



University of Dayton Department of Electro-Optics and Photonics

Fall 2022

Chair's Corner Andrew Sarangan

The last two years were nothing like we've ever seen before. However, even at the height of covid our department never really switched to remote work. All of us were in our laboratories and offices, albeit with caution and social distancing. We also hired two new faculty in the midst of covid – Miranda van Iersel and Swapnajit Chakravarty. With covid hopefully behind us, we can now look forward to an era where the best of in-person and on-line activities can seamlessly co-exist.



This Fall we welcome two new faculty into the EOP family. Rita Peterson is joining us (from AFRL) as a Visiting Assistant Professor in the Physics department, with a joint appointment in EOP. Jason Deibel joined UD (from Wright State) as the chair of the Physics department with a joint appointment in EOP. Both have a long history of relationship with EOP, so in that sense, they are not really new.

2022 was a spectacular year for EOP in many aspects, and the year is not even done yet! Swapnajit Chakravarty received an NSF grant for his research on silicon photonic integrated circuits. Paul McManamon received the SPIE book award for his book on Lidar technology. He also received a DURIP grant for a tunable mid-infrared laser. Partha Banerjee received a DHS contract for 3D finger printing technology, which received national media coverage. Five EOP students won travel grants to present their work at major international conferences. EOP also received two OFRN contracts worth over \$600K. Lyteloop Technologies donated \$1M in fiber optic equipment to EOP. Chenglong Zhao, joint faculty from Physics, received an NIH grant for \$1.5M. We received several industry grants (Intel, Lamm, Quantum Screening). We were able to raise our TA stipends through a cost-sharing agreement between EOP and Physics. We also formalized the relationship between EOP and Physics through a MoU. Last but not least, we had a very successful and well-attended EOP research showcase in May 2022. Yes, the list is long! You can find details of these stories inside this newsletter.

Research excellence makes EOP very unique within UD. My job as chair is to support our faculty and students who bring national and international notoriety through publications, citations, contracts and grants. In that sense, my job has been easy so far, thanks to our excellent faculty, and especially to Partha Banerjee who paved the road before me.

I look forward to another exciting and productive year!

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Multiple reflections inside a prism create an image resembling a face., reproduced from OPN.

Photo by Amal Mirando



Swapnajit Chakravarty receives NSF grant

Swapnajit started as an Associate Professor in EOP in Aug 2021, and hit the road running immediately with several proposal submissions. In less than a year, he received his first major award at UD from the National Science Foundation (NSF). Swapnajit will serve as the lead PI on this collaborative project with University of North Texas (UNT) to develop a handheld portable biosensor. He will utilize a 300 mm CMOS foundry, namely AIM Photonics to develop a low-cost platform

for testing silicon photonic biosensor chips. The platform is expected to find numerous applications in biomolecular diagnostics for detection of cancers and infectious diseases and drug discovery in healthcare and also in environmental pollution monitoring.

Total value of this grant is approx. \$500K, with \$340K coming to UD and \$160K to UNT.

EOP faculty are internationally recognized experts in their respective fields

Lytelooop donates \$1M in fiberoptic equipment

This summer, EOP received fiber optic equipment worth nearly \$1M in value. Lytelooop is a company based in New York which was ceasing operations. They chose UD and USC (University of Southern California) to donate their almost-new equipment assets. Thanks goes to Paul McManamon who was the key enabler for this, and to Cullen Bradley for coordinating the logistics and driving all the equipment from New York to Dayton.

SPIE Book Award



The 2022 SPIE Joseph W. Goodman Book Writing Award was given to Paul McManamon, Director of Lidar and Optical Communications Institute (LOCI).

This award, given once every two years, is for prominent book authorship in photonics. Paul's 2019 book on Lidar technology was based on many decades of his sustained contribution to this area. When Paul started a Lidar course at UD he decided there was no acceptable book. He then wrote a Field Guide, published in 2015, and then this tutorial book published in 2019. His short course taught each summer with Dr Ed Watson is very popular, drawing attendees

in person and online from all around the globe every year.

