

# GREG FURLICH

## Research Associate

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Research Associate and the Space Domain Awareness Research Lead for the Center for National Security Initiatives at the University of Colorado Boulder. Research interests include signal and image processing, remote sensing image analysis, algorithm development, and machine learning with images. PhD in Physics from the University of Utah with a thesis on the ultraviolet remote sensing of ultra-high energy cosmic ray interactions within the atmosphere.

## RESEARCH INTERESTS

**Remote Sensing:** image processing and analysis over many spectral regions (visible, infrared, ultraviolet, multispectral, hyperspectral) or from point cloud reflecting systems (Radar, Lidar, SAR) that form point cloud datasets

**Mission Data Processing:** signal and image processing; feature extraction and exploitation; algorithm development for dim target detection and disparate data fusion for target tracking and state estimation; event detection, classification, and typing

**Machine Learning:** image classification, image segmentation, automatic target recognition, synthetic image generation, anomaly detection, physics-informed neural networks

## EDUCATION

**Doctorate of Philosophy, Physics** 2014 - 2020

**Master of Science, Physics** 2014 - 2018

**University of Utah, Salt Lake City, UT**

**Bachelor of Science, Physics** 2010 - 2014

**Michigan Technological University, Houghton, MI** *Magna Cum Laude*

Minors: Mathematical Sciences and German

## RESEARCH EXPERIENCE

**Research Associate, Space Domain Awareness Research Lead** Aug 2022 - Present

**University of Colorado Boulder,  
Center for National Security Initiatives (NSI)**

**A/Al Research Engineer** May 2022 - Aug 2022

**Senior Research Scientist** Jan 2021 - May 2022

**Lockheed Martin Space Systems,  
Advanced Programs and Exploitations (APEX)**

- Developed innovative algorithms which improved the efficiency and accuracy in signal and image processing for a variety of sensor types (visible, infrared, ultraviolet, radar, lidar, and sAR). Developed data fusion algorithm for object detection, tracking, and state estimation.
- Designed novel machine learning networks for super resolution, image-to-image translation, and style transfer with Generative Adversarial Networks (GANs), image segmentation with UNETs and FCNs, and object classification with Convolution Neural Networks (CNNs).
- Improved methods for synthetic radiometric scene generation to enhance fidelity of an optical payload simulation.
- Selected as a Recognized Technical Talent for technical contributions within first year.
- Generated intellectual property which provided technical advantage for many applications and was therefore awarded and protected as a trade secret.

# RESEARCH EXPERIENCE CONTINUED

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## Graduate Research Assistant in Cosmic Rays

2014 - 2020

Telescope Array (TA) Cosmic Ray Observatory, Institute of High Energy Astrophysics,  
Department of Physics and Astronomy, University of Utah

Research Advisor: Douglas Bergman

Thesis : [Observation of the GZK Suppression with the Telescope Array Fluorescence Telescopes and Deployment of the Telescope Array Expansion](#)

- Analyzed 10 years of monocular fluorescence data to create a Cosmic Ray Energy Spectrum. Raw cosmic ray event data were analyzed by reconstructing event geometry and energy. The event information was aggregated into a large database to produce the event energy distribution. The aperture of the detectors in monocular mode was calculated through Monte Carlo thrown events over TA and simulating the response of the detectors.
- Analyzed the significance of the Greisen–Zatsepin–Kuzmin (GZK) Suppression at the highest energies of cosmic rays in the 10 year cosmic ray spectrum. Analyzed other features that give insight into cosmic ray populations or propagation effects.
- Classified weather over TA with the fluorescence detector photomultiplier tube baselines to create false color images of the detectors' field of view. Videos of these snapshots were then used as inputs in a Recurrent Convolution Neural Network (RCNN) model constructed with Keras machine learning framework to determine clear weather data for further cosmic ray analysis.
- Refurbished, tested, calibrated, and deployed the system of ultraviolet fluorescence telescopes for the TAx4 expansion. Collected first light with these new instruments.
- Analyzed the preliminary data from the new fluorescence detectors for the expansion of TA known as TAx4 into a preliminary Cosmic Ray Energy Spectrum and compared to previous results to gauge the new detector's abilities.

## Project Data Analyst

2019

[College of Computing, University of Utah](#)

- Collaborated on a College of Computing PhD Candidate's thesis project by analyzing air quality data with Python and Pandas DataFrames to query, aggregate, and present data in infographical plots in a rapid fashion during face-to-face interviews with study participants.
  - Aggregated outside data of local weather conditions and Air Quality Index through web application programming interfaces to give prospective to study participants about their collected home air quality data.
- Contributions are noted in:

*Exploring the Personal Informatics Analysis Gap: 'There's a Lot of Bacon'*, Jimmy Moore, Pascal Goffin, Jason Wiese, Miriah Meyer, IEEE Transactions on Visualization and Computer Graphics (VIS), 95-105, doi:10.1109/TVCG.2021.3114798, 2021

*An interview method for engaging personal data*, Jimmy Moore, Pascal Goffin, Jason Wiese, Miriah Meyer, The Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies (IMWUT), 5(4): 1-28, doi:10.1145/3494964, 2021.

