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Summary

Hybrid physicist–engineer with a Ph.D. in AMO physics (Columbia, 2022) and 4+ years building and shipping commercial automation hardware as Co-Founder & CTO of Rooted Robotics, which is being acquired by an industry competitor (close Q4 2026). Hands-on experience spans **molecular laser physics** (built complete ECDL, tapered-amplifier, and Raman-fiber-amplifier laser systems with sub-MHz frequency stabilization; designed UHV chambers and 4K cryogenic apparatus), **high-energy nuclear physics** (sPHENIX detector R&D at Brookhaven and Fermilab; C++ analysis code used in 20+ publications including a 2019 *Nature Physics* paper), and **commercial hardware product development** (sole designer of four shipped CEA automation products: mechanical, electrical, PCB, firmware, CV/ML pipelines; \$0 to \$700K revenue; 3 patents pending; CE certified). 22 publications, 1315 citations. U.S. Citizen.

Education

- 2017–2022 **Doctor of Philosophy, AMO Physics**, *Columbia University*, New York, NY.
Thesis: *Transverse Laser Cooling of Calcium Monohydride Molecules*
Advisor: Prof. Tanya Zelevinsky, Zelevinsky Lab
- 2013–2017 **Bachelor of Arts and Science, Magna Cum Laude**, *University of Colorado Boulder*, Boulder, CO.
Major: Physics

Professional Experience

Jan 2022–Present **Co-Founder & CTO**, *Rooted Robotics (formerly Urban Farms Inc.)*, Boulder/Denver, CO. Co-founded and led the company from formation through acquisition by an industry competitor (close Q4 2026; acquirer confidential). Raised \$1.2M through USDA SBIR grants and private investors. Led engineering team of 5 to design, manufacture, and ship four commercial CEA automation products from concept to market, growing revenue from \$0 to \$700K/year. Products achieved CE certification (EU market clearance); 3 patents pending.

- **Mechanical & Electrical Design:** Sole designer of all mechanical and electrical systems across four products — tabletop seeder, germination robot, vision-guided 6-axis harvesting arm, and tray washer. Full DFM, BOM management, tolerance analysis, PCB design, wiring harness design, sheet metal design, and enclosure fabrication.
- **Firmware & Motion Control:** Wrote all machine firmware and motion control software in Python and C++. Implemented closed-loop position and velocity control for DC, servo, and stepper motors, conveyors, linear actuators, and vision-guided pick-and-place.
- **Computer Vision & ML:** Deployed production CV/ML pipelines using Intel RealSense and OAK-D Pro W PoE depth cameras, YOLO V5, AWS Rekognition, Azure Vision, and LAVIS BLIP with custom-labeled on-site datasets for crop quality control, yield prediction, and automated harvesting.
- **Manufacturing & QC:** Designed and built the company's full manufacturing process, inventory system, QC testing protocols, and warehouse operations from scratch.

Research Experience

2018–2022 **Lead Graduate Researcher — Molecular Laser Physics**, *Zelevinsky Lab, Columbia University Physics Dept.*, New York, NY.

Directed the molecular laser-cooling experiment, progressing from junior student on the BaH cooling effort to senior student leading the CaH cooling experiment. Responsible for the complete laser system from design through daily operation.

- **Laser sources:** Built ECDLs in Littrow and Littman-Metcalf configurations, tapered amplifiers, injection locking amplifiers, and Raman fiber amplifiers from scratch.
- **RF / electro-optics:** Built full RF modulation chain (EOMs, AOMs, RF amplifiers, VCOs, DDS); operated scanning Fabry-Perot cavities for diagnostics.
- **Stabilization:** Implemented Doppler-free saturation spectroscopy and Fizeau interferometer locking; achieved sub-MHz laser frequency stabilization.
- **Vacuum:** Designed and fabricated custom UHV vacuum components and MOT chambers; designed in-vacuum optics and optomechanics.
- **Cryogenics:** Designed a 4K cryogenic buffer-gas cell, fabricated a charcoal absorber, and maintained the helium pulse tube refrigerator. Modeled cryostat thermal performance in COMSOL.
- **Detection:** Operated EMCCD single-photon cameras, silicon photomultipliers, and analogue PMTs for quantum state detection.
- **Software:** Wrote LabVIEW, Python, and C++ experiment control and data acquisition software.

