Shreyas Bakare

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Education

Indian Institute of Science Education and Research (IISER) *Sept. 2020 - May 2025*
Bachelor of Science (BS) and Master of Science (MS) Dual Degree [physics major] *Pune, India*

Research Experience

***Master's Thesis:* Graph-Based machine learning for enhanced particle analysis** *May 2024 - May 2025*
Supervisor : Prof. Sourabh Dube *IISER Pune*

- Acquired proficiency in ML techniques: DNN, CNN, autoencoders, and GNNs, developing from the ground up
- Designed and implemented GNN-based approaches to transform HEP data into custom graph datasets, which were then analyzed using graph convolutional models for event classification in various HEP processes
- Conducted a comparative study of various graph representations to evaluate how different structural designs impact classification performance, optimizing model accuracy and efficiency
- Utilized a toy detector simulation to generate tracker hit data, converting it into graph structures for classifying events based on high-momentum tracks, with ongoing work to address additional track-related challenges
- Investigating the use of topological data analysis, particularly persistent homology, for particle reconstruction and classification tasks in EHEP, and comparing its performance to GNN-based methods

Development of lepton pairing algorithm for multilepton final state analysis *Dec. 2023 - Apr. 2024*
Supervisor : Prof. Sourabh Dube *IISER Pune*

- Developed an algorithm to accurately pair leptons in multilepton analysis, identifying pairs from the same mother
- Designed six distinct loss functions based on lepton properties and invariant masses to address pairing ambiguities in processes like $t\bar{t}Z$ and ZZ and conducted a comparative study to assess their impact on pairing accuracy
- Enhanced lepton pairing accuracy in ZZ sample from 34% with a p_T-based approach to 99% using my algorithm

***CERN Summer Student Programme 2023:* Search for new phenomena in 4 lepton final states with the full Run 2 dataset at ATLAS detector at LHC, CERN** *May 2023 - Aug. 2023*
Supervisor : Prof. Aurelio Juste Rozas, Dr. Tamara Schroeder, Dr. Nazlim Agaras *CERN, Geneva, Switzerland*

- Generated first-ever Monte Carlo simulations for processes involving lepton-flavour-violating Z' in τ region, consistent with the μ (g-2) explanation, using MadGraph and Pythia. Compared the kinematics for various Z' masses
- Probed the Z' mass range from 10 GeV to 100 GeV, based on their cross sections. Subdivided the signal region by lepton flavour and plotted the number of signal events at a center-of-mass energy of 13 TeV
- Showcased my research at the CERN Poster Session 2023 *(poster link)*
- Engaged in discussing detector components like scintillators, wavelength shifters, and photodetectors. Measured light yield and quantum efficiency of a scintillator-photomultiplier setup, calculating gain and single photoelectron charge during a workshop with Dr. Jakobsen on characterization of a simple particle detector using cosmic particles

Measurement of charge misidentification rates at CMS detector at LHC *Jan. 2023 - Apr. 2023*
Supervisor : Prof. Sourabh Dube *IISER Pune*

- Measured charge misidentification rates for electrons and muons at the CMS detector using tag-and-probe method in the Z resonance, and analyzed it's dependence on transverse momentum (p_T) and pseudorapidity (η)
- Analyzed the complete 2018 Monte Carlo simulation of approximately 200 million Drell-Yan events to calculate and plot charge misidentification rates, to ensure sufficient statistical power

Basic data analysis at CMS detector at LHC *Aug. 2022 - Jan. 2023*
Supervisor : Prof. Sourabh Dube *IISER Pune*

- Performed nanoAOD analysis of unknown Monte Carlo samples to identify them as Drell-Yan, $t\bar{t}$, $t\bar{t}Z$, WZ, and ZZ processes using kinematic variables like masses and taggers such as b-tagging
- Explored ROOT data analysis framework, command-line operations, and version control with GitHub

Fundamentals of Relativity and Quantum Mechanics *May 2022 - Aug. 2022*
Supervisor : Prof. Ashish Arora *IISER Pune*

- Learned about relativity and quantisation effects in 2D quantum well, and calculated the transition energy of electrons in $Al_{0.3}Ga_{0.7}As/GaAs$ junction using python to solve the finite quantum well problem in semiconductors

Selected Additional Experience

Organizer: Lagrangians to Lasers *Since May 2024*
Physics Journal Club at IISER Pune *lagrangians2lasers.github.io*

- Focused on fostering interdisciplinary dialogue and bridging the gap between junior and senior students
- Developed the L2L website *(link)* to enhance outreach, offering easy access to past talks and upcoming events.

YouTube *Since March 2021*

STEM student mentorship & fun science activities *youtube.com*

- Scientific Interviewer for Dr. Chitraang Murdia (UC Berkeley) on YouTube series 'The Unconventional Reflections' by Gramoly, attracting over 100,000 views *(link)*

Donation Management Software *Jul. 2022 - Sep. 2022*

Cultural fest organised by Marathi Club (later adopted by other clubs) *IISER Pune*

- Solved the issue of donation money scam by implementing automated email receipt system by developing a donation management software using google app script and google sheets. Leading to increase in donations by 300%

Fingerprint based door locking system using Arduino NANO *Aug. 2022 - Nov. 2022*

Supervisor : Prof. Shouvik Datta *IISER Pune*

- Built a security system using fingerprint for the door lock with the help of Arduino Nano and solenoid lock.

