Ayan Paul

AI Research | Theoretical and Computational Particle Physics | Genetics
Building the Future with Interpretable and Robust AI
32 Williams St., Boston, MA 02119
+1 574 339 1593 | apaul2@alumni.nd.edu | desy.de/~apaul | ayan--paul | Google Scholar

Skills

- *Neural Networks:* 5+ years experience with TensorFlow: DNN for regression/classification, LSTM for time series prediction/signal classification.
- *Machine Learning:* Interpretable Machine Learning using Coalition Game Theory. Adept at BDT with XGBoost, SVM, RF, KNN, clustering.
- *Data Analytics:* Proficient in data extraction and parsing, multivariate analysis, Markov Chain Monte Carlo methods and Bayesian inference.
- *Coding:* Over 14 years of experience in developing open-source codes with C/C++, Python and FORTRAN. Familiar with R, Julia and Matlab.
- *Parallel Computing:* Extensive experience in parallelizing codes with MPI and OpenMP and simulations on large computer clusters (HPC).
- *Innovation:* Over 14 years of research experience in physics, mathematics, statistics, machine learning and coding for science.
- *Critical Thinking:* Highly trained in conceptualizing new ideas and building mathematical models for complex unexplored problems.
- *Leadership:* Co-founder of CoVis, shaping its technical and business foundations. Principal Investigator of several academic grants.
- *Team Work:* Involved in working with large teams and collaborations for planning and implementation of future collider projects.
- *Communications:* Recipient of teaching award and skilled in conveying scientific knowledge to non-experts. Native proficiency in English.

My contribution to open source codes: https://github.com/talismanbrandi.

Professional Experience

The Institute for Experiential AI, Electrical & Computer Enigineering, Northeastern University & Brigham and Women's Hospital, Harvard Medical School — *Boston, USA*

Research Fellow — *May 2022 - PRESENT*

- Build Graph Neural Networks to study the genetic predisposition for Pulmonary Diseases (team at Harvard Medical School).
- Repurpose BERT models for extracting semantics from DNA sequences to understand formation of mRNA.
- Interpretable ML using CNN/ResNets for identifying anomalies from peripheral blood cell images to aid in rapid cancer detection.
- Supervise a team of PhD students and junior postdocs along with other scientists and professors in the team.

KarmaV — *USA & Singapore*

Co-Founder and Chief Scientific Officer — *November 2021 - PRESENT*

- Design ML/AI algorithms (FairKarma™) for fair and ethical recruitment to be used with a customizable application tracking system.
- Take ownership of structuring and formation of the science division for KarmaV.

CoVis – a DESY Spin-Off — *USA & Germany*

Co-Founder and CEO (former CSO) — *April 2020 - June 2022*

- Designed and implemented the backend algorithms for COVID-19 risk prediction using AI (LSTM/GRU) from prototyping to deployment.
- Defined research strategies and incorporated results from medical literature using Bayesian methods to combine emerging data.
- Designed data streams using GraphQL/DynamoDB on AWS for regular updates and processing of data using ML algorithms.

Deutsches Elektronen-Synchrotron (DESY) & Humboldt Universität zu Berlin — *Hamburg & Berlin, Germany*

Fellow & Senior Scientist — *November 2017 - April 2022*

- Principal Investigator of a DESY Strategy Fund grant managing a team of 10 members for Technology Transfer R&D.
- Principal Investigator of a Volkswagen Foundation grant managing an interdisciplinary team of 7 members for academic research.
- Developed an Interpretable ML/AI framework for regression and signal-background classification for Higgs Physics using DNN and BDT.

Istituto Nazionale di Fisica Nucleare, Sezione di Roma I — *Roma, Italy*

Postdoctoral Fellow — *September 2012 - October 2017*

- Developed the open-source codes `HEPfit` and `BAT` in C++ for Bayesian multivariate analyses using Markov Chain Monte Carlo.
- Reduced the runtime of `HEPfit` by a factor of 50 – 200 using MPI and software caching. Built automation for large computing clusters.
- Implemented statistical model selection with non-linear multi-parametric models on noisy experimental data from CERN.

Research

- *Particle Physics:* Quantum Field Theory, Relativistic Quantum Mechanics, Higgs Productions and Decays, Symmetry Violation.
- *Data & Statistics:* Analytics for future physics colliders at CERN using Bayesian MCMC, Probabilistic Modeling, Simulations and ML.
- *Mathematical Epidemiology:* Automated Contact Tracing for COVID-19, Agent Based Models, ML applications, Multi-Layer Network Analysis.
- *Intelligence:* Structure and Dynamics of Intelligence and building fundamental frameworks for information processing.
- *Publications:* 30 papers in peer-reviewed high impact-factor journals with over 3100 citations. Top 1% most cited author in physics (10 yr).
- *Public Speaking:* Presented talks at more than 35 international conferences worldwide (Physics, Applied AI/ML, Mathematical Epidemiology).
- *Research Supervision:* Co-advisor for several masters and PhD students and supervised the work of several junior postdoctoral fellows.

Education

University of Notre Dame du Lac, Department of Physics — *Notre Dame, Indiana*

MS & PhD in Theoretical Particle Physics — *2005 - 2012*

- *Physics Graduate Research and Dissertation Award* for the best dissertation of the year.
- *Founding Member of the Executive Board* of Graduate Physics Society and GPS Spring Conferences.

Selected Publications

Total no. of publications (journals & proceedings): 40 [citations: 3187, h-index: 22]

Notable journals published in: Nature Reviews Physics, Nature Scientific Reports, Journal of High Energy Pysics, Pysical Review D, European Physical Journal C, Journal of the Royal Society: Interface, Journal of Physics: Complexity.

