Aim point management system for solar power towers

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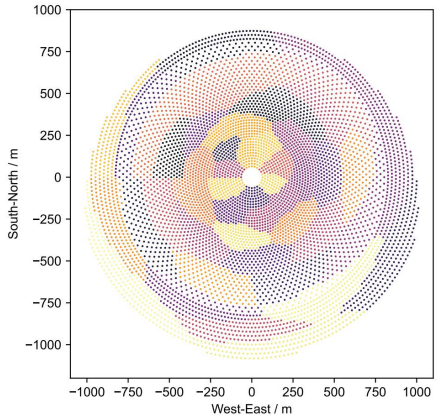
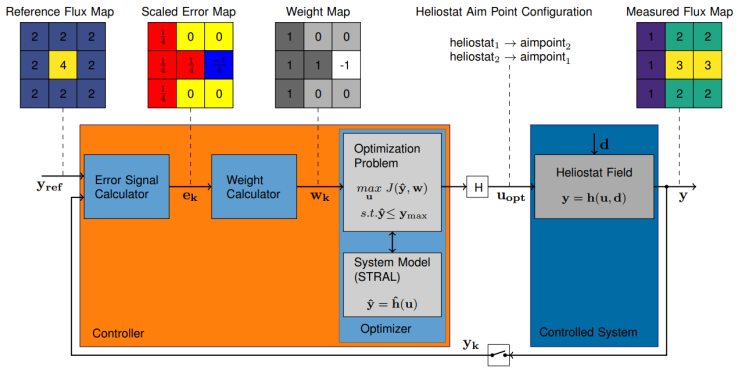
Aim point management system

