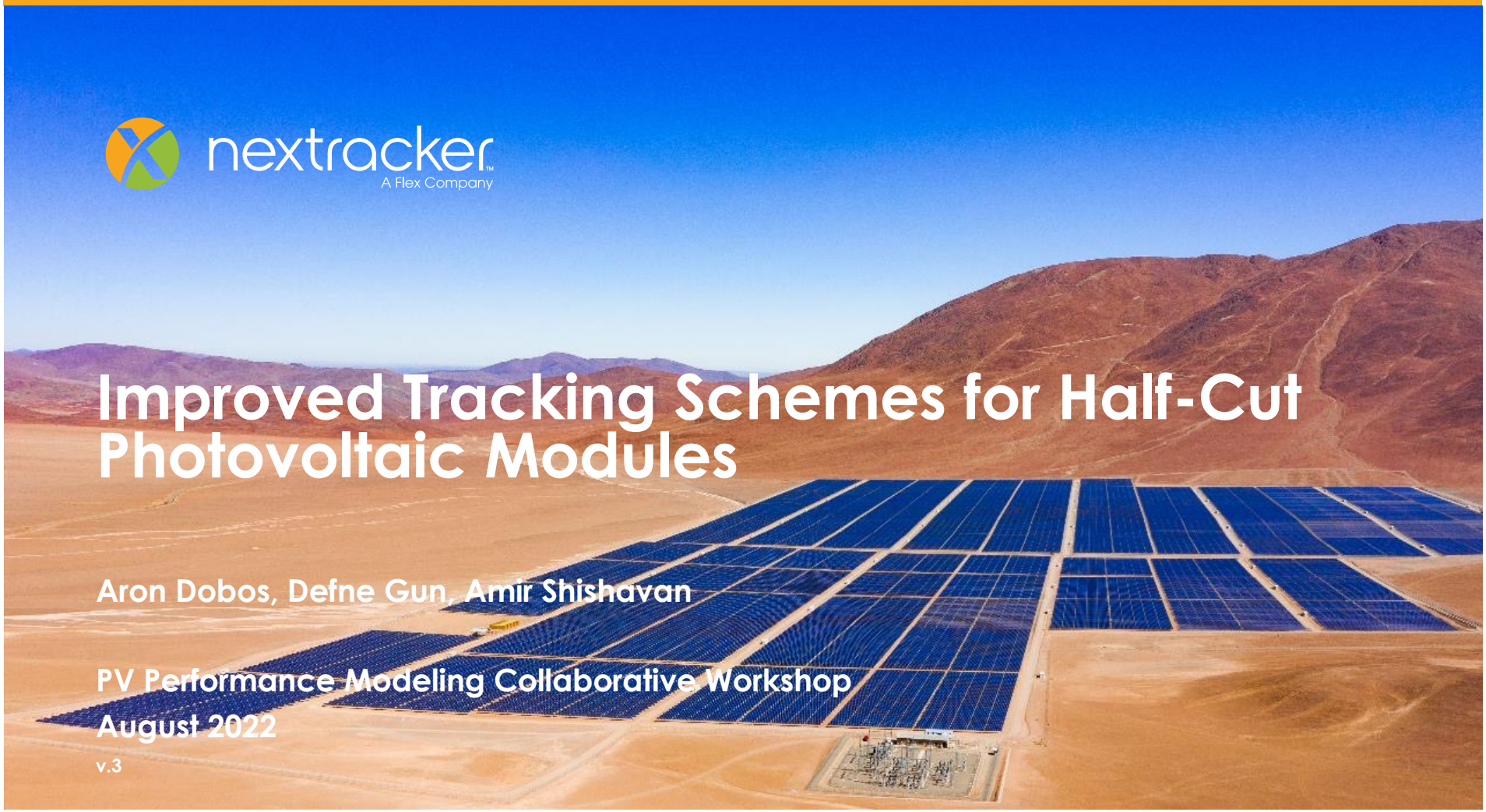

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Improved Tracking Schemes for Half-Cut Photovoltaic Modules

