Introduction to MCnet

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Just Join Mcnet!!

I'm doing my PhD in Bologna where I work for **ATLAS experiment.**
I've collaborated with measurement of **ttbar production** differential cross section at 8 and 13 TeV for events with an highly boosted top
I wanted to **improve my knowledge on MC-generator**, and in particular on simulation of events that contains boosted quark.

Applied for a short-term studentship in Goettingen

Started the three months period (1/03/2015 - 31/05/2015) with professor Steffen Schumann and Diogo Buarque Franzosi.

Project

The aim is to study the interference effects of New Physics signal and the SM background in events that contains a boosted top in the final state to see if there might be nontrivial interferences that make the current limit setting procedure not fully appropriate.

Proceed through different step

- Use 8 TeV analysis performed by ATLAS that enhance top quark identification efficiency in boosted regime to compare the public data with simulation obtained using SHERPA and MADGRAPH5+PYTHIA8 . Study different configuration of the generator to see how the distribution change and what can be used for BSM generation.
- Generate some BSM samples using UFO model and compare the obtained signal sample between the two generators (***Scalar, Pseudoscalar, Vector, Pseudovector and Scalar and Vector color octet resonances***).
- Study the interference effect between BSM and top continuum and generator systematics.

Analysis Description

We are using three different analysis to compare predictions and data on a large number of observables.

Ttbar cross section measurement , boosted Analysis at 8 TeV (Phys. Rev. D 93, 032009)

- Require exactly one isolated mu or e ($p_T > 25$, $|\eta| < 2.5$)
- An $antikt_{R=0.4}$ jet with $p_T > 25$ GeV, $|\eta| < 2.5$ and $\Delta R(lepton,jet\_0.4) < 1.5$
- $E_T^{miss} > 20$ GeV , $E_T^{miss} + m_T^W > 60$ GeV
- An $AntiKt_{R=1.0}$ jet with $p_T > 300$ GeV, $|\eta| < 2.0$, mass > 100 GeV and $\sqrt{d_{12}} > 40$ GeV $\Delta R(jet_{R=0.4}, jet_{R=1.0}) > 1.5$, $\Delta phi(l, jet_{R=1.0}) > 2.3$
- At least one b-jet in the event

  The large-R jet is identified as hadronic top, while the leptonic top isn't reconstructed.

  The differential cross section wrt the hadronic top transverse momentum is measured at particle level

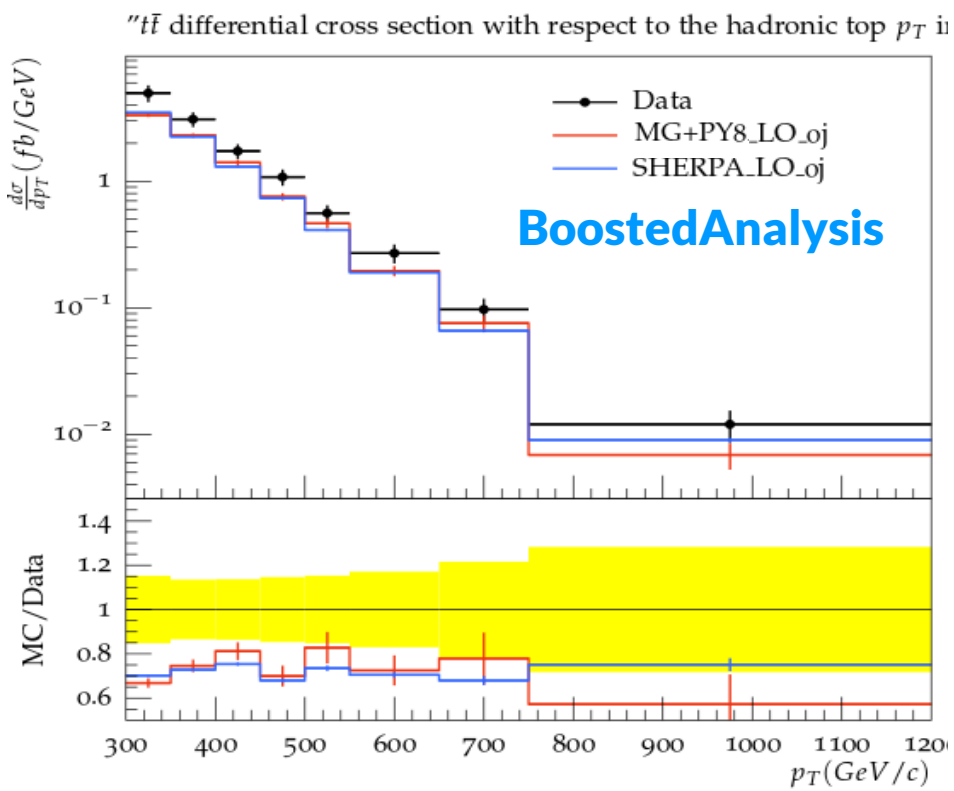
Ttbar cross section measurement , resolved Analysis at 8 TeV (arXiv:1511.04716)

