Parton Distributions and QCD

Precision QCD in the LHeC Era

Voica Radescu

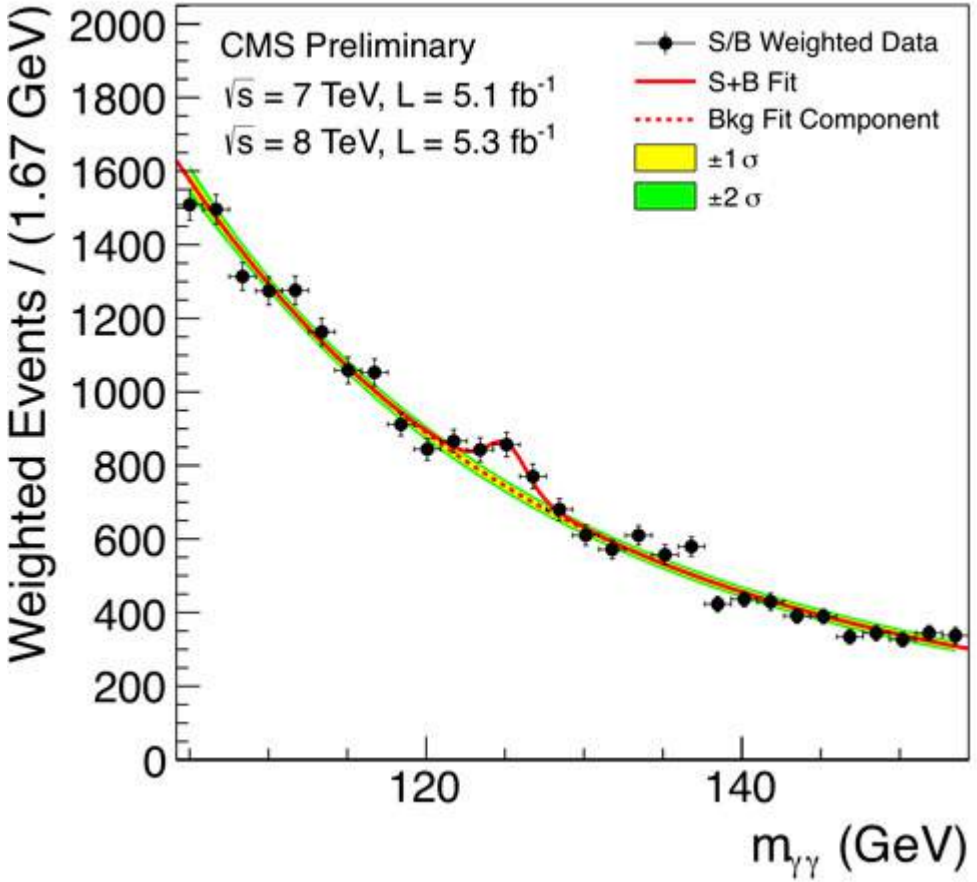
Fred Olness

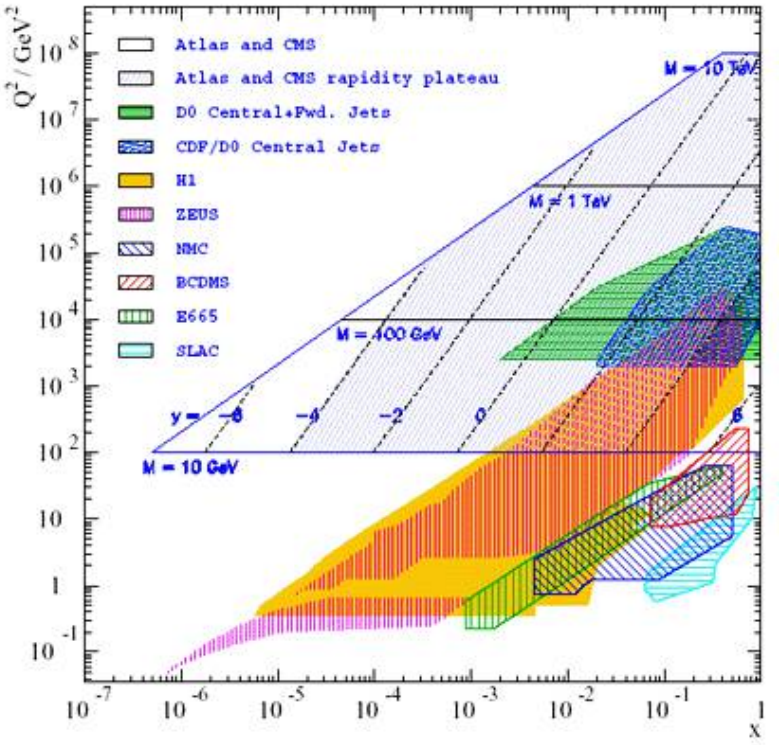
… part 1: Precision PDFs

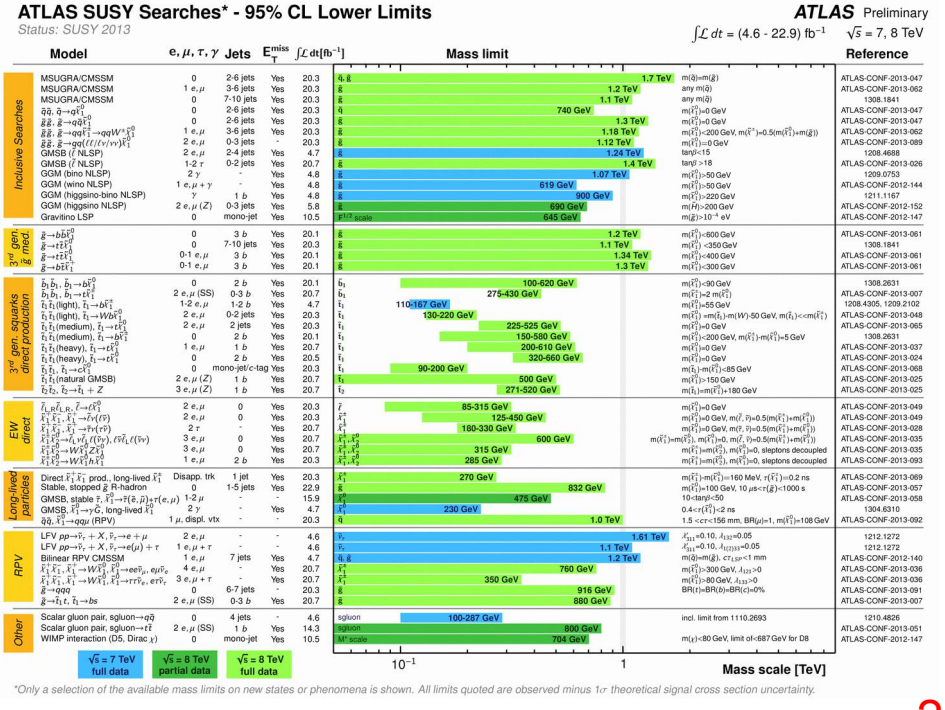
LHC: Stage 1: High Energy

Use increased ENERGY REACH (2⇒8⇒13 TeV)
to search for new particles

e.g., Higgs Boson discovery
