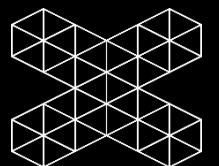




BEXUS23 OSCAR: Solar cell I-V monitoring system for space environments

Steven Nagels

23d ESA Symposium on European Rocket and Balloon Programmes and Related Research





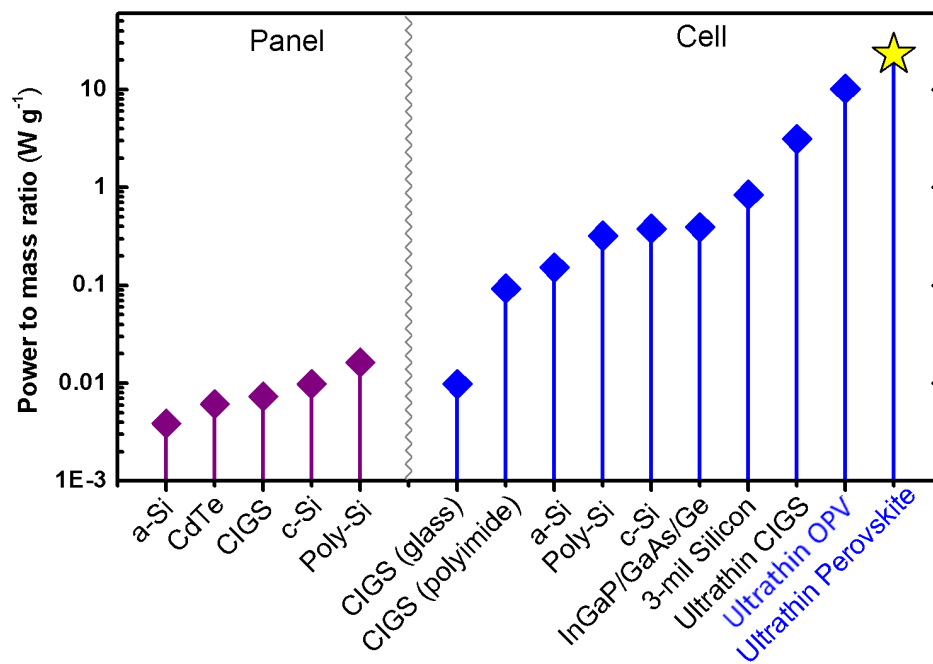
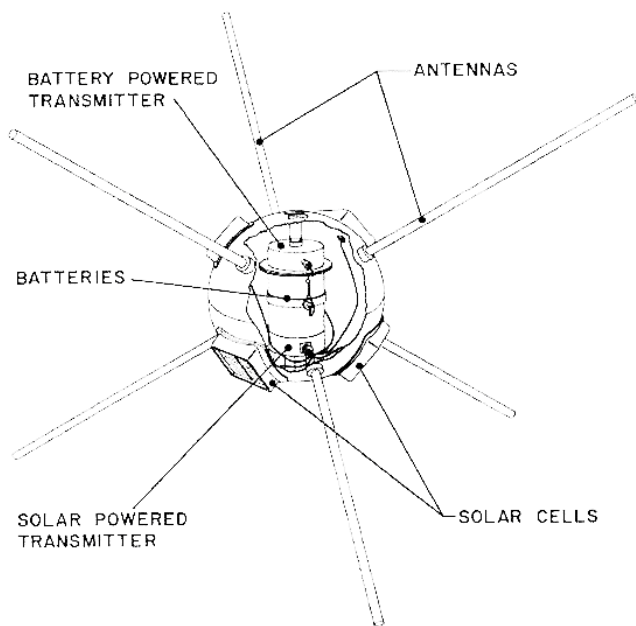
Who is OSCAR?

Our mission

Optical Sensors based on **CAR**bon materials

Thin film solar cells

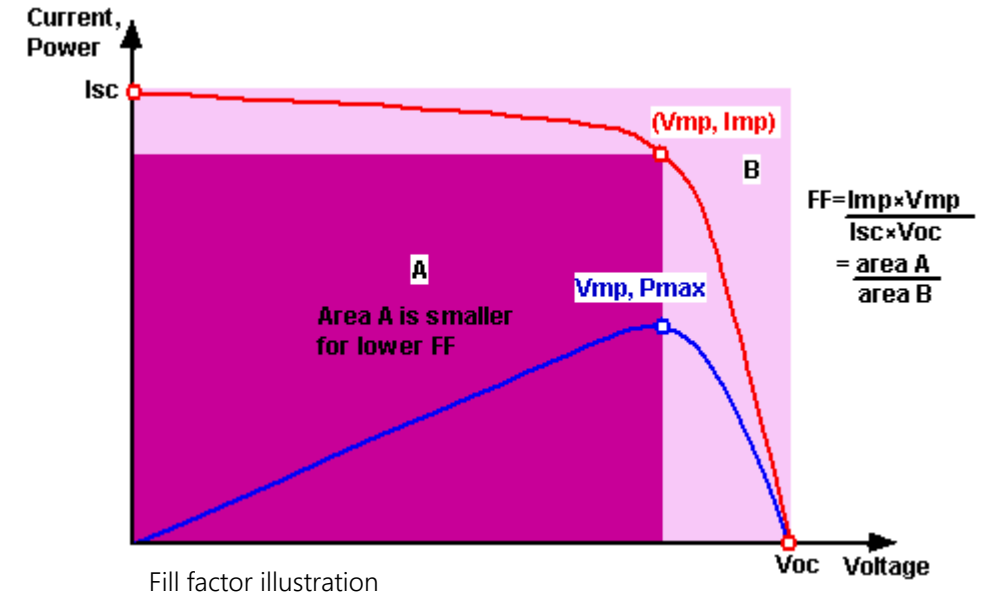
Diamond magnetometer



Adapted from: Kaltenbrunner *et al.*, Nat. Mater. 1032-1039(2015)

Our samples

#	Cell Type	V range	I range
A	IPV	0.00 --- 7.00V	-119 --- 411mA
B	MAPI	0.00 ---- 1.00V	-6.75 --- 3.50mA
C	PBDTTPD PCBM	0.00 --- 1,00V	-3.00 --- 14.0mA
D	CPDTQx PCBM	0.00 --- 0.85V	-3.00 --- 3.50mA
E	IAPP F4 SnPc	0.00 --- 0.85V	-1.07 --- 2.80mA
F	IAPP DCV5T ZnPc	0.00 --- 1.00V	-1.05 --- 2.10mA

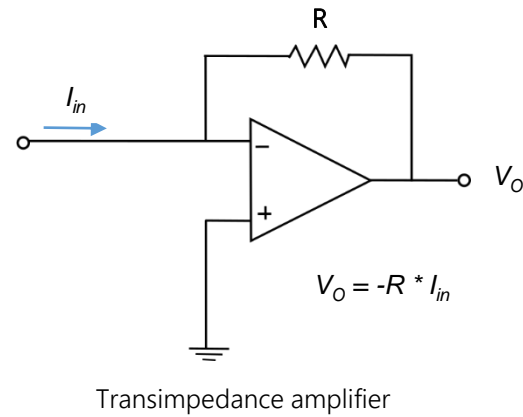
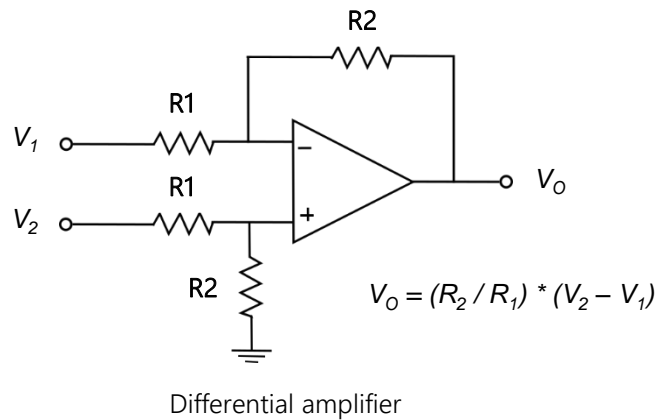


Measure 20 I-V point couples per sweep

Observe cell performance by monitoring fill factor from I-V curve

Basic system

OPAMP based conversion circuits



12 bit DAC

apply voltage

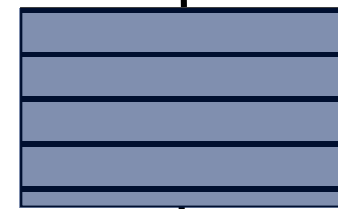


voltage



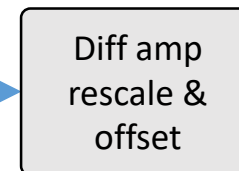
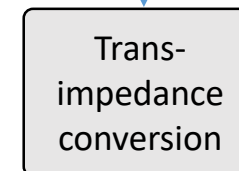
measure voltage

