

# Simon Jonathan Williams

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Postdoctoral Research Associate with a strong research and academic background, specialising in quantum computing approaches to high energy particle physics. I have a strong passion to pursue a career in academia and make an original contribution to high energy particle physics.

## Experience

- **Institute of Particle Physics Phenomenology, Durham University,** 2023-present  
**Postdoctoral Research Associate,** **Supervisor:** Prof. Michael Spannowsky.
- **Imperial College London,** 2023  
**Postdoctoral Research Associate,** **Supervisor:** Prof. Gavin Davies.

## Education

- **Imperial College London** 2019–2023  
**Ph.D. Physics,** funded by a research grant from the Royal Society. **Supervisor:** Dr. Sarah Malik.  
My main research effort is the development of novel quantum computing algorithms for high energy particle physics applications. With the rapid and continuous improvement of quantum computers, dedicated algorithms are needed to exploit the potential quantum computing can provide. Recently, I have concentrated on the development of quantum algorithms for simulating parton showers in high energy collisions (Phys. Rev. D **103**, 076020 (2021)). By reframing the parton shower in the quantum walk framework, we have shown (Phys. Rev. D **106**, 056002 (2022)) that the parton shower can be implemented in an efficient way, requiring dramatically less Quantum Volume than all previous known parton shower algorithms. Most recently, the quantum walk architecture has been used to create the first quantum algorithm able to simulate realistic high energy particle collision events on a Noisy Intermediate Scale Quantum (NISQ) device (J. High Energ. Phys. **2022**, 35 (2022)).
- **Royal Holloway, University of London** 2015–2019  
**MSci Physics with Particle Physics,** First Class (Hons)  
**Awards:** Principle's Excellence Scholarship (2015), Driver Prize for best Masters Thesis (2019).  
**Masters Thesis:** "Extended Higgs Sectors in Supersymmetric Models", **Supervisor:** Prof. Stephen West.  
Final year modules included Quantum Field Theory (2 courses), Advanced Particle Physics, The Standard Model and Beyond, General Relativity and a research review project: "Standard Model Higgs Phenomenology and Motivations for Beyond Standard Model Physics".
- **The Manor Academy, Mansfield Woodhouse** 2008–2015  
**A Levels:** Mathematics (A), Physics (A), Chemistry (A) and English (B).

## Publications

- K. Bepari, S. Malik, M. Spannowsky and S. Williams, **Towards a quantum computing algorithm for helicity amplitudes and parton showers**, Phys. Rev. D **103**, 076020 (2021)  
Correspondence author. I developed the circuit architecture for the parton shower algorithm on quantum devices available through the IBM Q Experience, and co-developed the implementation for the helicity amplitude calculation.
- K. Bepari, S. Malik, M. Spannowsky and S. Williams, **Quantum walk approach to simulating parton showers**, Phys. Rev. D **106**, 056002 (2022)  
Correspondence author. I developed the circuit architecture for the quantum walk parton shower and implemented the algorithm on quantum devices available through the IBM Q Experience.
- G. Gustafson, S. Prestel, M. Spannowsky and S. Williams, **Collider Events on a Quantum Computer**, J. High Energ. Phys. **2022**, 35 (2022)  
Correspondence author. I helped simplify and reframe the Discrete-QCD (DQCD) model as a random walk, allowing for the algorithm to be implemented on a real quantum device, the `ibm_algiers` Falcon r5.11 device. I developed the circuit architecture for the quantum DQCD algorithm, using a quantum walk with memory framework.
- C. Brown, M. Spannowsky, A. Tapper, S. Williams and I. Xiotidis, **Quantum Pathways for Charged Track Finding in High-Energy Collisions**, Front. Artif. Intell. 7 (2024) 1339785  
Correspondence author. I motivated and developed the application of Quantum Amplitude Amplification to charge-particle track finding, constructing a novel oracle operation to perform Quantum Template Matching.

- S. Abel, M. Spannowsky and S. Williams, **Simulating quantum field theories on continuous-variable quantum computers**, Phys. Rev. A **110**, 012607  
Correspondence author. In this paper, we develop a measurement-based quantum-computing approach to simulating the real-time evolution of a quantum state on a continuous-variable quantum computer. I developed the circuit architecture for the *evolver-gadget* and the machine learning algorithm for preparing the *evolver-state*.
- J. Ingoldby, M. Spannowsky, T. Sypchenko and S. Williams, **Enhancing quantum field theory simulations on NISQ devices with Hamiltonian truncation**, Phys. Rev. D **110**, 096016  
Correspondence author. In this paper, we present an alternative to traditional methods for simulating the real-time evolution in QFTs by leveraging Hamiltonian Truncation (HT), and demonstrate the HT approach's suitability to NISQ Devices.

