

-- BradCox - 2017-06-01

Comments Set 1 Jeff Richman

Title: Search for natural supersymmetry in events with top quark pairs and photons in pp collisions at  $\sqrt{s} = 8$  TeV

Fine!

Comment: Abstract

Results are presented from a search for natural gauge-mediated supersymmetry in a scenario in which the top squark is the lightest squark, the next-to-lightest SUSY particle is a bino-like neutralino, and the lightest SUSY particle is the gravitino. The strong production of top squark pairs can produce events with pairs of top quarks and neutralinos, with each neutralino decaying into a photon and a gravitino. The search is performed using a sample of pp collision data accumulated by the CMS experiment at  $\sqrt{s} = 8$  TeV, corresponding to an integrated luminosity of  $19.7 \text{ fb}^{-1}$ . The final state consists of a lepton (an electron or muon), jets, and one or two photons. The imbalance in the transverse momentum in the events is compared with expected spectrum from standard model processes. No excess event yield is observed above the expected background, and the result is interpreted in the context of a general model of gauge-mediated SUSY breaking, leading to the exclusion of top squark masses below  $650 \hat{a} 750$  GeV.

-In the original version, the phrase  $\hat{a}$  gravitino as the lightest SUSY particle with a bino-like mixing of the neutralino, the next-to-lightest SUSY particle, $\hat{a}$  seems hard to read.

- In the original version, a comma is definitely needed after  $\hat{a} 19.7 \text{ fb}^{-1} \hat{a}$  . Otherwise, the sentence implies that this lumi applies channel by channel. Having both the data sample and the signature in a single sentence seems like too much.

- In the original version, the phrase  $\hat{a}$  gauge-mediated SUSY breaking that leads to the exclusion $\hat{a}$  is grammatically fine, but I think it isn $\hat{a}$  t quite the meaning that you want. I think there should be a looser connection between the model and the result.

Response: The wording of the abstract is changed as suggested.

#### 1. Introduction

Comment: L6 \*\*\*Suggest changing  $\hat{a}$  and the lightest Higgsino [ $\hat{a}$  !] $\hat{a}$  to  $\hat{a}$  and the Higgsinos [ $\hat{a}$  !] $\hat{a}$

As far as I know (e.g., Papucci et al.) all four Higgsinos are expected to be light in natural SUSY. In fact, in the limit that they are pure Higgsino, they are mass degenerate.

Response: Done

Comment: L6-L8 \*\*\*I am not sure that I am following the logic of this sentence. It seems to say start with a theoretical motivation and the says that this indicates that there are many searches left to be done at the LHC. To me these are two separately true statements, but the first one does not imply the second one. Also, why are you referring to the little hierarchy problem here, whereas previously you referred to the hierarchy problem?

Here is a suggestion:

In such SUSY scenarios, the fine-tuning required to maintain low mass of the electroweak scale can be avoided, and many searches for light top squarks are being pursued at the CERN LHC.

I have changed the meaning of the last part of the sentence, and here I think that it would be appropriate to reference the top squark searches from ATLAS and CMS more broadly. Our papers allow reinterpretation in different models, so my guess is that their results could be relevant to this case as well.

Response: We have changed the wording.

Response 2: We have referenced a selection of Atlas and CMS Top squark seaches

Comment: L15

that decays to a photon and a gravitino leading to photons in the final state.  $\hat{\phantom{a}}$  suggest that decays to a photon and a gravitino, leading to photons in the final state.

Response: Done

Comment: L18

$\hat{\phantom{a}}$  Furthermore, if the top squark is the only colored particle sufficiently light to be produced at the LHC, SUSY production would proceed through pair production of top squarks. $\hat{\phantom{a}}$

\*\*\*This is OK, but I don't see why you need to go this far  $\hat{\phantom{a}}$  if there were other colored SUSY particles light enough to be produced, you would still have top squark pair production. And natural SUSY certainly allows other light-ish colored particles ( $\sim t_2$ ,  $\sim b_L$ , and  $\sim g$ ). The structure of the paragraph controlled by the fact that you start with the neutralino and gravitino and don't explain the SUSY production process until the end of the paragraph. So I think that the key role of the sentence here is to state the actual production process assumed  $\hat{\phantom{a}}$  you don't need to assume that it is the only SUSY production process. How about

