Single-Side vs Double-Side Illumination Method IV Measurements for Several Types of Bifacial PV Modules
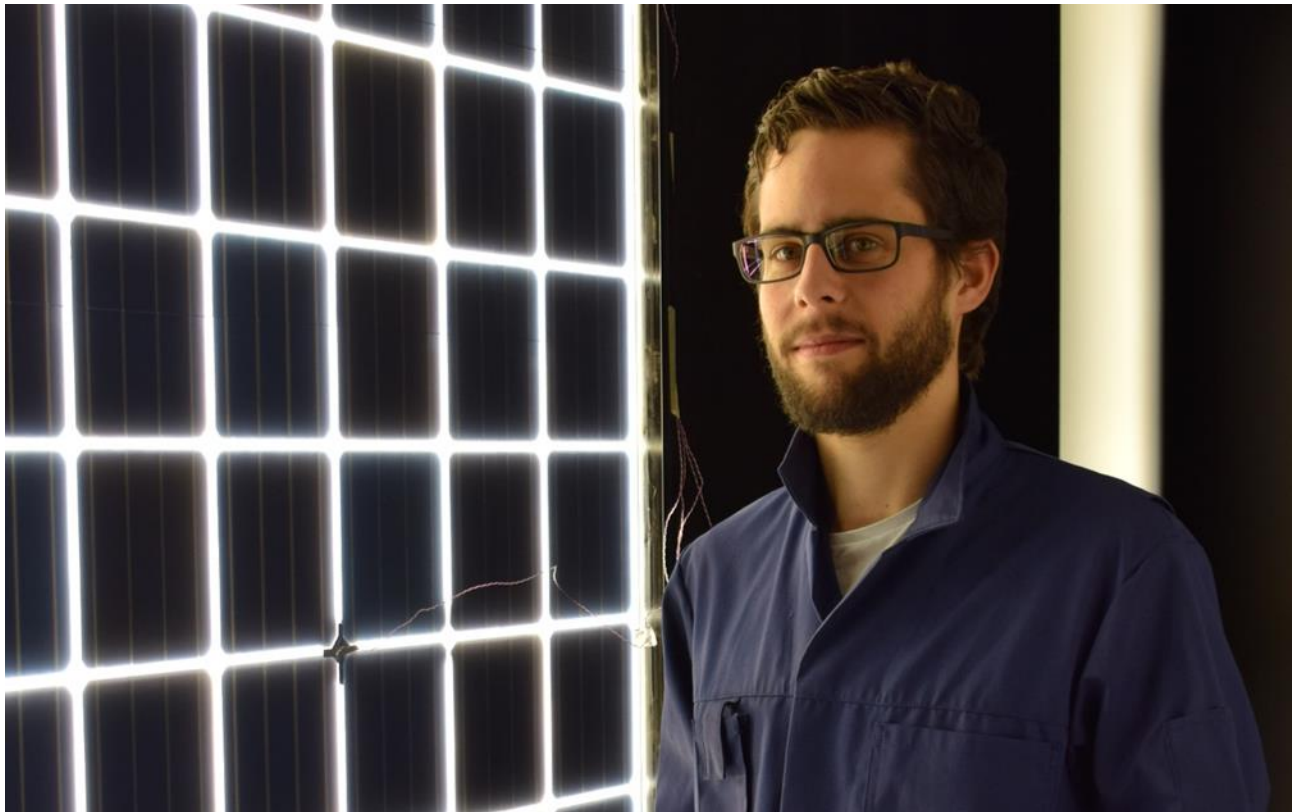
S. Roest[1], W. Nawara[1], B.B. Van Aken[2] and E. Garcia Goma[1,3]

