C(cubed)Sat: A Cosmic Climate Cuboid Nanosatellite for Monitoring Above Earth Cosmic Activity

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Georgia State University

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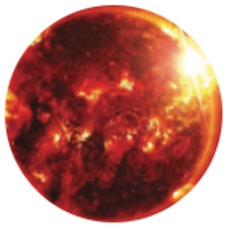
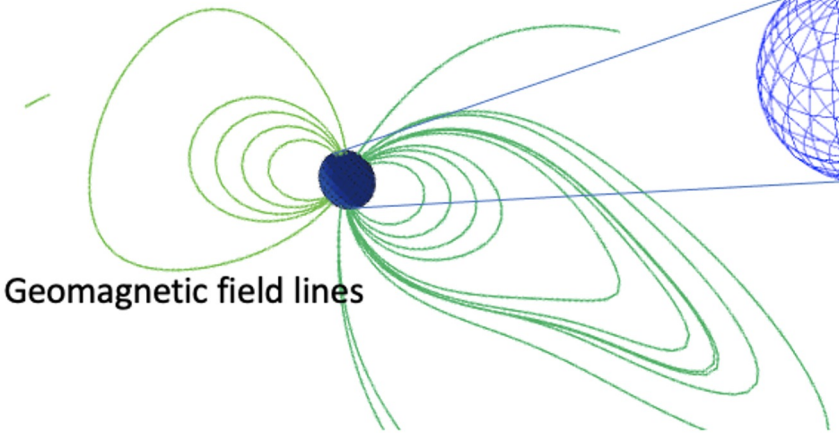
Primary and Secondary Cosmic Rays

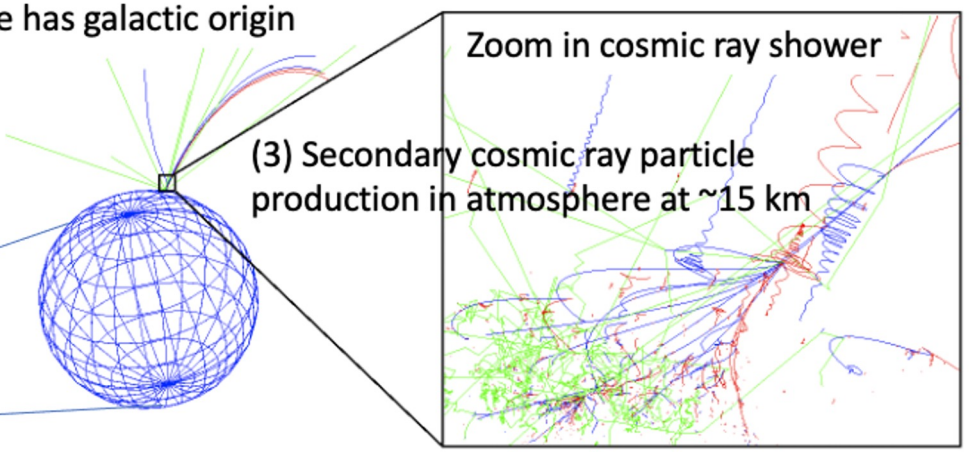
(1) Primary cosmic ray particle has galactic origin



(2) Amount of cosmic ray particles reaching the top of the earth atmosphere is affected by solar activities.



