# A Low-Cost Heliostat Design

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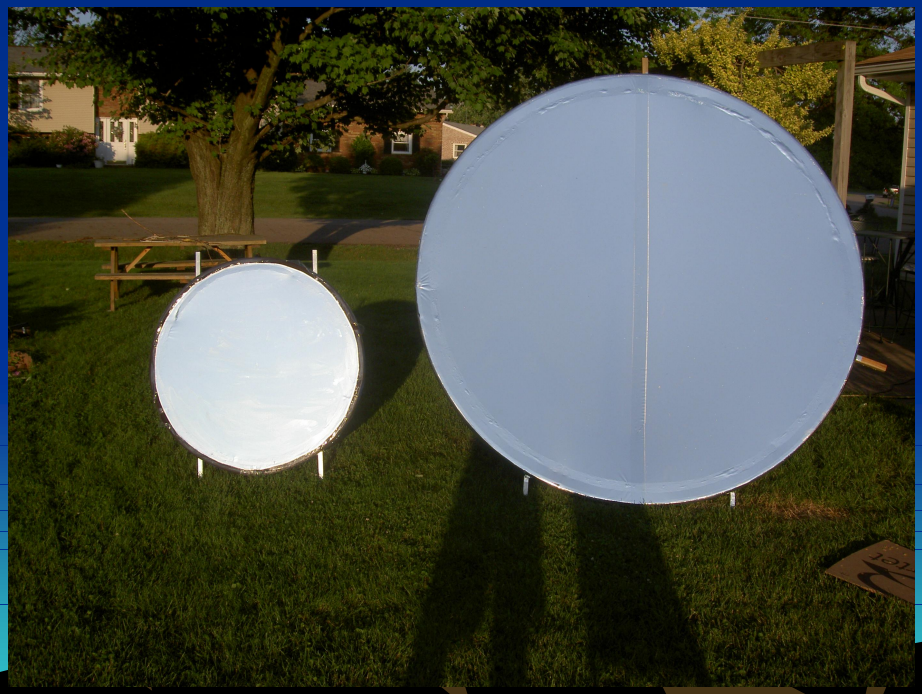
A Better Focus Co.



# Solar Cooking Perspective

# Problems

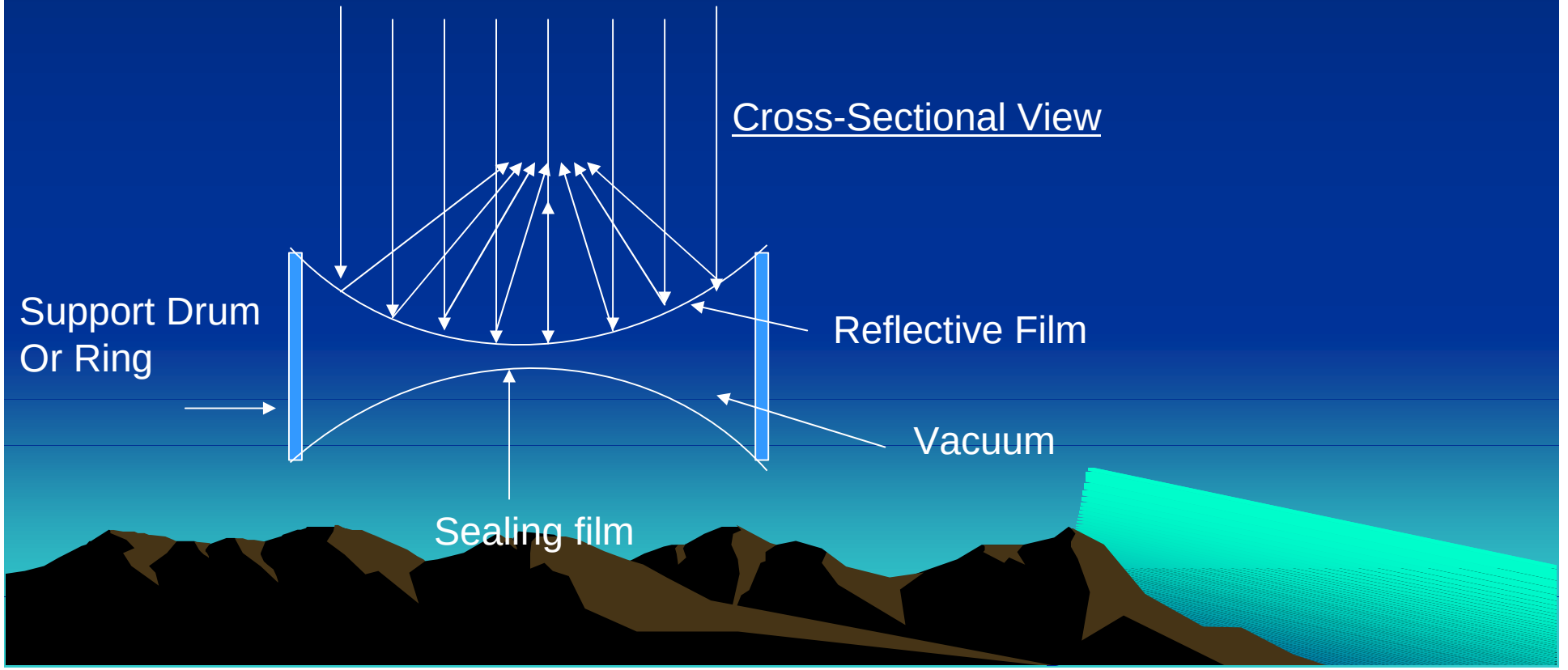
- Solar energy is plentiful, but very diffuse
- Concentrating systems provide higher energy levels for wider applications
  - Traditional Rankin Steam Cycles
  - Sterling and Other Heat Engines
  - Concentrating Photovoltaics
  - Air Conditioning

