PDFs for MCs

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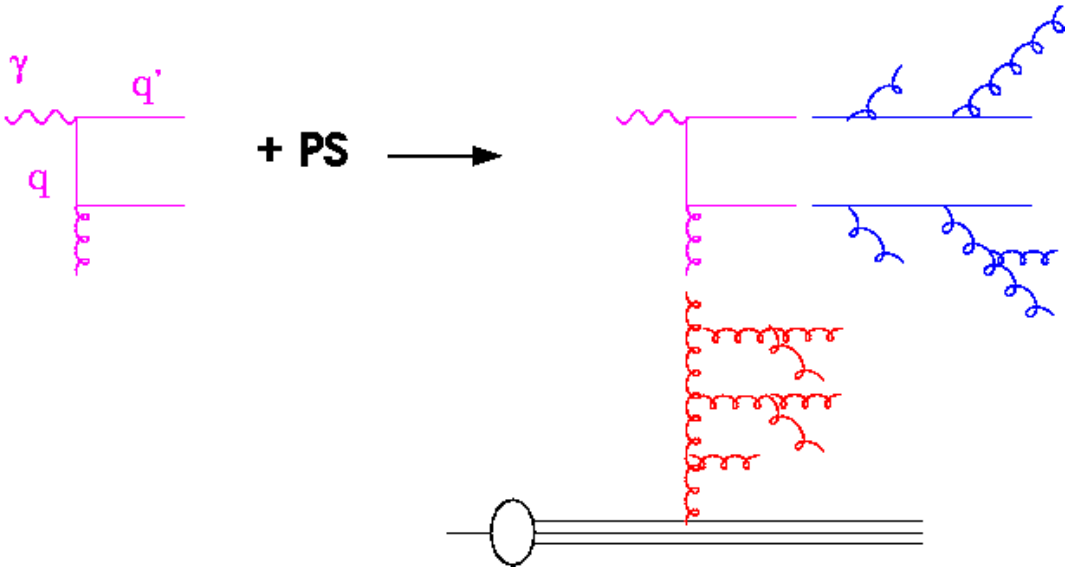
- Motivation:
  why special PDFs for MCs are needed, necessary and important
- Strategy:
  HOWTO obtain PDF4MC
  connection to uPDFs and collinear PDFs
- Proof of concept
  1st attempts
- Conclusions

Motivation: example from HERA



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

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s = 0$ ➔ $x = Q^2/(ys)$
- **BUT** final state radiation:

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s = m^2$ ➔ $x = (Q^2+m^2)/(ys)$
- **AND** initial state radiation:

  $(\gamma+q)^2 = q'^2$, $-Q^2 + x\,y\,s + q^2 = 0$ ➔ $x = (Q^2-q^2)/(ys)$
- **Collinear approach: $q'^2 = q^2 = 0$, order by order ....**
- Well known.... since years....
- NLO corrections... better treatment of kinematics... but still not all....

