



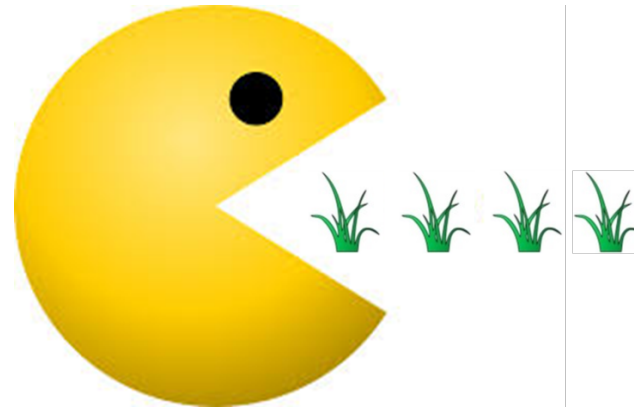
**PACMAN project: Designing, building and testing the prototype  
of a Plant Characterization Unit**

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MELISSA



## PaCMan Project

PIAnt Characterization unit for closed life support system  
engineering, MANufacturing & testing



# Partners



Coordinator, Engineering, Procurement



Engineering and Manufacturing



Hydroponic Sensors



Control System



Requirements, Life Test

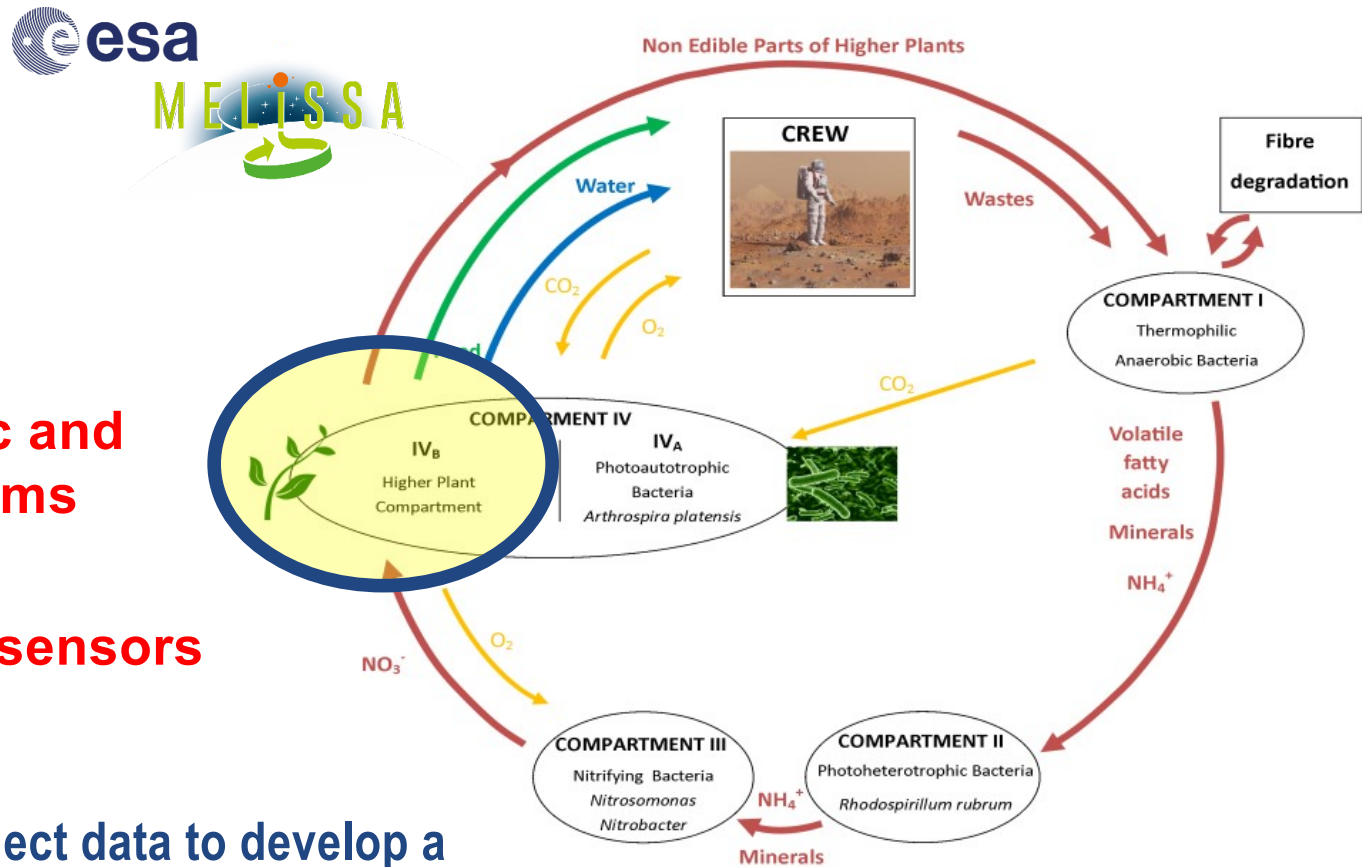


# Outline

- Requirements and motivation
- Major functionalities
- First achievements

# Requirements and motivation

# PaCMAN – Serving MELiSSA compartment IV



Leak Rate

Separate Hydroponic and Atmospheric systems

State of the art sensors

The PCU scope is to collect data to develop a model which characterizes higher plants growth

# PaCMAN objective and development

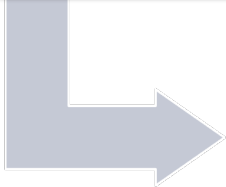
Design

- Atmospheric and Hydroponic units
- Sealed System
- Advanced measures and sensors
- Automated control



