

AdAstra: different approach for silicon-based tandem solar cells using perovskite on back-contacted devices with three- terminal wiring to go beyond 30 % power conversion efficiency.

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AdAstra aims to outperform the current mainstream PV technologies by demonstrating three-terminal tandem photovoltaic devices based on interdigitated back-contacted crystalline silicon bottom cells and perovskite top cells with > 30 % stable conversion efficiency at a cost of ownership < 20 c€/Wp.

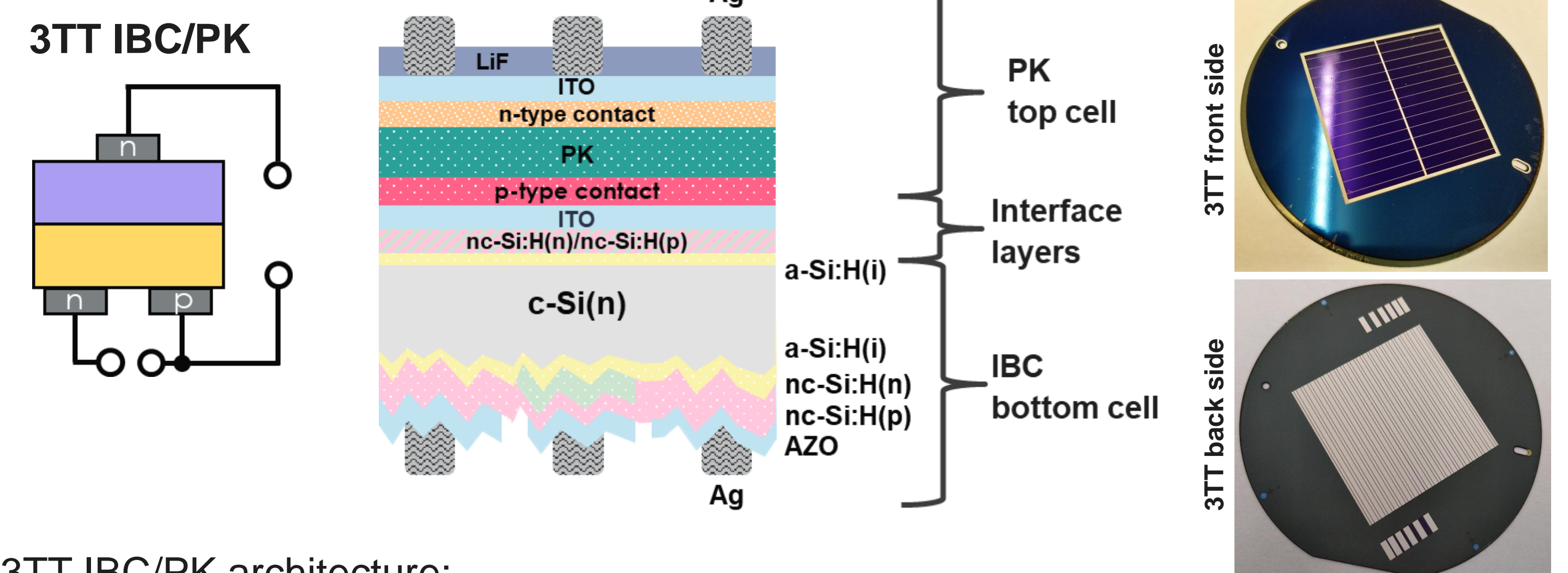
Three-terminal tandem (3TT) solar cells

Tandem solar cells – various configurations

Configuration:	2TT	3TT	4TT
Design:			
Sensitivity to top cell Eg:	High	Low	Low
Energy yield:	++	+++	+++
BOS:	€	€ €	€ € €
Process complexity:	Moderate	Moderate	High

- No constraint of current matching between subcells
- Subcells operated independently at their MPP
- Back contact shared by both subcells → minimization of parasitic absorption

