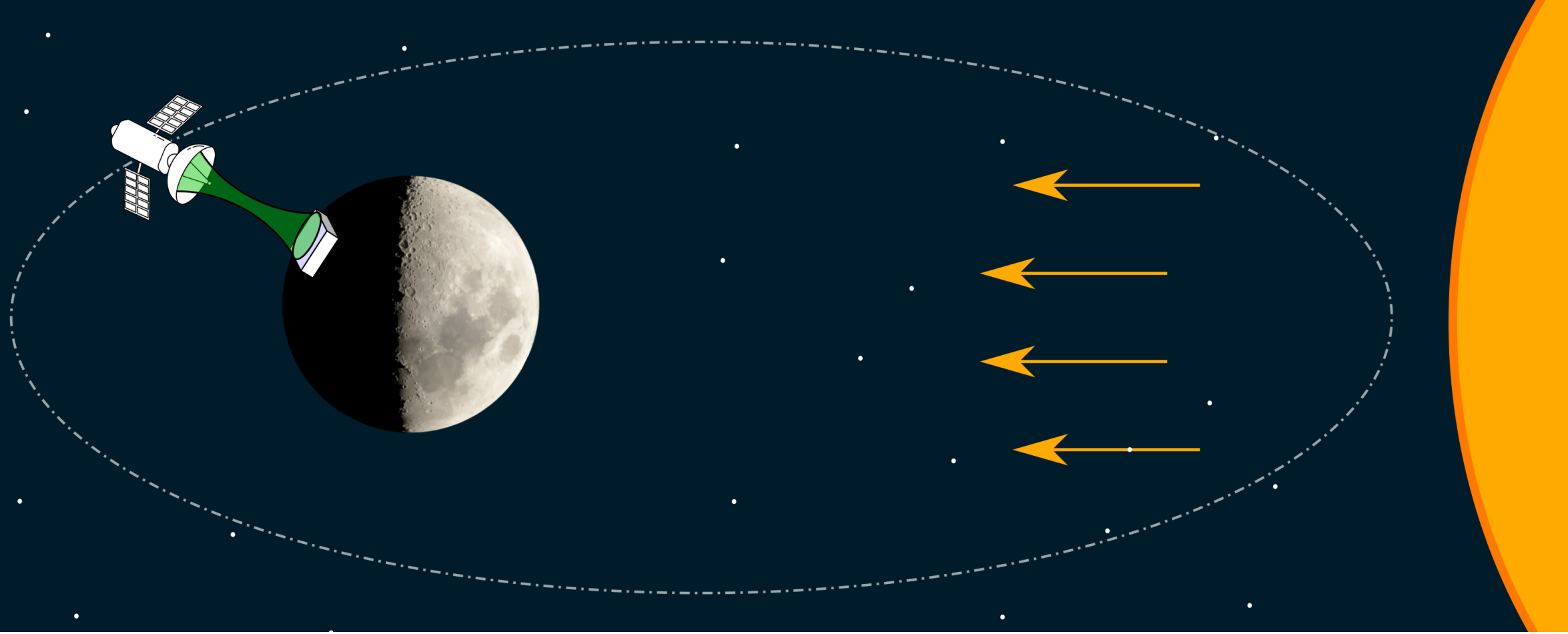


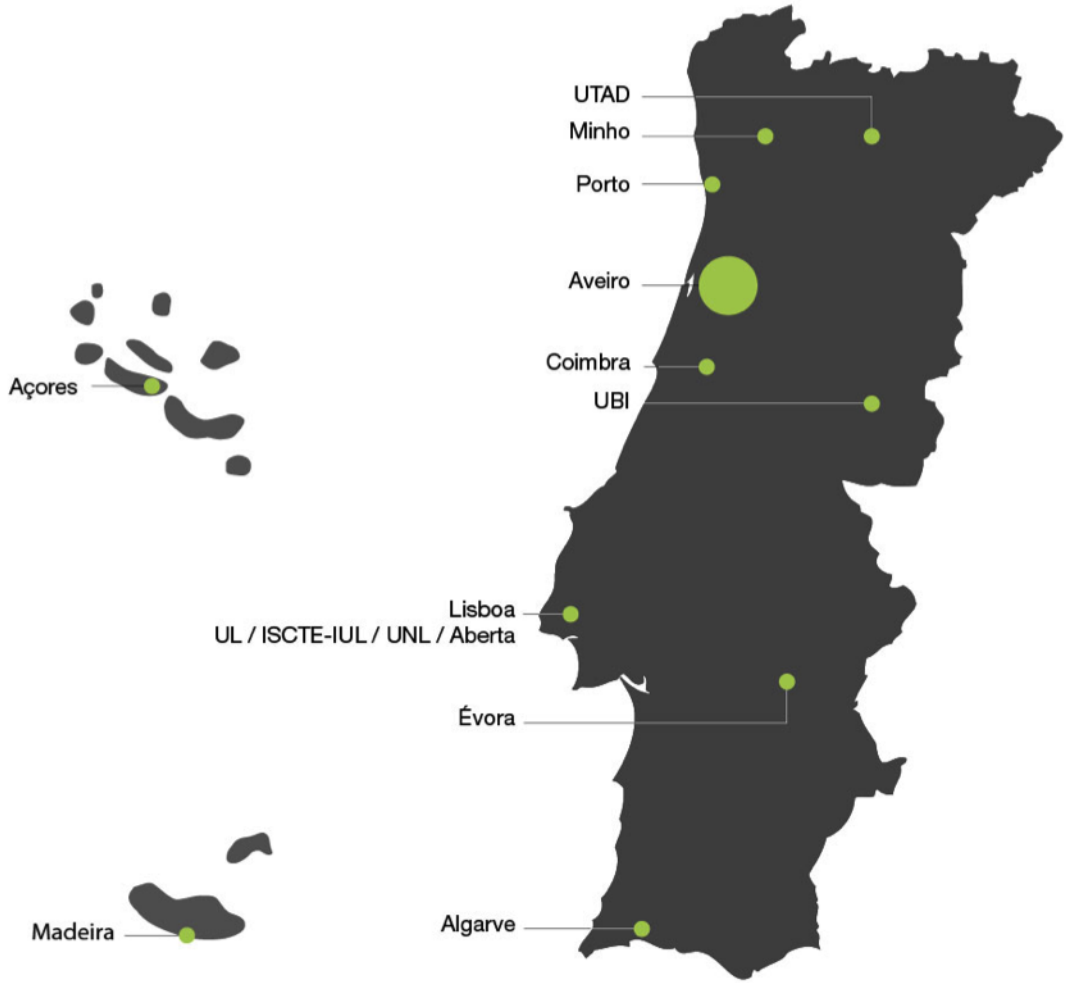
ENERGY MULES, A NOVEL SOLAR POWER SATELLITE SYSTEM ARCHITECTURE CAPABLE OF ENERGY STORAGE

University of Aveiro Team
r.pereira@ua.pt

radio systems · instituto de telecomunicações · deti universidade de aveiro departamento de eletrónica, telecomunicações e informática · universidade de aveiro

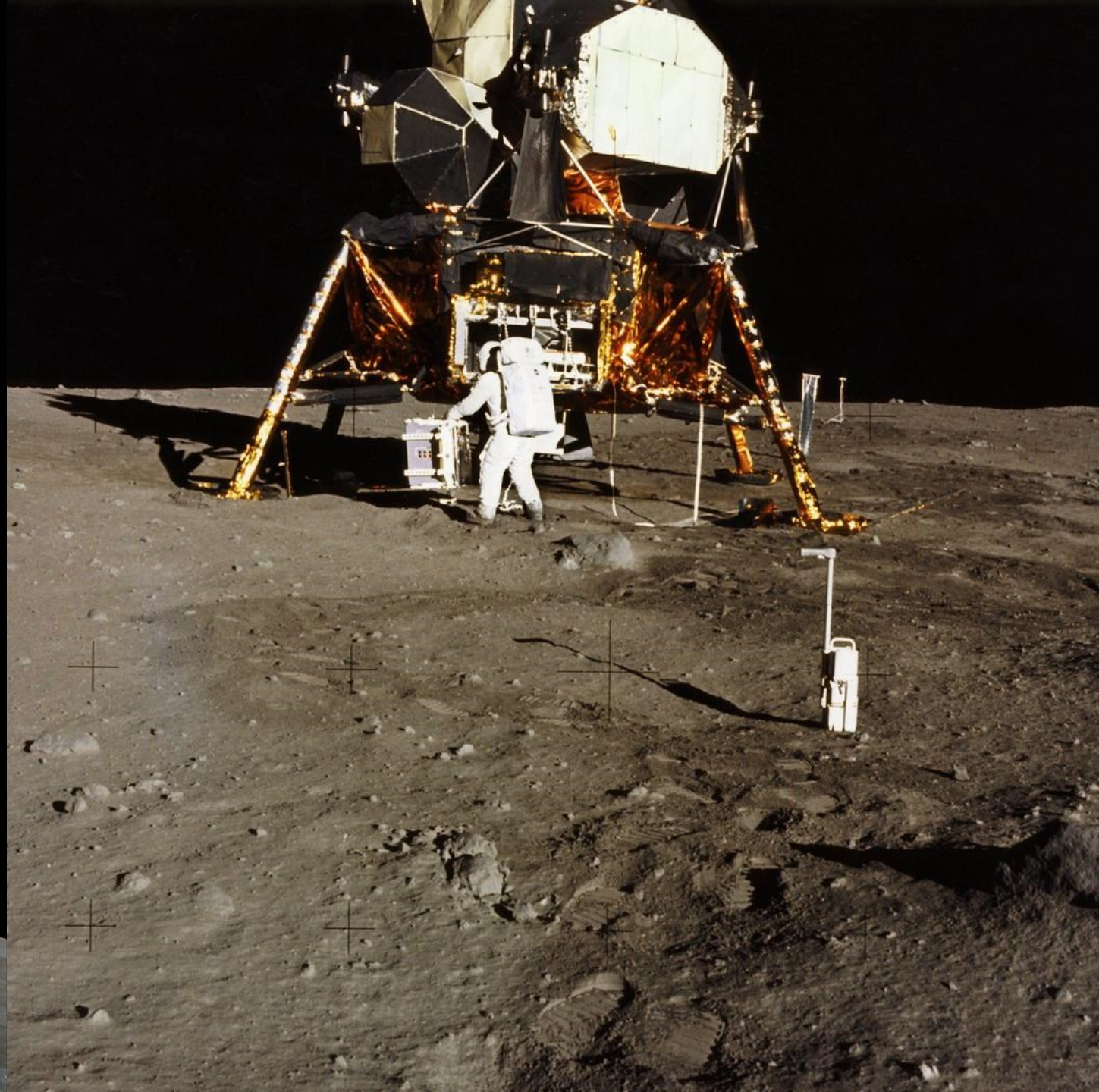
universidade de aveiro
um campus que pensa
1973.2013