Overview

Aim point optimization



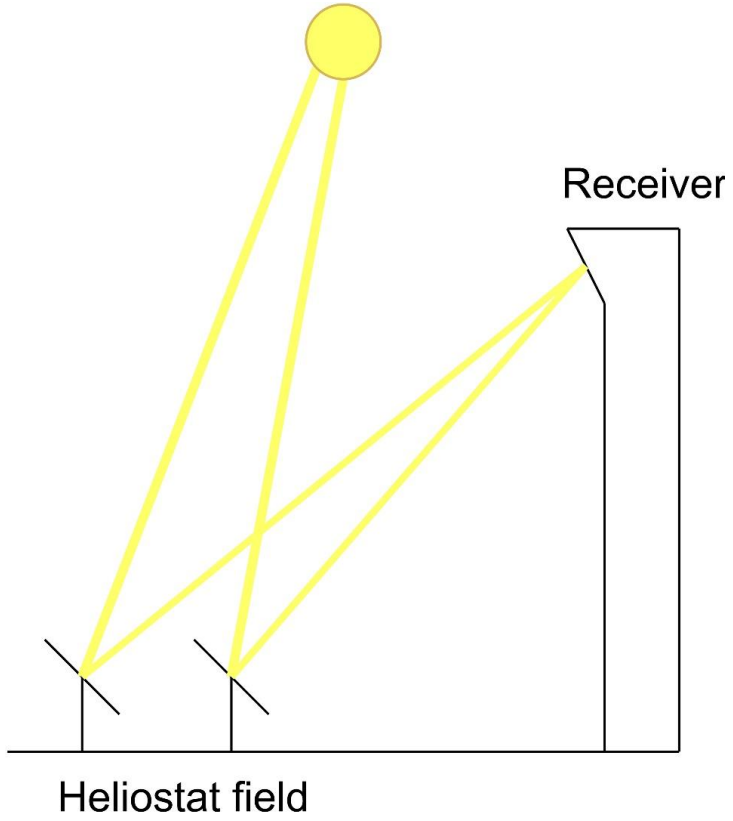
Closed-loop aim point control

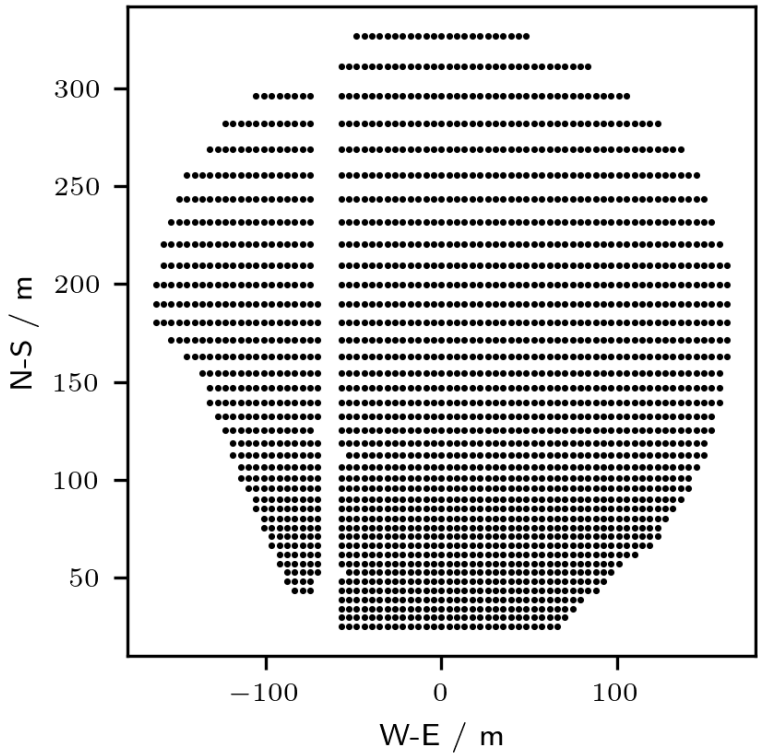


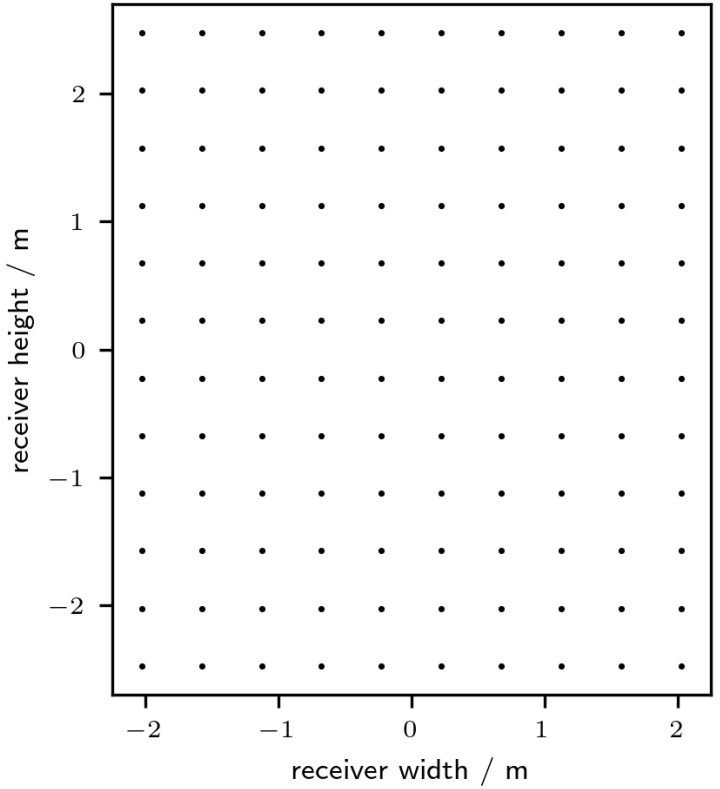
Validation

Aim point optimization

Aim point optimization
Motivation







- Transformation in optimization problem with combinatorial character
- Aim: optimization time below one minute

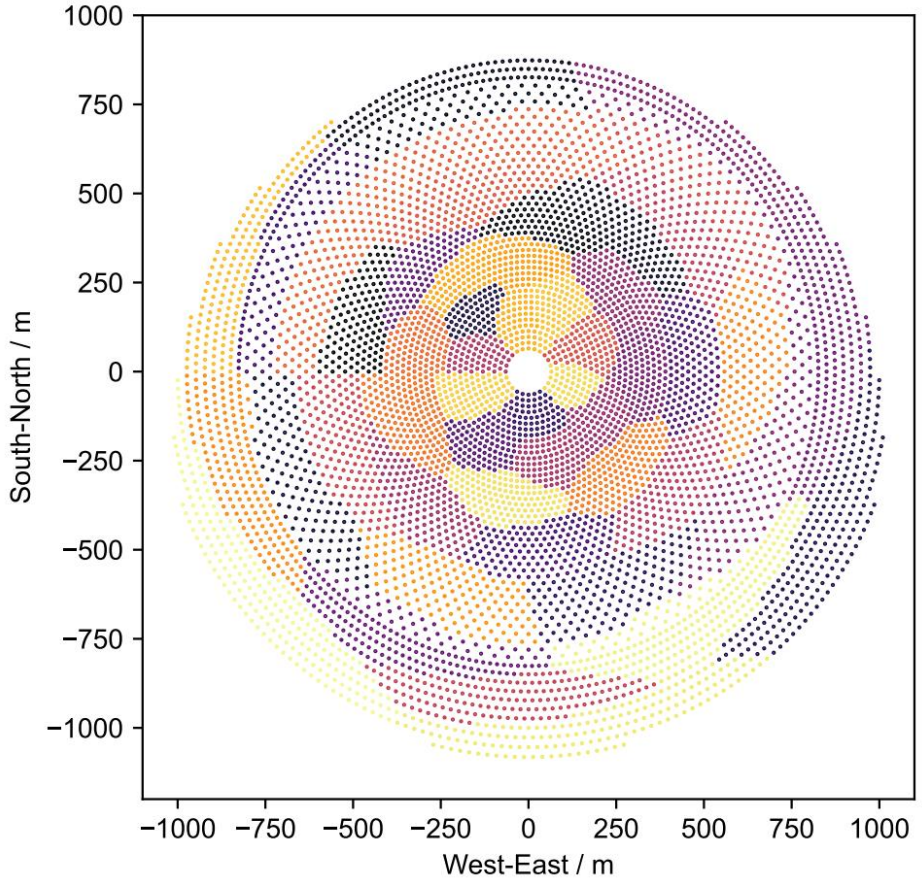
Aim point optimization
Enhancements of the algorithm

Grouping

- Reducing the search space by grouping the heliostats based on k-means clustering

Porting on GPU

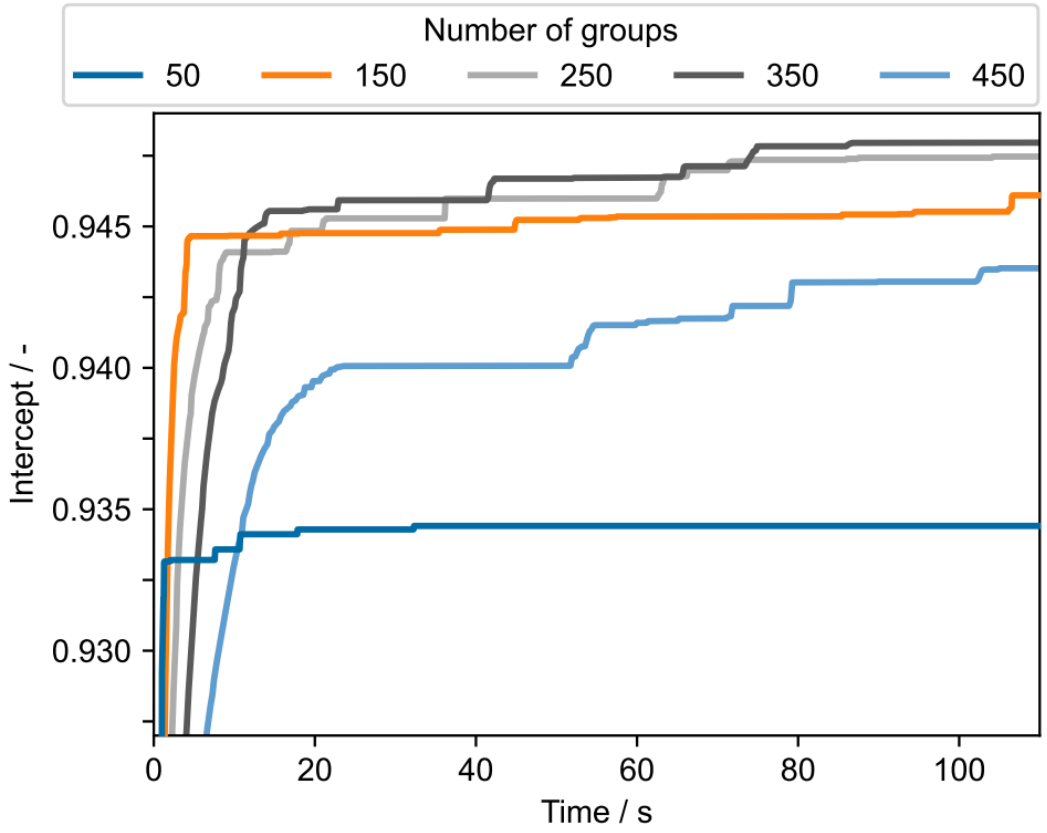
- Exploit parallelization potential of the algorithm by implementing it in CUDA
- NVIDIA GeForce 2080 Ti (999 $/250 W) ~ **30** Intel core i5-6300HQ (250 $/45 W)



[1]

[1] Oberkirsch et al., Solar Energy **220**, 1089-1098 (2021).

