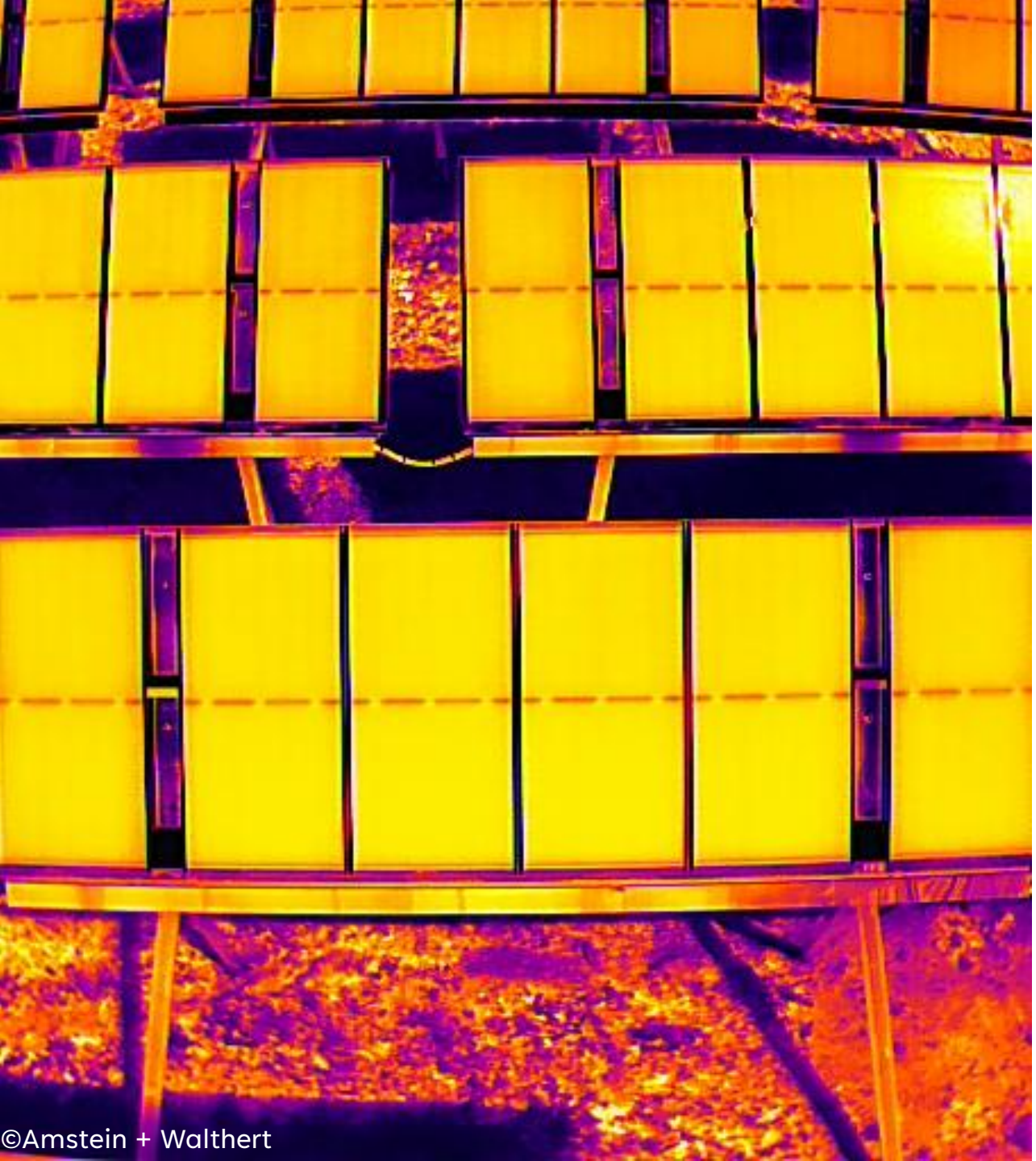

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SOLALPINE

SCHWEIZERISCHE INTERESSENGEMEINSCHAFT
FÜR WINTERSTROM AUS DEN ALPEN

Designing for Altitude: Technical and System-Level Optimization of Alpine PV Plants

Moritz Meier, Amstein + Walthert AG & Solalpine

Details define performance

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Solalpine

IG Solalpine – The Mediator

The **Interest Group IG Solalpine** is a non-profit association based in Wädenswil, Switzerland.
IG Solalpine acts as an intermediary between electricity supply companies, municipalities, landowners, and local municipal utilities. In collaboration with NGOs and political stakeholders, it advocates for favourable framework conditions for the construction of photovoltaic (PV) installations above the fog line.

The purpose of IG Solalpine is to plan and develop PV projects located above the fog layer in Switzerland. The association places strong emphasis on compliance with defined quality standards. Through the realization of these installations, IG Solalpine aims to help close the electricity supply gap — with climate-friendly, renewable power.

www.solalpine.ch

Klosters-Madrisa, evaluated by Solalpine

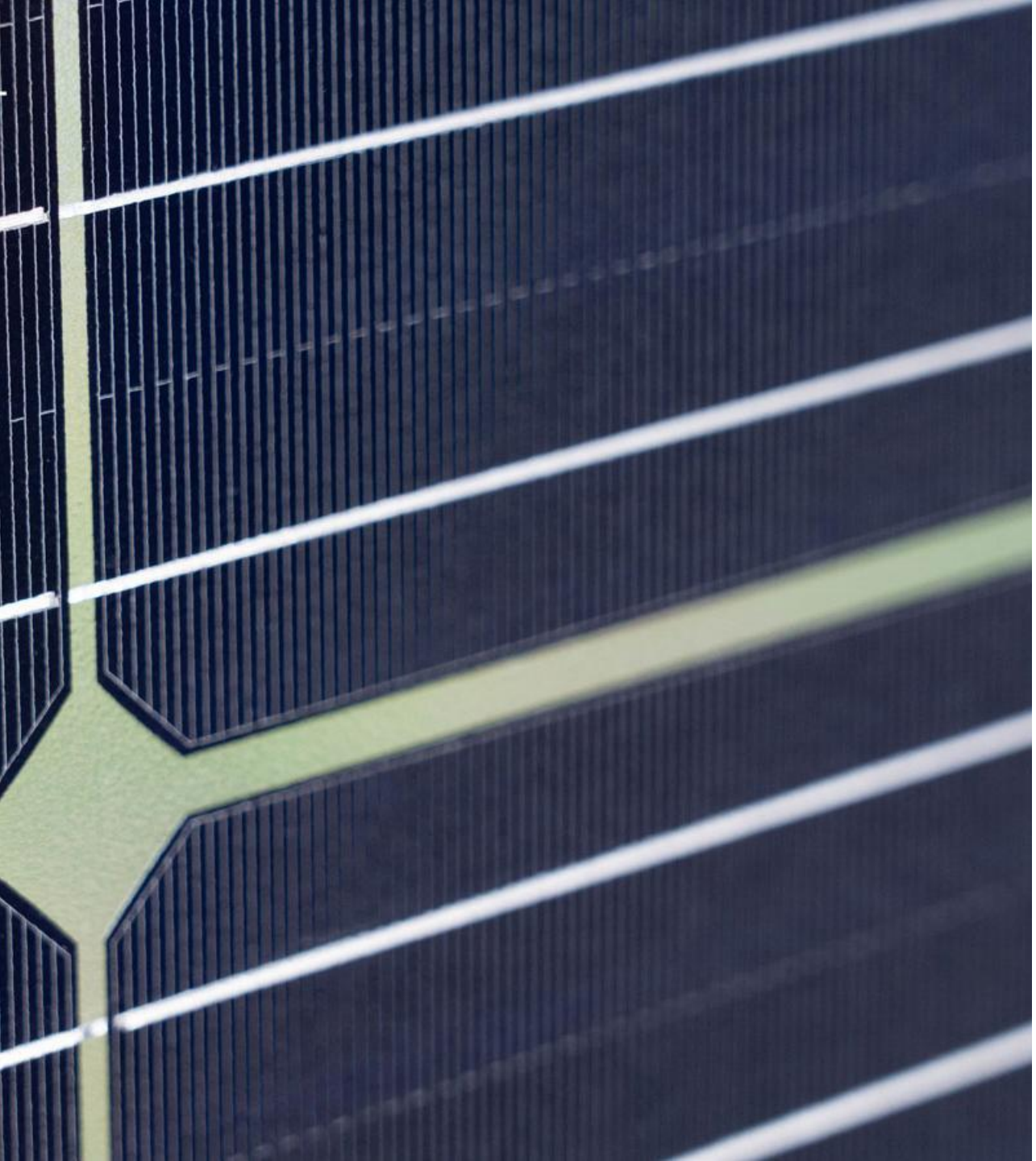
- Installed capacity: 11 MWp
- Landscape protection: Not a protected area
- Wildlife protection: Not located within a wildlife conservation zone
- Infrastructure proximity: Close to existing infrastructure and road access
- Grid access: Easy connection to the existing power network
- Land use: Dual use with summer livestock grazing (pasture)
- Ownership: Repower, EKZ, Municipality of Klosters

Positioned across Switzerland

1,100 experienced specialists

With a team of around 1,100 employees, we advise clients, plan and design the technology for buildings, facilities and infrastructure, and take care of the related operation and maintenance.