[1]Eternal Sun Group [2]ECN Solar Energy, [3]PVMD TU Delft

E. Garcia Goma – Module Characterization Researcher

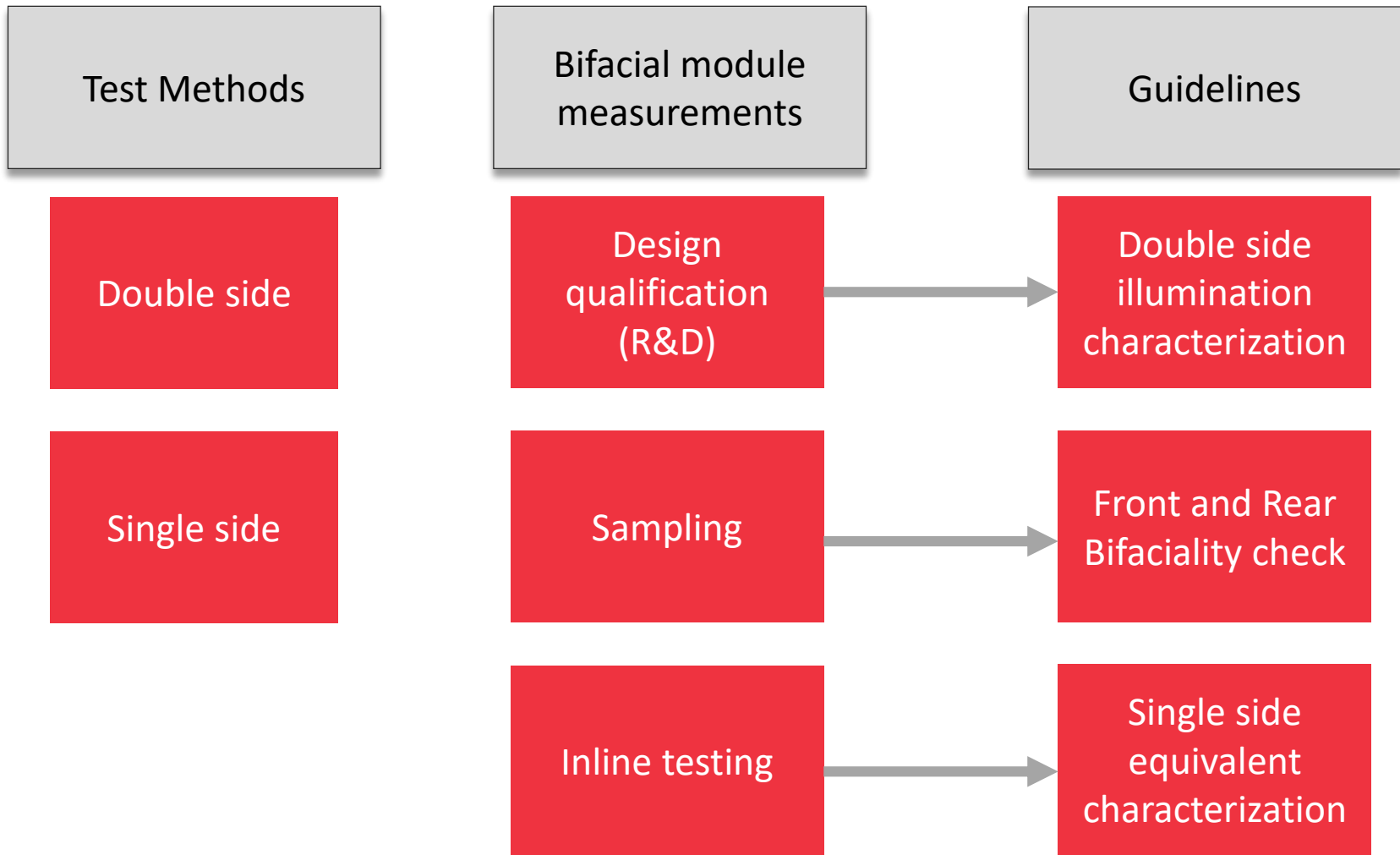# Eternal Sun Group and Spire: 750+ systems installed

- Acquired Simulator division of Spire Corp. in January 2016

AAA steady-state

For R&D and certification labs

A+A+A+ Single Long Pulse

For manufacturing, QC and labs
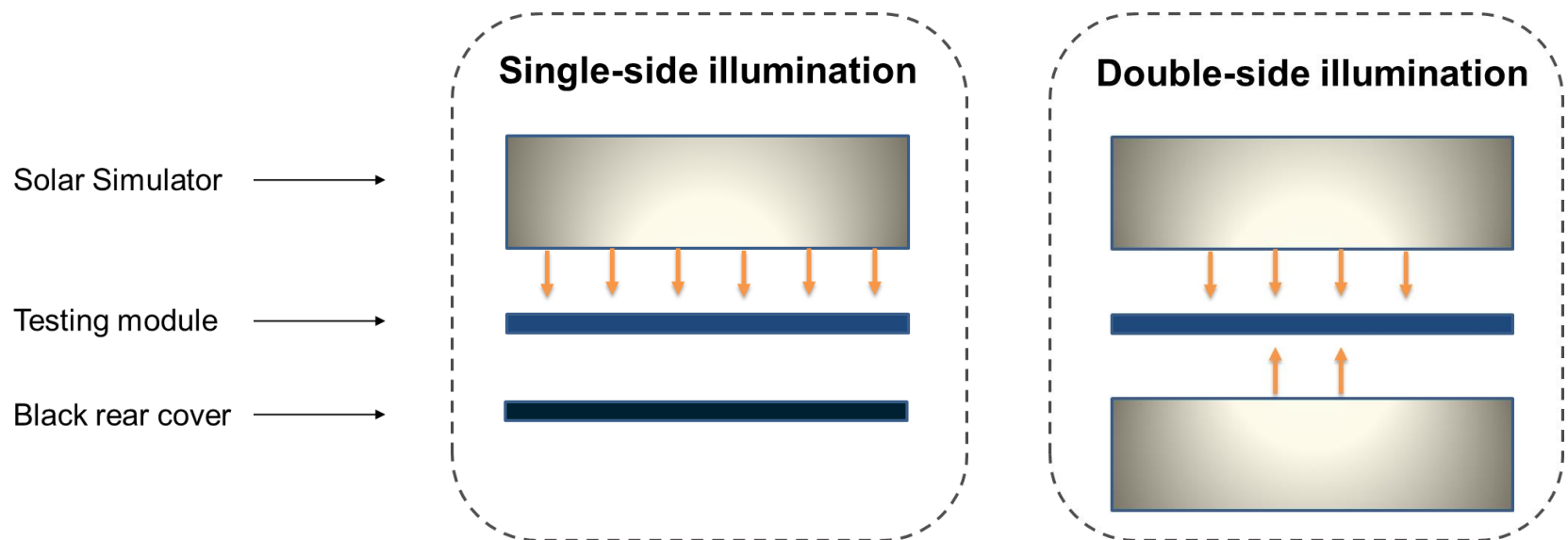
What will you see today?

