Search for the Supersymmetric partner of the top quark at the LHC with multivariate approach

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What's so attractive in Supersymmetry?

Meet SUSY!

In particle physics we consider two main classes of fundamental particles: **fermions** and **bosons**. Broadly speaking, we can say that fermions are matter particles and bosons are responsible for interactions. SUperSYmmetry, is the principle that proposes that for every particle in one class there's an associated one from the other class know as its **superpartner**, differing in spin by 1/2. This simple and elegant principle, if true, would solve major questions in the current Standard Model such as:

- A candidate for Cold Dark Matter
- Solving the Higgs mass hierarchy problem
- Evolution to the coupling constants in Grand Unified Theories

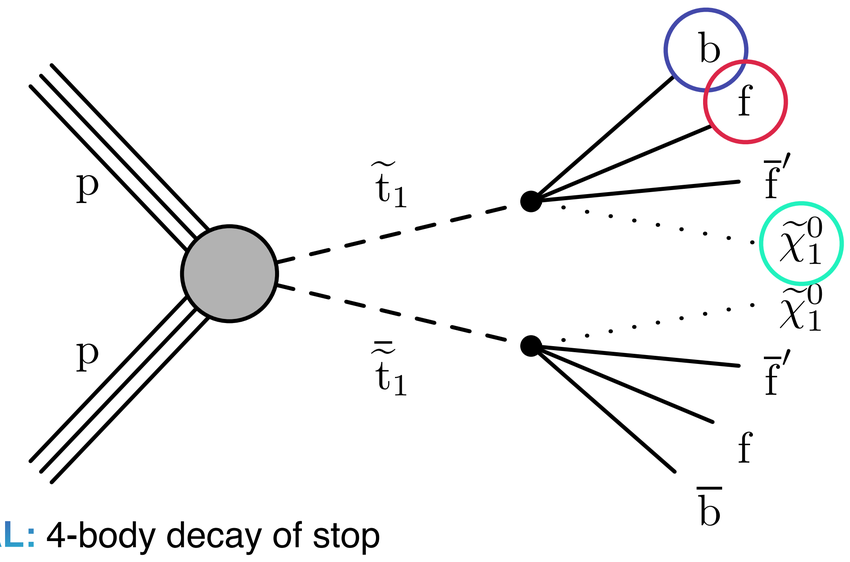
Finding stop

This is how we do it!

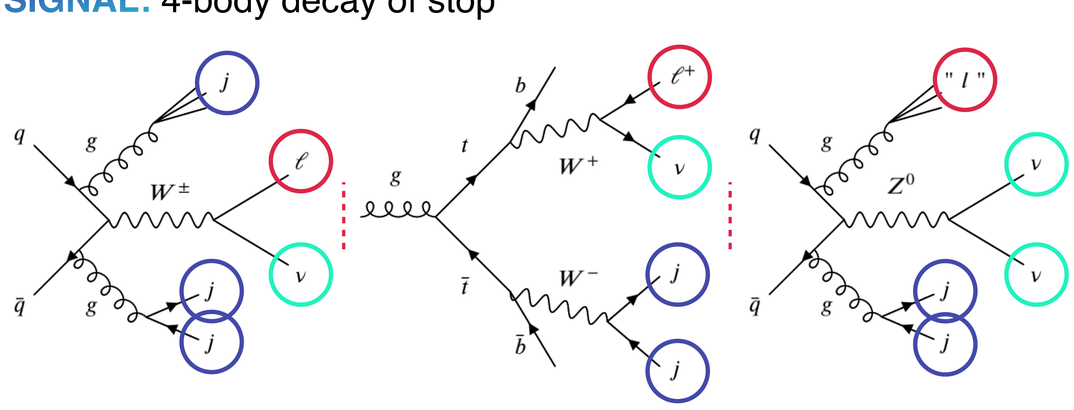
How do we verify particle physics theories? We find the predicted particles! Stop - $\tilde{t}_1$ - the supersymmetric partner of the top quark is the lightest squark in many SUSY models making it a preferable particle to search for at the **Large Hadron Collider** (LHC) using the **Compact Muon Solenoid** (CMS) detector.

We are specifically looking for the 4-body decay of $\tilde{t}_1$. The neutralino - $\tilde{\chi}_1^0$ - will escape CMS without being detected and contribute as missing energy.

