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

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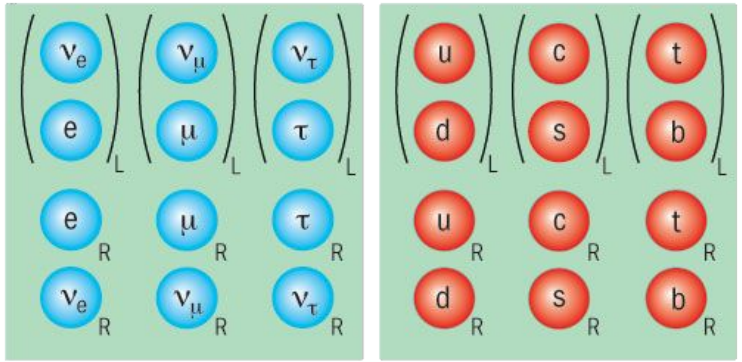
FCT Fundação para a Ciência e a Tecnologia

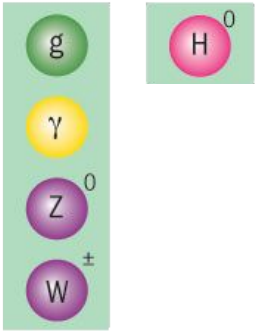
LIP LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS

Good old Standard Model

matter
fermion (s=½)

interactions
boson (s=1 or s=0)

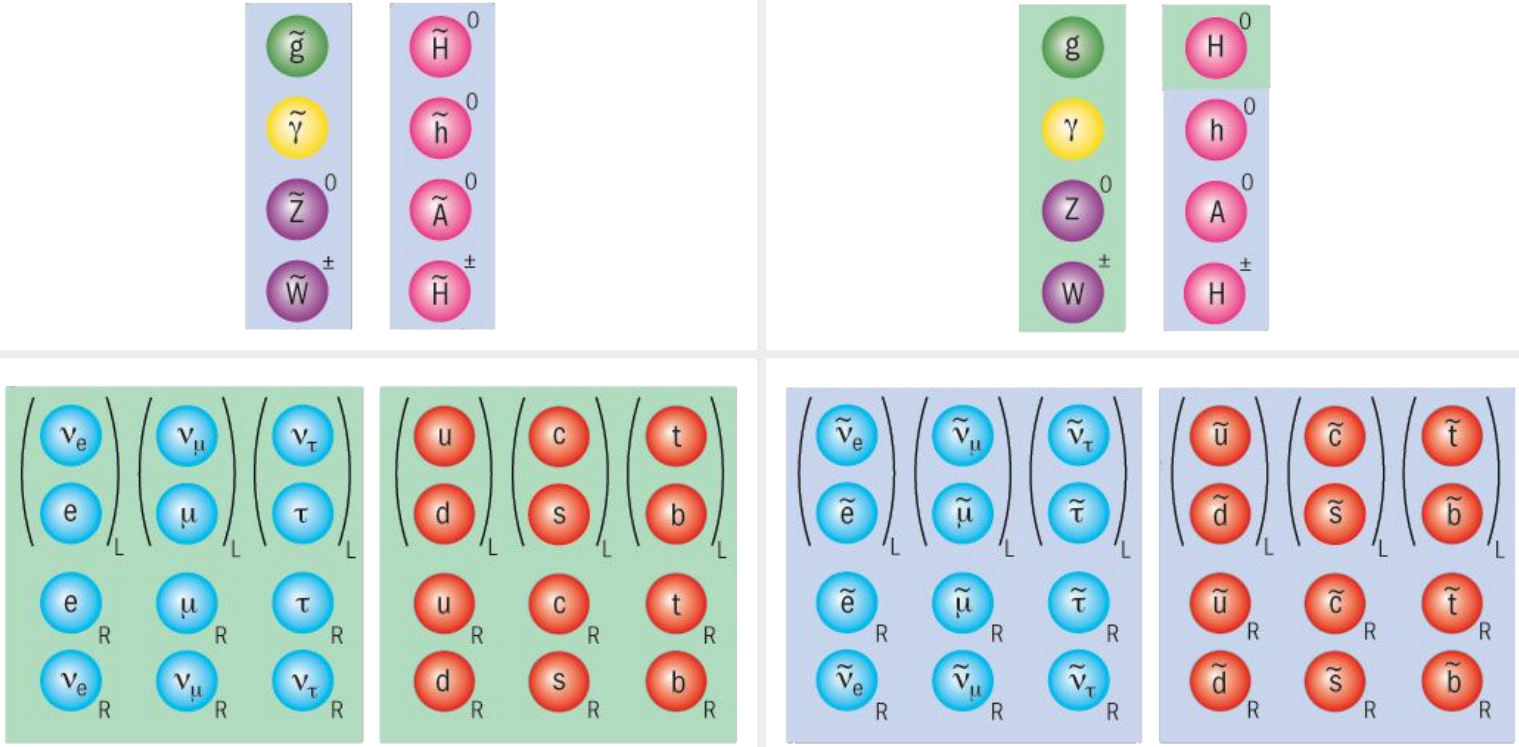




Meet SUSY!

