Cargese
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Double-Parton Interactions

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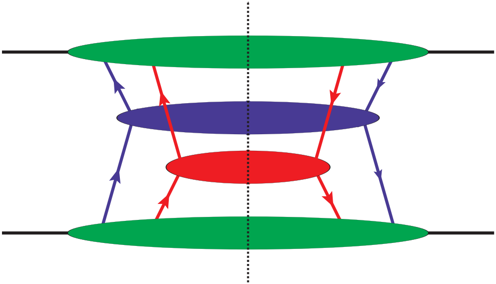
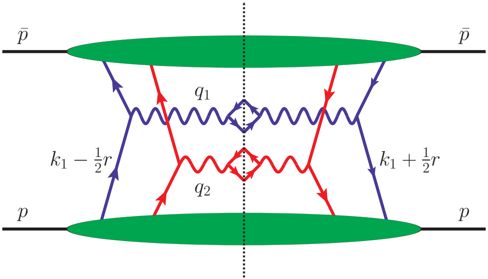


- Collisions with two hard interactions
- Multi-parton interactions observed at LHC (ATLAS), Tevatron (DØ/CDF), ...
- Information about proton structure (2 correlated partons)
- Background to other physics signals (e.g. Higgs)

(A. Del Fabbro, D. Treleani 2000)

- Relevance increases with energy



- Double Drell-Yan type of process ($W^{\pm}$, Z, γ^{*})

(J. R. Gaunt, C.H. Kom, A. Kulesza, W.J. Stirling, 2010, 2011; M. Myska, 2011)

- Momentum difference
- Interferences in color, flavor and fermion number
- Spin: unpolarized (q), longitudinally (Δq) and transversely (δq) polarized quarks
- Many double parton distributions $F_{a_1 a_2}(x_1, x_2, \boldsymbol{k}_1, \boldsymbol{k}_2, \boldsymbol{y})$

- Calculate the differential cross section for unpolarized, longitudinally polarized and transversely polarized quarks, taking interference effects into account

- Longitudinal polarization changes magnitude and angular distribution
- Transverse polarization induce transverse correlations between:
  - decay planes of vector bosons
  - decay planes and direction between the two collisions (i.e. momentum of vector bosons)

- Azimuthal correlations also in collinear cross section

$$d\sigma^{(2)} \sim \sin^2\theta_1 \sin^2\theta_2 \Big[A\cos 2(\varphi_1 - \varphi_2) - B\sin 2(\varphi_1 - \varphi_2) \Big] \times \int d^2\boldsymbol{y}\, f_{\delta q_1 \delta q_2}(x_1, x_2, \boldsymbol{y}) \bar{f}_{\delta \bar{q}_1 \delta \bar{q}_2}(\bar{x}_1, \bar{x}_2, \boldsymbol{y})$$

- Constrain size of spin correlations
- Probability interpretation of quark helicity eigenstates (color singlet, non-interference distributions)
- Derive positivity bounds, similar to single parton distributions

(A. Bacchetta, M. Boglione, P.J. Mulders, 1999; M. Diehl, Ph. Hägler, 2005)

$$f_{qq} \geq |f_{\delta q \delta q} - y^2 M^2 f^t_{\delta q \delta q}|$$

$$\Big(f_{qq} \pm (f_{\delta q \delta q} - y^2 M^2 f^t_{\delta q \delta q})\Big)^2 - \Big(f_{\Delta q \Delta q} \mp (f_{\delta q \delta q} + y^2 M^2 f^t_{\delta q \delta q})\Big)^2 \geq y^2 M^2 \Big(f_{\delta q q} \pm f_{q \delta q}\Big)^2$$

- Implying the weaker conditions

$$f_{qq} + f_{\Delta q \Delta q} \geq 2 y^2 M^2 |f^t_{\delta q \delta q}|$$

$$f_{qq} - f_{\Delta q \Delta q} \geq 2 |f_{\delta q \delta q}|$$