12 bit ADC



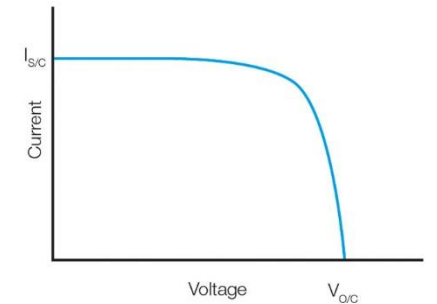
solar cell

current

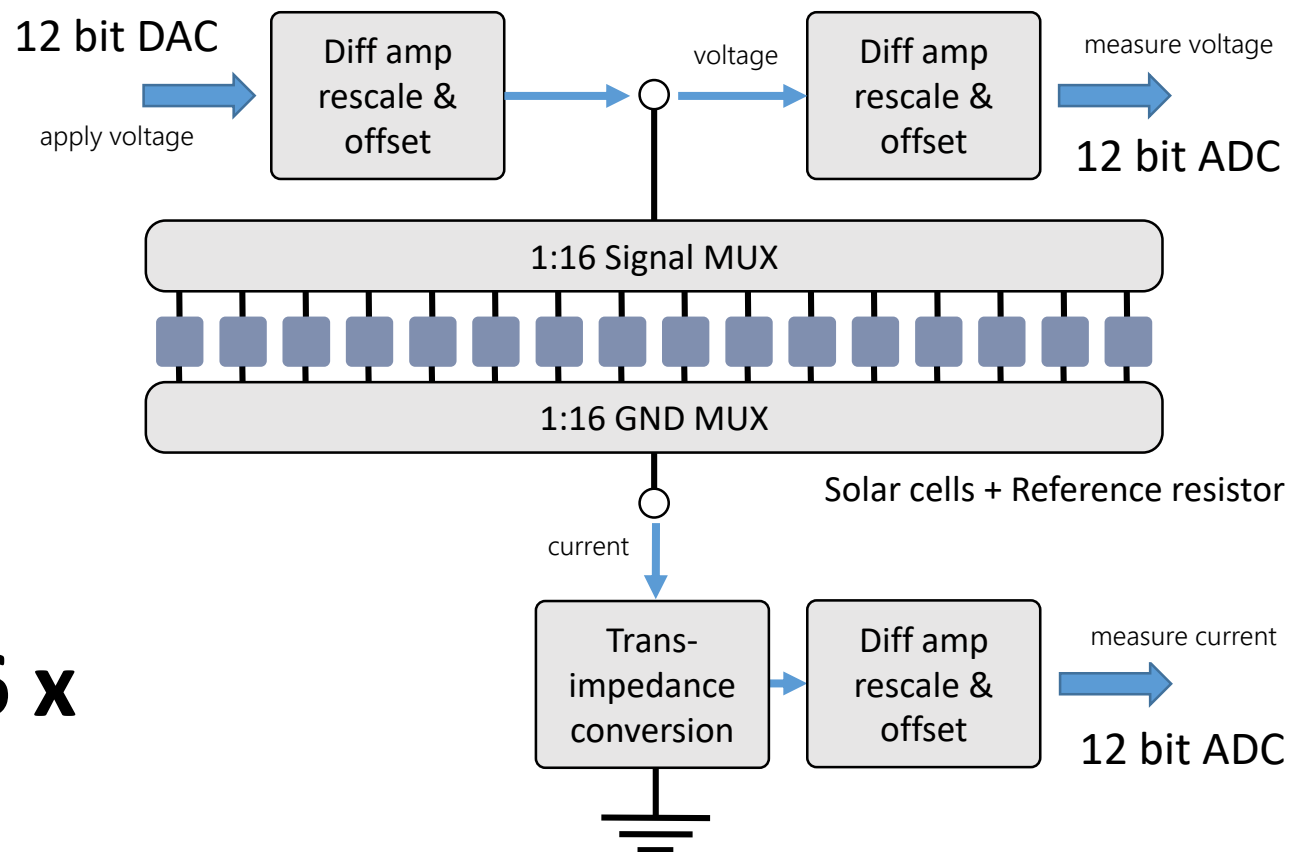


measure current

12 bit ADC



Expanded system



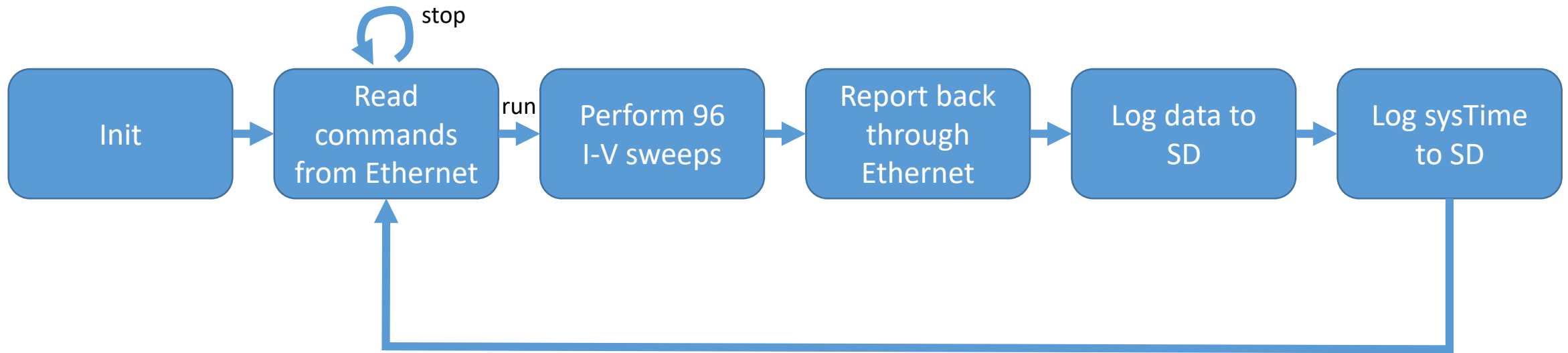
Type	V range	I range
1x IPVSTRETCH	0 --- 7.00V	-200 --- 500mA
2x BCF	0 ---- 1.00V	-6.0 --- 14mA
3x DEdiode	0 --- 0.85V	-5.0 --- 5.0mA

Measuring ranges of each subcircuit

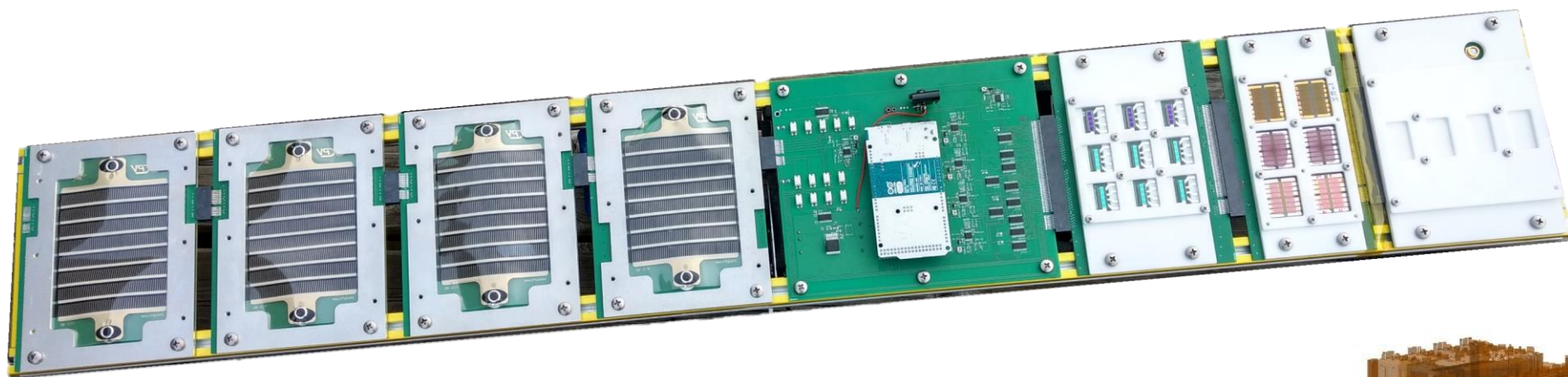
Type	V LSB	I LSB
IPVSTRETCH	1.709 mV	170.9 uA
BCF	0.244 mV	4.883 uA
DEdiode	0.208 mV	2.441 uA

