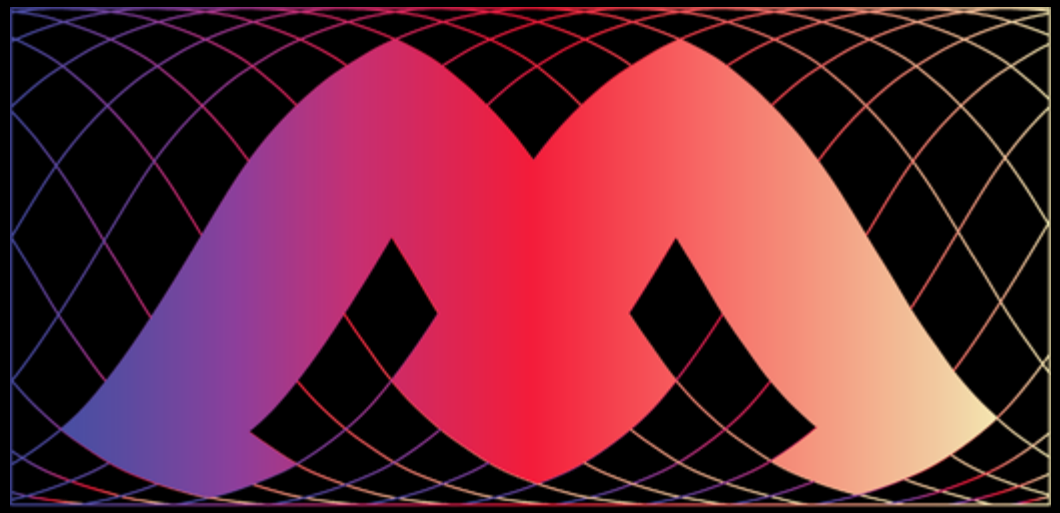


M.A.R.G.E.

The 6th
Mission Idea Contest
For Achieving Sustainable Development Goals with Human Spaceflight

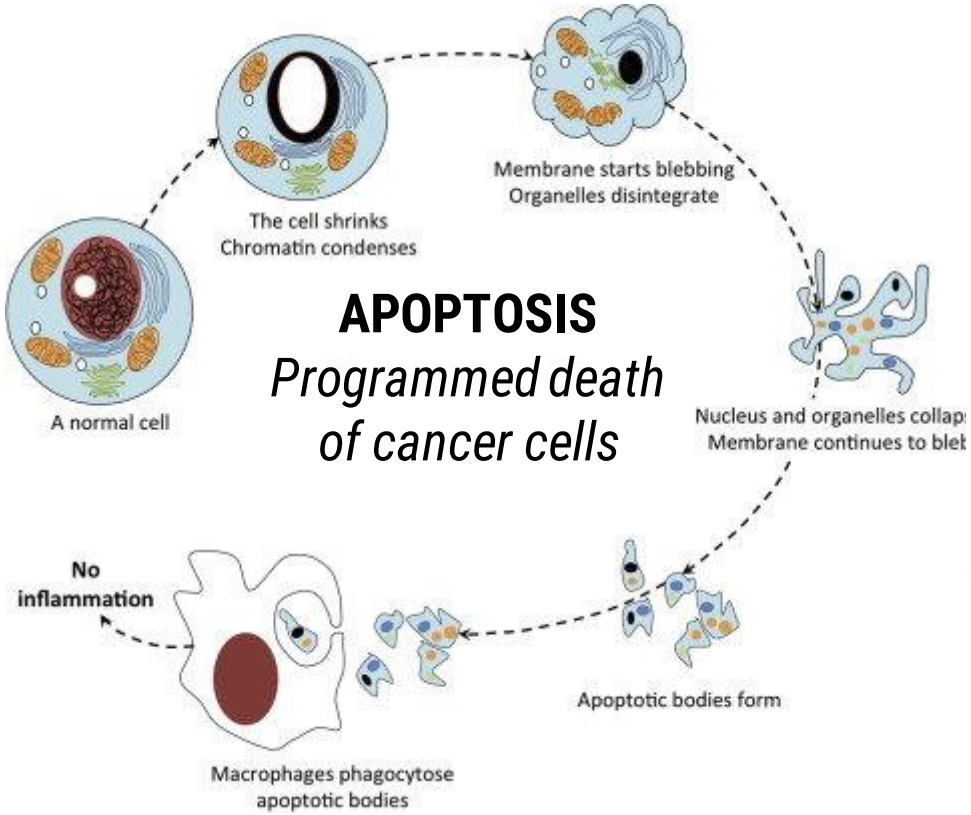
UNISEC GLOBAL
University Space Engineering Consortium

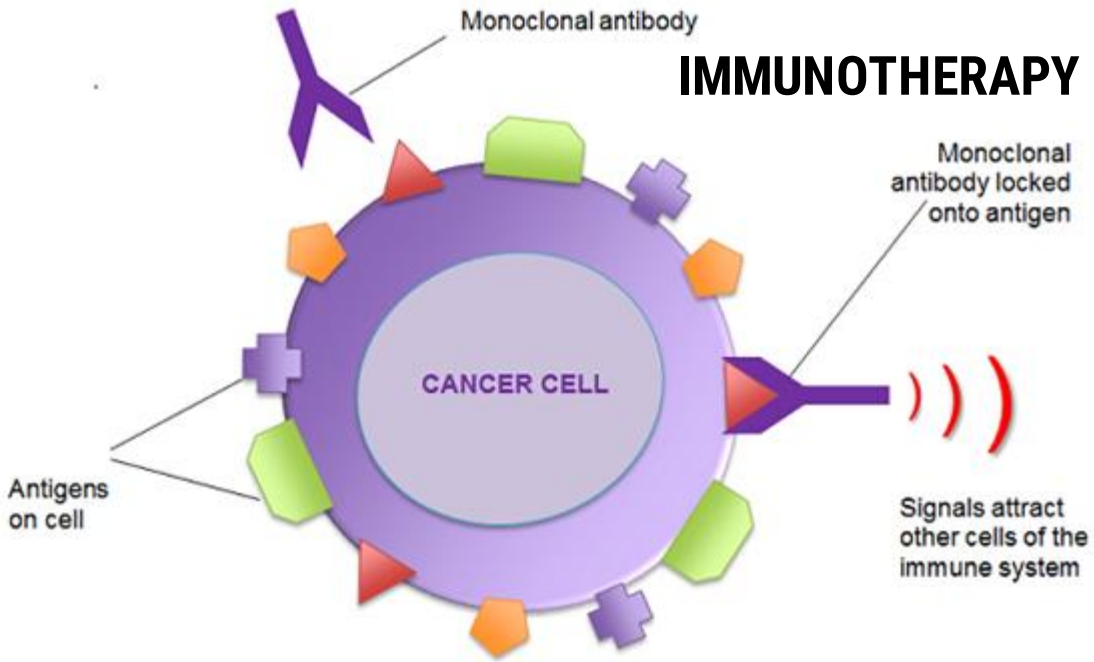
SAPIENZA
UNIVERSITÀ DI ROMA

CONTENTS

M.A.R.G.E.

Melanoma Apoptosis Reduced Gravity Experiment





SUSTAINABLE DEVELOPMENT GOALS

&

MISSION OBJECTIVES

3 GOOD HEALTH AND WELL-BEING

TO PROPOSE AN ALTERNATIVE CURE OF MELANOMA

9 INDUSTRIES, INNOVATION AND INFRASTRUCTURE

TO DESIGN A SMALL SCALE CELL CULTURE LABORATORY

17 PARTNERSHIPS FOR THE GOALS

TO FOSTER COLLABORATION BETWEEN AEROSPACE AND PHARMACEUTICAL INDUSTRIES

What is Melanoma?