Research and Development Associate *May 2022 - Aug. 2022*

14 Trees Foundation, Atal Incubation Centre - SEED Foundation *IISER Pune*

- Created a simplified and dynamic view of the database in Notion, with basic database management using MongoDB
- Developed an automated mailing system integrated with the database and contributed to on-site tech development

Awards and Fellowships

Innovation in Science Pursuit for Inspired Research (INSPIRE) *Dept. of Science and Technology (DST), Govt. of India*

- Received scholarship of INR 4,00,000 (INR 80,000 per annum) *Sept. 2020 - May 2025*

CERN Summer Student Programme 2023 *CERN, Switzerland*

- Received a total allowance of INR 7,80,000 (CHF 8,250) for my tenure at CERN *May 2023 - Aug. 2023*

Summer research internship 2022 *14 Trees Foundation, AIC SEED*

- Received scholarship of INR 50,000 *May 2022 - Aug. 2022*

INSPIRE-MANAK *DST, Govt. of India*

- Received INSPIRE Award of INR 5,000 and recognition for research innovation *2015*

Skills

Programming	C, C++, Python, LaTeX, GoogleScript (Jekyll, Ruby, CSS, JavaScript)
ML & Neural Network	PyTorch, PyG, TensorFlow, Keras, Pandas, Scikit-learn, Seaborn, Giotto-tda
Scientific & Visualization	ROOT, MadGraph, Pythia, Delphes, Arduino, Matplotlib, DaVinci Resolve, Manim
Development & Systems	Git, GitHub, MongoDB, VS Code, Jupyter Notebooks, Bash, Unix
Languages	English (Fluent), Hindi (Fluent), Marathi (Fluent), Sanskrit (Intermediate)

Related Workshops

HSF-India HEP Software Workshop *(indico)*
University of Hyderabad *Jan. 2025*

31st Raman Memorial Conference *(poster presentation)*
Savitribai Phule Pune University *Feb. 2025*

Lectures on Standard Model for Experimentalists *(indico)*
Dr. Nishita Desai, Tata Institute of Fundamental Research, Mumbai *2024*

CERN Summer Student Lecture Programme *(indico)*
Comprising over 25 topics in particle physics by world experts *2023*

ROOT and MADGraph workshops, ATLAS induction day & Openlab lectures *(indico)*
CERN Summer Student Programme *2023*

Summer Mini-Course : Understanding Experimental High Energy Physics
Prof. Sourabh Dube, IISER Pune *2022*

Fundamentals of Astronomy
B. M. Birla Planetarium & Amateur Astronomy Society, Jaipur *2021*

Gravitational Wave Analysis and EM Transients
Techfest IIT Bombay *2021*

Notable Honors

State Rank 1, National Physics Graduate Examination (NGPE) *IISER Pune*
Indian Association of Physics Teachers *Jan. 2022*

Gold medal, 24th National Children's Science Congress(NCSC) *VIIT Baramati*
DST, Govt. of India *2016*

- Awarded Gold Medal for successful project & survey based report on the 'Recycling of Thermocol' using 'like dissolves like' principle at the 24th NCSC selected from among 8 lakh participants across India

Gold Medal, Dr Homi Bhabha Young Scientist Examination *Mumbai, India*
The Mumbai Science Teachers' Assoc. *2014*

- Awarded Gold Medal for project on 'Environment in day-to-day life' from over 45,000 participants nationwide

Extracurricular Activity

Outreach	**GNNs Made Simple**, Created manim-based animations to clearly explain GNN concepts	*2024*
Outreach	**Particle Physics Outreach**, Built a CMS detector model for National Science Day and presented it, along with a Feynman diagrams game, to around 10,000 students in Pune	*2024*
History	**Indian astronomy**, Built a Python script showcasing the accuracy of Aryabhata's astronomy	*2024*
Astronomy	**Aakashganga: the astro club**, Volunteered & participated in star gazing trips	*2024*
Writer	**Science Club : Helicase Magazine**, Writer & Animator : Two articles & one animated video	*2021- 2023*
Core Team	**TEDxIISER Pune**, Core team: Media Coordinator	*2022- 2023*
Founder	**A₹THA: The Finance Club**, Head : Outreach, Publicity & Media Dept.	*2021- 2022*
Editor	**Drama Club**, Video Editor & Animator : Produced 4 short films *(YouTube)*	*2021- 2022*
Volunteer	**Marathi Club**, Assisted in organizing cultural festivals and played the flute	*2021- 2024*
Quiz	**Rank 1 (Scholarship of INR 3,000)**, Championship by Dr A. P. J. Abdul Kalam Vigyan Manch	*2019*
NCC	**National Cadet Corps** , Attended Annual Training Camp, 3 MAH Air Sqadron NCC, India	*2015-2018*