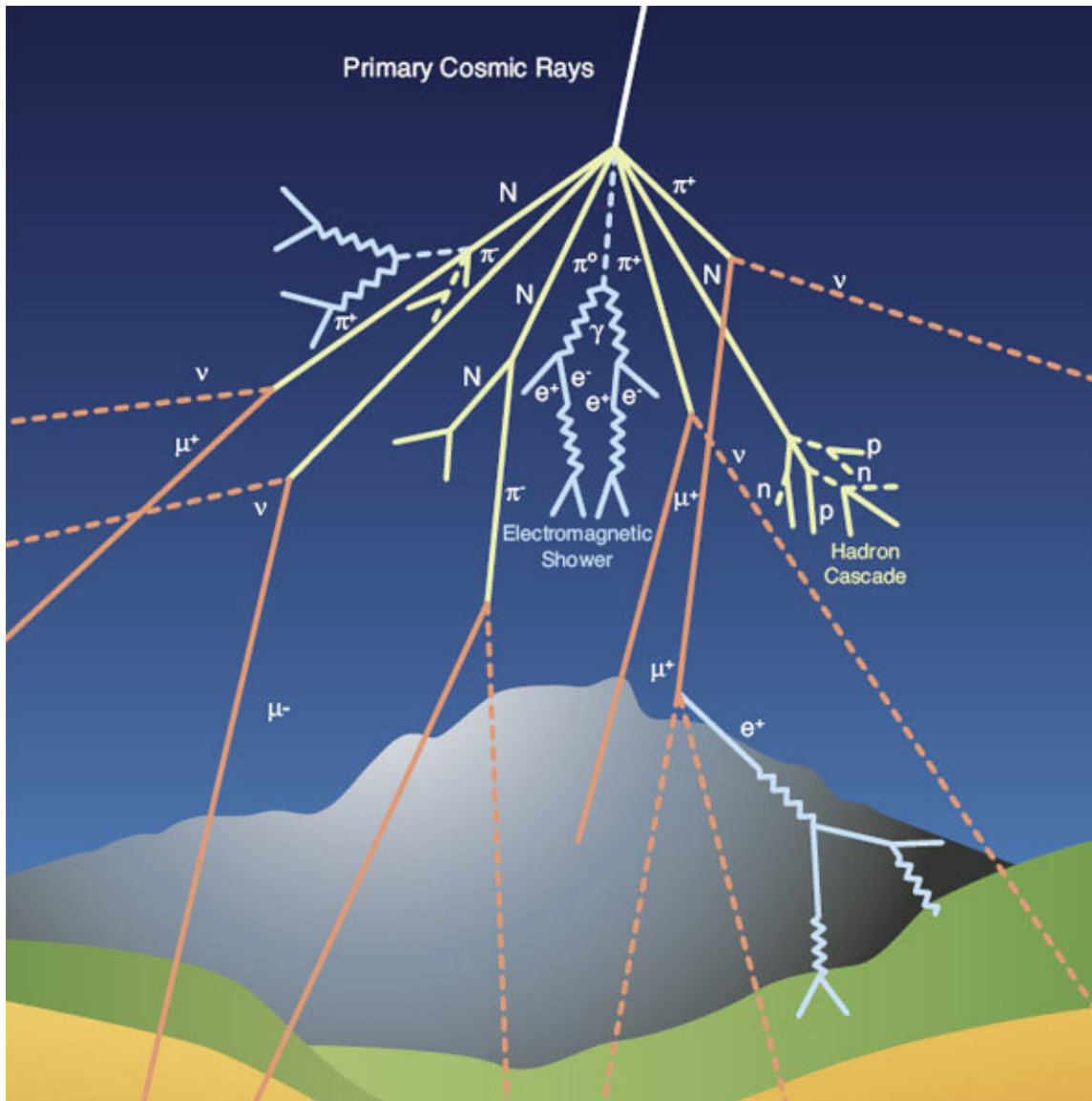


# **A Cosmic Ray Detectors for High Altitude Balloons**

Daniel Marlow



# Cosmic Rays



Primary cosmic rays comprise protons and heavy nuclei traveling through interstellar space.

