

**SUSY 2015, 23rd International
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Unification of Fundamental
Interactions**

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Book of Abstracts

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Fundamental/String Theory / 27

Degenerate Kerr vacuum and a D-brane correction

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We revisit an effective curvature formalism underlying a two form in a U(1) gauge theory on a D4-brane in presence of a background black hole metric. Alternately the scenario may be analysed in presence of an extra fifth dimension transverse to a vacuum created gravitational pair of 3-brane and anti 3-brane by the Kalb-Ramond quanta. Interestingly an electric (non-linear) charge independence of an event horizon in a “Kerr-Newman” brane universe is shown to describe a degenerate brane vacuum. In a low energy limit the electric charge regains significance at the expense of the degeneracy. In the limit the brane universe is shown to reduce to a typical 4D Kerr-Newman black hole in presence of an extra fifth hidden dimension. It is argued that a D-brane correction, underlying a propagating torsion, becomes insignificant in a low energy limit. Our analysis reveals that a degenerate “Kerr brane” may be viewed as a low energy perturbative string vacuum in presence of a non-perturbative correction.

SUSY Expt. and Phenomenology / 32

Higgscision in the Minimal Supersymmetric Standard Model

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We perform global fits to the most recent data (after summer 2014) on Higgs boson signal strengths in the framework of the minimal supersymmetric standard model (MSSM). The heavy supersymmetric (SUSY) particles such as squarks enter into the loop factors of the Hgg and $H\gamma\gamma$ vertices while other SUSY particles such as sleptons and charginos also enter into that of the $H\gamma\gamma$ vertex. We also take into account the possibility of other light particles such as other Higgs bosons and neutralinos, such that the 125.5 GeV Higgs boson can decay into. We use the data from the ATLAS, CMS, and the Tevatron, with existing limits on SUSY particles, to constrain on the relevant SUSY parameters. We obtain allowed regions in the SUSY parameter space of squark, slepton and chargino masses, and the μ parameter.

SUSY Expt. and Phenomenology / 33

Probing top-philic sgluons with LHC Run I data

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Many theories beyond the Standard Model predict the existence of colored scalar states, known as sgluons. Sgluons are expected to be copiously pair-produced at the LHC via strong interactions. In scenarios where they are top-philic, such as SUSY with Dirac gauginos, sgluons can be sought in multitop events at the LHC. We revisit two LHC Run I analyses that utilise events with either the same-sign dileptonic or single leptonic decay of a four-top-quark system.

Employing both parameterisations of the detector response and a novel Matrix-Element method, reinterpretation of these two analyses are performed in the context of sgluon production. Adopting a simplified model approach, this reinterpretation allows us to extract bounds on the sgluon mass, and for the first time in the field, its couplings.

Particle Cosmology / 34

Constraining multifield inflation and supersymmetry breaking in no-scale supergravity

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Since the building-blocks of supersymmetric models include chiral superfields containing pairs of effective scalar fields, a multifield approach is particularly appropriate for models of inflation based on supergravity. We discuss two-field effects in no-scale supergravity models motivated by string compactifications, and show how they can alter the model predictions for the scalar spectral index n_s and the tensor-to-scalar ratio r . In particular, we show that no-scale models naturally yield Planck-friendly results, in the form of an effective Starobinsky potential for the inflaton, or through a reduction of r to very small values, $r \ll 0.1$, due to an enhancement of the scalar power spectrum, in chaotic models with a quadratic potential.

We also discuss phenomenological aspects of our no-scale models, which exhibit a variety of possible patterns of soft supersymmetry breaking, including examples of the pure no-scale type $m_0 = B_0 = A_0 = 0$, of the CMSSM type with universal A_0 and $m_0 \neq 0$ at a high scale, and of the mSUGRA type with $A_0 = B_0 + m_0$ boundary conditions at the high input scale. We finally discuss inflaton decays and reheating bounds on inflation, including scenarios where the inflaton possesses direct Yukawa couplings to MSSM fields, where the inflaton decays via gravitational-strength interactions, and in the presence of a non-trivial gauge kinetic function.

Precision SUSY/Higgs/MCTools / 35

Prospects for SUSY discovery after the LHC Run 1

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We present the prospects for SUSY searches at the LHC, e^+e^- colliders, based on our pMSSM10 analysis as presented in arXiv:1504.03260. This talk is submitted on behalf of the MasterCode collaboration. It is not clear yet who will actually give the talk.

Particle Cosmology / 36

Prospects for SUSY DM after the LHC Run 1

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We present the prospects for the searches for DM at the LHC, future e^+e^- colliders and direct detection experiments, based on our pMSSM10 analysis as presented in arXiv:1504.03260. This talk is submitted on behalf of the MasterCode collaboration. It is not clear yet who will actually give the talk.

Precision SUSY/Higgs/MCTools / 37

Higgs to SUSY decays at the full one-loop level

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We present recent result for the decay of (heavy) SUSY Higgs bosons into SUSY particles (sfermions, charginos, neutralinos), based on a full one-loop calculation. We analyze in particular the dependence on the complex parameters of the model. We find corrections at the level of 10-20% or higher.

Flavor Violation / 38

Effects of Sfermion Mixing induced by RGE Running in the Minimal Flavor Violating CMSSM

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We analyze the effects of (squark and slepton) flavor violation induced by RGE running from the GUT scale within the CMSSM. We show that these effects, in particular in the scalar quark sector, can induce corrections to electroweak precision observables that can set an upper limit on the scalar mass parameter m_0 .

Precision SUSY/Higgs/MCTools / 39

Status and prospects of FeynHiggs

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We review the status and the prospects for (N)MSSM Higgs precision calculations, as incorporated into the code FeynHiggs.

Particle Cosmology / 40

Higgs inflation after Planck

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The only observed elementary scalar, the Higgs, is examined as a source of cosmological inflation. I would discuss how the collider data on Higgs would imply for the cosmology and how the latest cosmological data would affect the precision measurement of particle physics, especially in the top quark mass measurement and the Higgs quartic coupling measurement, based on Higgs inflation framework.

SUSY Expt. and Phenomenology / 41

Constraints on sneutrino dark matter from LHC Run 1

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A mostly right-handed sneutrino as the lightest supersymmetric particle (LSP) is an interesting dark matter candidate, leading to LHC signatures which can be quite distinct from those of the conventional neutralino LSP. Using SModelSv1.0.1 for testing the model against the limits published by ATLAS and CMS in the context of so-called Simplified Model Spectra (SMS), we investigate to what extent the supersymmetry searches at Run 1 of the LHC constrain the sneutrino-LSP scenario. Moreover, we discuss the most relevant topologies for which no SMS results are provided by the experimental collaborations but which would allow to put more stringent constraints on sneutrino LSPs. These include, for instance, the mono-lepton signature which should be particularly interesting to consider at Run 2 of the LHC. (This talk is based on arXiv:1503.02960)

SUSY Expt. and Phenomenology / 42

Exploring SUSY from below

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We analyse the mass reach for electroweakinos at future hadron colliders and their interplay with direct detection experiments. Motivated by the LHC data, we focus on split supersymmetry models with different electroweakino spectra. We find for example that a 100 TeV collider may explore Winos up to ~ 7 TeV in low scale gauge mediation models or thermal Wino dark matter around 3 TeV in models of anomaly mediation with long-lived Winos. We show moreover how collider searches and direct detection experiments have the potential to cover large part of the parameter space even in scenarios where the lightest neutralino does not contribute to the whole dark matter relic density.

SUSY/String Models / 43

SUSY $SU(3)_C \otimes SU(2)_L \otimes U(1)_{Y'} \otimes U(1)_{B-L}$ model with three identical right-handed neutrinos

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We build the complete supersymmetric version of a $SU(3)_C \otimes SU(2)_L \otimes U(1)_{Y'} \otimes U(1)_{B-L}$, where B and L are the usual baryonic and leptonic numbers, gauge model ($SUSY321Y'(B-L)$) with total lepton number $L = +1$ using the superfield formalism. This model is interesting because generate masses for all neutrinos; there is good candidate to Dark Matter; there are flat directions; the lightest right-handed sneutrino, due a Majorana phases in its masses matrices, can induce Leptogenesis and also CP violation, in order to explain the matter asymmetry in the universe.

We also, present an analysis of the mass spectrum of the fermions, gauge bosons and the scalar fields are presented.

SUSY Expt. and Phenomenology / 44

SUSY with radiatively-driven naturalness at the LHC and ILC

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Electroweak naturalness requires a SUSY μ parameter ~ 100 - 200 GeV while $m_{H_u}^2$ is driven radiatively to small negative values.

A small μ parameter can be easily generated from large $m_{3/2}$ via radiative breakdown of Peccei-Quinn symmetry.

Highly mixed top squarks may exist in the few TeV range at little cost to naturalness.

Imposing naturalness in both the EW and QCD sectors leads to two dark matter particles: the axion and a higgsino-like WIMP.

LHC13 can probe roughly half the natural SUSY parameter space although a unique same-sign diboson signature is distinctive.

The required light higgsinos means that ILC can make a thorough search for SUSY naturalness and will be a higgsino factory in addition to a Higgs factory.

Higgs Expt., Theory and Phenomenology / 46

Partially Natural Two Higgs Doublet Models

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It is possible that the electroweak scale is low in part due to selection effects, i.e., fine-tuning of the microscopic parameters. The experimental discovery of new light fundamental scalars other than the Standard Model Higgs boson would cast doubt on this theory, since generically such states imply parametrically worse fine-tuning with no compelling connection to selection effects. However, discovering new scalars does not guarantee that the electroweak scale is natural. We discuss counterexamples in which the Higgs boson is light because of fine-tuning and a second scalar doublet is light because of simple discrete symmetries. Such models typically require new vector-like fermions and can have a rich electroweak vacuum structure. The mechanism we discuss cannot be easily applied to protect a small m_A in split or high-scale SUSY-breaking scenarios of the MSSM due to an incompatibility between the discrete symmetries and holomorphy.

Alternative Theories / 47

SHiP: a new fixed target facility for searching for long-lived feebly interacting neutral particles

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SHIP is a new general purpose fixed target facility, whose Technical Proposal has been recently submitted to the CERN SPS Committee. In its initial phase, the 400GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating 2×10^{20} pot in 5 years. A dedicated detector, based on a long vacuum tank followed by a spectrometer and particle identification detectors, will allow probing a variety of models with light long-lived exotic particles and masses below a few GeV/c². The main focus will be the physics of the so-called Hidden Sector, namely the search for Dark Photons, light scalars and pseudo-scalars and massive neutrinos. Some of these particles may be relevant within the context of SUSY models, which provides an interesting phenomenology to e.g. Vector Portal. Direct detection of light and long-lived SUSY particles, such as RPV neutralinos, s-Goldstinos, pseudo-Dirac gauginos could also be performed in an unexplored parameter range. This talk will be largely based on the paper Alekhin et al, arXiv: 1504.04855v1.

Alternative Theories / 48

Searches for long-lived heavy particles at LHCb

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Thanks to its forward acceptance and good resolution, the LHCb experiment is competitive in searches for heavy long-lived particles beyond the Standard Model. We report a search for the stau particle with the LHCb detector and give our prospects for searches of Hidden Valley particles.

Flavor Violation / 49

CP violation measurements at LHCb

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B and D mesons provide an ideal laboratory for measurements of CP violation and searches for CPV beyond the Standard Model. We present recent LHCb results on measurements from several decay modes and based on different techniques, including time-dependent, time-integrated and dalitz analyses.

Flavor Violation / 50

Searches for long-lived light particles and Majorana neutrinos at LHCb

Author: Stefania Vecchi¹

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Many models extending the SM to account for dark matter or explain inflation predict the existence of O(1) GeV mass particles with long lifetimes. LHCb's detection capabilities for detached vertices are exploited to search for particles decaying to muon pairs. New results are presented.

Flavor Violation / 51

Electroweak penguin decays to leptons and Radiative decays at LHCb

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Electroweak and radiative penguin b-hadron and c-hadron decays set strong constraints on the SUSY parameter space. Recent LHCb measurements have shown indications of large unexpected asymmetries in $B \rightarrow K^* \mu \mu$ and hints of lepton universality violation. Latest results involving new decay modes are presented.

SUSY/String Models / 52

Non universal gaugino mass models vis-a-vis LHC and Dark Matter

Authors: Joydeep Chakraborty¹; Soumya Rao²; Subhendra Mohanty³¹ *IIT Kanpur*² *University of Adelaide*³ *PRL Ahmedabad*

We perform a comprehensive study of SU(5), SO(10) and E(6) supersymmetric GUT models where the gaugino masses are generated through the F-term breaking vacuum expectation values of the non-singlet scalar fields. In these models the gauginos are non-universal at the GUT scale unlike in the mSUGRA scenario. We discuss the properties of the LSP which is stable and a viable candidate for cold dark matter. We look for the GUT scale parameter space that leads to the lightest SM like Higgs mass in the range of 122-127 GeV compatible with the observations at ATLAS and CMS, the relic density in the allowed range of WMAP-PLANCK and compatible with other constraints from colliders and direct detection experiments. We scan universal scalar m_0 , trilinear coupling A_0 and SU(3)_C gaugino mass M_3 as the independent free parameters for these models. Based on the gaugino mass ratios at the GUT scale, we classify 25 SUSY GUT models and find that of these only 13 models satisfy the dark matter and collider constraints. Out of these 13 models there is only one model where there is a sizeable SUSY contribution to muon ($g-2$).

Higgs Expt., Theory and Phenomenology / 53

Scrutinizing the Alignment Limits in the Two Higgs Doublet Models

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After the discovery of a 125 GeV Higgs boson with properties close to those predicted in the Standard Model (SM), it is crucial to assess the existence of an extended Higgs sector. The framework of the two Higgs doublet models (2HDM) is particularly simple and well suited for such considerations. The alignment limit, realized either through decoupling of the additional Higgs states or the absence of mixing between the two doublets in the so-called Higgs basis, is often considered to recover SM-like properties of one of the CP-even state.

After a short review of the 2HDM and the constraints imposed from the observation of a SM-like Higgs boson, I will introduce the notion of alignment in the 2HDM. A numerical exploration of this regime is performed and results contrasting the alignment regimes with and without decoupling are discussed. Implications for the coming 13 TeV LHC run, including expectations regarding other lighter or heavier Higgs bosons are given.

Precision SUSY/Higgs/MCTools / 54

Naturalness and supersymmetry

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I review the Bayesian naturalness prior which incorporates the most widely used fine-tuning measures as special cases. Then I present the amount of Bayesian fine-tuning over parameter space slices of the Constrained MSSM, the Constrained NMSSM, and an 11 parameter NMSSM scenario.

Higgs Expt., Theory and Phenomenology / 55

Light Charged Higgs Bosons to AW/HW via Top Decay

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While current ATLAS and CMS measurements exclude a light charged Higgs ($m_{H^\pm} < 160$ GeV) for most of the parameter region in the context of the MSSM scenarios, these bounds are significantly weakened in the Type II 2HDM once the exotic decay channel into a lighter neutral Higgs, $H^\pm \rightarrow AW/HW$, is open. In this study, we examine the possibility of a light charged Higgs produced in top decay via single top or top pair production, with the subsequent decay $H^\pm \rightarrow AW/HW$, which can reach a sizable branching fraction at low $\tan\beta$ once it is kinematically permitted. With a detailed collider analysis, we obtain exclusion and discovery bounds for the 14 TeV

LHC assuming the existence of a 70 GeV neutral scalar. Assuming $\text{BR}(H^\pm \rightarrow AW/HW) = 100\%$ and $\text{BR}(A/H \rightarrow \tau\tau) = 8.6\%$, the 95% exclusion limits on $\text{BR}(t \rightarrow H^\pm b)$ are about 0.2% and 0.03% for single top and top pair production respectively, with an integrated luminosity of 300 fb^{-1} . The discovery reaches are about 3 times higher. In the context of the Type II 2HDM, discovery is possible at both large $\tan\beta > 17$ for $155 \text{ GeV} < m_{H^\pm} < 165 \text{ GeV}$, and small $\tan\beta < 6$ over the entire mass range. Exclusion is possible in the entire $\tan\beta$ versus m_{H^\pm} plane except for charged Higgs masses close to the top threshold. The exotic decay channel $H^\pm \rightarrow AW/HW$ is therefore complementary to the conventional $H^\pm \rightarrow \tau\nu$ channel.}

Precision SUSY/Higgs/MCTools / 56

Higgs Bosons in Heavy Supersymmetry with an intermediate M_A

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The MSSM leads to precise predictions of the properties of the light Higgs boson degrees of freedom that depend on only a few relevant supersymmetry breaking parameters. There is an upper bound on the mass of the lightest neutral Higgs boson, which for a supersymmetric spectrum of the order of a TeV, is barely above the measured $M_h = 125 \text{ GeV}$ at the LHC. Raising this bound by considering a heavier supersymmetric spectrum has consequences for what can be observed at the LHC. In a previous article, we studied the variation of the predicted lightest CP-even Higgs mass for large values of the scalar-top and heavy Higgs boson masses. We perform a similar analysis, considering also the case of CP-odd Higgs boson masses of the order of the weak scale. We perform the calculation using effective theory techniques, considering a two-Higgs doublet model and a SM-like theory and resumming the large logarithmic corrections that appear at scales above and below the CP-odd Higgs boson mass, respectively. We calculate the mass and couplings of the lightest CP-even Higgs boson and compare our results with the ones obtained by other methods.

Flavor Violation / 58

Flavor ratios of extragalactical neutrinos and neutrino shortcuts in extra dimensions

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The recent measurement of high energy extragalactic neutrinos by the IceCube Collaboration has opened a new window to probe non-standard neutrino properties. Among other effects, sterile neutrino altered dispersion relations (ADRs) due to shortcuts in an extra dimension can significantly affect astrophysical flavor ratios. We discuss an MSW-like resonant conversion arising from geodesics oscillating around the brane in an asymmetrically warped extra dimension. We demonstrate that this case has the potential to suppress significantly the flux of specific flavors such as ν_μ or ν_τ at high energies.

Higgs Expt., Theory and Phenomenology / 59**Dilepton constraints in the Inert Doublet Model from Run 1 of the LHC**

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Searches in final states with two leptons plus missing transverse energy, targeting supersymmetric particles or invisible decays of the Higgs boson, were performed during Run 1 of the LHC. Recasting the results of these analyses in the context of the Inert Doublet Model (IDM) using MadAnalysis 5, we show that they provide constraints on inert scalars that significantly extend previous limits from LEP. Moreover, these LHC constraints allow to test the IDM in the limit of very small Higgs-inert scalar coupling, where the constraints from direct detection of dark matter and the invisible Higgs width vanish.

Alternative Theories / 61**Improved bounds on heavy neutrino productions at the 8 TeV LHC**

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With the heavy Standard Model (SM) singlet neutrinos, the (inverse) seesaw mechanism provides us with a natural way to incorporate the neutrino mass in the SM. If the heavy neutrinos have their mass of the electroweak scale, they can be produced at the Large Hadron Collider (LHC) through their mixing with the SM light neutrinos. We investigate the heavy neutrino production processes at the LHC with a variety of initial states at the parton level, such as quark-quark annihilation, quark-gluon and gluon-gluon fusions, as well as the collision of proton with a photon radiated from the other proton, for the final states including up to two jets. We simulate signal events for the heavy neutrino productions for both pseudo-Dirac and Majorana cases. Comparing our simulation results with the current CMS and ATLAS data, we obtain the upper bound on the mixing angle between the heavy and SM light neutrinos. We find that the heavy neutrino production processes associated with two jets yield a sizable contribution to the total heavy neutrino production cross section and therefore, the upper bound on the mixing angle is improved from the one obtained in previous analysis.

Higgs Expt., Theory and Phenomenology / 62**Classically conformal U(1)' extended Standard Model and Higgs vacuum stability**

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We consider the minimal $U(1)'$ extension of the Standard Model (SM) with conformal invariance at the classical level, where in addition to the SM particle contents, three generations of right-handed neutrinos and a $U(1)'$ Higgs field are introduced. In the presence of the three right-handed neutrinos, which are responsible for the seesaw mechanism, this model is free from all the gauge and gravitational anomalies. The $U(1)'$ gauge symmetry is radiatively broken via the Coleman-Weinberg mechanism, by which the $U(1)'$ gauge boson (Z' boson) mass as well as the Majorana mass for the right-handed neutrinos are generated. The radiative $U(1)'$ symmetry breaking also induces a negative mass squared for the SM Higgs doublet to trigger the electroweak symmetry breaking. In this context, we investigate a possibility to solve the SM Higgs vacuum instability problem. The model includes only three free parameters ($U(1)'$ charge of the SM Higgs doublet, $U(1)'$ gauge coupling and Z' boson mass), for which we perform parameter scan, and identify a parameter region resolving the SM Higgs vacuum instability. We also examine naturalness of the model. The heavy states associated with the $U(1)'$ symmetry breaking contribute to the SM Higgs self-energy. We find an upper bound on Z' boson mass, $m_{Z'} \lesssim 6$ TeV, in order to avoid a fine-tuning severer than 10 % level. The Z' boson in this mass range can be discovered at the LHC Run-2 in the near future.

Precision SUSY/Higgs/MCTools / 63

Phenomenological constraints on an R-symmetric supersymmetric model from LHC and precision observables

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R-Symmetry is an additional symmetry which can be imposed on a supersymmetric model, leading to interesting phenomenological consequences like the prediction of Dirac Gauginos. A model with a minimal implementation of this symmetry is the MRSSM and in this talk an analysis of its Higgs sector in the light of the recent SM-like Higgs boson discovery will be presented.

Due to mixing with additional scalars, which may reduce the tree level mass substantially compared to the usual MSSM upper limit, and the absence of stop mixing induced by R-Symmetry, it is not immediately clear that this model can accommodate a 125 GeV SM-like Higgs. We will show the phenomenological impact of relevant one-loop and two-loop contributions in the MRSSM

that are necessary to overcome those issues.

