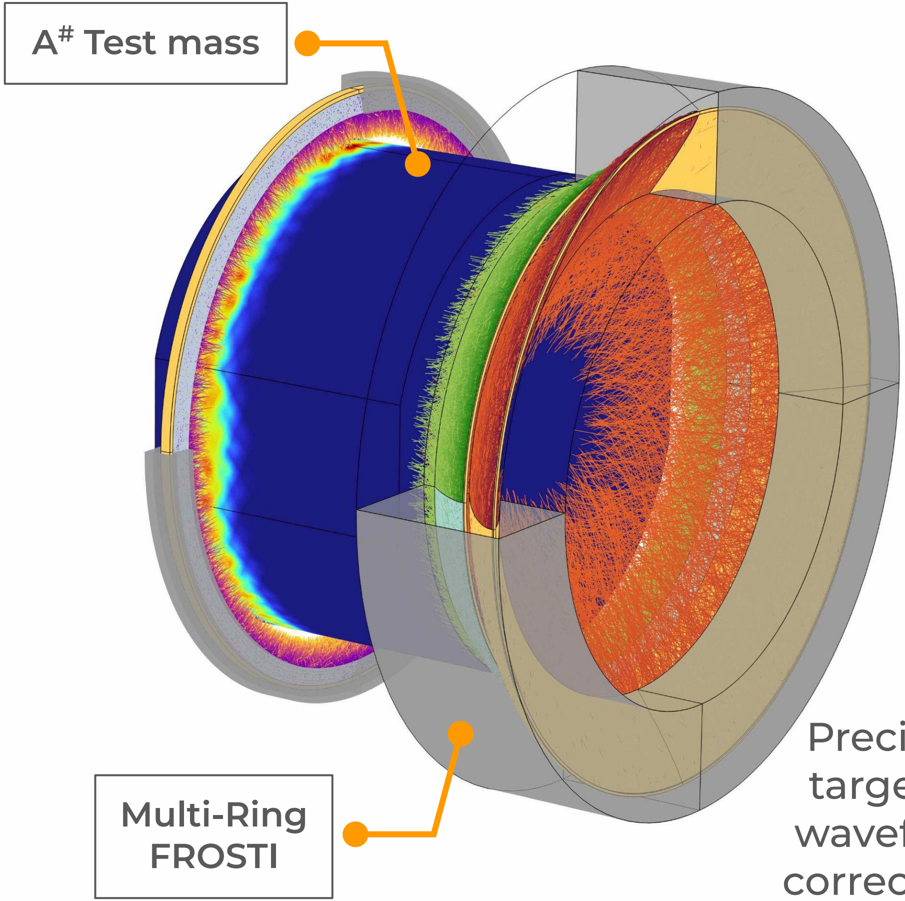
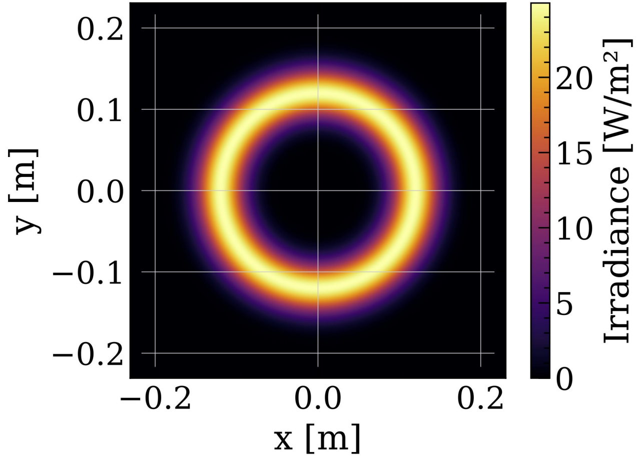
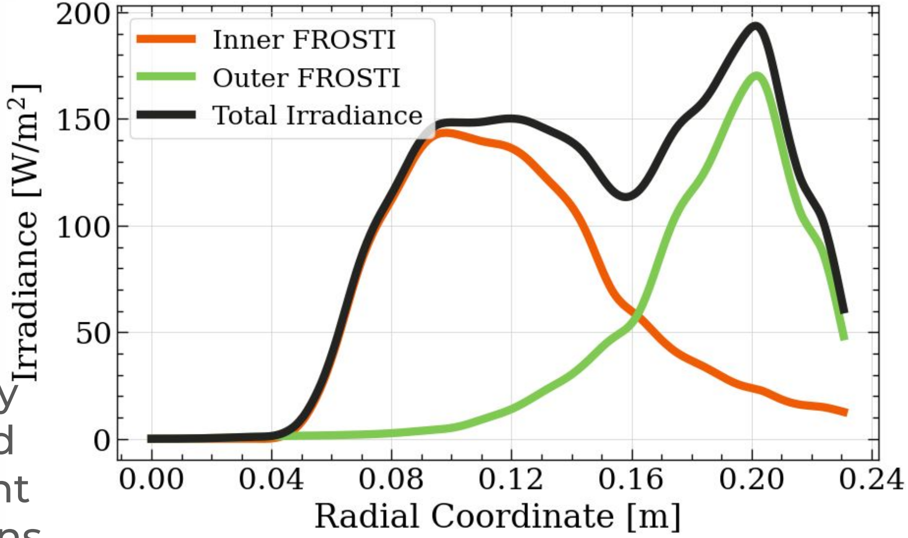
Multi-Ring FROSTI