3D Fingerprinting Technology



Partha Banerjee received a contract from the U.S. Department of Homeland Security Criminal Investigations and Network Analysis Center to create a better fingerprinting technology. "The science of fingerprints has been virtually unchanged since its debut more than a century ago", according to Partha. He plans to capture holograms of 3D fingerprints, which would open a new dimension in criminology and security. The team expects that

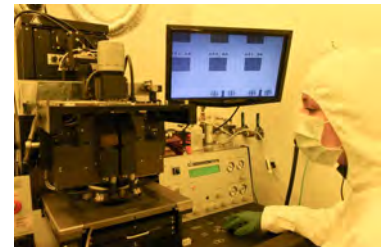
3D will become the new protocol for fingerprint analysis. Partha will work with Penn State professor Akhlesh Lakhtakia (also EOP Advisory Board member) on this project.

Chenglong Zhao receives \$1.5M NIH grant

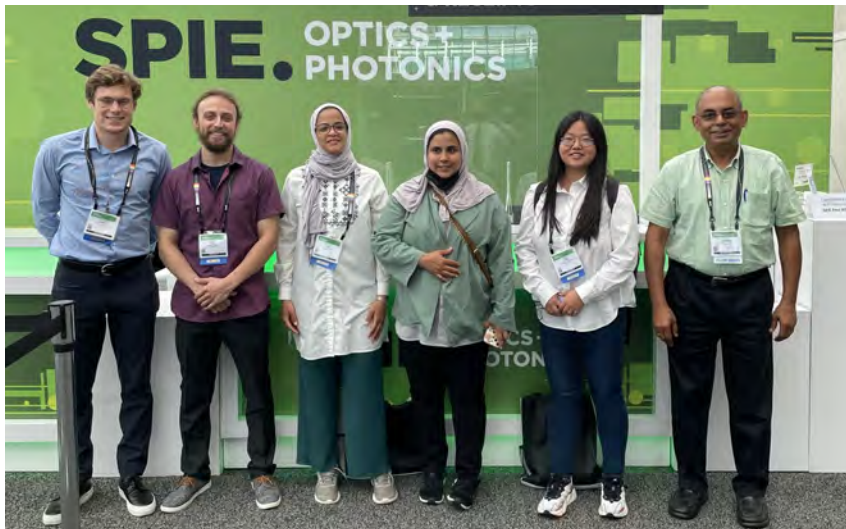
The National Institutes of Health (NIH) awarded Chenglong Zhao a four-year, \$1.5 million grant to develop a new super-resolution optical imaging system. Chenglong is the lead PI on this collaborative project with Duke University. By using acoustics and polymer microspheres, his proposed technique aims to achieve a resolution that is four times higher than a confocal laser scanning microscope, which has a limit of 200 nanometers. Chenglong is an Associate Professor in the Physics department with a joint appointment in EOP. He has mentored several EOP students to successful careers in optics and photonics.

The CHIPS Act

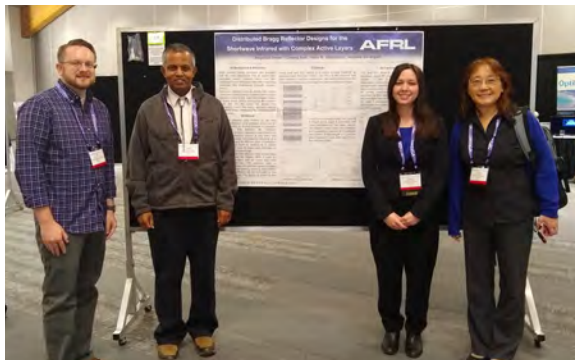
The federal CHIPS Act was recently passed, and Intel has broken ground in Columbus for their new semiconductor fab. UD recently received a grant from Intel, along with UC, Miami and Wright State, to develop and modernize our semiconductor manufacturing curriculum and infrastructure. There are many more federal solicitations in the pipeline. EOP is playing a central role in these efforts because our Nanofabrication Laboratory is the only comprehensive semiconductor device cleanroom at UD. Established in 2005 by Andrew Sarangan, this cleanroom has enabled a large number of sponsored research, theses and dissertations over the past 15 years.



EOP semiconductor cleanroom in the Science Center



Alex Skender, Austin Scott, Saleha Qissi, Nouf Alanazi and Guo Chen, with Partha Banerjee at SPIE Optics and Photonics conference in San Diego, CA. August 2022.



Angelica Drees, Lirong Sun (EOP Alum), Andrew Sarangan, Peter Stevenson (AFRL) at the Optical Interference Coating (OIC) Conference in Whistler, BC, Canada. June 2022.

