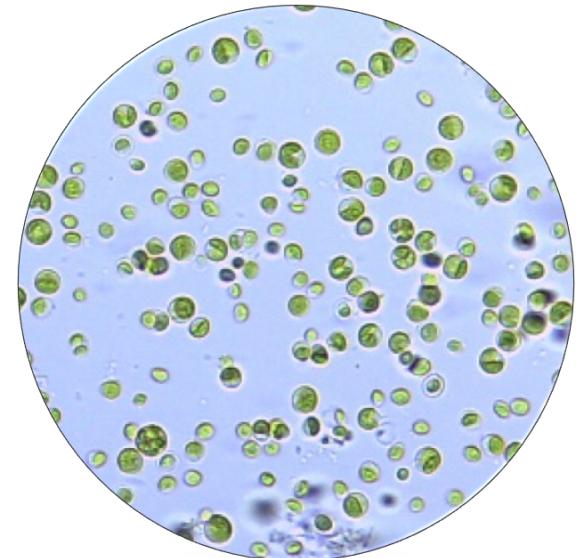


Photobioreactor Technology for Microalgae Cultivation to Support Humans in Space with Oxygen and Edible Biomass

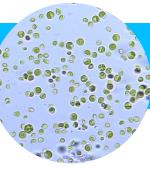
S. Belz, H. Helisch, J. Keppler, G. Detrell, S.
Fasoulas, R. Ewald, N. Henn

Photobioreactor Technology for Microalgae Cultivation to Support Humans in Space with Oxygen and Edible Biomass

1. Introduction
2. Long-term cultivation on-ground
3. Photobioreactor technology for space
4. Conclusions



PBR Technology for Microalgae Cultivation to Support Humans in Space



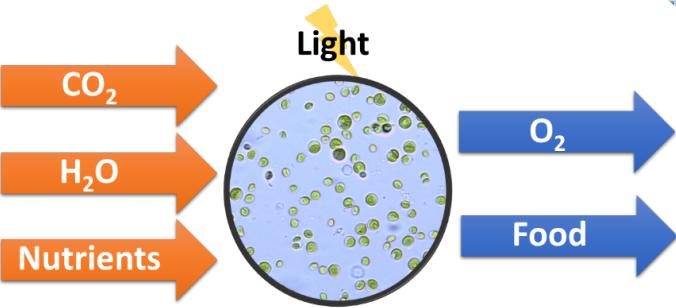
1. Introduction



© ESA/Foster + Partners

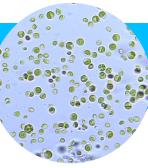
Open questions

- Experience in long-term cultivation
- Genetic stability over several generations
- Scale-up the system
- Low PBR hardware mass
- Etc.