> Our employees share a common understanding of quality, commitment and resilience - as well as a passion for forward-looking solutions.
>
> **Christian Appert**
> Group CEO



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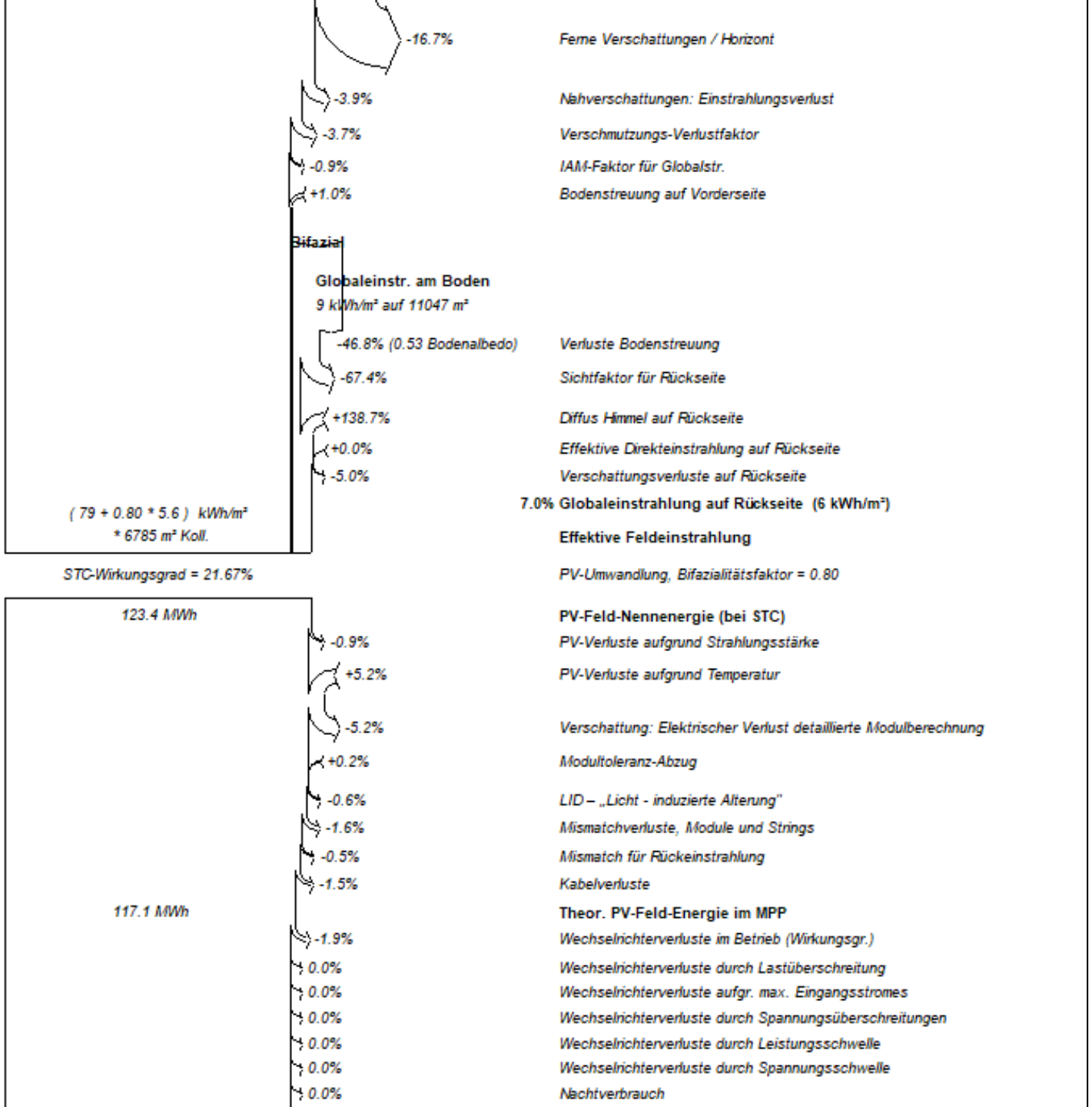
15+ alpine PV projects

- Overall project management
- DC engineering
- AC engineering
- Module layout
- HVAC systems
- Monitoring systems
- Building physics
- Fire safety



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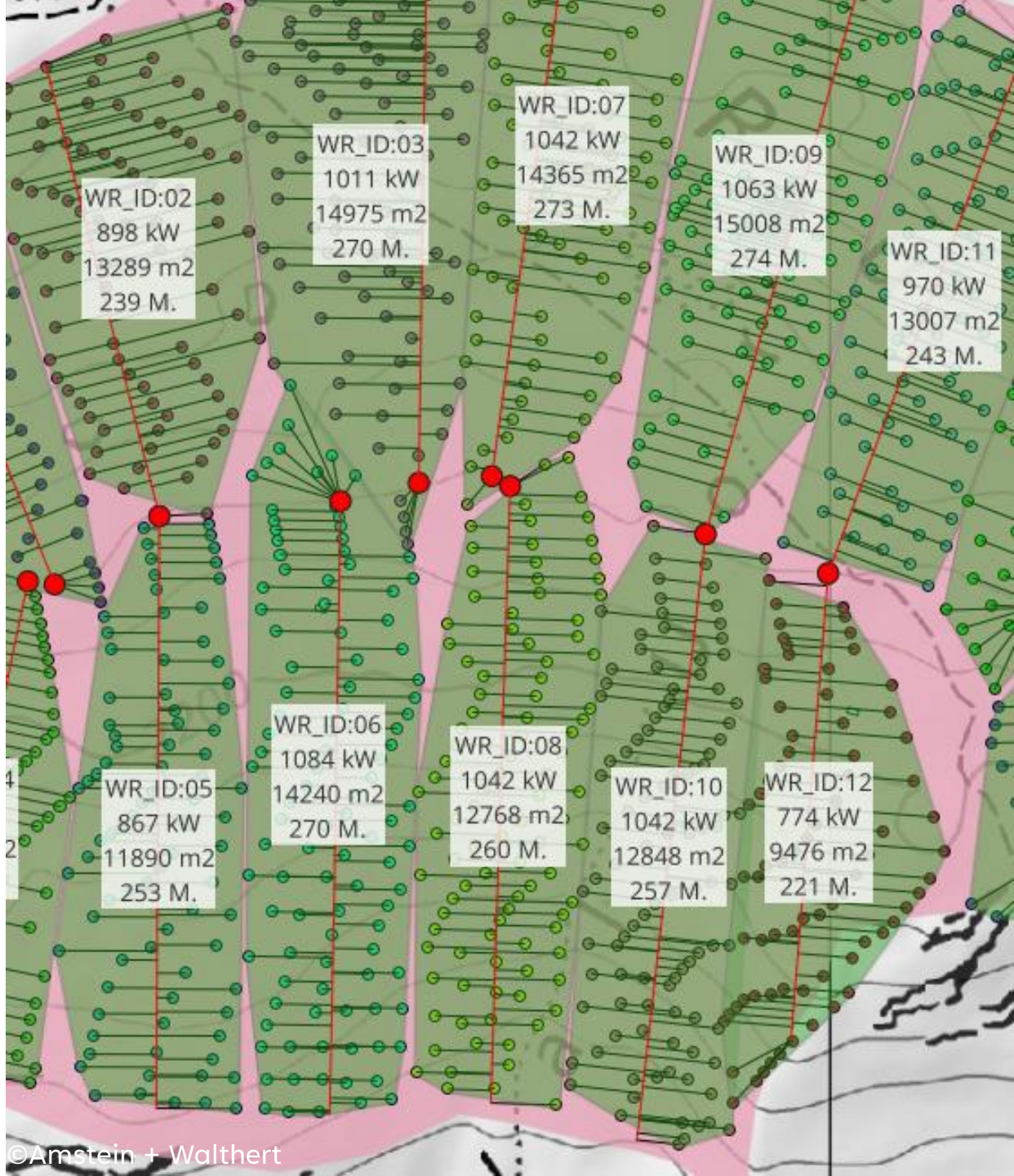
Today:
sun to grid