Participants in the Weiglhofer Symposium on Electromagnetic Theory in front of James Clerk Maxwell statue in Edinburgh, Scotland, UK. Attendees included Partha Banerjee and Akhlesh Lakhtakia (Penn State faculty & EOP Advisory Board member). July 2022.



UD faculty at the TFE3S workshop (Thin Films for Electronics, Electro-Optics, Energy and Sensors) co-organized by Partha Banerjee and Guru Subramanyam at Northeastern University in Boston, MA. August 2022.

International Conferences

All EOP students are highly encouraged to present at major SPIE, Optica and IEEE conferences. In 2022, five students received travel awards worth over \$5000 in total. Hearty congratulations to the following students:

- Nouf Alanazi - SPIE Optics and Photonics Conference (San Diego): \$1110
- Angelica Drees - OPTICA Optical Interference Coatings (Whistler): \$570.
- Saleha Qissi - SPIE Optics and Photonics Conference (San Diego): \$1110.
- Austin Scott - SPIE Optics and Photonics Conference (San Diego): \$1110.
- Alex Skender - SPIE Optics and Photonics Conference (San Diego): \$1110.

Following are some key conferences that EOP participates in:

- Optica FiO (October)
- IEEE IPC (November)
- SPIE Photonics West (January)
- SPIE Advanced Lithography (February)
- SPIE DCS (April)
- Optica/IEEE CLEO (May)
- Optica OIC (June)
- SPIE Optics and Photonics (August)
- Optica Digital Holography (July)

Mikhail Vorontsov's new company

Mikhail Vorontsov recently created a new company, Optonica LLC. A serial entrepreneur, this is not the first time Mikhail has successfully commercialized his inventions. His prior venture, Optonicus, was a very successful business and was eventually acquired by II-VI Corp (now Coherent Corp). Mikhail is a prolific researcher and is recognized as one of the leading experts in adaptive optics, atmospheric characterization, beam control, nonlinear spatio-temporal dynamics and image processing. He is the director of EOP's Intelligent Optics Lab (IOL).

EOP Graduate Student Research Showcase



EOP graduate students presented their research during this showcase event held on May 1 2022. This is the first time we've held this event. The attendance was fantastic, and we want to thank everyone who came, in particular Bob Wilkins, Brad Duncan and John Leland who took time from their busy schedule to visit us in Fitz Hall. Four winners were selected, and were treated to a luncheon and a small gift. **The winners were Shiqi Luo, Ethan Vantilberg, Roseanna Lawandi and Maureen Szymanski.** Congratulations, and thank you for your enthusiastic participation. Thanks also to Partha Banerjee for organizing this event.

Important Dates

Oct 15: Last date to apply for graduation
Nov 21: Last date for thesis/dissertation format review
Dec 2: Last date for defense
Dec 12: Final submission
Dec 17: Degrees conferred

Alum Profile: Haowen Zhou

Haowen graduated with an MS in EOP in 2021. He originally came to our department from HUST (China) in 2018 as an undergraduate research assistant and continued on as an MS student under Partha Banerjee. He was also a recipient of the Dean's fellowship in EOP.

Upon graduation from UD, he applied to and was admitted to the Caltech Electrical Engineering program for his PhD. His current research is under Dr. Changhui Yang in the area of computational microscopy and Fourier Ptychography. His interest is at the intersection of computer vision, artificial intelligence (AI), and optical microscopy, with applications in pathology. He recently received the Gupta S2I fellowship for his graduate studies at Caltech.

"EOP gave me a solid foundation in optics with a comprehensive course system, which is even better than Caltech", Haowen said.



"During my study at UD, Dr. Banerjee provided lots of support for my research and life in general", he recalled. He fondly remembers the close-knit group in EOP and how everyone was close to each other. "The facilities at UD were great, especially the Recplex with its indoor pool", he said. For his future career plan, he is open to a job either in academia or industry. "It is still very early for me to make the decision, I want to keep my options open in both areas," he said.