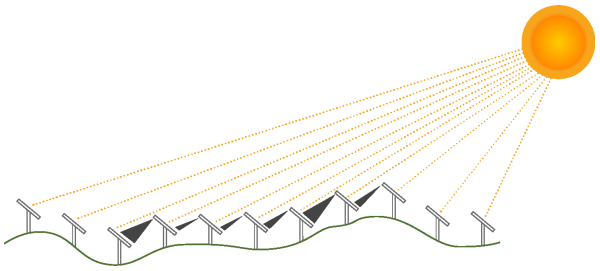
Aron Dobos, Defne Gun, Amir Shishavan

PV Performance Modeling Collaborative Workshop
August 2022
v.3

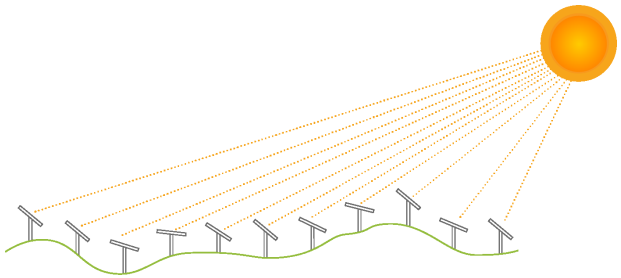
TrueCapture Smart Control System

Solving for Row-to-Row and Diffuse Light Challenges in the Real World

Row-to-Row Tracking:



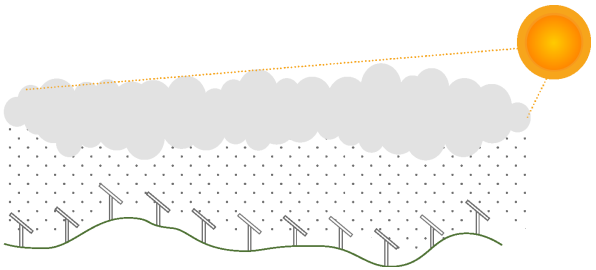
Industry Standard
Backtracking Methodology



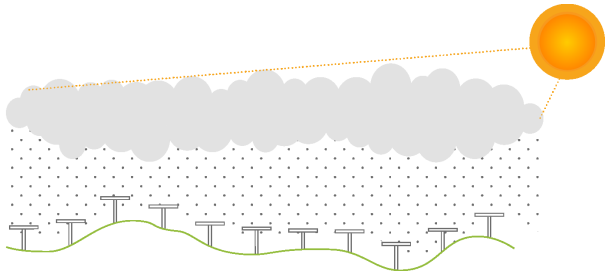
TrueCapture Eliminates
Shading Losses

E ⟷ W

Diffuse Light Tracking



Conventional Tracking



TrueCapture Diffuse Tracking

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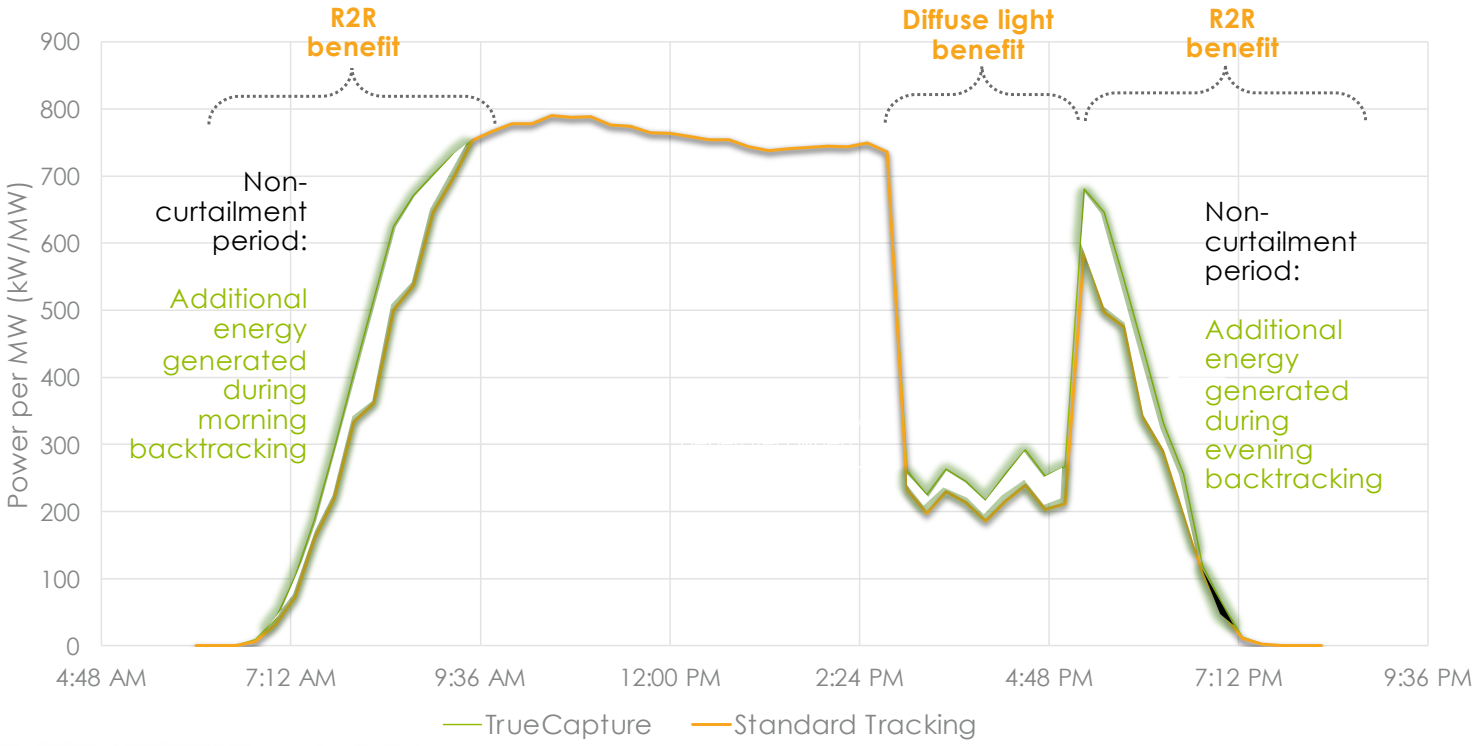
TrueCapture Day-in-the-Life: Energy Yield Benefit