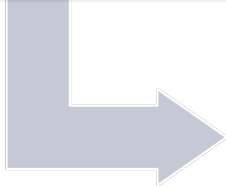
Procurement

- Equipment
- Sensors
- DAQ (Hardware & Software)



Manufacturing & Assembly

- Manufacturing and assembly of the complete system
- Functional testing



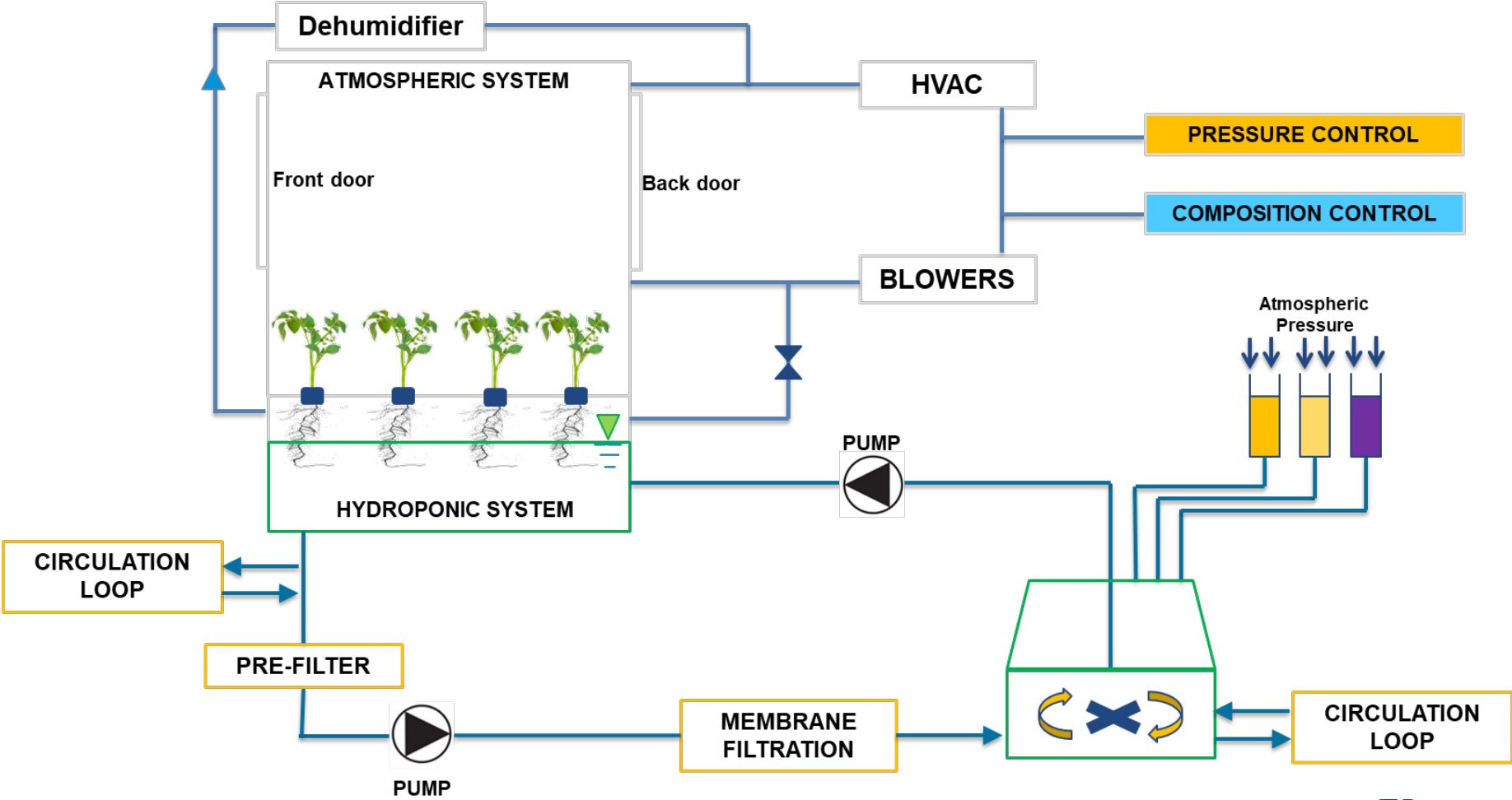
Validation

- Life test

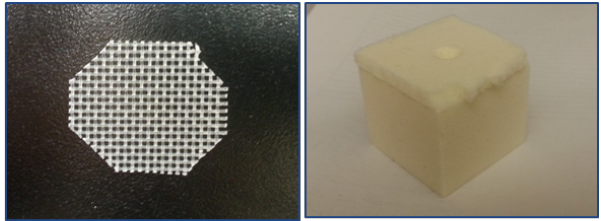
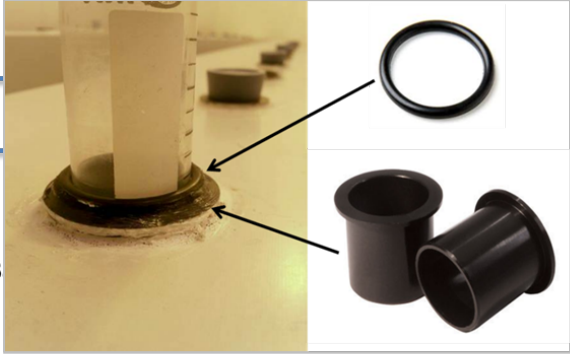
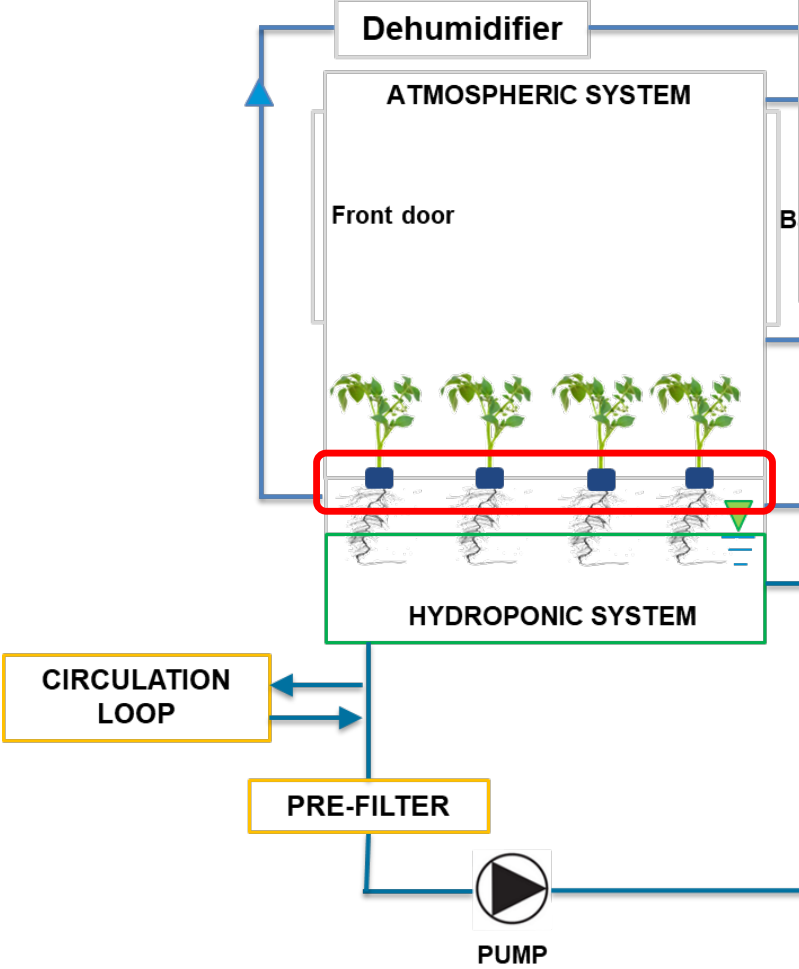
**Low Leak Rate**  
**Separate Hydroponic and Atmospheric systems**  
**State of the art sensors**

# Major functionalities

# System Architecture



# Plant Gully Interface







# Nutrient Delivery System



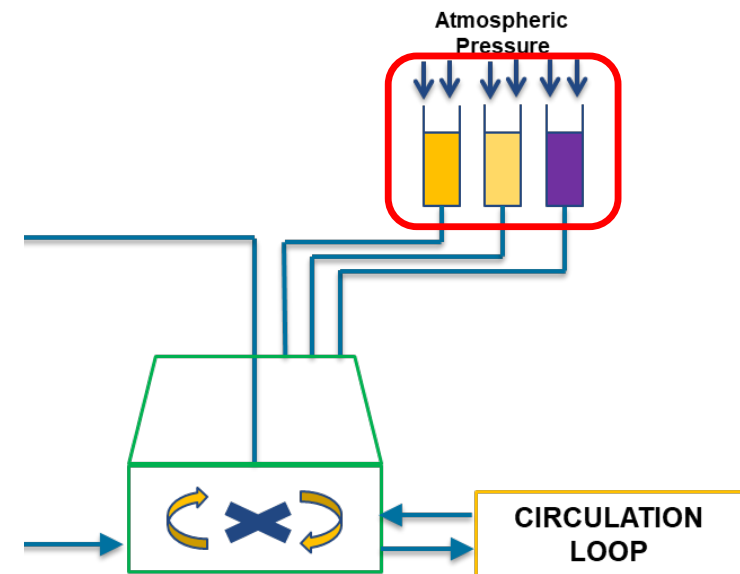
Monitoring and automatic control of pH and EC

- Automatic delivery of acid, base and 8 nutrient stock solutions (10 tanks)
- Stock solutions delivered by peristaltic pumps
- Liquid volume in tanks monitored by automatic logging of scales

Recipe Flexibility

- Advanced EC control
- Supported by advanced ions monitoring

## 8 Stock Solutions + Acid and Base



# Advanced Monitoring

- Controlled variable: EC, pH, T
- Monitored variable: DO<sub>2</sub>, DCO<sub>2</sub>, NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>, Ca<sub>2</sub><sup>+</sup>, K<sup>+</sup>, Na<sup>+</sup>, Cl<sup>-</sup>, Mg<sub>2</sub><sup>+</sup>, HPO<sub>4</sub><sup>2-</sup>

## Circulating Chambers

- Allow to easily isolate sensors for recalibration.