Theoretical resolution of each subcircuit

Software flow



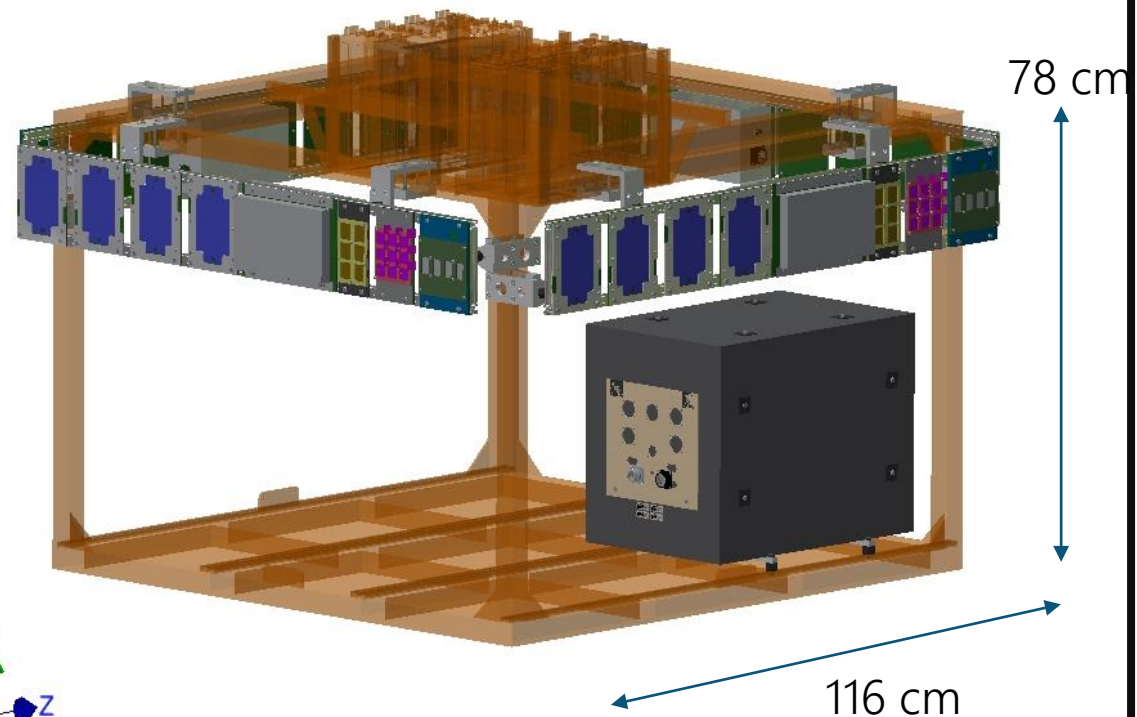
Electromechanical codesign



Brackets + spring loaded contacts

Edge connectors

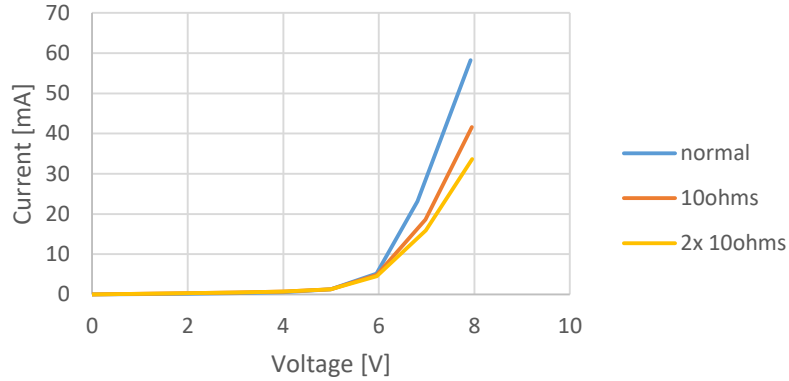
RF shielding



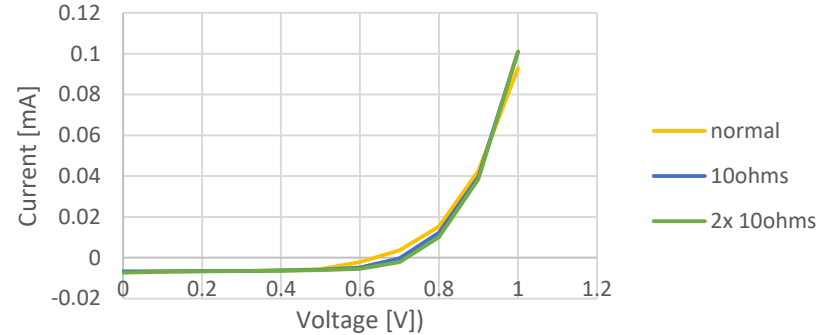
Testing

Series resistance influence

Influence of series resistance on IPV

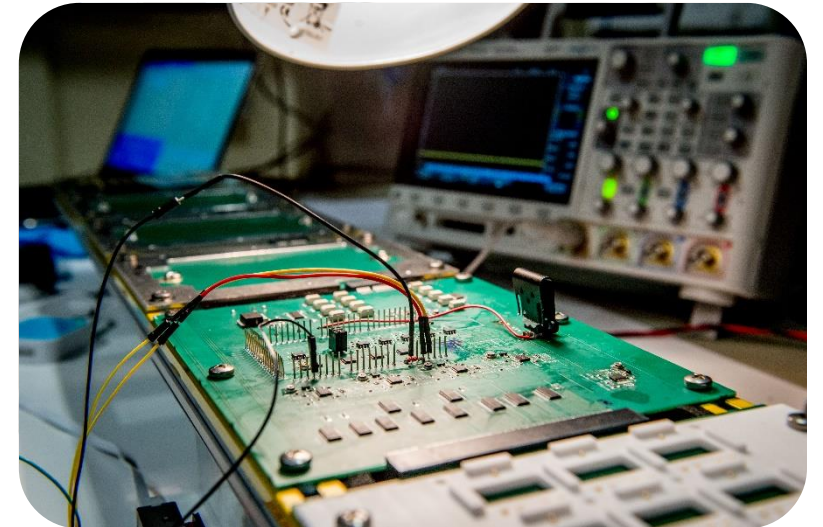
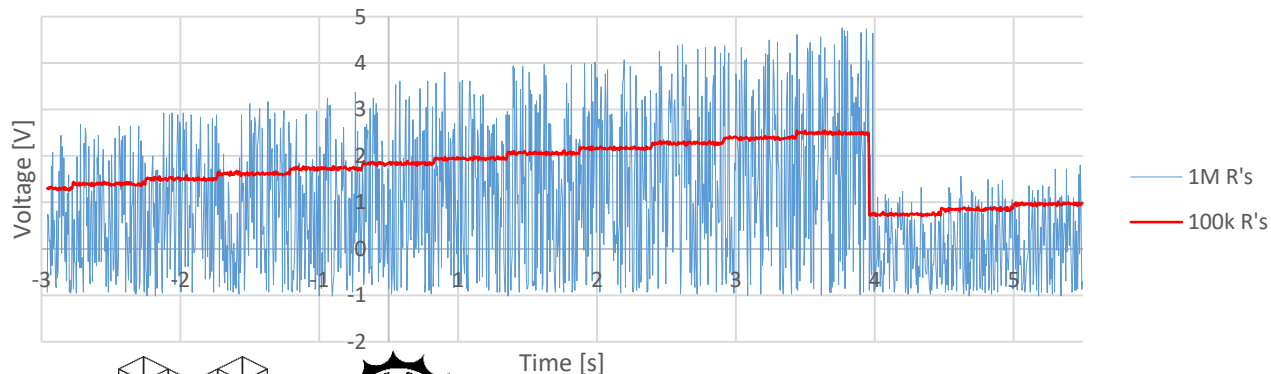