located in Portugal's central region



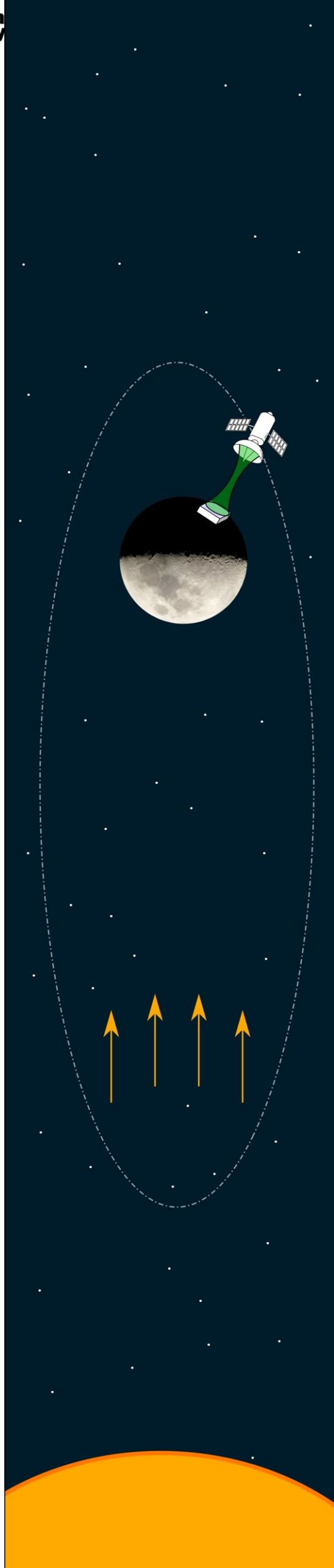
OUTLINE

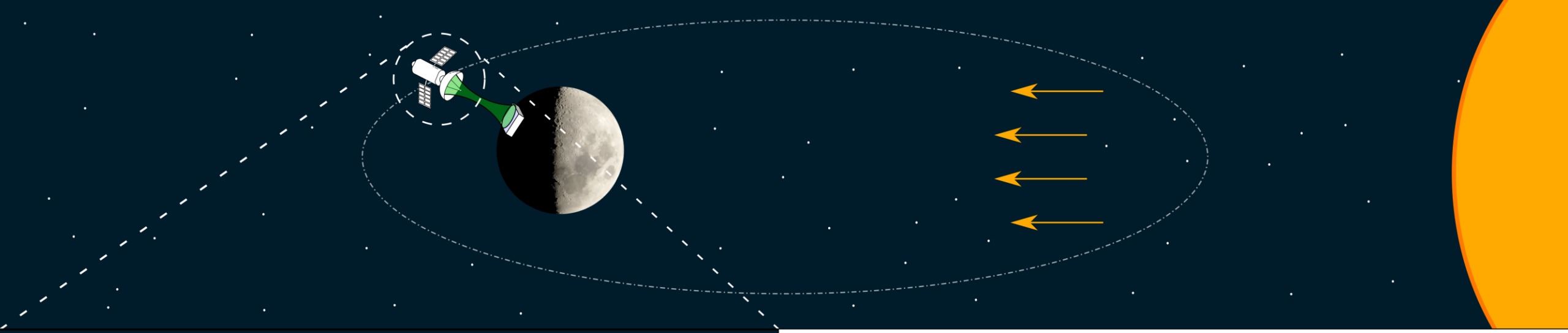
1. Introduction
2. Power Generation
3. Energy Storage
4. DC-RF Conversion
5. Beam Transfer
6. Power Reception
7. Environmental Impact
8. Near Term Demonstrator