Aim point optimization
Results of the enhanced algorithm at 500 MW_{th}-plant



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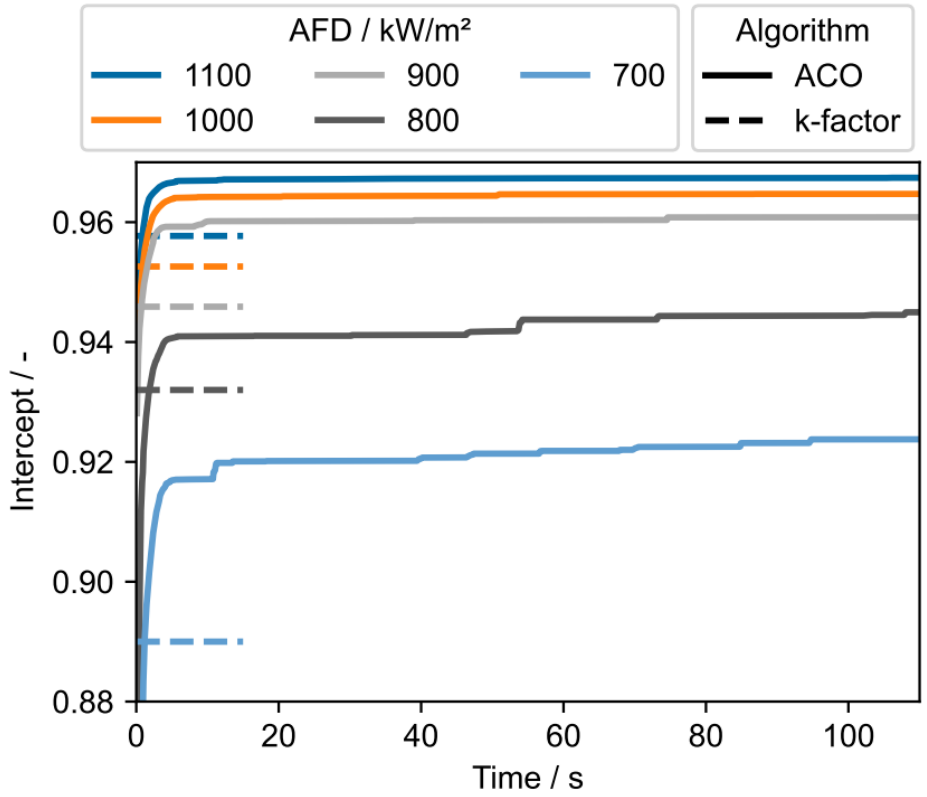


[1]

- Optimal group number between 150-350
- Intercept improves by 1-2%, spillage reduces by 19-28% compared to the k-factor-strategy as state of the art algorithm

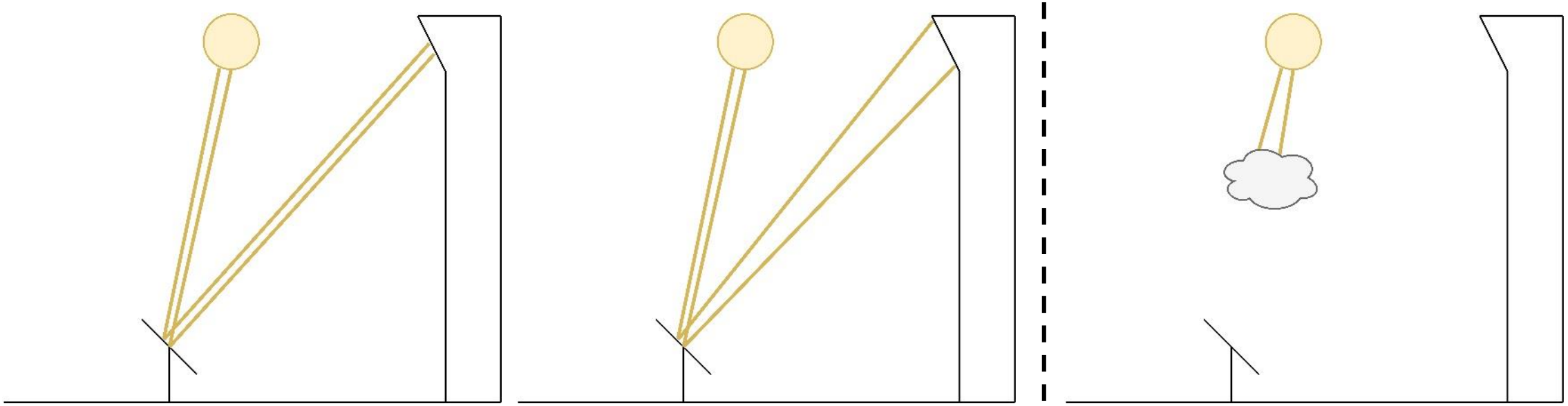
[1] Oberkirsch et al., Solar Energy **220**, 1089-1098 (2021).

