Intro to the Stau Long Exercise

CMS DAS 2025, January 15, 2025

Caleb Smith (Kansas), Hichem Bouchamaoui (Princeton),
Itzelli Salazar (UC Davis), Andrew Loeliger (Princeton),
Andrew Melo (Vanderbilt), and Zach Flowers (Kansas)

Facilitators!

Long Exercise: Search for stau pair production in CMS Run 3 data

Caleb Smith

Hichem Bouchamaoui

Andrew Loeliger

Andrew Melo

Itzelli Salazar

Zach Flowers

Students!

- Adam Vendrasco
- Akshat Shrivastava
- Tianyi Jian
- Rose Powers
- Danish Alam
- Max Zhao
- Natalie Bruhwiler
- Ashley Peters

Useful Information

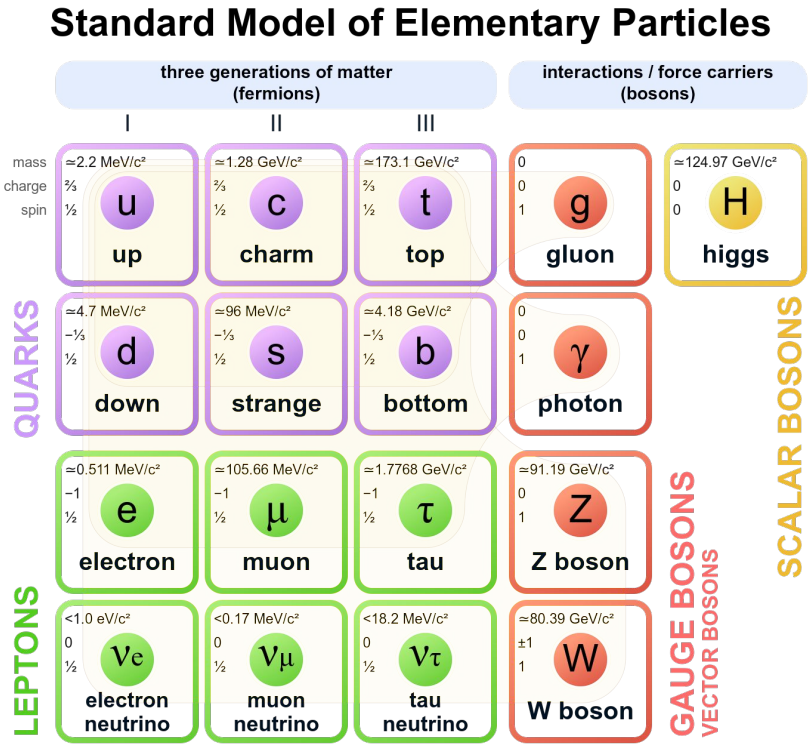
- The long exercise twiki: here
- The long exercise repository: here
- The analysis CADI (requires iCMS login): here
- The paper on arXiv: here
- The paper on PhysRevD: here

The Standard Model (SM)

The Standard Model (SM) describes elementary particles and forces.

- Fermions: matter
  - Quarks
  - Leptons
- Bosons: forces and interactions
  - Vector bosons: strong, weak, and electromagnetic forces (not gravity)
  - Scalar boson: mass

The SM is a very successful theory!

