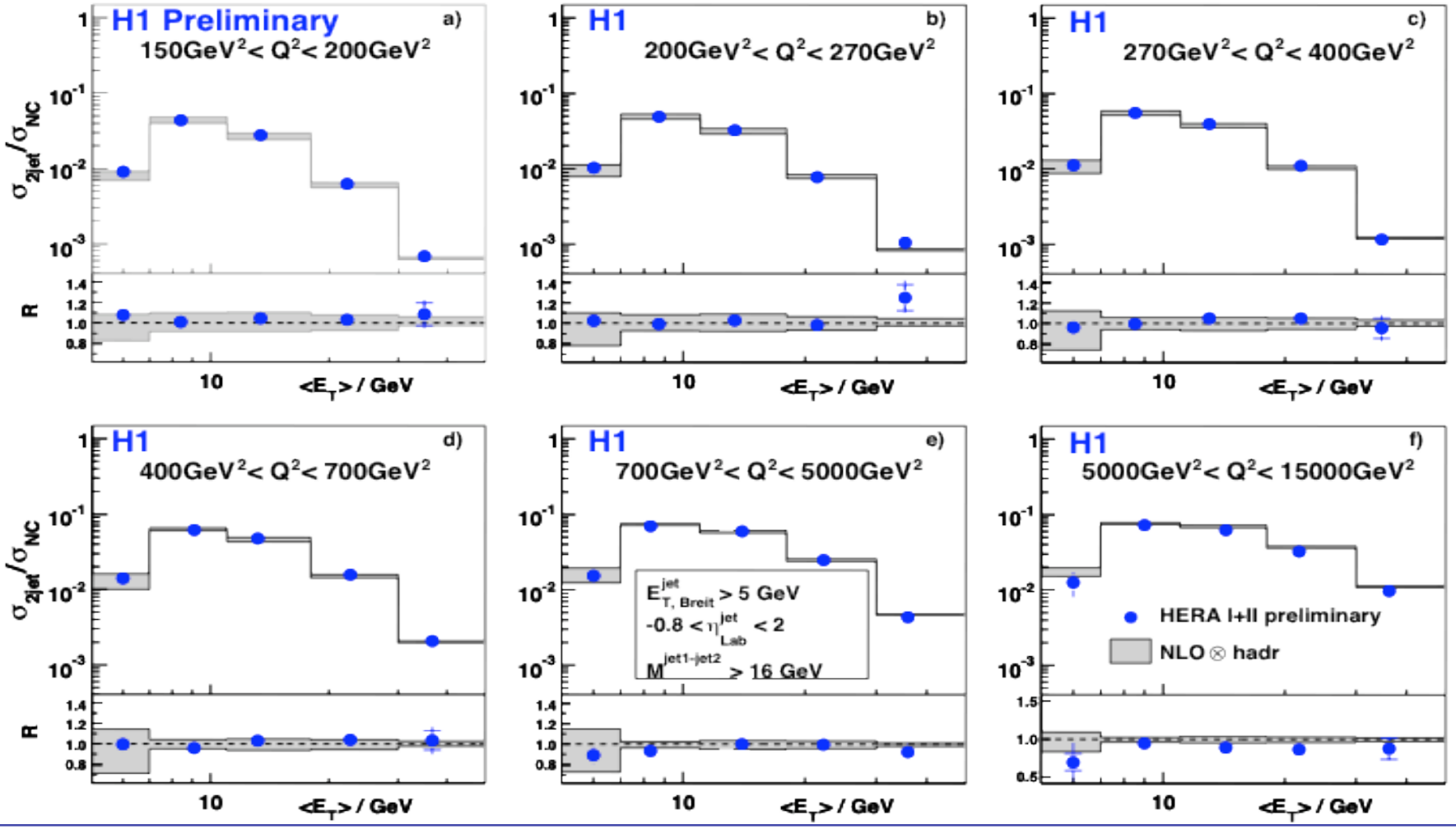
Normalized Jet Cross-Sections

- partial cancellation of experimental and theoretical uncertainties
- Inclusive, dijet and 3-jet normalized cross-sections

