Short update from CTEQ

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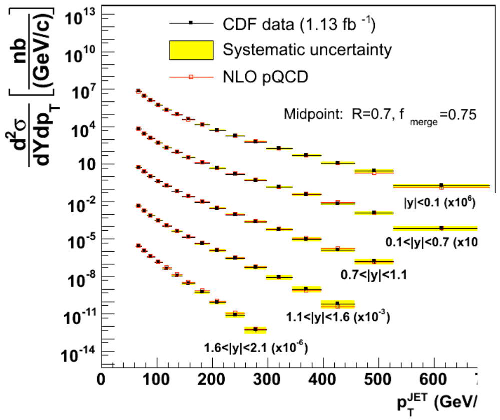
for the ‘TEA’ group
(Tung et al)

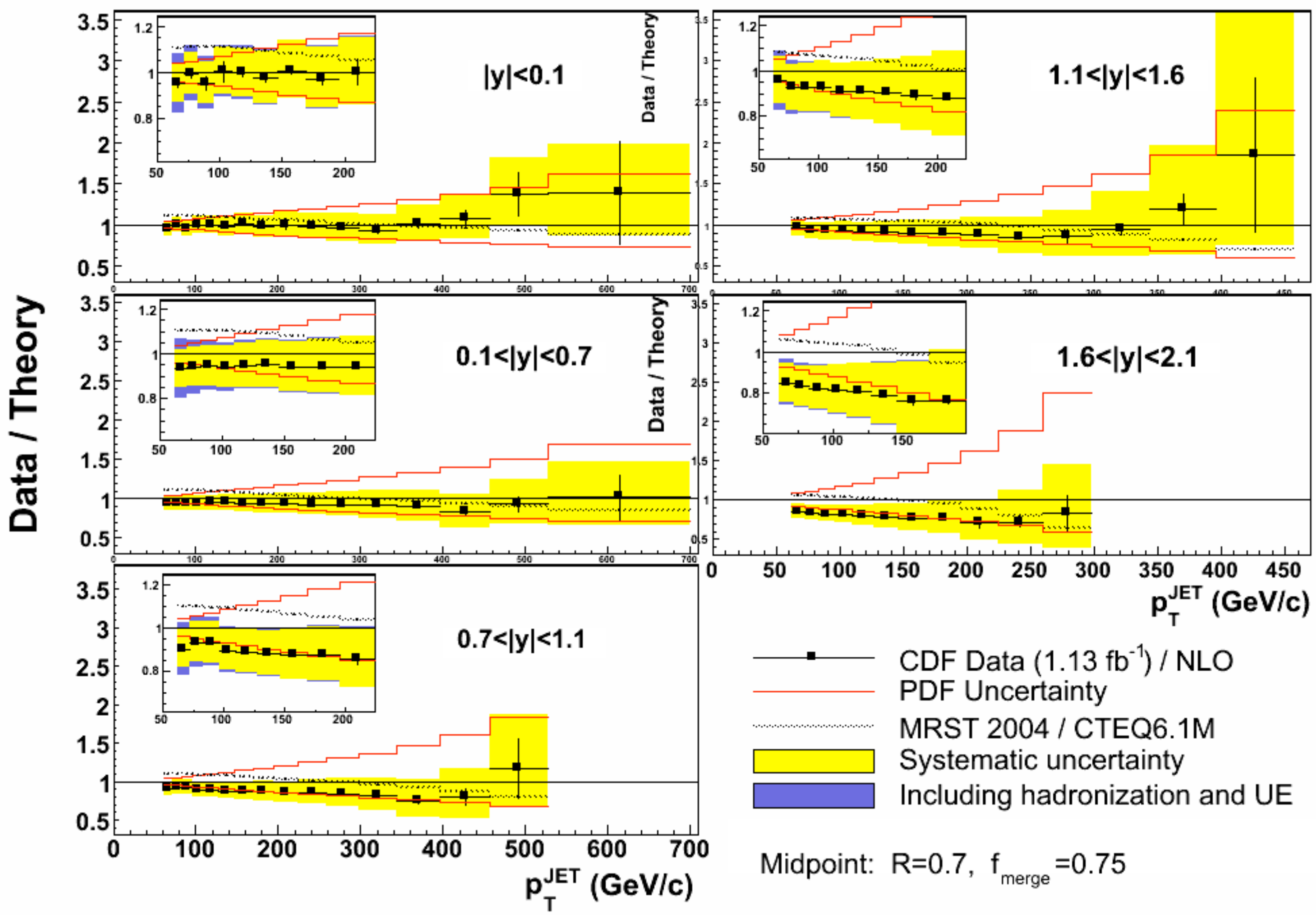
Ongoing work

- NLO
  - CT09 (presented by J. Pumplin at last PDF4LHC meeting)
    - arXiv: 0904.2424 (to appear in PRD)
  - inclusion of Tevatron Run 2 data (but retaining Run 1 data->different energy, wider rapidity coverage)
  - I'll show a few updated slides
- LO(*)
  - CTMC1, CTMC2 (1-loop, 2-loop α_s modified LO PDF's for Monte Carlos), presented by me at last PDF4LHC meeting
  - draft completed; some results for tuning to be shown today
- Combined (q_T, x) fits, simultaneous fits of PDF's and non-perturbative parameters for p_T distributions of Drell-Yan processes; correlation information for precision determinations of W mass at Tevatron and LHC
  - draft in progress
- NNLO PDF's
  - in progress
- Data set diagonalization: J. Pumplin
  - arXiv:0904.2425; talk in May meeting

CDF Run 2 jet results

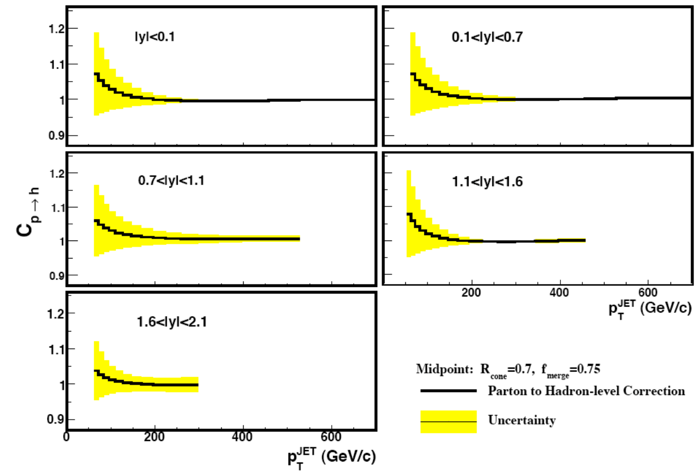


using CTEQ6.1



Full disclosure for experimentalists

- Every cross section should be quoted at the hadron level with an explicit correction given between the hadron and parton levels (if possible)
- More the exception than the rule at the Tevatron



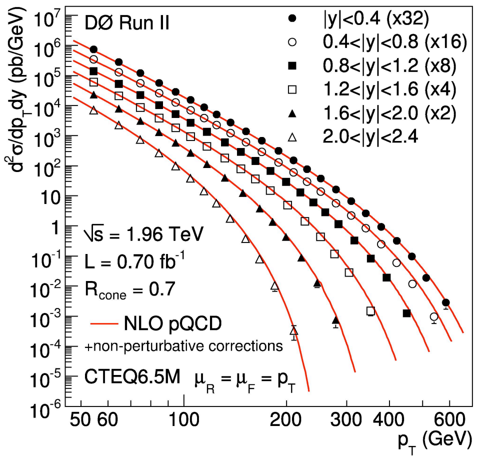
regions. The correction is derived from PYTHIA (solid line)
for the correction is conservatively taken as the systematic

TABLE IX: Measured inclusive jet cross sections as a function of p_T for jets in the region $0.1 < |y| < 0.7$ together with the statistical (*stat.*) and systematic (*sys.*) uncertainties. The bin-by-bin parton-to-hadron-level ($C_{p\rightarrow h}$) corrections are also shown.

