Implications of the Measurement of Ultra-Massive Boosted Jets at CDF

Oram Gedalia
Weizmann Institute of Science, Israel

The CDF collaboration recently reported an upper limit on boosted top pair production, and noted a significant excess above the estimated background of events with two ultra-massive boosted jets. We discuss the interpretation of the measurement and its fundamental implications. In case new physics is involved, the most naive contribution is from a new particle produced with a cross section that is a few times higher than that of the top quark, and a sizable hadronic branching ratio. We quantify the resulting tension of a possible larger top pair cross section with the absence of excess found in events with one massive boosted jet and missing energy. The measured planar flow distribution shows deviation from CDF's Pythia QCD prediction at high planarity, while we find a somewhat smaller deviation when comparing with other Monte Carlo tools. As a simple toy model, we analyze the case of a light gluino with R-parity violation, and show that it can be made consistent with the data.

Measurement

Introduction

- Common new physics searches at colliders focus on signals with leptons and/or missing energy.
- Multi-jet signals for particles of hadronic decays suffer from huge QCD background.
- The sensitivity can be increased by focusing on boosted (high-p_T) jets, thus reducing the background more than the signal.

The CDF Measurement

- Based on a sample of 5.95 fb^{-1} of CDF data.
- 1st channel: events with two boosted (p_T>400 GeV) massive (130-210 GeV) jets.
- 2nd channel: events with one such jet and large missing energy.
- Pseudorapidity cut: η<0.7.
- Jets algorithms used: Midpoint and anti-k_T with R=1.0.

Background Estimation

- QCD background was estimated based on data in channel with two light (30-50 GeV) jets or with one heavy jet and one light jet.
- Assuming that the masses of the two leading jets are uncorrelated within QCD, the number of events is: 13±2.4 (stat.) ±3.9 (syst.).
- Alternatively, from Monte-Carlo simulations: 15±2.8 (stat.) ±4.5 (syst.).
- Number of hadronically-decaying top pair events within the SM: 3.0 ±0.8.

Excess Estimation

• Number of observed events:	32
• Naïve (MC) QCD background:	− 13 (15)
• Top background:	− 3
• Excess of events:	16 (14)
• Excess in cross section:	11 (10) fb
• Significance:	3.4 (2.7) σ

Interpretation

QCD

- The most simple explanation: underestimation of the QCD background.
- This may occur if QCD is biased toward two massive jets.

Excess of Top Pairs

- Another explanation: non-SM production of top pairs.
- However, no excess was found in the channel with one boosted massive jet and missing energy (semileptonic decay of one top).
- Yet if all the excess in the hadronic channel comes from top pairs, then the tension with the semileptonic channel is only 1.4 σ.

New Particle

- The data may hint for the presence of a new particle.
- Features: large production cross section and hadronic final states.

Toy Model

- Supersymmetry with a light gluino (and all other new states heavy).
- Gluino mass – close to the top mass.
- A gluino decay channel to three quarks via R-parity violation.

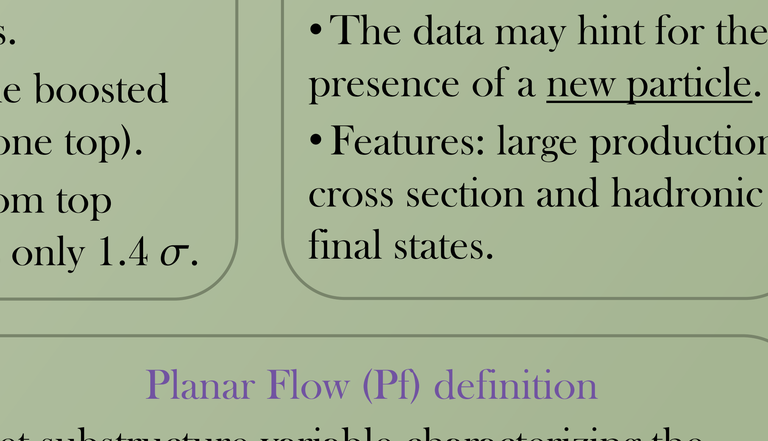
Particle	Cross Section [fb] Herwig
Gluino m=130 GeV	15
Gluino m=150 GeV	13
Gluino m=170 GeV	11
Hadronic top pair	1.6

Planar Flow (Pf) definition

- Jet substructure variable characterizing the planarity of the energy deposition inside the jet.
- QCD jets tend to a linear deposition: Pf→0.
- 3-body decays (such as top) tend to a planar deposition: Pf→1.

Planar Flow Distribution

- CDF presented the measured Pf distribution of the jets, compared to a MC calculation, exhibiting an excess for high Pf values.
- This hints for an excess of particles with 3-body decays.
- Here we calculate the Pf distribution of QCD and gluino jets using MC tools, and compare with the data.
- Our QCD distribution (Herwig, Pythia and MG/Pythia – all in agreement) show better agreement with the data than CDF's MC.
- A combination of QCD and gluino contributions would fit the data quite well.



Y. Eshel, O. Gedalia, G. Perez and Y. Soreq, arXiv:1101.2898 [hep-ph].