The energy of these primary particles is mostly dissipated in collisions in the upper atmosphere, but a penetrating component of muons makes it to ground level.

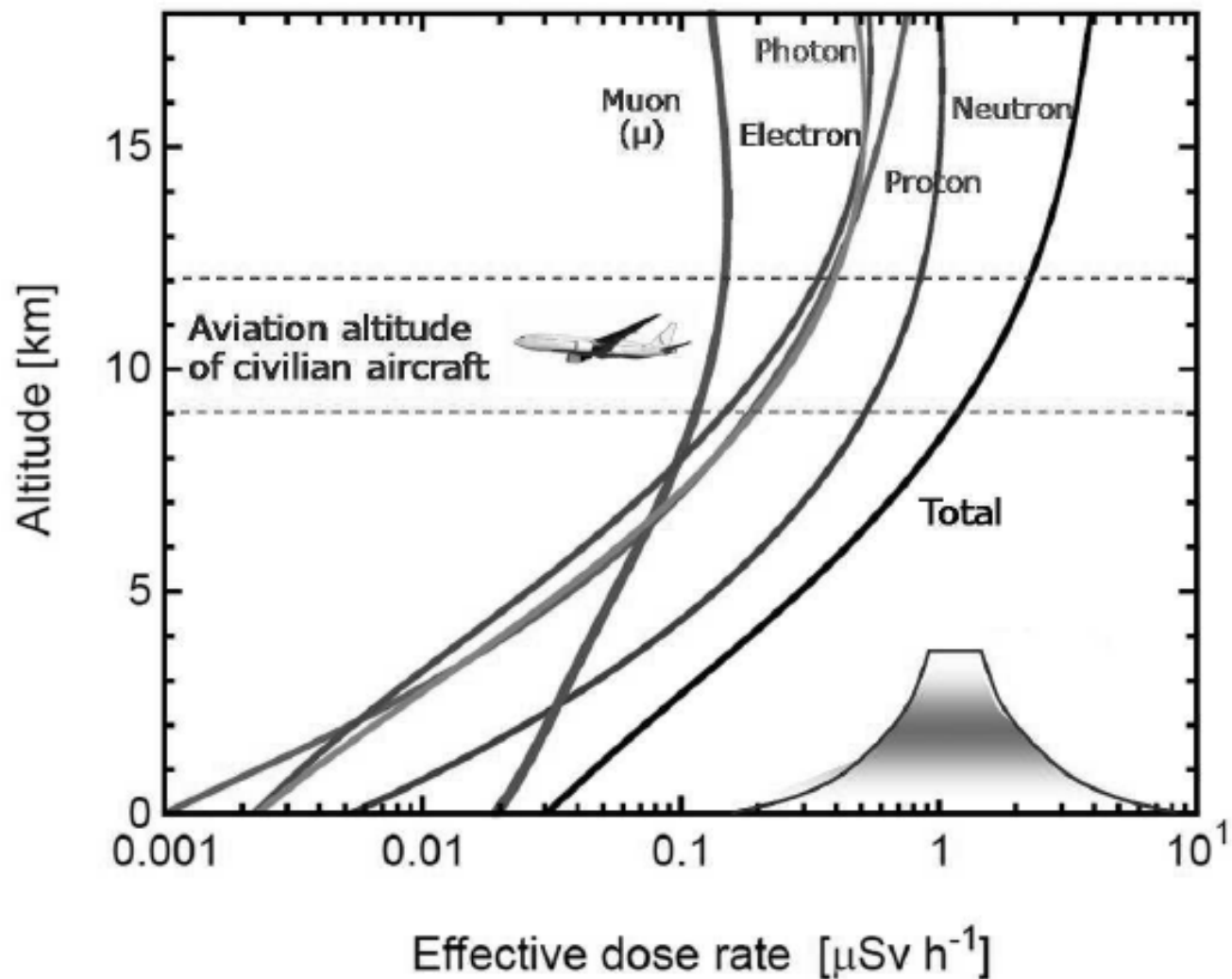
# Cosmic Ray Detection Rates

- The ionization trails of these cosmic ray muons can be detected with relative ease, using Geiger counters or scintillation detectors.
- The lifetime of a muon is 2.2 microseconds, which corresponds to a mean free decay path of 660 m, when traveling at the speed of light.