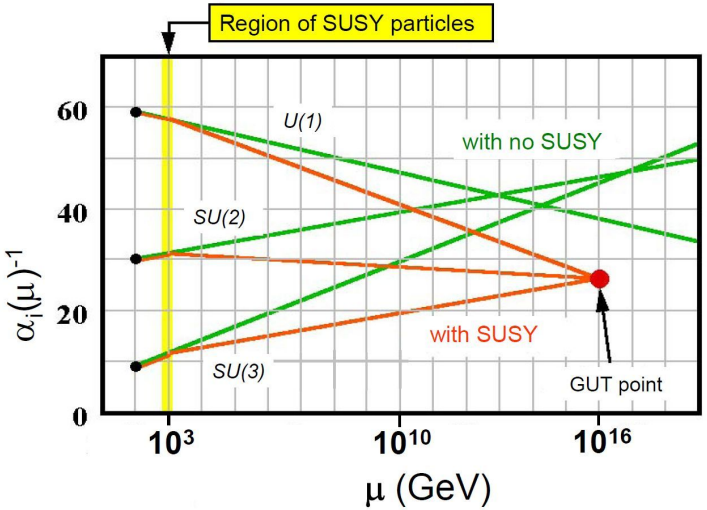
matter
fermion (s=½)

interactions
boson (s=1 or s=0)



Simple principle → solution for **complex** problems

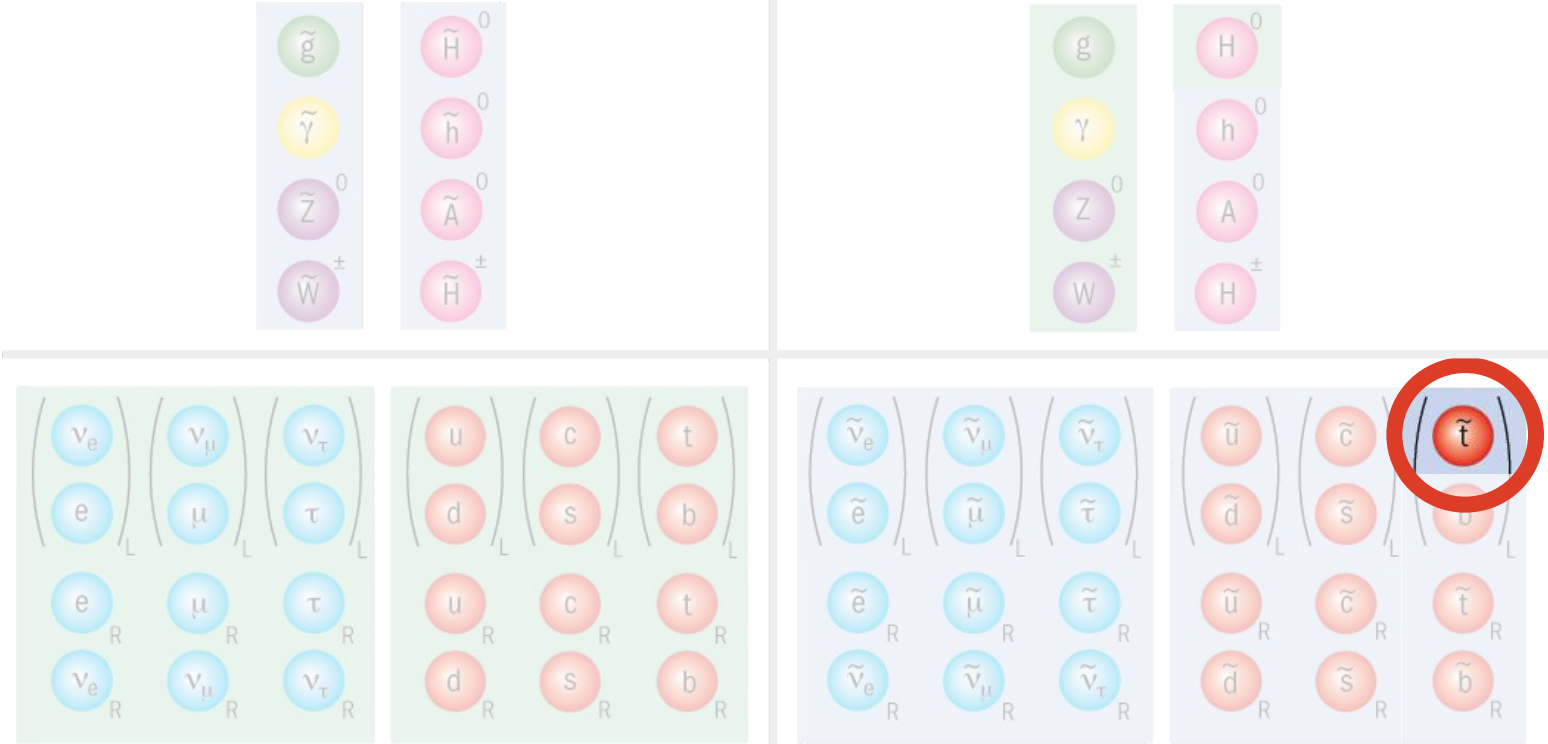
- A candidate for Cold Dark Matter
- Solving the Higgs mass hierarchy problem
- A different evolution to the coupling constants for Grand Unified Theories