Additionally, as potentially large contributions to EWPO can arise in the model, we will identify regions of parameter space where simultaneous agreement with the measured Higgs mass and constraints from precision measurements is possible.

Particle Cosmology / 64

Dark Photons from the Sun

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We propose a novel search for dark matter using the directional capabilities of the AMS-02 telescope to identify dark photons coming from dark matter annihilation. Dark matter collects in the core of the Sun and annihilates into dark photons which then decay to known particles on their way to the Earth. For weak-scale dark matter, dark photons of mass MeV – GeV, and kinematic mixing parameters between $10e-11$ and $10e-8$, this process produces smoking gun signals of dark matter that may be detected as positrons that point back to the Sun.

SUSY/String Models / 65

Chiral low-energy physics from squashed branes in deformed N=4 SYM

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We discuss the low-energy physics which arises on stacks of squashed brane solutions of SU(M) N=4 SYM, deformed by a cubic soft SUSY breaking potential. A brane configuration is found which leads to a low-energy physics similar to the standard model in the broken phase, assuming suitable VEV's of the scalar zero modes. Due to the triple self-intersection of the (fuzzy) branes, the matter content includes that of the MSSM with precisely 3 generations and right-handed neutrinos. No exotic quantum numbers arise, however there are extra chiral superfields with the quantum numbers of the Higgs doublets, the W,Z, e_R and u_R, whose fate depends on the details of the rich Higgs sector. The chiral low-energy sector is complemented by a heavy mirror sector with the opposite chiralities, as well as super-massive Kaluza-Klein towers completing the N=4 multiplets. The sectors are protected by two gauged global U(1) symmetries. Analogous solutions arise in the deformed IIB matrix model.

Fundamental/String Theory / 67

A relation between deformed superspace and Lee-Wick higher-derivative theories

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We propose a non-anticommutative superspace with the interesting property of relating to Lee-Wick type of higher derivatives theories, which are known for their interesting properties, and have led to proposals of phenomenologically viable higher derivatives extensions of the Standard Model. The deformation of superspace we consider does not preserve supersymmetry or associativity in general, however, we show that a non-anticommutative version of the Wess-Zumino model can be properly defined. In fact, the definition of chiral and antichiral superfields turns out to be simpler in our case

than in the well known $N = 1/2$ supersymmetric case. We show that, when the theory is truncated at the first nontrivial order in the deformation parameter, supersymmetry is restored, and we end up with a well known Lee-Wick type of higher derivative extension of the Wess-Zumino model. Thus we show how non-anticommutativity could provide an alternative mechanism for generation of these kind of higher derivative theories.

Flavor Violation / 70

A way to crosscheck μ -e conversion in the case of no signals of $\mu \rightarrow e\gamma$ and $\mu \rightarrow 3e$

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We consider the case that μ -e conversion signal is discovered but other charged lepton flavor violating (cLFV) processes will never be found. In such a case, we need other approaches to confirm the μ -e conversion and its underlying physics without conventional cLFV searches.

We study R-parity violating (RPV) SUSY models as a benchmark. We briefly review that our interesting case is realized in RPV SUSY models with reasonable set of parameters according to current theoretical/experimental status. We focus on the exotic collider signatures at the LHC ($pp \rightarrow \mu e +$ and $pp \rightarrow jj$) as the other approaches. We show the correlations between the branching ratio of μ -e conversion process and cross sections of these processes. It is first time that the correlations are graphically shown. We exhibit the RPV parameter dependence of the branching ratio and the cross sections, and discuss the feasibility to determine the parameters.

Higgs Expt., Theory and Phenomenology / 71

Exclusive Radiative Higgs Decays as Probes of Non-Standard Yukawa Couplings

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We present a detailed analysis of the rare exclusive Higgs-boson decays into a single vector meson and a photon and investigate the possibility of using these processes to probe the light-quark Yukawa couplings. We work with an effective Lagrangian with modified Higgs couplings to account for possible new-physics effects in a model-independent way. The $h \rightarrow V\gamma$ decay rate is governed by the destructive interference of two amplitudes, one of which involves the Higgs coupling to the quark anti-quark pair inside the vector meson. We derive this amplitude at next-to-leading order in α_s using QCD factorization, including the resummation of large logarithmic corrections and accounting for the effects of flavor mixing. The high factorization scale $\mu \sim m_h$ ensures that our results are rather insensitive to poorly known hadronic parameters. The second amplitude arises from the loop-induced effective $h\gamma\gamma^*$ and $h\gamma Z^*$ couplings, where the off-shell gauge boson converts into the vector meson. We devise a strategy to eliminate theoretical uncertainties related to this amplitude to almost arbitrary precision. This opens up the possibility to probe for $\mathcal{O}(1)$ modifications of the c - and b -quark Yukawa couplings and $\mathcal{O}(30)$ modifications of the s -quark Yukawa coupling in the high-luminosity LHC run. In particular, we show that measurements of the ratios $\text{Br}(h \rightarrow \Upsilon(nS)\gamma)/\text{Br}(h \rightarrow \gamma\gamma)$ and $\text{Br}(h \rightarrow b\bar{b})/\text{Br}(h \rightarrow \gamma\gamma)$ can provide complementary information on

the real and imaginary parts of the b -quark Yukawa coupling. More accurate measurements would be possible at a future 100\,TeV proton-proton collider.

Particle Cosmology / 72

Indirect and direct detection of sneutrino dark matter

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In this talk we present the phenomenology of a mostly right-handed sneutrino as the lightest supersymmetric particle (LSP) and dark matter candidate. We focus our attention on indirect detection signals such as enhanced monochromatic neutrino lines in the reach of future neutrino probe. Furthermore we illustrate the complementarity between indirect and direct detection of sneutrino LSP with LHC constraints in the context of simplified model spectra.

SUSY/String Models / 73

Radiative Breaking of the Minimal Supersymmetric Left-Right Model

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We propose a new variation to the SUSY Left-Right model (LRM) by extending the Minimal B-L model. Starting from energies of $\sqrt{s} > 7$ TeV, we can describe an intermediate scale for Grand Unification along the Pati-Salam path from $SO(10)$. Here the breaking of $SU(2)_L \times SU(2)_R \times U(1)_{B-L} \rightarrow SU(2)_L \times U(1)_Y$ is by a doublet rather than a triplet. Analyzing the RGE equations, the right handed neutral component of the doublet L_c acquires a negative mass squared at low energies. At least one generation spontaneously acquires a nonzero VEV and breaks the LRM symmetry into the MSSM. A seesaw is induced through gauge couplings maintaining light active neutrinos as well as heavy sterile neutrinos after Left-Right Breaking.

SUSY/String Models / 74

Light Fields and Flat Directions from Nonlinear Sigma Models in Supergravity

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We present a common solution to the puzzles of the light Higgs or quark masses and the need for a shift symmetry and large field values in high scale inflation. One way to protect, for example, the Higgs from a large supersymmetric mass term is if it is the Nambu-Goldstone boson (NGB) of a nonlinear sigma model (NLSM). However, it is well known that NLSMs with nontrivial Kähler transformations are problematic to couple to supergravity. An additional field is necessary to make the Kähler potential of the NLSM invariant in supergravity. This field must have a shift symmetry – making it a candidate for the inflaton (or axion). We give an explicit example of such a model for the coset space $SU(3)/SU(2) \times U(1)$, with the Higgs as the NGB. Along the way we clarify and connect previous work on understanding NLSMs in supergravity and the origin of the extra field (which is the inflaton here), including a connection to Witten-Bagger quantization. This framework has wide applications to model building; a light particle from a NLSM requires, in supergravity, exactly the structure for chaotic inflaton or an axion.

Higgs Expt., Theory and Phenomenology / 75

Phenomenology of Induced Electroweak Symmetry Breaking

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In this talk, I will discuss scenarios of induced electroweak symmetry breaking (EWSB), where the Higgs vacuum expectation value is induced by another EWSB source. These additional sources can be due to another Higgs vev or technicolor sector and can mitigate constraints on beyond the Standard Model theories (e.g. raising the Higgs mass in supersymmetric models). I will discuss the collider constraints and phenomenology of these models, showing that there are both viable parameter space and striking signatures of cascades with multiple electroweak gauge bosons and 3rd generation fermions. Finally, our projections indicate that searches at run 2 of the LHC can cover the remaining parameter space, reflecting how much the LHC can still discover about the mechanism of EWSB.

SUSY/String Models / 76

RPV from Discrete R Symmetries

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With LHC not observing superpartners, minimal supersymmetric versions of the Standard Model (SM) are very constrained. We consider supersymmetric extensions of the SM in which the usual R or matter parity gets replaced by another R or non-R discrete symmetry that explains the observed longevity of the nucleon and solves the μ problem of MSSM. Such R-parity violating scenarios may lead to interesting phenomenology and explain why superpartners have not been observed yet. In order to identify suitable symmetries, we develop a novel method of deriving the maximal Abelian Z(R)N symmetry that satisfies a given set of constraints (such as those from anomaly freedom and phenomenology). We identify R parity violating (RPV) and conserving models that are consistent with precision gauge unification and also comment on their compatibility with a unified gauge symmetry such as the Pati-Salam group. We shall also provide a counter-example to the statement found in the recent literature that the lepton number violating RPV scenarios must have μ term and the bilinear κ L Hu operator of comparable magnitude. Finally, we will briefly comment on how baryogenesis and certain baryon number violating processes may arise within such simple models.

Higgs Expt., Theory and Phenomenology / 77

Status of MSSM (BSM) XS and BR calculations

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I will review the current status of Higgs cross section and branching ratio calculations in the MSSM and other BSM theories with extended Higgs sectors.

SUSY Expt. and Phenomenology / 78

Inclusive searches for squarks and gluinos with the ATLAS detector

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Despite the absence of experimental evidence, weak scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS results on inclusive searches for promptly decaying supersymmetric squarks and gluinos in events containing jets, missing transverse momentum with and without light leptons. The results presented utilise 20/fb of 8 TeV pp collision data collected by the ATLAS detector at the LHC, and prospects for 13 TeV Run-2 data are also included. First results with run2 data will be included if available

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Searches for direct pair production of third generation squarks with the ATLAS detector

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Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Top or bottom squarks with masses of a few hundred GeV can also give rise to large direct pair production rates at the LHC. The talk presents recent ATLAS results from searches for direct stop and sbottom pair production, using 20/fb of 8 TeV pp collision data, and prospects for 13 TeV Run-2 data are also included.

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Searches for electroweak production of supersymmetric gauginos and sleptons with the ATLAS detector

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Many supersymmetry models feature gauginos and also sleptons with masses less than a few hundred GeV. These can give rise to observable direct pair production rates at the LHC. The talk presents results from searches for gaugino and slepton pair production in final states with leptons, using 20/fb of 8 TeV pp collision data collected by the ATLAS detector at the LHC, with an emphasis on compressed mass spectra.

SUSY Expt. and Phenomenology / 81

Searches for R-Parity violating SUSY with lepton number violation

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The violation of R-parity allows new signatures to be pursued in the search for supersymmetry at the LHC. This talk presents the latest results from the ATLAS experiment using 20/fb of pp LHC collision data of searches for R-parity violating SUSY scenarios with lepton number violation. The results presented are for dedicated searches for resonances, as well as a systematic analysis of the constraints placed on R-parity violating models with lepton flavour violation by the Run-1 ATLAS searches, including those which were originally developed to target R-parity conserving models.

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Searches for R-Parity violating SUSY with baryon number violation

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The violation of R-parity allows new signatures to be pursued in the search for supersymmetry at the LHC. This talk presents the latest results from the ATLAS experiment using 20/fb of pp LHC collision data of searches for R-parity violating SUSY scenarios with baryon number violation. The searches look for an excess of events with high jet multiplicities or resonances in fully hadronic final states with no explicit missing transverse momentum requirement, over the Standard Model expectation.

SUSY Expt. and Phenomenology / 83

Searches for SUSY in photons and tau channels with the ATLAS detector

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The talk presents searches for the prompt decay of supersymmetric particles in events containing photons or taus and large transverse missing momentum, performed by the ATLAS experiment. The final states considered are particularly motivated in gauge mediated supersymmetry breaking models with a light gravitino as the lightest supersymmetric particle. Results obtained with 20 fb⁻¹ of pp collisions at sqrt(s) = 8 TeV are presented.

SUSY Expt. and Phenomenology / 84

Searches for long lived SUSY particles

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Several supersymmetric models predict massive long-lived supersymmetric particles with lifetimes from fractions of a nanosecond to lifetimes that are effectively stable in the detector. Such particles may be detected through abnormal specific energy loss, disappearing tracks, displaced vertices, long time-of-flight or late calorimetric energy deposits. The talk presents recent results from searches for long-lived supersymmetric particles with the ATLAS detector. Results will be based on 20 fb⁻¹ of pp collisions at sqrt(s) = 8 TeV. First results with run2 data will also be included if available.

SUSY Expt. and Phenomenology / 85

The effect of ATLAS Run-1 supersymmetric searches in the pMSSM

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The results of supersymmetric searches at the LHC are typically presented in the context of simplified models, with a single specific production channel

and decay mode for the supersymmetric particles. In full SUSY models, several production and decay channels are expected, and the limits

on supersymmetric particle masses might be weaker. In this talk, results from the searches performed by the ATLAS experiment with the LHC

run1 data are used to place constraints on the 19-parameter phenomenological MSSM. The resulting exclusion limits on the masses of supersymmetric partners are presented and compared to those obtained with simplified models.

SUSY Expt. and Phenomenology / 86

Searches for squarks and gluinos in two lepton final states (covering Z+MET, di-lepton edge and 2L razor)

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The search for the supersymmetric partners of the Standard Model quarks and gluons is one of the priorities of the ATLAS experiment

in the quest for Beyond the Standard Model signals. Recent results in the channel with two electrons or muons, jets and missing transverse

momentum are presented. The results are obtained using 20/fb of proton-proton collisions recorded by the ATLAS experiment at the LHC

at a center of mass energy of 8 TeV.

Fundamental/String Theory / 87

Thermodynamics of Quasi-Topological Black Holes in Presence of Born-Infeld Field

Author: Mohammad Ghanaatian¹

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¹ *Payame Noor University*

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Quartic quasi-topological black holes in the presence of a nonlinear electromagnetic Born-Infeld field is presented. By using the metric parameters, the charged black hole solutions of quasi-topological Born-Infeld gravity is considered. The thermodynamics of these black holes are investigated and I show that the thermodynamics and conserved quantities verify the first law of thermodynamics. I also introduce the thermodynamics of asymptotically AdS rotating black branes with flat horizon of these class of solutions and I calculate the finite action by use of the counterterm method inspired by AdS/CFT correspondence.

Fundamental/String Theory / 88

Stability of Nonlinear Charged Black Holes in Anti-de Sitter Quasi-Topological Gravity

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¹ *Jahrom University*

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In this paper, we investigate the stability of nonlinear charged black holes in quartic quasitopological gravity in the presence of a nonlinear electromagnetic field. The entropy of the charged black holes of fourth order quasitopological gravity through the use of Wald formula is computed and the mass, temperature and the charge of these black holes are found as well. We show that black holes with spherical, flat and hyperbolical horizon in quasitopological gravity are stable for any allowed quasitopological parameters.

Higgs Expt., Theory and Phenomenology / 89

Heavy Higgs pure resonance dips in MSSM/2HDM

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We discuss new striking resonance shapes of MSSM heavy Higgs bosons from the resonance-continuum interference with a relative phase: pure resonance dips, nothingness and enhanced pure peaks. We derive conditions for them and devise the modified narrow width approximation (NWA) to work with non-zero imaginary parts. Importantly, $t\bar{t}$ resonance searches at the LHC are crucially impacted. But we will show that the pure A^0 resonance dip is a particularly interesting signal; we can still search for it based on current search techniques (even without any interferences taken into account) and the modified NWA.

ref: 1505.00291

SUSY Expt. and Phenomenology / 90

Long-Lived Sleptons at a 100 TeV Proton Collider (and the LHC)

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This talk, based on arXiv:1505.02996, focuses on collider searches for long-lived charged particles (LLCPs), i.e., charged particles which are observed stable in the detectors.

Their discovery will be extremely exciting and give significant implication for both particle physics and cosmology.

We studied expected sensitivity of such searches at a future proton collider with $\sqrt{s}=100$ TeV with an integrated luminosity of 3000 fb^{-1} .

Adopting the charged slepton as the benchmark candidate of LLCP, we found that a 100 TeV collider has a potential to exclude $m_{\text{slepton}} < 3.2\text{-}4.0$ TeV at 3000 fb^{-1} .

This reach fully covers the neutralino dark matter with slepton-neutralino co-annihilation, and partly does the possible parameter region of SuperWIMP scenario.

Through this work, we noticed two novel features of 100 TeV hadron colliders that affects the search. Firstly, in a 100 TeV hadron collider, radiative energy loss (bremsstrahlung etc.) from muons can be observed.

That is, some muons will be so energetic that lose their energy also via radiative process in the detectors.

It allowed us to distinguish LLCP from muons to reject 34% of background events.

Secondly, we found that, in 100 TeV collider, we should treat momentum resolution carefully.

Momentum resolution in trackers are often approximated as $\Delta p \propto p$, but for much larger p , it scales as $\Delta p \propto p^2$.

With this careful consideration, we found that the mass resolution of LLCPS is significantly deteriorated.

I would like to introduce the two feature to the audience (i.e., usefulness of muon radiative energy loss, and importance of careful treatment of momentum resolution), because they are not specific in LLCP searches, but will important for future discussion of both detector design and collider phenomenology.

Higgs Expt., Theory and Phenomenology / 91

Cutting into Higgs pairs

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Double Higgs production is a unique collider process, enabling the determination of the Higgs self-coupling. However, it is exceedingly rare in the Standard Model, due to the cancellation between the standard triangle and box contributions to the amplitude. I will demonstrate an analytic understanding of this cancellation, and its implications for the impact of new physics on Higgs pair production.

In particular, I will show how the invariant mass distribution in double Higgs production is sensitive to the spins of the particles in the loop diagrams.

Precision SUSY/Higgs/MCTools / 92

Invisible Higgs decays and the Galactic Center Excess in the NMSSM

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The NMSSM is, for several reasons, an attractive extension of the Standard Model. One of them is that the gamma ray excess from the galactic center can be explained with an NMSSM neutralino annihilating through a light pseudoscalar. Such light dark matter candidate will lead to invisible Higgs decays at the LHC. Using SFitter we connect the galactic center excess with the observed dark matter relic density and invisible Higgs decays. Typical branching ratios of a SM-like Higgs to NMSSM neutralinos can easily reach 30%.

Particle Cosmology / 93

Towards a Supersymmetric Description of the Fermi Galactic Center Excess

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Co-authors: James Gainer²; JoAnne Hewett¹; Matthew Cahill-Rowley³

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We attempt to build a model that describes the Fermi galactic gamma-ray excess (FGCE) within a UV-complete Supersymmetric framework; we find this to be highly non-trivial. At the very least a successful Supersymmetric explanation must have several important ingredients in order to fit the data and satisfy other theoretical and experimental constraints. Under the assumption that a single annihilation mediator is responsible for both the observed relic density as well as the FGCE, we show that the requirements are not easily satisfied in many TeV-scale SUSY models, but can be met with some model building effort in the general NMSSM with 10 parameters beyond the MSSM. We find that the data selects a particular region of the parameter space with a mostly singlino lightest Supersymmetric particle and a relatively light CP-odd Higgs boson that acts as the mediator for dark matter annihilation. We study the predictions for various observables within this parameter space, and find that searches for this light CP-odd state at the LHC, as well as searches for the direct detection of dark matter, are likely to be quite challenging. It is possible that a signature could be observed in the flavor sector; however, indirect detection remains the best probe of this scenario.

SUSY Expt. and Phenomenology / 94

Searching for top SUSY partners at compressed regions

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Light top superpartners play a key role in stabilizing the electroweak scale in supersymmetric theories. For R-parity conserved supersymmetric theories, traditional searches are not sensitive to the compressed region $m_{\tilde{t}} \approx m_\chi + m_t$ and $m_{\tilde{t}} \approx m_\chi + m_W + m_b$, where χ is the neutralino. In this talk, I will introduce a new observable R_M whose distribution has a peak at these regions. The position of the peak is strongly related to the mass of the top partner. With this property, I will show that a new multi-jets plus missingET analysis can close the gaps at these compressed regions. In particular, using the LHC with a center of mass energy of 13 TeV and a luminosity of 3000 fb^{-1} , the gap at $m_{\tilde{t}} \approx m_\chi + m_t$ can be closed up to $m_{\tilde{t}} \approx 800 \text{ GeV}$.

Alternative Theories / 95

Gauge-Higgs Grand Unification

Author: Naoki Yamatsu¹

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I will talk about an SO(11) gauge-Higgs grand unified model in the Randall-Sundrum warped space. I will show that orbifold boundary conditions and a brane scalar field correctly break the SO(11) grand unified group into the standard model gauge group; the zero modes of the SO(11) bulk gauge field are corresponding to the SM gauge fields and the SM Higgs field; the zero modes of an SO(11) spinor fermion field are corresponding to one generation of quarks and leptons. This talk is partly based on arXiv:1504.03817 [hep-ph].

Precision SUSY/Higgs/MCTools / 96

Killing the CMSSM softly

Authors: Ben O'Leary¹; Bjorn Sarrazin²; Herbi Dreiner³; Jose Camargo-Molina⁴; Klaus Desch²; Mathias Uhlenbrock²; Matthias Hamer⁵; Michael Kramer⁶; Peter Wienemann⁷; Philip Bechtel²; Tim Stefaniak⁸; Werner Rudolf Porod⁹

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The analysis of the data collected by the major LHC experiments during the LHC Run I has put strong constraints on supersymmetric models. We study the parameter space of the constrained Minimal Supersymmetric Standard Model (CMSSM) in a global fit, taking into account the non-observation of supersymmetry at the LHC, Higgs mass and rate measurements, as well as several cosmological and low energy observables. Before the start of the LHC, global fits of the CMSSM showed a favourable goodness-of-fit and indicated a strong preference for the existence of light SUSY particles. This region now has largely been excluded by the LHC. We present the final results of our study of the status of the CMSSM after the LHC Run1, where for the first time we use toy experiments to determine the p-Value of the model. A special emphasis is given on the dependence of the p-value on the choice of the observable set in the fit, where especially the Higgs rate measurements play a crucial role, since they had the potential for sensitivity to the CMSSM, had the Higgs boson been lighter. We find that the CMSSM is softly getting near its exclusion at the 95% CL.