Strategy

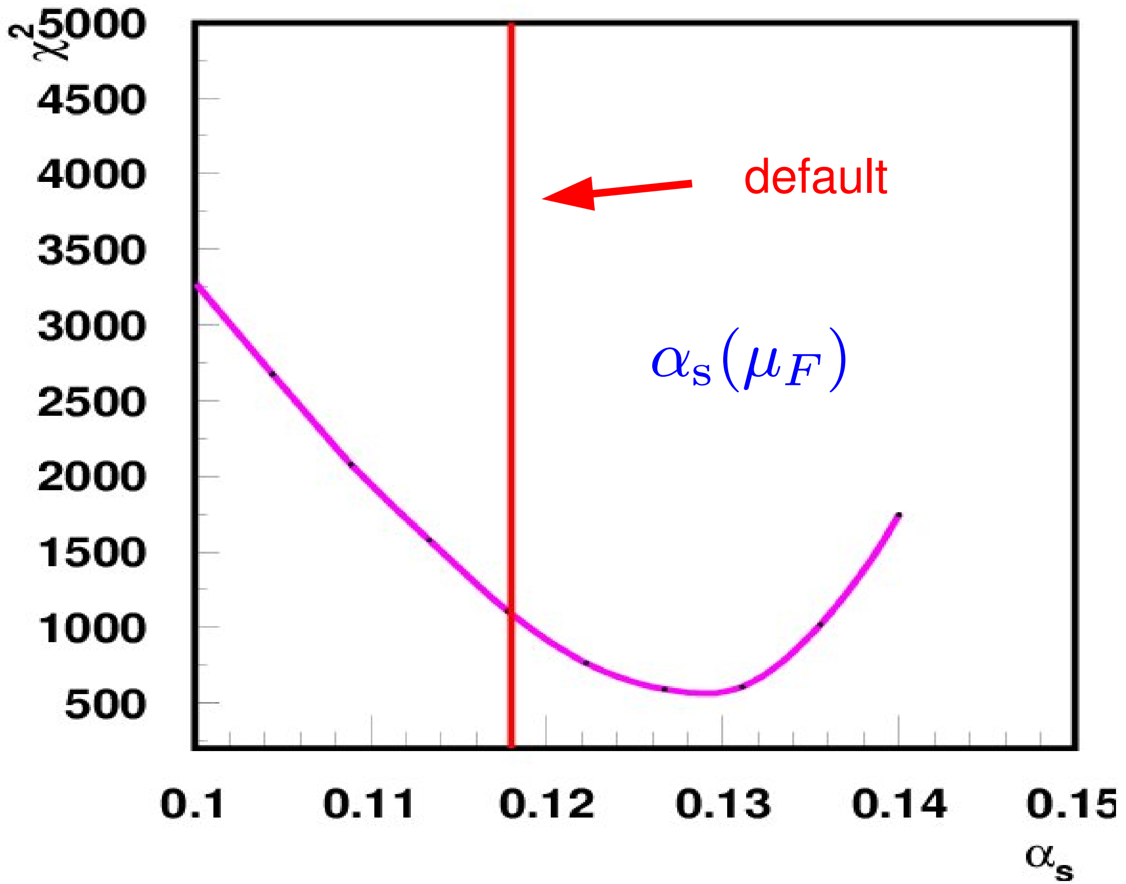
- fully consistent approach would require doubly uPDFs and appropriate factorization theorem, which will include collinear factorization and kt-factorization as asymptotic limits...
- branch 1: use uPDFs and k_t-factorization as done with CCFM and CASCADE
- branch 2: use standard MCEG like PYTHIA/HERWIG/RAPGAP 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
  - 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



Proof of Concept

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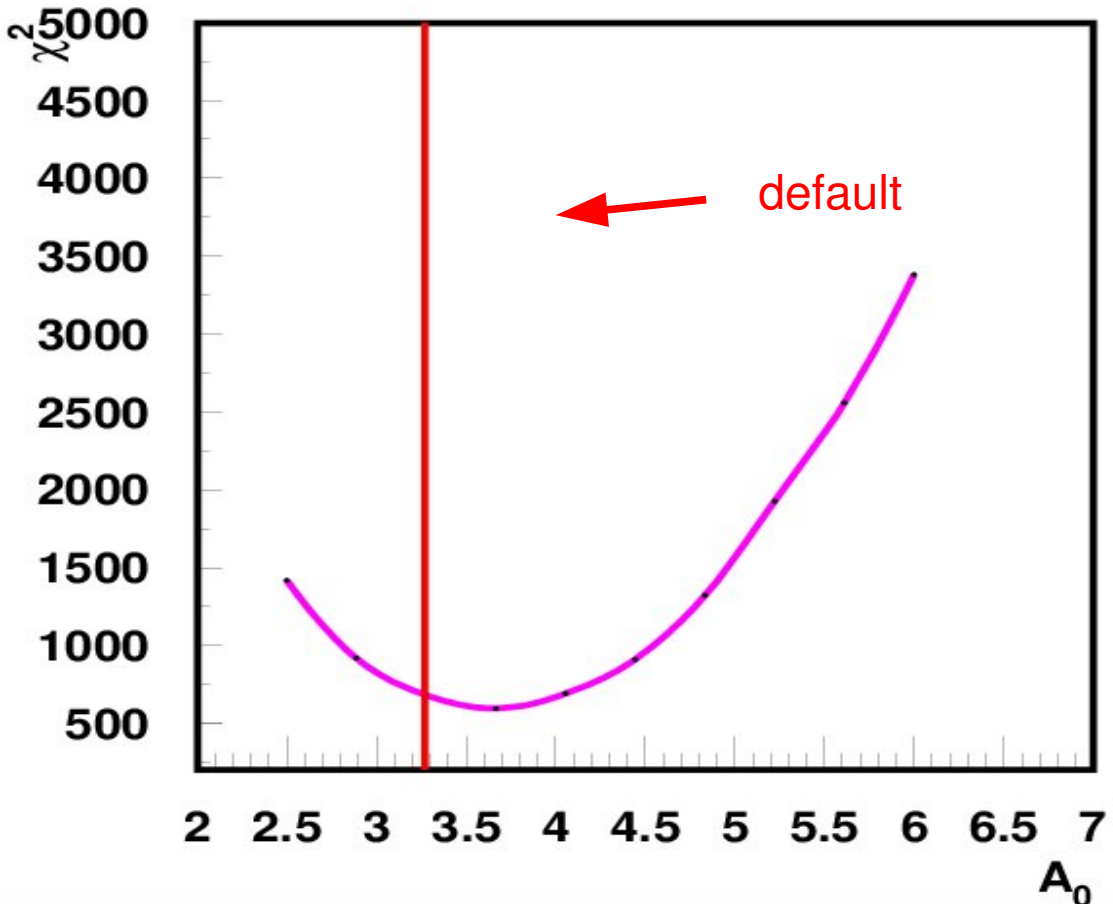
$$x\,G(x\,,\mu_0) \sim A_0 x^{A_1} \cdots$$

