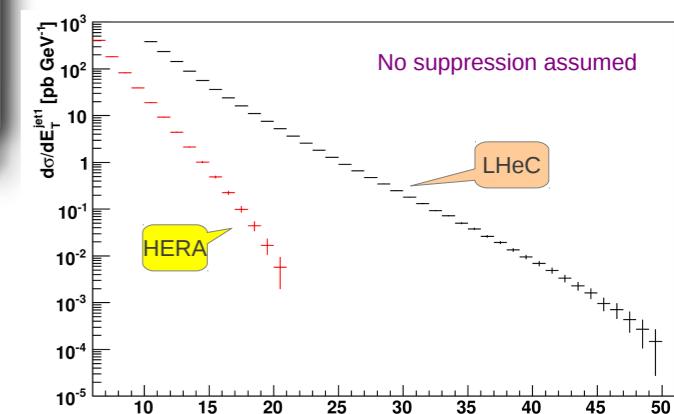
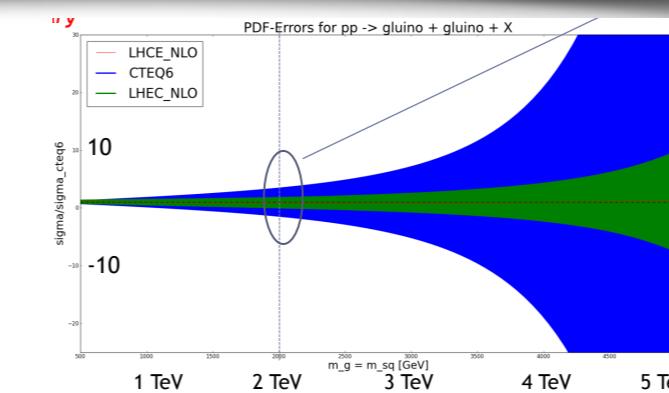
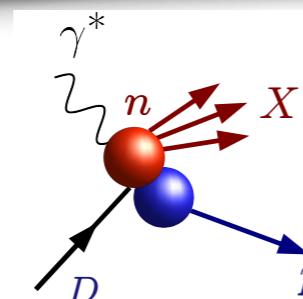


Summary Physics Session

Olaf Behnke and Anna Stasto

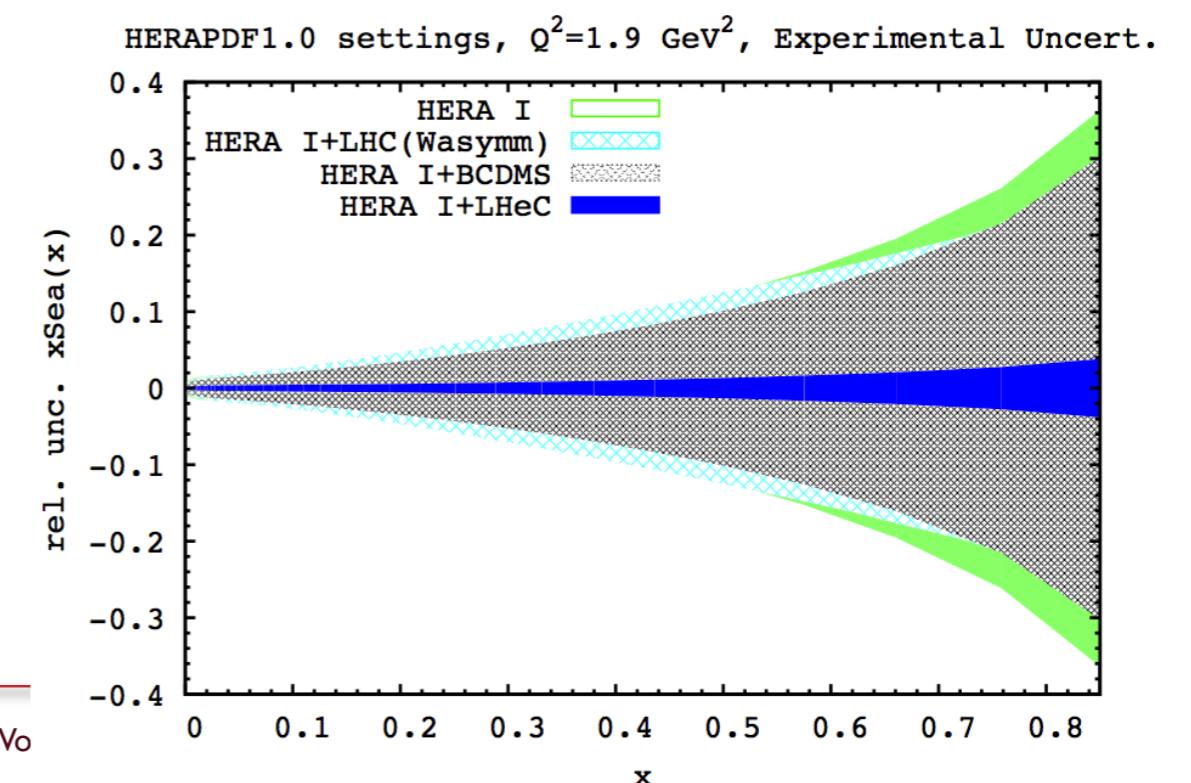
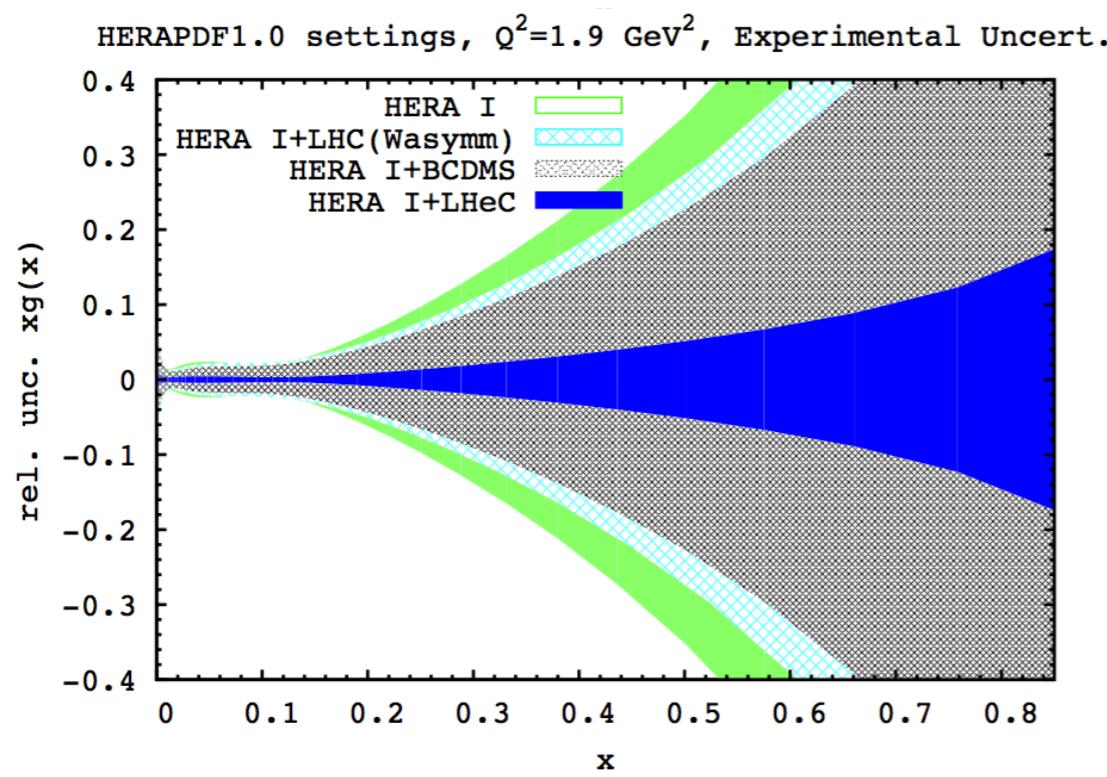
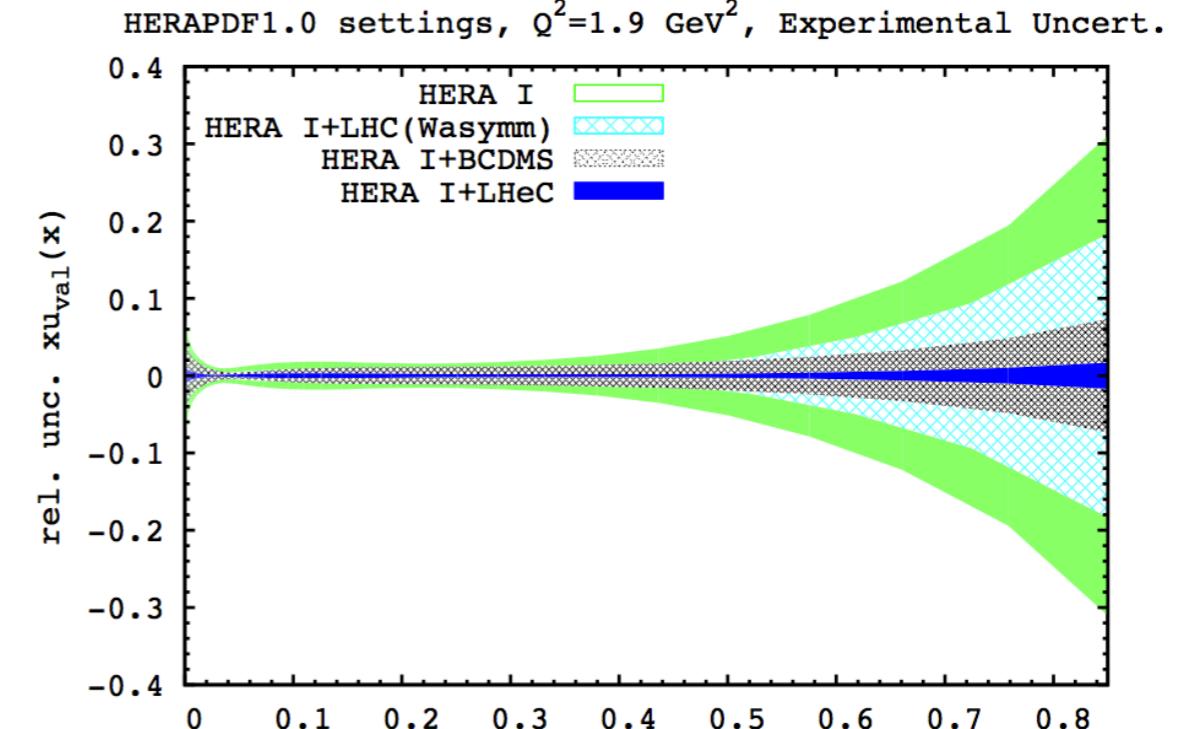
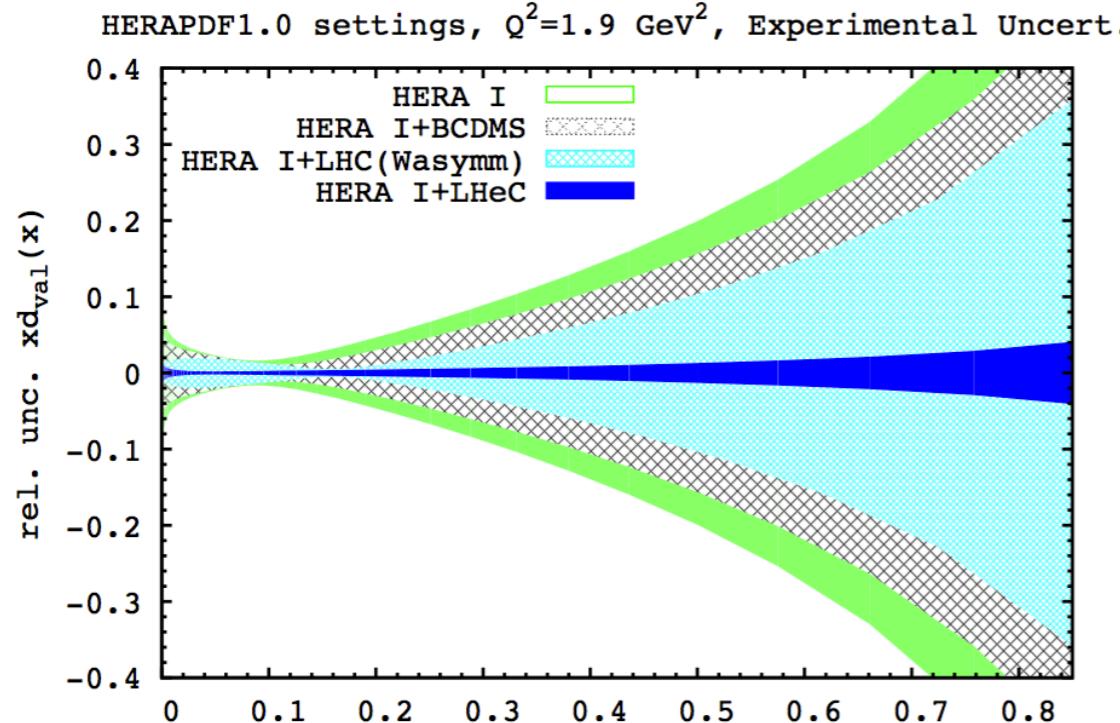


Physics Session

- Update on PDFs [Radescu](#)
- Strong coupling [Radescu,Blumlein](#)
- Nuclear PDFs [Zurita](#)
- Deutrons [Accardi](#)
- Heavy flavors [Behnke,Pascaud](#)
- Electroweak [Spiesberger](#)
- Real photon-proton scattering [Sultansoy](#)
- DIS with positrons [Klein](#)
- Generalized Parton Distributions [Pire](#)
- $eA/pA/AA$ [Salgado](#)
- Diffractive dijets [Zlebcik](#)
- Monte Carlo for ep [Plaetzer](#)
- Factorization [Forte](#)
- Higgs [Ishitsuka, Mellado](#)
- BSM [d'Onofrio,Azuelos](#)

Impact of LHeC on PDFs: zoom on high x

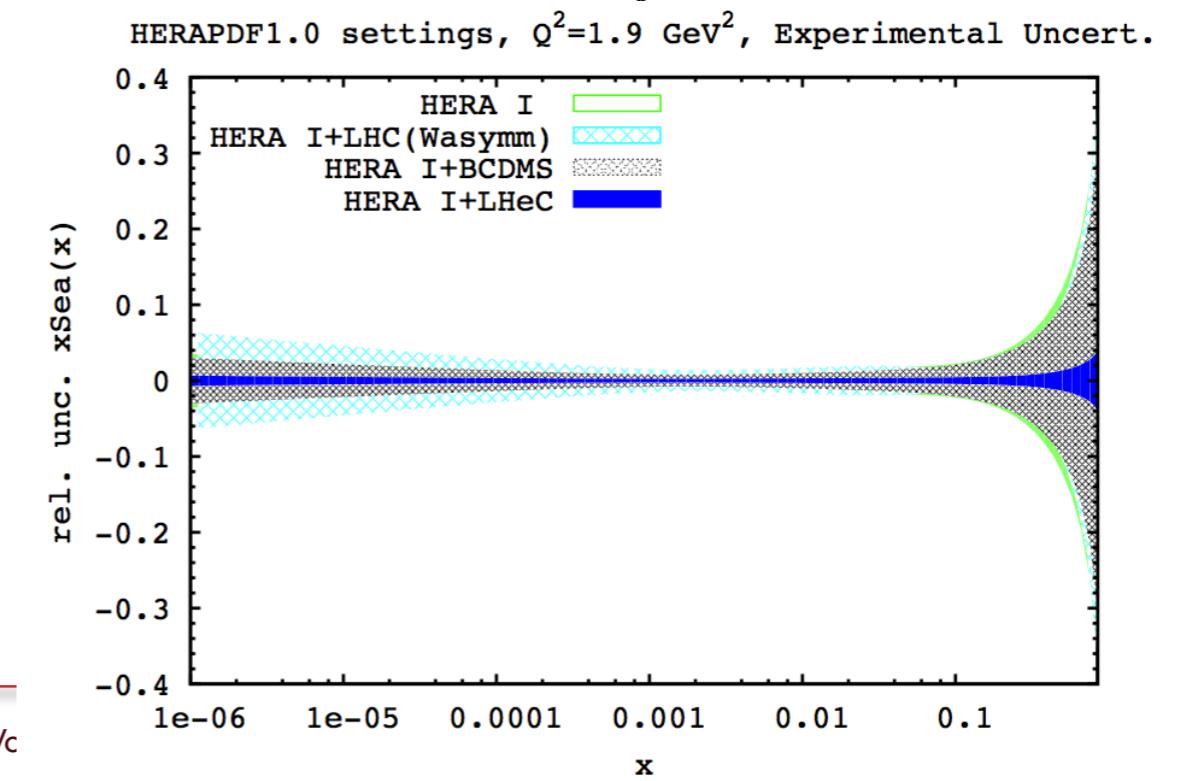
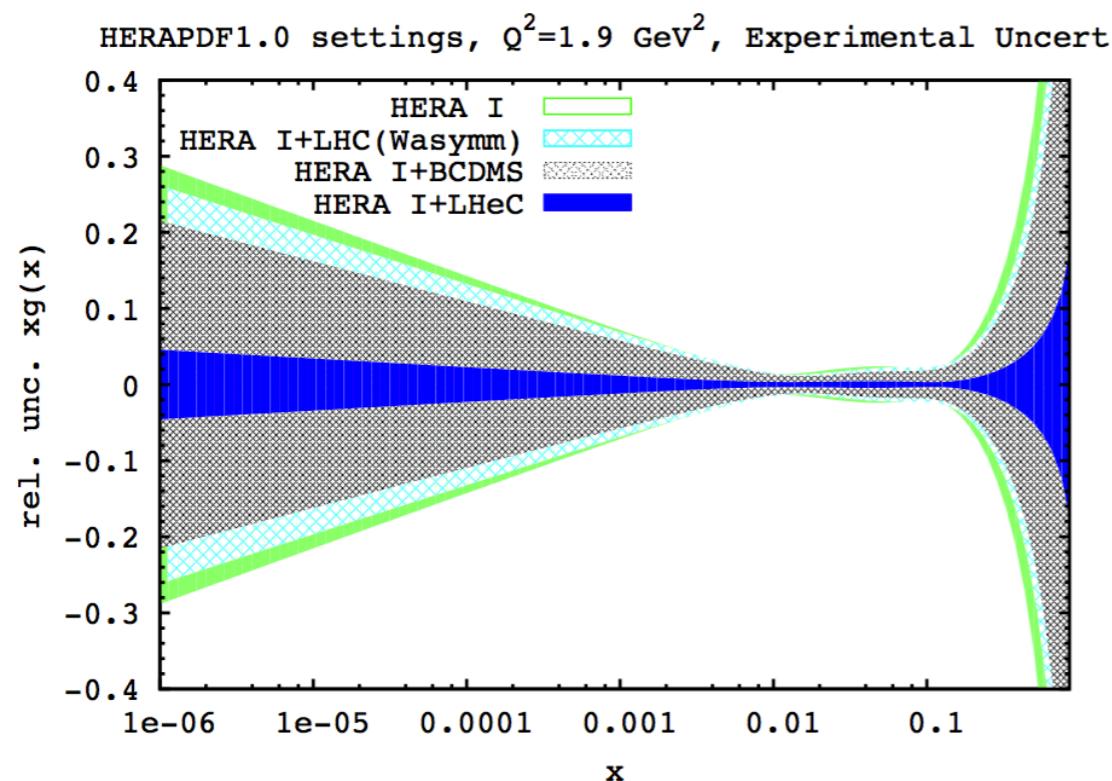
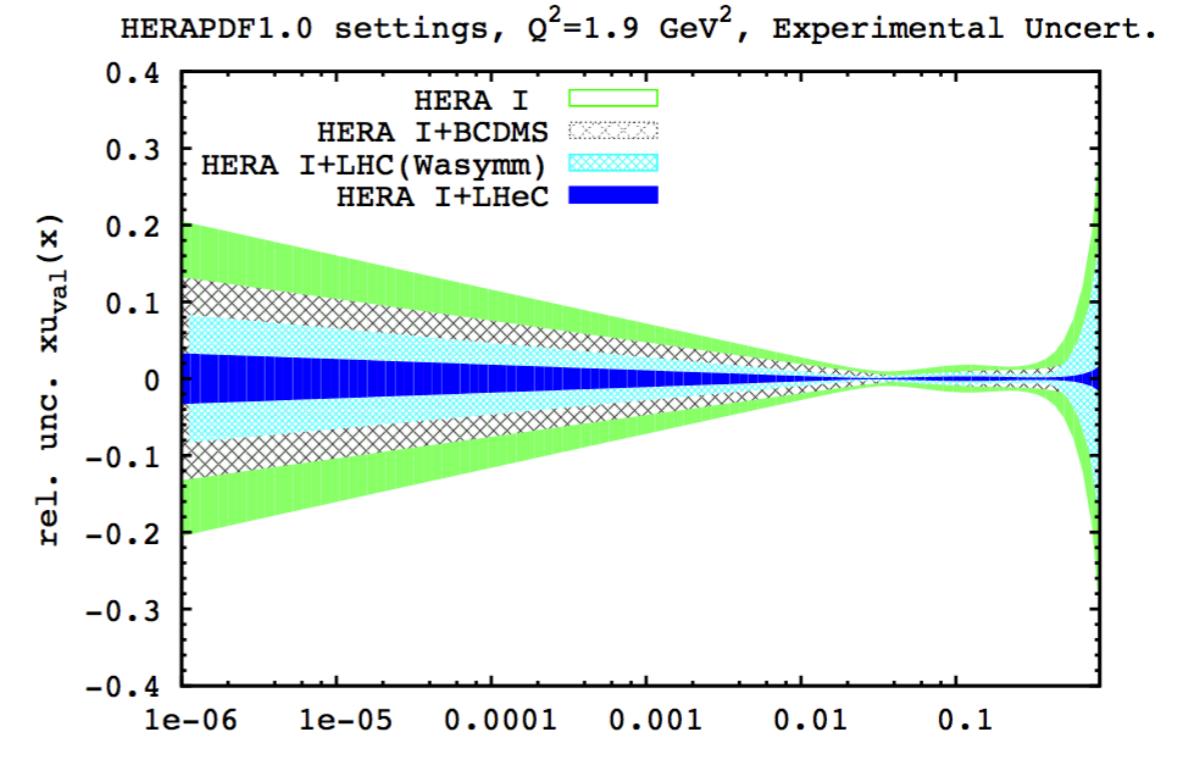
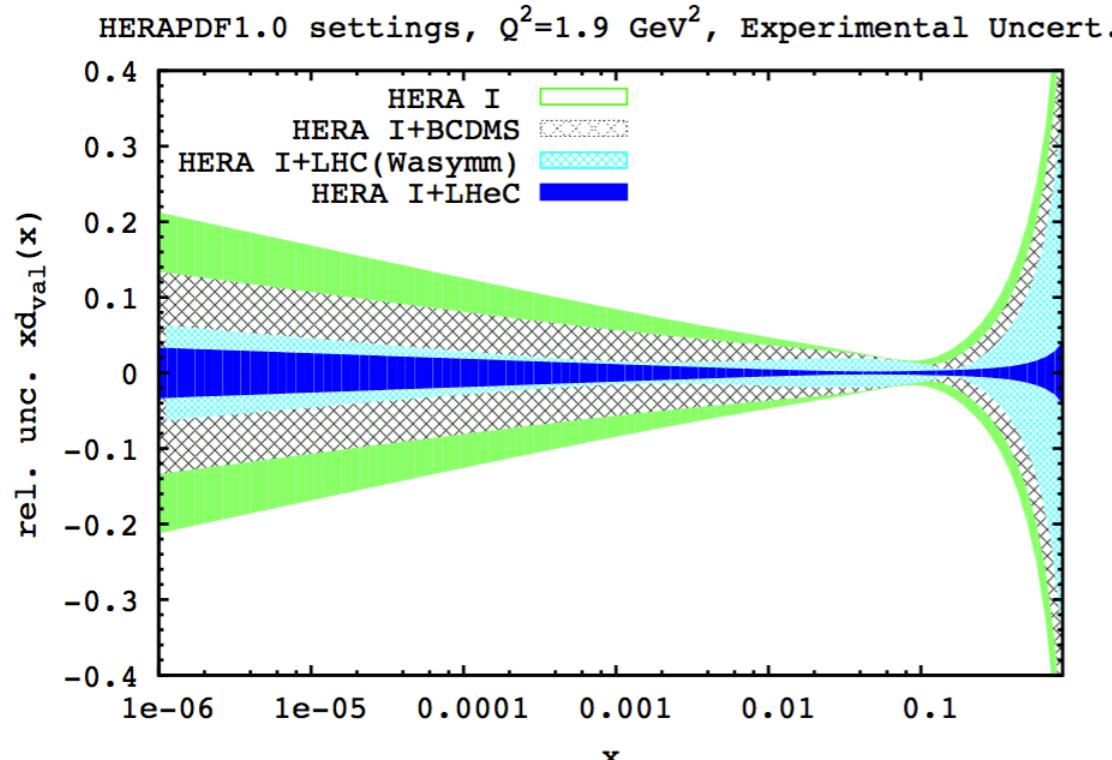
* Experimental uncertainties are shown at the starting scale $Q^2=1.9 \text{ GeV}^2$



