PDF4MC

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(DESY)

- PDF4MC

    why special PDFs for MCs are needed, necessary and important

    - Strategy:

        HOWTO obtain PDF4MC
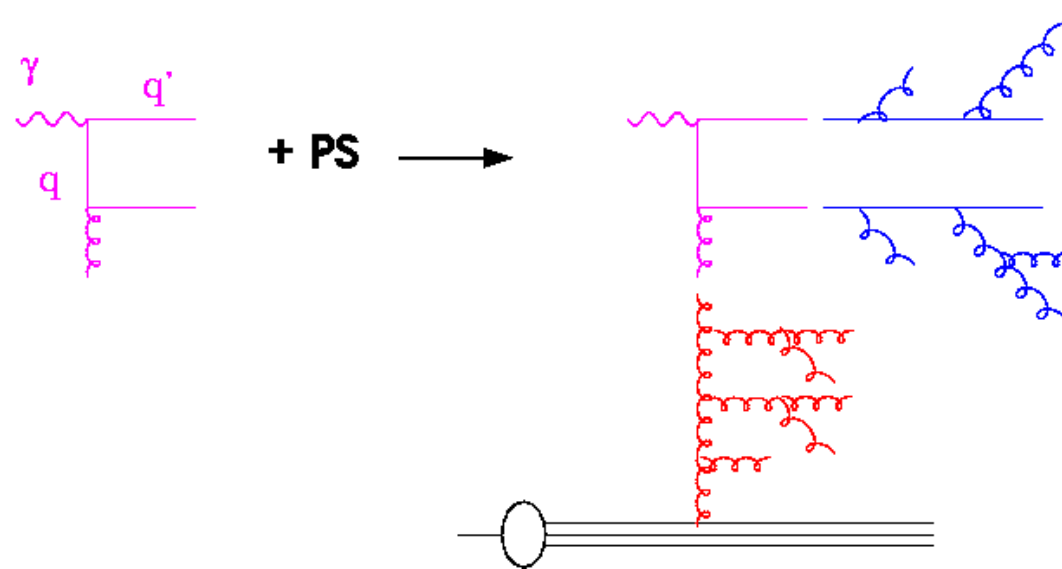
    - which data to use for fits

   final states from HERA

    - dependence on MC

- 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 steep !!!!**
- ➔ change of kinematics
- ➔ better treat kinematics from beginning
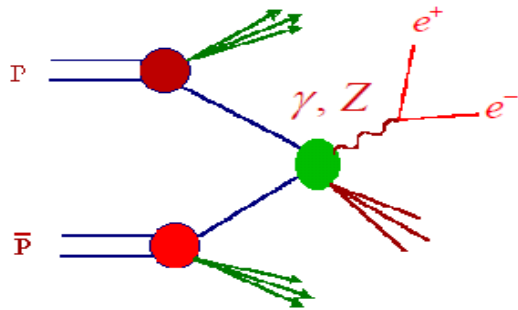- special machinerie in DIS needed....
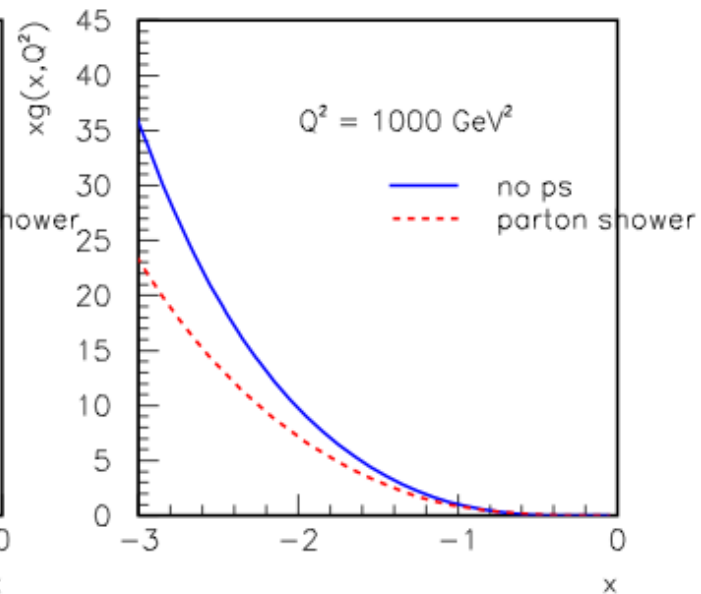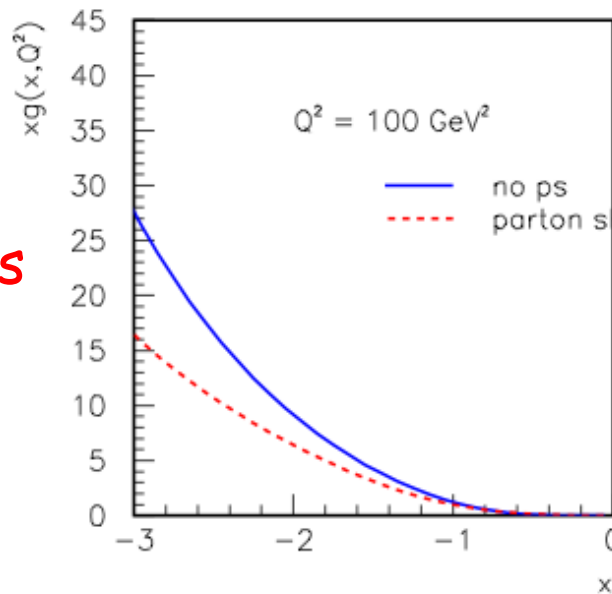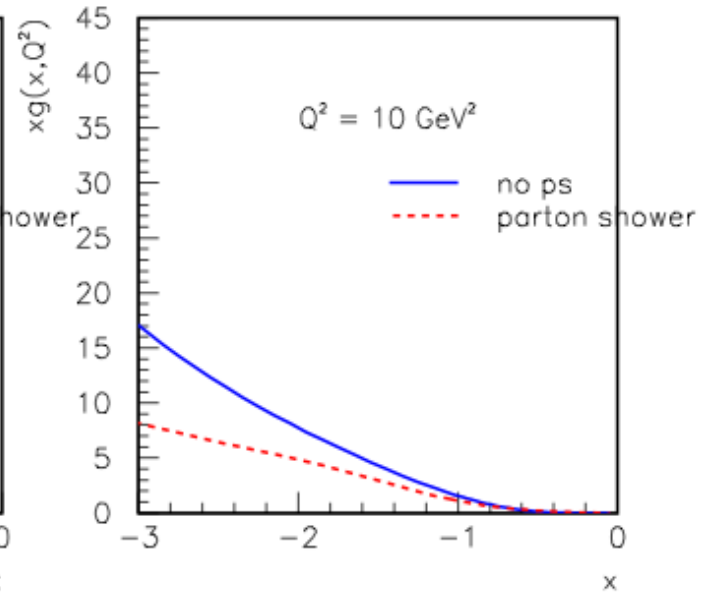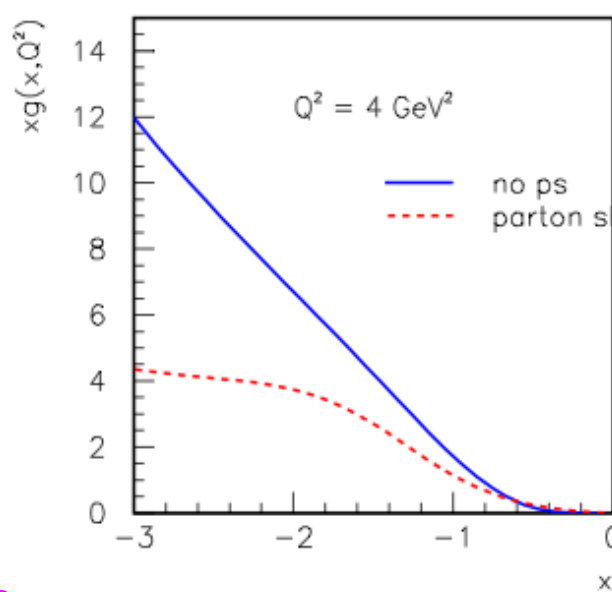
Motivation

