Jeff Schueler Ph.D. (He/Him)

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Positions Held

Postdoctoral fellow   April 2023 – Present
Department of Physics & Astronomy, University of New Mexico, Albuquerque, NM

Postdoctoral fellow   Aug. 2022 – Jan. 2023
Department of Physics and Astronomy, University of Hawaii, Honolulu, HI

Physics fellow (high school teaching fellowship)   June 2013 – Aug. 2015
New York City Teaching Fellows, New York, NY

Education

University of Hawai'i, Honolulu, HI   2015 – 2022
Ph.D in Physics (2022)
- Dissertation Title: *From neutrons to dark matter: Directional recoil detection and utilization of deep learning for gaseous time projection chambers*
- Thesis Advisor: Sven Vahsen

Pace University, New York, NY   2013 – 2015
M.S.in Adolescent Education: Physics (2015)

University of Washington, Seattle, WA   2009 – 2013
- B.S. with Honors in Physics
- B.S. in Mathematics
- Minors in Chemistry and Applied Mathematics
- Research Advisors: Dr. Thomson (Toby) Burnett, Dr. David Masiello

Research Interests

I am an experimental particle physicist specializing in applying computer vision techniques to improve the performance of imaging particle detectors. Recently, I came up with the idea of using object detection to enable data-driven machine learning training for rare-event search experiments. I successfully applied this idea to the MIGDAL experiment's search for the Migdal effect through the development of an object detection-based data processing and analysis pipeline that was trained on real-data and performs our experiment's search for the Migdal effect in real-time. I am currently advising an undergraduate who is adding keypoint detection to this pipeline, which would enable the ability to detect event vertices and reconstruct track directions. More broadly, I am interested in applying machine learning to improve detector simulations, developing solutions for event topology-based triggering in rare event search experiments (e.g. Ba-tagging for NEXT), and collaborating on interesting interdisciplinary problems.

Research Experience

University of New Mexico, Albuquerque, NM (Remote from WA state)   April 2023 – Present
Postdoctoral Research Fellow: MIGDAL collaboration–a rare event search experiment aiming to observe the Migdal effect for the first time.

- Developed migYOLO, a deep learning-based object detection pipeline for real-time end-to-end analyses of high resolution CMOS camera images (paper link)
  - Processes and performs automated Migdal effect searches on 40TB of images per day
  - Core of the pipeline is YOLOv8, which I custom trained on detector image data
  - Integrated the software with Label Studio for automated pre-annotations
- Created tkinter-based GUI displays for real-time detector performance monitoring using processed pipeline data
- Advising a graduate student on expanding the pipeline with keypoint detection to improve particle trajectory fitting and rare event search selections

University of Hawai'i at Mānoa, Honolulu, HI   Aug. 2022 – Dec. 2022
Postdoctoral Fellow: Researched and applied deep learning-based computer vision techniques to improve neutral particle identification and directional sensitivity in gas TPCs:

- Developed a custom Monte Carlo digitizer for our TPCs that reduces both memory consumption and computation time by over an order of magnitude compared to our previous digitizer.
- Implemented a data-driven tuning of simulation parameters, leading to statistical agreement between the 3D spatial-charge distributions of observed and simulated nuclear recoils in our TPCs.
- Generated millions of 3D voxel images with this simulation pipeline to train a 3D convolutional neural network to classify event directions, evaluated it on lab measurements, and found significant event-level head/tail recognition to sub-20 keV_{ee} nuclear recoils.
- Invited to present this work as an early career plenary speaker in the Coordinating Panel for Advanced Detectors (CPAD) 2022 workshop

University of Hawai'i at Mānoa, Honolulu, HI   Jan. 2017 – Aug. 2022
Research Assistant (PI: Sven Vahsen): Specialized in directional detection with gas TPCs, which is applicable for fast neutron measurements at particle accelerators and for directional dark matter detector R&D.

- Commissioned two generations of systems of TPCs at the SuperKEKB e^+e^- collider experiment in Tsukuba, Japan.
- Led the design, development, construction, documentation, and implementation of these systems, including remote operation, data collection, data processing, and analyses that were featured in five journal publications.
- Developed interactive 3D displays of events measured in these TPCs that have been featured in two publications and are prominently displayed in our group's talks and current PR material.

- Worked closely with other beam background group members to identify previously unknown Touschek scattering hotspots that led to collimator adjustments that ultimately reduced Touschek background rates outside of Belle II by 40%.
- Regularly presented TPC system status updates at semi-weekly beam background group meetings and triannual Belle II collaboration meetings, and invited to give hour-long beam background seminars at two Belle II Summer School workshops.
- Enhanced and maintained an EPICS database that updated and archived 1 Hz summary quantities from these TPCs.
- Created and maintained GUI displays that provided real-time (1 Hz) updates of over 50 quantities of interest from the SuperKEKB collider and most Belle II detectors. These displays are a centerpiece of cross-functional operational shifts that facilitate communication between Belle II detector operators and SuperKEKB accelerator operators.
- Utilized machine learning and deep learning techniques to improve electron background rejection in these TPCs by more than an order of magnitude.