IE reports from Leidos and RINA available upon request

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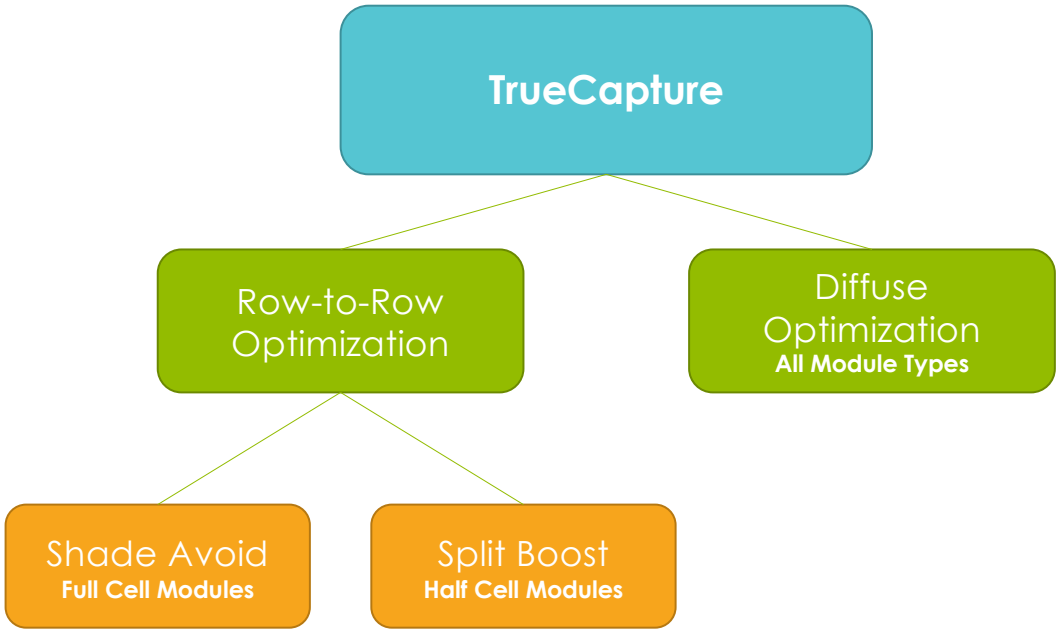
The TrueCapture Technology

