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***SPACE SOLAR POWER INTERNATIONAL  
STUDENT COMPETITION***

**Flexible Adjustment Model for SPS-ALPHA:  
Optical Solution**

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**TEAM: HARBIN INSTITUTE OF TECHNOLOGY (CHINA)**

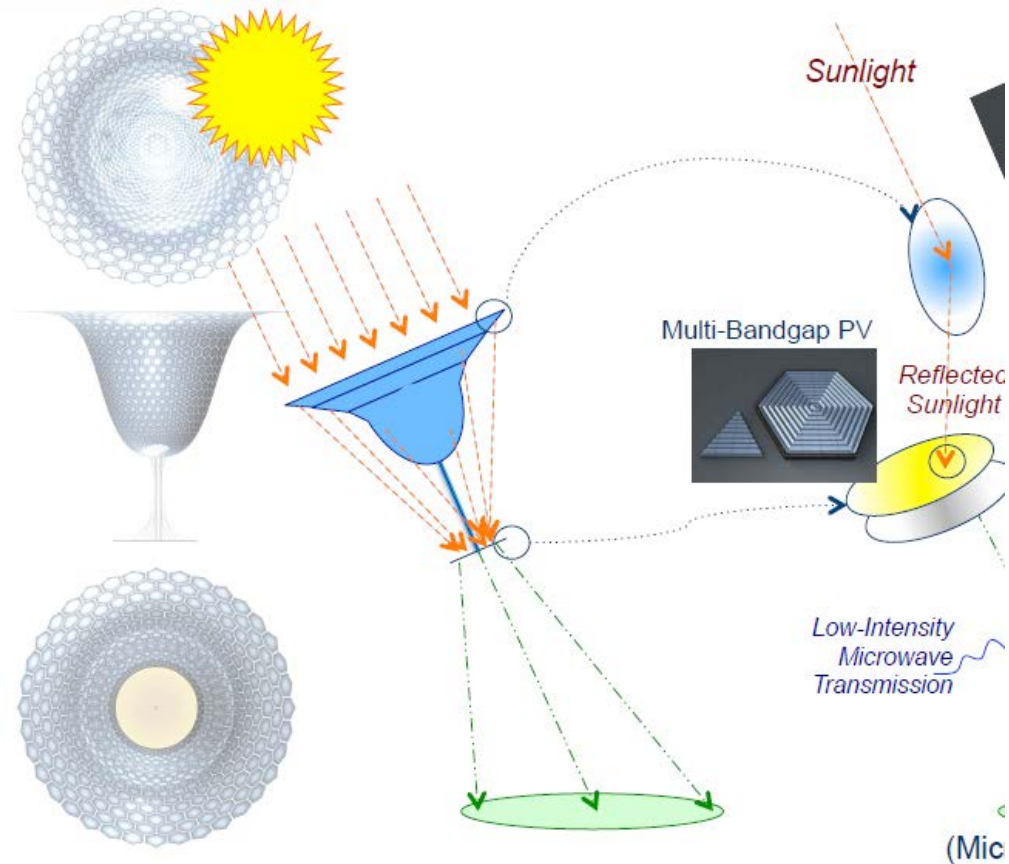
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Advisor: Prof. Xin-lin Xia

# Optical transmission is complex

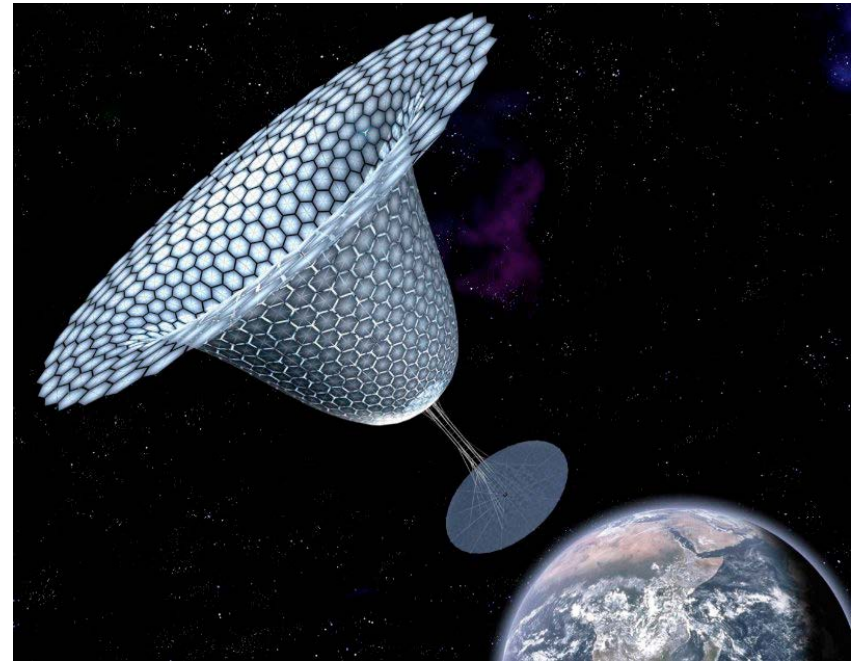
## Real-time 3-D tracking:

