Directly Probing the Higgs-top Coupling at High Scales^

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Abstract

• Top Yukawa y_t, at O(1), is the strongest interaction of the Higgs boson in SM and hence the most sensitive to BSM physics.

• Current measurements are at EW scale, $Q \sim v_{EW}$, and BSM effects scale as $(Q/\Lambda)^{n>0}$, Λ= NP scale.

• NP effects can be enhanced by exploring top Yukawa at high scales.

• In this work we **directly probe Higgs-top coupling at high scales** using on-shell Higgs production with high $p_{T,h}$.

• We look at the pp -> tth channel, where at high scales we can simultaneously enhance NP effects and suppress backgrounds.

• Sensitivity to new physics is parametrized in terms of the **EFT framework**, and a **non-local Higgs-top coupling form-factor**.

EFT Operators

We focus on two dim = 6 operators that contribute to the process:

$$\mathcal{O}_{t\phi} = (H^\dagger H)(\bar{Q}t)\tilde{H} + \text{h.c.}$$

which simply rescales the SM top Yukawa coupling and

$$\mathcal{O}_{tG} = i g_s(\bar{Q}\tau^{\mu\nu}T_A t)\tilde{H}G^A_{\mu\nu} + \text{h.c.}$$

the chromo-dipole moment which modifies the gtt vertx and introduces new vertices ggtt, gtth, and ggtth.

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Higgs-top coupling form factor

- Many well motivated scenarios consider the **top quark and Higgs as composite particles** arising from strongly interacting new dynamics at a scale Λ.
- In such scenarios top Yukawa has **momentum-dependent form-factor** rather than a point-like interaction.
- Motivated by nucleon form-factor we adopt the ansatz

$$\Gamma(Q^2/\Lambda^2) = \frac{1}{(1+Q^2/\Lambda^2)^n}$$

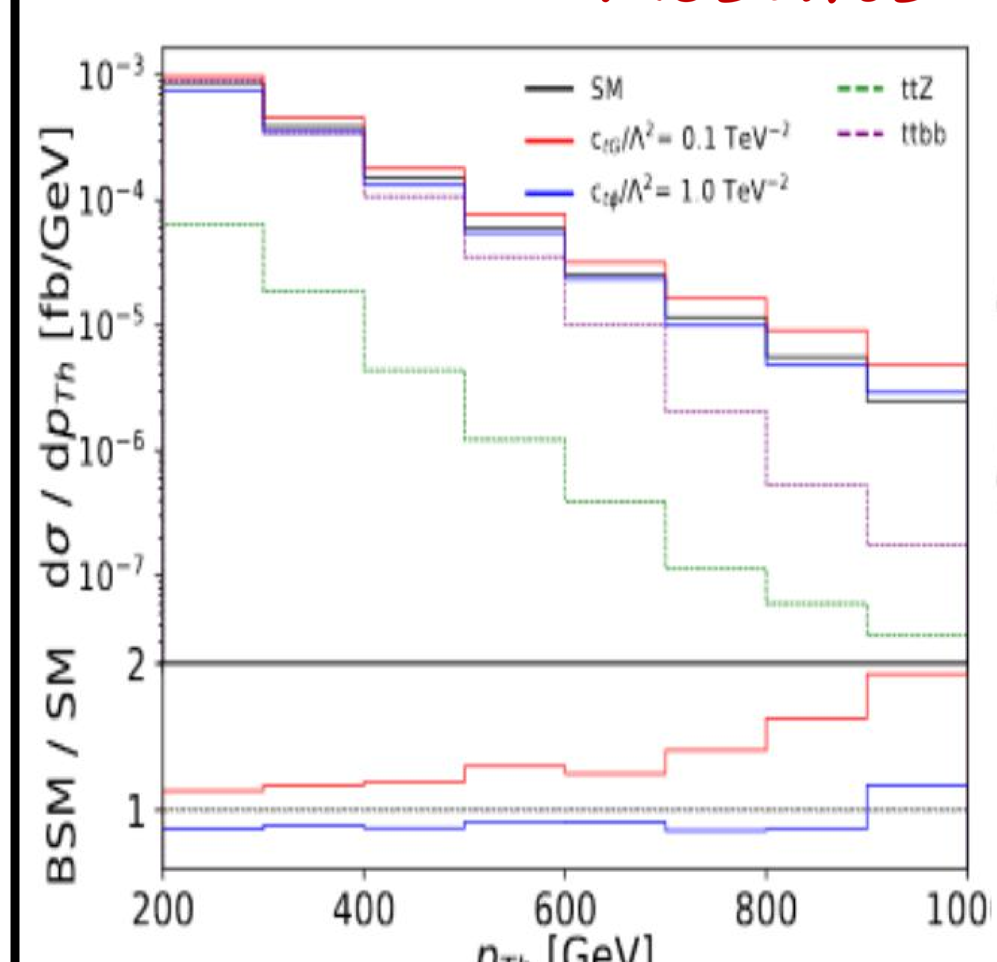
where n=2 is the dipole form factor corresponding to an exponential spatial distribution.