# Problems

- Increasing energy costs make all solar applications more viable
- But-- there is still a significant cost differential between delivered solar energy, and traditional sources
- We must close this cost gap in order for solar technology to gain widespread acceptance

# Heliostat Development Goals

- Achieve “best cost” design for a concentrating heliostat
- Progression
  - Stretched membranes possibly offer the lowest cost method of reflecting sunlight

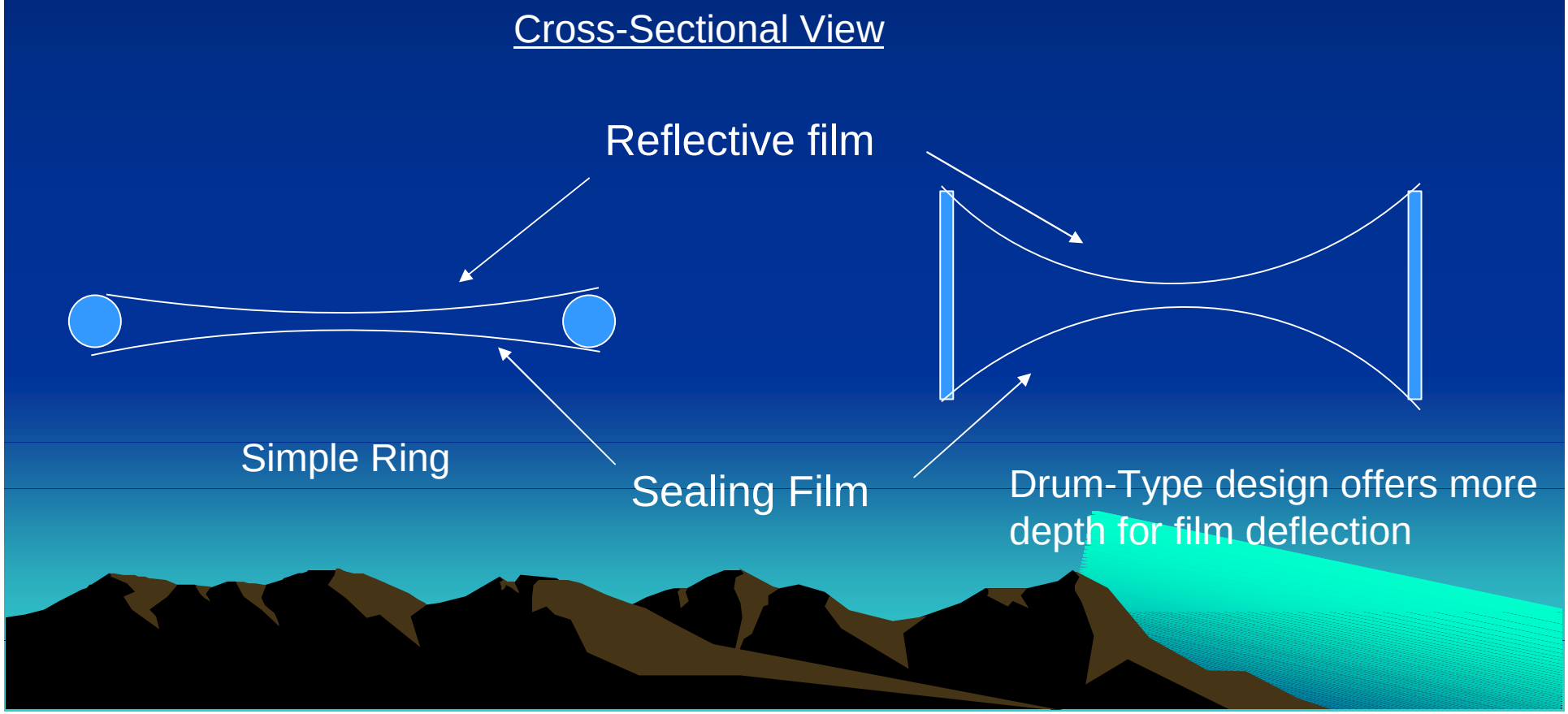


# Heliostat Development Goals

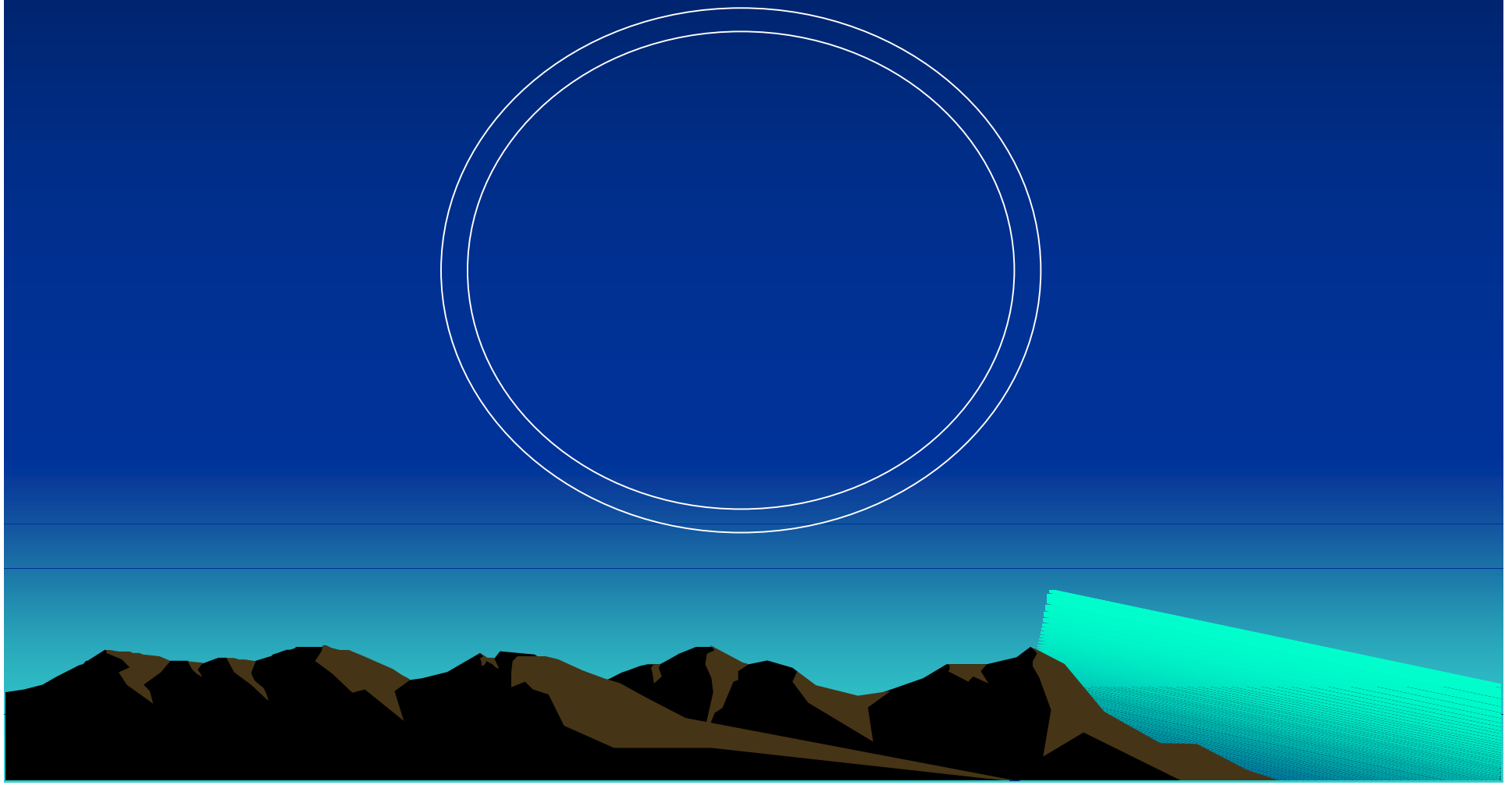