Melanoma is a dangerous skin cancer that begins in cells called **melanocytes**.

It occurs when DNA damage from burning or tanning due to UV radiation triggers mutations in the melanocytes.

Risk Factors

FAMILY HISTORY

SUN EXPOSURE

FAIR SKIN

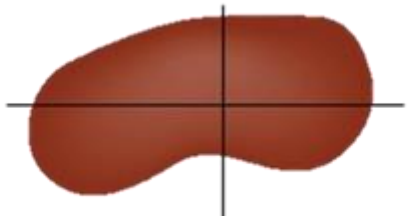
FRECKLES AND MOLES

AGE

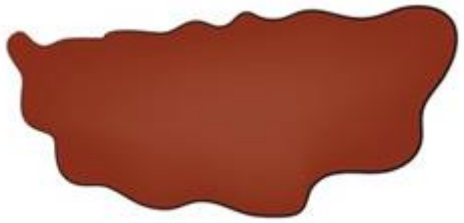
What to look for?

The ABCDE rule

Asymmetry



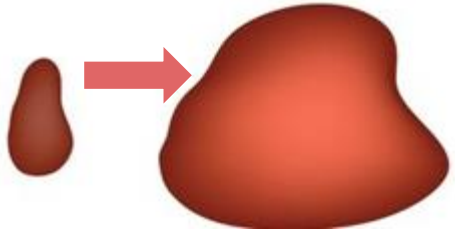
Border



Colour

Diameter

Evolution



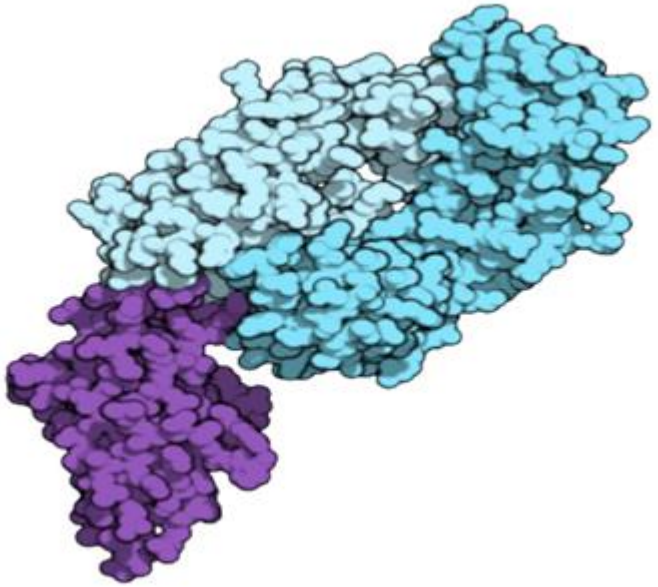
To make it easy for you to check your skin, dermatologist sum up these **simple steps** to detect skin cancer by **observing** the **moles** on the body.

Melanoma Therapy: how do you cure metastasized melanoma?

- Surgical excision
- **Immunotherapy**

Monoclonal antibodies:

- Nivolumab (Opvido)
- Vemurafenib (Zelboraf)

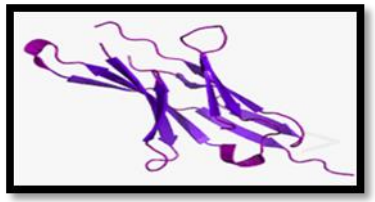


In 2018 James Allison and Tasuko Honjo won the **Nobel Prize in Phisiology and Medicine** for concluding successfully the study on how the immune system can be used to attack tumoral cells.

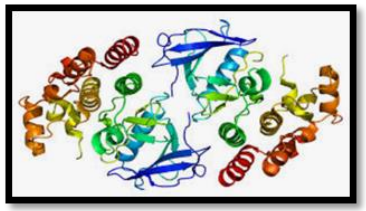
Pharmacodynamic

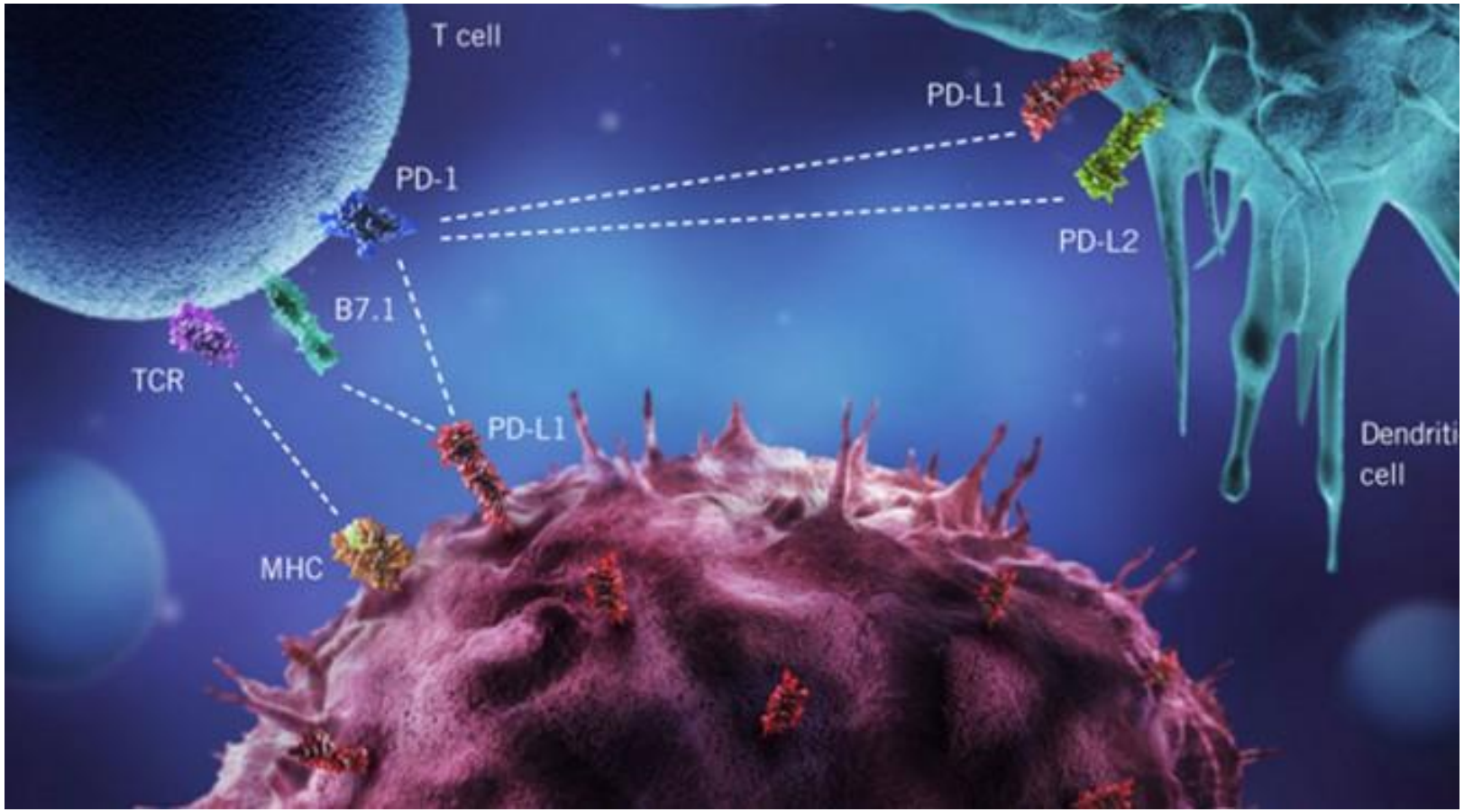
Therapeutic targets

- PD-1 Receptor



- BRAF Mutation





Combined effect of microgravity and immunotherapy

how could they act together?

