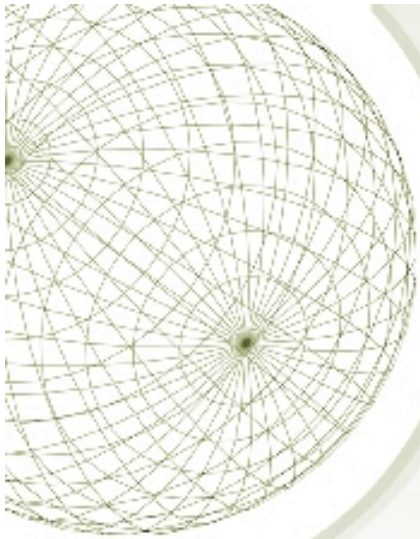

PDF uncertainties using Monte Carlo method

Voica A. Radescu/A. Glazov

DESY

- Introduction
- Method
- Gaussian distribution of errors
- Log-normal, uniform distribution of errors
- Summary

Introduction

The idea is to use a simple Monte Carlo technique to estimate PDF uncertainties which would provide:

- An independent cross check of the standard errors estimation
- Flexibility in testing various assumptions for the uncertainties distribution:

$$\sigma \sim \frac{N}{\mathcal{L}A}$$

  - A detector acceptance, $\mathcal{L}$ luminosity
- Systematic Uncertainties from A and $\mathcal{L}$ are non-Gaussians ($\mathcal{L}$,A >0)
  - Log-Normal distribution
- Some systematic uncertainties are “upper” limits:
  - Uniform distribution

voica@mail.desy.de

Method (1/2)

- Notations:
  - Data point → σ_i
  - Uncorrelated Uncertainty → δ_i^{uncorr}
  - Correlated systematic sources α_j with their effect on data points δ_{ij}^{corr}
- Prepare a shifted data set:
  - Shift the central value by taking into account the uncorr. and corr.errors:
    - For Gauss Distribution of the errors:
      - For only uncorrelated uncertainties: $\sigma_i = \sigma_i(1 + \delta_i^{uncorr} RAND_i)$
      - For correlated uncertainties: generate shifts for $\alpha_j \rightarrow RAND_j$

$$\sigma_i = \sigma_i(1 + \delta_i^{uncorr} RAND_i + \sum_j^{N_{sys}} \delta_{ij}^{corr} RAND_j)$$

RAND$_i$ is Gauss Random Number Generator with mean 0

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Method (2/2)

- Repeat the preparations for N times (here N $\geq$ 100)
- Perform the fit N times to extract PDFs
- PDF uncertainties =>from the RMS of the spread

- This study is performed using:
  - published H1-HERA I data of NC and CC e±p scattering cross sections [ref: Eur. Phys. J. C 30, 1-32 (2003)]
  - Fit program H1 QCDNUM implementation at NLO:
    - MSbar renormalisation scheme, DGLAP evolution at NLO, massless quarks, polinomial form for PDF parametrisation a la H1PDF2000