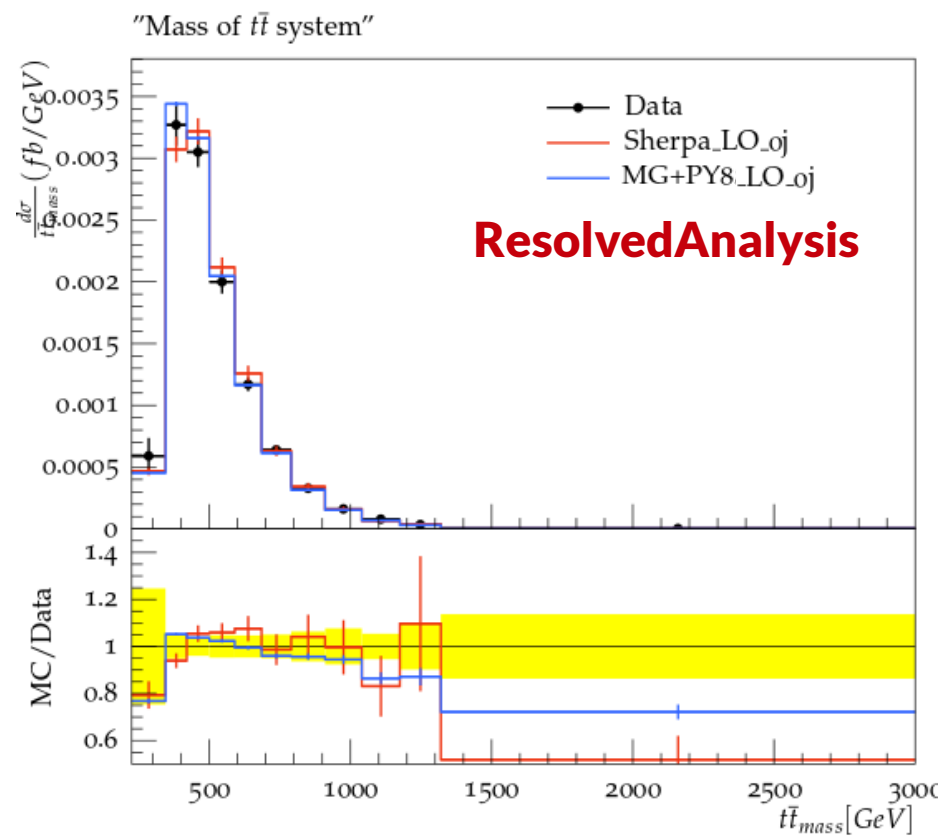
Jet shape measurement at 7 TeV(Eur. Phys. J. C (2013) 73:2676)

Project- step1

Test various generation configurations to find better agreement between SHERPA and MADGRAPH+PYTHIA 8.

- First comparison at LO without additional jets.
- Applied one cut on top transverse momentum to enhance generation efficiency.
- Underlying events on and QED corrections enabled (photon hard emission correction included up to the first order in α_{QED}) .

