

# Eshwen Bhal

PHD RESEARCHER

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## Profile

I am a final year PhD student in particle physics, searching for dark matter using big data from the Large Hadron Collider (LHC) as part of the CMS experiment at CERN. This involves statistical analysis of large datasets with expertise in Python, and solving wide ranging problems from physics standpoints to programming challenges. Additional responsibilities have included providing detector-related expertise and software, teaching undergraduates and doing public outreach. Aside from work, I partake in many activities such as taekwondo, weight lifting, hiking and skiing.

## Education

### University of Bristol

Bristol, United Kingdom

DOCTOR OF PHILOSOPHY IN PHYSICS

2016 – Present

- Thesis title: **Searches for dark matter with a focus on invisibly decaying Higgs bosons in the  $t\bar{t}H$ ,  $VH$ , and  $ggH$  channels using the full Run-2 dataset from the CMS experiment** — *Under supervision of H. Flücher. Expected submission in July 2020*
  - Explored various physics models in search of dark matter by analysing data from LHC's CMS experiment. Set **world leading limits** on Higgs boson decay to invisible states.
  - Executed robust, comprehensive statistical analysis on real and simulated data, meticulously documenting concepts, results and code.
  - Composed versatile, robust, efficient code to simulate data and perform each step of analysis. Written predominantly in Python, leveraging modern data science tools, vectorisation, and distributed computing to process multiple terabytes of data.
- **Postgraduate student representative** for the particle physics group, 2019–20 — *Role in Student-Staff Liaison Committee for School of Physics*
- Long term attachment at **CERN**, the world's largest particle physics laboratory — *18 month placement abroad in Geneva, Switzerland*
- **Calorimeter Layer-2 on call expert** and **Level-1 Trigger shifter**, Geneva, Switzerland — *Additional responsibilities at CERN*
  - Assisted in detector operations and monitoring so CMS experiment could take data efficiently and operate smoothly.
  - Developed and deployed software for subsystem of Level-1 Trigger to apply corrections and calibrations to data on the fly.

### University of Exeter

Exeter, United Kingdom

MASTER OF PHYSICS WITH HONOURS IN PHYSICS WITH ASTROPHYSICS. AWARD: FIRST CLASS

2012 – 2016

- Dissertation title: **Simulations of Exoplanet Light Curves** — *Under supervision of T. Harries*
  - Developed software in C to simulate photons interacting simple planetary atmospheres, producing light curves akin to data from telescopes. Visualised model planets with maps of density and composition.
  - Support for modelling more complex atmospheres for comparison to real exoplanets to infer their composition.
  - Utilised Monte Carlo random sampling for scattering of photons, and parallelisation to efficiently run the code over millions of them.

### Monmouth Comprehensive School

Monmouth, United Kingdom

SECONDARY SCHOOL QUALIFICATIONS

2005 – 2012

- **A Level**, 2010–12 — *Biology (A\*), Mathematics (A\*), Physics (B), Chemistry (AS Level) (B)*
- **Open University**, 2011–12 — *Introducing Astronomy (10 credit course)*
- **GCSE**, 2008–10 — *10 including English Language and Mathematics at grades A\* (4) to A (6)*

## Experience

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### University of Bristol

*Bristol, United Kingdom*

COMPUTATIONAL PHYSICS TUTOR

2019 – 2020

- Taught programming in Python to third year undergraduate students, with applications for numerically solving physics problems with numpy and visualisation with matplotlib. Formally marked assignments and provided feedback.

### University of Bristol

*Bristol, United Kingdom*

MATHEMATICS TUTOR

2017

- Taught mathematics for physicists to first year undergraduate students. Formally marked problem sheets, orchestrated discussions with the students, and taught concepts for subsequent assignments.

## Skills

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### Data analysis

- Primary focus of my PhD concerns statistical analysis of large (multi-terabyte) datasets collected by the CMS experiment from the Large Hadron Collider.
- Developed analysis software for dark matter searches and detector-effect calibrations in Python and C++, using modern data science tools such as numpy and pandas, and parallel programming on computing grids.
- Visualisation with ROOT and matplotlib. Formal presentations of results with LaTeX and Microsoft PowerPoint.

### Collaboration

- Belonging to, and working alongside, several groups of around a dozen people as well as a global research collaboration of over 4,000 people.

### Problem solving

- Principal component of any physics degree. As an undergraduate, conducted more traditional pen-and-paper problem solving in many topics. As a PhD student, wrote code to solve physics problems numerically and perform data analysis for high energy particle physics.

### Multitasking

- Often working on multiple projects at once with different people during PhD. These have included data analysis, software-implemented calibrations to data from detector effects, and expertise and shift work for subsystems of the detector.

### Communication

- Presented formally in my PhD at all levels: regular working group updates, research group and collaboration-wide talks, and several conference posters and talks.
- Participated in outreach to the public at the CERN Open Days 2019 and at @Bristol.

## Awards

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2016	<b>Dean's Commendation</b> , in recognition of outstanding achievement in my fourth year	<i>University of Exeter</i>
2015	<b>Physics Award</b> , for being one of the three students with the highest marks in my third year	<i>University of Exeter</i>
2014	<b>Dean's Commendation</b> , in recognition of outstanding achievement in my second year	<i>University of Exeter</i>
2013	<b>Physics Award</b> , for being one of the three students with the highest marks in my first year	<i>University of Exeter</i>
2013	<b>Dean's Commendation</b> , in recognition of outstanding achievement in my first year	<i>University of Exeter</i>