Influence of series resistance on MAPbl



Opamp ringing

BCF1 IMEAS diff amp stage 2



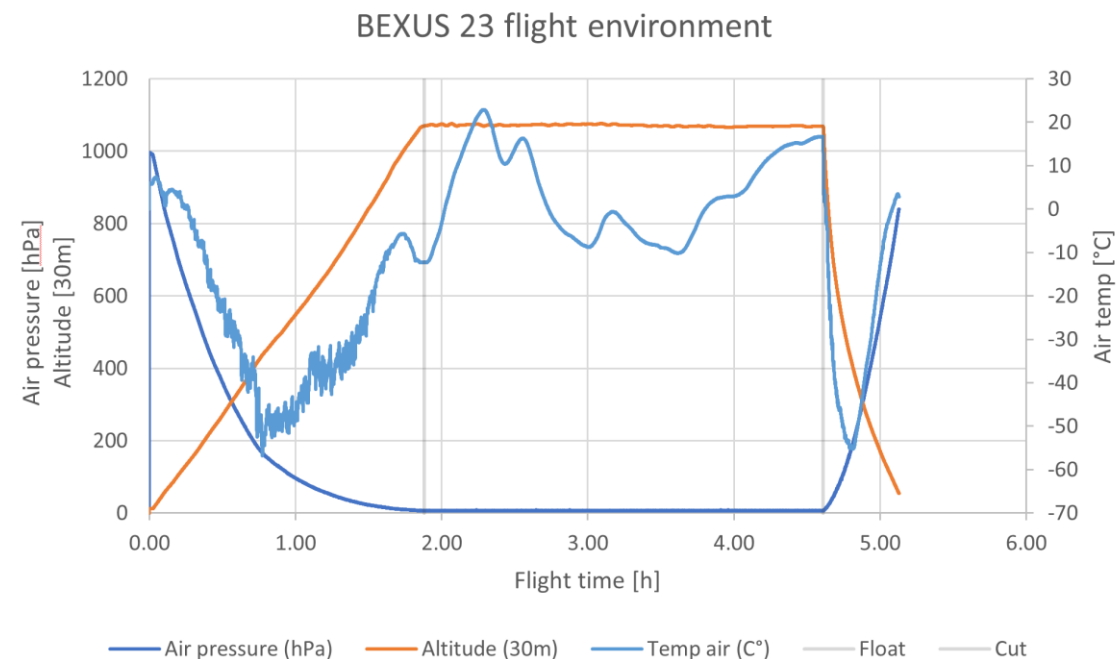
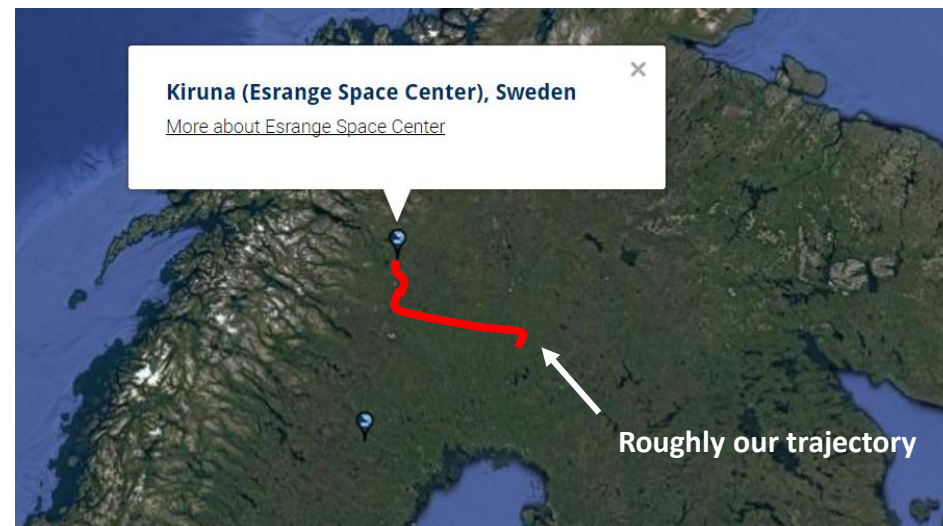
Flight

7th of October 2016

07:07:26 UTC

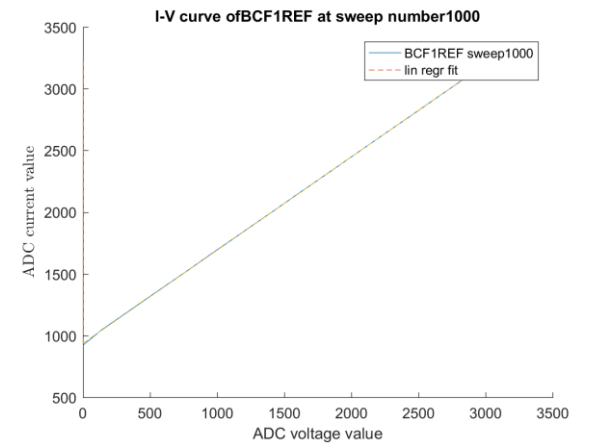
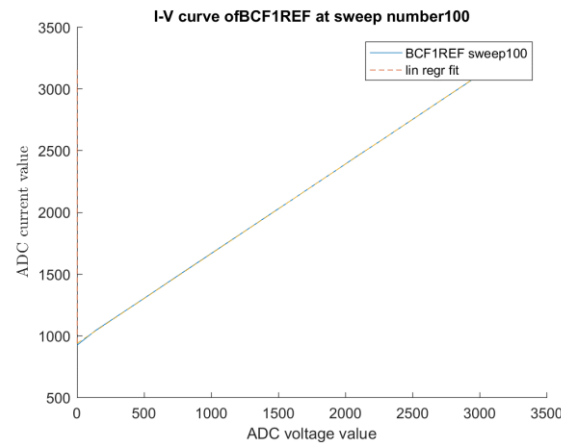
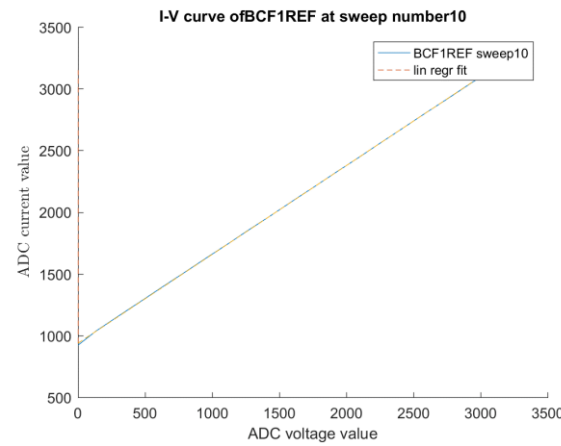
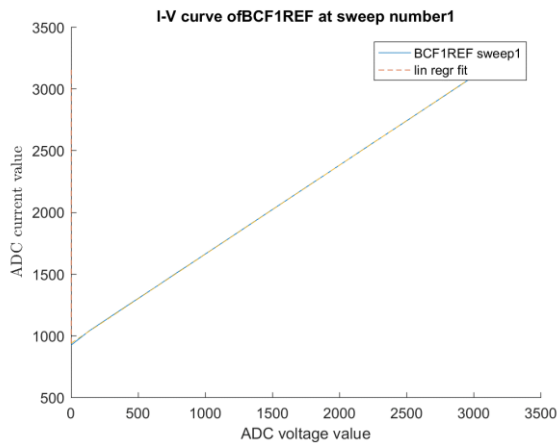
	Min	Max	Unit
Float time	1.88	4.61	h
Air pressure	6	997	hPa
Altitude	333	32290	m
Temperature	-56.8	22.9	°C
Vert. speed	-44.4	5.9	m/s

