Souvik Das

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Summary of Skills

- **Detector instrumentation.** Assembly and testing of silicon detectors. Carbon fiber detector support structure fabrication. Industry-standard software development for DAQ, calibrations, and online systems

- **Physics data analysis.** 13+ years of analysis experience with CLEO-c and CMS data, leading to a first observation of Dalitz decay in the charm sector and decay of the Higgs to $b\bar{b}$. Leading Higgs pair-production searches at CMS. Adept at state of the art machine learning methods

- **Leadership.** Managing the Purdue Silicon Detector Laboratory. Leading 15 undergraduates, 4 graduate students and 2 postdocs towards research goals. Overseeing laboratory spaces, equipment, and cleanrooms

- **Quantum computing.** Developed quantum annealing algorithm for high energy physics application on the D-Wave processor. Developing algorithms on the IBM-Q in collaboration with the US Air Force Research Laboratory

Education

- **Ph.D. Experimental High Energy Physics**. Cornell University. 2011. Advisor: Prof. Anders Ryd Dissertation: "Observation of the Dalitz Decay of the First Excited State of the Charmed-Strange Meson"

- **M.S. Physics**. Cornell University. 2007

- **B.Sc. (Honours) Physics**. University of Delhi, St. Stephen's College. 2003

Positions

- **Engineering Physicist (Staff)**. Purdue University. July 2017 – Current

- **Post-Doctoral Research Associate**. Purdue University. March 2017 – July 2017

- **Post-Doctoral Associate**. University of Florida. April 2011 – March 2017

- **Visiting Fellow**. Cornell University. August 2010 – February 2011

Awards, Grants, and Fellowships

- **Co-Principal Investigator** on DoD STTR 2019 grant for quantum algorithms technology transfer. Phase I funded

- **LPC Distinguished Researcher 2015** awarded by Fermilab and the LPC

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- **American Physical Society Student Travel Grant Award 2010** awarded by the Department of Particle and Fields

- **CMS Achievement Award 2009** awarded by the CMS Collaboration Board

- **Full academic scholarship at Cornell University** for M.S. and Ph.D. programs in Physics

- **Kishore Vaigyanik Protsahan Yojana Fellowship 2001–2003** awarded by the Department of Science and Technology of the Government of India, and the Indian Institute of Science

- **Inlaks 2003 Scholarship** awarded by the Inlaks Foundation, India

- **Paul Foundation 2003 Scholarship** awarded by The Paul Foundation of the Apeejay Surendra Group, India

Research Experience

- **Search for Higgs Pair-Production at CMS.** October 2012 – Current.

  – Designed the analysis and led the search for resonant Higgs pair production in the $b\bar{b}b\bar{b}$ final state. Served as Main Contact for the analysis. Work published in Phys. Lett. B, 749:560, 2015 and J. High Energ. Phys. 2018:152, 2018. Useful spin-off of the work was "a simple alternative to the Crystal Ball function" that is being used in BESII and astrophysics

  – Currently leading non-resonant Higgs pair production analysis at Purdue University using data-driven generative adversarial neural networks to bypass intensive background generation

- **Quantum Computing.** April 2018 – Current

  – Designed and led development of primary vertexing algorithm for collider physics using a D-Wave quantum annealer. Benchmarking against classical annealing reveals intriguing quantum advantage. Published in hep-ex:1903.08879, submitted for peer review

  – Collaborating with Purdue Research Foundation company FlightProfiler to bring quantum algorithms to the market with USAF funded STTR

- **Silicon Detector Modules Fabrication for CMS Phase II Inner Tracker.** June 2017 – Current

  – Leading wirebonding of CMS Inner Tracker (IT) Phase II readout chips to high density interconnects. Repaired defunct F&K 6400 G4 wirebonder by reverse-engineering unavailable circuit diagrams and fixing electromechanical relays by hand. Created decision-tree based Expert System, FixitFelix, to store instrument diagnostics

  – Supervising software development effort on the Aerotech A3200 gantry between Purdue University, University of Nebraska–Lincoln, and The Catholic University of America to achieve precise and reproducible encapsulation of wirebonds. Developed a parameterized model of encapsulant flow

  – Developing precision "pick and place" operations on the A3200 gantry for module assembly

  – Created a water-cooled Peltier-element based "cold-box" for thermal stress testing modules after assembly, with infrared monitoring

- **Design of Support Structures for Heat Extraction from the CMS Phase II Forward Inner Tracker.** June 2017 – Current

  – Developed a Through-plane Thermal Conductivity measurement apparatus that is ASTM D5470-based. 2% accuracy achieved with 12 thermistors. Used to determine through-plane conductivity of carbon fiber and structural epoxies with various doping