New Task of Global Analysis

Include Transverse Momentum p_T distributions

New from DIS07

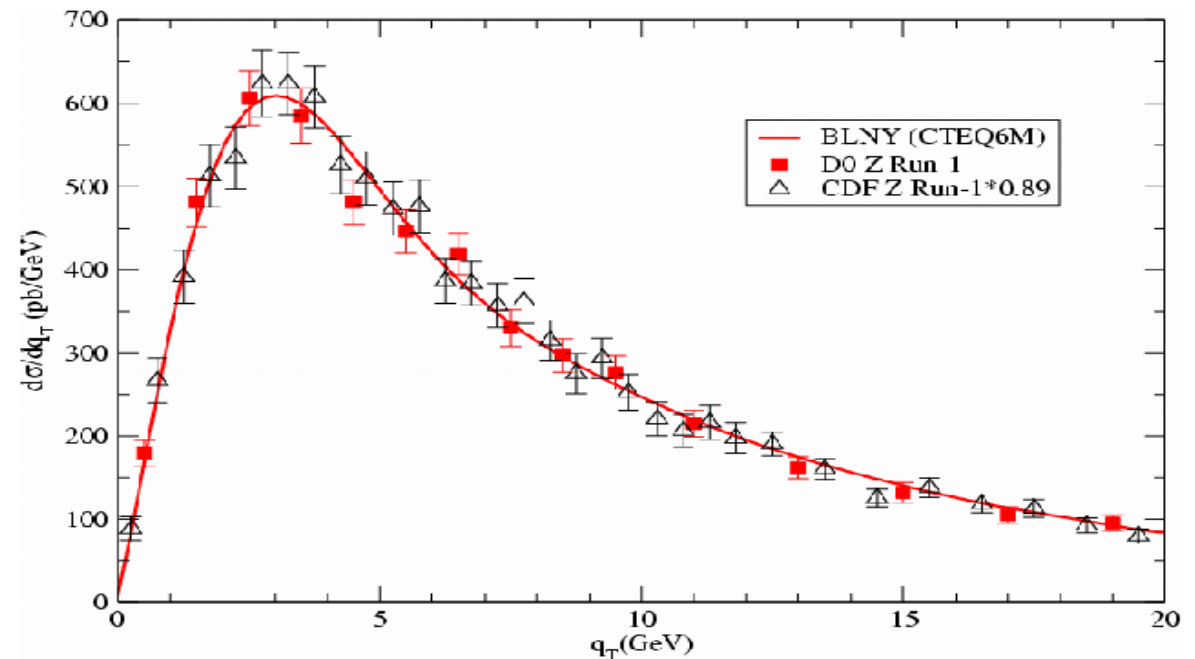- New Data: include not only rapidity (y) but also

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 talks at HERA-LHC WS 2008 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....
  - and at a later stage ....
    - TeVatron CDF/D0: jets, W/Z x section as fct of pt
- use general fit program (PROFFIT A. Bacchetta, A. Knutsson, K. Kutak)
  - 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)

Which MCs to use for PDF4MC fit ?

Lund string fragmentation

- PYTHIA 6
    - for pp ok
    - not really applicable for ep DIS
        - inclusive F_2: NOt really
        - charm in DIS: NO
        - dijets: ok
- PYTHIA 8
    - for pp ...
    - DIS and ep NOT implemented
- RAPGAP
    - applicable for ep DIS
    - using PS similar to PYTHIA (but not exactly (conserve x...)
    - virtuality ordered shower
    - use Lund string

Cluster fragmentation

- HERWIG 6
    - for pp ok
    - not fully applicable for ep DIS
        - inclusive F_2
        - charm in DIS
        - dijets
- HERWIG++
    - for pp
    - DIS and ep NOT implemented

- USE RAPGAP
    - for PDF4MC determiantion
- Use PYTHIA in dijets as x-check
- test "universality" of PDF4MC

Where to start ... ?