➔ normalization changed



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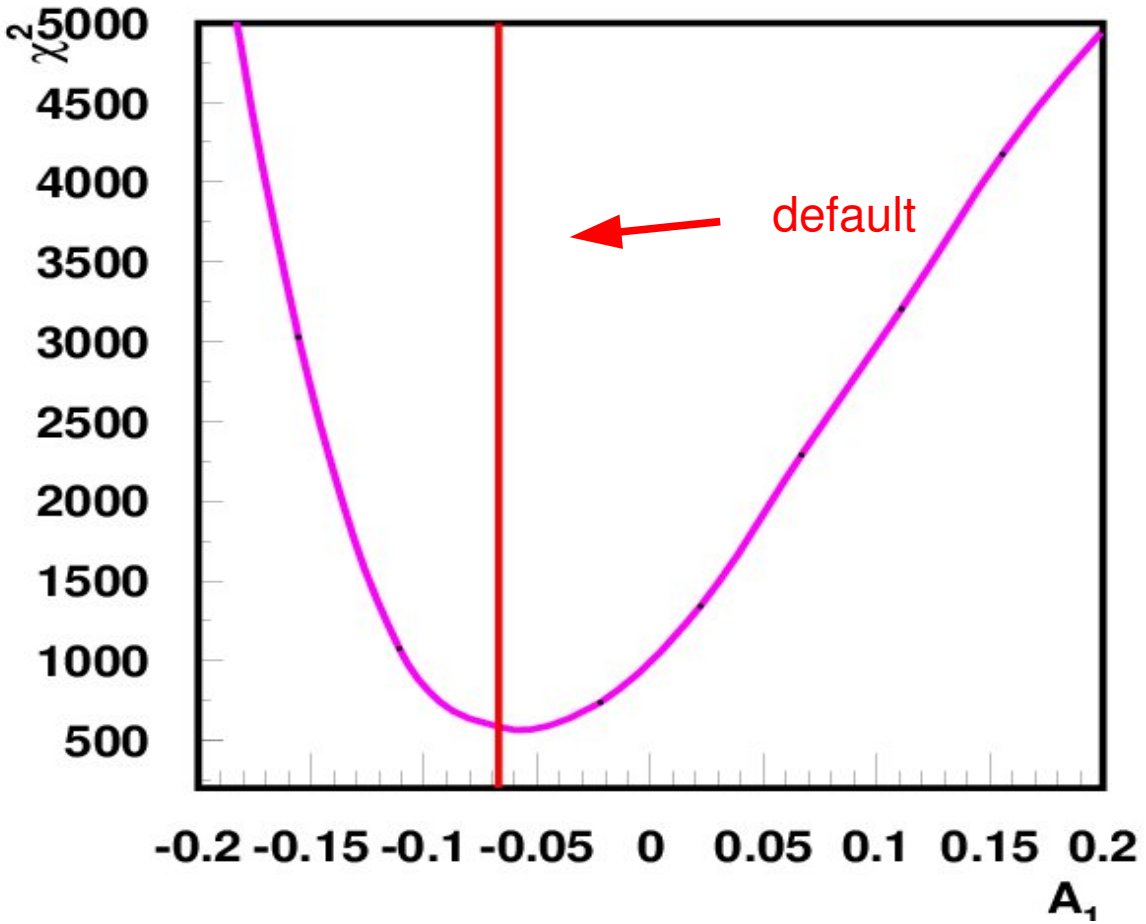


➔ normalization changed

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

The gluon after fitting ....

