Summary of PDF4LHC April 17 2013

A M Cooper-Sarkar

Herafitter User's Meeting April 2013

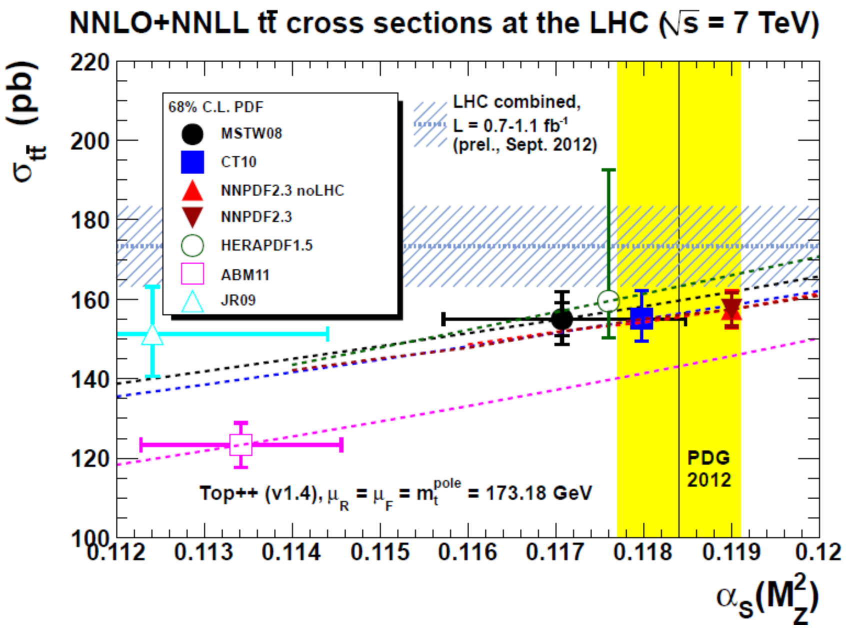
- Reports from PDF groups
- Reports from LHC experiments
- HERAFitter and LHAPDFv6 (now in C++)
- Overview of LHC observables
- PDFs for Higgs
- PDFs for Mw, $\sin^2\theta w$
- Low mass Drell-Yan
- Large x
- Largept
- LHeC

ABM12

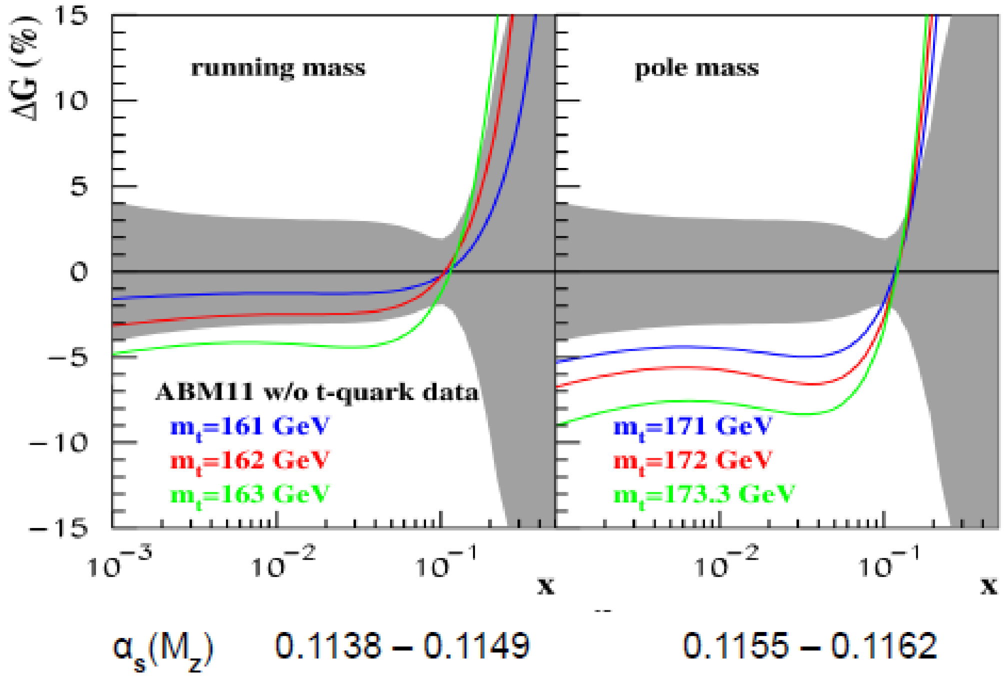
•NNLO corrections to jet production as high as ~20%--gg part has been calculated, was most of this already accounted in the threshold orrections of FastNLO?

•Comparison to LHC Drell-Yan data- good overall agreement. They disagree with the NNLO benchmarking of arXiv:1211.5142 wrt the χ2 for ABM

•Impact of t-tbar cross-sections on PDFs and $\alpha_S(M_Z)$



But the calculation of the t-tbar cross section also depends on what is taken for the top quark mass. The figure was for mt = 173 GeV.
And it depends on whether pole or running mass is used
ABM put these data into their own fit and they alter the shape of the gluon

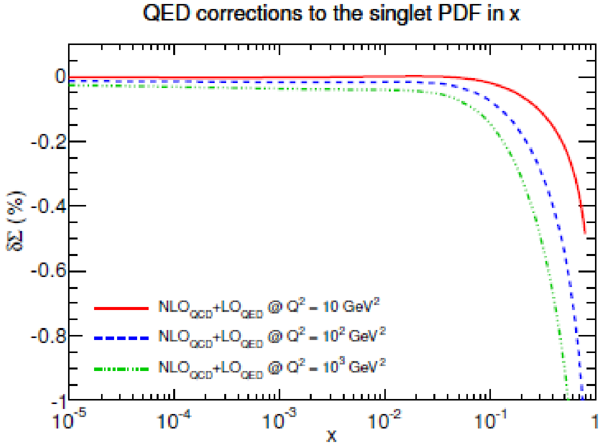


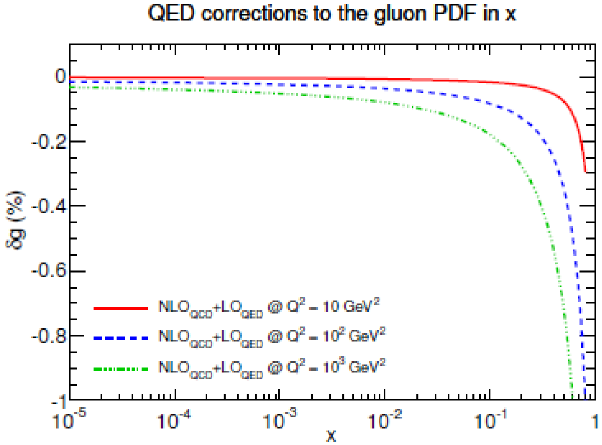
•Finally FFN and GMVFN schemes were compared and the uncertainties in the GMVFN schemes due to the various different choices that can be made were emphasized.

NNPDF

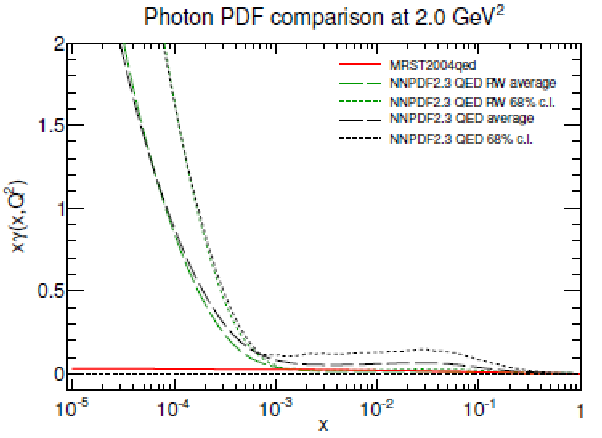
•Has been rewritten in C++
•Have included HERA combined charm data- moderate impact at low-x
•Have included HERA separate Run-II data sets- modest impact
•Working on LHC data—double-differential Drell_yan, CMS jets, W+charm, Z+jets

