PDF4MC

H. Jung (DESY)

- PDF4MC

  why special PDFs for MCs are needed, necessary and important

  - Strategy:

    HOWTO obtain PDF4MC

    connection to uPDFs and collinear PDFs

  - 1st attempts

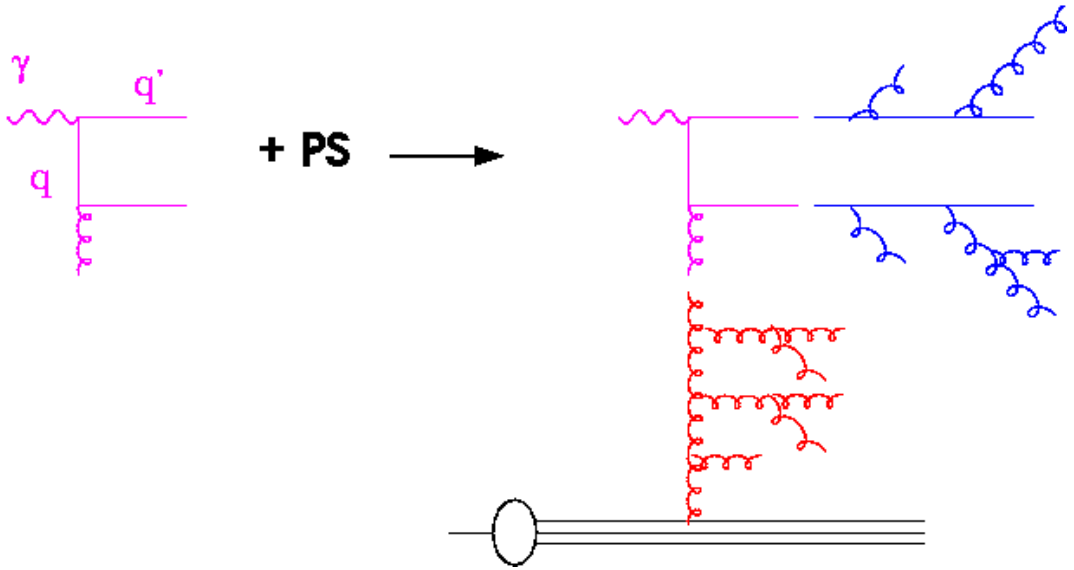
    F_2

    di-jets in DIS

    Z_0 at TeVatron

- Conclusions

Motivation: example from HERA



- **Collinear approach:** incoming/outgoing partons are on mass shell

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s = 0 \rightarrow x = Q^2/(ys)$

- **BUT** final state radiation:

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s = m^2 \rightarrow x = (Q^2+m^2)/(ys)$

- **AND** initial state radiation:

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s + q^2 = 0 \rightarrow x = (Q^2-q^2)/(ys)$

- **Collinear approach: $q'^2 = q^2 = 0$, order by order ....**
- Well known.... since years....
- NLO corrections... better treatment of kinematics... but still not all....

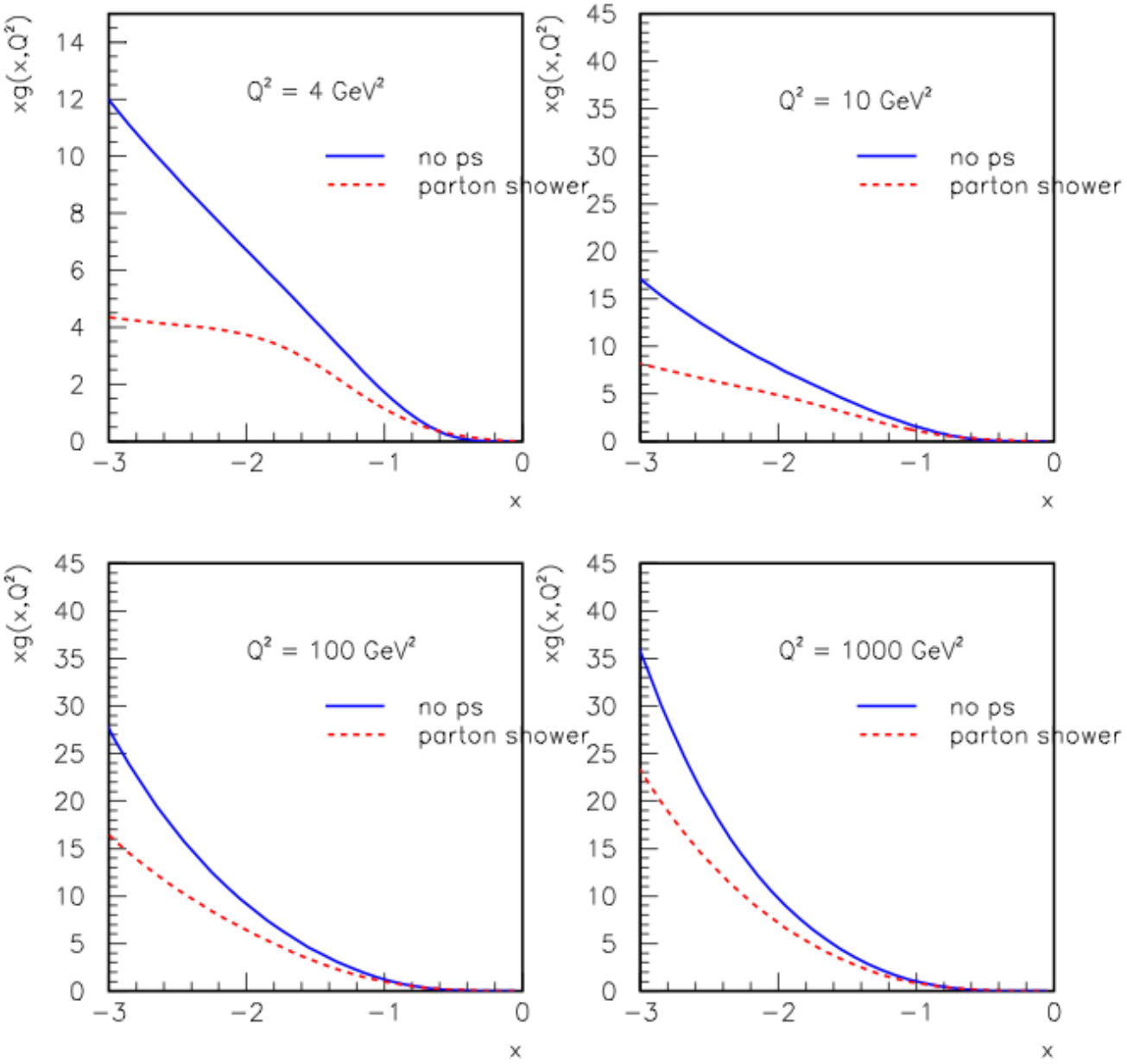
gluon from F_2

- F_2 described by PYTHIA with reasonable χ^2
- significant difference from including initial state parton showers
- gluon much less stee !!!!