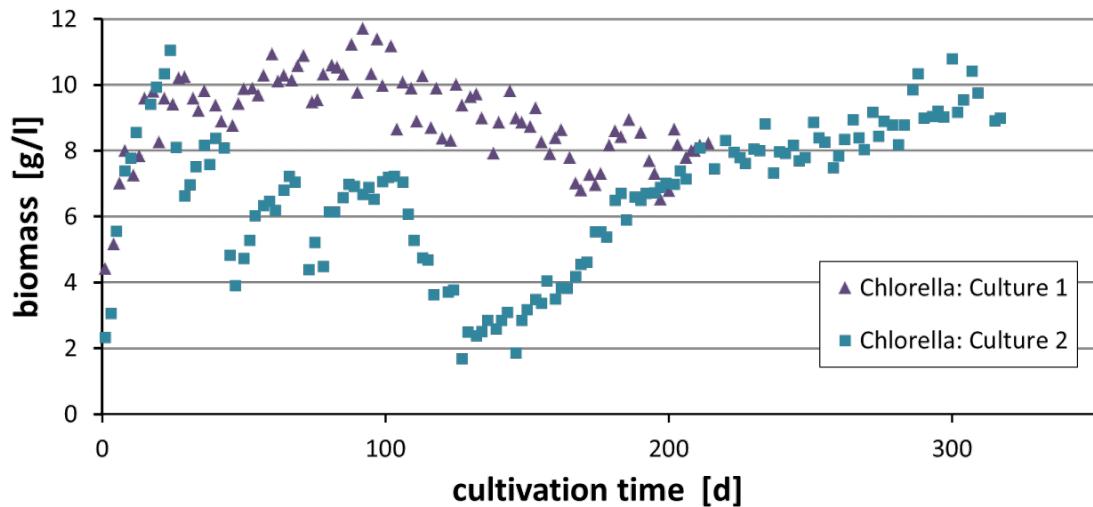
Algae vs. Plants

- Higher harvest index (>90%)
- Higher light exploitation
- More rapid growth
- Lower water demand
- Higher photosynthetic quotient
- Well controllable metabolism



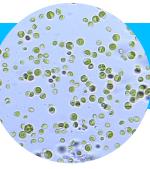
2. Long-term cultivation on-ground

- Since 2010, *Chlorella vulgaris*
 - Unicellular, spherical, immobile organism, \varnothing 4-10 μm
 - Non-axenic culture



Flat Plate Airlift PBR
subitec

PBR Technology for Microalgae Cultivation to Support Humans in Space

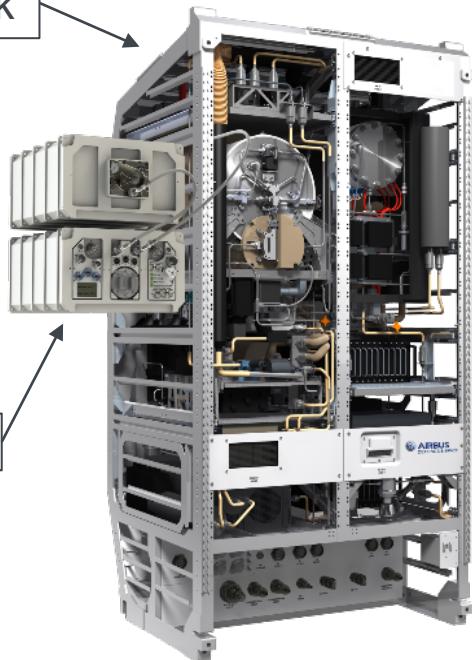


3. Photobioreactor technology for space

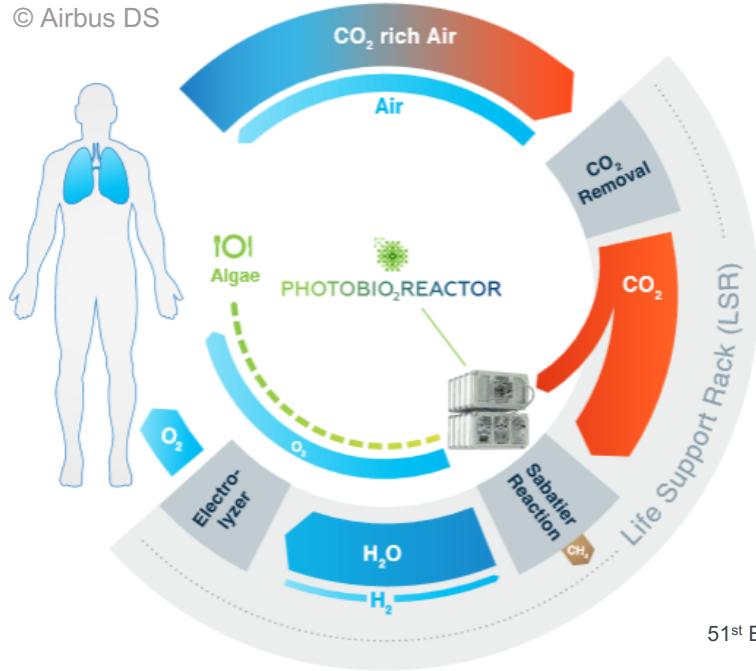
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Life Support Rack