- determination of gluon distribution
- use CTEQ 6L as starting distribution (evolution code is fast)
  - with NLO α_s
  - with heavy quark PDF ....
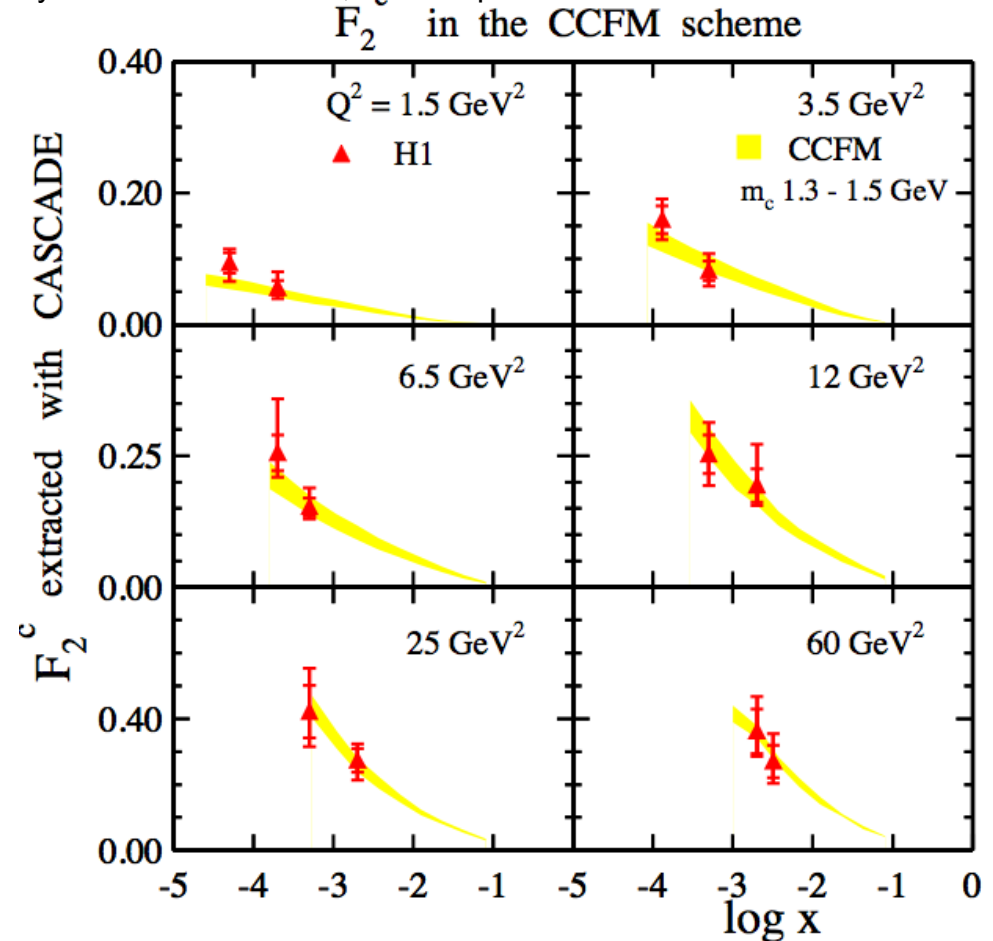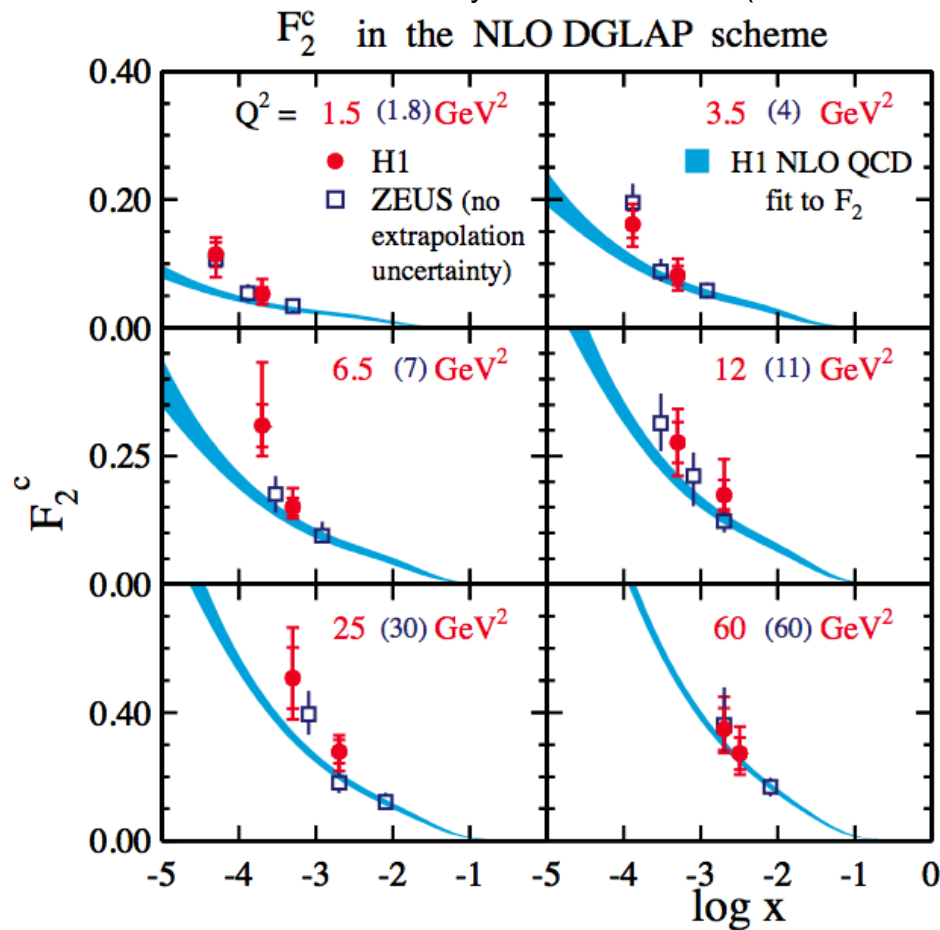- evolve starting distribution for every event

Which data to use for PDF4MC fit ?

