

Precision physics with jets and Heavy flavours at

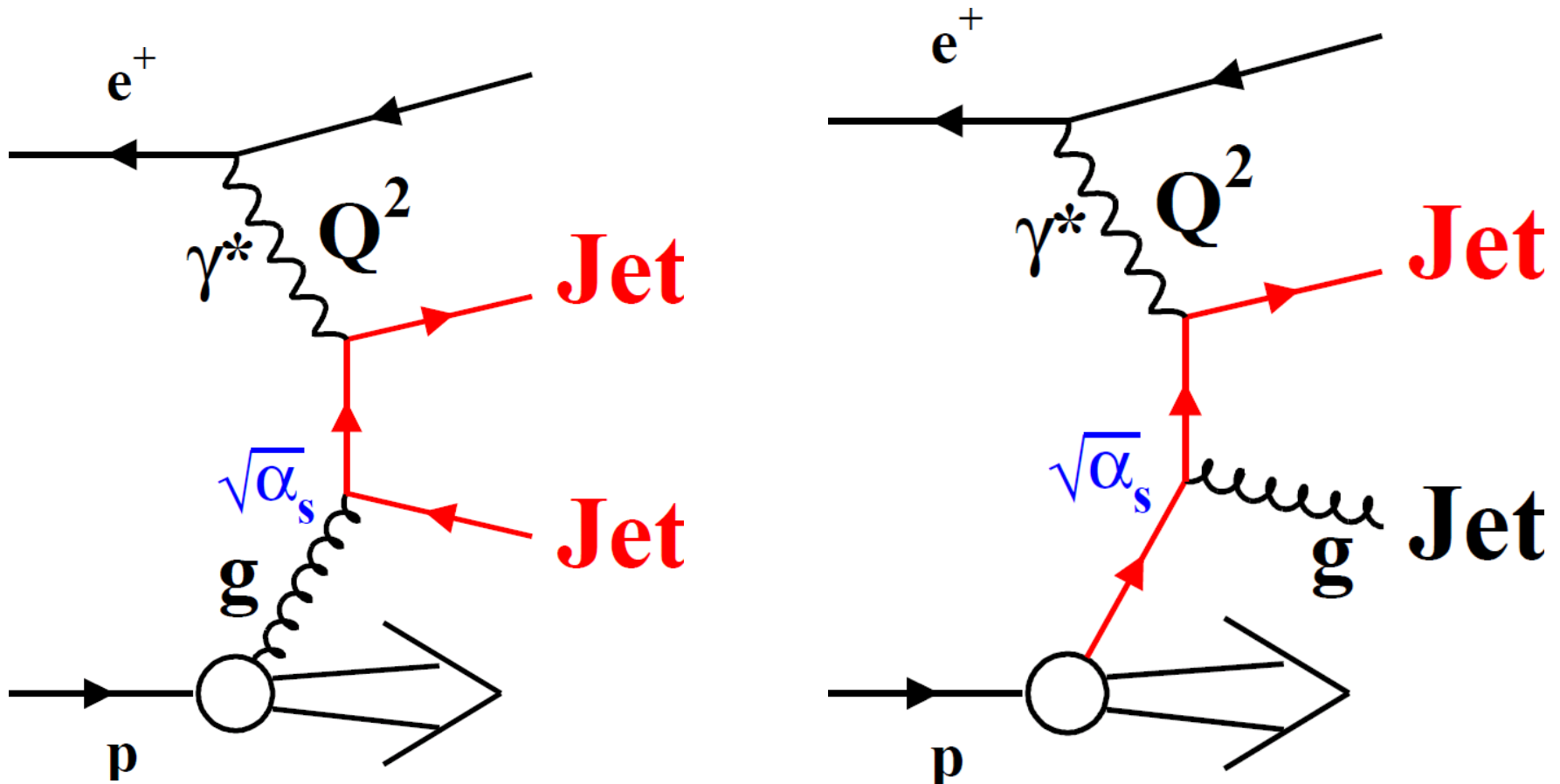


LHeC workshop Chavannes de Bogis, CH
14th june 2012

Olaf Behnke (DESY)

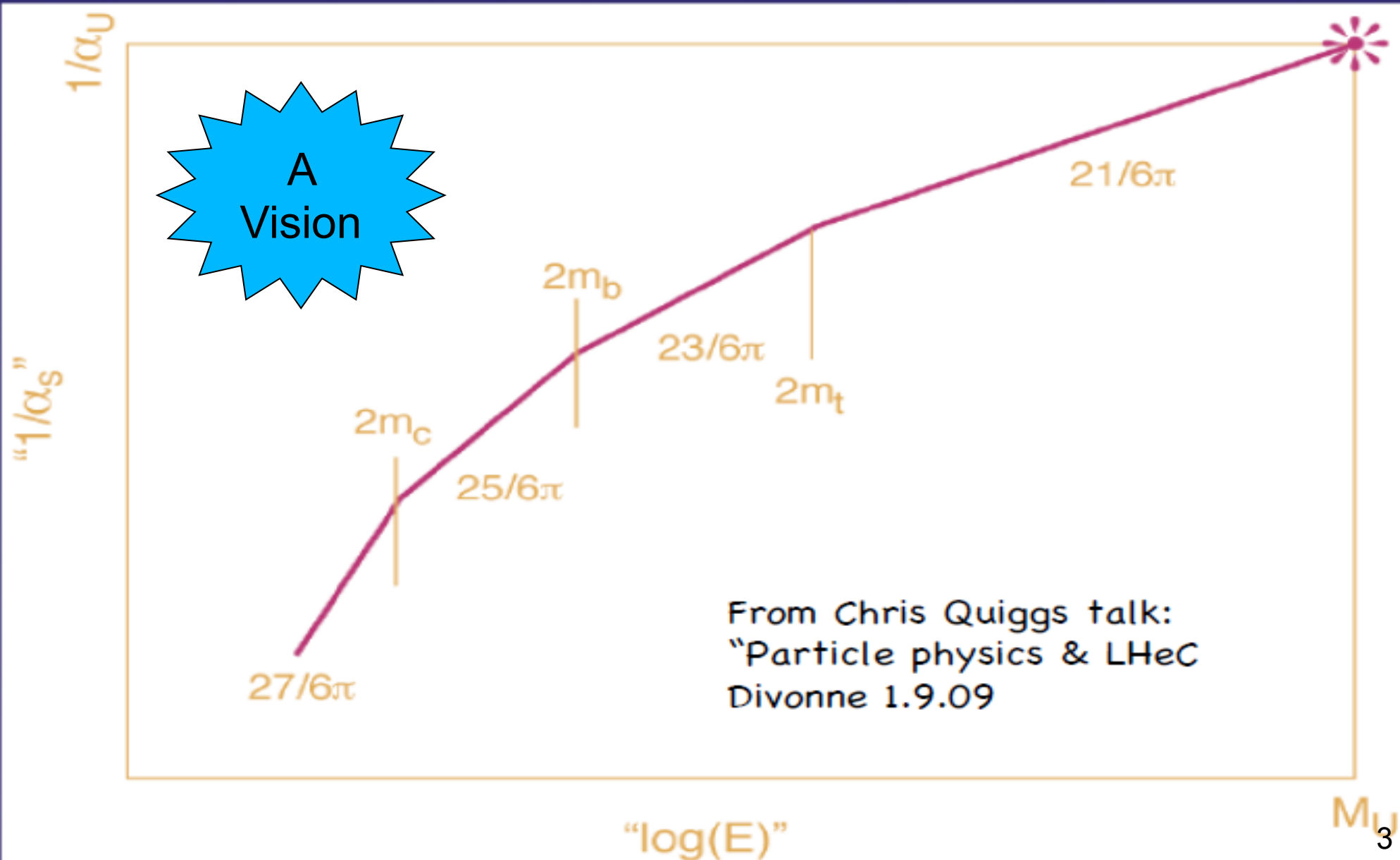
This is not at all an exhaustive talk on the CDR material, but showing only few (mostly new) studies and considerations