Agenda

A selection of details

- ↘ Location
- ↘ Module layout
- ↘ Near shading
- ↘ Module parameters
- ↘ Cable losses (DC)
- ↘ Challenges in construction



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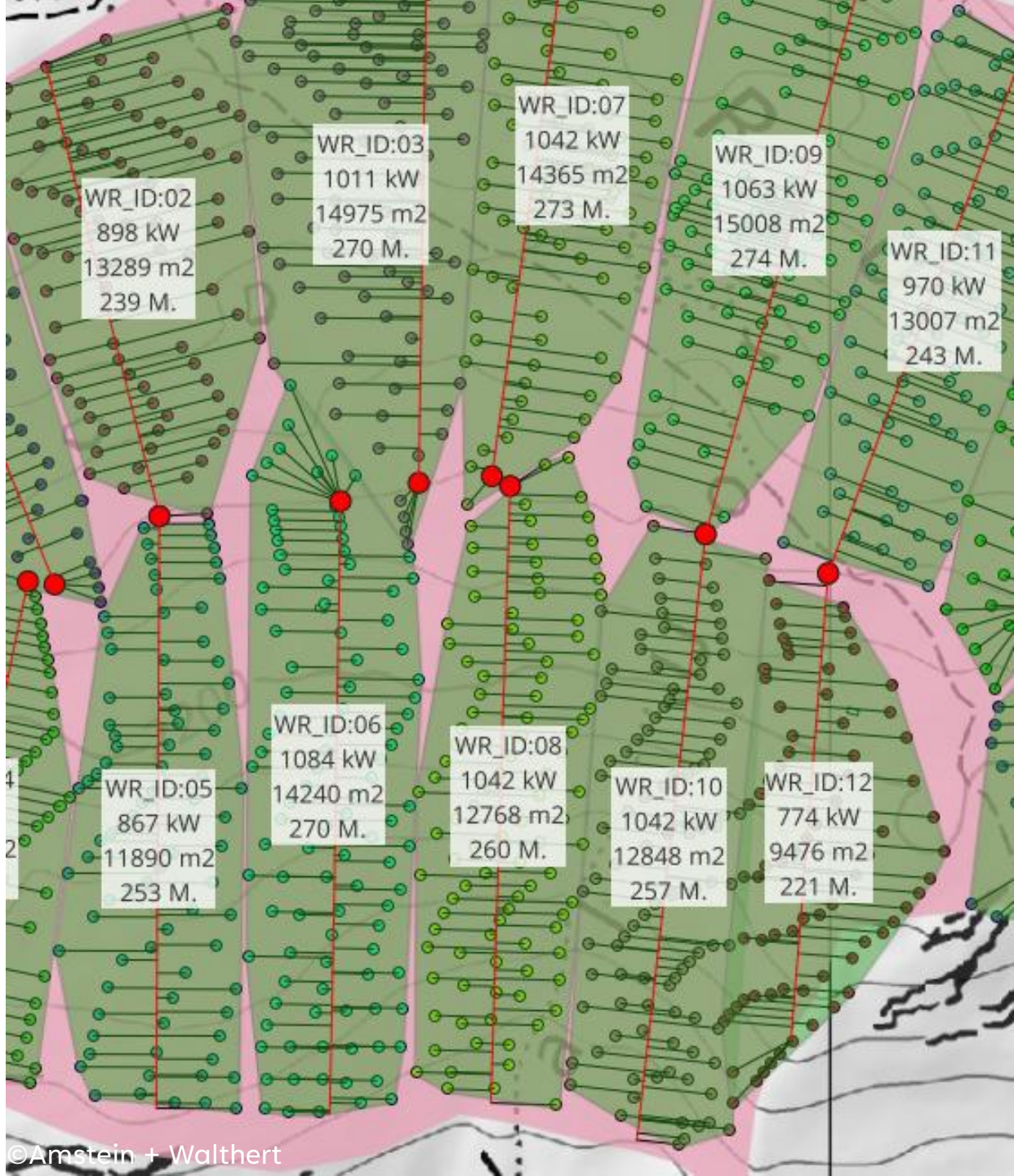

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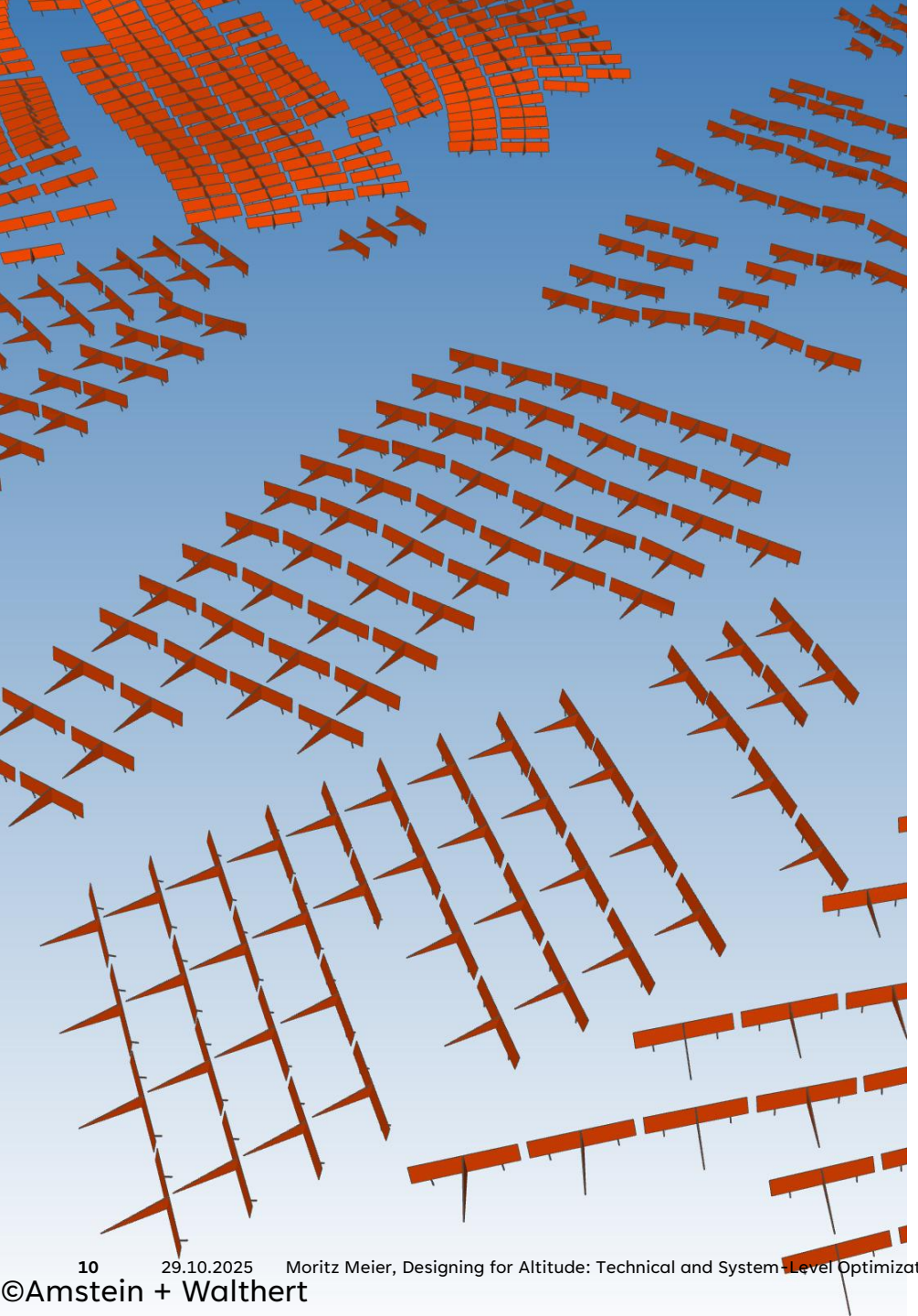

Module Layout

Goals and Process

- Min. 500 kWh/kWp in wintertime, min. 10 GWh/a
- Maximized yield for minimized steal consumption
- Maximized yield per ground area
- Adaptability to rough or uneven ground

- Layout and 3D model generation possible in multiple tools
  - GIS for rough estimations
  - Revit for finetuning and data management (BIM)
  - Civil 3D for Column length calculation

