西北工业大学
NORTHWESTERN POLYTECHNICAL UNIVERSITY

动力与能源学院
SCHOOL OF POWER AND ENERGY

SPACE SOLAR POWER INTERNATIONAL STUDENT COMPETITION FINAL

New optimization method for SPS-ALPHA Mark-Ⅱ based on improved ACO algorithm

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Northwestern Polytechnic University (China)

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Contents

Contents

New optimization method for SPS-ALPHA Mark-Ⅱ based on improved ACO algorithm
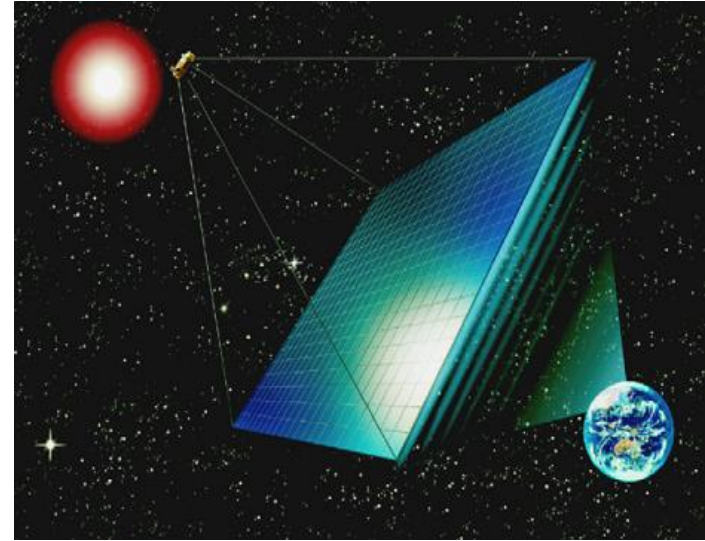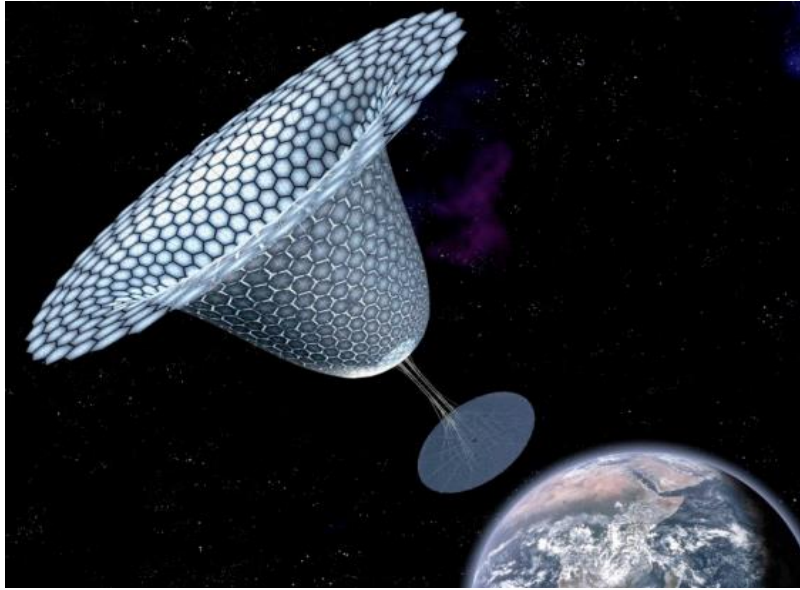
Background

Solar power on earth

- Atmospheric attenuation
- Large number of energy storage equipment
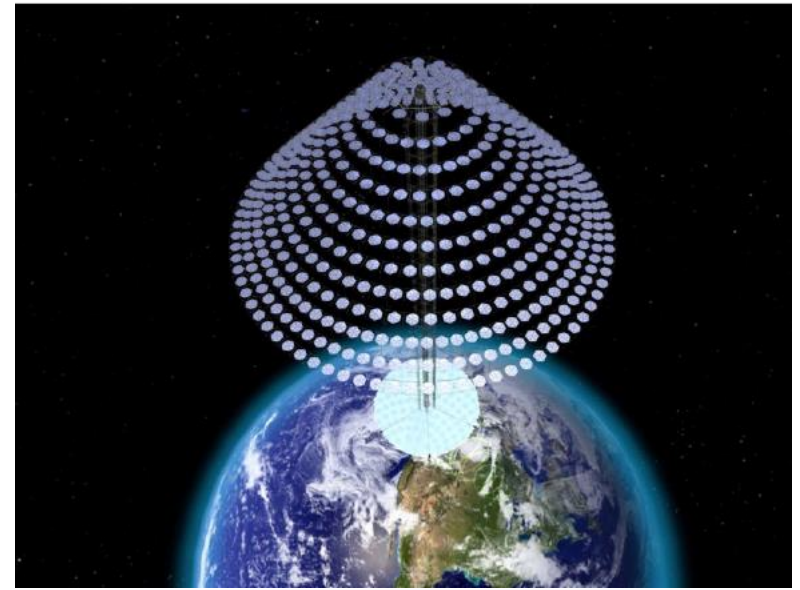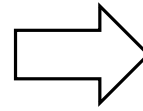- Take up a lot of cultivated land