Flavor Violation / 97

Probing the Standard Model with B-meson decays at BABAR

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We present a selection of recent studies performed by using the full data sample collected by the BABAR detector. Among them are a measurement of CP asymmetries in the B⁰-B⁰bar mixing process by using inclusive dilepton samples, an angular analysis of the B → K* l+l- decay, which might indirectly probe the presence of beyond-Standard-Model particles in the loop diagrams, and studies of semileptonic B- and D-meson decays.

Precision SUSY/Higgs/MCTools / 98

HiggsSignals: Testing new physics models against Higgs measurements

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The public computer tool *HiggsSignals* evaluates the chi-squared compatibility of the Higgs sector predictions of new physics models with the mass and rate measurements of the 125 GeV Higgs boson discovered at the LHC. It is designed for the application to extended Higgs sectors and automatically considers potential signal overlap of multiple Higgs bosons. The chi-squared test takes into account detailed information on experimental signal efficiencies (if known) and the correlations of some of the major systematic uncertainties. The program complements the related public tool *HiggsBounds*,

which tests the Higgs sector predictions against exclusion limits from LEP, Tevatron and the LHC. Together, these tools provide a convenient and complete framework for confronting new physics models with the experimental Higgs results.

In the talk we shall introduce the program *HiggsSignals*, discuss some recent developments and present a few example applications.

Precision SUSY/Higgs/MCTools / 99

MSSM Implications of Higgs searches during LHC Run 1

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We shall present results of a multi-dimensional fit of the phenomenological Minimal Supersymmetric Standard Model (pMSSM) to the LHC Run 1 results. The emphasis of our study lies in particular on the MSSM Higgs sector. We take into account various experimental constraints and measurements from Higgs searches at the LHC and LEP experiments, using the tools *HiggsBounds* and *HiggsSignals*. Furthermore we discuss the impact of including the anomalous magnetic moment of the muon and rare B decays in the fit.

Particle Cosmology / 100

Detecting Dipolar Dark Matter in Beam Dump Experiment

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² *Physical Research Laboratory, Ahmedabad*

We explore the possibility of detecting WIMP (Weakly Interacting Massive Particle) Dark Matter (DM) interacting via photon through its electric or magnetic dipole moments occurring at one loop, in so called Beam Dump experiments. We focus on one such experiment in particular, E613 in Fermilab, which involves a 400 GeV proton beam incident on a Tungsten target producing DM particles in this high energy collision. The DM particles so produced are then detected via scattering off lead nuclei placed behind appropriate shielding. We discuss the limits on the dipolar model of DM coming from such an experiment.

Higgs Expt., Theory and Phenomenology / 101

The low energy theories of the Higgs sector

Author: Daniel Egana-Ugrinovic¹

Co-author: Scott Thomas ¹

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Effective field theory provides an excellent way to organize deviations from the Standard Model Higgs properties, in the case of an extended Higgs sector.

In this talk, we present the low energy theories of the Higgs sector for some of the most popular beyond the standard model UV completions. For brevity, we only consider the Higgs sector extended with a real singlet (xSM) and with a second doublet (2HDM). We work at tree level and we consider all the effective dimension six effects, and the most interesting effective dimension eight effects. The results are simple, illustrative and provide valuable tools for studying the Higgs sector at LHC run II, and for understanding CP and flavor violating effects in a general 2HDM near the decoupling limit.

SUSY Expt. and Phenomenology / 103

Probing U(1) extensions of the MSSM at the LHC Run I and in dark matter searches

Authors: Alexander Pukhov¹; Genevieve Belanger²; Jonathan Da Silva³; Ursula Laa⁴

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The U(1) extended supersymmetric standard model (UMSSM) can accommodate a Higgs boson at 125 GeV without relying on large corrections from the top/stop sector. After imposing LHC results on the Higgs sector, on B-physics and on new particle searches as well as dark matter constraints, we show that this model offers two viable dark matter candidates, the right-handed (RH) sneutrino or the neutralino. Limits on supersymmetric partners from LHC simplified model searches are imposed using SModelS and allow for light squarks and gluinos. Moreover the upper limit on the relic abundance often favours scenarios with long-lived particles. Searches for a Z' at the LHC remain the most unambiguous probes of this model. Interestingly, the D-term contributions to the sfermion masses allow to explain the anomalous magnetic moment of the muon in specific corners of the parameter space with light smuons or left-handed (LH) sneutrinos. We finally emphasize the interplay between direct searches for dark matter and LHC simplified model searches. This talk is based on arXiv:1505.06243.

Plenary / 104

Overviews of BSM Higgs Physics from the ATLAS and CMS

Author: Tristan Arnoldus Du Pree¹

Co-author: ATLAS and CMS Collaborations ¹

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This talk will focus on Beyond Standard Model Higgs results from the ATLAS and CMS experiments.

Higgs Expt., Theory and Phenomenology / 105

ATLAS and CMS Prospects for Higgs Physics at the HL-LHC

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Co-author: ATLAS and CMS Collaborations²

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This talk will focus on the ATLAS and CMS Prospects for Higgs Physics at the HL-LHC, covering expected future performance and sensitivity in Higgs physics during the HL-LHC era.

Higgs Expt., Theory and Phenomenology / 106

Study of Higgs bosons decaying to bottom quarks at CMS

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The final LHC Run1 results in the search for a Higgs bosons decaying to bottom quarks performed by CMS is presented. Besides the standard model interpretation, well-motivated models with extended Higgs sectors are also being considered.

SUSY/String Models / 107

Gauginos mass in tree level R-symmetry breaking models

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We show that in a class of gauge mediation models with tree level R-symmetry breaking, where supersymmetry and R-symmetries are broken by different fields, the gaugino mass either vanishes or finds contribution from loop level R-symmetry breaking. Thus tree-level R-symmetry breaking is either no-go or redundant for phenomenology model building. Attempts to overcome the no-go are discussed.

Higgs Expt., Theory and Phenomenology / 108

BSM Higgs searches with the CMS experiment

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The most recent results about the Beyond Standard Model Higgs searches with the CMS experiment at the LHC will be presented. The talk would include material from SM Higgs, Exotica and SUSY analyses for the Higgs sector. Eventual new results for the Higgs searches with the Run 2 data will be detailed, if any.

Higgs Expt., Theory and Phenomenology / 109

Search for high mass Higgs-like bosons at CMS

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Searches for additional Higgs-like bosons are reported for Higgs boson masses between 145 GeV and 1 TeV. The search is based on proton-proton collision data corresponding to an integrated luminosity of up to 5.1 inverse fb at the centre-of-mass energy of 7 TeV and up to 19.3 inverse fb at 8 TeV, recorded by the CMS experiment at the LHC. Several final states of the WW, ZZ, gammagamma, and Zgamma decays are analyzed.

Higgs Expt., Theory and Phenomenology / 110

Higgs boson properties in bosonic final states at CMS

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The talk will present a summary of the measurement of the Higgs properties using the H->ZZ->4l, H->WW->2l2nu and H->gammagamma decay channels, and the full dataset recorded by the CMS experiment during the LHC Run 1, corresponding to an integrated luminosity of 5.1 fb-1 at a center-of-mass energy of 7 TeV and up to 19.7 fb-1 at 8 TeV. The talk will present the measurements of the Higgs boson mass, spin, and parity, the constraints on anomalous HVV couplings, and constraints on the Higgs width.

Higgs Expt., Theory and Phenomenology / 111

Study of Higgs bosons decaying to leptons at CMS

Author: CMS Collaboration¹

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The most recent results from CMS on the search for a neutral Higgs bosons decaying into a tau or a muon pair will be presented. The production of a neutral Higgs boson via the gluon fusion or through associate production with b quarks are considered.

Higgs Expt., Theory and Phenomenology / 112

Searches for charged Higgs boson with the CMS experiment

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Recent results on searches for charged Higgs bosons at the LHC by the CMS collaboration are presented. Charged Higgs bosons have been searched for in top quark decays for lower mass and directly produced for higher masses. Charged Higgs boson decays into tau nu, cs and tb have been exploited. Results are based on approximately 20 fb⁻¹ of data collected at sqrt(s) 8 TeV at the LHC.

Higgs Expt., Theory and Phenomenology / 113

Search for supersymmetric neutral Higgs bosons using the LHC run 1 data recorded by CMS

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A new boson of mass 125 GeV has been discovered at the LHC. Within the present experimental uncertainties the properties of the new boson are in good agreement with the expectation for a standard model (SM) Higgs boson. The discovered SM-like Higgs boson may however be just one of several Higgs bosons, predicted by theories beyond the SM. Searches for additional neutral Higgs bosons beyond the discovered SM-like Higgs boson of mass 125 GeV are presented. The searches are based on 4.9/fb of proton-proton collision data recorded by the CMS experiment at 7 TeV center-of-mass energy plus 19.7/fb of data recorded at 8 TeV. The results are interpreted in the context of supersymmetric extensions of the standard model (MSSM and NMSSM). Model independent interpretations are also given.

Plenary / 114

CMS results on SUSY searches

Author: Christian Sander¹

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This talk will review the CMS results on SUSY searches.

Plenary / 115

New Directions in SUSY Searches at LHC

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This talk will focus on the topic of new directions in SUSY searches and discuss new ideas about how to search for SUSY at LHC.

SUSY Expt. and Phenomenology / 116

Inclusive SUSY searches with the CMS detector

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We present results of searches for gluino and squark production with the CMS detector in final states containing jets, missing transverse momentum, and possibly leptons. The results are based on 20 fb⁻¹ of data collected during the 8 TeV LHC run. Various discriminants based on event kinematics are employed to suppress standard-model backgrounds. The results are interpreted in the context of several different SUSY models.

SUSY Expt. and Phenomenology / 117

Third generation SUSY searches with the CMS detector

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The latest results from CMS on searches for stop and sbottom squarks are presented. Searches for direct squark production and indirect production through gluino cascades in a variety of decay

channels are reviewed. The results are based on 20 fb⁻¹ of data collected during the 8 TeV LHC run.

SUSY Expt. and Phenomenology / 118

Search for compressed SUSY in final states containing one or two soft leptons with the CMS detector

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A search for supersymmetry in events with one or two soft leptons and large missing transverse momentum is presented, based on 19.7 fb⁻¹ of 8 TeV pp collisions recorded with the CMS detector. This final state is typical for SUSY scenarios with a small mass splitting between the LSP and the top squark or chargino (compressed mass spectra). A hard Initial State Radiation jet is used to trigger such events. The event selection and the methods for estimating the Standard Model background are presented. The data are found to be in agreement with the predicted yields from Standard Model processes, and as a result exclusion limits are set for different compressed signal scenarios.

SUSY Expt. and Phenomenology / 119

Search for compressed SUSY in hadronic final states with the CMS detector

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Searches for supersymmetric models with a compressed mass spectrum are presented using data samples corresponding to integrated luminosities of about 19.7 fb⁻¹, collected at a centre-of-mass energy of 8 TeV with the CMS detector at the LHC. Compressed mass spectra, where multiple SUSY particles are nearly degenerate in mass, present a unique challenge to SUSY searches at the LHC. Such spectra are often difficult to detect experimentally in traditional searches due to the low pt of decay products as a result of the small mass splittings. In this talk, several approaches are explored such as boosting the entire susy system with a recoil against one or more jets from initial state radiation, and the partial reconstruction of final states where some decay products may be too soft to fully reconstruct with high efficiency.

SUSY Expt. and Phenomenology / 120

Search for electroweak SUSY with the CMS detector

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Results for SUSY searches in the electroweak sector are summarized, based on ~ 20 fb⁻¹ of 8 TeV proton-proton collisions collected by the CMS detector. A variety of complementary final state signatures and methods are used to probe gaugino and slepton production. This talk includes the latest results from the first ever search for SUSY production through vector boson fusion processes in a topology of two leptons, two forward jets and missing transverse energy.

SUSY Expt. and Phenomenology / 121

Searches for R-parity violating SUSY with the CMS detector

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The latest results from searches for R-parity violating supersymmetry with the CMS detector will be reviewed. We present results using up to 20 fb⁻¹ of data from the 8 TeV LHC run. Interpretations of the experimental results in terms of production of squarks, gluinos, charginos, neutralinos, and sleptons within R-parity violating SUSY models are presented.

SUSY Expt. and Phenomenology / 122

Searches for SUSY with photons in the final state in CMS

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We present results of searches for SUSY production at CMS in events with one or two isolated photons, possibly coming from a Higgs decay, using up to 20/fb of data from the 8 TeV LHC run of 2012. The results are interpreted in the context of several different SUSY models, in particular gauge-mediation models, with the gravitino as the lightest supersymmetric particle.

SUSY Expt. and Phenomenology / 123

Search for SUSY in the di-lepton final state in CMS

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The results of searches for SUSY production at CMS in events with dilepton final states are presented using up to 20/fb of data from the 8 TeV LHC run of 2012. These include final states with Z bosons decaying to lepton pairs as well as non-resonant same- and opposite-sign lepton pairs. The results are interpreted in the context of several different SUSY model scenarios.

SUSY Expt. and Phenomenology / 124

Combination of CMS SUSY searches and interpretation in the pMSSM

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We interpret CMS new physics search results within the context of SUSY models, such as natural simplified models and the phenomenological MSSM (pMSSM), a generic 19-dimensional parametrization of the MSSM at the SUSY scale that captures most of the MSSM's phenomenological features. Searches in various final state topologies are included, and up to 20 fb⁻¹ of data from the 8TeV LHC run are included in the interpretations.

Flavor Violation / 125

Higgs, flavour at the high pT frontier, top and FCNC with the CMS experiment

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In this talk we present analyses involving Higgs bosons and heavy flavors at high transverse momentum by the CMS Experiment. In particular, we show results on searches for top quark flavor-changing neutral-current (FCNC) and top quark flavor-changing Higgs-current (FCHC) decays. In addition, measurements of the Higgs boson decays to leptons and bottom quarks, together with Lepton Flavor Violating searches will also be summarized.

Flavor Violation / 126

Heavy flavour results from CMS

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Rare decays and angular distributions of B mesons are particularly sensitive probes of physics beyond the Standard Model. This talk reviews results on these processes obtained with the data collected by the CMS experiment during the first Run of the LHC. We will show the most precise single-experiment results on the measurement of the $B_s \rightarrow \mu\mu$ branching fraction and search for $B_d \rightarrow \mu\mu$, along with the LHC combination. Results on the forward-backward asymmetry and other sensitive observables in $B \rightarrow K^* \mu\mu$ decays, determined as a function of the di-muon invariant mass, will be presented. The CP violating weak mixing phase ϕ_s , extracted from an angular and proper decay time analysis of the $B_s \rightarrow J/\psi \Phi$ decay, will be reported.

Plenary / 127

Status of Exotic Searches at LHC

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This talk will review the status of exotic searches at LHC.

Alternative Theories / 128

Search for Dark Matter recoiling from singly produced high pT objects at CMS

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CMS searches for dark matter recoiling from singly produced jets, photons, weak bosons and heavy quarks, using data from 2011-2012 are presented. Prospects for searches in LHC Run-2 are briefly discussed.

Alternative Theories / 129

Updated results on heavy neutrino searches in CMS

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Searches for heavy neutrino motivated by the discovery of neutrino oscillations become realistic at the LHC. CMS experiment has updated search results for heavy neutrinos at the LHC using the full 2012 data. We have looked for a signature of dileptons and two jets from heavy neutrino decay. In the talk, we report on the search results on heavy neutrino productions.

Alternative Theories / 130

Searches for Dark Matter in association with top quarks at CMS

Author: CMS Collaboration¹

¹ CERN**Corresponding Authors:** jonatan.piedra.gomez@cern.ch, sungwon.lee@cern.ch

We present results of searches for pair-produced dark matter in association with top quarks, using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 8 TeV. We investigate processes yielding top quark pairs or a single top quark plus a large amount of missing transverse energy due to the undetected dark matter particle pair. We search for an excess of events having large missing transverse energy, where expected Standard Model backgrounds are low. Results are interpreted in the context of an effective field theory approach, where limits are set on both the dark matter mass, as well as the scale of the four-fermion interaction resulting in the dark matter pair-production.

Alternative Theories / 131

Searches for $t\bar{t}$ and $t\bar{b}$ resonances at CMS

Author: CMS Collaboration¹¹ CERN**Corresponding Authors:** emanuele.usai@cern.ch, sungwon.lee@cern.ch

We present searches for resonant production of top quark pairs or top- and b quarks, using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 8 TeV. The search is performed by measuring the invariant mass distribution of the quark pair and testing for deviations from the expected Standard Model background. Final states with zero, one or two leptons are considered and the selection is optimized accordingly, taking into account the high Lorentz boost of the top quarks at high invariant masses. These boosted top quark signatures can be identified and reconstructed through the use of jet substructure and subjet b-tagging algorithms. The results are presented in the form of mass and cross section limits on three types of new physics models: both a narrow and wide Z' boson as well as an Randall-Sundrum Kaluza-Klein gluon or a heavy W' gauge boson.

Alternative Theories / 132

Searches for vector-like partners of top and bottom quarks at CMS

Author: CMS Collaboration¹¹ CERN**Corresponding Authors:** huaqiao.zhang@cern.ch, sungwon.lee@cern.ch

We present new results on searches for massive top and bottom quark partners using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 8 TeV. These fourth-generation vector-like quarks are postulated to solve the Hierarchy problem and stabilize the Higgs mass, while escaping constraints on the Higgs cross section measurement. The vector-like quark decays result in a variety of final states, containing boosted top and bottom quarks, gauge and Higgs bosons. We search using several categories of reconstructed objects, from multi-leptonic to fully hadronic final states. We set exclusion limits on both the vector-like quark mass and pair-production cross sections, for combinations of the vector-like quark branching ratios.

Alternative Theories / 133

Search for Displaced Supersymmetry in events with leptons with large impact parameters at CMS

Author: CMS Collaboration¹¹ CERN

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A search for new long-lived particles decaying to leptons is presented using proton-proton collisions produced by the LHC at $\sqrt{s} = 8$ TeV. Data used for the analysis were collected by the CMS detector and correspond to an integrated luminosity of approximately 20 inverse femtobarns. Events are selected with an electron and a muon, with no requirement of a shared vertex, and with di-lepton pairs that share a vertex. The resulting distributions are consistent with the expected background from standard model processes, and are interpreted in a variety of displaced BSM models. Any new results on the LHC Run 2 dataset will be presented if available.

Alternative Theories / 134

Search for excited leptons at CMS

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CMS searches for a possible compositeness of electrons and muons using data from Run1 at a center-of-mass energy of 8 TeV, corresponding to an integrated luminosity of 19.7 /fb, are presented. In these searches, excited leptons are assumed to be produced via contact interactions in conjunction with a standard model lepton and decaying via gauge interactions. The decays considered are $l \rightarrow l\gamma$ and $l \rightarrow lZ$ which, depending on the Z decay mode, give final states with four leptons or two leptons and two jets. Since the number of events observed in data are consistent with the expectation from the standard model, so exclusion limits on the excited lepton mass, and the compositeness scale, are presented.

Alternative Theories / 135

Search for RPV SUSY via LQD couplings in dileptons+jets final states at CMS

Author: CMS Collaboration¹¹ CERN

Corresponding Authors: skhalil@cern.ch, sungwon.lee@cern.ch

Unlike the most traditional SUSY searches, there exist many SUSY models that do not produce large missing transverse momentum (MET), such as compressed spectra, long live particles, stealth SUSY, and R-parity violating (RPV) models. Searches for RPV model via the LQD couplings have been performed at Run1, using event signatures of two opposite sign same flavor dileptons (electrons, muons, taus), and at least five jets, and low MET. No top squarks were observed during Run I, following these RPV models and the most recent limits for these channels will be presented.

Alternative Theories / 136

Search for dark matter in multijet events at CMS**Author:** CMS Collaboration¹¹ CERN**Corresponding Authors:** norraphat.srimanobhas@cern.ch, sungwon.lee@cern.ch

We present a search for dark matter production using proton-proton collisions recorded by the CMS experiment at the CERN LHC. The data correspond to an integrated luminosity of 18.8 fb^{-1} , at a center-of-mass energy of $\sqrt{s} = 8 \text{ TeV}$. Events are required to have at least two jets and no isolated leptons. The specialized razor variables are employed to quantify the transverse momentum balance. The search is carried out separately for events with and without jets originating from b quarks. The observed yields are consistent with the expected background; exclusion limits at 90% confidence level in the context of an effective field theory are obtained.

Alternative Theories / 137

Searches for new physics in dijet and multijet in CMS**Author:** CMS Collaboration¹¹ CERN**Corresponding Authors:** malgorzata.kazana@cern.ch, sungwon.lee@cern.ch

We present results of searches for new physics in event with inclusive dijet and multijet final states using up to 20 fb^{-1} of data collected during the 8 TeV LHC run. These include searches for narrow dijet resonances, new physics using dijet angular distribution, as well as pair production of new resonances decaying to two or more final state jets. New results with the Run 2 data will be also presented, if any.

Alternative Theories / 138

Search for high mass resonances in diphoton final states in CMS**Author:** CMS Collaboration¹¹ CERN**Corresponding Authors:** conor.henderson@cern.ch, sungwon.lee@cern.ch

This talk will present the most recent results of high mass resonance searches in the diphoton final state. The talk will include results from Randall Sundrum graviton searches (Exotica). Those searches are based on the full 2012 data collected from pp collisions at a center of mass energy of 8 TeV, corresponding to an integrated luminosity of 19.6 fb^{-1} . Such searches are essential to address the hierarchy mass problem and would help understand the unification of the four fundamental forces. The theoretical motivation will be introduced, the selection and its efficiency presented and the background determination techniques explained. Finally, the data/background comparison results will be shown as well as the limits on the mass of the first excitation of the RS graviton.