•Mostly about electroweak corrections to give an alternative to MRSTQED2004



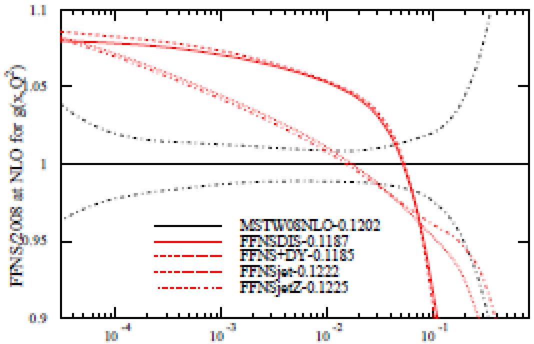


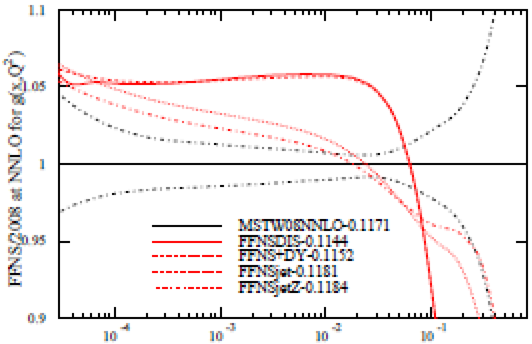
Then used ATLAS W, Z and high mass Drell-Yan to fit a photon PDF



MSTW

Focus on a study of FFN vs GMVFN scheme at NLO and NNLO (as far as possible





Very different gluon shape for FFN fit much bigger than varying the GMVFN scheme plus worse χ2 for FFN particularly when including Tevatron jet data.
The soft high-x gluon for FFN also results in a lower value for $\alpha_S(M_Z)$- more consistent to ABM. So the choice of heavy quark scheme explains MSTW/ABM differences

By contrast inclusion of higher twist and treatment of deuterium is not important

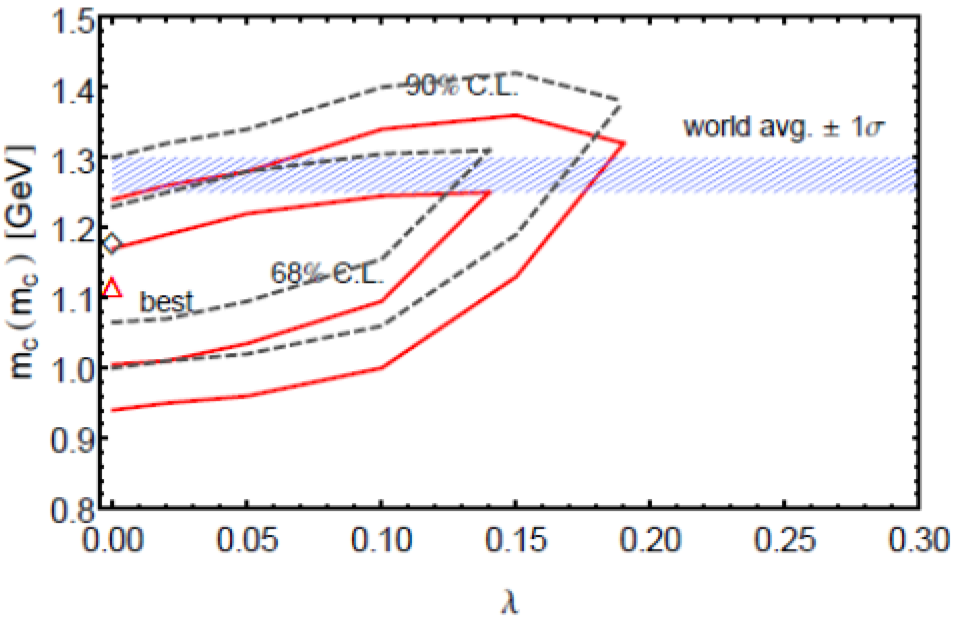
Update of MTSW

- Update to RT-optimal VFN scheme
- Include combined HERA inclusive data - this slightly changes LHC W,Z cross section predictions
- Include HERA combined charm data these data are used to fit mc~1.225GeV at NLO and mc~1.275GeV at NNLO
- Include ZEUS HERA-II Nce- and all HERA direct FL measurements
- Include D0 electron asymmetry and CDF W_asymmetry
- Had already updated treatment of low-x parametrisation of valence quarks and treatment of deuterium corrections to give MSTWCPdeut, which agrees better with CMS lepton asymmetry, this now agrees with the Tevatron asymmetries better.
- Some slight tension between ATLAS W,Z data and ZEUS Run-II NCe- data

CT10

•NNLO now published arXiv:1302.6246
•Working on CT1X-- includes HERA charm and FL + TeV LHC data– not much different to Ct10

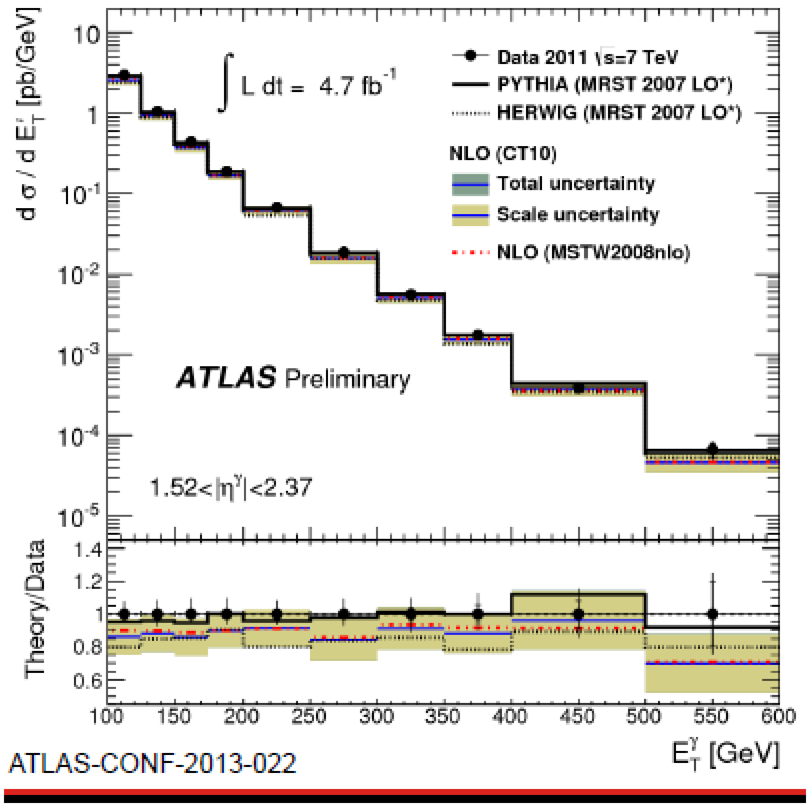
Charm quark mass dependence in a global QCD analysis
J. Gao, M. Guzzi, P. Nadolsky, arXiv:1304.3494

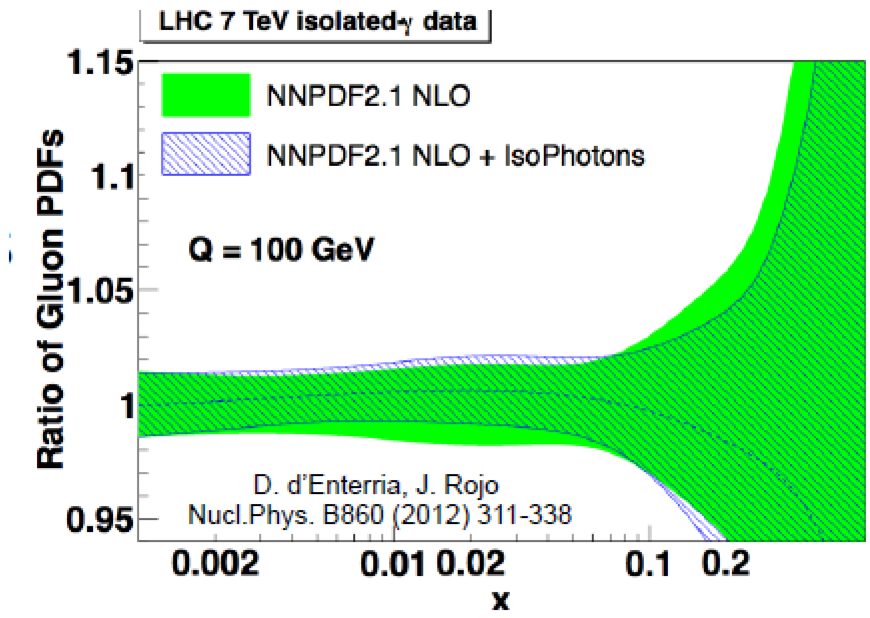


Value of charm quark running mass depends on exact choices of parameters in GMVFN scheme: λ is a rescaling parameter.
This affects predictions for LHC W,Z cross sections

•There is also CT10IC with intrinsic charm
•Photon PDFs are coming
•SNOWMASS/Les Houches needs you!

