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Search for scalar top quark pair production at the CMS experiment

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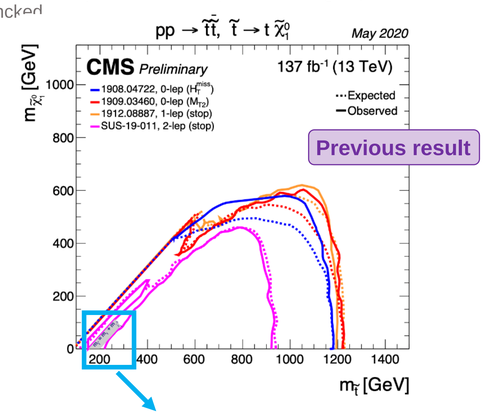
MOTIVATION

- The **stop quark** plays an essential role in understanding the SUSY models.
- Several searches with the full **Run 2 dataset** have been performed by the CMS Collaboration excluding stop masses up to 1.2 TeV, but most of these searches are not sensitive in the so-called "**top corridor**". This region requires special care because…

Fig 1. Summary of the exclusión limits obtained with full Run 2 dataset by the CMS Collaboration. The gray band on the bottom corresponds to the top corridor region, which is still blancked



TOP CORRIDOR

- The mass difference between stop and neutralino is close to the **top mass**.
- Signal and $t\bar{t}$ background have **similar kinematics**, especially at low neutralino masses.
- Signal events can only be detected as an **excess on the $t\bar{t}$ cross section**.

- **Combination** of three searches with 0, 1 and 2 leptons in the final state is also presented in this paper:
  - **Hadronic**: *Phys. Rev. D 104 (2021) 052001*
  - **Single lepton**: *JHEP 05 (2020) 032*
  - **Dileptons**: *Eur. Phys. J. C81(2021) 3*

TOP CORRIDOR ANALYSIS

- **Event selection:** $\ell\ell$, ≥ **2 jets,** ≥ **1 b-tagged jet,** $p_T^{miss} \geq$ **50 GeV,** $m_{T2} \geq$ **80 GeV.**
- **Backgrounds:** Main background is $t\bar{t}$ due to the similar kinematics with the signal process in this region. It is estimated from MC with an **accurate knowledge** to have sensitivity.

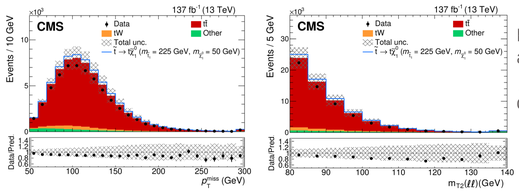


Fig 2. Data/MC agreement p_T^{miss} and m_{T2} distributions.

- **Main strategy:** use a **parametric Deep Neural Network** to separate signal from background. By introducing **stop and LSP masses** in the training we exploit the kinematic differences to **maximize sensitivity**.

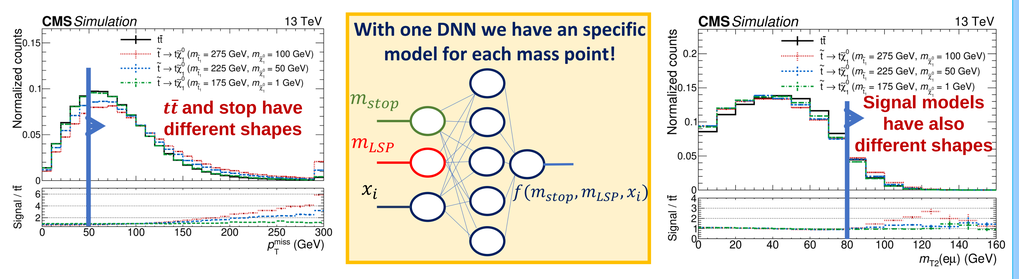


Fig 3. Normalized p_T^{miss} and m_{T2} distributions for $t\bar{t}$ in black and three signal models in other colours.