Space solar power

- Working 24h & 365d
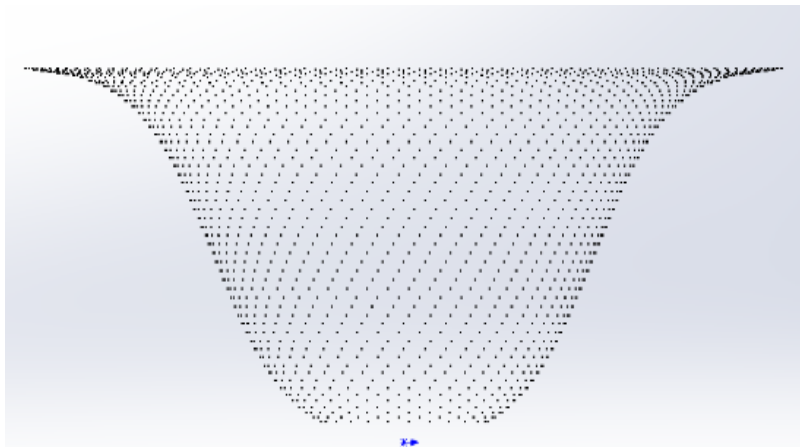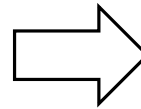- Higher transmission efficiency
- CPV type – Simple & Light
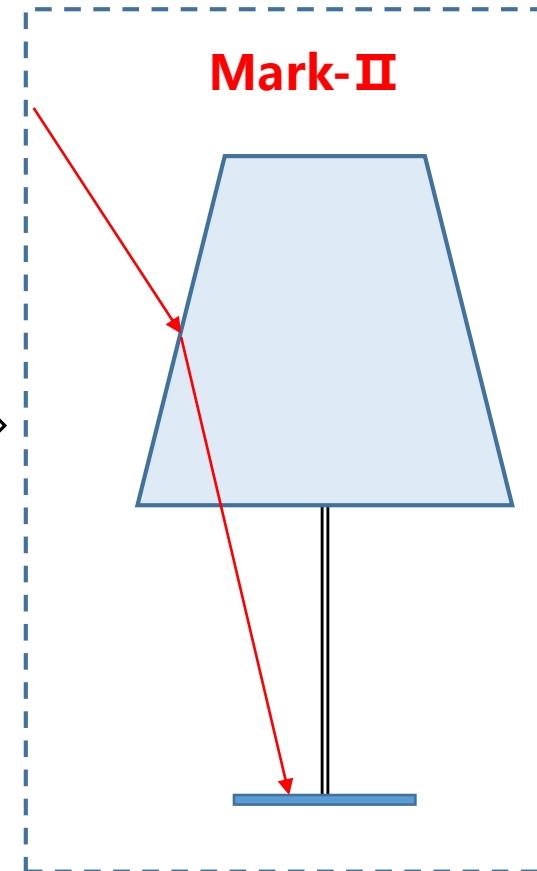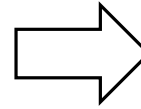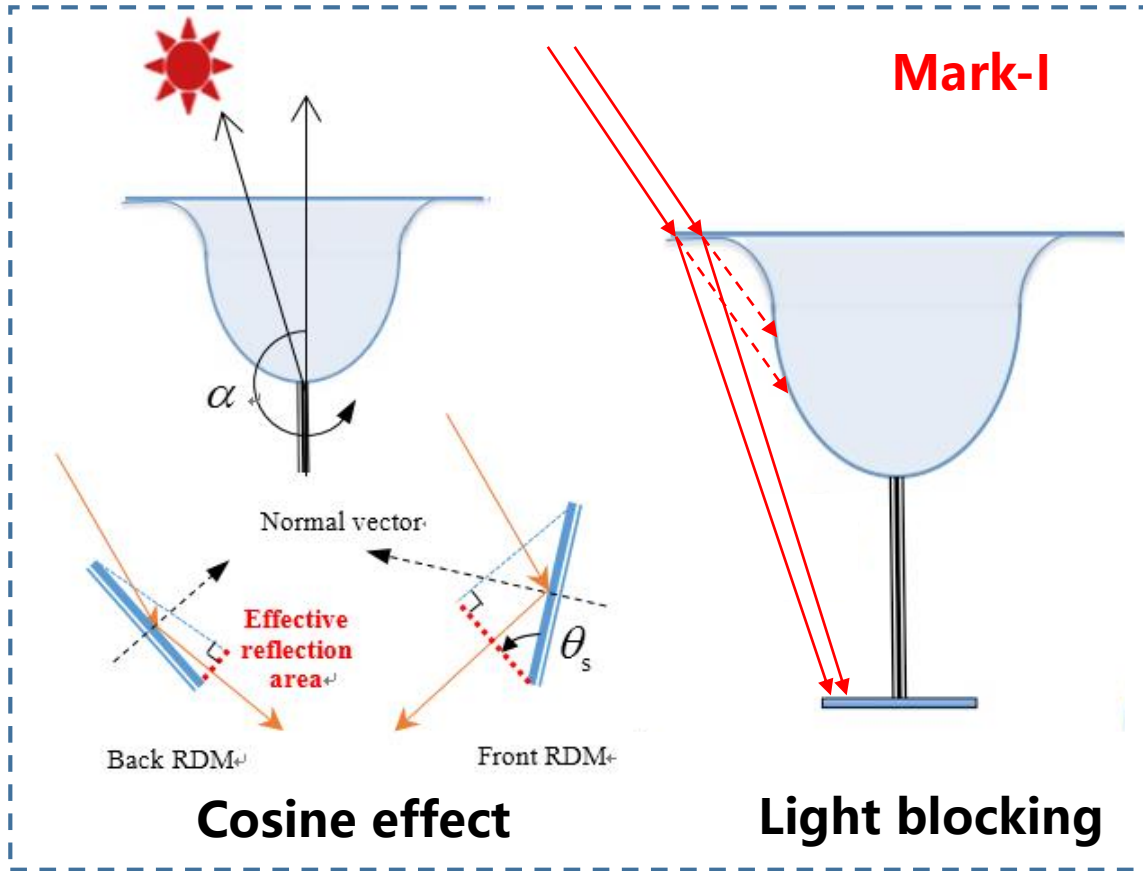
Background