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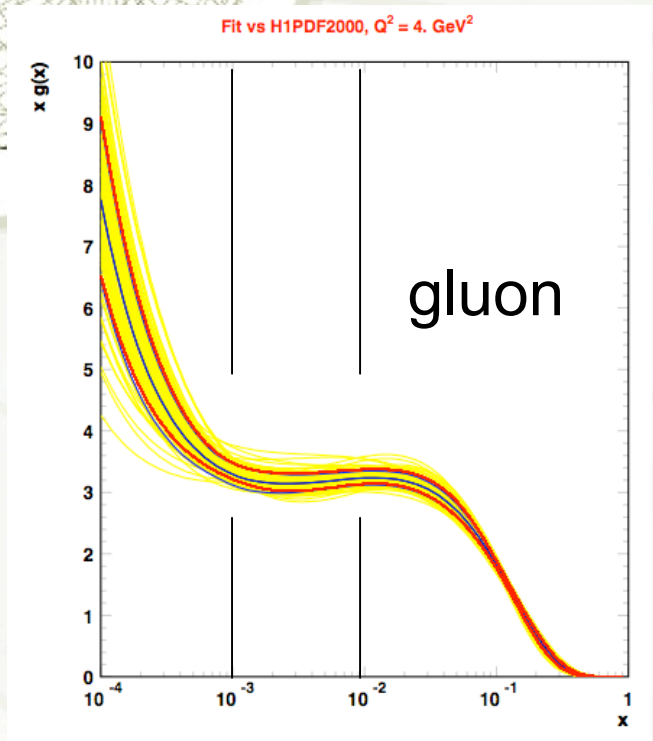
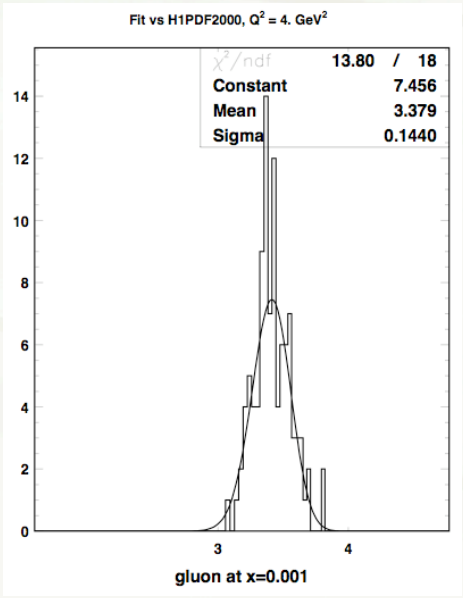
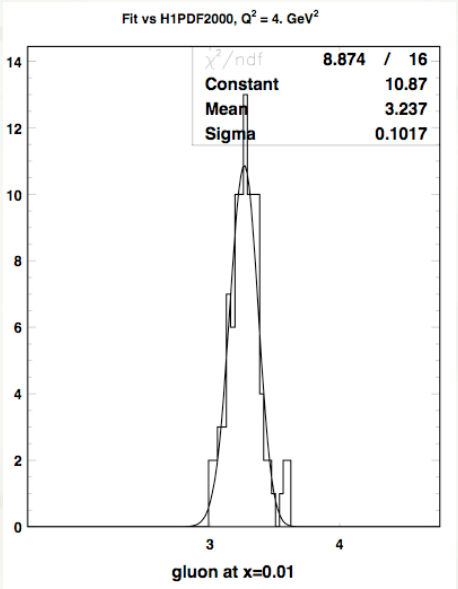
Gaussian Errors

- To test the method, assume all errors follow Gauss distribution and compare the results to standard error estimation

[PDF4LHC, April 2008]







- 400 Yellow lines
- Red lines: PDF uncertainties from RMS
- Blue lines: Hessian errors

Good agreement

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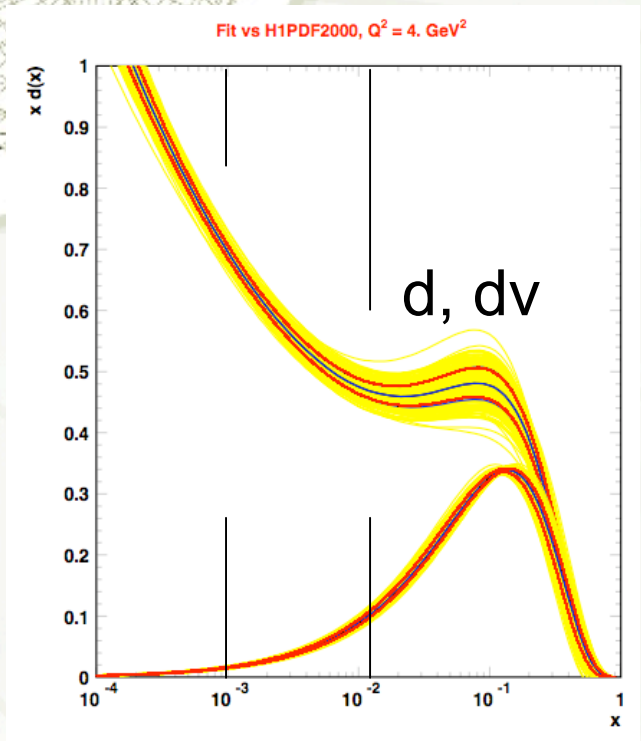

