Optimization of concentrated solar power system: Calculate the sensitivities by the method of MonteCarlo and its coupling with a method of Descente Gradient

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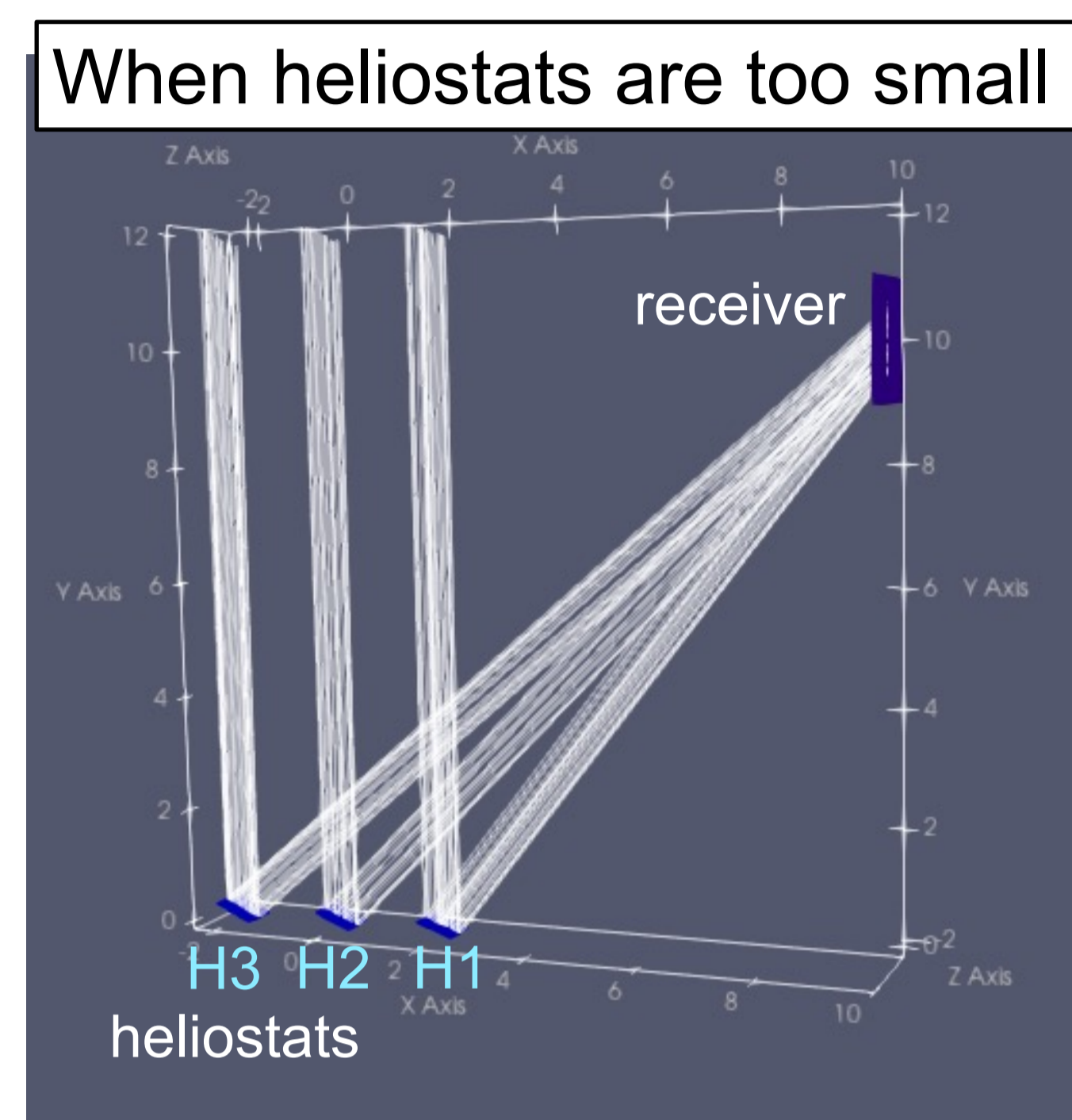**https://imt-mines-albi.hal.science/hal-03434184**

