



Plextronics OPV Outdoor Testing

Mike Pannone, Eric Karplus*, Darin Laird, Min Xiao

** Science Wares, Inc.*

Acknowledgement:

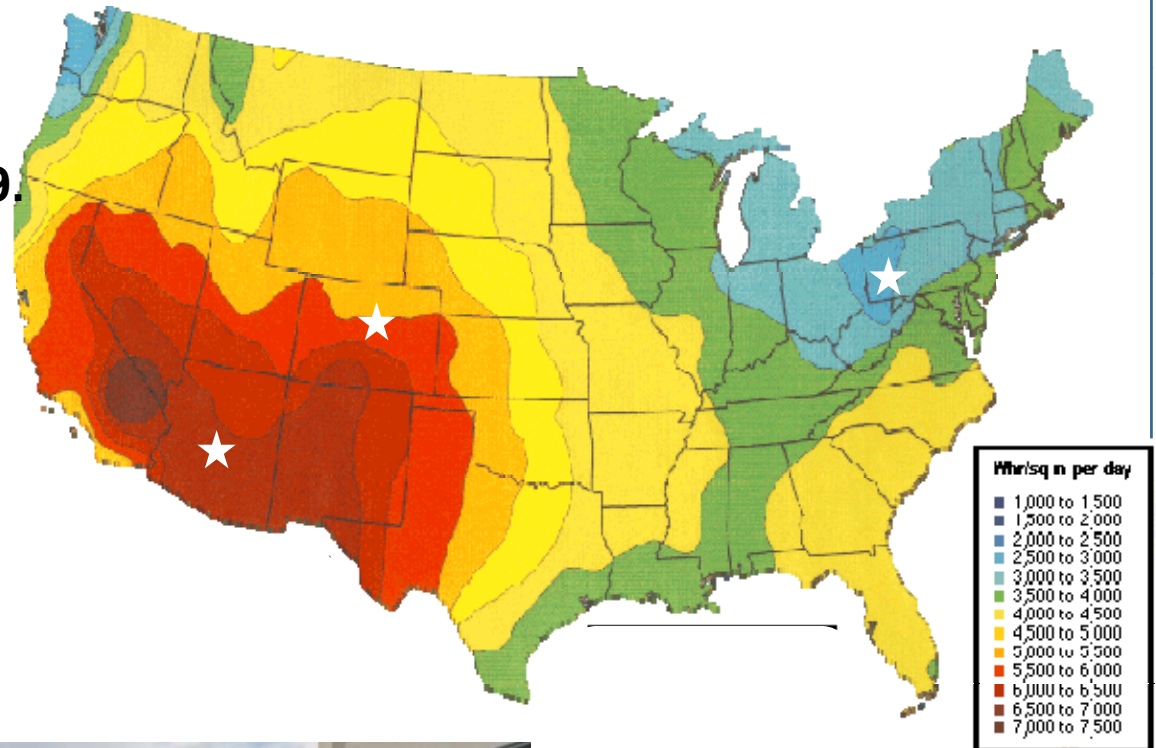
Joseph Del Cueto, Jose Rodriguez

PV Reliability Workshop, Feb. 16-17, 2011

This presentation does not contain any proprietary or confidential information.

Overview

- Plextronics started OPV outdoor testing since mid-2009.
- In Dec. 2009, 30 R&D modules were placed at three outdoor stations.
- We report here the results of these modules and lessons learned.

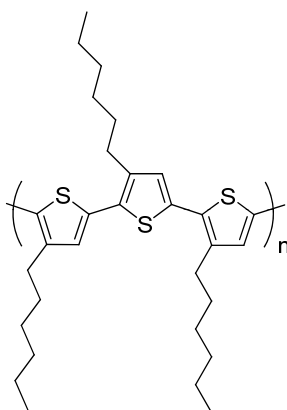
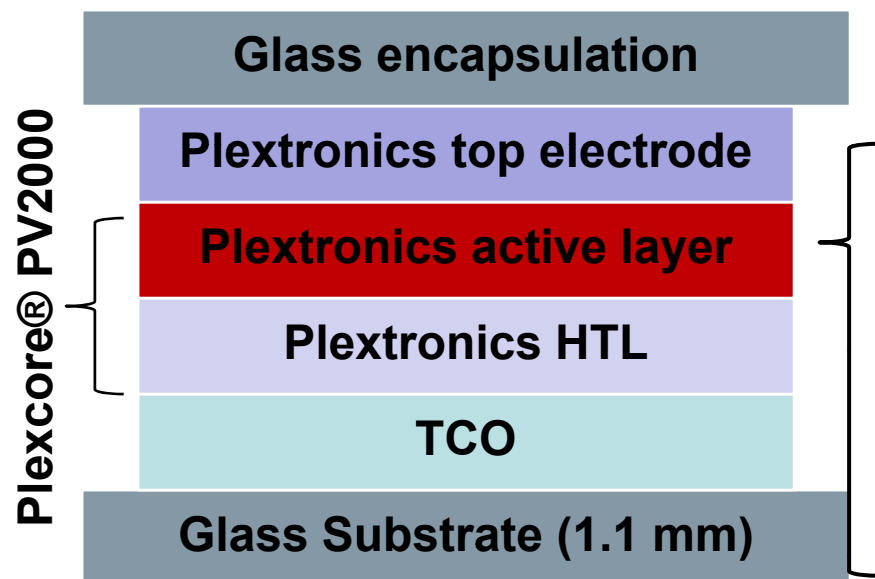


Device Description

- ❑ R&D modules
- ❑ Size: 6" x 6"
- ❑ 9 cells in series per column
- ❑ 6 columns in parallel

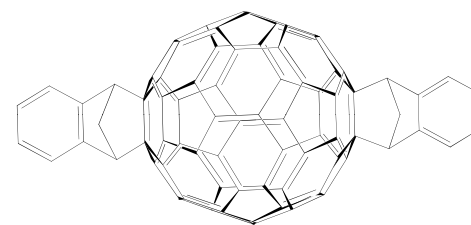
Initial Performance	Average	Range	
Jsc (mA/cm ²)	7.75	7.19	8.19
Voc (V)	6.82	6.2	7.0
FF	0.55	0.33	0.63
Efficiency (%)*	3.13	1.81	3.73

*Efficiency based on active area.



