# Cosmic Ray Muon Measurement at Global Scale for Monitoring the Space/Earth Weather

Cosmic ray radiation (i.e. mostly proton particles) is produced far in deep space, gets into the solar system and produces cosmic ray showers in the earth upper atmosphere.

We measure the shower particles at the surface of earth and decode the state of the space and earth weather.

# A Brief Overview

## Worldwide Cosmic Ray Muon Detector Network


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On behalf of the GSU RISE Team

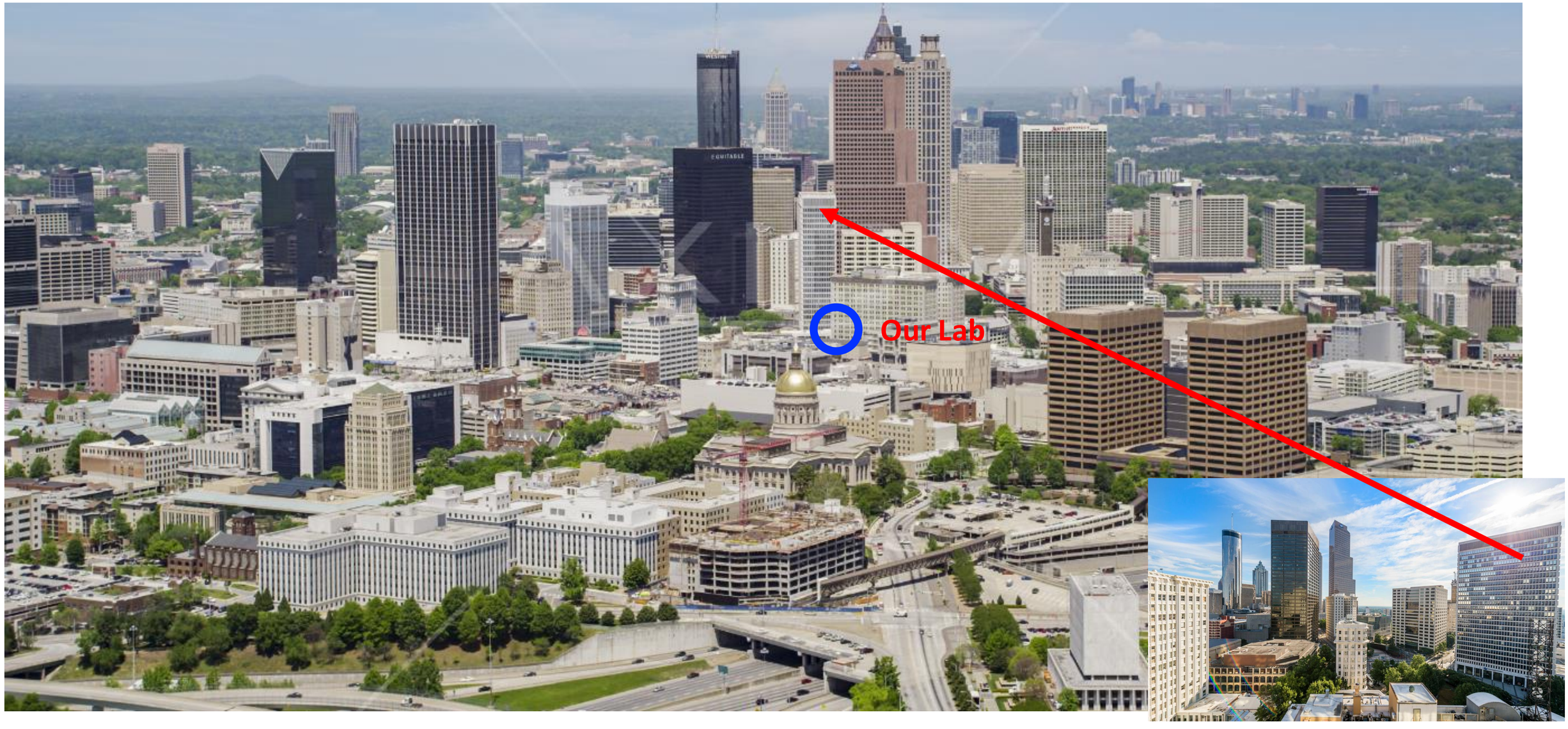
Department of Physics and Astronomy

Georgia State University

# Finding GSU on Map


GSU Campus in downtown Atlanta
(Campus de GSU en el centro de Atlanta)