High pt Jets

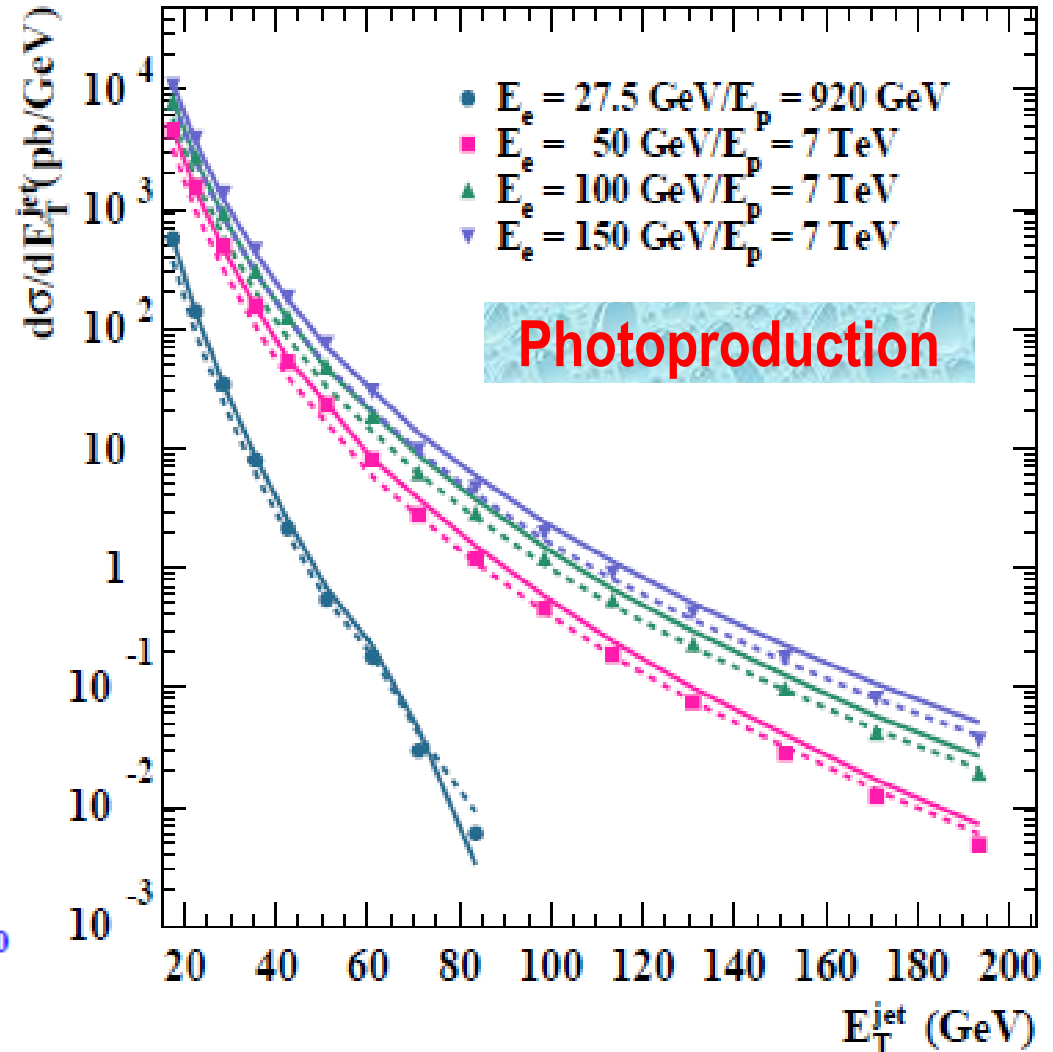
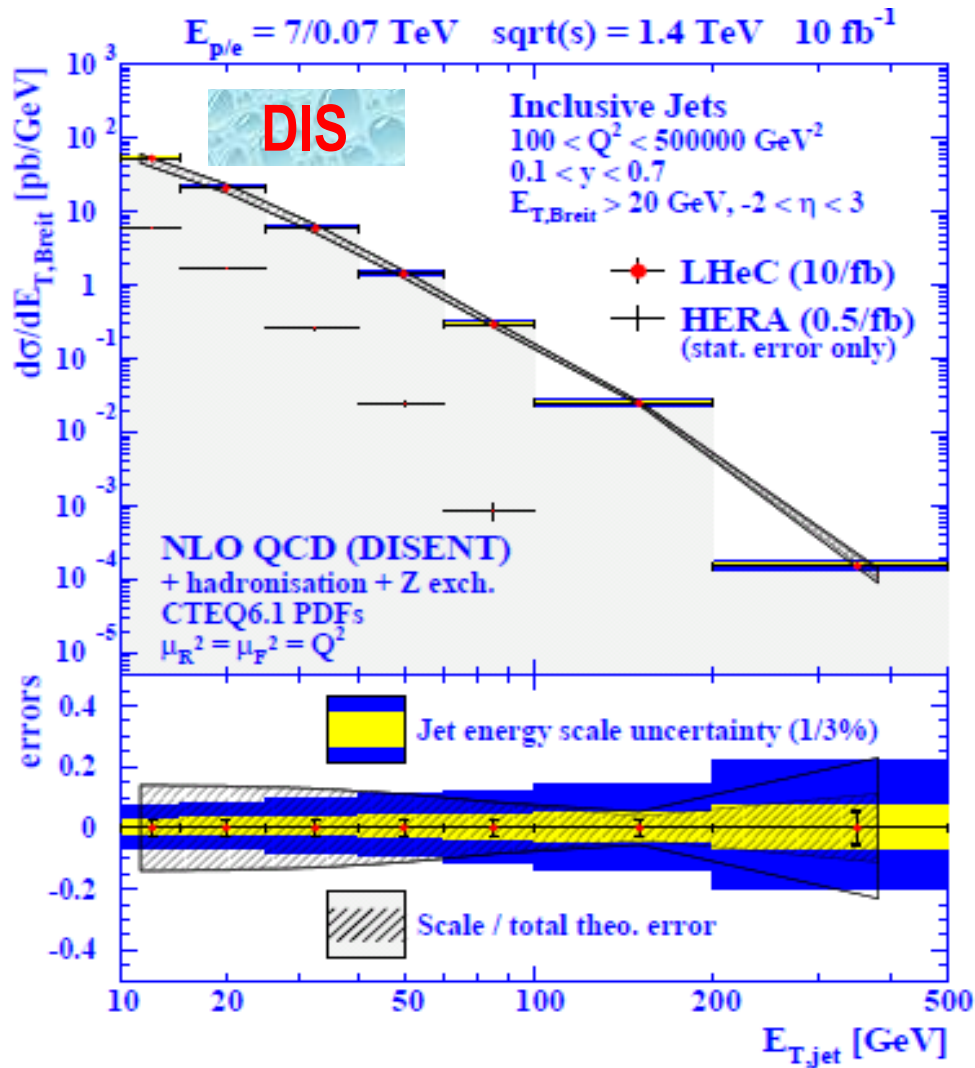


Different processes allow to disentangle $g(x)$ and α_s

Measure change in slope at top threshold?



Jet production projections at LHeC



➔ can study running of α_s up to 500 GeV



What about
Theory
uncertainties
?

Notes on jets in DIS at NNLO

Provided by Thomas Gehrmann

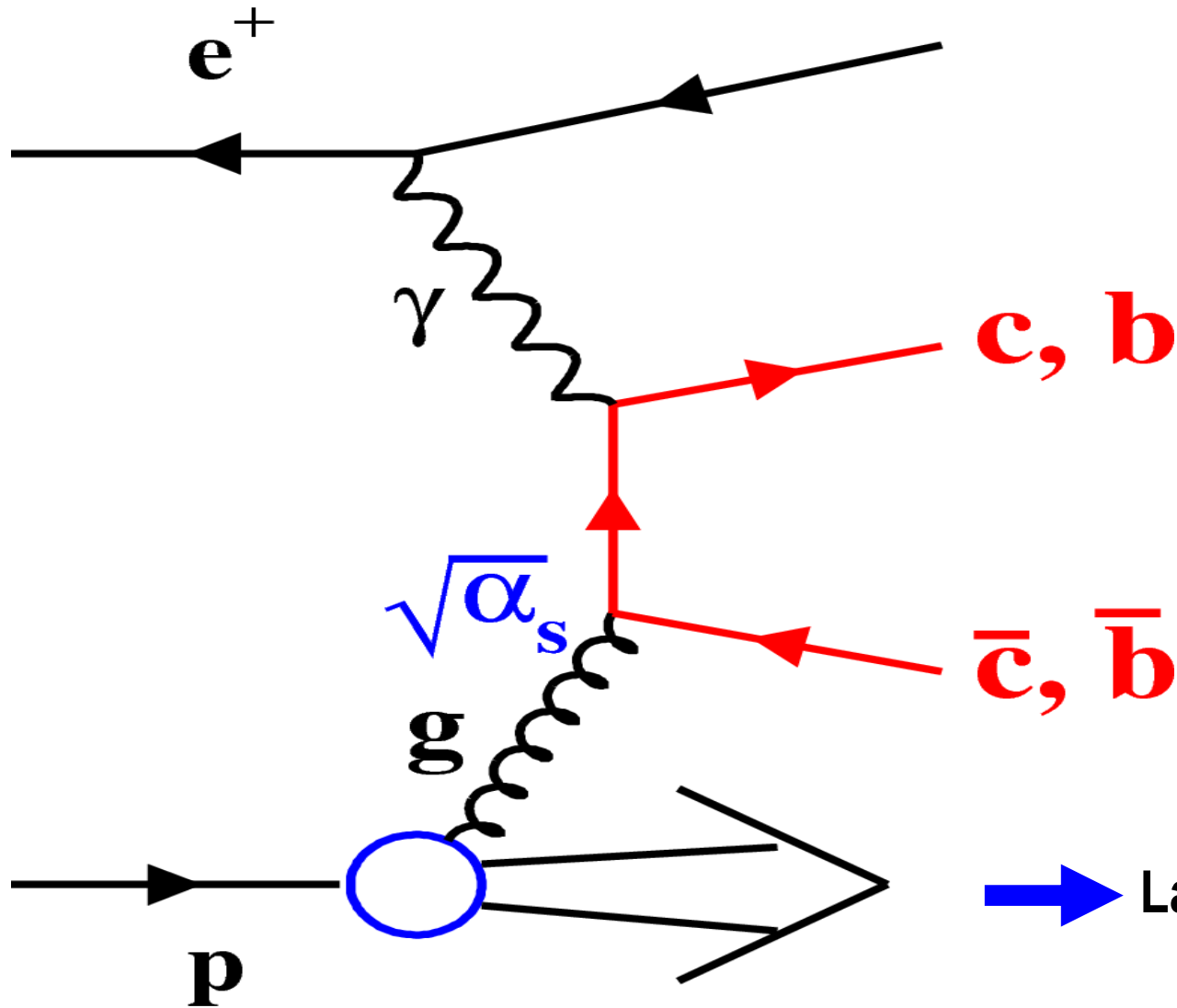
Jets in DIS at NNLO

- Motivation
 - (2+1) jet cross section measured to high precision at HERA, high-quality data anticipated from LHeC
 - Important probe of α_s and of gluon distribution
 - Theory description must be of the same accuracy as data (at most few per cent uncertainty)
 - Want consistent inclusion of jet data in NNLO parton distribution fits

Jets in DIS at NNLO

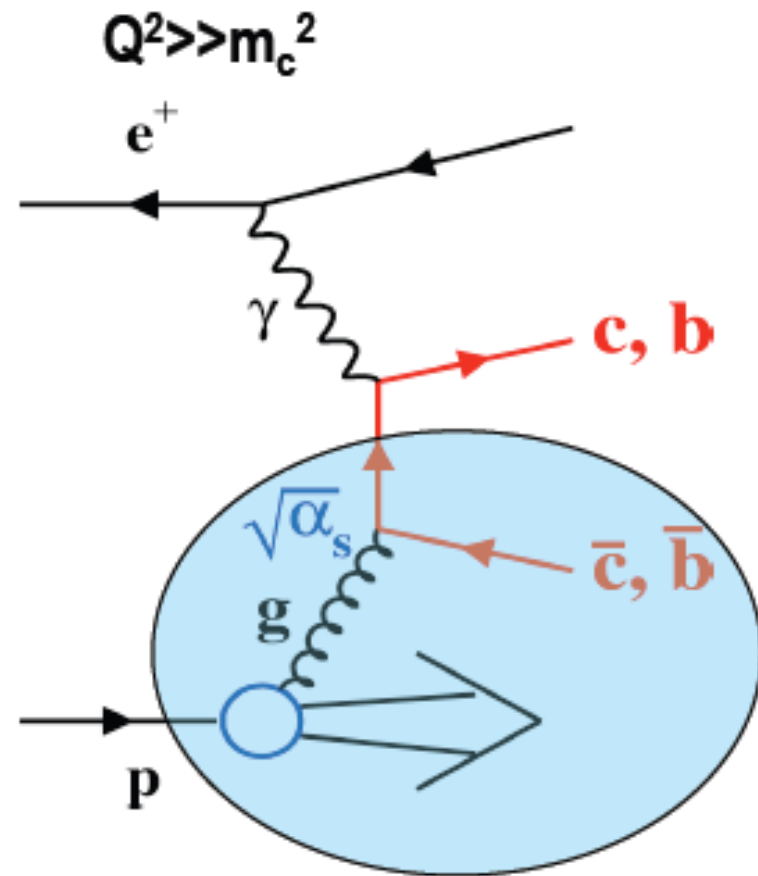
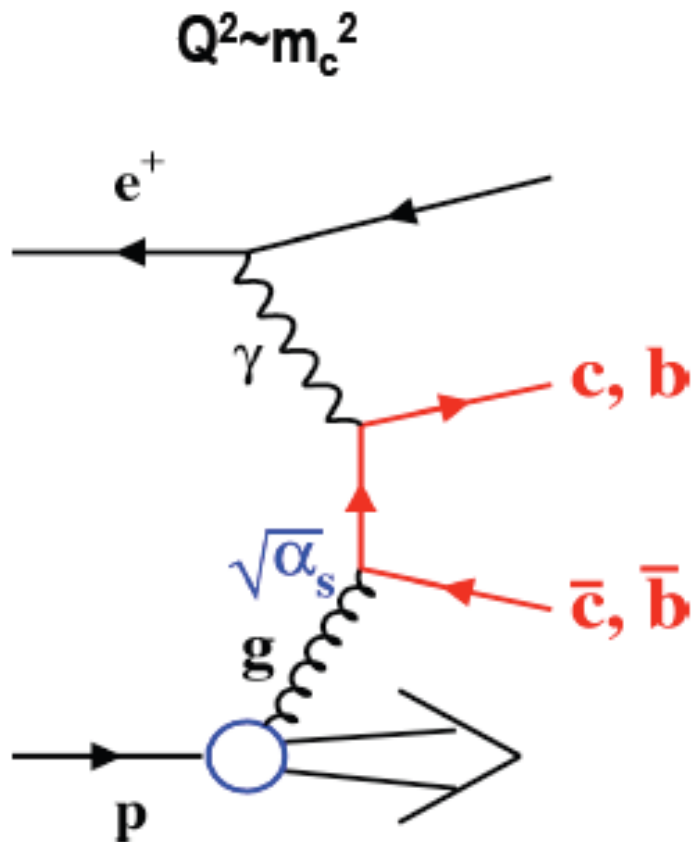
- Status
 - Know NNLO matrix elements
 - Real Radiation from NLO $(3+1)_j$ (NLOJET++: Z. Nagy)
 - Virtual two-loop corrections computed (T. Gehrmann, E.W.N. Glover)
 - Implementation into NNLO parton-level generator
 - Developed subtraction method: antenna subtraction for DIS (A. Daleo, A. Gehrmann-De Ridder, T. Gehrmann, G. Luisoni)
 - Implementation ongoing