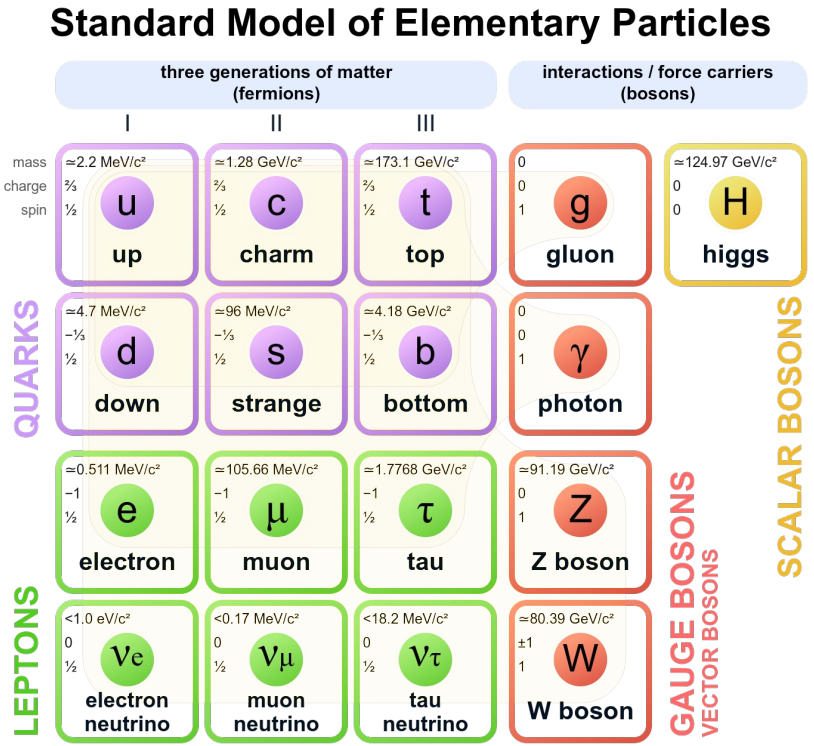


The Standard Model (SM)

The Standard Model (SM) describes elementary particles and forces.

- Fermions: matter
  - Quarks
  - Leptons
- Bosons: forces and interactions
  - Vector bosons: strong, weak, and electromagnetic forces (not gravity)
  - Scalar boson: mass

However, there are some unexplained mysteries, such as the hierarchy problem and the nature of dark matter, that hint at physics beyond the SM.

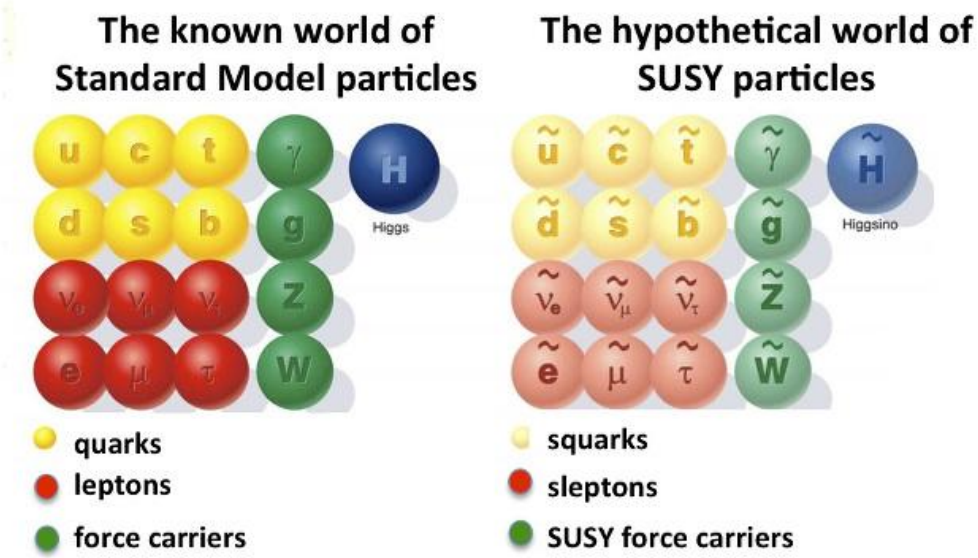


Supersymmetry (SUSY)

SUSY predicts:

- Each fermion has a bosonic superpartner.
- Each boson has a fermionic superpartner.

SUSY resolves the hierarchy problem and provides a dark matter candidate, which is the lightest supersymmetric particle (LSP).



