

Search for a Heavy Neutral Higgs Boson of MSSM Decaying to τ Pairs

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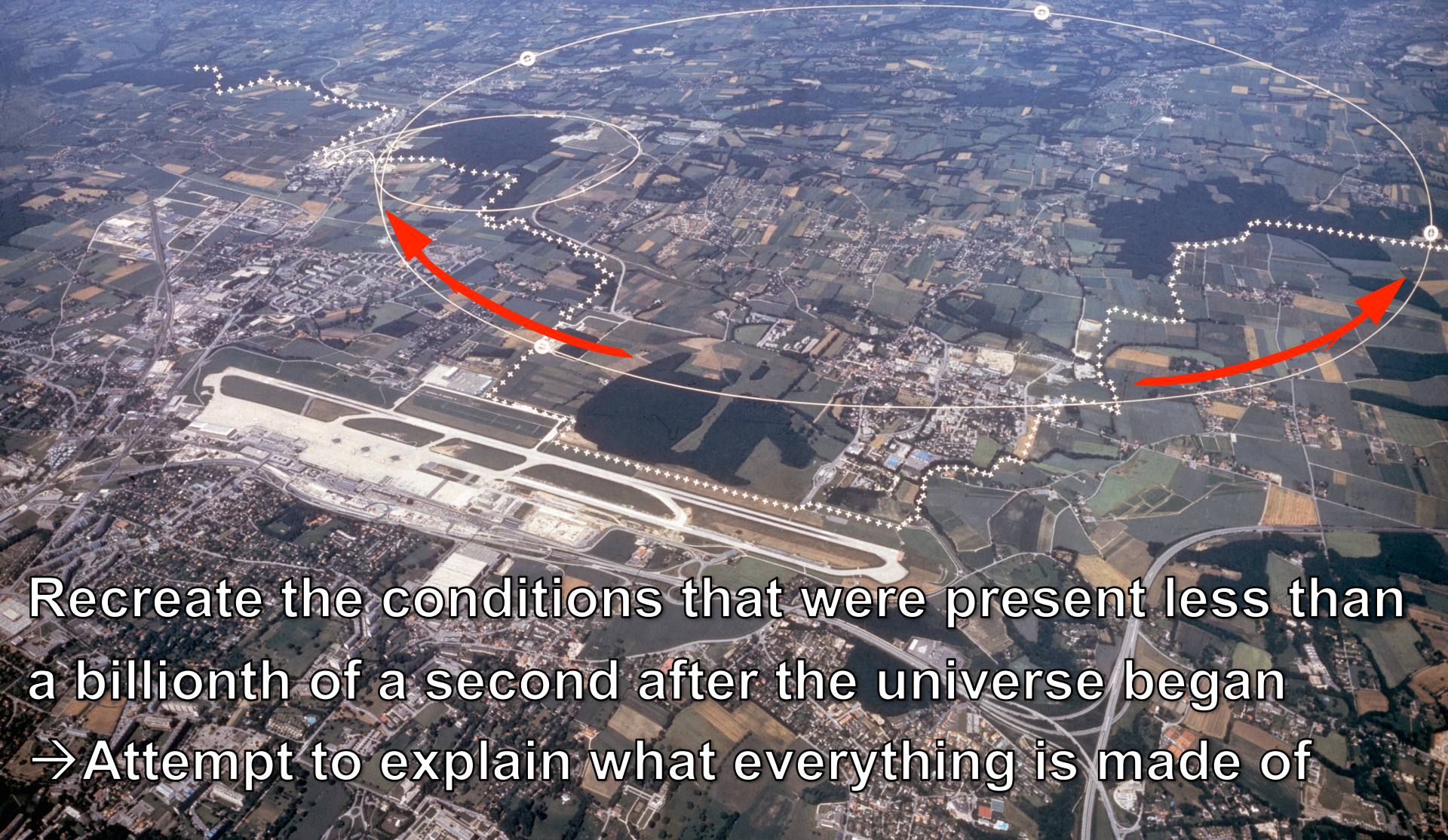
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The Large Hadron Collider

CERN → 27km in circumference



Recreate the conditions that were present less than a billionth of a second after the universe began
→ Attempt to explain what everything is made of