Nominal operation
until battery drainage



Results

I-V sweeps from reference resistors

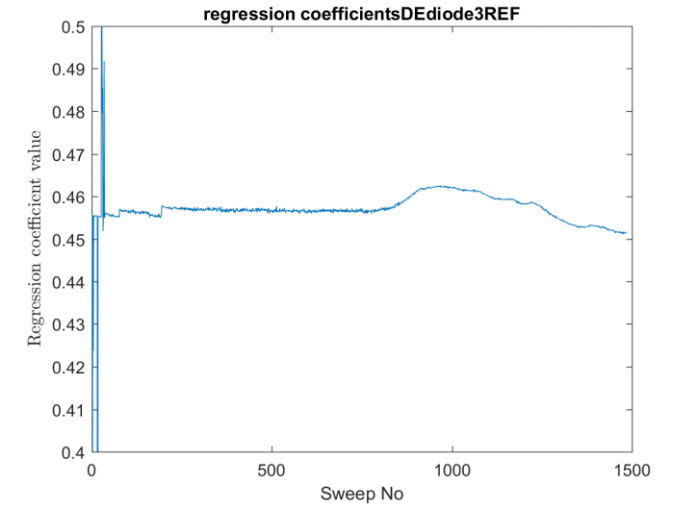
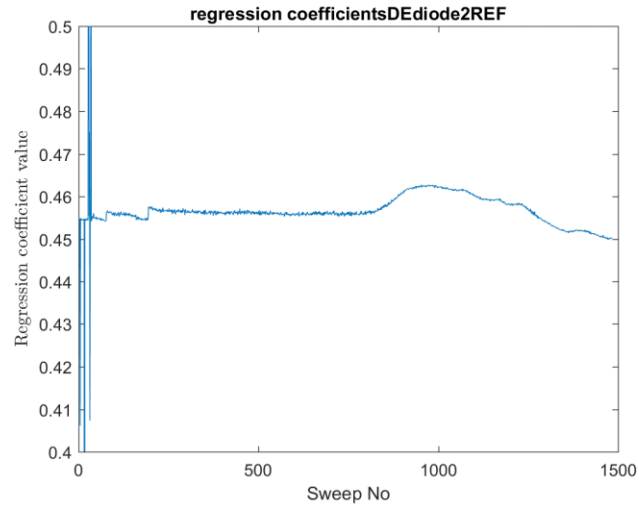
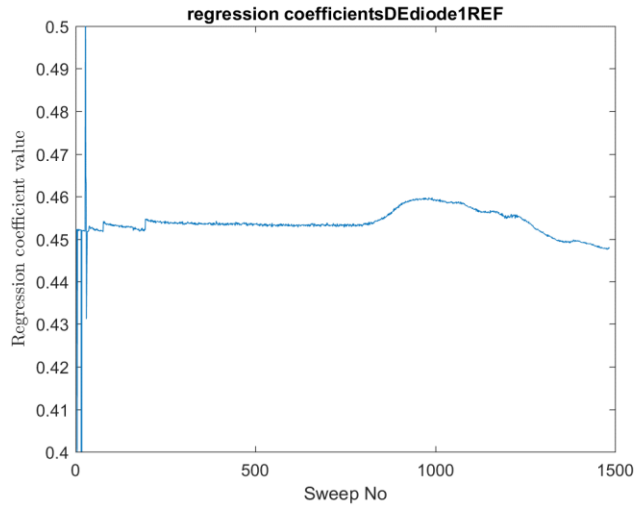
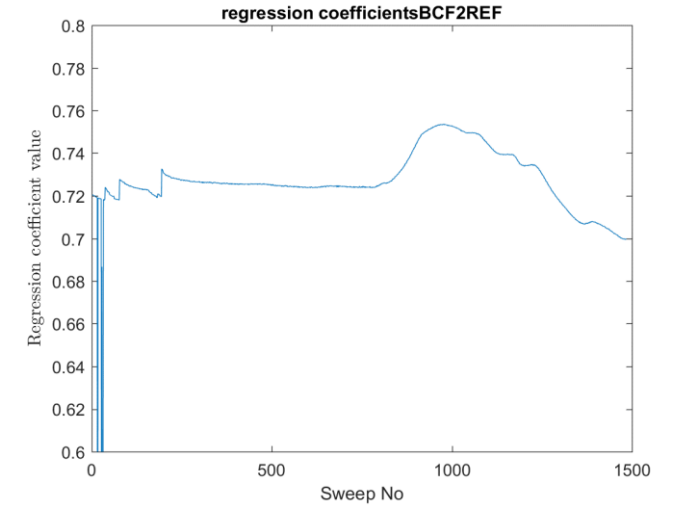
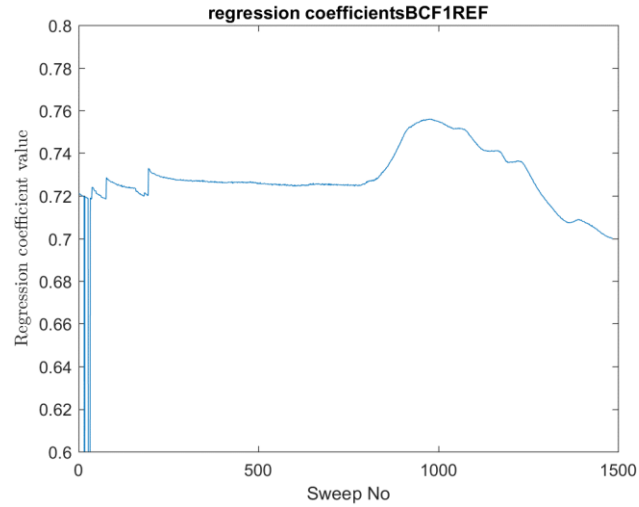


Sweeps at different moments in time

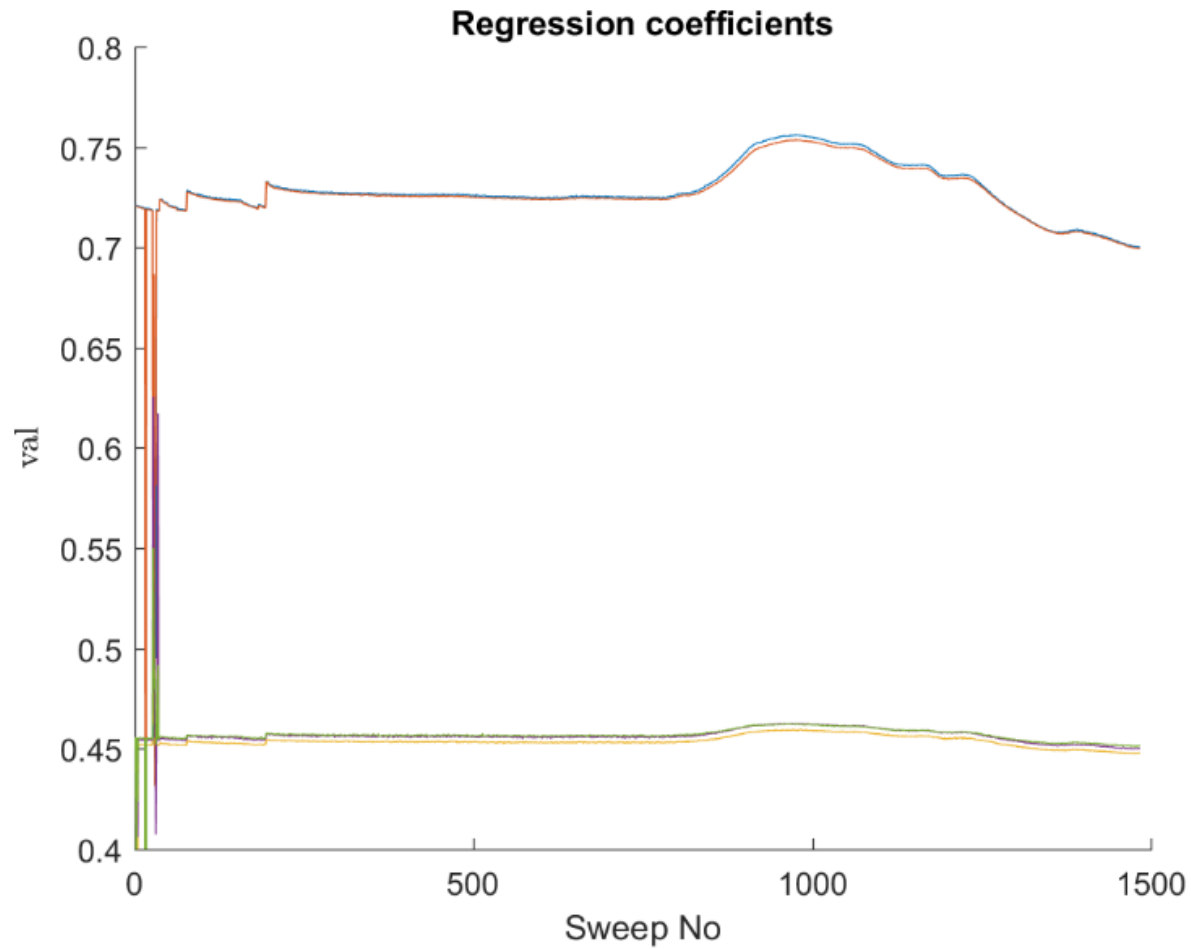
Slope = indication of R = measurement system performance indication