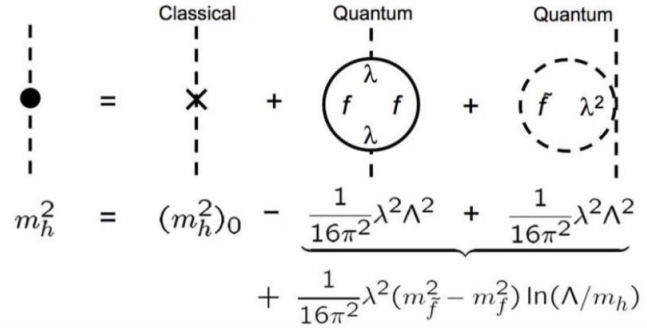
Supersymmetry (SUSY)

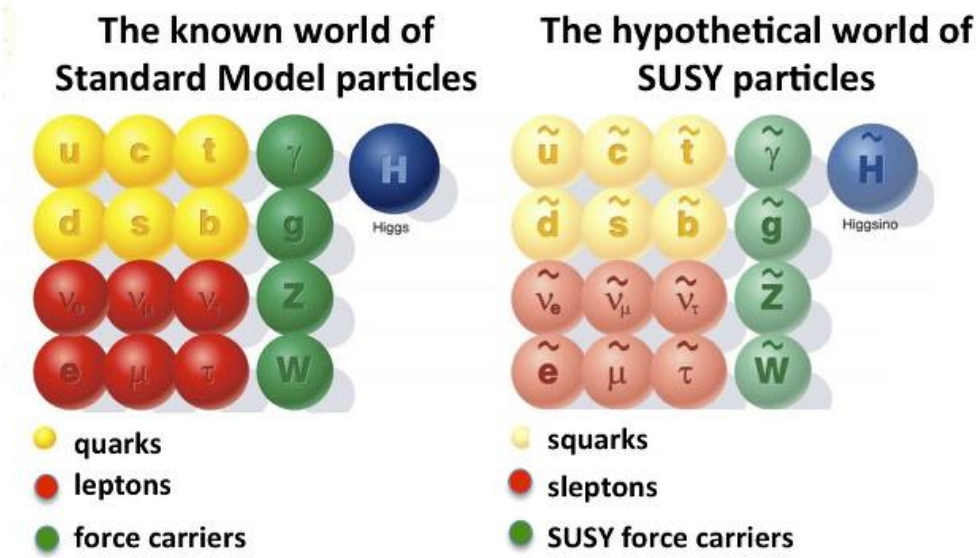
SUSY predicts:

- Each fermion has a bosonic superpartner.
- Each boson has a fermionic superpartner.

SUSY resolves the hierarchy problem and provides a dark matter candidate, which is the lightest supersymmetric particle (LSP).

Higgs mass calculation in SUSY





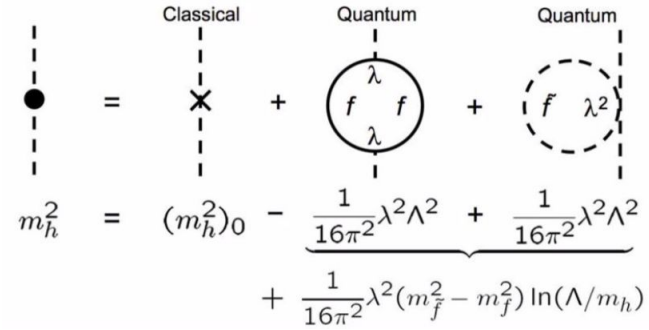
Supersymmetry (SUSY)