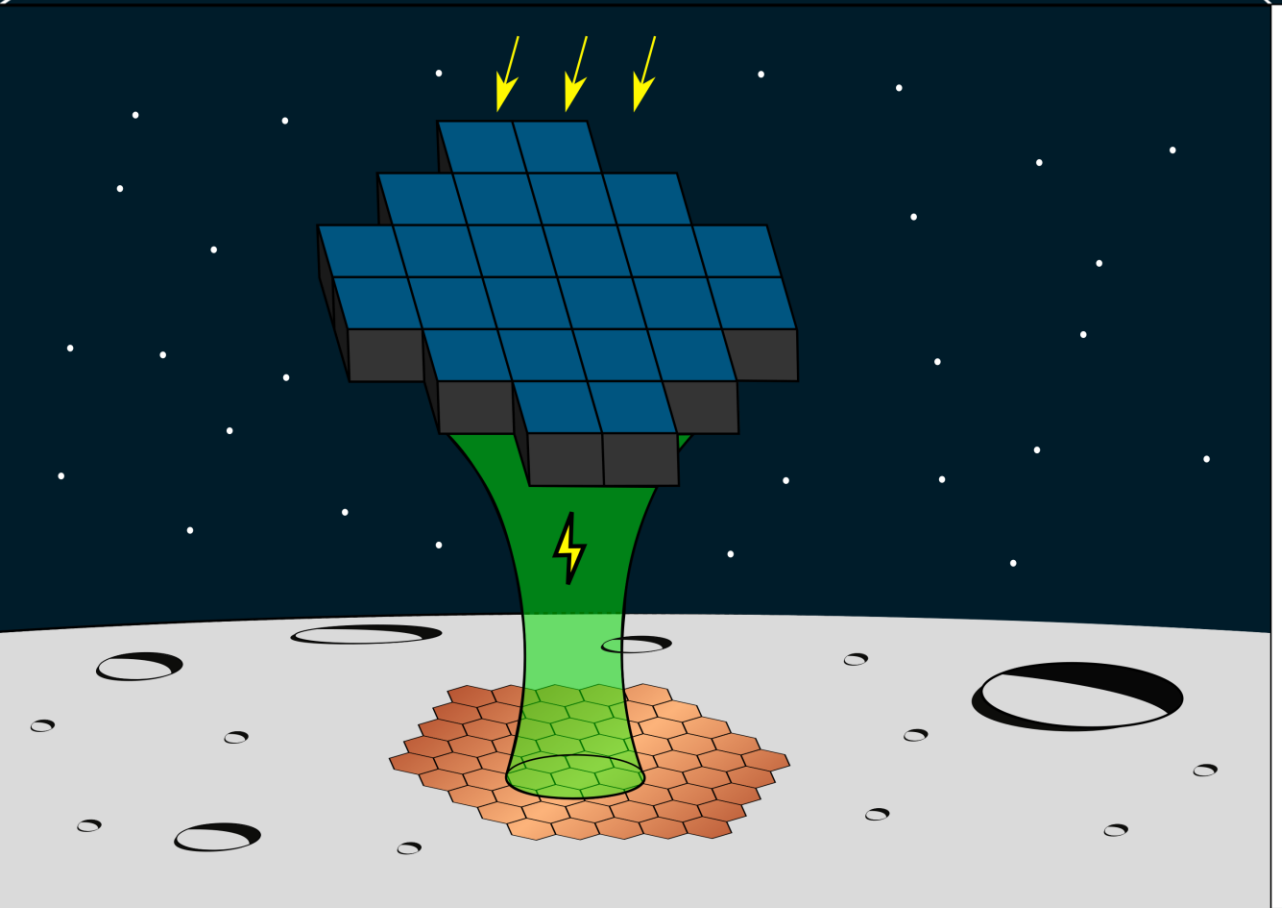


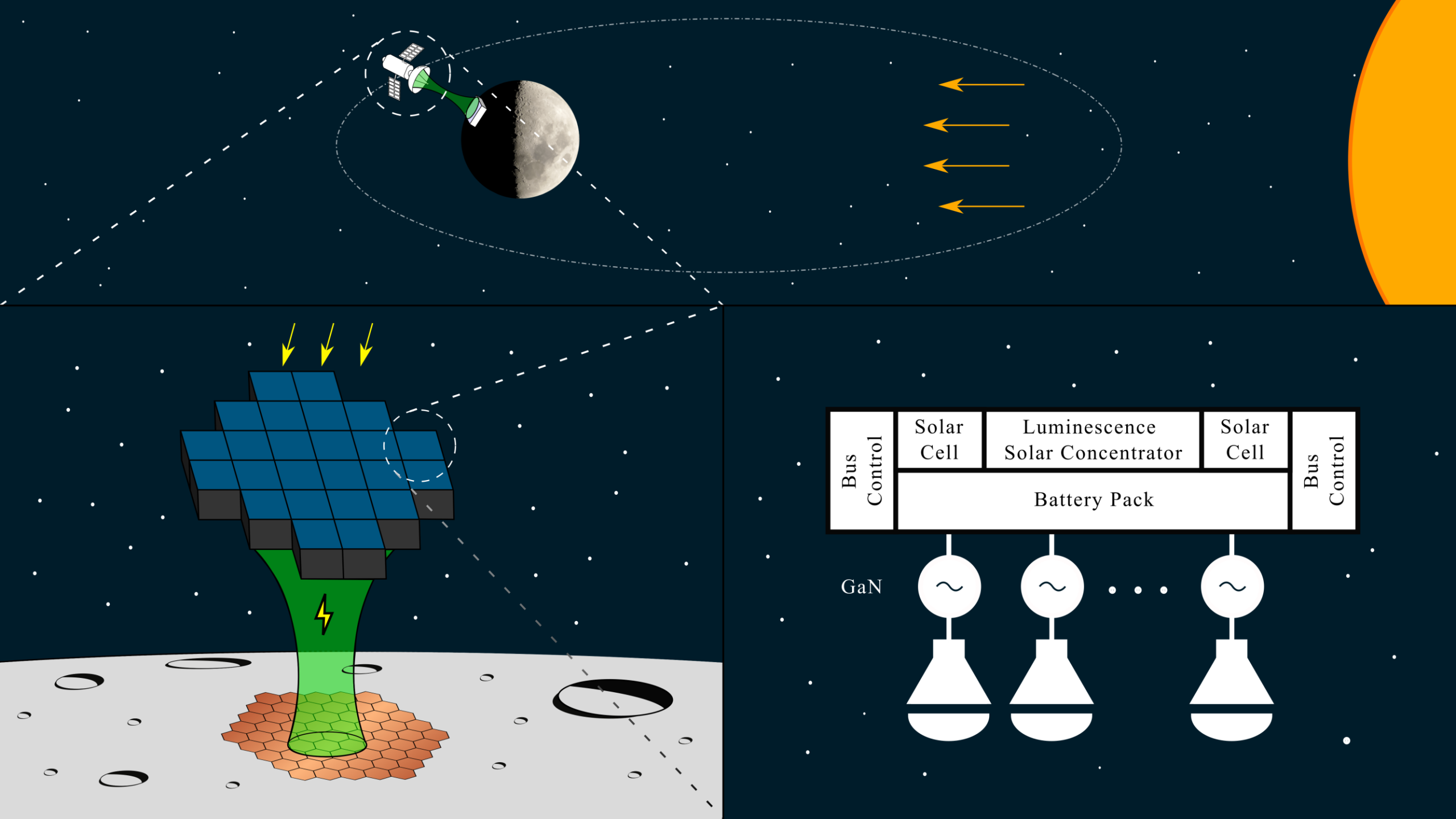
HOW TO SUPPLY ELECTRICAL POWER TO A LUNAR BASE?

The base will endure 14 days in the dark.








Bus Control
Solar Cell
Luminescence Solar Concentrator
Solar Cell
Bus Control
Battery Pack
GaN

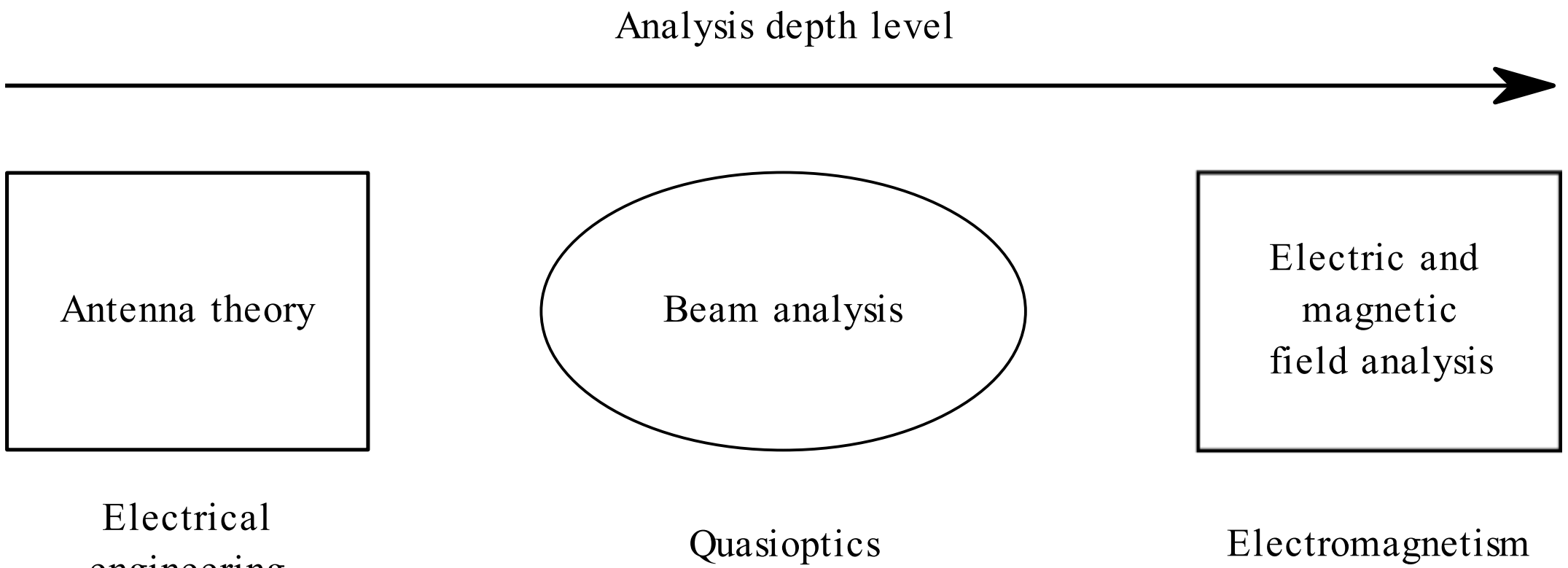
HOW TO SUPPLY ELECTRICAL POWER TO A LUNAR BASE?

The base will endure 14 days in the dark.

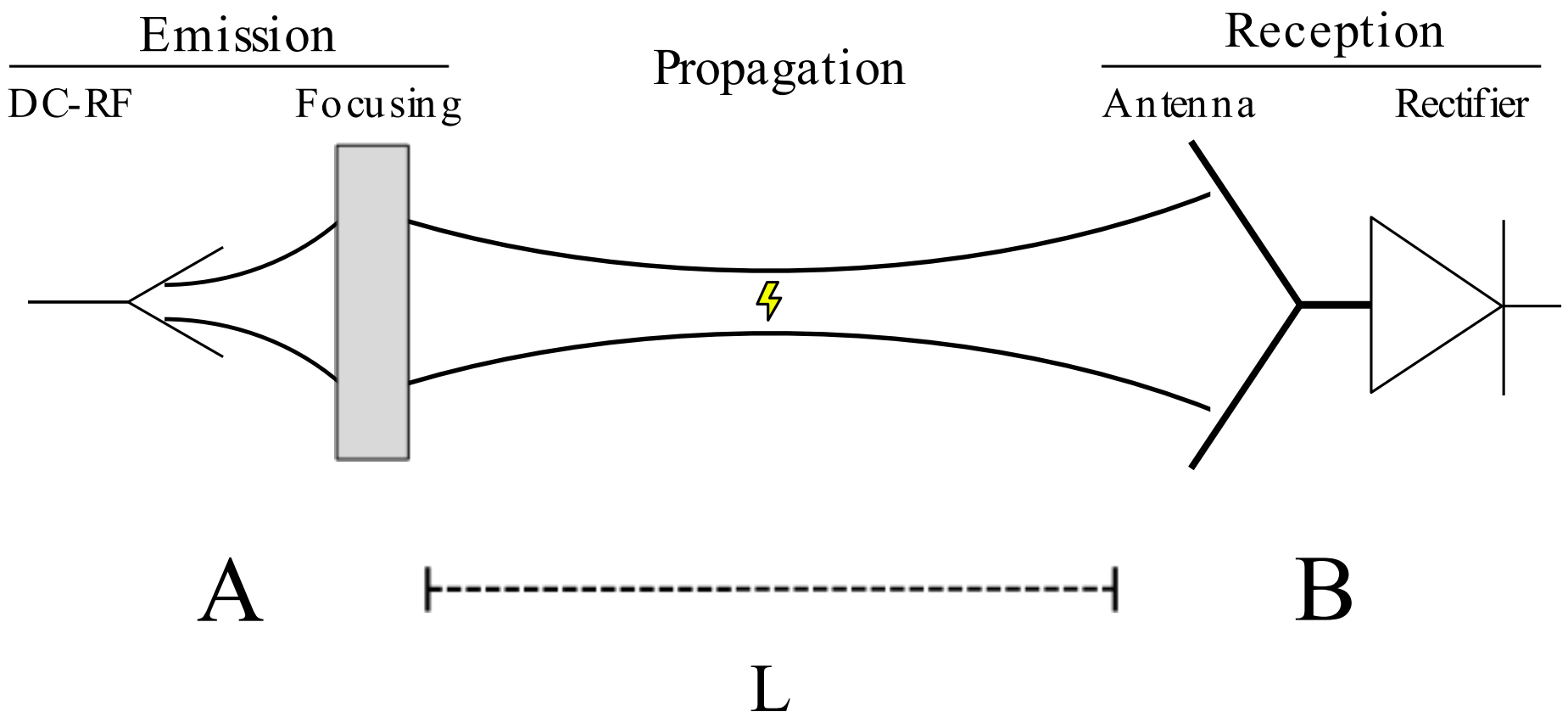
We propose a novel Solar Power Satellite System arquitecture:

- Clean energy
- Capable of energy storage
- Compact and efficient
- Applicable to other scenarios

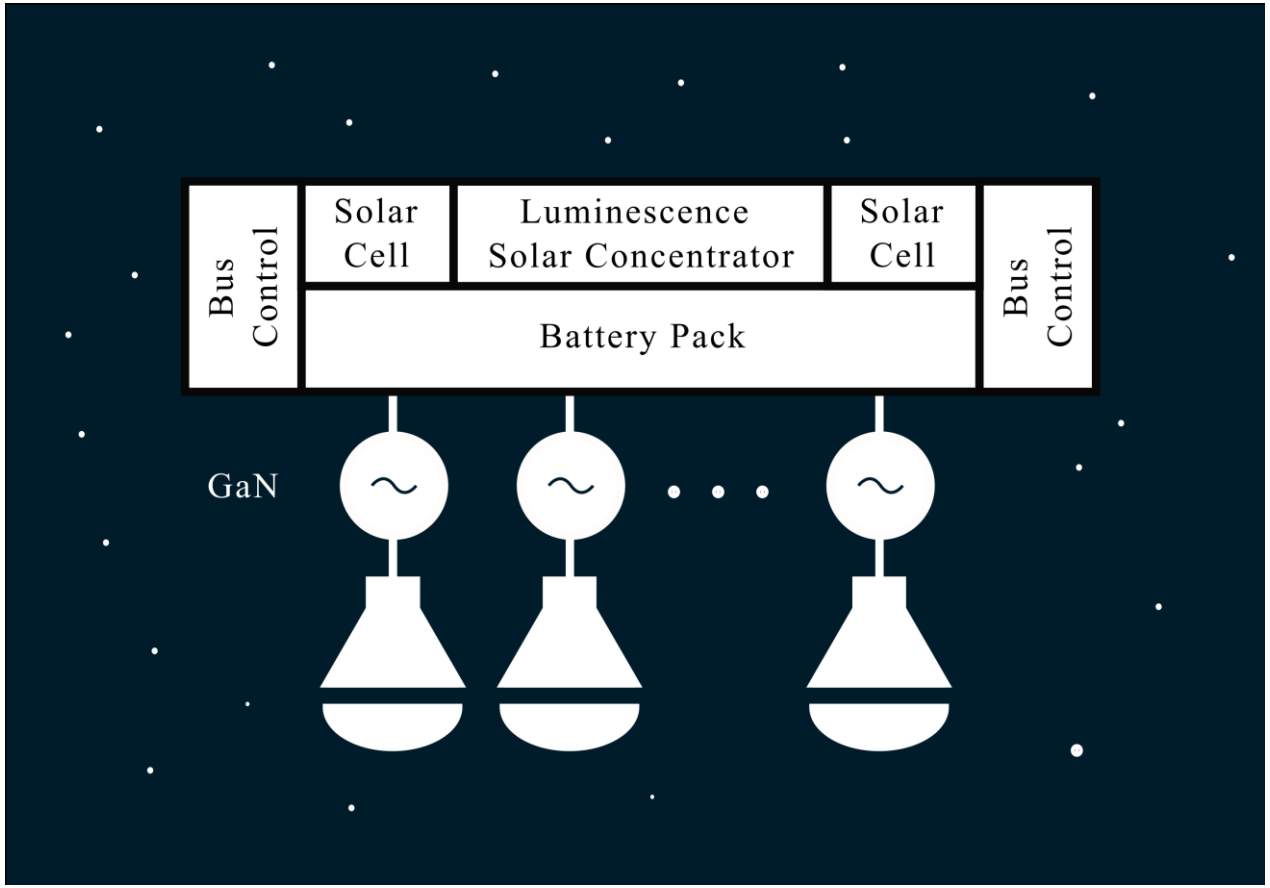
INTRODUCTION



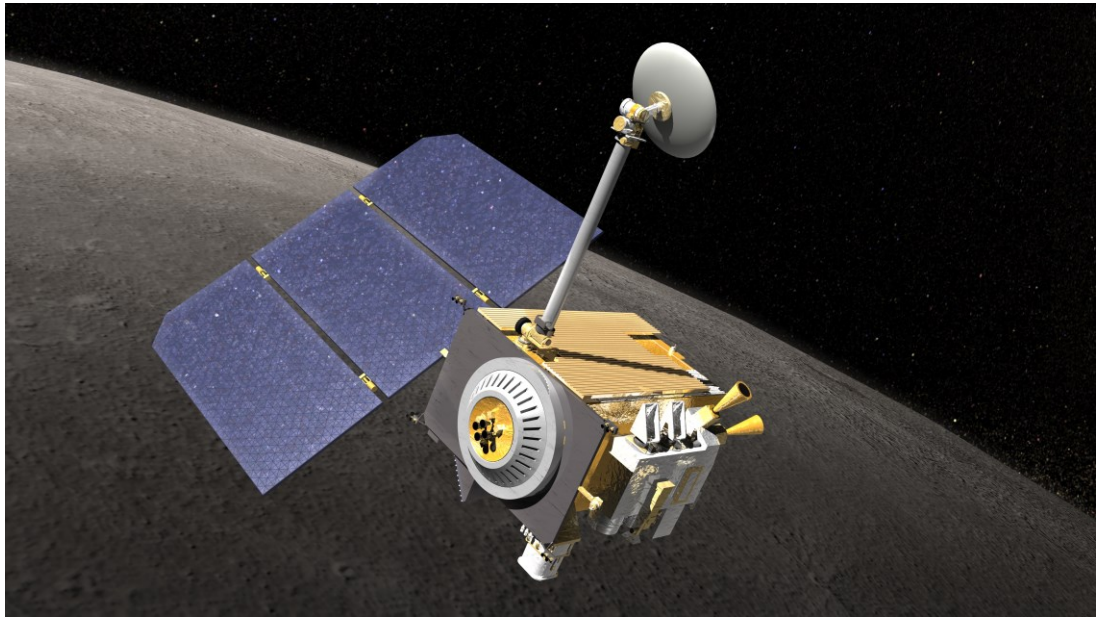
INTRODUCTION



INTRODUCTION



INTRODUCTION



© wikipedia

The minimum altitude will be the WPT distance:

L = 20 km

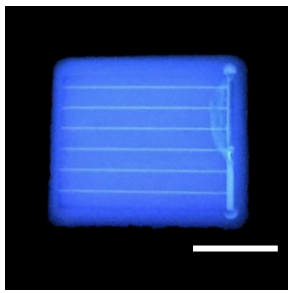
POWER GENERATION

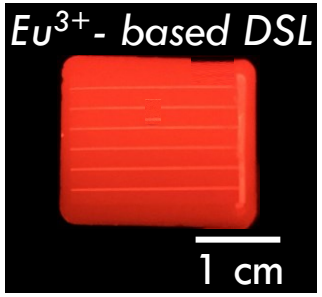
1st approach:

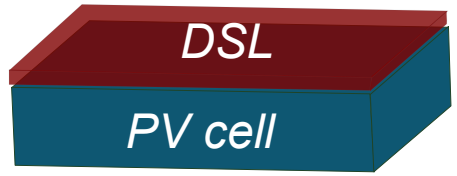
- Deposit a luminescent downshifting layer (DSL) on top of the solar modules.
- Convert unused UV radiation into visible light with high efficiency (~90%) leading to an enhancement of the power conversion efficiency of the solar devices.

