

MAYUKH BAGCHI

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EDUCATION

Ph.D. in Physics (Astronomy and Instrumentation) Sept 2023 – present (expected 2027)
Queen's University, Kingston, ON, Canada. Advisor: Prof. Laura Fissel

M.Sc. in Physics (Astronomy and Instrumentation) Sept 2021 – Sept 2023
Queen's University, Kingston, ON, Canada

B.Tech. in Electrical and Electronics Engineering May 2016 – July 2020
SRM Institute of Science and Technology, Chennai, India

RESEARCH INTERESTS

Space-based and balloon-borne very long baseline interferometry (VLBI) instrumentation; high-frequency VLBI; digital backends and high-speed recording; black hole imaging and photon ring science.

RESEARCH EXPERIENCE

Balloon-borne VLBI Experiment (BVEX) Jan 2022 – present
Queen's University, Kingston, ON, Canada

- Co-led four years of development of a 0.9 m, K-band (21–23 GHz) balloon-borne VLBI station targeting the first balloon-to-ground fringe detection; led the digital backend, data storage, timing chain, position tracking, power distribution, and thermal management
- Developed fine- and coarse-resolution spectrometers and a 2-bit VLBI packetizer on the radio-frequency system-on-chip (RFSoc) 4x2, with the 2027 reflight version streaming VLBI Data Interchange Format (VDIF) frames at 8.3 Gbps over 100 GbE
- Built the data recorder, which stores the stream on NVMe with zero dropped frames in DiFX-readable files, wrote the flight control software, and integrated the backend with the K-band receiver
- Designed the timing chain, in which a 60 ps time-interval counter measures the drift of the oven-controlled crystal oscillator (OCXO) against the GPS pulse-per-second (PPS)
- Flew BVEX on the Canadian Space Agency (CSA) STRATOS campaign (29 August 2025, Timmins, ON) with the backend and timing chain powered through the ascent and returning telemetry; now leading the BVEX 2.0 backend rebuild for the 2027 reflight from Palmas, Brazil

Submillimeter Balloon VLBI Forecasting Sept 2025 – present
Queen's University, Kingston, ON, Canada

- Modified `ngehtsim` and `eht-imaging` so that moving stations (recorded balloon trajectories, the BHEX orbit) are simulated with the ground arrays, and forecast what a 2.5 m balloon telescope adds at 345 to 690 GHz
- Found that the balloon adds little baseline length and that its advantage is access to 460 GHz, where Sgr A* is detectable, the ground array alone gives no photon ring constraint, and balloon baselines lie in the regime where the ring dominates the polarized signal

INSPIRESAT 12U CubeSat Assembly, Integration and Testing Sept 2025 – Apr 2026
Mitacs Internship, StarSpec Technologies, Cambridge, ON, Canada

- Wrote the satellite telemetry and downlink middleware and the magnetometer and thermistor integration software; programmed the power unit's keepalive function; designed and fabricated the RS-232 isolator boards between the power system and the flight computer

- Took part in the vibration test campaign of a 12U CubeSat, and wrote the procedures for and ran the post-vibration and system-level functional tests

Atmospheric Modeling and MKID Readout for CCAT-prime

2021 – 2023

Queen's University, Kingston, ON, Canada

- Modeled the atmosphere above the 5600 m Fred Young Submillimeter Telescope site with the `am` code to compute microwave kinetic inductance detector (MKID) loading and resonator frequency shift against elevation for the 220–850 GHz Prime-Cam bands; showed the 850 GHz array leaves its linear regime within 0.5° of elevation, which set the tone-tracking requirement, and supported its development by Adrian Sinclair (NRC)

Polarized Emission of Star-forming Cores

2021 – 2023

Queen's University, Kingston, ON, Canada

- Stacked JCMT POL-2 850 μm and Planck 353 GHz polarization maps at Herschel dense-core positions in NGC 1333 and Taurus against evolutionary stage; cores with a 70 μm protostellar source show higher stacked polarized intensity than cores without one

Dark Matter Detection, Windchime Collaboration

Nov 2020 – June 2021

Purdue University, West Lafayette, IN, USA (remote)

- Developed detection models, Monte Carlo signal simulations, and analysis pipelines for accelerometer-array dark matter searches

PROPOSALS & OBSERVING EXPERIENCE

Principal Investigator, Very Long Baseline Array proposal VLBA/25A-342

2025

Awarded Priority A on the High Sensitivity Array: four hours of target-of-opportunity ground-array observation in support of the BVEX flight. The ground stations observed during the flight. Calibrated and fringe-fit the correlated 3C 84 and 3C 454.3 data in Python and measured visibility amplitude against baseline length to scope the 2027 proposal.

Principal Investigator, High Sensitivity Array proposal for semester 2027A

2026

Ten hours for the 2027 Palmas campaign and its ground engineering tests, submitted July 2026. Under review.