- inclusive structure function measurements:

  - F_2 from HERA (not used here)

- heavy quark measurements at HERA:

  - F_2^c, D* in DIS, D* + dijets in DIS

- dijet measurements in DIS

$$\frac{d^3\sigma}{dx\,dQ^2\,dE_t}$$

The problem with charm

- F$_2^c$ depends on assumption for extraction ....

- large extrapolation factors

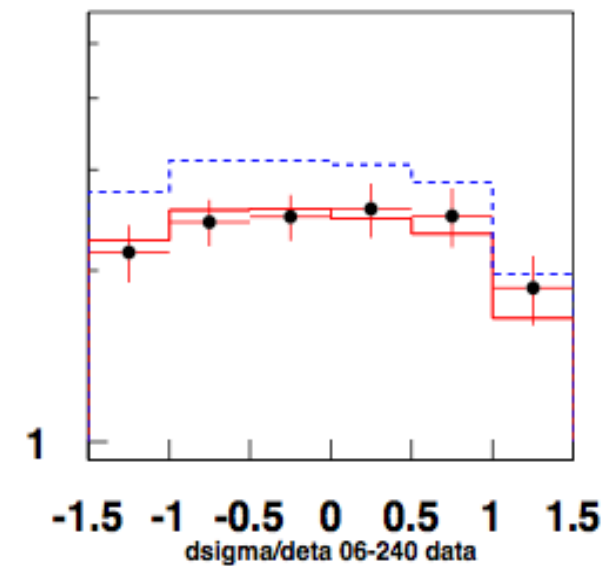- more results at ICHEP 08 .....