HT RR-P3HT

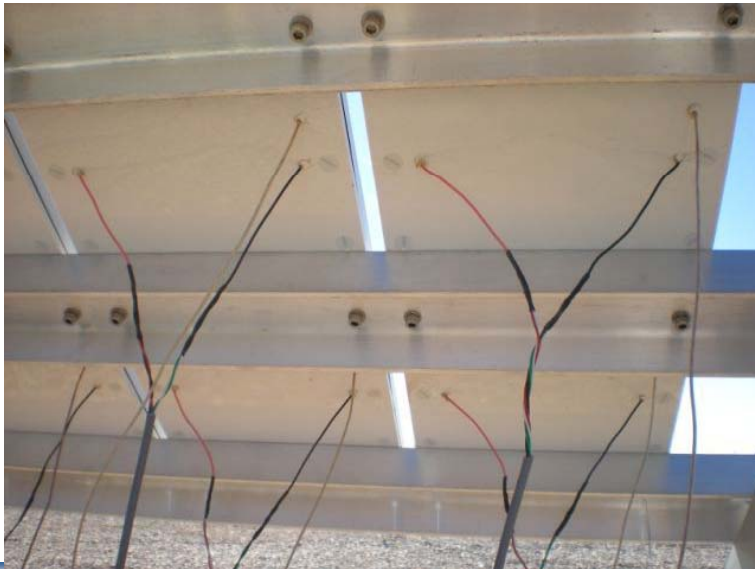
+



bis-indene[C60]

Outdoor Station Construction

- ❑ Custom module holders
 - Water-tight seals
 - Thermocouple on module back
- ❑ Custom tester
 - 16 channels
 - 1 pyranometer, 5 photodiodes
- ❑ Custom software
 - MPP maintained
 - IV curves taken every 10-15 minutes from sunrise to sunset.

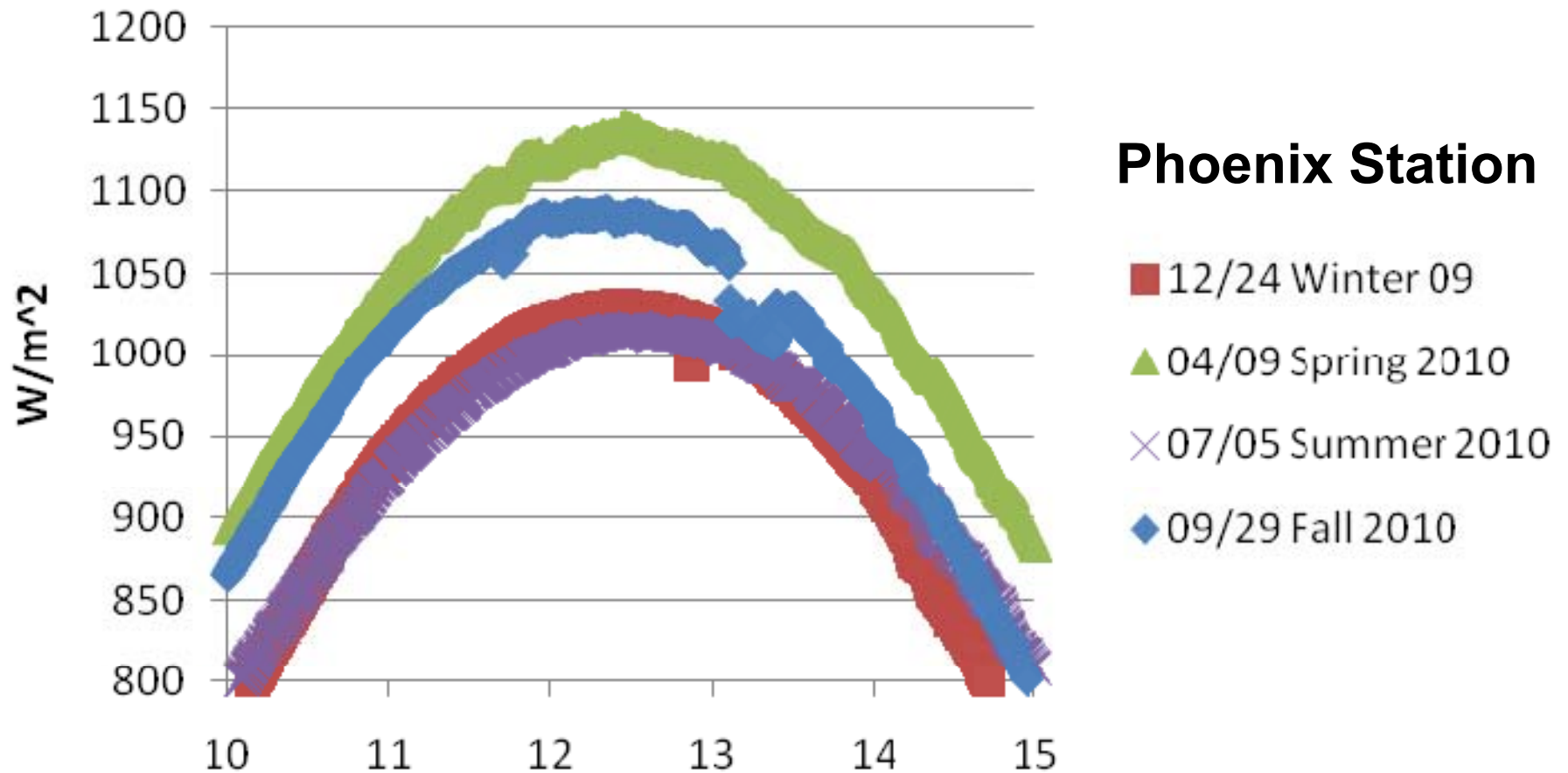


Data Analysis

- ❑ Goal: Track key parameters (I_{sc} , V_{oc} , MPP, FF, efficiency) as a function of time.
- ❑ Challenge: Extract data at fixed light intensity (close to “one sun”) and fixed light incident angle.
- ❑ Methods for setting filter criterion
 1. Peak intensity
 2. Fixed intensity range throughout the day
 3. Fixed intensity range over fixed hours of the day