Charm and Beauty



Large contributions to incl. DIS
sensitive to $g(x)$
sensitive to m_c, m_b

Subtle topic: heavy quark mass dependent terms in pQCD

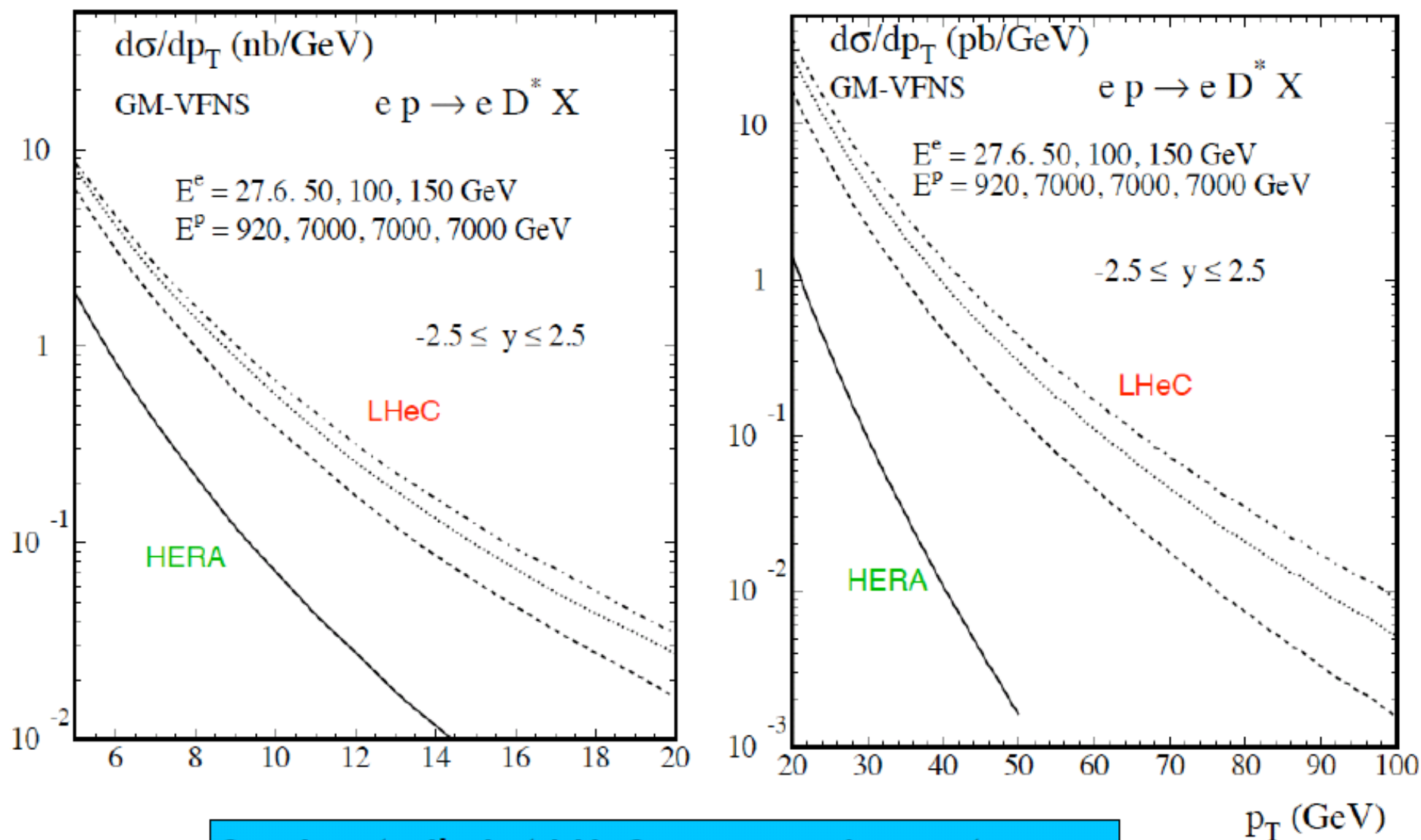


c, b = massless seaquarks

➡ How to make properly the transition from left to right picture is a longstanding problem **for PDF fits**

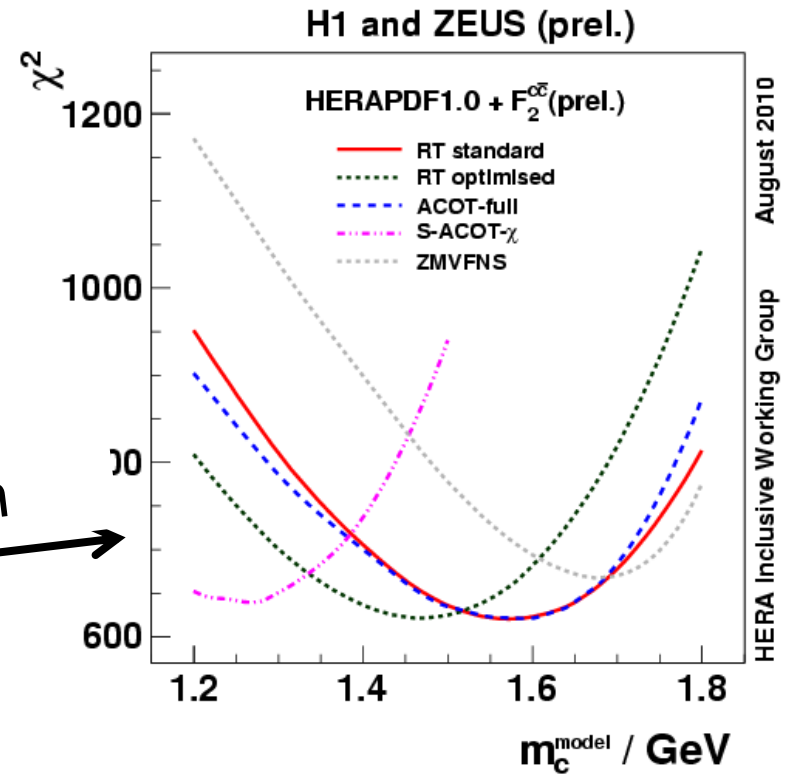
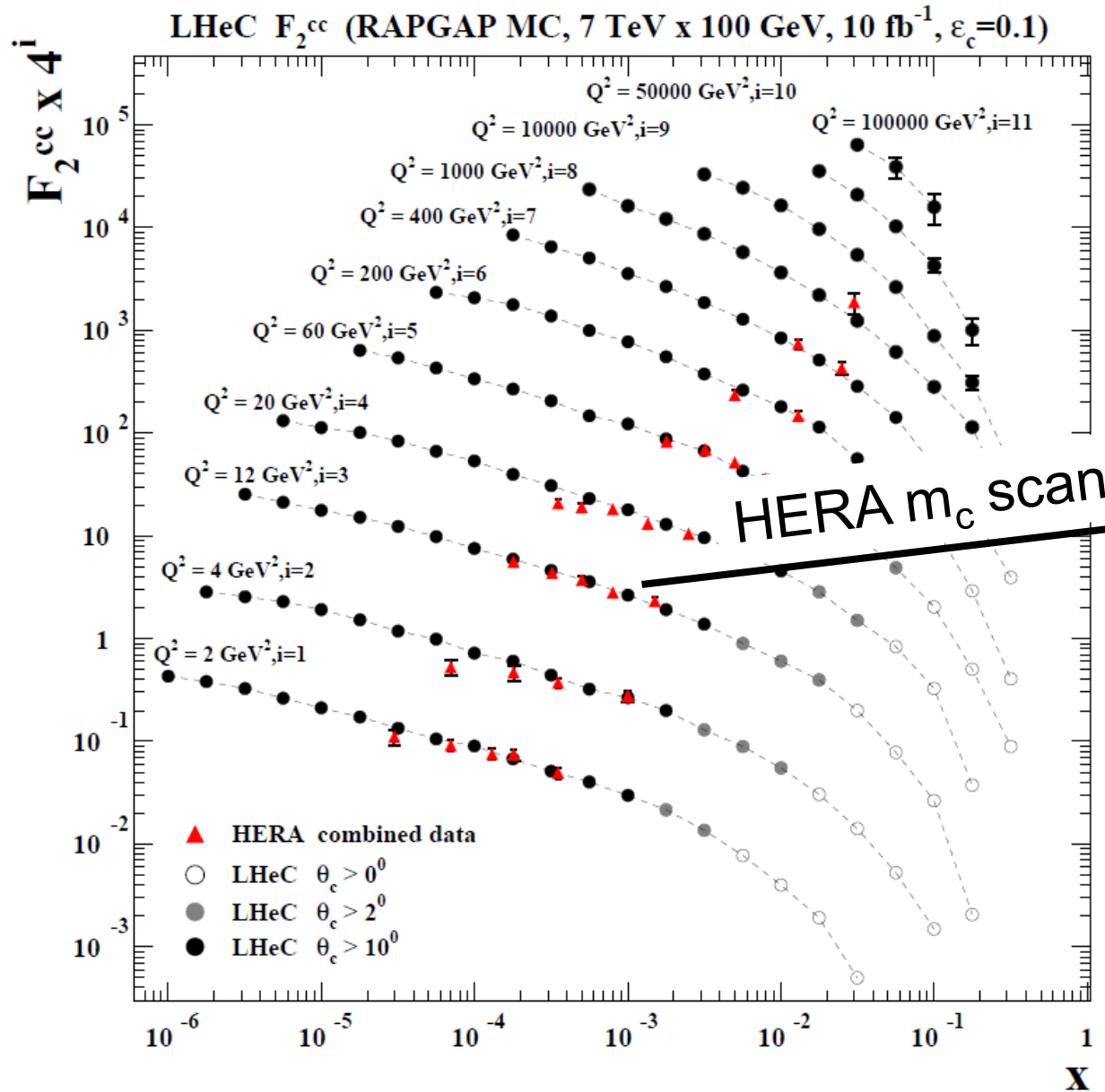
Inclusive photoproduction of D^* mesons at LHeC