Closed-loop aim point control

Closed-loop aim point control
Motivation

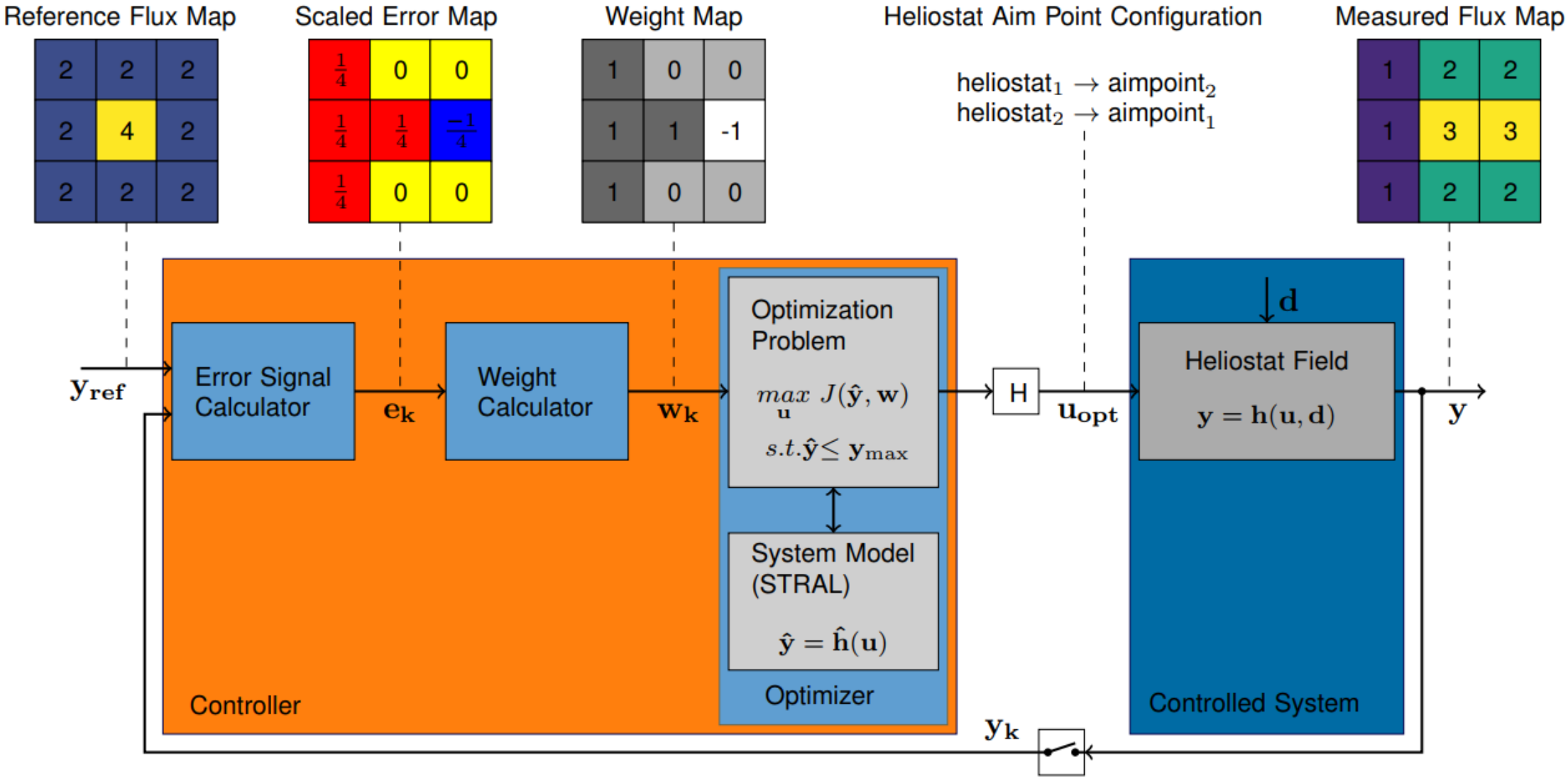
Static modeling errors like mirror errors

Dynamic disturbances



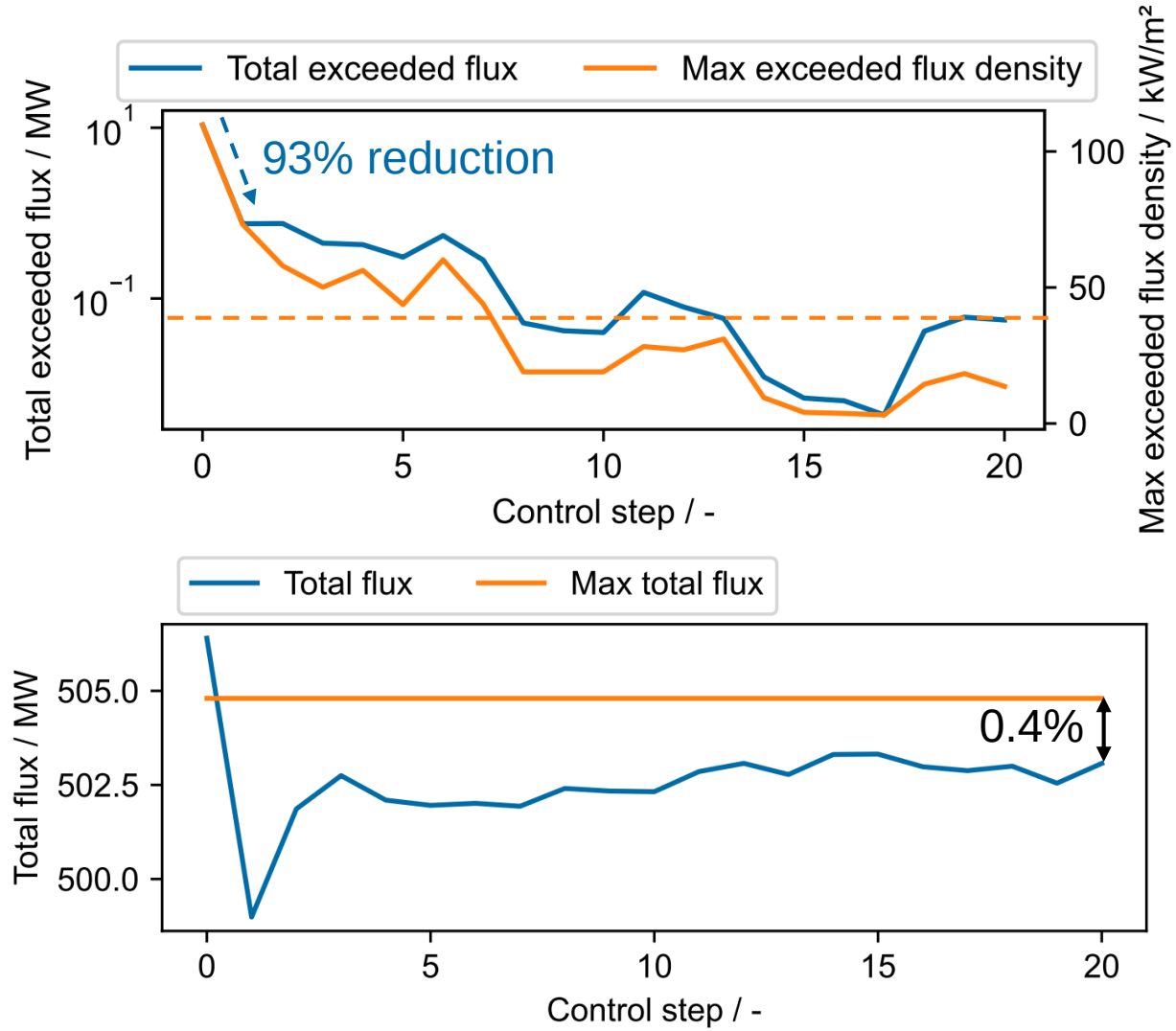
- Aims: compensate for modeling errors + reject disturbances due to clouds
- Deviations from the setpoint should be below the accuracy of the flux density measurement system (~5%)