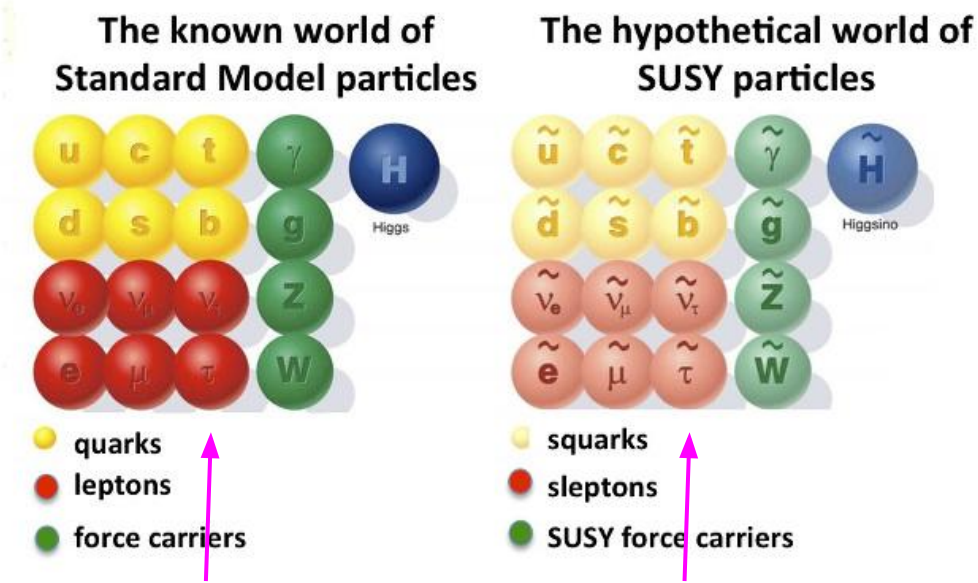
SUSY predicts:

- Each fermion has a bosonic superpartner.
- Each boson has a fermionic superpartner.

SUSY resolves the hierarchy problem and provides a dark matter candidate, which is the lightest supersymmetric particle (LSP).

Higgs mass calculation in SUSY

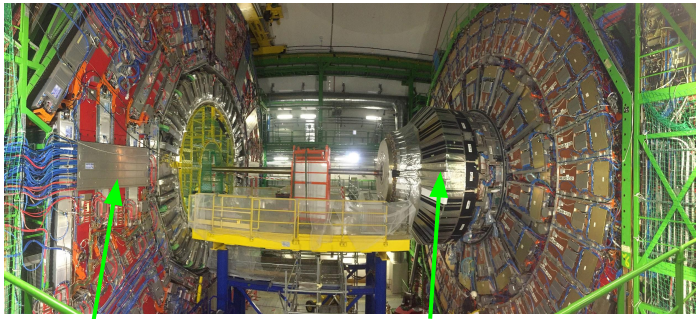




Third generation particles in the SM have larger masses and contribute larger terms to the Higgs mass calculation, which motivates searching for third generation SUSY particles.

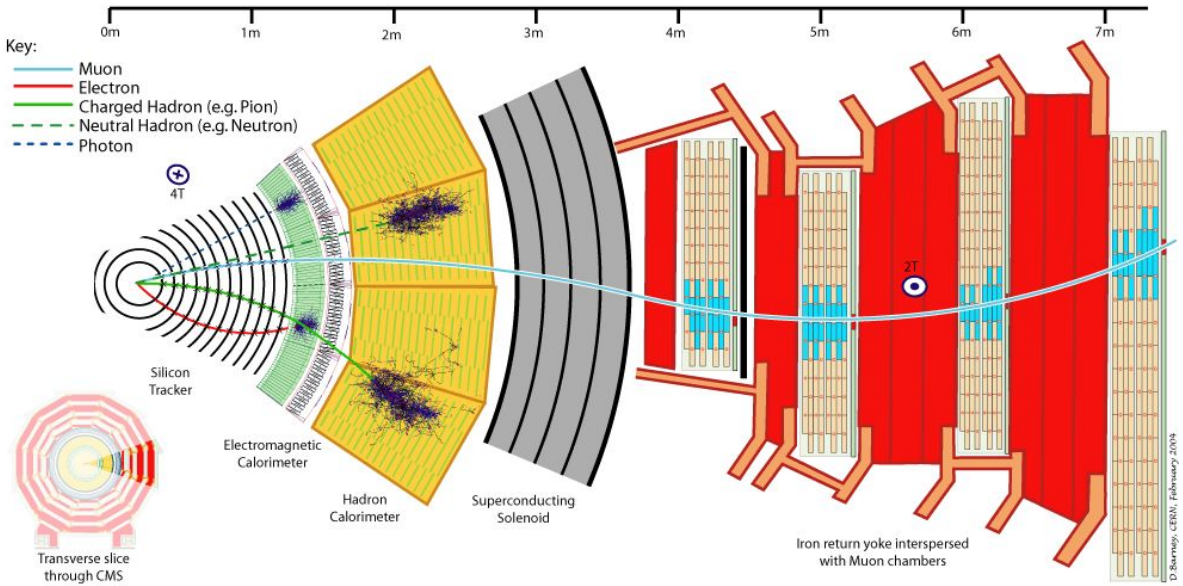
The Compact Muon Solenoid (CMS) Detector