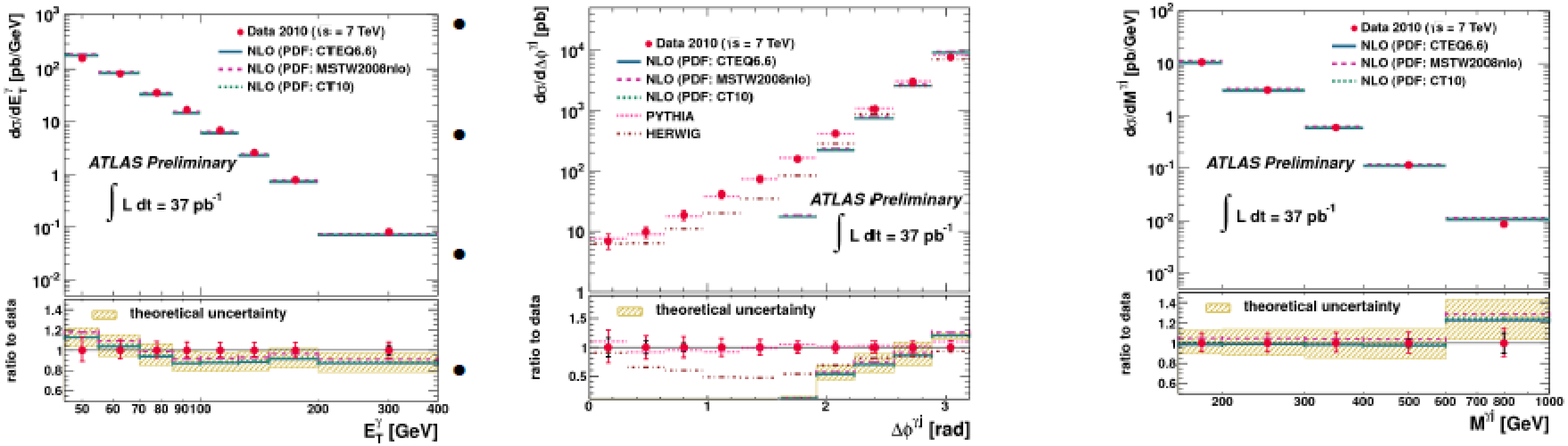
ATLAS





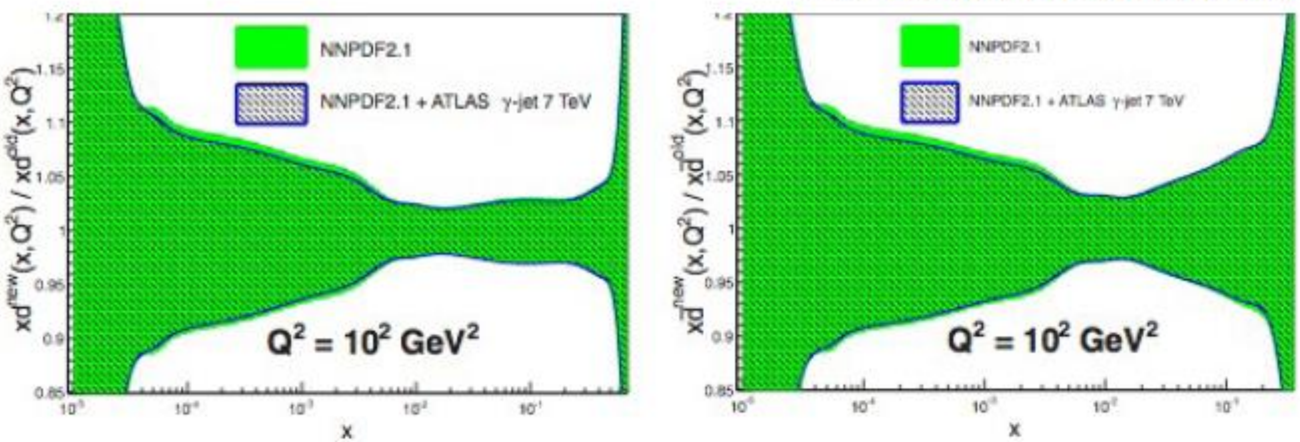
Prompt photon data can help to constrain the high-x gluon

Interface JETPHOX to Applgrid?



ATLAS-CONF-2013-023

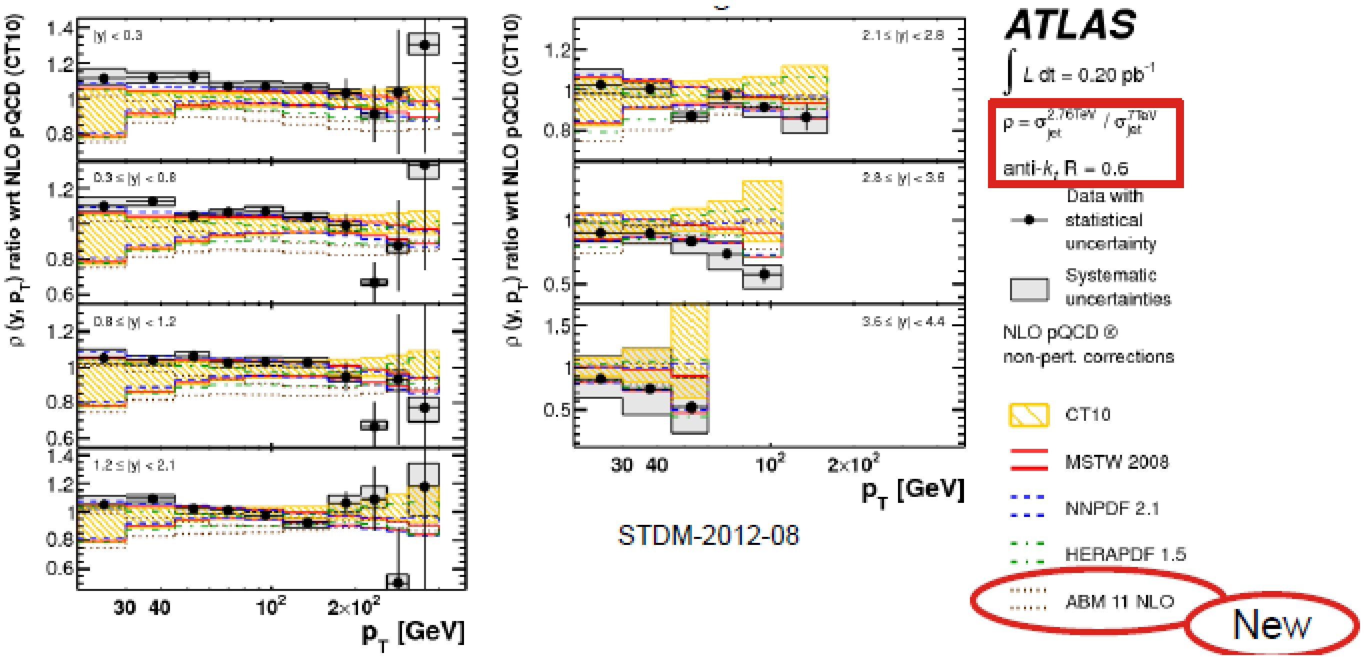
L. Carminati, et al., EPL 101 (2013) 61002



Photon +jet measurements also have potential

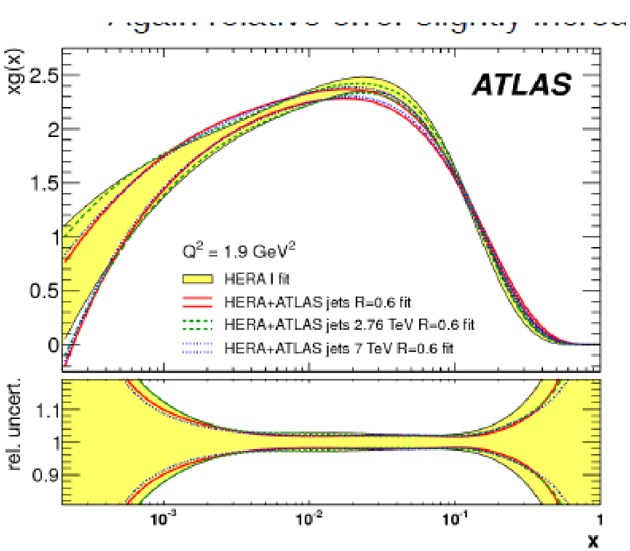
Investigating the same/opposite side nature of the photon/jet probes different fragmentation fractions

Ratio of 2.76/7 TeV jets has already been used in a PDF fit



STDM-2012-08

arXiv:1304.4739



Impacts on gluon shape and reduces uncertainties

CMS

Determination of α_s

From 3/2 jet ratios in 2011 7 Tev data

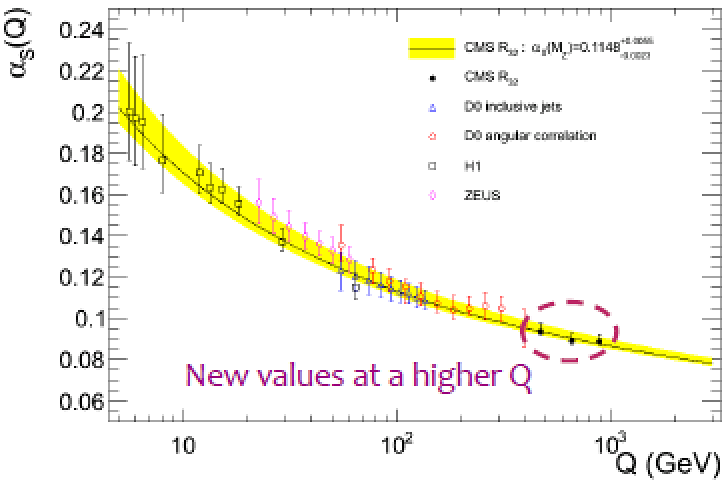
- χ^2 fit to the R_{32} distribution wrt α_s in the region $\langle p_{T1,2} \rangle$ > 400 GeV taking into account experimental uncertainties (use NNPDF predictions).