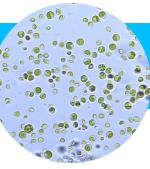


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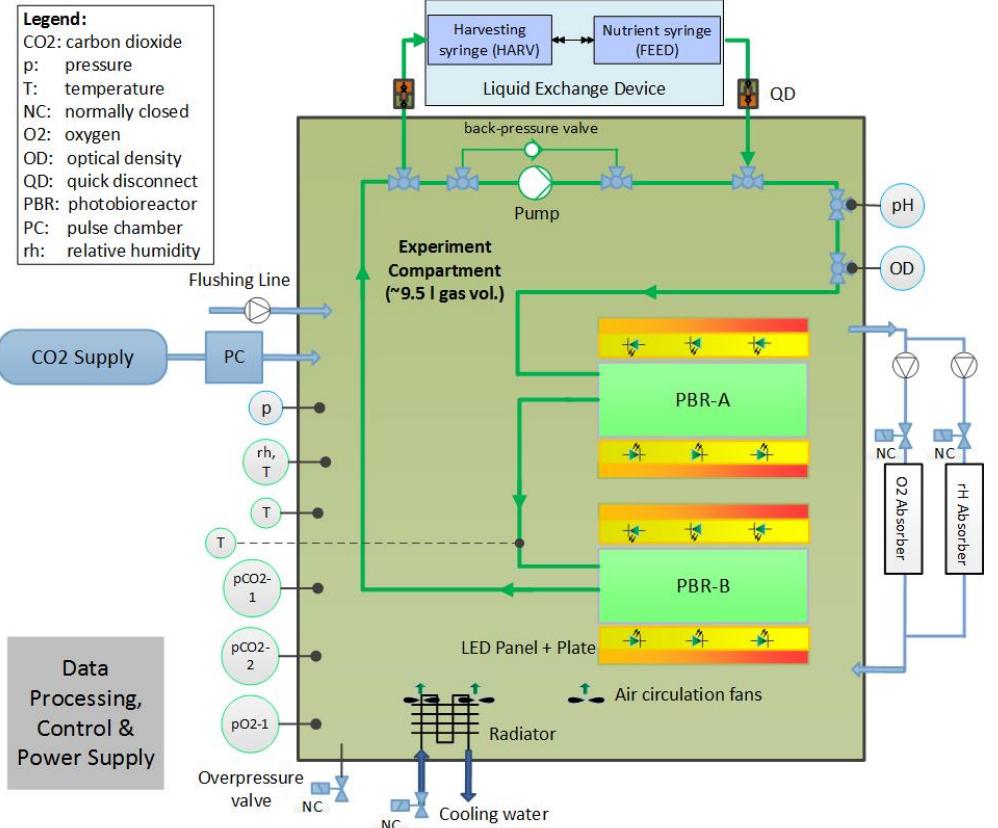


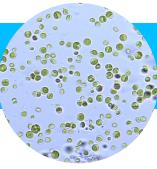
- surplus CO_2 (LSR)
- produce O_2 and potentially food
- partial closure of carbon cycle
- test of hybrid LSS