Student Profile: Ian Dilyard

Ian Dilyard joined EOP as a PhD student in the Fall of 2021 after earning his MS in Physics at Miami University. He worked in the area of cold atom trapping under Prof. Samir Bali at Miami. At UD, he is working on nonlinear optical materials. His research adviser is Rita Peterson. Nonlinear optical materials are used in optical frequency conversion, which is a critical technology that enables tunable laser sources, and for achieving emission at wavelengths outside of the commonly available laser lines. His research is funded by AFRL, and he spends several days a week at AFRL on this project.

Anyone who knows Ian will recognize that he has a noticeable stutter in his speech. "I've had this since I was two years old," he said. "But I never let that deter me. Saying what I want to say takes a bit longer. That's all. I don't view it as something negative. It's just part of me. If my stutter suddenly disappeared someday, then I wouldn't be me. I would be someone else".

Ian is an avid bowler and video gamer. He also likes to collect and build Lego sets.



TA stipends have been increased

Starting Fall 2022, the TA stipends have been increased to \$18k for the 9-month academic year. For more than 20 years, TA stipends have been stagnant at below-average levels. Our TA's teach undergraduate classes in the physics department, and conduct their academic work in EOP. The Physics department has been paying the stipend and tuition all these years. Under the new agreement, both departments will share this cost. The stipend will be paid by Physics, and the tuition (up to 19 credit hours per year) will be paid by EOP. This could not have happened without the support of our previous interim Dean Margie Pinnell and the previous interim chair of Physics Todd Smith. Thank you both for your support!

Publications

This is a partial list of journal publications during the last 12 months (excludes conference proceedings). For a complete list, please visit each faculty's Google Scholar site.

- Cong Deng, Chaminda Ranathunga, Partha P Banerjee, Xuelian Chen, Jiang F Zhong, Uttam K Sinha, "Practical tapered optical fiber system for in-situ label-free sensing of various antigens", *Optical Engineering*, 61(7), 074102 (2022).
- Haiyun Guo, Haowen Zhou, Partha P Banerjee, "Use of structured light in 3D reconstruction of transparent objects", *Applied Optics* Vol. 61, Issue 5, pp. B314-B324 (2022).
- Haowen Zhou, Haiyun Guo, Partha P Banerjee, "Non-recursive transport of intensity phase retrieval with the transport of phase", *Applied Optics* Vol. 61, Issue 5, pp. B190-B199 (2022).
- Haowen Zhou, Mallik MR Hussain, Partha P Banerjee, "A review of the dual-wavelength technique for phase imaging and 3D topography", *Light: Advanced Manufacturing* 3, Article number: 17 (2022).
- Shuo Sun, Roseanna Lawandi, Andrew Sarangan, Partha P Banerjee, "Dark electron tunneling current in metal-insulator-metal structures: modeling, fabrication, and measurement", *Optical Engineering*, 61(2), 027101 (2022).
- Valery V Kolosov, Victor A Kulikov, Ernst Polnau, "Dependence of the probability density function of laser radiation power on the scintillation index and the size of a receiver aperture", *Optics Express* Vol. 30, Issue 2, pp. 3016-3034 (2022).
- Z Li, Y Zhao, JD Gallagher, D Lombardo, A Sarangan, Imad Agha, J Kouvetakis, J Menéndez, J Mathews, "Room temperature emission spectroscopy of GeSn waveguides under optical pumping", *AIP Advances* 12, 075016 (2022).
- Chiao Chang, Hung-Hsiang Cheng, Gary A Sevison, Joshua R Hendrickson, Zairui Li, Imad Agha, Jay Mathews, Richard A Soref, Greg Sun, "Power-Dependent Investigation of Photo-Response from GeSn-Based p-i-n Photodetector Operating at High Power Density", *Materials*, 15(3), 989, (2022).
- Ernst Polnau, Mikhail A Vorontsov, "Atmospheric turbulence characterization using a neuromorphic camera-based imaging sensor", *Journal of Optics*, Volume 23, Number 12, (2021).
- Dylan Morden, Evan M Smith, Ivan Avrutsky, Joshua R Hendrickson, Imad Agha, Shivashankar Vangala, "Tunable angle-independent mid-infrared optical filters using GST-based micro resonator arrays", *Optical Materials Express* Vol. 12, Issue 3, pp. 1043-1054 (2022).
- José César Guerra Vázquez, Emmanuel Narváez Castañeda, Roberto Ramírez Alarcón, Imad Agha, Qiwen Zhan, William N Plick, "Generation of four-dimensional hyperentangled NOON states and beyond with photonic orbital angular momentum and detection-basis control", *Phys. Rev. A* 105, 032445, (2022).
- Gary A Sevison, Trent Malone, Remona Heenkenda, Joshua A Burrow, Andrew Sarangan, Joshua R Hendrickson, Imad Agha, "Independent measurement of phase and amplitude modulation in phase change material-based devices", *Optical Materials Express* Vol. 12, Issue 7, pp. 2899-2911, (2022).
- Roseanna Lawandi, Remona Heenkenda, Andrew Sarangan, "Switchable distributed Bragg reflector using GST phase change material", *Optics Letters* Vol. 47, Issue 8, pp. 1937-1940, (2022).
- Adam C Stahler, Piyush J Shah, Andrew M. Sarangan, and Ioana E Pavel, "Establishing the SERS-based sensing capabilities of silver nanorod thin films fabricated through oblique angle deposition at different temperatures", *Asian Journal of Physics* Vol. 31, No 2, 341-353, (2022).
- Remona Heenkenda, Keigo Hirakawa, Andrew Sarangan, "Tunable optical filter using phase change materials for smart IR night vision applications", *Optics Express* Vol. 29, Issue 21, pp. 33795-33803, (2021).

