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Rajat Gupta

Research Fellow

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Research Fellow at the University of Birmingham and Associated Member of the Personnel at CERN, working on Phase-2 ATLAS trigger upgrades for the HL-LHC. My research focuses on Level-0 Calorimeter and Global Trigger development, including infrastructure firmware, control software and real-time trigger systems. Previously, I led Run-3 missing-transverse-momentum trigger commissioning and HL-LHC Global Trigger algorithm development within ATLAS, alongside machine-learning innovations for real-time event selection and detector electronics.

SKILLS

Programming & Frameworks	Python (NumPy, Pandas, scikit-learn), C++, SQL, Bash; PyTorch, TensorFlow, Keras; XGBoost
Machine Learning & AI	Supervised learning (regression, decision trees, random forests, gradient boosting), clustering (K-means), deep learning (neural networks, autoencoders/VAEs), anomaly detection, generative models
Data Processing & Analysis	Pandas, Matplotlib; HDF5; ROOT (PyROOT, uproot)
HEP Software & HPC	Athena (ATLAS), ROOT; MadGraph, GEANT4; CUDA, MPI, OpenMP; real-time/edge ML, FPGA-based ML
Software & Tools	Git/GitHub, Docker, Conda, Jupyter/Colab, LaTeX, Excel

RESEARCH INTERESTS

SM QCD and MPI, BSM searches (dark matter / invisible Higgs), trigger and data-acquisition systems (Next-Generation Triggers; real-time event selection), Monte Carlo generator validation/tuning, muon and gaseous detectors, machine learning for real-time experimental HEP.

ACADEMIC APPOINTMENTS

Research Fellow 31 July 2026 — Present

University of Birmingham & CERN (ATLAS Collaboration)

Advisor: Prof. David Charlton

- Working on the Phase-2 ATLAS trigger upgrade for the HL-LHC within the L0Calo and Global Trigger projects.
- Developing infrastructure firmware and control software for the Phase-2 Global Trigger.
- Contributing to Level-0 Calorimeter trigger development in collaboration with the Birmingham ATLAS trigger team.
- Supporting ATLAS trigger operations and commissioning activities at CERN.

Postdoctoral Research Associate

1 May 2022 — 30 July 2026

University of Pittsburgh & CERN (ATLAS Collaboration)

Geneva, Switzerland

Advisor: Dr. Tae Min Hong

- Lead Run-3 operations and HL-LHC upgrade studies for calorimeter-based trigger systems, focusing on firmware-oriented algorithm development and fast simulation/validation workflows.
- Serve as VBF+MET analysis contact for ATLAS Run-2 and Run-3, coordinating analysis activities and driving studies for searches targeting dark matter / invisible Higgs signatures.
- Drive innovation in real-time anomaly detection for the ATLAS Level-1 Trigger, developing unsupervised ML methods and a novel distilled anomaly-detection trigger for deployment in the Level-1 Topological Trigger (L1Topo).
- Contribute to the ATLAS Phase-II upgrade via design and physics validation of pile-up suppression algorithms for the HL-LHC Global Trigger, optimized for FPGA constraints (latency/resources).
- Commission and perform physics validation of calorimeter-based missing-transverse-momentum triggers for ATLAS Run-3 operations.
- Optimising Microsoft BitNet (1-bit LLM) for FPGA deployment, targeting nanosecond-latency foundation model inference in real-time trigger systems.
- Led an industry-academic collaboration with Hewlett Packard Enterprise on ML-driven calorimeter data compression for future collider experiments; joint paper submitted to Nature Communications (arXiv:2602.15990).
- Co-supervising a Ph.D. student on the VBF + E_T^{miss} analysis for invisible Higgs searches.
- Contributing to a proposal under the US DOE Genesis Mission for SRAM-based neuromorphic chips capable of running foundation models on-chip, removing the Von Neumann memory bottleneck for real-time AI inference.

Assistant Professor

3 Nov 2017 — 30 Apr 2022

S.A. Jain (PG) College

Ambala City, India

- Taught undergraduate B.Sc. Physics courses including computer programming, thermodynamics, waves and optics, statistical physics, quantum and laser physics, spectroscopy, and electronics.
- Supervised laboratory sessions and guided students in foundational and applied aspects of physics; contributed to curriculum development and departmental academic activities.