Gustav Kramer,
Hubert Spiesberger



Can be studied at LHeC over very large p_T range

Charm production contribution to $F_2 = F_2^{\text{cc}}$

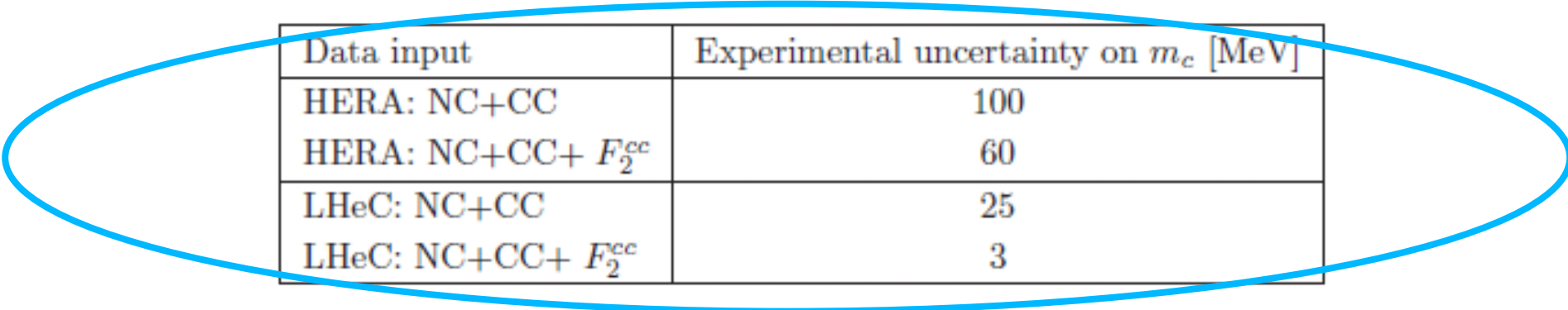


LHeC: Huge
 phasespace extension
 and high precision
 → ultraprecise m_c

Study of charm mass parameter m_c determination

R. Placakyte

A study is performed to estimate the sensitivity of the charm quark production at the LHeC to the m_c parameter which enters the QCD fits. As input the NC and CC pseudodata are used with their uncertainties as described in Section 4.1.5. In addition data of the charm structure function are simulated for a luminosity of 10 fb^{-1} . The assumed measurement method is the impact parameter tagging technique as has been used by H1. The statistical uncertainty is scaled according to the charm tagging efficiency, assumed to be 10 %, and a light quark background, of 1 %. The dominating systematic error comprises the correlated DIS cross section errors and an extra systematic uncertainty of 2 %.

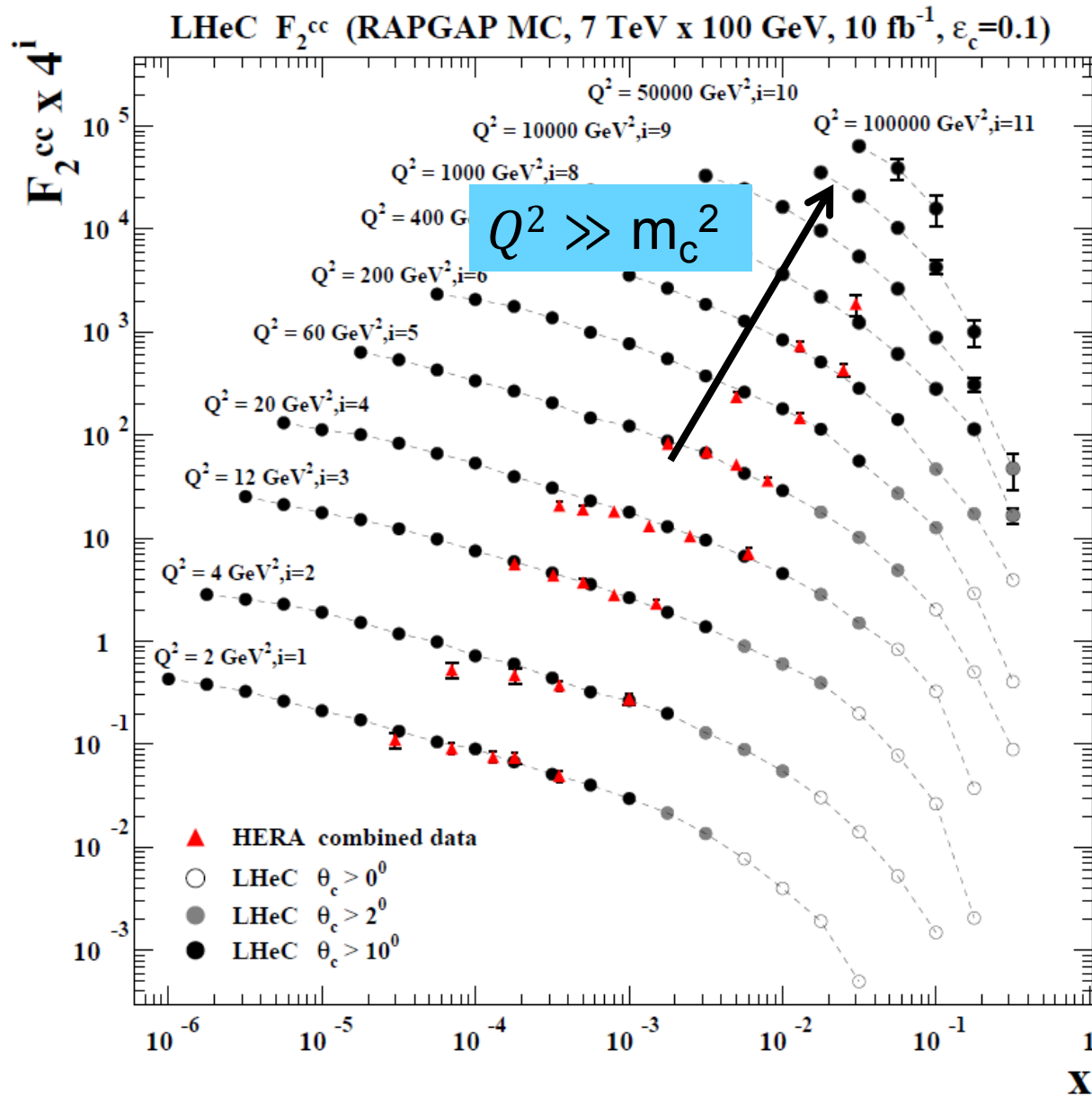


Data input	Experimental uncertainty on m_c [MeV]
HERA: NC+CC	100
HERA: NC+CC+ F_2^{cc}	60
LHeC: NC+CC	25
LHeC: NC+CC+ F_2^{cc}	3

Table 4.6: Experimental (statistical and systematic) uncertainty on the charm mass parameter, m_c , in NLO QCD analyses of the HERA neutral (NC) and charged (CC) current cross section data complemented by the HERA F_2^{cc} data (top) and the corresponding results estimated for the LHeC (bottom), see text.

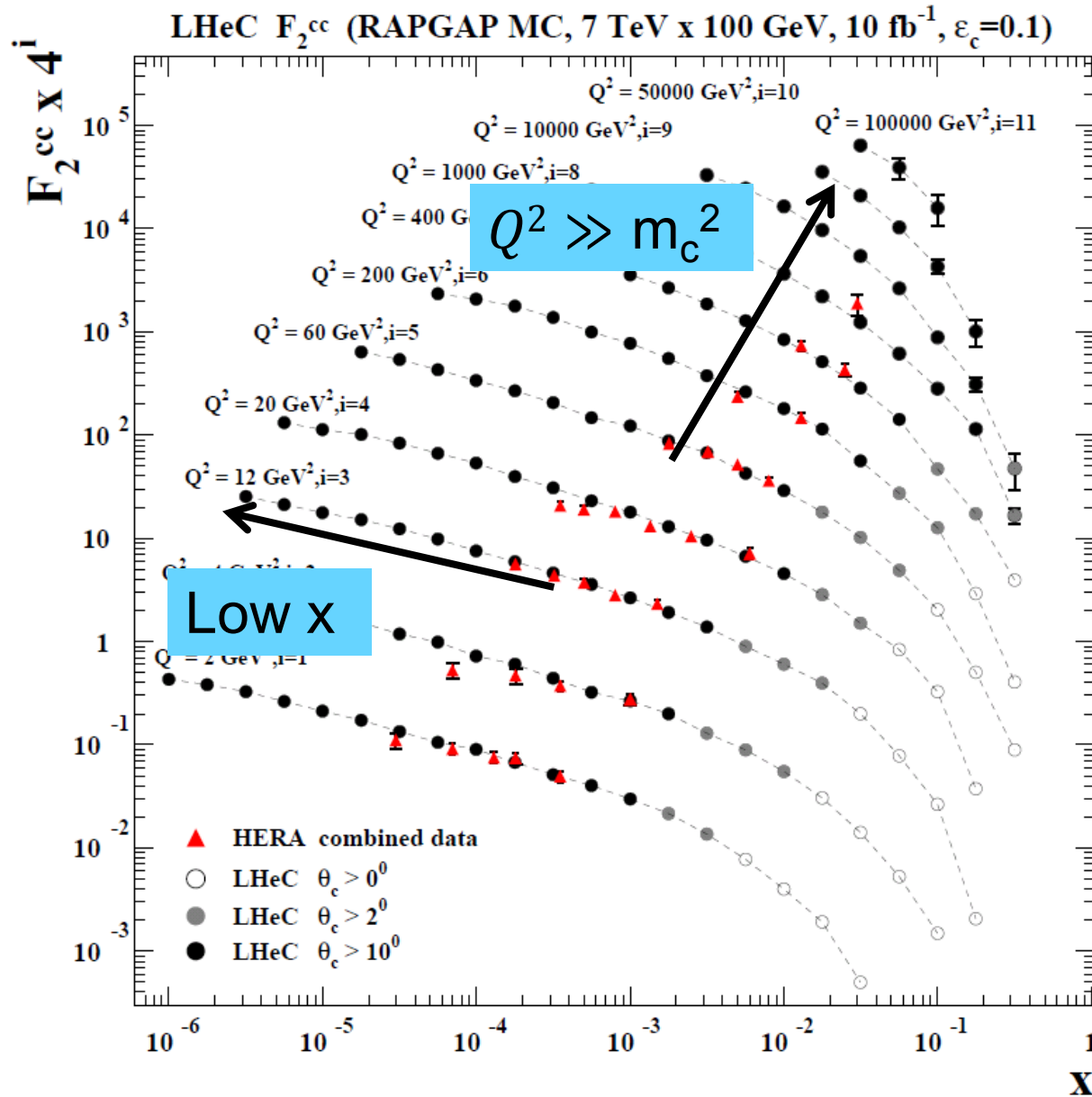
→ Interesting itself, but also important for precision PDFs, α_s and predictions at LHC