Test Methods	Bifacial module measurements	Guidelines
Double side	Design qualification (R&D)	→ Double side illumination characterization
Single side	Sampling	→ Front and Rear Bifaciality check
	Inline testing	→ Single side equivalent characterization

Development of a bifacial testing standard is challenging

- Bifacial tests requires control of front, rear and combined power output.
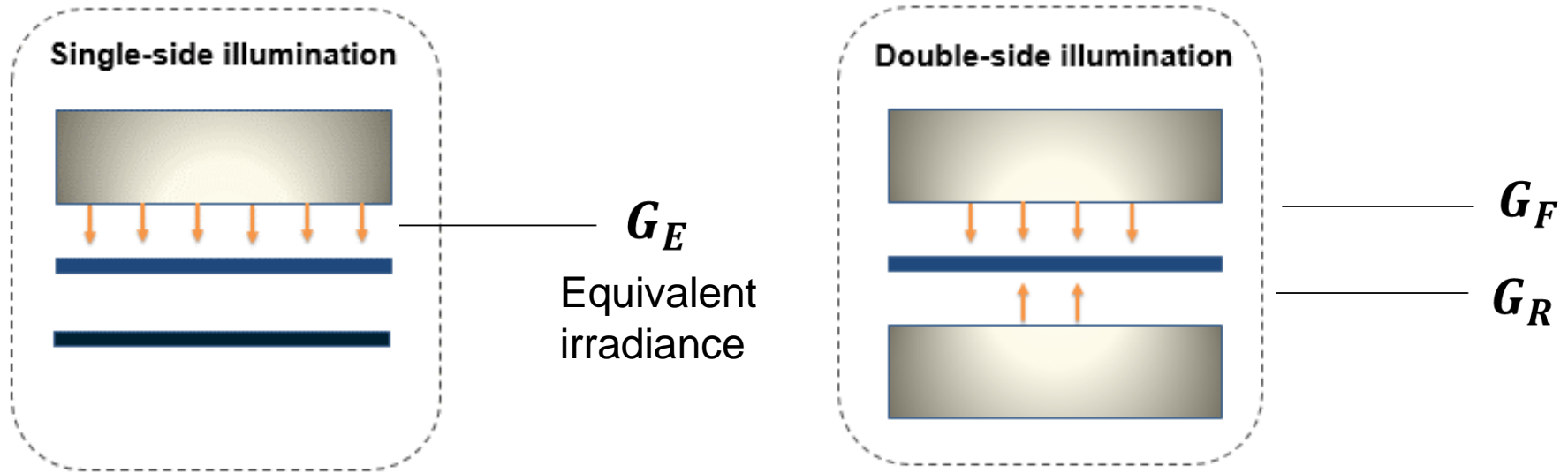- IEC WG2 project team has submitted draft standard.

IEC 60904-1-2: I-V characterization of bifacial devices

- Two main procedures are included:

Solar Simulator

Testing module

Black rear cover

Single-side illumination

Double-side illumination

How to compare single side vs double sided illumination?

$$G_E = G_F + Min(\varphi_{Isc,STC}, \varphi_{Pmax,STC}) * G_R$$

Example Conditions				Equivalent
$\varphi_{Isc,module}$ [-]	G_F [W/m^2]	G_R [W/m^2]		G_E [W/m^2]
0.85	1000	200		1170

How to combine a steady state simulator with a flasher
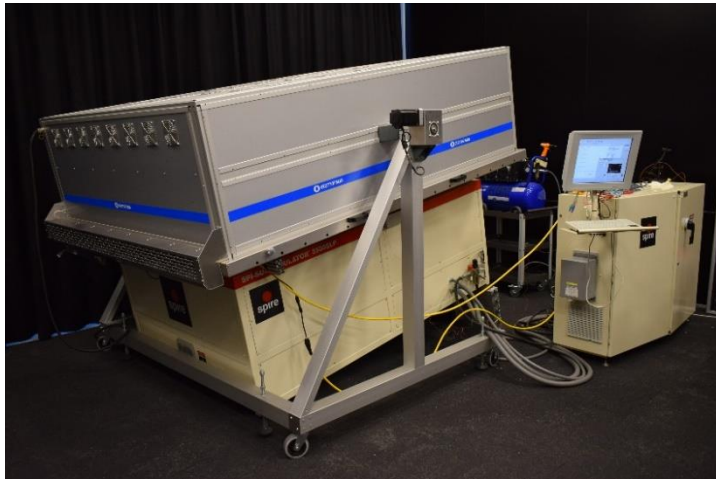
Single side measurements
- Single Long Pulse Flash simulator 100 ms.