Signature: jets + 1 lepton + Missing Transverse Energy (MET)

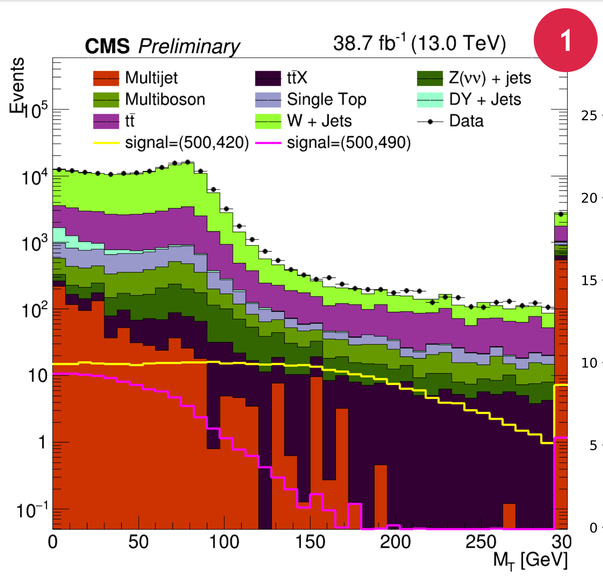


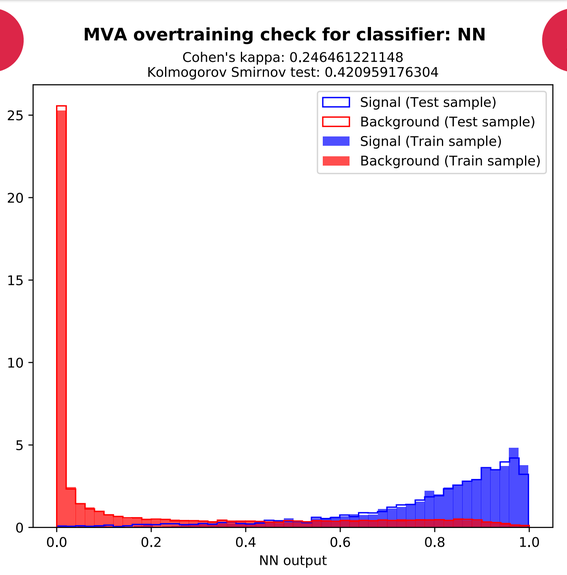
SIGNAL: 4-body decay of stop



SM BACKGROUND: W+jets, TTbar+jets and ZtoNuNu+jets

Using Deep Learning

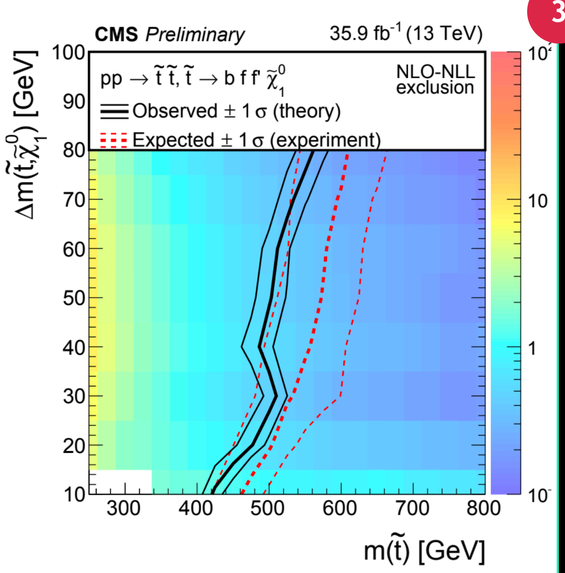




1 - Distribution of the transverse invariant mass in 2017 Data, Monte Carlo simulated background processes and signal

2 - Background and signal separation using a feed-forward Neural Network with 2 hidden layers with 14 neurons each as a classifier

3 - Exclusion limit at 95% CL as a function of m($\tilde{t}_1$) and Δm($\tilde{t}_1$, $\tilde{\chi}_1^0$). Using boosted decision trees for classification and 2016 Data, no excess above the predicted Standard Model background is observed [1]



[1] The CMS collaboration, Sirunyan, A.M., Tumasyan, A. et al. J. High Energ. Phys. (2018) 2018: 65. https://doi.org/10.1007/JHEP09(2018)065

Next Steps: full RunII analysis

Develop classification algorithm
- Improve NN architecture
- Train on samples 2016 + 2017 + 2018
- Bayesian hyperparameter optimisation

Perform physics analysis
- Finish 2017 physics analysis
- Repeat analysis for 2018 data taking
- Join all three years of data taking
- Publish **CMS RunII** Analysis Note

Did we find stop?
- If **yes**: ATLAS has to "see" the same before claiming discovery
- If **no**: exclude this phase space

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