## Research Assistant in Cosmic Rays

2013 - 2014

[Department of Physics, Michigan Technological University](#)

Research Advisor: Brian Fick

Senior Research Project: [Preliminary Search for Exotic Events in the Auger Cosmic Ray Observatory Surface Detector Data](#)

- Conducted a preliminary search for exotic particle events in the Pierre Auger Cosmic Ray Observatory surface detector data by identifying possible delayed development features in the cosmic ray's interaction in our atmosphere.

## Research Assistant in Nanofabrication

2011 - 2012

[Department of Physics, Michigan Technological University](#)

Research Advisor: Yoke Khin Yap

- Analyzed growth parameters for Boron Nitride Nanotubes and Vertically Aligned Multi-Walled Carbon Nanotubes in a Chemical Vapor Deposition method.
- Adapted Chemical Vapor Deposition synthesis method to a scanning thermal source for greater growth yield.

## KEY SKILLS

### Remote Sensing:

Electro-Optical and Infrared (EOIR) Multispectral Radar Lidar Synthetic Aperture Radar (SAR)  
Geostationary Operational Environmental Satellite (GOES) Sentinel Landsat Shuttle Radar Topography Mission (SRTM)  
Multilateration (TDOA/FDOA)

### Programming Languages:

Python (Keras, TensorFlow, Numpy, Scipy, Pandas, Pyroot) MATLAB C C++ CERN ROOT

### Development Environments:

Jupyter Notebooks Linux Virtual Machines (VMs) High Performance Computing (HPC)  
Graphical Processing Unit (GPU) Kubeflow

Miscellaneous: Strong analytic and problem solving experience, exceptional verbal and written communication skills, and collaborative finesse.

## AWARDS

Summer Faculty Fellowship Program, Air Force Office of Scientific Research	Summer 2023
Recognized Technical Talent, Lockheed Martin	Selected 2021
Departmental Scholar, Department of Physics, Michigan Technological University	2013
Sigma Pi Sigma, Physics Honor Society	Inducted 2013
Michigan Space Grant Consortium Recipient	2012

## PUBLICATIONS

*Infrared Small Target Detection Enhancement Using a Lightweight Convolutional Neural Network*, M. Gupta, J. Chan, M. Krouss, [G. Furlich](#), P. Martens, M. Chan, M. L. Comer, E. J. Delp, IEEE Geoscience and Remote Sensing Letters, vol. 19, pp. 1-5, 2022

*Sub-Pixel Localization of Objects Using Multiple Spectral Bands*, M. Gupta, S. Baireddy, J. Chan, M. Krouss, [G. Furlich](#), P. Martens, M. Chan, M. L. Comer, E. J. Delp, IEEE Aerospace Conference (AeroConf), pp. 1-15, 2022.

*Observation of the GZK Suppression with the Telescope Array Fluorescence Telescopes and Deployment of the Telescope Array Expansion*, [Greg Furlich](#), Thesis, University of Utah, April 2020

*Constraints on the diffuse photon flux with energies above  $10^{18} \text{ eV}$  using the surface detector of the Telescope Array experiment*, R.U. Abbasi et al. (Telescope Array Collaboration), Astropart. Phys. **110** (2019)

*Testing a Reported Correlation between Arrival Directions of Ultra-high-energy Cosmic Rays and a Flux Pattern from nearby Starburst Galaxies using Telescope Array Data*, R.U. Abbasi et al. (Telescope Array Collaboration), ApJ **867** 2 (2018)

*The Cosmic-Ray Energy Spectrum between 2 PeV and 2 EeV Observed with the TALE detector in monocular mode*, R.U. Abbasi et al. (Telescope Array Collaboration), ApJ **865** 74 (2018)

*Evidence of Intermediate-scale Energy Spectrum Anisotropy of Cosmic Rays  $E \geq 10^{19.2} \text{ eV}$  with the Telescope Array Surface Detector* R.U. Abbasi et al. (Telescope Array Collaboration), ApJ **862** 91 (2018)

*Depth of Ultra High Energy Cosmic Ray Induced Air Shower Maxima Measured by the Telescope Array Black Rock and Long Ridge FADC Fluorescence Detectors and Surface Array in Hybrid Mode*, R.U. Abbasi et al. (Telescope Array Collaboration), ApJ **858** 76 (2018)

*Gamma-ray Showers Observed at Ground Level in Coincidence With Downward Lightning Leaders*, R.U. Abbasi et al. (Telescope Array Collaboration), Journal of Geophysical Research: Atmospheres **123** (2018)

*Increasing the Yield of Boron Nitride Nanotubes in a CVD Method*, [Greg Furlich](#), Michigan Space Grant Consortium, Michigan in Space **14** (2012)