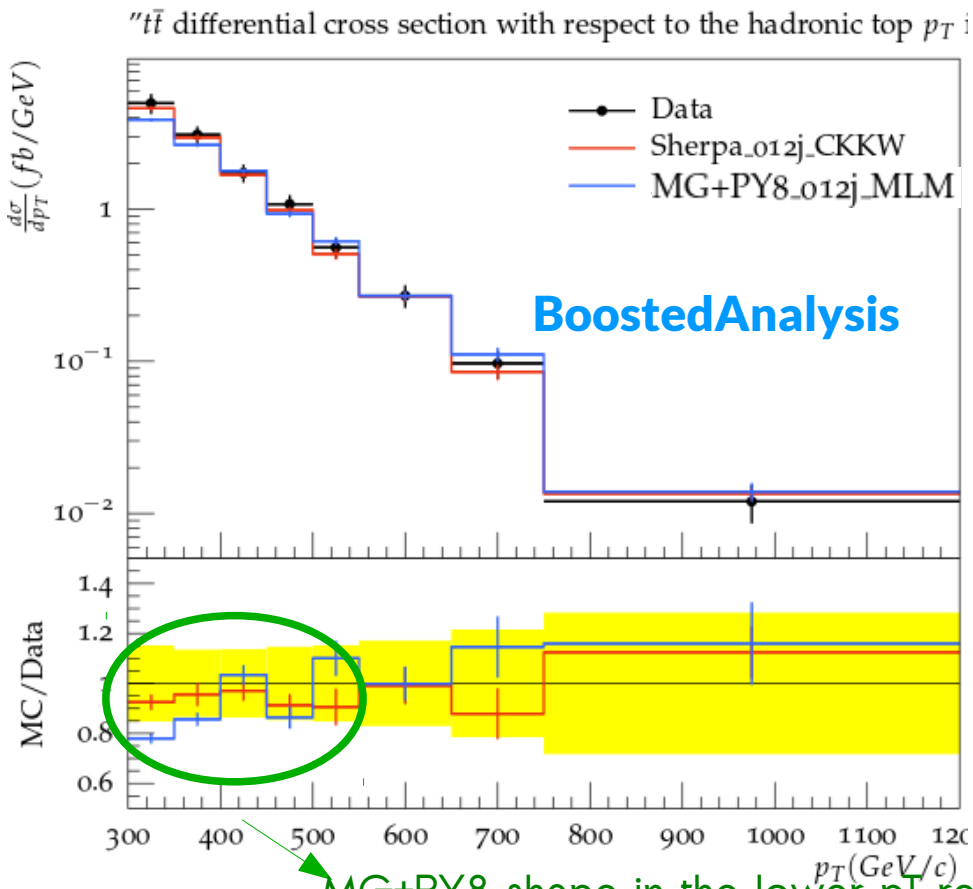


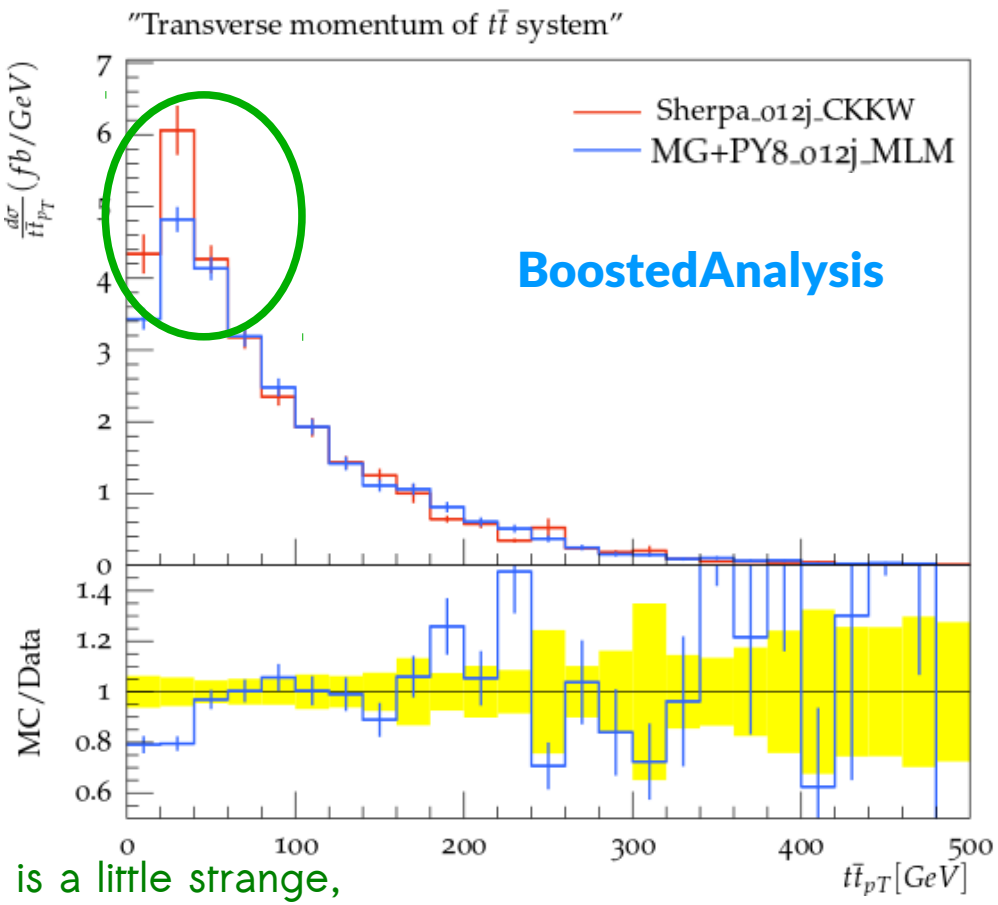


Project- step1

Tested the agreement with data using the sample ttbar + additional jet.