# City of Atlanta



# Interdisciplinary Research Team at Georgia State University

2 solar physicists

1 condense matter physicist

3 computer science faculty

1 geoscience faculty

4 nuclear physicists

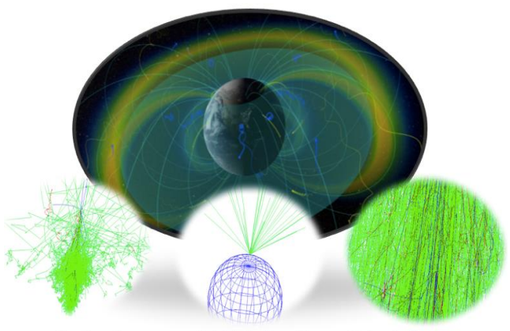
GaTech faculty
Env. engineering

In addition, we have a number of undergraduate and graduate students who are making critical contributions to this project.

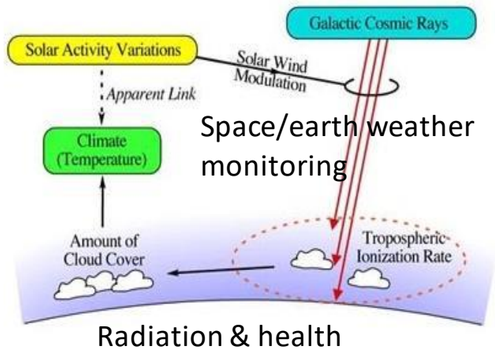
# Our Living Space

# Cosmic Ray Project at GSU

- Cosmic ray shower simulation
- Cosmic ray detector development
- Applications of cosmic ray flux measurements
- Students training



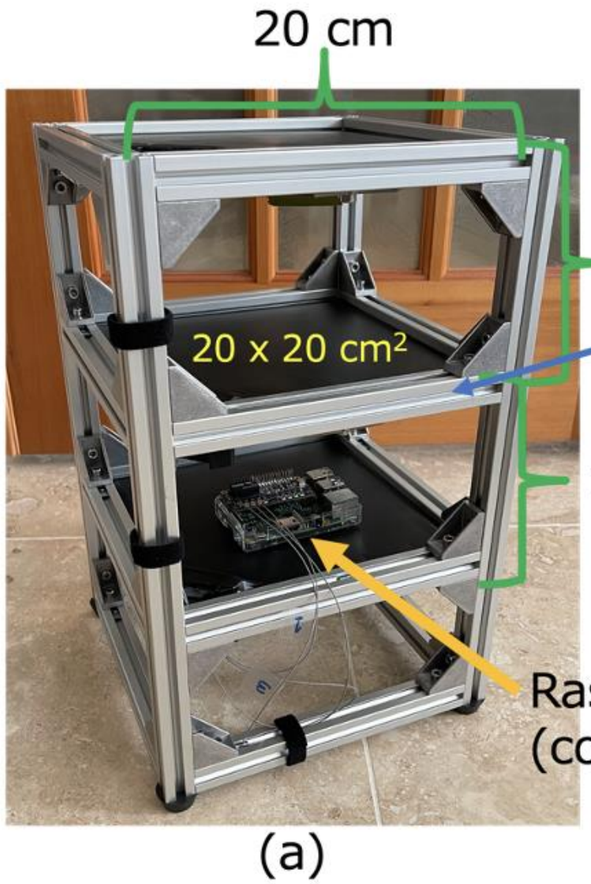
Cosmic ray flux measurement at global scale and the associated applications



