Adding Showers to a NLO Calculation

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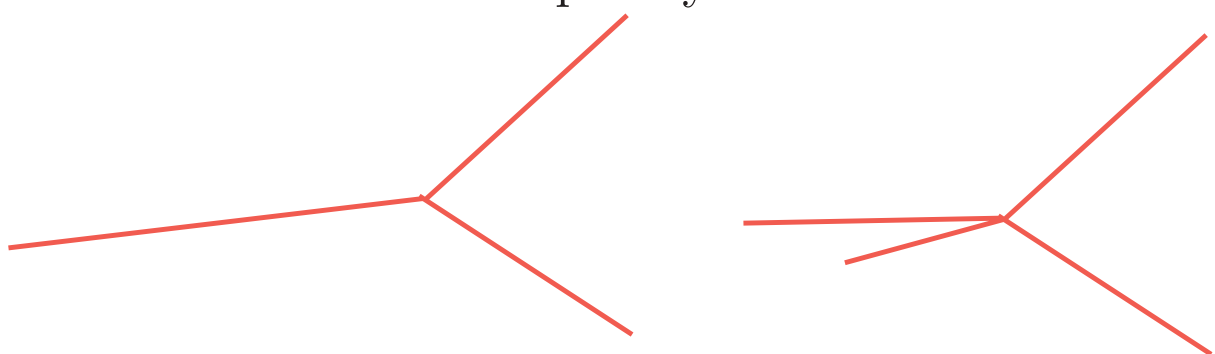
My topic for this talk is three jet cross sections in electron-positron annihilation.

NLO calculations

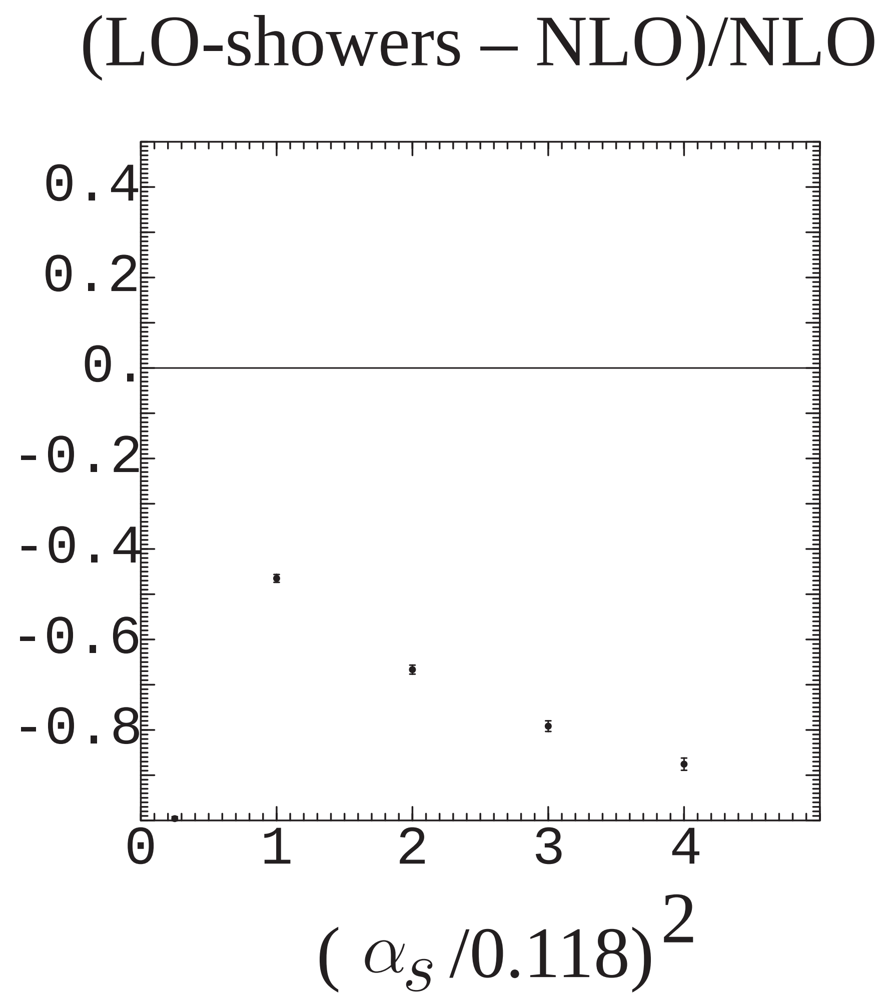
• NLO calculations are typically organized as Monte Carlo generators that generate (partonic) events with weights.
• They are useful, but their final states are completely unrealistic.



Parton Shower event generators

• Monte Carlo event generators based on lowest order matrix elemenets plus parton showers are enormously useful.
• Their final states are realistic.
• The accuracy of the predictions is not so good.

