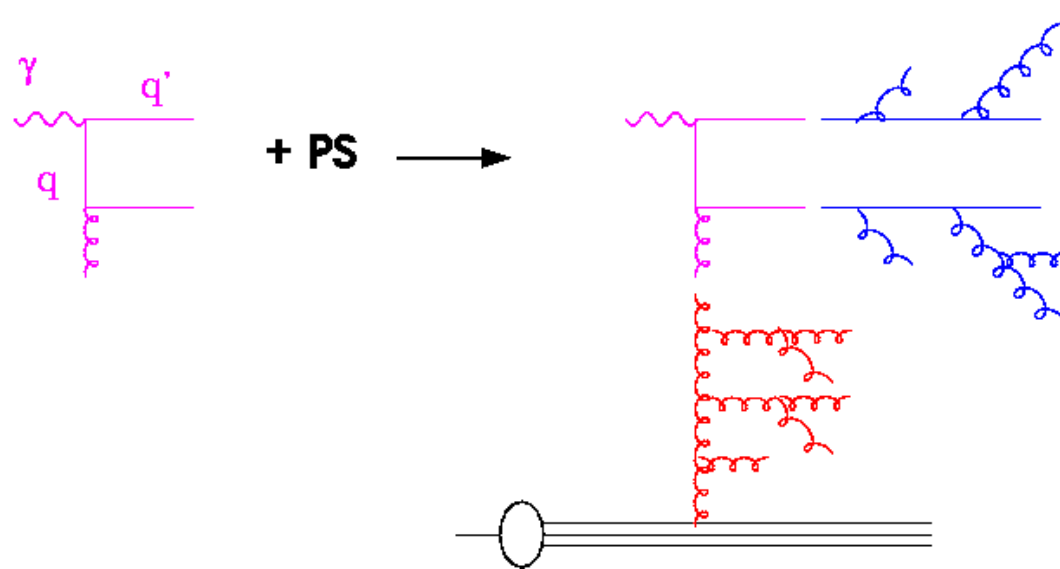


PDFs for MCs

H. Jung (DESY)

- **Motivation:**
why special PDFs for MCs are needed, necessary and important
- **Strategy:**
HOWTO obtain PDF4MC
connection to uPDFs and collinear PDFs
- **Proof of concept**
1st attempts
- **Conclusions**

Motivation: example from HERA



- **Collinear approach:** incoming/outgoing partons are on mass shell
 $(y+q)^2 = q'^2$, $-Q^2 + x y s = 0 \Rightarrow x = Q^2/(ys)$
- **BUT** final state radiation:
 $(y+q)^2 = q'^2$, $-Q^2 + x y s = m^2 \Rightarrow x = (Q^2+m^2)/(ys)$
- **AND** initial state radiation:
 $(y+q)^2 = q'^2$, $-Q^2 + x y s + q^2 = 0 \Rightarrow x = (Q^2-q^2)/(ys)$
- **Collinear approach:** $q'^2 = q^2 = 0$, order by order
- Well known.... since years....
- NLO corrections... better treatment of kinematics... but still not all....