MICROGRAVITY

IMMUNOTHERAPY

- Decrease focal adhesion
- Decrease invasion capacity
- Inhibition proliferation melanoma cells
- ***Apoptosis***

TUMOR REGRESSION

Concept

Studying the combined effect of microgravity and immunotherapy on cultures of melanoma cells

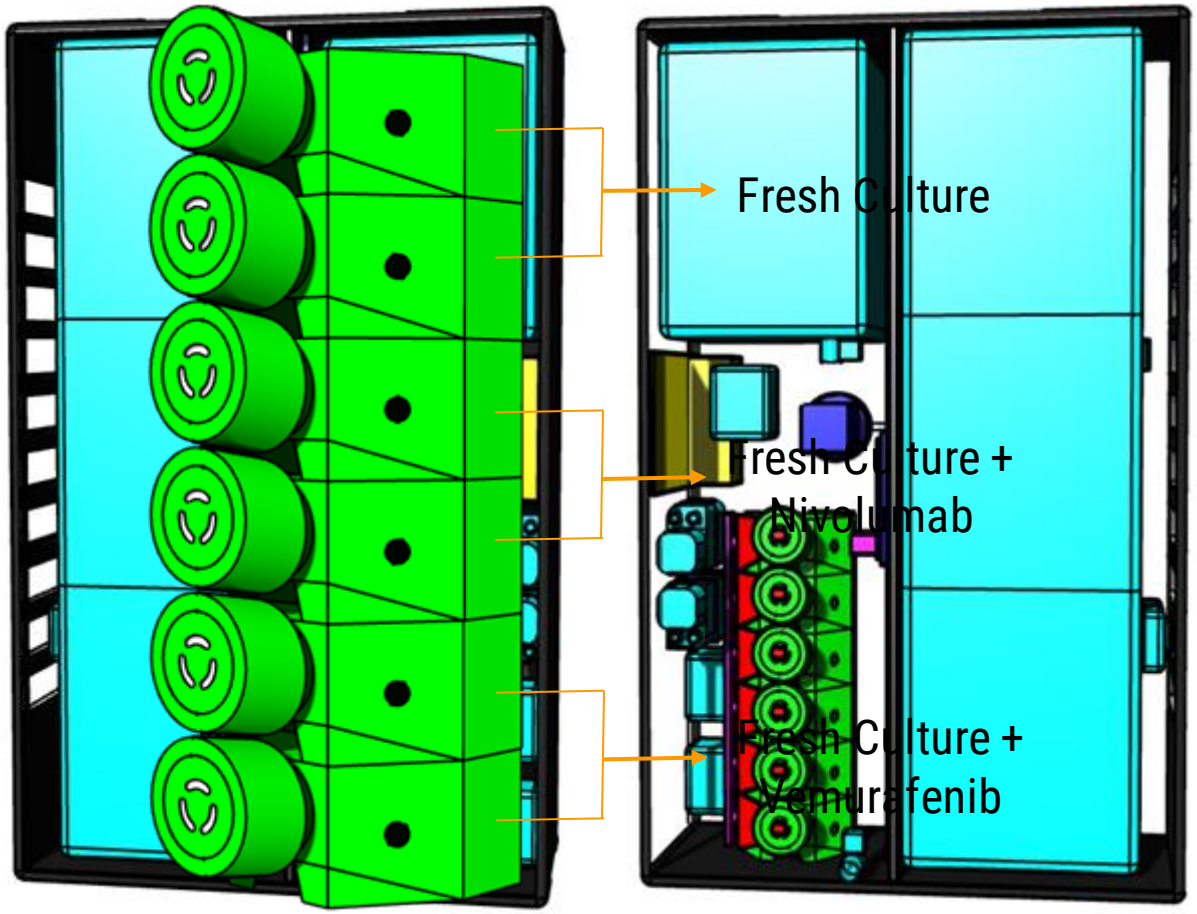
What should our experimental unit do?

- **Preserve** melanoma samples, cells culture and drugs
- **Administer** the **drugs** properly
- **Estimate** the **number of cells** and cells growth rate in each sample
- **Ensure** facility **integrity** even if a failure occurs

How should it do it?

- Thermal control system
- Hydraulic system
- Optical system
- Mechanical system
- Structures

Setup



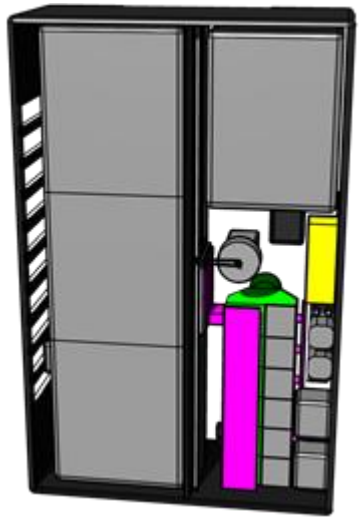
- **ICE Cubes** facility
- **Single-block** structure shaped like a **6U CubeSat**
- **Free samples** and technical **support** from “San Gallicano”
- Specific **installation** and **positioning** requested
- **4 months** in orbit

Mechanical system

ISG
ISTITUTO DERMATOLOGICO
SAN GALLICANO

ICECUBES
SPACE APPLICATIONS SERVICES

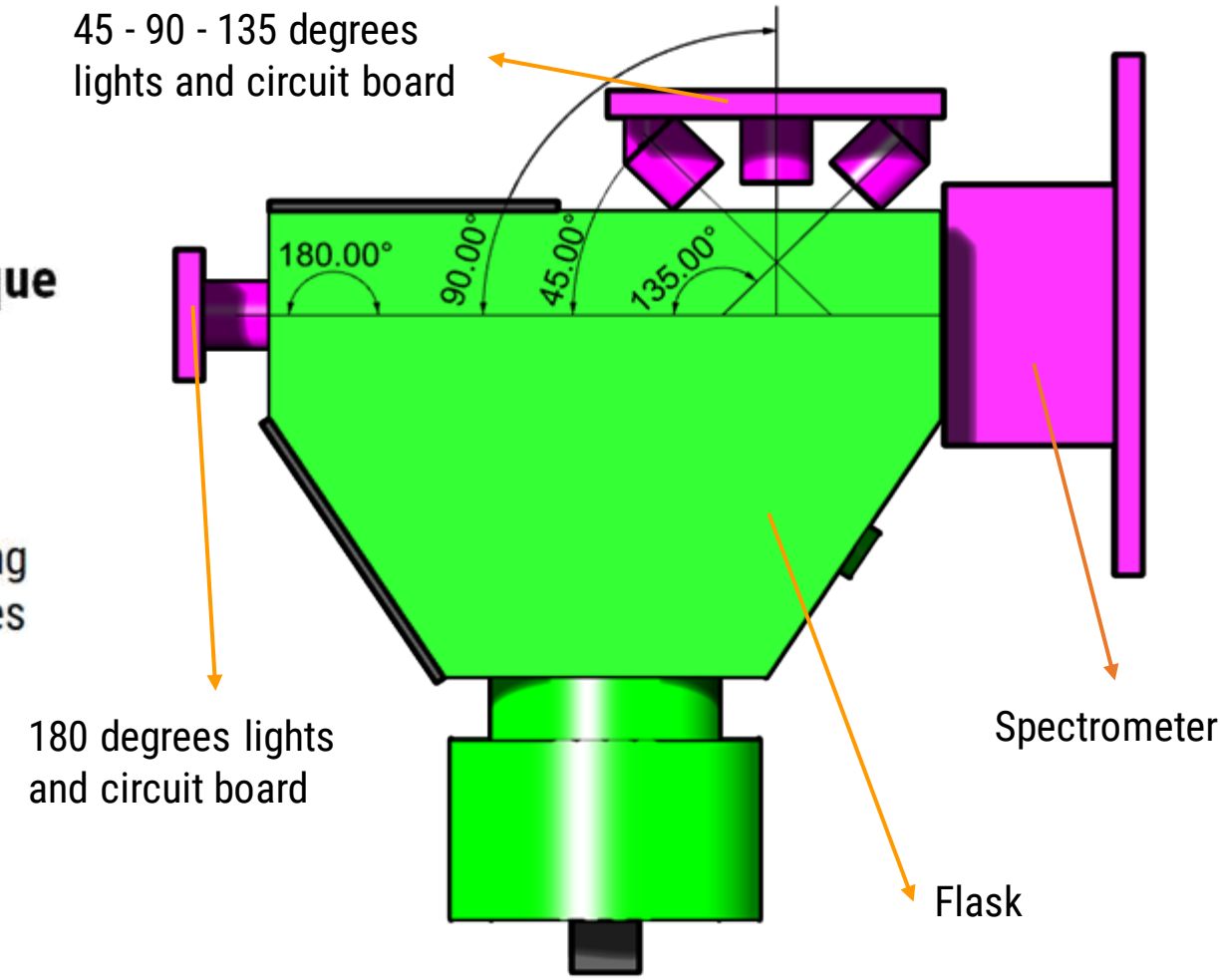
Space Segment description - optical and mechanical systems