3TT IBC/PK solar cells



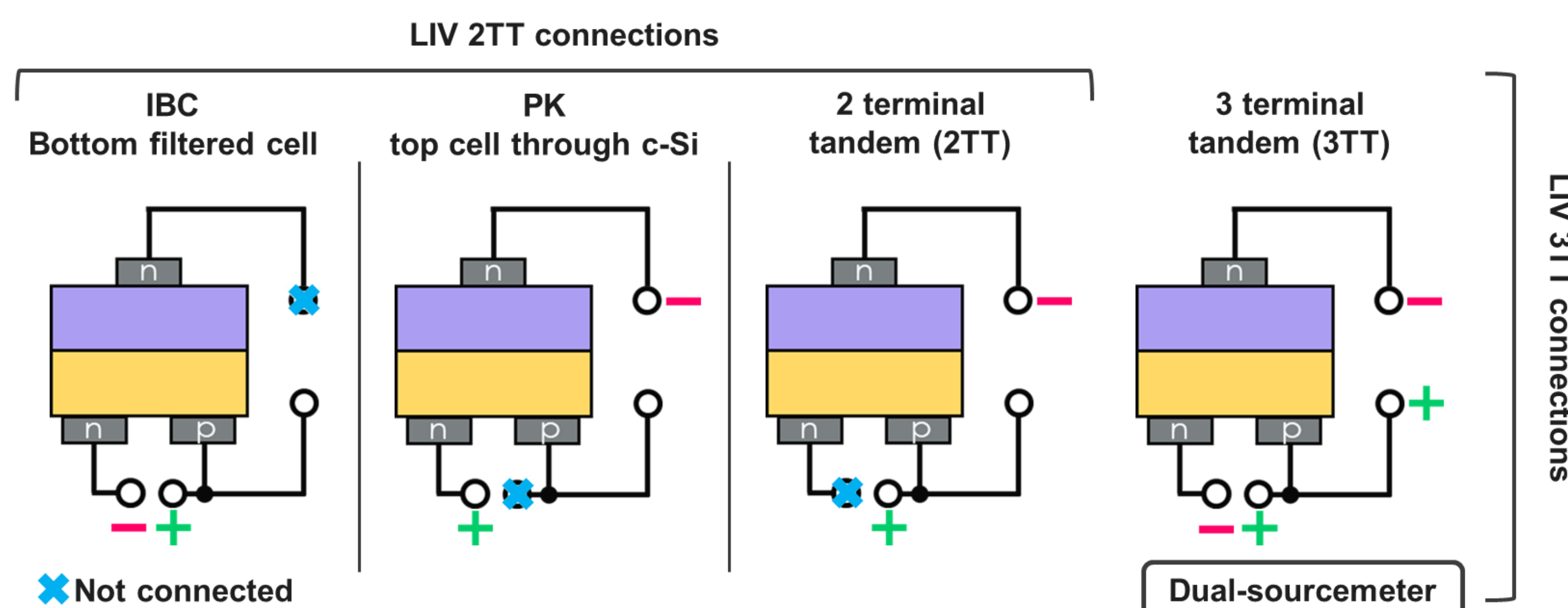
3TT IBC/PK architecture:

- Size **24.5 cm²**
- Single side textured c-Si(n) wafer
- SHJ IBC with tunnel junction technology^[1]
- Full area interface layers
- PK deposition with spin coating (p-i-n)
- Front ITO with shadow mask to define the cell area
- Front grid metallization with one middle busbar

[1] Tomasi et al, Nat Energy 2, 17062 (2017)

3TT investigation – interconnection and characterizations

Four different connection schemes:

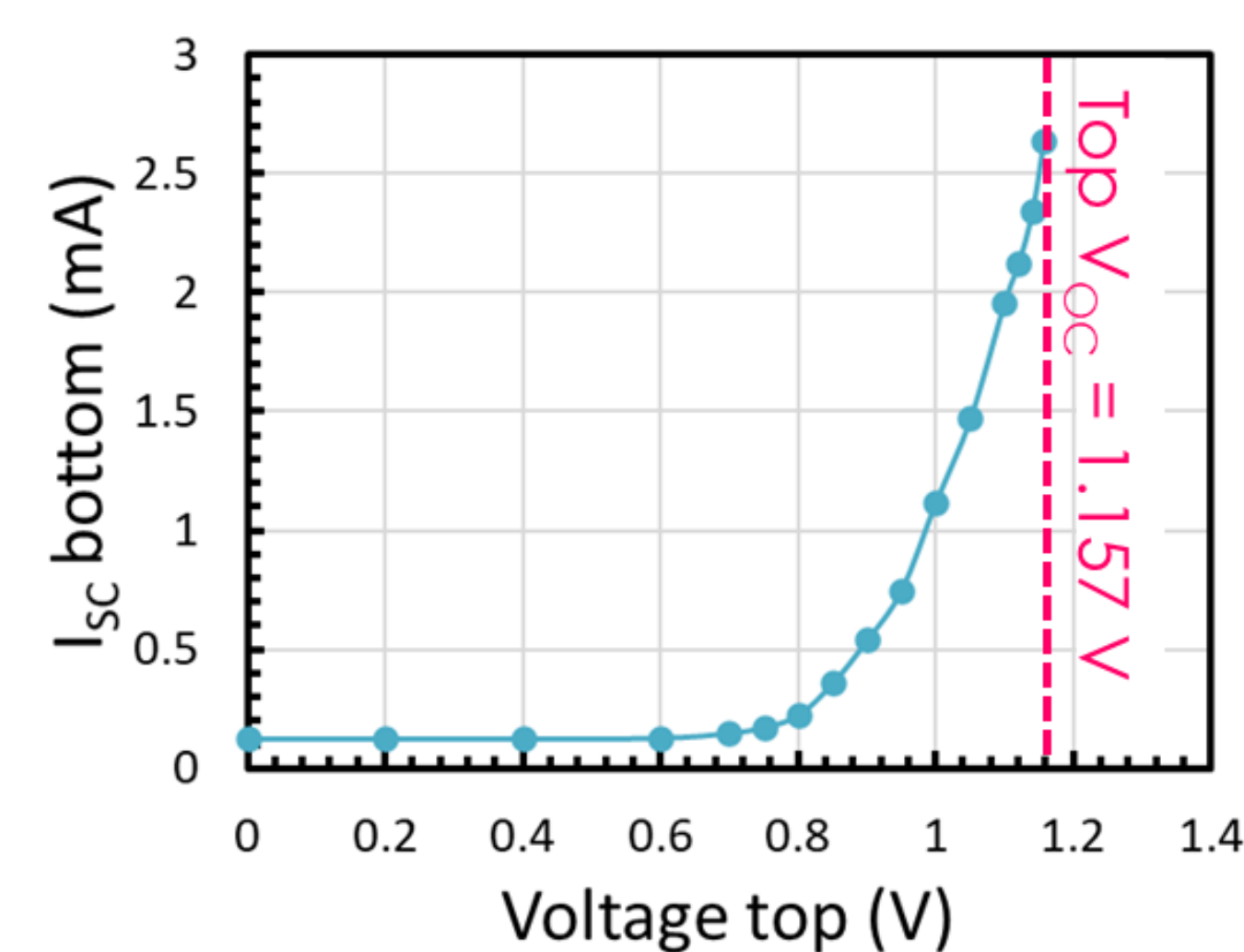


Full LIV curves and parameters of the bottom, top and 2TT cells measured independently

→ opens the way for deeper investigation and understanding of tandem devices

Cell	eff (%)	FF (%)	J _{SC} (mA/cm ²)	V _{OC} (mV)	J _{MPP} (mA/cm ²)	V _{MPP} (mV)
2TT	24.6	72.9	18.5	1828	16.3	1477
bottom	10.2	78.8	18.4	700	17.2	591
top	14.4	69.6	18.4	1127	16.4	881

