PDFs: the Monte Carlo perspective

Stephen Mrenna

Computing Division
Generators and Detector Simulation Group
Fermilab

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Event generators try to model the full structure of hadron-hadron collisions

The elements are:

- perturbative QCD
- data
- intuition (models of non-perturbative physics)

PDFs are an essential part of the modelling of hadronic collisions

They appear in:

- the hard scattering cross section

$$\int\int\int \frac{\mathrm{d}\tau}{\tau}\,\mathrm{d}y\,\frac{\hat{s}\beta_{34}}{2}\mathrm{d}z\; x_1 f_1(x_1,Q^2)\; x_2 f_2(x_2,Q^2)\,\frac{\mathrm{d}\hat{\sigma}}{\mathrm{d}\hat{t}}$$

- the initial state shower

$$\exp\left\{-\int_{t}^{t_{\max}}\mathrm{d}t'\sum_{a,c}\int\mathrm{d}z\,\frac{\alpha_{abc}(t')}{2\pi}\,P_{a\to bc}(z)\,\frac{x' f_a(x',t')}{x f_b(x,t')}\right\}\;,$$

- the underyling event

Underlying Event

⋯ the parton distributions to be used for subsequent scatterings must depend on all preceding x *values and flavours chosen. We do not know enough about the hadron wave function to write down such joint probability distributions. To take into account the energy 'already' used in harder scatterings, a conservative approach is to evaluate the parton distributions, not at* x_i *for the* i*:th scattered parton from hadron, but at the rescaled value*

$$x_i' = \frac{x_i}{1 - \sum_{j=1}^{i-1} x_j} \ .$$

New Models

⋯ the flavour content of the remnant is bookkept, and is used to determine possible flavours in consecutive interactions. Thus, the standard parton densities are only used to describe the hardest interaction. Already in the old model, the x scale of parton densities is rescaled ⋯ But now the distributions are not only squeezed in this manner, their shapes are also changed.

How Important?

% time	cumul. secs.	self secs.	calls	self ms/call	total ms/call	name
29.19	18.60	18.60	1109047	0.02	0.05	pysigh_
24.37	34.13	15.53	18165792	0.00	0.00	pyct5l_
19.27	46.41	12.28	1109047	0.01	0.01	pysgqc_
6.48	50.54	4.13	2270724	0.00	0.01	pypdfu_
5.29	53.91	3.37	1103819	0.00	0.00	pywidt_
3.78	56.32	2.41	6322	0.38	0.56	pystrf_
1.87	57.51	1.19	19796838	0.00	0.00	pyr_
1.21	58.28	0.77	6527	0.12	8.55	pymult_

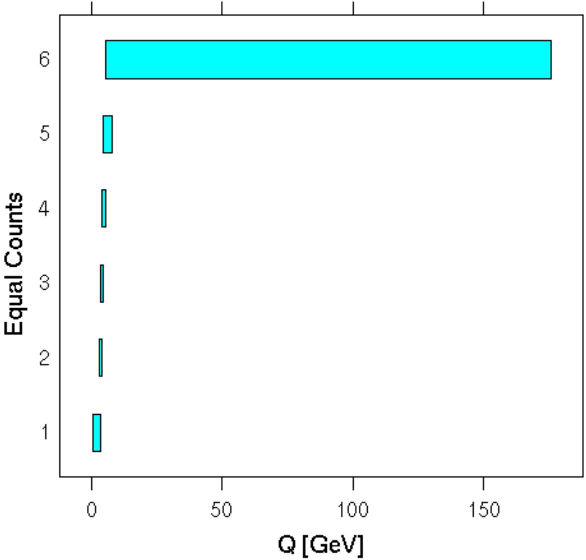
The PDFs are sampled over a wide range of x and Q, atypical of a standard QCD calculation

The proton itself has no arbitrary x or Q cutoffs

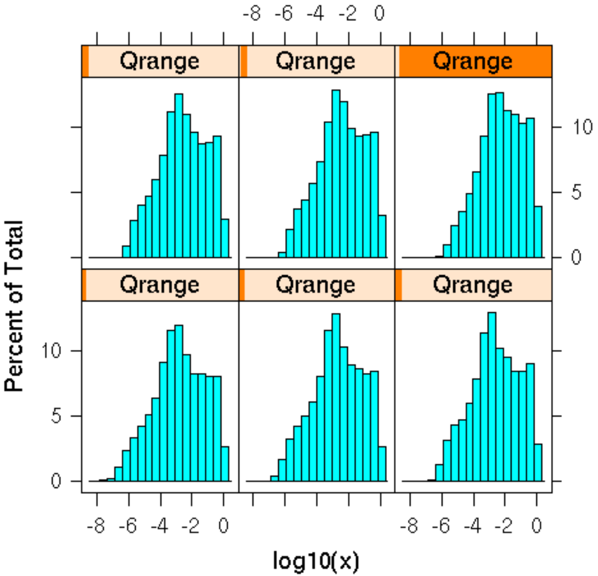
Numbers sampled in a typical Pythia run

	x	**Q [GeV]**
Min.	*9.633e-09*	*0.2777*
1st Qu.	*2.719e-04*	*3.2486*
Median	*3.017e-03*	*4.0423*
Mean	*8.340e-02*	*6.0933*
3rd Qu.	*4.741e-02*	*5.8401*
Max.	*9.995e-01*	*175.9226*

Q ranges with equal counts



x distribution in those ranges



Lessons for PDF fitters

- MC-ers might use your fits in ways you did not intend
- Cutoffs or wild behavior are not desired
- Computing efficiency is important