Double side measurements
- **Front side** Single Long Pulse Flash simulator 100 ms.
- **Rear side** using Steady State Solar Simulator.

Measurement temperature
- Single-side at 25 °C, double at 30 °C, temperature corrected.

Commercial Bifacial PV modules come in all shapes

- Material wise, most of the commercial bifacial PV modules are based in **PERC**, **PERT** and Heterojunction (**HJT**) solar cells.

- PV modules might have a **frame** that protrudes from one of the sides or be **frameless.**

- **Junction Box** is determinant as it can partially shade some of the cells. It can be white or black.
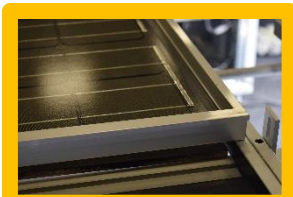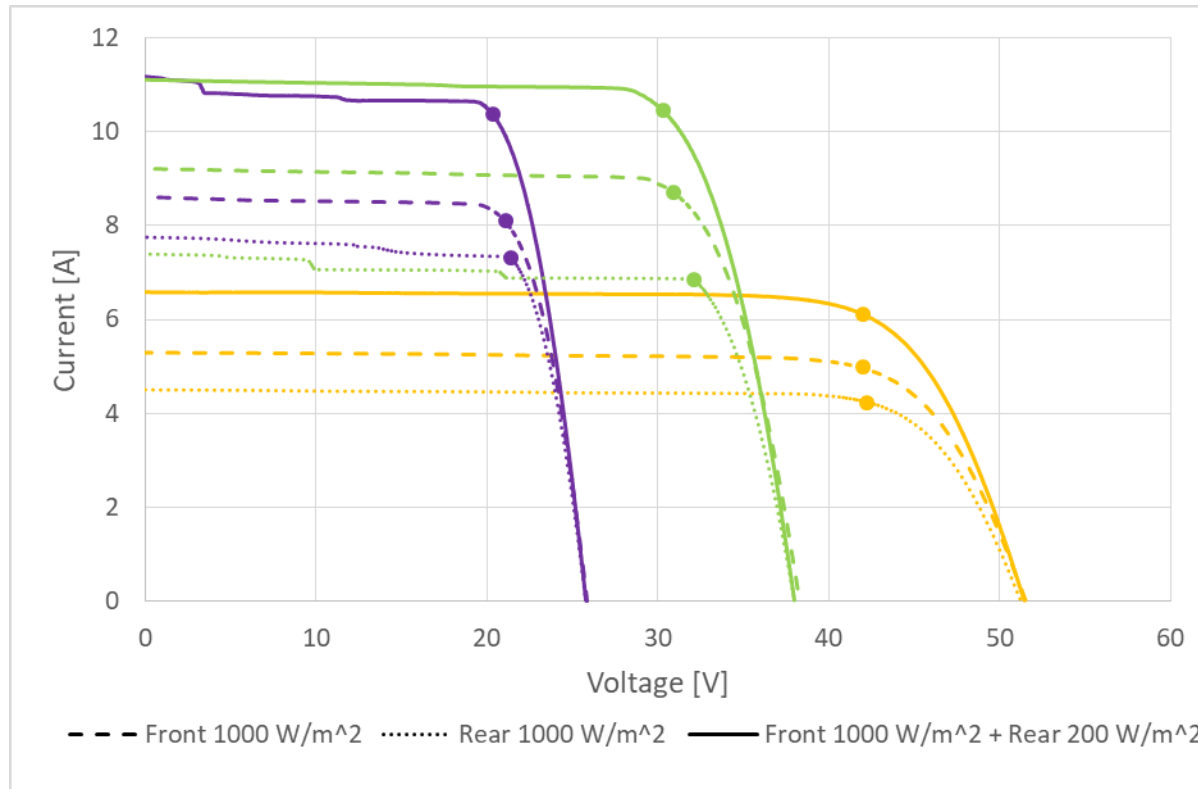
spire | eternal sun
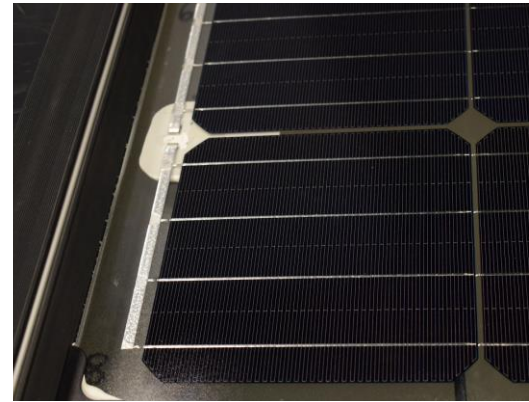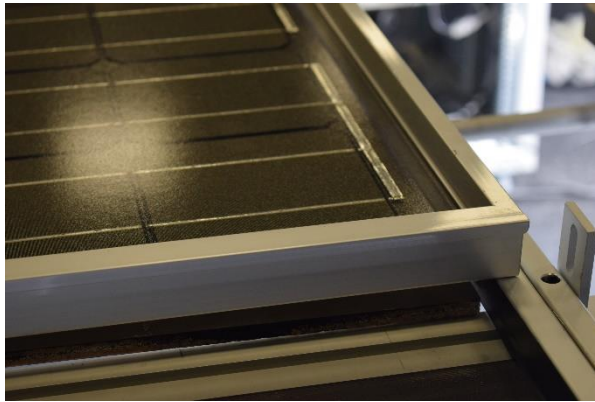
Modules of the same bin in production might yield differences