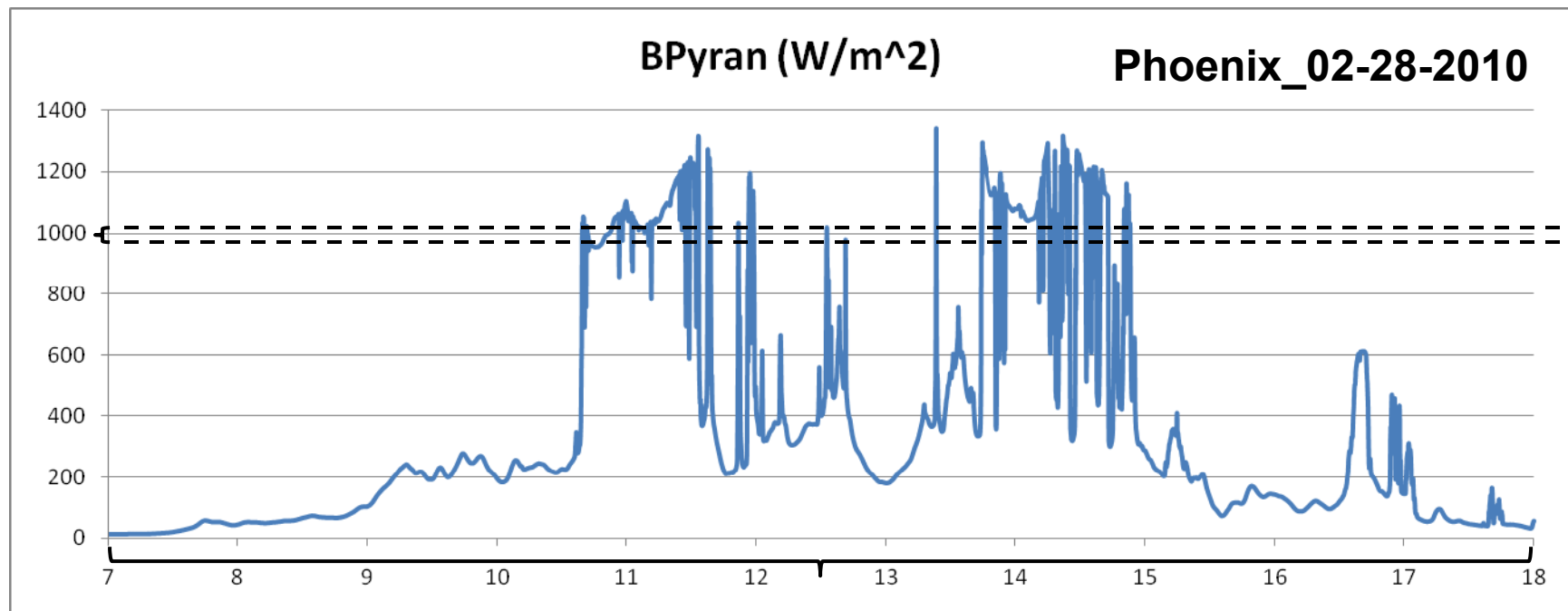
1. Peak Intensity Method

- ❑ This method uses peak value of pyranometer as criterion to select key parameters.
- ❑ However, peak intensity changes over the course of the year.



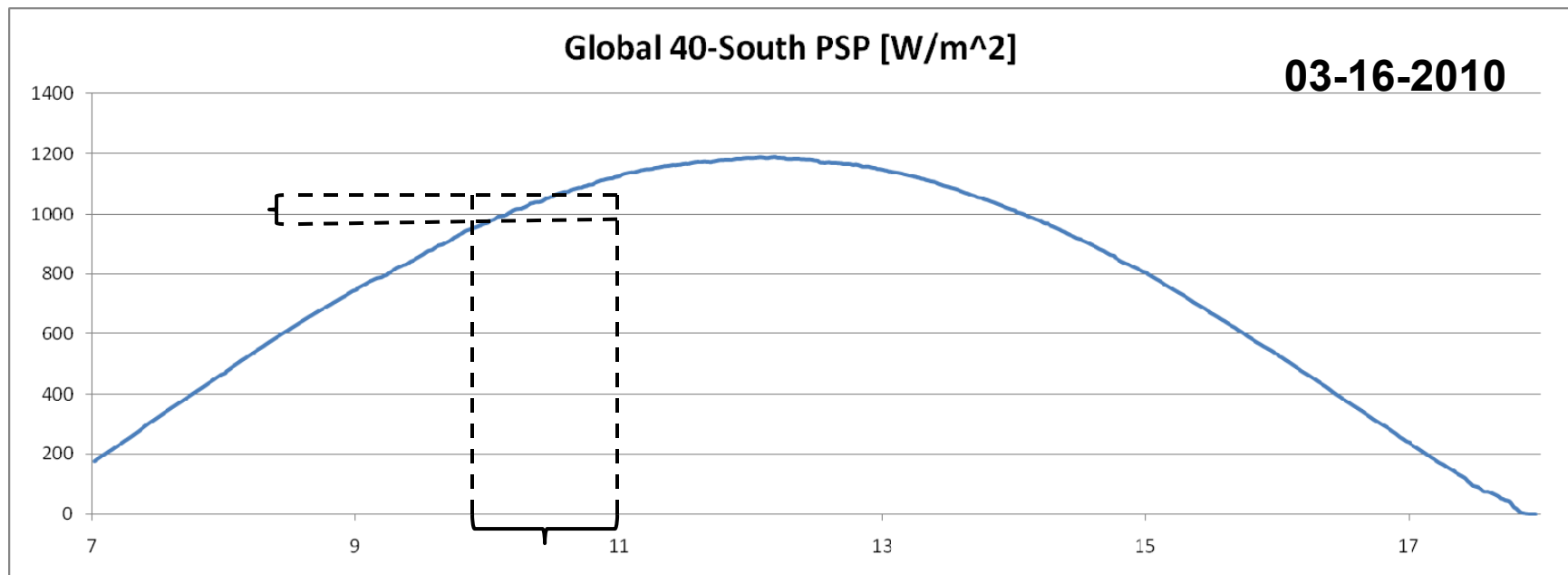
2. Fixed Intensity Range Throughout Day

- ❑ This method picks a fixed intensity range over the entire day.
- ❑ If the range is too large, qualified data can cover several hours, where the angle of incident also changes.
- ❑ If the range is too narrow, there may not be any qualified data for days.
- ❑ Data on cloudy or hazy days could also be challenging.