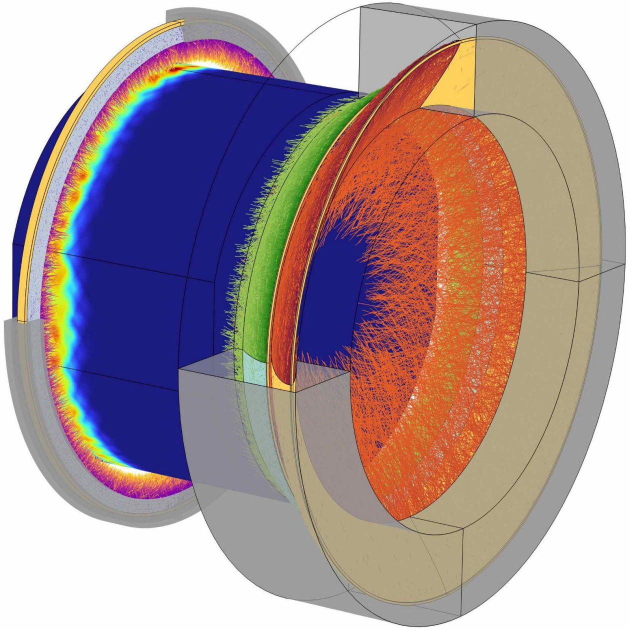
Multiple Gaussian annulus





Precisely targeted wavefront corrections

Multi-Ring FROSTI Design for $A^{\#}$ and CE



Design parameter space optimization

Minimize both the surf. and subs. RMSE, with N (most likely ≥ 2) heater rings

1. Width, location and individual power for each irradiance ring, DoF=2*3=6;
2. RH power, DoF=1; Location and width DoF=2;
3. In total 9D parameter space exploration.