➔ change of kinematics

➔ better treat kinematic from beginning

- special machinerie in DIS needed....



Motivation

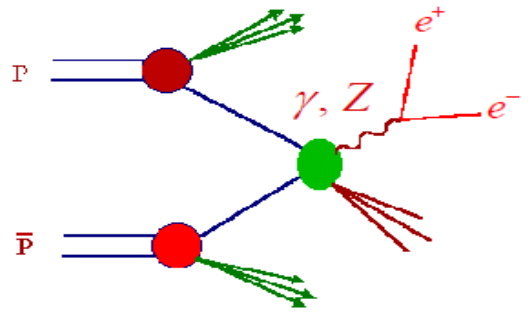
New from DIS07

CP. Yuan, DIS2007

New Task of Global Analysis

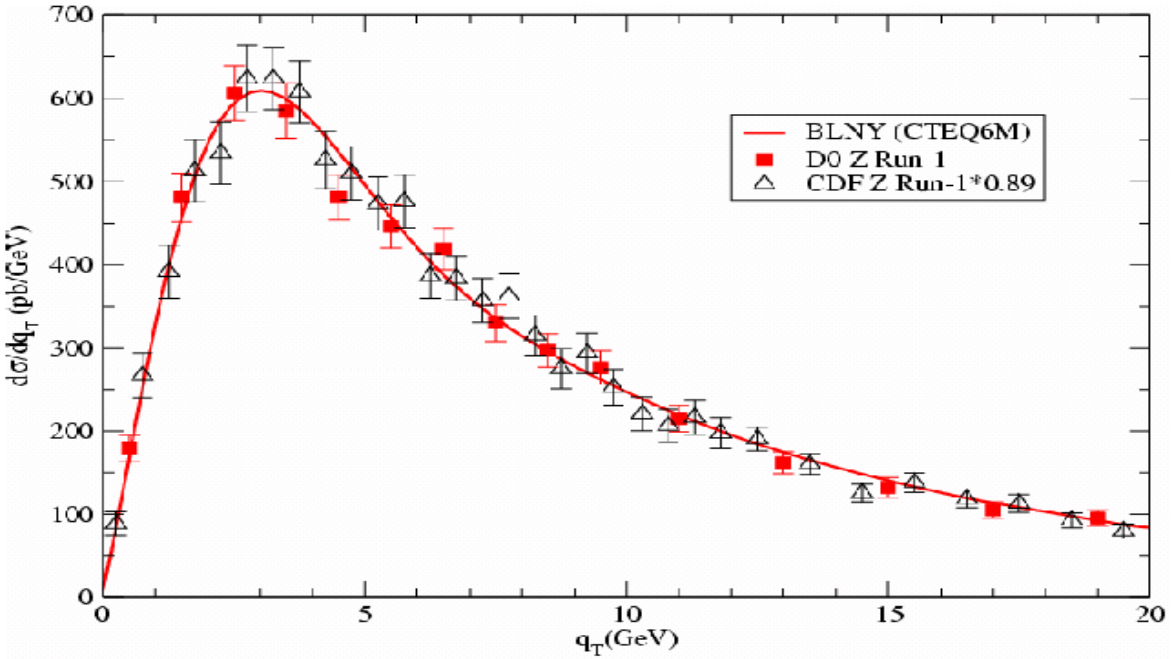
Include Transverse Momentum p_T distributions

- 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



PDF4MC – why ?

- MC generators include not only LO ME – calculations, but include resummation to all orders via parton showers
- as resummations are now included in PDF determiantions, parton showers should also
- "factorization scheme" in MC event generators is not DIS, nor MSbar, but a MC specific factorization scheme
- in a global analysis, PDF and also parton shower parameters can be simultaneously determined ...
- kinematic effects of including transverse momenta can be important for PDFs

Strategy

- fully consistent approach would require doubly uPDFs and appropriate factorization theorem, which will include collinear factorization and kt-factorization as asymptotic limits...
- branch 1: use uPDFs and k_t-factorization as done with CCFM and CASCADE (see talk by F. Hautmann, A. Knutsson and CASCADE)
- branch 2: use standard MCEG like PYTHIA/HERWIG/RAPGAP but also ALPGEN/SHERPA etc 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 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
- 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 (PROFFIT or PROFESSOR)
  - easily extendable for other MC generators and also NLO programs
  - Improvements for fits (in progress: A. Knutsson, K.Kutak, H. Hoeth)