SUSY/String Models / 142**The 2015+ Phenomenology of Deflected Mirage Mediation****Author:** Todd Garon¹**Co-authors:** Brent Nelson²; Bryan Kaufman²; Lisa Everett³¹ *UW-Madison*² *Northeastern University*³ *University of Wisconsin, Madison***Corresponding Author:** tgaron@wisc.edu

We consider the phenomenology of deflected mirage mediation, a “mixed” supersymmetry breaking scenario motivated by string compactifications in light of results from LHC8, PLANCK, and LUX. In this scenario, there are additional gauge mediation contributions along with the standard gravity and anomaly mediation contributions of the KKL_T-motivated mirage mediation scenarios, which drastically alter the low energy spectrum. We place bounds on the parameter space and discuss the discovery prospects for novel spectra at LHC13, future dark matter direct detection experiments, and a future 100 TeV collider.

Alternative Theories / 143**Searches for lepton-jets with the ATLAS detector at the LHC****Author:** Mahsana Haleem¹**Co-author:** Collaboration ATLAS²¹ *DESY Zeuthen*² *ATLAS Experiment***Corresponding Author:** mahsana.ahsan@cern.ch

Dark sector models, explaining the presence of dark matter in the Universe, predict signatures that can be tested at the LHC. Among those predicted, a smoking gun signature (when the dark sector particles are light) is the presence of a collimated pair of leptons or hadrons, called lepton-jets. Depending on the coupling between the dark sector and the Standard Model sector, the lepton-jets can have a displaced signature. In this talk, recent ATLAS searches for lepton-jets with LHC Run 1 data are presented. First LHC Run-2 results will be included if available.

Precision SUSY/Higgs/MCTools / 144**The Hierarchy Solution to the LHC Inverse Problem****Authors:** James Gainer¹; Konstantin Matchev¹; Myeonghun Park²¹ *University of Florida (US)*² *Asia Pacific Center for Theoretical Physics (APCTP) (KR)***Corresponding Author:** james.gainer@cern.ch

We provide a readily generalizable procedure for determining the number of sparticle mass hierarchies in a given SUSY model. As an application, we analyze the gravity-mediated SUSY breaking

scenario with various combinations of GUT-scale boundary conditions involving different levels of universality among the gaugino and scalar masses. For each of the eight considered models, we provide the complete list of forbidden hierarchies in a compact form. Our main result is that the complete (typically rather large) set of forbidden hierarchies among the eight sparticles considered in this analysis can be fully specified by just a few forbidden relations involving much smaller subsets of sparticles.

Precision SUSY/Higgs/MCTools / 145

Loops at Leading Order: Direct Detection of Dark Matter in the MSSM

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Most models of WIMPs that possess sizable tree-level interactions with the electroweak bosons of the Standard Model are under ever increasing pressure from the relentless Moore's law like progression of today's direct detection experiments. This has led many to consider various scenarios in which the dark matter candidate instead possesses 1 and 2-loop induced couplings to quarks and gluons at leading order. While much progress has been done in this regard, there remain many interesting avenues to explore. In this talk, I will summarize ongoing work in this direction within the context of the MSSM and discuss the viability to observe/rule-out a few of these types of models.

Particle Cosmology / 146

Evidence for Unresolved Gamma-Ray Point Sources in the Inner Galaxy

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Co-authors: Mariangela Lisanti²; Samuel Lee³; Tracy Slatyer

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We present a new method to characterize unresolved point sources (PSs), which generalizes traditional template fits to account for non-Poissonian photon statistics. Using Fermi Large-Area Telescope gamma-ray data, we use the method to characterize PS populations at high latitudes and in the Inner Galaxy. We find that PSs (resolved and unresolved) account for $\sim 50\%$ of the total extragalactic gamma-ray background in the energy range ~ 1.9 to 11.9 GeV. Within 10° of the Galactic Center (with $|b| > 2^\circ$), we find that $\sim 5\%$ of the flux is accounted for by unresolved PSs; the observed \sim GeV gamma-ray excess near the Galactic Center is preferentially absorbed by an unresolved PS template as compared to a dark-matter template.

Alternative Theories / 147**Gauge-Higgs Unification with the dynamical boundary conditions and its $SU(5)$ application****Author:** YAMAMOTO Kengo¹¹ *Department of physics, Osaka University***Corresponding Author:** yamamoto@het.phys.sci.osaka-u.ac.jp

Gauge-Higgs Unification is the candidate of Beyond Standard Model. The gauge symmetry of system can be spontaneously broken down by dynamics of Wilson line phase of gauge fields themselves in Gauge-Higgs Unification. This symmetry breaking pattern is highly depend on the boundary condition set which is imposed on fields for extra dimensional directions and in present gauge-Higgs study, these boundary conditions are given by hand even though there are many possible boundary condition sets. In our research, we regard boundary conditions as dynamical variables and focus our attention on $SU(N)$ Gauge-Higgs Unification on $M^4 \times S^1/Z_2$. We analyze these boundary condition dynamics by using matrix model analysis. We have found only restricted boundary condition sets in all possible sets practically contribute to the partition function of system. And we apply this result to $SU(5)$ model.

Alternative Theories / 148**Searches for long-lived massive particles in CMS****Author:** CMS Collaboration¹¹ *CERN***Corresponding Authors:** malgorzata.kazana@cern.ch, sungwon.lee@cern.ch

Long-lived massive particles are predicted in many supersymmetric and exotic models. The existence of such particles would manifest in the detector by unique signatures such as specific energy loss, late signal in the muon or calorimeter system, displaced vertices or non-pointing photons, appearing or disappearing tracks. The recent results of searches for long-lived signatures with the CMS detector will be presented.

Particle Cosmology / 149**Dark matter at the LHC: EFTs and gauge invariance****Authors:** James Dent¹; Nicole Bell²; Rebecca Leane²; Tom Weiler³; Yi Cai²¹ *University of Louisiana at Lafayette*² *University of Melbourne*³ *Vanderbilt University***Corresponding Author:** rleane@physics.unimelb.edu.au

Effective field theory (EFT) formulations of dark matter interactions are a convenient and popular way to quantify LHC bounds on dark matter. However, some EFT operators considered do not respect the weak gauge symmetries of the Standard Model. These operators break down at the electroweak scale, rather than the energy scale of new physics, and are invalid at LHC energies. We carefully discuss the circumstances in which such operators can arise, and use the mono- W process

to illustrate potential issues in their interpretation and application. We also discuss a simple UV complete model that avoids such difficulties.

Particle Cosmology / 151

Thermal goldstino production at low reheating temperatures

Authors: Angelo Monteux¹; Chang Sub Shin¹

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I will discuss thermal production of (pseudo-)goldstinos, the Goldstone fermions emerging from (multiple-) SUSY breaking, when the reheating temperature is well below the superpartner masses. In such a case, the production during the early matter-dominated era is more important than after reheating. Depending on the SUSY breaking scale, goldstinos are produced by freeze-in or freeze-out mechanism via $1 \leftrightarrow 2$ decays and inverse decays. Goldstinos can maintain chemical equilibrium far after they are kinetically decoupled from the thermal bath, and consequently goldstinos with different momentum decouple at different temperatures. As a result their momentum distribution function shows a peculiar shape and the final yield is smaller than if kinetic equilibrium was assumed. I will revisit the cosmological implications in both R-parity-conserving and R-parity-violating supersymmetric scenarios. For the former, thermally produced goldstinos can still be abundant enough to be dark matter at present times even if the reheating temperature is low, of order 1 GeV. For the latter, if the reheating temperature is low, of order 0.1–1 GeV, they are safe from the BBN constraints.

SUSY/String Models / 152

Renormalization Group Equation and Dynamical Symmetry Breaking in a Supersymmetry Abelian Chern-Simons Model with Arbitrary Parameter of Gauge

Author: Andres Quinto¹

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In this work, we investigate the consequences of the Renormalization Group Equation (RGE) in the determination of the effective superpotential in a supersymmetric model with an arbitrary parameter of gauge and, the impact of this improved calculation in the study of dynamical symmetry breaking. We consider an $\mathcal{N} = 1$ supersymmetric theory, including an Abelian Chern-Simons superfield coupled to N scalar superfields in $(2+1)$ dimensional spacetime. The classical Lagrangian presents scale invariance, which is broken by radiative corrections to the effective superpotential. We calculate perturbative corrections, up to two-loops, to the divergent vertex functions of the model, using dimensional regularization and minimal subtraction scheme, in order to calculate the renormalization group functions β and γ . Additionally, we compute the superpotential from the one point vertex function up to two-loops with an arbitrary parameter of gauge. In order to understand it, was necessary to use the identity of Nielsen for studying the behaviour of the superpotential minima. Using these , together with the RGE, we are able to calculate an improved version of the effective superpotential, from which the dynamical symmetry breaking can be studied and, the results can also be

Higgs Expt., Theory and Phenomenology / 153**Simplified Models for Higgs Physics Studies****Author:** JoAnne Hewett¹**Co-authors:** Matthew Dolan²; Michael Kraemer³; Thomas Rizzo¹ *SLAC*² *SLAC National Accelerator Laboratory*³ *Particle Physics***Corresponding Author:** hewett@slac.stanford.edu

Just as renormalizable Simplified Models can be used alongside of effective field theories for the study of dark matter interactions, Simplified Models can be used to describe new physics associated with the Higgs boson. The objective is for the Simplified Model to capture some of the new Higgs physics associated with a wide range of UV-complete theories. Such models allow for variations in the tree-level and loop-induced Higgs couplings in a somewhat uncorrelated manner, and necessarily predict the existence of new ‘mediator’ particles that can be searched for at the LHC and elsewhere. Here we present a simple example of one such model that employs both a vector-like, isosinglet top quark and a new isosinglet scalar, that generates the new quark mass as well as coupling to the 125 GeV Higgs. In this work the detailed phenomenology of this Simplified Model is examined in detail.

Particle Cosmology / 154**Axino LSP Baryogenesis and Dark Matter****Author:** Chang Sub Shin¹**Co-author:** Angelo Monteux¹¹ *Rutgers University***Corresponding Author:** csshinest@gmail.com

We discuss a new mechanism for baryogenesis, in which the baryon asymmetry is generated by the lightest particle in another sector, for example the supersymmetric particle (LSP), decaying to quarks via baryonic-number-violating interactions. As a specific example, we use a supersymmetric axion model with an axino LSP and baryonic R-parity violation. This scenario predicts large R-parity violation for the stop, and an upper limit on the squark masses between {15 and 130 TeV}, for different choices of the Peccei-Quinn scale and the soft X_t terms. We discuss the implications for the nature of dark matter in light of the axino baryogenesis mechanism, and find that both the axion and a metastable gravitino can provide the correct dark matter density. In the axion dark matter scenario, the initial misalignment angle is restricted to be $\ll(1)$. On the other hand, the reheating temperature is linked to the PQ scale and should be higher than 104–105 GeV in the gravitino dark matter scenario.

SUSY Expt. and Phenomenology / 155**Applications of the Recursive Jigsaw Technique to searches for gluino and stop pair production**

Authors: Christopher Rogan¹; Lawrence Lee Jr²; Paul Douglas Jackson³

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The “Recursive Jigsaw Technique” provides a powerful new approach to extract a kinematic basis of variables that can be used to categorise searches for new physics signals at the LHC. This talk will focus on topologies relevant to the LHC in 2015 namely strong production of gluinos and third generation squarks. We demonstrate sensitive analysis strategies to search for beyond standard model signatures by de-composing the final state objects into hemispheres and further sub-dividing them where necessary, based on the topology of interest. Backgrounds are controlled without recourse to conventional approaches based on variables such as missing transverse momentum and effective mass to select regions of sensitivity.

Precision SUSY/Higgs/MCTools / 156

The Recursive Jigsaw Technique

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Signal events where multiple missing neutral particles are present in a final state represent challenging topologies to search for new physics at the LHC. The key to any search is the ability to separate background-like events from signal-like events. Identifying such signal-like events, and extracting their properties, is exacerbated by a lack of knowledge of the particle masses and some missing kinematic handles. The “Recursive Jigsaw” technique introduces a new approach to extracting information in events with open final states resulting from pair-production of objects.

Flavor Violation / 157

Enhancement of $\text{Br}(B_d \rightarrow \mu^+ \mu^-)/\text{Br}(B_s \rightarrow \mu^+ \mu^-)$ in supersymmetric unified models

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The recent measurement of the branching fractions of the rare B meson decays, $B_d^0 \rightarrow \mu^+ \mu^-$ and $B_s^0 \rightarrow \mu^+ \mu^-$, is one of the most impressive achievements of the LHC experiments. The ratio of the branching fractions is about 2 sigma above the standard model prediction. Although the deviation is not very significant in the current statistical status, it is interesting to study a new physics model in which $\text{Br}(B_d \rightarrow \mu^+ \mu^-)$ is enhanced naturally but not $\text{Br}(B_s \rightarrow \mu^+ \mu^-)$ since in popular models to generate the new flavor violation the excess of $B_s \rightarrow \mu^+ \mu^-$ decay is also generated.

In this talk, we suggest an anti-symmetric coupling as a new source of flavor violation which can naturally explain the enhancement of the ratio, and study its implication in the framework of supersymmetric unified models, such as SU(5) and SO(10). The allowed parameter space is typically represented by pseudoscalar Higgs mass $m_A < 1$ TeV and $\tan\beta (= v_u/v_d) \sim 20$ for squark and gluino masses around 2 TeV.

[This talk is based on the paper arXiv:1501.02044, published in PRD]

Flavor Violation / 158

Improved analysis of the CLFV process: $\mu^- e^- \rightarrow e^- e^-$ in muonic atom

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We proposed a new charged lepton flavor violation (CLFV) process, $\mu^- e^- \rightarrow e^- e^-$ in a muonic atom, as one of the promising processes to search for new physics beyond the standard model [1]. It was found that the attractive interaction of leptons with the nucleus in the muonic atom enhances the transition rate of the $\mu^- e^- \rightarrow e^- e^-$ process. We report on our improved analysis of this process by taking account the distortion of the out-going electrons in the nuclear Coulomb potential and the relativistic treatment of the muon and the electrons. As results, we found significant enhancement of the transition rate. The transition rate for ^{208}Pb becomes about 7 times larger than the previous calculation, which enhances the sensitivity of this process to discover the CLFV process.

[1] M. Koike, Y. Kuno, J. Sato and M. Yamanaka, Phys. Rev. Lett. 105, 121601 (2010)

Precision SUSY/Higgs/MCTools / 159

Global Bayesian Analysis of the Higgs-boson Couplings

Authors: Diptimoy Ghosh¹; Enrico Franco²; Jorge de Blas²; Laura Reina³; Luca Silvestrini²; Marco Ciuchini⁴; Maurizio Pierini⁵; Satoshi MISHIMA²

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We present results of a bayesian fit to the Wilson coefficients of the Standard Model gauge invariant dimension-6 operators involving one or more Higgs fields, using data on electroweak precision observables and Higgs boson signal strengths.

Precision SUSY/Higgs/MCTools / 161**Update of the electroweak precision fit, interplay with Higgs-boson signal strengths and model-independent constraints on new physics**

Authors: Enrico Franco¹; Jorge de Blas¹; Laura Reina²; Luca Silvestrini¹; Marco Ciuchini³; Maurizio Pierini⁴; Satoshi MISHIMA¹

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We present updated global fits of the Standard Model and beyond to electroweak precision data, taking into account recent progress in theoretical calculations and experimental measurements. From the fits, we derive model-independent constraints on new physics by introducing oblique and epsilon parameters, and modified $Zb\bar{b}$ and HVV couplings. Furthermore, we also perform fits of the scale factors of the Higgs-boson couplings to observed signal strengths of the Higgs boson.

Alternative Theories / 162**Four-Quark Effective Operators at Hadron Colliders**

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The robustness of translating effective operator constraints to BSM theories crucially depends on the mass and coupling of BSM particles. This is especially relevant for hadron colliders where the partonic centre of mass energy is around the typical energy scales of natural BSM theories. The caveats in applying the limits are discussed using Z' and G' models, illustrating the effects for a large class of models, including composite Higgs and several dark matter mediator models. This analysis shows that the applicability of effective operators mainly depends on the ratio of the transfer energy in the events and the mass scale of the full theory. Moreover, based on these results a method is developed to recast existing experimental limits on four-quark effective operators to the full theory parameter space.

Precision SUSY/Higgs/MCTools / 163**FlexibleSUSY: spectrum generation for SUSY and non-SUSY models**

Author: Peter Athron¹

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FlexibleSUSY is a mathematica and C++ package which can be used to create a fast and precise spectrum generator for a SUSY or BSM model chosen the by the user. FlexibleSUSY is distributed with a large number of models already implemented and the user may also add new models of there own by creating simple model files. The spectrum generators created by FlexibleSUSY are very fast and the C++ code is very modular, allowing for easy modification, extension and reuse. I will review the many uses and features of this program, with particular emphasis on the new features, like the inclusion of non-SUSY models. I will discuss how FlexibleSUSY compares to existing public spectrum generators, such as those for the MSSM and NMSSM. Finally I will then discuss future features and other FlexibleTools which are planned for future releases.

Particle Cosmology / 164

The Latest Results From the LUX Dark Matter Experiment

Author: Matthew Szydagis¹¹ University at Albany**Corresponding Author:** mszydagis@albany.edu

The LUX collaboration has recently re-analyzed its initial WIMP search data, and it continues to lead the search for dark matter candidate particles in the $O(10-1,000)$ GeV mass range since the first analysis was released. LUX performs several advanced *in situ* nuclear and electron calibrations of the light and charge yields down to 1 keV of recoil energy, avoiding the need to extrapolate them from *ex situ* calibrations or simulation models. Consequences for the limit on the cross-section of interaction for low-mass WIMPs will be highlighted. Previous hints of WIMP signals from other detectors are more strongly discrepant now, assuming isospin invariance and the standard halo model. Both spin independent and spin-dependent-neutron limits will be discussed.

SUSY Expt. and Phenomenology / 165

Resonances in Final States with Leptons and Jets

Authors: Jeff Dror¹; Joshua Berger²; Wee Hao Ng¹; Yang Bai³¹ Cornell University² SLAC³ University of Wisconsin, Madison

We study the phenomenology of models that contain resonances yielding final states with leptons and jets. Recent searches for a first-generation leptoquark by the CMS collaboration have shown around 2.5 sigma deviations from Standard Model predictions in both the $e e j j$ and $e \nu j j$ channels. Furthermore, the $e e j j$ invariant mass distribution has another 2.8 sigma excess from the CMS right-handed W plus heavy neutrino search. We briefly overview models that could account for the excesses. We focus on supersymmetric models with R-parity violation in which the Higgs is

electron-like sneutrino, which could explain the lack of excess in analogous channels with muons. Finally, we make predictions for further signals in other channels.

Flavor Violation / 166

$B \rightarrow K^* \mu \mu$: Charming Penguins strike back again?

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We critically reassess the theoretical uncertainties in the Standard Model calculation of $B \rightarrow K^* \mu \mu$ observables, focusing on the low q^2 region. We point out that even optimized observables are affected by sizable uncertainties coming both from full form factors, when one considers the departure from the infinite mass limit, and from long distance effects. In particular, we stress that for the main one, the charm-loop contribution, power suppression is efficiently at work only for very low q^2 : consequently, the uncertainties are expected to increase close to the $c\bar{c}$ threshold. Taking these uncertainties into account, we perform a Bayesian analysis and present both predictions and fit results obtained using the state-of-the-art experimental information available at present for this decay from recent LHCb data. Eventually, our study aims to show that no clean evidence of New Physics is possible to claim in this channel within the current theoretical knowledge.

Particle Cosmology / 167

Looking for Dark Matter in Dwarf Spheroidal Galaxies

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Dwarf spheroidal galaxies (dSphs) are among the faintest objects observed in our Universe, representing an ideal laboratory for Dark Matter (DM) searches.

We review moment-based methods to model pressure-supported spherical systems like dSphs, and critically revisit the so called “mass-anisotropy degeneracy problem”, plaguing the mass profile determination of these galaxies.

We propose a novel approach to address it properly, based on the analytical inversion of the spherical Jeans equation.

The main goal of the work is to present a reliable approach to derive constraints on the line-of-sight integral of Dark Matter halo densities in dSphs, intimately related to the current tough upper-bounds on the velocity averaged cross-section of thermal relics like e.g. the neutralino in many SUSY extensions of the Standard Model.

Remarkably, we find dSph bounds to be solid and robust against the theoretical bias present in the modeling, so that nowadays they possibly constitute the milestone of indirect DM constraints.

Precision SUSY/Higgs/MCTools / 169

Top quark mass measurement using bottom quark energy at the LHC

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I will discuss a new method of precision top quark mass measurement using bottom quark energy at the LHC. The relevant technique is based upon the observation that if a certain heavier particle decays into a massless visible particle and another particle, the energy peak in the laboratory-frame energy distribution of the visible particle is the same as its corresponding monochromatic energy value measured in the rest frame of the heavier particle. Remarkably, this “invariance” is insensitive to the details of production mechanism of the heavier particle as far as it is produced in an unpolarized way. I will extend this observation to the case with higher order corrections considered, and discuss their impact upon the top mass measurement.

SUSY Expt. and Phenomenology / 170

LHC “excesses”: Have we found SUSY?

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Recent Supersymmetry (SUSY) collider search results have reported intriguing excesses at the 8 TeV run of the LHC. An excess of statistical significance 2.6 sigma in the invariant mass distribution of the opposite-sign same-flavor (OSSF) lepton pair has been found by the CMS collaboration (off-Z excess). Similar final state, albeit with different distribution of invariant mass, has been reported by the ATLAS collaboration at statistical significance of 3.0 sigma (on-Z excess). In this talk, I will describe our attempt to interpret the excesses within the framework of simplified SUSY models. For the off-Z excess, we do not find favorable SUSY scenario that can accommodate the excess without violating other LHC constraints from null search results. I will also review the status of the on-Z excess (which has been found to be stringently constrained by other LHC searches), and discuss the interpretation of the excess with goldstini models. Part of this talk is based on arXiv:1502.05712.