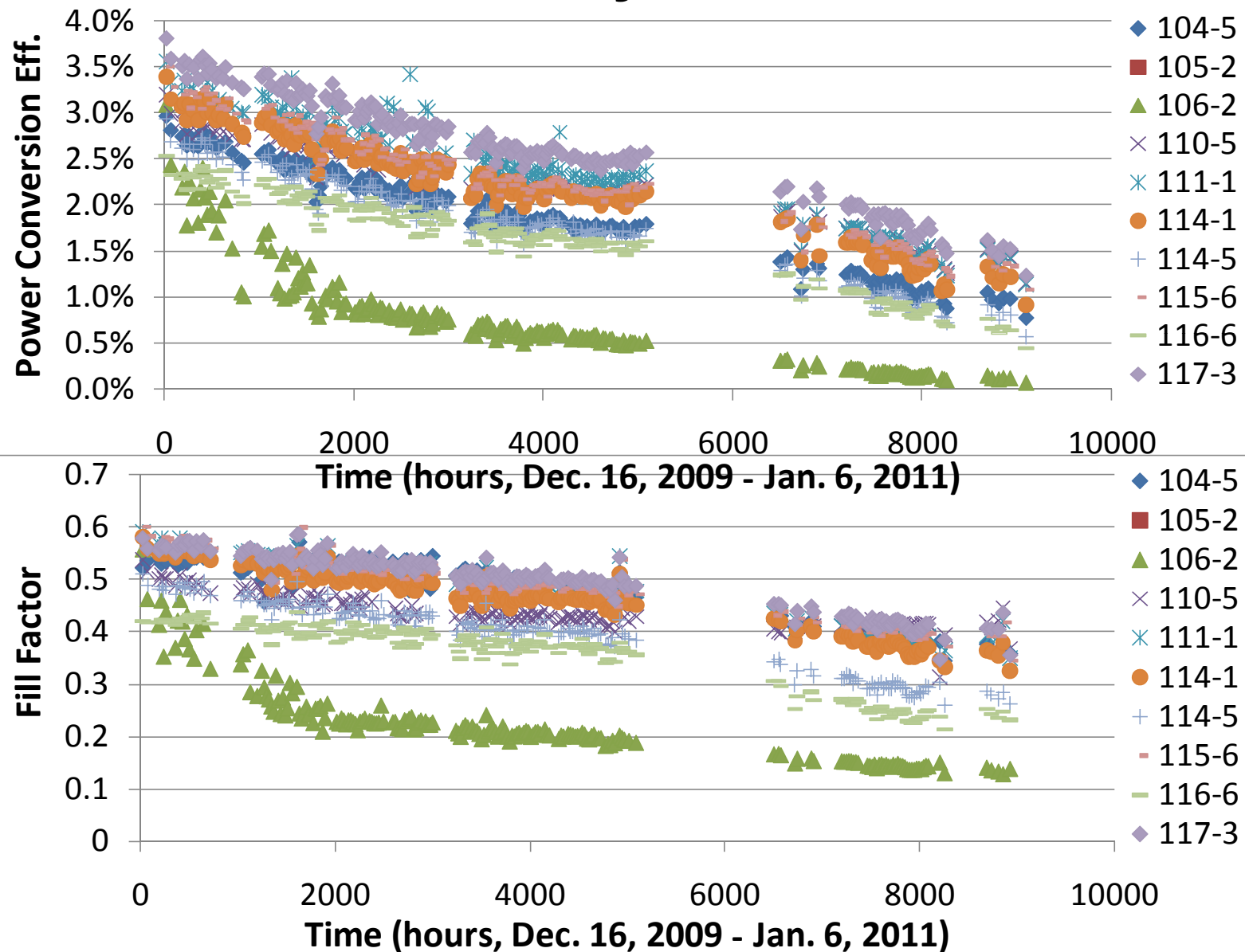


3. Fixed Intensity Range Over Fixed Hours of the Day

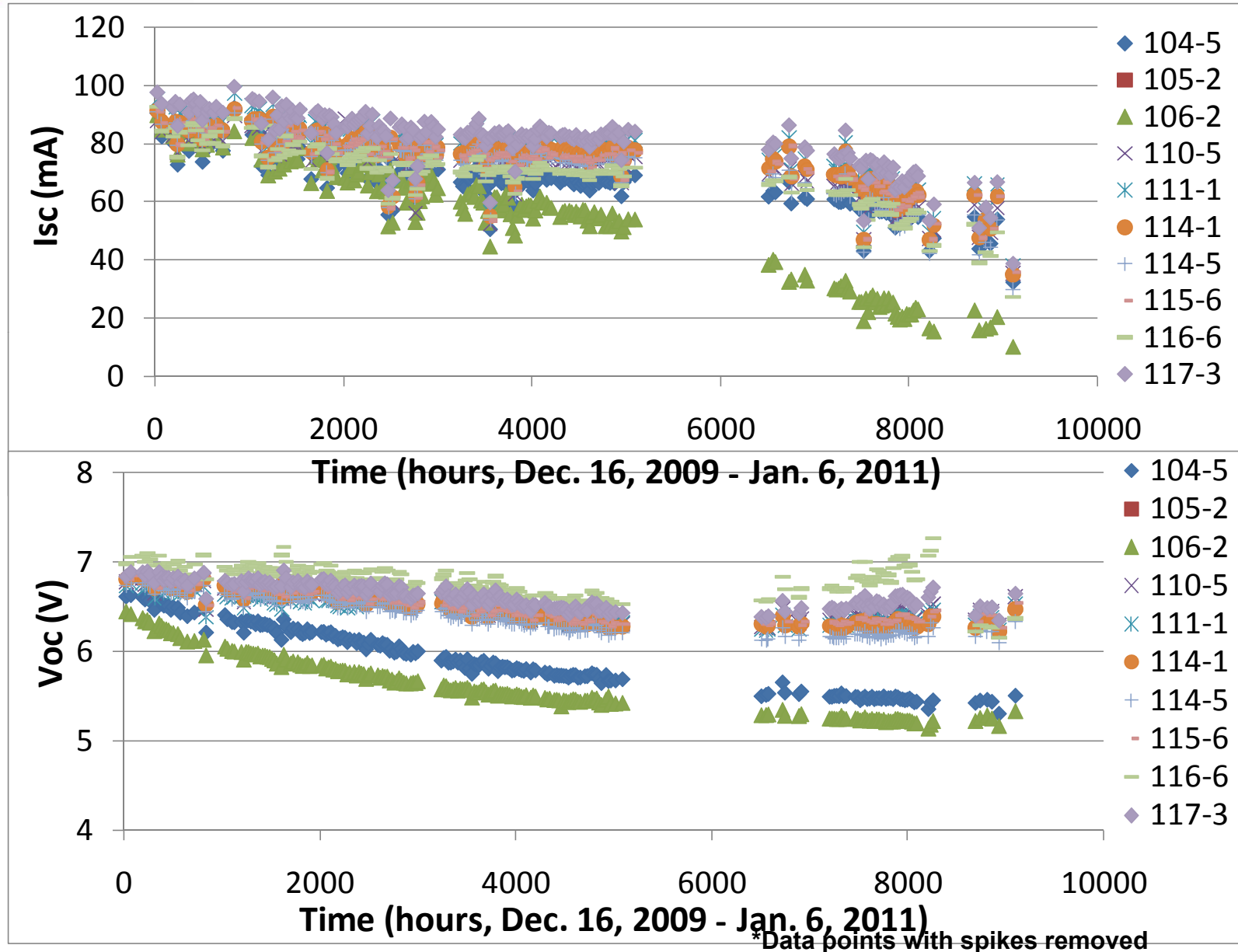
- ❑ This method was developed by Mike Pannone at Plextronics and used in our analysis. It chooses a particular irradiance and time window.
- ❑ A very tight intensity range was chosen centered around 1000 W/m².
- ❑ Data is captured in the morning only, generally between an hour interval to minimize changes of the solar incident angle.