Charm production contribution to $F_2 = F_2^{\text{cc}}$



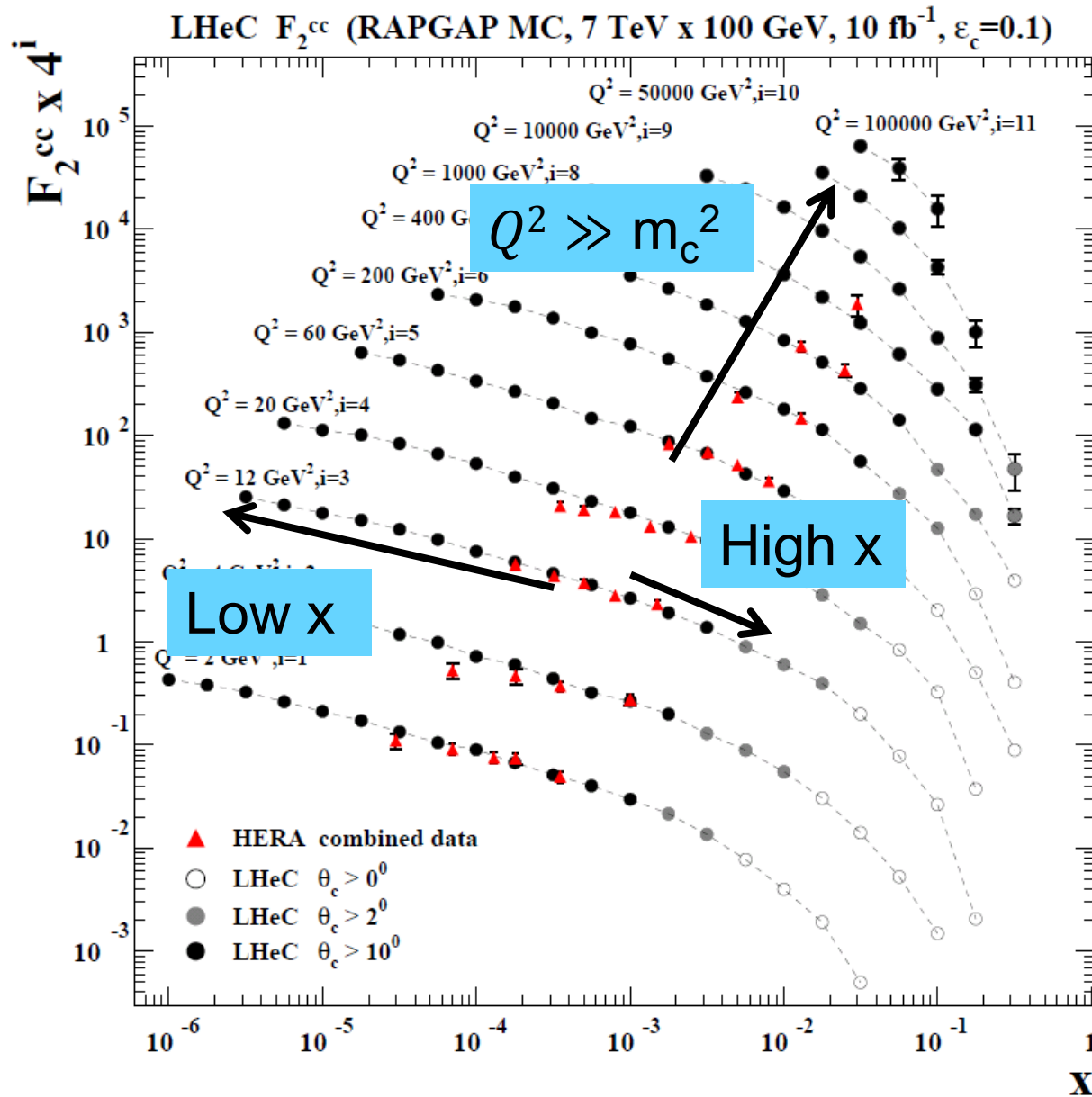
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 and high precision

Charm production contribution to $F_2 = F_2^{\text{cc}}$



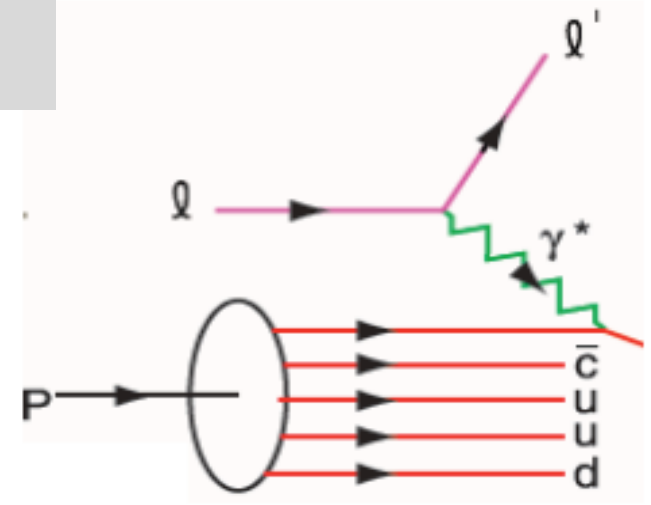
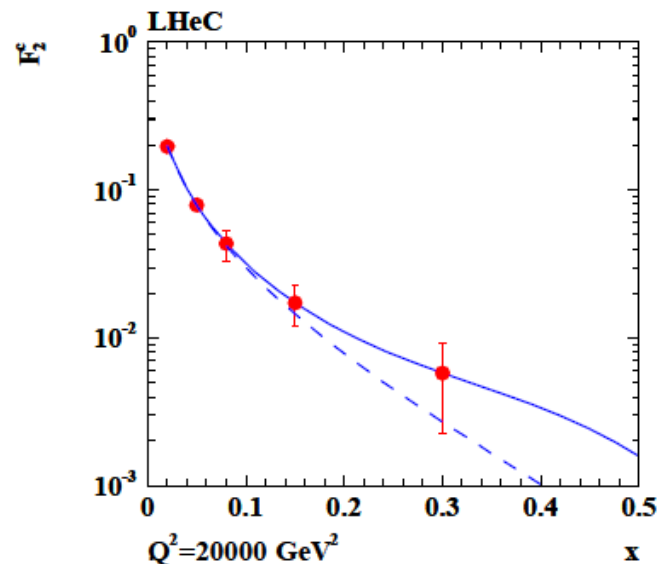
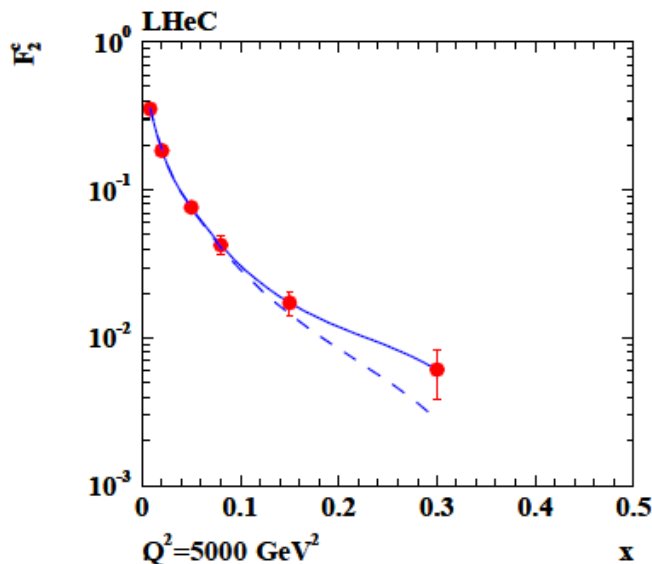
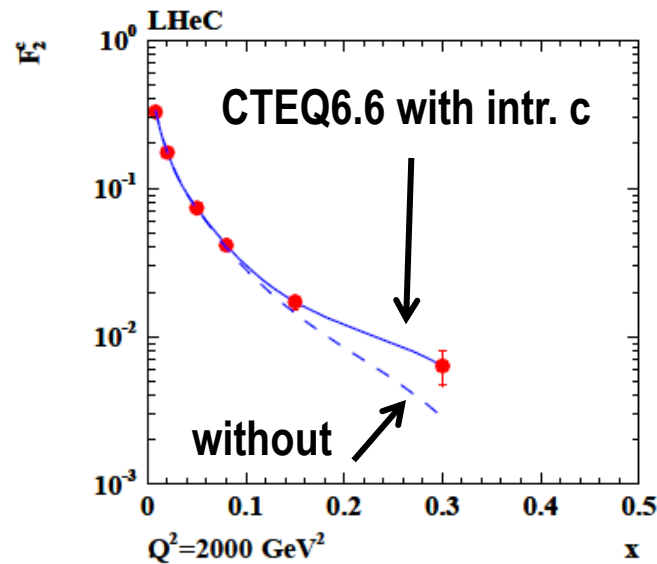
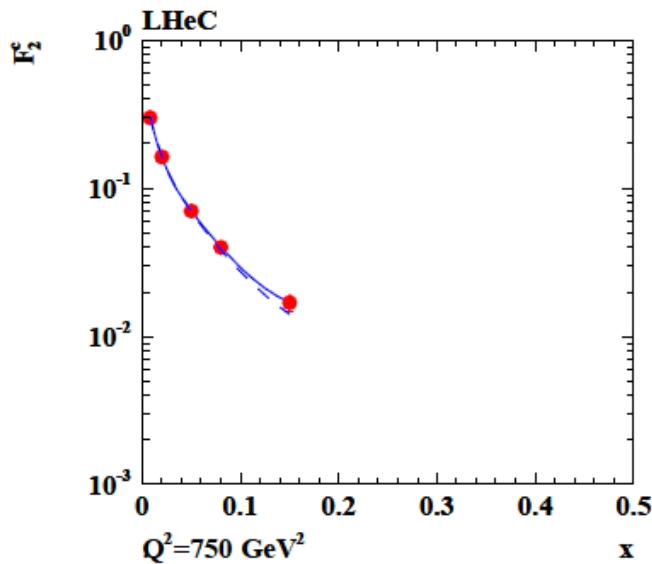
LHeC: Huge
phasespace extension
and high precision

