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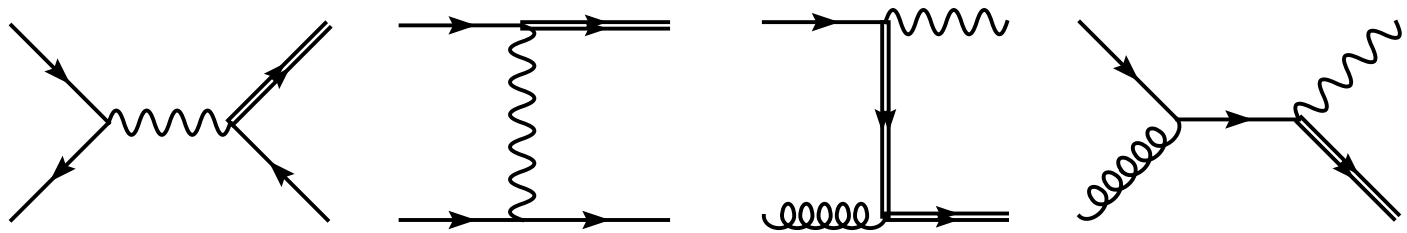
Wt Production & Next-to-eikonal Resummation

CERN theory workshop

Single Top Production

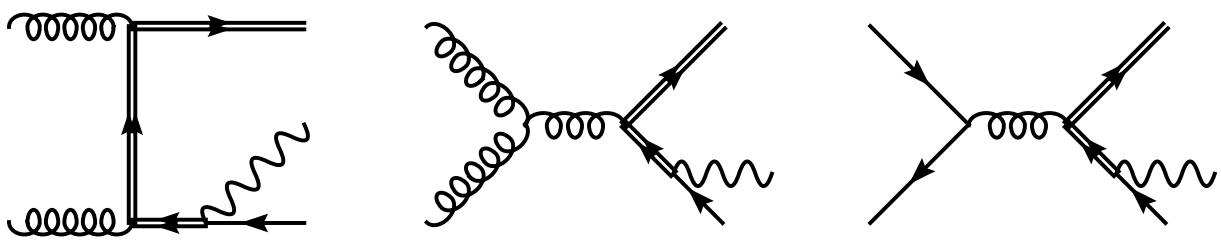


(1) (2) (3)

- Single top production important for both SM and BSM physics.
- Three modes of single top production at LO.
- Sizable LHC cross-section ($\simeq 320$ pb).
- *Wt* mode makes up about 20% of this, and is important for several reasons (e.g. V_{tb}, background to new physics).
- Theoretically difficult beyond LO in perturbation theory...

Interference Problem

- NLO real emission contributions to Wt production include:



- Wt production at NLO interferes with $t\bar{t}$ at LO.
- I.e. LO Wt well-defined, but huge correction at NLO (which is really due to $t\bar{t}$).
- Can one separate the two processes in a well-defined way, so that NLO effects can be included?
- If so, can add Wt and $t\bar{t}$ incoherently.
- What is the systematic uncertainty involved in such a separation?

Interference problem

- Previous NLO calculations all gave procedures for defining *Wt* (Campbell, Tramantano, Belyaev, Boos, Dudko, Tait).
- First definition in an all-orders, fully exclusive context was given by Frixione, Laenen, Motylinski, Webber, White.
- Implemented in MC@NLO event generator, with means of assessing theoretical uncertainty due to interference effects.
- Current work involves testing whether *Wt* does indeed make sense independently of $t\bar{t}$, and the prognosis is very good - arXiv:0908.0631.
- Important when *Wt* is a signal, and also when it is a background.

Soft resummation

- Multiple soft gauge boson emission can lead to large corrections to cross-sections.
- If ξ is the energy carried by soft bosons, typically get contributions:

$$\frac{d\sigma}{d\xi} = \sum_{n,m} \alpha^n \left[c^0_{nm} \frac{\log^m(\xi)}{\xi} + c^1_{nm} \log^m(\xi) + \dots \right]$$

- First set of terms corresponds to *eikonal approximation*, in which momenta $k_i \to 0$ for all (soft) emissions.
- Second set of terms is *next-to-eikonal* (NE) limit i.e. first order in k_i.
- Happens in abelian and non-abelian theories.

Eikonal resummation

- It has been known for decades how to resum eikonal logarithms. Abelian results date from the 1960s (Yennie, Frautschi, Suura)
- Non-abelian eikonal resummation dates from 1980s (Gatheral, Frenkel, Taylor, Sterman).
- Key to resummation in both cases is the fact that soft boson corrections *exponentiate* in terms of a subset of diagrams in the theory.
- Natural to consider whether this can be extended beyond eikonal logarithms.

Path integral methods

- A new approach for examining soft gluon corrections has been presented by Laenen, Stavenga, White - arXiv:0811.2067.
- Uses path integral methods to relate the exponentiation of subdiagrams to the known exponentiation of diagrams in quantum field theory.
- Recovers eikonal results, but is easily generalizable to next-to-eikonal emissions.
- Allows classification of the structure of NE terms in matrix elements.

$$\mathcal{M} = \mathcal{M}_0 \exp\left[\mathcal{M}^E + \mathcal{M}^{NE}\right] \times \left[1 + \mathcal{M}_{rem.}\right] + \mathcal{O}(NNE).$$

Path integral methods

- Current work involves rederiving the results using traditional methods, and validating by comparison with known fixed order results.
- Opens the door to resummation of next-to-eikonal logarithms in various contexts e.g. threshold resummation.
- May also have something to say about recent developments in all-order properties of $\mathcal{N} = 4$ SYM etc., and also QCD.