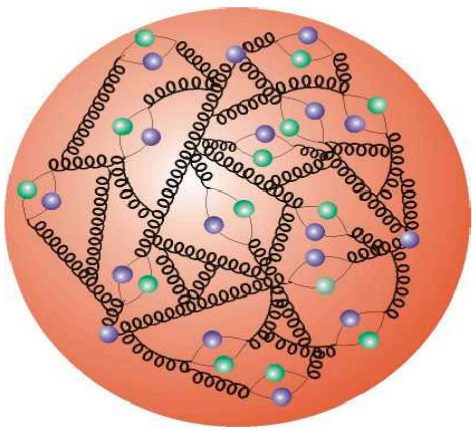
Proton Structure at the LHC: CMS

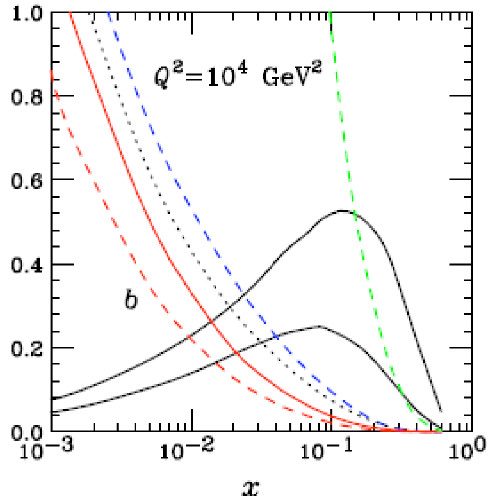
Albert De Roeck

IOP Meeting Cambridge

June 3rd 2009

Current picture of the proton





UNIVERSITY OF CAMBRIDGE 800 YEARS 1209 ~ 2009

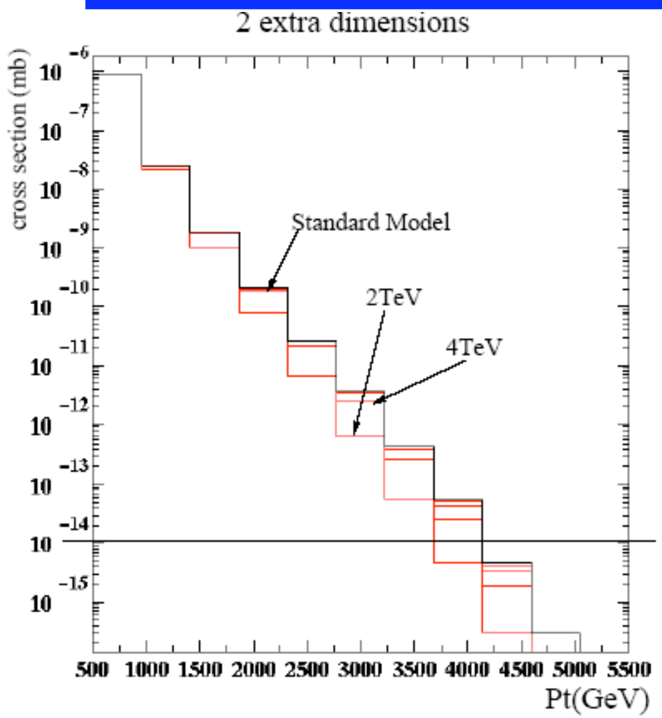
LHC & PDFs

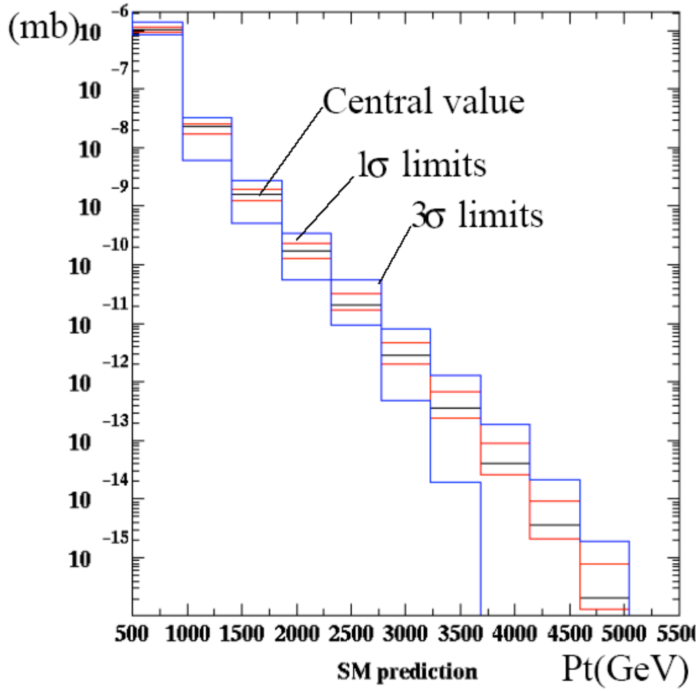
- Parton Distribution Functions are important at the LHC for
  - Discovery physics
  - Precision measurements
- In recent years the LHC community has become increasingly aware of the importance --and complications -- of PDFs, thanks to
  - Impressive progress in the PDF analysis/fitting area, made possible by lots of new precise data, and theory/phenomenology progress…
  - Detailed physics analyses carried out for the LHC (CMS PTDR, ATLAS CSC notes, LHCb,…) and feedback from the Tevatron (*)
  - Initiatives that focus on the central questions of the art of PDFs
    - E.g. the HERALHC workshop
      - and its spin-off PDF4LHC
    - DIS conference series…
    - Topical conferences, such as this one
- In all, we are getting in good shape for the initial LHC data, but still a lot to do

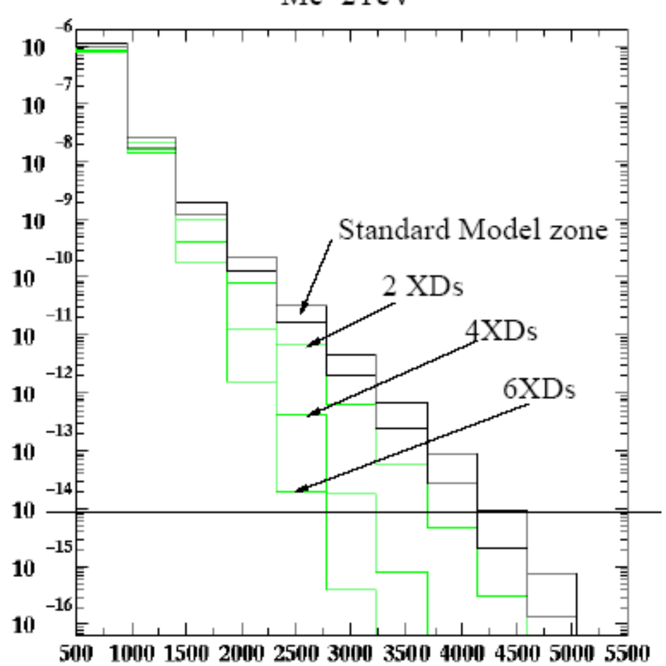
(*) And an increasing number of HERA people joining LHC

PDFs & Uncertainties: Eg Di-jet final state

Graviton exchange contributions reduce the cross section (interference)







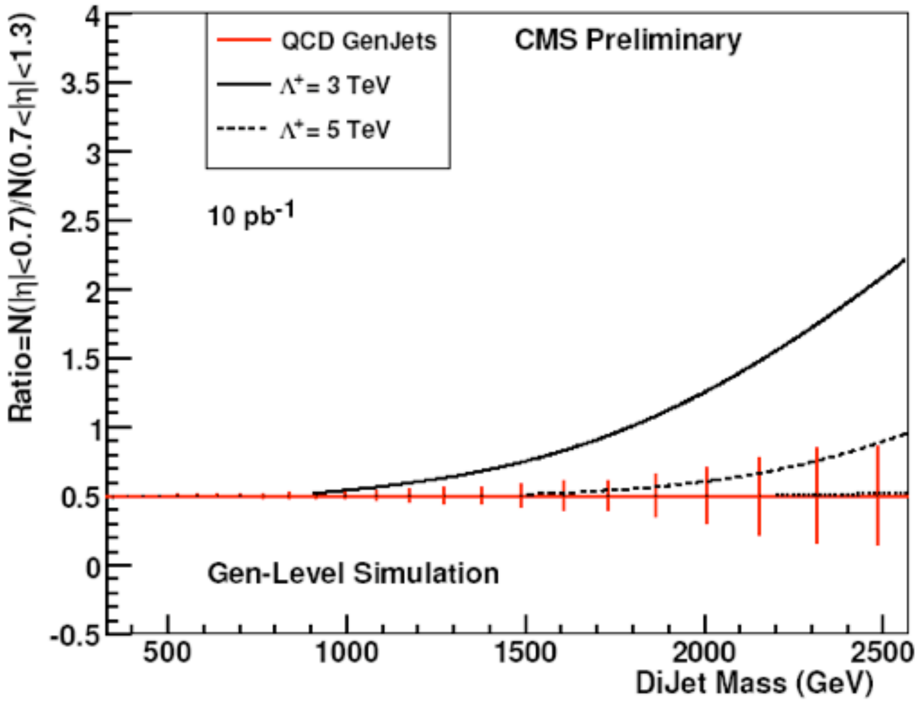
S. Ferrag/2004

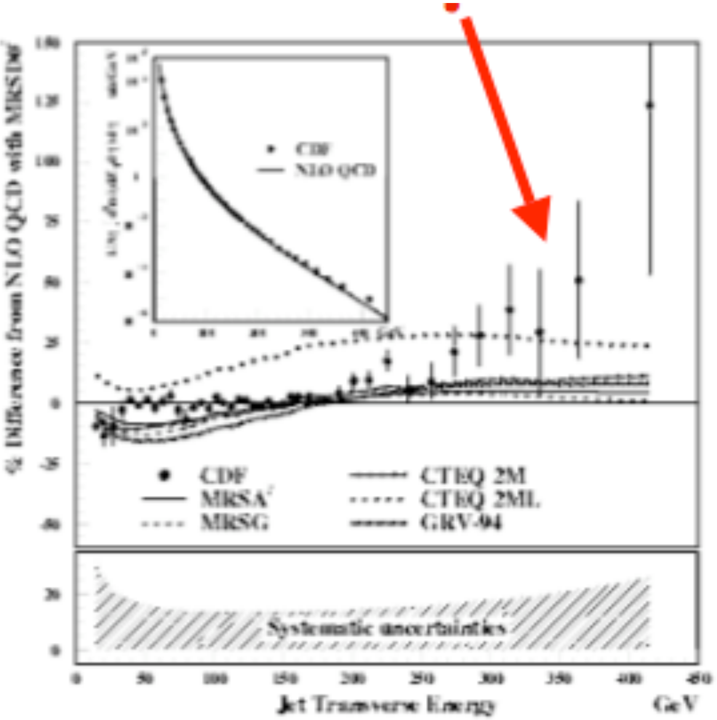
Reduction of the sensitivity due to PDF uncertainty (CTEQ6)

	2 extra-dimensions	4 extra-dimensions	6 extra-dimensions
Theoretically	5 TeV	5 TeV	5 TeV
including PDF uncertainties	< 2 TeV	< 3 TeV	< 4 TeV

The Fear Factor!

Dijet mass @ LHC





What if we see an unexpected rise at high mass/p_T...??

Can it be due to PDFs? People remember the 90's... ⇒PDF uncertainties!

Personal take: Understanding of the PDFs now quite different from mid-90's

PDF usage in CMS

- Standard mass production simulation (mostly QCD) now with CTEQ6L (this was CTEQ5L for the CMS PTDR in 2006)
- Recent years some reluctance to change too often PDFs due to
  - Connection with the underlying event descpription (UE)
  - Reproducability of results (validation) release by release. Software still changing to much in the experiment up to date.
  - Simulation productions are of the order of 500M events: long turn around for these samples, preparation phase…
- MRST/MSTW and more recent CTEQ versions used for special studies
- Next starting to look at the mLO PDFs (as implemented by Thorne and Sherstenev). These could become an option for production. A new UE tune will need to be made first (→ A Buckley, P.Skands…)
- Also NNPDFs are being considered for testing/not yet for production
- Note: no strong reason CMS has to stay with CTEQ/CT series for its entire life…

Connection with the Underlying Events

New PYTHIA 6.2 Tunes

Use LO α_s with Λ = 192 MeV!

NLO Structure Function!