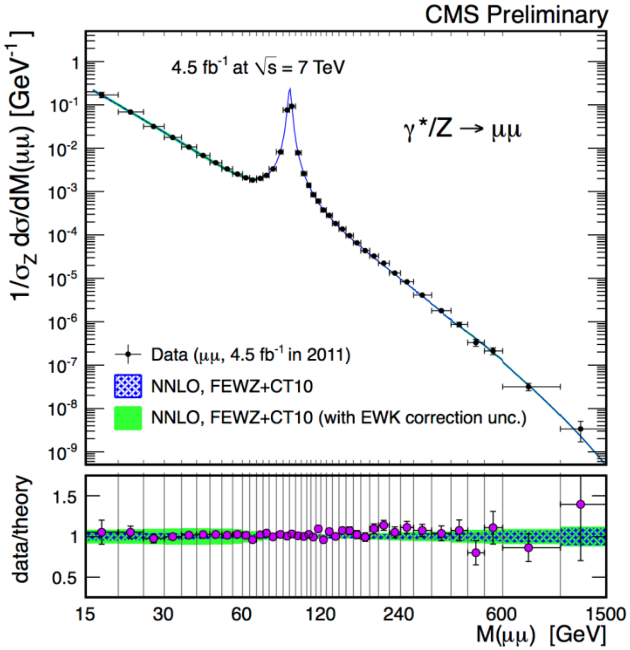
$$\alpha_S(M_Z) = 0.1148 \pm 0.0014\,(\text{exp.}) \pm 0.0018\,(\text{PDF})^{+0.0050}_{-0.0000}\,(\text{scale})$$

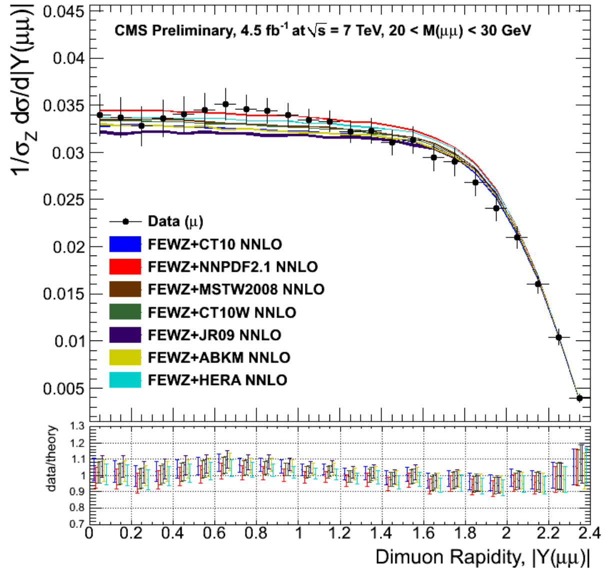
- PDF uncertainty: Repeat fit for each NNPDF replica and take RMS of the distribution of fitted α_s.
- Scale uncertainty: Repeat fit for six variations of (μ_r,μ_f). Take differences between central and highest/lowest values.

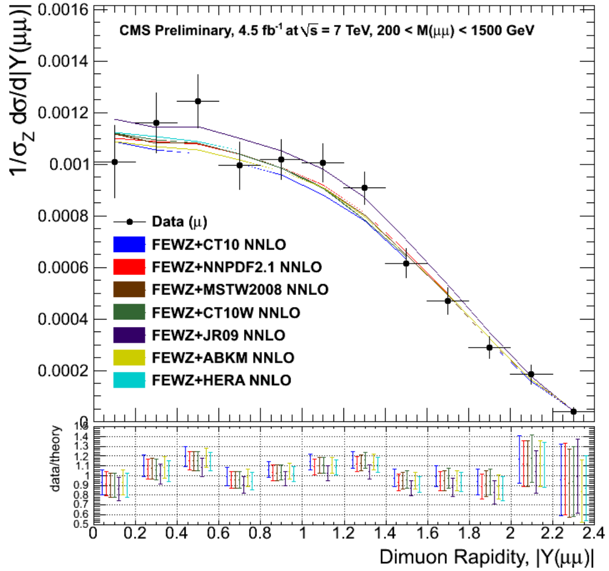
PDF set	$\alpha_s(M_Z)$
MSTW2008	0.1141 ± 0.0022 (exp.)
CT10	0.1135 ± 0.0019 (exp.)
ABM11	0.1214 ± 0.0020 (exp.)

- Extraction of α_s also in three independent $\langle p_{T1,2} \rangle$ subranges



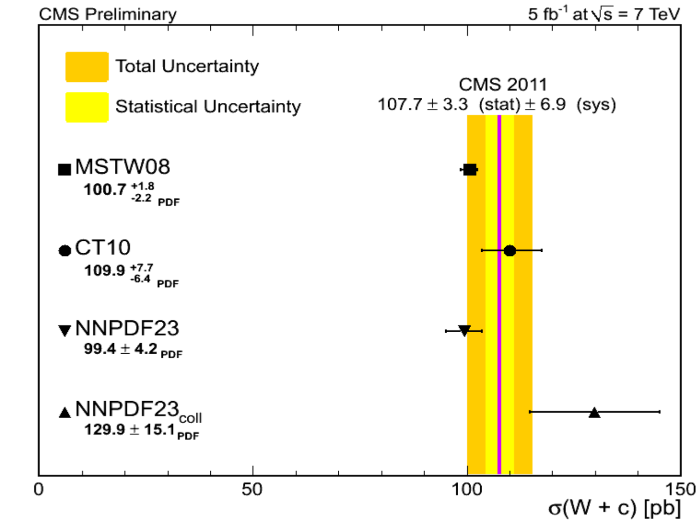






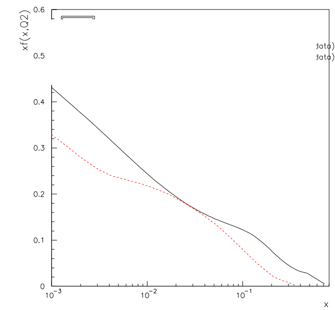
CMS updated their Drell-Yan analysis of 7 TeV 2011 data from CMS-EWK-11007 to CMS-SMP-13003

W+c production

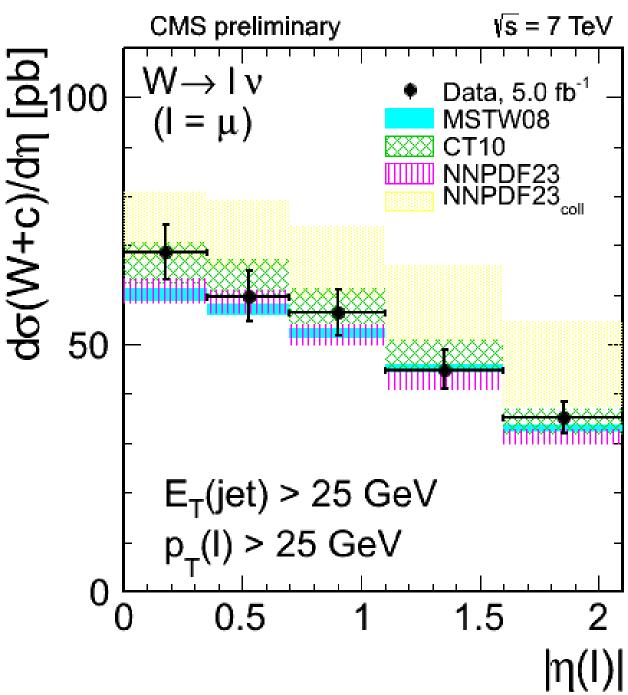


First compare W +c cross section for W's of both charges to predictions.