University of Washington – Seattle, WA June 2012–June 2013
Undergraduate Research Assistant (PI: Thompson (Toby) Burnett): Performed statistical analyses supporting research efforts for the Fermi Gamma-ray Space Telescope.

Advising and Mentoring Experience

Wesley Thompson (University of New Mexico; Graduate Student) 2024 – Present
Project title: *Directional reconstruction and characterization of diffusion of protons and alphas in the MIGDAL detector*

Stephanie Paiva-Flynn (University of New Mexico; Undergraduate) 2024 – Present
Honors Thesis: *Deep learning-based keypoint detection for electron recoil vertex identification and trajectory reconstruction*

Hima Bindhu Korandla (University of Hawaii; Graduate Student) 2021 – 2022
- Mentored Hima in her first year as a graduate student at the University of Hawaii
- Onboarded Hima in (1) operation of our Hawaii Group's TPCs, and (2) developing and maintaining the SuperKEKB/Belle II live detector monitoring GUI displays

Teaching Experience

University of Hawai'i at Mānoa – Honolulu, HI   **Aug. 2015 - May 2017; Fall 2019**

Graduate Teaching Assistant: Taught a total of nine introductory physics lab sessions, three introductory physics recitation sessions, and four senior-level quantum mechanics recitation sessions.
- Elected as Head TA responsible for mentoring all physics TAs teaching introductory courses.
- Developed all teaching materials used in the quantum mechanics recitation sessions, many of which have been passed on to future TAs.
- Awarded an Outstanding Physics TA prize.
- Twice nominated for the university-wide TA award.

Maspeth High School – New York, NY   **Sept. 2013 - June 2015**

Founding Physics Teacher: Tirelessly worked to deliver the principles of inquiry, equity, inclusion, and effective assessment through interactive and engaging lessons with data-driven assessment.
- Developed physics curriculum adhering to New York State Physics Core curriculum guidelines.
- Established both the school's AP Physics program and the school's physics lab.
- Wrote over 30 letters of recommendation, many for first generation college applicants.
- Mentored several groups of students who participated in the New York City Science Fair.

Awards

H. Keith and Sue Ernst ARCS Award and Scholarship (2021)
University of Hawaii Department of Physics Outstanding TA prize (2016)
Head Physics TA (2016)

Selected Publications

A complete list of my publications and contributions can be found at my [INSPIRE HEP page](#), which includes over 100 works affiliated with the Belle/Belle II collaborations. Below are publications I substantially contributed to:

J. Schueler, et. al. (MIGDAL Collaboration), *Transforming a rare event search into a not-so-rare event search in real-time with deep learning-based object detection* Phys. Rev. D 111, 072004 (2025) DOI: [10.1103/PhysRevD.111.072004](#)

J. Schueler, S.E Vahsen, P.M Lewis, M. Hedges, D. Liventsev, F. Meier, H. Nakayama, A. Natochii, T.N Thorpe, *Application of recoil-imaging time projection chambers to directional*

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neutron background measurements in the SuperKEKB accelerator tunnel, Nucl. Instrum. Methods Phys. Res., Sect. A 1040 (2022) 167291. DOI:10.1016/j.nima.2022.167291

Z. J. Liptak A. Paladino, L. Santelj, **J. Schueler**, S. Stefkova, H. Tanigawa, N. Tsuzuki, et al., *Measurements of beam backgrounds in SuperKEKB Phase 2*, Nucl. Instrum. Methods Phys. Res., Sect. A 1040 (2022) 167168. DOI: 10.1016/j.nima.2022.167168

P. M. Lewis, M. T. Hedges, I. Jaegle, **J. Schueler**, T. N. Thorpe, S. E. Vahsen, *Primary track recovery in high-definition gas ti*me projection chambers, Eur.Phys.J.C 82 (2022) 4, 324 DOI: 10.1140/epjc/s10052-022-10283-3

M.T. Hedges, S.E. Vahsen, I. Jaegle, P.M. Lewis, H. Nakayama, **J. Schueler,** T.N. Thorpe *First 3D vector tracking of helium recoils for fast neutron measurements at SuperKEKB,* Nucl.Instrum.Meth.A 1026 (2022) 166066 DOI: 10.1016/j.nima.2021.166066

A. Natochii et. al. (including **J. Schueler**) *Measured and projected beam backgrounds in the Belle II experiment at the SuperKEKB collider,* Nucl.Instrum.Meth.A 1055 (2023) 168550, DOI: 10.1016/j.nima.2023.168550