  – Developed an In-plane Thermal Conductivity measurement apparatus of novel design for anisotropic materials. Used to determine in-plane conductivity of carbon fiber

  – Performed Finite Element Analyses (FEA) on ANSYS to identify thermal bottlenecks that can cause runaway

  – Led investigation into thermal interface between carbon fiber and carbon foam for optimal adhesive penetration

  – Developing a compressed-CO_2 mixed-phase refrigeration system for realistic emulation of CMS cooling, necessary for testing carbon fiber and carbon foam based heat extraction structures. Supervised development of DAQ to monitor fluid temperature and pressure for mixed-phase

- **Design and Fabrication of CMS Phase II Inner Tracker Service Cylinder.** June 2017 – Current

  – Used experimental data and mechanical FEA to design smooth curves of Service Cylinder that mitigate stresses

  – Led mold design and manufacture of the first, second and third prototypes of the Service Cylinder

  – Supervised fabrication with carbon fiber of the first, second and third prototypes in industrial autoclaves

  – Supervised creation of a laser-based metrology station, and use of existing mechanical and optical metrology stations to measure deflections in Service Cylinder

- **Irradiation Campaigns for CMS Phase II Inner Tracker.** April 2019 – Current

  – Coordinating irradiation campaigns for structural materials and Phase II IT modules between Cornell University, Purdue University, and University of Colorado Boulder

  – Leading carbon fiber microscopy study to understand mechanical and thermal degradation due to radiation

- **Track-Triggering at CMS.** January 2014 – March 2017.

    – Contributed to simulation of track-triggering with Associative Memory (AM) for CMS Phase II

    – Developed a novel algorithm, the "Analytical Track Fitter", for track fitting with low latency on FPGAs

    – Developed two software packages, "AMTiming" and "PRBTiming", to model various parallelizations of track-trigger hardware at the AM Mezzanine Card and the crate levels to study latency against pileup and event types

- **Search for $H \to b\bar{b}$ at CMS.** April 2011 – October 2012.

    – Developed, maintained and characterized new triggers for the $Z(\nu\bar{\nu})H(b\bar{b})$ channel of the $H \to b\bar{b}$ analysis through 2011 and 2012 of Run I data taking. Results were published in Phys. Lett. B 710:284, 2012, Phys. Lett. B 722:207, 2013 and Phys. Rev. D 89:012003, 2014

    – Determined the feasibility of a Run I analysis in the $Z(b\bar{b})H(b\bar{b})$ channel for contributing to the $H \to b\bar{b}$ search sensitivity at CMS

- **First Observation of $D_s^{*+} \to D_s^+ e^+ e^-$ at CLEO.** July 2009 – August 2010. Supervised by Prof. Anders Ryd

    – Theoretically predicted and calculated rate of the first Dalitz decay in the charm sector, $D_s^{*+} \to D_s^+ e^+ e^-$

    – Observed channel with 5.3 σ significance using 586 pb^{-1} of e^+e^- data at CLEO-c. Measured the branching fraction consistent with theoretical prediction. Results published as Ph.D. dissertation and Phys. Rev. D 86:072005, 2012

- **Online Software and Calibrations for the CMS Pixel Detector**. March 2006 – September 2008. Supervised by Prof. Anders Ryd. Awarded CMS Achievement Award 2009 for effort

    – Designed cascading state machine structure of the CMS Pixel Online Software (POS)

    – Developed framework of POS, from low level Hardware Access Library commands to various Supervisor applications commanding crates of Front-End Controller and Front-End Driver boards. Includes web-GUI for all Supervisor applications

    – Integrated POS with Central Run Control and Detector Control Systems for powering

    – Developed calibration algorithm to center analog baseline levels

    – Developed calibration algorithm to determine all analog levels for digitization

    – Commissioned POS during early runs of CMS

- **Heat Conduction in a One-Dimensional Gas of Elastically Colliding Particles of Unequal Masses**. May 2001 – November 2002. Developed computer simulations of atomistic models of heat conduction in one dimension to address fundamental questions about the relation between Fourier's Law of Heat Conduction and the underlying microscopic dynamics. Also studied ratchet-like mechanisms of energy transport in such systems. Work performed at the Indian Institute of Science. Work published in Phys. Rev. E 66:050103(R), 2002 and covered by Nature News

Selected Talks

- "Reconstructing proton-proton collision positions at the Large Hadron Collider with D-Wave". September 26, 2019. **QUBITS 2019**. Newport, RI