Charm production contribution to $F_2 = F_2^{\text{cc}}$



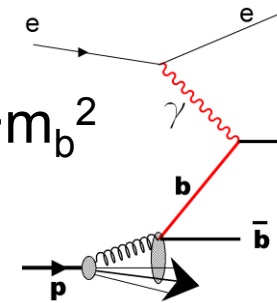
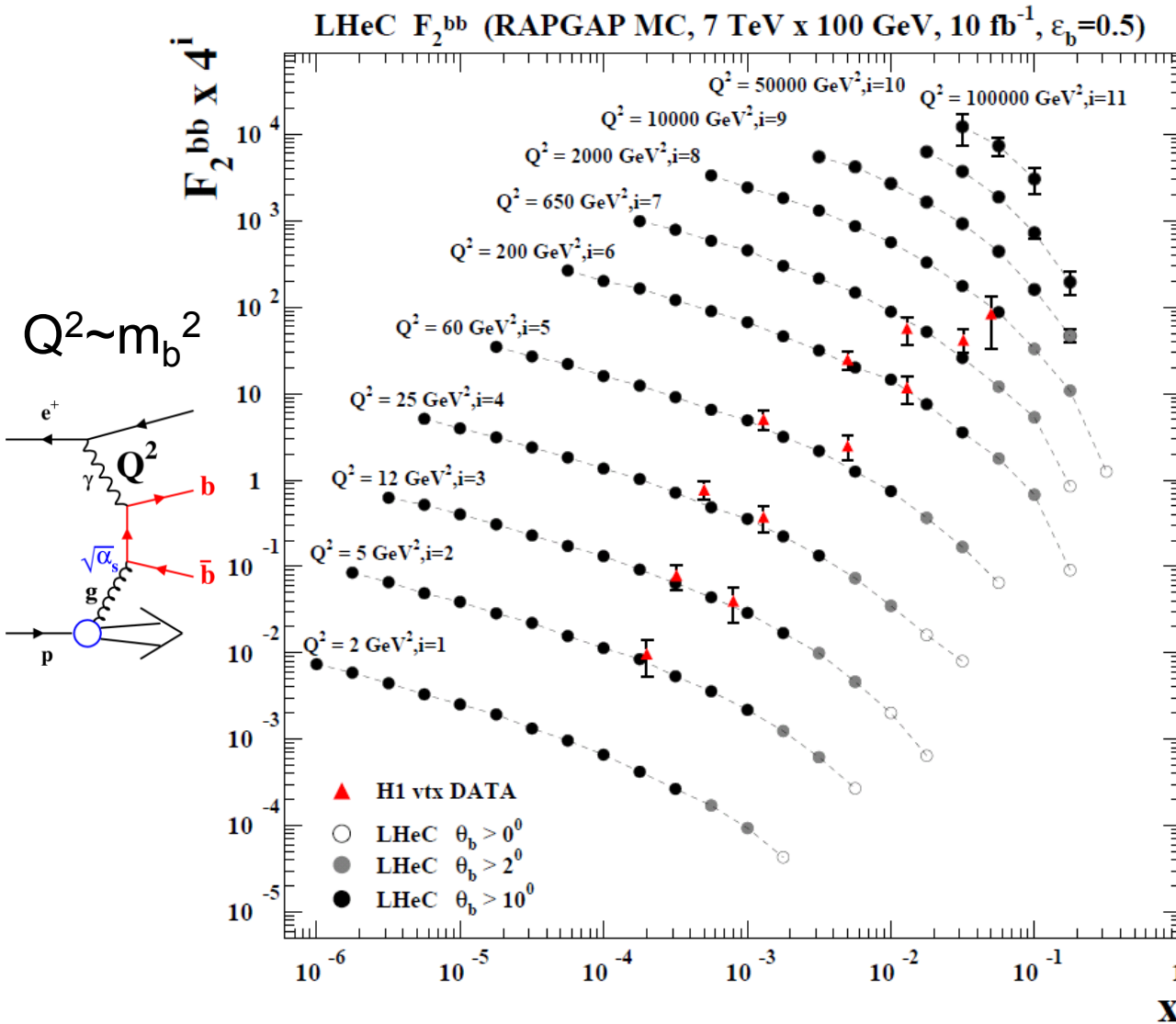
LHeC: Huge
phasespace extension
and high precision

Test intrinsic charm in proton

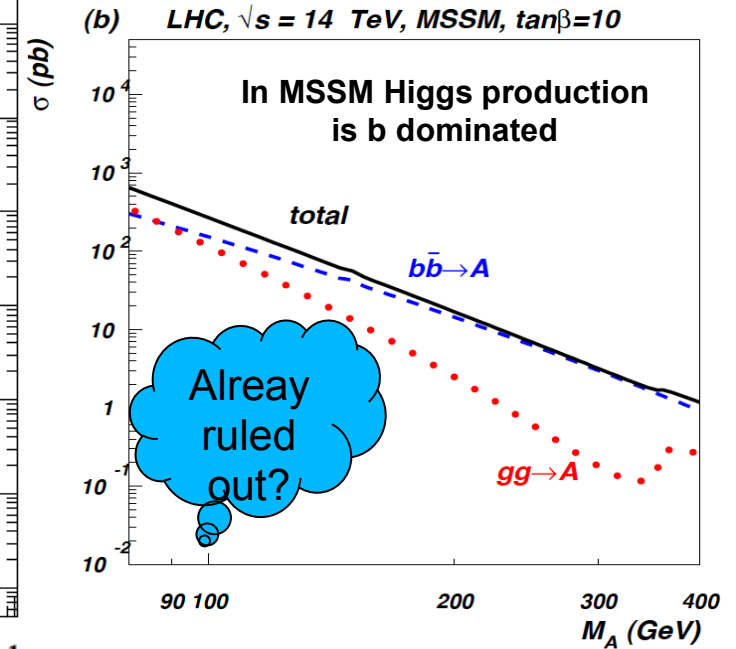


Have some sensitivity (with excellent forward c-tagging)


Beauty in DIS: F2bb projections



Use for LHC predictions



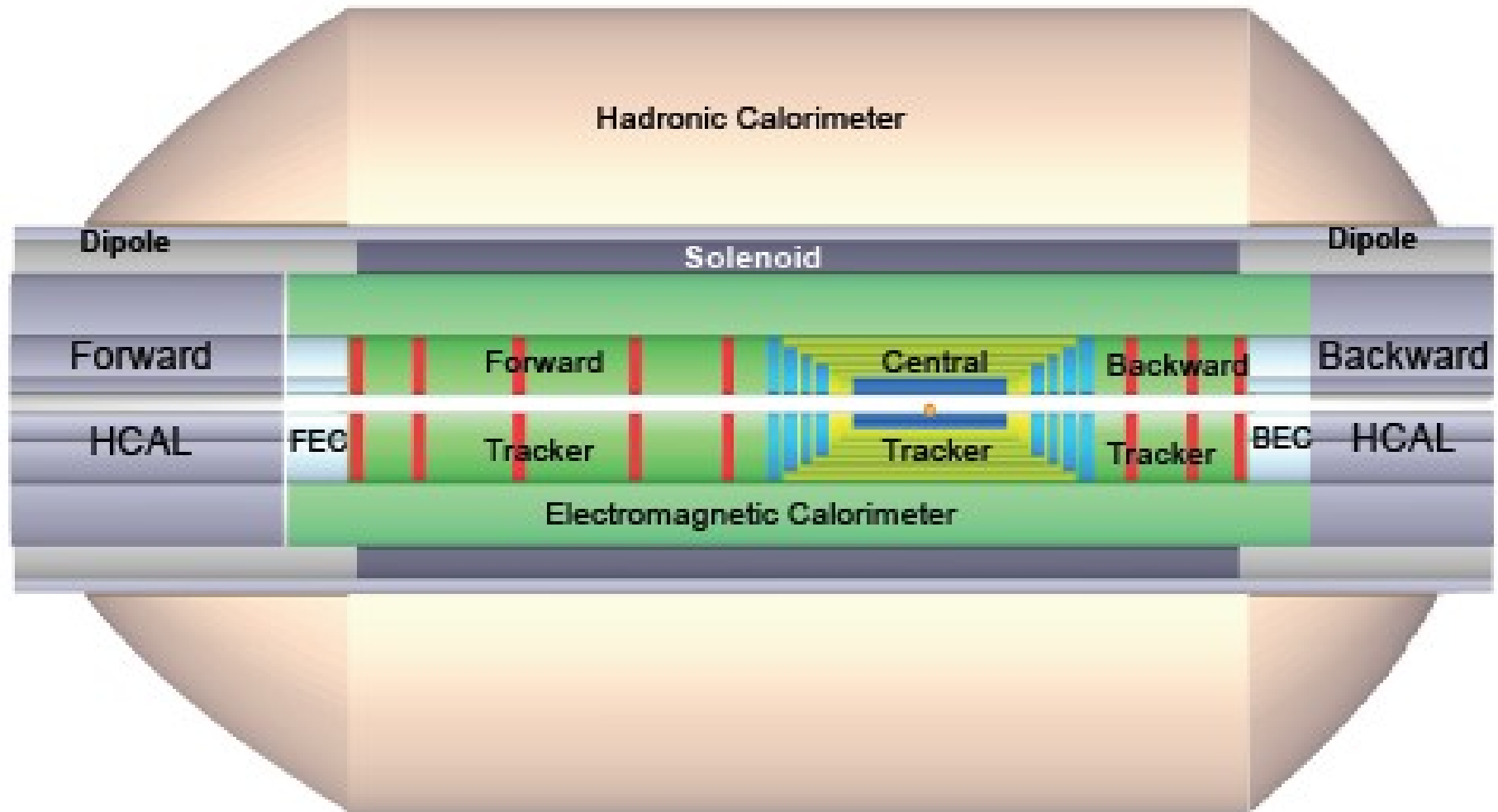
Summary

- Jets:
 - Precision QCD tests and α_s up to 500 GeV
 - NNLO $\mathcal{O}(\alpha_s^3)$ calculations underway \rightarrow essential to exploit experimental precision
- Charm & Beauty production at LHeC:
 - Key to understand treatment of mass dependent terms in pQCD
 - Precision determination of m_c and m_b

Also important for precision pdfs, α_s and LHC predictions
- Many more interesting studies/details can be found in CDR

Backup slides

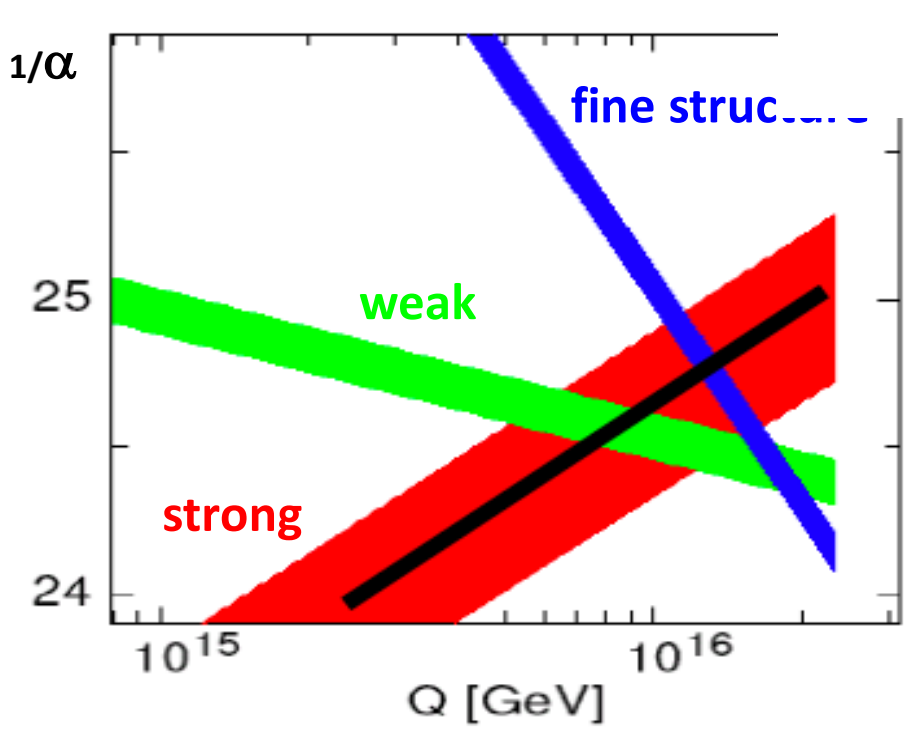
The Detector ‘that should do it’: Ring-Linac scenario



Outer detectors (HAC tailcatcher/muon detectors not shown)

also not shown: forward proton taggers, backward lumi monitors

Strong Coupling Constant from inclusive DIS



(sensitivity mainly from $dF_2/d\ln(Q^2)$)

Existing NNLO results

	$\alpha_s(M_Z^2)$	
BBG	$0.1134^{+0.0019}_{-0.0021}$	valence analysis, NNLO [80]
GRS	0.112	valence analysis, NNLO [81]
ABKM	0.1135 ± 0.0014	HQ: FFNS $N_f = 3$ [82]
ABKM	0.1129 ± 0.0014	HQ: BSMN-approach [82]
JR	0.1124 ± 0.0020	dynamical approach [83]
JR	0.1158 ± 0.0035	standard fit [83]
MSTW	0.1171 ± 0.0014	[84]
ABM	0.1147 ± 0.0012	FFNS, incl. combined H1/ZEUS data [85]
BBG	$0.1141^{+0.0020}_{-0.0022}$	valence analysis, N ³ LO [80]
world average	0.1184 ± 0.0007	[86]

~1% prec.

