PDF reweighting for charm impact studies

N. Sato, C. Weiss, LDRD Project "Nuclear gluons with charm at EIC," Meeting 17-Apr-12

- General problem: Given DIS data set and PDF best fit. What is the impact of "new" data on the fit?

  Shift in central value?

  Change of χ^2 variation? ←

- Impact can be studied without refitting: Reweighting

  Bayesian reweighting (MC) ←

  Hessian reweighting

  Widely used in HEP studies

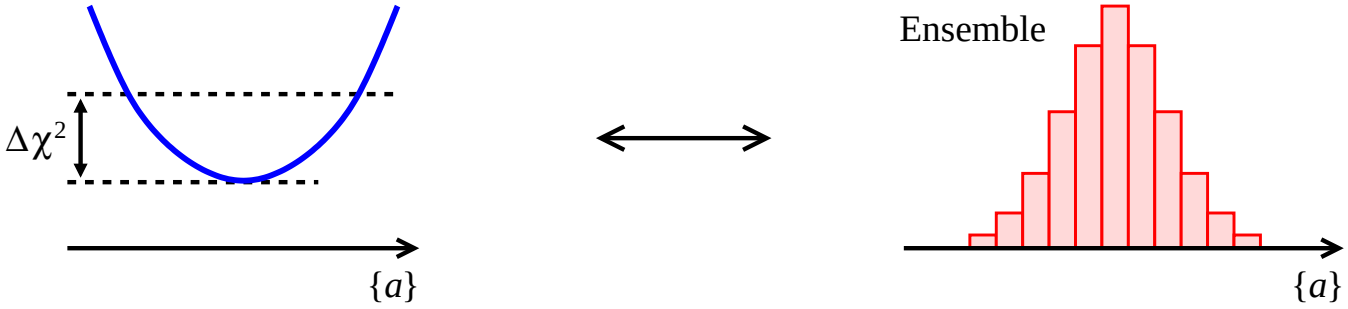
W. Giele, S. Keller, PRD58 (1998) 094023 [INSPIRE]

NNPDF Collaboration (R. Ball et al.) NPB849 (2011) 112 [INSPIRE]

H. Paukkunen, P. Zurita JHEP 1412 (2014) 100 [INSPIRE] and references therein

Used in JAM Collaboration (N. Sato et al.), PRD93 (2016) 074005 [INSPIRE]

PDF reweighting



- PDF parametrization and fit

  $f(x, Q^2)\{a\}$ PDF with parameters $\{a\}$

  $\chi^2[f] \equiv \chi^2\{a\}$ χ^2 function, minimum – best fit, variation – uncertainty

- Statistical ensemble of PDFs

  $f_k,\ k = 1 \ldots N$ PDF replicas with parameters scattered around best fit

  $\mathcal{P}[f_k]$ Probability density of replicas reproduces χ^2 distribution

$$\langle \mathcal{O} \rangle = \frac{1}{N} \sum_k^N \mathcal{O}[f_k], \qquad \langle (\delta \mathcal{O})^2 \rangle = \frac{1}{N} \sum_k^N (\mathcal{O}[f_k] - \langle \mathcal{O} \rangle)^2$$

Averages and uncertainties can be calculated as ensemble averages!

PDF reweighting II

- Include new data

  $\mathcal{P}_{\rm new}[f] \;\propto\; \mathcal{P}_{\rm old}[f] \times \mathcal{L}(\text{new data}|f)$ Bayes' theorem for updated probability

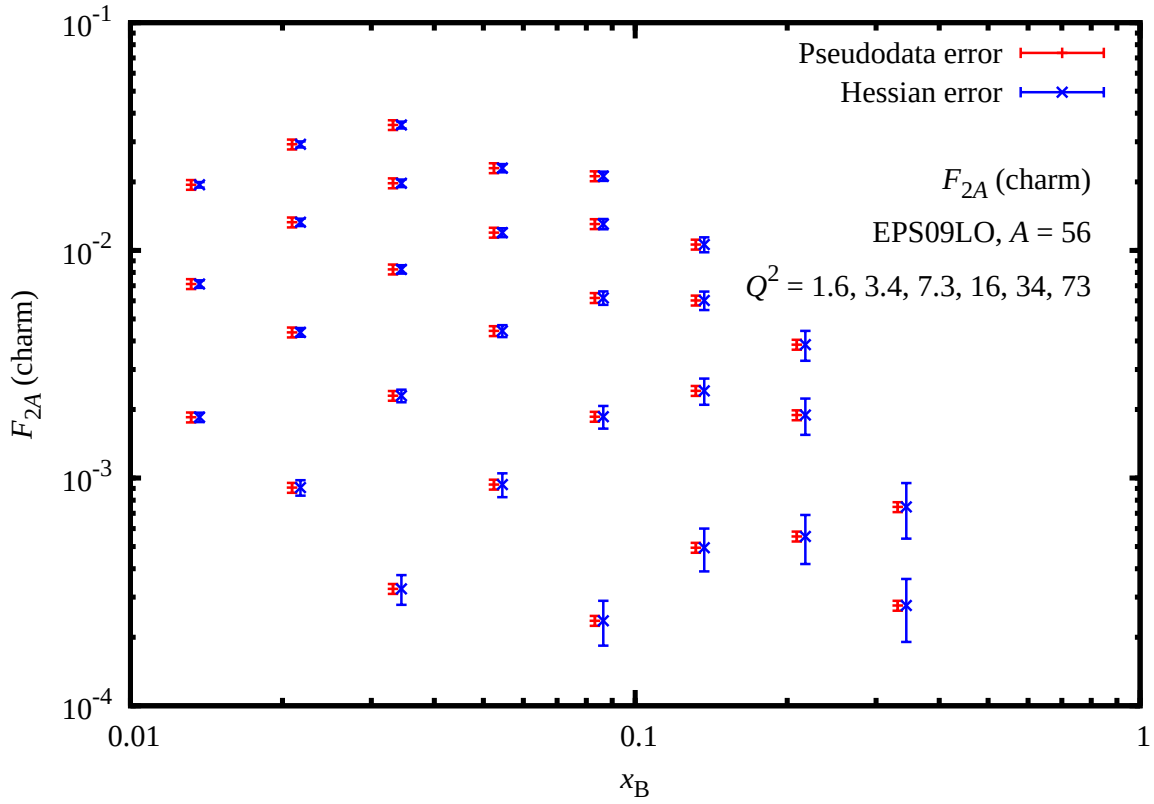
  $\mathcal{L}(\text{new data}|f)$ Likelihood of new data given PDF f, conditional probability