$\hat{\phantom{a}}$  Because top squarks are expected to be relatively light in natural SUSY scenarios, we search for top squark pair production, a strong process. [Then as before] Assuming a bino-like NLSP, each top squark would decay to a top quark and a neutralino, with the neutralino decaying to a photon and a gravitino, leading to a  $t\bar{t} + \gamma + \cancel{p}$  topology. $\hat{\phantom{a}}$

Response: Done

Comment: L23  $\hat{\phantom{a}}$  final state of the  $t\bar{t}$  pair that requires the presence  $\hat{\phantom{a}}$  suggest  $\hat{\phantom{a}}$  final state of the  $t\bar{t}$  pair, which requires the presence of

To me, this makes more sense as a non-restrictive clause.

Response: Done

Comment: L25 \*\*\* $\hat{\phantom{a}}$  and an enhanced lepton+jets mode in  $t\bar{t}$  decays. $\hat{\phantom{a}}$  Not sure what you are saying here  $\hat{\phantom{a}}$  could you please clarify? How is this different from what you just said?

Response: the phrase you point out is redundant and has been removed.

Comment: L27 that depend on the presence of one or two selected photons in the event suggest , depending on the presence of one or two selected photons in the event

Response: Done

Comment: L30 You define "false photons" on L105, so I don't see why you also need to do that here. I would just end the sentence at requirements.

Response: Done

2. The CMS detector

Fine.

3. Event and object reconstruction

Comment: L66 and have transverse momentum and to have transverse momentum [need parallel grammar]

The structure of this sentence is a bit odd. It looks like a 3-time list, but and appears twice. How about

Photons are reconstructed , are required to be , and must have or Photons are reconstructed . They are required to be isolated and to have [no comma].

Response: Sentence has been reworked to address the suggestions.

Comment: L78 and be and to be

Response: Done

Comment: L83-85 problem with parallel structure

are required to have  $p_T > 30$  GeV, be within , and have . are required to have  $p_T > 30$  GeV, to be within , and to have

Response: Done

Comment: L85 The phrase are used to identify extra leptons used to veto is repetitive. Suggest are applied to identify extra leptons that are used to veto

Response: Done

Comment: L88 thereby increasing sensitivity to signal. thereby increasing the signal sensitivity.

Response: Done

Comment: L90 The efficiency of selection is about . The selection efficiency is about

Response: Done

4. Analysis strategy

Maybe this section should be called "Event selection and analysis strategy" "

The section starts off with a very detailed discussion of triggers, lepton requirements, and photon requirements. It doesn't seem like a "strategy" discussion. I think it could be useful to have a 1-2 sentence overview.

There is a discussion of the trigger  $p_T$  thresholds for the leptons, but the offline cuts are given in the previous section. Seems a bit odd.

Response: We have changed the name of the section as suggested. We considered moving the trigger requirements for electrons and muons to the previous section but it did not seem to fit there since that deals with object reconstruction not even selection.

Comment: L103 "more than one photon candidates" "at least two photon candidates"

Response: Done

Comment: L106 "that are used to define two control regions" and are used to define two control regions"

Response: Done

Comment: L107 "one false and no genuine photons passing all requirements" "one false and no genuine photons"

Response: Done

Comment: L108 "passing all requirements" - again this seems redundant. Or am I missing something?

Response: Unnecessary phrase removed.

Comment: L116 - I don't see anything about GEANT being used to simulate the detector.

Response: We have added a comment on the use of GEANT in simulating the detector and a reference for GEANT.

Comment: L130 "The Z+jets and Z+gamma events correspond to small backgrounds in the muon+jets channel originating from the negligible misidentification of muons as photons."

It is odd to say that something "small" originates from something that is "negligible". This does not sound consistent. How about

"In the muon+jets channel, the background from Z+jets and Z+gamma events is very small [negligible], because of the low probability for a muon to be misidentified as a photon. In the electron+jets channel, however, these processes contribute more to the background, especially at low  $p_{T\text{miss}}$ , because the probability for an electron to be misidentified as a photon is much higher."