- "Heat extraction through structural components of the CMS Phase II Tracker Forward Pixel Detector". June 17, 2019. **Forum on Tracking Detector Mechanics 2019**. Cornell University, NY

- *Invited Talk:* "The Large Hadron Collider and particle physics. Discovering the Higgs boson and looking beyond". November 8, 2018. **Coe College**. Cedar Rapids, IA

- "Structure and cooling for the CMS Phase II Tracker Forward Pixel Detector". June 27, 2018. **Forum on Tracking Detector Mechanics 2018**. IFIC, Valencia, Spain

- "Searches for double Higgs production using the CMS detector". November 9, 2016. **Higgs Couplings 2016**. SLAC, Stanford

- "The Di-Higgs Effort in Run II". December 4, 2015. **Higgs Exotics Workshop**. CERN

- "Searches for resonant pair production of Higgs bosons using the CMS detector". May 4, 2015. **Phenomenology 2015 Symposium**. University of Pittsburgh, PA

- *Invited Talk:* "Searches for Higgs pair production at the CMS Experiment". April 27, 2015. **Higgs Pair Production for Colliders 2015**. Mainz Institute for Theoretical Physics, Germany

- "Search for the production of two Higgs bosons decaying to bottom quarks". November 14, 2014. **US LHC Users Association Meeting 2014**. Argonne National Laboratory, IL

- "Searches for the production of two Higgs bosons using the CMS detector". August 26, 2014. **Particles and Nuclei International Conference 2014**. Deutsches Elektronen-Synchrotron, Hamburg, Germany

- "$H \to b\bar{b}$ Tools for Supersymmetry Searches". June 13, 2013. **Electroweak Supersymmetry with Higgs**. Fermilab, IL

- "Search for $D_s^{*+} \to D_s^+ e^+ e^-$". February 13, 2010. **American Physical Society April 2010 Meeting**. Washington D.C.

- "The Status and Performance of the CMS Pixel Detector". March 12, 2009. **Technology and Instrumentation in Particle Physics 2009**. Tsukuba, Japan

Selected Publications with Direct Contributions

For a full list of publications, see inspirehep.net/author/profile/Souvik.Das.1

- S. Das, et al., "Track clustering with a quantum annealer for primary vertex reconstruction at hadron colliders", hep-ex:1903.08879, 2019 (Citations: 1)

- CMS Collaboration, "Combination of searches for Higgs boson pair production in proton-proton collisions at 13 TeV", Phys. Rev. Lett. 122:121803, 2019 (Citations: 14)

- CMS Collaboration, "Search for resonant pair production of Higgs bosons decaying to bottom quark-antiquark pairs in proton-proton collisions at 13 TeV", J. High Energ. Phys. 2018:152, 2018 (Citations: 15)

- S. Das, "A simple alternative to the Crystal Ball function", hep-ex:1603.08591, 2016 (Citations: 6)

- CMS Collaboration, "Search for narrow resonant pair production of the Higgs boson in the final state with four bottom quarks", Phys. Lett. B, 749:560, 2015 (Citations: 125)

- S. Das, "An Analytical Track Fitter for rapid least-χ^2 fitting", CMS DN-2015/004

- CMS Collaboration, "Search for the standard model Higgs boson produced in association with a W or a Z boson and decaying to bottom quarks", Phys. Rev. D 89:012003, 2014 (Citations: 150)

- CMS Collaboration, "Search for a Higgs boson decaying into a b-quark pair and produced in association with b quarks in proton-proton collisions at 7 TeV", Phys. Lett. B 722:207, 2013 (Citations: 53)

- CMS Collaboration, "Search for the standard model Higgs boson decaying to bottom quarks in pp collisions at 7 TeV", Phys. Lett. B 710:284, 2012 (Citations: 77)

- CLEO Collaboration 2012, "Observation of the Dalitz decay $D_s^{*+} \to D_s^+ e^+ e^-$", Phys. Rev. D 86: 072005, 2012 (Citations: 2)

- S. Das, K. Ecklund, B. Kreis, A. Ryd, S. Stroiney, and J. Thompson, "CMS Pixel Online Software and Calibrations", CMS Detector Note 2012:012

- S. Das, et. al.,"Trigger strategies for Higgs searches in 2011", CMS Analysis Note AN-11-065

- S. Das, "Observation of the Dalitz Decay of the First Excited State of the Charmed-Strange Meson", Cornell University Ph.D. Dissertation, 2011

- S. Das, "Status and performance of the Compact Muon Solenoid pixel detector", Nucl. Instrum. Meth. A623:147, 2010