Geometric param:
1. Width
2. location

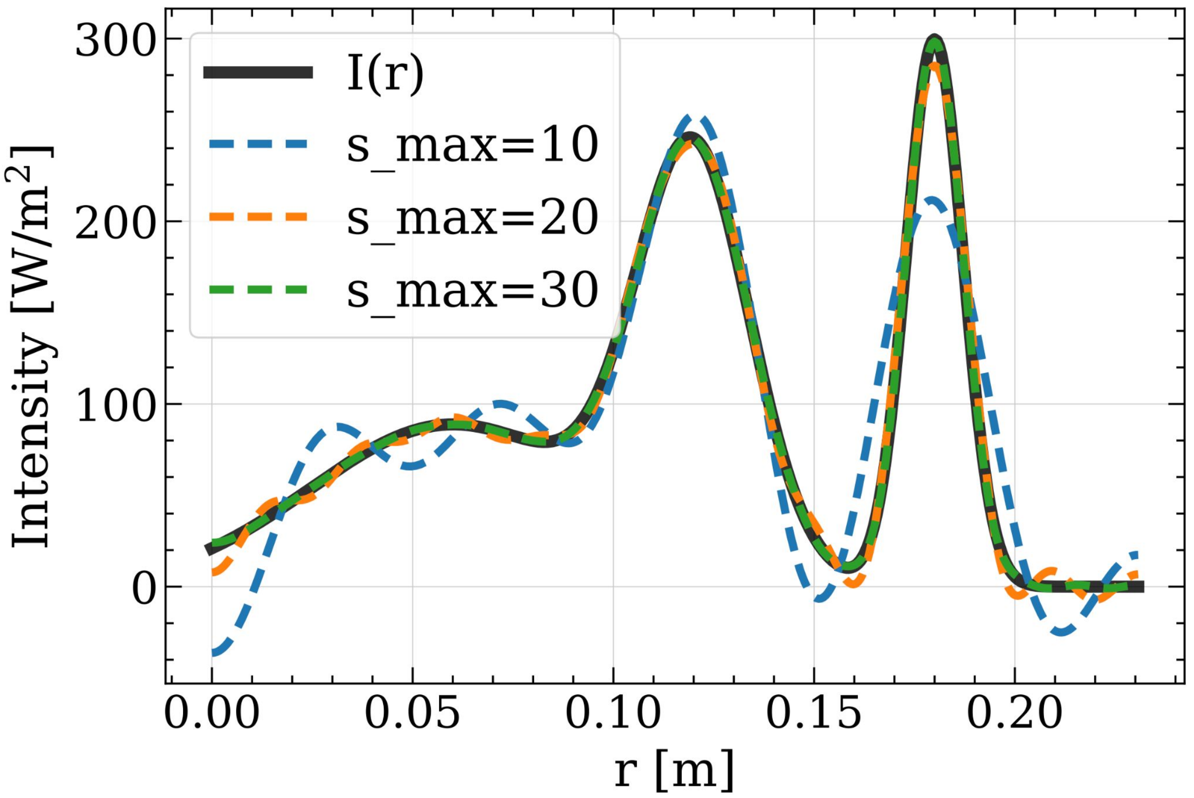
Optimization One

Nested loop

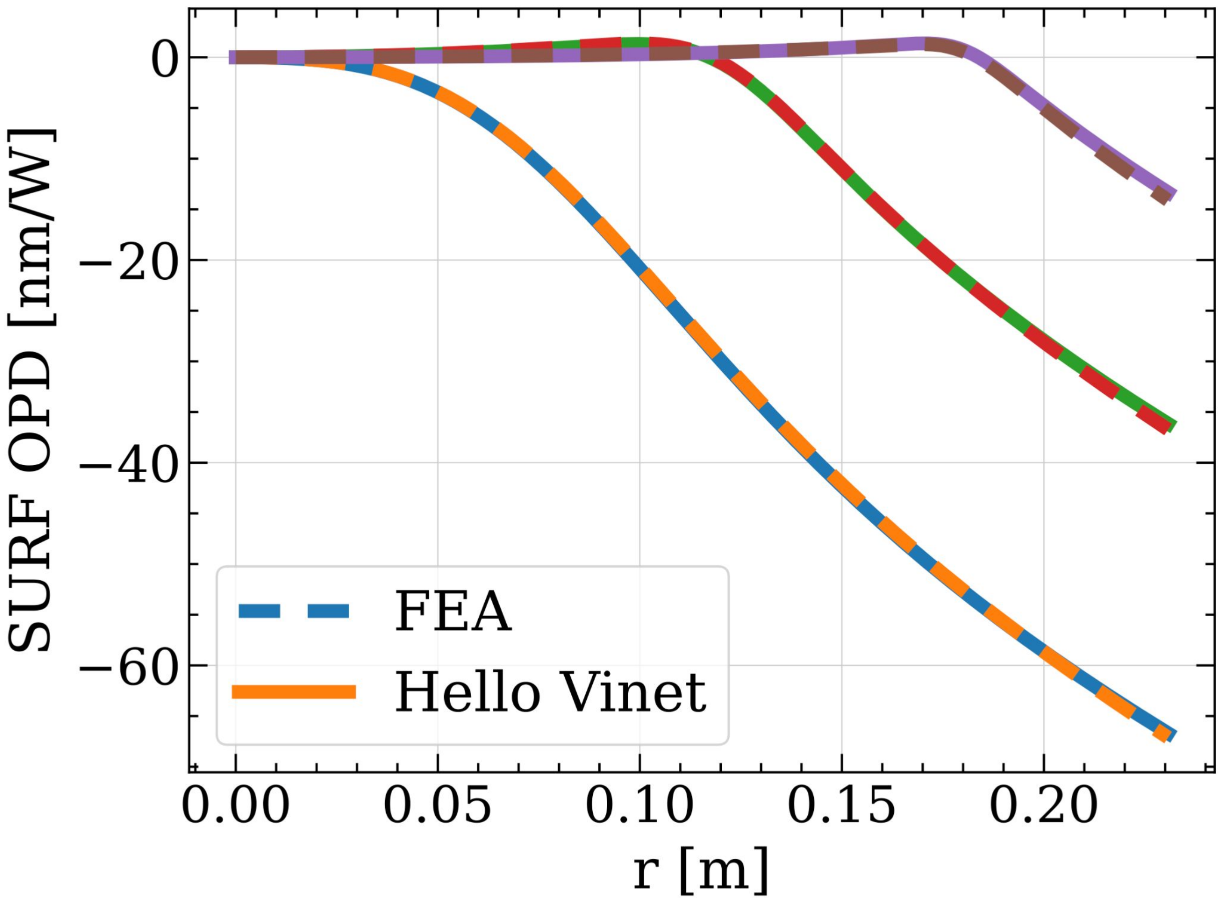
Power param:
1. FROSTI power
2. RH power

Optimization Two

For each step in optimization loop one, we need to run an FEA model over the width and locations.

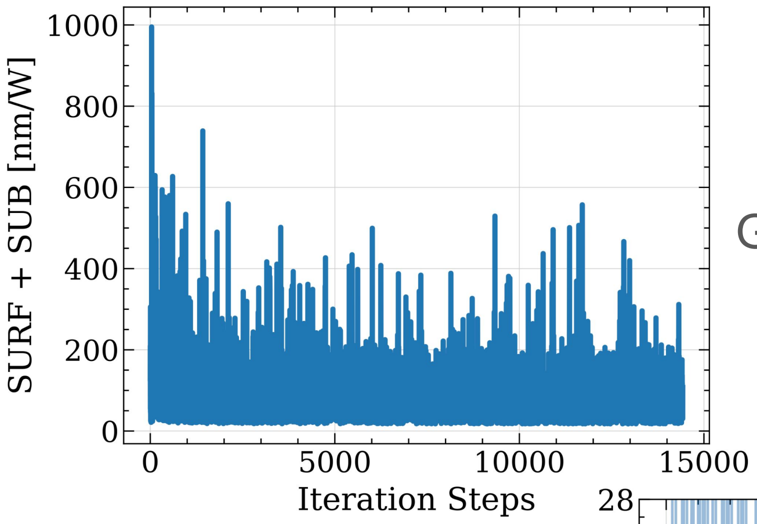


1. Hello-Vinet formulisms for **axisymmetric** heating profiles by **Fourier-Bessel** expansion.
2. S = 30 is enough to capture typical FROSTI irradiance with 3 components.



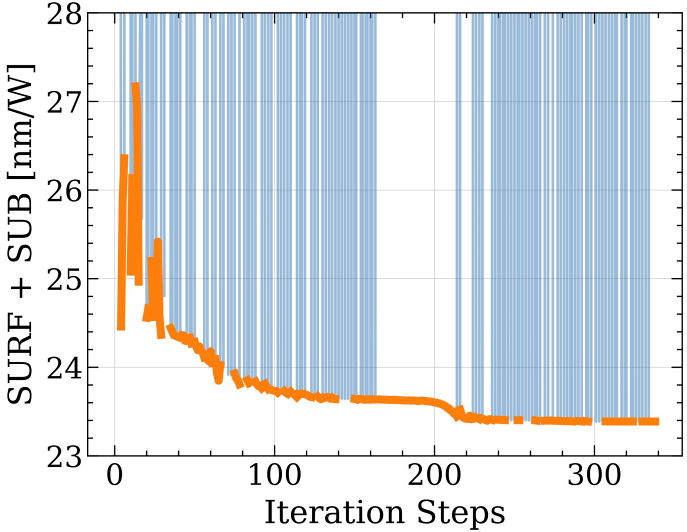
1. Hello-Vinet formulisms for **axisymmetric** heating profiles by **Fourier-Bessel** expansion.
2. H-V with S = 30 produces similar thermal responses as FEA models.