- Stretched membranes are not new,
  - First patents for solar applications date back to 1962
  - Many others have moved the art forward, but there have been problems
    - Expensive and heavy support structures
    - Wrinkling of film
    - Thermal stability
    - Vacuum overhead
    - Scaling
    - Cost
    - Weather ability
      - UV, rain, wind, abrasion resistance
      - Catastrophic Wind and Hail Events

# Heliostat Design Elements

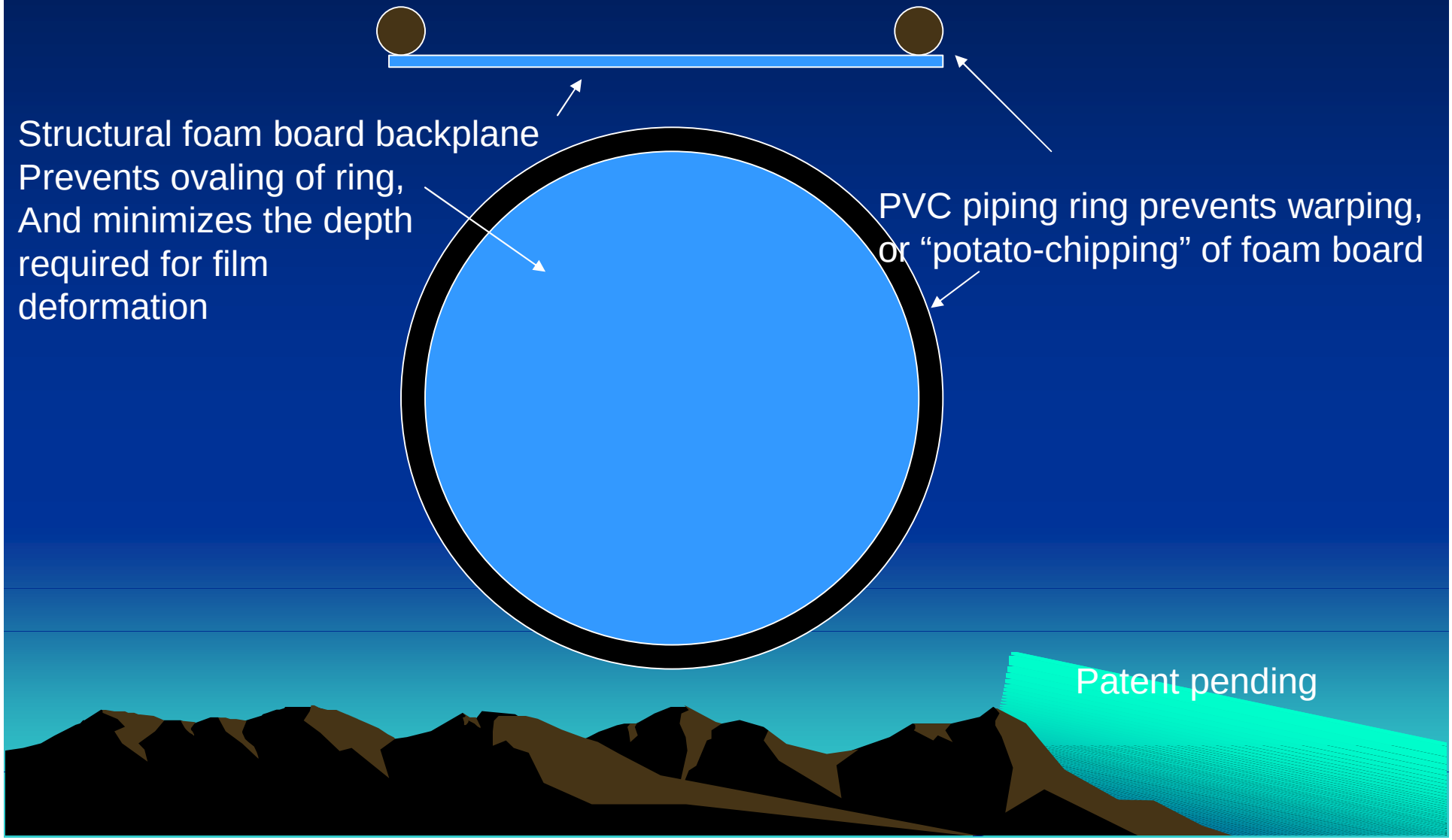
– Frame- providing
  - a raised planar surface for the attachment of the film
  - clearance for vacuum deformation