Parameter	Tune DWT	ATLAS	Tune D6T	Tune QWT	Tune QKT
PDF	CTEQ5L	CTEQ5L	CTEQ6L	CTEQ6.1	CTEQ6.1
MSTP(2)	1	1	1	1	1
MSTP(33)	0	0	1	1	1
PARP(31)	1.0	1.0	1.0	1.0	1.8
MSTP(81)	1	1	1	1	1
MSTP(82)	4	4	4	4	4
PARP(82)	1.9409 GeV	1.8 GeV	1.8387 GeV	1.1237 GeV	1.9409 GeV
PARP(83)	0.5	0.5	0.5	0.5	0.5
PARP(84)	0.4	0.5	0.4	0.4	0.4
PARP(85)	1.0	0.33	1.0	1.0	1.0
PARP(86)	1.0	0.66	1.0	1.0	1.0
PARP(89)	1.96 TeV	1.0 TeV	1.96 TeV	1.96 TeV	1.96 TeV
PARP(90)	0.16	0.16	0.16	0.16	0.16
PARP(62)	1.25	1.0	1.25	1.25	1.25
PARP(64)	0.2	1.0	0.2	0.2	0.2
PARP(67)	2.5	1.0	2.5	2.5	2.5
MSTP(91)	1	1	1	1	1
PARP(91)	2.1	1.0	2.1	2.1	2.1
PARP(93)	15.0	5.0	15.0	15.0	15.0

UE Parameters

K-factor (T. Sjostrand)

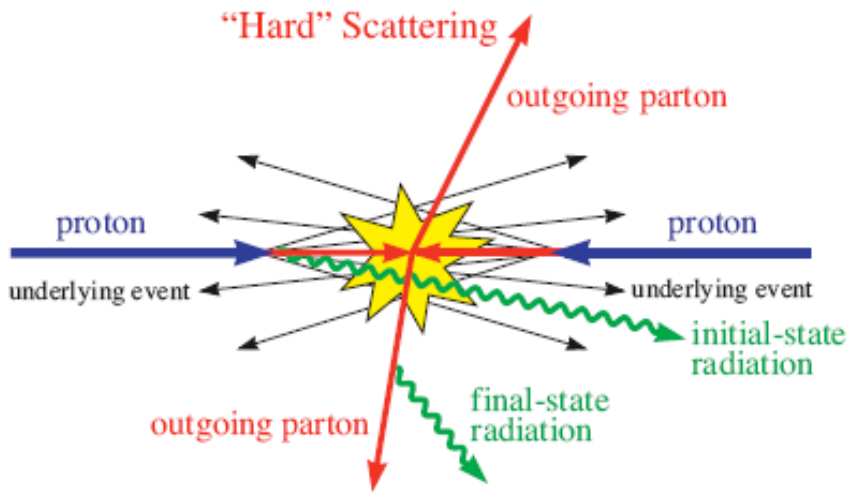
ATLAS energy dependence!

ISR Parameter

Intrinsic KT

R. Field '07

New PDFs need a new tune of the UE parameters to the available data



Can change particle production in 'away' regions by 10-30%

PDF Uncertainties

- Now: Calculated with the 40 CTEQ6M series
  - Calculate the asymmetric uncertainties

$$\Delta\sigma^{+}_{\mathrm{PDF}} = \sqrt{\sum_{i=1}^{n}\left(\max\left[\sigma(\delta_k^{+})-\sigma(\delta_0),\sigma(\delta_k^{-})-\sigma(\delta_0),0\right]\right)^2}$$

$$\Delta\sigma^{-}_{\mathrm{PDF}} = \sqrt{\sum_{i=1}^{n}\left(\max\left[\sigma(\delta_0)-\sigma(\delta_k^{+}),\sigma(\delta_0)-\sigma(\delta_k^{-}),0\right]\right)^2}$$

- A lot of questions on the uncertainty determination of PDFs
  - Offset ↔Hessian, tolerance in $\Delta\chi$ etc…?
- Looks like one of the most important issues to settle further
  - Eg a session at the PDF4LHC study like this week

13:45	MC vs Hessian way of computing uncertainties (15') (Slides)	Stefano Forte (*Univ. + INFN*)
14:00	MSTW uncertainties (20') (Slides)	Robert Thorne (*UCL*)
14:20	PDF uncertainties (20') (Slides)	Jon Pumplin (*Michigan State University*)
14:40	Uncertainties using LHCb pseudo data (15') (Slides)	Ronan McNulty (*University College Dublin*)
14:55	Comparing CTEQ errors with the ones of NNPDFs (15') (Slides)	Manuela Venturi (*INFN and Univ. Roma Tor Vergata*)
15:10	Discussion on uncertainties (20')	

LHC PDF Study Group

Request at the 2006 HERA-LHC workshop

NEED A JOINT EFFORT OF THEORISTS AND LHC EXPERIMENTALISTS:

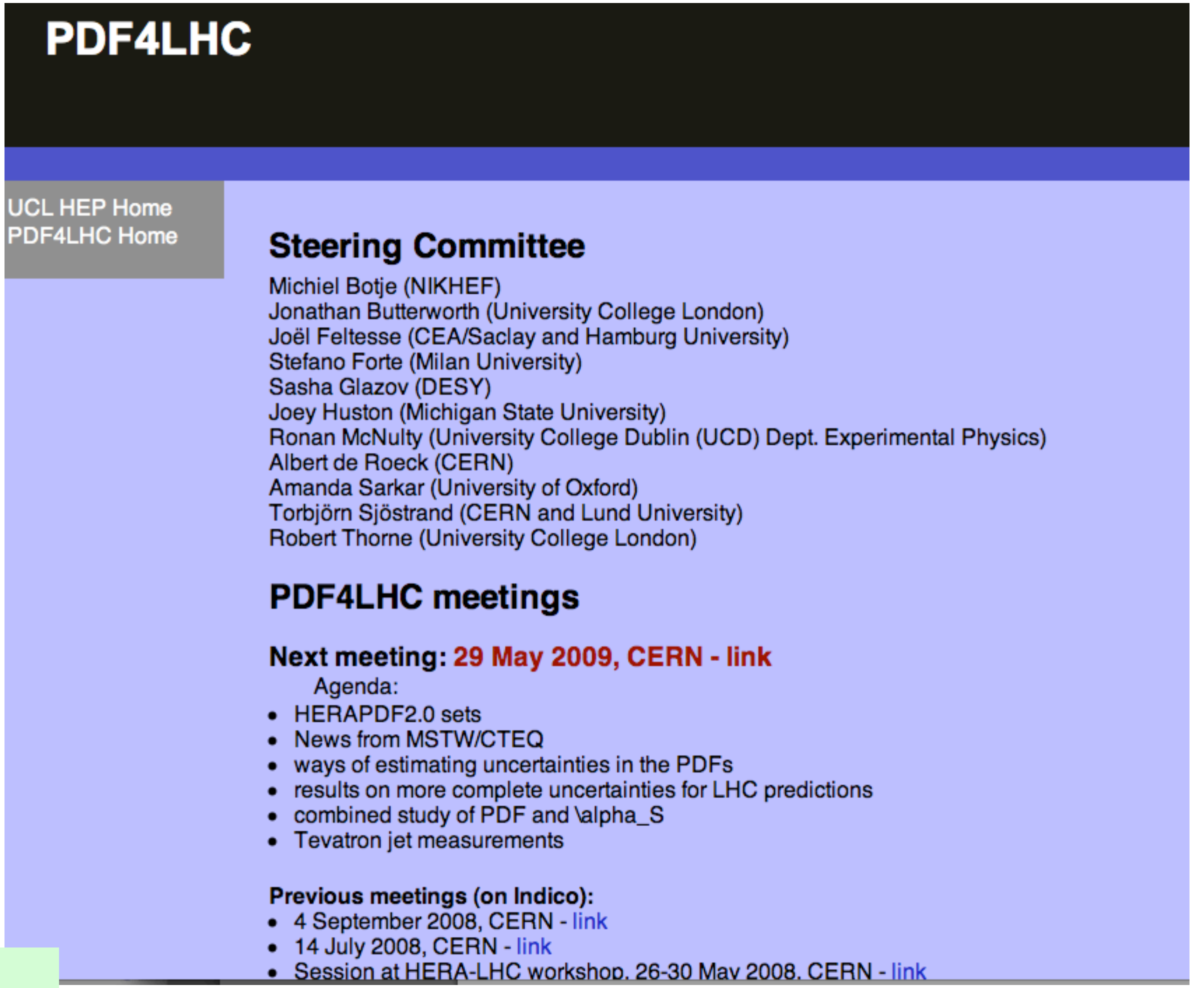
- WHICH PRECISION MEASUREMENTS ARE LIMITED BY PDFS?
- WHEN DOES LACK OF PDF KNOWLEDGE HIDE/SIMULATE NEW PHYSICS?
- HOW CAN LHC MEASUREMENTS IMPROVE PDF DETERMINATION?

Idea for an "PDF4 LHC" forum

- Aim to get at the "best" possible PDF(s) + error bands and uncertainties based on present fits and -selected- data (with PDF fitters) for the LHC
- Use future LHC data to improve PDFs. Needs close collaboration with theory colleagues (do we measure what the calculate, NLO, scales…?)
- Includes present and LHC experiments, PDF fitting groups, theory…
- Public meetings as of early 08

PDF4LHC

An organized forum for PDF discussions



Next meetings:
- August first half (CERN-TH institute)
- October 23 DESY

http://www.hep.ucl.ac.uk/pdf4lhc/

HERALHC PDF Report

SUMMARY REPORT FOR THE HERA - LHC WORKSHOP PROCEEDINGS
WORKING GROUP I: PARTON DISTRIBUTIONS

arXiv:0901.2504

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Abstract

We provide an assessment of the state of the art in various issues related to experimental measurements, phenomenological methods and theoretical results relevant for the determination of parton distribution functions (PDFs) and their uncertainties, with the specific aim of providing benchmarks of different existing approaches and results in view of their application to physics at the LHC.

We discuss higher order corrections, we review and compare different approaches to small x resummation, and we assess the possible relevance of parton saturation in the determination of PDFS at HERA and its possible study in LHC processes. We provide various benchmarks of PDF fits, with the specific aim of studying issues of error propagation, non-gaussian uncertainties, choice of functional forms of PDFs, and combination of data from different experiments and different processes. We study the impact of combined HERA (ZEUS-H1) structure function data, their impact on PDF uncertainties, and their implications for the computation of standard candle processes, and we review the recent F_L determination at HERA. Finally, we compare and assess methods for luminosity measurements at the LHC and the impact of PDFs on them.