SPS-ALPHA Mark-I

SPS-ALPHA Mark-Ⅱ

Based on sigmoid curve

Based on Stepped Cylinders

Background

Mark-I

α

Normal vector

Effective reflection area

θ_s

Back RDM

Front RDM

Cosine effect

Light blocking

Mark-II

◆ **Independent modules**

◆ **Better control of optical transmission**

◆ **Decrease light block/cosine effect**

Contents

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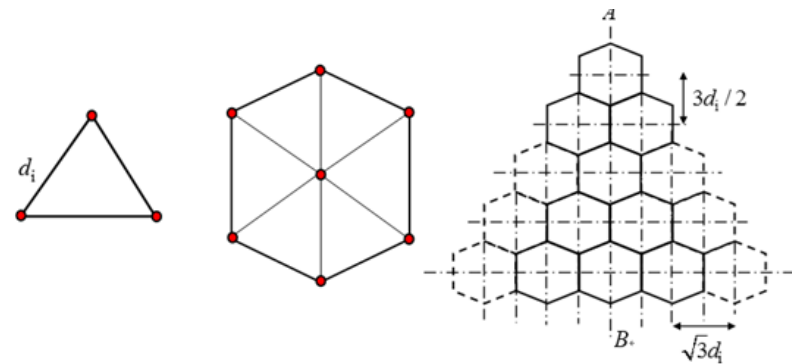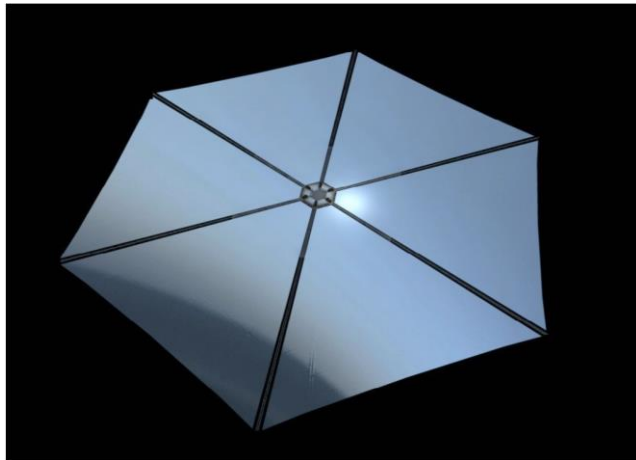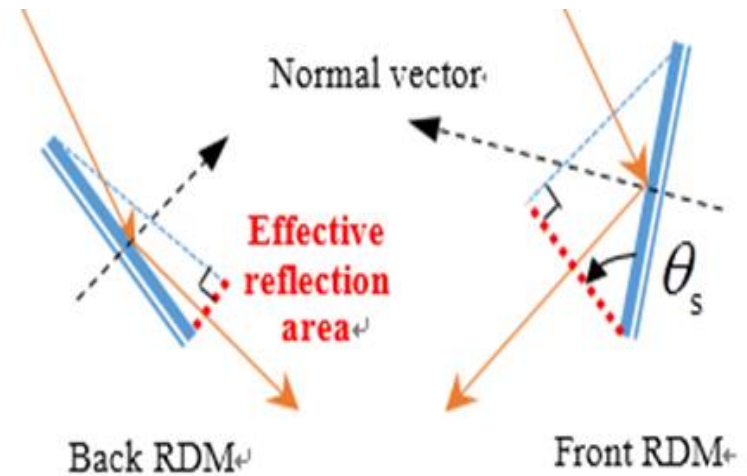
Challenges

Ideal Optical Performance for SPS:

➢ High optical efficiency for real time 3-D tracking

➢ High heat flux uniformity on solar panel

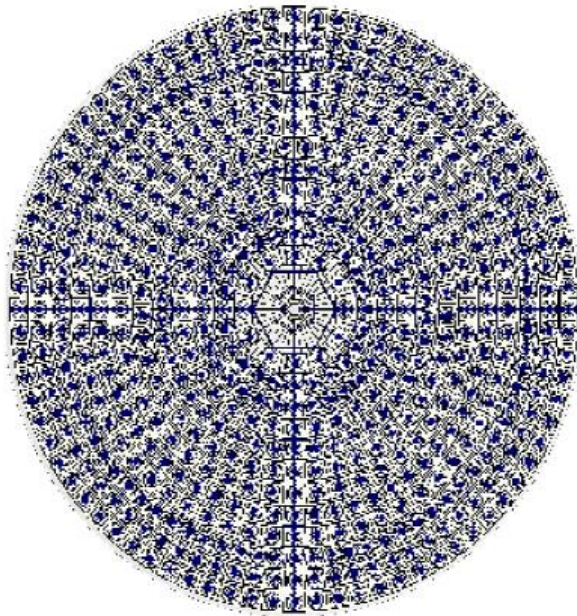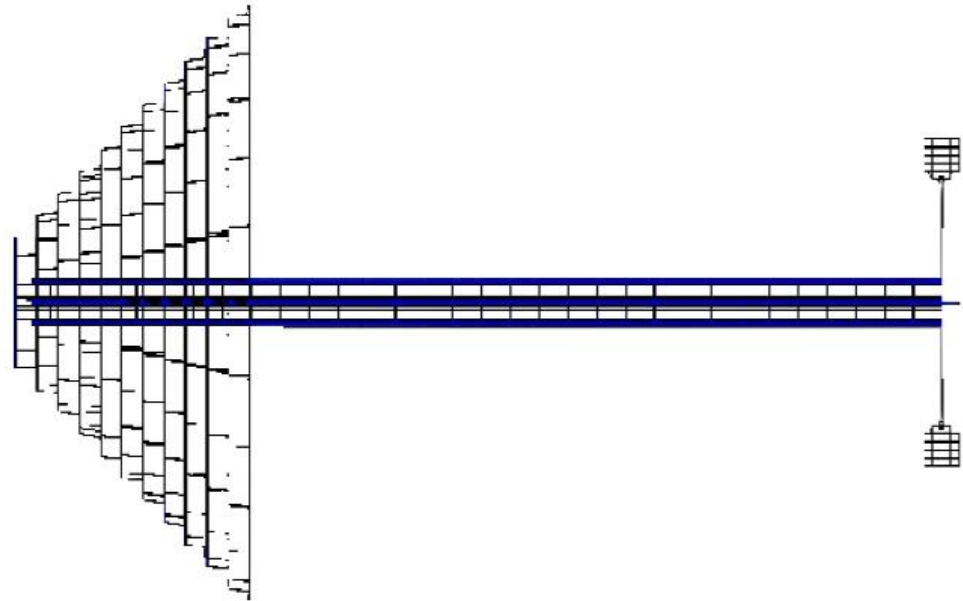➢ Stable solar concentration & safety

Sunlight

Multi-Bandgap PV

Reflected Sunlight

Low-Intensity Microwave Transmission

(Mic
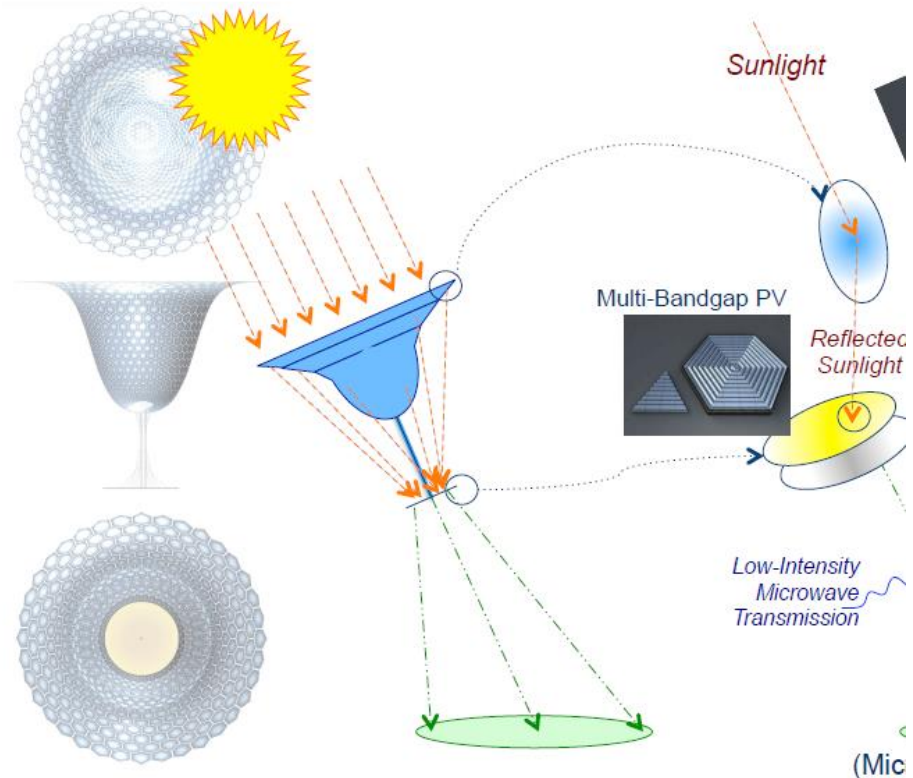
Challenges

➢ Optical efficiency:
Dependent on the cosine angle of every facets.

➢ Heat flux uniformity:
Tradeoff with optical efficiency

Normal vector

Effective reflection area

θ_s

Back RDM

Front RDM

d_i

$3d_i/2$

$\sqrt{3}d_i$

A

B

Challenges

TOP VIEW   SIDE VIEW

◆ **Too many reflectors: Several 1000s of thin film heliostats**

Number of heliostats   Number of Trials:

Solution Space: $|S| = n_Z^{n_H}$ $(5 \times 5)^{1000s}$

Number of aim points

Contents
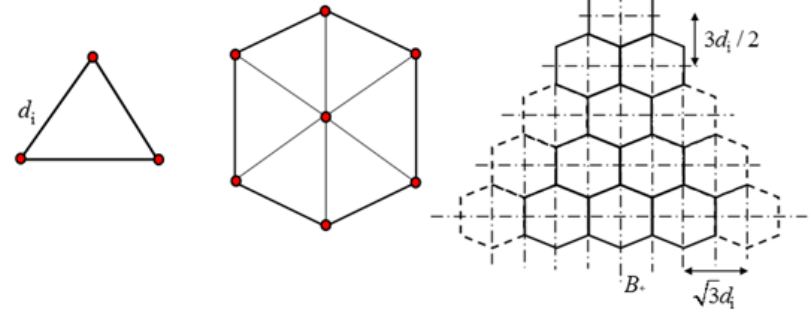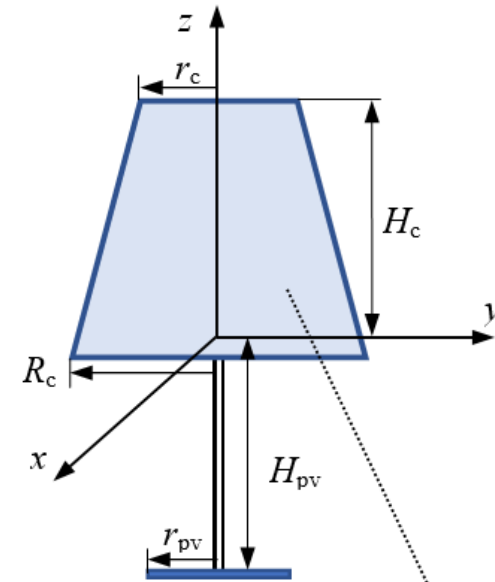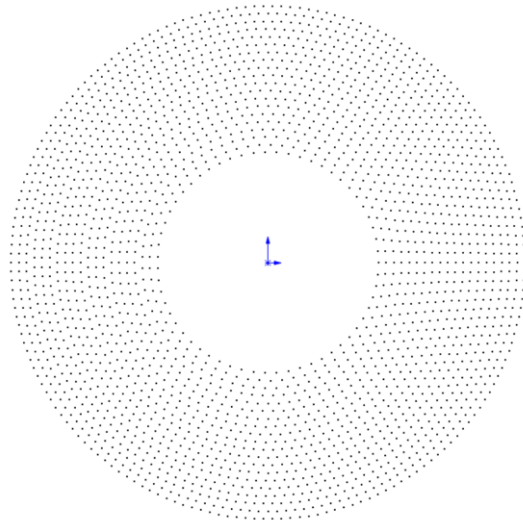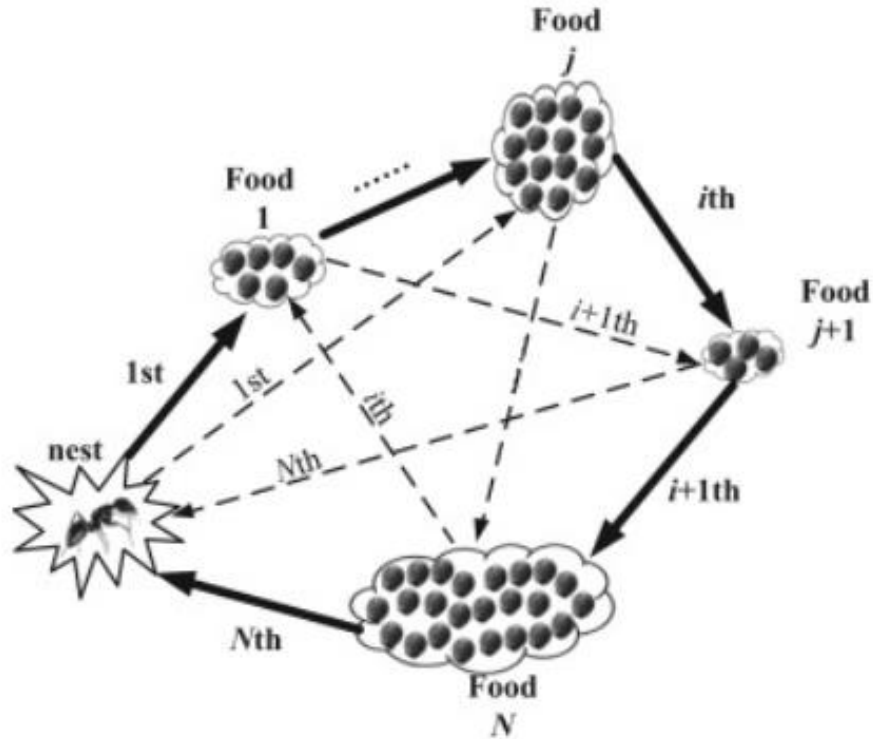
Modelling method

The solar will be reflected by the mirrors from upside.

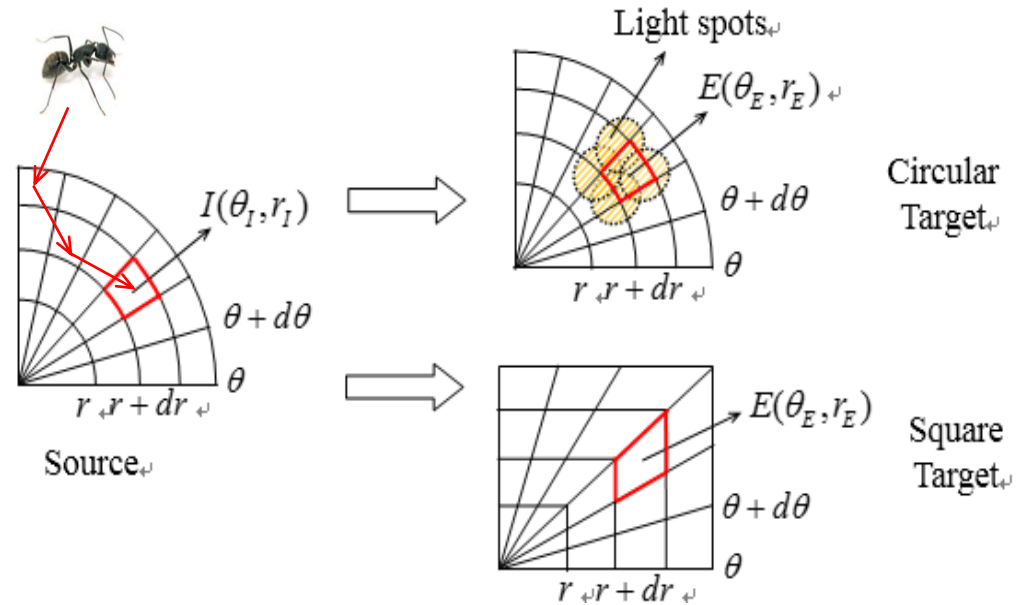Reach on the solar panel on the bottom.