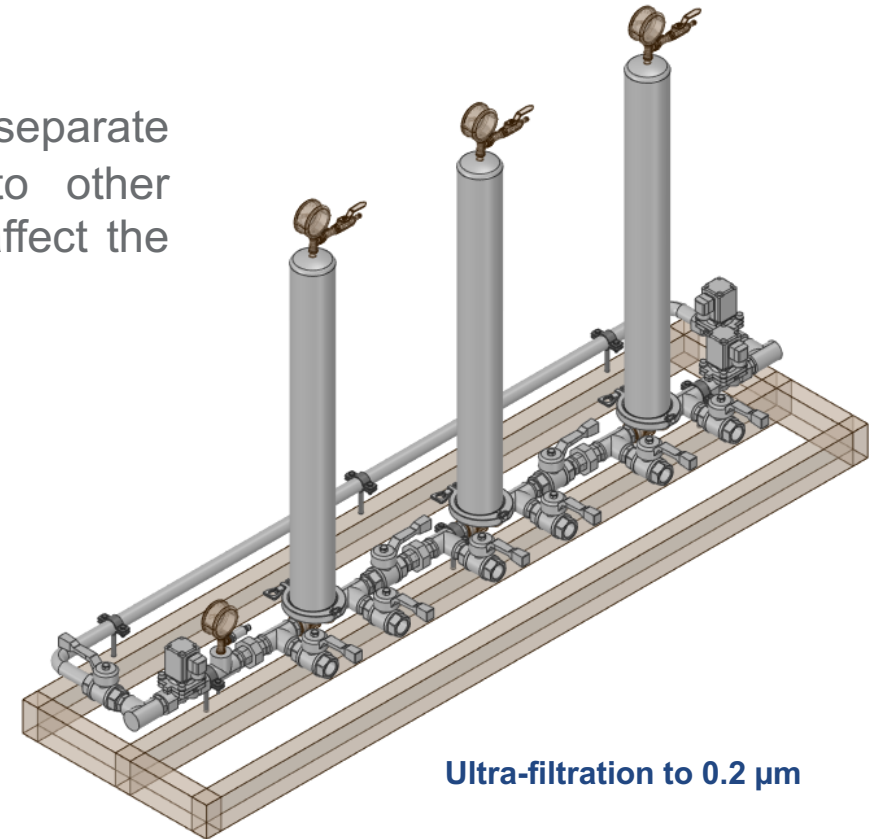
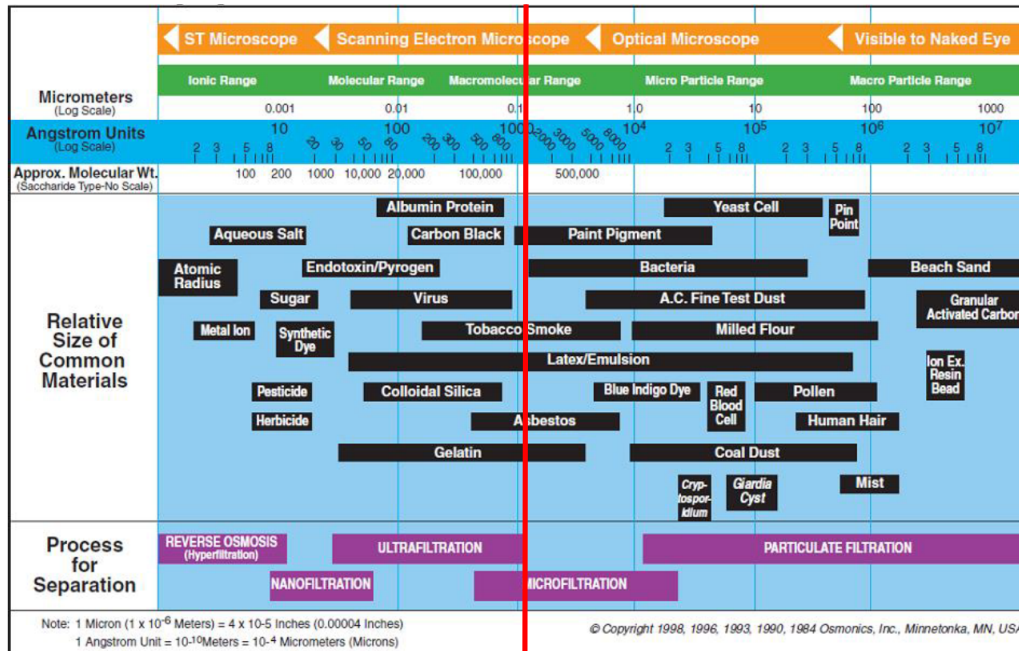
## Dilution Chamber

- Allows to implement nitrates sensor for “at line” monitoring.