Results

Reference resistance measurements throughout flight

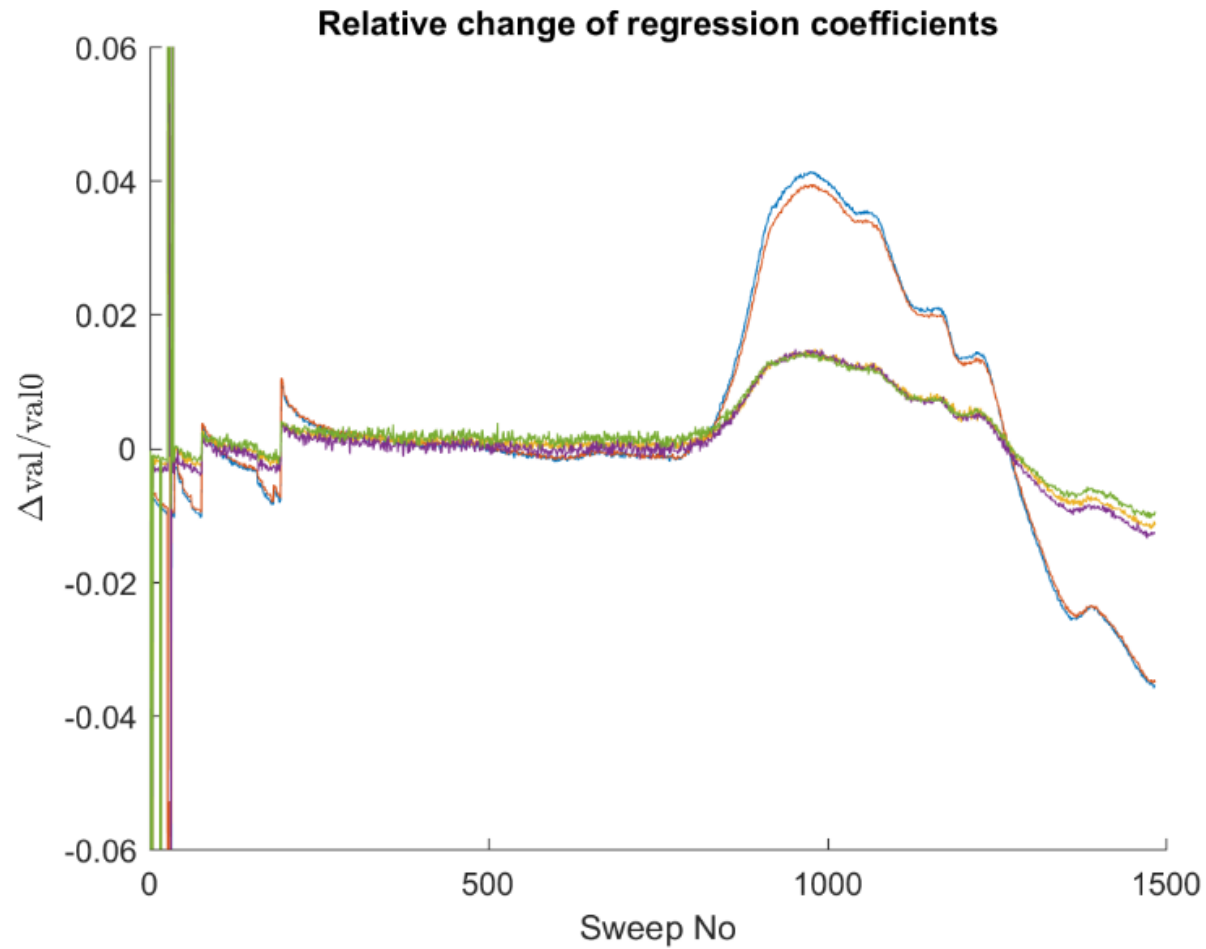


Results



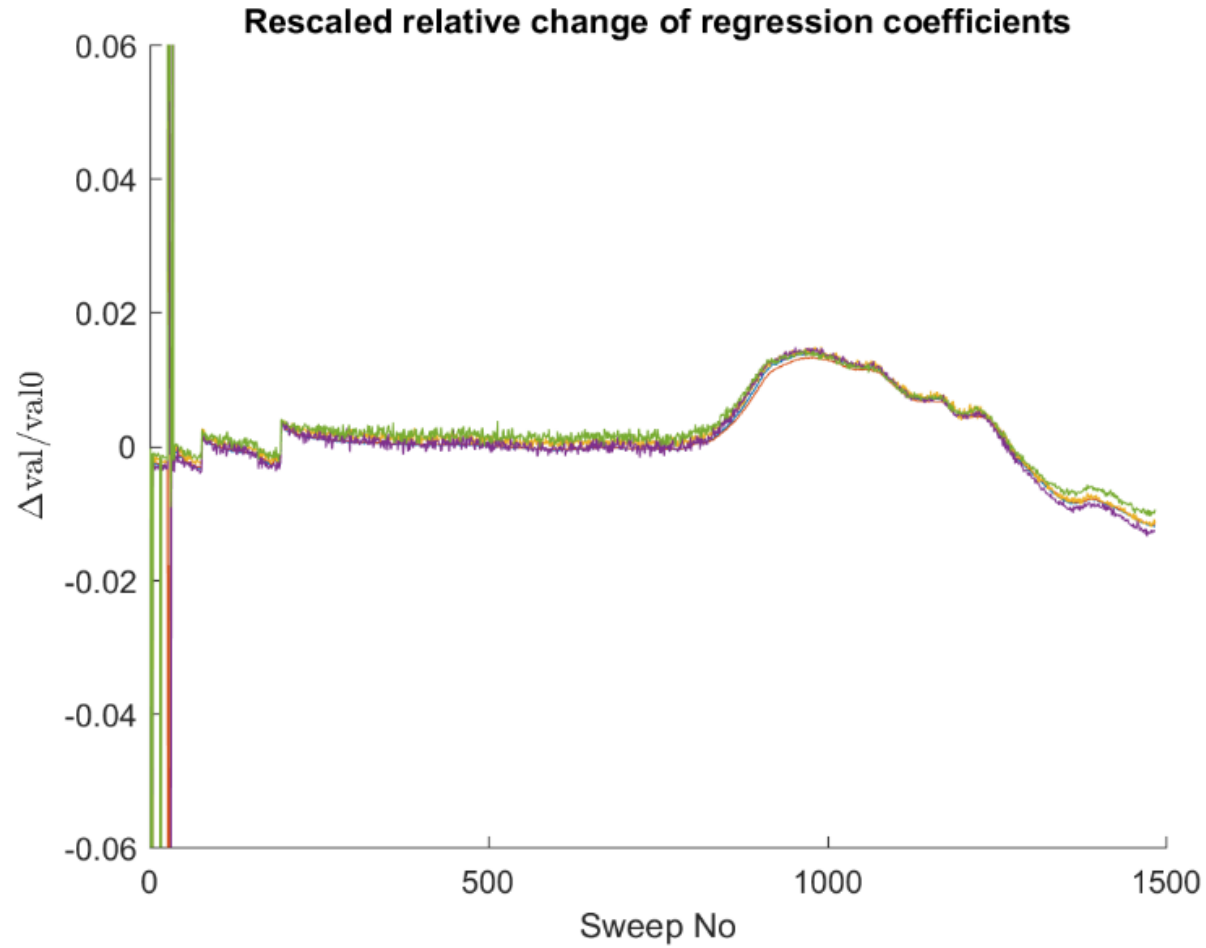
Each of the 5 channels on one graph

Results



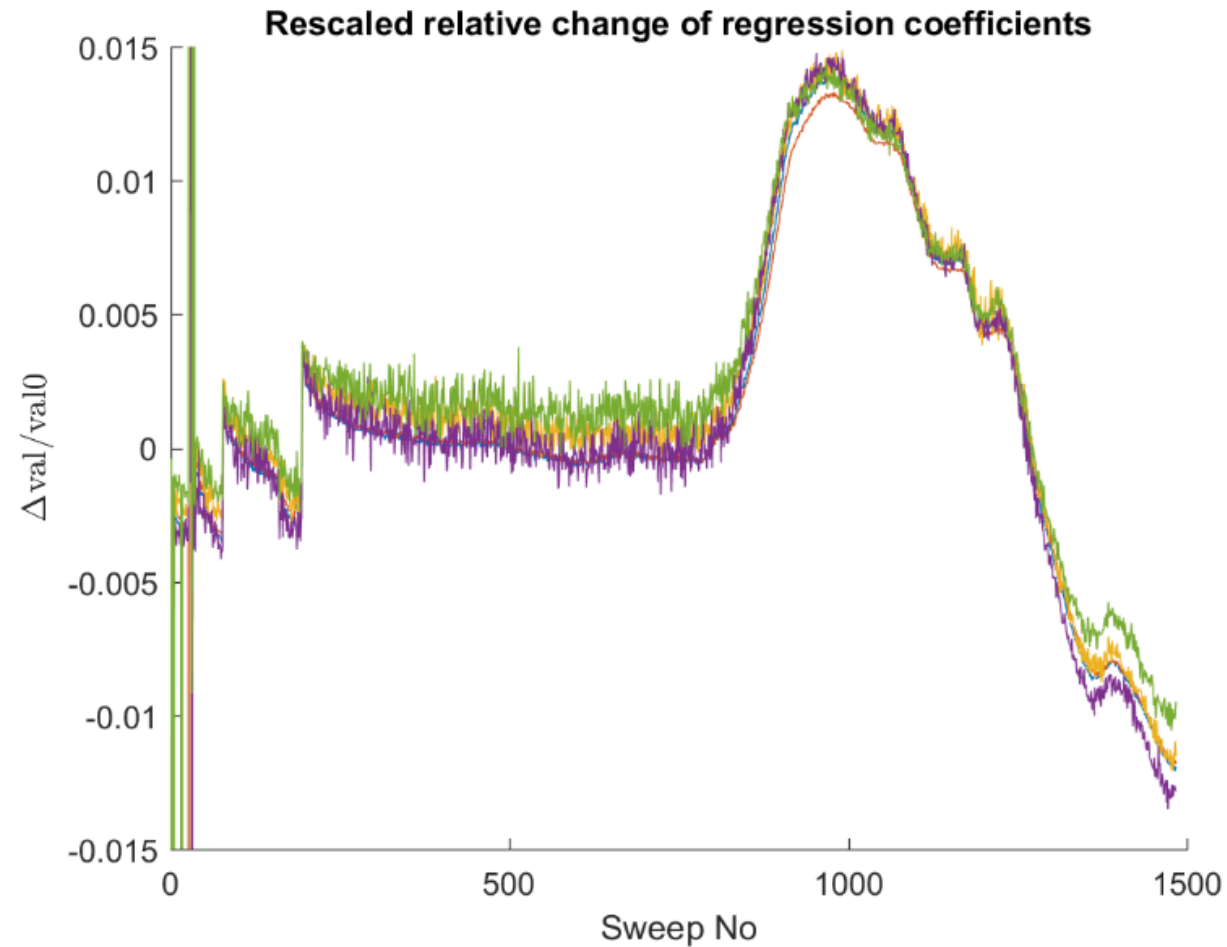
Plotted for relative change, gain error identified

Results

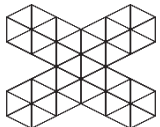


Gain error corrected

Results



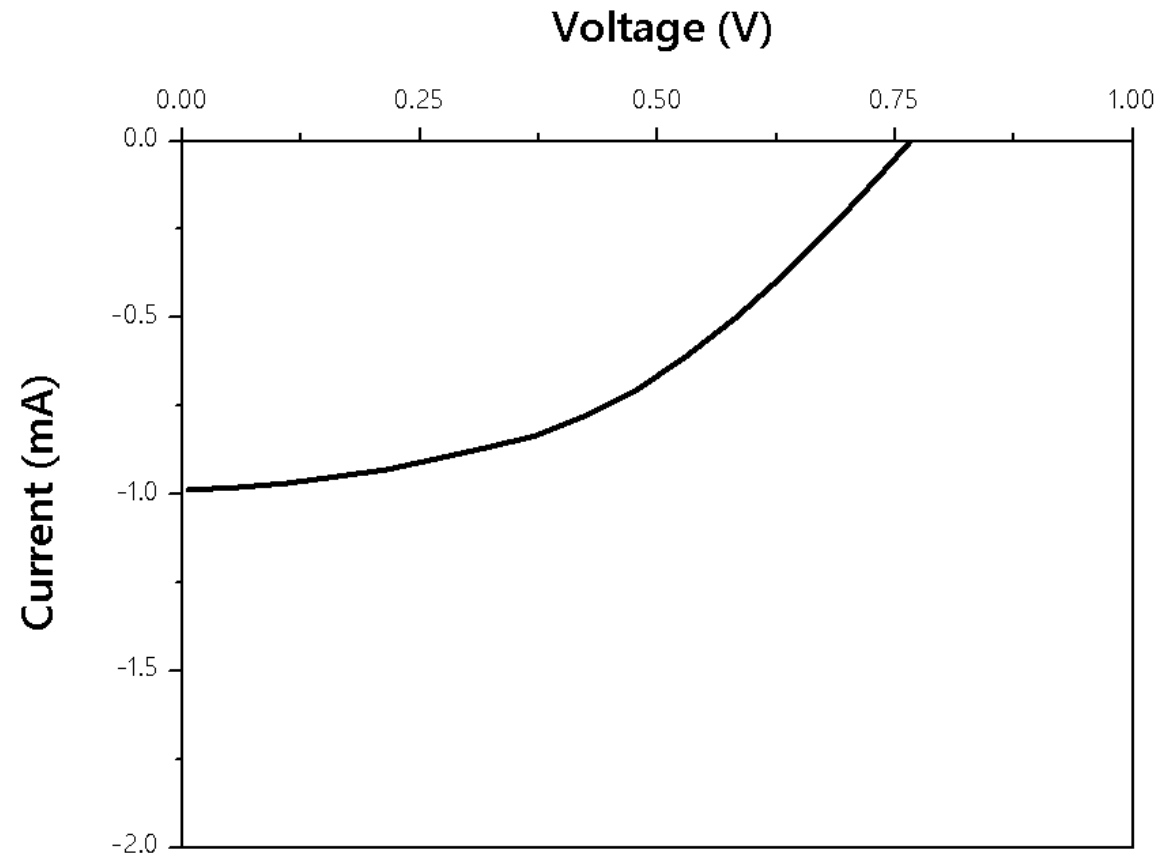