- Since the muons are produced at altitudes of 10 km or more, one might have expected essentially all of them to have decayed away before reaching the surface of the earth.
- Equivalently, one might expect that the muon flux increase dramatically with altitude.

# Cosmic Ray Detection Rates

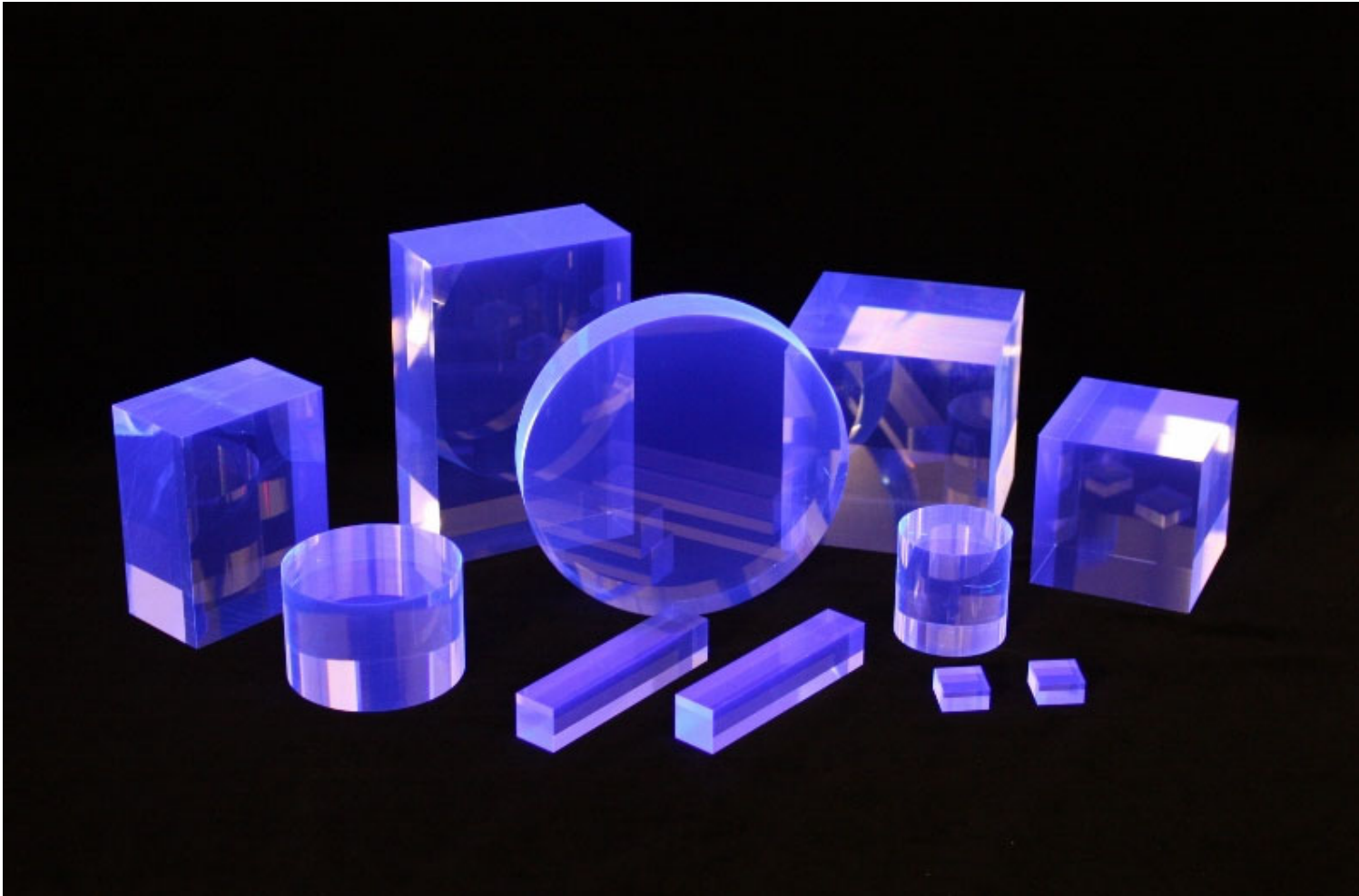
- As it happens, owing to the special relativity effect of time dilation, muons in flight appear to live much longer than those at rest.
- The proposed detector will allow us to test out this idea and to explore cosmic ray rates as a function of altitude more generally.