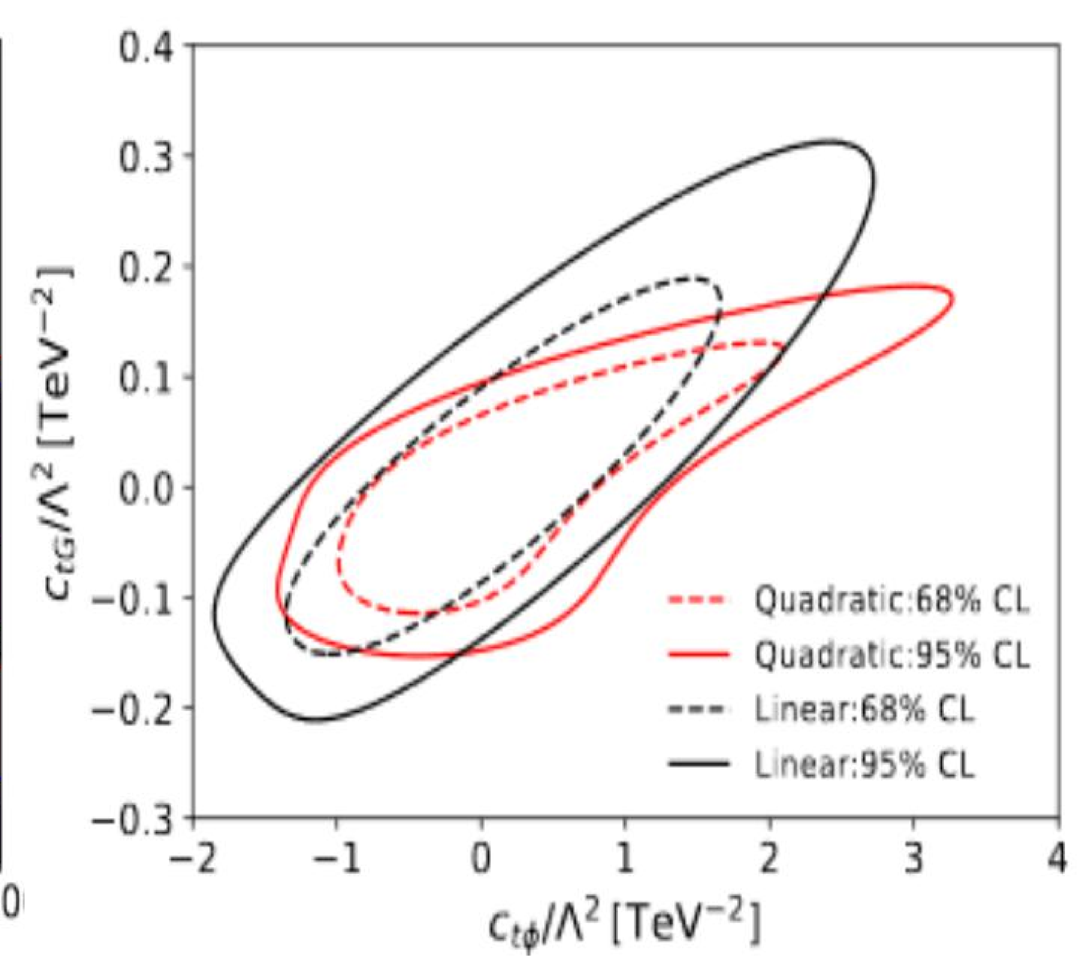
Event Analysis using Jet Substructure

- Our signal is pp ->tth with the h -> bb, and top-quark pair decaying leptonically. Final state is 4 b-tagged jets and 2 opp. sign leptons.
- Using jet sub structure techniques we can suppress the rates for our leading backgrounds ttbb and ttZ(ll).