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Long-Lived Superparticles with Hadronic Decays at the LHC

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Supersymmetry searches at the LHC are both highly varied and highly constraining, but the vast majority are focused on cases where the final-stage visible decays are prompt. Scenarios featuring

superparticles with detector-scale lifetimes have therefore remained a tantalizing possibility for sub-TeV SUSY, since explicit limits are relatively sparse. Nonetheless, the extremely low backgrounds of the few existing searches for collider-stable and displaced new particles facilitates recastings into powerful long-lived superparticle searches, even for models for which those searches are highly non-optimized. In this paper, we assess the status of such models in the context of baryonic R-parity violation, gauge mediation, and mini-split SUSY. We explore a number of common simplified spectra where hadronic decays can be important, employing recasts of LHC searches that utilize different detector systems and final-state objects. The LSP/NLSP possibilities considered here include generic colored superparticles such as the gluino and light-flavor squarks, as well as the lighter stop and the quasi-degenerate Higgsino multiplet motivated by naturalness. We find that complementary coverage over large swaths of mass and lifetime is achievable by superimposing limits, particularly from CMS's tracker-based displaced dijet search and heavy stable charged particle searches. Adding in prompt searches, we find many cases where a range of sparticle masses is now excluded from zero lifetime to infinite lifetime with no gaps. In other cases, the displaced searches furnish the only extant limits at any lifetime.

Flavor Violation / 172

Discrete family symmetries within the SM predict PMNS, CKM, and Weyl $E_8 \times$ Weyl E_8

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A different finite subgroup of $SU(2)$ for each lepton and each quark family leads to the first-principles determination of the mixing angles for neutrinos, quarks, and their PMNS and CKM mixing matrices. For example, the neutrino $\theta_{13} = 8.56^\circ$ and normal hierarchy are predicted. Connections of these subgroups to the j -invariant of elliptic modular functions (and the Monster group) lead to mass ratio predictions of 1:108:1728, which become adjusted to the actual mass values in each family by taking the linear superposition of the two original basis states in each subgroup to form the flavor states. Direct mathematical telescoping upward to R^8 for these subgroups when combined with Lorentz transformations *uniquely* dictates the discrete Weyl $E_8 \times$ Weyl $E_8 =$ 'discrete' $SO(9,1)$ at the Planck scale.

Alternative Theories / 174

Towards a No-Lose Theorem for Naturalness

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Theories of uncolored naturalness can realize untuned solutions to the hierarchy problem while avoiding LHC current exclusion bounds on colored top partners. Their unusual signatures demonstrate the range of phenomena that can be connected to stabilizing the electroweak scale, motivating searches for displaced vertices, exotic Higgs decays and emerging jets. I will give an overview of how to constrain these theories experimentally, and present recent work toward deriving a phenomenological 'no-lose theorem' for the discoverability of neutral naturalness. This lends strong model-independent motivation to build both proposed future lepton and 100 TeV colliders, since both are needed as discovery machines of general naturalness.

Precision SUSY/Higgs/MCTools / 175

Global fits of the two-loop renormalized Two-Higgs-Doublet model with soft Z_2 breaking

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We determine the next-to-leading order renormalization group equations for the Two-Higgs-Doublet model with a softly broken Z_2 symmetry and CP conservation in the scalar potential. We use them to identify the parameter regions which are stable up to the Planck scale and find that in this case the quartic couplings of the Higgs potential cannot be larger than 1 in magnitude and that the absolute values of the S-matrix eigenvalues cannot exceed 2.5 at the electroweak symmetry breaking scale. Interpreting the 125 GeV resonance as the light CP-even Higgs eigenstate, we combine stability constraints, electroweak precision and flavour observables with the latest ATLAS and CMS data on Higgs signal strengths and heavy Higgs searches in global parameter fits to all four types of Z_2 symmetry. We quantify the maximal deviations from the alignment limit and pinpoint the physical parameter regions compatible with a stable scalar potential up to the Planck scale. Motivated by the question how natural a Higgs mass of 125 GeV can be in the context of a Two-Higgs-Doublet model, we also address the hierarchy problem and find that the Two-Higgs-Doublet model does not offer a perturbative solution to it beyond 5 TeV.

SUSY Expt. and Phenomenology / 176

Indirect Searches of Degenerate MSSM

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A degenerate supersymmetric sparticle spectrum can escape constraints from flavor physics and at the same time evading the limits from the direct searches if the degeneracy extends to the gaugino sector. Inspired by this, we consider a scenario where all the soft terms have approximately a common mass scale at M_{SUSY} while allowing for splittings within $\mathcal{O}(10\%)$. As a result, the third generation sfermions have large to maximal (left-right) mixing, the same being the case with charginos and some sectors of the neutralino mass matrix. We study this scenario in the light of discovery of the Higgs boson with mass ~ 125 GeV. We consider constraints from B -physics, the anomalous magnetic moment of the muon (a_μ) and the dark matter relic density. We find that the supersymmetric spectrum as light as 600 GeV is still possible to escape the present limits from LHC and flavor physics and can account for the observed a_μ within 2σ . The neutralino relic density is too small to meet the observed data where as direct search limits from XENON100 and LUX put severe constraints on this scenario.

Particle Cosmology / 178**DEAP underground in Canada: the DEAP-3600 dark matter search****Author:** Benjamin Smith¹¹ *TRIUMF***Corresponding Author:** bsmith@triumf.ca

DEAP-3600 is a dark matter experiment at SNOLAB in Ontario, Canada, using 3600kg of liquid argon to search for spin-independent interactions of Weakly Interacting Massive Particles (WIMPs). The experiment uses pulse shape discrimination to separate WIMP-like nuclear recoils from the electronic recoils caused by most background events. Nuclear recoils produce more prompt scintillation light compared to electronic recoils, and this allows for excellent rejection of these background events. The collaboration has gone to extraordinary lengths to minimise the background from nuclear recoils, and < 0.6 background events are expected in the WIMP region of interest for 3 years of running. The projected cross-section sensitivity is 10^{-46} cm² for WIMPs of mass 100 GeV, which is an order-of-magnitude better than current experimental limits. This talk will detail the current status of the DEAP-3600 experiment, including highlights of the construction effort, and the latest results from commissioning the detector.

Alternative Theories / 179**The Holographic Twin Higgs****Authors:** Michael Geller¹; Ofri Telem¹¹ *Technion***Corresponding Author:** t10ofrit@gmail.com

We present the first realization of a “twin Higgs” model as a holographic composite Higgs model. Uniquely among composite Higgs models, the Higgs potential is protected by a new standard model (SM) singlet elementary “mirror” sector at the sigma model scale f and not by the composite states at m_{KK} , naturally allowing for m_{KK} beyond the LHC reach. As a result, naturalness in our model cannot be constrained by the LHC, but may be probed by precision Higgs measurements at future lepton colliders, and by direct searches for Kaluza-Klein excitations at a 100 TeV collider

Particle Cosmology / 180**Light Pseudoscalars and Coy Dark Sectors at the LHC****Author:** Jonathan Kozaczuk¹**Co-author:** Travis Martin¹¹ *TRIUMF***Corresponding Author:** jkozaczuk@triumf.ca

Many extensions of the Standard Model, such as the NMSSM, can predict new, relatively light pseudoscalars with Higgs-like couplings to Standard Model fermions. In particular, simple models of this type in which the pseudoscalar also couples to dark matter can explain the GeV Galactic Center excess as observed by the Fermi Large Area Telescope. In this talk, I will discuss the prospects for

observing these light states at the LHC through their couplings to Standard Model fermions. While existing searches effectively probe heavy (>90 GeV) pseudoscalars, the 13 TeV LHC could cover much of the interesting parameter space in the intermediate mass range in which the new state can have appreciable Yukawa-like couplings but would have escaped detection by LEP and other experiments. While I will focus on scenarios motivated by the Galactic Center excess, the searches I discuss apply generally to new physics scenarios featuring light pseudoscalars with significant couplings to Standard Model quarks and leptons.

Alternative Theories / 181

Direct searches for low-mass new physics particles at BABAR

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We present results from the BaBar experiment on searches for low-mass new physics. This includes a search for a light CP-odd Higgs boson (A_0) in $Upsilon(1S) \rightarrow \gamma A_0$, $A_0 \rightarrow c\bar{c}$ decays, providing limits on the product branching fraction $B(Upsilon(1S) \rightarrow \gamma A_0) \times B(A_0 \rightarrow c\bar{c})$ at the level of $7 \times 10^{-5} - 2 \times 10^{-3}$ for A_0 masses between 4.0 GeV and 9.25 GeV; a search for a dark photon (A'), a new light gauge boson introduced by dark sector models obtaining 90% confidence level upper limits on the mixing strength between the photon and dark photon at the level of $10^{-3} - 10^{-4}$ for dark photon masses in the range 0.02 - 10.2 GeV; and a search for neutral, long-lived particles produced in e^+e^- collisions or neutral B meson decays obtaining limits on the product of the production cross-section, branching fraction, and reconstruction efficiency are set for each final state.

SUSY/String Models / 182

Aspects of dynamical supersymmetry breaking and its mediation on magnetized tori

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We show some aspects of dynamical supersymmetry breaking (DSB) in super-Yang-Mills (SYM) theories in higher-dimensional space-time compactified on magnetized tori. The profile of background magnetic fluxes and Wilson-lines determines the breaking pattern of gauge symmetries as well as the number (degeneracy) of matter zero-modes in each representation under the remaining symmetries, with which the running of gauge couplings can be traced below the compactification scale. We search flux configurations which induce certain zero-mode spectra including those required for DSB in the four-dimensional effective SYM theories, and identify possible messengers mediating the breaking effects to visible sectors.

Particle Cosmology / 183

Monochromatic Gamma Rays from Dark Matter Annihilation to Leptons

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We investigate the relation between the annihilation of dark matter (DM) particles into lepton pairs and into 2-body final states including one or two photons. We parametrize the DM interactions with leptons in terms of contact interactions, and calculate the loop-level annihilation into monochromatic gamma rays, specifically computing the ratio of the DM annihilation cross sections into two gamma rays versus lepton pairs. While the loop-level processes are generically suppressed in comparison with the tree-level annihilation into leptons, we find that some choices for the mediator spin and coupling structure lead to large branching fractions into gamma-ray lines. We also explore the possibility of mediators which are charged under a dark symmetry and find that, for these loop-level processes, an effective field theory description is accurate for DM masses up to about half the mediator mass.

Particle Cosmology / 184

Gravitational Interaction of The Higgs and Dark Matter

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With the LHC Higgs discovery, we are strongly motivated to study gravitational interactions of the Higgs boson. In this talk, we study the unique dimension-4 operator of the Higgs with Ricci curvature in the effective field theory. This dimensionless nonminimal coupling affects weak gauge boson scattering amplitudes and yields perturbative unitarity violation in high energy. The same operator makes it possible to drive inflation by the Higgs in early universe. The analysis of unitarity constraints is extended to the Higgs inflation with large background field. It also modifies the Higgs self-interactions. Generally speaking, we could study Higgs self-interactions via diHiggs production with new physics contribution parametrized by dimension-6 operators. As motivated by this model, we identify a 2d parameter space and perform full analysis of $gg \rightarrow hh \rightarrow b\bar{b}\gamma\gamma$ process at pp(100TeV) hadron collider. We construct various benchmarks to explore the sensitivity in different region of parameter space. Along the same line, we study the possibility that the dark matter only talks to the SM via gravity. We construct a simple model with a scalar dark matter coupled nonminimally to the Ricci curvature. We find that only with the Higgs nonminimal coupling, the induced effective interactions between the DM and SM particles are able to account for the observed thermal relic abundance perturbatively. Such a scalar gravitational dark matter turns out to be highly predictive and testable in various searches.

Particle Cosmology / 185

Ratchet Baryogenesis during reheating

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We propose a new baryogenesis scenario, which occurs during reheating after inflation. During reheating, the oscillation of the inflaton field breaks thermal equilibrium, providing one of the necessary conditions for baryogenesis. The inflaton field is assumed to couple to a complex scalar field which carries baryon number, whose self coupling breaks B, C and CP, providing the remaining two conditions for baryogenesis. The dynamics of our scenario utilizes the so-called “ratchet mechanism” found in models of biological molecular motors. There, the driving force of the ratchet movement (of molecular motors) usually comes from the oscillatory change of temperature in the non-equilibrium state. In the present scenario this driving force is provided by the oscillation of the inflaton field. Baryon number is generated by the phase of the complex scalar field being driven in a preferred direction due to the oscillatory energy provided by the inflaton and the “ratchet” of the self-coupling potential. We argue that for the inflaton potential supported by recent Planck results, this scenario allows for the generation of a baryon-to-photon ratio compatible with observations.

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Z' limits and naturalness in $U(1)$ extended models

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Non-minimal supersymmetric models are able to solve some of the naturalness problems of the minimal supersymmetric standard model (MSSM), such as the need for large radiative corrections to accommodate a 125 GeV Higgs. Models with an additional $U(1)'$ symmetry at low energies may raise the tree level Higgs mass through F - and D -term contributions, reducing the need for such corrections, and also allow for the solution of the MSSM μ problem. On the other hand, in one example of such a $U(1)$ extension, the exceptional supersymmetric standard model (E_6 SSM), it has been found that a new tree level fine tuning arises due to large experimental limits on the Z' mass in this model. We investigate the fine tuning associated with these limits in a wider class of $U(1)$ extended models that are based on an underlying E_6 symmetry at the grand unification (GUT) scale. We adopt a conservative approach in which the soft parameters are set at low energies, thus removing any tuning that comes from assumptions about how SUSY is broken. In this case, we find that increasing the limits on the Z' mass increases the fine tuning, highlighting the importance of Z' searches at run II of the LHC for constraining naturalness in these models. In general, the severity of this tuning depends rather strongly on the choice of $U(1)'$ charges. As a result, models such as the $U(1)_I$ inert model are able to satisfy current Z' mass limits without having a large fine tuning, while in others the limits are already strong enough that a moderate degree of tuning is required.

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Sensitivity of CTA to dark matter annihilations in the galactic centre

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We analyse the sensitivity of the future Cherenkov Telescope Array (CTA) experiment to dark matter annihilations in the galactic centre using the most up to date instrument response functions and background simulation model provided by the CTA Collaboration. We systematically examine the different statistical methods for setting limits using CTA and provide a realistic assessment of the sensitivity of CTA to photon fluxes from dark matter annihilation by means of a binned likelihood analysis for the Einasto and Navarro-Frenk-White halo profiles.

Applying these projections to the phenomenological minimal supersymmetric standard model (pMSSM) we show that CTA is bound to exclude at the 95% C.L. almost all of the phenomenologically favoured ~ 1 TeV higgsino region of the pMSSM, effectively closing the window for heavy supersymmetric dark matter in many realistic models. CTA will be able to probe the vast majority of cases corresponding to a spin-independent scattering cross section below the reach of 1-tonne underground detector searches for dark matter. Altogether, CTA will provide a highly sensitive way of searching for dark matter that will be partially overlapping and partially complementary with 1-tonne detector and collider searches, thus being instrumental to effectively explore the nearly full parameter space of the pMSSM.

Fundamental/String Theory / 188

All rigid N=2 supersymmetric backgrounds

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I will discuss how to classify (up to discrete identifications) all rigid 4D N=2 supersymmetric backgrounds in both Lorentzian and Euclidean signatures that preserve eight real supercharges. These include backgrounds such as warped $S^3 \times \mathbb{R}$, warped $AdS_3 \times \mathbb{R}$, and $AdS_2 \times S^2$, as well as some more exotic geometries. Time permitting, I will also discuss how to construct all supersymmetric two-derivative actions involving hypermultiplets and vector multiplets in these backgrounds.

SUSY/String Models / 191

Chern-Simons SUSY Breaking and the Little Hierarchy Problem

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We propose a solution to (little) hierarchy problem based on SUSY breaking induced in asymmetric Chern-Simons theory. In such theory superparticles are lifted while standard model particles remain untouched. It starts with supergravity in AdS_n , where n can be 3,4,5. One can further take flat spacetime limit for AdS_3 or AdS_4 , or one can study RS model in AdS_5 .

In AdS space, the bulk theory is a supergravity theory with asymmetric Chern-Simons fields where the 1-form is identified to be R-gauge boson. The bulk theory is deformed by a boundary term involving this R-gauge field and a free scalar. It breaks SUSY completely and sources a marginal operator in the dual CFT. SUSY breaking is communicated by gauge interactions to bulk fields. Since the R-charges of scalar and spinor differ, this generates a SUSY breaking shift of their masses. The masses of R-neutral fields are maintained to all orders in the deformation despite the fact that these R-neutral fields can directly couple to R-charged fields. In this way our mechanism solves the little hierarchy problem. Multiple boundary insertions are summed to all orders in \hbar and the picture above is maintained by the non-perturbative result thus obtained. A flat space limit can be constructed which preserves SUSY breaking effects for R-charged fields.

Alternative Theories / 192

Lattice gauge theory for composite Higgs

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Lattice gauge theory enables non-perturbative investigation of strongly interacting systems from first principles. In recent years this approach has produced increasingly valuable information about strongly coupled gauge theories beyond QCD, in particular systems exhibiting non-perturbative near-conformal dynamics. I will present an overview of recent lattice results relevant to the composite Higgs paradigm, and discuss prospects for future progress.

Fundamental/String Theory / 193

N=4 supersymmetric Yang–Mills on a space-time lattice

Author: David Schaich¹¹ Syracuse University**Corresponding Author:** daschaich@gmail.com

Practical lattice discretizations of supersymmetric gauge theories are notoriously difficult to construct in four dimensions. N=4 supersymmetric Yang–Mills (SYM) is the only known 4d theory for which there exists a lattice formulation that exactly preserves a subset of the supersymmetry algebra. This exact supersymmetry has remarkable consequences that are crucial to the feasibility of non-perturbative lattice calculations from first principles. After reviewing some highlights of the N=4 SYM lattice formulation, I will present a selection of results from our ongoing numerical studies, including comparisons with analytic predictions.

SUSY/String Models / 194**Gauged R-symmetry and deSitter vacua in supergravity****Authors:** Ignatios Antoniadis¹; Rob Knoops²¹ *UPMC*² *KU Leuven (BE)***Corresponding Author:** rob.knoops@cern.ch

We explore the phenomenology of a supergravity theory based on a gauged R-symmetry. The model contains a chiral multiplet S , which can be the string dilaton or a compactification modulus, that has a gauged shift symmetry. Supersymmetry is then broken by a combination of F-term and D-term breaking, and allows for a tunable (parametrically small and positive) cosmological constant. We calculate the soft supersymmetry breaking terms and show that an extra field is needed in the hidden sector to prevent tachyonic scalar² masses for the MSSM sparticles. Gaugino masses are generated at one-loop by the so-called ‘anomaly mediation’ mechanism. We show that after a Kahler transformation, part of this mass can be retraced to a Green-Schwarz counter term that is needed to cancel the anomalous R-symmetry. Phenomenological implications are discussed.

Flavor Violation / 196**Exact SU(5) Yukawa matrix unification in the General Flavour Violating MSSM****Author:** Mateusz Kamil Iskrzynski¹**Co-author:** Kamila Kowalska²¹ *University of Warsaw*² *NCBJ***Corresponding Author:** mateusz.iskrzynski@fuw.edu.pl

The simplest Grand Unified Theory (GUT) embedding the Standard Model (SM) is based on the SU(5) symmetry. The unification of gauge couplings, failing in the SM, takes place in the R-parity conserving Minimal Supersymmetric Standard Model (MSSM).

We investigated the possibility of satisfying the minimal SU(5) boundary conditions also for Yukawa matrices at the GUT scale within the MSSM. We found a new region in the model’s parameter space consistent with this requirement.

In this talk, we consider non-vanishing flavour off-diagonal entries in the soft SUSY-breaking mass matrices. The diagonal A-terms are assumed to be proportional to the respective Yukawa couplings. We show that a precise bottom-tau and strange-muon Yukawa coupling unification is possible, while the phenomenological constraints are satisfied. These include the flavour and electroweak observables, Higgs physics and the LHC bounds as well as the dark matter relic density and the stability of vacuum.

Flavor Violation / 197**A Critical Examination of SU(3) in D to P P Decays**

Author: Ayan Paul¹**Co-authors:** Enrico Franco¹; Luca Silvestrini²; SATOSHI MISHIMA²¹ *INFN, Sezione di Roma*² *INFN Rome***Corresponding Author:** apaul2@alumni.nd.edu

The question of the validity of analyzing charmed meson decays to pairs of hadrons within the SU(3) framework has been long and often debated. While there are convincing arguments that small breaking of this symmetry can accommodate for the current experimental results, the inability to compute QCD effects in these modes render it quite impossible to justify with complete authority the physical interpretations of the parameters extracted from experimental data. In our work we explore the SU(3) framework for its strengths and weaknesses and cross-examine it with arguments derived from a diagrammatic approach. We show that isospin non-universality of QCD should be considered within this framework. We also consider $\eta - \eta'$ mixing in our attempt to build a complete analysis of these modes. A precise theoretical computation of these modes are desirable to get a handle on the sizes of the SM contributions, especially through the Penguin topologies as they directly affect the SM expectations of CP asymmetries in these modes. Dynamics beyond the SM can possibly manifest itself in the latter observables which will be measured with considerable precision in the coming years at both the B Factory at KEK and the LHCb.