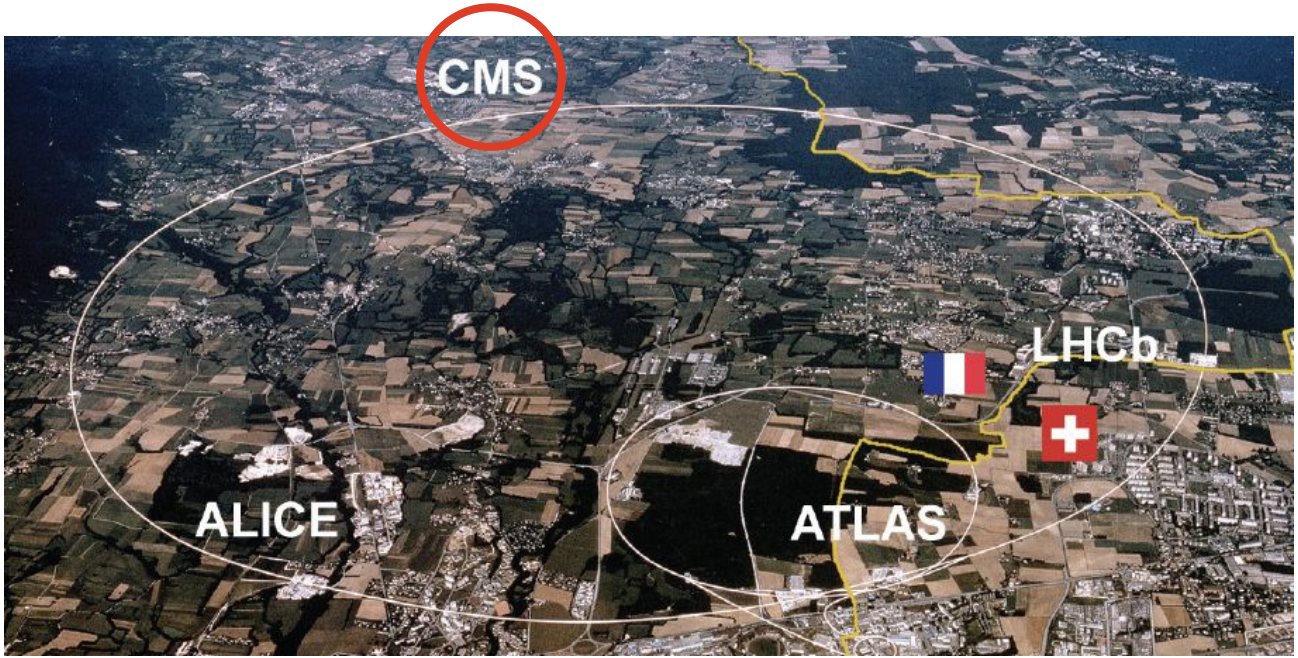
STOP

matter
fermion (s=½)

interactions
boson (s=1 or s=0)

