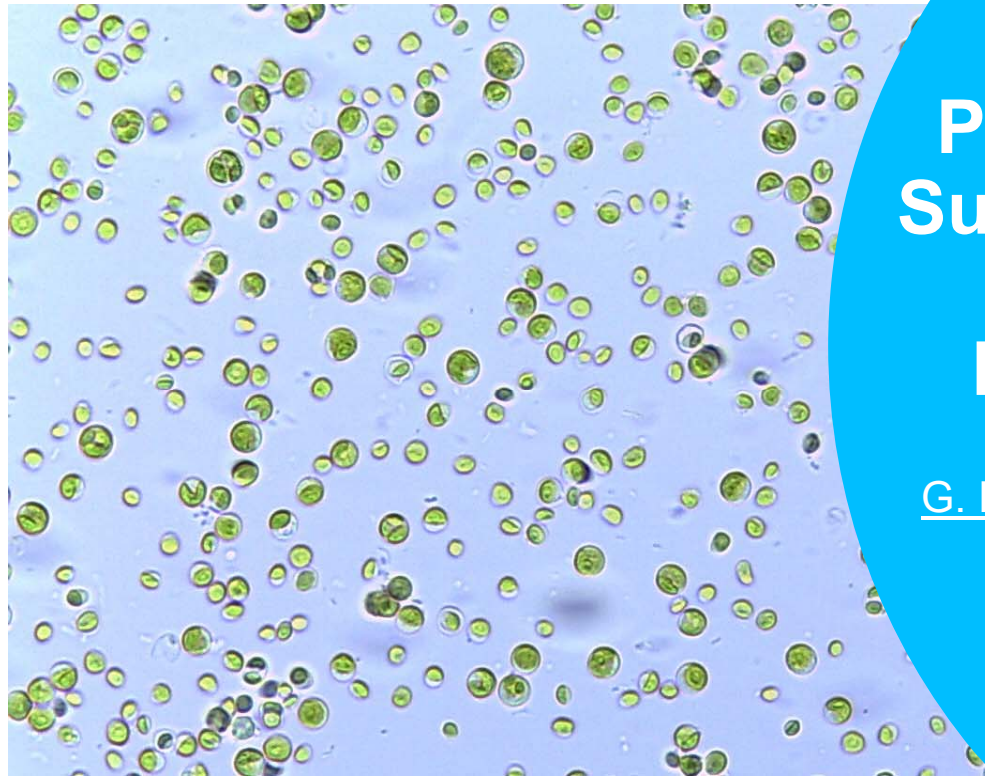


University of Stuttgart  
Institut of Space Systems



# PBR@LSR – A Hybrid Life Support System Experiment and Technology Demonstrator at the ISS

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

H. Hartstein (Airbus DS)

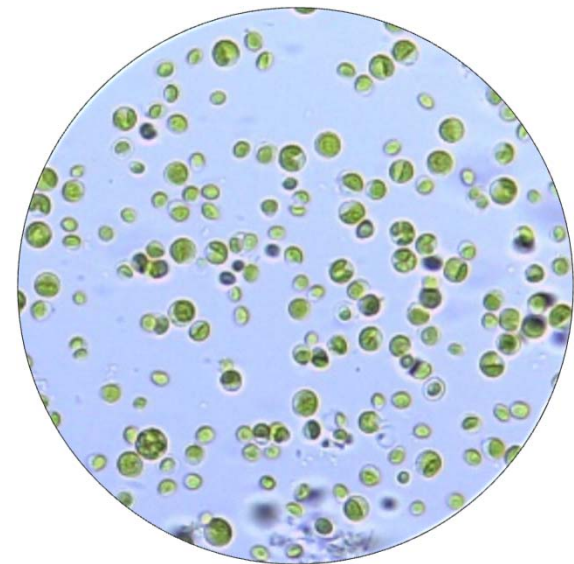
O. Angerer (DLR)

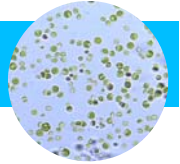
AgroSpace-MELiSSA workshop, 16 – 18 May 2018

 Institute of  
Space Systems

# PBR@LSR – A Hybrid Life Support System Experiment and Technology Demonstrator at the ISS

1. Introduction
2. Experiment Development
3. Flight Experiment
4. Conclusions





## 1. Introduction

### Why a Hybrid LSS?



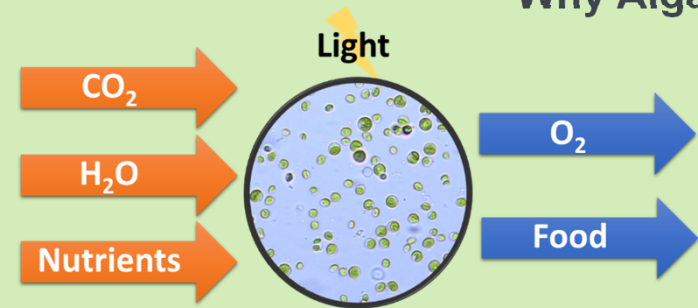
© NASA



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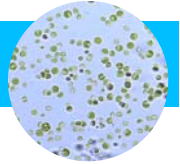


### Why Algae?



- High harvest index
- High biomass productivity
- Low water demand
- High light exploitation
- ...

