

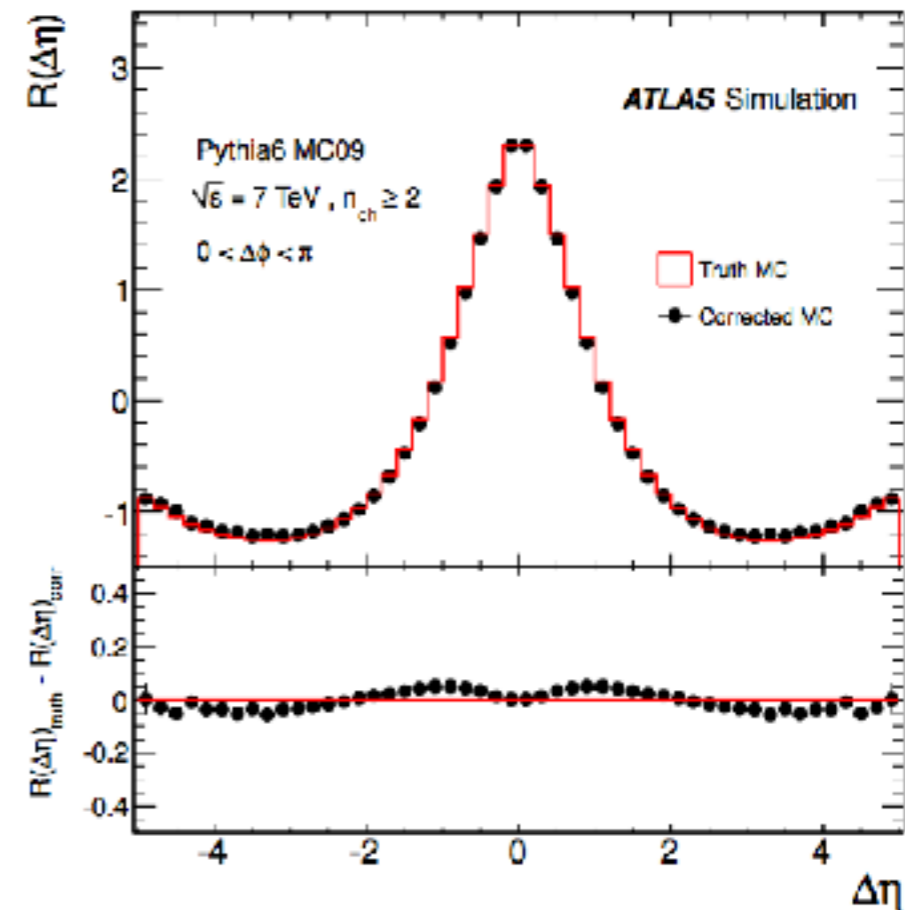
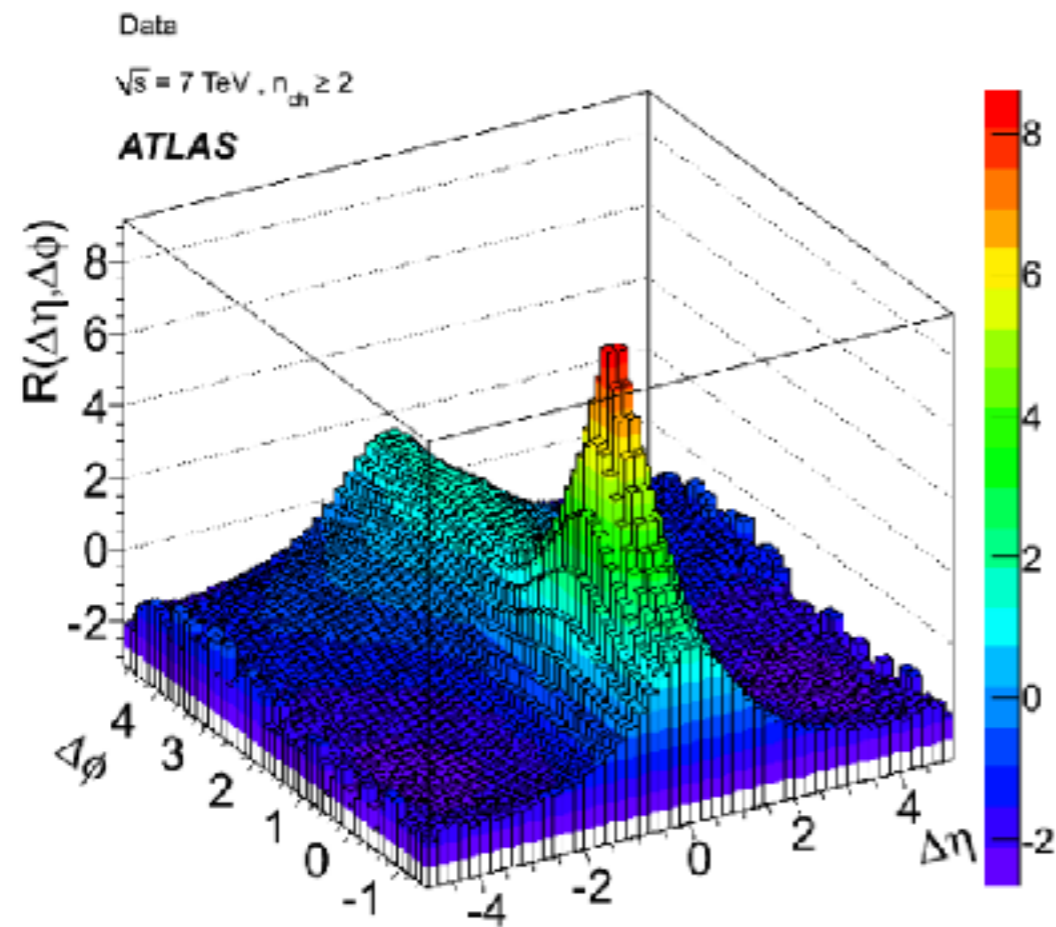
Experience & Interests