Plans for a similar report from PDF4LHC

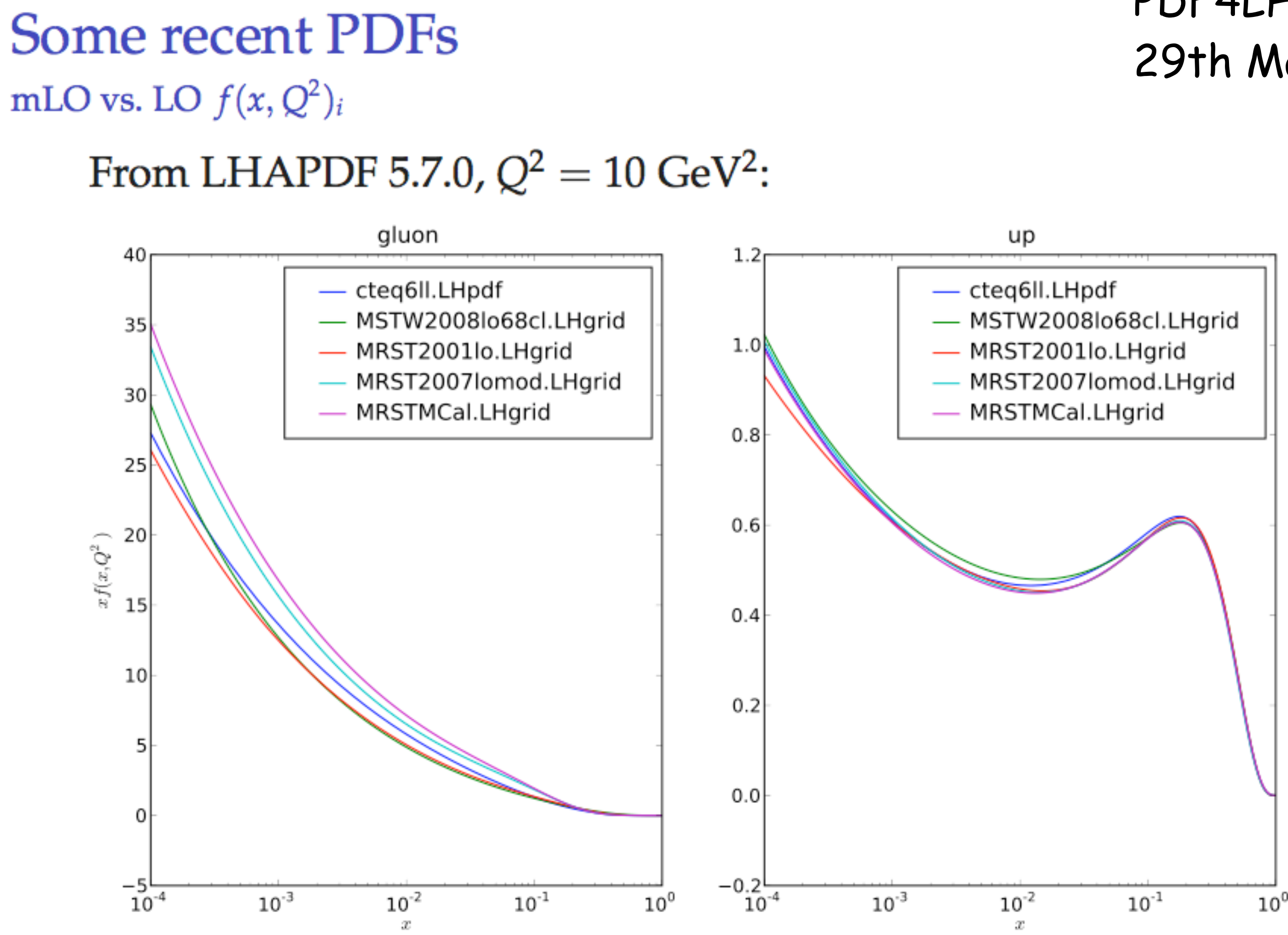
PDF4LHC Study Group

- LHC physics will need good PDFs… as good as we can get it, especially for precision measurements, setting of limits, even discoveries…
- Ideally ATLAS and CMS (and LHCb and ALICE) analyses will follow the same procedure for using PDFs. Such procedure is being put in place for other areas, eg significance estimates.
  - Note that changing PDFs often or for cross checks is non-trivial (connection with UE studies/parameter choices etc…)
- LHC studies will need PDFs AND a good estimate of the uncertainties.
- This advice should come from a group which has that authority.
  - CERN, LHC experiments seem keen on having such a group
- As a second goal this should be also a forum for discussions on how to include measurements from the LHC to constrain PDFs. Expect this can already happen with rather early data. Need to prepare for that well in time.

LHAPDF

In CMS: Legal code uses the LHAPDF Library ☺ !!

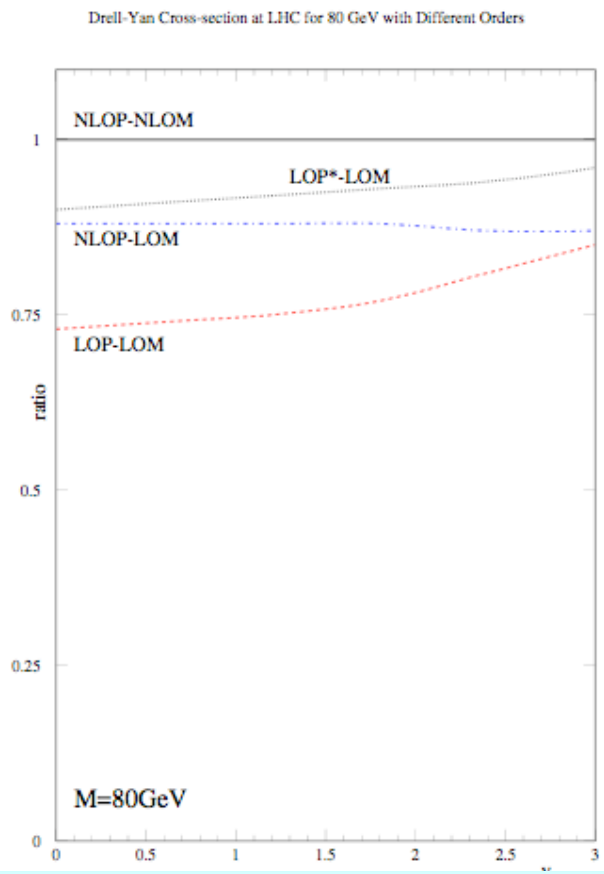
A. Buckley
PDF4LHC meeting
29th May 09



Modified LO PDFs for MC Generators

Thorne, Sherstenev

For LHC LO* partons lead to shape of comparable quality as NLO partons. Normalization better.



LO parton distributions with RELEASED momentum sum rule and NLO α_s
Blasphemy? Maybe not..

Consider first $Z \to \mu^+\mu^-$ production at the LHC with $p_T > 10\text{GeV}$ and $|\eta| < 5$

NLO(ME)$\otimes$ NLO(pdf)$= 2.40nb$.

LO(ME)$\otimes$ LO(pdf)$= 1.85nb$.

LO(ME)$\otimes$ NLO(pdf)$= 1.98nb$.

LO(ME)$\otimes$ LO*(pdf)$= 2.19nb$.

With very similar relative results for $W \to \nu\mu$, i.e.

NLO(ME)$\otimes$ NLO(pdf)$= 21.1nb$.

LO(ME)$\otimes$ LO(pdf)$= 17.5nb$.

LO(ME)$\otimes$ NLO(pdf)$= 18.6nb$.

LO(ME)$\otimes$ LO*(pdf)$= 20.6nb$.

Seems to work…
In December '08 CMS decided to look into these
Tune for UE required

Tunes for Modified LO PDFs

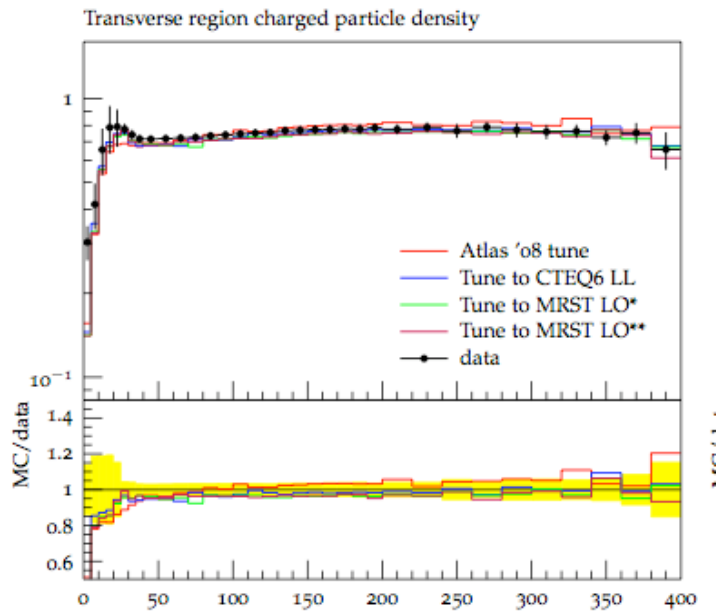
Tune to CDF/D0 data using RIVET/PROFESSOR

A. Buckley
PDF4LHC meeting
29th May 09

Tune parameters compared

Absolute values

Param		Atlas tune	Professor tunes CTEQLL	Professor tunes LO*	Professor tunes LO**
PARP(64)	ISR α_s scale	1.0	0.89	0.92	0.97
PARP(71)	FSR max virt.	4.0	1.72	1.29	1.20*
PARP(78)	FS colour reconn.	0.3	0.17	0.14	0.13
PARP(79)	Remnant x enh.	2.0	1.10	1.11	3.69
PARP(80)	Remnant cnctn.	0.1	———	0.01	———
PARP(82)	MPI $p_{\perp 0}$	2.1	1.83	2.10	2.28
PARP(83)	Matter overlap 1	0.8	1.72	1.68	1.67
PARP(84)	Matter overlap 2	0.7	———	N/A	———
PARP(89)	MPI reg ref scale	1800	———	1800	———
PARP(90)	MPI reg power	0.16	0.20	0.20	0.21
PARP(91)	$k_\perp$ width	2.0	1.85	2.15	2.11
PARP(93)	$k_\perp$ cutoff	5.0	6.86	6.79	5.08



CMS is interested in such tunes...

PDF4MC

Discussions that came up during the workshop:

- What PDFs to use in Monte Carlo Generators (with LO Matrix elements)?
- Neither LO nor NLO seem to be ideal/adequate ⇒ ideas:
  - New LO PDFs relaxing momentum sum rule
  - NLO for hard process and LO for showering
  - Special PDFs for MC generators: PDF4MC

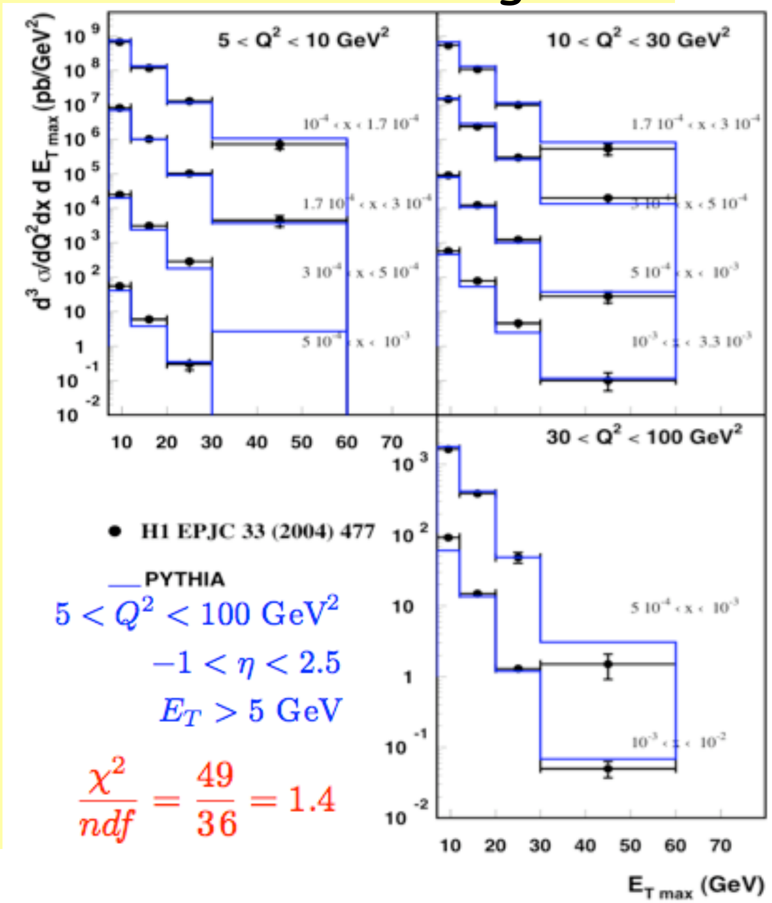
- Use MC predicted cross sections starting eg from CTEQ at low scale and evolve evt. by evt.

  ⇒ Consistent with initial and final state radiation of the MC

  ⇒ for every generator version one needs a (different) PDF

Alliance Analysis Center PDF group effort?

H. Jung



PDFs: What can the LHC do?

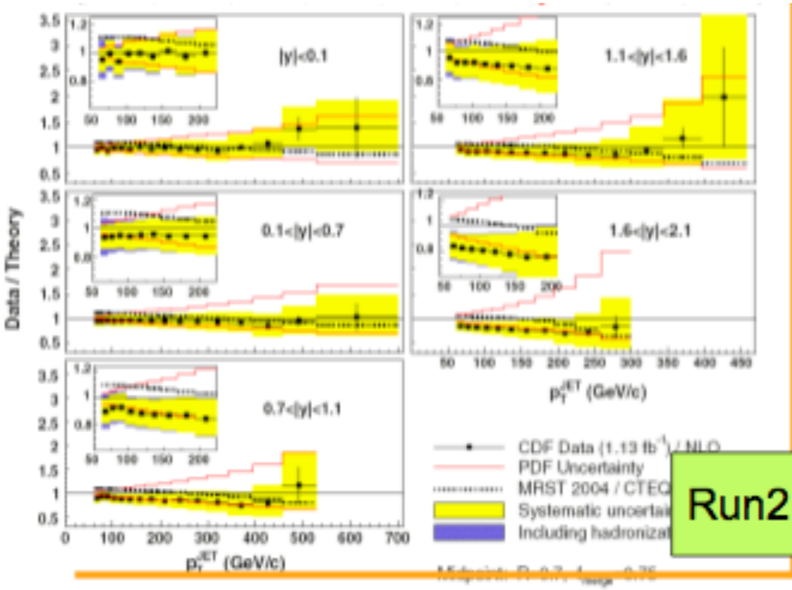
- Next: how can the LHC contribute to provide input for the PDFs
- Activities/plans in CMS
  - Hard scattering process
    - W,Z production/asymmetries
    - Dijet production
    - Prompt photon production (NOT used in PDF fits so far/initial KT problems. LHC?)
    - Drell Yan production
    - B and other heavy flavour cross sections
    - (Top cross sections)
  - Other ideas
    - Z-shape/tails: sensitivity to the PDFs
    - Z+jets
    - Perhaps do not need PDFs but parton luminosities (Dittmar et al. 07)