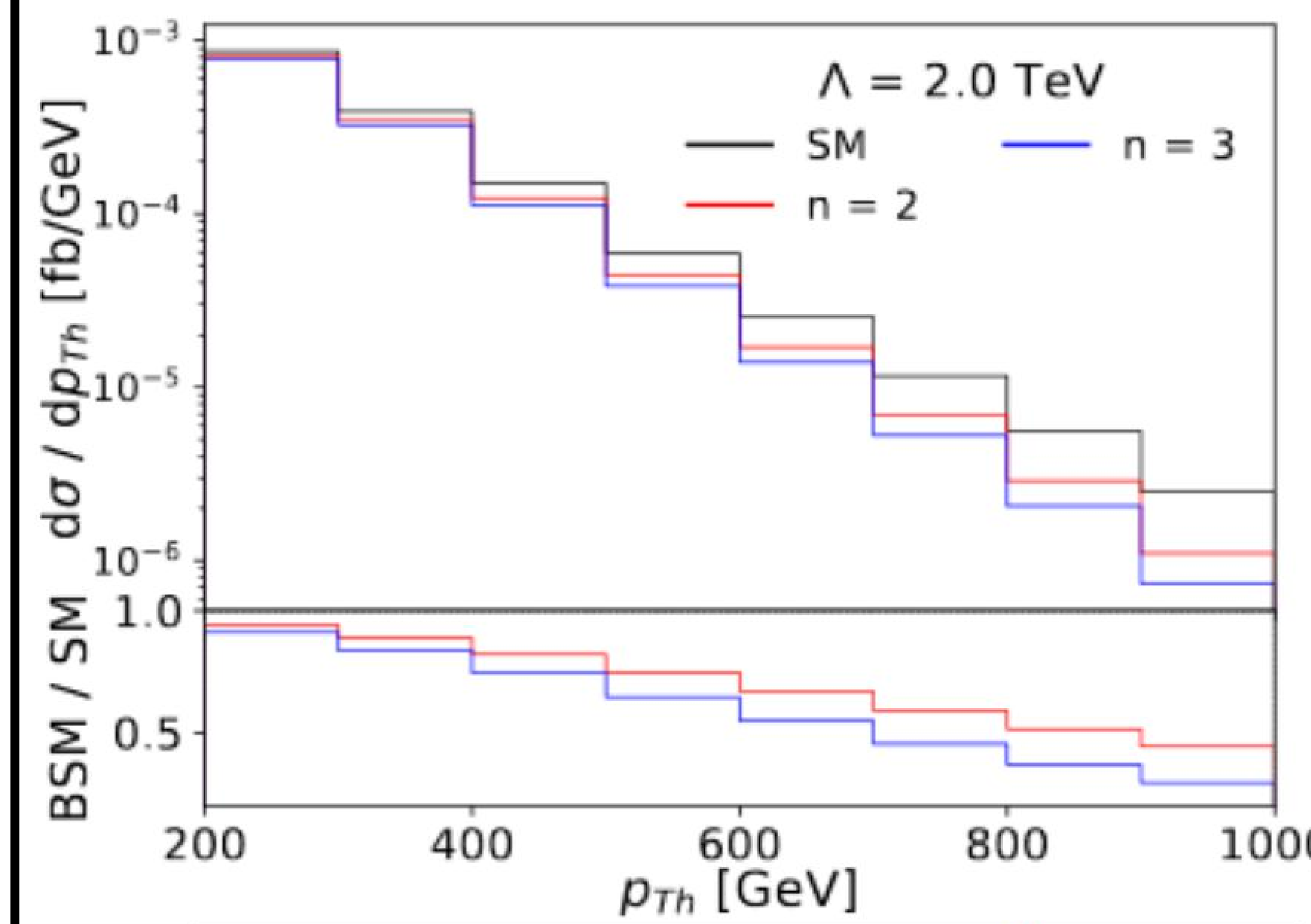
cuts	$t\bar{t}h$	$t\bar{t}b\bar{b}$	$t\bar{t}Z$
BDRS h-tag, $p_{T\ell} > 10$ GeV, $\|\eta_\ell\| < 3$, $n_\ell = 2$	3.32	6.35	1.02
$p_{Tj} > 30$ GeV, $\|\eta_j\| < 3$, $n_j \geq 2$, n_b=2	0.72	1.97	0.22
$\|m_h^{\text{BDRS}} - 125\| < 10$ GeV	0.15	0.14	0.009