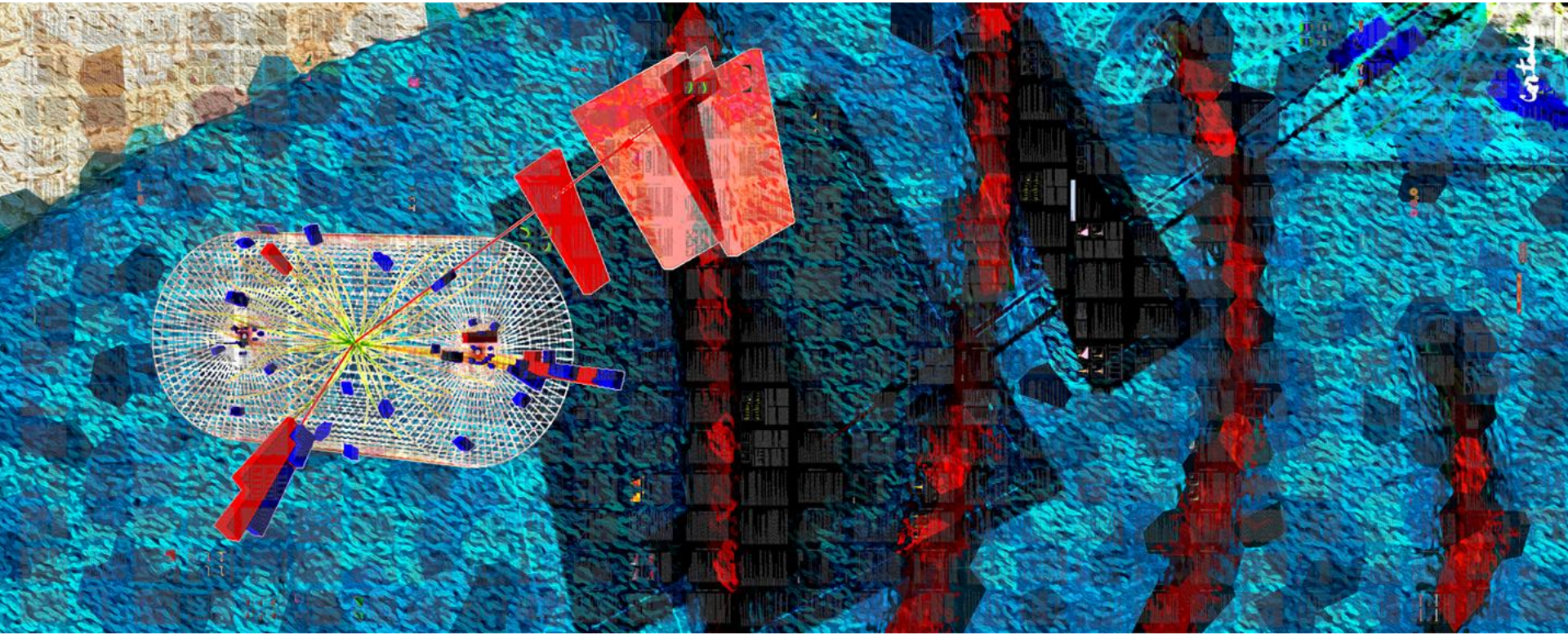


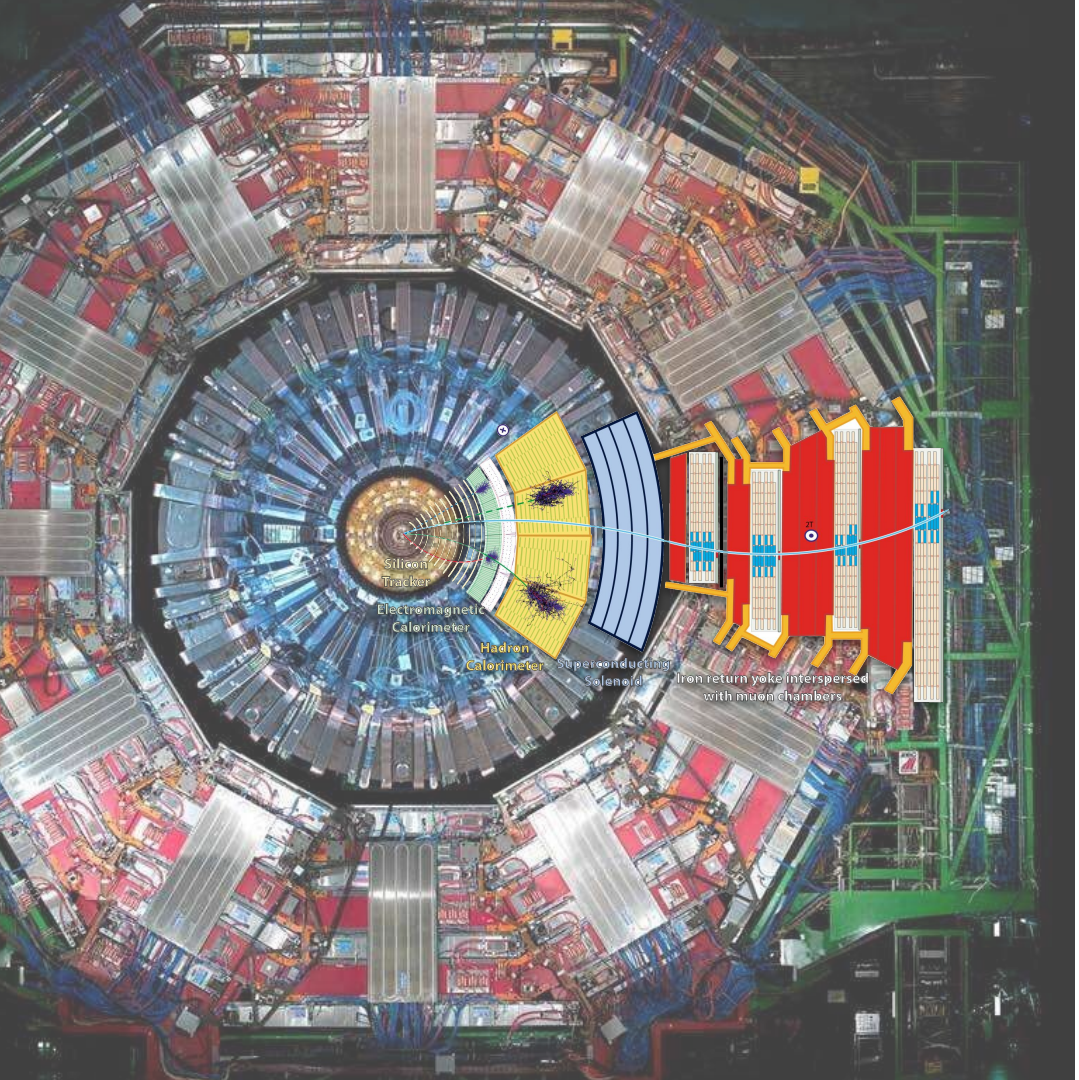
Large Hadron Collider



(the picture every experimental particle physicist will show you)

