

Current Work and Interests

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LHCtheory mini-workshop
27th January 2012, CERN



Unstable Tops and Effective Theory *

Research focus: **Top Physics**

In particular,

- Off-Shell effects for top quarks at hadron colliders
- Employing ideas/techniques from effective theory as well as from standard NLO calculations

Relax the (often made) assumption $p_t^2 = M_t^2$

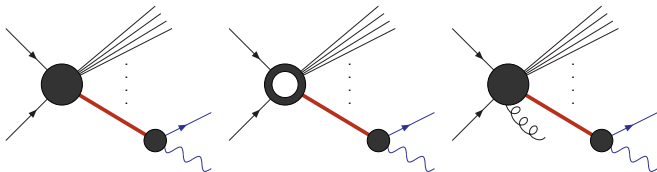
Involves the calculation of “non-factorisable” corrections and background diagrams.

For inclusive enough observables non-factorisable corrections have been shown to be **small**, $\mathcal{O}(\frac{\Gamma_t}{M_t})$ [V. S. Fadin et. al. '94][K. Melnikov, O. I. Yakovlev '94]

Need off-shell effects for accuracy of $\delta M_t \lesssim \Gamma_t$

*In collaboration with **Adrian Signer** (IPPP), **Paul Mellor** (IPPP), **Pietro Falgari** (Utrecht)

Resonant Top-Quark Production $p_t^2 \sim M_t^2$

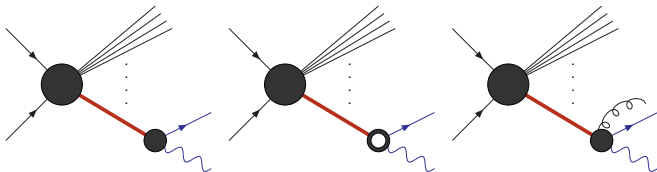


- non-factorizable corrections included
- (relevant) background diagrams included

- ✓ off-shell effects included
- ✓ spin-correlations and cuts on final states
- ✓ simpler calculation than fully off-shell
- ✗ not valid outside resonant region $p_t^2 \sim M_t^2$

Single Top: [P. Falgari et al. '10, '11]
 $t\bar{t}$: [P. Falgari, A.P., A. Signer - In Progress]

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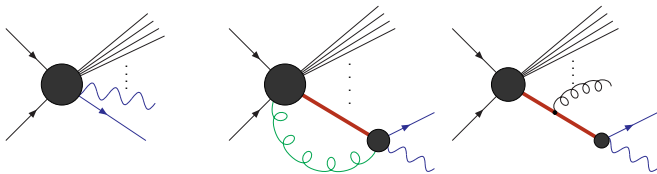


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Expansion Of Full Amplitude

Exploit widely separated scales present: $p_t^2 - M_t^2 \sim M_t \Gamma_t \ll M_t^2$

→ perform an expansion in the new small parameter $\Delta_t = \frac{p_t^2 - M_t^2}{M_t^2}$ $\left(\sim \frac{\Gamma_t}{M_t} \right)$
(Pole Expansion: [A. Aeppli, G. J. v Oldenborgh, D. Wyler '94])

Virtual Corrections: use Method of Regions [M. Beneke, V. A. Smirnov '98]

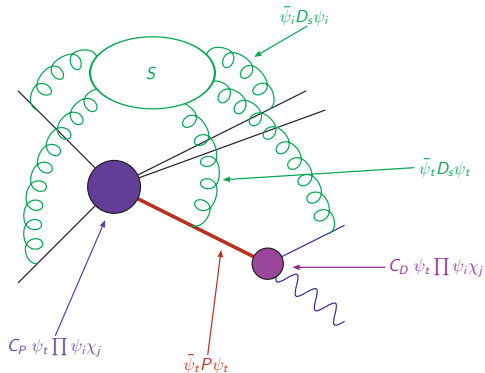
→ split corrections into 'hard' and 'soft' contributions

Real Corrections: split into production/decay/background contributions, in a way consistent with Method of Regions

Important

- only keep relevant terms in expansion
- expansion of full amplitude is **strictly gauge invariant** at each order in Δ_t
- method is systematically improvable

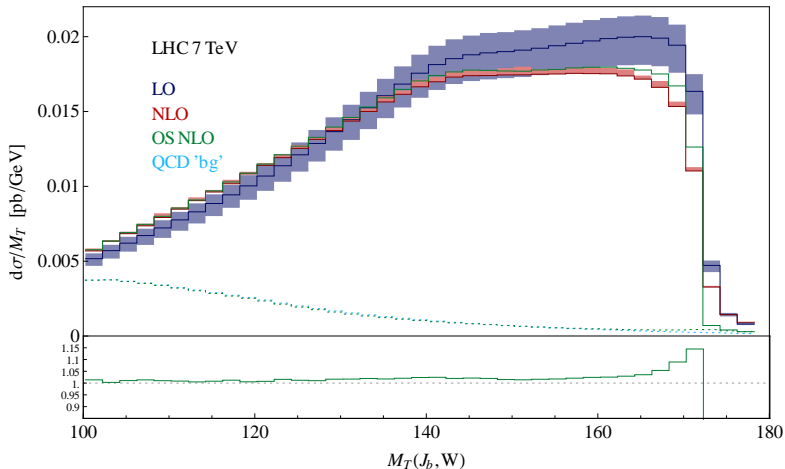
Effective Theory Picture



'Hard Contributions' contained in matching coefficients, C_P and C_D

$\bar{\psi}_t \not{D}_s \psi_t$ encodes dynamical degrees of freedom (soft gluons, cf SCET)

(Single-Top) Example Distribution: $M_T(\text{top})$



Off-shell effects **important**

Outlook

- Finish off $t\bar{t}$ calculation; full study of off-shell effects there
- include hadronic decays of W s
- add in anomalous couplings of tops [J.A. Aguilar-Saavedra '10][C. Zhang, S. Willenbrock '11]

Effective theory approach revealing structure behind amplitudes:

- progress towards resummation of large logs $\sim \log\left(\frac{\mu_s}{\mu_h}\right)$ for exclusive observables