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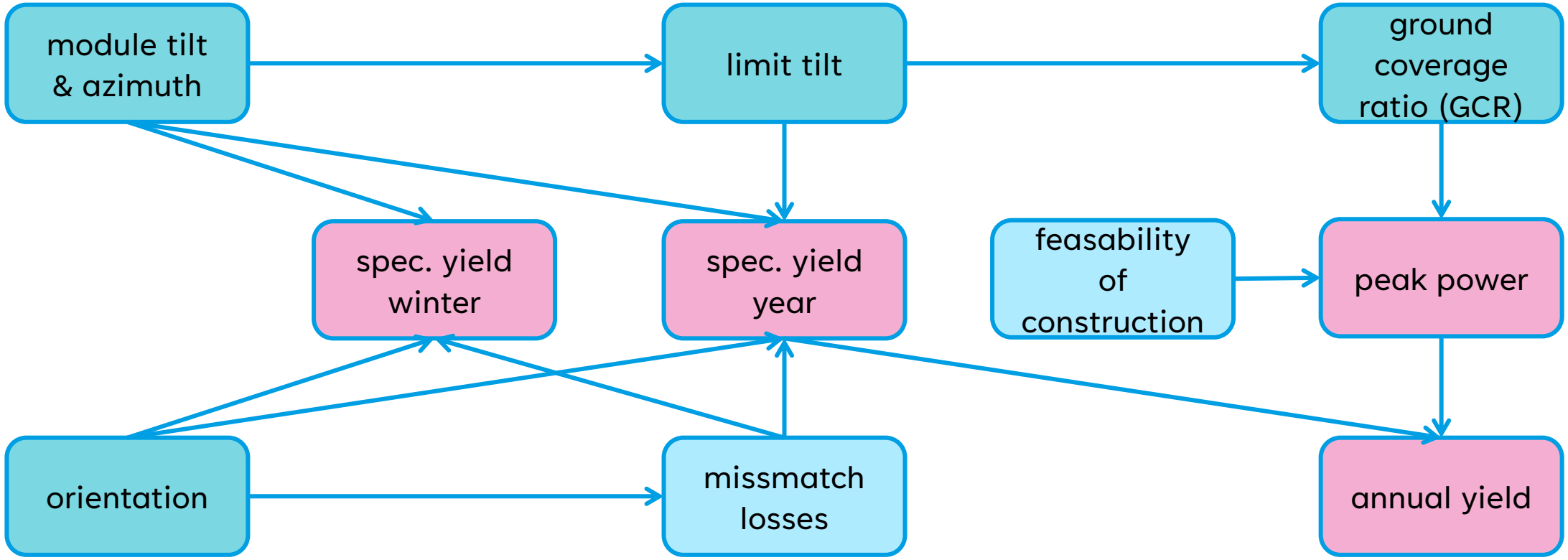
Module Layout

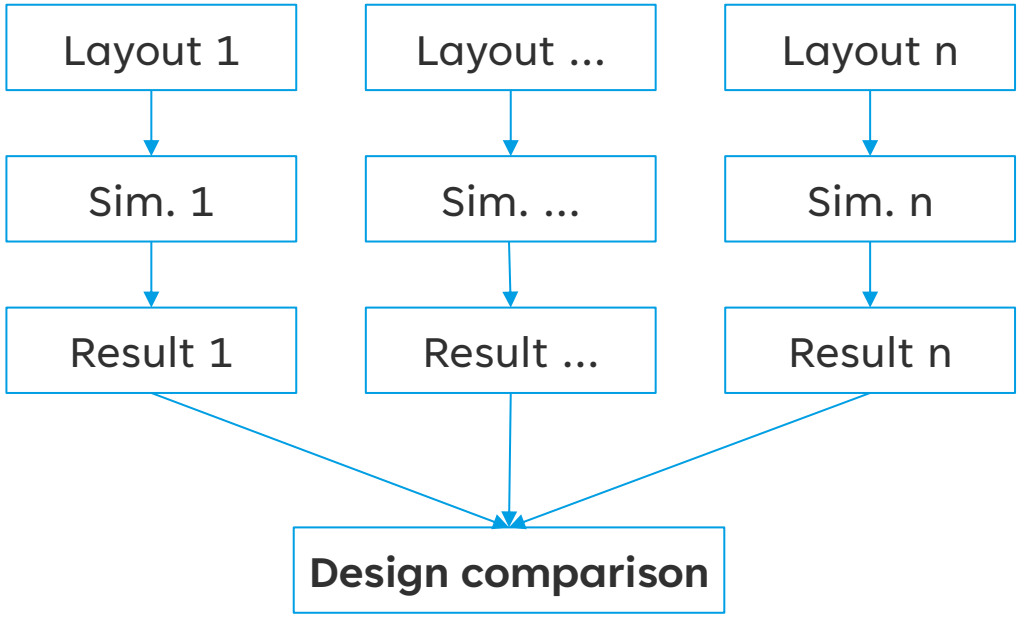
Interdependencies



Module Layout

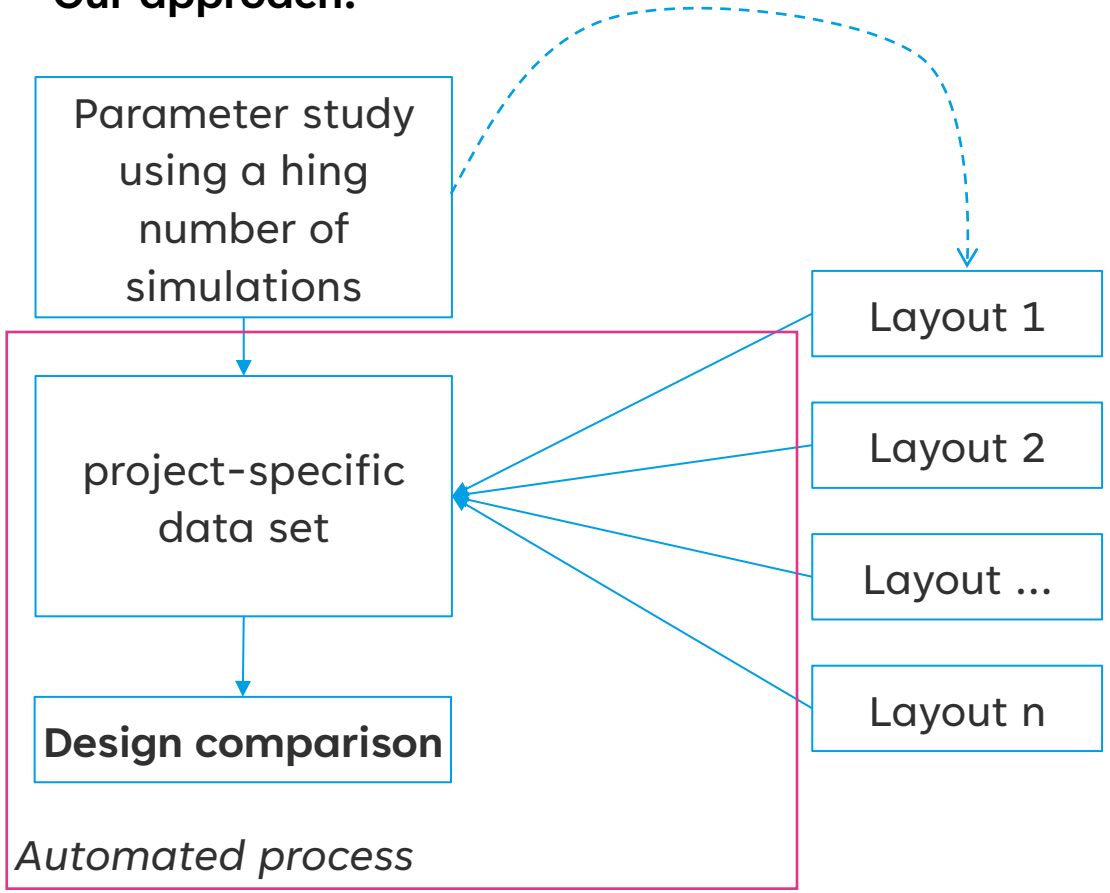
Optimization process

Classic approach:



Our approach:

Project-specific optimization graphs and layout-optimization



Trial and error ist not efficient here!!