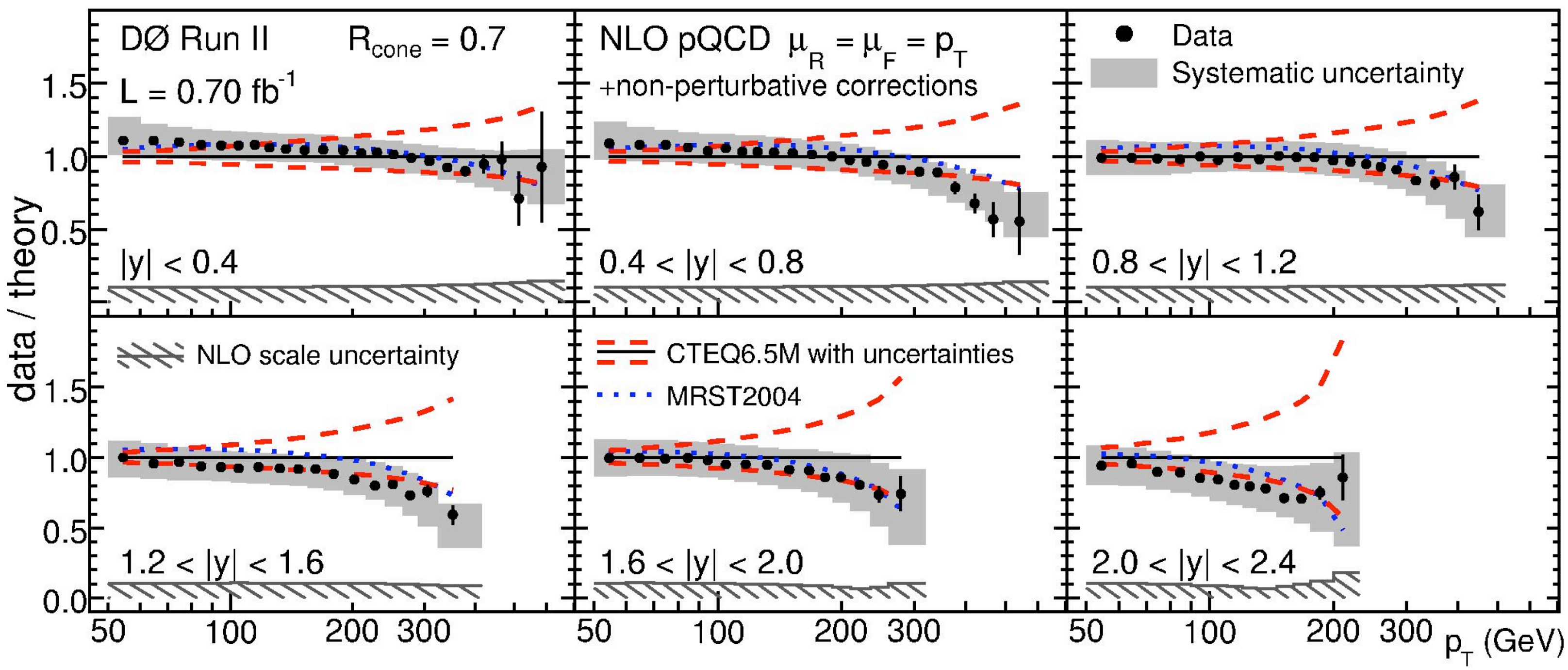
p_T (GeV/c)	$0.1 < \lvert y\rvert < 0.7$: $\sigma \pm (stat.) \pm (sys.)$ [nb/(GeV/c)]	$C_{p\rightarrow h}$
62 – 72	$(6.28 \pm 0.04^{+0.59}_{-0.56}) \times 10^{0}$	1.072 ± 0.108
72 – 83	$(2.70 \pm 0.02^{+0.26}_{-0.25}) \times 10^{0}$	1.055 ± 0.088
83 – 96	$(1.15 \pm 0.01^{+0.11}_{-0.11}) \times 10^{0}$	1.041 ± 0.071
96 – 110	$(4.88 \pm 0.03^{+0.51}_{-0.48}) \times 10^{-1}$	1.030 ± 0.057
110 – 127	$(2.07 \pm 0.01^{+0.22}_{-0.21}) \times 10^{-1}$	1.022 ± 0.045
127 – 146	$(8.50 \pm 0.04^{+0.98}_{-0.91}) \times 10^{-2}$	1.015 ± 0.035
146 – 169	$(3.30 \pm 0.01^{+0.41}_{-0.38}) \times 10^{-2}$	1.010 ± 0.027
169 – 195	$(1.24 \pm 0.01^{+0.17}_{-0.15}) \times 10^{-2}$	1.006 ± 0.020
195 – 224	$(4.55 \pm 0.05^{+0.67}_{-0.61}) \times 10^{-3}$	1.003 ± 0.014
224 – 259	$(1.56 \pm 0.01^{+0.25}_{-0.23}) \times 10^{-3}$	1.002 ± 0.010
259 – 298	$(4.94 \pm 0.06^{+0.91}_{-0.80}) \times 10^{-4}$	1.001 ± 0.006
298 – 344	$(1.42 \pm 0.02^{+0.30}_{-0.26}) \times 10^{-4}$	1.000 ± 0.003
344 – 396	$(3.53 \pm 0.08^{+0.85}_{-0.73}) \times 10^{-5}$	1.001 ± 0.001
396 – 457	$(6.87 \pm 0.35^{+1.93}_{-1.64}) \times 10^{-6}$	1.001 ± 0.000
457 – 527	$(1.22 \pm 0.13^{+0.40}_{-0.34}) \times 10^{-6}$	1.003 ± 0.001
527 – 700	$(7.08 \pm 1.97^{+3.09}_{-2.54}) \times 10^{-8}$	1.005 ± 0.001

note the correction rapidly approaches unity

D0 Run 2 jet results



- Preference for a weaker high x gluon?
- Pushing towards lower end of CTEQ6.5 pdf uncertainty band



From Jon's talk in May (and CT09 paper)

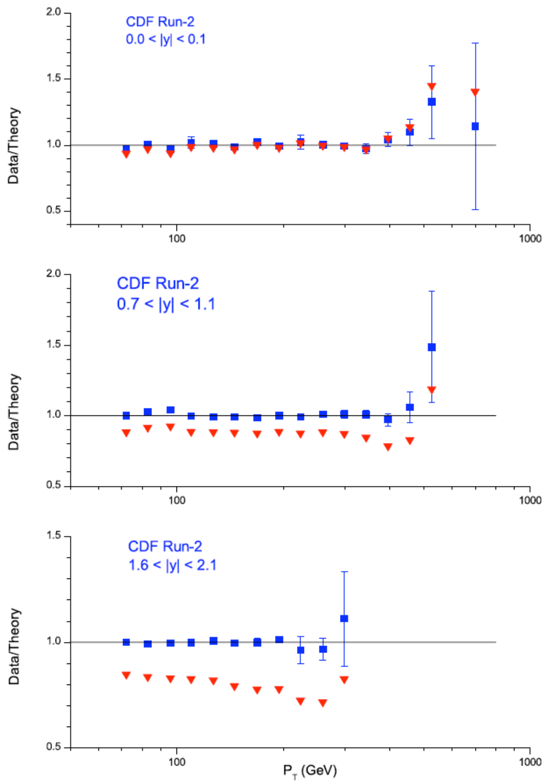
- Run I and Run II jet measurements consistent with each other
- Can test by assigning higher weight to a particular experiment and seeing by how much χ^2 of other jet data (and of non-jet data) increases