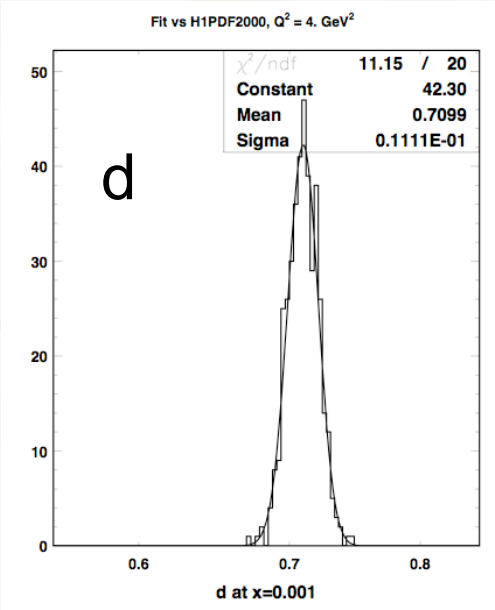

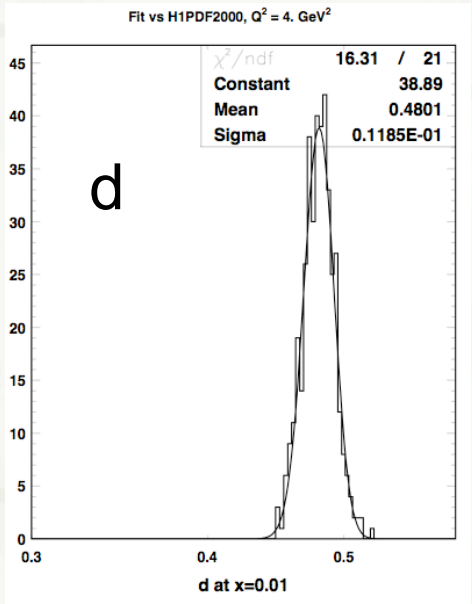

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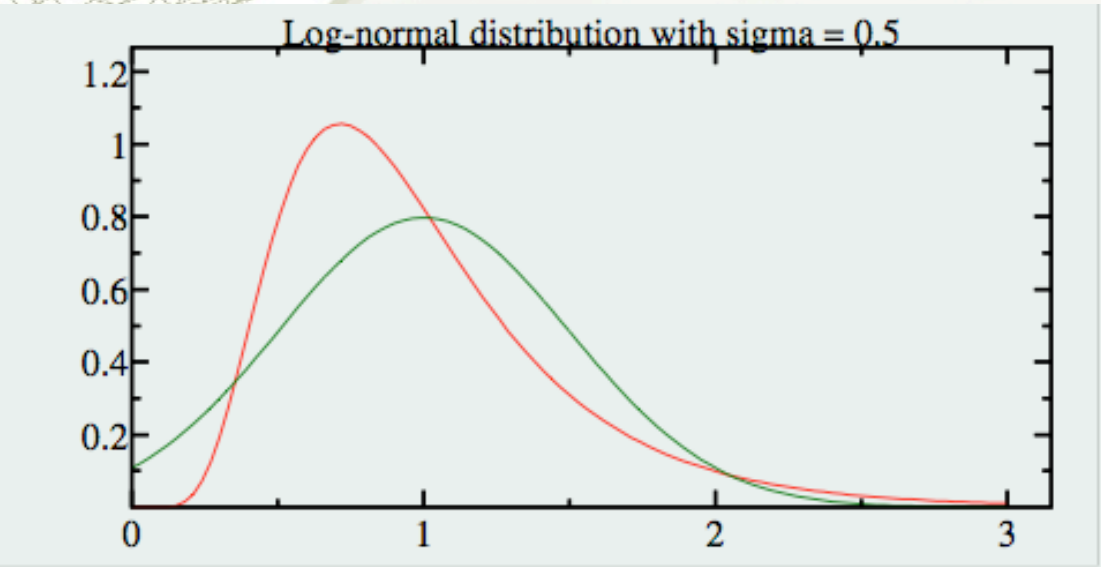
Log-normal Distribution