Modelling method

Ant Colony Optimization (ACO) algorithm

◆ Ants could always find the shortest path

◆ Ants deposit pheromone, an evaporable material, on the path they passed

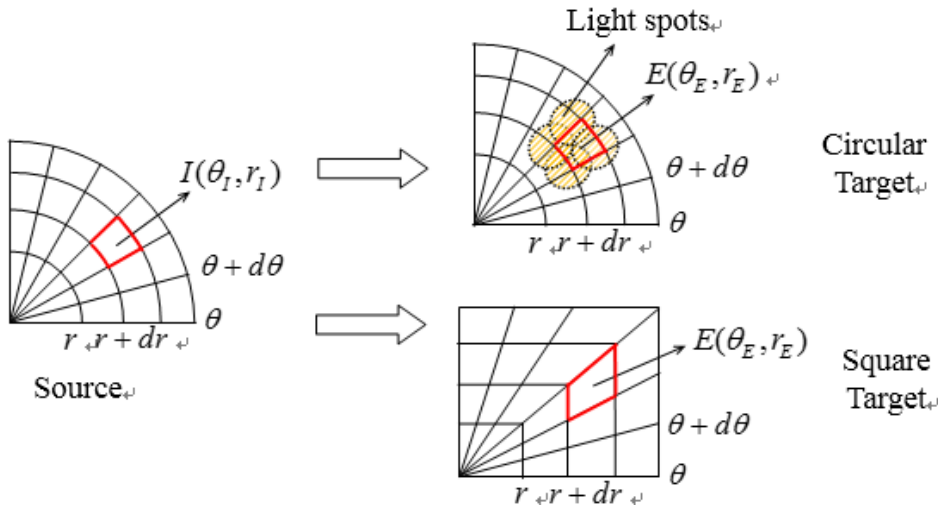◆ Ants tend to select the path with higher pheromone value

Modelling method

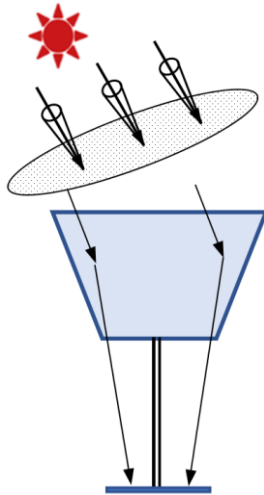**Tradeoff**
- Optical efficiency
- Uniformity

Current model:

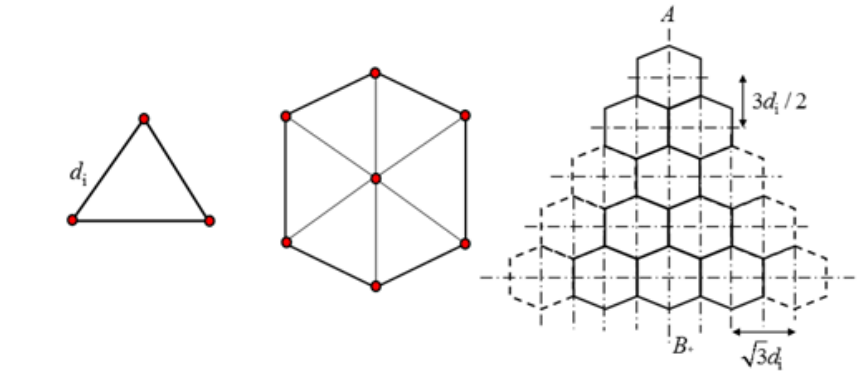**Source-target mapping**
ACO algorithm
Feedback simulation

Modelling method

$$\left(\theta_E, r_E\right) = \left(\theta_I, g\left(\theta_I, r_I\right)\right)$$

Source-target mapping

Geometrical modelling & Surface generation
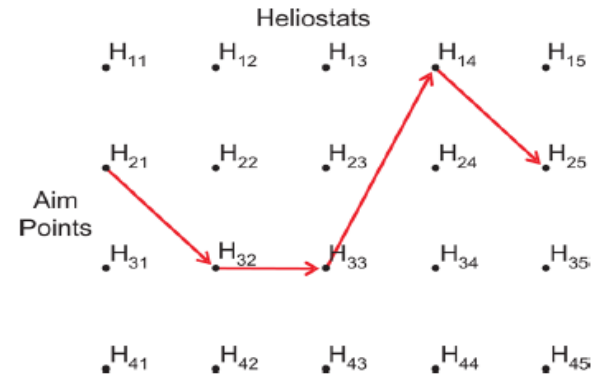
Monte-Carlo ray tracing