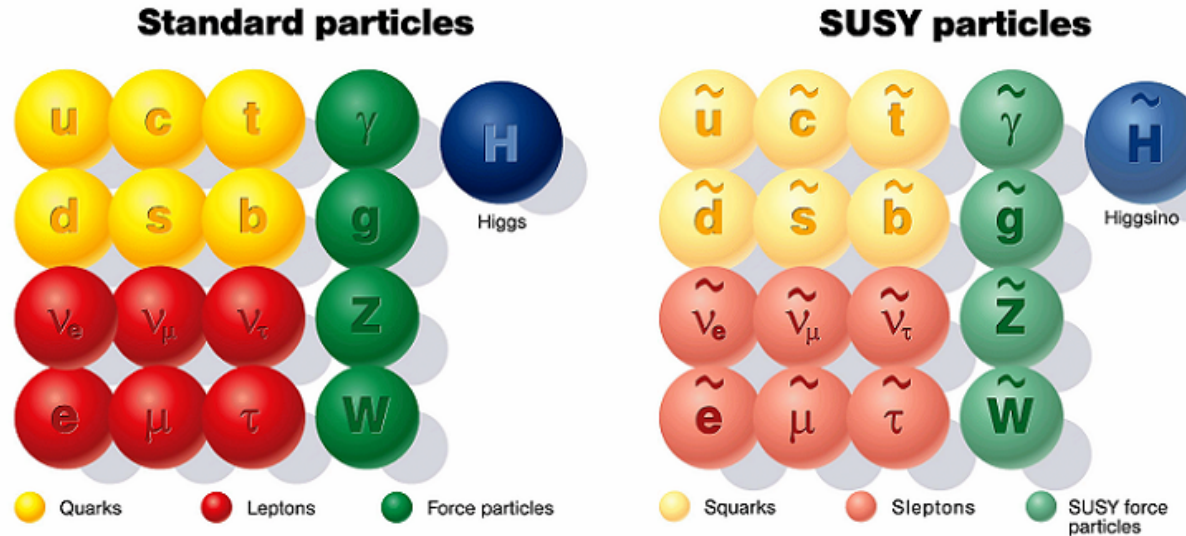
MSSM Overview



What is SUSY?

A model that introduces a symmetry between Bosons and Fermions

Each particle has a SUSY partner

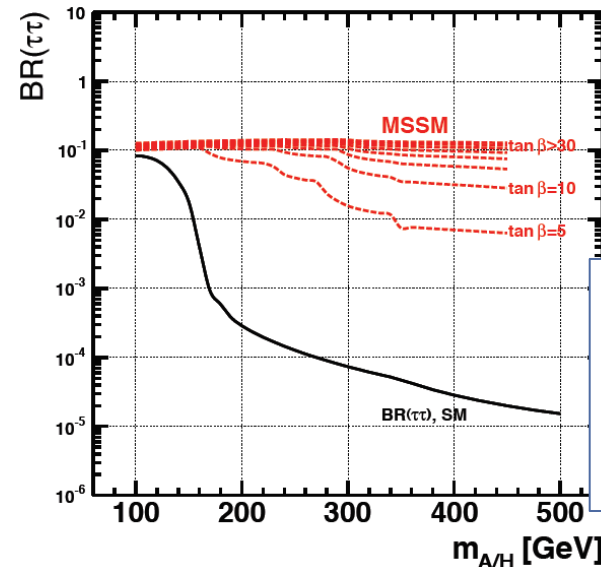


Why SUSY/MSSM?

