Update: Double parton scattering

Jonathan Gaunt, Marc Dunser, Deepak Kar, Tomas Kasemets, Sabrina Cotogno

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Recap

DPS = two hard scatters in a single proton-proton collision

Power suppressed correction to single scattering (SPS) in terms of total cross section, but can compete with SPS when SPS is suppressed by small/multiple coupling constants, or in certain phase space regions.

Also becomes more important for given $Q$ as collider energy grows $\rightarrow$ more important at HE-LHC

Cross section formula to compute DPS production of AB (parton model):

$$\sigma_D^{(A,B)} = \frac{m}{2} \sum_{i,j,k,l} \int F_h^{ik}(x_1, x_2, y; Q_A, Q_B) F_h^{jl}(x_1', x_2', y; Q_A, Q_B)$$

$$\times \hat{\sigma}_{ij}^A(x_1, x_1') \hat{\sigma}_{kl}^B(x_2, x_2') dx_1 dx_1' dx_2 dx_2' d^2 y$$

Parton level cross sections

Diehl, Ostermeier and Schafer (JHEP 1203 (2012))
Neglecting correlations between partons: ‘DPS pocket formula’

\[
\sigma_{DPS}^{(A,B)} = \sigma_{SPS}^{(A)} \sigma_{SPS}^{(B)} / \sigma_{eff}
\]

Geometrical factor \(\sim R_p^2\)

In pQCD, parton pair from one/both protons can arise from a perturbative \(1 \rightarrow 2\) splitting:

Theoretical framework to compute DPS that includes effects of perturbative \(1 \rightarrow 2\) splittings, and avoids double counting with SPS, introduced in JHEP 1706 (2017) 083

(JG, Diehl, Schoenwald)
Same-sign WW production

Same-sign WW – classic ‘clean’ channel to measure DPS

CMS study showed that at HL-LHC we can potentially discriminate between pocket formula predictions and predictions including correlations

Goal: add some predictions using framework of JHEP 1706 (2017) 083 to this plot, repeat exercise for HE-LHC energies
Steps needed for this prediction

• Upgrade the double parton distribution (DPD) evolution code to also include charm and bottom quarks and flavour thresholds.
  ✓ Done

• Put together a code to compute same-sign WW cross sections using these DPDs.
  Adapt an existing code written by T. Kasemets and S. Cotogno.
  Possibility to also look at contributions from spin correlations?

• Investigate effect of trying different low-scale inputs on predictions. For example, modify DPDs to approximately satisfy number / momentum sum rule constraints.
  Should be straightforward.
Luminosity plots relevant to same sign WW, both Ws at same rapidity $Y$, $Q=80$ GeV (very preliminary)

Contributions involving perturbative splitting not completely negligible, more prominent at 14 TeV.