Response: The sentences have been revised as suggested

Comment: L145 "estimate in the number of Z bosons" "estimate of the number of Z bosons"

Response: Done

Comment: L146 to obtain a second scale factor  $SF_{\gamma}$  to correct the misidentification of electrons as photons to obtain a second scale factor,  $SF_{\gamma}$ , which corrects the MC prediction for the rate of misidentification of electrons as photons

Response: Done

Comment: L156 each of these SF are listed in Table 1 each of these scale factors are listed in Table 1

Response: Done

Comment: Table 1 caption

Scale factors,  $SF_x$ , normalizing  $Z$ +jets backgrounds Measured values of the scale factors  $SF_x$  and  $SF_y$ , which are used to correct the Monte Carlo predictions for  $Z$ .

Response: Suggested changes on caption made.

Comment: Figure 1 caption

\*\*\*I am confused about the wording and (c) has the result of the fit for  $SF_x$  Maybe should be as? But the overall wording is awkward. I suggest splitting the discussion of the fit as a separate sentence.

Response: The caption has been reworded to make plane c description clearer

Comment: L181 \*\*\*The formula  $(1 - \text{Data}/\text{Background})$  is awkward. Is there are better way to do this? Do you even need this?

Response: The formula was suggested by the CWR reviewers . Attempts at a statement of what was done were relatively clumsy compared to a simple formula.

## 5. Results and interpretation

Comment: L194 there is some stray text here: label Interpretation .

Response: Latex fixed

L196 and assumed to be and are assumed to be

Response: Done

Comment: L202 The list here is awkward, because there is a sub-list, but only commas are used. Suggest ended sentence after in MC scale factors. Then start a new sentence

These include b tagging; electron, muon, and photon identification; and trigger efficiency.

So now you can use the ; for the main list and , for the sublist. This is standard.

Response: Done

Comment: L204  $\hat{t}$  shown in Fig. 3  $\hat{t}$   $\hat{t}$  as shown in Fig. 3

Response: Done

Comment: \*\*\*L207 I don't see anything about whether FastSim or FullSim was used here. Was this privately generated MC?

Response: We used FastSim for the signal MC and FullSim for all other simulations.

Comment: L208 no comma before  $\hat{t}$  and NLO cross sections

Response: Removed comma

Comment: L209 a bit odd to see  $\hat{t}$  top squark written out as text rather than as a symbol. Why not introduce the symbol in the Intro and use it?

Response: Not completely sure what is suggested here. We were told by the Pub chair to use top squark to refer to stops rather than symbols for stops in this paper. This was indicated as standard procedure.

Comment: L213  $\hat{t}$  are decoupled by setting them to very large masses to force  $\hat{t}$   $\hat{t}$  are decoupled by setting their masses to very large values. [then start a new sentence]

Response: Done

Comment: Table 2 caption - "unceraintie" -> "uncertainties"

Response: Done

Comment: Table 3 In expressions like "(460, 175)" need a space after the comma.

Response: Done

Comment; L227 Need to make sure that +- doesn't separate from 100. Can put the whole thing in math mode.

Response: Done

Comment: L230-L232 It is odd that you do not make any observations or comments about Fig. 4 and Fig. 5.

Response: It was thought that the captions and the plots were sufficient to explain with the conclusions as stated.

Comment: Figure 4 The symbol  $\sim t$  is used in the figure but not in the text. Actually, it is sometimes used in the figure (in the decay description) and sometimes not (in the inequalities). We need to be consistent in the notation. Note also the x-axis label and the figure caption.

Some symbols seem to be in boldface and others not. I don't see a reason why.

Response: Figure 4 and Figure 5 have been changed to delete the symbols for top squarks in the identification labels for the figure and the references in the figures. Boldface issues have been addressed.

\*\*\*\*\*

Comments Set 2: Keith Ulmer

type B

Comment: Introduction. Are there other relevant searches that you should be citing?

Response: We have cited a selection of top squark searches from Atlas and CMS.

Comment -line 16. I don't understand the connection between R parity and strong production. Maybe just drop the "Assuming that R parity is conserved" clause?

Response: The R parity connection is with "pair production", not strong interaction.

Comment: -line 32-35 This sentence is not so clear to me. Perhaps restructure it to say the following. "The normalization of the XXXXXXXX background(s) are allowed to float freely in the fit, which helps avoid uncertainty in the tt+jets, tt+gamma, and tt+gamma,gamma production cross sections."

