



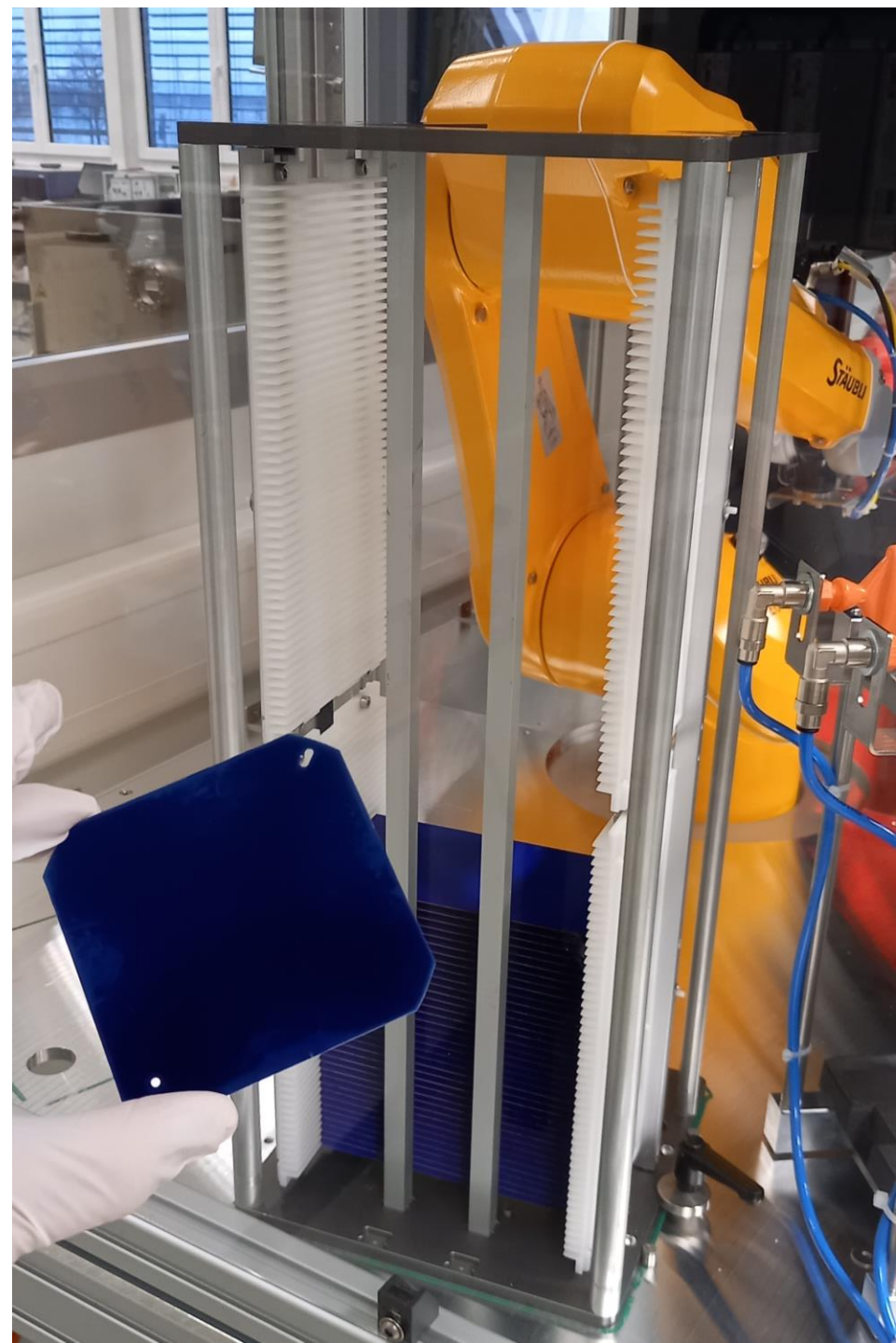
# Tunnel-IBC solar cells and modules

BC Workshop, 29/11/2023

Damien Lachenal, Head of Research & Development, Meyer Burger Research

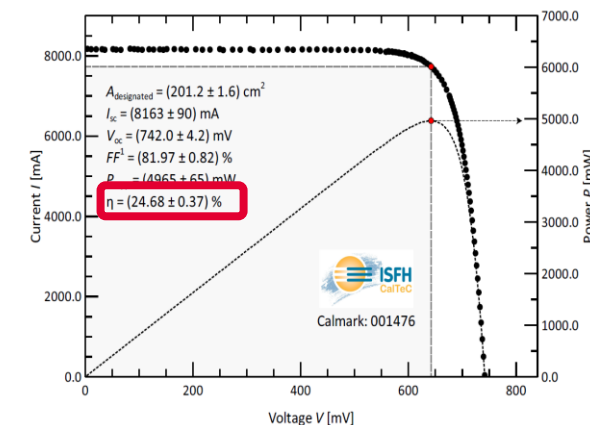
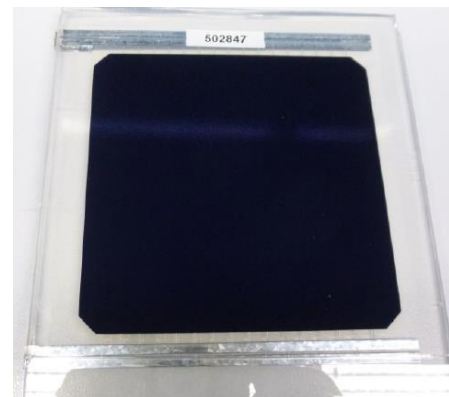
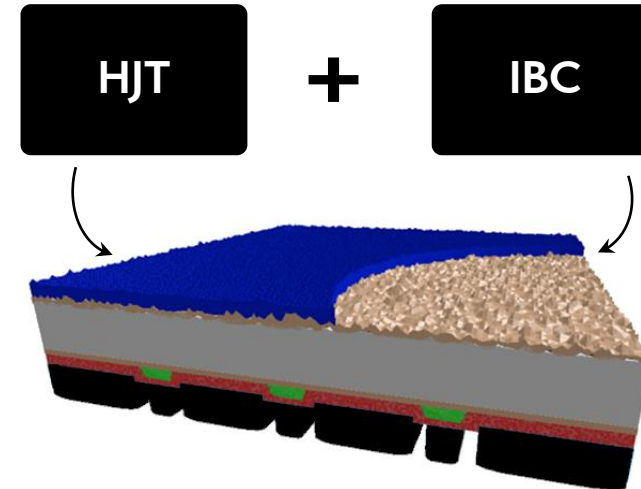
# Outline

- 1 Introduction
- 2 Sirius and Pilatus projects
- 3 Tunnel IBC solar cells
- 4 Tunnel IBC Modules