Module Layout

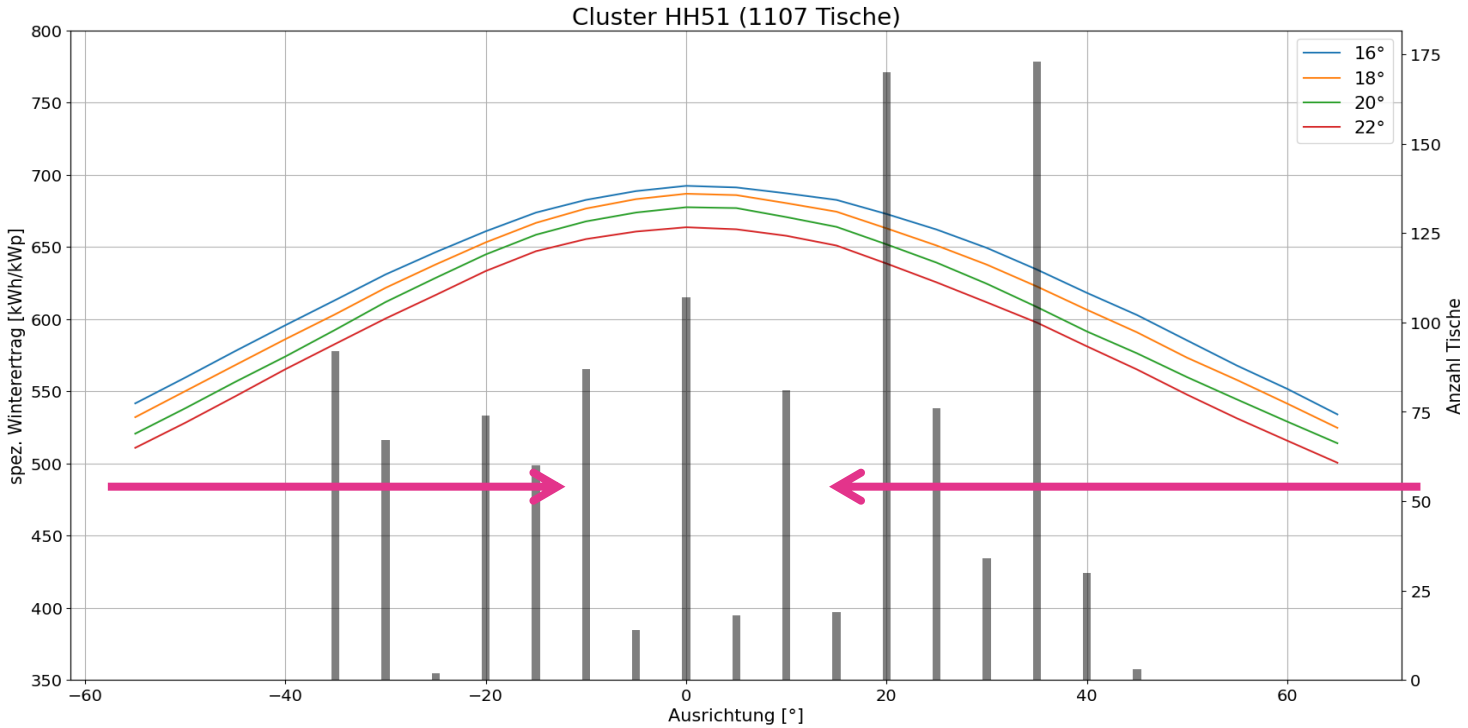
Project-specific optimization graphs

- Graphs for: Azimuth, limit angle, module angle, etc.
- Orientation is key, but hard to optimize

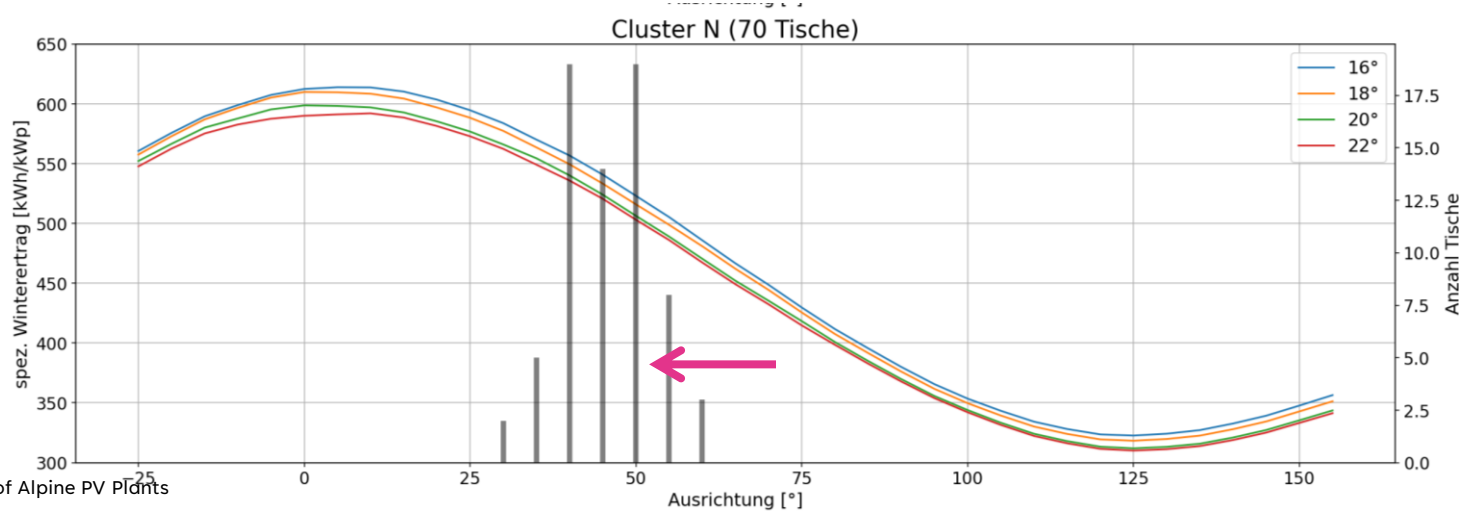
Example, two projects:

- Spec. Winter yield
- P1: High dependencie for limit angle
- P1: Peak arround 0° azimuth
- P2: Peak arround 13°west due to horizon
- P2: impact of limit angle varies with azimuth, in general less spread out

Project 1 (P1)



Project 2 (P2)



Module Layout

Example, project under development

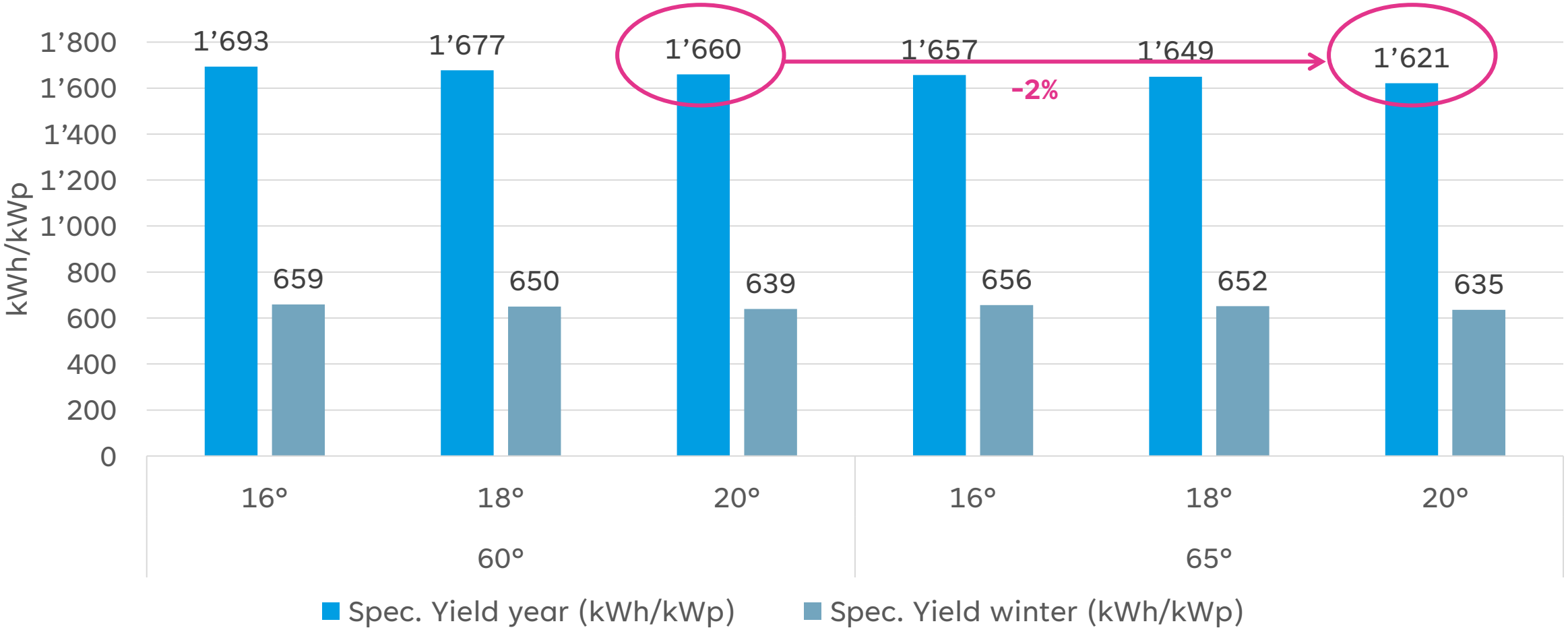
pictures and numbers must not match!