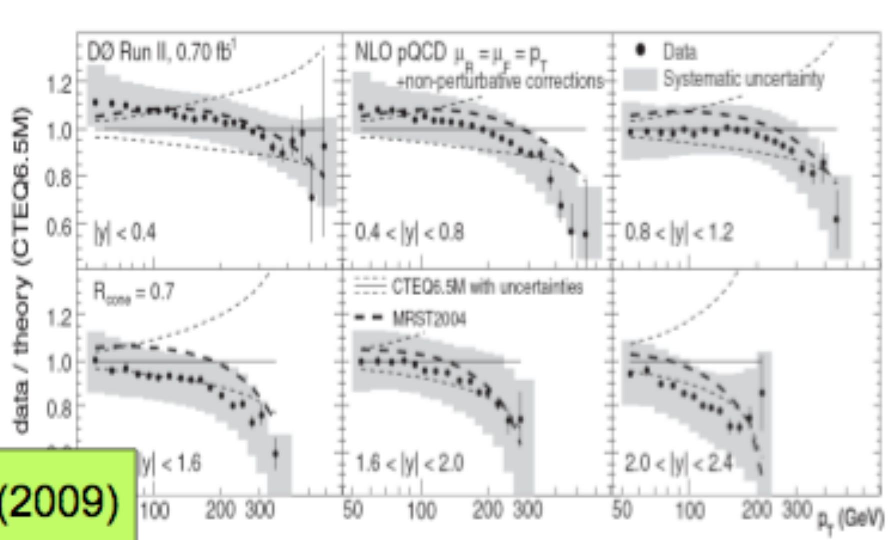
Jet Results at the Tevatron

J. Pumplin/ PDF4LHC workshop

CDF_I Wt	CDF_I χ^2	$D0_I$ Wt	$D0_I$ χ^2	CDF_{II} Wt	CDF_{II} χ^2	$D0_{II}$ Wt	$D0_{II}$ χ^2	$\Delta\chi^2$ non-jet
0	55.4	0	115.3	0	99.5	0	134.0	0.0
1	52.6	1	47.0	0	105.6	0	138.3	11.8
0	56.6	0	82.2	1	85.6	1	124.1	6.2
1	52.1	1	59.4	1	88.5	1	121.5	9.6
1	54.8	1	58.8	10	80.3	10	120.0	39.4
10	53.1	10	38.6	1	102.6	1	142.3	21.9
10	51.6	10	49.7	10	82.8	10	120.9	39.6
1	59.6	1	67.5	10	75.2	1	130.9	32.0
1	50.6	1	60.0	1	93.0	10	116.5	20.6

Jet measurements come of age…!!
RunII data consistent
Some tension between the data sets from the experiment (J. Pumplin)





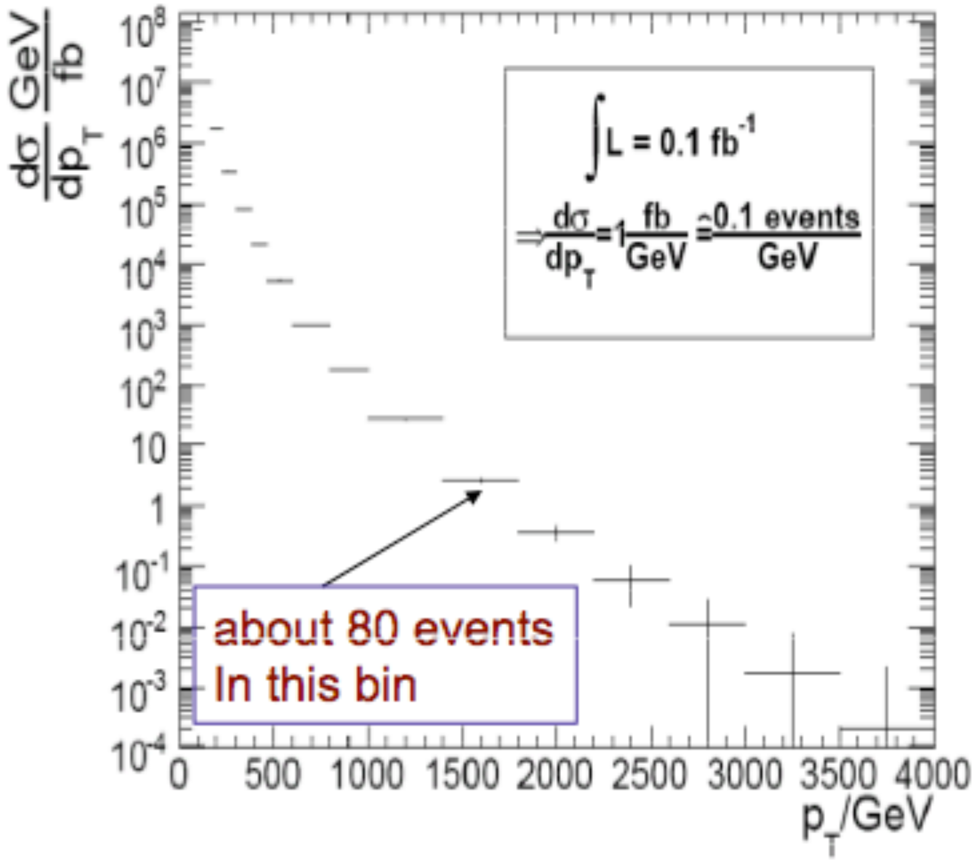
Run2 (2009)

Jet Cross Sections at LHC Startup

100 pb^{-1}

- We will have quickly a measurement of the Jet cross section with good statistical precision…

- … however, the Jet Energy Scale is a concern …

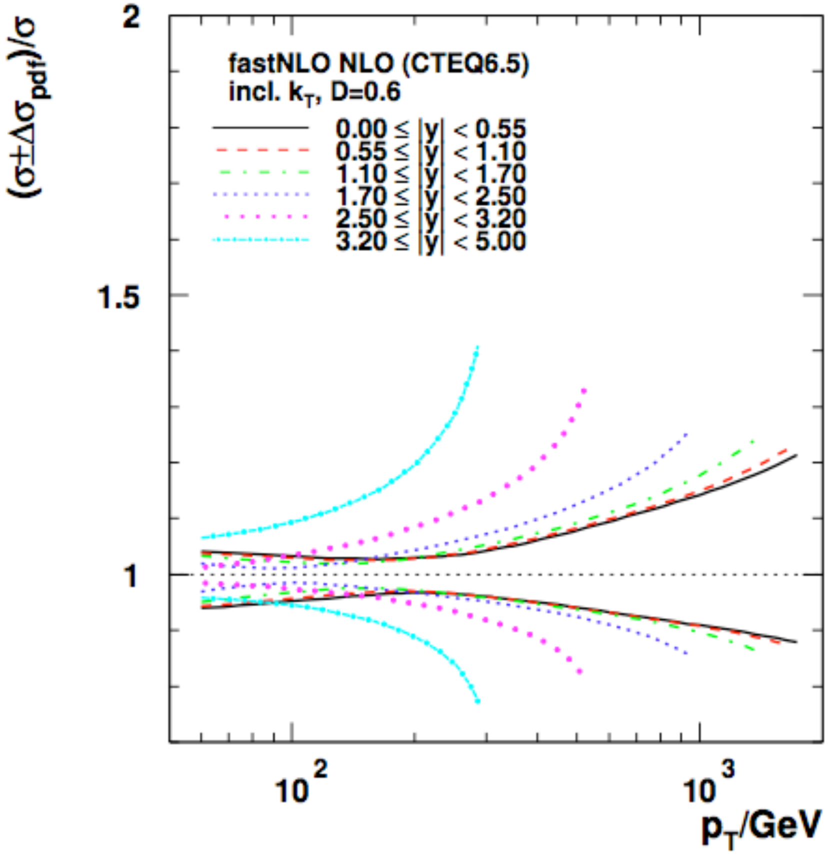


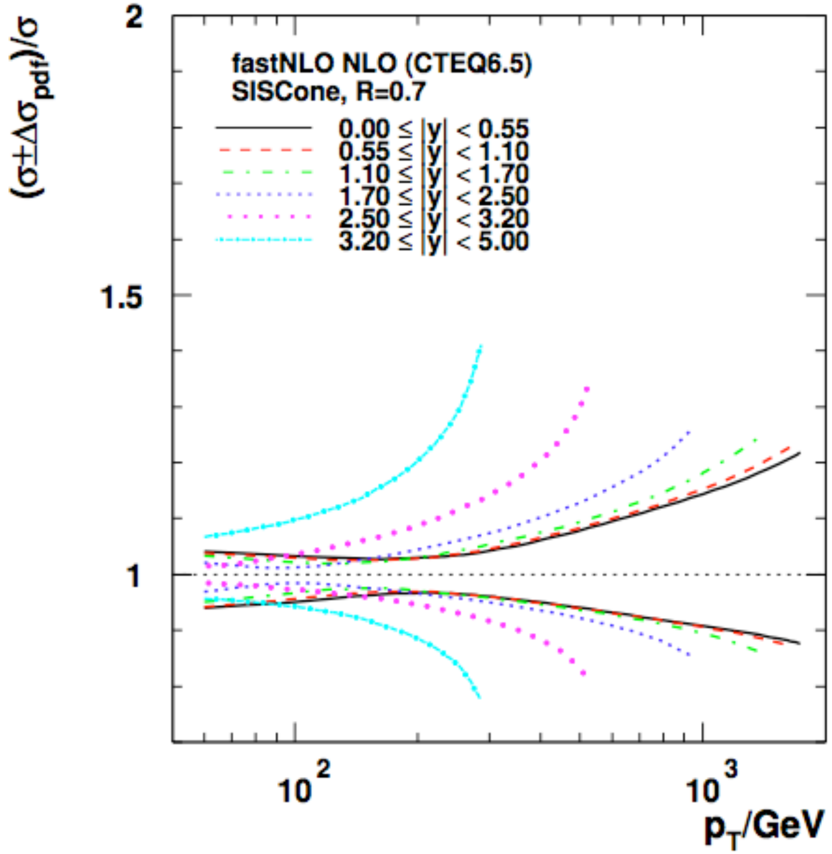
For PDF study input: Need all systematic shifts for all error sources…