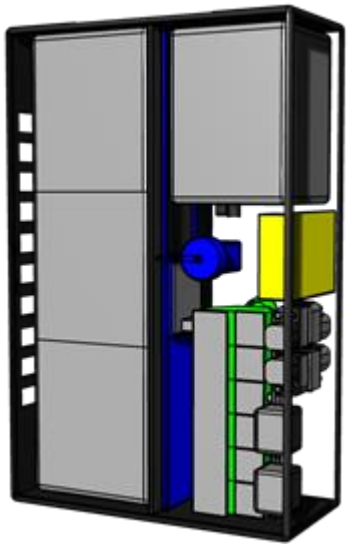
- Samples
- OBC and PDU
- Optical system and lights

Ratio Nephelometry technique

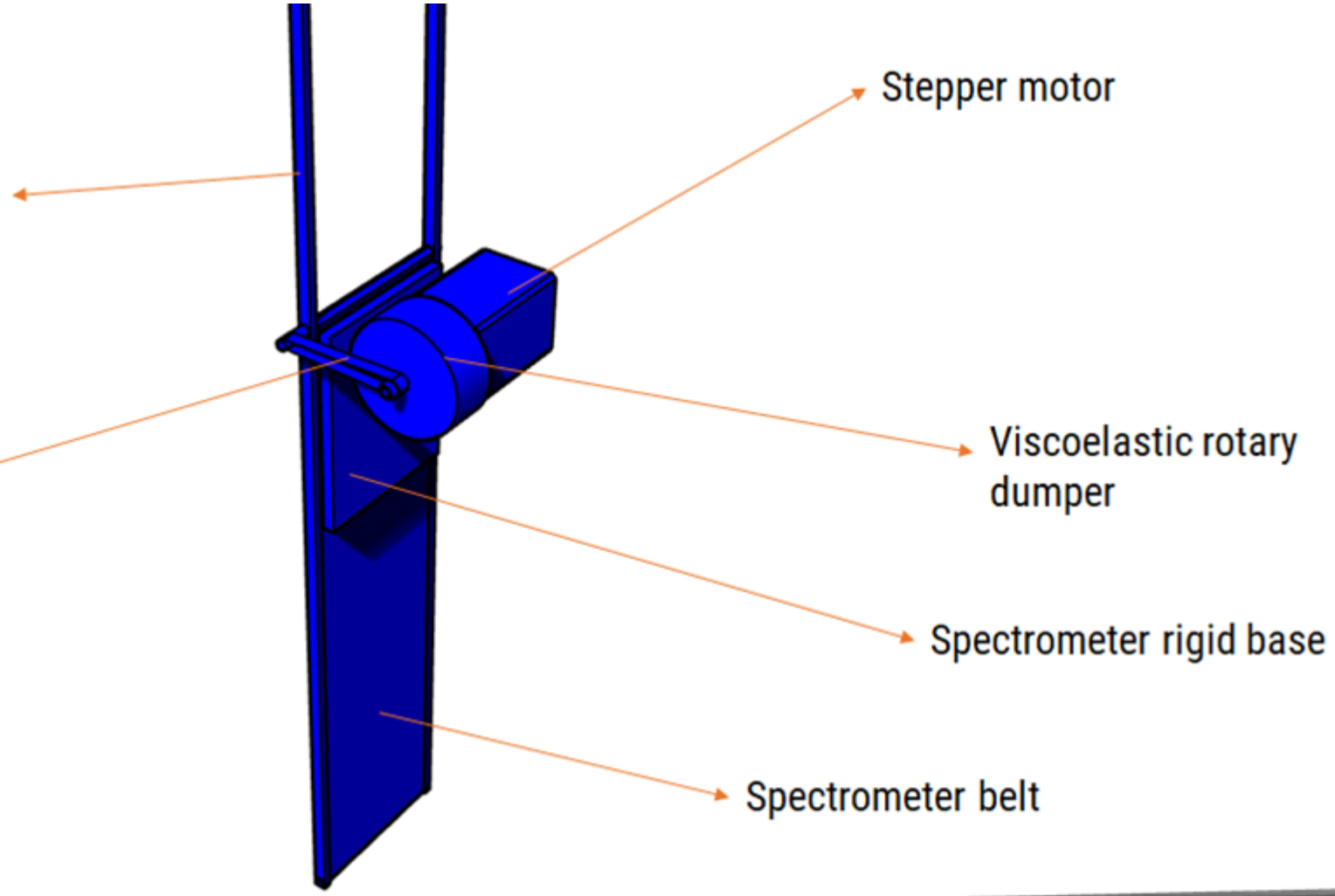
Improving accuracy by measuring scattered light at different angles



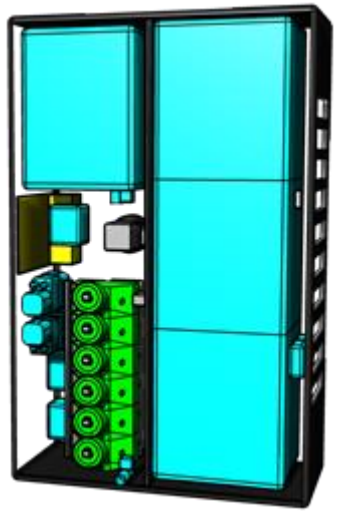
Space Segment description - optical and mechanical systems



