

Low energy leptons in High energy physics

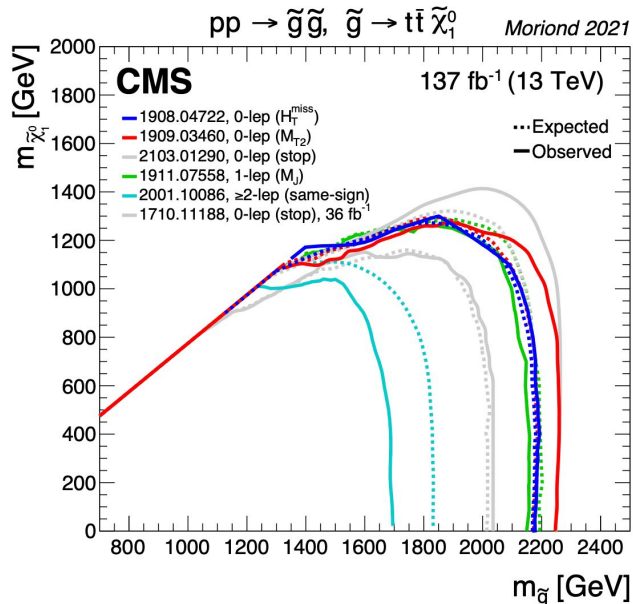
BSM physics searches & Level-1 Trigger development

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Introduction

- SUSY can provide answers to **many open questions** of the SM
 - No hint for SUSY at EWK scale (yet!)
 - Instead, **strong constraints** on sparticle masses
- Traditional strategy: search in events with **high (missing) p_T**
→ But this doesn't cover all phase-space!
- We have to target the **corners of phase-space** where SUSY may reside
 - Unconventional signatures → Experimentally hard to target
- My PhD aims to expand our physics reach using **low p_T (=soft) leptons**:



Data-analysis

Compressed SUSY

Search for SUSY in final states with multiple **soft leptons**

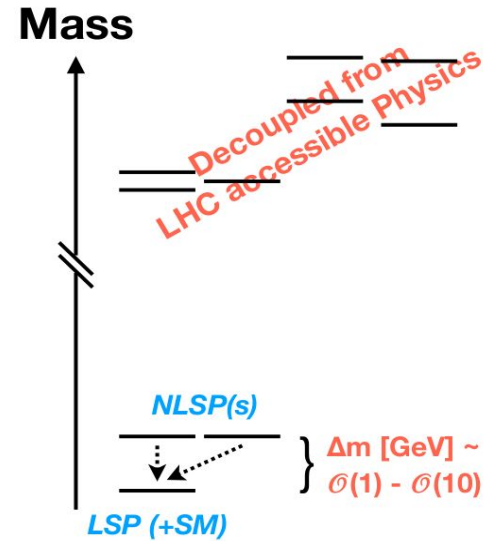
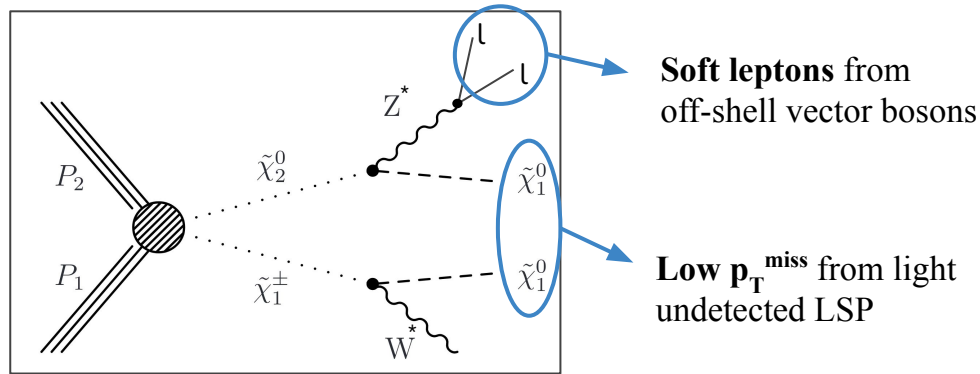
Detector development

