GlioLab and GlioSat: university space systems for biomedical research

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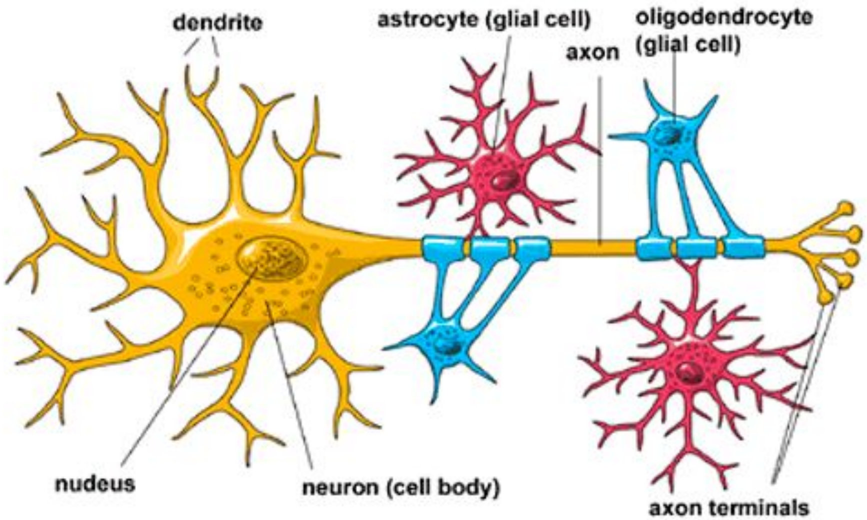
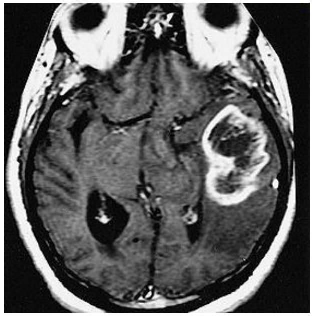
Mission Goal

The biological effects of ionizing radiation and microgravity on the human body in space are key concerns for space exploration and, at the same time, potentially provide successful ***biomedical applications and treatments****.*

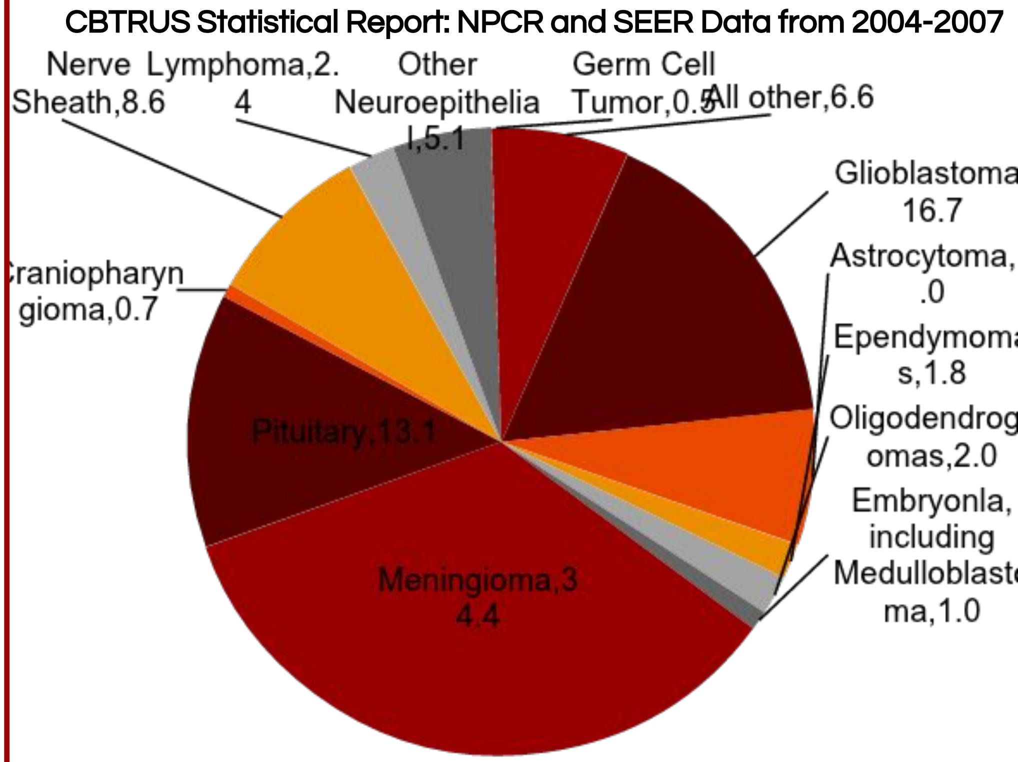
The biological goal of this research is to investigate the combined effects of microgravity and ionizing radiation on the gene expression of **Gliobastoma multiforme**.