28 GW contracted, 16 GW deployed, 200 sites, 5 continents, string and central inverters



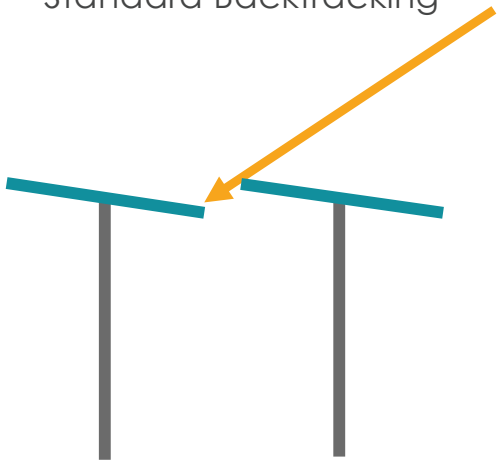
Our **product**

Two primary **means** of yield enhancement

Two R2R **specializations** for silicon module technology types

Standard Backtracking vs. Split Boost

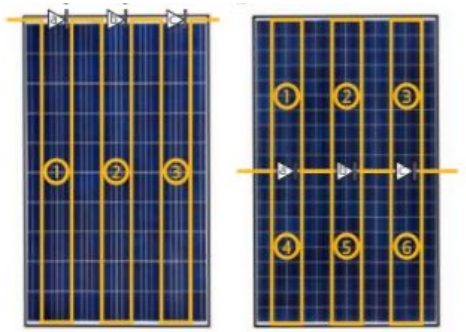
Standard Backtracking



Traditional Backtracking: At low sun elevation. 100% of any panel shading is avoided.

Split Boost

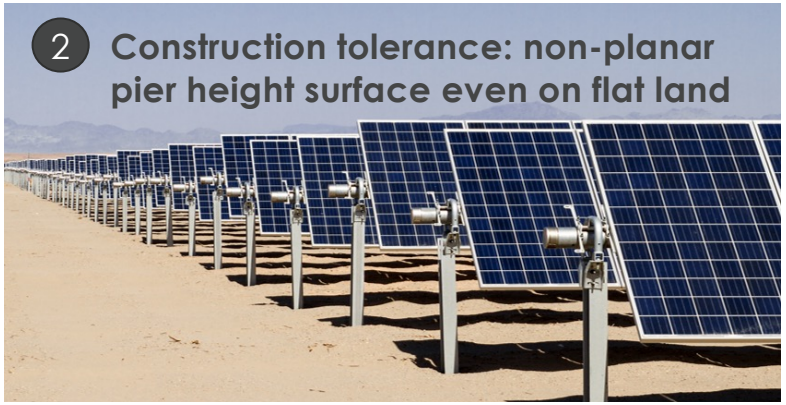
Split-Boost: Accommodate up to 50% shade on the panel and increase irradiance on top half.

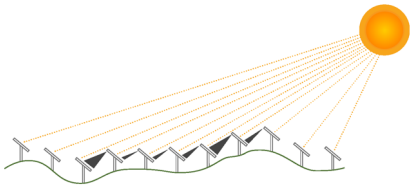


Source: https://www.recgroup.com/sites/default/files/documents/whitepaper_twinpeak_shading_properties_eng.pdf

	Full- Cell Module		Half-cut Cell Module	
2e: 3 strings	SHADE All diodes active		SHADE All diodes inactive	
	Voltage (V)	0%	Voltage (V)	100%
	Current (A)	0%	Current (A)	50%
	Power (Wp)	0%	Power (Wp)	50%