ACO algorithm

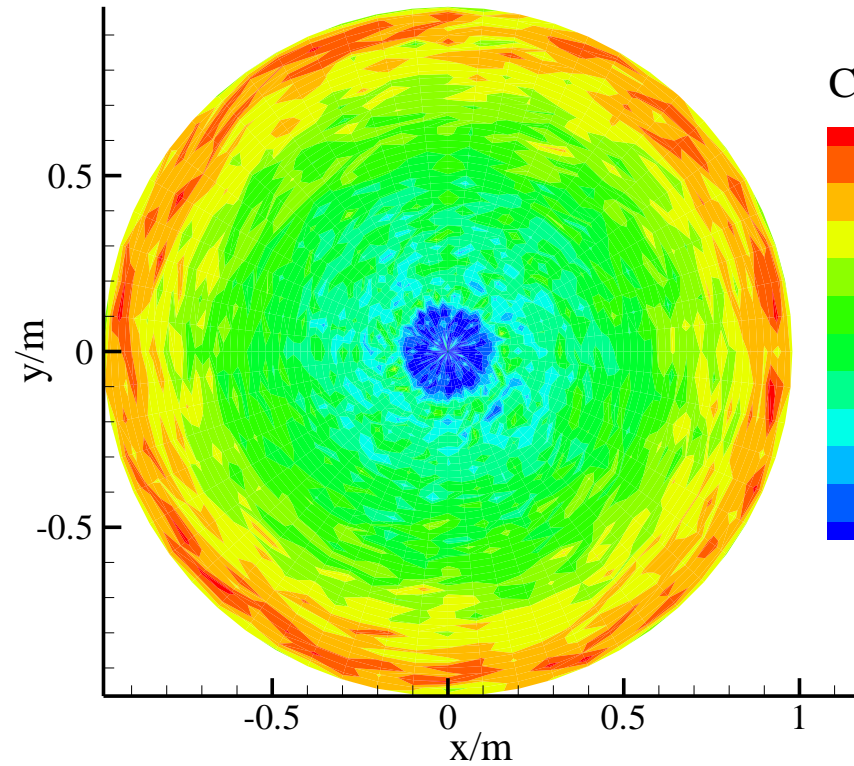# Contents
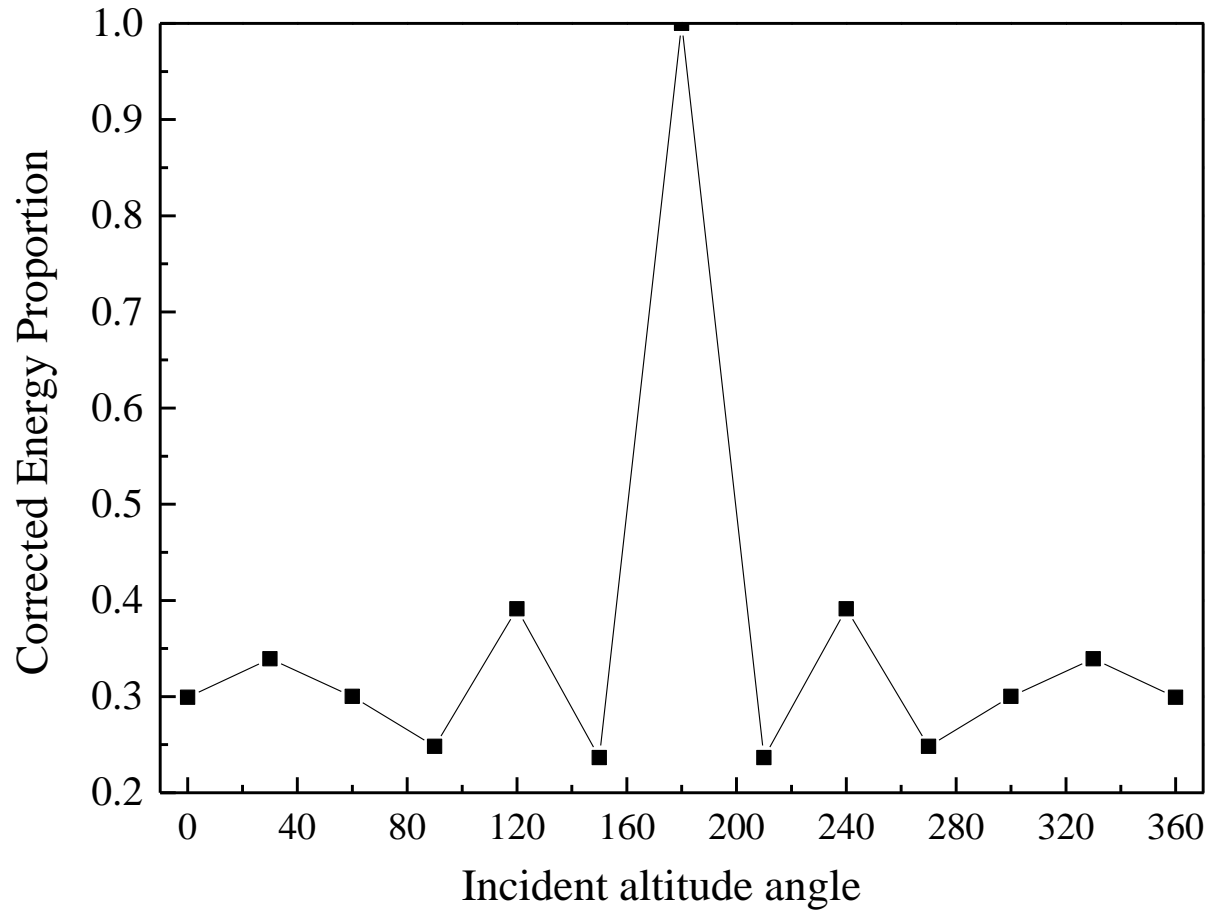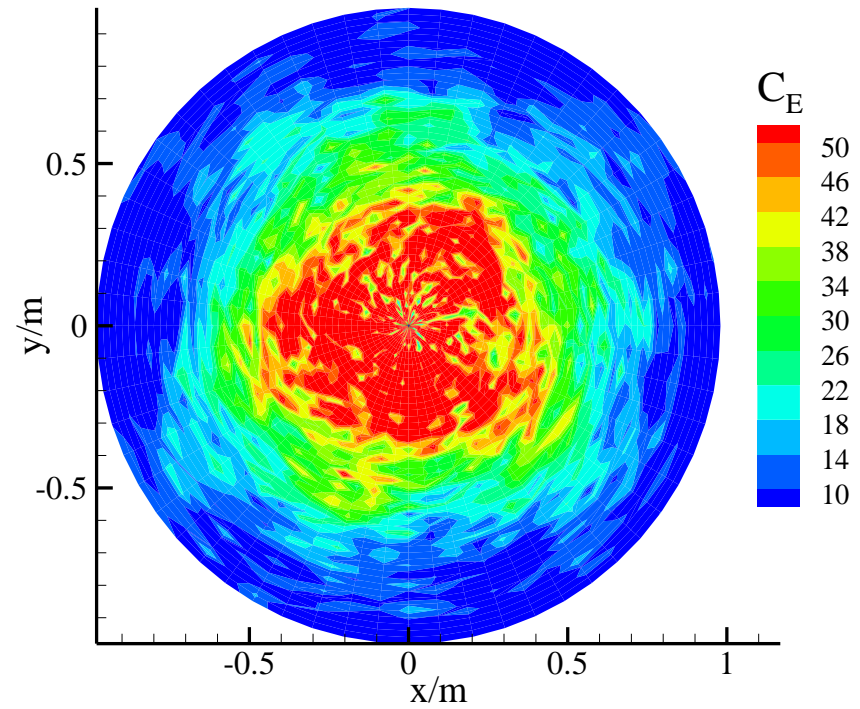
Results Analysis