Glioblastoma



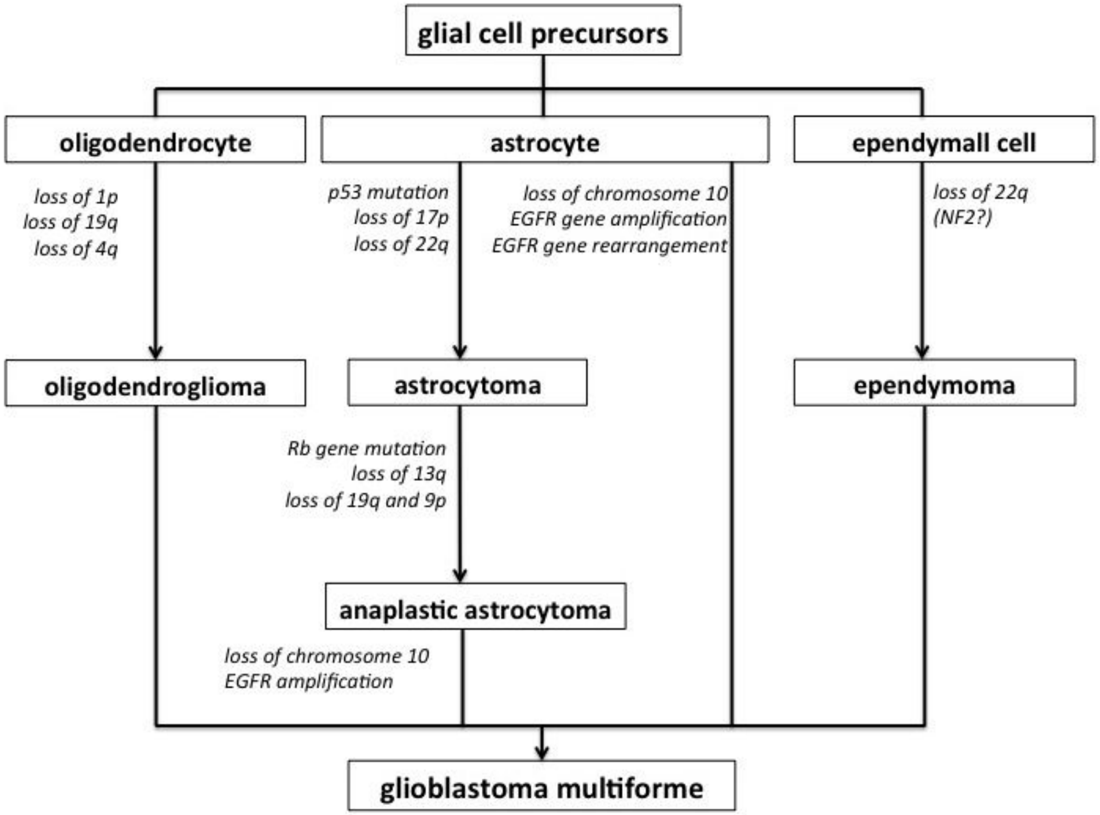


Survival rate:
57% @ 1 year,
16% @ 2 year
7% @ 3 year



Gliomas account for 31% of all tumors and 80% of malignant tumors; **Glioblastoma Multiforme (GBM)** is the most aggressive of these (grade 4) and also the most common in the humans.

Glioblastoma- Pathogenesis and treatments



Treatments

- ✓ Surgery
- ✓ Radiotherapy
- ✓ Chemotherapy
- ✓ Radiotherapy combined with chemotherapy

The studies of human genome are giving a lot of inputs on the expansion of ideas about brain tumor pathogenesis and consequently on their treatments.

Improve the knowledge of GBM performing studies under different environment conditions: micogravity and ionizing radiation