Very good agreement with CT10 and not in such good agreement with NNPDF2.3 (Coll) but this has VERY large strangeness



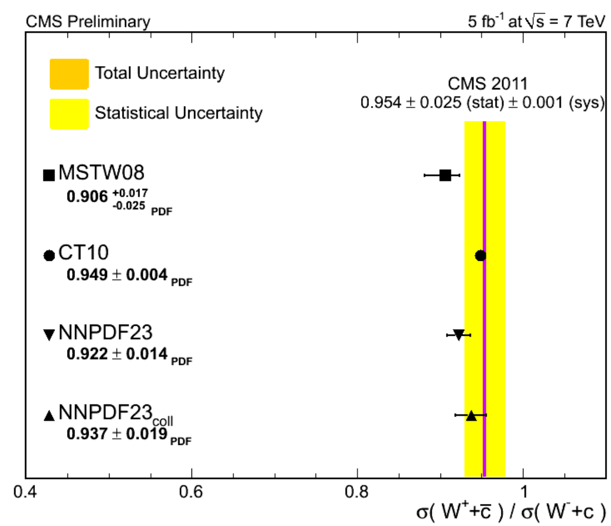
Q^2=2 GeV^2
NNPDF23(Coll)
Strange
Downsea



CT10 also describes the pseudo-rapidity spectrum of the lepton from the W

Finally CT10 does a good job on the ratio of the W^+ +c / W^- +c cross sections.

Strangeness asymmetry s ≠ sbar is small for all PDFs, for CT it is zero



LHC observables

PDF whishlist at the LHC

Traditional

- Inclusive jets and dijets, central and forward: **large-x quarks and gluons**
- Inclusive W and Z production and asymmetries: **quark flavor separation, strangeness**

New @ LHC

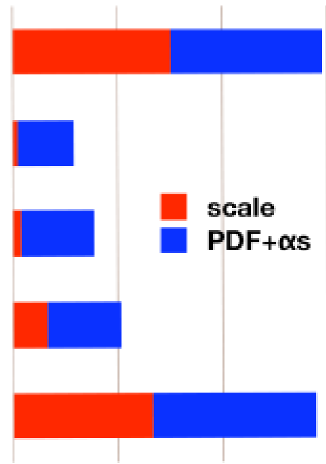
- Isolated photons, photons+jets: **medium-x gluons**
- W production with charm quarks: **direct handle on strangeness**
- W and Z production at high p_T: **medium and small-x gluon**
- Off resonance Drell-Yan and W production at high mass: **quarks at large-x**
- Low mass Drell-Yan production: **small-x gluon**
- Top quark cross-sections and differential distributions: **large-x gluon**

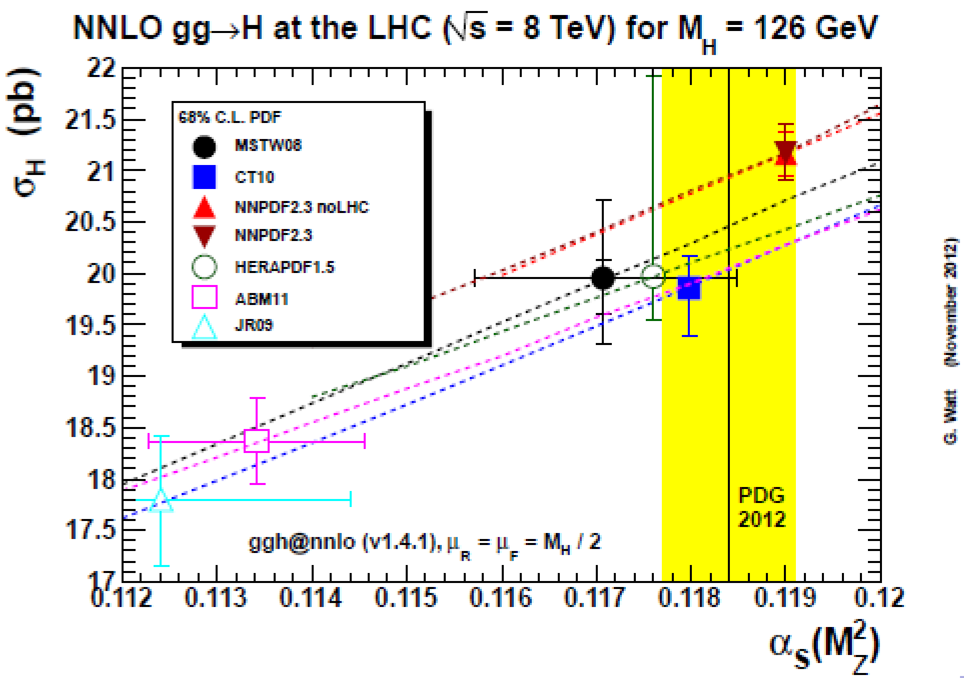
Speculative

- Z+charm: **intrinsic charm PDF**
- Single top production: **gluon and bottom PDFs**
- Charmonium production: **small-x gluon**
- Open heavy quark production: **gluon and intrinsic heavy flavor**

PDFs and the Higgs

		σ (8 TeV)	uncertainty
NNLL QCD +NLO EW	gg→H	19.5 pb	14.7%
NNLO QCD +NLO EW	VBF	1.56 pb	2.9%
	WH	0.70 pb	3.9%
	ZH	0.39 pb	5.1%
NLO QCD	ttH	0.13 pb	14.4%





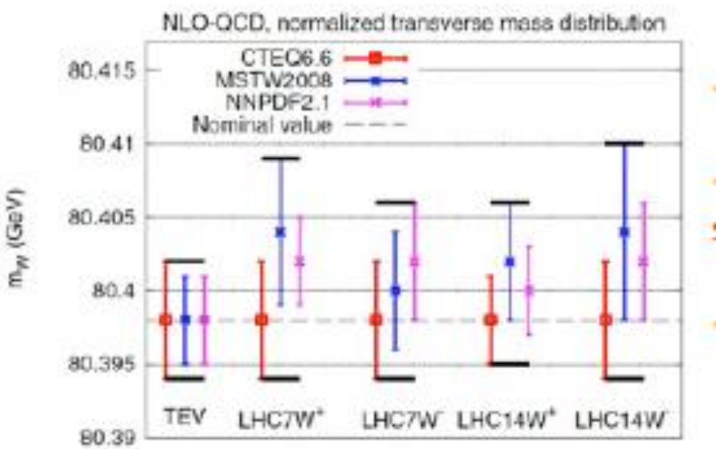
Very similar alphas dependence of t-tbar cross section- can use the t-tbar measurements to discriminate and improve PDFs and then use this for Higgs predictions

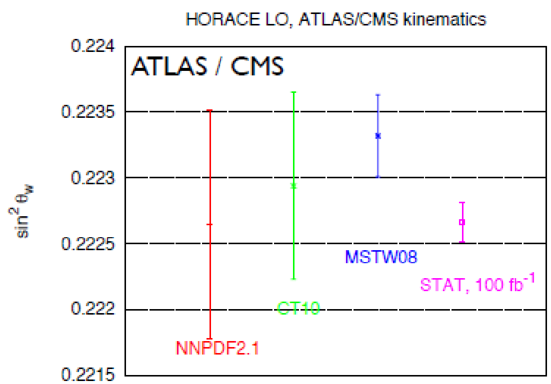
Ongoing work towards $gg \to H$ at N^{3}LO

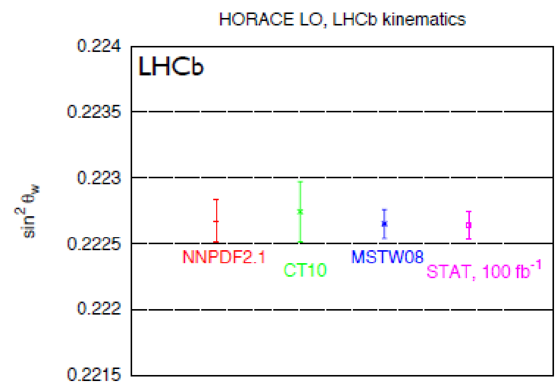
PDFs and Mw, sin²θw

CC-DY: lepton-pair transverse mass
lepton transverse momentum M_W, Γ_W jacobian peak: control of the lineshape at the per mille level

NC-DY: invariant mass A_FB asymmetry $\sin^2\theta_W$ possible thanks to the PDF unbalance in forward (backward) region between qqbar and qbarq initiated processes