Corrected energy proportion at different incident angles
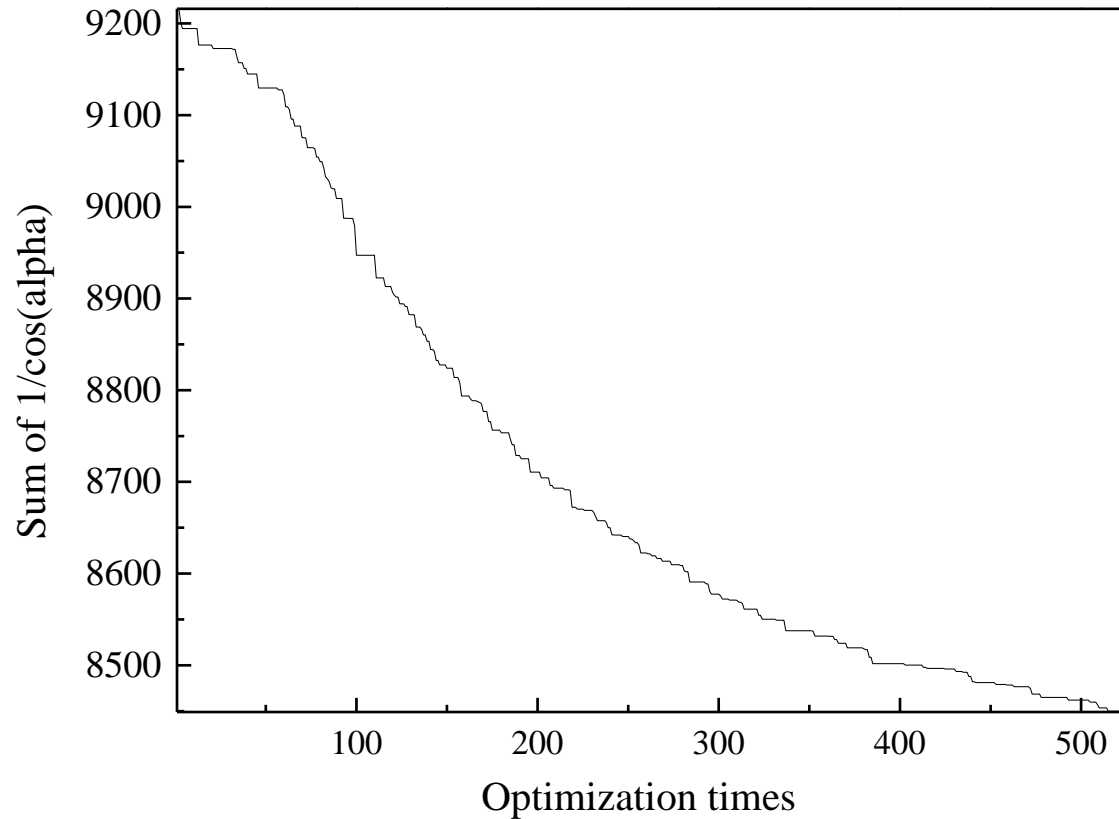
Results Analysis

Before optimizations

After ACO optimizations

Results Analysis

ACO optimization efficiency for
2368 source by 2368 target grids mapping

Conclusion

◆ The proposed model intend to solve the tradeoff between Optical efficiency & Heat flux uniformity

◆ Based on source-target mapping and ACO, considered Cosine effect, light blocking, solar cone angle...

◆ The optical efficiency is improved to **3.26** times at relative uniform distribution

Thank you!

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