SUSY & Exotic limits





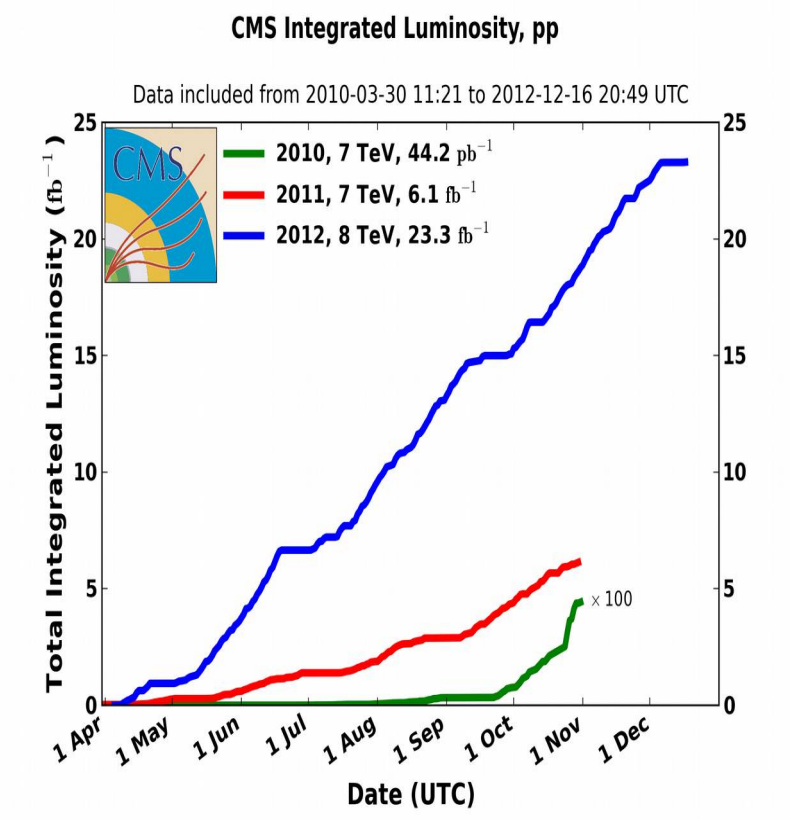


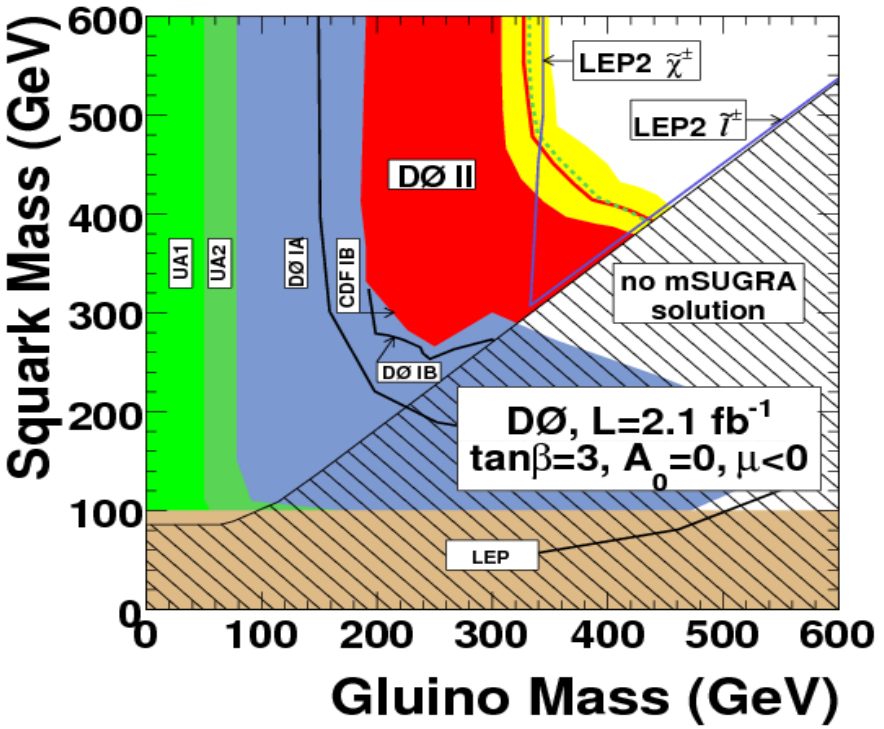
LHC: Stage 2: High Precision

Enter LHeC: provides important complement to LHC:

Use increased INTENSITY (stats + upgrades) for improved precision
-- this allows us to probe new physics beyond the machine energy