HERA I+II

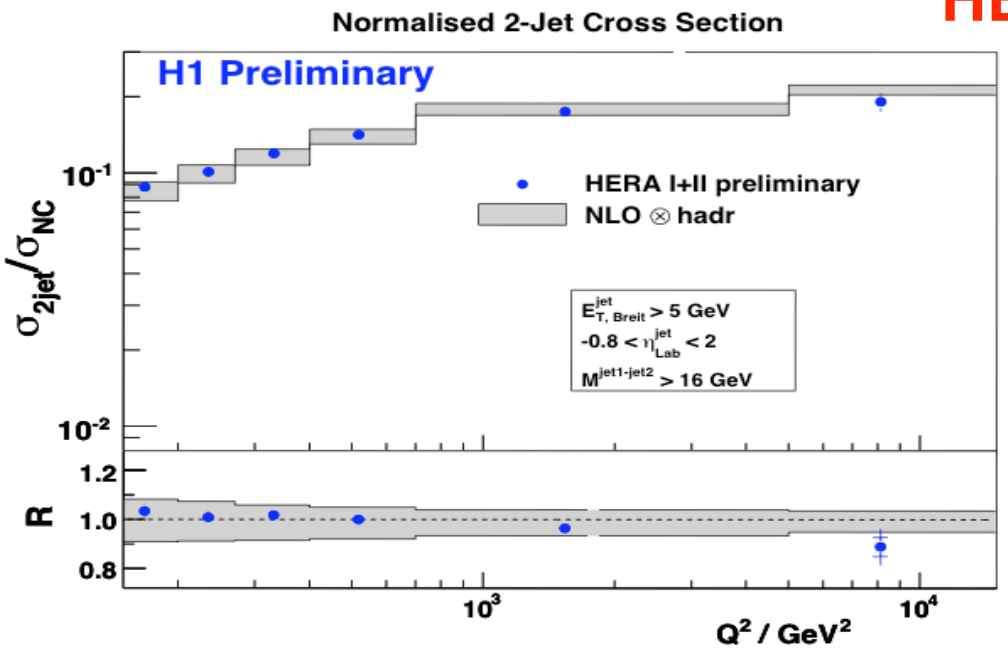
$\frac{\sigma_{2\,Jet}}{\sigma_{DIS}}$

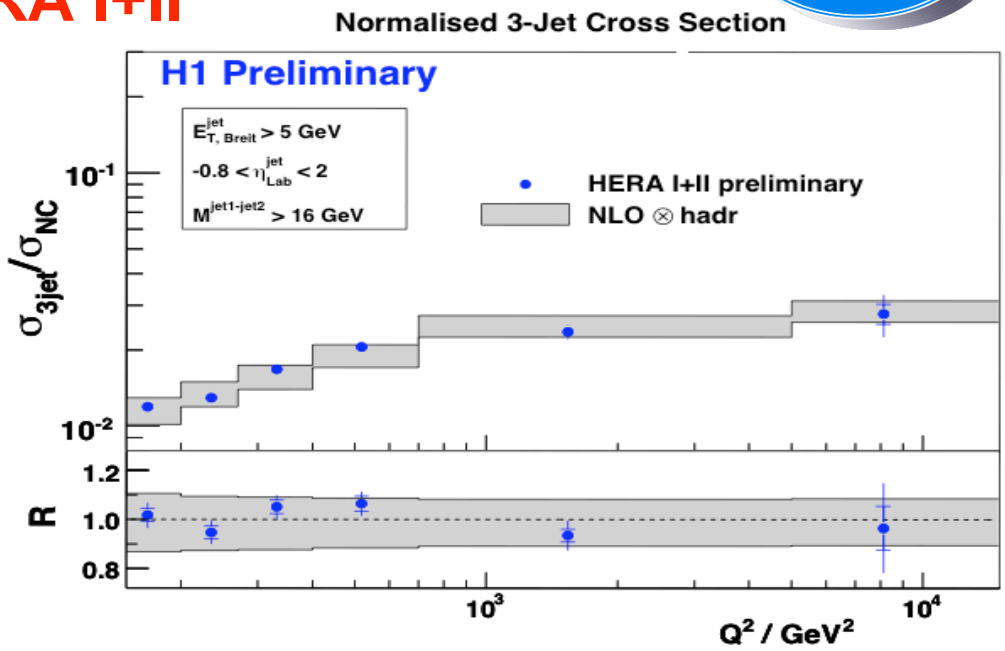
data/NLO



Normalized multi-jet cross-sections in DIS