Observing and data reduction: K-band single-dish observing with BVEX; raw VLBI data reduction in CASA and AIPS; analysis of archival JCMT POL-2 (Gould Belt Survey) and Planck dust polarization maps.

HONORS & AWARDS

- Best Student Poster Award, Canadian Astronomical Society (CASCA) Annual Meeting 2026
- Carl Reinhardt Fellowship, Queen's University 2021 – present
- Harold M. Cave Graduate Travel Scholarship, Queen's University 2023, 2025, 2026
- Runner-up, Best Student Poster Award, CASCA Annual Meeting, Waterloo 2022
- Merit-Based Scholarship, SRM Institute of Science and Technology 2016, 2017, 2018, 2019

SUMMARY OF PUBLICATIONS

Two SPIE conference proceedings, both published and on arXiv (one first-author). Two journal papers in final draft, one first-author (balloon VLBI forecasting, to be submitted to the *Astrophysical Journal*) and one BVEX instrument paper, and a third journal paper on the M87 jet in preparation. Full list on page 5.

PRESENTATIONS

Invited Talks, Colloquia & Seminars

1. **Bagchi, M.** “Observing Black Holes from the Stratosphere: Engineering a Balloon-borne VLBI Station and its Future Prospects.” Invited seminar, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Mumbai, India 2026
2. **Bagchi, M.** and Thiel, F. “Observing Black Holes from the Stratosphere.” Astroseminar, Waterloo Centre for Astrophysics, University of Waterloo, ON 2026
3. **Bagchi, M.** and Thiel, F. “Observing Black Holes from the Stratosphere: The Balloon-borne VLBI Experiment.” Colloquium, National Research Council Herzberg Astronomy and Astrophysics Research Centre, Victoria, BC 2026
4. **Bagchi, M.** “BVEX: Lessons from the Stratosphere and Future Correlation Prospects.” Special colloquium, Max Planck Institute for Radio Astronomy, Bonn, Germany 2025

Contributed Talks

1. **Bagchi, M.** “An RFSOC-based Backend and Timing System for the Balloon-borne VLBI Experiment.” SPIE Astronomical Telescopes + Instrumentation, Copenhagen, Denmark 2026
2. **Bagchi, M.** “BVEX: Balloon-borne VLBI Experiment, Technical Challenges and RFSOC-based Backend.” CASPER Workshop, ASTRON, Dwingeloo, Netherlands 2025
3. **Bagchi, M.** “An RFSOC-based Backend and Timing Reference System for the Balloon-borne VLBI Experiment.” Canadian Astronomical Society Annual Meeting, Toronto, ON 2024
4. **Bagchi, M.** “BVEX: Balloon-borne VLBI Experiment.” Canadian Astronomical Society Annual Meeting, Penticton, BC 2023
5. **Bagchi, M.** “Technical Challenges in Balloon-borne VLBI.” Scientific Ballooning Technologies Workshop, Minneapolis, MN 2023

Posters

1. **Bagchi, M.** “The Balloon-borne VLBI Experiment.” Canadian Astronomical Society Annual Meeting, Université de Montréal, QC. Best Student Poster Award 2026
2. **Bagchi, M.** “Improving Imaging of Supermassive Black Holes with Balloon-borne VLBI Stations.” Supermassive Black Holes 2026 conference, Montréal, QC 2026
3. **Bagchi, M.** “A Statistical Analysis of the Polarization Properties of Dense Cores.” Canadian Astronomical Society Annual Meeting, Waterloo, ON. Runner-up, Best Student Poster Award 2022

Schools, Workshops & Field Campaigns

- 20th Synthesis Imaging Workshop, National Radio Astronomy Observatory, Socorro, NM: radio interferometry imaging, calibration, and Very Long Baseline Array data reduction 2024
- CSA STRATOS Field Campaign, Timmins, ON: flew the BVEX position-tracking package on a French space agency (CNES) gondola 2023
- CASPER Workshop on FPGAs in radio astronomy, INAF, Cagliari, Italy 2022
- MIT Haystack Observatory collaboration visits, Westford, MA: BVEX tests against the Haystack 37 m telescope and VLBI correlation planning 2022, 2025

TECHNICAL SKILLS

- **Timing and Frequency References:** Integrating, testing, and flying ultra-stable quartz oscillators for VLBI; Allan deviation characterization at MIT Haystack Observatory; thermal-vacuum testing;

vibration-induced phase noise estimated from measured float accelerations; clock-drift measurement with time-interval counters; 10 MHz and PPS distribution on a flown payload