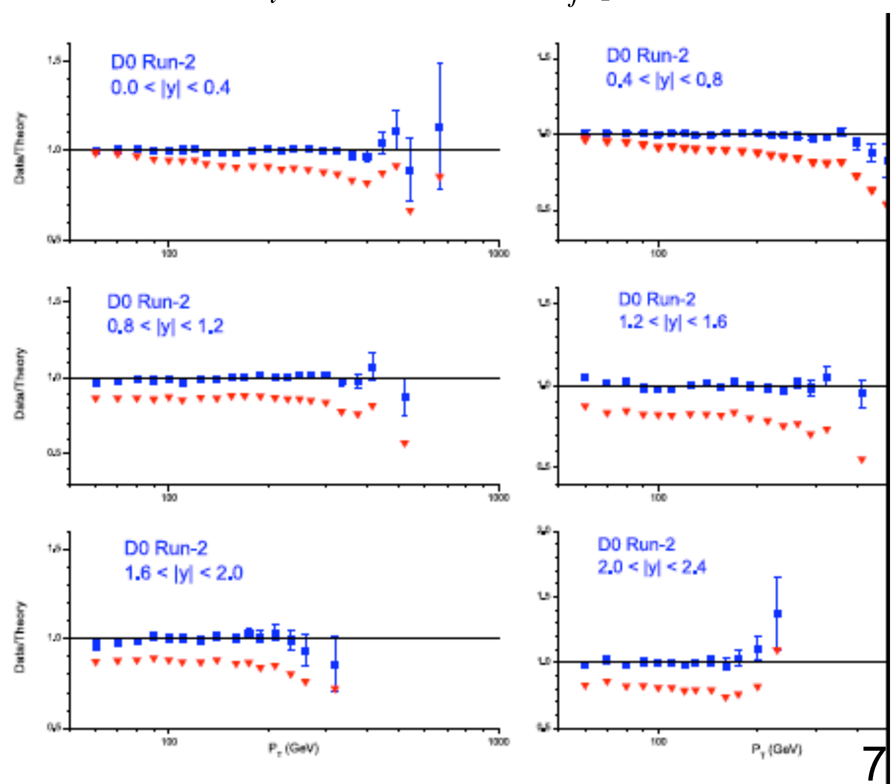
CDF_I		$D0_I$		CDF_{II}		$D0_{II}$		$\Delta\chi^2$
Wt	χ^2	Wt	χ^2	Wt	χ^2	Wt	χ^2	non-jet
0	55.4	0	115.3	0	99.5	0	134.0	0.0
1	52.6	1	47.0	0	105.6	0	138.3	11.8
0	56.6	0	82.2	1	85.6	1	124.1	6.2
1	52.1	1	59.4	1	88.5	1	121.5	9.6
1	54.8	1	58.8	10	80.3	10	120.0	39.4
10	53.1	10	38.6	1	102.6	1	142.3	21.9
10	51.6	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

CDF/D0 Run II jet data compared to CT09 predictions

- Red is uncorrected, blue is after systematic error corrections in global fit
- Each systematic error shift is of the order of 1 sigma or less, with standard penalty in global fit

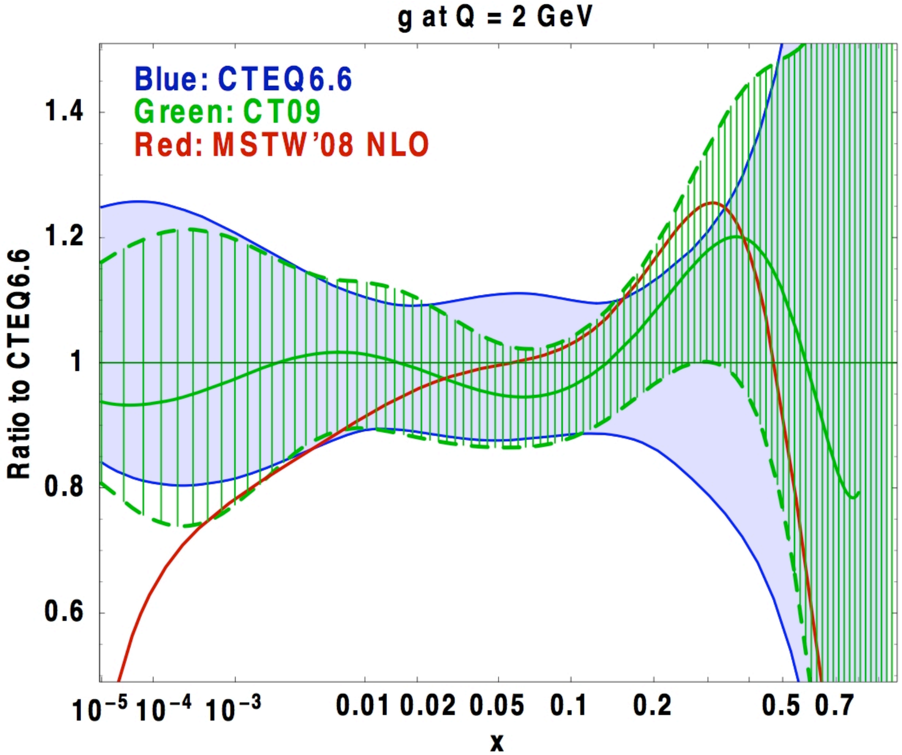
$$\chi^2 = \sum_i \frac{\left[\left(f_N D_i - \sum_{j=1}^{k} \beta_{ij} s_j\right) - T_i\right]^2}{\sigma_i^2} + \sum_{j=1}^{k} s_j^2$$