Simulated Microgravity

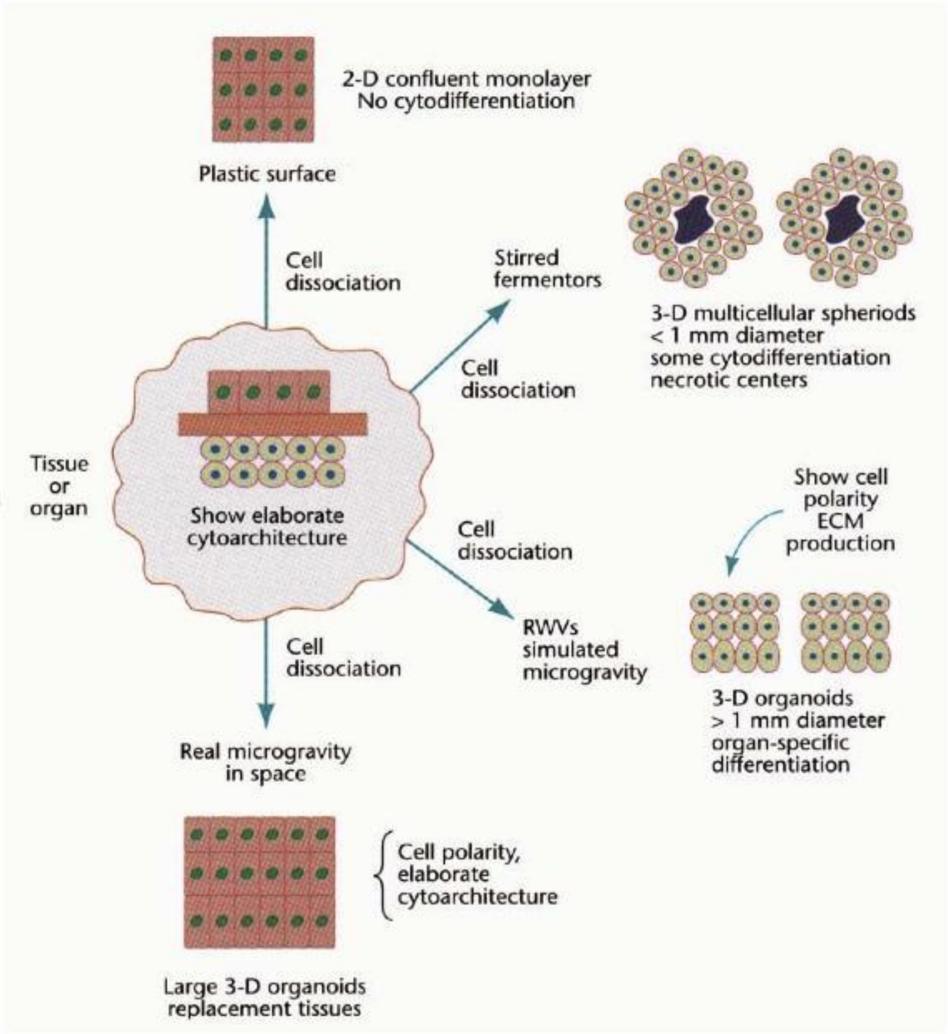
- induce apoptosis (Kossmehl)
- decreased secretory activity (Grimm)
- inhibited/enhanced cell differentiation (Saxena) of a variety of cancers.
- decreases the proliferation and enhances the chemiosensitivity in malignant glioma cells (Takede).

Microgravity studies in space indicate there are unique mechanisms of tissue differentiation/gene expression which are distinct from the best ground based simulations (Hammond,Clement)

Space Environment for Biomedical research

Cell culture in microgravity aboard the space systems provides an unique opportunity for studies of anti-cancer drug action under conditions that more closely mimic the in vivo ultra-structure than can be attained under gravitationally limited culturing protocols ()