IeCWo

Impact of LHeC on PDFs: zoom on low x

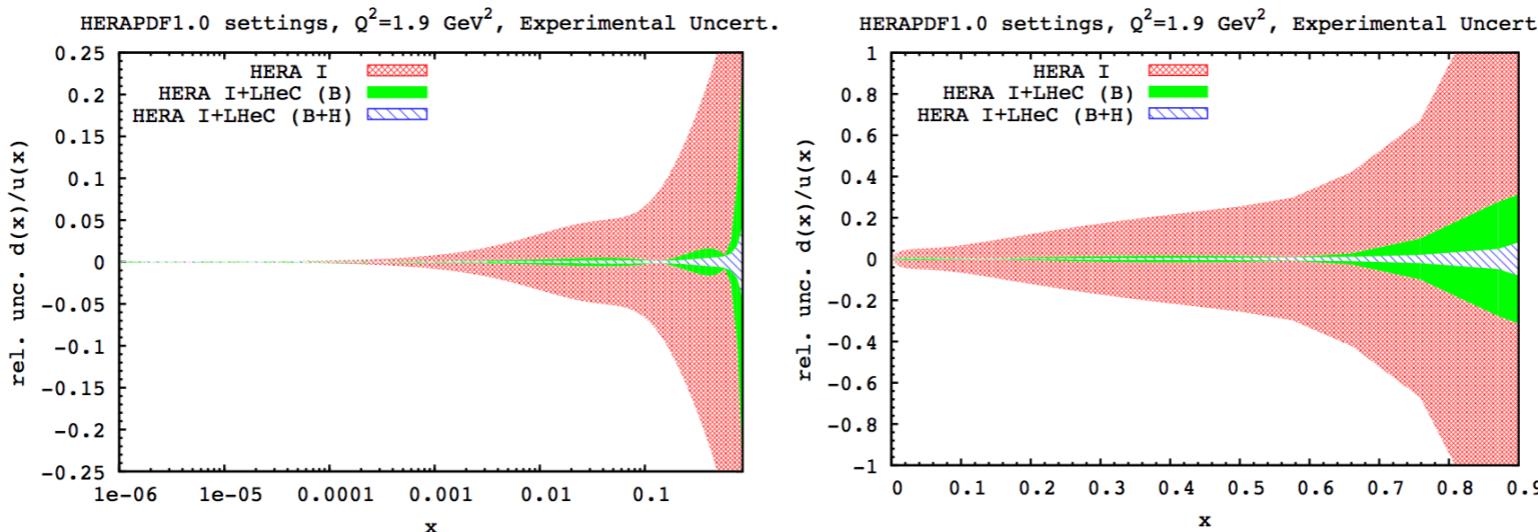
* Experimental uncertainties are shown at the starting scale $Q^2=1.9 \text{ GeV}^2$



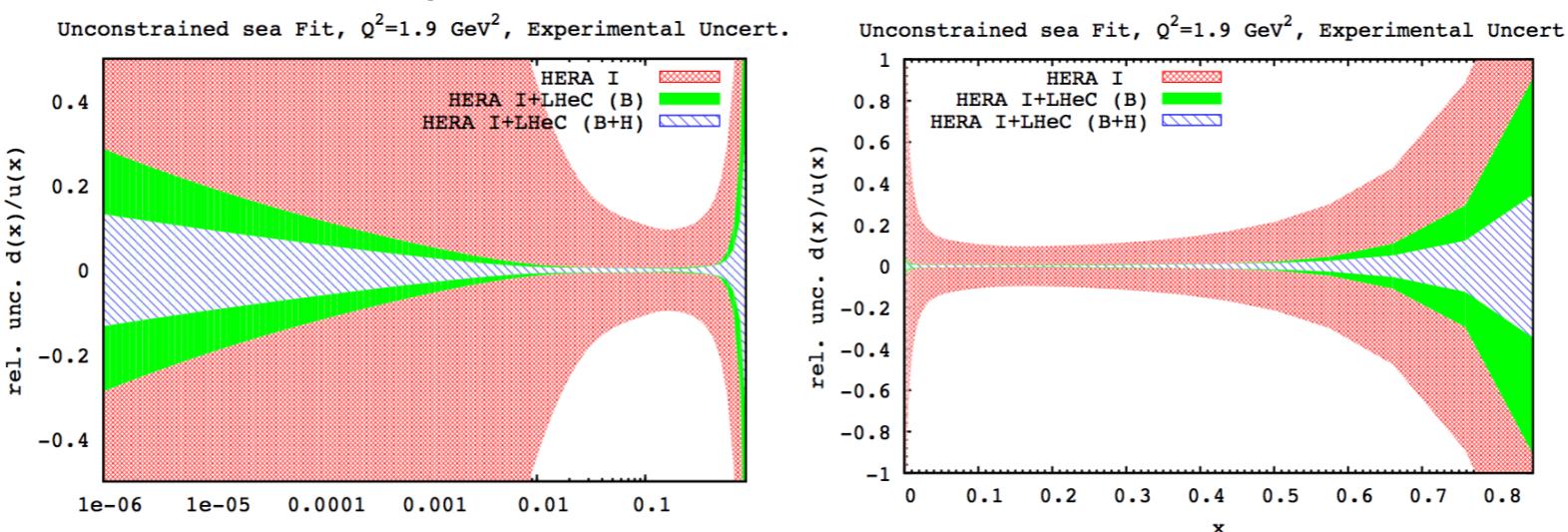
- Usual assumptions for light quark decomposition at low x may not necessarily hold.
- Relaxing the assumption at low x that $u=d$, we observe that uncertainties escalate:
 - One can see that for HERA data, if we relax the low x constraint on u and d , the errors are increased tremendously!
 - However, when adding the LHeC simulated data, we observe that uncertainties are visibly improved even without this assumption.

Impact on d/u ratios

- Constrained decomposition:



- Unconstrained sea decomposition:



Expected precision on alphas(Mz) from DIS

- A dedicated study to determine the accuracy of alphas from the LHeC was performed using for the central values the SM prediction smeared within its uncertainties assuming Gauss distribution and taking into account correlations.

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

Table 4.4: Results of NLO QCD fits to HERA data (top, without and with jets) to the simulated LHeC data alone and to their combination. Here 10p or 14p denotes two different sets of parametrisations, one, with 10 parameters, the minimum parameter set used in [38] and the other one with four extra parameters added as has been done for the HERAPDF1.5 fit. The central values of the LHeC based results are obviously of no interest. The result quoted as relative accuracy includes all the statistical and the systematic error sources taking correlations as from the energy scale uncertainties into account.

$\alpha_s(M_Z^2)$: Global DIS Comparison

Data Set	ABM11	BBG	NN21	MSTW
BCDMS	0.1048 ± 0.0013	0.1126 ± 0.0007	0.1158 ± 0.0015	0.1101 ± 0.0094
NMC	0.1152 ± 0.0007	0.1153 ± 0.0039	0.1150 ± 0.0020	0.1216 ± 0.0074
SLAC	0.1128 ± 0.0003	0.1158 ± 0.0034	> 0.124	$\begin{cases} 0.1140 \pm 0.0060 & \text{ep} \\ 0.1220 \pm 0.0060 & \text{ed} \end{cases}$
HERA	0.1126 ± 0.0002		$\begin{cases} 0.1199 \pm 0.0019 \\ 0.1231 \pm 0.0030 \end{cases}$	0.1208 ± 0.0058
DY	0.101 ± 0.025	—	—	0.1136 ± 0.0100
	0.1134 ± 0.0011	0.1134 ± 0.0020	0.1173 ± 0.0007	0.1171 ± 0.0014

Table 9: Comparison of the pulls in $\alpha_s(M_Z)$ per data set between the ABM11, BBG, NN21, MSTW analyses at NNLO.

Use: $W^2 > 12.5 \text{ GeV}^2$, $Q^2 > 2.5 \text{ GeV}^2$ and no HT: $\alpha_s(M_Z^2) = 0.1191 \pm 0.0016$

Use: $W^2 > 12.5 \text{ GeV}^2$, $Q^2 > 10 \text{ GeV}^2$ and no HT: $\alpha_s(M_Z^2) = 0.1134 \pm 0.0008$

MSTW08 and NNPDF: no HT corrections.

Taking into account error correlations is of importance.

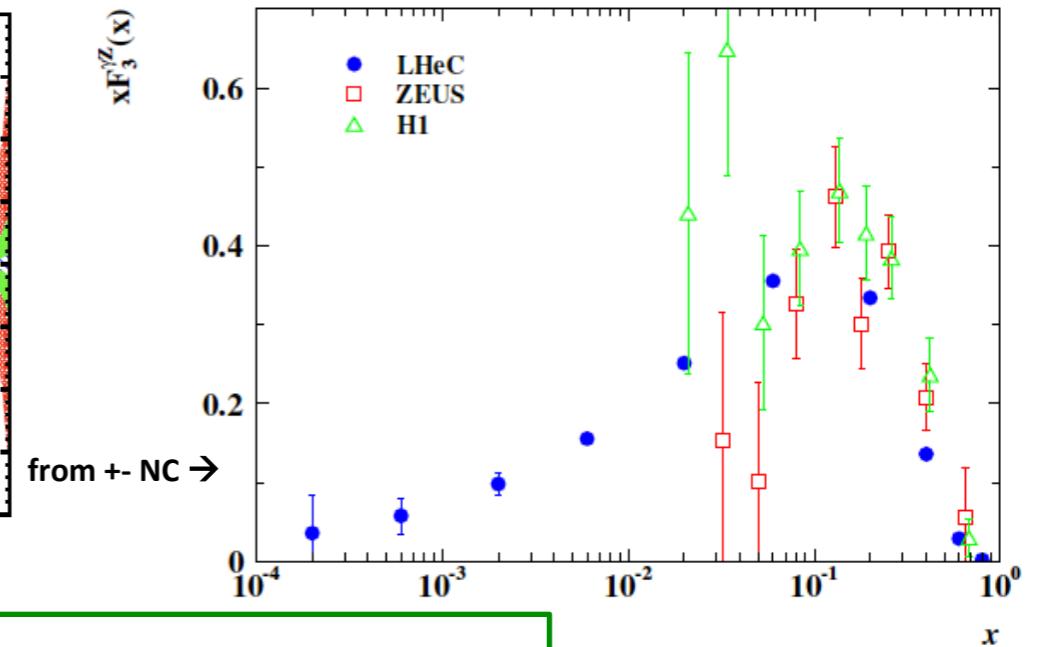
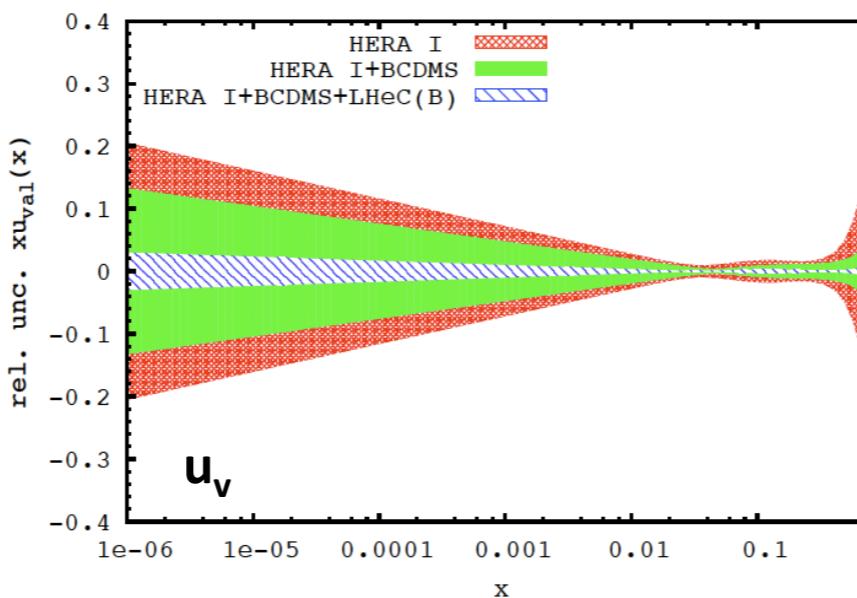
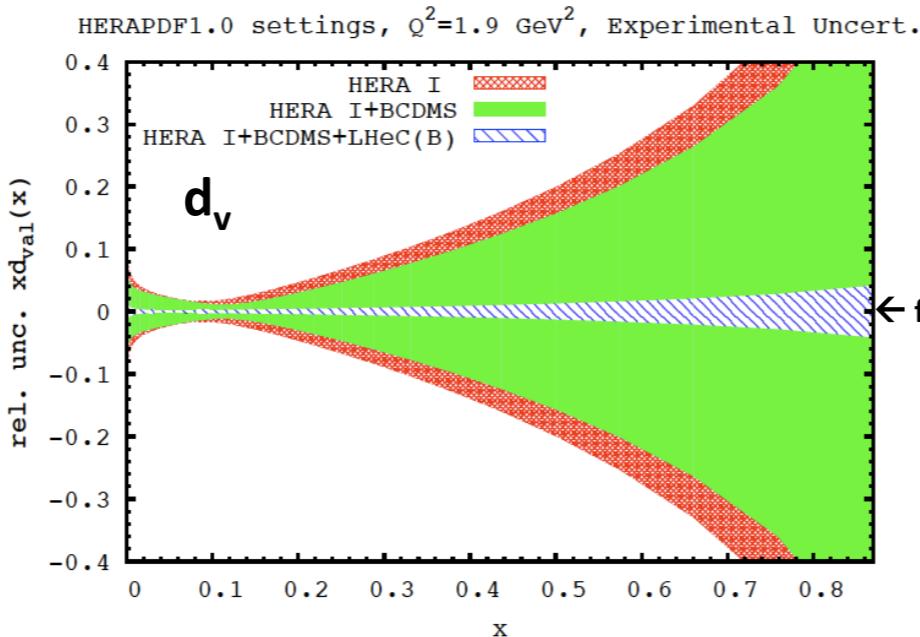
Importance of higher twists for determination of the strong coupling

Future Challenges

- Precise high Q^2 data from LHeC both for **protons** and **deuterons** with well controlled systematics are highly desireable.
- Try to perform non-singlet analyses, including charged current data.
- LHeC will have a rich host of heavy flavor data for dedicated QCD analyses.
- Higher Twist will be less important.
- Interesting other samples with more uniform systematics: $ep \rightarrow jets$.
- Constrain the Gluon from as many as possible precision measurements.
- Precision data from new facilities may finally evaluate whether the current high-precision data deliver a correct value of $\alpha_s(M_Z^2)$.