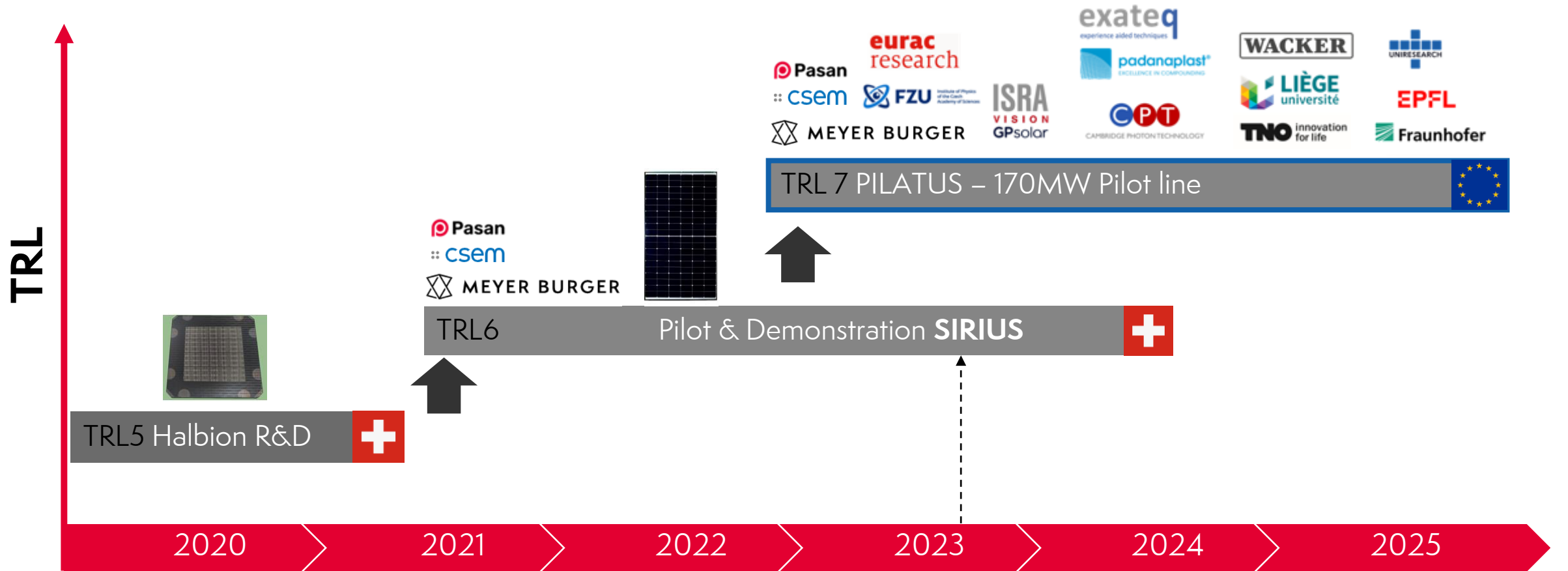


# Introduction to Tunnel IBC solar cells

- Co-developed at EPFL/CSEM, focus on simple process flow from the start to enable mass production lately
- Performance > 25%, industrial potential 26%
- 10 process steps only & single alignment
- Strong patent portfolio developed



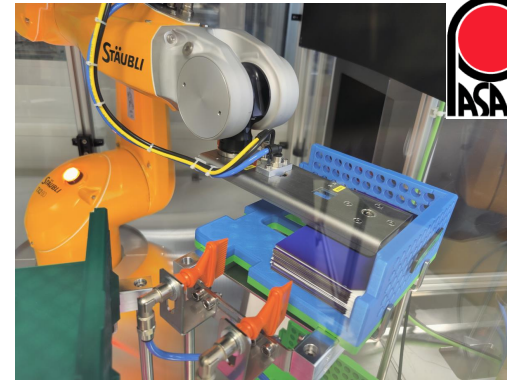
# SIRIUS & PILATUS projects



# SIRIUS Project

## M6/M10 New Machine prototypes development

Cells



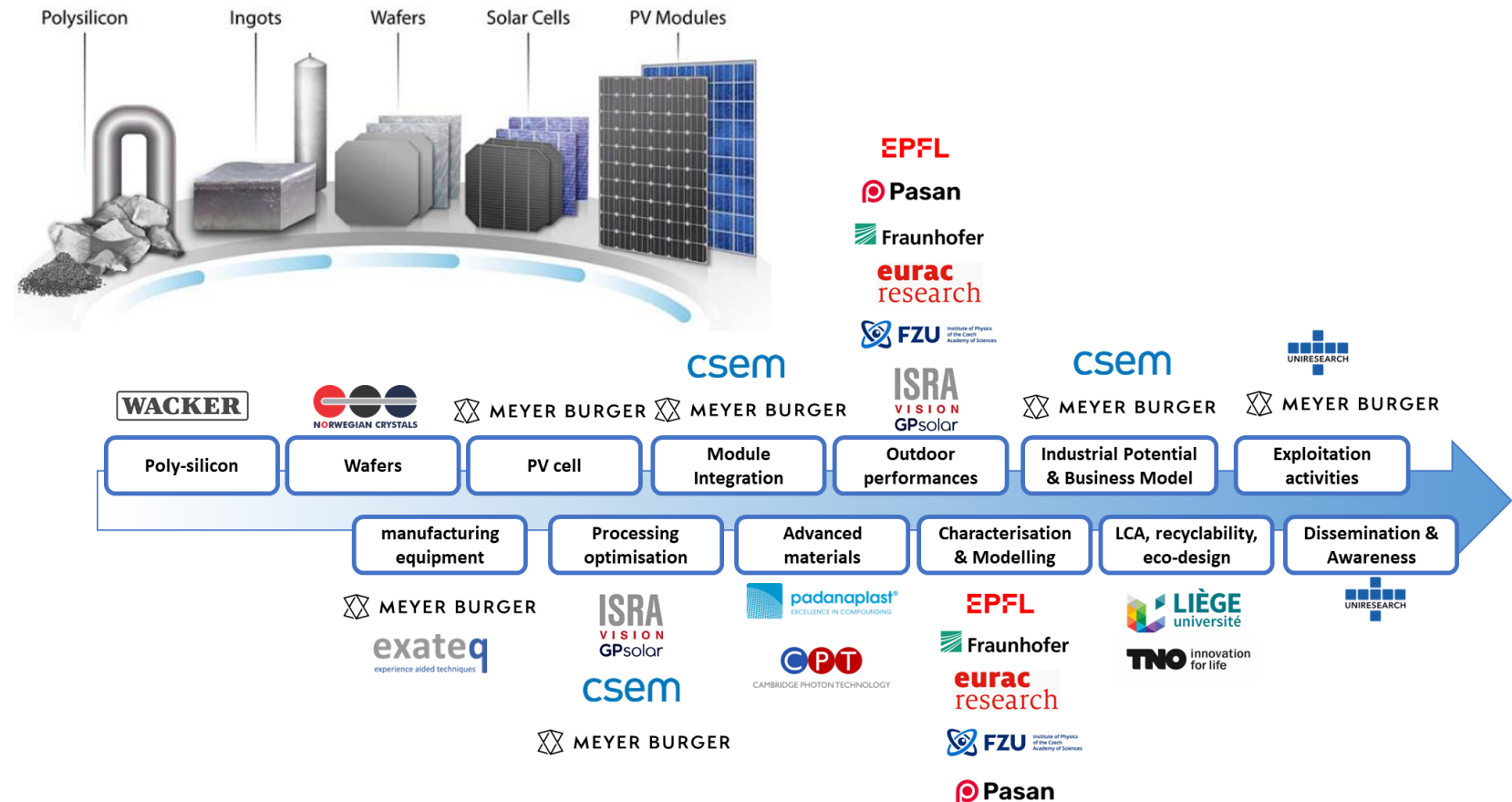
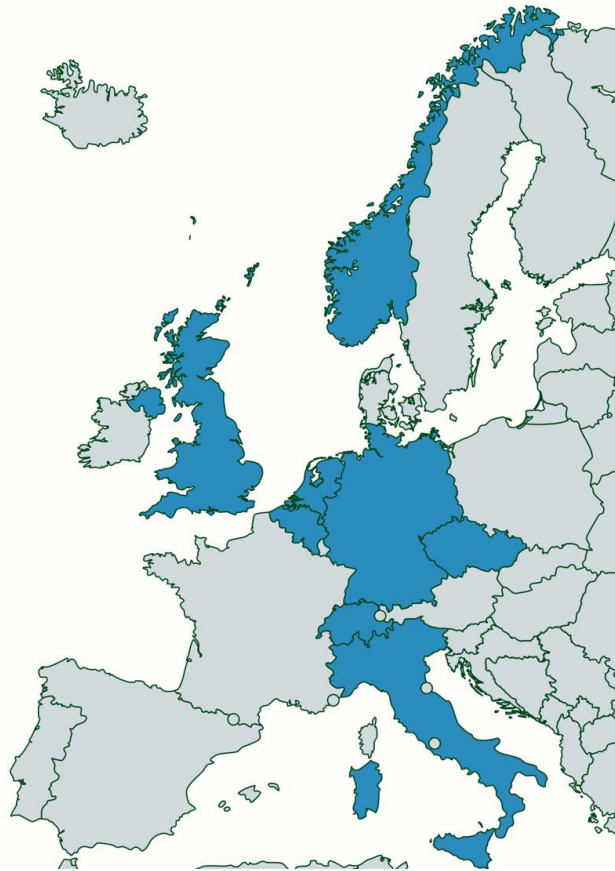
Module



