

# Rikab Gambhir

## Curriculum Vitae

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Center for Theoretical Physics, MIT  
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### Education

2020-Present **PhD Candidate (Expected 2025)**, *Center for Theoretical Physics*, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Advisor Jesse Thaler

2016-2020 **Bachelor of Science**, *Majors in Physics, Applied Science Engineering, and Mathematics*, Rutgers University Honors College - New Brunswick, New Jersey, USA.  
*GPA : 4.00/4.00, Graduated with Highest Honors, Ranked 1/992 in School of Engineering*

Advisor Stephen Schnetzer

Thesis A Search for Fully Hadronic Final State Vector-Like Quark Pair Production in 13TeV pp Collisions using CMS Data

### Honors & Awards

2022 **MIT Open Data Prize**, *Honorable Mention*.  
Prize awarded by MIT for use of open data tools

2020 **Weidner Award**.  
Prize awarded by the Rutgers Physics Department for academic performance

2019 **Barry Goldwater Scholar**.  
Selected by the Barry Goldwater Scholarship and Excellence in Education Foundation and the Department of National Defense Education Program for research

2019 **Mary Wheeler Wigner Memorial Scholarship**.  
Scholarship awarded by the Rutgers Physics Department for academic performance

2018 **Herman Y. Carr Scholarship**.  
Scholarship awarded by the Rutgers Physics Department for academic performance

2018 **Kuhl Memorial Engineering Scholarship**.  
Scholarship awarded by the Rutgers Engineering Department for academic performance and leadership

2017 **Aresty Summer Science Fellowship**.  
Fellowship awarded to rising sophomores for conducting research over the summer

### Publications

February 2023 **SHAPER: Can You Hear the Shape of a Jet?**, *Rikab Gambhir, Benjamin Nachman, and Jesse Thaler*, arXiv:2302.12266, J. High Energ. Phys. 2023, 195 (2023).  
Associated code: <https://github.com/rikab/SHAPER>

May 2022 **Bias and Priors in Machine Learning Calibrations for High Energy Physics**, *Rikab Gambhir, Benjamin Nachman, and Jesse Thaler*, arXiv:2205.05084, Phys. Rev. D 106, 036011.  
Associated code: <https://github.com/hep-lbdl/calibrationpriors>

May 2022 **Learning Uncertainties the Frequentist Way: Calibration and Correlation in High Energy Physics**, *Rikab Gambhir, Benjamin Nachman, and Jesse Thaler*, arXiv:2205.03413, Phys. Rev. Lett. 129, 082001.  
Associated code: <https://github.com/rikab/GaussianAnsatz/tree/main/JEC>

December 2020 **A search for bottom-type, vector-like quark pair production in a fully hadronic final state in proton-proton collisions at  $\sqrt{s} = 13$  TeV**, *CMS Collaboration*, arXiv:2008.09835, Phys. Rev. D 102, 112004.

## Works In Progress

**SPECTER: Efficient Evaluation of the Spectral EMD**, *Rikab Gambhir, Andrew Larkoski, and Jesse Thaler*.

We develop a differentiable code framework, SPECTER, for performing calculations and defining observables using the spectral energy mover's distance, significantly improving over the ordinary energy mover's distance

**Muon Beam Dump Phenomenology**, *Samuel Alipour-fard, Cari Cesarotti, and Rikab Gambhir*.

Calculations relevant for muon beam dump and muon collider searches for new physics

**Moment Pooling: Gaining Performance and Interpretability Through Physics Inspired Product Structures**, *Rikab Gambhir, Athis Osathapan, and Jesse Thaler*.

We develop new architectures, based on the Energy Flow Network [1810.05165], with built-in product structures to improve both the performance and interpretability of learned observables through a simple factorization.

## Presentations

2 August 2023 **Moment Pooling: Gaining Performance and Interpretability Through Physics Inspired Product Structures**.

BOOST 2023, 2 August 2023, Lawrence Berkeley National Lab, San Francisco, California

11 July 2023 **How Do I Take My Cup of CMS Open Data?**

Invited Talk, Fermilab Open Data Workshop, 11 July 2023, Batavia, Illinois

17 April 2023 **Moment Pooling: Gaining Performance and Interpretability Through Physics Inspired Product Structures**.

APS April 2023, 17 April 2023, Minneapolis, Minnesota

3 December 2022 **Learning Uncertainties the Frequentist Way: Calibration and Correlation in High Energy Physics**.

Poster, 3 December 2022, NeurIPS (Virtual)

12 November 2022 **Learning Uncertainties the Frequentist Way: Calibration and Correlation in High Energy Physics**.

Invited Seminar Speaker, 12 November 2022, ATLAS (Virtual)

13 September 2022 **Learning Uncertainties the Frequentist Way: Calibration and Correlation in High Energy Physics**.

Invited Seminar Speaker, 13 September 2022, University of California, Irvine (Virtual)

15 August 2022 **Can You Hear the Shape of a Jet?**

BOOST 2022, 15 August 2022, University of Hamburg, Germany

10 April 2022 **Can You Hear the Shape of a Jet?**

APS April 2022, 10 April 2022, New York, NY

7 July 2021 **Learning Uncertainties the Frequentist Way: Calibration and Correlation in High Energy Physics**.

ML4Jets2021, 7 July 2021, University of Heidelberg (Virtual)

