Rob Verheyen

rbvh | rob-verheyen | rbvh.github.io | r.verheyen@ucl.ac.uk | +31 683095896
Oxford, United Kingdom

Knowledge & Research Interests

- **Machine learning in particle physics**
  Anomaly detection and event classification with graph neural networks and transformers
- **Deep generative models**
  Normalizing flows; Variational autoencoders; Variational inference; Applications in particle physics
- **Computing**
  Monte Carlo techniques; High-performance computing; Algorithmic efficiency

Work Experience

Postdoctoral researcher Theoretical high energy physics Oct 2019 - present
University College London / University of Oxford (visitor), United Kingdom

- Author and developer in the PanScales collaboration, a project involving leading theorists that aim to improve theoretical accuracy and understanding of Monte Carlo event generators.
- Research on deep generative models, anomaly detection and event classification with models such as normalizing flows, graph neural networks and transformers.
- Experience with high-performance computing and algorithmic efficiency.

Education

PhD Theoretical high energy physics 2015 - 2019
Radboud University Nijmegen, the Netherlands

- Current author and developer in the PYTHIA collaboration, the leading particle physics Monte Carlo event generator and the most widely-used and cited software in the field.
- Research on deep generative models for particle collision events, a new and emerging field at the time.

MsC Theoretical high energy physics (*Summa cum laude/with highest honors*) 2013 - 2015
Radboud University Nijmegen, the Netherlands

- Research with focus on numerical techniques in calculations for supersymmetric field theory.

BsC Physics and Astronomy (*Cum laude/with honors*) 2009 - 2013
Radboud University Nijmegen, the Netherlands

Selected projects

- Autoregressive normalizing flows for sampling particle physics collision events with weighted training (with B. Stienen) [code].
- Surjective transforms in normalizing flows for sampling and anomaly detection in particle physics, with the goal of handling permutation invariance, varying number of objects and mixed discrete-continuous features [code].
- Development of efficient Monte Carlo algorithms for branching processes in particle physics [code].
- Contributed to the development of an ML algorithm for fast diagnosis of SARS-CoV-2, led to publication in Clinical Chemistry and Laboratory Medicine.
- Graph generative models for particle physics with F. Dreyer (ongoing).
- Normalizing flows for Monte Carlo integration (ongoing).

Selected publications

Full list of 24 publications on Inspire or Google Scholar

Climbing four tops with graph networks, transformers and pairwise features
L. Builtjes, S. Caron, P. Moskvitina, C. Nellist, R. Ruiz de Austri, R. Verheyen, Z. Zhang, [arXiv]

Event Generation and Density Estimation with Surjective Normalizing Flows
R. Verheyen, SciPost Physics 2022 [arXiv] [code]

Rare and Different: Anomaly Scores from a Combination of Likelihood and Out-of-distribution Models to Detect New Physics at the LHC
S. Caron, L. Hendriks, R. Verheyen, SciPost Physics 2022 [arXiv] [code]

The Dark Machines Anomaly Score Challenge: Benchmark Data and Model Independent Event Classification for the Large Hadron Collider
T. Aarrestad et al.
SciPost Physics 2022 [arXiv] [code]

A Comprehensive Guide to the Physics and Usage of PYTHIA 8.3
C. Bierlich, S. Chakraborty, N. Desai, L. Gellersen, I. Helenius, P. Ilten, L. Lönnblad, S. Mrenna, S. Prestel, C. Preuss, T. Sjöstrand, P. Skands, M. Utheim, R. Verheyen,
SciPost Physics Codebases 2022 [arXiv] [code]

Event Generation and Statistical Sampling for Physics with Deep Generative Models and a Density Information Buffer
S. Otten, S. Caron, W. de Swart, M. van Beekveld, L. Hendriks, C. van Leeuwen, D. Podareanu, R. Ruiz de Austri, R. Verheyen, Nature Communications 2021 [arXiv]

Phase Space Sampling and Inference from Weighted Events with Autoregressive Flows
B. Stienen, R. Verheyen, SciPost Physics 2021 [arXiv] [code]

Competing Sudakov Veto Algorithms
R. Kleiss, R. Verheyen, The European Physical Journal 2016 [arXiv] [code]

Selected talks

More complete list here.

Inter-experimental Machine Learning meeting, CERN Invited talk — Dec 2022
Normalizing flows for event generation and anomaly detection at the LHC

Heidelberg University, Germany Invited seminar — Jun 2022
Event Generation and Density Estimation with Surjective Normalizing Flows

Monash University, Australia Invited talk — Mar 2019
Event Generation and Statistical Sampling with Deep Generative Models

Skills

ML frameworks	PyTorch, TensorFlow, dgl
Programming languages	C++, Python (NumPy, Pandas, Matplotlib, SciPy), Mathematica
Software	LaTeX, git, svn, slurm
Languages	Dutch (native), English (fluent)

Last updated: November 20, 2022