Positrons at LHeC

Weak Currents - Valence Quarks (d_v , low x)



→ There is a strong demand from physics to maximize the positron luminosity too

(with probably less emphasis to the e^+ beam polarisation which is yet another complication)

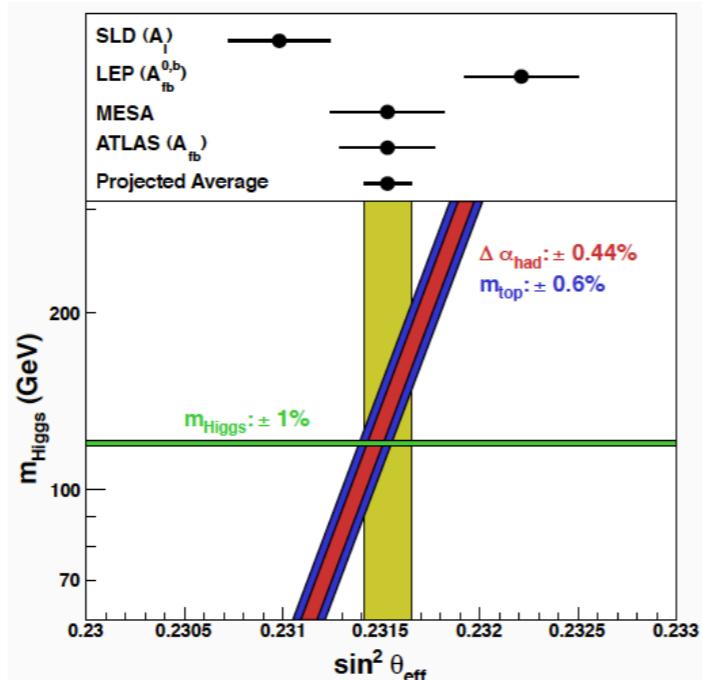
→ A setup with 100 fb⁻¹ electrons and 1 fb⁻¹ positrons is tolerable but requires $L+ = O(L/10)$

If the positron luminosity was much lower than for electrons, one would be tempted not to “waste” running time on positrons and thus the integrated luminosity came out to be even lower, relatively to electrons

The valence quarks are still not well known, because of nuclear and non-pert. corrections.

Uncertain are particularly the d -valence and the low x region, which are important for LHC discovery and precision physics (M_W)

The LHeC needs positrons for both d_v at high x (from CC scattering at high luminosity, 10fb⁻¹) and for a measurement of $2u_v+d_v$ at low x (from the NC charge asymmetry with few fb⁻¹)

STANDARD MODEL RELATION: HIGGS BOSON MASS VERSUS $\sin^2 \theta_W(\mu)$ 

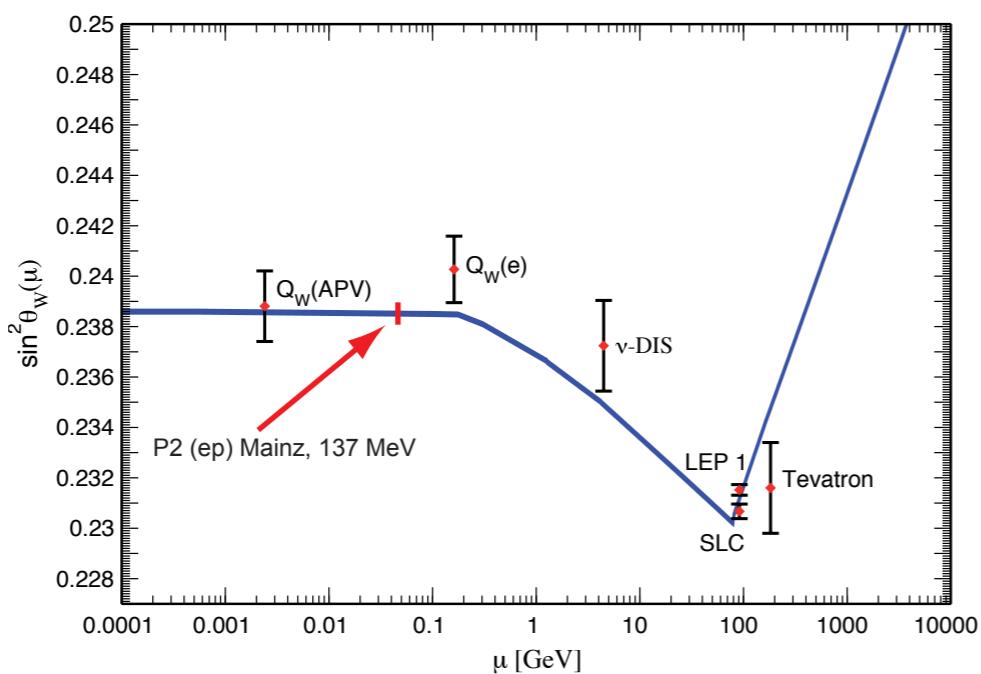
Combination of precision measurements at the Z -pole

→ $M_{\text{Higgs}} - \sin^2 \hat{\theta}_W(\mu)$ relation
(red-blue band)

Precision measurement of $\sin^2 \hat{\theta}_W(\mu)$ provides indirect evidence for the allowed range of M_{Higgs}

Combination of measurements provide strong tests of the SM,
... and maybe evidence for new physics

Notice conflicting measurements from LEP/SLD

SCALE DEPENDENCE OF $\sin^2 \hat{\theta}_W$: LHeC

Existing and projected measurements

- Atomic parity violation (Cs)
- Neutrino scattering
- LEP and SLC (Z -pole)
- Tevatron
- Moller (expect 0.1 % after 2020)
- Q-weak (started running, 0.3 %?)
- LHC
- Mainz MESA, at $\mu = 0.05$ GeV:
 $\Delta \sin^2 \hat{\theta}_W = \pm 0.00037$ (i.e. 0.15 %)

Neutral current at tree level, polarized e^\pm scattering

$$\frac{d^2\sigma_{NC}}{dx dQ^2} = \frac{2\pi\alpha^2}{Q^4 x} \left(Y_+ \mathbf{F}_2 + Y_- x \mathbf{F}_3 - y^2 \mathbf{F}_L \right)$$

Paramters: $\alpha, m_Z, \sin^2 \theta_w$; maybe $v_e, a_e; v_q, a_q$

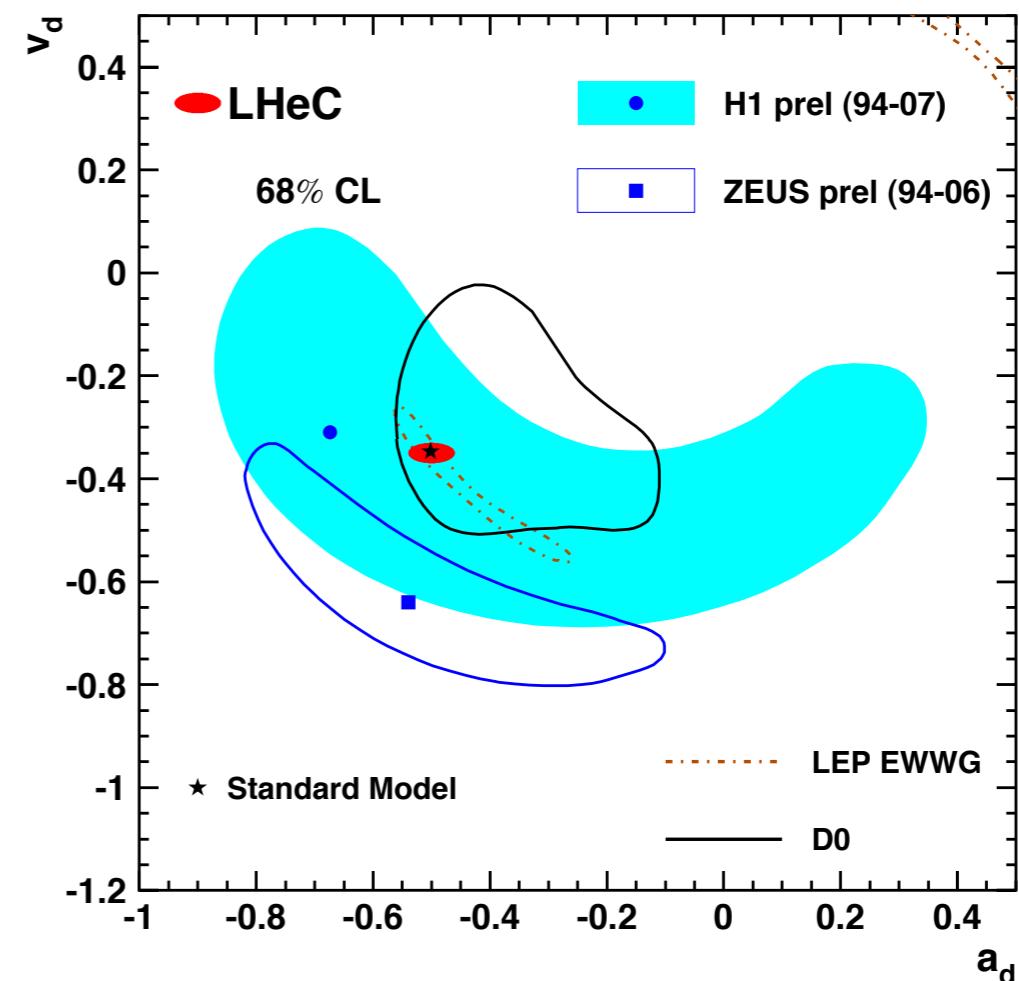
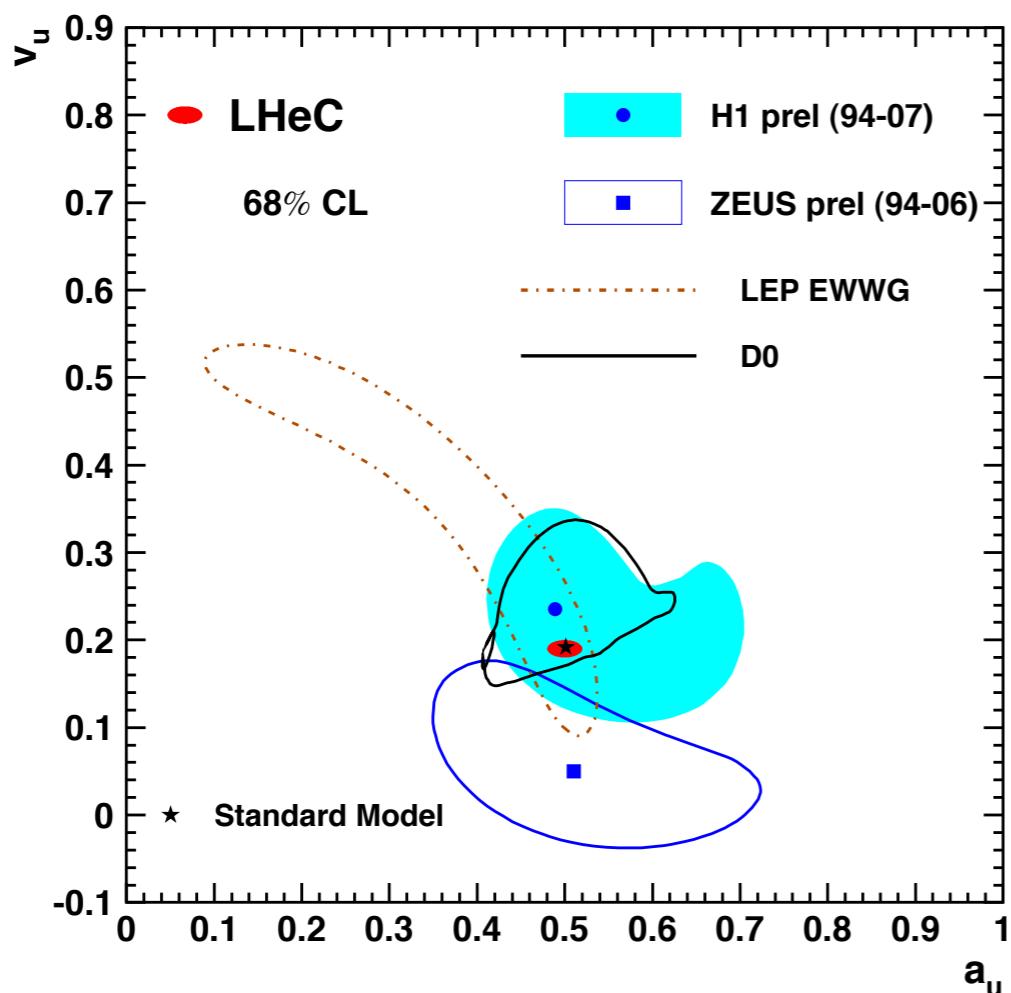
Charged current at tree level

$$\frac{d^2\sigma_{CC}}{dx dQ^2} = \frac{1 \pm P}{2} \frac{2\pi\alpha^2}{Q^4 x} \kappa_W^2 \left(Y_+ \mathbf{W}_2 \pm Y_- x \mathbf{W}_3 - y^2 \mathbf{W}_L \right)$$

with

$$\kappa_W(Q^2) = \frac{Q^2}{Q^2 + m_W^2} \frac{1}{4 \sin^2 \theta_w}$$

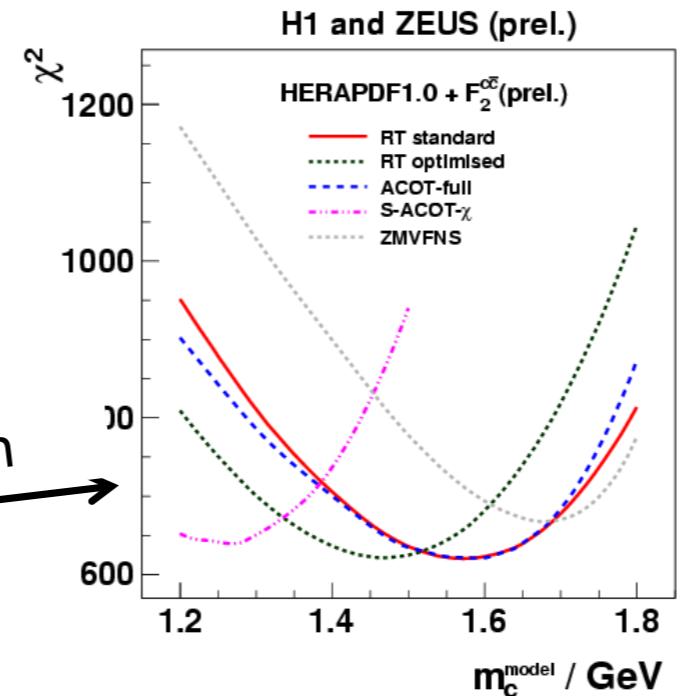
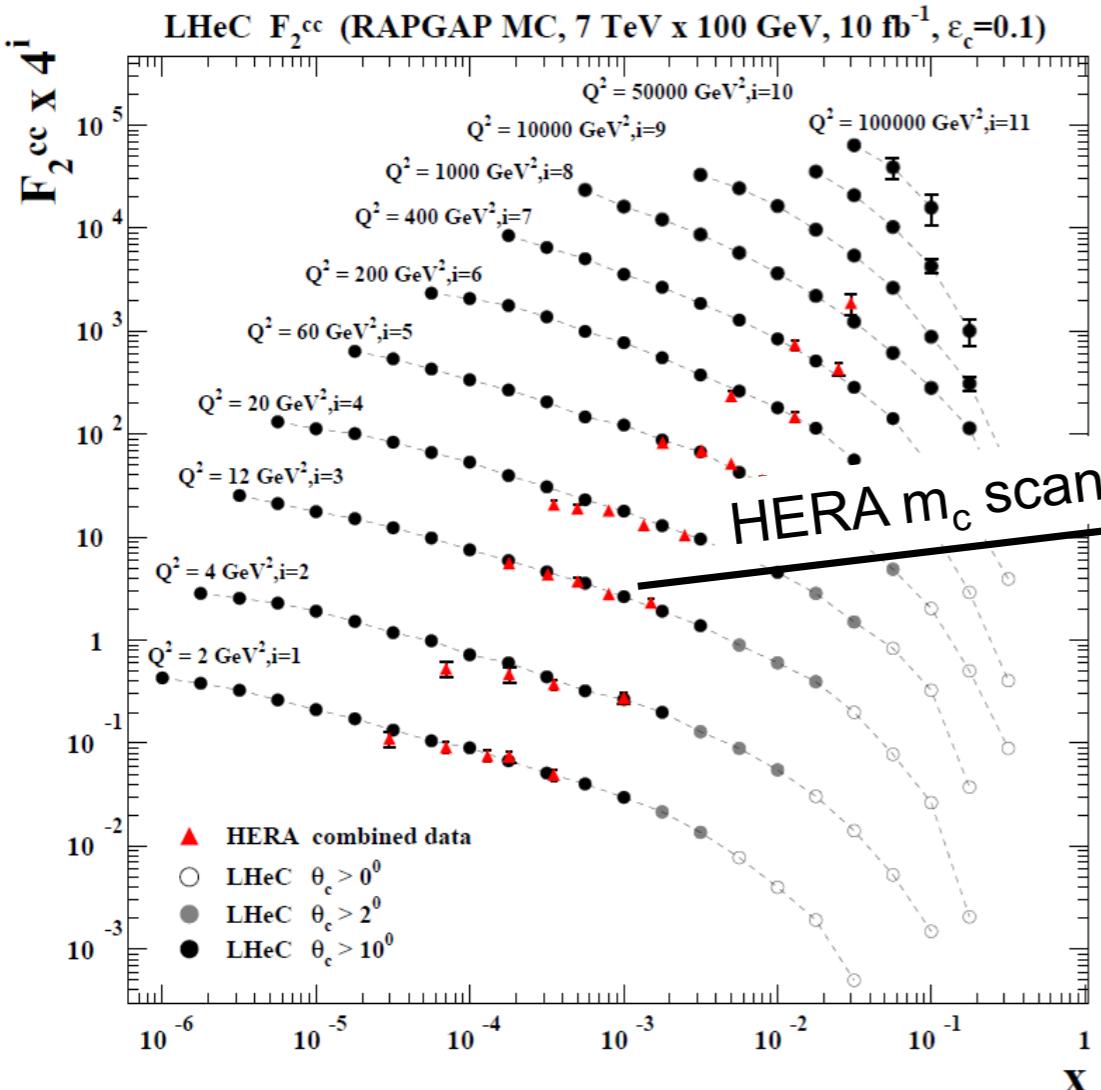
Paramters: $\alpha, m_W, \sin^2 \theta_w$



LHeC: v_q, a_q

From fits to NC and CC
great improvement
on measurements
of quark vector and
axial-vector couplings