I. Jaegle, P. M. Lewis, M. Garcia-Sciveres, M. T. Hedges, T. Hemperek, J. Janssen, Q. Ji, D.-L. Pohl, S. Ross, **J. Schueler**, I. Seong, T. N. Thorpe, S. E. Vahsen, *Compact, directional neutron detectors capable of high-resolution nuclear recoil imaging,* Nucl.Instrum.Meth.A 945 (2019) 162296, DOI: 10.1016/j.nima.2019.06.037

Publications in preparation

J. Schueler, S.E. Vahsen, *First observation of the head/tail effect in sub-10 keV nuclear recoils* [In preparation; 2025]

MIGDAL Collaboration et. al. (including **J. Schueler**), *Performance of the Optical Time Projection Chamber of the MIGDAL Experiment* [In preparation; 2025]

D. Edgeman et. al. (including **J. Schueler**) *Optical effects in Gas Electron Multipliers* [In preparation; 2025]

J. Schueler, M. Ghrear, S.E. Vahsen, P. Sadowski, C. Deaconu, *Deep learning for improved keV-scale recoil identification in high resolution gas time projection chambers* [In preparation for journal submission] DOI: https://doi.org/10.48550/arXiv.2206.10822

Invited Talks

Talk titles and links to slides are included in cases where a link to the event is not provided.
- **University of Washington: CENPA Seminar**   March 20th, 2025
- **University of New Mexico: NUPAC Seminar**   Sept. 24th, 2024

- **Berkeley Institute for Data Science Seminar**   Sept. 17th, 2024
  Title: *Object detection enabling data-driven ML training for rare event searches*
- **Stanford/SLAC: FPD Seminar**   Sept. 12th, 2024
- **LUX-ZEPLIN UK/Europe/Australia meeting**   June 20th, 2024
  Title: *A deep learning-based object detection pipeline for real-time Migdal effect searches on CMOS camera data from the MIGDAL experiment*
- **Los Alamos National Lab: Particle Physics Seminar**   Nov. 15th, 2023
  Title: *Deep Learning for Improved Analyses of High Resolution Gaseous TPC Data*
- **CPAD Workshop 2022** (Early Career Plenary)   Nov. 30th, 2022
- **2020 Hawaii US Belle II Summer School**   July 7th, 2020
  Title: Measurement of Neutron Backgrounds with Time Projection Chambers
- **2019 BNL US Belle II Summer School**   July 31st, 2019
  Title: Beam Induced Backgrounds at SuperKEKB

Other Presentations

- **8th International Conference on Micro Pattern Gaseous Detectors**   Oct. 14th, 2024
  (Presented on behalf of the MIGDAL collaboration)
- **APS April Meeting 2024**   Apr. 4th, 2024
- **CPAD Workshop 2023**   Nov. 9th, 2023
- **APS April Meeting 2021**   Apr. 17th, 2021
- **APS April Meeting 2019**   Apr. 15th, 2019

Selected Software

migYOLO – Companion software for the MIGDAL collaboration's paper *Transforming a rare event search into a not-so-rare event search in real-time with deep learning-based object detection.* The software is self-contained and includes all tools discussed in the paper.
GitHub | Documentation | doi.org/10.5281/zenodo.12628436

MIGDAL_simulator – Fast TPC detector simulation. Includes tools for simulating primary tracks, drifting and diffusing them in a gas mixture, amplification with any number of GEMs, and digitization. Also includes rudimentary GPU support which I may improve upon with CUDA Python.
GitHub | Documentation

objectKeyPointLabelStudio - General framework (with a catchy name!) to automatically generate XML code that enables an object-keypoint detection data labeling interface in LabelStudio. This software includes a custom YOLOv8-pose model I pre-trained to demonstrate ML-assisted labeling with LabelStudio. This software is built to be flexible and can be adapted to object-keypoint detection workflows outside of physics.
GitHub

Outreach, professional development, and other service

- Physics Department Graduate Student Organization (GSO) Representative (2016-2017)
  - Regularly informed graduate students in the Physics department about funding opportunities through the GSO.
  - Coached graduate students on putting together GSO funding applications and advocated for them at monthly university-wide GSO meetings to receive travel funding for conferences, workshops, or specialized research activities.
- University of Hawaii Physics Day volunteer (2015-2016)
- ISEE Professional Development Program participant (2015)
  - Attended 10 days of education-focused professional development focused on inquiry, equity/inclusion, and assessment in university lab instruction.
  - Used backward design principles to develop and teach a 6 hour interactive inquiry lab to an introductory astronomy lab course at the University of Hawaii
- New York City Science Fair judge (2014)
- Taught Saturday Physics Prep courses as volunteer work to public high school students in New York City (2013-2014)