Level 1 Trigger for Phase 2

Development and implementation of trigger algorithms targeting **soft electrons**

SUSY with compressed mass-spectra

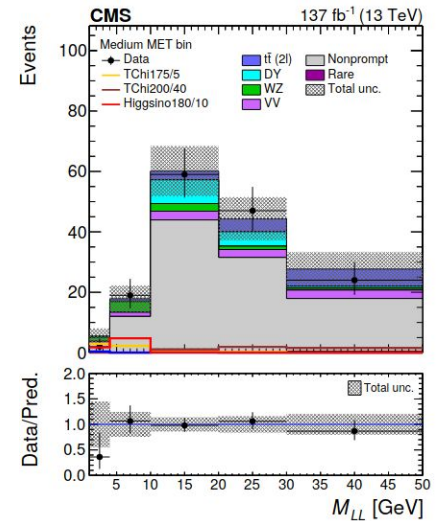
- Natural SUSY most elegant solution to the Hierarchy Problem
 → Suggests **light Higgsinos ($\sim m_H$)** with **small mass-splittings**



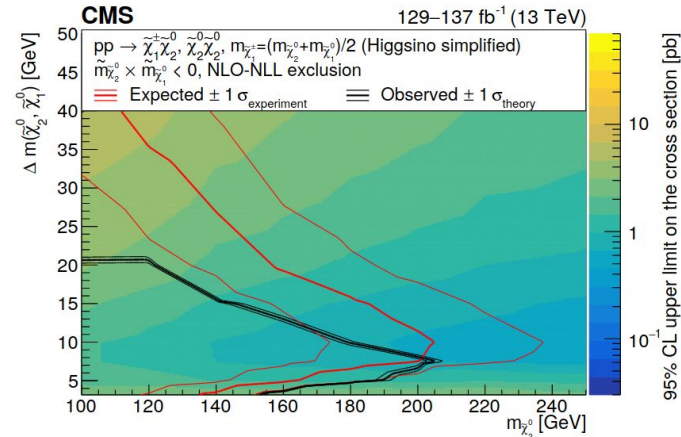
- Very challenging search:
 - ~No handle to select events online (trigger)
 - Low event yields
 - Dominant background from non-prompt (fake) leptons hard to estimate

SUSY with compressed mass-spectra

- Exclusion limits are set on sparticle masses
 - [Recent CMS results](#) excluded higgsino masses up to 205 GeV at mass-splittings of 7.5 GeV
 - Search also sensitive to compressed Winos, sleptons and stops!
- But the story doesn't end here!
 - Target scenarios where sparticles are compressed AND displaced → Completely different background, reconstruction methods, ...
 - We also simply need more data!

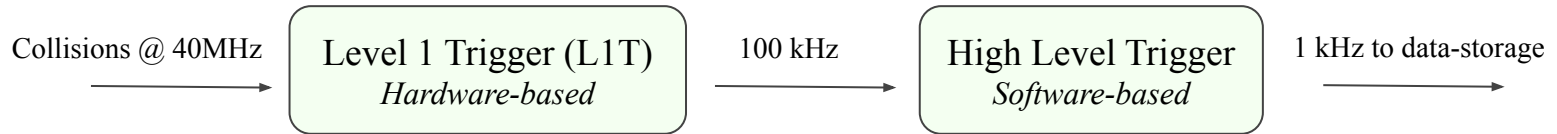


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Level-1 Trigger development

- Many new physics searches are statistically limited
 - Future HL-LHC will provide $\sim 4000 \text{ fb}^{-1}$ due to the **much higher instantaneous luminosity**
- **Drawback:** Pile-up (PU) increased by a factor 5!
 - More particles traveling through the detector → Problem for the CMS Trigger system*