Gain error \sim temperature effect (different TC)



Results

Spin-coated polymer:fullerene PV

Performance remains stable throughout the flight

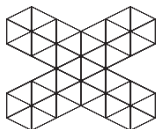


Cardinaletti *et al.*, manuscript in preparation



UHASSELT

KNOWLEDGE IN ACTION

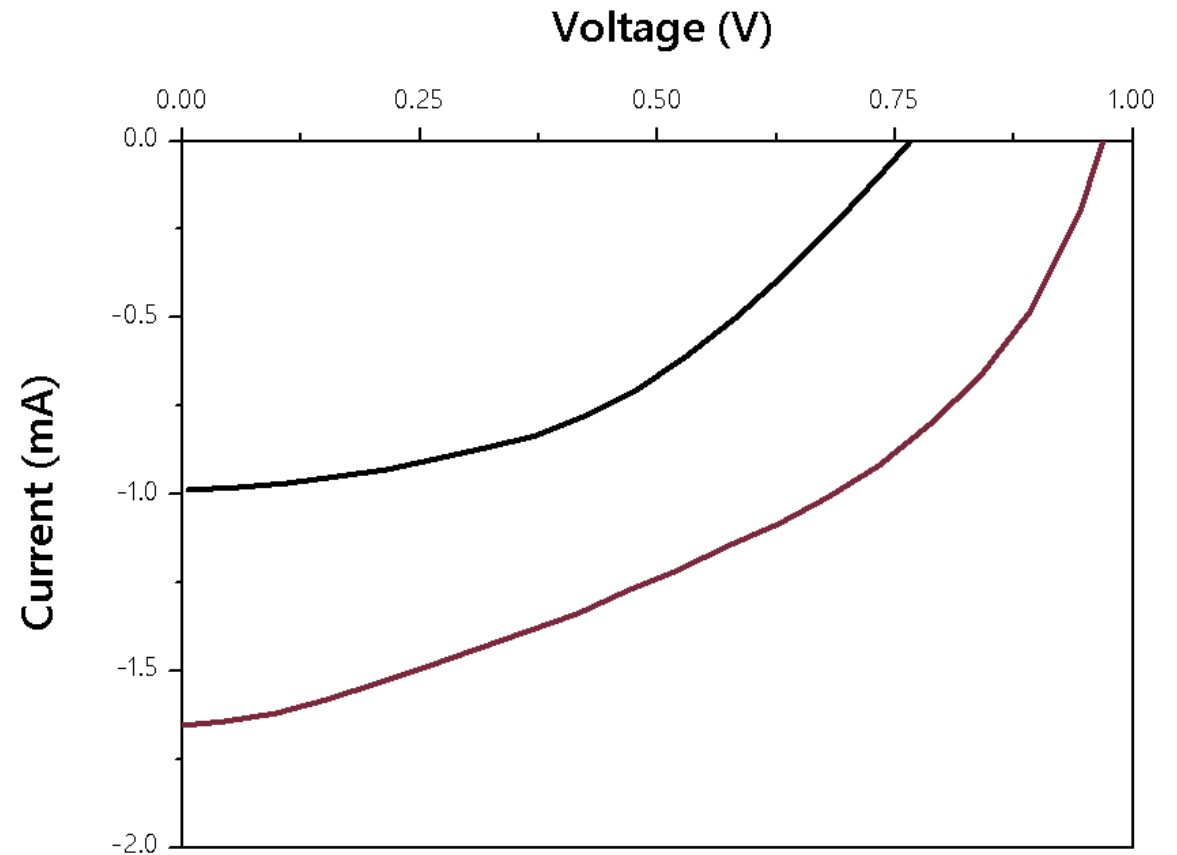


SCAR

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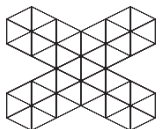