Data from each CMS subdetector is used to reconstruct electrons, muons, photons, and hadronic jets (from quarks and gluons).



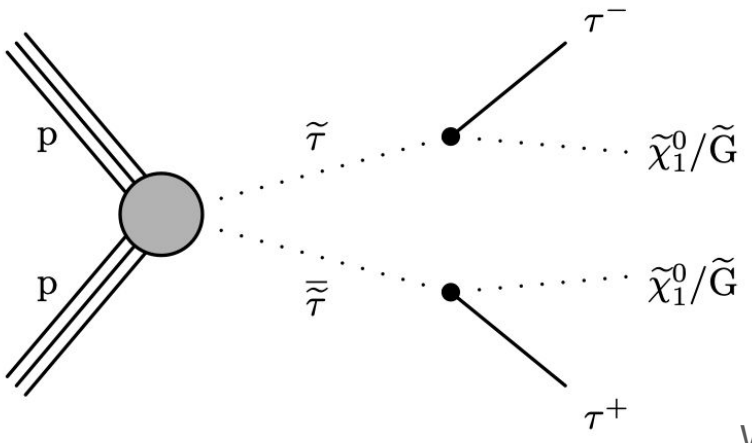
Barrel Endcap (1 of 2)

Cross section of CMS

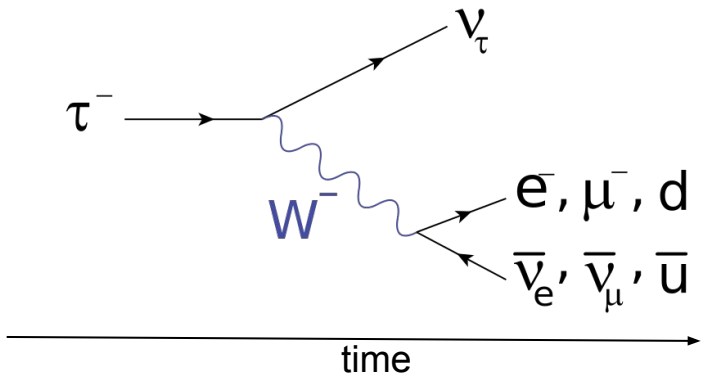


Signal: stau pair production

Direct stau pair production



Tau decays



We will use the semi-hadronic final state: τ_h + μ (tauh + mu)

The final state also has MET! Where is the MET from?

Long Exercise Overview

- Part 0: Prerequisites (set up working area on cmslpc)
- Part 1: Create ntuples (flat trees) from NanoAOD
- Part 2: Analyze ntuples (flat trees)
- Part 3: Use Combine to produce limits
- Part 4: Use ReAna to make this analysis reinterpretable (if time allows…)

Don’t be afraid to ask questions! We are all here to work and learn together. 😀

Good luck and have fun!

Backup