	Limit angle: 20 Module tilt: 60	Limit angle: 20 Module tilt: 65
Peak power	7.03 MWp	6.69 MWp
Spec. yield winter	639 kWh/kWp	635 kWh/kWp
Spec. Yield year	1’660 kWh/kWp	1’621 kWh/kWp

- Surprizingly low difference for winter yield!
- For this project 60° module angle more suitable, for other projects 65°

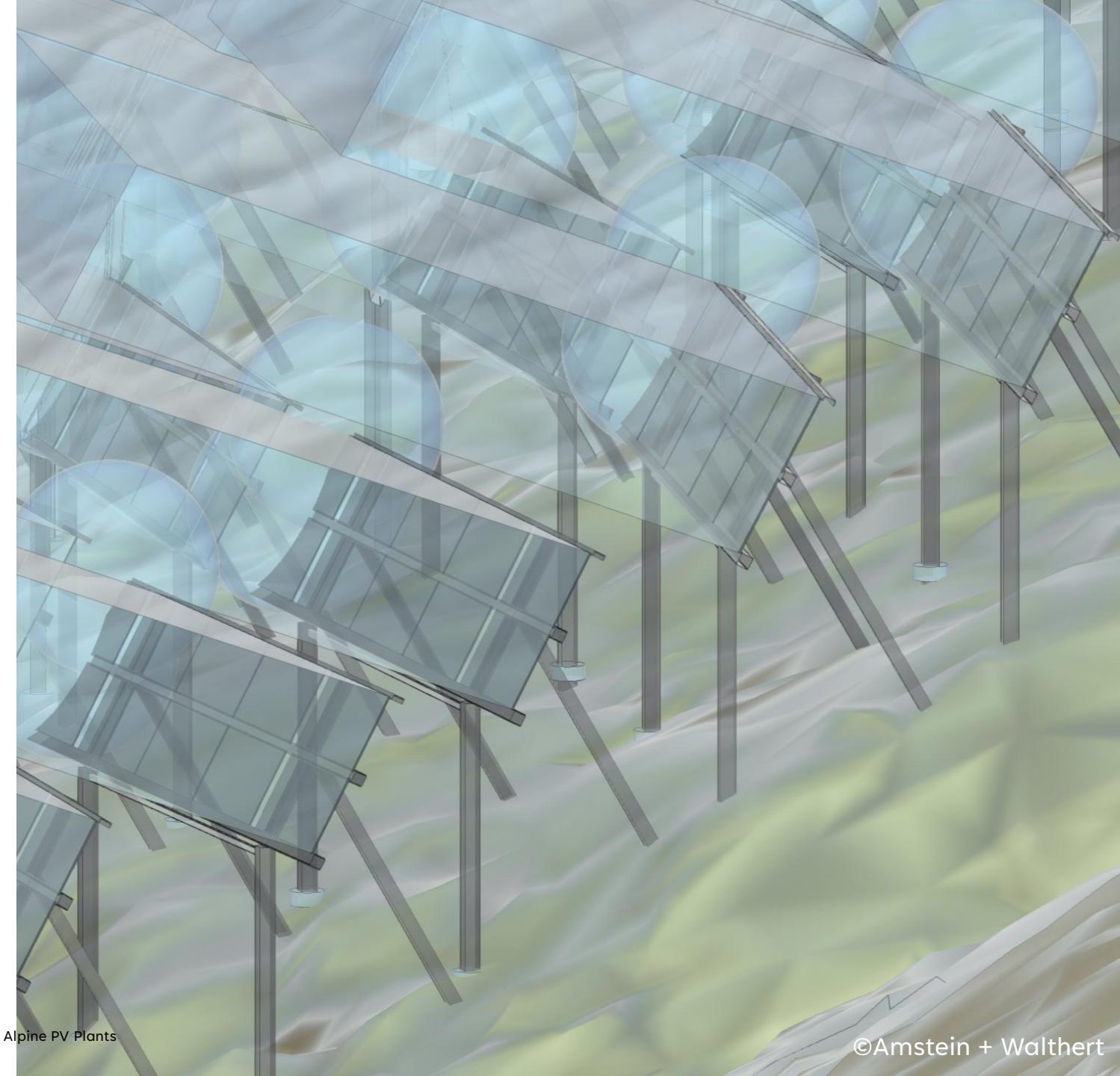
Module Layout

Example, project under development



Near Shading
Quality & Optimization

- Calculation and optimization of limit angles
- For Quality controll and to ensure the limit angle and the homogeneity of the limit angle
- For further detail omptimization



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Near Shading

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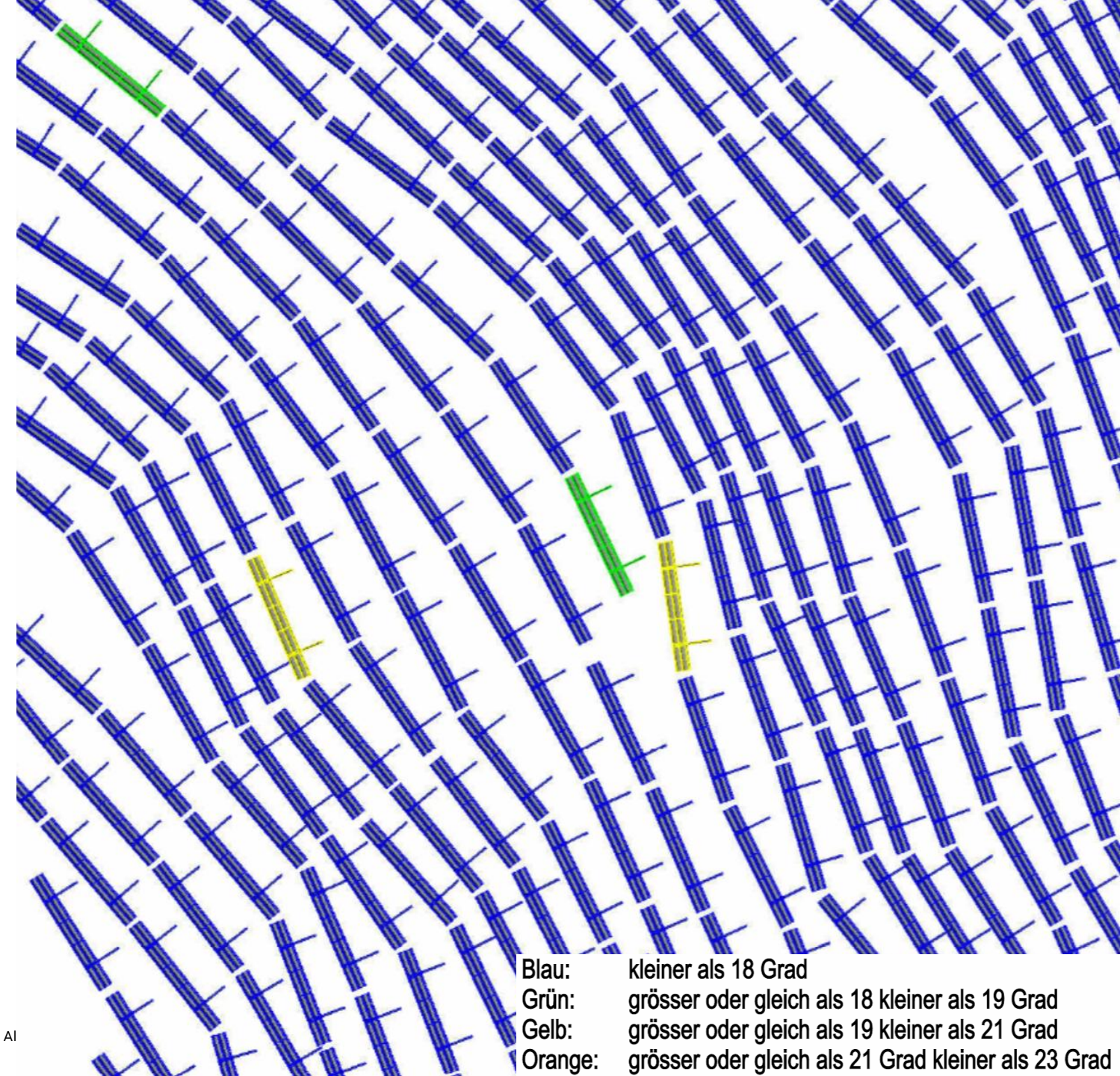
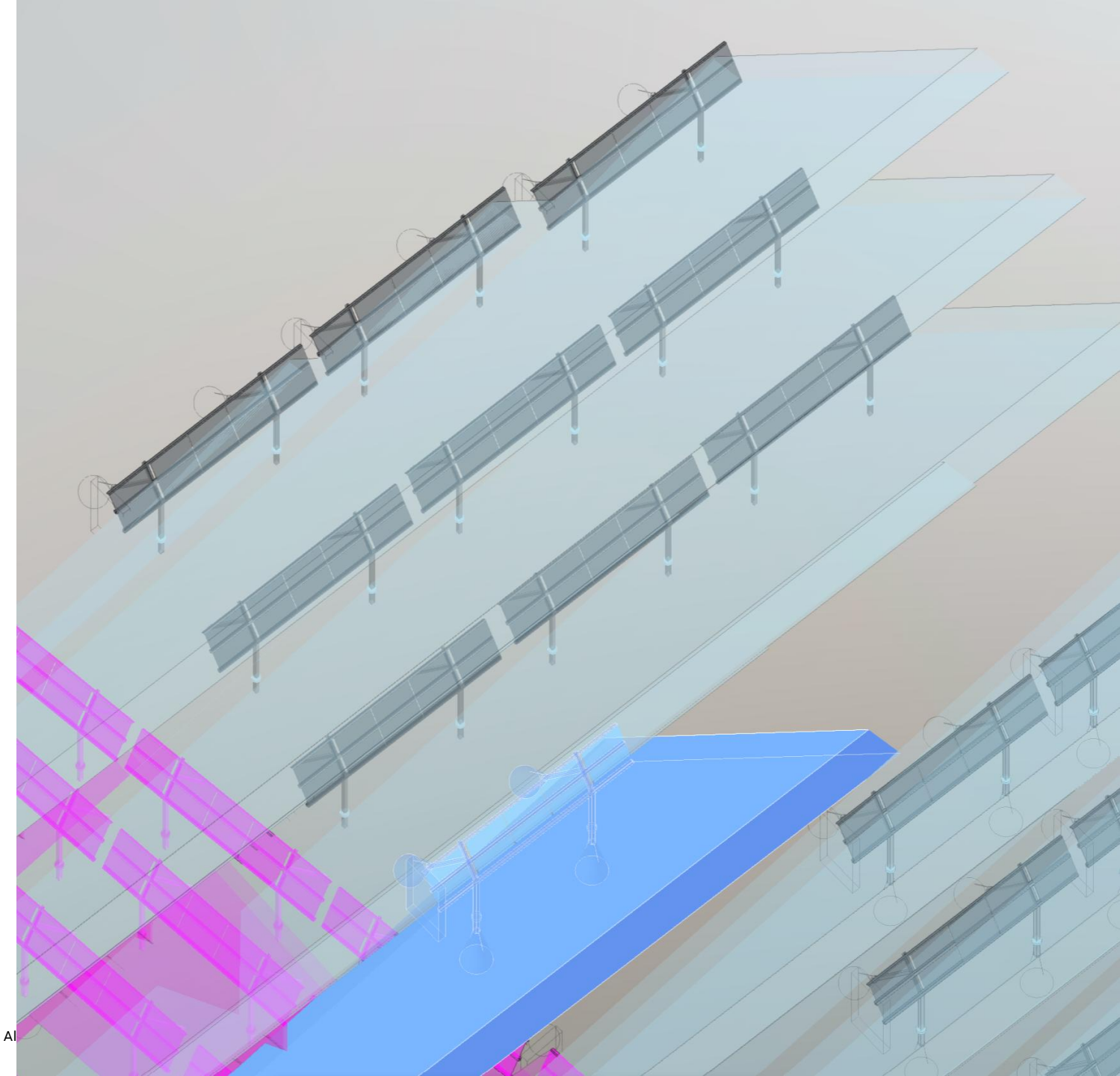