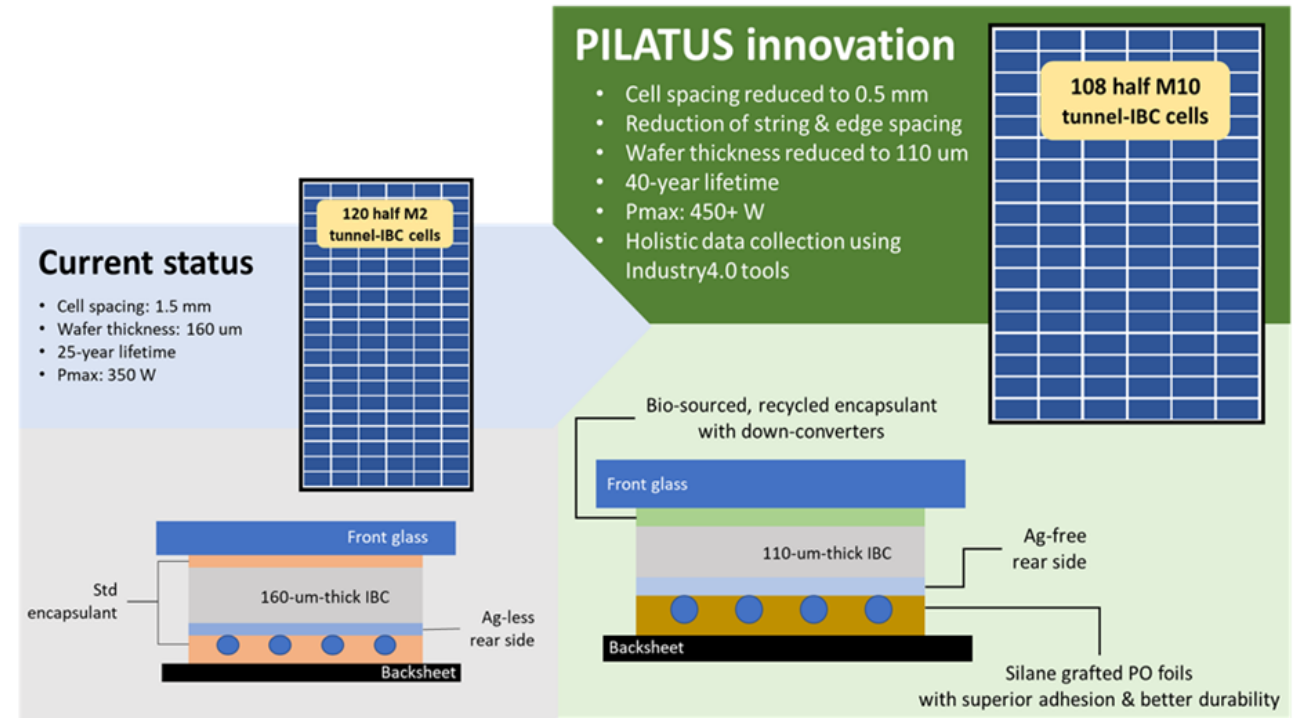
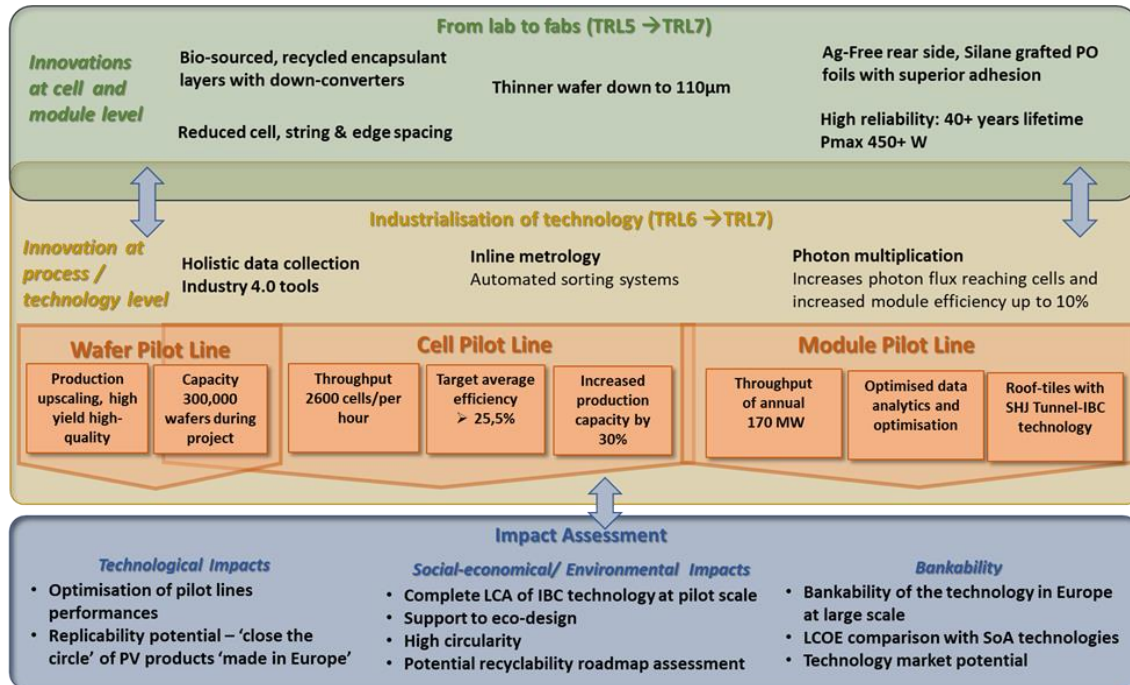
### Technology platform for Tunnel IBC cells & Module :

- Tools prototype development (Cells & Module)
- 400W – 120HM6 Module power
- Silver metallization cost down
- Module Reliability > 30 years

# PILATUS Consortium covering the complete PV Value Chain

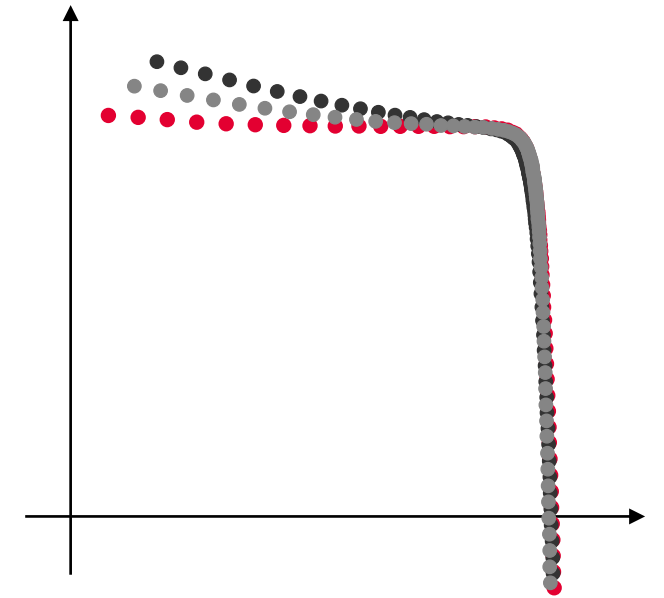
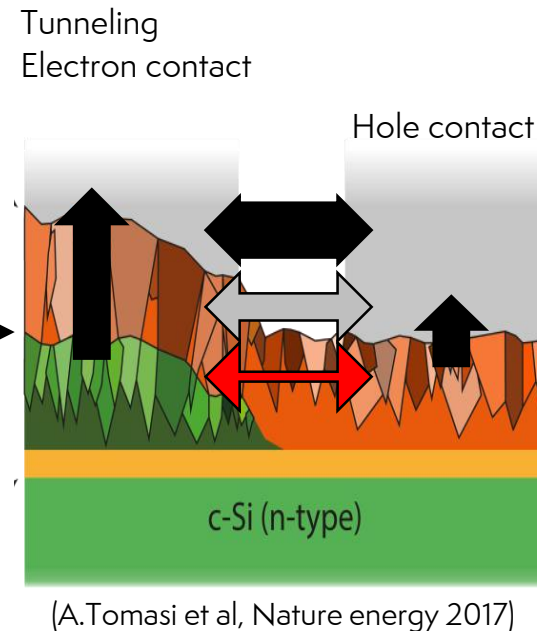
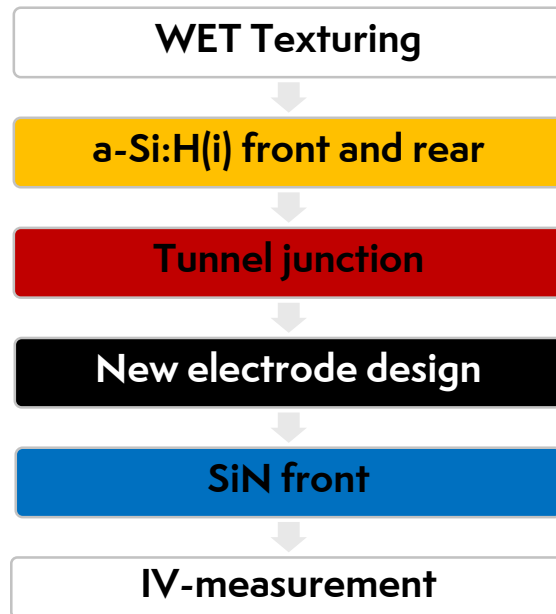