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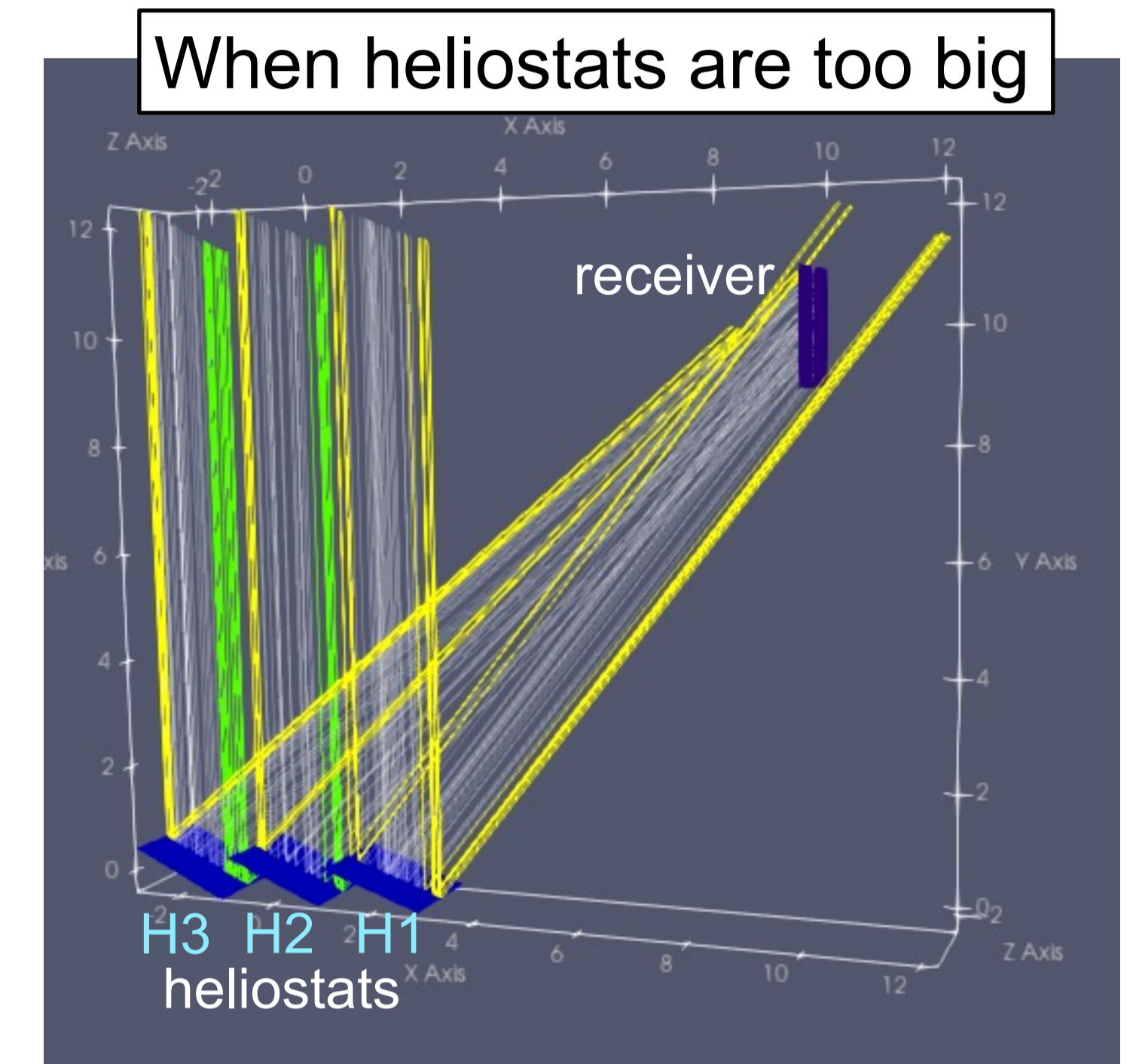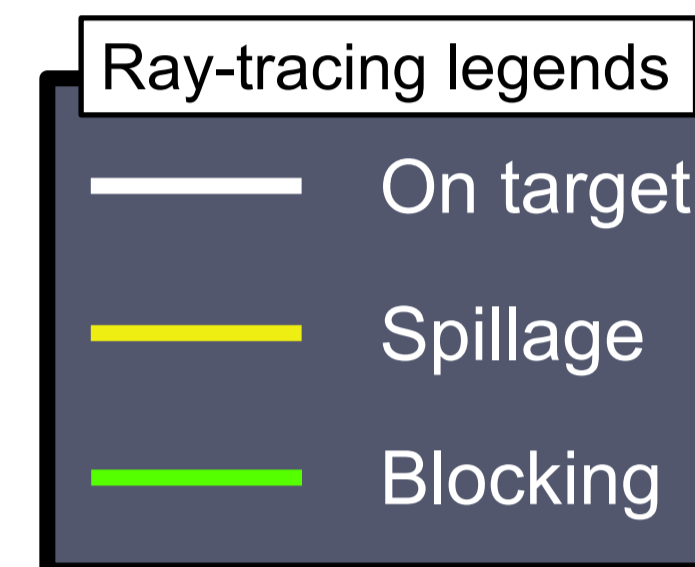
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|Méso|Star>
Understanding complex systems