HERA I+II



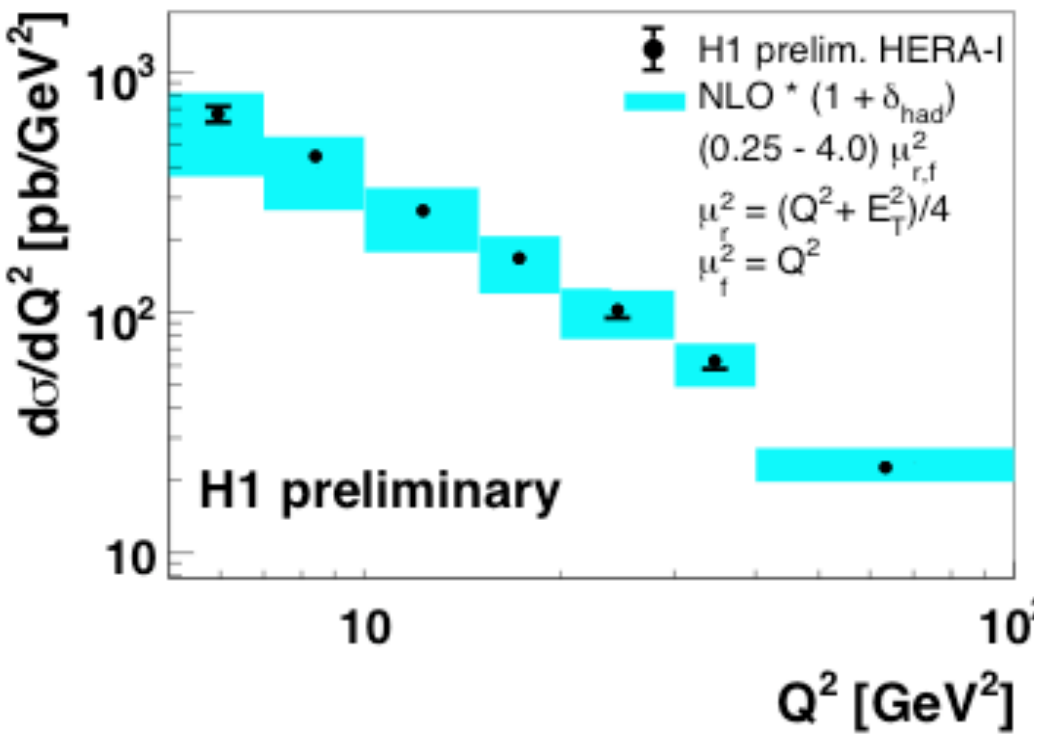


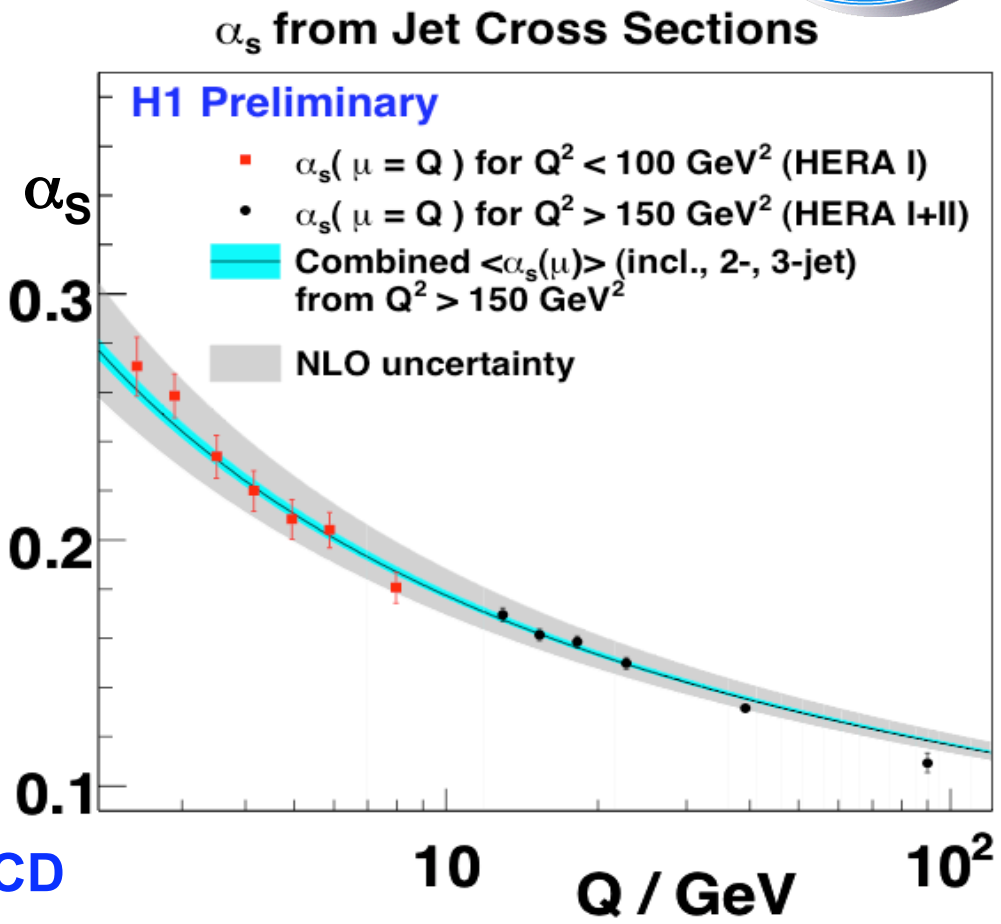
- good agreement with NLO predictions (NLOJET/DISENT)
- α_s-fit to inclusive, 2- and 3- jet normalized cross-sections are good
- combined fit to all observables:

$$\alpha_s(m_Z) = 0.1182 \pm 0.0008\,(\text{exp}) \,{}^{+\,0.0041}_{-\,0.0031}(\text{th}) \pm 0.0018\,(\text{PDF})$$