e.g., as Tevatron+HERA did for Higgs/SUSY/exotics searches
Note: HERA essential for PDFs at both Tevatron and LHC





Make use of LHeC to probe kinematic "corners" to look at QCD under extreme conditions:

Small-x:
saturation, BFLK, ln(1/x)

Large-x:
TMC,
Higher-Twist,
fermi motion

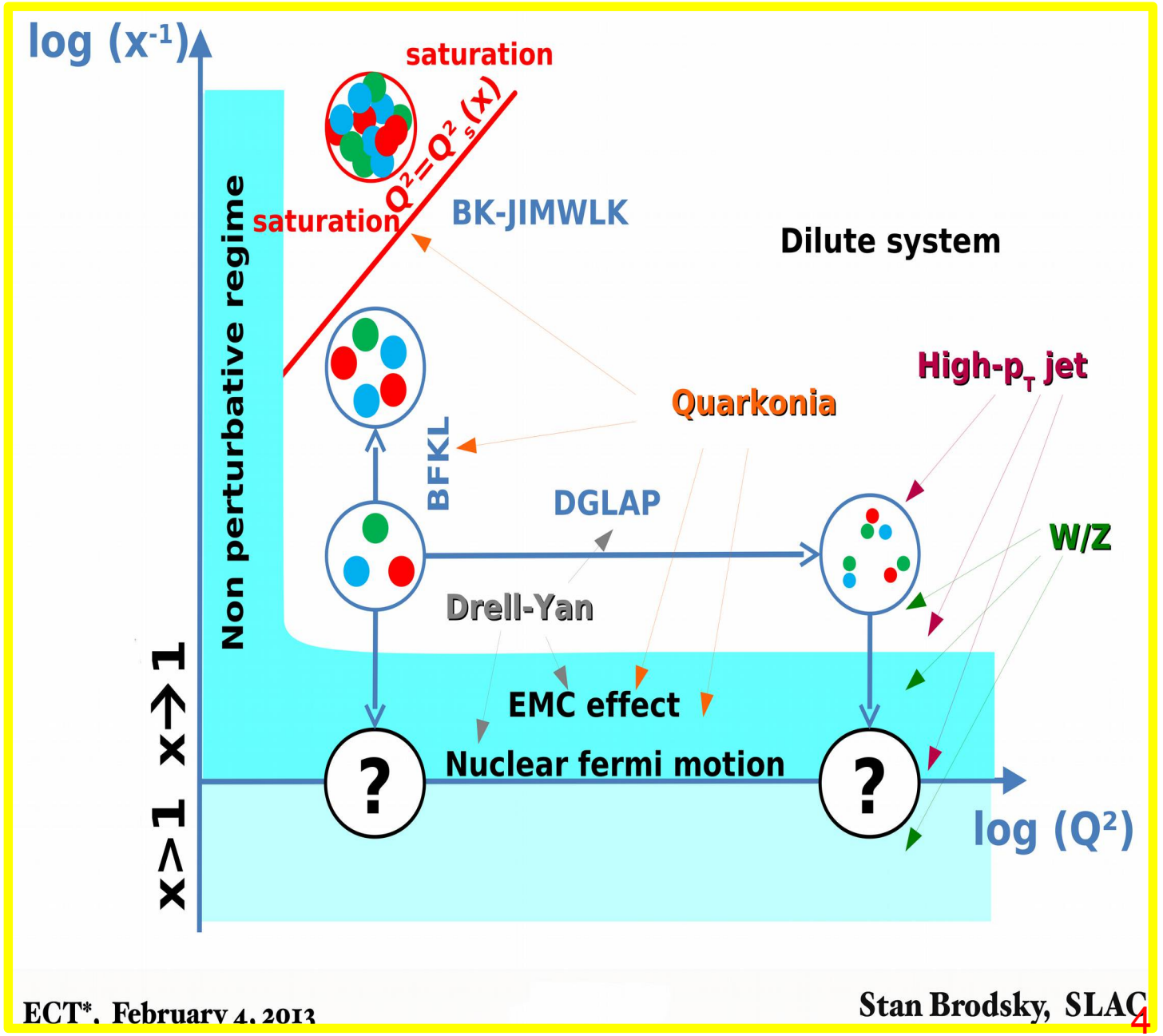
Low Q:
Strong coupling
Non-perturbative effects