Terrain Shade Loss in Utility-scale Systems

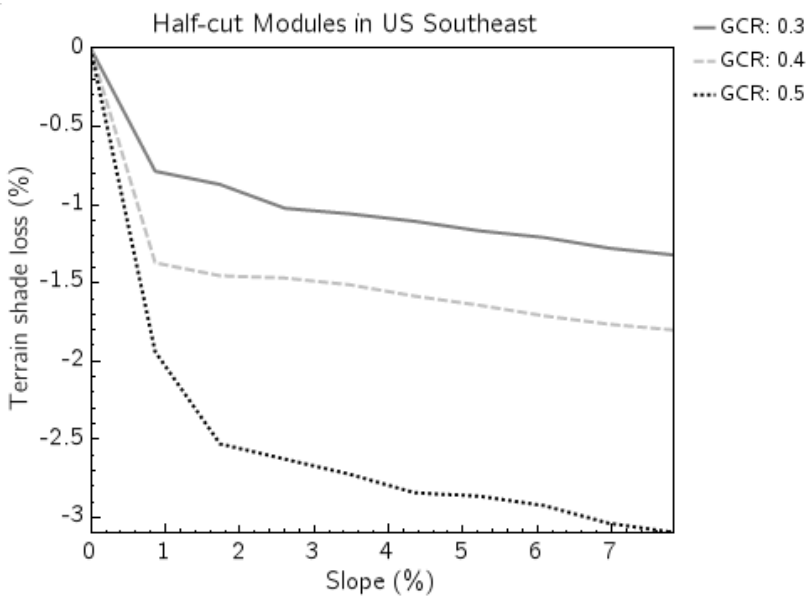




All result in row-to-row shading and power loss

$$Terrain\ shade\ loss = 1 - \frac{Y_{terrain}}{Y_{flat}}$$

Half-cut Module Shade Loss



Even for "shade tolerant" half-cut modules, in a location with relatively high diffuse content :

3 % ground slope can result in annual losses between 1%-2.5% depending on GCR, using standard backtracking, relative to flat terrain.

Sources of Split Boost Gains

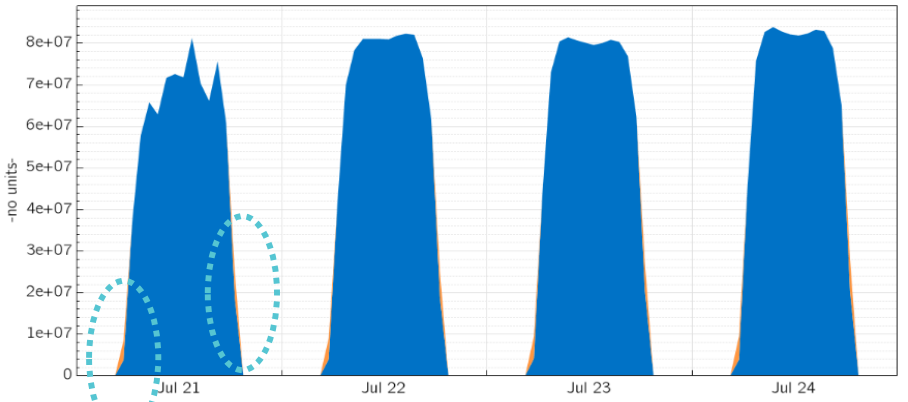
Two opportunities to boost power with half cut modules:

1. Electrical architecture of module
2. Shading from terrain & construction variance

Electrical part observable in simple modeling:

There are times during shoulder periods of the day when truetracking > backtracking with a half cell module.

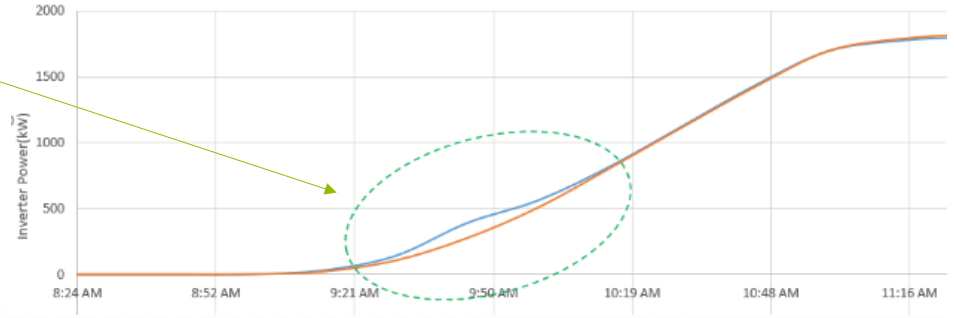
Up to +0.5 % gain from electrical benefit alone even on flat ground!