- Not sorting the cells per rear performance can induce greater current mismatch between cells.

- If J. Box is partially shading any of the cells, a variation in its mounting from module to module can cause differences in IV curve.
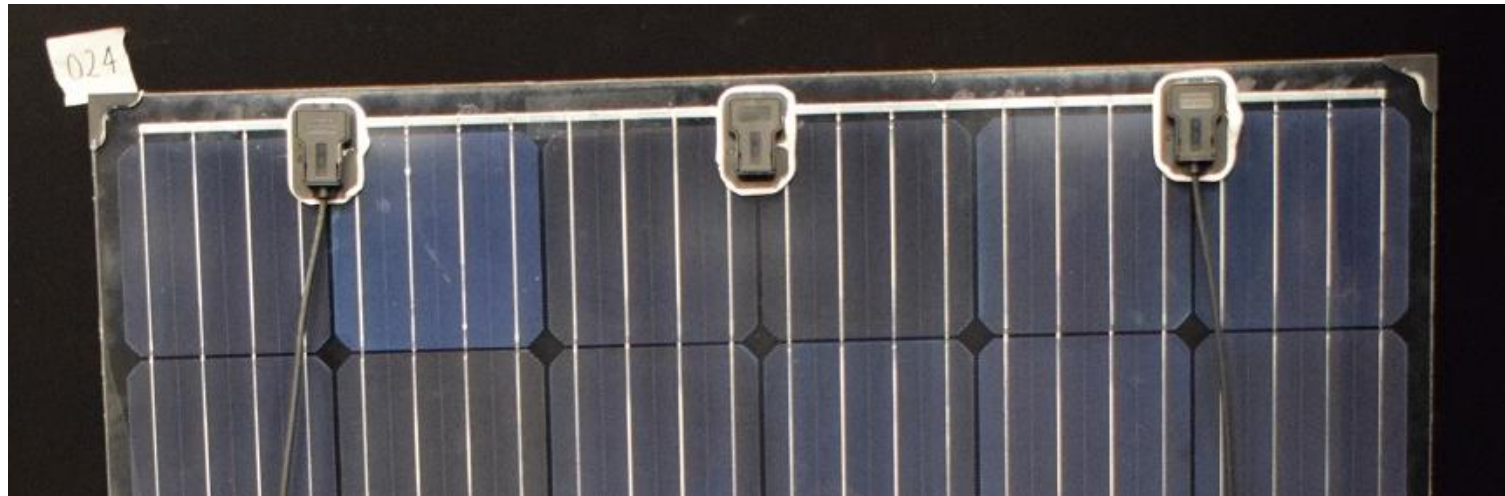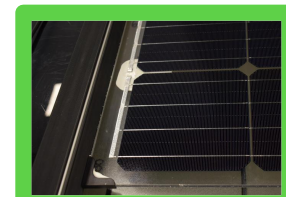
Different double side IV curve behaviour per design
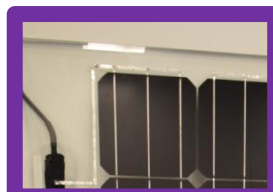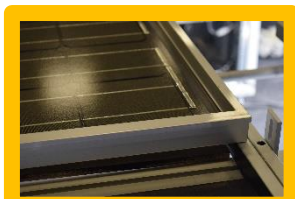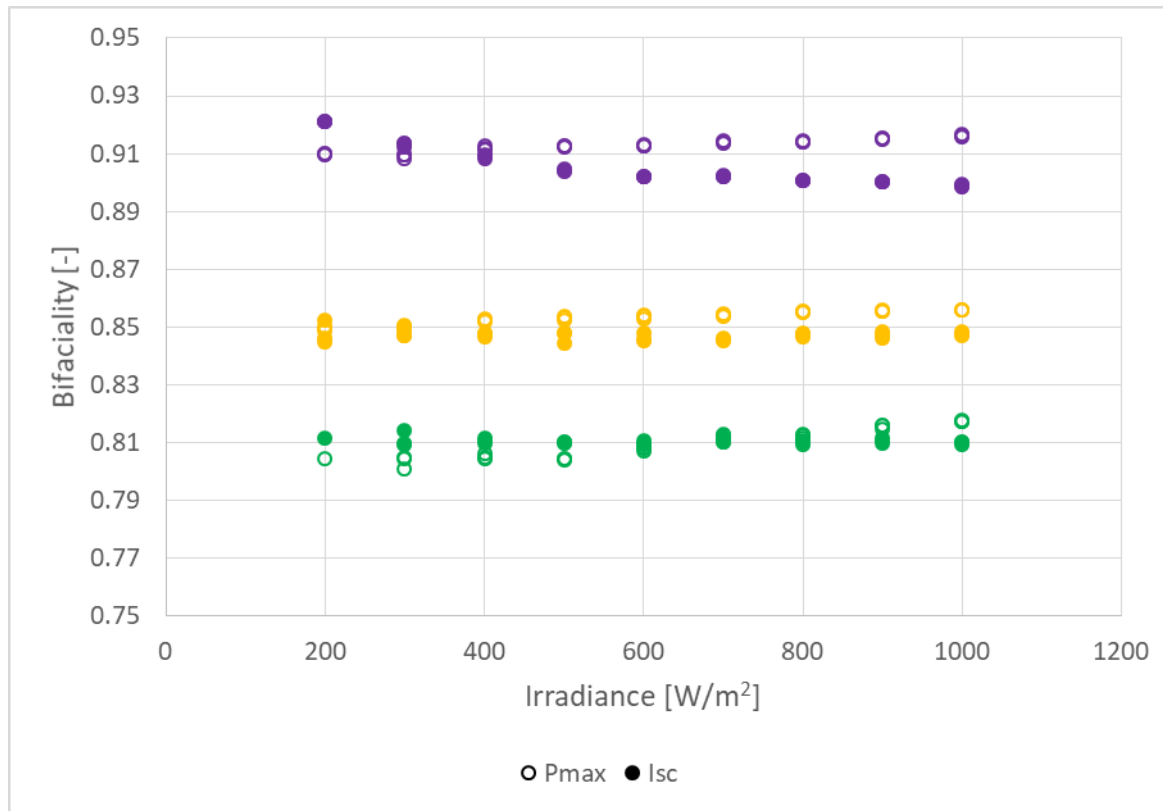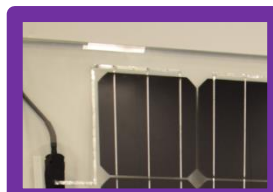