- Sherpa : using CKKW method for merging using Qcut variable = 20
- MG+PYTHIA8 : using MLM method for merging using xqcut = 10 and Qcut = 30



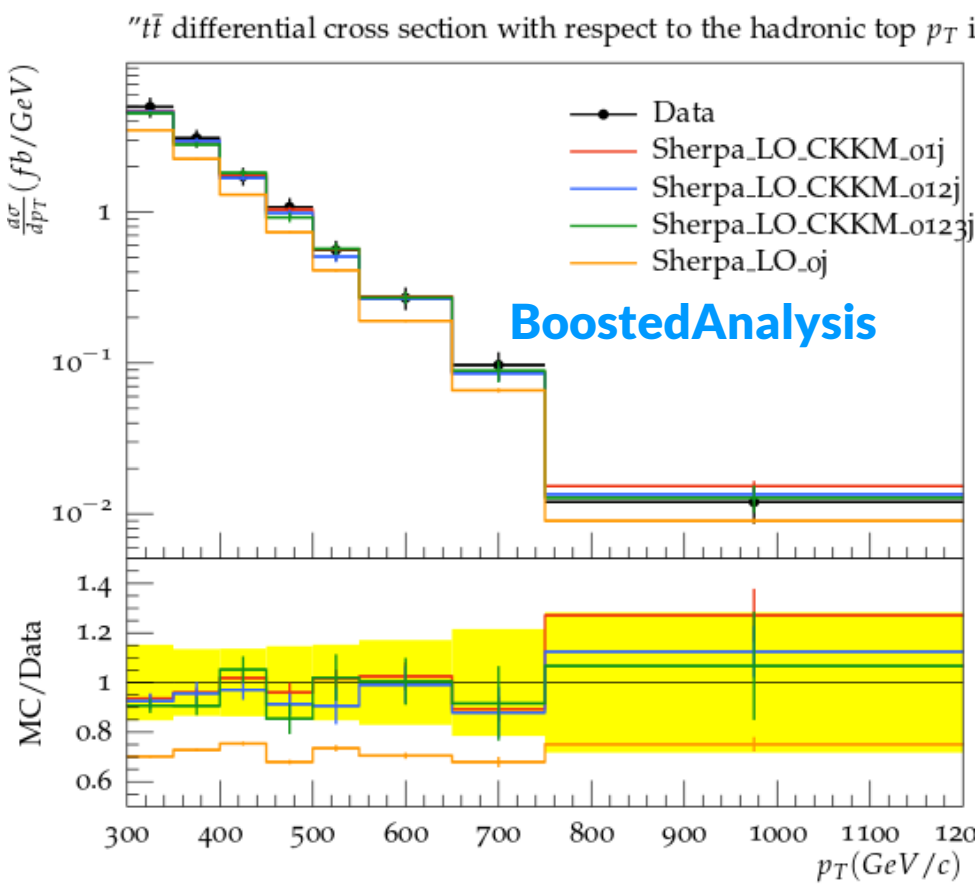


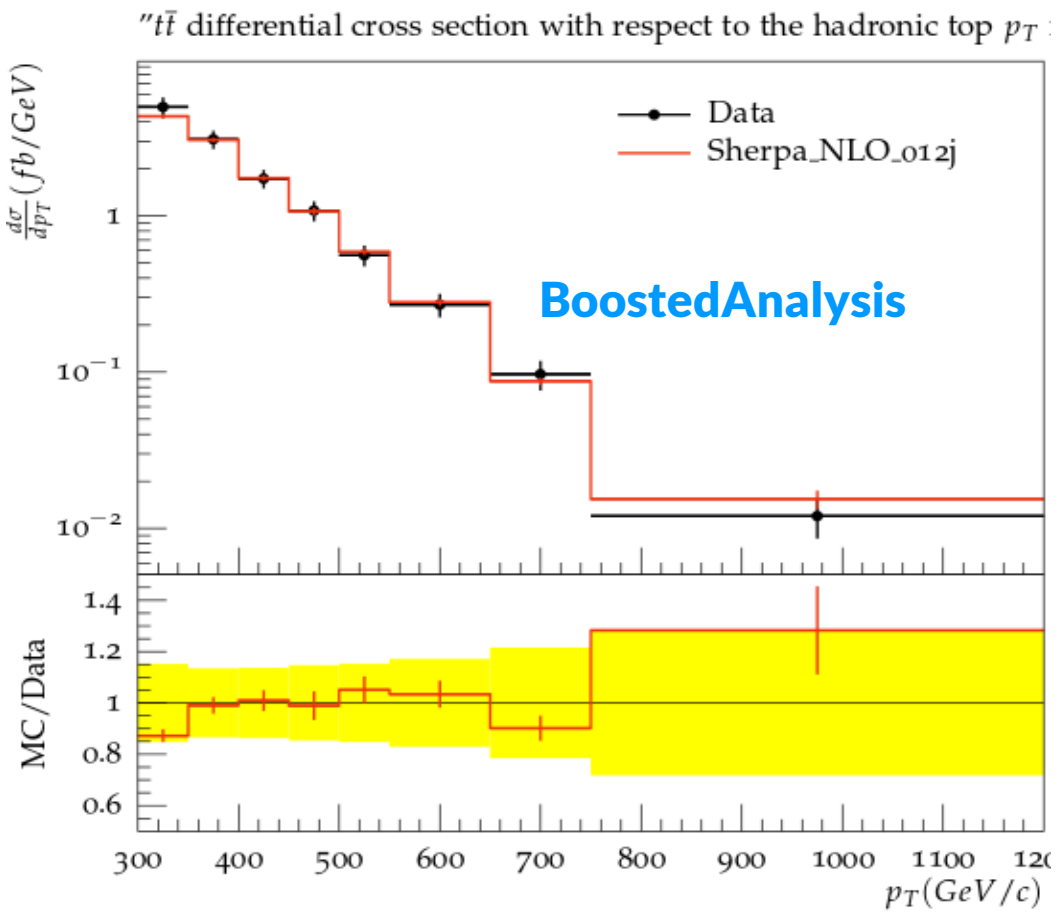
MG+PY8 shape in the lower pT region is a little strange, possible problem with matching merging?