Motivation: example from TeVatron

CP. Yuan, DIS2007

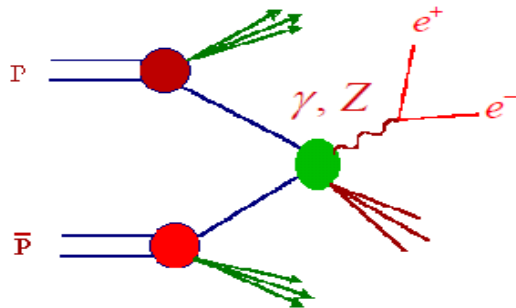
New from
DIS07

New Task of Global Analysis

Include Transverse Momentum p_T distributions

- New Data: include not only rapidity (y) but also

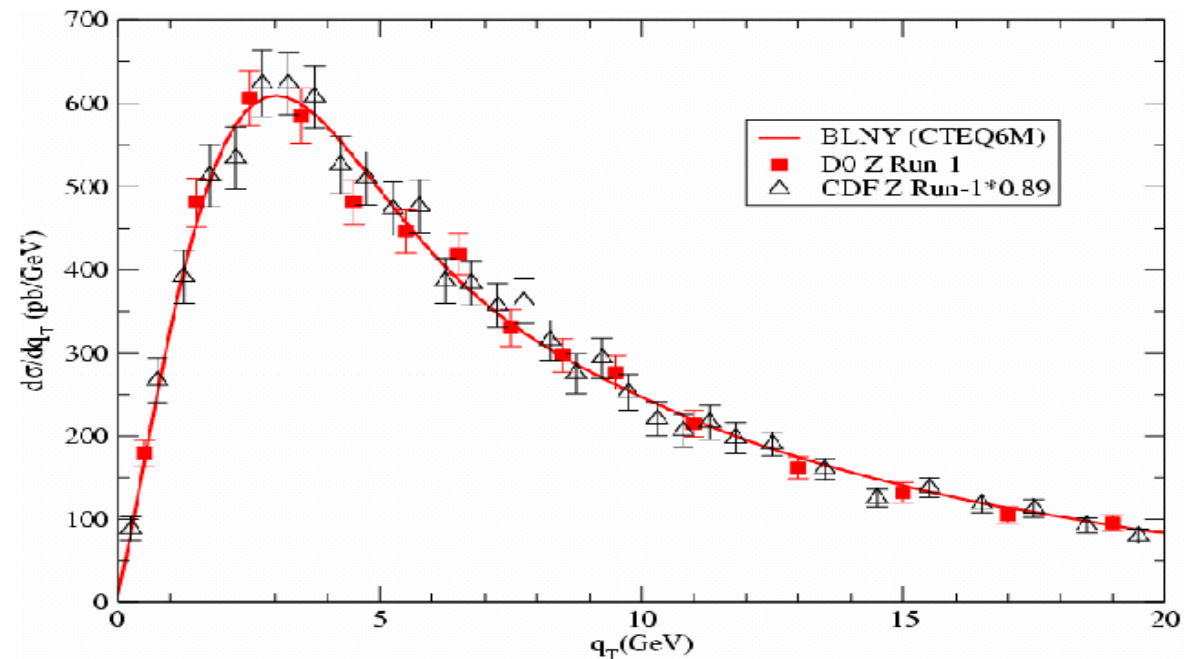
p_T of Drell-Yan pairs and Z bosons



QCD P_T Resummation
Global Analysis

hep-ph/0212159

Brock, Landry, Nadolsky, CPY



Motivation: example W/Z

Campbell, Huston Stirling
Rep.Prog.Phys 70 (2007) 89

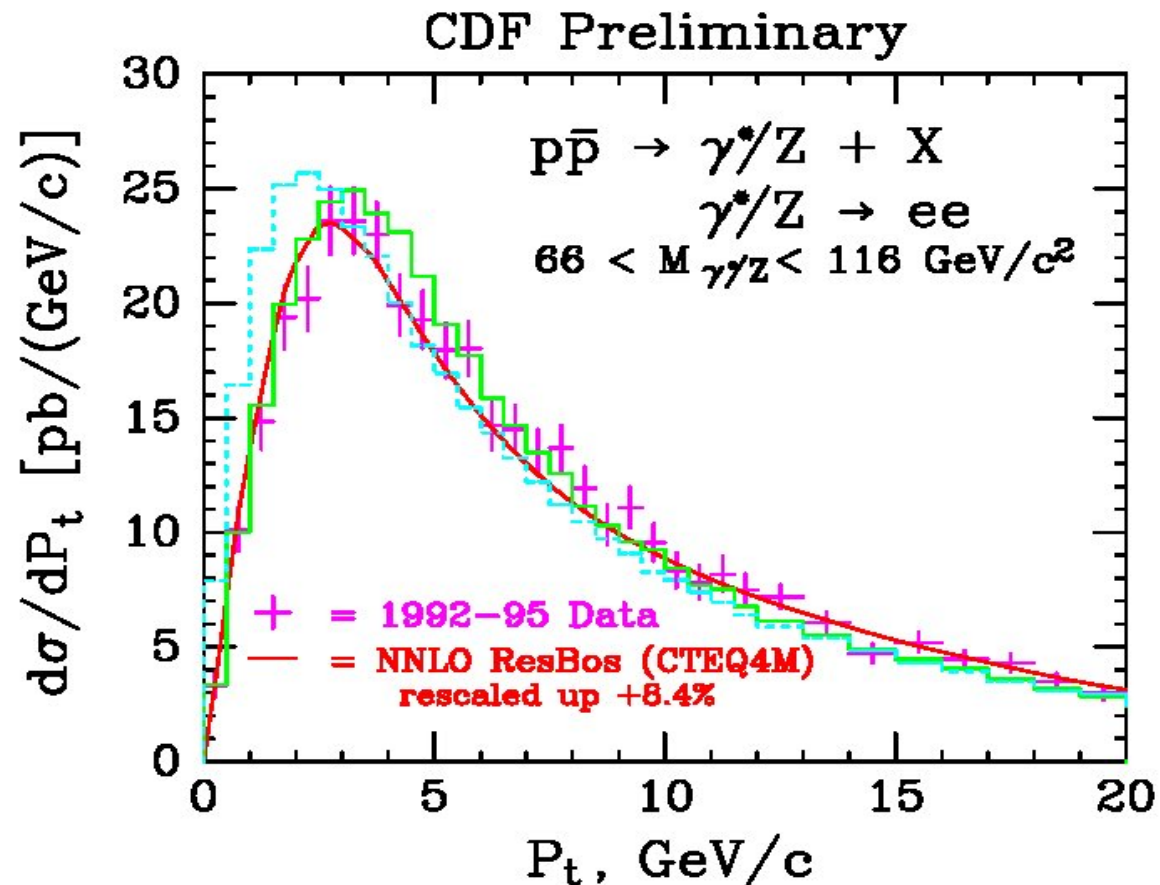


Figure 40. The transverse momentum distribution (low p_T) for $Z \rightarrow e^+e^-$ from CDF in Run 1, along with comparisons to predictions from PYTHIA and ResBos. The dashed blue curve is the default PYTHIA prediction. The PYTHIA solid-green curve has had an additional 2 GeV of k_T added to the parton shower.

Arguments for PDF4MC

Campbell, Huston Stirling
Rep.Prog.Phys 70 (2007) 89

In addition, it is often useful to examine variations in acceptances in Monte Carlos using the families of NLO error pdfs; thus, it is important to also compare with the predictions using the central (NLO) pdf. It is our recommendation, then, that NLO pdfs be used for predictions at the LHC, even with LO matrix element programs and parton shower Monte Carlos. There are two consequences: (1) the pdfs must be positive-definite in the kinematic regions of interest as they will be used to develop the initial-state showering history and (2) underlying event tunes must be available using the NLO pdfs. An underlying event model that uses multiple-parton interactions depends strongly on the slope of the low x gluon distribution. The NLO gluon distribution tends to have a much shallower slope than does the LO gluon and thus a different set

Is that the end of the story ?