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



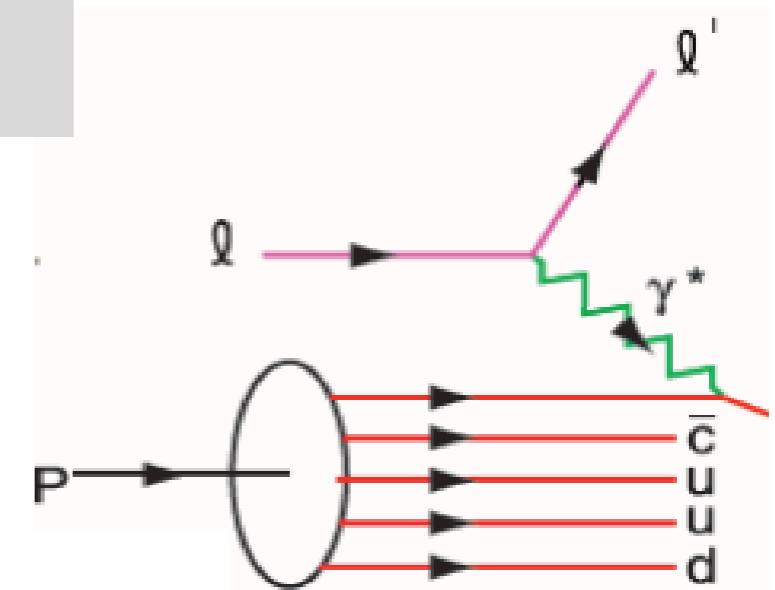
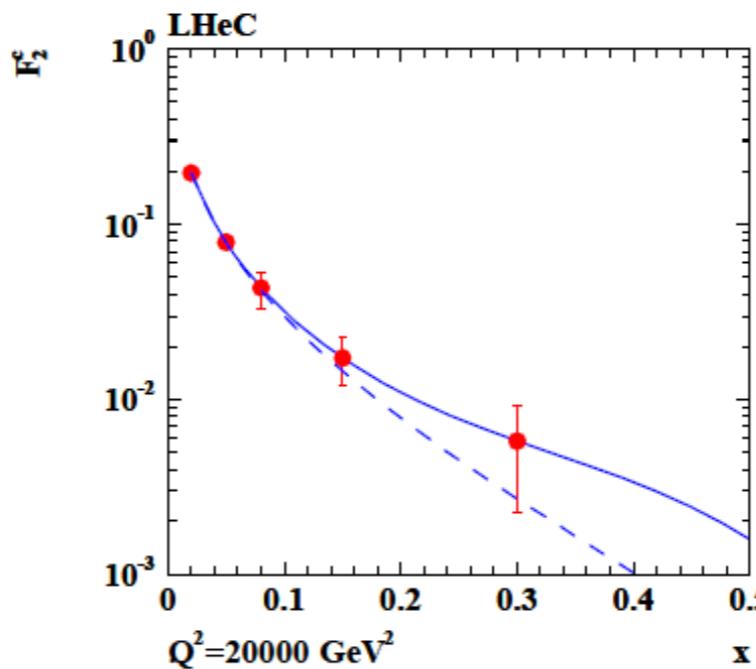
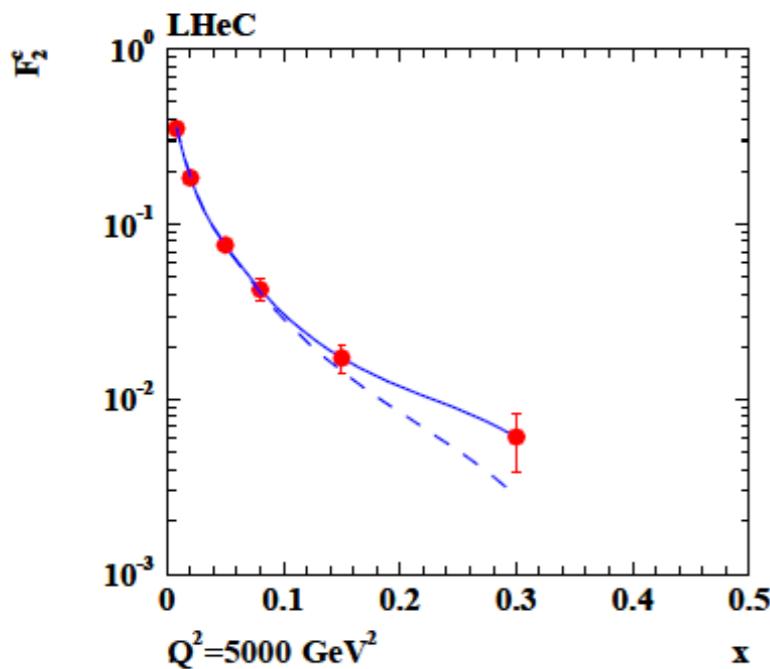
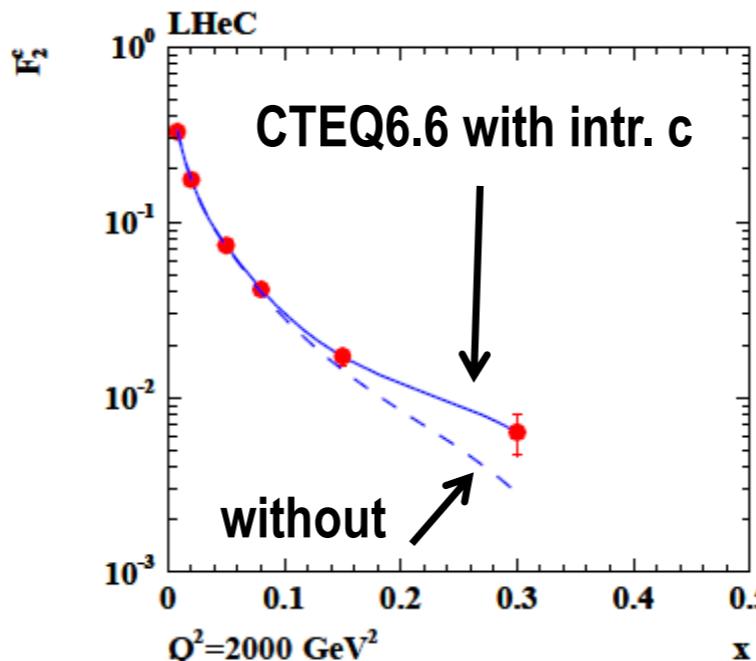
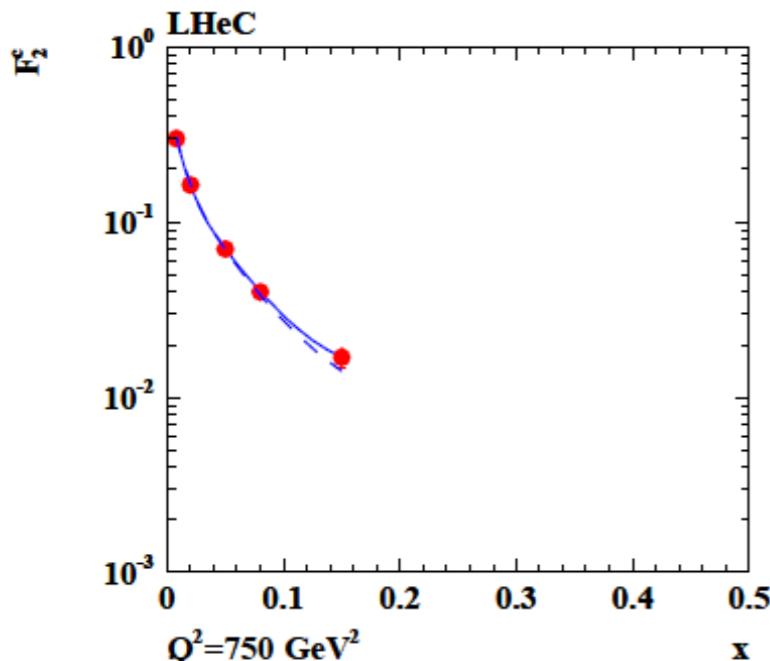
LHeC: Huge
phasespace extension
and high precision
→ ultraprecise m_c

32

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

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

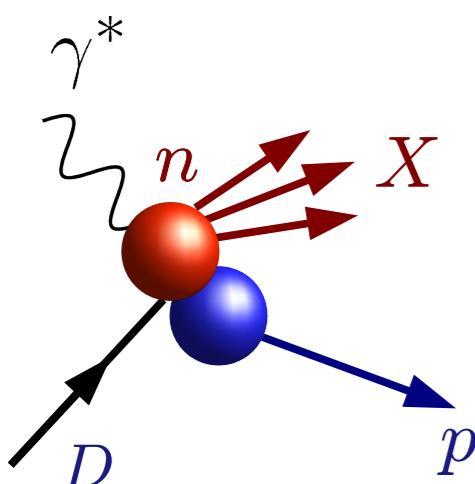
Test intrinsic charm in proton



→ Have some sensitivity (with excellent forward c-tagging)

Summary: why deuteron?

- Flavor separation, baseline for nuclear PDF fits
- Nuclear effects from low to high x
 - Verify shadowing calculations, approach to sat., $F_2^D(n)$
 - Bound nucleons without $1/Q^2$ corrections
 - “Superfast quarks”
- Proton/neutron tagging
 - DIS, diffraction on neutrons
 - Free vs. bound, off-shell protons
- Diffraction (not covered in this talk)
 - Coherent, breakup, incoherent



Why deuteron?

- Deuteron as effective neutron beam

- Quark flavor decomposition

$$F_2(p) \propto 4u + d$$

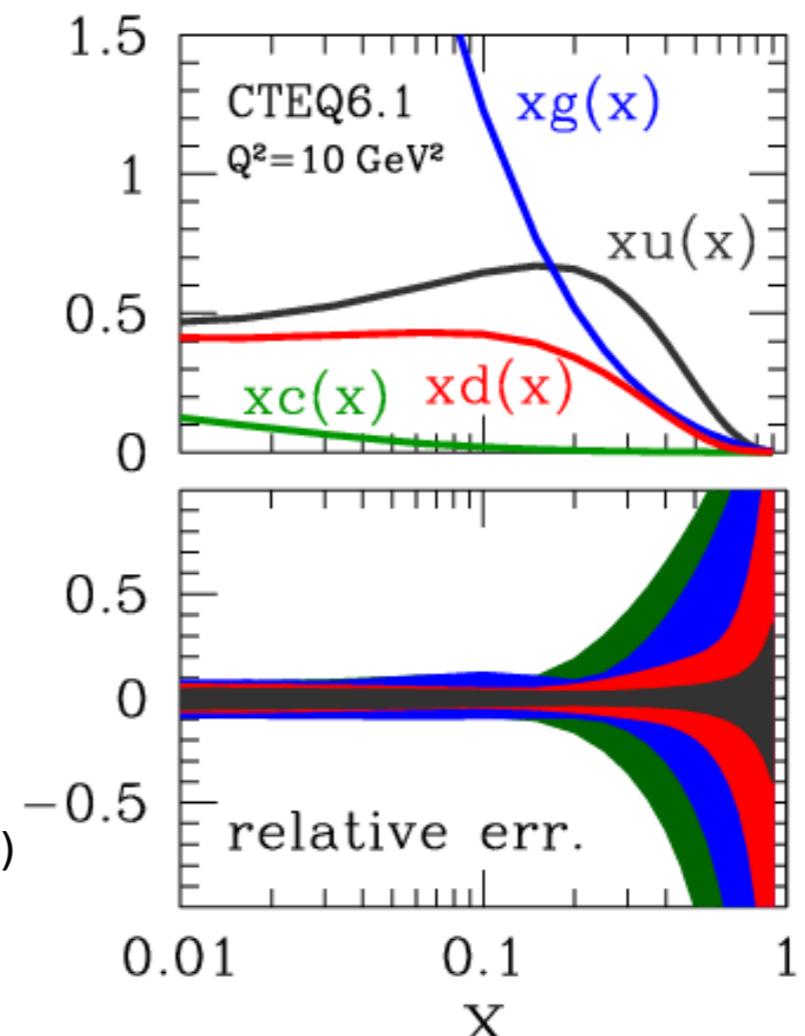
$$F_2(n) \propto u + 4d$$

- Particularly important at large x

- Large d-quark uncertainty
 - d/u ratio at $x \rightarrow 1$ probes non perturbative proton structure

Accardi et al. [CTEQ-JLab collab.] PRD84(2011)

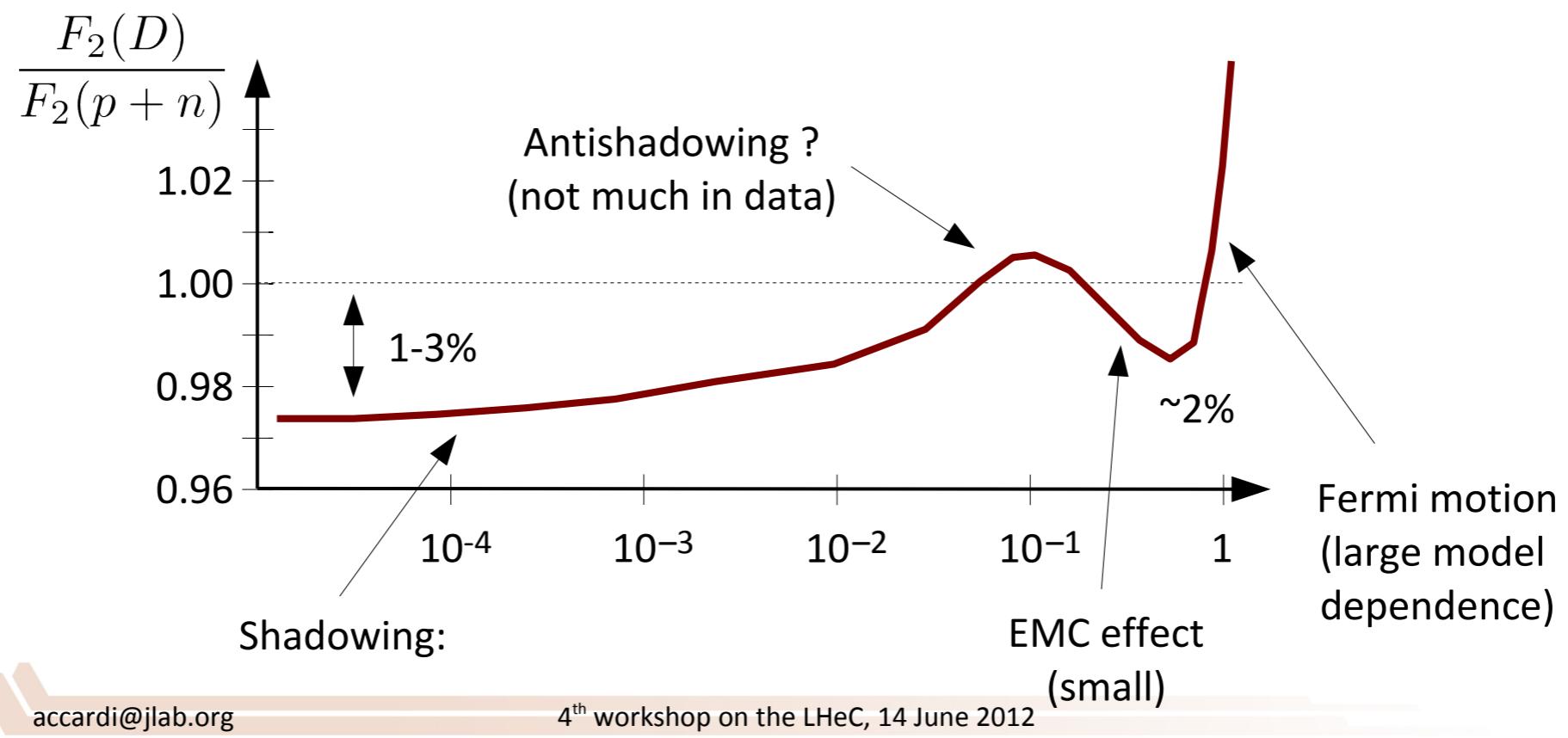
- At $x \lesssim 10^{-2}$ sea quarks dominate, expect $F_2(p) \approx F_2(n)$

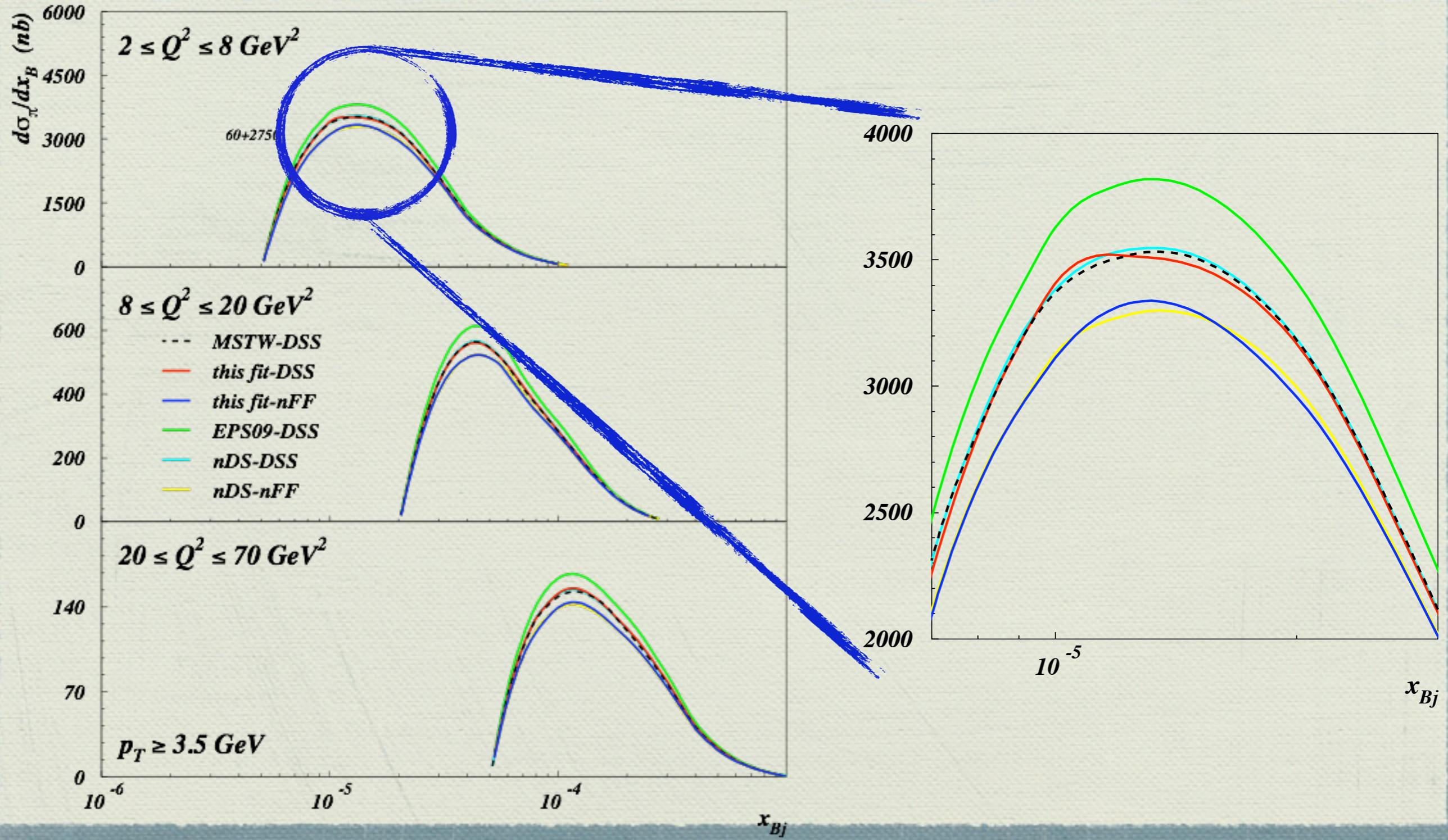


Why deuteron?