- Mirrors face to sun
- Solar panel point to the ground
- Changing all the time (hour/day/season)
- Large number of mirrors



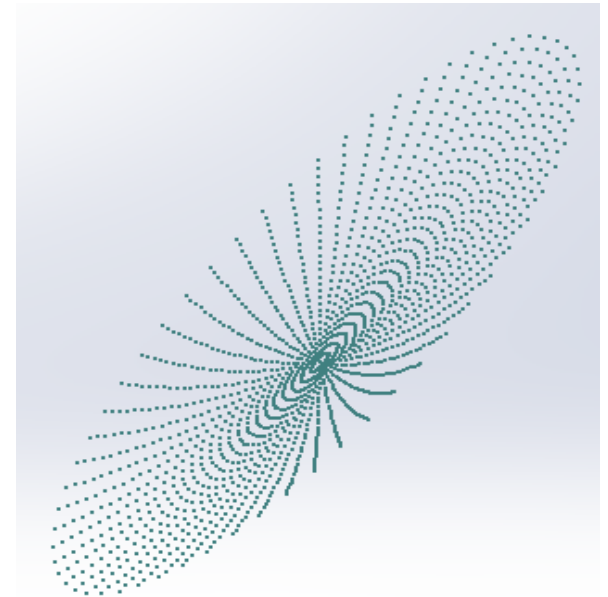
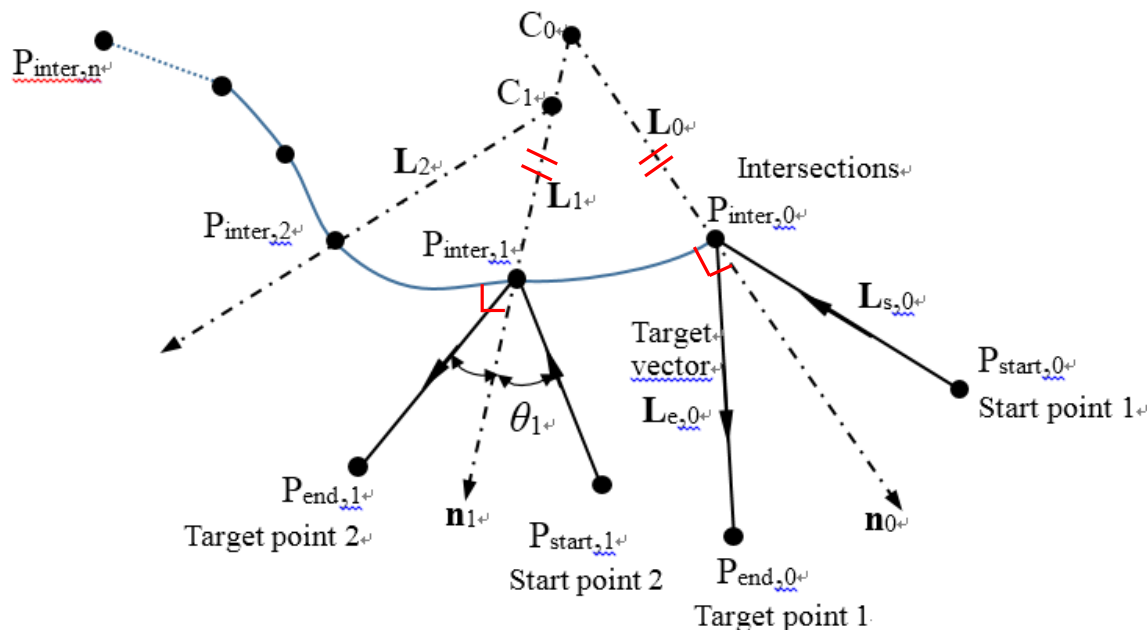
## Ideal Optical Performance for SPS:

- High optical efficiency for real time 3-D tracking
- High heat flux uniformity on solar panel
- Stable solar concentration & safety
- Moving fewer & smaller

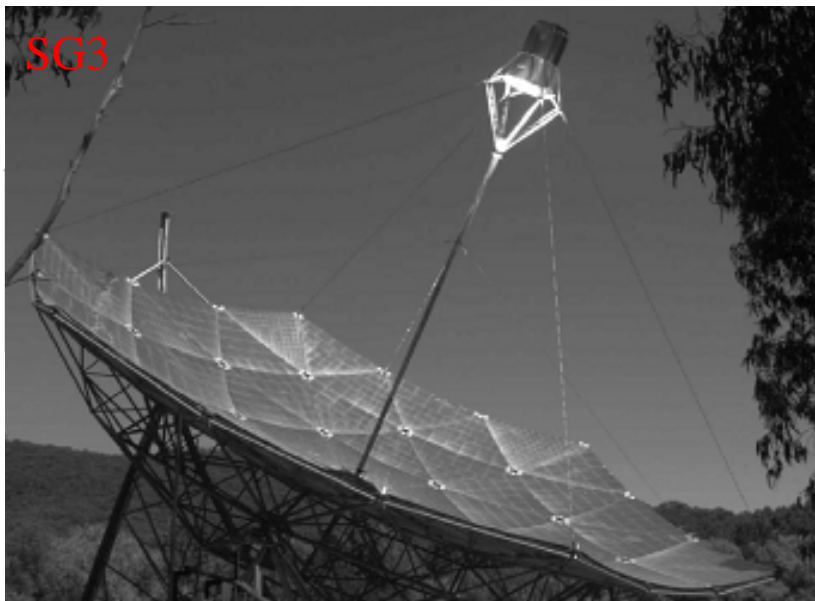


## Self-developed model: Vector based approach for the control of solar heat flux using freeform optics

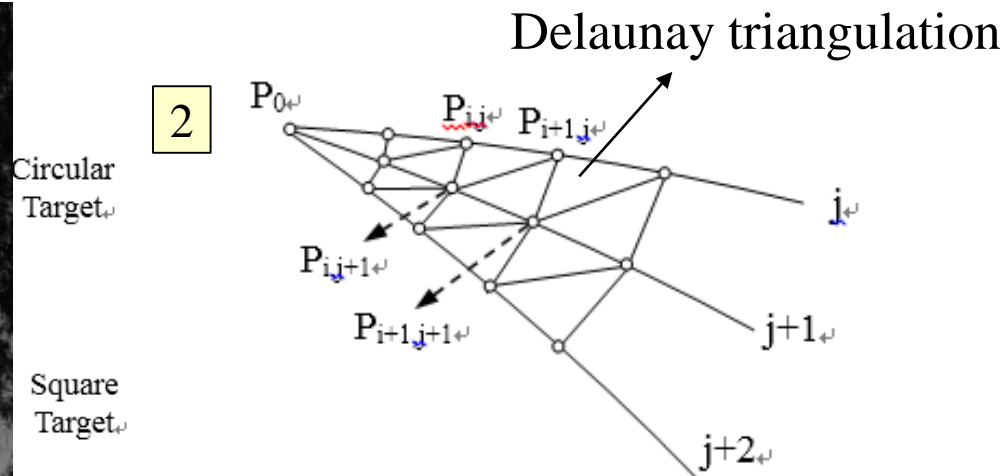
- Matrix-based skew ray tracing in homogeneous coordinates
- Reverse problem for target heat flux and shape
- Close-loop programming, but can export IGS
- Source-target mapping considering solar cone angle