Closed-loop aim point control
Static optimal control



Closed-loop aim point control
Results of the static optimal control

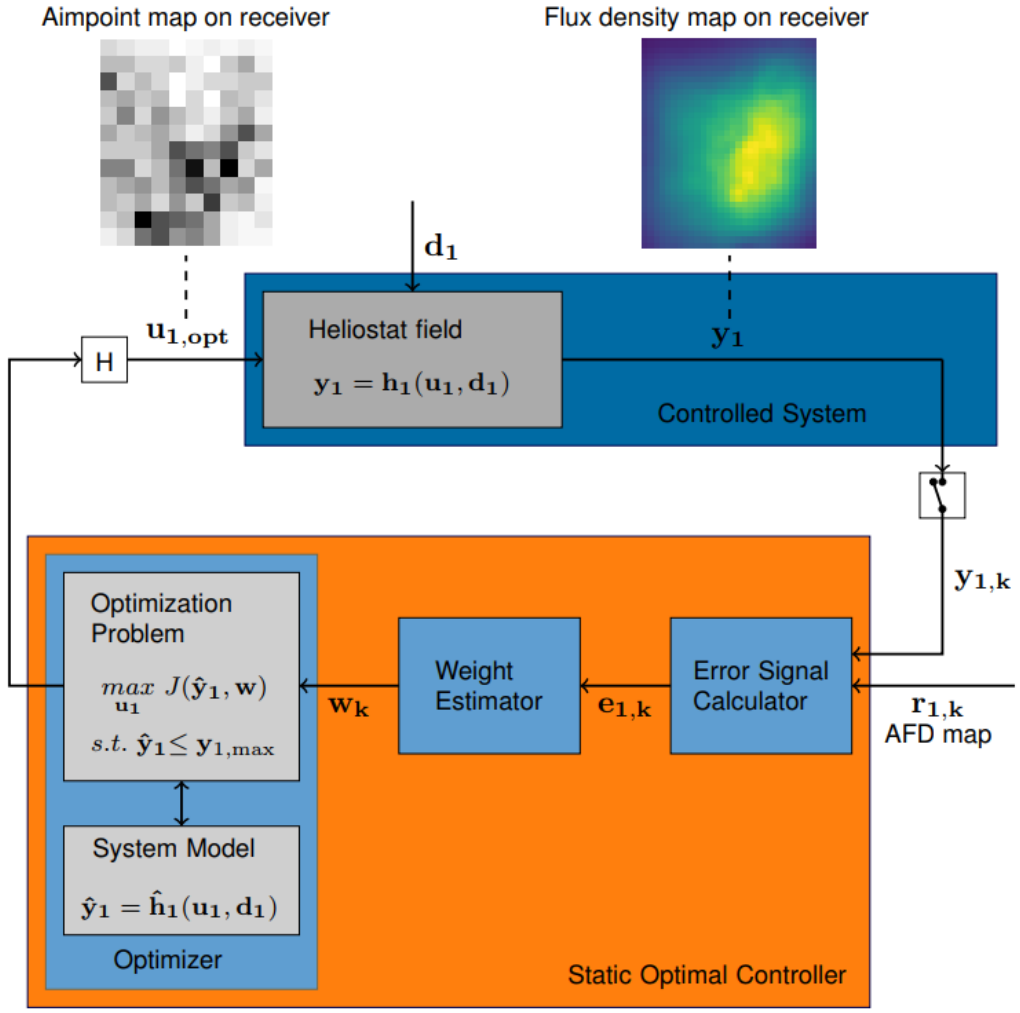
- Simulation: 2.0 mrad mirror error
- Reality: 1.5 mrad mirror error
- Thermal power: 500 MW_{th}
- Conventional approach:
  - 9% intercept loss



