

# ABHISHEK

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📍 Bhubaneswar, India

## EDUCATION

**Integrated M.Sc Physics CGPA 8.36/10**

**July 2019 - July 2024**

*National Institute of Science Education and Research (NISER), Bhubaneswar, India*

**Senior-Secondary School (Class-12th) Percentage 83%**

**2018**

*Central Board of Secondary Education (CBSE), Delhi, India*

## RESEARCH PROJECTS

**Investigation of  $\rho^0(770)$  Meson Production** [Aug, 2024 - Present]

*Central University of Tamil Nadu, India*

*Dr. Nirbhay Kumar Behera*

Short-lived resonances, with lifetimes similar to the quark-gluon plasma (QGP), are useful for studying high-energy collisions. They can be analyzed through their decay products in proton and heavy-ion collisions. This project investigates the production of  $\rho^0(770)$  mesons in pp collisions at  $\sqrt{s} = 13.6$  TeV by calculating the invariant mass of  $\pi^+\pi^-$  in bins of sphericity. The invariant mass is reconstructed by subtracting the like-sign background. Events are generated using Pythia.

**Classification of hadrons in Granular Hadron Calorimeters Using Deep Sets.** [Aug, 2024 - Present]

*INFN-Padova, Italy*

*Dr. Tommaso Dorigo*

A deep learning model is being used to explore whether increasing the granularity of the hadron calorimeter can improve the discrimination power among protons, pions, and kaons. To investigate this, a geometry with  $100 \times 100 \times 100$  cells, made of Lead Tungstate, is simulated using GEANT4. Features such as energy deposition, momentum, and the number of interactions are recorded for each cell and will be used to train the model.

**Developing Imaging Algorithms and RPCs for Muography Studies** [Aug, 2023 - Jun, 2024] **[Master Thesis]**

*NISER, India*

*Prof. Bedangadas Mohanty & Dr. Raveendrababu Karnam*

This project focuses on track reconstruction algorithms and the construction of detectors for Muon Scattering Tomography (MST). Following the successful simulation of MST during the 2023 summer project, the next step involves constructing a physical muon telescope, referred to as the "Muoscope" within our laboratory. The design centers around utilizing Resistive Plate Chambers (RPCs) and is divided into two parts: simulation and experimentation. In the simulation phase, algorithms such as the Point of Closest Approach (POCA) and Binned Clustering Algorithm (BCA) are implemented to reconstruct the 3D images. Moving to the experimental phase, three  $16 \times 16$   $cm^2$  glass RPCs are built and fully characterized. Data acquisition from these RPCs has been facilitated using FPGA and ASIC-based DAQ systems.

**Cosmic Muons Scattering Simulation Using GEANT4** [May, 2023 - Jul, 2023] **[Report]**

*Université Catholique de Louvain, Belgium*

*Dr. Andrea Giammanco*

This project utilized Geant4 simulation and ROOT analysis to study cosmic muon scattering. A four-layer muoscope was designed to compute muon scattering and distinguish materials by atomic number. The Point of Closest Approach (PoCA) algorithm was implemented for material imaging, with Garfield++ integration enhancing simulation accuracy.

**Forward-Backward Sphericity Correlation in pp Collisions at  $\sqrt{s} = 13$  TeV** [May, 2022 - Jul, 2022] **[Report]**

*Indian Institute of Technology Bombay, India*

*Dr. Sadhana Dash*

During this project, the event shape observable sphericity was analyzed to classify event shapes as either jetty (hard QCD) or isotropic (soft QCD) in pp collisions. Soft processes are particularly important as they could provide insights into new physics in pp collisions, such as heavy-ion-like signatures. Using Pythia simulations of minimum bias events, a notable forward-backward correlation in sphericity was also observed in small systems.

## ACADEMIC PROJECTS AND TALKS

**Advanced Physics Lab-I: Metamaterial hyperlens demonstration of propagation without diffraction** **[Report]**

- Developed hyperlens allowing diffraction-free microwaves using cost-effective ribbon cable arrays.
- Successfully demonstrated diffraction-free propagation with this metamaterial.

**Advanced Physics Lab-II: Construction of a straw tube proportional gas flow counter** **[Report ]**

- Proportional Counter: Utilizes gas multiplication for ionizing radiation detection in pulse mode.
- Experiment Achievements: Constructed a Single-wire Proportional Counter for Iron-55 X-ray detection and a Straw Tube Proportional Counter without a window using OHP Sheet and aluminum tape.