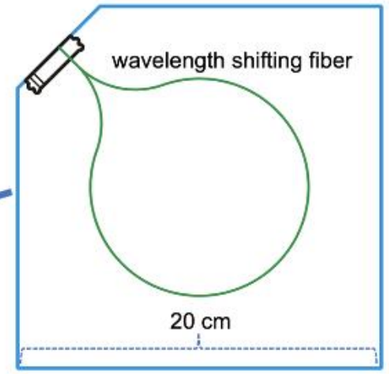

Space/earth weather monitoring

Radiation & health

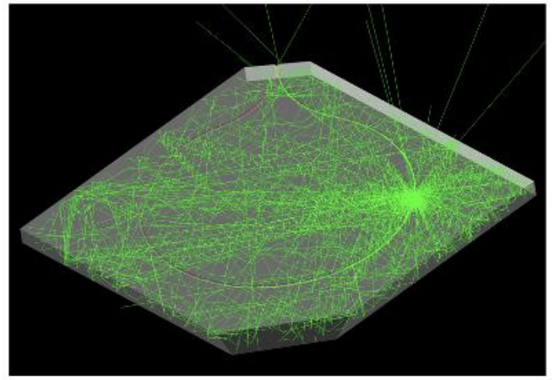
# Cosmic ray muon detector description

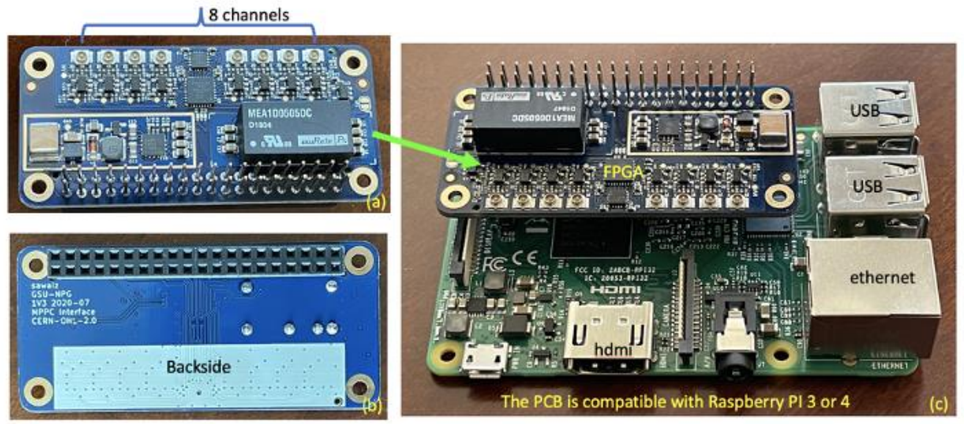



(a)




Simulated scintillation process






The cosmic ray muon detector consists of three layers of plastic scintillator (20x20 cm$^2$). Its dimension is shown in the figure above. Scintillation light is generated when a muon particle passes through the scintillator, which is recorded by a silicon photomultiplier (SiPM) mounted at the corner of the layer. The voltage of the SiPM is supplied by a small PCB which is mounted on the Raspberry PI (credit-card-size low cost computer). The detector automatically starts data taking once it is powered up. One needs a network IP address in order to share the data and reconfigure the detector with remote access.

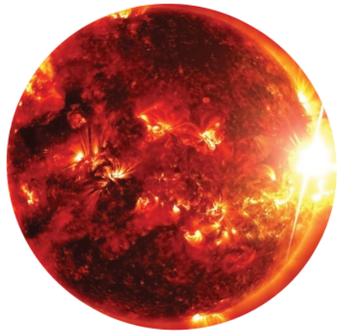
Prepared by X. He on 8/15/2023

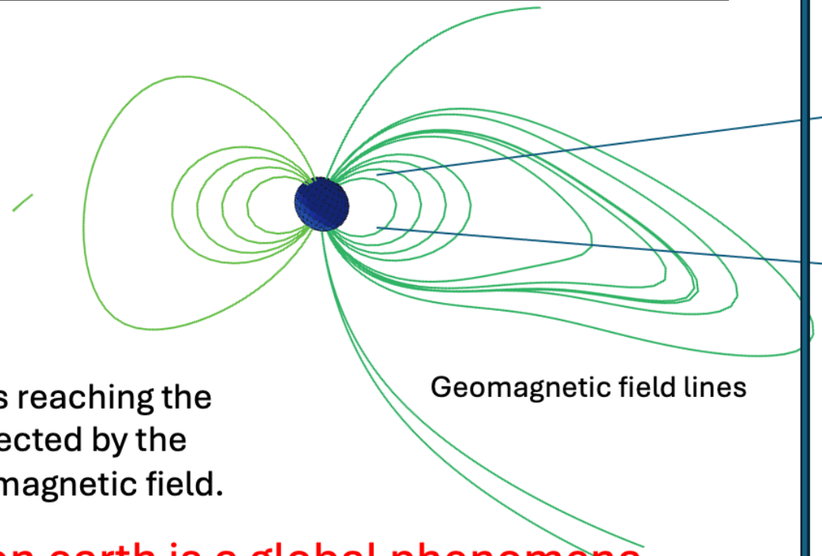
**It is cheaper to buy this detector than to buy an iPhone!**