## Research Skills

### Quantum Computing

- I am proficient in **Qiskit** and **Strawberry Fields** Python packages for implementation on gate quantum computers and quantum photonic devices respectively.
- I am a member of the **IBM Quantum Researcher's Program** which provides advanced systems and services on the IBM Q network. My paper J. High Energ. Phys. **2022**, 35 (2022) benefitted from the Researcher's Program and access to the `ibm_cloud` via **Qiskit Runtime**.
- I am experienced in constructing quantum algorithm architectures. Recently I have specialised in Discrete-Time **Quantum Walks** (DTQWs), including **Quantum Walks with Memory** (QWM).

### Programming Languages

- **Python** (including **Qiskit** and **Strawberry Fields**), **C++**, **LaTeX** (including **TikZ**), **ROOT**.

## Conferences and Seminars

### Conferences

- **Corfu Summer Institute, Workshop on Future Colliders** *May 2024*  
Plenary talk on modelling high energy collision events using a quantum computer.
- **795th Wilhelm Else Heraeus Seminar on Simulations of Quantum Field Theories, Oberwölz** *Sept 2023*  
Invited plenary talk on simulating parton showers and generating collider events on a quantum computer.
- **First Lund Jet Plane Workshop, CERN** *July 2023*  
Invited talk on simulating parton showers and generating collider events on a quantum computer.
- **Toward Quantum Advantage in High Energy Physics** *April 2023*  
Topical workshop on quantum computing for high energy physics purposes.
- **Quantum Computing for High Energy Physics** *April 2023*  
Plenary talk on the development of quantum algorithms for the simulation of parton showers in high energy collisions.
- **Resummation, Evolution, Factorization 2022** *Oct 2022*  
Invited plenary talk on the simulation of synthetic collider events on a quantum computer.
- **Imperial College London Natural Sciences Showcase** *Sept 2022*  
Invited plenary talk on quantum simulation for High Energy Physics, specifically the simulation of collider events.
- **International Symposium on Multiparticle Dynamics 2022** *August 2022*  
Short talk and Poster on the simulation of realistic parton showers using a Discrete-QCD model on quantum computers.
- **Imperial College London Postgraduate Symposium** *July 2022*  
Parallel session talk on quantum computing approaches to parton showers. **Award:** Best Talk in High Energy Physics.
- **IoP 2022 - Joint APP/HEPP Conference** *April 2022*  
Parallel session talk on quantum computing applications for high energy particle physics at the IoP HEPP Conference 2022, Rutherford Appleton Laboratory.
- **Lake Louise Winter Institute 2022** *Feb 2022*  
Invited plenary talk on quantum computing approaches to simulating parton showers at the Lake Louise Winter Institute 2022, Alberta, Canada.
- **Snowmass 2021 Workshop on Quantum Computing for High Energy Physics** *Dec 2021*  
Contributed talk on quantum simulation of parton showers and helicity amplitude calculations, and on the discussion panel at the Snowmass Quantum Computing for HEP Workshop. Consequently cited by the Snowmass White Paper.
- **YTF 2021** *Dec 2021*

Talk on quantum computing approaches to parton shower simulation and helicity amplitude calculations at YTF2021, Durham.