“Hybrid” Optimization Strategy: Global + Local



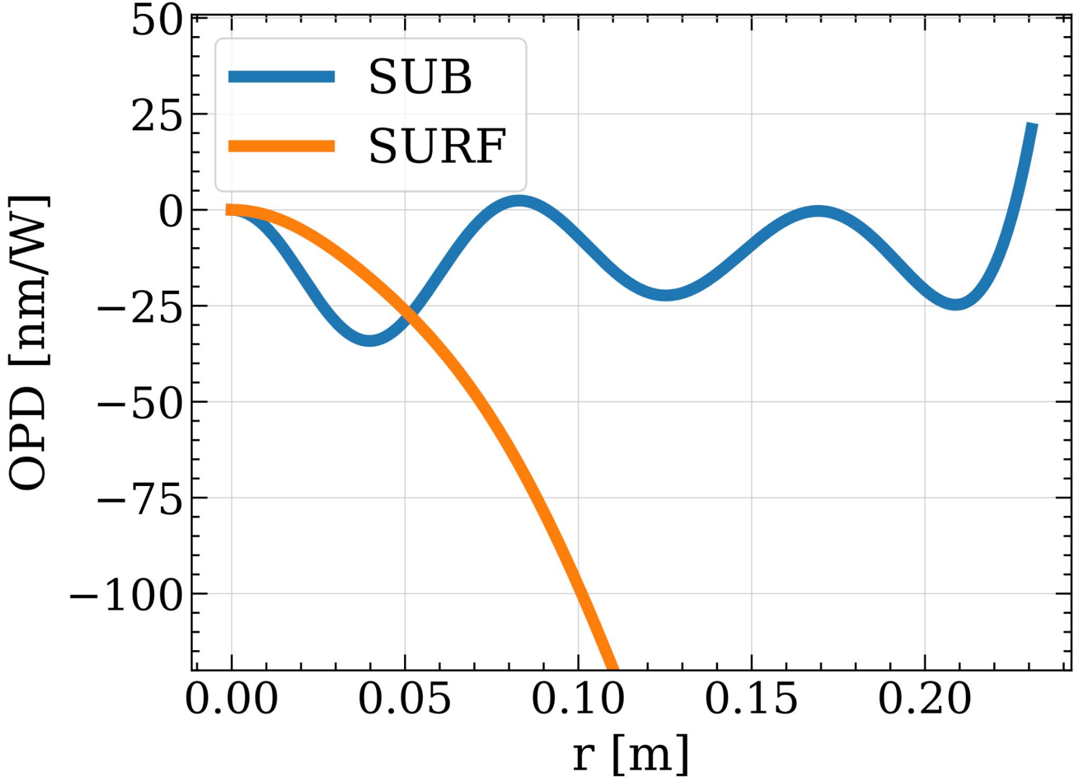
Global Exploration:
Particle Swarm

Local Optimizer:
Scipy gradient-based



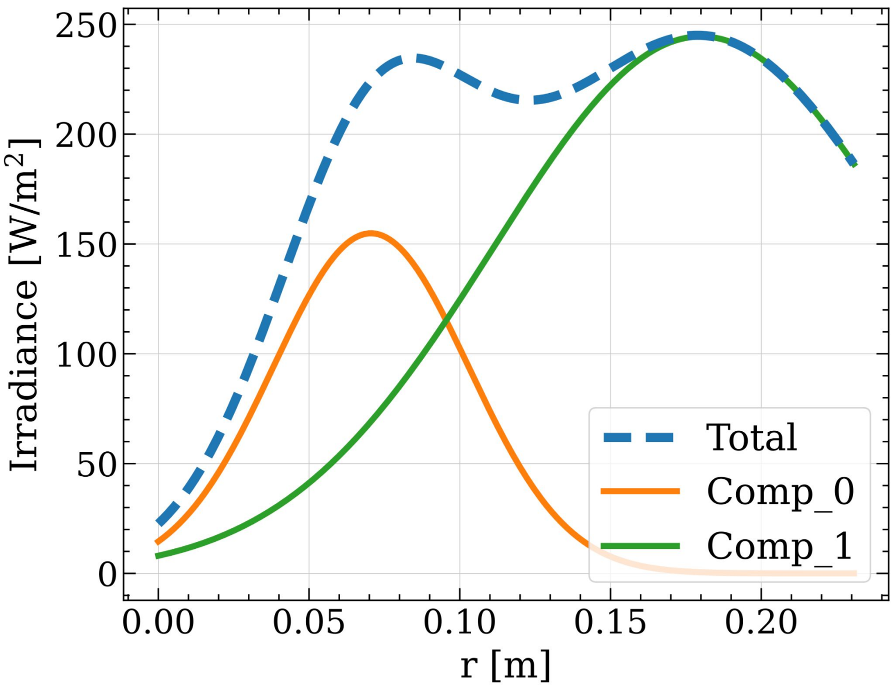
Loss function = Surface RMS (Gaussian weighted) + Substrate RMS (Full aperture)

First use particle swarm optimization to get us close to the optimum (finds the right valley), then we switch to SciPy local optimizer (descends to the bottom)



Optimization results for multi-ring FROSTI with 2 heater components:

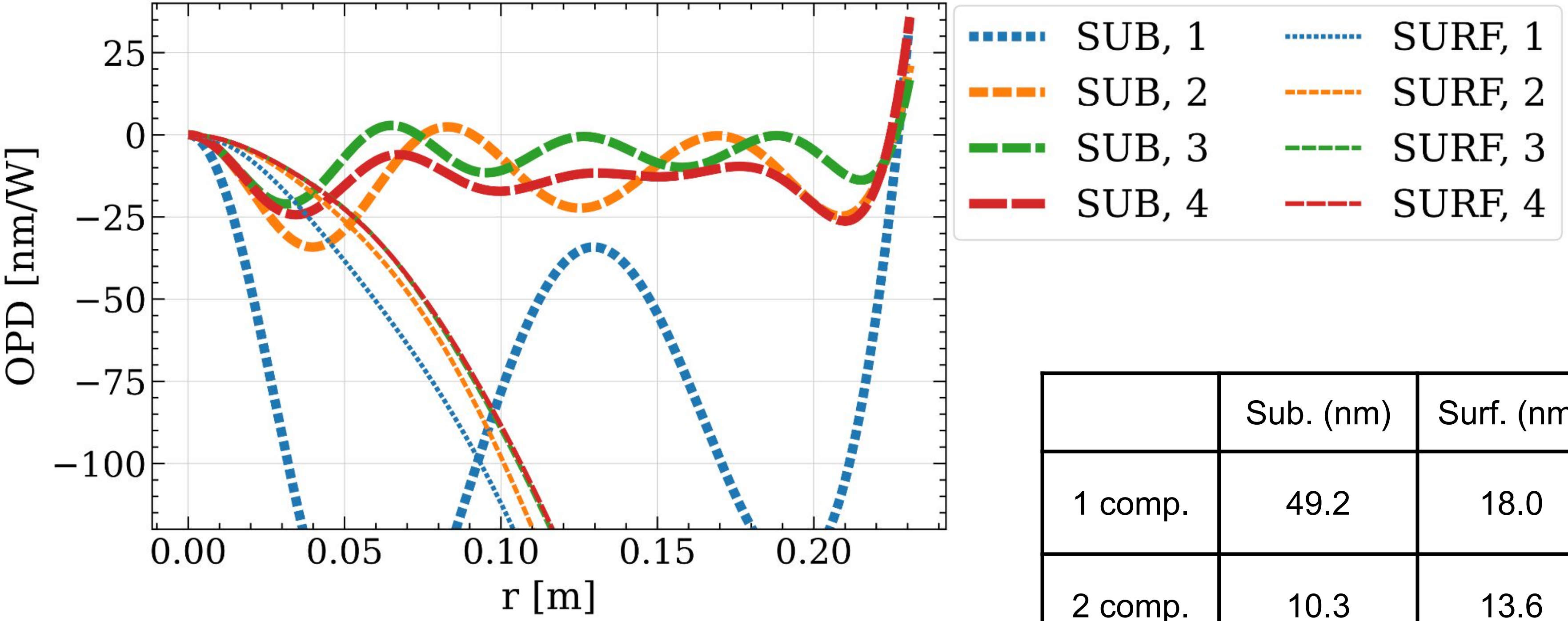
	Sub. (nm)	Surf. (nm)
2 comp.	10.3	13.6
	Full Aperture	Gaussian Weighted



r: Major radius [cm]
w: Minor radius [cm]
P: Component power [W]

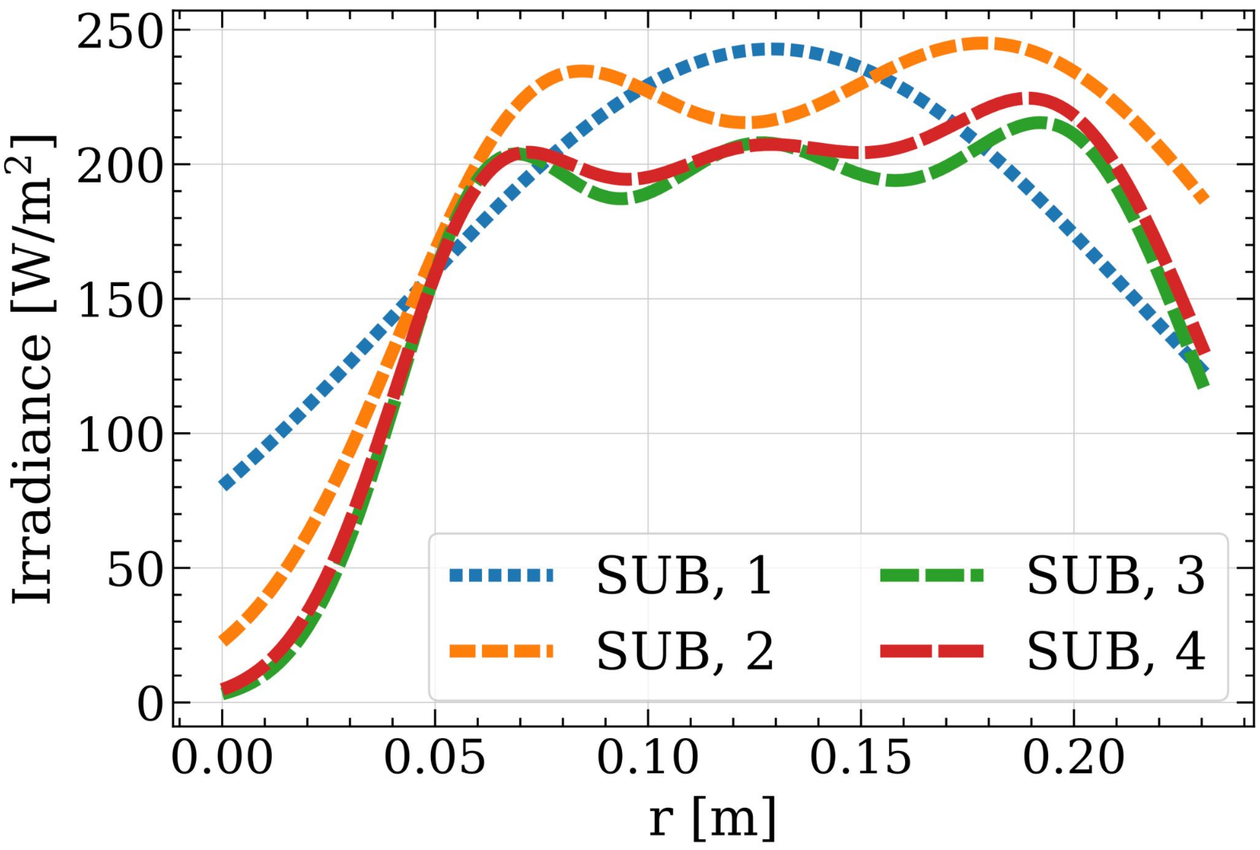
	(r, w, P)
Comp 1	(7.1, 4.6, 5.6)
Comp 2	(18.0, 9.7, 47.8)
RH*	44.4

*RH is moved to the AR surface by 8 mm



Optimization results for multi-ring FROSTI with 1/2/3/4 components:

	Sub. (nm)	Surf. (nm)
1 comp.	49.2	18.0
2 comp.	10.3	13.6
3 comp.	5.6	12.2
4 comp.	5.3	12.1