Solar Racer, Geo Kids

Under UV irradiation (365 nm)

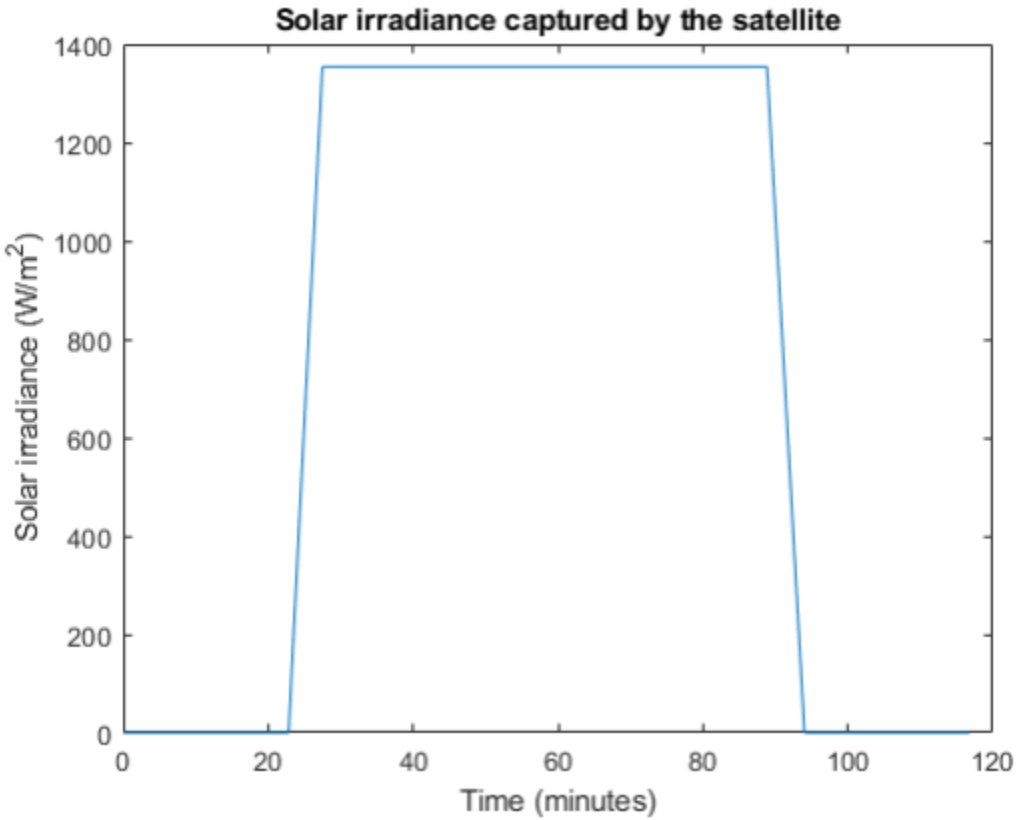


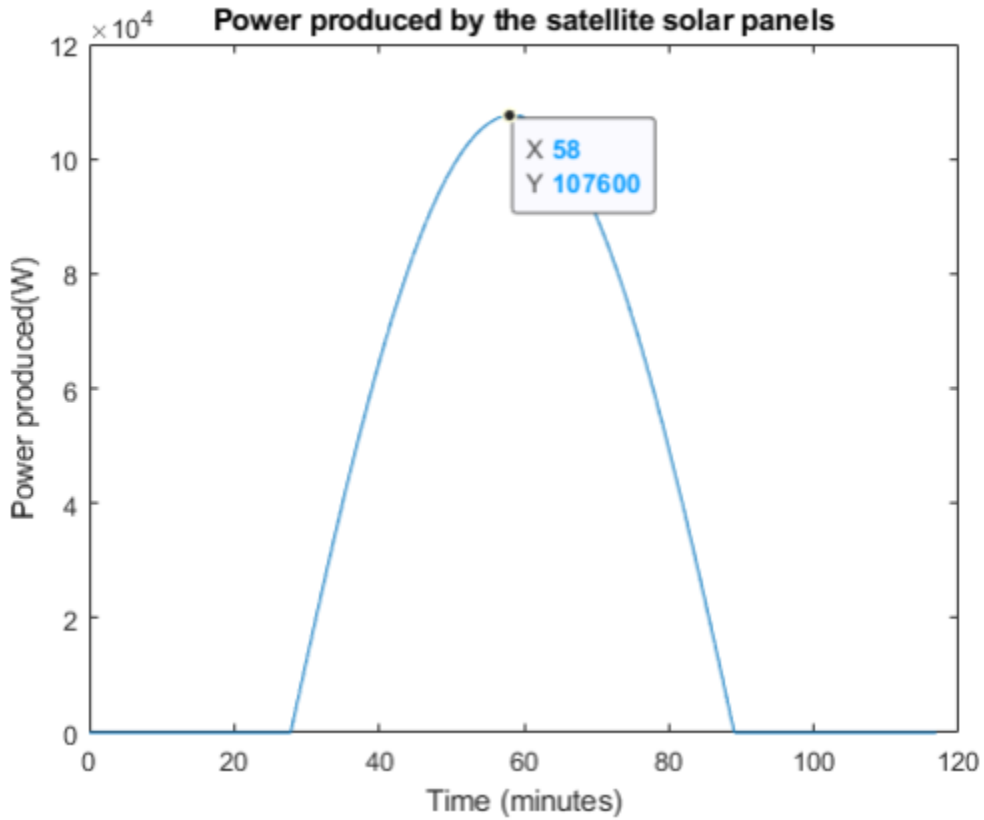




Correia *et al.*, *Opto-Electron. Adv.*, 2, 190006 (2019)

POWER GENERATION





Correia *et al.*, *Opto-Electron. Adv.*, 2, 190006 (2019)

POWER GENERATION

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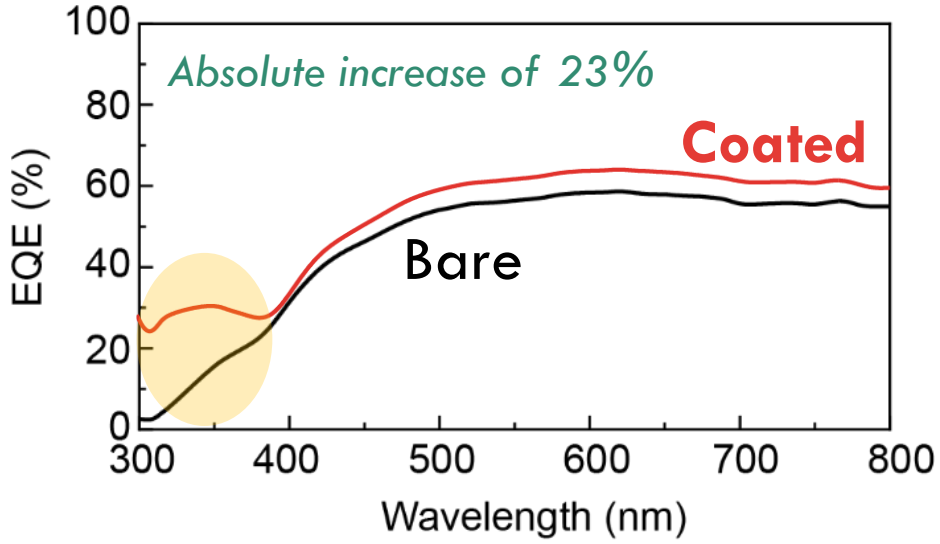
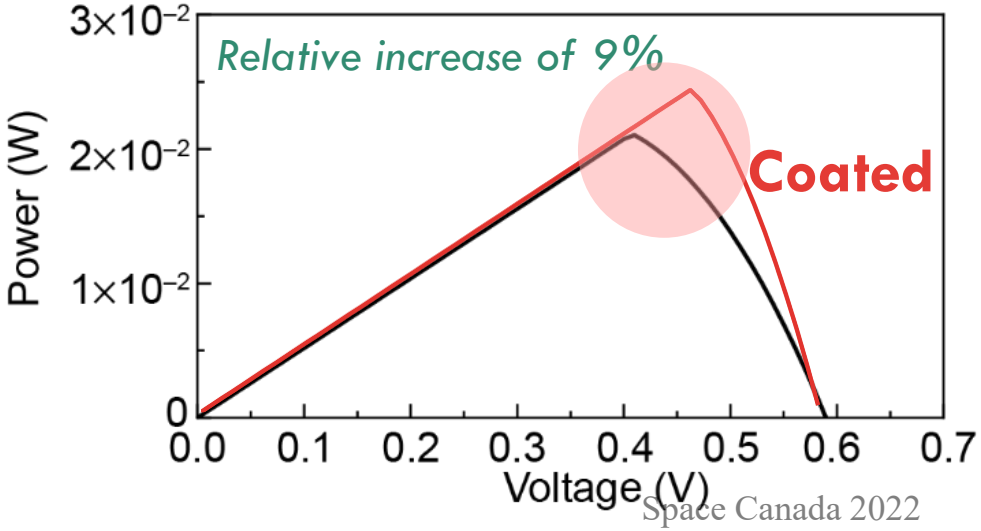
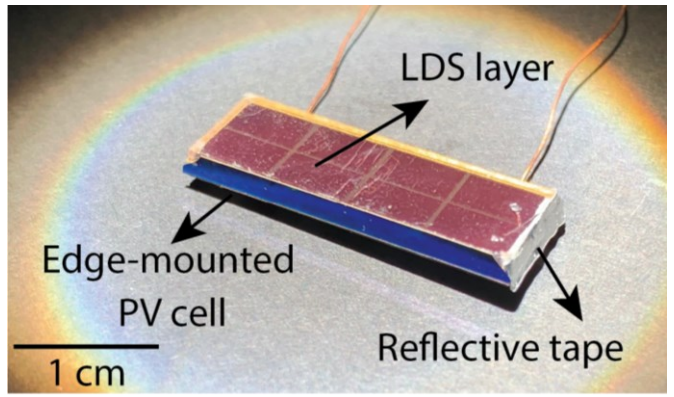