# Problem- simple ring or drum tends to oval under load, or it’s own weight



# Design Solution- Structural Foam Board Backplane



# Design Solution- Structural Foam Board Backplane

With Application of vacuum,  the structural foam board backplane becomes slightly concave, increasing The strength of the total assembly

Patent pending

# Design Elements

- Expensive and heavy support structures
- Wrinkling of film
- Thermal stability
- Vacuum overhead
- Scaling
- Cost
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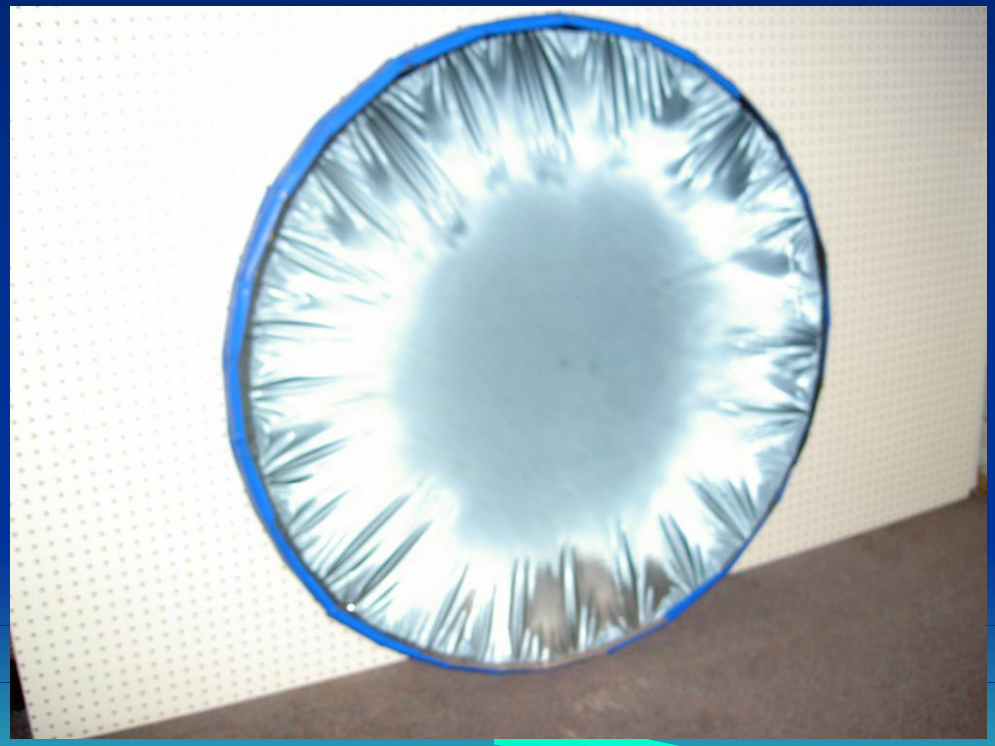
# Heliostat Design Elements

- Film Wrinkling
  - Reflective film tends to wrinkle badly as the vacuum deforms it into a concave shape



# Heliostat Design Elements

- Film Wrinkling
  - Solution is a floating batten that stops the inward propagation of the wrinkles.

* Batten depicted on the outer surface of the film for clarity

Dish with floating battens attached to the inner surface of the reflective film.