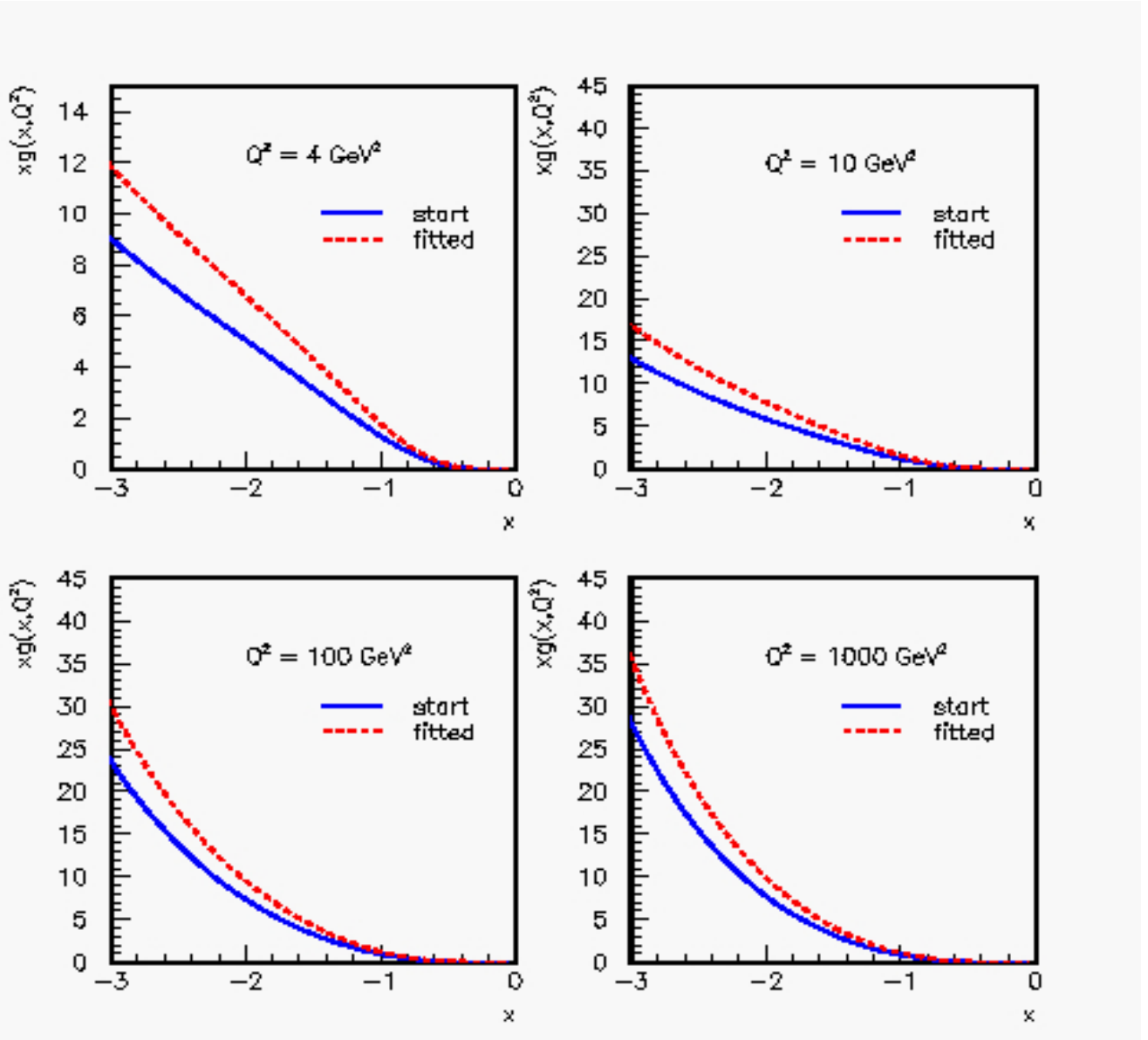
- Use LO fit....
- Fit F_2 by varying

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

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....