HJT Framed No Jbox
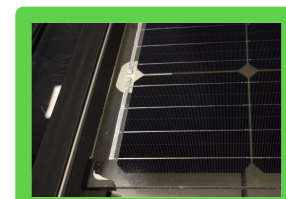
PERT Frameless No Jbox

PERT Frameless White Jbox

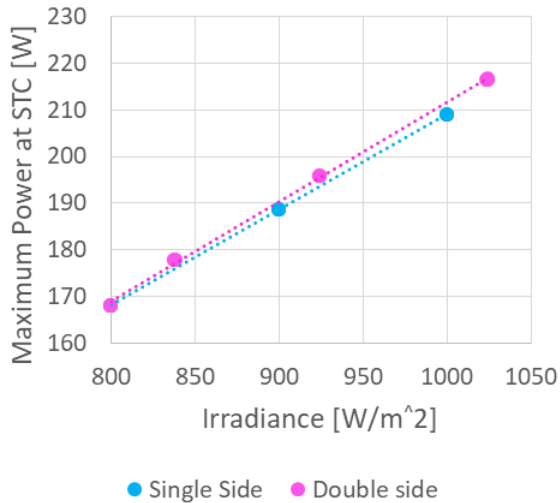# Different bifaciality behaviour per design
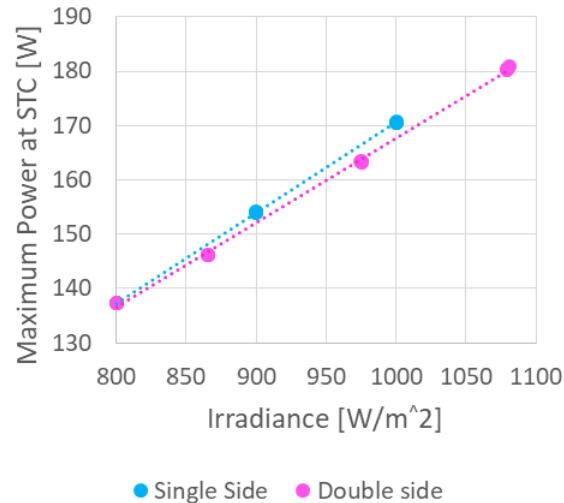