Near Shading
Quality & Optimization

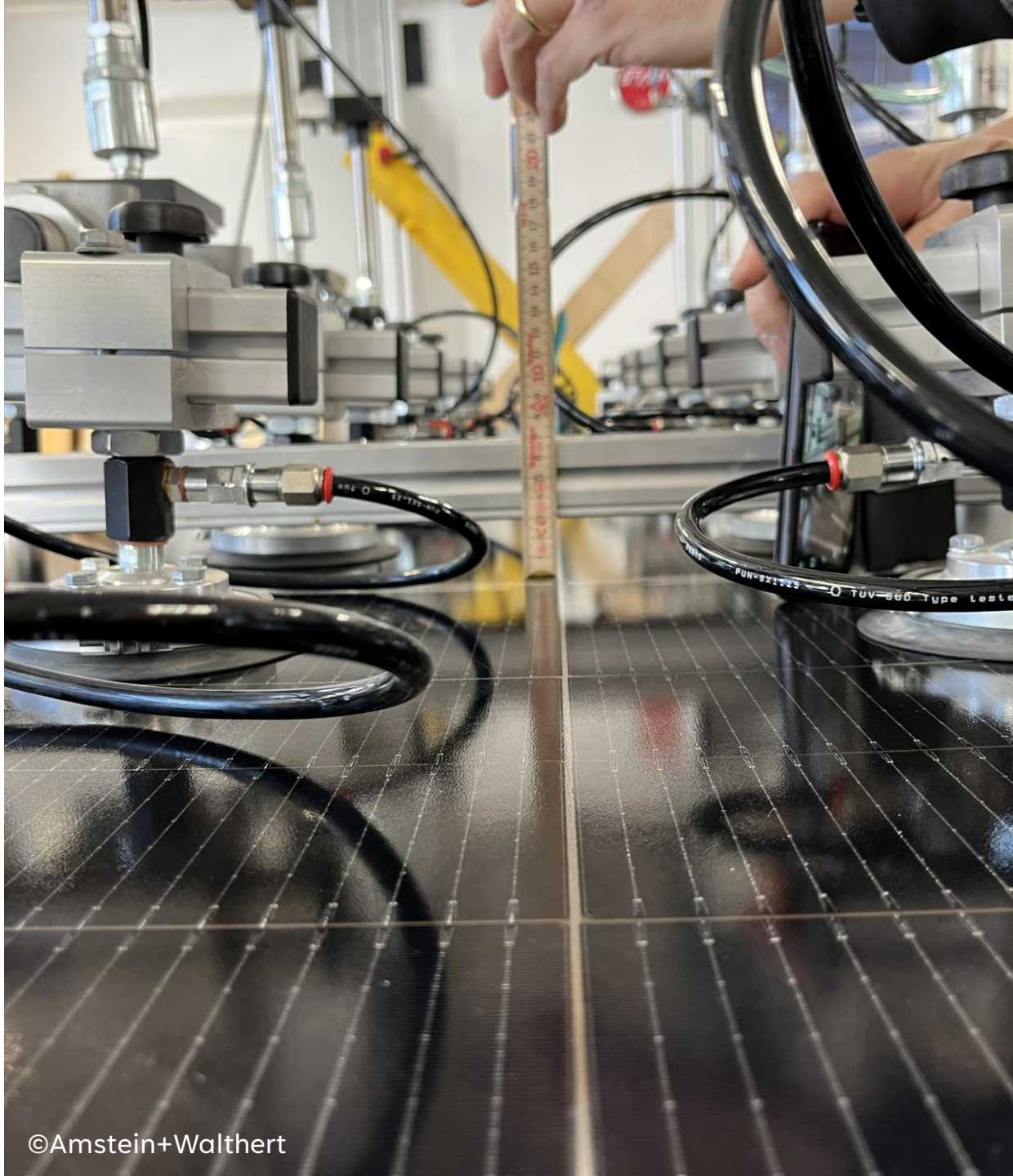
- Calculation and optimization of limit angles
- For Quality controll and to ensure the limit angle and the homogeneity of the limit angle
- For further detail omptimization
- Minimize near shading of sunrise and sunset depending on horizon