Results of Modules in Phoenix: Efficiency, Fill Factor

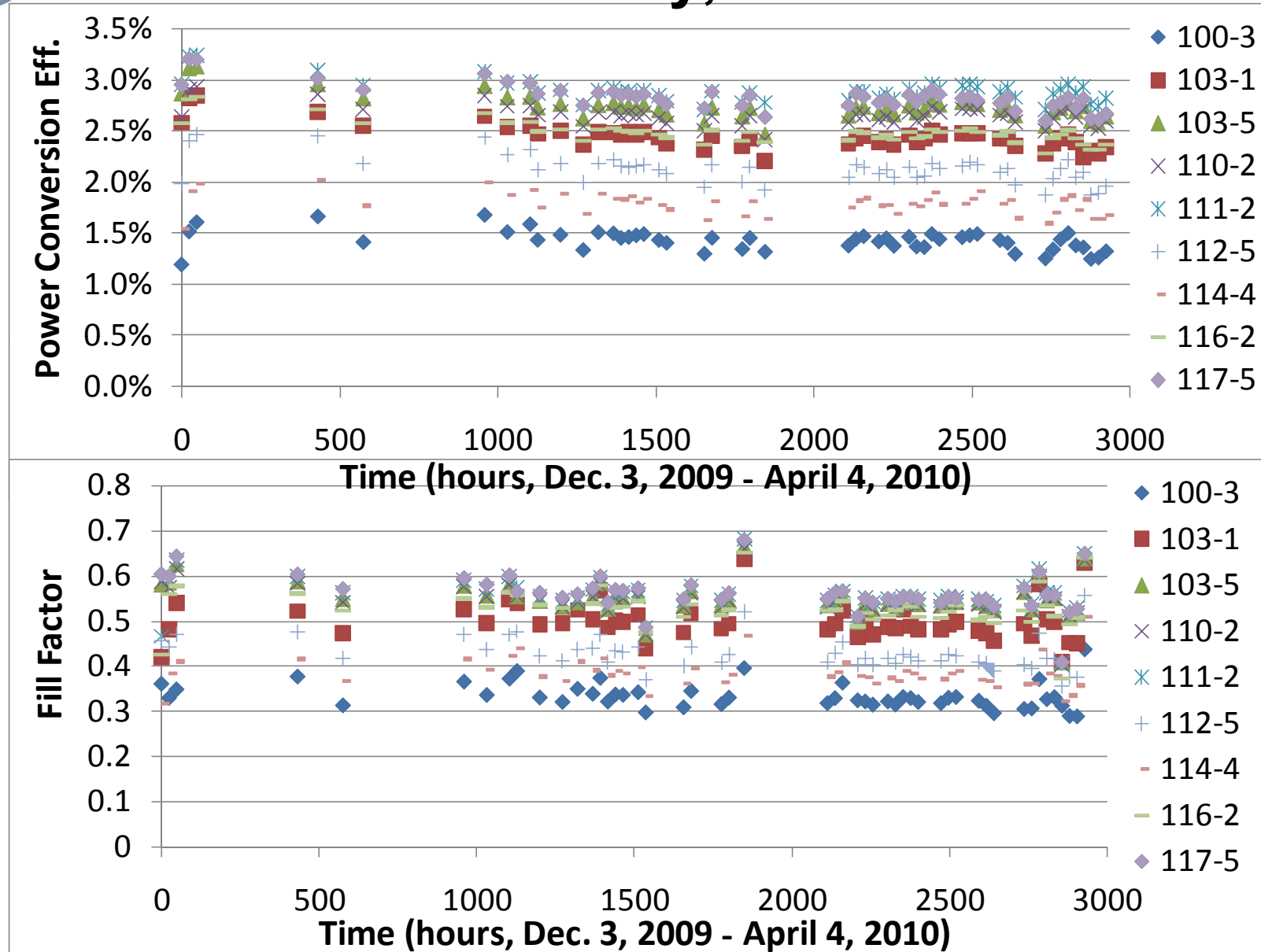


Results of Modules in Phoenix: Isc, Voc

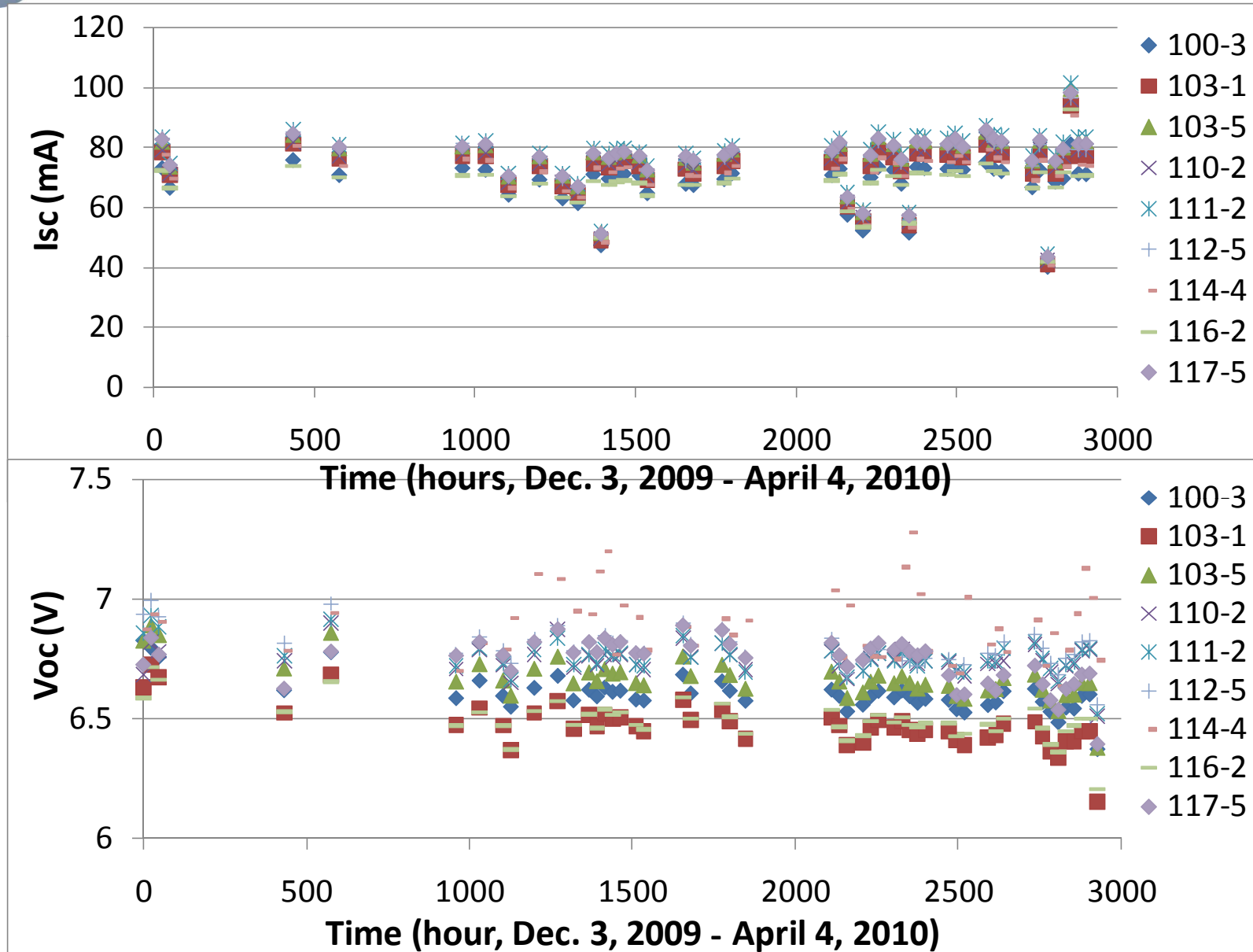