- Backtracking: avoid all shade
- Truetracking: point directly at sun and take shade

Initial Concept Validation

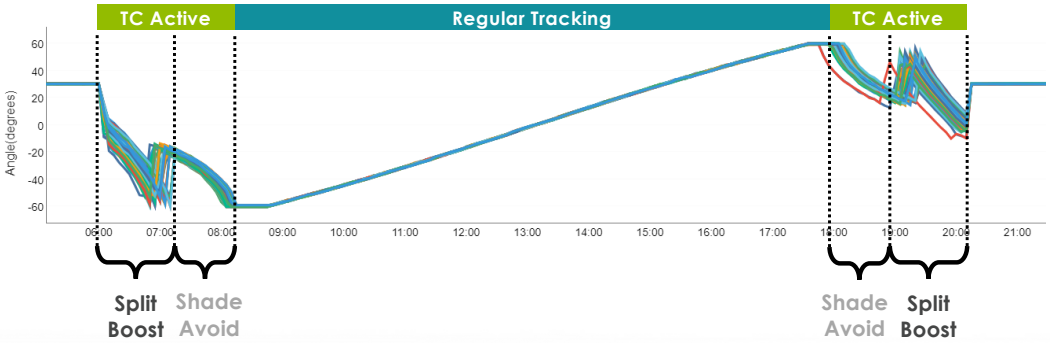
- Testing in December 2020
- Estimated benefit: +1.6 %
- Short term field data showing gains between +0.4 % and +1.9% depending on the location in the plant
- Electrical benefit of half cell tracking observed in early morning and late afternoon.
- Followed up with tests at scale



Split Boost Field Performance

12/30/20 6:43am – Split Boost: Up to 50% panel shaded

12/30/20 7:39am – Shade Avoidance: No panel shading



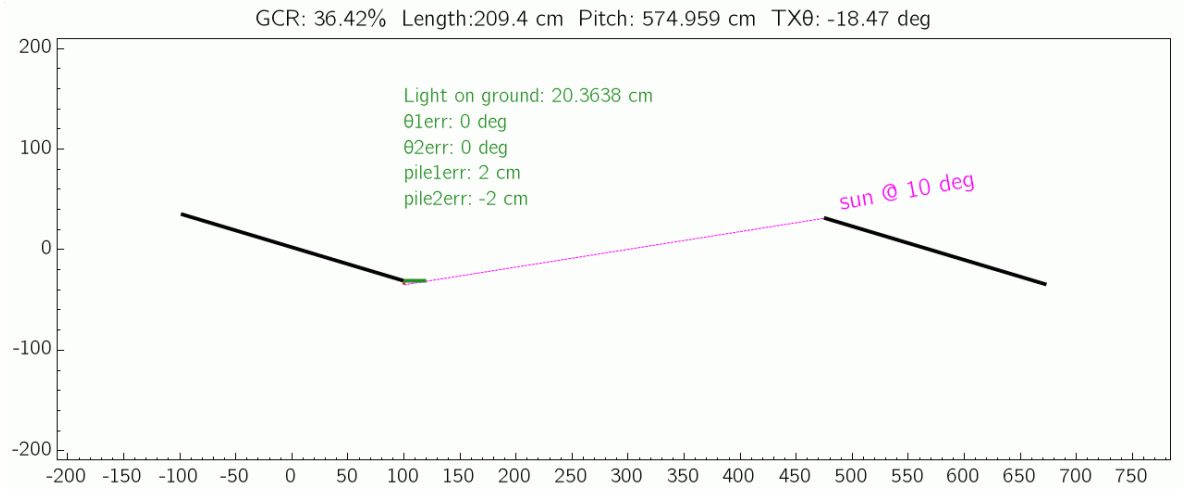
Location	Measured Gain	Test Duration
Michigan, US	**1.53 %**	9 months
Utah, US	**1.24 %**	12 months
Georgia, US	**0.92 %**	12 months
California, US	**1.37 %**	6 months
United Kingdom	**0.68 %**	6 months
New South Wales, AUS	**1.08 %**	6 months

Table shows in-field measured gains on test blocks running alternating day TrueCapture vs standard backtracking, normalizing for temperature and irradiance between ON/OFF days.