Simulated Microgravity vs Real Microgravity



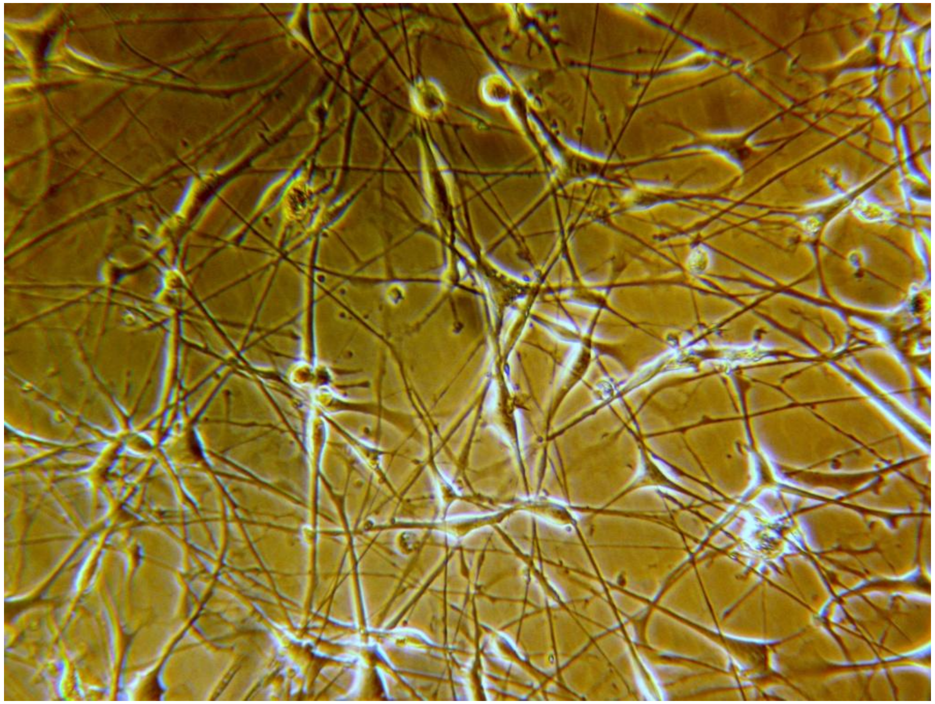
International Collaboration

Aerospace Engineering School
University of Rome Sapienza

Space Science Center Morehead State University

FONDAZIONE DI RELIGIONE E DI CULTO
Casa Sollievo della Sofferenza
OPERA DI SAN PIO DA PIETRELCINA
SAN GIOVANNI ROTONDO

Biological Samples



ANGM-CSS

- GBM cell line derived from a 65-year-old male.

Normal Human Astrocytes

- NHA, CC-2665) obtained from Lonza Walkersville Inc.

Radiosensitive

- U87MG and U251MG GBM cell lines more sensitive to radiations

Each experimental culture will have a paired culture exposed to gravity maintained and handled experimentally in an identical fashion: one suitable for DNA isolation and genome studies, the other one for RNA isolation and transcriptome studies

Phase 0- GlioLab Precursor

STS-134 Mission

- Launch: 16th May 2011
- Landing: 1st June 2011

STS-135 Mission

- Launch: 8th July 2011
- Landing: 21st June 2011

Biomedical Samples

- 1 (2) LMA
- 5 (10) ml of DMEM 10% FBS +

  ANGM Glioblastoma Cells (15,000 cells per ml)
- 25 (50) ml of RNA Protect Cell Reagent (Qiagen)

LMA Liquid Mixing Apparatus System

Phase 0- GlioLab Precursor-Results

ecreasing of ANGM-CSS cells survival rate

BUT

- No monitoring system
- No control environment system
- Vials (and not flasks) have been used

Young Students Cara DeMoss and Will Grey integrate the samples on NASA KSC facilities

Phase 1: GlioLab

Phase 1- GlioLab

- ✓ Cubelab (Nanoracks) inside the ISS
- ✓ Imaging will be performed during all the mission phases
- ✓ Thermal control system to keep alive the cells

After 30 days of exposure the system will then be returned to Earth for RNA transcription analysis and genome .
A control experiment will simultaneously be conducted on the ground.

ISS is shielded against ionizing radiation

Phase 2: GlioSat

Phase 2- GlioSat

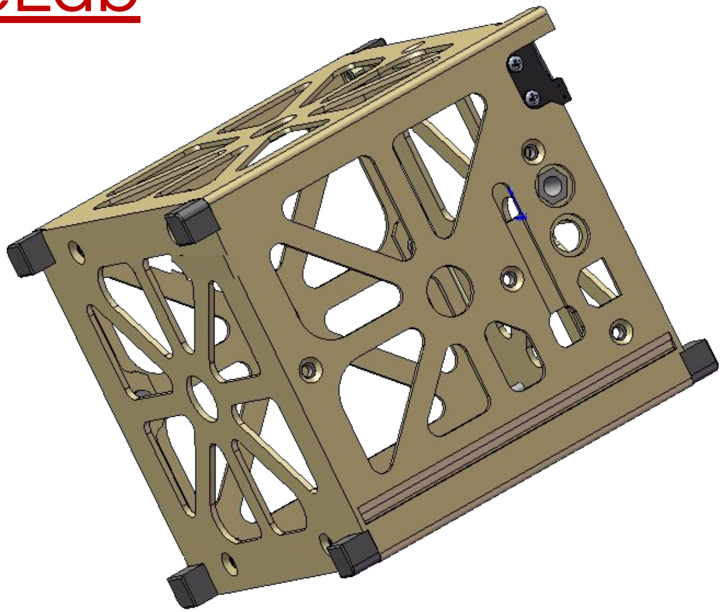
- ✓ The cells will be exposed to microgravity conditions and ionizing radiations using completely autonomous satellite
- ✓ Imaging will be performed during all the mission phases
- ✓ Thermal control system to keep alive the cells
- ✓ Impedance system to monitor the cells growth rate
- ✓ Data will be collected during the mission

A control experiment will simultaneously be conducted on the ground.