- Normalisation error follows a log-normal distribution
  - product of random variables

[V. Blobel]



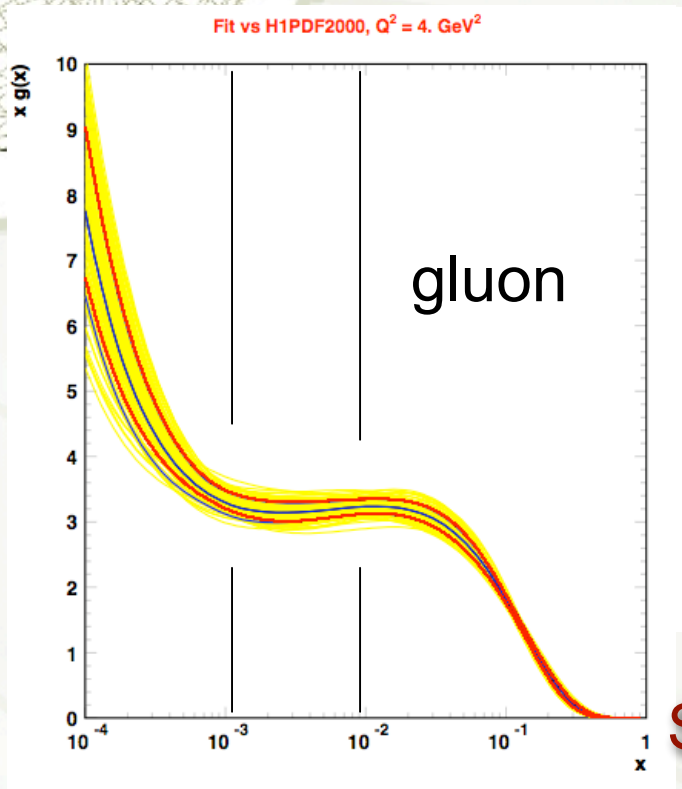
- Comparison between Log-normal and Gauss Distribution:
  - same mean (here 1)
  - shifted peaks

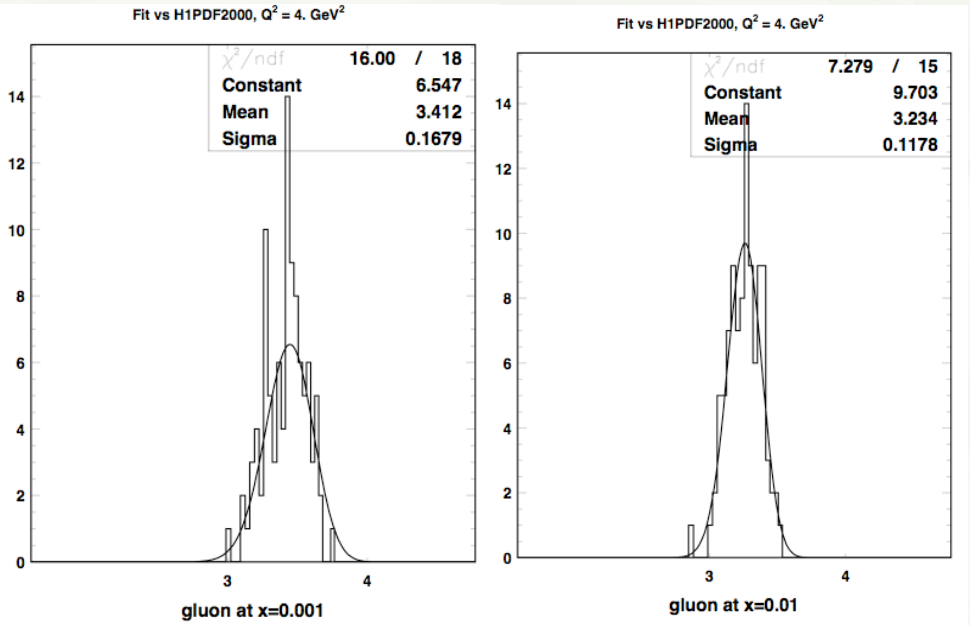
Hence, it is interesting to test the effect on PDFs!