# A global network of cosmic ray detectors is a key to success

# Variation in cosmic ray flux at ground level reflects the effects of the space and terrestrial weather

**(1)** Primary cosmic ray particles mostly have galactic origin. Solar energetic particles (mainly protons) can contribute as well.

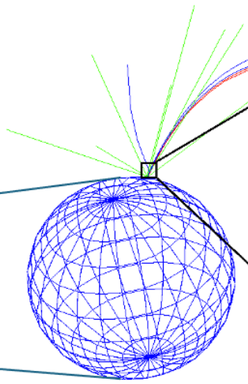




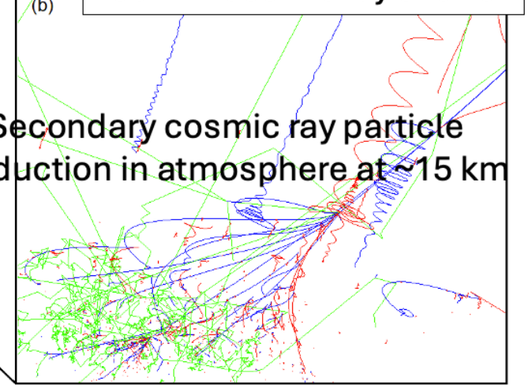
Geomagnetic field lines

**(2)** Amount of cosmic ray particles reaching the top of the earth atmosphere is affected by the solar activity and the state of the magnetic field.