*Data points with spikes removed

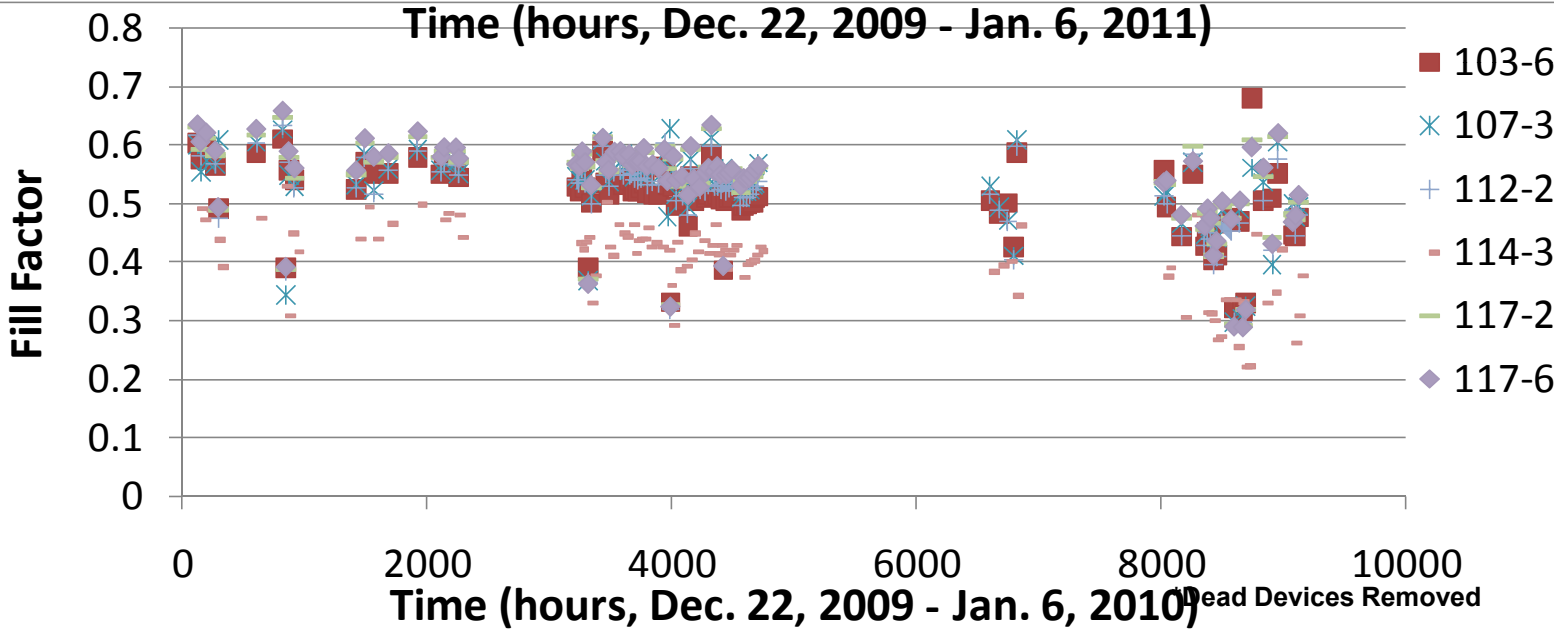
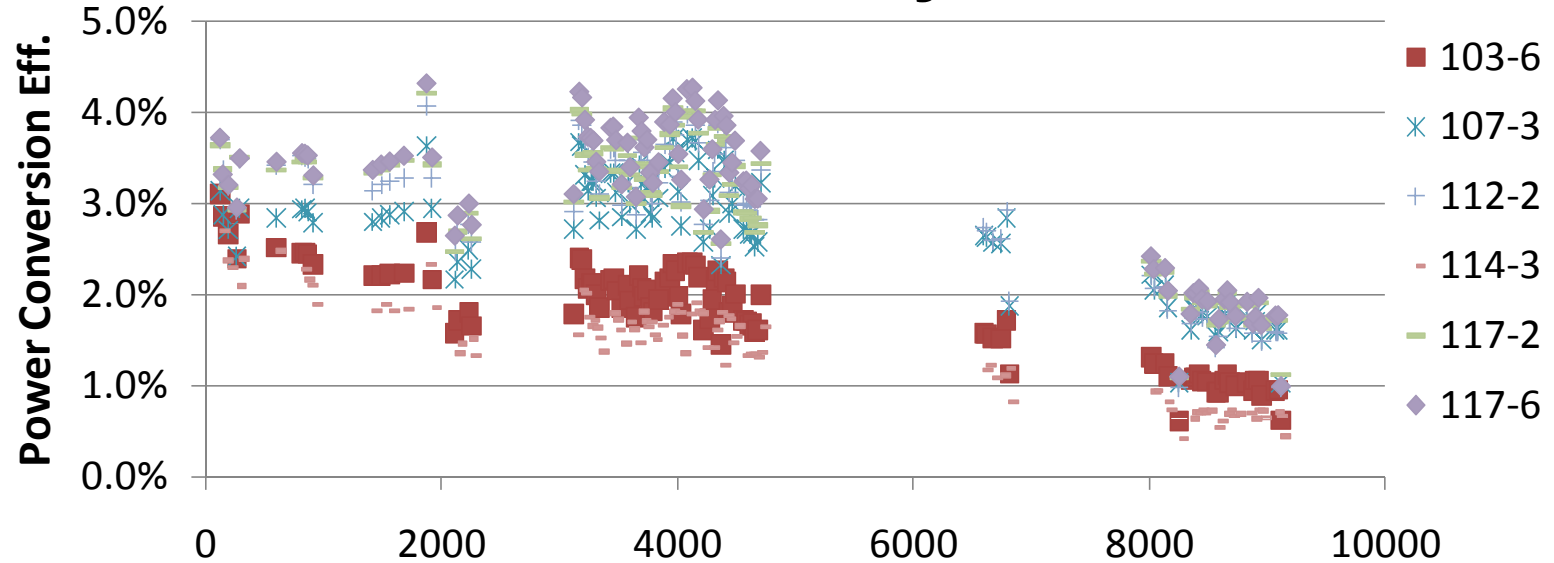
Results of Modules in Golden: Efficiency, Fill Factor