Aim point management system

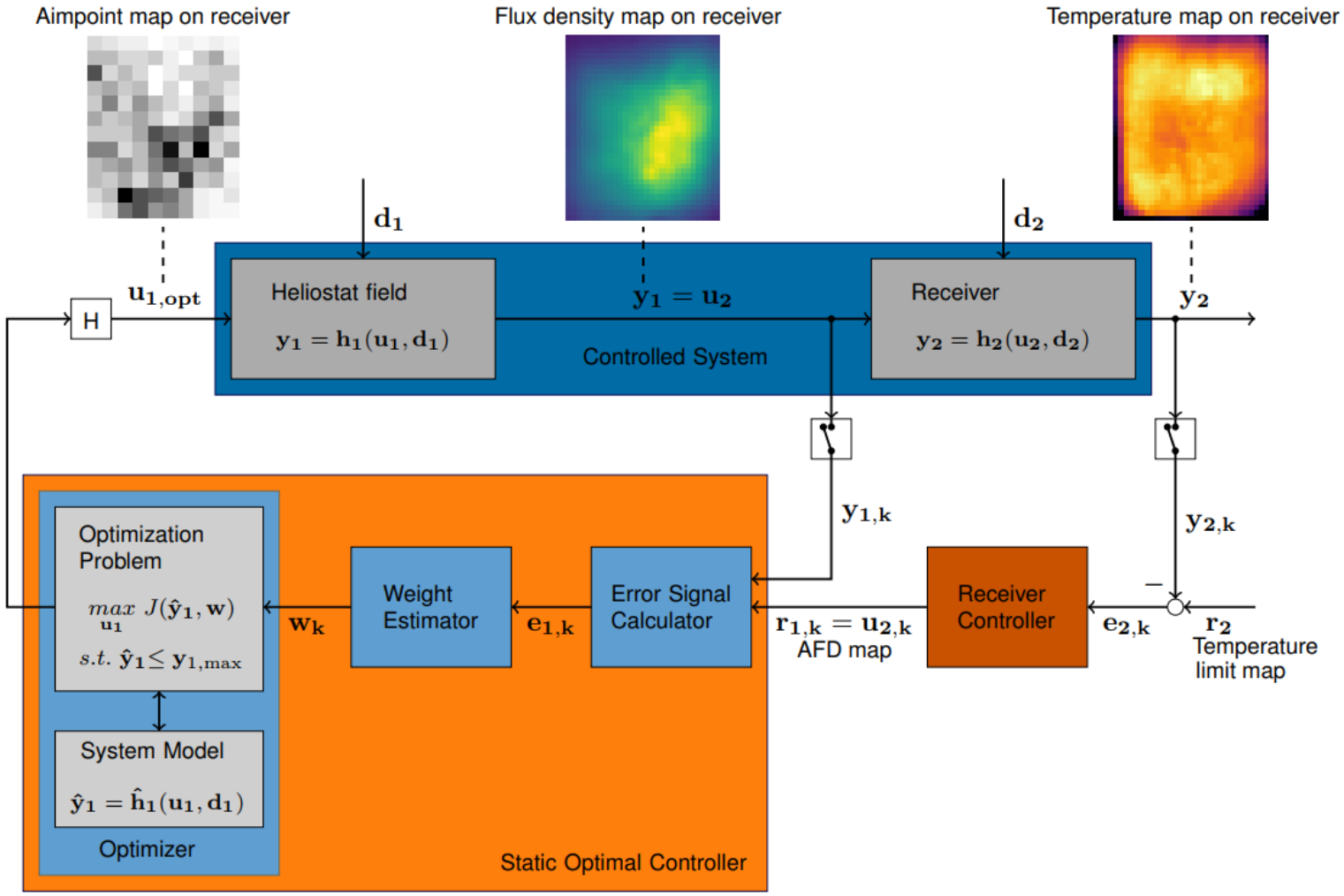
Aim point management system
Cascade control

- Inner control loop:
  Static optimal control



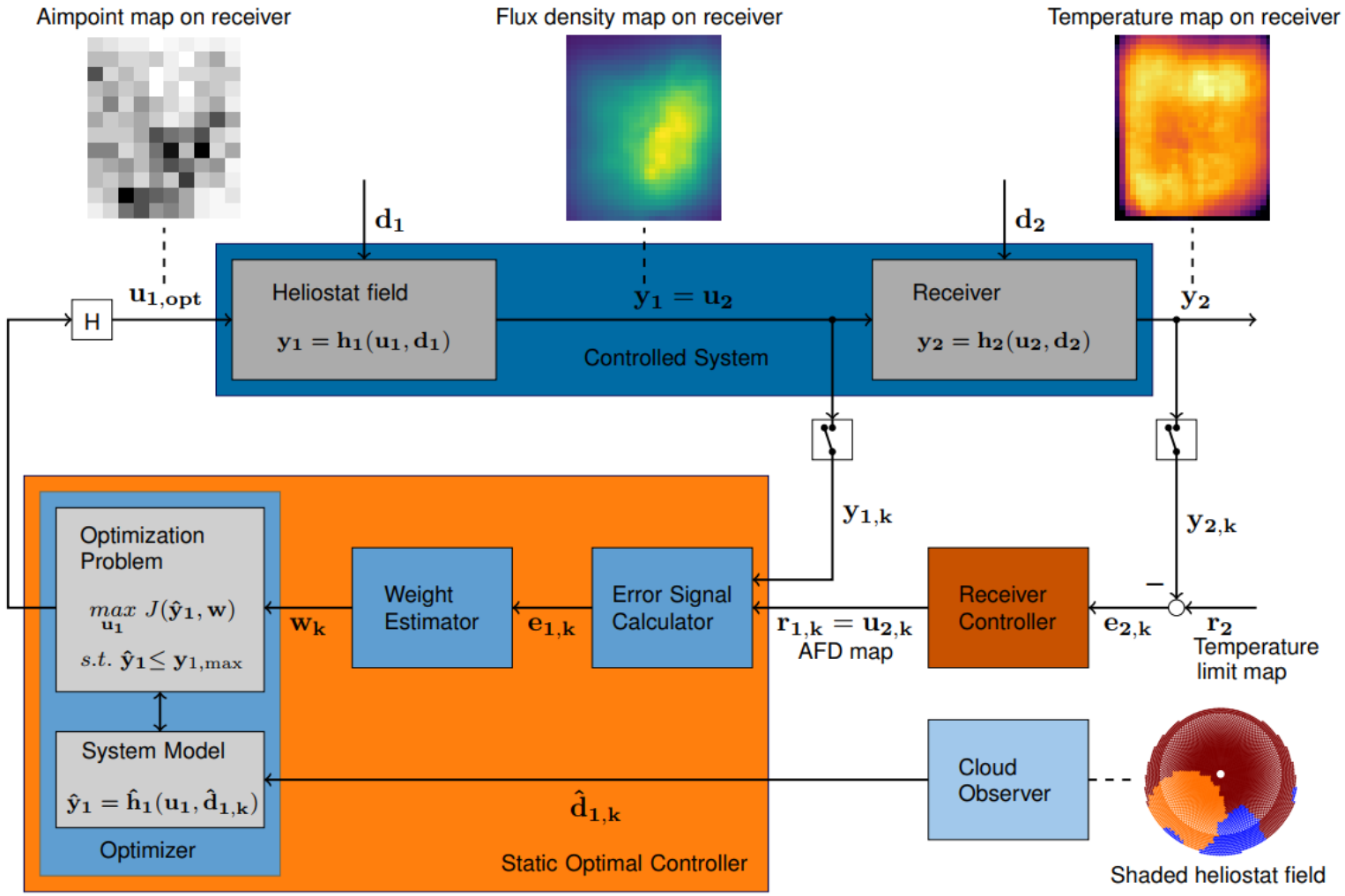
Aim point management system
Cascade control