COMBINATION

Fully hadronic analysis:

- High Δm: advanced jet tagging algorithms to identify hadronically decaying top quarks and W bosons.
- Low Δm: dedicated algorithm to identify very low p_T B hadrons.

Single lepton analysis:

- M_T to suppress $t\bar{t}$+jets/W+jets.
- Modified topness (t_{mod}) to discriminate against $t\bar{t}$.
- Hadronic top tagger categories (unmerged, merged and resolved).

Dilepton analysis:

- p_T^{miss} Significance to supress Drell-Yan.
- $m_{T2}(\ell\ell)$ and $m_{T2}(b\ell b\ell)$ to suppress $t\bar{t}$+jets.
- ttZ(Z→inv) main irreducible background.

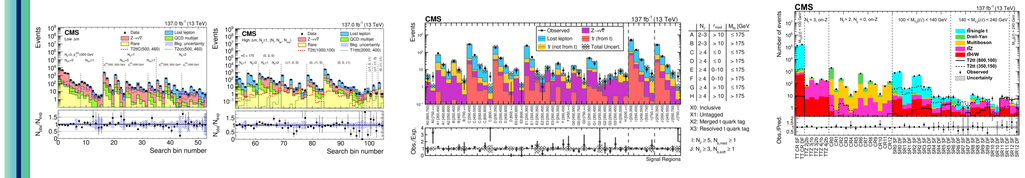


Fig 4. Postfit data/MC agreement distributions of the different signal regions in each analysis.

RESULTS

Fig 5. Postfit data/MC agreement of the DNN distribution in different signal points..

- The DNN score has different shapes due to the parametric training: **there is one signal and one background distribution for each mass point**.

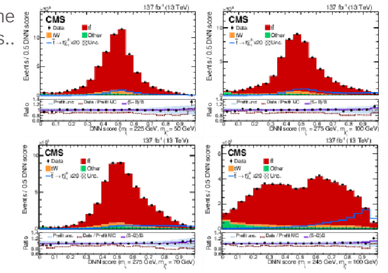
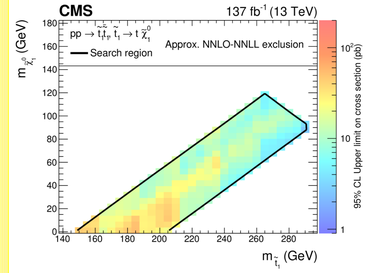


Fig 6. Exclusion limits in the top corridor.



- **No excess** is observed and for the signal extraction the DNN output is used.
- Results are presented in terms of **upper limits** on the production cross section of top squark pairs at 95% confidence level for the T2tt model.

Full top corridor region is excluded for the first time by CMS!

RESULTS

- A **statistical combination** of the results of the 3 searches is performed, **extending the sensitivity** to stop and neutralino masses by about **50 GeV**.

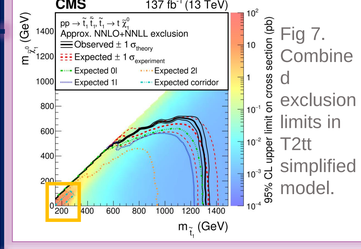
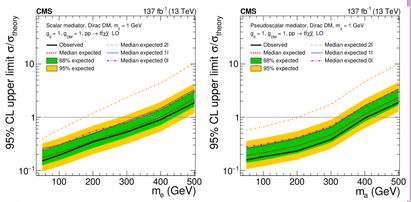


Fig 7. Combined exclusion limits in T2tt simplified model.

Fig 8. Upper limits on the cross section for different ϕ and a mediator masses.



- Results are also interpreted in an alternative **DM signal** model where a **scalar (ϕ) or pseudoscalar** (a) particle mediates the interaction between the DM candidate particle and SM quarks.

REFERENCES

CMS Collaboration, "Combined searches for the production of supersymmetric top quark partners in proton–proton collisions at$\sqrt{s}$= 13 TeV", Eur. Phys. J. C 81 (2021) 970