

PDF Prospects for Run II at ATLAS and CMS

*Stefano Camarda and Katerina Lipka on behalf of
ATLAS and CMS PDF Fora*

PDFs and their uncertainties

The LHC data are used to obtain constraints for the determination of PDFs

PDF uncertainties have to be estimated for

- 1) **experimental uncertainties of the measurement** (acceptance, unfolding)
 - need good description of the data by central PDF
 - need consistent treatment of PDFs in Monte-Carlo by experiment
 - need best statistical meaning of the uncertainty
 - need practical solutions for analyses

- 2) **comparison to models and phenomenological interpretation**
 - need to cover the full spectrum of phenomenology and assumptions (all available PDFs)

- 3) **calculation of limits, in searches for new physics**
 - need to be conservative
 - need consistency of PDF choice and error calculation for possible limit combinations

Recommendations might be helpful for 2) and 3)

Difficult to have a general recommendation for 1) since each analysis has specific requirements

1) Experimental Uncertainty: PDFs in MC

General guidelines for both ATLAS and CMS wrt PDFs in MC generators:

- will use only VFNS PDFs
- PDFs of 3 groups (CT, NNPDF, MMHT)
- for special cases, the pp-unbiased PDF (HERAPDF) will be used
- appropriate order of PDF for LO and NLO ME, PS and MPI

- open issues with reweighting PDFs in NLO+PS generators
- address correlation between PDF and PS, MPI tunes uncertainties
- technical aspects: how to run the generation of samples with multiple PDF weights.

- METAPDF are not used so far

PDF in MC generators

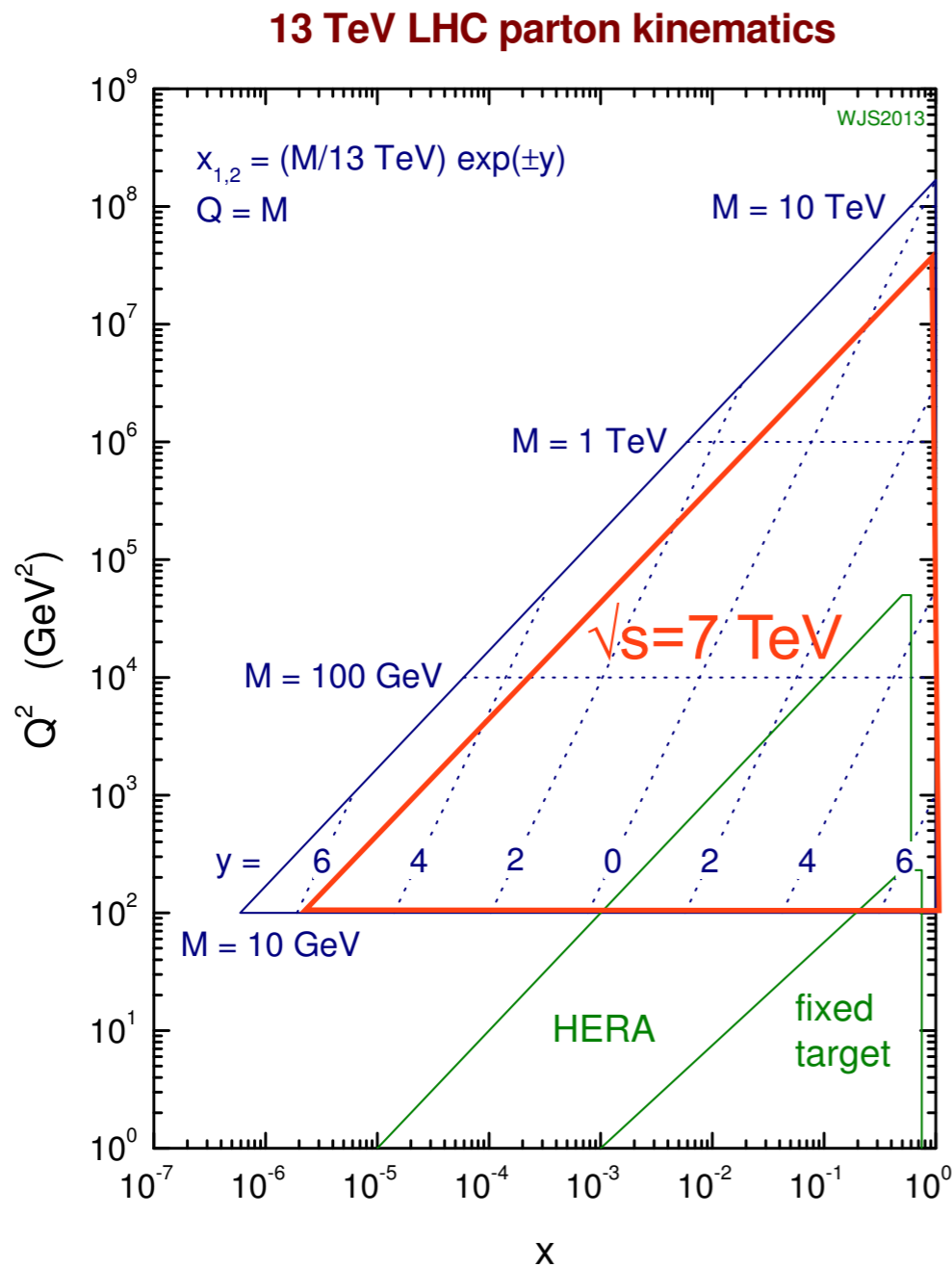
Run II Monte-Carlo production with PDF and their uncertainties:

generator	PDF sets used	
	CMS	ATLAS
Madgraph	NNPDF30_lo_as_0130.LHgrid + uncertainties NNPDF30_lo_as_0130_nf_4.LHgrid +uncertainties NNPDF30_lo_as_0118.LHgrid (central set only) NNPDF23_lo_as_0130_qed.LHgrid + uncertainties NNPDF23_lo_as_0119_qed.LHgrid (central set only) cteq6l1.LHgrid MMHT2014lo68cl.LHgrid + uncertainties MMHT2014lo_asmzsmallrange.LHgrid + uncertainties HERAPDF15LO_EIG.LHgrid + uncertainties NNPDF30_nlo_as_0118.LHgrid (central set only) NNPDF23_nlo_as_0119.LHgrid (central set only) CT10nlo.LHgrid + uncertainties MMHT2014nlo68cl.LHgrid (central set only)	<p>Currently used:</p> <ul style="list-style-type: none"> • For LO ME and PS: NNPDF2.3LO $a_s=0.130$ (a_s set independently in ISR and FSR shower) • For NLO ME CT10 and CT10nlo ($a_s = 0.118$) <p>Planned:</p> <ul style="list-style-type: none"> • LO ME: MSTW2008lo, MSTW2008nlo, HERAPDF (but still NNPDF2.3LO in the shower). • NLO ME : NNPDF3.0NLO, HERAPDF <p>For Sherpa, use the PDFs for which a tune is provided by the authors</p>
aMC@NLO	NNPDF3.0 + weights for errors are included	
POWHEG	NNPDF30_nlo_as_0118 + uncertainties NNPDF30_nlo_as_0117 central value NNPDF30_nlo_as_0119 central value MMHT2014nlo68cl + uncertainties MMHT2014nlo_asmzsmallrange + uncertainties CT10nlo + uncertainties CT10nlo_as_0117 (one member only) CT10nlo_as_0119 (one member only)	

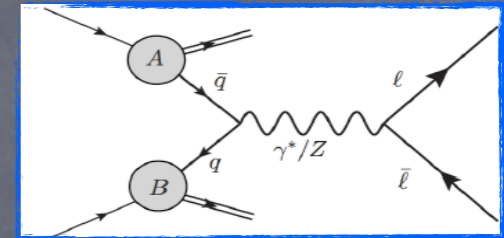
PDF sets and uncertainties includes as weights, PDF change affects ME, not PS

Vision for Run II PDF constraints from LHC

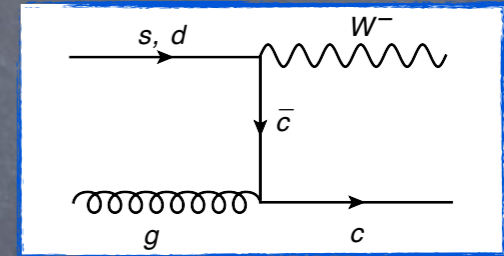
J. Stirling <http://www.hep.ph.ic.ac.uk/~wstirling/plots/plots.html>