Summer 2017 **Graduate Researcher — Laser Stabilization**, *Will Group, Columbia University*, New York, NY.

Built PID lock boxes for laser frequency stabilization. Constructed a Doppler-free absorption spectroscopy frequency reference for cesium. Calculated confinement potentials for a 2D MOT to improve atomic loading efficiency.

2015–2017 **Undergraduate Researcher — High-Energy Nuclear Physics**, *Nagle Group, University of Colorado Boulder*, Boulder, CO.

Designed and built an automated QC test stand for the sPHENIX hadronic calorimeter at Brookhaven National Lab, measuring gain uniformity across scintillator panels. Developed a C++ pile-up detection algorithm incorporated into the PHENIX collaboration software library and used in 20+ published nuclear physics analyses, including *Nature Physics* 2019 quark-gluon plasma droplet measurements.

April 2016 **Visiting Researcher — High-Energy Physics**, *Fermi National Accelerator Laboratory*, Batavia, IL.

Assembled and tested sPHENIX hadronic calorimeter prototype components; operated the collider DAQ system.

■ Leadership & Management

2022–Present **Co-Founder & CTO — Engineering, Operations, External Affairs, *Rooted Robotics*, Boulder/Denver, CO.**

Co-founded and led the company from formation through acquisition by an industry competitor (close Q4 2026; acquirer confidential). Owned the technical side of the company: solved any and all technical problems, led the engineering organization, and represented the technical side of the company to customers, investors, and strategic partners.

- **People management:** Sole hiring authority and direct manager for all engineering, manufacturing, and customer support staff. Built a CU Boulder intern-to-hire pipeline (juniors and seniors) as the primary vetting funnel for full-time hires. Weekly 1:1s with each direct report covering project status, timelines, and blockers.
- **Performance & difficult exits:** Managed underperformance with a structured toolkit — increased meeting cadence, detailed production schedules, and resource reallocation. Direct experience exiting team members at every level: interns, entry-level engineers, board members, and off-payroll strategic partners.
- **Executive leadership:** Weekly executive team meetings; co-owned strategic decisions on product roadmap, pricing (raised prices to hit margin targets; redesigned a \$10K SKU into a \$3K ultra-budget product line in response to customer demand), and warranty governance (denied service for documented machine abuse).
- **Sales & marketing enablement:** Coordinated custom-project quotes for the sales team; led production of sales collateral (CAD renders, machine-maintenance footage, instructional videos) and marketing content for YouTube, LinkedIn, and Instagram.
- **Customer partnerships:** Led the technical side of major industry partnerships with Kalera, 80 Acres, Sensei, Hippo, Coldwater Fresh, and Aerofarms — custom design specs, quotes, timelines, maintenance contracts, and on-site training. Co-managed accounts with CEO (who led payment terms and IP negotiations).
- **Strategic partnerships:** Sole owner of the Siemens Small Business Accelerator partnership (free components, training, and software development on key projects in exchange for branding and customer referrals to Siemens for facility controls and digital-twin work). Built the CU Boulder Engineering School credit-for-internship program that unlocked the intern pipeline.
- **International business development:** Attended European industry conferences; closed distributor partnerships in France and Spain. Conducted Spanish-language negotiations and an on-site visit to formalize the Spanish distributor relationship.
- **Fundraising (grants):** Wrote successful grant applications including the Colorado Office of Economic Development grant (founding capital), the State of Queensland (Australia) Department of Primary Industries grant (autonomous UVC rover for powdery mildew on hydroponic strawberries), and USDA SBIRs.
- **Legal & IP:** Led discussions with legal counsel on IP ownership for custom builds, NDAs with clients sharing proprietary designs and SOPs, hiring terms (equity, salary, hourly), customer disputes, and patent filings (3 pending).
- **Distributor strategy & compliance:** Defined maintenance plans, training programs, and market-specific requirements with distributors — localized operator manuals and HMI menus, specified safety features (interlocks, E-stop placement, warning labels) for target markets.
- **Teaching & outreach:** Two guest lectures at the CU Boulder School of Engineering (hardware-startup-in-Colorado; design process for the ag industry). Faculty sponsor for a 10-engineer mechanical/electrical senior design capstone (precision pelleted-seed seeder for commercial nurseries).