# Cosmic Ray Rates vs Altitude

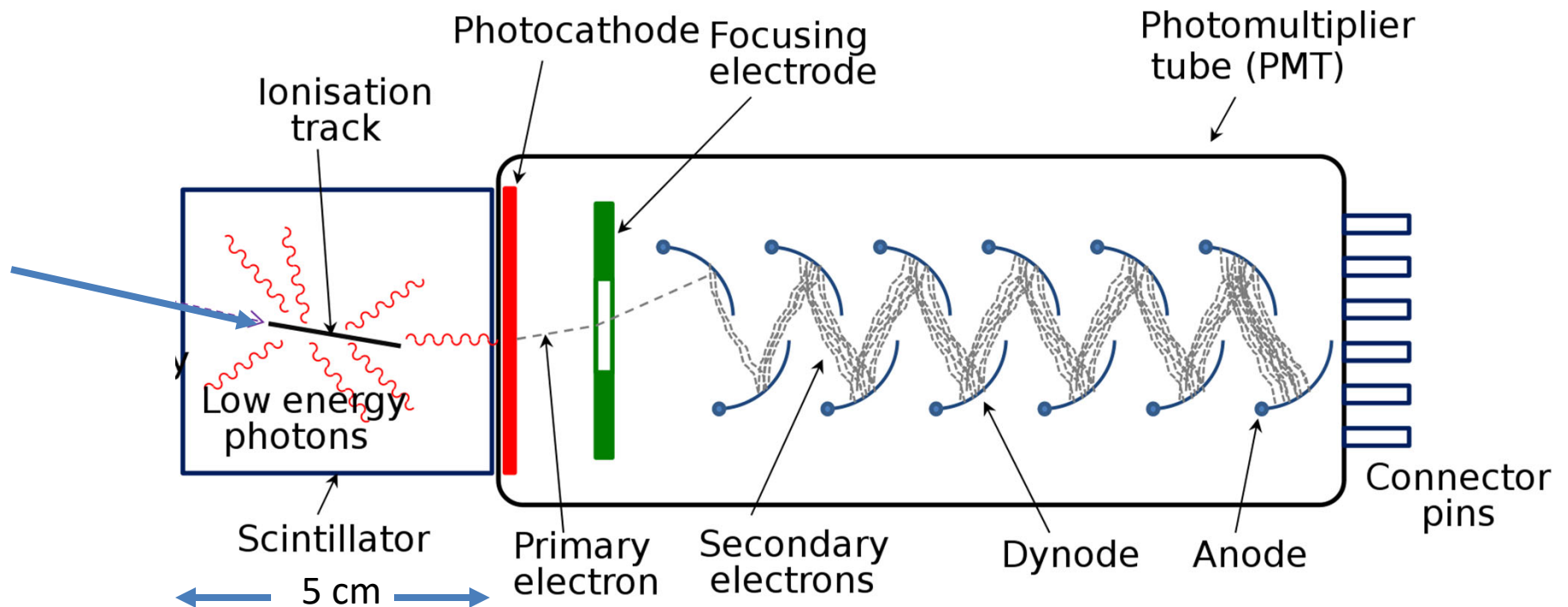




# Plastic Scintillator



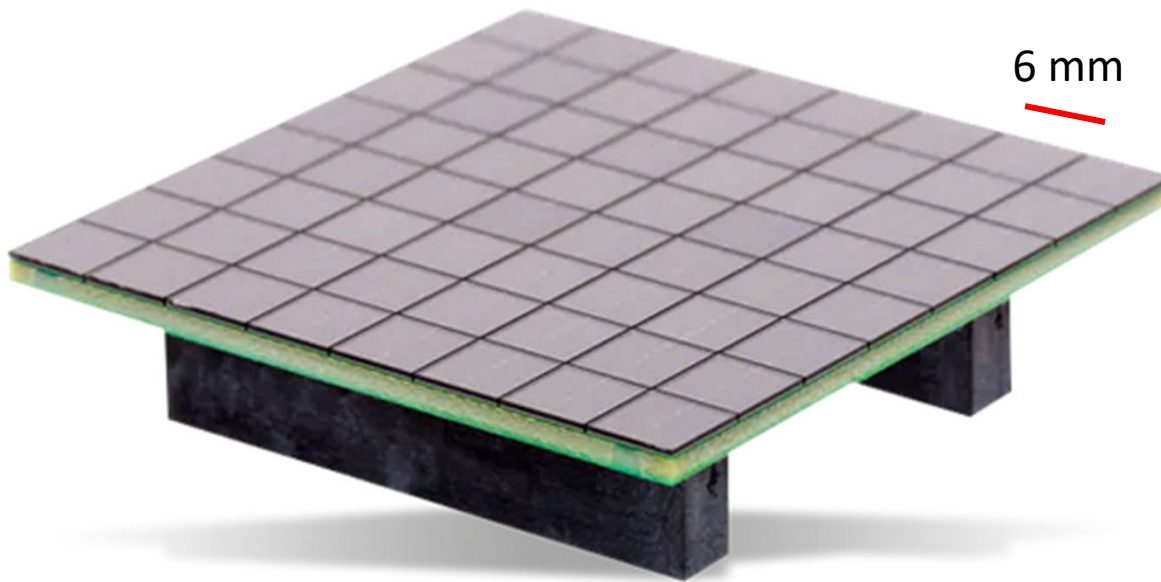
# Scintillation Detector System



Scintillation detectors have been around for a long time now. Until 5-10 years ago, most followed the design sketch above. The PMT