Prospects of α_s determinations in DIS

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1st ECFA-CERN LHeC Workshop
Divonne
1-3 September 2008

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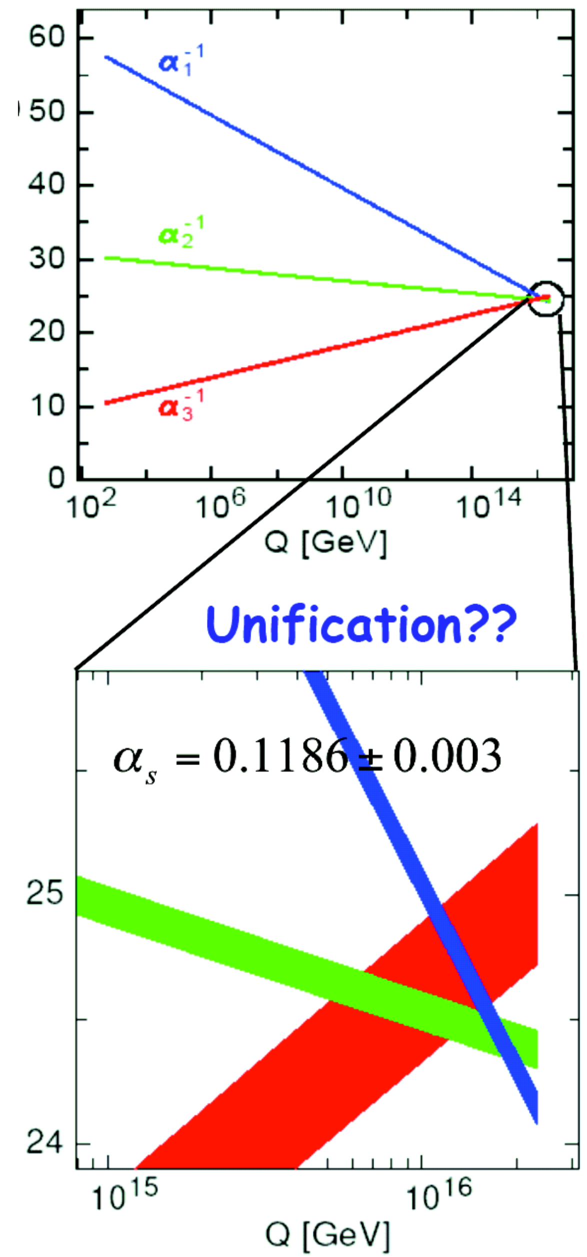
Motivation

α_s : free parameter of QCD

strength of a fundamental force

important to know α_s precisely

- affects almost any cross section in high energy collisions
- need to know QCD “background” precisely to discover new physics
- validation of Grand Unification of Forces?