Particle Cosmology / 199

A Photon Line From Decaying Goldstini Dark Matter

Author: Zachary Thomas^{None}**Co-authors:** Jesse Thaler¹; Matthew Mccullough²; Mobolaji Olukayode Williams³¹ *MIT*² *CERN*³ *Massachusetts Inst. of Technology (MIT)***Corresponding Author:** ztthomas@umn.edu

When multiple sectors break supersymmetry, there is a corresponding multiplicity of goldstini, which may comprise some or all of the dark matter in our universe. In this talk, we identify a previously overlooked goldstino decay channel which leads to a smoking gun photon line signature. This new contribution can be interpreted as arising either from a supersymmetry-breaking Fayet-Iliopoulos term or from supersymmetric kinetic mixing between standard model hypercharge and a (real or effective) hidden sector U(1). In generic scenarios of supersymmetry breaking and mediation, goldstini decay on cosmologically relevant timescales and the photon line is the dominant decay mode even if other channels are kinematically accessible. We discuss the prospects for detecting goldstini dark matter in current and upcoming indirect detection searches.

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Little Conformal Symmetry

Authors: John Terning¹; Kit Colwell¹; Rachel Houtz¹¹ *UC Davis*

Given the lack of conventional SUSY signals in the LHC data, a more complicated story may be required to explain weak scale physics. We introduce a new scheme for canceling the quadratic divergence of the Higgs mass by addition of a new gauge boson. We can impose this cancellation between the gauge boson contribution and the top contribution to the Higgs mass at one scale while simultaneously setting the top Yukawa coupling at its fixed point. Embedding this in an approximately conformal theory allows the cancellation to hold over a large range of energy scales. While we remain technically agnostic as to the UV theory above the conformal breaking scale, explaining heavier SUSY partners without fine tuning motivated the model building.

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Generating Luminous and Dark Matter During Inflation

Author: Neil Barrie^{None}

Co-author: Archil Kobakhidze¹

¹ *The University of Sydney*

We propose a simple mechanism for generating ordinary luminous and dark matter during cosmic inflation. This scenario involves an extension of the Standard Model through the introduction of a dark matter candidate/s and an anomalous $U(1)_X$ gauge group. The general framework developed is found to be able to replicate both the observed matter-antimatter asymmetry and the dark-to-visible matter mass density. (Based on arxiv: 1503.02366)

SUSY/String Models / 202

Shifted focus point scenario from the minimal mixed mediation of SUSY breaking

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We employ both the minimal gravity- and the minimal gauge mediations of supersymmetry breaking at the grand unified theory (GUT) scale in a single supergravity framework, assuming the gaugino masses are generated dominantly by the minimal gauge mediation effects. In such a “minimal mixed mediation model,” a “focus point” of the soft Higgs mass parameter, $m_{\{h_u\}}^2$ emerges at 3-4 TeV energy scale, which is exactly the stop mass scale needed for explaining the 126 GeV Higgs boson mass without the “A-term” at the three loop level. As a result, $m_{\{h_u\}}^2$ can be quite insensitive to various trial stop masses at low energy, reducing the fine-tuning measures to be much smaller than 100 even for a 3-4 TeV low energy stop mass and $-0.5 < A_t/m_0 < +0.1$ at the GUT scale. The “ μ ” parameter is smaller than 600 GeV. The gluino mass is predicted to be about 1.7 TeV, which could readily be tested at LHC run2.

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The XENON Dark Matter Search Program

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The XENON program has helped develop the two-phase xenon time-projection-chamber technology into the most powerful means of directly detecting WIMPs. The program currently consists of the XENON100 and XENON1T experiments. The XENON100 experiment completed 225 live-days of data taking in 2012 that resulted, at the time, in the most stringent spin-independent elastic-scattering constrain on WIMPs. Currently, it is running and being used for detector and calibration R&D for future generations of Dark Matter detectors. Complementarily, the XENON1T experiment is under construction and will begin taking data this year. With a sensitive volume of 2.2 tons, the XENON1T experiment aims for a ~ 100 improvement over its predecessor. I will discuss the status of both experiments and our planned upgrade XENONnT, with a designed sensitivity of few times 10^{-48} cm².

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SUSY-related lepton and hadron flavour results from Belle

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Various decays of B mesons have sensitive to the physics beyond the Standard Models. New particles such as SUSY particles might enter in the loop diagram. Charged scalar particles such as charged Higgs bosons might contribute in addition to the W boson. We present results constraining the new physics with a large data samples that contains 772 million BB pairs collected at the Upsilon(4S) resonance and 121.4 fb⁻¹ collected at the Upsilon(5S) resonance with the Belle detector at the KEKB asymmetric-energy e+e- collider.

Higgs Expt., Theory and Phenomenology / 205

Higgs constraints on left-right supersymmetry

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We study left-right symmetric supersymmetry and the constraints on its Higgs sector from LHC data. The model has a light doubly charged Higgs, whose mass comes from radiative corrections. The LHC bounds on the doubly charged Higgs mass reduce the parameter space significantly. We look at Higgs branching ratios and low energy constraints. We find that the Higgs decay width to bottom quarks can differ largely from the SM prediction at large tan beta and hence moderate values of tan beta are favoured.

Flavor Violation / 206**Heavy Majorana Neutrino Phenomenology in the Inverse Seesaw****Authors:** Cedric Weiland¹; Ernesto Arganda²; Xabier Marcano³; maria herrero⁴¹ *IFT UAM/CSIC*² *Universidad de Zaragoza*³ *IFT-UAM/CSIC*⁴ *Universidad Autonoma de Madrid***Corresponding Author:** xabier.marcano@uam.es

Within low scale seesaw mechanism, in contrast to standard type-I seesaw, one can get compatible with data light neutrinos with the addition of low scale heavy Majorana neutrinos that can still have large Yukawa couplings, leading to new potentially interesting phenomenology. Taking the Inverse Seesaw model as an explicit realization of this kind of models, we study different aspects of this phenomenology, including processes with Lepton Flavor Violation and possible signal at the LHC. We also comment on the enhanced LFV rates in the SUSY version of this model.

Particle Cosmology / 208**A Hidden Dark Matter Sector, Dark Radiation, and the CMB****Authors:** Sungwoo Hong¹; Takemichi Okui²; Yanou Cui³; Zackaria Chacko¹¹ *University of Maryland, College Park*² *Florida State University*³ *Perimeter Institute for Theoretical Physics***Corresponding Author:** sungwoo83hong@gmail.com

We consider theories where dark matter is composed of a thermal relic of weak scale mass, whose couplings to the Standard Model (SM) are however too small to give rise to the observed abundance. Instead, the abundance is set by annihilation to light hidden sector states that carry no charges under the SM gauge interactions. In such a scenario the constraints from direct and indirect detection, and from collider searches for dark matter, can easily be satisfied. The masses of such light hidden states can be protected by symmetry if they are Nambu-Goldstone bosons, fermions, or gauge bosons. These states can then contribute to the cosmic energy density as dark radiation, leading to observable signals in the cosmic microwave background (CMB). Furthermore, depending on whether or not the light hidden sector states self-interact, the fraction of the total energy density that free-streams is either decreased or increased, leading to characteristic effects on both the scalar and tensor components of the CMB anisotropy that allows these two cases to be distinguished. The magnitude of these signals depends on the number of light degrees of freedom in the hidden sector, and on the temperature at which it kinetically decouples from the SM. We consider a simple model that realizes this scenario, based on a framework in which the SM and hidden sector are initially in thermal equilibrium through the Higgs portal, and show that the resulting signals are compatible with recent Planck results, while large enough to be detected in upcoming experiments such as CMBPol and CMB Stage-IV. Invisible decays of the Higgs into hidden sector states at colliders can offer a complementary probe of this model.

Particle Cosmology / 209

Mu-term Hybrid Inflation with Low Energy Consequences

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We explore the implications of a new minimal supersymmetric hybrid inflation model in which the MSSM μ term arises from a coupling of the Higgs doublets to the inflaton sector, with $|\mu|$ required to be greater than the gravitino mass m_G . Successful inflation with the scalar spectral index $n_s = 0.96-0.97$, is followed by a relatively high reheat temperature, $T_{RH} \approx 10^{12}$ GeV, in the presence of this new coupling. Consistency with big bang nucleosynthesis favors $m_G \geq 5 \times 10^7$ GeV, so that the gravitino decays before the LSP neutralino freezes out. With $\mu \sim m_G \sim 5 \times 10^7$ GeV, and soft scalar masses of the same order, the correct value for the SM-like Higgs boson is realized for $\tan\beta \sim 1.7$. An LSP wino with mass ~ 2 TeV turns out to be the simplest dark matter candidate. The tensor to scalar ratio r , a canonical measure of gravity waves, can approach 0.001 in some cases.

Particle Cosmology / 210

Spinodal Backreaction During Inflation and Initial Conditions

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We investigate how long wavelength inflationary fluctuations can cause the background field to deviate from classical dynamics. For generic potentials, we show that, in the Hartree approximation, the long wavelength dynamics can be encapsulated by a two-field model operating in an effective potential. The latter is given by a simple Gaussian integral transformation of the original inflationary potential. We use this new expression to study backreaction effects in quadratic, hilltop, flattened, and axion monodromy potentials. We find that the net result of the altered dynamics is to slightly modify the spectral tilt, drastically decrease the tensor-to-scalar ratio, and to effectively smooth over any features of the potential, with the size of these deviations set by the initial value of power in large scale modes and the shape of the potential during the entire evolution.

Flavor Violation / 211

SUSY-QCD corrections to squark production at LHC in the MSSM with general flavour mixing

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Already at tree-level the theoretical prediction for the cross section of $PP \rightarrow \tilde{q}_i \tilde{q}_i^*$, $\tilde{q} = \tilde{u}, \tilde{d}; i = 1, \dots, 6$, can have a strong dependence on squark flavour mixing parameters. Such a case is not taken into account in any published LHC study up to now. As a logical next step we calculate the leading one-loop corrections to that processes, namely the SUSY-QCD corrections with gluon and gluino loops. This study is still ongoing and we will report on the actual status.

Particle Cosmology / 213

The LZ Dark Matter detector

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The nature and origin of Dark Matter is one of the most compelling mysteries of contemporary science. For over two decades, physicists have been trying to detect Dark Matter particles via collisions on target nuclei, with little success.

The LZ collaboration is designing a massive Dark Matter detector, to be installed at the 4850 level of the Sanford Underground Research Facility in Lead, South Dakota. This detector will feature several tons of target nuclei and use the established liquid xenon TPC technology to achieve unprecedented sensitivity to a wide range of Dark Matter candidates.

This experiment will reach a sensitivity to WIMP-nucleon spin-independent cross section approaching $2 \cdot 10^{-48} \text{ cm}^2$ in 3 years of operation. This represents an improvement of almost three orders of magnitude over current results, covering a substantial range of theoretically-motivated dark matter candidates.

Particle Cosmology / 214

Tight Scrutiny of Electroweak Phase Transitions.

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Baryogenesis at the electroweak scale requires the EW phase transition to be first order, and the discovery of the 125 GeV Higgs confirms that it is second order in the standard model. A myriad of extensions to the Higgs sector have been proposed to still allow for EW baryogenesis. Most approaches to testing the success of these BSM extensions employ a high temperature, small coupling approximation to estimate the strength of the phase transition and to resum diagrams to all order (also called Daisy diagrams) in order to restore perturbation theory. We relax both these approximations and extend the analysis to temperatures comparable to the EW scale, as well as include ‘Super Daisy diagrams’ and explore the quantitative implications to various models.

SUSY/String Models / 215**New Calculations in Dirac Gaugino Models: Operators, Expansions, and Effects****Author:** Jessica Goodman¹**Co-author:** Linda Carpenter²¹ *The Ohio State University*² *Ohio State University***Corresponding Author:** jgoodman@physics.osu.edu

In this work we calculate important one loop SUSY-breaking parameters in models with Dirac gauginos, which are implied by the existence of heavy messenger fields. We find that these SUSY-breaking effects are all related by a small number of parameters, thus the general theory is tightly predictive. In order to make the most accurate analyses of one loop effects, we introduce calculations using an expansion in SUSY breaking messenger mass, rather than relying on postulating the forms of effective operators. We use this expansion to calculate one loop contributions to gaugino masses, non-holomorphic SM adjoint masses, new A-like and B-like terms, and linear terms. We also test the Higgs potential in such models, and calculate one loop contributions to the Higgs mass in certain limits of R-symmetric models, finding a very large contribution in many regions of the μ -less MSSM, where Higgs fields couple to standard model adjoint fields.

Particle Cosmology / 216**Gravothermal evolution of galactic dark matter halos with velocity-dependent self-interactions****Authors:** Rouven Essig¹; Samuel McDermott^{None}; Yiming Zhong¹¹ *Stony Brook University***Corresponding Author:** yiming.zhong@stonybrook.edu

The evolution of galactic dark matter halos would be modified if dark matter were self-interacting. The early heat conduction from the halo envelope to the core would enlarge the core size and reduce the central cusps. The late heat conduction from the core to the envelope would collapse the core into a singular state. Previous studies have focused on constraining the velocity independent self-interaction from the gravothermal evolution of the dark matter halo. In this talk, we investigate the velocity dependent scenario, including both power-law and non-power-law velocity dependence. The latter case satisfies all astrophysical constraints.

Particle Cosmology / 217**Light dark Higgs and the role of isospin violating effect****Author:** YUN JIANG¹**Co-authors:** Bohdan Grzadkowski²; Jack Gunion³¹ *UC Davis*² *University of Warsaw*³ *University of California Davis (US)*

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With protection by an extra Z_2 symmetry, non-SM Higgs boson could be a possible DM candidate. As an example, we consider the singlet extension of the two-Higgs-doublet model. Intriguingly, the dark matter interaction with nucleons in the model could violate isospin symmetry and thus lead to a solution to alleviating the conflict between LUX and other direct detection experiments. Simultaneously, the value of $\tan\beta$ is well-determined. The consequences from the latest cosmological observations and experimental exclusion limits will be discussed.

Alternative Theories / 218

Colorless Top Partners at the LHC

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The impressive sensitivity of the LHC to new colored states has begun to constrain the simplest solutions to the hierarchy problem. Taking naturalness and experiment at face value, we are led to consider models that can address the hierarchy problem without light colored partners to the standard model fermions. I consider three representative models with colorless top partners and detail how they can be tested at the LHC, both through Higgs precision measurements and novel collider signatures.

SUSY/String Models / 220

TeV Supersymmetry with Dynamical Axion Decay Constant

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We are developing a simple supersymmetric axion theory by extending the MSSM with a gauge singlet axion field and right-handed neutrinos. To our surprise, this simple model has been overlooked in the literature, while models that introduce more singlet fields are intensively studied. In addition to the Peccei-Quinn solution to the strong CP problem, the achievements of our model are as follows. The μ problem in the MSSM is solved by the Kim-Nilles mechanism with an intermediate-scale axion decay constant (10^9 - 10^{11} GeV) generated from dimension transmutation, unlike other axion models' PQ breaking from the tree level potential minima. From the axion VEV, the right-handed neutrinos obtain a mass suitable for the seesaw mechanism. Dark matter is overproduced by the axino Freeze-In process, where the Higgsinos in the thermal bath decay to the SM Higgs and the axinos with feeble couplings. However, one can obtain the observed dark matter abundance using dilution from large entropy production of late decaying particles, like inflatons or moduli. Interestingly, the aforementioned Higgsino decay also leads to displaced vertices at LHC for a wide range of the parameter space in TeV-scale Supersymmetry.

Particle Cosmology / 222

Affleck-Dine Sneutrino Inflation

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Motivated by the coincidence between the Hubble scale during inflation and the typical see-saw neutrino mass scale, we present a supergravity model where the inflaton is identified with a linear combination of right-handed sneutrino fields. The model accommodates an inflaton potential that is flatter than quadratic chaotic inflation, resulting in a measurable but not yet ruled out tensor-to-scalar ratio. Small CP-violation in the neutrino mass matrix and supersymmetry breaking yield an evolution in the complex plane for the sneutrino fields. This induces a net lepton charge that, via the Affleck-Dine mechanism, can be the origin of the observed baryon asymmetry of the universe.

Higgs Expt., Theory and Phenomenology / 223

Probe the Electroweak Phase Transition at the LHC

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We study the correlation between the Higgs trilinear coupling and the nature of Electroweak Phase Transition. We use two examples to illustrate this correlations – a simplified model where we include higher order terms in the effective potential, and the NMSSM. We find a large deviation in the trilinear coupling from its Standard Model value in a theory that exhibits a strong first order Electroweak Phase Transition. Then we study how to probe the trilinear coupling from the double Higgs production at the LHC. We develop a new approach to probe the values of the trilinear coupling that have a large deviation from its Standard Model value. At LHC 14 TeV, with an integrated luminosity of 3ab^{-1} , we expect a 3.3σ significance for the Standard Model value of the trilinear coupling and a 5σ significance for a trilinear coupling $\lambda_3 = 6.5\lambda_3^{\text{SM}}$ for the $b\bar{b}g\gamma$ channel.

SUSY Expt. and Phenomenology / 225

LHC signals from R-parity violating chargino decays

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Collider searches for supersymmetric models with R-parity violation (RPV) generally focus on the decay of the (effectively) lightest supersymmetric particle (LSP) through RPV operators. The signal then depends both on the nature of the LSP and the relevant RPV operators. Here we identify scenarios where RPV decays of charginos are important, either because the R-parity conserving decay modes are suppressed by a small chargino–neutralino mass difference, or because the chargino is itself the LSP. These scenarios can potentially lead to striking collider signatures, such as resonances of three charged leptons.

SUSY/String Models / 226

Susy and non-susy Trinification - A framework with radiatively broken symmetry

Author: Antonio Morais¹

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We present a new supersymmetric (SUSY) and non-SUSY versions of a Grand Unified Theory based upon the trinification gauge group $(SU(3)_L \otimes SU(3)_R \otimes SU(3)_C)$ and global flavour $SU(3)_F$ symmetry. In contrast to previous realizations of trinification models, the proposed SUSY version automatically provides unification of the Yukawa couplings as well as Higgs-lepton unification by placing them in a common $(3, \bar{3}, 1)$ representation. The proposed model contains a significantly reduced set of free parameters when compared, for example, to the Minimal Supersymmetric Standard Model (MSSM) and, in contrast to conventional SUSY models, both supersymmetry and gauge symmetry are simultaneously broken at quantum-level. In this talk we discuss how such gauge and SUSY breakdown to the Standard Model gauge group is accomplished and how low-scale parameters are dynamically generated by studying the one-loop effective potential. For the non-SUSY version, while trinification symmetry is readily broken at tree-level a remnant $SU(2)_L \otimes SU(2)_R \otimes U(1)$ symmetry is broken by quantum effects. Such remarkable features of the proposed model may provide a consistent framework for the mass and mixing hierarchies in the Higgs and fermion sectors, by treating them in the same footing without inclusion of extra free parameters. In this talk, preliminary studies/results are reported and further milestones in development of this promising framework are outlined.

Alternative Theories / 228

Exotic quarks in Twin Higgs models

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In UV-complete realizations of the Twin Higgs mechanism, exotic fermions charged under both SM and twin gauge symmetries appear. Some of these states carry visible color, and can therefore be

produced with sizable rates at hadron colliders. The decays of these exotic quarks give rise to striking signatures, which involve a combination of prompt and displaced objects. We present an analysis of the relevant phenomenology.

Higgs Expt., Theory and Phenomenology / 229

Singlet-like Higgs bosons: models and phenomenology

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The presence of extra scalar singlets is a feature of several motivated extensions of the Standard Model, and the mixing of such a singlet with the Higgs boson is allowed to be quite large by current experiments. I will consider both direct and indirect searches, and quantify the current constraints as well as the prospects for future hadron and lepton machines. The results are first presented in a general scalar singlet extension of the Standard Model, taking advantage of the very small number of parameters relevant for the phenomenology. Finally, I will specify the same analysis to a few most natural models, i.e. the Next-to-Minimal Supersymmetric Standard Model and Twin Higgs.

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Recent Theoretical Constraints on Thermal Dark Matter

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We review recent theoretical constraints on models with thermal dark matter. We consider scenarios where the dark matter annihilates via neutral and charged bosons. The latter, annihilation via e.g. colored scalars, is common in supersymmetric scenarios. These theoretical constraints are compared with the increasingly stringent experimental constraints.

SUSY Expt. and Phenomenology / 231

Capturing soft particles at the LHC for studies of degenerated SUSY spectra

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In this talk I will explain how we can enhance sensitivities for the degenerated SUSY mass spectra, especially for a natural supersymmetric framework.

Particle Cosmology / 232

Vector Dark Matter via Higgs Portal

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We discuss options and challenges associated with building viable models of Vector Dark Matter which interact with the Standard Model via the Higgs boson. Higgs portals are often treated with an effective operator, here we instead discuss possible UV complete models to replace the effective operator. The primary focus will be a model where the portal is generated radiatively. We further examine how such a model can complement similar tree-level portals. Finally, experimental constraints and future sensitivities on these models will also be considered.

Higgs Expt., Theory and Phenomenology / 233

Charged Higgs boson searches with the ATLAS detector

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Charged Higgs bosons, H^\pm , are predicted by many models with an extended Higgs sector. This presentation reports ATLAS studies and results of searches for charged Higgs bosons in various final states. Exclusion limits are given and interpreted in the context of the Minimal Supersymmetric extension of the Standard Model.

Higgs Expt., Theory and Phenomenology / 234

Search for the pseudoscalar Higgs boson A of two Higgs doublet models (2HDM) with the ATLAS detector

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We search for the pseudoscalar Higgs boson A of 2HDMs in the decay modes $A \rightarrow \tau\tau$ and $A \rightarrow Zh$. In the latter case, h is the lightest neutral scalar Higgs boson and is assumed to be the newly discovered 125 GeV particle. The results are interpreted in the context of 2HDMs and the Minimal Supersymmetric Standard Model (MSSM).

Higgs Expt., Theory and Phenomenology / 235

Searches for exotic decays of the 125 GeV Higgs boson and the lightest neutral Higgs boson in NMSSM with the ATLAS detector

Author: Kristina Anne Looper¹

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We present the results of searches for non-Standard Model decays of the 125 GeV Higgs boson, including decays to dark sector bosons, lepton flavour violating and flavour changing decays, and decays to a light pseudoscalar neutral Higgs boson (a) predicted by the next-Minimal-Supersymmetric-Standard-Model.