Relative PDF uncertainties

Inclusive Jets NLO all rapidity, kT algorithm/SISCone

LHC 10 TeV

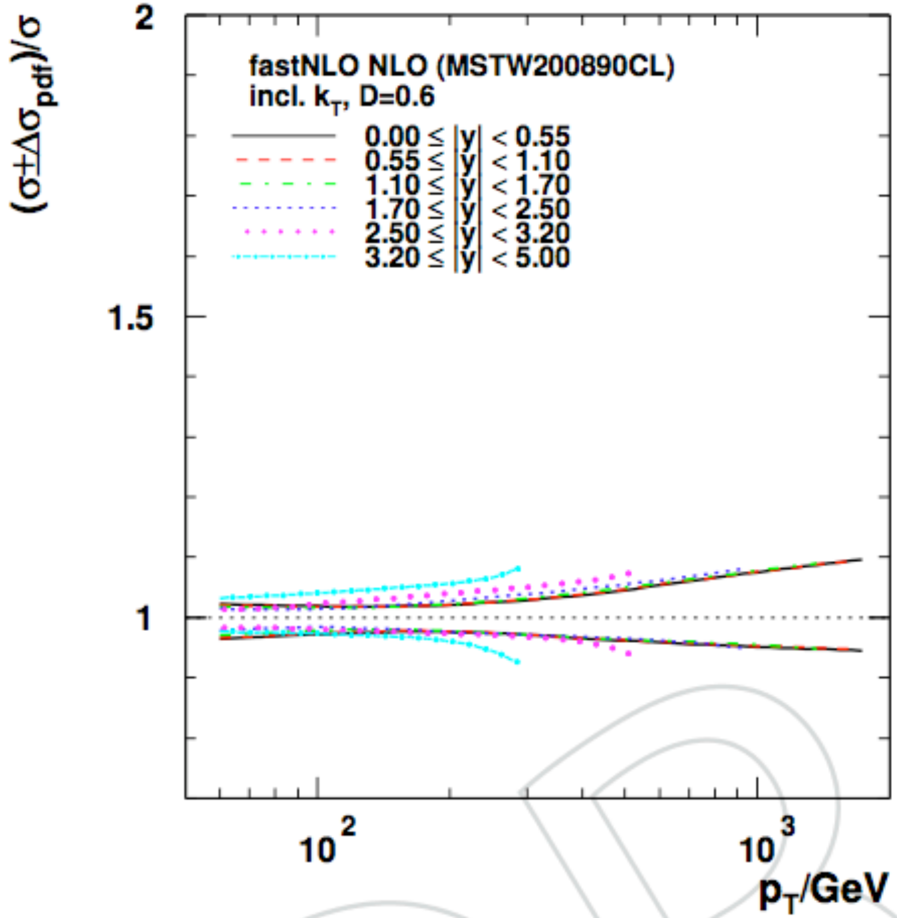


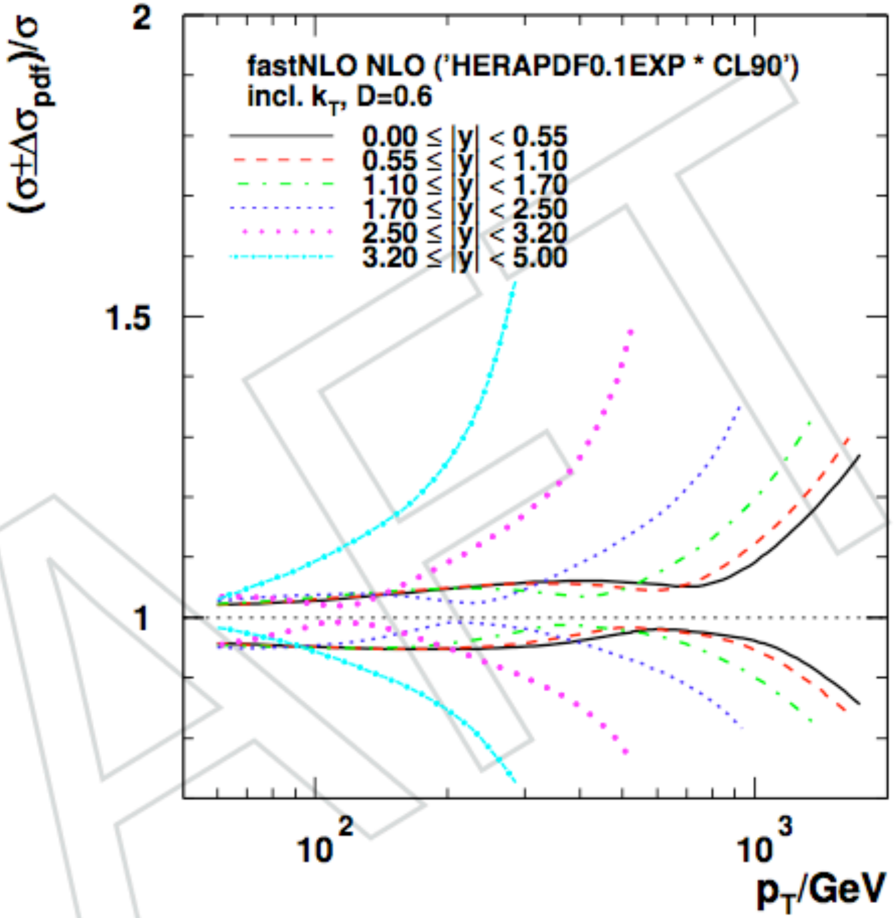


M. Heinrich, A. Oehler, K. Rabbertz NLOJET++

Relative PDF uncertainties

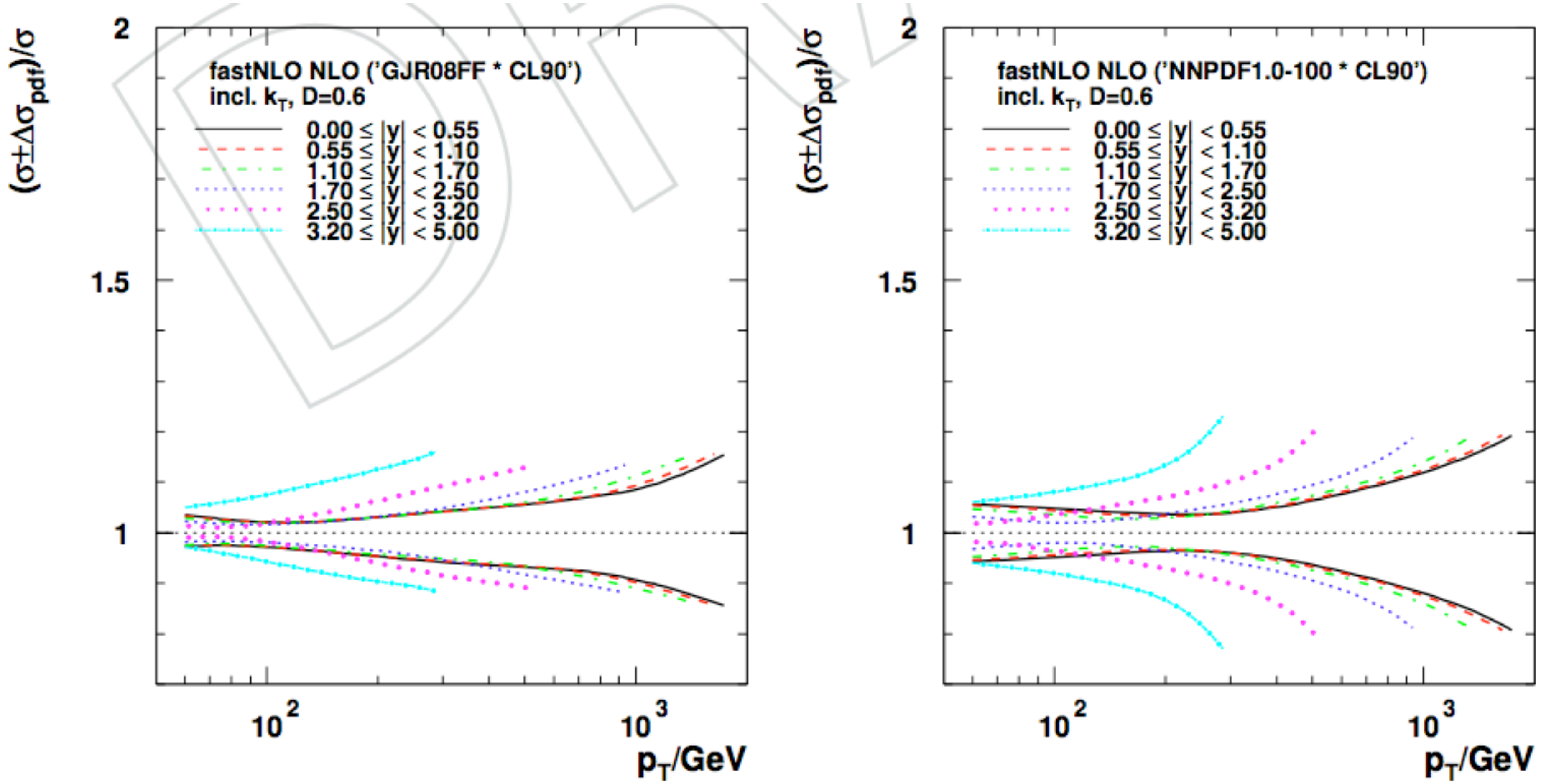
Inclusive Jets NLO all rapidity, kT algorithm





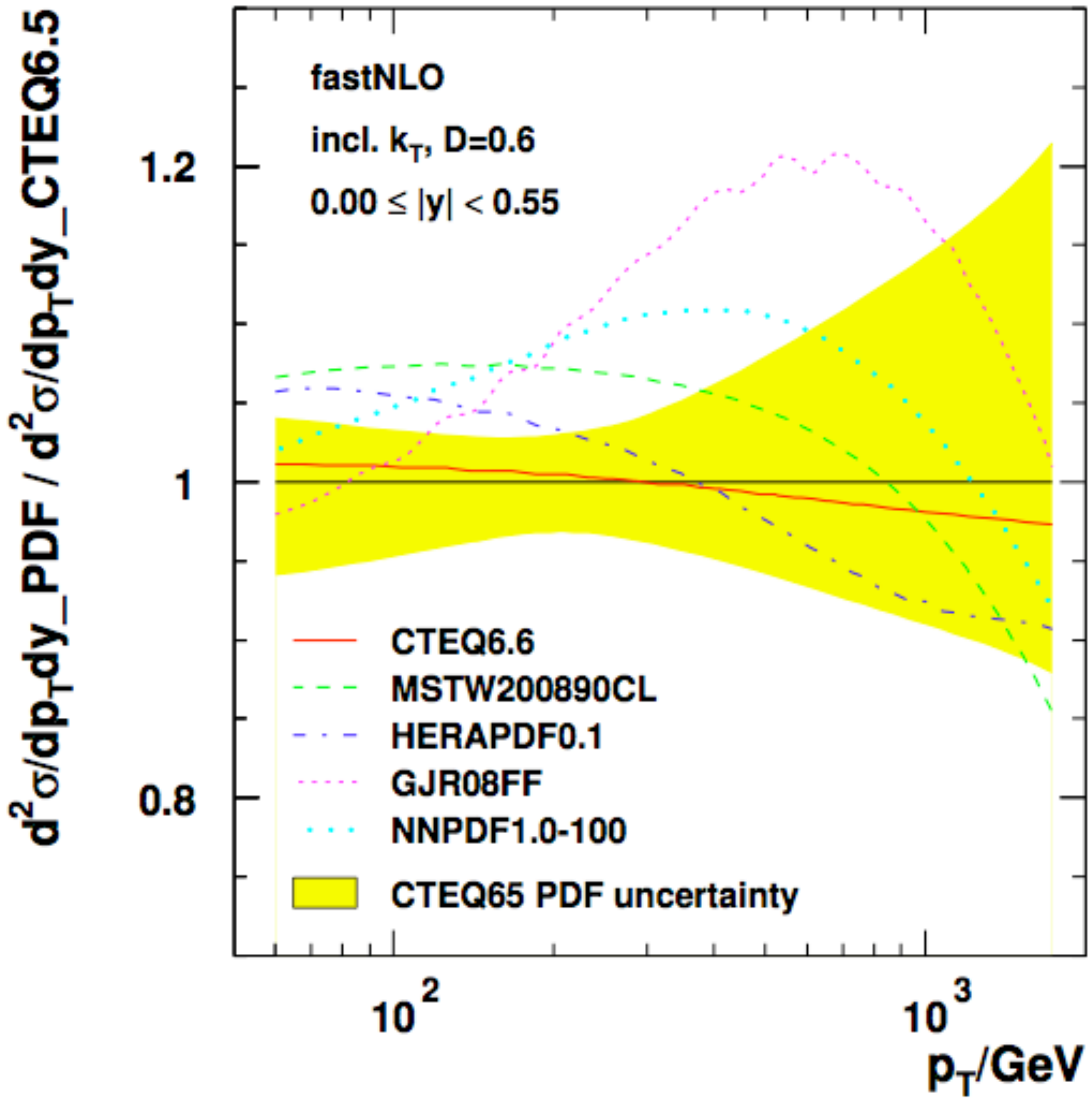
Relative PDF Uncertainties

Inclusive Jets NLO all rapidity, kT algorithm



Jets and PDFs

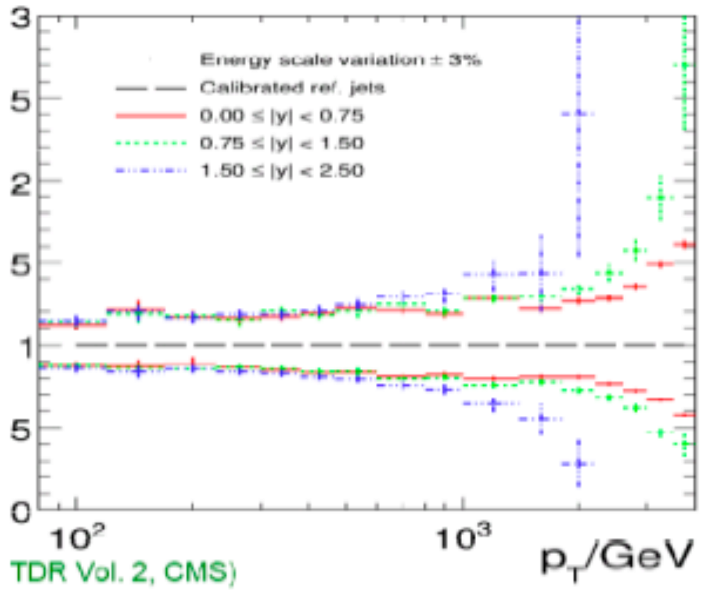
LHC 10 TeV



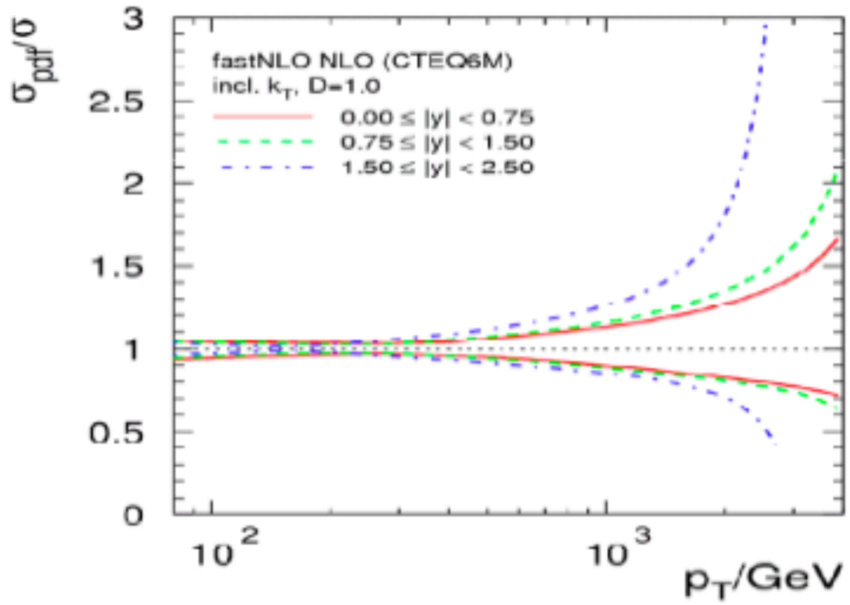
Jets & PDFs

The issue : Jet Energy Scale

Variation of JES (±3%)