# Membrane Filtration

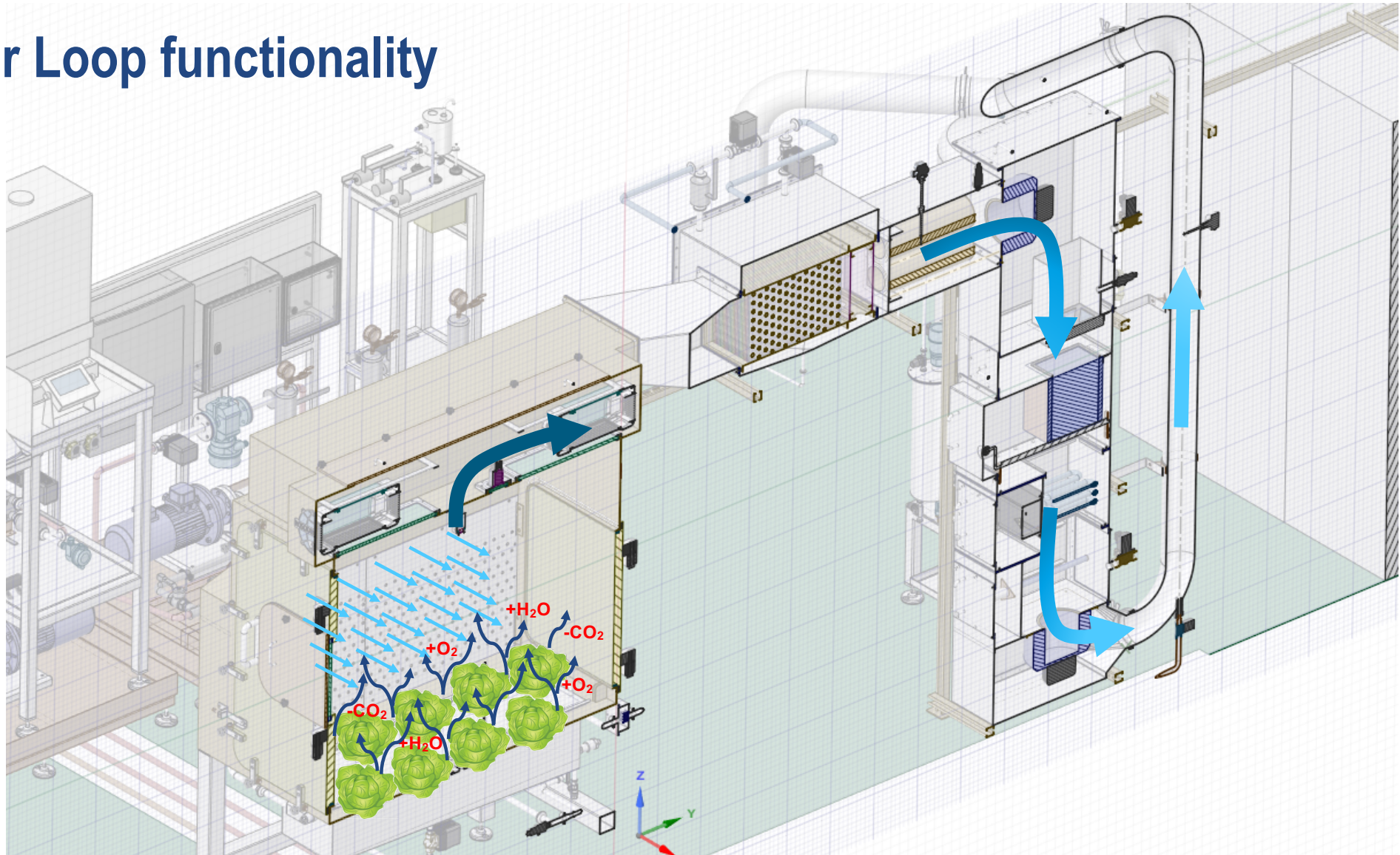
Three membranes with different pore-size to separate microorganisms and suspended particles. Compared to other sterilization techniques it has the main advantage not to affect the nutrient solution



