

# Raghav Kansal

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## Education

### UC San Diego/CERN/Fermilab

PHD IN PHYSICS, GPA: 3.97/4.00

La Jolla, USA; Geneva, Switzerland; and Chicago, USA

2019 -

Topic: Machine Learning and Particle Physics | Advisor: [Javier Duarte](#)

### UC San Diego

BS IN PHYSICS & COMPUTER ENGINEERING, GPA: 3.98/4.00, *summa cum laude*

La Jolla, USA

2015 - 2019

Divisional and Departmental Highest Honors

## Publications

- [1] [R. Kansal](#) et al. "Particle Cloud Generation with Message Passing Generative Adversarial Networks". In: *NeurIPS*. 2021. arXiv: [2106.11535](#).
- [2] F. Mokhtar, [R. Kansal](#), et al. "Explaining machine-learned particle-flow reconstruction". In: *4th Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2021. arXiv: [2111.12840](#).
- [3] S. Tsan, [R. Kansal](#), et al. "Particle Graph Autoencoders and Differentiable, Learned Energy Mover's Distance". In: *4th Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2021. arXiv: [2111.12849](#).
- [4] [R. Kansal](#) et al. "Graph Generative Adversarial Networks for Sparse Data Generation in High Energy Physics". In: *3rd Machine Learning and the Physical Sciences Workshop at NeurIPS*. 2020. arXiv: [2012.00173](#).

## Honors and Awards

Nov 2021 **2020-21 Carol and George Lattimer Graduate Award for Excellence**

UCSD Division of Physical Sciences

One of two recipients of this award, which 'honors outstanding graduate students in the Division of Physical Sciences who seek interdisciplinary approaches to problem solving and have a strong commitment to education, mentorship, and service.'

2021-2022 **Fermilab LPC Artificial Intelligence Fellowship**

Fermilab

For ML-based fast simulation software, ML techniques for reconstruction, compression, and anomaly detection tasks, and a boosted Higgs to WW tagger for precision measurements. [Full description](#).

Aug 2019 **CERN Openlab Summer Students Lightning Talks Award Runner-Up**

CERN

For the talk '[Deep Graph Neural Networks for Fast HGCal Simulation](#)'

Jun 2019 **2019 IRIS-HEP Fellowship**

IRIS-HEP

For the project '[HGCal Fast Simulation with Graph Networks](#)'

Jun 2019 **2019 John Holmes Malmberg Prize**

UCSD Department of Physics

Sole recipient of this prize, which is 'presented annually at commencement to a graduating physics student who is recognized for potential for a career in physics and a measure of experimental inquisitiveness.'

May 2019 **2018-2019 Physical Sciences Dean's Undergraduate Award for Excellence**

UCSD Division of Physical Sciences

One of 33 students from the departments of Mathematics, Physics and Chemistry 'recognized for excellence in academics and fundamental research'.

Jul 2018 **2018 William A. Lee Undergraduate Research Award**

UCSD Division of Physical Sciences

For the project '[Arbitrary ultra-cold atomic lattices using holographic optical tweezers](#)'

## Projects

### MPGAN

[paper](#) [slides](#) [github](#)

Jun 2019 -

- Leading the effort on developing a graph-based generative adversarial network, which we call MPGAN, which has proven effective at generating sparse data with irregular underlying geometry.
- Our latest work on this has been accepted to the 2021 NeurIPS main conference.
- We're now experimenting with a conditional GAN version and variable-sized graphs, as well as applications to other datasets such as CERN detector data.

## HH→bbVV

[github](#)

Jun 2019 -

- Leading the analysis of 2016-2018 data collected at CERN looking for two Higgs bosons (H) decaying to beauty quarks (b) and vector bosons (V).
- Developing a new graph neural network to classify between H→VV particle clouds and backgrounds.

## JetNet Library

[github website](#)

Sep 2021 -

- Developing a library and website for convenient access to jet datasets, in particle cloud representations, along with several useful utilities for jet-based machine learning development.
- Has been used so far for our group's MPGAN and LGAE projects, and continues to be expanded.

## Machine Learning for Particle Flow

[github](#)

May 2021 -

- Developing graph neural networks to perform event reconstruction in the CMS experiment at CERN.
- Interpreting results using the Layerwise Relevance Propagation (LRP) method; latest work on this has been submitted to the Machine Learning for Physical Science workshop at NeurIPS 21.

## Lorentz Group Equivariant Autoencoder

[review github](#)

Dec 2020 -

- Wrote a review of deep learning models that are equivariant to physics-relevant group transformations for Prof. John McGreevy's fantastic group theory course.
- Led to our group developing a graph-based autoencoder equivariant to Lorentz group transformations (LGAE)
- Our latest work has been submitted to the Machine Learning for Physical Sciences workshop at NeurIPS 2021.

## Particle Graph Autoencoders

[github](#)

Dec 2020 -

- Developing graph-based autoencoders for compression of and anomaly detection in particle cloud representations of Large Hadron Collider data.
- Our latest work has been submitted to the Machine Learning for Physical Sciences workshop at NeurIPS 2021.

