Rocky Bala Garg

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Professional Experience

Jan 2020 – Present	**Postdoctoral Researcher,** Stanford University, USA.
Jan 2019 – Dec 2019	**Research Associate,** University of Delhi, India.
Oct 2011 – Nov 2018	**Doctoral Researcher,** University of Delhi, India.
Aug 2009 – May 2011	**High School Physics Teacher,** India.

Education

Oct 2011 – Nov 2018	**Ph.D. in Physics,** University of Delhi, India. Dissertation title: *Search for quark compositeness in γ+jet final states in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the CMS detector at the Large Hadron Collider* CERN-THESIS-2018-026.
July 2007 – June 2009	**M.A. in Physics with 1st Rank,** Guru Jambheshwar University, India. *Awarded Gold Medal for achieving top position in the university.*
July 2004 – June 2007	**B.A. in Physics with High Honors,** Kurukshetra University, India. *Distinction in General Scholarship.*

Awards & Scholarships

2024	**US ATLAS Equity Diversity and Inclusion Award 2024 ($10,000),** For promoting an inclusive space for women in software and advocating for women and minorities in leadership roles. For playing a key role in the HSF-India project and being a dedicated mentor for students from India and other developing countries.
2011 – 2018	**Junior and Senior Research Fellowships (JRF/SRF),** Fully-funded Ph.D. scholarship awarded to selected candidates through a national-level examination (known as NET JRF) in India.
2009	**University Gold Medal,** For securing top rank in M.A. Physics program.

Leadership Roles

Nov 2024 – Present	**Editorial Board:** LUP - Emerging jets Run 3 analysis (Glance)
Oct 2024 – Present	**Convener:** Tracking and Vertexing for Prompt and Displaced Vertices (TVPD) subgroup in ATLAS Tracking CP group
April 2024 – Present	**Analysis Contact:** s-channel Leptonic + Hadronic Semi-Visible Jets analysis (ATLAS)
Oct 2022 – Present	**Analysis contact:** s-channel fully Hadronic Semi-Visible Jets analysis (ATLAS)
Jan 2020 – Present	**Collaborator:** IRIS-HEP
Nov 2023 – Oct 2024	**AI/ML Liaison:** ATLAS Tracking CP group
July 2024	**Organizing Committee:** US-ATLAS Summer Workshop, University of Washington, Seattle
March 2022 – Oct 2023	**Editorial Board:** $H \to \omega/K^*+\gamma$ analysis (Glance)

Nov 2023	**External Reviewer:** Track reconstruction for the COMET Phase-II experiment with ACTS (JINST 19 P01011)
March 2022	**External Reviewer:** NeurIPS 2022 Competition Track (NeurIPS2022)
Dec 2017 – Dec 2019	**b-tagging Object Expert:** CMS-Exotica group
March 2016 – Nov 2018	**Analysis contact:** Excited quark ($q^* \rightarrow \gamma$+jet) analysis (CMS)
Aug 2015 – Dec 2015	**Validation Contact:** HLT laser corrections in CMS

Research Activity

Dark Matter Searches in Semi-Visible Jets in ATLAS (Oct 2022 – Present)

- Leading searches in rich Dark Sector scenarios, focusing on Hidden Valley models.
- Responsible for establishing Run 3 research efforts and finalizing Run 2 measurements.
- Spearheading two key analyses: one for fully Hadronic Semi-Visible Jets (SVJ) and another exploring a unique final state with leptons embedded in jets (SVJL).
- Kicked-off the SVJL analysis within ATLAS, introducing innovative search strategies.
- Significantly enhanced SVJ sensitivity through a machine learning-based semi-supervised approach.
- Coordinating and leading the integration of systematic uncertainties into the limit calculation framework for the SVJ analysis.
- Enhancing sensitivity to the SVJL signal using innovative isolation methods and anomaly detection, with a particular focus on exploring the low-mass region via Partial Event Building (PEB) scheme.
- Currently mentoring three students across both analyses, guiding them in methodology, data analysis, and result interpretation.

Dark Matter Searches via the Higgs Portal in ATLAS (May 2020 – Dec 2022)

- Led a search for Dark Matter (JHEP) focusing on dark photon signals arising from Higgs boson decays.
- Developed Machine Learning techniques including neural networks and boosted decision trees to effectively distinguish dark photon signals from Standard Model (SM) background.
- Achieved a twofold increase in signal sensitivity, doubling the analysis reach despite the low cross-section of the process and setting significantly tighter limits compared to theoretical predictions.