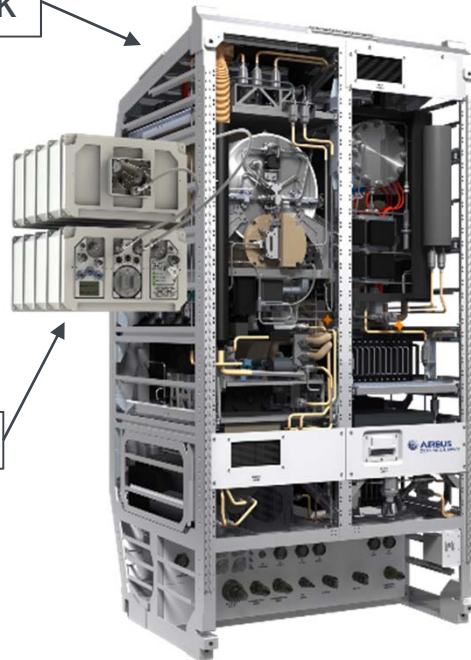
# PBR@LSR – A Hybrid LSS Experiment and Technology Demonstrator at the ISS



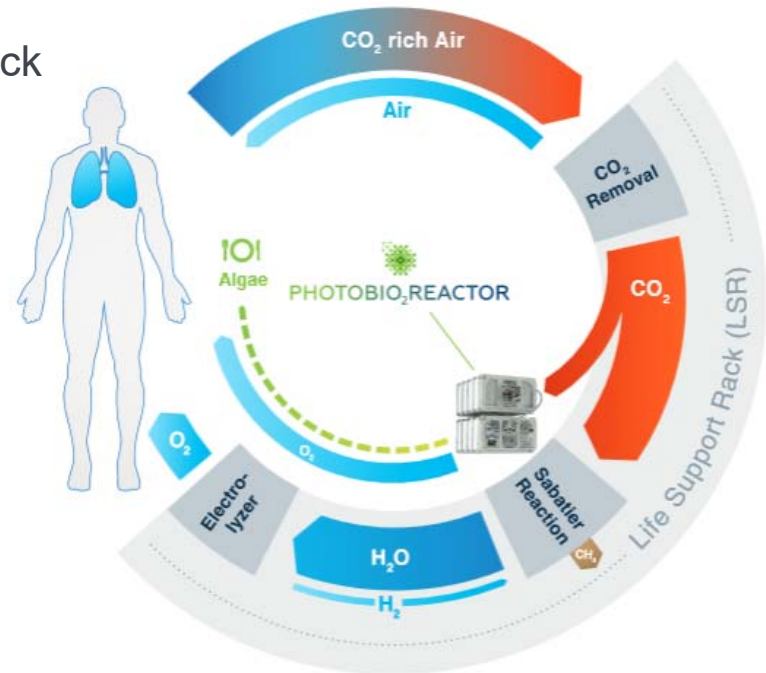
## 1. Introduction

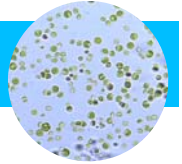
**PBR@LSR** = Photobioreactor @ the Life Support Rack

Life Support Rack



Photobioreactor





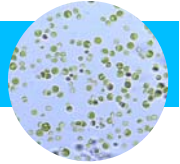
## 1. Introduction



# PHOTOBIO<sub>2</sub>REACTOR

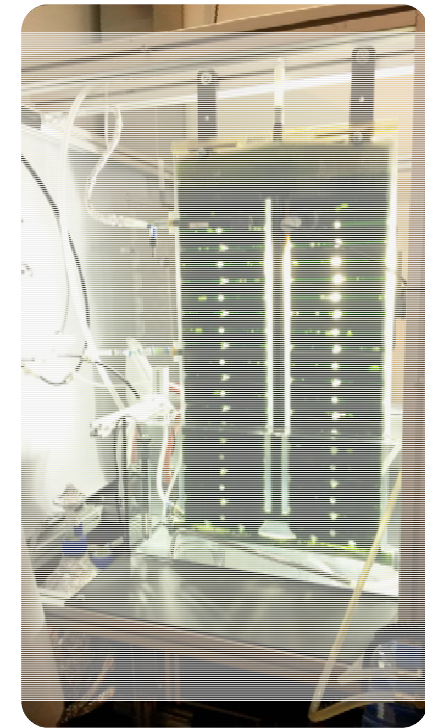
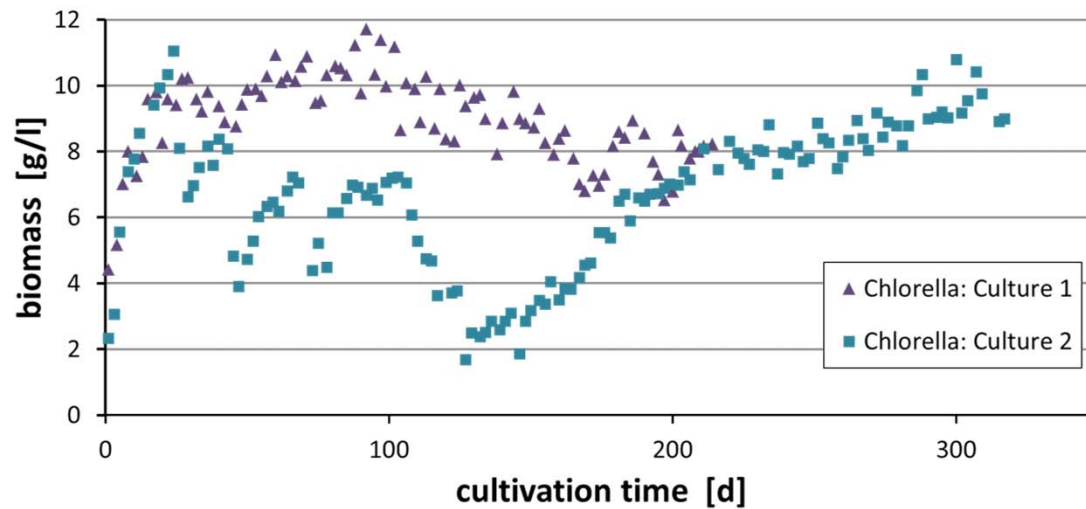
### The goals are:

- functionality and feasibility of the hybrid system in a real environment
  - the short- and long-term performance of photosynthetic conversion of concentrated CO<sub>2</sub> into biomass and O<sub>2</sub>
- stability of the algae system in a real environment (μg, radiation)

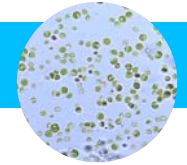


## 2. Experiment Development

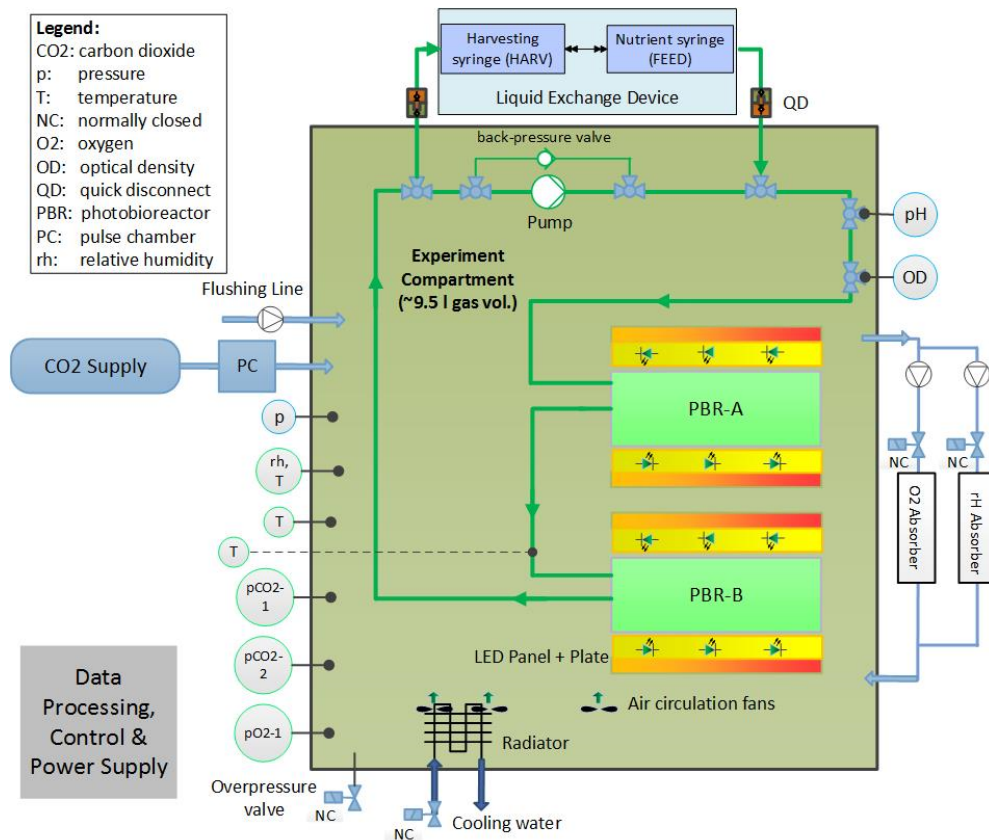
- Since 2010, @ IRS cultivation of *Chlorella vulgaris*
  - Unicellular, spherical, immobile organism,  $\varnothing$  4-10  $\mu\text{m}$
  - Non-axenic culture