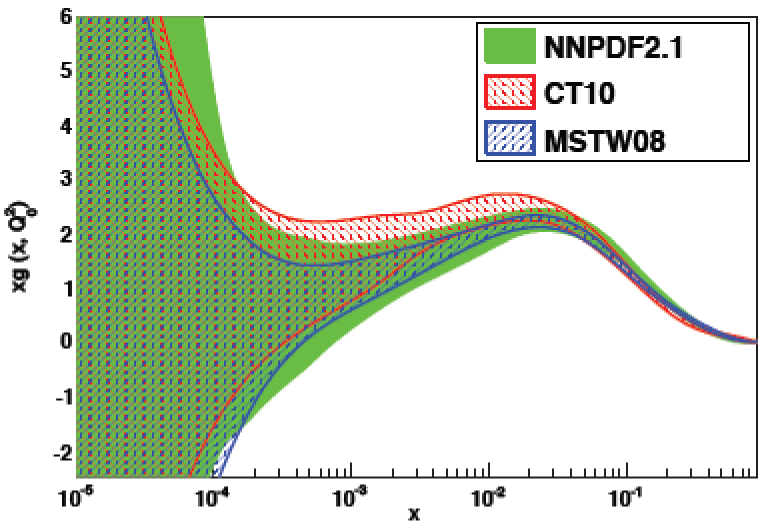


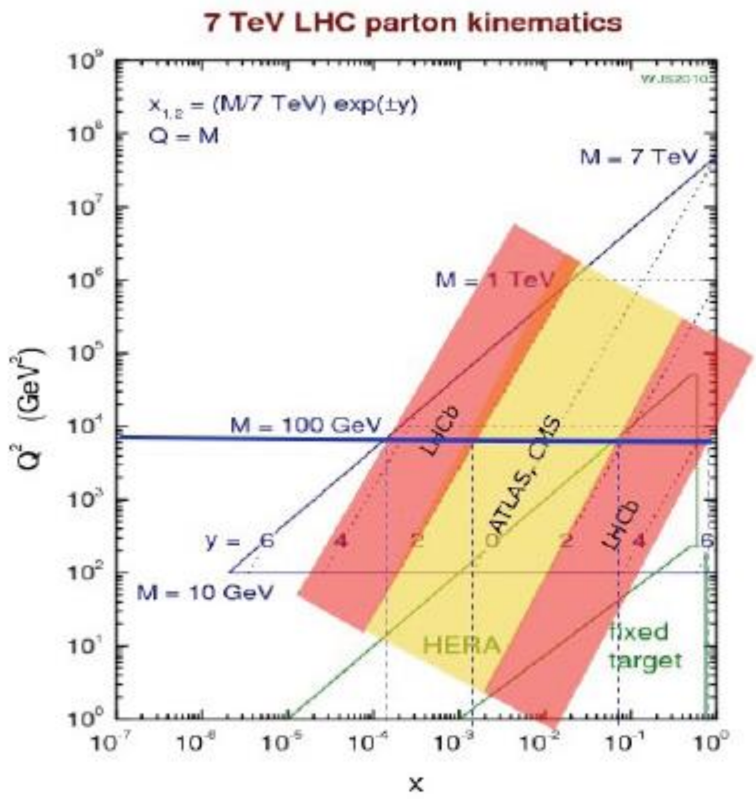
Which observables can help?

- W charge asymmetry
- W+charm production
- NC-DY invariant mass and inv. mass A_{FB}

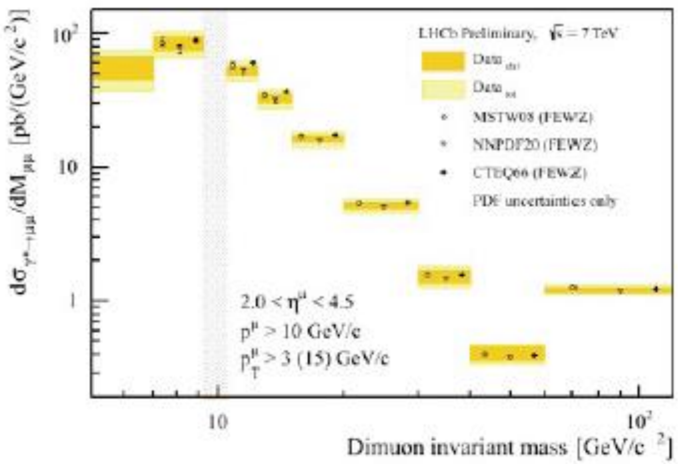
Low mass Drell-Yan

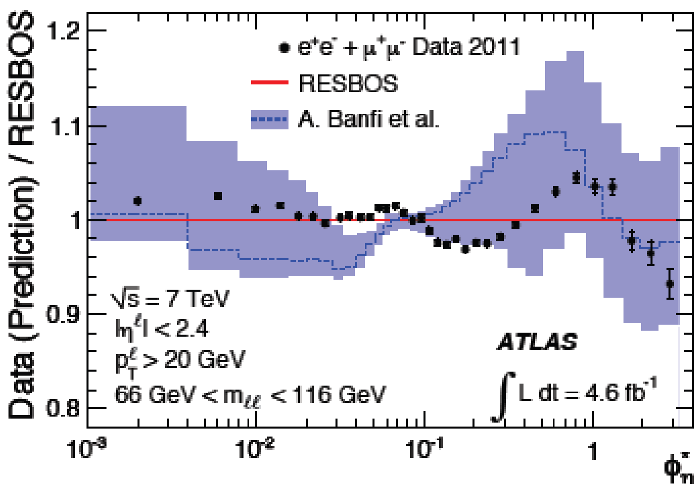
Probes low-x– particularly for LHCb





PDFs are not well-known but do we even have the right theory? Do we need ln(1/x) resummation? Or even non-linear evolution?





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ATLAS collaboration
arXiv:1211.6899

LHCb low-mas Drell-Yan looks in agreement with conventional DGLAP evolution, but errors are large

To do better we need re-summed evolution equations and re-summed coefficients functions

Some calculations exist for DIS at low-x

Altarelli Ball Forte, Thorne and White

What can we use for Drell-Yan?

Ball and Marzani 0812.3602 for invariant mass or Caola, Forte and Marzani 1012.2743 for rapidity distribution

Maybe Z transverse momentum spectrum can also be tackled Banfi, DasGupta, Marzani, Tomlinson 1205.4760