The gluon from F_2^c ...
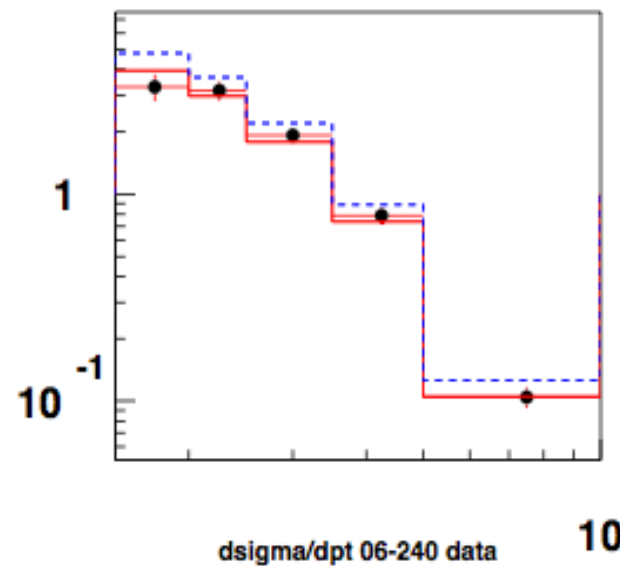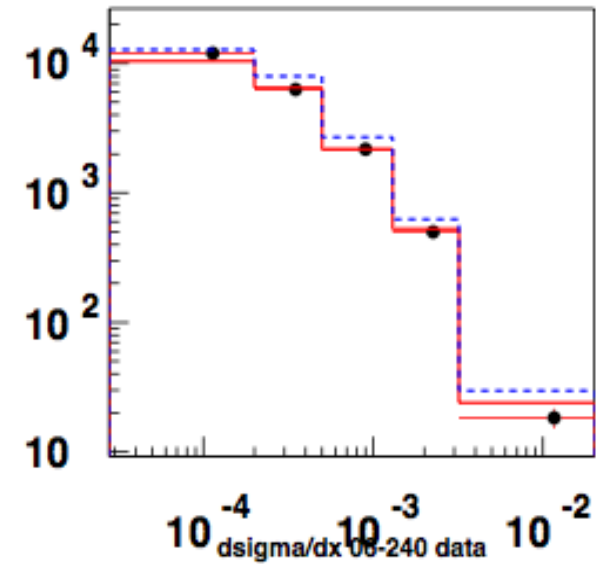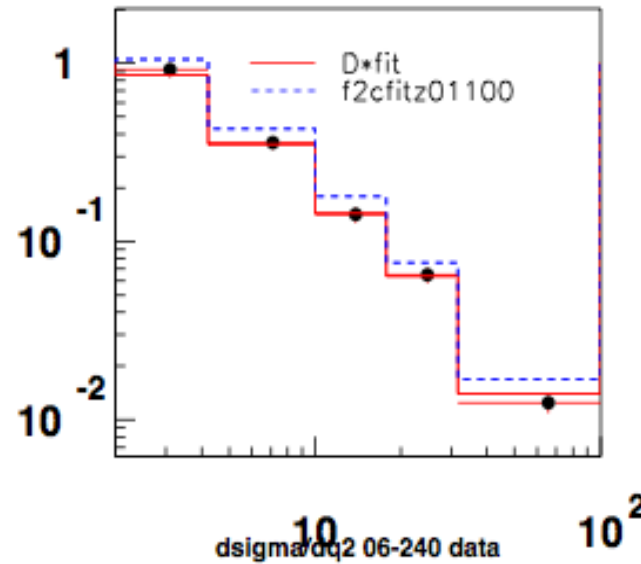
- Fit DGLAP F2c to obtain gluon
- use RAPGAP with massive MEs in LO + PS
- steep gluon obtained ...
- is this a problem of the way F_2^c is "measured" ?
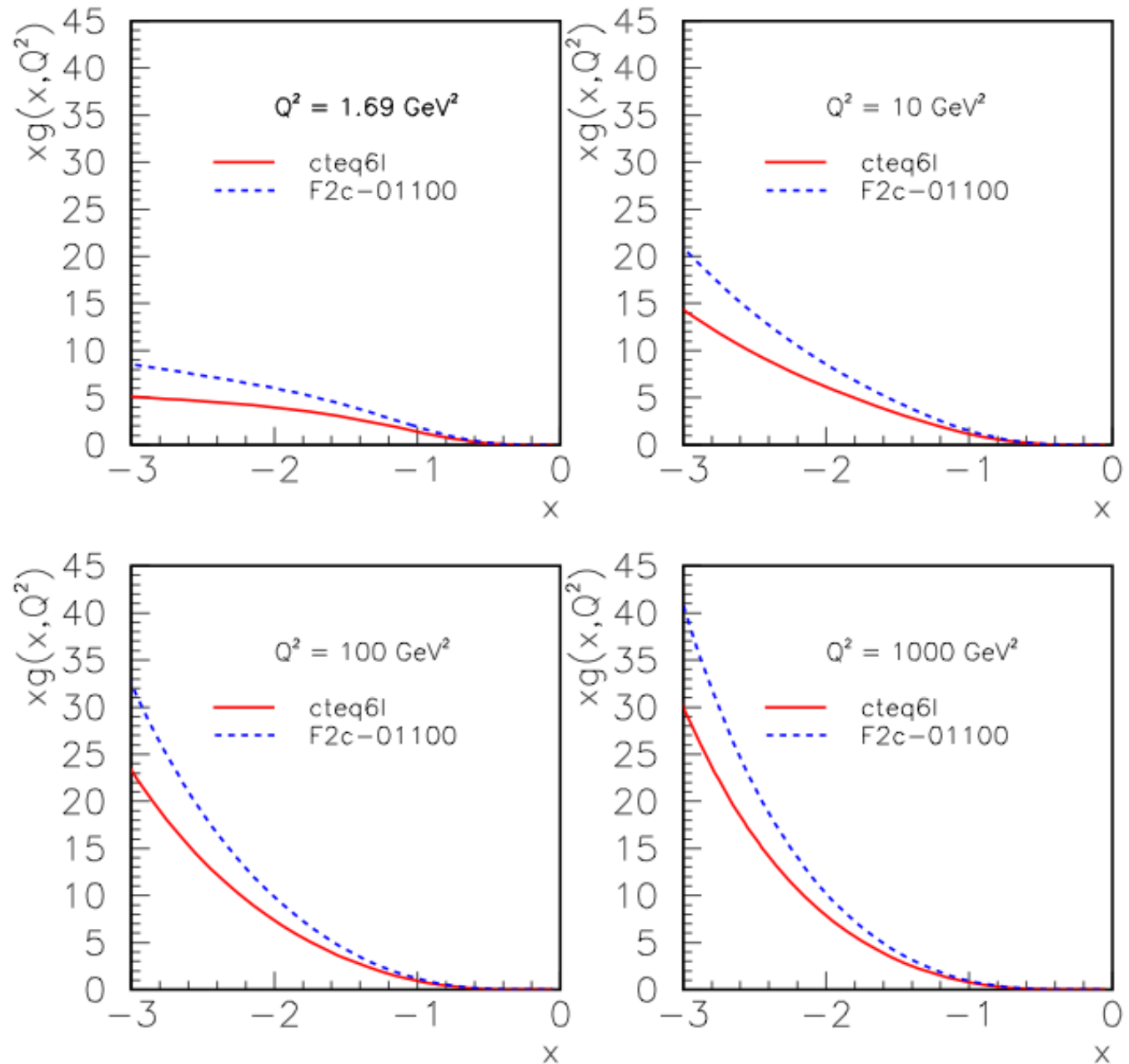
Fits to D* cross section