- 5 years in ATLAS.
- CMS author for two years.
- Independent phenomenology studies.



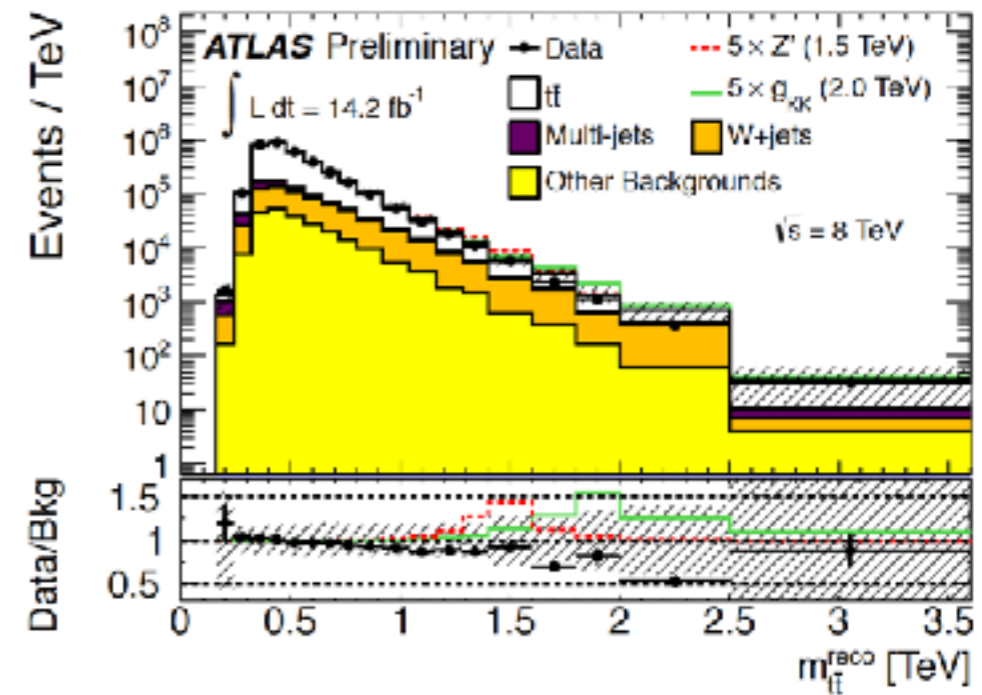