# PILATUS Project



# Tunnel IBC solar cells

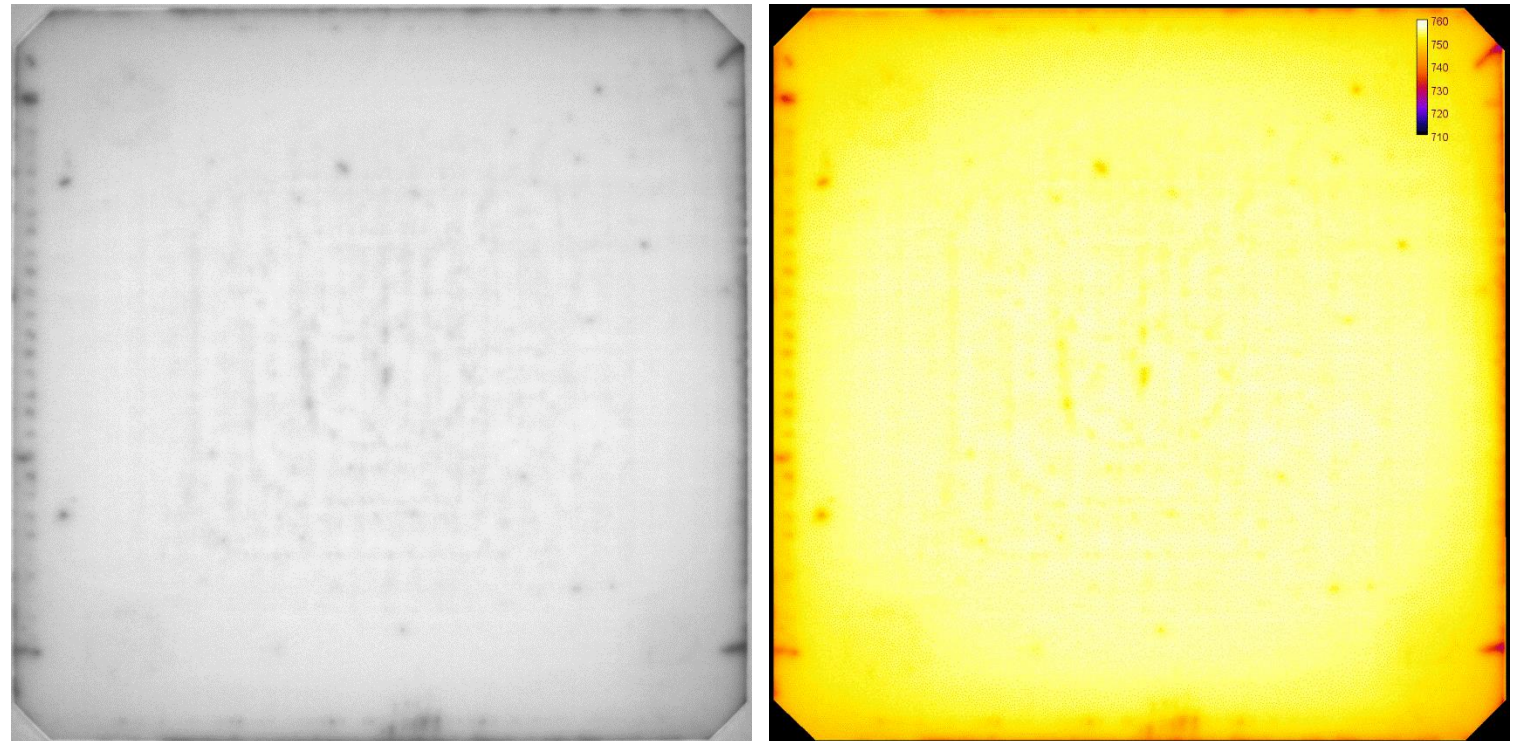
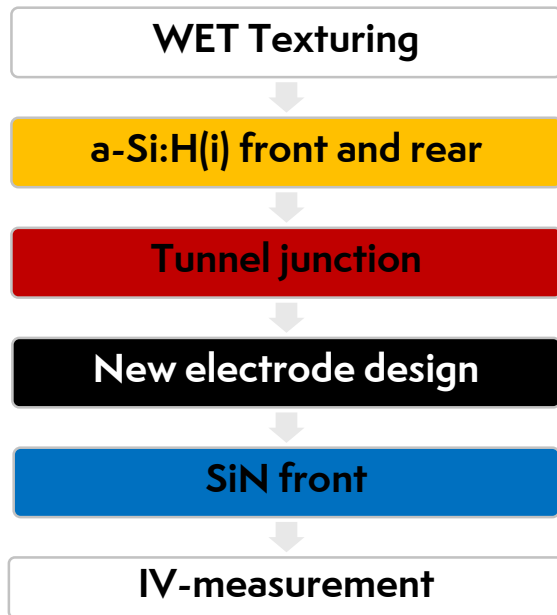
- amorphous silicon passivation
- nc-Si:H(n,p) layer engineering allows depositing different materials for electron or hole contacts