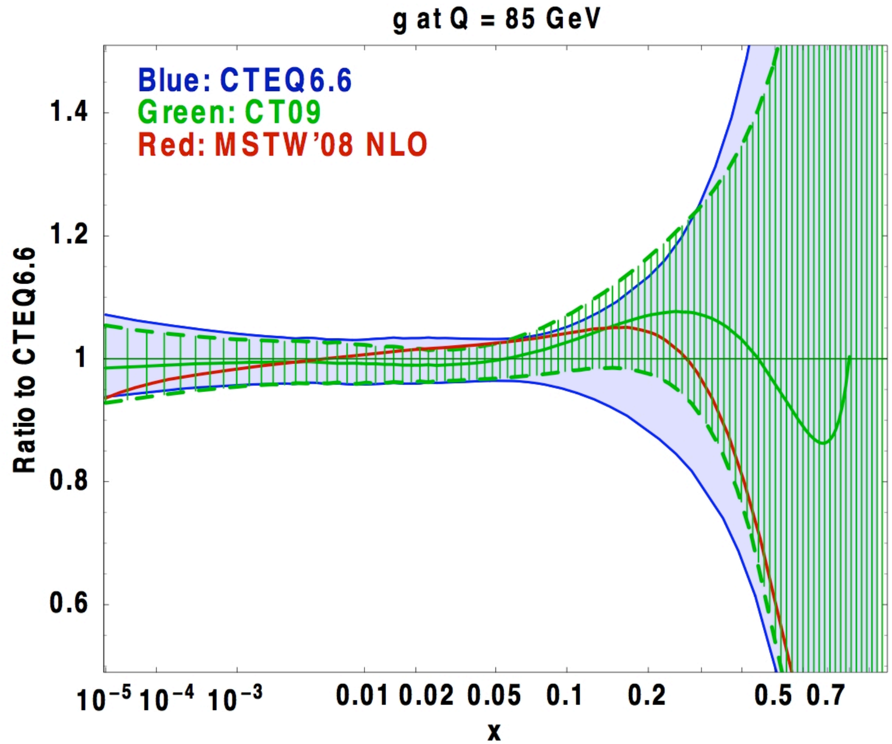




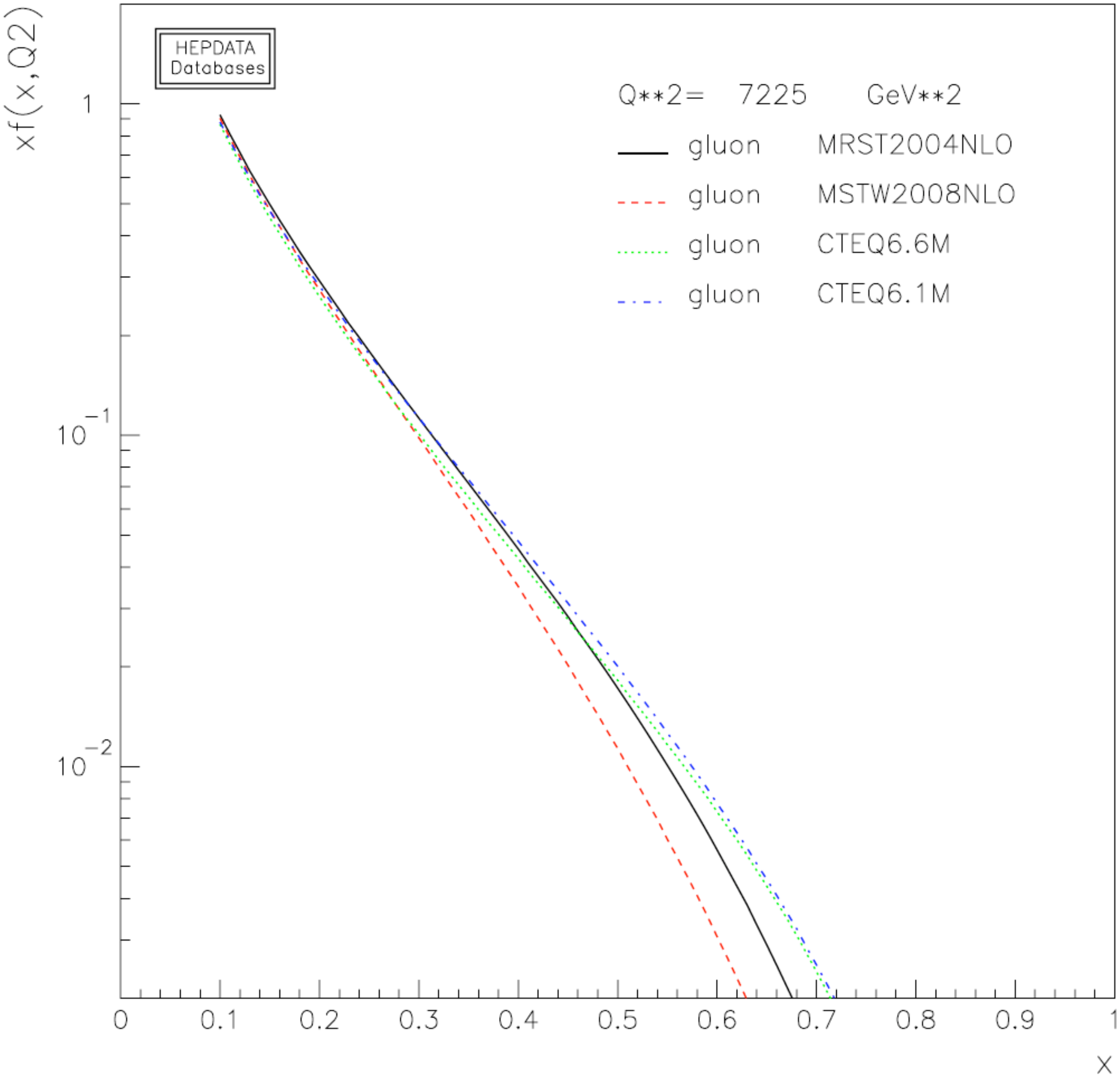
Comparison of gluons

- Sizeable differences in large x gluon behavior between CT and MSTW pdf's
- At high Q, very close in rest of x range





