

# INDARA SUAREZ

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## EDUCATION

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November 2014 **Ph.D. Physics**, *Texas A&M University, College Station, TX*  
Title: Search for New Heavy Resonances Decaying into  $\tau^+\tau^-$  pairs  
at the LHC with  $\sqrt{s} = 7$  TeV ( $L = 5.0 \text{ fb}^{-1}$ ).  
Advisor: Alexei Safonov

December 2007 **B.S. Physics**, *University of California, Los Angeles, CA*

## RESEARCH EXPERIENCE

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November 2014 - Present

*UC President's Postdoctoral Fellow, CMS*

**University of California, Santa Barbara**

*Supervisor: Claudio Campagnari*

**Performing and leading a search for the supersymmetric partner of the top quark, using the Run 2 data collected by the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC)** A relatively light partner to the top quark ( $\sim 1$  TeV) is common in natural supersymmetry (SUSY) and could explain the observed value of the Higgs mass as well as have ties to dark matter. [\[3\]](#),[\[2\]](#)

- Major contributions to the development of the search strategy and estimation of backgrounds for the search for top squark pair production characterized by a final state with a single lepton and large missing transverse energy (MET).
- Developed new signal regions for this search to increase sensitivity to "natural SUSY" scenarios with a compressed gaugino sector.
- Coordinating a team of students and postdocs from four institutions (UCSB, UCSD, Fermilab, and the IPHC in Strasbourg) devising the analysis strategy to take advantage of the full Run 2 data. With the expected  $O(100 \text{ fb}^{-1})$  of Run 2 data, we expect to be able to probe much of the theoretically interesting mass ranges.

**Feasibility studies on the search for SUSY particles using the upgraded CMS detector in the HL-LHC era** I work together with a group of postdocs from UCSB, UCSD, DESY, and Fermilab led by Anadi Canepa conducting studies of the expected physics performance obtainable with the HL-LHC data. I am responsible for assessing our ability to tag high-pT jets in the forward region, which result from Vector Boson Fusion (VBF) processes, with the upgraded CMS detector. With this study, we also hope to understand possible gains of VBF production modes in the search for compressed or weakly interacting new physics scenarios postulated by dark matter and natural supersymmetric models.

**Playing a leading role in the Detector Performance Group (DPG)** as a DPG convener (previously as subconvener) for the Cathode Strip Chamber (CSC) muon subsystem of CMS.

- Coordinate a group of 30 CMS students and scientists from 9 international institutions who:
  - \* conduct data quality monitoring (DQM) and performance studies
  - \* calculate calibration constants needed for offline reconstruction
  - \* maintain local reconstruction and develop new reconstruction algorithms
  - \* perform simulation studies to address the challenges of the High-Luminosity LHC
- Leading several studies to address the challenges of high luminosity conditions on the algorithms used to reconstruct the CSC segments that form muons in the endcap region. One of these algorithms has been deployed in CMS software and is currently being used to reconstruct muons for Run2 analyses.
- Reformatted DQM shifts to increase prompt communication between shifters and CSC experts (operations managers, DPG conveners, and data certification experts)
- Coordinated CSC performance studies (spatial and time resolutions, local trigger and segment efficiencies) used for a Run 2 muon performance paper currently being prepared for publication. [1]

**Muon DPG Office CSC Representative** I work together with other DPG representatives from the muon subsystems in CMS to coordinate activities for the muon system as a whole. This includes publication of performance studies, coordination with muon Particle Object Group (POG) and muon alignment group, and collaboration on studies addressing the challenges of the High Luminosity LHC.

- Helped develop new muon system data certification procedure unifying the efforts of the four separate muon subsystems.
- Coordinating the development of an automatic DQM tool which will use machine learning algorithms to robustly detect problems during data-taking and help with data certification.

**CSC Detector On Call Expert** Detector expert for the CSC muon system. Responsible for ensuring the every day running of the experiment, coordination with CMS shift leader during global runs, and troubleshooting system when problems arise.

**January 2010 - November 2014**  
*NSF Graduate Research Fellow, CMS*

**Texas A&M University**  
*Supervisor: Alexei Safonov*

**Performed searches for new heavy resonances decaying into  $\tau^+\tau^-$  pairs.** The generic search for heavy particles decaying into a pair of leptons allowed us to probe a variety of theories which aim to describe physics beyond the standard model. This search was highly important at the beginning of the LHC Run 1 since the large increase in center-of-mass energy provided

by the LHC allowed us to search for new particles at much higher masses than ever before with relatively small datasets. In addition, searches with  $\tau^+\tau^-$  final states are sensitive to theories with preferential couplings to third generation particles. Our group extended the limit for our benchmark model from 399 GeV to 1.4 TeV. [4]

- Fully responsible for the  $Z' \rightarrow \tau\tau \rightarrow \tau_e\tau_h$  channel analysis search strategy, signal optimization, and background estimation.
- Development of statistical analysis tool for combining the results of the four channels of the  $Z' \rightarrow \tau\tau$  analysis.