# Tunnel IBC solar cells

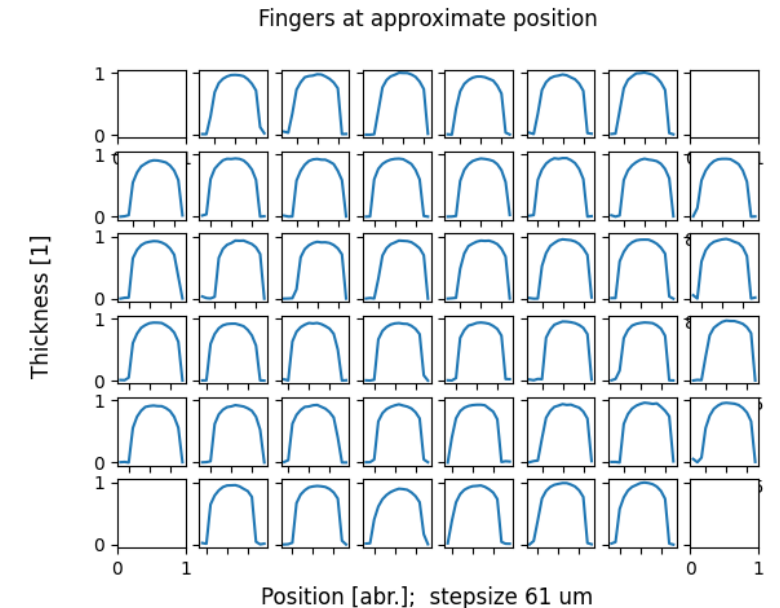
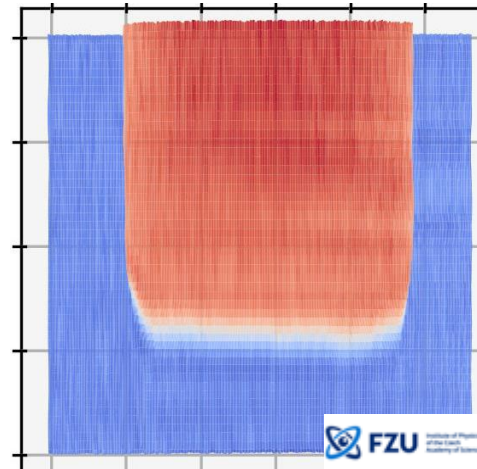
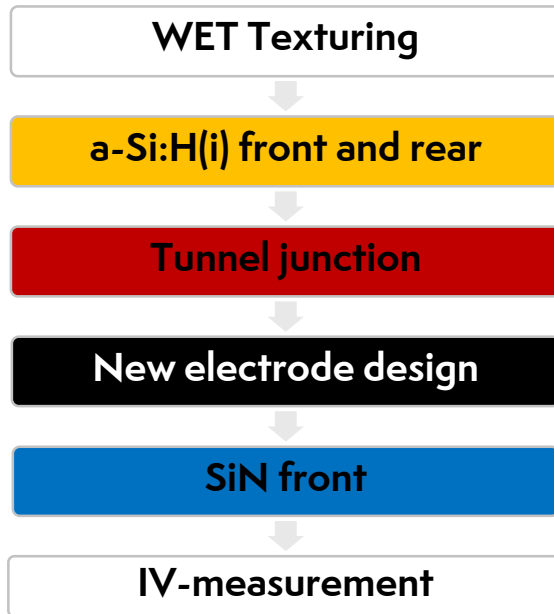
3<sup>rd</sup> generation of masking technology "damage free"



Photoluminescence picture (1sun) with i/nuc<sup>mask</sup>/puc

# Tunnel IBC solar cells

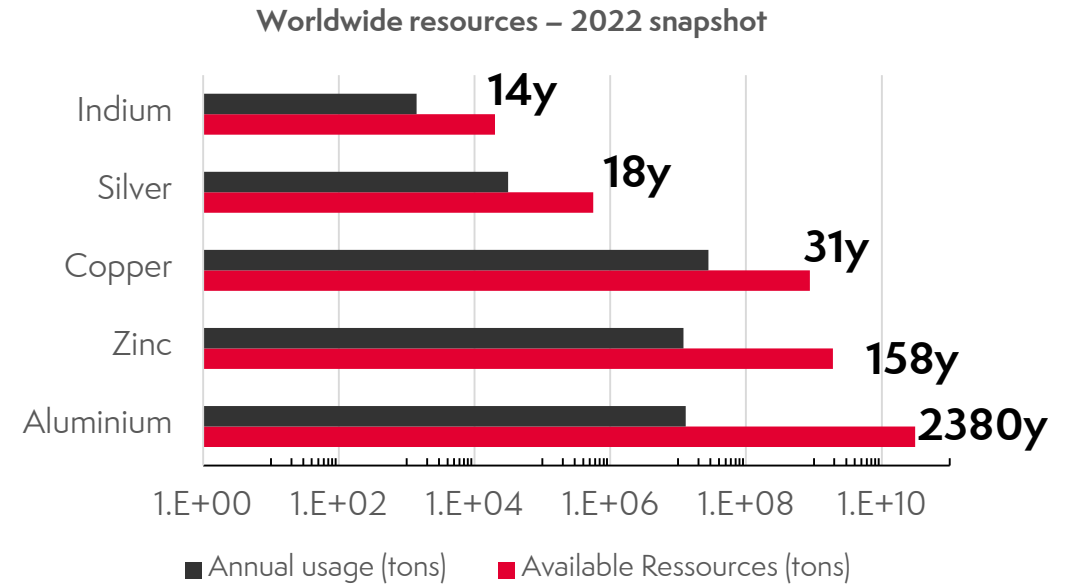
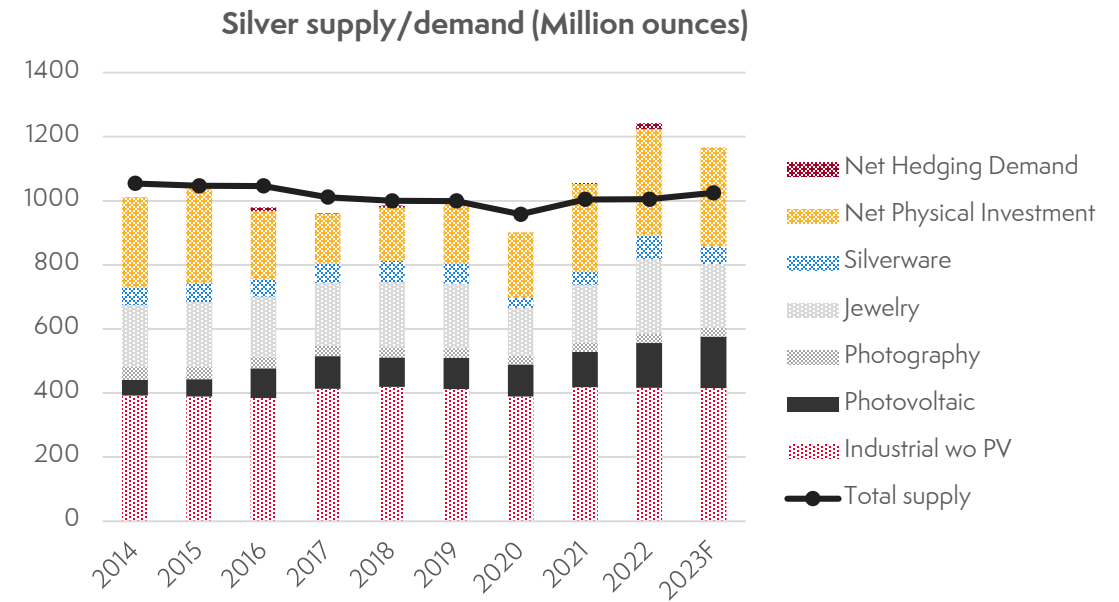
## 3<sup>rd</sup> generation of masking technology



- Sharp and uniform nc-Si:H layer over the whole wafer
- Layer uniformity +/- 3% over the whole wafer
- Technology is up scalable to any wafer format (M10, M10R, G12...)

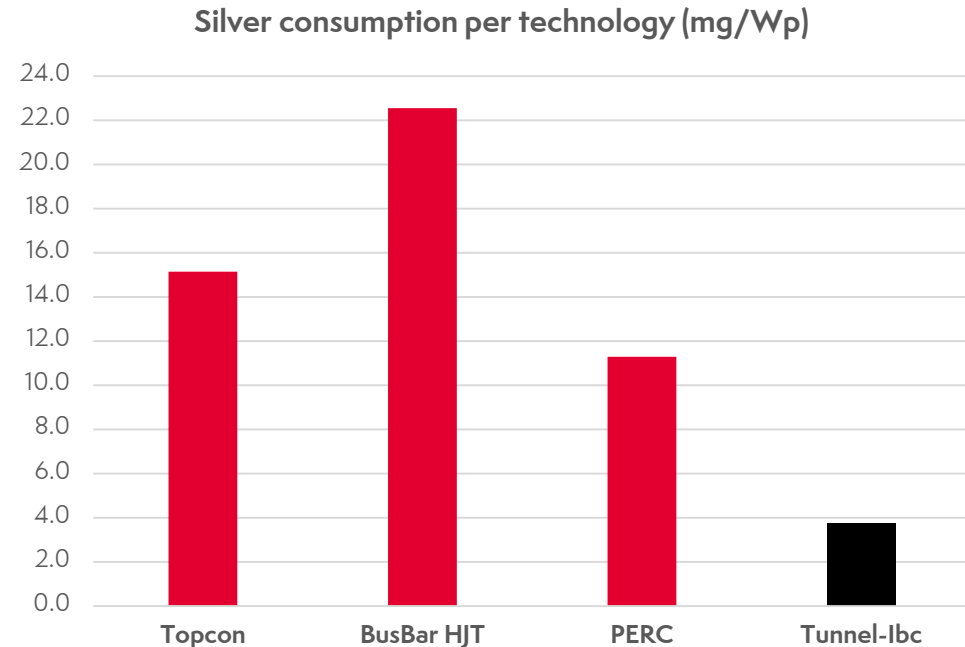
# Tunnel IBC solar cells

- 3<sup>rd</sup> consecutive year of **supply < demand**
- PV Silver consumption 2023: +15%
- New electrode design was developed to limit Ag consumption