- **Receivers and Radio Frequency Systems:** K-band receiver integration and characterization, including noise temperature by the Y-factor method with hot and cold loads; spectrum analyzers, signal generators, and vector network analyzers; radio-frequency circuit and printed circuit board design (KiCad, EasyEDA)
- **FPGA and Digital Backends:** AMD Xilinx RFSoc, Vivado, VHDL, CASPER toolflow; 100 Gb Ethernet data paths and high-rate packet capture (AF_XDP); correlation of VDIF in DiFX; microcontrollers
- **Space and Balloon Hardware:** CubeSat assembly, integration, and testing; conduction-cooled electronics design for balloon payloads
- **MKID Loading and Readout Modeling:** atmospheric loading and resonator linear-regime modeling, tone-tracking requirements
- **Software and Data Analysis:** Python, C/C++, MATLAB, CASA, AIPS, DiFX, `eht-imaging`, `ngehtsim`, `am`, Astropy, NumPy, SciPy, Git, Linux

SOFTWARE

- Primary developer of the BVEX flight control software (`fissellab/bcp`), the RFSoc spectrometer and VLBI firmware (`mayukh4/BVEX_rfsoc_4x2`), and the command system (`mayukh4/bvex_cmd`)
- Author of the RFSoc 4x2 VDIF packetizer and AF_XDP recorder (`mayukh4/bvex-vdif-rfsoc`, MIT license), built on the CASPER RFSoc VDIF design of J. Kocz
- Contributor to the BVEX ground station (`fissellab/bvex_gs`) and author of CCAT-prime atmospheric modeling tools (`mayukh4/CCAT-P-Atmospheric-Modelling`)
- Co-developer of the moving-station extensions to `eht-imaging` and `ngehtsim` used in the balloon VLBI prospects paper; under review before public release

TEACHING & MENTORING

Undergraduate Research Mentoring, BVEX, Queen's University 2022 – 2026
Mentored six undergraduate summer students on BVEX electronics, power distribution, position tracking, housekeeping, and GPS subsystems: Muhammad Mubeen (2026, power electronics and position-tracking hardware), Terry Yang and Rafael Costa (2025, including the STRATOS flight campaign), Amna Hasnain (2024), Jess Lo and Thomas Emo (2022–2023). Supervised Alex Chase's Engineering Physics design project (ENPH 455, 2023–2024), a tone generator on RFSoc 2x2 DACs.

Lab Developer, CRASIES Summer School, McGill University May 2026
Co-designed and co-built the wok radio telescope for the Canadian Radio Astronomy Summer Institute and Extended School, and wrote its observing and analysis software (`mayukh4/CRASIES_wok_telescope`).

Teaching Assistant, Queen's University 2022 – 2025
Introductory astronomy, electronics laboratory, and thermodynamics courses.

Head Teaching Assistant, Engineering Physics Laboratory, Queen's University 2021 – 2023
Coordinated the teaching-assistant team and set rubrics and grading standards for first-year laboratory reports.

PROFESSIONAL SERVICE & OUTREACH

- Web Administrator, Graduate Physics Society, Queen's University Jan 2026 – present
- Co-founder, Go Look Up (`golookup.ca`), public astronomy outreach 2026 – present

- Science communication on YouTube through an astronomy channel (youtube.com/@mayukh_bagchi) and a technology channel (youtube.com/@mayukhbuilds); volunteer for Queen’s Observatory public open houses and Science Rendezvous 2021 – present

LANGUAGES

English (fluent), Hindi (native), Bengali (native)

PUBLICATIONS

Journal Papers in Preparation

1. **Bagchi, M.**, Pesce, D. W., Thiel, F. M., Fissel, L. M., and Blackburn, L. “Prospects for (sub)millimeter VLBI with a Stratospheric Balloon-borne Telescope.” Final draft; to be submitted to the *Astrophysical Journal*.
2. The BVEX Collaboration, **Bagchi, M.**, Fissel, L. M., Thiel, F. M., et al. “The Balloon-borne Very Long Baseline Interferometry Experiment.” Final draft; to be submitted to the *Journal of Astronomical Instrumentation*.
3. Thiel, F. M., **Bagchi, M.**, et al. “Studying the Near-horizon Jet of M87 using Millimeter Balloon-borne VLBI.” In preparation.

Conference Proceedings

1. **Bagchi, M.**, Thiel, F. M., Fissel, L. M., Oxford, M., Blackburn, L., et al. (2026). “An RFSoC-based Backend and Timing System for the Balloon-borne Very-Long Baseline Interferometry Experiment.” *Proc. SPIE* **14153**, *Radio Telescopes, Technologies, and Methods*, 141530Z. doi:10.1117/12.3101053; arXiv:2609.11605.
2. Thiel, F. M., **Bagchi, M.**, Fissel, L. M., Shah, A., Blackburn, L., et al. (2026). “The Balloon-borne VLBI Experiment (BVEX) Radio Telescope and Position Tracking System.” *Proc. SPIE* **14153**, *Radio Telescopes, Technologies, and Methods*, 1415316. doi:10.1117/12.3101054; arXiv:2609.11676.

Thesis

1. **Bagchi, M.** (2023). “Advances in Microwave and Sub-mm Astronomical Instrumentation and Analysis.” M.Sc. thesis, Queen’s University.