## Impact of space weather on earth is a global phenomena



Zoom in cosmic ray shower




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

Cloud formation

Triggering lightning

## Atmospheric influence on cosmic ray flux

Need to disentangle the two effects to the cosmic flux variation

Space weather monitoring

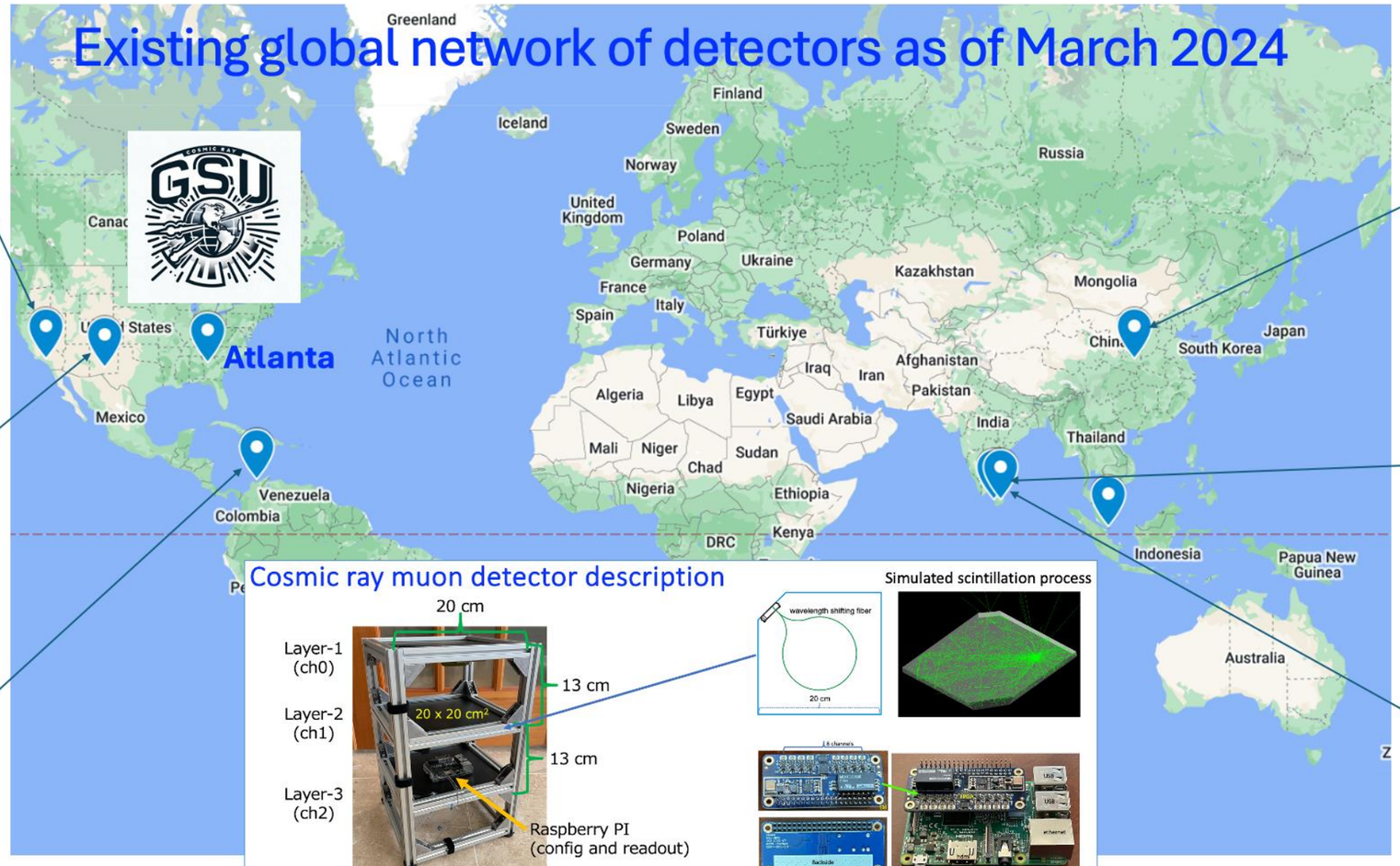
Terrestrial weather monitoring

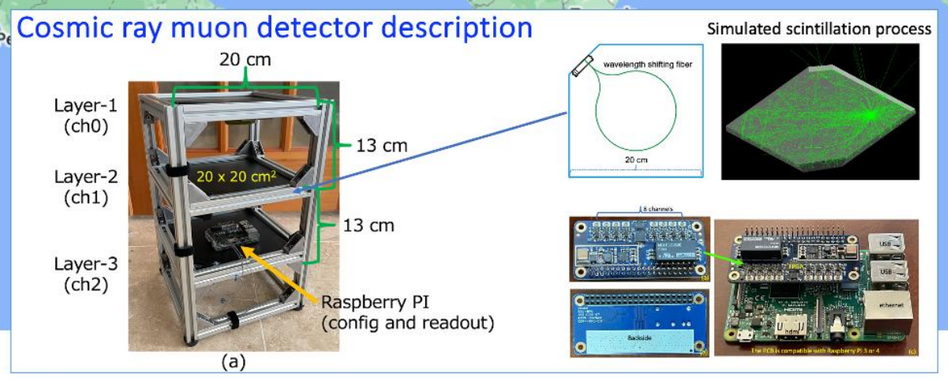
# Existing global network of detectors as of March 2024