Response: The sentence in question has been restructured.

Comment -line 58. There's something wrong in the parenthetical list. muons and photons at least should be there, I guess.

Response: Done

Comment -line 66. Should add a reference to something for the photon ID.

Response: Reference 27 for photon reconstruction and ID is a line or two later in the text

Comment -lines 93-95 on the trigger would fit better at the beginning of Sec. 3.

Response: We tried positioning 93-95 at the beginning of section 3 but it fits better in our estimation in section 4 which has been relabeled as Event selection and analysis.

Comment -lines 96-99. Say explicitly that one lepton is required here.

Response: Done

Comment -lines 96-99. I'd move the sentence about the extra lepton veto to the end of this paragraph.

Response: Done

Comment -lines 116-129. You should mention GEANT used for the simulation somewhere.

Response: We have added a mention of the use of GEANT and a reference to GEANT at line 126 of the new version.

Comment -line 152. I don't understand "data MC sample." Is it maybe just a typo and should be "data sample?"

Response: yes, you are correct. Changed to just data.

Comment -line 182. Is there a reference for the Kolmogorov-Smirnov test?

Response: We have added a reference for the KG test.

Comment -line 194. Fix the latex here.

Response: Done

Comment -line 205-206. The sentence with the reference to Table 2 should go at the end of the previous paragraph, i.e. at line 202.

Response: Done

Comment -line 210. I guess "100% bino-like" is meant to signify that the decay is 100% to photon, gravitino. It would be better to also say that explicitly.

Response: Done

Comment -line 207-216. Give the gravitino mass, too. As it's written now, it looks like it would be decoupled, which certainly isn't what you mean.

Response: The gravitino mass was 1 KeV.

Comment -line 207-216. Mention FastSim, if you are using it (or GEANT if you are not).

Response: We have added a mention of GEANT and a reference.

-line 221 "that are integrated over in the analysis" I don't understand this clause.

Response: This phrase is confusing to us also. We have deleted the clause/

type A

Comment -abstract line 3 rewrite as "...with a bino-like neutralino as the next-to-lightest SUSY particle." There is more than one neutralino, so writing "the neutralino" doesn't seem right to me.

Response: Done

Comment -line 2 remove "is considered to be"

Response: Done

Comment -line 8 "still remain to be pursued" => "are worth pursuing"

Response: Done

Comment -line 25 drop ", and an enhanced leptons+jets mode in tt decays." Or else rewrite that to make it more clear what the point is. I don't get what you mean as it is written now.

Response: Dropped the unnecessary phrase.

Comment -line 30. "false photons" is a strange construction to me. I'd prefer "fake photons," but I'm guessing someone else has already asked to you to change from that. I leave this one

up to you at this point.

Response: We deleted the reference to label "false photons" altogether to avoid the issue at this point.

Comment -line 59. "PF-particles" => "PF-particle"

Response: Done

Comment -line 103 "photon candidates" => "photon candidate"

Response: Done

Comment -line 118. I've never seen LO written as "lowest-order." I think "leading-order" is more common.

Response: Done

Comment -line 151 "size of" => "statistics available for"

Response: Done

Comment -line 156 "to each" => "for each"

Response: Done

Comment -line 164 "distribution" => "shape"

Response: This choice of "distribution" verses "shape" was imposed by the language editor. I prefer shape myself so I will make the change.

Comment -Fig. 1 caption "(c) has" => "(c) shows"

Response: Done

Comment -line 181-182 "(1-Data/Background) percent" => "fractional"

Response: The explicit formulae was suggested in the CWR. I have changed "percentage" to "fractional"

Comment -line 183. Probably don't need so many significant figures in the 0.6575 number.

Response: Reduce to two significant figures.

Comment -line 184. "determine uncertainty" => "determine an uncertainty"

Response: Done

Comment -line 224 "form" => "shape"

Response: Same remark as before. A language editor choice. I will change back to "shape".

Comment -line 231 "smaller" => "less stringent"

Response: Done

Comment -line 232 consider adding "with exclusions up to 750 GeV in stop mass."

Response: Added exclusion remark.

\*\*\*\*\*

Comments Set 3 Filip Moortgat

Title: fine

Abstract:

Comment: - First sentence: I suggest to stop the sentence after "and the gravitino as the lightest SUSY particle". The rest is not needed in the abstract, I believe.