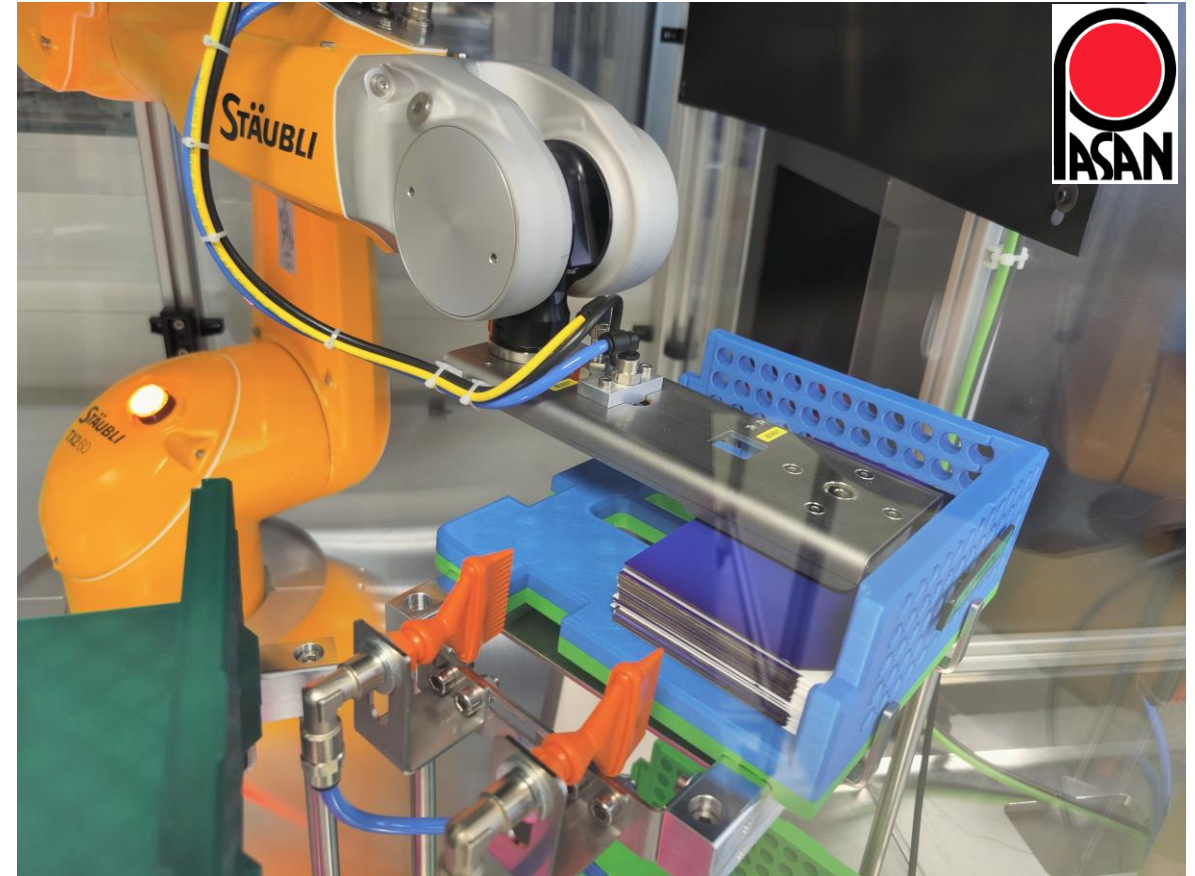
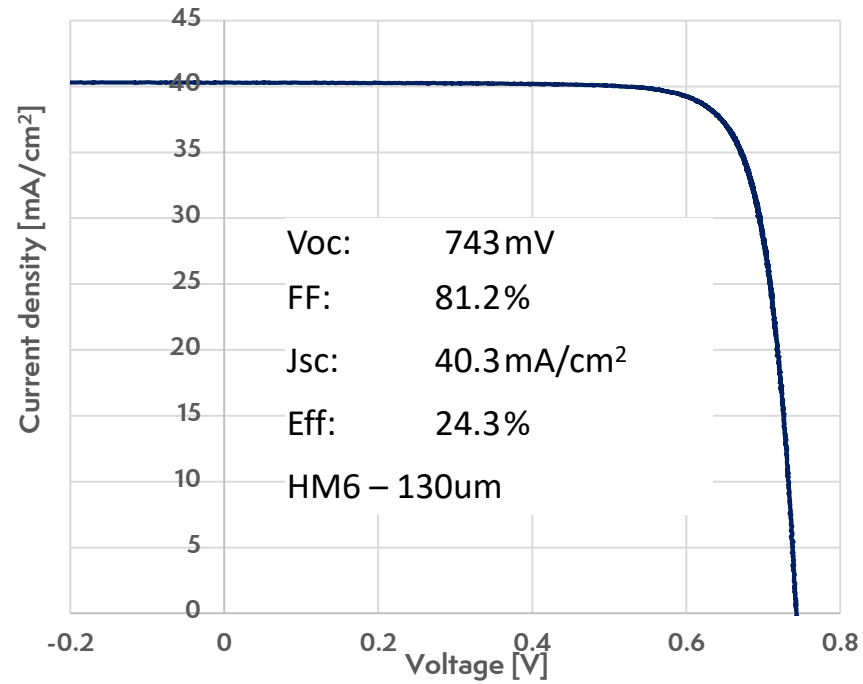


# Tunnel IBC solar cells

- **New rear electrodes design with multiple fonctions:**
  - Indium free and silver consumption reduced to 3.7mg/Wp.
  - A better reliability against moisture ingress.
  - Low processing cost without the need of plating.
  - Fully compatible with our new SWCT interconnection technology.