TMD PDFs:
Soft gluon resummation
(now in HERA-Fitter)

Heavy Quarks:
Multi-scale issues

Nuclear Dimension:
Nuclear Corrections
High Temperature
QGP, deconfinement

QED Corrections:



Nuclear Correction:

Comparisons:

Preliminary

$$\frac{f^{Pb}(x,Q^2)}{f^{p}(x,Q^2)}$$

Large uncertainties,
especially when compared to proton

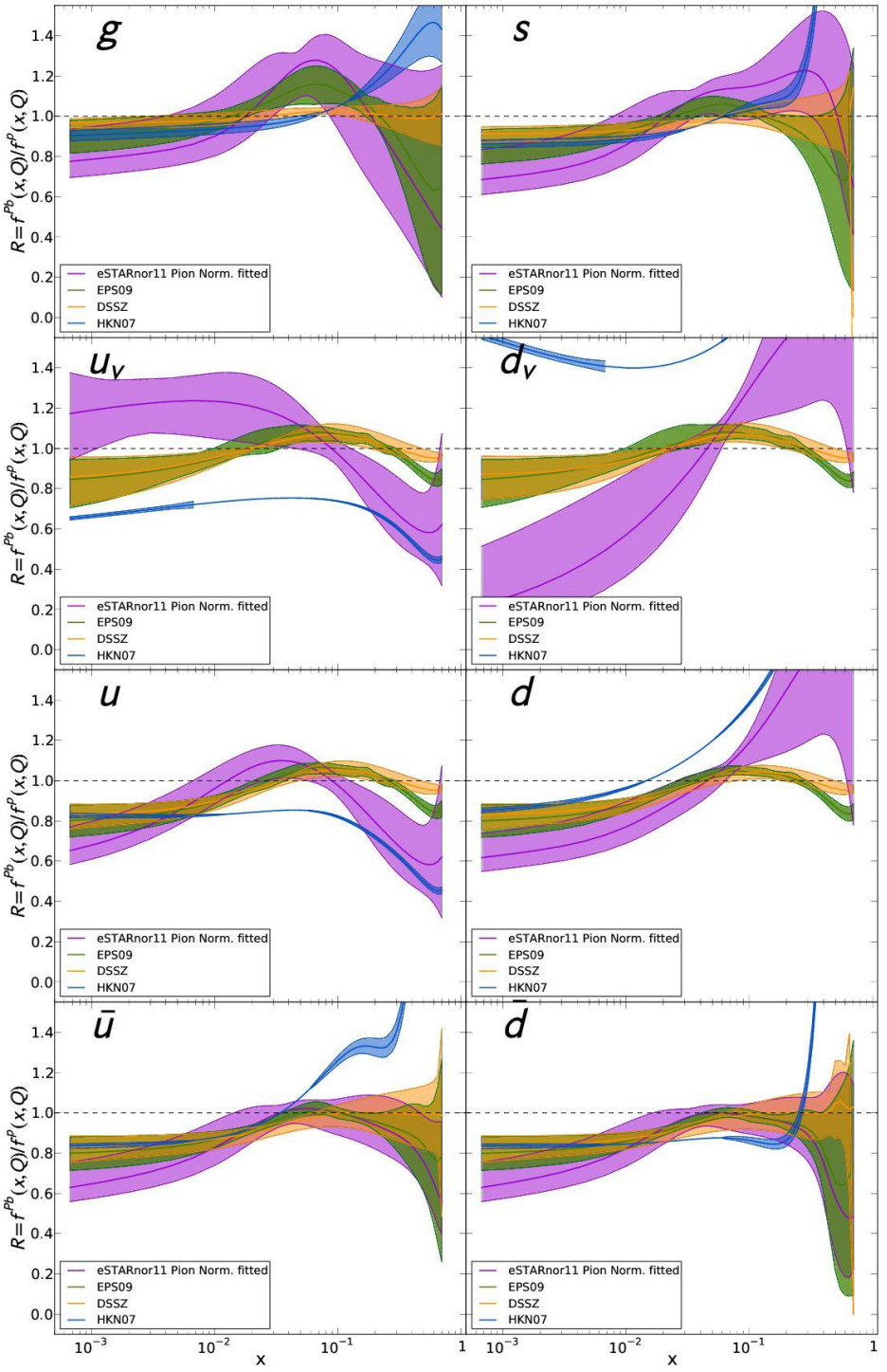
Example:

Nuclear Corrections

νN DIS ⟷ *s(x,Q)*

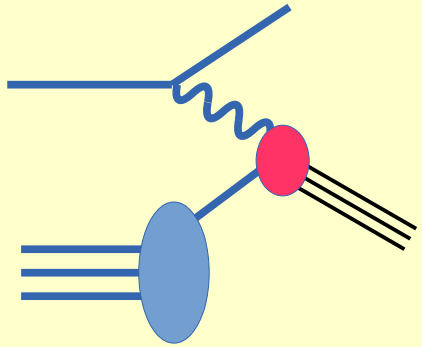
↕

W/Z @LHC

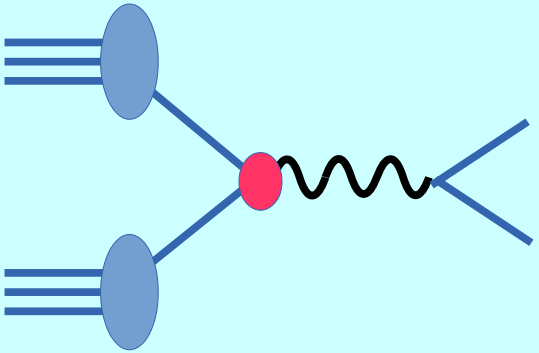


Leftover

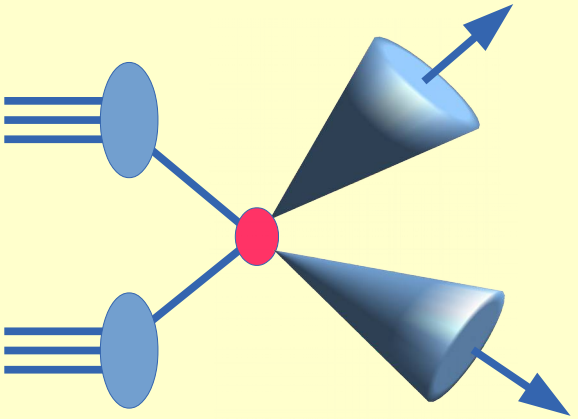
PDF Flavor Differentiation: *A difficult problem*



DIS Production



Drell-Yan



Jet Production

$$F_2^{\nu} \sim [d + s + \bar{u} + \bar{c}]$$
$$F_2^{\bar{\nu}} \sim [\bar{d} + \bar{s} + u + c]$$

$$F_3^{\nu} = 2[d + s - \bar{u} - \bar{c}]$$
$$F_3^{\bar{\nu}} = 2[u + c - \bar{d} - \bar{s}]$$

$$F_2^{\ell^{\pm}} \sim \left(\tfrac{1}{3}\right)^2 [d + s] + \left(\tfrac{2}{3}\right)^2 [u + c]$$