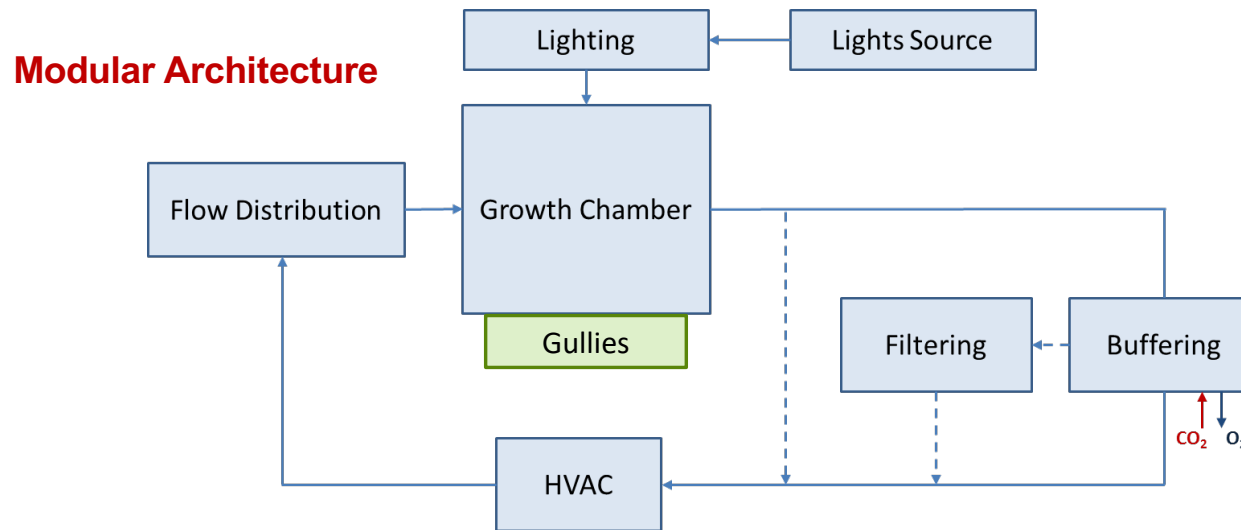
Ultra-filtration to 0.2 µm



# Air Loop functionality



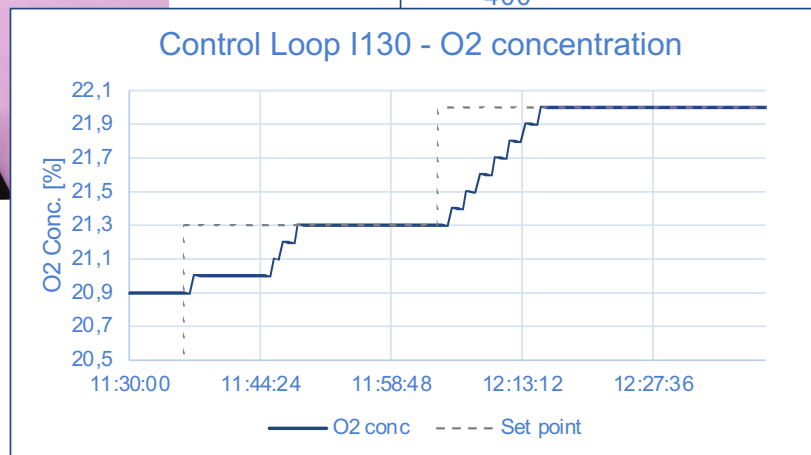
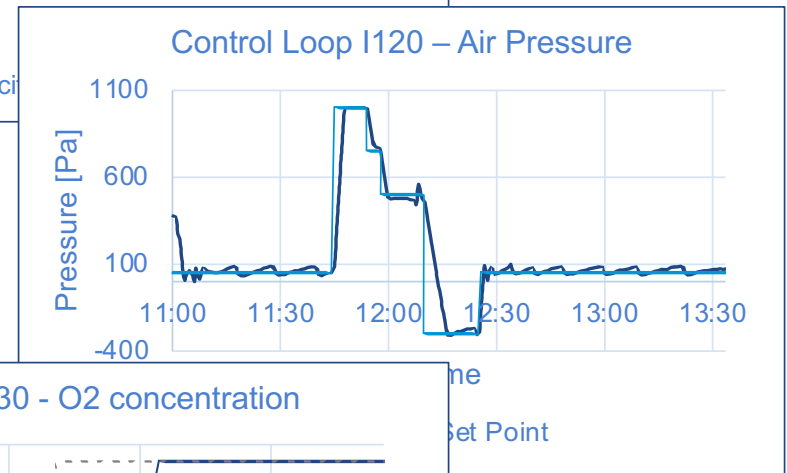
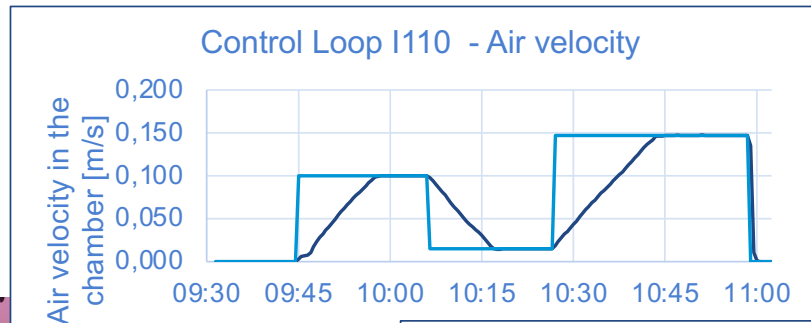
# Air Loop functionality - Modularity



1. **Unit level:** the basic seven units are assembled with a rack-like approach, where