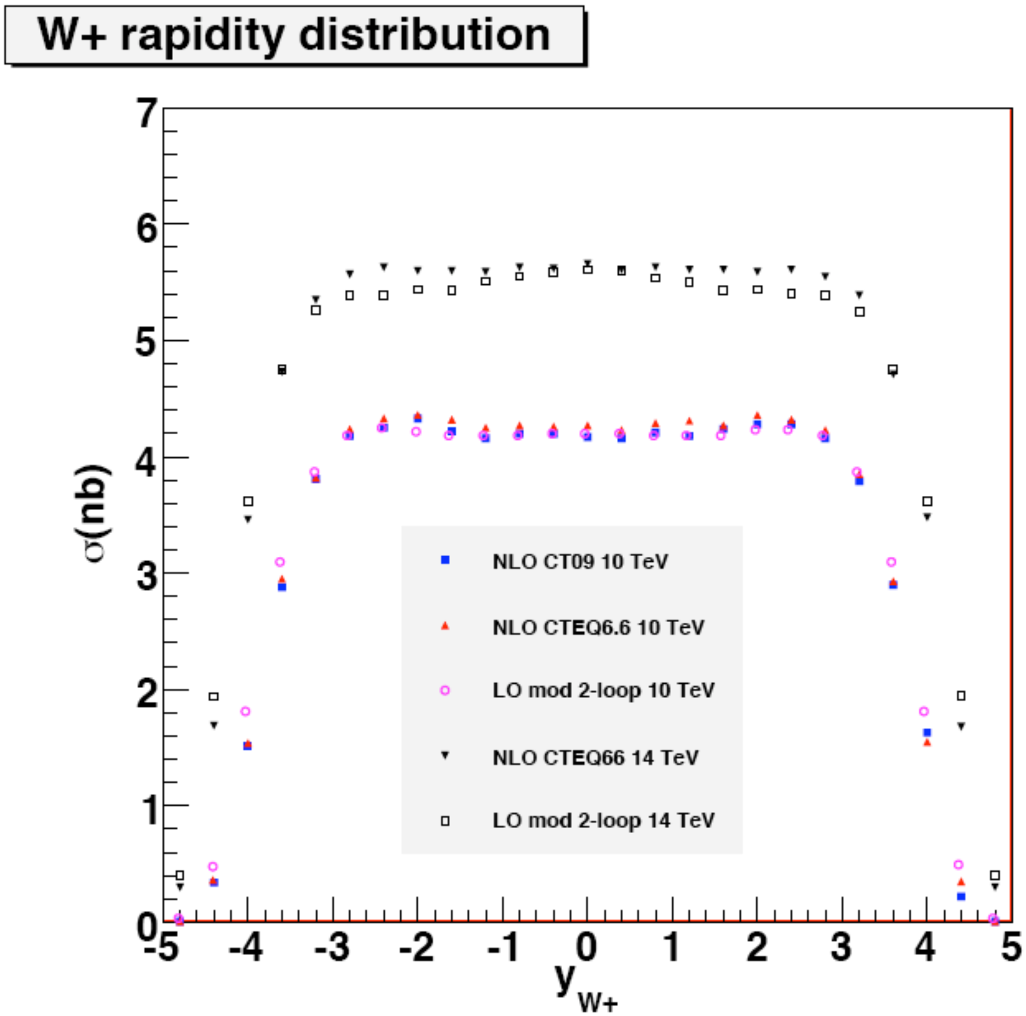
High x gluon



CT09 not yet in LHAPDF

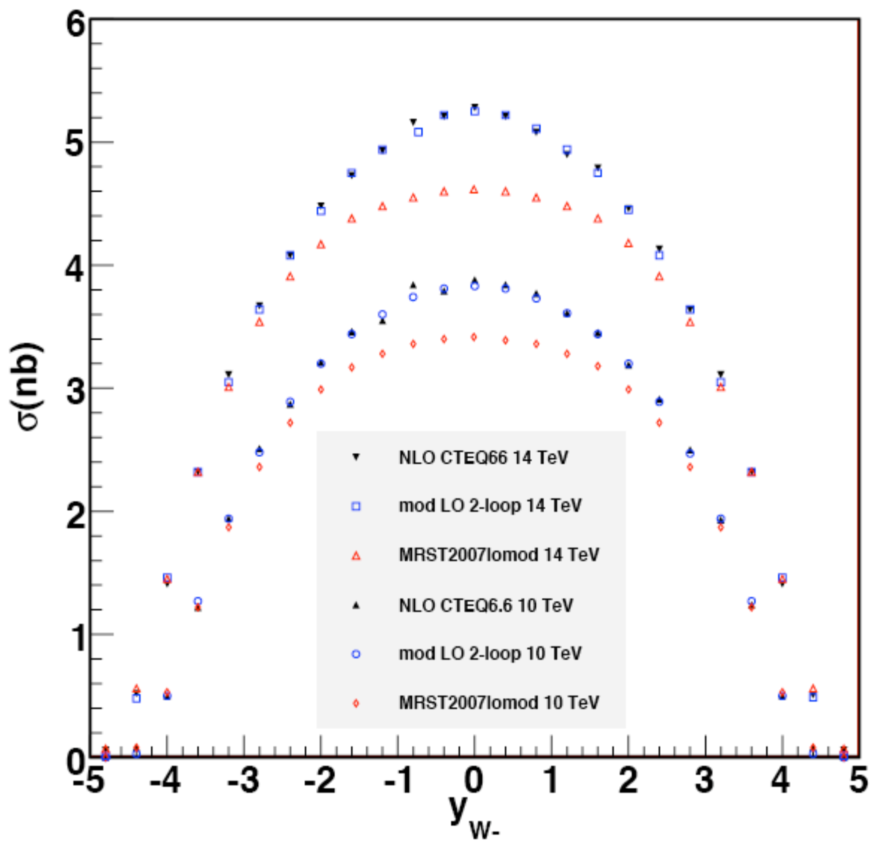
Mod LO pdf's

- Both 2-loop α_s and 1-loop α_s versions
- Mod LO W^+ rapidity distribution agrees better with NLO prediction in both magnitude and shape
- Agreement at 10 TeV (not in fit) even better