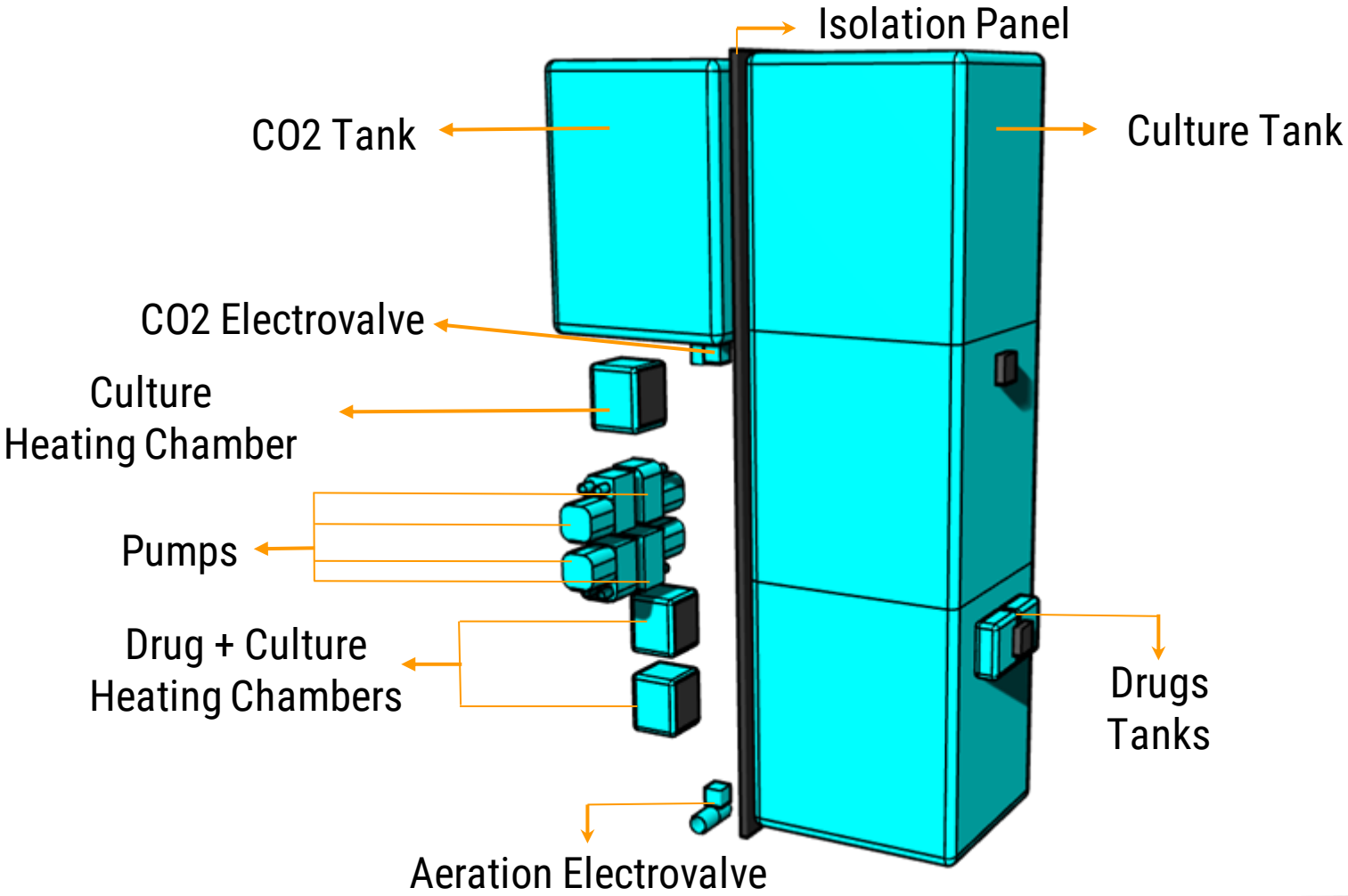
- Samples
- OBC and PDU
- Mechanical system



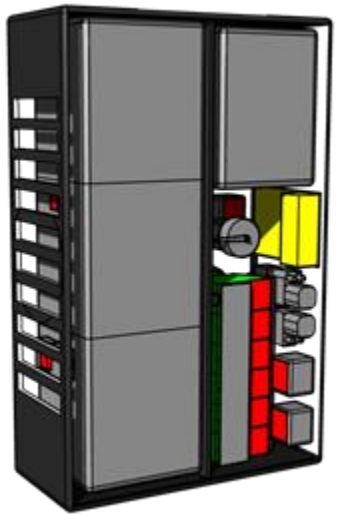
Space Segment description - hydraulic and thermal system

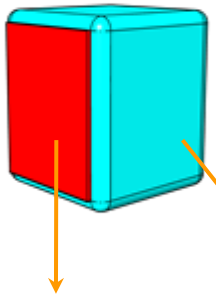


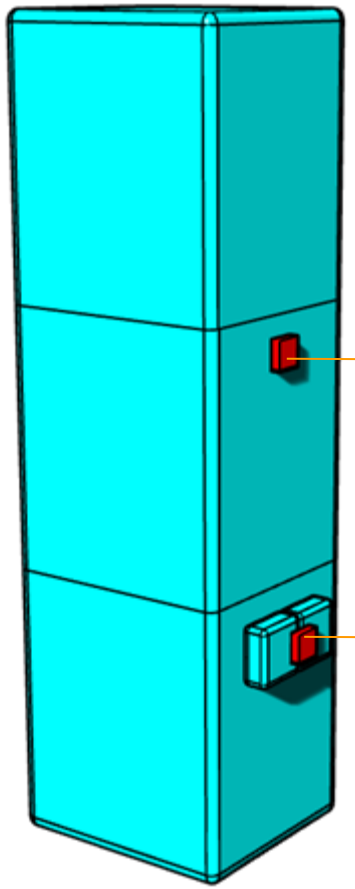
- Samples
- OBC and PDU
- Hydraulic system

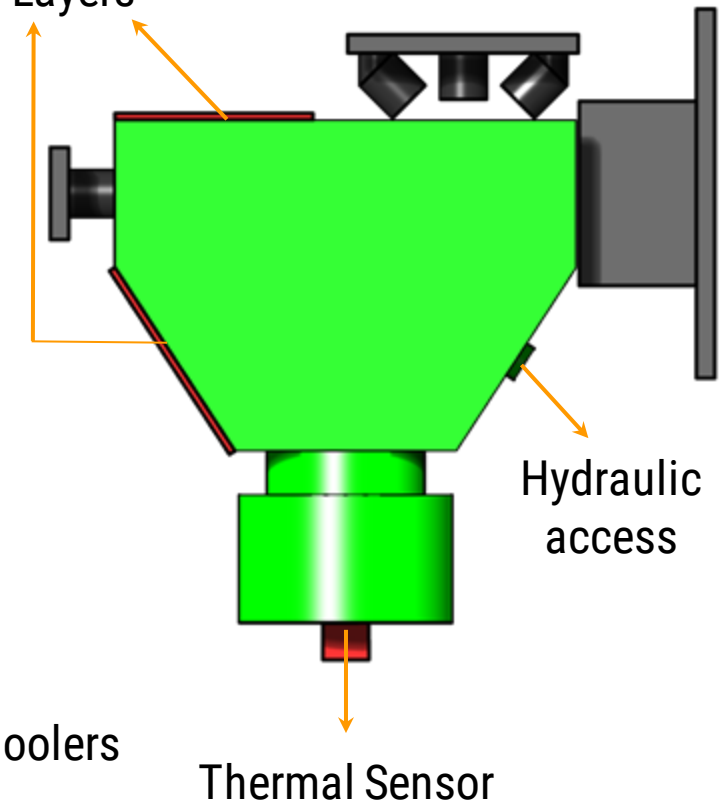


Space Segment description - hydraulic and thermal system









- Samples
- OBC and PDU
- Hydraulic system
- Thermal system

Pre-Flight

Samples **extraction** and **arrangement** in flasks and in the case for launch

Chemical heater and **cooler** for survival of the samples and culture in the launch phase

Installation:
- **launcher**: as close as possible to the scheduled launch time
- **facility**: immediate upon arrival on ISS