each unit can be easily isolated or retrofitted for upgrades or redesign
2. **Component level:** each component is easily reachable for maintenance or replacement

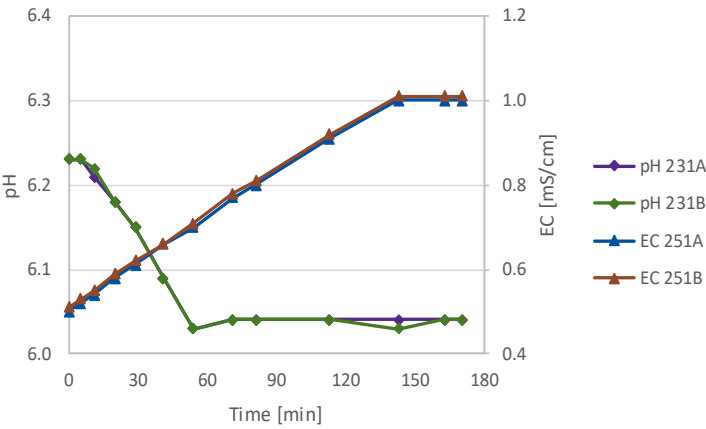
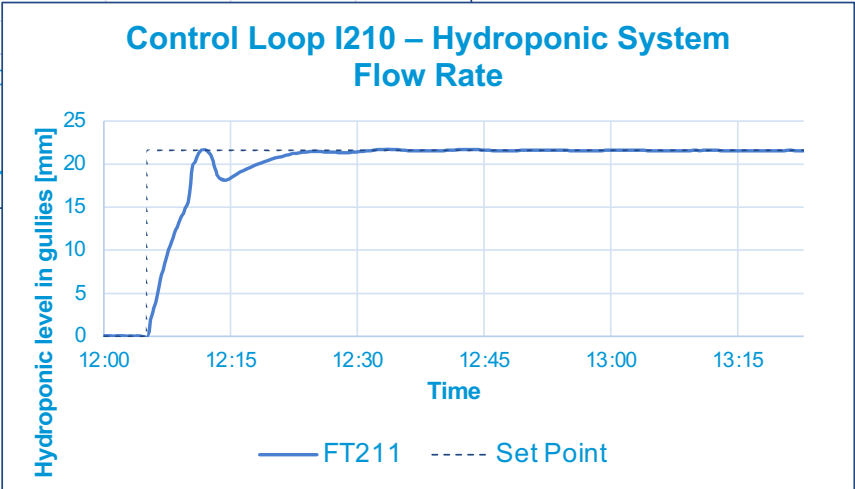
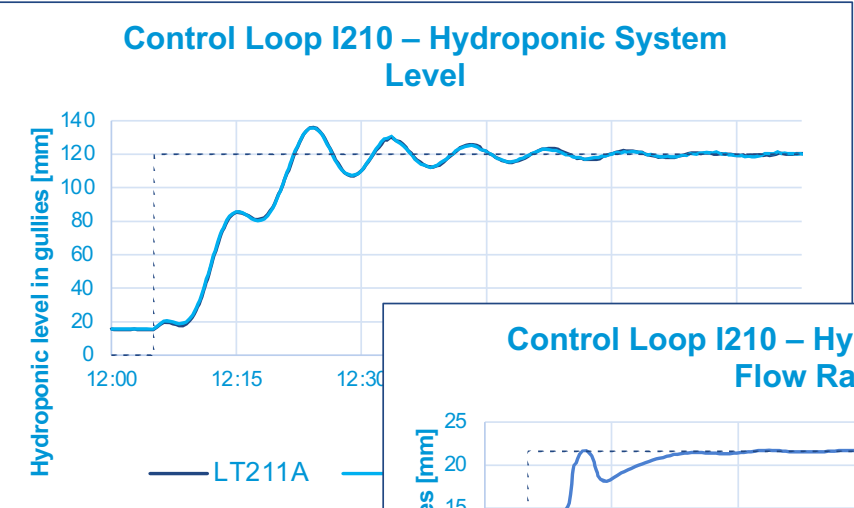
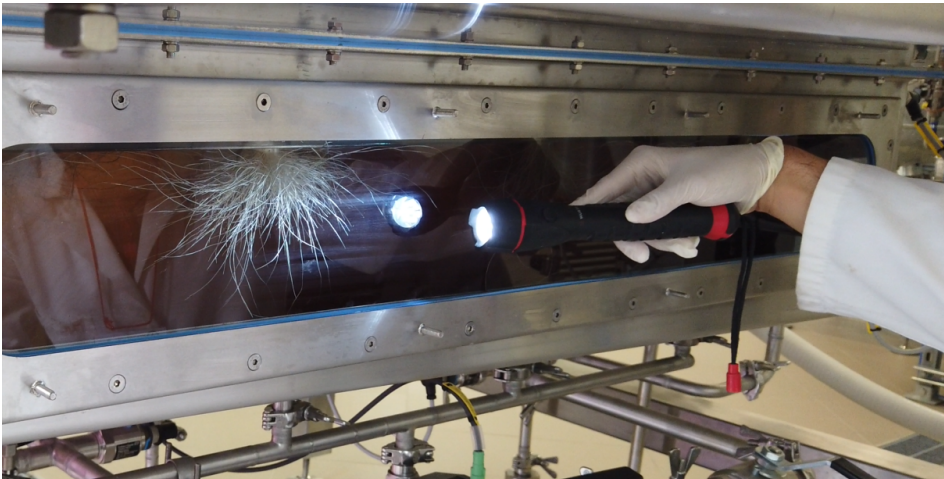
# First achievements