Address important **limitations** in the Standard Model

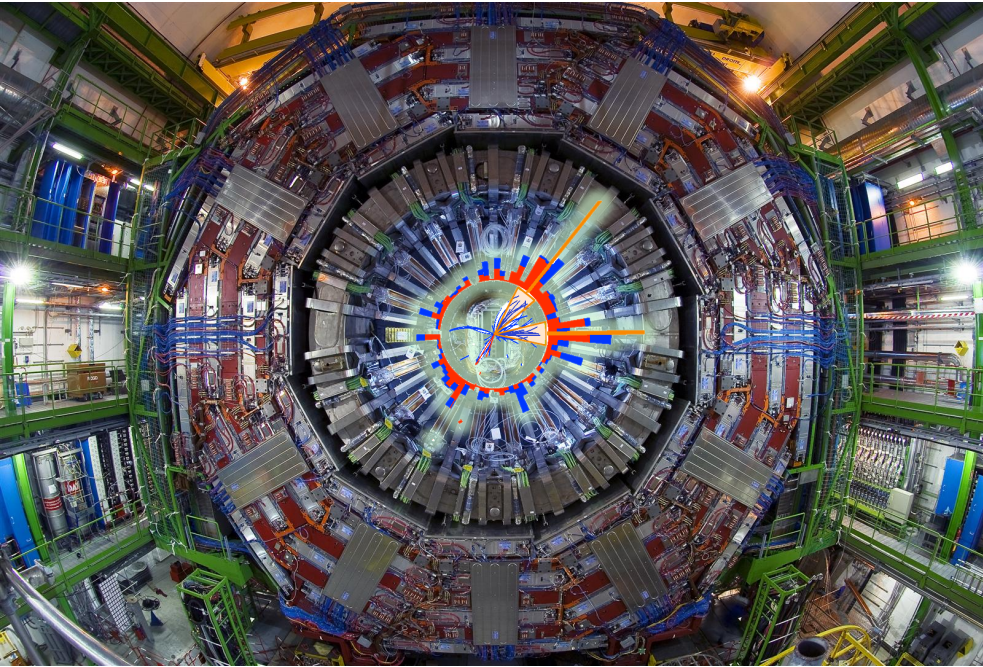
→ MSSM is applicable down to distances much shorter than the Electroweak scale

→ Possible explanation for **Dark Matter** and **Dark Energy**



$\tau\tau$ branching ratio 8-10% at high $m_{A/H}$, $\tan \beta$

Detection/Signatures



CMS Detector

→ 14,000 tonnes

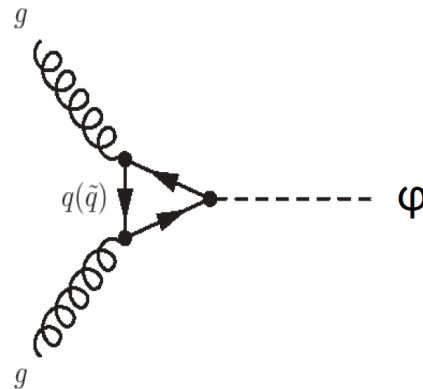
Detectors + trigger capture a “photograph” of a p-p collision

Trigger system reduces 40million events per second to a few hundred per second

Search for Events with:

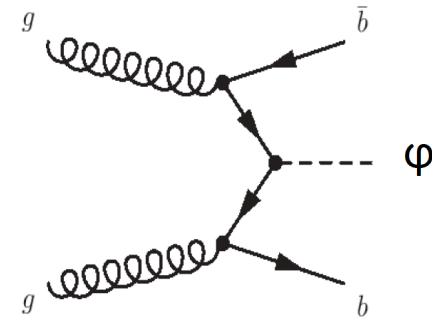
Two tau-leptons

→ Very short lifetime, decay in the tracker and must be reconstructed



Two tau-leptons and one or more b-quark jets!

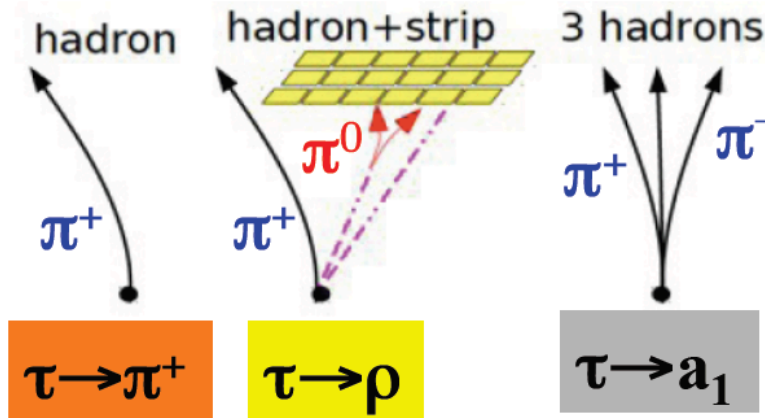
Undergo a messy hadronization, use a variety of traits to identify