Geomagnetic field lines

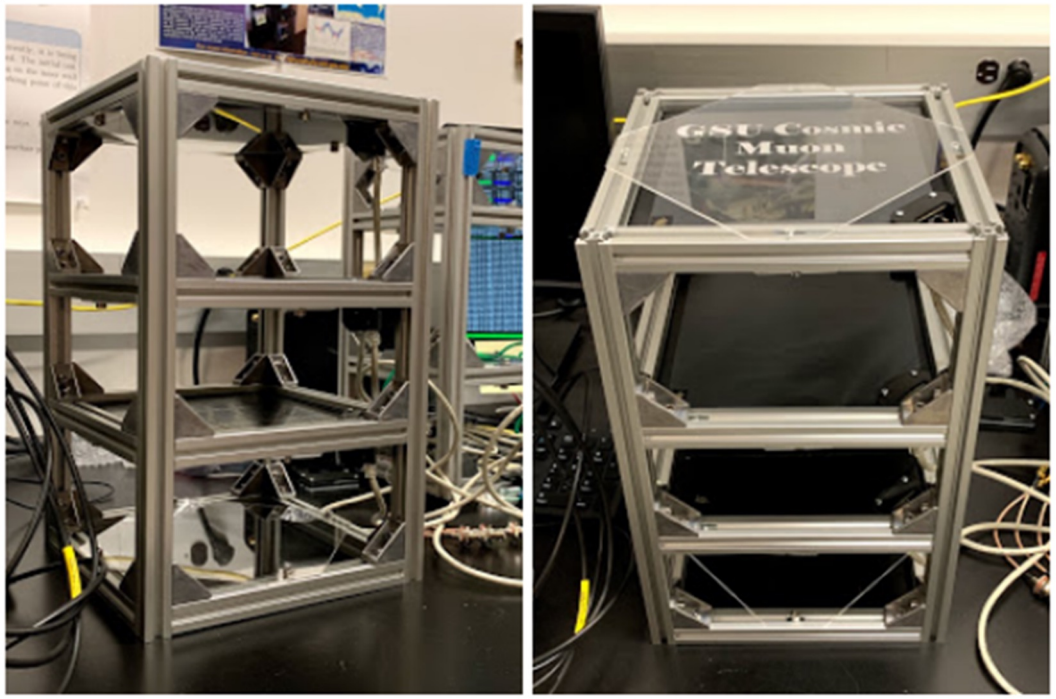


(3) Secondary cosmic ray particle production in atmosphere at ~15 km

These ionizing particles are regarded as health hazards for flight crew

(4) Most particles reaching to the surface of earth are muon particles together with a few percent of neutrons. By measuring muon flux variation around the world allows us to derive the state of space weather and atmospheric profile in real-time.

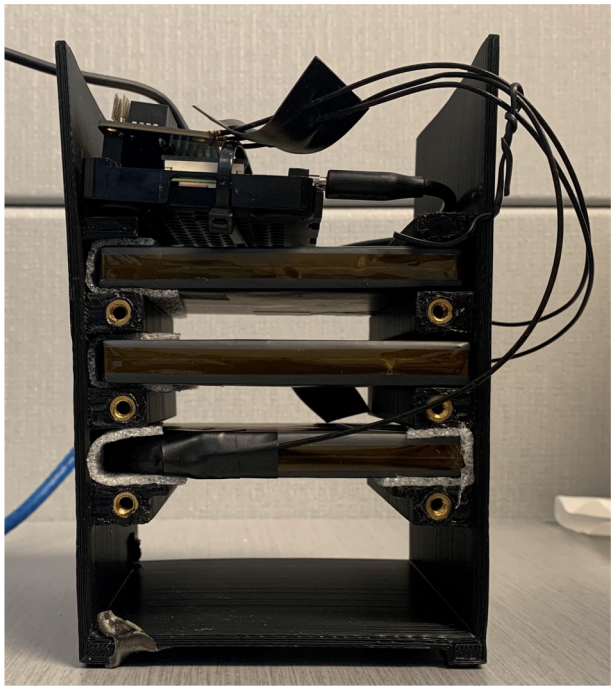
Portable and Low-Cost Cosmic Rays Detector



- Developed by Nuclear Physics Group at GSU, Cosmic Muon Telescopes offer a low-cost and portable detector network to monitor cosmic rays.
- Each detector offers 3 20 cm x 20cm scintillator tiles stacked in an aluminum frame with 13 cm of separation between the tiles.
- This design allows us to install detectors for weather monitoring across the globe because of their low-cost.

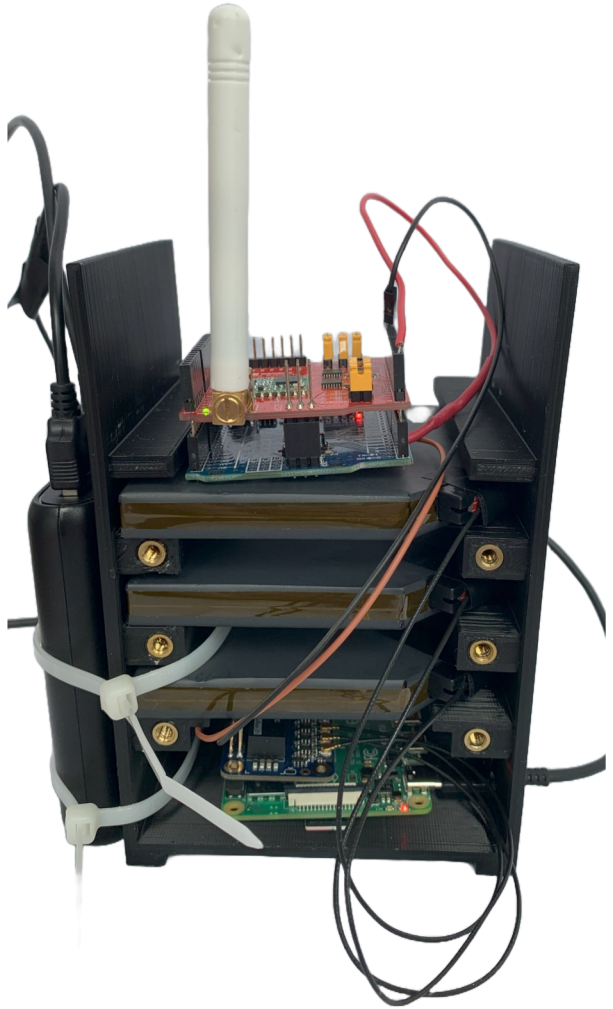
Tracking Space Weather Effect on Cosmic Ray Flux