Patent pending

# Heliostat Design Elements

- Expensive and heavy support structures
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  - UV, rain, wind, abrasion resistance
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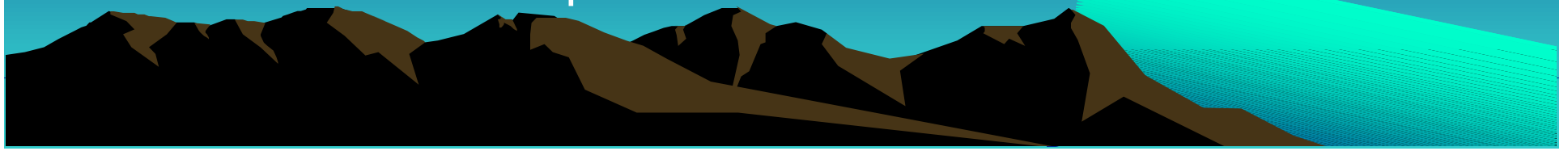
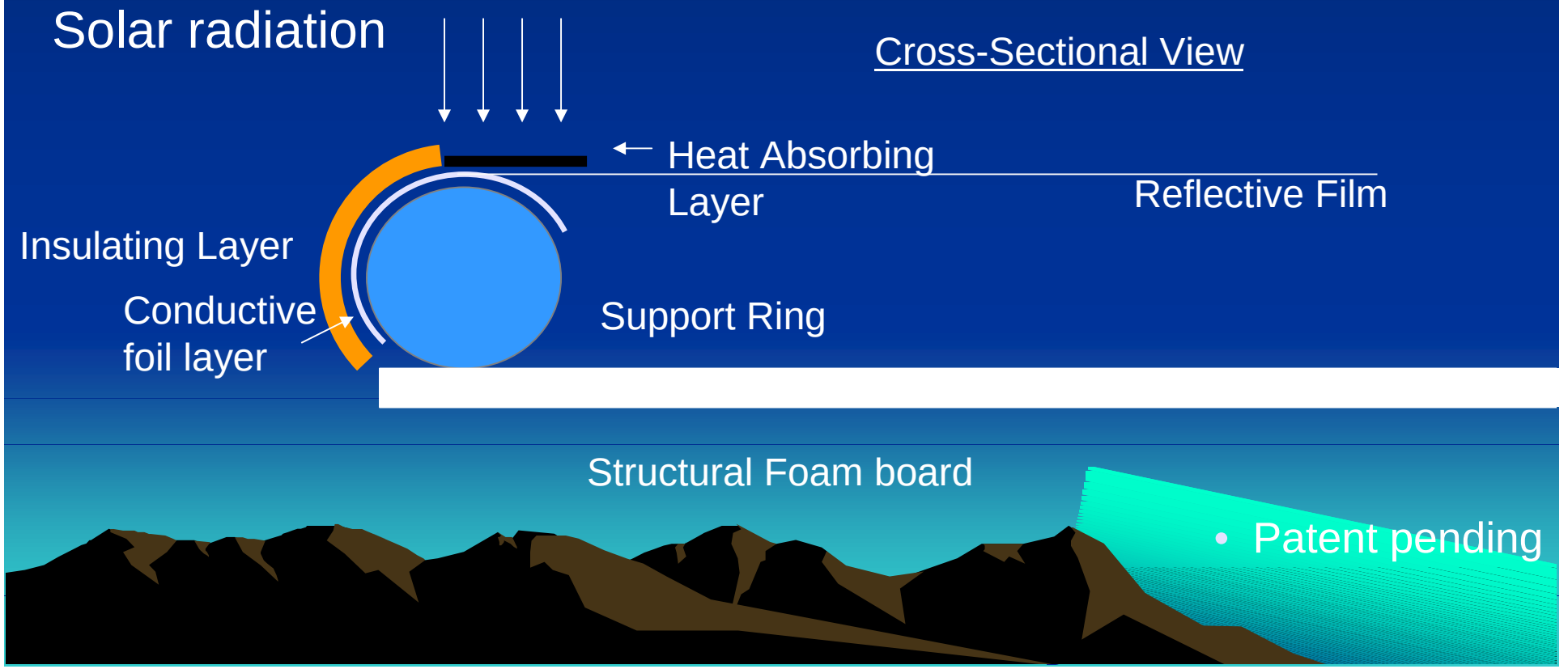


# Heliostat Design Elements

- Thermal Stability
  - Reflective film has a different coefficient of expansion than the supporting ring.
  - Film gets loose when exposed to temperatures lower than those at which it was stretched.

# Heliostat Design Elements

- Thermal Stability
  - Solution is solar heating of the support ring
  - Since a heliostat is intended to always face the sun, this heating is always at work



# Heliostat Design Elements

- Thermal Stability
  - 26 degree F ambient temp.
  - RH dish w/o solar tensioning
  - LH dish with solar tensioning

*Solar tensioning works only with sunlight

- Patent pending

# Heliostat Design Elements

- Expensive and heavy support structures
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- Vacuum overhead
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# Heliostat Design Elements

- Vacuum Overhead
  - Stretched membrane systems require a vacuum to focus light
  - Energy required to establish and maintain a vacuum must be subtracted from the total energy generated
  - Leakage rates average 1 foot loss of focal length per 30 minutes
  - No measurements of vacuum pump energy requirements have been taken, however
- One advantage of vacuum systems is once the vacuum is released, the dish returns to a safe flat mirror state

# Heliostat Design Elements

- Expensive and heavy support structures
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- Vacuum Overhead
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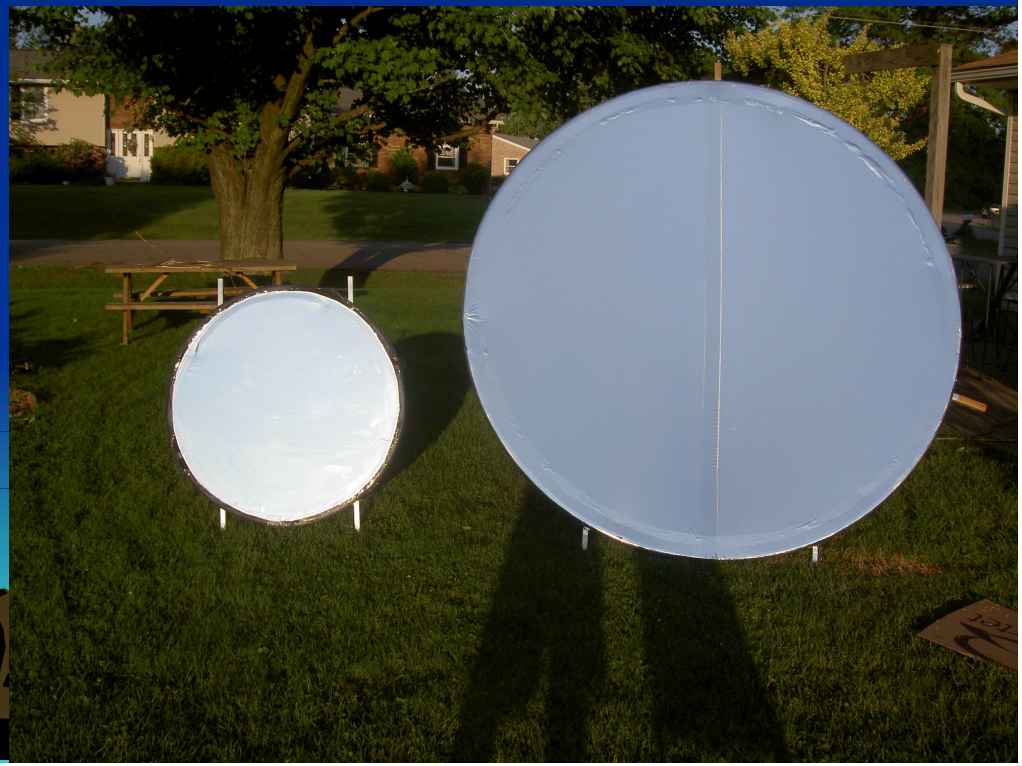
# Heliostat Design Elements

- Scaling
  - 4’ diameter dishes are currently manufactured in low volumes.
  - 8’ diameter prototype is in testing
  - 10’ diameter is feasible.