Optimized irradiance for multi-ring FROSTI with 1/2/3/4 components

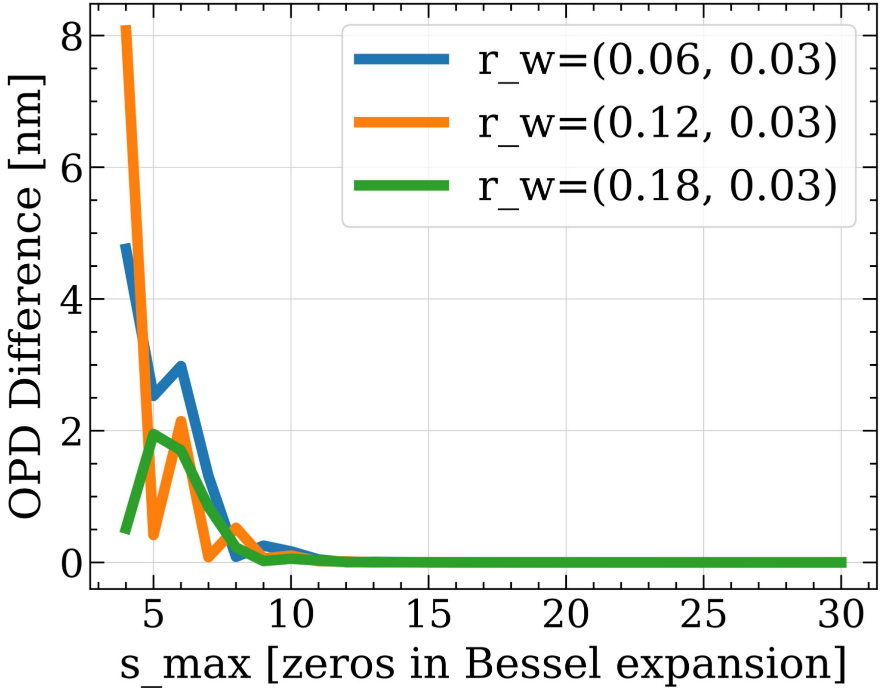
Additional Slides

Hello-Vinet Formalism

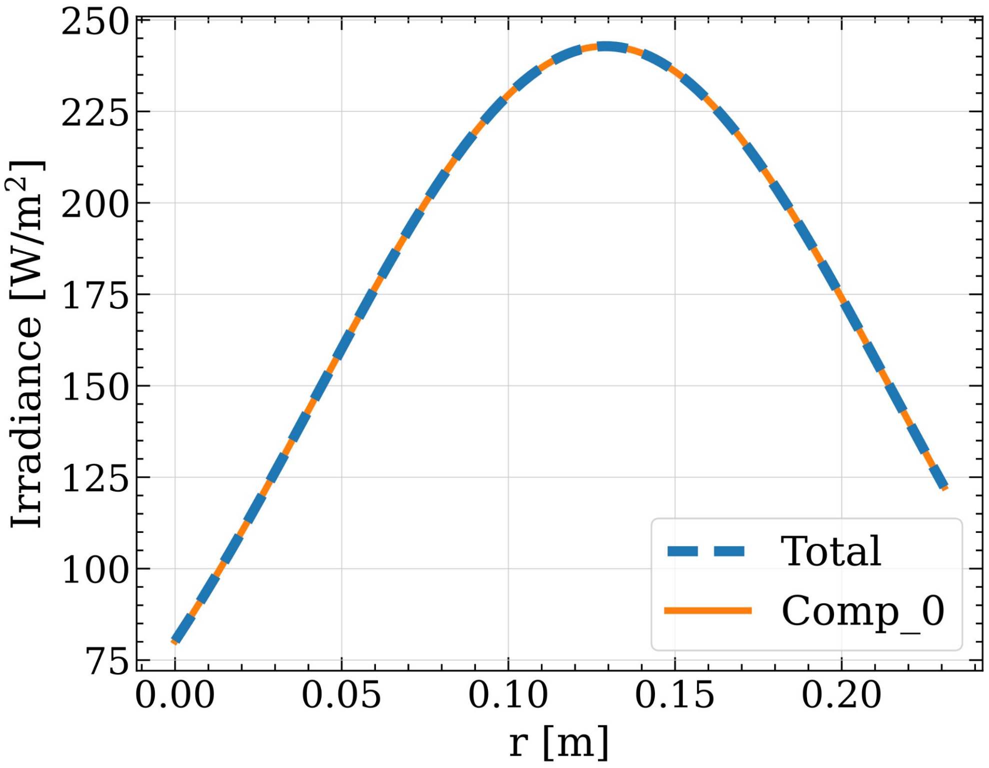
$$I_n(r) = \frac{P}{\pi a^2} \sum_{s>0} p_{n,s} J_n(\zeta_{n,s} r/a).$$

$$Z_{\text{coat}}(r) = \frac{dn}{dT} \frac{\epsilon P}{\pi K} \sum_s \frac{p_{n,s}}{\zeta_{n,s}} \frac{\sinh \gamma_{n,s}}{d_{1,n,s}} J_n(k_{n,s} r/a)$$