- To completely gain an understanding of how space weather is impacting terrestrial weather, it is important we have detector between the sun and earth in Low Earth Orbit to monitor space weather effect.
- CubeSats are nanosatellites which offer one possible solution.
- With the CubeSat gathering a measure of the space weather effect in the atmosphere, this effect can be removed from atmospheric effects to begin predicting microclimate data in real-time.



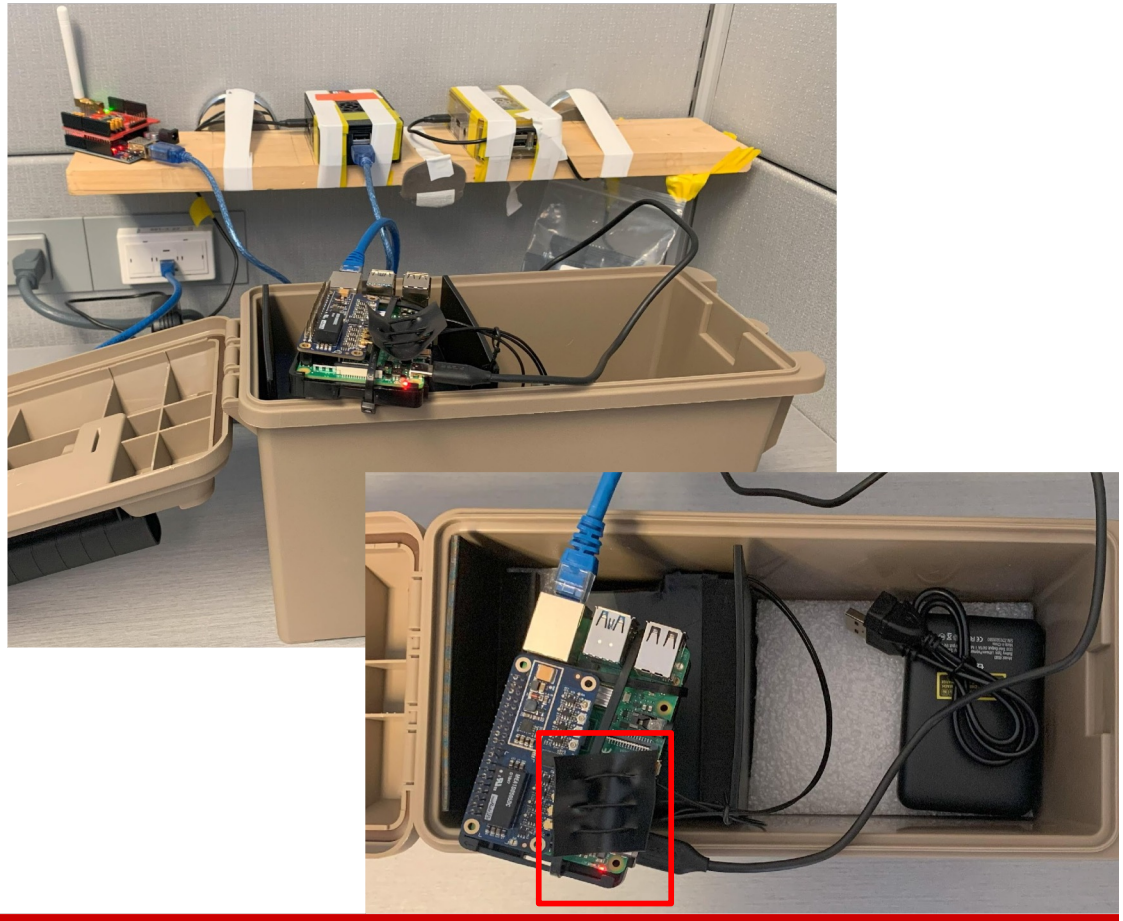
Hardware Implementation

CPU	Raspberry Pi 4
Power	Anker 13,000 mAmp Litihum Ion Battery Pack
Sensors	Three 9 cm x 9 cm x 1cm Scintillator Tiles
Chassis	10 cm x 10 cm x 15 cm (1.5 U) design featuring three 1 cm thick platforms for the tiles 3D printed in PLA
Communication (under exploration)	LoRA (Low-power Long Range Wireless using 915MHz band)