Project- step1

Tested SHERPA with 1,2,3 additional jet to see if the description of the system is enough good without the NLO predictions (no BSM NLO prediction) .

(Need to check also for the other analysis)

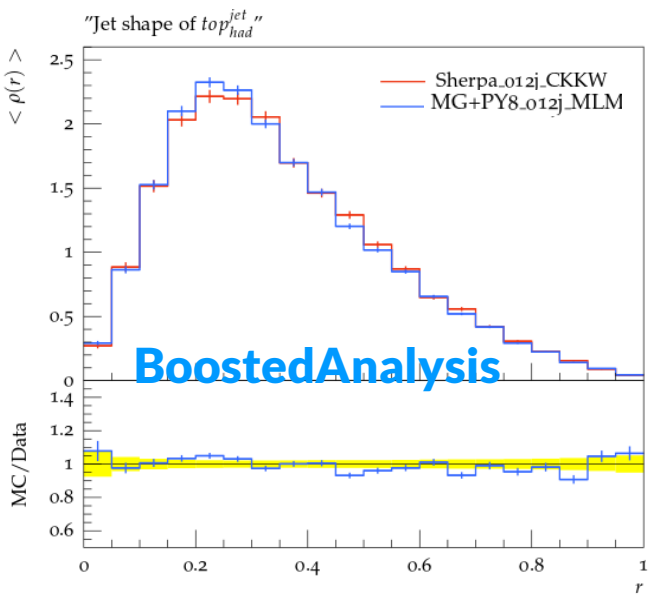


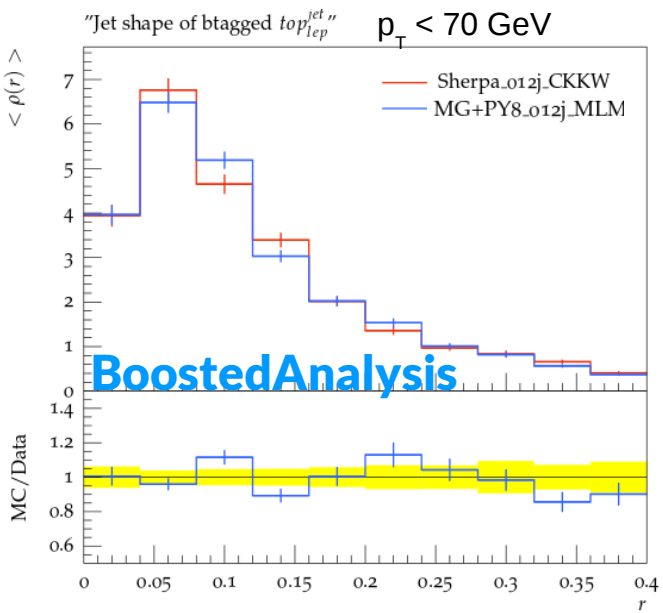


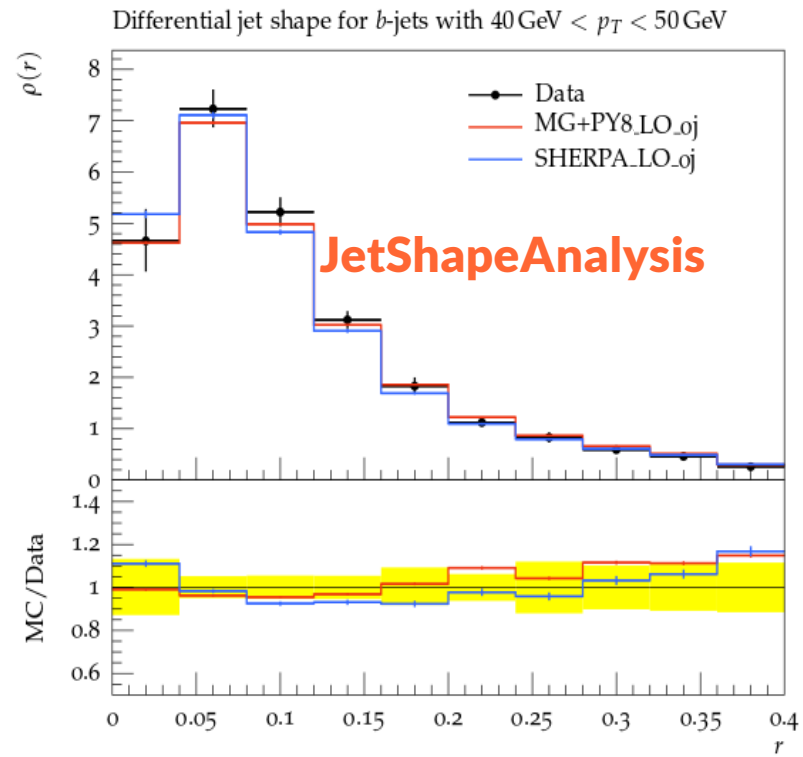
Project- step1

Looked at the 7 TeV analysis to see if both the MC predictions gave a good description of jet shape, and added this variable to boosted analysis for small and large-R jet.

Jet shape: $$\langle \rho(r) \rangle = \frac{1}{\Delta r} \frac{1}{N_{jets}} \frac{\sum_{jets} p_T(r-\Delta r/2, r+\Delta r/2)}{p_T(0,R)}$$