Search for Quark Substructure in CMS (Jan 2014 – April 2018)

- Led the search for Quark Substructure (PLB) by investigating excited quark states in γ+jet final state.
- Sole Analyst and Developer for the analysis.
- Most sensitive limits for excited quarks in the γ+jet final state with partial Run 2 data.
- Pioneered the first Search for excited b-quarks at $\sqrt{s}$ = 13TeV.

Development of a Novel Vertex Finding Algorithm for ATLAS (May 2021 – Present)

- Led the development of PV-Finder (PubNote), an innovative algorithm for the ATLAS experiment aimed at improving primary vertex reconstruction.
- The algorithm leverages Kernel Density estimation from input track features and Convolutional Neural Networks (CNNs) to accurately compute primary vertex positions.
- Outperformed the ATLAS Adaptive Multi-Vertex Finder (AMVF) in rigorous comparisons, achieving comparable efficiency and two times better resolution.
- Currently Advising a Postbaccalaureate Student on further refining the algorithm and integrating it into ATLAS track reconstruction workflows.

Development of Novel Optimization Techniques within ACTS (Jan 2021 – Present)

- Challenged traditional brute-force tuning of tracking algorithm parameters by developing innovative methods for automatic parameter optimization.

- Achieved superior efficiency and significantly reduced duplication rates using these algorithms.
- Integrated the optimization suite into the ACTS framework (link), enabling seamless utilization by researchers across various experiments.
- Continuing to enhance optimization techniques to improve robustness and ensure detector-agnostic performance.

Optimization of Track Reconstruction in Muon Collider Environment (April 2024 – Present)

- Optimizing particle track reconstruction in the presence of beam-induced backgrounds in $\sqrt{s} = 10$ TeV Muon Collider simulations using the ACTS framework.
- Transitioning the Marlin-based simulation framework to the Gaudi software architecture.

Optimization of Single Electron Trigger for CMS (Jan 2014 – Nov 2014)

- Optimized the single electron trigger to account for changes in ECAL crystal transparency due to the high radiation environment during data taking.
- Calculated Trigger Efficiency across various corrections and devised a strategy to achieve optimal performance.

Outreach Activity

Jan 2020 – Present	**Mentor:** IRIS-HEP and HSF-India Fellows.
Aug 2023 – Present	**Author:** ATLAS training initiatives paper (arXiv), submitted in *Frontiers in Big Data* journal.
May 2022 – Present	**Instructor:** ATLAS analysis tutorial and ACTS developers workshop.
2022 – Present	**Facilitator:** HSF-India Project, fostered collaborations between scientists from the USA and India, enhancing cross-border research partnerships.
Jan 2023	**Featured in IRIS-HEP news article:** *"Developing an Inclusive Space for Women in Software at IRIS-HEP"* (article).
Aug 2022 – Oct 2022	**Developer:** new hands-on pedagogy based tutorial format for ATLAS analysis tutorial.

Research Publications

Co-authored over 900+ publications (InspireHEP) in peer-reviewed journals through CMS, ATLAS and independent collaborations. Publications with significant contributions are listed below:

Journal Articles

1. The ATLAS Collaboration[1], "Search for semi-visible jets in the s-channel using Run 2 data in ATLAS," *target journal: J. High Energ. Phys.*, Ongoing Analysis.
2. R. B. Garg *et al.*, "Training and onboarding initiatives in high energy physics experiments," *submitted to journal: Frontiers in Big Data*, 2024. arXiv: 2310.07342.
3. The ATLAS Collaboration[1], "Search for dark photons from Higgs boson decays via ZH production with a photon plus missing transverse momentum signature from pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector," *J. High Energ. Phys.*, no. 133, 2023. DOI: 10.1007/JHEP07(2023)133.
4. R. B. Garg *et al.*, "A common tracking software project," *Comput Softw Big Sci*, vol. 6, no. 8, 2022. DOI: 10.1007/s41781-021-00078-8.

[1] Papers are published with the entire collaboration author list in alphabetical order.

5. The CMS Collaboration[1], "Search for excited quarks of light and heavy flavor in $\gamma+$ jet final states in proton–proton collisions at $\sqrt{s} = 13$TeV," *Phys. Lett. B*, vol. 781, pp. 390–411, 2018. DOI: 10.1016/j.physletb.2018.04.007. arXiv: 1711.04652.