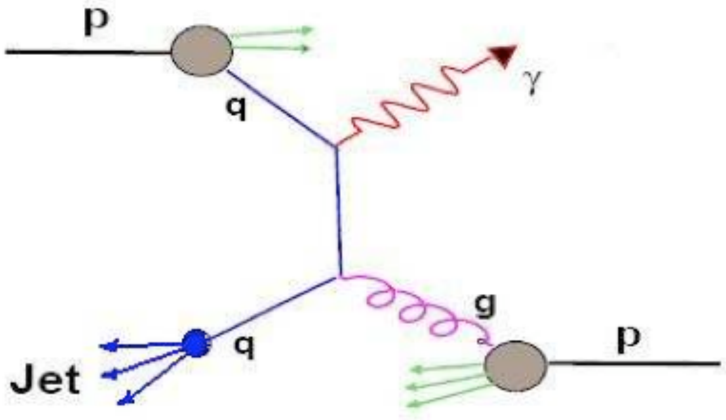


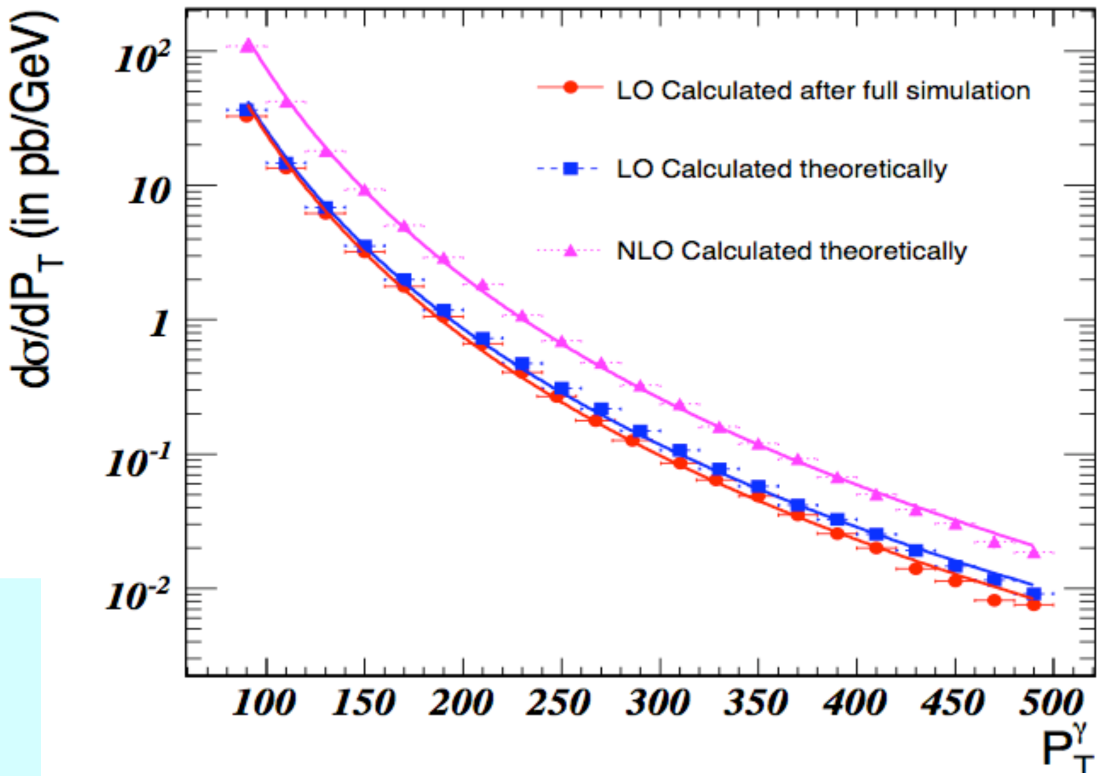
PDFs (CTEQ6.1) in NLO



… long way before arriving at 3% in JES … expect to start at ~ 10%

Photon + Jet Events





Interesting process for direct access to the gluon
However present data not really used in PDF fits. Higher p_T needed?

Measurement prospect with 1 fb^{-1}. Stat errors only

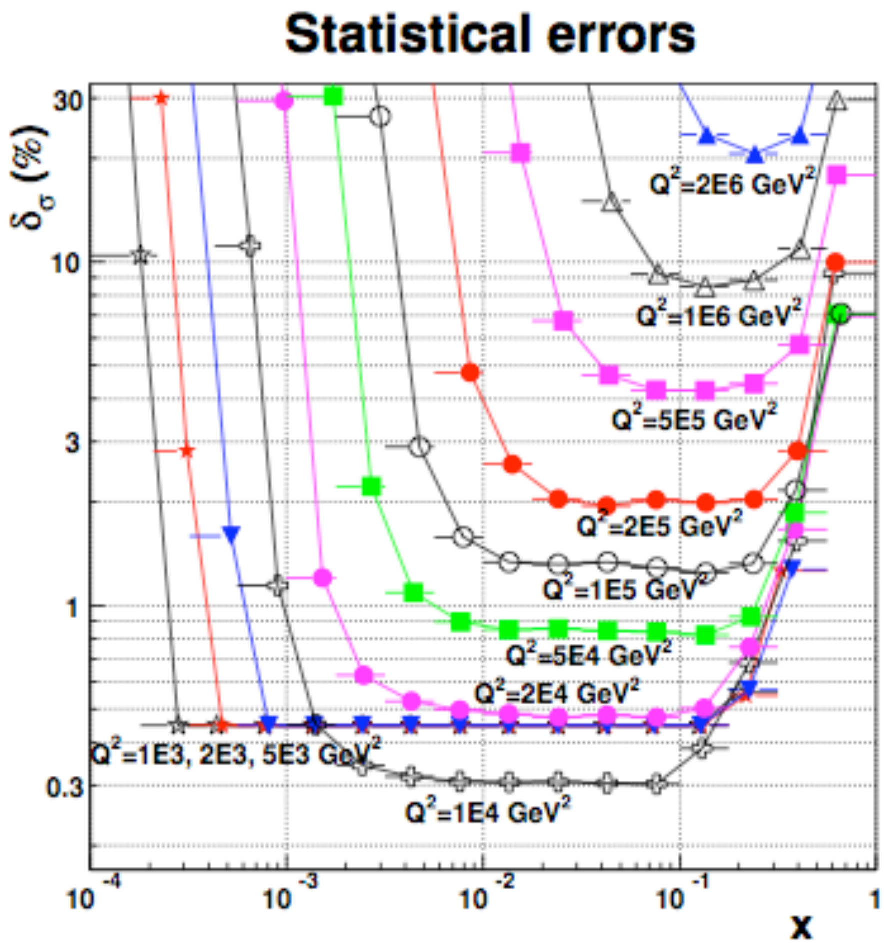
Can LHC high p_T photon data be used for PDFs?

Kinematic Reach and Statistical Precision

Photon + jet data at 14 TeV

Initial studies…
(Workshop plot/generator)

20 fb^{-1}



For $Q^2 = 1000$ **-** $1000\,000\,GeV^2$**:** $\delta_\sigma^{min} = 0.3$ **-** 8%**.**

$\delta_\sigma^{min} < 10\%$ **at:** $x^{max} = 0.7$ **and**

$x^{min} = 0.0004$ **-** 0.1 **for** $Q^2 = 1000$ **-** $1000\,000\,GeV^2$

$\Longrightarrow$ **kinematical region for PDF measurement:** $10^3 < Q^2 < 10^6\,GeV^2$,

$2 \cdot 10^{-4} < x < 0.7$.

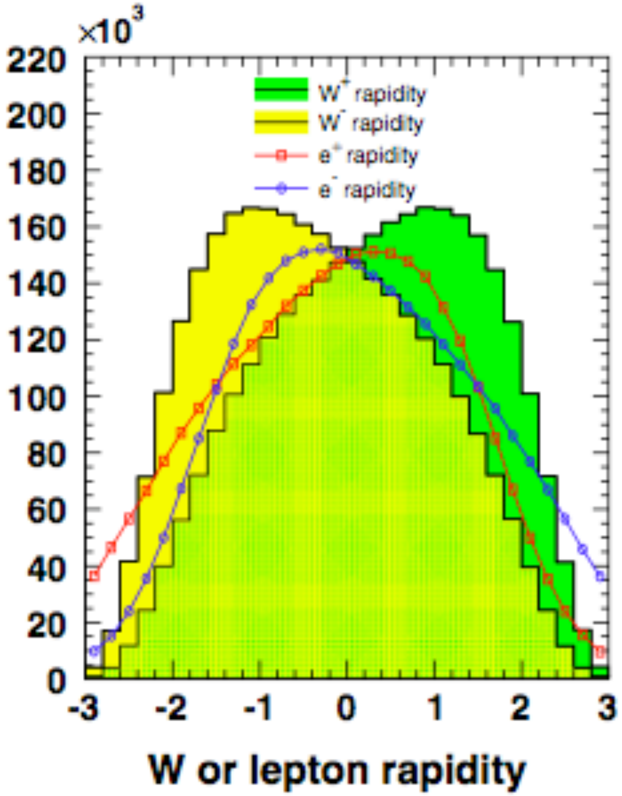
W Charge Asymmetry

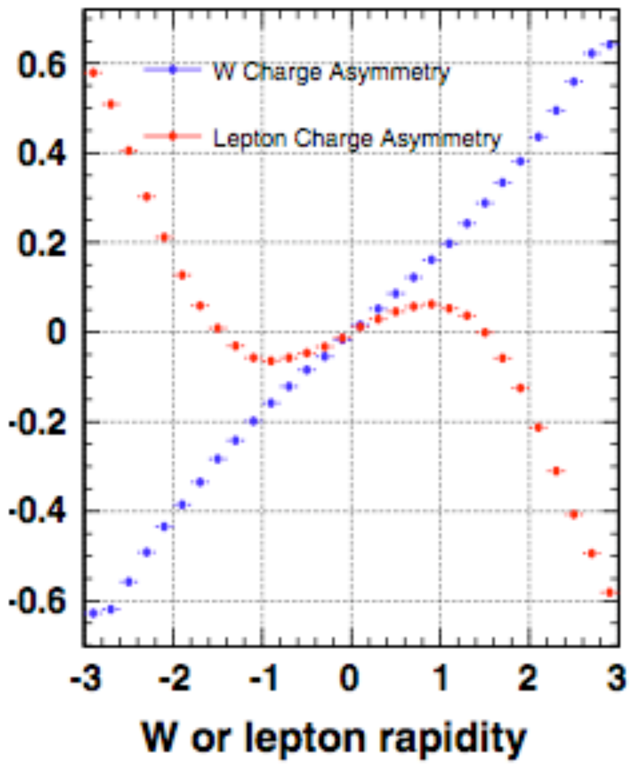
$$A(y) = \frac{d\sigma^+/dy - d\sigma^-/dy}{d\sigma^+/dy + d\sigma^-/dy} \approx \frac{d/u(x_1) - d/u(x_2)}{d/u(x_1) + d/u(x_2)}$$

u quarks carry on average larger momentum than d quarks. The W^+ is preferentially boosted along proton direction.

