

Search for Weak Scale Supersymmetric Particles in Compressed Scenarios

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Abstract

This is the abstract

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Contents

1	The Standard Model and Supersymmetry	1
1.1	Introduction	1
1.2	The Standard Model	2
1.3	Supersymmetry	4
2	Motivating the Search for SUSY	10
2.1	Introduction	10
2.1.1	Stabilizing the Higgs mass	11
2.1.2	The Muon Anomalous Magnetic Moment	12
2.1.3	The W boson mass	14
2.2	The current status of SUSY	16
3	The CMS experiment	18
3.1	Introduction	18
3.2	The Large Hadron Collider	18
3.3	The CMS Detector	19
4	The Tag-and-Probe	21
4.1	Introduction and Methodology	21
4.2	Lepton Object Definitions	24
4.3	Electron Tag-and-Probe	27
4.4	Muon Tag-and-Probe	31
4.5	Lepton Systematics and Scale Factors	37

List of Figures

1.1	particles figure cite wiki	3
1.2	stolen from this springer thesis book, probably make my own figure later https://link.springer.com/chapter/10.1007/978-3-030-25988-4_4 . .	5
1.3	mass structure winno vs higgsino modelpoints	7
1.4	xsec strucutre wino vs higgsino modelpoints	7
1.5	N2 BFs	8
1.6	mll reweight with w/b or H interpretations from atlas paper in grahams talk	9
2.1	figures from https://www.particlebites.com/?p=8972 which cites pdg	13
2.2	SUSY diagrams explaining g-2 from sven's talk	13
2.3	plot from CDF paper	15
2.4	sven plot from paper	15
2.5	strong limits	16
2.6	limits	17
3.1	plot from CMS of CMS	20
4.1	Example Tag-and-Probe Z di-muon fits for passing,failing, and all probes with the Medium Id, $ \eta < 1.2$, and $p_T < 20$ GeV	23
4.2	Gold (Top-Left), Silver (Top-Right) and Bronze (Bottom) MC truth matching in TTJets sample 2017. Signal is defined here as prompt electrons from a W decay.	26
4.3	Gold, Silver, and Bronze efficiency on truth matched prompt electrons as signal and secondary electons as Fakes.	27

4.4	2017 efficiencies	29
4.5	2017 electron GSB efficiency and SF	30
4.6	Tag-and-Probe efficiencies for the Medium Id in 2017. The left plots show the barrel while the right plots show the endcaps. The top fits use J/ψ resonance while the bottom use the Z resonance.	34
4.7	The fitted muon isolation and SIP3D efficiencies for 2017. Includes both data and MC which are separated between barrel and endcap.	35
4.8	The combined efficiency components from equations 4.5 and 4.6 and Very Loose for 2017. The low- p_T region (< 20 GeV) includes the contributions from J/ψ as well as the isolation and SIP3D extrapolations. Propagated errors are treated as uncorrelated.	36
4.9	Tag-and-Probe di-muon mass distributions for both passing and failing probes. The top set of plots consist of probes below 20 GeV and the bottom set are about 20 GeV.	37
4.10	Example systematic spread from various fit models and binnings for muons. Includes the four combinations of regions either low or high pt and central and forward eta.	38

List of Tables

4.1	The criteria that define the minimum requirements for an accepted lepton. The electron and muon requirements are equivalent in terms of pseudorapidity, vertexing, and isolation but vary in p_T threshold and the MVA VLooseFO working point. The MVA VLooseFO ID also varies between years.	25
4.2	Data and MC samples for each year used for the electron Tag-and-Probe. . .	27
4.3	selection	28
4.4	31
4.5	add ref to this table later, premade jpsi tnp trees for id	32
4.6	muon binning	32
4.7	The electron systematic error derived from the Tag-and-Probe for 2017 data and split into p_T and $ \eta $ regions.	39
4.8	The muon systematic error derived from the Tag-and-Probe data and split into p_T and $ \eta $ regions.	39

Chapter 1

The CMS experiment

1.1 Introduction

The Compact Muon Solenoid (CMS) experiment consists of a detector housed at the Large Hadron Collider (LHC). The detector encapsulates two synchronous bunches of high energy protons which counter rotate through the LHC accelerator ring. The protons collide at the center of the detector with a significantly large energy and the expectation that more massive and potentially new particles are produced. Each particle produced in the collision can either decay, interact, or escape the detector. The particles that interact have their energy or momentum measured by the detector, where different layers specialize in measuring certain classes of particles. From the final state energy and momentum measurements, the initial state proton-proton collision and everything in between is reconstructed.