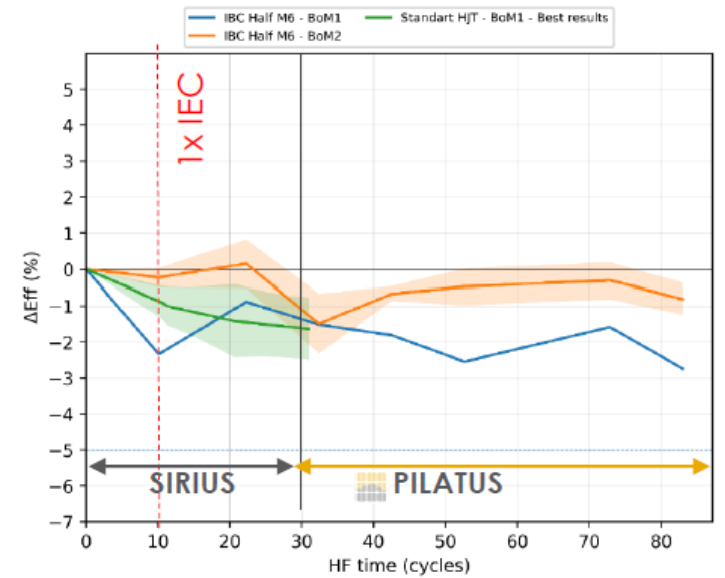
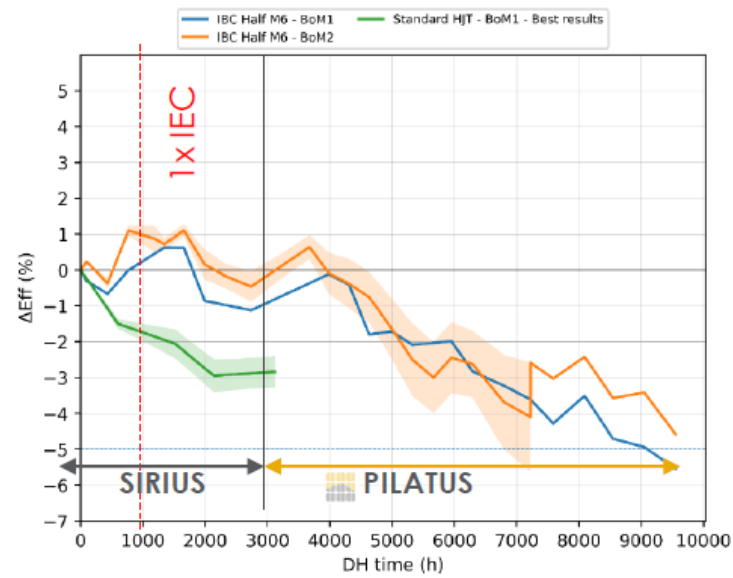
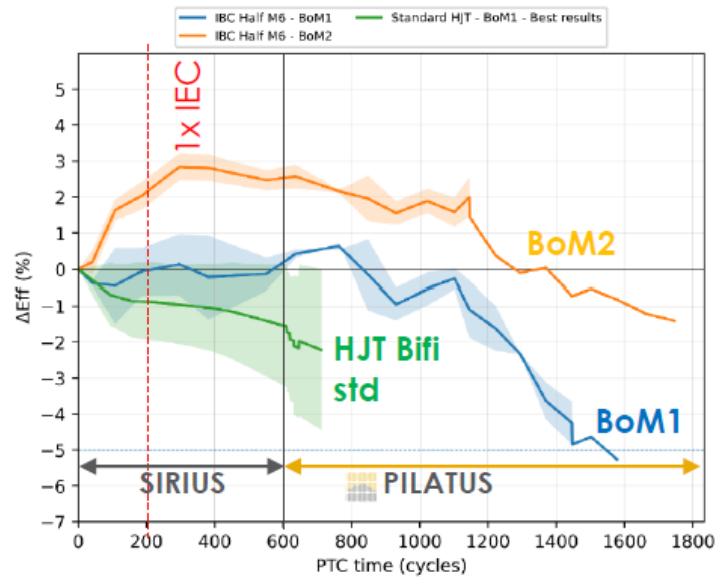
# Tunnel IBC solar cells



300wph IV-DIV-EL-PL "Swiss Knife tool"

# Reliability tests

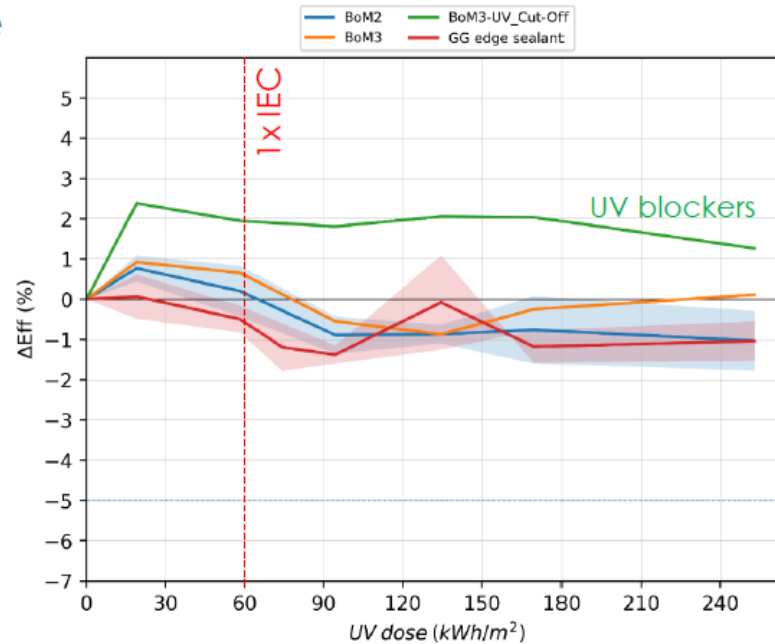
Goal: extended degradation time in TC, DH or HF until failure (< 95% initial performances) on SIRIUS samples



- >8x the requirements time in Thermo-Cycling (TC) IEC standard
- >9x the requirements time in Damp Heat (DH) IEC standard
- >8x the requirement time in Humidity Freeze (HF) IEC standard
- More reliable than the standard HJT modules

# Reliability tests

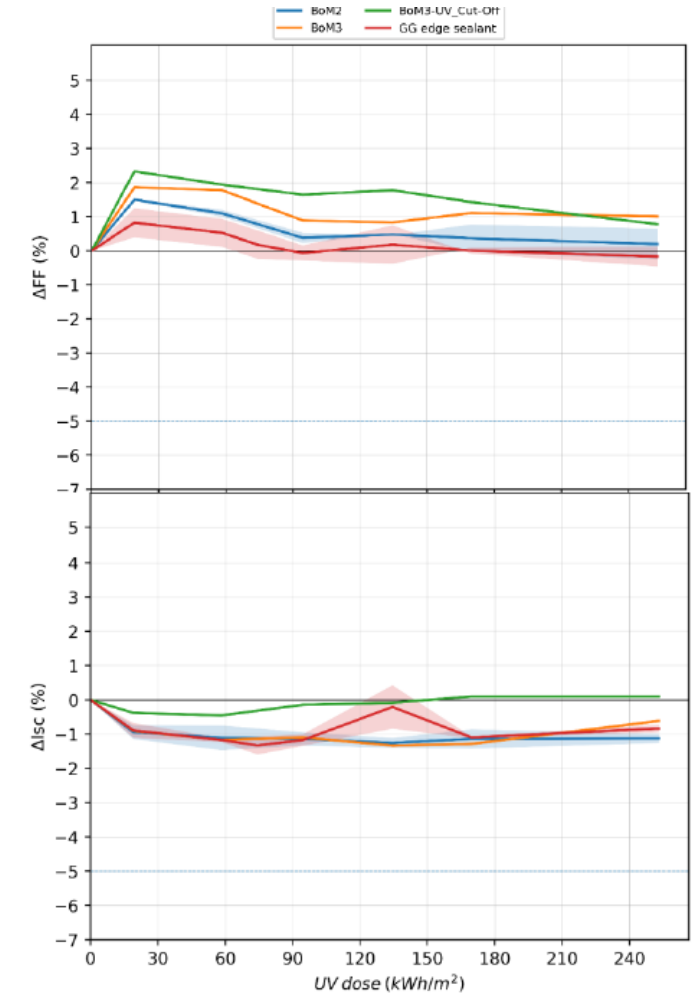
Goal: Test reliability of HJT-IBC modules under UV light soaking (LS) exposure



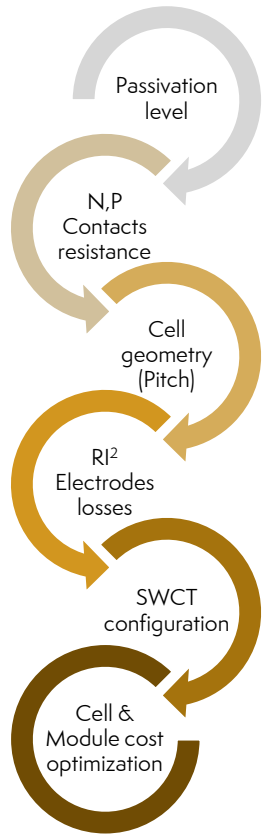
~ -1% degradation observed after 250kWh/m<sup>2</sup> UV dose