→ use Log-Normal Random Number Generator in the data preparation to extract PDFs from the fits

1. Log-normal dist. for Lumi

- Assume that all errors, apart from Lumi uncertainty follow Gauss
- Distribution for lumi uncertainty is assumed Log-normal here





Similar effect to pure gaussian case!

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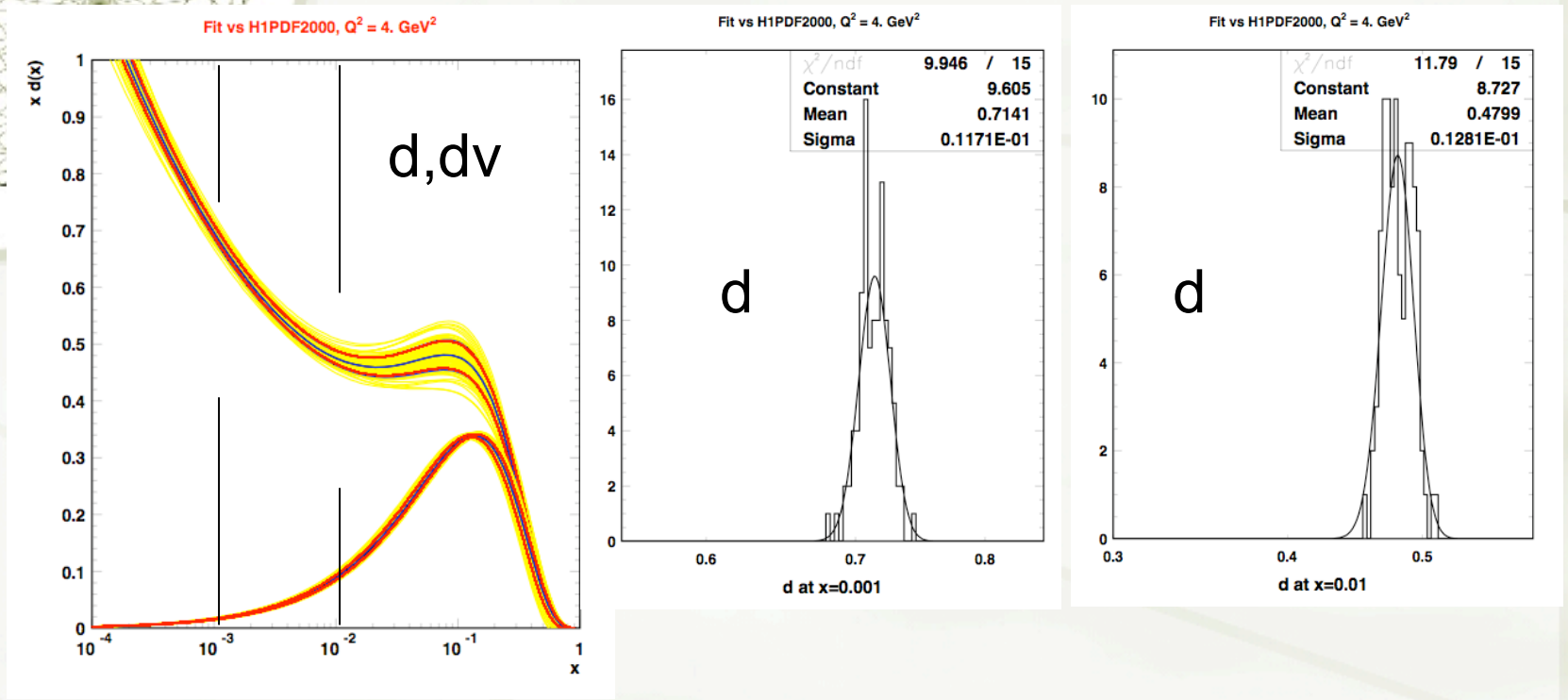