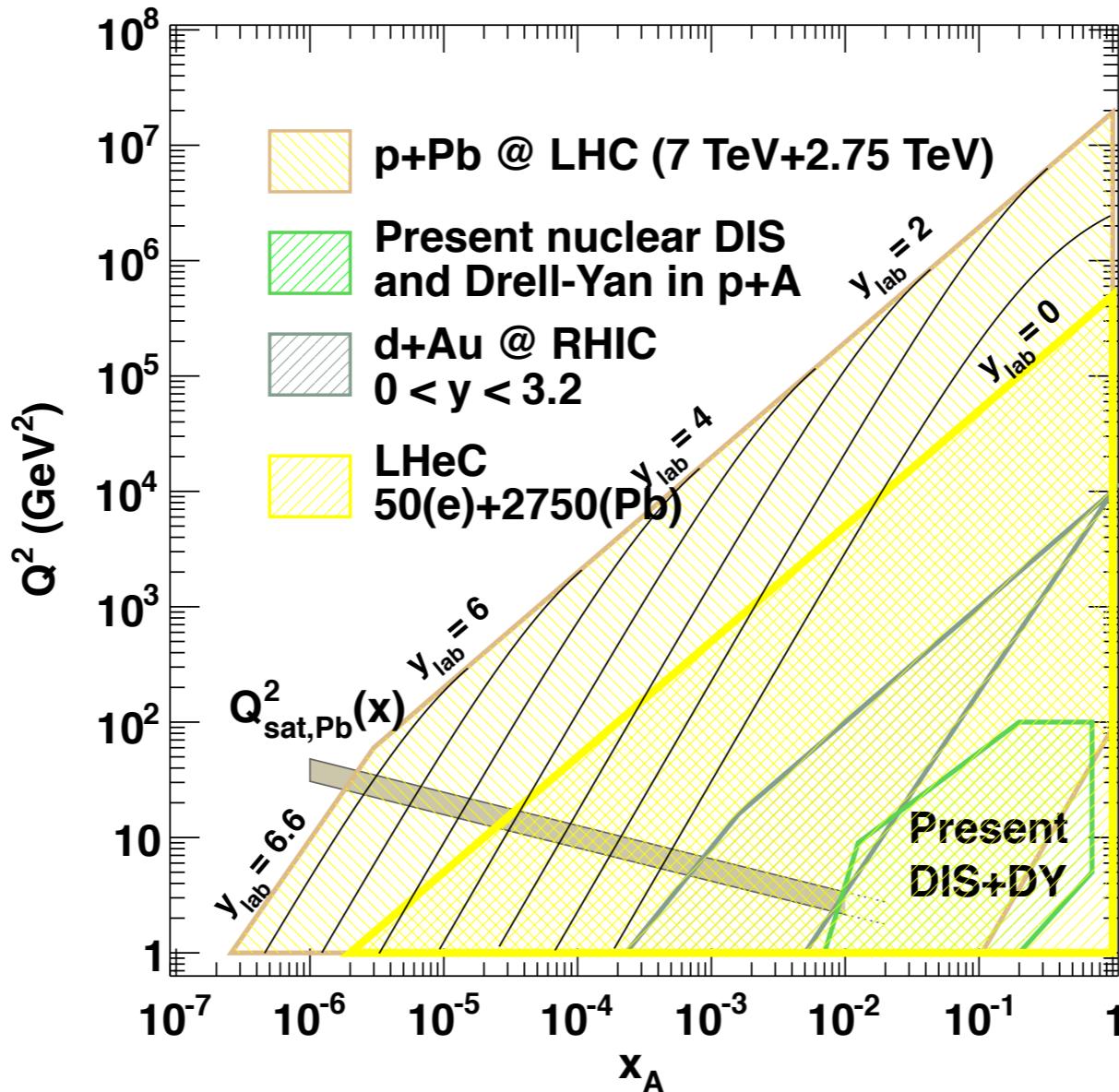
□ The simplest nucleus:

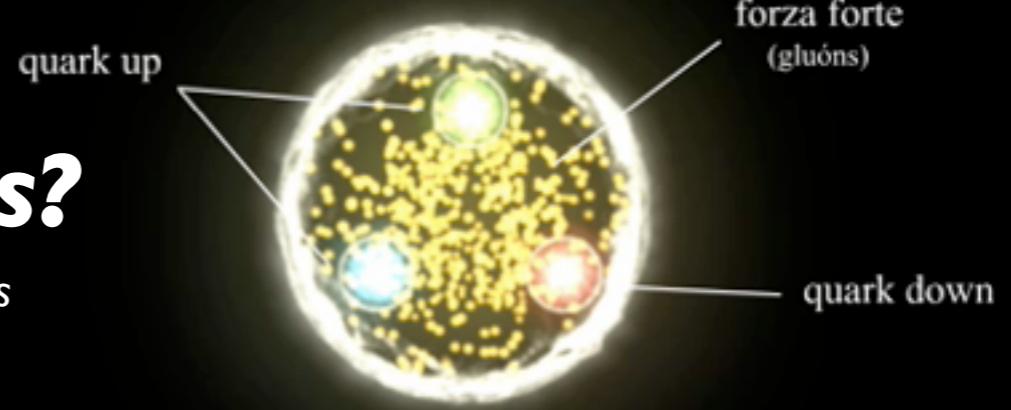
- Nuclear few-body calculations of p, n wave function available
- Testbed for nuclear effects calculations and modeling



π^0 spectrum


Kinematical reach in nuclear collisions





The diagram illustrates the internal structure of a proton or nucleus. It features a central yellow core composed of three quarks (up, down, and strange) and a surrounding cloud of gluons. Labels indicate 'quark up' (green), 'quark down' (red), and 'forza forte (gluôns)' (blue).

Why proton-nucleus?

[To study the structure of a large object make collisions with smaller objects (Rutherford experiment...)]

The proton structure is constrained by DIS + other data

- HERA data of utmost importance

Need pA to study the high-energy nuclear structure

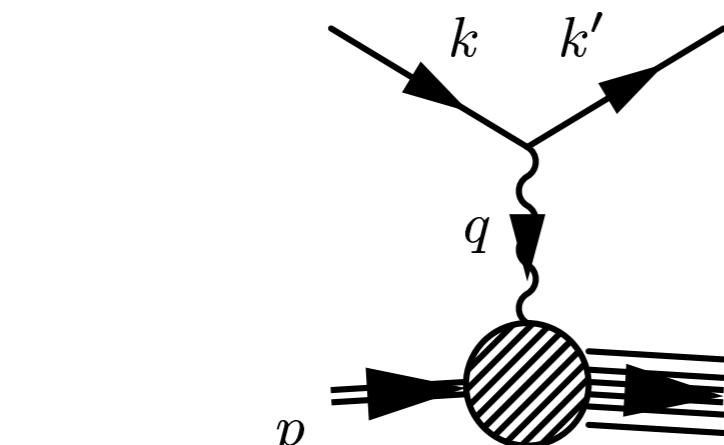
- DIS data is old (90's) short number and with limited range
- pA@LHC is the only experimental condition available before an eventual lepton-A collider (LHeC, eRHIC?)
- Needed as benchmark for the AA program
- High-density effects (saturation) enhanced in nuclei

Workshop on the LHeC - June 2012

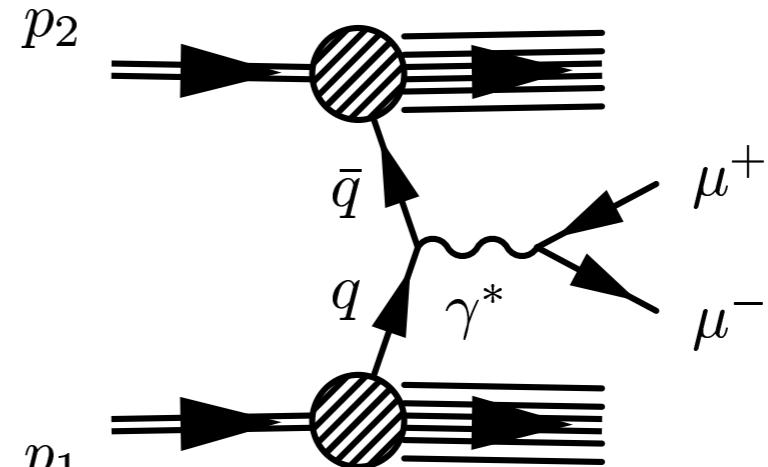
AA-pA-eA complementarity 6

Factorization

LEPTON-HADRON



HADRON-HADRON



DIMENSIONLESS CROSS SECTIONS $\sigma(x, M^2) = \frac{1}{\tau\sigma_0} \frac{d\sigma}{dM^2}$ FACTORIZES:

LEPTOPRODUCTION $\sigma_{DIS}(x, M^2) = \int_{\tau}^1 \frac{dz}{z} C_{DIS}(z, \alpha_s(M^2)) f\left(\frac{x}{z}\right); x = Q^2/2p \cdot q$

HADROPRODUCTION $\sigma_{DY}(\tau, M^2) = \int_{\tau}^1 \frac{dz}{z} C_{DY}(z, \alpha_s(M^2)) \mathcal{L}\left(\frac{\tau}{z}\right); \tau = \frac{M^2}{s}$

PARTON LUMINOSITY: $\mathcal{L}(\tau) = \sum_{a,b} \int_{\tau}^1 \frac{dx}{x} f_{a/h_1}(x) f_{b/h_2}(\tau/x)$ FROM PDFS $f(z)$

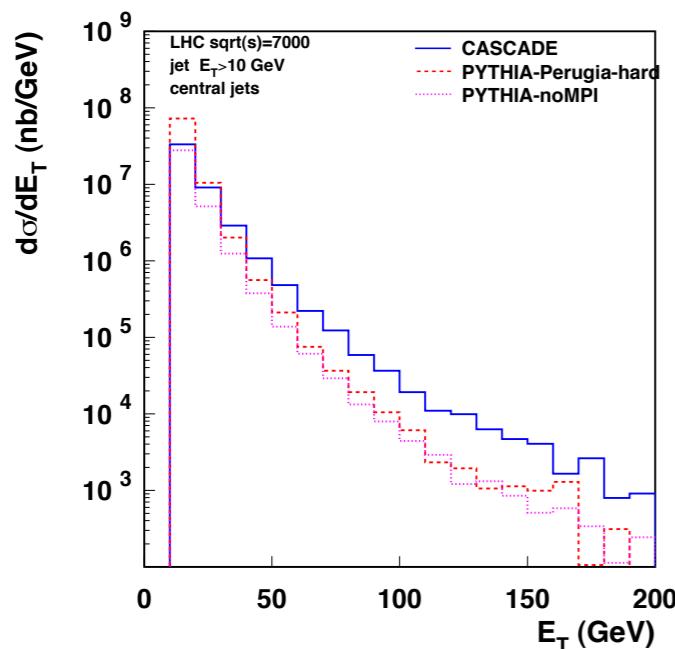
- SOLID CONTROL OF FACTORIZATION IS A NECESSARY INGREDIENT FOR PRECISION DISCOVERY PHYSICS
- FACTORIZATION, BEYOND THE SIMPLEST CASES, IS ESTABLISHED BY AN INTERPLAY OF THEORY AND PHENOMENOLOGY
- THE CAPABILITY OF TESTING FACTORIZATION IN ELECTROPRODUCTION ALLOWS FOR DETAILED QCD STUDIES AND ENABLES NEW DISCOVERY CHANNELS AT THE LHC

Note: eA necessary for clean and precise extraction of nuclear PDFs. pA cannot substitute eA in that aspect (much less clean, factorization not shown in pA)

- **COLLINEAR FACTORIZATION**
 - THE BASICS: EW FINAL STATES
 - JETS: THE EVIDENCE
 - THE USES OF EXTENDED FACTORIZATION
- **CLASSIC EXTENSIONS OF FACTORIZATION**
 - SOFT GLUONS
 - HIGH ENERGY
- **BEYOND THE CLASSIC EXTENSIONS**
 - UNINTEGRATED AND TMD PDFs
 - DIFFRACTION & FRACTURE FUNCTIONS

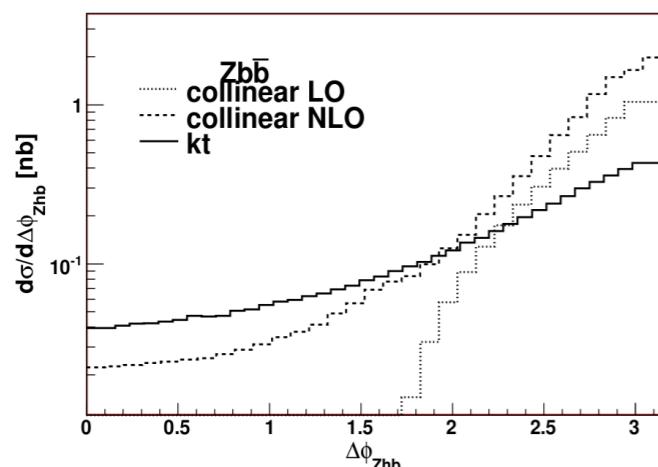
UNINTEGRATED AND TMD PDFS

FORWARD JETS: k_t -FACT VS COLLINEAR



(Deak, Hautmann, Jung, Kutak,
2010)

$Z\bar{b}b$: k_t -FACT VS COLLINEAR

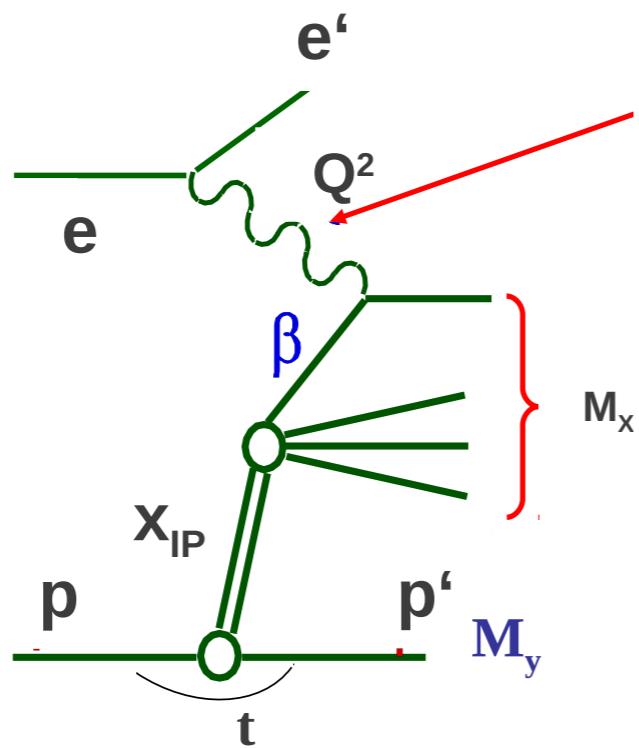


(Deak, Schwennsen, 2010)

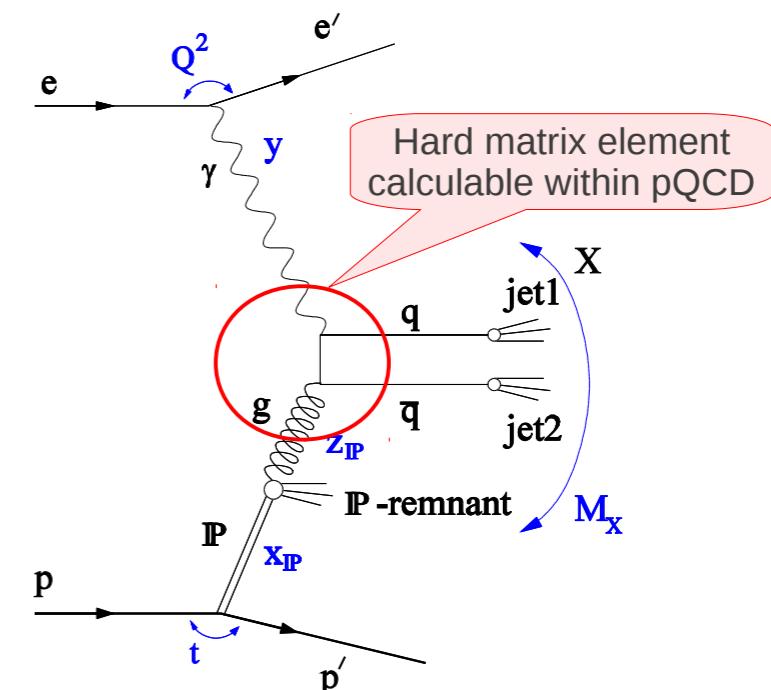
- INTERPRET HIGH-ENERGY FACTORIZATION

$$\sigma_{DIS}(x, M^2) = \int d^2 \vec{k}_T \int_{\tau}^1 \frac{dz}{z} C_{DIS}\left(\frac{x}{z}, \frac{|\vec{k}_T|^2}{M^2}, \alpha_s(M^2)\right) f(z, \vec{k}_T)$$
AS A k_T FACTORIZATION
& ASSUME IT TO BE MORE GENERALLY VALID
- PDFS BECOME k_T DEPENDENT (TMD)
- k_T -DEP PDF CAN BE USED FOR PARTON SHOWERING (COLLINS, HAUTMANN, 2000)
- IMPLEMENTED IN MONTE CARLO GENERATORS (CASCADE, H.Jung)
- SIGNIFICANT IMPLICATIONS FOR LHC OBSERVABLES & SEARCHES
- TMD FACTORIZATION BROKEN FOR HIGH p_T JETS (Mulders, Rogers, 2010)
- FACTORIZATION MUST BE ESTABLISHED BY COMPARING ELECTRO- AND HADROPRODUCTION

Inclusive diffraction



Diffractive dijets



Factorization in Diffraction

QCD factorization holds for inclusive and exclusive processes if:

- photon is point-like (Q^2 is high enough)
 - higher twist corrections are negligible (problems for small Q^2 around $\beta \simeq 1$)
- QCD factorization theoretically proven for DIS (Collins 1998)