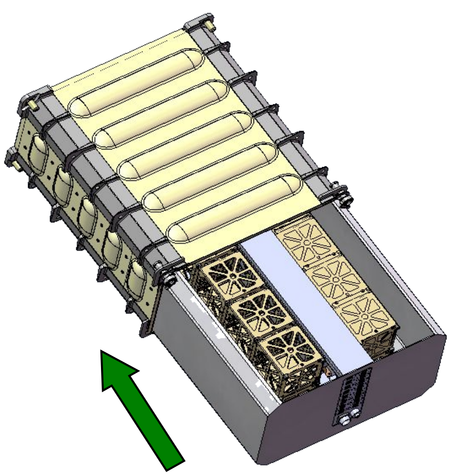
No Return to the Earth!

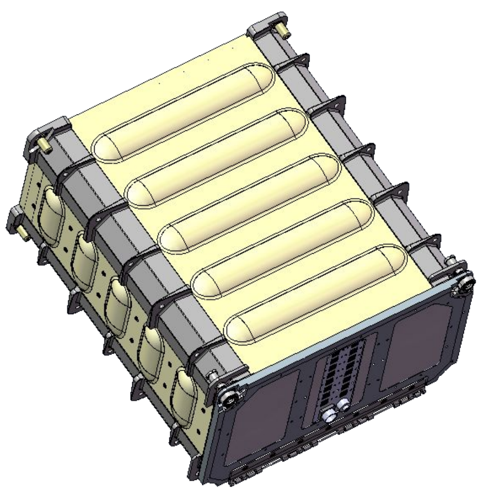
GlioLab

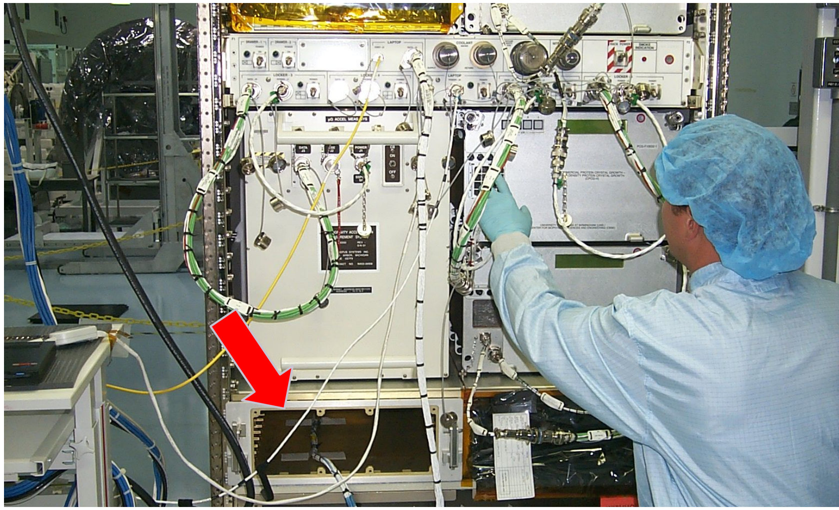
NanoRacks- CubeLab



- ✓ Integrate payloads on the ISS
- ✓ 30-day mission
- ✓ Provides power – 5V @ 2W
- ✓ Provides communications – USB
- ✓ CubeSat form factor
- ✓ First flights Spring 2010







GlioLab Mechanical Structure

NanoRacks- CubeLab

- ✓ 2 U CubeLab : 227mm x100 mm x 100mm
- ✓ Weight ≈ 2Kg
- ✓ Aluminum 6061T6
- ✓ ISS: Triple Containment
- ✓ 6 OptiCell Flasks
- ✓ Injection System (RNA fissative)

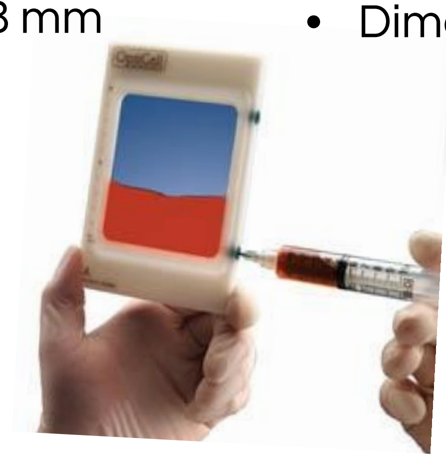
Cells Containers : Flasks

BD Bioscience Labware

- Growth area: 12,5 cm^2
- Dimensions: 81.85x44.45x26.18 mm

Nunc 170920 Flasks on slide

- Growth area: ≈10 cm^2
- Dimensions: 52.5x22 x21mm



OptiCellTM

Growth area of 50 cm2, total 100 cm2 2 for each flask.
Dimensions: 132x84x6mm reduced to 85x79x 6mm.
Two membranes with 75µm thick are separated by only 2 mm.

