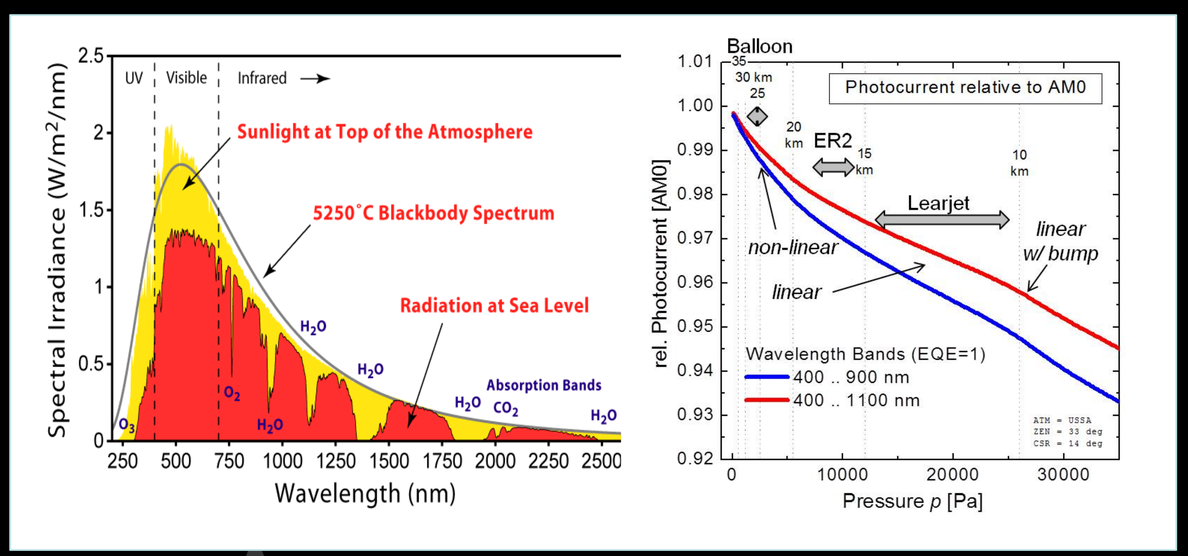
# HIGH-ALTITUDE BALLOON SYSTEM FOR SPACE PHOTOVOLTAIC CALIBRATION

JUSTIN LORENTZEN // BLACK SKY AEROSPACE SYSTEMS

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## SOLAR CELL CALIBRATION

The calibration of multi-junction solar cells and their isotype counterparts under near space conditions is an important step in the characterization and evaluation of novel space photovoltaic technologies. In order to measure solar cell performance under conditions close to those in space, high-altitude measurement platforms are necessary to overcome atmospheric absorption and scattering effects.




Left: Terrestrial and extra-terrestrial spectral irradiance [1].
Right: Photocurrent as function of atmospheric pressure and altitude. The operation altitude of various high-altitude platforms is indicated [2].

## HIGH ALTITUDE PLATFORM

BlackSky Aerospace Systems has developed a high altitude balloon-borne tracking and stabilization platform offering payload orientation control at altitudes over 30km in a rugged, FAA compliant package. The sun tracking system is capable of extremely fine control and rapid rotational adjustment, allowing for continuous high-precision and high-accuracy orientation control.

Typical tracking performance for payloads up to 700g above 26km (85kft) maintains desired sun angle within 1° **continuously** and within 0.75° greater than 99% of the time, Resulting in sun angle introducing deviations in generated photocurrent of less than 0.015%. Orientation relative to the solar position is determined by a sun angle sensor array that combines wide field of view with very high precision (~ +/- 0.01°) sensors. Multiple configurations are currently available for payloads up to 1200g.