Note: *Authors are always listed alphabetically arranged by their last name in Particle Physics and Computational Socioeconomics papers.*

Machine Learning:

- L. Alasfar, R. Gröber, C. Grojean, A. Paul and Z. Qian, *Machine learning the trilinear and light-quark Yukawa couplings from Higgs pair kinematic shapes*. JHEP**11** (2022) 045. [arXiv:2207.04157].
- C. Grojean, A. Paul, Z. Qian and I. Strümke, *Lessons on interpretable machine learning from particle physics*. Nat Rev Phys 4, 284–286 (2022). DOI:10.1038/s42254-022-00456-0.
- C. Grojean, A. Paul and Z. Qian, *Resurrecting $b\bar{b}h$ with kinematic shapes*. JHEP**04** (2021) 139. [arXiv:2011.13945]. [arXiv:2011.13945]
- T. Banerjee, A. Paul, V. Srikanth and I Strümke, *Causal connections between socioeconomic disparities and COVID-19 in the USA*, Sci. Rep. **11**, 18891 (2022). DOI:10.1038/s41598-022-18725-4.
- A. Paul, P Englert and M. Varga, *Socio-economic disparities and COVID-19 in the USA*, J. Phys. Complex. **2** (2021) no. 3, 035017. DOI:10.1088/2632-072X/ac0fc7.

Bayesian Inference using Markov Chain Monte Carlo:

- A. Paul and M. Valli, *Violation of custodial symmetry from W-boson mass measurements*, Phys. Rev. **D 106** (2022) 013008. [arXiv:2204.05267].
- M. Ciuchini, M. Fedele, E. Franco, A. Paul, L. Silvestrini and M. Valli, *Lessons from the $B^{0,+} \to K^{*0,+}\mu^+\mu^-$ angular analysis*, Phys. Rev. D **103** (2021) 1, 015030. [arXiv:2011.01212].
- L. Alasfar, A. Azatov, J. de Blas, A. Paul, M. Valli, *B anomalies under the lens of electroweak precision*, JHEP**12** (2020) 116. [arXiv:2007.04400].
- J. De Blas, G. Durieux, C. Grojean, J. Gu and A. Paul, *On the future of Higgs, electroweak and diboson measurements at lepton colliders*. JHEP**12** (2019) 117. [arXiv:1907.04311].
- J. de Blas et. al., `HEPfit`: *a Code for the Combination of Indirect and Direct Constraints on High Energy Physics Models*. Eur. Phys. J. **C80** (2020) no.5, 456. [arXiv:1910.14012].
- M. Ciuchini, A. Coutinho, M. Fedele, E. Franco, A. Paul, L. Silvestrini and M. Valli, *New Physics in $b \to s\ell^+\ell^-$ confronts new data on Lepton Universality*, Eur. Phys. J. **C79** (2019) no.8, 719. [arXiv:1903.09632]
- M. Ciuchini, A. Coutinho, M. Fedele, E. Franco, A. Paul, L. Silvestrini and M. Valli, *On Flavourful Easter eggs for New Physics hunger and Lepton Flavour Universality violation*, Eur. Phys. J. **C77** (2017) no.10, 688. [arXiv:1704.05447].
- A. Paul and D. Straub, *Constraints on new physics from radiative B decays*, JHEP**04** (2017) 027. [arXiv:1608.02556.]
- M. Ciuchini, M. Fedele, E. Franco, S. Mishima, A. Paul, L. Silvestrini and M. Valli, *$B \to K^*\ell^+\ell^-$ decays at large recoil in the Standard Model: a theoretical reappraisal*. JHEP**06** (2016) 116. [arXiv:1512.07157].

Workshop Papers & Preprints

ML/AI Research:

- F. Bishara, A. Paul, J. Dy, *High-Precision Regressors for Particle Physics*. Paper submitted to **ICLR 2023** for peer-review.
- F. Bishara, A. Paul, J. Dy, *Skip Connections for High Precision Regressors*. Machine Learning and the Physical Sciences, Workshop at the 36th conference on Neural Information Processing Systems **(NeurIPS 2022)**.

Grants & Awards

2020	**Corona Crisis and Beyond (119,200€)**, Volkswagen Stiftung. PI with a team of 3 scientists. Project: "Talisman: Intelligent Algorithms for COVID-19 mitigation casting virtual safety nets to protect and empower the society" (Duration: 21 months, Project overheads borne by DESY)	*Berlin, Germany*
2020	**DESY Strategy Fund for COVID-19 (100,000€)**, DESY, PI with a multidisciplinary team of 7. Project: "CoVis: empowering health decisions, delivered by intelligent algorithms to contain COVID-19" (Duration: 16 months) – Leading to a DESY Spin-off (Technology Transfer): Covis Inc.	*Hamburg, Germany*
2012	**Research and Dissertation Award**, Dept. of Physics, University of Notre Dame du Lac	*Notre Dame, IN USA*
2011	**Notebaert Prof. Dev. Fund**, Graduate School, University of Notre Dame du Lac	*Notre Dame, IN USA*
2011	**Joseph F. Downes Memorial Award**, Graduate School, University of Notre Dame du Lac	*Notre Dame, IN USA*
2010	**W. & L. Stavropoulos Fellowship**, Graduate School, University of Notre Dame du Lac	*Notre Dame, IN USA*
2010	**Kaneb Outstanding Graduate Teaching Assistant Award**, University of Notre Dame du Lac	*Notre Dame, IN USA*
2009	**Reilly Fellowship**, Graduate School, University of Notre Dame du Lac	*Notre Dame, IN USA*