ER-2 High Altitude Solar Cell Calibration Flights

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Test Platform Overview

**Demonstrated Capabilities**
Altitude: 70,000ft+
Illuminated Area: 5.6 x 5.6 inches
Pointing Accuracy: <2° deviation
Temperature Control: (+/-) 0.5°C
Number of devices per flight: 12 Maximum
Cell Measurements: Isc, Voc, IV Curve
Fiber-optic Port for spectrometer or other sensor
Flight Season: April through September

**Instruments Flown**
Keithley 2425 Source/Measure Unit
Ocean Optics HR2000+ Spectrometer
Ocean Optics NIRQuest NQ512-1.9 Spectrometer
Flight Profile

Ideal Regular Season Flight Path

Finish: 55,000ft
34° 20' Parallel
Start: 65,000ft

Los Angeles

Actual Altitude Profile

Altitude vs. Time

Data Collection

Time (Minutes)

Altitude (feet)
Data Correction Method

1.) Using a models for the AM0 spectrum, daily ozone distribution, and the measured cell EQE, the measured cell Isc vs. pressure data is corrected for residual ozone.

2.) Pressure is converted to airmass and a modified Langley plot method is used to extrapolate the zero pressure cell Isc.

3.) Corrections are made for earth-sun distance and solar elevation angle.
Corrected Isc Results

- Data shown for GRC 2x2cm ZTJ sub cells (two top cells and one middle)
- Ozone corrections based on established Learjet methods
- Further atmospheric correction methods are being investigated
  - SMARTS or other ozone models
  - Using only higher altitude data
  - Ozone correction coefficients using cell EQE data
IV Curves show good repeatability over multiple flights and a predictable change with pressure.
Device Temperature Control

- Mounting Plate temperature is used for heater feedback control
- All cell temperatures are monitored independently using AD590 IC temperature transducers
- After a slight bump caused by initial solar illumination, all cell temperatures were maintained within approximately 0.25°C from the target of 25°C
- Variation of temperature for any individual cell was on the order of 0.1°C after the initial on-sun disturbance
Sun Pointing
Summary ER-2 Campaigns

- Fifteen flights have been flown between October 8\textsuperscript{th} 2014 and May 15\textsuperscript{th}, 2017
- Data taken between 55,000 and 70,000 feet
- Around sixty unique devices tested
- Cell sizes flown include (in cm) 2x2, 4x8, 8x8 and 6x13
- Cell technologies include sub cells and full stack from 3-junction to 5-junction

Twelve 2x2cm cell configuration

4x8, 8x8 Configuration

6x13 Configuration
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Summary ER-2 Campaigns

GRC Isc Historical Data, ZTJ Sub-Cells (mA)
Recent Updates

- Ground test stand was built to test PV instrument in a flight-like electrical configuration
- New wiring harnesses built by AFRC technicians were integrated into the instrument
- Software developed to automate and formalize process of AM0 Isc extrapolation (SCHACK)
- Collimation tube baffles redesigned to further eliminate glare
- 2017 season saw six flights with 28 unique cells flown
Summary of ER-2 Capability

- Flights can be conducted once every one to two days during a campaign
- Flight season runs from April through September
- Twelve 2x2cm cells can be flown per flight, or any other configuration that fits inside of the 14.2x14.2cm illuminated area
- This capacity could be doubled if the second ER-2 pod is used
- Data supplied includes Isc, Voc, IV curve, and cell temperature
- Other optical or atmospheric sensors can be flown as able
Questions