Insight Bulletin: A Multidisciplinary Interlink International Research Journal
Peer Reviewed International, Open Access Journal.
ISSN : 3065-7857 / Website: https://ibrj.us / Volume-3, Issue-5 / May - 2026

Original Article

AI in Particle Physics: Applications, Challenges, and Future Prospects

Nayan S. Nagargoje[1], Sourabh V. Gaikwad[2]
[1,2]Department of Physics, Dalit Mitra Kadam Guruji Vidnyan Mahavidyalaya, Mangalwedha, MH India

Manuscript ID:
IBMIIRJ -2026-030529

Submitted: 12 Apr. 2026
Revised: 22 Apr. 2026
Accepted: 09 May 2026
Published: 31 May 2026

ISSN: 3065-7857
Volume-3
Issue-5
Pp. 150-151
May 2026

Correspondence Address:
Nayan S. Nagargoje
Department of Physics, Dalit Mitra Kadam Guruji Vidnyan Mahavidyalaya, Mangalwedha, MH India
Email: nayannagargoje@gmail.com

OPEN ACCESS
Quick Response Code:
Web. https://ibrj.us

DOI: 10.5281/zenodo.21698351
DOI Link:
https://doi.org/10.5281/zenodo.21698351

Abstract

Particle physics experiments generate large datasets that are too complex to analyze using standard statistical techniques. Machine Learning (ML) and Deep Learning (DL), as a subset of Artificial Intelligence (AI), have turned out to be a highly convenient means of looking at and interpreting this information. In this paper, the application of AI in particle physics is discussed, including such topics as event classification, noise reduction, simulation acceleration, detector optimization, and real-time data analysis. It also discusses the primary applications of experiments such as ATLAS and CMS in CERN and the issues that they are currently experiencing and in the future.

Keywords: *Artificial Intelligence, Machine Learning, Deep Learning, Particle Physics, High-Energy Physics, CERN, Large Hadron Collider, Event Classification, Detector Optimization, Graph Neural Networks, Generative Adversarial Networks, Real-Time Data Analysis, Explainable AI, Quantum Computing*

Introduction

The study of particle physics focuses on the fundamental components of matter and their interactions. One such instance is CERN's Large Hadron Collider (LHC), which collides high-energy particles and generates petabytes of data every year. It is extremely difficult to extract useful information from this data. The more conventional techniques based on manual selection criteria and statistical models tend not to be effective as they are either too large or too complex.

In the past few years, AI, and in particular, ML and DL, have transformed particle physics by accelerating analysis, improving accuracy, and automating it. AI models are able to discover concealed patterns, categories occurrences, and enhance the functionality of detectors, which accelerates discoveries in simple physics by a significant margin.

Literature Review

Early particle physics data analysis techniques used manual feature extraction and likelihood-based fitting. But as datasets grew, researchers started using machine learning (ML) techniques like decision trees and support vector machines (SVMs). These days, the most common deep learning systems are Convolutional Neural Networks (CNNs), Graph Neural Networks (GNNs), and Generative Adversarial Networks (GANs).

- Important steps:
- Higgs boson discovery in 2012: ML techniques were used to locate rare signals in a large amount of background.

Dark Matter searches. Deep learning has been applied to sift through potential dark matter signals.

- Neutrino Experiments: AI-based algorithms simplified the process of assembling neutrino events using detector data.

Applications of AI in Particle Physics

1. Event Classification: AI can tell the difference between signal events (new physics) and background noise (known processes). CNNs and GNNs are great at working with data from detectors that have multiple dimensions.

2. Noise Reduction: Raw detector data has electronic noise and signals that aren't needed. Denoising models that use deep learning help get rid of noise, which makes signals clearer.

3. Speeding up simulations: Monte Carlo simulations take a lot of computer power. GANs can make realistic simulated events much faster, which cuts down on the time it takes to do calculations.

How to cite this article:
Nagargoje, N. S.& Gaikwad, S. V. (2026). AI in Particle Physics: Applications, Challenges, and Future Prospects. Insight Bulletin: A Multidisciplinary Interlink International Research Journal, 3(5), 150–151. https://doi.org/10.5281/zenodo.21698351

4. Optimizing Detector Design: AI helps improve the shape and calibration of detectors. Reinforcement Learning (RL) has been used to test how to make good detector layouts.
5. Real-Time Data Analysis: AI models can analyze collision data as it is being collected, which speeds up decision-making and cuts down on the need for post-processing.

Case Studies
1. CERN ATLAS and CMS Experiments: AI models classify billions of proton-proton collisions to identify rare physics events.
2. Ice Cube Neutrino Observatory: ML algorithms improve neutrino event reconstruction from Cherenkov light signals.
3. Cosmic-Ray Detection: AI has enhanced event reconstruction and energy estimation in cosmic-ray experiments.
Challenges and Limitations
Interpretability: AI models, especially deep networks, are black boxes, and it is difficult to know the reason why a certain decision was made.
1. Computational Resources: Large amounts of computational resources are needed to train large models. Bias and Overfitting: AI systems tend to overfit to the modelled data, and this is not applicable in real-world experiments.
2. Faith in Discoveries: Physicists need to be transparent and explainable to be able to make groundbreaking claims, which AI has not accomplished yet.

Future Prospects
1. Quantum Computing and AI: It is possible to apply quantum algorithms to data analysis with the help of AI in order to make it faster.
2. Hybrid Models: Precise prediction of physics-driven neural networks and conventional simulations.
3. Open Science Projects: The Open Data Portal of CERN is an open-source programme providing scientists worldwide with a chance to test new AI solutions.
4. Explainable AI (XAI): Interpretable model generation will enable high-stakes physics discoveries to be accepted and used more.

Conclusion
Artificial Intelligence has played a central role in particle physics, resulting in the discovery of new phenomena within the shortest time, simulation, and the classification of events. Even though issues such as interpretability and needs in computing are not eliminated, the future involving AI and physics synergy is certain to revolutionize the future. As the datasets continue to increase, AI will consume massive shares of the mystery of the universe.

Acknowledgment
The authors express their sincere gratitude to the Department of Physics, Dalit Mitra Kadam Guruji Vidnyan Mahavidyalaya, Mangalwedha, Maharashtra, for providing the academic environment, institutional support, and facilities necessary for carrying out this review work.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

References:
1. Radovic, A., et al. 'Machine learning at the energy and intensity frontiers of particle physics. 'Nature 560, 41–48 (2018).
2. Guest, D., Cranmer, K., & Whiteson, D. 'Deep learning and its application to LHC physics. 'Annual Review of Nuclear and Particle Science 68, 161–181 (2018).
3. Baldi, P., et al. 'Searching for exotic particles in high-energy physics with deep learning.' Nature Communications 5, 4308 (2014).
4. Albertsson, K., et al. 'Machine learning in high energy physics community white paper.' Journal of Physics: Conference Series 1085, 022008 (2018).