GlioLab Thermal System

Target: temperature range between 25°C and 39 °C with an ideal temp of 37°C.

- ✓ During the launch phase the temperature range is approximately between 10°C and 46°C.
- ✓ The temperature range inside the Station is not so critical for the experiment.
- ✓ All heat generating elements, like microprocessor and similar, will be thermally bonded.
- ✓ Additional power to maintain the temperature before the integration inside the Express Racks.

GlioLab Thermal System

The thermal control system consists of:

- ✓ **Sensors** with a temperature accuracy of 0.5°C and 0.1°C , placed inside the second level.
- ✓ **Insulating materials** will maintain the temperature on the due temperature range.
- ✓ **Heaters** have been designed and manufactured in order to increase the temperature when it is needed.
- ✓ **Electronic Board** based on MSP430 (On board Computer)

GlioLab Image System

<u>COTS Microscope</u>

<u>CMOS Sensor and lens</u>

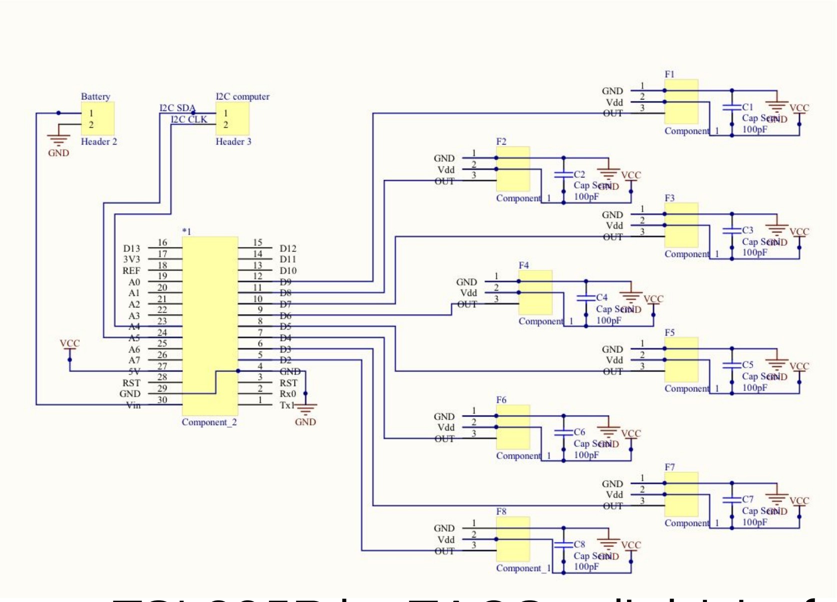
✓ **Electronic Board** based on MSP430 (On board Computer)

Ionizing Radiation Monitoring

Scintillation detector

- ✓ Scintillators
- ✓ Photodiodes.

Alpha ray	Blocked by satellite structure
Beta ray and low energy electron	Blocked by satellite structure
High energy electron	Antracene, Naftalene
Neutron	$CdWO_4$, Lil(Eu)
Gamma ray	$CdWO_4$, CaF_2(Eu), BiGeO, $LaCl_3$, $PbWO_4$; Ce:YAG
X ray	$CdWO_4$, CsI, $PbWO_4$, NaI(Tl), Ce:YAG



TSL235R by TAOS, a light-to-frequency converter that combines a silicon photodiode and a current-to-frequency converter on a single monolithic CMOS integrated circuit.

GlioLab Power System & Data System

Power

Before to reach the ISS:

✓ **Alkaline batteries:** imposed by NASA Standard.

Inside the ISS:

✓ Two USB Type B female connectors to provide two 2 W 5 volt power feeds from the Nanoracks (total: **4 W available**).

Communications

Inside the ISS:

✓ NanoRacks will provide communication system:

NanoRacks → EXPRESS Rack Laptop → Tracking and Data Relay Satellite System TDRSS network → a secure internet connection.