Module parameters

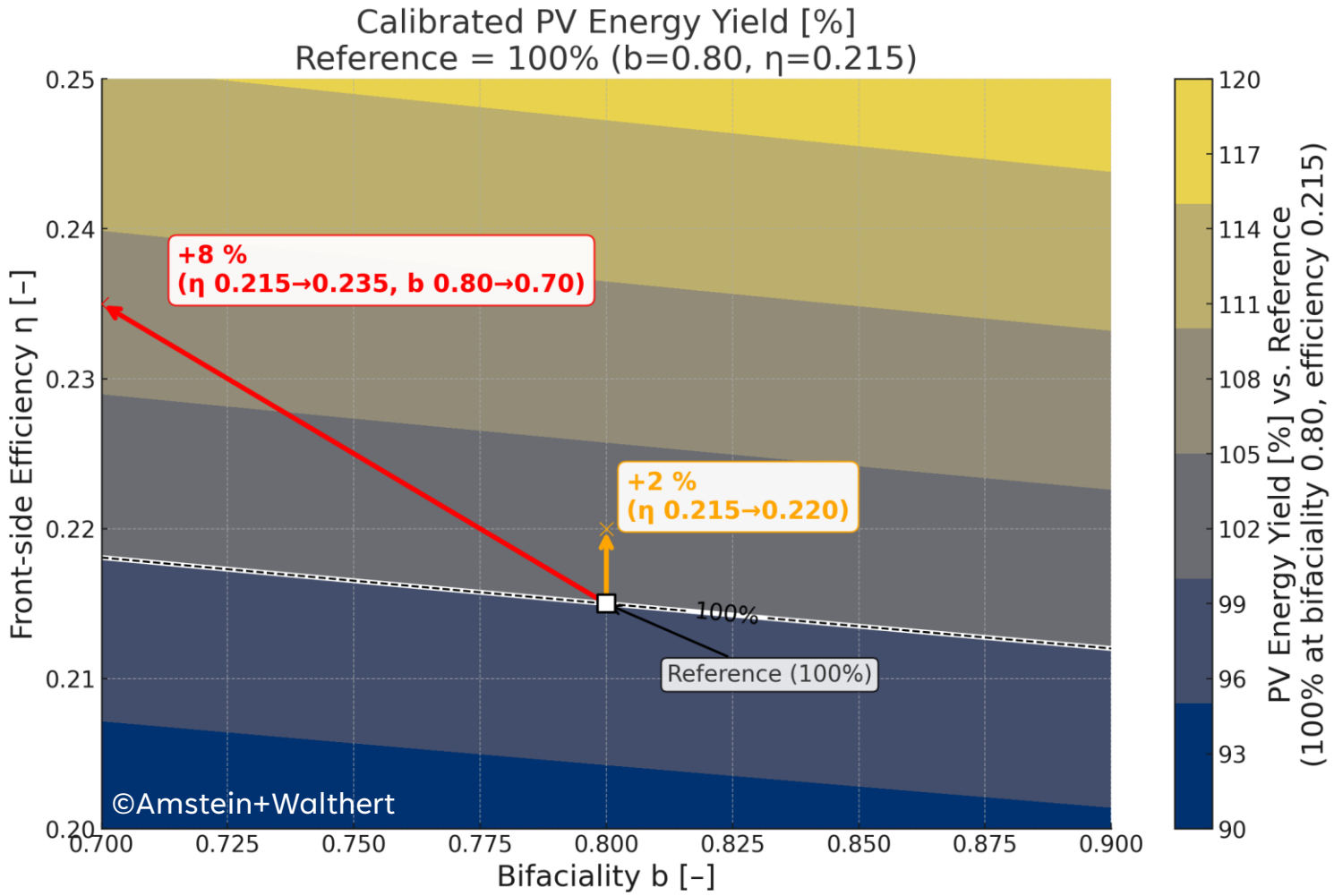
Reduced degradation

- Reliability of modules is key in alpine projects
- Modules need to be specially designed for this use case!
- Key factors
  - N-type cell
  - >16 busbars
  - Encapsulant must match the cell-technology (e.g. PEO or EPE for TopCon cells), UV-converter
  - Sufficient diode rating and reverse current (e.g. 30 A)
  - Frame-design for low snow and water accumulation



Module parameters
Bifaciality

- Bifacial gain crucial
- Bifaciality = Efficiency front side / Efficiency rear side
- Bifaciality dependent on cell technology



Module parameters

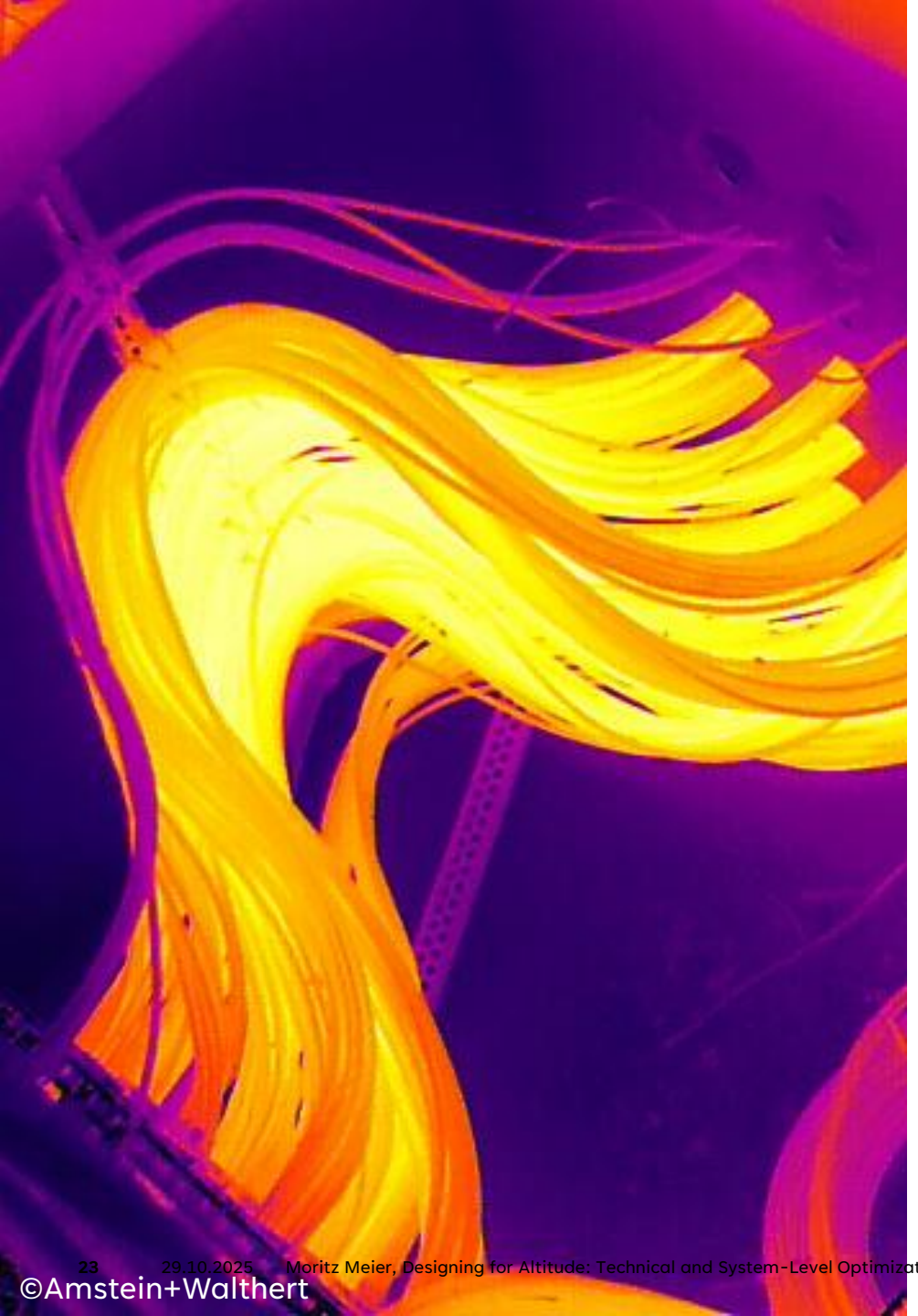
Spontaneous cracks in the rear glass layer of the PV module

- Global phenomena with several causes, especially important for alpine PV
- Main causes: poor glass quality and glass-edge quality, glass tempering, poor module-statics
- Solutions:
  - guaranteed fully tempered glass front and rear
  - glass thickness >2.5 mm front and rear (despite static load requirements)
  - rodded glass edges

DC strings
Cable losses

- Calculation static (worst case) or dynamic (e.g. PVSyst-simulation)
- Example:
  - String: 240 m → combination of 4 mm^2 (module), 10 mm^2 (horizontal connection on table), 95 mm^2 (underground)
  - Copper and aluminium, Max. string-current
  - Result: 0.81%, 8.5V → more than 50% by module-cables

- Optimization: Module cables 6 instead of 4 mm2
  → loss reduction by 34% (ca. 1.3V)
  → costs: +1.6%



Challenges in construction

Selection

1. **Sufficient numbers of offers from the contractors**

2. **Data management**:
   many individual parts need to be placed in 3D, calculated and verified

3. **Logistics of material**:
   Which parts must be delivered to which location, at what quality level, and by when?

4. **Untypical match of building disciplines**
   Most of it is new, for everyone!

5. **Weather**
   wind, rain, snow

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Thank you!

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