Response: The sentence referred to has been reworded.

Comments - line 7-8: "in the electron+jets and muon+jets channels that require one or two photons in the final states": I suggest to replace this with "in final states containing an electron or a muon, jets, and one or two photons" or similar.

Response: something similar has replaced the phrase referred to.

1. Introduction

Comment - I would suggest to add a (feyman-like) diagram of the simplified model that you are targeting.

Response: The early versions of this paper had such a diagram but it was removed at the suggestions of the CWRers since it was redundant with the text and too up room

Comment - 1.2 : "theoretical option for avoiding" --> "extension of the Standard Model that avoids"

Response: Done

Comment - 1.3: "hierarchy problem evident from the recent discovery" --> I'm not sure that the recent discovery of the Higgs made the hierarchy problem evident. What about "hierarchy problem, which became particularly relevant since the recent discovery" or similar.

Response: Done

Comment - 1.6-8: I would remove this sentence ("Since such LHC."). It's confusing and not needed.

Response: Since the other final readers wanted references to other top squark searches, I left this sentence in since it is the natural place to cite the other Atlas and CMS searches.

Comment - 1.9: I would remove "based on events with pairs of photons" since you discuss the final state later.

Response: Done

Comment - 1.10: "in data corresponding" --> "in a dataset corresponding"

Response: Done

Comment - l.15: remove "leading to photons in the final state." (it's obvious from the rest of the sentence)

Response: Done

Comment - l. 16: check spelling of "R-parity" (with or without hyphen)

Response: R-parity is the traditional way to refer to this quantity. I have added a hyphen.

Comment - l. 16-18: I would remove the sentence "Assuming R-parity at the LHC". It's not needed here. I would directly say "In this analysis we focus on pair production of top squarks, where each top squark decays to a top quark and a neutralino, which in turns decays to a photon and a neutralino."

Response: I think the reference to R-parity is needed to justify the pair production. We would prefer to keep it.

Comment - l. 23-26: I don't understand this sentence. What about "The analysis concentrates on the semileptonic decay of the  $t\bar{t}$  pair and therefore requires the presence of ..." and stopping the sentence after "gamma+jet backgrounds." (on l. 25).

Response: We have rephrased the sentence in question.

Comment - l. 30: is "false photons" really an appropriate name?

Response: We have deleted the phrase referring to "false photons" since it was unnecessary to label them at this point.

Comment - l. 32-35: I would not discuss the freely floating normalisation of  $t\bar{t}j$  and  $t\bar{t}\gamma$  in the introduction (I only understood on l. 227 what you exactly mean). So I would remove the sentence on l. 32-35 "To reduce  $\dots$  in  $p_{T\text{miss}}$ ".

Response: I have deleted the sentence in question.

2. The CMS detector

fine.

3. Event and object reconstruction

Comment - l. 58: "Objects in the event" --> "All physics objects ..."

Response: Done

Comment - l. 59: "PF-particles candidates" --> I would suggest either "PF candidates" or "PF particles" (on l.64 you use "candidates")

Response: I use PF candidates

Comment - l. 84: is the isolation cone for muons really 0.4? (not 0.3 for electrons) Why? Can you double check?

Response: This is correct.

Comment - 1. 88: I would remove "thereby increasing sensitivity to signal", since you are just talking about objects here.

Response: Done

- 1. 91: remove "for tagging" in this sentence.

Response: Done

4. Analysis strategy

- 1. 93-95: you mention the trigger thresholds here, but you do not discuss the trigger efficiency (100% I guess, but you should say that). Also, since this is the section where you outline the analysis strategy, it's worth to repeat that the offline cuts on electrons and muons are 30 GeV.

Response: Done

- 1. 114-115: "jet component of the lepton + jets ttbar decays" --> what about "jets from the top decays"?

Response: Done

Comment: - 1. 117: "many selected photons"? What about saying "where selected photons may originate from"

Response: Done

Comment- 1. 118 and 1. 125: "lowest-order" --> "leading order"

Response: Done

Comment- 1. 129: shouldn't you mention that GEANT was used for the detector simulation?

Response: A sentence is inserted stating this. Response 2: We have added a remark and reference to GEANT in the text.