# Atmospheric system testing





# Hydroponic System testing



# Challenge: Mass balances assessment

One of the main objectives of the PCU is to characterize the plant behavior during the photosynthesis and respiration phases:

- Water renewal
- CO<sub>2</sub> consumption
- O<sub>2</sub> production



**Leakage is a critical issue considered during the design of the system.**

# Anti-leakage strategy

## Leak requirements

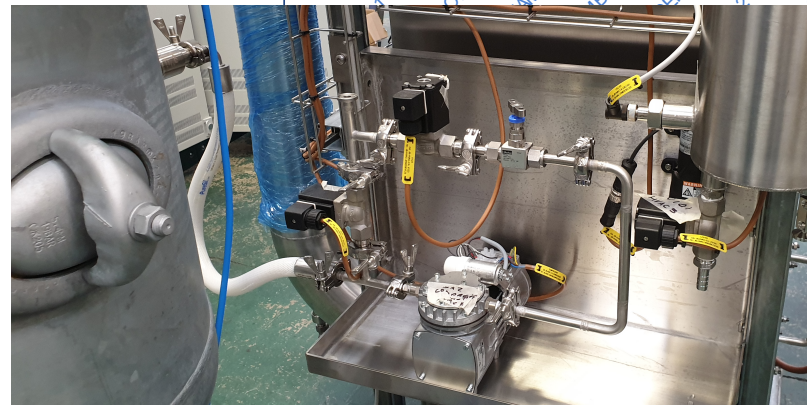
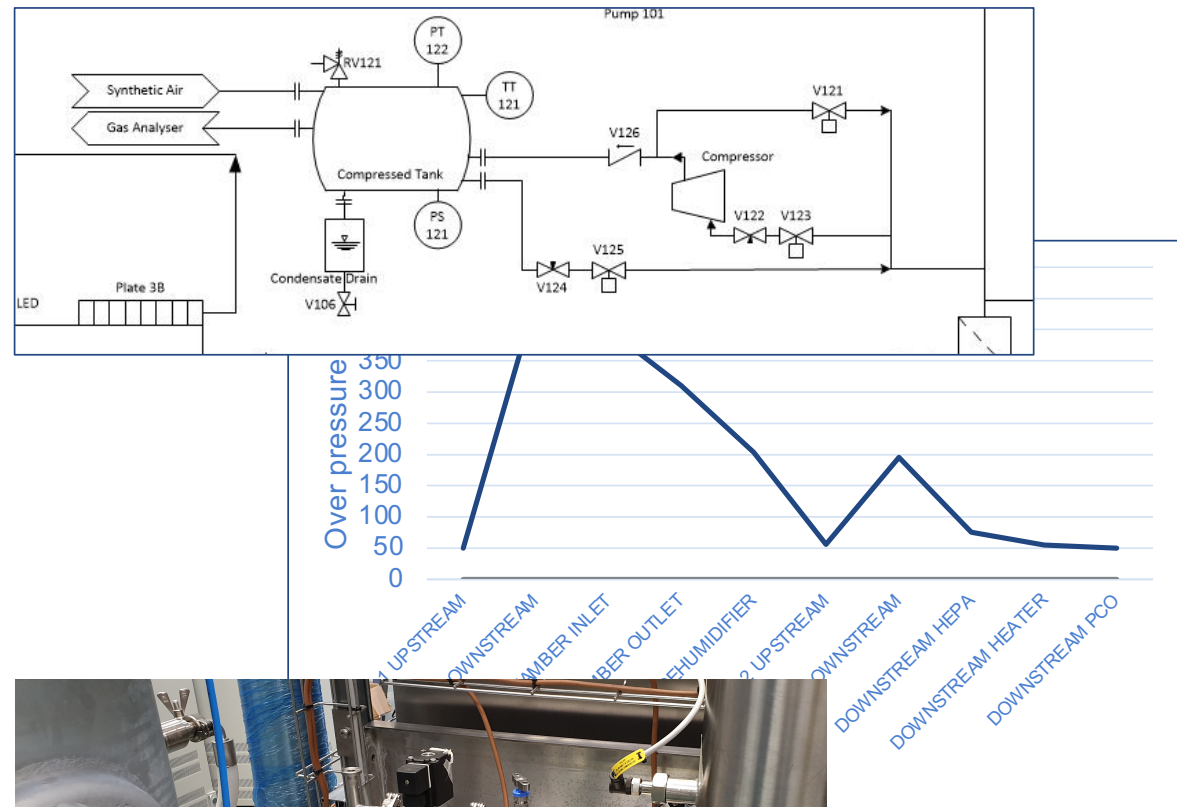
Leak rate below 0.05%  
Requirement demand higher than known industry standard