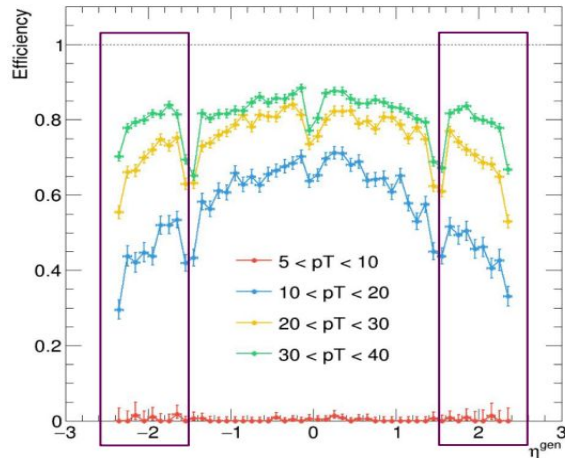


- Using the L1T algorithms of Phase 1 in the running conditions of Phase 2 would increase the rate to $\sim 4000 \text{ kHz}$, which is **beyond technical feasibility**
 - **New L1T algorithms are needed to maintain Phase 1 physics acceptance**

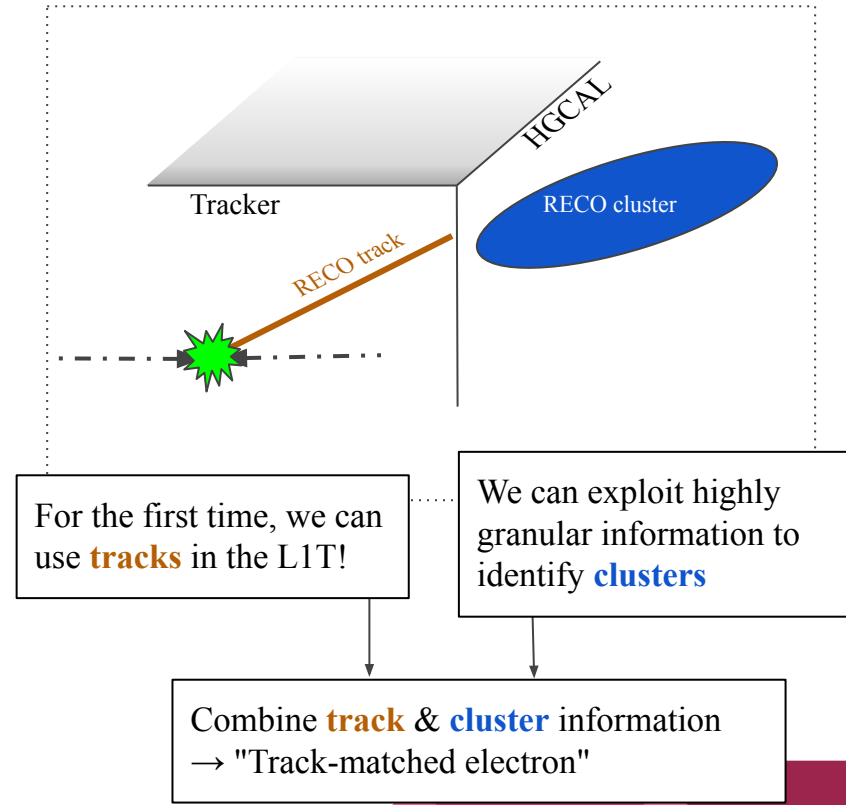
Level-1 Trigger development

- My PhD focusses on L1T algorithms for **(soft) electrons**
- **Track-matched electrons** are the only way to construct single-electron triggers with sustainable rates in Phase 2
 - Efficiency is decreases for softer electrons

→ Exploring alternative strategies to improve efficiency



CMS in Phase 2



Backup



Main challenges

- **Online event selection (triggering)**

- Moderate E_T^{miss} and soft leptons difficult to select online
 - Require **ISR activity** to boost the sparticles → Sufficient p_T^{miss} for trigger
 - Developed **dedicated $\mu\mu + p_T^{\text{miss}}$ trigger**

- **Non-prompt background**

- Leptons from e.g. B-hadron decays easily imitate (fake) leptons from signal
 - Isolation and (MVA) identification are key!
- These backgrounds are hard to simulate with Monte-Carlo
 - Rely on **data-driven estimations**

- **Low statistics**

- Low signal cross-section
- Large p_T^{miss} requirement (trigger) kills significant part of signal