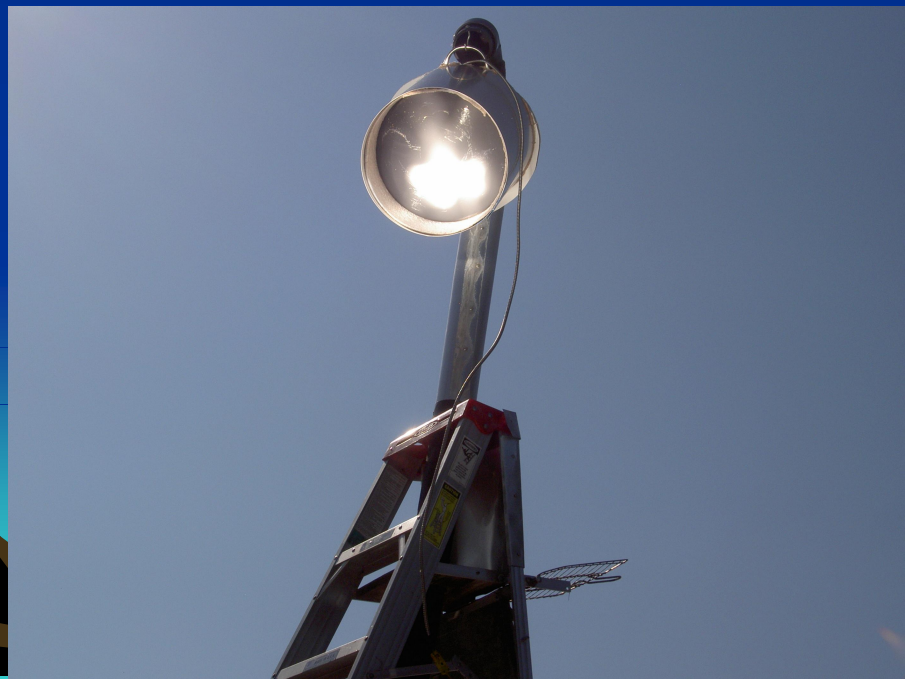


# Performance

- Performance of 8’ diameter dish
  - 1250 F maximum temperature
    @ 850 W/M$^2$ Solar Insolution

# Performance

- Receiver Test Rig
  - Heating water in Insulated pot
  - Type K  Thermocouple
  - Daystar meter