Updated August 2022

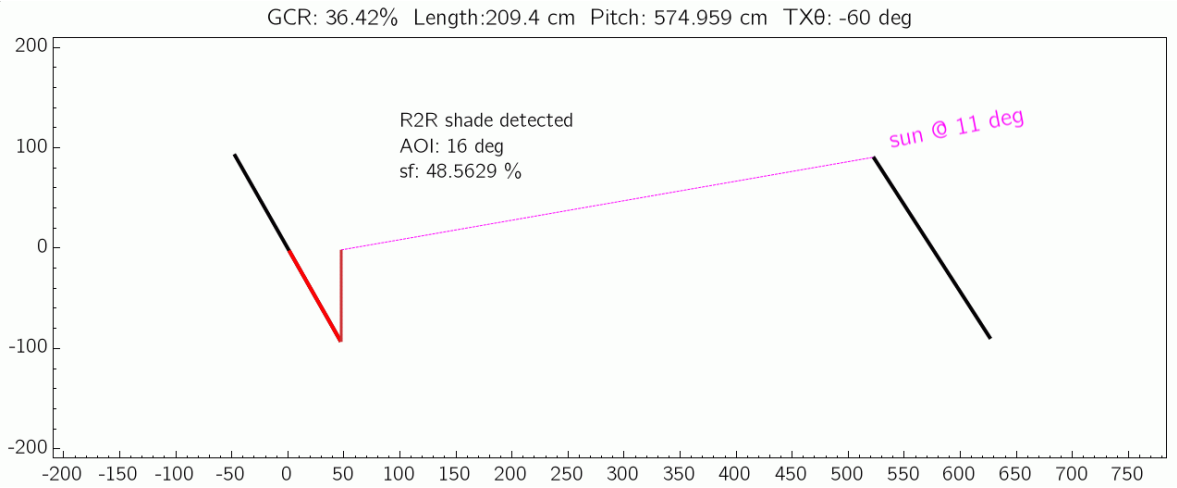
Real-World Challenges #1

How accurately can we avoid shade on adjacent trackers in the field at low sun elevation angles?



Real-World Challenges #2

How accurately can we cast a shade line on an adjacent tracker at low sun elevation angles?

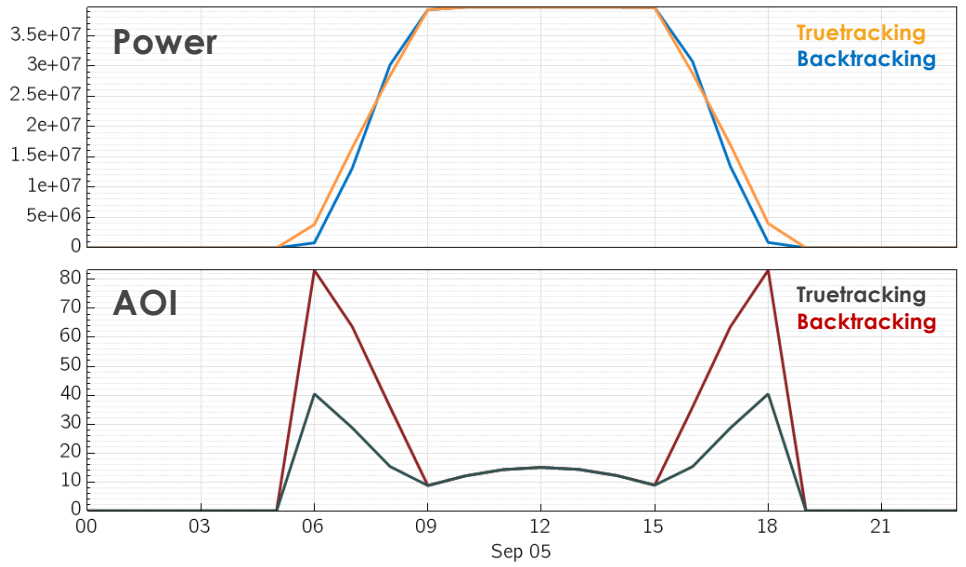


2P Trackers and Half Cut Modules

Truetrack, Backtrack, or TrueCapture?

- Consider a 2P+HC site with a high GCR, modest eastward ground slope
- For annual TMY on flat ground, difference between TT and BT energy production is small, but BT is worse by about -0.35%
- Backtracking with topography is likely the worst option in this case:
  - You incur the AOI loss from aggressive backtracking
  - You still take shade from adjacent rows in the afternoon
- We don't do TrueCapture for 2P+HC – there is a theoretical benefit you could probably model, but it's too subtle to meaningfully implement and measure in the field

Example clear sky day profile is for flat ground



Summary

- Long term field tests in many locations show real meaningful gains for TrueCapture Split Boost
- TrueCapture specializes the tracking scheme to module technology and tracker architecture
- Seasonality in irradiance content is important to consider in field tests
- Accommodating real-world issues like clipping and curtailment in field data analysis is essential
- Independent row technology allows for maximum gain opportunity
- Real-world implementation of advanced algorithms can be trickier than in software models

Thank you!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