For the thermal lens caused by coating absorption



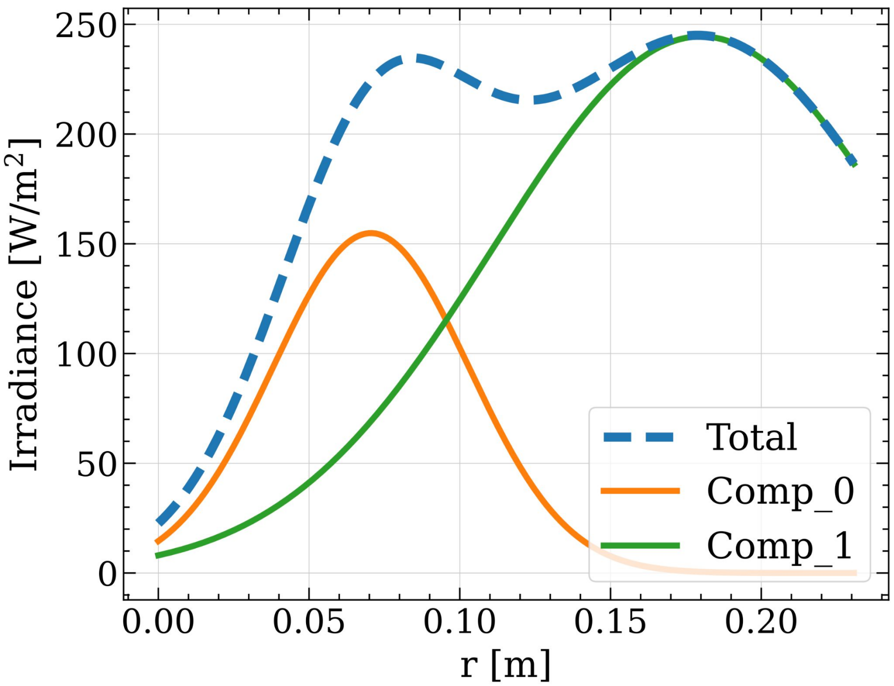
s_max = 30



r: Major radius [cm]
w: Minor radius [cm]
P: Component power [W]

	(r, w, P)
Comp 1	(12.9, 12.3, 43.7)
RH*	47.1

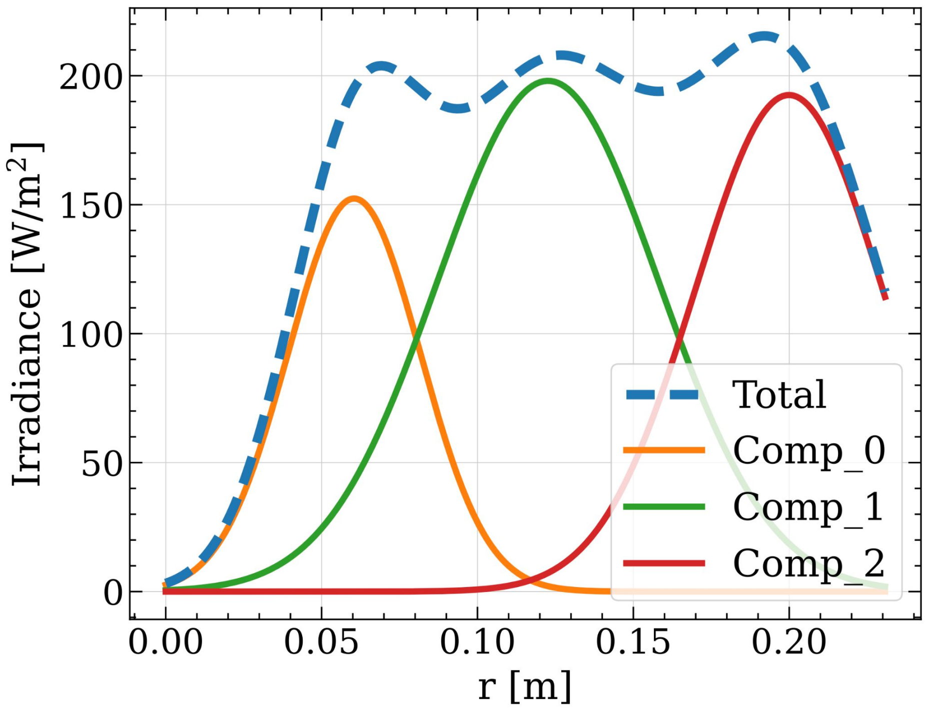
*RH is moved to the HR surface by 34 mm



r: Major radius [cm]
w: Minor radius [cm]
P: Component power [W]

	(r, w, P)
Comp 1	(7.1, 4.6, 5.6)
Comp 2	(18.0, 9.7, 47.8)
RH*	44.4

*RH is moved to the AR surface by 8 mm

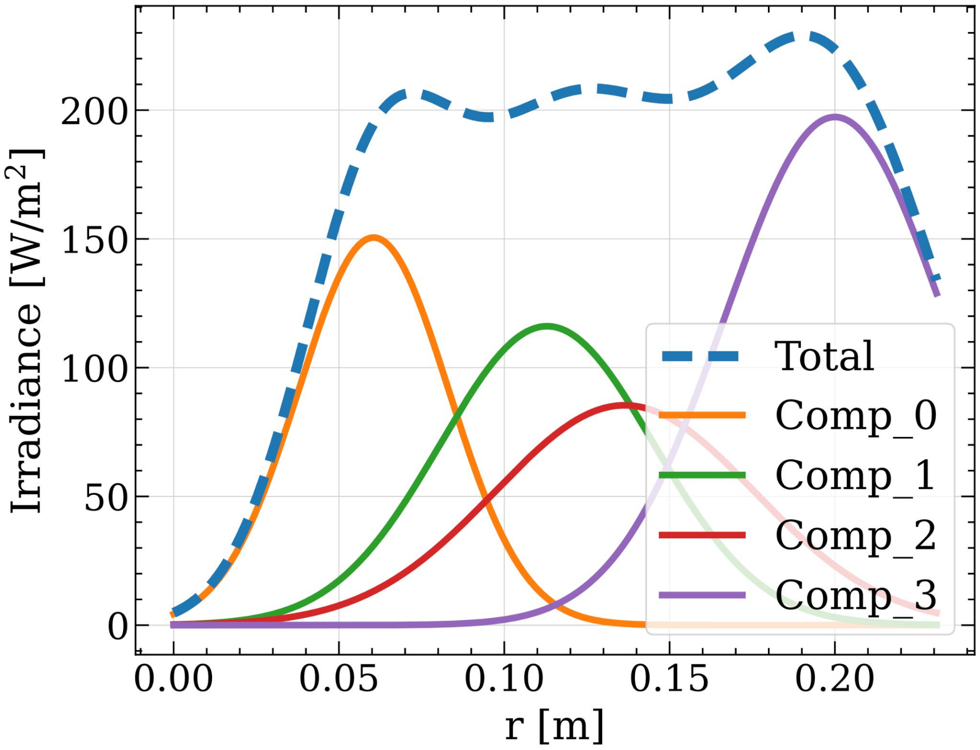


r: Major radius [cm]
w: Minor radius [cm]
P: Component power [W]