Higgs Expt., Theory and Phenomenology / 236

Search for a high mass neutral Higgs boson using the ATLAS detector

Author: Graham Cree¹

¹ *Carleton*

The results of searches for high mass Higgs bosons decaying to diboson (ZZ,WW,yy) final states by the ATLAS experiment are reported. In absence of the presence of a signal in the data, exclusion limits are presented.

Higgs Expt., Theory and Phenomenology / 237

Constraints on new phenomena through Higgs coupling measurements with the ATLAS detector

Author: Lydia Brenner¹

¹ *Nikhef*

The discovery of the Higgs boson opens many perspectives to explore physics beyond the Standard Model. This talk describes constraints of new physics in a number of models using the combined measurements of the coupling strength of the 125 GeV Higgs particle using the entire ATLAS run-I data. The various models presented include an additional real electroweak singlet, two Higgs doublet models, a simplified Minimal Supersymmetric Standard Model, and a Higgs portal to dark matter.

Higgs Expt., Theory and Phenomenology / 238

Combination of the 125 Higgs Boson Properties Measurements using the ATLAS Detector

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The combined measurements of the properties of the Higgs boson using the ATLAS detector and up to 25 fb⁻¹ of 7 TeV and 8 TeV pp collision data collected in 2011 and 2012, are discussed. The results are obtained combining all channels measured at run 1. They include strengths of production and decay modes, couplings to fermions and bosons, spin and CP properties.

Higgs Expt., Theory and Phenomenology / 239

Latest results on the Higgs boson in the diphoton decay channel

Author: Florian Bernlochner¹

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Recent results on studies of the Higgs boson in the diphoton decay channel are reported including limits on its width through interference effects, a study of its properties in the context of an effective field theory, and its production in association with missing transverse energy.

Higgs Expt., Theory and Phenomenology / 240

Search for the Higgs boson in the ttH production channel using the ATLAS detector

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Since the discovery of a Higgs boson by the ATLAS and CMS experiments at the LHC, the emphasis has shifted towards measurements of its properties and the search for less sensitive channels in order to determine whether the new particle is the Standard Model (SM) Higgs boson. Of particular importance is the direct observation of the coupling of the Higgs boson to top quarks. In this talk a review of ATLAS results in the search for the Higgs boson in the ttH production mode.

Flavor Violation / 241

Searches for lepton flavor violation and new physics signatures with the ATLAS detector at the LHC

Author: Dai Kobayashi¹

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Hints of new physics observed in B-physics have lead to considerable interests on the flavor sector and lepton flavor violating (LFV) effects observable at the LHC. Searches for LFV decays of the Standard Model particles or new heavy particles have been conducted at the ATLAS experiment. Run 1 LFV search results are presented in this talk, together with searches for other signatures at ATLAS. First LHC Run-2 results will be included if available.

Alternative Theories / 242

Dark Matter searches with Mono-X signatures at the ATLAS experiment

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Searches for strongly produced dark matters using events with jets, photons, heavy-flavor quarks or massive gauge bosons recoiling against large missing transverse momentum in ATLAS are presented. These “mono-X” signatures provide powerful probes to dark matter production at the LHC, allowing to interpret results in terms of effective field theory and/or simplified models with pair production of WIMPs. Recent ATLAS results on dark matter searches at LHC Run 1 are presented. First LHC Run-2 results will be included if available.

Alternative Theories / 243

Searches for long-lived particles in Hidden Valley scenarios with the ATLAS detector at the LHC

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Searches for long-lived neutral particles decaying into hadronic jets have been performed with the ATLAS detector. The search strategy depends on the lifetime and mass of such particles, and experimental techniques to reconstruct decay vertices in various ATLAS detector components have been developed. This talk summarizes ATLAS searches for long-lived particles and their connection to hidden sectors with LHC Run 1 data. First LHC Run-2 results will be included if available.

Plenary / 245

Brane/antibrane dynamics and KKLT stability

Author: Joseph Polchinski¹

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String theory has few or no stable nonsupersymmetric vacua, only metastable ones. Antibranes are a simple source of supersymmetry breaking, as in the KKLT model, but various arguments have

been given that these lead to rapid instability. Proper analysis of the system requires identifying the correct effective field theory at various scales. We do so, and find no evidence of rapid instability.

Alternative Theories / 246

Searches for non-MSSM top/bottom quark partners with the ATLAS detector at the LHC

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Title : Searches for non-MSSM top/bottom quark partners with the ATLAS detector at the LHC

Abstract : The naturalness is a paradigm for theories beyond the Standard Model (BSM), incorporating mechanism to cancel mass divergence for the Higgs boson. The presence of fermionic top/bottom quark partners, usually referred to as vector-like quarks (VLQs), may be an important ingredient for such mechanism in non-SUSY scenarios. Searches for vector-like quarks have been performed in various final states at the ATLAS experiment. This talk highlights recent VLQ searches at ATLAS with LHC Run 1 data. First LHC Run-2 results will be included if available.

Alternative Theories / 247

Searches for monopoles and other exotic particles using LHC data at the ATLAS experiment

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Search for highly ionizing particles such as magnetic monopoles or long-lived particles with an electric charge more than the elementary charge has been subject for many experiments over the past decades. Unique signatures for such particles require techniques to be developed on the trigger, identification and reconstruction with tracking detectors and calorimeters. This talk reports searches for highly ionizing particles using LHC Run 1 at ATLAS. First LHC Run-2 results will be included if available.

Particle Cosmology / 248

The relic density of heavy neutralinos

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We will discuss the relic density of TeV-scale wino-like neutralino dark matter in the pMSSM. We have recently developed a framework enabling us to calculate the Sommerfeld enhanced relic density in general pMSSM scenarios. We will present the results of a thorough investigation of certain regions of parameter space, focussing in particular on departures from the well known pure wino scenario: namely the effect of sfermion masses being non-decoupled and of allowing non-negligible higgsino or bino components in the lightest neutralino. The results reveal a number of phenomenologically interesting but so far unexplored regions of parameter space. Near the region where the Sommerfeld enhancement is resonant, the combined effect of non-decoupled sfermions and significant higgsino-wino mixing allows regions with both the correct relic density and the potential for sizeable indirect detection rates.

Alternative Theories / 249

Searches for $t\bar{t}$ resonances with the ATLAS detector at the LHC

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Many extensions of the Standard Model predict the presence of particles decaying into a pair of top-quarks, ranging from narrow resonances such as leptophobic topcolor Z' boson to broader resonances like Kaluza-Klein excitation of the gluon in a Randall-Sundrum model of extra dimensions. The search exploits the technique based on large-radius jets and jet substructure to enhance sensitivity for boosted top quarks produced from high-mass resonance decays. Recent ATLAS results for $t\bar{t}$ resonance searches at LHC Run 1 are presented in this talk. First LHC Run-2 results will be included if available.

Alternative Theories / 250

Searches for new physics in diboson resonances with the ATLAS detector at the LHC

Author: Paolo Mastrandrea¹

¹ *Stony Brook and LAPP*

Resonant production of two massive bosons (WW , WZ , ZZ and HH) is a smoking gun signature for physics beyond the Standard Model. Searches for diboson resonances have been performed in final states with different numbers of leptons and jets including fat-jets with jet substructure. This talk highlights ATLAS searches for diboson resonances with LHC Run 1 data. First LHC Run-2 results will be included if available.

Plenary / 251

Scattering amplitudes

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There has in recent years been remarkable progress in our understanding of the mathematical structure of scattering amplitudes. This will be an overview talk on some of these developments, with particular emphasis on the role of supersymmetry.

Alternative Theories / 252

Searches for leptoquarks and similar signatures with the ATLAS detector at the LHC

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Leptoquarks are hypothetical particles with non-zero lepton and baryon numbers, predicted by many extensions of the Standard Model, and can provide an explanation for the similarity between the quark and lepton sectors. Searches for pair-produced scalar leptoquarks have been performed with final states including charged leptons. In this talk, recent ATLAS results on searches for leptoquarks and new particles with similar signatures using LHC Run 1 data are presented. First LHC Run-2 results will be included if available.

Higgs Expt., Theory and Phenomenology / 253

Heavy Higgs Bosons at 14 and 100 TeV

Authors: Jan Hajer¹; John Shiu¹; Tao Liu²; Ying Ying Li¹

¹ *HKUST*

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Searching for Higgs bosons beyond the Standard Model (BSM) is one of the most important missions for hadron colliders. As a landmark of BSM physics, the MSSM Higgs sector at the LHC is expected to be tested up to the scale of the decoupling limit of $O(1)$ TeV, except for a wedge region centered around $\tan \beta \sim 3-10$, which has been known to be difficult to probe. In this talk, we present a dedicated study testing the decoupled MSSM Higgs sector, at the LHC and a next-generation pp-collider, proposing to search in channels with associated Higgs productions, with the neutral and charged Higgs further decaying into $t\bar{t}$ and $t\bar{b}$, respectively. In the case of neutral Higgs we are able to probe for the so far uncovered wedge region via $pp \rightarrow bbH/A \rightarrow b\bar{t}t$. Additionally, we cover the the high $\tan \beta$ range with $pp \rightarrow bbH/A \rightarrow b\bar{b}\tau\tau$. The combination of these searches with channels dedicated to the low $\tan \beta$ region, such as $pp \rightarrow H/A \rightarrow t\bar{t}$ and $pp \rightarrow t\bar{t}H/A \rightarrow t\bar{t}t\bar{t}$ potentially covers the full $\tan \beta$ range. The search for charged Higgs has a slightly smaller sensitivity for the moderate $\tan \beta$ region, but additionally probes for the higher and lower $\tan \beta$ regions with even greater sensitivity, via $pp \rightarrow t\bar{b}H^\pm \rightarrow t\bar{b}t\bar{b}$. While the LHC will be able to probe the whole $\tan \beta$ range for Higgs masses of $O(1)$ TeV by combining these channels, we show that a future 100 TeV pp-collider has a potential to push the sensitivity reach up to $\sim O(10)$ TeV.

Plenary / 254

Tools for SUSY and new physics at the LHC

Author: Jamie Tattersall¹

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The era of the LHC has completely changed the landscape for Beyond the Standard Model theories. Firstly, the discovery of the Higgs Boson along with precision mass and coupling measurements severely constrain models. Secondly, the null results from the huge number of experimental searches now place strict bounds on new states at the TeV scale.

In order to make sense of the wealth of new results, a multitude of tools have been developed to automatically test the huge number of theories that exist. In addition, if new physics begins to appear in the forthcoming 13 TeV LHC run, the programs will help us determine which model best describes the data. In this talk I will review many of the current tools, explain which approaches are best for different scenarios and offer a view about how they may be improved in the future.

Plenary / 255

High Scale Moduli Stabilization and Axion Inflation

Author: Ralph Blumenhagen¹

¹ *Max-Planck-Institut fuer Physik*

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We present a scheme of tree-level string moduli stabilization via geometric and non-geometric fluxes that is motivated by realizing recent ideas on F-term axion monodromy inflation. We find a set of non-supersymmetric vacua that show a specific scaling type behavior allowing for gaining parametric control over the various mass scales. Generic features and limitations of this approach are highlighted, as well.

Alternative Theories / 256

Hidden Photons and other WISPs - Opportunities at the Low Energy Frontier

Author: Joerg Jaeckel¹

¹ *ITP Heidelberg*

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We review theoretical and phenomenological motivations for hidden photons (aka dark photons, etc.) and other very light and very weakly coupled new particles. New experiments operating at low energies but offering high sensitivities provide interesting opportunities for discoveries. Additional motivations comes from possible connections to dark matter, which also opens avenues for extremely sensitive tests.

Alternative Theories / 257

Searches for boosted dibosons in CMS

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Searches for boosted dibosons (WW, WZ, WH, ZH, etc.) may be sensitive probes of new physics in scenarios where Higgs bosons are composite particles or in certain extra-dimensional models. The recent results of boosted diboson searches with the CMS detector will be presented.

Flavor Violation / 259

Heavy Flavour Physics with ATLAS

Author: Cristobal Padilla Aranda¹

¹ *IFAE-Barcelona (ES)*

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The large amount of Heavy Flavour data collected by the ATLAS experiment is potentially sensitive to New Physics, which may be found in the mixing of B meson states, or through processes that are naturally suppressed in the Standard Model. We present the most recent results on the measurement of the decay of the Bs into J/psi phi based on full data collected in LHC Run-1 and with updated flavour tagging improving the accuracy in the CP-violating phase phi_s. We also discuss the measurement of the decay time difference in the Bd system and the most recent results on the search for the rare decay Bs (B0) -> mu+mu- as well as results on the angular distribution parameters describing the decay Bd -> K*mu+mu- -> K+pi-mu+mu-.

Flavor Violation / 260

Higgs, flavour at the high pT frontier, top & FCNC

Author: Cristobal Padilla Aranda¹

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Heavy Flavours
Higgs and flavour (Higgs to light lepton+quark couplings, Higgs CPV, Higgs flavour violation)
flavour at the high pT frontier,
flavour related searches,
not trivial SUSY/composite searches (non-degenerate SUSY and not SUSY partners, MFV DM),
top FCNC
with specific emphasis on lepton and quark flavour.

Plenary / 261

Flavored supersymmetry: theory models and LHC searches

Author: Yael Shadmi¹

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Flavor dependent soft terms can be consistent with low-energy bounds on flavor violation, and affect LHC searches for supersymmetry. I'll discuss such spectra and their LHC implications using both a bottom-up and a top-down approach, focusing in particular on Flavored Gauge Mediation models.

Plenary / 262

Dark Matter in Supersymmetry

Author: Kyu Jung Bae¹

Co-authors: Andre Lessa²; Chang Sub Shin³; Eung Jin Chun⁴; Hasan Serce¹; Howard Baer⁵

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In supersymmetric models, the lightest neutralino explains the whole dark matter abundance and predicts observable signals in direct and indirect searches. However, recent experiments constrain the natural parameter space for neutralino dark matter. On the other hand, if the neutralino is thermally underabundant, the axion is a good candidate for accompanying dark matter to make up the rest of the dark matter abundance. Moreover, superpartners of the axion can provide non-thermal production of supersymmetric dark matter. In this presentation, I briefly review neutralino dark matter. I also discuss the supersymmetric axion model as a natural dark matter model.

Precision SUSY/Higgs/MCTools / 263

Reaching for Squarks and Gauginos at 100 TeV

Authors: Bob Zheng¹; Sebastian Ellis¹

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I will discuss the prospect of extending the reach for squarks and gauginos via associated production at a $\sqrt{s} = 100$ TeV proton-proton collider, given 3 ab^{-1} integrated luminosity. Depending on the gluino mass, the discovery reach for squarks in associated production with a gluino can be up to 40 TeV for compressed spectra (small gluino-LSP mass splitting), and up to 32 TeV for non-compressed spectra. The discovery reach for Winos can be up to between 4 and 6 TeV depending on squark masses and Wino decay kinematics. Binos of up to 2 TeV could similarly be discovered. Squark-gaugino associated production could prove to be the discovery mode for supersymmetry at a 100 TeV collider in a large region of parameter space.

Plenary / 264

From Underlying Planck Scale M-theory to Predictions for TeV Scale Superpartners

Author: Gordon Kane¹

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Beginning from a few discrete assumptions, such as compactifying the M-theory fluxless sector on a G2 manifold to the MSSM, we show moduli are successfully stabilized in a de Sitter vacuum, and supersymmetry is broken. The gravitino mass is calculated to be about 50 TeV, and gaugino masses are always suppressed to about a TeV (gluino 1.5 TeV, wino 620 GeV, bino 450 GeV). $\mathcal{N}=1$ is included by Witten's approach via the Kahler potential and his discrete symmetry. LHC and future collider cross sections and decays are calculated. Electroweak symmetry is broken, with the Higgs boson mass and decay branching ratios correctly (summer 2011) predicted via the quartic coefficient. The superpotential, Kahler potential, and gauge kinetic function are all generic, with no adjustable parameters. The dark matter is expected to be from a hidden sector. The talk focuses on LHC physics.

Plenary / 265

Status of Weak Scale Supersymmetry

Author: Stephen Martin¹

¹ *Northern Illinois University*

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I will discuss the status of weak scale supersymmetry at the beginning of the LHC Run 2.

Plenary / 266

Composite Higgses

Author: Brando Bellazzini¹

¹ *CEA-Saclay*

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I will present an overview of composite Higgs models in light of the discovery of the Higgs boson. I will classify the various models based on their predictions for the Higgs potential, review the basic ingredients of each of them, and quantify the amount of tuning needed. I will review the generic predictions of this class of models that can be tested at the LHC.

Plenary / 267

ATLAS results on SUSY searches

Author: Tommaso Lari¹

¹ *University and INFN, Milano*

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Despite the absence of experimental evidence, weak scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS results for searches for supersymmetric (SUSY) particles. Weak and strong production in both R-Parity conserving and R-Parity violating SUSY scenarios are considered. The searches involved final states including jets, missing transverse momentum, light leptons, taus or photons, as well as long-lived particle signatures. Sensitivity projections for the data that will be collected in 2015 are also presented.

Plenary / 269

Higgs in the B(MS)SM: susy and non-susy

Author: Julia Shelton^{None}

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Placeholder

Precision SUSY/Higgs/MCTools / 270

SusyFit: A Bayesian Analysis Tool for Electroweak, Flavour and Higgs Observable

Author: Ayan Paul¹

Co-author: . SusyFit²

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² *Susyfit Collaboration*

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With new data, and hopes for observation of new physics, well on the way with the LHC Run II it is necessary to have computational tools at hand that will link experimental observables to model parameters through a global fit done within a rigorous statistical framework. We present SusyFit, a Markov Chain Monte Carlo based Bayesian Analysis tool that can perform global fits with electroweak precision data, flavour observables and Higgs observables to build constraints on model parameters. Built in a modular structure for easy user customization, the code comes with the SM, SUSY, THDM, Dimension 6 basis for Higgs Physics and other models implemented both at the model and observable levels. The code is parallelized and can easily be deployed both on multicore personal computers and on clusters. SusyFit is built up as a common platform for the use by both theorist and experimentalists keeping an eye on statistical rigour, a large and varied physics menu and highly flexible end user customizability.

Plenary / 271

Advances in F-theory Constructions of Particle Physics

Author: Mirjam Cvetič¹

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We present developments in F-theory compactifications with an emphasis on the implications for particle physics. We spell out techniques to construct globally consistent F-theory compactifications to four-dimensions that result in particle physics gauge symmetries, such as $SU(5)$ GUT and Standard Model, chiral matter families and Yukawa couplings. We highlight the first globally consistent constructions with the Standard Model gauge symmetry, and three families of quarks and leptons. We also spell out technical advances in constructions of F-theory compactifications with higher rank Abelian and discrete symmetries, and highlight explicit constructions for $U(1) \times U(1)$ and Z_3 discrete symmetry.

Plenary / 272

Physics opportunities at Hadron colliders, LHC and beyond

Author: Liantao Wang¹

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Since the discovery of the Higgs, there have been much discussion about future of high energy physics, centering on next steps at the LHC and next generation colliders. This leads to new proposals and related studies. In this talk, I will review the physics cases of various options being considered, focusing on hadron colliders.

Plenary / 273

Status of Quark Flavour

Author: Thomas Blake¹

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I will review the state of quark flavour physics at the start of run 2 of the LHC. The talk will summarise recent measurements from the LHC experiments and the B-factories on rare b-hadron decays and measurements of CP violation in the Bd and Bs systems.

Flavor Violation / 274

CANCELED - Analysis of the quark sector in the 2HDM with a four-zero Yukawa texture using experimental CKM matrix data

Author: Olga Felix^{None}

Co-authors: Alfonso Rosado ¹; Felix Gonzalez Canales ²; Jaime Hernandez Sanchez ¹; Roberto Noriega Papaqui ³; Stefano Moretti ⁴

¹ Benemerita Universidad Autonoma de Puebla

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We analyse the Yukawa matrices structure, $\tilde{Y}_{1,2}^q$, by assuming a four-zero texture ansatz for their definition, in the frame of the general 2-Higgs Doublet Model. Explicit and exact expressions for $\tilde{Y}_{1,2}^q$ are shown. Naturally, these expressions have a functional structure like to Cheng and Sher ansatz. Furthermore, we perform a χ^2 -fit based on current experimental data on the quark masses and the matrix V_{CKM} , which give us results agreement with the bounds obtained taking into account constraints on Flavour Changing Neutral Currents reported in the literature.

Higgs Expt., Theory and Phenomenology / 275

Trilinear Higgs self-couplings in $S(3)$ SM

Author: Olga Felix^{None}

Co-authors: Ezequiel Rodriguez Jauregui ¹; J. Enrique Barradas Guevara ²

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In this work, the analysis of the Higgs sector in the context of the minimal $S(3)$ -invariant extension of the Standard Model ($S(3)$ SM) is performed. Three Higgs fields, which are $SU(2)$ doublets, and CP invariant, are considered to compute the exact and analytical physical Higgs boson masses. Furthermore, within this model an explicit form of the trilinear self-couplings λ_{ijk} are obtained, in terms of the Higgs masses and two free parameters, θ_S and w_3 . Hence, one can see that the Higgs masses and trilinear Higgs bosons self-couplings are closely linked to the Higgs potential structure given by the discrete symmetry $S(3)$, which can be helpful to distinguish this model from other extensions. In the analysis, the lightest Higgs boson mass is taken to be fixed to 125 GeV. Finally, one find that the numerical values λ_{ijk} of $S(3)$ SM are significantly different from the trilinear Higgs self-coupling of the Standard Model.