PBR Technology for Microalgae Cultivation to Support Humans in Space

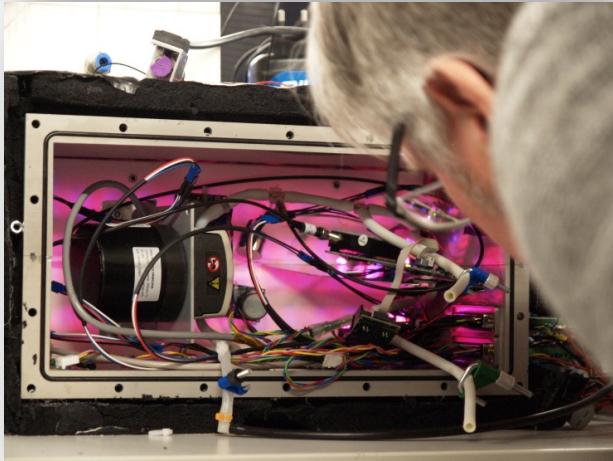
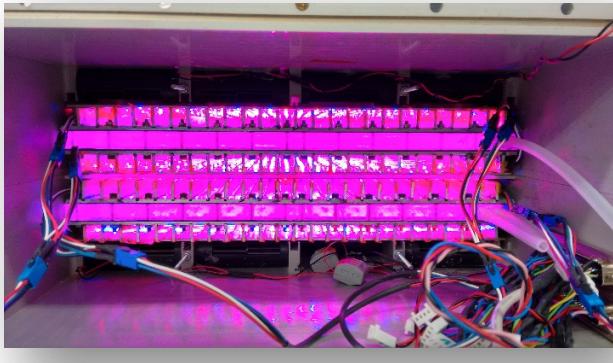
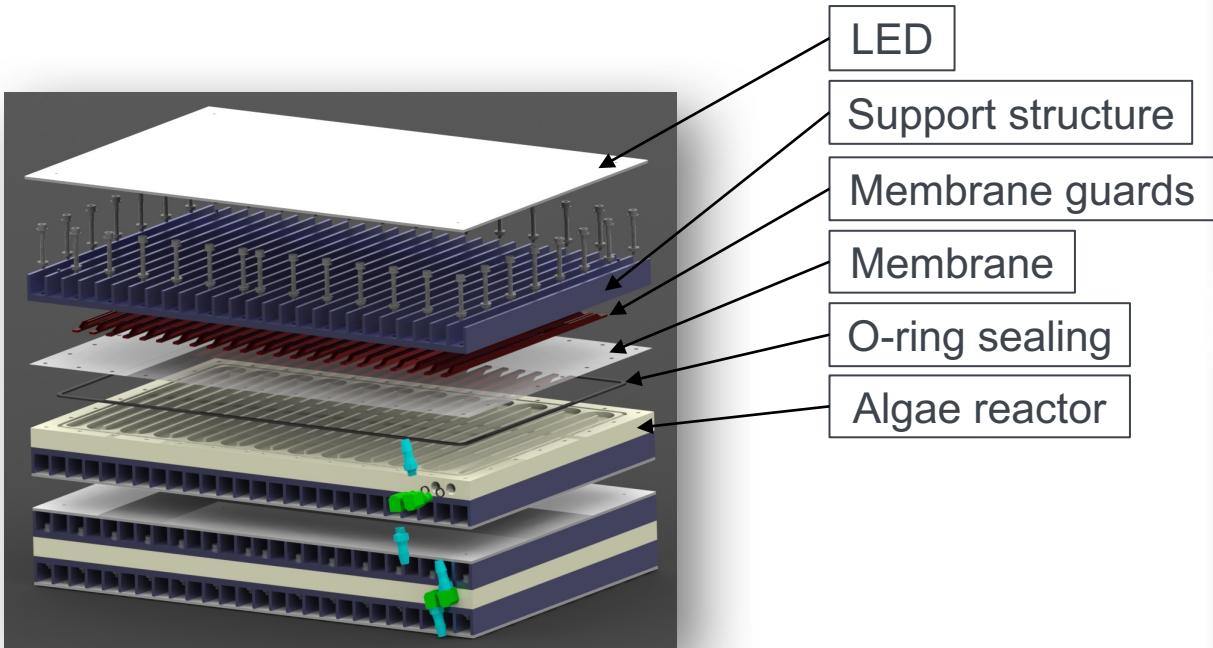


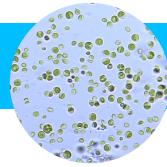
3. Photobioreactor technology for space





3. Photobioreactor technology for space



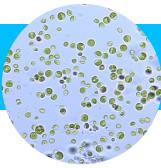


3. Photobioreactor technology for space

Pre-flight experimentation on prototypes (Breadboards 1 – 2)

- Biology
 - nutrient supply ✓
 - thermal stress ✓
 - material compatibility ✓
 - sensors ✓
 - lighting regime ✓
 - bacterial stress ✓
 - pre and post experiment storage ✓
- Engineering
 - sizing ✓
 - thermal balancing ✓
 - pump selection ✓
 - lighting selection ✓
 - reactor optimization ✓
 - performance & stability ✓
 - operational concept ✓





3. Photobioreactor technology for space

Pre-flight experimentation on prototypes (Breadboard 3)