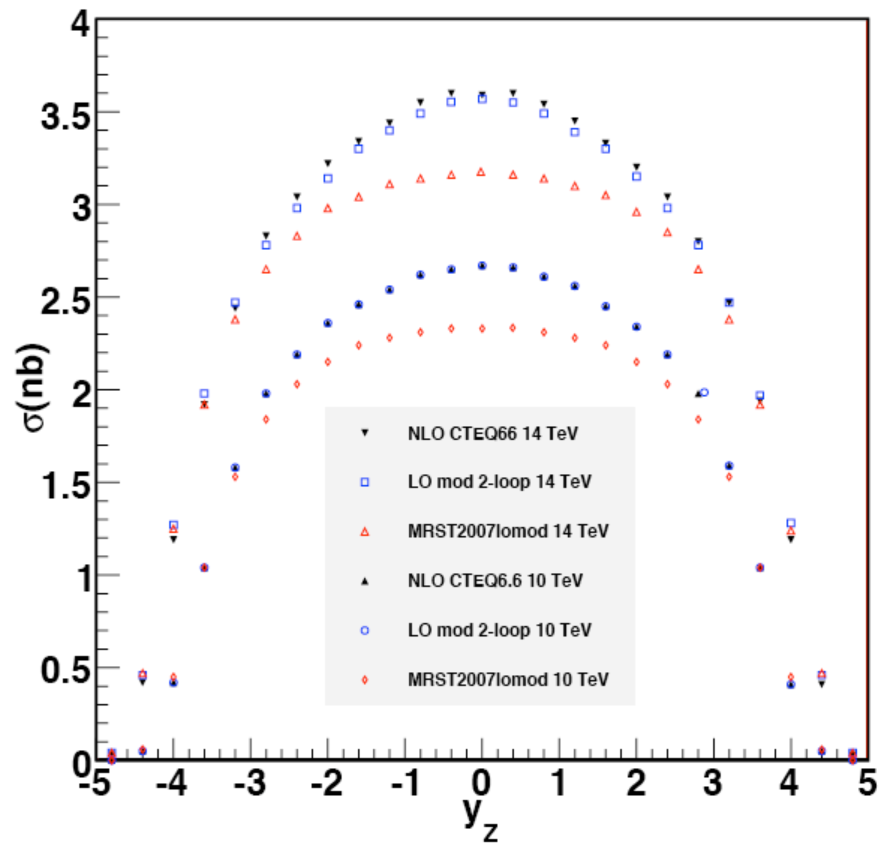


Results

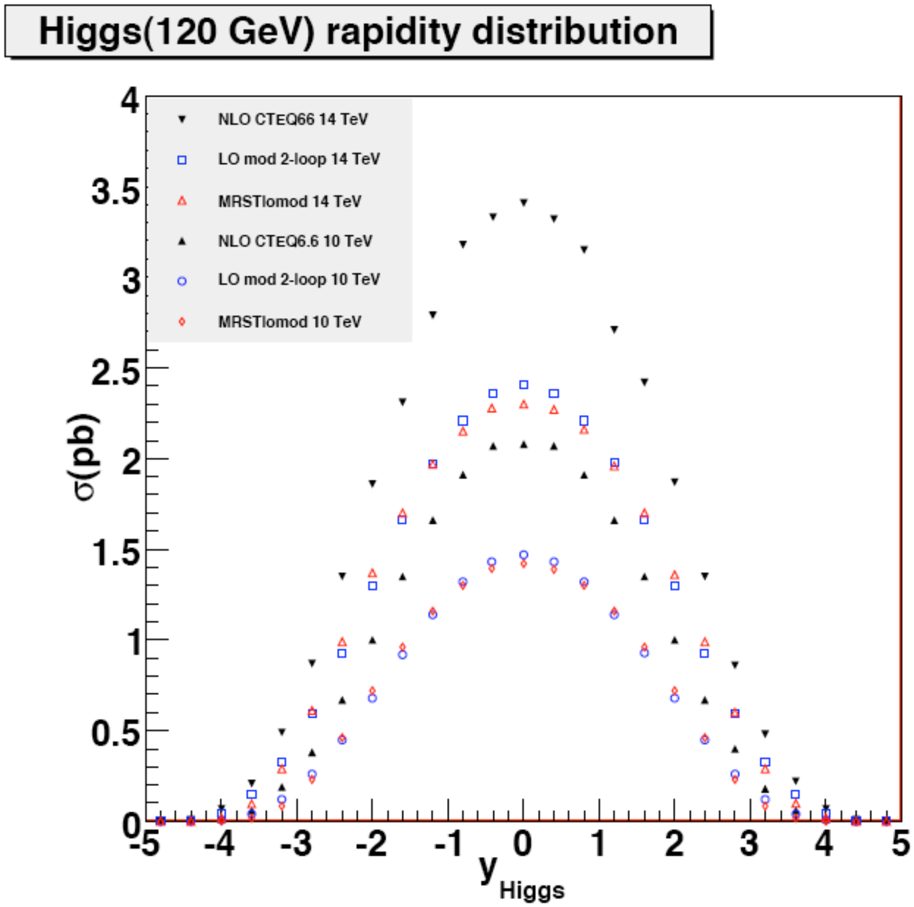
W- rapidity distribution

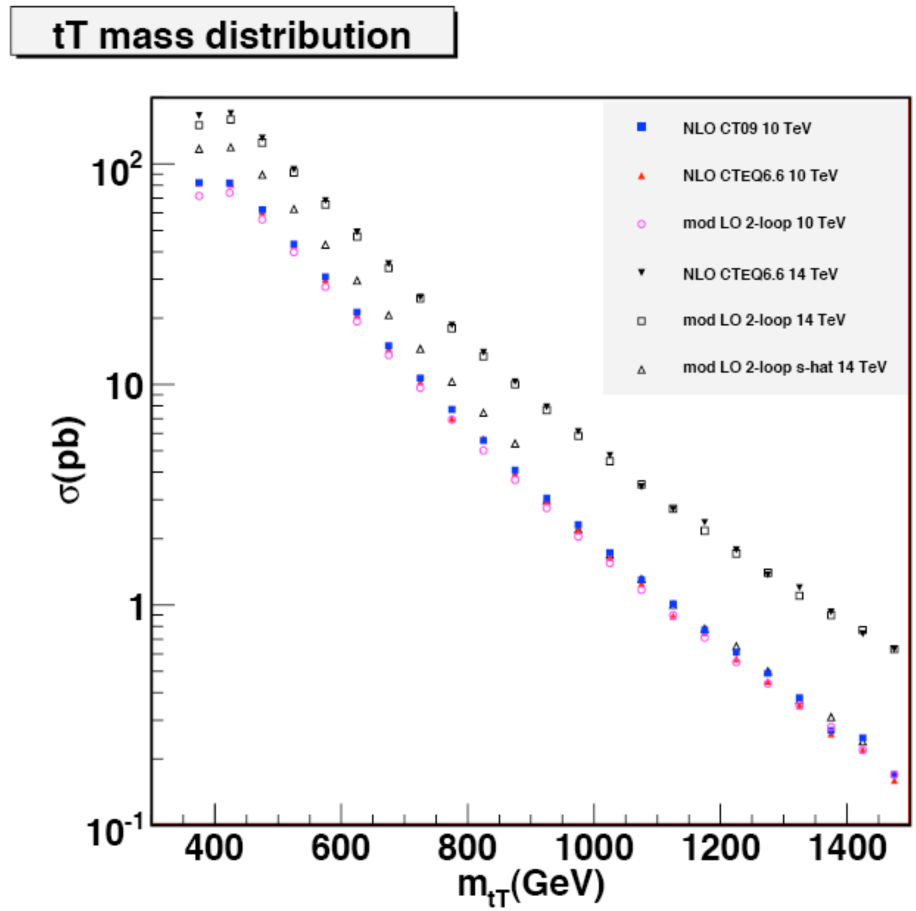


Z rapidity distribution



Results


Higgs(120 GeV) rapidity distribution
NLO CTEQ66 14 TeV
LO mod 2-loop 14 TeV
MRSTlomod 14 TeV
NLO CTEQ6.6 10 TeV
LO mod 2-loop 10 TeV
MRSTlomod 10 TeV
σ(pb)
0
0.5
1
1.5
2
2.5
3
3.5
4
-5
-4
-3
-2
-1
0
1
2
3
4
5
y Higgs


tT mass distribution
NLO CT09 10 TeV
NLO CTEQ6.6 10 TeV
mod LO 2-loop 10 TeV
NLO CTEQ6.6 14 TeV
mod LO 2-loop 14 TeV
mod LO 2-loop s-hat 14 TeV
σ(pb)
10^-1
1
10
10^2
400
600
800
1000
1200
1400
m tT(GeV)

K-factors smaller using mod LO pdf's

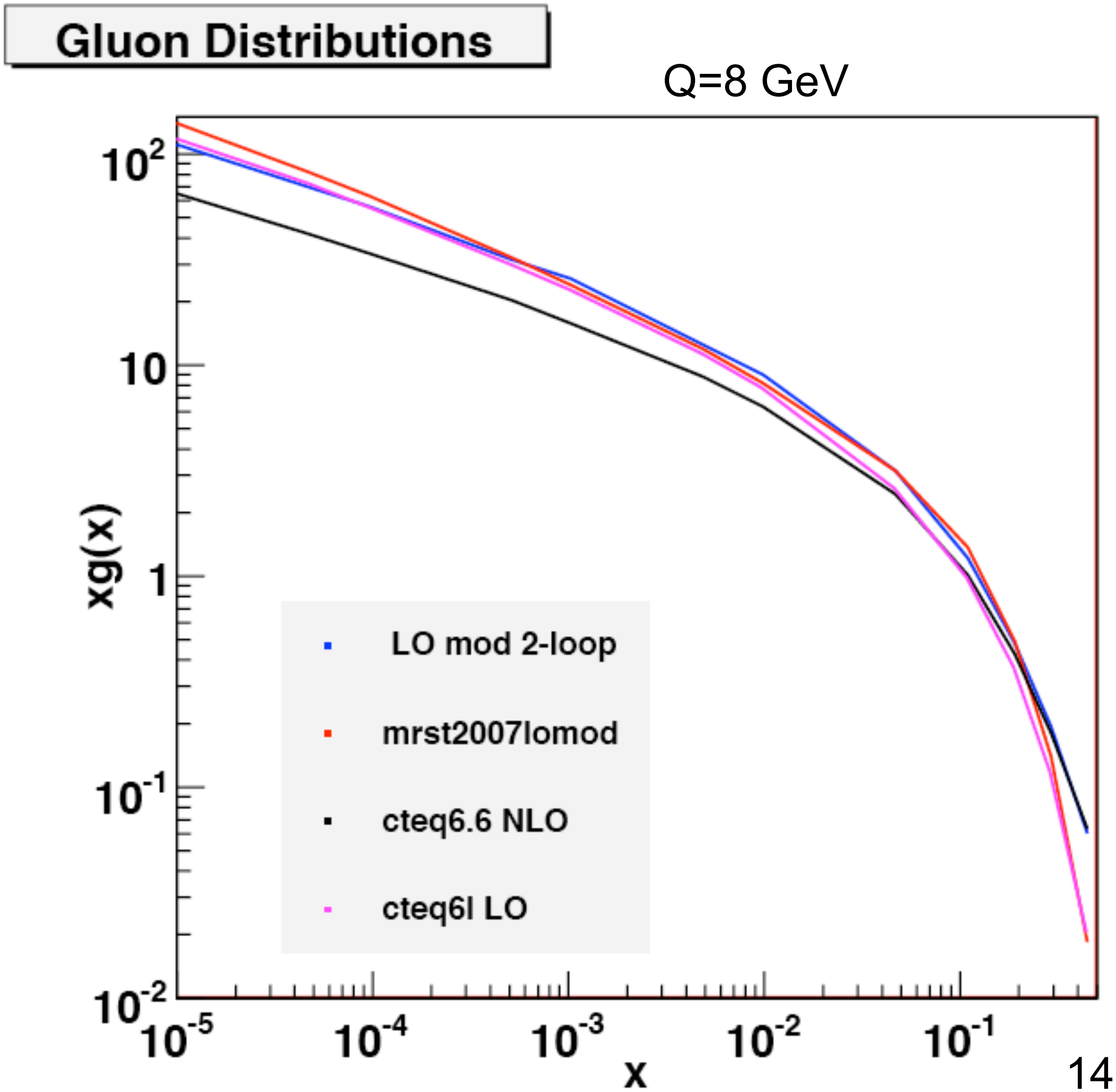