is in many ways a wonderful device, but it tends to be bulky, heavy, expensive, and it requires a high voltage power supply (typically 1000 V or more).

# Silicon Photomultipliers (SiPMs)

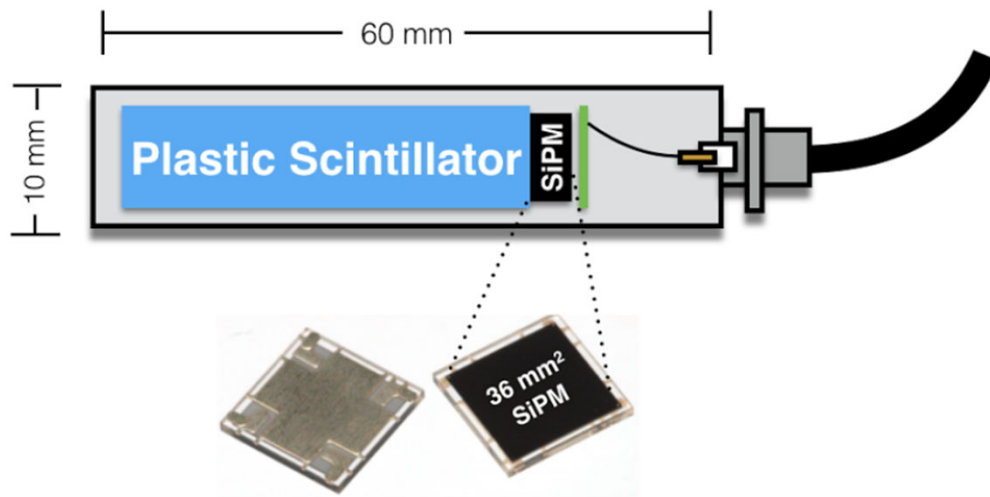
SiPMs by contrast are compact, light, inexpensive, and operate at low voltage.