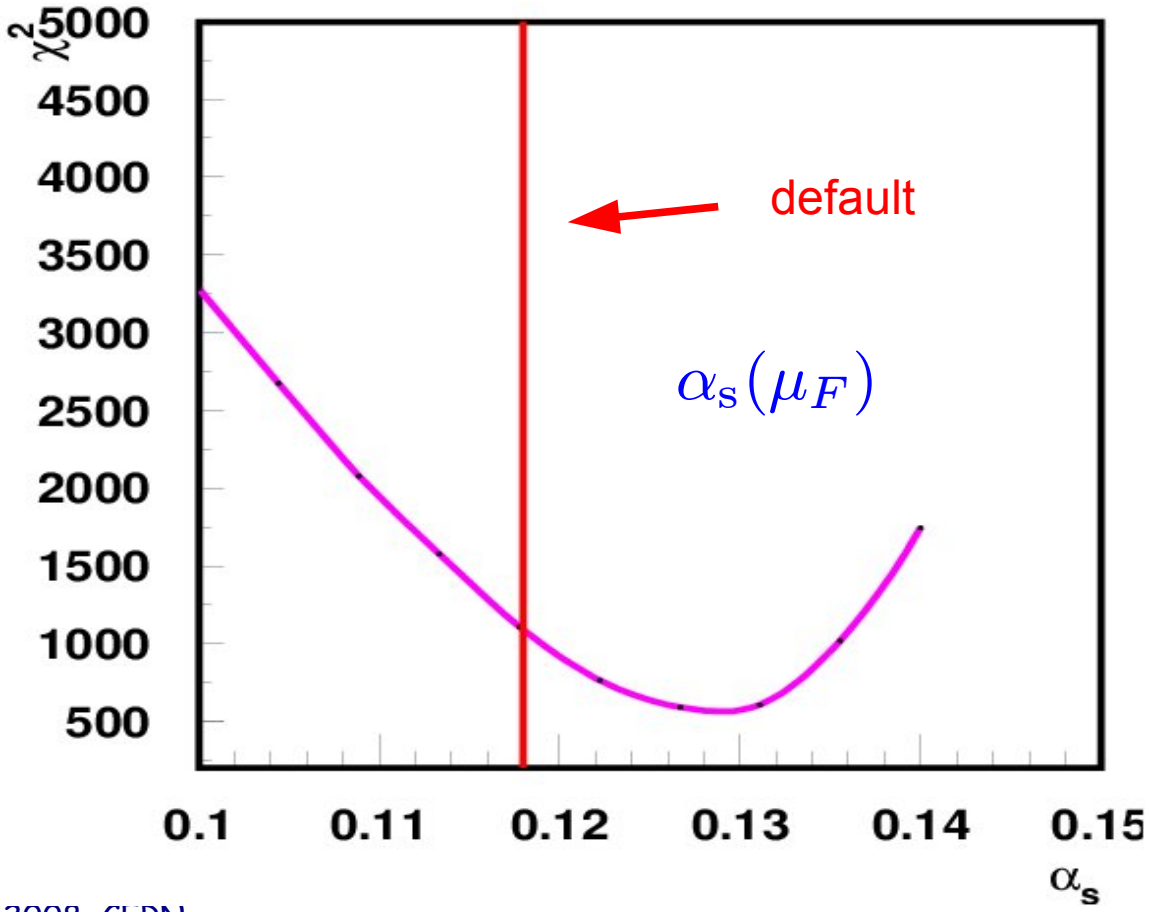
➔ calculation in grid points

➔ parametrization

➔ fit to data (including uncertainties)

1st attempts: F_2

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



1st attempts: F_2

- fit F_2 with PYTHIA
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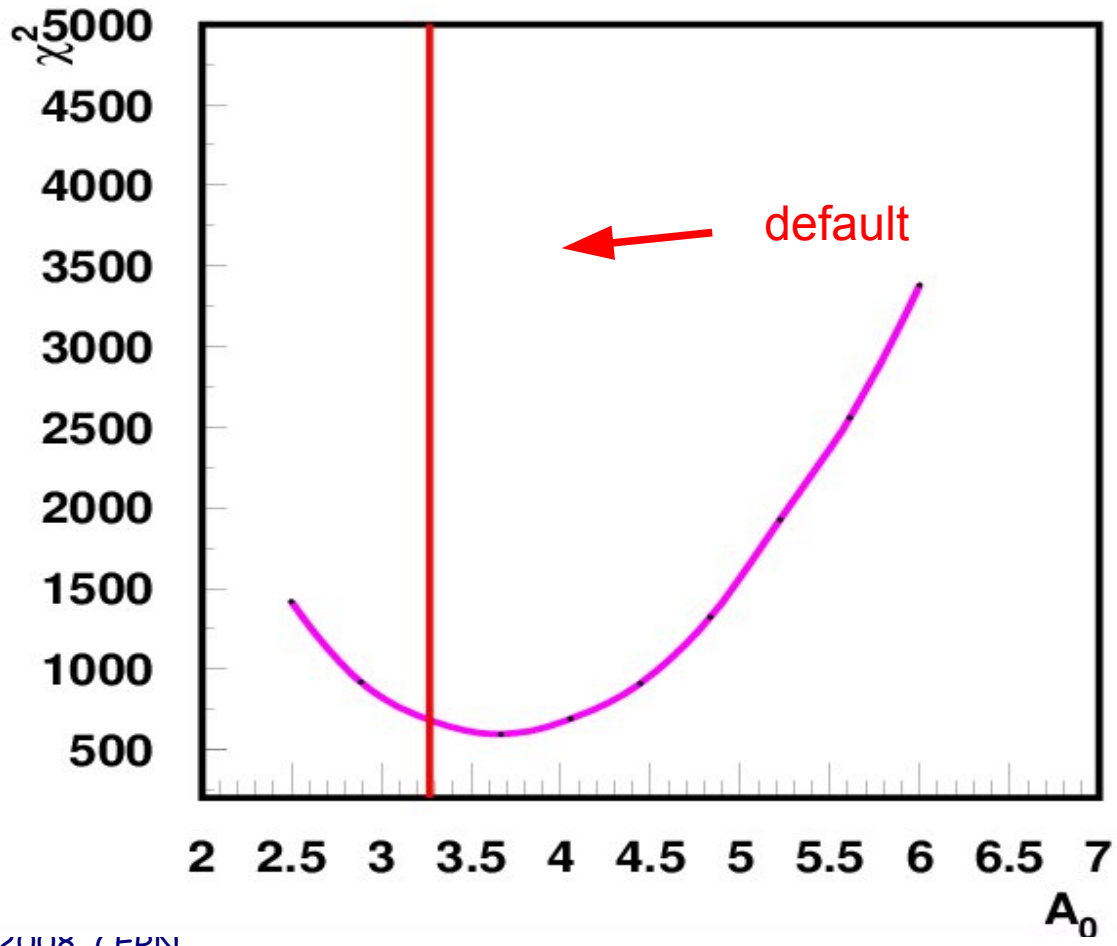
$$xG(x,\mu_0) \sim A_0 x^{A_1} \cdots$$