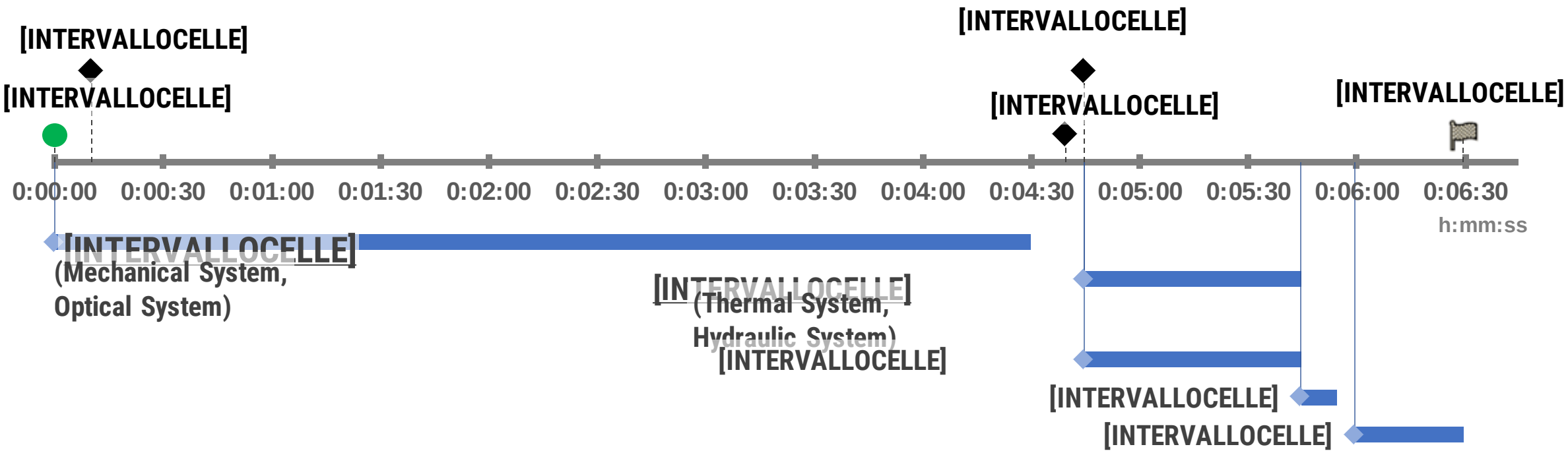
Post-Flight

Studying the **combined effect** of **immunotherapy** and **microgravity** on the samples

Compare the ISS results with the ground analysis

Coordinate with ICE Cubes to retrieve the samples

Cycle of operation



Mass budget

SYSTEM	MASS [gr]
On Board Computer	135
Biological System	5195,3
Thermal System	160,9
Hydraulic System	2278,9
Optical System	80
Mechanical System	293
TOTAL	**8143,1**

Power budget

SYSTEM	PEAK POWER [W]	ENERGY CONSUMPTION [Wh]
Data Collection Cycle *(On Board Computer, sensor, electric heater, Optical System, Mechanical System)*	**27,653**	**/**
Sample Maintenance Cycle *(On Board Computer, sensor, electric heater, Thermal System, Hydraulic System)*	**22,954**	**/**
Ventilation and Air Conditioning *(Ventilation Valve, CO_2 Valve, Peltier cooler)*	**34,454**	**/**
TOTAL		**34,5051**

Preliminary risk register

Risk and Consequence	P	S	P x S	Mitigation Action
Malfunction of the hydraulic system, cells do not hire medicinal neither nutrition.	B	4	Low	More detailed tests will be performed on the Hydraulic system in order to prevent the failure of the subsystem.
Malfunction of the heating system, thermal sensor breakdown.	B	4	Low	More tests will be performed on the Heating system in order to prevent the failure of the subsystem.
Malfunction of the optical system: Camera breakdown and/or failure of turbidimetry analysis system	A	1	Very Low	Tests will be performed on the optical subsystem to guarantee the correct functioning in order to prevent loss of preliminary data during operations.
The MARGE project team fails to obtain mission authorization and qualification of the payload	A	4	Very Low	Upon launch, the team will be coordinated by personnel with experience on acquiring legal authorization and qualification for ISS launches.
Load Factor during the launch leads cell damage	A	4	Very Low	It can lead to several cell membrane damages. Tests will be performed in order to esteem the lower risk of damaging cell membrane possible, in accordance to the load factor of the launch.
Delay in components procurement and insufficient funding for mission development	B	4	Low	Several funding sources are taken into account during the preliminary phase of the project and procurement phase will be started in time in order to prevent delays.
Load Factor leads to experiment break up	A	5	Medium	Experiment structure will be over-tested in order to reduce probability of damages or break ups during launch.

Implementation plan

Project Planning
2 years

Procurement
6 moths

Design
8 moths

Subsystem development
2 months

-Structure -OBDH
-EPS -TT&C
-Biological Payload

Testing Phase
2 months

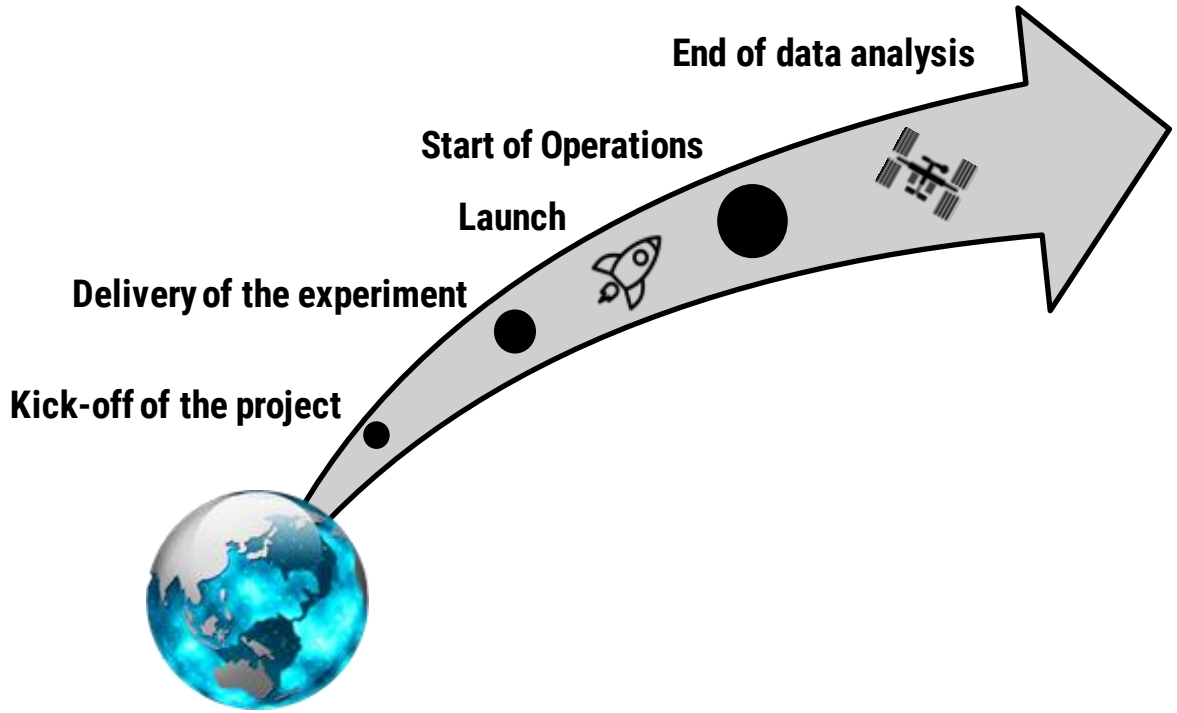
Launcher integration

Software preparation
10 months

Experimental Operation
4 months

Data analysis
9 months

Milestones



Conclusion

It has been proven that microgravity can induce **apoptosis**

Interest in studying the **combined effect** of microgravity and monoclonal drugs on **melanoma**

