Computing normalized spin-correlations through expanded ratios

A. Behring (arnd.behring@kit.edu)
Institute for Theoretical Particle Physics, KIT, Karlsruhe, Germany,

M. Czakon (mczakon@physik.rwth-aachen.de),
Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, D-52056 Aachen, Germany,

A. Mitov (adm74@cam.ac.uk),
A. Papanastasiou (andrewp@hep.phy.cam.ac.uk) and
R. Poncelet (poncelet@hep.phy.cam.ac.uk)
Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK.

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To evaluate the expansion of a normalized differential cross section we consider the following perturbative expansions

$$\sigma = \sigma^0 + \alpha_S \sigma^1 + \alpha_S^2 \sigma^2 \tag{1}$$

$$\frac{\mathrm{d}\sigma}{\mathrm{d}X} = \frac{\mathrm{d}\sigma^0}{\mathrm{d}X} + \alpha_S \frac{\mathrm{d}\sigma^1}{\mathrm{d}X} + \alpha_S^2 \frac{\mathrm{d}\sigma^2}{\mathrm{d}X} \tag{2}$$

To specify the used PDFs we consider

$$\sigma^{\mathrm{LO}} = \sigma^0 \qquad \text{all } \sigma^i \text{ with LO PDFs,} \tag{3}$$

$$\sigma^{\mathrm{NLO}} = \sigma^0 + \alpha_S \sigma^1 \qquad \text{all } \sigma^i \text{ with NLO PDFs,} \tag{4}$$

$$\sigma^{\mathrm{NNLO}} = \sigma^0 + \alpha_S \sigma^1 + \alpha_S \sigma^2 \qquad \text{all } \sigma^i \text{ with NNLO PDFs} \tag{5}$$

and similar for the differential ones. We expand the normalised differential cross section in the following way

$$R = \frac{1}{\sigma}\frac{\mathrm{d}\sigma}{\mathrm{d}X} = R^0 + \alpha_S R^1 + \alpha_S^2 R^2 \tag{6}$$

$$R^0 = \frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^0}{\mathrm{d}X}\,, \tag{7}$$

$$R^1 = \frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^1}{\mathrm{d}X} - \frac{\sigma^1}{\sigma^0}\frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^0}{\mathrm{d}X}\,, \tag{8}$$

$$R^2 = \frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^2}{\mathrm{d}X} - \frac{\sigma^1}{\sigma^0}\frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^1}{\mathrm{d}X} + \left(\left(\frac{\sigma^1}{\sigma^0}\right)^2 - \frac{\sigma^2}{\sigma^0}\right)\frac{1}{\sigma^0}\frac{\mathrm{d}\sigma^0}{\mathrm{d}X} \tag{9}$$

in α_S.

To again specify the used PDFs we define analogous:

$$R^{\mathrm{LO}} = R^0 \qquad \text{all } \sigma^i \text{ with LO PDFs,} \tag{10}$$

$$R^{\mathrm{NLO}} = R^0 + \alpha_S R^1 \qquad \text{all } \sigma^i \text{ with NLO PDFs,} \tag{11}$$

$$R^{\mathrm{NNLO}} = R^0 + \alpha_S R^1 + \alpha_S R^2 \qquad \text{all } \sigma^i \text{ with NNLO PDFs} \tag{12}$$