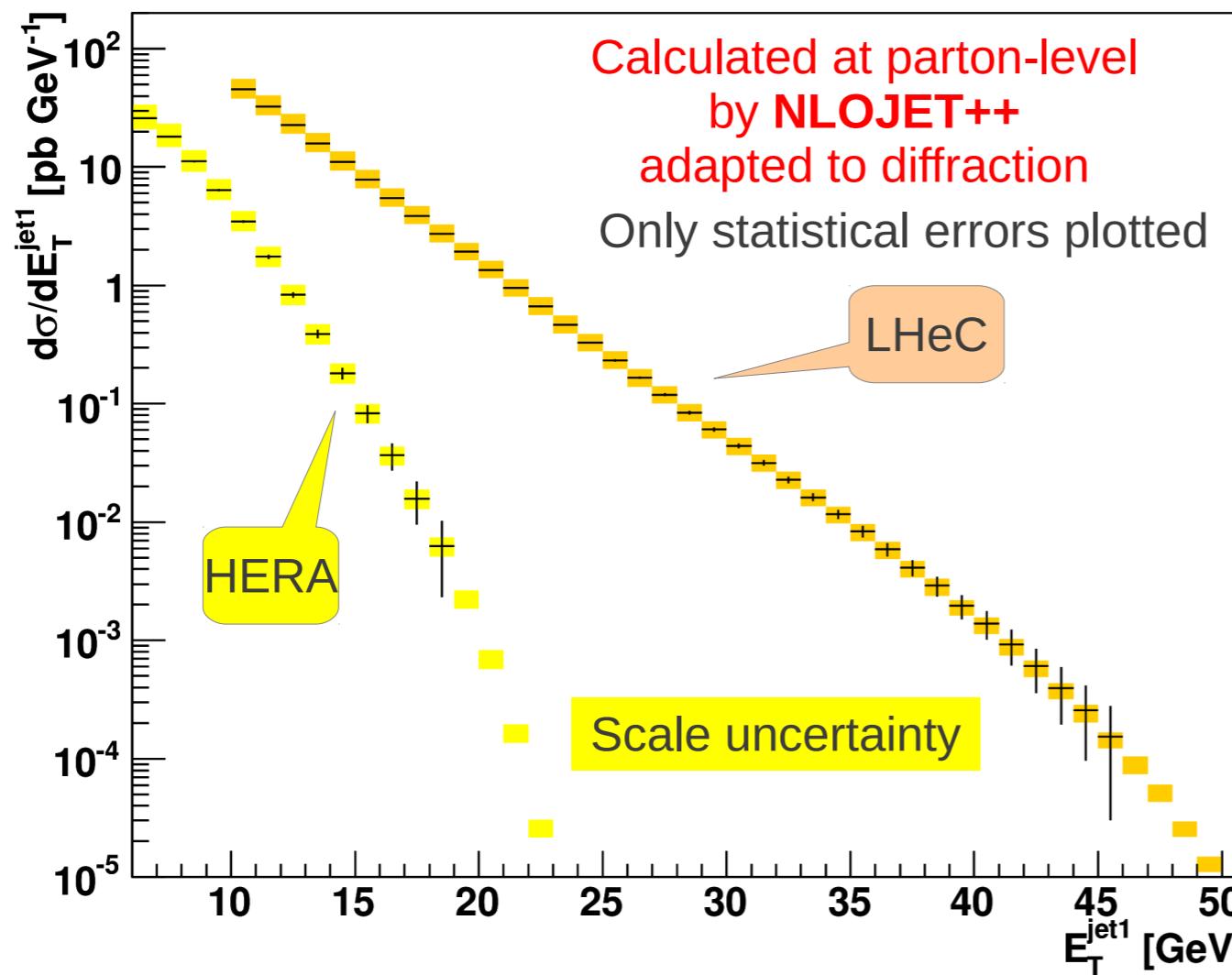
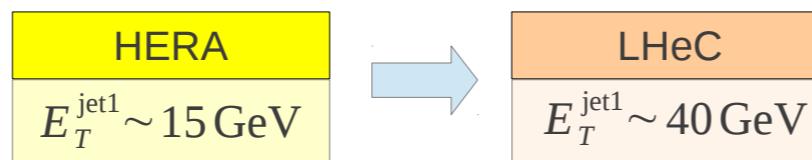
$$d\sigma^D(\gamma p \rightarrow Xp) = \sum_{parton_i} f_i^D(\beta, Q^2, x_{IP}, t) * d\hat{\sigma}^{\gamma i}(x, Q^2)$$

f_i^D DPDFs, obeys DGLAP evolution, process independent

$d\hat{\sigma}^{\gamma i}$ Process dependent partonic x-section, calculable within pQCD

DIS Dijets HERA vs LHeC Comparison of Synthetic Data

- Higher CMS energy makes higher scales accessible



920 + 27.5 HERA (400 pb^{-1})

$Q^2 > 4 \text{ GeV}^2 \wedge 0.1 < y < 0.7$

$x_{IP} < 0.03 \wedge |t| < 1 \text{ GeV}^2$

$M_Y < 1.6 \text{ GeV}$

$E_T^{jet1} > 6 \text{ GeV}$

$E_T^{jet2} > 4 \text{ GeV}$

$-1 < \eta^{\text{jets}} < 2$

7000 + 60 LHeC (10 fb^{-1})

$Q^2 > 2 \text{ GeV}^2 \wedge 0.1 < y < 0.7$

$x_{IP} < 0.01 \wedge |t| < 1 \text{ GeV}^2$

$M_Y < 1.6 \text{ GeV}$

$E_T^{jet1} > 10 \text{ GeV}$

$E_T^{jet2} > 6.5 \text{ GeV}$

$-3 < \eta^{\text{jets}} < 3$

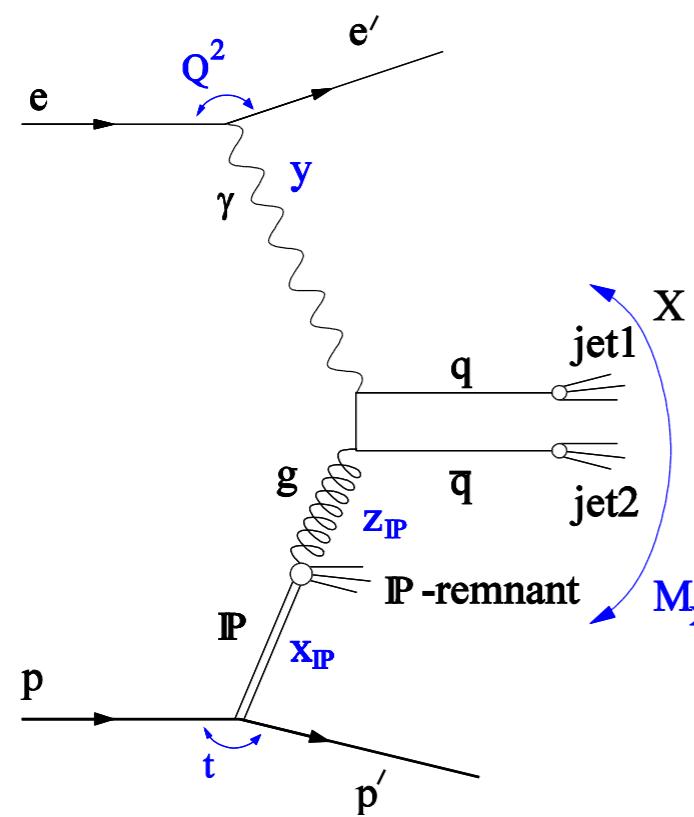
$Q^2 > 2 \text{ GeV}^2 \rightarrow \theta_{el} < 178.5^\circ$

$Q^2 > 4 \text{ GeV}^2 \rightarrow \theta_{el} < 176.5^\circ$

Diffractive Dijet Photoproduction

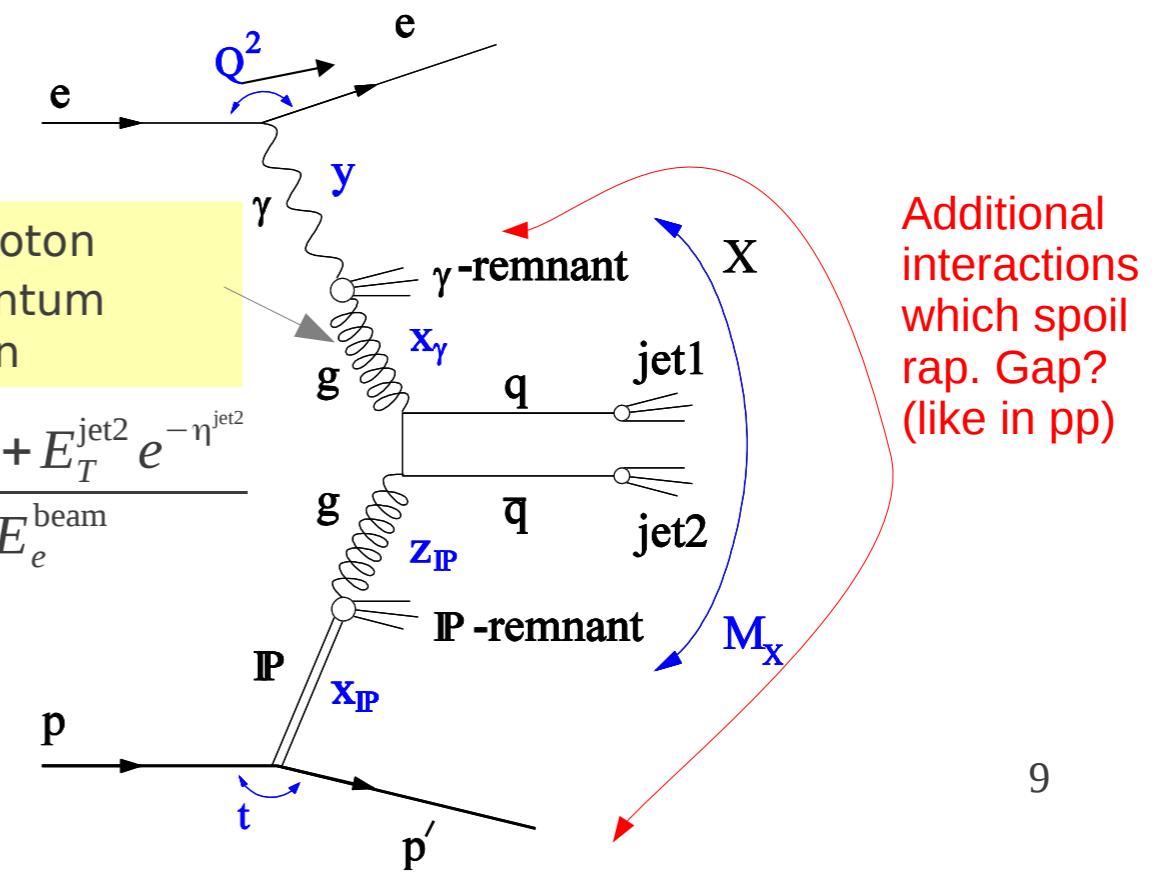
Direct
 No photon remnant
 $x_\gamma = 1$ (at parton-level)
 Dominant for high Q^2
 (near DIS region)

Resolved
 photon remnant
 $x_\gamma < 1$
 Dominant for low Q^2 , γ -PDF introduced:



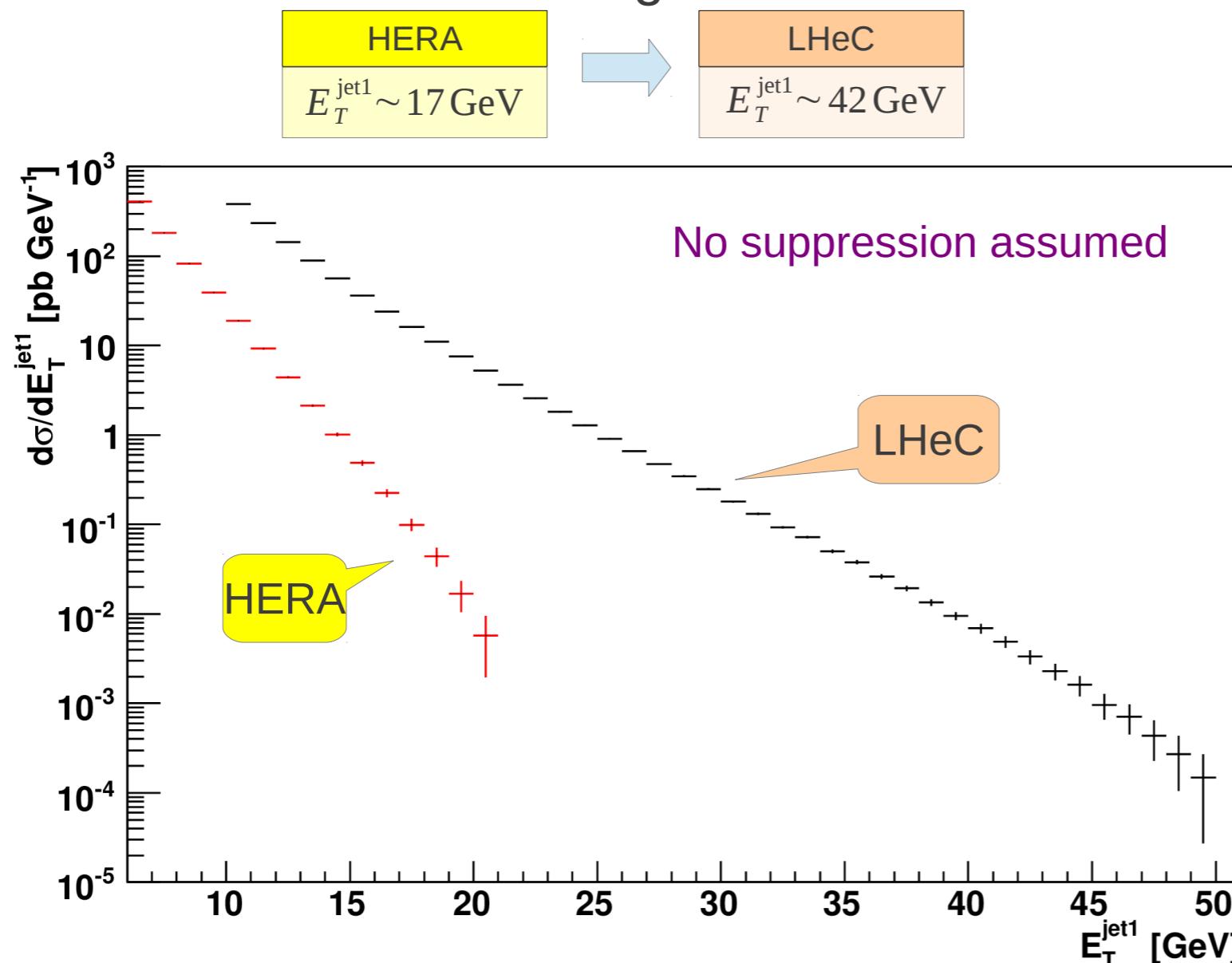
$$x_\gamma = \frac{E_T^{jet1} e^{-\eta^{jet1}} + E_T^{jet2} e^{-\eta^{jet2}}}{2y E_e^{\text{beam}}}$$

x_γ - photon momentum fraction



PHP Dijets HERA vs LHeC

- Due to much higher $E_T^{\text{jet}1}$ jets at LHeC is LHeC better tool to investigate possible factorisation breaking



Only statistical errors of synthetic data depicted
No acceptance and detector smearing effects take into account

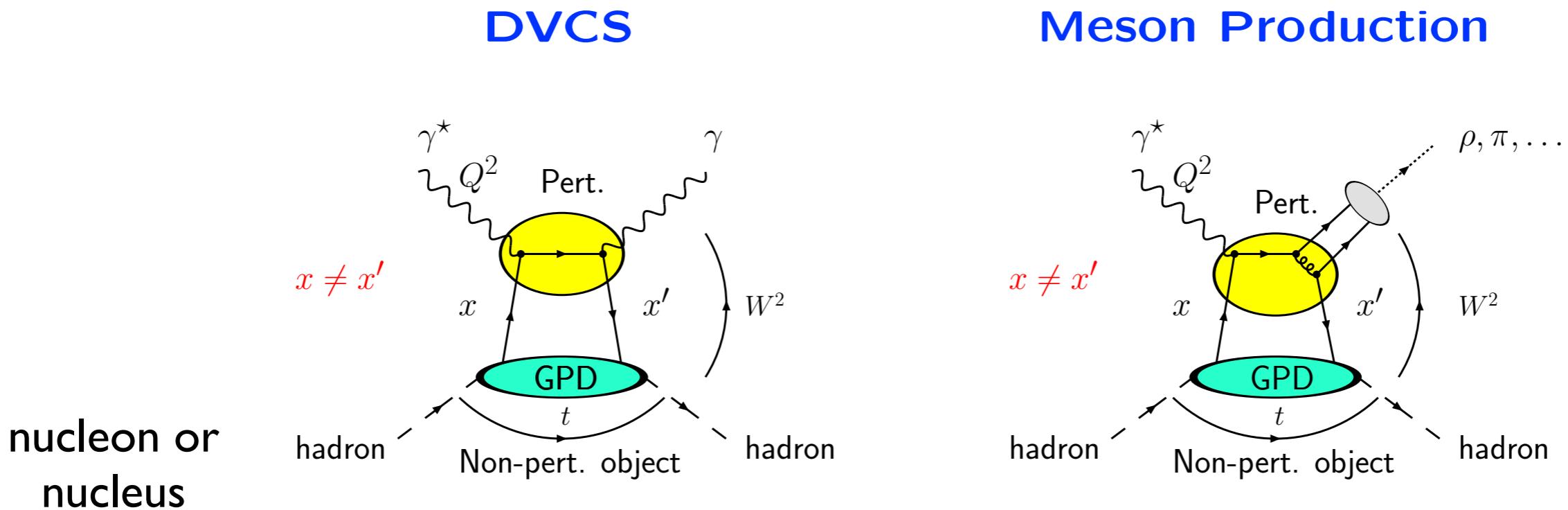
Calculated at parton-level
by **Frixione NLO**
adapted to diffraction

920 + 27.5 HERA (400 pb $^{-1}$)
$Q^2 < 2 \text{ GeV}^2 \wedge 0.2 < y < 0.8$
$x_{IP} < 0.03 \wedge t < 1 \text{ GeV}^2$
$M_Y < 1.6 \text{ GeV}$
$E_T^{\text{jet}1} > 6 \text{ GeV}$
$E_T^{\text{jet}2} > 4 \text{ GeV}$
$-1 < \eta^{\text{jets}} < 2$

7000 + 60 LHeC (10 fb $^{-1}$)
$Q^2 < 2 \text{ GeV}^2 \wedge 0.2 < y < 0.8$
$x_{IP} < 0.01 \wedge t < 1 \text{ GeV}^2$
$M_Y < 1.6 \text{ GeV}$
$E_T^{\text{jet}1} > 10 \text{ GeV}$
$E_T^{\text{jet}2} > 6.5 \text{ GeV}$
$-3 < \eta^{\text{jets}} < 3$

Generalized Parton Distributions

QCD factorization in Exclusive processes



☞ Factorisation between a hard part (perturbatively calculable) and a soft part (non-perturbative) *Generalized Parton Distribution* demonstrated for

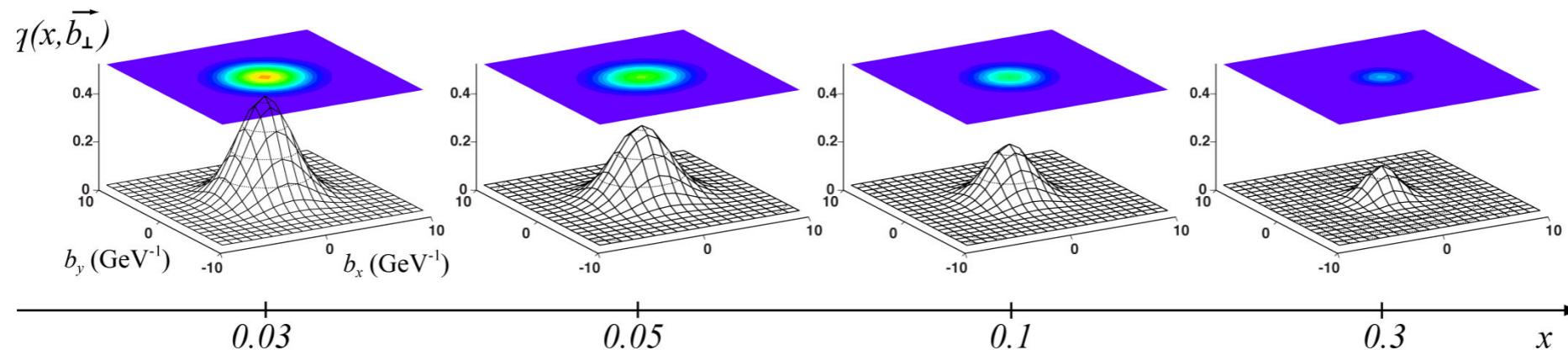
$$Q^2, W^2 \rightarrow \infty, x_B = \frac{Q^2}{Q^2 + W^2} \text{ fixed and } |t| \ll Q^2 \text{ fixed}$$

D. Mueller *et al.*, X. Ji, A. Radyushkin, J. Collins *et al.*, '94, '96, '98

one needs accurate measurement down to small values of ξ

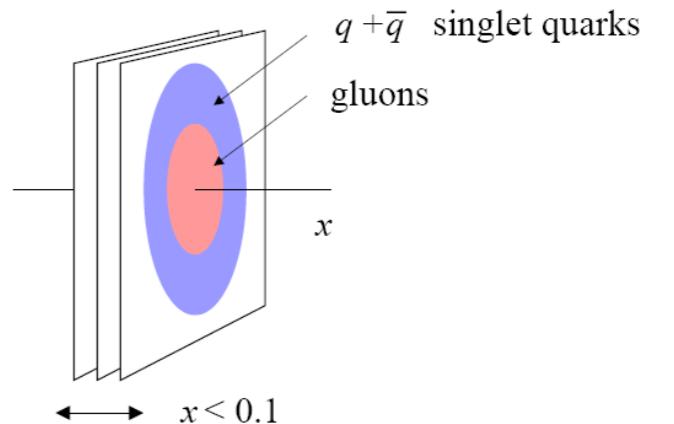
→ High energy, high luminosity electron nucleon colliders essential

t dependence of GPDs maps transverse position b_T of quarks.