Contracts and Grants

This is a list of EOP-lead grants that were active during calendar year 2022.

- Partha Banerjee, Azimuth Corp, "Photorefractive Materials and Thin Films Research", \$130,000, 12/04/19—07/31/22
- Partha Banerjee, Defense Engineering Corp "Algorithm and Simulation Expertise for Laser Radar", \$90,000, 08/01/21—09/30/23
- Partha Banerjee, Quantum Screening, "Development of Portable Compact Fiber Sensor Monitor For Detection and Quantification of Biomolecules in Body Fluids", \$105,835, 09/21/21—06/21/22
- Partha Banerjee, UES Inc, "Studies in Non-linear Optical Materials", \$33,514, 12/03/21—10/31/22
- Partha Banerjee, GMU, "Digital Holographic Acquisition, Storage, Retrieval and Analysis of Three-Dimensional Fingermarks Developed with the Nanoscale Columnar-Thin-Film", \$150,000, 04/01/22—06/30/23
- Swapnajit Chakravarty, NSF, "Collaborative Research: PIC: Slow Wave Enhanced Electrooptically Tuned Michelson Interferometer Biosensor for On-Chip Dual Polarization Interferometry", \$338,076, 09/01/22—08/31/2025
- Mikhail Vorontsov, NMSU, "Characterization of atmospheric turbulence in the lower atmosphere", \$899,928, 09/01/17—01/31/23
- Mikhail Vorontsov, ONR, "Metallic Laser Additive Manufacturing Using 20 Arrays of Scanning Laser Power Sources for Advanced Structural Material Processing", \$449,999, 03/01/19—08/28/22
- Mikhail Vorontsov, MDA, "Deep Learning-Enhanced Control of High-Power Laser Phased Arrays with Giant Numbers of Fiber Tiles", \$365,967, 07/01/20—07/01/22
- Thomas Weyrauch, ONR, "Scanning Temperature Measurement System (SteMS) for Real-time Process Monitoring During Laser Additive Manufacturing of Metallic Structural Materials", \$300,000, 03/01/19—02/28/23
- Thomas Weyrauch, II-VI, "Support of High Energy Laser Network (HEL-NET) Development", \$150,000, 01/07/22—01/06/23
- Ernst Polnau, II-VI, "Support of Modeling of Atmospheric Conditions and Optical Wave Propagation through the Atmosphere", \$301,124, 06/22/21—09/22/22
- Ernst Polnau, Optonica, "AI-Enhanced Atmospheric Turbulence in-situ Sensing and Forecasting", \$20,000, 11/03/21—02/03/22
- Andrew Sarangan, Blue Halo, "Fast Optical Limiters with Enhanced Dynamic Range", \$376,910, 11/21/18—08/21/22
- Andrew Sarangan, Azimuth Corp, "Novel Optical Thin Films", \$65,000, 06/16/21—07/31/22
- Andrew Sarangan, Strategic Ohio Council, "Growth and Evaluation of Laser and Nonlinear Optical Materials", \$100,482, 08/15/21—10/31/23
- Andrew Sarangan, UES Inc, "Vanadium Oxide Growth & Characterization", \$15,800, 08/24/21—03/24/23
- Andrew Sarangan, OSU, "ALTITUDE: Affordable Lidar Technologies for Integration and Unmanned Deployment", \$240,487, 12/14/21—04/30/23
- Paul McManamon, AFOSR, "A Tunable Mid Wave IR and Long Wave IR Laser for Research in MWIR and LWIR Materials, and Applications", \$403,741, 09/30/21—09/29/22
- Paul McManamon, OSU, "Development of High Data Rate Modulator Technology", \$322,550, 10/29/21—04/29/23