Motivation

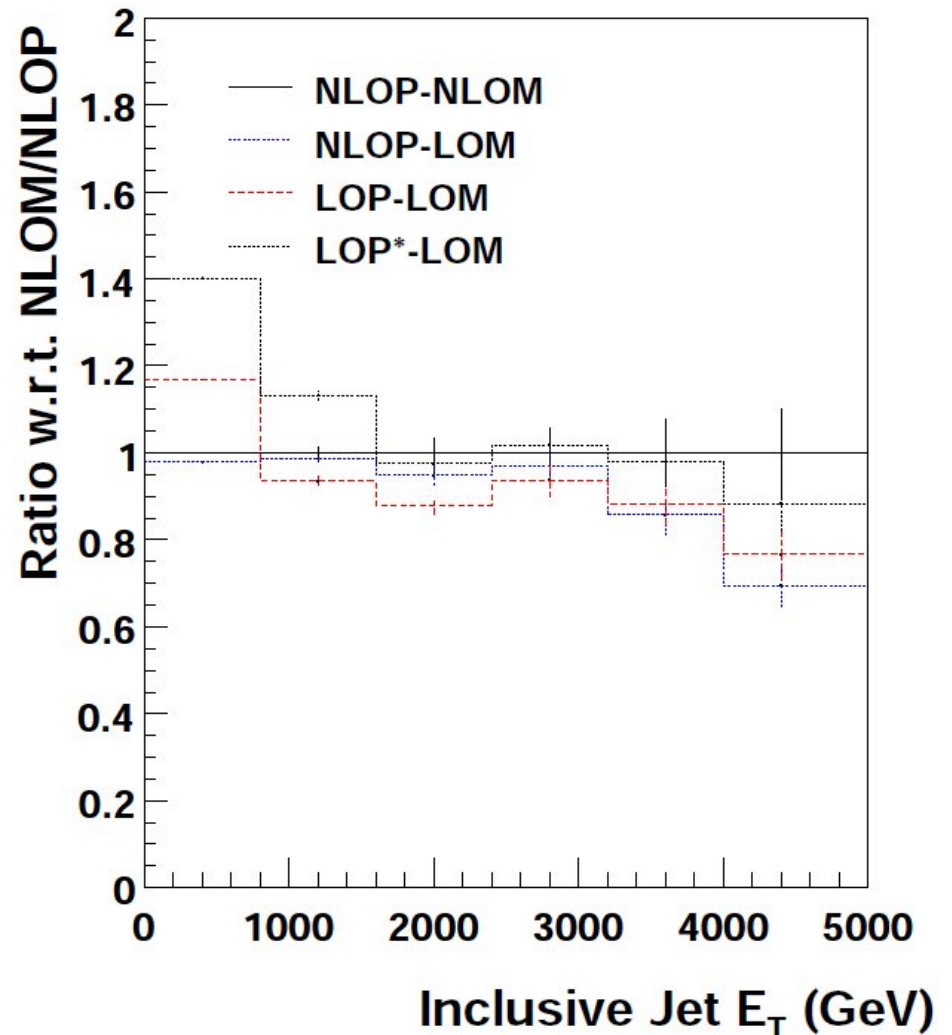
R. Thorne
DIS07

Also look at other quantities, e.g. very high- E_T jets at ATLAS (thanks to Claire Gwenlan).

Compare LO* partons with CTEQ6 partons at LO and NLO.

Ignoring lowest E_T bin where hadronization and underlying event (not yet considered), and possibly small x physics, an issue, LO and LO* a bit better in normalization and shape than NLO.

→ Why not performing LO/NLO fits directly with the MC including all kinematic effects, which are neglected here ?



Strategy

- fully consistent approach would require doubly uPDFs and appropriate factorization theorem, which will include collinear factorization and k_t -factorization as asymptotic limits...
- branch 1: use uPDFs and k_+ -factorization as done with CCFM and CASCADE
- branch 2: use standard MCEG like PYTHIA/HERWIG/RAPGAP and obtain PDFs from fits to F_2 and TeVatron data, as done in global analyses
 - neither LO or NLO is appropriate
 - define MC-PDFs, depend on generator, parton showers etc
 - **MC-factorization scheme.... instead of \overline{MS} bar**
 - include proper treatment of parton showers in initial and final state
 - include all kinematics from full simulation, no approximations

Strategy (cont'd)