## Seminars

- **Fundamental Particle Physics Seminar, University of Liverpool** *November 2024*  
Invited seminar talk on simulating the real-time evolution of quantum systems using novel techniques for both continuous and discrete variable quantum computers.
- **CERN TH QTI Seminar** *August 2024*  
Invited seminar talk on simulating quantum field theories on NISQ era quantum computers using Hamiltonian Truncation.
- **Dalitz Seminar Series on Fundamental Physics, University of Oxford** *February 2024*  
Invited seminar talk on the simulation of event generation using quantum computers, focusing on the realistic simulation of QCD parton showers.
- **Rutherford Appleton Laboratory HEP Seminar** *February 2024*  
Invited seminar talk on the application of quantum computing in particle physics.
- **Imperial College London HEP Seminar** *November 2023*  
Invited seminar talk on simulating realistic high energy particle collision events using a quantum computer and applications of quantum computing in particle physics.
- **University of Bristol HEP Seminar** *November 2023*  
Invited seminar talk on the charged-particle track finding and the simulation of realistic high energy particle collision events using a quantum computer.
- **University of Cambridge HEP Seminar** *May 2023*  
Invited seminar talk on the first quantum algorithm with the ability to simulate realistic high energy particle collision events.
- **University of Manchester** *March 2023*  
Invited seminar talk on the first quantum algorithm with the ability to simulate realistic high energy particle collision events.
- **Joint Phenomenology Seminar, University of Milan - Bicocca and Statale** *Jan 2023*  
Invited seminar talk on the development of parton shower algorithms using quantum walks.
- **Institute for Particle Physics Phenomenology, Durham University** *Nov 2022*  
Invited seminar talk on using a Discrete-QCD method to simulate realistic high energy particle collisions using a quantum device.
- **Higgs Centre, University of Edinburgh, Particle Physics Theory Series** *Oct 2022*  
Invited seminar talk on quantum simulation and simulating collider events on quantum devices.
- **Royal Holloway, University of London, Particle Physics Seminar** *Oct 2022*  
Invited seminar talk on the simulation of realistic quantum parton shower algorithms using a discrete-QCD approach.
- **Brookhaven Nation Laboratory, Quantum Journal Club** *May 2022*  
Invited seminar talk on quantum simulation of parton showers in high energy collisions.
- **Imperial College London HEP Seminar** *Dec 2021*  
Invited seminar talk on quantum simulation of parton showers and helicity amplitude calculations in high energy collisions.
- **QuantHEP Seminar** *Dec 2021*  
Invited seminar talk on the quantum walk approach to simulating parton showers in high energy collisions.
- **Quantum Universe Center, Korea Institute for Advanced Study** *Nov 2020*  
Invited seminar talk on quantum computing approaches to parton showers and helicity amplitude calculations.

## Experience

### Teaching

- **Level 1 Tutor:** *2021-2023*  
I deliver tutorials to first year students on the Physics and Natural Sciences courses at the University of Durham. The teaching covers all courses in the first year of physics.
- **Graduate Teaching Assistant: Rapid Feedback Demonstrator** *2021-2023*  
I deliver lecture style sessions as a supplement to the lecture course for Unification (A fourth year module on the Standard Model) and Foundations of Quantum Mechanics (A third/fourth year module) at Imperial College London. In these sessions I give solutions to the weekly problem sheets and answer questions from the students relating to the lecture course.

### Other academic roles

- **Pint of Science, Durham** *2023-present*  
In this role I help organise the Durham Pint of Science festival (needs updating...).
- **Postgraduate Student Representative** *2021-2023*

In this role I represent the postgraduates of the High Energy Physics group. The role includes organising postgraduate social events and providing a voice for the postgraduates at department and faculty level.

- **Equality, Diversity and Inclusivity Committee Member** *2021-2023*  
The High Energy Physics (HEP) EDI committee aims to promote a diverse, inclusive and welcoming environment for all in the HEP community, and focuses on improving opportunities available to people from all backgrounds. In my role as a committee member, I am involved in organising EDI related events and representing the postgraduate cohort as the postgraduate representative.

## Outreach

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- **Imperial Particle Physics Masterclass and Summer School** *2019-2023*  
I help teach and supervise A-Level students at the annual Particle Physics Masterclasses and Summer Schools, which aim to give the students an experience of working in a research environment.
- **Student Physics Outreach Ambassador, Royal Holloway University of London** *2015-2019*  
In this role I worked at many outreach events, including the Royal Holloway Science Festival and gave talks and workshops at schools.

## References

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| <ul style="list-style-type: none"><li>○ <b>Prof. Michael Spannowsky</b>,<br/>Director of the IPPP,<br/>Durham University,<br/>email: michael.spannowsky@durham.ac.uk</li><li>○ <b>Prof. Gavin Davies</b>,<br/>Head of the High Energy Physics Group,</li></ul> | <p>Imperial College London,<br/>email: g.j.davies@imperial.ac.uk</p> <ul style="list-style-type: none"><li>○ <b>Dr. Stefan Prestel</b>,<br/>Senior Quantum Software Developer,<br/>Quantum Brilliance,<br/>email: stefan.prestel.work@gmail.com</li></ul> |
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