2017–2022 **Senior Graduate Student — Technical Lead & Mentor**, *Columbia University, Zelevinsky Lab*, New York, NY.

- **Technical leadership under crisis:** Solo-rebuilt the entire molecular cooling laser system (1064 nm IR → 635 nm visible red — all lasers, AOMs, EOMs, beam and imaging optics, and the cryogenic ablation cell) for the BaH→CaH species transition after losing both the previous senior graduate student (graduated) and the lab postdoc (left academia for industry), during the COVID-19 pandemic in NYC.
- **Mentoring:** Trained two junior graduate students from scratch on the full experimental stack: ECDLs, Raman and tapered amplifiers, EOMs/AOMs, fiber coupling, hardware PID lock boxes, NdYAG ablation laser operation, pulse tube refrigerator, EMCCD single-photon imaging, and data analysis (molecular temperature, scattering rate, transition line-widths/frequencies, vibrational branching ratios).
- **External collaboration:** Coordinated directly with theory collaborators on the CaH molecular structure model — reconciling theoretical vs. experimental transition frequencies, state lifetimes, and vibrational branching ratios (the dominant loss channel in the experiment).
- **Teaching (3-year formal TA appointment):** Two years for Physics 1 and Physics 2 (recitations, lab sections, exam review sessions, grading); one year for graduate-level AMO Physics (weekly recitation and grading).
- **Department & community:** Representative of the Hispanic Students in Physics interest group; led department outreach efforts and taught math two hours per week for two years in Spanish in a Harlem ESL course. Presented results at APS conferences and Physics Department journal club; first-author thesis paper.

Technical Skills

Laser Sources: ECDLs (Littrow & Littman-Metcalf, custom aluminum cavities), Tapered Amplifiers, Injection Locking Amplifiers, Raman Fiber Amplifiers, Fiber Coupling, Single-Mode Fiber Networks.

Laser Stabilization: Doppler-Free Saturation Spectroscopy, Fizeau Interferometer Locking, PDH Locking; sub-MHz linewidth control.

Electro-Optics: AOMs, AODs, EOMs, Scanning Fabry-Perot Cavities, DDS RF Signal Generators.

RF Electronics: Spectrum Analysers, RF Amplifiers, VCOs, PID Lock Boxes, AOM/EOM Drivers, Custom RF Chains.

Photon Detection & Imaging: EMCCD Single-Photon Cameras, Silicon Photomultipliers, Analogue PMTs, Imaging System Design, In-Vacuum Optics Design & Fabrication, Optomechanical Design.

Vacuum: Custom UHV Chamber Design & Fabrication, MOT Chambers, In-Vacuum Optics, Optomechanical Design.

Cryogenics: Custom 4K Cryogenic Cell Design (waterjet-cut copper buffer-gas chamber), Helium Pulse Tube Refrigerator Maintenance, Charcoal Absorber Fabrication, Cryogenic Vacuum Systems.

Nuclear / Detector Hardware: Hadronic Calorimeter Assembly & Test, Collider DAQ Operation, Detector QC Automation, Pile-Up Analysis Algorithms.

Robotic Arms & Manipulation: ROS/ROS2, MoveIt, Python-controlled 6-Axis Arms, Custom End Effectors, Pick-and-Place.

Robotic Sensing: Intel RealSense Depth Cameras, OAK-D Pro W PoE, IMUs, Control Moment Gyroscopes, Photoeye Sensors.