HJT Framed No Jbox

PERT Frameless No Jbox

PERT Frameless White Jbox
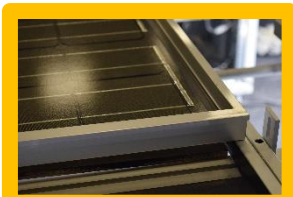
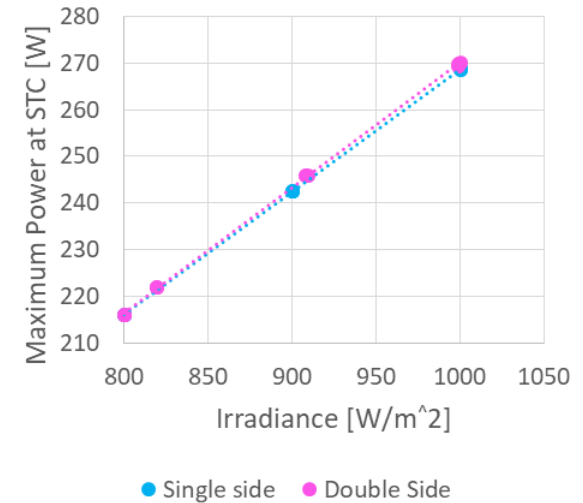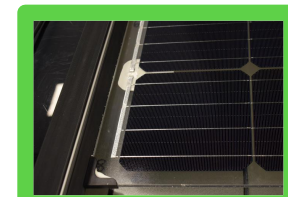# Maximum power deviation between methods at 1000 W/m²
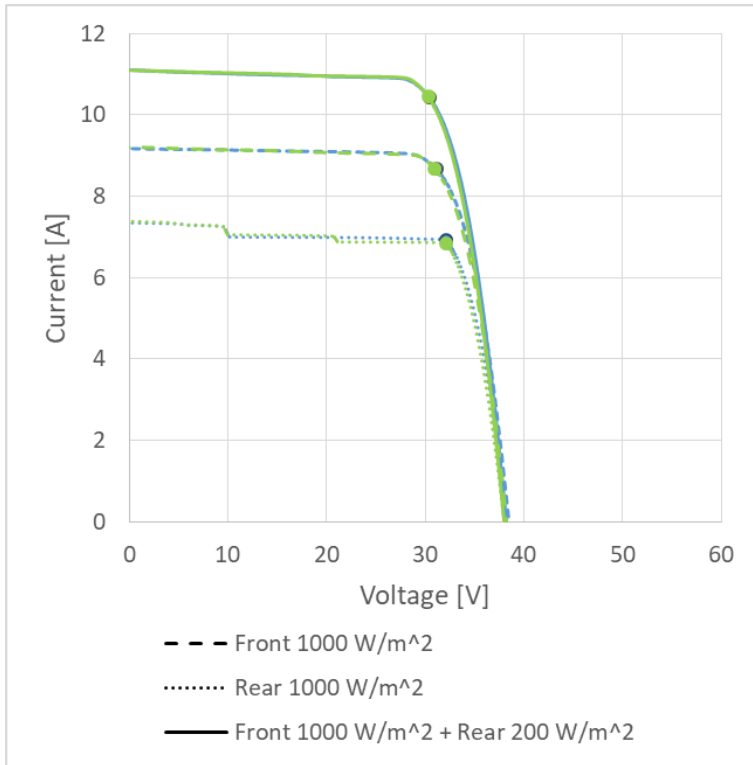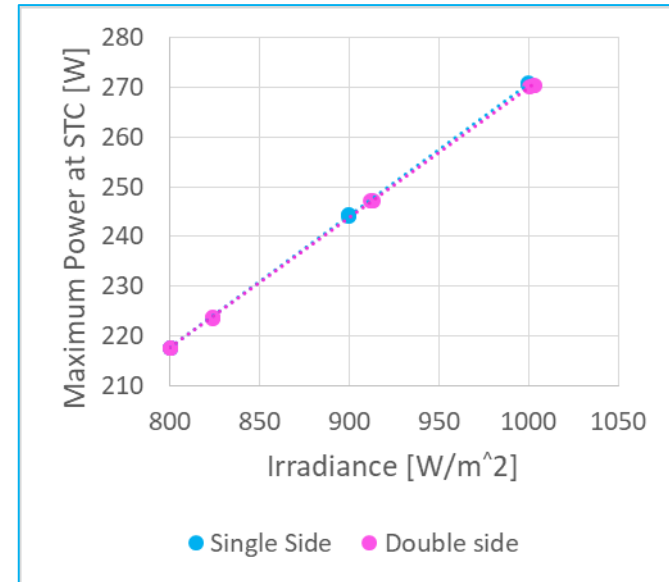