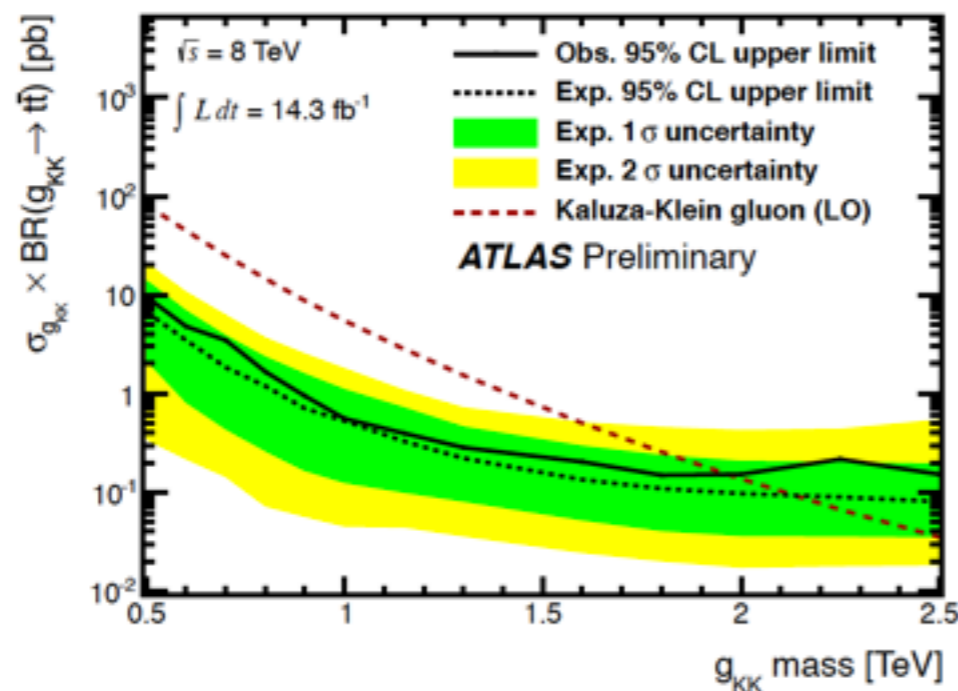
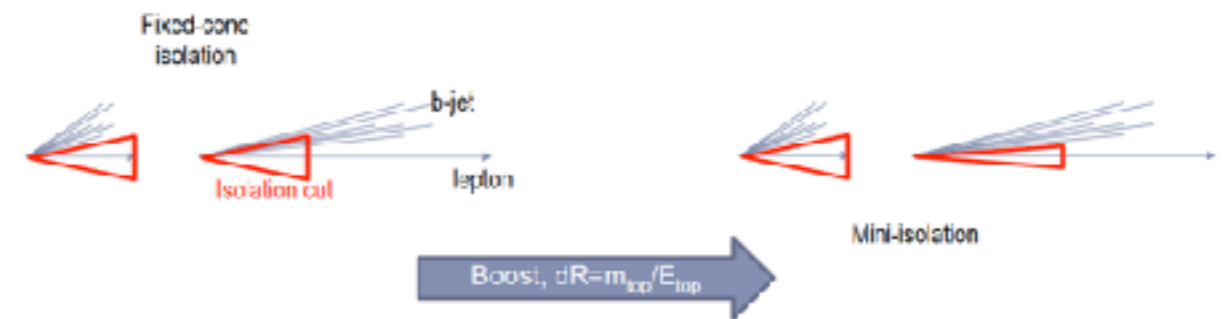
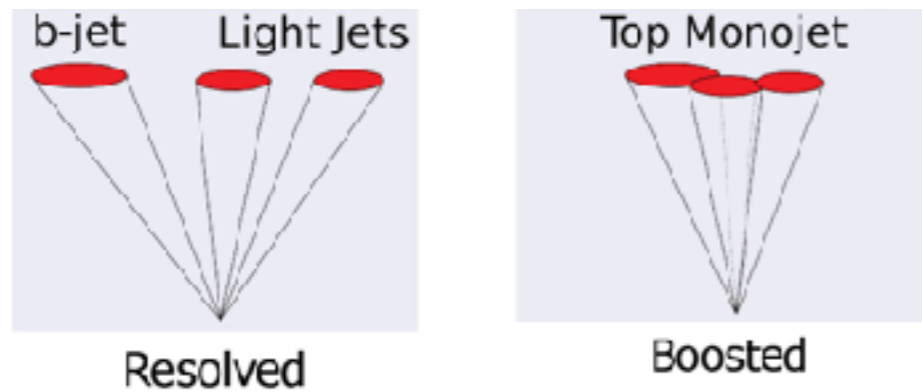
Experience & Interests