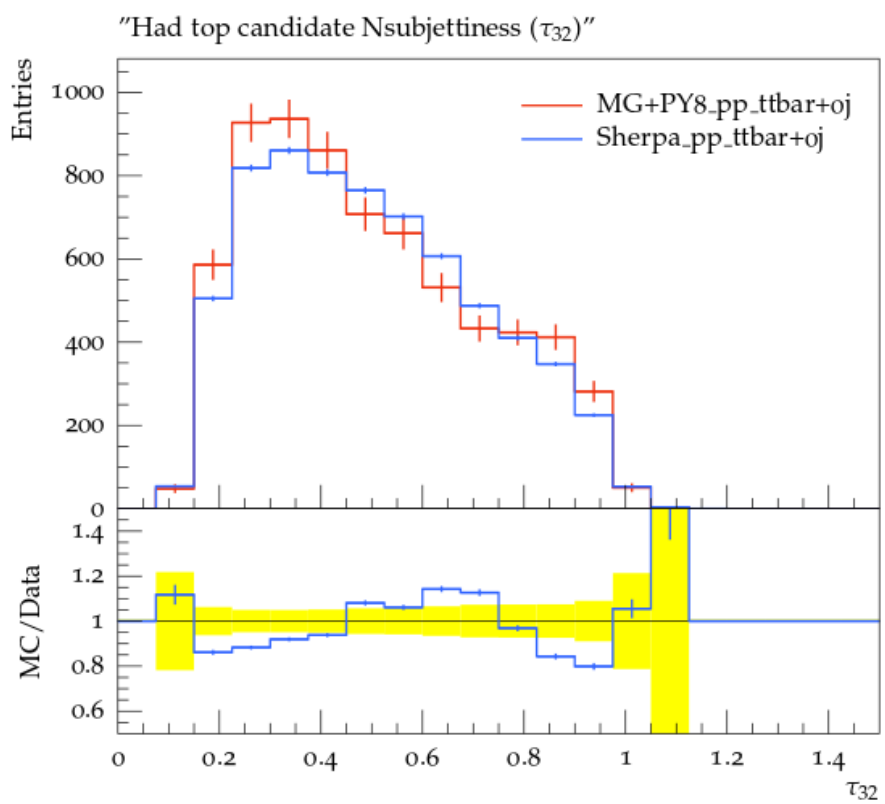


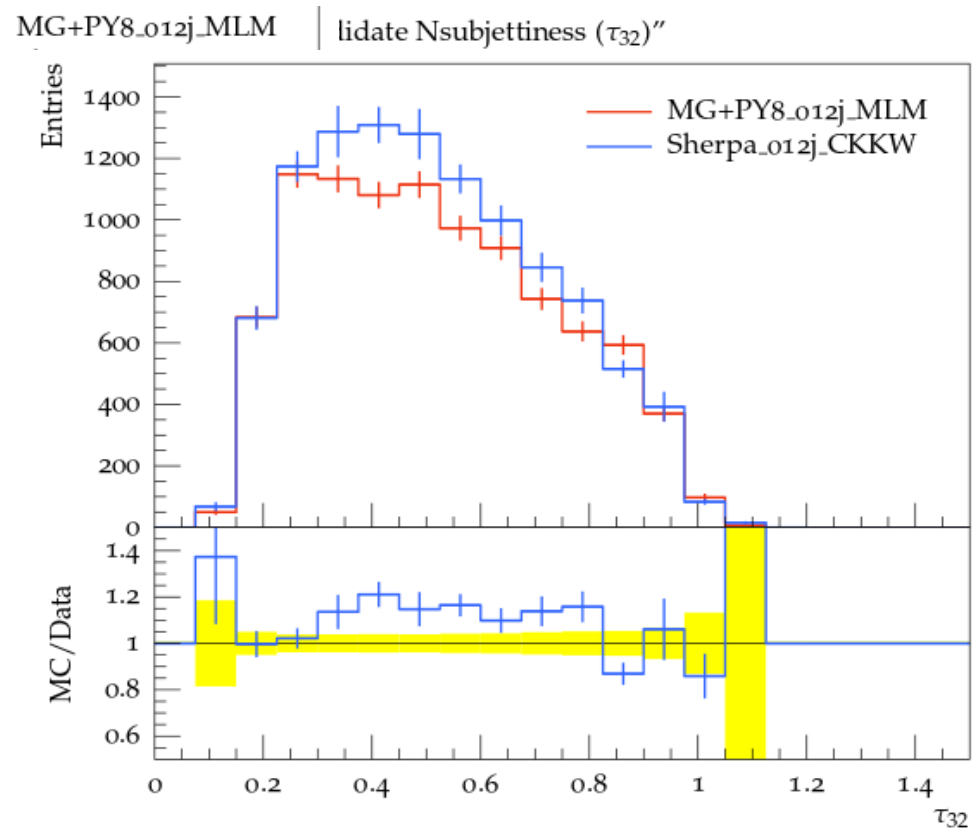
Project- step1

Added to the Boosted Analysis some variable on the jet substructure properties, to see if these variables are sensible to difference between generators and can be used in identification of BSM physics.

Here showed N-subjettiness.

