Some comments on simulation of the underlying event

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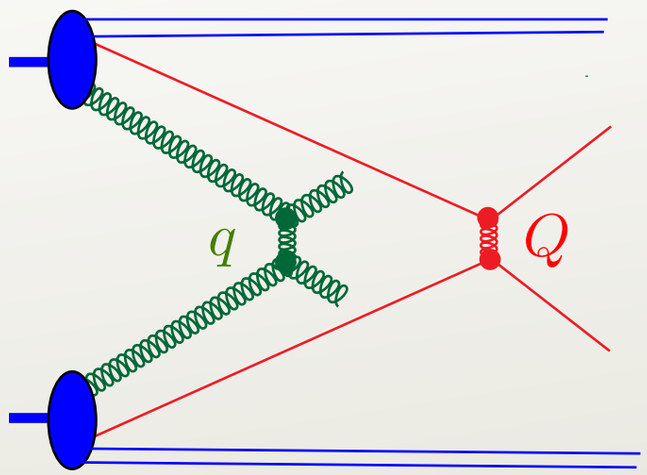
from conversations with Markus Diehl and Zoltan Nagy

Workshop on
Modeling the underlying event and minimum bias events,
Eugene, March 2011

The underlying event as double parton scattering

- Markus Diehl analyzed two hard scatterings with similar virtuality scales and measured k_T for each.
- Here, I consider something else, but still using double parton scattering.
- My main concern is how multiple parton interactions can be simulated in a parton shower event generator.



$$Q^2 \gg q^2 \gg \Lambda^2$$

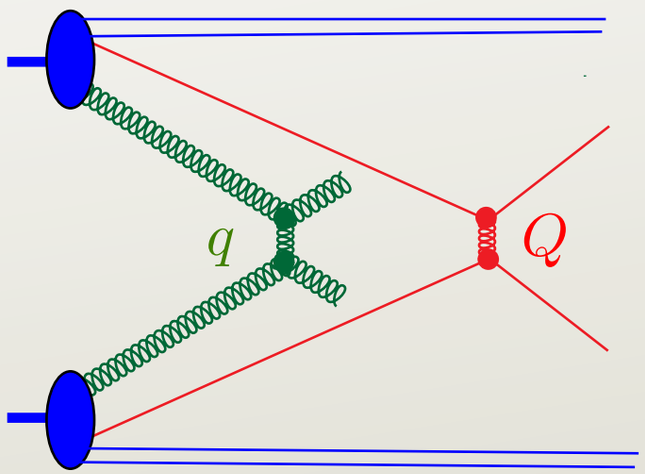
$$\int dQ_\perp \int dq_\perp$$

$$\frac{d\sigma}{dQ^2\, dY\; dq^2\, dy} = \frac{d\sigma}{dQ^2\, dY}\,\frac{dP}{dq^2\, dy}$$

Ordinary hard scattering cross section

We are interested in this probability.

The double parton scattering is power suppressed



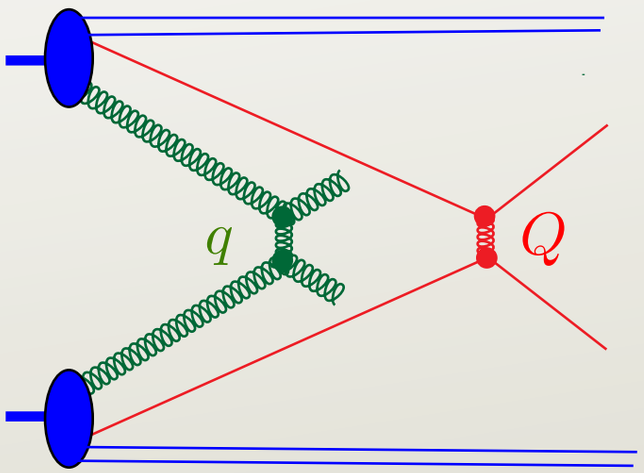
$$\frac{d\sigma}{dQ^2\,dY\;dq^2\,dy} = \frac{d\sigma}{dQ^2\,dY}\,\frac{dP}{dq^2\,dy}$$

$$\int_{q^2_{\rm min}}^{Q^2} dq^2\;\frac{dP}{dq^2\,dy} \sim \alpha_s^2\,\frac{\Lambda^2}{q^2_{\rm min}}\;[xf(x)]^2$$