This is the reason I consider GPDs as a major breakthrough in QCD physics

- ⇒ Beautiful progress in **forward** exclusive photon (DVCS) and meson (DVMP) experiments and analysis
- ⇒ Need to test universality of GPDs : **TCS vs DVCS** extractions
- ⇒ Need to better understand NLO and twist 3 contributions ($\rightarrow \rho_T$)
- ⇒ Need to resum soft gluon contributions (**Altinoluk et al 2012**)
- ⇒ Need to go to higher energies, smaller skewness (**EIC ; LHeC**)



- Do singlet quarks and gluons have the same transverse distribution?
 - Hints from HERA: $\text{Area}(q+\bar{q}) > \text{Area}(g)$
 - Dynamical models predict difference: pion cloud, constituent quark picture **[Strikman, Weiss 09]**
 - No difference assumed in present pp MC generators for LHC!
- gluon size from J/ψ , singlet quark size from DVCS

Monte Carlo status for ep

DIS LO multijet merging in Sherpa

Improving parton showers

Two established directions:

- NLO *matching*
- LO multijet *merging*

LHC age multipurpose Monte Carlos have not forgotten about ep.

Still many things to be addressed before claiming LHeC readiness.

But we're on the way.

A personpower problem, as always.

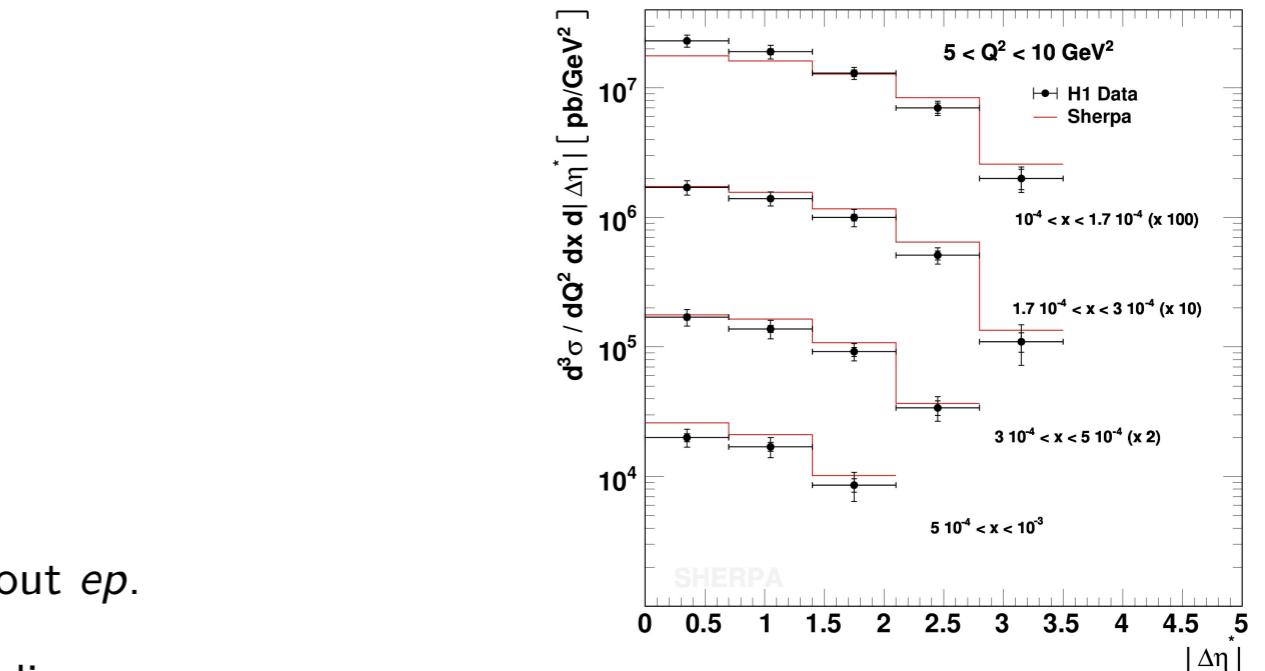
Most important will be higher order matrix elements and multiple jets.

The infrastructure available is very generic.

We'll have to test:

- showers and improvements,
- hadronization,
- multiple interactions.

Against HERA data, of course.



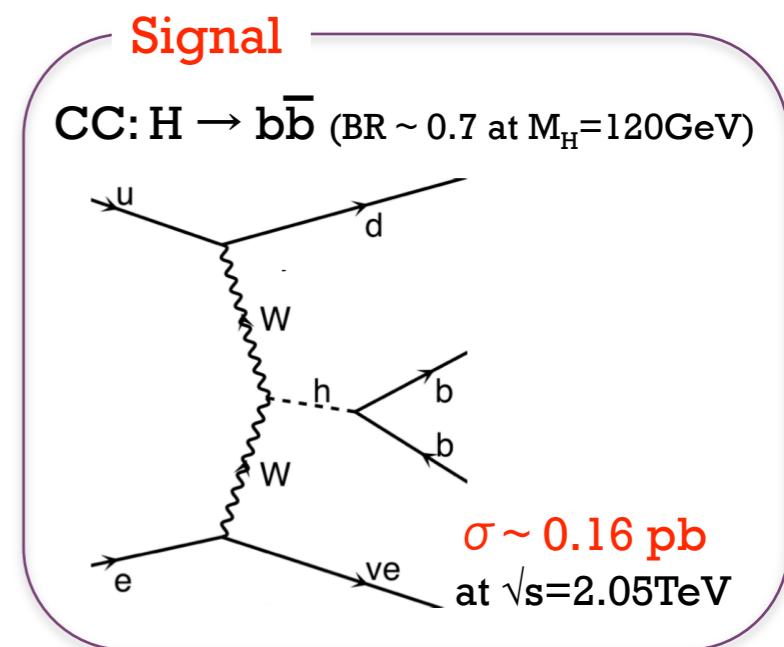
- For ongoing analyses and future LHeC data, please provide
- particle level observables,
 - in the fiducial volume,
 - without any further corrections,
 - based on *operational* definitions.

Will only be of limited use otherwise ...



Higgs at LHeC

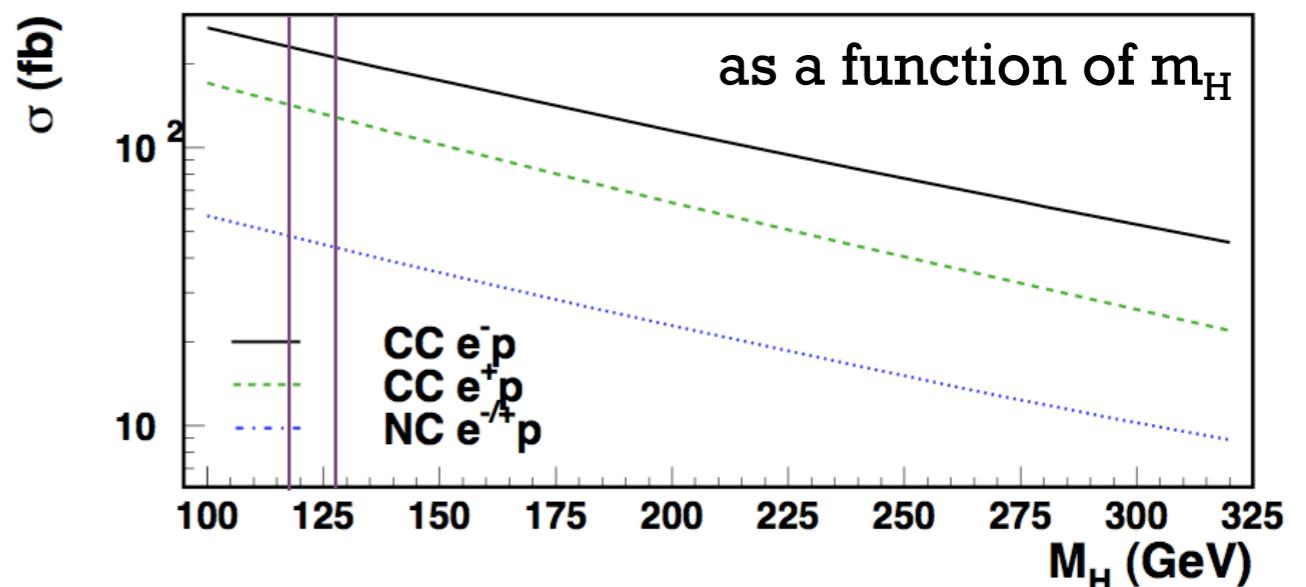
- Constraint to SM Higgs within 117.5 – 127.5 GeV
 - ATLAS and CMS with $\sim 5 \text{ fb}^{-1}$ data at $\sqrt{s} = 7\text{TeV}$
- LHC has discovery potential to the mass range with 2012 data
- Following discovery, LHeC aims to measure $Hb\bar{b}$ coupling
 - Branching ratio to $b\bar{b}$ pair: 52 – 67% at 117.5 – 127.5 GeV
 - $H \rightarrow b\bar{b}$ is still challenging channel with large QCD background
 - Measurement of Higgs to fermion coupling is essential to confirm Higgs field is accounting for fermion mass via Yukawa couplings
 - It is important to show that it is a SM Higgs (see CP study talk)
 - $H \rightarrow b\bar{b}$ may be observed in exclusive production mode in clean environment



Higgs production cross-section
at $\sqrt{s} = 1.98\text{TeV}$ ($E_e = 140\text{GeV}$, $E_p = 7\text{TeV}$)

CC Higgs production cross-section
($M_H = 120 \text{ GeV}$)

Electron beam energy	50 GeV	100 GeV	150 GeV
cross-section (fb)	81	165	239



+ Selection of $H \rightarrow b\bar{b}$

■ NC rejection

- Exclude electron-tagged events
- $E_{T,\text{miss}} > 20\text{GeV}$
- $N_{\text{jet}} (p_T > 20\text{GeV}) \geq 3$
- $E_{T,\text{total}} > 100\text{GeV}$
- $y_{JB} < 0.9, Q^2_{JB} > 400\text{GeV}$

■ b-tag requirement

- $N_{b\text{-jet}} (p_T > 20\text{GeV}) \geq 2$

■ Higgs invariant mass

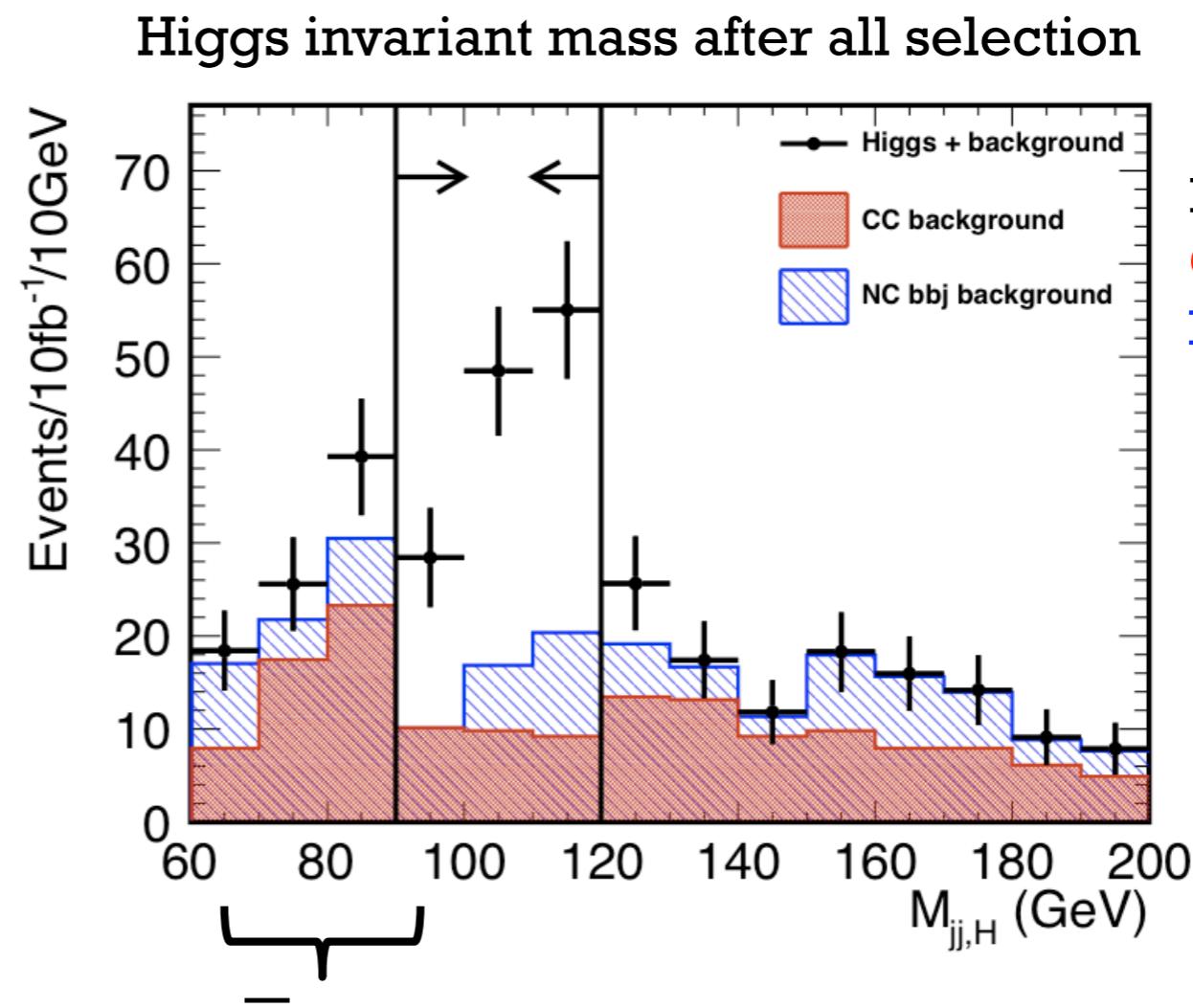
- $90 < M_H < 120\text{GeV}$

■ Single top rejection

- $M_{jjj,\text{top}} > 250\text{GeV}$
- $M_{jj,W} > 130\text{GeV}$

■ Forward jet tagging

- $\eta_{\text{jet}} > 2$ (lowest η excluding b-tagged jets)



- Beam energy:
 - Electron beam
 - Proton beam
- SM Higgs mass
- Luminosity

150 GeV
7 TeV
120 GeV
 10 fb^{-1}

Signal and background cut flow

	$\mathbf{H \rightarrow bb}$	$\mathbf{CC \ DIS}$	$\mathbf{NC \ bbj}$	$\mathbf{S/N}$	$\mathbf{S/\sqrt{N}}$
NC rejection	816	123000	4630	6.38×10^{-3}	2.28
+ b-tag requirement + Higgs invariant mass	178	1620	179	9.92×10^{-2}	4.21
All cuts	84.6	29.1	18.3	1.79	12.3

- Beam energy:
 - Electron beam
 - Proton beam
- SM Higgs mass
- Luminosity

150 GeV \Rightarrow 60 GeV
7 TeV
120 GeV
 $10 \text{ fb}^{-1} \Rightarrow 100 \text{ fb}^{-1}$

	$\mathbf{E_e = 150 \text{ GeV}}$ (10 fb^{-1})	$\mathbf{E_e = 60 \text{ GeV}}$ (100 fb^{-1})
H \rightarrow bb signal	84.6	248
S/N	1.79	1.05
S/\sqrt{N}	12.3	16.1

- We can explore other channels
 - NC Higgs production in ZZ fusion
 - Other light Higgs decay channels

CP properties of Higgs

Higgs Couplings with pair of gauge bosons (ZZ/WW) and the pair of heavy fermions (t/τ) are largest. Study \mathcal{CP} in a model independent way (most studies so far)

$$H f \bar{f} : -\frac{g m_f}{2 M_W} \bar{f} (a_f + i b_f \gamma_5) f H$$

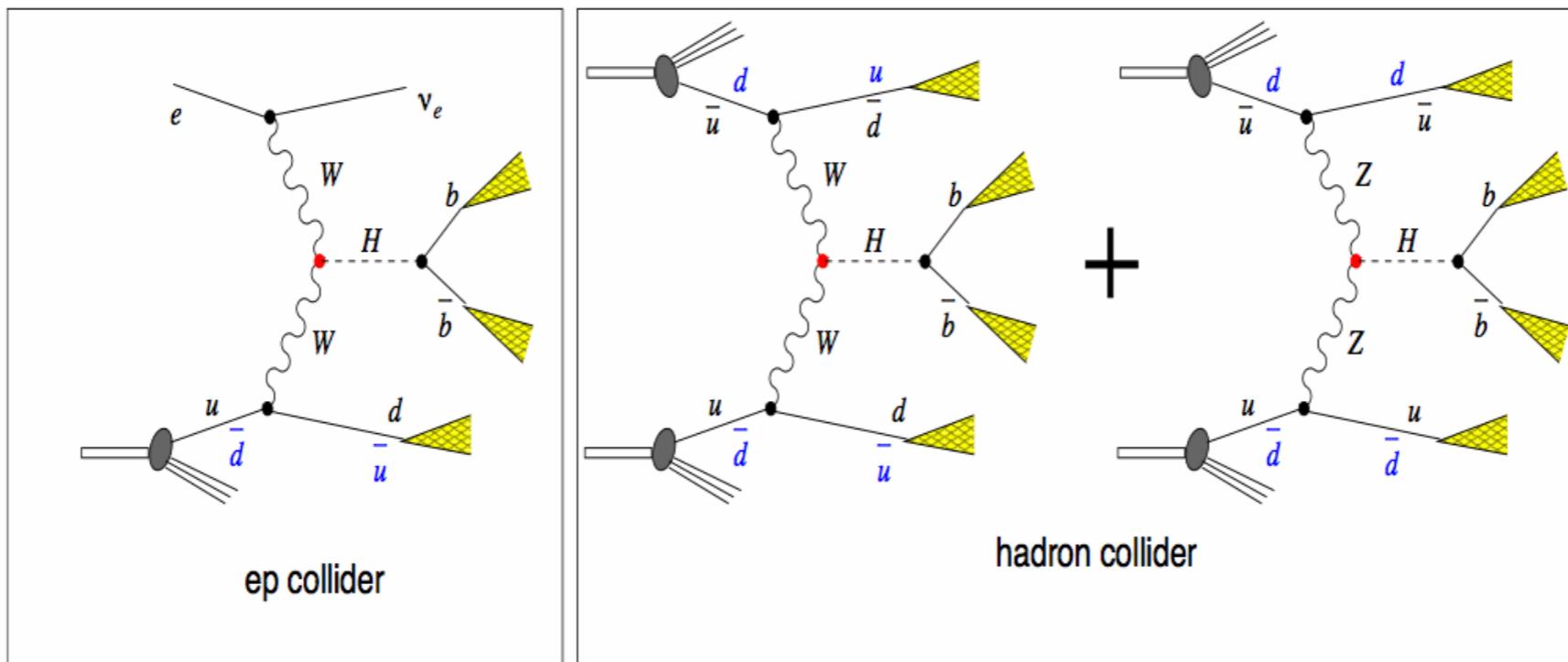
HVV:

$$V_{HVV}^{\mu\nu} = -ig [f_1 g_{\mu\nu} + f_2 (g_{\mu\nu} k_1 \cdot k_2 - k_{1\nu} k_{2\mu}) + f_3 i \epsilon_{\mu\nu\alpha\beta} k_1^\alpha k_2^\beta],$$