EDUCATION

Ph.D. in Physics

Panjab University & CERN (CMS Collaboration)

14 Jan 2016 — 20 April 2022

Chandigarh, India

- Thesis: *Study of Multiple Parton Interactions using the CMS Detector at LHC*
- Advisors: Prof. J. B. Singh; Dr. Sunil Bansal

M.Sc. in Physics

Panjab University

Aug 2013 — July 2015

Chandigarh, India

- Marks: 86.35% (Gold Medalist)
- Master's Thesis: *Fabrication and performance studies of Glass and Bakelite Resistive Plate Chambers (RPC)*

B.Sc. (Hons.) in Physics

Panjab University

Aug 2010 — July 2013

Chandigarh, India

- Marks: 79.8% (4th position in University)

AWARDS & HONORS

- Breakthrough Prize in Fundamental Physics (2025) — awarded as part of the ATLAS Collaboration at CERN.
- Ranked among the top 3% of scientists worldwide (AD Scientific Index, 2023; rank 3318/1,351,098).
- Best Poster Award, XXII DAE-BRNS High Energy Physics Symposium (DAE-HEP 2023), University of Delhi, India.
- DST-INSPIRE Fellowship (JRF) during Ph.D. (2016).
- Qualified Graduate Aptitude Test in Engineering (GATE) (2016).

ROLES

Roles as ATLAS Collaboration Member

- Analysis contact for invisible Higgs / dark matter searches.
- Developing machine learning methods (e.g. boosted decision trees) for background estimation and designing a new nTuple framework to streamline analysis workflows.
- Contributing to the ATLAS HL-LHC Phase-II upgrade through the design and validation of pile-up suppression algorithms for the Global Trigger, optimized for FPGA implementation under stringent resource and latency constraints.
- Driving innovation in real-time anomaly detection, developing unsupervised ML algorithms for deployment in the ATLAS Level-1 Topological Trigger during Run-3.
- Supporting ATLAS Run-3 operations and Phase-I upgrades, including commissioning and physics validation of calorimeter-based missing-energy algorithms for Level-1 triggers.
- Engaging in additional ML-driven projects for physics analysis and detector operations.

Roles as CMS Collaboration Member

- Served as contact author on multiple physics analyses, including underlying event measurements using the Drell-Yan process at 13 TeV (FSQ) and double parton scattering measurements using Z +jets at 13 TeV (SMP).
- Contributed to generator development and tuning, including the CMS PYTHIA8 tuning paper, and acted as Monte Carlo generator contact in the FSQ and SMP groups.
- GEM: timing resolution studies (ME0), granularity studies (GE2/1); long-term member since 2016; involved in quality control, assembly, and testing of GE1/1 detectors at Panjab University and CERN.
- RPC: efficiency analysis using Tag-and-Probe on 2017 data.
- Level-1 Trigger: performance studies of jets and missing-energy triggers.
- Extensive operational experience, including Muon DOC3, Trigger Expert Analyst (TEA), Trigger Prompt Feedback Expert (PFE), and Technical DCS shifts.
- Hands-on detector experience: GEM and RPC assembly/testing and performance validation (CERN GEM Lab & Panjab University); DAQ experience with NIM, CAMAC and VME systems.

SELECTED PUBLICATIONS AND CONFERENCE PROCEEDINGS

- **Memristive tabular variational autoencoder for compression of analog data in high energy physics**, arXiv:2602.15990 (2026).
Submitted to Nature Communications.

Contribution: Led the industry-academic collaboration with Hewlett Packard Enterprise. Designed and trained the variational autoencoder for calorimeter data compression, developed the decision-tree-based distillation into tabular format for ACAM deployment, and coordinated the overall research programme.

- **Study of Z boson plus jets events using variables sensitive to double-parton scattering in pp collisions at 13 TeV**, JHEP 10 (2021) 176.
Contribution: Analysis contact and lead author. Responsible for the full analysis chain, including data–MC validation, systematic uncertainties, unfolding, result interpretation, and paper writing.
- **Extraction and validation of a new set of CMS PYTHIA8 tunes from underlying-event measurements**, Eur. Phys. J. C 80 (2020) 4.
Contribution: Performed underlying-event studies using updated CMS PYTHIA8 tunes; results incorporated into the final publication.
- **Layout and Assembly Technique of the GEM Chambers for the Upgrade of the CMS First Muon Endcap Station**, Nucl. Instrum. Meth. A 918 (2019) 67.
Contribution: Involved in detector fabrication, assembly, quality control, and performance validation of GEM chambers as part of the CMS muon upgrade program.
- **Measurement of the underlying event activity in inclusive Z boson production in proton–proton collisions at 13 TeV**, JHEP 07 (2018) 032.
Contribution: Analysis contact and lead contributor. Carried out the full analysis, including event selection, systematic studies, unfolding, final results, and manuscript preparation.
- **Double parton scattering measurements at CMS**, Springer Proc. Phys. 261 (2021) 109.
Contribution: Conference proceedings for oral talk.
- **Fabrication and Characterization of Gaseous Detector for the Identification of High Energy Particles**, IOP Conf. Ser.: Mater. Sci. Eng. 1033 (2021) 012055.
Contribution: Conference proceeding.
- **Latest results on Soft QCD and DPS from the CMS experiment**, EPJ Web Conf. 206 (2019) 06006.
Contribution: Conference proceeding for oral talk.
- **Recent CMS results on soft and small- x QCD physics**, arXiv:1910.01939.
Contribution: Conference proceedings for oral talk.
- **Underlying Event and Double Parton Scattering Measurements at CMS**, Nucl. Part. Phys. Proc. 294 (2018) 7.
Contribution: Conference proceedings for oral talk.
- **Underlying Event Measurements at the CMS**, SLACeConf-C170626, CMS-CR-2017-374 (2017).
Contribution: Conference proceedings for oral talk.