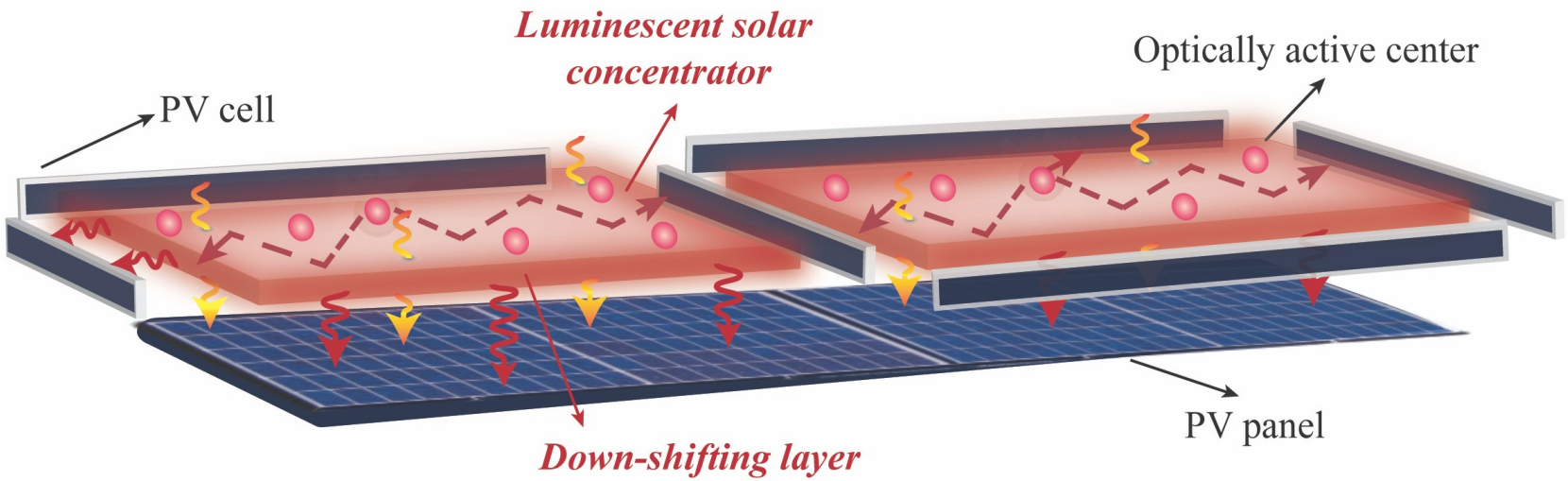


POWER GENERATION

2nd approach:

- Collection of guided radiation by PV cells applied on the borders of DSL



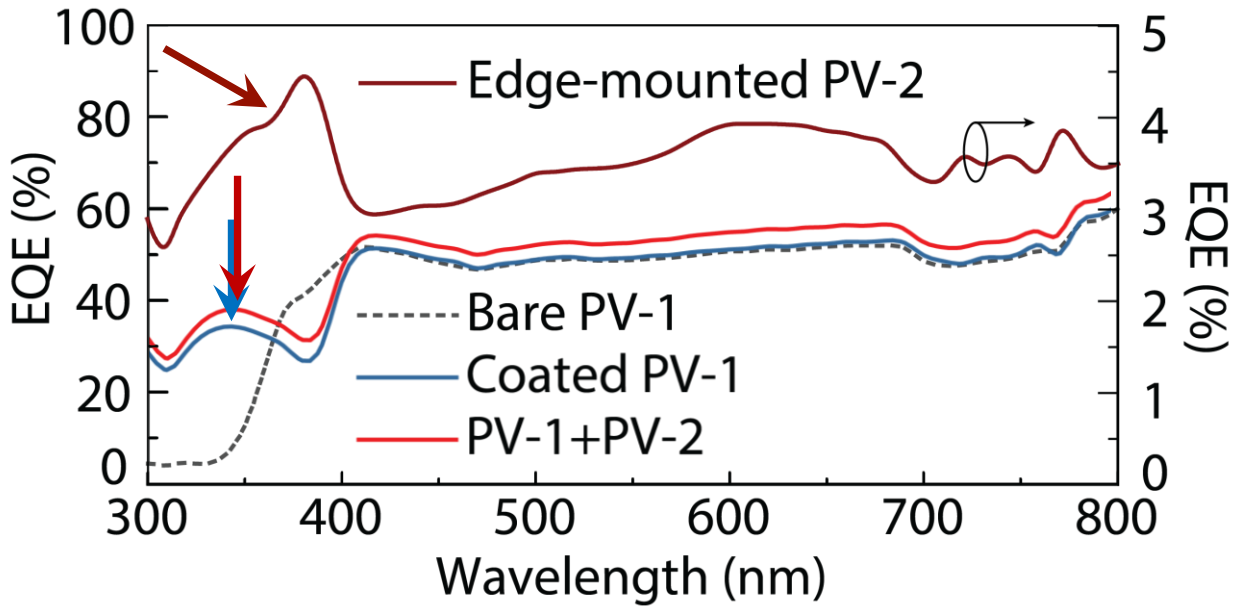


Cardoso *et al., J. Rare Earth* 38, 531 (2020).

POWER GENERATION

2nd approach: **Overall performance**

- ✓ ***32% absolute EQE increase in the UV spectral region.***
- ✓ ***The overall performance of the system increased ~13% relative to the bare PV cell.***



Cardoso *et al., J. Rare Earth* 38, 531 (2020).

POWER GENERATION

Advantages of the selected material:

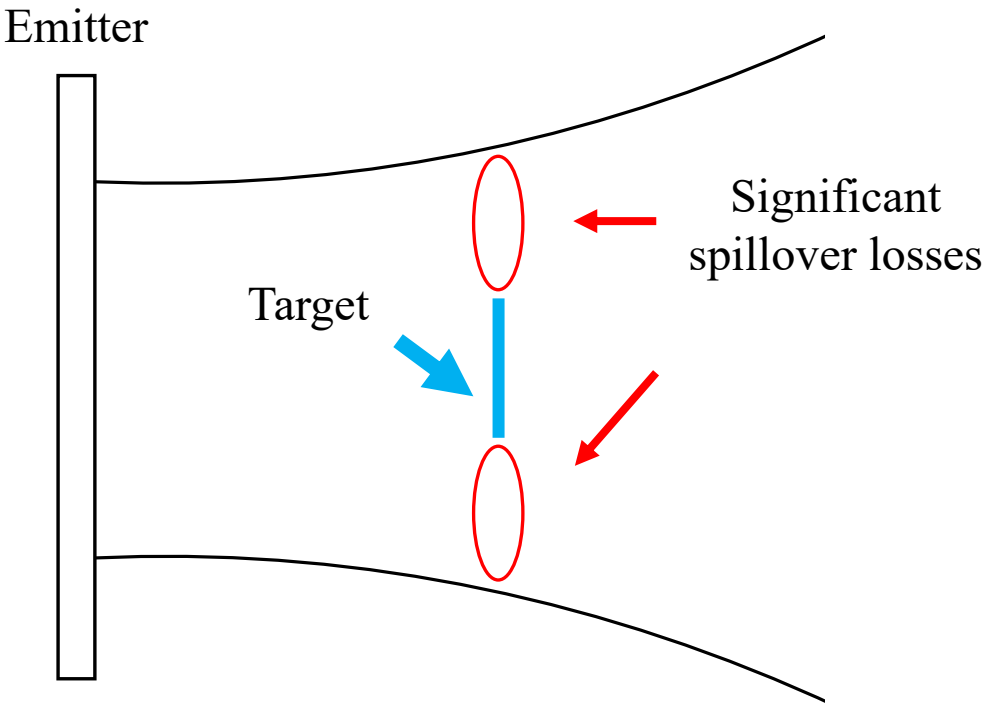
1. High power absorption coefficient
2. High Q values
3. Large ligands-induced Stokes shifts
4. High thermal stability