Comment- 1. 130: "correspond to small backgrounds" --> "represent small backgrounds"

Response: This sentence has been changed due to other input from other reviewers such that the suggestion is no longer pertinent.

Comment- Table 1: in the last sentence of the caption you mention "fluctuating the template distributions by the syst uncert." It isn't clear what you mean here. I suggest to explain this in the text and shorten the caption.

Response: We have rephrased this sentence to, hopefully, make it clear. We have left the sentence in the caption since it is the second uncertainty type.

Comments- Figure 1: these plots are used to determine the SF but the ratios seem to be very close to 1 in the Z-region. Are the SF's already applied here? Can you clarify?

Response: The appropriate scale factors have already been applied for plots a, b, and c.

Comments- 1. 158: "component" --> "ingredient"?

Response: Done

Comments - 1.170-173: unclear what you mean here. It only gets clear at l. 226. So I suggest to shorten or remove this sentence.

Response: We think both statements of this floating issue should be stated. The statement in 226 is couched in statistical language that may be less accessible to some of the readers.

Comments- 1. 174: "provide an evaluation of the performance of the prediction" --> maybe "allow us to validate the prediction"?

Response: Done

Comments- 1. 181-182: unclear what you mean with "(1-d/b) percent uncertainty" do you mean "fractional uncertainty"? Please rephrase.

Response: We have rephrased changing to "fractional uncertainty".

Comment - 1. 182-185 and Fig. 2 (bottom): since you don't use CR2, I suggest you drop the plot of CR2 (fig. 2 bottom) and just argue that due to the limited number of events in CR2, you decided to use an alternative method to determine the uncertainty on SR2.

Response: We prefer to keep the CR2 plot since it validates our non-use of it.

Comment- 1. 187-188: please rephrase "signal region simulation of the distributions in pTmiss in the control region"

Response: We have revised this sentence significantly to reflect what was done to obtain the systematic errors in CR1, SR1, and SR2.

Comment - 1. 189 and 190: "difference" difference in what? I assume in pTmiss shape?

Response: Yes, pTmiss shape. This is more clearly stated in the new version of this sentence.

Comment- 1. 192: which distributions? pTmiss?

Response: Yes, I have added pTmiss labels to the differences to make this clear.

## 5. Results and interpretation

Comment- 1. 194: fix latex label

Response: Done

Comment- 1. 198: "normalizations of cross sections affected by choices in PDF and factorization and normalization scales" --> I would just say by "by PDF and scale uncertainties"

Response: Done

Comment- 1. 201: "obtained from" --> "derived from"?

Response: Done

Comment - l. 202: the citations are partially missing here

Response: We have added additional references.

Comment - l. 209: I would suggest to change " $m_{\text{top squark}}$ " in to " $m_{\tilde{t}}$ "

Response: The publication committee has designated  $m_{\text{top squark}}$  as the official nomenclature.

Comment - Table 2: caption: typo in "uncertainties"

Response: Fixed

Comment - l. 214: "to force the strong production" --> "so that the only relevant process is the production of ..."

Response: Done

Comment- l. 225: "taken as syst. uncert. for both their upwards and downwards fluctuations" : please rephrase

Response: Done

Comment- l. 226 - 228: "single +- 100% nuisance parameter": please rephrase this sentence in proper english.

Response: An attempt has been made.

Comment - l. 231: I would prefer that you quote the precise mass limits (corresponding to the highest and lowest LSP mass)

Response: We have quoted the range of top squark mass exclusion for the extremes of the bino mass range.

Comment - l. 231: "mass-exclusion contours" --> "exclusion contours"

Response: Done

Comment - Figure 4 caption: say "observed (top) and expected (bottom) upper limits"

Response: Done

6 Summary

Comment - l. 236: "distribution in" --> "distribution of"

Response: Done

Comment - l. 238: be specific about which LSP mass these numbers correspond to

Response: We have done so.

Comment - l. 240: drop this last sentence

Response: We believe this statement to be true. We have not been able to find a result that contradicts this assertion. It has not been objected to by the other CWR or FR reader.

Comments Set 4

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This topic: Main > ResponsesToFRForSUS1500901

Topic revision: r8 - 2017-06-05 - BradCox



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