τ -lepton/b-quark Jet ID



Hadronic Tau ID



Identify tau-leptons via their **decays to hadrons**

Or to **lighter leptons** (electron, muon)

$\tau_\mu \tau_h, \tau_e \tau_h, \tau_h \tau_h, \tau_e \tau_\mu, \tau_\mu \tau_\mu$

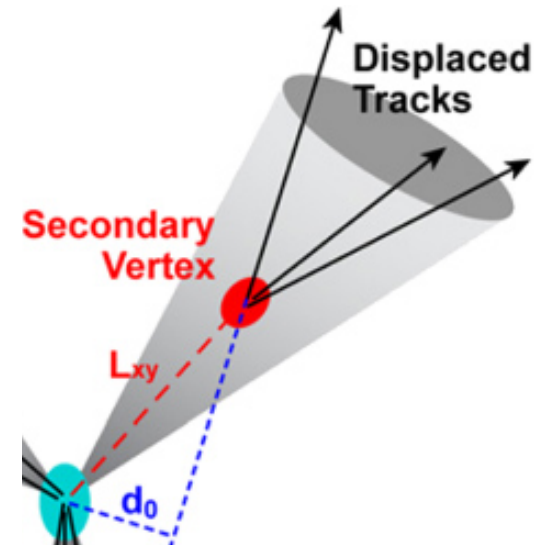
→ 5 combinations used for this analysis

Search for b-Hadrons

→ Look for b-Hadron qualities (many tracks associate to the jet, Impact parameters of these tracks, ect.)

→ For example, Search for a vertex in the jet which is separated from the primary vertex (due to a \sim long life b-Hadron time)

b-quark Jet ID



Analysis Techniques



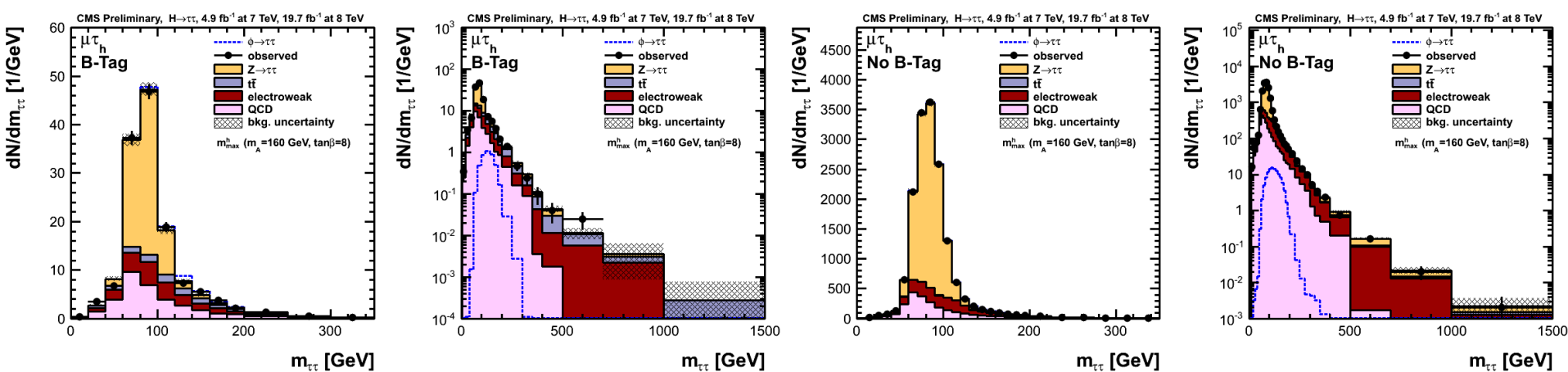
Simulate Events using a variety of Monte Carlo generators

→ Model the signal ($A/Z/h \rightarrow \tau\tau$) and backgrounds, $W+\text{Jets}$, $Z \rightarrow \tau\tau$, $t\bar{t}$, QCD (estimated using data) and check agreement in control regions