- use measured xsection of D*
- fit Q^2, x, p_t, η

- improve χ^2 by 6 units compared to starting values
- much improved χ^2 compared to F2c fit

D*fit
f2cfitz01100

dsigma/dq2 06-240 data

dsigma/dx 06-240 data

dsigma/dpt 06-240 data

dsigma/deta 06-240 data

Gluon from D* with jets

- only slightly changed parameters
- BUT further constraints due to different kinematic regions
- Gluon can be well determined from visible charm x-section
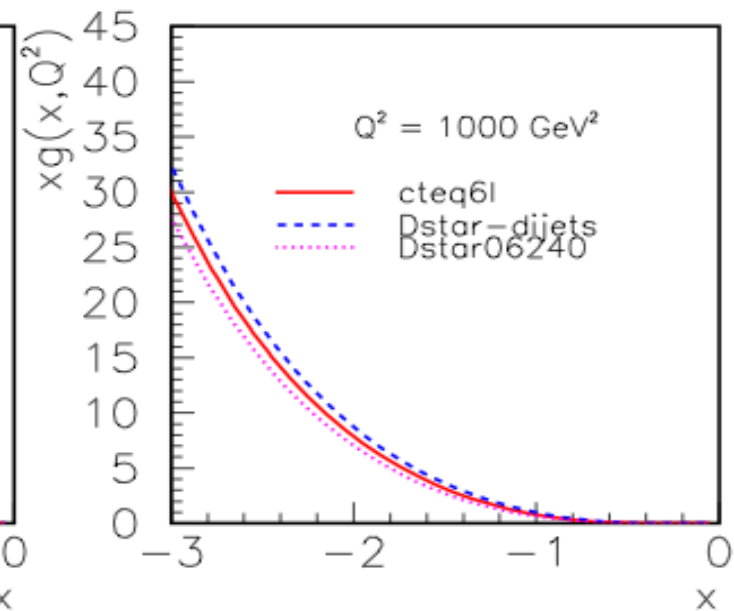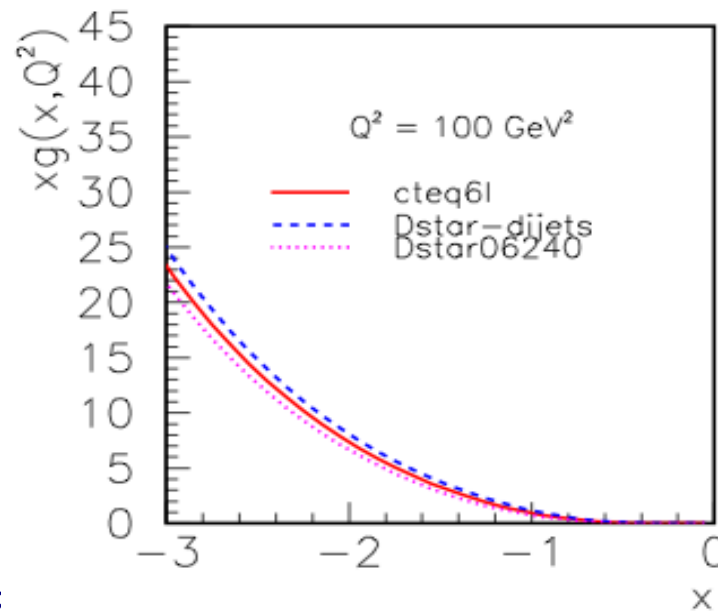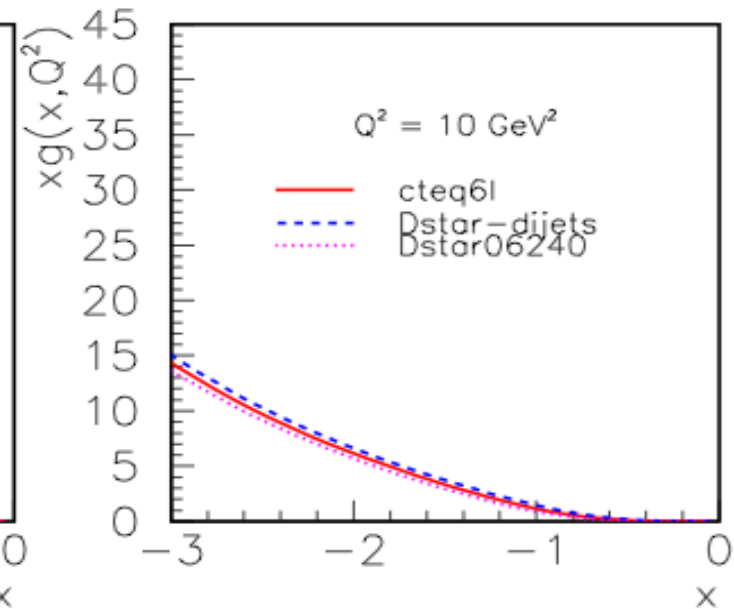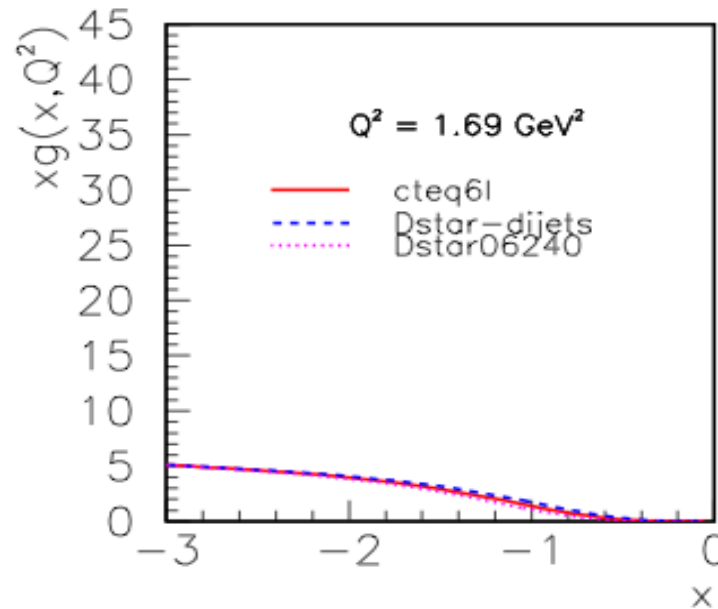
Resume from heavy quarks

- use only visible cross sections,
    - at least for MC fits.... extrapolations to total x-section highly model dependent
    - D* and D*+jet measurements give consistent results for gluon
    - result is nearly identical to CTEQ6l
        - BUT pdf in massless scheme, and ME massive ...
        - NLO alphas in pdf, BUT LO alphas in ME
        - need to check consistency on mass parameters etc

PDF4MC from dijets in DIS

- dijets in DIS, sensitive to gluons but also to quarks ...
- dijets can be calculated by PYTHIA and RAPGAP
    - consistency check and check for "universality" of PDF4MC

Jets in DIS

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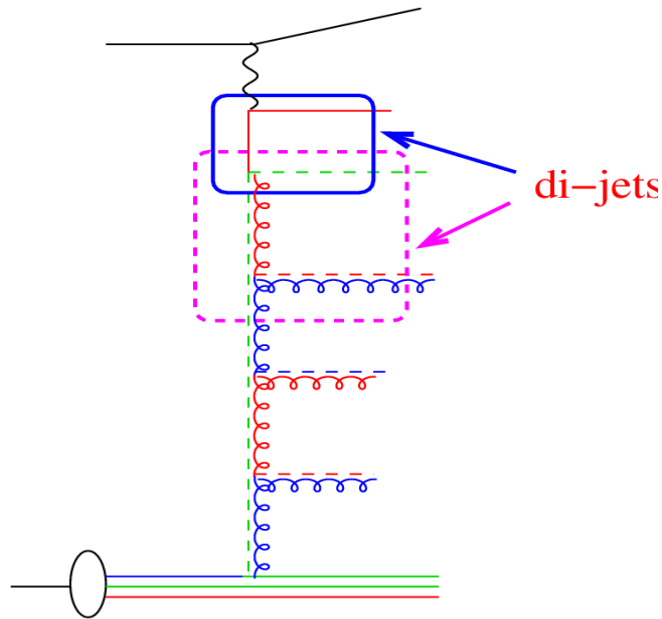
- Using PYTHIA for jets in DIS NEW !!!
- gives reasonable results...
- for E_t distributions gives