$\Rightarrow$ 20-40% improvement of experimental and theory errors

Inclusive Jet Production at Low Q^2

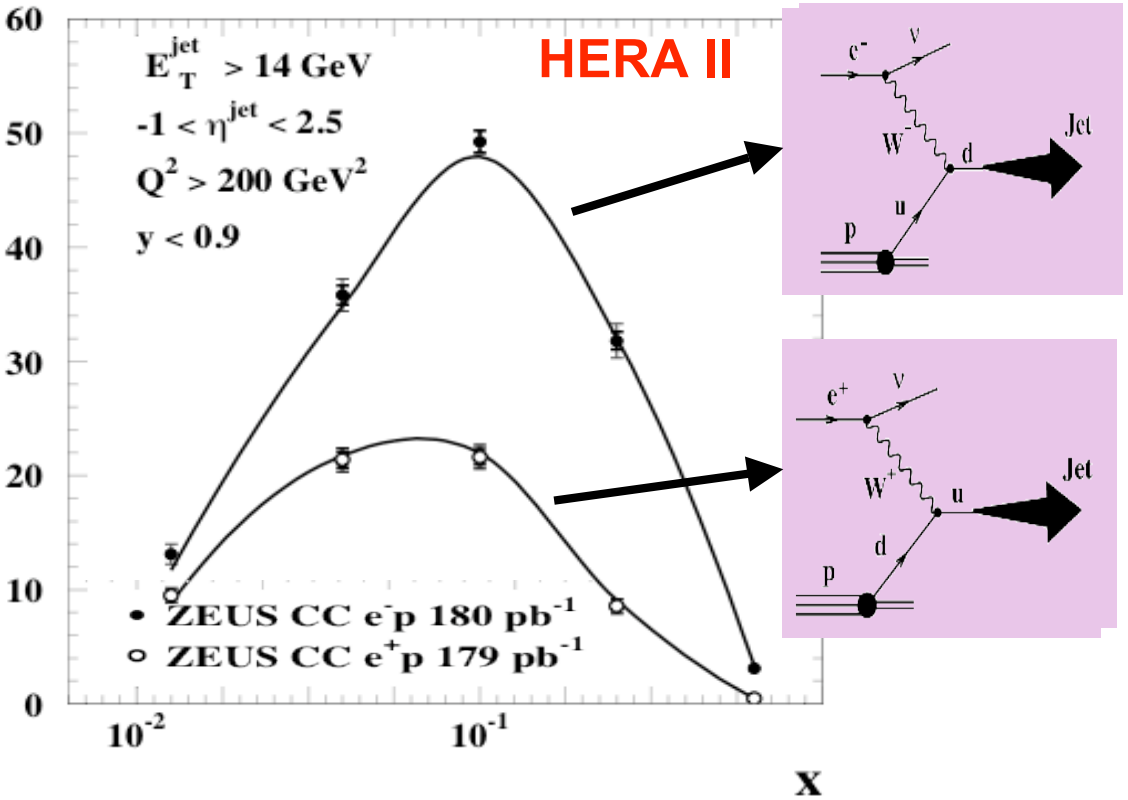




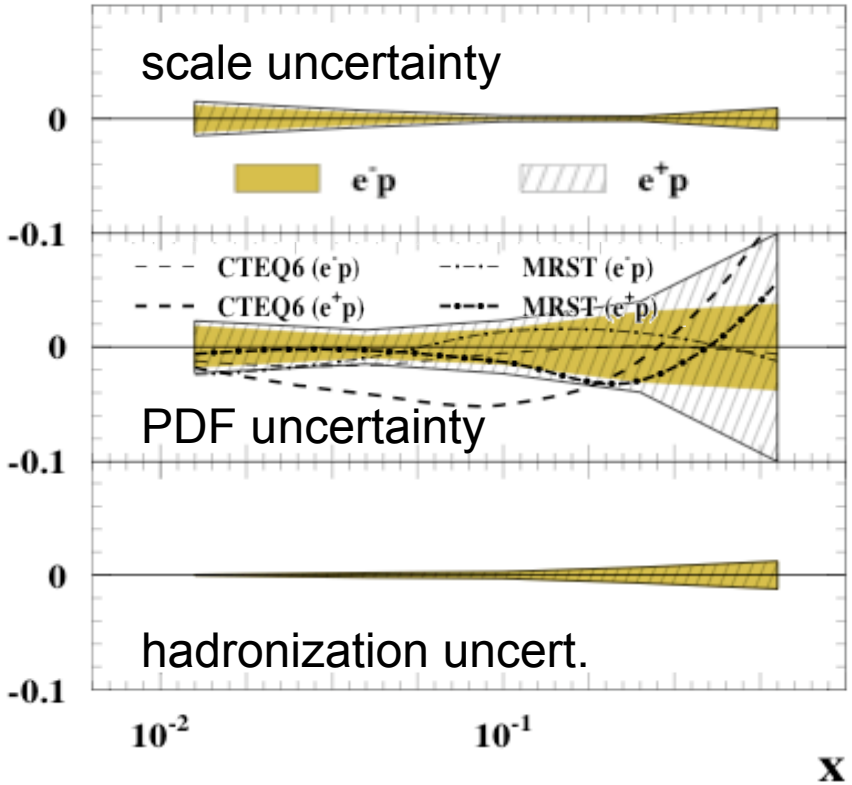
- Q^2 = 5-100GeV^2, E_T > 5GeV
- cross-section data agree with NLO pQCD
- agreement of fitted α_S with running from high Q^2 multi-jet cross-section fit
- $\alpha_s(m_Z) = 0.1186 \pm 0.0014\,(exp) + 0.0132 - 0.0101(th) \pm 0.0021\,(pdf)$

Jet production in Charged Current DIS

inclusive jet cross-section [pb]