Aims:

► Optimize the size of heliostats in a CSP system for a maximum received power

When heliostats are too small

What is the best size for these heliostats?

Ray-tracing legends
— On target
— Spillage
— Blocking

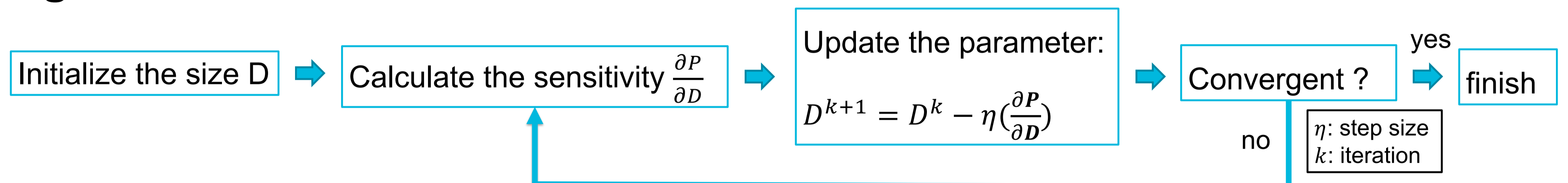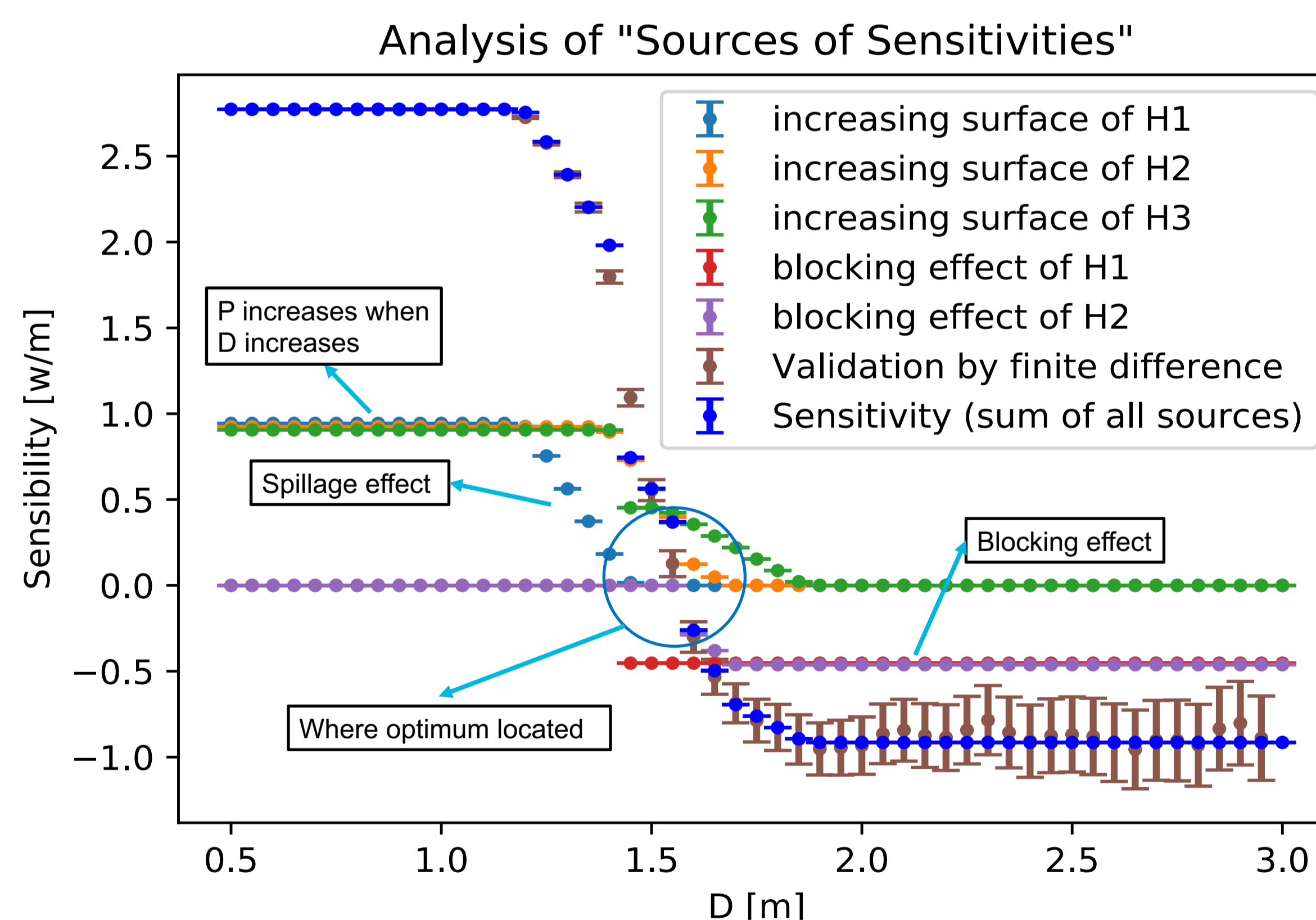When heliostats are too big