➔ normalization changed



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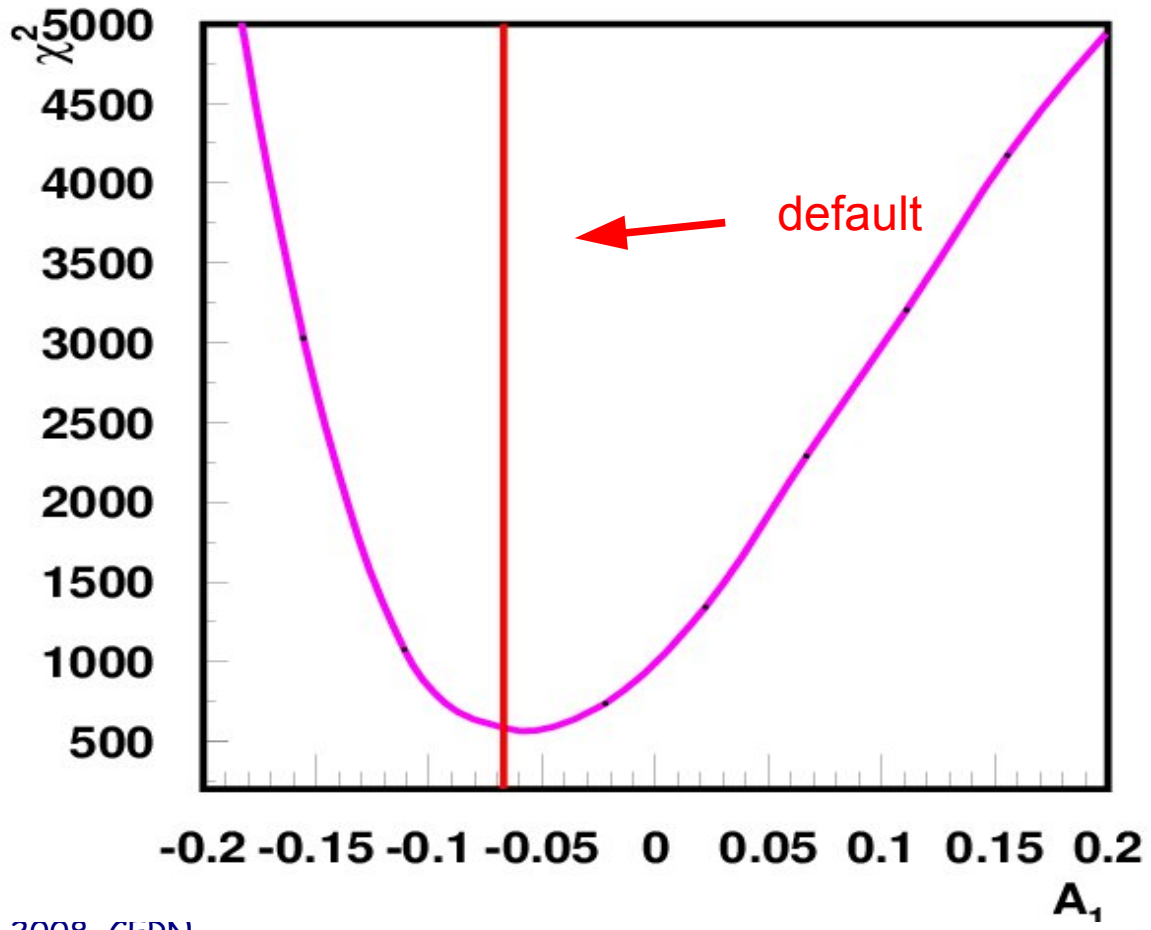


➔ normalization changed

➔ small x-dependence of gluon changes slightly !!!