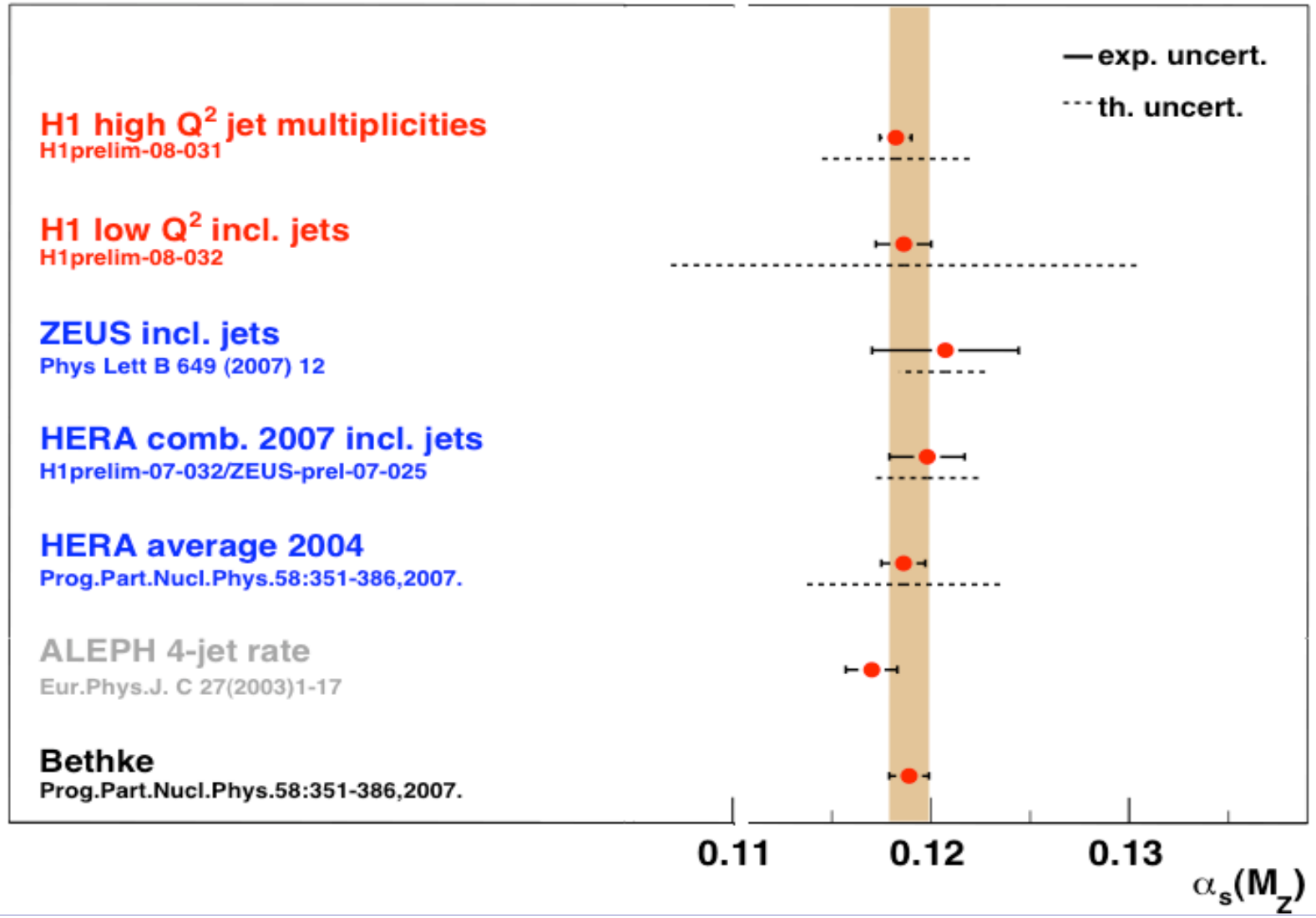
theor. uncertainties



- inclusive and 2-jet cross-sections well described by NLO
- largest uncertainty from PDF for e+ at high x: d-quark density
- *CC DIS constrains flavour content of the proton at high x*

Summary

jet observables at HERA (H1 and ZEUS) provide a wealth of high precision measurements of $\alpha_s(m_Z)$