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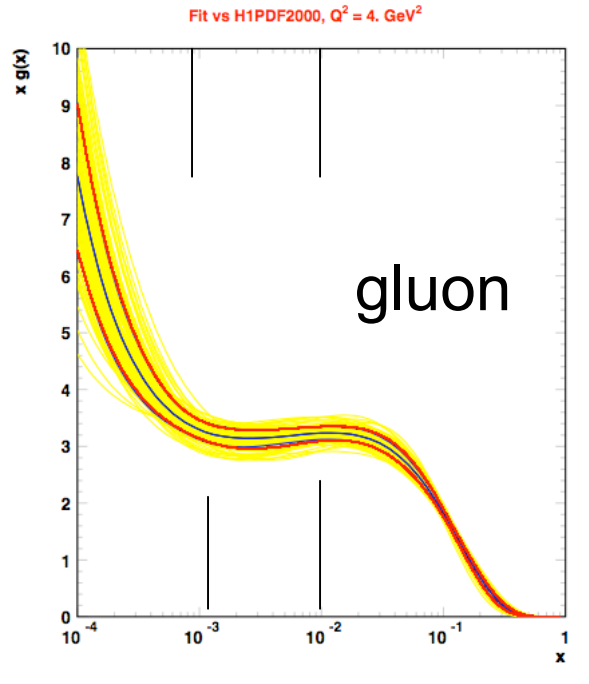
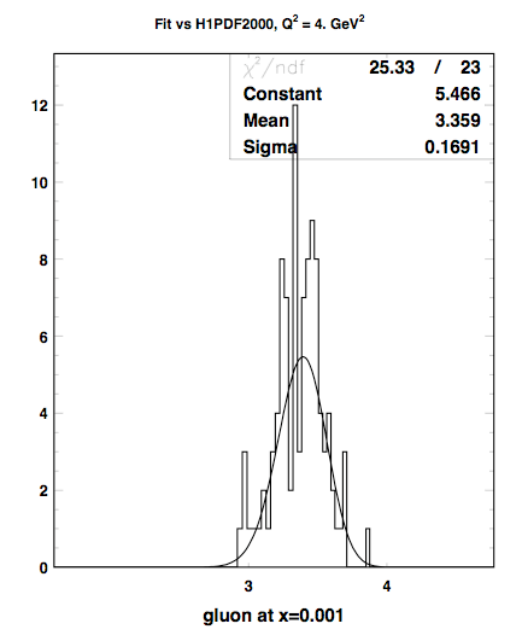
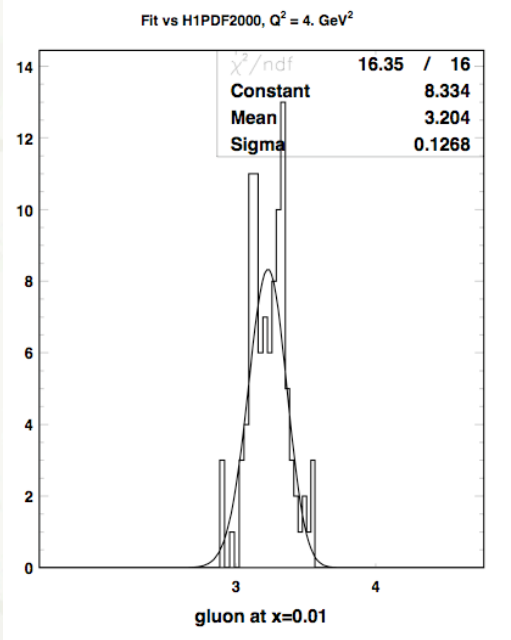
2. Uniform dist. for all errors