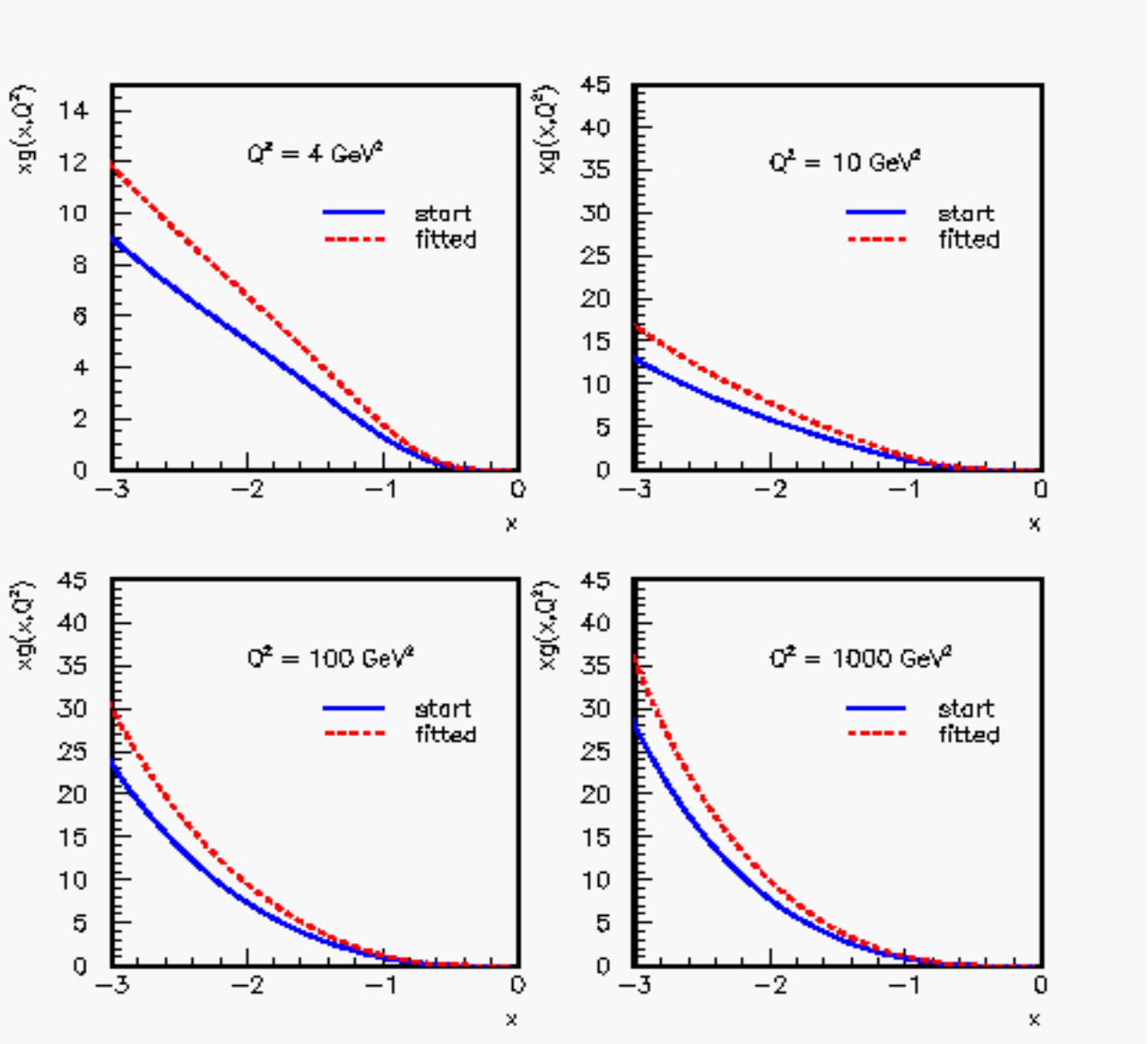
The gluon after fitting F_2

- Use LO fit....
- Fit F_2 by varying

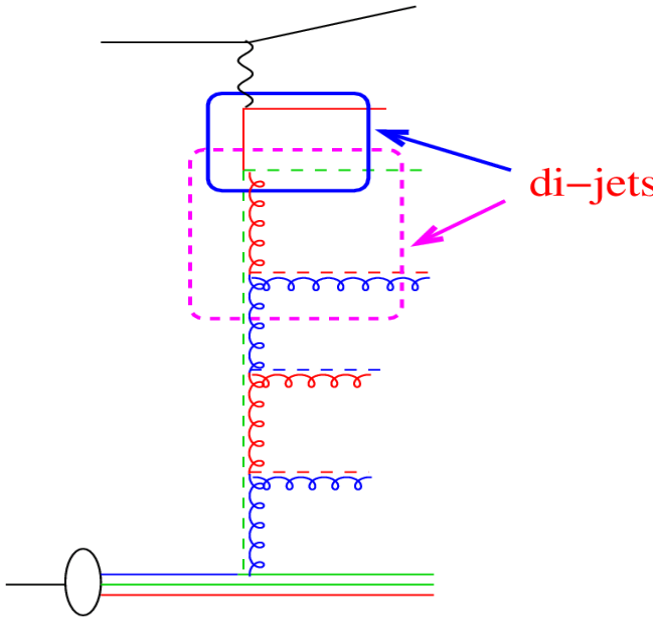
  $xg(x,\mu) = A_0 x^{A_1} \cdots$

  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...



Jets in DIS



- Using PYTHIA for jets in DIS
  NEW !!!
- gives reasonable results...
- for E_t distributions gives

$$\frac{\chi^2}{ndf} = \frac{66}{36} = 1.8$$

with CTEQ6L

- Using H1 jet measurements
  (H1 EPJC 33 (2004) 477)

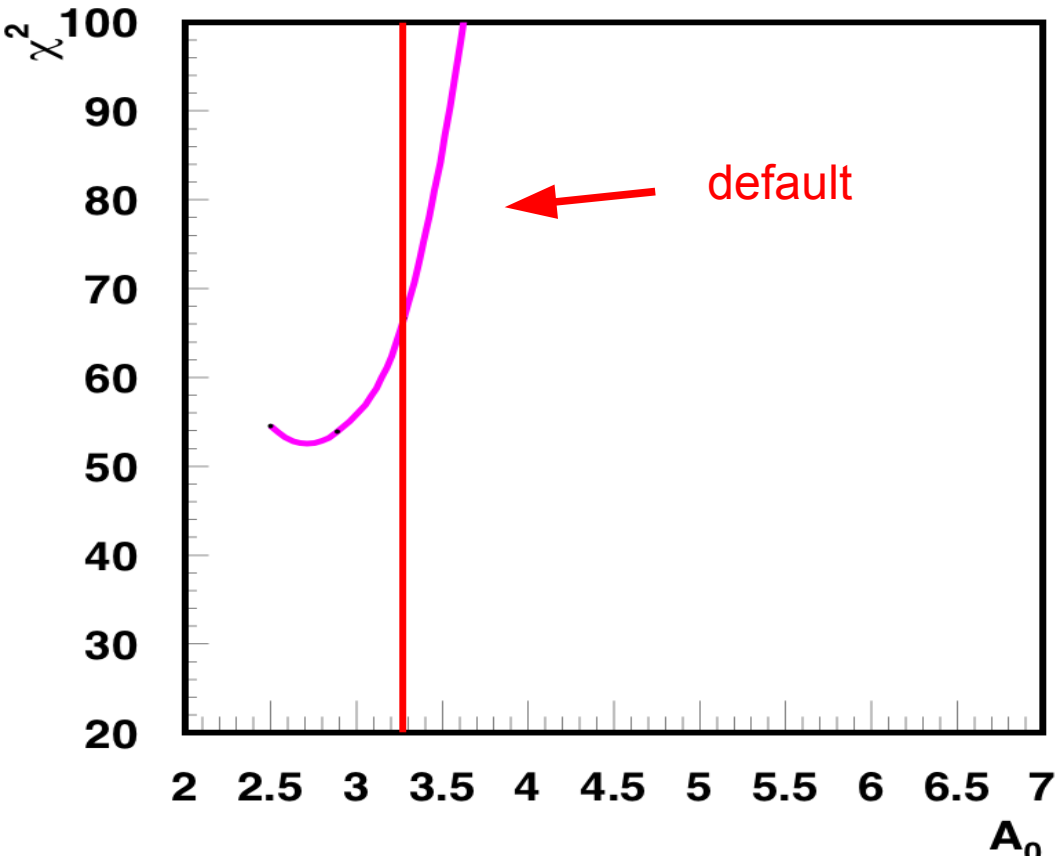
$$5 < Q^2 < 100 \text{ GeV}^2$$
$$-1 < \eta < 2.5$$
$$E_T > 5 \text{ GeV}$$

- investigate x dependence of starting distribution

Gluon after Jet fit

- fit DIS dijets with PYTHIA
- use CTEQ6L as starting distribution
- scan different parameters

$$xG(x,\mu_0) \sim A_0 x^{A_1} \cdots$$



➔ normalization changed

➔ and as a consequence also the quark distributions...