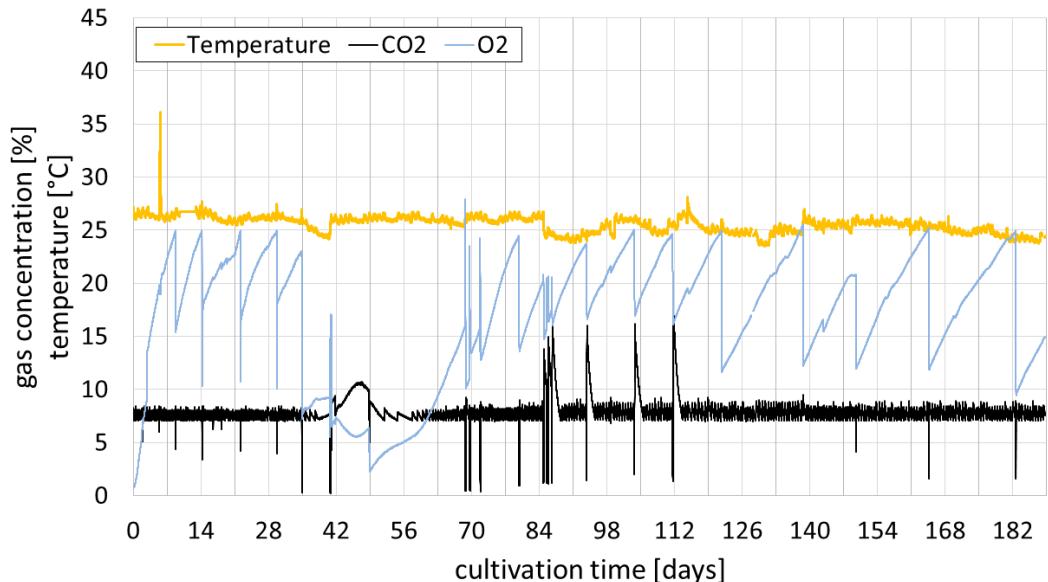
180-days Experiments

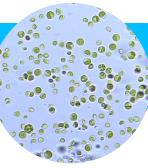
- 1st September 2016 - March 2017
- 2nd June – December 2017



„Openning“

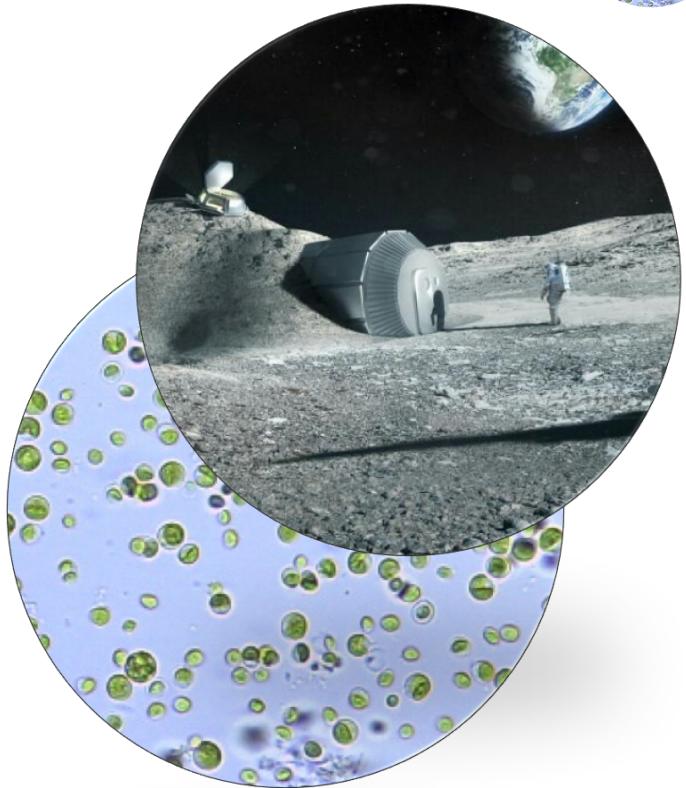
15th December

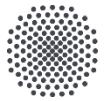




4. Conclusions

- Algae potential candidate for long duration missions
- On-ground experience in long-term cultivation
- PBR@LSR Experiment (2018) first technology demonstrator – hybrid LSS:
 - 180-day performance
 - Algae sample return → µg and radiation effects





University of Stuttgart
Institut of Space Systems

Acknowledgments



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