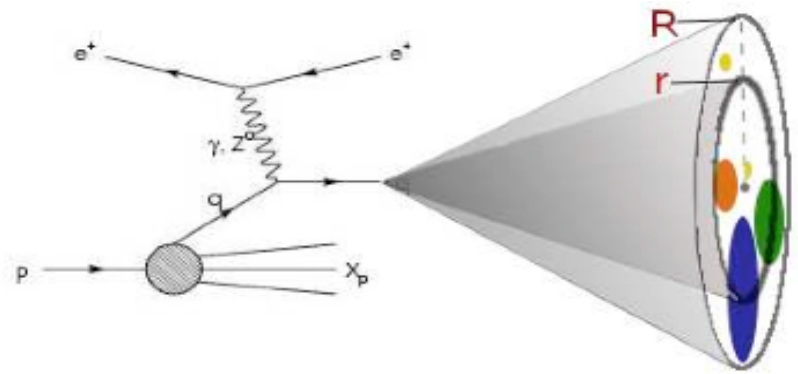


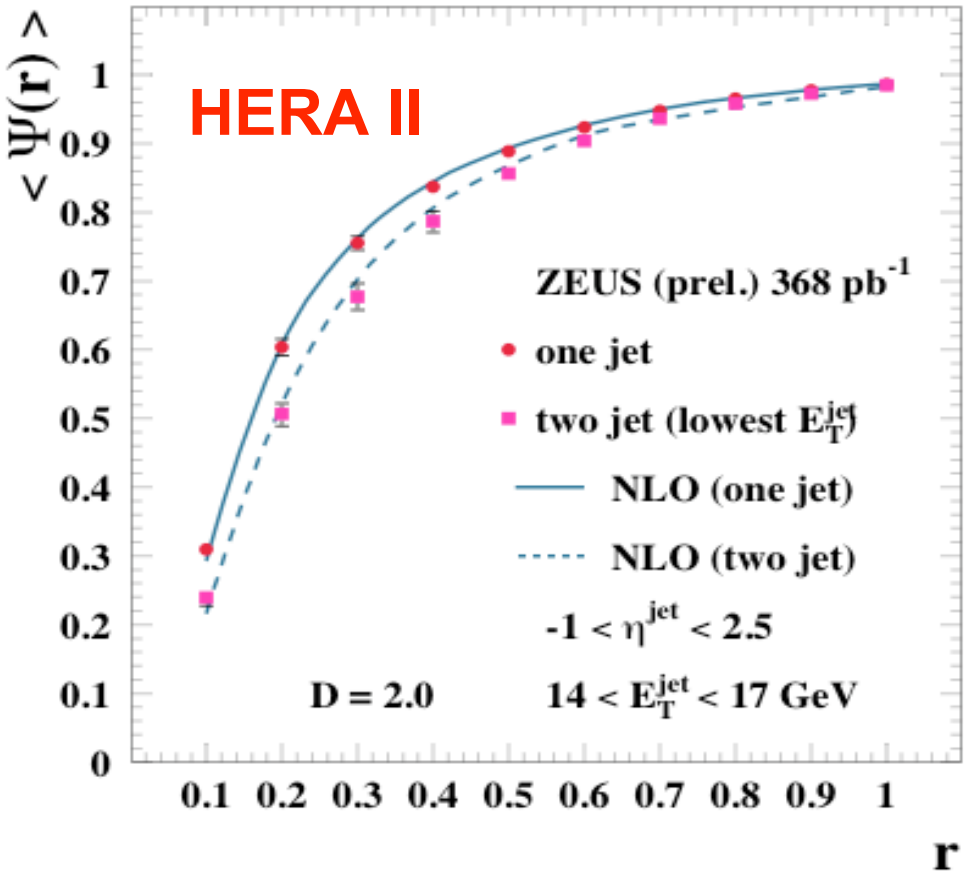
BACKUP SLIDES

Jet Substructure

Observable: **average jet shape**

$$\langle \psi(r) \rangle = \frac{1}{N_{jets}} \sum_{i=1}^{N_{jets}} \frac{E_T^i(r)}{E_T^i}$$





- broader jet shape for 2-jet-sample: gluon enriched
- shape for 1-jet and 2-jet sample well descirbed by NLO