⇒ PDFs

Tevatron

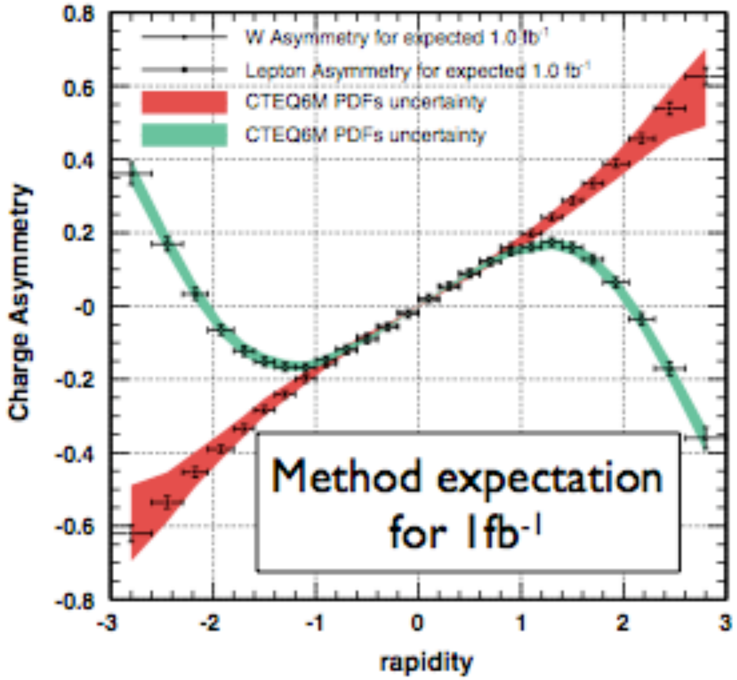


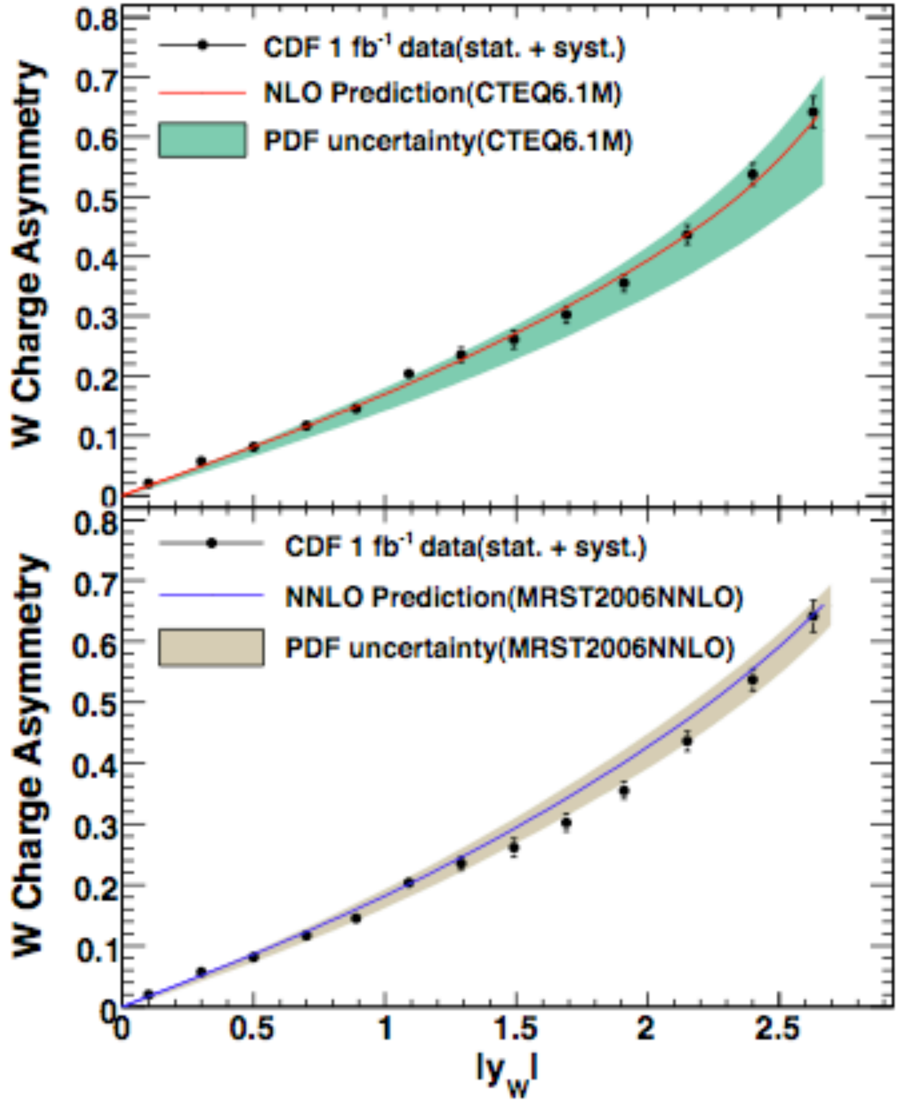


The W charge asymmetry is translated into a lepton charge asymmetry – albeit watered down by the V–A structure of the decay.

W Charge Asymmetry

Increased sensitivity to PDFs



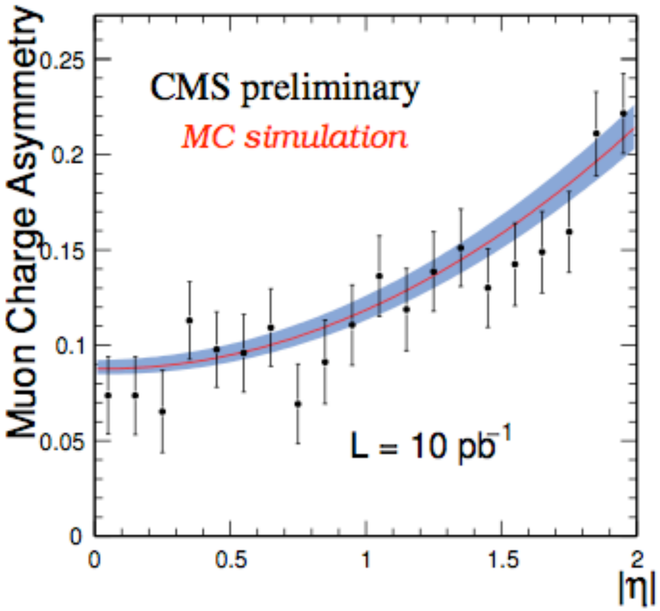


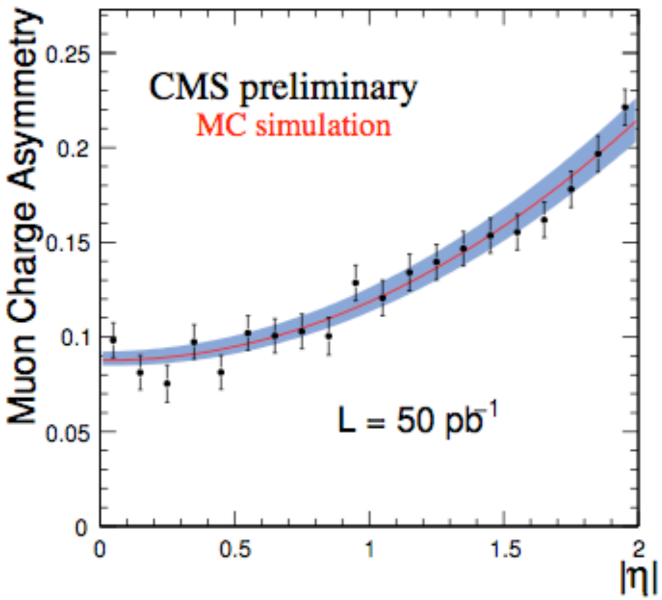
Results:

compare with CTEQ 6.1 (NLO)

and MRST2006 (NNLO)

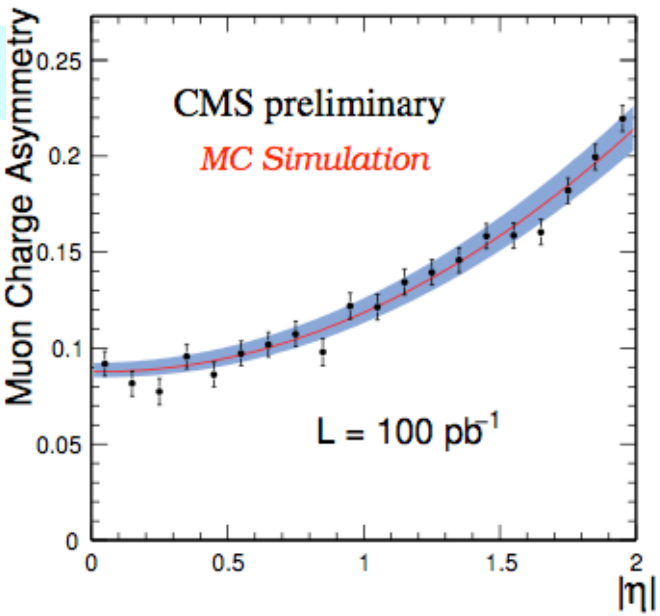
Muon Charge Asymmetry: Expected Precision





For different values of early luminosity

p_T muon >25GeV/c

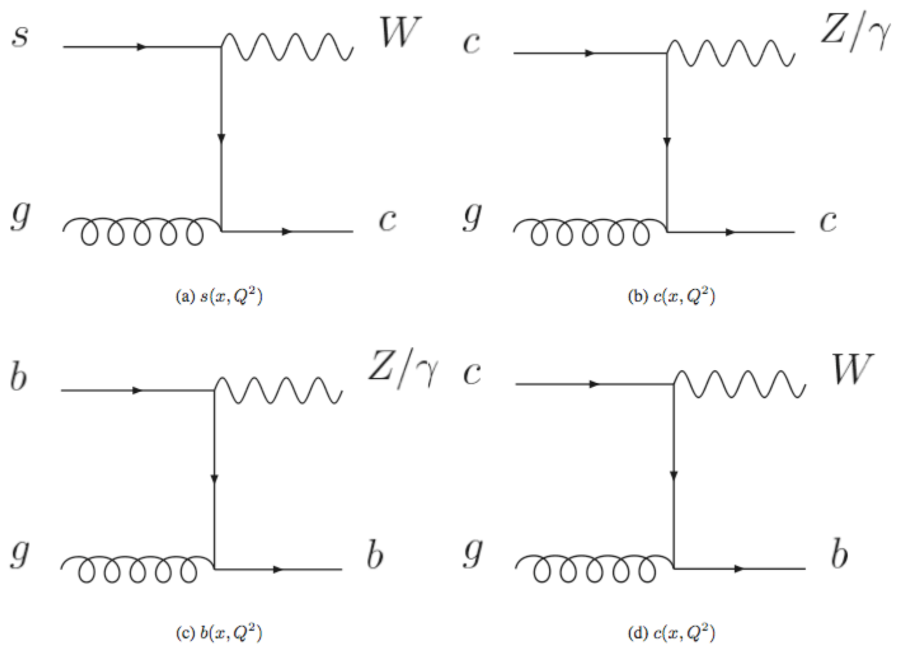


$$A(\eta) = \frac{\frac{d\sigma}{d\eta}(W^+ \to \mu^+\bar{\nu}_\mu) - \frac{d\sigma}{d\eta}(W^- \to \mu^-\nu_\mu)}{\frac{d\sigma}{d\eta}(W^+ \to \mu^+\bar{\nu}_\mu) + \frac{d\sigma}{d\eta}(W^- \to \mu^-\nu_\mu)}$$

Statistical uncertainties only but Systematic uncertainties are small

Other Processes for information on PDFs

Vector boson + associated heavy flavor production

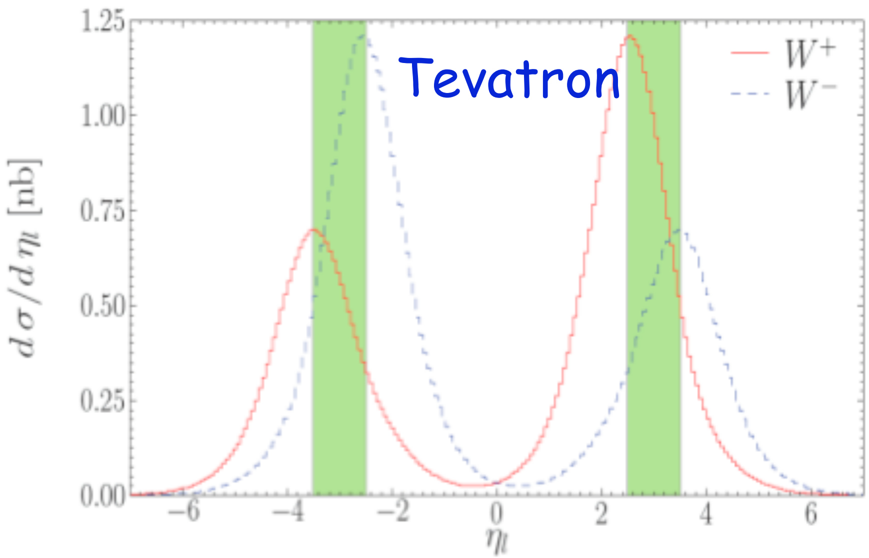


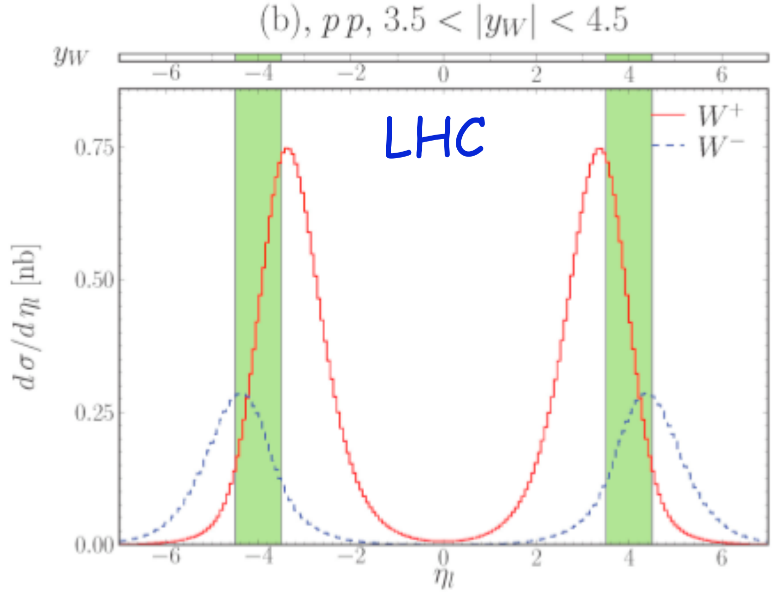
Low mass Drell-Yan production → Low x parton region (10^{-6})

Some activity ongoing in CMS on these channels

Precision EW Measurements at the LHC

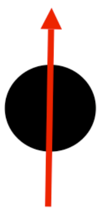
Can we determine the mass of the W boson to O(10) MeV at the LHC?