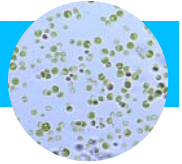
Flat Panel Airlift PBR 



## 2. Experiment Development



© Airbus DS

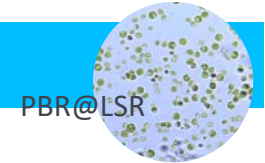


## 2. Experiment Development

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

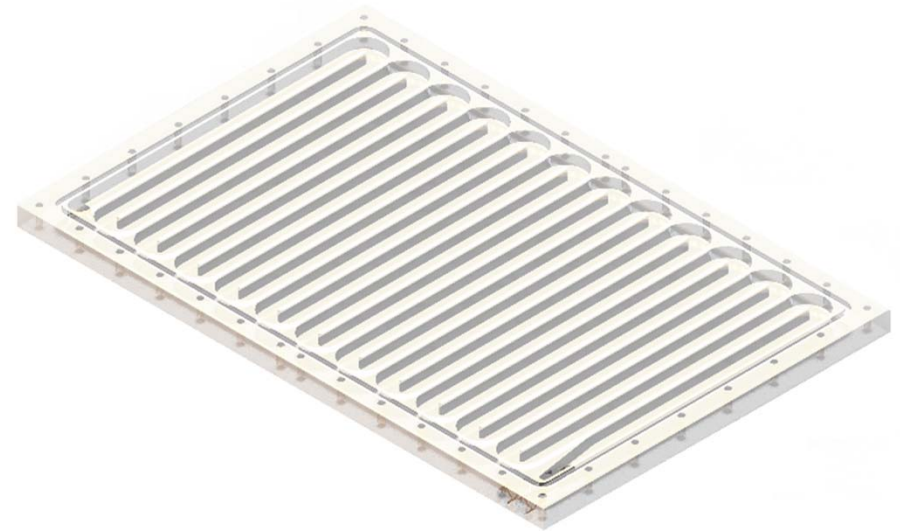
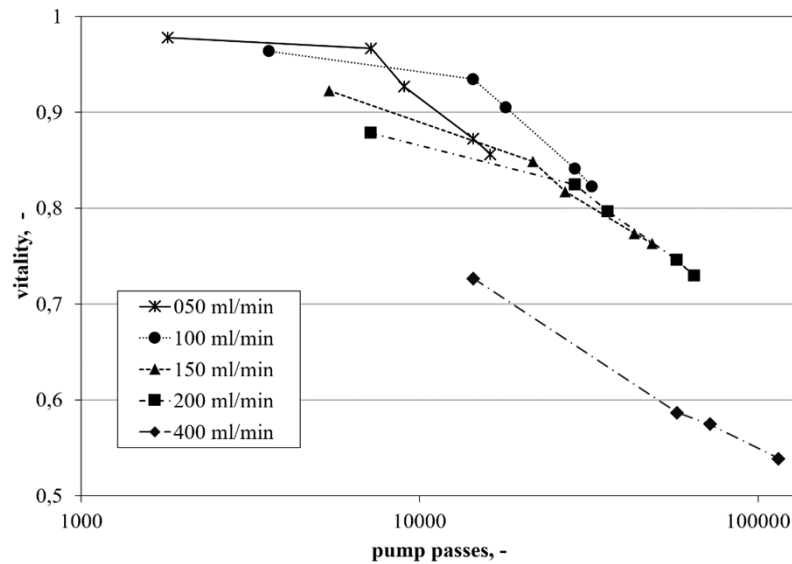
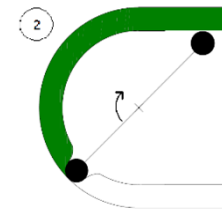
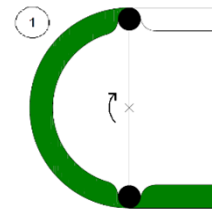
- Biology
  - nutrient supply ✓
  - thermal stress ✓
  - material compatibility ✓
  - sensors ✓
  - lighting regime ✓
  - bacterial stress ✓
  - pre and post experiment storage ✓
- Engineering
  - sizing ✓
  - thermal balancing ✓
  - pump selection ✓
  - lighting selection ✓
  - reactor optimization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

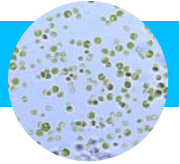




## 2. Experiment Development

- Algae-loop





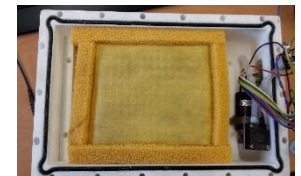
## 2. Experiment Development

### • Gas Handling

- CO<sub>2</sub> supply via pulse chamber
- Gas mixing in Experiment Compartment (EC) via fans
- Gas transfer from liquid Algae Suspension Loop to gaseous phase in EC and vice versa via membrane
- O<sub>2</sub> reduction via absorber
- Humidity Control via absorber