ENERGY STORAGE

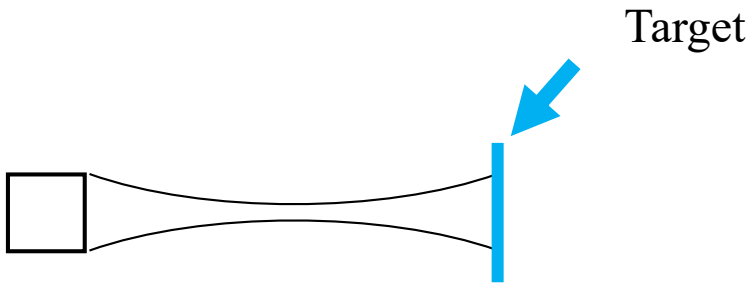
- A step-up DC-DC converter will be used to generate a constant voltage to be able to charge a battery
- To manage the energy stored in the battery, another DC-DC converter will be used (step-down).
  The output of this converter will be connected to two linear voltage regulators
- The system microcontroller must trim these converters

i7C4W008A120V-0F1-R Module

QUASIOPTICAL APPROACH



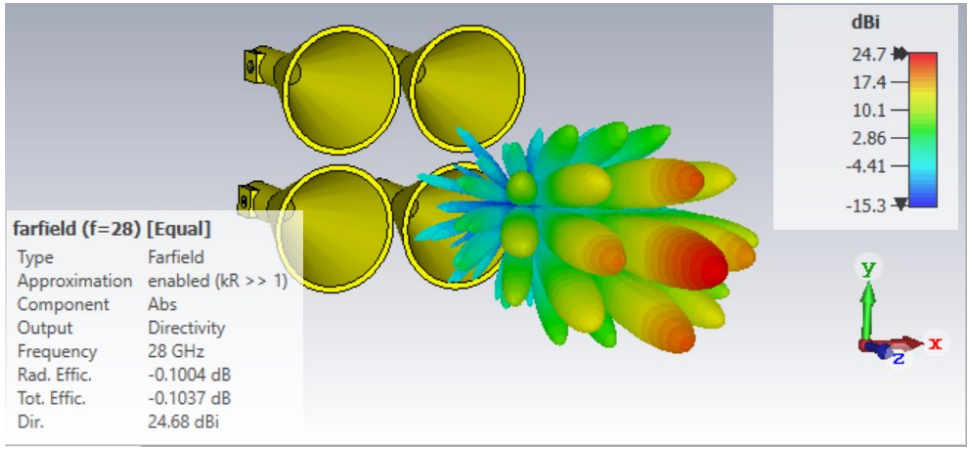
Without considering the beam's divergence



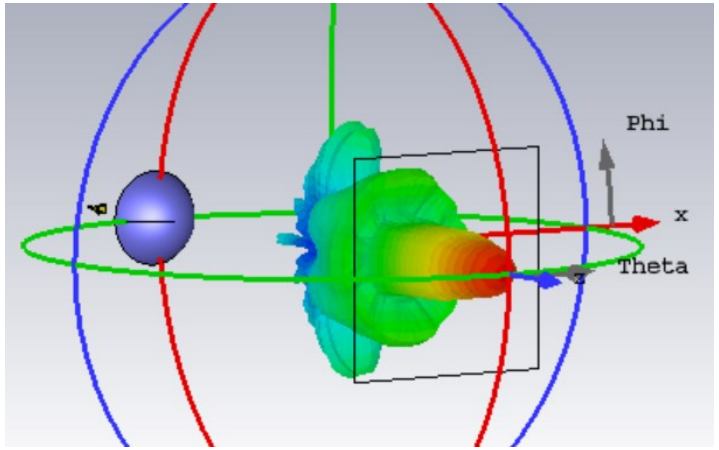
Our approach

POWER TRANSFER

1. Horn antenna arrays

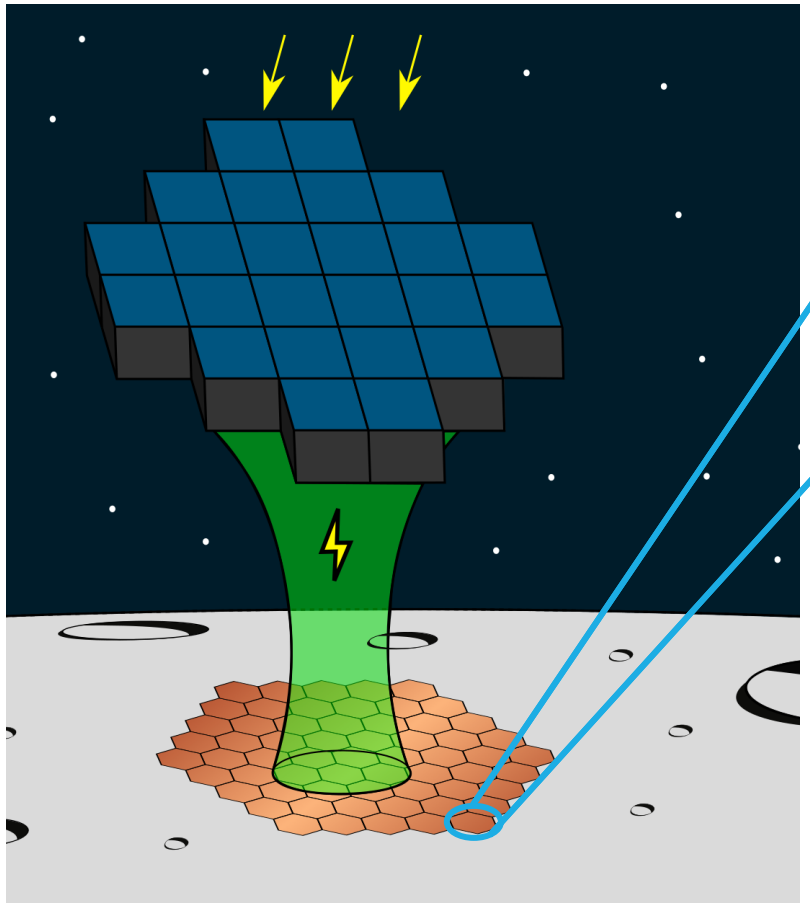


2. Dielectric lenses



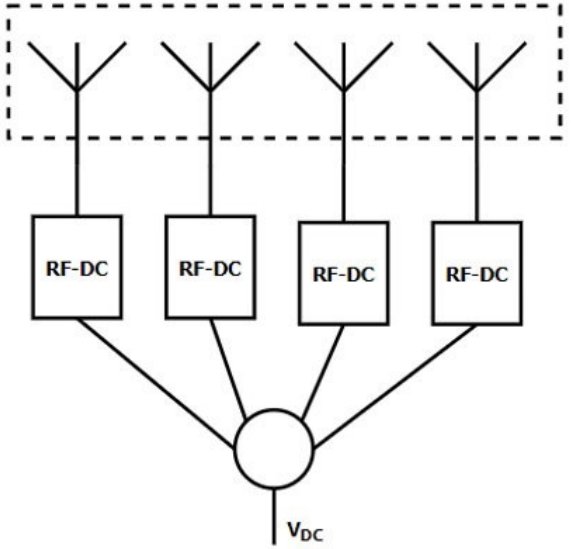
Frequency of operation	28 GHz
WPT distance	20 km
Beam radius at emission and reception	8.26 m