CMS - Compact Muon Solenoid





Tracker

Trajectory of charged particles

ECAL

Energy deposits of photons and electrons

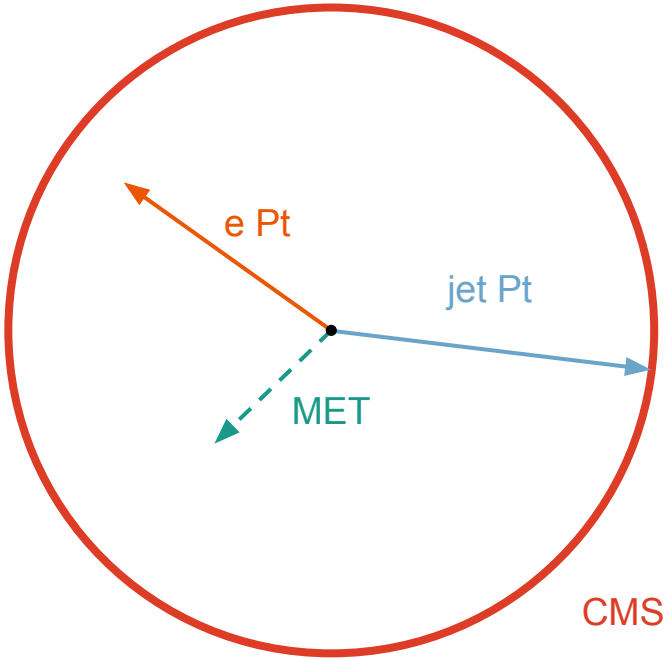
HCAL

Energy of Hadrons

Muon Chambers

Muons energy and trajectory

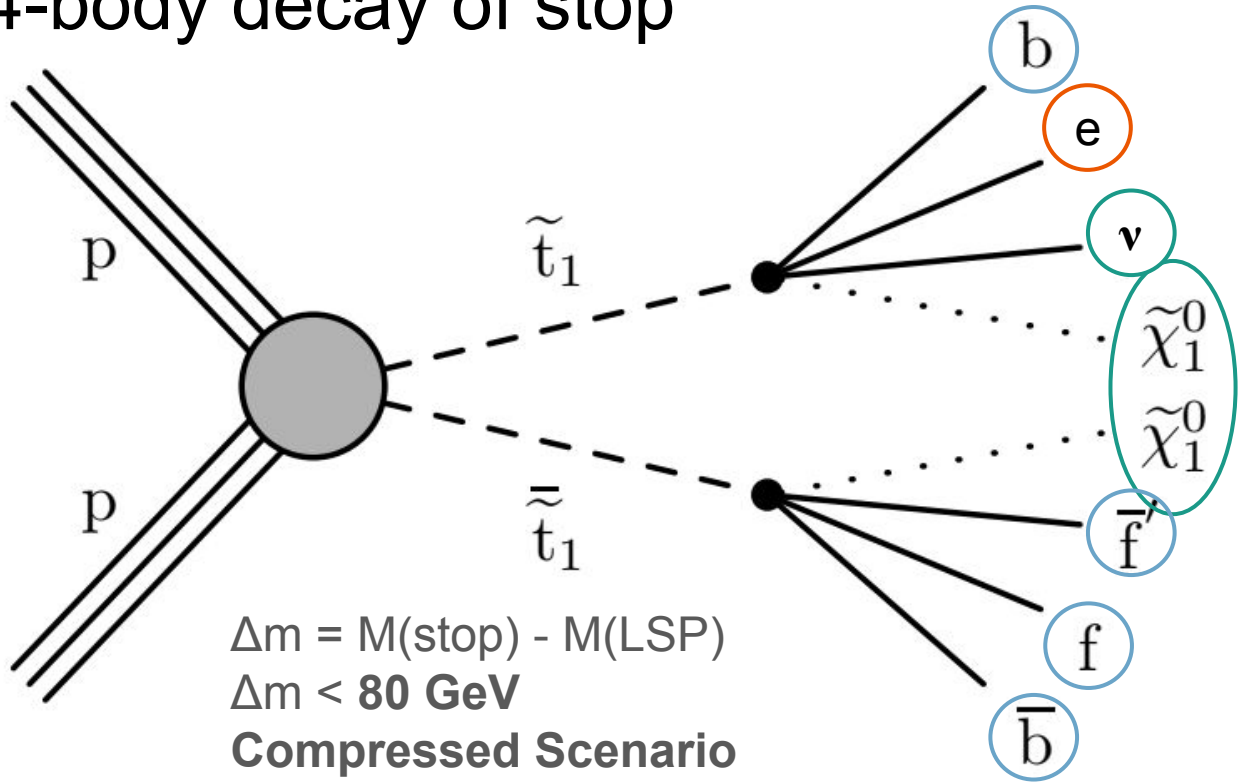
Missing Transverse Energy - MET



CMS transversal projection

MET: Energy not detected carried by particles that interact weakly → neutrinos or BSM particles