  e.g. $\mathcal{L} = \exp[-\frac{1}{2}\chi^2(\text{new data}|f)]$

- Procedure
  - Generate ensemble of PDF replicas with old probability distribution
  - Calculate likelihood of new data for each replica
  - Calculate ensemble averages with updated probability: $\langle f\rangle$, $\langle(\delta f)^2\rangle$, $\langle\mathcal{O}\rangle$, ...

  Implemented as Python code, on github [N. Sato]

Charm pseudodata



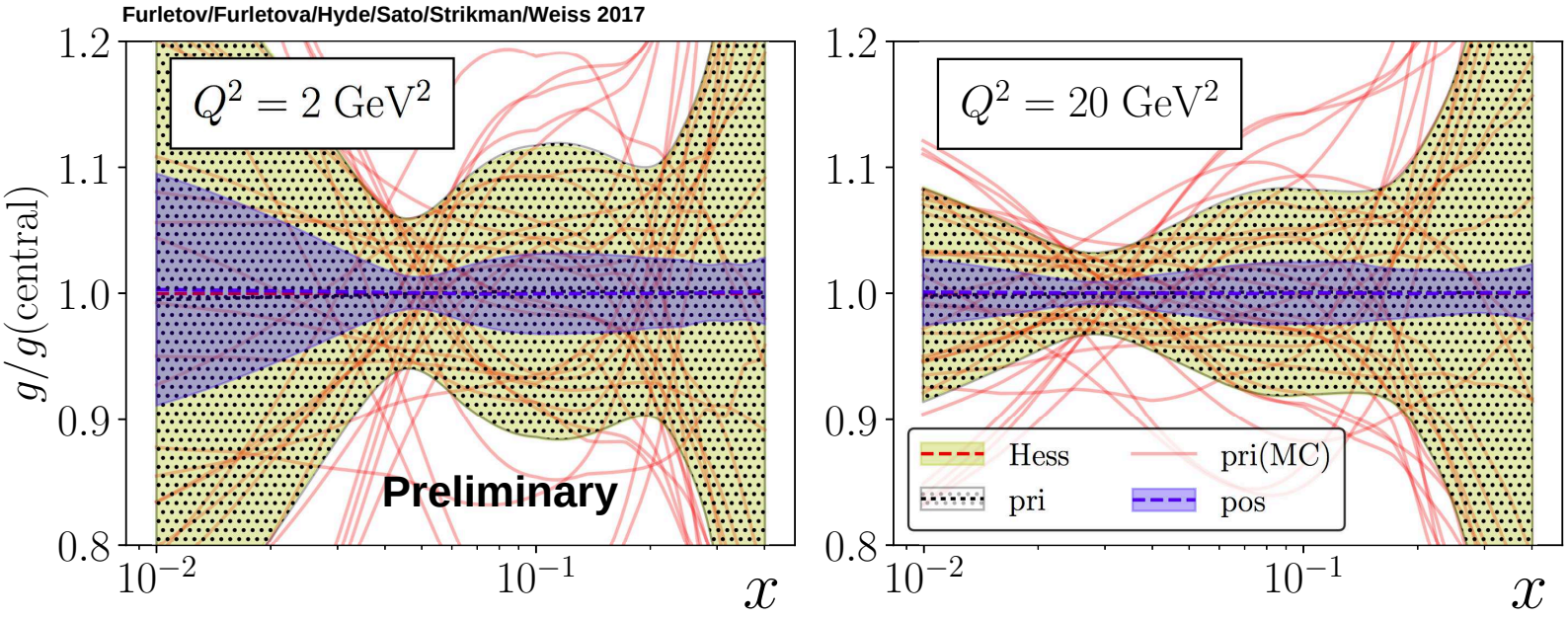
- Sample $F_{2A}(\mathrm{charm})$ pseudodata

  5 bins/decade in x, 3 bins/decade in Q^2

  Assume 10% total error, dominated by systematics, point-to-point

  Can be refined/improved

Impact on nuclear gluon density



- Bayesian reweighting of EPS09

  Equivalence to Hessian reweighting demonstrated

- Substantial impact on large–x nuclear gluons

- Procedure can be extended to other charm observables $\mathcal{O}[g]$

  Differential cross sections, photoproduction, high-p_T pairs, . . .