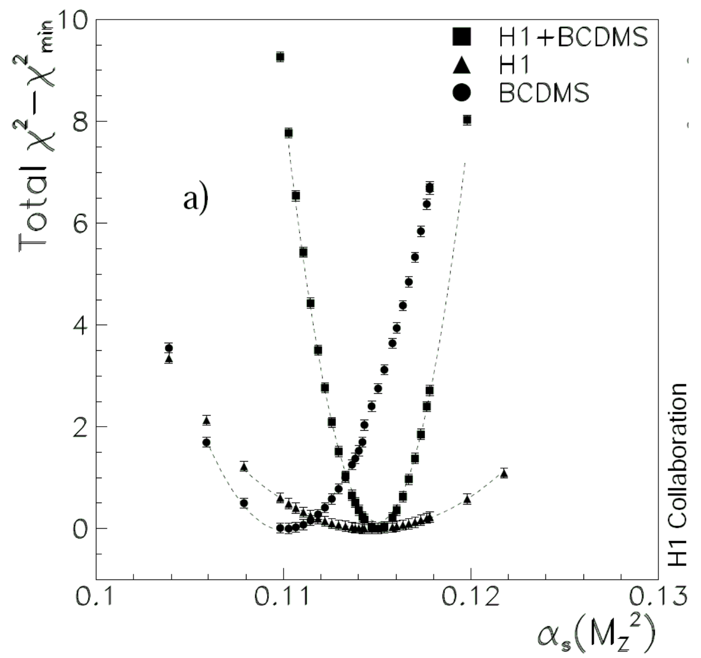
hep-ph/0407067 B.Allanach ... P.Zerwas

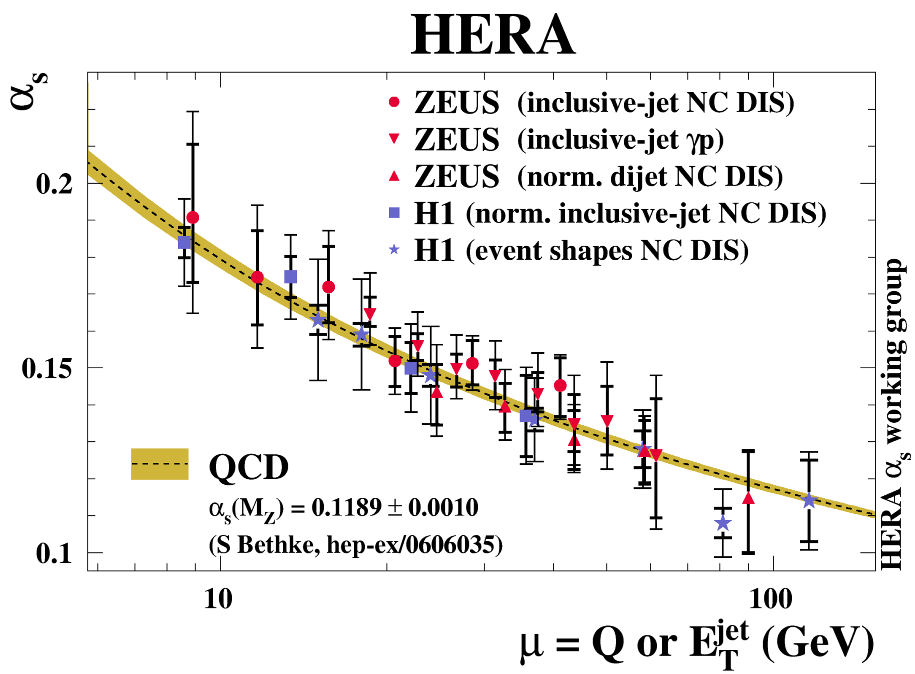
Role of DIS

α_s in DIS from

I. structure functions

II. final states





- complementary to other determinations
  - many observables & scales

- competitive precision (at high energies)
  - exp. error of 2-3% (theo. 3-5%)

Structure Functions

H1 analysis of gluon density and α_s Eur.Phys.J.C21:33-61,2001

$$\alpha_s(M_Z^2) = 0.1150 \pm 0.0017\,(exp)\,{}^{+\,0.0009}_{-\,0.0005}\,(model)\,.\ \pm 0.005\ \text{scale}$$ NLO

- using H1 96/97 and BCDMS data
- 1.5% exp. error (4.5% w/o BCDMS)
- new data in the pipeline
  - twice the luminosity
  - improved systematics
  - expect precision of ~<1%
  - H1/ZEUS combination ~0.8%?

analysis uncertainty	$+\delta\ \alpha_s$	$-\delta\ \alpha_s$
$Q^2_{min} = 2$ GeV^2		0.00002
$Q^2_{min} = 5$ GeV^2	0.00016	
parameterisations	0.00011	
$Q^2_0 = 2.5$ GeV^2	0.00023	
$Q^2_0 = 6$ GeV^2		0.00018
$y_e < 0.35$	0.00013	
$x < 0.6$	0.00033	
$y_\mu > 0.4$	0.00025	
$x > 5 \cdot 10^{-4}$	0.00051	
uncertainty of $\overline{u} - \overline{d}$	0.00005	0.00005
strange quark contribution $\epsilon = 0$	0.00010	
$m_c + 0.1$ GeV	0.00047	
$m_c - 0.1$ GeV		0.00044
$m_b + 0.2$ GeV	0.00007	
$m_b - 0.2$ GeV		0.00007
total uncertainty	0.00088	0.00048