The photo above shows an array of SiPMs, but for our purposes a single device will suffice.



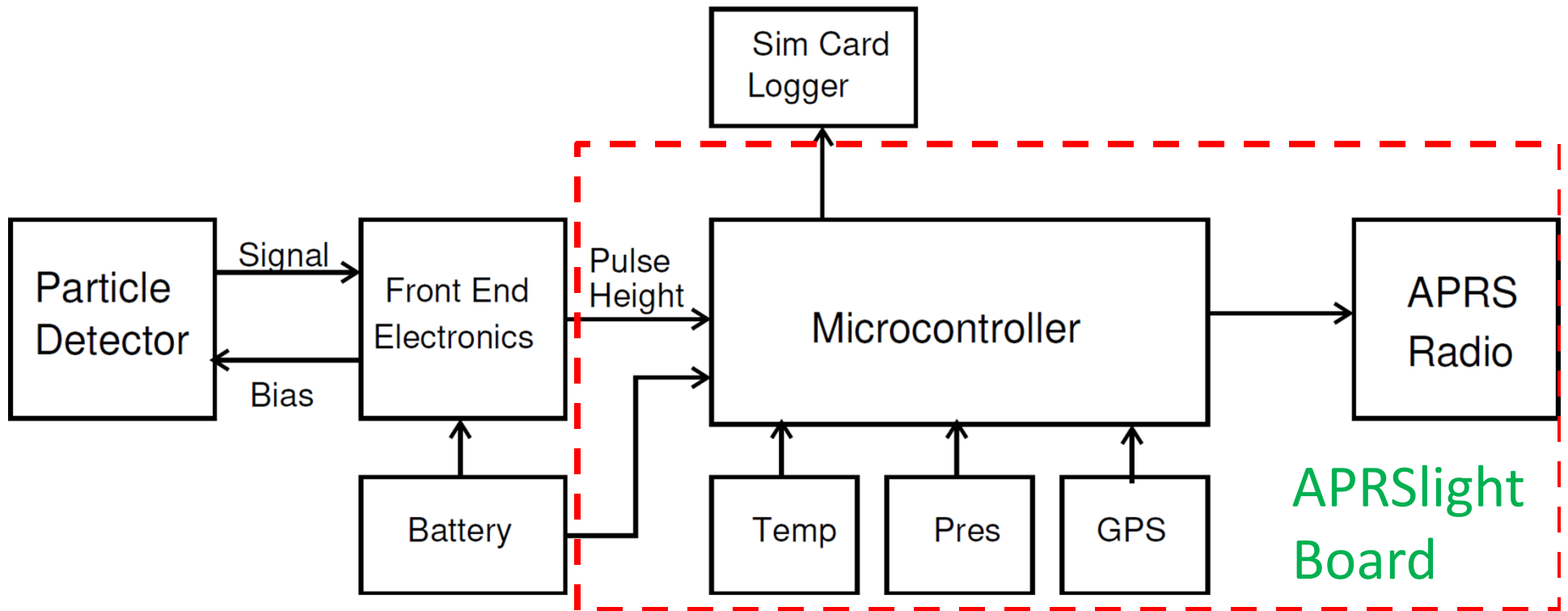
# MIT Cosmic Watch Project



The system proposed here will follow the MIT Cosmic Watch project design, with modifications to make it suitable for a balloon.