-1.2 %

+1.8 %

-0.5 %

HJT Framed No Jbox
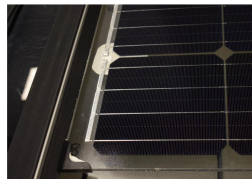
PERT Frameless No Jbox

PERT Frameless White Jbox

Deviation in same bin of production line

+0.4 %

Serial **#1**

PERT Frameless White Jbox

Serial **#2**
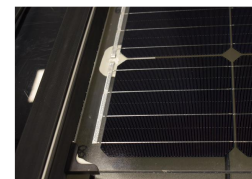
PERT Frameless White Jbox

What to take home

Methods	Bifacial module measurements	Guidelines
Single side	Design qualification (R&D) →	Double side characterization
Double side	Sampling →	Front and Rear Bifaciality check
	Inline testing →	Single side equivalent characterization

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Questions?
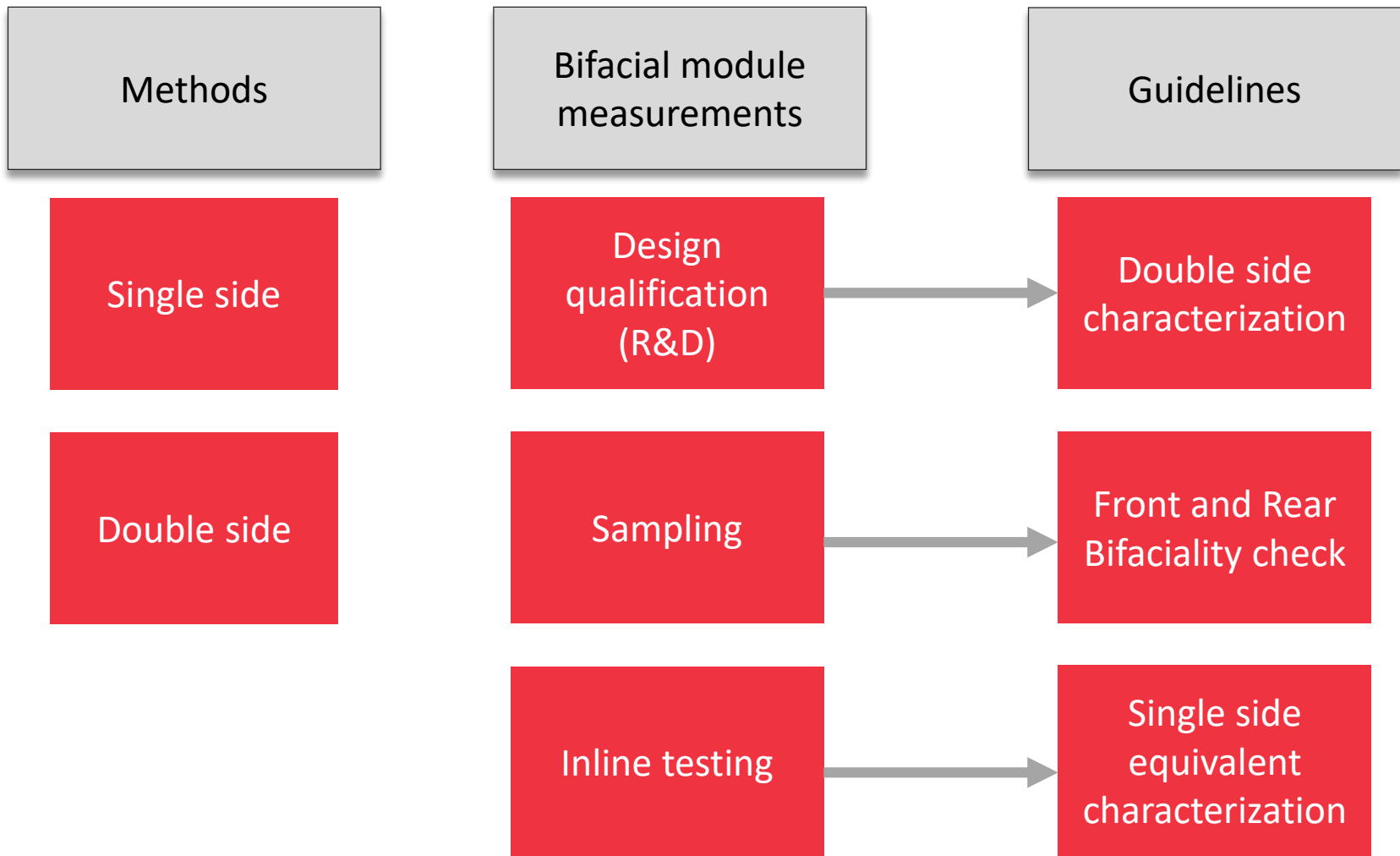
Special thanks for support:

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ECN

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