

The $t\bar{t}VV'$ background to Four-Top quark production: Towards New Physics Studies

Luz Silvana Rodríguez Meléndez

Dr. Manfred Kraus

Física del Quark Top

Tiempo de vida

$$\tau_t \sim \frac{1}{\Gamma_t} \sim 5 \times 10^{-25} s,$$

$\ll$

Tiempo de hadronización

$$\tau_{had} \sim \frac{1}{\Lambda_{QCD}} \sim 10^{-23} s.$$



El Top tiene un fuerte acoplamiento con el Higgs:

$$\mathcal{L}_Y \supset -m_t \bar{t}t - \frac{m_t}{v} h\bar{t}t.$$

$$y_t = 0.995.$$

$$m_t = \frac{y_t v}{\sqrt{2}},$$



Búsqueda de nueva física

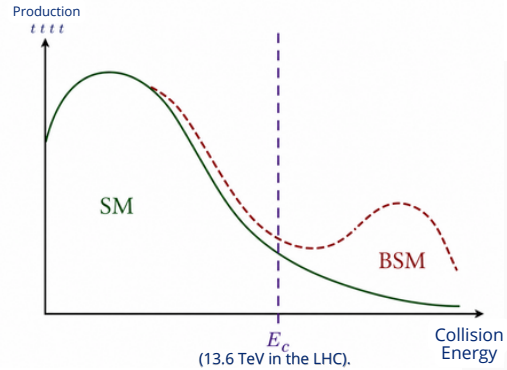


Fig. 7 Schematic representation of resonances for four top-quark events at different energies.

Producción SM

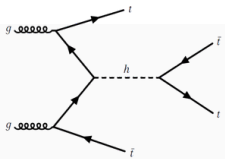


Fig. 3 Four top quark production within the SM.

Producción BSM

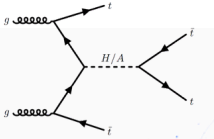


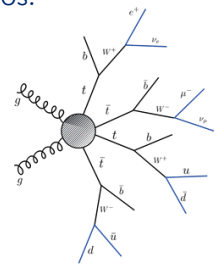
Fig. 4 Four top quark production in 2HDMs [22].

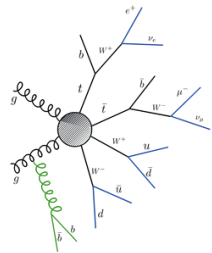
La nueva física podría encontrarse más allá de la región de energía actual.

Pero las deviaciones sí pueden comenzar a detectarse mucho antes en el rango energético.

Backgrounds

Dos procesos pueden tener exactamente la misma firma, por lo que pueden contaminar la señal de lo que buscamos.





Backgrounds de 4 tops:

$t\bar{t}W$	$t\bar{t}Z$	$t\bar{t}WW$	$t\bar{t}ZZ$	$t\bar{t}WZ$
Estudiado con gran exactitud	Estudiado con gran exactitud	Nuestro objetivo Nuestro objetivo	Nuestro objetivo Dra. Fabiola Fortuna	Nuestro objetivo Dr. Edier Paredes

Interacción en la vida real

Para ello:

Más términos en la expansión perturbativa

+

Incorporar la **cascada de partículas** (Parton Shower) que viene después.

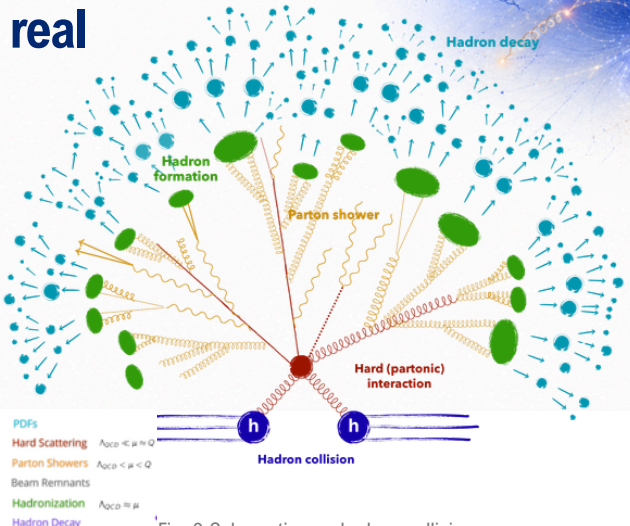


Fig. 9 Schematics on hadron collisions.