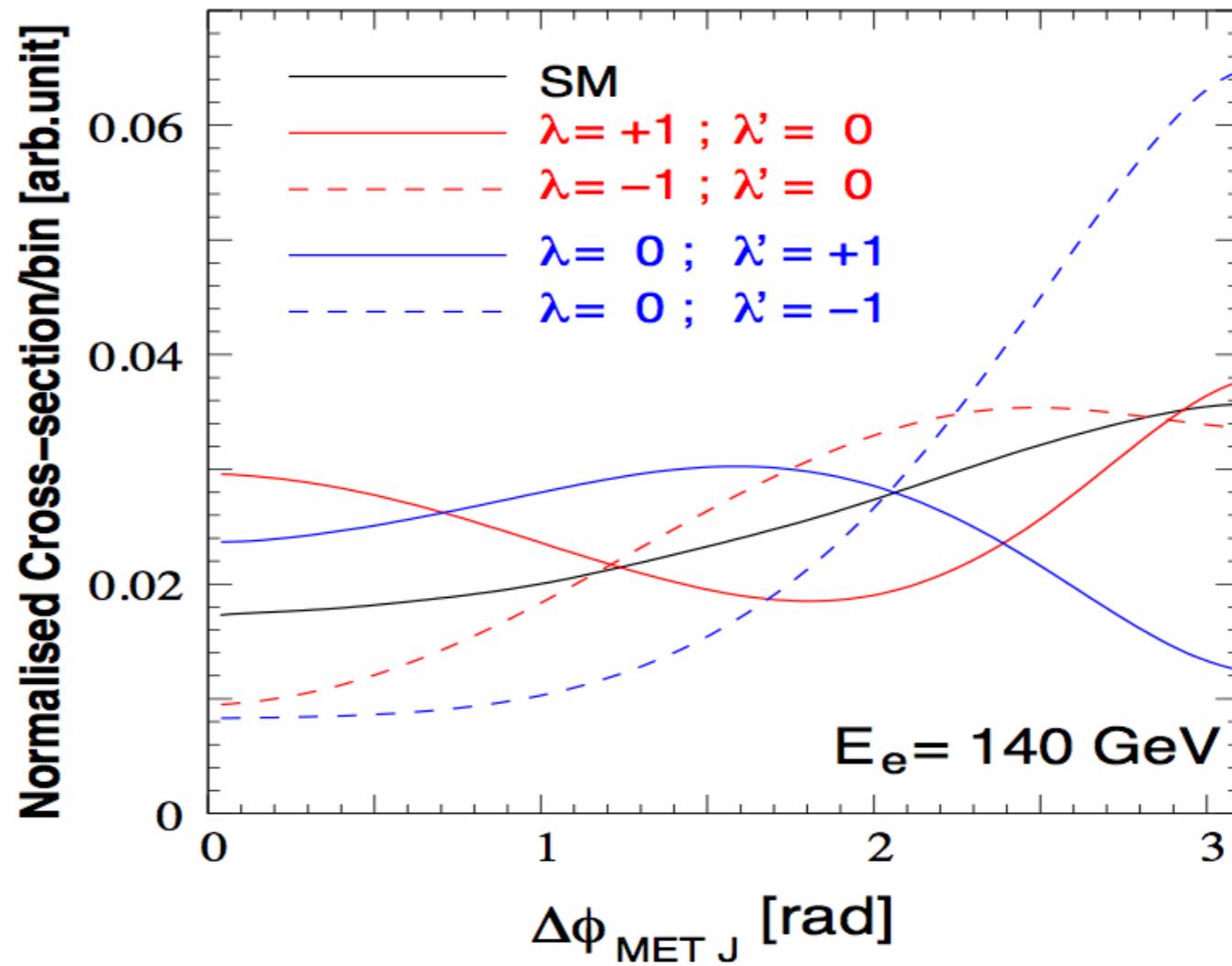
with

$$f_1 = m_W \quad , f_2 = \lambda/m_W, f_3 = \lambda'/m_W$$

higgs + 2jets: VBF (LHC), higgs + jet + missing E_T (LHeC)



ep process uniquely addresses the HWW vertex.



12

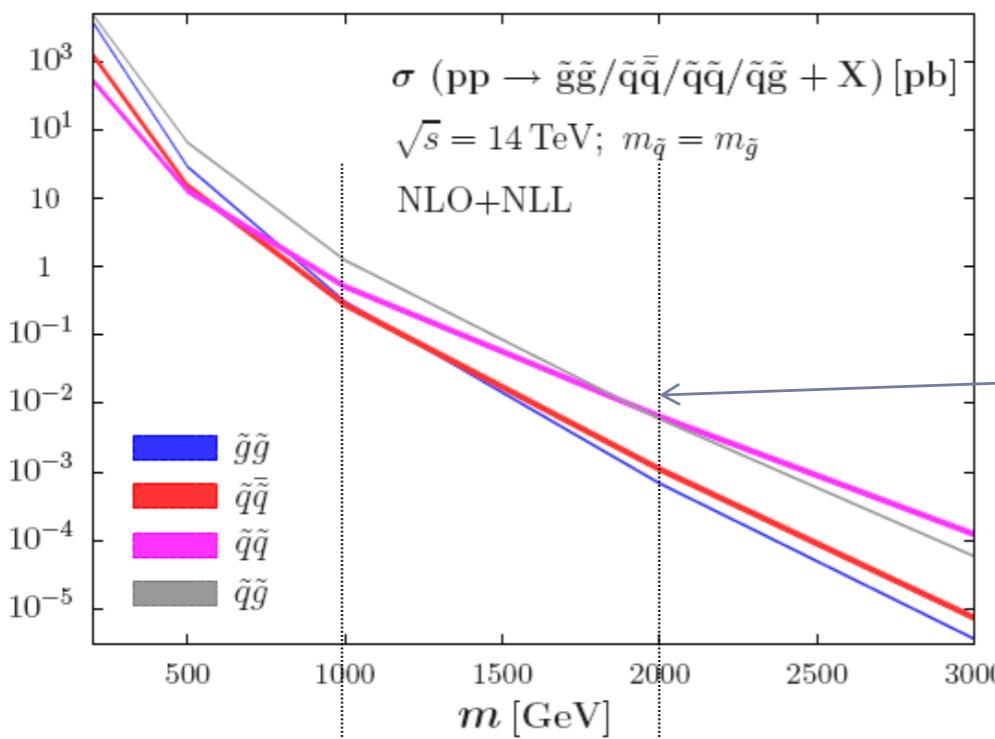
- With the isolation of the $H \rightarrow bb$ signal at the LHeC a window of opportunity opens for the exploration of the CP properties of the HVV vertex
- The LHeC offers a number of advantages
 - Separation of HWW and HZZ couplings
 - Excellent signal to background ratio
 - Identification of backward forward directions

▶ SUSY @ LHeC

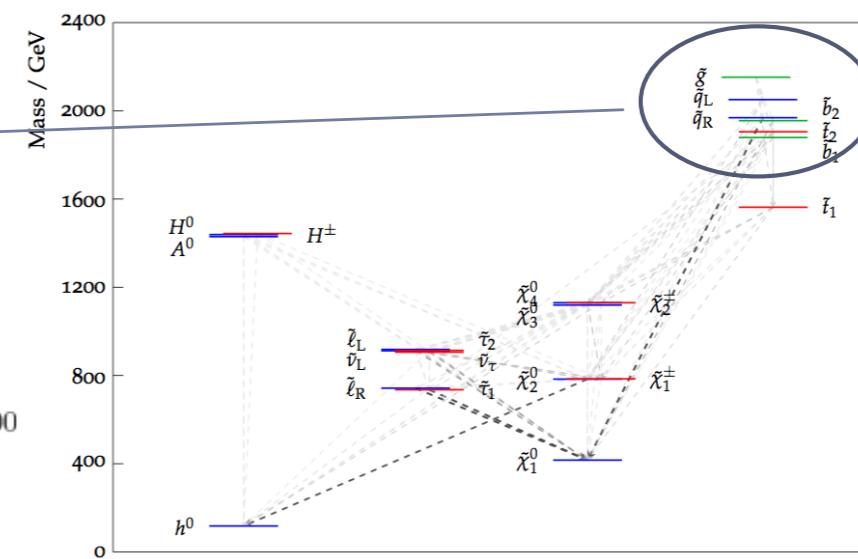
- ▶ Possible searches in R-parity violation SUSY scenarios
- ▶ complementarities with LHC:
 - ▶ Implication of LHC findings for LHeC reach
 - ▶ Implication of LHeC PDF constraints on SUSY for the LHC
 - ▶ New uncharted scenarios

Strong production

- ▶ xsection $\sim 2.5 \text{ pb}$ for $m = 1000 \text{ GeV}$, $\sim 0.01 \text{ pb}$ for $m(\text{squark, gluino}) = 2 \text{ TeV} \rightarrow$ clearly, high stats samples are needed.



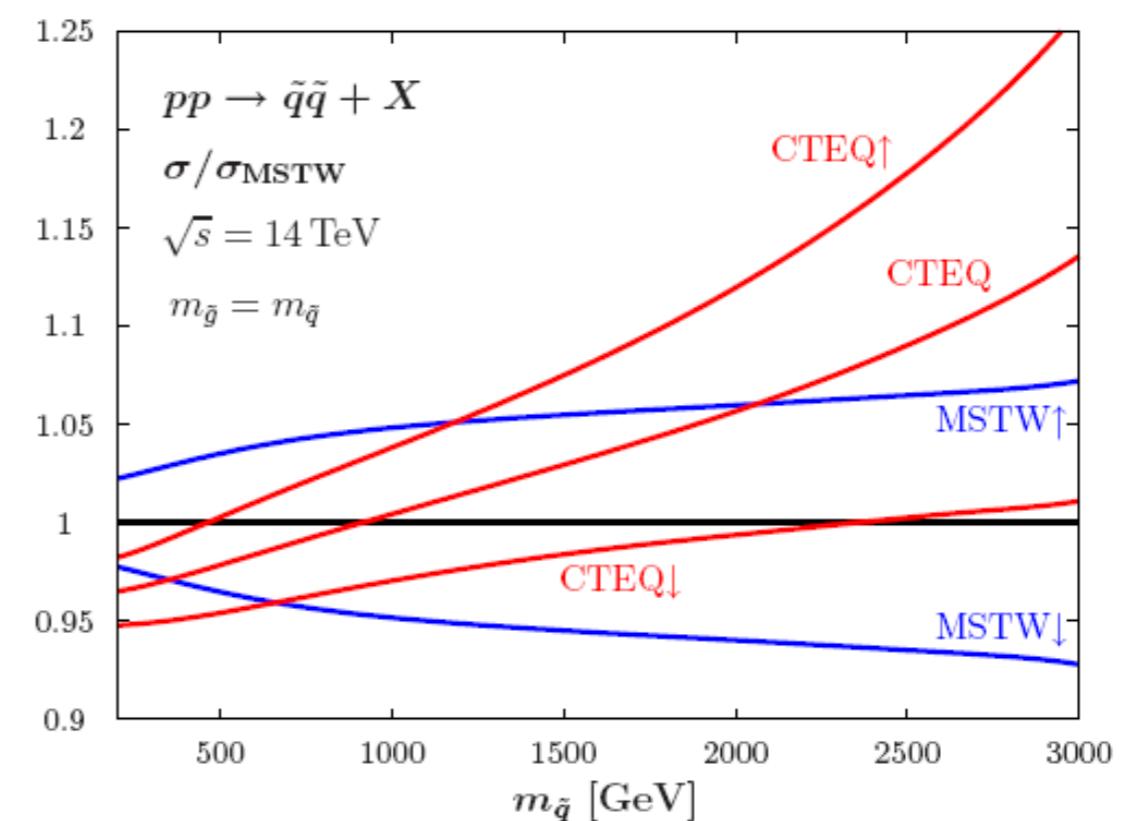
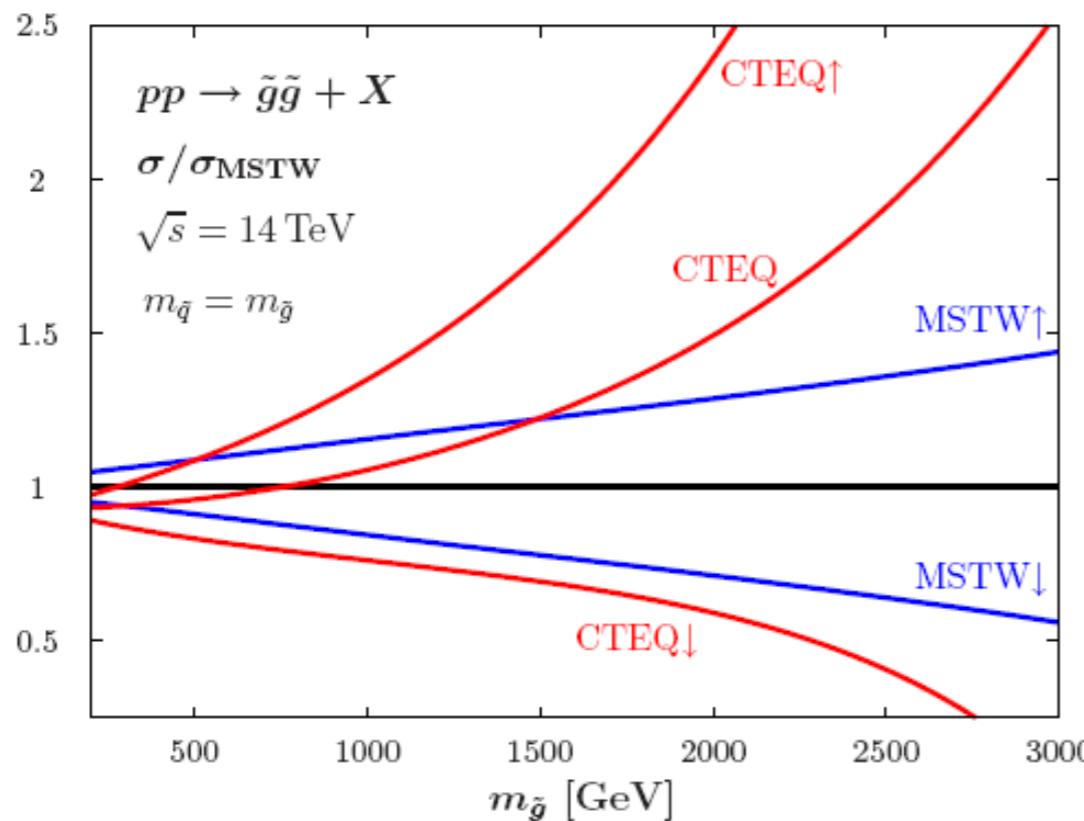
mSUGRA reference point:
 $m_0=650, m_{1/2}=975, \text{xs } 1.1\text{E-}05 \text{ nb}$



Decay chain might be complex, including Z or Higgs

Importance of PDF

- ▶ If we see deviations from SM, will be important to characterize the physics underneath
- ▶ The case of strong production:



→ driven by gluon pdf at large x

→ sizeable uncertainty $\approx \pm 25\%$ for $m \approx 1 \text{ TeV}$

→ driven by valence quark pdfs at large x

→ small uncertainty $\approx \pm 5\%$ for $m \approx 1 \text{ TeV}$

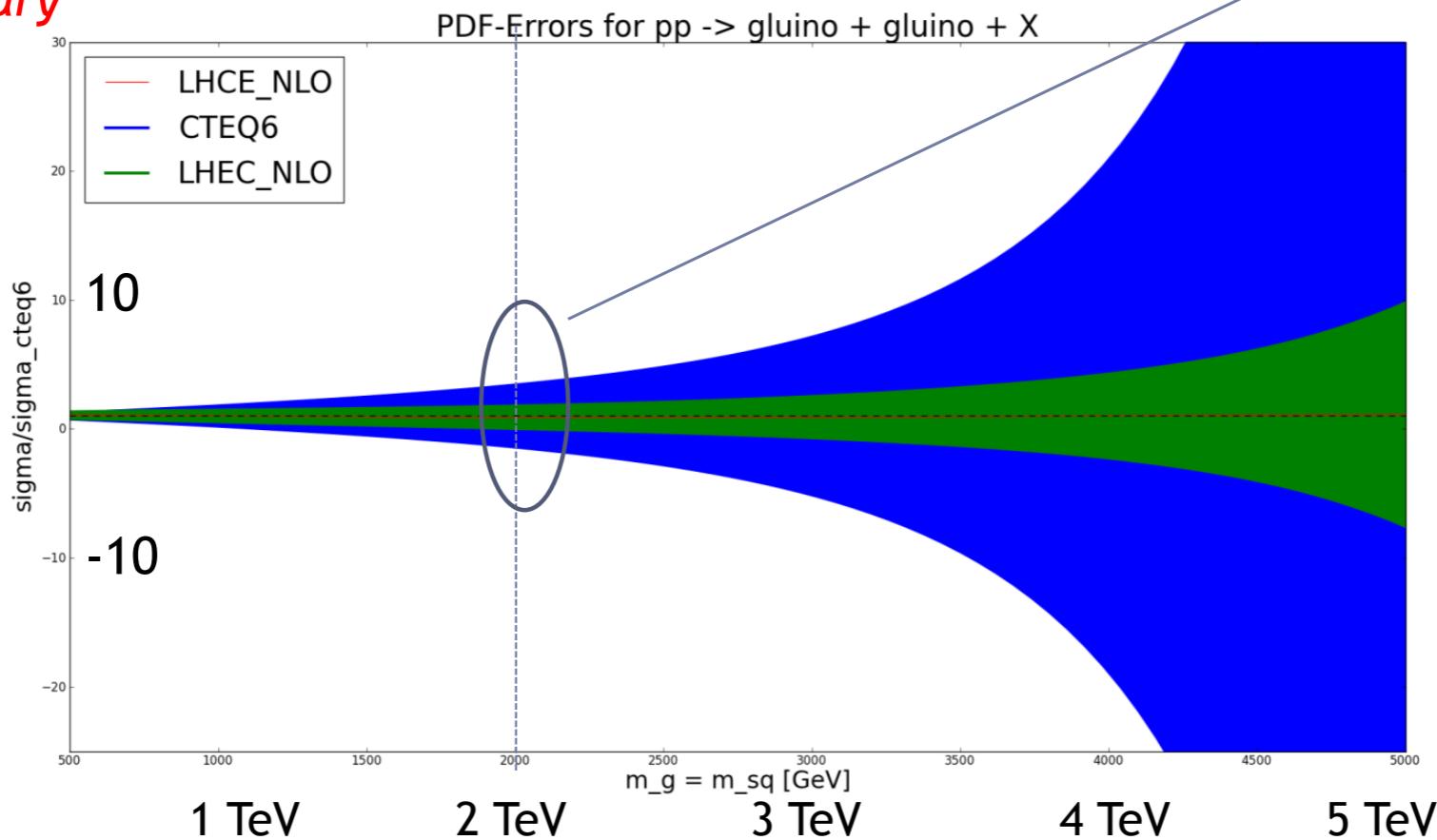
What the LHeC can do

- ▶ M.Kramer and R.Klees working on impact of improved PDF fits on theoretical predictions for SUSY process:

- ▶ Example: gl-gluino production (assuming $m_{gl} = m_{sq}$)
 - ▶ without(blue, CTEQ6) and with (green) LHeC PDF

Improve of
factor of 2-3 @ 2 TeV
factor of 10 at 3.5 TeV

preliminary



Precise determination of the PDFs at higher scales absolutely necessary for searches of New Physics.

We would like to thank all
the speakers !