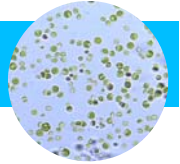
Membrane



O<sub>2</sub> absorber

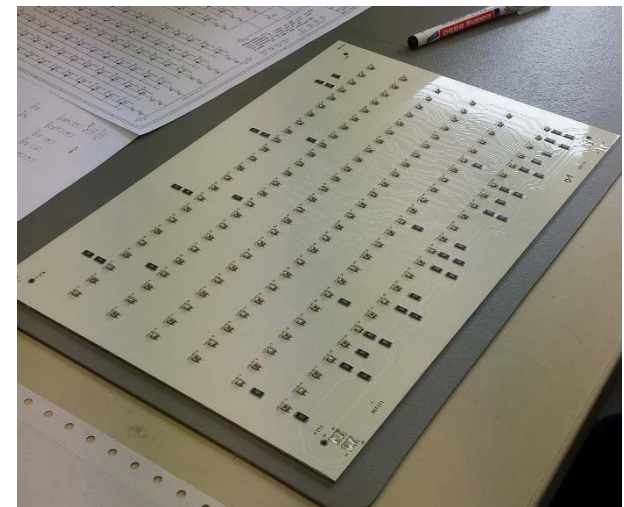
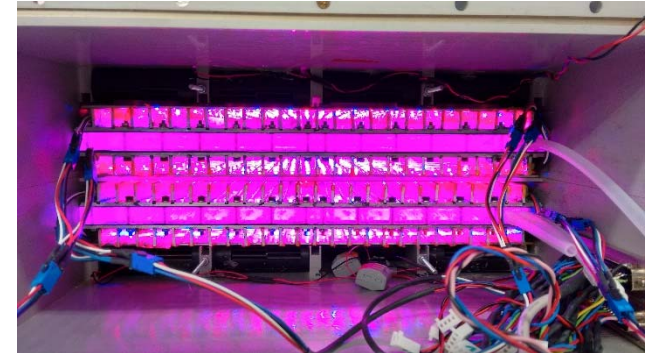
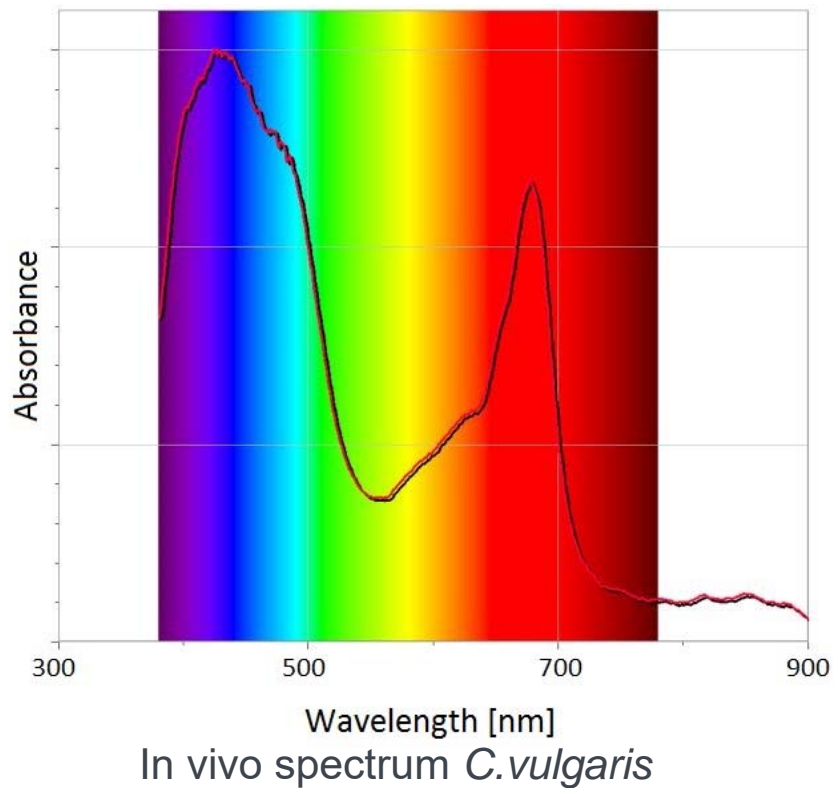


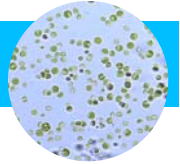
rh absorber



## 2. Experiment Development

- Lighting





## 2. Experiment Development

### • Reactor Assembly

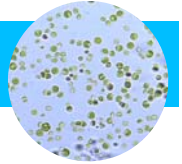


### • Sensors

- P, T, rh, CO<sub>2</sub>, O<sub>2</sub>
- Biomass conc., pH

### • Actuators

- T/C, CO<sub>2</sub> pulse chamber, O<sub>2</sub> absorber, Pump, Liquid Exchange Device, rh absorber