- 5 years in ATLAS:
 - Minimum Bias: two-particle correlations.



Experience & Interests

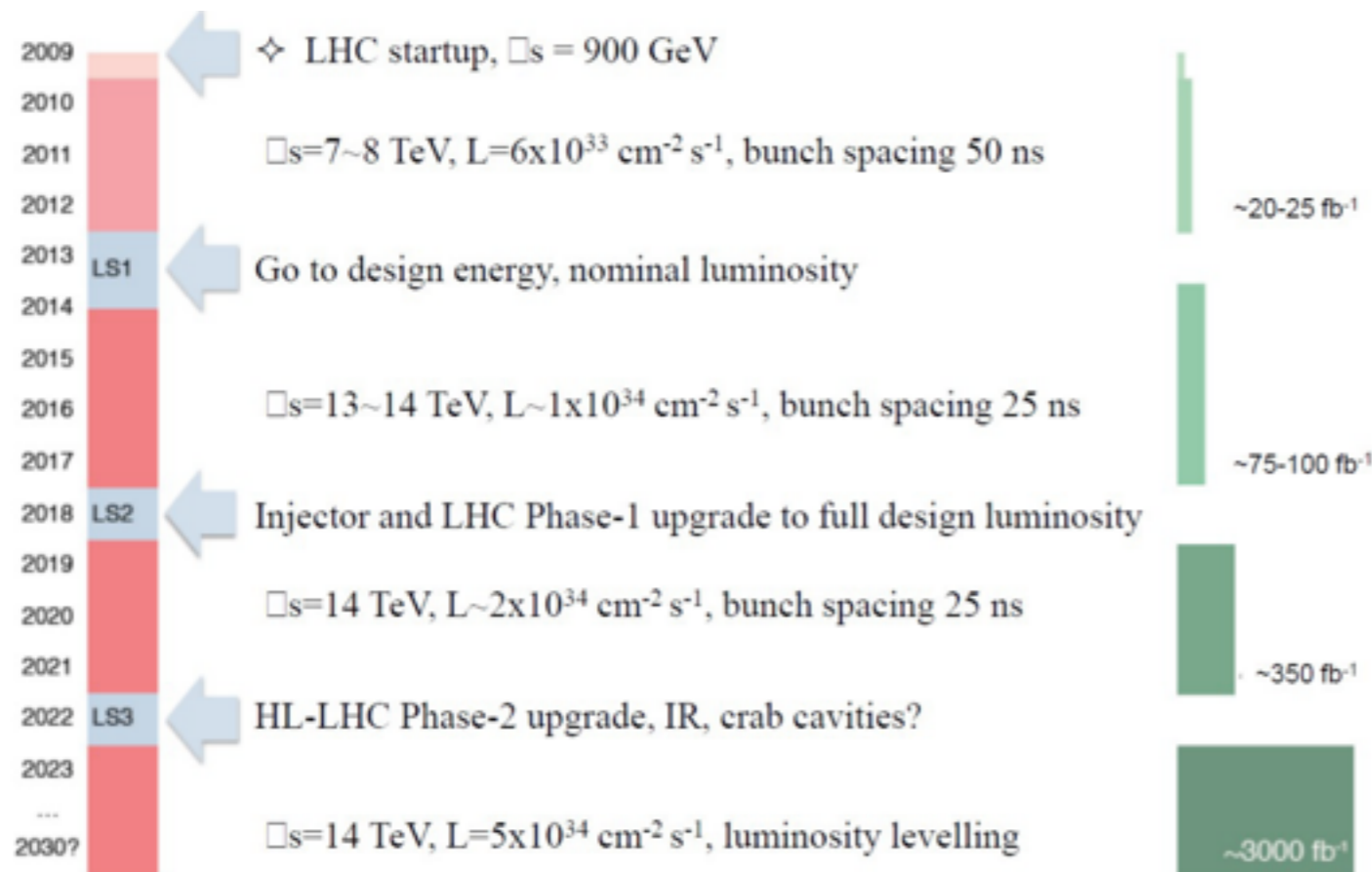
- 5 years in ATLAS:
- Exotics: $t\bar{t}$ resonances searches.