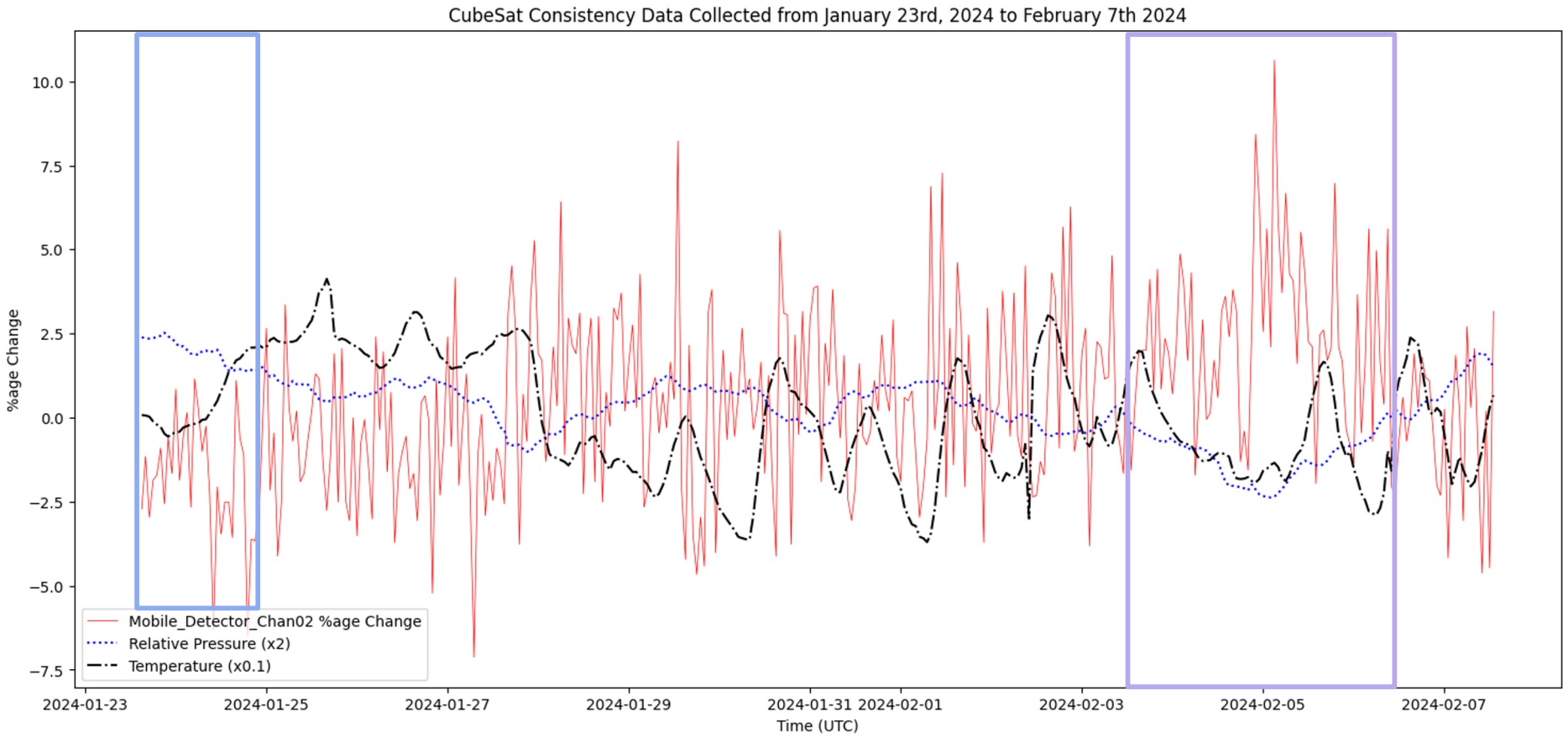


CubeSat Consistency Analysis

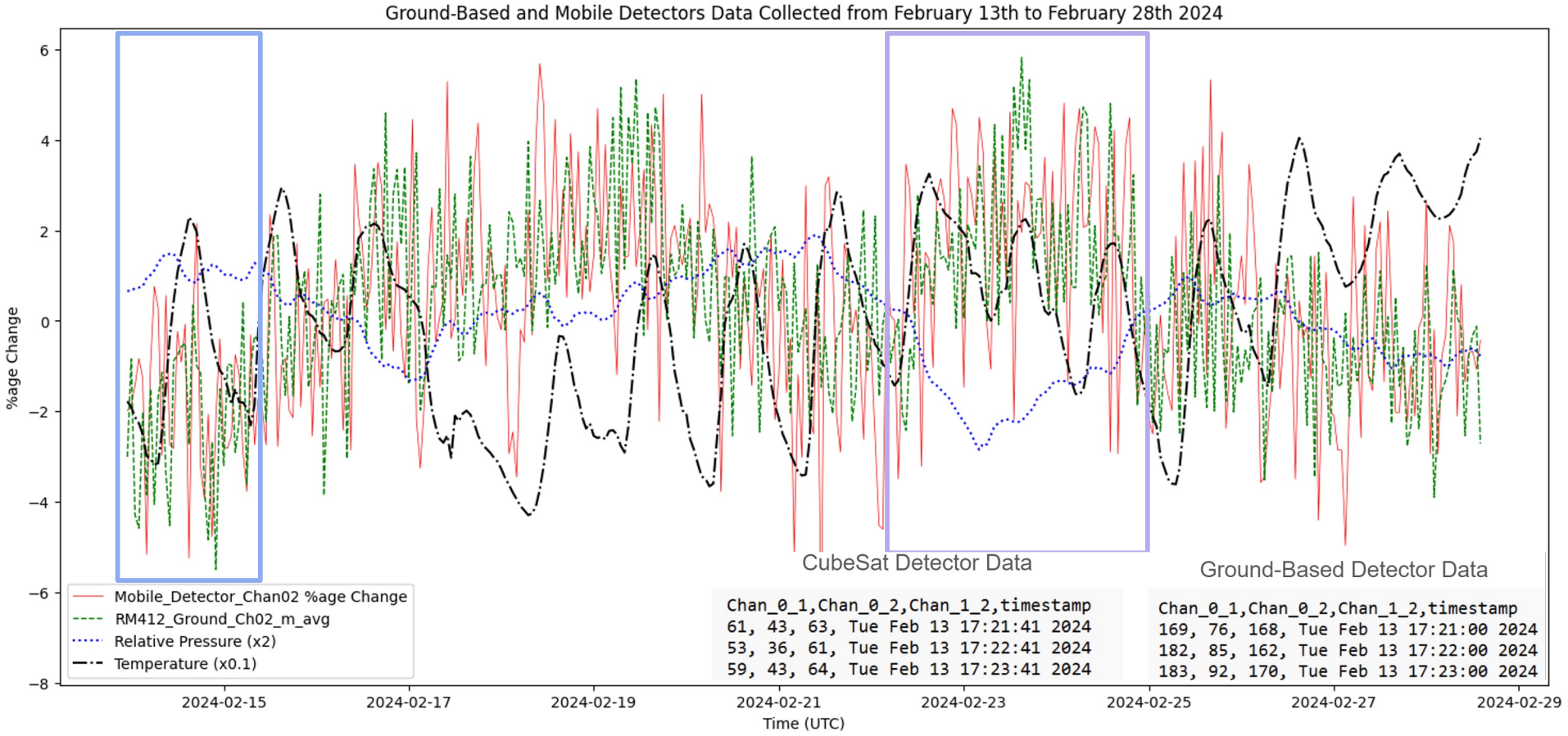
- With an updated design, it was important to reexamine the data being received for consistent data captures.
- After completing consistency testing, the CubeSat design was placed with a ground detector to verify we receive similar results.
- The red box highlights a small piece added to verify that the U. FL wires stay separated to help reduce noise from previous experiments.