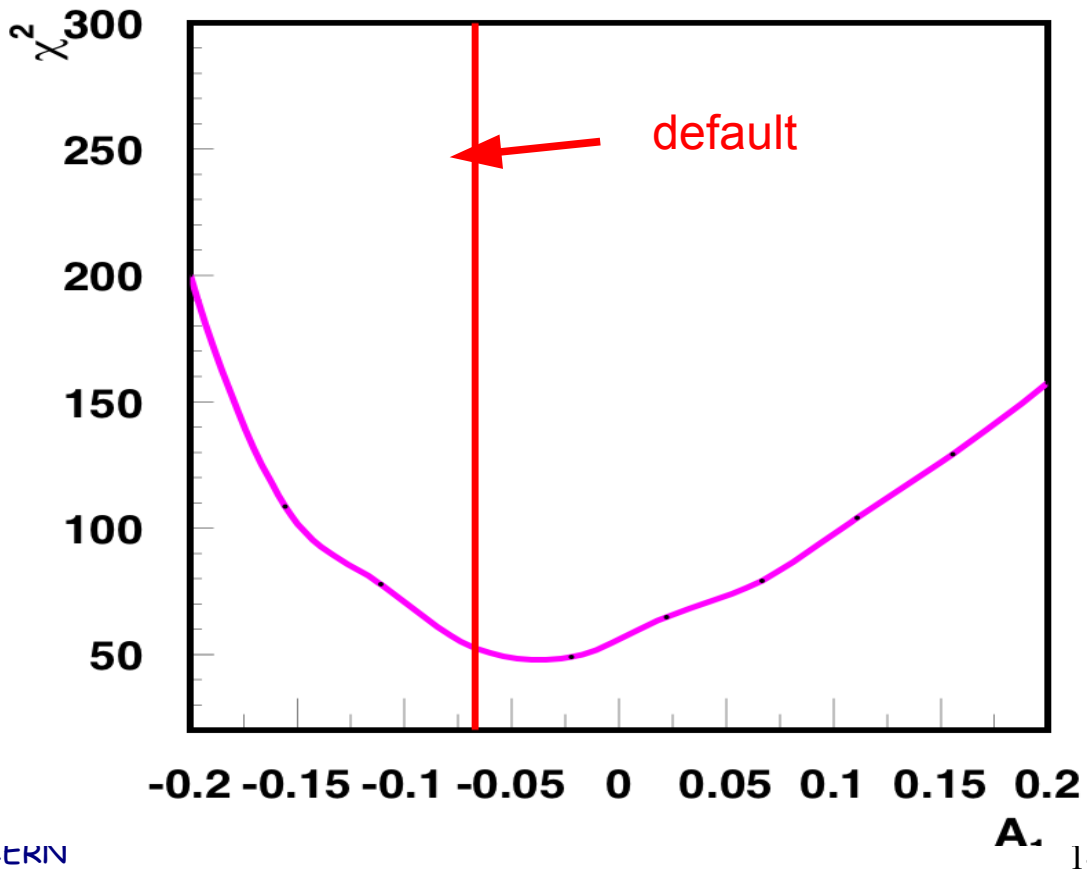
Gluon after Jet fit

- fit DIS dijets with PYTHIA
- use CTEQ6L as starting distribution
- scan different parameters

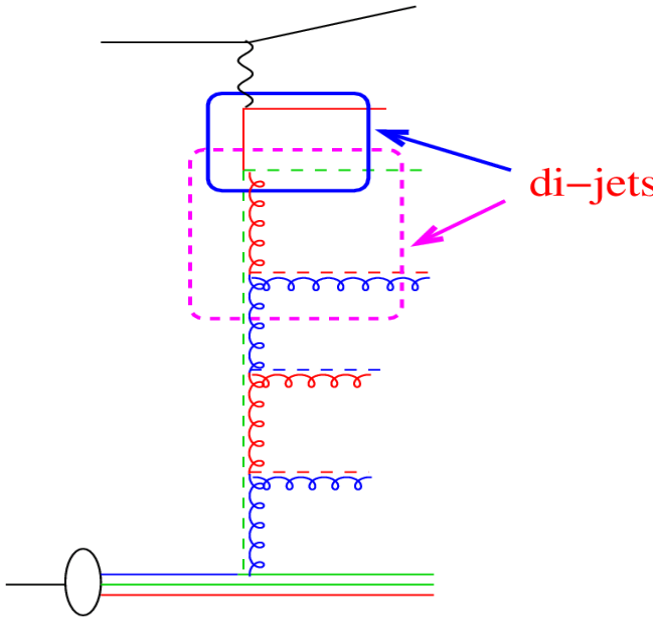
$$xG(x,\mu_0) \sim A_0 x^{A_1} \cdots$$

Consistent result is obtained

- ➔ normalization changed
- ➔ small x-dependence of gluon does not change much
- ➔ overall χ^2 improves by 10 units
- ➔ NOTE: changing the gluon changes also the quarks via mom.sum rule



Jets in DIS... after fit ...