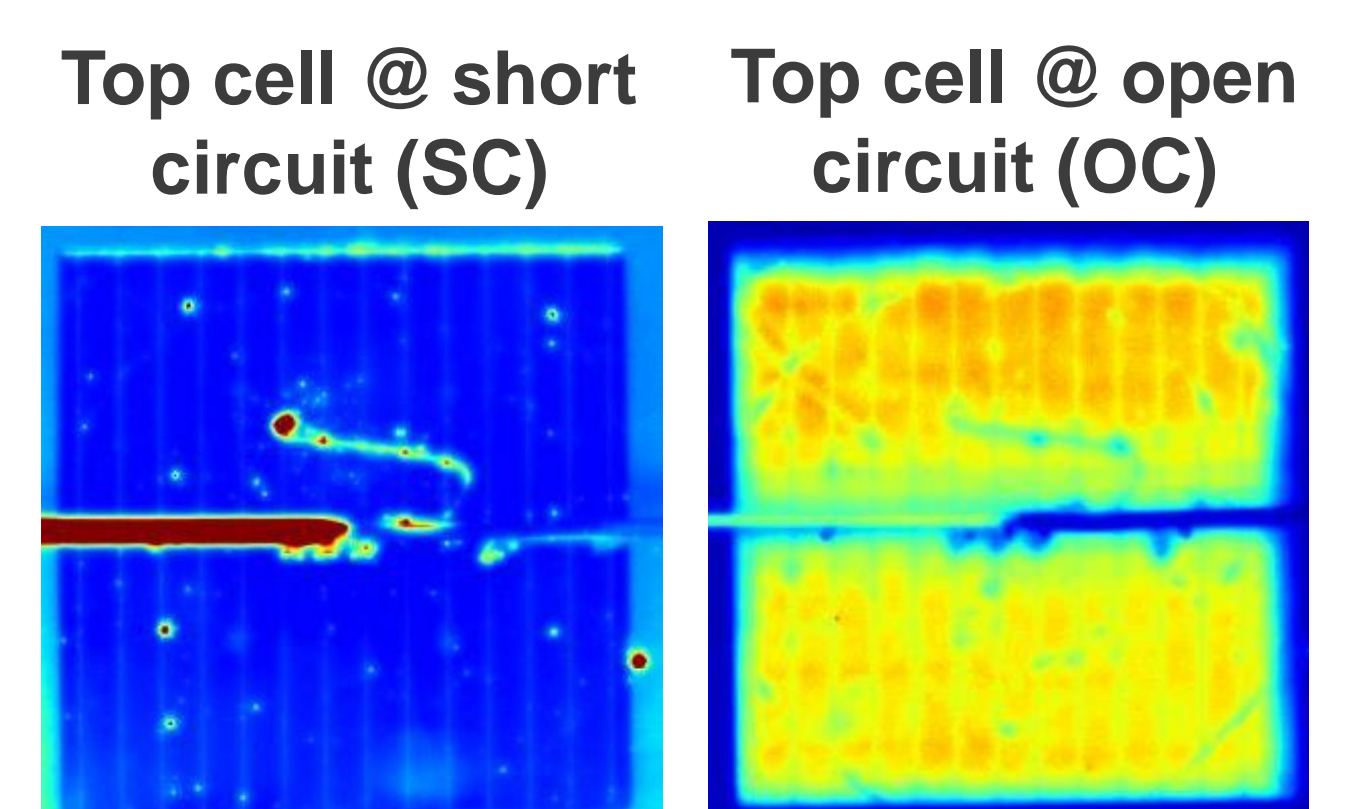
Luminescent coupling



Maximal short circuit current (I_{SC}) for the top @OC = **2.64 mA**

→ Direct measurement of the luminescent coupling between the top and the bottom cell