Conference Proceedings

1. S. Akar, M. Elashri, **R. B. Garg**, *et al.*, "Advances in developing deep neural networks for finding primary vertices in proton-proton collisions at the LHC," in *Proceedings of the 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP)*, 2023. arXiv: 2309.12417.
2. **R. B. Garg**, "Exotic production and decays of the 125 GeV Higgs – ATLAS," in *Proceedings of the 11th Large Hadron Collider Physics Conference (LHCP)*, 2023. URL: https://indico.cern.ch/event/1198609/contributions/5367320/.
3. **R. B. Garg**, C. Allaire, A. Salzburger, H. Grasland, L. Tompkins, and E. Hofgard, "Potentiality of automatic parameter tuning suite available in ACTS track reconstruction software framework," in *Proceedings of the 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP)*, 2023. arXiv: 2309.12422.
4. L. Tompkins, L. AlSarayra, and **R. B. Garg**, "Studying a new Primary Vertex (PV) identification algorithm within ACTS framework," in *Proceedings of the 8th Connecting The Dots workshop (CTD)*, 2023. URL: https://indico.cern.ch/event/1252748/contributions/5521444/.
5. **R. B.Garg**, E. Hofgard, L. Tompkins, and H. Gray, "Exploration of different parameter optimization algorithms within the context of ACTS software framework," in *Proceedings of the 7th Connecting The Dots workshop (CTD)*, 2022. DOI: 10.5281/zenodo.8119778. arXiv: 2211.00764.
6. A. Salzburger, C. Allaire, E. Hofgard, H. Grasland, L. Tompkins, and **R. B. Garg**, "Auto-tuning capabilities of the ACTS track reconstruction suite," in *Proceedings of the 21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT)*, 2022. URL: https://indico.cern.ch/event/1106990/contributions/4998102/.
7. P. Chatain, **R. B. Garg**, and L. Tompkins, "Evolutionary algorithms for tracking algorithm parameter optimization," in *Proceedings of the 25th International Conference on Computing in High Energy and Nuclear Physics (CHEP)*, 2021. DOI: 10.1051/epjconf/202125103071.
8. **R. B. Garg**, "Excited states searches for light and heavy flavour quarks with CMS data at $\sqrt{s} = 13\,TeV$," in *Proceedings of the XXII DAE High Energy Physics Symposium*, 2018. DOI: https://doi-org.ezproxy.cern.ch/10.1007/978-3-319-73171-1_159.

Other Public Documents

1. The ATLAS collaboration, *Primary Vertex identification using deep learning in ATLAS*, 2023. URL: https://cds.cern.ch/record/2858348.

Teaching and Mentorship

Teaching

2021 — **Instructor for Physics 290 course**, Stanford
Physics 290: Research Activities at Stanford is aimed at introducing new graduate students to the diverse research conducted within the physics department at Stanford University.

2009 – 2011 — **High School Teacher,** India
Taught Physics to High School students in India.

Mentorship

Throughout my Postdoctoral tenure at Stanford, I have been actively engaged as a mentor to both undergraduate and graduate students, including IRIS-HEP and HSF-India fellows. Here, I highlight a few of these mentorship experiences:

Sadaf Aliah Kadir
- Ph.D student in High Energy Physics at Stanford (July 2024 – Present)
  Ph.D Thesis Project: *Search for dark matter in ATLAS data, focusing on the Leptonic Semi-Visible Jets signature*

Qi Bin Lei
- Postbaccalaureate student at Stanford (Aug 2024 – Present)
  Project: *Implemented Neural Networks for Kernel Density Estimation in the PV-Finder algorithm*

Noe B. Gonzalez
- Graduate student under research rotation program (Aug 2024 – Present)
  Project: *Creating analysis framework in RDataFrame for Leptonic Semi-Visible Jets analysis*

Samuel Ferraro
- IRIS-HEP Fellow (June 2024 – Sept 2024)
  Project: *Improvement and optimization of track reconstruction algorithms for Muon collider*
  Current Position: *Mathematical Physics Student at Brown University*

Ananya Singha
- HSF-India Fellow (June 2023 – April 2024)
  Project: *Using Neural Networks to generate Kernel Density Estimations for Primary Vertex Identification in ATLAS data*, results presented in CTD2023 conference
  Current Position: *Research Intern at Microsoft India*

Layan AlSarayra
- Visiting student at Stanford and IRIS-HEP Fellow (Feb 2023 – Oct 2023)
  Project: *Studying a new Machine Learning based Primary Vertex finding algorithm using ACTS framework*, results presented in CTD2023 conference
  Current Position: *Graduate student at San Francisco State University*