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

with CTEQ6L

- Using H1 jet measurements

(H1 EPJC 33 (2004) 477)

$$5 < Q^2 < 100 \text{ GeV}^2$$

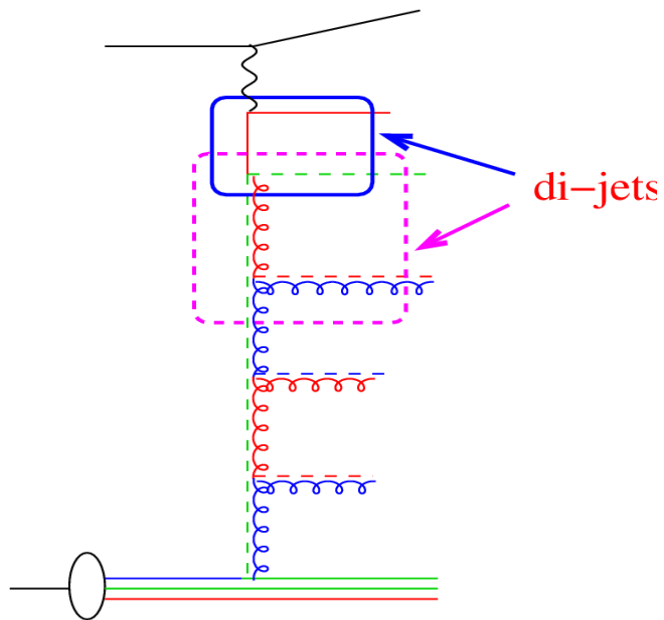$$-1 < \eta < 2.5$$

$$E_T > 5 \text{ GeV}$$

- investigate x dependence of starting distribution

Jets in DIS... after fit ...

di-jets

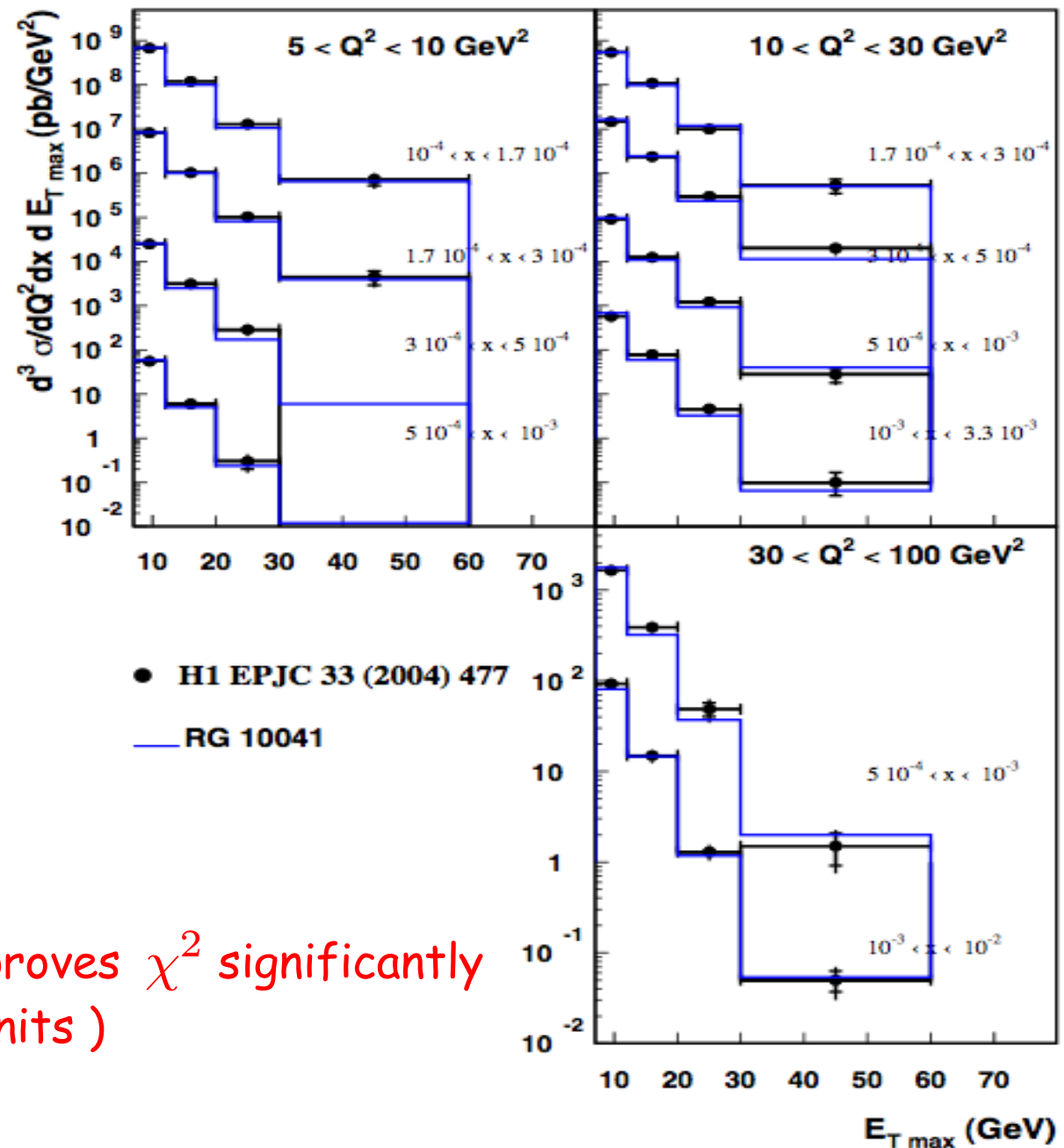Using H1 jet measurements

(H1 EPJC 33 (2004) 477)

$$5 < Q^2 < 100 \text{ GeV}^2$$

$$-1 < \eta < 2.5$$

$$E_T > 5 \text{ GeV}$$

Fit improves χ^2 significantly (~30 units)