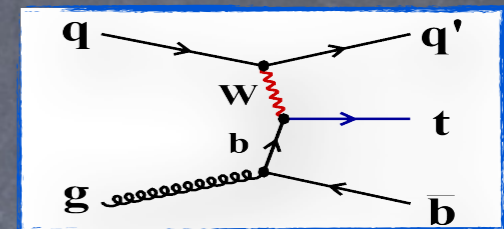
- W, Z: light quarks
low and high x



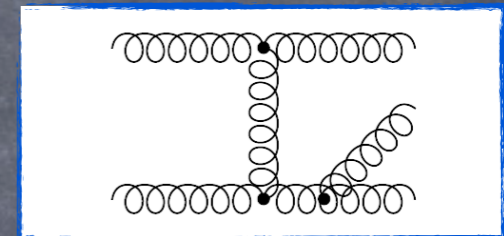
- W+c: s-quark
medium x



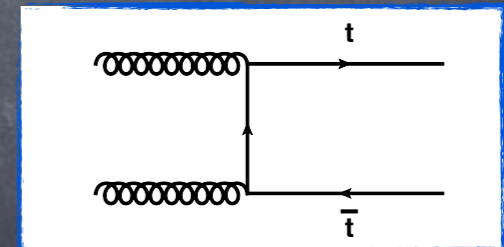
- single top: u, d, b



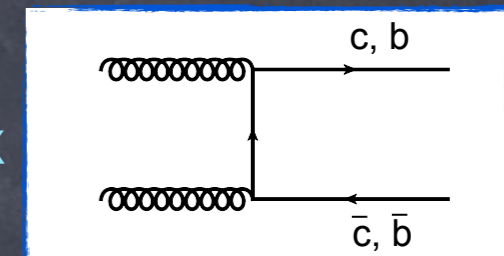
- jets: gluon, α_s
medium x



- top-pairs: gluon
high x



- forward c, b: gluon
low & high x

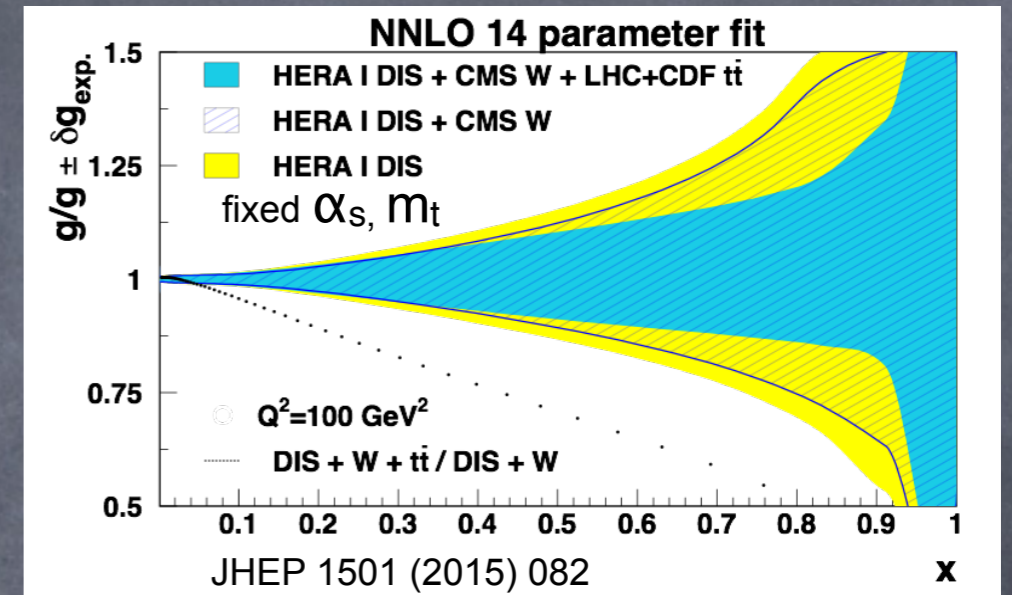
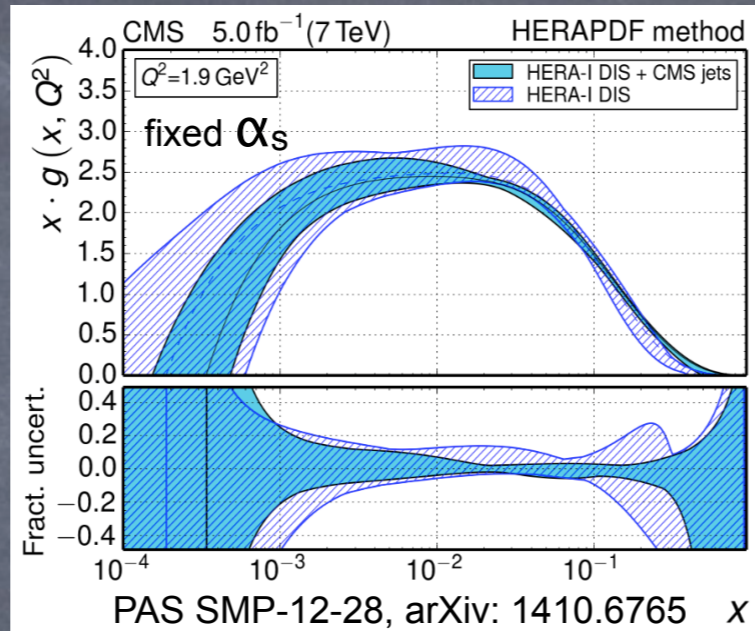
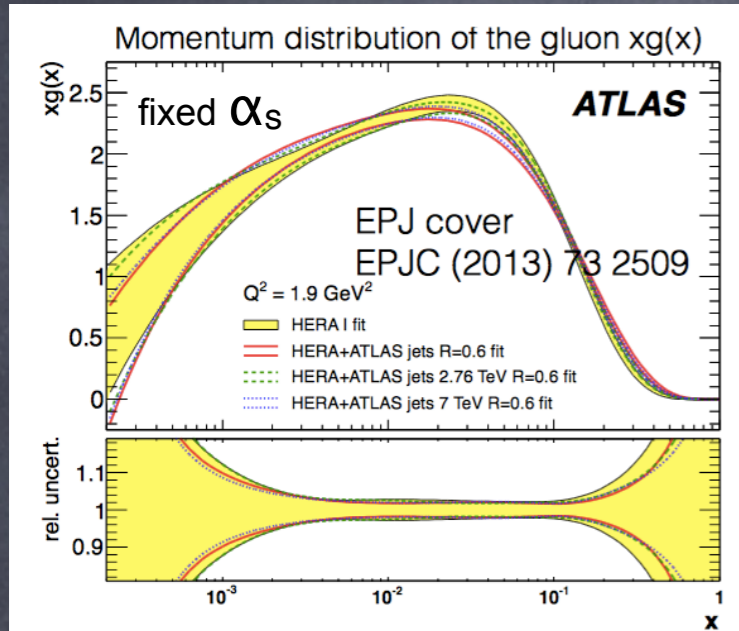