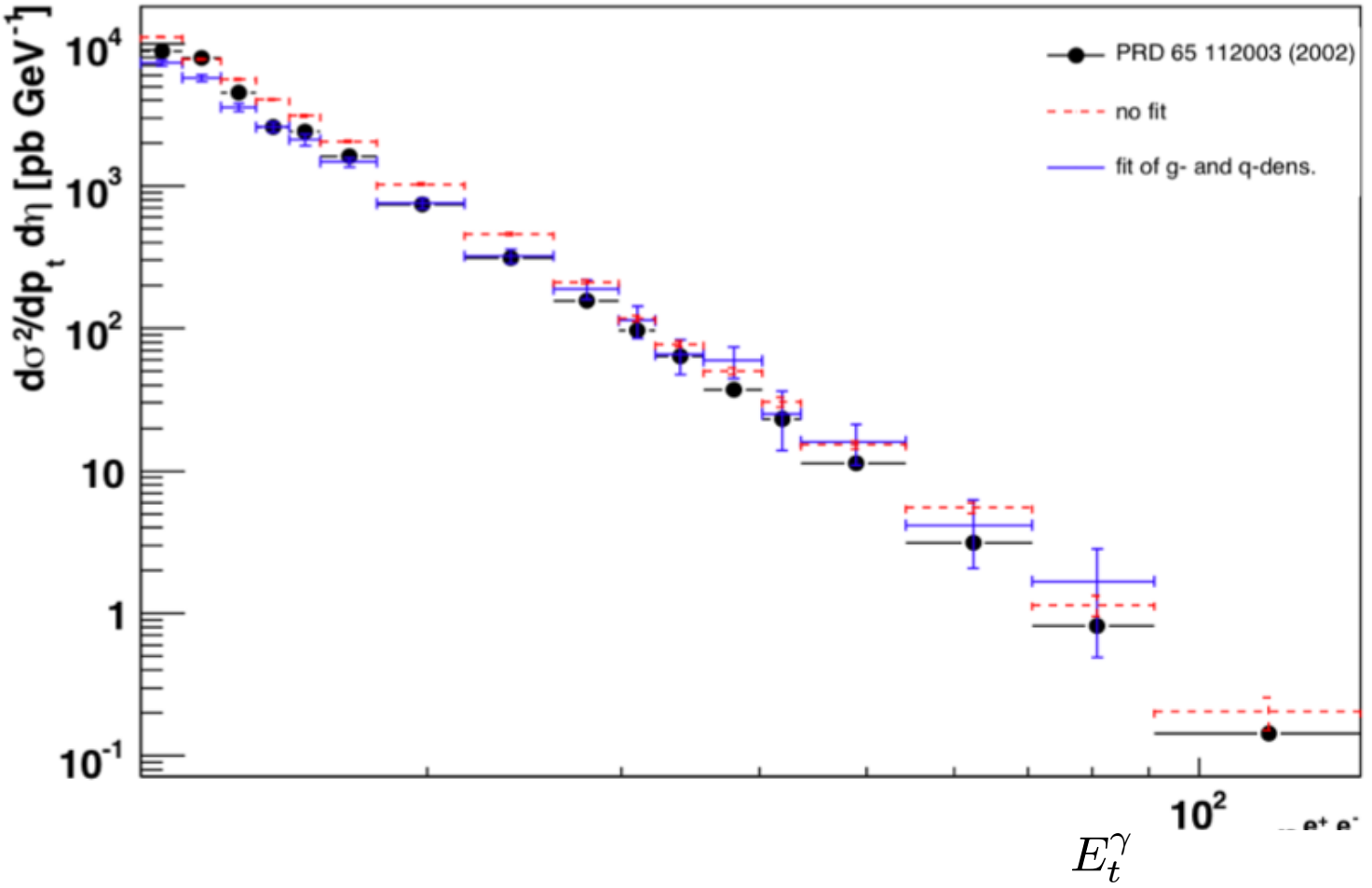
➔ Not yet the final answer...