Methods:

► Take the new approach (Sensitivity Transport Models for Domain Deformation [1]) to calculate the sensitivity $\frac{\partial P}{\partial D}$ by Monte-Carlo method [2]

► Optimize size of heliostats by gradient descent method

P [w]: arriving power on receiver
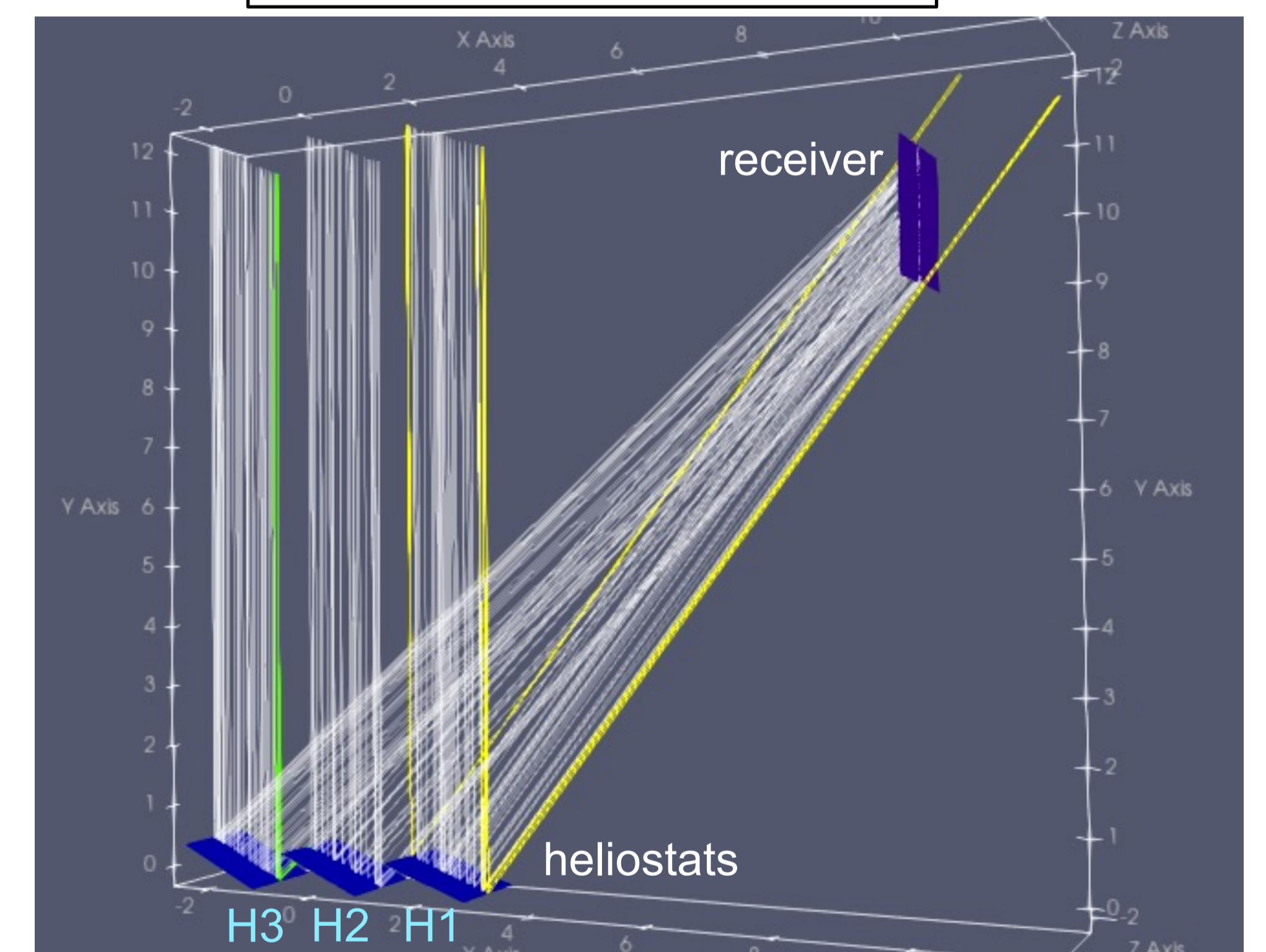D [m]: size of heliostats

Algorithm:

Initialize the size D → Calculate the sensitivity $\frac{\partial P}{\partial D}$ → Update the parameter: $D^{k+1} = D^k - \eta(\frac{\partial P}{\partial D})$ → Convergent ?
yes → finish
no

η: step size
k: iteration

Results:

Analysis of "Sources of Sensitivities"

- increasing surface of H1
- increasing surface of H2
- increasing surface of H3
- blocking effect of H1
- blocking effect of H2
- Validation by finite difference
- Sensitivity (sum of all sources)

P increases when D increases

Spillage effect

Where optimum located

Blocking effect

Optimized heliostats size

Conclusion:

► The new approach of calculating geometrical sensitivity[1][2] by Monte-Carlo method allows detailed analysis of blocking, spillage and shadowing effect in 2D with 3 heliostats

► Such approach is coupled with a method of gradient descent to optimize the sizes of heliostats for a maximum received power

Perspectives:

► Generalize the method for 3D configurations and for higher numbers of heliostats

► Optimize the position, pointing strategy and heliostat deformation in a CSP system

Contact

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[1] Lapeyre, P., S. Blanco, C. Caliot, J. Dauchet, M. El Hafi, R. Fournier, O. Farges, J. Gautrais, and M. Roger. "Monte-Carlo and Sensitivity Transport Models for Domain Deformation." Journal of Quantitative Spectroscopy and Radiative Transfer 251 (August 1, 2020): 107022. https://doi.org/10.1016/j.jqsrt.2020.107022.
[2] Farges, Olivier. "Conception optimale de centrales solaires à concentration : application aux centrales à tour et aux installations 'beam down.'" Phdthesis, Ecole des Mines d'Albi-Carmaux, 2014. https://tel.archives-ouvertes.fr/tel-01135529.