PL images of the top cell



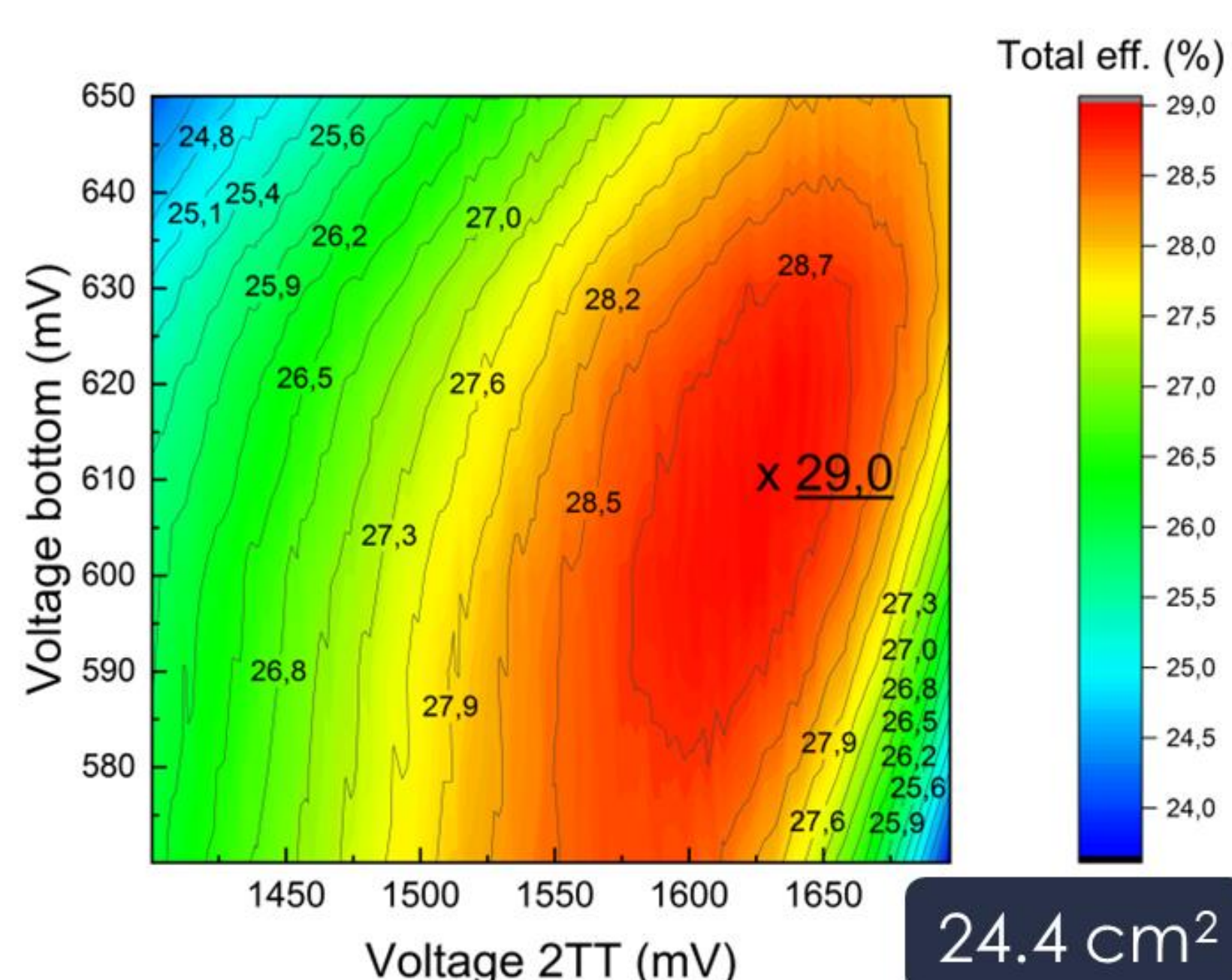
- Too high current to be explained by the V_{OC} of the PK → Investigation of the model given in literature on-going^[1,2]
- Topic of upcoming publication

[1] Jäger et al., Solar RRL, vol. 5, 3 (2021)

[2] Caprioglio et al., Adv. Energy Material, vol. 9, 33 (2019)

3TT devices – world record efficiencies for single cell and string interconnection