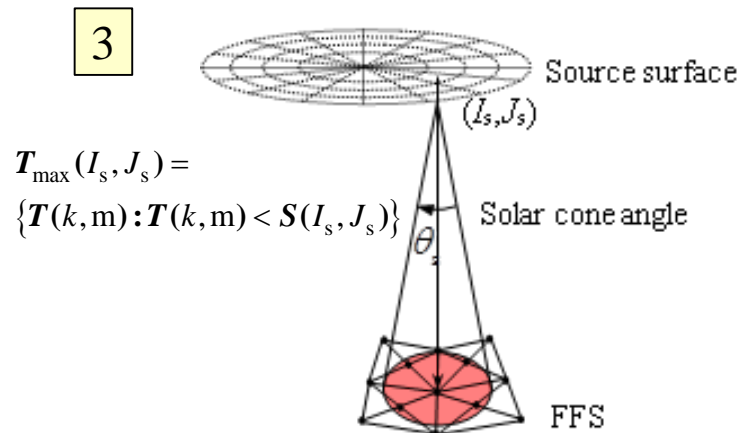
# Solution Procedure



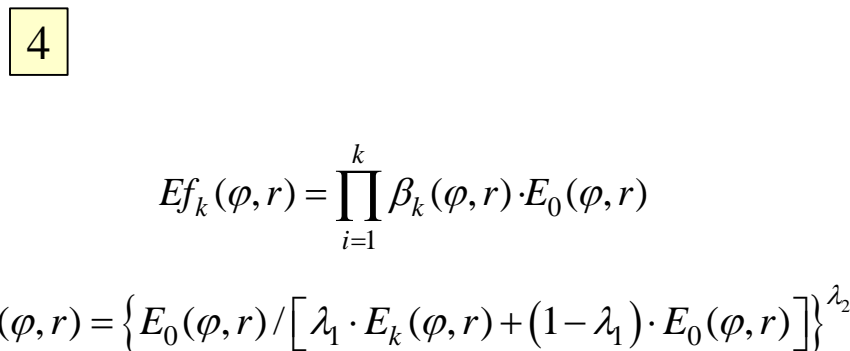
Source-target mapping



Geometric construction method



High speed MC ray tracing using solar cone constraint



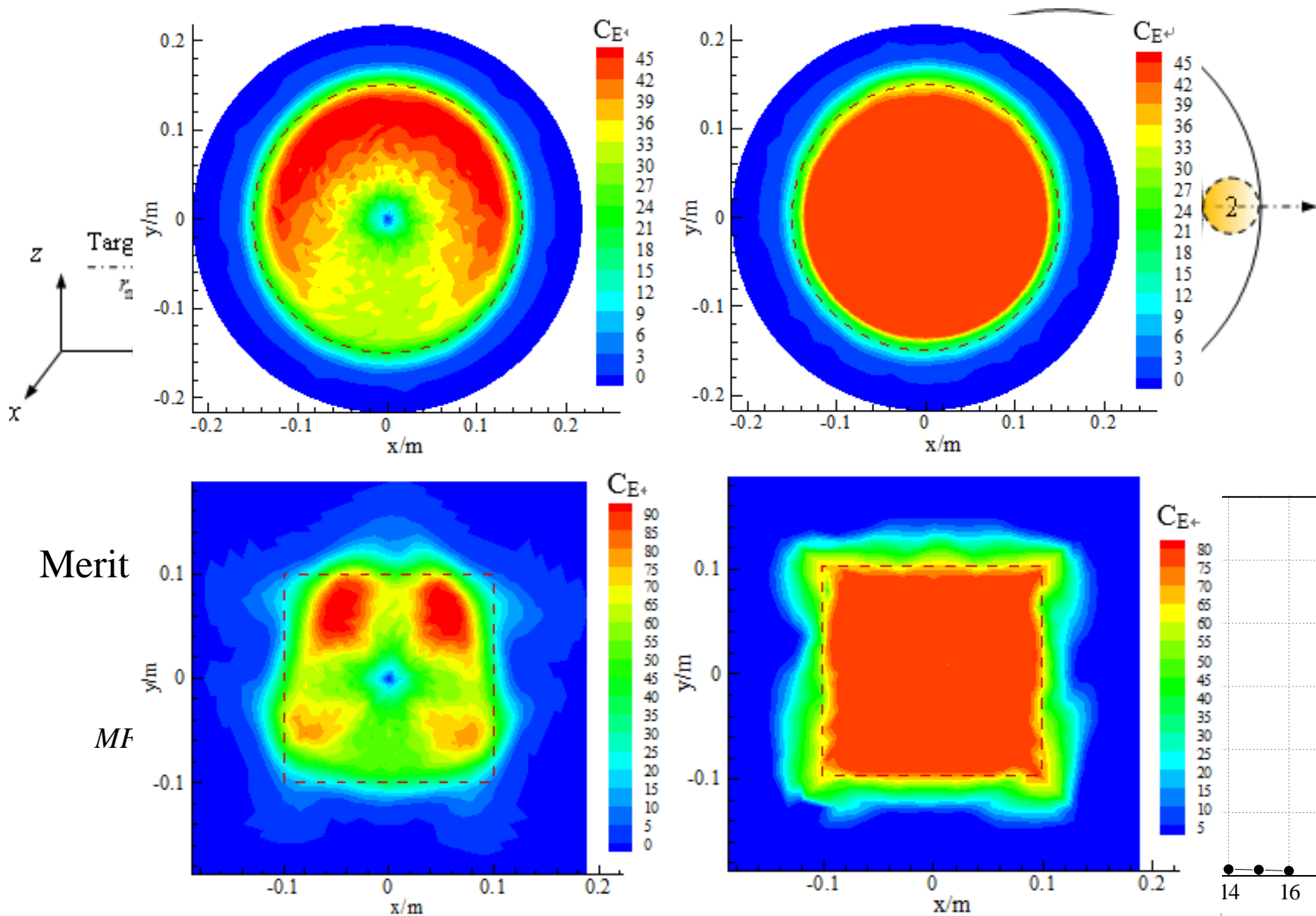
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$$E f_k(\varphi, r) = \prod_{i=1}^k \beta_k(\varphi, r) \cdot E_0(\varphi, r)$$