- + further processes...

Vision for Run II PDF constraints from LHC

Example: new constraints on gluon at medium & high x

(multi-) jets production in pp : gluon and quarks at medium x , strong correlation with α_s
 top-pair production in pp : gluon at high x , strong correlation with α_s and m_t



→ PDF, α_s , m_t fit at NNLO including jet and top-pair production cross sections :

- light quarks well constrained by HERA data and W-boson production at LHC 7 & 8 TeV
- jet measurements precise experimentally, need NNLO
- tt measurements at 13 & 14 TeV needed for stronger constraints
- need to understand, if there are correlations to be taken into account between ATLAS and CMS measurements for W, jet and top
- need agreement on phase space and object definition

Advantage of LHC SM Combinations for PDF fits

- identify correlations between different measurements at an early stage
- address consistency between experiments before inclusion into the PDF fit

Run II measurements from LHC would benefit from combination / combined fit to:

production cross sections of W, Z, DY, jets, top, W+charm

Issues: common phase space definition, final state measurement definition (parton/particle, born/dressed), non-perturbative QCD corrections, QED FSR, fragmentation assumptions

NB: particle-level measurements are in general preferred to parton-level measurements. However in most of the cases fast predictions for PDF fits are available only at parton level.

→ measurements sensitive to PDFs should be provided at both levels, or equivalently at particle level together with factors to correct the theory prediction from parton to particle (from born to dressed) level.

ATLAS and CMS Fora preparation for Run II

Discussions between ATLAS and CMS just started:

- Usage of PDFs in MC

- Harmonization of PDF-sensitive measurements:

start with available Run I data and include similar measurements by ATLAS, CMS and LHCb into PDF fits and start re-investigating the consistency between data sets and possible cross-correlations, work together where it is possible with the LHCC

→ learn what to improve for Run II.