El algoritmo
POWHEG

Para observables, por ejemplo la sección eficaz:

$$\sigma_{PW} = \int \mathrm{d}\Phi_n \overline{B}_s(\Phi_n) \left(\Delta_{M_s}(\Phi_n, p_T^{min}) + \int \mathrm{d}\Phi_r \frac{R_s(\Phi_{n+1})}{B(\Phi_n)} \Delta_{M_s}(\Phi_n, p_T) \right) + R_h(\Phi_{n+1}) \mathrm{d}\Phi_{n+1},$$

donde añadimos la probabilidad de radicaión por medio del Sudakov Form Factor:

$$\Delta_M(\Phi_n, p_T) = \exp\left(- \int \mathrm{d}\Phi_r \frac{R(\Phi_{n+1})}{B(\Phi_n)} \Theta(k_T - p_T) \right)$$



Nuestro trabajo

Generador de eventos para $t\bar{t}VV'$

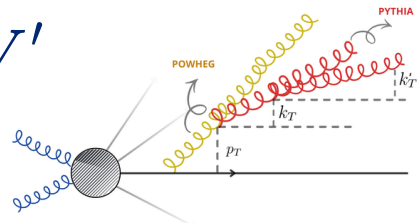
Diseñamos generadores Monte Carlo para simular el evento junto con sus primeras radiaciones (que tienden a ser más delicadas),

↓

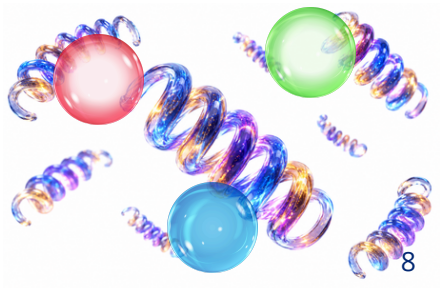
Radiaciones subsecuentes se generan con otros programas como Pythia o Sherpa.

¡RESULTADO!

Hacer predicciones de interés con mayor exactitud física del evento que nos interesa caracterizar.

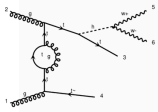
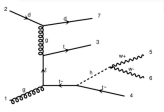


La radiación que trabajamos es radiación QCD



Detalles y resultados

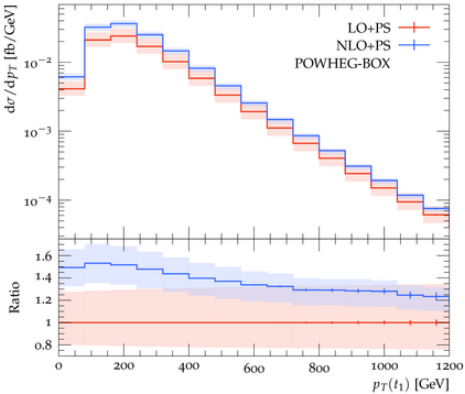
Detalles

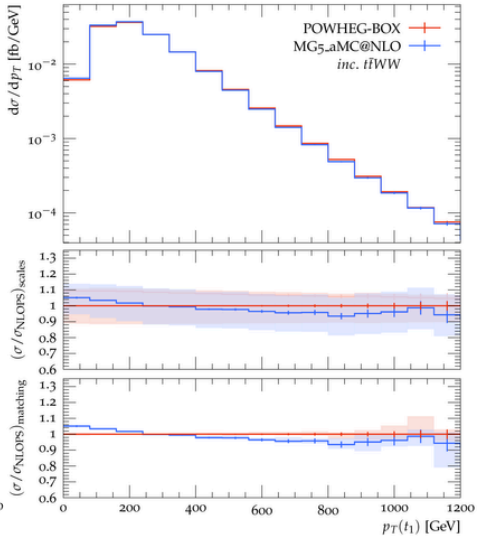
n partículas de salida **nivel árbol**	
n partículas de salida **un loop**	
$n+1$ partículas de salida **nivel árbol**	

Algunos números

	Número de diagramas	Subprocesos
Born	103	9
Virtual	2189	9
Real	2298	41
Total	4590	59