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UHASSELT

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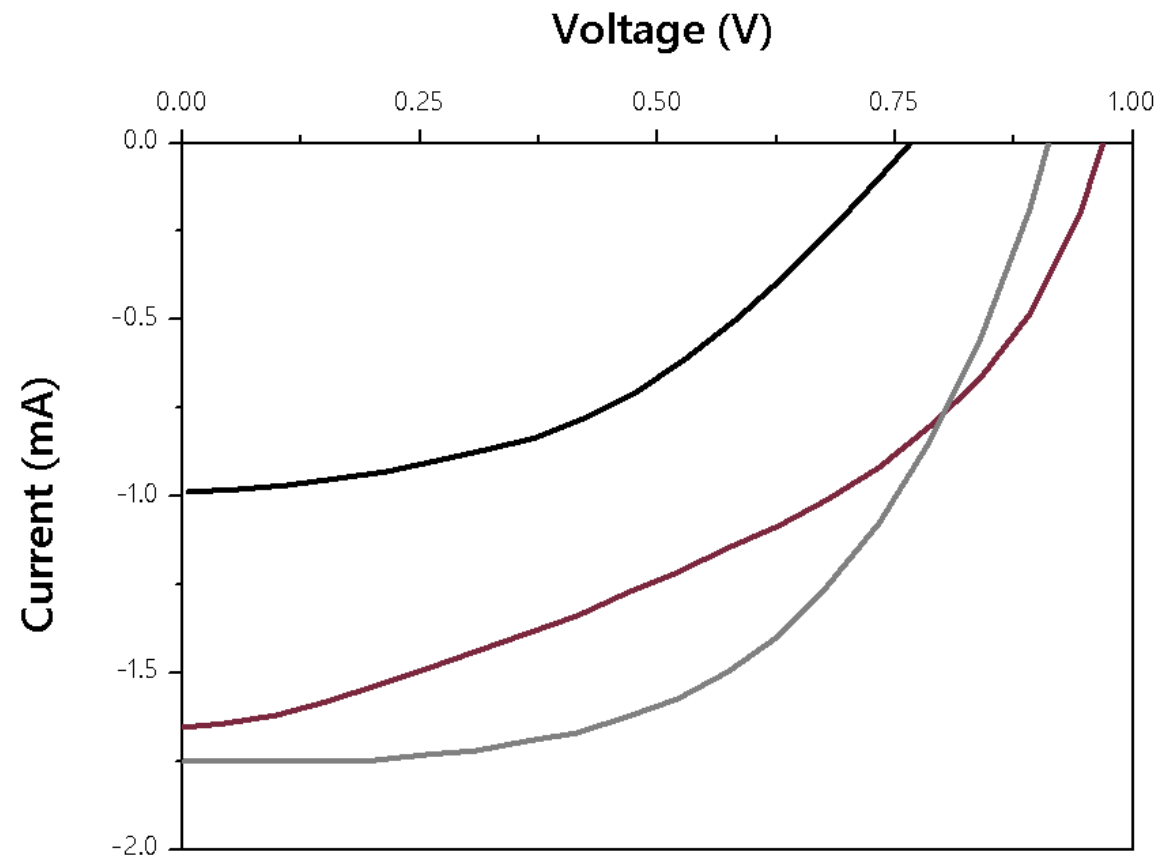


SCAR

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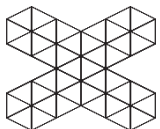


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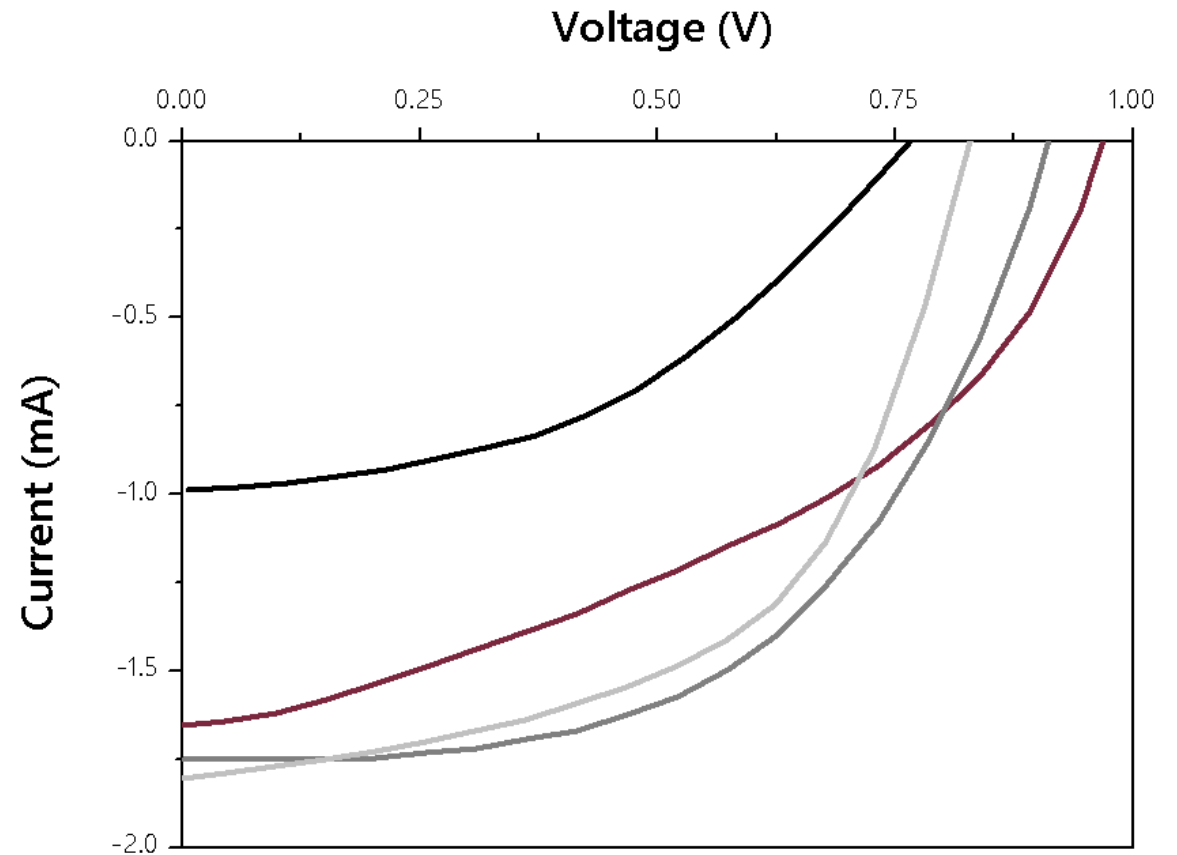


SCAR

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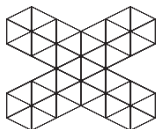


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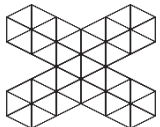
KNOWLEDGE IN ACTION



SCAR

Conclusions

- Successful flight
- Many stray variables afterwards
- Organic solar cells did not degrade drastically during flight
- Better in-flight calibration of measuring system was needed



Future work

- Study degradation over longer periods of time (SPB?)
- Study degradation at higher altitudes/more space-like conditions

Advice

- Measure and log your sample's direct environment
- Put measuring unit in thermally controlled housing
- Use separate test equipment and calibrate your complete system
- Keep a uniform timebase between all your subsystems
- When filtering, log some unfiltered data to monitor filter performance
- Perform offset compensation on opamps

BEXUS23 OSCAR: Solar cell I-V monitoring system for space environments

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