- 19 April 2020 **A Search for Fully Hadronic Final State Vector-Like Quark Pair Production in 13 TeV pp Collisions using CMS Data.**  
APS April 2020, 19 April 2020, Washington D.C (Virtual)
- 29 July 2019 **A Search for Fully Hadronic Final State Vector-Like Quark Pair Production in 13 TeV pp Collisions using CMS Data.**  
2019 Meeting of the Division of Particles & Fields of the American Physical Society, 29 Jul-2 Aug 2019, Boston, MA
- 4 August 2017 **How Can We Model Insect Flight Quickly and Accurately?.**  
2017 Rutgers Summer Aresty Symposium, 4 Aug 2017, New Brunswick, NJ

## Mentorship

- Summer 2023 **Xinyue Wu**, (*MSRP*) Undergraduate MIT Independent Research, Supervised by Jesse Thaler, Using SHAPER to study jet shapes in CMS Open Data.
- Summer 2022 **Sergio Diaz**, (*MSRP*) Undergraduate MIT Independent Research, Supervised by Jesse Thaler, Using the GaussianAnsatz to study  $W$  and  $Z$  boson masses.
- Summer 2021 **Athis Osathapan**, Undergraduate MIT Independent Research, Supervised by Jesse Thaler, Summer 2022 Building the Moment-EFN product structure.
- Summer 2021 **Pedro Rivera-Cardona**, (*MSRP*) Undergraduate MIT Summer Research Program, Supervised by Jesse Thaler, Adding symmetries to Energy Flow Networks.

## Community & Outreach

- October 2023 **Cambridge Science Festival.**  
Developed the primary demonstration, OpenAI-mer ([github.com/rikab/chatXYZ](https://github.com/rikab/chatXYZ) – a chatbot representing a theoretical physicist), for the festival. Represented IAIFI and ran the demonstration for festival attendees, including high school students and younger.
- Summer 2019 **High School Teacher Qiskit Workshop.**  
Worked alongside Prof. Stephen Schnetzer to run workshops and tutorials for training high school teachers and advanced students to use quantum computing and Qiskit in the classroom
- 2016 - 2020 **Director of the Rutgers Machine Learning & AI Club.**  
Gave weekly lectures on deep learning topics, ranging from basic statistics to advanced network architectures, and led students in building and designing their own neural network projects

## Software Libraries & Code

In general, (almost) all of my papers have associated analysis and plotting code which I have made public, which can be used to reproduce the results and plots of that paper. These are listed alongside their paper in the “Publications” section. Below are the more general-use software packages I have developed or contributed to and don’t necessarily correspond to a paper.

- 2023- **SHAPER**, Hosted at [github.com/rikab/SHAPER](https://github.com/rikab/SHAPER), Install with `pip install pyshaper`, Python Package [Primary Developer].  
SHAPER, or **S**hape **H**unting **A**lgorithm using **P**arameterized **E**nergy **R**econstruction, is a framework for defining, building, and evaluating generalized shape observables for collider physics, as defined in [2302.12266]. Tutorial and examples can be found within the github.
- 2022- **GaussianAnsatz**, Hosted at [github.com/rikab/GaussianAnsatz](https://github.com/rikab/GaussianAnsatz), Install with `pip install GaussianAnsatz`, Python Package [Primary Developer].  
The Gaussian Ansatz is a machine learning framework for performing frequentist inference, complete with local uncertainty estimation, as described in [2205.03413]. Examples can be found within the github.

## Teaching

Responsibilities included holding office hours, proctoring and grading exams and quizzes, managing teams of undergraduate teaching assistants, and assisting during class time. For my TEAL-style teaching, additional

responsibilities include leading problem solving sessions during class time.

- Fall 2023 **MIT 8.02**, *Physics II: E&M*, Teaching Assistant, TEAL-style.  
Under Prof. Michelle Tomasik
- Spring 2023 **MIT 8.011**, *Physics I: Mechanics*, Teaching Assistant, TEAL-Style.  
Under Prof. Richard Milner
- Fall 2021 **MIT 8.03**, *Physics III: Vibrations and Waves*, Teaching Assistant.  
Under Prof. Long Ju

## Refereeing

- October 2023 **Machine Learning and the Physical Sciences Workshop at NeurIPS 2023.**

## Media Coverage

- 19 July 2023 **Can you hear the shape of physics?**, *Imperial College London News*, <https://www.imperial.ac.uk/news/246302/can-hear-shape-physics/>.
- 14 May 2019 **From Ocean Currents to Theoretical Particles: Three Rutgers Students Receive Goldwater Scholarships**, *Rutgers Today*, <https://www.rutgers.edu/news/ocean-currents-theoretical-particles-three-rutgers-students-receive-goldwater-sch>

## Other & Just for Fun

- April 2023 **ChatJesseT**, Helped to develop ChatJesseT (<https://chatjesset.com/>), trapping the soul of my PhD advisor in a robotic body.
- 2021-2023 **Twitter**, Was the @FinitePhysicist, ~50k followers. Retired.
- 2016-2018 **Avagadr.io**, Wolfram Alpha-style app for solving college-level chemistry problems. Was available on the Google Play Store until 2018, 4.415 star lifetime rating.