power suppression

Ratio of double parton distributions to single, for two hadrons

$x^2 = q^2/s$



$$x^2 = q^2/s$$

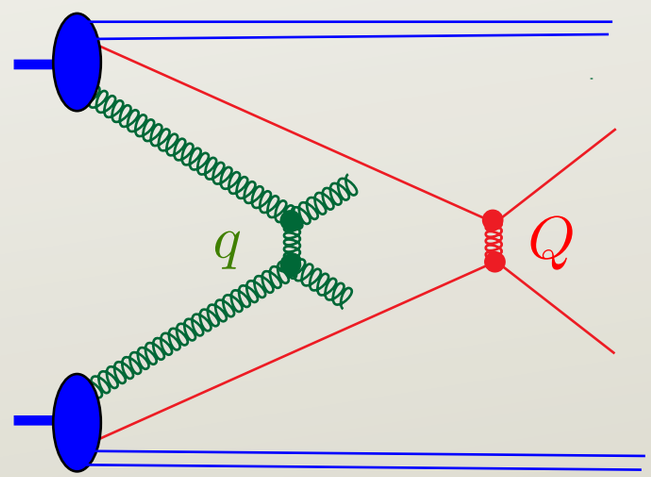
$$\int_{q^2_{\rm min}}^{Q^2} dq^2 \, \frac{dP}{dq^2\, dy} \sim \alpha_s^2 \, \frac{\Lambda^2}{q^2_{\rm min}} \, [x f(x)]^2$$

This factor is large.

It grows as q^2 decreases.

So the probability can be of order 1 for $q \sim 5$ GeV.

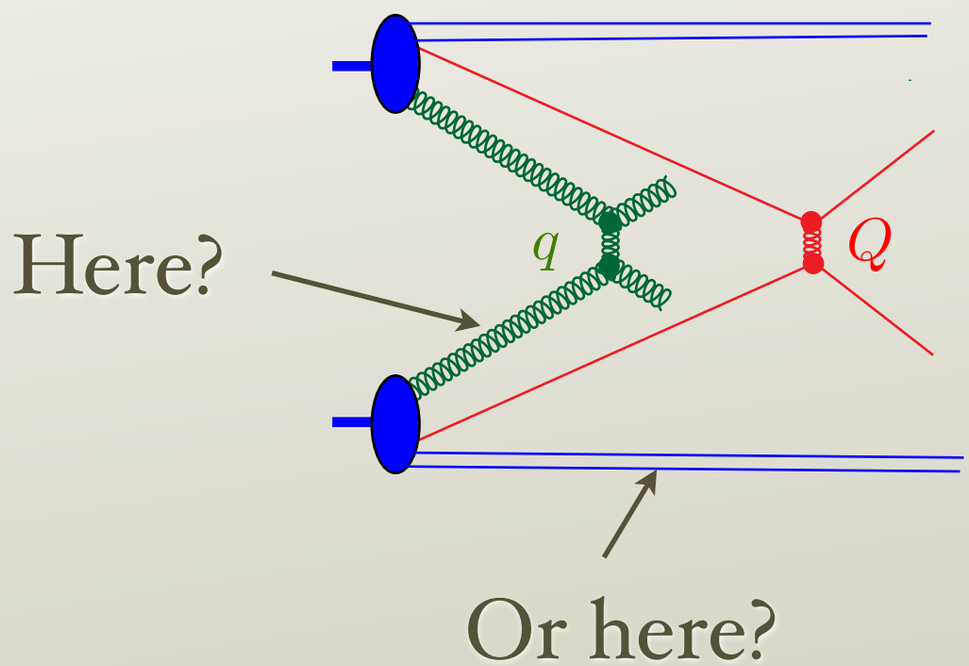
Structure in transverse position?



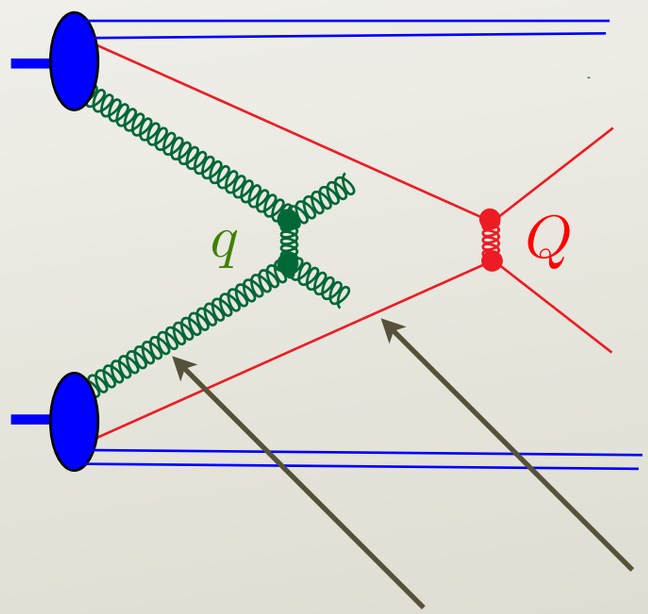
- See presentation of Mark Strikman concerning the distribution of the difference in transverse position, y, between the red and green scatterings.

Color?

- Where does the color line from the hardest parton go?