$$\beta_k(\varphi, r) = \left\{ E_0(\varphi, r) / \left[ \lambda_1 \cdot E_k(\varphi, r) + (1 - \lambda_1) \cdot E_0(\varphi, r) \right] \right\}^{\lambda_2}$$

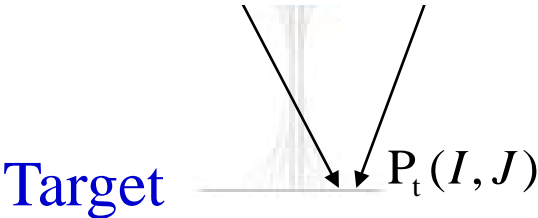
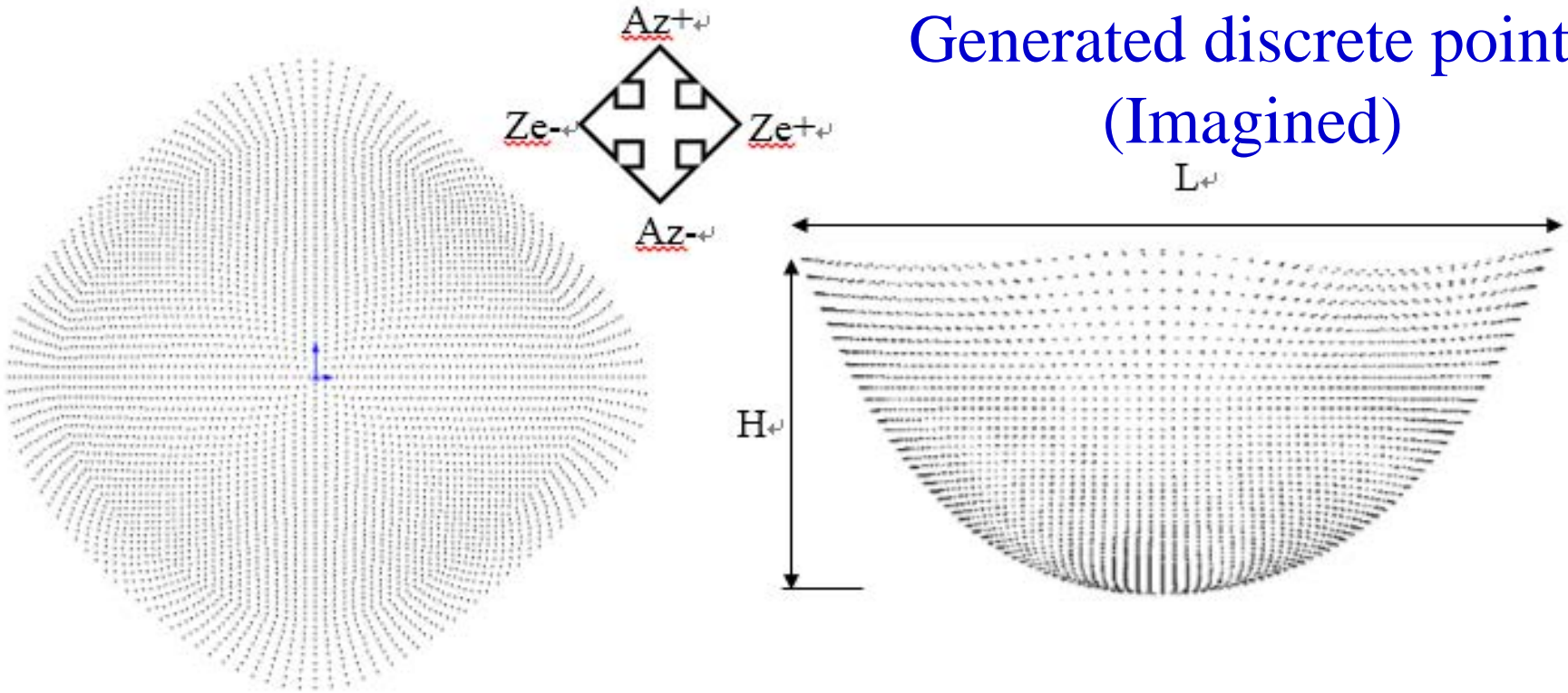
Feedback modification method