Particle Cosmology / 276

A stable vacuum with vector dark matter

Authors: Bohdan Grzadkowski¹; Mateusz Duch²; Moritz McGarrie¹

¹ University of Warsaw

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I will discuss an extension of the Standard Model by an additional $U(1)$ gauge group and a complex scalar Higgs portal. As the scalar is charged under this gauge factor this simple model supplies a vector dark matter candidate satisfying LUX bounds, the

observed relic abundance and limits from direct dark matter searches. An additional Higgslike state, that may be heavier or lighter than the observed Higgs, is present and satisfies LEP and LHC bounds whilst allowing for absolute stability of the electroweak vacuum in a range of parameter space.

Plenary / 277

Searches for Dark Matter at the LHC

Author: Priscilla Pani¹

¹ *Stockholm University (SE)*

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Astrophysical observations have provided compelling proof for the existence of a non-baryonic dark component of the universe: Dark Matter (DM). The DM abundance is precisely measured but its nature is still not known. A compelling hypothesis is that the DM is composed of a weakly interacting massive particle (WIMP) which can be produced and detected at the LHC. This talk will present an overview of the DM search programs in the ATLAS and CMS collaborations, both in terms of experimental strategies and theoretical benchmark models. The talk will outline the most important results from LHC Run I as well as the sensitivity prospects and, when available, the new results from Run II.

Particle Cosmology / 278

Constraints on Axion Inflation from the Weak Gravity Conjecture

Author: Tom Rudelius¹

¹ *Harvard University*

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Since the BICEP2 detection of B-mode polarization announced in March 2014, there has been a renewal of interest in models of large-field inflation. Axions have gained popularity in this regard, as they may provide a way to realize large-field inflation consistent with the principle of naturalness. However, recent work has revealed additional challenges facing axion inflation, which are linked remarkably to the problem of black hole remnants through the mysterious “Weak Gravity Conjecture.” In this talk, I will present an introduction to this connection between black holes and axion inflation and discuss the prospects for overcoming these obstacles and realizing axion inflation in a manner consistent with quantum gravity.

Particle Cosmology / 279

Recent Developments from the Effective Field Theory of Large Scale Structures

Authors: Leonardo Senatore¹; Matt Lewandowski²; Simon Foreman¹

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The Effective Field Theory of Large Scale Structures (EFTofLSS) is a novel research program that aims at developing a systematic understanding of large scale structures at long distances by expanding in the smallness of the long wavelength perturbations. This program is particular relevant given the importance of large scale structure surveys for our progress in cosmological information in the next decade. Many interesting and encouraging results have been obtained so far in the context of the EFTofLSS. I will present a general overview and the most recent developments.

Alternative Theories / 280

Recent Theoretical Constraints on Thermal Dark Matter (invited)

Author: Devin Walker^{None}

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We review recent theoretical constraints on models with thermal dark matter. The constraints include perturbative unitarity constraints as well as constraints from dark matter bound state formation. We focus on scenarios where the dark matter annihilates via neutral and charged bosons. The latter includes annihilation via colored and electrically charged scalars, which is common in supersymmetric scenarios. We also compare these theoretical constraints with the increasingly stringent experimental constraints.

Higgs Expt., Theory and Phenomenology / 281

Status of Higgs coupling strength determination from ATLAS and CMS

Author: Maria Moreno Llacer¹

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Since the discovery of a Higgs boson by the ATLAS and CMS experiments at the LHC, the emphasis has shifted towards measurements of its couplings in order to determine whether the new particle is the Standard Model Higgs boson. Combined analyses of the Higgs boson production and decay rates as well as of its coupling strengths to vector bosons and fermions have been performed using 7 TeV and 8 TeV pp collision data collected in 2011 and 2012. In this talk a review of the Higgs coupling strength determination will be presented.

Plenary / 283

Precise knowledge of the Higgs-boson mass in the SM and in the MSSM

Author: Pietro Slavich¹

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The measurement of the Higgs-boson mass at the LHC completes our knowledge of the fundamental parameters of the SM, and imposes important constraints on the parameter space of its SUSY extensions. To properly exploit this long-awaited experimental information, high-precision calculations of the predictions of the SM and its extensions are necessary. In this talk I review recent advances in the precise determination of the Higgs sector in both the SM and the MSSM, and discuss their implications for the energy scale at which new physics should be expected, and for the prospects of discovering SUSY particles at the LHC.

Flavor Violation / 284

Higgs, flavor at the high p_T frontier, top, and FCNC

Author: Andrew Chen¹

¹ *U. of Michigan*

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The top quark pairs at Tevatron are produced mainly through proton anti-proton interaction. The asymmetry of this production is intriguing. The search for new physics beyond the Standard Model is on going using CDF RUN II data. The latest results of top quark production asymmetry, searching for Fermiophobic Higgs and FCNC will be given at the conference.

Fundamental/String Theory / 285

Implications of torsion gravity

Author: Ivan Schmidt^{None}

Co-authors: Cristobal Corral ¹; Sergey Kovalenko ¹; Valery Lyubovitskij ²

¹ *Universidad Técnica Federico Santa Maria (Chile)*

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After a brief review of the main ideas of gravity with torsion, a scenario allowing a solution of the strong charge parity problem via the Peccei-Quinn mechanism, implemented in gravity with torsion, is presented. In this framework there appears a torsion-related pseudoscalar field known as Kalb-Ramond axion. It is compared with the so-called Barbero-Immirzi axion recently proposed in the literature also in the context of the gravity with torsion. We show that they are equivalent from the viewpoint of the effective theory. The phenomenology of these torsion-descended axions is completely determined by the Planck scale without any additional model parameters. These axions are very light and very weakly interacting with ordinary matter. We briefly comment on their astrophysical and cosmological implications in view of the recent BICEP2 and Planck data.

Higgs Expt., Theory and Phenomenology / 286

kappa, EFT ... status and prospects

Author: Cen Zhang¹

¹ *Brookhaven National Laboratory*

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The discovery of the Higgs boson allows us to test the standard model at a new level. Ongoing and near future experiments on precision Higgs and EW observables requires a theory for SM deviations. While the kappa framework has been successful as a first attempt, a more consistent theory is required as one moves beyond leading order. In this talk I will summarize recent progress in the Higgs effective field theory framework, and discuss its future prospects.

Plenary / 287

Indirect searches for dark matter: Signal candidates and constraints

Author: Christoph Weniger¹

¹ *University of Amsterdam*

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The currently leading hypothesis for dark matter in the Universe are Weakly Interacting Massive Particles (WIMPs), and the best studied example for a WIMP is the lightest neutralino in supersymmetric theories. Searches for WIMP self-annihilation products are a promising way to identify these particles for the first time. Recent data from gamma-ray, radio, neutrino and cosmic-ray telescopes allow the detailed study of a large number of promising targets. However, with increasing observational precision it becomes also more and more challenging to understand astrophysical fore- and backgrounds at the required level. Here, I will give an overview over some of the recent signal candidates, the most relevant constraints, and the future of indirect searches for WIMP dark matter.

Precision SUSY/Higgs/MCTools / 288

Generalization of J_{E_T} for two-prong objects

Author: Ran Lu^{None}

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Recently we proposed the J_{E_T} algorithm in which jets are defined as subsets of event maximizing some jet functions. In this talk I will discuss how to generalize the concept to study more complicated configurations, focusing on the two-prong objects, and its application in studying W/Z/H decay.

SUSY/String Models / 289

PeV Scale Supersymmetric Neutrino Sector: neutrino masses, sterile neutrino dark matter, PeV neutrinos, and a 3.5 keV line

Author: Bibhushan Shakya¹

Co-authors: James Daniel Wells²; Samuel Roland³

¹ *MCTP*

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Obtaining light active neutrino masses as well as phenomenologically interesting (keV-GeV) sterile neutrino masses without any unnaturally small parameters hints at a new symmetry in the neutrino sector that is broken at the PeV scale, presumably tied to supersymmetry breaking. This framework can also explain the recently observed PeV energy neutrinos at IceCube and the 3.5 keV X-ray line.

Precision SUSY/Higgs/MCTools / 290

Reconstructing CMSSM parameters at the LHC with $s\sqrt{=14}$ TeV via the golden decay channel

Authors: Andrew Fowlie¹; Leszek Roszkowski²; Malgorzata Kazana³

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We identify a benchmark point in the CMSSM's heavy stau-coannihilation region, which is favored by experiments, and demonstrate that it could be accessible to the LHC at $s\sqrt{=14}$ TeV with 300/fb of integrated luminosity via a golden decay measurement. With Monte-Carlo, we simulate sparticle production and subsequent golden decay at the event level and perform pseudo-measurements of sparticle masses from kinematic endpoints in invariant mass distributions. We find that two lightest neutralino masses and the first and second generation left-handed slepton and squark masses could be rather precisely measured with correlated uncertainties. We investigate whether from such measurements one could determine the CMSSM's Lagrangian parameters by including a likelihood from our pseudo-measurements of sparticle masses in a Bayesian analysis of the CMSSM's parameter space. We find that the CMSSM's parameters can be accurately determined, with the exception of the common trilinear parameter. Experimental measurements of the relic density by Planck and the Higgs boson's mass slightly improve this determination, especially for the common trilinear parameter. Finally, within our benchmark scenario, we show that the neutralino dark matter will be accessible to direct searches in future one tonne detectors.

Alternative Theories / 291

Search for the dark photon in π^0 decays

Author: Cristina Biino¹

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A sample of 17 million fully reconstructed π^0 Dalitz decays produced in charged kaon decays in flight collected by the NA48/2 experiment at CERN in

2003-04 is analysed to search for the dark photon (A) via the decay chain

$$\pi^0 \rightarrow \gamma A, A \rightarrow e^+ e^-.$$

No dark photon signal is observed, and the most stringent limits on the dark photon mixing parameter in the mass range 9-70 MeV are established. Limitations of the method and possible future directions are discussed.

Flavor Violation / 292

Prospects for $K^+ \rightarrow \pi^+ \nu \nu$ observation at CERN in NA62

Author: Cristina Biino¹

¹ *INFN Torino (IT)*

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The rare decays $K^+ \rightarrow \pi^+ \nu \nu$ are excellent processes to make tests of new physics at the highest scale complementary to LHC thanks to their theoretical cleanliness.

The NA62 experiment at CERN SPS aims to collect of the order of 100 events in two years of data taking, keeping the background at the level of 10%.

Part of the experimental apparatus has been commissioned during a technical run in 2012. The physics prospects and the status of the experiment will be reviewed after the commissioning run of 2014.

Plenary / 293

Summary and outlook

Author: Joseph David Lykken¹

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A thematic summary of the conference and outlook on possible futures

Plenary / 294

Overview of SM Higgs Physics from ATLAS and CMS

Author: Attilio Andreazza¹

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This talk will focus on Standard Model Higgs results from the ATLAS and CMS experiments.

Plenary / 295

Non-Standard Dark Matter

Author: Stephen West¹

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I will review non-standard dark matter models including alternative genesis mechanisms and nuclear dark matter.

Plenary / 296

Implications of CMB Observations

Author: Raphael Flauger¹

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I will review the recent CMB measurements by the Planck as well as BICEP/Keck collaboration and discuss their implications for early universe cosmology.

Plenary / 297

Neutral Naturalness of the Weak Scale

Author: Nathaniel Craig¹

¹ *UC Santa Barbara*

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This talk will survey models of “neutral naturalness”, in which the weak scale is stabilized against radiative corrections via partner particles whose gauge quantum numbers differ from their Standard Model counterparts.

Plenary / 298

Physics opportunities at future e+e- colliders

Author: Tomohiko Tanabe¹

¹ *The University of Tokyo*

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The discovery of the Higgs boson has sparked interest in future electron-positron colliders, such as the ILC, CLIC, FCC-ee, and CEPC, where the Higgs boson could be studied in great detail. The talk will review the prospects for the precise measurements of the Higgs boson, the top quark, and selected topics on new particle searches including light supersymmetric particles without color charges, at these proposed facilities.

Plenary / 299

Current Issues in the Theory of Inflation

Author: Matthew Kleban¹

¹ *New York University*

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I will give an overview and status report on current issues in the theory of inflation. These include initial conditions and whether inflation really solves the horizon and flatness problems, eternal inflation and its discontents, potential observational signatures of the multiverse, large tensor amplitude and the consequent trans-Planckian field range, and the fundamental question of the microphysical origin of inflation.

SUSY/String Models / 300

Advances in smooth heterotic string theory

Corresponding Author: jamesgrayphysics@gmail.com

I will give a brief summary of the status of the heterotic approach to string phenomenology. I will begin by giving a broad-brush overview of what has and has not been achieved in this field. I will then describe two recent pieces of work on smooth heterotic compactifications to indicate the type of progress which is currently being made.

Plenary / 301

Soft susy breaking in moduli stabilised IIB string compactifications

Author: Fernando Quevedo¹

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Abstract:

A phenomenological analysis is performed regarding the soft susy breaking scenarios obtained by moduli stabilised compactifications of IIB string theory in which soft terms can be computed explicitly. Sequestered and unsequestered scenarios are discussed. In particular late cosmological decay of moduli fields put strong phenomenological constraints on susy dark matter scenarios that are contrasted with current and future experimental constraints.

Plenary / 302

The Search for Dark Matter: Current Status and Future Prospects

Author: Mariangela Lisanti¹

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Dark matter constitutes nearly 85% of the matter in the Universe, and yet we know very little of its fundamental properties. There are currently a wide array of searches for this missing matter—ranging from collider to direct and indirect detection experiments. I will review the current status of these searches and discuss the implications for theories of dark matter.

Plenary / 303

Preview of SUSY 2016

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Double Disk Dark Matter

Author: lisa randall¹

¹ *harvard*

After briefly reviewing the current status of dark matter theory and searches. I will discuss how ideas about dark matter are branching out, with a focus on my work on an independent charged dark matter component that could lead to the formation of a dark disk. I will discuss the different implications this disk can have in laboratory searches for dark matter and in astronomical measurements, including some updated bounds we have done on a dark disk.

Plenary / 305

Status of Precision SM Higgs Cross Section and Branching Ratio Calculations

Author: Radja Boughezal¹

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The future of the high energy physics program will increasingly rely upon precision studies looking for deviations from the Standard Model. Run I of the LHC triumphantly discovered the long-awaited Higgs boson, and there is great hope in the particle physics community that this new state will open a portal onto a new theory of Nature at the smallest scales. A precision study of Higgs boson properties is needed in order to test whether this belief is true. New theoretical ideas and high-precision QCD

tools are crucial to fulfill this goal. They become even more important as larger data sets from LHC Run II further reduce the experimental errors and theoretical uncertainties begin to dominate.

In this talk, I will review recent progress in understanding Higgs properties, including the calculation of precision predictions needed to identify possible physics beyond the Standard Model in the Higgs sector.

Plenary / 306

Higgs flavor studies and rare decays

Author: Hideki Okawa¹

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The ATLAS and CMS Collaborations have discovered a Higgs boson in 2012. Remaining questions are to understand the property of the Higgs sector with precision, and to search for signs of physics beyond the Standard Model. Flavor studies and search for rare decays of the Higgs boson are promising probes to search for new physics. This talk presents an overview of the results of such studies at the ATLAS and CMS experiments in LHC Run-1.

Particle Cosmology / 307

Coannihilating Dark Matter at the LHC

Author: sonia el hedri¹

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We present a general classification of minimal models where the Dark Matter coannihilates with another particle X. Besides this new particle, such coannihilation processes typically require the existence of a mediator, M. Assuming tree-level and renormalizable interactions, we construct all the possible combinations of Dark Matter, X and M that respect gauge and Lorentz invariance. Our framework allows to identify the main categories of LHC signatures associated with coannihilation. We discuss the different aspects of these signatures, with an emphasis on new possible topologies that could be explored at colliders. We briefly comment on constraints arising from relic abundance as well as from direct and indirect detection.

Particle Cosmology / 308

A Manifestly Local Theory of Vacuum Energy Sequestering

Authors: Antonio Padilla¹; David Stefanyszyn¹; George Zahariade²; Nemanja Kaloper²

¹ *University of Nottingham*

² *UC Davis*

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We present a manifestly local, diffeomorphism invariant and locally Poincare invariant formulation of vacuum energy sequestering. In this theory, quantum vacuum energy generated by matter loops is cancelled by auxiliary fields. The auxiliary fields decouple from gravity almost completely. Their only residual effect is an *a priori* arbitrary, finite contribution to the curvature of the background geometry, which is radiatively stable. Its value is to be determined by a measurement, like the finite part of any radiatively stable UV-sensitive quantity in quantum field theory.

Plenary / 309

Recent Progress in the Conformal Bootstrap

Author: David Simmons-Duffin¹

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Recently, a new tool has emerged for studying strongly-coupled Conformal Field Theories, based on the old idea of the Conformal Bootstrap. I will describe how the modern bootstrap (originally motivated by questions about Higgs physics) is providing new quantitative and conceptual results about field theories in diverse dimensions.

Plenary / 310

Status of Lepton Flavor

Author: Yury Kolomensky¹

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We will review the experimental status of searches for Lepton Flavor Violation. We will discuss searches in muon and tau decays, at colliders as well as fixed target facilities. Status and prospects for the future experiments currently in preparation will be reviewed as well.

Plenary / 311

Flavourful Directions towards Unravelling New Physics

Author: Emmanuel Stamou¹

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In this talk I discuss aspects of physics related to flavour dynamics. I focus on observables appearing to be most promising as far as their sensitivity to beyond the Standard Model physics is concerned in view of the awaited data from Run-II of the LHC. I shall look into three complementary directions that are already being pursued individually: One, B- and K-physics probes with new-physics sensitivity and the emerging pattern of possible deviations from the Standard Model expectations. Two,

the flavour information buried in current Higgs data and what improvement we can expect from next stages of the LHC. Three, the intriguing possibility of discovering lepton-flavour violation in decays of the Higgs and its consequences for extensions of the Standard Model.

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TBA

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Plenary / 313

EW phase transition and Baryogenesis

Author: Jing Shu¹

¹ *Institute of Theoretical Physics, Chinese Academy of Science*

In this talk, I will first give a heuristic sketch of the intrinsic connection between electroweak baryogenesis & Higgs physics, based on the fact that baryon asymmetry and elementary particle masses are generated simultaneously during the strongly 1st order phase transition. For the strongly 1st order EW phase transition, I will use a super master formula to demonstrate that either it requires new particles strongly coupled to the Higgs or tuning of the Higgs potential to be shallow. In each case, I will give several popular examples and comment on their current situation based on the new LHC data. The CP violation, on the other hand, requires an imaginary part of the amplitude in the Higgs production and decay, therefore can affect both the Higgs global fits (total amplitude) and direct Higgs CP violation searches (phases). The low energy electric dipole moment (EDM) constraint on Higgs CP violation is also discussed and a general cancellation mechanism will be introduced. The current interplay between LHC Higgs CP physics and EDM experiments, together with the future collider Higgs CP measurements and projected future EDM experiments will be mentioned at the end of the talk.

Particle Cosmology / 314

Dark Matter Annihilation Decay at the LHC

Authors: LianTao Wang¹; Yue Zhao²; Yuhsin Tsai³

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I will discuss the possibility of producing DM bound states at the LHC, emphasizing on two popular scenarios that contain large DM self-couplings: the higgsinos in the lambda-SUSY model, and the DM particles in the self-interacting DM (SIDM) framework. Instead of generating missing energy signatures, these dark bound states have annihilation decays into visible particles in the detector and provide interesting signals for the heavy resonance search.

Precision SUSY/Higgs/MCTools / 315**NLO accurate simulations of SUSY processes with MadGraph5_aMC@NLO**

Authors: Fabio Maltoni¹; Hua-Sheng Shao²; Olivier Mattelaer³; Paolo Torrielli⁴; Rikkert Frederix⁵; Stefano Frixione⁵; Valentin Jonathan Hirschi⁶

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We present NLO QCD accurate predictions of colored scalar pair production matched to parton showers, within a simplified model that can accommodate the case of stop and gluon pair production. The computation is performed fully automatically within the MadGraph5_aMC@NLO framework, starting from the Lagrangian renormalization with FeynRules and NLOCT down to event generation. This work paves the way towards general and flexible NLO simulations for BSM processes, which can eventually improve SUSY experimental analysis and strengthen the corresponding limits. Throughout this presentation, I will give an overview of the current developments and capabilities of MadGraph5_aMC@NLO, including the recent support for the simulation of loop-induced processes.

Plenary / 316**Direct Detection of Dark Matter**

Author: Harry Nelson¹

¹ *UCSB*

A variety of experiments devoted to the laboratory detection of dark matter are underway, approved for the future, and planned. I will review these experiments and the prospective sensitivities.

SUSY/String Models / 317**Split Supersymmetry and Flat Directions**

Author: Kin-Wang Ng¹

¹ *Academia Sinica*

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We discuss the flat directions in the context of split supersymmetry, including the effects of supergravity. The discovered shift symmetry along certain flat directions may have implications to the inflation model and the baryon asymmetry of the Universe.

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test**Corresponding Author:** gunion@physics.ucdavis.edu**Alternative Theories / 319****Low Scale Composite Higgs Model and 1.8 ~ 2 TeV Diboson Excess****Corresponding Author:** jshu@itp.ac.cn

We consider a simple model to explain the recent diboson excess observed by ATLAS and CMS Collaborations in the “General Composite Higgs” framework with the coset $SO(5)/SO(4)(SU(2)_L \times SU(2)_R)$. The $SU(2)_L$ triplet vector boson ρ_L with mass range of 1.8 ~ 2 TeV, which would be produced through the Drell-Yan process with sizable diboson decay branching ratio, can account for the excess. By imposing first Weinberg sum rule and positive gauge boson form factors as the theoretical constraints, we also study the other $SU(2)_L \times SU(2)_R$ bidoublet axial resonance a , which would cancel all deviations of electroweak observables induced by ρ_L . Furthermore the correlation between tree level S parameter and the $h \rightarrow Z\gamma$ process suggest a large a contribution to $h \rightarrow Z\gamma$ and it is indeed a $\mathcal{O}(1)$ effect in our parameter space which provides a strong hint for our scenario if this diboson excess is confirmed by the 13 ~ 14 TeV LHC Run II.