4-body decay of stop



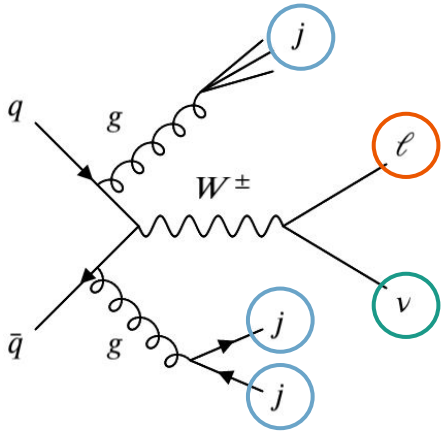
Δm = M(stop) - M(LSP)
Δm < **80 GeV**
Compressed Scenario

Final state:
jets
1 lepton
MET

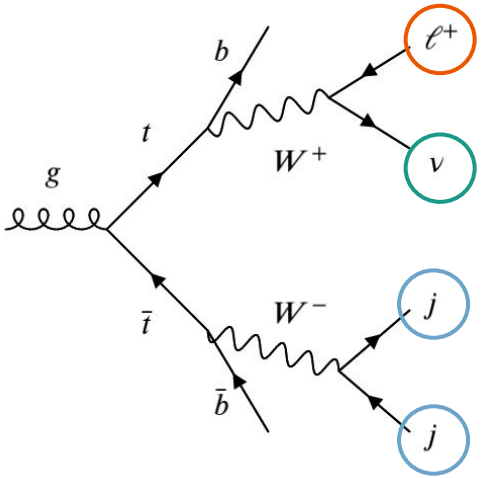
$\tilde{\chi}_1^0$ - Neutralino : Supersymmetric neutral particle. The **Lightest Stable Particle** in many SUSY models