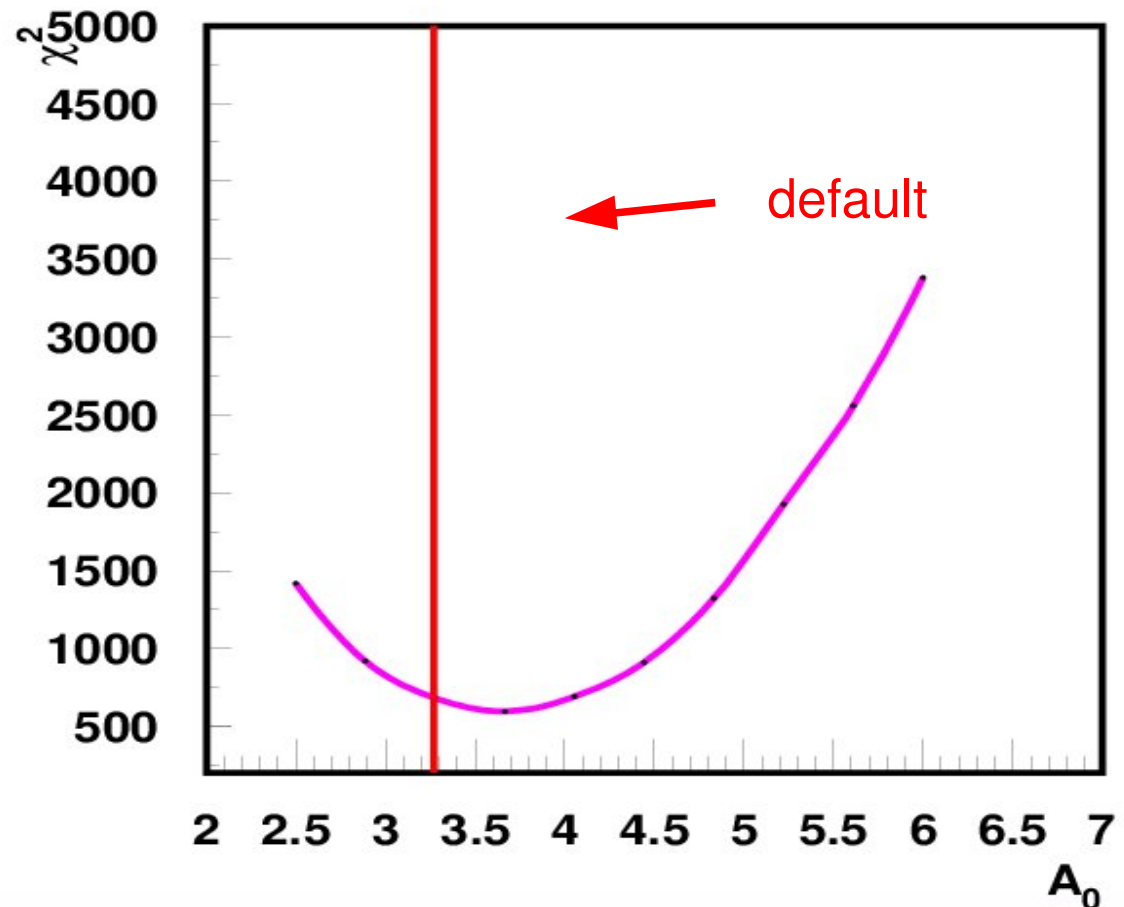
- use LHAPDF library for parton evolution and alphas
 - use any distribution and evolution code
 - evolve for every call (fast enough, can be improved if necessary...)
 - massive/massless treatment
 - LO/NLO etc
- use HZTool/RIVET for comparison of MC prediction with measurements
 - HERA H1/ZEUS: F_2 , F_2^c , jets etc....
 - TeVatron CDF/D0: jets, W/Z x section as fct of pt
 - (CTEQ also wants to do this.....)
- use general fit program (as used for CASCADE uPDF fits)
 - easily extendable for other MC generators and also NLO programs
 - BUT it is slow !!!
 - Improvements for fits (in progress: A. Knutsson, K.Kutak (DESY))
 - calculation in grid points
 - parametrization
 - fit to data (including uncertainties)

Proof of Concept

- fit F_2 with PYTHIA !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
- use CTEQ6L as starting distribution
- scan different parameters