The DIS combinations have historically been particularly useful

Different linear combinations – key for flavor differentiation

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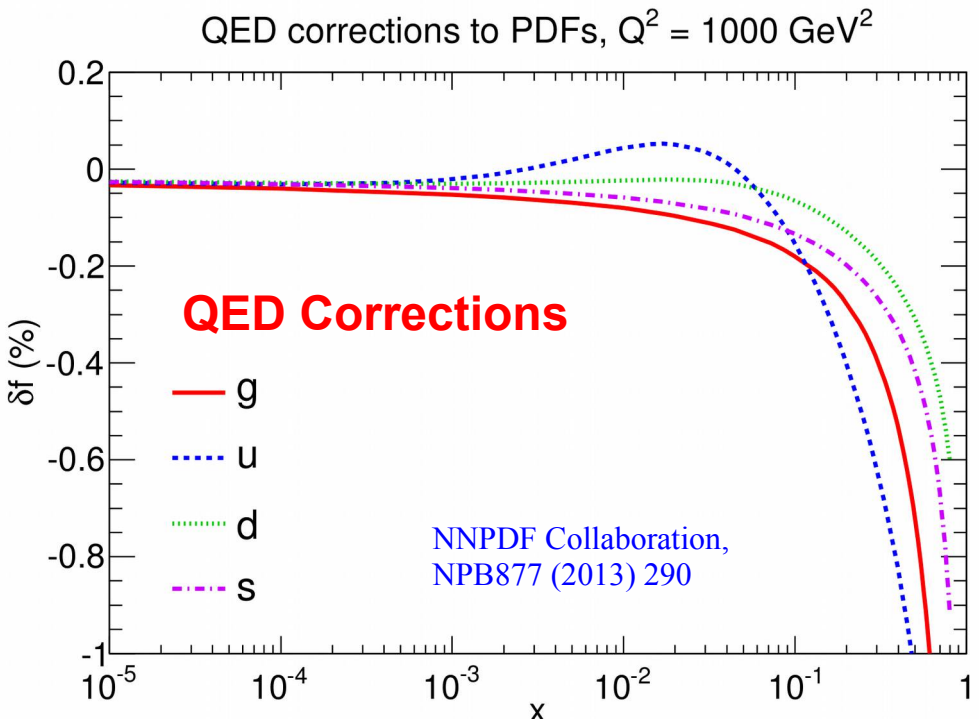
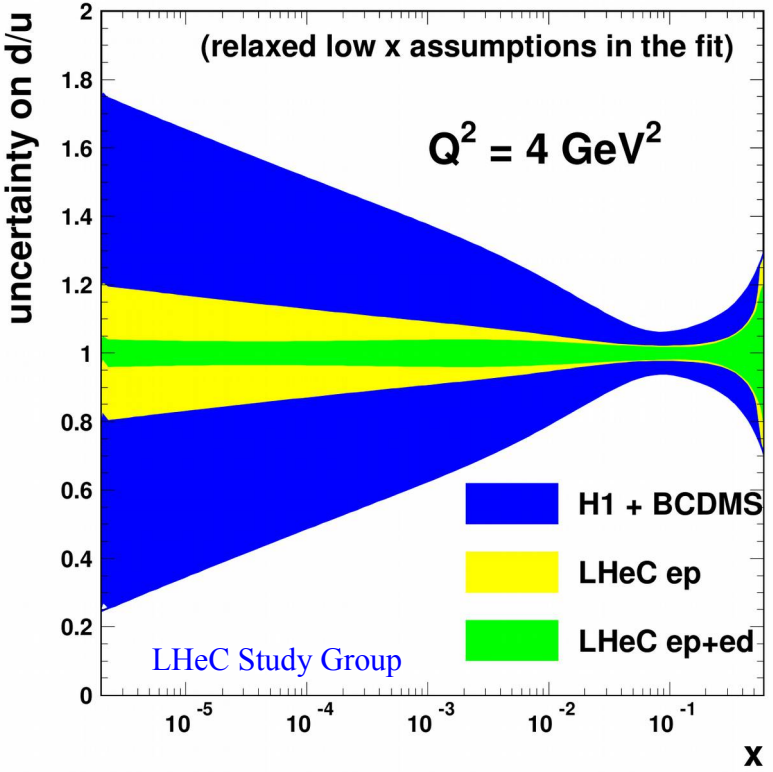
The n-DIS data typically use heavy targets, and this requires the application of ***nuclear corrections***

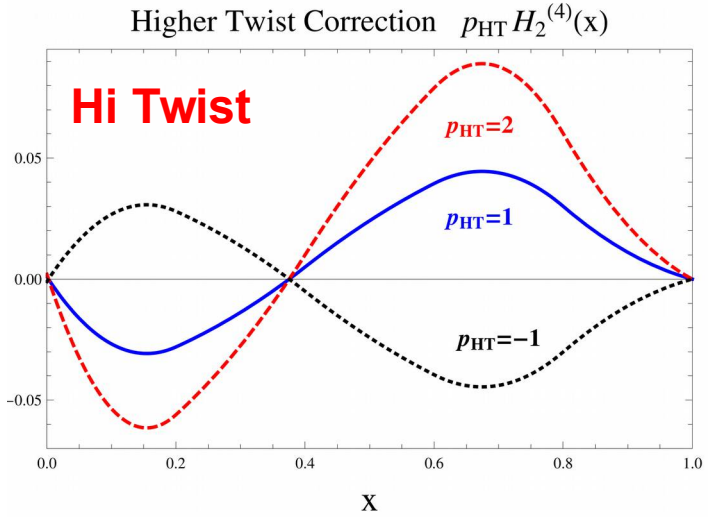
see next talk: *Heavy Ion Physics in e-A and p/A-A,* ***Nestor Armesto Perez***