**Study of associated WH production with  $H \rightarrow \tau_h\tau_h$  in pp collisions with Run 1 Data.**

After the Higgs discovery, understanding how the Higgs couples with vector bosons and leptons is important to determine the nature of the particle. I applied my expertise with di-tau analyses to develop a search strategy and background estimation methods in order to establish the search for production of the Higgs boson in association to a W boson, where the Higgs decays to two hadronic taus. [5]

**Played a leading role in the development, integration, and commissioning of new electronics for the innermost muon endcap CSC chambers in preparation for the LHC Run 2 data taking.** I coordinated and worked together with scientists, students, and engineers to achieve readiness review and installation deadlines. Awarded CMS Achievement Award for my work on this project.

- Worked with senior engineer in the design and testing of Optical Trigger Mother Board (OTMB) upgrade for the ME1/1 system of the CMS muon endcap.
- Designed an emulator board with Altium software to help test TMB data input functions and developed techniques to test OTMB firmware prototypes.
- Led a group of engineers, scientists, and students to develop the techniques and software needed test new on-chamber electronics and off-chamber electronics (hardware and firmware) at a test stand. These techniques and software were later used for certification and commissioning of chambers equipped with the new electronics.
- Set-up and coordinated facility where chambers were assembled with new electronics and underwent quality testing prior to being installed in the CMS cavern
- Led the commissioning of the upgraded chambers once installed in the CMS cavern.
- Radiation testing of electronic components for the ME1/1 upgrade. [6],[7]

**January 2008 - August 2009**

*UCLA Post-Baccalaureate Research Scholar*

**University of California, Los Angeles**

*Supervisor: Bernard Nefkens*

- Study of  $3\pi^0$  photoproduction on the proton from threshold to 1.4 GeV [8],[9]
- Responsible for the energy calibration of the Crystal Ball Detector. Completed calibration of PMTs using a Am/Be source and offline calibration by reconstructing the  $\pi^0$  mass.

**January 2004 - August 2004**

*Summer Student Intern*

**SRI International, Menlo Park, CA**

*Supervisor: Dr. Harald Oser*

- Detection of Explosives and Explosive Related Compounds. Initial set-up of femtosecond laser and development of experimental techniques for the detection of explosive- related compounds by laser photoionization time-of-flight mass spectrometry. [10]

## **LEADERSHIP EXPERIENCE**

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- Convener of the SUSY single lepton stop working group. (August 2017 - Present)
- Cathode Strip Chamber (CSC) Detector Performance Group convener. (Sept. 2017 - Present)
- CSC Detector Performance Group (DPG) deputy convener. (Sept. 2015 - August 2017)
- Muon DPG Office CSC Representative. (Nov. 2015 - Present)
- Deputy leader for system integration and commissioning of new trigger electronics for the CSCs (2013 - 2014)

## **TEACHING, MENTORSHIP AND OUTREACH EXPERIENCE**

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**As part of my leadership roles, I have mentored several students and postdoctoral scholars in a wide variety of projects (amongst them hardware commissioning, reconstruction software, and physics analyses). I have provided detailed supervision and guidance for 5 graduate students:**

- Nick Amin (UCSB graduate student) - Understanding muon reconstruction in the HL-LHC environment.
- Sicheng Wang (UCSB graduate student) - Implementation of heavy object taggers into the single lepton stop analysis. Timing calibration for the CSC detector and timing performance studies.
- Daniel Klein (UCSB graduate student) - Development of analysis strategy for compressed regions in the single lepton stop analysis.
- Bennett Marsh (UCSB graduate student) - Development of machine learning and statistical comparison tools for the automatic assessment of the quality of data being collected by the CMS muon detectors.
- Jack Bradmiller-Feld (UCSB graduate student) - Studies to assess the impact on physics analysis of the MEX/1 CSC upgrade for HL-LHC.

and 7 undergraduate students:

- Jonathan Guiang (UCSB undergraduate)
- Nick Amin (Texas A&M Univ. undergraduate)
- James Maniscalco (Northeastern Univ. undergraduate, now Cornell graduate student)
- Austin Schneider (Texas A&M Univ. undergraduate, now Univ. of Wisconsin - Madison graduate student)
- Brant Rumberger (Northeastern Univ. undergraduate, now Univ. of Colorado-Boulder graduate student)
- Daniel King (Northeastern Univ. undergraduate, now Harvard Univ. graduate student)
- SriTeja Upadhyayula (UCLA Undergraduate, now Texas A&M Univ. graduate student)

### **Teaching**

- Graduate Teaching Assistant for introductory mechanics and electromagnetism for non-physics majors, Texas A&M Univ. (2009-2010)

### **Outreach:**

- Organizing interactive visits between local, underrepresented middle schools students and CERN researchers (2016) ([link](#))
- Virtual Tours for Southern California Middle Schools (2013-present) ([link](#))
- Interview for Forbes, Mexico ([link](#))
- Article for the Texas A&M Univ. College of Science about my work at CERN, (2013) ([link](#))
- South Central Conference for Undergraduate Women in Physics (2012, 2013)
- Expanding Your Horizons Geneva (2013)
- CMS Fundamental Physics Scholarship Committee (2013 - 2014)
- CERN Open Days Volunteer (2013, 2014)
- Official CMS and ATLAS Experiment Tour guide (2013- present)
- Texas A&M Physics and Engineering Festival, (2011)

## HONORS AND AWARDS

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**2017** **Fermilab LPC Distinguished Researcher**

Research proposal: "Explore the use of heavy object identification tools to target difficult kinematic regions in the search for top squarks with the full Run-2 dataset of  $O(100)$  fb-1. Understand the potential gains from proposed extensions to detector upgrades for the LHL-LHC era in order to assess the importance of VBF production modes in the search for compressed or weakly interacting new physics scenarios postulated by dark matter and natural supersymmetric models."

**2016** **USCMS Education and Outreach Grant**

Outreach proposal: "Lead interactive visits between local, underrepresented middle schools students and CERN researchers to make available to students the work exciting work going on at the LHC and encourage them to see a career in science as a possibility for their future."

**2014 - present** **UC President's Postdoctoral Fellowship**

Research proposal: "Search for direct top squark pair production in the single lepton final state at  $\sqrt{s} = 13$  TeV"

**2014** **Lederman Fellowship, Fermilab (declined)**

Research proposal: "Search for new physics with same-sign di-lepton signature at the Large Hadron Collider at  $\sqrt{s} = 13$  TeV"

**2013** **CMS Achievement Award**

Awarded "for her work on the integration and commissioning of the new electronics for the ME1/1 region of the Cathode Strip Chambers."

- 2011 - 2014** **National Science Foundation Graduate Student Fellowship**  
**2012** **George Bush Presidential Library Foundation Grant for College of Science**  
**2011 - 2014** **Texas A&M Office of Graduate Studies Prestigious Scholarship**  
**2008 - 2009** **UCLA Post-Baccalaureate Research and Education Program Scholar**  
**2005 - 2007** **UCLA Center for Academic Research Excellence Scholar**  
**2004** **Edison Scholarship**

## SELECTED PRESENTATIONS

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**"Searches for Production of Third Generation Squarks at CMS"**

EPS Conference on High Energy Physics. Venice, Italy. July 6, 2017.

**"CSC Operations and DPG Report" & "Muon Operations Summary"**

2017 US CMS Annual Collaboration Meeting. Wayne State University Detroit, Michigan. May 17 - 20, 2017

**"A Stop To Natural SUSY?"**

Particle Physics Seminar at UC Davis. Davis, CA, 21 Feb. 2017

**"A Stop To Natural SUSY?"**

Particle Physics Seminar at UC Riverside. Riverside, CA, 4 Nov. 2016

**"Searching for Known Unknown"**

Particle Physics Seminar at Texas A&M University. College Station, TX, 22 Sept. 2016

**"Search for top squarks at the Large Hadron Collider"**

UC President's Postdoctoral Fellowship, Academic Retreat. Lake Arrowhead, CA, 16 April, 2016

**"Searching for New Physics with the Large Hadron Collider"**

Physics Department Colloquium at Cal State University, Dominguez Hills. Dominguez Hills, CA, 10 May, 2016

**"Search for top squarks at the Large Hadron Collider"**

Academic Retreat for the President's and Chancellors' Postdoctoral Fellowship Programs. Lake Arrowhead, CA, April 2015

**"Cathode Strip Chamber upgrade for the CMS Endcap at the HL-LHC"**

Meeting of the American Physical Society Division of Particles and Fields. University of California, Santa Cruz, CA, 13-17 Aug 2013

**"Search for high mass di-tau resonances in pp collisions at  $\sqrt{s} = 7$  TeV."**

APS April Meeting. Atlanta, GA. 30 March - 3 April, 2012.