Process	Typical scales μ_0	μ_1	Tevatron K-factor $\mathcal{K}(\mu_0)$	$\mathcal{K}(\mu_1)$	$\mathcal{K}'(\mu_0)$	LHC K-factor $\mathcal{K}(\mu_0)$	$\mathcal{K}(\mu_1)$	$\mathcal{K}'(\mu_0)$	$\mathcal{K}''(\mu_0)$
W	m_W	$2m_W$	1.33	1.31	1.21	1.15	1.05	1.15	0.95
W+1jet	m_W	$p_T^{\rm jet}$	1.42	1.20	1.43	1.21	1.32	1.42	0.99
W+2jets	m_W	$p_T^{\rm jet}$	1.16	0.91	1.29	0.89	0.88	1.10	–
WW+jet	m_W	$2m_W$	1.19	1.37	1.26	1.33	1.40	1.42	–
$t\bar{t}$	m_t	$2m_t$	1.08	1.31	1.24	1.40	1.59	1.19	1.09
$t\bar{t}$+1jet	m_t	$2m_t$	1.13	1.43	1.37	0.97	1.29	1.10	
$b\bar{b}$	m_b	$2m_b$	1.20	1.21	2.10	0.98	0.84	2.51	–
Higgs	m_H	$p_T^{\rm jet}$	2.33	–	2.33	1.72	–	2.32	1.43
Higgs via VBF	m_H	$p_T^{\rm jet}$	1.07	0.97	1.07	1.23	1.34	0.85	0.75
Higgs+1jet	m_H	$p_T^{\rm jet}$	2.02	–	2.13	1.47	–	1.90	1.33
Higgs+2jets	m_H	$p_T^{\rm jet}$	–	–	–	1.15	–	–	1.13