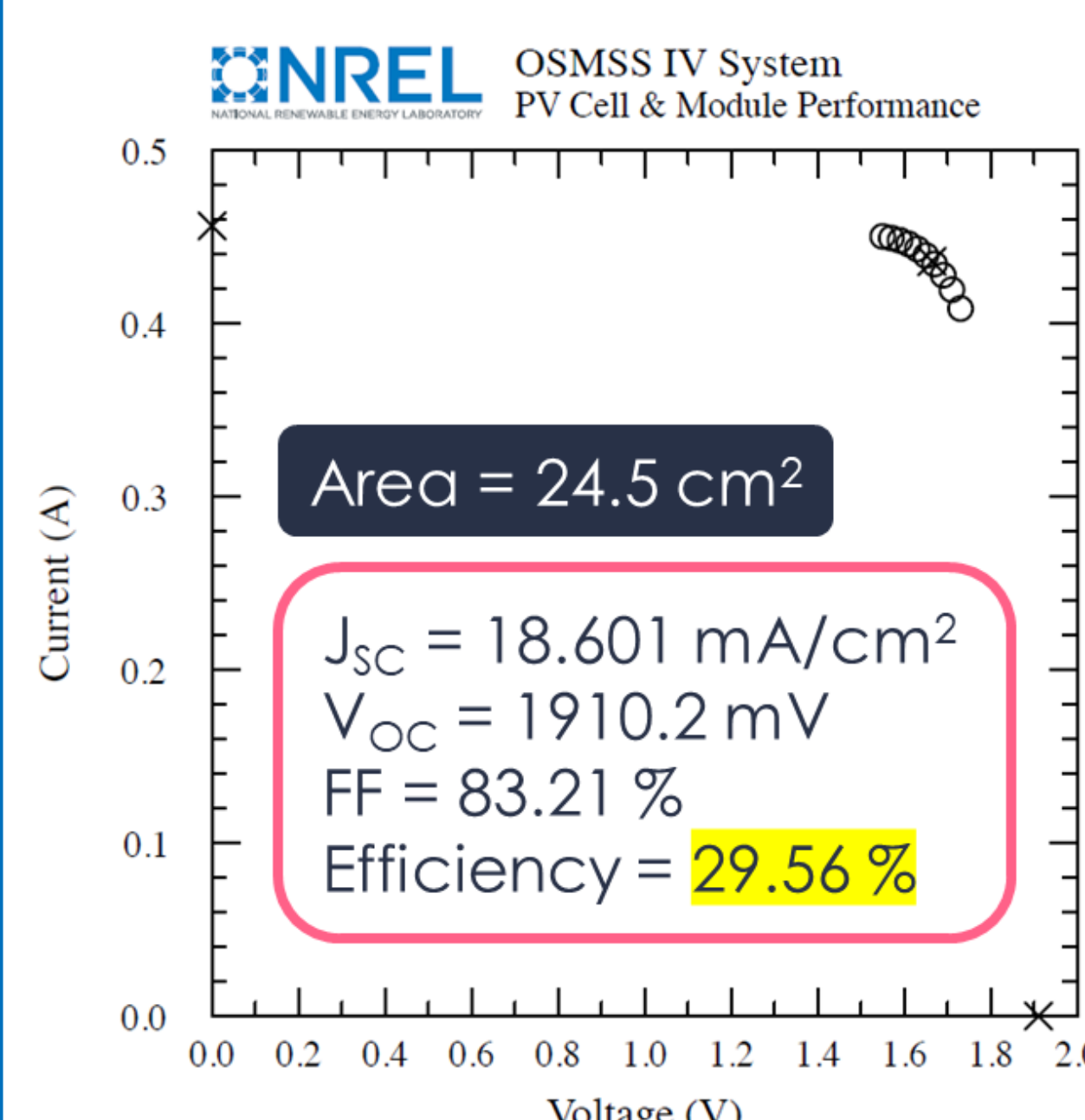
3TT efficiency mapping



- Voltage of the bottom fix and voltage of the 2TT swept
- Sum of the two powers to get the total efficiency

Efficiency up to 29.0 % on 24.4 cm² measured in 3TT configuration (in-house)