- S. Das, O. Narayan, and S. Ramaswamy, "Ratchet for energy transport between identical reservoirs", Phys. Rev. E 66, 050103(R), 2002 (Citations: 3)

Peer Review

- Member of the CMS **Analysis Review Committee** for "Search for non-resonant pair production of Higgs bosons in the $b\bar{b}b\bar{b}$ final state with 13 TeV CMS data" CMS HIG-16-026 Analysis. July 5 – August 2016

- Member of the CMS **Analysis Review Committee** for "Search for resonant pair production of Higgs bosons decaying to $b\bar{b}$ and $\tau\bar{\tau}$" CMS EXO-15-008 Analysis. September 2015 – January 2016

- Member of the CMS **Analysis Review Committee** for "Measurement of the associated production of a Z boson and b jets in pp collisions at 8 TeV". CMS SMP 14-010 Analysis. July 2014 – Current

- Participated in CMS **Institutional Reviews** for "Search for supersymmetry in proton-proton collisions at 13 TeV using 137/fb of data in final states with jets and large missing transverse momentum" (hep-ex:1908.04722), "Search for W boson decays to three charged pions" (Phys. Rev. Lett. 122:151802, 2019), "Search for long-lived particles decaying into displaced jets in proton-proton collisions at 13 TeV" (Phys. Rev. D 99:032011, 2019), "Particle-flow reconstruction and global event description with the CMS detector" (JINST 12 (2017) P10003), "Measurement of the inclusive jet cross section in pp collisions at 2.76 TeV" (Eur. Phys. J. C 76 (2016) 265), "Jet Energy Scale and Resolution in the CMS Experiment" (JINST 12 (2017) P02014), "Pseudorapidity distribution of charged hadrons in proton-proton collisions at 13 TeV" (Phys. Lett. B, 751:143, 2015), "Search for lepton-flavor-violating decays of the Higgs boson to electrons and tau leptons, and to electrons and muons, at 8 TeV" (Phys. Lett. B, 763:472, 2016), "Angular coefficients of Z bosons produced in pp collisions at 8 TeV and decaying to $\mu^+\mu^-$ as a function of transverse momentum and rapidity" (Phys. Lett. B, 750:154, 2015), "Identification techniques for highly boosted W bosons that decay into hadrons" (J. High Energy Phys. 12 (2014) 017), "Exclusive $\gamma\gamma \to \mu^+\mu^-$ production in proton-proton collisions at 7 TeV" (J. High Energy Phys. 01 (2012) 052), "Measurement of the inclusive Z cross section via decays to tau pairs in pp collisions at 7 TeV" (J. High Energy Phys. 08 (2011) 117).

Mentoring and Teaching

- **Mentoring several undergraduate students, and 3 Ph.D. candidates** at Purdue University on a variety of hardware, analysis and quantum computing projects since April 2017

- **Mentored an undergraduate student** from the South Dakota School of Mines and Technology through the **Fermilab Quarknet** intership program to create a virtual reality event display for CMS in June – August 2015

- **Mentored a University of Florida Ph.D. student** who graduated in April 2015

- **Instructed Ph.D. students** at the CMS Data Analysis School of 2014 and 2015 in searching for the Higgs boson and triggering at the CMS experiment

- **Teaching Assistant** at Cornell University. Delivered several self-prepared classroom lectures in a week, preparing experiments, and grading students. Heat and Electromagnetism in Fall 2005 with Prof. L. Gibbons, General Physics in Summer 2004 with Prof. A. Giambattista, Waves, Optics and Particles in Spring 2004 with Prof. H. Tye, Classical Mechanics in Fall 2004 with Prof. P. Krasicky, Heat and Electromagnetism in Summer 2003 with Prof. R. Wheeler, Heat and Electromagnetism in Spring 2003 with Prof. A. LeClair, and Heat and Electromagnetism in Fall 2003 with Prof. V. Elser

Media, Outreach and Organization

- **Fermilab Today** featured the $X \to HH \to b\bar{b}b\bar{b}$ search led by me

- **Advocated for science funding** to Representatives and Senators in Washington D.C. with the Fermilab User's Executive Committee in 2015 and 2017

- Coordinator for the **Fermilab LPC Coffee Hour** in 2015

- Delivered several outreach talks on the Large Hadron Collider and particle physics to schools and universities between 2009 and 2015. The presentation is now an official outreach resource on the CMS website

- **CMS Times**, published online by CERN, described my research in instrumentation of the CMS detector

- **CMS Times** featured my experience as a Ph.D. student at CERN

- **Nature News** featured research led by me in theoretical condensed matter physics