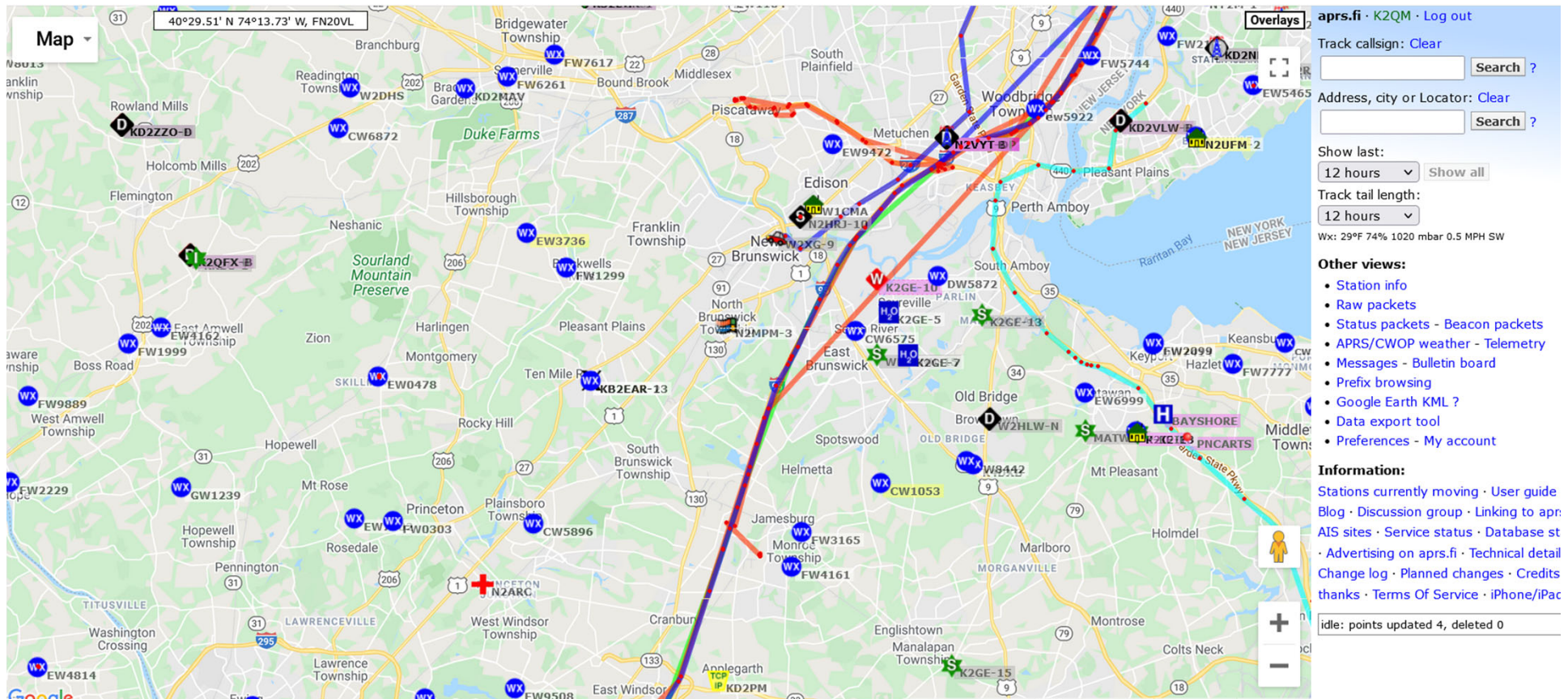
<http://www.cosmicwatch.lns.mit.edu/about#intro>

# System Diagram



<http://shop.qrp-labs.com/lightaprs>

# Automatic Packet Reporting System (APRS)



APRS is a network of amateur radio “digipeaters” that receive and rebroadcast digital packets from mobile transmitters. It is ideal for tracking hikers, vehicles, boats, balloons, and satellites.

<https://aprs.fi>