# 3-D example

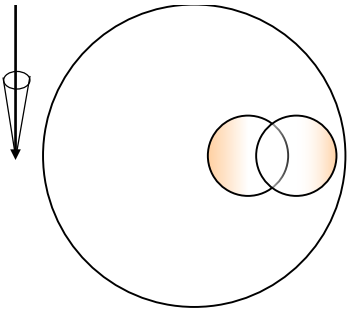




# Generated discrete points (Imagined)



cone angle  $16'$

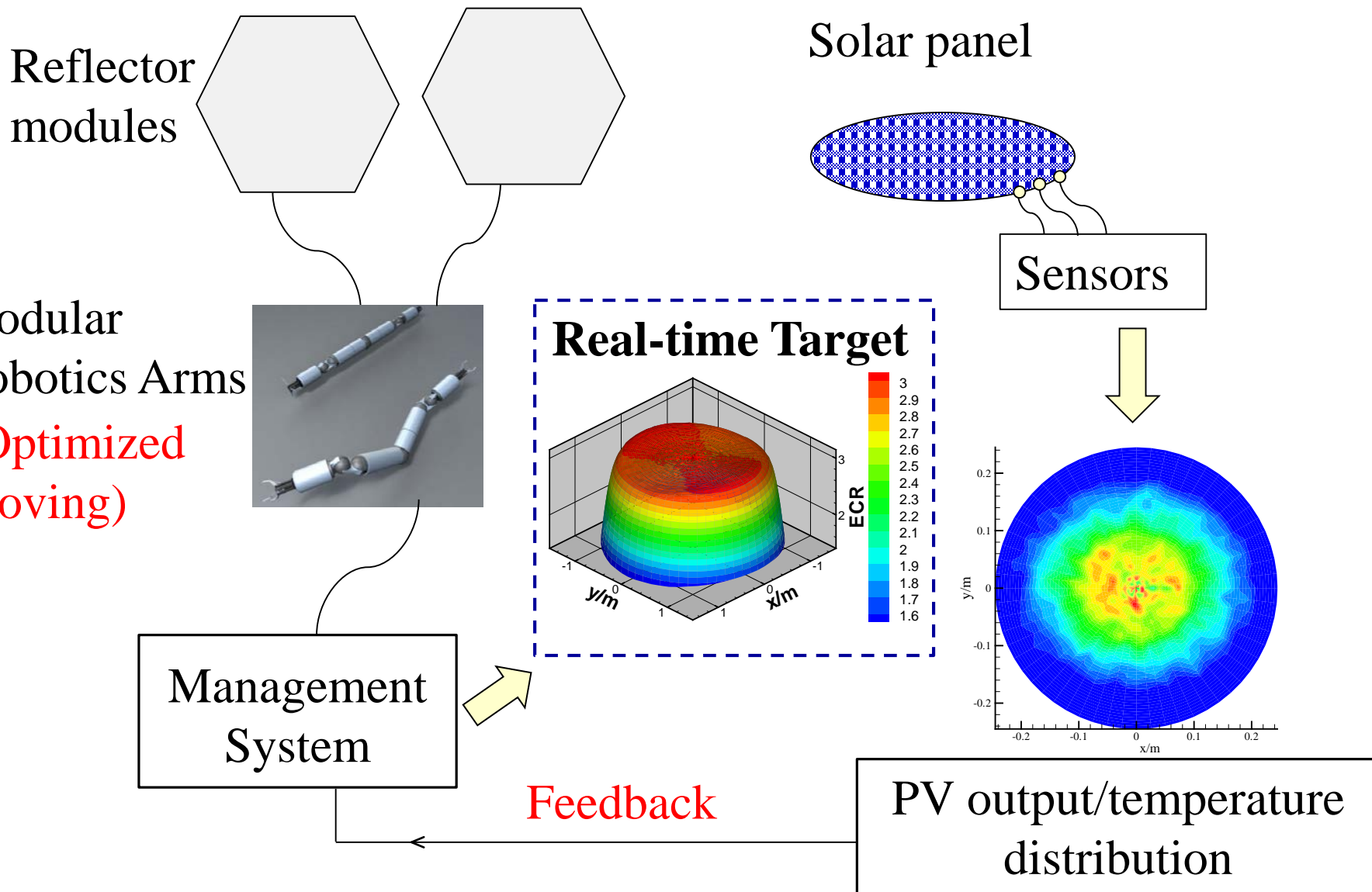


Overlap Effect  
(Point-Area mapping)

Multiple reflections  
& solutions

Different pattern for  
sun-tracking