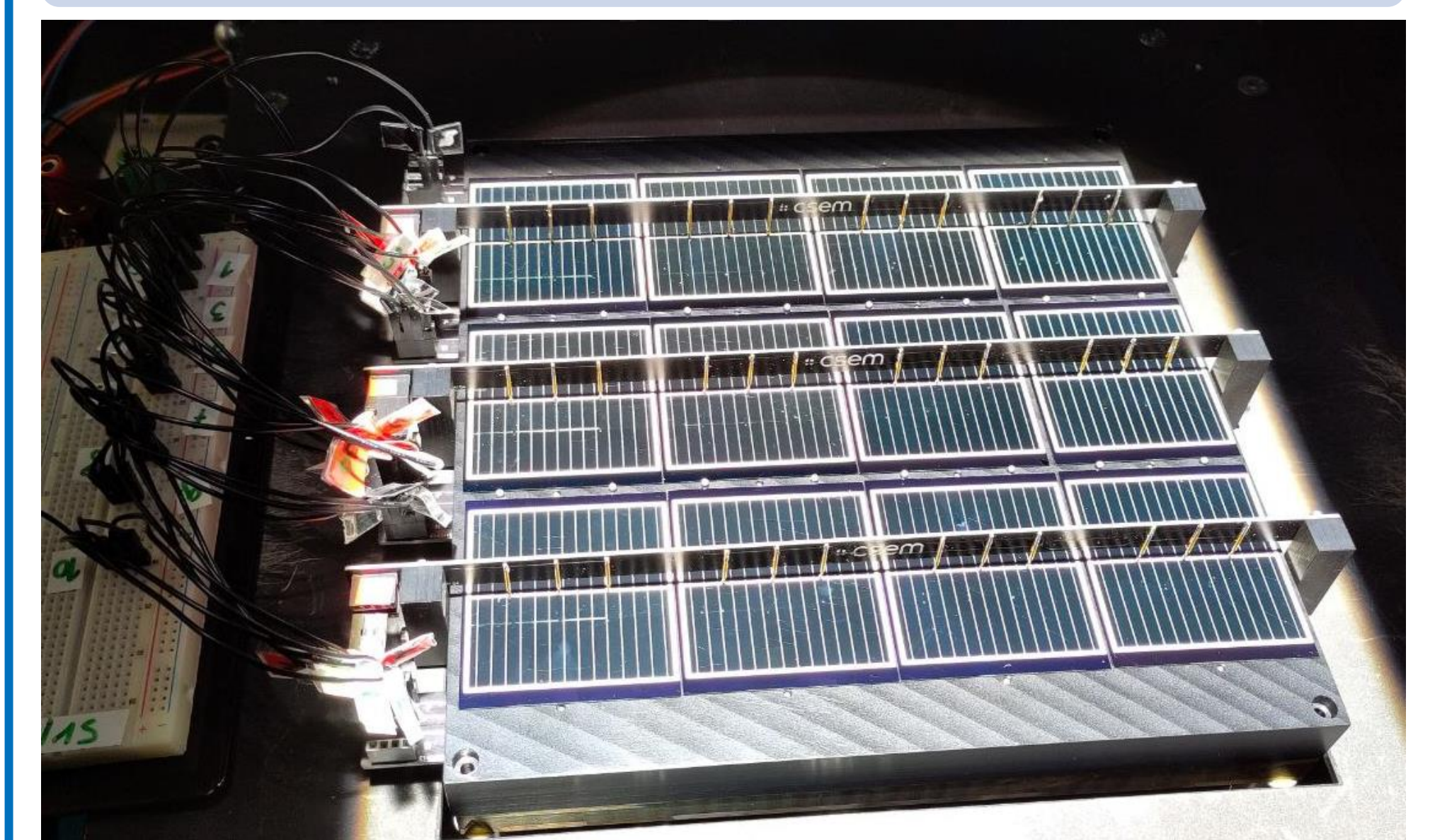
2TT certification



- Certification not yet possible in 3TT configuration
- Higher efficiency expected when measured in 3TT conf.

World record efficiency for such Si/PK tandem size of 24.5 cm² → promising for upscaling

3TT string interconnection



Config	Isc (mA)	Voc (mV)	FF (%)	eff
2TT	469.4	22969.1	67.3	24.2
3TT - 2/1s	1399.6	6462.2	66.7	20.1
3TT - 3/2s	2342.1	3270.2	64.1	16.4

First experimental proof of concept of 3TT solar cells interconnection in module string configuration