$$x G(x, \mu_0) \sim A_0 x^{A_1} \dots$$

→ normalization changed

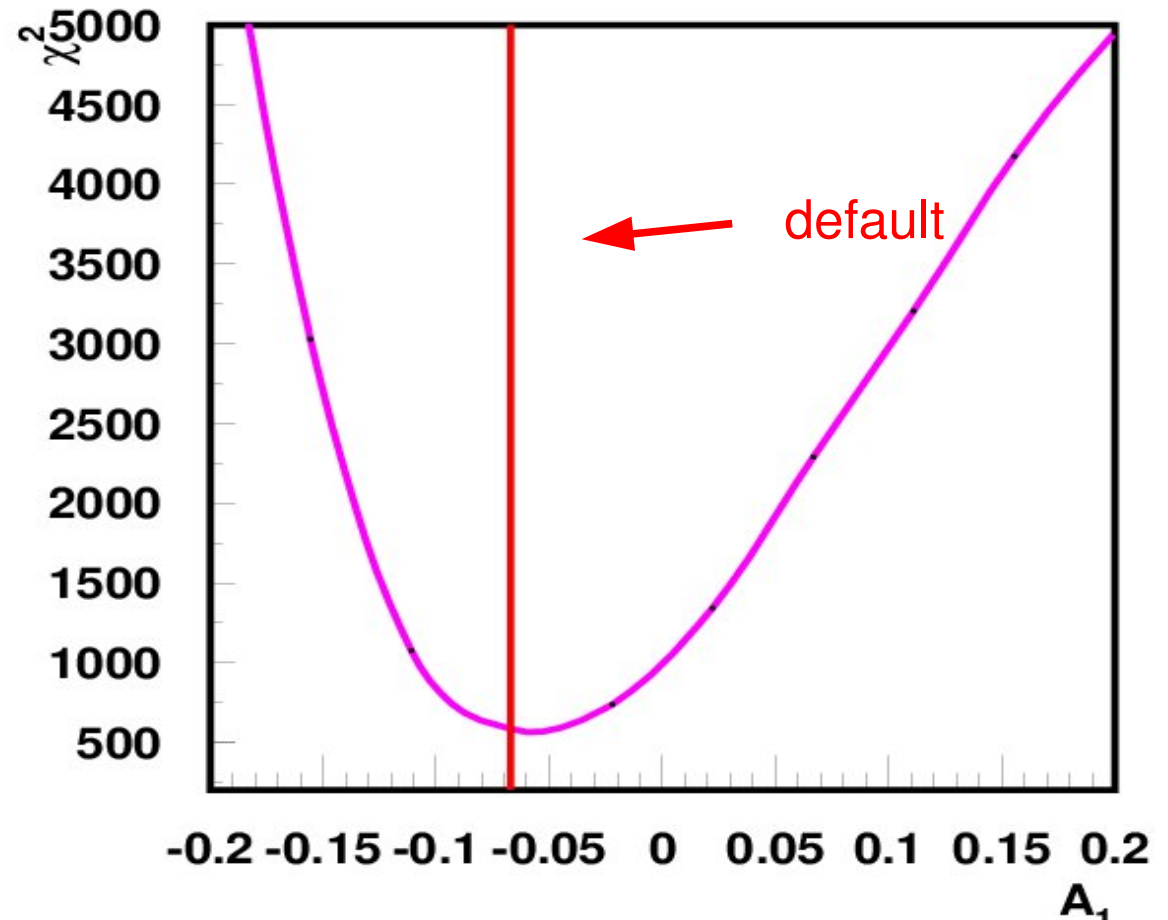


Proof of Concept

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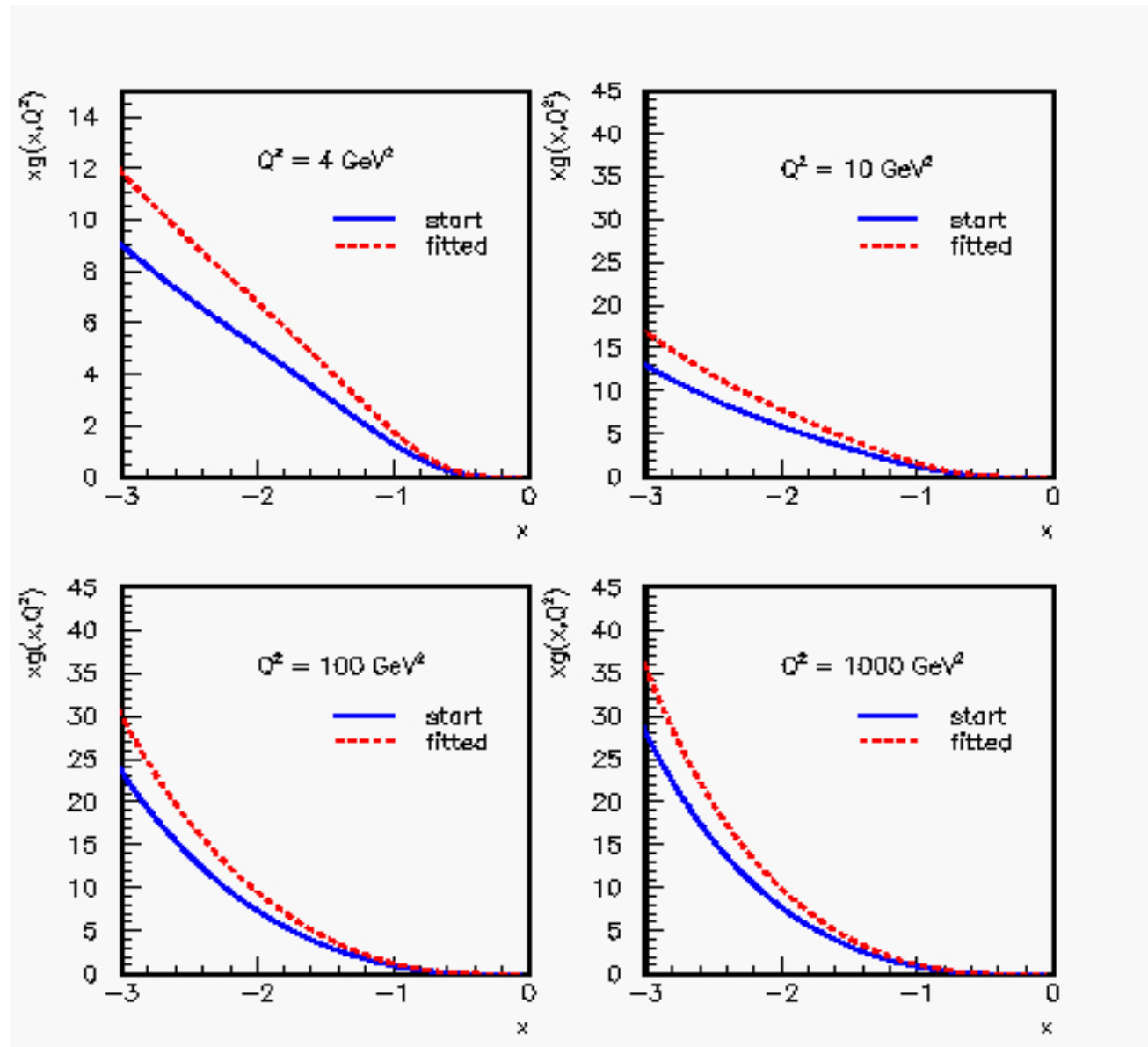
$$x G(x, \mu_0) \sim A_0 x^{A_1} \dots$$

- normalization changed
- small x -dependence of gluon changes slightly !!!



The gluon after fit

- Use LO fit....
- Fit F_2 by varying
$$xg(x, \mu) = A_0 x^{A_1} \dots$$
and $\alpha_s(\mu)$
- Fit changes normalization and slope of gluon ... as seen in the scan....
- χ^2/ndf improves...., but can still be better....
- ➔ Not yet the final answer...



Conclusions

- use PDF4MC helps to improve description of data by MCs
 - use it for better detector simulation
 - will improve model dependence of data correction to hadron level
 - smaller systematic uncertainty
- use of PDF4MC improves our physics understanding:
 - includes kinematic effects
 - allows to use all order resummed predictions (from PS MCs)
 - allows to analyze data which cannot be compared to parton level NLO calculations ...
- PDF4MC can be directly used at LHC with much improved predictive power
 - consistent treatment of $\alpha_s(\mu)$
 - consistent treatment of parton showers
 - consistent treatment of pt cutoffs and other parameters

Plans

- perform 1st fits to F_2 during summer
- comparison with final state measurements
- include all HERA data
- include TeVatron with W/Z and Jets
- end of summer: 1st HERA PDF4MC