Mt Wilson, California

Apache Point Observatory, NM

Santa Marta, Colombia

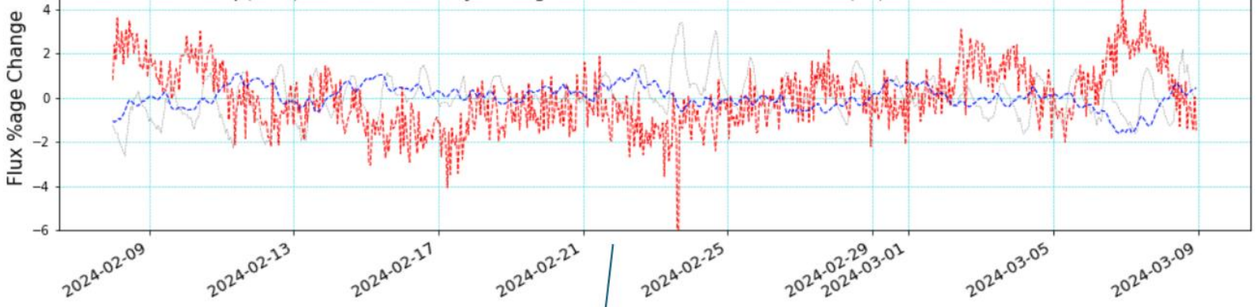


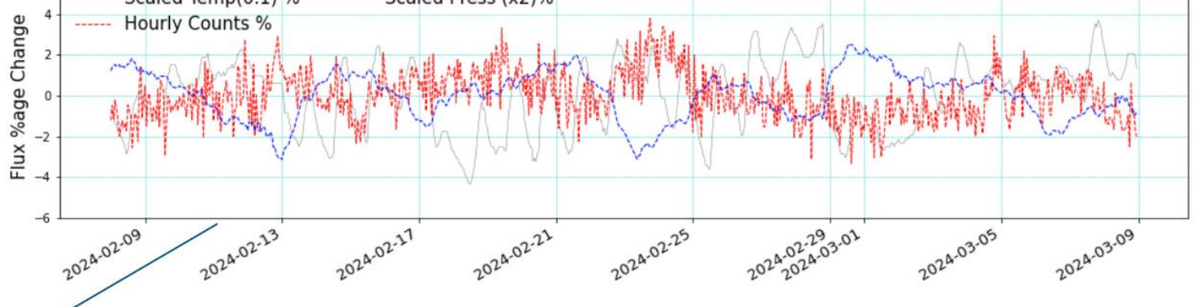




Xian, China

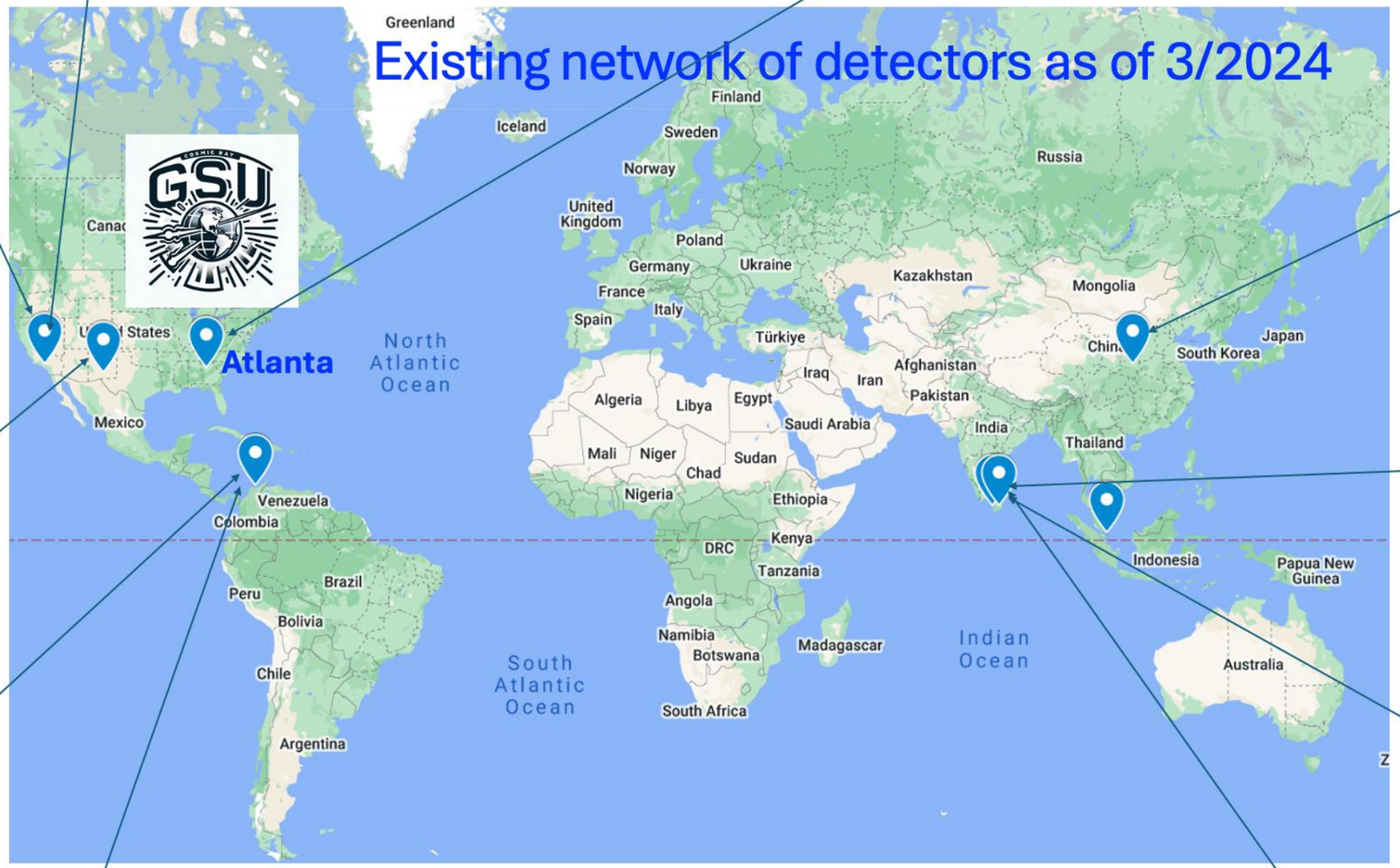
Colombo, Sri Lanka

Uva Wellassa, Sri Lanka




# Existing network of detectors as of 3/2024

