Update: Double parton scattering

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HL/HE-LHC Workshop

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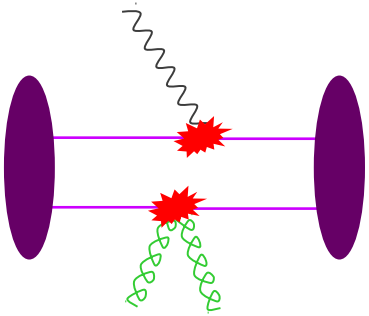
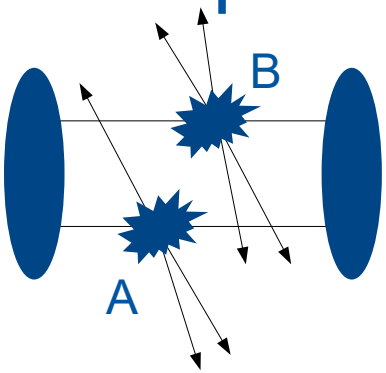


Recap



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 → more important at HE-LHC

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

Symmetry factor

Collinear double parton distribution (DPD)

$$\sigma_D^{(A,B)} = \frac{m}{2} \sum_{i,j,k,l} \int F_h^{ik}(x_1, x_2, \mathbf{y}; Q_A, Q_B) F_h^{jl}(x_1', x_2', \mathbf{y}; Q_A, Q_B) \times \hat{\sigma}_{ij}^{A}(x_1, x_1') \hat{\sigma}_{kl}^{B}(x_2, x_2') \mathrm{d}x_1 \mathrm{d}x_1' \mathrm{d}x_2 \mathrm{d}x_2' \mathrm{d}^2\mathbf{y}$$

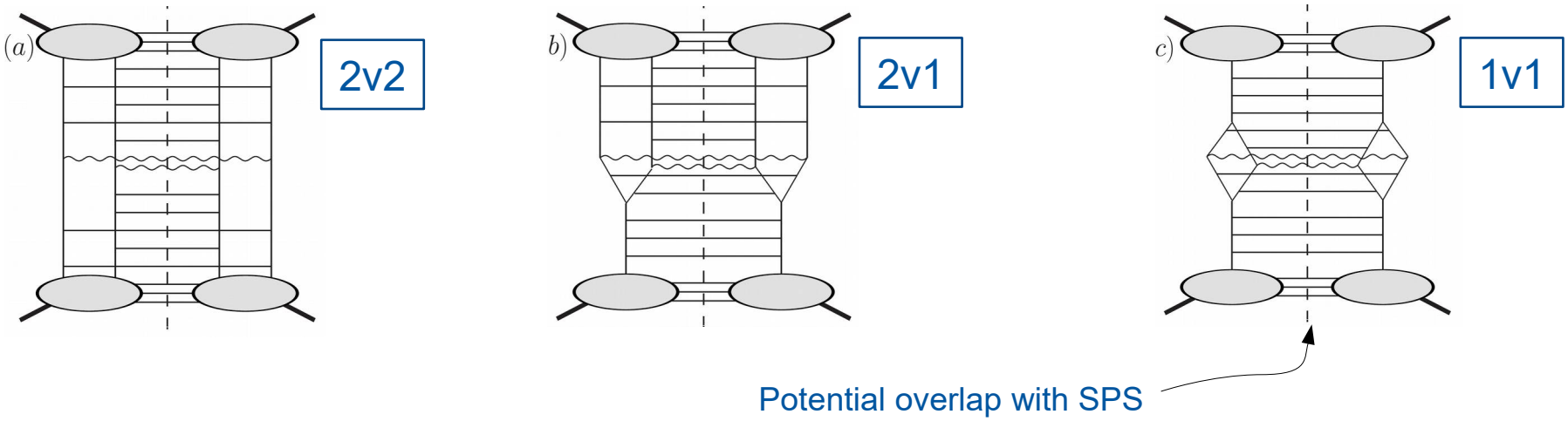
Parton level cross sections

N. Paver, D. Treleani, Nuovo Cim. A70 (1982) 215.
M. Mekhfi, Phys. Rev. D32 (1985) 2371.
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 ~R_p^2

In pQCD, parton pair from one/both protons can arise from a perturbative 1→2 splitting:

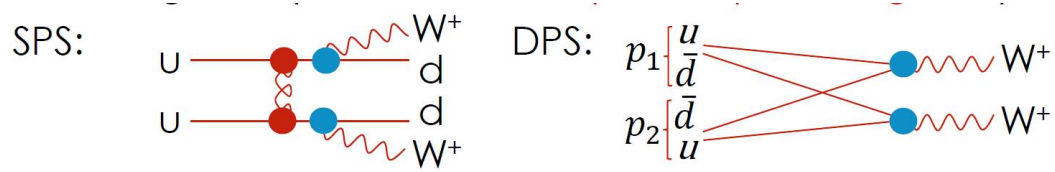


Theoretical framework to compute DPS that includes effects of perturbative 1→2 splittings, and avoids double counting with SPS, introduced in JHEP 1706 (2017) 083