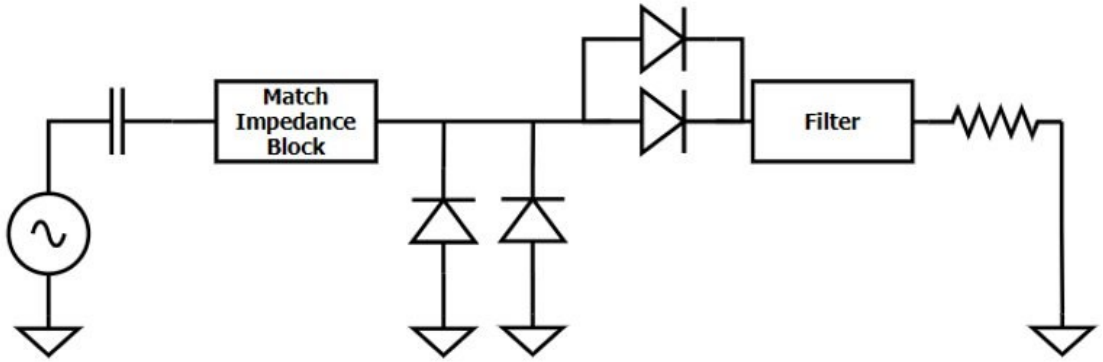
POWER RECEPTION



Antenna Array

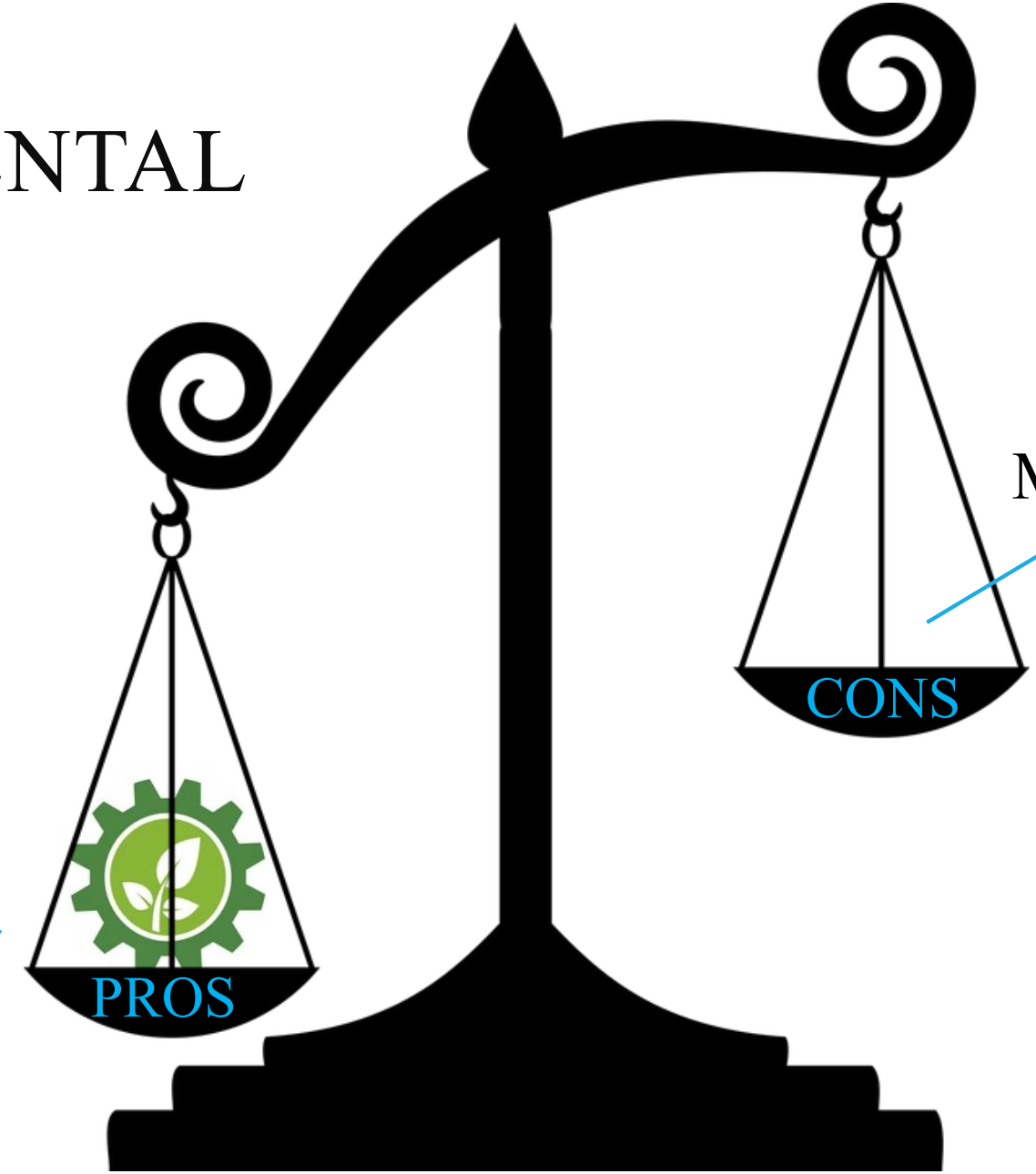
RF-DC Converters





ENVIRONMENTAL IMPACT

Clean energy
Reduced size
Increased Efficiency



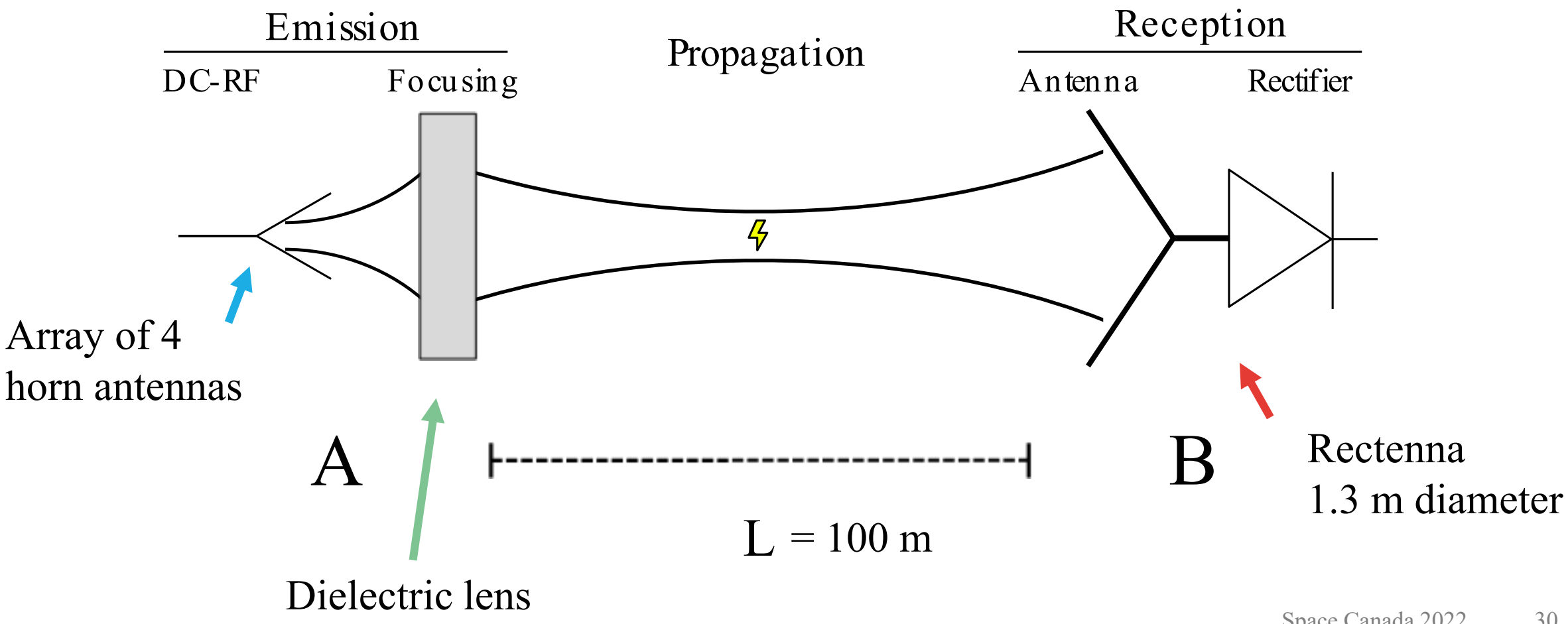
More complexity

NEAR TERM DEMONSTRATOR

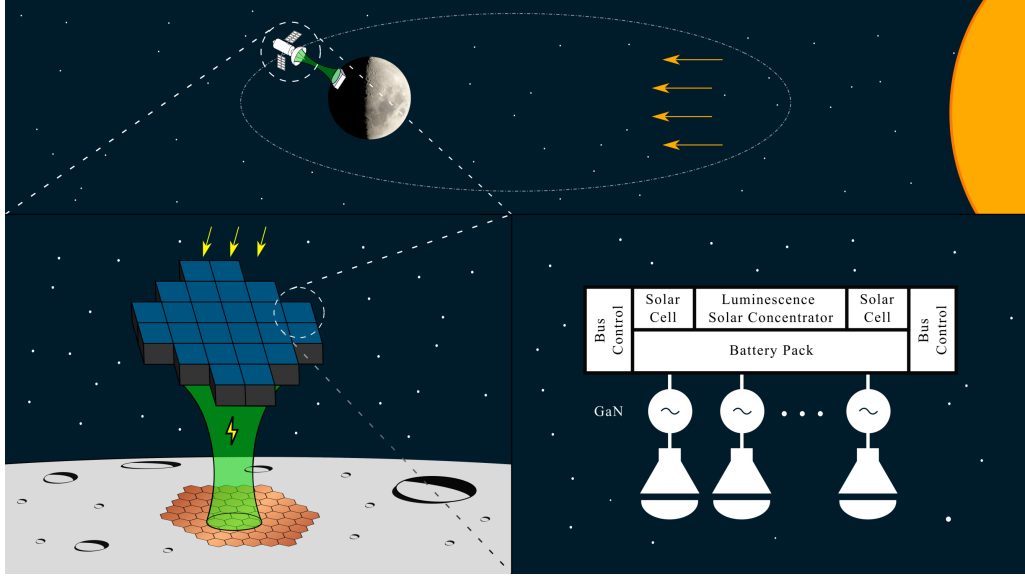
Proof of concept

- Demonstration of a complete system tile (28 GHz)
- 100-m wireless power transfer experiment
- Array of 4 horn antennas
- Lens with 1.3 m of diameter

NEAR TERM DEMONSTRATOR



CONCLUSION



Proposed a novel solar power satellite system arquitecture

- Capable of energy storage
- Adaptable to various scenarios (moon, asteroids, Earth, etc)
- Detailed all system components
- Supply green energy
- We are working towards a near term demonstrator
  - Performance of a single tile

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Ricardo A. M. Pereira

Graduate Students

Nuno Borges Carvalho

Sandra F. H. Correia

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