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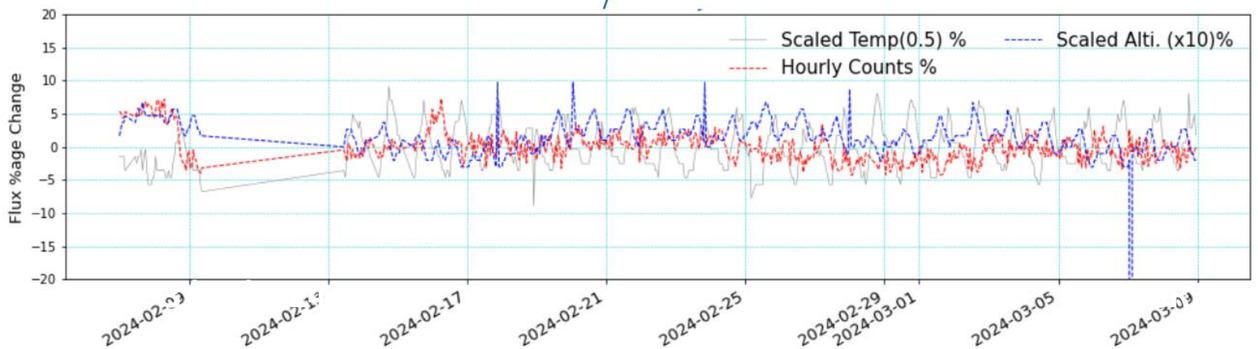


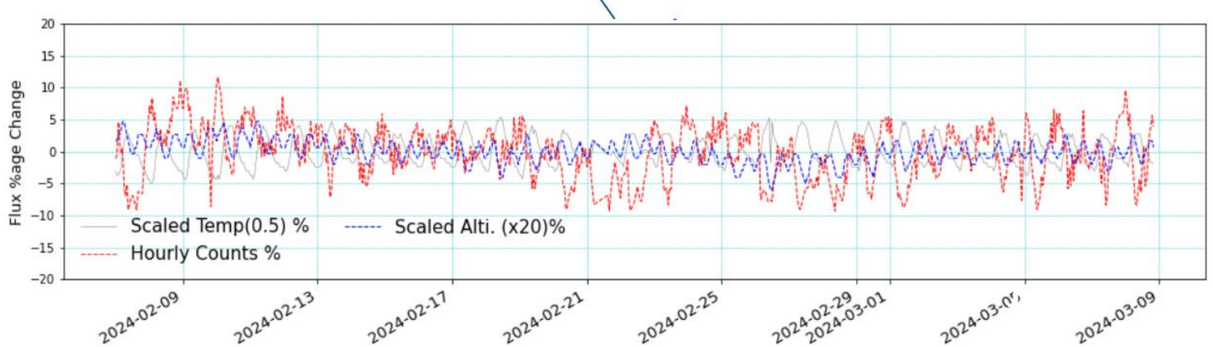

# Expanding the Network


**It just a beginning**

Many thanks in advance to join us for building this network. We hope that someday there will be one detector in every country in the world, including at the earth's low orbit.