No degradation with UV cut-off encapsulant

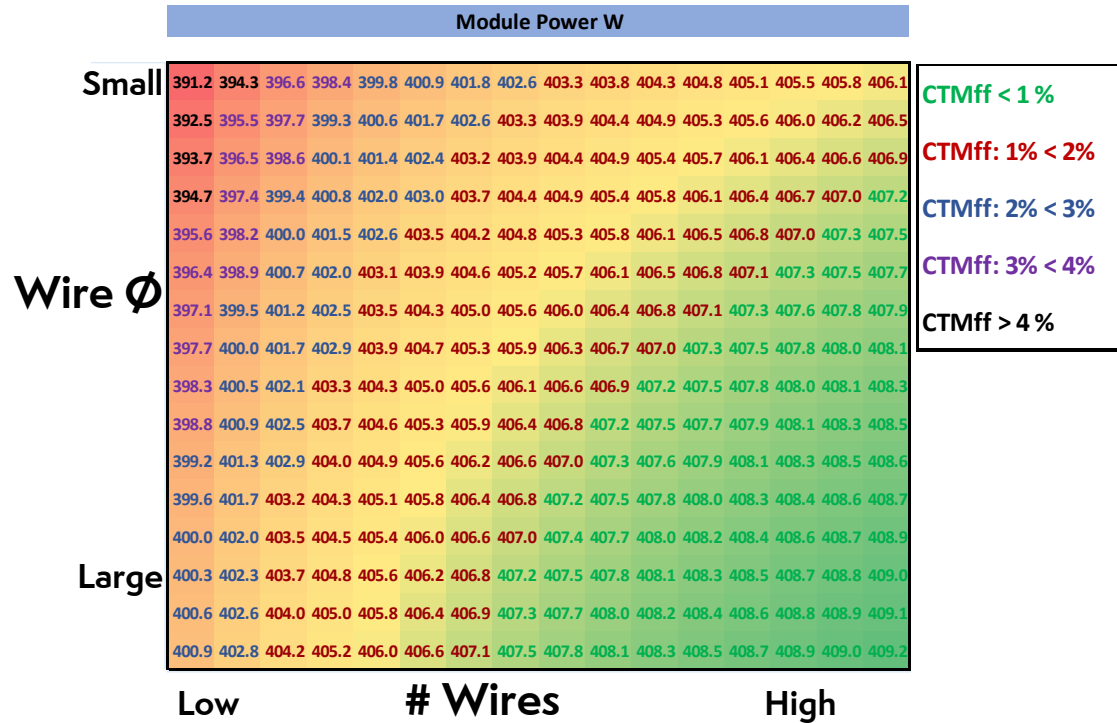
Light soaking effect improves module performances



# Interconnection Loss model



25% Tunnel-IBC cell – 120xHM6 model

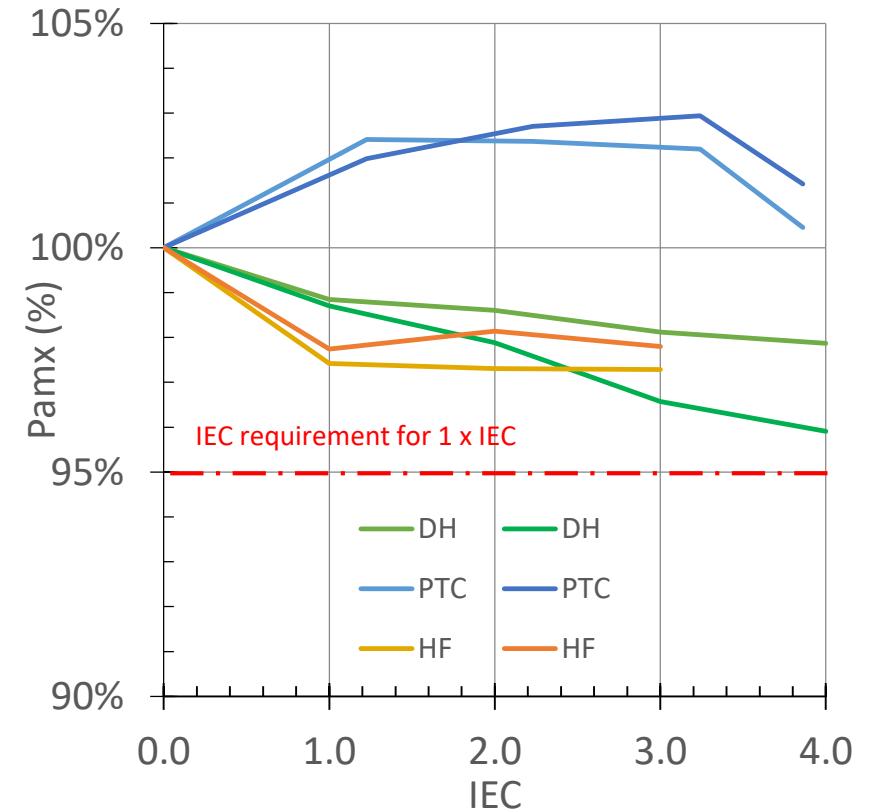
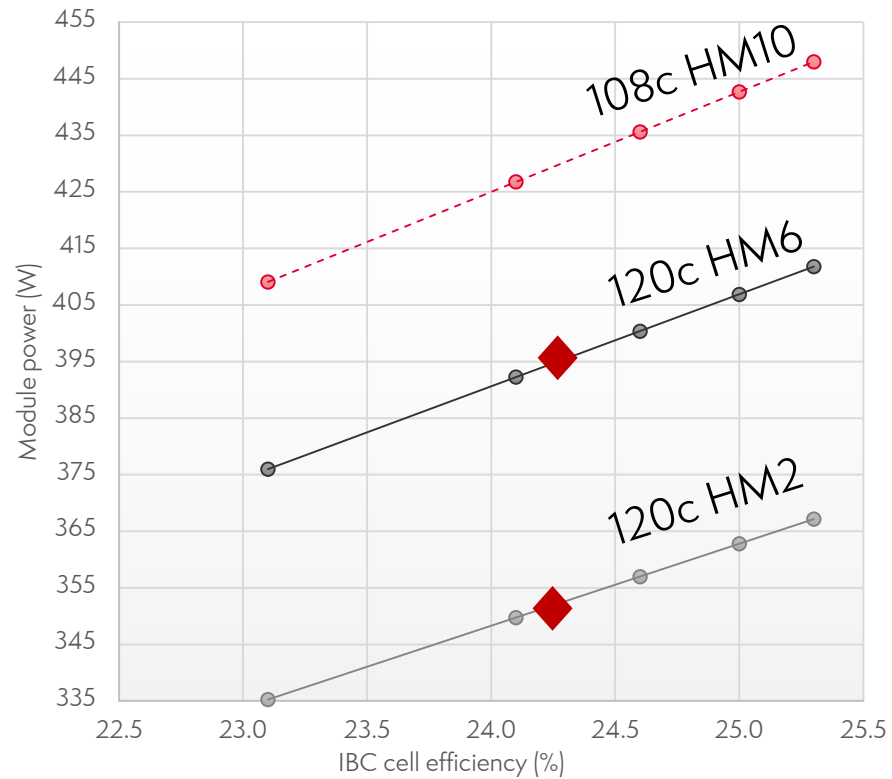


## Advantages compared to HJT

- -20% wires
- -50% SWCT foil (only on the back)
- Less encapsulant per module
- → significant cost saving per module



# Modules development



- Only 13 modules manufactured in HM6 configuration
- 430W 108c HM10 is expected at start - Potential beyond 445-450W
- Promising reliability results on full size module exceeding 3x to 4xIEC

# Conclusions

- **Tunnel IBC cells and modules:**
  - Very low silver consumption down to 3.7mg/Wp
  - Mini-modules outstanding reliability 8-9x IEC (DH, PTC, HF)
  - 395W in 120x HM6 configuration
  - Performance potential to 450W for residential market
- **Next steps (Pilatus):**
  - Installation of a fully automated line tunnel IBC cells at Meyer Burger Germany
  - Conversion of RRU & Cell stringer to HM10 in Switzerland
  - Modules under consecutive stress tests & outdoor monitoring
  - LCA & LCOE analysis

**The SIRIUS project is supported by the pilot and demonstration program of the Swiss Federal Office of Energy SFOE**

**Funded by the European Union under grant number 101084046. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.**