## Automated Pressure compensation system

Control system ensures to keep gradients from external environment below 50Pa

## High quality gaskets and pressurized seals

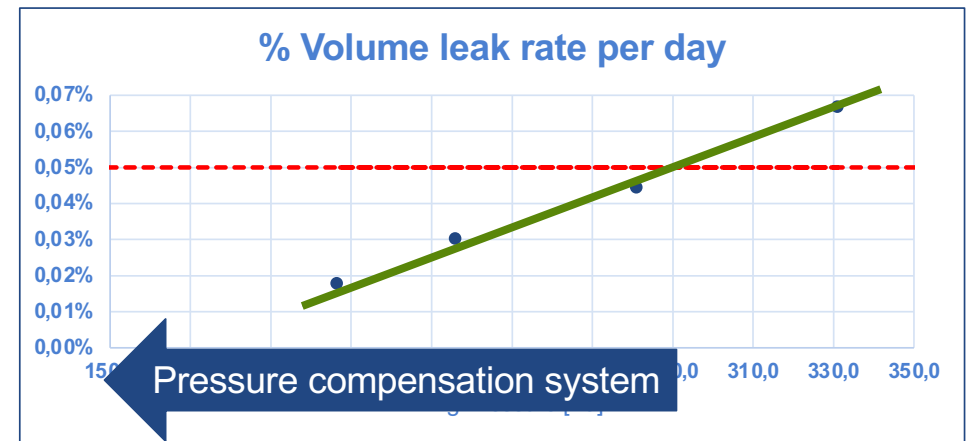
Airtight door closure is achieved using inflatable seals.



# Anti-leakage strategy: performance

## Pressure decay test

Verifies the performance of the sealing of the system

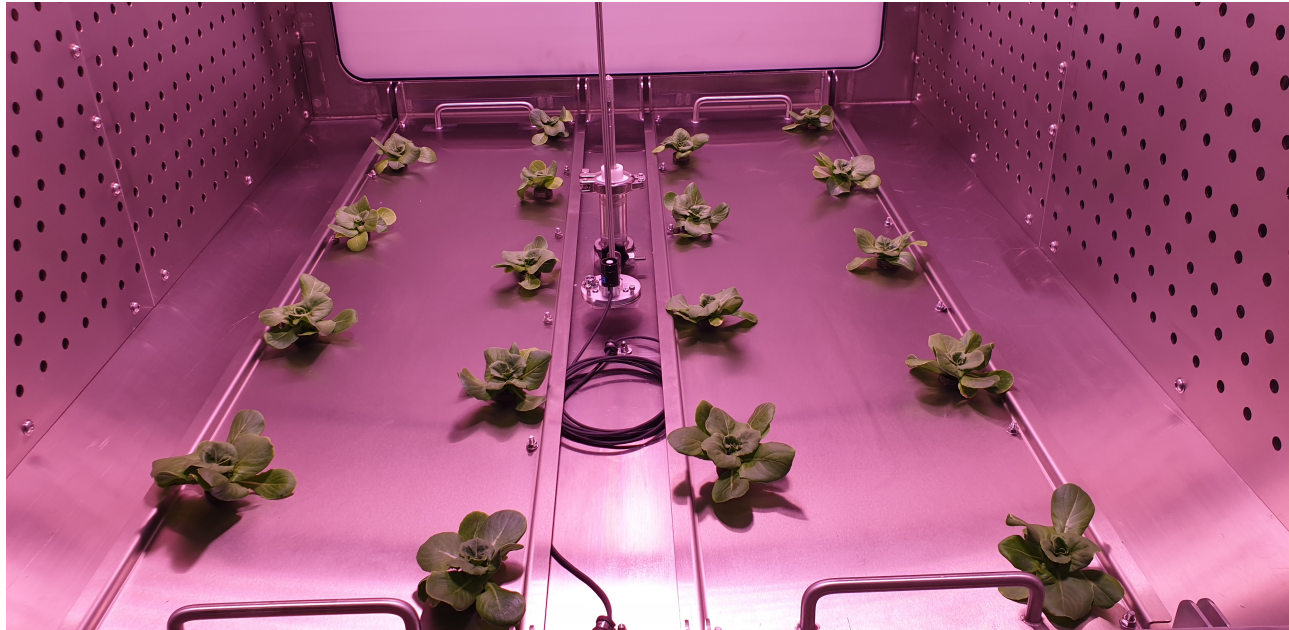


Results achieved comparable with the nuclear industry standard

*The anti-leakage property of the PCU gives the possibility to compute mass balances and allows reliable measurements for scientific testing.*



## Next steps



Life Test



*Thank you!*

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