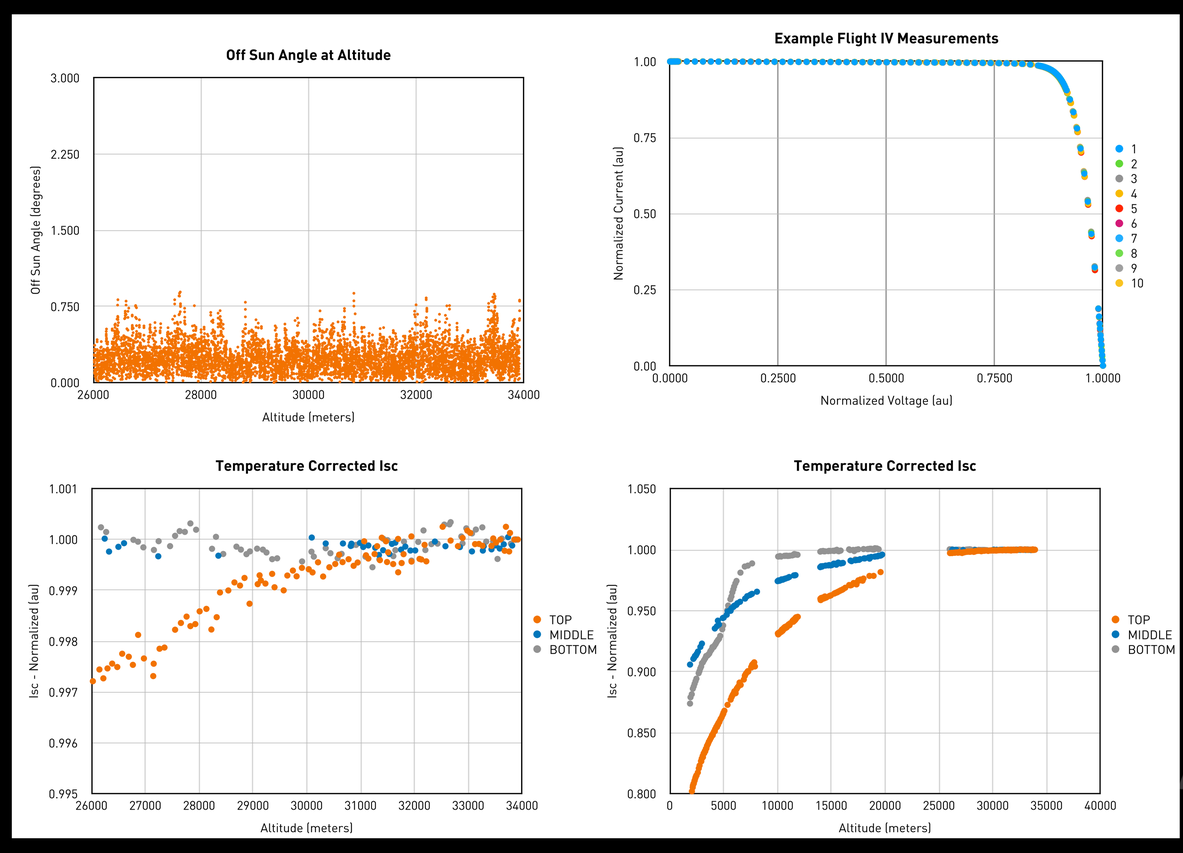
| Degrees | Tilt | Tilt % | Yaw | Yaw % | Total | Total % |
|---|---|---|---|---|---|---|
| **0.10** | 3460 | 52.4% | 2510 | 38.0% | 927 | 14.0% |
| **0.25** | 6032 | 91.3% | 4892 | 74.1% | 3828 | 58.0% |
| **0.5** | 6601 | 99.9% | 6357 | 96.2% | 6252 | 94.7% |
| **0.75** | 6605 | 100.0% | 6583 | 99.7% | 6569 | 99.5% |
| **1.0** | 6605 | 100.0% | 6605 | 100.0% | 6605 | 100.0% |

The count of all sun-angle measurements over 26km, along with the percentage this count represents of the total taken above this altitude.

## CAPABILITIES AND FEATURES

- Multiple redundant bidirectional communications systems provide highly reliable system information, control and tracking. (No payload has ever been lost)
- Small, portable system can be launched on short notice for low cost compared with traditional platforms.
- IV characterization available. Active bipolar measurements at up to 40V and 10A.
- System can be configured for 2x2cm through 15cm cells and concentrator solar cells of comparable dimensions.
- Alternate payload (spectrometers, radios, etc.) configurations are also available.
- Each IV datapoint performed simultaneously with reference voltage measurement.

## EXAMPLE RESULTS




Top Left: Flight data of the sun angle sensor shown in degrees from normal.
Top Right: Final IV measurements from flight shown, demonstrating step size progression.
Bottom Left: Isc above 26km as measured at 0V, corrected to 25C.
Bottom Right: Isc for entire flight as measured at 0V. Gaps indicate either sun angle over 3° or IV protection fault (to prevent reverse bias or other damage mechanism).

## NEXT STEPS

1. Demonstrate range of capabilities of high altitude platform with different payloads.
2. Improve range of operational conditions via guided descent and altitude control.
3. Increase payload capacity and decrease costs.
4. Provide expanded measurement capability:
   1. Active temperature control
   2. Cell biasing
   3. Off-angle characterization

References: [1] www.wikipedia.com, [2] Hoheisel, Wilt et al, IEEE-PVSC, 2014.