Full list: inspirehep.net/authors/1483072

COLLABORATION PUBLIC NOTES

- “Measurement of distributions sensitive to double parton scattering using Z bosons produced in association with jets at 13 TeV”, CMSPAS-SMP-20-009 (2021).
- “Level-jets and energy sums trigger performance with full 2017 dataset”, CMS-DP-2018/004 (2018).

CONFERENCE TALKS AND PRESENTATIONS

- **Fast ML for Science (ETH Zurich, Switzerland), Sep 2025** — “NomAD: Low-Latency Unsupervised Anomaly Detection for the ATLAS Trigger” (poster).
- **ATLAS Week (CERN, Geneva, Switzerland), Jun 2025** — “NomAD: Anomaly Detection for Dimuon Events at the ATLAS Level-1 Trigger” (poster).
- **Pheno 2025 (University of Pittsburgh, Pittsburgh, USA), May 2025** — “NomAD: Nanosecond anomaly detection using muons in Run 3 L1Topo” (talk).
- **ATLAS ML Workshop, Apr 2025** — “NomAD: Nanosecond anomaly detection using muons in Run 3 L1Topo” (presentation).
- **US-ATLAS Workshop 2023 (Yale University, New Haven, USA), Jul 2023** — “Status of ATLAS Level-1 Calorimeter Trigger” (talk).
- **MPI@LHC 2021 (Lisbon, Portugal), Oct 2021** — “Double-parton scattering studies using gauge bosons and jets at CMS” (talk).
- **ISMD 2021 (Video only), Jul 2021** — “Recent CMS results on soft QCD physics” (talk).
- **EPS-HEP 2021 (DESY & University of Hamburg, Video only), Jul 2021** — “Double parton scattering studies in CMS” (poster).
- **LHCP 2021 (Paris, Video only), Jun 2021** — “Nucleon Structure and Soft QCD from CMS” (talk).
- **XXIV DAE-BRNS High Energy Physics Symposium (NISER Bhubaneswar, India), Dec 2020** — “Recent CMS results on soft and small- x QCD physics” (talk).
- **EDS 2019 (Qui Nhon, Vietnam), Jun 2019** — “Measurements of soft QCD in CMS” (talk).
- **CHASCON-2019 (Panjab University Chandigarh, India), Mar 2019** — “Double Parton Scattering Measurements at LHC” (poster).
- **XXIII DAE-BRNS High Energy Physics Symposium (IIT Madras, Chennai, India), Dec 2018** — “Double parton scattering measurements at CMS” (talk).

- ISMD 2018 (National University of Singapore, Singapore), Sep 2018 — “Recent CMS results on soft and small- x QCD physics” (talk).
- MPI@LHC 2017 (Shimla, India), Dec 2017 — “Minimum Bias and UE measurements at CMS” (talk).
- QCD 2017 (Montpellier, France), Jul 2017 — “Underlying Event and Double Parton Scattering Measurements at CMS” (talk).
- EDS 2017 (Prague, Czech Republic), Jun 2017 — “Underlying Event Measurements at the CMS” (talk).
- XXII DAE-BRNS High Energy Physics Symposium (University of Delhi, India), Dec 2016 — “Recent UE Measurements @ 13 TeV” (poster).
- CMS Week (TIFR Mumbai, India), Nov 2016 — “Recent UE Measurements @ 13 TeV” (poster).
- IWFEILH (Aligarh Muslim University, Aligarh, India), Nov 2016 — “Recent UE Measurements @ 13 TeV” (poster).
- CHASCON-2016 (Panjab University Chandigarh, India), Mar 2016 — “Drell-Yan: a tool for understanding soft QCD” (poster).

WORKSHOPS, CONFERENCES AND SCHOOLS ATTENDED

- TDAQ Week, University of Heidelberg, Heidelberg, Germany (Sep. 2022).
- “Quarks to Cosmos with AI”, Virtual Conference, Carnegie Mellon University, Pittsburgh, USA (Aug. 2021).
- CERN-Fermilab HCP Summer School (Online) (Aug. 2021).
- “Symmetries and Phase Transitions – from Crystals and Superconductors to the Higgs Particle and the Cosmos”, Technical University of Dresden, Dresden, Germany (Aug. 2017).
- National School cum Workshop in Accelerator Physics, Panjab University, Chandigarh, India (Mar. 2016).

LANGUAGES

English (fluent), Hindi (native), Punjabi (native)

REFERENCES

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