Use a variety of fit techniques

Construct the $\tau\tau$ mass ($m_{\tau\tau}$), search for fluctuations consistent with a **massive particle decay at high $m_{\tau\tau}$**

Model High Mass region and perform Maximum Likelihood Fit for all backgrounds and signals



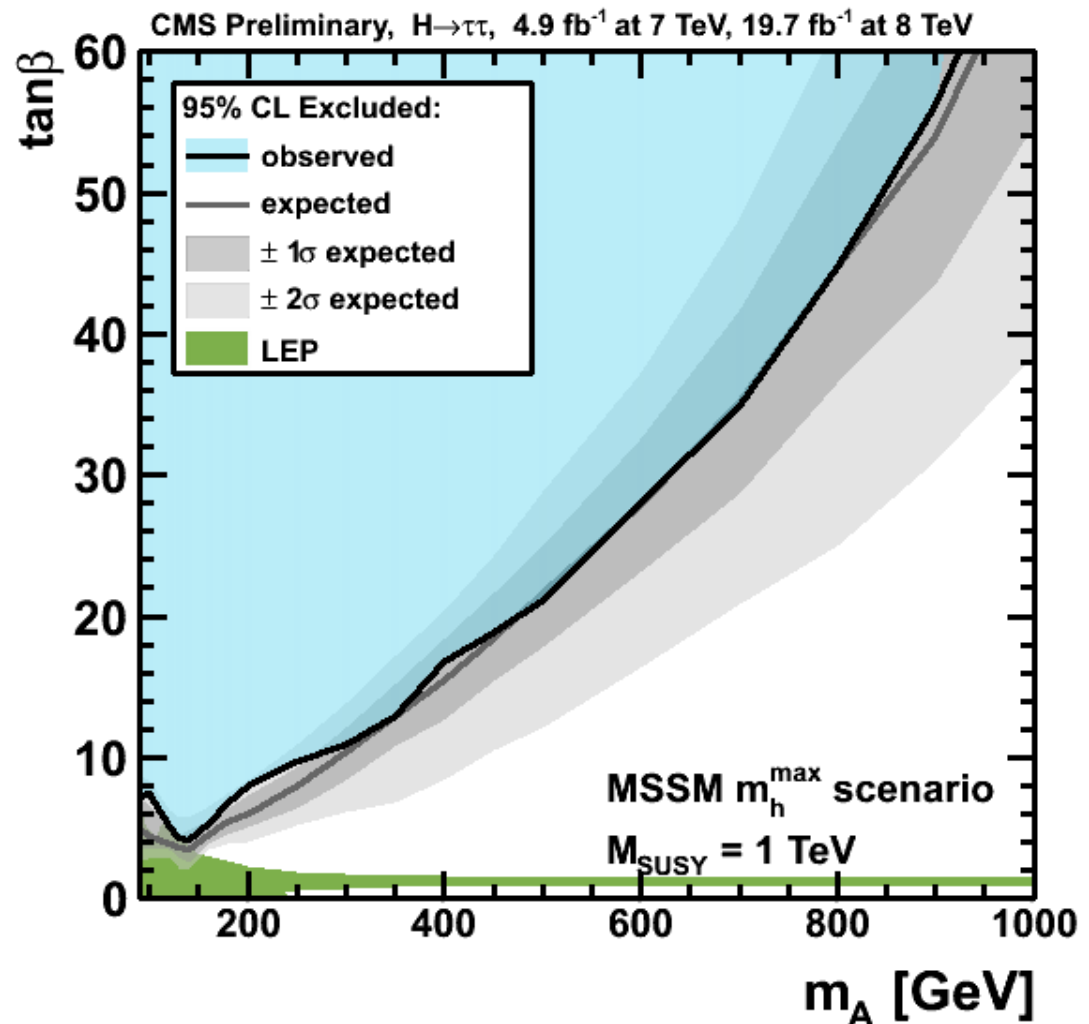
Results



Comparing expected and observed limit

→ Most stringent limits ever set for $A/Z/h \rightarrow \tau\tau$

→ No discoveries in MSSM sector with $\tau\tau$ final state yet...



Stay Tuned! Exciting times to come as we perform essential upgrades and begin the 2015 run!