$5 < Q^2 < 10 \text{ GeV}^2$

$10 < Q^2 < 30 \text{ GeV}^2$

$30 < Q^2 < 100 \text{ GeV}^2$

● H1 EPJC 33 (2004) 477

— RG 10041

H. Jung, PDF4LHC workshop, July 14, 2008, CERN

Gluon from dijets

- fit normalisation of gluon, other params give similar results.
- significant χ^2 improvement in
- norm different from D* fits
- need to investigate influence of quarks... which also lead to similar χ^2 improvement in
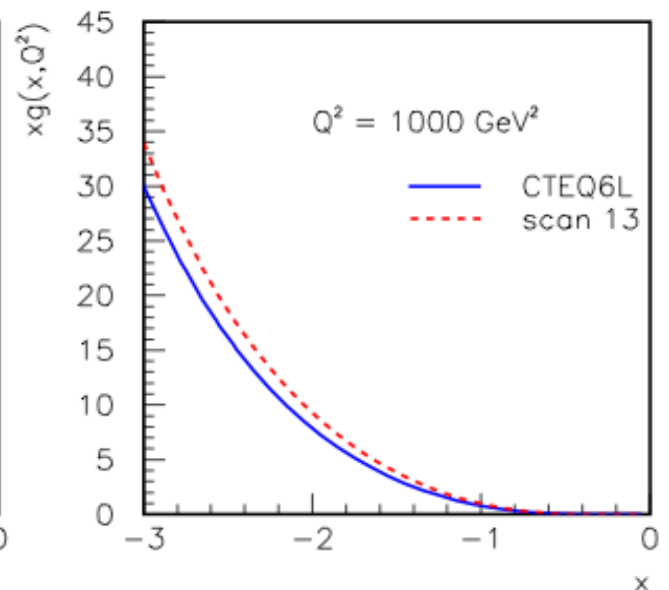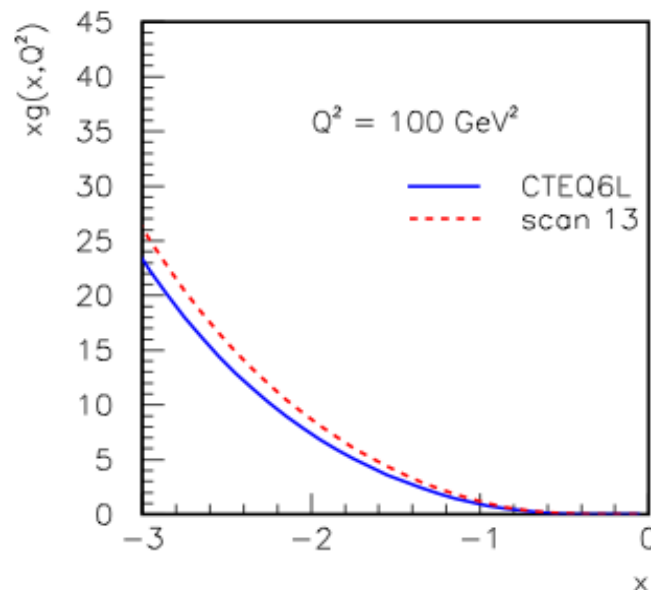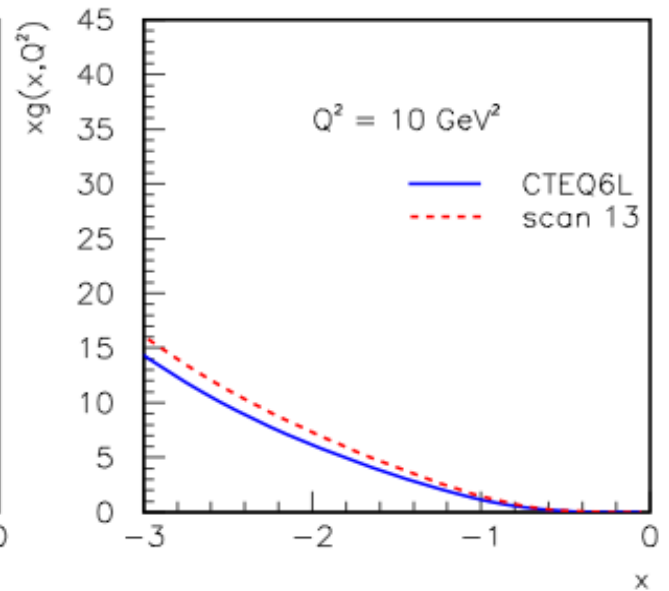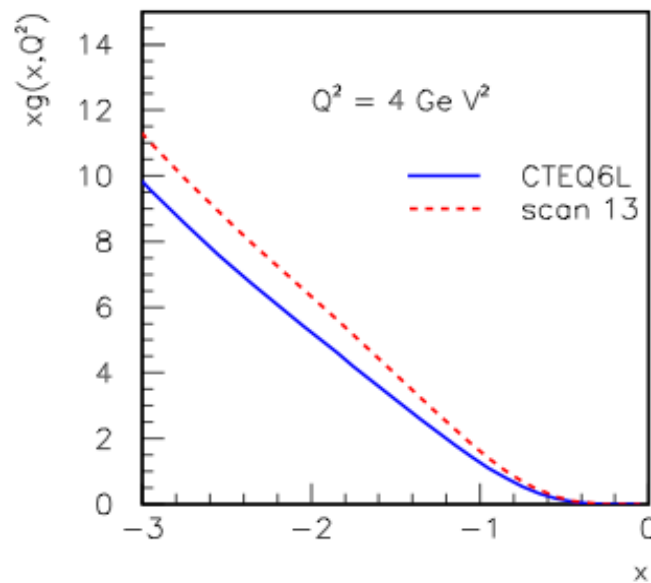
Universality checks

- Dijets in DIS calculated with PYTHIA / RAPGAP
  - both using Q^2 ordered PS and Lund string fragmentation
  - matrix element and ME+PS matching is different
- Important check for consistency of both MCs
  - never done before, in terms of PDF fits
- consistency of PDF fits with both generators
- ➔ little dependance on details of PS

Next steps ...

- tools are available ...
- relevant data are selected and available (would be even better to use precise preliminary measurements of D* !!!!!)
- investigate fitting of quark initial parameters
- real fits including error treatment can start now
- expect 1st PDF4MC during summer

➔ PDF4MC is one of the activities of MC group of Terascale Analysis Center at DESY ....

Conclusions

- using PDF4MC helps to improve description of data by MCs
- PDF4MC are "universal":
  - ➔ depend on parton showers and fragmentation (?)
  - ➔ do not depend on MC generator (if same PS is used...)

- concept of PDF4MC works
  - ➔ fitted parameters are close to global fits
    - ➔ but improve χ^2 significantly
  - ➔ ready for a global PDF4MC fit of HERA

- Plan to have 1st PDF4MC from HERA final state released by end of summer (2008) !