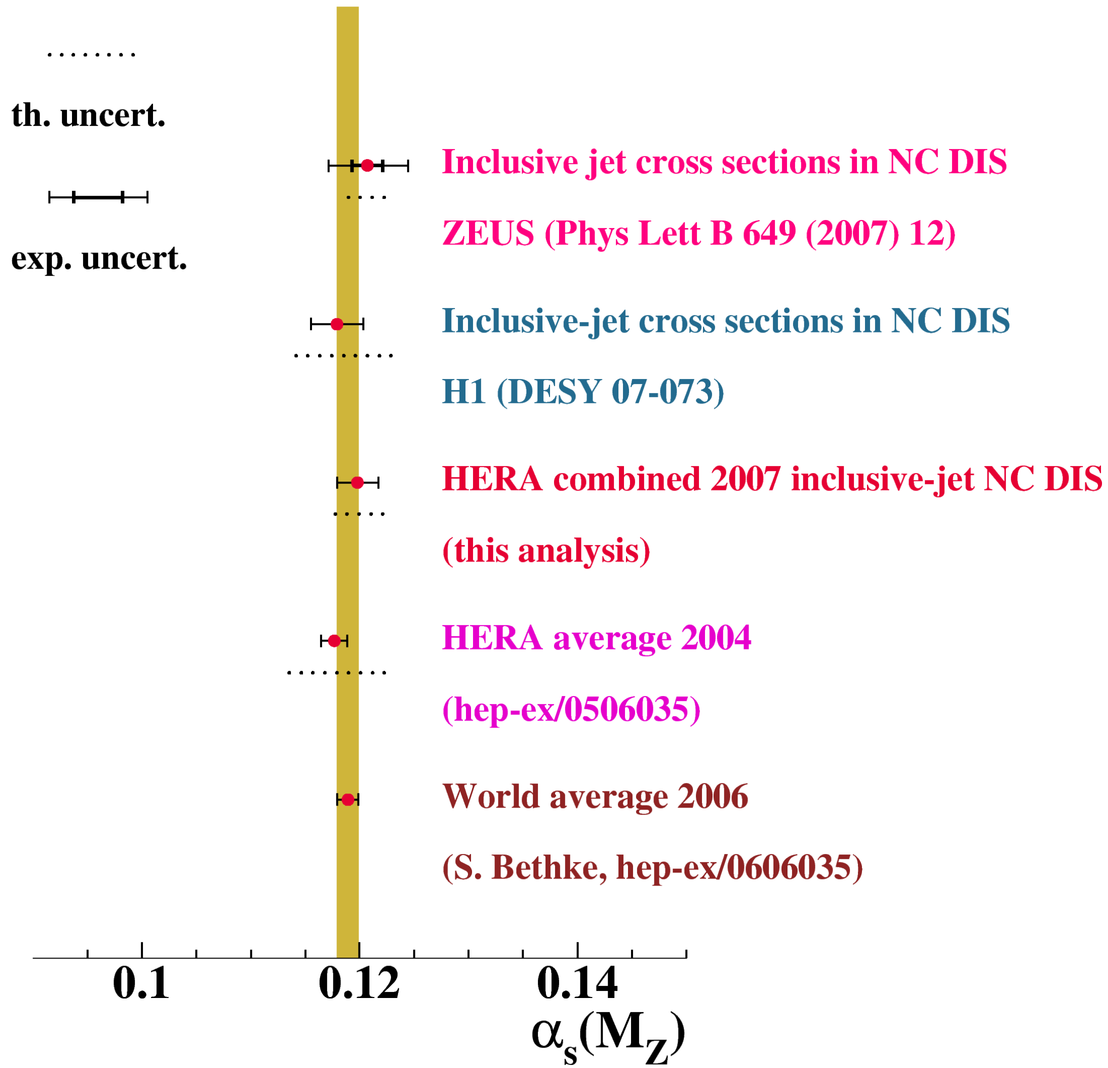
HERA prospects

H1/ZEUS combinations

- incl. jets at high Q^2

HERA average 2007 total error <3%

$$\alpha_s(M_Z) = 0.1198 \pm 0.0019\,(\mathrm{exp.}) \pm 0.0026\,(\mathrm{th.})$$



- to be continued...
  - gp jets
  - normalised jet cross sections

LHeC prospects

	LHeC	HERA
beam energies	70 x 7000 GeV^2	27.6 x 920 GeV^2
center of mass energy	1.4 TeV	320 GeV
int. luminosity	10 fb^{-1}	1 fb^{-1}
angular acceptance	1-179°	7-177°
tracking resolution	0.1mrad	0.2-1mrad
EM energy scale	0.1%	0.2-0.5%
HAD energy scale	0.5%	1%
luminosity	0.5%	1%

QCD fits to LHeC toy data, determination of α_s

Fit á la H1 2000 PDF, leave α_s free

LHeC "data" smeared by assumed error around H1 fit

LHeC Fits

- 70 x 7000 GeV^2, 10 fb^{-1} for e^+ and e^- each
- NC & CC inclusive cross section
- stat. error forced >0.1%
- total error typical O(1%) per Q^2-x bin
- uncorrelated syst.: efficiencies, γp background, noise
- correlated syst.: E(e'), θ(e'), E(hadrons)
- 0.5% normalisation uncertainty
  whereof 0.25% correlated between datasets (NC/CC, e^+/e^-)

LHeC Fits

DATA	exp. error on α_s
NC e^+ only	0.48%
NC	0.41%
NC & CC	**0.23% :=(1)**
(1) $\gamma_h > 5°$	0.36% :=(2)
(1) +BCDMS	0.22%
(2) +BCDMS	0.22%
(1) stat. *= 2	0.35%

- seems possible to reach ~2‰ error (adequate detector provided)
- BCDMS data can help with forward acceptance
- with 20 fb^{-1} statistics is not a major issue

Outlook

- HERA results on α_s from structure functions and HFS in the pipeline
- H1/ZEUS combinations will result in the final HERA numbers
  - expect experimental error of ~<1%
  - can theory catch up? - NNLO for heavy flavour, jets?
- first studies indicate that the LHeC has the potential for O(2‰) experimental uncertainty on α_s
  - obviously very challenging for the detector
  - again, theory/model error will need major effort

Backup