- Not so much phenomenology has been done so far

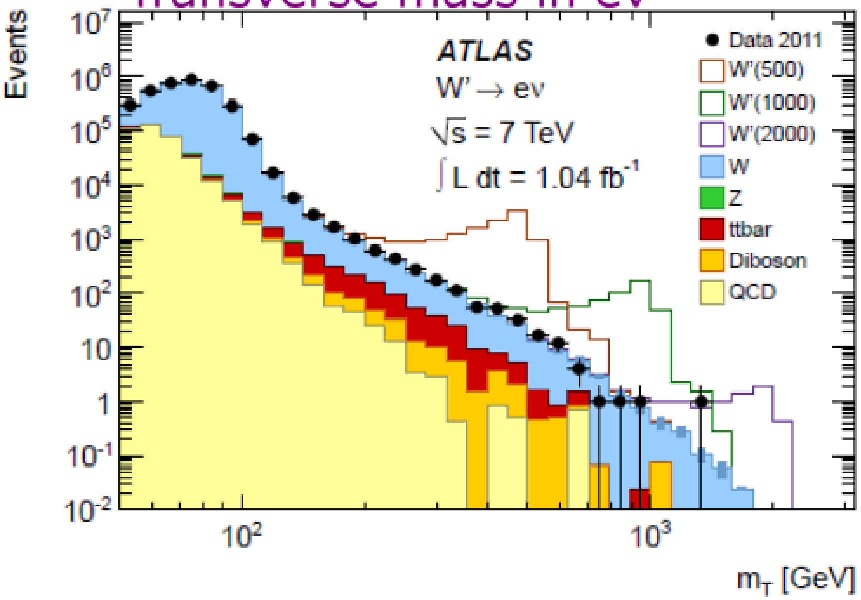
Large- x

THE MOTIVATION
SEARCHES FOR NEW PHYSICS

PDFS AT LARGE x DOMINATE SEARCHES FOR NEW PHYSICS

EXAMPLE: W' SEARCHES AT CMS

Transverse mass in ev

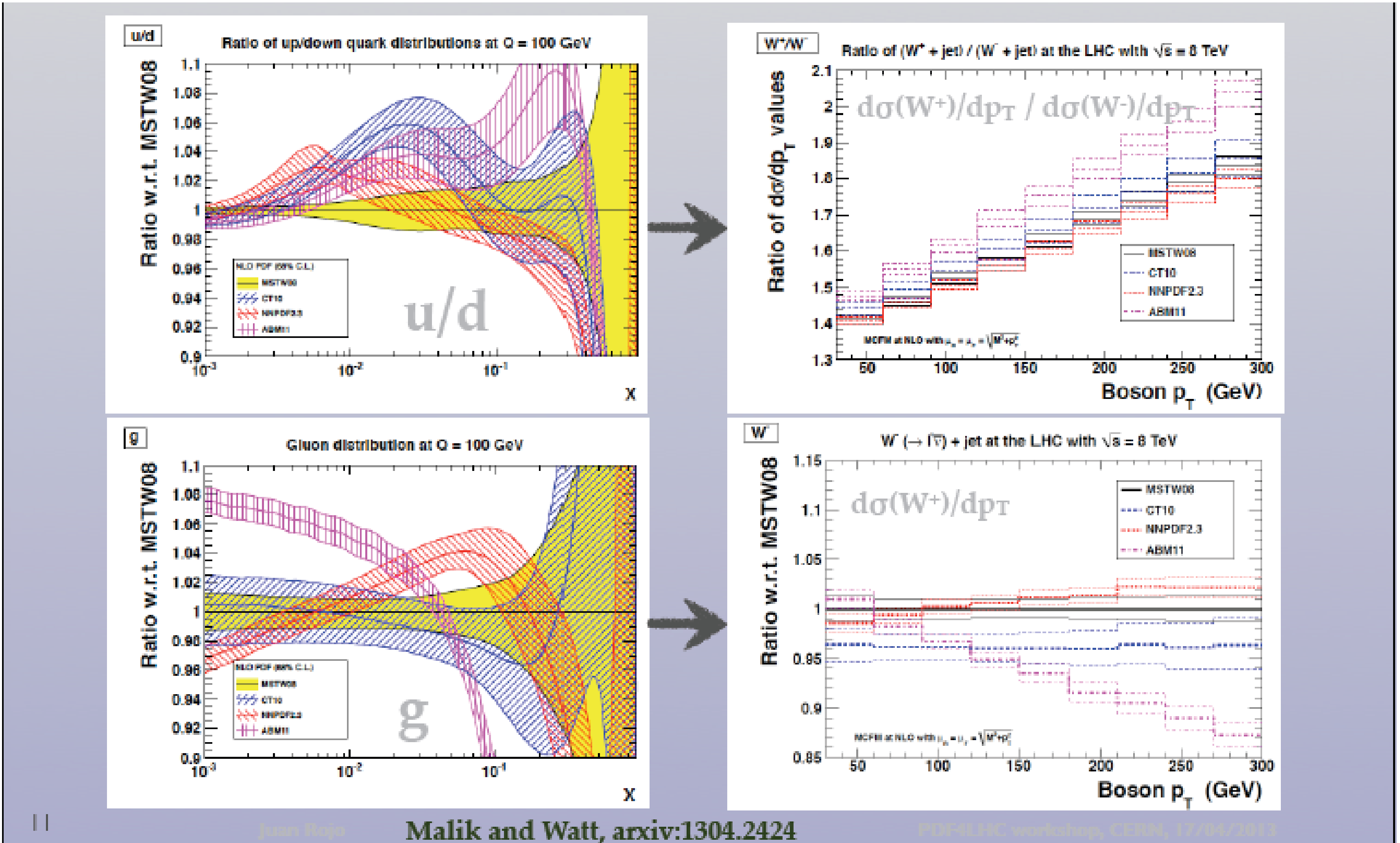


Events

- PARAMETRIZATION BIAS
- NUCLEAR CORRECTIONS
- THRESHOLD RESUMMATION

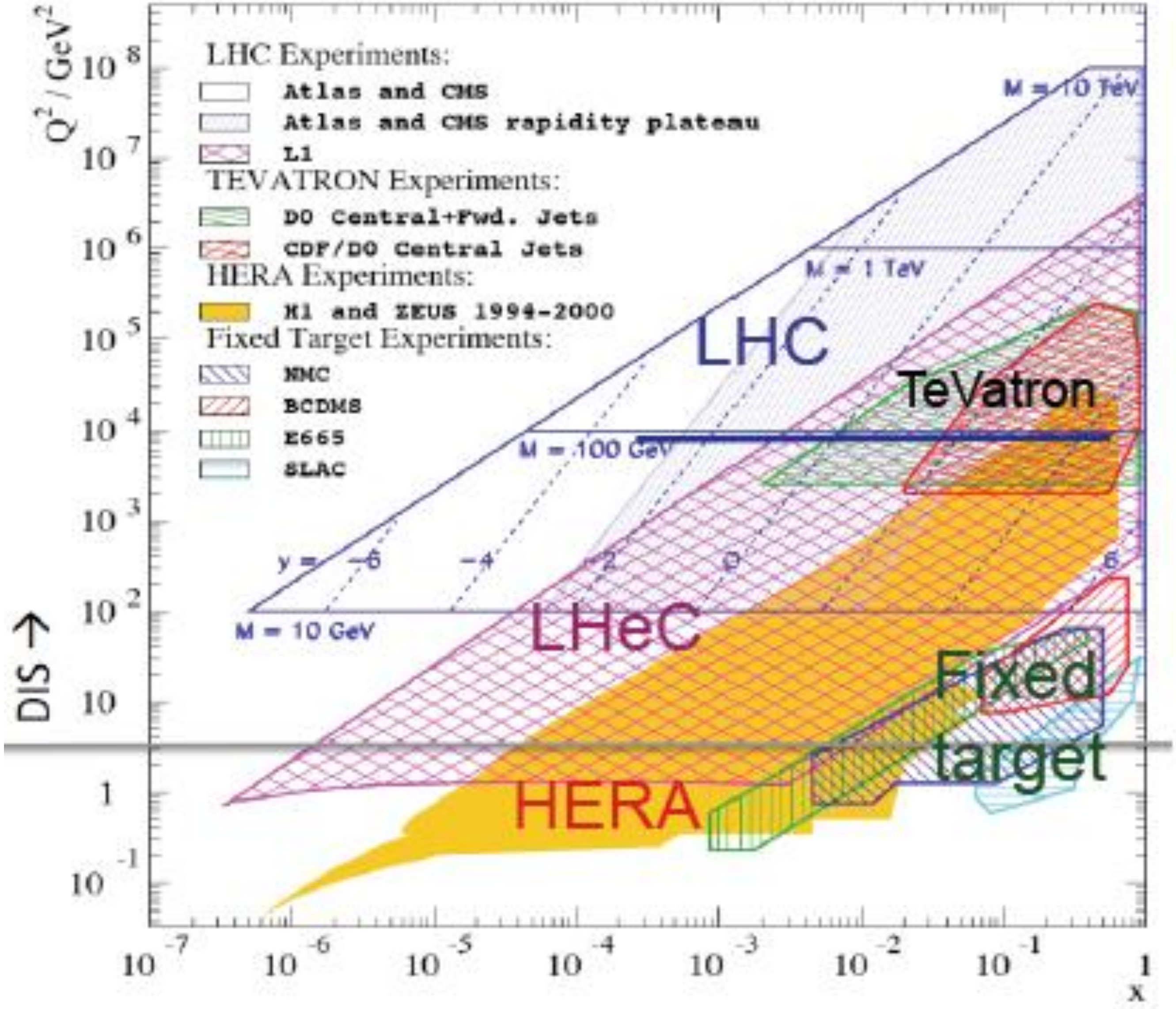
Vector boson at high pt

ArXiv:1304.2424



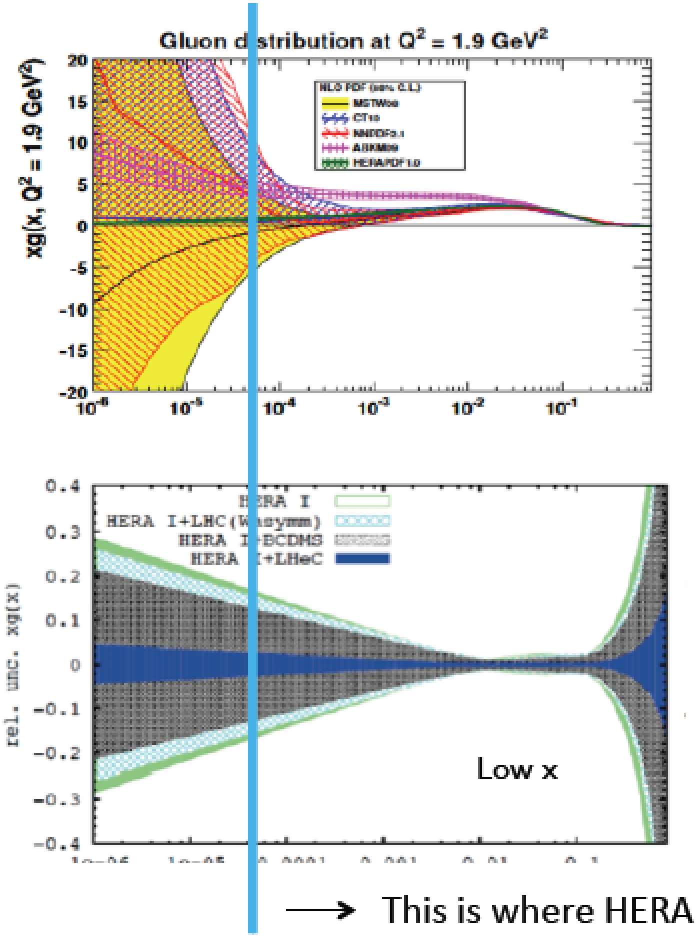
High pt spectra may discriminate gluon but needs NNLO and electroweak corrections, ratios may have an advantage