About the EOP Department

The Electro-Optics and Photonics (EOP) department is one of only a handful of academic programs in the U.S that offers M.S and PhD degrees in photonics. All of our faculty are internationally recognized experts in their respective fields, with a significant publication, citations and funding record. Our students publish in leading academic journals, and present at major international conferences. Our research areas directly align with those of commercial industries and government labs, enabling students to obtain real-world and highly marketable experience.

Recent Graduates

- **Elforjani Jera**, "Focusing Properties of Vectorial Optical Fields and its Applications", **PhD**, May 2022
- **Shuo Sun**, "Photon-Assisted Tunneling In Metal-Insulator-Metal Rectenna", **PhD**, May 2022
- **Hammid Al-Ghezi**, "Optical Propagation in Anisotropic Metamaterials: Application to Analysis and Design of Metallo-Dielectric Filters", **PhD**, December 2021
- **Joshua Burrow**, "3D Nanopatterning of Phase Change Material $\text{Ge}_2\text{Sb}_2\text{Te}_5$ Towards Novel and Improved Reconfigurable Photonic Devices", **PhD**, December 2021
- **Ankita Khanolkar**, "Effect of Spectral Filtering on Pulse Dynamic of Ultrafast Fiber Oscillators at Normal Dispersion", **PhD**, December 2021
- **Zairui Li**, "Experimental Investigation of $\text{Ge}_{1-x}\text{Sn}_x$ Waveguide Amplified Spontaneous Emission and Theoretical Modeling Development", **PhD**, December 2021
- **Andrew Reinhardt**, "Evaluating and Correction 3D Flash LiDAR Imagers", **PhD**, December 2021
- **Joseph Riley**, "Noise Function Turbulence Optical Phase Screens and Physics Based Rendering", **PhD**, December 2021
- **Yimin Zang**, "Spatiotemporal Manipulation of Optical Vortices", **PhD**, December 2021
- **Shiqi Luo**, "A Maskless Lithography System Based On Digital Micromirror Device (DMD) And Metalens Array", **MS**, August 2022
- **Guo Chen**, "Analysis of Propagation Across Multilayered Metamaterials for Subwavelength Focusing and Bandpass Filtering Applications", **MS**, August 2022
- **Alexander Skender**, "Characterization of Single Photon Avalanche Diodes Using a Black Body Source", **MS**, August 2022
- **Gongxu Bai**, "Numerical Modeling of Photoresist Profiles in Laser Interference Lithography", **MS**, December 2021
- **Haiyun Guo**, "Applications of Structured Light to 3D Surface Topography Using Moire Pattern and to 3D Imaging of Phase Objects", **MS**, December 2021
- **Maggie Lankford**, "Measurement of Thermo-Mechanical Properties of Co-Sputtered $\text{SiO}_2\text{-Ta}_2\text{O}_5$ Thin Films", **MS**, December 2021
- **Jiaqi Li**, "Study of Nano-Transfer Technology for Additive Nanomanufacturing and Surface Enhanced Raman Scattering", **MS**, December 2021
- **Dylan Morden**, "Nanopatterned Phase Change Material for Mid-Infrared Tunable Optical Filters using Germanium Antimony Telluride", **MS**, December 2021
- **Fanli Wei**, "Temporal Manipulation of Spatiotemporal Optical Vortex via Temporal Airy Profile", **MS**, December 2021



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Department of
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Photonics

EOP Department

University of Dayton
300 College Park Ave
Dayton, OH 45469

Phone: 937-229-3190
E-mail: sarangan@udayton.edu



Cullen Bradley at the Lidar and Optical Communications Institute (LOCI) laser range hall