Before to reach the ISS:

✓ Autonomous data storage system

GlioLab On Board Computer

MSP
430

GlioSat

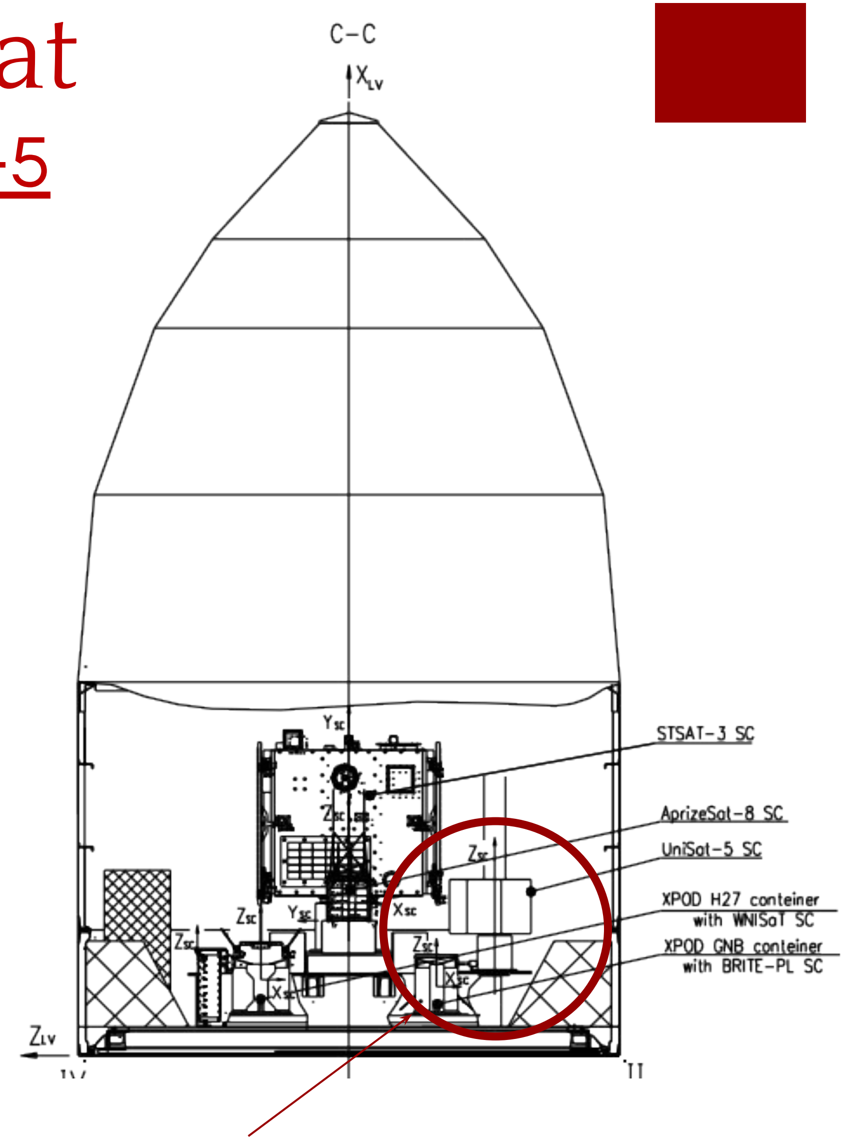
UniSat-5

Payloads:

1. GR-Gamma Ray
2. GlioSat
3. MRFOD

Orbit:

4. Semi-major Axis : 6978Km
5. Eccentricity: 0
6. Inclination : 97,8
7. LTAN: 22 hours 30 min

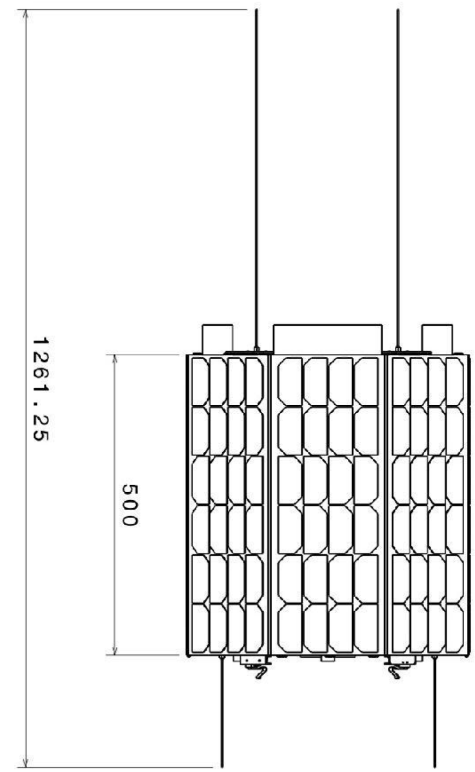


Unisat-5 will be launched on the second half of 2012 using Dnepr Launch Vehicle

GlioSat Mechanical Structure

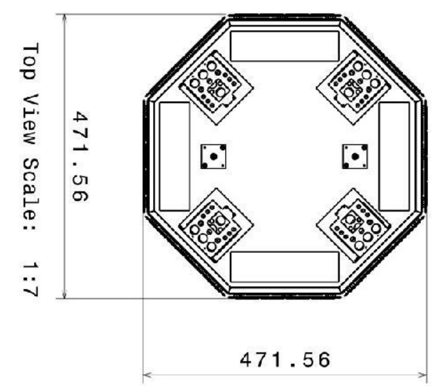
UniSat-5

- ✓ Octagonal Prism Shape
- ✓ Dimensions each side: 500x250
- ✓ Weight ≈ 12Kg
- ✓ Aluminium: 6061T6 and Honeycomb
- ✓ Deployable Solar Panels



GlioSat

- ✓ Injection System (RNA fissative)



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GlioLab Observing System

<u>CMOS Sensor and lens</u>

✓ **Electronic Board** based on MSP430 (On board Computer)

GlioLab Power System & Data System

Power

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GlioSat TT&C System

VHF

UHF

S Band

✓ **Alkaline batteries:** imposed by NASA Standard.

<u>Inside the ISS:</u>

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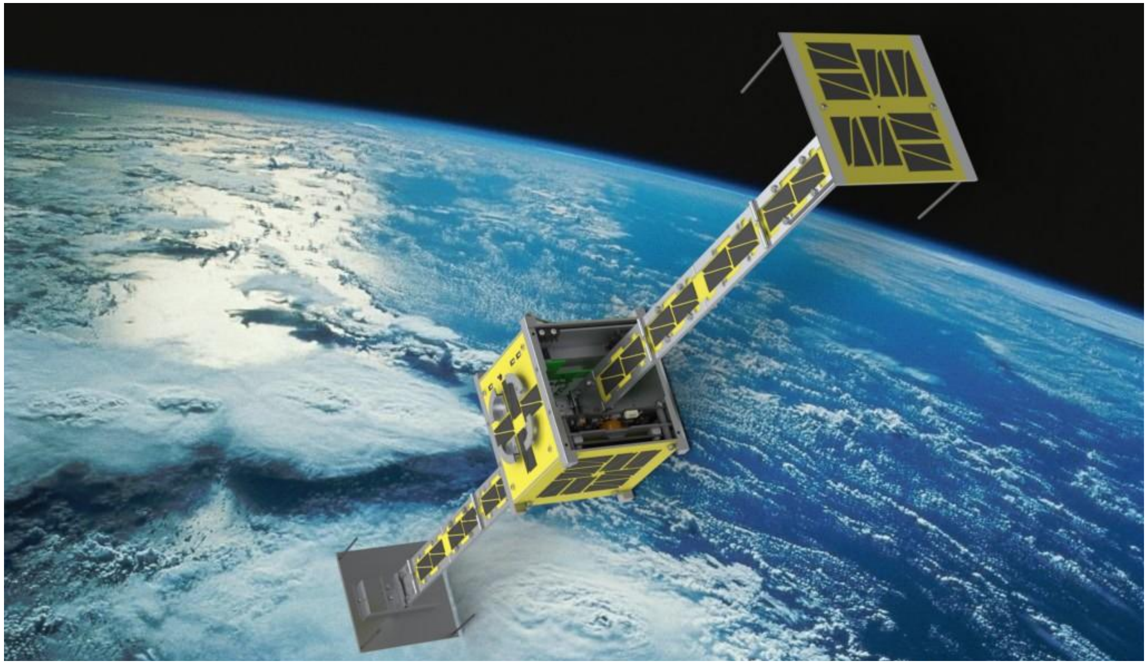
Conclusion

1. A biomedical research at **Aerospace Engineering School** in Roma, involving also the Space Science Center in Morehead State University in Kentucky and the Genetic department of IRCCS-Hospital CSS San Giovanni Rotondo in Italy, has been started.
2. Two preliminary flights on board **Space Shuttle** has already be done
3. An **autonomous system** to test biomedical samples inside the **ISS** has been designed and manufactured
4. A biomedical **payload** for next **UniSat-5** satellite has been designed and manufactured.
5. ….**.Future flights opportunities** : NanoRacks (2012) and UniSat-5 (Sept 2012)

Future…

1. Design a system able to expose sample directly to the ionizing radiation.
2. Design of a lab on a chip system able to monitor the cells during all the mission phases

➡ Use of a boom similar to the one boarded on UniCubeSat-GG



Design of a reentry module or use of autonomous reentry capsule (i.e. IRENE)