Experience & Interests



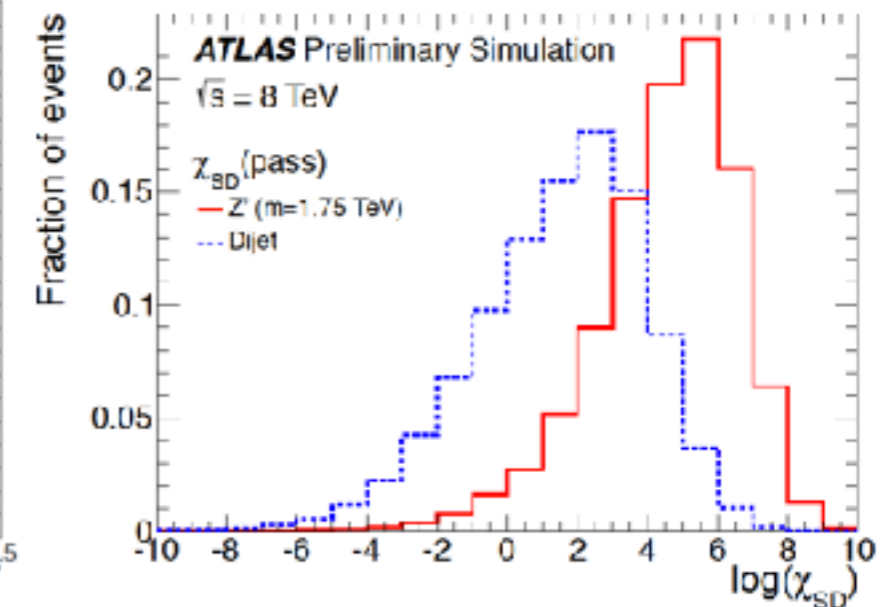
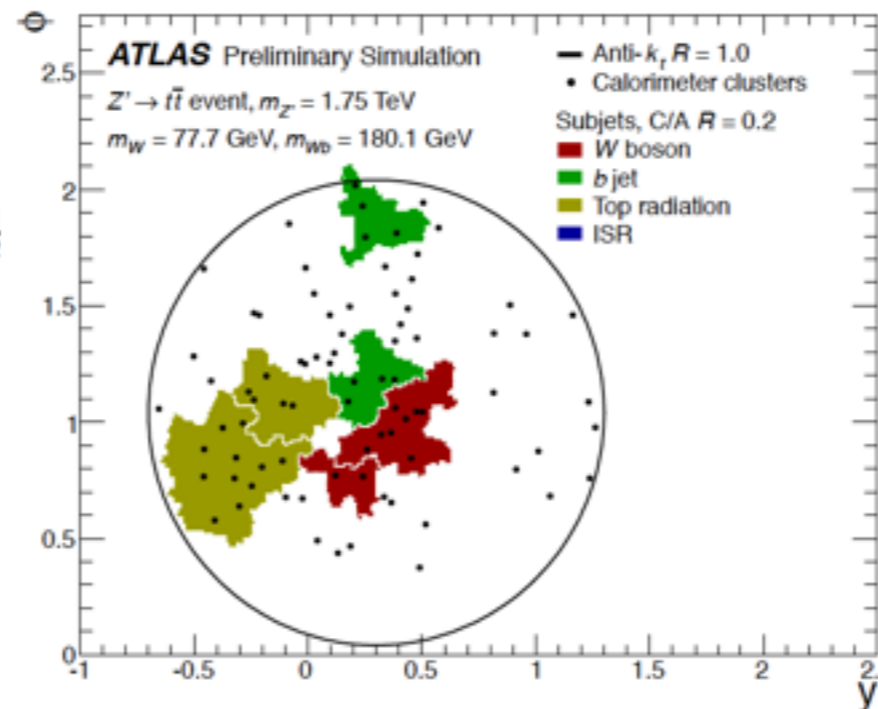