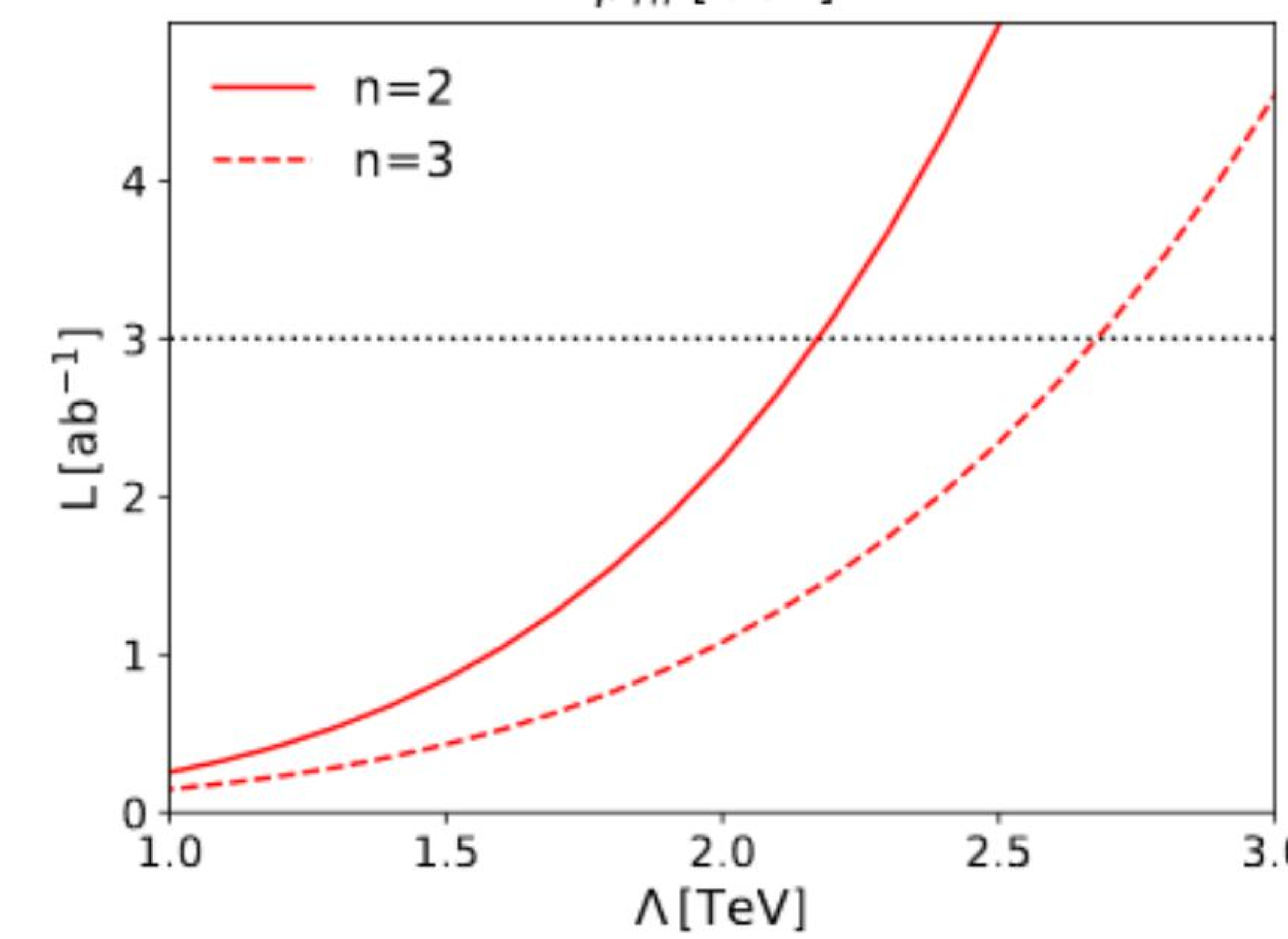
Results - EFT





Results - Form Factor





Conclusions

Combining jet substructure techniques to reduce backgrounds and focussing on high scales to enhance NP effects we are able to place competitive bounds on the scale of NP for both the scenarios we consider.

	c_i/Λ^2 [TeV^{-2}] 95% CL range	$\Lambda/\sqrt{c_i}$ [TeV] BSM scale
c_{tG} (linear)	[-0.11 , 0.12]	2.9
c_{tG} (quadratic)	[-0.13 , 0.08]	2.8
$c_{t\phi}$ (linear)	[-1.04, 1.00]	1.0
$c_{t\phi}$ (quadratic)	[-0.97 , 1.04]	1.0
n=2	*	2.1
n=3	*	2.7