- Using H1 jet measurements

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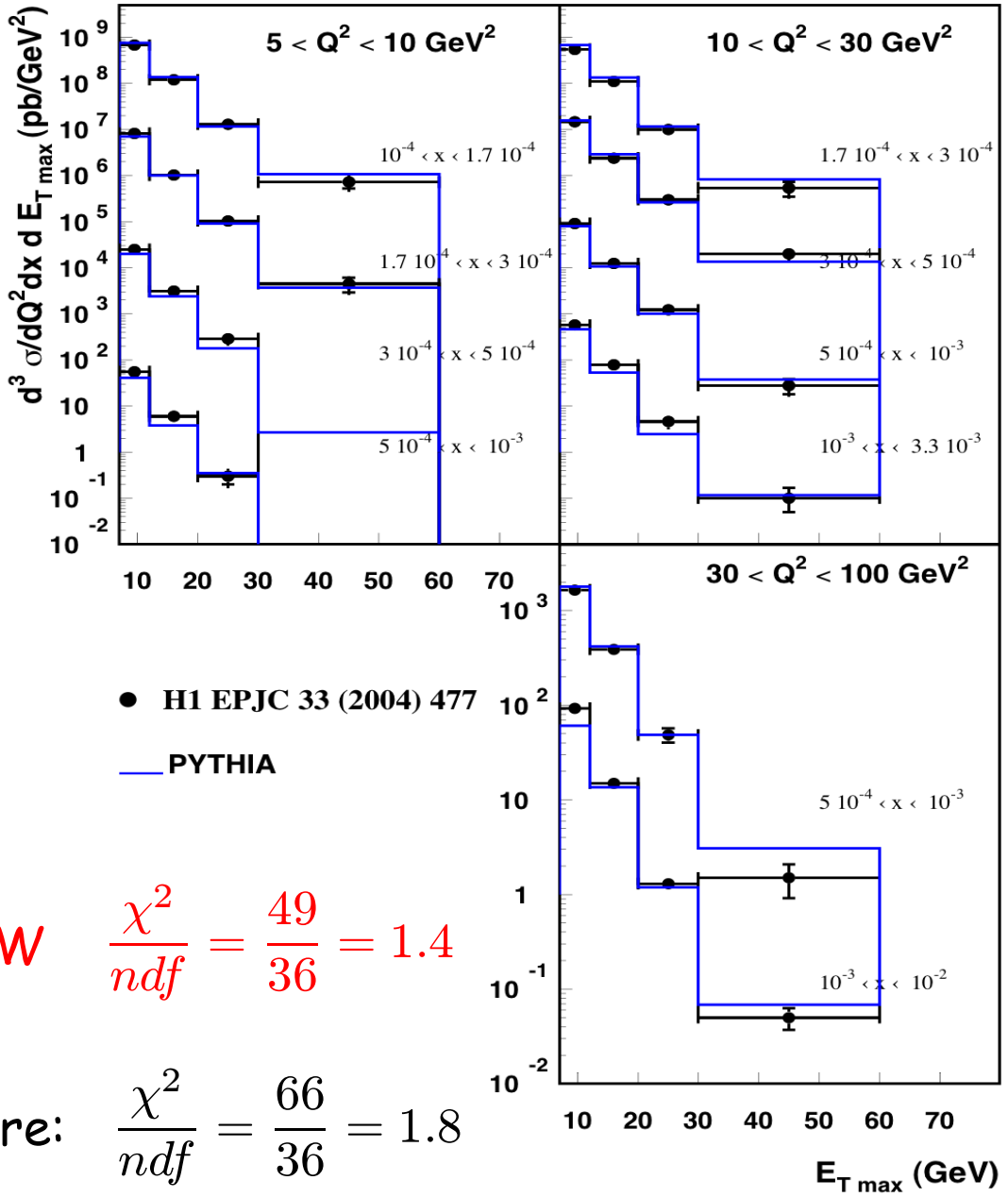
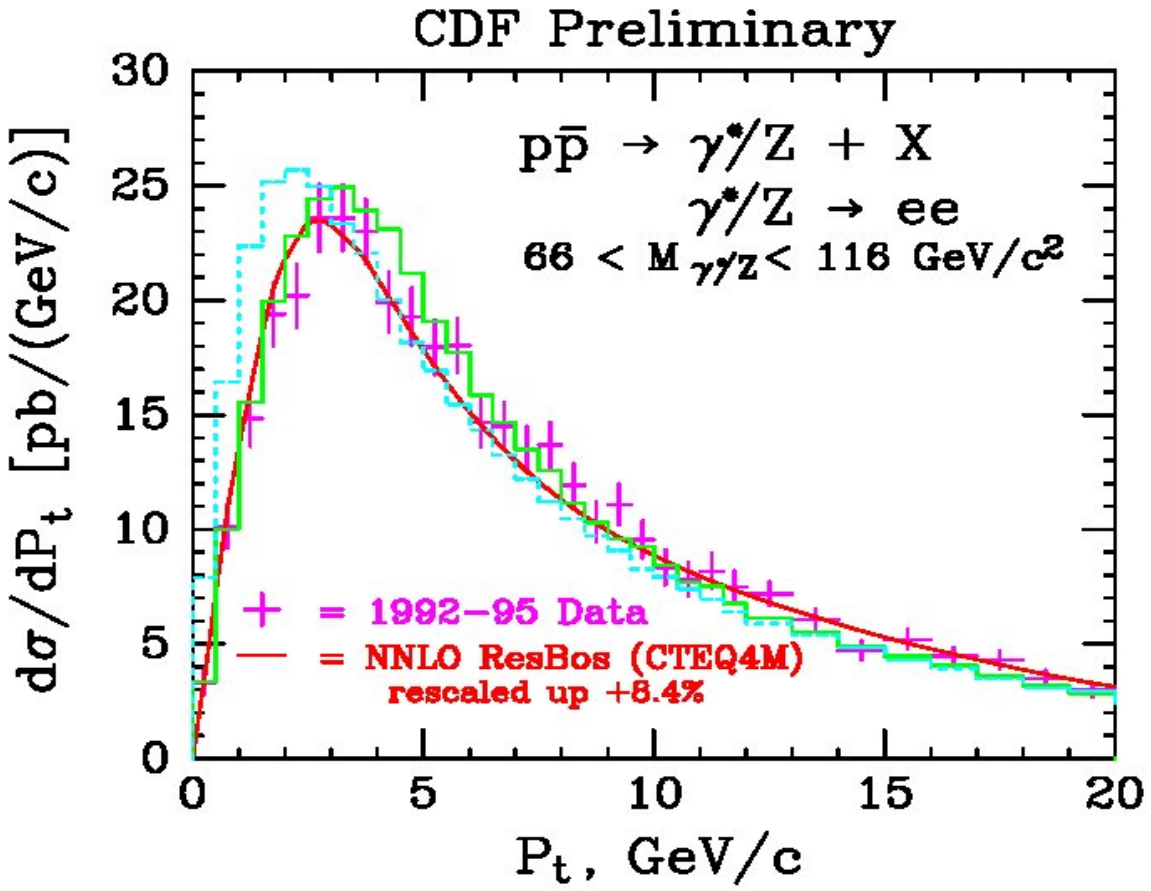