Actuation & Motion Control: DC, Servo & Stepper Motors, Linear Actuators, Pneumatics, Conveyors, Closed-Loop Position/Velocity Control, ClearCore Motion Controllers, Siemens Motor Drives.

Mechanical CAD: SolidWorks, Onshape (drove company-wide migration for remote collaboration, native version control, and automated BOM); FEA structural analysis (bandsaw frame tensioning, racking-system load modeling); sheet-metal design, DFM, tolerance analysis, BOM management, enclosures, optomechanical design.

Electrical / PCB: KiCad (motor-control boards, power distribution, M12 & Molex connectorization), Wiring Harnesses, Motor Drives, Custom Electronics Enclosures.

Embedded & Firmware: ESP32 (HMI applications), Arduino IDE (motor-controller programming shell), Raspberry Pi running Ubuntu 24.04 (HMI-controller bridge, data logging, web-app connectivity, Tailscale remote SSH fleet access), ClearCore motion controllers, Siemens PLCs. Firmware in Python and C++.

Industrial Communications: CAN, Modbus, EtherCAT, Profinet, Ethernet/IP, TCP/IP, Serial (HMI ↔ motion controllers).

Machining & Prototyping: Manual Mill & Lathe, FDM & SLA Resin & Metal 3D Printing, Laser Cutter, Waterjet, Sheet-Metal Press Brake. Personally built every Rooted Robotics prototype and shipped unit.

Regulatory & Compliance: CE Marking to Machinery Directive 2006/42/EC (4 products certified); safety features (interlocks, E-stop placement, warning labels); operator manual & HMI localization for international markets.

Fluid & Process Systems: Cryogenic (helium pulse-tube refrigerator, charcoal absorber, cryogenic vacuum); hydroponic (fertilizer-salt dosing, main vertigation plumbing, organic & particulate filtration); water sanitation (ozone, UV, peracetic acid, nano-bubblers) for pathogen and algae mitigation.

ML Frameworks: PyTorch, YOLO V5, LAVIS BLIP.

CV Hardware: Intel RealSense, OAK-D Pro W PoE Depth Cameras.

Datasets: Custom-labeled on-site datasets, data collection pipelines.

Software: Python, C++, MATLAB, LabVIEW, SQL, $\text{\LaTeX}$; Git & GitHub (public repo: `newrootedgit/rooted-machines-code`); custom experiment control software.

Cloud & DevOps: Docker (dev VMs & deployment); AWS EC2, S3, Lambda (CV compute, training-data storage, remote machine logs); AWS Rekognition; Azure Vision.

Application Development: Django (customer-facing web apps), Vercel (hosting/deployment), Tailscale (remote SSH fleet management), Apache/PHP legacy stacks.

Simulation: COMSOL (multiphysics & thermal), Zemax / OpticStudio, LightTools, Mathematica.

Technical Writing: Grant proposals (Colorado OED, Queensland DPI, USDA SBIR), peer-reviewed physics publications, customer project proposals & engineering specifications.

Publications

Summary 22 publications, 1315 citations. Full list: [Google Scholar](#)

- First-author S. Vázquez-Carson et al., *Direct laser cooling of calcium monohydride molecules*, New Journal of Physics, 2022. arXiv:2203.04841
- Co-author R. McNally, I. Kozyrev, S. Vázquez-Carson et al., *Optical cycling, radiative deflection and laser cooling of barium monohydride (BaH)*, New Journal of Physics, Vol. 22, 2020. arXiv:2004.09570
- Co-author C. Aidala et al., *Creating Small Circular, Elliptical, and Triangular Droplets of Quark-Gluon Plasma*, Nature Physics, 2019, Vol. 15.

Patents & Certifications

- Patents 3 patents pending (CEA automation hardware, Rooted Robotics).
- Certifications Rooted Robotics product line: CE certified (EU market clearance).

Languages

- English Native (U.S. Citizen) Spanish Native