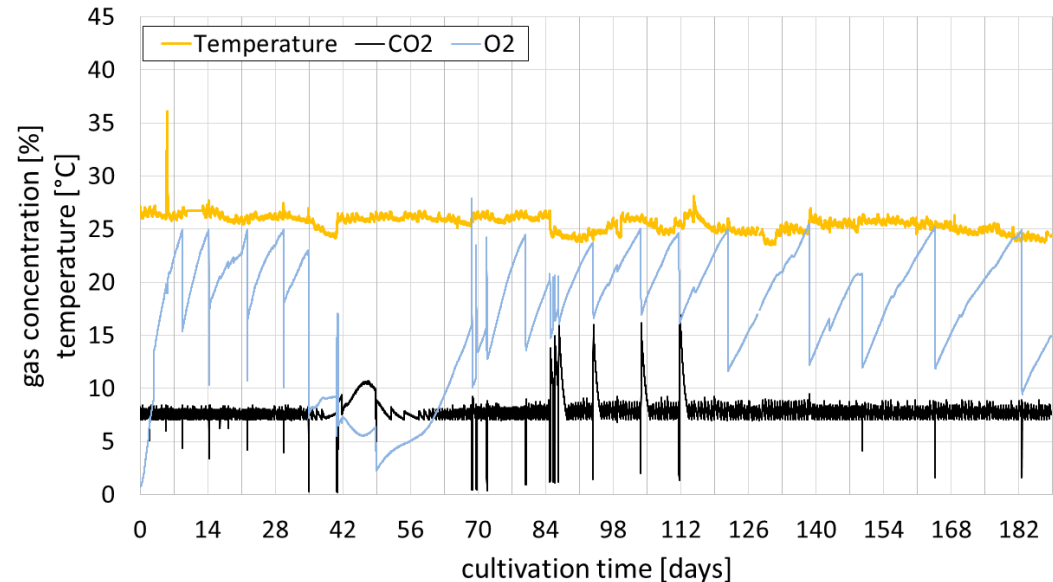


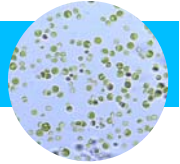
## 2. Experiment Development

Pre-flight experimentation on prototypes (Breadboard 3)

### 180-days Experiments

- September 2016 - March 2017
- June – December 2017



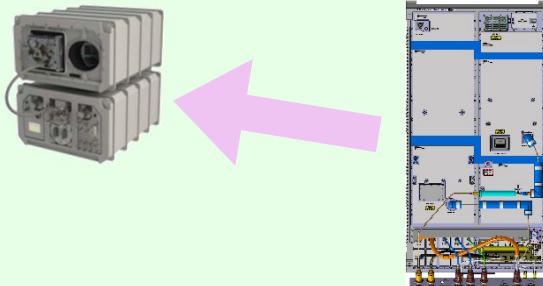


### 3. Flight Experiment

*Installed in Express Rack 1, Lockers 7&8, LAB102*

#### Primary mode

*CO<sub>2</sub> provided by  
Life Support Rack*



passive module



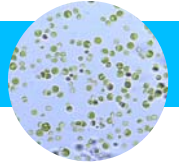
#### Standalone mode

*CO<sub>2</sub> provided by gas bottle*

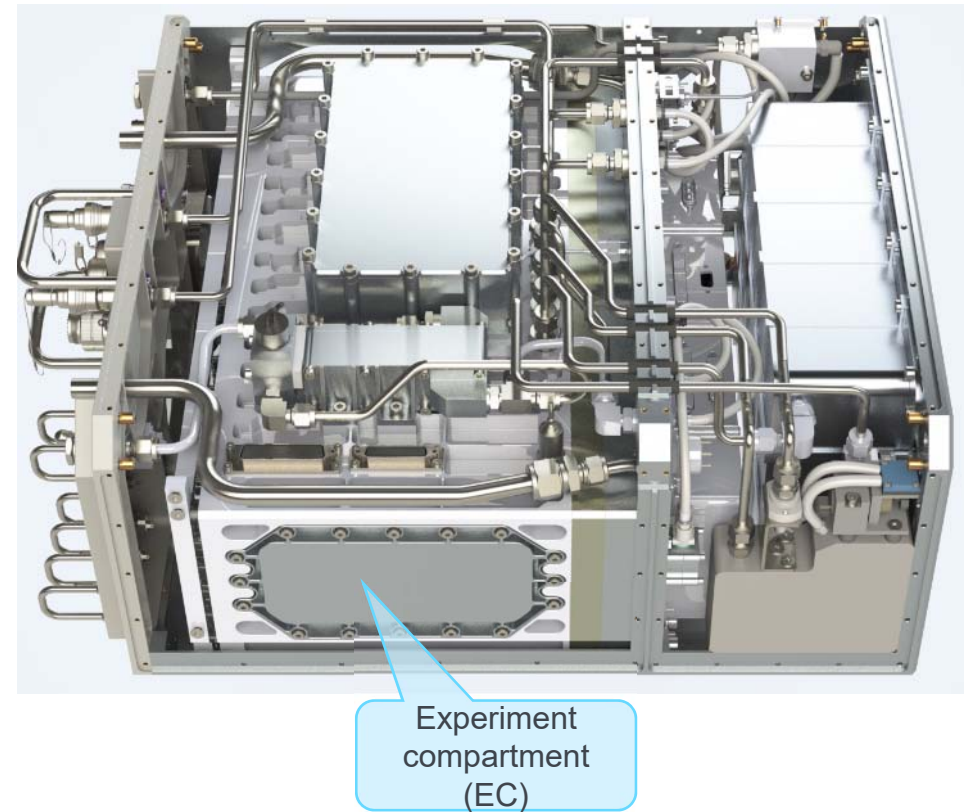
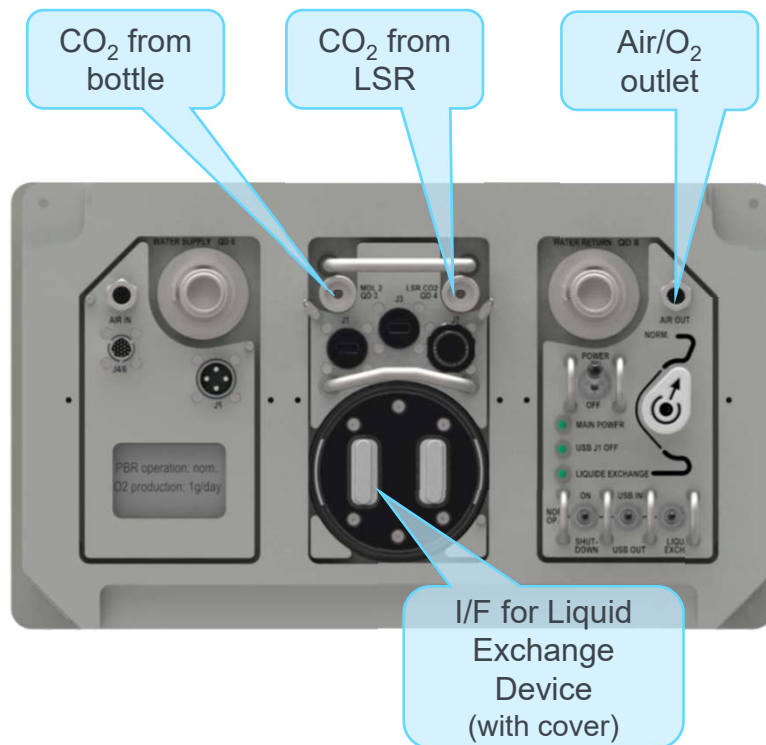
Required to ensure  
continuous operations  
when LSR is off