CubeSat Consistency Analysis

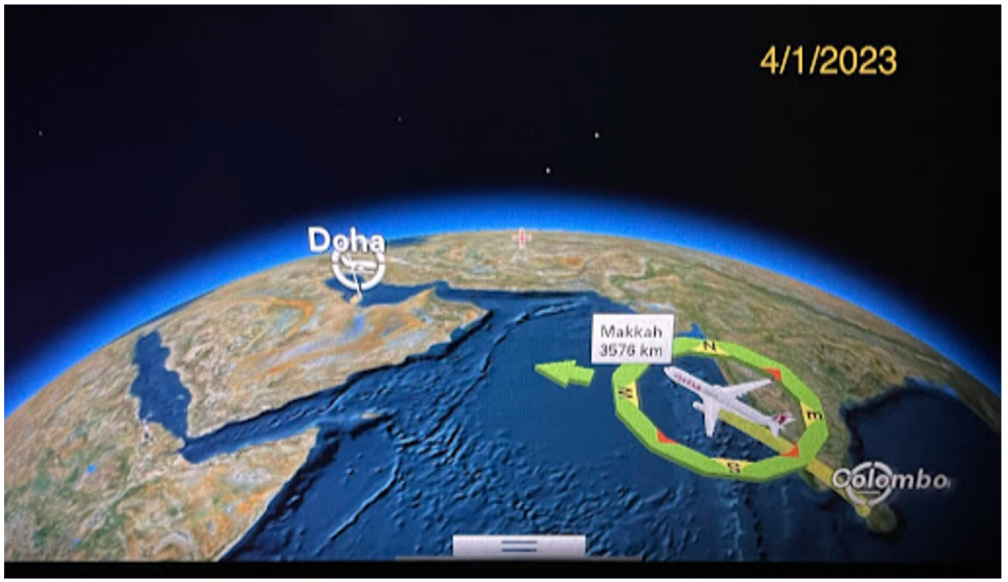


Comparison of CubeSat and Ground-Based Detector

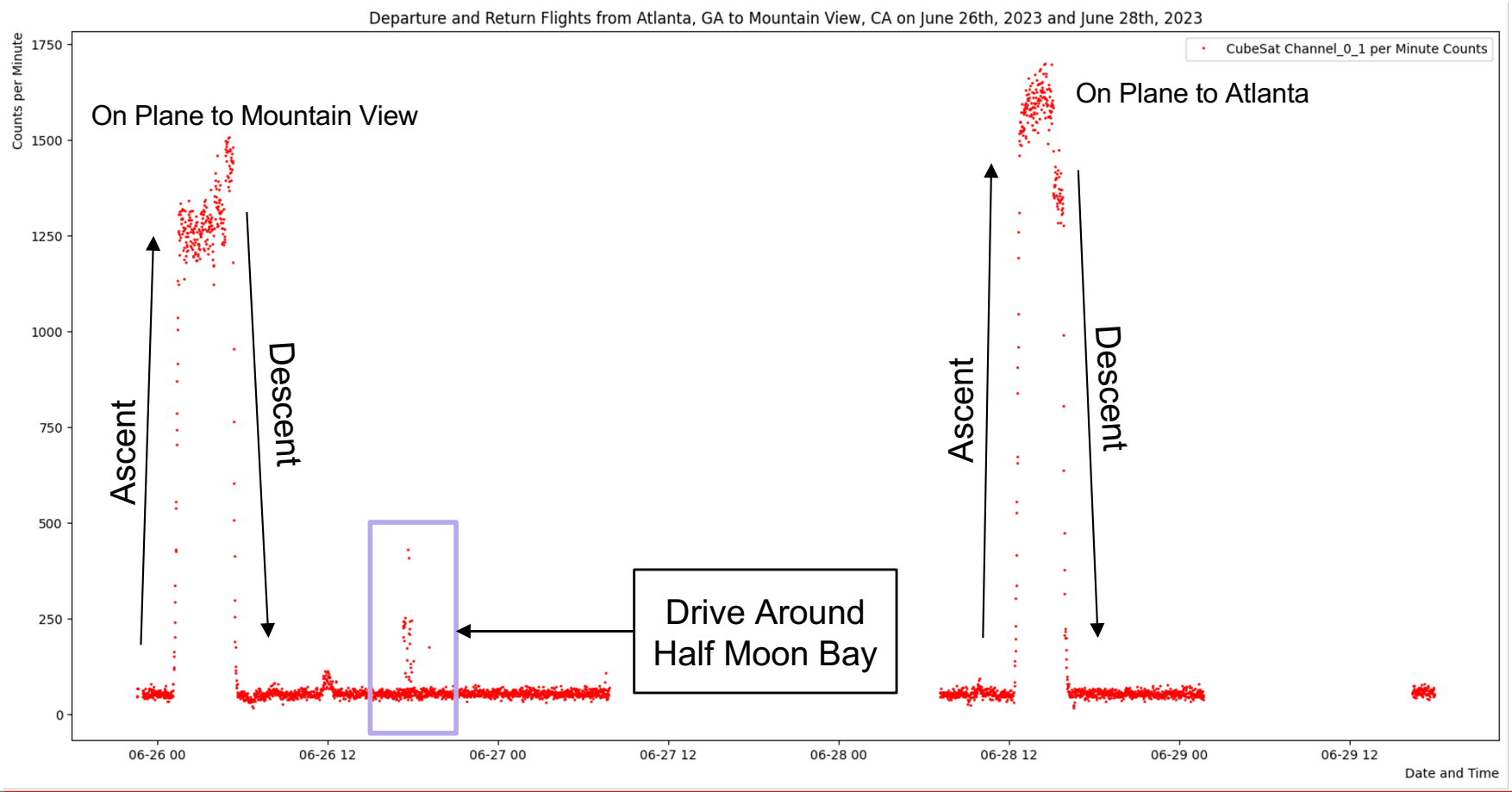


Flight-Based Performance Testing

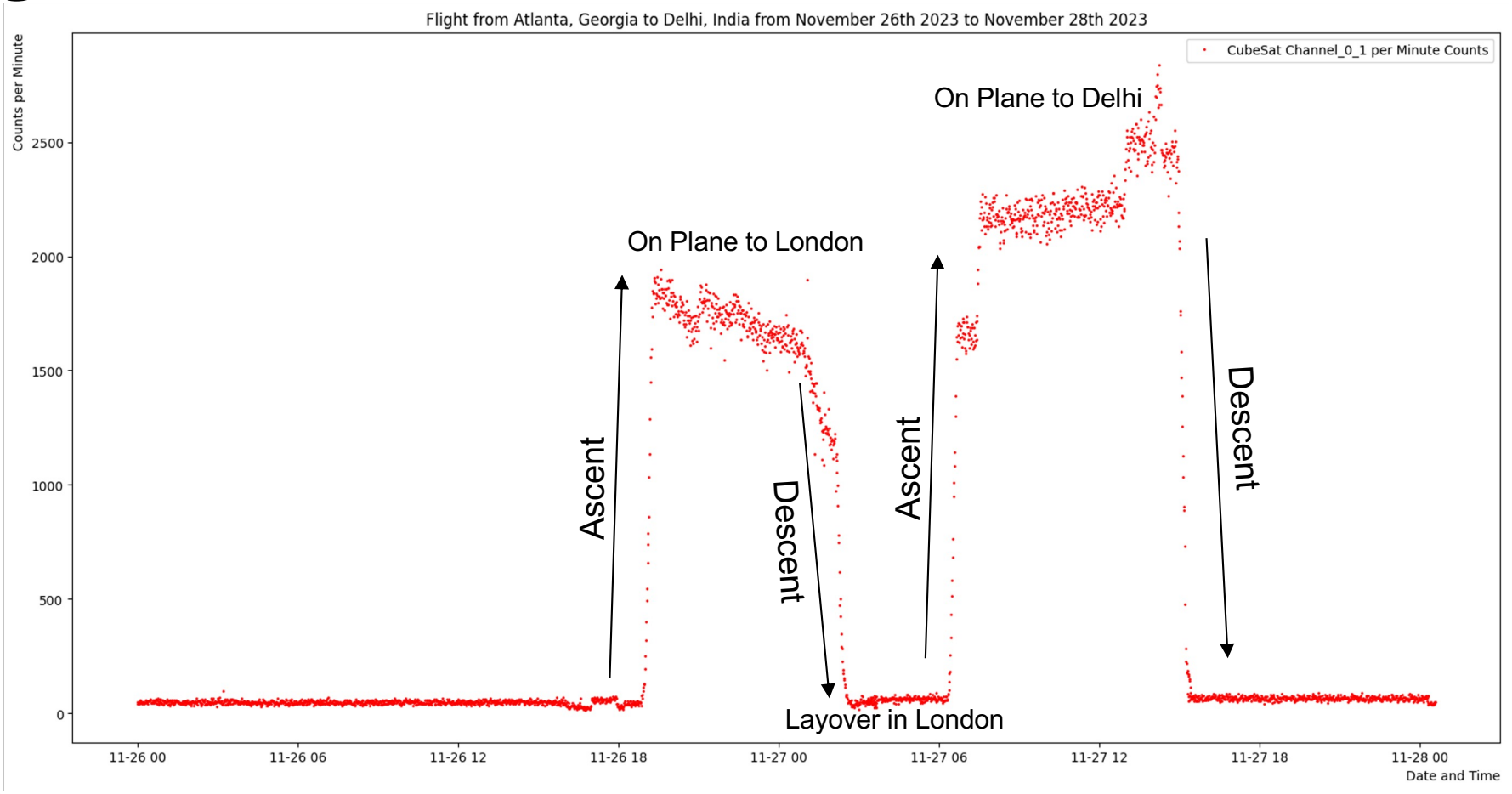
- These studies have helped gain an understanding of the relationship between secondary cosmic ray particle generation compared to the altitude within the atmosphere.
- Flight-based testing became an essential form of experimentation for the CubeSat to determine the solar effect we see on cosmic rays while in the atmosphere.