Autonomous system allocated in a 6U CubeSat

Monitoring of the samples during the in orbit time made by a **turbidimetric analysis**

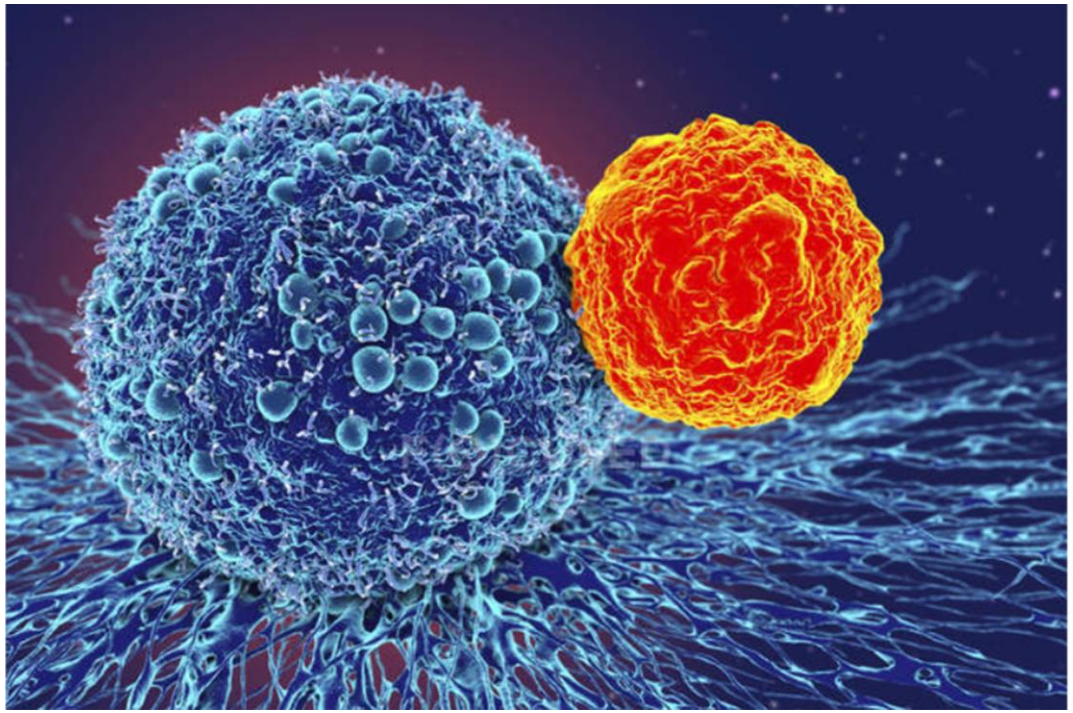
Post analysis of the **expected effects** of microgravity after the **4 months of operational phase**

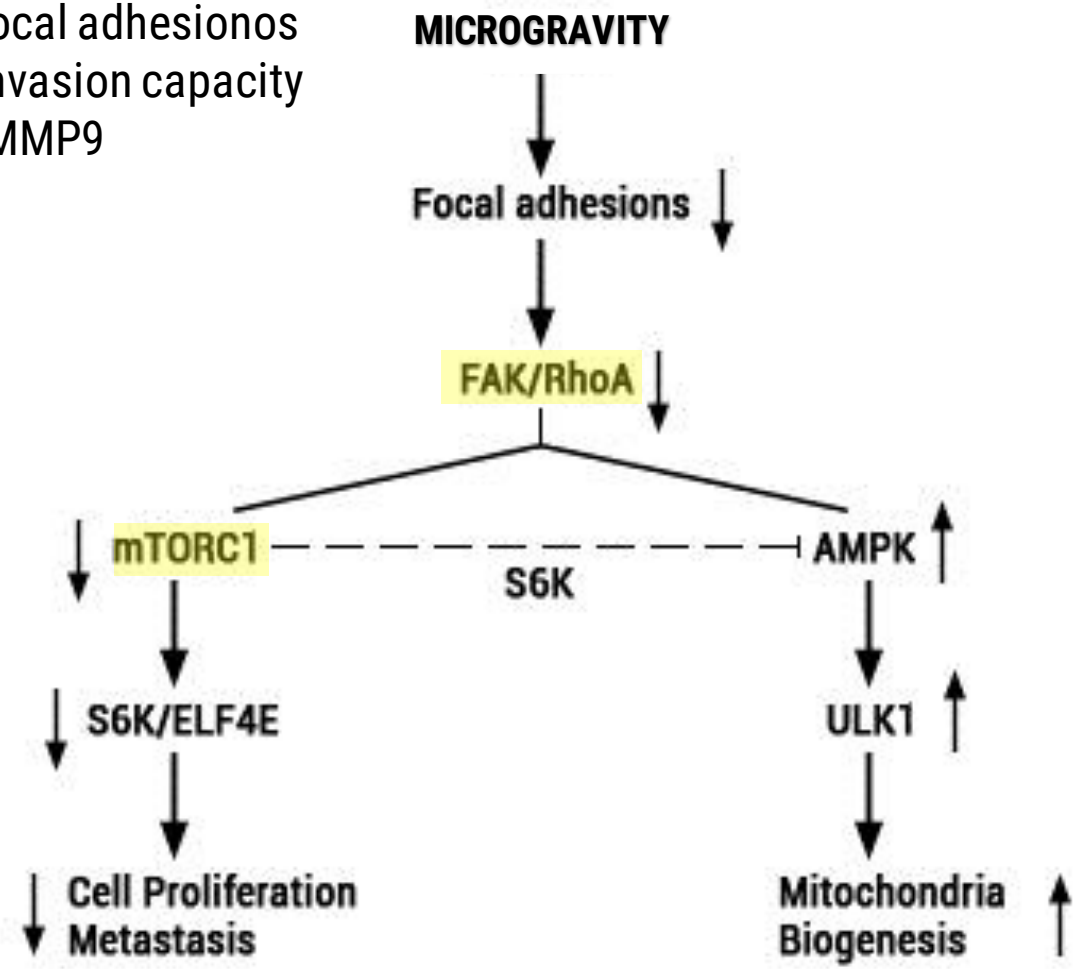
Thank you for your attention!