## Sequential Modeling for Soccer Predictions

[github](#)

Mar 2018 - Mar 2019

- Fun project mostly to gain experience with RNNs and Attention
- I achieved a 71% testing accuracy in predicting the outcome of European soccer matches

## Optical Tweezers and a Quantum Gas Microscope

[poster](#)

Jun 2017 - Jun 2019

- Created dynamic, sub-micron holographic optical tweezers and a Quantum Gas Microscope with sub-micron resolution in order to manipulate individual atoms (or qubits) for quantum computing and quantum information science experiments
- This work won a William A. Lee Research award, and will be published soon

## GRAD: An interactive graph-based degree planning app

[github](#)

Jan 2017 - Mar 2017

- Created an app for visualizing course requirements with a user-friendly UI
- I was the Back-end and Algorithms Lead for a team of 10, and personally wrote the server, scraping and graphing algorithms for the app
- We were one of 8 finalists out of 60 projects in the UCSD 2018 software engineering course

## Selected Talks and Posters

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See [raghavkansal.com/event](http://raghavkansal.com/event) for a complete list, as well as links, slides, posters, and videos.

Dec 2021	<b>NeurIPS 21 Main Poster Session</b> Particle Cloud Generation with Message Passing GANs	<i>Virtual (Poster)</i>
Nov 2021	<b>University of Washington EPE Machine Learning Seminar</b> Particle Cloud Generation with Message Passing GANs	<i>Virtual (Talk)</i>
Nov 2021	<b>ACAT Poster Session</b> Particle Cloud Generation with Message Passing GANs	<i>Virtual (Poster)</i>
Nov 2021	<b>LPCC FastSim Workshop</b> Validation Techniques for Machine-Learned FastSim	<i>Virtual (Talk)</i>
Jul 2021	<b>ML4Jets Workshop</b> Particle Cloud Generation with Message Passing GANs	<i>Virtual (Talk)</i>
Jun 2021	<b>Mainz Institute for Theoretical Physics Machine Learning for Particle Physics Workshop</b> Particle Cloud Generation with Message Passing GANs	<i>Virtual (Talk)</i>
May 2021	<b>CMS ML Forum</b> Sparse Data Generation	<i>Virtual (Talk)</i>

Mar 2021	<b>James Madison University Artificial Intelligence and Machine Learning Seminar</b> Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Talk)
Mar 2021	<b>Berkeley Institute for Data Science Deep Generative Models for Fundamental Physics Meeting</b> Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Talk)
Feb 2021	<b>Imperial College London DataLearning Seminar</b> Graph Generative Adversarial Networks for High Energy Physics Data Generation	Virtual (Talk)
Dec 2020	<b>NeurIPS 2020, Machine Learning and the Physical Sciences Workshop</b> Graph Generative Adversarial Networks for Sparse Data Generation in High Energy Physics	Virtual (Poster)
Aug 2019	<b>CERN Openlab Lightning Talks</b> Deep Graph Neural Networks for Fast HGCAL Simulation, Runner-Up Award	CERN (Talk)
Aug 2018	<b>William A. Lee Undergraduate Research Award Poster Presentations</b> Arbitrary Positioning and Manipulation of Ultra-Cold Atoms with Optical Tweezers	UCSD (Poster)

## Experience

### Duarte Lab, UC San Diego

UCSD/CERN

#### MACHINE LEARNING AND PARTICLE PHYSICS RESEARCHER

Sep 2019 -

- Developing new graph generative models for sparse and irregular data like that prevalent in particle physics
- Graph neural network (GNN) autoencoders for compression and anomaly detection, machine learning for particle flow reconstruction, Lorentz-group equivariant autoencoders, JetNet library for convenience and reproducibility in machine learning development in high energy physics
- Developing and applying state-of-the-art GNN classifiers to set the most stringent constraints to date on double-Higgs production, allowing insight into the metastability of the universe

### Machine Learning for Particle Physics Group, CERN

CERN

#### CERN OPENLAB INTERN

Jun - Aug 2019

- Started our project on graph generative models for particle physics simulations, motivated primarily by the CMS experiment's new High Granularity Calorimeter (HGCAL)

### Kleinfeld Lab, UC San Diego

UCSD

#### NEUROPHYSICS RESEARCHER

Sep 2018 - Jun 2019

- Used two-photon microscopy to measure pO<sub>2</sub> in the mouse somatosensory cortex
- Imaged the cortex to measure vasomotion relative to pO<sub>2</sub>

### Barreiro Lab, UC San Diego

UCSD

#### EXPERIMENTAL QUANTUM INFORMATION SCIENCE RESEARCHER

Jun 2017 - Jun 2019

- Designed and implemented a setup for a quantum gas microscope (QGM) to image with single-site resolution
- Generated 2D dynamic, arbitrarily arranged, sub-micron optical tweezers, integrated with the QGM, via two methods, using: 1) a Digital Micromirror Device (i.e. holography), and 2) an acousto-optic deflector
- Characterized a high (0.8) Numerical Aperture objective for the QGM using OSLO optical simulations and point-spread function image analysis in Python
- Using an FPGA device, outputted RF waveforms that modulate laser beams with parabolic spatial intensity in order to produce a Bose-Einstein Condensate
- Programmed FPGA and C electronic devices, and created and (3D) printed mechanical mounts and electronics circuits for experimental use

### Focus Analytics

Mumbai, India

#### SOFTWARE INTERN

Jul 2016 - Sep 2016

- Interned at a software startup which has since been bought by Moka
- Developed and deployed a location prediction SparkJava server with Cassandra and Redis databases
- Implemented ML k-means clustering and SVM linear classification algorithms on location data
- Wrote NodeJS servers and pages for receiving users' predicted locations and displaying the live data on maps
- Designed Cassandra and MySQL databases storing user tracking data, and wrote server APIs for accessing/updating, along with web panels for easy viewing of the data (using said APIs)