Flight Test: Atlanta to Mountain View



Flight Test: Atlanta to New Delhi



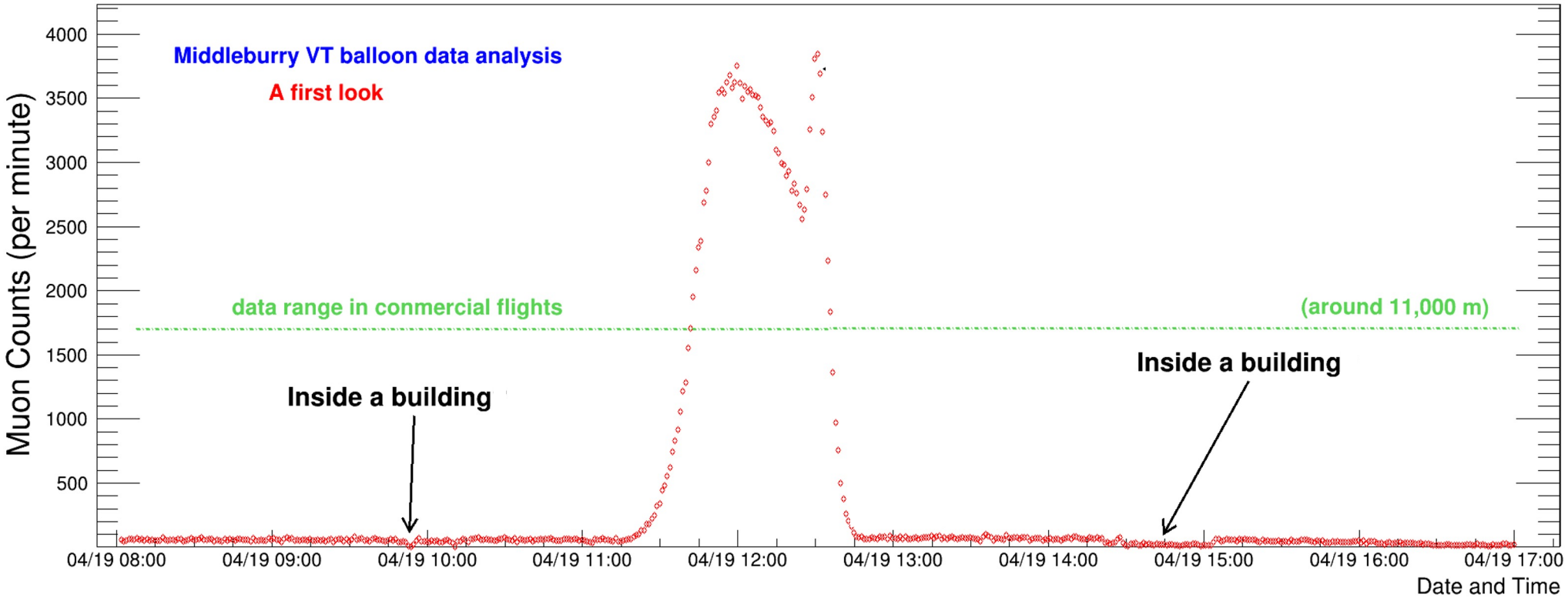
High Altitude Balloon Preliminary Testing

- In collaboration with the Physics Department from Middlebury College located in Middlebury, Vermont, we launched our CubeSat using a high-altitude balloon on April 19th.
- Using a high-altitude balloon from Launch With Us, we were able to collect data around roughly 35 km above Earth's surface to determine the amount of radiation we may see in the stratosphere.

Middlebury College

launch with us

High Altitude Balloon Test Results



Future Outlooks

- Launch the current model as a payload of a CubeSat to gather initial findings from the atmosphere.
- Build a prediction model with the comparison to ground-based data to begin predicting Earth weather using cosmic ray interactions with the atmosphere.
- Build multiple more CubeSats for this project with the goal to have a small constellation so we can receive data globally.

gLOWCOST: Global Cosmic Ray Detector Network

The Earth is an integrated system of dynamic interactions between the atmosphere, ocean, land, ice, and human society. Its evolving and emerging characteristics must be continually explored through observation

["Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space", National Academic of Science, Engineering, and Medicine, 2018]

Mt Wilson, California

Apache Point Observatory, NM

Santa Marta, Colombia

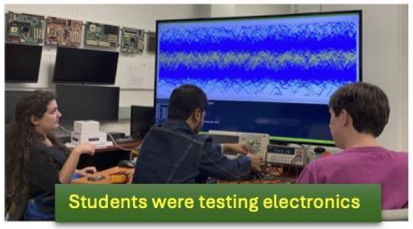
Xian, China

Colombo, Sri Lanka

Uva Wellassa, Sri Lanka

New design ideas by high schoolers in Atlanta (2022)

Lecture in Santa Marta, Colombia, in Aug 2023



Students were testing electronics

We work hard, we are hopeful

What is the cost?

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Observing the 2024 eclipse effect on the earth's atmosphere using cosmic rays

Thank You!
Questions?

Special Thank You to Collaborators: Razat Sutradhar, Jason Yu, Bao Nguyen, May Norrington, Carter Stephan, and the Nuclear Physics Group at Georgia State University