Combined effect of microgravity and immunotherapy

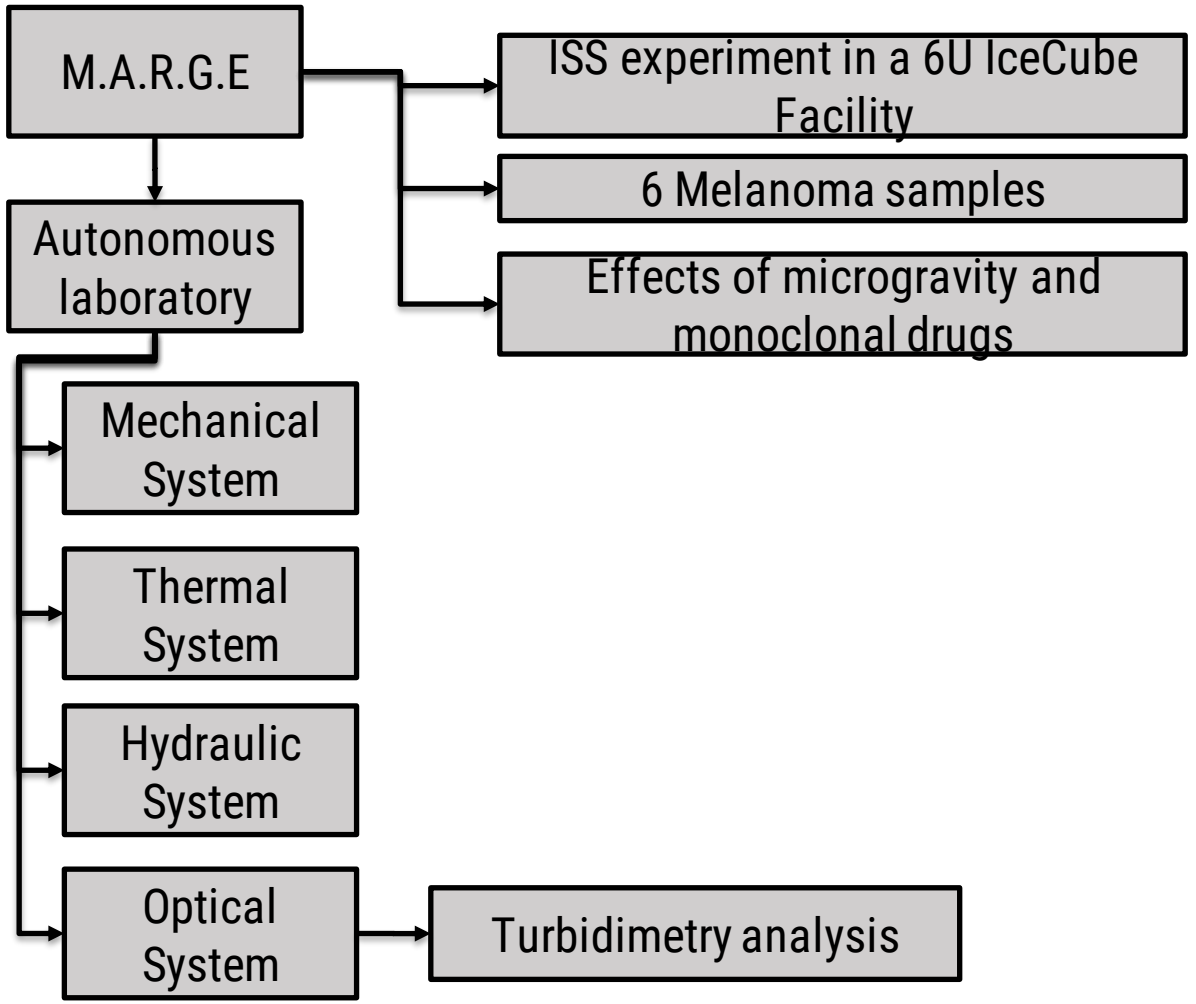
- Apoptosis
- Inhibition proliferation of melanoma cells
- Loss of function mTORCH1
- Structural alteration of Cytoskeleton

- Decrease of focal adhesionos
- Decrease of invasion capacity
- Inhibition of MMP9

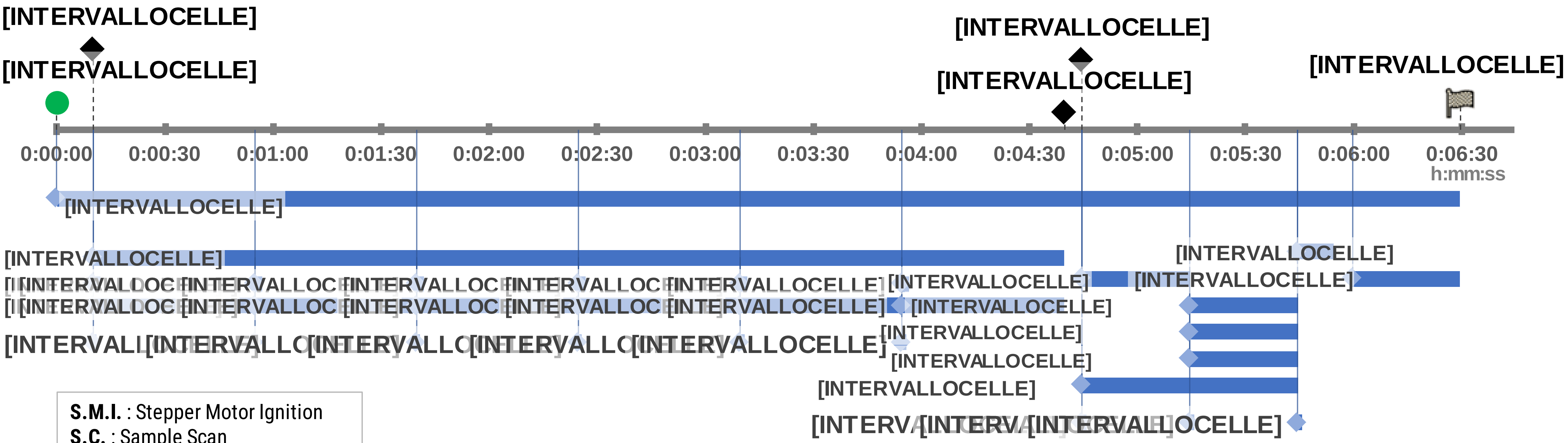




Q & A


M.A.R.G.E
ISS experiment in a 6U IceCube Facility
6 Melanoma samples
Effects of microgravity and monoclonal drugs
Autonomous laboratory
Mechanical System
Thermal System
Hydraulic System
Optical System
Turbidimetry analysis

Timeline



S.M.I. : Stepper Motor Ignition
S.C. : Sample Scan
D.C.C. : Data Collection Cycle
S.M.C. : Sample Maintance Cycle

Mass budget

SYSTEM	COMPONENT	MASS [kg]
Thermal System	Thermal Sensor (x11) (TMP36)	0.1320
	Electric Heaters	0.0089
	Peltier Cell (x2)	0.0200
Hydraulic System	Pumps (x5)	0.0760
	Electric Valve for CO_2	0.0900
	Culture Aluminum Tank	1.4235
	CO_2 Aluminum Tank	0.5421
	Drug Tanks Aluminum	0.0461
	Heat Chamber Aluminum	0.0812
	Tubes	0.0200
OBC	Raspberry Pi 4 B	0.0700
	Driver	0.0650
Biological System	Melanoma Samples	0.1200
	Culture Medium	4.800
	Nivolumab	/
	Vemurafenib	/
	CO_2	0.0342
	Sample Flask (x6)	0.2411
Optical System	PCB Light 180	0.0100
	PCB Light 45/90/135	0.0300
	Spectrometer	0.0400
Mechanical System	Camera Engine (Stepper Motor NEMA 14)	0.1800
	Viscoelastic rotary Damper	0.0120
	Transmission Belt	0.0007
	Sensor Belt	0.0659
	Support structure and Sensor base	0.0313
	Heat insulator (Depron)	0.0031
TOTAL		**8.1431**

Power budget

COMPONENT	D.C. PEAK POWER [W]	D.C. PEAK POWER [W]	S.M. 1 PEAK POWER [W]	S.M. 2 PEAK POWER [W]	S.M. 3 PEAK POWER [W]	O.C. PEAK POWER [W]	A.C. PEAK POWER [W]	ENERGY CONSUMPTION [Wh]
Sensor (x11)	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$	$1.928*10^{-3}$
Electric Heater	2.652	2.652	2.652	2.652	2.652	2.652	2.652	2.6524
Heat Chamber (X3)			5.3					0.0024
Peltier Cooler (x2)						16.8		16.62
SBC (Single Board Computer)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Culture and Waste Pumps (x3)				0.6				$7.5*10^{-4}$
Drug Pumps (x2)				0.4				$4*10^{-8}$
Air Pump							0.2	0.034
Electric CO_2 Valve					4.8			0.0044
Spectrometer and Lighting	10							0.156
Camera Engine		3.9						0.0379
POWER USED	**27.653**	**21.554**	**22.954**	**18.654**	**22.454**	**34.454**	**17.854**	
TOTAL ENERGY CONSUMPTION								**5051.**