# PROCEEDINGS AND PRESENTATIONS

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*Multispectral Object Detection Algorithms*, Joint Algorithm Workshop, Lockheed Martin, Orlando, Florida, April 2022

*Recent measurement of the Telescope Array energy spectrum and observation of the shoulder feature in the Northern Hemisphere*, D. Ivanov, D. Bergman, [G. Furlich](#), R. Gonzalez, G. Thomson and Y. Tsunesada, Proceedings of Science 395 (ICRC2021), 341, 37th International Cosmic Ray Conference, Berlin, Germany, July 2021

*Telescope Array 10-Year Monocular Spectrum*, Douglas Bergman, [Greg Furlich](#), Proceedings of Science 395 (ICRC2021), 339, 37th International Cosmic Ray Conference, Berlin, Germany, July 2021

*Observation of the GZK Suppression with the Telescope Array Fluorescence Telescopes and Deployment of the Telescope Array Expansion*, Thesis Defense, University of Utah, April 2020

*Telescope Array FD Weather Classification using Machine Learning*, [Greg Furlich](#), Proceedings of Science (ICRC2019) 261, 36th International Cosmic Ray Conference, Madison, WI, July 2019

*Towards a Telescope Array 10 Year FD Monocular Energy Spectrum*, [Greg Furlich](#), Douglas Bergman, Proceedings of Science (ICRC 2019) 260, 36th International Cosmic Ray Conference, Madison, WI, July 2019

*Weather Classification using Machine Learning at the Telescope Array Cosmic Ray Observatory*, APS April Meeting, Denver, CO, April 2019

*Weather Classification using Machine Learning at the Telescope Array Cosmic Ray Observatory* (Poster), Department of Physics and Astronomy Annual Symposium, University of Utah, Salt Lake City, UT, April 2019

*Machine Learning Weather Classification with Fluorescence Detector Pedestal Data at the Telescope Array Cosmic Ray Observatory*, APS Four Corners Meeting, University of Utah, Salt Lake City, UT, Oct. 2018

*Machine Learning Weather Classification with Fluorescence Detector Pedestal Data at the Telescope Array Cosmic Ray Observatory*, Graduate Research Seminar, University of Utah, Salt Lake City, UT, Oct. 2018

*Dark Nights and Desert Air: Understanding the Highest Energy Particles in the Universe*, Great Basin Astronomy Festival, Great Basin National Park, NV, Sept. 2018

*TAx4 Fluorescence Detection* (Poster), Physics and Astronomy Symposium, University of Utah, Salt Lake City, UT, April 2017

*Hosting Your Own Website from Home with a Raspberry Pi*, Graduate Research Seminar, University of Utah, Salt Lake City, UT, Oct. 2017

*Once More Unto the Breach: Advice from a Physics graduate Student*, Physics Seminar, Weber State University, Ogden, UT, Feb. 2017

*Peer Mentoring: Training and Supporting Physics TAs at the University of Utah* (Poster), AAPT Idaho-Utah Section Meeting, Pocatello, ID, April 2016

*Preliminary Search for Exotic Events in the Pierre Auger Cosmic Ray Observatory Data*, Physics Senior Research Oral Presentations, Michigan Technological University, Houghton, MI, April 2014

# SERVICE

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## Research Mentor, Lockheed Martin

Synthetic Image Generation Explainability, United States Military Academy Cadet	2022
Sub-pixel localization and multispectral signal processing, Purdue University PhD Candidate	2021 - 2022
Machine learning cloud segmentation in satellite imagery, United States Military Academy Cadet	2021 - 2022

## Academic Senate, University of Utah

Member, Graduate Assembly Ad Hoc Committee	2019
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## College of Science, University of Utah

Member, College of Science Council	2017 - 2018
Member, College of Science Curriculum Committee	2017 - 2018
Member, College of Science College Student Council	2017 - 2018

## Department of Physics and Astronomy, University of Utah

Chair, Graduate Student Advisory Council	2017 - 2018
Member, Graduate Student Advisory Council	2015 - 2019

## Science Outreach

Volunteer, Physics Open House, Weber State University	2017, 2018, 2019
Volunteer, Science Day, University of Utah	2017, 2019
Volunteer and Speaker, Great Basin Astronomy Festival, Great Basin NP	2018

## Society of Physics Students, Michigan Technological University Chapter

Treasurer	2012 - 2013
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# MEDIA COVERAGE

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*Weather Classification using Machine Learning*, University of Utah, Center for High Performance Computing, Research Highlights

*Keeping the Student Voice: Student Involvement in the Tenure Process*, Katelyn Collett, The Daily Utah Chronicle, May 22, 2019

Pictured in *Telescope Array TAx4 expansion work: Installation of surface particle detector begins in extreme cold* (translated), Makio Nakamura, ICRR News, **104**, Winter and Spring 2019

*PhD candidate sheds light on work of Millard County cosmic-ray observatory that's largest in Northern Hemisphere*, Rhett Wilkinson, Millard County Chronicle Progress, Sept. 19, 2018