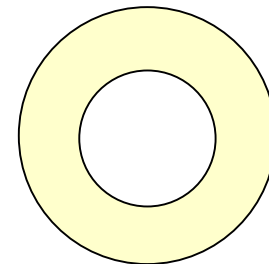
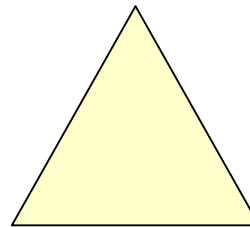
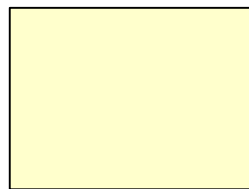
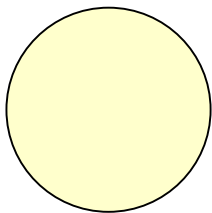
# Real-time Feedback Method





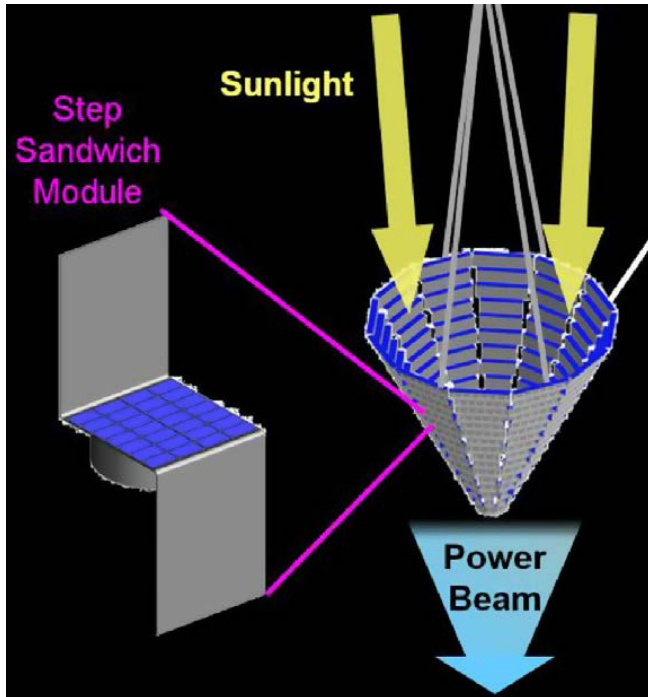
Based on real-time feedback modification method,  
SPS-ALPHA can have:

**Any heat flux & shape for target receiver at  
any time & any sun-tracking pattern:**

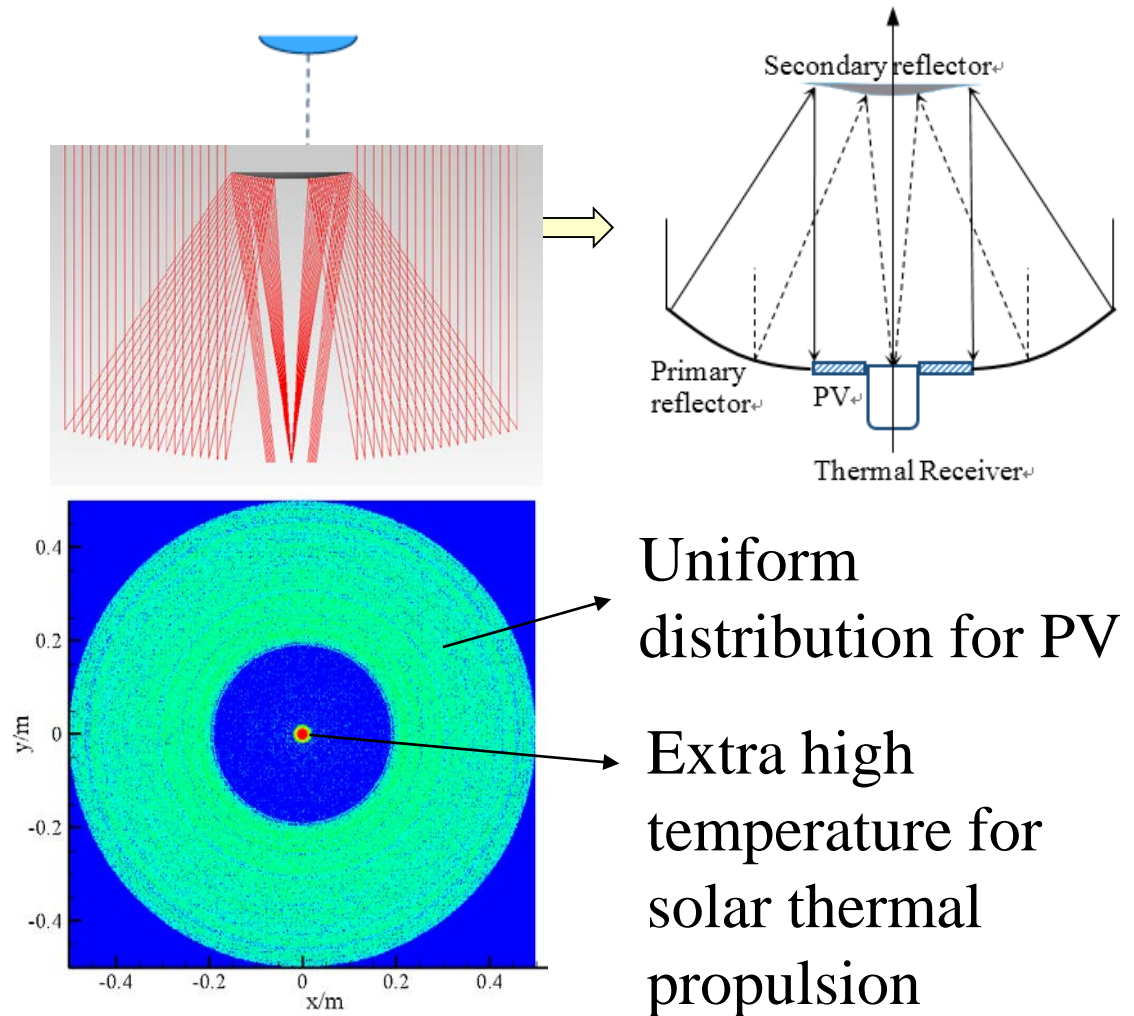


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# Receiving solar panel options



1. 3-D Step module concept (Paul Jaffe, US)



Uniform distribution for PV  
Extra high temperature for solar thermal propulsion

2. Hybrid PV/Thermal generation

## Vector based approach for the optical solution of SPS-ALPHA

- Source-target mapping considering **solar cone angle**
- Satisfy **arbitrary target** heat flux & shape
- Optimize between the **multiple solutions** for real-time sun-tracking condition
- Adjust intelligently & Moving fewer and smaller

**Thank you!**