$$\tau_N = \frac{1}{d_0} \sum_k p_T^k \min(\Delta R_{1k}, \Delta R_{2k}, \ldots, \Delta R_{Nk}) \qquad d_0 = \sum_k p_{Tk} R_0 \qquad k \text{ jet costituent}, N \text{ candidate subjet}$$



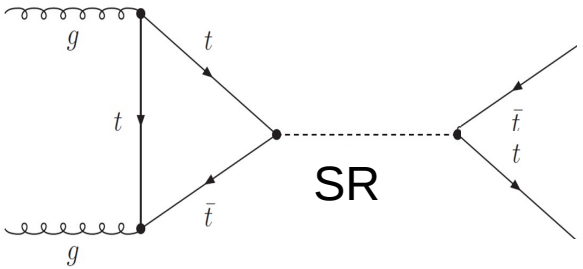


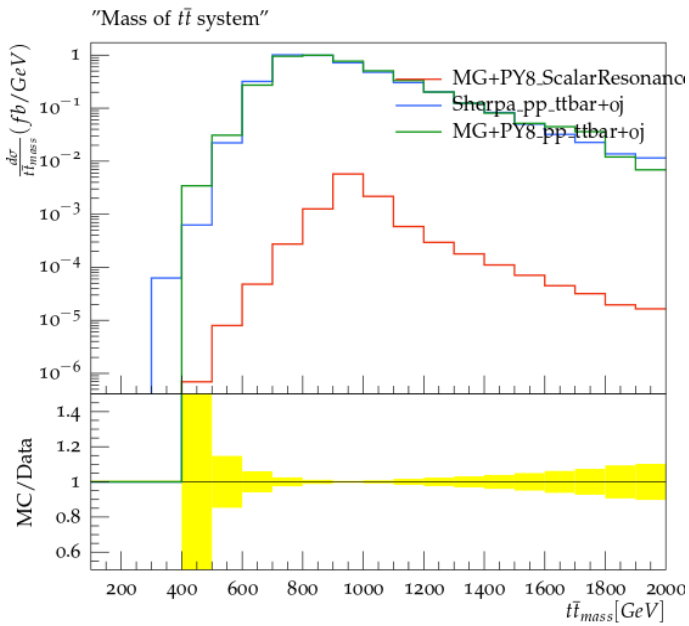
Project- step2 (just started)