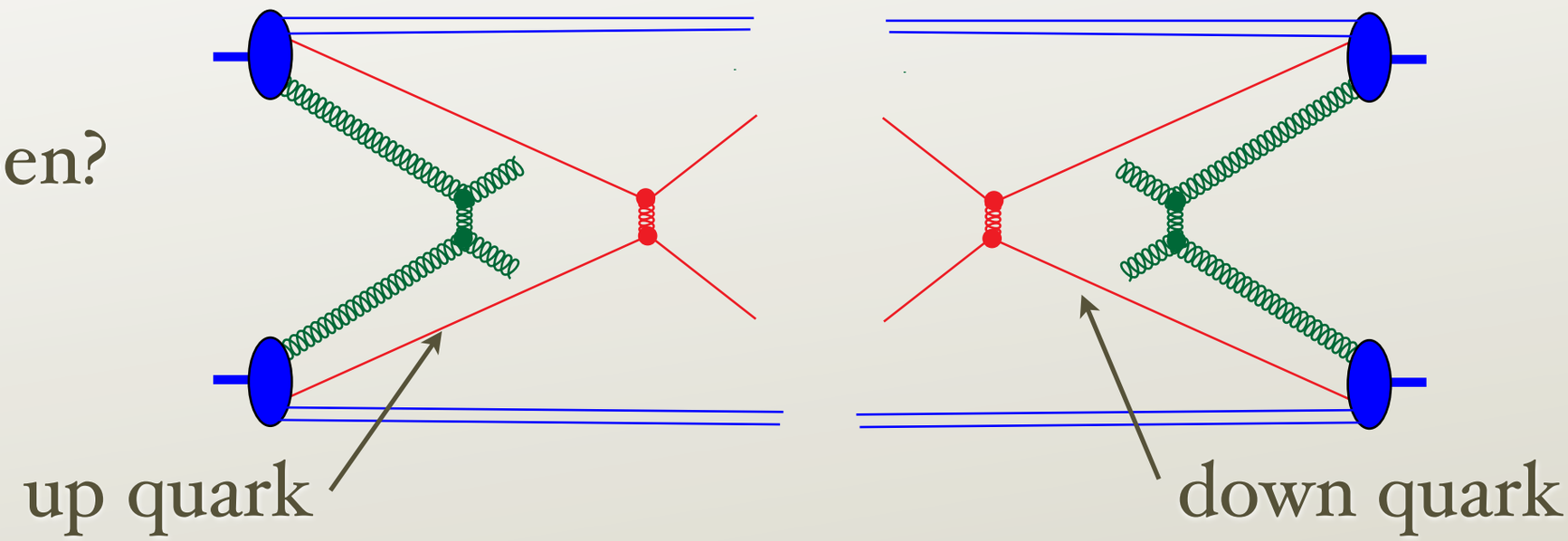
Spin?



- Can the spins of the two partons be correlated?
- Yes.
- But that is a general feature of quantum mechanics that is not well described in standard parton shower event generators.

Flavor?

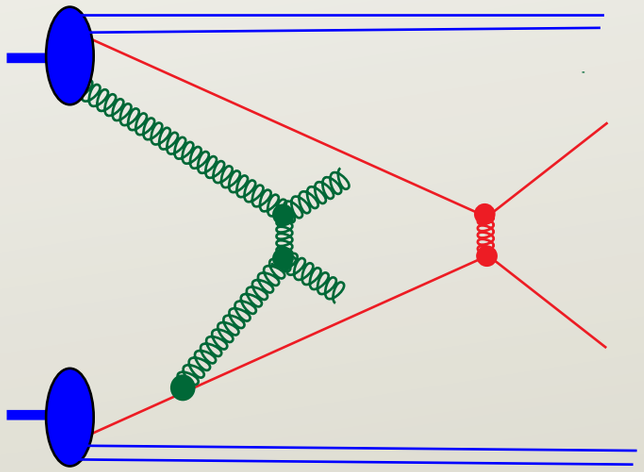
- Can this happen?



- This doesn't conserve flavor in the t-channel.
- That could be fixed by using an appropriate quark instead of the gluon.
- But that would be suppressed at small x.
- More crucially, it is wrong for the hardest interaction.

One parton to two partons?

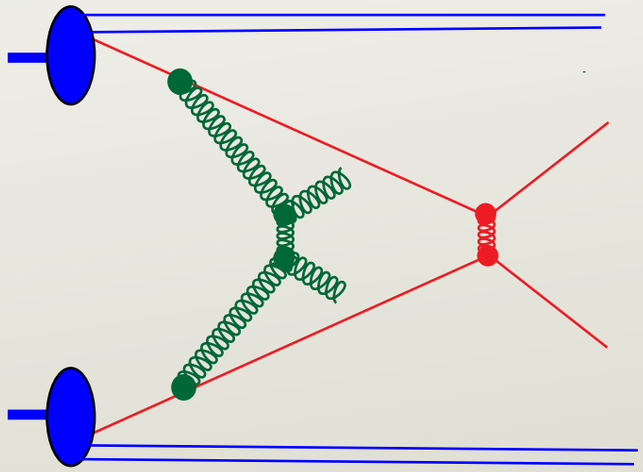
- Do we need to consider this?



- If "y" for the other two partons is of size R, then the parton splitting is too soft to be generated before the end of the shower.

One parton to two partons twice?

- Do we need to consider this?



- It appears that the loop integral here is dominated by transverse momenta of order q, so y is of order $1/q$.
- If so, this is a new sort of interaction that can occur at higher order, not a true double parton scattering.