### Term Paper: Ads/CFT correspondence and lower bound of $\eta/s$ [\[Report\]](#)

We used the Ads/CFT correspondence to calculate the correlation function of the stress-energy tensor in the gravity regime and to compute the shear viscosity  $\eta$  of a strongly coupled Yang-Mills plasma and use the known entropy density  $s(T)$  to calculate  $\eta/s$ . We review the KSS bound on  $\eta/s$  and describe possibilities for the lower bound to be violated.

### Term Paper: Introduction to Artificial Neural Networks [\[Report\]](#)

This paper presents the study and implementation of an Artificial Neural Network (ANN) from scratch using Python. First, it was implemented using the code provided by J. Sargent & John Stachurski, and then some new methods were tested to improve the overall efficiency and usage of the ANN.

### Term Paper: Introduction to Matrix Product States [\[Report\]](#)

This report provides a concise overview of Matrix Product States (MPS) and Tensor Networks in quantum physics. It discusses Singular Value Decomposition (SVD) in the context of MPS. The report concludes by solving the 1D Ising model and computing magnetization and correlation length.

## RELEVANT ELECTIVE COURSES

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1. Quantum Field Theory, 2. Particle Physics, 3. Introduction to Phase Transition And Critical Phenomena, 4. Relativistic Nucleus-Nucleus Collision And Quark-Gluon Plasma, 5. Introduction To Quantum Optics, 6. Computational Physics, 7. Quantum information & Quantum computation, 8. Experimental Techniques

## SCHOOLS

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- ESCAPE summer school on data science for Astronomy, Astroparticle and Particle Physics (June 2021). [\[Certificate\]](#)
- Statistical Methods and Machine Learning in High Energy Physics at ICTS Bengaluru.

## SCIENTIFIC CONTRIBUTIONS

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- First Author, "A modular muon telescope for tomography and radiography applications," Nuclear Inst. and Methods in Physics Research, A., <https://doi.org/10.1016/j.nima.2025.170399> [\[Publication\]](#)
- Co-Author, "Hadron Identification Prospects With Granular Calorimeters," at 4th MODE Workshop - Valencia (Spain). This work received the award for Best Poster at the conference, MDPI Particles. [\[Publication\]](#)
- Co-Author, "Neuromorphic Readout for Homogeneous Hadron Calorimeters," MDPI Particles. [\[Publication\]](#)
- Co-Author, "End-to-End Detector Optimization with Diffusion models: A Case Study in Sampling Calorimeters" MDPI Particles. [\[Publication\]](#)
- "Particle Identification in Highly Granular Calorimeters With Deep Sets" at Fifth MODE workshop - Crete (Greece). [\[Poster\]](#) [\[Slides\]](#)

## SKILLS

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|---------------------------------|---|
| • <b>Data Analysis</b>          | ROOT <sup>‡</sup> , Python <sup>‡</sup> , C++ <sup>‡</sup> .  |
| • <b>Python Libraries</b>       | Pandas <sup>‡</sup> , NumPy <sup>‡</sup> , Uproot <sup>*</sup> , Awkward <sup>*</sup> , Numba <sup>°</sup> , SciPy <sup>*</sup> .   |
| • <b>Monte Carlo Simulation</b> | GEANT4 <sup>‡</sup> , Pythia <sup>*</sup> , Garfieldpp <sup>*</sup> .   |
| • <b>Machine Learning</b>       | JAX <sup>*</sup> , PyTorch <sup>‡</sup> ; Algorithms: Decision Trees <sup>‡</sup> , Graph Neural Networks <sup>*</sup> , DeepSets <sup>*</sup> .  |
| • <b>Additional Tools</b>       | JupyterLab <sup>‡</sup> , Git <sup>*</sup> , SSH <sup>*</sup> , VNC <sup>*</sup> , Multi-threading <sup>*</sup> , Linux <sup>‡</sup> , ECoMuG <sup>‡</sup> , L <sup>A</sup> T <sub>E</sub> X <sup>‡</sup> . |
| • <b>Communication</b>          | Hindi (Native), English (Fluent).   |
| • <b>Hardware</b>               | ASIC <sup>°</sup> , FPGA <sup>°</sup> , NIM and CAEN modules <sup>‡</sup> .   |

<sup>‡</sup> Expert <sup>‡</sup> Proficient <sup>\*</sup> Competent <sup>°</sup> Novice

## AWARDS/ACHIEVMENT

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- **DISHA** fellowship by the Department of Atomic Energy (DAE) in India. This fellowship is granted to only a few students selected from DAE-aided institutions.[\[Certificate\]](#)