LHeC



There was also a talk on LheC ion collider for nuclear PDFs which I will not cover

Gluon PDF at low x



- HERA sensitivity stops at 5×10^{-4}

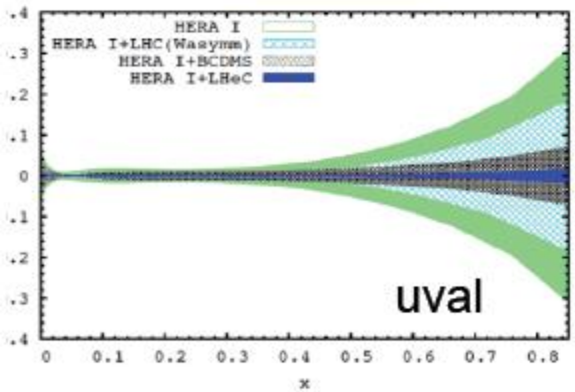
→ The uncertainties are driven by the parametrisation

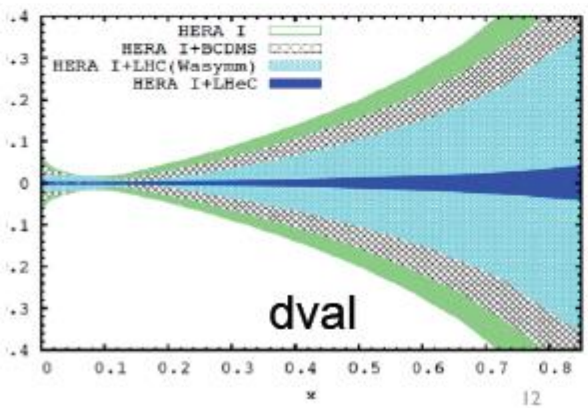
- LHeC sensitivity extends to $x=10^{-6}$
  - LHeC sensitivity to gluon can be improved by the F_L data as well (not included in this study):
    →Allows to study BFKL vs DGLAP

⟶ This is where HERA sensitivity stops

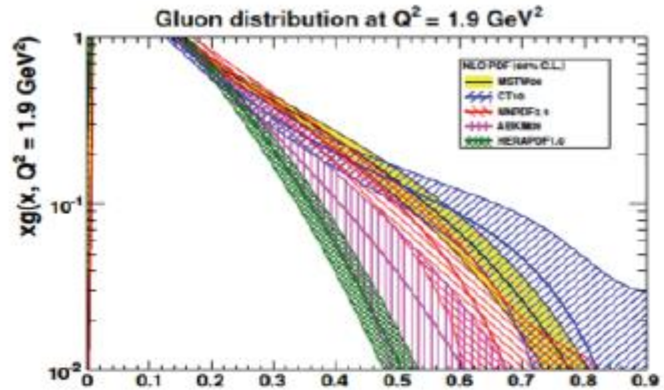
And promise of per-mille accuracy on $\alpha_S(M_Z)$

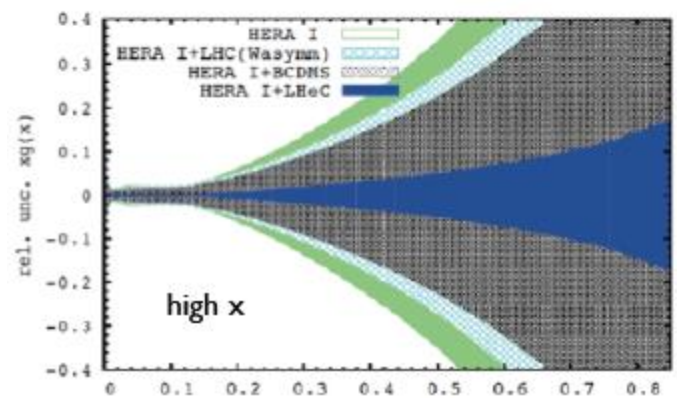
Valence distribution





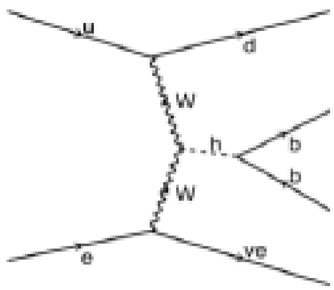
Gluon PDF at high x

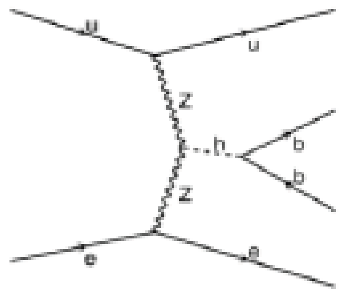




And of course one may also be ale to release standard constraints like ubar=dbar at low-x

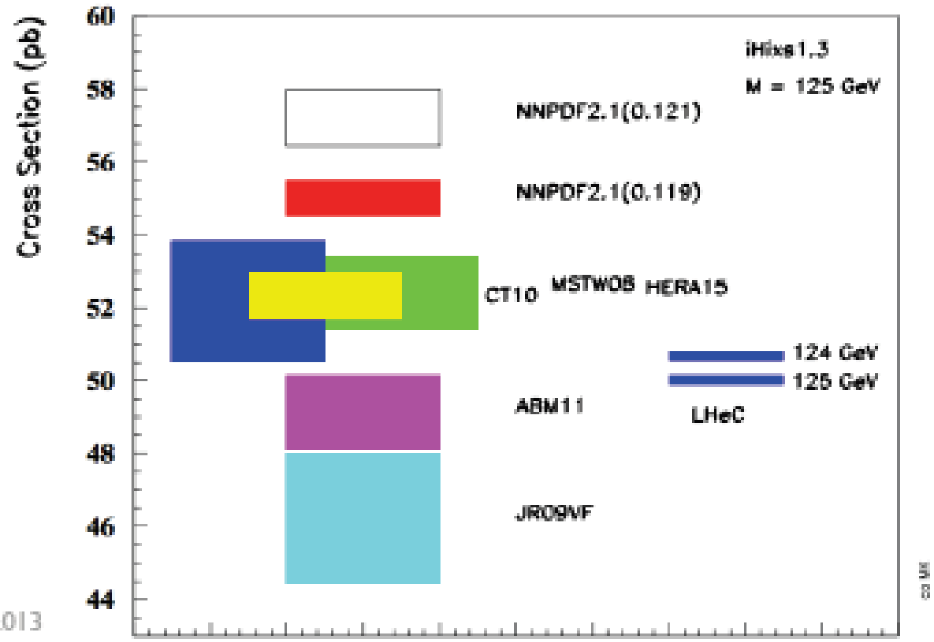
- At the LHeC the Higgs boson is cleanly produced via ZZ or WW fusion and it is complementary to the dominant gg fusion at pp

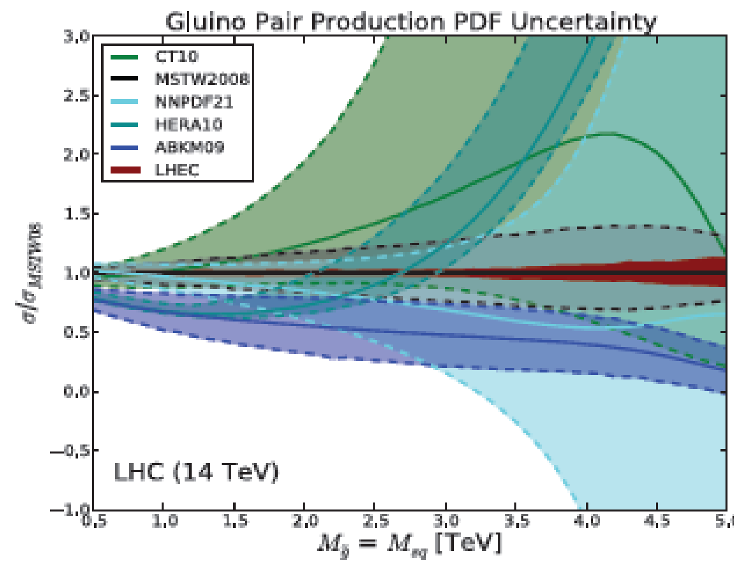




But LHeC is also good for Higgs

And for SUSY





14 TeV gg → H total cross section at the LHC calculated for a variety of PDFs at 68% CL

- precision from LHeC can add a very significant constraint on the mass of the Higgs