	(r, w, P)
Comp 1	(6.0, 3.0, 3.1)
Comp 2	(12.3, 5.0, 13.6)
Comp 3	(20.0, 4.3, 18.3)
RH*	39.8

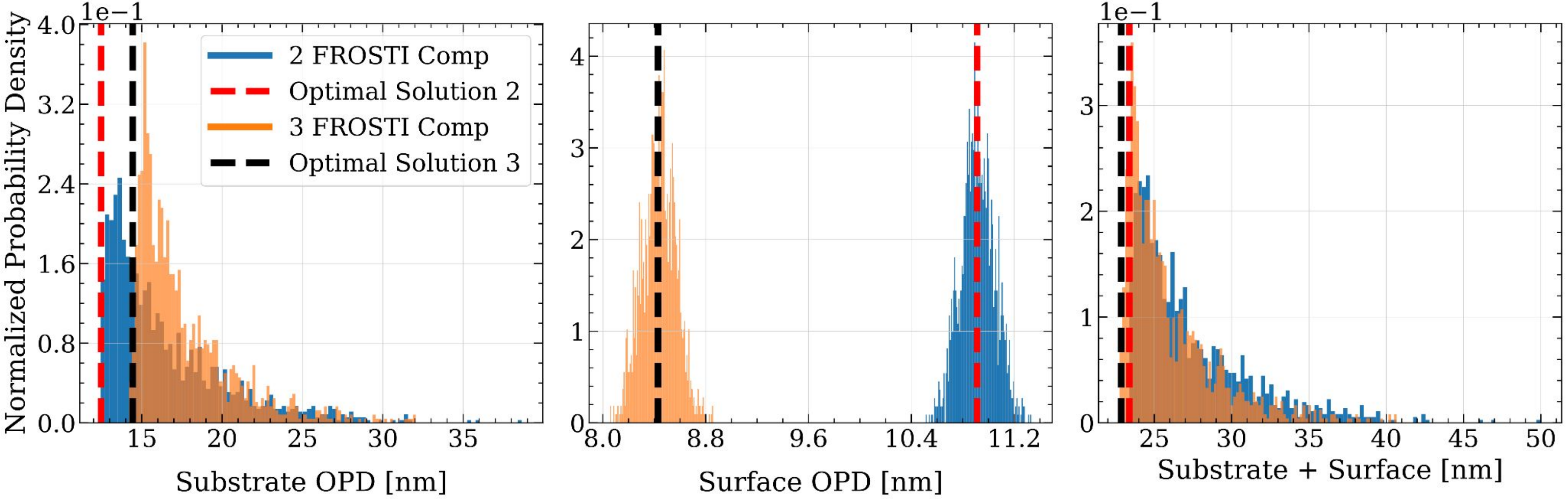
*RH is moved to the HR surface by 6 mm

r: Major radius [cm]
w: Minor radius [cm]
P: Component power [W]



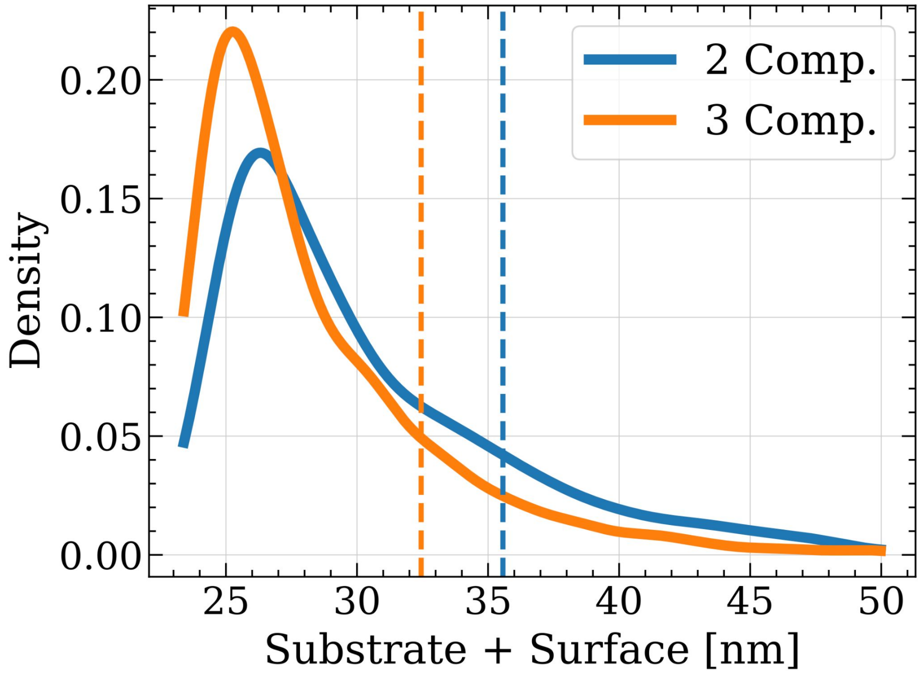
	(r, w, P)
Comp 1	(6.0, 3.2, 3.2)
Comp 2	(11.3, 4.6, 6.3)
Comp 3	(13.6, 5.6, 7.7)
Comp 4	(20.0, 4.7, 20.0)
RH*	40.8

*RH is moved to the AR surface by 10 mm



Power uncertainty for each FROSTI component: 0.1%,
Position/Width uncertainty for each FROSTI component: 1 mm.

Two component solution is more susceptible to realistic errors.



Two component solution is more susceptible to realistic errors:

95th percentile value larger by 3 nm.