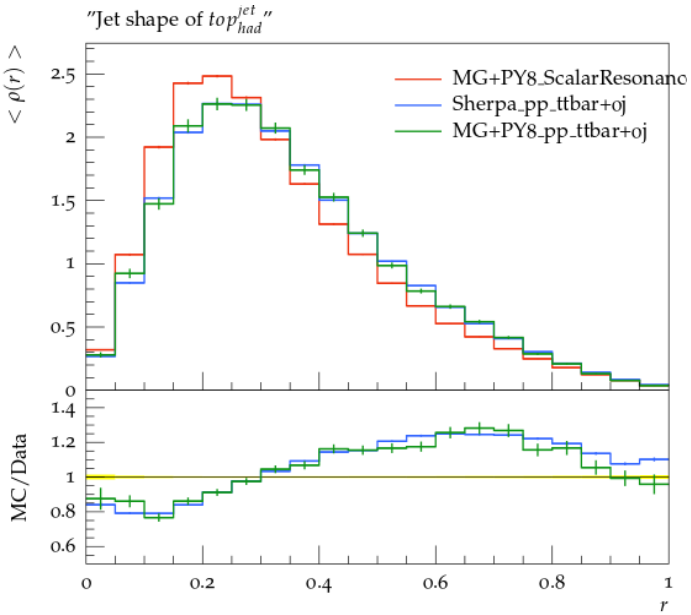
Generate signal sample using MG+PY8 and Sherpa starting from different UFO models both with full loop form factor and approximated (eft).

At the moment very preliminary study to understand how to use the framework and how to change model parameters (mass,width...)

First process considered: g g → SR → $t\bar{t}$







Next steps

- Produce the signal sample using different model for all the new resonance (scalar, vector...) both with Sherpa and MG+PY8 to see if there are differences in the distributions.

- At the moment the energy used for the simulation of pp collisions is 8 TeV to compare with public data. All BSM sample will be generated at 13 TeV using as analysis the Resolved and Boosted measurement of ttbar differential cross section performed at 8 TeV.

- After the preliminary study on different signal samples start to analyze the interference figure.

Refereces

Interference computed [1, 2]. Implemented in MC in [3]. EW corrections [4]. QCD correction using EFT [5]. Very recent analysis [6]. Angular observables [7, 8].

[1] K. J. F. Gaemers and F. Hoogeveen, Higgs Production and Decay Into Heavy Flavors With the Gluon Fusion Mechanism, Phys. Lett. B146 (1984) 347.

[2] D. Dicus, A. Stange, and S. Willenbrock, Higgs decay to top quarks at hadron colliders, Phys.Lett. B333 (1994) 126-131, [hep-ph/9404359].

[3] R. Frederix and F. Maltoni, Top pair invariant mass distribution: A Window on new physics, JHEP 01 (2009) 047, [arXiv:0712.2355].

[4] S. Moretti and D. A. Ross, On the top-antitop invariant mass spectrum at the LHC from a Higgs boson signal perspective, Phys. Lett. B712 (2012) 245-249, [arXiv:1203.3746].

[5] W. Bernreuther, P. Galler, C. Mellein, Z. G. Si, and P. Uwer, Production of heavy Higgs bosons and decay into top quarks at the LHC, arXiv:1511.05584.

[6] S. Gori, I.-W. Kim, N. R. Shah, and K. M. Zurek, Closing the Wedge: Search Strategies for Extended Higgs Sectors with Heavy Flavor Final States, arXiv:1602.02782.

[7] V. Barger, W.-Y. Keung, and B. Yencho, Azimuthal Correlations in Top Pair Decays and The Effects of New Heavy Scalars, Phys. Rev. D85 (2012) 034016, [arXiv:1112.5173].

[8] S. Choi and H. S. Lee, Azimuthal decorrelation in $t\,\bar{t}$ production at hadron colliders, Phys Rev. D87 (2013), no. 3 034012, [arXiv:1207.1484].

Back up

Using CKKW and MLM as merging scheme respectively in Sherpa and in Madgraph+pythia8.

The Qcut definition is the same for the two schemes:

$$k_{T,ij}^2 = 2\,min\left(p_{Ti}, p_{Tj}\right)^2 \frac{\left[\cosh\left(\eta_i - \eta_j\right) - \cos\left(\varphi_i - \varphi_j\right)\right]}{D^2}$$