**"Search for high mass di-tau resonances in pp collisions at  $\sqrt{s} = 7$  TeV."**

Texas Section APS/AAPT/SPS Joint Meeting. San Angelo, TX. 22-24 March, 2012.

**"Searching for the Higgs at the Large Hadron Collider."**

South Central Conference for Undergraduate Women in Physics. College Station, Texas. January 13, 2012.

## SELECTED PUBLICATIONS

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As a member of the CMS collaboration, I am an author on several hundred publications. Below is a selected list of publications in peer reviewed journals to which I have made significant personal contributions and was one of a small number of primary authors.

- [1] CMS Collaboration, "**Performance of the CMS muon detector and reconstruction with pp collisions at  $\sqrt{s}=13$  TeV**" CMS-PAPER-MUO-16-001 Being prepared for submission.
- [2] CMS Collaboration, "**Search for top squark pair production in pp collisions at  $\sqrt{s}=13$  TeV using single lepton events**", JHEP 10 (2017) 019, doi:10.1007/JHEP10(2017)019 (4 citations)
- [3] CMS Collaboration, "**Searches for pair production of third-generation squarks in  $\sqrt{s} = 13$  TeV pp collisions**", Eur. Phys. J. C 77 (2017) 327, doi:10.1140/epjc/s10052-017-4853-2 (22 citations)
- [4] CMS Collaboration, "**Search for High Mass Resonances Decaying into Tau-Lepton Pairs in pp collisions at  $\sqrt{s} = 7$  TeV**", Phys. Lett. B 716, 82-102, hep-ex/1206.1725, 2013. (54 citations)
- [5] CMS Collaboration, "**Evidence for the 125 GeV Higgs boson decaying to a pair of tau leptons**", Journal of High Energy Physics as doi:10.1007/JHEP05(2014)104 (326 citations)
- [6] J. Gilmore (Texas A-M), J. Haley (Northeastern U.), V. Khotilovich, J.K. Roe, A. Safonov, I. Suarez, S. Yeager, "**Very forward muon trigger and data acquisition electronics for CMS: Design and radiation testing**", JINST 8 (20), 2013. (2 citation)
- [7] B. Bylsma, D. Cady, A. Celik, L.S. Durkin, J. Gilmore, J. Haley, V. Khotilovich, S. Lakdawala, J. Liu, M. Matveev, B.P. Padley, J. Roberts, J. Roe, A. Safonov, I. Suarez, D. Wood, I. Zawisza, "**Radiation testing of electronics for the CMS endcap muon system**", Nuclear Instruments and Methods in Physics Research A 698 242 - 248, 2013. (4 citations)
- [8] Crystal Ball Collaboration at MAMI Collaboration, "**Search for the charge-conjugation-forbidden decay**", Phys. Rev. C 79:065201, 2009. (7 citations)
- [9] Crystal Ball Collaboration at MAMI Collaboration, "**Measurement of the Slope Parameter alpha for the decay with the Crystal Ball at MAMI-C**", Phys. Rev. C 79:035204, 2009. (81 citations)
- [10] B.V. Pond, C. Mullen, I. Suarez, J. Kessler, K. Briggs, S.E. Young, M.J. Coggiola, D.R. Crosley, H. Oser. "**Detection of explosive-related compounds by laser photoionization time-of-flight mass spectroscopy**", Applied Physics B86, 735-742, 2007 (17 citations)



## ANALYSIS REVIEW COMMITTEES

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I have served on the analysis review committees (ARC) for the following public results:

CMS Collaboration **"Search for dark matter in  $tt(2l)+MET$  with 2016 data"**  
CMS-PAS-EXO-17-014

CMS Collaboration **"Search for new physics in the context of top quarks in the dilepton final state at  $\sqrt{s}=13$  TeV"** CMS-PAS-SUS-17-001

CMS Collaboration **"DM interpretation of a search for direct stop-pair production in the dilepton final state"** CMS-PAS-EXO-17-013

CMS Collaboration **"Search for dark matter in final states with a top quark and missing transverse momentum using new hadronic top quark tagging techniques"**  
CMS-PAS-EXO-16-051