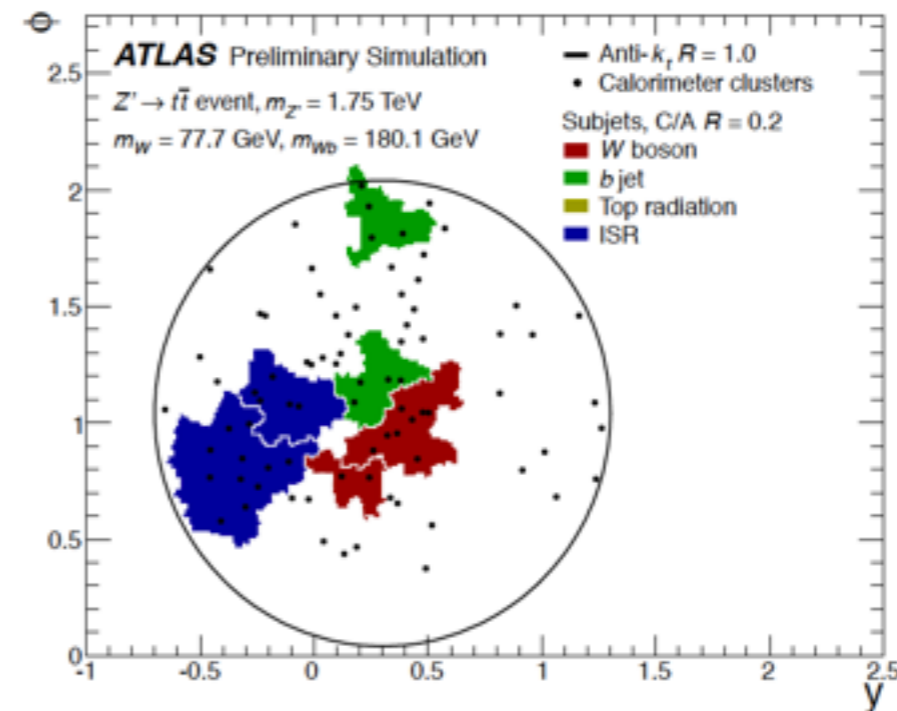
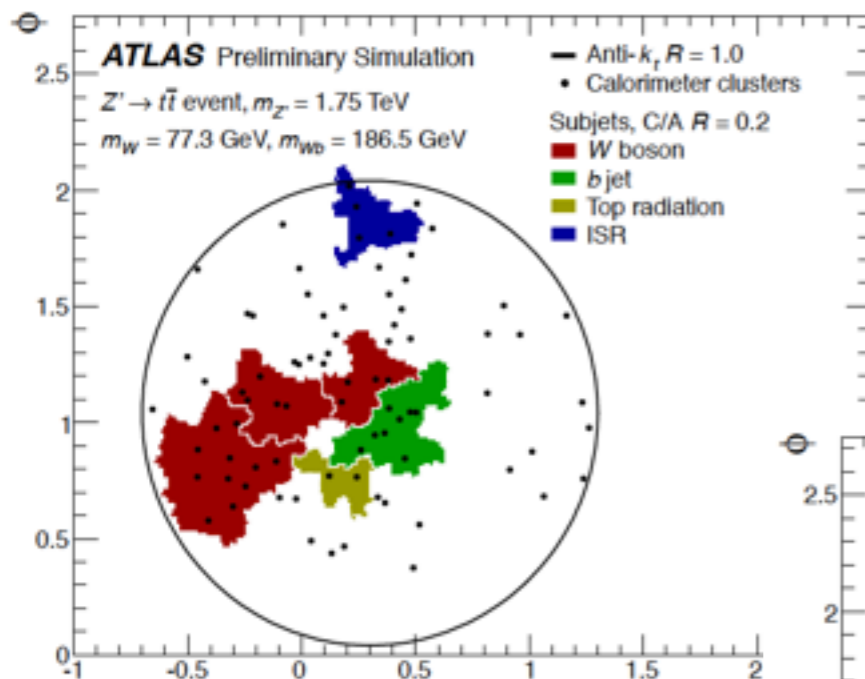
- 5 years in ATLAS:
- HL-LHC: Higgs self-couplings.