HERA + LHeC

case	cut [Q^2 in GeV ²]	α_s	\pm uncertainty	relative precision in %
HERA only (14p)	$Q^2 > 3.5$	0.11529	0.002238	1.94
HERA+jets (14p)	$Q^2 > 3.5$	0.12203	0.000995	0.82
LHeC only (14p)	$Q^2 > 3.5$	0.11680	0.000180	0.15
LHeC only (10p)	$Q^2 > 3.5$	0.11796	0.000199	0.17
LHeC only (14p)	$Q^2 > 20.$	0.11602	0.000292	0.25
LHeC+HERA (10p)	$Q^2 > 3.5$	0.11769	0.000132	0.11
LHeC+HERA (10p)	$Q^2 > 7.0$	0.11831	0.000238	0.20
LHeC+HERA (10p)	$Q^2 > 10.$	0.11839	0.000304	0.26

~0.1% precision

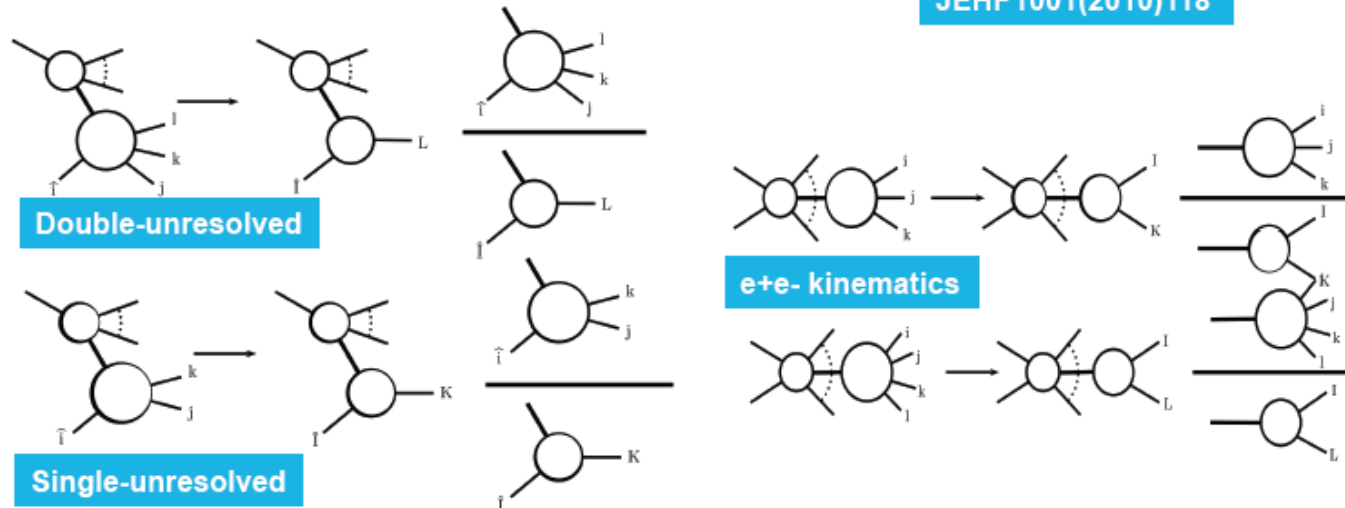
- > NNLO calculations are ongoing. Matrix elements are either
 - already derived (NLO corrections to 3-jet production in DIS, Z. Nagy, NLOJET++) or
 - Contained in work by Gehrmann/Glover (for the two-loop 2-parton final state).

PLB676(2009)146

- > Required: subtraction method!

- Gehrmann et al.: antenna subtraction method (for DIS).

JHEP0704*2007)016
JHEP1001(2010)118



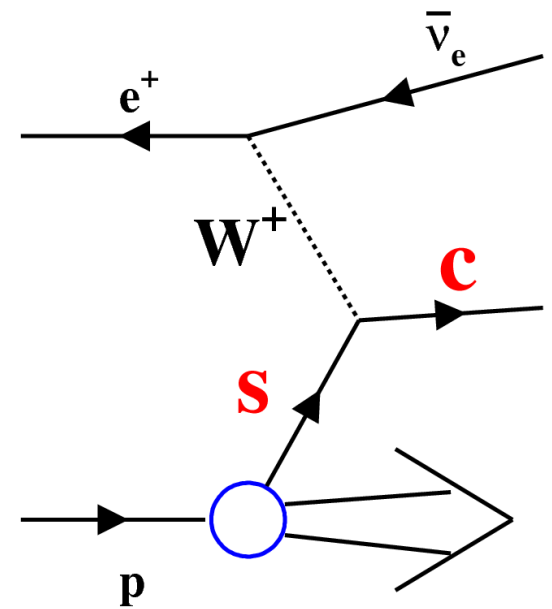
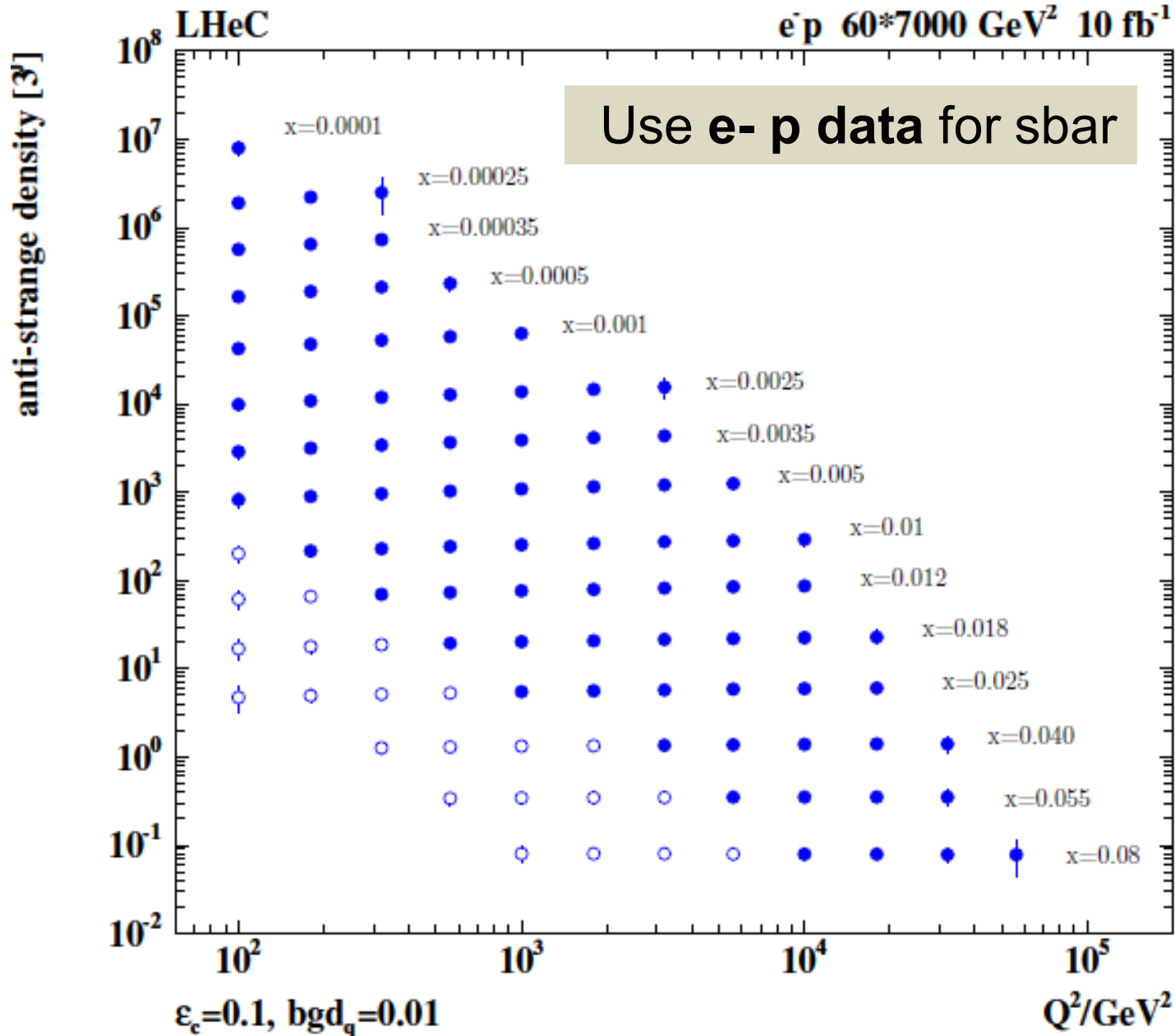
- > Currently implementing method into program for DIS jet production.

Thomas Schoerner-Sadenius | Jets @ LHeC | 12/13 November 2010 | Seite 38



Will reduce significantly theory (higher order) uncertainty for α_s extraction from jet data