Standard Model Background

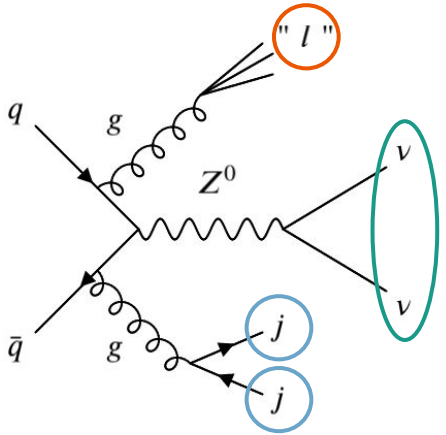
W+Jets



TTbar+Jets



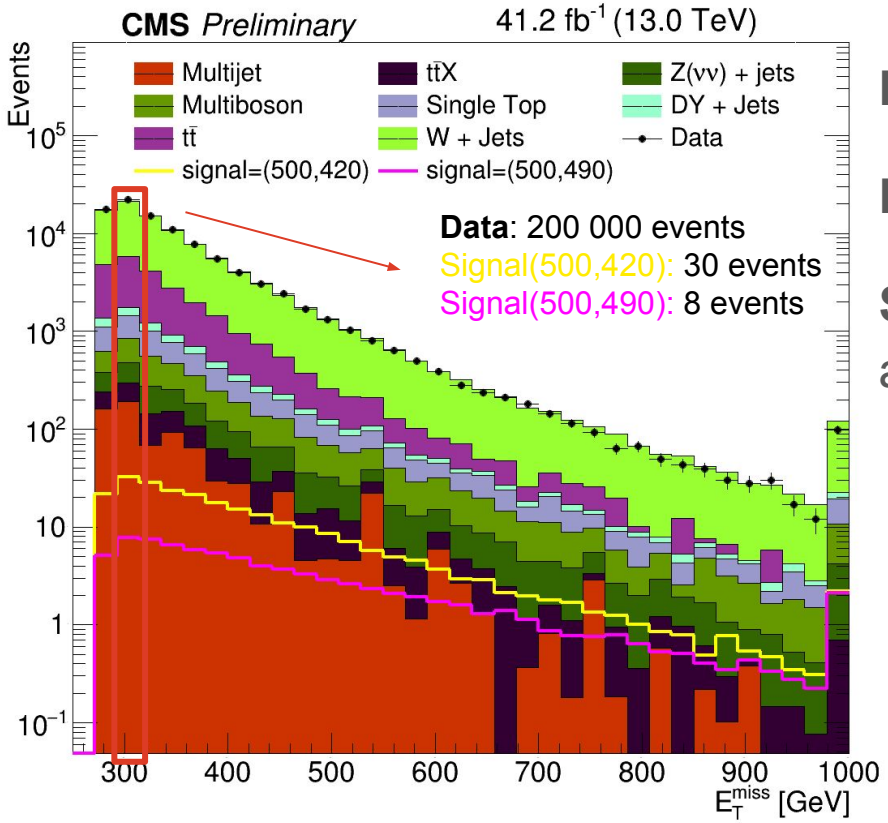
ZtoNuNu+Jets



Signature: jets + 1ℓ + MET

Other: Drell-Yan+Jets; Single Top; Multiboson; TTbarX; QCD

MET - 2017 Data and Monte Carlo samples



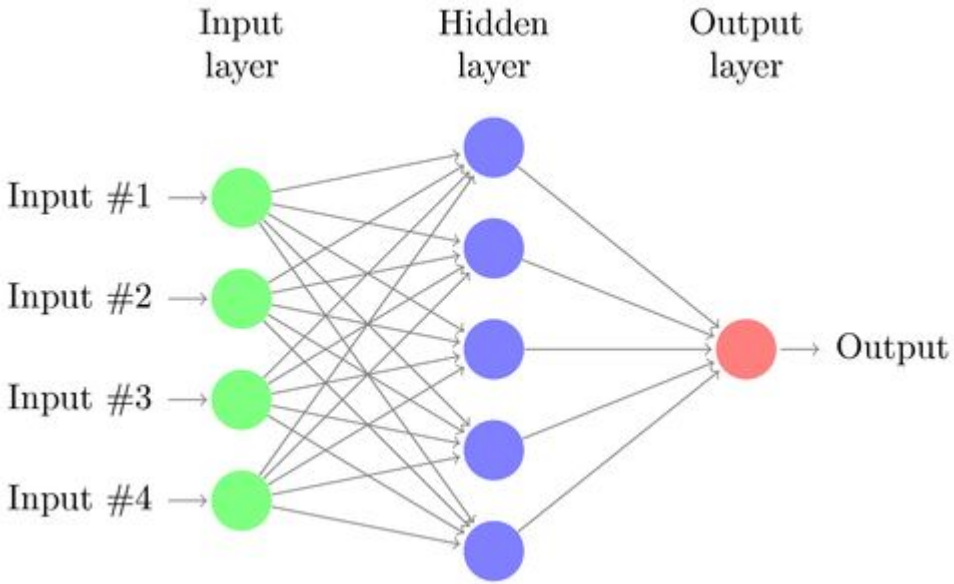
Muon final state: good Data/MC agreement

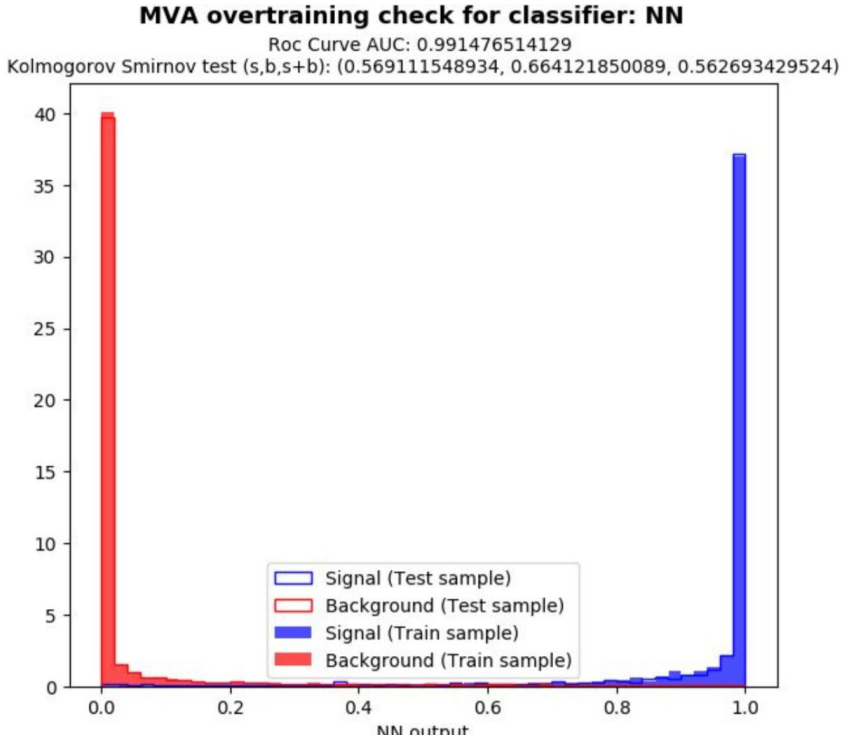
Background: SM Processes

Signal: depends on the mass of our initial and final SUSY particles - **stop**, **neutralino**