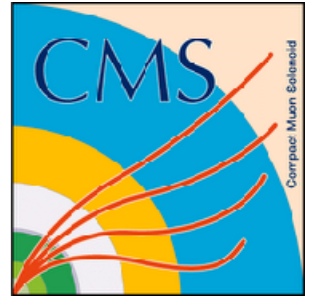
Channel	BR(%)	$\sigma \times \text{BR}$ (fb)	Events @ 14 TeV ($L = 3000 \text{ fb}^{-1}$)
bb+bb	33.41	11.33	34 k
bb+WW	24.97	8.36	26 k
bb+$\tau\tau$	7.36	2.50	7.5 k
WW+WW	4.67	1.58	4.7 k
ZZ+bb: (ZZ+bb \rightarrow 4l+bb)	3.09	1.03	3.1 k (\rightarrow 13.9)
ZZ+WW	1.15	0.39	1.2 k
$\gamma\gamma$+bb	0.27	0.09	270
bb+$\mu\mu$	0.013	0.004	12.8

Experience & Interests

- 5 years in ATLAS:
 - Shower-deconstruction.



Experience & Interests



- CMS:
 - RPC: cluster size distribution.
 - Jets: PUPPI (Pile-up per particle identification).

Experience & Interests



- Phenomenology studies:
 - Single production of top-partners.
Juan Bernardo García García (Ibero)
 - New physics and machine learning (starting in 2018).
Javier Orduz Ducuara (FES-Acatlán UNAM)

Experience & Interests



Reconstruction of singly-produced top partners in decays to Ht

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Institute for Particle Physics Phenomenology, Durham University

I. Introduction

To address the naturalness problem of the Standard Model (SM), several theories have been proposed that predict the existence of heavy vector-like quarks (VLQ). It is often assumed that these VLQ couple strongly to the third generation quarks from the SM, top (t) and bottom (b); this is why they are also referred to as top partners.

A viability study is proposed for the detection of VLQ at the $\sqrt{s} = 14$ TeV LHC, using Monte Carlo (MC) simulations. The focus is on the single production mode of top partners T (charge $+2/3$). Although the cross-section for this mechanism is smaller than the one for pair production [1], the presence of forward jets can be exploited to suppress the contribution of the dominant background processes.

For this analysis, the VLQ model [2] as implemented in FeynRules is used, in which the extra terms to the SM Lagrangian that describe the interactions of these extra particles are given by:

$$\mathcal{L} = \sum_{ij} \sqrt{\frac{g_i}{F_i}} \lambda_{ij} \bar{T} \ell_i q_j + \mathcal{L}_{SM}$$

The decay channel under study is shown in Figure 1. To optimise the reconstruction of the T in a wide mass range, two different final state topologies are studied: Resolved, in which the decay products can be identified as independent objects, and Boosted, in which the Higgs boson is reconstructed as a single large-radius jet (Figure 2).