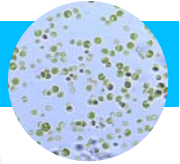
Supply sufficient  
for ~150 days

active module



## 3. Flight Experiment





## 3. Flight Experiment

- Liquid exchange device (LiED)

used by Astronauts for:

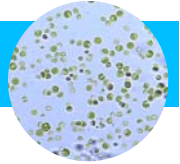
- Medium/Algae inoculation
- Nutrients provision
- Termination
- harvesting (sample collection)

Dedicated syringes

connection to experiment's F/P

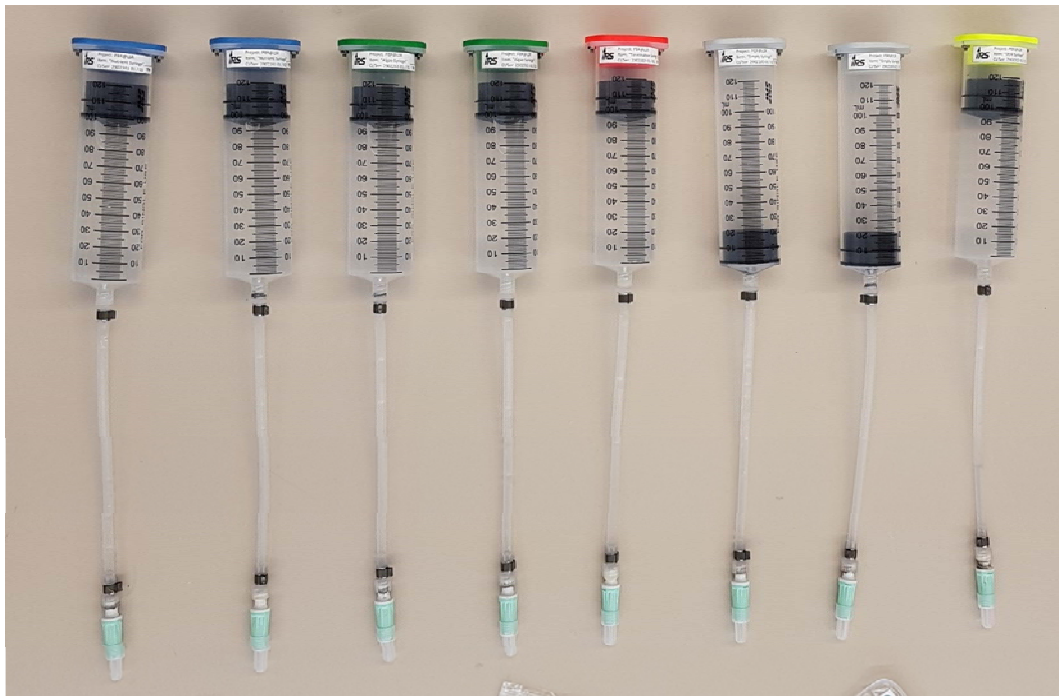




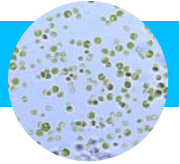


## 3. Flight Experiment

- Syringes

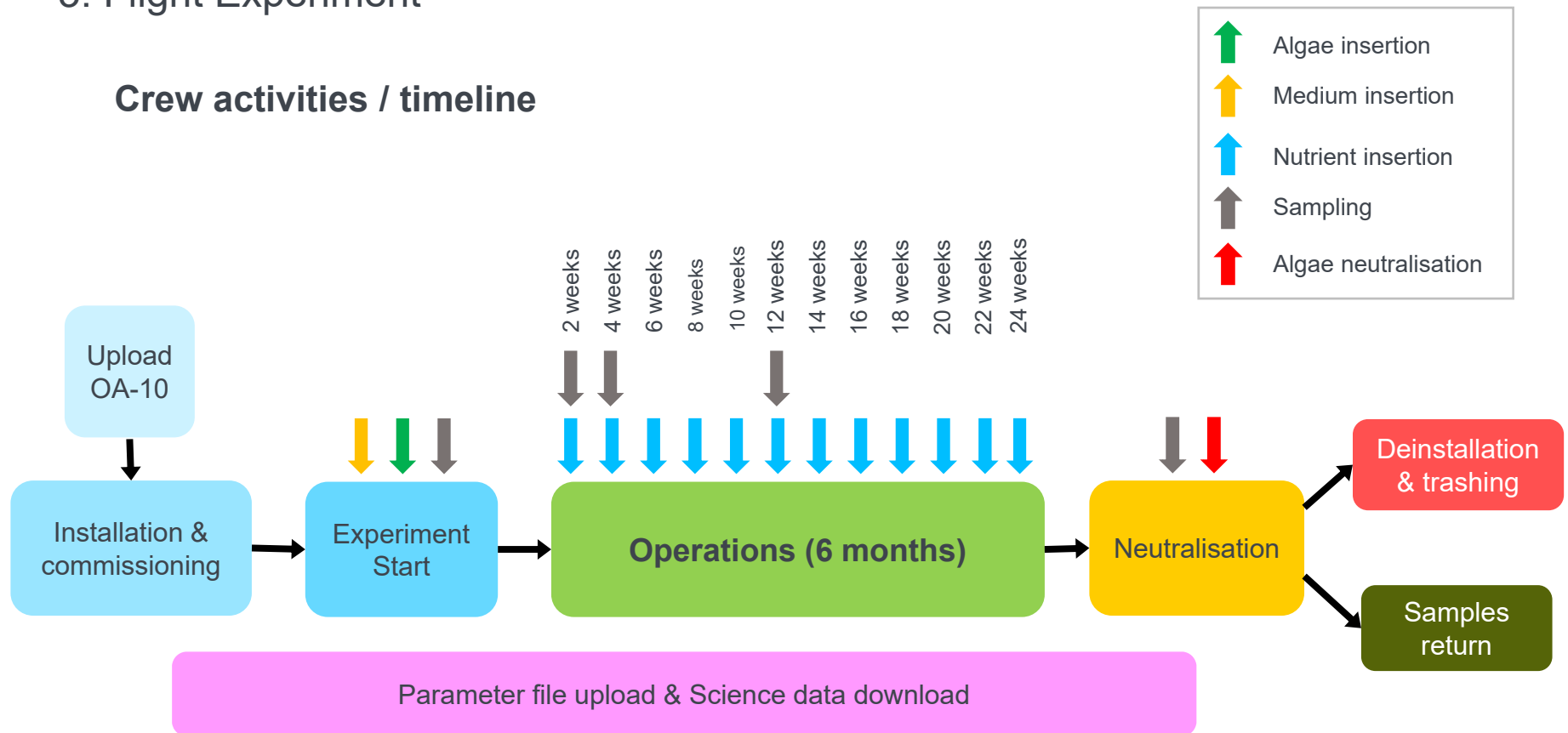


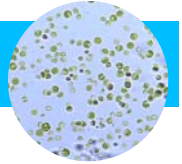
- Contain *fixation liquid* (PVP)