- Inner control loop:
  Static optimal control
- Outer control loop:
  Decoupled PID-control

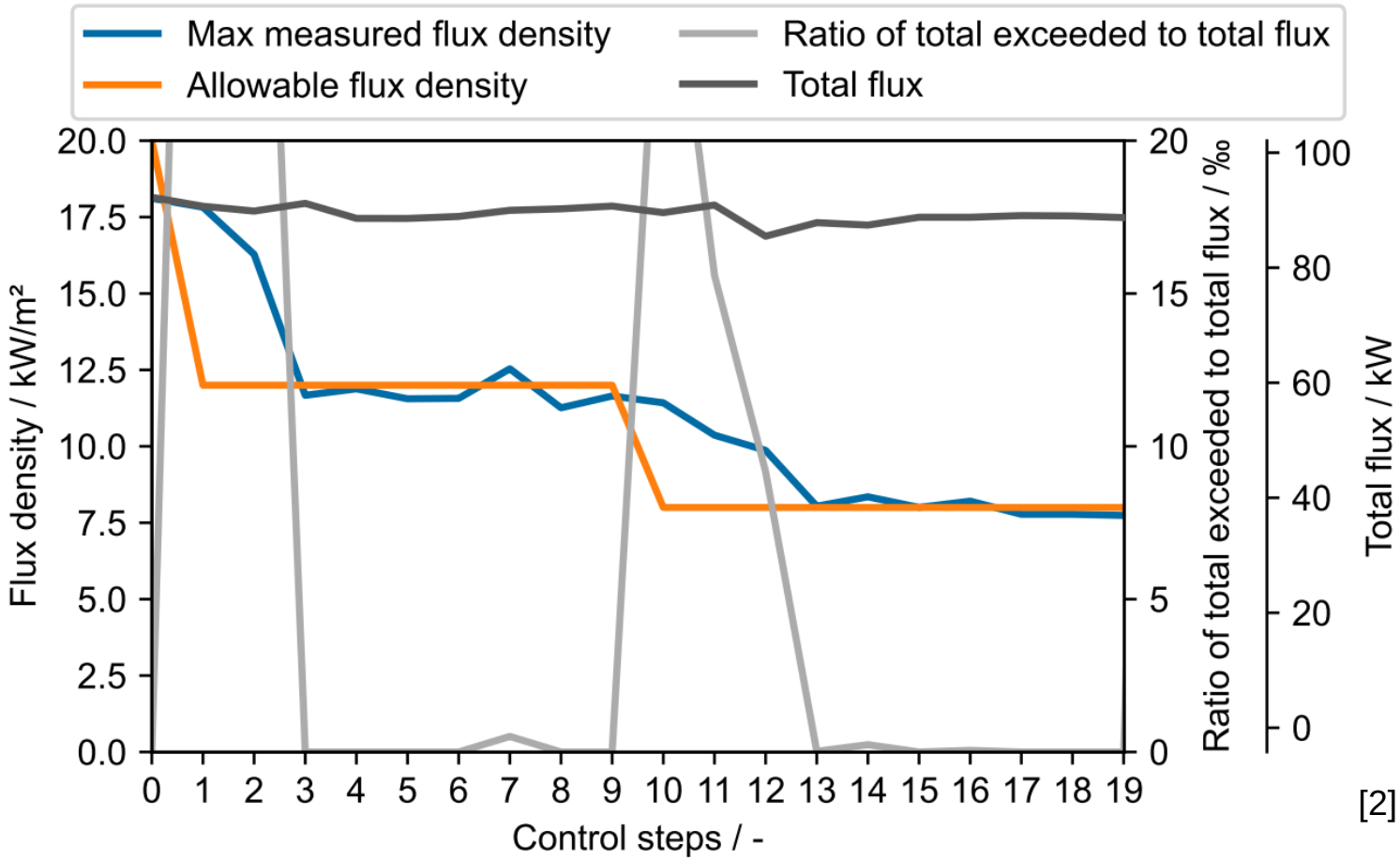


Aim point management system
Cascade control

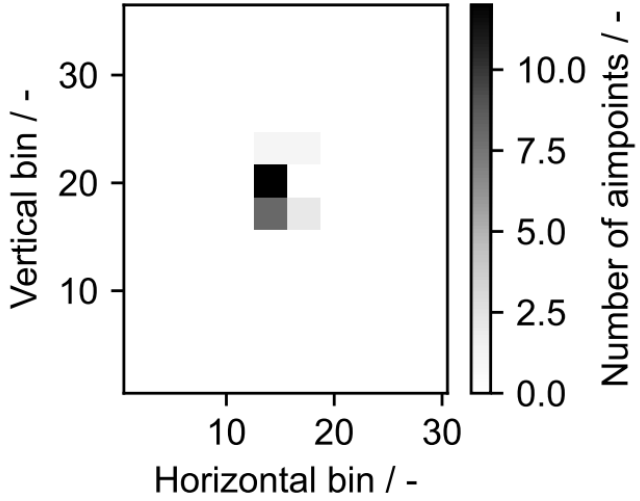
- Inner control loop:
  Static optimal control
- Outer control loop:
  Decoupled PID-control
- ASI-based nowcasting:
  Feed-forward control

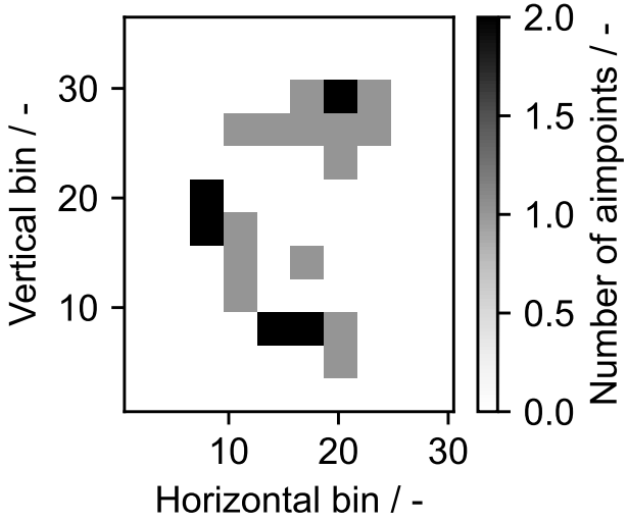


Aim point management system
Results at the Jülich solar tower – inner control loop