1.2 The Large Hadron Collider

The LHC is a circular collider designed to collide proton beams with a centre-of-mass energy of 14 TeV and an instantaneous luminosity of $10^{34} \text{cm}^{-2} \text{s}^{-1}$. (cite lhc paper direct quote). The main accelerator ring consists of two counter rotating proton beams which are incased in an ultra high vacuum to prevent unintended interactions. The beams are accelerated with cryogenic electro-magnets which operate at -273C and are cooled by liquid helium. There are two types of magnets present, 1232 dipole magnets which bend the beam around the ring and 392 quadrapole magnets which focus the beams. The beam itself is structured with

proton bunches, with each bunch spaced 25ns apart and 2808 bunches per beam. The period of recording collision data are referred to as runs. There are two completed runs, denoted as Run I, and Run I with integrated luminosities 58fb^{-1} and 138fb^{-1} respectively. There is also an expected cumulative integrated luminosity of up to 500fb^{-1} including the presently ongoing Run III.

1.3 The CMS Detector

The CMS detector is a hermetic shell that encapsulates the two counter rotating proton beams. The beams collide at the center of the detector and produce outgoing showers of particles that travel transverse to the beam axis. The observable outgoing particles, depending on the type of particle, are then measured in one of the specialized concentric layers of the detector. The initial transverse depiction of sub atomic interaction and intermediate particles can then be reconstructed from the energy and momentum measured in the detector. The total longitudinal momentum is not reconstructable for two reasons: first being that the momentum fraction of the initial quarks is unknown and second is that some particles travel along the beam line outside detector acceptance. There are an abundance of collision seen by the detector but not every event is recorded. Instead, interesting events, say due to the presence of a muon or large missing energy, trigger the detector to take a snap shop and permanently record said interesting event.

The chronology of a particle traversing the detector show in Figure 3.1 is as follows. Particles are produced post-collision at a primary interaction point, or primary vertex, other p-p interactions can occur in the same snapshot and are denoted as pile-up which is a form of noise obfuscating the primary interaction. From either primary or secondary vertices, both charged and neutral particles traverse the first region of the detector, the silicon tracker. The silicon tracker consists of concentric thin electronic sensors that register "hits" from only charged particles. Each sequence of hits can be connected into a "track" represents the

path and origin of the charged particle. The next stop for particles, is the Electromagnetic Calorimeter (ECAL). The ECAL consists of scintillating PbWO₄ crystals that are designed to stop and measure the energy deposits of photon and electrons. The energy deposits from the two are distinguished by tracks that seed ECAL showers. Anything that makes it through the ECAL, encounters the hadronic calorimeter (HCAL). The HCAL consists of brass and plastic scintillators that stop the remaining massive particles and measures their energy. The last two regions of the detector are generally only seen by muons and are the centerpieces of CMS. First is the the solenoidal magnet, which generates a 4 Tesla uniform magnetic field throughout all of the inner regions of the detector. The magnetic field allows the measurements of two important observables charge and momentum. A charged particle's path will bend in the presence of a magnetic field, and the clockwise or counter clockwise trajectory indicates the charge while the curvature of the bend determines the momentum. The outer-most part of the detector is the muon chamber, which similar to the tracker, registers a sequence of hits via drift tubes or cathode strips. The tracks in both the tracker and muon chambers can then be combined to precisely measure the momentum of the muon in addition to resistive plate chambers which act as a hardware level muon trigger.

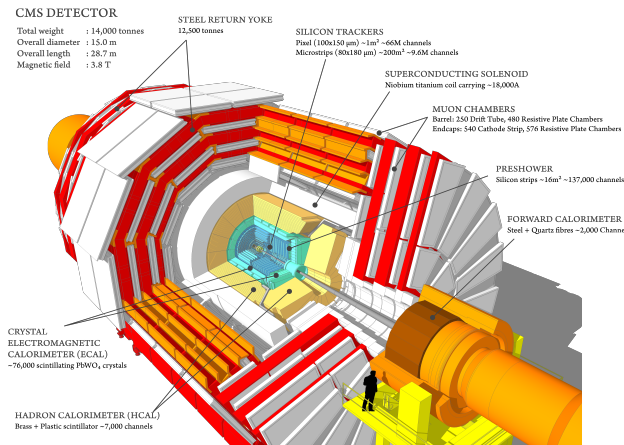


Figure 1.1: plot from CMS of CMS