- Assume that all errors follow Uniform Distribution







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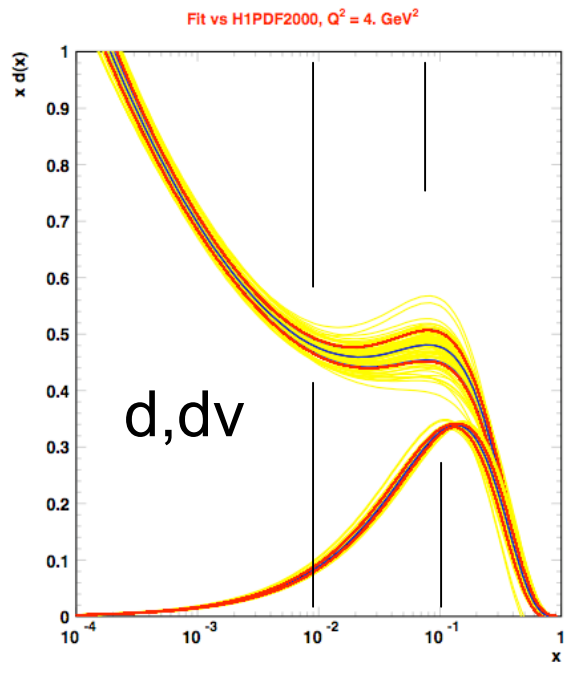

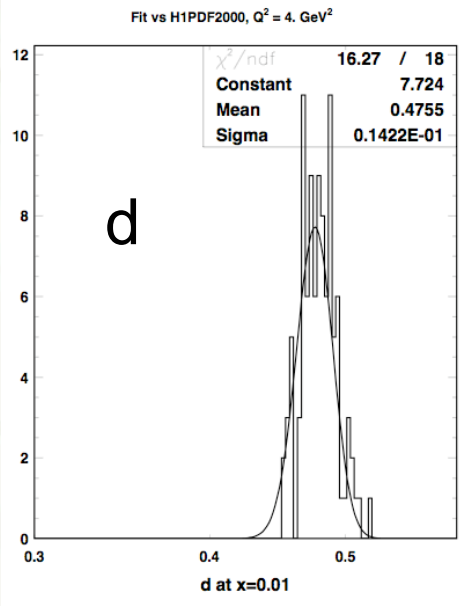

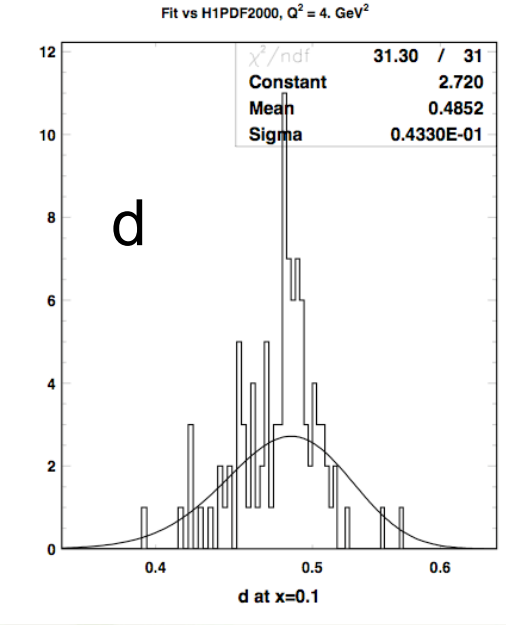

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Summary

- A simple method to estimate PDF uncertainties built within QCD Fit framework:
  - Assuming only Gaussian distribution of the errors agrees well with the standard error estimation
- Allows to check non-Gaussian distributions for the experimental uncertainties:
  - Results are similar to Gaussian case when using log-normal and uniform distributions of the uncertainties
- Method could be extended for other variables (i.e. cross sections) for cross checks with standard error evaluation