- Will be returned to ground
- Stowed: 4 °C before use  
-80 °C when filled with algae



## 3. Flight Experiment

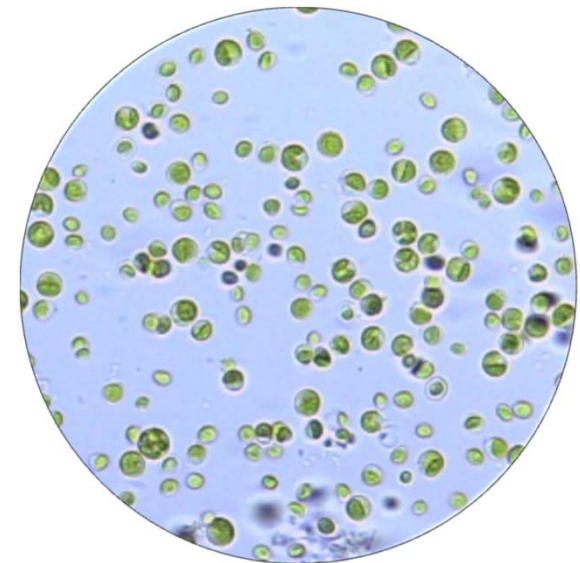
### Crew activities / timeline





### 4. Conclusions

- Hybrid Life Support Systems for future exploration missions might be required
- Algae could be a complement to current existing physico-chemical systems
- The Experiment PBR@LSR will test this hybrid approach and the long-term performance and stability of an algae-based biological component
- The experiment will start in November 2018 and last for up to 6 months!





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