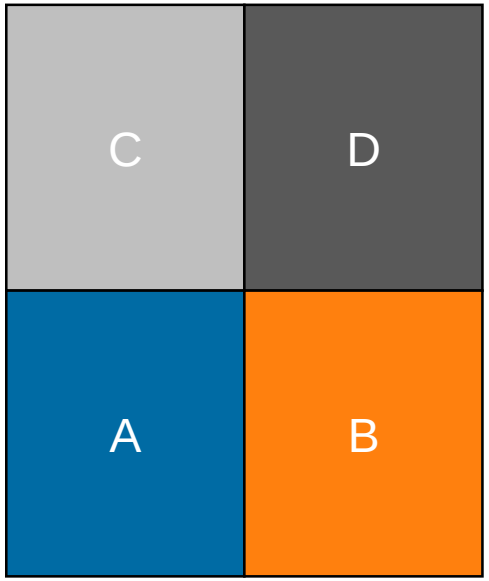
[2]

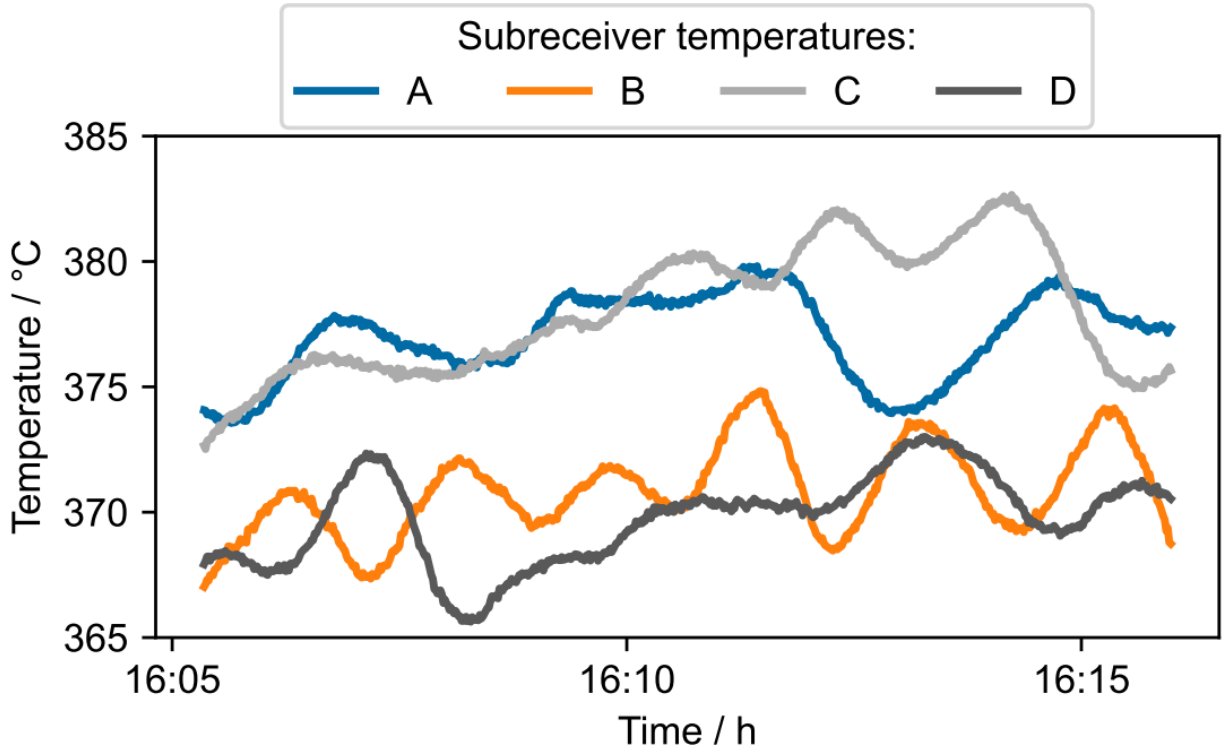




[2] Oberkirsch et al., SolarPACES 2021 (2021).

Aim point management system
Results at the Jülich solar tower – outer control loop





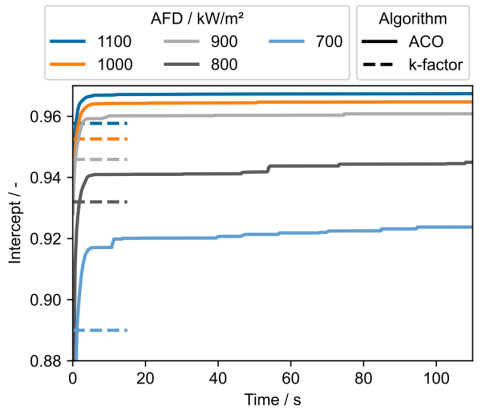
- Closed-loop aim point control leads to narrow temperature range of 15 K
- Alternative to throttling flaps

Aim point management system

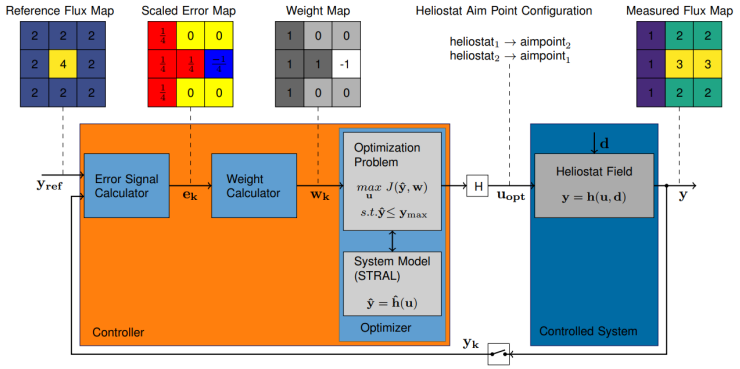
Conclusion

Aim point optimization

1-2% higher intercepts



Closed-loop aim point control



0,4% vs 9% performance loss

Validation

- Additional yield of 1% amouts to 600.000 €/a for a 100 MW_{el}-plant

THANK YOU FOR YOUR ATTENTION!
ANY QUESTIONS?

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Imprint

Topic:	**Aim point management system for solar power towers** Aim point optimization by enhanced ACO meta-heuristic Closed-loop aim point control by novel static optimal controller Nested closed-loop aim point management system
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