- M(stop)=500; M(neutralino)=420
- M(stop)=500; M(neutralino)=490

Multivariate analysis: Neural Network

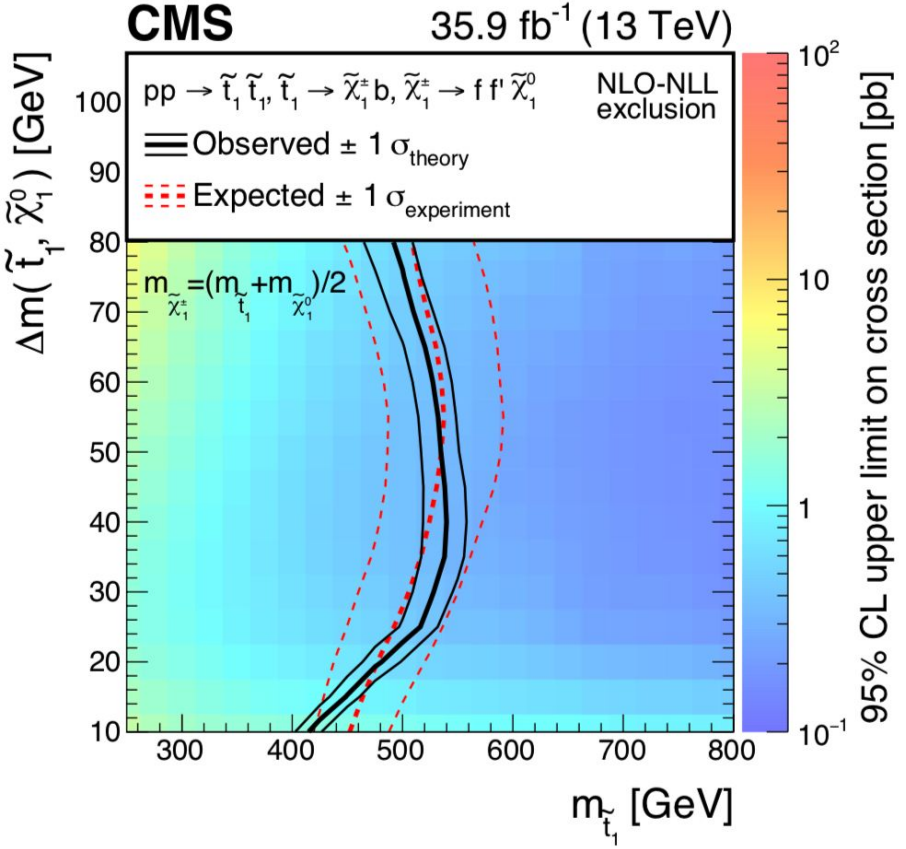




DISCOVERY

(before claiming discovery, results still needed to be confirmed within the CMS group and by ATLAS)

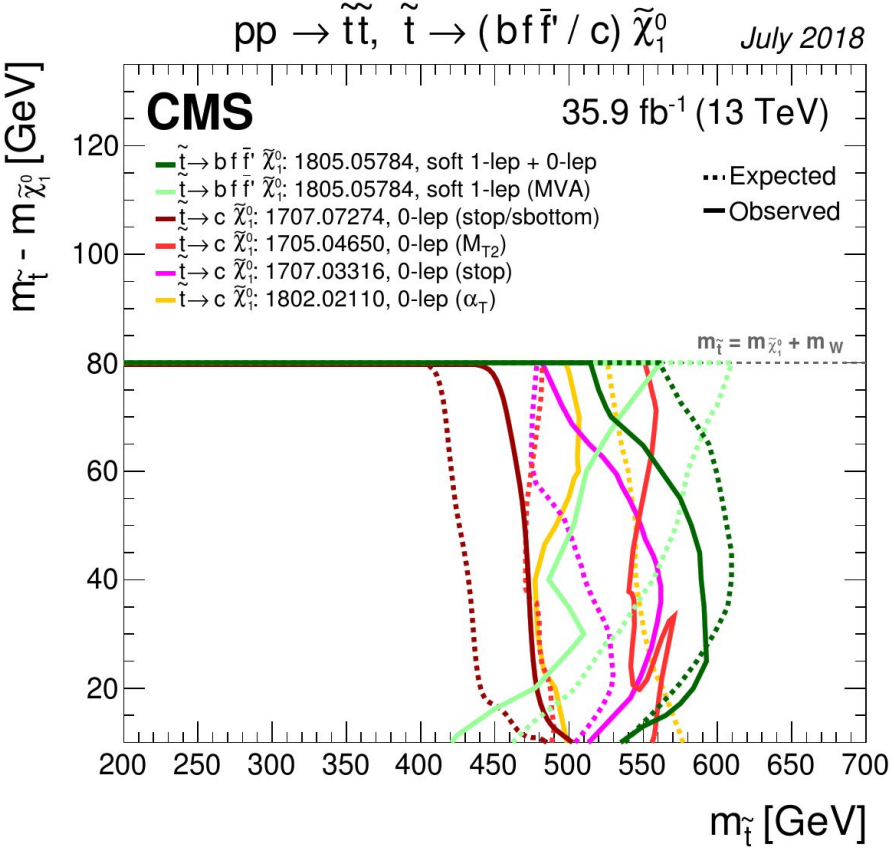
Region excluded: 2016 publication



Final result of 2016 publication ([SUS-17-005](SUS-17-005)):

- My PhD builds on top of this analysis
- Data collected only on 2016
- MVA: Boosted Decision Trees
- Low sensitivity at low and high Δm
- **No evidence** for direct stop production is observed

Summary



SUSY **is not** an excluded theory

Our goal is to improve the previous analysis

- Better methods
  - Object identification
  - Data driven background prediction methods
- Better Background/Signal separation: NN approach
- Full RunII data

2016 Delivered Luminosity : 41.0 fb^{-1}

2016+17+18 Delivered Lumi: **158,7 fb^{-1}**

Work in progress and Next steps

Work in Progress:

- Preparing summer internship
- BDT training for 2 benchmark signal points
- Data driven prediction of TTbar and WJets for 2 benchmark signal points

Next steps - Finish 2017 analysis:

- Corresponding systematics
- Data Cards & CLs
- Repeat for 2016+2017+2018 data analysis - publish RunII Legacy paper