Elliott Kauffman
- IRIS-HEP Fellow (May 2022 – May 2023)
  Project: *Adapting PV-Finder to the CMS and ATLAS Experiments*, results presented in CHEP2023 conference
  Current Position: *Ph.D. student in High Energy Physics at Princeton University*

Elyssa Hofgard
- Master thesis research (Sept 2021 – May 2022)
  Project: *Parameter optimization in ACTS framework*, results presented in CTD2022 conference
- Undergraduate thesis research (Jan 2021 – Aug 2021)
  Project: *Using Boosted Decision Trees (BDT) for signal-background discrimination in Dark Photon analysis*, research published as a peer-reviewed article in JHEP
  Current Position: *Ph.D. student in Electrical Engineering and Computer Science (EECS) at MIT*

Peter Chatain
- Undergraduate summer student (May 2020 – April 2021)
  Project: *Parameter optimization in ACTS track seeding using Evolutionary Algorithms technique*, results presented in vCHEP2021 conference
  Current Position: *Ph.D student in Computer Science at Stanford*

Conferences and Workshops

Nov 2024 — *Technical Tools for Future Collider Studies* – **Presentation** in 4D tracking workshop – SLAC, USA.

Oct 2024 — *How to do ATLAS analysis - a hands on tutorial* – **Served as a tutor** in ATLAS software tutorial workshop for newcomers – SLAC, USA.

Aug 2024 — *Advancements in ACTS: Speed and Adaptability for the Muon Collider* – **Selected Poster** in Inaugural US Muon Collider Meeting – Fermilab, USA.

July 2024 — *Harnessing Anomaly Detection Tools as Novel Analysis Resources for High Energy Physics* – **Selected talk** in US-ATLAS Summer Workshop – Seattle, USA.

May 2024 — *Training and on-boarding in HEP* – **Selected talk** in WLCG/HSF Workshop 2024 – DESY, Germany.

April 2024 — *New Deep Learning based approach to Primary Vertex finding in ATLAS experiment* – **Selected talk** in APS April Meeting 2024 – Sacramento, USA.

Jan 2024 — *Advances in developing deep neural networks for finding primary vertices in proton-proton collisions at the LHC* – **Selected talk** in 6th Inter-experiment Machine Learning Workshop, CERN.

Oct 2023 — *Studying a new Primary Vertex (PV) identification algorithm within ACTS framework* – **Selected talk in Plenary session** at 8th Connecting The Dots (CTD2023) Workshop – Toulouse, France.

— *How to do ATLAS analysis - a hands on tutorial* – **Served as a tutor** in ATLAS software tutorial workshop for newcomers – SLAC, USA.

May 2023 — *Exotic production and decays of 125 GeV Higgs – ATLAS* – **Invited talk**[2] at 11th Large Hadron Collider Physics (LHCP2023) Conference – Belgrade, Serbia.

— *Advances in developing deep neural networks for finding primary vertices in proton-proton collisions at the LHC* – **Selected talk in parallel session on Artificial Intelligence and Machine Learning** at 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP2023) – Norfolk, VA, USA.

— *Potentiality of automatic parameter tuning suite available in ACTS track reconstruction software framework* – **Selected talk in parallel session on Offline Computing** at 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP2023) – Norfolk, VA, USA.

— *ATLAS software tutorial: evolving to accelerate integration* – **Selected poster** at 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP2023) – Norfolk, VA, USA.

Oct 2022 — *Auto-tuning capabilities of the ACTS track reconstruction suite* – **Selected poster** at 21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT2022) – Bari, Italy.

— *ACTS for IRIS-HEP* – **Selected talk** at IRIS-HEP Institute Retreat – Princeton University, USA.

— *How to do ATLAS analysis - a hands on tutorial* – **Played a significant role in the development of the tutorial and served as a tutor** in ATLAS software tutorial workshop for newcomers – SLAC, USA.

Sept 2022 — *ACTS Developers Workshop* – **Served as a tutor** in the workshop for ACTS developers – CERN.

June 2022 — *Exploration of different parameter optimization algorithms within the context of ACTS software framework* – **Selected talk in Plenary session** at 7th Connecting The Dots (CTD2022) Workshop – Princeton University, USA.

May 2021 — *Evolutionary Algorithms for Tracking Algorithm Parameter Optimization* – **Selected talk** at 25th International Conference on Computing in High Energy and Nuclear Physics (vCHEP2021) – Virtual.

[2] Talks for International events are assigned by the collaboration's speakers committee based on the speaker's expertise in the subject and service to the collaboration.