Resultados



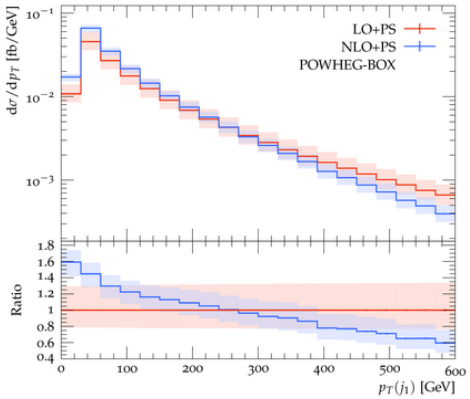


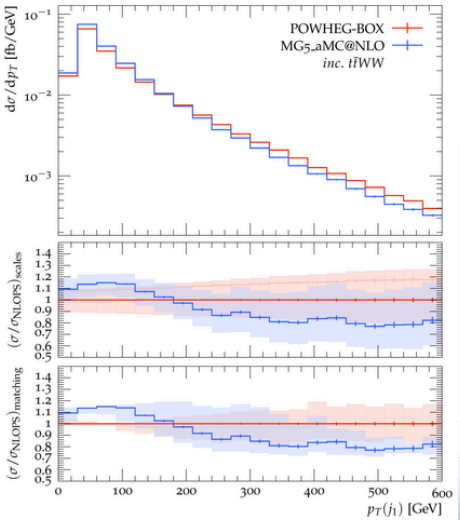
Transverse momentum of the hardest top quark;

$$p_T(t_1)$$

- NLO shape corrections.
- Suppressed high-transverse-momentum emissions.
- Reduced scale uncertainties.
- Good POWHEG-MG5 agreement.

Resultados



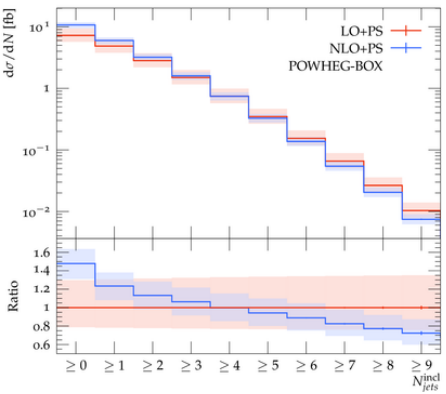


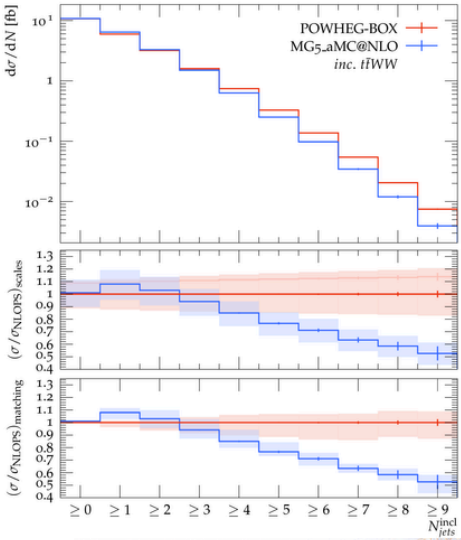
Transverse momentum of the hardest jet;

$p_T(j_1)$

- NLO shape corrections.
- Suppressed high-transverse-momentum emissions.
- Reduced scale uncertainties.
- Good POWHEG-MG5 agreement.

Resultados





Number of inclusive jets

N_{jets}^{incl}

- NLO shape corrections.
- Highly depends on radiation.
- Reduced scale uncertainties.
- Uncertainty bands overlap.
- No agreement with POWHEG–MG5.

Discusión



Discussion

- ttWW is a relevant background to four-top production.
- Inclusive observables show good agreement between POWHEG and MG5_aMC@NLO.
- NLO corrections modify both the normalization and shape of distributions.
- Scale uncertainties are reduced with respect to lower-order predictions.
- A consistent damping prescription is essential in POWHEG.
- Exclusive jet observables are more sensitive to the matching procedure.
- Jet multiplicity is a useful discriminator between ttWW and tttt.

Backup slides

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