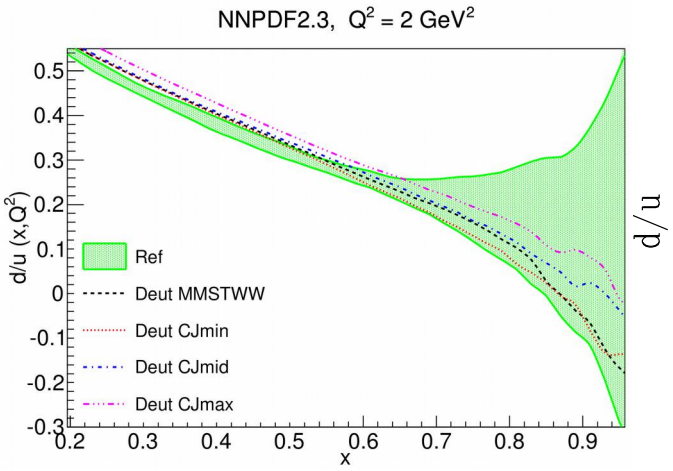
Isospin Symmetry Violation, Higher Twist, Nuclear Corrections ...

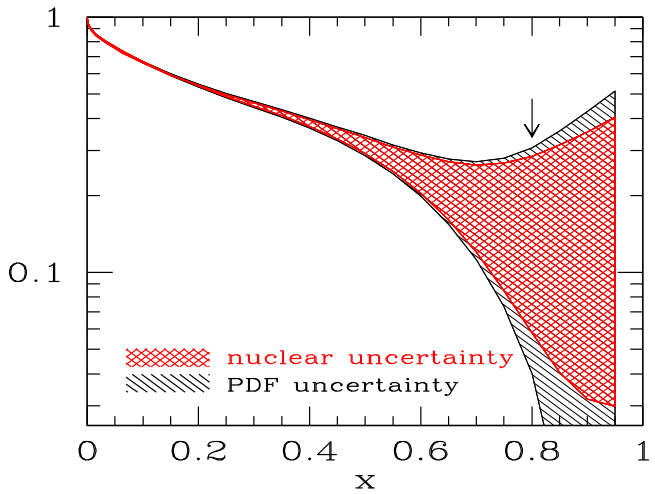




Nuclear Corrections or Parameterization???