• Here are results for the second moment of the thrust distribution. I compare the leading order result including (my) showers to the NLO result.

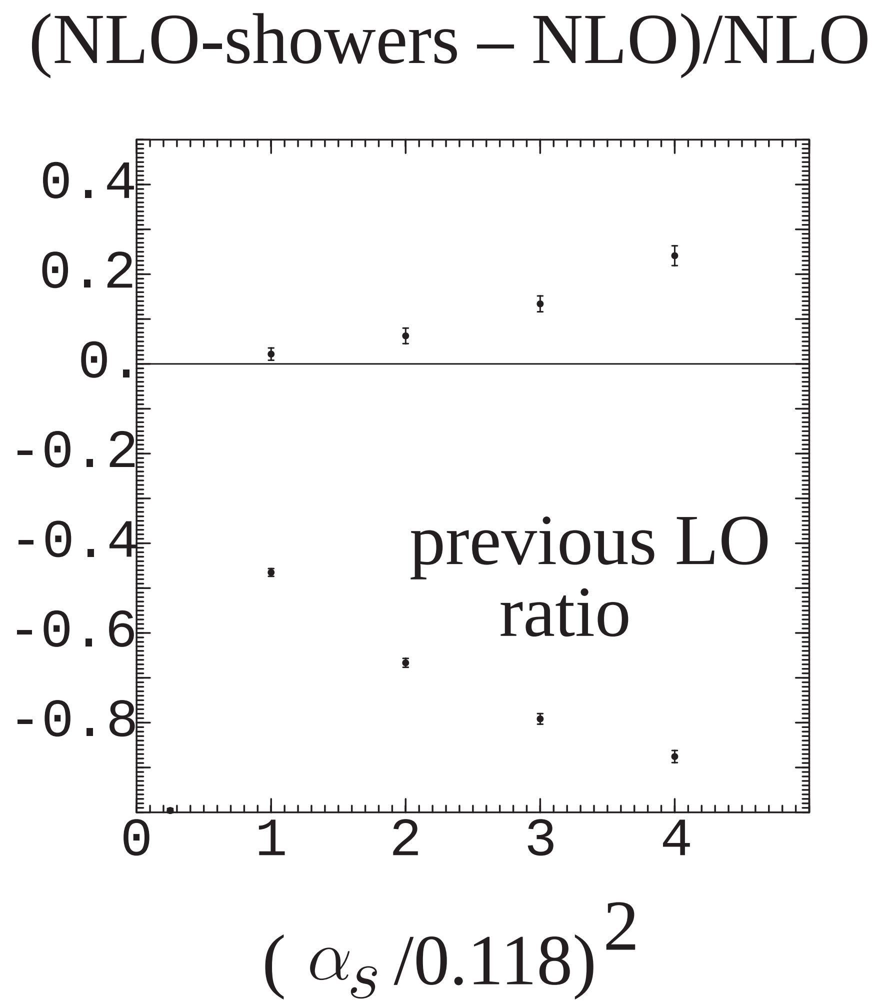


• Exactly what you get depends on the parameter choices. Here we see the result with one particular setting.

Add parton showers to the NLO calculation

- Their final states are more realistic. (See demo.)
- (Or they would be if we fed them to a hadronizer)
- The accuracy of the predictions is better.

• Here are results for the second moment of the thrust distribution. I compare the NLO result including (rather limited) showers to the pure NLO result.



• Exactly what you get depends on the parameter choices. Here we see the result with one particular setting.