Table 3: K-factors for various processes at the LHC calculated using a selection of input parameters. Have to fix this table. In all cases, the CTEQ6M PDF set is used at NLO. $\mathcal{K}$ uses the CTEQ6L1 set at leading order, whilst $\mathcal{K}'$ uses the same set, CTEQ6M, as at NLO and $\mathcal{K}''$ uses the modified LO (2-loop) PDF set. For Higgs+1,2jets, a jet cut of 40 GeV/c and $|\eta| < 4.5$ has been applied. A cut of $p_T^{\rm jet} > 20$ GeV/c has been applied for the $t\bar{t}$+jet process, and a cut of $p_T^{\rm jet} > 50$ GeV/c for WW+jet. In the W(Higgs)+2jets process the jets are separated by $\Delta R > 0.52$, whilst the VBF calculations are performed for a Higgs boson of mass 120 GeV. In each case the value of the K-factor is compared at two often-used scale choices, where the scale indicated is used for both renormalization and factorization scales.

Note K-factor for W < 1.0, since for this table the comparison is to CTEQ6.1 and not to CTEQ6.6, i.e. corrections to low x PDFs due to treatment of heavy quarks in CTEQ6.6 "built-in" to mod LO PDFs

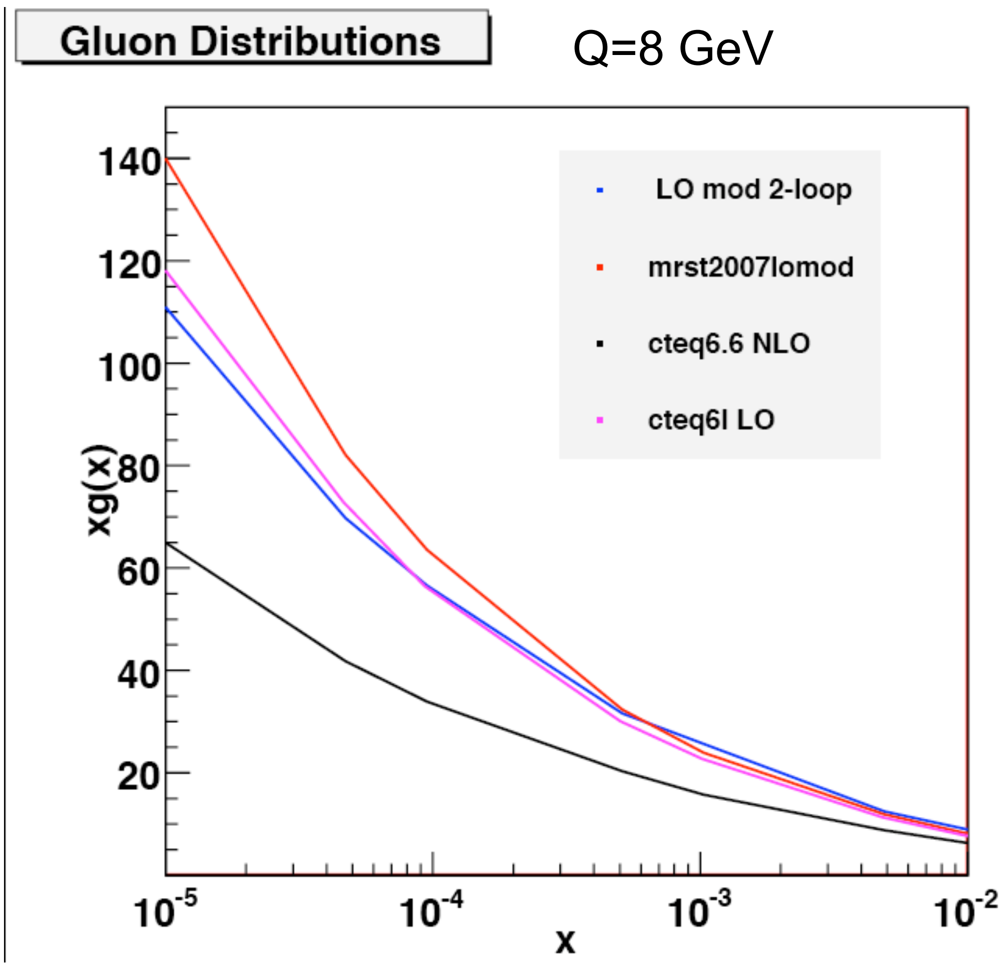
Some PDF comparisons

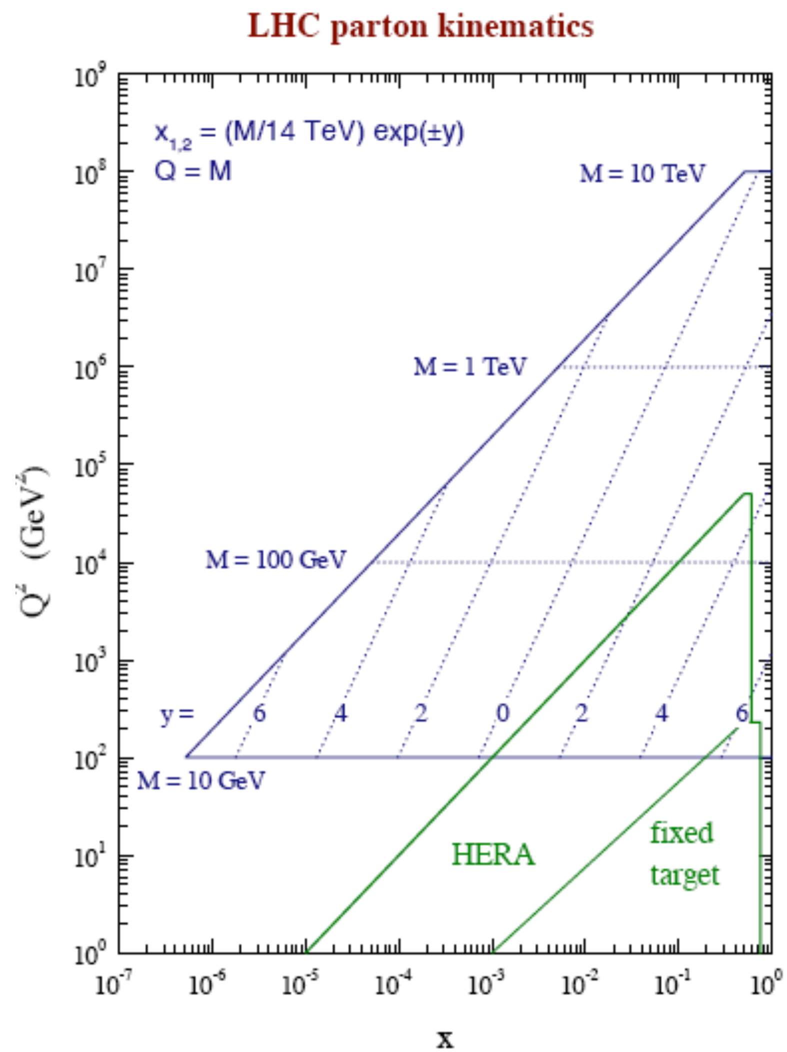
- The 2-loop modified LO PDF is similar to CTEQ6L at low x and to CTEQ6.6 at high x, as designed
- Also shown for comparison is the mrst2007lomod gluon PDF



Mini-jet production

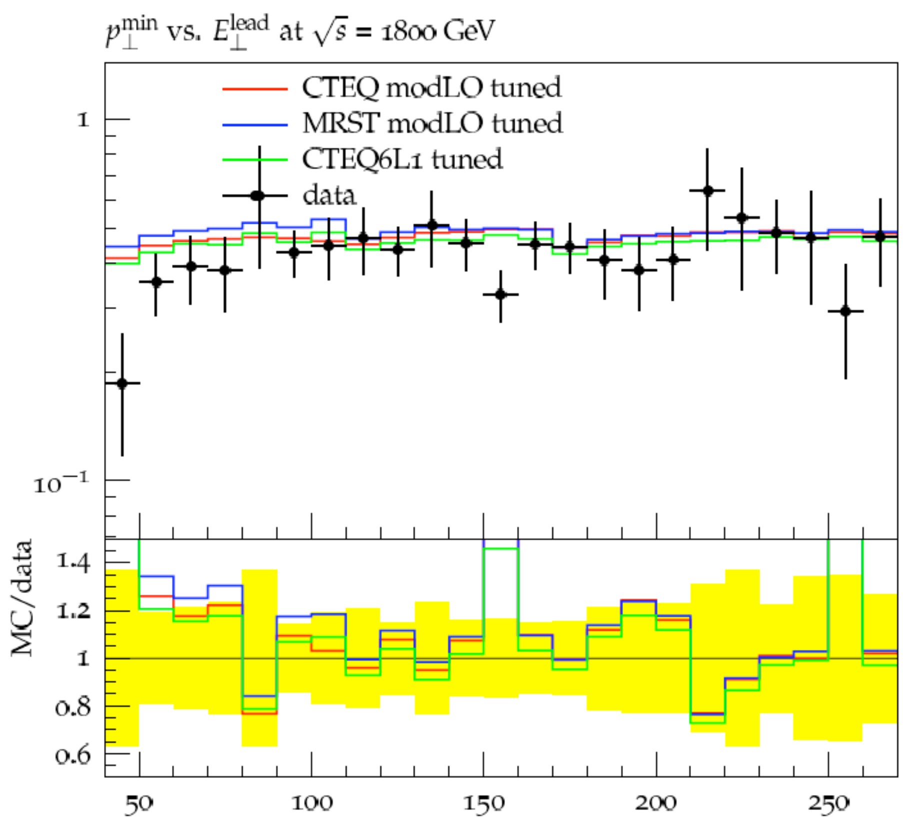
- …will be especially sensitive to gluons in x range of 1E-05 to 1E-02

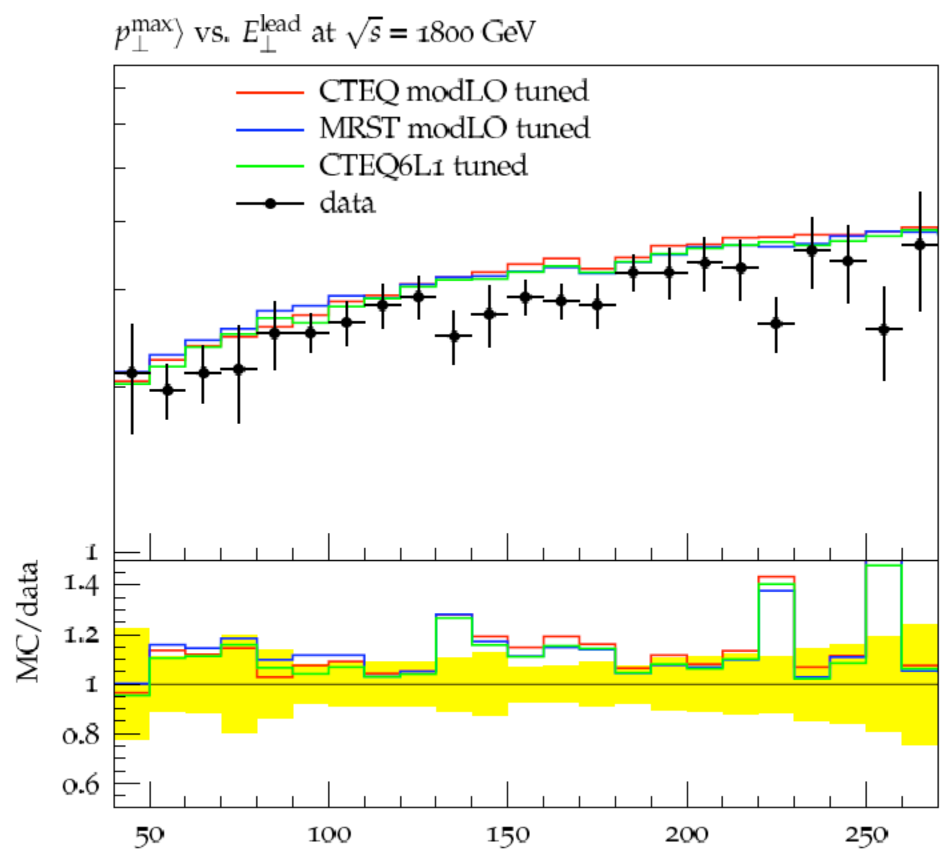




Plots from Markus Warsinsky

- Low x gluon not so different from CTEQ6L(1), so relatively easy to tune underlying event
- See Liza Mijoviv talk on Friday





Conclusions

- Broad range of pdf-related analysis from CTEQ/TEA group
- Hope to have combined fit and NNLO results to present in the near future