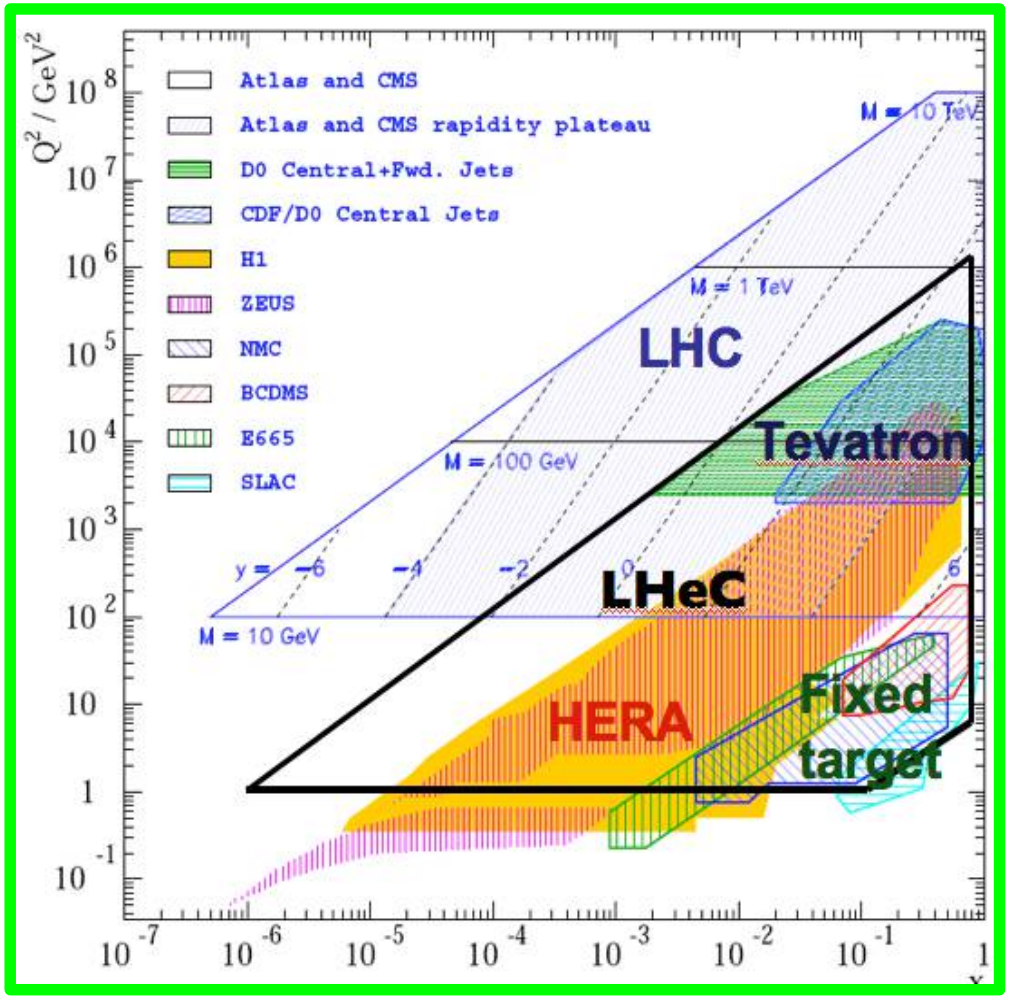




The NNPDF Collaboration, PLB723 (2013) 330

CTEQ-CJ: Phys.Rev. D84 (2011) 014008

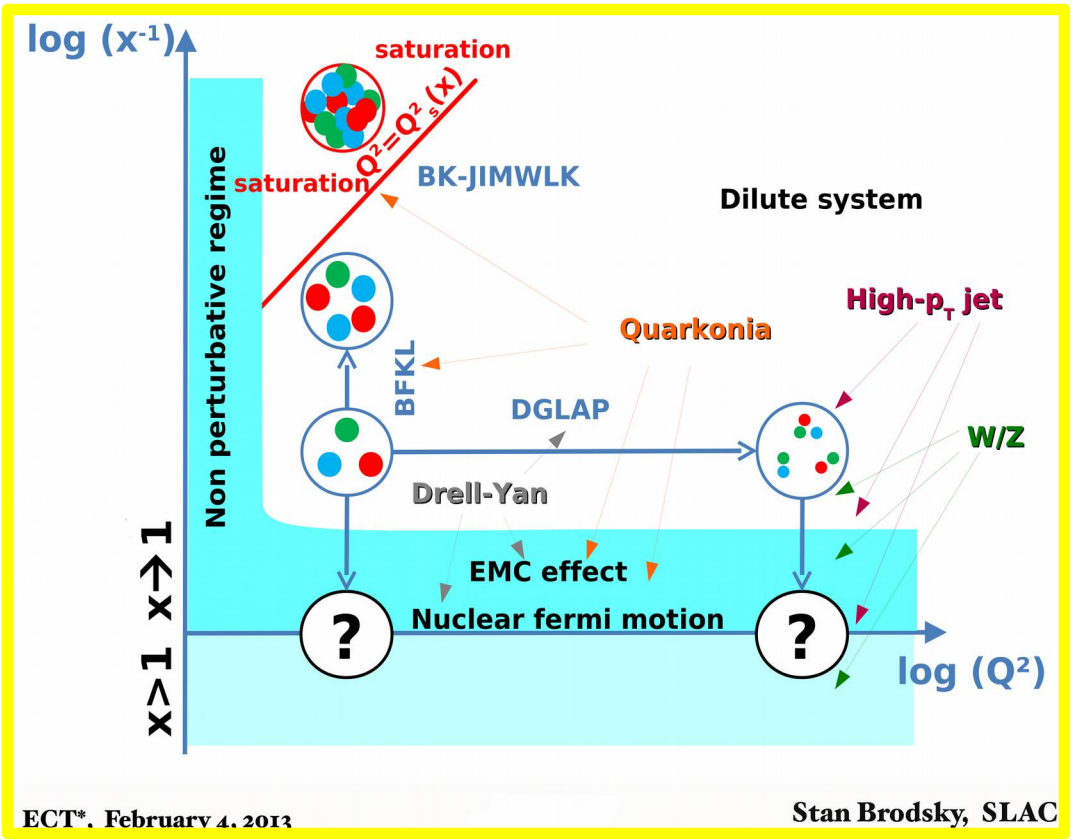
Kinematic Reach of LheC: Extremes of QCD



DGLAP: $\ln(Q^2)$

HQ: $\ln(m^2/Q^2)$

BFKL: $\ln(1/x)$



$$\sigma_{P\gamma\to c} = f_{P\to a} \otimes \hat{\sigma}_{a\gamma\to c}$$

Experimental Observables

WHAT ABOUT PDF'S ???

Theoretical Calculations