# Performance

- ASHRAE Standard x580
- $W=(T_f-T_i)MC_v/S$, where

  W= Watts

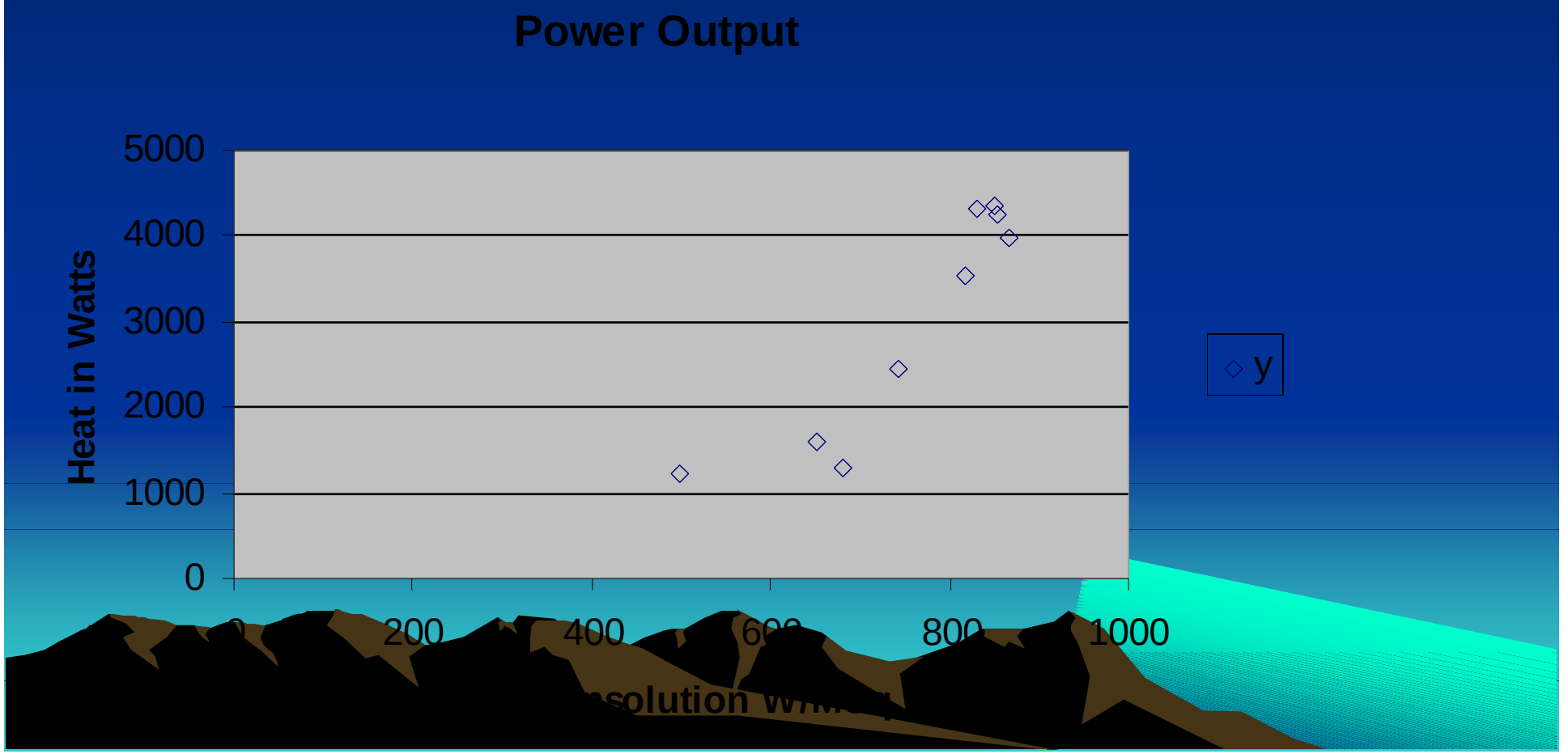
  $T_f$= Final Temperature

  $T_i$= Initial Temperature

  M= Mass of Water + Mass of pot

  $C_v$- Specific heat of water and pot

  S= Seconds



# Heliostat Design Elements

- Expensive and heavy support structures
- Wrinkling of film
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# Heliostat Design Elements

- Material Cost
  - 4’ diameter dishes are currently manufactured in low volumes
  - Material cost is  $ 24/$M^2$
  - 8’ diameter prototype material cost is $35/$M^2$
- Labor hours are currently very high, but the design is suitable for high-volume manufacture
  - Powered rotary fixtures
  - Combining multiple operations in each revolution
- Weather able film will increase material cost significantly

# Heliostat Design Elements

- Expensive and heavy support structures
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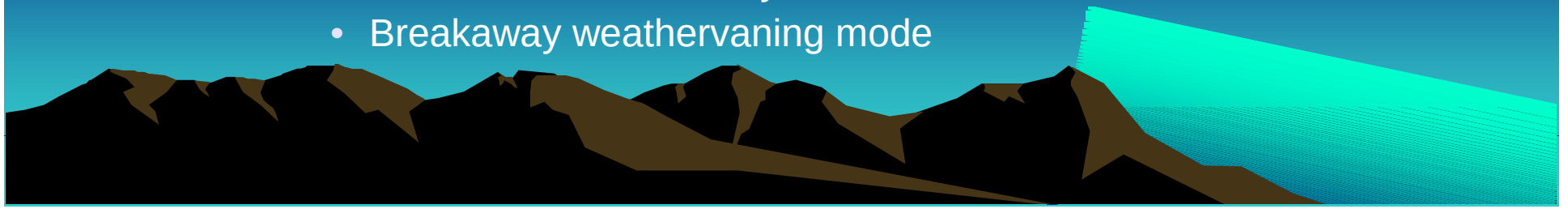
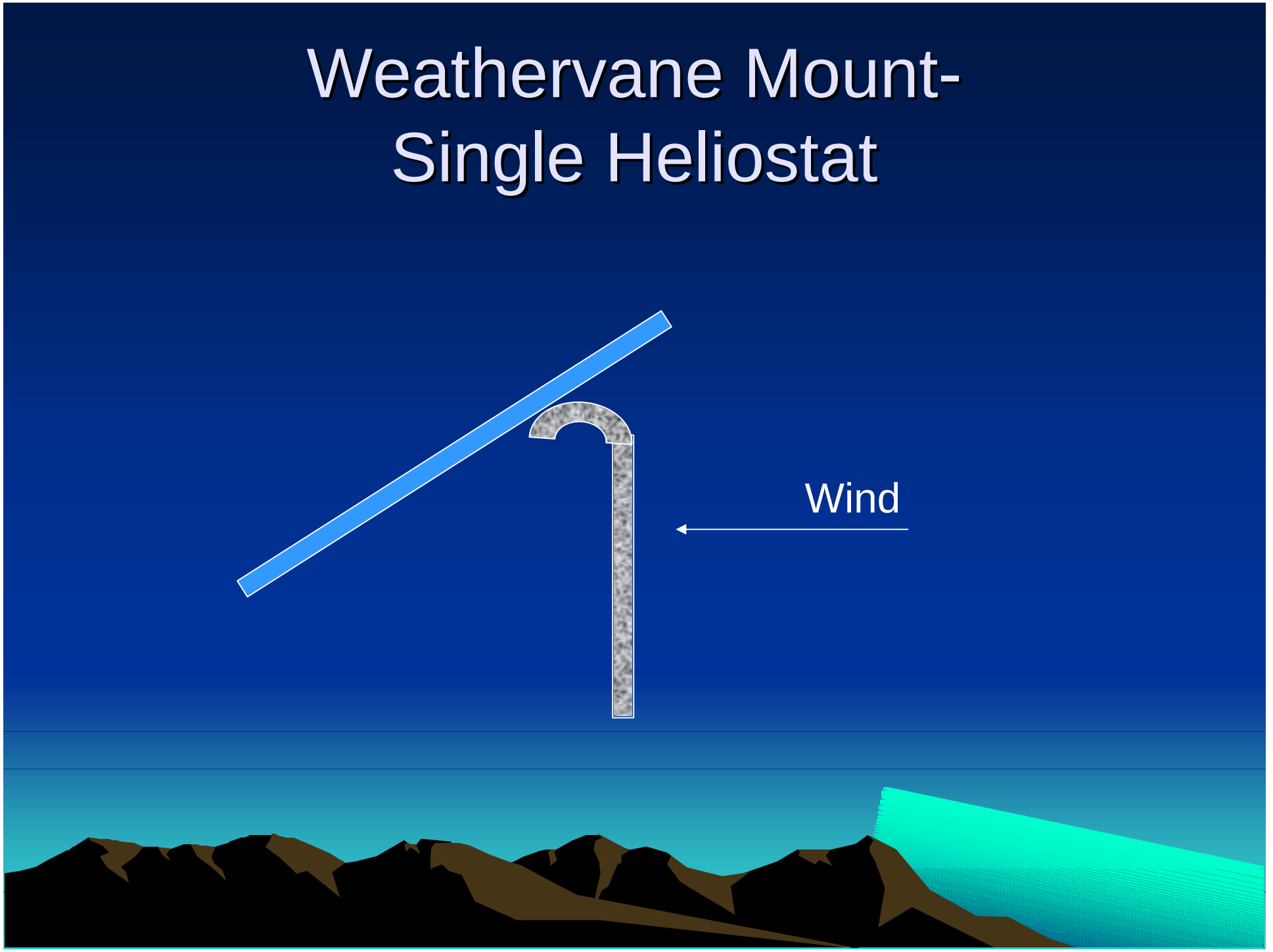
# Heliostat Design Elements