prompt photon at TeVatron

work done by: Federico von Samson-Himmelstjerna
summerstudent at DESY 2007

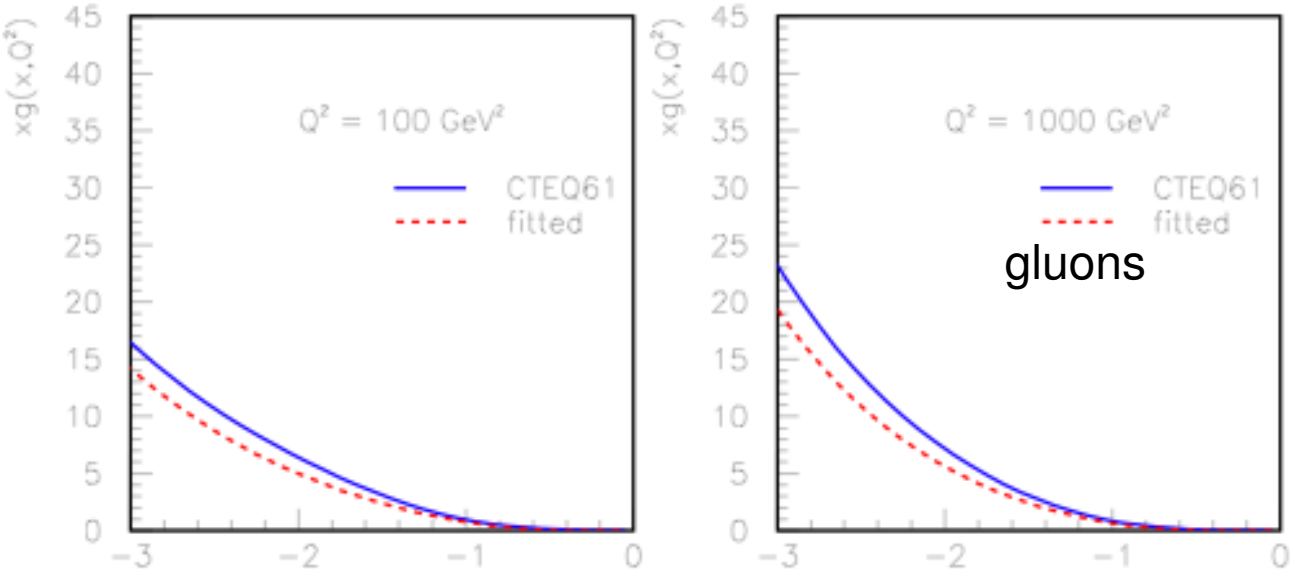
- using prompt photon from PRD 65 11203 (2002)

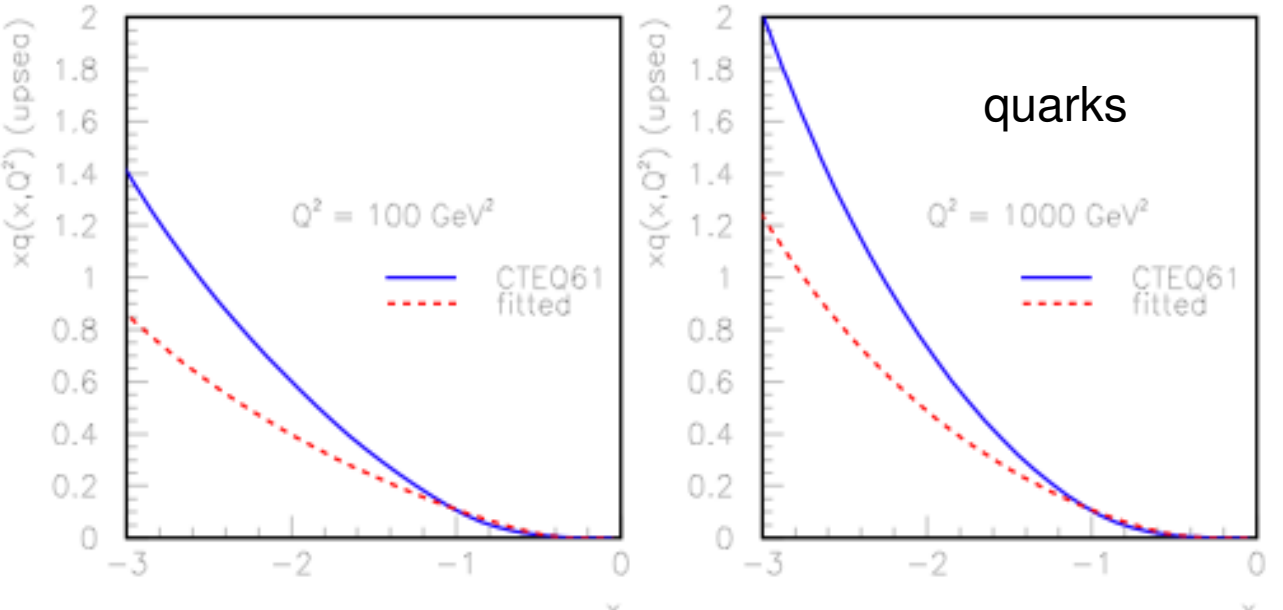


PDFs from fit

work done by: Federico von Samson-Himmelstjerna
summerstudent at DESY 2007

- PDF from fiting sea quarks and gluons





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