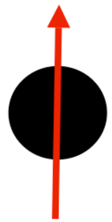


$W^+ \rightarrow l^+ \nu$

$W^- \rightarrow l^- \nu$



- θ = lepton emission angle w.r.t. spin vector
- $W(\theta) = 1 + \cos(\theta)$
- reflects V-A coupling

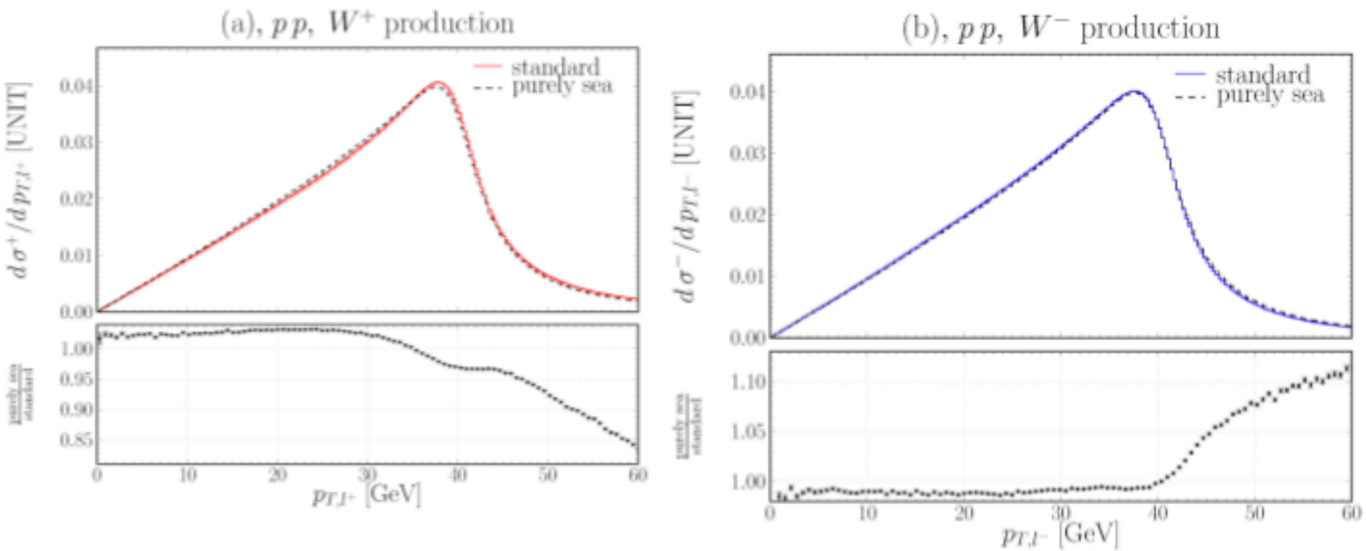


- $W(\theta) = 1 - \cos(\theta)$

W. Krasny, F Dydak: No, unless….

W-mass measurements and PDFs

Valence quark as W polarizer



M.W. Krasny
PDF4LHC meeting
May 29 '09

estimated shifts of the peak position due to polarisation effects

Fit range	Channel	$\varpi_{\mathrm{standard}} - \varpi_{\mathrm{sea}}$ [MeV]
$37\,\mathrm{GeV} < p_{T,l} < 39\,\mathrm{GeV}$	W^+	166.2
	W^-	-9.8
$37\,\mathrm{GeV} < p_{T,l} < 40\,\mathrm{GeV}$	W^+	178.7
	W^-	-40.3
$37\,\mathrm{GeV} < p_{T,l} < 52\,\mathrm{GeV}$	W^+	178.0
	W^-	-23.8

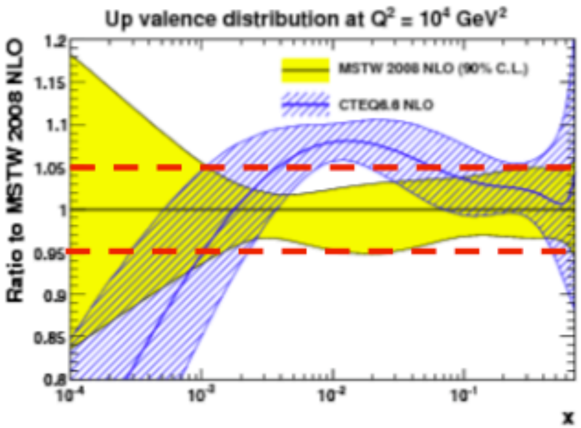
Effect of the first quark family

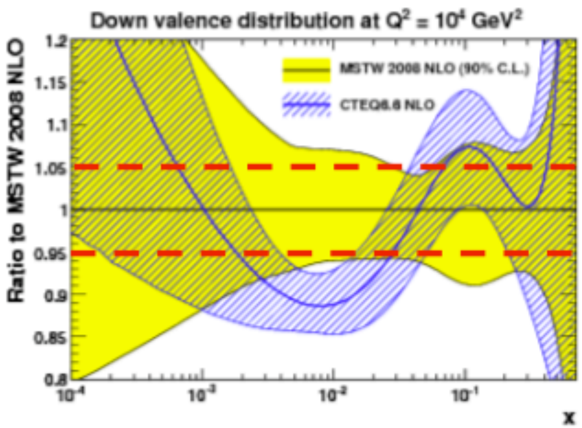
Expected biases in the measured values of M_{W+}-M_{W-}

$u^{(v)}, d^{(v)(*)}$	$u^{(v)}_{max} = 1.05\, u^{(v)}$ $d^{(v)}_{min} = d^{(v)} - .05\, u^{(v)}$	114.5
	$u^{(v)}_{min} = 0.95\, u^{(v)}$ $d^{(v)}_{max} = d^{(v)} + .05\, u^{(v)}$	-138.5
	$u^{(v)}_{max} = 1.02\, u^{(v)}$ $d^{(v)}_{min} = 0.92\, d^{(v)}$	85.2
	$u^{(v)}_{min} = 0.98\, u^{(v)}$ $d^{(v)}_{max} = 1.08\, d^{(v)}$	-85.9

Expected biases in the measured values of M_W

$u^{(v)}, d^{(v)}$	$u^{(v)}_{max} = 1.05\, u^{(v)}$ $d^{(v)}_{min} = d^{(v)} - .05\, u^{(v)}$	79
	$u^{(v)}_{min} = 0.95\, u^{(v)}$ $d^{(v)}_{max} = d^{(v)} + .05\, u^{(v)}$	−64
	$u^{(v)}_{min} = 1.02\, u^{(v)}$ $d^{(v)}_{max} = d^{(v)} - .02\, u^{(v)}$	32
	$u^{(v)}_{min} = 0.98\, u^{(v)}$ $d^{(v)}_{max} = d^{(v)} + .02\, u^{(v)}$	−18
	$u^{(v)}_{max} = 1.02\, u^{(v)}$ $d^{(v)}_{min} = 0.92\, d^{(v)}$	48
	$u^{(v)}_{min} = 0.98\, u^{(v)}$ $d^{(v)}_{max} = 1.08\, d^{(v)}$	−32





Note: Only mutually compensating shifts leave the Z-boson rapidity distributions invariant

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Solutions?

Programme 1: Isoscalar beams at the LHC (elegant .. but unrealistic)

- Isoscalar beams $u^{(v)} = d^{(v)}$ (up to a small ~0.2 % QED corrections) - cancellation of relative polarization effects for W and Z

Expected biases in the measured values of M_{W+} - M_{W-} [MeV]

	Systematic ξ	pp - $\lvert\eta_l\rvert < 2.5$	pp - $\lvert\eta_l\rvert < 0.3$	pp - $\lvert y_W\rvert < 0.3$	dd - $\lvert\eta_l\rvert < 2.5$
$u^{(v)}, d^{(v)(*)}$	$u^{(v)}_{max} = 1.05\, u^{(v)}$ $d^{(v)}_{min} = d^{(v)} - .05\, u^{(v)}$	114.5	74.4	-38.1	2.4
	$u^{(v)}_{min} = 0.95\, u^{(v)}$ $d^{(v)}_{max} = d^{(v)} + .05\, u^{(v)}$	-138.5	-83.8	59.8	2.9
	$u^{(v)}_{max} = 1.02\, u^{(v)}$ $d^{(v)}_{min} = 0.92\, d^{(v)}$	85.2	51.2	-34.7	4.1
	$u^{(v)}_{min} = 0.98\, u^{(v)}$ $d^{(v)}_{max} = 1.08\, d^{(v)}$	-85.9	-53.2	47.2	-0.1

PDF context: the measurement of the W-bosons charge asymmetry constrain directly the s-c distribution…

…Or perform a precision DIS experiment

- Measure: the radiative-corrected asymmetry $Asym_{DIS}^{(p,n)}(Q^2,x)$ in a dedicated precision O(0.1%) deep inelastic scattering of muons on deuterium and proton targets:

$$Asym_{DIS}^{(p,n)}(Q^2,x) = (d\sigma^p/dQ^2dx - d\sigma^n/dQ^2dx)/(d\sigma^p/dQ^2dx + d\sigma^n/dQ^2dx)$$

…where $d\sigma^n/dQ^2dx = d\sigma^d/dQ^2dx - d\sigma^p/dQ^2dx$

- Constrain fully $u^{(v)}$, $d^{(v)}$, $u^{(s)}$, $d^{(s)}$ using the values of $Asym_{DIS}^{(p,n)}(Q^2,x,E)$ measured at the three energy settings (tools for such an "inverse" extrapolation are being prepared…S. Jadach et al.)

(details in a LOI for such an experiment … to be submitted to SPSC by F. Dydak and M.W. Krasny) 43

Challenging!

Proposal to use COMPAS for such a measurement with a special target

Summary

- Awareness of the complexity of the PDFs and their uncertainties is growing@ LHC. How well do we really know the PDFs?
  - Benchmark question: how well do we know the W and Z cross sections at the LHC? Remember CTEQ6.1 →CTEQ6.5
  - Good use for dedicated workshops and a discussion forum like PDF4LHC
- These standard uncertainties may be fine for standard physics, but do they also cover the needs for discovery physics?
- LHC experiments: common base-line choice on how to use the uncertainties on the PDFs? Still have to work further towards that…
- Monte Carlo Generator PDFs. Good progress. Will most likely be used by the experiments
- Prepare for making measurements with early data at the LHC that will further constrain the PDFs

Backup

Summary

- New fits with new data and progress in theory constrain the PDFs further.
- Present PDF uncertainties and procedures have to be taken with care
  - We have seen movements outside the errors (CTEQ6.1 →CTEQ6.5)
  - Choice of the initial gluon parametrization affects the results strongly
- Awareness of the complexity of the PDF uncertainty problem growing.
  - Lots of information and comparisons presented at the meeting which allow to move to next steps
    - Data selection (exercise is being set up)
    - Discussion of model uncertainties to be included in the error bands
    - Procedure to be choosen (if we can agree/converge)...
- These uncertainties will be fine for normal physics, do they also cover the needs for discovery physics?
- PDF set for MC: become available and can be tested/validated.

⇒To be continued at the next Meeting