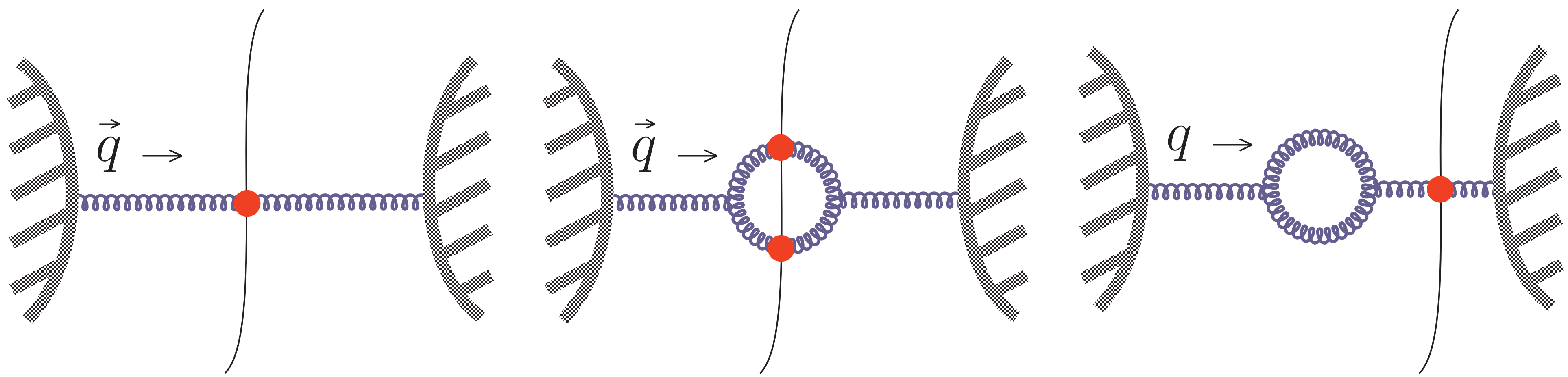
How it works

- I sketch just the main idea, for the splitting of a single parton.
- This covers "collinear" singularities. The program includes "soft radiation" but I leave that out.

The NLO way

$$\mathcal{I}[\mathrm{Born}] + \mathcal{I}[\mathrm{real}] + \mathcal{I}[\mathrm{virtual}] =$$

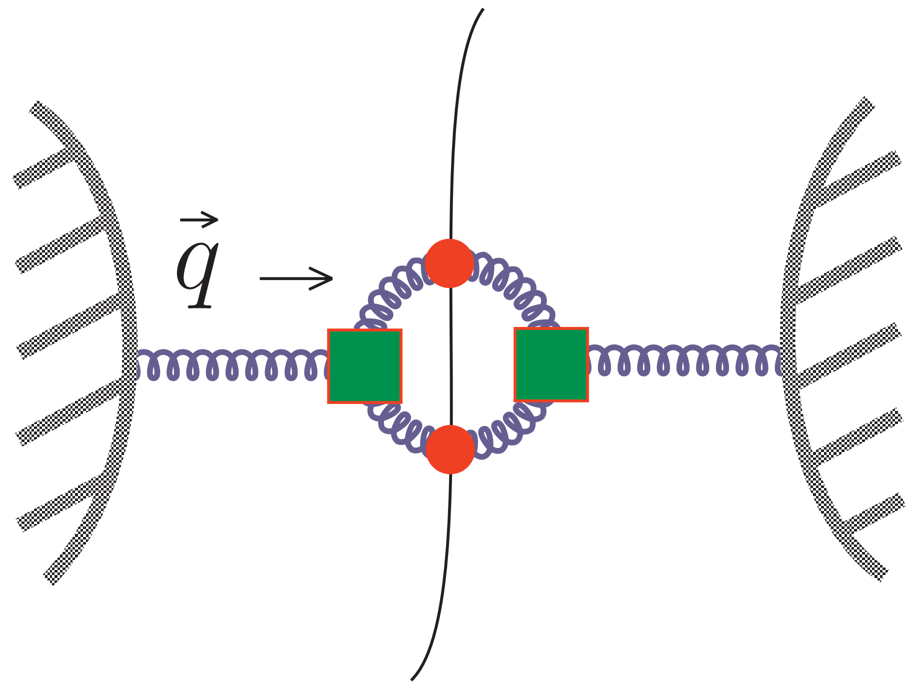
$$\int \frac{d\vec{q}}{2|\vec{q}\,|}\ \mathrm{Tr}\left\{ \not{q}\, R_0 + \int_0^\infty \frac{d\bar{q}^2}{\bar{q}^2} \int_0^1 dx \int_{-\pi}^{\pi} \frac{d\phi}{2\pi}\ \left[\mathcal{M}_{g/q}(\bar{q}^2, x, \phi) R(\bar{q}^2, x, \phi) - \frac{\alpha_s}{2\pi} \mathcal{P}_{g/q}(\bar{q}^2, x)\, \not{q}\, R_0 \right] \right\}.$$



The shower way

$$\mathcal{I}[\text{shower}] = \int \frac{d\vec{q}}{2|\vec{q}|}\ \mathrm{Tr}\biggl\{\int_0^\infty \frac{d\bar{q}^2}{\bar{q}^2}\int_0^1 dx \int_{-\pi}^{\pi}\frac{d\phi}{2\pi}$$

$$\times \mathcal{M}_{g/q}(\bar{q}^2, x, \phi) R(\bar{q}^2, x, \phi) \exp\left(-\int_{\bar{q}^2}^{\infty}\frac{d\bar{l}^2}{\bar{l}^2}\int_0^1 dz\ \frac{\alpha_s}{2\pi}\,\mathcal{P}_{g/q}(\bar{l}^2, z)\right)\biggr\}.$$



The connection

$$\mathcal{I}[\text{Born}] + \mathcal{I}[\text{real}] + \mathcal{I}[\text{virtual}] = \mathcal{I}[\text{shower}] \times \left(1 + \mathcal{O}(\alpha_s^2)\right).$$