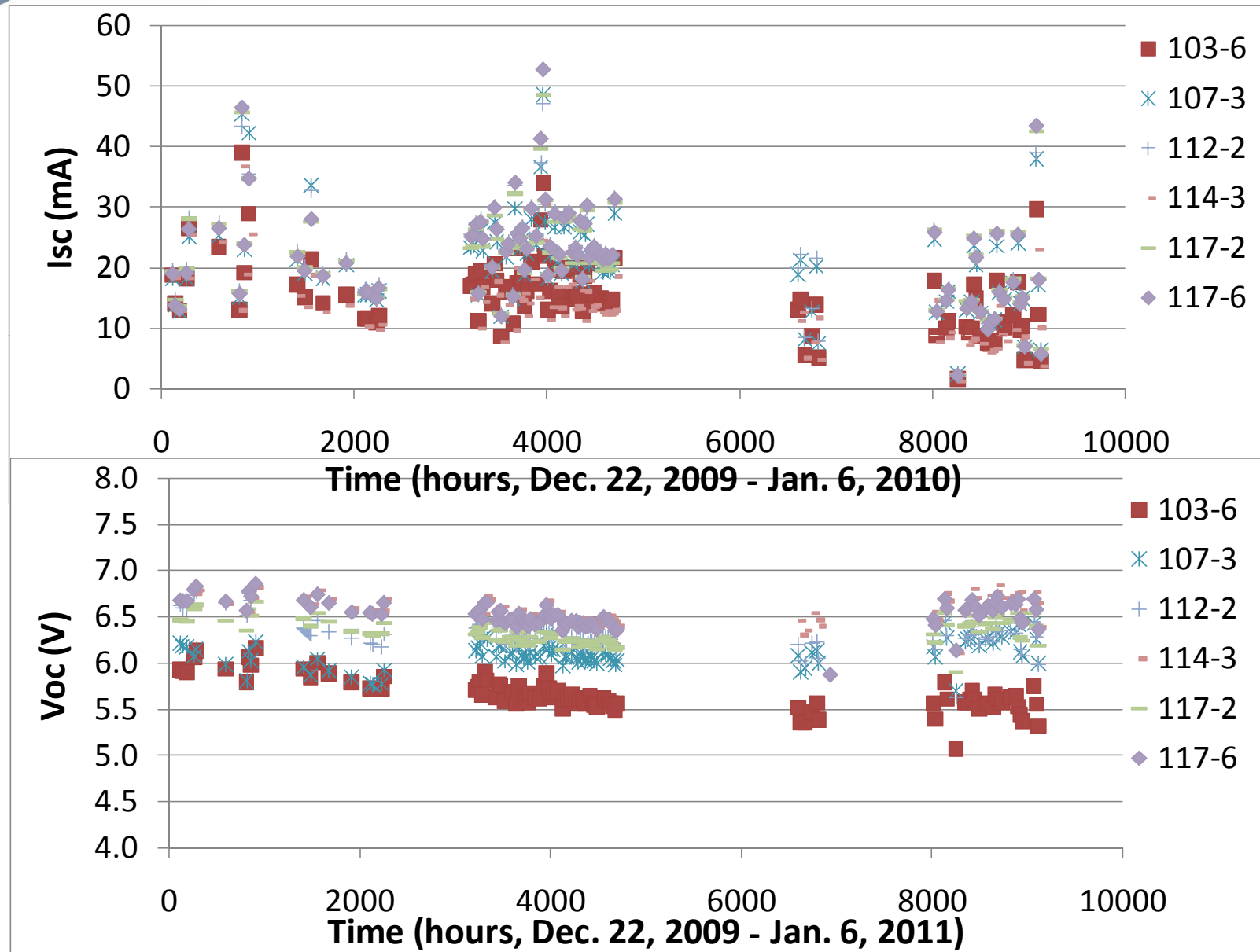
Results of Modules in Golden: Isc, Voc



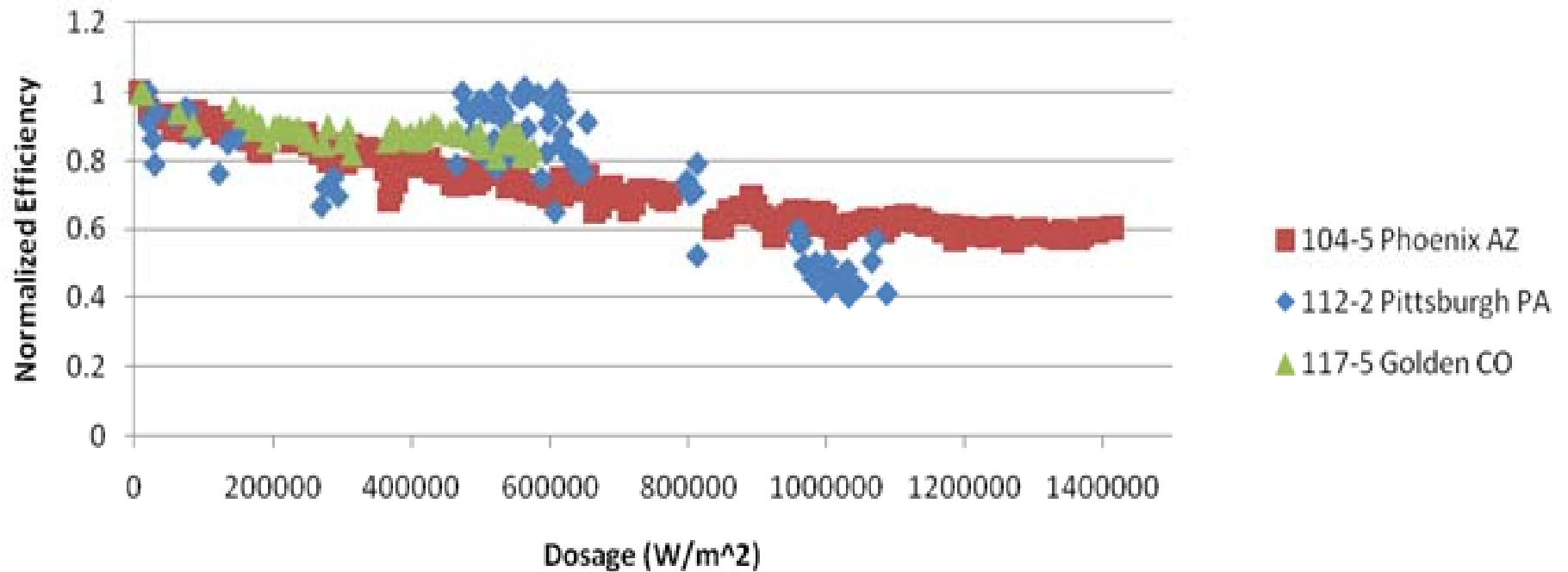
Results of Modules in Pittsburgh: Efficiency, Fill Factor



Results of Modules in Pittsburgh: Isc, Voc



Comparison Across Different Locations



After taking dosage into consideration, the decay trend at three different locations appears to be similar.

Lessons Learned

	Challenges	Solutions
Weather	Hail storm on June 11, 2010 in Golden, CO destroyed 7 out of 10 modules.	Acrylic cover. Thicker substrate.
	Modules at Atlas were covered in dirt.	Subscribe service to wash weekly.
	Pyranometer had different snow coverage from modules.	
Robustness of Parts	Glass cracking, resulting in catastrophic failure.	Treat glass edges.
	Pyranometer failure.	Use photodiode as backup.
Data Analysis	Power outages causing missing data.	Install backup power supply.
	Malfunctioning of software causing missing data.	pgrade software.
	Data spikes. U	
	Daylight savings not observed on NREL tower and in Arizona.	Analyze data based on local time instead of relying on Windows OS system clock.

Summary

- ❑ 30 R&D modules were placed at three custom outdoor stations in Dec. 2009: Pittsburgh, PA, Phoenix, AZ, Golden, CO. Data analysis methods were developed.
- ❑ Phoenix, AZ
 - 9 out of 10 modules showed gradual degradation during 12 months.
 - Most of the degradation was in current.
- ❑ Pittsburgh, PA
 - 4 modules showed catastrophic failure due to glass cracking.
- ❑ Golden, CO
 - No appreciable degradation in the first four months.
 - 7 out of 10 modules destroyed in a hail storm in June, 2010.
- ❑ Decay trend vs. dosage similar across three stations.
- ❑ Valuable experience gained in testing OPV outdoors.