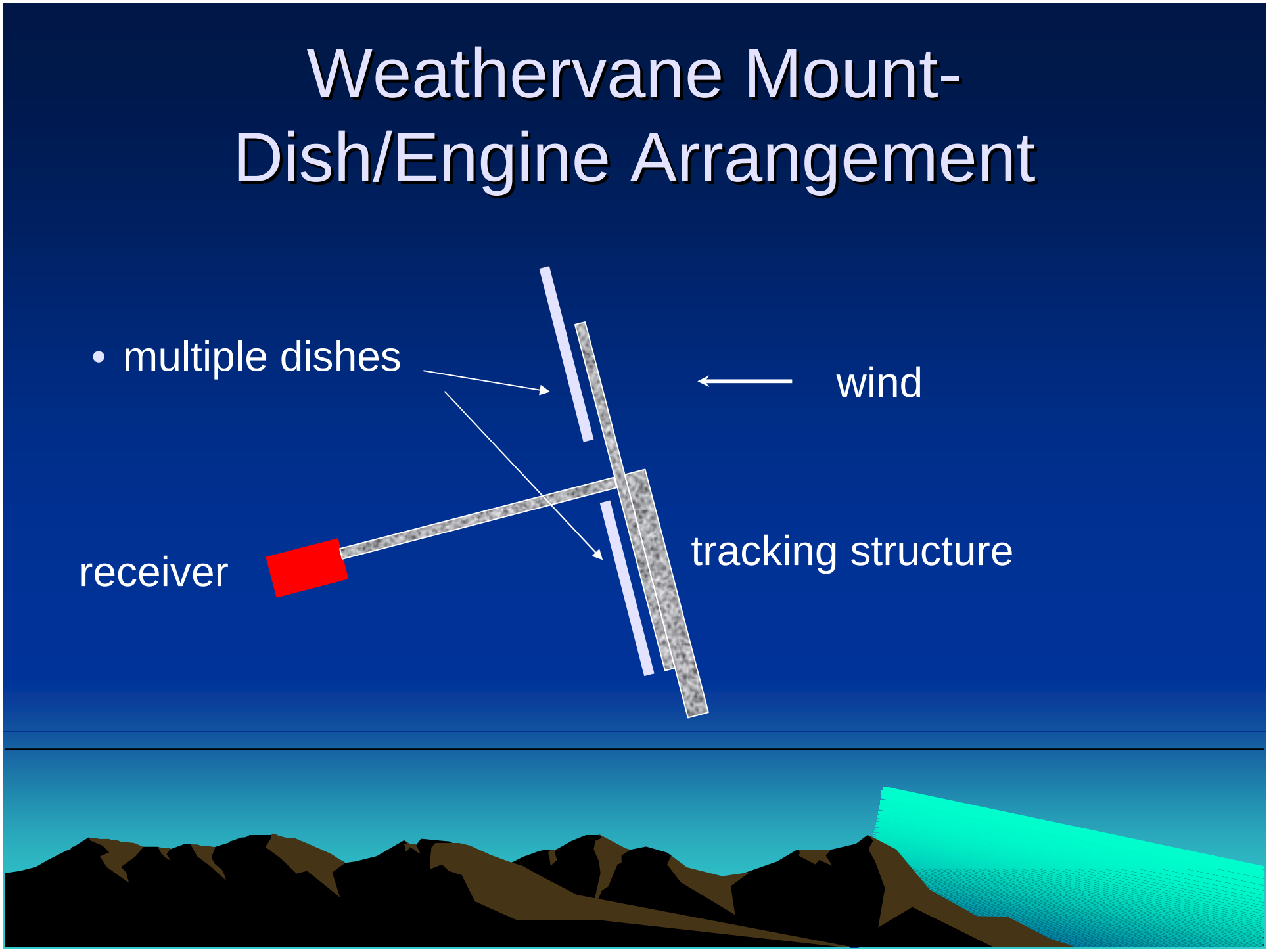
- Weather ability
  - All current dish materials are weather able, except reflective film (polyethelyne)
    - PVC lined foam board
    - Silicone and polyurethane sealants
- NREL's Advanced Materials Group is conducting accelerated life testing on film materials. 10 year life may be possible.
- No reflective film is likely to survive major wind and hail events.
    - Tracking mechanism with redundant stowage modes
      - Active mode initiated by anemometer/wind direction
      - Breakaway weathervaning mode



# Weathervane Mount-Single Heliostat



# Weathervane Mount-Dish/Engine Arrangement



# Heliostat Design Elements

- Plan Moving Forward
  - 7/06- Look for a test partner to verify performance
  - 10/06- construct 8’ dish with weather able film
    - Begin outdoor testing
  - winter 06/07- Design dish/engine mechanism
    - Tracking
    - Stowage
  - Spring 07- construct and test 10’ prototype
  - Summer 07- begin construction of dish/engine components

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