NEW $\dfrac{\chi^2}{ndf} = \dfrac{49}{36} = 1.4$

compared to before: $\dfrac{\chi^2}{ndf} = \dfrac{66}{36} = 1.8$

steps toward global fit: Z at pp

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



to produce Z, need:
x ~ 0.05 ... E~45 GeV

transverse momentum is ca 10 %

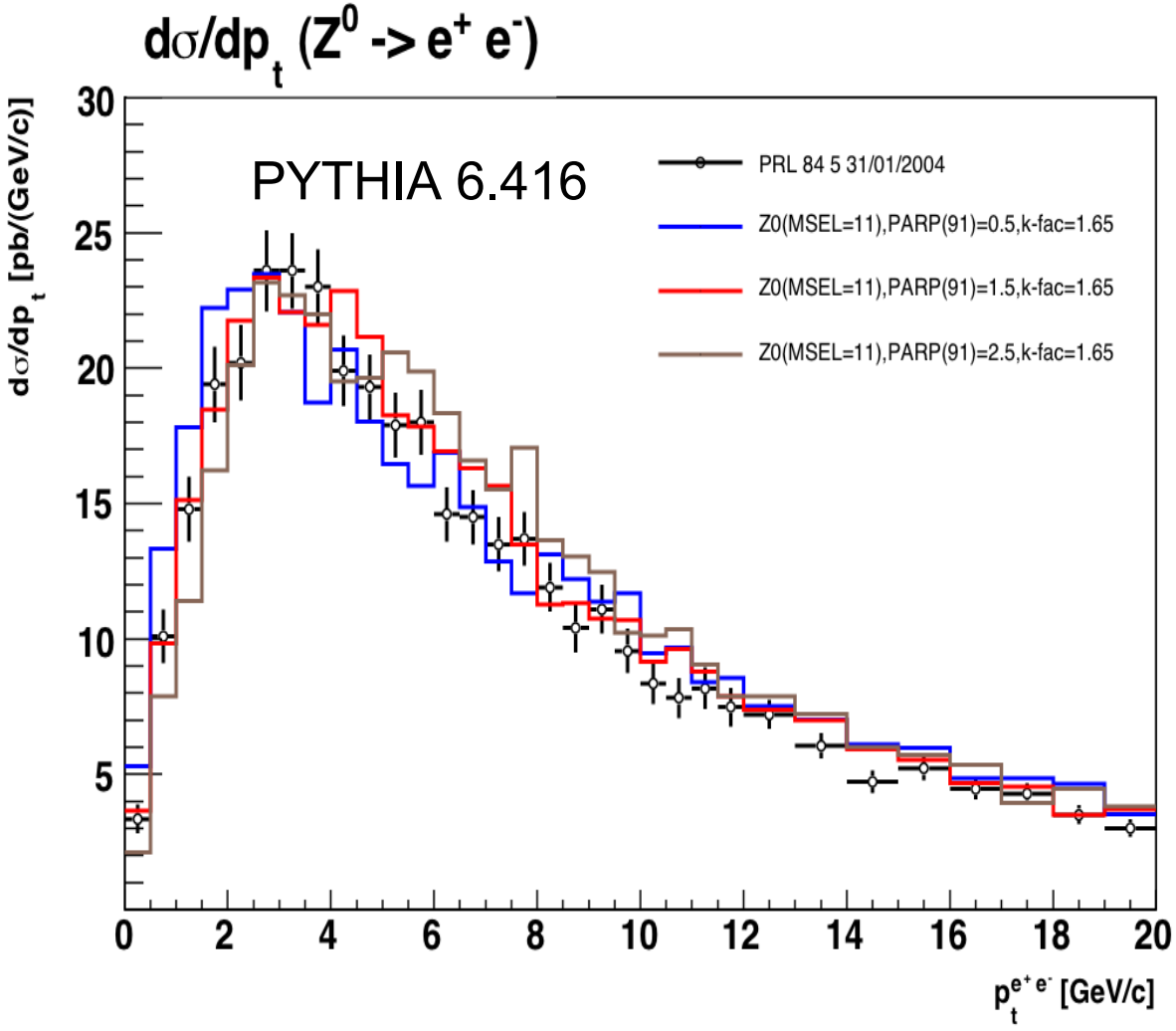
can have effect on x ..

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.

Z_0 in pp with PYTHIA

- 1st studies on p_t spectrum of Z at Tevatron
- reasonable description after adjusting intrinsic kt... ~ 2 GeV ...
- What is the effect on PDFs ?
- What is the effect on HERA measurements ?
- Perform a global fit including also other HERA measurements !!!

from Federico Samson-Himmelstjerna (DESY)



Next steps ...

- tools are available ...
- start with fits: (Federico Samson-Himmelstjerna, DESY)
  - HERA inclusive data (F2c, F2 (?), DIS jets, photoprod jets and charm)

  ➔ determine gluon, sea quarks
  - perform fits to parton shower parameters (together with pdfs)
- perform global fits
  - include Tevatron Z for intrinsic kt and IPS
  - .... study quark pdfs, etc ..
  - collaborate with tuning at Tevatron/LHC including multiple interactions etc ...

- PDF4MC is one of the activities of MC group of Terascale Analysis Center at DESY .... (see presentation tomorrow)

Conclusions

- using PDF4MC helps to improve description of data by MCs
  - ➔ will improve model dependence of hadron level correction
  - ➔ smaller systematic uncertainty

- concept of PDF4MC works

➔ to be extended for a global fit of HERA and other data using PROFFIT

- use of PDF4MC is important to
  - ➔ include kinematic effects
  - ➔ use all order resummed predictions (from PS MCs)
  - ➔ is the only consistent way to use PDFs in MC generators