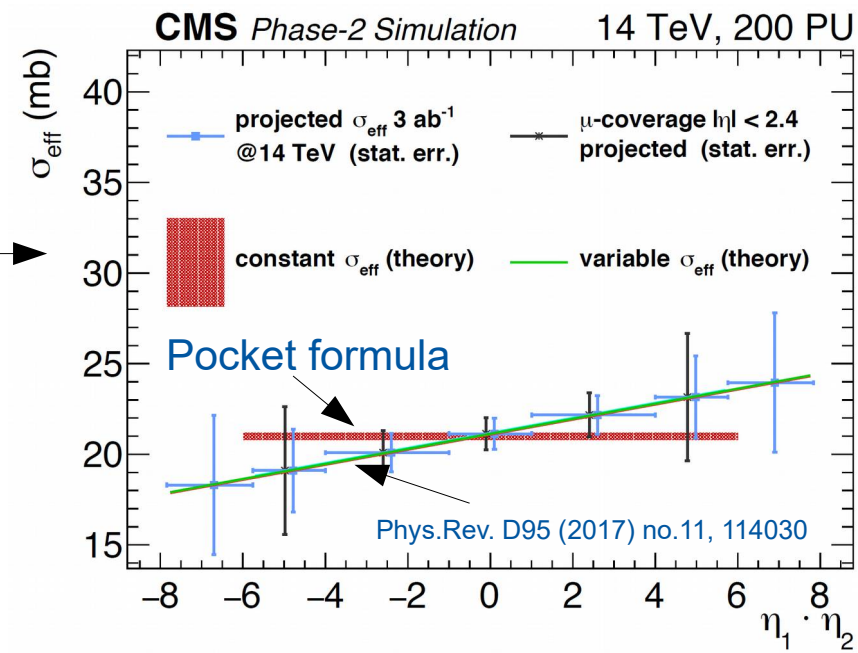
(JG, Diehl, Schoenwald)

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.

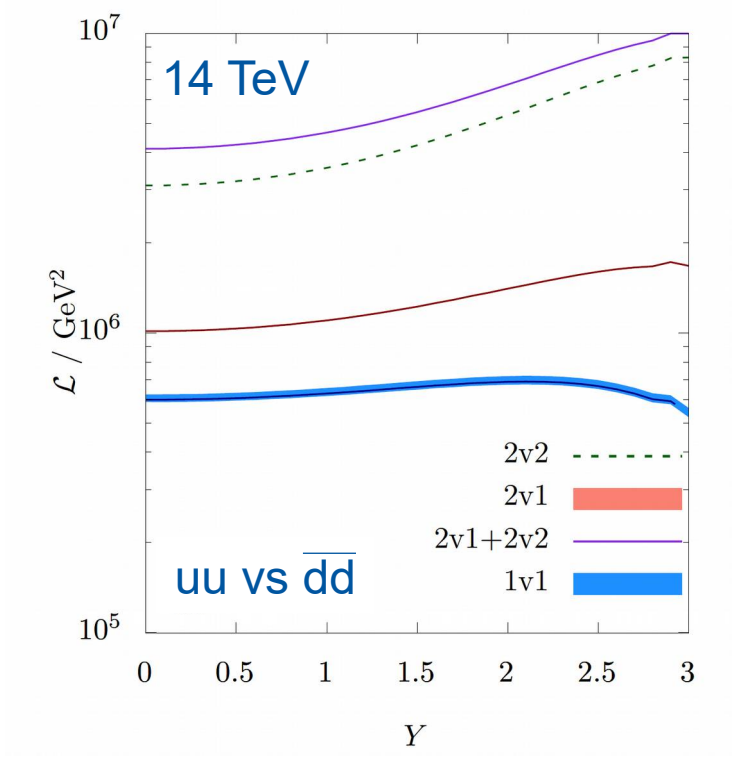
  Adapt an existing code written by T. Kasemets and S. Cotogno.

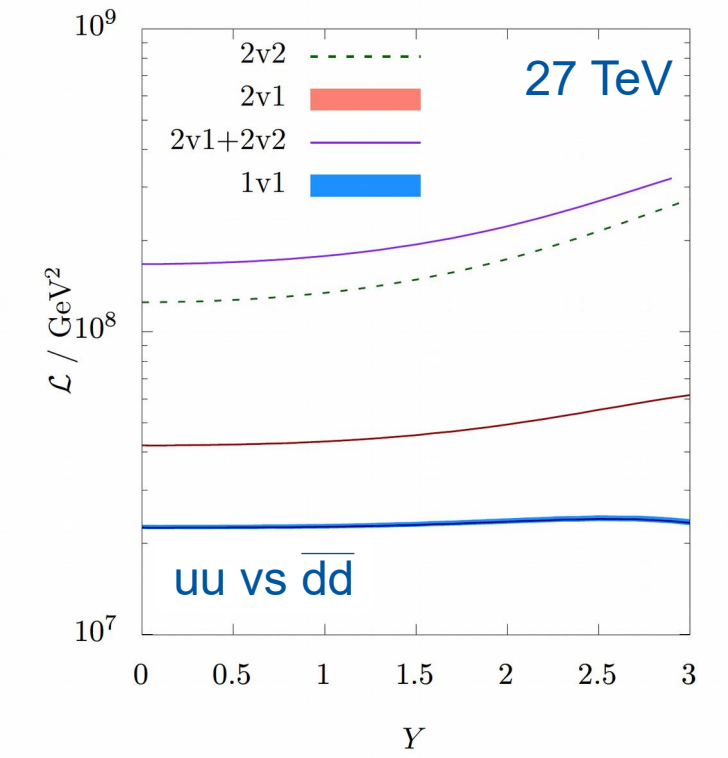
  Possibility to also look at contributions from spin correlations?

- 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.