IV. Event selection and reconstruction

Common Selection:

- 1 lepton (e, μ)
- 1 neutrino (e, μ)
- 1 b -jet with $R_{eff} > 0.4$
- 1 b -tagged jet with $R_{eff} > 0.4$
- 1 b -tagged anti- b jet with $R_{eff} > 0.4$

Boosted Selection:

- 1 b -tagged anti- b jet with $R_{eff} > 0.4$
- 1 b -tagged jet with $R_{eff} > 0.4$
- 1 b -tagged anti- b jet with $R_{eff} > 0.4$
- 1 b -tagged jet with $R_{eff} > 0.4$

Resolved Selection:

- 1 b -tagged anti- b jet with $R_{eff} > 0.4$
- 1 b -tagged jet with $R_{eff} > 0.4$
- 1 b -tagged anti- b jet with $R_{eff} > 0.4$
- 1 b -tagged jet with $R_{eff} > 0.4$

For the boosted selection, the top quark candidate is reconstructed by adding the 4-momenta of the lepton, the neutrino and the closest b -jet to the lepton. The large-radius jet is taken to be the Higgs boson candidate. The reconstruction of the top partner T is further achieved by adding the 4-momenta of the large-radius jet and the top quark candidate.

For the resolved selection, the top and Higgs candidates are constructed using the combination of jets that minimises the following function:

$$\chi^2 = \left[\frac{E_{jet} - W_{top} E_{top}}{E_{top} E_{jet}} \right]^2 + \left[\frac{E_{jet} - E_H}{E_H} \right]^2$$

The top partner candidate is reconstructed by adding the 4-momenta of the top and Higgs candidates.

II. Signal and background samples

Signal samples were generated with MadGraph5 v2.3.3 for the hard-scatter and further showered with Pythia 8.186. Samples for top partner masses from 700 to 1700 GeV were produced. The following table shows the cross-section and width for each mass-point.

Mass [GeV]	700	900	1100	1300	1500	1700
Width[GeV]	9.37	20.36	31.41	43.02	54.47	65.71
$\sigma[fb]$	83.24	41.23	22.30	12.14	7.27	4.66

For the $t\bar{t}$ background, POWHEG BOX v2 was used for the hard-scatter and Pythia 8.212 for fragmentation and hadronization. The total cross-section of the semi-leptonic decay is taken directly from POWHEG and its value is 378.643 fb.

III. Jet Substructure

Hadronic decays of massive resonances, such as Higgs bosons or top quarks, are usually boosted objects. Jet substructure techniques provide us with a powerful tool to discriminate gluon- or quark-initiated radiation from the hadronic decay of a heavy resonance. They can help to either directly identify subjets within a fat jet, measure the energy flow in a jet or even to improve the jet's mass resolution.

Subjetness is a tagging method that takes advantage of the kinematics in the decay pattern of boosted hadronic objects to effectively weight the number of subjets in a given fat jet by determining the angular distribution of radiated energy away from the candidate subjet directions.

V Results

The selection criteria applied in this analysis provides a good reconstruction of the signal, as shown here for a benchmark mass of 1500 GeV. To correctly compare to the background distributions and extract signal-to-background ratios and significances, the number of selected events has to be scaled to the cross-section and the luminosities expected at the LHC. A comparison between two different scenarios is presented.

VI. Summary

A viability study for the detection of singly-produced top partners in the Ht channel at the $\sqrt{s} = 14$ TeV LHC using MC simulations is presented. For the particular model used in this search it is found that, although the selection and reconstruction criteria provide a very good reconstruction of the kinematic distributions, the overwhelmingly large background cross-section hampers the signal making the detection not viable. Should the cross-section for the production of VLQ be any larger, these analysis techniques could become of importance.

References

[1] J. A. Aguilar-Saavedra, Journal of High Energy Physics, vol. 2009, pp. 11, p. 020, 2009.
 [2] M. Buchkremer et al., Nuclear Physics B, vol. 871, pp. 2, pp. 376–417, 2013.

Experience & Interests

- Interests:
 - Join an analysis group in CMS.
Preferably on new physics searches, top physics.
 - Jet algorithms for boosted topologies.
Jet substructure.