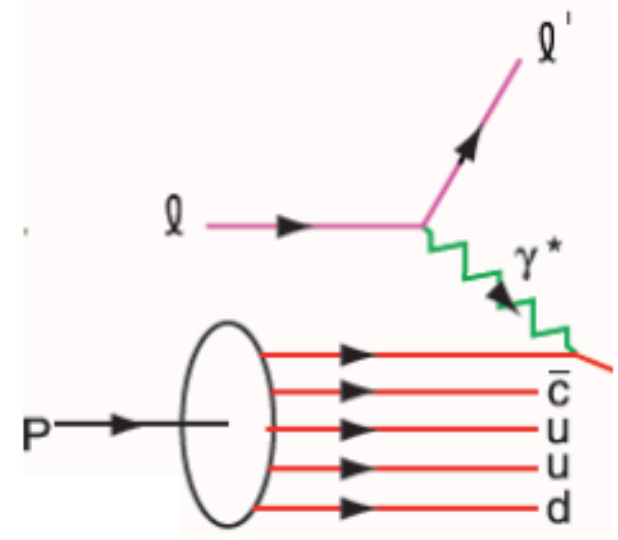
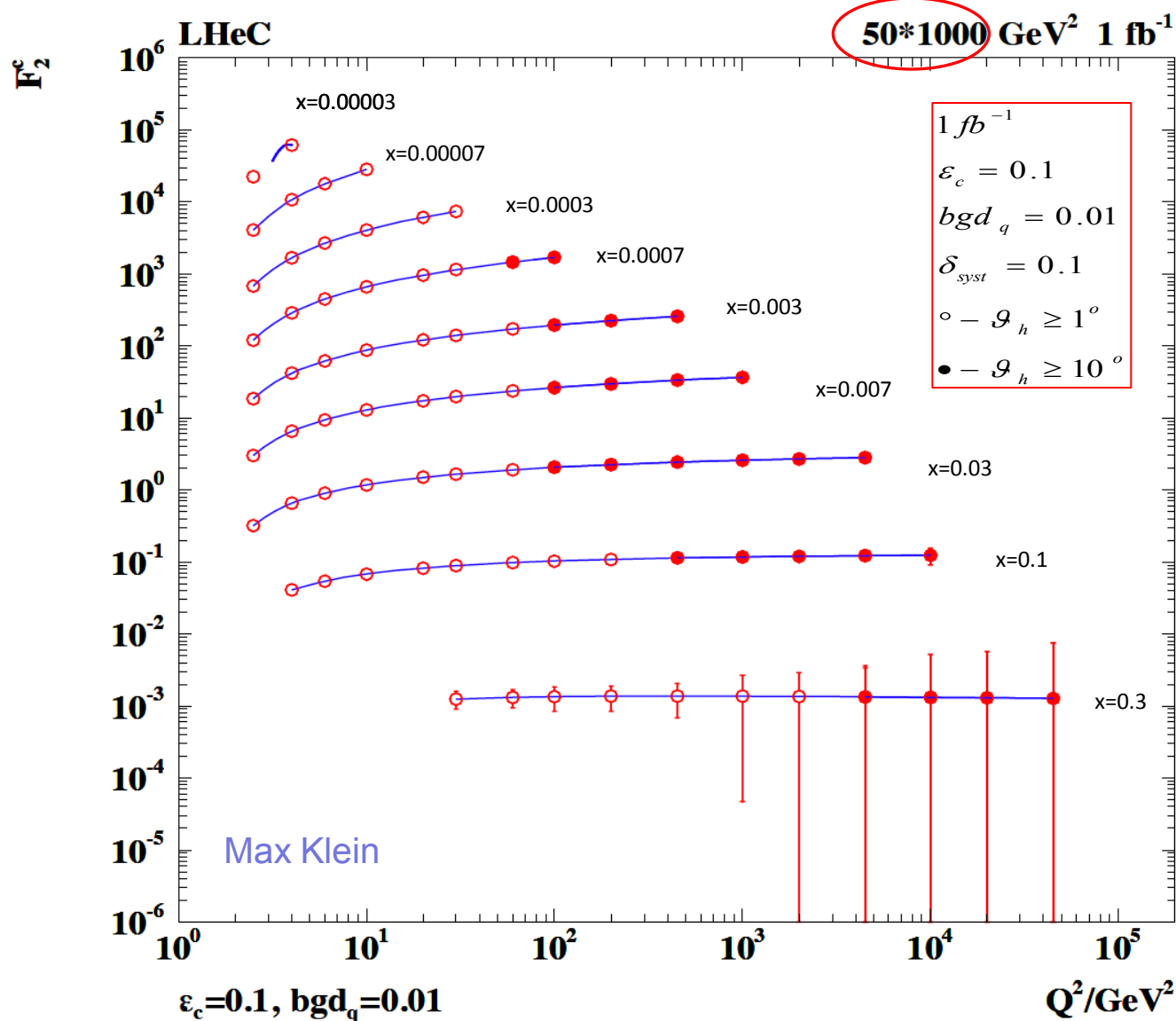
Strange =? Anti-strange quark density



Some dimuon and K data,
but never properly measured

➔ Pin down
s & sbar

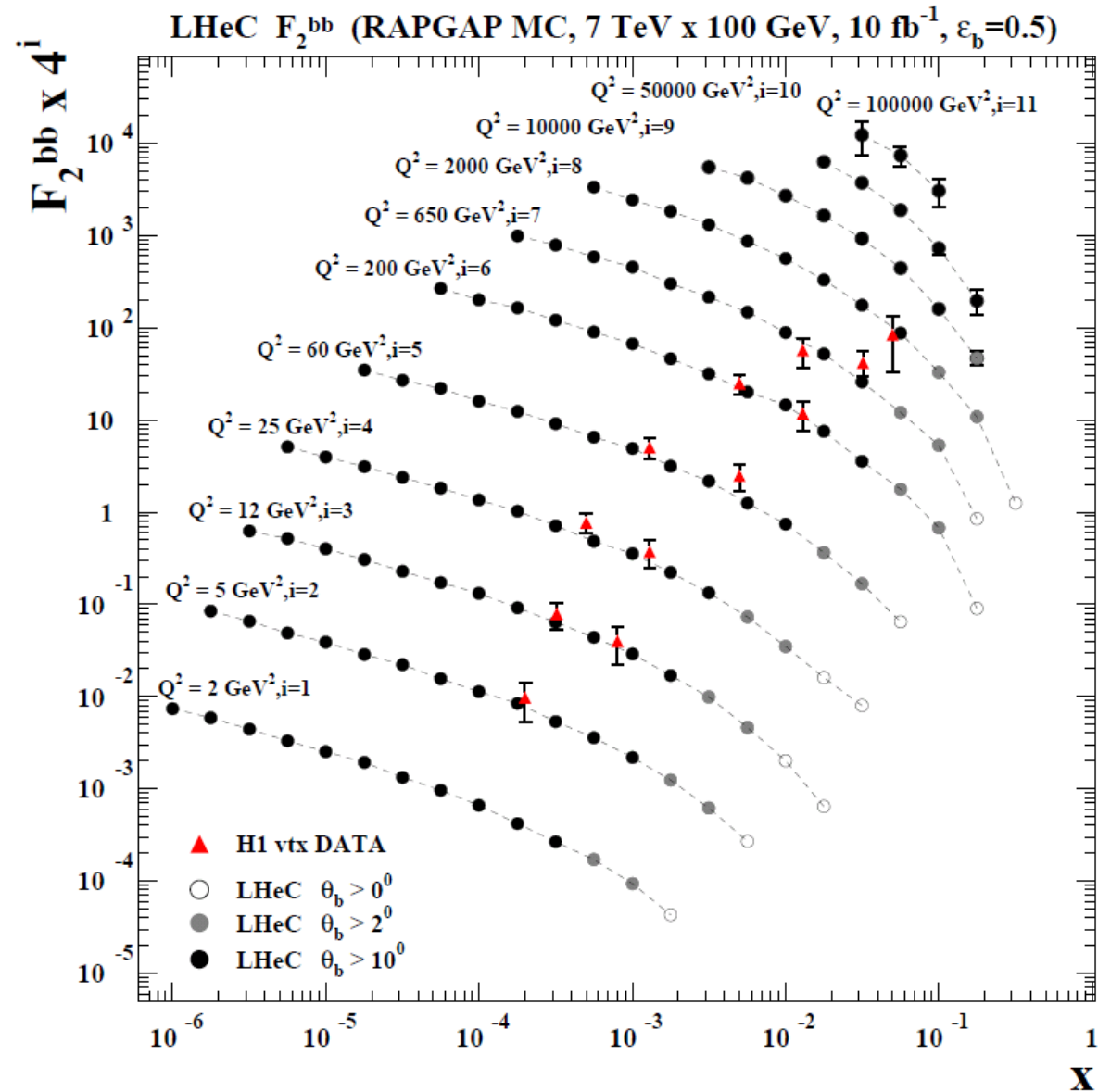
Charm in DIS: test intrinsic charm in p



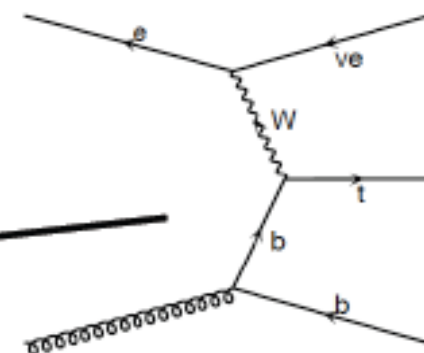
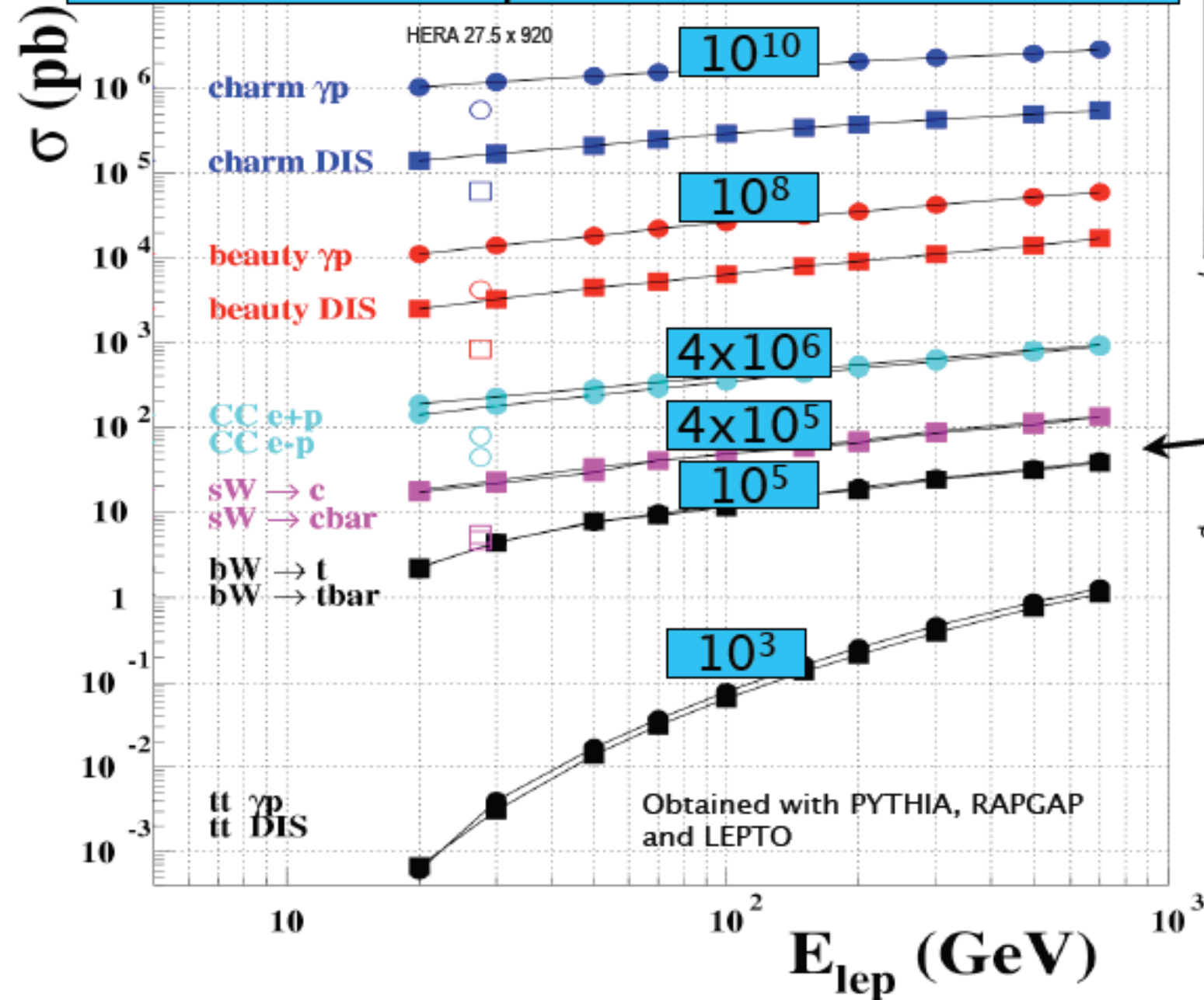
Expected to show up
at $x_b > 0.1$

➡ Requires c-tagging in very forward direction ($\theta \sim 1$ deg.)

Beauty production contribution to $F_2 = F_2^{bb}$



Events per 10 fb⁻¹ Lumi



LHeC is a
flavour factory